Best Practice Analysis of Bioretention Cells and Rain Gardens

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III. Executive Summary

Since 1998 Western Michigan University has been concerned with stormwater retention and filtration. Water purification, retention and flooding have been large problems on campus. Previously the method to deal with stormwater was direct discharge, or pipe to creek. In 2002 Western Michigan University started to take measures to deal with some of the runoff water on campus more thoroughly. Some of the current stormwater project areas are parking lot 23, which is across the road from the Elmwood apartments, the Chemistry Building, South Kohrman Hall/Richmond Center for the Arts, the area around the The Valley residence halls, WMU’s Parkview campus, and Asylum Lake. These projects use mechanisms, natural and manmade, to deal with stormwater. Some natural buffers already in use are native grasses and other purposeful landscaping, and rain gardens. Man made solutions include things like leaching pipes, drainage systems, and sub-surface structures which are for directing and retaining stormwater.

One type of structure on campus that contributes a great deal to rainwater runoff and flow are the many parking lots. Because of their immense size of impermeable surface space, parking lots collect massive amounts of rainwater during every rainfall and when all of this water flows across the pavement it collects and accumulates everything from soil and pebbles to garbage and automotive fluids. This mixture is then carried to the lowest point of the parking lot where it either collects and forms a body of standing water or it flows into a storm drain where it is carried, along with all of the collected chemicals and debris, to a larger body of water. It is here where the damage is done. When the contaminated water flows into a pond or river, the effects can be an ecological disaster. The most obvious effects are the solid waste and debris found in the water and along the shore line. These unnatural items can affect everything from plants and plankton in the water to large organisms such as water fowl. All organisms play crucial roles in maintaining a healthy ecosystem. Simply removing one species of either plant or animal can have drastic effects. Because these fragile relationships ultimately depend on water to survive, the quality of the water is of utmost importance.

Along with parking lots being major storm water retention structures, rooftops contribute a great deal as well. Depending on the the material being used on the rooftops, the stormwater runoff will collect and transport any chemical and/or debris found on a rooftop. Once this runoff flows off of the rooftop, it will carry everything it collects and eventually flow into the same water system as those mentioned above.

We are proposing in order to address this issue is the implementation of a rain garden or a series of rain gardens. By placing a large rain garden or multiple rain gardens in strategic locations near certain parking lots and/or near a building that is prone to large amounts of stormwater runoff coming from the rooftop, storm water runoff could be greatly filtered before it enters an existing body of water. Rain gardens work by collecting large amounts of rainwater and runoff water into a specially designed “garden” that has been planted with water-susceptible grasses, shrubs, flowers, etc. When the contaminated water flows into the rain garden, it is collected and then slowly filtered first through the topsoil with the plant roots, then a bottom layer of sand or small pebbles which lays on top of a special filter cloth or paper, and finally to a drainage system that leads to a designated body of water.

One of the greatest benefits of a rain garden is that once it is established and has had time to mature, it requires very low maintenance from there on out. The first few years after being established rain gardens require regular care and observation in order to guarantee the garden takes hold and develops properly, but once it is developed only regular routine maintenance is required. An obvious benefit to implementing a rain garden is that
they are more appealing to the eye than some mechanical filtration device; after a rain garden has had time to develop and flourish, it can be a very beautiful addition to any landscape. Finally, the most beneficial aspect to using a rain garden is that it doesn’t require any kind of fuel to operate, making it a carbon neutral tool on campus.

When looking at the future use of rain gardens on campus, the outlook appears very promising. Western’s campuses already have rain gardens and similar structures implemented to deal with stormwater runoff; because of this Landscaping Services already has vast knowledge about building and maintaining rain gardens. With this being the case, if our analysis is successful in encouraging the development of a new rain garden on campus, then it would be safe to assume that it will be maintained and will function successfully for many years to come.
IV. Introduction

The purpose of this analysis is to identify the stormwater runoff problems near the upcoming new Hoekje and Bigelow residence halls and to study similar areas with similar issues that have already been addressed both on Western’s campus and on other university campuses in the nation by means of best practice reviews. Because there have been issues with stormwater at other locations on campus, there is a reasonable probability that there will be draining and flooding here as well. Adding a stormwater feature to these new buildings will decrease the likelihood of flooding, pollution of the nearby Goldsworth Valley Pond, and erosion of steep inclines. This area currently has little permeable space to help absorb runoff water from the buildings and parking lots.

Stormwater is created by infrastructure, and by having impermeable surfaces clustered together. Thus, campuses, cities, and other similar entities all must figure out what to do with this water. We can manage it responsibly, or not. As the Environmental Protection Agency explains:

“Stormwater is rainwater and melted snow that runs off streets, lawns, and other sites. When stormwater is absorbed into the ground, it is filtered and ultimately replenishes aquifers or flows into streams and rivers. In developed areas, however, impervious surfaces such as pavement and roofs prevent precipitation from naturally soaking into the ground. Instead, the water runs rapidly into storm drains, sewer systems, and drainage ditches and can cause: downstream flooding, stream bank erosion, increased turbidity (muddiness created by stirred up sediment) from erosion, habitat destruction, changes in the streamflow hydrograph (a graph that displays the flow rate of a stream over a period of time), combined sewer overflow, infrastructure damage and contaminated streams, rivers, and coastal water” (“Stormwater Management”).

Managing stormwater effectively can prevent many of these problems. Since humans insist on taking away many of the natural buffers nature provides for us, we must now figure out how to recreate nature.

Currently, parking lots 41 and 47, behind Bigelow and Hoekje residence halls, have large problems with runoff water. As of now the majority of the runoff from these large parking lots flows into Goldsworth Valley Pond unfiltered. This poses a serious ecological and environmental threat to the pond due to the garbage and
various chemicals that run off of the parking lot surfaces, along with the stormwater, directly into the pond. The damage does not end here however; the chemicals and debris that drain into Goldsworth Valley Pond will eventually flow into Arcadia Creek, which eventually flows into the already heavily polluted Kalamazoo River, which in turn flows to Lake Michigan. The polluted water can also get into the groundwater, where Kalamazoo tap water comes from. This site needs, and will continue to need, help with directing stormwater either away from Goldsworth Valley Pond or filtering it before it reaches the pond, especially when the new residence halls are built. At this site we are proposing that a storm water feature, specifically a rain garden, be built in with the construction of the new residence halls.

With plans being finalized for replacing the Bigelow and Hoekje dorms with newer, up-to-date dormitories, the timing could not be better to encourage the incorporation of multiple stormwater filtration features near these new buildings. This would also be an ideal opportunity to incorporate a much needed stormwater filtration feature near parking lot 47. Currently there are plans already being discussed for the implementation of these features, so what we are hoping to provide through this analysis is a best practices review of both Western's stormwater retention/filtration features and stormwater management features found on other universities. By researching and providing these features, we hope to give examples of multiple successful stormwater retention/filtration features so that when the times comes for construction to start, there will be extensive plans prepared for multiple stormwater features to be implemented. One feature that we believe will be the best in regards to promoting both sustainability and education is a rain garden.

“A rain garden is one type of “bioretention” - a system of pond area, soil, plants and mulch that will retain water and soak it up instead of letting it run off…” (Rain Gardens of West Michigan). Research from the University of Michigan states the importance of rain gardens:

“Rain gardens are natural or human-made depressions. Their purpose is to retain stormwater on-site and divert any resulting surface water run-off, especially from impervious surfaces, such as roofs of buildings and paved roads and walkways, from reaching municipal storm sewers. Rain gardens filter stormwater, improve water quality, and minimize soil erosion. They also foster biodiversity by providing habitat for plants such as deep-rooted native perennial species” (“Rain Gardens”).

Implementing a rain garden on campus follows the mission set out by Western Michigan University as well as Western’s Landscaping Services. As they explain:

“While Western Michigan University has always strived to implement sustainable practices and promote environmental stewardship on campus, WMU Landscape Services has recently taken it a step further. In addition to the 132 acres of natural wooded areas on WMU's campus, the University owns two nature preserves (322 acres) and maintains natural stormwater detention/retention basins. In recent years, the University has made the conscious decision to not only maintain safety in these areas, but to begin managing for ecological health and education opportunities. The Natural Areas Program is unique in that very few universities currently dedicate resources to programs which actively manage natural areas for research, education, passive recreation and ecological health” (“Landscape Services”).

Ecological health is very important to our lives as humans, even when we don’t realize it. Maintaining the health of our waters are especially important as the tap water in Kalamazoo comes from the groundwater. Western Michigan University is a very large municipality in the Kalamazoo area, thus it has a responsibility to purify and dispose of it’s runoff water properly. Implementing any type of rain garden or bioretention cell will help achieve this goal, and keep our drinking water clean.
V. Methodology and Data

Originally our plan was to create and implement a rain garden at a specific location on campus by the end of the semester, but after emailing Tim Holysz, director of Landscaping Services, who directed us to Steve Keto, the manager of Natural Areas and Preserves, it became clear that that was not what was currently needed. After deciding we still wanted to work on a rain garden project and being advised by Dr. Glasser, director of the Office for Sustainability, on what our options were, we switched the focus of our attention to putting together a best practice analysis of rain gardens in order to provide information and encouragement to the planners of the new Hoekje and Bigelow residence halls so that they would have materials on hand in case they could be persuaded to implement a rain garden into their landscaping plans around the new buildings. Once this decision was made, our research began.

Much of the information that we required we found through internet searches about rain gardens; this was how we found information about rain gardens, how they function, their ecological importance, and ways to create rain gardens, as well as being what lead us to business, government, and college organization websites with pertinent information. We were able to find the departments in charge of stormwater management on multiple college campus’s, including Western, and from there locate people to contact or brochures/reports about the practices that they had in place. One of the group members was in charge of on campus best practice research and so she was in contact with Steve Keto via emails and personal interviews throughout the project. From him she received a great deal of information about the stormwater management practices that Western has in place through talking with him and reading the brochure, projects, and reports that he provided that Landscaping Services has put together over the years. She also found information online through searching for Western’s stormwater management systems. Another group member was in charge of off campus best practice research and she researched online nearby colleges and universities that had rain gardens in place and found contact information for several universities to interview about their experiences with rain gardens. She was in contact with Erik Larson, a senior engineer in Facilities Management and Project Manager at the University of Minnesota-Duluth, Doug Collins, Director of Grounds and Off-Site Facilities at the University of Toledo, and Patrick Lawrence, Chair of the UT Presidents Commission on the River, all via email. From them she received information in the form of answers to the rain garden questionnaire we constructed as well as links to their web pages with relevant information and pdf’s about their stormwater systems.

We created a Google+ document that we were all allowed to edit so that we could pool information and create this report that we could work on and have access to at all times.
VI. Examples of best practice on campus

On Western Michigan University’s campus we have had a large problem with flooding and stormwater more generally. Thus WMU has implemented many low maintenance and creative ways of dealing with runoff water and stormwater. Many of our currently implemented stormwater features are sub-structures. Using more stormwater features that are above ground will help cultivate awareness for sustainable water runoff practices.

One of the most extensive stormwater management systems is on WMU’s Parkview campus. They have implemented “complete onsite stormwater retention” this includes features such as: “leaching pipes, vegetative storage ponds and native grass buffer strips” (DeLong, et al.). These features, especially the latter two, add to the aesthetics of this campus. Parkview’s campus is beautiful, the natural vegetation is a phenomenal example of campus beautification.

One of the smaller projects is a site near the Chemistry Building. WMU built a rain garden/leaching pond to collect water from this area on campus. Around this site Landscaping has planted many native plants on the vegetated slopes and swales to help absorb and filter water before it reaches the rain garden portion of this feature. There are also sub-surface structures to direct the water from sidewalks into this water retention/filtration area. This site creates visual interest on campus and elicits student reaction. Frequently when walking by this site, one hears students wondering out loud “What do these stairs do/go to?” and “What are these rocks for?” Having a sign in front of this helps people educate themselves about campus, but also can spread the word about sustainable stormwater practices.

Much of what has been accomplished at the S. Kohrman site is underground. There is a network of leaching pipes and leaching storage here. This helps to filter much of the water that comes off of the largest parking area on campus, Miller parking garage.
As Steve Keto states: “The stretch along Stadium Drive from Kalamazoo Christian school to the power plant has some good features” (Keto). By eliminating some of the parking space in parking lot 23 and adding a detention/infiltration basin with stormwater substructures, WMU was able to reduce the stormwater load of this site. Stormwater had an estimated reduction of Total Suspended Solids (TSS) by 7.5 tons per year and Total Phosphorus by 85 pounds per year from a total of 28.57 acres (DeLong, et al.). “Although lot 23 may be undersized it has some positive points being so close to the creek. We have been managing vegetation there for only a short time but it seems to be responding. I hope we can improve the rest of that parking lot to continue to protect the Creek” (Keto). Many of these sites are works in progress, and they will gradually improve water flow on campus and ecosystem functioning.

This photo shows the Lot 23 area. In red one can see the eliminated parking area, that was replaced by a detention basin and stormwater drainage pipes. (Photo credit: Delong, Cari et al).

All of these features have helped campus prevent flooding and filter much of the water that permeates through and then leaves campus. Western Michigan University is lacking a true rain garden, which also means it is lacking a great educational opportunity. Having a centrally located rain garden can increase awareness of stormwater management practices and sustainability in general.
VII. Examples of best practice on other campuses

The University of Michigan Dearborn houses the Environmental Interpretive Center, where they have constructed two rain gardens on its grounds bordering the building. The first 1/2 acre rain garden was established on the northeastern side of the main entrance in 2007-2008. A second 1/2 acre rain garden was established in spring 2010 outside the southeastern corner of the Center (“Rain Gardens”). These rain gardens are successful examples of stormwater purification and urban landscaping. Although these are two great examples of rain gardens, they are not on the University of Michigan’s Ann Arbor campus where they could have higher educational value as they would get a lot more attention from students and the general public there.

At Michigan State University they integrate rain gardens and porous pavement into their parking lots (Kline-Robach). These have been successful initiatives since 2010 in reducing runoff water from parking lots.

Eastern Michigan University has it’s own rain garden on campus, near the Westview on campus apartments. One article in the Eastern Michigan University housing-apartments newsletter promotes the underway rain gardens by stating:

“Not only are rain gardens beneficial to the environment, tenants and university students will gain an advantage as well. First off, rain gardens are attractive scenery features that increase the value and uniqueness of a residence. The garden plants create wildlife habitats and attract butterflies and birds.

Another added bonus is that because of its proximity to EMU campus, various educational programs at EMU can organize educational field trips centered around the rain garden” (Tsai).

The idea of utilizing a rain garden as an educational tool is very important. Utilizing the features of campus for education is a way to incorporate hands on learning that is also relatable to students. Not only would a rain garden educate the people inhabiting the building but anyone who passes by the building. Having a sign explaining the purpose and function of the rain garden will help spread the word about stormwater runoff, and sustainability in general.

The University of Toledo has two rain gardens that were created as “demonstration projects for the capture of parking lot, sidewalk and/or building storm water runoff. The intent was to raise awareness and understanding regarding the issue of direct discharge of stormwater runoff on our campus into the 3,700 feet section of the Ottawa River that passes through our main campus” (Lawrence). Because these gardens were created as demonstration projects about possible ways to address storm water runoff and river contamination on an urban campus landscape, there is no close monitoring or record keeping done concerning the volume of water trapped by the garden or the amount of sediments or contaminants filtered, but those who work with them say that they seem to be fully functional gardens that are having positive impacts on water quality. These gardens have mostly been important educational and awareness tools, with many classes and tours observing and working with the gardens as a hands-on learning experience. One of the gardens is located next to a parking lot for the football stadium by the river and another is in a depression in a courtyard between two residence halls also next to the river, both are highly visible and in areas that get a lot of foot traffic. The signs that are located next to each garden explaining what they are and what they do receive a lot of attention and help people understand the importance of their functions. All of UT’s work with rain gardens and other types of stormwater management systems have been in an effort to clean up the highly polluted Ottawa River that runs through their main campus.
Best Practice Example from Another Campus:

University of Minnesota-Duluth created their first rain garden to address issues of flooding and popping manhole covers from one of their largest parking lots during large rainfalls, as well as to create educational opportunities about water management and to protect the nearby Oregon Creek. They had many issues during the creation of this 1/3 acre rain garden, including too much rainfall when they were removing the non-porous soil so it could be replaced with more porous soils and the below ground infrastructure could be put in place and too little rainfall after the flowers, grasses, and trees were planted. After a lot of hard work was put in by Facilities Management and the contractor groups, this massive rain garden was finally completed and it has been completely functional for eight years. The garden can hold up to 60,500 gallons of water when fully operational, which is 88% of rainfall from a 1” rainstorm (“Rain Garden”). Larson stated that the garden is “Very successful” (Larson) from an ecological perspective as well as from an administrative one. The garden has an information pamphlet on site for self-guided tours and there are many guided tours of the garden whose participants have range from prospective students to state senators.

The rain garden is split into four zones: the ornamental zone, the woodland zone, the wetland zone, and the dry zone, and each zone has a very specific function that contributes to the overall success of the garden. The ornamental zone has many native plants along with bright, colorful flowers that attract attention, and the interpretive sign is placed within this zone. The woodland zone surrounds the ornamental zone, it is filled with many native plant and tree species that are both dry and wet adaptable and it functions as a water filtration system just like a natural forest ecosystem does. The wetland zone contains a sediment basin at its entrance point next to a large parking lot, which helps filter out debris while allowing water to flow into the rest of the zone. The wetland zone is filled with mostly native plants that have high water tolerance, which helps them act like the filtration system that a natural wetland would be capable of performing as. There is also a water level structure within the wetland zone that helps regulate the water level in the zone throughout the year. The dry zone is around the outside of the garden and is filled with flowers and grasses that do well in dry conditions as this zone acts as the transition between the rain garden and the surrounding environment (UMD Rain Garden).

Many of the professors use UMD’s first, and largest, rain garden as an educational opportunity and a demonstration site, as do other environmental organizations and gardening groups in the area. UMD’s nine rain gardens, along with their other stormwater management systems, protected the campus from much of the damage that the rest of the city of Duluth suffered after the June 20th, 2012 flooding that caused Duluth to be named a FEMA disaster site. Because of the garden’s visibility and their excellent functioning, stormwater runoff and sustainability practices in general have become a focus of the university, and local and state attention on the gardens has made the administration very grateful of their existence (Larson).
VIII. Discussion

Through comparing various rain gardens one can easily see how diverse the plans and outcomes can be. When looking to prevent flooding and larger stormwater events many campuses use sub-surface structures to control the water, however, rain gardens and bioretention cells can have larger effects on runoff water’s quality than many substructure devices alone. Rain gardens can function as miniature wetland habitats, collecting, cooling, and filtering water before it is returned back into the larger natural water system. Besides being incredibly useful stormwater management features, these gardens can also do what all gardens do, which is to provide areas of beauty that brightens the surrounding areas as well.

Another important aspect of rain gardens is their education factor. Wherever there is a rain garden there must be, at minimum, signs. This is an extremely important facet, because through signs awareness of ongoing campus projects can be raised and all those who chose to read the signs can be educated as to the purpose and function of the rain gardens. Education is the first step towards gaining support from students and faculty and the community as a whole. On Western Michigan University’s campus we have a large flooding problem. Not only do we need stormwater management, we need to educate people on campus. A rain garden would hopefully help inform people about stormwater and also environmentally friendly practices in general.

Rain gardens are very useful tools in stormwater management practices, which Western and especially Landscaping Services strongly believe is important, so the implementation of a rain garden into the landscaping around the new Hoekje and Bigelow residence halls would allow Western to meet their standards of excellent stormwater management systems while increasing environmental education and the beauty of campus. Erik Lawson from the University of Minnesota-Duluth stated that the Vice-Chancellor of his university told him after the second group of state senators toured the rain garden there that the garden was one hundred percent worth its cost due to the positive publicity that it generated for the school (Larson). As Western is currently struggling with decreasing admissions and seeks to find ways to encourage prospective students to attend, the positive impacts of a well put together, beautiful, functioning rain garden located next to brand new residence halls cannot be underestimated.
This table shows all of the rain gardens/bioretenion cells that we analyzed for this report, on and off campus. Almost every example that we looked at has substructures to help the garden function, as well as native vegetation and plants. Each site has different strengths and weaknesses, depending on location. Some sites are very large and extensive while others are more simply native vegetation and a small storage pond.

<table>
<thead>
<tr>
<th>Rain Garden</th>
<th>Parking lot 23</th>
<th>Chemistry building</th>
<th>Parkview</th>
<th>S. Kohrman Hall</th>
<th>Environmental Interpretive Center</th>
<th>College st. near Lot B</th>
<th>N. Tennis courts/ Area 10 Parking</th>
<th>Westview apartments</th>
<th>Various Parking lots</th>
</tr>
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<tbody>
<tr>
<td>Campus</td>
<td>WMU</td>
<td>WMU</td>
<td>WMU</td>
<td>WMU</td>
<td>University of Michigan-Dearborn</td>
<td>University of Minnesota</td>
<td>University of Toledo</td>
<td>Eastern Michigan</td>
<td>Michigan State University</td>
</tr>
<tr>
<td>Location/building</td>
<td>Between Elmwood apartments and Stadium drive</td>
<td>Chemistry building</td>
<td>Engineerin g campus</td>
<td>Near Miller Parking structure</td>
<td>Dearborn</td>
<td>Duluth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dates of operation</td>
<td>2008-present and 2010-present for the second one</td>
<td>2001-present</td>
<td>2009-present</td>
<td>2010-present</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain garden</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Bioretention cell</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Retention Pond</td>
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<td>✓</td>
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<td>✓</td>
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<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Other storm water feature</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Does it include: Leaching pipe, sub-surface structures</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vegetation? Native plants, swales, buffer strips, slopes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
</tr>
</tbody>
</table>

- Sub-surface pipes and retention basins
- Sub-surface pipes directing water
- Leaching pipes
- Sub-surface pipes directing water
- Water drain control system, water level control system, water drain tiles
- Retention basin/filer, A lot of work here is done making sure the river that runs through campus stays clean
- Porous pavement in parking lots
- Vegetative slopes and features
- Native vegetation, storage ponds, natural grass buffer strips
- Porous grass and gravel material to absorb excess water
- Native vegetation including: herbs, grasses, and shrubs. They also have berries, flowers and butterfly weed.
- Flowers, grass and turf grass, trees and shrubs, and a sand filter
- Native vegetation, and storage pond

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IX. Limitations of your analysis and proposed future work

Although rain gardens and bioretention cells are fairly simple, one will always run into setbacks. Some limitations that one could encounter while implementing a rain garden are landscaping space, construction, and maintenance. The places where a rain garden would be most useful as a stormwater management tool are not always the best places land-wise for a garden to exist, so in order for a rain garden to be implemented there the land will need to be excavated, subsurface structures put in place, and then a more porous soil type that is necessary for the correct functioning of a rain garden must be brought in to cover the structures. Once that has been accomplished the rest of the construction of the rain garden can begin. All totaled the construction costs for a well constructed rain garden can be fairly high; the rain gardens at the University of Toledo cost about $10,000 each (Lawrence), while the University of Minnesota-Duluth rain garden, because of its size along with complications and setbacks in time and materials during construction, cost about $225,000 (Larson). What this means for Western, should they choose to create a rain garden, is that very conscientious choices must be made about the size and scale of the future rain garden; smaller, simpler rain gardens like those at Toledo will cost less while larger, more complex rain gardens like those at UMD will tend to cost more, and any unexpected incidents will always raise the costs, which is true of any type of construction project. Larson stated that building a rain garden is “really more like installing a septic system than a flower garden” (Larson) and this mindset would be useful to follow when thinking about constructing a rain garden. The vegetation of a rain garden requires little maintenance after the first years when plants becomes well established, although the gardens must constantly be monitored for invasive species that must be removed before they have a chance to take over the garden. It is the structures within the rain garden that require the most maintenance, they must be cleaned and checked to ensure proper functioning on a regular basis. Fortunately for WMU we will have an ideal space for the rain garden we are proposing, access to contractors and tools needed for construction, and Landscaping Services able to maintain the garden.

Ideally one would implement a rain garden along with the construction of a building, in order to properly integrate the garden into the final plans for the given area. WMU is already planning on building new residence halls in order to replace the outdated Hoekje and Bigelow residence halls; this is the perfect opportunity to build a rain garden into the proposed landscaping so that it can collect stormwater from the building rooftops as well as from the nearby parking lots. Because the new residence halls will be on the top of a very large hill, the rain garden will be ideally located to catch runoff water before it has a chance to spread over campus and most importantly into the nearby Goldsworth Valley Pond. WMU also has a highly competent Landscape Services department in place that already takes care of the rain gardens and bioretention cells in existence on campus for whom the care of another rain garden would not be too excessively burdensome. Landscape Services has specific plans in place to keep up with stormwater management projects and various landscaping duties. For example, at the Chemistry Building storm water detention basin site they have daily, weekly, quarterly, and semi-annual/yearly goals. The daily goals at this site are to pick up trash and debris from the basin and surrounding area. Weekly landscaping inspects hardscape (boulders, retaining walls, etc) and inspects and repairs washout areas among other tasks. Quarterly landscaping removes yard waste and checks the bottom of the detention basin for excessive silt and heavy soils. On a yearly basis landscaping performs percolation tests on the bottom of the detention basin and determine whether supplemental planting is required.
Rain gardens and bioretention cells are extremely important to our campus, especially because of our history of flooding problems. With any new construction on campus, we need to take stormwater and stormwater management features into consideration. Adding stormwater features like a rain garden to the constructed landscaping of the new residence halls will help control and purify stormwater runoff, educate students, faculty, and visitors about the purpose and function of rain gardens and the need for stormwater management, and add to the beautification of campus.
X. Conclusions/Recommendations

After all of our research and analysis of rain gardens in general and best on and off campus examples, we would like to recommend that a rain garden or bioretention cell be integrated into the landscaping construction plans for the new Hoekje and Bigelow residence halls near the Bernhard Center. With this rain garden being built directly into the new landscaping around new buildings, it could be constructed in such a way as to optimize its ability to control and reduce the amount of stormwater coming from the rooftops of these building as well as from the parking lots nearby. As this stormwater runoff is directed to the rain garden, it loses its potential to be able to flood other areas and pick up more contaminants and pollutants as it travels downhill towards natural systems. Once in the rain garden, the water will be cooled and filtered through natural interactions with the plants and the soil, and it will be have much better quality when it reaches the main water system than it would have had it not interacted with the rain garden. Here at Western existing stormwater management systems like rain gardens and bioretention cells have had a marked effect on reducing flooding and increasing water quality, and they have had similar success stories on many other campuses in and out of state.

By implementing rain gardens on campus, not only would Western Michigan University be investing in effective stormwater control features that are both ecologically friendly and carbon neutral, but they would also be investing in features that are very appealing to the eye and serve as outstanding learning tools. These rain gardens provide educational opportunities to the public about the importance of stormwater management and ways to address these issues, as well as providing beautification to the campuses they are located on. Western Michigan University has a vision to be a more sustainable, environmentally friendly university while increasing its student enrollment, and we believe that the creation of this rain garden will be able to help the university in both capacities.

Western Michigan University’s main campus is an extremely large part of the Kalamazoo area and it has the potential to be a burden to the surrounding community, both human and ecological, by adding large amounts of pollution to the groundwater and above ground water sources through stormwater runoff, but this does not have to be the case. WMU can take care of its stormwater in an ecological way that will also benefit the community through the construction of a rain garden. Rain gardens address issues of stormwater runoff and management, clean water, and provide education and beautification. These gardens can draw student, administrative, and community attention to sustainable practices in a beautiful, interactive setting.
XI. References


University of Minnesota Duluth Facilities Management. *Stormwater Tour of UMD Campus*. UMD-FM and

XII. Appendices

Appendix 1-Current contact list

<table>
<thead>
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Appendix 2-Contact list and logs

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- Glasser, Harold- Executive Director for Campus Sustainability and Professor of Environmental Studies at Western Michigan University.
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- Lawrence, Patrick- Chair of UT Presidents Commission on the River and Professor/Department Chair of the Department of Geography and Planning at the University of Toledo.
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This is the Parkview campus, which is the largest stormwater project at Western Michigan University. This map shows in red all of the substructures that make up the leaching pipes, and vegetative storage ponds at this site. Because all of the vegetated areas are between the roads it makes for a beautiful drive as well as ecologically advantageous. (Photo credit: Delong, Cari et al.)
Cross section of a rain garden (Photo credit: Rain Garden Planning)
The water retention basin at the entrance to the wetland zone of the University of Minnesota Duluth’s rain garden. All water from the parking lot runs into this basin where most of the debris and chemicals are filtered out and the cleaner water overflows into the wetland zone for further retention and filtration. This basin is cleaned regularly to ensure its proper functioning. (Photo credit: Minnesota Environmental Partnership).