University of Wisconsin-Green Bay Stormwater Management: Regulations and Best Management Practices

Aleeca A. Forsberg
Jessica A. McCuskey
Christian S. Waltman

Environmental Science and Policy 763

Fall 2005

Final Paper

16 March 2010

Introduction

The University of Wisconsin-Green Bay (UW-Green Bay) is in an interesting situation. During the construction of the university, the City of Green Bay did not have storm sewers extending to the land occupied by the campus. Needing appropriate storm water drainage to prevent flooding and maintaining a safe environment, it was decided to install storm sewers that discharge to nearby waterways (Mahon Creek and the bay of Green Bay). Since the university owned the sewer system, the City of Green Bay was not required to maintain it. Several areas of the campus are drained by sewers that lead to a pond on the golf course. The water in the pond is then used for irrigation. For 35 years, UW-Green Bay has not been required to treat its storm water discharge or charged for any type of permitting fees.

Changes in the Clean Water Act (CWA) and subsequent rule implementation by the U.S. Environmental Protection Agency (EPA) have impacted the way that the university must deal with its storm water discharge. In 1999, the EPA issued Phase II Stormwater Program. Under Phase II rules, small MS4s (municipal separate storm sewer system) must take responsibility for stormwater discharges to ensure a reduction in the amount of non-point source pollutants entering U.S. waterways. This is a follow-up to the Phase I Stormwater Management Program promulgated as part of the 1990 amendments to the CWA. Phase I rules applied only to large municipalities (population >100,000), which excluded the City of Green Bay at that time. The 1999 Phase II rules now apply to small “urbanized areas” (UAs), including the City of Green Bay.

Subsequent legislation in the State of Wisconsin has been introduced to complement and set enforcement standards to EPA Phase II. Wisconsin Natural Resources Regulations NR151 and NR216 closely follow the standards set in EPA Phase II, and allow for state control over stormwater discharges into waters of the state, as well as sediment erosion control at construction sites. NR 151 grants stormwater permitting authority to individual MS4s. Typically, the permitting authority is the municipality (or industry) that owns and maintains the storm sewer system. In our case, the City of Green Bay is the permitting authority.

UW-Green Bay is in an odd situation, as the university owns and maintains a storm sewer system that is completely separate from the system maintained by Green Bay. A stormwater fee is paid to the city, without regard to storm sewer ownership or maintenance. This fee is based on the fact that the university lies within the UA of Green Bay, and is calculated by the amount of impervious surface present on campus.

Although permitting authority is currently with the City of Green Bay, UW-Green Bay can obtain its own permit as an MS4. Once the university is permitted as an MS4, it will be required to meet the regulations set forth in EPA Phase II, as well as Wisconsin NR151 and NR216. UW-Green Bay will have to implement Best Management Practices (BMPs) for runoff control to meet these requirements.

The following sections describe the stormwater management laws that will impact the University of Wisconsin-Green Bay campus as well as several BMPs that can be implemented to comply, or even exceed the regulations. As a community leader, UW-Green Bay should stormwater infrastructure up do date with current BMPs. This will help reduce contaminant loading into the waters of Green Bay and provide potential for both graduate and undergraduate research work on stormwater management.

Stormwater Regulations

EPA Phase II Stormwater Requirements

In 1999, the EPA issued new rules, as required by Section 402(p) of the Clean Water Act regarding the discharge of storm water to MS4s. At issue is the effects of urbanization on water quality and stream flow characteristics. Suspended solids, nutrients, heavy metals and toxic materials, typically found in high concentrations in stormwater runoff, have a serious impact on water quality.

Runoff from urban areas is channeled as soon as possible to avoid flooding, which tends to increase peak discharge in rivers and streams, which increases erosion rates. Urban areas have a large percentage of impervious surfaces, which can contribute to groundwater depletion by reducing infiltration. Large storm events can also overwhelm sanitary sewer systems, if the municipality operates a combined sanitary/storm water sewer system.

Amendments to the CWA in 1987 prompted the EPA to implement stormwater discharge regulations in two phases. Phase I was promulgated in 1990 (55 FR 47990), and required medium and large cities (population >100,000), as well as several industrial sectors, to develop storm water management plans. Also, construction sites larger than five acres were required to obtain a storm water management permit. Phase II regulations, promulgated in 2000, require some small MS4s and construction sites disturbing more than one acre to permit storm water discharges. Regulated small MS4s are required to implement BMPs and are also required to be evaluated in the six following goals:

- "Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention/good housekeeping for municipal operations." (EPA 2000)

Phase II rules require designation of small MS4s based on delineation of UAs. Not only are municipalities included, but also highway departments, universities and industrial operations located within the UA. The National Pollution Discharge Elimination System (NPDES) Permitting Authority (MS4 in charge of permitting for the UA) is charged with determining whether or not to incorporate a small MS4 based on the following criteria:

- Discharge to sensitive waters
- High population density
- High growth or growth potential
- Contiguity to UA
- Significant contributor of pollutants to waters of the U.S., and

- Ineffective protection of water quality concerns by other programs. (U. S. EPA 2000).

There is a chance for a small MS4 to receive waivers from the NPDES Permitting Authority. These waivers can be permitted if the small MS4 can show that its discharges do not cause or have the potential to cause water quality impairment. The first waiver applies to jurisdictions with population less than 1,000 people that are not contributing significantly to the pollutant loadings of the regulated NPDES Permitting Authority. The small MS4 must also show their discharge does not contain any pollutants shown to cause impairment to the receiving water, or the concentration of pollutants is below the EPA Total Maximum Daily Load (TMDL) for the pollutant of concern.

The second waiver applies to jurisdictions with population less than 10,000 people, and the small MS4 can show that storm water controls are not needed based on wasteload allocations within the TMDL. Also, it must be shown that future discharges from the small MS4 will not exceed water quality standards.

Prior to the 2000 Census, the City of Green Bay was not included in the Phase II regulations, as the population was less than 100,000. The 2000 Census showed that the population had risen over the threshold of 100,000, and Green Bay was required to implement Phase II Storm Water rules as the NPDES Permitting Authority. Since UW-Green Bay is within the UA of City of Green Bay, it was subject to the permit drafted by the city.

This situation is a bit odd, as the university has, and continues to maintain its own storm water sewer system. To make matters more challenging, the City of Green Bay has imposed a charge of approximately $80,000/year on UW-Green Bay for stormwater management. While the City has a legal right to collect the storm water fees, it does seem a bit excessive to charge that much, considering that the university maintains the storm water sewer. This does, however, provide motivation for the UW-Green Bay to become its own permitting authority.

NR 151

Wisconsin's NR151 regulation establishes standards to manage polluted runoff from non-agricultural facilities. The regulation sets forth general practices to be used to meet required water quality standards.

NR151 regulates both pre- and post-construction runoff as well as runoff generated during redevelopment. The best management practice (BMP) for each type of development differs but all types of disturbance require a written plan. For example, new development requires BMPs that reduce 80% of the sediment runoff load produced by landscape disturbance during construction. However, for redevelopment, the regulation requires BMPs that reduce 40% of the total sediment runoff load. The reduction values are based on the amount of sediment that would leave the site if no management controls were in place. The law also requires the use of stormwater structures that allow for infiltration of stormwater, where applicable.

The University of Wisconsin-Green Bay, as a commercial development, must meet one of the following requirements when new development is undertaken (note that only roof-tops and parking lots are considered): post-construction development must infiltrate at least 60% of predevelopment infiltration or 10% of post-development runoff infiltrated from the 2-yr, 24-hr storm. If the latter requirement is to be met, less than 2% of the developed site is required to be an infiltration area.

By virtue of their purpose, parking lots may acquire heavy metals, sediment and other automotive fluids (e.g. antifreeze and motor oil), which become incorporated into stormwater runoff during precipitation events. NR151 requires pretreatment of parking lot and new road construction runoff to remove these pollutants from the stormwater prior to infiltration. Various types of pretreatment options are mentioned such as biofiltration, swales and filter strips.

We are interested in the sub-sections of NR151 that will be affected by EPA Phase II regulations for sediment runoff reduction. UW-Green Bay does not currently have a WPDES (Wisconsin Pollutant Discharge Elimination System) permit but filed for a permit in 2003 and will file again in 2005(OMNNI, 2005). Because the university has filed and will again file for a WPDES permit, it will be required to meet the sediment reduction limits required by EPA Phase II of 20% reduction by 2008 and 40% reduction by 2013.

Most of UW-Green Bay's stormwater discharges directly into the bay of Green Bay, a water of the state, either via Mahon Creek or from a storm sewer fallout to the bay. Waters of the state are defined under the CWA (1990) as any navigable waterway. Stormwater runoff not discharged into the bay (i.e., from the Studio Arts parking lot and student housing) discharges into a pond on the Shorewood Hills Golf Course; the water is then used to irrigate the golf course.

The newly drafted UW-Green Bay Master Plan (Master Plan) includes construction of various academic and residential buildings and the parking/pedestrian infrastructure that goes along with university expansion. However, the Master Plan does not plan the infrastructure, or lack thereof, needed to move and treat the increased amounts of stormwater runoff to be generated by the expansion. NR151 requires a written stormwater management plan prior to approval of any construction/development plan, especially if the proposed disturbance is greater than one acre.

NR 216

Natural Resource Regulation 216 (NR216) regulates municipal, industrial and construction stormwater discharges. The goal of NR216 is to regulate the discharge of pollutants into waters of the state and promote practices that will enable the standards laid out in NR151 to be implemented. Under NR216, a municipality is defined in such a way that the university would, in and of itself, fall into this category. Therefore, it is likely that UW-Green Bay will be permitted on an individual basis because the university has an MS4 which is maintained by the state and discharges directly into waters of the state.

The municipal permits are established in order to determine if WPDES permits are required and to address water quality concerns associated with urbanized areas. Not only will the university be permitted under a municipal stormwater permit, it will also be under a construction site

discharge permit for the various developments that are proposed in the Master Plan for the next several years.
If permitted separately from the city of Green Bay, the university will have very definite responsibilities. First, it will be necessary for the university to provide adequate public education and outreach regarding stormwater issues, and allow for public participation in decisions regarding stormwater management. Additionally, UW-Green Bay will be responsible for detecting, and if possible, eliminating illicit discharges (which are defined as discharges of water to an MS4 that are not made up entirely of stormwater and are not under a separate specific permit). This is to be accomplished by creating a storm sewer system map that will identify where illicit discharges exist. Furthermore, a schedule of compliance must be created in order to eliminate any pollution problems that are identified in association with stormwater management issues. Pollution prevention measures must be established and an annual report must be submitted. Moreover, for any construction projects undertaken by the university, a site storm water management plan must be put into place with pollution control as a priority.

The university, as a public institution, is in an excellent position to easily follow through with public education and involvement. Additionally, illicit discharges must be identified and the source of them determined in the creation of a storm sewer system map, which is also required. Again, as a learning institute, this would make an excellent student project, putting the university in an excellent position to accomplish this requirement. Construction requirements will be considered before new projects are undertaken both by project engineer as well as the contractor and, as such, will not need to be dealt with by university officials directly.

Management of the increased runoff from proposed buildings is of concern. As stated above, the university will be required to meet sediment reduction requirements under EPA Phase II rules. Therefore, the university cannot continue to allow stormwater runoff to flow into the waters of the state untreated. This basic premise was addressed in both the UW-Green Bay Master Plan (2005) and the OMNNI, Assoc (2005) draft stormwater management plan; each plan made its own recommendations on how to deal with the upcoming problem.

The UW-Green Bay Master Plan (2005) recommends the use of vegetative filter strips in all new parking lots, extended to existing parking lots as they are re-paved and the construction of two detention ponds. Whereas the OMNNI, Assoc. (2005) draft plan recommends the construction of five wet ponds (described below). It is our opinion that neither of these BMPs, alone, will reduce sediment runoff but other pollutants will still enter Mahon Creek and the bay of Green Bay. Based on this opinion, we make the following recommendations which we strongly encourage the university to incorporate into existing stormwater management as well and all new stormwater management plans.

In order to control and prevent pollution that would be detrimental to the quality of nearby waterway, several recommendations are made in the following section.

Recommendations

Rain Gardens and Bioretention Cells

For decades, many European communities have implemented Low Impact Development (LID) when developing open areas. LID is defined by the Low impact Development Center (2005) as "…an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls." Removing pollutants from stormwater runoff is an important step in improving water quality in waters that receive the discharge. Some common stormwater LID practices include the use of green roofs, pervious concrete, bioretention cells, rain gardens, treatment trains and conditioned soils. These engineered stormwater structures promote the filtration and infiltration of runoff prior to discharge to a waterway.

Site characteristics play a significant role in which LID practices can be employed. Slope, average rainfall and soil characteristics are very important factors to consider when looking at LID. Only recently has the U.S. begun to incorporate LID into stormwater management plans (Derry *et al*. 2004).

A Means to Treat Stormwater

The use of rain gardens as a part of LID can have a significant impact on stormwater quality, as well as maintaining an aesthetically pleasing environment. As defined by Dussaillant (2004), a rain garden is "a landscaped garden in a shallow depression that receives the stormwater from nearby impervious surfaces, focusing recharge." As the term implies, it is a garden that soaks up precipitation and snowmelt that would normally run off of impervious surfaces. Rain gardens can be fed by roof gutters, parking lots and even turf. Properly constructed, a rain garden is capable of infiltrating 30% more water than a conventional lawn (Strobel 2002).

During precipitation events, water will slowly infiltrate the soil until saturated. Once the soil is saturated, stormwater will then flow overland, but is often slowed by vegetation. Between infiltration and water velocity reduction caused by vegetation, much of the pollutant load in the runoff can be removed prior to reaching a water body. Urbanization has short-circuited this natural cycle by decreasing the amount of area available for infiltration. Impervious surfaces in urban areas are designed to remove water as quickly as possible.

Stormwater runoff is a serious concern in many urban areas. Since urban areas tend to have a large percentage of impervious surfaces (roofs, roads, compacted soils, etc) stormwater generally flows quickly from these surfaces into storm sewers, where it travels directly to the receiving water body without treatment. Stormwater picks up contaminants along its flow path, such as suspended solids, greases and oils, heavy metals, de-icing salts, pesticides and nutrients (CMHC 2005). The transportation of these materials into our waters is detrimental to water quality. Recently, there has been a move towards designing stormwater management systems to mimic natural systems. Engineered wetlands and detention ponds are becoming low-cost but very effective ways to manage stormwater runoff (CMHC 2005).

Rain gardens are very effective at removing pollutants. However, rain gardens are not suitable for use in areas where native soils do not permit adequate infiltration, such as those found on the UW-Green Bay campus. In this situation, a bioretention cell can be used instead of a rain garden. A bioretention cell is a rain garden that has been modified by adding an underdrain system. The underdrain system is a series of perforated pipes placed in a layer of coarse materials at the bottom of the structure designed to act as a reservoir drain. The underdrain system then connects to existing or new storm sewers. Since the bioretention cell slows the flow of water to the storm drain, smaller diameter pipes can be used to move water away from the bioretention cell. This can significantly reduce costs of installing new storm sewer infrastructure.

Bioretention cells can remove an average of 90% heavy metals, 80% phosphorus, 97% chemical oxygen demand, 86% total suspended solids and 67% oil and grease. The design of the bioretention cell can be changed to remove certain pollutants more effectively, if needed (LID Center 2005).

Designing and Locating a Rain Garden or Bioretention Cell

Rain gardens are typically constructed in a low-lying area, at least 4 meters away from any structures that may be affected by increased infiltration of groundwater. As the size of the rain garden increases, the distance from foundations, septic systems and other sensitive structures should also increase. Rain gardens should not be built on slopes greater than 12% to ensure infiltration occurs instead of runoff. Also, ensure that the slope is not toward any structures to keep basements and foundations from receiving the infiltrated water. Figure 1 shows some general parameters on how to locate a rain garden.

Dussaillant (2004) used the Richards Equation as a basis for a computer model designed to calculate the effective infiltration rates of rain gardens. In general, the area of a rain garden can be sized between 5% and 10% of the area to be treated. In Dussaillant’s study, a small (area = $5.4m^2$, volume $=6.5m^3$) rain garden could infiltrate water at a rate of 5 to 7 cm/hr and treat an impervious area of approximately $100m^2$. A rain garden recently constructed by University of Minnesota, Duluth covers approximately 1/3 acre will have a capacity of 229,000 liters of water when fully operational (Agar *et al.* 2005). Theoretically, this rain garden should have the ability to treat runoff from an area approximately three acres. Although bioretention cells are not designed to infiltrate water, the same general principles in determining the dimensions of the structure can be applied, as the basic function of the structure is exactly the same for both.

In constructing the rain garden or bioretention cell, dig an area out in a low spot where runoff would normally flow. Fill the base of the hole with a coarse material, such as sand or fine gravel. This will act as a reservoir while the native soil infiltrates the water. Above the sand layer, add a layer of planting soil (if plants are desired in the rain garden) and then a final layer of mulch or wood chips. If oil and grease pollution is a problem, such as in a parking lot, an additional layer of mulch groundcover can be used to provide soil bacteria that degrade oil and grease contaminants. (Derry *et al*. 2004).

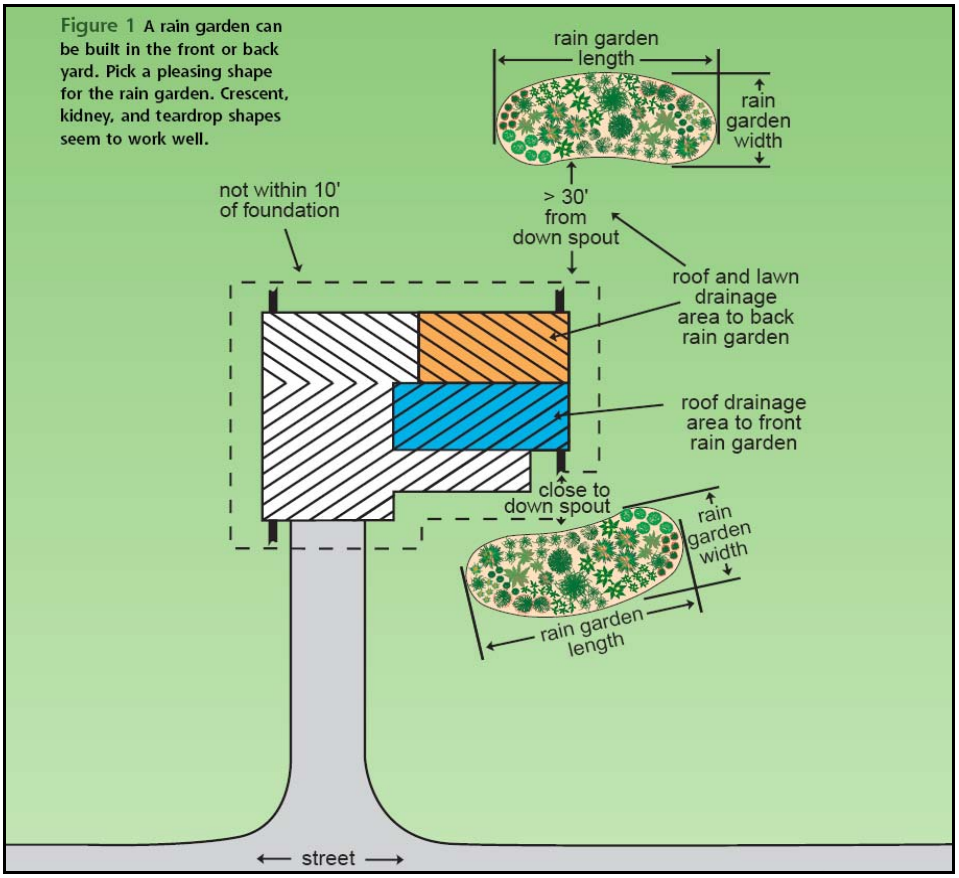

Figure 1: Locating a rain garden. (Source: University of Wisconsin Extension Publication GWQ037)

The size of the rain garden should be calculated by determining the amount of water that will need to be treated and the infiltration rate of the soil. It is important to make sure that the water will not remain standing in the rain garden for more than two days, as this can cause damage to plants in the garden as well as provide breeding areas for mosquitoes and other vectors. The shape of the rain garden can be determined by the designer. However, the length should be at least 1.5 times the width and should be orientated with the longer dimension perpendicular to the slope. This will maximize runoff capture.

The type of vegetation planted in a rain garden should be tolerant of both wet and dry conditions. Choose plants that are adapted to the climate and environment where you are constructing your rain garden. Several reports listing plant species suitable for use with rain gardens and bioretention cells have been published. A University of Wisconsin-Madison report (UW-Madison 2004) on this subject is an excellent starting point. If plants are not desired, loose, hard materials, such as gravel, crushed brick or crushed glass can be an attractive way to line the bottom of the garden (CMHC 2005).

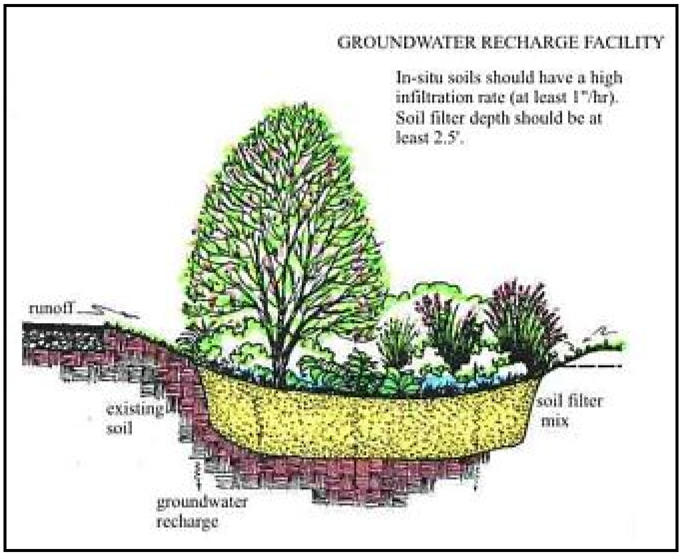

Figure 2: Diagram of typical rain garden. (Source: LID Center)

Designs of rain gardens are very site-specific. A variety of plans are available, and consultants are able to assist in the planning and construction of rain gardens. For individuals interested in installing their own rain garden, refer to "Rain Gardens: A How-To Manual for Homeowners" (Bannerman and Considine 2003). This is a detailed guide on how to site and build a rain garden and what types of plants work well. See Figure 2 for an example of rain garden construction.

In areas where soils are hard-packed or clay-rich, adaptations of rain gardens are a better option. A bioretention cells is essentially rain garden with an underdrain system. The underdrain system pipes off water that has been infiltrated through the bioretention cell, but unable to percolate through the soil. This can be tied into an existing stormwater sewer system, which can make retrofitting an older system much easier (Derry *et al*. 2004). Figure 3 is a diagram showing the basic design of a bioretention cell.

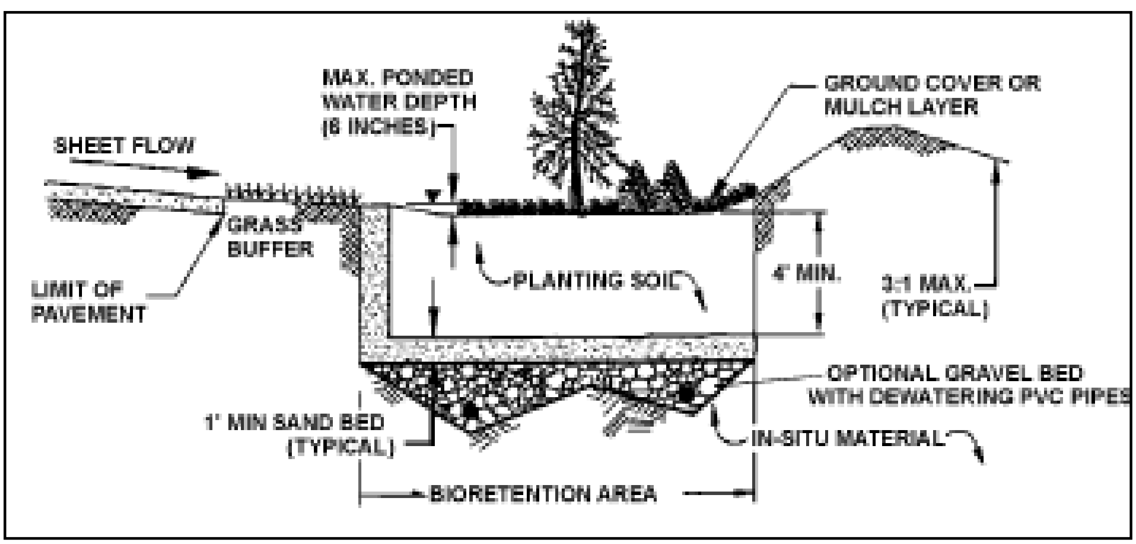

Figure 3: Typical Bioretention Cell Construction (Source: Short Elliot Hendrickson, Inc. 2001)

The Use of Rain Gardens and Bioretention Cells at UW-Green Bay

Considering the clay-rich soils on campus, the use of rain gardens at UW-Green Bay would probably not work well. However, the University has many locations suitable for the use of bioretention cells. Parking lots, already serviced with storm sewers are prime candidates for the use of bioretention cells. The same holds true for buildings, which drain rooftops into underground storm sewers. If the University is permitted separately from the City of Green Bay under EPA Phase II rules, these structures would be imperative to meet the goals of the EPA's Phase II Stormwater Discharge rules. Also, once UW-Green Bay is permitted as a small MS4, Wisconsin NR 151 requires a 20% reduction in total suspended solids in 2008, followed by a 40% reduction by 2012. The expense associated with the construction of the structures could be outweighed by the reduction in stormwater runoff, with the added benefit of reducing pollution loads entering the waters of Green Bay.

The use of a large number of planter strips in many of the parking lots has been discussed in the current draft version of the UW-Green Bay Master Plan. Parking lots can be easily modified to work with bioretention cells, and are already serviced by storm sewers. Replacing some of the parking rows with bioretention cells placed over an existing storm sewer drains will require no additional sewer lines. This will significantly reduce infrastructure costs and provide exceptional runoff pollution control while minimizing the amount of parking area lost to stormwater management structures.

Snow removal and ice buildup in a poorly drained parking area is a concern for Facilities Management. Using larger, but fewer bioretention cells in the parking lots can effectively treat stormwater runoff. Also, snow removal becomes less time-consuming when plowing around several large structures instead of many small obstacles.

An overflow system leading directly to a storm sewer should be installed to handle excess water flowing into the ponding area of the bioretention cell. This can effectively eliminate the concern of ponding during freeze-thaw cycles common during the winter months in Green Bay. The City of Burnsville, MN has several bioretention cells and rain gardens that have been successfully used for several years without the problems of slow infiltration during the winter. (Short Elliot Hendrickson, Inc 2001).

Stormwater Treatment Trains

Stormwater treatment trains are comprised of different BMPs constructed in a series with the purpose of removing different pollutants at each step (Figure 4). Treatment trains are advantageous in many ways. First, travel time to the receiving water when routed through a treatment train is decreased. Second, water quality can be improved through infiltration or pollutant uptake by vegetation. Third, groundwater can be recharged using infiltration basins, infiltration trenches or grassed swales. Fourth treatment train systems can be used to meet EPA Phase II regulations and sediment reduction requirements under NR151. Last, treatment train systems can be cheaper to build and maintain than traditional stormwater management infrastructure (CDF 2003).

No single treatment train design is universal. Each site has its own characteristics that must be taken into consideration prior to the design and construction of treatment trains, as with any conventional type of stormwater management infrastructure.

Different BMPs are available to help the university meet its sediment reduction requirements. Three main pond types, the wet extended detention pond, the dry detention pond and wet ponds can be built to suit. Pond type is dependant on permanent pool volume or extended detention option which allows for treatment through settling. Constructed wetlands, similar to stormwater ponds, can be constructed to infiltrate and treat polluted stormwater runoff. Various types of infiltration BMPs (i.e., porous pavements, infiltration trenches or infiltration basins) can be employed to recharge groundwater and remove pollutants through biological processes. Filtering BMPs (i.e., rain gardens, biofiltration cells, underground sand filters, etc.) treat stormwater runoff as flow is routed through a filtering medium such as sand. Open channel BMPs use a combination of filtration via vegetation and infiltration.

For example, infiltration BMPs such as trenches and basins cannot be used if the natural infiltration rate is less than 0.6" per hour (UW-Madison 2004). Moreover, these structures would not be best placed in areas of high pollutant loading as they may increase the incidence of groundwater pollution (CWP 1997). However, if a sand and/or gravel bed is used as the basal layer for the infiltration structure, as recommended by the Center for Watershed Protection (CWP 1997); the adverse affects of both caveats can be decreased.

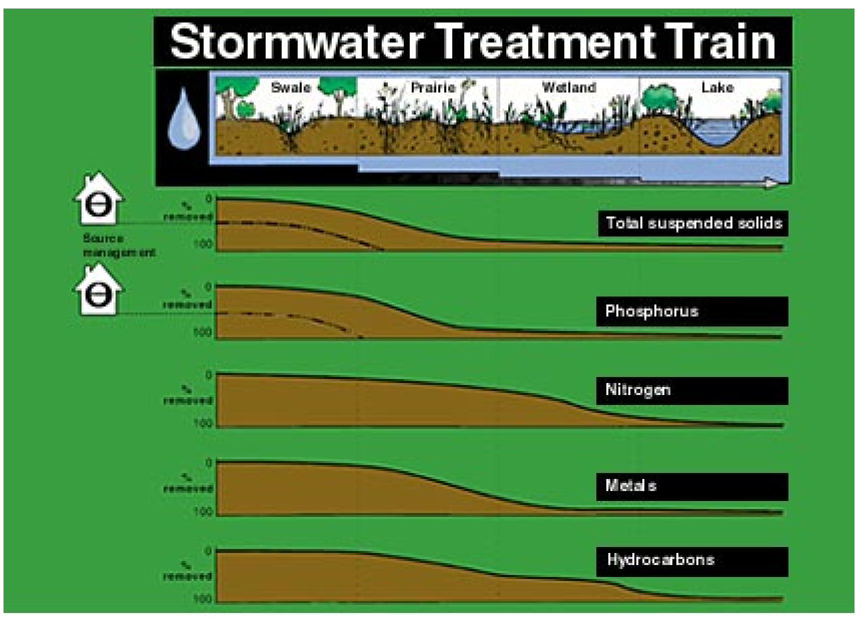

Figure 4: Schematic of a stormwater treatment train showing amount of runoff infiltrated at each BMP and the amount of different pollutants removed as each BMP. (Source: Applied Ecological Services
http://www.appliedeco.com/Projects/Stormwater%20Treatment%20Train.pdf)

We also must take into account the long freeze period present in northeastern Wisconsin, where we are focusing our attention, and note that a substantial amount of runoff can be generated during the spring snow melt. Freezing temperatures experienced in Green Bay throughout the winter months can decrease efficiency of some BMPs (e.g., pipes may freeze or pond capacity may be compromised) and may decrease the likelihood of certain pollutant removal by microbial activity and vegetation uptake.

Therefore, all BMPs must be designed to contain most, if not all, of the projected snow melt and consideration must be given to any adverse affects caused by temperatures below freezing for an extended period of time. The Center for Watershed Protection (CWP 1997) recommends no more than 5% of annual runoff volume should bypass any treatment during a spring snowmelt.

The CWP surveyed a panel of stormwater experts from cold regions of the United States and Canada for opinions on how to best construct and design stormwater BMPs in cold climates (CWP 1997). The biggest concern expressed by most experts, as relayed by the CWP (1997) was building the BMP with enough storage capacity to account for increased discharge due to snow melt. To mitigate this problem, experts suggest sizing the BMP to account for snow melt runoff as well as the generally accepted flood (2-yr, 24-hour storm) event.

Best Management Practices

Wet Extended Detention Ponds

Wet extended detention (ED) ponds are consistently full of water and require a permanent pool to adequately treat water (CWP 1997) through microbial activity and settling. As a combination of dry ED ponds (no permanent pool) and wet ponds, pollutant treatment in wet ED ponds is partially through extended detention. Extended detention allows pollutants and sediment to settle, and pollutant removal through vegetation uptake and microbial activities. Moreover, wet ED ponds have the ability to reduce flow (IDEQ n.d.) and can be aesthetically pleasing.

Wet ED ponds should be designed to maintain some water level throughout most of the year with extra storage above the permanent pool to be used for detention of stormwater runoff during precipitation events (CASQA 2003). Because wet ED ponds are already constructed to hold large volumes of runoff, increasing the capacity to account for snowmelt can be easily done. Table 1 contains features and descriptions normally incorporated into stormwater treatment pond systems. The CWP (1997) lists various recommendations and modifications to wet ED ponds that may increase effectiveness and efficiency in cold climates (see Appendix I).

Some infrastructure, described below, is required in the construction of wet ED ponds. Nevertheless, construction costs can be less than for traditional stormwater infrastructure. Inflow pipes should be a minimum of 15-18” in diameter. These inflow pipe recommendations are significantly less than current stormwater outfalls at UW-Green Bay of 29”, 36” and 54” in diameter (OMNNI 2005). To decrease the likelihood of pipe rupture due to freeze/thaw cycles, the CWP (1997) recommends burying pipes below the frost line if slopes are >1%. By burying pipes below the frost line on largely sloping areas the chance of ice blocking the pipe is decreased. However, if inflow into the wet ED pond is routed along a meandering swale (Figure 5) or gravel-based creek type system, no inflow pipes will be needed.

Outlet structures vary and can be constructed based on specific need or placement of wet ED pond along the treatment train system. For example, weirs can be used as long as the base is buried below the frost line (CWP 1997). Most weirs can be easily constructed from materials already present on site, further decreasing cost of pond construction. Weirs can be most effective if wet ED pond outflow was routed to a grass swale or infiltration trench. A weir is an artificially constructed object placed where flow restriction is desired (Hornberger *et al.* 1998). By restricting flow at the outlet of the wet ED pond, it is possible to retain runoff long enough for sedimentation to occur.

A forebay system (small area of ponded water separated from the permanent ED pond) is recommended by the CWP (1997) for use of some stormwater runoff storage as well as increasing amount of snow and snow melt storage. A forebay also serves to increase the amount of snow melt runoff treated during large snow melt events. Runoff that would usually bypass the treatment system during winter months is slowed down in the forebay area and forced to flow through a weir, effectively increasing the amount of time the runoff is retained in the treatment system.

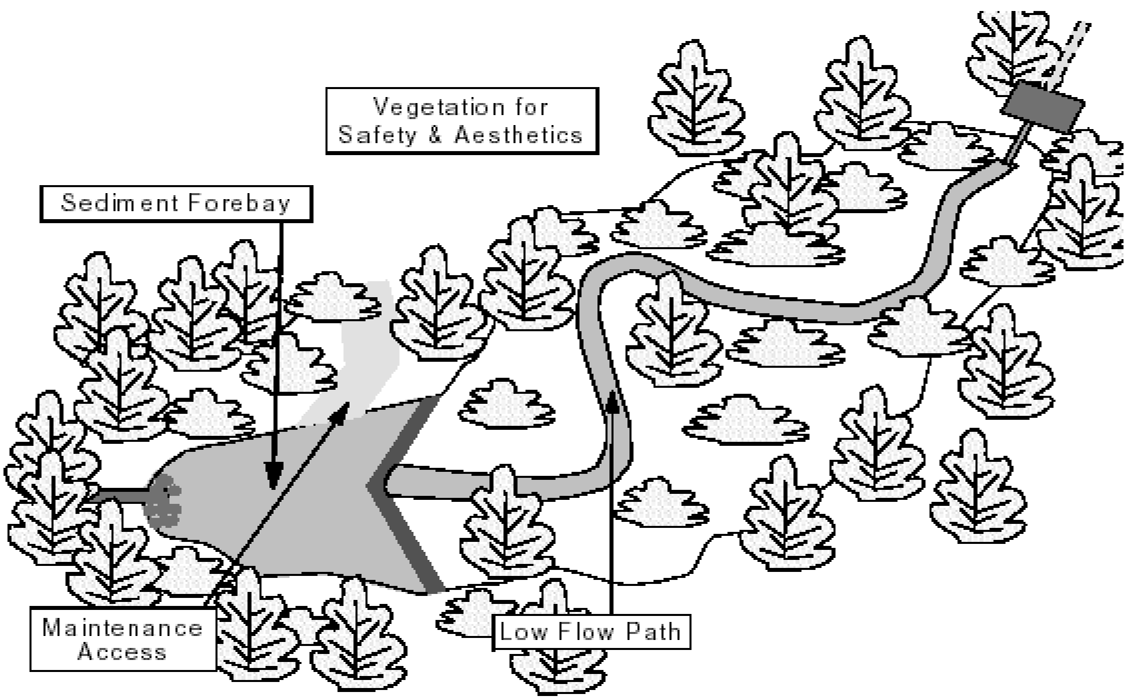

Figure 5: Schematic of meandering inflow system into a wet ED pond with included sediment forebay. (Source: http://www.ene.gov.on.ca/envision/gp/4329eimages/figure4.29.gif**)**

Table 1: Criteria and description of wet ED pond components as modified for cold climates. (Source: CWP 1997).

Criteria	Description
Adequate Water Quality Treatment Volume	(See Section 2).
Multiple Treatment Pathways	Provide longer flowpaths, high surface to volume ratio or different treatment methods (e.g., pool and marsh).
Pond Geometry	Ponds should be wedge-shaped, narrowest at the inlet and widest at the outlet. Maximum depth should be 8', with an average depth of 4'-6'.
Pretreatment	Each pond should have a sediment forebay, with maintenance access for cleaning.
Non-Clogging Low-Flow Orifice	Accomplish this with a trash rack or other protection mechanism.
Riser in the Embankment	For convenience, safety, maintenance access and aesthetics.
Pond Drain	Used to drain the pond for maintenance or emergencies.
Adjustable Gate Valve	The pond drain and the extended detention pipe (if a pipe is used) should be equipped with an adjustable gate valve.
Principal Spillway	Designed to safely pass the 5- to 10-year storm.
Emergency Spillway	Designed to safely pass the 50- to 100- year storm.
Embankment Specifications	Designed to prevent dam breach or seepage (NRCS dam safety criteria).
Inlet Protection	Protect against erosion or scour at the inlet.
Outfall Protection	Use flared end pipe sections, and stabilize the downstream channel. Prevent stream warming with an underdrain channel or by limiting tree-clearing.
Pond Benches	Provide flat-sloped safety and aquatic benches at the pond edge for safety purposes and to promote wetland vegetation.
Pondscaping Plan	The plan describes how the pond areas will be vegetated.
Wetland Elements	Use of wetlands plants in pond systems is encouraged in shallow pond areas.
Buffers	A vegetated buffer should be provided at least 25' outward from the edge of the pond.
Maintenance Measures	Maintenance will include some mowing, annual inspection, periodic removal of sediment from the forebay, spillway structural measures as necessary and correction of erosion problems.
Maintenance Access	A right-of-way should be provided for maintenance vehicles, and riser structures should be easily accessible through lockable manhole covers.

Constructed Wetland System

Wetlands can be constructed to meet the needs of stormwater treatment and may be used in conjunction with wet ED ponds or other BMPs.

Constructed wetlands can be used to remove suspended pollutants and decrease water velocity through the treatment system. According the U. S. EPA (1993) constructed wetlands are designed to take advantage of many processes which occur in natural wetlands and utilize soils, vegetation and microbes in a controlled environment to treat and remove pollutants from urban stormwater runoff. Besides treating stormwater runoff, properly constructed wetlands can aid UW-Green Bay in maintaining important ecological communities on campus.

Two main types of wetland construction, subsurface flow system and free water surface systems (U.S. EPA 1993) can be used for stormwater treatment. When making the decision for which type to use, cost is important. One system uses inflow piping and subsurface flow systems and the other system utilizes inflow from open sources, such as stream or creek systems and maintains a permanent pond.

Free water surface systems employ aquatic biota and natural wetland vegetation to remove pollutants via plant uptake and biotic decomposition (U. S. EPA 1993). This constructed wetland type can be further broken down into three variations, as defined by the CWP (1997): shallow marshes, pond/wetland system and the extended detention (ED) wetlands. The difference in the three water surface wetland variations is area and storage (Figure 6).

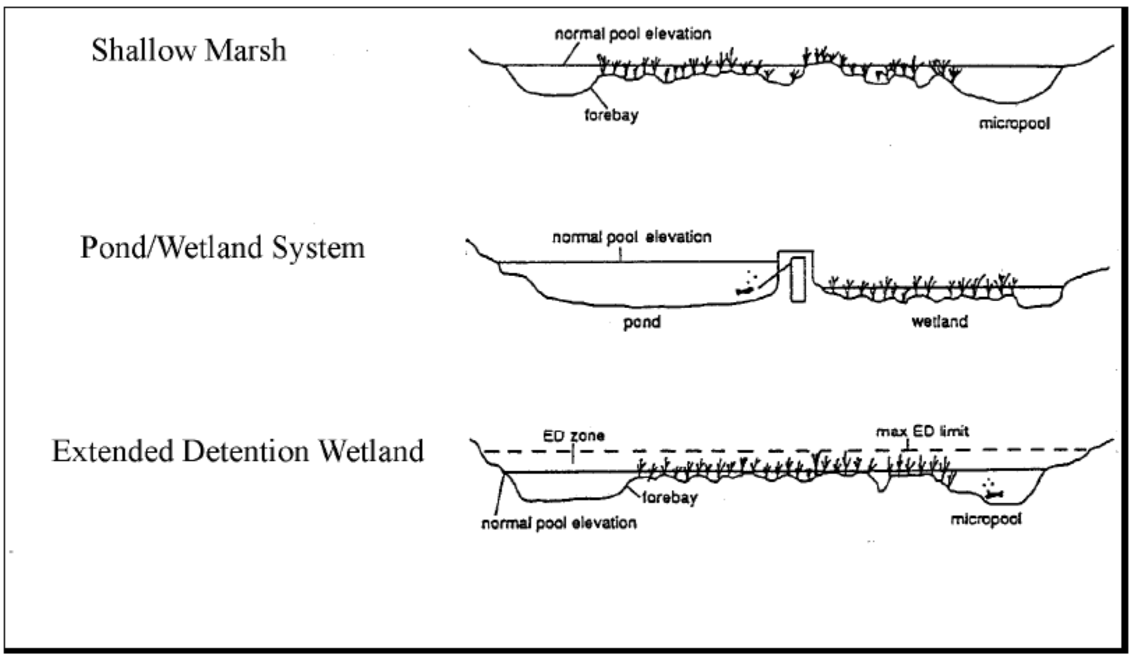

Figure 6: Schematic of different wetland types which could be employed in cold climates for stormwater treatment. (Source: CWP 1997).

Native wetland vegetation should be used for this type of system and can be planted or transplanted. The use of transplanted native vegetation minimizes the time required for vegetation establishment and the short growing season, present in northern Wisconsin, and does not adversely affect establishment or retention of vegetation at the constructed wetland site.

Construction costs can be mitigated by using the pond/wetland system, especially if a pond system (i.e., a wet ED pond) is already in use or has been decided upon as a stormwater treatment option. Less space is used and treatment effectiveness increased with the combination of the two BMPs. Modification for wetland systems for use in cold climates is similar to that recommended for wet ED pond modifications and deal mostly with required area for snow melt treatment and any conveyance structures (CWP 1997).

If pond/wetland systems are used in conjunction with a grassed infiltration area the impact of chlorides and other salt related materials can be reduced. By routing melt water to a grassed infiltration area prior to permitting the water to flow into the pond/wetland system chlorides can be removed from the water. However, this may increase maintenance costs due to affects of salts on the vegetation in the infiltration area (CWP 1997). It may be possible to use native salt-tolerant vegetation in the grassed infiltration area, or grass swale, but emphasis should be placed on native vegetation. Other salt-tolerant vegetation can quickly become or are already, noxious to other native wetland species (i.e., *Phragmites australis*).

Infiltration Basins/Trenches

Due to the soil types present on campus (OMNNI 2005), infiltration areas are not suitable for most areas of the campus. Moreover, frozen soils are not able to infiltrate snow melt and chlorides present in melt water may pollute groundwater.

Infiltration trenches may be used in circumstances where runoff or melt water quantity is too great to be treated by other systems. In these cases, infiltration trenches may serve to decrease runoff velocity and runoff amount. Effectiveness of infiltration trenches can be increased by lining the trench base with gravel or sand (CWP 1997), which acts as a reservoir.

The Use of Treatment Trains and UW-Green Bay

Recommendations already set forth in the OMNNI (2005) draft stormwater management plan and the UW-Green Bay Master Plan and stated above should be expanded upon using some of the BMPs mentioned above. The aforementioned BMPs are by no means the only stormwater management practices that should be considered but are those which can be easily added to pre-existing plans. The recommended BMPs also present more cost-effective options in comparison to traditional stormwater systems while ensuring the university meets water quality requirements for a WPDES permit, as outlined under EPA Phase II, NR151 and NR216.

Treatment trains, in the form of multiple pond systems combined with initial meandering inflow and wetland/pond systems combined with bioretention cells may well be some of the best options for the university to adopt. As a less infrastructure intensive option treatment trains can decrease the cost incurred by UW-Green Bay during construction of new academic and residential buildings and parking lots. Cost for these stormwater management systems will vary. Appendix II contains a cost comparison of traditional stormwater conveyance systems and alternate options such as those presented here (Conservation Design Forum 2003).

Permeable Pavement

Instead of dealing with stormwater after impervious surfaces are in place, it is necessary that we begin to take real steps to reduce stormwater runoff when designing structures. One means of helping to reduce the detrimental quality of the continually growing urban infrastructure is to begin to use such technology as pervious pavements. There are many such options available. These include simple things like paving stones and more complex options such as porous asphalt and porous concrete.

Design of Porous Pavement Systems

Porous pavement, in general, is made particularly useful when used as a stormwater system to allow water to infiltrate from the surface and recharge ground water (Figure 7). The porous pavement is placed over a layer of open-graded gravel which acts as a reservoir for runoff. Under the gravel layer a filter fabric is laid out to screen fine particulate matter. Often, a discharge pipe is laid within the gravel layer funneling water to an open swale area. This can be used as an overflow pipe. In areas with low permeability soils, a thicker layer of gravel would be used to store the water giving it time to slowly infiltrate. Additionally, an outflow pipe (Figure 7) would need to be installed.

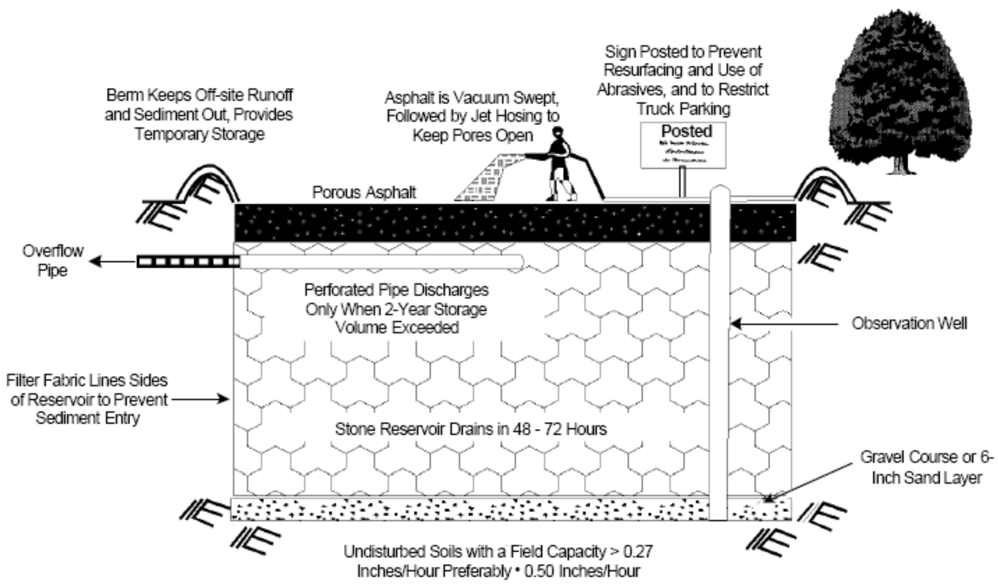

Figure 7: Model of a Permeable Pavement System. (Source: http://www.epa.gov/owm/mtb/porouspa.pdf)

Porous concrete consists of course aggregate, Portland cement, flyash or slag, water and admixtures. To make it porous, it has a larger percentage of aggregate in the mix than non-porous concrete. Porous asphalt consists of standard bituminous asphalt that has been screened to remove smaller particles (which are present in non-porous asphalt) so that the asphalt is made up of courser material that allows rainwater to pass through (Adams 2003). Typically, a large percentage of the materials used to produce both porous concrete and porous asphalt are previously recycled materials. Furthermore, both of these materials can usually be recycled to make new concrete or asphalt after it has exceeded its life cycle.

Recently, porous concrete has been produced with 12-15% pore spaces which can easily hold up under freeze/thaw conditions. It was previously designed with higher percentages of void space, however it was determined that in freeze/thaw climates it did not hold up. Therefore, lower percentages of void spaces are now used in northern climates (Kevin McMullen, personal communication, Nov. 8, 2005). Porous asphalt has significantly higher percentages of void spaces (up to 40%), but must be laid out much thicker in order to avoid cracking in freeze/thaw climates (Adams 2003).

Environmental Advantages of Permeable Pavements

Both porous pavement and porous asphalt are designed to allow stormwater to drain into the sub-grade for filtration which allows for ground water recharge. These pavement options can also be used to prevent erosion and stabilize slopes. Additionally, as shown in Table 2, porous pavements when properly utilized can remove large amounts of pollutants by acting as a filter for water flowing through the system (Adams 2003). Clearly, the use of these materials provides an excellent opportunity for the university to meet the water quality requirements laid out in NR151 and NR216.

Maintenance of any porous pavement system is necessary. In order to keep the pores clean, and the system functional, the pavement must be periodically cleaned using either a vacuum system or a power washer at regular intervals. How often this sort of upkeep should be done depends on the amount of traffic, type of traffic and conditions of nearby surfaces (i.e. how much sediment will be carried on site from nearby areas). As important as it is to maintain porous concrete, the clogged material is actually responsible for much of the pollutant removal that occurs as water percolates through the pervious material. As sand or sediment builds up within the pore space, water is more thoroughly filtered as it travels through the smaller spaces between sediment particles.

Porous pavements allows for water to infiltrate the ground rather than flooding into storm sewers or rushing into nearby waterways. It allows for natural watering of nearby vegetation, minimizing the need for irrigations (Figure 8). Allowing stormwater to infiltrate the pavement also provides for the natural recharge of aquifers much like a natural filtering would. Furthermore, by using a material that allows water to naturally infiltrate the system, it is not necessary to install and maintain curb and gutter systems, actually saving money (EPA 1999).

Porous concrete is an environmental advantage not only in directly reducing the amount of stormwater flowing off of impervious materials, but also in reducing heat island affects that are created as a direct result of large amounts of impervious surfaces used in a small vicinity. It does this because it is light in color, reflecting the sun's heating rays rather than absorbing them and adding more heat to the environment. This not only helps to reduce the heat island affect, it also prevents the drastic difference in the temperature of any water that may run off of the surface. This increase in temperature that causes heat island effects is associated with darkly colored pavements, such as asphalt, and can change the temperature (and therefore the ecology) of local waterways. Furthermore, by using by using a concrete, rather than asphalt or other darkly colored pavements, surface lighting requirements can be lowered by up to 40% (Kevin McMullen, personal communication, November 8, 2005). Not only does this save in energy, it also creates brighter and therefore, safer nighttime environments.

Porous pavements in general are a safety advantage in that they allow water to quickly infiltrate the ground, rather than pooling on the surface leading to hydroplaning and slippery walking conditions. For this reason, permeable and semi-permeable pavements are becoming much more common on highways.

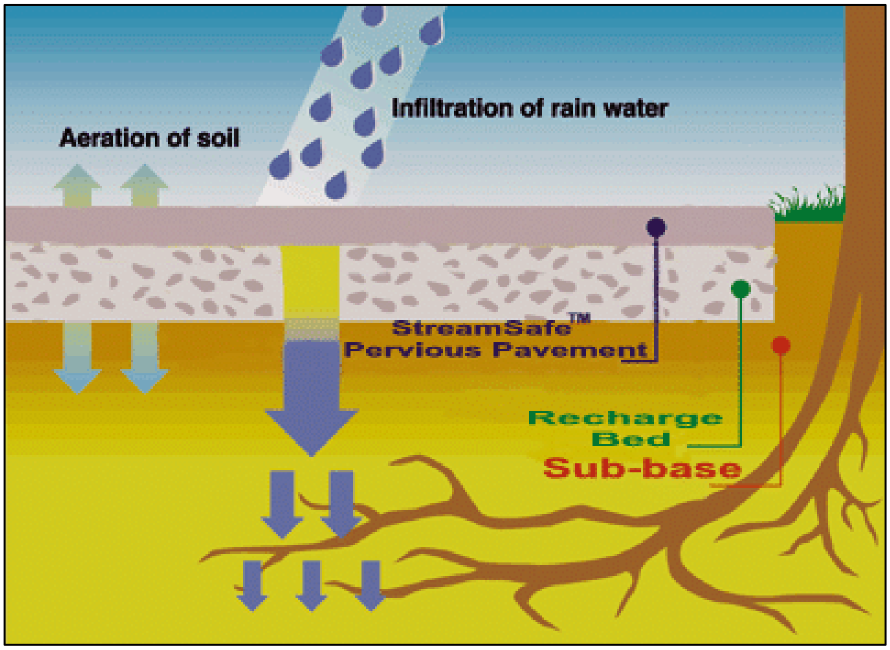

Figure 8: Demonstrates how water moves through permeable pavement to recharge area and reaches vegetation roots reducing the need for irrigation. (Source: WI Concrete Pavement Association).

In areas such as sidewalks, permeable pavements (typically porous concretes) are still a very feasible option. However, another option for this situation would be paving stones. Paving stones that are left with a permeable material such as sand in the spaces between the stones are an ideal medium for walkways and sidewalks. Paving stones, like porous pavements, do require some degree of maintenance to prevent these void spaces from becoming completely clogged. However, snow removal and winter maintenance is often the same as that used on more traditional sidewalk surfaces. Additionally, paving stones are an aesthetically pleasing way of improving water quality and preventing excessive runoff.

The Use of Permeable Pavements at UW-Green Bay

The University of Wisconsin, Green Bay will likely be permitted under an individual municipal stormwater permit in the very near future. Under this permit they will be required to meet all water quality standards laid out in EPA Phase II, NR151 and NR216 regulations. In order to achieve the levels of pollution prevention required under this permit, and the level of environmental concern that has come to be expected of a university with reputation as an environmental campus, new and innovative methods of stormwater management will need to be instigated.

Table 2: Demonstrates cleaning properties of porous pavements. (Adams, 2003)

Pollutant Removal Efficiencies for Infiltration BMPs (with porous paving highlighted)					
Water-Quality Parameter	**Infiltration BMP Type**				
	Trench	**Trench**	**Porous Paving**	**Porous Paving**	**Average Removal Efficiency**
Total Suspended Solids	90%	---	95%	89%	91%
Total Phosphorous	60%	68%	71%	65%	66%
Total Nitrogen	60%	---	---	83%	72%
Total Organic Carbon	90%	---	---	82%	86%
Lead	---	---	50%	98%	74%
Zinc	---	---	62%	99%	81%
Metals	90%	---	---	---	90%
Bacteria	90%	---	---	---	90%
Biochemical Oxygen Demand	75%	---	---	---	75%
Cadmium	---	---	33%	---	33%
Copper	---	---	42%	---	42%
Total Kjeldahl Nitrogen	---	53%	---	---	53%
Nitrate	---	27%	---	---	27%
Ammonia	---	81%	---	---	81%

The UW-Green Bay Master plan calls for expanding existing parking lots, building new parking lots and adding additional impervious surfaces in the form of building rooftops, sidewalks and roadways. It is highly recommended that the university seriously consider achieving these goals in the most sustainable way possible. As such, it is advisable for the university to use permeable pavement options such as porous concrete and porous asphalt for all new parking and roadway structures. Furthermore, in order to maintain the aesthetic values and environmental quality that students and faculty take pride in throughout the inner campus area, it is recommended that paving stones are used for additional sidewalks throughout campus.

Additional Recommendation for UW-Green Bay

The university currently pays the City of Green Bay an annual fee of approximately $80,000 for the maintenance of storm sewer infrastructure, street sweeping, permit compliance, etc. (Ed Wiesner, personal communication, 10/31/2005). The fee is new, starting this year (Dean Rodeheaver, personal communication, 11/07/2005) and is assessed based on the amount of impervious surface on campus. The City of Green Bay Department of Public Works (GBDPW) offers two different types of credits to commercial institutions that reduce the utility fee. The first type of credit available is a 10% maximum reduction in annually assessed fees and can be obtained for approved on site treatment of stormwater using detention ponds. The detention ponds must be designed and engineered to act as a stormwater facility. However, as we understand this credit, the pond must have been built prior to the implementation of the stormwater plan and intended solely for use in a stormwater system.

The second type of credit is a 66% reduction in the annual utility fee. This fee is applicable to institutions whose stormwater discharges directly into the bay of Green Bay, the Fox River or the East River. As previously stated, the university owns and maintains all stormwater infrastructures on campus, including the storm sewer outfall that discharges directly into the bay of Green Bay.

In light of these available credits from GBDPW, we recommend the university further investigate their eligibility for these credits based on the requirements outlined in Green Bay City Ordinance 30.

Appendix 10 of the UW-Madison ‘Innovating Stormwater Management on the University of Wisconsin-Madison Campus’ (2004) lists and describes different case studies where funding was obtained under the CWA 319. The Wisconsin DNR has funding available through their Urban Nonpoint Source and Storm Water Management Grants Programs to aid in required implementation of NR151. The Wisconsin Department of Administration (DOA), through the Coastal Management Grant Program, funds projects for non-point source pollution control (DOA 2005). More research should be done to determine what other grant monies are available for innovative stormwater management projects.

Conclusions

While any decrease in cost to UW-Green Bay is important, it should not be the sole reason for including the stormwater management practices recommended here. As an academic institution, the university has a responsibility to the surrounding community to include new and innovative ideas both in the classes that are taught and in the design and construction of their campus. This has already been done in the construction of Mary Ann Cofrin Hall, which serves as a milestone that other campuses aspire to emulate. UW-Green Bay can maintain this excellence by implementing an innovative stormwater management plan that includes natural systems, such as wetlands, and protects important communities within the university borders. In doing so, the university invites the public, the city of Green Bay and Brown County to become more pro-active in their stormwater management.

As a community example, UW-Green Bay invites student research and entices high caliber students to enroll. Many different senior projects and graduate thesis could be constructed by careful study of implemented stormwater management systems thereby bringing prestige to the university.

References Cited

Adams, Michael C. (2003). *Porous asphalt pavements with recharge beds: 20 years and still working.* Retrieved Oct. 12, 2005 from The Journal for Surface Water Quality Professionals Website: http://www.forester.net/sw_0305_porous.html

Agar, Clint and Cheryl Reitan. (2005) Rain Garden Handles Storm Water Run-off. Retrieved Nov. 8, 2005 from: http://www.d.umn.edu/news/2005/September/23.html

Bannerman, Roger and Ellen Considine. (2003) Rain Gardens: A How-To Manual for Homeowners. University of Wisconsin-Extension Publication GWQ037. Madison, WI.

Canada Mortgage and Housing Corporation. (2005) Rain Gardens: Improving Stormwater Management in Your Yard. Retrieved Nov. 8, 2005 from:

CASQA (California Stormwater Quality Association). (2003). California Stormwater BMP Handbook. Retrieved Dec. 2, 2005 from CASQA website: http://www.cabmphandbooks.com/Documents/Development/TC-20.pdf.

CDF (Conservation Design Forum). (2003). A Comparison of Sustainable and Traditional Landscapes. Retrieved Sept. 30, 2005 from http://www.cdfinc.com/CDF_Resources/Sustainable_Landscape_Cost_Comparison.pdf

Center for Watershed Protection, Inc. (2000). *Stormwater Management Factsheet: Porous Pavement.* Retrieved Oct. 8, 2005 from, Stormwater Management's Resource Center (SMRC) Website: http://www.stormwatercenter.net/Assorted Fact Sheets/Tool6_Stormwater_Practices/Infiltration Practice/Porous Pavement.htm

Center for Watershed Protection. (1997). Stormwater BMP Design Supplement for Cold Climates. Retrieved Oct. 15, 2005 from the CWP website: http://www.cwp.org/cold-climates.html.

Department of Natural Resources. (2004). Chapter NR 216 Stormwater Discharge Permits (No. 583).

Department of Natural Resources. (2004). Chapter NR 151 Runoff Management (No. 583).

Derry, Bill, Carolyn Butchart and Patrick Graham. (2004) Review of Low-Impact Development Techniques. Technical Memorandum 1. CH2M HILL.

Dussaillant, Alejandro R. (2004) Infiltration in a Rain Garden: Richards Equation Numerical Model and Field Experiment. University of Wisconsin. Madison, WI.

Environmental Protection Agency. (1999). *Stormwater Technology Fact Sheet Porous Pavement.* Retrieved Oct. 8, 2005 from EPA Website: http://www.epa.gov/owm/mtb/porouspa.pdf

Hornberger, G.M, Raffensperger, J.P., Wiberg, P.L., Eshleman, K.N. (1998). Elements of Physical Hydrology. The Johns Hopkins University Press, Baltimore, MD 21218-4363. http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_075.cfm

IDEQ (Idaho Department of Environmental Quality). (no date). Catalog of Stormwater BMPs for Cities and Counties; BMP #47-Wet Extended Detention Pond. Retrieved Dec. 3, 2005 from IDEQ website: http://www.deq.id.us/water/data_reports/storm_water/stormwater_catalog_bmp47.pdf

Low Impact Design Center. (2005) Watershed Benefits of Bioretention Techniques. Retrieved Nov. 6, 2005 from: http://www.lid-stormwater.net/bioretention/bio_benefits.htm

OMNNI Associates. (2005). University of Wisconsin Green Bay Draft Stormwater Management Plan.

Short Elliot Hendrickson, Inc. (2001) Burnsville, Minnesota Water Resources Guide, Appendix B. Retrieved Oct. 16, 2005 from: http://www.burnsville.org/government/WMRP/appendixB.pdf

Strobel, Jeffrey. (2002) Rain Gardens: A Household Way to Improve Water Quality in Your Community. University of Wisconsin-Extension. Madison, WI.

U.S. Environmental Protection Agency. (1993). Constructed Wetlands for Wastewater Treatment and Wildlife Habitat. Retrieved Nov. 28, 2005 from EPA website: http://www.epa.gov/owow/wetlands/pdf/ConstructedWetlands-Complete.pdf

U. S. Environmental Protection Agency (2000) Stormwater Phase II Compliance Assistance Guide. U. S. EPA Office of Water. Washington, D.C.

UW-Green Bay. (2005). University of Green Bay Master Plan, Final Draft.

UW-Madison (University of Wisconsin-Madison). (2004). Innovating Stormwater Management on the University of Wisconsin-Madison Campus: Water Resources Management Workshop 2003. Retrieved Oct. 7, 2005 from UW-Madison website: http://www.ies.wisc.edu/wrm/workshops/2003/

Wisconsin Department of Administration (DOA). (2005). Wisconsin Coastal Management Grant Program. Retrieved Mar. 16, 10 from WDOA website: http://www.doa.state.wi.us/pagesubtext_detail.asp?linksubcatid=250

Appendices

Appendix I: Section 3. Ponds; Stormwater BMP Design Supplement for Cold Climates
http://www.cwp.org/Cold%20Climates/CHAPT3%20-%20PONDS.pdf

Appendix II: A Comparison of Sustainable and Traditional Landscapes
http://www.cdfinc.com/CDF_Resources/Sustainable_Landscape_Cost_Comparison.pdf