Stormy Weather and Stormwater Impacts:
Keeping Michigan Clean and Green

A Report from the Center for Water Sciences
2009 Water Fellows
Workshop Series on Stormwater

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Water Fellows and Executive Steering Committee

The views expressed in this report are the sole views of the participants and this report is by no means meant to be viewed as a comprehensive or consensus document, but as a report on the discussions during the workshops. The Water Fellows participated in the workshop series as individuals. This document does not reflect the views of the Water Fellows’ respective organizations nor does it imply any endorsement by those organizations. The following individuals served as Water Fellows for this workshop series:

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The following Steering Committee members organized the workshop series and contributed to the report of the Water Fellows:

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Joan B. Rose, Homer Nowlin Chair in Water Research
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All workshop materials, including white papers by the speakers and webcasts of the public seminars, are available online at http://www.cws.msu.edu/stormwater.htm.

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The Workshops’ Bottom Line

Stormwater runoff, the water flowing over land from rain and snowmelt, can either be a source of pollution or an opportunity for innovation. Unfortunately, it is commonly a source of pollution. Stormwater runoff, in both urban and agricultural environments, can wash pollutants such as nutrients, pathogens, metals, and toxins off the surface of the land and into water. According to the US Environmental Protection Agency (EPA), this is the leading cause of water quality problems in the United States today.

We typically deal with stormwater by trying to get it off our property as quickly as possible. Our communities have built gutters, drains, and storm sewers to collect and convey stormwater off the land. Where does it go? Into our rivers, lakes and streams - all without any prior treatment.

However, there is an alternative. Stormwater can be viewed as a resource, rather than as waste to be discarded as quickly as possible. By managing stormwater on site, many negative impacts can be avoided. Approaches such as Low Impact Development (LID) can be used to reduce the amount of stormwater generated at a site and to improve the water quality of the runoff. There are also opportunities for collecting and re-using stormwater and to create artful designs that turn stormwater runoff into an amenity. This alternative just takes a shift in how we think about and deal with stormwater.

The workshop participants (Water Fellows) in this Water Fellows Series have created a plan for improving Michigan’s approach to stormwater management. The workshops brought together leading national scientists and practitioners with representatives from Michigan’s many water stakeholders in government, industry, agriculture, environmental advocacy, and higher education.

The recommendations summarized below outline the Water Fellows’ plan. More details about the science behind the recommendations and the workshops themselves comprise the rest of the report.
### Summary of Recommendations

**Government:** governments responsible for stormwater management, including municipal separate storm sewer system (MS4s),

- **Encourage adoption and implementation of Low Impact Development (LID).** Local governments can require LID approaches through local ordinances and codes. In addition, they can encourage LID through incentives for developers, using LID in local government projects, sharing information about LID projects, and conducting education and outreach campaigns for stormwater.

- **Establish a stormwater utility to fund stormwater projects.** Stormwater utilities are used across the country to fund stormwater programs. The stormwater utility in Ann Arbor can serve as a model for other local governments across the state.

- **Require inspection and maintenance of stormwater Best Management Practices (BMPs).** Proper installation and maintenance is critical for effective BMPs.

- **Use a watershed-based approach.** Water Fellows recommend that local governments work on these stormwater and water planning issues on a watershed-scale.

**Professionals:** government staff, engineers, consultants, landscapers, etc.

- **Incorporate LID approaches in design.** Use LID techniques instead of or in conjunction with traditional stormwater management approaches (pipe and pond) when designing sites.

- **Share information about LID projects.** Information about designs, costs, performance, and maintenance are valuable to others working in the stormwater arena. Document case studies and share information so that others can learn from current projects.

- **Treat stormwater as a resource, not as a waste product.** During design, think of how stormwater can be used on site and the amenities that can be created with artful stormwater design.

**Public:** homeowners, school children, the “general public”

- **Take responsibility for runoff.** Incorporate a LID strategy on your property (build a rain garden, re-direct down spouts, use a cistern, etc.).

- **Take charge - work to make improvements in your community.** Participate in local government by volunteering and serving on local committees and commissions such as the planning commission, natural resources committee, etc.

- **Participate in stormwater education and stewardship activities.** Local governments, schools, and organizations across the state run stormwater outreach campaigns. Citizens can participate in local events such as stream clean-ups, storm drain labeling, and constructing rain gardens.
The Problem of Stormwater

According to the US EPA, stormwater runoff is the leading cause of water quality impairment in the United States. Urban stormwater runoff occurs when rain or snowmelt flows over impervious surfaces, such as buildings, roads, driveways, sidewalks, and compacted soils. Along its way, stormwater picks up debris, chemicals, bacteria, and other pollutants and carries them directly to rivers, lakes and streams. Polluted stormwater runoff can have many adverse impacts on plants, animals, and humans. For example, most waterborne disease outbreaks in the United States are associated with large storm events.

Impervious surfaces are a key component of the stormwater problem. Impervious surfaces prevent precipitation from naturally infiltrating into the soil and, as a result, precipitation falling on these surfaces increases stormwater runoff. Many studies have examined the relationship between impervious surface area in a watershed and biological indicators of river and stream health. From these studies we have learned that as the amount of impervious area in a watershed increases, the biological integrity of rivers and streams declines. This pattern is found across the United States with a variety of aquatic organisms used as environmental health indicators, from fish to aquatic insects. We start to see negative impacts on aquatic ecosystems when 10% of a watershed is covered in impervious surfaces and once the level of impervious surface area reaches 25%, stormwater impacts seem unavoidable.

Parking lots are just one example of an impervious surface that does not allow water to infiltrate into the soil.
**What are the negative impacts of stormwater?** Urbanization and increased impervious surface area cause changes in natural water flow patterns that affect all aspects of aquatic ecosystems. The frequency, magnitude and volume of water increase because more precipitation is delivered to rivers and streams via surface runoff from storms. Channels become more unstable and begin to erode. Water quality declines due to the pollutants, such as nutrients, metals, and pathogens that are carried to streams in the stormwater runoff. The changes in water quality and stream habitat result in declines in macroinvertebrate and fish communities. Thus, stormwater runoff has the potential to negatively impact the physical, chemical and biological features of aquatic ecosystems. In which case, these urban waterbodies are no longer able to provide critical ecosystem services such as water purification, waste assimilation, flood control and maintenance of biodiversity.

**What has been done to address these impacts?** In the past, stormwater management focused on flood prevention and control. Management focused on decreasing peak runoff rates and moving water off property as quickly as possible. However, this meant that stormwater, and the pollutants it carries, moved more quickly from land to rivers, lakes and streams. **Altering the natural way in which water moves through the landscape is a major reason for the negative impacts due to stormwater.**

Recent management approaches focus on trying to mimic more natural flow patterns in the built environment. Low Impact Development (LID) is one management approach based on the principle of using and mimicking natural hydrologic patterns. LID seeks to manage rainfall at the source using distributed, decentralized small-scale controls. The goal of LID is to mimic a site’s predevelopment hydrology by using design techniques and best management practices (BMPs) that infiltrate, filter, store, evaporate, and detain runoff close to its source. This approach is also based on the premise that stormwater is not waste. Instead of collecting and conveying stormwater to large, costly, end-of-pipe facilities such as detention ponds, LID manages stormwater through small, cost-effective landscape features on-site. Such landscape features include rain gardens, bioretention cells, swales, and porous pavements.
Overview: Purpose and Major Themes

The Stormwater Workshop Series was designed to bring together nationally renowned stormwater experts and individuals (Water Fellows) who have an interest and stake in the future of water resources in the State of Michigan. The goal of the 2009 workshop series was to learn about the impacts of stormwater on Michigan’s water resources and to explore potential solutions.

Several major themes emerged during the workshops:

- **Stormwater management in Michigan should focus on source control and reducing the amount of stormwater runoff generated at a site.** Traditional approaches to managing stormwater in Michigan focus on reducing peak flows. However, this approach does not address any of the negative impacts caused by the increase in volume of stormwater. New approaches to stormwater management, such as LID, focus on source control. Source control uses on-site techniques near the source of stormwater to reduce and manage stormwater quantity and improve water quality.

- **Funding stormwater management programs is a challenge faced by many local governments and the state needs to find mechanisms to provide dedicated funding for local government stormwater programs.** There are currently legal constraints which need to be overcome in the state of Michigan to appropriately fund stormwater programs. Options include but are not limited to stormwater utilities, grants, dedicated funding through user fees and bonding.

- **Michigan should encourage LID in planning and practice.** Both local communities and the state need to examine regulations and incentives to implement LID in existing and new development.

- **Stormwater management needs to recognize and address climate change.** The current designs for stormwater infrastructure have been based on historical precipitation and flow data. However, due to climate change, future conditions cannot be adequately predicted based on these records. Future stormwater management needs to recognize that climate change will alter precipitation and flow patterns. We will need to plan for adaptive, resilient stormwater infrastructure.

- **The state needs to improve and expand education programs for watershed management, including stormwater, and incorporate them into the state benchmarks.** There is a need to teach children about watersheds and incorporate watershed management, including stormwater issues, into school curricula (K-12 and university) and the state standards. There is also a need to broaden training...
at all levels and examine interdisciplinary approaches to education that include multiple audiences. In addition, local governments, professionals and communities should use, partner with, and actively engage with universities. Many of these groups would also benefit from having access to educational tools for advocating innovative stormwater management approaches such as LID.

- Local governments and professionals need one definitive Michigan-specific source of easily accessible information on stormwater management. There are thousands of websites that contain stormwater information, which makes finding relevant information a challenge. The state would benefit from creating a single credible website that is interactive and provides up-to-date information on resources for stormwater management in Michigan.

What Was Discussed at the Workshops?
The speakers and Water Fellows discussed six topics at the workshops:

- Climate change, stormwater and Michigan
- Stormwater assessment and monitoring
- Governance Structures: An Example from the Ohio River Sanitation Commission
- Ecosystem Impacts and Approaches
- Green Best Management Practices and Low Impact Development
- Getting Creative with Stormwater: Artful Rainwater Design

All materials from the workshops, including webcasts of the public seminar, white papers, and presentations, are available online from the Center for Water Sciences at Michigan State University (http://www.cws.msu.edu/stormwater.htm).

Assessment of Status & Needs: Where are we now?
Many communities across Michigan are now faced with stormwater issues and although many communities recognize the need to manage stormwater, addressing the problem is challenging because of several critical knowledge gaps:

- Local governments in Michigan lack financial mechanisms to support local stormwater programs. Many communities across the US finance their stormwater programs through stormwater utilities; however, because of the Bolt decision (Bolt v. City of Lansing, 459 Mich 152, 1998; see text box) creating a stormwater utility in Michigan can be a challenge. Case studies are needed to demonstrate how communities in Michigan can create their own funding mechanisms.

- Michigan lacks information on how to effectively implement new approaches to stormwater management, including LID. Although information on stormwater management techniques is available and the state has developed a
LID manual, there is still a knowledge gap when it comes to actual on-the-ground implementation of LID and what policies need to be adopted and/or revised to encourage implementation. Effective implementation includes ensuring correct installation, maintenance, inspections and incorporating dynamic and evolving information regarding techniques and BMPs. Michigan also does not have a long-term history implementing LID, so there is an experience gap.

- **There is a lack of effective stormwater educational programs at multiple levels.**
  From primary schools to universities, stormwater is not currently broadly integrated into the curriculum. Also, Michigan currently lacks certification programs for BMP installation and maintenance. Stormwater should be part of science curriculum in K-12 education. Stormwater science, research and education at our universities need to be supported and advanced across multiple disciplines. In addition a certification and re-certification program should be developed to effectively train those who install and maintain BMPs.

**Framework for the Future**

Given the challenges in dealing with stormwater, the Water Fellows recommend creating an online Michigan Stormwater Learning Community website as a means to provide the technical assistance needed to move stormwater management in Michigan forward. The site would serve as a central hub for stormwater information and networking. The Learning Community would meet several identified needs by providing a single, user-friendly source of stormwater information for Michigan; creating an interactive site where users can provide rankings, comments, and feedback on the information on the site; and providing a venue for communication and networking. We discuss the Learning Community idea in more detail in the “Michigan Stormwater Learning Community” section of this report.
In addition to the creation of a Learning Community website, the Water Fellows developed recommendations for several target audiences: government, stormwater professionals, and the public. During the course of the workshop series, several additional recommendations unrelated to these categories also arose and we have included them under the “other” category. Following are the main recommendations for each target audience:

**Government:**
- Offer incentives for developers to use LID
- Establish a stormwater utility to fund stormwater projects
- Adopt a post-construction stormwater ordinance that promotes LID
- Do small LID projects to demonstrate success
- Share information about LID projects (designs, costs, maintenance) and document case studies
- Require inspections and maintenance of BMPs
- Create effective education and outreach campaigns regarding land development and behaviors to reduce stormwater pollution
  - In messages to the public, where applicable: link stormwater with green economy and quality of life issues

**Professionals:**
- Incorporate LID approaches in design
- Share information about LID projects (designs, costs, performance, maintenance) and document case studies
- Treat stormwater as a resource, not as a waste product, and think of amenities that can be created with artful stormwater design.

**Public:**
- Take responsibility for runoff on your property
- Incorporate an LID strategy on your property (build a rain garden, re-direct down spouts, use a cistern, etc.)
- Learn about stormwater by participating in local stormwater activities

**Other:**
- Create a certification program for installation and maintenance
- Create a central hub for stormwater and LID information
The Workshop Series

Participants
The Steering Committee, who organized the workshop series, invited individuals from across Michigan to participate as Water Fellows. The Water Fellows are a group of citizens from Michigan who represent diverse backgrounds including government, industry, agriculture, academia, and environmental organizations and have an interest in water resources in Michigan.

Structure of the Workshops
The workshops featured nationally-recognized scientists and professionals who are experts in subjects regarding stormwater. These experts gave public lectures that introduced the latest scientific knowledge and cutting-edge technologies to address problems involving stormwater. The workshop speakers also each wrote a white paper on their respective topics for the series. After the public lectures by the speaker, the Water Fellows and speaker(s) discussed the topic of the day in a facilitated interactive session. There were several guiding questions used to direct the interactive discussion sessions at all of the workshops. The guiding questions fell into three categories: basic science and knowledge, approaches for addressing stormwater, and policy questions.

- Basic science & knowledge
  - What are the impacts of stormwater runoff on water resources? Ecosystems? Human health?
  - What best management practices can be used to manage stormwater?
  - How effective are those best management practices?
- Approaches
  - What are successful techniques for preventing stormwater impacts?
  - What are potential solutions that would work in Michigan?
  - How can we design landscapes that meet human needs while minimizing stormwater runoff?
- Policy
  - What are the costs and financial incentives associated with stormwater management?
  - What information does the state, local government and professionals need to address the stormwater issue successfully?
  - What incentives are needed to encourage novel approaches to stormwater management, such as Low Impact Development?

These guiding questions were discussed at all of the workshops in addition to specific questions about the topic of the day.
Summary of the Workshops

All materials from the workshops are available online at [http://www.cws.msu.edu/stormwater.htm](http://www.cws.msu.edu/stormwater.htm). The materials include webcasts of the public seminar, slides from the presentations, white papers by the speakers, links to resources, and all products from the series. Below we provide a brief summary of the six workshops.

1. Climate Change, Stormwater and Michigan

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology</td>
<td>↑ frequency of overland flow</td>
</tr>
<tr>
<td></td>
<td>↑ frequency of erosive flow</td>
</tr>
<tr>
<td></td>
<td>↑ magnitude of high flow</td>
</tr>
<tr>
<td></td>
<td>↓ lag time to peak flow</td>
</tr>
<tr>
<td></td>
<td>↓ recharge to aquifers</td>
</tr>
<tr>
<td>Water Quality</td>
<td>↑ nutrients (e.g., nitrogen, phosphorus)</td>
</tr>
<tr>
<td></td>
<td>↑ toxicants (e.g., oils, greases, metals)</td>
</tr>
<tr>
<td></td>
<td>↑ water temperature</td>
</tr>
<tr>
<td></td>
<td>↑ salt</td>
</tr>
<tr>
<td>Channel Morphology</td>
<td>↑ channel width</td>
</tr>
<tr>
<td></td>
<td>↑ pool depth</td>
</tr>
<tr>
<td></td>
<td>↑ scour</td>
</tr>
<tr>
<td>Biota</td>
<td>↑ tolerant fish and invertebrates</td>
</tr>
<tr>
<td></td>
<td>↓ sensitive fish and invertebrates</td>
</tr>
<tr>
<td>Ecosystem Processes</td>
<td>↓ organic matter retention</td>
</tr>
<tr>
<td></td>
<td>↓ nutrient uptake</td>
</tr>
<tr>
<td>Public Infrastructure</td>
<td>↑ cost for installation and maintenance</td>
</tr>
</tbody>
</table>

Dr. Alan Steinman, Director of Grand Valley State’s Annis Water Research Institute began the workshop series with an overview of stormwater issues in Michigan. Like the rest of the country, many streams and rivers in Michigan are experiencing the “urban stream syndrome” due to stormwater impacts (Table 1). This syndrome is typical of waterbodies in urban areas with high amounts of impervious cover.

Dr. Steinman also presented information on the relationship between stormwater and climate change in Michigan. He spoke about several studies that have examined potential impacts. Climate model projections for the southern Wisconsin region show that extreme high precipitation events will become 10 to 40% stronger (Patz et al. 2008). In the Great Lakes region, precipitation events of greater than 2 to 2.5 in (5-6 cm) often result in stormwater discharge of contaminants into water bodies (McLellan et al. 2007). The analysis by Patz et al. (2008) revealed that the frequency of events exceeding the 2
to 2.5 in threshold is anticipated to increase by 50 to 120% by the end of the 21st century. They concluded that without improvements to our waste and stormwater infrastructure, these extreme events may overwhelm the combined sewer systems and lead to overflow events that threaten human health and the recreational-based economy in the region.

Climate change is not only an issue for the state, but is currently one of the most vigorously debated topics on Earth (Easterling 2009). The National Environmental Satellite, Data, and Information Service (NESDIS) data centers are central to answering some of the most pressing global climate change questions that remain unresolved. We were privileged to have Dr. David Easterling of the National Climatic Data Center present the latest climate change information at the workshop series. Dr. Easterling provided an overview of known observations and projections about climate change. The observed and projected changes due to climate change and potential impacts for the Midwestern US are summarized in Table 2.

2. Stormwater Assessment and Monitoring

Mr. Roger Bannerman, from the Wisconsin Department of Natural Resources, provided examples from Wisconsin on monitoring stormwater impacts, the effectiveness of BMPs, and overall approach to stormwater in Wisconsin. Stormwater management in Wisconsin focuses on several important resource management questions:

- What are the designated uses for the waterbody of interest?
- Are the designated uses being achieved?
- What pollutants or factors (such as flow) are impacting the resource?
- What are the pollutant reduction goals?
- What are the sources of the pollutants?
- What are the most cost-effective treatment practices?
- What are we achieving?

Mr. Bannerman discussed multiple examples of stormwater projects across Wisconsin. These examples demonstrate that infiltration practices, such as rain gardens and bioretention areas, can be effective in the Great Lakes region. These practices have the potential to reduce stormwater volume and peak runoff rates as well as pollutant loads in runoff.
Table 2. Summary of observed and projected changes and impacts on water resources in the Midwestern United States (OH, MI, IN, IL, WI, MN, IA, MO) due to climate change (from Karl et al. 2009)

<table>
<thead>
<tr>
<th>Observed Changes in Climate¹</th>
<th>Climate Change Projections²</th>
<th>Climate Change Impacts</th>
</tr>
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<tbody>
<tr>
<td>A noticeable increase in average temperatures in the Midwest has been observed, despite the strong year-to-year variations. The length of the frost-free or growing season has been extended by more than one week, mainly due to earlier dates for the last spring frost. Heavy downpours are now twice as frequent as they were a century ago. Both summer and winter precipitation have been above average for the last three decades, the wettest period in a century. Decrease in lake ice, including on the Great Lakes. Since the 1980s, large heat waves have been more frequent in the Midwest than any time in the last century.</td>
<td>Heat waves will become more frequent, more severe, and longer lasting. Waterborne diseases will present an increasing risk to public health because many pathogens thrive in warmer conditions. Higher temperatures will mean more evaporation and therefore a likely reduction in the Great Lakes water levels. Reduced lake ice increases evaporation in winter, contributing to the decline. Lake levels projected to fall between 1 and 2 feet. Precipitation is projected to increase in winter and spring, and to become more intense throughout the year. In the summer, with increasing evaporation rates and longer periods between rainfalls, the likelihood of drought will increase and water levels in rivers, streams, and wetlands are likely to decline. Reduced summer water levels are also likely to reduce the recharge of groundwater, cause small streams to dry up (reducing native fish populations), and reduce the area of wetlands in the Midwest. The projected increase in winter and spring precipitation and flooding is likely to delay planting and crop establishment. Disease-causing pathogens, insect pests, and weeds (including invasive weeds) projected to increase. Plant winter hardiness zones (each zone represents a 10°F change in minimum temperature) in the Midwest are likely to shift one-half to one full zone about every 30 years. In some lakes, increases in air and water temperature will lead to an earlier and longer period in summer during which mixing of the relatively warm surface lake water with the colder water below is reduced. All major groups of animals, including birds, mammals, amphibians, reptiles, and insects, will be affected by impacts on local populations, and by competition from other species moving into the Midwest region.</td>
<td>During the summer, public health and quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and insect and waterborne diseases. In the winter, warming will have mixed impacts. Significant reductions in Great Lakes water levels, which are projected under higher emissions scenarios, lead to impacts on shipping, infrastructure, beaches, and ecosystems. The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer would lead to more periods of both floods and water deficits. While the longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests. Native species are very likely to face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species moving in from warmer regions.</td>
</tr>
</tbody>
</table>

¹ Since 1970s unless otherwise stated
² Under high emissions scenario
3. Governance Structures: An Example from ORSANCO

Mr. Alan Vicory, Executive Director and Chief Engineer of the Ohio River Valley Water Sanitation Commission (ORSANCO), discussed ORSANCO as a model for regional governance of water resources. ORSANCO was created by a state compact among the states of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia to address interstate pollution problems along the Ohio River. ORSANCO’s principal authorities are to:

- Study the pollution problems of the Ohio Valley drainage within the signatory states (termed the Ohio River Valley Water Sanitation District) and report to the states on those problems.
- Recommend uniform state legislation aimed at eliminating interstate water pollution.
- Adopt of standards of treatment for discharges of pollution to interstate streams (in the District).
- Consult with any party or entity with regard to pollution problems in the District.

ORSANCO is funded by the states involved and a federal Clean Water Act grant (Section 106), with supplementary funds for special projects from a variety of granting sources.

ORSANCO demonstrates the effectiveness and strengths of a regional authority for water management. For example, the Commission has established an extensive monitoring network in the Ohio River basin that provides critical data for management decisions, has created an early detection system for spills, is involved in establishing stream criteria, and delineation of best available technologies for treatment of wastes. ORSANCO is an independent but multi-jurisdictional agency. It represents the states collectively, but no state individually. The commitment of the members to the multi-jurisdictional authority is critical for success. In the case of ORSANCO, the states have formally committed their cooperation and are thus answerable to each other in what they are and are not doing relative to that commitment. Such a model can be employed at any level of government or for multiple levels of government.
4. Ecosystem Impacts and Approaches

The premise of Mr. David Drullinger’s presentation was that runoff volume reduction (or volume control) alone can provide measurable reduction of impacts on receiving waters. Volume control holds promise across a variety of land uses, pollutant types, and wet weather events. The success of volume control depends on proof that it is effective, economical, and sustainable. Volume control strategies, such as bioretention and other LID techniques, show promise for both urban and agricultural land uses.

Dr. Laurie Fowler from the University of Georgia’s Odum School of Ecology, presented a case study from the Etowah River watershed. Researches and local governments in the Etowah watershed are developing a Habitat Conservation Plan (HCP) under the Endangered Species Act in order to protect threatened and endangered fish species in the Etowah River and its tributaries. Part of the HCP is a runoff limits program that requires no net increases in the amount of stormwater generated at a site (volume and peak runoff rates) in priority areas in the watershed. In lower priority areas, slight increases in stormwater runoff, as compared to pre-development conditions, are allowed. The runoff limits program can be used as a model for other parts of the country.

5. Green Best Management Practices and Low Impact Development

Dr. William Hunt, North Carolina State University and Ms. Amy Mangus, Southeastern Michigan Council of Governments (SEMCOG) discussed green BMPs and LID. Dr. Hunt presented an overview of green BMPs, such as rain gardens, bioinfiltration, and porous pavements that have proved effective in many parts of the country. Proper design, installation and maintenance are critical for the effectiveness of these BMPs. North Carolina has started a successful training and certification program for those installing and maintaining stormwater BMPs to ensure their success.

Ms. Mangus discussed the new LID manual, developed by SEMCOG and partners for the state of Michigan. The Michigan LID manual provides design information on LID practices and model ordinances for communities to adopt in order to encourage LID. Many informational resources for LID exist; however, the current challenge is in implementation, particularly given the poor economy. Although many studies have shown that LID and water protection have economic benefits, many communities are hesitant to jump into LID by mandating it from development. In Michigan, LID implementation has evolved by integrating LID into municipal projects and slowly integrating it throughout the community. Providing demonstration sites shows developers and communities that certain technologies can be successful in Michigan.
and meet regulatory approval. Ms. Mangus presented 10 tips for implementing LID in Michigan:

1. Implement LID in local government projects: lead by example
2. Protect sensitive and special value features
3. Use native plants to vegetate or re-vegetate areas
4. Minimize disturbed areas
5. Reduce impervious surfaces
6. Use good housekeeping practices
7. Update plans and policies to incorporate LID
8. Develop ordinances that directly support LID implementation
9. Educate the public
10. Provide incentives

This last tip is critical and incentives such as allowing for a state income tax credit for qualifying LID techniques and offering a bonus such as increased floor area (e.g., floor area ratio) if LID practices are used that accomplish stormwater management goals are possibilities. Governments could also accelerate plan reviews for site plans implementing LID techniques, reduce fees charged to the applicant (e.g., plan review fees, utility fees) for site plans implementing LID techniques, and offer a density bonus (e.g., allow for an additional lot) to developments that implement LID practices.
6. Getting Creative with Stormwater: Artful Rainwater Design

Mr. Patrick Judd, Conservation Design Forum and Dr. Stuart Echols, Pennsylvania State University discussed how stormwater can be used as an amenity. Both gave examples of site designs that treat stormwater as a resource, in terms of water use and aesthetics. The presentations demonstrated that stormwater design can accomplish multiple goals including reducing the volume and peak rate of runoff, reducing pollutant loads, and serving as an amenity.

Stormwater management can be artful. Designs can serve multiple purposes, achieving water quality improvements while creating enjoyable spaces for people. Images: Drawings from Willow Run Park project; Second from left, The Dell; far right, Growing Vine Project from Artful Rainwater Design.
The Water Fellows recommended creating an online learning community through an interactive website for learning about stormwater management in Michigan. This site would provide one-stop shopping for stormwater information for the state. It would be designed with three target audiences in mind: local governments, stormwater professionals, and the public. The site would provide recommendations and resources tailored to each audience. In addition, it would include means to find collaborators and funding opportunities for stormwater projects. Incentives for participating in the Learning Community include advertising on the site as well as highlighting local projects.

**Content and Structure**

The website would be organized similar to the Sustainability Science at Michigan State University website [http://espp.msu.edu/sustain/index.html](http://espp.msu.edu/sustain/index.html). The home page of the site would provide links for the target audiences as well as links to go directly to a search for collaborators and funding opportunities (Figure 1). In order to use the site, users must register and provide their contact information which will be used to add them to the searchable database of collaborators. Clicking on one of the target audience links would take a user to a page with the Water Fellows’ recommendations for that target audience as well as links to resources. These resources would include guidance on implementing the recommendations, case studies from Michigan, and stormwater information resources from around the country (see Appendices).

**An Interactive Resource**

The website would allow users to rate and comment on information presented on the site. The Water Fellows envision a rating system similar to reviews on Amazon.com. In this way, users can quickly sort through information based on what others have found most helpful. In addition, users will be able to comment and submit additional resources. The site managers would develop a standard format for case studies so users could submit their own work for inclusion on the site after approval by the website manager. In addition, the site will allow registered users to ask the learning community questions and pose challenges to the group concerning difficult stormwater management sites or failures of BMPs.
Figure 1. Site map for the Michigan Stormwater Learning Community website
References


Appendices

A. Resource Guide for Governments and Stormwater Management Professionals

B. Resource Guide for the General Public
Appendix A. Resource Guide for Governments and Stormwater Management Professionals

This guide provides a list of helpful resources for local governments and professionals responsible for stormwater management. The list is based on EPA’s Resource List for Stormwater Management Programs (Revised May 2007, EPA 833-F-04-003) with additions and revisions by the Water Fellows. It is by no means a comprehensive list, but we encourage you to explore these resources.

This guide is divided into several sections:
- General stormwater information
- Public education and outreach
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction site runoff control
- Pollution prevention/good housekeeping
- Funding Sources
- Artful stormwater design
- Stormwater management manuals from Great Lakes states
- Michigan-specific resources

General Stormwater Information
EPA Stormwater Website – Contains technical and regulatory information about the NPDES stormwater program. It is organized according to the three types of regulated stormwater discharges: construction activities, industrial activities, municipal separate storm sewer systems.
www.epa.gov/npdes/stormwater

American Water Resources Association (AWRA) - the American Water Resources Association is a non-profit professional association dedicated to the advancement of men and women in water resources management, research, and education. The website provides links to publications such as the Journal of the American Water Resources Association (must be member to access) as well as other publications, events, and water news.
http://www.awra.org


Center for Watershed Protection – The Center for Watershed Protection works to protect, restore, and enhance our streams, rivers, lakes, wetlands, and bays. Their site has many resources and publications on watershed protection topics including stormwater management and better site design.
http://cwp.org/

2003 Construction General Permit – This 59-page document is EPA’s new Construction General Permit (CGP).

Construction General Permit – Describes EPA’s construction general permit and provides links to fact sheets and the new electronic notice of intent web site.
www.epa.gov/npdes/stormwater/cgp

Construction Industry Compliance Assistance Center – Developed by the National Center for Manufacturing Sciences, provides explanations of environmental rules for the construction industry. Also provided are links to detailed information, including state regulations and other resources.
www.cicacenter.org
**EnviroFacts Data Warehouse** – EPA’s one-stop resource for environmental topics. Includes advanced search capabilities for maps, reports and queries.
[www.epa.gov/enviro/index_java.html](http://www.epa.gov/enviro/index_java.html)

**EPA’s Electronic Stormwater Notice of Intent (eNOI) Homepage** – Allows construction sites and Industrial facilities to apply for EPA’s General Construction Permit (GCP) or Multi-Sector General Permit (MSGP-2000) electronically.
[www.epa.gov/npdes/stormwater/enoi](http://www.epa.gov/npdes/stormwater/enoi)

**Fact Sheet on EPA’s 2003 Construction General Permit** – This 38-page document describes EPA’s Construction General Permit.

**Greening Stormwater** – Publication by American Rivers


**International Stormwater Best Management Practices (BMP) Database** – Developed under a cooperative agreement between EPA and ASCE, provides access to BMP performance data for 200 BMP studies conducted over the past 15 years.
[www.bmpdatabase.org/](http://www.bmpdatabase.org/)

**Local Water Policy Innovation: A Road Map for Community Based Stormwater Solutions**

**Menu of Best Management Practices (BMPs) for Phase II** – Contains more than 100 fact sheets detailing BMPs for each minimum control measures.
[www.epa.gov/npdes/stormwater/menuofbmps](http://www.epa.gov/npdes/stormwater/menuofbmps)

**Measurable Goals Guidance** – EPA developed this website to help small MS4 communities select measurable goals to evaluate their program.

**Nonpoint Source News Notes** – A periodic report on the condition of water-related environment, the control of nonpoint water pollution and ecological management and restoration of wetlands.
[www.epa.gov/newsnotes/](http://www.epa.gov/newsnotes/)

**NPDES News** – Use this website to sign up for EPA’s NPDES News listserv to receive updates on the EPA’s NPDES program.
[http://cfpub.epa.gov/npdes/newsregister.cfm](http://cfpub.epa.gov/npdes/newsregister.cfm)

**Nonpoint Source Pollution Information (NPSINFO) Listserv** – A forum for open discussion of nonpoint source pollution issues. Participants exchange information on urban runoff, hydrologic modification, technology and more. Sponsored by the EPA’s Office of Wetlands, Oceans and Watersheds.
[www.epa.gov/OWOW/info/NewsNotes/notifi.htm](http://www.epa.gov/OWOW/info/NewsNotes/notifi.htm)

**Stormwater: The Journal for Surface Water Quality Professionals** – Features articles, interviews and news about water quality improvement and protection.
[http://stormh2o.com/sw.html](http://stormh2o.com/sw.html)

**Stormwater Authority** – A comprehensive online source for relevant information, news, events and education on stormwater.
[www.stormwaterauthority.org/](http://www.stormwaterauthority.org/)
Stormwater Case Study: Monroe County, New York – Monroe County enlists the aid of volunteers to help monitor streams and large water bodies.
http://cfpub.epa.gov/npdes/stormwater/casestudies_specific.cfm?case_id=16

Stormwater Control Operation and Maintenance Model Ordinance – Developed to assist managers in developing their own ordinances.
www.epa.gov/owow/nps/ordinance/stormwater.htm

Stormwater Phase II Final Rule Fact Sheet Series – Developed these fact sheets to explain the Phase II rule, minimum control measures and permitting.
http://cfpub.epa.gov/npdes/stormwater/swfinal.cfm

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices – Provides detailed guidance on the development of storm water pollution prevention plans (SWPPP) and identification of best management practices (BMPs) for construction activities. It provides technical assistance and support for all construction activities subject to pollution prevention requirements established under NPDES permits for storm water point source discharges. It includes a set of worksheets, a checklist, and a sample SWPPP (EPA 832-R-92-005).
www.epa.gov/npdes/pubs/own0307.pdf

Stormwater Management – Center for Watershed Protection developed this website to provide managers with links to helpful manuals and other web sites.
www.cwp.org/stormwater_mgt.htm

Stormwater Manager’s Resource Center – Contains many resources for stormwater managers, including guidance documents, slide shows, model ordinances, and fact sheets.
www.stormwatercenter.net/

Stormwater Practices for Cold Climates – Developed by the Center for Watershed Protection can be downloaded for free.
www.cwp.org/cold-climates.htm

Stormwater training resource locator – Site provides links to training resources in Michigan, the Great Lakes, and other states.
www.envcap.org/statetools/swt/swt.cfm?st=MI

UNH Stormwater Research Center – The University of New Hampshire’s online stormwater database contains factsheets, research materials, articles and links to other stormwater sites.
www.unh.edu/erg/cstev

USDA – The USDA has many resources related to stormwater runoff, both from agricultural and urban areas. Search the site for runoff or stormwater to find relevant resources.
http://www.usda.gov

Watershed Academy Web: Online Training in Watershed Management – This online distance learning program offers self-paced training modules for a basic introduction to the watershed management field.
www.epa.gov/watertrain/

Public Education and Outreach

After the Storm Video – New ½ hour television program about watersheds co-produced by EPA and The Weather Channel premiered on Feb. 4, 2004 (EPA 840-V-04-001).
www.epa.gov/weatherchannel/

American Oceans Campaign – Contains helpful materials for educating the public, such as a video narrated by Ted Danson, links to stormwater resources in California, and a special report developed by AOC.
www.oceana.org/north-america/media-center/
City of Los Angeles Stormwater Program – Includes links to public outreach resources, industry BMPs, teacher workshops and educational programs, and much more.
www.lastormwater.org/WPD/program/pubedpage.htm

Communicator’s Guide for Federal, State, Regional, and Local Communicators – The Federal Communicator’s Network developed this guide to offer some general guidance to improve the trust between government and the public by helping officials communicate clearly to the public and by making government's message relevant.
http://govinfo.library.unt.edu/npr/library/papers/bkgrd/communicators.html

Community Culture and the Environment: A Guide to Understanding a Sense of Place, Nov. 2002 – Explores the concepts of community and culture and provides tools for identifying, assessing, and working cooperatively within the social dynamics and local values connected to environmental protection (EPA 842-B-01-003).
www.contextsensitivesolutions.org/content/reading/epa_community/

Earthwater Stencils – Provides ideas for public involvement activities for stormwater programs.
www.earthwater-stencils.com/

Enviroscapes – Allows the development of realistic, three-dimensional models of watersheds, landfills, wetlands and more. An effective demonstration tool for students interested in learning about point sources and non point sources of water pollution.
www.enviroscapes.com


Fostering Sustainable Behavior Listserv - To subscribe, simply send an email to web@cbsm.com with "subscribe" in the subject

Getting In Step: A Guide for Conducting Watershed Outreach Campaigns – Provides some of the tools you will need to develop and implement an effective watershed outreach plan. If you're a watershed practitioner trained in the sciences, this manual will help you address public perceptions, promote management activities, and inform or motivate stakeholders (EPA 841-B-03-002).
www.epa.gov/nps/outreach.html

http://www.epa.gov/watertrain/gettinginstep/

Getting in Step: Engaging and Involving Stakeholders in Your Watershed – Provides the tools needed to effectively identify, engage, and involve stakeholders throughout a watershed to restore and maintain healthy environmental conditions.
www.epa.gov/owow/watershed/outreach/documents/stakeholderguide.pdf

Getting Your Feet Wet With Social Marketing – A Social Marketing Guide for Watershed Programs, Jack Wilbur, Utah Department of Agriculture and Food

Kids, Students, Teachers – Provides information and curricula on educating a variety of age groups on the environment and water pollution.
www.epa.gov/epahome/students.htm

Know Your Watershed – Developed by the Conservation Technology Information Center, has a good list of helpful resources (including guidebooks) for watershed groups.
www2.ctic.purdue.edu/kyw/kyw.html

Nonpoint Source Outreach Digital Toolbox - Includes a catalog of over 700+ materials (TV, print, radio, giveaways, mascots, public attitude surveys, and evaluations of public response to media campaigns) that can be used in a stormwater public education campaign.
www.epa.gov/nps/toolbox

Polluted Runoff (Non Point Source Pollution): Outreach – Contains information and links to a variety of non point source pollution documents, factsheets, testimonials, videos and more.
www.epa.gov/owow/nps/outreach.html

Public Education and Outreach Menu of BMPs (EPA) – Links to 19 factsheets on different BMPs for educating the public.
www.epa.gov/npdes/stormwater/menuofbmps/publiceducation

Public Involvement and Participation Menu of BMPs (EPA) – Links to 10 fact sheets detailing ideas and activities on how to get the public involved.
www.epa.gov/npdes/stormwater/menuofbmps/publicinvolvement

Responsive Management on Water Resources - A collection of research on public attitudes and research toward water resources.
http://www.responsivemanagement.com/waterprojects.html

The Sprink Stormwater Education – PSAs and websites on stormwater education developed by a private firm for MS4s and available for a fee.
http://www.stormwatereducation.com/index.html

Social Marketing Listserv - To subscribe, send an e-mail message to:
LISTPROC@LISTPROC.GEORGETOWN.EDU and in the body of the message write: "subscribe SOC-MKTG (your name)" and type your actual name in place of "your name."

Stormwater Outreach Materials and Reference Documents - Provides outreach materials that municipalities, watershed groups, state, and local governments can customize and use for their own stormwater outreach campaigns.
http://cfpub.epa.gov/npdes/stormwatermonth.cfm

Stormwater Case Studies on Public Education - Includes case studies of how a Phase I or Phase II community has implemented the public education requirements.
http://www.epa.gov/npdes/stormwater/menuofbmps/publiceducation

Think Blue San Diego – Provides an overview of San Diego’s stormwater pollution prevention program Think Blue San Diego. Includes program objectives and organization.
www.sandiego.gov/thinkblue

Volunteer Monitoring – Check out this EPA website to download helpful fact sheets and methods manuals, learn about upcoming events, and link to other helpful resources.
www.epa.gov/owow/monitoring/volunteer/

Water Environment Federation for Students – Check out this web page to download WEF’s materials and curricula for educating various age groups. Also provides information in Spanish.
www.wef.org/Home

Illicit Discharge Detection and Elimination
www.cwp.org/idde_verify.htm
Illicit Discharge Detection and Elimination Manual – The New England Interstate Water Pollution Control Commission developed this manual to provide an overview of the IDDE component of the Phase II regulations and practical information on various approaches municipalities can use to carry out the requirements of the regulations. www.neiwpcc.org

Illicit Discharge Detection and Elimination (IDDE) Menu of BMPs – Links to 8 fact sheets outlining various IDDE best management practices. www.epa.gov/npdes/stormwater/menuofbmpps/idde

Illicit Discharges Model Ordinances – EPA developed this website to assist managers in developing their own ordinances. www.epa.gov/owow/nps/ordinance/discharges.htm

Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide – Contains information to allow the design and conduct of local investigations to identify the types and to estimate the magnitudes of non-stormwater entries into storm drainage systems (EPA-600-R-92-238). www.epa.gov/npdes/pubs/investigating_inappropriate_pesds.pdf

Sanitary Sewer Overflows (SSOs) – EPA developed this website to provide more information on SSOs, including fact sheets and an SSO toolbox. www.epa.gov/npdes/ssos

Construction Site Runoff Control
Best Management Practices for South Florida Urban Stormwater Management Systems – The South Florida Water Management District has prepared this document to increase public awareness about the management of urban stormwater runoff and how best management practices (BMPs) can be used to improve water quality. https://my.sfwmd.gov/pls/portal/docs/PAGE/PG_GRP_SFWMED_ENVIROREG/PORTLET_REGULATORY/DANCE/TAB383509/BMP_MANUAL.PDF

EPA’s Construction Site Runoff Control Menu of BMPs – Links to 39 fact sheets outlining various IDDE best management practices. www.epa.gov/npdes/stormwater/menuofbmpps/construction

EPA’s Erosion and Sediment Control Model Ordinances – Assists managers in developing their own ordinances. www.epa.gov/owow/nps/ordinance/erosion.htm

International Erosion Control Association – The International Erosion Control Association is a non-profit, member organization that provides education and resource information for professionals in the erosion and sediment control industry. www.ieca.org/

International Stormwater Best Management Practices Database – Provides access to BMP performance data for about 200 BMP studies conducted over the past 15 years. www.bmpdatabase.org


Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices – Provides detailed guidance on the development of storm water pollution prevention plans (SWPPP) and identification of best management practices (BMPs) for construction activities. It provides technical assistance and support for all construction activities subject to pollution prevention requirements established under NPDES permits for storm water point source discharges. It includes a set of worksheets, a checklist, and a sample SWPPP (EPA 832-R-92-005). www.epa.gov/npdes/pubs/owm0307.pdf
Post-Construction Site Runoff Control
Biotreatment Applications: Fact Sheet – Two case studies (in Largo, Maryland, and Tampa, Florida) demonstrate the potential to use low impact development practices in the design of new parking facilities and as retrofits for existing parking facilities to reduce runoff volume and remove pollutants. Includes monitoring data.
www.epa.gov/owow/nps/lid/lidlit.html

Green Roofs for Healthy Cities – This non-profit industry association’s website collects and publishes technical information on green roof products and services.
www.greenroofs.org

Low Impact Development Center – The Low Impact Development Center strives to help communities use proper site design techniques to protect their water resources.
www.lowimpactdevelopment.org/

Low Impact Development Practices for Stormwater Management – Sponsored by the housing industry discusses building products, materials, new technologies, business management and housing systems.

Low-Impact Development Page – Developed by EPA, provides links to EPA documents and other helpful organization’s web sites.
www.epa.gov/owow/nps/lid/

Low Impact Development Integrated Management Practices Guide – Prince George’s County Maryland developed this manual to push the site design envelope to show how stormwater controls can be integrated into a site in innovative ways. The practices are pure concepts which are presented to provide the user with examples of what could be done to control stormwater.

Low Impact Development: Urban Design Tools – Provides watershed managers with tools and techniques for meeting regulatory and receiving water protection program goals for urban retrofits, redevelopment projects and new development sites.
www.lid-stormwater.net/

Natural Approaches to Stormwater Management – Produced by the Puget Sound Action Team, showcases early examples of the efforts of planners, developers and engineers to transition to low impact development.
www.psat.wa.gov/Publications/LID_studies/LID_approaches.htm

Post Construction Controls Model Ordinance – EPA developed this website to assist managers in developing their own ordinances.
www.epa.gov/owow/nps/ordinance/postcons.htm

EPA’s Post-Construction Site Runoff Control Menu of BMPs – Links to 39 fact sheets outlining various structural and non-structural best management practices for post-construction runoff control.
www.epa.gov/npdes/stormwater/menubmps/postconstruction

Puget Sound Online: Low Impact Development – Sponsored by the Puget Sound Action Team Partnership, this web page addresses issues and innovations in low impact development.
www.psat.wa.gov/Programs/LID.htm

EPA’s Smart Growth – Provides information on various smart growth topics and EPA funding sources, and links to other helpful web sites.
www.epa.gov/livability/

Smart Growth Online – Sponsored by the Smart Growth Network, this site is a forum for discussing smart growth BMPs, innovative policies, tools and ideas.
www.smartgrowth.org/sgn/default.asp?res=800
Smart Growth for Clean Water: Helping Communities Address the Water Quality Impacts of Sprawl – This report from the National Association of Local Government Environmental Professionals identifies five smart growth approaches, and profiles several local partnerships that have reaped the economic and environmental benefits of these approaches.

www.nalgep.org/publications/PublicationsDetail.cfm?LinkAdvID=42157

Street Storage for Combined Sewer Surcharge Control – Highlights two case studies in Illinois that reduce the rate of runoff entering combined sewer systems by using street storage and catch basin modifications. October 2000 (EPA-841-B-00-005C).

http://www.lowimpactdevelopment.org/ftp/Street_Storage_Factsheet.pdf

Street Storage System for Control of Combined Sewer Surcharge: Retro fitting Stormwater Storage into Combined Sewer Systems – Describes a case study-based evaluation of street storage technology, highlighting strategies for temporarily storing stormwater on urban surfaces (EPA-600-R-00-065). Also available through NTIS: NTIS NO: PB2000-107451.

www.epa.gov/ednnrmrl/publications/reports/epa600r00065/epa600r00065.pdf

Vegetated Roof Cover: Fact Sheet – Case study in Philadelphia, Pennsylvania on vegetated roofs. The study demonstrates the use of a vegetated roof to reduce runoff, conserve energy and improve community aesthetics. Includes design information and monitoring data (EPA-841-B-00-005D).

www.epa.gov/owow/nps/lid/lidlit.html

Pollution Prevention/Good Housekeeping

National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Contains information on the best available methods to economically reduce urban-generated surface and ground water pollution.

www.epa.gov/owow/nps/urbanmm/index.html

EPA’s Pollution Prevention and Good Housekeeping Menu of BMPs – Links to 13 fact sheets outlining various best management practices for pollution prevention and good housekeeping.

www.epa.gov/npdes/stormwater/menuofbmps/goodhousekeeping

Techniques for Tracking, Evaluating and Reporting the Implementation of Non Point Source Control Measures – Helps federal, state, regional and local environmental professionals track the implementation of BMPs used to control urban non point source pollution.

www.epa.gov/owow/nps/urban2.html

Funding Sources


http://stormwaterfinance.urbancenter.iupui.edu/

Catalog of Federal Funding Sources for Watershed Protection – The Catalog of Federal Funding Sources for Watershed Protection Web site is a searchable database of financial assistance sources (grants, loans, cost-sharing) available to fund a variety of watershed protection projects.

http://cfpub.epa.gov/fedfund/

Grants.gov – Searchable website for all federal grant programs.

http://grants.gov/

State Revolving Fund – State Revolving Fund programs in each state and Puerto Rico are funded by EPA and operated like banks. Assets are used to make low- or no-interest loans.

http://www.epa.gov/owm/cwfinance/cwsrf/index.htm
Artful Stormwater Design
Artful Rainwater Design – Website explains the concepts of artful rainwater design and presents case studies from across the US.
http://www.artfulrainwaterdesign.net/

Conservation Design Forum – Firm based in Chicago (with an office in Ann Arbor, MI) that specializes in integrated water-based ecological designs.
http://wwwCDF.com/

Atelier Dreiseitl- German firm specializing in designing with water- great inspiration!

Stormwater Management Manuals from Great Lakes States
Illinois
Illinois Urban Manual
http://www.il.nrcs.usda.gov/technical/engineer/urban/contents.html

Michigan
BMP Design Manual
http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714-118554--.00.html

Minnesota

New York
New York State Stormwater Management Design Manual
http://www.dec.ny.gov/chemical/29072.html

Ohio
Rainwater and Land Development Manual
http://www.dnr.state.oh.us/tabid/9186/default.aspx

Pennsylvania
http://www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1437&q=529063&watershedmgmtNav=

Wisconsin
Stormwater Manual
http://www.dnr.state.wi.us/RUNOFF/stormwater/publications.htm#uwex

Michigan-specific Resources
City of Ann Arbor Water Resources Stormwater page- Site provides information on Ann Arbor’s stormwater utility and rate structure.
http://www.a2gov.org/government/publicservices/systems_planning/waterresources/Pages/stormwater.aspx

Greater Lansing Regional Committee for Stormwater Management – The Greater Lansing Regional Committee for Stormwater Management (GLRC) is a guiding body comprised of participating Phase II Stormwater communities within the Greater Lansing Region. The committee has been established to guide the implementation of the entire Phase II Stormwater Program for the communities within three identified watersheds: the Grand River, the Red Cedar River and the Looking Glass River watersheds. Site provides links to info on stormwater, model ordinances, and publications.
www.mywatersheds.org

Lawrence Tech Stormwater Research – Site provides information on stormwater research conducted by LTU and also has links to case studies for projects in southeast Michigan.
www.ltu.edu/stormwater
Michigan Association of Counties – MAC offers members educational programs, legislative representation, local workshops, a legislative and summer conference, and produces a MAC newspaper, commissioner directory, and legislative communications to keep members up to date on the latest events that affect county governments.
http://www.micounties.org

Michigan Department of Environmental Quality (MDEQ) – Main site for the MDEQ.
http://www.michigan.gov/deq

MDEQ Stormwater Site – links to MDEQ stormwater regulations, requirements, and guidance.
http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3716---,00.html

Michigan Department of Natural Resources – Main page for MDNR.
http://www.michigan.gov/dnr

Michigan Government – Main Michigan government site with links to all agencies and the legislature.
http://michigan.gov/

Michigan Association of County Drain Commissioners – Site has information regarding the latest standards, technologies and methods for storm water management, water resource protection, drainage, financial management, customer service, and public administration.
http://maedc.net/

Michigan Low Impact Development Manual – Developed by SEMCOG with the assistance and input of agencies and professionals throughout Michigan, the manual includes technical and policy guidance in implementing LID specific to Michigan conditions
http://www.semcog.org/LowImpactDevelopment.aspx

Michigan Municipal League – Provides services, events, and resources targeted to municipalities in Michigan.
http://www.mml.org/home.html

Michigan Townships Association – Provides services, events, and resources targeted to townships in Michigan.
http://www.michigantownships.org/

Millers Creek Watershed site – Site by the Huron River Watershed Council providing information on the restoration of Millers Creek Watershed which drains into the Huron River.
http://wiki.mtri.org/display/milcreek/Millers+Creek+Website

MSU Center for Water Sciences Stormwater Workshop Series – Site provides white papers, webcasts, presentations, and products from the Water Fellows workshop series on stormwater.
http://www.cws.msu.edu/stormwater.htm

MSU Environmental Science and Policy Program (ESPP) – ESPP is an umbrella group for environmental research and education at MSU. The site offers information on environmental sustainability, environmental events at MSU, a “Find an MSU Expert” search, and funding opportunities.
http://www.espp.msu.edu/index.php

MSU Extension – Site provides information on agriculture, community, environment, horticulture and more.
http://www.msue.msu.edu/portal
Rain Gardens of West Michigan - Information on rain gardens, including outreach materials and “how to” guides.
http://www.raingardens.org/Index.php

Southeastern Michigan Council of Governments (SEMCOG) – SEMCOG supports local government planning on regional issues in the areas of transportation, environment, community and economic development, and education. Members include Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne Counties.
http://www.semcog.org/

Washtenaw Water Quality Programs - the Washtenaw County Water Resources Commissioner is responsible for the design, construction, and operation and maintenance of over 500 storm water management and flood control systems (County Drains). The Water Quality Programs page provides information on programs for the community, businesses and homeowners.

Waterways at Risk: How Low-Impact Development Can Reduce Runoff Pollution in Michigan - The Public Research Group in Michigan (PIRGIM), in coordination with American Rivers, released a report documenting the risks that development poses to Michigan’s water quality. The report discussed how LID can mitigate these risks.
Appendix B. Stormwater Resources for the Public

After the Storm- Brochure developed by EPA provides a broad overview of stormwater pollution, including runoff from residential and commercial properties, farms, construction sites, automotive facilities, forestry operations, and others.
http://www.epa.gov/npdes/pubs/after_the_storm.pdf

Clinton River Watershed Council- Stormwater page educates public about issues surrounding stormwater and steps they can take to reduce impacts.

Girl Scout Water Drop Patch- The Girl Scouts and EPA have developed this patch for girl scouts to learn all about watersheds and water pollution and to take action to protect water resources.
http://www.epa.gov/adopt/patch/

GLRC Resources for Educators- links to curriculum, materials in print and online, events, and other information regarding stormwater education.
http://www.mywatersheds.org/for_educators.html

Lincoln Park, MI Stormwater Pollution Prevention Tips- Tips to reduce stormwater pollution, including de-icing in the winter.

Make Your Home the Solution to Stormwater Pollution Brochure - This short EPA brochure is targeted directly to homeowners and provides tips on a wide variety of simple things that homeowner's can do to prevent stormwater pollution.
http://www.epa.gov/npdes/pubs/solution_to_pollution.pdf

North Carolina Stormwater Workbook- Covers stormwater basics, what you can do, and pollution solutions.
http://www.ncstormwater.org/pages/workbook_main.html

Protecting Water Quality from Urban Runoff - This EPA fact sheet explains how urbanized areas affect water quality through increased runoff and pollutant loads and what homeowners can do to prevent stormwater pollution.

Rain Gardens of West Michigan- Learn how to create a rain garden and other information about stormwater
http://www.raingardens.org/Index.php

Stormwater Activities- Games for kids from Kane County, Illinois
http://www.co.kane.il.us/kcstorm/education/kids/activities.asp

Stormwater Management for Homeowners
http://www.soil.ncsu.edu/assist/homeassist/stormwater/

Stormwater Resources for Homeowners (also have resources for officials & real estate pro’s)
http://www.bae.ncsu.edu/topic/resources-stormwater/homeowners.html

Urban Slobber- North Carolina Clean Water Education Partnership’s page for kids. Includes projects and experiments for kids to learn about stormwater.
http://www.nccwep.org/involvement/kids/slobber.php
**Water Efficient Landscaping** - This EPA booklet describes the benefits of water-efficient, low-impact landscaping. It includes examples of successful projects, programs, and contacts
[http://cfpub.epa.gov/npdes/stormwatermonth.cfm](http://cfpub.epa.gov/npdes/stormwatermonth.cfm)

**Where You Live** - Outreach materials, searchable by state. Includes fact sheets, radio ads, and other educational materials.
[http://www.epa.gov/nps/toolbox/whereyoulive.htm](http://www.epa.gov/nps/toolbox/whereyoulive.htm)