A Practical Guide to Implementing Integrated Water Resources Management & the Role of Green Infrastructure

Prepared for:

GREATER LAKES

Reconnecting the Great Lakes Water Cycle

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1.0 INTEGRATED WATER RESOURCES MANAGEMENT – A GUIDE FOR MUNICIPAL USE

This guide was developed to aid municipalities that are considering implementing integrated water resources management (IWRM). It provides a brief summary of the type of information that should be considered, a series of questions that can guide a municipality to a logical position, a recommendation of how best to proceed, and an example of how to implement this guidance, including tools to aid the municipality. Each section also includes a series of links to other notable, related articles/tools. IWRM can provide sustainable practices that address water resource challenges in a comprehensive manner. Because water management is impacted by many entities, changes are likely to be slow and incremental.

This guide is divided into eight sections listed below:

Section 1 – Integrated Water Resources Management – A Guide for Municipal Use
Section 2 – Establish Municipality Specific Priorities
Section 3 - Assemble Available Information
Section 4 - Providing Cost-Effective Drinking Water Systems
Section 5 - Providing Cost-Effective Wastewater Management
Section 6 - Providing Cost-Effective Drainage Systems
Section 7 – Identifying & Prioritizing Project Lists
Section 8 - Identifying Funding Needs & Opportunities
Section 9 - A Practical Path Forward - Aggregating Projects for Large-Scale Implementation

This guide addresses the hydrologic cycle as it affects municipalities - water supply and distribution; wastewater collection and treatment; and stormwater management. However, special emphasis is given to stormwater management and the use of green infrastructure. While water supply and wastewater treatment are highly regulated with specific performance standards, stormwater remains less regulated – even though it has tremendous impact on the hydrologic cycle and water and wastewater management. Effective integrated water resources management requires efficient and powerful stormwater management that encourages infiltration, reduces peak flows, and scales down total runoff volumes. Appropriately designed, constructed, and maintained green infrastructure is capable of delivering these results.

Preparing a successful integrated management plan can be a staged, multi-step process targeting the root causes of water management challenges, presents options for best management practices, and provides a cost benefit analysis to guide the decision-making process. The plan must address the unique challenges of each municipality. It should also provide a cost-efficient method of retrofitting aging infrastructure in a resilient, sustainable way – all within restricted operating budgets. An integrated management approach simultaneously manages drinking water, wastewater treatment, and stormwater and offers a cost-effective, alternative solution to address expensive infrastructure improvement costs.

A municipality interested in addressing their challenges in an integrated manner should begin by considering the following tasks, which are described in more detail in Section 9.

1) IDENTIFYING THE EXISTING CONDITION – The integrated water resources plan should be customized to address the most pressing issues. An assessment of the current condition should be made. All entities responsible for drinking water sources, drinking water treatment, drinking water delivery, stormwater collection, wastewater collection, and wastewater treatment should be included. This initial planning group can identify the largest outstanding challenges including water availability, water quality, flooding, droughts, failing infrastructure, or the need for additional capacity and predicted problems or threats.
2) DATA COLLECTION - Integrated water resources management requires information to be viewed through a slightly different lens that focuses on how municipal assets affect the water resources on which they depend.
3) WATER BUDGET - A very basic water budget should be computed to simply identify where water is extracted from the natural environment and where it is returned. The location and quality of the water returning to the natural environment should be assessed. This simple overview helps provide an initial overview of where the system is challenged and where changes in approaches can yield the largest benefit.
4) PRIORITIZE POTENTIAL PROJECTS - A list of projects and/or practices that focuses on water conservation, stormwater/wastewater reduction, source water protection, and operational efficiency should be compiled. The collection of projects should focus on strategies that improve the management of water infrastructure and include wastewater treatment facilities, storm and sanitary sewer systems, stormwater detention facilities, and drinking water production and distribution utilities. They should be evaluated and prioritized based on their capacity to improve operational efficiency and capacity, reduce water demand, reduce wastewater, and lessen stormwater runoff.
5) ECONOMIC & SUSTAINABLE ANALYSIS - The financial benefits should be clearly quantified, but the larger environmental benefits also should be listed. These benefits should drive the prioritization of proposed projects. The economic value should be assessed to provide a standard cost benefit analysis. These projects/practices should be coupled with the sustainability benefits.
6) IMPLEMENTING THE STRATEGY - Select appropriate projects/practices with an understanding of the long- and short-term implementation costs.

Many municipalities have embraced IWRM, but they also recognize there are a plethora of regulatory and institutional constraints that impede a rapid deployment. Equally important is the fact that practices in one department – e.g., drainage - impact the services provided in other departments – e.g., drinking water supply – yet, funding constraints often preclude sharing resources that could benefit both. The goal of IWRM is to assist and coordinate the decision making and management to provide a sustainable supply and use across all water-related services at the least cost.

1.1 INTEGRATED WATER RESOURCES MANAGEMENT

IWRM has been defined by the Global Water Partnership (GWP) as "*a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*." (http://www.gwp.org/en/ToolBox/ABOUT/IWRM-Plans)

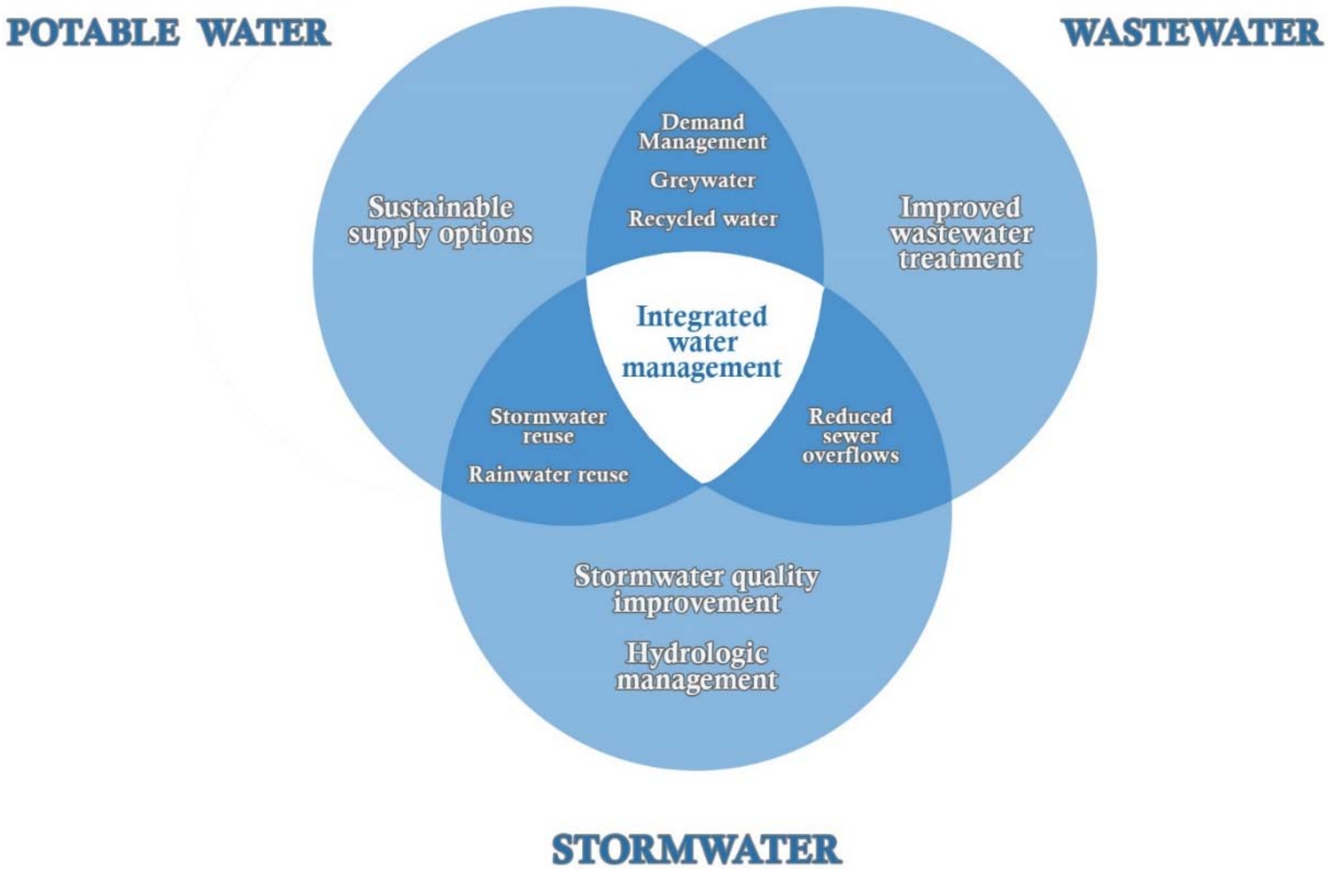
Initially, IWRM was used to better manage scarce water resources in developing countries. IWRM programs were designed to assure that planning, design and resulting projects would have sufficient water to provide minimum water-use impact to either the upstream or the downstream communities. While the challenges facing Great Lakes communities are significantly different, the principles of IWRM are applicable to all communities. Unlike much of the world, the Great Lakes region is fortunate to have a massive water supply. This abundance has masked some practices that are shortsighted and should be revisited. Past practices have led to drinking water supply shortages, pollution concerns, and extensive and imposing costs to address these challenges. IWRM provides a sustainable solution to the challenges facing Great Lakes communities.

Drinking water is one of the most critical aspects of water resources management. Citizens demand plentiful, clean water and municipalities are expected to deliver it. Appropriate management of this critical resource can be summarized as: 1) use it sparingly, 2) minimize waste, 3) provide it economically, and 4) provide it sustainably. Drinking water is typically offered by a single entity. This often allows a more expeditious implementation of efficient and effective modifications to the infrastructure.

Municipal officials can protect and conserve the water source while minimizing water loss through many existing programs. Similarly, they can minimize and/or delay the need for new infrastructure by curtailing water use at the consumer level, especially during peak demand times. This project utilizes a tracking tool developed by the Alliance for Water Efficiency (AWE) to evaluate water conservation and compare the costs and benefits of efficiency programs. The AWE is a project partner, and can be found online at www.allianceforwaterefficiency.org. For details on this tool see the Greater Lakes Project companion product entitled "Improving Water Conservation & Efficiency in Six Great Lakes Communities" at http://glc.org/files/projects/greaterlakes/AWE-FinalReport-April-2016.pdf.

Citizens expect their governments to prevent flooding and protect the public health in both surface water and groundwater. However, stormwater/wastewater/groundwater management programs are, unfortunately, typically more disjointed, and outdated habits conflict with what would now be considered as current best practices. The practices – and the regulations that drove them – were developed during simpler times and usually addressed single issues with little consideration to long-term impacts and/or correlating issues. We've found that this mindset of solving one issue at a time is exacerbating flooding, reducing groundwater recharge, and threatens drinking water supply sources.

Figure 1-1: IWRM is a nexus of best practices related to potable water, wastewater, and stormwater



1.2 IMPLEMENTATION

Water efficiency is becoming commonplace as municipal leaders recognize the cost-effectiveness of these programs. Green infrastructure has been slow in becoming mainstream. It is welcomed by urban planners and city visionaries; however, some public works professionals remain hesitant because they can be risk adverse and remain, rightfully, concerned about the health and safety of their residents. Thus, *inherent in this guide is the belief that green infrastructure is first and foremost infrastructure.* It must protect human health and safety by protecting drinking water sources, minimize flooding, lower the cost of wastewater and stormwater management, all while enhancing the quality of life for the citizens of the community.

2.0 ESTABLISH MUNICIPALITY-SPECIFIC PRIORITIES

The water resources-related priorities of each municipality are different, and are typically driven by the age of the infrastructure and the impact of that aging infrastructure.

Public health is always the primary concern for public officials, and drinking water infrastructure remains the number one priority. To maintain an excellent drinking water treatment/distribution system, a continual investment must be made to repair leaks and replace old piping, especially as newer, safer materials are made more affordable. Original water pipes were made from inappropriate materials, e.g., lead, which we now know is harmful to human health.

Source water availability is also a concern. If water supplies are impaired or the supply becomes scarce, other infrastructure systems, such as stormwater management, can dramatically impact these supplies both positively and negatively. Thus, it is imperative to have extensive knowledge of the working relationship between all the entities in the Great Lakes that manage water-related infrastructure, even if those entities vary between the public and private sectors.

2.1 ESTABLISH A STEERING COMMITTEE

If a municipality wishes to implement IWRM, the first step is to establish a technical steering committee to guide the municipality though the planning, prioritization, and implementation phases of the project. The committee should be made up of public works professionals responsible for operating and maintaining existing infrastructure. It is not uncommon that these individuals rarely interact and are very busy managing their narrow scope of services. However, these same individuals need to be aware of how their efforts impact the work of other public works professionals. For this reason, their buy-in is critical. This steering committee should be augmented with individuals responsible for public finance as well as advocates and/or the non-governmental organization (NGO) community to help facilitate the political and financial changes needed to implement the ultimate program.

This steering committee will be tasked with assembling a priority list of potential projects/actions. This will be more difficult than it sounds as members view their own drivers – permit compliance, budget, and public perception – as being most important and want it ranked highest on the list. However difficult, this group is best suited to complete this exercise. Management can review and modify the list with the intent of assuring the priorities are consistent with protecting public health, ensuring a long-term water supply, and protecting the environment.

This type of prioritization was not practiced for many years. As a result, infrastructure investment was often prioritized as a reaction to regulatory compliance. Financially-strapped communities invested massive amounts of funds to address permit-required “rare events” (e.g., combined sewer overflows) while other critical infrastructure (e.g., drinking water) deteriorated. The U.S. Environmental Protection Agency (EPA) recognized this challenge and issued the “Integrated Stormwater Wastewater Planning Approach” policy on June 5, 2012.

"Integrated planning can facilitate the use of sustainable and comprehensive solutions, including green infrastructure, that protect human health, improve water quality, manage stormwater as a resource, and support other economic benefits and quality of life attributes that enhance the vitality of communities." (Integrated Municipal Stormwater and Wastewater Planning Approach Framework – June 5, 2012)

Regulators encouraged communities to initiate integrated planning that allows municipalities without the financial means to delay compliance-related public works investments in favor of other, more critical, failing infrastructure, such as clean drinking water. The EPA understood that communities could only build/maintain what they could afford, and this shift allowed communities to use what funds they had to address their most critical infrastructure challenges without fear of repercussions. Yet, only a handful have chosen to initiate the new approach with many favoring practices established in the 1950s and earlier.

To change the culture of an organization, one must first seek advice from those closest to the operation. If they do not (eventually) embrace the change, it will not occur. The discussion must begin with officials across the various public works departments that manage portions of the water infrastructure. Once these key players are engaged, the discussion must include a larger group of stakeholders – including elected officials and the public. The larger discussion would be wide ranging and would likely require the group to:

1. Assemble known existing infrastructure needs, future development plans, and identify the infrastructure shortcomings anticipated
2. Capture the "institutional memory" (unwritten historic information, data, and practices) of municipal officials and stakeholders
3. Facilitate a discussion between public works officials, elected officials, and stakeholders
4. Investigate the constraints precluding "horizontal, integrated delivery of services" including:
    - Regulatory constraints
    - Financing constraints
    - Administrative challenges
5. Establish a list of needed water resources-related improvements and work with all stakeholders to establish priorities
6. Create a vison of new ways to manage water
    - Providing cost-effective, efficient drinking water systems
    - Value and costs of green infrastructure when improving drainage
    - Prioritizing the challenges in your community
    - Selecting design drivers for your community
    - Identifying and prioritizing the list of potential projects
        - Maximizing benefit
        - Minimizing cost
7. Re-evaluate administrative responsibilities for integrated water management

8. Rank long-term and short-term opportunities for evaluation by public works officials, elected officials, and stakeholders
9. Specify actions, roles and budgets
   - Detail roles and responsibilities
   - Develop technical designs, budgets, and timeframes
   - Identify funding needs and opportunities
   - Monitor progress and revisit long-term opportunities
10. Construct required practices
    - Aggregate projects for large-scale implementation
    - Finance large-scale implementation
11. Provide the technical support and capacity needed to allow elected officials and stakeholders to understand and accept a new path forward
12. Align these “givens” and assess the community’s financial ability, technical skill set, and institutional capacity to implement a new path forward
13. Communicate across the municipality the benefits (including financial benefits) provided by IWRM

This list of tasks is ambitious and is unlikely to all happen initially. However, once a culture of change is embraced, many of these tasks become easier because the need is obvious and the benefit is great.

2.2 PRIORITIZE THE CHALLENGES

Before implementing an IWRM, it must be clear what problem(s) is being solved. The most pressing challenge varies from community to community as some experience recurring flooding while others have water supply (quantity) issues and others have water quality issues in both groundwater and surface water. On top of these concerns are the ever increasing regulations designed to protect water sources and preserve water quality for future generations. Many, if not most, of these regulations have placed additional responsibilities, including financial, on communities. Communities seek to comply with these regulations in a manner that is both cost-effective and improves the quality of life for their residents.

Communities can begin by asking the following questions:

Is our drinking water source sufficient?

- What is the source of my drinking water?
- Is the source adequate for the foreseeable future?
- Is the quality and quantity sufficient for current use?
- Is my community experiencing problems associated with peak demand?
- Do I expect a significant investment in new water supply infrastructure?

Is our drainage system sufficient?

- Does my community experience surface flooding?
- Does my community experience basement flooding?
- Does my community experience combined sewer overflows?

- Does my community experience sanitary sewer overflows?
- Does my community experience environmental challenges associated with drainage?
- Do I expect a significant investment in drainage infrastructure?

Once a community answers the large-scale questions, most will fall into one or more of the following large groups: 1) communities that should increase groundwater infiltration, 2) communities that need to reduce peak stormwater discharges, 3) communities that need to reduce the volume of stormwater/groundwater entering the sanitary sewer system, and 4) communities that need to clean stormwater before discharging it to the surface or groundwater.

3.0 ASSEMBLE AVAILABLE INFORMATION

To support a comprehensive water resources management plan, all available information must be collected on the existing infrastructure that withdraws, treats, and distributes drinking water, as well as collects, treats, and discharges wastewater for the community. Most public utilities have a comprehensive list of the equipment for which they are responsible. Many have gone so far as to initiate an asset management plan allowing them to set priorities on what infrastructure will need to be repaired/replaced in the future. Beyond publicly-owned infrastructure, the information collection phase should also collect general information about the privately-held infrastructure, such as house connections and pipes, and the relative age of that infrastructure. Typically, over 50 percent of the in-place infrastructure in a municipality, is under private control. Because of this, the condition of the private infrastructure strongly influences the quantity and quality of clean water delivered and dirty water removed.

A typical service provider has a long-term construction plan, often in the form of a capital improvement program (CIP) financed from bond proceeds. These same entities will have an ongoing repair and replacement program, often financed from operations. Together, these programs provide a proposed construction program, a schedule for that construction, and a means for financing that construction.

Beyond water infrastructure, information on other public infrastructure expenditures needs to be collected as well. Of particular importance is federal, state/provincial, and local, road programs. Roads comprise the largest publically-owned stormwater management collection system and must be incorporated into an IWRM plan. Equally important, water-related repair and replacement can be provided more cost efficiently if coordinated with road repairs.

Once the proposed construction programs are collected from the water supplier, the sewage treatment provider, and the drainage provider, they can be combined into one plan, which will reduce overall construction costs and minimize public disruption.

4.0 PROVIDING COST-EFFECTIVE DRINKING WATER SOURCES

There is no more important role of public works professionals than providing safe, reliable drinking water. Until recently, this was almost taken for granted by residents in the Great Lakes basin. Then, events in Walkerton, Ontario, Toledo, Ohio, and Flint, Michigan, gained international attention and led people to question the safety and quality of their own drinking water. Safe, reliable, and quality drinking water requires ongoing and regular investment to monitor and replace/update aging infrastructure. Most importantly, it relies on an ample water supply. These two characteristics affect the required treatment as well as the importance of appropriate water management practices.

Water Supply – If a municipality is fortunate enough to have access to the Great Lakes, they have access to a tremendous volume of fresh water typically of very high quality. These operators are somewhat insulated from the challenges caused by excessive withdrawals and contaminated runoff, although the Toledo water crisis was the result of run-off to Lake Erie. The vast volume of the Great Lakes masks most of these problems. Municipalities that rely on river or groundwater sources are far more vulnerable to the adverse impacts of poorly-managed stormwater and wastewater and outdated practices.

Limitations on water quantity - River withdrawals are challenged when traditional development occurs upstream. This type of development often leads to much higher peak flows and lower low flows. These low flows can limit the available capacity for the downstream water supplier. Equally challenging is the impact of the upstream urban runoff on the water quality, which can also create conflicts in terms of needs of habitat, wildlife, and human use.

Groundwater sources are the most vulnerable to excessive withdrawals. Because groundwater recharge is a slow process, groundwater tables can continue to lower over many years before they reach a critical stage. However, they also will take many, many years to recover once the damage is done.

While the connection between wastewater and stormwater is often not obvious to local officials, sustainability requires that groundwater recharge be maximized to support groundwater and river low flows, peak discharge rates be moderated to minimize urban wash off and erosion, and the quality of urban stormwater and wastewater discharge be sufficiently high quality to not impact the treatment efficiency of the water supplier.

Every water supplier has a source water protection plan. These operators need encouragement to work with the wastewater and drainage entities that impact their supply, as well as updated education and training to incorporate sustainable-use practices that boost groundwater recharge.

5.0 PROVIDING COST-EFFECTIVE WASTEWATER MANAGEMENT

One of the largest challenges in operating a compliant, efficient wastewater treatment facility is to keep stormwater out of the collection system. Wastewater treatment facilities operate most efficiently and effectively when the influent flows are moderated. Excessive stormwater entering the sewage flow causes tremendous variations in flow volume and quality leading to operational issues and sewage overflows. Combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) are caused when excess flows enter the collection system and utility managers are forced to decide between discharging sewage to the rivers or allowing that water to back up into basements and/or streets. This tough decision is very common in older, poorly-maintained systems.

Modern wastewater collection systems are designed to keep stormwater out. This has not always been the case. Combined sewer systems were not originally designed as such – they are, instead, a relic of historic urban growth. The oldest urban areas simply diverted sewage from households into the creeks and rivers that drained the cities as a means of making the sewage “go away.” Even with regular flushing caused by rain events, these waterways became most unpleasant. To eliminate the stench, they were enclosed and transported “downstream” of the urban population. Ultimately, wastewater treatment plants were required to treat this combined flow, but these were sized to the high end of “normal flow” with no intention of treating the entire peak flow. From a practical point of view, even if the wastewater treatment capacity was sufficient, there is little chance of “ramping up” the treatment operation in time to accommodate this highly variable flow rate.

Even older, “separate” sewer systems have these large flow variations. Some are affected by old design standards that allowed footing drains and roof drains to be directly connected to the sewage system. However, a larger portion of the problem is caused by old, poorly-maintained collection systems that simply leak. This allows a preferred drainage path for pooling stormwater resulting in large increases in flow within the pipes.

Eliminating CSOs and SSOs utilizing only gray infrastructure solutions is extremely expensive. As the pollution from large, infrequent storms is controlled, the cost of capture is very, very high – all for eliminating a very infrequent event.

The least-cost means of reducing these costs – both regulatory and operational – is to find low-cost ways of removing stormwater. In most cases, green infrastructure can accomplish this. If that excess stormwater can be captured on site, stored for a brief period, and ultimately infiltrated into the ground, then the cost of wastewater treatment is reduced, the compliance cost of addressing overflows can be eliminated, the groundwater recharge is increased, the nearby river low flows are augmented, and the hydrologic cycle is repaired.

The application of green infrastructure techniques is becoming more common, even within compliance agreements. This suggests that regulators and public works staff alike have recognized that green infrastructure can reduce sewage treatment costs. Implementing these changes takes various forms. In some municipalities, the stormwater fee structure encourages private landowners to implement green infrastructure to avoid excessive stormwater fees. In other municipalities, post-construction stormwater requirements drive a substantial reduction in offsite stormwater runoff.

Regardless of the driver, removing stormwater improves the municipal compliance record, lowers the operational costs, and improves the local water quality. It also increases the groundwater quantity and quality while augmenting critical low flows in rivers and streams.

All of the green infrastructure techniques discussed in the following section are effective; some more so than others. Each application is very site-specific, but each makes an incremental improvement. What becomes increasingly clear, however, is that the wastewater entity can be strongly impacted by the drainage entity though often these entities fail to interact. It is clear that a cooperative IWRM program would benefit both.

6.0 PROVIDING COST-EFFECTIVE DRAINAGE SYSTEMS

The sustainability of our water supply requires that the amount of water infiltrated increases. The installation of green Infrastructure is a practical way to accomplish this goal. A great deal of work has been performed to document the cost-effectiveness of green infrastructure. The following sections summarizes some of the most respected work. When applied appropriately, green infrastructure can provide least cost, sustainable solutions to the public works challenges facing most communities.

6.1 VALUE OF GREEN INFRASTRUCTURE

Early reports produced by national groups, including the U.S. Environmental Protection Agency's (EPA) *Reducing Stormwater Cost through Low Impact Development (LID) Strategies and Practices (EPA, 2007),* suggested that green infrastructure was less costly in nearly all situations. Subsequent works by municipalities and the EPA have concluded that the most resilient solution with the least cost is a combination of gray infrastructure augmented by green infrastructure (*Odefey, 2012*). Some notable work products on this topic include (see bibliography for complete citation):

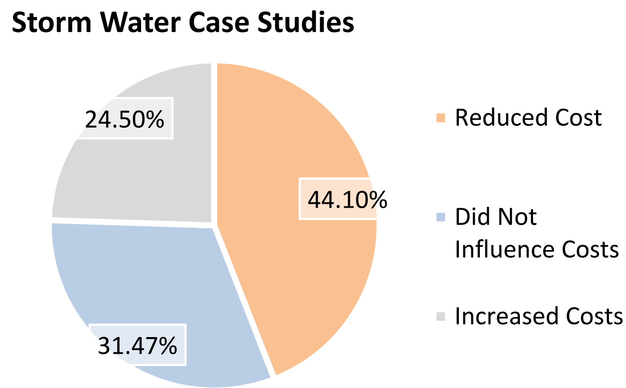
- Banking on Green, 2012.
- Northeast Ohio Regional Sewer District Green Infrastructure Plan, 2012.
- The Value of Green Infrastructure, 2010.
- Milwaukee Metropolitan Sewer District Regional Green Infrastructure Plan, 2013.
- A Business Model Framework for Market - Based Private Financing of Green Infrastructure, 2014.

The EPA recently initiated (but never concluded) a national rulemaking to establish a comprehensive program to reduce stormwater runoff from new development and re-development projects, and made other improvements to strengthen its stormwater program. As a part of this rule-making process, the EPA evaluated sustainable green infrastructure design techniques that mimic natural processes to evapo-transpire, infiltrate and recharge, and harvest and reuse stormwater. As a part of this evaluation, the EPA asked the American Society of Landscape Architects (ASLA) to collect case studies on projects that successfully and sustainably manage stormwater. ASLA members responded with 479 case studies from 43 states, the District of Columbia, and Canada. The table below represents a compilation of projects in the Great Lakes states where an analysis of green versus gray infrastructure cost comparisons were carried out. It shows that, in many cases, installing green infrastructure can result in significant savings.

Table 6-1: A comparison of green infrastructure cost savings (ASLA 2015)

State	Project type	Green or Gray infrastructure cost-effective?	Cost savings
Wisconsin	Bioretention, green roof, bioswales, permeable pavers	Gray	None, slightly more expensive overall, excellent infiltration
Ohio	Bioretention, green roof, bioswales, permeable pavers, CSO avoidance and compliance instrument	Green	Over 50% reduction in cost
Ohio	Bioretention, green roof, bioswales, permeable pavers, CSO avoidance and compliance instrument	Green	20% of gray costs
Minnesota	Bioretention, green roof, bioswales, permeable pavers	Gray	Slightly increased costs
Minnesota	Bioretention, green roof, bioswales, permeable pavers	Green	Construction and site development restrictions made green infrastructure the only option.
Minnesota	Bioretention, green roof, bioswales, permeable pavers	Gray	Green costs were 9% higher than gray
Minnesota	Bioretention, green roof, bioswales, permeable pavers	Green	Green infrastructure saved a great deal off stormwater fees.
Minnesota	Pervious pavement and other treatment options	Gray	Green pavement 40% more expensive
Illinois	Bioretention, green roof, bioswales, permeable pavers	Green	Lower overall life cycle costs
Illinois	Pervious pavers	Green	Green significantly cheaper thanks to avoided infrastructure installations
Indiana	Rain Gardens, Porous Pavers, Curb Cuts	Green	Slightly reduced costs
Indiana	Biorentention facility and bioswales	Green	Green capital costs higher, long term costs less so there is a payoff period
Indiana	Rain Gardens, Porous Pavers, Curb Cuts	Green	10% cost savings over installing gray infrastructure
Indiana	Bioretention, green roof, bioswales, permeable pavers, CSO avoidance and compliance instrument	Green	Lower overall cost
Indiana	Biorentention facility and bioswales	Green	Savings in maintenance and site redevelopment

Figure 6-1: Answer to question "How did use of Green Infrastructure impact costs" in a survey of 465 case studies from across the country (ASLA 2015) *The complete list of projects evaluated for the ASLA report can be found at http://www.asla.org/stormwatercasestudies.aspx*

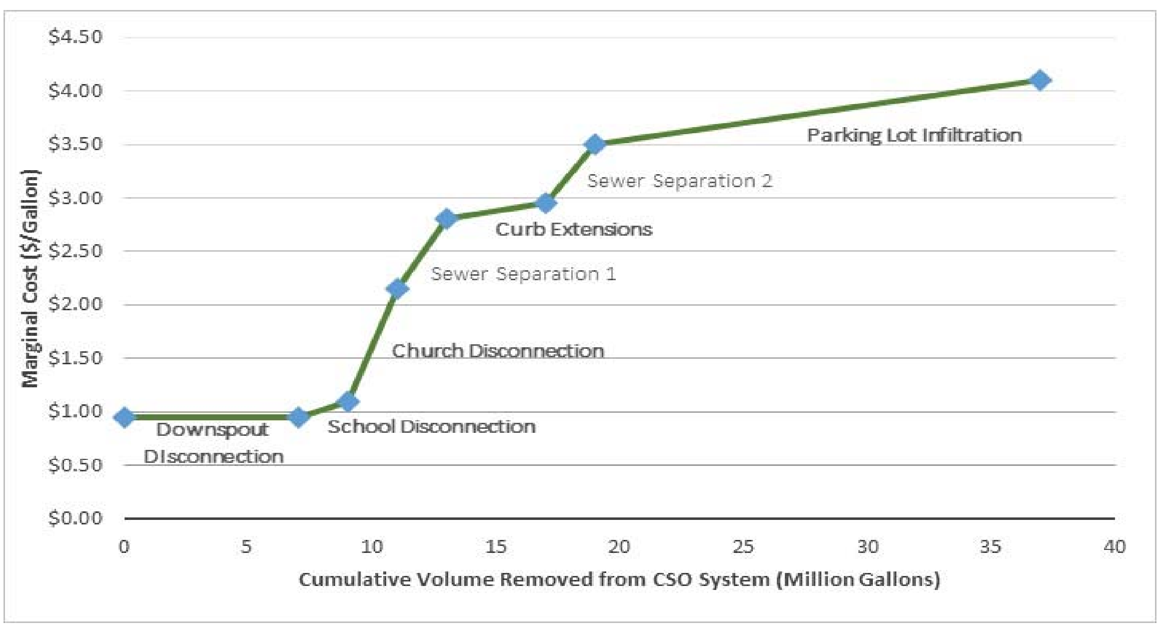


6.2 UNDERSTAND THE COST OF GREEN INFRASTRUCTURE

The public works community has assembled summaries of realistic cost estimates for green infrastructure *(e.g., Northeast Ohio Regional Sewer District, 2012).* These costs allow comparisons using cost-per-gallon captured or cost-per-linear foot of road to easily compare green and gray solutions. Using this combined data set, a municipality can integrate green and gray approaches to prioritize projects using the marginal cost-per-gallon removed as a metric.

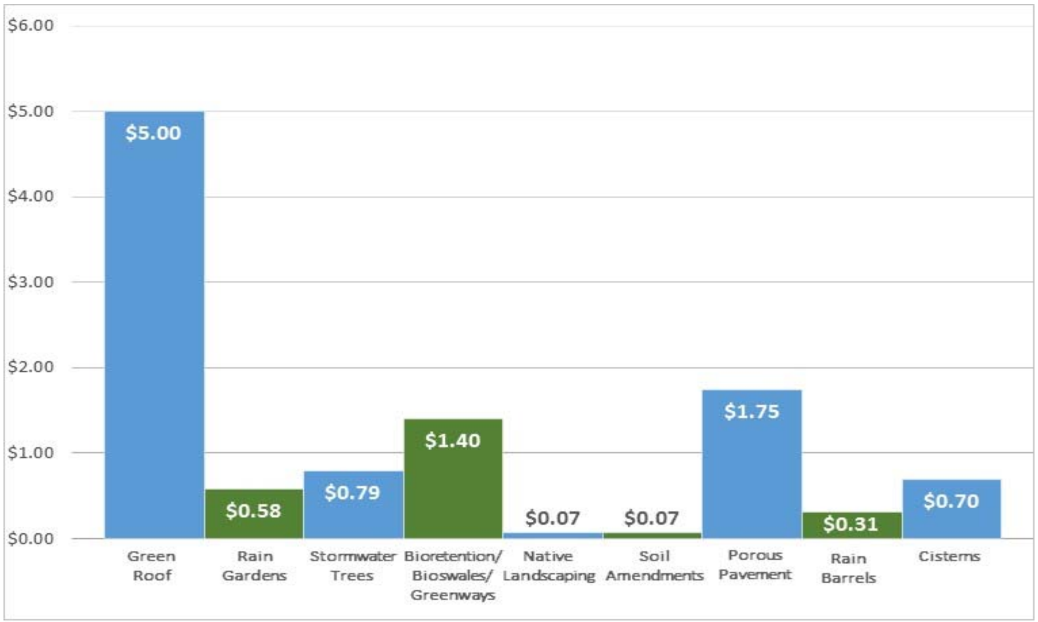
> *"The City of Portland, Oregon, integrated green and (gray) approaches to stormwater to demonstrate that downspout disconnections, curb extensions that include vegetated swales, and parking lot infiltration were among the most cost-effective options for meeting CSO abatement goals. The costs for these approaches ranged from $0.89 to $4.08 per gallon removed." (Odefey, 2012) (See Figure 6-2)*

Figure 6-2: City of Portland Costs and Cumulative Volume of Stormwater Removed from the CSO System through Various Gray and Green Strategies (Green in Bold). *(Odefey, 2012)*



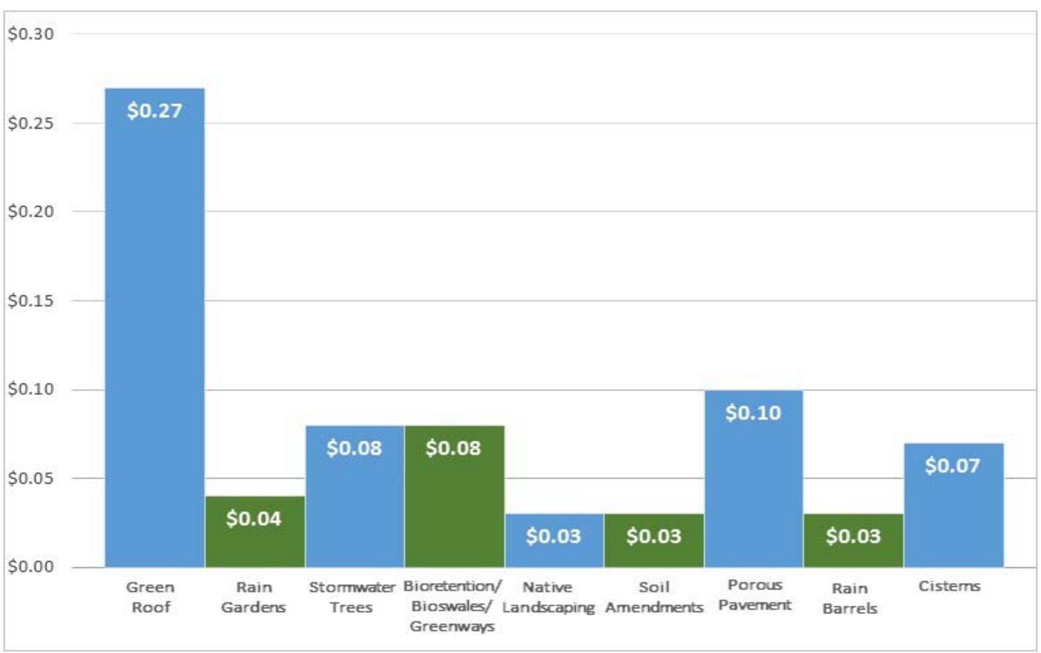
Additional estimates of green infrastructure costs from Milwaukee Metropolitan Sewerage District's (MMSD) Regional Green Infrastructure Plan are presented in Figures 6-2, 6-3 and Table 6-2.

Figure 6-3: Incremental Cost per Square Foot Managed *(Milwaukee Metropolitan Sewerage District, 2013)*



Note: The green infrastructure strategies supporting green alleys, streets, and parking lots are included in other strategies. The wetlands Green Infrastructure Strategy is encouraged but not quantified in the plan.

Figure 6-4: Incremental Cost per Annual Gallon Captured *(Milwaukee Metropolitan Sewerage District, 2013)*



Note: The green infrastructure strategies supporting green alleys, streets, and parking lots are included in other strategies. The wetlands Green Infrastructure Strategy is encouraged but not quantified in the plan.

Table 6-2: Stand-alone Costs (per green infrastructure SF and per SF managed) and the Relationship to Incremental Costs (*Milwaukee Metropolitan Sewerage District, 2013)*

Green Infrastructure Strategy	Stand-alone Cost ($/SF)	Loading Ratio (Ratio of Area Managed to Area of GI)	Stand-alone Cost ($/SF Managed)	Incremental GI Cost Compared to Stand-alone Cost	Description of Cost Assumption
Green Roofs[1]	$11.50	1.0	$11.50	43%	Median PWD cost ($11.50/SF)
Rain Gardens	$10.00	12.0	$0.83	70%	Middle of FCGS range rounded up to $10/SF
Stormwater Trees[2]	$0.80	0.5	$1.58	50%	FCGS cost
Bioretention/Bioswale	$24.00	12.0	$2.00	70%	Average between PWD[3] and SUSTAIN[4] demonstration project
Native Landscaping/Soil Amendments	$0.11	1.0	$0.11	60%	Middle of FCGS[5] range, rounded up to nearest $1,000
Porous Pavement	$10.00	4.0	$2.50	70%	$10/SF, approximately 90 percent of median PWD costs
44-gallon Rain Barrels[6]	$120 (each)	N/A	$0.34	90%	Middle of FCGS range rounded up to nearest $10
1,000-gallon Cisterns[7]	$5,000 (each)	N/A	$0.78	90%	$5/gal., middle of FCGS range for 1,000-gal cistern

[1]Incremental cost of green roofs set to 43 percent to match MMSD's $5/SF ($217,800/acre) green roof incentive program.
[2]Trees are assumed to have an average 10-foot canopy radius (314 SF), with 50 percent assumed to be overhanging impervious area.
[3]PWD is Philadelphia Water Department.
[4]SUSTAIN is from (MMSD 2011) Determining the Potential of Green Infrastructure to Reduce Overflows in Milwaukee.
[5]FCGS is "Fresh Coast Green Solutions" (MMSD 2009).
[6]Each rain barrel is assumed to manage 350 SF of rooftop; therefore, 124.5 barrels are required for 1 acre of roof.
[7]Each 1,000-gallon cistern is assumed to manage 6,500 SF of impervious area; therefore, 6.7 cisterns are required for 1 acre.

6.3 SELECT DESIGN DRIVERS

Before initiating a green infrastructure program (as part of an IWRM implementation), a municipality must assure they are spending their limited financial resources to address the most critical problems. Once a municipality determines what physical challenges they are attempting to overcome, they should review the regulatory requirements coupled with the demands of the public they serve. This can begin by considering the following questions.

- Are there regulatory requirements for:
  - Water supply?
  - Water distribution?
  - Sewage collection?
  - Sewage treatment?
  - Sewage overflows?
  - Stormwater quantity/quality?
  - What environmental challenges is the municipality facing?
  - Flooding?
  - Basement flooding?
  - Groundwater depletion?
  - Degraded groundwater?

- Sewage overflows?
- Degraded surface water?
  - Flashiness?
  - Dissolved oxygen issues?
  - Bacterial issues?
  - Low flow issues?
  - Chemical pollution?

Each green infrastructure practice has specific attributes that make them more applicable for addressing individual challenges. Appendix A provides a list of commonly utilized green infrastructure practices segregated into the broad categories of the challenges that the municipalities have established as critical.

6.4 PRIORITIZE GREEN INFRASTRUCTURE PROJECTS

Once a community commits to considering green infrastructure, it must match the appropriate green solution to a site-specific problem. Public works officials are practiced in selecting and designing traditional drainage solutions and can evaluate the cost and size requirements for each proposed green infrastructure solution. Once the appropriate solution is identified, the municipal official can commit the resources needed to proceed with final design and preparation of plans and specifications.

Prioritizing projects from an integrated water resource management point of view can be done by using some or all of the following variables (not an exhaustive list):

- Return on investment
- Actionable: short-term versus long-term
- Ease of implementation
- Long-term maintenance
- Impact on achieving overall socio-economic-environmental goals

The actual selection of the prioritization procedure varies between communities. Once the final ranking of the drainage program is completed, the ranked projects should be shared with the larger IWRM Steering Committee and the community to garner input on additional expected benefits, as well as potential construction savings if projects were coupled with public works projects anticipated in other areas.

As part of this project, the Greater Lakes Green Infrastructure Optimization Tool was developed to generate stormwater runoff volumes, identify the areas needed to manage those volumes and then compare the costs of various green management practices to manage the predicted volume. The results allows the user to make informed decisions, including cost comparisons (with traditional detention basin systems) when making stormwater management decisions. Go to http://glc.org/projects/water-resources/greater-lakes/greater-lakes-storm-water-calculator/.

A summary of the most readily available Green Infrastructure calculators is included at (http://www.uni-groupusa.org/calculators.html) including the U.S. Environmental Protection Agency, Center for Neighborhood Technologies, Sustainable Technologies Evaluation Program and the Water Environment Research Foundation as well as state, regional or municipal calculators and programs by educational institutions Others include the National Green Values™ Calculator (http://greenvalues.cnt.org/) which was developed to demonstrate the ecological and economic gains that result from implementing green infrastructure practices. The Minimal Impact Design Standards (MIDS) best management practice (BMP) calculator (http://bit.ly/GreenInfrastructureOptimizationTool) is a tool used to determine stormwater runoff volume and pollutant reduction capabilities of various green infrastructure BMPs.

Beyond the dollars and cents portion of the decision-making process, a discussion of how to consider green space and quality of life should be included among the larger stakeholder group.

Green infrastructure has other benefits beyond water quality and quantity, but these benefits are often much more difficult to identify and measure. Understanding the individual psychological, physical, and spiritual health benefits of having native plants, pollinators, and green space and how these benefits scale up for larger communities provides a more complete assessment of the benefits of green infrastructure. Incorporating some of these less-tangible benefits into the early stages of green infrastructure planning can help put some of the capital construction costs into context. Distance metrics, such as walking, biking, or foraging distance, or landcover metrics, such as percentage or acres with native plants, percentage or acres with wooded areas, percentage or acres of green space, etc., can be used to determine priority locations for green infrastructure. These metrics are easily measurable proxies of the real-world benefits that are very difficult to measure. When integrated early in the planning process, these proxies can help guide site selection and build support for green infrastructure beyond water quality and quantity benefits.

A summary of example metrics is provided in the article entitled, Health Benefits of Urban Vegetation and Green Space" (http://journalistsresource.org/studies/environment/cities/health-benefits-urban-green-space-research-roundup).

7.0 IDENTIFYING & PRIORITIZING PROJECT LISTS

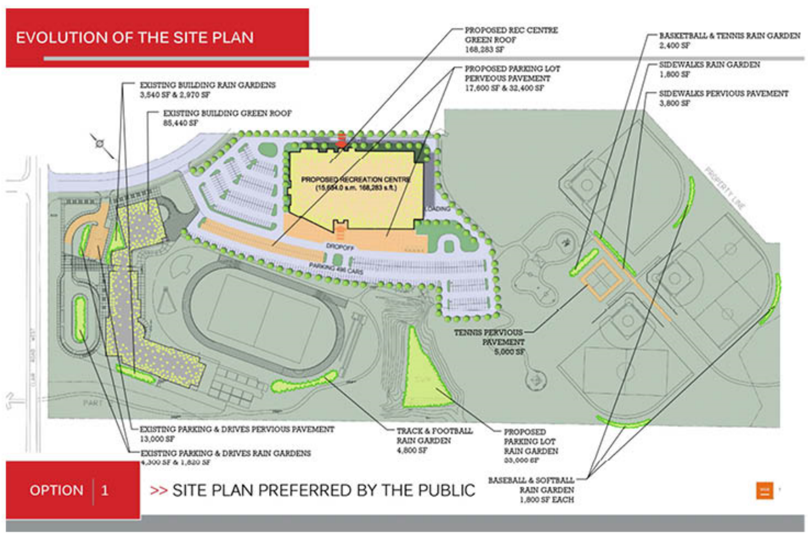
7.1 MAXIMIZE BENEFIT

Using the drivers as a method of prioritizing management practices, the list of potential projects should also be reordered to ensure that the initial projects return the largest benefit in terms of volume infiltrated, peak flow reduction, or pollutant reduced, depending on the community's most urgent issue. It is best if this prioritization is performed without regards to cost to assure public works officials that the targeted reductions can be achieved if sufficient green infrastructure is put in place.

Water Supply Challenges for the City of Guelph, Ontario

The City of Guelph is grappling with decreasing groundwater levels, which supplies drinking water to the municipality. The challenge is exacerbated because development has increased raising the overall amount of paved surface, which, in turn, has escalated the amount of stormwater runoff produced leading to a corresponding reduction in groundwater.

To encourage long-term recovery of the groundwater sources, the City of Guelph is encouraging green infrastructure as an effective means of managing stormwater.



Example GI plan for recreation area in Guelph, Ontario

As part of the Greater Lakes Project, ECT conducted a stormwater analysis for two sites in Guelph. One site was a municipal campus; in this case, a park with a recreation center on site. The other was a roadway. For each site, stormwater runoff volumes were measured based on the area of impervious versus pervious surfaces. Space constraints were different between each site. The park site has high-density use with a large recreation center building, extensive impervious parking and patio areas, and recreation fields, including baseball and basketball, among others. The road site has space constraints related to the existing right-of-way width, but there are additional stormwater management opportunities in existing parkland and vacant lots adjacent to the proposed roadway improvement route. The road is bordered on either side by high density single

Example GI plan for road construction in Guelph, Ontario

family residential private property. This private property is not available for stormwater management purposes. The analysis for these sites compared multiple green infrastructure management practices that were sized for the proposed runoff volumes using the “Green Infrastructure Optimization Tool” developed for the Greater Lakes Project. The two sites were compared based on the area needed, proposed construction costs, and proposed maintenance costs. The analysis found the least expensive management practice for both sites to be cisterns. Cisterns, whether aboveground or belowground, have relatively low space requirements, are effective at storing runoff, and are effective at reducing peak flows. However, cisterns do not provide any habitat or infiltration value, and they are also often considered unsightly. For projects specifically intended to help recharge groundwater, cisterns would not be the best management practice to choose unless they were coupled with a management practice designed specifically for infiltration, such as a rain garden or bioswale. The most expensive management practice considered for the park site was a green roof. Although green roofs are considerably more expensive than other options, they are able to make valuable use of rooftop space, which is often the only space available in dense urban settings. In addition, green roofs are beautiful, visible, provide

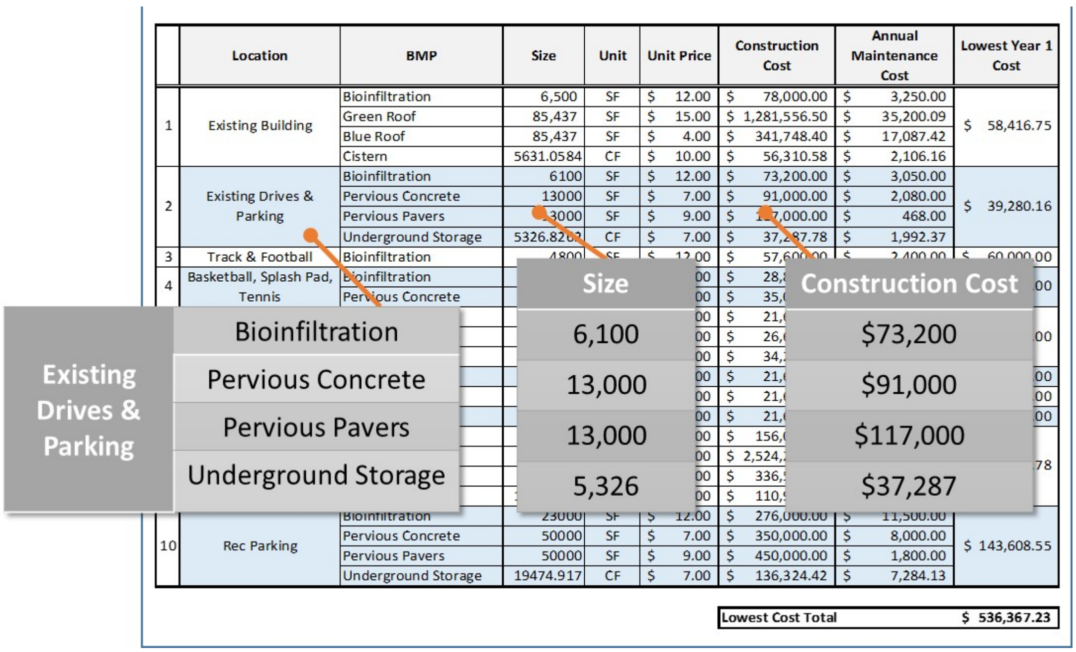


Figure 7-1: Identifying least cost management practices at a community park

habitat value, and have a high insulation effect on buildings. Return on investments are likely to come much faster from the energy savings of a green roof installation than the stormwater benefits. The most expensive management practice considered for the road site was pervious pavers. Although the entire road did not need to be constructed of pavers, even using them just in the parking lane, the minimum area required to capture the first one inch of runoff, the cost was still higher than the other management practices considered. Pervious pavers do not provide habitat value, but they do facilitate infiltration through a surface that can function as an impervious surface. Sites with high intensity use may find pervious pavers desirable because area dedicated for infiltration does not need to be taken out of production from other uses.

7.2 MINIMIZE COST & MAXIMIZE BENEFIT

The potential projects should then be costed and reordered to reflect the benefit on a dollar weighted basis. This analysis is useful in the very early stages of the green infrastructure planning process because it allows decision makers to compare costs and space requirements for various management practices sized specifically for their site. It also provides alternative stormwater management designs to be compared while minimizing upfront design costs. Ultimately, the management practices chosen will be determined by project-specific goals, aesthetics, and other desires for the site, but this analysis can provide useful information for the decision-making process. The most successful projects, both from a stormwater management and financial perspective, will include several management practices incorporated in different locations for different purposes.

8.0 IDENTIFYING FUNDING NEEDS & OPPORTUNITIES

The largest challenge for implementing IWRM is the challenge of funding programs that benefit other sections, departments, utilities, and/or other governments. As an easy example, a management practice implemented by a roads department may reap significant benefit to a stormwater utility or a drinking water supply agency, but funds are not easily shifted between those agencies. To increase the use of progressive practices, innovative ways of encouraging (or requiring) these most promising practices must be considered.

To determine challenges faced by a given municipality, it is useful to review specifically how all water infrastructure is funded in your community. The following questions are a good starting point.

- How is the water infrastructure funded?
    - Is the existing water supply sufficient for near-term growth?
    - Are individual residents metered?
    - Are water rates tied to volume used?
    - Are major investments expected in the future?
    - Are future investments needed to manage peak flows?
    - If funded through water rates, are the rates sufficient to fully fund the repair and replacement?
- How is the sewage infrastructure funded?
    - Is the collections system separated or combined?
        - Is the sewer charge tied to the water use?
        - Is there a drainage charge? If so, does it vary?
- What percentage of the drainage area is impervious area?
- What percentage of the drainage area is directly connected impervious area?
- What management practices affect stormwater quantity and quality?
- Is there any regulatory requirement limiting the peak flow release rate?
    - Is the sanitary sewage collection system separated or combined?
- Is there a stormwater drainage charge? If so:
    - Does the drainage charge vary with impervious area?
    - Does the drainage charge vary with directly connected impervious area?
    - Are there required management practices that affect the drainage charge?
    - Is there a regulatory required peak flow release rate?
- How is the drainage system infrastructure funded?

A number of communities have addressed these challenges. The following is a summary of some of the most promising work:

- Using sewer rates to construct green infrastructure
- Establishing drainage ordinances that encourage green infrastructure
- Establishing a stormwater utility
- Crafting local ordinances that drive green infrastructure.

9.0 A PRACTICAL PATH FORWARD - AGGREGATING PROJECTS FOR LARGE-SCALE IMPLEMENTATION

Aggregating green solutions outperforms the measurable benefits of numerous, uncoordinated projects. Preparing a successful integrated management plan can be a staged, multi-step process that targets the root causes that create water management challenges, presents options for best management practices, and provide a cost benefit analysis to guide the decision making process. The plan must be municipality specific to address the unique challenges of that entity. It should also provide a cost efficient way of retrofitting aging infrastructure in a resilient, sustainable way – all within restricted operational budgets. An integrated management approach that simultaneously manages drinking water, wastewater treatment, and stormwater builds momentum and offers a cost-effective, alternative solution to address expensive infrastructure improvement costs. A municipality interested in addressing their challenges in an integrated manner must begin by considering the following tasks.

9.1 TASK 1 - IDENTIFYING THE EXISTING CONDITION

The most successful projects begin by establishing a stakeholder committee and determining what are the most pressing problems to be addressed. Every community has differing water resources challenges and thus, each integrated water resources plan needs to be customized to address the most pressing issues. Before proposing any change, an assessment of the current condition should be made. This includes identifying all of the public and private entities that currently manage water-related programs and inviting them to participate in an initial planning process. These would include entities responsible for drinking water sources, drinking water treatment, drinking water delivery, stormwater collection, wastewater collection, and wastewater treatment. Often, the most pressing issues are associated with the least-funded entities and special considerations must be made. These preliminary assessments and rough budget estimates should be viewed as the initial step to identifying the factor (or factors) that are currently guiding water management policy and decision making.

Together, this initial planning group can identify the largest outstanding challenges. These could include water availability, water quality, flooding, droughts, failing infrastructure, or the need for additional capacity. The ability (or inability) to generate funds should also be identified. These challenges need to be reflective of current conditions relative to the management challenges pertaining to both source and receiving waters.

The largest challenges are typically easy to identify. The media often report on major concerns, like the depletion of groundwater resources from overuse, the frequency of combined sewer overflows during wet weather events, or excessive periods of peak drinking water demand that exceeds operational capacity. Water quality concerns are less likely to reach headlines, but they, too, can require substantial public investment. Thus, communities must be cognizant of receiving water regulatory requirements as well as beneficial use impairments (BUIs), as identified in local watershed management plans, remedial action plans, discharge permits, TMDLs, regulatory lists, etc.

Simplified summary of this task:

1) Identify all public and private entities that manage, or influence water-based utilities.
2) Meet with identified entities to analyze current treatment systems, capacities, and reoccurring issues (e.g., CSO overflows, flood-prone areas, failing infrastructure, etc.), and prioritize by greatest need. These will then need to be cross referenced with relevant regulatory criteria (e.g., NPDES permit criteria, the AOC Program, MDEQ 303d list, etc.).
3) Draft an outline of the roles, responsibilities, needs, issues, and available funding sources to serve as the basis for the development of an integrated water management plan.
4) Estimate the level of effort for each entity and prepare a preliminary budget assessment to proceed in developing an integrated water management plan.

9.2 TASK 2 - DATA COLLECTION

The initial task should have generated a wide array of potential water resource management issues, some broad-based baseline information, and some statistical data related to the capacity of the water utilities. Much of this information is readily available in most well-run operations. In fact, the most progressive operations have asset management systems built around managing this information. However, IWRM requires that this information be viewed through a slightly different lens that focuses on how these assets affect the water resources on which they depend. The following is an example list of some of the data needed to prepare the baseline assessment:

- Age of infrastructure
- Age of treatment facilities
- Capacity of wastewater treatment facility
- Capacity of water treatment facilities
- Number of CSOs and SSOs
- Land use/cover open space available
- Percentage of impervious surface
- Population trends
- Population density
- Source of water
- Water distribution loss
- Water withdrawal versus wastewater treated
- Inflow and infiltration volume
- Wellhead protection areas

Obtaining baseline information is typically obtained by survey or by interviewing of the operational staff of the utility. The process provides the opportunity to identify operational challenges, as well as gauge interest in potential programs and strategies designed to improve water management.

This information can be used to complete an impact analysis that identifies and quantifies the major challenges facing the given municipality. For example, if a drinking water utility has a capacity to produce a specified quantity of drinking water per day, and residential metering data shows that a fraction of the produced quantity was actually delivered to customers, the conclusion can be made that there is significant water loss in the utility’s water distribution system. This broad-based information often leads to more detailed analysis.

There are many effective programs for minimizing water loss that could be instituted. Conversely, if the amount of water used can be reduced through water efficiency measures, similar results can be seen. In this particular example, the economic impact of these effects can be quantified using the Alliance of

Water Efficiency's Excel-based Water Conservation Tool to determine the implications from a water resource management and operations cost perspective. The results of the baseline assessment can be used to construct a priority listing of the root causes that will be used to facilitate management practice selection and guide decision making.

Simplified summary of this task:

1) Gather baseline information through a utility survey and/or interview key operations staff to obtain baseline information and identify critical programmatic or capital improvement needs.
2) Initiate additional studies to address the most pressing issues in the existing system. Utilize the baseline information data into the tool and run a baseline scenario reflecting the water utility's current operational capacity.
3) Prepare a very brief summary of the baseline conditions, the noted challenges, and areas where additional studies are warranted.

9.3 TASK 3 – WATER BUDGET

Once the initial data has been collected, a very basic water budget should be computed. This should not be a detailed modeling project. The goal is to simply identify where water is extracted from the natural environment and where it is returned (i.e., is water extracted from groundwater but then discharged to a river). Secondarily, the location and quality of the water returning to the natural environment should be assessed. This simple audit helps provide an initial overview of where the system is challenged and where changes in approaches can yield the largest benefit.

Simplified summary of this task:

1) Prepare a Water Budget - Identify all source and receiving waters that are utilized by the utility.
2) Assess the effect of water extraction on the source water(s).
3) Identify areas with known degradation of water quality of the receiving water(s).

9.4 TASK 4 – PRIORITIZE POTENTIAL PROJECTS

Based on the baseline assessment, a list of projects and/or practices that focuses on water conservation, stormwater/wastewater reduction, source water protection, and operational efficiency can be compiled. Specifically, the collection of projects will focus on strategies that improve the management of water infrastructure and include wastewater treatment facilities, storm and sanitary sewer systems, stormwater detention facilities, and drinking water production and distribution utilities. They should be evaluated and prioritized based on their ability to improve operational efficiency and capacity, reduce water demand, reduce wastewater, and stormwater runoff. Practices successfully utilized by other municipal utilities, agencies, and organizations should be considered for applicability, especially if their success has been documented by case studies.

New technologies must also be evaluated. The conservative nature of the public works industry makes the introduction of new technologies difficult; however, improved technologies and methods can lower cost and improve performance. As such, new applications must be evaluated, even if only on a trial basis. The performance of the proposed practices should be assessed in the same manner as the baseline assessment so that the projected benefits are quantifiable. The results, when compared to the baseline data, will determine an approximate reduction (or increase) in water use, waste and stormwater generated, and energy consumed. This information will be shared with stakeholders to build the public support for the new way forward.

Simplified summary of this task:

1) Identify needed projects and practices across multiple water practices.
2) Evaluate practices that improve efficiency and/or moderate use in an effort to delay capital investments freeing available funds for sustainable practices.
3) Research and prepare list of “green” alternatives based on current conditions identified from the baseline scenario and the water budget.
4) Evaluate the impacts – both positive and negative - of each proposed project on all practices and prioritize those projects in a manner that minimizes overall cost and yields the most sustainable benefits.

9.5 TASK 5 – ECONOMIC & SUSTAINABLE ANALYSIS

Calculating the benefits of integrated water management is difficult because many of the benefits are difficult to quantify, even with extensive assessment. Thus, it is recommended that the financial benefits be clearly quantified along with the larger environmental benefits. Together, these benefits should drive the prioritization of proposed projects with public input. Once these benefits are calculated, the economic value should be assessed to provide a standard, cost-benefit analysis to determine the overall feasibility of each project/practice. These projects/practices should be coupled with the sustainability benefits. These sustainability benefits will vary by practice and by municipality. For example, the increased infiltration provided by certain green infrastructure practices is more valuable to a municipality served by a receding groundwater source versus a municipality with a Great Lakes source. Still, there is value to the green infrastructure solution to both.

Once the enhanced cost benefit analysis has been completed for the projects/practices and a prioritization has been established, funding alternatives are evaluated. If grants are available, the decision is easy. However, if the project relies on traditional funding sources, decisions can be more difficult. Local ordinances, bond covenants, and established policies limit what can be done with public works funds. These challenges should be identified early and concurrently as plans move forward. Typically, projects are categorized as operational or capital driven, and this defines the funding mechanism. If the project is small and improves the on-going operations and maintenance of a system, operations funds (i.e., generated by rates) can be used to implement the practice. Larger practices requiring significant capital are likely to require financing – through bond sales, private financing, or a combination of both – and relies on a dedicated revenue source, typically the full faith and credit of that municipality.

Operational changes that do not require capital investment are the easiest to implement. Programmatic projects that are strategies to require or incentivize better manage drinking water demand and/or wastewater treatment can be easily built into existing rates. For instance, if the community is having difficulty with water supply, consumer based strategies designed to reduce demand can be implemented. Examples of these strategies may include implementing a rain barrel incentive program, enacting water use restrictions during the summer months, and issuing rebates for purchasing low-flow water fixtures. These practices generally have lower implementation costs and may provide a measureable advantage for smaller water utilities; however, there are limitations to the effectiveness. When larger reductions are required, capital is typically needed.

Capital-driven projects/practices are larger in scale and involve upgrading, creating, or repairing water-based infrastructure. Examples include inflow and infiltration reduction, water main repair projects, and regional stormwater management projects. Capital-driven projects generally provide greater financial and sustainable benefits but are much more expensive and sometimes cost prohibitive.

Simplified summary of this task:

1) Identify the costs of each proposed project.
2) Identify the economic benefits of each project.
3) Identify the sustainability benefits of each project
4) Provide estimated return on investment for all projects.
5) Rank the projects based on economic benefits.
6) Re-rank the projects incorporating the sustainability benefits.
7) Identify the funding mechanism for each project.
8) Revise the prioritized project list incorporating financial viability given funding constraints.

9.6 TASK 6 – IMPLEMENTING THE STRATEGY

Once the analysis of the selected projects/practices has been completed, each utility will be asked to select appropriate projects/practices with an understanding of the long- and short-term costs of implementation. Thus, without radically changing the institutions themselves, an integrated water resources management strategy can be devised enabling stakeholders and decision makers to:

- Develop long-range capital plans with capital requirements.
- Quickly compare alternative sustainability measures in terms of their water savings potential, impact on system costs, and potential benefits to utility customers.
- Track the implementation, water savings, costs, and benefits of actual conservation activities over time.
- Evaluate a utility's changing revenue requirement while incorporating sustainability.
- Maximize the level of benefit while remaining fiscally responsible.

To perpetuate this alternative approach to providing public services, an annual report should be provided to each contributing entity as well and to their respective governing bodies and the residents in the community.

Simplified summary of this task:

1) Share the prioritized list of projects with the responsible entities and public.
2) Evaluate the additional positive impacts on the long-term water supply and water quality.
3) Quantify the benefits in financial terms as well as non-financial terms utilizing atypical measures, such as increases in groundwater levels, increase in river flows during extreme low events, or reduction in stormwater loads and/or erosion.
4) Identify existing and creative funding alternatives.
5) Measure progress annually and report to all stakeholders.

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APPENDIX A
SELECTING DESIGN DRIVERS

Once a municipality determines what physical challenges they are attempting to overcome, they should review the regulatory requirements coupled with the demands of the public they serve. This can begin by considering the following questions.

- Are there regulatory requirements for:
  - Water Supply?
  - Water Distribution?
  - Sewage Collection?
  - Sewage Treatment?
  - Sewage Overflows?
  - Stormwater Quantity/Quality?
- What are the environmental challenges your municipality faces?
  - Flooding?
  - Basement Flooding?
  - Groundwater depletion
  - Degraded Groundwater
  - Sewage Overflows
  - Degraded Surface Water
    - Flashiness
    - Dissolved Oxygen Issues
    - Bacterial Issues
    - Low Flow Issues
    - Chemical Pollution

Each green infrastructure practice has specific attributes that make them more applicable for addressing individual challenges. The following is a list of commonly utilized green infrastructure practices segregated into the broad categories of the challenges that the municipalities have established as critical.

Urban Reforestation is a management practice well suited for urban settings with green and open space. Trees can intercept precipitation, increasing opportunities for evaporation, and retain rainfall in their biomass, increasing storage of water on site. Tree plantings also help stabilize soils and stream banks with their root systems, which helps prevent surface erosion. The trees also provide shade, minimizing the water temperature of runoff. Trees require seasonal watering and wind protection until the urban forest has matured. Other required maintenance techniques include raking leaves, weeding, and trimming.

Forest Retention areas provide shallow stormwater retention areas planted with trees. The retention basin is sized to capture a predetermined amount of stormwater while the trees provide extra water storage capacity in their biomass. Retention basins should be designed to store no more than 6” of water depth to preserve the vitality of the trees. Forest retention will work best in suburban green space and should be placed adjacent to impervious surfaces to be the most effective.

Forest Retention

- ✓ Increases runoff storage and infiltration
- ✓ Detains water from reaching CSO’s during peak flows
- ✓ Between 0.25 acres to 1 acre in size

Wet Meadows are meadows planted with upland or wetland plants native to naturally occurring wet meadows in the region. The meadows should have hydric soils, withstand wet and dry conditions, and receive either sheet or piped runoff drainage. The wet meadows allow retention of stormwater to provide an opportunity for groundwater infiltration. Their water storage capacity allows them to minimize peak flows thereby reducing CSO runoff and discharges. To work well, the wet meadows must be maintained through invasive plant management and periodic replantings.

Wet Meadow

- ✓ Acts as shallow detention basins
- ✓ Large enough volume can capture discharge from CSO facilities and decrease runoff volume
- ✓ Retains runoff to infiltrate or evaporate
- ✓ Can receive overland or pipe flows
- ✓ Plants that survive in wet and dry conditions are most effective
- ✓ Used on large sites (> 1 acre)

Native Prairie and Agriculture plots should be used in open urban areas. They will work best with deep-rooted vegetation that can withstand wet and dry conditions. To maximize effectiveness, this management practice should be densely planted to slow runoff and provide an opportunity for infiltration.

Rain gardens are shallow retention basins densely planted with native deep rooted plants. Amended soils covering a stone subsurface base provide opportunities for increased rates of infiltration in comparison with the surrounding urban compact soils. Rain gardens are designed to not hold more than 6” of standing water in order to protect the plants, which are chosen for their hardiness and ability to withstand both wet and dry conditions. The plants help slow runoff, evapotranspire a portion of the stormwater, and increase rates of infiltration with their root systems. Rain gardens are not designed to hold water for any longer than 24 hours.

Rain Gardens

- ✓ Depressed vegetated area providing storage
- ✓ Allows runoff to infiltrate into subsurface soils
- ✓ Uses deep rooted vegetation
- ✓ Plants that survive in wet and dry conditions are most effective
- ✓ Minimum size of 200 square feet

Bioswales/Vegetated Swales are designed to slowly transport stormwater to a desired location while providing opportunities for infiltration. Bioswales are essentially ditches with enhanced infiltration and habitat capacity through use of amended soils, stone subbases, and native deep rooted plantings. The plant species chosen should be able to withstand both wet and dry conditions. Generally, wetland plants can transpire more water and uptake more nutrients than their upland counterparts. This management practice is often used in residential areas, adjacent to parking lots, or smaller open spaces in urban settings where space available for infiltration is limited to linear corridors.

Bioswale

- ✓ A vegetated swale with stone sub-base that transports water above ground
- ✓ Filters stormwater runoff as water migrates through plants
- ✓ Can reduce quantity and cost of storm drains and pipes
- ✓ Can provide habitat for small wildlife
- ✓ Uses grasses and native plants
- ✓ Can be used on smaller land areas, for example, along parking lots
- ✓ Minimum of 10 foot width

Bioswales can work independently or be designed as a part of a treatment train where multiple swales form a system of transport on a site. Swales can reduce the number and cost of storm drains and piping required when developing a site. Required maintenance includes summer irrigation, weeding, occasional replanting, and regular inspection. Inspection is critical in the first year because large storms can wash away seeds and young plants that have not yet developed a deep root system.

Maximizing Infiltration - Some management practices specialize in capturing peak flows and then infiltrating large amounts of stormwater. Designed with both a stone base and amended planting soil, these management practices create a porous zone to maximize infiltration. Rain gardens and bioswales are considered bioinfiltration, which uses vegetation to facilitate the infiltration process. Infiltration trenches can be designed with river rock or gravel as an alternative to vegetation.

Controlling Peak Flows – Other management practices capture excess runoff volumes for future reuse or holding peak volumes allowing maximum infiltration. Controlling peak flows is all about preventing large amounts of stormwater from reaching the sewer at one time. Underground storage, cisterns, and retention/detention ponds all function in the same way. They store water during the peak storm event and slowly release the water after the storm has passed. This stored water can be released into irrigation systems, gray water systems, or the sewerage system. Retention/detention ponds hold the water at the surface level where it is available for infiltration, evaporation, and habitat.

Diverting water from Sewerage Systems – Diverting runoff is often viewed as a gray infrastructure solution but when used in concert with green solutions, sewage capacity is saved for treatment of sewage rather than stormwater. Typical projects can include downspout disconnection programs, foot drain disconnection programs, and partial separation of combined sewer areas.

Disconnecting downspouts from the sewer system prevents all precipitation that falls on a roof from immediately discharging into the sewer. Alternatively, that water can be discharged into a bioinfiltration cell (rain garden, bioswale, etc.) or surface flow toward the street, where it has the opportunity to evaporate, infiltrate, or evapotranspirate via plant metabolism. All management practices that promote infiltration, most notably rain gardens and bioswales, divert water from the sewer. In addition to management practices that are specifically designed to infiltrate stormwater, landcover can have a huge impact on the volume of water diverted from sewers. Plants take up water, and larger plants such as trees take up significantly more water than smaller plants such as cool season lawn grasses. Areas that can be set aside for dense tree cover, dense deep-rooted prairie grass cover, and/or wetland "soggy" spaces, can also be very effective in diverting water from the sewerage system.

Capturing and reducing erosion - Erosion is caused by fast-moving water. Any management practice that slows water or infiltrates water helps prevent erosion, and the most effective management practice for the project is site-specific. More dense vegetative cover is more effective at slowing and infiltrating stormwater than impervious cover or lawn. Any bioinfiltration management practice (most notably rain gardens and bioswales) will slow stormwater and reduce surface flow. Erosion can also occur within natural drainage channels that may exist on a site. These may include ephemeral streams or low points on the property where surface water naturally drains. Increasing the surface area (width) of these drainage channels can reduce the velocity of the stormwater thereby reducing its erosive capacity. Widening drainage channels enough in certain areas along the drainage channel can create sediment basins. Sediment basins slow stormwater enough to facilitate any sediment held in the water column falling out of solution, and therefore preventing the sediment from leaving the site.

Treating stormwater runoff - Stormwater can contain many soluble and insoluble contaminants such as nutrients, salt, bacteria and other microbes and pathogens, sediment, garbage and other solids, petroleum hydrocarbons, heavy metals, synthetic organics, and other chemicals. Metabolic processes both in plants and soil can break down these contaminants rendering them harmless or facilitate plant uptake removing their mobility in the water. The key factor for stormwater treatment is time. If the water drains through a system in a matter of minutes, few contaminants will be removed from the water. However, if water stays in place for a significant amount of time before slowly infiltrating or evaporating out of the system, the system has a higher water treatment capacity. The management practice most suitable for a project is determined mostly by scale. Constructed wetlands are designed to treat large amounts of impaired water, whereas bioinfiltration cells will treat smaller amounts of impaired water, which will then infiltrate. Further treatment will occur once the water is held in the upper soil horizons. Much in the same way land cover choices can divert water from the sewerage systems, land cover choices can also facilitate stormwater treatment. An extreme example is phytoremediation, which is a process through which certain species of trees, usually hybrid poplars, are planted in areas with known contaminated soils. These trees take up contamination into their biomass removing the pollutants from the soil and associated ground water.