

The Business Case for Green Infrastructure

RESILIENT STORMWATER MANAGEMENT IN THE GREAT LAKES REGION

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RESILIENT STORMWATER MANAGEMENT IN THE GREAT LAKES REGION

The Urban Land Institute – Michigan District Council

District Councils are ULI at the local level. By providing educational forums, community outreach programs and industry expertise to community leaders, the opportunity to influence local land use policy continues to be the focus of ULI's District Councils.

The Michigan District Council of the Urban Land Institute (known at the time as ULI Detroit) was founded in 1999. Starting with just a few members, the District Council has grown to more than 400 members in the past 18 years.

In September 2011 ULI Detroit announced that in order to facilitate growth and better serve regions outside of Southeast Michigan, the District Council will be expanding its annual programming and services to a statewide level, and would be changing its designation from "Detroit" to "Michigan" to reflect its expansion efforts.

In 2016, the Advisory Board of the Michigan District council established a Resilience Task Force with the mission to identify best practices in storm water management and analyze the economic case for developers to voluntarily adopt these practices with a recognition that a financial return on water related infrastructure exists, much like other energy savings practices.

About the Urban Land Institute

The Urban Land Institute is a global, member-driven organization comprising more than 40,000 real estate and urban development professionals dedicated to advancing the Institute's mission of providing leadership in the responsible use of land and creating and sustaining thriving communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 76 countries.

The extraordinary impact that ULI makes on land use decision making is based on its members sharing expertise on a variety of factors affecting the built environment, including urbanization, demographic and population changes, new economic drivers, technology advancements, and environmental concerns.

Peer-to-peer learning is achieved through the knowledge shared by members at thousands of convenings each year that reinforce ULI's position as a global authority on land use and real estate. In 2016 alone, more than 3,200 events were held in 340 cities around the world. Drawing on the work of its members, the Institute recognizes and shares best practices in urban design and development for the benefit of communities around the globe.

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Schostak Brothers & Company

Robert Taubman
The Taubman Company

William Watch
First Commerical Realty & Development

PRIMARY AUTHOR

Lauren Carlson
LC Planning

CONTRIBUTING AUTHOR

Patricia White
Detroit Revitalization Fellow, ULI - Michigan

ULI MICHIGAN STAFF

Shannon Sclafani
Senior Director
Patricia White
Detroit Revitalization Fellow

PRIMARY DESIGNER

Kurt Wisthuff
Arc Group Ltd, Designer

ULI MICHIGAN PROJECT DESIGNER

Sara Reeside
Breathe Graphic Design

ULI NATIONAL STAFF

Billy Grayson
Executive Director, Center for Sustainability and Economic Performance

Katharine Burgess
Senior Director, Urban Resilience, Center for Sustainability and Economic Performance

Leah Sheppard
Project Employee, Center for Sustainability and Economic Performance

James A. Mulligan
Senior Editor

Laura Glassman
*Publications Professionals LLC,
Manuscript Editor*

Betsy Van Buskirk
Creative Director

Anne Morgan
Graphic Designer

2017 ULI MICHIGAN RESILIENCE TASKFORCE

Shannon Sclafani
ULI Michigan

Kathleen Lomako
SEMCOG

Jim Bieri
Stokas Bieri Real Estate

Gregory McDuffee
Detroit-Wayne Joint Building Authority

Jill Ferrari
Ostara Companies

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Domino's Farms Corporation

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SME

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Butzel Long

Kelly Karll
SEMCOG

Amy Mangus
SEMCOG

Valerie Strassberg
The Nature Conservancy

Cari Easterday
Midtown Detroit, Inc.

Tony Thomas
SME

Ashley Lesser
PM Environmental

Lauren Carlson
LC Planning

Beth Gotthelf
Butzel Long

Susan Johnson
Butzel Long

Patricia White
ULI Michigan

Leslie Banas
Banas & Associates

Lesley Rivera
The Nature Conservancy

David Tobar
Eastern Market Corporation

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As ULI members, you are part of the oldest and largest network of cross disciplinary real estate and land use experts in the world. From a variety of professions and from around the globe, we come together with our shared commitment to the open exchange of ideas among leaders dedicated to creating better communities. Today, that open exchange includes a radical new approach to stormwater that goes against everything we thought we knew about water management. Rather than moving water off the property and into the sewer as quickly as possible, green infrastructure mimics the natural water cycle, retaining, cleaning and even reusing water on your project site.

For those of us in the Great Lakes region, water is always at the heart of our work. We take great pride in being custodians of the largest freshwater system on Earth. Our waterfronts have been the birthplaces of early development and the basin's resources sustain quality of life for 40 million people.

For leadership in green infrastructure, we need look no further than our colleagues in Toronto, the first city in North America to require green roofs on new development. Working closely with real estate and land use experts, they piloted cost share and incentive programs. And in less than a decade, they went from a paper commitment to 1.2 million square feet of new green space.

Depending on where you are building, you may have very different reasons for wanting to learn more about green infrastructure. You may be working in a municipality like Toronto that requires or incentivizes green infrastructure in new builds. You may be working with a client who sees the value of "the green premium;" higher rents for properties with ecologically friendly amenities and features. With this guide, we hope to show you another reason – it just makes good business sense.

We set out to create a resource custom tailored just for you, the real estate and land use professional. We answer your basic questions and provide regional case studies, but most importantly we present you with a value proposition: investing in green infrastructure can provide both cost savings and increased earnings. As ULI members, you are committed to being leaders that build communities that thrive, but we also know you are still a business. And while you strive to create top of the line properties, you also need to keep an eye on your bottom line.

As we continue this journey together, we hope this guide helps you navigate the dynamic art of green infrastructure while growing the value of your portfolio.



Gregory McDuffee, Executive Director
Detroit-Wayne Joint Building Authority
Chair, ULI Michigan Resilience Task Force



Shannon Sclafani
Senior Director, ULI Michigan

EXECUTIVE SUMMARY

The Urban Innovation Grant for Stormwater Resilience seeks to assist District Councils with resources to build more resilient practices in urban development. Created and funded through the Urban Land Institute Foundation Annual Fund, this report acknowledges the need for more thoughtful and comprehensive stormwater management practices and provides insight and recommendations, identifying where opportunities exist.

As a companion to the report *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate* (Urban Land Institute, 2017) this report is a regional approach, written to further analyze green infrastructure needs that can improve the quality of our freshwater resources.

This research shows that developers and municipalities, together, can manage the risks that increased stormwater events present, by supporting wise development practices that will improve the likelihood that costly impacts, including flooding and untreated sewage discharges, can be minimized, making our cities more resilient.

The business case in stormwater mitigation and maintenance is to reduce the cost of pumping and treating water, and the potential impacts of flooding. Effective stormwater management strategies can have a positive return on investment on these very real stormwater costs, and can be cheaper than increasing water treatment capacity and/or cleaning up after a stormwater event. Smart stormwater management is a low-cost alternative to traditional practices.

This report examined previous academic and peer group studies, municipal policies and case studies from developers, professional service firms and other institutions and have compiled key findings for developers and other real estate professionals, to highlight the need that our urbanized communities have and the potential for success that they already exhibit.

Beyond the chapters that address the status of our region, the cost benefit analysis, and the local policy climate that

surrounds green infrastructure, the case studies feature projects and associated development partners and leaders who have made early strides to green and clean stormwater on their project's site, before it reaches the connected wastewater system.

These regional examples along with the many interviews that were conducted, contributed to this report and provide insight into how green infrastructure can be successfully implemented to support freshwater resources, protect infrastructure capacity and needs, while laying the path for cost effective, mindful development.

By examining the state of our wastewater systems and understanding the trajectory of our urbanized environments, this report offers solutions to the challenges that communities in the Great Lakes region are facing and provides insight into how the development community can practically implement green infrastructure techniques. The recommendations that follow lay the path for green infrastructure implementation that will increase community resilience and enhance livability throughout the Great Lakes region.



The Great Lakes Region as viewed by satellite.
(Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC)

Introduction

The Great Lakes region is defined by water: physical access to it and resources from it. More than just the geographic landscape that is connected, the cities in the Great Lakes basin, and the larger region, are bound to the industry of water and the economic success that it can produce.ⁱ

The Great Lakes Region

The 140 harbors and channels and 63 commercial ports in the Great Lakes navigation system are part of the fourth largest economic zone in North America.ⁱⁱ These industry centers help to ship 200 million tons of cargo through the Great Lakes every year.ⁱⁱⁱ

Of the freshwater natural resources that are within North America and the world, the Great Lakes Basin contains 84% and 21% respectively, as the largest surface freshwater system on Earth.^{iv} Within approximately 9,000 miles of shoreline, the Great Lakes make up 95% of the freshwater supply in the United States.^v

Great Lakes cities, however, have important defining characteristics other than just the geographic location. When the scope of comparison is widened, Great Lakes cities have similar features ranging from not only available resources, but also economy, industry and environment.

Many Great Lakes cities are within the Rust Belt and have a similar economic history and structure based in the decline of industry, population, and service capacity. Overwhelmingly, these cities also have aging and inadequate combined sewer systems.^{vi}

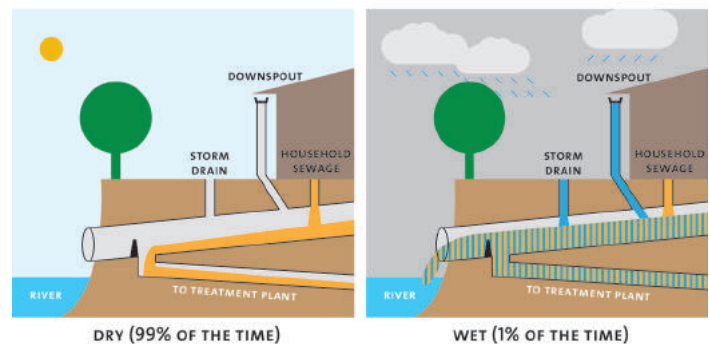
These shared challenges produce an environmentally dangerous situation. When an older city with a combined sewer system faces an unexpected weather event such as a large downpour, flood, or excessive snow melt, and the system that is designed to carry this wet weather away from the surface is overloaded or inadequate, the result is untreated discharges that pollute the receiving body of water.

This cycle then repeats as many cities are unable to financially afford the mitigation costs of their sewer system challenges and the systems are unprepared to deal with increasingly variable weather events.

The reality is the Great Lakes are being contaminated. If the infrastructure and the behaviors that support it don't change, then tourism, economic development, fishing and agriculture, and freshwater resources will suffer. Communities will suffer if floods and unregulated and untreated discharges continue to occur. Money will continue to be spent and lost through unachievable maintenance and repairs of outdated networks, high flood insurance premiums and stormwater fees. The challenges that the Great Lakes region faces are significant, but they



Great Lakes Basin
(Image courtesy of the Great Lakes Commission)



Combined Sewer Overflow Diagram
(Credit: Annemieke Beemster Leverenz/GrowNYC)

By taking a proactive approach to stormwater management, the real estate community can help safeguard the resources and assets that make the Great Lakes region so unique.

are not insurmountable. The region and these cities are rich in a wide variety of assets - anchor institutions, historic architecture, available land, cultural fabric, and natural resources.

Taking action to protect the regional resources and our nation's assets further secures the Great Lakes region as a fundamental contributor to the nation's economic, environmental, and agricultural success.^{vii}

Action Opportunity: Green Infrastructure, Real Estate, and the Great Lakes Region

The Urban Land Institute defines green infrastructure as mechanisms that enable natural systems to capture stormwater runoff, enhance water and air quality, and create green space. By using materials from the earth, either naturally occurring or intentionally placed, to filter, capture, and/or participate in the processing of stormwater is how green infrastructure techniques are integrated into development and how urbanized environments can build resilience.^{viii}

With land available and a continued need for fresh water, the region is primed for redevelopment that integrates green infrastructure best management practices to improve the quality of life among residents, increase property values, and protect our natural resources.

Developers that lead the way and incorporate green infrastructure solutions into projects demonstrate how sustainable practices can become the hallmark of modern development in not only critically sensitive urbanized areas but across the

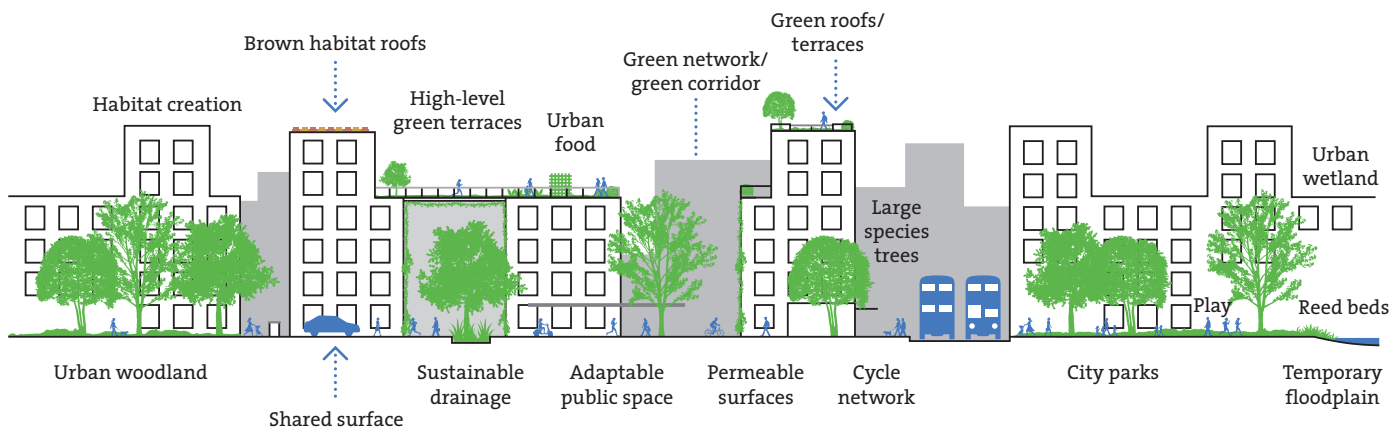
country as well. Ending untreated discharges due to sewer system inadequacies is the goal. The tools exist. The need is real.

Green Infrastructure Projects and Opportunities

Green infrastructure projects can provide the following benefits in addressing the Great Lakes region's stormwater challenges. Green Infrastructure has the potential to:

- be less expensive and carry less life-cycle costs than maintaining and updating existing gray infrastructure;
- decrease municipal capital costs, infrastructure charges, and stormwater processing fees that can be directly passed on to property owners;
- help to eliminate point-source pollution due to antiquated stormwater management systems keeping freshwater supplies clean;
- increase property values and quality of life thresholds when integrated at large and small scales in residential and commercial settings;
- safeguard our urbanized environments against extreme weather events and enhance the sustainability of our regional urban assets.

By implementing green infrastructure techniques and tools, developers play the most significant role as project stakeholders by reducing costs (immediate and long-term), eliminating pollution, and safeguarding the future of our Great Lakes communities.



Green infrastructure can take on a range of forms, shapes, and sizes depending on the stormwater management goals, building types, and surrounding development context. *(Graphic based on original by ARUP)*

Water, Infrastructure, Weather, and Resilience

A significant portion of the Great Lakes region, the Great Lakes Basin (GLB), is comprised of 158 counties and 13 major urbanized areas, inhabited by approximately 34 million people in the U.S. and Canada.^x Water drawn from the Great Lakes provides drinking water to 40 million people in 8 states and two Canadian provinces.^x

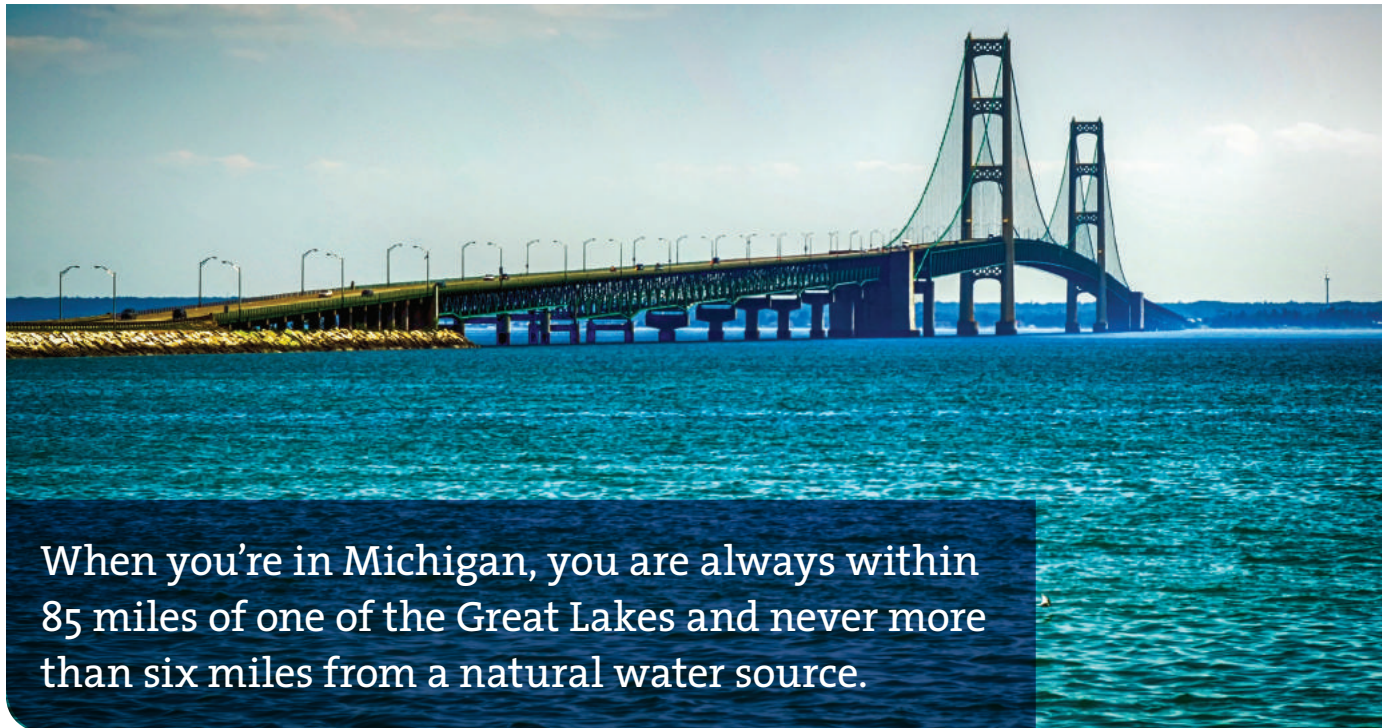
Not only are the water resources in the Great Lakes region significant, the infrastructure to supply drinking water and process wastewater is also vast. Both systems, region-wide, have reached a break-point that requires burdensome financial infrastructure, and as the frequency of severe weather events continues to increase the need for implementable solutions becomes more critical.

Freshwater

The three largest urbanized areas located on the Great Lakes are focused around Chicago, Toronto, and Detroit. These cities and their metropolitan areas significantly contribute to the industry, economy, and vitality of the largest freshwater system in the world, the Great Lakes.

Today, the Detroit Water and Sewerage Department (DWSD) is the third largest provider of high-quality drinking water and wastewater treatment services in the United States.^{xi} And although only 30% of the sewer systems in southeast Michigan are combined sewers, 95% of wastewater systems in the city of Detroit are combined sewers.^{xii}

Treating approximately 650 million gallons of wastewater per day, the network of Detroit wastewater treatment plants process and discharge wastewater from 76 southeast Michigan



When you're in Michigan, you are always within 85 miles of one of the Great Lakes and never more than six miles from a natural water source.

communities. This problem is not only Detroit's.^{xiii} Within the GLB there are 13 major urbanized areas that process and provide water within broader regional areas.^{xiv} For example, the City of Chicago Department of Water Management provides nearly 1 billion gallons of water every day and removes waste water and stormwater runoff for the city and 125 suburban communities.^{xv}

While the water coming from the Great Lakes supplies fresh water to more than 40 million people, aging and failing water and sewer infrastructure networks and outdated standards and water management practices in the region are putting the future of this precious limited resource at risk.

Infrastructure

Many of the water and sewer systems in the Great Lakes region are over 150 years old and although most cities budget for partial updates and limited utility replacements as needed, the costs to protect drinking water and remediate pollution by preventing system overflows and untreated discharges is increasingly overwhelming.

The American Society of Civil Engineers (ASCE) publishes an infrastructure report every four years, assessing the nation's 16 major infrastructure categories and depicting the condition and gaps in the performance of current infrastructure. In 2017, ASCE scored America's infrastructure a dismal D+, while individual states within the Great Lakes region need wastewater system updates and maintenance ranging from \$2 billion to over \$36 billion, over the next 20 years.^{xvi}

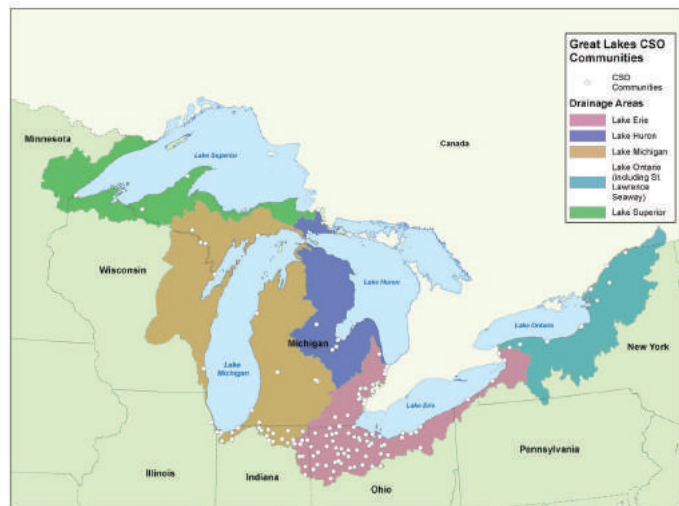
Combined Sewer Systems

Combined sewer systems are regionally concentrated in older communities in the Northeast and Great Lakes regions and are common in 32 states nationwide, consisting of 746 communities according to the Environmental Protection Agency (EPA).^{xviii} Within the Great Lakes Basin (GLB) there are 184 combined sewer systems designed to collect and transmit wastewater and stormwater through a single network of pipes.^{xix}

The design of a combined sewer system is effective at removing and treating sewage in dry weather, yet because of the increase in the variability of weather events these systems are no longer effective. When concentrated volumes of rain and snowmelt enter the system, the capacity of the sewer is over-run with more flow than the infrastructure allows, resulting in an overflow of untreated sewage and stormwater into natural waterways.^{xx}

Flooding

Combined sewer overflows can cause backups in city streets and on residential and commercial properties causing costly damage to property owners and municipalities.



Within the Great Lakes Basin there are 184 combined sewer systems designed to collect and transmit wastewater and stormwater through a single network of pipes.^{xix}

(United States Environmental Protection Agency)

	DRINKING WATER NEEDS*	WASTEWATER NEEDS*
Michigan	\$13.80 billion	\$2.07 billion
Ohio	\$12.20 billion	\$14.58 billion
Indiana	\$5.90 billion	\$7.16 billion
Illinois	\$19 billion	\$17.50 billion
Wisconsin	\$1 billion	\$6.33 billion
Minnesota	\$7.40 billion	\$2.39 billion
New York	\$38.70 billion	\$36.20 billion
Pennsylvania	\$13.90 billion	\$28 billion

*estimated over the next 20 years

(American Society of Civil Engineers, 2017 Infrastructure Report Card, <http://www.infrastructurereportcard.org>)

Factors like an unpredictable increase in wet weather events cause current stormwater systems to be only moderately successful, even when additional gray infrastructure components are added. Research shows that the performance of green infrastructure during peak weather events brings security to real estate owners and operator's investments, and reduces the need for buried storm sewer systems.^{xxi}

A 300 Year Storm... Every Few Years?

Hailed as a 300-year storm event, the severe weather event that occurred in metro Detroit on August 11th, 2014, highlights the potential for what can go wrong when sewer system demand exceeds capacity.^{xxii}

Four to six inches of torrential rain fell in only four hours on the densely-populated area, recording the second highest rainfall in a single day for the area. More than \$1.8 billion in

“The 100-year storm event is really a misleading term because it implies that the event will happen only once every 100 years. Really, we should call it the 1 percent chance storm—because there is a 1 percent chance it will occur in a specific location every year. In the Houston region, the 1 percent storm is about 12 inches or 13 inches of rain in 24 hours.”

RANDY JONES, PRINCIPAL, TERRA VISIONS LLC



Highway flooding and embankment collapse, August 2014
(Michigan State Police Emergency Management and Homeland Security Division)

direct flood damages were incurred to the city of Detroit and the 12 inner ring suburbs of the tri-county region (Wayne, Macomb, and Oakland counties). Damage included the city’s overwhelmed sewer pumps, roads and bridges, and around 75,000 homes and businesses.^{xxiii}

Although this type of storm event is uncommon, the age and condition of stormwater infrastructure most likely exacerbates effects and damages of severe events when pipes, facilities, and technology lacks the capacity to handle the increased volume that modern weather patterns are creating.

Metro Detroit is not the only region to have suffered the fate of a severe weather event that caused the combined sewers to overflow at unmanageable levels.

In 2013, Toronto received 3.5 inches of rainfall in just two hours causing approximately 264 million gallons (or 1 billion liters) of sewage to flood into Toronto’s streets and harbor on Lake Ontario.^{xxiv}

And in May of 2017, the City of Chicago had so many consecutive days of rain that flooding occurred across the city and the suburbs, causing the Elmhurst Flood Control Facility to open its

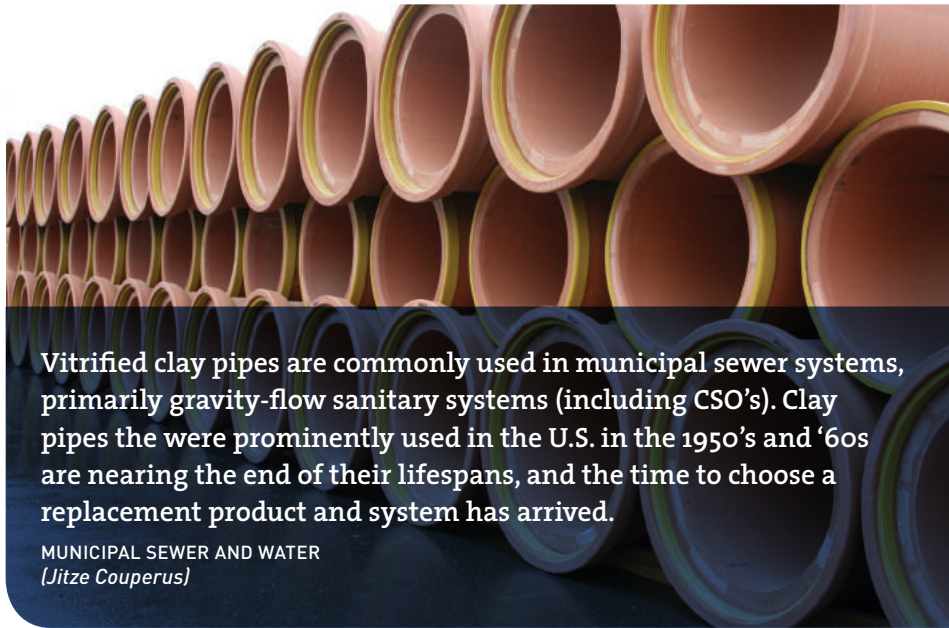
gates to divert water from a nearby creek and river to prevent additional residential flooding.^{xxv}

In all of these cases, when the volume of stormwater runoff is reduced and alternatively allowed to filter into the earth, flooding can be minimized. As severe weather events in Michigan continue to increase (see timeline, p. 8-9) green infrastructure practices can help to manage the severity of local flooding by controlling where stormwater runoff goes.^{xxvi}

Polluting Fresh Water

In the urbanized environment, paved surfaces and the systems (pipes, curbs, gutters, drains) put in place to remove water, causes stormwater runoff to move faster offsite and into combined sewer and stormwater systems. The overflow may be caught in retention treatment basins or it may be forced directly into the nearest body of water, potentially harming the environment and public health.^{xxvii}

The Michigan Department of Environmental Quality estimates that since 2008, an average of 5.7 billion gallons of untreated sewage flowed into Michigan waterways annually. In the event



Vitrified clay pipes are commonly used in municipal sewer systems, primarily gravity-flow sanitary systems (including CSO's). Clay pipes that were prominently used in the U.S. in the 1950's and '60s are nearing the end of their lifespans, and the time to choose a replacement product and system has arrived.

MUNICIPAL SEWER AND WATER
[Jitze Couperus]



(Environmental Health Perspectives)

that occurred in 2014 in the Metro Detroit area, almost 10 billion gallons of sewer overflow entered Michigan waterways in just a few days.^{xxviii}

The primary cause of point-source (from a specific outlet) pollution in our fresh water systems is from urbanized environments that discharge into the natural water bodies through municipal sewer systems and from stormwater runoff. This runoff and resulting discharge includes contamination from residential, commercial, and industrial properties.^{xxix}

In addition to the wastewater that is discharged and compromises water quality, stormwater also carries additional pollutants (e.g. oil, grease, fertilizer, sediment, and pesticides) into the sewage system and nearby bodies of water.^{xxx}

Discharging untreated combined wastewater to a natural body of water causes stress on the quality of the ecosystem and the lives of the residents that are exposed to this risk. Green infrastructure helps to alleviate the stress that severe weather has on urbanized environments and can be a valuable investment by enhancing the resilience of buildings, neighborhoods, and communities.^{xxxi}

Building Resilience

A resilient city utilizes myriad tools and resources to support and develop its capacity, security, and its potential. The working gears of a resilient city include the evaluation of possible influences and consider how to adapt, survive, and grow.

By incorporating green infrastructure and stormwater best management practices, a city can build resilience that can create value for and safeguard the assets of the individuals, institutions, and communities that reside within it.

Green infrastructure uses natural systems to slow water down, using it as a resource, conveying it in landscape amenities, and as a result reduces potable water use. Natural drainage systems mimic the flow of water, creating bayous and corridors that can serve as attractive open spaces as well as water channels, to remove water from impervious surfaces and areas.^{xxxiii}

For the development community, green infrastructure often refers to building materials and design features that can capture, retain, and slow the release of stormwater during routine and peak events, rather than traditional infrastructure components of buried pipes and centralized, end-of-pipe detention basins.

Frequently, green infrastructure reduces the need for these types of gray infrastructure elements, therefore lowering the infrastructure costs (in development and redevelopment) and sometimes provide more developable land than traditional water management solutions.^{xxxiv}

Many cities are encouraging private developers to utilize green infrastructure techniques to improve stormwater management and decrease the amount of wastewater in combined sewer systems. As the frequency of sewer overflows passes the capacity that traditional sewer systems can hold, municipal wastewater departments are looking to alternative management techniques to defray the cost of system updates and expansions.

As the architects of resilience, developers must use the development community's resources and reach to preserve the assets that make the Great Lakes region so unique. Leaders in the development industry can make the health of the region a priority by implementing best management practices in stormwater design on every site, in every city, forging the way to innovation and resilience.

WEATHER EVENTS TIMELINE IN MICHIGAN

Extreme weather events are on the rise globally, nationally, and in Michigan. This timeline highlights major climate events that have occurred in Michigan in the last decade. While definitions vary slightly, a heat wave is usually three or more consecutive days with temperatures above 90 degrees Fahrenheit. A storm is considered extreme when more than two inches of rain fall within 24 hours.

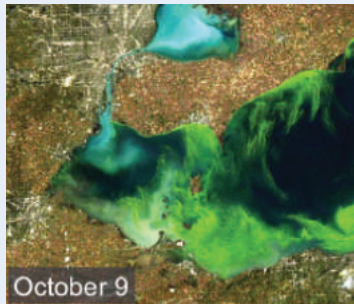
- ALGAE BLOOMS
- STORMS AND FLOODING
- TEMPERATURE CHANGE

July 17, 2006

A combination of severe winds and thunderstorms originating in the Upper Peninsula spread across the northern part of the Lower Peninsula, leaving over 270,000 residents without power. Wind gusts reached 111 mph, uprooting trees, damaging homes, and ruining the grape and cherry crops.

2011

Toxic algae, more correctly known as cyanobacteria, in Lake Erie's Western Basin made water unsafe for body contact. According to the World Health Organization, toxic levels were 1,200 times higher than the limit for safe drinking water. Toxic algae can cause rashes, vomiting, numbness and restricted breathing.



December 2013

An ice storm caused a blackout for hundreds of thousands of home for nearly two weeks. The violent storm knocked over trees and power lines across Michigan and the Northeast.

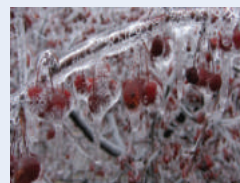


June 2008

In the wettest June to date, with up to 10 inches of rainfall in less than 24 hours in some areas, a record-breaking storm turned 11 counties into federal disaster areas. The storm killed at least eight people and over 730,000 homes experienced a blackout. In 2013 dollars, this storm caused \$16.2 billion in damage, and other states in the region suffered even worse impacts.

January - August 2012

Surpassing the mark set in 1998, 2012 becomes the hottest year on record. March 2012 stands out, as 23 different temperature records are broken in that month alone.



March - May 2012

Following an unusually warm spring, a cold snap of freezing weather destroyed 90% of the tart cherry crop, the worst year ever recorded in Michigan, with an estimated \$210 million in damages across the state.

April 2013

Three dates within the month of April exceeded two inches of rainfall in a day. In Grand Rapids, the Grand River rose nearly two feet above its previous record level in 1985. The river did not breach the flood wall, but 435 million gallons of partially-treated sewage entered the river. Some 700 people were evacuated, and the mayor declared a state of emergency.



(Weather Events Timeline graphical depiction courtesy of Land Information Access Association (LIAA). Original graphic can be viewed in the Planning For Resilience in Michigan handbook: www.resilientmichigan.org/handbook.asp)

Summer 2014

Considered one of the most serious public health disasters of 2014 in the Midwest, an algae bloom in Lake Erie left 400,000 people across Michigan and Ohio without drinkable water. Algae blooms are partially caused by warmer waters.

August 2014

A storm swamped Detroit with 6 inches of rainfall in just 8 hours, causing \$1.8 billion in damages, flooding the metro region and resulting in a federal disaster declaration.

November 2015

The largest algae bloom yet in Lake Erie; it was the size of New York City.

Summer 2016

The hottest summer on record in Metro Detroit. Although it didn't set the record for the number of 90-degree days, it was consistently hot throughout the summer, with 12 days of 90+ degree weather.

Winter 2013-2014

In the winter of the "polar vortex," temperatures dipped considerably below average. The Mayor of Lansing issued a snow emergency that prohibited non-essential travel. In February, daily record lows were set in Gaylord (-29°F), Flint (-16°F), Grand Rapids (-12°F), and Newberry (-41°F).

August 2015

Severe storms hit northern Michigan with hail the size of a softball, the largest hail ever documented in the state. With winds up to 80 mph, thousands of trees were uprooted and power lines were downed.



December 2015

A tornado touched down in Canton, the first tornado to strike in the winter months. Unseasonably warm air combined with strong winds enabled the tornado to develop very quickly, with little time to issue a warning.

August 2016

Six tornadoes hit western Michigan, five of which from one storm. Two of the tornadoes were rated EF-1, with the maximum wind speeds ranging between 90-100 mph. At 50-100 yards wide, these tornadoes were larger than usual and caused considerable damage.

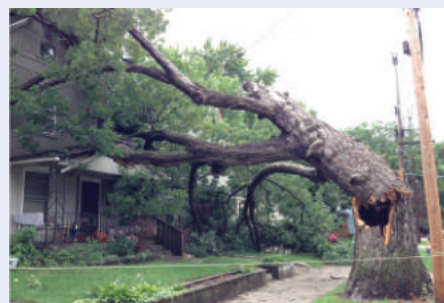


Photo sources (from left to right): 1. http://www.huffingtonpost.com/2014/08/04/lake-erie-algae-bloom-2014-_n_5647824.html 2. http://www.disclose.tv/action/viewvideo/228621/northern_hemisphere_crop_losses_spring_2016_cherry_80_apricot_60_wheat_6_and_more/ 3. <http://interactives.woodtv.com/photomojo/gallery/6944/136725/mid-april-storms-cause-flooding/division-avenue/> 4. <https://consumersenergyinyourcommunity.wordpress.com/2013/12/22/ice-storm-results-in-thousands-of-power-outages-across-michigan/> 5. <http://www.weather.gov/apx/2015Aug2recap> 6. <http://www.freep.com/story/news/local/michigan/2016/08/20/tornado-strikes-grand-rapids-extensive-damage-reported/89051482/>

Dollars and Sense

Financial Incentives for Green Infrastructure

The business case for stormwater management for the developer produces decreased costs of municipal water use, lowered risk of business-disrupting storm events, and lower insurance premiums because of mitigation steps taken by the developer.

When a private developer makes green infrastructure investments, the benefits reach far beyond the property line. By retaining and treating stormwater on-site, developers are decreasing the strain on the public sewer system and reducing the flood risk for themselves and their neighbors, creating a symbiotic public-private partnership.

Where stormwater systems have reached capacity, reduced costs and increased benefits are measured in decreased fees, rates, and charges. Monthly, per-acre charges can be reduced through the implementation of green infrastructure techniques that utilize a variety of tools.

Some communities with combined sewer systems have increased drainage fees and “sewer rates” to raise funds to upgrade their infrastructure. In cities across the country, more than 1,400 local jurisdictions have implemented new drainage charges and increased sewer rates to generate income to improve outdated systems, prevent wastewater overflows, and manage stormwater runoff.^{xxxix}

Property owners can mitigate these charges by taking part in capital improvement credit programs for green infrastructure projects, applying for project installation grant dollars from nonprofits and foundations whose mission it is to protect the local resources, and in some cities, by participating in credit-trading or tax credit programs.^{xl}



Kresge Foundation

(Kresge Foundation)

POTENTIAL GREEN INFRASTRUCTURE BENEFITS

- Improved water quality.
- Reduced municipal water use.
- Ground water recharge.
- Flood risk mitigation.
- Increased resilience to climate change impacts such as heavier rainfalls, hotter temperatures, and higher storm surges.
- Reduced ground-level ozone.
- Reduced particulate pollution.
- Reduced air temperatures in developed areas.
- Reduced energy use and associated greenhouse gas emissions.
- Increased or improved wildlife habitat.
- Improved public health from reduced air pollution and increased physical activity.
- Increased recreation space.
- Improved community aesthetics.
- Cost savings.
- Green jobs.
- Increased property values.

Source: United States Environmental Protection Agency, Office of Sustainable Communities, *Enhancing Sustainable Communities with Green Infrastructure* (2014).



Ford Rouge Plant

(Flickr Randy Stern)

Often the cheapest, quickest, easiest way to decrease pressure on existing stormwater infrastructure is to reduce the amount of stormwater flowing into the system. Private developers (given the right incentives) can significantly reduce pressure on cities stormwater infrastructure, often at a cost that is far less than expanding the cities stormwater and water treatment infrastructure.

In many communities, developers are rewarded for their investment. While cities promote and encourage green infrastructure implementation, more often incentives are jointly offered to the private sector real estate developers for the use of green infrastructure tools and techniques.

DEVELOPMENT INCENTIVES Cities can offer expedited permitting, decreased fees, and/or reduced stormwater requirements to developers implementing GI.

TAX CREDITS Offered for one or more years and usually capped at an amount or percentage of the cost of materials and installation, tax credits decrease the overall cost of implementation.

REBATES Communities seeking to meet precise stormwater goals may offer rebates for specific GI measures, such as amount of runoff captured. Applicants are screened and projects are monitored to track progress.

GRANTS Some municipalities maintain a fund to offer grants to private entities for GI measures. Grant amounts are often determined by the amount of stormwater captured.^{xii}

Returns on Green Investments

By incorporating innovative stormwater management measures into projects, developers can realize both cost savings and increased earnings. Green infrastructure can reduce capital and operational costs, create long term value, improve user experience, and differentiate GI products in the market.

Investing in green infrastructure provides developers with an invaluable public benefit by helping municipalities to reduce the strain on outdated and overwhelmed stormwater systems. Beyond the range of environmental, social and aesthetic benefits, green infrastructure offers many substantial, quantifiable financial benefits.

Savings

The alternative to gray infrastructure that traditionally exists in our cities, green infrastructure has an increasingly positive effect on the real estate market rates and property values, municipal wastewater systems, the overall quality of life, and the health of the local environment.^{xliii}

As detailed in the companion report to this document, *Harvesting the Value of Water*, Philadelphia, New York City, and decision makers in Idaho and North Carolina determined that alternative stormwater management strategies would save their communities billions compared to gray infrastructure plans that included tunnels, pumps, and storm drains.

Detroit's Stormwater Drainage Fees

When first introduced, the Detroit Water and Sewerage Department (DWSD) planned to charge a drainage fee of \$750 per impervious acre, per month for non-residential properties. Customers could reduce the drainage fee up to 80 percent by implementing green infrastructure measures and reducing stormwater flow into the DWSD combined sewer system.

For a property with one acre of impervious surface, green infrastructure can reduce the monthly bill to \$150/month, saving \$7,200/year and giving that developer an edge on the competition by providing sustainable "green" amenities in their immediate environment.¹





Green roof on historic restoration in New Center district, Detroit
(Trisha White)

For the developer, benefits can include cost savings in design and construction, retrofitting already built and established developments, and particularly through the life-cycle of a project, when compared to the maintenance, update, or replacement of gray infrastructure systems. Lower upfront and maintenance costs can also make green infrastructure more accessible, resilient, and cost-effective than large-scale gray infrastructure investments.^{xliii}

REDUCED PERMITTING TIME AND CHALLENGES

Throughout this research, due to the reduced impact on the environment and public infrastructure, many developers could see decreased review periods, fewer design revisions, and less time waiting for permits. In a recent study conducted by the American Society of Landscape Architects, a review of 479 case studies found that 88 percent of the green infrastructure projects were supported by local regulators.^{xliv}

REDUCED CONSTRUCTION COSTS

Conventional stormwater and wastewater management systems are expensive. Using measures that take advantage of the natural drainage and infiltration assets on-site has been shown to often cost less than man-made drainage infrastructure and other stormwater management facilities.

REDUCED OPERATING AND MAINTENANCE COSTS

Perhaps the greatest cost savings are reduced operational and maintenance costs over time. Green infrastructure can help bring down utility costs. Depending on the materials and tools used, developers can reduce the life-cycle costs of green infrastructure products. The maintenance required for green infrastructure systems is lower than that for conventional landscapes that require frequent mowing, fertilizing, weeding and watering.

Green roofs extend the timeframe for replacement of traditional roofing products (20-year traditional life-span v. 40-year green), as well as lower the overall cost of heating, ventilating and air conditioning needed in these buildings.^{xlv}

While permeable pavers may carry a greater initial cost, studies have shown that compared with asphalt, and when whole paving installation and systems (e.g. drains, reinforced-concrete pipes, catch basins, outfalls, stormwater connections) are included in the cost analysis, there is a lower overall life-cycle cost.^{xlvi, xlvii}

By capturing stormwater on-site and reducing runoff into the public system, owners can reduce the stormwater drainage fees where assessed and tools like rain barrels and cisterns decrease costs of landscape irrigation, and other non-potable water uses.^{xlviii}

Since most stormwater fees are based on the amount of impervious area on a property, green infrastructure practices reduce impervious surface area and runoff, thereby leading to a reduction in drainage fees. Additionally, by lessening the burden on city stormwater systems, therefore reducing the long-term costs of local governments and taxpayers, individual payers can cut costs through reduced utility fees.^{xlix}

REDUCED FLOOD DAMAGE LOSSES

By incorporating green infrastructure, projects are likely to enjoy greater resilience to heavy rainfall and peak weather events. As such, GI projects can expect lower costs associated with localized flooding such as reduced property damage and cleanup costs after storms.^{li}

Earnings

Attractive landscaping, abundant tree cover, or green streets are factors that contribute to an increase in consumer spending, more frequent visits, and further travel to destinations. Customers indicate that within an area of a mature tree canopy, they are willing to pay 8 to 12 percent more in urban business districts and strip malls.^{lii}

With the addition of landscaping improvements and green infrastructure features, residential property values have been estimated to see increases from 2 percent to as much as 7 percent, while one study showed that green roofs could add up to 16 percent to the average rental rate for multifamily units.^{liii}

INCREASED PROPERTY VALUE

Green infrastructure does double duty; not only does it manage stormwater, it looks good while doing it, and attractive landscaping increases property value. Residential property values with green infrastructure landscaping have been found to increase by as much as 7 percent.^{liv}

The market exacts a premium for sustainable features. Green infrastructure helps commercial buildings attain eco-labeling certifications such as Leadership in Energy and Environmental Design (LEED) and EnergyStar, both shown to increase property values, occupancy rates in office buildings, and rental rates in residential buildings.^{lv}

INCREASED RENTS

Many of the same amenities that increase property values – landscaping, energy efficiency, eco-labeling – increase occupancy rates and rents in commercial buildings. One study found

Curb cuts allow stormwater to easily drain into rain gardens and bioswales. With dense vegetation, absorbent soils, and underground storage capacity, these installations help treat stormwater and prevent flooding of homes and streets.

(Center for Neighborhood Technology)





Permeable Pavers
(Sam Beebe)



Permeable Alley
(Plannerd)

that high-quality landscaping added as much as 7 percent to the average rental rate for office buildings.^{lvii}

Increased revenue for retail tenants can then translate into rental premiums for retail building owners that provide green infrastructure amenities.

INCREASED MARKETING OPPORTUNITIES

Properties with enhanced landscape and recreational appeal, better social and environmental conditions can differentiate themselves in the market as sustainable, eco-developments or communities.^{lvii}

INCREASED PLACEMAKING AMENITIES

Green infrastructure improves community aesthetics but is also functional as a focal point for placemaking. By increasing

recreation and outdoor meeting spaces, GI features offer a sense of place that boosts community cohesion and quality of life.


INCREASED QUALITY-OF-LIFE BENEFITS

Additional benefits, which are sometimes hard to quantify, are also present when green infrastructure is put into commercial and residential environments. Landscaping, water features, green and open areas, and outdoor recreation areas add property value benefits by improving the urbanized aesthetic and community livability.

Research has shown that office workers will have improved health and job satisfaction, and reduced levels of stress when there is nature near their work environment. Other landscaping features, if designed appropriately, can improve the safety and security in urbanized environments with high levels of vegetation, specifically when they provide places for people to gather.^{lviii}



Toronto City Hall Green Roof
(Flickr Padraic)



The Environmental Protection Agency (EPA) analyzed the economic benefits of GI through a look at 13 case studies across the U.S. Considering the weighted perceptions that are often associated with green infrastructure developments, the EPA addressed some of the most common concerns that are expressed when evaluating economic benefits.

Perception: The up-front capital costs associated with low-impact development/green infrastructure (LID/GI) are often more than those associated with traditional infrastructure.

Reality: In some cases, entities found the capital costs required for LID/GI approaches, or mixed green/gray approaches, *to be less than the capital costs required for traditional gray infrastructure*. Furthermore, when life-cycle costs (including capital, operation and maintenance, and replacement costs over time) are taken into account, *cost savings compared to traditional infrastructure can be even more significant*. In addition, communities are finding that even when the capital costs are higher—for example, in urban areas with no land available for infiltration—the associated benefits that accrue from the implementation of LID/GI practices often provide the value to justify adoption of these practices.

(United States Environmental Protection Agency, Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure Programs 2013.)

Cost Benefit Analysis

The Green Learning Curve

As a stormwater management technique, green infrastructure (GI) has been used in a wide variety of developments since the 1990s. Sometimes regarded as expensive or eccentric, green infrastructure practices have yet to become standard practice in the same way that fire safety or HVAC standards are for developers.

This chapter provides more detail in calculating the costs and benefits of green infrastructure, and finds the most cost-effective strategies that can deliver the best ROI to move green infrastructure from innovative ideas to business-as-usual practices. Developers will get a sense of costs and will have a perspective into how much can be saved and earned, from green infrastructure projects.

When thoughtfully executed, an investment in stormwater management can lower construction and operational costs, reduce permitting burdens, and increase the value and marketability of properties while providing environmental and aesthetic assets for clients and community.

How to Choose Green Infrastructure (GI) Tools

Green infrastructure isn't a one-size-fits-all practice. Depending on a developer's goals, green infrastructure offers a variety of tools that can be customized to meet the unique needs of the site or project. From new construction to renovation, from small to large scale, and from structural to nonstructural solutions, there are green infrastructure tools and techniques for any project and every budget.

DETERMINE HOW TO INCORPORATE GI:

- **What is required by law?** GI most likely won't affect the ability to meet regulations and building codes, but with more communities developing GI standards and requirements, it's important to always confirm with municipal codes and design standards.
- **What assets and constraints occur on the site?** Site evaluation includes soil type, slope of landscape, amount of impervious surface and any opportunities for eliminating, reducing, and disconnecting directly connected impervious surfaces.



(Cawrse Associates)

- **What is the budget?** GI tools, techniques, and solutions come in many different shapes, sizes, and costs. A limited budget should not preclude developers or property owners from GI implementation.

GI CAN BE INCORPORATED INTO EVERY PROJECT, FROM NEW CONSTRUCTION TO RETROFIT.

Different types of GI are suitable for projects ranging from urban infill to lower-density (such as masterplanned suburban residential). Additionally, green infrastructure tools can be designed and implemented in new construction projects and can be used to retrofit existing structures built with insufficient stormwater management. For example, new construction would be designed to support any additional weight of a green roof, while for existing structures, structural engineers can determine if the rooftop can support the additional load.

GI CAN BE INCORPORATED INTO EVERY PROJECT, FROM SMALL TO LARGE SCALE.

Simple disconnection – detaching gutter downspouts and redirecting stormwater runoff into a lawn, raingarden or bioretention area – is often the simplest and least expensive option for treating stormwater runoff. Larger projects may include everything from green roofs to massive underground stormwater vaults.

GI CAN BE INCORPORATED INTO EVERY PROJECT, FROM LANDSCAPING TO STRUCTURAL.

Landscape systems incorporate plantings at the ground level and can be customized through various designs on a variety of scales. Structural practices include porous pavement, green roofs, cisterns, and subsurface tanks.

What Does Green Infrastructure Cost?

Because each green infrastructure project will be unique, designed specifically for each site, estimating direct or proportional cost comparisons between innovative stormwater management and conventional is problematic. As with all development projects, costs are extremely variable and can be affected by everything from soil type to contractor experience.

The range of costs and types of green infrastructure techniques allows the developer to tailor solutions that meet individual needs and budgets. With investment estimates and online calculators, developers can determine where investments can be best made to stay within the budget.

Calculators

While there is tremendous value in professionally detailed estimates, a tool doesn't yet exist that considers various landscapes, technique options and policy restrictions in a wide range of communities. For general cost estimates and pricing that can be transferred to areas outside of the considered areas, online tools are available.

The National Green Values Calculator from the Center for Neighborhood Technology (CNT) is a comprehensive and accessible resource to evaluate sustainable design opportunities based on extensive research on the long-term costs and benefits of green infrastructure approaches.

A simple, user-friendly web interface invites users to enter site specific information. The calculator estimates construction, operation, and maintenance costs, as well as runoff volume and environmental benefits. CNT cautions that while results are accurate estimates, they are not a substitute for formal design and engineering assessments.^{ix}

The Rainwater Rewards Green Infrastructure Benefits Calculator was developed by West Michigan Environmental Action Council (WMEAC), Grand Valley State University (GVSU), and Michigan Tech Research Institute (MTRI) with funding from the US Forest Service (USFS) and Great Lakes Restoration Initiative (GLRI). This web-based calculator estimates baseline runoff, the reduced runoff after the adoption of GI, and the net economic benefit of those systems.^{ixi}

THE AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS (ASLA) COLLECTED 479 CASE STUDIES OF GREEN INFRASTRUCTURE PROJECTS AND FOUND THE FOLLOWING BREAKDOWN OF COSTS:

- \$100,000–\$500,000 — 29.2%
- \$1,000,000–\$5,000,000 — 22.1%
- \$500,000–\$1,000,000 — 13.2%
- \$50,000–\$100,000 — 12.9%
- \$10,000–\$50,000 — 12.1%
- <\$5,000,000 — 7.0%
- \$10,000 — 3.5%

*percentages are based on total number of case studies considered and the category of total incurred costs.

SOURCE: American Society of Landscape Architects, "Stormwater Overview" (accessed June 6, 2017), www.asla.org/stormwateroverview.aspx.

GREEN VALUES STORMWATER MANAGEMENT CALCULATOR

Calculator FAC Meteorology Feedback

Green Interventions:

- Roof Drains to Rain Gardens at All Downspouts
- Half of Lawn Replaced by Garden with Native Landscaping
- Porous Pavement used on Driveway, Sidewalk and other non-street pavement
- Green Roofs
- Provide Tree Cover for an Additional 25% of Lot
- Use Drainage Basins instead of Stormwater Pipes

Site Statistics:

- Select a scenario: New Development, Suburban
- Is this an existing site? (Exclude in construction costs included)
- Total size of site: 40 acres
- Number of lots: 80
- Average Roof Size, including Garage: 1200 sq ft
- Average Number of Trees on Lot: 0
- Average Driveway Area: 400 sq ft

RESULTS

The difference between the conventional system and the green intervention(s) you chose decreases the total 100 year life cycle costs and increases benefits by \$1,277,400! This strategy reduces peak discharge by 28%.

Compare Use to No intervention

Hydrologic	Financial	Financial Detail	Benefits Detail
Hydrologic Results			
Lot Level Improvements:	Conventional	Green	Reduction
Lot Discharge (cf)	1,908	1,328	33.3%
Lot Peak Discharge (cfs)	0.48	0.34	37.4%
Total Site Improvements:	Conventional	Green	Reduction
Total Peak Discharge (cfs)	66.75	41.08	27.7%
Discredit Run Interventions:	Conventional	Green	Reduction
Total Detention Required (ft)	146,908	99,078	49%
Annual Discharge Improvements:	Conventional	Green	Average Annual Ground Water Recharge Increase
Average Annual Discharge (acre ft)	43.07	31.02	7.04

Rainwater Rewards green infrastructure benefits calculator

WMEAC about this tool

1. CHOOSE LOCATION

Enter ADDRESS -OR- Click on MAP -OR- Select NEIGHBORHOOD TYPE

2. ADD GREEN INFRASTRUCTURE

Select type...

3. VIEW SUMMARY



View of the Renaissance Center from the green roof on the Coleman A. Young Municipal Center in downtown Detroit (Trisha White)

GREEN INFRASTRUCTURE AND WATER MANAGEMENT STRATEGIES

Many of today's stormwater policies encourage or require a range of water management and green infrastructure strategies. Real estate developers who are conversant with the full suite of options will be able to leverage the tools most beneficial to their work. Key green infrastructure tools include the following:

Bioswales

Green areas that are similar to rain gardens, bioswales are used to reduce stormwater runoff through infiltration, storage, or both. However, unlike rain gardens, bioswales are designed to manage runoff from a large impervious area like a parking lot or street. Bioswales are deeper than rain gardens and often require engineered soils that can filter and handle larger stormwater flow rates.ⁱ



(© Aaron Volkering, Flickr)

Blue roofs

Blue roofs are designed to store rainwater within detention systems on roofs, thus preventing stormwater from initially entering the sewer system after a storm.

Cisterns

Large storage facilities, often built below ground, at ground level, in parking facilities, or on rooftops, cisterns store stormwater, often for reuse.



(Trisha White)

Curb cuts

A curb cut is part of a street curb removed to connect the street level with another surface, often a stormwater management or green infrastructure mechanism that can absorb water in place of the traditional drainage system.



(© Center for Neighborhood Technology, Flickr)

Green roofs

Green roofs use rooftop vegetation to absorb rainwater and heat. In addition to managing stormwater and cooling surrounding ambient air, green roofs help decrease energy needs for the building and improve overall air quality.ⁱⁱ



(© Joyfnp/Stock)

Permeable surfaces

Permeable surfaces include porous asphalt, porous concrete, and porous interlocking paving bricks that allow flowing water to infiltrate through the surface into the ground below. Permeable surfaces can be used for sidewalks, parking lots, alleys, and streets and have cooling properties caused by their reduced heat storage compared to regular pavement.ⁱⁱⁱ The porous asphalt, concrete, and interlocking paver industries offer design and installation credentialing programs.



(© Gdoalf/Stock)

Rain gardens

Rain gardens are small plots of vegetation that are designed to reduce stormwater runoff through infiltration, storage, or both. They are typically placed where stormwater naturally flows and are commonly incorporated in other landscape designs or streetscapes.^{iv} In parts of the country where soils do not allow natural infiltration because of their clay content, underdrains or pipes can send cleaned water into nearby creeks, bayous, or storm sewers.



(© Chris Hamby, Flickr)

Rainwater harvesting

Rainwater harvesting is the collection and storage of rainwater in containers; the water is then released into the stormwater management system or desired location for filtration. Rainwater harvesting systems can be created on a small scale, for example, by using roof downspouts, or on a large scale, depending on the needs of the stormwater management system.



(© Kodachrome25/Stock)

Stormwater vaults

This type of detention basin or subsurface facility, commonly made of concrete, steel, or fiberglass, manages stormwater in an urban setting.



(© Arbitrarily0)

Tree pits

Tree pits perform like small reservoirs, capturing and purifying runoff that flows into the uncompacted soil, which then diverts the water into a stormwater management system.^v

The following frameworks for real estate development and design advocate for many of the preceding green infrastructure tools:

- **Low-impact development (LID):** A land planning and design approach that emphasizes mimicking natural system processes to store, infiltrate, retain, and detain precipitation and rainfall as close to its source as possible; and
- **Stormwater best management practices (BMPs):** Methods that have proven to be the most effective, practical means of preventing or reducing pollution from a source that needs to be controlled, such as stormwater runoff.^{vi} BMPs provide a basis for estimating the performance, costs, and economic impacts of achieving management quotas and policies.

i. Soil Science Society of America website, "Rain Gardens and Bioswales," <https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure/important-terms/rain-gardens-bioswales>.

ii. Georgetown Climate Center, *Green Infrastructure Toolkit*, www.georgetown-climate.org/adaptation/toolkits/green-infrastructure-toolkit/green-infrastructure-strategies-and-techniques.html.

iii. Soil Science Society of America, "Rain Gardens and Bioswales."

iv. Ibid.

v. Lisa Nisenon, *Using Smart Growth Techniques as Stormwater Best Management Practices* (Washington, DC: U.S. Environmental Protection Agency, 2014), <https://www.epa.gov/sites/production/files/2014-04/documents/stormwater-best-management-practices.pdf>.

vi. Ibid.

Is Green Infrastructure More Expensive Than Gray Infrastructure?

The American Society of Landscape Architects (ASLA) collected 479 case studies of green infrastructure projects across the United States and Canada. They found 44 percent of the projects saw a decrease in costs by using green infrastructure, 31 percent showed no difference and just 25 percent had higher upfront costs. Even when the initial investment in green infrastructure is higher, developers may find that long-term financial benefits compare favorably with conventional methods.^{lxii}

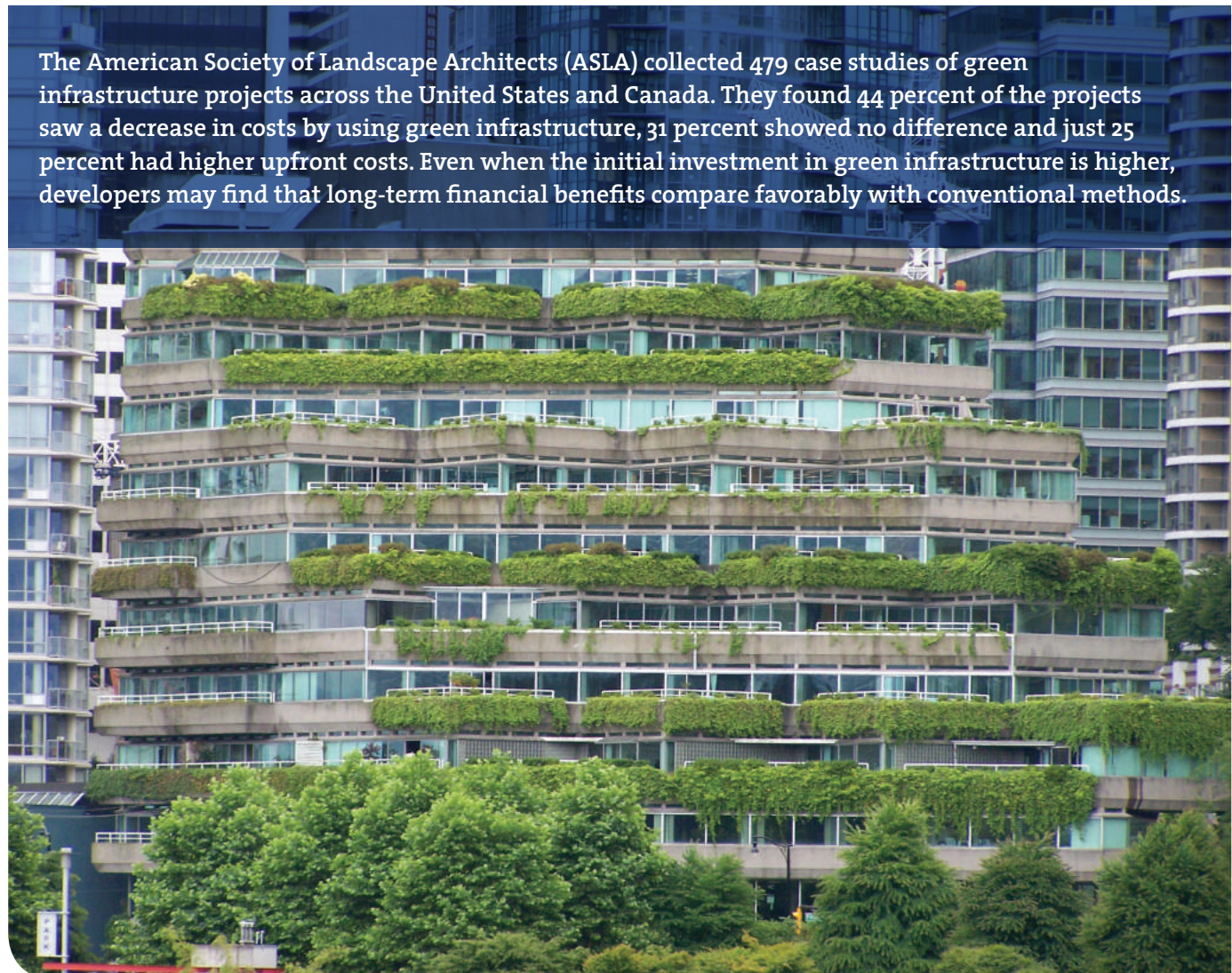
Prairie Glen, a 39-acre development in New Hampshire found construction costs lower using green infrastructure. First, they maintained the site's naturally occurring drainage topography, protected the 4.2-acre wetland and set aside 23 acres of open space. A side-by-side analysis of conventional versus green

costs shows lower costs for green infrastructure in all but one category, landscaping. Overall, conventional costs were estimated at \$1,758,385 while the green options were \$1,194,621, a 32 percent cost savings at the construction stage.^{lxiii}

In the Montreal suburb of Vaudreuil-Dorion, officials planned an eco-sustainable development close to the urban perimeter of the city that would protect the city's greenbelt. Estimates showed that green infrastructure would increase capital costs 11-29 percent over conventional design. However, those upfront cost differences were eclipsed by the 15-27 percent increases in property values due to the green market premium.^{lxiv}

While exact cost lists for green infrastructure tools/techniques are unavailable, true costs based on actual projects and estimates for products are featured on the page to the right.

Residential building in pyramidal form with green infrastructure, Vancouver, B.C.
(NNECAPA Photo Library)



The American Society of Landscape Architects (ASLA) collected 479 case studies of green infrastructure projects across the United States and Canada. They found 44 percent of the projects saw a decrease in costs by using green infrastructure, 31 percent showed no difference and just 25 percent had higher upfront costs. Even when the initial investment in green infrastructure is higher, developers may find that long-term financial benefits compare favorably with conventional methods.

GREEN INFRASTRUCTURE TOOLS/TECHNIQUES POTENTIAL COSTS

TOOL	DEFINITION	EXAMPLE OR ESTIMATED COST	SOURCE
Bioswale	A green infrastructure technique that captures stormwater runoff from a large impervious surface in sloped vegetated area. Slopes usually use native species and allow the water infiltrate into the ground slowly.	Grand Rapids Benefit-Cost Analysis, 2017 \$24.02/sf Ohio EPA Cost Summary, 2011 Average: \$16.25/sf Range: \$2.75 – 41.95/sf	Cawrse & Associates, Chagrin Valley, Ohio \$21,000: \$42 LF Cost includes vegetation, planting, soil mix, soil stabilization, rock and earthwork Pepper Pike - \$57/LF – 800 LF of Bioretention Installed by City Service Department Project total \$45,000
Cistern	A large storage facility, often built below ground, at ground level or on rooftops that stores stormwater.	1,700 gallon underground cistern \$1,567.00 5,000 gallon water storage tank \$1,900	Plastic Mart (internet search 5.10.2017) National Tank Outlet (internet search 5.10.2107)
Curb Cut	A part of a street curb removed to connect the street level with another surface often a stormwater management or green infrastructure mechanism that can absorb water in place of the traditional drainage system.		
Green roof	A green infrastructure technique that uses rooftop vegetative plantings to absorb rainwater and heat, in addition to improving air quality and decreasing energy needs for the building below.	Grand Rapids Benefit-Cost Analysis, 2017 \$9-20/sf plus installation costs of \$3/sf Ohio EPA Cost Summary, 2011 Average: \$14.35/sf Range: \$4.66 – 29.00/sf	
Permeable surface	Engineered porous paver, concrete, or asphalt that allows runoff to filter through strata and into a drainage system or directly into the aquifer.	Grand Rapids Benefit-Cost Analysis, 2017 \$14/sf Ohio EPA Cost Summary, 2011 Average: \$14.35/sf Range: \$4.66 – 29.00/sf	Cawrse & Associates Parking Lot and Drive: \$72,000 • Paver system, earthwork, excavation, curb, soil borings • Pavers: \$7-8/SF - product, stone and labor Top Gun Supply Chester Township – Approximately 15,000 square feet of pavers – Installed for approximately \$5.00 square foot
Rain garden	A small vegetated area designed to be located where stormwater naturally flows, which captures and infiltrates runoff into the ground. It is a commonly used green infrastructure technique in landscape and streetscape design.	Grand Rapids Benefit-Cost Analysis, 2017 \$6.79/sf for porous asphalt Ohio EPA Cost Summary, 2011 Average: \$13.53/sf Range: \$3.80 – 26.00/sf	Cawrse & Associates Rain Garden: \$8,600 • \$26.87/SF • Vegetation, planting, earthwork, and soil mi
Rainwater harvesting	A green infrastructure technique that collects and stores rainwater for future use.	Average cost of rain barrel, 2017 \$102.85	45-55 gallon rain barrels, costs averaged from True Value, Lowe's and Home Depot (internet search, 5.10.2017)
Stormwater vault	A type of detention basin, this subsurface facility commonly made of concrete, steel, or fiberglass, manages stormwater in an urban setting because of its ability to capture large quantities of water.	Average cost of rain barrel, 2017 \$102.85	Grand Rapids - Plainfield Islands bioretention project, 2105. Seven bioretention islands in street medians, tree pits, raingarden, underground tank, 2.2 acres \$328,000 or \$55.12/sf
Tree Pit	A commonly used green infrastructure technique that collects stormwater runoff, particularly in urbanized areas where space is limited, and diverts stormwater into the sewer system or subsoil.	Ohio EPA Cost Summary, 2011 Average: \$1,317.08/sf Range: \$501.75 - \$3200/sf	

Sources:
Grand Rapids Benefit-Cost Analysis, 2017. Grand Valley State analysis of the benefits and costs of stormwater management.
<https://wmeac.org/wp-content/uploads/2017/01/Stormwater-document-17Aug6.pdf>

Ohio EPA Cost Summary, 2011. Details from bids from 8 projects in Chagrin River watershed communities.
http://epa.ohio.gov/Portals/41/storm_workshop/lid/CRWP_LID_Cost%20Study.pdf

Beyond Compliance

The Great Lakes freshwater system is the largest in the world. Although water as a renewable, yet limited, natural resource is widely undervalued, for centuries people have settled near water sources for agriculture, transportation, and commerce. While cities harvested water from these natural bodies to sustain the local residents and industry, they also polluted this resource. What was once acceptable practice is not today, as increased population, deferred maintenance, and issues associated with water pollution grow. Overhauling this system will be incredibly expensive and take a really long time.

The good news is that cities, working with developers, can ease the pressure on this system, and do it in a way that is cheaper, quicker, and more effective than trying to build out more centralized stormwater and water treatment infrastructure. They can also avoid some of the costs and major disruptions associated with major storm events.

Unfortunately, large rain events in many Great Lakes cities still causes raw sewage and untreated wastewater to be released into our rivers, streams, and lakes due to the insufficient capacity of combined sewer systems. And while municipalities are making efforts to mitigate these present capability disparities, the private real estate and development community has an important role to play.

It is not only the responsibility of the city but also of the property owner to take strides to managing the flow of surface

REGIONAL PARTNERSHIP

The city of Detroit's Water and Sewerage Department (DWSD) manages water and sewer utilities for a city of almost 680,000 residents comprising more than 200,000 Detroit residential and commercial accounts. The Great Lakes Water Authority (GLWA) and DWSD reached a lease agreement that began on January 1, 2016, providing GLWA with control of regional water, sewer, and wastewater infrastructure and facilities. Although the regional assets still belong to DWSD, the agreement generates funding and oversight of the replacement and rehabilitation of the aging water and sewer system.

The Authority assumes the operation and control of the Detroit water and sewerage systems supplying wholesale customers across the region while the DWSD will retain responsibility for maintaining and repairing infrastructure within the City limits.

Serving 127 municipalities in 7 southeast Michigan counties, the Detroit water system and the greater regional system provides water services for nearly 40 percent of water customers in Michigan. But providing water is only part of the immense regional water system. Seventy-six communities discharge sewage into regional interceptors that

filter through a single wastewater treatment plant, pumping stations, and combined sewer overflow retention treatment basins.^{lxviii}

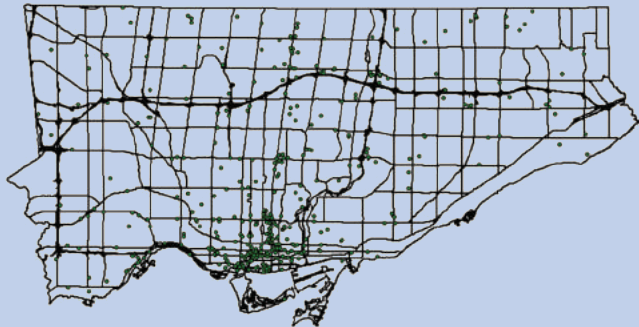


Detroit Water and Sewerage Department Sewer Cap
(Michael Kumm)

STORMWATER POLICY TOOLS

On-site water retention requirements	These policies require developments over a certain size threshold to capture a specific minimum volume of water on site, typically measured by inches of rain or percentage of a certain type of rain event.
Credit-trading schemes	Credit-trading schemes, such as the innovative new policy in Washington, D.C., offer real estate developers the opportunity to adhere to on-site mitigation policies or purchase credits from other sites that have voluntarily complied with the requirements.
Green area ratios	Green area ratios encourage the layered use of different stormwater mechanisms through the use of a score-based tool that requires a certain percentage of a site to be covered by green infrastructure, with different points awarded to different interventions.
Frameworks and design guidelines for low impact development	This largely bottom-up, market-driven approach offers developers the tools to use the LID approach for their projects, providing resources such as guidebooks, development incentives, and expedited permitting. LID refers to systems that mimic natural processes to manage water and protect water quality.
Stormwater fees	Stormwater fees are charged based on the amount or percentage of impervious surface on a site, encouraging the incorporation of impermeable or green surfaces. Sites that put larger burdens on the public drainage systems are required to contribute more.
Development incentives	Development incentives for green infrastructure have included FAR bonuses, tax abatements, and rebates.
Implementation of total maximum daily loads (TMDLs)	Calculated in watersheds discharging too much pollution, TMDL refers to the maximum amount of a pollutant that a body of water can receive while adhering to water quality standards. Reducing the volume of runoff from a development directly reduces the pollutant load and can help achieve the required pollutant load reduction.
Community grant programs and design competitions	Cities have sought to generate new ideas about green infrastructure and to inspire innovation through ideas competitions aimed at the design community. Community grant programs have supported citizen-led stormwater management and community greening projects.
Monitoring and open data programs	Green infrastructure is one of the many topics that can be analyzed through open data platforms, with cities releasing green infrastructure data to gain insights on effectiveness and performance.
Toolkits for households	Beyond policies affecting large-scale residential, mixed-use, commercial, and office development, cities have introduced policies, toolkits, and incentives to encourage private homeowners to make small-scale, low-cost alterations to their properties to reduce impervious surfaces.
Demonstration projects	Numerous municipalities have shown their commitment to green infrastructure by initiating demonstration projects in the public realm intended to spark discussion and inspire private sector action.

GREEN ROOFS IN THE CITY OF TORONTO



stormwater through effective policy. When the development community advocates for good policy and actively participates in the resilience of the city, communities are positively affected. **When communities are positively affected, they thrive. When communities thrive, developers thrive.**

Who Regulates What?

Before the Clean Water Act (CWA), was enacted in 1948 and the Federal Water Pollution Control Act Amendments of 1972 were adopted, wastewater (including raw sewage), and pollution of all kinds (e.g. commercial, industrial, agricultural) were often dumped into lakes, rivers and coastal waterways all across the country.

Creating the basic structure to regulate pollution discharges and quality standards for surface waters in the United States, the CWA also set wastewater standards for industry and made it illegal to discharge any pollutant unless a permit is obtained.^{lxxix}

Under the purview of the United States Environmental Protection Agency (EPA), as created by the Clean Water Act (CWA), the National Pollutant Discharge Elimination System (NPDES) permit program controls stormwater and wastewater discharges and is mainly enforced at the state level. Permits are obtained by any facility that discharges directly into U.S. waterways, however, combined sewer discharge permits are specifically applied for by municipalities.

What Are the Standards and Expectations?

In 1994, the EPA issued the Combined Sewer Overflow (CSO) Control Policy, the national framework for control of CSOs, mandating that communities eliminate or reduce their CSOs to improve sewage systems and reach Clean Water Act goals. This policy also required communities to develop CSO Long-Term

Control Plans (LTCP) to chart the course of major sewer system construction activities and implementation of enforceable CSO controls.^{lxxx}

According to the Environmental Protection Agency and the NPDES permitting process, success is measured when unregulated sewage overflows cease to exist or are minimized to a permitted limit. In Detroit, Michigan's largest city, there has been significant progress made in implementing the Long-Term Control Program that was first submitted in 1996, resulting in a 1997 NPDES permit.^{lxxxi}

In addition to the four management practices mentioned in chapter 2, the long-term control program elements being implemented in Detroit include 6 retention/treatment basins, 3 screening/disinfection facilities, and 13 storage dams in the collection system sewers for temporary storing and transport of combined flow to the wastewater treatment plant.^{lxxxii}

In 2014 a green infrastructure plan was created for north-west Detroit that proposed green infrastructure practices for 17 specific outfalls along the Rouge River. Through this plan, the Detroit Water and Sewerage Department is required to invest \$15 million in green infrastructure between 2013-2017 to reduce 2.8 million gallons of stormwater flow.^{lxxxiii}

Additionally, throughout the city a drainage charge has been implemented with a dual purpose: increase the funding it will take to update and maintain the current sewer system, and reduce the amount of storm flow in the system. By charging a fee that is assessed per impervious acre, per month, the city hopes to spur private property owners to implement site specific green infrastructure throughout the city.

When Green Infrastructure Policy Increases City Capacity

Nationwide, there are myriad communities with combined sewer systems that have increased drainage fees and "sewer rates" to raise funds to upgrade their infrastructure. More than 1,400 local jurisdictions have implemented new drainage charges and increased sewer rates to generate income to improve outdated systems, prevent wastewater overflows, and manage stormwater runoff.^{lxxxv}

By identifying the best management practices in cities across the country, policies can be transferred to communities and applied appropriately. Some blue-ribbon examples include:

The District of Columbia has implemented the Clean Rivers Impervious Area Charge (CRIAC) based on the contribution to rainwater runoff of impervious area (buildings, asphalt, or concrete) on the property. Generated funds are used to cover costs of the Clean Rivers Project, a \$2.7 billion capital project mandated by the federal government.^{lxxxvi}

In Seattle, Washington a city-wide drainage fee is billed to all property owners through the property tax statement to assist with the fees incurred due to stormwater runoff. This charge helps to benefit the drainage system through flood control and improvement of water quality. The Stormwater Facility Credit Program (large parcels) and the RainWise Program (residential) exists to reward property owners with a reduced drainage fee when property specific stormwater systems help reduce the impact of stormwater on the city's system.^{lxxvii}

When Toronto's City Council adopted construction standards in 2009 that required all new buildings and retrofits with more than 21,528 square feet of floor area to include a green roof, more than 1 million square feet of additional green roofs have begun the planning phase.^{lxxviii}



Coleman A. Young Municipal Center Green Roof
(Trisha White)

Conclusion

As real estate and land use professionals, developers are part of a long and storied legacy of innovation and transformation, shaping the world we live in, from the hearth to the high-rise. It has been your relentless quest to build - and rebuild - that created both home and neighborhood, weaving individual projects into communities.

And as leaders, you understand change. In fact, you have been the agents of change. When challenges arise, ULI members use design to innovate solutions, brick by brick. You can see where a single building on a single block can transform an entire neighborhood.

While green infrastructure represents a new standard of development for our industry, we know you are ready to rise to the challenge. As ULI members, you will not only embrace the change, you will step up and take your place as leaders. Where municipalities are unable to adapt, you can innovate and find new ways to deliver high quality properties for resilient. The time to implement is now. The future of our urban environments, the health of our residents, and the state of our necessary resources depend on the leaders of the development community to redefine common practices and take action.

CITIES/RULES & REQUIREMENTS

According to the Michigan Department of Environmental Quality (MDEQ), the largest burden on communities that prevents updating current systems is the direct costs associated with wastewater infrastructure improvements and the significant infrastructure investments involved with CSO long-term control plans (LTCP).

Because the costs are burdensome on municipal budgets, many cities are taking multi-prong approaches to address CSO's. **In Detroit, a four-part strategy has been adopted to manage stormwater flows and resulting discharges.**

- **Source Reduction** – Decreasing the amount of stormwater flow that enters the wastewater system from the source by implementing green infrastructure techniques to assist in the processing of stormwater;
- **In-system storage** – Maximizing the use of existing storage space in the sewer system during storms;

- **Wastewater treatment plant expansion** – expand capacity of primary treatment from 1.5 to 1.7 billion gallons per day to treat more flows during storms; and
- **End-of-pipe treatment** – construct facilities to store and treat the combined sewage before the discharge point to prevent it from entering area waterways unless treated and disinfected.^{xxxii}

Detroit is working to reduce the impacts of an under-equipped combined sewer system, but like many cities, every player must perform their part in efforts to prevent overflows and pollution from damaging our communities. Many cities have already begun to pass along the costs and responsibilities to the development community through building requirements and new policies.

Case Studies

Carrington Reserve

QUICK FACTS

Location: West Dundee, IL

Project type: Single family residential, new development

Status: Purchased in 2007, opened in 2011

Site size: 232 acres

Developer/Team: Pulte Homes

Design team: Planning Resources Inc., Applied Ecological Services, Bollinger, Lach & Associates, Inc., Landscape architect: Keven Graham, ASLA

Water management features: Bioretention facility, bioswale, stormwater basins with a positive treatment train using flow management to improve water quality, infiltration galleries to recharge the wetland fen underground water system

Carrington Reserve is a Pulte Homes multi-use development project outside Chicago. Designed to preserve and protect precious natural features on the 232-acre site including steep ravines, a creek and a rare wetland fen, the project accommodates 314 luxury single family homes, 28 acres of retail/commercial and more than 100 acres of open space.

Context

An hour west of Chicago is the village of West Dundee and Carrington Reserve, a 232-acre mixed use planned development with 28 acres of retail, 314 luxury single family homes, and more than 100 acres of open space. All of this in a high quality, sensitive wetland fen.

(Applied Ecological Services)



Prior to creating site development plans, the team conducted extensive environmental studies in close coordination with Illinois EPA and the Army Corps of Engineers, collecting baseline groundwater data as benchmarks for future performance monitoring. By ensuring the health of the wetland recharge zone, they were able to create infiltration galleries and monitoring systems.

WEST DUNDEE, ILLINOIS

How do you preserve environmentally sensitive habitat and scenic beauty while responsibly planning for sensible growth? Carrington Reserve was creatively designed for Pulte Homes by professionals from a variety of disciplines, including Planning Resources Inc., Applied Ecological Services, Bollinger, Lach & Associates Inc. The team aspired to increase property value enhancements and maximize usable green space for residents while protecting sensitive natural features including steep ravines and a high-quality wetland fen.

Prior to creating site development plans, the team conducted extensive environmental studies in close coordination with Illinois EPA and the Army Corps of Engineers, collecting baseline groundwater data as benchmarks for future performance monitoring. By ensuring the health of the wetland recharge zone, they were able to create infiltration galleries and monitoring systems.

Wetland conservation and stormwater management best practices were the building blocks of the development, and included:

1. protecting and buffering the high quality wetland fen;



(Applied Ecological Services)

2. enhancing open space corridors by restoring degraded habitat and creating additional wetland area;
3. creating swales planted with native prairie and wetland vegetation, as a first level treatment of stormwater;
4. requiring residents to use slow release organic fertilizers and developing landscaping plans for residential yards that include buffer strips of native wildflower plantings;
5. designing the site with a unique surface water to ground water reintroduction system.

Carrington Reserve has been awarded the Greater Chicago Home Builders Association's Silver Key Award and the Outstanding Conservation Project from EPA Region 5 and Chicago Wilderness in 2010.

Value Proposition

Due to the sensitive nature of the high quality wetland on site, this project had to incorporate extensive green infrastructure methods in addition to traditional stormwater conveyance. Conveying stormwater through wetland infiltration areas reduced the overall costs by one to nine percent.

In addition, direct access to ample preserved green space created valuable amenities for residents and improved livability for the development. The project includes both passive and active recreation, play areas, and two educational overlooks for residents.

Green amenities – including the preservation and restoration of Jelke Creek – have become a critical component to marketing Carrington Reserve as a top dollar luxury development.

Sources:

ASLA Green Infrastructure & Stormwater Management Case Study: Carrington Reserve, Kevin Graham Dundee, 2011. https://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20118%20Carrington%20Reserve,%20West%20
The Carrington Reserve Homeowners Association website <http://crdundee.org/>

LESSONS LEARNED

The design team for Carrington Reserve set out to create an environmentally responsible development and in the end created a livable, highly desirable community with many active amenities. Now that the project has been operating for several years, managers report ongoing monitoring of groundwater to authorities, demonstrating the impact of stormwater control.

Cawrse & Associates Office

QUICK FACTS

Location: Chagrin Falls, Ohio (Cleveland area)

Project type: Office and parking lot

Status: Finished

Green infrastructure project cost: \$125,000

The project received a grant from Chagrin River Watershed Partners to help defray the costs of the green stormwater measures.

Site size: 1.4 acres

Developer/Team: Cawrse & Associates, Inc.

Design team: Cawrse & Associates, Inc.

Water management features: Permeable paver parking lot, rain garden, use of drought tolerant native plants, bioswale, bioretention basin

In 2007, Cawrse & Associates designed a new two story, 6,400 square foot office building on a 12 acre site in Chagrin Falls, Ohio. In line with their commitment to sustainable design, Cawrse incorporated green infrastructure and innovative stormwater management measures including permeable pavers, rain garden, bioswale and a bioretention pond.

Context

Cawrse & Associates is an award-winning landscape architectural and land planning firm serving both private and public clients throughout Ohio. In a wide range of design projects from single family homes to streetscapes to industrial site plans, Cawrse designs utilizes inventive technologies to reduce environmental impacts, connecting site, ecological processes and local culture while envisioning a sustainable future.

When designing their own new office building in 2007, practicing what they preach was a priority. Retaining and restoring the natural features and systems present on the site was key to their vision of an environmentally sensitive and sustainable design.

(Cawrse Associates)



“Restoring and retaining the natural environmental systems through a design that is conscientious of natural features is a key point in the project vision.” | CRAIG CAWRSE, CEO, CAWRSE & ASSOCIATES, INC.

The building placement conformed to natural features on-site and respected an existing stream, partially fed by the designed green infrastructure stormwater system. Open space remained naturalized and was enhanced by native plantings in the bioswale and bioretention basins.

Because of the environmental benefits of the project, Cawrse received a grant from the Chagrin River Watershed Partners who designated the project as an Innovative Stormwater Management System. The grant helped offset the costs. Sensors and monitoring equipment were installed throughout the site to provide real-time performance data to the United States Geological Survey (USGS) for rainfall and chemical analysis.

Instead of conventional pavement, the parking area used 8,200 square feet of Unilock Eco-Optilock permeable pavers. After peak storm surges, stormwater runoff infiltrates the pavers, is detained and naturally infiltrates the subsurface to slowly recharge groundwater aquifers rather than immediately overwhelming a conventional sewer system. Excess runoff is diverted into a bioswale of native plantings, gravel riffles and rock weirs to slow the water and increase infiltration. Roof runoff travels from gutters to a rain garden of water tolerant plants that retain water before recharging groundwater.

Finally, the design includes a bio retention basin; a wet/dry pond that includes forebay, mudflat, and saturated areas with native plants placed according to the wetness conditions. Native plants absorb and clean the water before releasing it, holding the water on site instead of flowing down stream.

Cawrse's office design earned the Smart Growth Association Award for Sustainable Site Practices in 2007. Today, the complex is documented by USGS as a case study for permeable pavers and serves as a demonstration site for students, environmental professionals, and municipal officials who visit to learn more about implementing green stormwater systems.

Value Proposition

Permeable pavers are cost effective and competitive with the installed cost of an asphalt, or concrete parking lot which have storm water management systems, i.e. catch basins, storm lines, retention ponds, and curb inlets. Long term maintenance costs for the permeable pavers is significantly less without having to replace settling catch basins, maintain retention ponds, patch asphalt, etc.

The green infrastructure components have definitely contributed in helping to control on-site flooding. In July 2015, there was 5 inches of rain in one hour and no flooding in the parking lot. The rain garden contained the roof runoff and the bioretention/bioswale stored rainwater and did not contribute to flooding on surrounding properties, which were under more than a foot of water.

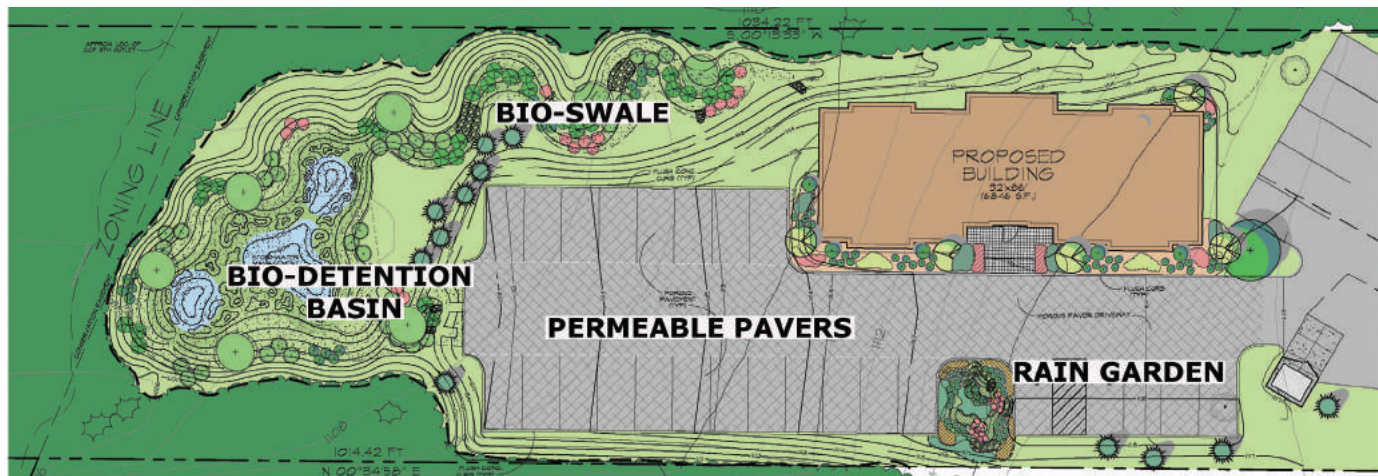
An added benefit to the implementation of green infrastructure techniques was that the stormwater management was viewed in a practical and aesthetically pleasing way. This has led to numerous design projects incorporating green infrastructure, the largest being 345,000 sf of permeable pavers for the Cleveland Clinic Avon Hospital, which functions for storm water storage underneath the pavers. No separate storm water basin was needed.

Sources:
Cawrse & Associates website
<https://www.cawrse.com/cawrse-office-site/>
<https://www.cawrse.com/cawrse-office-site-1/>

LESSONS LEARNED

Green infrastructure helps meet stormwater management mandates.

(Cawrse Associates)



Coleman A. Young Municipal Center

QUICK FACTS

Location: Detroit, Michigan

Project type: Green roof

Status: Complete

Green infrastructure project cost: \$175,000

Site size: 20,000sf

Developer/Team: Bright Roof and Restoration, Elevated Landscape Technologies (ELT)

Design team: Hines

Water management features: Green roof

When the city of Detroit needed to replace the roof on their downtown headquarters, a tight budget, limited access, and weight limits meant they would have to get creative. City officials worked together with roofing experts and new green building technology to implement a modular green roof system without adding costs or additional weight.

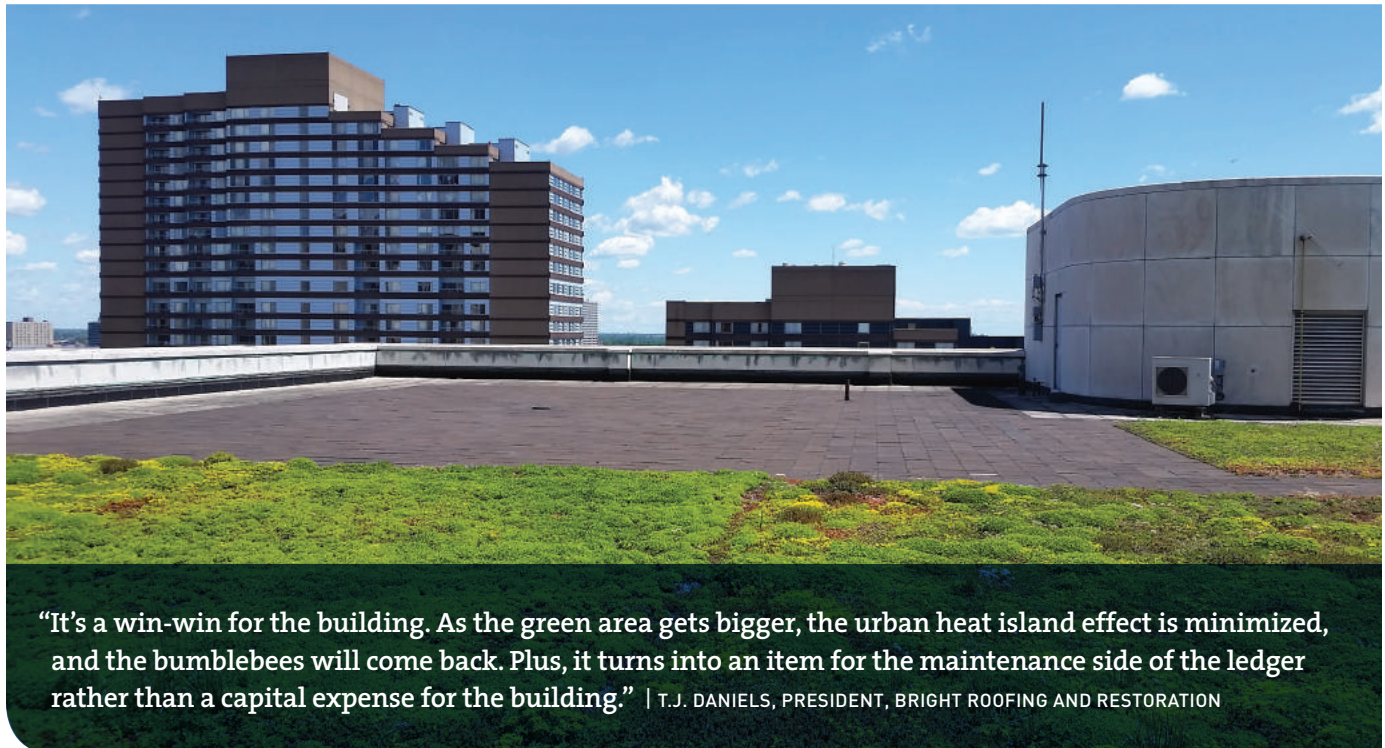
Context

Built in the early 1950s, the Coleman A. Young Municipal Center (CAYMC) serves as the city of Detroit government headquarters. Standing at 20 stories in two towers, it houses a library, a courthouse, and the city hall. Designed by architects Harley, Ellington and Day, the modernist International style marks a centerpiece for the downtown district.

When the building was re-roofed in 1985, the building design restricted roofing options to lightweight 12 inch by 12 inch pavers. Over time, decades of harsh Michigan winters took a toll on the pavers and by 2010, the building was due for another roof replacement. Bright Roofing and Restoration of Detroit had been servicing the roof and was asked for an estimate on a replacement that would minimize cost without adding weight.

To their surprise, while some of the pavers were crumbling, the membrane beneath was in excellent condition. The pavers had protected it from UV radiation and flashings had been maintained, with no leaks or compromises at the perimeter. So the question became, do we need a roof replacement or simply a restoration?

(Patricia White)



“It’s a win-win for the building. As the green area gets bigger, the urban heat island effect is minimized, and the bumblebees will come back. Plus, it turns into an item for the maintenance side of the ledger rather than a capital expense for the building.” | T.J. DANIELS, PRESIDENT, BRIGHT ROOFING AND RESTORATION



(Patricia White)



(Patricia White)

The CAYMC occupies an entire city block and stands at 20 stories tall, making for a difficult installation and expensive replacement – with estimated costs at more than \$1 million and months of disruptions to city offices and courtroom activity.

T.J. Daniels, owner and president of Bright Roofing and Restoration, looked instead at a restoration and long term plan that would save the city money and minimize disruptions to building operations. His incremental green roof plan would allow the city to implement green infrastructure over time without adding extra weight and at the same cost as replacing the damaged pavers.

His plan included:

1. restore the membrane with a reflective coating
2. replace insulation and reinforce seams
3. retain and re-use all existing pavers in good condition
4. replace broken pavers with green roof
5. repurpose broken pavers

Elevated Landscape Technologies (ELT) is a global company specializing in sustainable building technologies including pre-grown green roof and wall systems. ELT Easy Green roof modules have an interlocking water retention layer, filter fabric, and root reinforcement layer. Modules are delivered pre-vegetated, ready for placement. They can be used with retrofits or new roofs, flat or sloping, and thrive in all climates.

Tradesmen were able to complete the 20,000 sf project in only three days, with minimal disruption to building operations. Materials were lightweight and easily transported via the freight elevator. Green panels are installed dry and watered after they are in place, significantly reducing the weight and labor needed to get them to job sites.

Installation of 500 sf of green modules took just over one hour, creating a seamless carpet of sedum. All failed pavers were ground into a decorative edging, further reducing the cost

of removing them. Over time, as the remaining pavers fail they are replaced by additional green roof modules – a new section was installed May 2016 – until eventually the entire roof surface will be green.

Value Proposition

Being able to restore instead of replace the roof was an immediate capital savings for the city of Detroit. And because the materials and installation were reduced, disruptions to tenants were minimized.

By converting to a green roof using an incremental plan, the city was able to invest in green infrastructure that will save money in operations over time. The green roof will reduce utilities and allow CAYMC management to offset increases in Detroit's stormwater drainage fees.

Sources:

Personal communication, Mike Kennedy General manager, Hines
 Personal communication, Gregory McDuffee, executive director of Detroit-Wayne Joint Building Authority
 Green Gains a Foothold in the Motor City
<http://www.roofingcontractor.com/articles/86481-green-gains-a-foothold-in-the-motor-city-1>

LESSONS LEARNED

In many cases, retrofitting the existing roof on older buildings has great potential. Modular systems allow roofing contractors to learn green roofing with familiar methods and warranties from major manufacturers.

Ford River Rouge Plant

QUICK FACTS

Location: Dearborn, Michigan

Project type: Industrial, restoration

Status: Finished, 10+ years complete
Completed 2000

Project cost: \$2 billion for entire renovation

Site size: 600 acres total, green roof on
1.1 million sf plant

Development Program: Master plan and
stormwater management plan

Developer/Team: Owner, Ford Motor Company,
Nelson Byrd Woltz, D.I.R.T. Studio, Landscape
Planning Partners

Design team: William McDonough + Partners

Water management features: Green roof,
bioswales, porous pavement, wetland, wet meadow

Twenty years ago, transforming the Ford Rouge Assembly Plant into a model of industrial sustainability was a radical and seemingly risky idea. Green infrastructure was still relatively new in the United States and had never been attempted at such a grand scale. Facing a \$50 million clean up for toxic storm water, Ford chose the green route with a living roof, porous pavement and wetlands over more expensive traditional gray infrastructure. Today, that bold decision is recognized as a milestone in American green building. Marrying natural and industrial systems proved to be both productive and profitable for the Ford family.

Context

What do you do when a legendary manufacturing facility – once the largest industrial complex in the world – needs a facelift? If you're Henry Ford's great grandson, you uphold your manufacturing heritage and create a 21st century industrial complex and model of sustainable manufacturing.

In 1997, when others were downsizing and decentralizing, William Clay "Bill" Ford, Jr. committed to modernizing the massive Rouge in ways that demonstrated how environmental improvements are wise investments.

The very assets that drew Henry Ford to the Rouge site in the early 1900s – namely the confluence of the Rouge and Detroit rivers – became environmental liabilities 80 years later. The rivers provided Ford easy access for shipping, but the combination of low lying land, impervious surface, and box culverts created massive runoff, flooding facilities during heavy rains and polluting the rivers. Using traditional grey infrastructure to meet new EPA water quality mandates would have cost an estimated \$50 million.

Ford chose world renowned green architect William McDonough to develop a master plan that weaves the built and natural environment together, incorporating stormwater management into a 100-acre industrial landscape.

(Tricia White)

"It sustains a dynamic ecosystem of over 35 insect, spider and bird species, and 11 plant species. Within five days of the living roof being installed, local killdeer had nested and laid eggs in the sedum." | BILL MCDONOUGH,

FOUNDING PRINCIPAL,
WILLIAM MCDONOUGH +
PARTNERS.



“We wanted the Rouge again to be the most copied and studied industrial complex in the world. My great-grandfather would have thought the Rouge Revitalization—a project imagined, planned, and executed by William McDonough + Partners and a team of consultants—was fantastic.” | William C. Ford, Jr., Chairman, Ford Motor Company

Native vegetation lines the roadways and hedgerows frame visitors’ view of the blast furnaces. New trucks roll off the assembly line onto a 16-acre lot of porous pavement. Several stormwater ponds and wetlands along with 20,000 shrubs and hundreds of trees make green space and extensive wildlife habitat.

The crown jewel of the Rouge is the 10.4-acre green roof atop the 1.1 million square foot truck assembly plant. Due to the size, the team chose light, thin pre-vegetated sedum mats instead of loose soil. The drought resistant sedum captures and treats more than 4.3 million gallons of runoff each year.

Together, the roof, porous pavement, wetlands, and swales work in harmony to attenuate, clean, and convey runoff before it reaches the Rouge River. Experts estimate that it now takes 48 hours for a single drop of rain to flow through the system. The Ford Rouge Center has received several awards from the design and construction industries, and the green roof remains one of the five largest in the world.

Value Proposition

McDonough’s landscape based design brought a hefty \$15 million price tag, but still cost less than one third that of conventional grey infrastructure due to a minimum use of buried pipes. The green roof reduces energy costs by shading and insulating the plant, keeping it 10 degrees warmer in winter and 10 degrees cooler in summer. By reducing the urban heat effect



(Flickr Nicole Yeary)

created by tarred roofs, the green roof’s life expectancy extends to twice that of a conventional roof, saving millions in replacement costs.

Sources:

Ford’s green roof caps a decade of innovation | November 2013
<https://www.greenbiz.com/blog/2013/11/22/fords-pioneering-green-roof-celebrates-10-years-sustainability>
 Ford Rouge Center Landscape Master Plan
<http://mcdonoughpartners.com/projects/ford-rouge-center-landscape-master-plan/>
 The Henry Ford | Living Roof
<https://www.thehenryford.org/visit/ford-rouge-factory-tour/highlights/living-roof/>
 Ford Dearborn Truck Plant Green Roof at the Rouge Complex: Looking Back Ten Years
<http://www.greenroofs.com/content/articles/109-Ford-Dearborn-Truck-Plant-Green-Roof-at-the-Rouge-Complex-Looking-Back-Ten-Years.htm#.WSMdimjyvb0>
 Henry Ford’s old place has shed its gritty past
http://legacy.sandiegouniontribune.com/uniontrib/20040427/news_1b27ford.html

LESSONS LEARNED

The Rouge proved that pre-vegetated sedum mats are practical and effective for large scale projects without excessive routine maintenance.

The Kresge Foundation Headquarters

QUICK FACTS

Location: Troy, Michigan

Project type: Commercial Office
Retrofit of existing property

Status: Finished; Start 2004, finish 2006;
Expansion 2015

Site size: 43,850 sf facility on 3 acres

Developer/Team: Owner

Design team: Conservation Design Forum, Valerio
Dewalt Train, Farr Associates, ARUP

Water management features: Bioretention
facility, rain garden, bioswale, green roof, cistern,
downspout removal, porous pavers, curb cuts

The Kresge Foundation's headquarters' expansion integrated the renovation of a historic 19th century fieldstone farmhouse and barn, juxtaposed with the construction of a contemporary aluminum and glass office building on their three-acre campus in Troy, Michigan. The project spread over several phases and more than a decade from 2004 to 2015. The new 43,850 square foot office building uses natural light, a geothermal well for heating/cooling, and is surrounded by a Midwestern prairie landscape and wetlands. All rainwater is captured and treated onsite with a stormwater management system approach through a series of bioswales, cisterns, and pervious pavers.

Context

For more than 80 years, the Kresge Foundation has promoted environmental responsibility through their philanthropic activities. When expanding their headquarters facility, they saw an opportunity to create a campus that reflects their dedication to sustainable design; reducing the footprint of their own operations while creating a demonstration of a beautiful, functional workplace that is also good for the environment.

Designers at Valerio Dewalt Train Associates were challenged to combine the old and new. They retained and renovated the historic 19th century fieldstone farmhouse and barn that had served as Kresge's offices for several years. Together, the low rise rural farm structures dominate the view from the road, preserving the rustic character of the site.

Then they integrated the old with the new when they juxtaposed a contemporary, modern, state-of-the-art environmentally efficient 19,500 square foot office building with the original structures. Beginning with the orientation of the building east and west on the site guaranteed ample daylight to reduce electricity use and a geothermal well system heats and cools the building. The three-acre campus sits on a restored Michigan prairie featuring more than 50 native species of grasses and wildflowers. Two ponds, bioswales, pervious pavers, and a

(Kresge Foundation)

"We set a high bar for ourselves," says Rip Rapson, president of the Kresge Foundation. Rapson credits Kresge's trustees and staff for the prominent role they played in achieving the LEED's Platinum certification. "Excellent design, planning and execution have contributed to making this an extraordinary office environment."



“I love the way the green roof looks in the snow, or seeing foxes or herons from our conference rooms during a meeting. As a major funder of environmental programs, we are living the world we hope to help create.” | Employee, Kresge Foundation

constructed wetland work in concert with an 18,000-gallon cistern to retain rainwater, limiting runoff and providing irrigation for the vegetated green roofs during dry periods.

Starting in 2004, the entire project was completed in phases with Phase 1 completed in 2006 and an expansion completed in 2015 that added a 120-seat meeting facility, a healthy cafeteria, and living green walls.

The U.S. Green Building Council awarded the Kresge Foundation headquarters a Platinum certification, the highest attainable level in the LEED Green Building Rating System.

Today, foundation staff invite visitors to tour the space, learning about the nuts and bolts of environmentally sustainable construction and renovation.

Value Proposition

The overall costs of the site design and development project were not affected by preservation of the historic buildings or the innovative stormwater management measures. And many of the green infrastructure measures have the added bonus of reducing operation and utility costs. Solar panels and natural sunlight reduce electricity use and the embedded foundation provides natural insulation to ease HVAC costs.

You can't put a price on health and happiness, but Kresge's headquarters shows the added value of a healthy workplace and a happy staff. Offices have natural light and views overlook the prairie, wetlands and wildlife including herons, ducks, hummingbirds, red fox, and Canadian geese. Living walls improve indoor air quality and the cafeteria offers healthy dining options. Staff are encouraged to stay active with sit-to-stand desks and a quarter mile walking path through the campus' prairie landscape.

Sources:

Kresge Foundation website

<http://kresge.org/sites/default/files/Kresge-headquarters-case-study.pdf>

“Kresge shows off its Troy headquarters expansion,” John Gallagher. Detroit Free Press. March 22, 2016.

<http://www.freep.com/story/money/business/michigan/2016/03/22/kresge-rapson-detroit-philanthropy-foundation-sustainability-valerio-architecture/82124844/>

Landscape Performance Series

<https://landscapeperformance.org/case-study-briefs/kresge-foundation-headquarters>

LESSONS LEARNED

Rapson stresses the importance of developing an integrated, whole-building approach to sustainable design to ensure that the various architectural, lighting, heating and cooling systems in the building are not working at cross purposes with each other.

“My advice to anyone seeking LEED certification for a building is to decide early in the project which level they're going to consider,” he says. “Also, it's important to get wide consensus from the owner, designers, and contractor. The entire team must agree on a set of sustainable goals right from the beginning.”

Lawrence Technical University

QUICK FACTS

Location: Southfield, Michigan

Project type: Parking lot

Status: Complete

Site size: Half acre

Developer/Team: Parjana Distribution and Lawrence Tech University

Water management features: Permeable, porous pavers, underground water storage, energy-passive groundwater recharge products

Lawrence Technological University (LTU) in Southfield, Michigan is leading a collaboration of industry partners in a multi-state demonstration project featuring the implementation of an innovative and scalable integrated drainage system that significantly captures, retains and cleans parking lot stormwater runoff

Context

LTU partnered with Parjana Distribution LLC to improve stormwater infiltration through the use of new green technology called energy-passive groundwater recharge products (EGRPs).

Energy passive groundwater recharge products (EGRPs) are small C-shaped plastic tubes drilled vertically into the soil, drawing water to move down the tubes more rapidly than it would through normal soil. This unique solution addresses soil moisture imbalance, excess water runoff, and lack of underground water recharge by facilitating the movement of water between horizontal soil layers.

In January 2016, a 20x25 sf section of an existing parking lot was removed, about the size of two parking spots. The area was excavated to five feet around an existing catch basin, which was maintained as an overflow structure. EGRPs were installed via drilling around the entire perimeter of the reservoir.

(Don Carpenter)



“We need to treat stormwater as a resource, not a waste product.” | Donald Carpenter, Professor of Civil Engineering,

Lawrence Technological University

As an integrated and dynamic system, the elements work together to absorb, retain, and clean up to an inch of rain during a 24-hour period. Capturing and infiltrating the first inch improves water quality as that is the volume with the highest pollutant loads. Sensors are housed in 12 test wells, measuring water levels and quality at various soil levels.

The new integrated drainage system combines:

1. permeable pavement surface (XeriPave pavers)
2. underground engineered soil storage reservoir (Haydite)
3. drainage technology (EGRP) (Parjana)

As an integrated and dynamic system, the elements work together to absorb, retain, and clean up to an inch of rain during a 24-hour period. Capturing and infiltrating the first inch improves water quality as that is the volume with the highest pollutant loads. Sensors are housed in 12 test wells, measuring water levels and quality at various soil levels.

The LTU site is the first of several test sites around the country, followed by systems in California, Florida, Ohio, and the District of Columbia. Other sites were chosen to allow for testing the system's effectiveness in reducing stormwater runoff under different hydrologies, weather systems and soil types.

Utilizing below grade sensors, experts at Lawrence Tech intend to use performance data (groundwater levels, soil moisture, temperature, and water quality) to establish a national design protocol for replicating the integrated drainage system.

Demonstrating LTU's leadership in stormwater management, the project was among several water quality improvement projects from the public, private, academic, and nonprofit sectors showcased at the 2016 White House Water Summit, held in tandem with United Nations Water Day. The event was held to raise awareness of critical water issues and potential solutions developed via innovative science and technology.

Don Carpenter, professor of civil engineering at LTU, served on Michigan's Low Impact Development Technical Implementation Committee and founded the Great Lakes Stormwater Management Institute. Carpenter created a stormwater education trail on campus as a showcase for best management practices such as bioswales, porous pavers, rain

gardens and a green roof. The campus master plan includes all these as well as wetlands and riparian buffers with a goal to eventually capture 100 percent of runoff.

Value Proposition

The project is an academic-industry partnership between LTU and Parjana, creators of the EGRP. Together, they received a \$100,000 seed grant with a challenge to raise an additional \$300,000 to complete the pilot projects at other sites. Over time, the data collected from the pilot sites will provide valuable information on the effectiveness of the combined technologies in stormwater management.

Sources:

Personal communication, Donald D. Carpenter, Ph.D, PE, LEED AP Professor and Director, Great Lakes Stormwater Management Institute

Lawrence Technical University website
https://www.ltu.edu/news/?_from=/index.asp&_opt=detail&_cid=1fb72515-eae2-4cc6-bd49-06fe4bf5807e

Lawrence Technological University leading national project on reducing stormwater runoff. Russ White. MLive.com. February 1, 2016. http://www.mlive.com/environment/index.ssf/2016/02/lawrence_technological_univers.html

LESSONS LEARNED

Obtaining funding for and implementing innovation can be challenging in an industry (civil engineering; land development) that is risk adverse and overall, prefers status quo on design.

6568 Woodward LLC

QUICK FACTS

Location: Detroit, Michigan | New Center neighborhood
Project type: Mixed use, residential, office and retail
Status: Under construction
Project cost: \$7 million overall project cost, \$500,000 for green infrastructure
Site size: 30,000 sf, three stories
Developer/Team: Midtown Detroit Inc., ROK Construction Services
Design team: McIntosh Poris Associates, architect
Water management features: Green roof, patio with permeable pavers, four cistern tanks, greywater toilet flushing



(Trisha White)

INCORPORATING EFFICIENCY AND GREEN INFRASTRUCTURE MEASURES INCREASED THE BASE CONSTRUCTION COST AS FOLLOWS:

Upgraded HVAC System	\$135,000
Water Conservation	\$70,000
Green Roof Systems	\$150,000
Building Automation	\$75,000
Additional Costs:	\$70,000
Total Sustainable/Resilience Budget:	\$500,000

Midtown Detroit Inc. (MDI) is currently redeveloping a 30,000 square foot historic building in its New Center district which will be anchored by The Ralph C. Wilson, Jr. Foundation (RCWJF) and include ten new residential units and a restaurant at the street level.

MDI and RCWJF are both committed to environmentally sensitive design and practice, believing the work they do must demonstrate these values while educating the community on the myriad ways they can achieve the same impacts. The 6568 Woodward building incorporates a combination of energy efficiency, stormwater management, and high tech automation in an adaptive reuse of an historic building.

Context

When Midtown Detroit Inc., a nonprofit real estate developer, expanded their focus north of midtown, they acquired 11 store fronts in the up and coming New Center District, including 6568 Woodward. Occupying a prominent corner space at the intersection of two iconic thoroughfares, this historic gem will be a highlight and showcase the entry way into the midtown Detroit district.

In preparation for the redevelopment, MDI convened a design charrette to provide input on sustainable and resilient strategies for the project. Participants identified four opportunities to significantly improve the building's efficiency as well as include green infrastructure to mitigate stormwater runoff, all while respecting the historic status of the building.

INCREASE THE EFFICIENCY OF THE HVAC SYSTEMS

The HVAC system initially designed for the building would achieve an 82% AFUE heating/cooling performance level, balancing the capital costs for the developer with monthly costs for tenants. Unfortunately, the system included large air handlers that would be located on the roof, limiting options for a green roof and minimizing the available space for an outdoor patio area.

The proposed higher efficiency system would also have a higher price tag, but would result in significantly reduced operating costs related to electrical and natural gas usage and would achieve an efficiency rating of 95 percent AFUE. In addition, the majority of the system would be located inside the building, freeing up precious rooftop space for green infrastructure measures.

IMPLEMENT WATER CONSERVATION STRATEGY

In light of the increased drainage fees from Detroit Water & Sewer Department (DWSD), the design team sought ways to reduce the drainage fee, recycle water for use within the building, and mitigate the impact to the overburdened DWSD sewer system.

The water conservation plan includes rain water storage, re-use of rain water or greywater for irrigation and the public toilet system. Four cistern tanks housed in the basement will store the stormwater captured from the green roof. This greywater will then be used as replacement or supplement for municipal water in the building's public toilets and as irrigation water for the rooftop garden. The

team estimated that more than 600 gallons of water will be reused each week under normal occupancy and use.

IMPLEMENT GREEN/SUSTAINABLE INFRASTRUCTURE ON ROOFTOPS

The building footprint is lot line to lot line, and all impervious surface. With no natural green space on site, the team had to get creative. They opted for installation of green roofs to reduce the negative impact of the existing impervious surfaces while providing numerous environmental, economic, and social benefits. A green roof will improve storm water management by reducing runoff and improving water quality. It will conserve energy, mitigate the urban heat island, increase longevity of roofing membranes, reduce noise and air pollution, sequester carbon, and provide space for urban agriculture. And compared to traditional roofs, green roofs provide a more aesthetically pleasing and healthy environment to work and live, while improving the actual return on investment.

Based on accessibility, available space and cost, the team identified two of the three roofs as viable locations to implement various green roofs and pervious systems. The patio roof will include a green roof system, pervious pavers, sustainable plantings and other elements which would not only make the space environmentally friendly but would provide a healthy outdoor space for employees and guests. The mezzanine roof will incorporate a green roof system with irrigation supplied by the water conservation system. The restaurant tenant will use planters and vertical green walls for growing herbs and vegetables to be served on their menu.

INSTALL A BUILDING AUTOMATION SYSTEM

The team identified an integrated building automation system which would control and monitor all the mechanical, electrical, plumbing, roofing and water conservation systems throughout the building. The controls and monitoring will allow both the tenants and owners to adjust for efficiency and comfort. The system would capture all the data and be able to provide automatic, dynamic analytical information. The analytics would be able to be used for many different purposes:

- Track key performance indicators by tracking defined key performance indicators and operational metrics.
- Quantify and define energy/water consumption and demand baselines (including weather normalization) and compare actual demand and consumption against those baselines.
- Perform financial analysis given costs factors including calculating payback analysis and other analytical functions.
- Correlate energy consumption usage with equipment operation.

- Provide building system data through analysis of critical performance data for presentation for dashboard reflecting near real-time communications.

The system includes a web-based and onsite dashboard which can be used to demonstrate the real impacts the sustainable/resilience features bring to the building and an education tool for the community in understanding the cost/benefits of these types of sustainable investments.

Value Proposition

Resilience development and infrastructure has been a key focus of all design and development work MDI has done in the past few years particularly evident in the five green alley projects MDI successfully completed and raised \$2 million upfront in funding to achieve.

The Wilson Foundation views the sustainability and healthy building upgrades as a physical manifestation of their goals as a foundation. In designing 6568 Woodward, they expressed their desire to create not only a functional workspace but a demonstration project specifically to showcase green infrastructure.

The green infrastructure and efficiency upgrades are a demonstration for others in the community and provide valuable information to assist nonprofit groups and developers in understanding how the implementation of resilience measures can create benefits for them and for the environment.

Beyond the environmental benefit of not discharging the water to the combined sewer system – an estimated 600 gallons each week – owners and tenants will receive an economic benefit of reducing the water and sewer utility monthly fees through lower of the water usage and a stormwater drainage credit.

Sources:

Personal communication, Cari L. Easterday, Chief Financial Officer, Midtown Detroit Inc.

LESSONS LEARNED

- **Do your homework and choose quality partners who understand both the mechanics and ethos of green infrastructure investments. An experienced and informed design team will help guide decision making throughout the process.**
- **Include green infrastructure at the earliest stage of design. In the case of 6568 Woodward, green infrastructure wasn't considered until after the first round of drawings, causing delays.**

Toronto Green Roof Bylaw



(Flickr Padraic)

Once-skeptical private developers are now embracing green roofs. After learning more about the environmental and economic benefits such as extended life expectancy of the roof membrane, lower energy use, and increased property value, developers view green roofs as a sustainable and cost saving measure.

Most densely populated, highly urbanized metropolitan areas are characterized by an abundance of impervious surface and lack of green space, leading to common – and costly – environmental problems such as air pollution, higher temperatures, and combined sewer overflows.

In an effort to address these environmental concerns and reduce the associated costs, Toronto became the first city in North America to require green roofs. By replacing dark, impervious roof surfaces with soil and vegetation, a green roof will retain stormwater, improve air quality, lower ambient temperatures, reduce building energy use and create attractive and useful outdoor amenities. And with roofs making up 21 percent of the area of Toronto, the potential green benefit was great.

Making Green Roofs Happen

Beginning in 2005, Toronto made a commitment to greening all municipal building roofs and had assembled a team of experts. By collecting data on Toronto's roofs and monetizing the benefits of a significant increase in green roofs, the team was able to provide evidence to support the promotion of green roofs.

By 2006 they launched a pilot cost share program to incentivize green roof construction on private buildings. Toronto City Council adopted an official strategy, "Making Green Roofs Happen," to encourage the construction of green roofs on privately owned buildings using public education, financial incentives, and a favorable development approval process. In May 2009, Toronto became the first city in North America to require and govern the construction of green roofs on new development.

Toronto's Green Roof Bylaw took effect in 2010 for all commercial, institutional and residential building developments with a minimum gross floor area of 2000m², and applied to new industrial developments in 2012. Developers can use the Green Roof Screening Tool to quickly determine if and how the bylaw will impact their projects.

The amount of required green roof coverage is graduated, ranging from 20 to 60 percent depending on the size of the building. For industrial buildings, owners may choose between a 10 percent green roof or a 100 percent cool roof (high solar reflectance and thermal emittance) with other stormwater retention measures sufficient to capture 50 percent of annual rainfall.

Residential buildings under six stories are exempt and all new builds may request a variance to compliance, allowing a smaller amount of green roof by making a cash-in-lieu payment of \$200/m² for the reduced area. Those in-lieu payments are invested in incentives to green existing roofs.

The Eco-Roof Incentive Program promotes green and cool roofs in Toronto by providing funds to retrofit existing roofs. Eligible green roof projects can receive \$50 per m² up to a maximum of \$100,000, and cool roof projects can receive \$2 to \$5 per m² up to \$50,000. Priority is given to existing buildings in Toronto's employment district where the impacts of the urban heat island effect are greatest.

TORONTO, ONTARIO, CANADA

Today, green roofs are a rapidly growing industry and Toronto is widely recognized as a leader and authority for their successful green roof program. Early successes have included:

- 1.2 million square feet of new green space;
- Reduction of 435,000 cubic feet of stormwater (enough to fill 50 Olympic size swimming pools) annually;
- Saving over 1.5 million KWH in energy annually for building owners;
- 125 full time jobs related to the manufacture, design, installation and maintenance of the roofs;

- Reducing the polluting sewer overflows enough for three extra beach days per year.

Once-skeptical private developers are now embracing green roofs. After learning more about the environmental and economic benefits such as extended life expectancy of the roof membrane, lower energy use, and increased property value, developers view green roofs as a sustainable and cost saving measure.

Sources:

http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2013/03/GR_Econ.pdf
About Green Roofs <https://www.greenroofs.org/about-green-roofs/>
Alter, Lloyd. Toronto makes green roofs the law. 2009. <https://www.treehugger.com/corporate-responsibility/toronto-makes-green-roofs-the-law-approves-controversial-bike-lanes.html>
<http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=3a7a036318061410VgnVCM10000071d60f89RCRD>
What is a cool roof? <https://www.certainteed.com/residential-roofing-commercial-roofing/what-cool-roof-0/>
Benfield, Kaid. What Cities Can Learn from Toronto's Green Roof Policy. 2012. <https://www.citylab.com/design/2012/04/what-cities-can-learn-torontos-green-roof-policy/1846/>
City of Toronto Green Roof website <http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=3a7a036318061410VgnVCM10000071d60f89RCRD>
[http://www.mindengross.com/docs/publications/green-roofing-101-toronto-s-green-roof-bylaw---melodie-eng-\(may-10\)](http://www.mindengross.com/docs/publications/green-roofing-101-toronto-s-green-roof-bylaw---melodie-eng-(may-10))
<https://www.citylab.com/design/2012/04/what-cities-can-learn-torontos-green-roof-policy/1846/>
<http://www.hgtv.ca/outdoors/blog/toronto-becomes-first-city-in-na-to-mandate-green-roofs-29045/>
Viola, Daniel. Toronto a leader in green roof industry. 2013. <https://www.reminetwork.com/articles/toronto-a-leader-in-green-roof-industry/>



(Flickr Padraic)

University of Minnesota Duluth (UMD)

QUICK FACTS

Location: Duluth, Minnesota

Project type: Parking lots

Status: Completed

Site size: 51,836 sf

Developer/Team: Owner

Design team: Lot G – LHB, Inc.; Lot B – Design by Barr Engineering; Constructed Summer 2005 by LKO Contracting / UMD Grounds

Water management features: Underground storage, rain garden

With 32 percent of campus covered by impervious surface, and polluted stormwater runoff draining into sensitive watersheds, the University of Minnesota Duluth had to dig deep for solutions. If you visit campus today, you will find more than 60 different green infrastructure measures, from underground water storage to green roofs.

Two of the largest projects address runoff from large parking lots. Lot G now has a 74,000 gallon underground storage system while Lot B drains into a large rain garden with native plants that retain and filter the water during normal and extreme weather events. Both systems are designed to slow water down, cool, and clean it before releasing it into the sewer system.

Context

The University of Minnesota Duluth's campus covers 244 acres, with more than 60 buildings totaling 3.4 million square feet. The campus sits within three watersheds, discharging stormwater to Lake Superior and sensitive designated trout streams.

In 2003, UMD developed a comprehensive program to tackle their stormwater discharge. They joined the Regional Stormwater Protection Team (RSPT), a coalition of local municipalities and other stakeholders to share solutions and promote stormwater education. They also established the UMD Stormwater Pollution Prevention Program (SWPPP) to meet state and federal stormwater discharge permit requirements. And on campus, they have created more than 60 green

(Heidi Bringman, LHB)



“One of the common misconceptions is that it will be like a swamp or hold water a long time and breed mosquitoes. That’s not true. The longest it should hold water is 72 hours, and that would be extremely rare.” | Candice Richards, UMD Facilities Management Associate Director



(Heidi Bringman, LHB)

infrastructure measures to capture and/or treat stormwater runoff, including rain gardens, pervious pavement, green roofs, filtration ponds, and underground water storage vaults.

UMD has more than 25 separate parking lots across campus, but no covered ramp parking. Where they were unable to fit rain gardens or green roofs, they needed to utilize parking lots. UMD created an ambitious and impressive system under one of UMD's largest public parking lots, Lot G. Runoff from the 51,836 sf parking lot flows through a Stormceptor, a hydrodynamic type separator device that removes sediment from surface water flows.

The Stormceptor was built using three rows of 78" diameter corrugated aluminized pipe, holding a total volume of 74,456 gallons of water. The upper half of the pipes is used for detention and reduction of peak discharge flows, sufficient to provide peak flow reduction to predeveloped conditions for up to a 2 year, 24-hour storm event in the Duluth area. The lower half of the pipes act as permanent pool storage to remove sediment and allow the water to cool.

Because the system discharges to a protected trout stream, water temperature must be low and quality must be high. Collected sediment is cleaned out periodically using a mobile hydrovac equipped vehicle. Outflow can be controlled and an overflow riser can discharge major events up to and including the 100 year, 24 hour storm event.

Across campus, Parking Lot B is home to a rain garden, a lower tech but no less effective stormwater mitigation measure. Runoff from the 2.5 acre parking lot flows to a catch basin where sediment sinks and overflow runs to the 1/3 acre rain garden that holds up to 60,000 gallons. Native plants were chosen that could survive the weather and provide robust root growth to break up subsoil and promote infiltration. Overflow water enters



(Heidi Bringman, LHB)

the rain garden, waters the plants, infiltrates soil layers and evaporates before reaching the storm sewer.

Value Proposition

First and foremost, the Stormceptor and rain garden on the UMD campus are successful compliance measures under the Clean Water Act's National Pollutant Discharge Elimination System (NPDES). Under federal law, municipalities and other large organizations like UMD are required to reduce the transport of pollutants in stormwater runoff to downstream waters of the United States.

Sources:

Personal communication, Heidi Bringman, PLA*, LEED BD+C, CWD Senior Landscape Architect | Wetland Specialist
University of Minnesota Duluth website
<http://fm.d.umn.edu/stormwater/umd-rain-garden/>
<http://fm.d.umn.edu/wp-lib/wp-content/uploads/2016/01/UMD-Home-Page-Story-September-2005.pdf>
<http://fm.d.umn.edu/wp-lib/wp-content/uploads/2016/01/Duluth-News-Tribune-Rain-Garden-Article-2005.pdf>

LESSONS LEARNED

Because the Stormceptor system is under a paved surface, access for maintenance is a challenge. Other green infrastructure measures on campus such as bioswales can be designed into small spaces and are easier to maintain. While pipe leakage can be a concern, modern products on the market today are stronger and less resistant to leaking.

GLOSSARY

Aquifer

An underground surface or geological formation that holds or conducts groundwater.

Baffle box

A concrete or fiberglass structure used to removal pollutants from stormwater by slowing the flow velocity through sediment settling chambers. It also contains a screen that skims the top, capturing floating materials and trash.^{lxxxix}

Basin

A landform or area draining to a point of interest. A stormwater basin collects water to reduce the risk of flooding.

Berm

A constructed area of compacted earth, designed to direct water or restrict flow.

Best management practices (BMPs)

Methods that have proven to be the most effective, practical means of preventing or reducing pollution from a source that needs to be controlled, such as stormwater runoff.^{lxxx} BMPs provide a basis for estimating the performance, costs, and economic impacts of achieving management quotas or policies.

Bioinfiltration

A stormwater management practice that uses vegetative land cover to filter and cleanse stormwater runoff into an aquifer.^{lxxxii}

Bioretention

The process by which water is collected in a treatment area to advance infiltration and remove sediment.

Bioswale

A green infrastructure technique that captures stormwater runoff from a large impervious surface in a sloped vegetated area. Slopes usually use native species and allow the water to infiltrate into the ground slowly.^{lxxxiii}

Cistern

A large storage facility, often built below ground, at ground level, or on rooftops, that stores stormwater.

Clean Water Act

An act passed by the U.S. Congress and enforced by the EPA that established the structure for regulating pollutant discharge into U.S. bodies of water. The act implements pollution control programs and water quality standards.

Combined sewer overflow (CSO)

During rain or snow events, drainage systems in a combined sewer system exceed the capacity of the collection system, discharging untreated sewage and stormwater into designated lakes, streams, and other bodies of water.^{lxxxiii}

Combined sewer system

Wastewater collection system that is designated to carry both sanitary sewage and stormwater in a single piping system to a treatment facility.^{lxxxiv}

Credit-trading scheme

A program policy that offers real estate developers the opportunity to purchase or sell credits for stormwater compliance in an open market. Those who own credits have met regulatory requirements for retaining stormwater.

Curb cut

A part of a street curb removed to connect the street level with another surface, often a stormwater management or green infrastructure mechanism that can absorb water in place of the traditional drainage system.

Daylighting

The process of uncovering a waterflow that was previously piped, covered, or buried to create an open channel, which improves aesthetics and allows biological activity and infiltration.

Detention pond/basin

A low-lying, porous, sometimes vegetated, area that is designed to hold water for a temporary amount of time after a weather event. Although effective at holding stormwater, detention basins do not traditionally offer water quality treatment.

Fee structure

A program that requires financial payments based on the amount of impervious surface on a site, encouraging investment in permeable surfaces or green infrastructure methods.

Filter medium

A material, often consisting of sand and organic matter, that removes pollutants through filtration.

Green area ratio

A score-based tool that encourages including multiple stormwater management techniques by awarding points for different mechanisms.

Green infrastructure

Mechanisms that enable natural systems to capture stormwater runoff, enhance water and air quality, and create green space. Some examples are bioswales, green roofs, permeable pavement, rainwater harvesting, rain gardens, and tree pits.

Green roof

A green infrastructure technique that uses rooftop vegetative plantings to absorb rainwater and heat, in addition to improving air quality and decreasing energy needs for the building below.

Groundwater

Water flowing beneath the earth's surface, between rock, sand, and soil. Groundwater is the source of water for wells and springs.

Impervious surface

A hard surface that prevents or impedes the flow of water to the soil mantle, such as concrete.^{lxxxv}

Infiltration

The process by which water percolates from the land's surface into the ground.

Leadership in Energy and Environmental Design (LEED)

A rating system administered by the U.S. Green Building Council that provides the development and building industry with quantitative standards for sustainable design. The system takes into consideration five key areas: sustainable site development, water savings, energy efficiency, material selection, and indoor environmental quality.^{lxxxvi}

Low-impact development (LID)

A land planning and design approach that emphasizes mimicking natural system processes to store, infiltrate, retain, and detain precipitation and rainfall as close to its source as possible.

Municipal Separate Storm Sewer System (MS4) Permit

A permit required to develop stormwater management programs to prevent harmful contamination to the watershed, required for publicly owned conveyance that discharges into federal or state waters.

National Pollutant Discharge Elimination System (NPDES)

Provision of the Clean Water Act that forbids pollutant discharge into U.S. water systems by regulating point sources.

Natural drainage system

A quality of many green infrastructure mechanisms; systems that mimic the natural flow of water to create attractive open spaces while channeling stormwater.

Nonpoint-source pollution

Pollution that occurs when water runs over land, development, or through the ground and picks up pollutants that are ultimately carried into lakes, rivers, coastal waters, or groundwater.

Nonpotable water

Water that is not of drinking quality but that still may be used for other purposes, such as toilet flushing and clothes washing.

On-site mitigation requirements

Policies that require a development to capture a specific minimum volume of water, usually measured by inches of rain or a percentage of type of rain event, to deter stormwater from entering drainage or sewer systems.

Peak runoff rate

Maximum speed or flow rate of water during a storm event.

Percolation

Process by which water passes through a filter.

Permeable

Allowing liquid or gas to filter through.

Permeable pavement or pavers

Engineered porous paver, concrete, or asphalt that allows runoff to filter through strata and into a drainage system or directly into the aquifer.

Potable water

Water that is of drinking quality.

Rain barrel

A container or storage device that collects water, often from a roof.

Rain garden

A small vegetated area designed to be located where stormwater naturally flows, which captures and infiltrates runoff into the ground. It is a commonly used green infrastructure technique in landscape and streetscape designs.^{lxxxvii}

Rainwater harvesting

A green infrastructure technique that collects and stores rainwater for future use.

Retention pond/basin

A low-lying, sometimes concrete, area that is designed to hold water from a weather event for an indefinite amount of time. Retention basins hold harvested water or are connected to the sewer system for slow release.

Retrofit

A best management practice installed into a previously developed area to improve stormwater quality or reduce stormwater quantity when compared to current conditions.

Riparian

Related to a stream, river, or bank of a waterway.

SITES

A rating system administered by Green Business Certification Inc. that measures performance and value of sustainable landscaping. SITES certification projects include developments with or without buildings and range from parks to corporate campuses, streetscape, and residential homes.^{lxxxviii}

Stormwater management

Structural and nonstructural mechanisms used to control and prevent stormwater runoff over impervious surfaces into sewer systems.

Stormwater runoff

Portion of precipitation that flows over impervious surfaces and carries pollutants in quantities unmanageable by sewer and natural water systems.

Stormwater vault

A type of detention basin, this subsurface facility commonly made of concrete, steel, or fiberglass, manages stormwater in an urban setting because of its ability to capture large quantities of water.

Total maximum daily load (TMDL)

A regulatory term used within the U.S. Clean Water Act that describes the calculated maximum amount of a pollutant that a body of water can assume while maintaining designated water quality standards.

Tree pit

A commonly used green infrastructure technique that collects stormwater runoff, particularly in urbanized areas where space is limited, and diverts stormwater into the sewer system or subsoil.

Urbanization

An increase in human concentrations within dense urban areas and outer suburban periphery, which leads to the replacement of natural landscape with impervious surfaces.^{xxxix}

Watershed

An area of land, which is often regional, that drains to a single place, such as a river, stream, bay, or ocean.

Wetland

An area of land saturated by ground or surface water for all or part of the year. Wetland habitats typically support both aquatic and terrestrial species.

NOTES

CHAPTER 1

- i American Society of Civil Engineers, *2017 Infrastructure Report Card*, <http://www.infrastructurereportcard.org/gamechanger-item/dredging-p3/>.
- ii United States Army Corps of Engineers, *Great Lakes Navigation System: Economic Strength to the Nation* (2013), http://www.lcships.com/wp-content/uploads/2015/07/GLN_Strength-to-the-Nation-Booklet2013v2_final2w.pdf.
- iii National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, <https://www.glerl.noaa.gov/education/ourlakes/economy.html>.
- iv United States Environmental Protection Agency, "Great Lakes Facts and Figures" (accessed May 1, 2017) <https://www.epa.gov/greatlakes/great-lakes-facts-and-figures>.
- v National Oceanic and Atmospheric Administration, *Great Lakes Regional Land Cover Change Report 1996-2010*, <https://coast.noaa.gov/data/digitalcoast/pdf/landcover-report-great-lakes.pdf>.
- vi Legacy Cities Partnership (accessed April 26, 2017). www.legacycities.org/.
- vi *ibid.*
- viii Burgess, Katharine, et al. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate*. Washington, D.C.: Urban Land Institute, 2017.

CHAPTER 2

- ix National Oceanic and Atmospheric Administration (NOAA) Regional Collaboration, "Great Lakes Region," <http://www.regions.noaa.gov/great-lakes/index.php/regional-snapshots/>.
- x Michigan Sea Grant, "About the Great Lakes" (accessed May 2, 2017), <http://www.miseagrant.umich.edu/explore/about-the-great-lakes/>.
- xi Detroit Water and Sewerage Department, "The History of DWSD," http://archive.dwsd.org/pages_n/history.html.
- xii City of Detroit, "Stormwater," (accessed April 3, 2017), <http://www.detroitmi.gov/How-Do-I/Find/Storm-Water#one>.
- xiii Michigan Department of Environmental Quality, "City of Detroit Water and Sewerage Department / Detroit Wastewater Treatment Plant," http://www.michigan.gov/documents/deq/deq-wrd-npdes-DetroitWWTP_FS_415425_7.pdf.
- xiv National Oceanic and Atmospheric Administration (NOAA) Regional Collaboration, "Great Lakes Region," <http://www.regions.noaa.gov/great-lakes/index.php/regional-snapshots/>.
- xv City of Chicago, "Water Management" (accessed May 2, 2017), www.cityofchicago.org.
- xvi American Society of Civil Engineers, *2017 Infrastructure Report Card*, <http://www.infrastructurereportcard.org/>.
- xviii United States Environmental Protection Agency, *Report to Congress - Impacts and Control of CSOs and SSOs* (2004), https://www.epa.gov/sites/production/files/2015-10/documents/csosortc2004_full.pdf.
- xix United States Environmental Protection Agency, *Report to Congress - Combined Sewer Overflows into the Great Lakes Basin* (April 2016), https://www.epa.gov/sites/production/files/2016-05/documents/gls_cso_report_to_congress_-_4-12-2016.pdf.
- xx United States Environmental Protection Agency, National Service Center for Environmental Publications (NSCEP), *Green Parking Lot Resource Guide* (2008).

- xxi Burgess, Katharine, et al. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate*. Washington, D.C.: Urban Land Institute, 2017.
- xxii Gautz, Chris, "Officials Study Ways to Lessen Burden on Storm Systems," *Crain's Detroit*, August 17, 2014, <http://www.craindetroit.com/article/20140817/NEWS/308179982/officials-study-ways-to-lesser-burden-on-storm-systems>.
- xxiii National Weather Service, National Oceanic and Atmospheric Administration, *United States Flood Loss Report - Water Year 2014*, <http://www.nws.noaa.gov/hic/summaries/WY2014.pdf>.
- xxiv Ellison, Marc, "Toronto Flooding Released Raw Sewage in a Sweep to Lake Ontario," *Toronto Star*, July 9, 2013, https://www.thestar.com/news/gta/2013/07/09/toronto_flooding_released_raw_sewage_in_a_sweep_to_lake_ontario.html.
- xxv D'Onofrio, Jessica, and Phil Schwarz, "Chicago Weather: Rain to end Tuesday; Many Areas Still Flooded," *WLS-TV, ABC 7 Eyewitness News - Chicago*, May 2, 2017. <http://abc7chicago.com/weather/chicago-weather-rain-to-end-tuesday;-many-areas-still-flooded/1943966/>.
- xxvi Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value*, (2013), <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.
- xxvii Tibbetts, John. "Combined Sewer Systems: Down, Dirty, and Out of Date." *Environmental Health Perspectives* 113.7 (2005): A464-A467.
- xxviii *Crain's Detroit Business*, "Aftermath of August Flooding: 10 billion gallons of sewer overflows, \$1 billion in damages" (accessed May 2, 2017), www.craindetroit.com
- xxix Great Lakes Information Network, "Areas of Concern (AOC's)" (Accessed May 2, 2017), <http://www.great-lakes.net/teach/pollution/aoc/aoc2.html>.
- xxx Burgess, Katharine, et al. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate*. Washington, D.C.: Urban Land Institute, 2017.
- xxxi *ibid.*
- xxxii Detroit Water and Sewerage Department, "Combined Sewer Overflow Facilities" (accessed April 17, 2017), http://archive.dwsd.org/pages_n/facilities_cso.html.

CHAPTER 3

- xxxiii Burgess, Katharine, et al. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate*. Washington, D.C.: Urban Land Institute, 2017.
- xxxiv *ibid.* p.4
- xxxv Urban Land Institute: *Returns on Resilience: The Business Case*. ULI Center for Sustainability. Washington, D.C.: the Urban Land Institute, 2015.
- xxxvi Urban Land Institute and EY. *Infrastructure 2014: Shaping the Competitive City*. Washington, D.C.: Urban Land Institute, 2014.
- xxxvii 21st Century Infrastructure Commission Report (2016), http://www.michigan.gov/documents/snyder/21st_Century_Infrastructure_Commission_Report_555079_7.pdf.

CHAPTER 4

- xxxviii Tibbetts, John. "Combined Sewer Systems: Down, Dirty, and Out of Date." *Environmental Health Perspectives* 113.7 (2005): A464-A467.
- xxxix Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), p. 15, <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

xi United States Environmental Protection Agency, National Service Center for Environmental Publications (NSCEP), *Green Parking Lot Resource Guide* (2008).

xii Water Environment Federation, StormwaterReport, “Five types of green infrastructure incentive programs” (2013), <http://stormwater.wef.org/2013/01/five-types-of-green-infrastructure-incentive-programs/>.

xiii Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value*, (2013), p. 9, <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

xiv Burgess, Katharine, et al. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate*. Washington, D.C.: Urban Land Institute, 2017.

xv American Society of Landscape Architects, “Stormwater Overview” (accessed May 2, 2017), <https://www.asla.org/stormwateroverview.aspx>.

xvi Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), p. 26, <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

xvii Ibid. p. 10

xviii Ibid. p. 27

xix Ibid. p. 9

l United States Environmental Protection Agency, National Service Center for Environmental Publications (NSCEP), *Green Parking Lot Resource Guide* (2008).

li Detroit Water and Sewerage Department, “Drainage” (accessed April 28, 2017), <http://www.detroitmi.gov/drainage>.

lii New Jersey Future, *New Jersey Developers’ Green Infrastructure Guide* (2017), http://www.njfuture.org/wp-content/uploads/2017/03/NJ-Developers-Green-Infrastructure-Guide_FINAL_web.pdf.

liii Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), p. 9, <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

liiii Ibid. p. 16

lv Been, V., and I. Voicu, “The Effect of Community Gardens on Neighboring Property,” *Real Estate Economics* 36 (2): 241–283 (2007).

lvi Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

lvii Laverne, R.J., and K. Winson-Geideman. 2003. “Influence of Trees and Landscaping on Rental Rates at Office Buildings.” *Journal of Arboriculture* 29(5): 281–289.

lviii Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

lix Ibid. p. 11

CHAPTER 5

lix Green Infrastructure Center, “What is Green Infrastructure” (accessed May 26, 2017), <http://gicinc.org>

lx Center for Neighborhood Technology, “Green Values Stormwater Toolbox” (accessed May 2, 2017), <http://greenvalues.cnt.org/>.

lxi West Michigan Environmental Action Council (WMEAC), “Rainwater Rewards Calculator” (accessed May 4, 2017), <http://rainwaterrewards.com>

lxii American Society of Landscape Architects, “Stormwater Overview” (accessed May 2, 2017), <https://www.asla.org/stormwateroverview.aspx>.

lxiii National Oceanic and Atmospheric Administration, Office for Coastal Management, *A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction* (2015), <https://www.coast.noaa.gov/data/docs/digitalcoast/gi-cost-benefit.pdf>.

lxiv Beauchamp, Pierre and Ian Adamowski, Different Methods to Assess Green Infrastructure Costs and Benefits in Housing Development Projects. *Journal of Sustainable Development*. Volume 5 No 4 (2012): page 12.

CHAPTER 6

lxv City of Detroit, “Water and Sewerage Department” (accessed April 26, 2017), <http://www.detroitmi.gov/Government/Departments-and-Agencies/Water-and-Sewerage-Department/About-DWSD>.

lxvi Great Lakes Water Authority, *History in the Making: Creating a Water Authority for the Region* (2015), http://www.glwater.org/wp-content/uploads/2015/03/Creating-a-Water-Authority-for-the-Region_web-format.pdf.

lxvii Great Lakes Water Authority, “About Us” (accessed May 26, 2017), <http://www.glwater.org/about-us/>.

lxviii Great Lakes Water Authority, *History in the Making: Creating a Water Authority for the Region* (2015), http://www.glwater.org/wp-content/uploads/2015/03/Creating-a-Water-Authority-for-the-Region_web-format.pdf.

lxix United States Environmental Protection Agency, “Clean Water Act (CWA) Compliance Monitoring” (accessed May 2, 2017), <https://www.epa.gov/compliance/clean-water-act-cwa-compliance-monitoring>.

lxx Michigan Department of Environmental Quality, *Combined Sewer Overflow (CSO), Sanitary Sewer Overflow (SSO), and Retention Treatment Basin (RTB) Discharge, 2014 Annual Report*, http://www.michigan.gov/documents/deq/wrd-cso-ss0-2014-annual-report_528853_7.pdf

lxxi Michigan Department of Environmental Quality, “City of Detroit Water and Sewerage Department / Detroit Wastewater Treatment Plant,” http://www.michigan.gov/documents/deq/deq-wrd-npdes-DetroitWWTP_FS_415425_7.pdf.

lxxii Michigan Department of Environmental Quality, “Information for Detroit WWTP” (accessed April 26, 2017), http://www.deq.state.mi.us/csosso/facility_info.asp?optFacility=MI0022802&cmdSubmit=View+Selected+Facility.

lxxiii City of Detroit Water and Sewerage Department, “Green Infrastructure Projects” (accessed April 26, 2017), <http://www.detroitmi.gov/Government/Departments-and-Agencies/Water-and-Sewerage-Department/Green-Infrastructure-Projects>.

lxxiv Tibbetts, John. “Combined Sewer Systems: Down, Dirty, and Out of Date.” *Environmental Health Perspectives* 113.7 (2005): A464–A467.

lxxv Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value*, p. 15 (2013), <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

lxxvi District of Columbia Water and Sewer Authority, “Rates and Metering: Understanding Rates” (accessed April 26, 2017), <https://www.dwater.com/rates-and-metering>.

- ^{lxxvii} City of Seattle Public Utilities, “Stormwater Facility Credit” (accessed April 26, 2017), <http://www.seattle.gov/Util/ForBusinesses/DrainageSewerBusinesses/StormwaterFacilityCredit/index.htm>.
- ^{lxxviii} Natural Resources Defense Council, *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value* (2013), <https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf>.

GLOSSARY

- ^{lxxix} U.S. Environmental Protection Agency, *Office of Water, Stormwater Technology Fact Sheet: Baffle Boxes* (Washington, DC, 2001), 1. <https://nepis.epa.gov/Exe/ZyPDF.cgi/P100IL55.PDF?Dockey=P100IL55.PDF>.
- ^{lxxx} Lisa Nisenson, *Using Smart Growth Techniques as Stormwater Best Management Practices* (Washington, DC: U.S. Environmental Protection Agency, 2014), <https://www.epa.gov/sites/production/files/2014-04/documents/stormwater-best-management-practices.pdf>.
- ^{lxxxi} U.S. Environmental Protection Agency, “Terminology Services (TS),” https://iaspub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do.
- ^{lxxxii} Lenny Librizzi, *Green Infrastructure Techniques* (New York: GrowNYC, 2015), https://www.grownyc.org/files/osg/Green%20Infrastructure%20Manual_2015_web.pdf.
- ^{lxxxiii} Librizzi, *Green Infrastructure Techniques*.
- ^{lxxxiv} Department of Ecology, State of Washington, “Combined Sewer Overflows,” last updated November 2015, www.ecy.wa.gov/programs/wq/permits/cso.html.
- ^{lxxxv} Nisenson, *Using Smart Growth Techniques as Stormwater Best Management Practices*.
- ^{lxxxvi} U.S. Environmental Protection Agency, “Green Infrastructure,” <https://www.epa.gov/green-infrastructure>.
- ^{lxxxvii} Librizzi, *Green Infrastructure Techniques*.
- ^{lxxxviii} The Sustainable SITES Initiative website, www.sustainablesites.org/.
- ^{lxxxix} U.S. Environmental Protection Agency, “What Is Urbanization?,” in *CADDIS Vol. 2: Sources, Stressors & Responses*, https://www3.epa.gov/caddis/ssr_urb_urb1.html.

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Heidi Bringman, PLA*, LEED BD+C, CWD

Senior Landscape Architect | Wetland Specialist
LHB

Jack Broughton

Director of Communications
Applied Ecological Services

Mark Brucki

Executive Director, Corporate & Community Partnerships
Lawrence Technological University

Katharine Burgess, AICP

Senior Director, Urban Resilience, Urban Land Institute

Victoria Olivier

Director of Land Use and Sustainability, Detroit Future City

Michael Cadieux

Rok Services

Donald D. Carpenter, Ph.D, PE, LEED AP

Professor and Director, Great Lakes Stormwater Management
Institute, Lawrence Technological University

Rick Carter, FAIA

Integrative Design Team Leader, LHB

Gina Cavaliere

Chief Community Impact Officer, Downtown Detroit Partnership;
Director, BIZ

Ann Cawrse

Cawrse & Associates, Inc.

Craig E. Cawrse, FASLA

CEO, Cawrse & Associates, Inc.

Caren Dewar

Executive Director, ULI Minnesota

Cari L. Easterday

Chief Financial Officer, Midtown Detroit Inc.

Jela Ellefson

Grants/Community Development Director, Eastern Market

Shannan Gibb-Randall, PLA

InSite Design Studio, Inc.

Linda Hamill

ULI Cleveland

Ritchie Harrison

Planner, Riverfront Development, Detroit Riverfront Conservancy

Jenny Hebert

InSite Design Studio, Inc.

Carol Hufnagle, P.E.

National Wet Weather Practice Leader, Tetra Tech

Sarah Hurt Evans, PLA

Landscape Architect + Marketer, Williams Creek

Michael Kennedy

Hines

Cindy McSherry

ULI Chicago

Jennifer L. Milliken, Director

ULI Indiana and Kentucky

Neil B. Myers

Principal, Williams Creek

John C. Neely

Partner, Topline Partners LLC

David L. Nelson

Applied Ecological Services

Kandyce Perry

Planning and Policy Associate, New Jersey Future

John Petz

Dominos Farms Corporation

Matthew Robertson

Rok Services

Swasti Shah

ULI Chicago

John W. Shardlow, FAICP

Senior Principal, Stantec

Shayna Stott

Planner, City of Toronto

Lesley Rivera

Urban Strategies Project Manager, The Nature Conservancy

Leah Sheppard

Project Employee, Urban Resilience, Urban Land Institute

Valerie Strassberg, P.E.

Urban Conservation Director, The Nature Conservancy

Alana Tucker

Sustainability Initiatives Manager, Downtown Detroit Partnership



Urban Land Michigan
Institute