CITY OF CHICAGO

GREEN STORMWATER INFRASTRUCTURE STRATEGY

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CITY OF CHICAGO
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Foreword

Credit: City of Chicago Photography Services

Flooding can have a devastating effect on families and their homes, and green stormwater infrastructure serves as a key piece of reducing risk to Chicago homeowners and residents. By committing to these improvements and policies, the City will be in much better position to reduce flooding in future storms and protect the environment going forward. This strategy will change the way the City manages stormwater in the future and allow Chicago to continue to develop new technologies and approaches on behalf of residents and businesses.

As the City rebuilds streets in neighborhoods that are more likely to flood, projects will include permeable pavement that can absorb water that would otherwise wind up in our sewer system, and ultimately in the river. As the City plants trees, the pit will be deeper and wider to capture several times the amount of rainwater as traditional tree plantings. And as schools rebuild playgrounds in areas at risk for flooding, the City will fund green infrastructure to capture more water and create a learning opportunity for public school kids.

Chicago launched one of the largest water infrastructure investment programs of any city in America. Over the next decade, the City will replace 900 miles of water main, replace or reline 760 miles of sewer pipes, line 160,000 catch basins, and renew 12 pumping stations and 2 purification plants. The City is rebuilding, block by block, Chicago's water infrastructure.

This Green Stormwater Infrastructure Strategy builds on these efforts and is a key step toward achieving the goals of Sustainable Chicago 2015 and Building a New Chicago. The strategy presented here is a major step forward, but by no means the final step. The City will continue to implement cleaner, greener infrastructure and work every day to ensure a greater city for all Chicagoans.

Sincerely,

Rahm Emanuel

Rahm Emanuel
Mayor
City of Chicago

Overview


Introduction
Credit: City of Chicago Photography Services

The Importance of Water in Chicago

Chicago is a city of water. The backdrop of Chicago's downtown set along the protected Lake Michigan waterfront is an iconic image known around the world. Beyond the Lake Michigan shoreline, our water resources extend throughout, and beneath, the city. They are the Chicago River, Lake Calumet, the Calumet River, thousands of acres of wetlands, creeks, streams and lagoons, as well as canals and channels. Equally important are the thousands of miles of pipes that have—for over 100 years—delivered drinking water and helped us manage stormwater. Water is our most valuable natural resource and a vital part of Chicago's past and its future.

Beyond providing a source of safe drinking water, Chicago's waterways support a wide variety of uses that are critical for our economy, recreation, public health, natural assets, and quality of life. With 26 miles of public lakefront and 28 miles of riverfront, enjoyment of and access to water is an amenity that exists for all 2.7 million Chicagoans. The city's 24 free public beaches along Lake Michigan are invaluable assets that serve over 20 million visitors per year. Annually, more than 50,000 commercial and passenger vessels travel the Chicago River, serving as a crucial route for shipping and recreation. Our waterways also serve as critical habitat for wildlife, from migrating birds to the 70 species of fish that are known to live in the Chicago River.

Chicagoans before us acted to preserve our freshwater assets. Now it is our turn to build upon their efforts to improve stormwater management and enhance our waterways.

With continued investment and sustainable stewardship, Chicago is poised to strengthen its competitive advantage as a leader in water quality, management, and access. We are taking major strides to improve the long-term sustainability of the water system and our waterways. These efforts include renewing water infrastructure, conserving water, greening water operations, and sustainably managing stormwater. We are also transforming the Chicago River into our second waterfront through major initiatives such as completing the Chicago Riverwalk and constructing boathouses at key locations. Through these investments, we are creating a platform for economic growth, reducing flooding risk, strengthening neighborhoods, and expanding opportunities for residents to live healthier and more active lifestyles.

Chicago's History of Water Management

Chicago has a long history of managing water resources. After thousands died from outbreaks of cholera and diphtheria in the 1840s, city leaders devised a system of sewers to remove sanitary sewage and discharge it directly into waterways. In 1857, the City of Chicago began to implement a plan for a sewer system that served an area of approximately seven of the 18 square miles that then comprised the city.

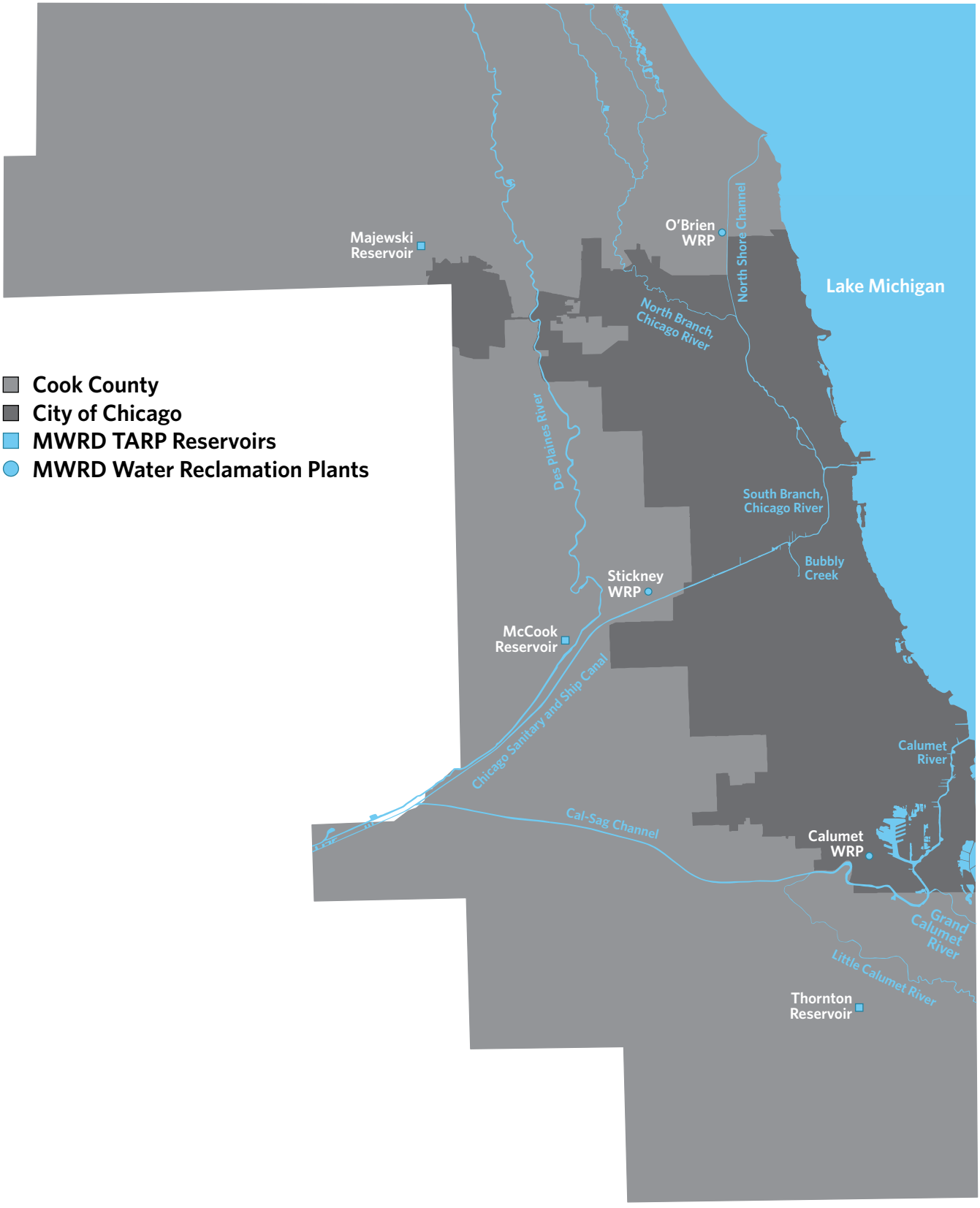
Repeated outbreaks of epidemic diseases compelled the city leaders to find a way to stop the flow of polluted water into Lake Michigan. The Metropolitan Sanitary District of Greater Chicago was created in 1889 to safeguard Chicago's drinking water and determine an acceptable way to dispose of waste. In 1900, a massive engineering effort addressed Chicago's sewage contamination when engineers constructed the Chicago Sanitary and Ship Canal to reverse the Chicago River's natural flow from eastward to westward, thereby steering human and industrial waste away from Lake Michigan.

Flooding and water quality problems persisted, however; so in 1972, the Metropolitan Water Reclamation District of Greater Chicago (MWRD) started constructing the large-scale, multi-purpose Tunnel and Reservoir Plan (TARP), commonly known as the "Deep Tunnel." This plan calls for deep rock tunnels and surface reservoirs that capture, convey, and store sewage and stormwater during storms until it can be pumped to existing treatment plants when capacity becomes available.

By 2006, MWRD completed Phase I of TARP, which includes over 109 miles of tunnels with 2.3 billion gallons of capacity. Phase II of TARP includes three reservoirs that will increase the TARP system storage volume to approximately 20 billion gallons. MWRD currently expects to complete TARP by 2029.

Chicago's current infrastructure is comprised of an extensive network of approximately 5,000 miles of sewers, over 4,400 miles maintained by the City's Department of Water Management and over 500 miles maintained by MWRD. This network is one of the city's most significant assets, and has improved the health of generations of Chicagoans. Approximately 99.5 percent of the city's sewered area is comprised of sewers that collect stormwater and sanitary sewage in the same pipes and then direct the combined flow to one of MWRD's water reclamation plants for treatment before discharge. When MWRD does not have capacity for treatment at their plants, the combined flow of stormwater and wastewater overflows to TARP. If TARP is also full, then a mixture of sewage and stormwater will overflow through one of approximately 200 combined sewer outfalls that are located along the Chicago River, the North Shore Channel, Bubbly Creek, the Chicago Sanitary and Shipping Canal, Lake Calumet, and the Calumet River.

Overview of Chicago Area Waterway System and Major Stormwater Infrastructure



Credit: Chicgao Dept. of Water Management

Chicago's Stormwater Challenges

Causes

Managing stormwater in a large city like Chicago is a monumental task. One inch of rain citywide generates approximately 4 billion gallons of stormwater. Some of the stormwater that falls in our neighborhoods soaks into the ground, while most flows into the city's sewer system.

Chicago's stormwater management challenges are rooted in our history of development. Spanning over 150 years, development in Chicago has converted permeable natural areas into thousands of acres of impervious surfaces such as rooftops, roads, sidewalks, parking lots, and driveways. Today, close to 60 percent of Chicago's land area is either paved or covered with buildings. These surfaces do not allow rainwater to infiltrate into the ground as most are designed to drain stormwater away as fast as possible.

Without green space to absorb rainfall, the sewer system is required to handle large volumes of stormwater. Stormwater sent to our sewers is no longer available to naturally irrigate our lawns or recharge groundwater. This combined system not only misses a valuable opportunity to use rainwater as a resource, but also uses a substantial amount of energy and chemicals to treat the combined stormwater and sewage.

Effects

Stormwater runoff from developed land in Chicago causes a number of problems when it is not effectively managed. During heavy rains, stormwater can overwhelm the sewer system, thus resulting in public health risks, beach closings, and property damage. The three main effects of excess stormwater can be combined sewer overflows, basement flooding, and backflow of water from the Chicago River into Lake Michigan.

Combined Sewer Overflows
Approximately 99.5 percent of Chicago's sewered area is comprised of sewers that collect stormwater and sanitary sewage in the same system. On a dry day, Chicago's wastewater treatment plants have enough capacity to handle the City's sewage. But during larger storms, the combined flow is often more than the wastewater treatment plants and TARP can accommodate and treat. The combined sewer system was designed to divert excess flow to local waterways instead of flooding the treatment plants or sending a mix of sewage and stormwater back up into streets and buildings. This mixture of sewage and stormwater is discharged, untreated, through outfalls into the river and canal system. This is commonly referred to as a combined sewer overflow (CSO). CSOs result in the discharge of coliform bacteria, organic matter, floatables, and other hazardous substances from runoff, industrial processes, or cleaning and household products.

This type of sewer system is not unique. Combined sewer systems are remnants of the country's early infrastructure and are typically found in older communities. As a result, CSOs are a major water pollution concern for over 700 cities and approximately 40 million people who are concentrated in the Northeast, Great Lakes, and Pacific Northwest regions of the United States.

In Chicago, a rain event of as little as 0.67 inches in a 24-hour period can trigger a CSO in the Chicago River. From 2007-2012, CSO events occurred on 314 days, an average of approximately one per week.

Basement Flooding
Basement flooding can be caused by many different issues, including storms that exceed sewer system capacity, clogged drains, failed sump pumps, cracked foundations, damaged private sewer service lines, improper protections on below grade fixtures, or localized blockages from grease, tree roots, or other debris that restrict flow in the system.

Chicago skyline before a rain storm

When too much rainfall enters our sewer system and cannot flow fast enough to a wastewater treatment plant or a combined sewer outfall, that water can back up into homes and other buildings. Sewer back-ups occur when the level of sewer water rises to the level of openings such as fixtures or drains that are below street grade. As the water seeks its own level, it will rise through openings in basements unless they are above the surcharge height or unless protective measures, such as backwater valves, are in place.

Basement flooding is a challenge that can impact thousands of properties throughout Chicago during severe rain storms. This challenge is widespread and not easily defined in geographic terms. The problem correlates with the ability of underground sewer infrastructure to manage stormwater runoff from the aboveground city surfaces. The problem most often does not correspond to traditional land use boundaries such as community areas or City Council ward boundaries. Basement flooding threatens neighborhoods on the North, West, and South Sides, and almost all wards have at least one area that is at risk of basement flooding.

Lake Michigan Reversals

During extreme storm events, when TARP becomes full and the rivers are at risk of overtopping their banks, MWRD and the Army Corps of Engineers open the locks that normally separate the Chicago and Calumet Rivers from Lake Michigan. This event, called a "Lake Michigan Reversal," releases a mixture of river water, rainwater, and sewage into Lake Michigan.

Since 1985, MWRD has had 27 Lake Michigan Reversals that have caused a total of over 44 billion gallons to overflow from the Chicago Area Waterways System (CAWS) to Lake Michigan. Of these 27 reversals, 12 have discharged at the Chicago River Controlling Works, which is located near Navy Pier in the center of Chicago.

Since Lake Michigan Reversal events typically occur only during severe storms, the water from the CAWS is more likely to be contaminated with a mix of rainwater and sewage due to the correlation between combined sewer overflow events and severe storms. These events can pollute the drinking water supply that serves more than 5 million people a day and the 24 beaches used by over 20 million visitors each year.

Climate Change

In recent years, Chicago has witnessed numerous intense rainfall events that have caused citywide basement flooding occurrences and the opening of the locks at Lake Michigan. Unfortunately, these storms have exceeded expectations and point the way to a new normal.

The Illinois State Climatologist periodically publishes storm frequency tables that list expected rainfall amounts based on historic rainfall patterns. The most recent publication of this type, titled "Rainfall Frequency Atlas of the Midwest," and also known as "Bulletin 71," provides expected rainfall volumes for specific rain event recurrence intervals. As an example, this document states that a rain event that results in 4.96 inches in a 2-day period is considered a "10-year storm" since an event like that would be expected to occur once every ten years based on past trends.

The Chicago region has experienced 4 storms in the last 6 years that have exceeded the rainfall amount of a "10-year storm" as measured over a 2-day period at the rain gauge at O'Hare International Airport. A storm on September 13-14, 2008 brought 6.64 inches, making it a "25-year storm." On July 23-24, 2010, the 6.43 inches of rain was also a "25-year storm." Chicago experienced a "100-year storm" on July 22-23, 2011 with 8.41 inches of rainfall, and the 6.86 inches that fell on July 23, 2011 was the largest single-day rainfall amount since records began in 1871. And on April 17-18, 2013, the 5.55 inches of rain registered as a "10-year storm."

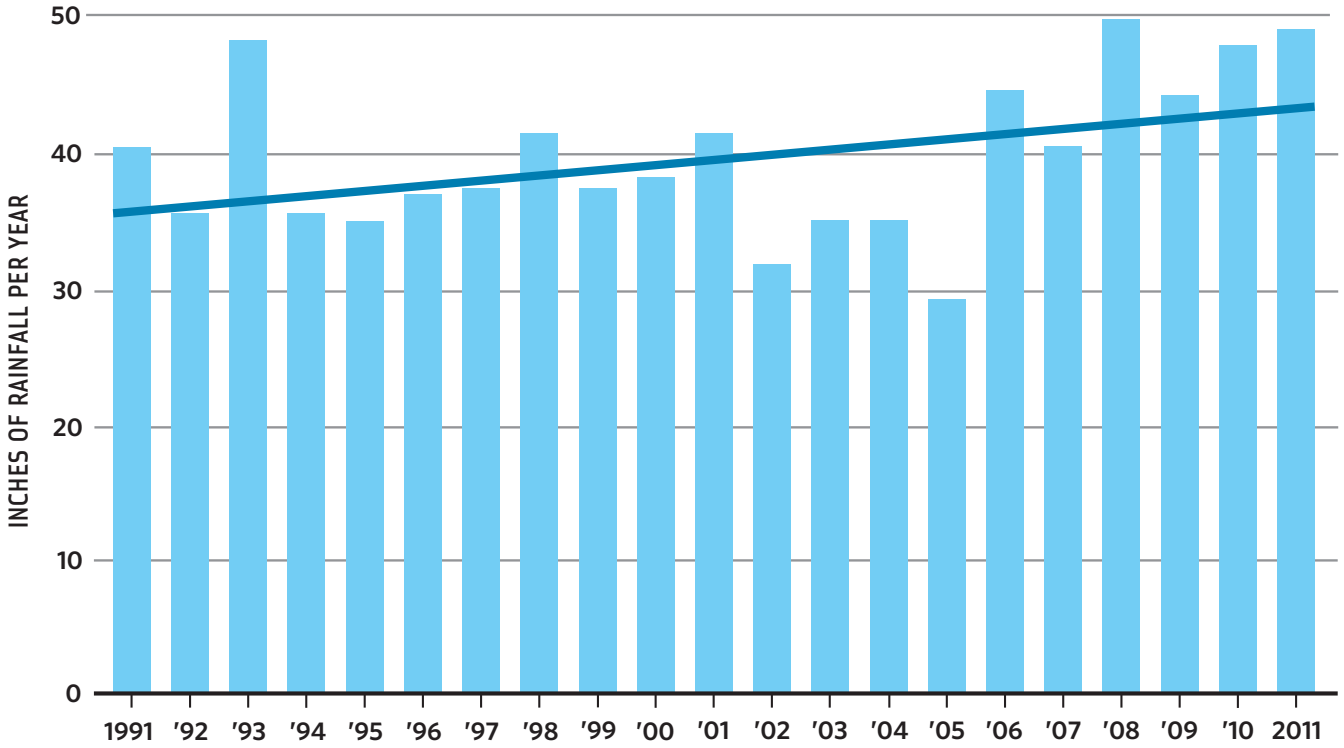
The recent April 17-18, 2013 storm did not bring as much rain as several other intense storms in recent years, but the damage was still extensive. The TARP tunnels filled up in the early morning of April 18, which was well before the heaviest rainfall. This resulted in combined sewer overflows at 132 separate outfall locations. To prevent overland flooding, MWRD and the Army Corps opened the Chicago River Controlling Locks for nearly 23 hours, leading to a discharge of over 10.7 billion gallons into Lake Michigan. Basement flooding occurred citywide, with the City receiving over 2,500 "water in basement" calls to 311 from residents in 49 of the 50 wards.

While it is not possible to attribute a single storm event to climate change, the numerous strong storms that have impacted Chicago in recent years are consistent with the climate change projections that are supported by the overwhelming majority of the world's scientists.

Climate change is one of the most serious issues facing the Earth today. There is strong consensus that most of the changes in world climate during the last 50 years are a result of human-made emissions of greenhouse gases (GHGs), which have been heating the Earth's atmosphere. Naturally occurring levels of GHGs keep temperatures on Earth stable. But the burning of fossil fuels and increasing rates of deforestation have produced growing amounts of carbon dioxide (CO_2), methane, and other heat-trapping gases. In the last 50 years, levels of CO_2 have risen 25 percent. Levels of methane, an even more potent greenhouse gas, have more than doubled. Because of these increases in heat-trapping gases, average temperatures are projected to increase over the coming decades. According to the Federal government's U.S. Global Change Research Program, the global average temperature since 1900 has risen by about 1.5 °F. By 2100, it is projected to increase another 2 to 11.5 °F.

Average Annual Rainfall in Chicago: 1991-2011

Illinois State Water Survey Cook County Precipation Network Station 10



Source: Illinois State Water Survey

In 2008, the City of Chicago commissioned a study titled "Climate Change and Chicago: Projections and Potential Impacts" as part of the process to create the Chicago Climate Action Plan. This investigation indicated that climate change will impact Chicago in significant ways, resulting in higher temperatures, more precipitation, and more frequent and intense storms. As a result of global climate change, summer rainfall will occur in more intense storms.

This research showed that changes to the climate have already occurred. The frequency of heavy rainfall events has doubled since the 1970s. The time of year when precipitation falls most heavily is changing, and more precipitation is falling as rain instead of snow. There is less snow in winter, and the snow melts earlier in spring.

Climate change will bring additional precipitation changes during the coming century. Annual precipitation could increase by about 10 percent by mid-century and 20-30 percent by the end of the century. Most of this increase is expected to occur in winter and spring. There is as likely as not to be little change in overall summer and fall precipitation volumes, although heavy precipitations events are expected to increase considerably. Precipitation patterns are likely to change in the summer, as rain falls more heavily but at fewer times with long dry periods in between the downpours.

These changes to our climate have had and will continue to have serious consequences for stormwater management in Chicago. As we plan for the future, we will incorporate projections of climate change to ensure that we are addressing the city's long-term challenges.

Moving Forward

This Green Stormwater Infrastructure Strategy is the next step by the City of Chicago as we strengthen our role as a world water leader and prepare for the future. This strategy builds upon and extends the commitments made by Sustainable Chicago 2015, Mayor Emanuel's roadmap for environmental stewardship and economic development, and the Chicago Climate Action Plan.

Green infrastructure is a key tool in the City's stormwater management kit. The City's successful green infrastructure strategies, such as the Stormwater Ordinance, the green roof initiative, and the Green Alleys program, have proven the ability of sustainable techniques to keep water out of our overburdened sewer system while also providing multiple other benefits such as enhancing property values and reducing energy use. The implementation of just green roofs and permeable pavement in Chicago has provided the capacity to capture over 85 million gallons of stormwater each year.

We will continue to invest in green stormwater infrastructure because it provides meaningful stormwater management benefits now, and it offers long-term potential to serve as a cost-effective supplement or alternative to traditional grey stormwater infrastructure investments. Through this strategy and our future efforts, we will determine the best balance between investing in green and grey stormwater infrastructure to most cost-effectively manage stormwater and provide the greatest benefits to Chicagoans.

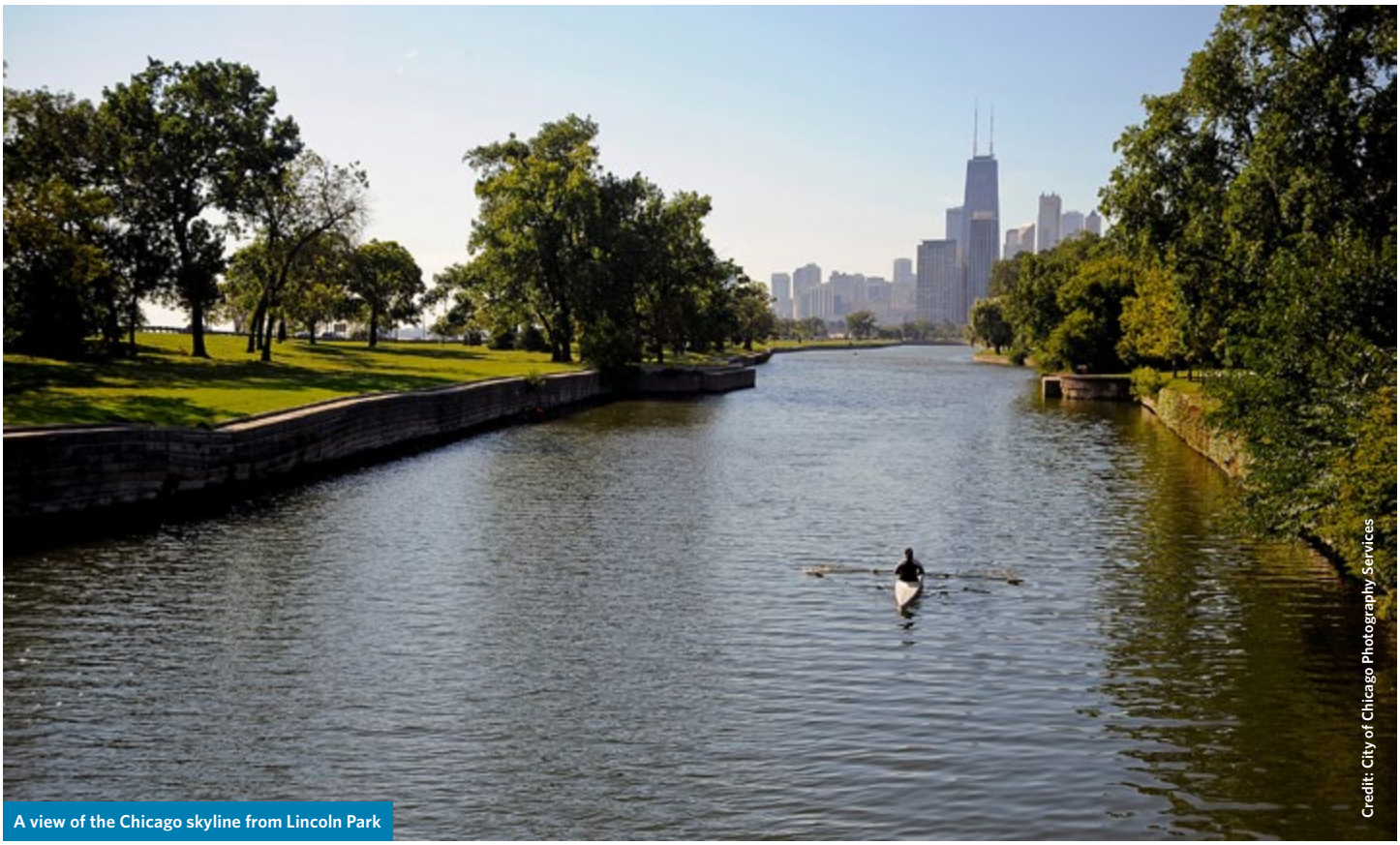
This strategy provides a framework and initial implementation plan to meet the goals of using green stormwater infrastructure to enhance stormwater management, protect water quality, and build a vibrant economy on 21st century infrastructure. Dealing with stormwater management challenges is critical for the future of the city, and this strategy lays out steps to build green stormwater infrastructure now as well as plan for the future through additional analysis concerning long-term water infrastructure strategies and needs.

This strategy recognizes many important existing conditions, strengths and limitations regarding stormwater management in Chicago. This strategy's initiatives are designed to address these issues.

First, we recognize that significant long-term investment in stormwater infrastructure is necessary. Our challenges with combined sewer overflows, basement flooding, and water quality pollution are longstanding problems. They were caused by a complex set of factors and decisions that have occurred through the last 150 years. Many of these decisions, such as industrialization and dense urban development, have allowed Chicago to emerge as a modern city that plays a vital role in the world's economy. While we will not be able to solve our stormwater challenges overnight, we know that we can make steady, significant progress through good planning, smart investments, and a sustained commitment.

Second, this strategy acknowledges that the completion of the Tunnel and Reservoir Plan is a critical step toward improving water quality and increasing flood protections for Chicago and its region. Over 109 miles of TARP tunnels already exist, and work is currently underway to finish reservoir projects that will provide an additional 17 billion gallons of capacity when finished. However, TARP is currently not scheduled for completion until 2029, and there is much more that we can do in the meantime to improve stormwater management and enhance the quality of life for Chicagoans. And even when TARP is eventually finished, our work will not be done. Even if TARP is completed, and absent other significant stormwater infrastructure investments, Chicagoans would still face sizable risks from basement flooding since the City does not have the capacity to convey stormwater fast enough from many neighborhoods through local sewers to the TARP reservoirs.

Third, while this strategy specifically addresses the role of green stormwater infrastructure to keep water from flowing into our sewers, we recognize that traditional grey stormwater infrastructure investments are also critical. Green stormwater infrastructure manages



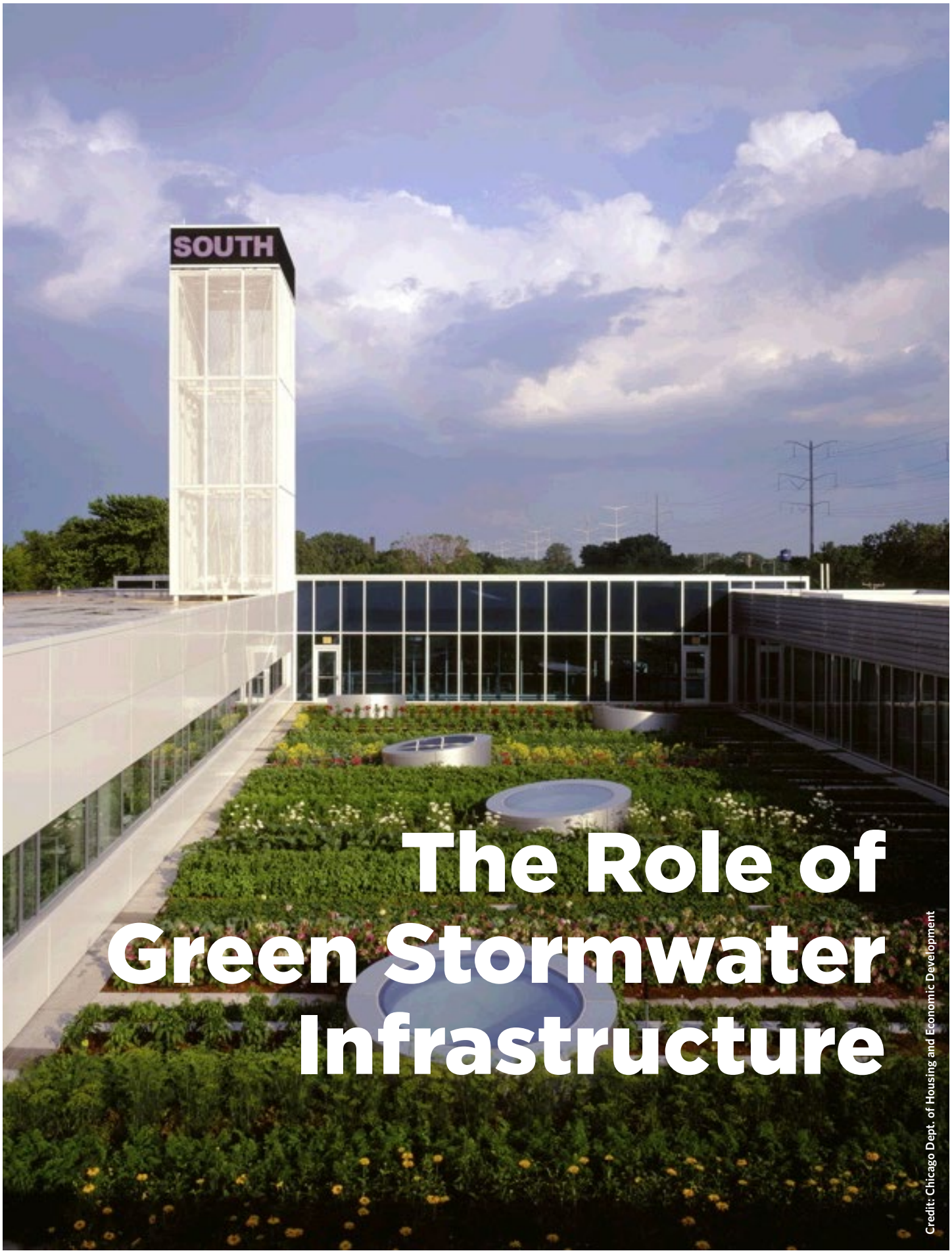
A view of the Chicago skyline from Lincoln Park

Credit: City of Chicago Photography Services

stormwater at its source where it falls and runs into the sewers as opposed to attempting to manage stormwater at the end of the pipe through traditional grey stormwater infrastructure such as conveying the water through a sewer to a wastewater treatment plant or an outfall into a waterbody. Our planning and implementation efforts recognize that Chicago green and grey stormwater infrastructure are ultimately one integrated system that must work in concert to effectively address our runoff challenges.

Last, solving our stormwater challenges will require meaningful and sustained collaboration among key stakeholders. Within the local government, many City departments and sister government agencies have critical roles to play. The Metropolitan Water Reclamation District is a crucial partner as they have direct responsibility for and important expertise in stormwater management. Many non-governmental organizations, philanthropies, environmental groups, business community leaders, and neighborhood associations have provided leadership in this area for years, and their continued participation is essential. Finally, solving our stormwater challenges will require the efforts or private landowners and citizens since their actions can meaningfully contribute to finding and implementing solutions.

Chicago has made significant progress over the last decade upgrading sewer infrastructure and implementing green stormwater infrastructure. Our next step is to continue critical sewer replacement projects, build additional green stormwater infrastructure, and develop a citywide implementation plan for stormwater management. This strategy is a major step toward solving our stormwater challenges, but much more work is needed.



The Role of Green Stormwater Infrastructure

Credit: Chicago Dept. of Housing and Economic Development

Defining Green Stormwater Infrastructure

"Green stormwater infrastructure" is a term used to refer to strategies for handling storm precipitation where it falls rather than after it has run off into a sewer system. Green stormwater infrastructure is therefore an alternative or complement to conventional stormwater management approaches. These conventional approaches, or "grey stormwater infrastructure" strategies, typically involve enlarging sewer systems, increasing the capacity of wastewater treatment plants, or building containment facilities or "deep tunnels" for collecting stormwater before treating and releasing effluent into natural waterways.

Using a green stormwater infrastructure approach means designing the built environment to capture rainfall and storing it for use or letting it filter back into the ground, replenishing vegetation and groundwater supplies. The goal is to keep water out of overtaxed sewer systems and better mimic conditions that existed before the occurrence of urban development.

Green stormwater infrastructure employs natural systems such as vegetation, wetlands, and park space to handle rainfall. It can also include the use of manufactured solutions such as rainwater harvesting systems or permeable pavement. Green stormwater infrastructure strategies are sometimes also referred to as "low impact development" (LID), "best management practices" (BMPs), or "source controls." Examples of green stormwater infrastructure include green roofs, bioswales, rain gardens, rain barrels, cisterns, permeable pavers and porous concrete and asphalt.

Green stormwater infrastructure strategies can provide multiple benefits beyond just managing rainfall and runoff. These benefits include environmental, economic, and social improvements, such as cooling and cleansing the air, reducing asthma and heat-related illnesses, decreasing water loss in the region, lowering heating and cooling energy costs, boosting economic development, creating jobs, enhancing recreational amenities, and beautifying neighborhoods.

Conventional grey stormwater infrastructure, such as sewers, wastewater treatment plants, and underground storage systems, addresses the symptoms of stormwater runoff. Instead, green stormwater infrastructure focuses on the root problem, which is the imperviousness caused by land development. Green stormwater infrastructure utilizes an underlying philosophy of pollution prevention and the premise that it is better to prevent pollution that to treat it. This approach views stormwater as a resource, not a waste.

This document focuses on green stormwater infrastructure, which encompasses a set of tactics that are specifically focused on managing the impacts of rainfall and runoff. Many use the term "green infrastructure" to refer to all natural and vegetated systems that provide ecological services. These include natural features such as wetlands, trees, flowers, grasslands, urban agriculture, lakes, rivers, and ponds. Others go further by considering "green infrastructure" to include any sustainable strategy such as energy efficient lighting, materials with post-recycled content, and bike lanes. All of these approaches are important for creating a sustainable city, but this document is focused specifically on green infrastructure that is explicitly built and maintained for stormwater benefits. To address the broader set of issues that one might consider green infrastructure, the City has other strategies and planning efforts, such as the Nature and Wildlife Plan, the capital program of the Chicago Park District, the Calumet Open Space Reserve Plan, the CitySpace Plan, and Sustainable Chicago 2015.

A National Stormwater Movement

Cities across the United States are increasingly using green stormwater infrastructure to improve water quality, reduce flooding, and build resilience to climate change.

Chicago is widely recognized as an early adopter of green stormwater infrastructure strategies. For over ten years, the City has pioneered the installation of green rooftop gardens, the use of permeable pavement in alleys and streets, the greening of arterial streets, the widespread distribution of rain barrels, and land use regulations that require greater levels on on-site stormwater management through green practices.

Other cities have also led the way. The City of Philadelphia is implementing a $2.5 billion, 25-year stormwater management plan called "Green City, Clean Waters." Philadelphia developed this plan primarily to fulfill their legal obligations to reduce CSOs under the U.S. Clean Water Act. Of the $2.5 billion in this plan, Philadelphia anticipates that 85 percent will fund green stormwater infrastructure. Their plan requires the retrofit of nearly 10,000 acres to manage runoff before it enters their sewer system. This will be done by building public green infrastructure in streets, sidewalks, schoolyards, and public building rooftops. Their plan also heavily relies on private green infrastructure construction through increased development regulations and private property incentive programs. Philadelphia expects the water quality benefits from their strategy to be equivalent to building a $10 billion "deep tunnel."

New York City is embarking on a similarly ambitious effort. Their "Green Infrastructure Plan," released in 2010, calls for spending $2.4 billion in public and private funding for targeted green infrastructure installations, as well as $2.9 billion in cost-effective grey infrastructure upgrades over 20 years. This plan replaced a previous all-grey stormwater infrastructure approach that would have resulted in the construction of several "deep tunnel" projects and other costly traditional grey stormwater projects. By integrating green stormwater infrastructure into their overall stormwater management strategy, the City of New York expects a savings of $1.4 billion from substituting grey infrastructure with green infrastructure and an additional $2 billion in deferred costs.

A stormwater bump-out in Portland, Oregon

Many other cities are also demonstrating leadership in green stormwater infrastructure. Portland and Seattle are pioneers who developed many of the innovative strategies that other cities are now adopting. In the greater Midwest, the metropolitan water and sewer utilities in Cincinnati, Cleveland, and Milwaukee are all working to implement formal green infrastructure plans.

A New York City Right-of-Way Bioswale

Credit: NYC Dept. of Environmental Protection

A rendering of potential green stormwater infrastructure in Philadelphia

Credit: Philadelphia Water Department

A Seattle Street Edge Alternative (SEA) Street project

Credit: Abby Hall

The Federal government has recently taken steps to follow the lead of cities on green stormwater infrastructure planning and implementation. Green infrastructure is strongly supported in the 2011 strategic agenda of the U.S. Environmental Protection Agency (USEPA), and the agency is increasingly allowing cities to use green stormwater infrastructure to meet Clean Water Act mandates. In an October 27, 2011 memo on achieving water quality improvements, the USEPA stated that they "strongly encourages the use of green infrastructure and related innovative technologies, approaches, and practices to manage stormwater as a resource, reduce sewer overflows, enhance environmental quality, and achieve other economic and community benefits."

It is important to note that most of the cities making substantial financial commitments to green stormwater infrastructure, such as Philadelphia and New York City, are doing so to comply with federal consent decrees that are mandated to comply with Clean Water Act requirements by decreasing overflows of sewage from combined sewer systems. The City of Chicago does not have a federal consent decree mandating investments to reduce combined sewer overflows. That obligation is held by the Metropolitan Water Reclamation District of Greater Chicago.

Benefits

Using green stormwater infrastructure can provide many benefits beyond improving the management of rainfall and runoff. These benefits include environmental, economic, and social improvements.

Environmental

Green stormwater infrastructure, particularly those strategies that use trees and vegetation, provide multiple environmental benefits. Green stormwater infrastructure can improve air quality by filtering and removing pollutants from vehicles and industrial sources. Some strategies can reduce the urban heat island by providing shade or converting impervious surfaces into vegetated or permeable landscapes. Increasing vegetation can also improve biodiversity by expanding the number of plants and providing additional species habitat. All of these benefits improve the quality of life for Chicago residents and help achieve other environmental objectives, such as reducing energy use and building resilience to the impacts of climate change.

Green stormwater infrastructure can also decrease water loss in the region. Chicago's traditional stormwater and wastewater grey infrastructure sends treated effluent, or discharged water, into one of the city's rivers or channels, which then eventually flows through the Mississippi River Basin to the Gulf of Mexico. This water is therefore diverted from Lake Michigan, which is a vital resource for the region and a water body that witnessed a historic low water level in early 2013. Since green stormwater infrastructure captures water before it enters the sewer system, more water remains in the watershed, either through a decrease in potable water that is used for irrigation or by an increase in rainfall that is infiltrated or evaporated.

Economic

Widespread implementation of green stormwater infrastructure potentially offers significant economic benefits, such as deferring or even replacing costly large grey stormwater infrastructure projects. These large installations, such as major sewer expansions and deep tunnels, are costly to construct and take years to complete. They also have long lead times for planning, design, bonding and construction, leaving them vulnerable to escalating costs from external market conditions for materials, labor, and financing. Compared to large grey infrastructure projects, the incremental construction of green stormwater infrastructure typically uses more level cash flows that provide flexibility and better financing.

Green stormwater infrastructure reduces the costs for treatment at water reclamation plants since this rainfall is instead filtered and treated naturally. Green stormwater infrastructure can also reduce the need for water purification if the runoff is captured and used for irrigation. This decreases the costs for energy and chemicals and also reduces air pollution and carbon emissions.

Social

Implementing green stormwater infrastructure provides opportunities to increase the quality of neighborhoods and add community amenities. Installing grey stormwater infrastructure typically means digging up streets to install underground infrastructure or tunneling deeper below the city's surface. These projects provide benefits for stormwater management, but the end result is typically a restored street that functions the same as before the project but with a better paved surface. Green stormwater infrastructure can provide additional social benefit, such as through planting trees that offer shade, installing green roofs that provide open space, or enhancing parks that serve as public gathering places.

Current Constraints

Green infrastructure provides many benefits, yet there are also several unknown issues where additional data and analysis will help determine how green stormwater infrastructure can best complement traditional grey stormwater infrastructure.

Cities across the country, including Chicago, have implemented green stormwater infrastructure strategies for at least a decade. This has allowed policymakers, engineers and designers to understand the great potential that green stormwater infrastructure offers for solving urban stormwater management challenges. However, no city in the United States has yet fully implemented a city-wide, large-scale green stormwater infrastructure program. Therefore, water management experts still have much to learn and analyze about the ability of green stormwater infrastructure to minimize basement flooding or reduce combined sewer overflows.

One of the largest knowledge gaps surrounding green stormwater infrastructure is around the actual costs and benefits to manage stormwater. Many cities have built important pilot or demonstration projects that provide cost information and short-term performance data, but these studies are not able to provide cost information for building many installations at a large scale, nor are they able to provide the stormwater benefits of implementing many installations in close proximity within a watershed or large community area. Also, since few cities have implemented green stormwater infrastructure projects over many years, there is limited data concerning long-term effectiveness and maintenance needs.

Green stormwater infrastructure installations can also have physical limitations depending on the technique used. The most significant limitation in dense urban areas is space. Stormwater management strategies such as detention ponds are a staple of systems in suburban areas but require too much area and are therefore not feasible in most parts of Chicago. Other physical constraints limit the effectiveness of infiltration techniques, such as the presence of underground utilities or poorly infiltrating soils like clay, which is found throughout much of Chicago.

Compared to centralized grey stormwater infrastructure, decentralized green stormwater infrastructure is built gradually, often by non-municipal actors on private property. The effectiveness of such decentralized systems depends upon the aggregate, cumulative effects of many small-scale measures. Since it takes many years of adoption to achieve significant numbers of installations, a decentralized green stormwater infrastructure strategy requires that public agencies, community groups, and private landowners have a decades-long commitment to a comprehensive green stormwater infrastructure program. Just as the city's surfaces were paved and developed over time, they can only be modified gradually.

Maintenance is also a critical consideration. Green stormwater infrastructure installations may have diminishing effectiveness over time or failure if not properly maintained. When implementing a large-scale green infrastructure program, it is necessary to ensure that there are sufficient resources and people that are trained to properly install and maintain installations.

Lastly, it is important to recognize that green stormwater infrastructure installations are well-suited to handle the rainfall volume from small rain events, but that large storms can generate immense stormwater runoff that can easily overwhelm installations like rain gardens, rain barrels, and bioswales.

Opportunities

Chicago is a large, dense city, yet there are still many opportunities to implement green stormwater infrastructure. Building green stormwater infrastructure in a dense city requires policymakers, planners, designers and engineers to think differently about how they construct the fundamental components of the built environment, including buildings and sites, streets and sidewalks, and parks and open spaces.

Buildings and Sites

There are three basic green stormwater infrastructure strategies for buildings and sites – manage water on the roof, manage water as it flows off of the roof, or manage water where it falls on site.

Rooftops cover a significant part of Chicago's land area, and many of those rooftops are flat surfaces that are conducive to capturing and holding rainfall. A wide range of buildings in Chicago have flat roofs. All of these could be candidates for either a green roof, sometimes referred to as a rooftop garden, or a "blue roof," which is a form of rooftop detention.

Green roofs treat stormwater through retention or bioretention. Green roofs are comprised of a structurally sound roof, a waterproofing and root barrier, a drainage layer, a permeable fabric, a growing medium, and vegetation. Blue roofs, or rooftop detention systems, are a detention technique where a flow restriction device around a drain holds back water until the storm passes. If the ponded water depth exceeds the established threshold amount, the water flows over the collar into the roof drain. Blue roof systems require a flat, watertight roof with enough load-bearing capacity to support the weight of ponded water and an appropriate number of drains to support desired water flow.

Managing water as it flows off of the roof requires disconnecting downspouts and redirecting water to a green stormwater infrastructure installation. In Chicago, many houses, garages, and nearly all commercial and institutional structures have downspouts that are connected directly to combined sewers. Therefore, sewers are receiving a significant volume of water from rooftops that could otherwise take a natural course through a lawn or other pervious land and then, only after these areas were saturated, would stormwater flow into sewer systems.

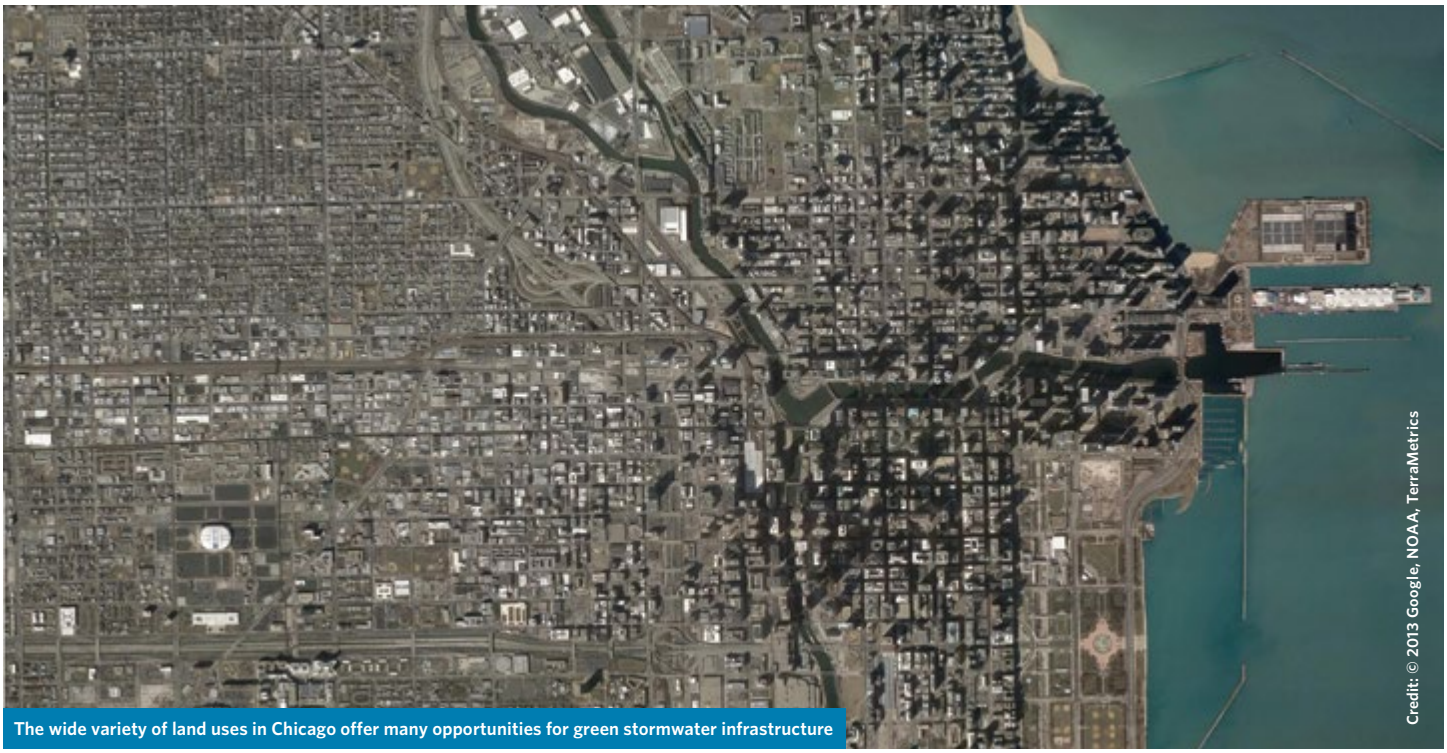
Downspout disconnection involves eliminating the direct sewer connections and redirecting downspouts to pervious areas to allow stormwater to infiltrate into a vegetated or permeable area. Downspouts also can connect to a stormwater retention device such as a rain barrel or a cistern. Rain barrels are small above-ground barrels that typically measure 50 gallons. Rain barrels are well-suited for parcels with landscaped areas since the captured water can be used for irrigation. Cisterns are similar to rain barrels, except they are larger and can sometimes be stored underground. Cistern sizes are typically between 300 and 1,000 gallons and are most often used with larger buildings.

Rain gardens are small vegetation-filled depressions that accumulate runoff, promoting increased infiltration as well as providing additional storage. Rain gardens can be placed in front or back yards in residential areas or on green space in commercial parking lots. Yard and roof runoff reaches the rain garden by way of overland flow, downspouts, or emptying of rain barrels. In a rain garden, flow has an opportunity to infiltrate into the soil or escape into the atmosphere via transpiration.

Streets and Sidewalks

Chicago's public right-of-way represents 23 percent of the city's land area and an even higher percentage of the city's impervious surfaces. The city's over 4,000 miles of streets and approximately 2,000 miles of alleys represent a critical opportunity to keep stormwater out of our overtaxed sewer system.

There are two basic green infrastructure strategies for streets, sidewalks, and alleys – capture stormwater in vegetated areas or use permeable pavement strategies to allow water to percolate into the ground.



The wide variety of land uses in Chicago offer many opportunities for green stormwater infrastructure

Vegetated controls include tree pits, bioswales, rain gardens, filter strips, Green Streets, and stormwater planters. They are typically designed to capture runoff from the adjacent sidewalk and street, typically through a specially designed inlet. Soil systems in vegetated controls usually contain a high-infiltration soil layer underlain by more typical planting soils and gravel. Plant selections for vegetated controls that accept street runoff are made to account for the impacts of pollutants and salt that can be carried into the installation.

Permeable pavement technologies, including permeable pavers, porous asphalt or porous concrete, allow water to pass through or between the paved surfaces into a specially-designed subgrade gravel bed or other porous medium. Permeable pavement systems can act as a detention or retention technique since water stored in the subgrade medium can percolate into the ground, evaporate, or leave the system laterally through an overflow pipe or underdrain.

Chicago has extensive areas of alleys, sidewalks, driveways, parking lots, plazas, bike lanes, and other low-traffic areas that represent potential permeable pavement sites. Permeable pavements generally are used on surfaces that are subject to low-speed, low-impact use by vehicles. Permeable pavements are typically not installed over underground utility vaults, subways, underground parking lots, on sites with a history of intense soil contamination.

Parks and Open Spaces

Chicago has a wide variety of open spaces that could be utilized for green stormwater infrastructure, including parks, playgrounds, schoolyards, and vacant lots. Open spaces and natural areas can be harnessed to absorb and filter stormwater that would otherwise go into the sewer or flood our roads.

Parklands contain significant permeable surfaces that already absorb rainwater. If properly designed and integrated into ongoing restoration work, many park sites can be enhanced to create hydraulic connections to larger land areas that are generally impervious. Therefore, green stormwater infrastructure in parklands and natural areas can be used to capture runoff from surrounding roadways and other impervious surfaces. In particularly, schoolyards represent a significant opportunity for green stormwater infrastructure since Chicago has over 600 public schools, many of which are characterized by large expanses of impervious surfaces. Vacant lots also provide an opportunity for additional stormwater control if properly designed and integrated into a broader neighborhood revitalization effort.

Green Stormwater Infrastructure in Chicago

Chicago is already a leader in green stormwater infrastructure. The City has implemented a wide range of plans, ordinances, policies and programs that are contributing to our goal of making Chicago an environmentally sustainable city. This strategy builds on and incorporates a series of sustainable stormwater management initiatives that are underway by City of Chicago agencies.

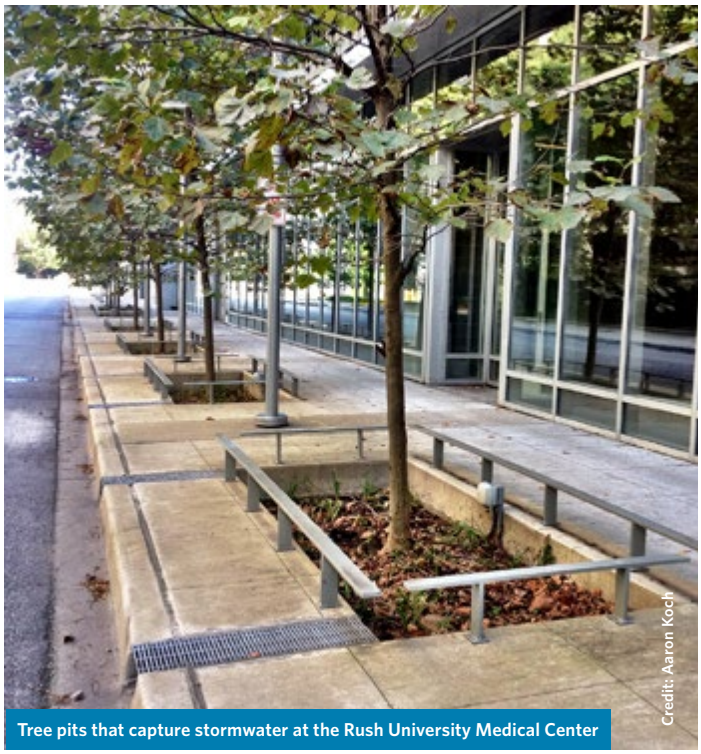
Policies

Chicago Stormwater Ordinance
The Stormwater Ordinance, adopted in 2008, provides standards and restrictions for development and major renovation projects that connect to the City's sewer system. The ordinance requires that any building with a footprint over 15,000 square feet or any parking lot over 7,500 square feet detain at least the first half inch of rain on-site. Alternatively, the building or parking lot may meet the requirements of the ordinance by reducing prior imperviousness of the site by 15 percent. The Stormwater Ordinance also establishes requirements for the rate at which stormwater is released from these sites into the city's sewers. The Stormwater Ordinance and Manual promote the use of green stormwater infrastructure as a key strategy for capturing stormwater. The Stormwater Ordinance has resulted in the reduction of over 3 million square feet of impervious surfaces since 2008.

Sustainable Development Policy
Published in 2004 and updated in 2008, the Sustainable Development Policy requires certain green stormwater infrastructure strategies on new buildings and developments that receive certain special land use approvals or public financing. This policy applies to all new Redevelopment Agreements, Planned Developments, Site Plan Approvals and Amendments to existing Planned Developments reviewed by the Department of Housing and Economic Development. The Sustainable Development Policy requires the installation of green roofs and other sustainability measures, such as meeting LEED standards or exceeding the requirements of the Stormwater Ordinance.

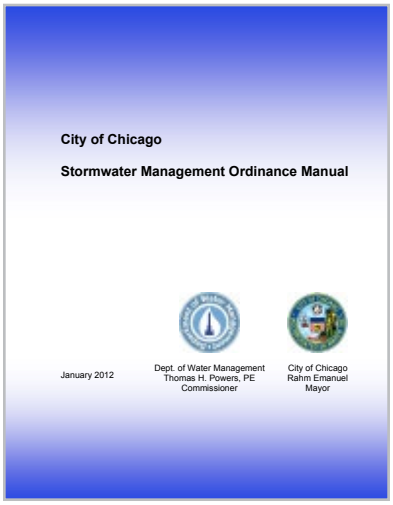

Credit: Chicago Dept. of Transportation

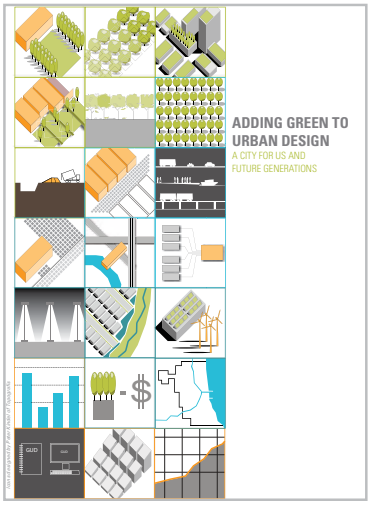
Permeable paver parking lot and bioswale at the Maxwell Street Market


Credit: Aaron Koch

Tree pits that capture stormwater at the Rush University Medical Center

A green roof constructed at Coyne College





Adding Green to Urban Design

In 2008, the Chicago Plan Commission adopted a comprehensive plan titled, "Adding Green to Urban Design: A City for Us and Future Generations." The plan provides direction to the Chicago City Council in regulating urban design and to the Chicago Plan Commission in reviewing individual development projects The plan included 21 key action items that seek to improve the design of important green infrastructure areas in the city such as rooftops, building facades, landscaping around buildings and in parking lots, sidewalks, parkways, and streets. Most significantly, this plan promotes coordination among the City's agencies and the inclusion of green stormwater infrastructure in public projects.

Sustainable Urban Infrastructure Guidelines

In 2013, the Chicago Department of Transportation released their Sustainable Urban Infrastructure Guidelines to formalize standards and policies for implementing innovative techniques into transportation projects. The purpose of the Sustainable Urban Infrastructure Guidelines is to establish an agency-wide approach for integrating environmental performance goals into infrastructure design. The guidelines focus on major aspects of transportation infrastructure including water, energy, materials & waste, placemaking, urban ecology, and climate & air quality. The Sustainable Urban Infrastructure Guidelines includes many critical City commitments, such as creating Green Alleys and incorporating green stormwater infrastructure into streetscape projects.

Chicago City Hall green roof

Programs

Green Roofs

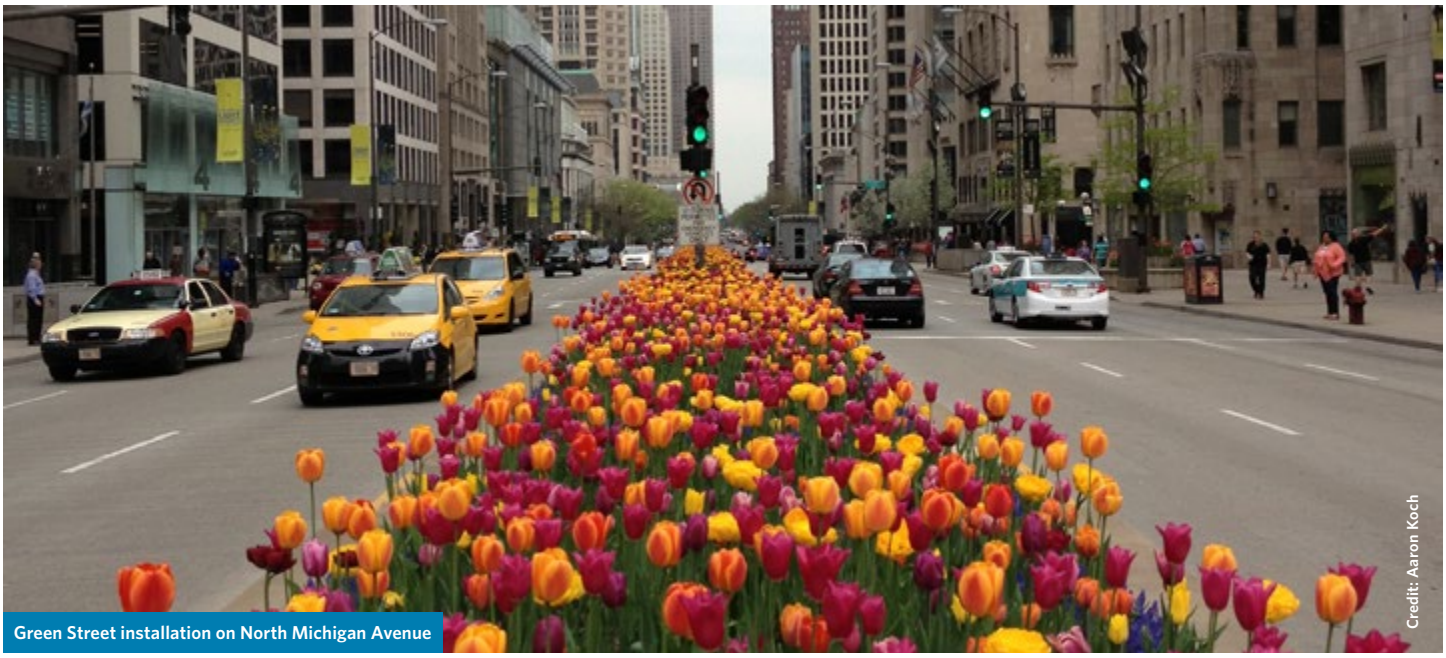
Chicago is a leading city in the United States for green roof installations, with over 350 green roofs totaling over 5,500,000 square feet of surface area. At the beginning of Chicago's green roof initiative, the City led by example by placing a green roof on City Hall in 2001, as well as retrofitting 12 public buildings with green roof installations. Today, a majority of the city's green roofs exist on private buildings, many of which were spurred by the City's leadership and installed to fulfill the City's Sustainable Development Policy and Stormwater Ordinance. The green roofs in Chicago have the capacity to capture approximately 70 million gallons of stormwater annually.

Green Alleys

Chicago has approximately 2,000 miles of public alleys, more than any other city in the world. This adds up to over 3,500 acres of paved impermeable surface area. Flooding is often an issue in alleys because many alleys in the City were built without a connection to the City's sewer system. In 2006, the City began the innovative Green Alley Program to reduce basement flooding and sewer overflows by converting pavement in alleys into permeable surfaces. Since 2006, over 200 Green Alleys have been installed. In total, the Chicago Department of Transportation has installed over 330,000 square feet of permeable pavement, which can detain approximately 17 million gallons of runoff each year.

Green Streets

Chicago's Green Streets program plants trees along and near major streets and targets areas with high "urban heat island" effects and lower levels of tree canopy cover. Since its creation twenty years ago, the program has planted over 70,000 trees. Combined with other sources, 3,900 trees were planted in 2011 alone. The City will continue tree planting in the public roads to support a citywide increase in tree canopy cover.


Green Street installation on North Michigan Avenue

Credit: Aaron Koch


Green Alley - Before

Credit: Chicago Dept. of Transportation


Green Alley - After

Credit: Chicago Dept. of Transportation

Downspout Disconnections

During the course of a year, approximately 29,000 gallons of water will drain from a typical Chicago roof. The City engages with communities and citizens to demonstrate how this water can instead serve a productive purpose by disconnecting the downspouts from the sewers and directing the water into a rain barrel, rain garden, or yard. The City has actively encouraged homeowners to disconnect their downspouts through public service announcements, community meetings, instructional videos and brochures, and by providing discounts to homeowners on materials for downspout disconnection.

Sustainable Backyard Program

This program helps Chicago residents manage their backyards more sustainably, especially through the implementation of green infrastructure that reduces runoff and provides other benefits. The Sustainable Backyards Program accomplishes this by educating the public and distributing rebates for rain barrels, compost bins, native plants, and trees. In 2011, the City distributed 420 rebates to residents that resulted in the planting of over 1,200 native plants and 397 trees and the installation of 133 rain barrels and 116 compost bins. Also, through the MeterSave program, the City expects to distribute over 3,000 rain barrels per year.

Our Plan

Goals and Initiatives

Credit: Chicago Dept. of Transportation

Goals for Stormwater Management

Chicago is one of the world's great waterfront cities with a long history of managing water. This strategy builds on that legacy and sets a course to enhance our local waterways and improve the quality of life within our communities, thus strengthening the overall economic competitiveness of the city.

Green infrastructure is a key tool in the City's stormwater management kit. The City has demonstrated that techniques such as green roofs, permeable pavement, and bioswales can successfully capture runoff and provide multiple other benefits. We will invest in green stormwater infrastructure because it provides immediate benefits and has the potential to serve as a long-term, cost-effective supplement or alternative to traditional grey stormwater infrastructure investments.

The initiatives within this strategy, including the future planning studies and the initiatives that will come out of these studies, signify a strategic and thoughtful approach to stormwater management.

First, we will take a data-driven, fact-based approach. We will analyze both green and grey stormwater infrastructure options to determine the costs and benefits of each. We will incorporate advanced technologies, such as a computer model that simulates the hydraulics of the city's sewer system, to identify priority areas, analyze potential solutions, and design strategies that suit Chicago's unique conditions. This will also include using the best science available to consider future climate conditions, not just historical rainfall patterns.

Second, we will build on our existing and planned assets. Chicago has invaluable grey infrastructure, from existing sewers and tunnels to planned storage capacity from TARP. Likewise, the city also has invaluable existing natural assets, including over 8,100 acres of public parkland, more than 3.5 million trees, over 530 acres of wetlands, and hundreds of thousands of valuable backyards and open spaces. All of these assets provide great stormwater management value to Chicagoans today, and the City's long-term stormwater management plan must consider how future green and grey stormwater infrastructure investments complement and enhance these existing systems. Investing in both green and grey strategies will be necessary for Chicago to continue to lead and innovate in the rapidly evolving field of urban stormwater management.

Third, we will seek the most cost-effective solutions to provide the most benefits to Chicagoans. Maintaining and enhancing water infrastructure is costly, and most major U.S. cities are spending as much or more on water infrastructure as they are on other critical infrastructure items such as schools and transportation. Since the Federal government is no longer providing significant financial grants to cities for water infrastructure, these costs falls to local citizens, primarily through water rates. While the rates for water are a tremendous value considering the life-sustaining importance of water, and particularly compared to other utility expenses such as cable, phone, internet, gas and electricity, we are conscious of the impact that water rates have on the economic competitiveness and affordability of the city. We still seek to develop and implement solutions that provide good value to our ratepayers.

This approach will guide us as we seek to a long-term stormwater management strategy designed to achieve four long-term stormwater management goals:

1. Minimize basement flooding in Chicago's most impacted neighborhoods
2. Reduce pollution to Chicago's rivers and Lake Michigan
3. Enhance environmental quality through water infrastructure investments
4. Increase the city's resilience to extreme rain events and climate change

Through this strategy, we will determine the best balance for investing in green and grey stormwater infrastructure to most cost-effectively manage stormwater and provide the greatest benefits to Chicagoans.

Green Stormwater Infrastructure Initiatives

Green stormwater infrastructure is a key tactic in Chicago's efforts to reduce basement flooding risk and improve the quality of the city's waterways. This strategy builds on a series of successful policies and programs by pursuing two main objectives - committing additional public funding to build green stormwater infrastructure and launching studies to determine the long-term role that green stormwater infrastructure can play alongside traditional grey stormwater infrastructure as we address the city's rainfall runoff challenges.

Build Green Stormwater Infrastructure

We will demonstrate near-term action by allocating $50 million over the next five years to build green stormwater infrastructure. This funding will go to projects that will deliver immediate benefits and improve our knowledge and understanding of green stormwater infrastructure. We will target these investments in communities that have the biggest challenges with basement flooding and stormwater management. We will evaluate these projects to determine how these initiatives may be scaled up in the future.

We will focus on implementing cost-effective green stormwater infrastructure strategies, with a particular emphasis on integrating green stormwater designs into existing and future capital projects. This will allow us to leverage our funding by making incremental investments which are less costly than building stand-alone stormwater infrastructure projects, ultimately maximizing value to our ratepayers. This significant investment in green stormwater infrastructure will result in important reductions in the volume of stormwater that flows into our sewer system.

This significant investment in green stormwater infrastructure will result in important reductions in the volume of stormwater that flows into our sewer system. Our $50 million commitment has the potential to provide 10 million gallons of stormwater storage, which could reduce runoff in Chicago by 250 million gallons each year.

Infiltration planter on the Berteau Avenue Neighborhood Greenway

INITIATIVE 1

Capital Projects

We will incorporate green stormwater infrastructure into future public capital projects

A significant portion of the City's budget goes toward implementing a capital program that renews and enhances the critical infrastructure that Chicagoans rely on every day. This includes essential investments such as upgrading water pipes, repairing roads, building parks, constructing public facilities, and renovating schools. Through innovative design and engineering, these projects can be built in a way that incorporates green stormwater infrastructure to capture runoff.

We will establish an interagency government process to review capital projects located in priority stormwater management areas to determine green infrastructure components that could be constructed and maintained using dedicated funding. The Department of Water Management will lead this effort and work closely with multiple City agencies such as the Departments of Housing and Economic Development, Transportation, Fleet and Facility Management, and Streets and Sanitation. We will also evaluate capital projects with

The Chicago Center for Green Technology is a showcase for many green stormwater infrastructure strategies

sister agencies, such as Chicago Public Schools, Chicago Park District, Chicago Transit Authority, the Public Building Commission, and the Chicago Housing Authority.

This interagency process will review City capital projects to determine opportunities to incorporate green infrastructure into designs. The Department of Water Management will select eligible projects and provide green stormwater infrastructure funding to pay for the incremental costs for adding the green components. Agencies will work together to develop uniform design standards for common green infrastructure stormwater installations such as sidewalk tree pits that capture street runoff, parkway bioswales, rain gardens, green roofs, and permeable pavement parking lanes. Lastly, agencies will create memorandums of understanding to govern both the construction and maintenance of projects created using green infrastructure funding.

This process will leverage existing and planned capital projects to maximize value to the city. It is more cost-effective to pay the incremental cost to add green stormwater infrastructure into an already-planned capital project than to create a comparable green stormwater infrastructure installation independently. By partnering across City agencies, we will leverage resources that otherwise would not be available for water infrastructure. By using green stormwater infrastructure in City capital projects, we will also help to address other citywide priorities, such as reducing the urban heat island effect, improving recreation opportunities, and reducing building energy use.

Permeable pavement in the Cermak/Blue Island Sustainable Streetscape project

Credit: Chicago Dept. of Transportation

INITIATIVE 2

Permeable Streets

We will incorporate permeable pavement into appropriate sewer main replacement projects

In Chicago we are transforming streets so that they are not just for moving cars from one point to another. We recognize that streets can serve a broad range of transportation modes while also playing a critical role as public space, including by offering space for pedestrians to linger in specially-designed plazas or areas known as "People Spots." Similarly, we recognize that streets can do more than just move stormwater quickly to a catch basin and into the sewers. Streets can be designed for water to linger as well, primarily through the use of permeable pavements.

Chicago is a leader in the use of permeable pavement. The Green Alley program has demonstrated that we can successfully use innovative types of pavement to capture water. These installations offer a strong base of knowledge about permeable pavement design, construction, and maintenance. The City's reconstruction of a stretch of Blue Island Avenue and Cermak Road in the Pilsen neighborhood further demonstrates green stormwater infrastructure strategies. The project is diverting up to 80 percent of the typical average annual rainfall from the combined sewer through a combination of bioswales, rain gardens, stormwater features, and permeable pavement in the parking lane and bike lane. The Department of Transportation will standardize these types of innovative design strategies in their future projects through the adoption in 2013 of the Sustainable Urban Infrastructure Guidelines.

Through "Building a New Chicago," the City's $7 billion, three-year infrastructure program, we are making a historic investment in water infrastructure. This includes an ambitious commitment to replace water and sewer mains that are well past their useful life. Over the next decade, we will replace 880 miles of water mains and 250 miles of sewer mains. The traditional way to restore the street after these replacement projects is to use standard asphalt; however, these projects provide an opportunity to incorporate green infrastructure while the streets are already under construction. While permeable pavement may not be appropriate for main travel lanes of streets, the parking lanes of residential streets could be appropriate locations based on the low impacts from vehicle traffic.

Permeable pavers that allow runoff to infiltrate into the ground

Credit: Chicago Dept. of Transportation

Installing permeable pavers at Cermak/Blue Island

Credit: Chicago Dept. of Transportation

Efficiencies and overall cost savings are possible by adding green stormwater infrastructure into existing street work as opposed to building stand-along green infrastructure installations. We can achieve overall savings by building on the existing resources that are already used for planning, design, procurement, equipment mobilization, and street excavation that would need to occur twice if green and grey projects were completed separately. Since existing contracts are already in place that specify standard street resurfacing for projects through upcoming fiscal years, these standard specifications would need to be modified.

Incorporating permeable pavement into water and sewer main replacement projects could leverage valuable reconstructions resources; yet there are challenges to implementing permeable pavement into these projects. Since the City has only constructed a few permeable pavement parking lanes, we do not have much data on costs, performance, maintenance, and long-term durability. Installing permeable pavement may be more expensive than conventional asphalt resurfacing, but we have not yet fully analyzed the costs of implementing a large-scale program for permeable pavement.

For sewer replacement projects, the whole street is typically resurfaced, but that is typically not the case with water main replacement projects. For those projects, the excavation is typically only in a narrow trench, and the water mains in the city vary in their location, with some located in the parking lane, but others located in the parkway or in the center of the street. Restoring these projects with permeable pavement would likely requiremuch greater excavation and additional costs. The challenge is complicated by the prevalence of clay soils that are found throughout the City. These soils do not infiltrate water, so permeable pavements designed over clay would need to be designed with underdrains and other considerations for storing water below grade. Also, infiltrating water into the roadway could result in conflicts with underground utilities such as water mains and gas lines.

We will build permeable pavement parking lanes in conjunction with sewer replacement projects so that we can decrease the amount of stormwater runoff. We will target stormwater management priority areas to ensure that these green stormwater infrastructure investments will have the most impact on reducing basement flooding and achieving other sustainability goals. We will work with street design experts to create standard design details and specifications for installing permeable pavement in parking lanes. We will also develop maintenance procedures and establish monitoring protocols to measure the effectiveness of permeable pavement installations and determine the best design and maintenance specifications for long-term implementation. This will provide us with the knowledge to better understand the cost-effectiveness of implementing this strategy on a broader scale.

Bioswale in the Cermak/Blue Island Sustainable Streetscape project

Credit: Chicago Dept. of Transportation

Bioswale in the Cermak/Blue Island Sustainable Streetscape project

Credit: Chicago Dept. of Transportation

INITIATIVE 3

Bioswales

We will increase the use of green stormwater infrastructure in streetscape projects

In 1837, the City of Chicago incorporated with "Urbs in Horto" as its motto. This phrase, Latin for "City in a Garden," was selected because Chicago's early planners believed that the preservation of nature would have important value for life in a growing metropolis. This remains true today, especially since trees, vegetation, and gardens are very effective at capturing stormwater.

Street trees intercept and absorb rain, reducing and slowing the amount of runoff that makes its way to the sewer system. A mature tree can intercept about 1,000 gallons of rainfall per year in their crowns and can intercept more than twice that amount in their pit, particularly when designed with an inlet to accept stormwater runoff. Mature trees provide exponentially more benefits than newly-planted trees, so it is particularly important to preserve mature trees as well as plant new trees that contain enough soil volume to allow for full maturation.

Trees in urban areas have a positive return on investment. In New York City, a 2007 study indicated that for every dollar spent on trees, the city would receive $5.60 in benefits. Based on this data, in 2007, Mayor Bloomberg committed $400 million in public funds to plant one million trees by 2017. The City of New York has also determined that constructing sidewalk bioswales, or elongated tree pits specially designed to accept street runoff, is the most effective green stormwater infrastructure strategy in dense urban areas. As part of their $1.5 billion green infrastructure strategy, NYC intends to build over 7,000 bioswales by 2017.

Chicago also has a recent history of making significant investments in trees and Green Streets. In the last twenty years, the City has planted over 70,000 trees, and we have a goal to increase tree canopy cover from 17 percent to 20 percent by 2020. We are doing this because the city's urban forest provides tremendous benefits to Chicagoans. Because of the positive effects that trees provide for cleaning the air, reducing energy use, minimizing the urban heat island effect and enhancing property values, the structural value of Chicago's 3,585,000 trees is estimated at $2.3 billion.

Chicago has approximately 520,000 parkway trees, yet since 2011 the city has had a net loss of approximately 6,000 street trees due to extreme weather events and other natural causes. Further, the city's parkway trees are threatened by invasive species such as the Emerald Ash Borer, which threatens around 17 percent of the City's street tree population, or about 85,000 trees.

We will construct a network of parkway bioswales and increase the number of green stormwater infrastructure installations in streetscape projects. We will allocate funding for parkways bioswales that incorporate new tree plantings and are specially designed to capture and retain road runoff. The Departments of Water Management, Transportation, and Streets and Sanitation will collaborate to develop standard specifications and guidelines for parkway bioswales and ensure successful implementation and maintenance for new plantings.

Green roof on the CTA headquarters building

Plan for the Future

With this strategy, we are taking action now while we also collect and analyze new information to scale up as we move forward. We will develop a long-term stormwater management strategy by launching a series of planning studies. By planning for the future while simultaneously building green stormwater infrastructure, we recognize that green strategies are an important tool in our kit, particularly when they are cost-effectively integrated with other capital projects that would happen anyway. We also recognize that we need better data and more analysis to determine the long-term cost-effectiveness of green infrastructure to solve our basement flooding and water quality challenges.

Our planning effort will engage consultants, City and sister agency partners, environmental advocates, civic groups, and other key stakeholders to evaluate the best solutions to our stormwater challenges. We will build on our existing sewer master planning and modeling process by fully evaluating the costs and benefits of using green stormwater infrastructure on a broad scale. We will learn from the green stormwater infrastructure installations that have already been built in Chicago, and we will study the lessons from other leading cities who are implementing green strategies on a broad scale. We will seek knowledge from other places and from our past, but we will tailor our approach to Chicago's unique conditions and future needs. After we complete the studies, we will release a stormwater management plan that lays out a long-term vision and strategy for implementing both grey and green stormwater management infrastructure.

INITIATIVE 4

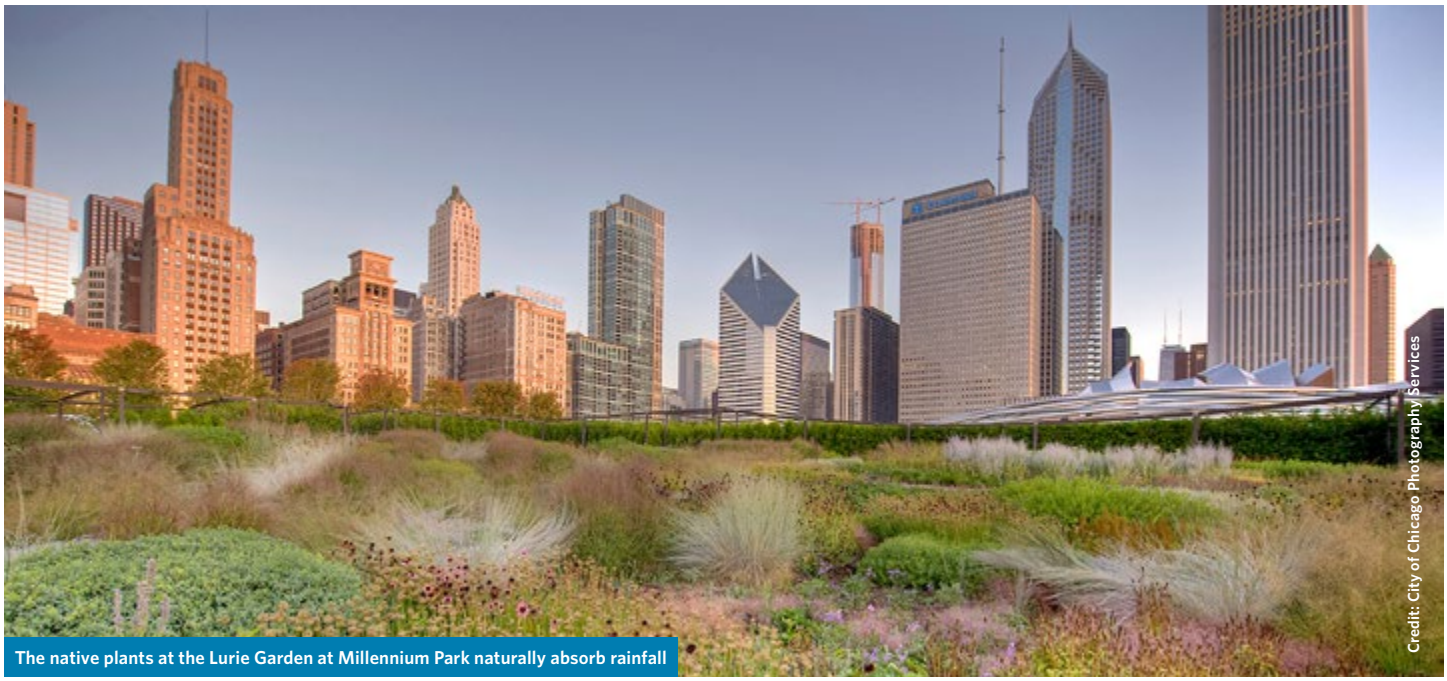
Green Stormwater Infrastructure Study

We will undertake a study to determine the costs and benefits of using green infrastructure to manage stormwater

We have learned much in the last ten years about how to design, build, and maintain green infrastructure, but we need additional data and analysis to determine the appropriate type, amount, and location of green stormwater infrastructure to address our challenges into the future.

Green stormwater infrastructure is an important and effective strategy. However, we do not yet have data to determine how a large-scale, citywide investment in green stormwater infrastructure might cost-effectively displace needed potential investments in future grey stormwater infrastructure. Additional work and analysis is necessary to determine the best balance between green and grey stormwater management infrastructure and the most cost-effective overall approach to address long-term stormwater challenges.

There are two primary aspects of green stormwater infrastructure that we must study further – analyzing the costs and benefits of potential long-term green implementation scenarios and using a computer model to simulate the effects on sewer system performance and project reductions basement flooding risk and improvements to water quality.



The native plants at the Lurie Garden at Millennium Park naturally absorb rainfall

First, we will evaluate the full costs and benefits of green stormwater infrastructure. Many environmental and engineering organizations and academics have evaluated the costs and benefits of green stormwater infrastructure, yet we do not currently have up-to-date data that reflects the true costs to build green infrastructure in Chicago or the expected performance of these installations to manage stormwater. We will take an inventory of existing green stormwater infrastructure in Chicago and develop a catalog of the costs and benefits from various types of installations, such as bioswales, permeable pavements, on-site rainwater storage, green roofs, and other techniques.

We will then evaluate various scenarios for a large-scale implementation of green stormwater infrastructure citywide and by neighborhood. These scenarios will be based on the unique land use conditions of the city and consider the feasibility of various green infrastructure strategies by area. This analysis will provide us with an understanding of the costs and benefits for widespread green infrastructure implementation and an estimate for the total volume of stormwater that we could keep out of our sewer system.

Next, we will use our sewer computer model to determine how keeping large quantities out of our sewer system through various large-scale green infrastructure scenarios translates into achieving our goals such as reducing basement flooding risk and improving water quality.

For the last five years, the Department of Water Management has utilized a computer model to simulate the wet weather flows of the City's trunk sewer system. The model considers underground conditions, such as the size of pipes, the rate of water flow, the availability of TARP storage, and the ability for water to travel to combined sewer outfalls. It also factors in above-ground conditions, such as impervious land cover and the way water flows over city surfaces and into catch basins. This model assists in facilities planning and the allocation of resources. It allows the Department of Water Management to better resolve the capacities of our overflow points, and thus manage our wet weather inputs in a more detailed and accurate fashion.

The Department of Water Management has used the sewer computer model to conduct preliminary analysis on the potential impacts of widespread impervious surface reductions as a proxy for green infrastructure installations, but we have not yet fully evaluated the costs and performance of green infrastructure scenarios as a standalone strategy or in combination with traditional grey infrastructure investments. This effort will help us to understand where and in what amounts a large-scale implementation of green stormwater infrastructure may be cost-effective.

A continuous tree pit on West Roosevelt Road

INITIATIVE 5

Rainfall Frequency Analysis

We will work with leading climate scientists to develop rainfall frequency data that incorporates recent storms as well as climate change projections

The vast majority of the world's climate scientists have reached consensus that climate change has already begun and that we will experience more extreme rain events in the future. This is consistent with the patterns of storms that have caused significant flooding, damage, and water pollution in recent years.

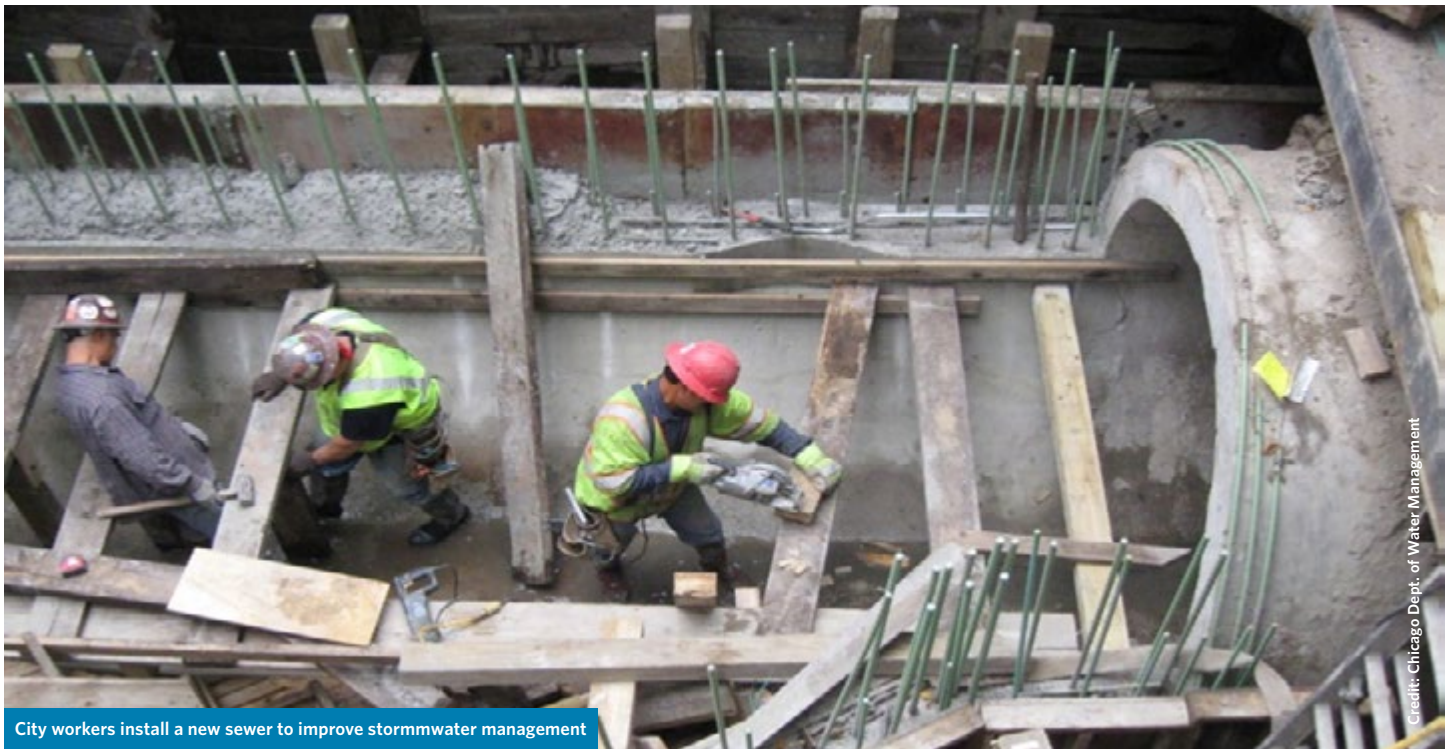
The current impacts and future risks from climate change make planning for stormwater management and water infrastructure challenging. While many climate change projections and scenarios exist, there is still uncertainty on the eventual level of climate change, partially due to the limits of science and global climate models and also partially due to the fact that global carbon emissions continue to increase, thus speeding the rate and amount of future climate change.

Planners and engineers have traditionally used historic rainfall patterns as the baseline for designing and sizing water infrastructure. Looking back at historic rain events was adequate before the climate started to change, but now this historic data is inherently out-of-date as a tool for planning water infrastructure due to climate change.

In Illinois, most planners and engineers base their decisions on the "Rainfall Frequency Atlas of the Midwest," which is also known as "Bulletin 71." Most significantly, Bulletin 71 provides the rainfall distribution table that is used to categorize rainfall events into certain categories such as the "5-year storm" or the "100-year storm." So when engineers decide to plan water conveyance or storage capacity to meet a certain level of service or a certain storm, they are relying on this table to determine how much rainfall to expect over a particular time period.

This document, published by the Illinois State Climatologist and the Illinois State Water Survey at the University of Illinois at Urbana-Champagne, was released in 1992, but the rainfall data used in this document is based on historic rain events that occurred up to the mid-1980s. Therefore, almost thirty years of climate change has occurred since this data was published. Further, the water infrastructure that we build has a long lifespan and anything that we build today will likely be providing service for the next 50-100 years. As evidence, more than 40 percent of our sewer mains are over 100 years old. So, if we are building infrastructure that might be in the ground until the end of this century, we should also consider what climate may exist at the end of the century and develop a stormwater management strategy that confronts this challenge.

To address the need for better rainfall data and climate change projections, we will form a partnership with the Illinois State Climatologist and the Illinois State Water Survey to update the historic rain patterns to reflect recent climate change as well as develop climate change projections for potential future rain patterns. We will use this data and knowledge to inform our planning process and to influence our decisions about appropriate levels of water infrastructure investment.



City workers install a new sewer to improve stormmwater management

INITIATIVE 6

Citywide Stormwater Management Plan

We will create a comprehensive plan that establishes a long-term vision and implementation strategy for managing stormwater with green and grey stormwater infrastructure

Green stormwater infrastructure will be a key strategy in addressing our stormwater management challenges, and it will complement our efforts to increase and enhance sewer and storage capacity. By 2015, we will create a long-term public plan for how the City will comprehensively invest in stormwater management infrastructure to reduce basement flooding risk and improve water quality.

The creation of this citywide stormwater management plan will be informed by the studies we are launching to analyze the costs and benefits of green stormwater infrastructure and the impacts of climate change. The plan will also build on and be informed by two other major efforts – the City's previous and ongoing master planning work for sewers and the MWRD's ongoing and upcoming planning for stormwater management and green infrastructure.

The Department of Water Management has used its sewer computer model to calculate basement flooding risk, identify priority areas, and analyze potential sewer and tunnel projects. This master planning process informs our sewer capital program and our selection of the sewer projects that are built to achieve our goal of replacing 250 miles of sewers in the next ten years. This planning process also provides us with a strong understanding of the potential ways that we could upgrade our sewer network to reduce basement flooding and convey water faster to MWRD's interceptor sewers, wastewater treatment plants, and TARP.

What we don't yet know is how a large-scale investment in green stormwater infrastructure can supplement or serve as an alternative to potential sewer and tunnel projects from a cost and performance perspective. Several cities, such as New York City and Philadelphia, have determined that a large-scale investment in green stormwater infrastructure is more cost-effective than certain traditional grey infrastructure investments. However, in Chicago, we have not yet determined the costs and benefits of large-scale green stormwater infrastructure implementation. Cost-effectiveness depends on a complex set of issues that are specific to a particular place and a distinct set of existing infrastructure conditions. This is particularly true in

Credit: Metropolitan Water Reclamation District of Greater Chicago

Rain garden at Haines Elementary School created through a partnership of CPS, MWRD, the Dept. of Water Management, and the Water Environment Federation

Chicago since we are dealing with a 4,300 mile long network of sewers that have been incrementally built over the last 150 years. It is also true because, unlike Philadelphia and New York City, we are planning to connect to a network of TARP tunnels that are already built and reservoirs that are mandated for completion by the Federal government.

As the City analyzes green stormwater infrastructure and determines a long-term stormwater management strategy, collaboration with MWRD is increasingly critical. The City's sewer infrastructure is directly connected to MWRD's infrastructure, and we share a common mission.

MWRD is undertaking a stormwater planning process and will increasingly invest in green stormwater infrastructure in the future. In December 2011, the USEPA and the US Department of Justice announced a draft consent decree for how MWRD will take action to comply with the conditions of the Clean Water Act. The consent decree has not yet been finalized, but the draft commitments establish a timeline for MWRD to complete TARP by 2029 and also implement a green infrastructure plan that contains 10 million gallon of design retention capacity.

We have an opportunity to collaborate with MWRD on planning for stormwater management and green infrastructure. MWRD does not have sufficient land ownership in Chicago to implement a large-scale green infrastructure program or the legal ability to construct green infrastructure on City property, so we have the potential to partner on the construction of green stormwater infrastructure in Chicago.

Over the next year we will work with MWRD and other key stakeholders to analyze our complex stormwater management challenges and evaluate the role that green stormwater infrastructure can play as a part of the solution. We will create a citywide stormwater management plan by 2015 that establishes a long-term vision and implementation strategy for managing stormwater with both green and grey stormwater infrastructure. Through this strategy and our future efforts, we will determine the best balance between investing in green and grey stormwater infrastructure to most cost-effectively manage stormwater and provide the greatest benefits to Chicagoans.

Conclusion

Credit: Aaron Koch

A Cleaner, Greener Chicago

Chicago has a long history of innovative and successful water management and stewardship, and we are building on that legacy. We are making substantial investments to replace water mains, renew our sewer network, and upgrade our pumping stations and purification plants. This strategy complements these water traditional infrastructure investments by adding initiatives that will use green stormwater infrastructure to create a cleaner, greener Chicago.

Our investments in green stormwater infrastructure will keep runoff out of our overburdened sewer system while also enhancing the environment. By building bioswales, permeable pavement, green roofs, and other capital projects that incorporate green stormwater infrastructure, we will deliver immediate benefits to Chicago's citizens and neighborhoods. And by undertaking additional studies and planning for green stormwater infrastructure, we will determine how these natural strategies might play a larger role in the future. Ultimately, our investments in both traditional stormwater infrastructure and green stormwater infrastructure will help us meet our long-term goals to minimize basement flooding, reduce pollution to our waterways, enhance environmental quality, and increase our resilience to extreme rain events and climate change.

The promise of a cleaner, greener Chicago will only be met if we make smart choices about how we plan and build water infrastructure. That is why we will take a data-driven approach that is based on the best available science and engineering. This means analyzing the most cost-effective way to build on our existing assets such as our sewer system and MWRD's tunnel and reservoir plan. It also means taking a forward-looking approach that considers how climate change will increase the amount and frequency of intense storms that can overwhelm our sewer system.

Ultimately, reducing the risks posed by intense storms and climate change will not be achieved through a single plan or action-it must be achieved through sustained investment, successful collaboration, and an ongoing planning process that is responsive to the latest scientific information and a thorough understanding of the potential costs and benefits of our actions. Our strategy will remain flexible so that it can be adapted to changing needs, but we are taking steps now that have tangible benefits today and even greater benefits in the future.

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