The First Generation of Green Infrastructure in Buffalo

RAINCHECK

Spring 2018

Acknowledgements

The Buffalo Sewer Authority (Buffalo Sewer) extends its gratitude to the many partner agencies, community organizations, and customers that have contributed to the ongoing success of Rain Check.

Through Mayor Byron W. Brown's leadership, the program benefited from unprecedented partnerships across City Hall, including support from the Department of Public Works, Parks & Streets; the Mayor's Office of Strategic Planning; and the Department of Permits and Inspections Services.

Buffalo Sewer is grateful to the Community Foundation for Greater Buffalo for its support in launching the Rain Check brand, communications campaign and public education materials that helped get the program started. Community groups from across the city helped shape projects and inform what green infrastructure can do for the City of Buffalo and its neighborhoods.

Buffalo Sewer also acknowledges the many consultants who designed green infrastructure projects in Buffalo and supported the planning for the initiative.

Finally, Buffalo Sewer thanks the many state and federal government agencies and foundations that have supported the programmatic development of Rain Check as well as the implementation of green infrastructure projects in Buffalo.

CITY OF BUFFALO
MAYOR BYRON W. BROWN

Project management and technical support

ARCADIS

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School of Architecture and Planning
UB Regional Institute

Foreword

A message from Buffalo Sewer Authority

BUFFALO SEWER AUTHORITY

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Protecting public health and the environment from water pollution.

Buffalo Sewer protects public health and our Great Lakes waterways from water pollution. To do this, we capture dirty water, treat and clean it so that it can be safely returned to our rivers and lakes. Established in 1935, Buffalo Sewer serves more than 550,000 customers in the City of Buffalo and 11 surrounding municipalities. Every day, Buffalo Sewer collects and cleans sewage and waste from homes, businesses and factories, as well as roadways, parking lots and rooftops. Buffalo Sewer also builds and maintains infrastructure—pipes, tanks and structures below ground, and landscape installations above ground—through over $20 million in capital projects each year. These investments are levers to engage and educate communities, create employment opportunities and revitalize disinvested neighborhoods.

With the Rain Check program, Buffalo Sewer is championing green infrastructure solutions with a comprehensive approach to improve local water quality. As part of Buffalo's Long Term Control Plan, approved by state and federal regulatory agencies in 2014, Buffalo Sewer committed to investing $380 million over 20 years on projects to reduce combined sewer overflows into local waterways. Working hand-in-hand with local, state, and national water protection partners, Buffalo Sewer is implementing a careful balance of traditional gray infrastructure projects with smart approaches and green solutions. We champion green infrastructure solutions because they provide opportunities for a holistic approach to managing stormwater, while positively impacting the city's triple bottom line and supporting Mayor Byron W. Brown's vision to make Buffalo a more sustainable, equitable city.

While much remains to be done, Buffalo Sewer and its partners across government and in the community are forging progress on sustainable, equitable water management through green infrastructure. Together, we have already completed a number of green infrastructure projects on roadways, parking lots and vacant lots across Buffalo. We are hard at work investing in, planning for and implementing the next generation of green infrastructure projects in Buffalo to protect our Great Lakes and ensure that every resident can access and benefit from clean, healthy water resources.

Oluwole A. McFoy, P.E.

GENERAL MANAGER

RAINCHECK is Buffalo's green infrastructure program.

Officially launched in 2015, Rain Check aims to protect and restore the health of Buffalo's waterways by addressing today's most pressing water-related challenge–stormwater. This report describes what that challenge is, the unique role green infrastructure plays in addressing it, what we've done so far, and how we'll take green infrastructure to the next level.

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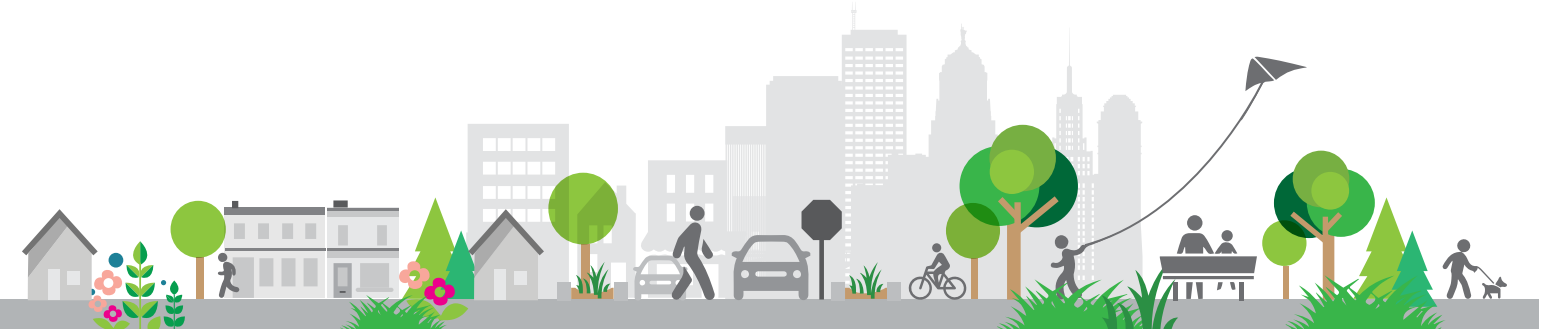

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What we've learned from the first generation of green infrastructure in Buffalo.

The first generation of green infrastructure in Buffalo focused on tackling the parts of our built environment that create the most runoff from stormwater—streets, parking lots, and roofs. Projects created **green streets** that manage stormwater with elements that beautify neighborhoods, **green parking lots** that collect and soak up water, **greening of vacant lots after demolitions** to absorb rain and snowmelt, and engaging homeowners to keep stormwater out of the sewer with **rain barrels** and downspout disconnections.

Green Streets

Green Parking Lots

Demolitions and Vacant Lot Restoration

Rain Barrels and Downspout Disconnections

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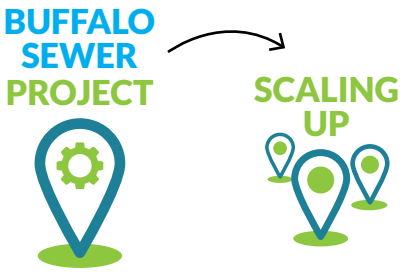
How we'll take green infrastructure to the next level.

The next chapter of green infrastructure in Buffalo will look to **scale up and expand the types of projects** we take on, continuing to make **community engagement** and education a priority, and finding **new partnerships** to tackle collaborative projects across the city.

Community engagement

Community partnerships



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Water is Buffalo's greatest resource

Great Lakes Watershed

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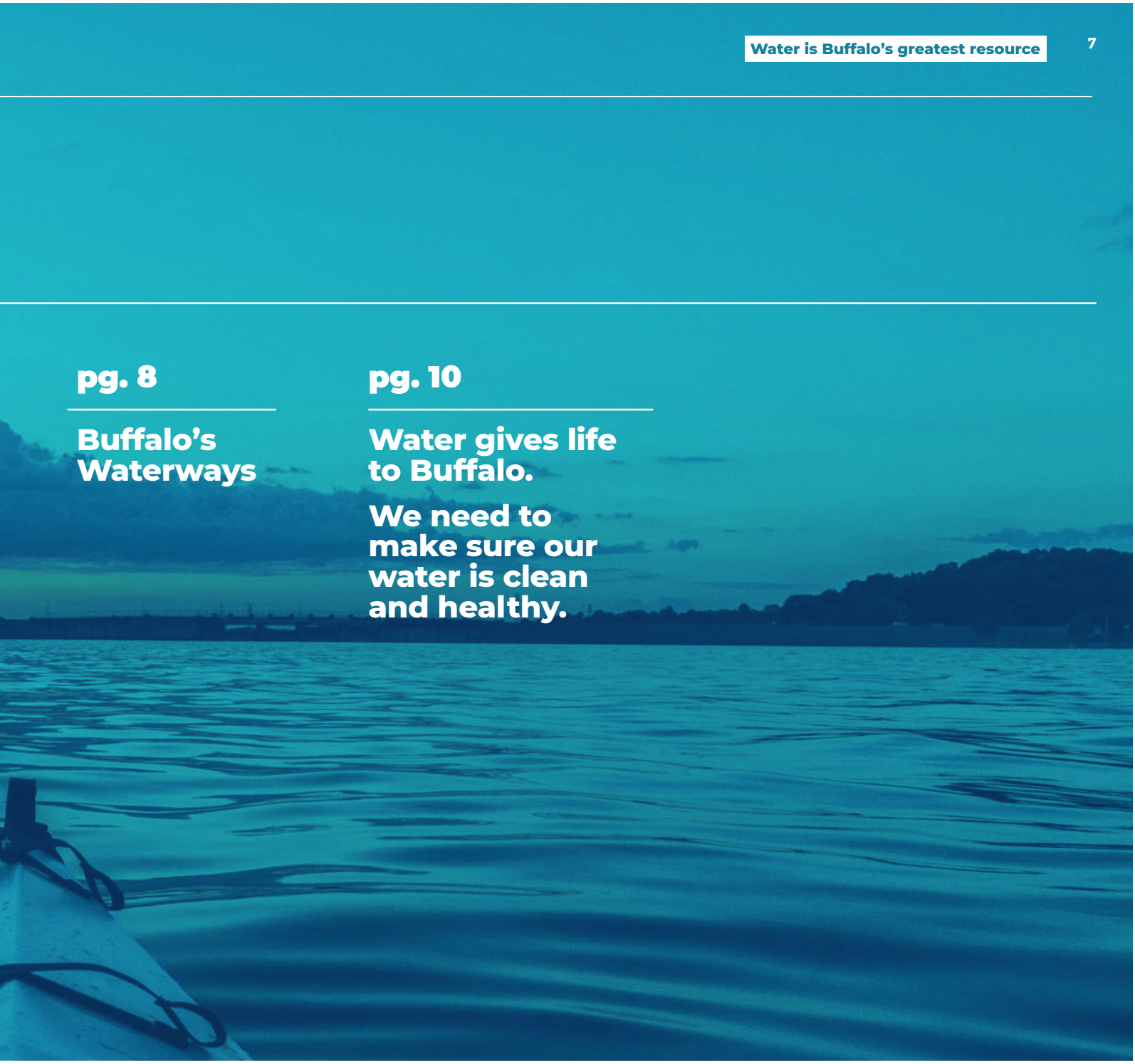
of the world's freshwater flows past Buffalo as it moves from the western Great Lakes through the Niagara River and into Lake Ontario.

Buffalo has a special place in the Great Lakes system. All the water that drains into the western Great Lakes flows past Buffalo and into the Niagara River before running over Niagara Falls, into Lake Ontario, and into the Saint Lawrence River. This makes the City of Buffalo a steward for all the water in the Great Lakes—about one-fifth of the world's freshwater.

The creeks and streams that run through the City of Buffalo also drain into the Great Lakes system. So while the health of local waterways depends on the health of this broader system, what we do to care for our local waterways can also have big impacts on water quality throughout the Great Lakes. And the water quality in the Great Lakes has huge impacts on the environment, public health, and economy of all communities across the basin. Buffalo is a critical link and an important player in this Great Lakes mega-region, which contains 18 percent of U.S. population and 17 percent of Gross Domestic Product (GDP).[1]



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Buffalo's Waterways

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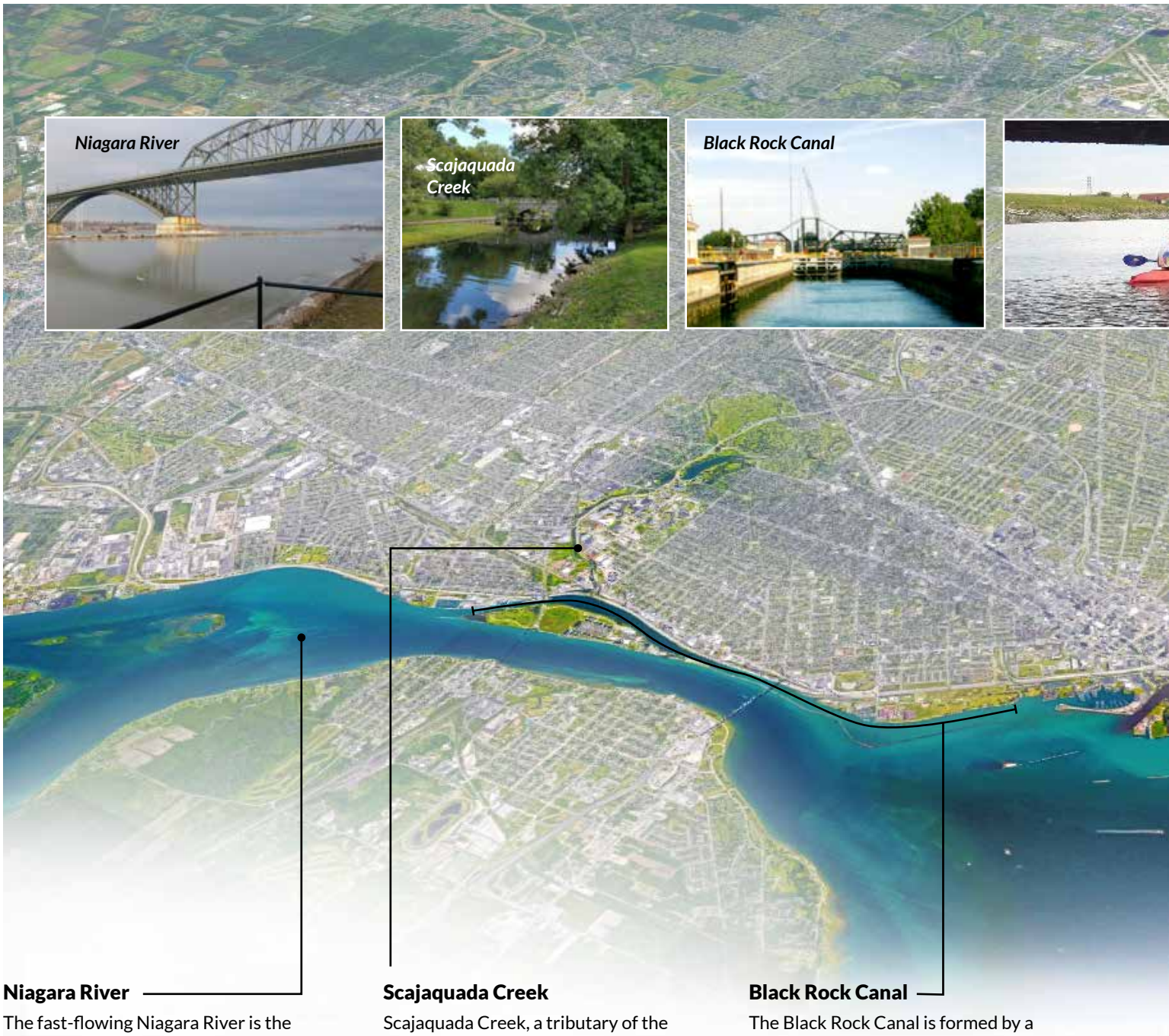
Water gives life to Buffalo.

We need to make sure our water is clean and healthy.



Niagara River

The fast-flowing Niagara River is the distinctive waterway of the Buffalo Niagara region. The 37-mile river feeds the world-famous Niagara Falls, connects Lake Erie to Lake Ontario and forms part of the border between the U.S. and Canada. Today, the Niagara River is widely used by residents and tourists for fishing, boating, sight-seeing and recreation.

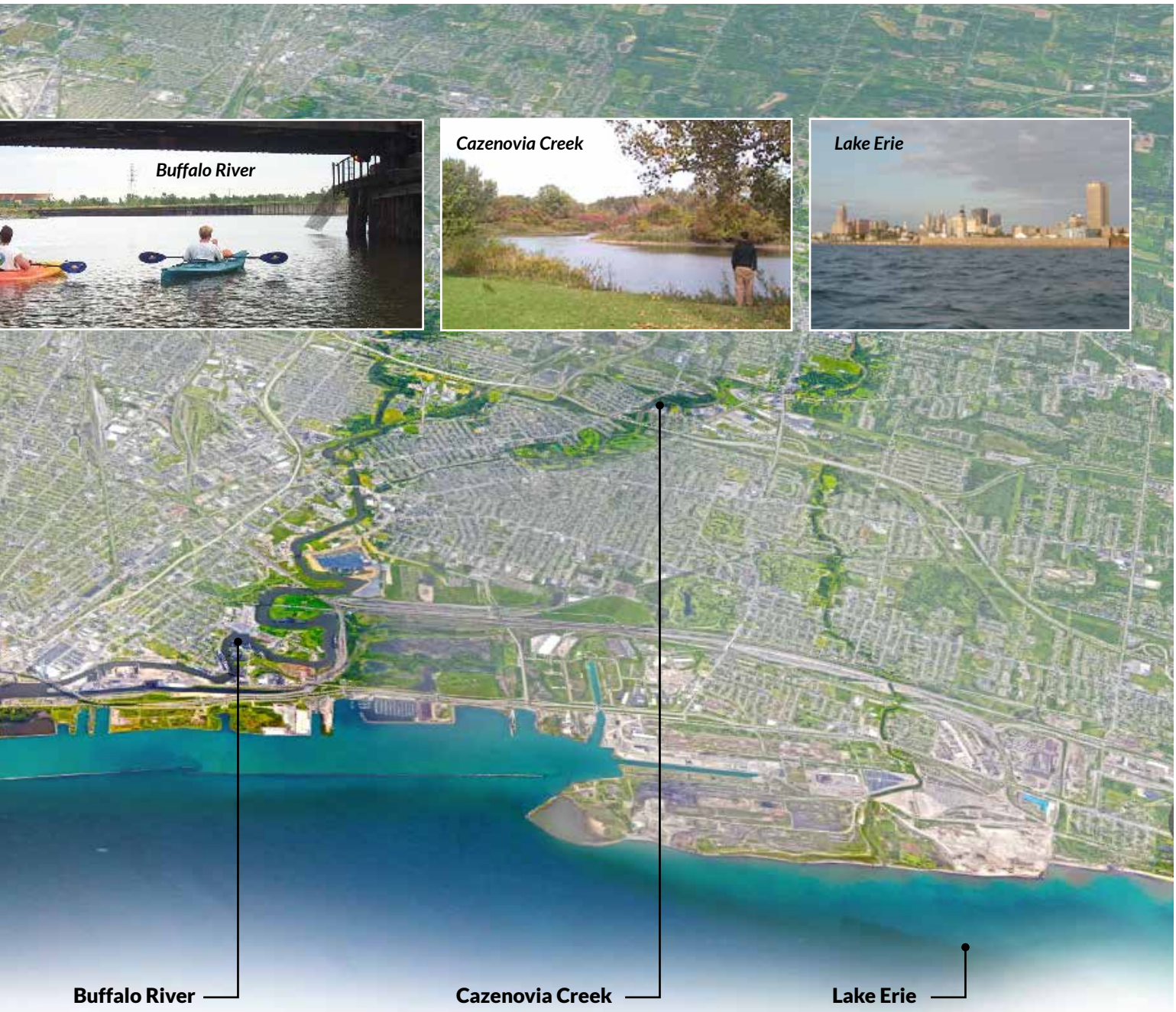
Scajaquada Creek

Scajaquada Creek, a tributary of the Niagara River, begins in the town of Lancaster and flows west through Cheektowaga where it enters an underground channel before resurfacing at Forest Lawn Cemetery in Buffalo. From there, the creek travels through the cemetery and is a key feature of the Olmsted-designed Delaware Park, ultimately flowing into Black Rock Canal.

Black Rock Canal

The Black Rock Canal is formed by a break wall that reroutes the Niagara River waters between Unity Island and the city's shoreline. This channel was constructed so ships could travel from Buffalo to Tonawanda more safely by avoiding the rapid current of the Niagara River. Today, the Black Rock Canal is a prime destination for boating, fishing and for taking in waterfront scenery.

Buffalo's waterways



Buffalo River

The Buffalo River starts just east of the city where Cayuga Creek and Buffalo Creek meet, and winds through South Buffalo before draining into Lake Erie at the city's Inner Harbor. Historically, the Buffalo River is where the city's industry took root. It still serves that purpose, by carrying large freighters to grain elevators for instance, but today the river is increasingly being used for recreation and tourism.

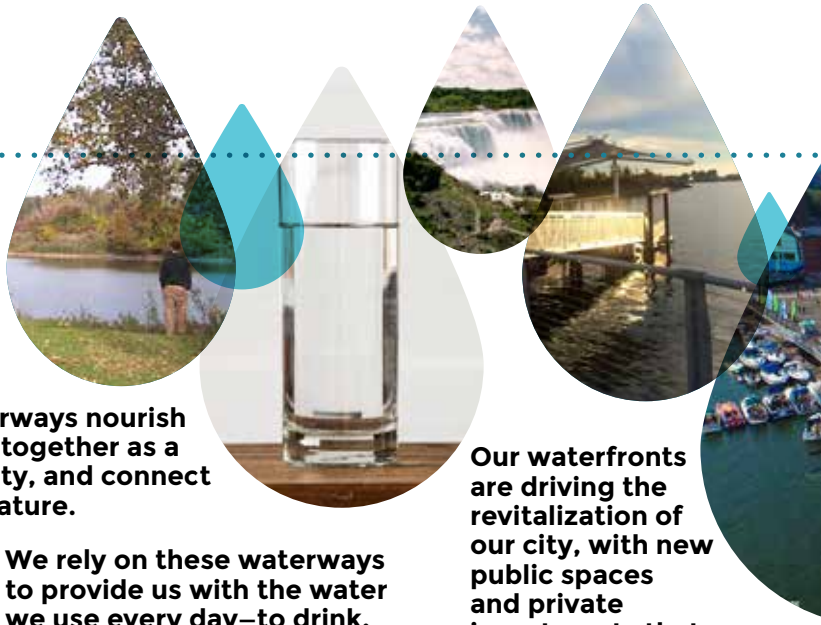
Cazenovia Creek

A tributary of the Buffalo River, Cazenovia Creek forms in southern Erie County, traveling through various towns before entering the City of Buffalo. It flows through South Buffalo neighborhoods and forms the prime water feature of Cazenovia Park, part of the city's Olmsted Park system.

Lake Erie

Lake Erie, the smallest Great Lake in terms of overall volume, links Buffalo with major shipping channels and has a substantial impact on our climate. The Great Lakes to the west, and tributary streams south of the city, feed into Lake Erie which is the source of all of Buffalo's water supply.

Water gives life to Buffalo.



Our waterways nourish us, tie us together as a community, and connect us with nature.

We rely on these waterways to provide us with the water we use every day—to drink, cook, clean, grow plants—in our homes and workplaces.

Our waterfronts are driving the revitalization of our city, with new public spaces and private investments that attract economic activity and droves of visitors.

Buffalo formed and prospered because it was connected to major waterways, like Lake Erie, the Niagara River, and the Erie Canal. And today, our city's waterways are still the backbone of our communities, and a big benefit to our quality of life.

Water supply

Our waterways supply all the water we use every day, from drinking water to watering plants, washing dishes, taking showers, and doing laundry. The city's waterways are a key ingredient for many important and growing industries, like construction, health care, agriculture and food service. Our water is also essential for important public services, like firefighting and street sweeping.

Habitat and scenery

Our waterfronts and waterways provide critical habitat for wildlife, and stunning scenery for visitors. Places like the Tifft Nature Preserve provide an important habitat for migratory birds, and a great place for people to view these species, other wildlife, and to take in the city's waterfront.

Fishing

Many people use the waterways to fish, for recreation, or for food. Broderick Park is one fishing spot that attracts many residents and visitors throughout the year and especially at community events, like the Family Fishing weekend that draws hundreds of visitors each June.

We need to make sure our water is clean and healthy.

Waterways and shorelines are critical habitat for wildlife that draw more visitors, like birdwatchers.

Community members use the waterways for many types of recreation, from swimming, boating, paddling, and other sports.

Many people fish along the city's waterways for recreation, but also for sustenance, using water as a source of food.

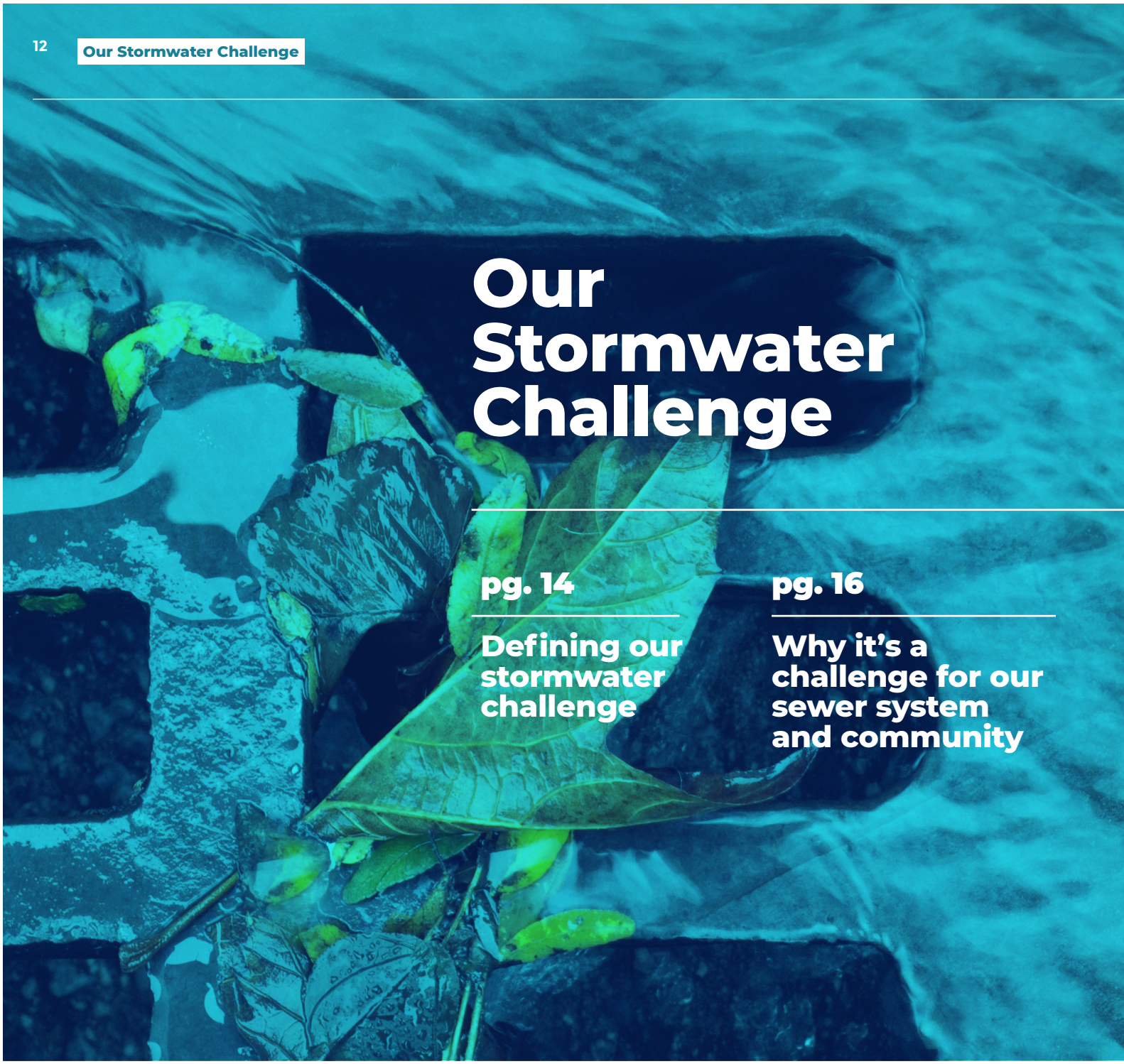
Boating and paddling

Sailboats, motorboats, canoes, kayaks, paddleboards, and even water bicycles are common sights in the Buffalo Harbor on sunny days. Paddlers and boaters can take in the natural scenery on the open waterways, or along nature preserves, but also tourism destinations and waterfront attractions like Canalside and the Naval and Military Park.

Economic development

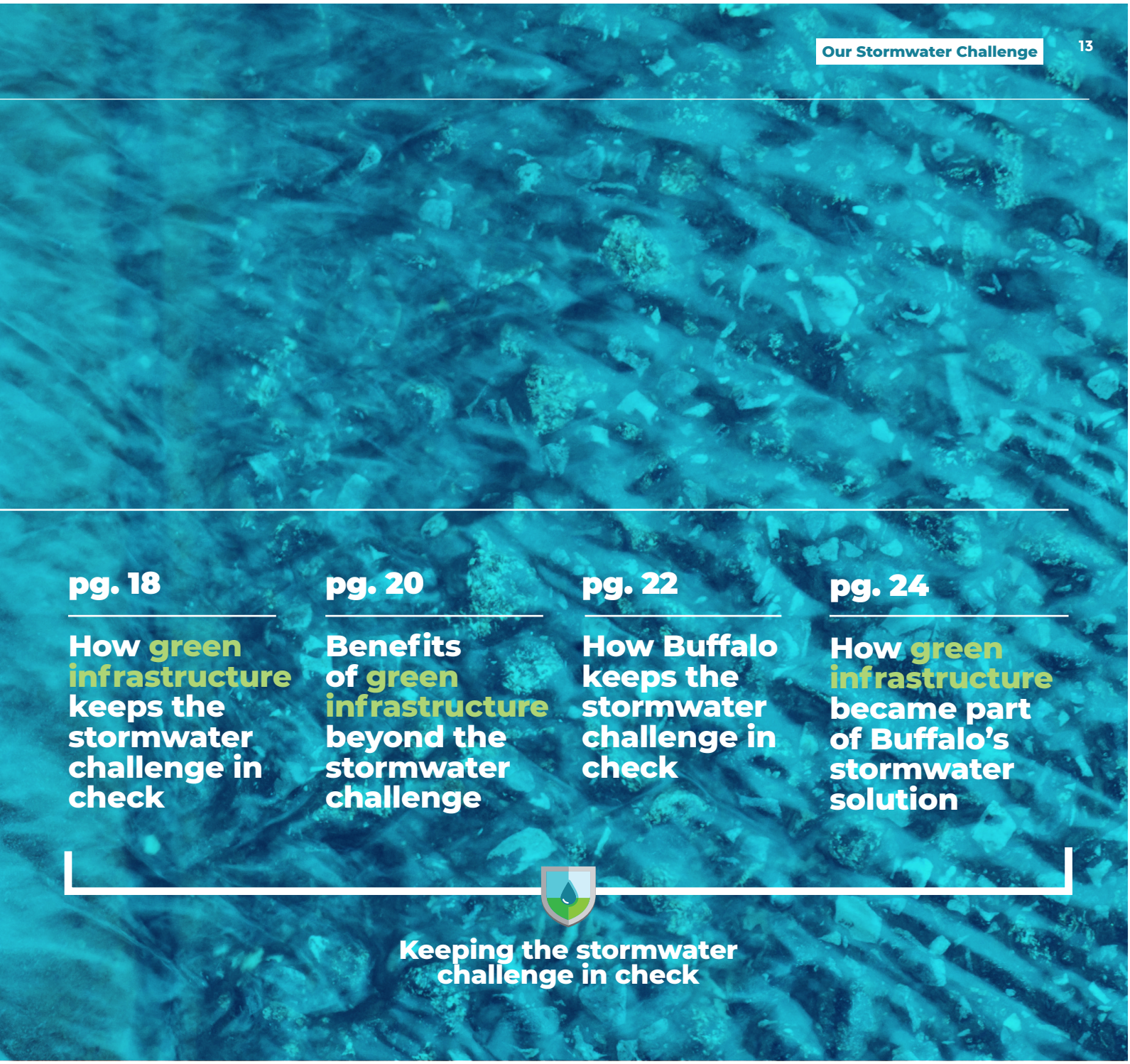
The waterfront is the historical, cultural and economic center of Buffalo. Building on this history, recent waterfront investments are helping to steer the economic revitalization of the city and the entire Buffalo Niagara region. The waterfront is also home to regional tourist attractions, like HarborCenter, and many major employers. Water is a necessary component to the operations of many industries, including energy and manufacturing.

Buffalo's 21st century future will be fueled by our access to fresh water. It is imperative that we protect and restore this tremendous resource for the benefit of future generations.



Our Stormwater Challenge

To fully benefit from all the opportunities offered by our waterways, we need to make sure they are clean and healthy. Today, the biggest challenge facing local waterways comes from **stormwater—the water that flows over the ground when it rains or snow melts.**



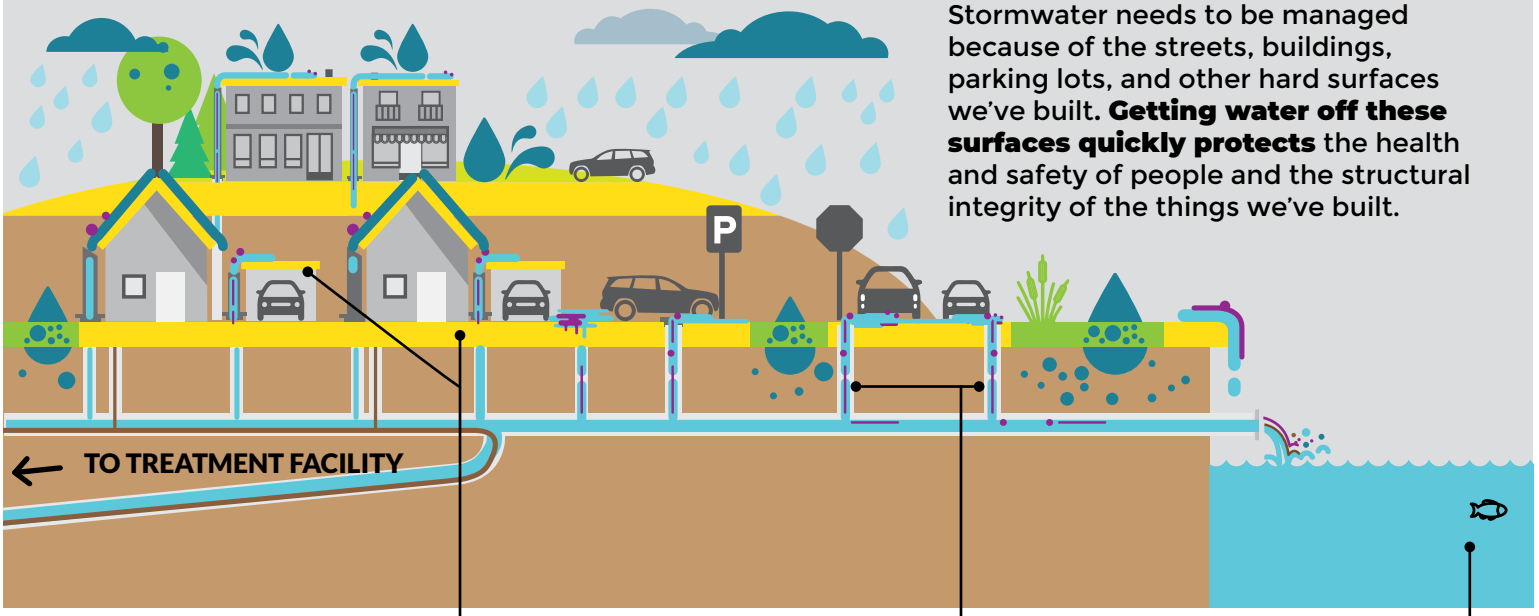
Keeping the stormwater challenge in check

Defining our stormwater challenge

Stormwater itself is a resource. It helps us grow food, feeds our plants and greenspaces, and replenishes rivers, streams, creeks and lakes. But because we need to move it off the surfaces of our streets, sidewalks, homes, and parking lots, it causes a challenge to our sewer system and waterways.

When stormwater falls in an urban environment

Stormwater needs to be managed because of the streets, buildings, parking lots, and other hard surfaces we've built. **Getting water off these surfaces quickly protects** the health and safety of people and the structural integrity of the things we've built.



Sidewalks, roads, driveways, and roofs **don't absorb stormwater** because they are **impervious surfaces**.

As stormwater flows across these **impervious surfaces,** it picks up dirt and **pollutants**, creating **runoff**.

This **polluted runoff** combines with **wastewater** from homes and businesses, often **overflowing into waterways**.

The challenge of impervious surfaces.

Much of our city is covered by impervious surfaces—**hard materials like asphalt, concrete, and rooftops designed to be impenetrable to water**. When it rains or snow melts, water puddles up and flows across these surfaces until it finds places to be absorbed or deposited.

The challenge of runoff.

Stormwater that travels down streets, driveways, and across the urban environment is called runoff. As it moves across impervious surfaces, it picks up all sorts of pollutants like trash, animal waste, pesticides from our lawns, oil and grease from our cars, and everything else we spill or drop on the ground.

When stormwater runoff meets our sewer system and waterways.

Stormwater runoff and the pollutants it picks up as it travels along impervious surfaces need a place to go. Some of that water finds its way into the ground or into local creeks, rivers, or tributaries. But most of the water enters our sewer system through the sewer inlets on our streets, sewer grates in parking lots, and downspouts on the sides of homes and businesses.

When stormwater falls in a natural environment

Natural landscapes, soil and wetlands **can absorb stormwater** because they are **porous.**

Green infrastructure is designed to mimic how the natural environment manages stormwater.

Why stormwater is a challenge for our sewer system and community

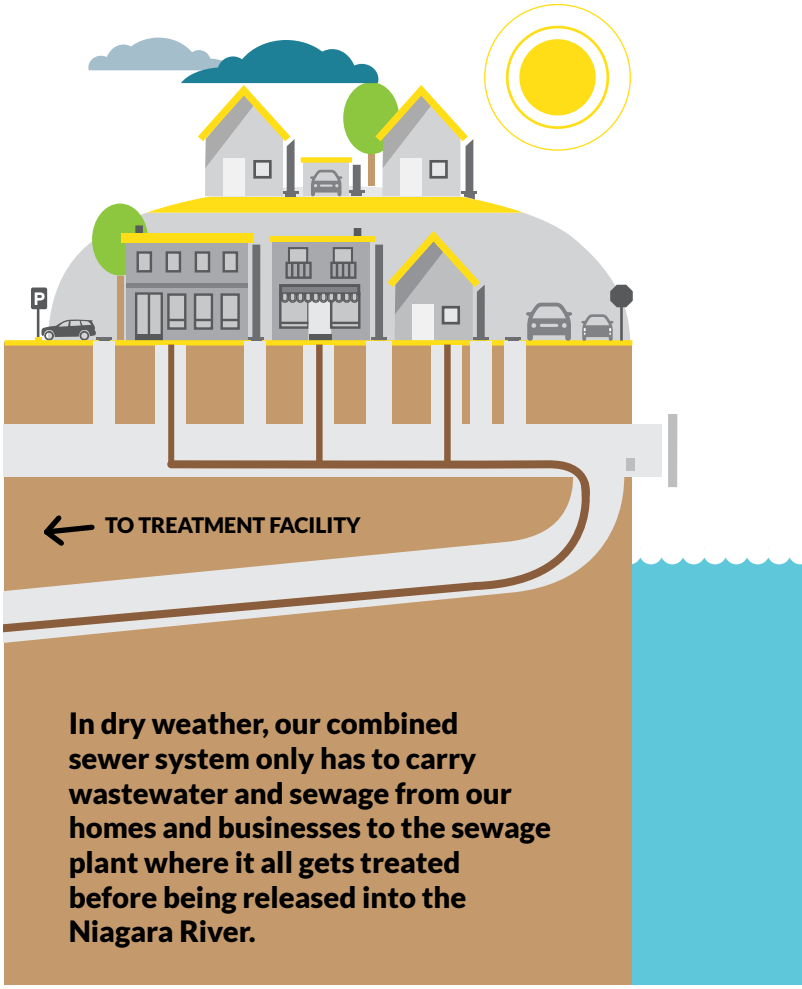
The stormwater challenge is essentially a wet-weather challenge. When it rains or snow melts, stormwater that falls on impervious surfaces, like roads and rooftops, runs off into the combined sewer system and mixes with wastewater from homes and businesses. When this happens, our system, by design, releases any excess waste and stormwater directly into waterways in order to prevent basement backups. These occurrences are called sewer overflow events and the more precipitation we receive, the more untreated stormwater overflows into the Niagara River, and the bigger the stormwater challenge becomes.

This is a significant problem for the City of Buffalo which receives, on average, 40 inches of rainfall and 94 inches of snow every year.[2] And the problem seems to be growing as the frequency and intensity of extreme precipitation events has increased across the northeastern U.S.[3]

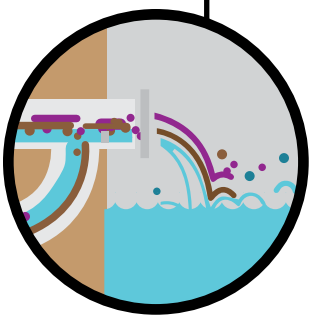
Green infrastructure practices keep the stormwater challenge in check by reducing and managing the impervious surfaces of the city that produce stormwater runoff, particularly on streets and buildings. While traditional underground infrastructure is still needed, especially in extreme precipitation events, green infrastructure is a powerful, cost-effective way to prevent sewer overflows from happening and to keep our stormwater challenge in check.

How Buffalo's **combined sewer system** works in...

...dry weather.



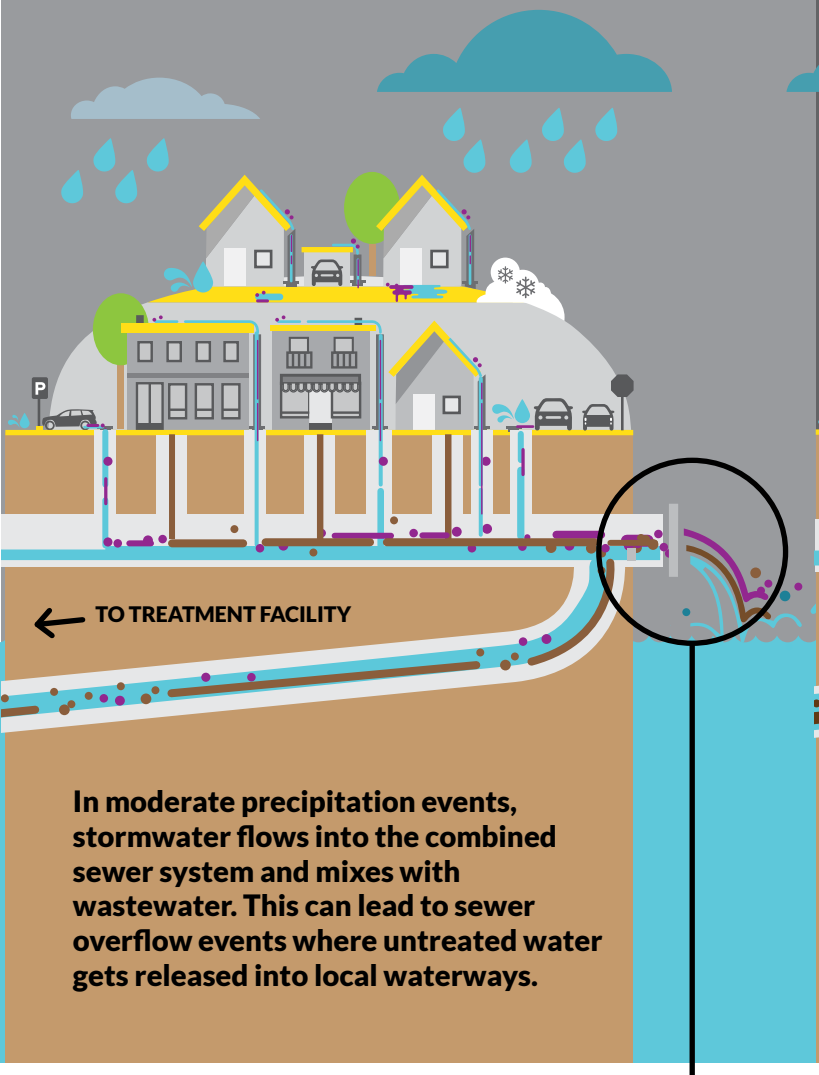
In dry weather, our combined sewer system is able to treat all our wastewater before it is released into local waterways.



A total of 1.75 billion gallons of wastewater and untreated stormwater are estimated to enter our waterways during the 69 overflow events that happen during a typical year.

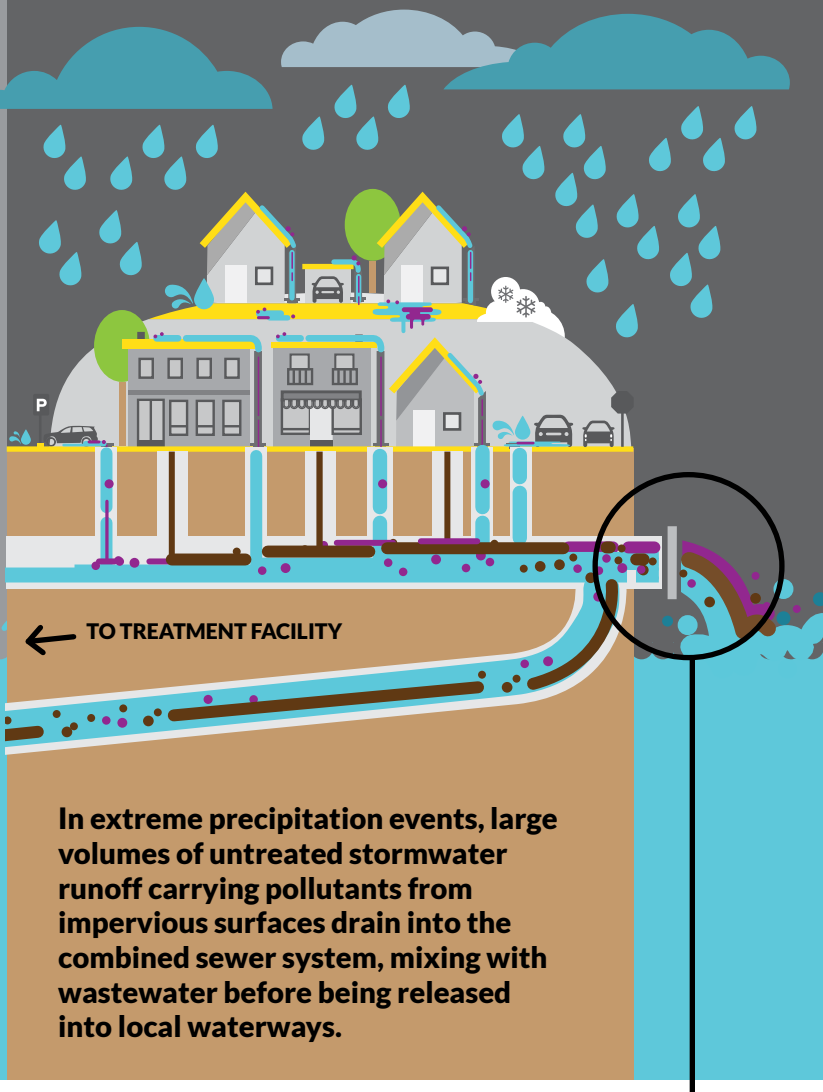
For details on methodology and assumptions, see the Appendix.

...**moderate** precipitation events of **1 inch or less** of rain or snowmelt.



In moderate precipitation events, stormwater flows into the combined sewer system and mixes with wastewater. This can lead to sewer overflow events where untreated water gets released into local waterways.

...**extreme** precipitation events with **more than 1 inch** of rain or snowmelt.



In extreme precipitation events, large volumes of untreated stormwater runoff carrying pollutants from impervious surfaces drain into the combined sewer system, mixing with wastewater before being released into local waterways.

Green infrastructure is a great solution for moderate precipitation events. Most, if not all, of these events could be taken care of by techniques that absorb, collect, or divert water when it rains or snow melts.

Moderate precipitation events in Buffalo account for...

...**88%** of sewer overflow events.

...and **44%** of the volume of untreated wastewater released into local waterways.

Green infrastructure can be a big part of the solution in extreme events. We also need **to invest in underground infrastructure** to prevent sewer overflows in extreme precipitation events.

Extreme precipitation events in Buffalo account for...

...only **12%** of sewer overflow events.

...but **56%** of the volume of untreated wastewater released into local waterways.

For details on methodology and assumptions, see the Appendix.

How green infrastructure keeps the stormwater challenge in check

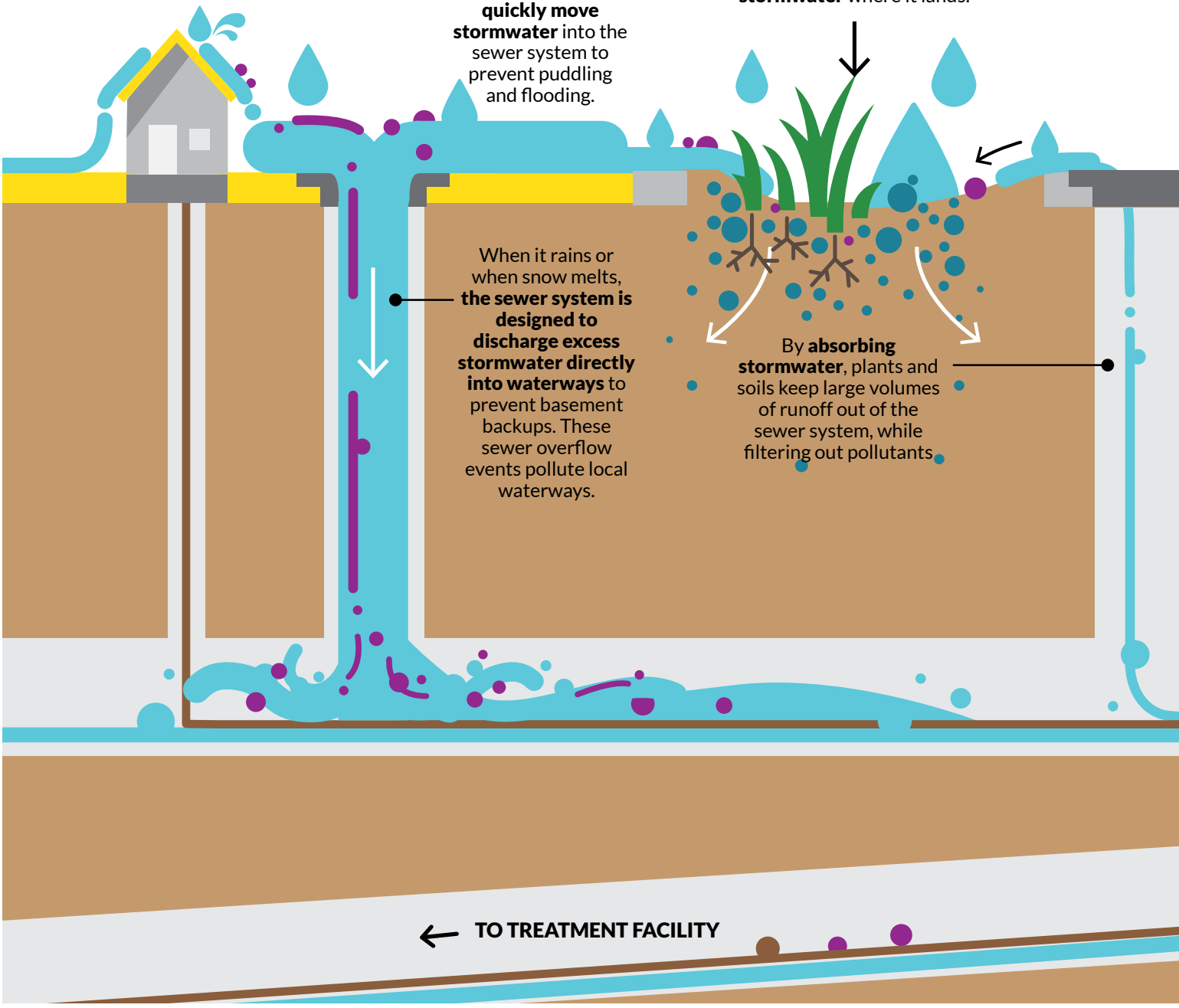
Green infrastructure manages water where it falls.

It slows down the flow of stormwater into our sewer system, or keeps it out of sewers altogether.

Green infrastructure absorbs stormwater

Green infrastructure often involves planting vegetation and other natural elements in urban environments to **absorb and treat stormwater** where it lands.

Impervious surfaces are designed to **quickly move stormwater** into the sewer system to prevent puddling and flooding.



Green infrastructure diverts stormwater

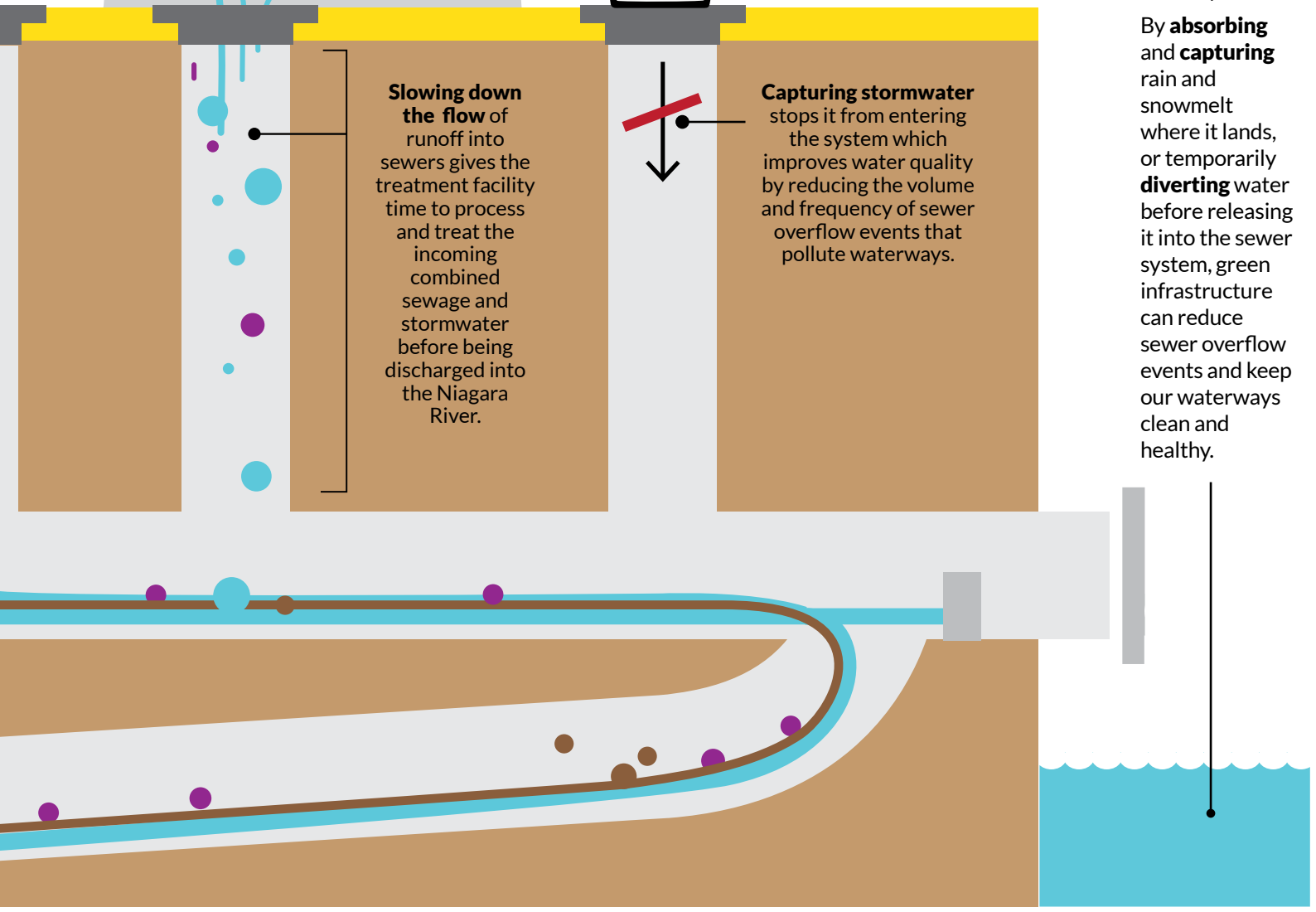
Green infrastructure can **reroute and slow down the flow** of stormwater entering the sewer system, particularly during extreme precipitation events.

Slowing down the flow of runoff into sewers gives the treatment facility time to process and treat the incoming combined sewage and stormwater before being discharged into the Niagara River.

Green infrastructure captures and stores stormwater

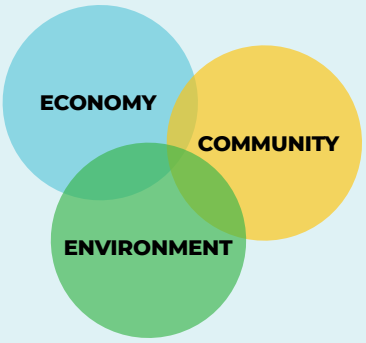
Green infrastructure practices can **capture stormwater** where it lands and **store water** so it can be used on site at a later time.

Capturing stormwater stops it from entering the system which improves water quality by reducing the volume and frequency of sewer overflow events that pollute waterways.



By **absorbing** and **capturing** rain and snowmelt where it lands, or temporarily **diverting** water before releasing it into the sewer system, green infrastructure can reduce sewer overflow events and keep our waterways clean and healthy.

Benefits of green infrastructure beyond the stormwater challenge



Because green infrastructure investments are above ground for all to see, they can offer unique benefits to our environment, economy, and community.

Offers public and private cost savings

Compared to gray infrastructure, the costs of installing and maintaining green infrastructure are often lower, which saves local governments, private developers, and taxpayers money. Some green infrastructure strategies allow property owners, especially households, to cut down on water usage and save money on energy bills.

Directs public investment into neighborhoods

Unlike conventional stormwater infrastructure, green infrastructure directs public investments above ground and in neighborhood spaces across the city. Neighborhood greening initiatives in underinvested communities are an important strategy to reverse historical legacies of disinvestment.

Re-greens urban areas

By replacing underused or vacant land with plants, trees, and gardens, green infrastructure incorporates natural elements into urban environments. These natural areas provide vegetation and soils that can help reduce air temperatures, purify the air, and provide habitat for wildlife.

Enhances community aesthetics

Green infrastructure features improve the local aesthetics of a community. When incorporated into neighborhood business districts or major transportation corridors, green infrastructure can help beautify and revitalize areas, making them more attractive to private investment.

Supports public health and recreation

By improving pathways, creating places to gather, and providing shade during warm weather, trees and other green spaces promote active, healthy lifestyles and recreation. As part of compact development strategies, green infrastructure supports walkable communities and helps cultivate a strong sense of place and well-being.

Improves public safety

Green infrastructure features can support public safety by enhancing traffic calming measures like bump outs and bike lanes that make streets safer for pedestrians and bicyclists. Some green infrastructure strategies also remove hazardous structures and green vacant lots, which can create a sense of place and improve neighborhood safety.

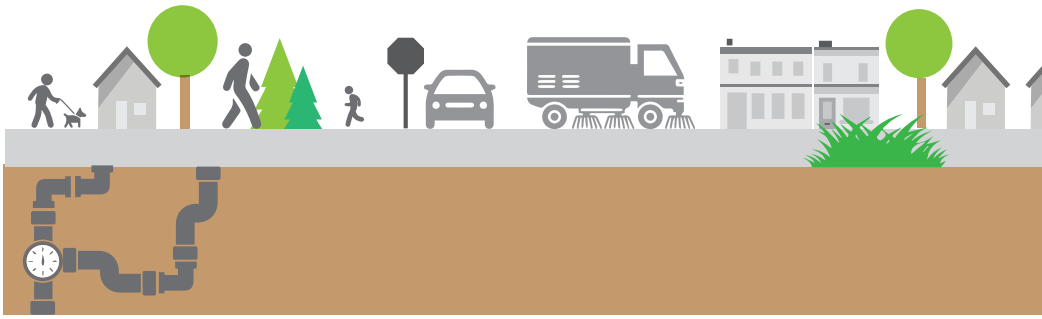
Cultivates public education and engagement opportunities

Green infrastructure is above ground, allowing people to see and touch installations in their communities and creating unique opportunities to develop public awareness around the importance of sustainable water management. The installation and management of green infrastructure projects thrive on community participation and partnership, with many opportunities to include residents, property owners, community groups, and neighborhood volunteers in the development process.

Creates green job opportunities

Implementing green infrastructure creates a wide variety of green job opportunities. Each project involves a range of design professionals, community engagement specialists, project managers, construction workers and maintenance teams. Through agency leadership, professional and workforce training programs, and first source and minority hiring programs, the green infrastructure job ladder can eliminate barriers for under-represented community members and actively support an equitable and inclusive green infrastructure workforce.

The ways Buffalo keeps the stormwater challenge in check



Buffalo keeps the stormwater challenge in check in many ways. Some are "smart" and gray, others are green. All are designed to promote healthy waterways.

Tackling the problem underground with pipes, pumps, and "smart" sensors.

Pipes, pumps, and gray, underground infrastructure are the foundation of how we collect wastewater from local homes and businesses. They also collect stormwater from the 18,000 storm drains maintained by Buffalo Sewer across the city. On days with minimal or no rain or snowmelt, this system filters out wastewater and pollutants from water before it gets deposited back into our waterways.

Contemporary gray infrastructure investments can fix compromised pipes or modernize older technology so that it performs at a higher level. Increasingly, Buffalo Sewer is looking at "Real Time Control" measures to maximize sewer performance and minimize how much untreated water goes directly into our water bodies. Using sensors, this "smart" technology can tell what parts of the system will be under the most stress during a rain or snowmelt event, and divert waste and stormwater, "in real time," to parts of the system that will be less stressed.

Getting pollutants off our streets so they never enter our sewer systems and waterways.

Preventing pollutants from entering our waterways is a lot cheaper and more effective than treating and cleaning contaminated water. In maintaining streets and parks, Buffalo uses various "best management practices" to keep the stormwater challenge in check. The Department of Public Works, Parks & Streets regularly sweeps and vacuums city streets to keep all sorts of pollutants (road salt, oil and grease, pet waste, etc.) out of the sewer system and away from our waterways. City departments also refrain from using pesticides in maintaining green space and parks. This makes our parks healthier places for residents and keeps these materials out of our streams and sewer system.

GREEN INFRASTRUCTURE AT WORK

Incorporating practices that protect, restore, and maintain our natural areas.

Protecting and maintaining our natural areas includes investments in our parks, trees, and shoreline areas. Buffalo boasts more than 150 parks, most of which are covered in grass or vegetation that can soak up rain and snowmelt. Throughout our streets, public spaces, and parks are well over 150,000 trees, estimated to keep more than 42 million gallons of stormwater out of the sewer each year. Shoreline restoration projects, like the Scajaquada Creek restoration project at Forest Lawn Cemetery, construct wetlands and buffers to filter and slow water from rain or snowmelt before it enters waterways.

Creating policies and regulations that require private development to minimize the amount of water that runs off their buildings and land.

The 2017 debut of the Buffalo Green Code replaced a fifty year-old, outdated planning framework, with a modern set of policies, regulations and design guidelines. The Green Code helps check the stormwater challenge by: requiring on-site stormwater management for all new development greater than 1/4 acre (including most parking lots); prioritizing compact development and open space that minimizes impervious surfaces; and encouraging landscaping, innovative paving materials, and water collecting technology like rain barrels, gardens, and cisterns.

RAINCHECK PROGRAM 1.0

Removing impervious surfaces through demolition.

As a strategy to remove blight and enhance the health and safety of our neighborhoods, Buffalo implemented a comprehensive **demolition program** that removed over 6,600 abandoned residential and commercial structures between 2001 and 2017. In many cases, demolitions replace impervious surfaces (buildings and driveways) with vacant lots that soak up water where it falls.

Making targeted changes to the built environment that mimic the natural water cycle.

Roadways, parking lots, and rooftops are the highest runoff sites in our city. Buffalo has implemented a range of projects and programs targeted at these areas, including a **residential rain barrel and downspout disconnection program**; integrating water absorbing elements, like **rain gardens**, into **streetscape projects**; and retrofitting neighborhood **parking areas** with special materials and designs that collect and soak up rain and snowmelt.

How green infrastructure became part of Buffalo's stormwater solution

Gray Approach 2004-2008

Gray Meets Green 2008-2014

Buffalo Sewer explores green infrastructure solutions with support from local partners and national peers. The work starts with a series of green infrastructure projects that engage and educate citizens on green approaches and the stormwater challenge.

2004

Buffalo Sewer submits ***draft Long-Term Control Plan (LTCP)*** *for state/federal agency review. Plan includes only gray infrastructure solutions.*

2007

August 2007, Mayor Byron W. Brown announces large scale multi-year plan to remove blighted structures.

2009

Buffalo Sewer begins "smart" sewer program evaluation focusing on capacity opportunities throughout sewer system.

2010

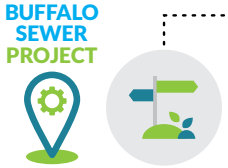
Downspout disconnection pilot project: *Buffalo Sewer launches project in Old First Ward (later Hamlin Park and Elmwood Village), partners with* ***Buffalo Niagara Waterkeeper*** *to conduct community outreach.*

Green infrastructure feasibility study: Buffalo Niagara Waterkeeper *received funding support from* ***Community Foundation for Greater Buffalo*** *and the* ***John R. Oishei Foundation****. Supported by Buffalo Sewer, the study calls for a mix of gray and green infrastructure solutions, the creation of a citywide green infrastructure program.*

2011

Buffalo Sewer's ***first green street project supported by NYS Environmental Facilities Corp. (EFC):*** *Work begins on*

Claremont Ave
Clarendon Pl
Elmwood Ave
Parkdale Ave
Windsor Ave



2012

Buffalo Sewer conducts ***community outreach meetings and focus groups*** *to inform development of LTCP. Community expresses interest in green infrastructure solutions.*

Buffalo Sewer submits ***updated draft LTCP*** *for state, federal agency review,* ***including green infrastructure*** *options.*

2004 2005 2006 2007 2008 2009 2010 2011 2012

Gray and Green make it official 2014

10 years after draft LTCP with no green options, Buffalo Sewer finalizes with "smart + green" options.

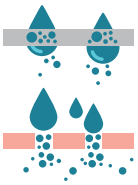
Green approaches scale up 2015-Present

With a finalized "smart + green" Long Term Control Plan, Buffalo Sewer and the City launch new projects around parking lots and vacant lots. Work is scaled up with a citywide downspout disconnection and rain barrel program and the completion of several major complete green street projects. New partnerships expand to make green infrastructure approaches grow.

2013

Buffalo Sewer and the City *partner with* ***PUSH Buffalo*** *on green vacant lots in the West Side.*

Buffalo Sewer and City *construct* ***Carlton St project*** *including porous asphalt. Work on* ***Ardmore Place*** *reveals brick under the asphalt, creating an opportunity to restore the historic street and make it a green at the same time.*



BUFFALO SEWER PROJECT

2014

Buffalo Sewer *finalizes LTCP, includes the first generation of green infrastructure projects, with focus on* ***green streets, green demolitions and vacant lots****.*

LTCP is approved by NYSDEC and EPA.

Buffalo Sewer and the City *construct Fillmore Ave project and introduce green parking lots to the East Side.*

2015

Rain Check: ***Buffalo Sewer*** *partners with* ***Community Foundation for Greater Buffalo*** *to secure a national Partners for Places grant, also coordinates with* ***Buffalo Niagara Waterkeeper*** *and* ***PUSH Buffalo*** *on community outreach and program implementation.*

Post demolition green infrastructure pilot study: ***Buffalo Sewer*** *receives funding through* ***NYS EFC*** *and awards a contract to* ***Buffalo Neighborhood Stabilization Corporation*** *to provide on-site training and technical assistance for the study.*

RENEW Fellows: ***Buffalo Sewer*** *and City partner with* ***UB RENEW Institute*** *to establish fellowship program, and receives technical assistance for green infrastructure program.*

Ohio St *green street completed.*

2016

Buffalo Common Council *adopts* ***Buffalo Green Code****, updated city zoning ordinance that includes on-site stormwater management requirements for all new development.*

Kenmore Ave *green street completed.*

2017

Buffalo Sewer and the City *install* ***green parking lots at JFK and Pratt Willert Community Centers****.*
Buffalo Sewer *partners with* ***Community Action Organization*** *on youth green infrastructure education program.*

Niagara St *Gateway Project Phase 1 completed.*

Genesee St *green street completed.*

2018

Buffalo Sewer and the City *partner with* ***Ralph C. Wilson Foundation and Community Foundation for Greater Buffalo*** *to launch Rain Check 2.0, second generation of green infrastructure projects with focus on expanded engagement and partnerships.*

RAINCHECK

2013 | 2014 | 2015 | 2016 | 2017 | 2018 2034

Buffalo Sewer's Long Term Control Plan, with "smart + green" options, sets the stage for green infrastructure investments through 2034.

Rain Check 1.0 strategies in Buffalo

pg. 28

The first generation of public green infrastructure investments

RAINCHECK

Rain Check 1.0 marked the first generation of green infrastructure in Buffalo. The program tackled the stormwater challenge through four distinct strategies–**green streets**, **green parking lots**, **demolitions and vacant lot restoration**, and **rain barrels and downspout disconnections**. Each project completed in Rain Check 1.0 tells a unique story of how collaborative efforts to reduce stormwater runoff with green infrastructure bring broader benefits to the city, like beautifying neighborhoods, improving safety, cutting public costs, creating jobs, and engaging the community. Through this work, Buffalo Sewer built partnerships and learned practical lessons that can help maximize the future impacts of the next phase of green infrastructure in Buffalo.

pg. 30

Green Streets

pg. 44

Green Parking Lots

pg. 56

Demolitions and Vacant Lot Restoration

pg. 68

Rain Barrels and Downspout Disconnections

For each Rain Check strategy, you'll find:

Keeping the stormwater challenge in check

Where the approach works in Buffalo

How do we benefit from the approach

Case Study Examples

RAINCHECK

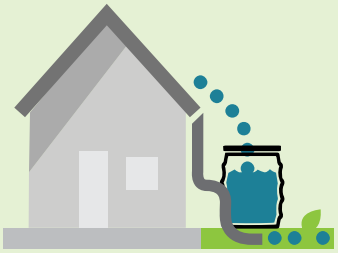
The First Generation of Public Green Infrastructure Investments

The first generation of Rain Check projects focused on four key strategies...

Green Streets

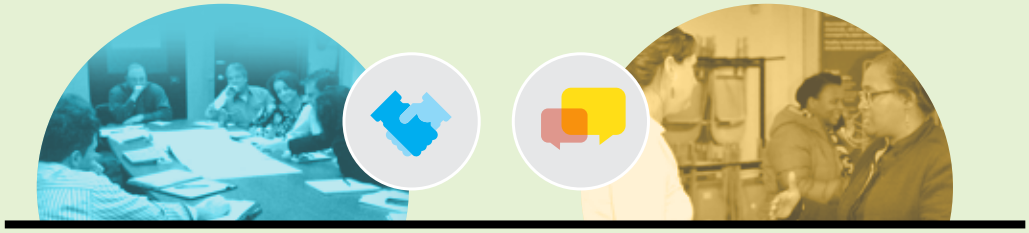
Green Parking Lots

Demolitions and Vacant Lot Restoration



Rain Barrels and Downspout Disconnections

...shaped through collaboration with governmental and community partners...



...and designed to tackle the stormwater challenge and offer added benefits to Buffalo.

Collectively, these four strategies enabled Buffalo Sewer to make an impact on the stormwater challenge, build partnerships necessary to make green infrastructure projects happen, and gain perspective on how to grow and fine-tune green infrastructure in Buffalo for the future.

Green Streets

Green streets bring **water-friendly landscapes into larger streetscape projects**. They introduce surfaces that absorb water and integrate special features that collect rain and snowmelt before they enter the sewer system. They also play a key role in transforming our commercial corridors and neighborhood streets to benefit residents and businesses.

Green Parking Lots

Green parking lots provide neighborhood parking solutions with **designs specifically aimed at collecting and absorbing water** when it rains or snow melts. They can involve plantings and enhanced lot designs that help beautify neighborhoods while making lots safer and less prone to puddling.

Demolitions and Vacant Lot Restoration

Demolitions remove buildings and pavement from sites to protect public health and safety. Buffalo Sewer also explored new ways to **maximize the amount of water that vacant lots capture** when it rains or snow melts and worked with community partners to introduce rain gardens and other green infrastructure to vacant lots that help contribute to community character.

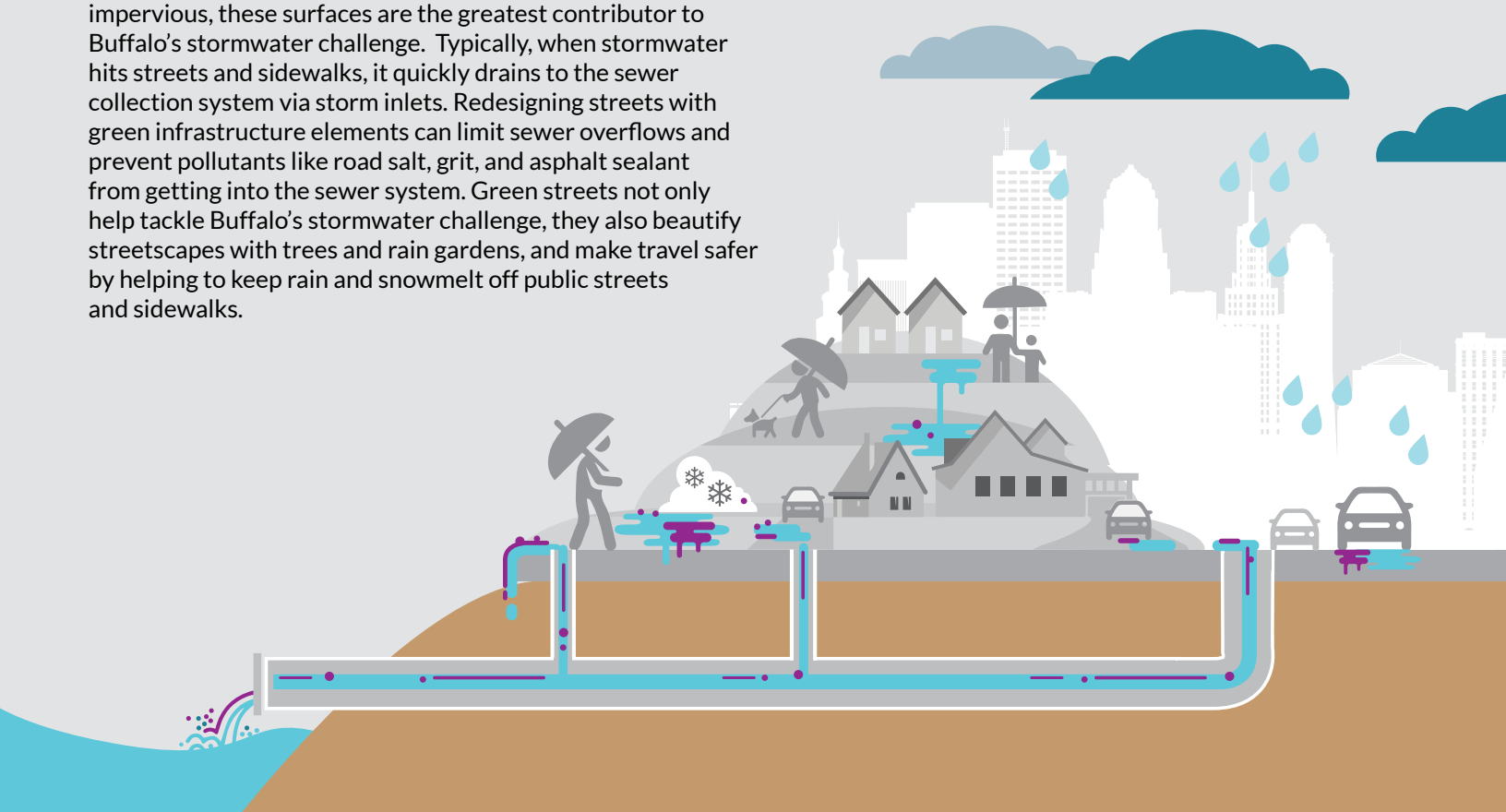
Rain Barrels and Downspout Disconnections

Rain barrels and downspout disconnections **allow residents and businesses to keep roof rain and snowmelt out of the sewer system**. They not only inform residents of the stormwater challenge facing our community, but also provide an easy, low-cost way for them to participate in green infrastructure solutions. They can also save money on water bills and keep stormwater away from foundations or basements.

Green streets involve features that manage stormwater and beautify neighborhoods.

Stormwater runoff from roads, sidewalks and other impervious surfaces can lead to sewer overflow events.

Roadways, driveway aprons, snow storage areas, and sidewalks represent a relatively small amount of our city's land area — around 17 percent.[4] But since almost all of this land is impervious, these surfaces are the greatest contributor to Buffalo's stormwater challenge. Typically, when stormwater hits streets and sidewalks, it quickly drains to the sewer collection system via storm inlets. Redesigning streets with green infrastructure elements can limit sewer overflows and prevent pollutants like road salt, grit, and asphalt sealant from getting into the sewer system. Green streets not only help tackle Buffalo's stormwater challenge, they also beautify streetscapes with trees and rain gardens, and make travel safer by helping to keep rain and snowmelt off public streets and sidewalks.



Keeping the stormwater challenge in check

Green Infrastructure Approaches

De-Paving

Reducing the amount of paved surfaces on streets or sidewalk areas offer more green space to absorb water, keeping it out of the sewer system.

Porous Pavement

Porous pavement gives rain and snowmelt a place to go rather than the storm inlets on the sides of curbs. Water absorbs through the pavement and into the underlying soil.

Brick/ Cobblestone Restoration

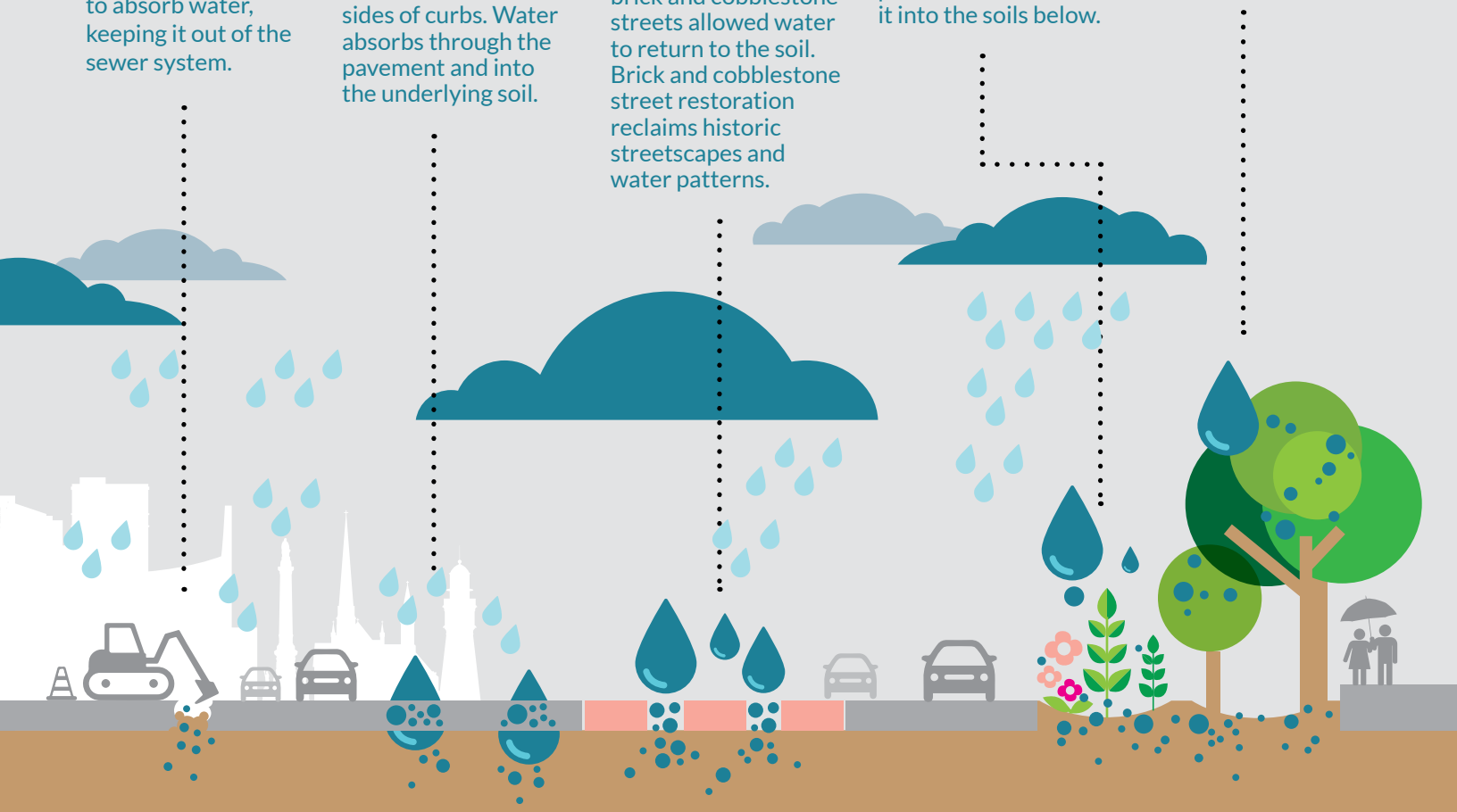
Before the widespread use of asphalt, Buffalo's brick and cobblestone streets allowed water to return to the soil. Brick and cobblestone street restoration reclaims historic streetscapes and water patterns.

Rain Gardens

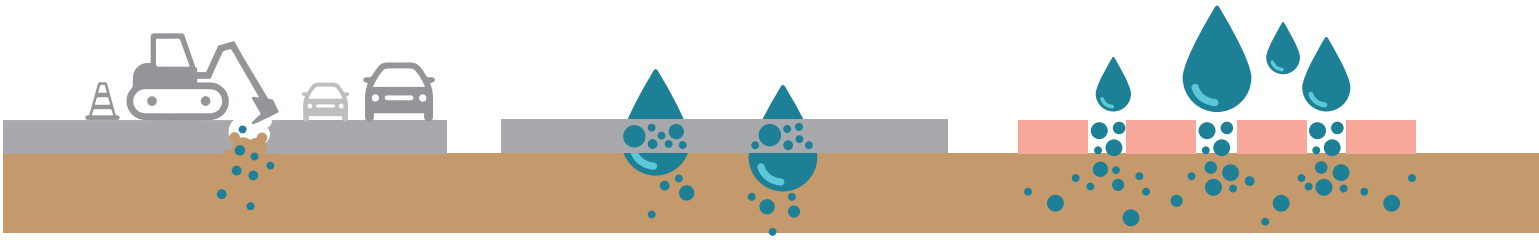
These plant beds collect stormwater runoff from street and sidewalk pavement and absorb it into the soils below.

Street Trees

Trees capture and store rain in their leaves and roots and release it into the atmosphere.



Where **green street** approaches work in Buffalo



De-Paving

De-paving is a good fit in street reconstruction projects aimed at slowing traffic and reducing the number of travel lanes through road diets. Areas where paved surfaces are removed can also offer opportunities to add other green infrastructure, like street trees or rain gardens. Examples of recent road diets include the work on Ohio Street, Pearl Street, and William Street.

Pearl Street between Edward Street and West Tupper Street, where the paved surface between curbs was reduced from approximately 50 feet to 30 feet.

Porous Pavement

Where roadway width must be preserved to accommodate vehicle travel, bicycle travel lanes and parking, porous paving may be employed to control stormwater on site. To date, porous asphalt has been used on streets, bike lanes/paths, and in parking lanes. Examples of porous pavement projects include Kenmore Avenue, Clarendon Place, Carlton Street, Claremont Avenue, and William Street.

Carlton Street in the Fruit Belt neighborhood adjacent to the Buffalo Niagara Medical Campus.

Brick/Cobblestone Restoration

Buffalo is estimated to have more than two dozen cobblestone streets and nearly 100 brick streets, though many of these have been covered by asphalt over time.[5] When these streets are scheduled for a typical "mill and overlay" repaving treatment, there may be an opportunity to restore these streets as porous systems that limit stormwater runoff into sewers.

Ardmore Place on the city's West Side was able to be restored as a historic brick street in response to residents' requests for restoration and traffic calming.

Rain Gardens

Rain gardens are often a good fit where changes are made to sidewalks or the area between sidewalks and the street. As is the case with almost all green infrastructure, rain gardens should be placed where they can intercept the most stormwater runoff while avoiding utility lines, building vaults, and foundations. Since rain gardens require regular maintenance, planning for their continual upkeep is also an important placement consideration.

Rain gardens installed along Genesee Street helped transform the major corridor into a welcoming gateway from the city's East Side to downtown Buffalo.

Street Trees

There are more than 47,000 suitable locations to plant street trees in the City of Buffalo, according to the 2003 City of Buffalo Urban Forest Master Plan.[6] Trees proven to offer the greatest benefits to stormwater include the London planetree, and pin oak.[7] The City of Buffalo's Division of Parks and Recreation has established street tree planting standards for evaluating proposed planting sites and guiding decisions on exactly where and what to plant.

More than 270 trees were planted along Ohio Street, contributing to the corridor's changing character and helping to meet the stormwater challenge.

How do we benefit from constructing **green streets** across Buffalo?

101.5 acres
managed for stormwater

15.9 acres
of impervious surfaces reduced

Keeping the stormwater challenge in check

Green street projects initiated between 2013-2017 manage runoff for **101.5 acres** of the city, an area the size of 44 city blocks.

Green street projects use a variety of approaches, including replacing nearly **16 acres** of asphalt and concrete with plantings and other materials that absorb water.

These investments have the potential to keep **1,908,045 gallons** of water out of our sewer system when it rains or snow melts. That's enough water to fill 180 NHL ice rinks.

1,908,045

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Calculations by Buffalo Sewer. For details on methodology and assumptions, see Appendix.

Benefits beyond the stormwater challenge

Reinforces our Complete Streets policy
Integrating green infrastructure into larger streetscape enhancement projects helps Buffalo implement its Complete Streets ordinance, which requires that when a roadway is constructed or repaired, equal consideration is given to travelers of all kinds — including bicyclists, pedestrians, public transportation users, children, people pushing baby strollers and people with disabilities.

Revitalizes neighborhoods and promotes safety
Some elements that make for a good complete street can be addressed with investments that also control stormwater runoff. For example, rain gardens and trees can contribute to beautification efforts and make streets more inviting to small businesses and foot traffic. Road diets and brick street restorations can better manage automobile traffic, while making it safer and easier for people to cross the street.

Offers cost savings
By integrating green infrastructure into complete street projects, overall cost savings can be achieved as it allows projects to draw on multiple funding sources and shared project management resources for the design and construction of projects.

More than 9 miles of green streets across Buffalo

are helping us meet our stormwater challenge

Building upon the adoption of a Complete Streets ordinance in 2008, the City of Buffalo proposed a system of complete, green streets that connect key areas and developments including downtown, waterfronts, urban parkways, historic neighborhoods and commercial corridors through a variety of transportation options. These projects draw on a variety of green street approaches and help to address stormwater and quality of life concerns on residential streets and large commercial corridors.

1. Kenmore Avenue
2. Parkdale Avenue
3. Claremont Avenue
4. Elmwood Avenue
5. Windsor Avenue
6. Clarendon Place
7. Ardmore Place
8. Niagara Street (Phase 3&4)
9. Northland Avenue
10. Carlton Street
11. Niagara Street (Phase 1&2)
12. Pearl Street
13. Genesee Street
14. William Street
15. Ohio Street

Completed **In Progress**

CASE STUDY

Niagara Street

Creating a green gateway along the Niagara River

Niagara Street is one of the city's major commercial corridors, a highly utilized public transit route, a growing target for private investment, a rising employment hub, and a gateway to downtown. The street runs parallel to the Niagara River, but is disconnected from the water in terms of access and views. The Niagara Street corridor is home to diverse communities, all of which contribute to the heritage and culture of the city. The street is also known as "Avenida San Juan," serving as the city's Hispanic Heritage Corridor between Porter Avenue and Georgia Street. As a signature corridor of Buffalo, Niagara Street is being transformed from a high-speed thoroughfare for automobiles into a scenic, waterfront boulevard that is safe and welcoming for pedestrians and bicyclists.

Community Partnerships

The Niagara Street project involved many partners, including Buffalo Sewer, the City of Buffalo Department of Public Works, Parks & Streets, and design and community engagement consultants. Extensive community engagement was a key focus of the project, grounding the street redesign in community values and educating stakeholders on potential green infrastructure elements. The process engaged more than 600 residents, business owners, and stakeholders, representing diverse voices and perspectives from along the corridor. Highlights included a door-to-door community survey made available in English, Spanish, Somali, Nepali, Burmese, and Karen; several interactive, hands-on, public workshops; and targeted stakeholder meetings with business owners, community groups, and block clubs from nearby neighborhoods.

Keeping the stormwater challenge in check with green infrastructure on Niagara Street

2.1 acres of impervious surfaces removed

46 bump outs

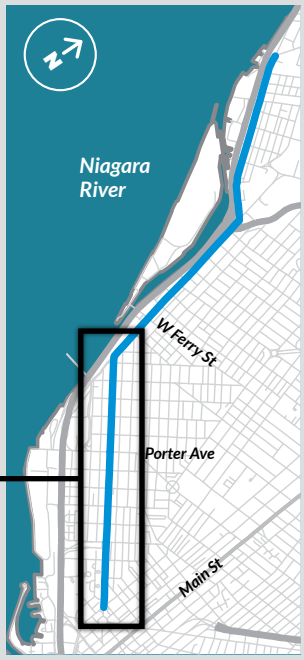
255 rain gardens planted

574 trees planted

These investments on Niagara Street manage stormwater for 30.9 acres of the city.

612,934

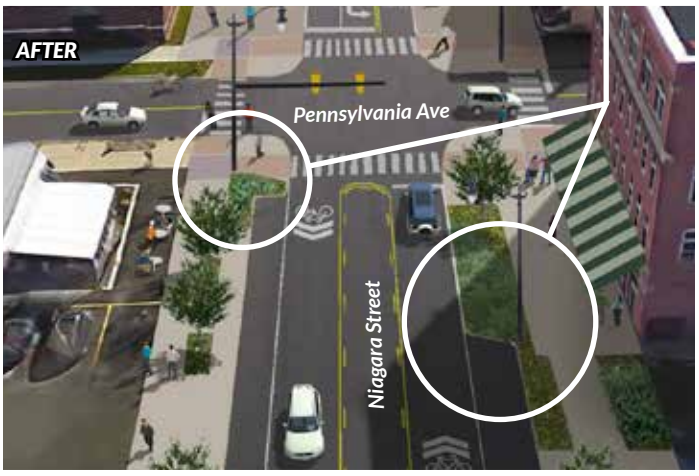
gallons of runoff prevented from entering the sewer system in a typical rainfall event.



Green Infrastructure on Niagara Street

The Niagara Street reconstruction project is a multi-phased redesign of the street from Niagara Square in downtown up to Ontario Street in Riverside/Black Rock. The project stands out as the longest green street in the city. Through a combination of green infrastructure elements including bump outs, rain gardens, and impervious surface reduction, the project reduces the stormwater volumes flowing to Buffalo's combined sewer system where the overflow discharges directly to the Niagara River. The initial phases of the project focused on the lower portion of the street, from Niagara Square to Porter Avenue.

Reducing impervious pavement and installing trees and green spaces allows for water to be captured before it enters the street and sewer system. Curb bump outs and bike lanes make the street safer for pedestrians and bicyclists.



CASE STUDY

Ardmore Place

Uncovering a historic brick street on the city's West Side

Ardmore Place is a quaint residential street on the city's West Side, stretching just one block between Baynes Street and Richmond Avenue. The narrow tree-lined street features large multi-story homes, most of which were built in the early 20th century and have historic charm. At the west end of the street is Lafayette International High School, a large stone, brick, and terra-cotta building in the French Renaissance Revival style and one of the oldest public schools in the city. Ardmore is also home to one of the city's numerous brick and cobblestone streets. Workers laid the bricks on Ardmore more than a century ago, but they were covered with layers of asphalt and blacktop for decades. During a typical street resurfacing project in 2013, neighbors noticed the bricks beneath the pavement and advocated for their restoration. The original brick street offers benefits that asphalt pavement does not—it gives the street a charming, historic appearance that contributes to a distinct community character; it slows vehicles making the street safer for pedestrians; plus, it lets rain and snowmelt seep into the ground rather than running off into the sewer system.

Community Partnerships

The Ardmore Place Block Club drove the effort by getting neighborhood residents to band together to petition the City's Department of Public Works, Parks & Streets to restore the brick street, rather than repave it with asphalt—and the City listened, partnering with Buffalo Sewer to carry out the restoration project. The effort to restore the brick surface was a unifying force for the community, as residents banded together to appeal to local government officials for the restoration.

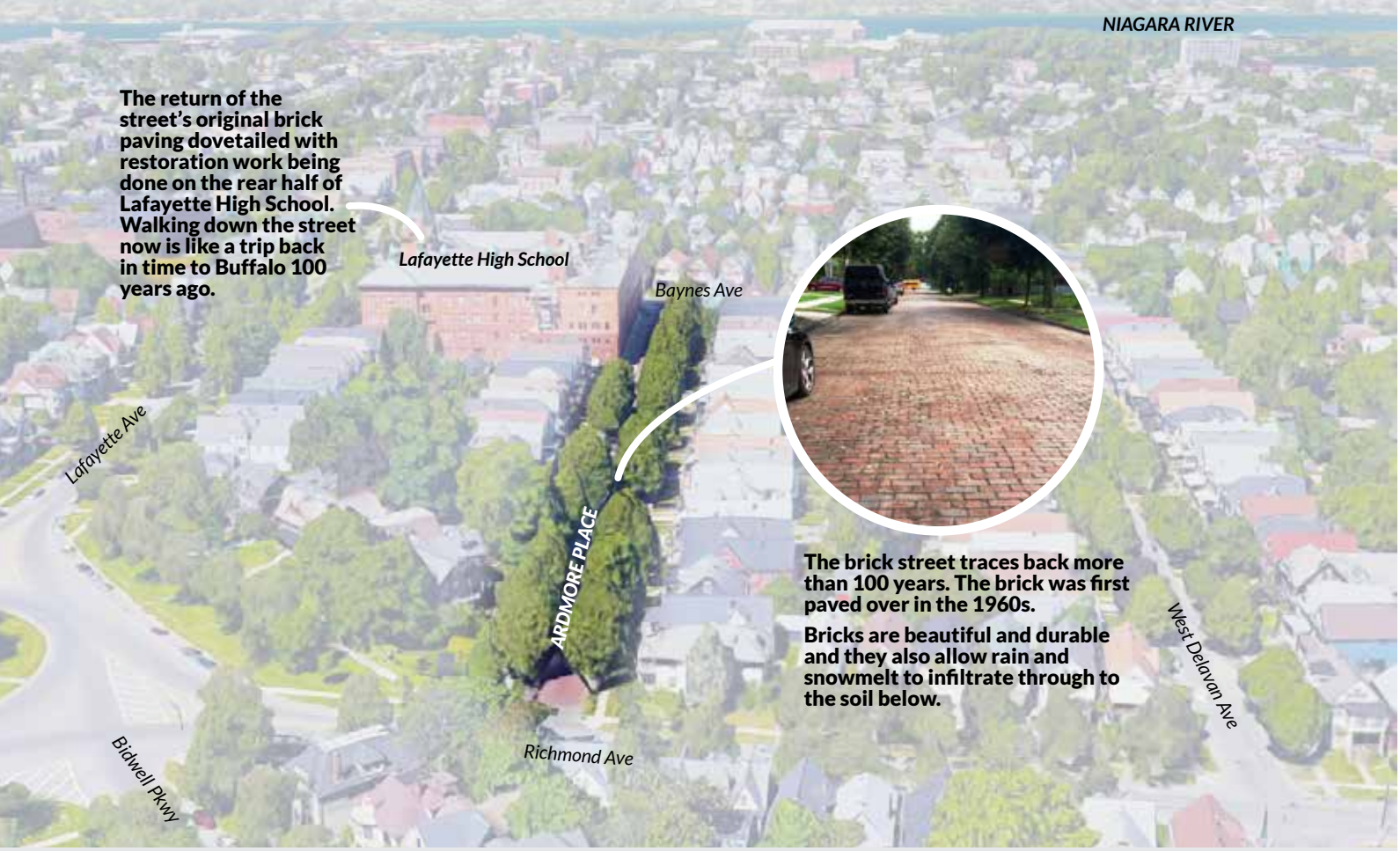
Keeping the stormwater challenge in check with green infrastructure on Ardmore Place

0.7 acres of impervious surfaces removed

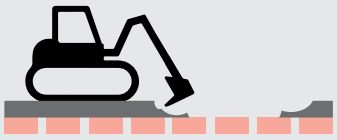
These investments on Ardmore Place manage stormwater for 1.4 acres of the City.

11,973

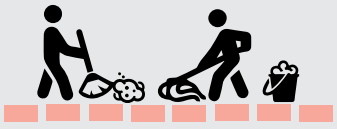
gallons of runoff prevented from entering the sewer system in a typical rainfall event.



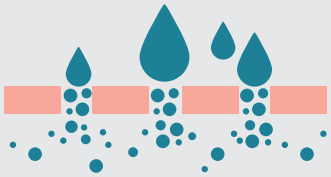
Green Infrastructure on Ardmore Place



In preparation for a street resurfacing project in 2013, City of Buffalo crews began removing asphalt from Ardmore Place and uncovered an intact brick street underneath. Buffalo Sewer partnered with the City to transform the project from a mere repaving job to a brick street restoration.



The effort to restore the brick surface brought together neighbors to advocate for the restoration. Residents joined together to chip away at the asphalt and hose down the weathered bricks.



Uncovering the bricks from this 0.2 mile-long street removes nearly 12,000 gallons of stormwater from entering sewers in a typical rainfall event.

CASE STUDY

Ohio Street

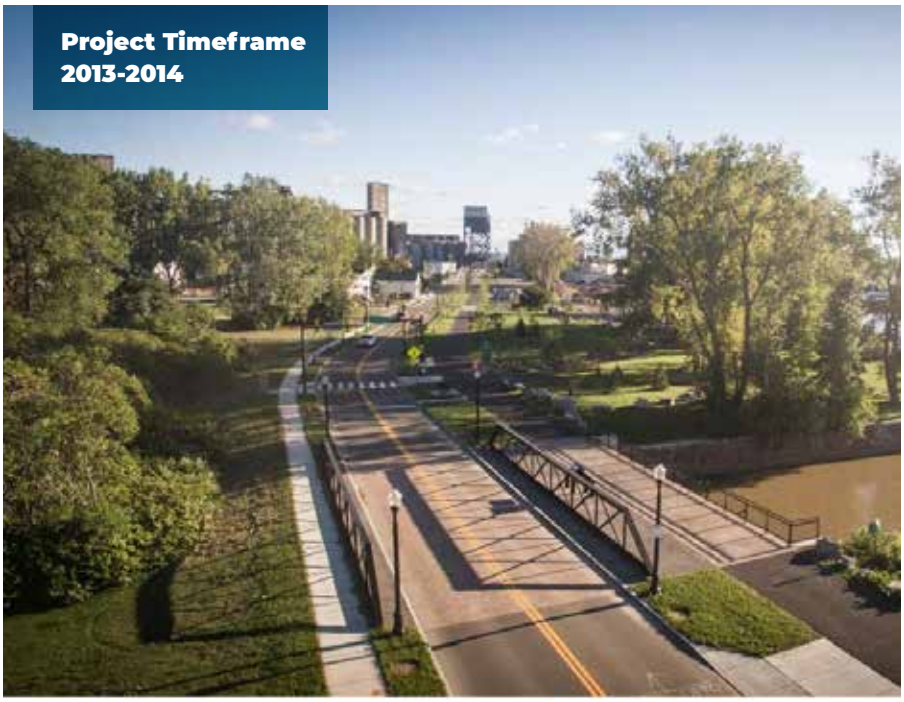
Transforming an industrial corridor into a tree-lined waterfront parkway

Located southeast of the central business district on the edge of the industrial waterfront areas, Ohio Street was a key site in the city's industrial development. Industries developed along the Buffalo River, transforming the city into a manufacturing center during the 19th century. Today, Ohio Street is one of the major connectors between the city's inner and outer harbors, playing an important role in the revitalization of Buffalo's waterfront. The Ohio Street corridor links major activity centers including Canalside, the Cobblestone District in the Inner Harbor, Gallagher Beach, Wilkeson Point, and Buffalo Harbor Park in the Outer Harbor. The area is also home to the historic Old First Ward neighborhood, first settled in the 19th century by Irish immigrants who worked in the industries that lined the Buffalo River. Many current residents are of Irish descent and every year the neighborhood hosts the "Old Neighborhood" St. Patrick's Day Parade. The recent conversion of Ohio Street into a waterfront parkway helps link local neighborhoods and residents to the transformation happening along the waterfront.

Community Partnerships

The Ohio Street project included a wide range of partners and community collaborations led by the City of Buffalo and Erie Canal Harbor Development Corporation. Buffalo Sewer, City of Buffalo Department of Public Works, Parks & Streets, and NYS Department of Environmental Conservation were all involved in the design of green infrastructure for the project. Buffalo Sewer and project partners also collaborated with neighborhood organizations, including Old First Ward Community Center and Valley Community Association, Buffalo Niagara Waterkeeper, elected officials, and property and business owners as part of the planning and design process.

Project Timeframe
2013-2014



Keeping the stormwater challenge in check with green infrastructure on Ohio Street

3.2 acres of impervious surfaces removed

260 trees planted

These investments on Ohio Street manage stormwater for 12.7 acres of the City.

70,824

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Green Infrastructure on Ohio Street

The streetscape project transformed this underutilized, four-lane commercial roadway built for automobiles, into a complete street that makes travel safe and comfortable for pedestrians, bicyclists and transit riders. A central feature of the project was the reduction and re-allocation of travel lanes to provide space for a multi-use pathway and green infrastructure. A 12-foot-wide shared-use path and new parking lanes were installed with porous asphalt to reduce pressure on the sewer system during heavy rain or snowmelt events. Over 260 trees were also planted along the corridor to capture and store rain and snowmelt.

Road diet measures on Ohio Street reduced over 3.2 acres of impervious surface and allowed for a shared-use path to be built for pedestrians and bicyclists.

CASE STUDY

William Street

Celebrating local African American heritage in neighborhood spaces

Located just east of downtown Buffalo, the Willert Park neighborhood has historically been home to important African American businesses and cultural institutions. William Street is a prime corridor for the neighborhood that directly links it to downtown and the Michigan Avenue African American Heritage Corridor.

At the intersection of William Street and Michigan Avenue is Jesse Clipper Square, a pocket park featuring a memorial for African American veterans. A pink granite stone memorializes the sacrifice of Jesse Clipper, the first African American soldier from Buffalo to die in World War I. The memorial also pays tribute to other African Americans who served in World War II, the Korean War, and the Vietnam War. Today, Jesse Clipper Square is being expanded and enhanced with a new layout based on the original 1938 design from John Edmonston Brent (1889-1962), Buffalo's first African American architect who spent the majority of his career working in the city and is well-known for designing Buffalo's Michigan Avenue YMCA, a building that became a cultural center for the African American community in Buffalo.

Community Partnerships

Neighborhood residents and community groups were involved and engaged throughout the William Street project. Buffalo Sewer and its project team members, including engineers and landscape architects, participated with neighborhood residents in walking tours to identify where green infrastructure makes sense in the context of neighborhood conditions. The public also gave feedback in preliminary and final design updates. Public education on the uses and benefits of green infrastructure was a key component of this work.

Keeping the stormwater challenge in check with green infrastructure on William Street

1.3 acres of impervious surfaces removed

64 trees planted

0.66 acres of porous pavement added

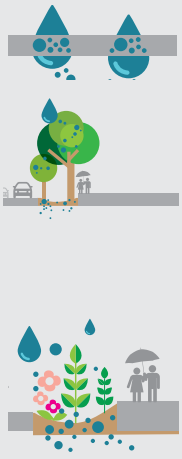
These investments on William Street manage the stormwater across 25.2 acres of the City.

284,357
gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Expanding the roadway median from 15 feet to 38 feet removed 1.3 acres of impervious surfaces and allowed for Jesse Clipper Square to be expanded.

Green infrastructure on William Street

The ongoing William Street reconstruction project added several green infrastructure elements along William Street from Michigan to Jefferson Avenue. Porous pavement was installed in the parking lane on the north side of the street, and the median was widened with new trees and plantings featuring rain gardens to manage stormwater runoff from the street. Jesse Clipper Square at the corner of William and Michigan has been expanded and enhanced with a new layout based on the original 1938 design by John Brent, thanks to recent research that has uncovered significant contributions to architectural design and landscape architecture made by Brent in the city. Collectively, these green infrastructure elements promote infiltration of rain and snowmelt into the surrounding soils, provide temporary stormwater storage and improve water quality.



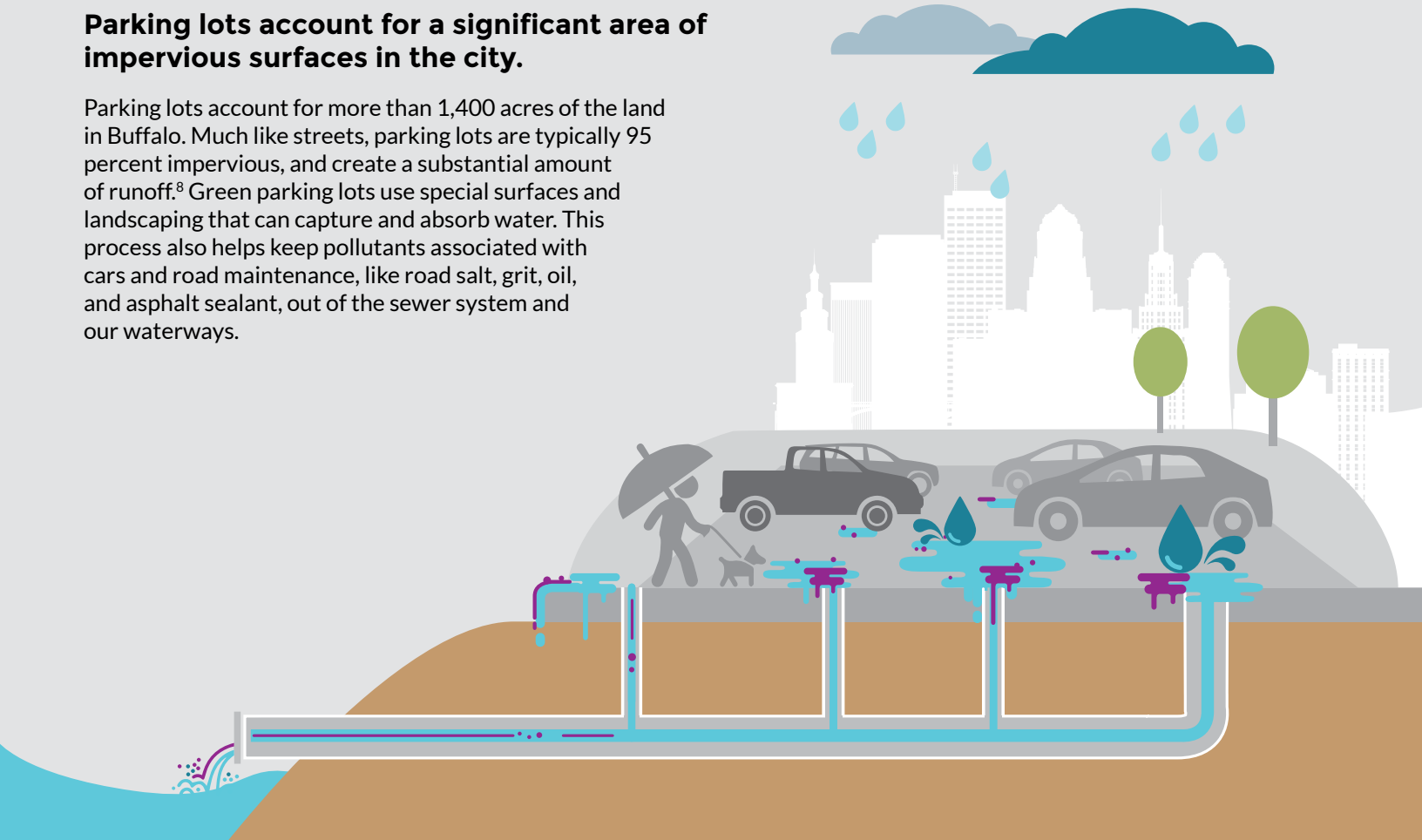
Drainage Area on William Street

The design of green infrastructure for this section of William Street was informed by the topography of the surrounding area. The residential streets that abut the north edge of William slope downward towards the street. Stormwater runs south along these streets and empties into sewer drains along the north edge of William. To reduce these stormwater flows into the sewer system, porous pavement was installed along the north parking lane of William.

Green parking lots use special materials and designs that collect and soak up rain and snowmelt.

Parking lots account for a significant area of impervious surfaces in the city.

Parking lots account for more than 1,400 acres of the land in Buffalo. Much like streets, parking lots are typically 95 percent impervious, and create a substantial amount of runoff.[8] Green parking lots use special surfaces and landscaping that can capture and absorb water. This process also helps keep pollutants associated with cars and road maintenance, like road salt, grit, oil, and asphalt sealant, out of the sewer system and our waterways.



Keeping the stormwater challenge in check

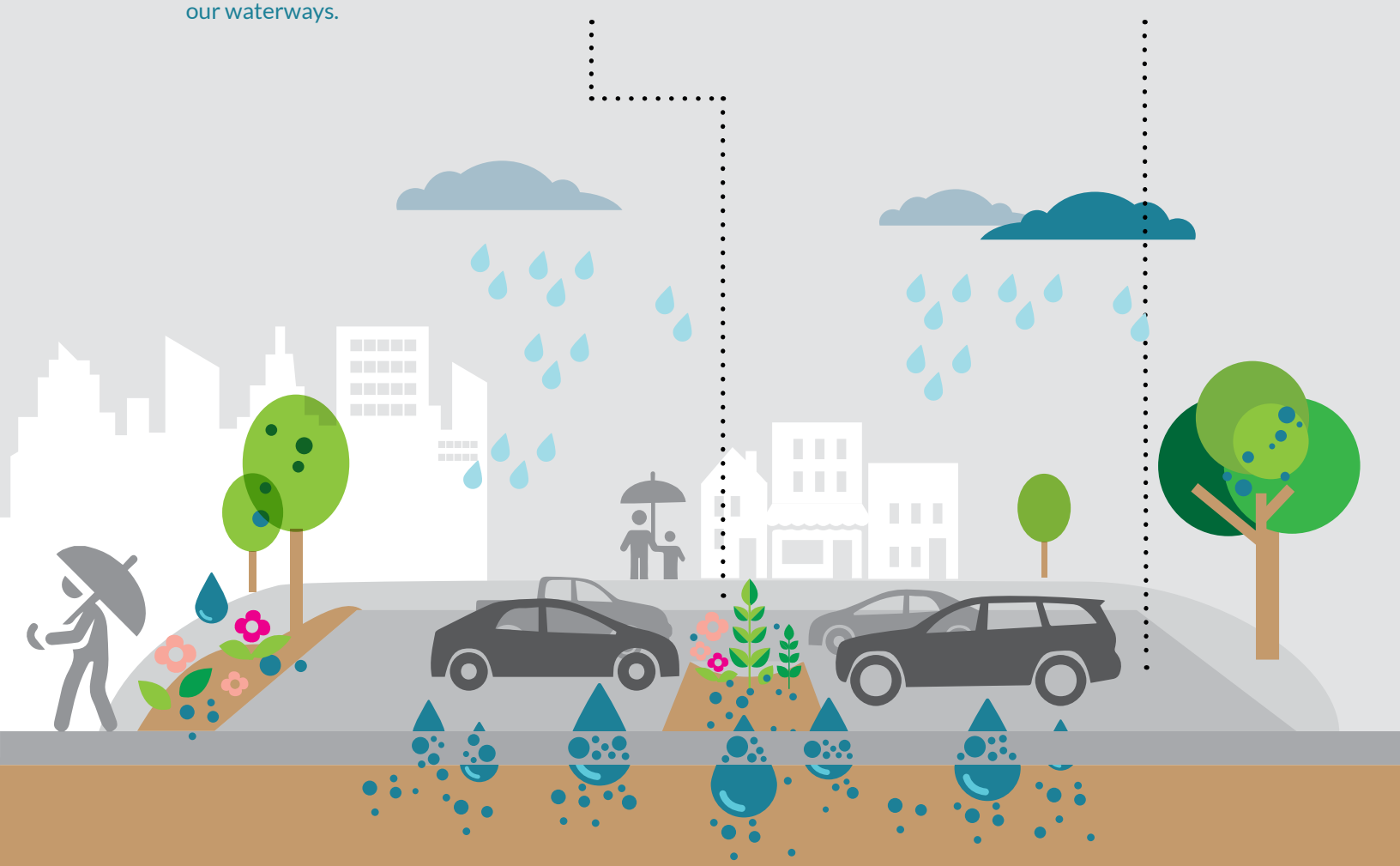
Green Infrastructure Approaches

Rain Gardens

These plant beds collect stormwater runoff from parking lots, streets and sidewalks, allowing rain and snowmelt to absorb into the ground rather than running off the lot and eventually reaching our waterways.

Porous Pavement

Porous pavement uses special types of street surfacing material, like porous asphalt, that allows rain and snowmelt to pass through the surface and flow into the ground.



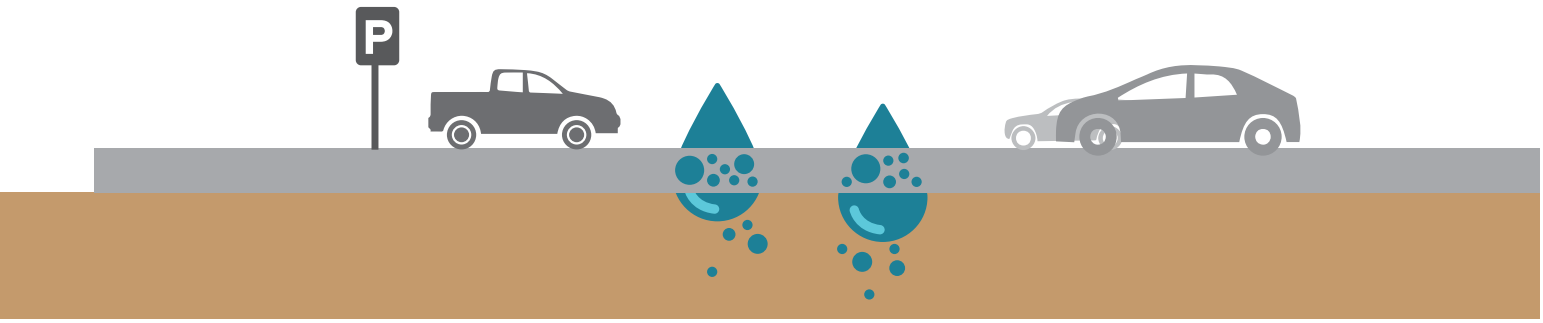
Where green parking lot approaches work in Buffalo

Rain Gardens

Rain gardens in parking lots can help screen cars, beautify properties, and meet Green Code landscaping requirements. They also provide attractive amenities or educational areas for building users. Siting requires careful analysis of site conditions to identify locations that will intercept stormwater runoff, while also avoiding building foundations and utilities. Selection of plants and soils for rain gardens may also consider native landscaping, aesthetic design, and maintenance requirements.

Green infrastructure design and construction activities at JFK Community Center on Hickory Street offered unique, hands-on opportunities to engage and educate youth on the benefits of green infrastructure in their communities.

Rain gardens in the parking lots at the Pratt Willert (top) and JFK Community Centers (bottom) provide attractive landscaping and stormwater management for the parking areas of the neighborhood recreation facilities.



Porous Pavement

Porous pavement is a good fit on large, uneven and sloping parking lots that direct high volumes of stormwater into sewers. Porous surfaces work best on lots with permeable underlying soils and deep bedrock that can absorb more stormwater. To avoid added excavation costs, clean soils are also key. As porous pavement is more susceptible to wear and tear from heavy vehicles, it can last longer on lots with less traffic, especially from commercial trucks.

During a rain or snowmelt event, porous pavement in the expanded parking area at North Buffalo Ice Rink absorbs water beneath the ground (on the left side of the image), while water puddles on the ground in the older asphalt parking area (on the right).

Two porous parking lots were created on City-owned vacant parcels as part of a Fillmore Avenue streetscape project.

How do we benefit from green parking lots across Buffalo?

6.8 acres
managed for stormwater

2.7 acres
of impervious surfaces reduced

Keeping the stormwater challenge in check

Across six green parking lot projects, green infrastructure investments manage stormwater runoff for 6.8 acres of the city—an area nearly the size of 3 city blocks.

These investments manage much of the surface area of the parking lots themselves, as well as some impervious area from adjacent buildings and nearby sidewalks and streets.

Additionally, through plantings, rain gardens, and porous pavement, these projects have replaced 2.7 acres of asphalt and concrete with materials that absorb water.

When it rains or snow melts, these parking lots keep 257,083 gallons of water out of sewers. That's enough water to do 6,400 loads of laundry.

257,083

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Calculations by Buffalo Sewer. For details on methodology and assumptions, see Appendix.

Benefits beyond the stormwater challenge

Supports parking solutions
Neighborhood commercial districts and recreation attractions often require parking solutions that are sensible and contribute to the overall character of their surroundings. Bringing green infrastructure resources to restore, expand or create new parking areas can enhance resident and visitor access to neighborhood businesses and destinations.

Creates "cooler" and nicer looking lots
Despite the necessity of parking, lots can detract from the vibrant, walkable nature of commercial corridors and contribute to the "urban heat island effect," which raises the air temperature and elevates smog in the summer. Green parking lots can better integrate parking facilities into a community's character, and provide for a more pleasant atmosphere. Plantings, trees, and shrubs, placed around parking lot edges can serve as screens for pedestrians passing by, and can help breakup continuous strips of asphalt viewed from the street.

Offers smarter parking options
Vegetation can help breakup a large parking lot by dividing it into sections, which can help manage lot traffic. Even elements like porous asphalt benefit the community as it can help limit puddling and melt snow and ice faster than traditional asphalt.

2.35 acres of green parking lots across Buffalo

are helping us meet our stormwater challenge

Buffalo Sewer partnered with the City of Buffalo on six green parking lot projects. While relatively small in number and size, green parking lots represent significant investments to important community spaces across Buffalo, including a historic waterfront park on the West Side, a popular recreational ice skating rink in North Buffalo, a key commercial corridor near Martin Luther King Jr. Park, and two community centers in the Willert Park neighborhood.

6 Green Parking Lot Projects

1. North Buffalo Ice Rink
2. Broderick Park
3. 1401 Fillmore Avenue
4. 1384 Fillmore Avenue
5. Pratt Willert Community Center
6. JFK Community Center

CASE STUDY

Broderick Park

Renovating a waterfront park to embrace Underground Railroad heritage

Located at the foot of West Ferry Street on the scenic Niagara River, Broderick Park is a key site in the history of slavery and freedom on the Underground Railroad and a popular recreational space for the racially and ethnically diverse population on the city's West Side. The park is steeped in history, most notably as a major terminus of the Underground Railroad between the United States and Canada. The park pays tribute to the people who crossed the water from that point to freedom in Canada and is listed as a designated Network to Freedom site by the U.S. National Parks Service, a national network of historic places and educational or interpretive programs associated with the Underground Railroad. Recent renovations to the park include new entrance features, a small performance amphitheater, a waterfront promenade, new shelters, and revised parking facilities--all with the intent to uplift the space as a public memorial to the incredible local history of the Underground Railroad.

Community Partnerships

The City of Buffalo worked closely with community stakeholders on the project. Organizations such as the Buffalo Quarters Historical Society, Niagara River Anglers Association, Buffalo United Front, Rich Products, and the Broderick Park Advisory Committee were important partners on the project. Hundreds of citizens were engaged through a series of community meetings hosted by Mayor Brown and the City of Buffalo Division of Parks and Recreation, sharing ideas, suggestions, and comments about what enhancements they wanted to see in the park.

Project Timeframe
2013-2014

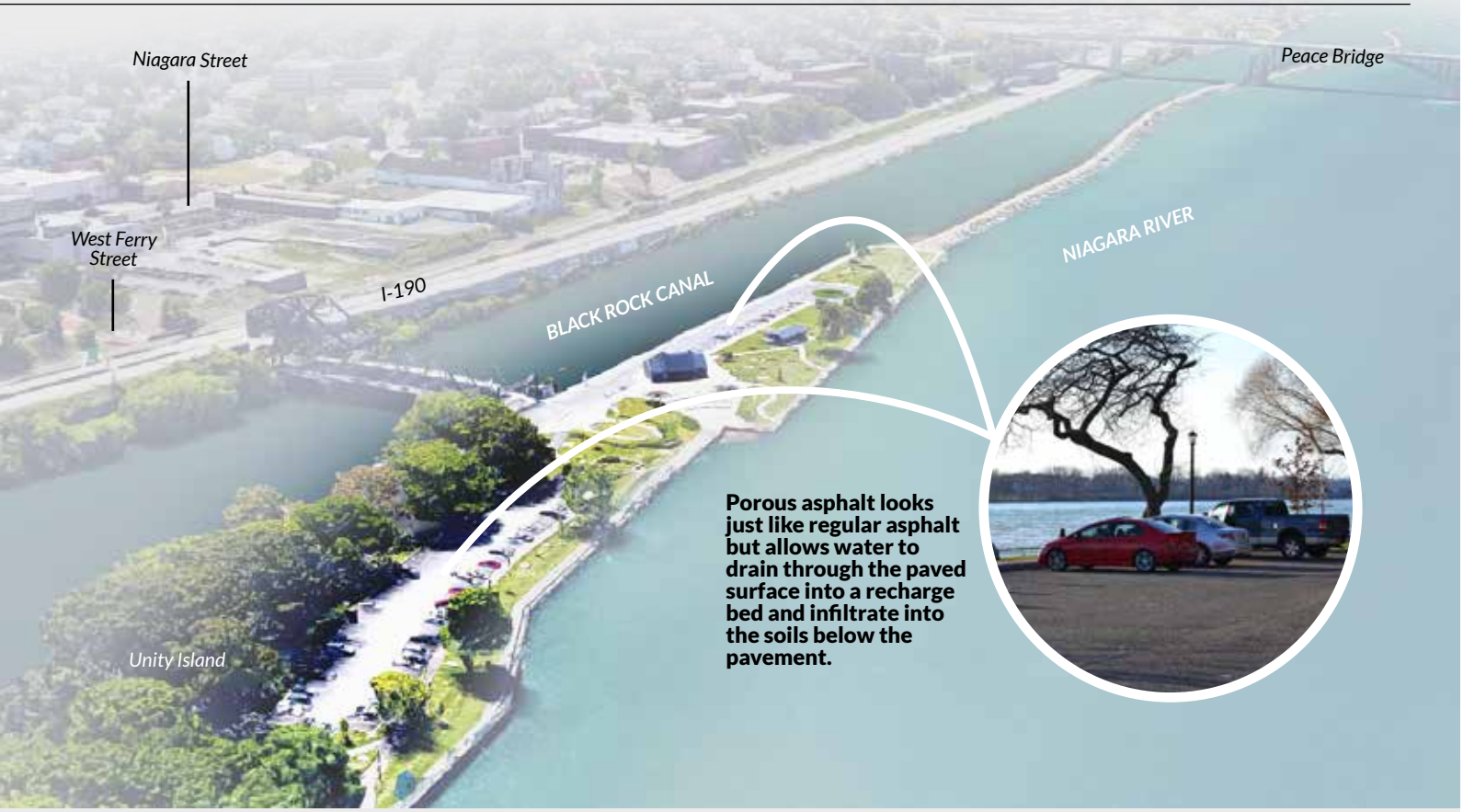
Keeping the stormwater challenge in check with green infrastructure in Broderick Park

1.0 acre of impervious surfaces removed

These investments in Broderick Park manage stormwater for 4.3 acres of the city.

124,326

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

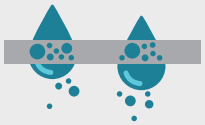


Green infrastructure in Broderick Park

The City of Buffalo recently invested over $1 million in a range of renovations to the park, including updated parking facilities with green infrastructure elements. By using porous asphalt in the parking areas, the pavement surface promotes infiltration and keeps over 124,000 gallons of stormwater from entering sewers in a typical rainfall event, improving local water quality.

Water moves along an impervious surface ⟷ **Water drains through a porous surface**

Replacing impervious surfaces with porous asphalt can provide cost-effective pavements that promote infiltration and improves water quality.



BRODERICK PARK MASTER PLAN

CASE STUDY

North Buffalo Ice Rink

Modernizing a community recreation center in North Buffalo

Located on Tacoma Avenue, the North Buffalo Ice Rink (formerly known as Lafayette Ice Rink) is an important community asset that is frequently used by neighborhood residents, local schools, and athletic organizations for hockey and skating. The ice rink is a major recreational resource for Buffalo's youth hockey. It is also very popular for other forms of skating, including open skates.

The North Buffalo Ice Rink originally opened in 1990 as the third public ice rink in the city. In a continuing effort to ensure the vitality of this community asset, the City has invested $3.4 million in the facility since 2006. As part of that ongoing investment, the City made substantial functional upgrades to the interior, as well as an expansion of the facility's parking lot. The City partnered with Buffalo Sewer to utilize porous pavement in the parking expansion.

Community Partnerships

The North Buffalo Ice Rink is owned by the City of Buffalo and operated by the Bison Hockey Organization, an association made up of about 400 families.

Keeping the stormwater challenge in check with green infrastructure at North Buffalo Ice Rink

0.7 acres of porous pavement added

These investments at North Buffalo Ice Rink manage stormwater for 0.7 acres of the City.

112,208

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

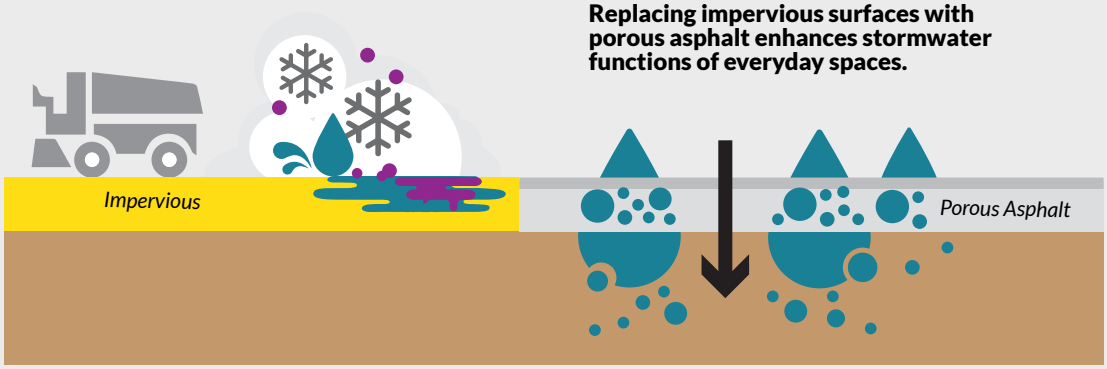
Water puddles on the older asphalt parking lot, shown on the right. The new, expanded parking area on the left uses porous asphalt, enabling it to absorb stormwater beneath the ground.

Green infrastructure at North Buffalo Ice Rink

The facility's porous parking area enables rain and snowmelt to seep directly into the ground rather than spreading across the parking lot and draining into the sewer system. With the capacity to absorb over 112,000 gallons of runoff in a typical rainfall event, these improvements ensure that the North Buffalo Ice Rink remains a high-quality facility for active recreation while limiting its environmental impact.

Even on sunny, dry days, the ice rink's Zamboni generates as much as 24,000 lbs of compacted snow which is deposited in the ice rink's parking lot, eventually melting and entering the sewer system.[9]

Replacing impervious surfaces with porous asphalt enhances stormwater functions of everyday spaces.



CASE STUDY

JFK and Pratt Willert Community Centers

Regenerating neighborhood community spaces on the city's East Side

The JFK and Pratt Willert Community Centers are important community assets in the Willert Park neighborhood on the city's East Side. These neighborhood centers provide community meeting spaces, recreational facilities, services and programs to build healthy communities. The Community Action Organization (CAO), a local antipoverty agency, operates both centers and provides several health and education programs for community members. The City's Division of Parks and Recreation also offers a variety of youth athletic programs and other community services at these community centers, and works with local residents to ensure these facilities are providing services that improve quality of life for local residents.

Community Partnerships

Local residents and community groups were consulted throughout the planning and design of the project. The project team participated with neighborhood residents in walking tours to identify where green infrastructure makes sense in the context of neighborhood conditions. This process identified the JFK and Pratt Willert Community Centers as prime locations for green parking lots. The public also gave feedback in preliminary and final design updates. Buffalo Sewer commissioned the development of a youth STEM education program called Water Worx to connect youth participating in Community Action Organization (CAO) programs at both community centers with the projects.

Keeping the stormwater challenge in check with green infrastructure at JFK and Pratt Willert

3 rain gardens planted

These investments at JFK and Pratt Willert manage stormwater for 0.9 acres of the city.

14,063

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

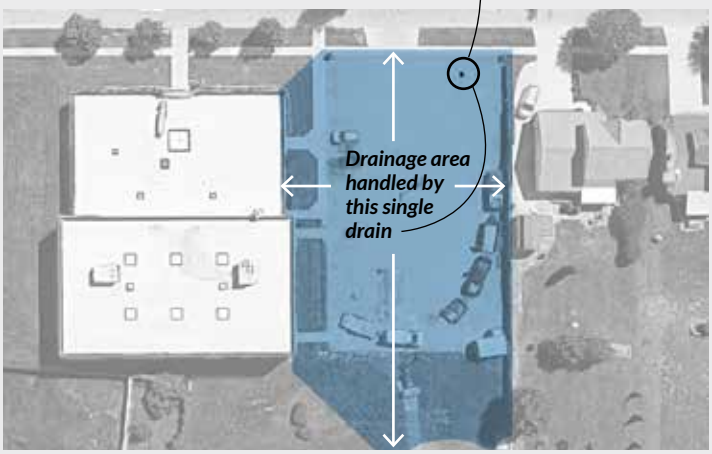
Green infrastructure at JFK and Pratt Willert Community Centers

Buffalo Sewer and City agencies recently invested in infrastructure improvements to reduce stormwater runoff from parking facilities at both of the community centers. The removal of impervious surfaces and installation of rain gardens in the parking areas at the centers redirect rain and snowmelt into the surrounding soils. These rain gardens can collectively keep over 14,000 gallons of stormwater from entering the sewer system during the typical rainfall event, while beautifying vital neighborhood spaces and educating residents on the benefits of green infrastructure.

How Pratt Willert's parking lot was turned into a green parking lot

BEFORE

Stormwater runoff for the parking lot used to flow into a single drain at the southeast edge of the parking lot and discharged directly into the combined sewer in Pratt Street.



AFTER

Stormwater runoff flows into a rain garden constructed in the corner of the existing parking lot.

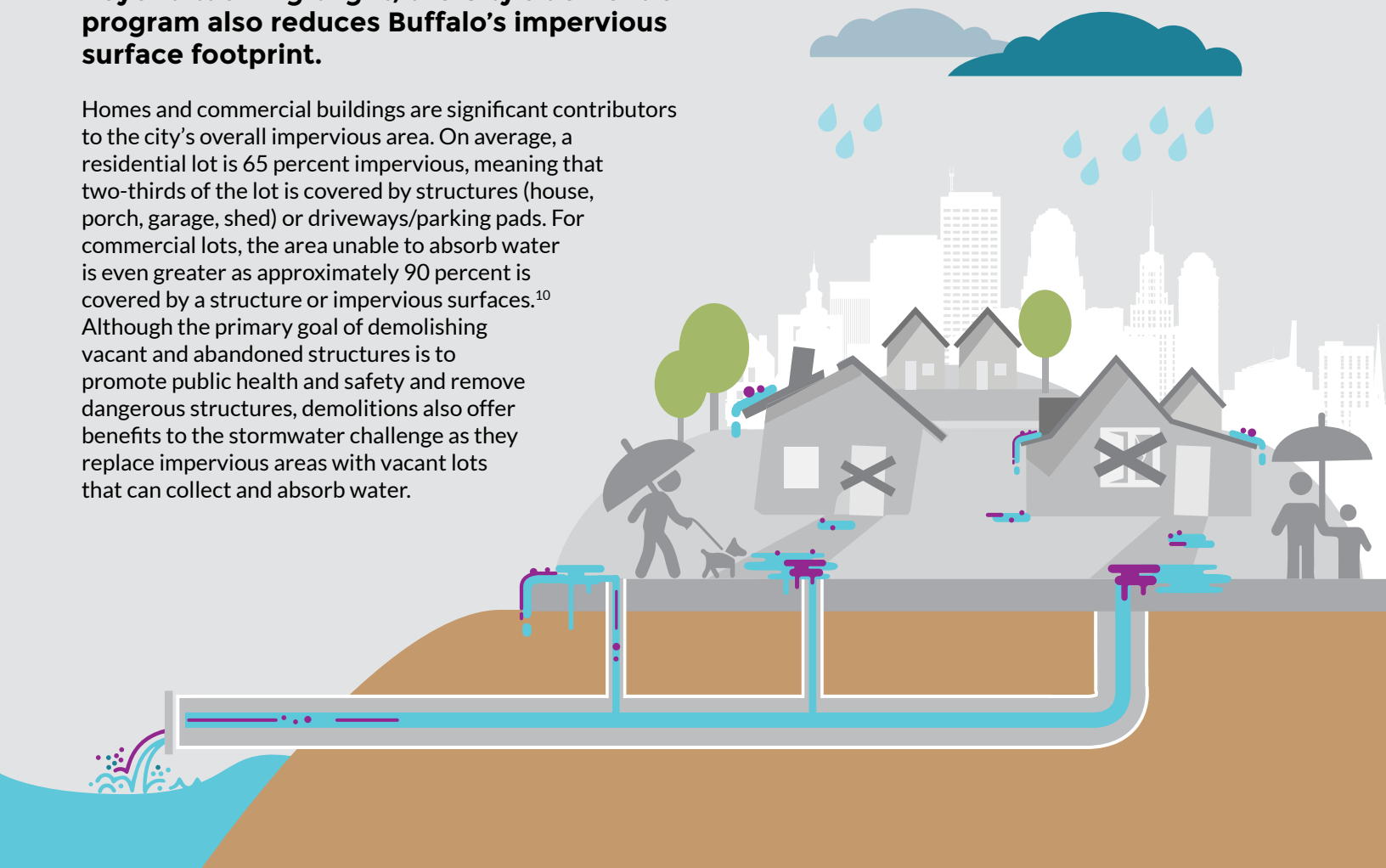
Work began with the removal of a section of existing asphalt pavement and installation of a storage basin under the rain garden to hold stormwater before slowly releasing it into soil.

Soil and plants were added to help absorb and filter rain and snowmelt from the parking lot.

Demolition of blighted structures creates vacant lots that can capture stormwater.

Beyond tackling blight, the City's demolition program also reduces Buffalo's impervious surface footprint.

Homes and commercial buildings are significant contributors to the city's overall impervious area. On average, a residential lot is 65 percent impervious, meaning that two-thirds of the lot is covered by structures (house, porch, garage, shed) or driveways/parking pads. For commercial lots, the area unable to absorb water is even greater as approximately 90 percent is covered by a structure or impervious surfaces.[10] Although the primary goal of demolishing vacant and abandoned structures is to promote public health and safety and remove dangerous structures, demolitions also offer benefits to the stormwater challenge as they replace impervious areas with vacant lots that can collect and absorb water.



Keeping the stormwater challenge in check

Green Infrastructure Approaches

Traditional demolitions

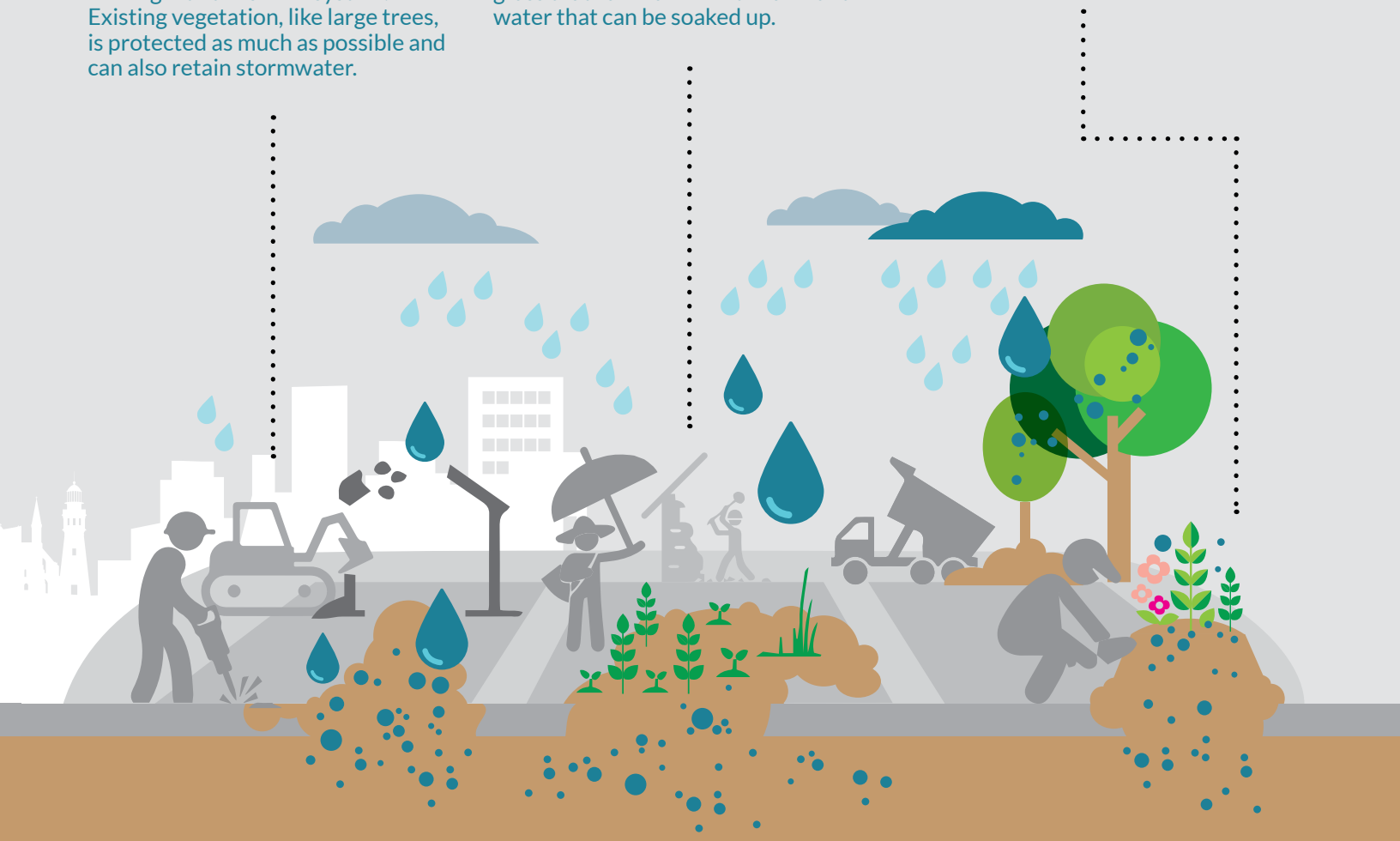
Demolition removes impervious surfaces, like roofs and driveways, from lots. This allows stormwater to soak into the ground where a building once stood rather than flowing into the sewer system. Existing vegetation, like large trees, is protected as much as possible and can also retain stormwater.

Green post-demolition treatment

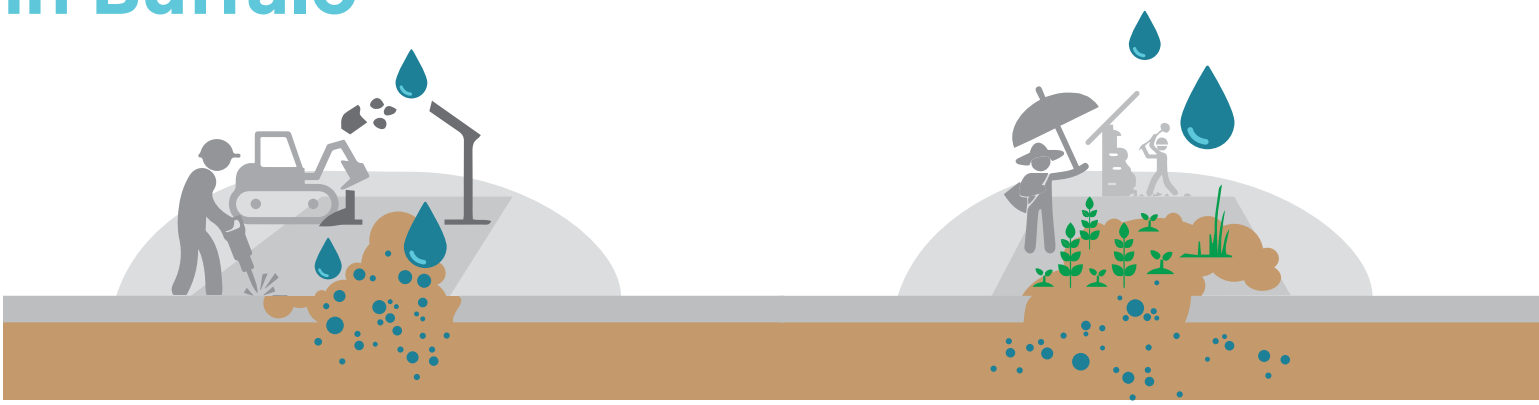
Once all structures and paved surfaces are demolished and removed from the site, 4 to 6 inches of spongy soil and seed mix can be added to encourage development of a low growing turf grass that can maximize the amount of water that can be soaked up.

Filling vacant lots with green infrastructure

Where vacant lots are permanently protected (or owned) by community members, enhanced landscape features like pollinator or community gardens can be installed.



Where demolitions and vacant lot restoration approaches work in Buffalo



Traditional demolitions

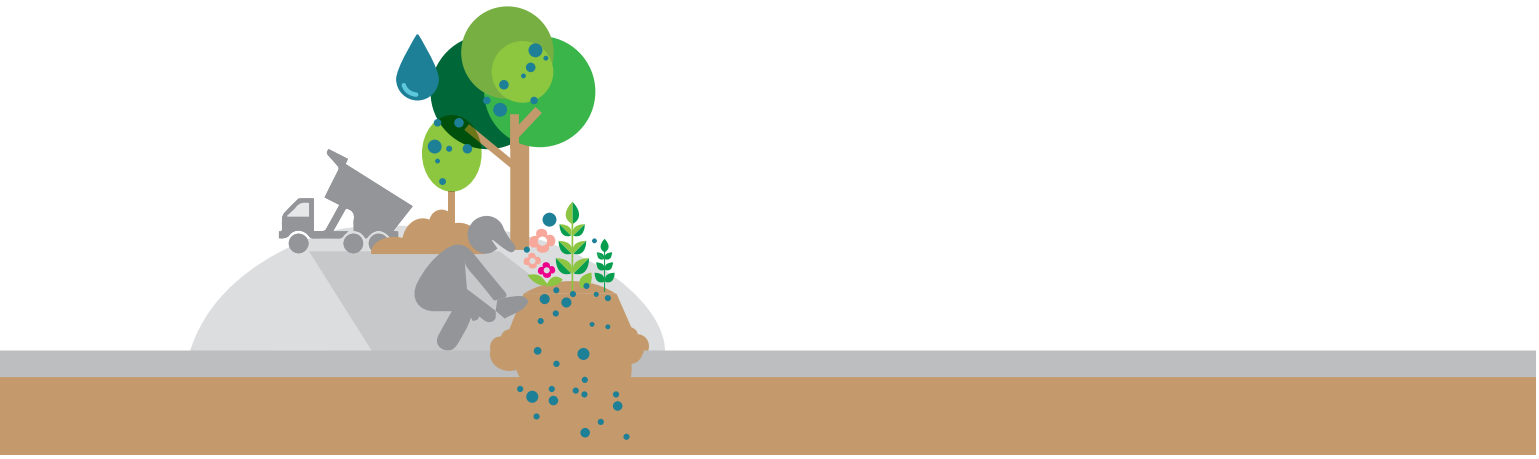
The City of Buffalo's demolition program helps stabilize and improve neighborhoods by removing unsafe, blighted and abandoned structures. Between 2001 and 2017, the City's demolition program removed over 5,900 residential structures and over 700 commercial buildings. This aggressive, multi-year approach targeted the most dangerous and deteriorated properties, many of which were vacant for more than 18 months and suffered considerable deterioration. In many cases, environmental conditions and looting of the plumbing and architectural features makes cost-effective renovation impracticable.

Demolition of vacant and dangerous structures helps improve public health, safety, and welfare. By removing impervious surfaces, demolition can also provide stormwater benefits.

Green post-demolition treatment

Green post-demolition treatment can be applied to any residential or commercial demolition once all structures and paved surfaces are demolished and removed from the site. The treatment improves surface site conditions and reduces maintenance requirements, while also improving the stormwater function of vacant lots. As a result, the treatment can enhance the potential of sites to be redeveloped into green spaces or other uses. The treatment also improves the curb appeal of vacant lots for prospective purchasers, including adjacent owners under the City's homesteading program.

A vacant lot on the city's East Side is being prepared for a green post-demolition treatment. The treatment enhances stormwater capture through seeding, grading and leveling the lot.



Filling vacant lots with green infrastructure

Introducing rain gardens, as well as other green infrastructure techniques like cisterns and bioswales, to vacant lots can add to community character and help educate neighborhood residents about the stormwater challenge. These installations are particularly suitable for vacant lots owned or managed by community members or neighborhood groups with the ability and commitment to maintain investments over time. By harvesting water that can be used to care for plants and vegetation, green infrastructure on vacant lots can also complement the use of these lots for urban agriculture or community gardens.

A vacant lot on the city's West Side is transformed into an urban farm with numerous green infrastructure that all harvest rain water for use by gardeners. Features include a green roof picnic shelter, downspout disconnections on adjacent properties, and a cistern to collect water.

A vacant lot on Chenango Street on the city's West Side is transformed with a rain garden and a permeable walking surface.

How do we benefit from **demolitions and vacant lot restoration** across Buffalo?

931 acres
managed for stormwater

628 acres
of impervious surfaces reduced

Keeping the stormwater challenge in check

City of Buffalo demolitions completed between 2001 and 2017 removed **628 acres** of impervious surface (buildings, driveways, parking areas). Altogether, the vacant lots created by these demolitions manage stormwater runoff for 931 acres of the city—about the size of 405 city blocks.

During a typical rainfall event, these lots are capable of keeping **14,650,161 gallons of water** out of our sewer system. That's enough water to fill 22 Olympic-sized swimming pools.

14,650,161

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Calculations by Buffalo Sewer. For details on methodology and assumptions, see Appendix.

Benefits beyond the stormwater challenge

Removes blight
Vacancy and abandonment is most prevalent in Buffalo's most vulnerable neighborhoods, including those with high concentrations of people in poverty. By targeting blight, demolition can increase property values in neighborhoods that have experienced sustained disinvestment.

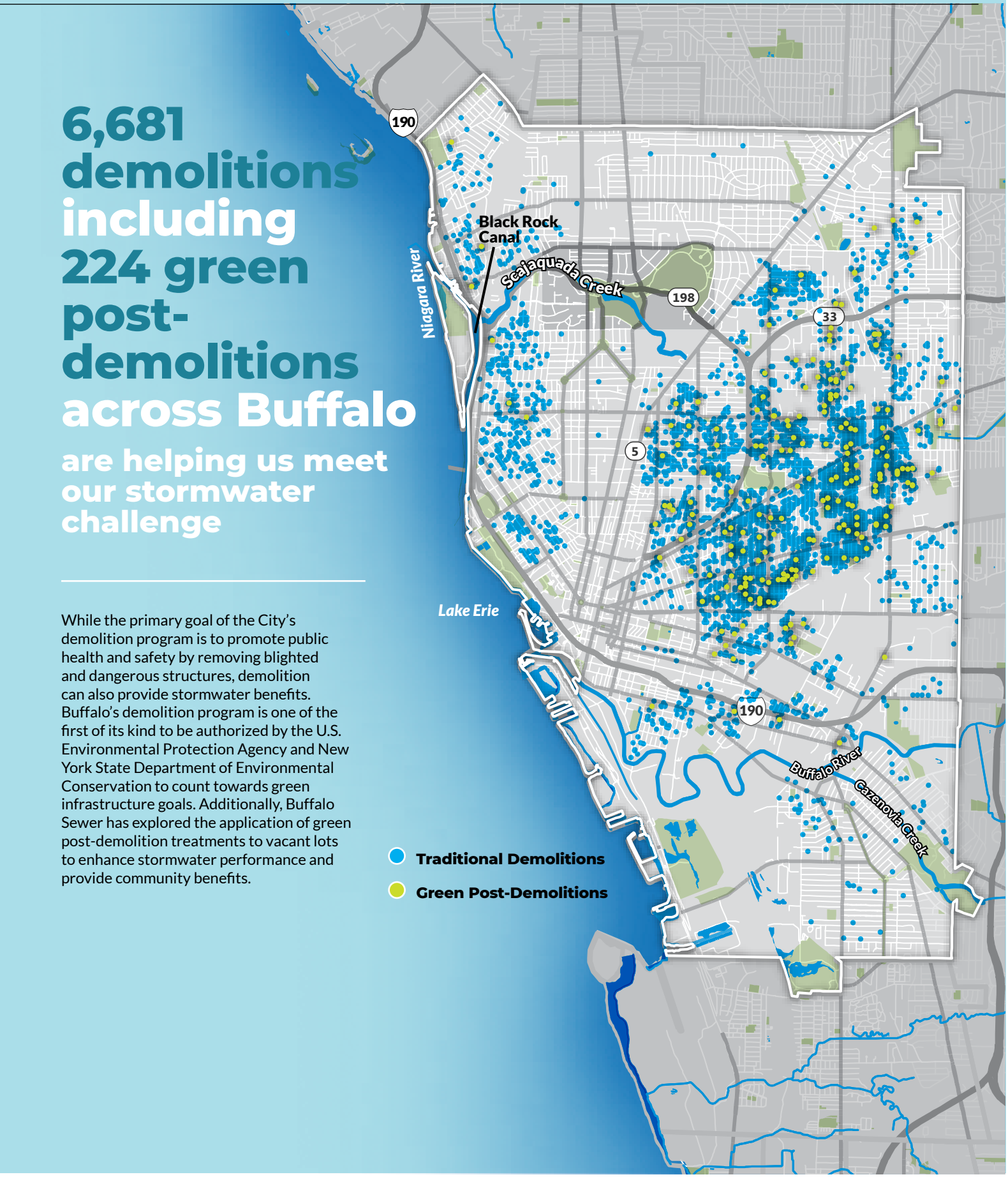
Stabilizes neighborhoods
Neighborhood blight threatens the health, safety, and economic well-being of Buffalo and its neighborhoods. It contributes to falling property values, disinvestment, and the overall destabilization of neighborhoods. Though demolition is not a cure to neighborhood blight, it can be an instrumental tool to help stabilize neighborhoods by removing problem properties that attract illegal activities, rodents, and arson.

Creates opportunities for infill development
Demolishing vacant properties opens possibilities for infill development on these sites, whether as community gardens, neighborhood green spaces, or for new residential and commercial uses. When vacant lots are seeded with low growing turf grass or enhanced with rain gardens and other green infrastructure installations, their appeal often increases to prospective purchasers, while also beautifying neighborhoods and enabling stormwater to be harvested for outdoor uses.

6,681 demolitions including 224 green post-demolitions across Buffalo

are helping us meet our stormwater challenge

While the primary goal of the City's demolition program is to promote public health and safety by removing blighted and dangerous structures, demolition can also provide stormwater benefits. Buffalo's demolition program is one of the first of its kind to be authorized by the U.S. Environmental Protection Agency and New York State Department of Environmental Conservation to count towards green infrastructure goals. Additionally, Buffalo Sewer has explored the application of green post-demolition treatments to vacant lots to enhance stormwater performance and provide community benefits.



CASE STUDY

Traditional Demolitions

Removing blight to promote public health and safety

The primary goal of the City's demolition program is to enhance public health, safety, and welfare through the removal of unsafe, blighted and dangerous structures. When a blighted structure is demolished, contractors are required to remove just about everything on the site, including foundation walls and any pavement. In addition, all utility connections, including water and sewer service, are disconnected. Existing large trees are protected through demolition as much as possible and left on site.

Although the purpose of the program is blight removal and neighborhood stabilization, it also creates stormwater benefits through impervious surface reduction.

Community Partnerships

Buffalo's blight removal strategy involves many City departments and relies on neighborhood-level insights from the community. The Department of Permit and Inspection Services leads the process and assesses which properties pose the greatest threat to health and safety. It also relies on the fire and police departments to identify problem properties; the Mayor's Office of Strategic Planning to align blight removal with neighborhood priorities; the Department of Assessment and Taxation for site acquisition; and the Division of Citizen Services to bring together all sorts of data on blight indicators through the Mayor's 311 Call and Resolution Center. Neighborhood organizations, block clubs, and other community groups all help to identify which properties threaten quality of life on residential streets.

Project Timeframe
2001-2017

Keeping the stormwater challenge in check with blight removal

5,949 blighted and unsafe residential buildings demolished

732 blighted and unsafe commercial buildings demolished

514.3 acres of impervious surfaces removed

Vacant lots created through the City's blight removal program manage stormwater for 911.0 acres of the City.

14,356,650
gallons of runoff prevented from entering the sewer system In a typical rainfall event.

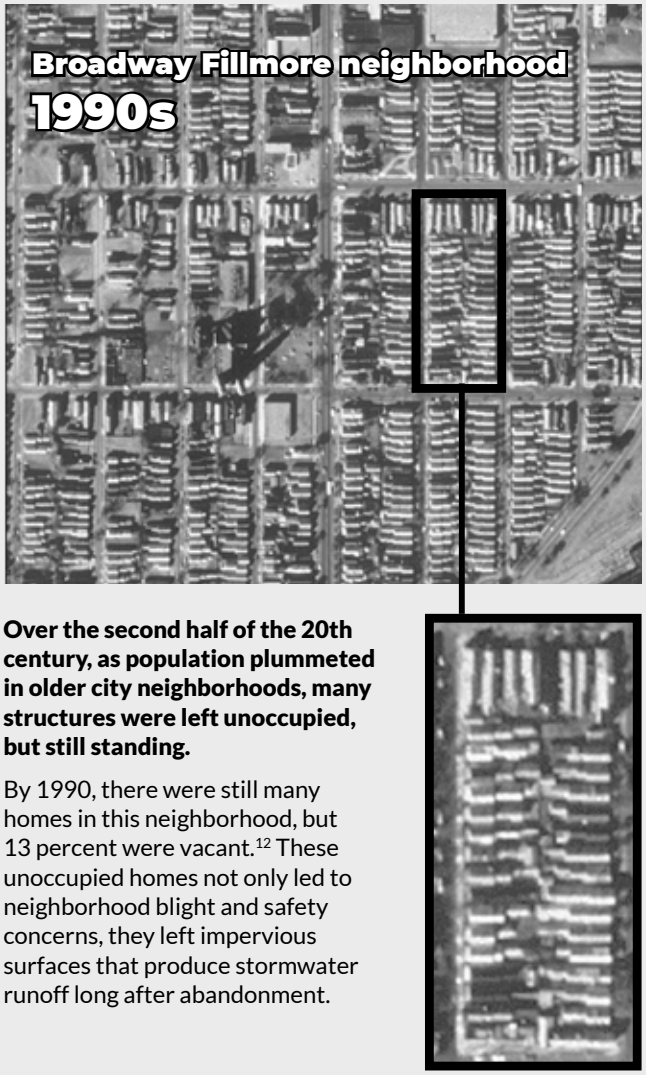
By removing the impervious surfaces on a property, rain and snowmelt can absorb into the ground instead of entering our sewer system.

Buildings, roofs, driveways and concrete entryways on a property prevent water from being absorbed into the ground where it lands.

When impervious surfaces are removed, water is absorbed into the ground where it falls.

An aerial view of blight removal in Buffalo neighborhoods

In the 1950s, industry was booming and downtown neighborhoods were thriving. Back then, the neighborhood shown below, located just west of the Central Terminal, was densely populated, with around 47 people per acre. So naturally there were a lot of homes—about 14 per acre. These homes added a lot of impervious surfaces, but 99 percent were occupied by residents.[11]



Over the second half of the 20th century, as population plummeted in older city neighborhoods, many structures were left unoccupied, but still standing.

By 1990, there were still many homes in this neighborhood, but 13 percent were vacant.[12] These unoccupied homes not only led to neighborhood blight and safety concerns, they left impervious surfaces that produce stormwater runoff long after abandonment.

Since 2001, the city's blight removal program removed over 5,900 abandoned homes and over 700 commercial buildings, targeting structures that pose the greatest threat to health and safety.

These demolitions also converted large areas of unused impervious surfaces to vacant lots that absorb stormwater. Neighborhoods like this are not as densely populated as they once were, but now they have far fewer blighted structures, and more open spaces to keep stormwater in check.

Source: Density of population and homes, and residential vacancy rates from U.S. Census Bureau (1950 and 1990). Aerial imagery from U.S. Geological Survey (1995); and U.S. Department of Agriculture (2017). See Endnotes for more information.[13]

CASE STUDY

Green Post-Demolition Initiative

Greening vacant lots after demolition to maximize stormwater capture

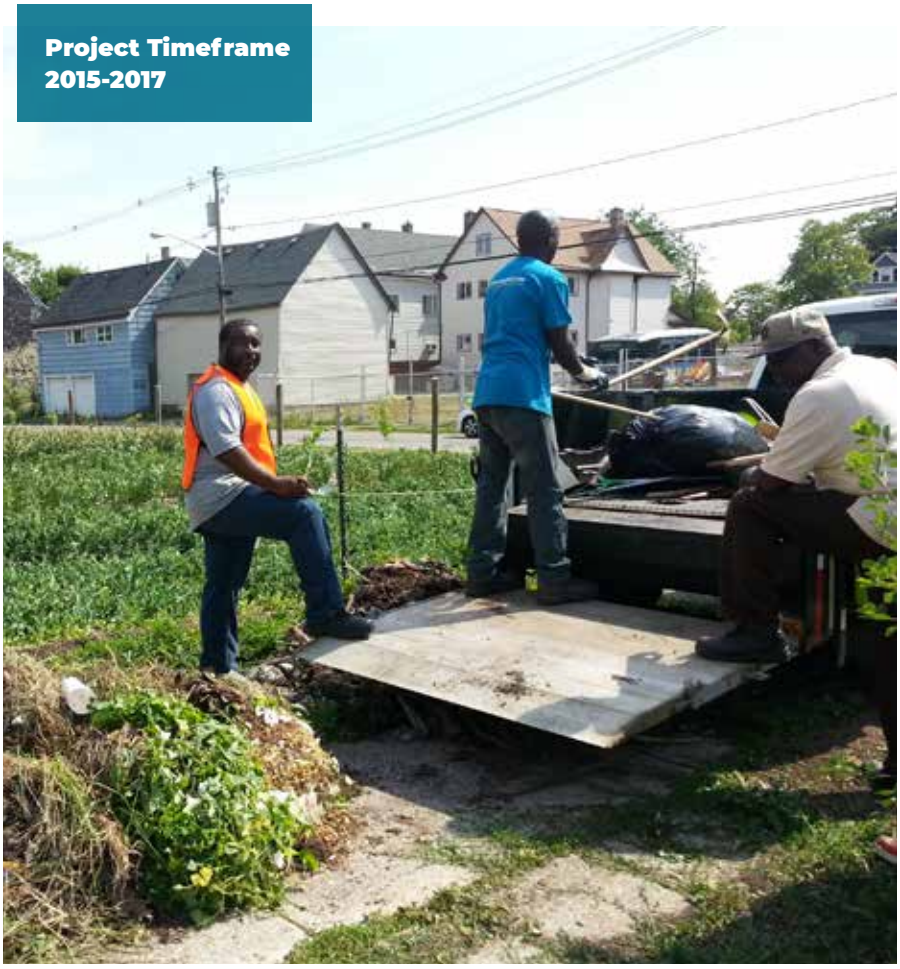
Buffalo's large-scale, multi-year demolition program targets the most dangerous properties in neighborhoods across Buffalo for removal of all structures, including properties damaged by fire emergencies and those that have suffered from long-term vacancy and abandonment. Demolition of blighted structures improves public safety and contributes to neighborhood revitalization. There is also potential for demolition to contribute to stormwater management. Through consultation and collaboration with local and national partners, Buffalo Sewer studied how landscape treatments on City-funded demolition sites can maximize the capacity of these spaces to capture and absorb water.

Community Partnerships

BUFFALO SEWER PROJECT

The green post-demolition study was made possible through a Buffalo Sewer partnerships with the Mayor's Office of Strategic Planning, Department of Permit and Inspection Services, and the Department of Public Works, Parks & Streets, with funding support from the NYS Environmental Facilities Corporation and consultant support from Arcadis and Buffalo Neighborhood Stabilization Corporation (BNSC). The initiative put 53 people to work to carry out the green post-demolition treatment, including on-site training, and most of these workers (64 percent) were from the city, while over half were people of color.

Project Timeframe
2015-2017



Keeping the stormwater challenge in check with green post-demolitions

224 post-demolition sites with green treatments

13.3 acres of impervious surfaces removed

These investments on green post-demolitions manage stormwater for 20.4 acres of the City.

293,511

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Step-by-Step Process of a Green Post-Demolition

Green infrastructure with Green Post-Demolitions

While traditional demolitions provide stormwater benefits through impervious surface reduction, Buffalo Sewer has also explored the application of landscaping treatments to vacant lots created by demolition to enhance stormwater performance.

The green post-demolition treatment on select City-funded demolition sites was well-received by both partner City agencies and community members. The green post-demolition treatment to newly vacant lots in neighborhoods across Buffalo offers a number of benefits, including: reducing impressions of abandonment; reducing the need for site amendments for community gardening projects; and improving curb appeal for prospective buyers. Overall, green post-demolition treatments can enhance the ability of vacant lots to meet stormwater management goals and provide community benefits.

After the demolition work is complete, workers remove any remaining debris from the site.

The site is filled with a “stormwater” mix of compost and topsoil.

The lot is graded to minimize stormwater runoff from the site.

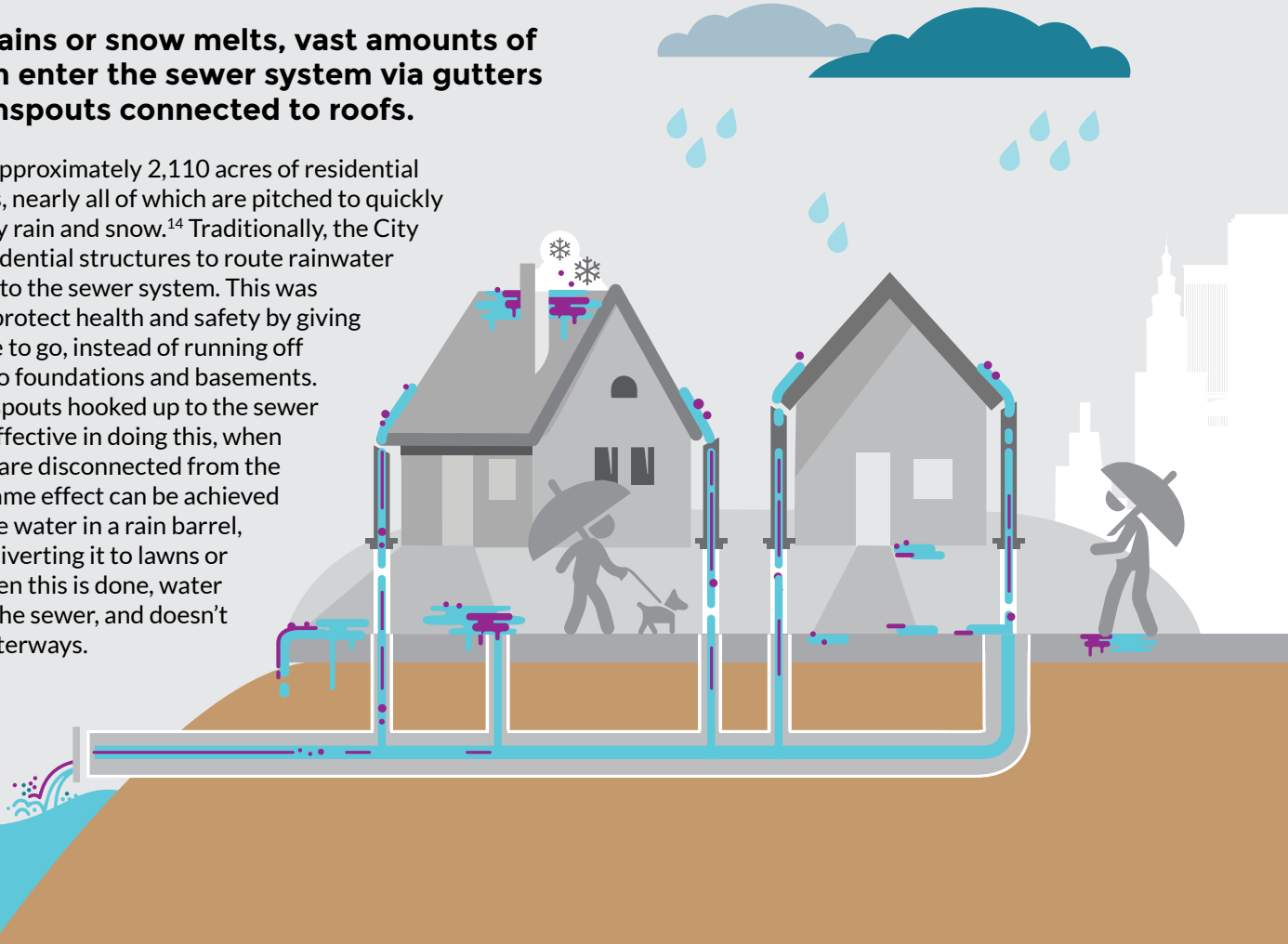
The lot is seeded with a “low growing turf” seed mixture for minimal maintenance.

Ready for the stormwater challenge!

Rain barrels and downspout disconnections engage residents and businesses to keep roof rain and snowmelt out of the sewer system.

When it rains or snow melts, vast amounts of water can enter the sewer system via gutters and downspouts connected to roofs.

Buffalo has approximately 2,110 acres of residential roof surfaces, nearly all of which are pitched to quickly release heavy rain and snow.[14] Traditionally, the City required residential structures to route rainwater from roofs into the sewer system. This was designed to protect health and safety by giving water a place to go, instead of running off roofs and into foundations and basements. While downspouts hooked up to the sewer system are effective in doing this, when downspouts are disconnected from the sewer, this same effect can be achieved by storing the water in a rain barrel, or properly diverting it to lawns or gardens. When this is done, water stays out of the sewer, and doesn't harm our waterways.



Keeping the stormwater challenge in check

Green Infrastructure Approaches

Downspout Disconnections

Downspout disconnections redirect water that would otherwise flow into the sewer system into alternative water collection systems, like lawns, flower beds, or specially designed infiltration systems and rain gardens.

Rain Barrels

Rain barrels capture and store stormwater runoff to be used for outdoor household needs. Though not safe for drinking, this water can be used for other activities that would normally require using the tap, like watering plants or washing cars.

Where rain barrels and downspout disconnections work in Buffalo

Downspout Disconnections

Some residents don't want to deal with a rain barrel, or a rain barrel's placement may interfere with their driveway. In these instances, a downspout disconnection may work better. This may be especially true in older parts of the city where driveways were originally designed for horse and carriage and are narrower, and closer to home foundations.

An example of a downspout disconnection at a private residence in Buffalo. When a downspout is disconnected from the standpipe, it is redirected so that stormwater drains to a yard or landscape.

At this home in the Elmwood Village, a downspout has been disconnected and directed into a front lawn rain garden that provides a unique landscape that contributes to the home's curb appeal.

Rain Barrels

Rain barrels work for most Buffalo houses, but are a best fit when the resident is committed to regularly using the rain barrel as a water resource for gardening or other non-drinking water needs. Rain barrels may also be more preferable for homes on slightly wider lots so they are not as likely to interfere with driveways or neighboring homes.

Mayor Byron W. Brown and local stakeholders from government, non-profit and philanthropic sectors gather to celebrate the launch of the City's Rain Check downspout disconnect and rain barrel installation program in 2015.

A rain barrel installed at a home in Masten Park provides a free water source for gardening and watering plants.

How do we benefit from using rain barrels across Buffalo?

7.4 acres
of rooftops managed for stormwater

Keeping the stormwater challenge in check

Though controlling roof runoff with rain barrels doesn't remove any impervious areas, the 1,018 rain barrels installed in 2015 and 2016 approximately manage roof area equivalent to **7.4 acres**—an area bigger than 3 city blocks.

During a typical rainfall event, these investments have the capacity to keep **172,920 gallons of water** out of our sewer system. That's enough water to take over 10,000 showers.

172,920

gallons of runoff prevented from entering the sewer system in a typical rainfall event.

Calculations by Buffalo Sewer. For details on methodology and assumptions, see Appendix.

Benefits beyond the stormwater challenge

Promotes awareness
Rain barrels and other roof runoff interventions can empower residents and businesses to take an active role in solving a critical community-wide challenge. They help educate Buffalonians about the stormwater challenge, the importance of using water wisely, and ways we can all contribute to healthy waterways.

Saves money on water bills
For individual home or business owners, using roof water more wisely can save money on water bills and ease reliance on the city's water supply. According to the Environmental Protection Agency, garden and lawn irrigation accounts for 30 percent of residential water use during the summer.[15] Instead of drawing water from the tap, rain barrels allow residents to use captured rainwater to irrigate lawns, gardens, and plants or to wash their cars.

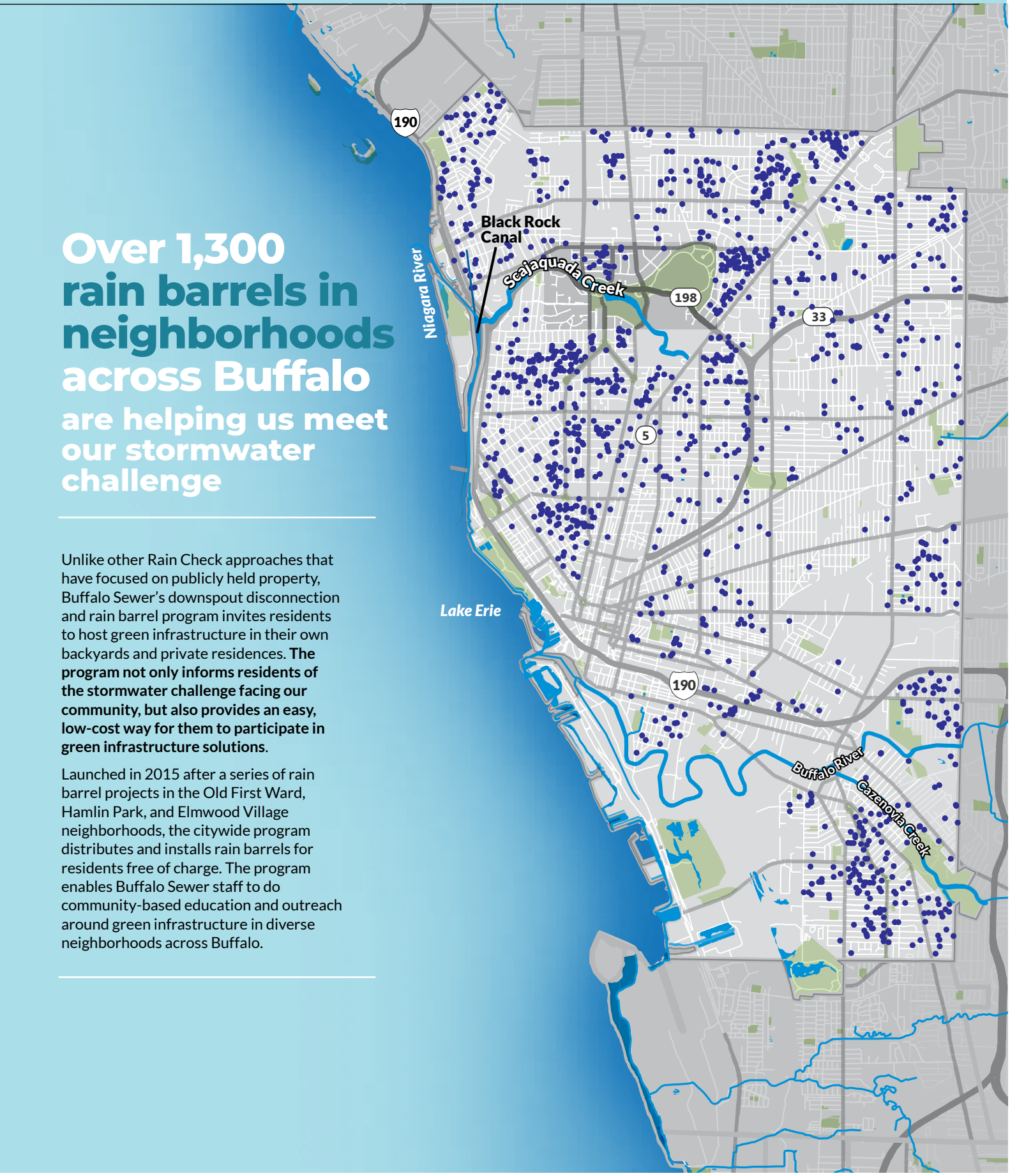
Protects homes
In some cases where residential sewer pipes are compromised, rain barrels and downspout disconnections can help keep water away from foundations or basements.

Over 1,300 rain barrels in neighborhoods across Buffalo

are helping us meet our stormwater challenge

Unlike other Rain Check approaches that have focused on publicly held property, Buffalo Sewer's downspout disconnection and rain barrel program invites residents to host green infrastructure in their own backyards and private residences. **The program not only informs residents of the stormwater challenge facing our community, but also provides an easy, low-cost way for them to participate in green infrastructure solutions**.

Launched in 2015 after a series of rain barrel projects in the Old First Ward, Hamlin Park, and Elmwood Village neighborhoods, the citywide program distributes and installs rain barrels for residents free of charge. The program enables Buffalo Sewer staff to do community-based education and outreach around green infrastructure in diverse neighborhoods across Buffalo.

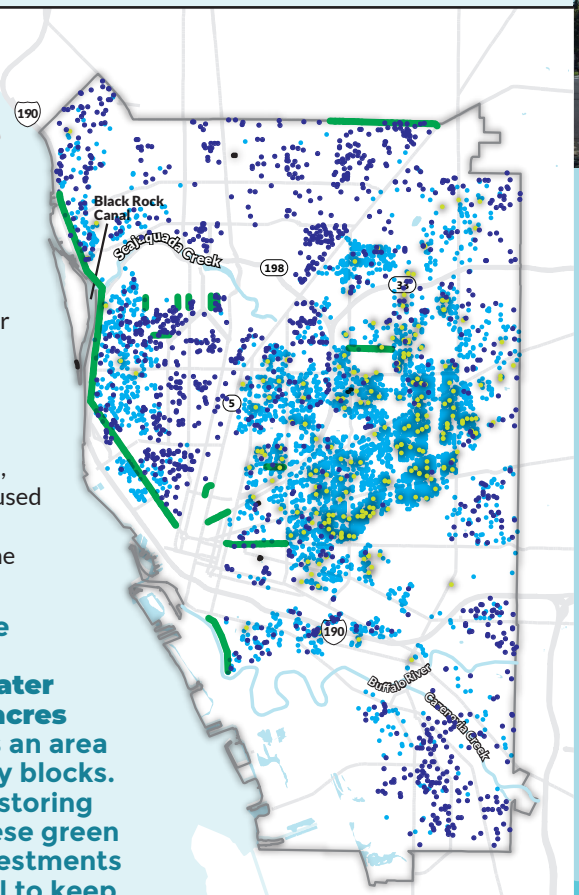


RAINCHECK in neighborhoods across Buffalo

Buffalo's first generation of green infrastructure investments concentrated on tackling the parts of our built environment that create the most runoff from stormwater – streets, parking lots, and roofs. With the exception of the rain barrel and downspout disconnection program, this work has been focused on infrastructure or properties owned by the City of Buffalo.

Collectively, these investments can manage stormwater runoff for 1,047 acres of the city. That's an area the size of 455 city blocks. By capturing and storing water on-site, these green infrastructure investments have the potential to keep nearly 1 billion gallons of water from entering the underground sewer system during a typical year.

At the end of the day, these investments are helping to solve the stormwater challenge by reducing the frequency and impact of sewer overflows into our local waterways.



Keeping the stormwater challenge in check with green infrastructure investments

1,047 acres
managed for stormwater

649 acres
of impervious surfaces reduced

952,449,460

gallons of runoff prevented from entering the sewer system in a typical year.

Calculations by Buffalo Sewer. For details on methodology and assumptions, see Appendix.




9 miles of green streets

(that's longer than Main Street from Canalside to UB South Campus)

9 miles


1,310 rain barrels
with a capacity of storing
132 gallons
of stormwater at one time.

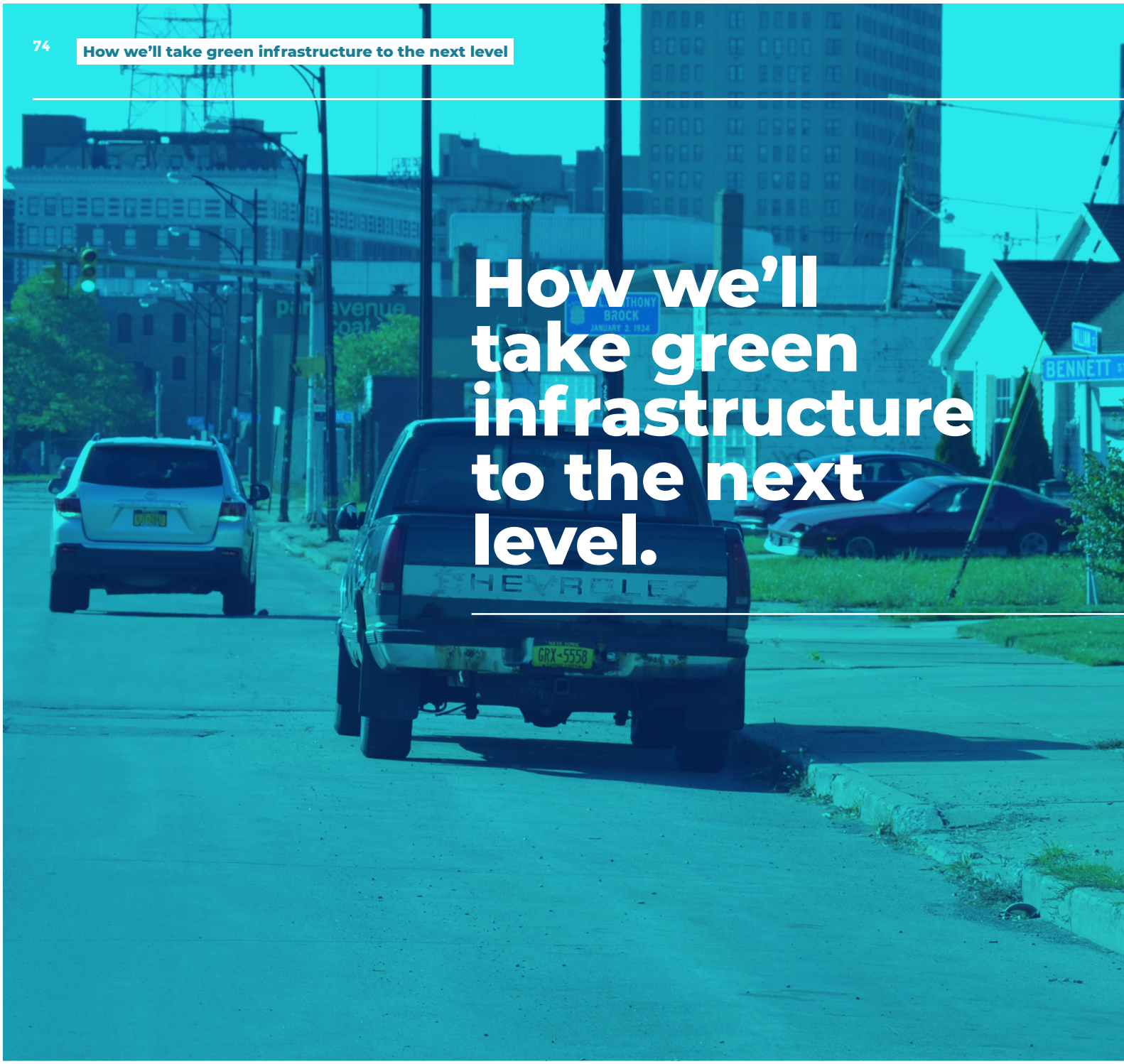




5,949 residential demolitions

732 commercial demolitions

224 green post-demolitions

How we'll take green infrastructure to the next level.

RAINCHECK 2.0

Buffalo is ready for the next chapter of green infrastructure. Through the first several years of the Rain Check program, we have learned a great deal about what works, where we can do better, and how we can maximize the impact of our investments. As we look to scale up and expand the types of projects we take on, Buffalo Sewer will continue to make community engagement and education a priority and find new partnerships to tackle collaborative projects across the city. Together, we will create solutions to the stormwater challenge and contribute to building a better Buffalo for all.

pg. 78

Continue to raise the bar in how we engage communities

pg. 80

Expand partnerships to grow opportunities and impact

pg. 82

Take Green Infrastructure projects to the next level

Continue to raise the bar in how we engage communities.

Expand the communication and education toolbox for scaling up green infrastructure and community engagement.

Through the initial phase of Rain Check, Buffalo Sewer has seen first hand how effective communication tools can broaden the table for participation in shaping green infrastructure investments. As the program scales up, it will be critical to develop a robust set of engagement tools that allow Buffalo Sewer and its partners to engage diverse communities on the web and in-person. This includes an expanded website with easy-to-understand educational materials, as well as interactive content that can be used at the meetings of block clubs, community organizations, and public meetings.

Create opportunities for the community to "see and touch" green infrastructure.

People commonly say a picture is worth a thousand words. But sometimes, a picture just isn't enough. Offering opportunities for residents, business owners, and community stakeholders to see what a project looks like can help people understand how it will appear at early stages of growth/installation and at maturity during both the growing season and in winter. Drawing on its existing portfolio of projects, Buffalo Sewer will develop ways to connect residents with green infrastructure projects, through signage at high profile project sites, an online map that can support self-facilitated guided tours, and by exploring ways to let residents "try on" a project concept by creating temporary installations through the concept of "tactical urbanism."

Tailor engagement approaches to meet the needs of diverse communities.

Buffalo is made up of many different neighborhoods shaped by diverse cultures and histories. Engagement approaches must respect this diversity and find ways to make complex concepts relatable to people who may have varying prior knowledge of green infrastructure and why it is important. In engaging diverse communities, Buffalo Sewer will work to present materials in several different formats to allow for different types of learners and tailor materials to reflect the specific population, languages, buildings, institutions, landscapes and climate of the project location.

Engage individual property owners to gain support and willingness to pitch in with maintenance.

Property owners play an important role in making green infrastructure a success, as they can act as stewards to maintain installations on or adjacent to their property. Based on the initial round of green infrastructure projects, Buffalo Sewer has found that some property owners embrace, or at least are OK with, taking on maintenance, while others are resistant or are less likely to be committed to maintaining green infrastructure over the long-term. As Buffalo Sewer broadens its range of projects and the areas of the city it is installing green infrastructure, it will need to continue to find smarter and predictable ways of bringing individual property owners into the process early, and secure their support and commitment over the long run.

Leverage green infrastructure as a visioning tool that can help shape the future of communities.

Green infrastructure can be a tool to shape the physical environment residents and stakeholders envision for their community. Plant selection and landscape can help punctuate and reinforce the identity of an area. Differing approaches help create a sense of activity in a mixed use, neighborhood commercial district, slow down and quiet traffic in a residential space, or create a sense of formality in a central business district. This is particularly valuable in areas that are transitioning from high vacancy levels or one use to a new development vision. Some of Rain Check's most successful projects, like the William Street and Niagara Street green street projects, positioned green infrastructure as a tool in a broader visioning process. As Buffalo Sewer moves to expand its portfolio of projects, it will seek to continue to do this in creative ways.

Build "Champions" for green infrastructure in neighborhoods across the city.

Neighborhood-level stakeholders play an important role in connecting community members to public engagement processes, while opening doors to a range of audiences — property owners, tenants, customers, community institutions and their members, neighborhood or block clubs and business organizations, real estate professionals, and/or regional, issue-focused organizations. Engagement of stakeholder organizations can change dramatically over time as membership and leadership changes. Engaging multiple representatives and/or members directly helps to ensure designs are responsive to a wide range of stakeholders and are resilient to turnover.

Expand partnerships to grow opportunities and impact.

Ramp-up engagement with developers, businesses, institutions, and large property owners to meet green infrastructure goals through private sector projects.

Development regulations require that projects account for stormwater management in new developments. However, there currently is not a targeted financial incentive program for developers to install and commit to maintaining green infrastructure on private properties. More than two-thirds of the city's land area is privately owned, so this offers a unique opportunity that builds on models developed elsewhere, like the Onondaga County's Green Improvement Fund (GIF), which provides grant funding for green infrastructure and related investments in the Syracuse area.[16] Buffalo Sewer will perform outreach and engagement with the development community, churches, and large property owners to study how a program like this could work in Buffalo.

Work more closely with government partners outside of City Hall – Buffalo Public Schools, Erie County, SUNY, and more.

Beyond private development, other public sector and nonprofit entities – Buffalo Public Schools, Erie County, local colleges and universities, hospitals, etc. – are significant property owners in Buffalo and have facilities that include large areas of impervious surfaces (like parking lots). Building partnerships with governmental agencies and anchor institutions outside of City of Buffalo government can open opportunities for further expansion of Buffalo's green infrastructure. To that end, Buffalo Sewer will lead a stakeholder engagement process in 2018 that will explore barriers and opportunities of integrating green infrastructure on public facilities outside of the City of Buffalo's ownership.

Build multi-sector project teams representative of Buffalo and its neighborhoods.

As green infrastructure projects evolve to include landscape installations and/or multiple maintenance partners, Buffalo Sewer will continue to work with design and engineering teams that offer diverse capacities and approaches. This includes ensuring teams have landscape architects and experienced public engagement specialists to balance community needs and environmental performance goals. Teams may also incorporate expertise from ecologists, horticulturists, computer mapping (GIS) experts, and more.

Equally important, Buffalo Sewer is committed to working with project teams that reflect the diversity of our community in terms of race and gender. Buffalo Sewer already incorporates goals for women- and minority-owned business participation. As we take on the next phase of green infrastructure projects, Buffalo Sewer will continue to make inclusivity and diversity a priority in the types of firms and agencies it engages.

Grow the workforce development pipeline for green infrastructure.

Because green infrastructure draws on a wide range of skillsets for the planning, design, engineering, construction, and maintenance of projects, it requires a range of jobs involving varying levels of skill, experience, education, and credentials. As we look to scale up green infrastructure in Buffalo, there is a tremendous workforce development opportunity with the potential to spread opportunity across the city, including to low-income and unemployed residents. This can happen through training or re-training residents in the design, construction, and maintenance of green infrastructure. It can also involve partnering with the Buffalo Public Schools and local colleges and universities to integrate green infrastructure into curriculum and internship opportunities.

Take Green Infrastructure projects to the next level.

Focus investments in geographic priority areas where projects can have the greatest impact on meeting the stormwater challenge.

Based on modeling and analysis of the frequency, intensity and location of sewer overflows into our waterbodies, Buffalo Sewer has identified six "Combined Sewer Overflow Priority areas" where it seeks to concentrate green infrastructure installations in the coming years. This will allow Buffalo Sewer to make the greatest impact on the stormwater challenge and protect the health of our waterways.

Analyze and evaluate the full range of opportunities for green infrastructure projects in priority areas.

Now that Buffalo Sewer knows where green infrastructure can have the greatest impact, it needs a comprehensive understanding of the types of projects that work with the unique characteristics of these places. Working with a consultant team, Buffalo Sewer will conduct detailed mapping, stakeholder engagement, site visits, and best practice analysis of the types of projects that fit well in these target areas. This detailed analysis will identify where new forms of green infrastructure will have the greatest impact, what it could look like, and what it would take to implement targeted opportunities.

Explore potential for leveraging targeted tree plantings to meet green infrastructure goals.

Each medium-sized tree has the potential to intercept over a thousand gallons of stormwater each year, serving as low-cost options for advancing green infrastructure goals. Though street trees have been integrated as green infrastructure elements in various green streets projects, Buffalo Sewer will explore scaling up and expanding tree plantings, on both public and private lands, as a comprehensive, targeted approach to meeting green infrastructure goals.

Operationalize equity and opportunity into Buffalo Sewer decision-making to maximize benefits to diverse communities.

Equity refers to just and fair inclusion—a condition in which everyone has an opportunity to participate and prosper. Our stormwater challenge affects all of our communities, but it is also important to recognize that some communities—such as lower-income people, communities of color, and immigrants and refugees—face historic or contemporary barriers to economic and social opportunities and a healthy environment. Green infrastructure solutions to our stormwater challenge offer opportunities to create a more equitable water future in Buffalo by changing how diverse communities connect to and benefit from our city's water resources and environment, and how they are engaged through decision-making processes around public infrastructure investments. As we design, fund, construct, and maintain green infrastructure projects, priority and attention should be given to people, places, processes, and projects that: (1) ensure all people in our community have access to clean, safe, and affordable water services, (2) maximize community and economic benefits of infrastructure investments, and (3) foster community resilience in the face of a changing climate.

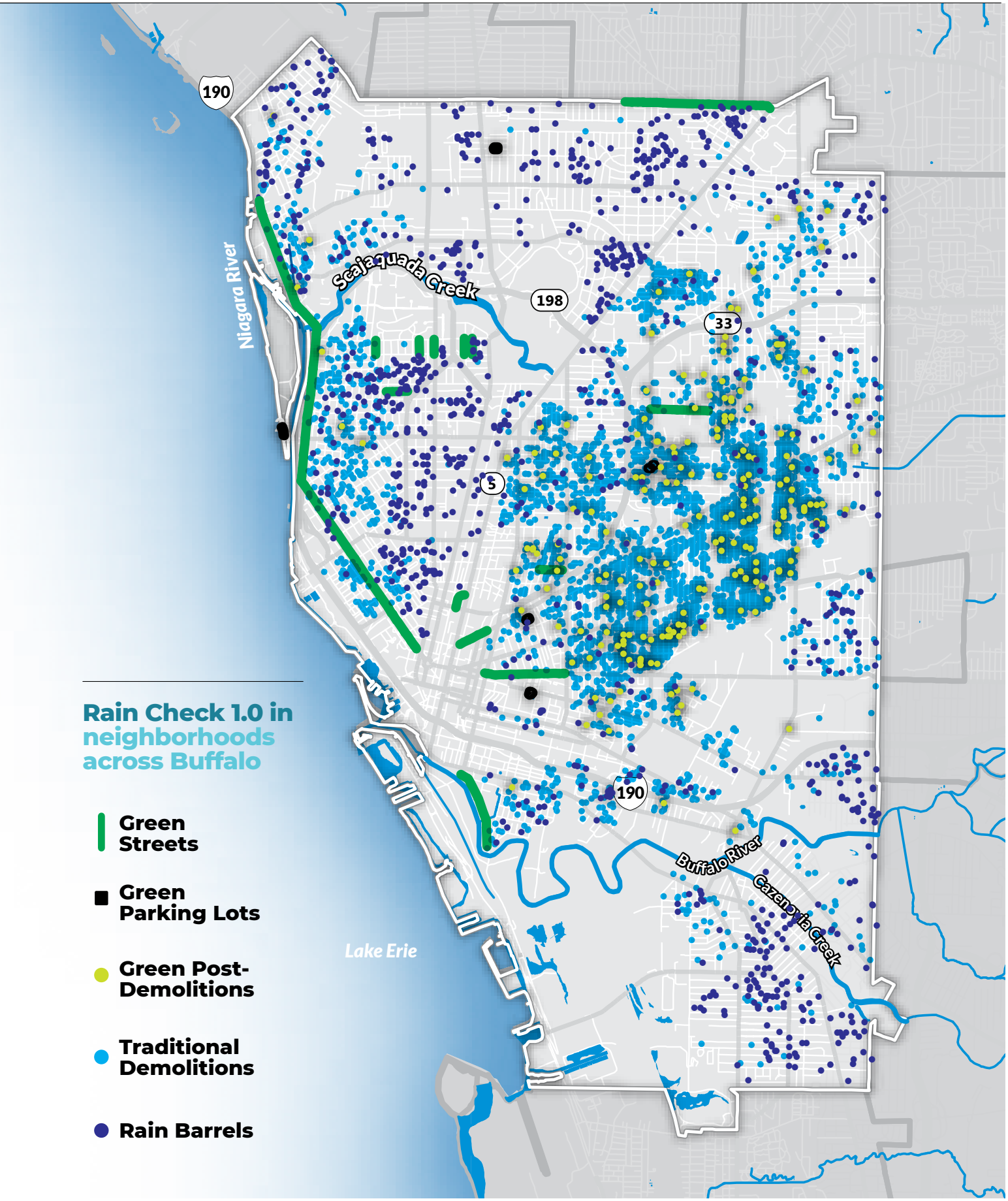
Advancing equitable outcomes across Buffalo neighborhoods has been an important priority of green infrastructure projects to date. As Buffalo Sewer enters this next phase of green infrastructure planning and implementation, it will explore ways to maximize the impact our work has on disadvantaged neighborhoods. This will include integrating equity analysis in its planning for the next generation of Rain Check projects, as well as exploration of developing assessment tools that can evaluate the impact that projects may have on advancing opportunities for people of color and other marginalized groups.

Appendix

Rain Check 1.0 Projects

		ESTIMATED TOTAL AREA MANAGED (acres)	ESTIMATED IMPERVIOUS AREA REDUCED (acres)	IN A TYPICAL RAINFALL EVENT: ESTIMATED CHANGE IN RUNOFF (gallons) IN A TYPICAL (.9") RAINFALL EVENT	ANNUALLY: ESTIMATED CHANGE IN RUNOFF (gallons) DURING A TYPICAL YEAR
Green Streets	**TOTAL**	**101.5**	**18.4**	**1,908,045**	**60,777,929**
	Ardmore Place	1.4	0.7	11,973	646,684
	Carlton Street	5.9	0.9	199,550	5,607,301
	Claremont Avenue	1.3	1.3	136,894	1,235,507
	Clarendon Place	1.6	0.2	159,335	1,520,624
	Elmwood Avenue	1.6	1.6	3,838	197,681
	Genesee Street	2.5	0.0	59,762	2,347,463
	Kenmore Avenue	5.2	0.5	188,285	4,913,516
	Niagara Street	30.9	2.1	612,934	29,376,956
	Northland Avenue	8.8	0.5	144,464	8,364,143
	Ohio Street	12.7	3.2	70,824	3,060,256
	Parkdale Avenue	1.0	1.0	12,433	950,390
	Pearl Street	1.1	0.3	3,999	276,472
	William Street	25.2	1.3	284,357	23,949,82
	Windsor Avenue	2.4	1.8	19,397	2,280,936
Green Parking Lots	**TOTAL**	**6.8**	**2.7**	**257,083**	**6,471,632**
	1384 Fillmore Avenue	0.4	0.4	2,910	392,723
	1401 Fillmore Avenue	0.5	0.5	3,576	520,358
	Broderick Park	4.3	1.0	124,326	4,048,661
	JFK Community Center	0.5	0.0	8,079	456,187
	North Buffalo Ice Rink	0.7	0.7	112,208	654,539
	Pratt Willert Community Center	0.4	0.0	5,984	399,164
Demolitions and Vacant Lot Restoration	**TOTAL**	**931.4**	**627.6**	**14,650,161**	**885,199,899**
	Green Post-Demolitions	20.4	13.3	293,511	19,433,575
	Traditional Demolitions	911.0	514.3	14,356,650	865,766,324
Rain Barrels and Downspout Disconnections	**TOTAL**	**7.4**	**N/A**	**172,920**	**7,061,398**
TOTAL		**1,047.1 acres**	**648.7 acres**	**16,988,207 gallons**	**952,449,460 gallons**

Calculations by Buffalo Sewer. For details on methodology and assumptions, see page 92.


Rain Check 1.0 in neighborhoods across Buffalo
Green Streets
Green Parking Lots
Green Post-Demolitions
Traditional Demolitions
Rain Barrels
Niagara River
Scajaquada Creek
Lake Erie
Buffalo River
Cazenovia Creek
190
198
33
5
190

Raincheck Glossary

Bump Out

Also known as a curb extension; a technique used to calm traffic and reduce pedestrian crossing distances by extending the sidewalk into the parking lane to narrow the roadway and provide additional pedestrian space at key crossing locations such as corners and mid-block. Curb extensions can often be lengthened to create public spaces, landscaped areas, or transit waiting areas.

Combined Sewer Overflow (CSO)

Buffalo has a combined sewer system that collects stormwater runoff in the same set of pipes as domestic sewage and industrial wastewater, and transports the water to a treatment facility where it is treated and then discharged to a water body. During heavy rains or snowmelt, the volume of water can exceed the capacity of the sewer system or treatment plant, and the system is designed to overflow and discharge excess wastewater directly to nearby water bodies.

Demolitions and Vacant Lot Restoration

Demolitions remove buildings and pavement from sites to protect public safety. Buffalo Sewer helped test new ways to maximize the amount of water that vacant lots capture when it rains or snows and worked with community partners to introduce rain gardens and landscaping to vacant lots that help contribute to community character.

Downspout Disconnections

Downspout disconnections redirect water from roofs that would otherwise flow into the sewer system into alternative water collection systems, like lawns, flower beds, or specially designed infiltration systems and rain gardens.

Equity

Equity refers to just and fair inclusion—a condition in which everyone has an opportunity to participate and prosper. Our stormwater challenge affects all of our communities, but it is also important to recognize that some communities—such as lower-income people, communities of color, and immigrants and refugees—face historic or contemporary barriers to economic and social opportunities and a healthy environment. Green infrastructure solutions to our stormwater challenge offer opportunities to create a more equitable water future in Buffalo by changing how diverse communities connect to and benefit from our city's water resources and environment, and how they are engaged through decision-making processes around public infrastructure investments. As we design, fund, construct, and maintain green infrastructure projects, priority and attention should be given to people, places, processes, and projects that: (1) ensure all people in our community have access to clean, safe, and affordable water services, (2) maximize community and economic benefits of infrastructure investments, and (3) foster community resilience in the face of a changing climate.

Gray Infrastructure

Gray infrastructure includes the pipes, pumps, tanks, and structures such as sewerage mains, tunnels, and wastewater treatment facilities engineered by people to collect, convey, and treat wastewater and stormwater. These traditional stormwater management solutions are commonly referred to as "gray" because they are often made of concrete and steel.

Green Infrastructure

Green infrastructure aims at treating rain and snowmelt at the source. Green infrastructure allows water to be reintroduced into the water cycle where it falls and melts, reducing the volume of stormwater entering drains and providing the community with other benefits, such as greener, healthier environments and safer neighborhoods.

Green Parking Lots

Green parking lots use special surfaces and landscaping that can capture and absorb water. This process also helps keep pollutants associated with cars and road maintenance, like road salt, grit, car oil, and asphalt sealant, out of the sewer system and our waterways.

Green Post-Demolition Treatment

A special soil and seed mix applied to a vacant lot once all structures and paved surfaces are demolished and removed from the site. This specialized treatment encourages development of a low-growing turf grass that helps maximize the amount of water that can be absorbed by the site.

Green Streets

Green streets bring water-friendly landscapes into larger streetscape projects. They introduce surfaces that absorb water and integrate special features that collect rain and snowmelt before they enter the sewer system. They also play a key role in transforming our commercial corridors and neighborhood streets to benefit residents and businesses.

Impervious Surface

Surfaces like concrete, pavement, and rooftops are impervious, meaning water cannot travel through them.

Long Term Control Plan (LTCP)

A Long Term Control Plan is a phased approach to control combined sewer overflows that will ultimately result in compliance with the NYS water quality standards and Clean Water Act requirements.

Porous Pavement

Porous pavement gives rain and snowmelt a place to go rather than the storm inlets on the sides of curbs. Water absorbs through the pavement and into the underlying soil.

Rain Barrels

Rain barrels capture and store stormwater runoff to be used for outdoor household needs. Though not safe for drinking, this water can be used for other activities that would normally require using the tap, like watering plants or washing cars.

Rain Check 2.0

Rain Check 2.0 is the second generation of green infrastructure projects in the city of Buffalo. Through a partnership with the Ralph C. Wilson, Jr. Foundation, the City and Buffalo Sewer will continue completing green infrastructure projects across the city, but with a stronger emphasis on expanded engagement and partnerships.

Rain Garden

These plant beds collect stormwater runoff from street and sidewalk pavement and absorb it into the soils below.

Road Diet

This technique reduces the number of travel lanes on a street, in turn removing excess impermeable surfaces and making streets safer and more pedestrian friendly.

Runoff

Runoff is rainwater, snowmelt and other water that is not absorbed into the ground because it is blocked by impervious surfaces, which then flows down stormdrains and downspouts into the sewer system.

Smart Infrastructure

Smart infrastructure refers to the use of information and communications technologies to monitor, manage, and enhance key infrastructure assets, including sewerage infrastructure such as mains, tunnels, and wastewater treatment facilities. Data from real-time systems and sensors can provide decision-makers with up-to-date information to maximize the capacity of existing sewerage infrastructure and to improve the delivery and efficiency of wastewater services, offering cost savings and improving quality of life.

Stormwater

Stormwater describes water generated during heavy rain events; typically, stormwater is either absorbed by the earth where the ground is permeable, or becomes stormwater runoff when it flows into the sewer system because it cannot be absorbed due to impermeable surfaces such as pavement and concrete.

Treatment Facility

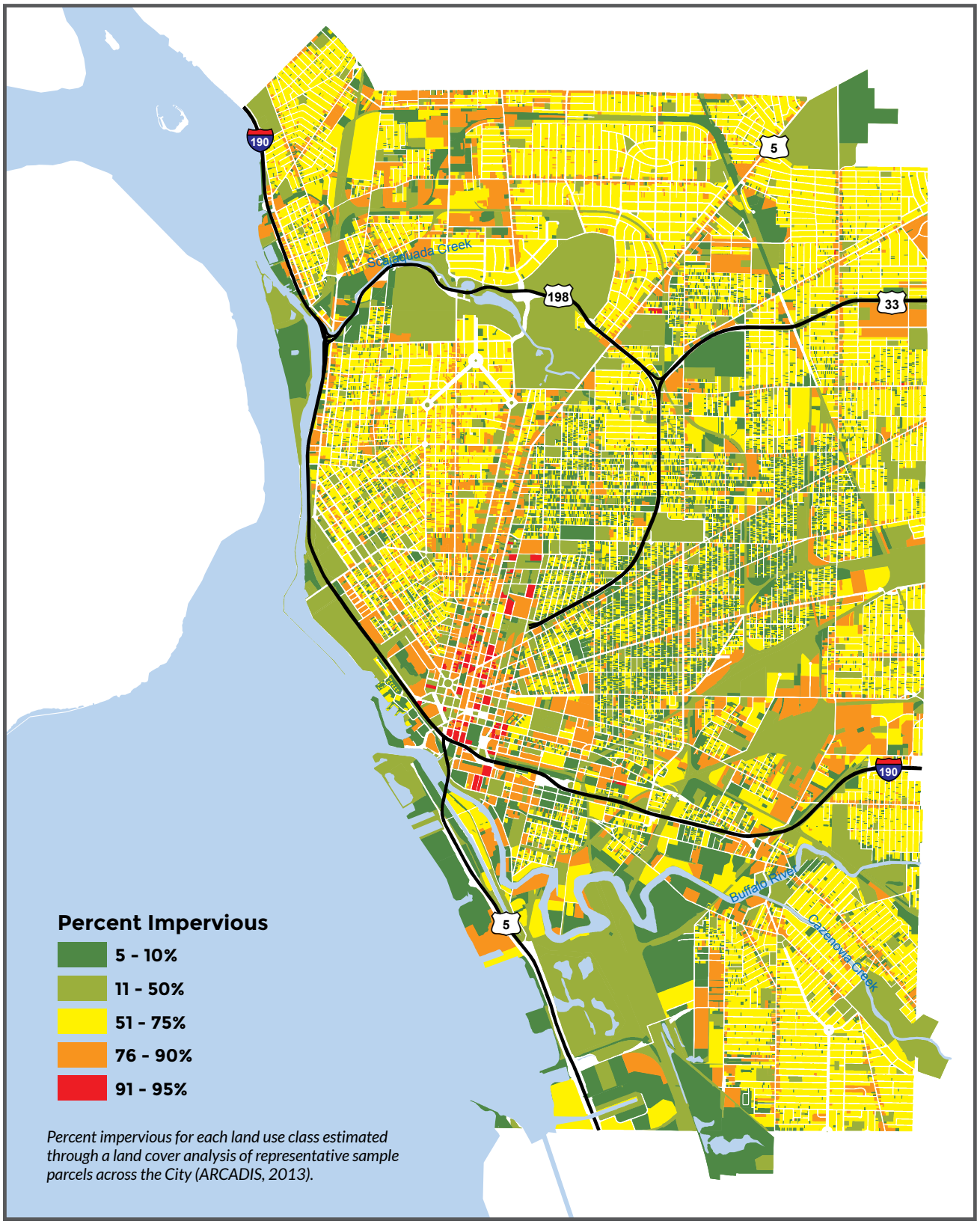
The facility where wastewater and stormwater traveling through the sewer system is conveyed and cleaned before it can be released to local waterways. At a wastewater treatment facility, the sanitary waste, litter, toilet paper, and other solids are removed from wastewater using screening and skimming techniques, as well as biological systems. During heavy rains or snowmelt, the volume of water can exceed the capacity of the sewer system or treatment facility, and the system is allowed to overflow and discharge excess wastewater directly to nearby water bodies.

Distribution of Impervious Surfaces in Buffalo by Land Use

Land Use Type	Total Acres	Acres of Impervious Surfaces[4]	Average % Impervious	% of All Impervious Surfaces in Buffalo
Buildings and Lots				
Detached residential	7,029	3,965	56% [1]	27.4%
Multi-family Residential	739	665	90% [2]	4.6%
Commercial	2,256	2,030	90% [1]	14.9%
Industrial	1,289	967	75% [2]	6.6%
Public services/Utilities	640	320	50%	1.8%
Community services/Entertainment	1,809	723	40% [3]	4.9%
Transportation				29.3%
Street rights-of-way	4,401	4,181	95% [2]	28.9%
Parking lots - Public	19	19	96% [2]	0.2%
Parking lots - Private	58	55	96% [2]	0.3%
Vacant Land				1.1%
Public	1,519	76	5% [2]	0.4%
Private	2,037	102	5% [2]	0.7%
Open Spaces				0.9%
Recreation	712	64	9% [3]	0.4%
Wild, forested, conservation lands	1,372	69	5%	0.5%
Unclassified/Unknown	2,106	1,053	50%	8.5%
City-wide	**25,984**	**14,490**	**56%**	**100.0%**

NOTES:
1. Estimated by ARCADIS using sample parcels across the City (2013).
2. From Buffalo Niagara Waterkeeper analyses.
3. From New York State Department of Environmental Conservation's Stormwater Management Design Manual.
4. Estimates of percent impervious surface by land use category found reported in the 2014 Long Term Control Plan were applied to a more recent 2016 parcel file to yield the impervious surface acres by land use category shown here. Acres of impervious surfaces by land use category do not sum to city-wide totals due to rounding.

Estimated Percent Impervious Surface by Parcel



Percent impervious for each land use class estimated through a land cover analysis of representative sample parcels across the City (ARCADIS, 2013).

Long Term Control Plan

Buffalo Sewer has developed a Long Term Control Plan (LTCP) comprised of system optimization, green infrastructure, plant improvements and new storage facilities to abate CSO discharges from its sewer system. The plan contains a balance of traditional gray infrastructure, "smart" solutions that use real time control sensors, and innovative "green" solutions. The LTCP was developed in consultation with a community stakeholder panel and benefited from formal and informal stakeholder input over the past decade.

The final LTCP was approved by the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation in 2014. The BSA's recommended LTCP plan has an expected capital cost of $380 million to implement over a 20 year period with full completion due in 2034.

GOALS OF THE PLAN

Dramatically reduces the number of combined sewer overflow events to local waterways

Upon completion of the long term control plan, only 12 of the 52 permitted CSO discharge points are expected to be used. (40 will remain in place but not activate). Of those 11 will activate six or fewer times per year. Only CSO 55 will be activated more often (9 times per year) but water quality modeling shows that those activations do not prevent the attainment of Niagara River water quality objectives.

73% reduction in the volume of CSO flow to local waterways

Over 97%

of all sanitary and stormwater flow is captured and cleaned at the treatment facility.

HOW WE'LL GET IT DONE OVER 20 YEARS

Smart sewer projects that maximize use of existing capacity

$50,450,000 (13%)

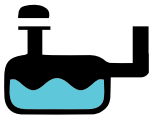
Green Infrastructure

Goal is to manage the runoff from between 1,315-1,620 acres of impervious surfaces.

$92,600,000 (24%)

Plant Capacity Improvements

$41,000,000 (11%)



New Collection System Storage

$196,280,000 (52%)

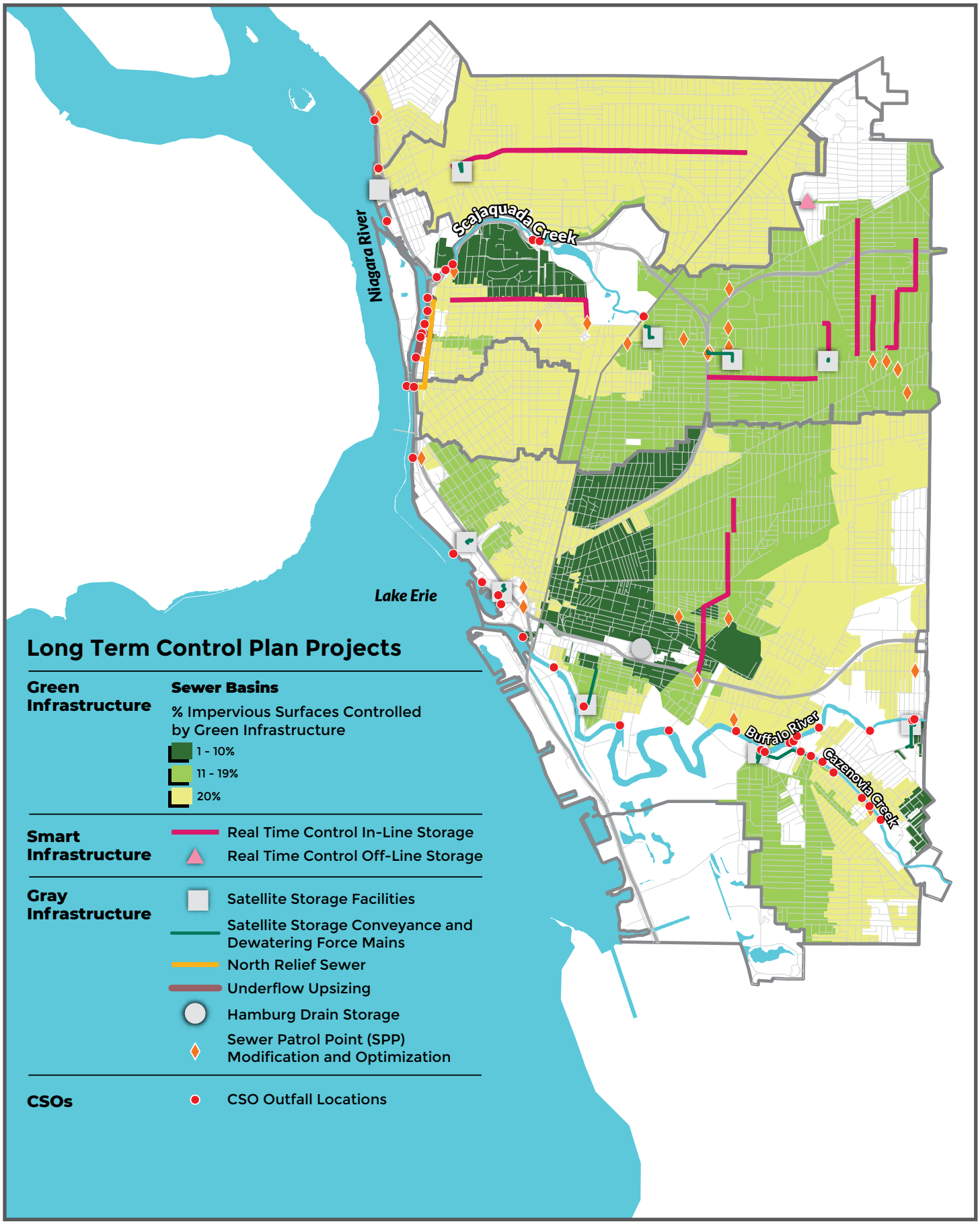
Cost Estimate

$380,330,000

Long Term Control Plan Project Highlights

Receiving Water Body / Projects	Project Cost	Storage Capacity (gallons)	Engineering Start Year
Black Rock Canal			
CSO 013	$4,500,000	300,000	2019
North Relief Sewer	$54,000,000	-	2019
CSO 008/010, 061, 004 Underflow Upsizing	$750,000	-	2021
Cazenovia Creek – C			
CSO 028/044/047	$18,300,000	2,300,000	2028
Buffalo River			
CSO 052	$5,850,000	600,000	2030
CSO 064	$3,000,000	100,000	2030
Scajaquada Creek			
Jefferson Avenue & Florida Street (SPP 170B)	$14,250,000	2,600,000	2025
SPP 336 a/b (SPP165A, SPP165B, SPP 336A, SPP336B)	$17,250,000	4,200,000	2024
SPP 337	$6,000,000	700,000	2023
Niagara River (Cornelius Creek)			
CSO 055	$27,750,000	7,500,000	2027

NOTES: Project costs are planning level estimates measured in year 2012 dollars. All costs are rounded. Right-of-way and land acquisition are not included in cost estimates.


Niagara River
Scajaquada Creek
Lake Erie
Buffalo River
Cazenovia Creek
Long Term Control Plan Projects
Green Infrastructure
Sewer Basins
% Impervious Surfaces Controlled by Green Infrastructure
1 - 10%
11 - 19%
20%
Smart Infrastructure
Real Time Control In-Line Storage
Real Time Control Off-Line Storage
Gray Infrastructure
Satellite Storage Facilities
Satellite Storage Conveyance and Dewatering Force Mains
North Relief Sewer
Underflow Upsizing
Hamburg Drain Storage
Sewer Patrol Point (SPP) Modification and Optimization
CSOs
CSO Outfall Locations

Endnotes

1. Regional Plan Association: America 2050, "Emerging Megaregions: The Great Lakes Megaregion," 2016. Retrieved March, 2018 from http://www.america2050.org/great_lakes.html

2. U.S. Climate Data, "Average weather Buffalo, NY." Retrieved April, 2018 from https://www.usclimatedata.com/climate/buffalo/new-york/united-states/usny0181

3. Kunkel, Kenneth E., Cooperative Institute for Climate and Satellites - NC, "Observed Change in Very Heavy Precipitation," 2013. Retrieved April, 2018 from https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing Note: From 1958 to 2012 ,the amount of precipitation received in extreme events (defined as the heaviest 1% of all daily precipitation events) increased by 71% in the Northeast, more than any other region in the U.S.

4. Buffalo Sewer, GIS analysis of parcel data from the City of Buffalo Mayor's Office of Strategic Planning, 2012.

5. Buffalo's Department of Public Works, "Index of Paved Streets," 1994.

6. The City of Buffalo, Bureau of Forestry, "Urban Forest Master Plan," 2003.

7. NYC Municipal Forest Resource Analysis US Department of Agriculture Forest Service, Center for Urban Forest Research, Pacific Southwest Research Station, "New York City, New York Municipal Forest Resource Analysis," 2007.

8. Buffalo Sewer, GIS analysis of parcel data from the City of Buffalo Mayor's Office of Strategic Planning, 2012.

9. Estimates by UBRI based off of information provided by Frank J. Zamboni & Company, Inc. (2018), retrieved April, 2018 at https://zamboni.com/about/fun-facts/. 60 cubic feet of snow are produced each time the ice is resurfaced. Assuming the ice is resurfaced 20 times per day, and that 1 cubic foot of snow weighs 20 pounds, the Zamboni would move 24,000 pounds of snow in one day.

10. Buffalo Sewer, GIS analysis of parcel data from the City of Buffalo Mayor's Office of Strategic Planning, 2012, and aerial imagery, 2011. Several representative residential lots located within high demolition or distressed neighborhoods were analyzed to determine average imperviousness. This analysis found that, on average, approximately 65 percent of each residential lot was impervious surface comprised of structures (house, porch, garage, shed) and driveways and parking pads. A similar sampling method used to estimate the percentage of impervious surfaces on commercial lots found that, on average, 90 percent of each lot was covered by building or parking lot surfaces prior to demolition.

11. U.S. Census Bureau, 1950. Figures represent Erie County Census Tract 16. Area of tract (in acres) is calculated using ArcGIS software to find population and housing density.

12. U.S. Census Bureau, 1990. Figures represent Erie County Census Tract 16.

13. U.S. Geological Survey, Digital Orthophoto Quadrangle. Image taken March 28, 1995. Retrieved March 29, 2018 from https://earthexplorer.usgs.gov. Original color-infrared image was converted to natural color using ArcGIS software by UBRI; U.S. Department of Agriculture, National Agriculture Imagery Program (NAIP). Image taken October 2, 2017. Retrieved March 29, 2018 from https://earthexplorer.usgs.gov.

14. Buffalo Sewer, GIS analysis of parcel data from the City of Buffalo Mayor's Office of Strategic Planning, 2012.

15. U.S. Environmental Protection Agency, "How We Use Water," 2017. Retrieved February, 2018 at https://www.epa.gov/watersense/how-we-use-water

16. UBRI analysis of parcel data from the City of Buffalo Mayor's Office of Strategic Planning, April, 2016. GIS software was used to calculate the area of all privately-owned land parcels. This figure was divided by the total area of all land parcels in the City (70%).

Methodology and Assumptions

Change in Runoff Calculations

Green infrastructure projects seek to reduce the quality, quantity and/or speed of runoff from a project site. The impact of any given intervention depends upon the size and slope of the geographic area that is draining to a practice; the types of surfaces (paving, turf, vegetation, etc) existing before and after a project; underlying soils; the ability of practices to "catch" water through inlets, elevation, etc; the amount of storage capacity created, if any; and the intensity and duration of the flow event.

While standard engineering practice is well established for calculating these factors, each project is different. Whenever possible, Buffalo Sewer has used the detailed drainage and/or stormwater management calculations and reports prepared by project engineers for this report.

In the case of the impervious surface reduction projects, including traditional demolitions, Pearl Street road diet and Ardmore projects, the runoff reduction was calculated using the Water Quality Volume formula contained in the NYS Stormwater Management Design Manual and was based upon the change in impervious surfaces from pre and post conditions.

Buffalo Sewer requires that green infrastructure projects be designed to capture 100% of the 90th percentile storm (0.9") to the maximum extent practicable. Therefore individual project capacity calculations assume 0.9" of precipitation for a "typical event". Annual figures in the Projects table on page 82 represent a typical year given a 24 hour antecedent.

For the rain barrels, the calculation is very simply based upon the volume of each barrel (132 gallons) times the number of barrels (1,310).

Modeling

Buffalo Sewer maintains a sophisticated Stormwater Management Model of its highly interconnected collections system. The model reflects land use conditions, such as impervious and pervious conditions, as well as smart, green and gray infrastructure projects. The model utilizes a "typical year" precipitation profile to estimate the number and volume of combined sewer overflows. The model is periodically updated and recalibrated to ensure that industry best practices and existing field conditions are fully reflected.

Converting Green Infrastructure Statistics to Relatable Terms

Various sources of information were used to convert the gallons of runoff reduced by green infrastructure investments to relatable terms. According to NBC Learn, there are 10,600 gallons of water in an NHL ice hockey rink (https://www.nbclearn.com/portal/site/k-12/flatview?cuecard=56618). According to the Patagonia Area Research Alliance, there are 660,430 gallons of water in an Olympic-sized swimming pool (http://www.patagoniaalliance.org/wp-content/uploads/2014/08/How-much-water-does-an-Olympic-sized-swimming-pool-hold.pdf). According to the U.S. Environmental Protection Agency, a shower consumes 17.2 gallons of water, on average. A typical washing machine uses 40 gallons per load of laundry (http://homeguides.sfgate.com/many-gallons-water-average-washing-machine-hold-full-80612.html). The engineering standard for the size of one typical city block was assumed—100,000 square feet, or 2.3 acres (http://www.land4ever.com/block.htm).

The Green Code and Green Infrastructure

The Buffalo Green Code incorporates City and neighborhood level land use policies recommended in both the NYS Stormwater Management Design Manual as well as the EPA's "Using Smart Growth Techniques as Stormwater Best Management Practices" and "Water Quality Scorecard". These policies promote the protection of natural hydrological resource areas and minimization of impervious areas. In particular, the Buffalo Green Code:

- Promotes compact, mixed use and transit oriented development, reducing the amount of impervious surface needed for new buildings and associated transportation services;
- Promotes street oriented development with build-to lines that help to minimize driveway lengths;
- Promotes traditional urban lot sizes, encouraging taller buildings with smaller impervious footprints;
- Preserves significant open space areas that retain, filter and store rainwater;
- Removes minimum parking requirements, discouraging the creation of unnecessary paved areas;
- Includes tree conservation, street tree, parking lot and other landscape provisions, with specific direction to integrate parking lot landscape with stormwater management
- Requires on site stormwater management for all new development with detailed engineering review for all projects greater than one-quarter acre in scope; and
- Requires management of construction runoff for projects greater than one-quarter acre in scope.

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