NEW YORK, NY

Cloudburst Infrastructure Workshop for New York City Housing Authority

A ULI Resilient Land Use Cohort
Executive Summary Report

February 9–10, 2022

Urban Land Institute

About the Urban Land Institute

The Urban Land Institute (ULI) is a global, member-driven organization comprising more than 45,000 real estate and urban development professionals dedicated to advancing the Institute's mission of providing leadership in the responsible use of land and in creating and sustaining thriving communities worldwide. ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and the Asia Pacific region, with members in 80 countries.

More information is available at uli.org. Follow ULI on Twitter, Facebook, LinkedIn, and Instagram.

About the ULI Urban Resilience Program

ULI's Urban Resilience program is focused on how buildings, cities and communities can be more resilient to the impacts of climate change and other environmental vulnerabilities. The program works with ULI members to provide technical assistance, advance knowledge through research, and catalyze the adoption of transformative practices for real estate and land use policy.

About ULI New York and the Technical Assistance Panels (TAPs) Program

ULI New York is a District Council of ULI. District Councils carry out the ULI mission locally by sharing best practices, building consensus, and advancing solutions through educational programs and community outreach initiatives. The objective of ULI New York's Technical Assistance Panels (TAPs) program is to provide expert, multidisciplinary, and objective advice on land use and real estate issues facing local governments, public agencies, and nonprofit organizations throughout its local geographies. Drawing from its extensive membership base, ULI New York conducts one- and two-day panels offering unbiased, pragmatic solutions, best practice advice, and market-based strategies to local decision-makers on a wide variety of complex land use challenges, ranging from site-specific projects to public policy questions. The TAPs program is intentionally flexible to provide a customized approach to specific land use and real estate issues.

Learn more at newyork.uli.org.

About the Resilient Land Use Cohort

This Implementation Grant report is part of a larger series of resilience technical assistance and learning opportunities called the **Resilient Land Use Cohort (RLUC)**. The RLUC is a network of ULI district councils, member experts, and community partners in eight cities working together to identify strategies to be more resilient in the face of climate change and other vulnerabilities, including floods, extreme storms, drought, wildfire, and extreme heat, as well as the related social, environmental, and economic impacts. RLUC provides on-the-ground technical assistance through ULI's flagship technical assistance models – Advisory Services Panels and Technical Assistance panels.

These panels leverage ULI member expertise to advise on complex real estate and land use challenges related to climate resilience, addressing planning, zoning, land use, development strategy, housing, and infrastructure. ULI's Urban Resilience program convenes the cohort regularly to learn from national best practices and discuss peer cities' next steps advancing resilience through land use policies and development strategies. Funding for this engagement and the cohort is provided by the ULI Foundation with support from JPMorgan Chase.

Cover photo: Douglass Houses, New York City Courtesy of the New York City Housing Authority

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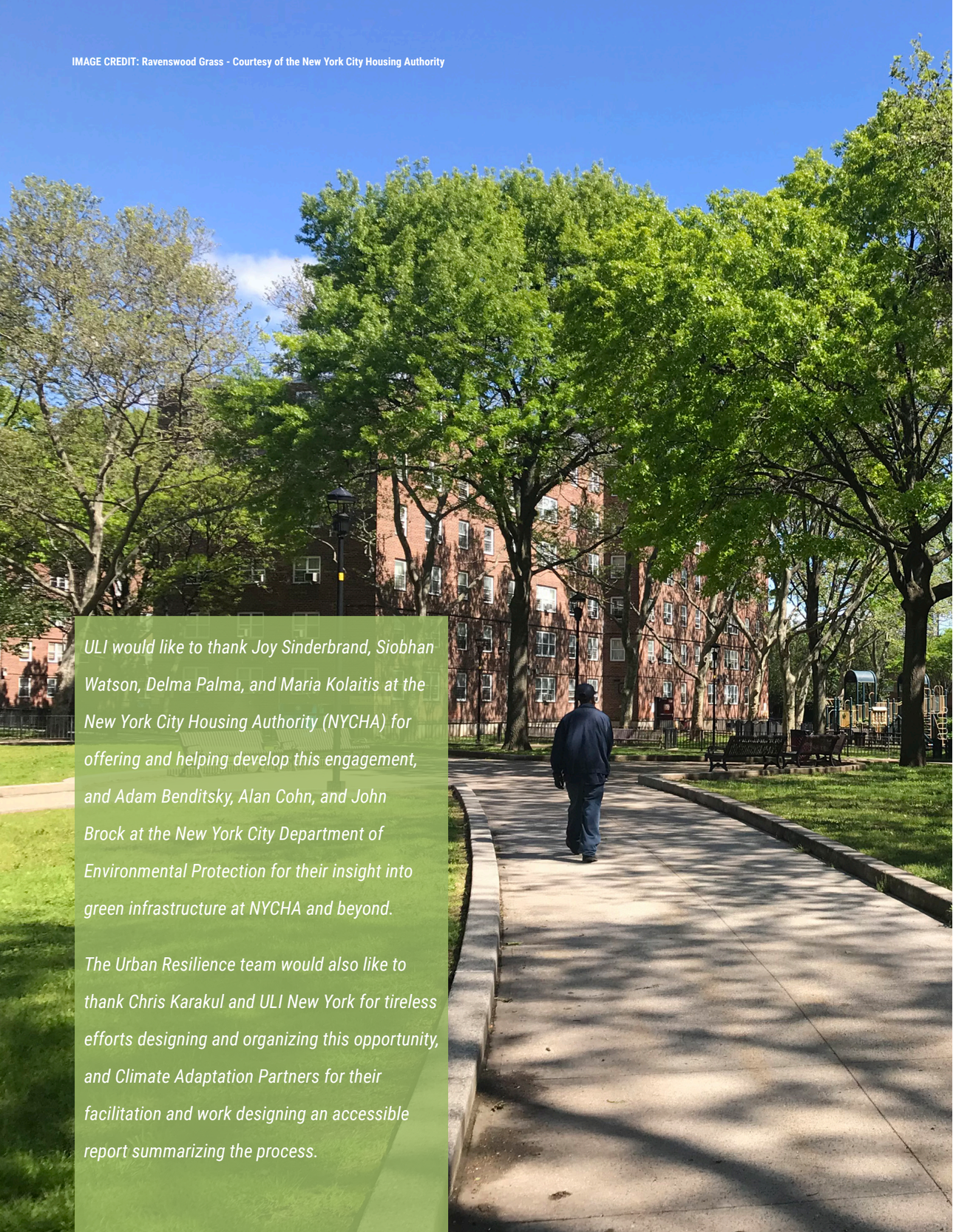

IMAGE CREDIT: Ravenswood Grass - Courtesy of the New York City Housing Authority

ULI would like to thank Joy Sinderbrand, Siobhan Watson, Delma Palma, and Maria Kolaitis at the New York City Housing Authority (NYCHA) for offering and helping develop this engagement, and Adam Benditsky, Alan Cohn, and John Brock at the New York City Department of Environmental Protection for their insight into green infrastructure at NYCHA and beyond.

The Urban Resilience team would also like to thank Chris Karakul and ULI New York for tireless efforts designing and organizing this opportunity, and Climate Adaptation Partners for their facilitation and work designing an accessible report summarizing the process.

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NYCHA Cloudburst Workshop Overview

On February 9 - 10, 2022, ULI New York and the ULI Urban Resilience Team conducted a technical assistance workshop with the New York City Housing Authority (NYCHA) to focus on innovative cloudburst infrastructure that can protect against future extreme rainfall events while providing opportunities for passive and active recreation during everyday conditions. Prior to this workshop NYCHA explored ways to address cloudburst events through pilot work at South Jamaica Houses, where a sunken basketball court will help store stormwater. Additionally, it will serve as a location for a neighborhood farmer's market, as a place to show outdoor movies, and as an after-school playground. In this way, the solution offers many opportunities to improve the daily experience for NYCHA residents, and provides resources suitable for a range of ages and interests. NYCHA intends to expand this type of approach as it seeks to manage its stormwater.

South Jamaica Houses Basketball Court
Concept by Grain Collective

This work is timely as New York City, like many other areas in the United States, faces a future of more extreme rain events and resultant flooding. The New York City Panel on Climate Change (NPCC) and the New York State Energy Research and Development Authority (NYSERDA) are running parallel assessments to capture greater understanding of the expected frequency of these rain events and their associated intensity. In May 2021 the City released its first Stormwater Resiliency Plan to communicate the impact of extreme rainfall and share approaches to strengthen the City's sewer infrastructure, including pilots for innovative long-term strategies like cloudburst management. The Plan reflects critical science that says:

- Precipitation events are intensifying
- Extreme rain events can cause flooding in neighborhoods that are inland, away from the coast
- Extreme rain is hard to predict and can occur suddenly.

The Plan was released along with the City's first official citywide maps depicting flood risk from extreme rainfall events. As recently as the fall of 2021, Hurricane Ida swept through the region causing such a rain event in which the intensity of the storm quickly overwhelmed the capacity of stormwater infrastructure.

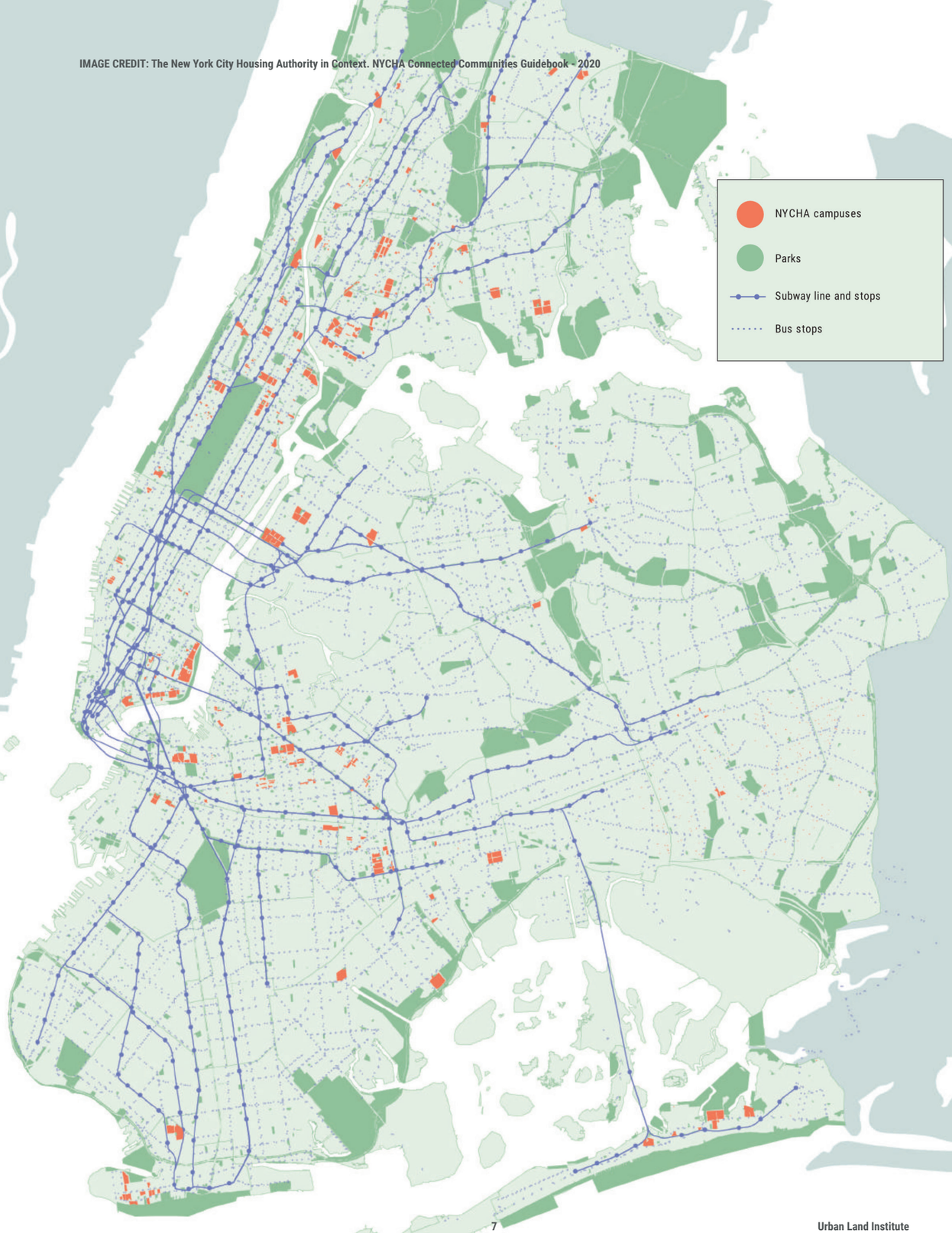
As such events increase in New York's future, NYCHA's focus on bolder, multi-functional, community-centered solutions will have lasting positive impact. Given its scale, NYCHA's potential to substantively shift stormwater impacts in New York offers opportunities across the five boroughs.

NYCHA asked ULI New York to convene this workshop with professionals experienced in developing cloudburst infrastructure and as such the workshop was acutely focused on practical solutions, with proven implementation examples from the United States and elsewhere in the world. During the workshop, participants toured two NYCHA developments to better understand representative spaces that could be improved for cloudburst management. Spaces included buildings, pathways, parking lots and NYCHA internal streets, and open spaces such as playgrounds or courts, seating areas, and lawn areas.

These types of spaces exist at most NYCHA developments and while the specifics of the site tour helped to set context for the space typologies, the focus was not site-specific solutions. Instead, participants were asked to identify examples outside of the portfolio of approaches currently implemented in NYCHA campuses that might leverage such spaces while better protecting NYCHA developments from cloudburst-event flooding. Following the site tour, participants developed examples of how cloudburst infrastructure precedents could be adapted across NYCHA's portfolio. The workshop resulted in this reference book of multi-functional cloudburst infrastructure solutions that could be integrated into NYCHA campuses and maximize co-benefits of stormwater infrastructure for NYCHA residents.

Coined in 2011 after the city of Copenhagen experienced unprecedented rainfall during a storm event, the term "cloudburst" has been used to describe extreme rainfall during a short period of time.

IMAGE CREDIT: The New York City Housing Authority in Context. NYCHA Connected Communities Guidebook - 2020



Combining Stormwater & Microclimate Infrastructure

A city's portfolio of infrastructure assets can be enhanced by considering how existing stormwater infrastructure assets can support broader goals and provide multiple benefits, becoming 'microclimate infrastructure'. Traditional rainwater capture and stormwater detention basins and their conveyances can be expanded in function to become roof gardens, parks, performance venues, event spaces, public plazas, nature trails, gardens, and bike paths. Each microclimate investment opportunity can contribute to enhanced quality of life for residents and visitors.

NYCHA and Combined Sewer Overflow (CSO)

Currently NYCHA and the New York City Department of Environmental Protection (DEP) collaborate on green infrastructure programs. The DEP Green Infrastructure Program provides a buffer to alleviate pressure on the sewer system with the primary objective to reduce combined sewer overflow into New York Harbor. The DEP Green Infrastructure Program at NYCHA includes rain gardens, bioswales, porous surfaces and sub-surface retention chambers, all recognized best management practices (BMPs).

To complement these BMPs, this workshop focused on identifying additional strategies to address cloudbursts that introduce multiple community benefits and that are practical and scalable in concert with NYCHA planned capital improvements. The workshop focused on open space program composition and investments in higher campus-specific stormwater management performance by matching existing NYCHA real estate portfolio assets to their water storage potential.

The more that NYCHA reduces its direct contribution to the NYC stormwater system, the less potential for flooding of the city's sewer systems - particularly given NYCHA's scale as the largest city-owned portfolio outside of New York City Parks.

IMAGE CREDIT: "New York Rain 3" by ahisgett (CC BY 2.0)

Workshop Typologies

NYCHA identified four spatial typologies to consider during the workshop:

- Buildings
- Pathways
- Parking and NYCHA Streets
- Open Spaces

Buildings

are the housing units and the support buildings owned by NYCHA

Pathways

are the paved sidewalks that connect NYCHA buildings to one another and to the public sidewalk and street system

Parking and NYCHA Streets

are the parking lots, parking adjacent areas, and internal NYCHA streets

Open Spaces

are the structured play spaces such as playgrounds, basketball courts, soccer fields, and outdoor seating areas and lawns

Slow, Store, and Restore

Workshop participants characterized NYCHA's opportunities for cloudburst management with three interrelated approaches to slow down the water, store it temporarily, and restore NYCHA's landscapes.

Drawing from established best practices, these principles form an interconnected system that interrupts the speed of stormwater runoff, that holds water where it falls, and that creates restorative landscapes that improve stormwater management while enlivening places for people. These principles work across each of the space typologies and, when coordinated, work across scales. NYCHA parcels and NYCHA streets connect to the fabric of adjoining parcels and streets, which introduces the possibilities of district-scale stormwater management, improved environments for NYCHA residents, and reduced combined sewer overflows to New York Harbor.

Slow

Slowing water helps to reduce flooding and the burden on stormwater management systems

Catch water where it falls using rooftops, pathways, parking and streets, and open spaces, and where possible, encourage water to infiltrate into the ground. Trees, understory planting, and other vegetation help to slow and filter stormwater as well as keep soils aerated.

NYCHA's Urban Forest program is ongoing, including recent work to catalog canopy on multiple development sites. The addition of understory planting and broader types of vegetated cover to this program increases the stormwater uptake that a traditional canopy offers.

Principles

1. Expand the duration that stormwater stays where it lands before directing it toward other systems
2. Increase surface friction but plan for the water to flow to another area
3. Intentionally direct stormwater from where it lands toward detention and retention areas
4. Prevent concentration of water flows and distribute across site

Store

Storing water temporarily reduces the immediate impact on stormwater systems at times of peak flow

Integrate stormwater detention and retention into NYCHA open spaces and parking areas to provide additional storage for cloudburst events. Designed to function as holding areas, these places will be the first to fill during cloudbursts. When dry, they return to their previous functions.

Most effective at a larger scale, such storage solutions have potential to substantially impact the stormwater system.

Principles

1. Assess where it makes sense to invest for sea-level rise, flooding, and cloudburst events
2. Detain the rain falling on NYCHA sites, which in turn helps the surrounding areas
3. Consider how to also help manage rain falling on nearby sites, especially in areas close to the waterfront
4. Recharge groundwater to counter or reduce saltwater intrusion
5. Add risers to subsystems for possibilities to link to detention areas

Restore

Restoring degraded landscapes enhances the services that these spaces provide and NYCHA residents' quality of life

Improve NYCHA's public realm to provide additional stormwater storage and to offer more variety of experience for NYCHA residents. These restorative areas provide space for periodic inundation when needed, while offering more diverse respite experiences when not needed.

Link these ideas to NYCHA's Connected Communities Initiative for a holistic approach to redevelopment.

Principles

1. Treat NYCHA open space as an asset contributing to the neighborhood and, given NYCHA's scale, the City of New York open space and stormwater system
2. Create stimulating and varied landscapes for residents using water movement as a design device
3. Reconsider connections between NYCHA water systems and city systems to mutually strengthen capacities
4. Restore the capacity of NYCHA grounds to hold water
5. Restore ecosystem functions and natural water flow paths
6. Rewild for pollinator pathways, introducing moisture, mineral landscapes, and enhancing natural channels
7. Improve water quality from the site to rivers and watersheds
8. Improve vegetation diversity to better hold and filter water
9. Reuse water and soils in NYCHA developments for irrigation, car washing, berming, and microtopography

Suitability

Each cloudburst management tactic was evaluated for assumed cost of maintenance, level of multifunctionality or benefit, assumed size of the drainage area served, and groundwater depth suitability.

Suitability Index

- Maintenance Cost Required: $ (low) to $$$ (high)
- Multifunctionality Achieved: * (low) to *** (high)
- Drainage Area Served: Small, Medium, Large
- Groundwater* Depth: High or Low

* Groundwater

The toolkit necessarily varies with local groundwater and subsurface conditions. In areas of high groundwater or bedrock (2-3 feet below surface), prioritize rooftop disconnection and surface-level storage and conveyance to areas of infiltration and interconnected subsurface storage. In areas of lower groundwater and sand or good infiltration soils, introduce more subsurface storage.

Slow: Buildings

As roofs are replaced in the capital improvement cycle, develop as blue-green roofs that integrate solar and connect to other community-focused water management programs.

1. Make Smarter Roofs

A. Slow the conveyance of water from rooftops. Create local detention through blue or green roofs
B. Pilot inclusion of solar on blue-green roof using bio-solar best practices
C. Use smart roof technology to manage with cloudburst monitoring

Suitability Index

- Maintenance Required: **$$$**
- Multifunctionality Achieved: ***
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

Lesson Learned: Integrating green and blue roof strategies with solar arrays can boost output of the system. Smart roof technology that regulates the level of stormwater retention in real time to local conditions can reduce roof-load issues and protect against stormwater damage.

Biosolar Roofs

Biosolar roofs integrate solar photovoltaic systems (PV) and blue-green roof systems in a networked system and can lead to improved PV efficiency and output, increased roof cooling, and increased rooftop habitat diversity. Rooftop vegetation provides a cooling effect of the microclimate around the PVs, which improve efficiency. As well, the PVs themselves provide additional shading and cooling of the roof surface.

RESILIO, a joint collaboration between the City of Amsterdam and key academic research, solar, and green-blue roof technology experts, studied blue-green / smart roof technologies in real-world implementations and established the efficacy of smart-grid systems in large-scale (city-region) adaptation strategies.

IMAGE CREDIT: Innovation Lab Ite Boeremastraat | RESILIO | © Wieke Braat

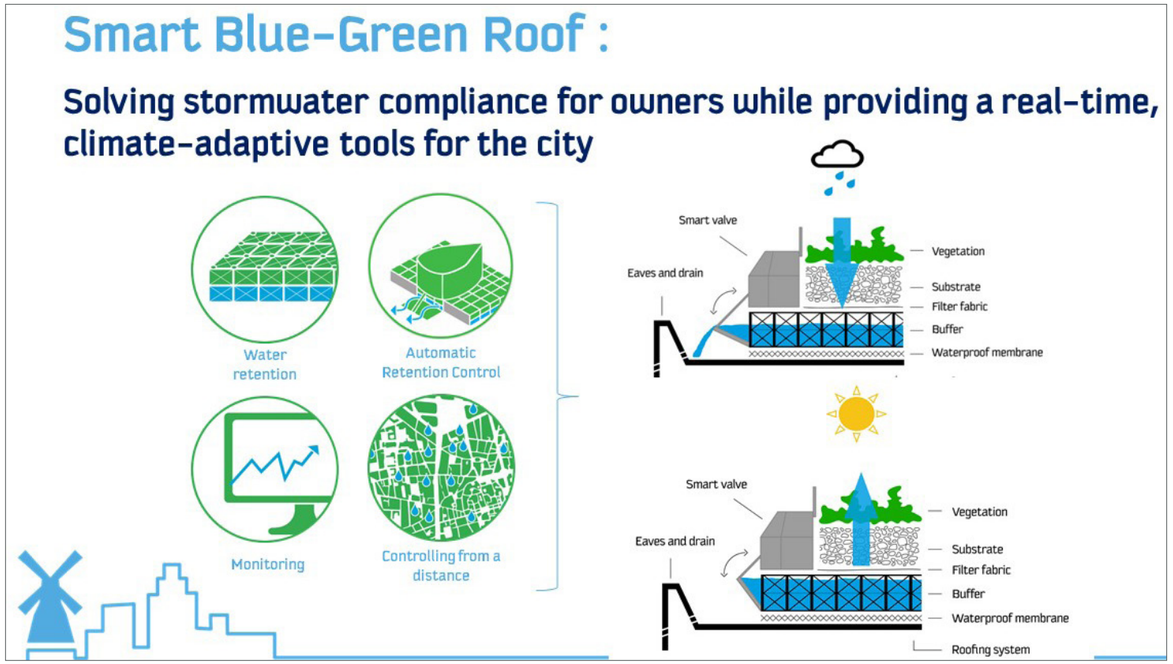


IMAGE CREDIT: MetroPolder Company

Slow: Buildings

As roofs are replaced in the capital improvement cycle, develop as blue-green roofs that integrate solar and connect to other community-focused water management programs.

2. Work with the NYCHA Community to Reduce Building Wastewater Load in Concert with Stormwater Practices

A. Referencing DEP's Wait program, focus on water use reduction during rainstorms
B. Expand community engagement with events to encourage reduced water use during peak rain events. Promote outcomes to date such as DEP's reported 5% reduction in water use during rain storms.
C. Connect to other NYCHA climate actions for wastewater management such as low flow fixtures
D. Consider gaming strategies to increase reductions in water usage during peak events

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **N/A**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: New York City Department of Environmental Protection

New York City Department of Environmental Protection - WAIT Program

NYC DEP created the WAIT Program to help educate citizens of the stress that everyday water usage places on the city's water infrastructure during severe storms. The program emphasizes the importance of delaying activities like laundry, showers, dish washing, and toilet flushing during storms to help alleviate the pressures on the combined sewer system.

IMAGE CREDIT: New York City Department of Environmental Protection

Slow: Pathways

Reconsider paved pathways to remove excess pavement, increase permeability, improve shading, and improve canopy health.

1. Raise, Grade, and Depave

A. Revisit pathway width requirements to reduce amount of paved pathway and to increase adjacent open space that could hold stormwater
B. Depave some secondary pathways, replacing with gravel and grills for accessibility
C. Intentionally grade pathways to direct sheet flow to adjacent open spaces
D. In the context of circulation analyses, designate secondary pathways to flood and primary pathways to be raised for continuous access or emergency access

Suitability Index

- Maintenance Required: **$**
- Multifunctionality Achieved: ******
- Drainage Area: **Small initially, but with aggregation, Medium-Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: Tasinge Plads - Climate Adaptation Partners

Tasinge Plads - Copenhagen, Denmark

Created by LYTT Architecture to address cloudburst effects in Copenhagen's Osterbro district, the design for Taasinge Square accommodates multiple strategies, including rooftop rainwater collection and diversion into storage tanks and park sculptures that collect rainwater, both for use in irrigation of the park.

Landscape berming and grading is used to control water flow and to divert water away from pedestrian pathways.

Slow: Pathways

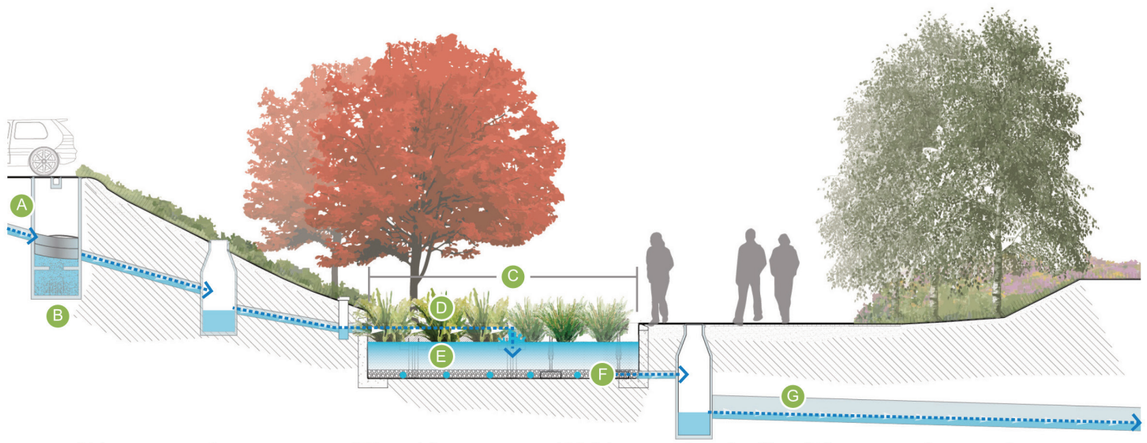
Reconsider paved pathways to remove excess pavement, increase permeability, improve shading, and improve canopy health.

2. Integrate Shade with Canopy and Tree Well and Paving Improvements

A. Integrate shade structures along primary pathways
B. Improve tree wells to improve canopy health and to promote stormwater infiltration
C. Regrade tree planting areas to prevent debris from floating out of planting area
D. Introduce more permeable paving and infiltration opportunities as part of an overall tree well / landscaping system
E. Inventory overall current canopy health and assess potential impacts of climate changes. Identify preparation and timing required for canopy shifts given changing climatic conditions

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Small initially, but with aggregation, Medium-Large**
- Groundwater Depth: **High or Low**



(A) untreated stormwater (B) swirl separator (C) bioretention facility (D) water tolerant plants (E) special soil media (F) underdrain to collect treated stormwater (G) clean stormwater out to city system

IMAGE CREDIT: City of Tacoma, Washington | University of Washington-Tacoma

Stormwater Treatment Facility

The City of Tacoma, WA and the University of Washington - Tacoma co-created a regional stormwater treatment facility in a new park on the University campus. Incorporating the existing, abandoned rail bed, the system collects stormwater from the adjacent parking lot into a pre-treatment swirl separator (removing sediment and floating debris) and conveys the runoff into a bioretention facility in the rail bed below the parking lot. Retention media and plant root systems aid in the filtration and removal of pollutants before the water is conveyed into the city stormwater system, and ultimately, into the Thea Foss Waterway.

IMAGE CREDIT: Google Earth - Climate Adaptation Partners

Slow: Parking & NYCHA Streets

Use parking and NYCHA streets to redirect water flow by integrating more infiltration and subsurface detention while improving adjacent canopy and shading.

1. Introduce More Permeability, Detention, and Retention

A. Enhance permeability at parking perimeter and in select locations within parking areas
B. Increase subsurface detention/retention in paved areas
C. Use curbs and speedbumps to channel or sheet water flow
D. Re-contour street profiles from crowned to V-profile, where possible, to aid retention and conveyance
E. Add bioswales to direct water and improve infiltration and detention

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: *****
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low, accordingly**

Streets for Retention and Conveyance

As part of Amsterdam Rainproof's cloudburst management toolkit, The "Hollow Road" strategy flips the traditional road profile from a crowned shape, which sheds water to the sides towards the buildings, to a v-shaped profile that collects water to the center. In normal rain events, the water flows to the center and drains normally. In an extreme rain event, the entire street is allowed to flood to retain and convey the excess water. In addition to conveying water along a roadway, this measure has been deployed in combination with on-street parking to create multiple channels between the roadway and adjacent parking spaces.

IMAGE CREDIT: Hollow Road | Merlin Michon | Amsterdam Rainproof

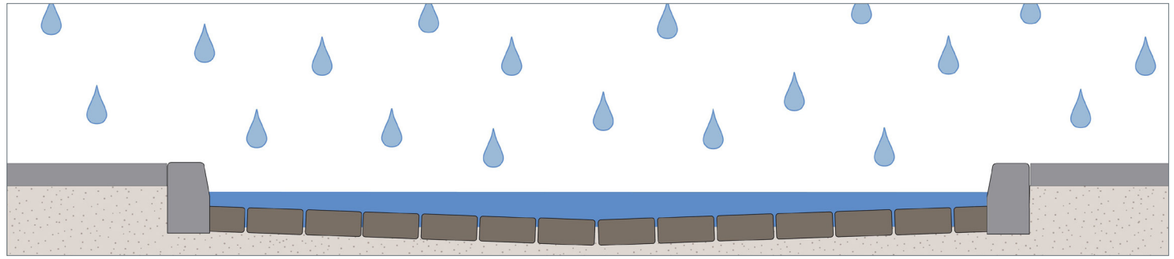


IMAGE CREDIT: Hollow Road | Amsterdam Rainproof

IMAGE CREDIT: Hollow Road | Merlin Michon | Amsterdam Rainproof

Slow: Parking & NYCHA Streets

Use parking and NYCHA streets to redirect water flow by integrating more infiltration and subsurface detention while improving adjacent canopy and shading.

2. Improve Canopy and Shading Within, and Adjacent to, Parking and Streets

A. Expand tree canopy and understory planting areas within parking areas and alongside streets
B. Integrate shade and seating structures along pathways adjoining parking/streets
C. Introduce more permeable paving and rainwater infiltration opportunities near parking areas

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ***
- Drainage Area: **Small**
- Groundwater Depth: **High or Low**

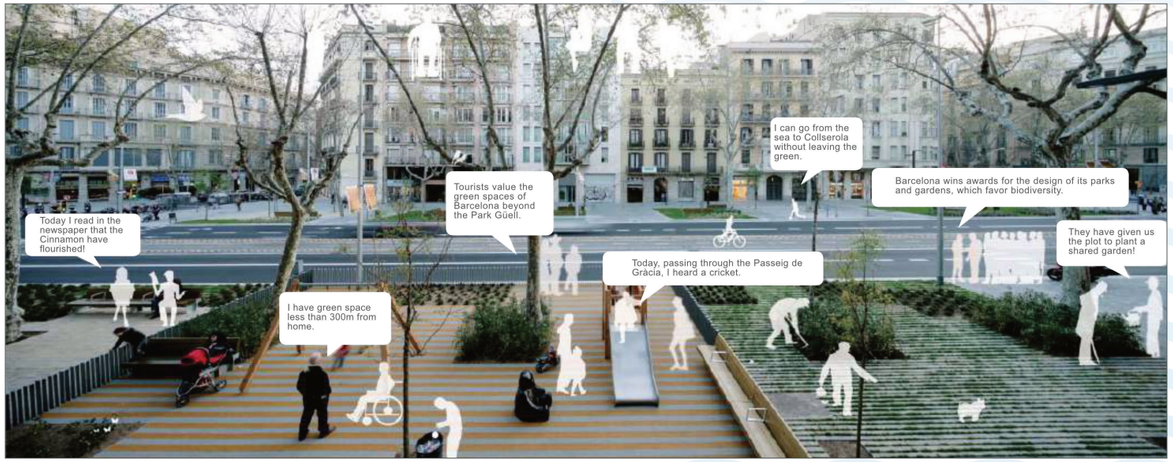


IMAGE CREDIT: 2020 Green Infrastructure and Biodiversity Plan - City of Barcelona, Spain

IMAGE CREDIT: 2020 Green Infrastructure and Biodiversity Plan - City of Barcelona, Spain

Barcelona Green Infrastructure and Biodiversity Plan 2020

In 2020 the City of Barcelona created the city's Green Infrastructure and Biodiversity Plan as a "strategic instrument that defines the challenges, goals, and commitments of the municipal government regarding conservation of green space and biological diversity" within the city. The plan defines the city's natural resources as ecological infrastructure that provide environmental and social services to the citizens. In concert with the 2020 European Union Strategy for Biodiversity, the Barcelona plan seeks to create a network of natural spaces that mitigate the harshness of the urban condition with greening and planting strategies that also help address runoff and flooding.

Slow: Open Spaces

Adjust open space program composition, reducing lawns and investing in higher campus-specific stormwater management performance by matching programs of spaces to water storage potential.

1. Retrofit Existing Lawns and Enhance Canopy and Understory

A. Reduce lawn with alternative, lower maintenance plantings. Pilot and monitor options for greater performance. Tie to community garden initiatives
B. Improve soil infiltration through subsoiling/decompaction
C. Regrade lawns to introduce terracing and embankments to slow and control flow
D. Expand and optimize tree canopy and vegetation for climate resilience and stormwater uptake as well as soil improvements. Enhance existing tree canopy through intentional understory planting of dense groundcover. Allow leaf litter to remain, reducing maintenance and enhancing habitat value
E. Develop alternative programming for previous lawn spaces with alignment with water storage potential. Connect to places for play and respite

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ***
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: Spaarndammerhart | Amsterdam Rainproof | Dennis de Smet

Amsterdam Rainproof

Initiated in 2014, Amsterdam Rainproof is a network organization of multidisciplinary experts and practitioners engaged in an effort to expand Amsterdam's resilience to cloudburst events and make Amsterdam "rainproof" by 2050 through engagement with private land holders and public entities. Strategies and policies for controlling and capitalizing on rainwater are developed through research and the use of case studies that introduce solutions at multiple scales. The Spaarndammerhart in Amsterdam, for example, is a redeveloped apartment complex that introduces green roofs and roof water storage for use in communal gardens that have been graded to manage water.

IMAGE CREDIT: Spaarndammerhart | Amsterdam Rainproof | Dennis de Smet

Slow: Open Spaces

Adjust open space program composition, reducing lawns and investing in higher campus-specific stormwater management performance by matching programs of spaces to water storage potential.

2. Reduce Impervious Surfaces

A. Within NYCHA, reduce impervious surface over subsurface detention and around green infrastructure conveyance inlets to allow for pretreatment of stormwater to reduce maintenance and add detention beyond CSO goals
B. Create health-focused or competitive resident programs to promote depaving by creating incentives for paving removal, creative reuse of paving materials, and outdoor physical activity

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: *****
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

Community-Focused Depaving

The Pierce Conservation District's depave initiative identifies and removes impervious surfaces in a community-driven process utilizing community volunteers and local businesses and sponsors. The McKinley Business District project incorporated multiple community events and donated services from local contractors to remove 7,000 square feet of pavement, install amended topsoil, and plant 30 new trees and 2,800 shrubs.

NK Tegelwippen is a community-based competition between Dutch municipalities to see which community can remove the most paving tiles and replace them with natural landscape elements as a means to increase resilience. Awards are given to the municipality that removes the most tiles and the municipality that removes the most tiles per 1000 people (TPI).

IMAGE CREDIT: Pierce Conservation District - Puyallup, WA - McKinley Business District

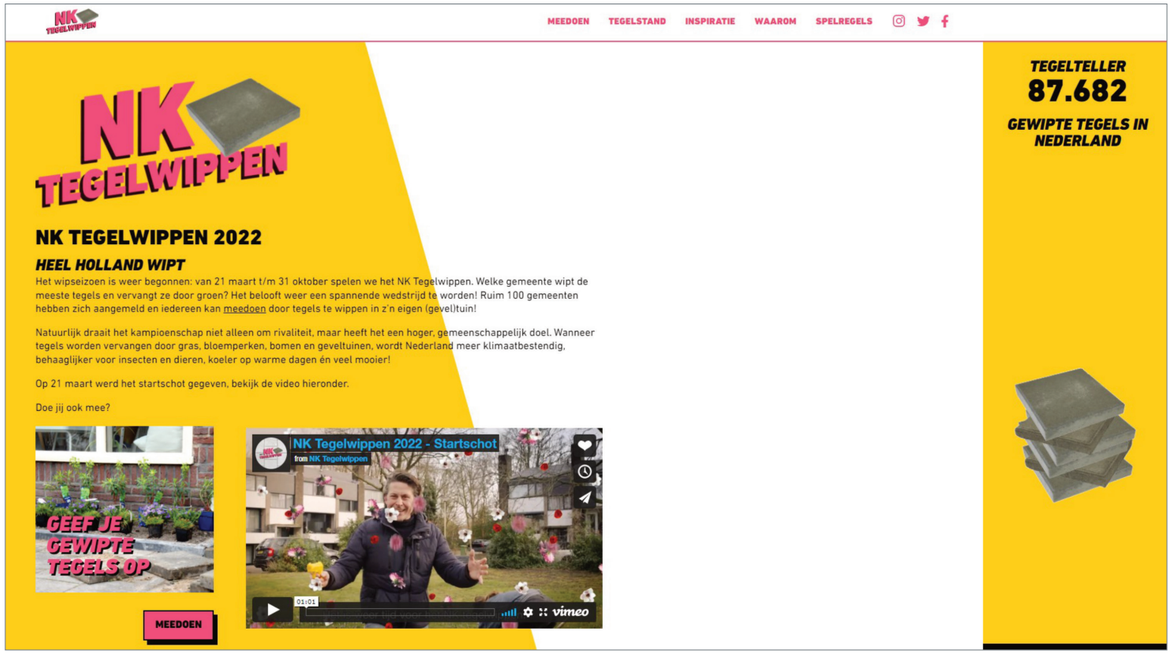


IMAGE CREDIT: NK Tegelwippen: Ministry of Infrastructure and Water Management and Our Water, The Netherlands

Store: Buildings

As roofs are replaced, develop alternative strategies for stormwater diversion and collection.

1. Detain Water on Roofs and Divert Water from Internal Drain Systems

A. Disconnect downspouts from roof drains. Divert roof runoff to external leaders to detain volume at ground level, or in basements, or subsurface storage, which in turn helps with internal leaks
B. Store water in above ground, or underground, cisterns
C. Consider grey water reuse of runoff for irrigation. Engage community members in landscaping programs that use grey water
D. Encourage grey water reuse for car washing activities, adding to community connections and youth programs

Suitability Index

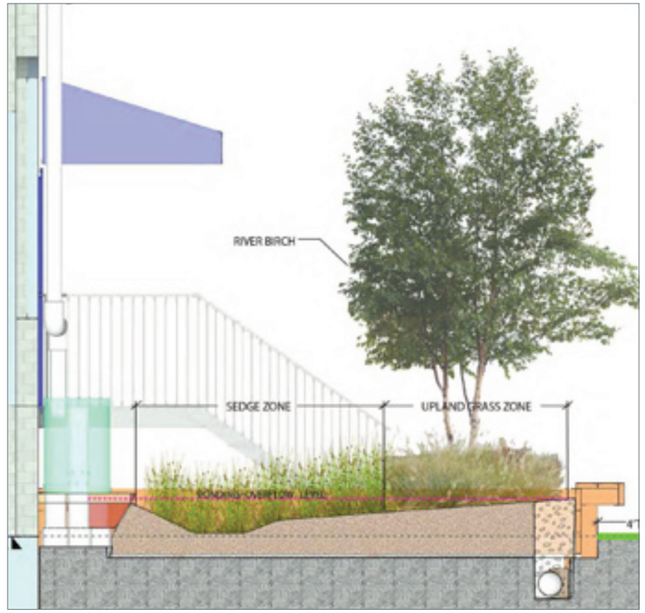
- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: Baltimore County Toolbank Stormwater Management - Biohabitats

Baltimore County Toolbank

Two stormwater treatment approaches, both capitalizing on diverted roof water, were implemented by Biohabitats for Baltimore County Toolbank. The first diverts roof water into two elevated bioretention planters at the front of the building. The second diverts roof water into a series of cisterns at the building perimeter for use in tool washing and irrigation of native plants in raised planters. Both systems slow stormwater flows and lightly filter and clean runoff before it enters the city storm drain.

IMAGE CREDIT: Baltimore County Toolbank Stormwater Management - Biohabitats



Store: Pathways

When renovating pathways, create water storage below pathways where possible and in concert with larger adjoining stormwater storage areas, including targeted surface flooding.

1. Walk and Store

A. Evaluate and prioritize adjoining parking or open space retrofits to aggregate impact of water storage
B. Invest in subsurface water storage when pathways are retrofitted; add integrated ditches for storage adjacent to pathways
C. Prioritize surface conveyance and backup after subsurface storage is full

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Medium-Large**
- Groundwater Depth: **Low**

Self-Draining Sidewalks

The city of Copenhagen has utilized a sidewalk tile developed by Tredje Natur that allows storm water to pass through the surface into sub-surface storage and conveyance systems. The product is currently installed in the Copenhagen's Nørrebro district.

Climate Tile –a green and scalable climate adaption system for dense cities

Climate change is pushing the boundaries in our cities. The Climate Tile is a scalable climate adaptation tool which rethinks sidewalks as water management systems. The main component is essentially a hybrid between a concrete tile, an intelligent water pipe system and a permeable surface. The tile's purpose is to positively answer the climate change challenges whilst creating new adventures and green, urban spaces in cities. The Climate Tile can catch and redirect 30 percent of the extra rainwater projected to come due to climate change and thereby prevent overflows from the existing drainage infrastructure. In addition to this, it also brings other qualities into play as it allows for watering of trees and plants, spaces for stay and a more beautiful surface. The water contributes to the growth of an urban nature and an improved microclimate which benefits local citizens as it contributes to making the city both a healthier and more attractive place to live. The scaling potential of the product is comprehensive – for example New york City has 20,000 km of sidewalks.

(Courtesy: TREDJENATUR, IBF and ACO Nordic with financial support from Realdania and The Market Development Fund)

IMAGE CREDIT: Ministry of Environment of Denmark / Environmental Protection Agency / State of Green / Tredje Natur

Store: Pathways

When renovating pathways, create water storage below pathways where possible and in concert with larger adjoining stormwater storage areas, including targeted surface flooding.

2. Flood Targeted Pathways

A. Assess primary pathway requirements and designate secondary or non-essential pathways for temporary flooding when cloudburst events occur
B. Educate residents on expectations for flood and recovery periods as well as use of alternative pathways during these times
C. Pilot initial area and monitor for effectiveness, maintenance, and resident input following cloudburst event

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High**

IMAGE CREDIT: Water Flow Assessments | Amsterdam Rainproof

IMAGE CREDIT: Conducting Rainwater by Path | Amsterdam Rainproof | Workshop Dreiseitl

Zoned Flooding and Conveyance

Rainproof Amsterdam includes measures that incorporate zones of water conveyance along pedestrian and vehicular streets and pathways. Areas for recreation are designed for retention and conveyance during extreme rain events.

Store: Parking & NYCHA Streets

When improving parking or streets, use NYCHA parking areas and NYCHA internal streets for shallow storage.

1. Park and Store

A. Add subsurface storage and/or permeable pavers in parking spaces and parking lots
B. Use planned capital improvements as opportunities to amplify stormwater management potential

Suitability Index

- Maintenance Required: **$**
- Multifunctionality Achieved: *****
- Drainage Area: **Medium-Large**
- Groundwater Depth: **Low**

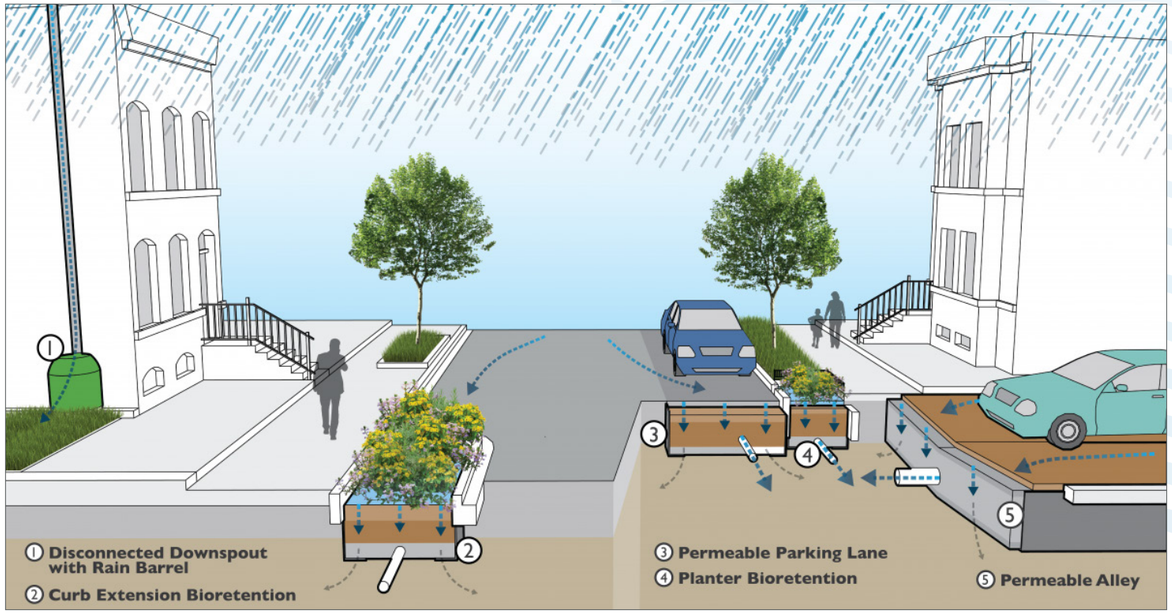


IMAGE CREDIT: DC Water - District of Columbia Green Infrastructure Plan

Parking and Alley Retention and Conveyance

The District of Columbia's Green Infrastructure Program, which is part of DC Water's Clean Rivers Project, mitigates the impact of extreme rain events through the implementation of green infrastructure projects throughout the city. Permeable parking lanes and alleys and planter bio-retention areas are strategically distributed to reduce the volume of combined sewer overflows to the District's waterways and to generally improve water quality.

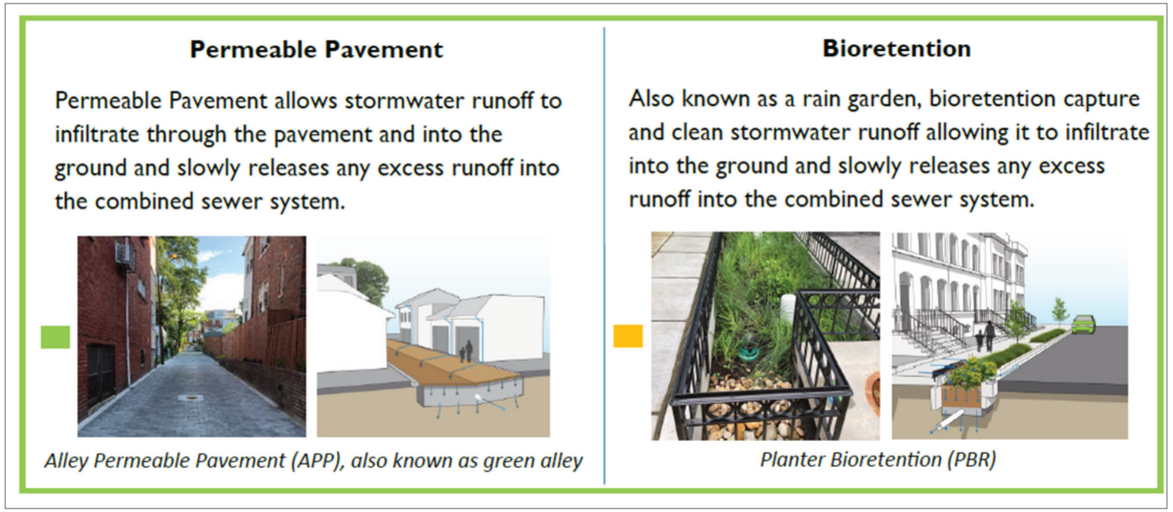


IMAGE CREDIT: DC Water - District of Columbia Green Infrastructure Plan

Store: Parking & NYCHA Streets

When improving parking or streets, use NYCHA parking areas and NYCHA internal streets for shallow storage.

2. Flood Targeted Parking

A. Flood parking lots to manage up to 2 inches of rainfall with an overflow to another detention area and high curbs
B. Break up parking surface and promote infiltration and shallow ponding

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

Langelands Plads Car Park and Stormwater Retention

The redevelopment of Langelands Plads in Copenhagen incorporates surface level recreation spaces, green roofs on site structures, and an underground car park for 200 cars. Permeable pavers or perimeter drains allow surface water to pass into infiltration crates or other absorptive layers that trap the water and slowly release it into the soil or municipal drainage system after a cloudburst rain event.

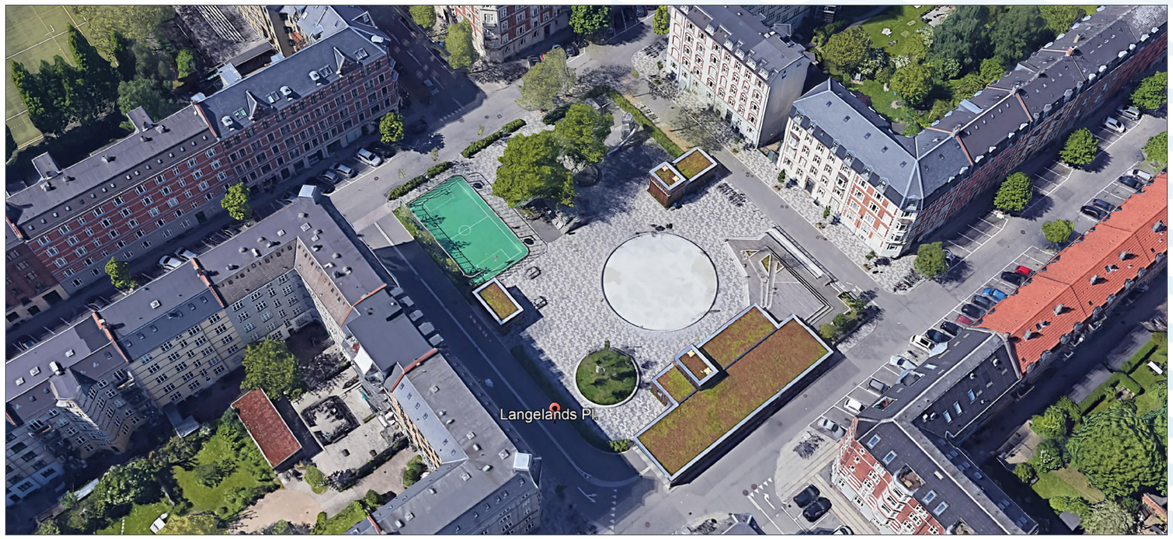


IMAGE CREDIT: Google Earth

IMAGE CREDIT: Infiltration Crates | Rainproof Amsterdam | www.indra-infra.com

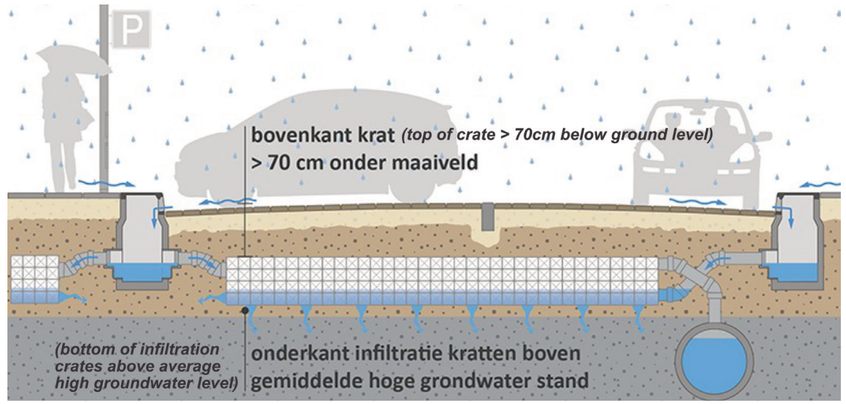


IMAGE CREDIT: Infiltration Crates | Rainproof Amsterdam | Atelier GREEN BLUE

Store: Open Spaces

Develop a NYCHA/City of New York District Open Space Cloudburst Plan in concert with an Open Space Planning and Hazard Mitigation Assessment for ingress/egress.

1. Catalog and Prioritize Impact Areas

A. Create a catalog of available park/play/sport areas and identify spaces that can flood in certain times. Prioritize open spaces that can do more work for water management
B. Connect systems, such as basketball courts, parking lots and adjacent open spaces with additional detention. When developing small activity spaces, oversize them for future points of water entry. When capital projects for surrounding green/open space are planned, grade those for drainage to the activity spaces
C. Add detention in areas that are fenced
D. Add infiltration by subsoiling and depaving
E. Improve evapotranspiration through targeted planting in open spaces

Suitability Index

- Maintenance Required: **$$$**
- Multifunctionality Achieved: ***
- Drainage Area: **Medium-Large**
- Groundwater Depth: **High or Low**

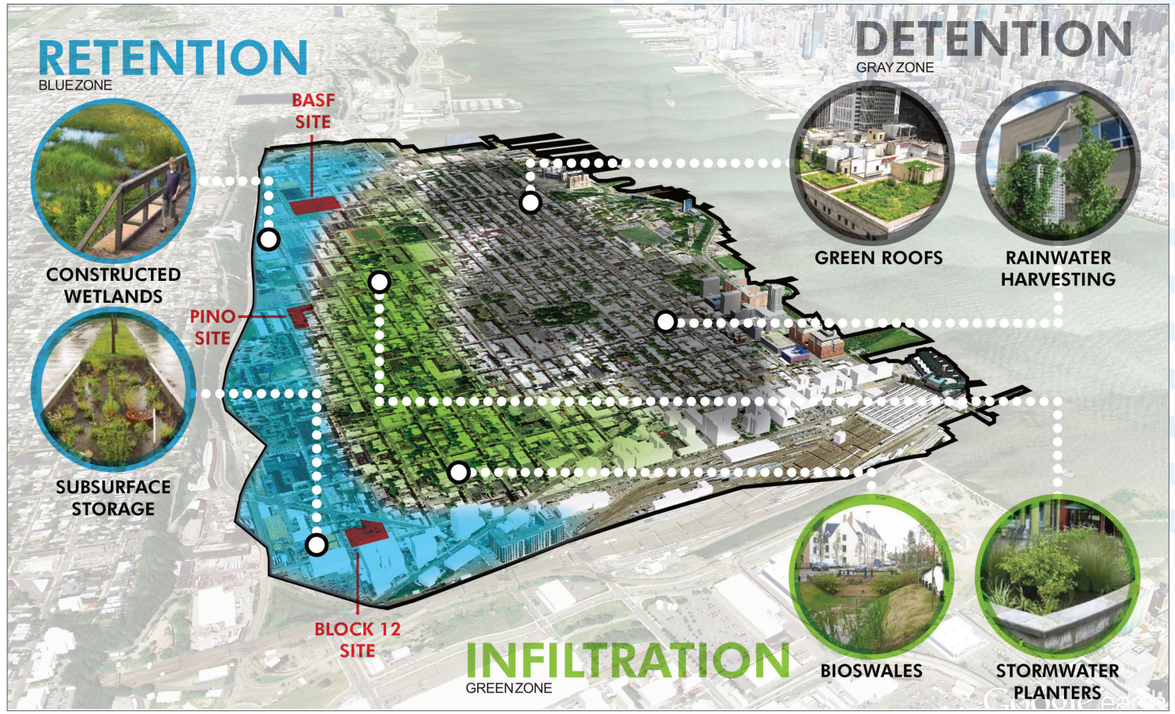


IMAGE CREDIT: City of Hoboken, NJ

City of Hoboken Infrastructure Strategic Plan, Hoboken NJ

In the aftermath of Hurricane Irene and Superstorm Sandy, the City of Hoboken established a green infrastructure (GI) strategic plan to help reduce pressure on the city's overtaxed combined sewer system. This effort created a citywide and district level GI framework, identified the most cost-effective, place-based management practices, improved the resilience of the transit network, located and prioritized assets most in need of protection, and developed implementation strategies for the city.

Store: Open Spaces

Develop a NYCHA/City of New York District Open Space Cloudburst Plan in concert with an Open Space Planning and Hazard Mitigation Assessment for ingress/egress.

2. Expand Open Space and Tree Network

A. Expand open spaces to include sunken playgrounds and sunken grassy zones that can also serve as rainwater detention areas
B. Leverage NYCHA Open Space Plan and organizations such as GrowNYC to identify and connect open spaces for varieties of uses
C. Connect Open Space Plan and Urban Forest Plan to prioritize and enhance existing tree canopy and pathways. Include intentional understory planting
D. Improve existing tree health by enlarging grills around trees. Add infiltration crates under new tree pits. Allow pathways for trees to link to each other underground
E. Connect NYCHA Urban Forest and NYC Street Trees programs to aggregate value of canopy for multiple benefits
F. Develop a NYCHA "Cool Walk" app (modeled on Barcelona's Cool Walk app), that highlights NYCHA's developments' varying microclimates and the cool pathways to notable or important landmarks around each development

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ***
- Drainage Area: Small-**Medium-Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: 2020 Green Infrastructure and Biodiversity Plan - City of Barcelona, Spain

Barcelona Greening and Cool Walks Programs

Barcelona's city-wide 2020 Green Infrastructure and Biodiversity Plan establishes a network of connected parks to balance and regulate the water cycle, improve air quality, improve urban acoustic quality, regulate the ambient humidity level and improve urban comfort, and generate ecological habitat connectivity throughout the city.

The city of Barcelona created an online tool, Cool Walks, to help identify cool pathways between start and stop points that compares heat exposure along the route at different times of day.

IMAGE CREDIT: Barcelona Cool Walks: Barcelona Regional Urban Development Agency

Restore: Buildings

Designate building areas for resilience hubs that function for community support throughout the year. Connect exterior restoration areas to these hubs to improve respite opportunities for residents who may not use play spaces.

1. Connect Respite Areas

A. Use berming techniques outside of buildings to redirect water and create a sense of place using natural features. Consider different berming options to establish unique micro-environments that encourage group activity such as senior gatherings, or children's play
B. Link indoor and outdoor spaces to encourage use and grow community awareness

Suitability Index

- Maintenance Required: **$$-$$$**
- Multifunctionality Achieved: ****-*****
- Drainage Area: **Small or Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: Outdoor Room - Cornell University Campus - Long Island City - Climate Adaptation Partners

Connective Outdoor Spaces

The Cornell campus on Long Island City, NY incorporates multiple landscaping strategies to manage stormwater and to create active, useful outdoor spaces for students, staff, and visitors. Areas of respite, contemplation, and play are woven between the buildings with many offering direct connection to these outdoor rooms.

Restore: Pathways

Create stimulating and restorative environments as part of primary and secondary pathways, seeking ways to improve resident experiences alongside ecosystems.

1. Create Berms Around Pathways, Parking, and Streets to Direct Water

A. Reuse excavation material to create infiltration berms for landscape visual interest, for children's play, or for community performances to save soil on-site and reduce removal costs. Design for ease of maintenance and spatial variety
B. Program targeted pathways for dry access while designing others to handle temporary flooding
C. Engage the community in the planning and monitoring of these pathways

Suitability Index

- Maintenance Required: **$-$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Small**
- Groundwater Depth: **High** or **Low**

Lessons Learned: Locate in drainage area and with existing site contexts. May be used to create landscape complexity, and to limit, or expand, viewsheds. Balance cut/fill, strategic placement of soil to protect buildings from flooding.

IMAGE CREDIT: Hunter's Point South Park - Climate Adaptation Partners

Landscape Conversion

Hunter's Point South Park in Long Island City transformed 11 acres of abandoned post-industrial waterfront into a sculpted landscape and new wetlands that provide protection from tidal surge. Walkways at higher elevations provide dry path access along the East River connecting services and recreational facilities while lower pathways providing access to the water's edge will be inundated during an extreme storm.

IMAGE CREDIT: Hunter's Point South Park - Climate Adaptation Partners

Restore: Pathways

Create stimulating and restorative environments as part of primary and secondary pathways, seeking ways to improve resident experiences alongside ecosystems.

2. Rewild Targeted Areas

A. Rewild designated areas to improve overall biodiversity and ecosystem function, such as transitioning mowed lawn to a wild meadow. Connect to community activities such as migratory birdwatching
B. Use slightly more landscaped buffer between rewilded areas and pathways or traditionally maintained areas. Such buffering helps to convey the intention of rewilding
C. Develop and connect pollinators across NYCHA and between NYCHA and City Parks. Connect these to food events and urban farming at NYCHA developments
D. Develop educational materials and activities to explain program intentions and how these changes provide value to residents

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ***
- Drainage Area: **Small-Medium-Large**
- Groundwater Depth: **High or Low**

Historic Fourth Ward Park - Phase I

HDR, working for the Atlanta Beltline, the City of Atlanta Department of Watershed Management, and the City of Atlanta Department of Parks and Recreation, transformed a blighted, underutilized five-acre parcel in Atlanta's historic Fourth Ward into a valuable urban park that also solves a significant drainage issue in the area. Located adjacent to the new Beltline Trail, the park addresses the persistent challenge of combined sewer overflows (CSO's) and stormwater runoff in the Clear Creek Watershed. A stormwater retention basin within the rewilded landscape anchors the new park, which also includes walking trails, urban plazas, native plants, and an amphitheater. Design and engineering solutions combine to "celebrate" water as it enters the site from each direction.

IMAGE CREDIT: HDR | Urban Land Institute (ULI) | Steve Carrell

IMAGE CREDIT: HDR | Urban Land Institute (ULI) | Atlanta Beltline

Restore: Parking & NYCHA Streets

Create stimulating and restorative environments as part of primary and secondary pathways, seeking ways to improve resident experiences alongside ecosystems.

1. Add Step Pools to Manage Sheet Flow and Create Visual Interest

A. Introduce step pool systems along the gutter of NYCHA streets. Use mineral materials for aesthetics and/or for holding and reducing velocity of water
B. Establish neighborhood fitness programs, like 'Step this Way' to encourage walking for exercise or respite alongside step-pools or between milestones in a connected green network

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ****-*****
- Drainage Area: **Small or Large**
- Groundwater Depth: **High or Low**

Lessons Learned: These can work without vegetation and will require maintenance for collected debris.

a. Step Pool Conveyance

Step pool conveyance channels lined with mineral and other natural materials are effective in filtering and holding stormwater sediments as the water is conveyed. A portion of the stormwater flow is converted to groundwater flow during the conveyance. Step pools also help remove some of the pollutants and sediments contained in the stormwater.

b. Fitness Programs

Cascades Park in Tallahassee, FL incorporates a fitness trail as an added benefit to the stormwater management infrastructure incorporated into the park.

IMAGE CREDIT: Step Pools - Biohabitats

IMAGE CREDIT: Cascades Park Fitness Trail - Climate Adaptation Partners

Restore: Parking & NYCHA Streets

Create stimulating and restorative environments as part of primary and secondary pathways, seeking ways to improve resident experiences alongside ecosystems.

2. Pilot Green Parking in Targeted Locations

A. Create green parking areas (parking gardens) that can further infiltrate water as well as provide alternative uses when car spaces are not in use, such as social activities or farmer's markets
B. Monitor stormwater, maintenance, and urban heat island indicators to determine benefits of replicating strategy

Suitability Index

- Maintenance Required: **$-$$**
- Multifunctionality Achieved: ****-*****
- Drainage Area: **Small or Large**
- Groundwater Depth: **High or Low**

IMAGE CREDIT: Technical University of Denmark - Google Earth

Technical University of Denmark Parking Garden

As part of a broader effort in Copenhagen to reduce the impact of hard impervious surfaces on the environment, the Technical University of Denmark employs permeable parking surfaces throughout its Lyngby campus' parking zones. In addition to filtering and reducing pollutants and reducing runoff quantity, these green zones provide significant cooling effects for the campus.

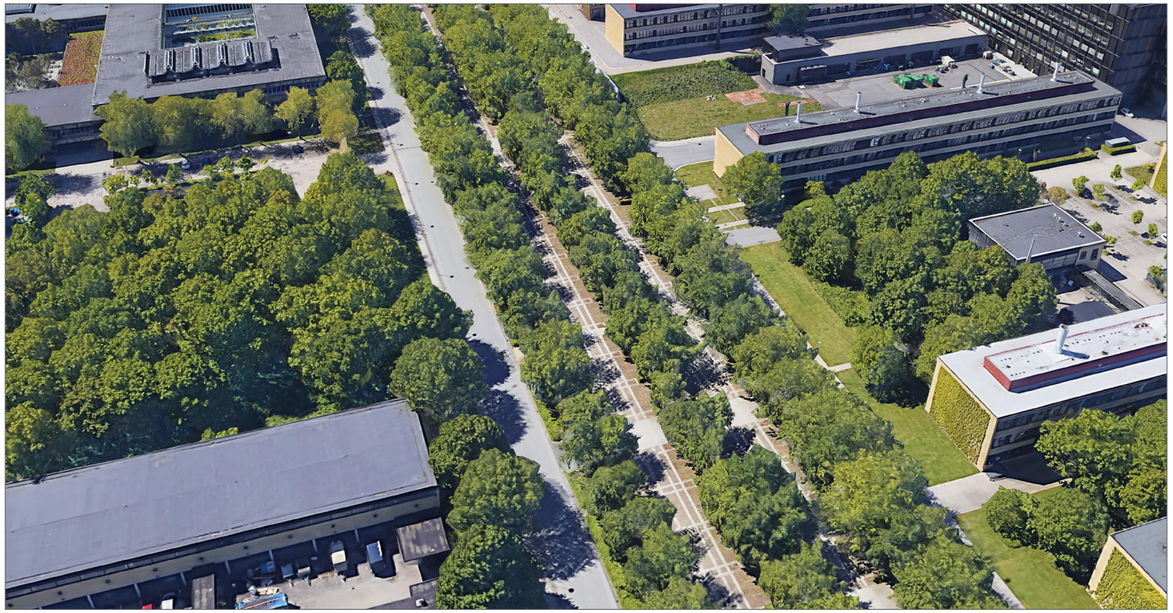


IMAGE CREDIT: Technical University of Denmark - Google Earth

Restore: Open Spaces

Improve open space performance through targeted, low-cost interventions such as subsoiling. Plan for longer-term changes such as daylighting stream flows.

1. Target Areas for Subsoiling, Renourishment, and Reseeding

A. Loosen soil (with tractor/deep tilling from 6 - 22 inches) for greater stormwater penetration and storage, and to slow runoff from existing open spaces
B. Renourish soil with compost to restore soil health
C. Reseed degraded areas with groundcover that has deep roots which will help to maintain structure

Suitability Index

- Maintenance Required: **$**
- Multifunctionality Achieved: *****
- Drainage Area: **Small or Large**
- Groundwater Depth: **High or Low**

Lessons Learned: Consider soil context, typical site access and site use, before determining to subsoil. Protect area from heavy traffic use. Such small interventions over large areas make a difference. Subsoiling restores the natural hydrology of the site and cleans and cools water before entry into waterways. With relatively low costs and ease of implementation as well as manageable operations and maintenance every year or two, this tactic should be one of the first on NYCHA's list for open space restoration.

Subsoiling

Subsoiling is the process of loosening and decompacting soils that have, over time, been compacted from traffic, animals, or other natural processes. Benefits include improvements in infiltration and rooting by removing layers of compaction that can develop just below the top-soil layer.

IMAGE CREDIT: Aerating and Decompacting the Soil - Biohabitats

IMAGE CREDIT: Prepping Area for Renourishment and Reseeding - Biohabitats

IMAGE CREDIT: Compost Material for Soil Renourishment - Biohabitats

Restore: Open Spaces

Improve open space performance through targeted, low-cost interventions such as subsoiling. Plan for longer-term changes such as daylighting stream flows.

2. Daylight Underground Waterways

A. Open natural pathways/channel designs adjoining to open space where overflow, like a floodplain, could be held. By connecting water in this way, further leverage the sum of all on-site interventions

Suitability Index

- Maintenance Required: **$$**
- Multifunctionality Achieved: ******
- Drainage Area: **Small or Large**
- Groundwater Depth: **High**

Watercourse Daylighting

The process of identifying and uncovering, or daylighting, existing streambeds or watercourses and restoring them to their original riparian condition can have positive ecological, social, economic, and resilience impacts. Daylighting previously buried watercourses can reduce runoff, improve species habitat, and enhance the general quality of the environment. The City of Tallahassee, FL daylighted the St. Augustine Branch Stream as part of the development of Cascades Park. The park is, first and foremost, a stormwater management system designed to flood during cloudburst events and includes additional recreation, historical, and social amenities.

IMAGE CREDIT: St. Augustine Branch Stream, Cascades Park, Tallahassee, FL - Climate Adaptation Partners

Synthesis

Slow

Slowing water helps to reduce flooding and the burden on stormwater management systems

Store

Storing water temporarily reduces the immediate impact on stormwater systems at times of peak flow

Restore

Restoring degraded landscapes enhances the services that these spaces provide and NYCHA residents' quality-of-life

Buildings

are the housing units and the support buildings owned by NYCHA

1. **Make Smarter Roofs**
2. **Work with the NYCHA Community to Reduce Building Wastewater Load in Concert with Stormwater Practices**

1. **Detain Water on Roofs and Divert Water from Internal Drain Systems**

1. **Connect Respite Areas**

Pathways

are the paved sidewalks that connect NYCHA buildings to one another and to the public sidewalk street system

1. **Raise, Grade, and Depave**
2. **Integrate Shade with Canopy and Tree Well Improvements**

1. **Walk and Store**
2. **Flood Targeted Pathways**

1. **Create Berms Around Pathways, Parking, and Streets to Direct Water**
2. **Rewild Targeted Areas**

Parking & NYCHA Streets

are the parking lots, parking adjacent areas, and internal NYCHA streets

1. **Introduce More Permeability, Detention, and Retention**
2. **Improve Canopy and Shading Within, and Adjacent to, Parking and Streets**

1. **Park and Store**
2. **Flood Targeted Parking**

1. **Add Step Pools to Manage Sheet Flow and Create Visual Interest**
2. **Pilot Green Parking in Targeted Locations**

Open Spaces

are the structured play spaces such as playgrounds, basketball courts, soccer fields, and outdoor seating areas and lawns

1. **Retrofit Existing Lawns and Enhance Canopy and Understory**
2. **Reduce Impervious Surfaces**

1. **Catalog and Prioritize Impact Areas**
2. **Expand Open Space and Tree Network**

1. **Target Areas for Subsoiling, Renourishment, and Reseeding**
2. **Daylight Underground Waterways**

Limitations & Recommendations

1. Planned Investments Evaluated

The half-day workshop presented challenges in terms of the time required to fully explore and coordinate across systems. While having three separate teams focused on Slow, Store and Restore generated unique ideas, the time limitation reduced the opportunity for shared ideas to be explored as systems-based strategies. For NYCHA to make the most use of these various strategies, each campus or district within its portfolio can be assessed as a system of connections. Those connections can then be cross-referenced with NYCHA's planned capital improvements, and those of adjoining city or privately held properties, to determine where to find the most leverage for stormwater management and how to practically apply guidance over time, with each capital project building deeper capacity.

2. Lessons Learned

Recently NYCHA-completed CSO-focused green infrastructure improvements represent significant investments and are representative of NYCHA's commitment to the health and resilience of the City and of the residents served by the agency. Other key expenditures, while providing significant benefits to the residents, provide key lessons that can guide NYCHA in expanding its portfolio of resilient infrastructure when viewed through the lens of this workshop. The recently completed sunken basketball court at Brownsville, for example, is a great amenity typology that could be enhanced in future executions to provide the additional benefit of a stormwater holding site. It will be important for NYCHA, in concert with DEP, to determine where, within the portfolio of proposed projects and other capital investments, there are opportunities for interventions to gain greater functionality.

3. Systems Perspective Needed

Water management works best at a systems level. Given NYCHA's portfolio scale, a watershed or "CSO-shed" analysis would help NYCHA understand stormwater and coastal flooding at a district level and the ways in which the NYCHA developments' stormwater relates to surrounding communities. This could be particularly valuable in consideration of saltwater intrusion and how NYCHA's campus stormwater management might be best leveraged to reduce that intrusion.

Similarly, as NYCHA considers how to proceed, it could be helpful to pilot on different types of campuses, such as denser sites with less green spaces as compared to park-like settings, and if applicable, sites with combined sewer as compared to sites with separated sewers.

4. Circulation Priorities Defined

Proposed solutions can be integrated with circulation analyses to understand which pathways are essential for emergency ingress and egress during flooding and which are less crucial or secondary.

5. Community Included

'Nothing about us without us' is a maxim that NYCHA follows thoughtfully. As referenced in their Connected Communities work, "Community engagement is a trust-building exercise, and projects that promote an inclusive participatory design are more likely to succeed." (See NYCHA Connected Communities, page 33) The community is a central figure in brainstorming and developing ideas that move from community participation to community leadership. Community characteristics, interest areas, and diversity should be part of the reprogramming for stormwater. This short workshop did not include direct engagement with residents and so the ideas offer a toolkit of options, but not site-specific solutions.

6. Site Specifics Analyzed

By focusing on developing a toolkit of possibilities, this panel lacks the specifics of any site infrastructure, the unseen network of underground connections, that introduces opportunities and challenges to the types of transformational changes that are possible at NYCHA.

7. Impacts Verified

Lastly, without community input, site specifics, and design development, the panelists were not able to provide magnitude or volume of stormwater managed, or costs.

Similarly, the workshop was unable to explore how NYCHA might monetize the value of stormwater capture at a neighborhood scale. If NYCHA were to explore the possibilities for net positive stormwater capture, i.e. holding water that falls outside of NYCHA boundaries for the greater good of the community, there may be ways to value that contribution and explore impact investing or other revenue-generating options worth piloting.

IMAGE CREDIT: "Cloudburst at Zürich Stadeholfen 2" by Ramón Cahenzli | CC BY 2.0

About the Experts

The Urban Land Institute extends its thanks and appreciation to the experts who shared their perspectives, experiences, and insights during the site tours and workshop.

Amy MacDonald
Principal & Head of Resilience - **Thornton Tomasetti**

Amy MacDonald oversees Thornton Tomasetti's resilience practice and has a broad background in geotechnical engineering, hazard mitigation, disaster response and recovery work. She specializes in providing clients with strategies to offset physical and financial risk and has consulted on numerous projects ranging from the everyday to the catastrophic. Amy has managed multi-hazard risk assessments, resiliency and mitigation design projects for property owners, insurance companies and public entities. Her experience spans four continents and includes leadership roles in the response, damage assessment and recovery phases of natural disaster events, such as the 2007 Northland floods and landslides, the Gisborne earthquake in 2007 and the 2010-11 Canterbury earthquake sequence, all in New Zealand, as well as Hurricanes Harvey, Irma, Maria and Sandy in the U.S.

Barbara Barnes, RLA, LEED^{AP}
Project Manager - **HDR**

Barbara Barnes' is a registered Landscape Architect who currently works as a Project Manager for Henningson, Durham, and Richardson P.C. on sustainable urban landscapes in the New York Metro Area. She focuses on habitat restoration and green infrastructure. Currently, as part of a HDR team, Barbara is working with the New York City Department of Environmental Protection and Department of Parks and Recreation to integrate stormwater best management practices, such as bioswales, permeable pavement, and detention and infiltration techniques into city parks.

Haythem Shata, EIT
Design Engineer - **Sherwood Design Engineers**

Haythem Shata has nearly a decade of experience as a civil engineer working on projects throughout the region, nation, and internationally. This includes green infrastructure and design at the institutional and city scales. He is a strategy driven engineer who specializes in sustainable, adaptable, and resilient solutions that fit within a project's identity past and present. Through his projects, Haythem promotes water balance, low impact design, flood mitigation, and green infrastructure planning throughout the nation. At Sherwood, Haythem has worked on several sustainability driven projects include NYC & ATL Water Reuse Studies, Resilient Bridgeport, Google District Stormwater, Semarang – Water as Leverage, Tulane SSE District, Gowanus Canal CSO Impact Study, Domino Sugar Blackwater Feasibility Study, Atlanta Bellwood Quarry Park, Oceanix Floating City, and Atlanta Boulevard Crossing Park. Prior to joining Sherwood, he had worked on projects throughout the Southeast Region and led efforts to optimize green infrastructure measures for projects throughout Atlanta including Kathryn Johnson Memorial Park and The Kendeda Building, which implements Living Building design. These designs were adapted to fit within the layers of history, infrastructure, and drainage patterns to create an appropriate green infrastructure system treating millions of gallons of stormwater a year. He spent his early career implementing the adaptive integration of the Georgia Tech Stormwater Master Plan and campus master plans with flood mitigation, green infrastructure, ecology, blackwater reuse, and connectivity. Haythem's ambition has helped him solve complex stormwater management and utility infrastructure issues using sustainable approaches. His abilities of creating visualizations that represent the built framework help define design considerations for sustainable and connective communities and campuses.

Janice Barnes, PhD, LEED^{AP}, RELi^{AP}
Founding Partner, **Climate Adaptation Partners**

Janice Barnes, founding partner of Climate Adaptation Partners, a NYC-based woman-owned business, focuses on planning, advocacy, and partnership-building for climate adaptation. With over 30 years of experience, technical training in architecture and organizational behavior, she helps clients to critically evaluate their possible adaptation pathways given current and expected exposures and link these to appropriate design and financing or funding options. Working from the intersection of climate change and public health, Janice links environmental, social and economic indicators to advance resilience principles and connect knowledge across communities. Recent work includes collaboration with The Nature Conservancy and Southern Environmental Law Center tracking federal disaster funding, the City of Houston Resilient Neighborhoods, a replicable resilience district program, Resilient by Design Amsterdam focused on heat and health, Charleston Medical Resilient Health District, New York City Mayor's Office of Resiliency AdaptNYC, City of Hampton Newmarket Creek Resilience Plan which leveraged Environmental Impact Bond funding to capitalize resilience projects and ClimateReadyDC, a globally-recognized climate adaptation plan. Prior to starting CAP, Janice led the global resilience lab for Perkins+Will, working with 24 offices across multiple countries to advance resilience in concert with in-country initiatives.

About the Experts

Justine Shapiro-Kline
Associate - **ONE Architecture & Urbanism**

Justine Shapiro-Kline is an architect and planner with nearly a decade of experience working with communities, public agencies, and organizations on strategic initiatives, revitalization plans, and visioning efforts for adaptation to climate change and its impacts. Her practice prioritizes participatory design and integration of natural systems to support the development of sustainable communities and resilient places. She is an Associate at One Architecture & Urbanism in New York City and the co-founder of the Community Adaptation Learning Exchange, a peer-learning collective focused on advancing climate adaptation efforts at the community level.

Kevin Dahms, PE
Water Resource Engineer - **Biohabitats**

Kevin Dahms is a water resources engineer working out of Biohabitats' Hudson River Bioregion. His interdisciplinary background in engineering and environmental science led to a passion for incorporating ecological design into stormwater management, urban planning, and coastal resilience initiatives. He has applied this approach to a variety of green infrastructure, low impact development (LID), watershed planning, hydrologic monitoring, habitat restoration, and coastal protection projects. He has led and participated in various phases of project implementation including planning, site investigation, survey, conceptual through final design, construction documents, permitting, construction oversight, operations and maintenance, and stakeholder engagement. In his free time, he enjoys hiking, running, and paddling along the waterbodies, in the watersheds, and through the habitats that are the focus of his restoration and preservation work.

Lot Locher
International Director for Climate - **ONE Architecture & Urbanism**

Lot Locher is an architect, urbanist and strategist who set up the internationally acknowledged social-network organization Amsterdam Rainproof to make the capital of The Netherlands climate robust. Based on its success, she initiated the nationwide organization, Together Climate Proof, part of the Dutch water management Deltaprogram Adaptation (2018). She worked as a strategist and program manager on urban climate adaptation for the public water-cycle company Waternet and the Metropolitan Region of Amsterdam, mainstreaming climate adaptation in all policies and actions of public and private urban stakeholders.

Meghan Gloyd
Senior Water Resources Engineer - **Biohabitats**

Meghan Gloyd is a water resources engineer with fourteen years of experience in stormwater management, stream restoration design, hydrologic & hydraulic modeling, and development of construction plans. She has worked on projects at both the site and watershed scales with private homeowners and municipalities. Her experience also includes construction oversight and inspection. Prior to joining Biohabitats, Meghan was contracted to the Division of Watershed Stewardship within the State of Delaware Department of Natural Resources and Environmental Control providing engineering and project management services to both the Dam Safety Program and the Drainage Program. She reviewed sunny-day failure models and mapping, performed hydrologic and hydraulic modeling on state owned high-hazard dams, and performed dam inspections for the dam safety program. Her work for the drainage program included project management for contracted projects, engineering design for drainage and stream restoration project, cost estimates, and channel maintenance. Meghan is proficient in AutoCAD, HEC-RAS, HEC-RAS 2D, HEC-HMS, HydroCAD, HY-8, ArcGIS, and Visual Basic.

Michael Spina, RLA, CERP
Associate - **SCAPE**

Michael Spina has over a decade of experience in ecological landscape design and works with project teams to develop strategies that enhance ecosystem structure and function. He is focused primarily on the planning, design and execution of living shorelines and green infrastructure, paying particular attention to waterfront access, soils, streetscapes and habitat restoration. Michael holds a Master's in Landscape Architecture from the City College of New York (CCNY) and a Bachelor's in Urban Studies and Architecture from Fordham University.

Nathalie Beauvais
Community Planning Resiliency Lead - **HDR**

Nathalie Beauvais is an architect, planner and urban designer who brings design and stakeholder engagement to the forefront of her projects, working for the development of resilient buildings, grey and green infrastructures, nature-based solutions, and innovation for integrated design approaches. She has led Climate Change Vulnerability Assessment and Resiliency Plans for several cities and state agencies including the Massachusetts Department of Housing and Community Development, the City of Cambridge, MA, and Washington D.C. She is also leading the resiliency expertise for projects in Canada developing guidelines for the Kingston Health Center, Ontario, Canada. She contributed to The World Bank final report for Sustainable and Resilient Futures for Ho Chi Minh City, Vietnam. She has been teaching on resiliency and sustainability at Harvard University Graduate School of Design, Northeastern University and Wentworth Institute of Technology, since 2011. In 2016, Ms. Beauvais started the BSA/BSLA Global Design Initiative for Refugee Children. The Initiative was awarded the 2020 AIA National Collaborative Achievement Award.

Yadiel Rivera-Diaz, PLA
Partner, Landscape Architect - **Marvel**

Yadiel Rivera-Diaz is a registered landscape architect with 16 years of experience designing landscape architecture, architecture and urban design projects in the United States, Puerto Rico and abroad. He leads Marvel's landscape architecture studio where he has been managing various landscape and open space master plans projects. Through his experience as a multidisciplinary designer, he has developed an interest for negotiating the intersection between interior and exterior, the natural and urban, with a strong focus on designing together with the communities the projects serve. He was the project manager in charge of the design and construction oversight of the first ever open streetscape and park along the Las Vegas Strip, bringing back native desert vegetation and local noble materials to Las Vegas, while keeping its sense of wonder and excitement. He currently manages various projects in NYC, including Bronx Point, a waterfront promenade project along the Harlem River that extends Mill Pond Park to the south, creating a new nature walk framed by a renewed native ecosystem, and open access and views to the water for the neighbors in the Bronx.

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