Southwest and Buzzard Point Flood Resilience Strategy

June 2, 2023

Draft for Public Review

DEPARTMENT OF ENERGY & ENVIRONMENT

GOVERNMENT OF THE DISTRICT OF COLUMBIA
MURIEL BOWSER, MAYOR

RESILIENT DC

ACKNOWLEDGEMENTS

The Southwest and Buzzard Point Flood Resilience Strategy was completed by the District Department of Energy and Environment (DOEE) in partnership with a wide range of civic group representatives, District agencies, and neighborhood residents, property owners, and other members of the Southwest and Buzzard Point community. This Strategy would not have been successful without the integral participation of these community stakeholders, as well as District and Federal partners. In particular, we would like to acknowledge the Southwest Business Improvement District, Capital Riverfront Business Improvement District, SW DC Action, Southwest Neighborhood Assembly (SWNA), and ANC 6D.

District and Federal partners were involved from start to finish, participating in interagency meetings, one-on-one meetings, and attending public events. Public sector agencies who contributed to the development of the Strategy included:

- District Department of Transportation (DDOT)
- DC Department of Parks and Recreation (DPR)
- DC Office of Planning (DCOP)
- District Department of Energy and Environment (DOEE)
- District Department of Homeland Security and Emergency Management Agency (HSEMA)
- DC Housing Authority (DCHA)
- DC Water
- Washington Metropolitan Area Transit Authority (WMATA)
- National Capital Planning Commission (NCPC)
- National Park Service (NPS)
- Commission of Fine Arts
- US Army Corps of Engineers (USACE)
- Fort L. McNair

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Ramboll — Bright ideas. Sustainable change.

moody graham

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designgreen

KARP STRATEGIES

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KEY TERMS

Blue-Green Infrastructure (BGI): Stormwater management projects that connects urban stormwater functions (blue) with vegetation systems (green) and offers valuable solutions for urban areas facing the challenges of climate change. BGI generates social and environmental value for the local area and may often reduce the need for traditional grey infrastructure.

Climate Factor: A climate factor is a complex multiplier applied to present-day precipitation patterns to account for expected changes to intensity and frequency due to climate change. The climate factor is assessed depending on geographic location and return period informed by regional climate models.

Cloudburst Event: A sudden, heavy downpour where a large amount of rain falls in a short amount of time. Cloudburst events can overwhelm storm sewers, causing flooding, property damage, disruptions to critical infrastructure, and pollution to waterways. “Cloudburst” is often used interchangeably with other terms such as “extreme rainstorm,” “extreme rain event,” or extreme precipitation.

Co-Benefits: Co-benefits is a term often used to describe the added benefits of BGI, in addition to the primary benefit of flood risk reduction. Commonly cited co-benefits of BGI include improved air quality, added recreational value, moderated micro-climate, enhanced traffic safety, biodiversity and noise reduction. Thus, BGI achieves goals beyond traditional stormwater infrastructure. This is valuable because in dense urban environments it is important for spaces to achieve multiple functions and goals.

Conveyance System: Stormwater facilities that are intended to transport water in a controlled way to floodable detention sites. Examples include drainage pipes, roadways, and bioswales.

Detention System: Stormwater facilities that are used to temporarily store water in a controlled manner during cloudburst events. Once the storm passes and the drainage system empties, detention facilities drain into the existing sewer network. Examples include bioswales, sunken athletic fields, and sunken parking lots.

Design Storm: A design storm is a defined rainfall event including potential climate factors, whose intensity, duration, and frequency are selected as a desired level of protection and design criteria for resilience planning.

Green Infrastructure: Measures that use plant or soil systems, permeable surfaces, and landscaping to store, infiltrate, or absorb stormwater and reduce flows to sewer systems and waterways.

Nature-Based Solutions: Planning, design, management, and engineering practices that mimic natural features and processes into the built environment to provide environmental, social, and economic benefits and promote adaptation and resilience.

Rainwater-driven Flooding: When rainfall cannot drain to sewers or natural waterways nor infiltrate into the ground, it will accumulate on land that is normally dry. This type of flooding can happen quickly during heavy rains (flash flooding) when sewers are overwhelmed or during normal rainfall events when runoff gathers in low lying areas.

Return Period: The return period defines how frequently and how intense rain events of the same magnitude will occur in a specific location. For example, a ‘10-year event’ would have a 10 % chance to occur every year. This does not guarantee that this rain event would occur once every 10 years but would instead provide the probability that the storm would occur in a given year.

Riverine Flooding: Flooding as a result of upstream rainfall causing overflow downstream in the river or a result of storm surge.

Service Level: The stormwater service level describes the expected or designed capacity of the storm sewer system. Service Levels are often expressed using a Return Period, such as a 5-year rain event.

Storm Surge: The rise in seawater or river water level including wave action and potential freeboard caused by a coastal storm.

Ringsted Torv.
Place: Ringsted, Denmark.
Source: Ramboll.

INTRODUCTION

Project Overview

The purpose of the Southwest and Buzzard Point Flood Resilience Strategy (the Strategy) is to develop a new approach to protecting the Southwest and Buzzard Point neighborhoods from flooding from extreme rain events. Extreme rain events are projected to become more frequent and damaging with the impact of climate change. For communities like Southwest and Buzzard Point with large public housing developments, clusters of especially vulnerable populations, and critical pieces of infrastructure within its flood plain, this is an added risk that requires the District of Columbia to adopt a new approach to stormwater management and open space. For this reason, the District Department of Energy and Environment (DOEE) worked with residents, stakeholders, and government agencies, both local and federal, to develop this Southwest and Buzzard Point Flood Resilience Strategy. The Strategy creates a network of Blue-Green Infrastructure leveraging open spaces and streets to increase flood resilience while providing additional benefits for residents such as improved parks, increased greenery, lower summer temperatures, and safer streets.

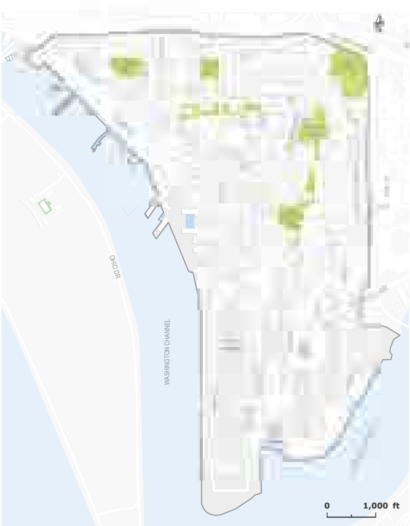


Figure 1: Project Area Map

Source: Ramboll, DC Open Data

The genesis of this project can be traced back to the DC Office of Planning's 2015 SW Neighborhood Plan. The SW Neighborhood Plan identified the 100-year floodplain in the Southwest neighborhood, which is home to several thousand District residents, including hundreds of public housing residents as a concern to be further studied. In addition to recognizing vulnerable populations, planners identified several large open spaces and parks in the flood plain as an opportunity to combine state-of-the-art and forward-thinking stormwater solutions with improved parks for residents. Since then, DC planners and staff have been advocating for further study of this flood plain in several city-wide and local plans, including Climate Ready DC, the Buzzard Point Vision Framework Plan, Resilient DC, and the updated

DC Comprehensive Plan. In 2016, Climate Ready DC recognized Southwest DC as a Priority Planning Area with "increased vulnerability to climate change". In 2019, Resilient DC then selected Southwest as one of its two pilot locations. According to Resilient DC,

> "large areas of Southwest DC are at risk from several types of flooding. In this area, we will create a strategy to design, prioritize, and construct capital improvements on parklands (e.g., Randall, Lansburgh, 3rd and I Street Park, and King Greenleaf) and transportation right-of-way to manage stormwater and mitigate flood risk. This strategy will also identify and adopt Special Design Guidelines for Southwest DC, such as parks that capture and treat large amounts of stormwater."

To do so, the District set aside close to $500,000 of local capital funds for DOEE to develop a strategy to increase the community's flood resilience.

With the funding in place for the study, the District turned to the Federal Emergency Management Agency (FEMA) for funding to implement the Strategy. In 2021, the District of Columbia Homeland Security and Emergency Management Agency (HSEMA) received two grants from the FEMA Building Resilient Infrastructure and Communities (BRIC) grant program totaling about $18,000,000 to construct the first pilot project identified in the Strategy and to fund community engagement activities. The District will match the federal funds with $6,000,000 of local funding.

Once the District had funding in place it procured the services of a mix of international and local firms to support the development of the strategy. The lead firm for the study is Ramboll, a Danish architecture, engineering, and consultancy firm known for its leadership in flood resilience engineering. Ramboll was supported by a set of local firms including landscape architecture firms with a strong local record in designing sustainable landscapes in the nation's capital.

DOEE, with the support of its consultants, kicked off the public planning process in March of 2022 and, after multiple community engagement workshops, completed the Southwest & Buzzard Point Flood Resilience Strategy in June of 2023 after a public review and comment period.

Project Summary

Overall Approach

The integrated network of Blue-Green Infrastructure (BGI) projects resulting from this strategy is designed to protect the community from flooding due to extreme rain events. Re-designed open spaces and streets will function as a network of connected, floodable, multipurpose infrastructure that can retain excess stormwater during extreme rain events and easily return to their primary function after the excess stormwater is absorbed or conveyed away.

Ramboll has developed a four-step approach to cloudburst resiliency planning, based on experiences from Denmark and around the world. Geographic Information System (GIS) data acts as the foundation of the study and is crucial in providing a solid basis for informed decision-making. Spatial overlay of datasets and analyses at multiple levels help to identify potential synergies and cumulative effects. The four steps in the process are (Figure 2):

1. Determine Risk
2. Plan & Design
3. Measure Effect
4. Evaluate Costs

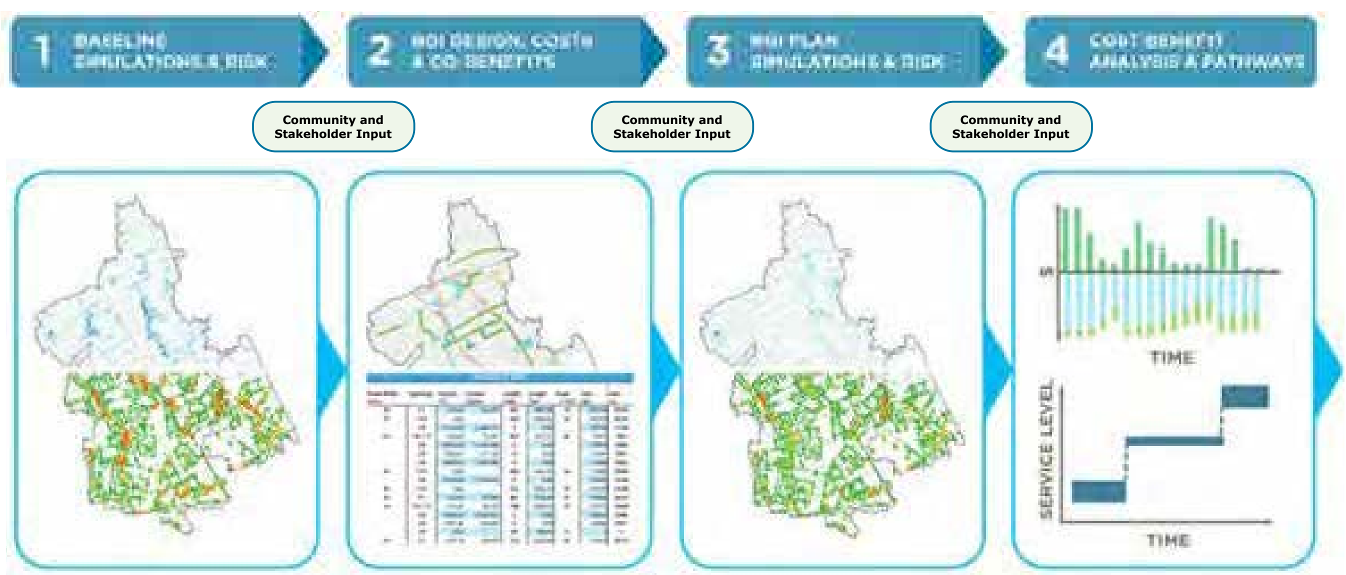


Figure 2: Cloudburst Resiliency Approach

Source: Ramboll

This is an iterative process, moving from initial determination of risks to the development of a Flood Resilience Strategy, and documenting the adaptation effect through a Benefit-Cost Analysis (BCA). The initial risks assessment (1) informs the BGI Network Plan & Designs (2). The effects of the proposed plan are measured (3) against predetermined design criteria using flood and risk models. If the desirable outcomes are not met iterations are activated until the desirable impacts is reached. Cost, benefits, and co-benefits are evaluated (4) in a BCA including the direct costs of project implements, risk reduction benefits, as well as broader co-benefits of implementing the BGI Network, such as traffic safety, energy savings, and improved recreational assets.

Applying BGI for stormwater management can create additional social value by

Keeping temperatures cool in the summer

Creating spaces for recreation

Creating spaces for sport and play

Creating spaces for gathering and community events

Improving air quality and biodiversity

Summary of Project Objectives

The Southwest and Buzzard Point Flood Resilience Strategy aims to mitigate the risk of stormwater flooding while simultaneously building spaces and resources that strengthen the health and wellbeing of residents and their environment. Recognizing the legacy of inequitable urban renewal programs and development schemes in Southwest that, over half a century ago, resulted in the relocation and concentration of vulnerable populations in the floodplain, this Strategy is founded on building resilience for at-risk populations and those with less adaptive capacity in the face of a changing climate. Community engagement, interagency collaboration, and a holistic approach to community planning have informed these BGI projects.

Incorporating BGI into civic spaces and the public realm is an opportunity to rethink urban environments and create value for the community beyond simply managing stormwater. In addition to managing stormwater volumes, BGI increases the quality of urban spaces by:

- Moderating temperatures in the summertime
- Improving air quality
- Filtering and treating stormwater runoff to reduce pollutants
- Creating spaces for environmental education
- Creating spaces for sport and play
- Improving gathering spaces for community events
- Providing restorative and calm spaces for passive enjoyment
- Improving traffic safety and promoting alternative means of transportation

Planning Process and Outcomes

Over the course of the Strategy development, from March 2022 to June 2023, the project team met with residents, local stakeholders, and District and Federal Agencies. At three key milestones during the process, the team held workshops to gather feedback on project objectives, preliminary project ideas, and conceptual designs. Finally, a draft of the Strategy was made available to the public for a review and comment period before being finalized and published in June of 2023. This community planning process has culminated in the creation of a Strategy for Southwest and Buzzard Point to mitigate stormwater flooding from extreme rain events. Once implemented, the Strategy's BGI Network will also reduce more common, nuisance flooding that has a negative impact on quality of life within the community. In addition to developing a BGI Network for the entire Project Area, this process also included development of conceptual designs for Lansburgh Park, Delaware Avenue, and 2nd Street and schematics for King Greenleaf Park since these projects have been identified during the planning process as pilot projects to be implemented first.

The Strategy includes the following components. Each of these are summarized in this document. Where appropriate, more detailed content are included in a technical appendix.

- Existing Conditions Analysis
- Existing and Projected Flood Modeling
- Blue-Green Infrastructure Framework Plan
- Typologies for BGI in Parks and Rights-of-Way
- Conceptual Design for Phase One project
- 10-year Construction Phasing Plan
- Benefit-Cost Analysis
- Financing Strategy

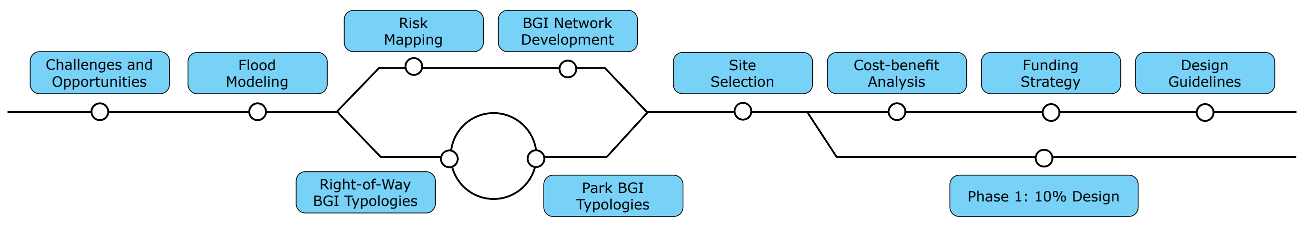


Figure 3: Project Timeline

Implementation and Next Steps

Following completion of the Strategy, the District should continue working toward implementation of each of the BGI projects described in this plan. Each individual project will provide some level of protection against future extreme rain events, but ultimately the District's goal should be to complete the BGI Network to mitigate future flooding. The first pilot project includes upgrades to Lansburgh Park and King Greenleaf Park and is already funded through a mix of FEMA and local funds. For completing the other BGI projects, the District will have to find funding through a mix of federal grants, local funding and partnerships with private and federal property owners. The Construction Phasing Plan and Financing Strategy in Section 5 provide a roadmap for completing future projects in the network.

The District has adopted enhanced stormwater protection regulations in recent years, evidenced by growing implementation of green infrastructure and standardization of best management practices throughout the city. The progressive approach to stormwater management extends beyond the public sector, with private developments incorporating nature-based solutions to manage stormwater on-site. It should be emphasized that the Strategy is not intended to replace the District's existing regulations. Rather, it should be viewed as an expanded protection against extreme rain events.

SECTION 1: DEFINING THE PROJECT AREA

Existing Conditions

Project Area

The Project Area for the Southwest and Buzzard Point Flood Resilience Strategy (the Strategy) encompasses almost the entirety of the SW quadrant of the District of Columbia. The Project Area is bounded by Washington Channel and the Anacostia River, providing access to waterfront assets and proximity to East Potomac Park. The northern boundary of the Project Area is I-395/695 and the eastern boundary is South Capitol Street SW. The National Mall, United States Capitol, and Washington Monument are approximately 1/2 mile north of the northern boundary. Nationals Park and the Navy Yard neighborhood are just east of the eastern boundary.

The Project Area is generally made up of two distinctive neighborhoods and a large military base. Southwest is the northernmost neighborhood, extending from I-395/695 to P Street. Southwest includes The Wharf along the Washington Channel; several public housing and subsidized housing developments (Greenleaf, Syphax, and James Creek); and open spaces such as Randall Park, Lansburgh Park, and King Greenleaf Recreation Center. Several of these communities and assets are within the large floodplain that cuts through the Buzzard Point peninsula and goes north reaching the National Mall. Major roadways in Southwest include Maine Avenue along the Wharf, M Street (the primary east-west route), and Delaware Avenue. Delaware Avenue was one of the original diagonal axes designed by Pierre L'Enfant and was originally intended to provide an unobstructed view toward the U.S. Capitol Building. Today, however, Delaware Avenue is cut off by I-395 and serves only local traffic.

The Buzzard Point neighborhood extends south of P Street and east of 2nd Street. The Buzzard Point neighborhood has almost completely transformed from an underutilized industrial area of stone-crushing plants, cement manufacturing and scrap yards, to a new mixed-use neighborhood. This redevelopment occurred following the 2018 development of Audi Field, the stadium that hosts the D.C. United and Washington Spirit professional soccer teams which are major regional attractions. The area has seen substantial development in recent years and additional mixed-use developments are under construction or in planning stages. Most of these new buildings have been developed to meet or exceed the current flood plain regulations and are more resilient to potential flooding from the rivers than most older buildings in the area.

Finally, the Project Area includes Fort McNair, which is south of P Street and west of 2nd Street. Fort McNair is a U.S. Army fort that is home to the National Defense University, National War College, the Eisenhower School of National Security, and additional U.S. Army assets. The Fort has been an army post for more than 200 years making it the third oldest US military base by length of service. The military reservation was established in 1791 by Major Pierre Charles L'Enfant who included it in his plans for Washington, the Federal City, as a significant site for the capital defense. Additionally, the fort was also the site of the trial and execution of President Lincoln's murder conspirators. As such, Fort McNair is both a significant emergency asset as well as a historical site.

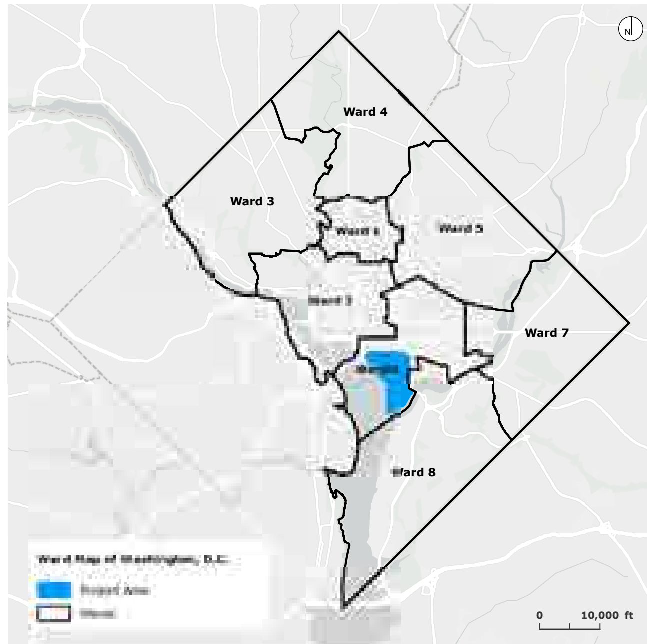


Figure 4: Washington, D.C. Ward Map

Source: Ramboll, DC Open Data

Figure 5: Three Neighborhoods

Source: Ramboll

Figure 6: Project Area Map

Source: Ramboll, Google Earth

Land Use

Existing Land Use in the Project Area is largely multi-family residential, however there are also three areas, The Wharf, the 4th St SW retail block, as well as new and planned development in Buzzard Point, that have seen substantial new mixed-use development in recent years. Multi-family land uses include three public housing sites: Greenleaf Gardens, Syphax Gardens, and James Creek, which are managed by the DC Housing Authority.

Greenleaf Gardens public housing complex includes a combination of mid-rise apartments and townhouses. The 15-acre facility was built during the DC urban renewal program in 1959 and includes a ball field, basketball court, and recreational center. There are a total of 493 units, ranging in size from 1-bedroom to 5-bedroom units. The DC Housing Authority, in partnership with Greenleaf District Partners (Pennrose, EYA, and Paramount), has released preliminary plans for the revitalization of this old public housing community by creating a new mixed-income community with additional market-rate and subsidized residential units, while replacing all public housing units with new ones for current residents. The new development would include a total of 1,400 units.

Syphax Gardens is a 174-unit facility with 2-bedroom and 3-bedroom units. The site also includes a social service center, baseball field, and basketball court. James Creek was constructed in 1942 and includes a total of 239 townhome units ranging in size from 1-bedroom to 6-bedrooms. The site includes a ball field and basketball court.

There are also smaller areas with single family housing, notably along G Street and Half Street. Key recreational sites include major parks, such as Randall Park, Lansburgh Park, and King Greenleaf Recreation Center. Audi Field is also categorized as a recreational land use within the study area. Finally, there are several major institutional land uses in the Project Area, including Fort McNair, the Southwest Public Library, Arena Stage, the newly opened Rubell Museum, the Buzzard Point Electrical Substation, and Jefferson Middle School.

The District's Future Land Use Map indicates that described land use patterns will generally remain the same. The Project Area will remain predominantly residential in character, with mixed-use districts at The Wharf and Buzzard Point. Fort McNair will remain a substantial Federal institutional use. Existing parks and recreational sites are expected to remain.

History

Emerging from master planner Pierre L'Enfant's District Plan completed in 1791, Southwest D.C. began largely as an industrial shipyard, with fishermen selling directly off their boats until the Municipal Fish Market was established. In the years that followed, Southwest grew into a bustling community with commercial corridors along 4th and 7th Streets. The diverse neighborhood was notable at the time for its large African American, Jewish, and immigrant populations.

Beginning in the 1950s, Southwest was targeted for inclusion in the federal government's urban renewal program. Under urban renewal, the neighborhood was essentially torn down and rebuilt from the ground up. A traumatic time in the history of Southwest DC, approximately 23,000 mostly Black and low-income residents and 1,500 businesses were displaced to make way for the redevelopment. With the large-scale urban renewal redevelopments of the 1970s, Southwest is now known for its distinctive mid-century modern architecture. It was during this period of urban renewal and redevelopment that federal planners decided to concentrate subsidized and, therefore, vulnerable populations in the less desirable James Creek floodplain that cuts through Southwest.

In the years that followed urban renewal, Southwest became known as a quaint residential neighborhood along the waterfront with a significant federal government footprint in Southwest Federal Center. It wasn't until the 2000s that the development boom occurring in D.C. reached Southwest; including a

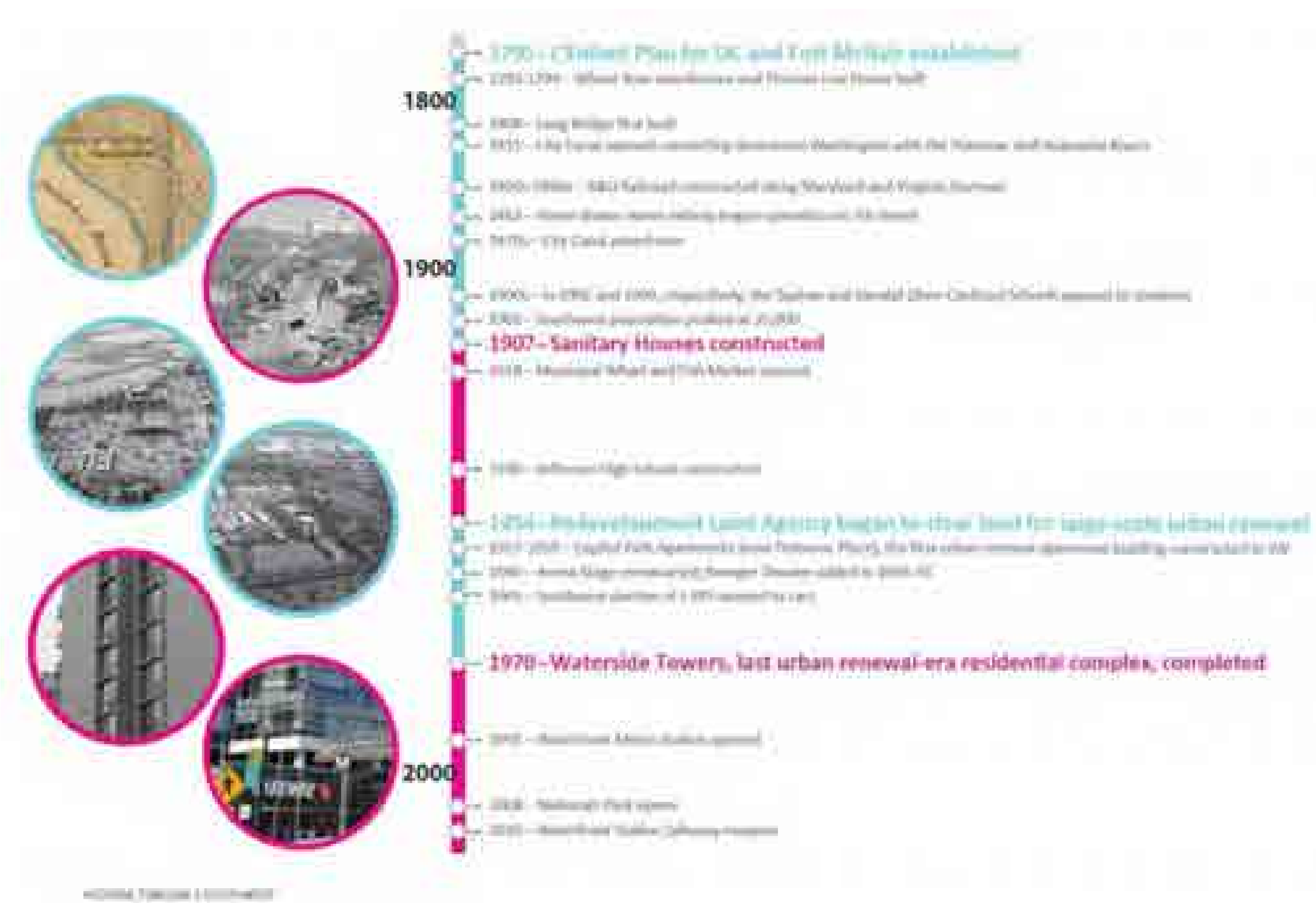


Figure 7: History of Southwest DC

Source: DC Office of Planning Southwest Neighborhood Plan redesigned Arena Stage, the new Waterfront Station complex, and the groundbreaking of the Wharf. Since this latest wave of development, there has been substantial investment in new construction that is slowly changing both economic activity and the character of the neighborhood.

In 2017, Hoffman-Madison Waterfront (HMW) opened the new $2.5 billion, mixed use waterfront neighborhood called The Wharf DC.

Most recently Southwest has also seen an increase in museums with the opening of the Museum of the Bible, in Southwest but north of the study area, and the recent opening in 2022 of the contemporary art focused DC Rubell Museum on I St SW.

Historic Aerial of the Wharf

4th Street SW

Southwest during Urban Renewal

Demographics

The vast majority of the planning area falls within four Census Tracts, which have been used to summarize demographic data for this study. Note that the Census Tracts are not contiguous with the Project Area boundary in some locations. The northern end of the Project Area extends marginally into two other Census Tracts, but the area is largely made up of government buildings and therefore does not have a substantial impact on demographic statistics.

According to the US Census 2020 American Community Survey, the median household income for DC was $90,842. Each of the census tracts in the Southwest and Buzzard Point neighborhoods have a similar or higher median household income, with one exception. Census tract 64, which encompasses much of Buzzard Point, has a substantially lower income of $27,574. This area includes James Creek and Syphax Gardens public housing facilities. Even as new luxury housing is developed in Buzzard Point, these public housing communities will remain.

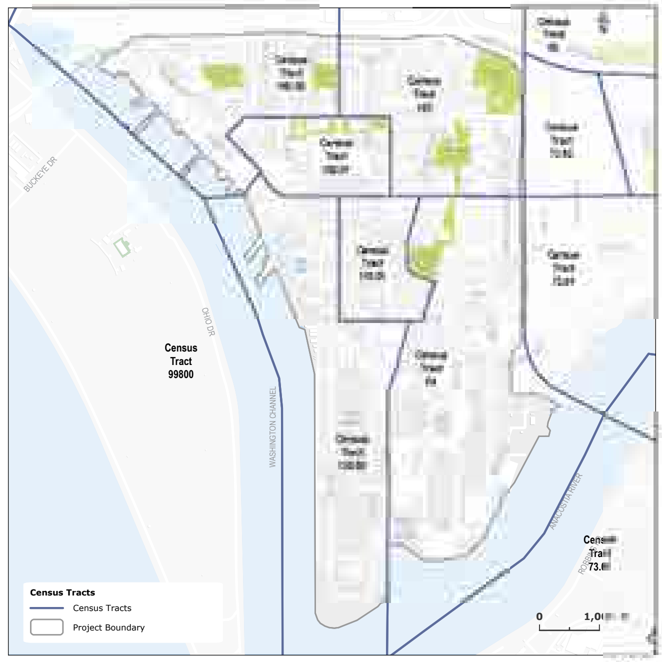
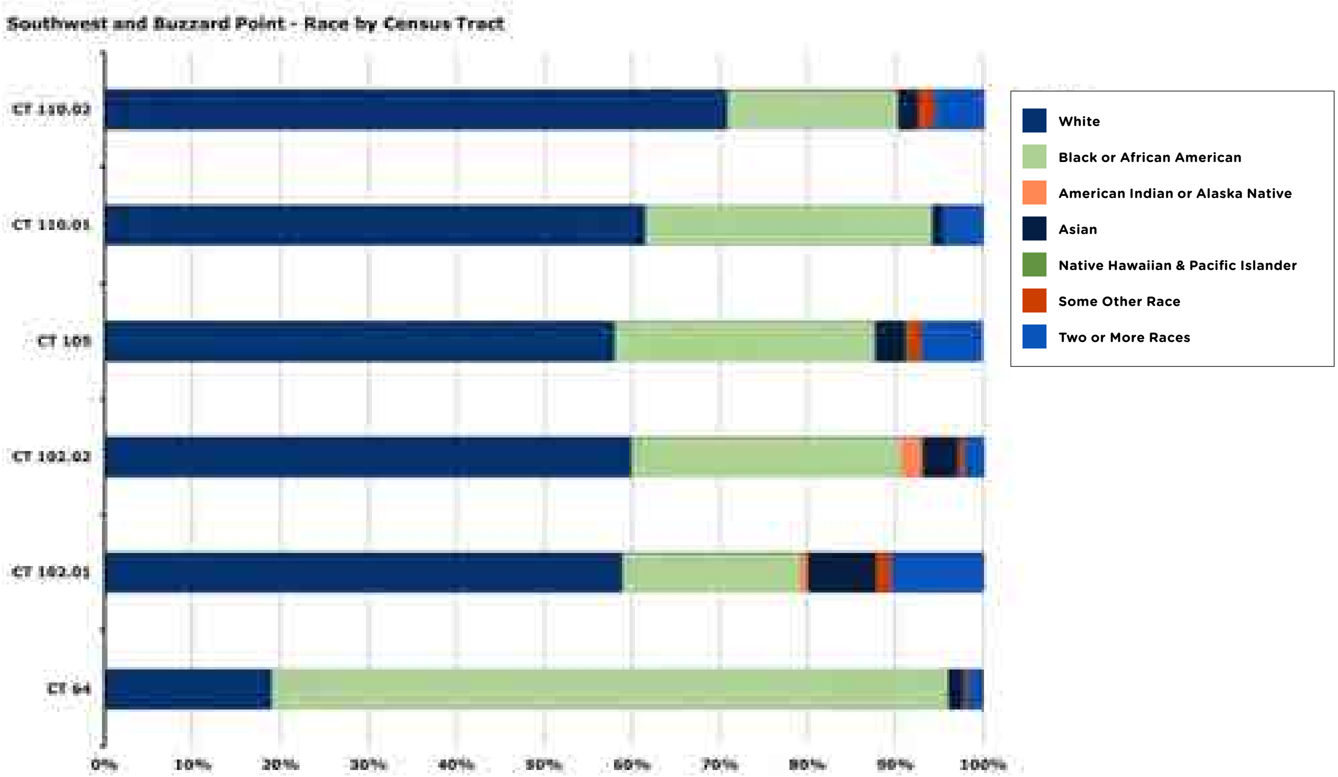


Figure 8: Census Tract Map

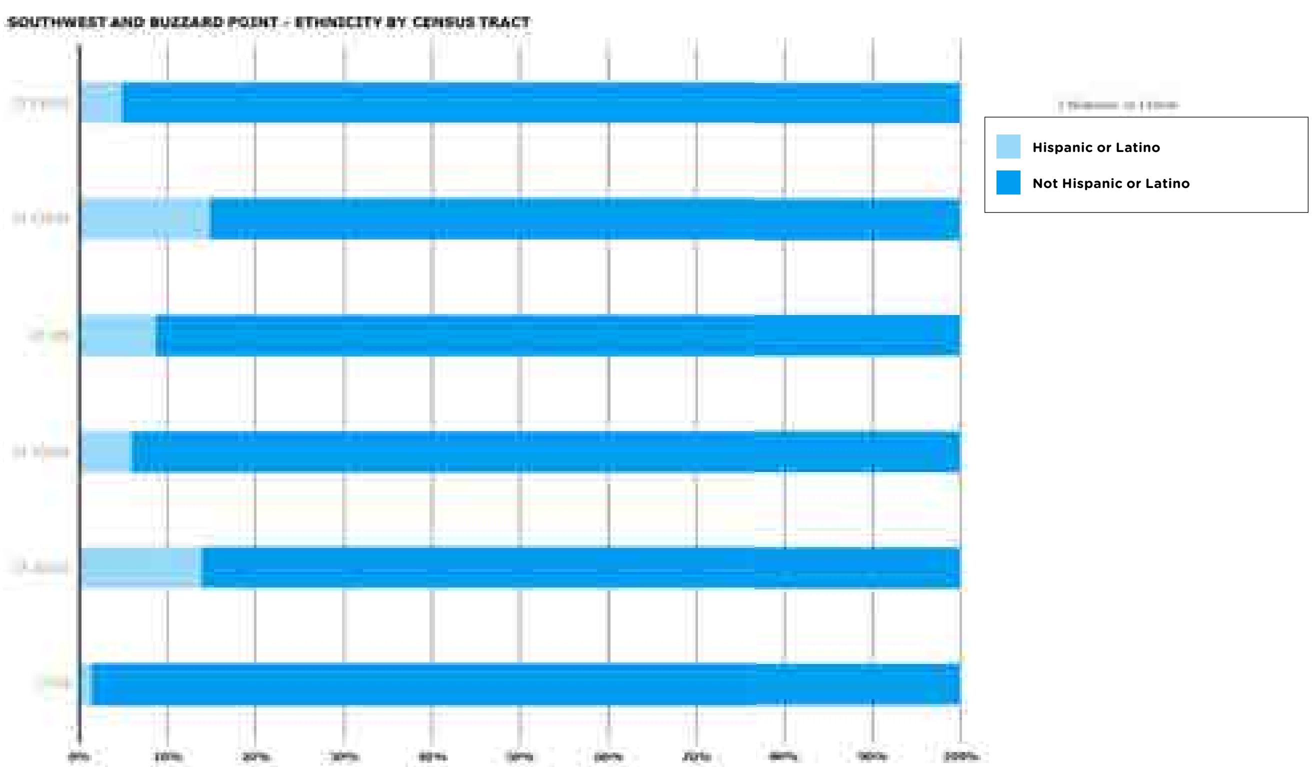
Source: Ramboll, DC Open Data

	Census Tract 102.02	Census Tract 105	Census Tract 102.01	Census Tract 110.01	Census Tract 110.02	Census Tract 64
Total Population	**1,707**	**3,927**	**2,297**	**2,345**	**1,760**	**2,602**
Median Age	**36**	**35**	**35**	**44**	**52**	**32**
Educational Attainment % of residents with a Bachelor's Degree	**33.5%**	**32.7%**	**40.3%**	**33.8%**	**25.6%**	**27.4%**
Median Household Income	**$100,333**	**$92,083**	**$85,648**	**$115,1114**	**$105,182**	**$27,574**

Source: U.S. Census Bureau, 2020 American Community Survey 5-year estimates



Source: U.S. Census Bureau, 2020 American Community Survey 5-year estimates



Source: U.S. Census Bureau, 2020 American Community Survey 5-year estimates

Transportation and Mobility

Roadway Infrastructure

The Project Area is well-served by major roadways, but access to public transit is not comprehensive. The northern and eastern boundaries of the site are I-395/695 and South Capitol Street. I-396/695 provides connections across the Potomac River to Virginia and east toward Maryland. South Capitol Street crosses the Anacostia River to the Anacostia neighborhood and also provides access north toward the U.S. Capitol. Within the Project Area, arterial roads include Maine Avenue, M Street, 4th Street, and P Street. Collectors include Delaware Avenue, Canal Street, and 2nd Street. Accessibility and operation of these roads is prioritized in the Blue Green Infrastructure Plan to preserve service routes and emergency evacuation during flood events.

Figure 9: Roadway Infrastructure

Source: Ramboll, DC Open Data

Public Transportation

The Project Area includes just one Metro station. The Waterfront station is located at the intersection of M Street and 4th Street and is serviced by the Green Line. The nearest Metro access to Orange, Silver, Blue, and Yellow Lines is at L'Enfant station (north of the Project Area). The Project Area is served by several bus lines, including the DC Circulator, P6, 52, and 74. Electric scooters and bike sharing have grown in popularity and are accessible throughout the Southwest and Buzzard Point neighborhoods. There are 8 Capital Bikeshare docking stations scattered throughout the Project Area.

Figure 10: Public Transportation Infrastructure

Source: Ramboll, DC Open Data

Bicycle Infrastructure

The Project Area is served by several bike lanes of varying types. There are new protected bike lanes on Maine Avenue, 2nd Street, P Street, and Potomac Avenue. The Maine Avenue bike lane is grade-separated from automobile traffic, providing increased protection and safety for bicyclists. The 2nd Street bike lane was recently converted from a parking lane and is separated from the lane of traffic by low concrete curbing. Other bike lanes in the Project Area are along 4th Street and I Street. These lanes are striped, but not separated from the lane of traffic with buffers or barriers. A more complete network of grade-separated and protected bike lanes would improve safety and encourage bicycle ridership in the Project Area.

Figure 11: Bicycle Infrastructure

Source: Ramboll, DC Open Data

Community Assets

The Southwest and Buzzard Point neighborhoods have a wide range of community assets that support local culture, education, recreation, and history. The Southwest Library is a critical resource that provides free community services ranging from Family Story Time to Tax Assistance sessions. Arena Stage is a beloved community anchor that's been in Southwest since 1960 and was the first racially integrated theater in Washington, D.C. There are several houses of worship in Southwest that serve members of the community, including a large Baptist community. Recreational facilities and parks such as Randall Field and King Greenleaf Recreation Center provide active outdoor space and programming opportunities for young people in the area. The SW Duck Pond also offers a shaded, urban retreat for residents, office workers, and students. The Southwest Farmer's Market is held in the parking lot opposite the Waterfront Metro station in addition to live music and events for community gathering.

Historic landmarks in the Project Area include the Pepco Buzzard Point Power Station, Army War College in Fort McNair, Saint James Mutual Homes, Thomas Jefferson Junior High School, Randall Public School, which has been and re-opened in 2022 as the Rubell Museum DC.

Educational assets in the Project Area include the National Defense University in Fort McNair, Jefferson Middle School, and Amidon-Bowen Elementary School. There are several parks and open spaces within the Project Area, but these are generally more prevalent in the northern section of the Project Area. These include Benjamin Banneker Park, Jefferson Field, Amidon Field, Town Center Park, Randall Field, Lansburgh Park, King-Greenleaf Park, Southwest Waterfront Park, and Buzzard Point Park. The Buzzard Point neighborhood to the south has fewer parks, mostly in the form of small waterfront parks owned by the National Park Service that are in need of improvement. Parks and greenspaces present an opportunity for improved civic space and stormwater management.

Social services, including affordable housing facilities, shelters, and homeless services, are also vital to the Southwest and Buzzard Point community livelihood.

Southwest's strong civic engagement and community organizing culture is rooted in its history of urban renewal, a recent history that created distrust in government initiatives and an urgency for community self-organizing. This long civic tradition has created meaningful social capital in the community made apparent by the number of community and civic organizations in the area including the Southwest Business Improvement District (SW BID), Southwest Neighborhood Assembly (SWNA), SW Action, a strong and active Advisory Neighborhood Commission (ANC), as well as one of the few truly hyper-local printed newspapers: The Southwestern.

Critical Infrastructure

Critical Infrastructure such as public safety assets, emergency services, and utilities are especially vulnerable to impacts of flooding. These assets must remain operational to support emergency preparedness in the event of extreme weather events and flooding. Critical infrastructure assets in the Project Area include the Metropolitan Police Department First District Headquarters, several fire stations, and the Pepco Power Station in Buzzard Point.

Figure 12: Critical Infrastructure

Source: Ramboll, DC Open Data

Water Infrastructure

Blue-Green Infrastructure works by combining nature-based solutions for managing stormwater with existing stormwater infrastructure. Therefore, the Blue-Green Infrastructure Network is developed based on an understanding of the existing stormwater and sewer network. The Project Area is served by several sewer sheds. Most of the sewer networks within the Project Area drain directly to the rivers through the Municipal Separate Storm Sewer System (MS4). During heavy rain events, stormwater runoff exceeds the capacity of the MS4 system, causing localized neighborhood flooding that puts properties at risk.

The north-eastern part of the site is a combined stormwater and sanitary sewer network and is directed to the DC Water Blue Plains treatment plant. Combined sewer overflows (CSOs) from the combined system may occur during heavy rain events when the volume of stormwater exceeds the pipe capacity carrying stormwater to the treatment plant.

The District has many policies in place to reduce stormwater runoff. The District Department of Energy and Environment (DOEE) seeks to reduce stormwater runoff with a series of laws and regulations, by providing the Stormwater Management Guidebook, and by offering incentives for property owners who construct green infrastructure facilities. Existing green infrastructure in the Project Area helps to reduce stormwater runoff and can improve the effectiveness of the Blue-Green Infrastructure network. Existing stormwater best management practices (BMPs) in the Project Area include bioretention, green roofs, pervious surfaces, rain gardens, and tree preservation.

Figure 13: Sewer Sheds

Source: Ramboll, DC Water

Combined Sewer Overflows (CSOs):
A combined sewer system collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe. Under normal conditions, it transports all of the wastewater it collects to a sewage treatment plant (DC Water Blue Plains) for treatment, then discharges to a waterbody. During heavy rain events, the volume of wastewater can exceed the capacity of the combined sewer system or treatment plant. When this occurs, untreated stormwater and wastewater, discharges directly to nearby streams, rivers, and other waterbodies. CSOs contain untreated or partially treated human and industrial waste, toxic materials, and debris as well as stormwater. They are a priority water pollution concern. (US EPA)

Figure 14: Gravity Mains

Source: Ramboll, DC Water

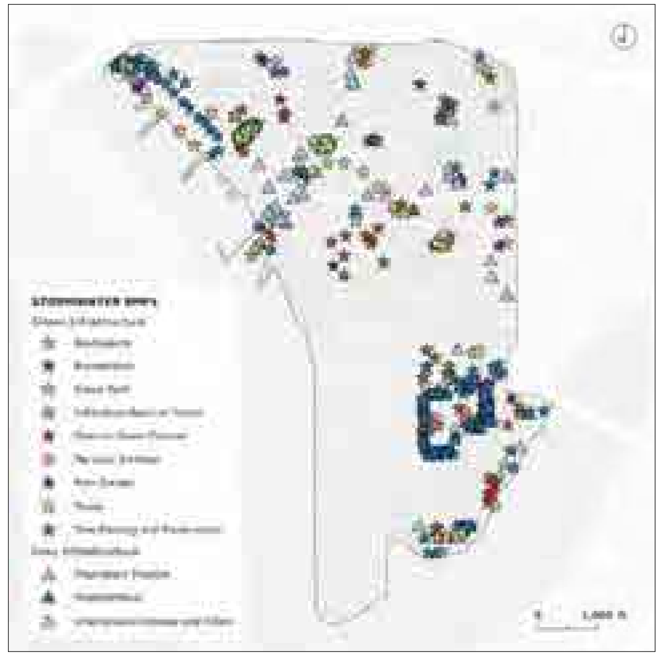


Figure 15: Stormwater BMPs

Source: Ramboll, DC Open Data

Previous Plans, Studies, and Applicable Regulations

The Southwest & Buzzard Point Flood Resilience Strategy builds on the foundation of a long sequence of local and city-wide planning documents. with a focus on sustainability, resilience to climate change, and flood mitigation. In particular, this Strategy was developed in order to comply with the 2021 District's Comprehensive Plan, which requires the District to create neighborhood-based flood mitigation strategies for communities known to have a flood risk. The District Department of Energy and Environment (DOEE) developed the Southwest & Buzzard Point Flood Resilience Strategy to meet this requirement and to create a roadmap for similar studies throughout the District.

A series of prior plans and studies has led up to the development of this Strategy. In 2016, the District created Climate Ready DC, which is the District's plan to adapt to climate change. Climate Ready DC includes strategies to adapt and prepare for more dangerous heatwaves, severe rainstorms, and flooding along the rivers. The plan specifically identifies Southwest DC as a priority planning area for flood resilience planning. In 2019, Resilient DC built on the objectives of Climate Ready DC to create the District's first resilience strategy to provide a roadmap to promote actions related to inclusive growth, climate change, smart cities, health, and equity. This Strategy is funded as a direct early implementation project of the Resilient DC plan. The DC Comprehensive Plan was completed in 2021, further solidifying the District's goals related to climate adaptation.

Most recently, the D.C. Flood Task Force formed in 2021 to identify policies and projects to bolster flood readiness and protect District residents and businesses from flood damage. As part of their recommendations, the Flood Task Force identified the Southwest and Buzzard Point neighborhoods as a priority area for flood resiliency work.

In addition, the District has conducted a series of plans within the Project Area to expand open space access, boost economic development, and increase housing opportunities within the Southwest and Buzzard Point neighborhoods (Figure 16).

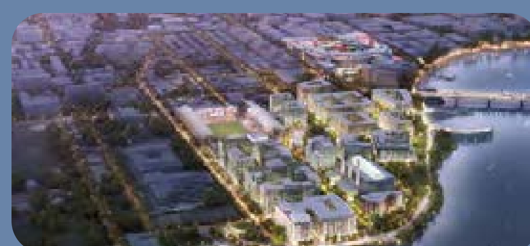
Timeline of Sustainability, Climate Resilience, and Flood Mitigation Plans that support the development and implementation of the Southwest and Buzzard Point Flood Resilience Strategy

Figure 16: Timeline of Sustainability, Climate Resilience, and Flood Mitigation Plans in D.C.

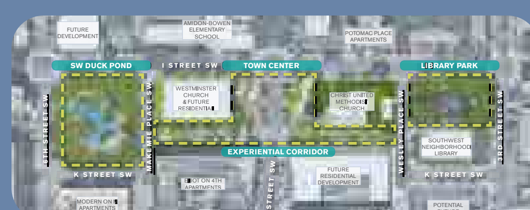
Anacostia Waterfront Trail
The 2003 Anacostia Waterfront Initiative (AWI) Framework Plan created an innovative vision for a revitalized Anacostia waterfront and the creation of new waterfront neighborhoods and amenities including Buzzard Point and the Anacostia Waterfront Trail. The continuous 20-mile trail, now almost fully complete, provides a new recreational amenity on both sides of the Anacostia River. The trail is designed for a wide range of users and provides seating, bike racks, and interactive maps. The new neighborhoods of Navy Yard and Buzzard Point which were created out of the redevelopment of marginal industrial areas, federal properties and surface parking lots, where first envisioned as part of the AWI Framework Plan.

Southwest Neighborhood Plan
The 2015 Southwest Neighborhood Plan is a community-based strategy to enhance parks, pedestrian and street connections, integrate community amenities, enhance transportation choices, and accommodate and guide the direction of future growth in the Southwest neighborhood. It was during this planning process that the city planners noticed the overlap between the SW flood plain and several public housing communities in SW (the threat) as well as its overlap with several large parks (the opportunity).

Buzzard Point Vision and Design Review Guide
Planning and urban design foundation to shape a mostly industrial area into a mixed-use waterfront neighborhood along the Anacostia River. This 2017 plan provides strategies for a coordinated approach to infrastructure and provides design guidance that will improve the physical and programmatic resilience of Buzzard Point.



Town Center Parks Plan
Visioning process to connect the public space that stretches from the SW Duck Pond Park to the 3rd and I St Park. The objective is to revitalize this park system with community input to better connect the neighborhood. The plan includes renovation to the SW Duck Pond and a vision for the larger Town Center Park system.



Greenleaf Redevelopment
The Greenleaf Redevelopment includes renovation of 1,400 affordable housing units and development of additional mixed-income units. The development is a public-private partnership between DC Housing and a private development team to preserve affordability of existing low-income units while improving existing units, constructing new housing units, and improving open spaces. The phased project provides needed infrastructure improvements, while ensuring that all current residents are re-housed in the new development so that no residents are displaced.

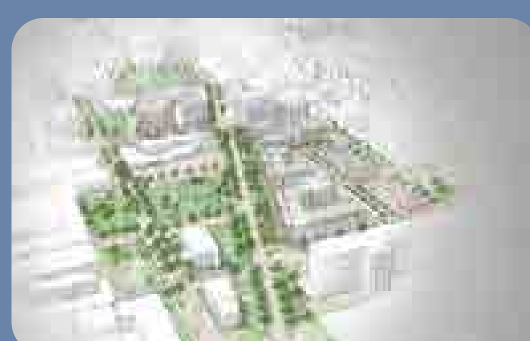


Figure 17: Visions and Plans for Southwest and Buzzard Point

Source: Ramboll, Google Earth

Opportunities and Challenges

Understanding the existing and future challenges and opportunities that may emerge in the Southwest and Buzzard Point neighborhoods is key to ensuring efficient and effective design of flood mitigation measures. The considerations for BGI projects are not limited to flood risk related themes, but also include local design preferences, public health, social cohesion, and the local economy. This Strategy also considers the potential barriers to implementing BGI projects, such as local and federal agency policies, private property, and the need to establish a firm business case to justify investment in new infrastructure.

Opportunities

Anacostia Waterfront Initiative provides a roadmap for open space improvements in the project area.

Long history of planning documents provide a foundation for the need for flood mitigation and a mandate from the District to seek out solutions.

The District has already made progress in developing strong stormwater management guidelines, providing a baseline understanding among District agencies and private developers.

Southwest Small Area Neighborhood Plan features the goal of enhancing existing parks and green spaces with sustainable stormwater management practices to reduce future flood risk.

Community members recognize the need for improved stormwater protections in the Project Area and were supportive of the Strategy throughout the planning process.

The Flood Task Force and development of the Integrated Flood Model indicate a groundswell of work within the District to improve flood mitigation measures. The Southwest & Buzzard Point Flood Resilience Strategy provides a roadmap to create similar Blue-Green Infrastructure Master Plans in other neighborhoods.

Challenges

BGI is a new concept in the U.S. context and is not currently included in D.C.'s policies and standards.

Important to consider how BGI projects intersect with other priorities, such as coastal flood protections, DDOT safe passage strategies, and other capital improvement plans.

Federal partners (Fort McNair, National Park Service) in the project area may be interested in stormwater management on federally owned property, but city agencies have no jurisdiction to mandate BGI projects on these sites.

The BGI network is generally limited to District-owned parks and rights-of-way to ensure that implementation is feasible.

Private property can provide a barrier to implementing BGI.

DC Flood Task Force

The Flood Task Force for the District of Columbia was established by the Office of City Administrator (OCA) in September 2021 to identify policies and projects to bolster flood readiness while equitably protecting the District's residents and economy from the damage that floods can cause.

The Task Force shall identify equitable ways to reduce the risk of water damage from coastal, interior, riverine, and sewer back up floods in the District, as well as ways to reduce financial impacts of flooding on low- and fixed-income homeowners. In considering potential actions, the Task Force shall prioritize the protection of vulnerable populations, maintenance of the District's affordable housing stock, increasing the District's housing supply in a safe and resilient manner, supporting ongoing economic development, and mitigating disparities in real estate access and equity.

The Task Force reports to the Deputy Mayor for Operations and Infrastructure (DMOI), who also serves as a voting member, and is jointly co-chaired by the Director of the Department of Energy and Environment (DOEE) and the Chief Executive Officer and General Manager of the District of Columbia Water and Sewer Authority (DC Water).

Public Workshop Event
Source: Ramboll.

SECTION 2: GATHERING INPUT FROM THE COMMUNITY

The Southwest and Buzzard Point Flood Resilience Strategy was developed with the input of community members and key stakeholders from start to finish. Community input was critical to ensuring that the proposed BGI solutions achieve the objectives and priorities of people who live and work in the Southwest and Buzzard Point neighborhoods. Input from the community helped the project team develop BGI projects that address stormwater flooding, while also creating co-benefits that improve quality of life for the local community. The key principles that guided the community engagement process included:

The planning process was developed with early and inclusive engagement that continued throughout the process. The goal of the community engagement plan was to foster meaningful dialogue to support stakeholder-driven design and deliver a transparent and accountable process.

The project team worked with DOEE and the Southwest Business Improvement District (SW BID) to identify community stakeholders. The extensive list of stakeholders who were invited to participate in the planning process included District and federal agencies, local community groups, public housing residents, large property owners, and the broader community in the Southwest and Buzzard Point neighborhoods.

The community engagement process was organized around three series of in-person workshops:

1. Listen (June 2022): Input from the community with respect to concerns about flooding and aspirations around open space, nature, and recreation.
2. Design (October 2022): Review the draft BGI Network Plan, identify synergies to community aspirations and challenges.
3. Pilot (February 2023): Co-design the Phase One pilot project to foster community ownership.

During each series of meetings and workshops, the project team worked with DOEE and the SW BID to hold inclusive and interactive events to share information about the planning process and gather feedback from the community. The outcomes of each series of meetings and workshops follows below. In addition to these in-person events, the project team also held several virtual meetings with critical District and federal agencies to ensure that the BGI Network Plan and pilot projects were consistent with agency priorities.

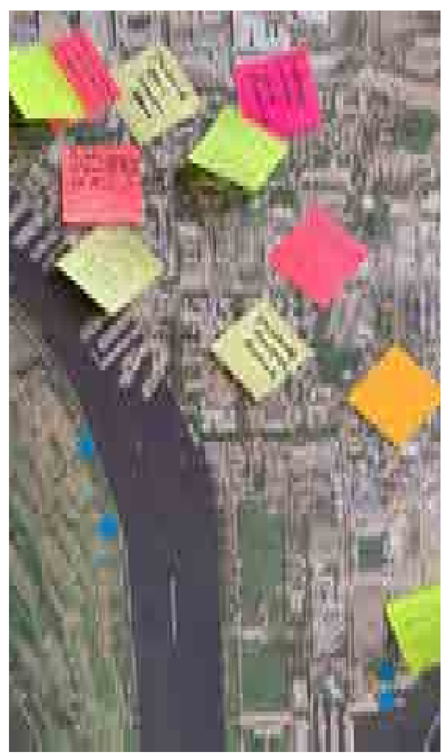
June 2022 Workshops

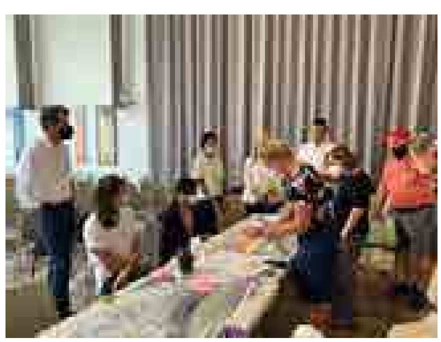
Civic Group Workshop

The Civic Group Workshop was held on Friday, June 24, 2022, at the Westminster Presbyterian Church. Invitees included a wide range of local community organizations representing the Southwest and Buzzard Point neighborhoods. Attendees included representatives from The Wharf, ANC 6, Capitol Riverfront BID, Southwest BID, Southwest Neighborhood Action, and Living Classroom, as well as representatives from DOEE and the project team.

The workshop began with a brief presentation about the planning process and objectives. Following the presentation, participants were led through a series of facilitated activities. First, they were asked to write one to two opportunities or challenges on post-it notes. These ideas were grouped thematically to provide input to the project team on key priorities. Participants identified major challenges related to historic development patterns in the neighborhood--notably, the location of public housing developments in low-lying, flood prone areas. However, participants also recognized opportunities for improved amenities and flood mitigation strategies in these same areas, since open spaces like Lansburgh Park and King Greenleaf Recreation Center could be leveraged for Blue-Green Infrastructure.

Then, participants were asked to draw on maps the location of existing flooding that they have experienced, as well as potential opportunities for new projects to address flooding. Big move ideas included covering I-395 with a park and daylighting James Creek Canal adjacent to 2nd Street. While some of these larger ideas may not be as feasible to implement, they highlighted the need to identify BGI strategies that also achieve other goals and priorities for the community, such as repairing the harm caused by urban renewal.





Flood Fest

On Saturday, June 25, 2022, DOEE hosted a Flood Fest in partnership with the Southwest Business Improvement District (SWBID). The Flood Fest was held at the Southwest Farmers Market and included information about the Southwest and Buzzard Point Flood Resilience Strategy, a link to provide additional feedback online, as well as water-themed games and activities for kids. Representatives from DOEE, the SWBID, and Ramboll attended the event, which attracted several dozen participants. Participants were able to review the informational materials displayed on posters and provide input about their experiences with flooding in the area directly to the project representatives and through the survey link.

Inter-Agency Workshop

On Monday, June 27, 2022, DOEE hosted an Inter-Agency Workshop, which included representatives of several District and Federal agencies. The objective of this workshop was to connect these different agencies, explore opportunities for innovation in the BGI plan, and initiate a discussion about defining design storm levels and acceptable levels of risk. Attendees included representatives from the District Department of Energy and Environment (DOEE), District Department of Transportation (DDOT), DC Water, District Department of Parks and Recreation (DPR), Homeland Security and Emergency Management Agency (HSEMA),the District State Historic Preservation Office (SHPO), DC Housing Authority (DCHA), National Capital Planning Commission (NCPC), the US Army Corps of Engineers (USACE), and the National Park Service (NPS), as well as members of the project team from Ramboll, Moody Graham, and Designgreen.

The workshop began with a brief presentation about the planning process and objectives. Following the presentation, participants gathered in small groups to review maps of flood models and discuss potential BGI projects.

There was no agreement during the workshop as to design storm, acceptable levels of risk, or climate projections for stormwater modeling. However, there was a wide interest in learning more about these aspects from other cities and taking the conversations to the District Flood Risk Task Force to advance on decision making within these critical aspects. The agreement was for Ramboll to bring the conversation to the group in October with recommendations for each of the aspects.

Major Property Owners Meeting

On Tuesday, June 28, 2022, DOEE hosted a meeting with major properties owners located in the Southwest and Buzzard Point neighborhoods. The objective of this meeting was to educate property owners about the project and start discussing potential synergies with recent and planned development in the area. Attendees included representatives from EYA, Donohoe, Akridge, Somerset Development, SWBID, and Capitol Riverfront BID, as well as members of the project team from DOEE, Ramboll, Moody Graham, Designgreen, and LAB.

The workshop began with a brief presentation about the planning process and objectives. Following the presentation, the group held an open question & answer session about key issues and opportunities. Then, the group gathered around maps of the project area to identify additional opportunity sites. The meeting helped to identify future development sites that could be targeted for coordination with the BGI Network Plan.

LISTEN: Key Takeaways

- Community members reinforced the need for BGI projects to help repair the harms of urban renewal by providing improved public space for the neighborhood.
- As an original L’Enfant Street, Delaware Avenue could be reimagined as a “green spine” though Southwest.
- There is an opportunity to implement BGI facilities at schools and sports fields to improve recreation assets while also mitigating rainwater flooding.
- BGI projects should be integrated into the Greenleaf redevelopment plan.
- Splash parks could double as BGI facilities in public parks, such as Randall Field.
- It is critical to coordinate with DDOT on BGI projects that would be designed in rights-of-way.
- There is a need to establish a design storm to guide the sizing of BGI facilities.

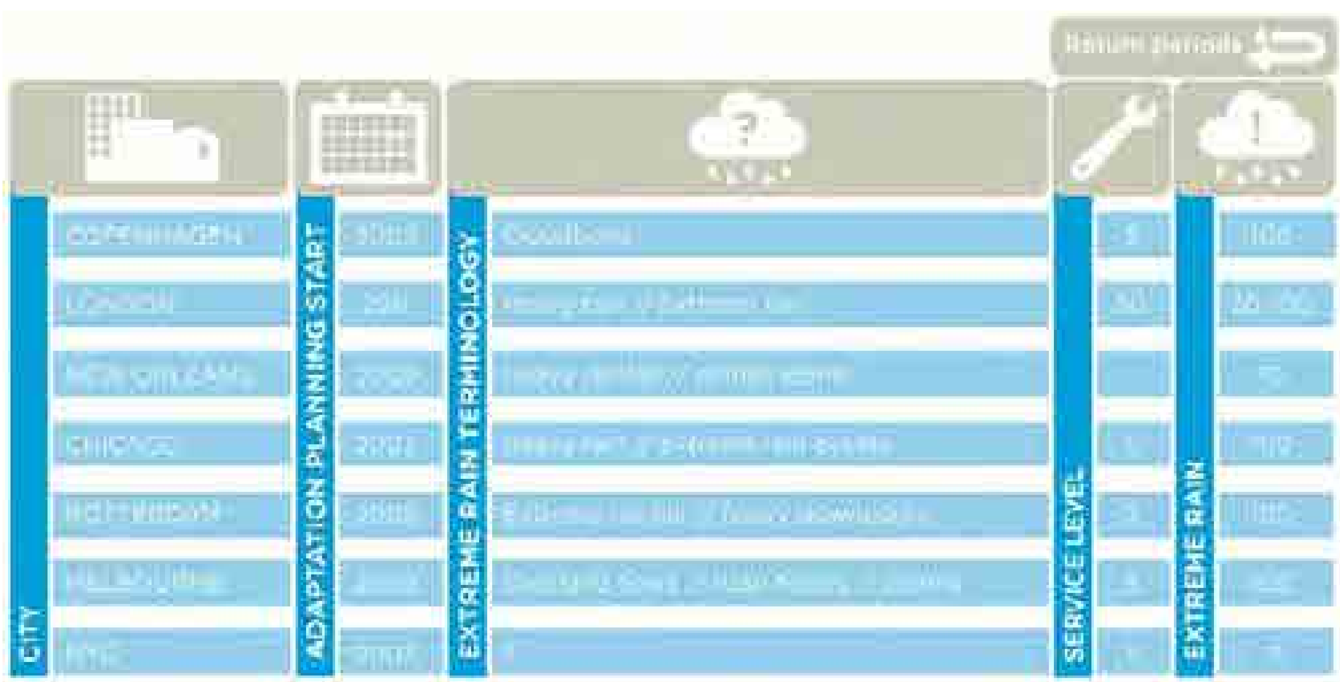


Figure 18: Cloudburst Policy Examples from Around the World

Source: Ramboll

October 2022 Workshops

In October 2022, the project team held a series of meetings with key stakeholders to present initial design concepts for discussion. At this stage of the process, the team had received public input during the June 2022 workshops and developed technical analysis to understand the potential impacts of flooding in the Project Area. Based on these inputs, the team developed preliminary conceptual designs for Lansburgh Park, Delaware Avenue, and 2nd Street. During the series of meetings in October 2022, the team sought input from stakeholders about these preliminary concepts to guide future development of the conceptual designs.

Civic Groups Workshop

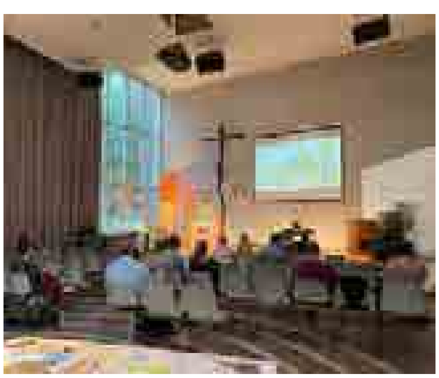
The second Civic Groups Workshop was held on Thursday, October 13, 2022. Invitees included a wide range of local community organizations representing the Southwest and Buzzard Point neighborhoods. Attendees represented ANC 6, Capitol Riverfront BID, Southwest BID, and Southwest Neighborhood Action, as well as representatives from DOEE, Ramboll, Moody Graham, MKSK/LAB, and Designgreen.

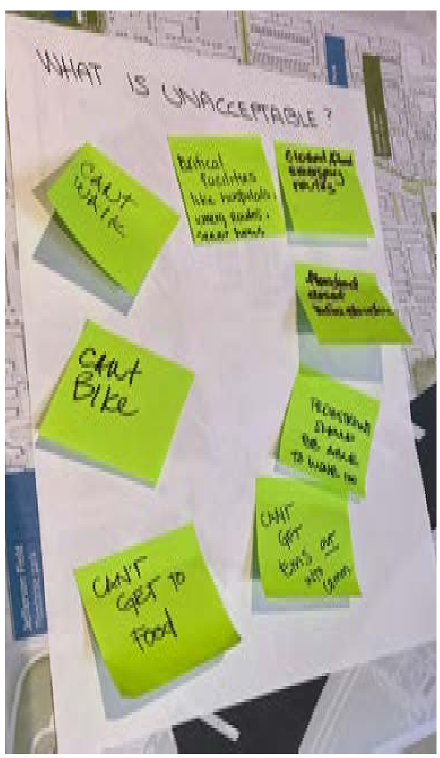
The workshop began with a brief presentation about the overall process and preliminary design ideas. Following the presentation, participants were led through a series of facilitated activities. The group participated in a visual preference survey to consider which characteristics of BGI would be most beneficial as part of redesigned parks and rights-of-way.

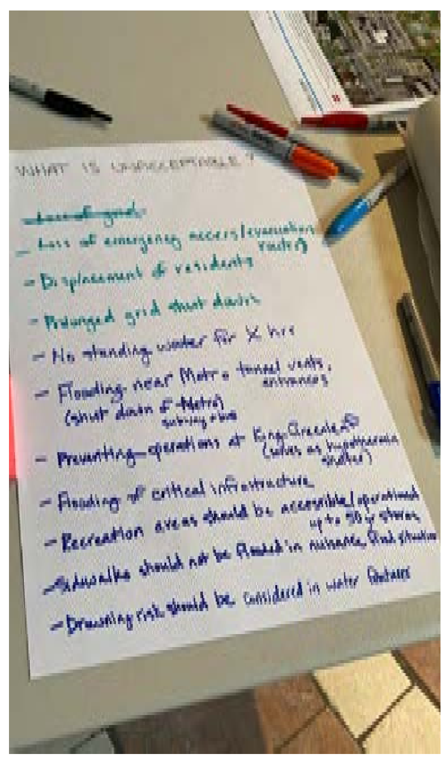
Inter-Agency Workshop

The second Inter-agency Workshop was held on Thursday, October 13, 2022. Participants included representatives of a wide range of District and Federal agencies, including DOEE, DC Water, DPR, OP, HSEMA, DCHA, NCPC, USACE, NPS, as well as members of the project team from Ramboll, Moody Graham, MKSK/LAB, and Designgreen.

The workshop began with a brief presentation about the planning process and objectives. Following the presentation, participants gathered in small groups for facilitated discussions. The group reviewed and commented on preliminary design ideas. Then, the project team facilitated small group discussions about key questions for consideration in designing the BGI network. Participants were asked to identify what







risks or outcomes should be considered unacceptable. These unacceptable outcomes can then help to guide design and development of BGI projects.

Farmers Market

On Saturday, October 15, 2022, the project team set up a booth at the Southwest Farmers Market to present preliminary design ideas and gather feedback from members of the community. During this event, Farmers Market visitors were invited to learn about the Southwest & Buzzard Point Flood Resilience Strategy and provide feedback on preliminary design ideas. The booth included a visual preference survey, where participates could place dots to vote on which types of parks and rights-of-way would be most beneficial in the neighborhood.

DESIGN: Key Takeaways

- Risks that BGI projects should be designed to mitigate:
    - Loss of emergency access and evacuation routes.
    - Prolonged interruption of utility services.
    - Flooding of the Metro and other critical infrastructure.
    - Preventing nuisance flooding of sidewalks.
    - Loss of life.
    - Pedestrian access.
    - Basement flooding of residential buildings.
    - Disparate impacts on vulnerable populations.
- Risks were grouped in to two different categories:
    - Extreme impacts that create serious health and safety risks.
    - Everyday events that result in meaningful reduction in quality of life.

February 2023 Workshops

Public Workshop

The final public workshop was held on February 4, 2023, at Arena Stage. The format of the workshop was an open house, allowing participants to join at any time and view the materials at their own pace. The workshop was organized around six stations:

- Station 1: Project Overview
- Station 2: What is Blue Green Infrastructure
- Station 3: Flooding in Southwest and Buzzard Point
- Station 4: Blue Green Infrastructure Master Plan
- Station 5: Right-of-Way Conceptual Design
- Station 6: Lansburgh Park Conceptual Design

At each station, participants were invited to learn about the overall planning and design process, ask questions of facilitators from DOEE and the consultant team, and provide their own feedback about BGI opportunities in the neighborhood. Approximately 80 members of the public attended.

Some of the key takeaways from the workshop included:

Station 1: Project Overview

- People love walking all over the neighborhood, particularly along the waterfront, including 2nd Street.
- There was a lot of interest in continuing the bike trail between Buzzard Point, through 2nd Street, to the Titanic Memorial (parts of those are intact bike trails already but people noted that the trail cuts off at some point between the two end points).
- One participant remarked on how surprised they have been about how unusable Lansburgh Park is as it currently stands. This is also reflected by the lack of people who marked Lansburgh Park as a park they love to use.
- The majority of people who marked Lansburgh Park as a usable park know the park well as they use it for the community garden.

Station 2: What is Blue Green Infrastructure

- Participants recognized Lansburgh Park as an opportunity to both mitigate stormwater flooding while also improving open space for the community.
- Concerns about food security, especially for low-income residents within the project area.

Station 3: Flooding in Southwest and Buzzard Point

- Many participants noted that they have not experienced severe flooding within the Project Area. This is an indication that the District is bring proactive about addressing flood risk before a disaster strikes.

- There is a need for more communication between the District and local residents about potential flood risks in the current climate, as well as projected flood risks in the future.

Station 4: Blue Green Infrastructure Master Plan

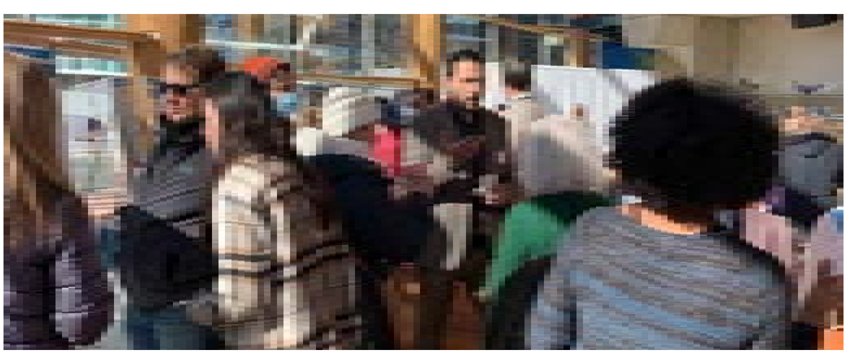
- The most important co-benefits identified by participants included increasing recreational opportunities, improving air quality, regulating microclimates to reduce urban heat island effect, and increased traffic safety.
- Several residents of condo buildings with shared open space expressed a need for improved stormwater management on the building's property, as well as an interest in using their shared open space to contribute to the BGI network.
- Participants identified a need to conduct outreach to residents of Greenleaf Houses for feedback on design ideas for Lansburgh Park.

Station 5: Right-of-Way Conceptual Design

- Participants noted that the volume of foot traffic on 2nd Street has been steadily increasing due to the new development at Buzzard Point. As a result, they suggested that the proposed shared use path on 2nd Street may not be wide enough.
- There is a perception of safety issues walking on east side of 2nd Street.
- There has been habitat loss around Fort McNair due to recent development at Buzzard Point. Participants recognized the opportunity to restore habitat in new bioswales along 2nd Street.

Station 6: Lansburgh Park Conceptual Design

- There is concern about a loss of trees due to a new condominium development on the north side of the park that resulted in the cutting of several large sized trees. Participants were pleased to see that existing trees are preserved in the new Lansburgh Park concepts and several more are planned to be planted.
- There is concern about trash in the park and participants view the park redesign as an educational opportunity for environmental stewardship.
- Participants expressed concern about the rocks in the open pebble concept and a preference toward the rectangular allee.
- Participants would like to see reduced fencing (or lower fencing) around the MPD parking lot, dog park, and basketball courts.
- Concerns about lighting included both the need for more lighting and the need for lighting to be dark sky friendly.



PILOT: Key Takeaways

- The workshop further reinforced the need for BGI projects to improve pedestrian and bicyclist safety on the roads, as well as recreational resources in the parks.
- Participants highlighted recreational opportunities, improved air quality, reduced urban heat island effect, and increased traffic safety and the most important co-benefits of BGI projects.
- Neighborhood residents noted that there are potential areas to implement BGI outside of publicly owned properties, including within lawn areas of condo developments. This could lead to opportunities for the District to pursue strategies to implement BGI through public-private partnerships.
- Participants emphasized the need for ongoing community engagement, especially among residents of the Greenleaf development.
- Increased pedestrian and bicycle traffic in the area is a reason to further emphasize the need for high quality streetscapes.
- The re-design of Lansburgh Park should keep what people love about it (trees, the community garden) and improve upon the areas that need some work (site-lines, lighting, educational opportunities).

Rainwater Flooding at Greenleaf Houses
Source: DOEE

SECTION 3: DETERMINING RISK

In addition to studying neighborhood conditions and gathering input from the community, the Strategy is based on anticipated risk to assets and residents. This section provides an overview of the risk modeling process.

Climate risk analysis is an essential input in climate adaptation and risk mitigation projects. The risk analysis assesses the expected annual damages (EAD) from the climate hazard in $/year and provides a spatial overview of areas particularly at risk. The Southwest and Buzzard Point risk analysis focuses specifically on flood-related hazards. Flood modeling was performed for the “do-nothing-scenario” and the planned scenario (i.e., after the BGI Network is implemented) to assess if design measures will reduce the risks to an acceptable level.

Risk is defined as the result of the probability of a given hazard and the vulnerability of a given area. Probability relates to the climate hazard and indicates how often the event, in this case flooding, occurs. Vulnerability relates to the given area and is a product of the exposure, sensitivity, and adaptive capacity of the systems, assets, and/or communities in the area. For example, an old wooden house will be more sensitive than a brand-new brick building in the same location, but if measures (adaptive capacity) are in place to ensure the wooden house isn’t exposed in a flood event, the total vulnerability (and eventually risk) will be much lower than without flood measures.

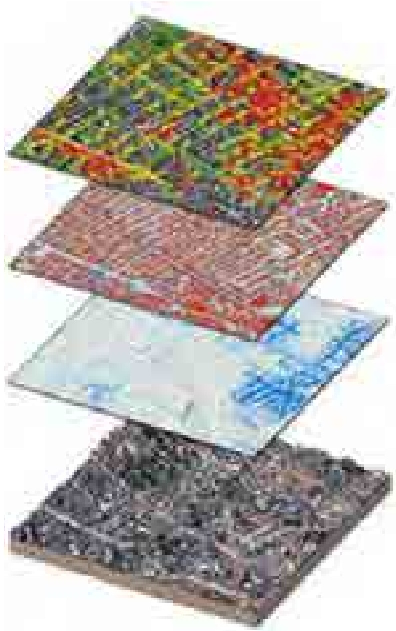


Figure 19: Risk, Vulnerability, and Probability

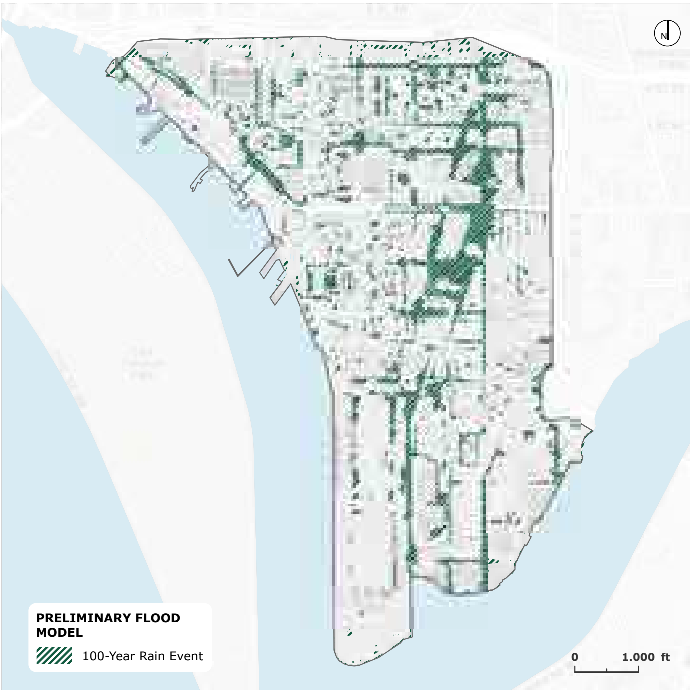
Source: Ramboll

Different Types of Flooding

The purpose of this study is to address risk from rainwater-driven flooding caused by rain events that can overwhelm existing stormwater infrastructure and cause flash flooding. This isn't the only type of flooding that coastal communities like Southwest and Buzzard Point can experience. In fact, these communities are also at risk of flooding from storm surge events that bring water from the Chesapeake Bay into the Potomac and Anacostia Rivers and riverine floods when the Potomac, Washington Channel and the Anacostia Rivers overflow their banks. Storm surge and riverine flooding requires federal agencies' leadership and cooperation with the District as coastal protection requires construction of flood infrastructure on mostly federal land (NPS and Fort McNair) as well as federal funds and expertise (FEMA and US Army Corps of Engineers). This Strategy is limited to rainwater-driven flooding. However, the District and federal partners continue to evaluate the risks, potential impacts, and adaptation measures for storm surge flooding.

Rainwater-driven flooding should be mitigated where the rain falls on the ground through a mix of nature-based solutions, grey infrastructure, and multi-purpose projects. By creating space throughout the neighborhood, we can detain rainwater temporarily—and in a controlled way. Controlled detention of rainwater can help to reduce damage from flooding. The detained rainwater can then be conveyed in storm sewers after the rain stops and the stormwater pipes regain their capacity to discharge.

Inland (Rainwater-driven) Flooding

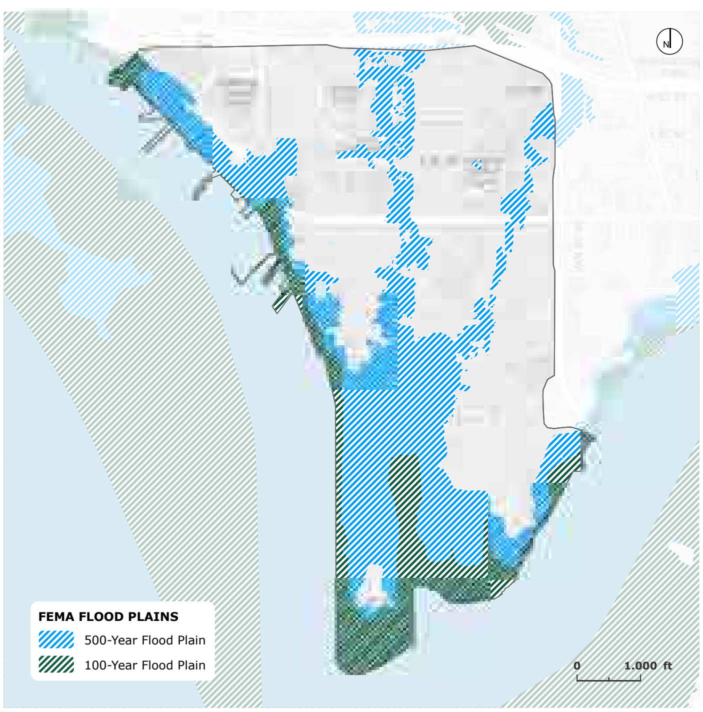


Hydraulic Model

A simulated 100-year rain event in today's climate conditions. Today this rain event has a 1% annual chance of occurring. Due to climate change this probability is projected to increase in the future.

Create temporary space for rainwater during extreme rain events.

Riverine Flooding



FEMA Flood Plain Map

100-year flood plain is defined as the 1% Annual Chance Flood Hazard

500-year flood plain is defined as the 0.2% Annual Chance Flood Hazard

Work at the water's edge to keep storm surge flooding out.

Figure 20: Inland (Rainwater-driven) Flooding v. Riverine Flooding

Source: Ramboll

Modeling Flood Risk

Flood models provide a science-based evaluation of hydraulic and hydrologic systems to project how rainwater will flow through the neighborhood. This analysis includes how the effects of climate change will impact river water levels, precipitation patterns, and the benefits of new or improved drainage measures. High intensity rain events are expected to increase due to the impacts of climate change. This climate change impact is included by applying a "climate factor". Extreme rainfall events that currently occur every 20 years are projected to occur every 5 years by the end of the century.

To assess the expected annual damages from extreme rain events, hydrodynamic flood results for several rainfall sizes ("return periods") throughout time are required. Hydrodynamic modeling is performed for three time horizons (Present day, Mid-Century, End-Century) and six return period events (5-year, 10-year, 15-year, 20-year, 50-year, and 100-year storms) to understand impacts to the Project Area. The flood model estimates existing drainage and flood conditions during rainfall events and provides insight into the dynamics of river water levels, flooding extents, natural streamlines, flow velocities and capacity in conveyance structures, and outflows. The conveyance of the existing drainage network is quite high and is expected to be able to accommodate initial- and tail-end of long-term rain events. This project focuses on short duration, high-intensity rain events ("cloudbursts"), which is assessed as the primary risk in Buzzard Point for inland flooding. Hence, a 1-hour rain event is applied in the hydraulic models.

Flood Models simulate how water naturally flows and accumulates throughout the neighborhood. Flowlines and catchment areas are largely driven by topography and development patterns. Stormwater tends to gather in low-lying, impermeable areas with limited sewer network connections. Understanding the water's way through the neighborhood is fundamental to the development of a well-functioning BGI network.

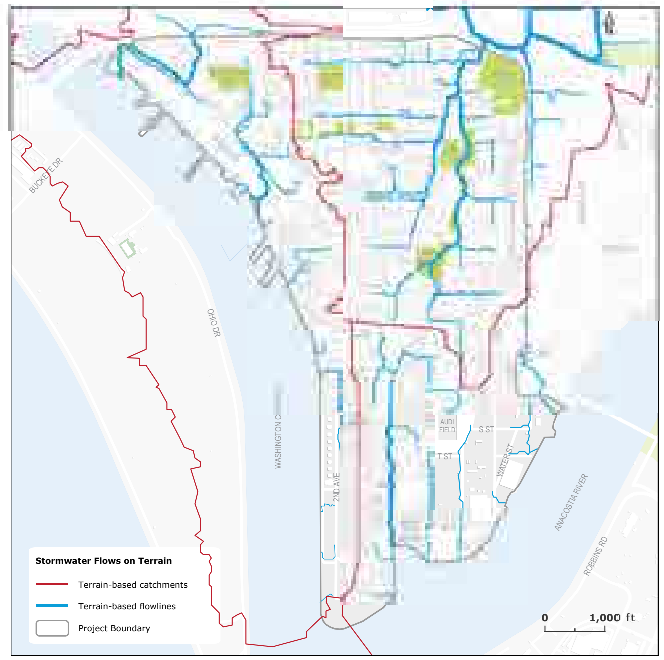


Figure 21: Flowlines

Source: Ramboll

Components of the Flood Model

Below is a summary of the components that go into setting up the flood model.

Digital Terrain Model

A surface model of the site including buildings that defines overland flow paths and existing depressions in the terrain to determine the flows and accumulations of stormwater throughout the neighborhood.

Precipitation Data

Precipitation data includes rainfall intensity, duration, and frequency. This data is based on historical rainfall data from local meteorological stations and future projections of rainfall data produced by the International Panel on Climate Change (IPCC). In the flood model, precipitation data is input using Intensity-Duration-Frequency (IDF) curves.

Climate Factors

A climate factor is a value added to rain data to account for future precipitation patterns in projected climate conditions. The climate factor is typically based on a review of global and regional climate models and may vary depending on how long into the future the climate is projected.

Runoff Coefficients

A runoff coefficient describes the difference between the rain that falls on a surface and the resulting runoff. The coefficient reflects absorption in the soil, infiltration, evaporation, filling smaller depressions in the terrain, slopes, and vegetation. Impermeable surfaces like streets, parking lots, and buildings have high runoff coefficients. Permeable surfaces like lawns and vegetated areas have low runoff coefficients because they allow some infiltration into the ground.

River Water Levels

River water levels are a “boundary condition” within the flood model. Although the river itself is not modeled in detail, the water level is used to understand how much rainwater can outflow to the river and how much river water might flow into the existing drainage network.

Sea Level Rise

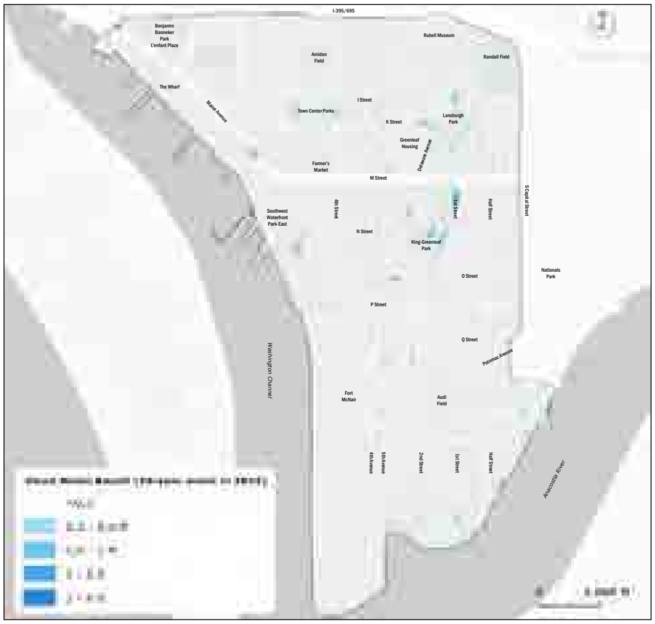
Sea level rise due to climate change may impact rainfall flooding because it may reduce drainage to the rivers.

Stormwater Network Capacity

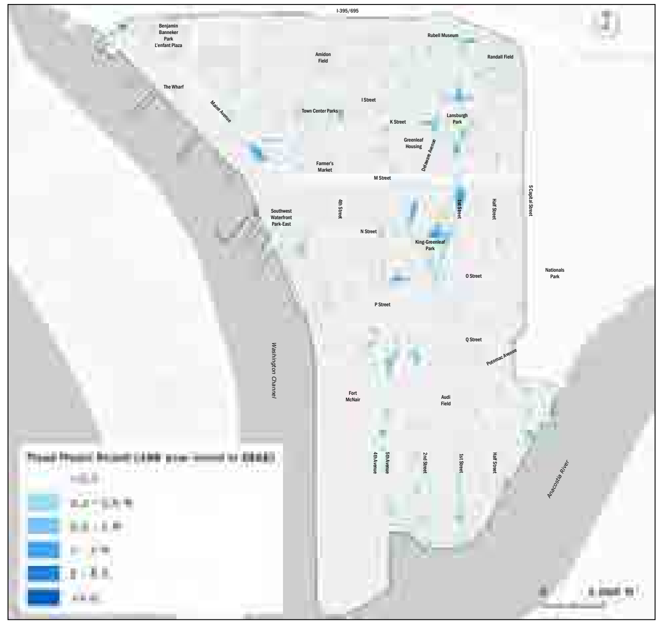
The flood model estimates the capacity of the existing stormwater and sewer network as part of the overall flood impact analysis.

Present-day (2022) Rainwater Flood Maps

20-year Rain Event in 2020

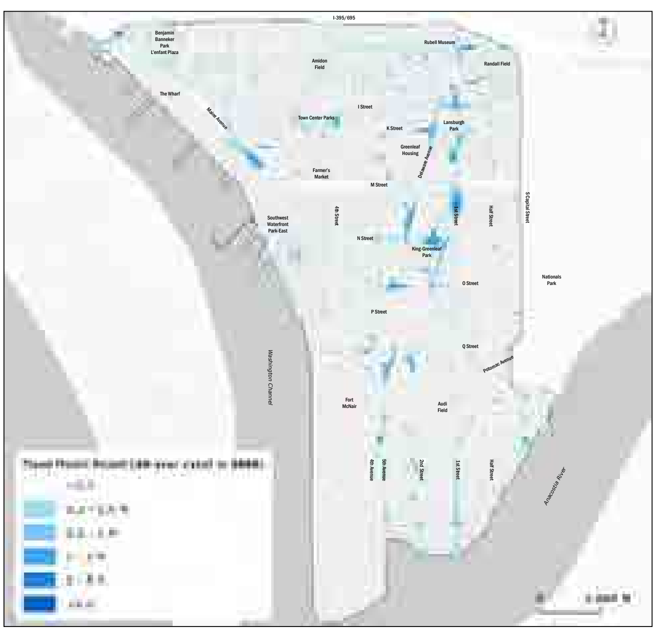


100-year Rain Event in 2020



Projected Rainwater Flood Maps (2080)

20-year Rain Event in 2080



100-year Rain Event in 2080

Figure 22: Flood Model simulations for the 20 and 100-year rain events under 2022 and 2080 climate conditions

Source: Ramboll

Consequences of Flooding

A fundamental component of determining the risks of flooding is understanding the consequences. Sometimes areas flood and it is acceptable. This could be large grass areas or underutilized parcels. Other times it is not acceptable. This could be hospitals, residential buildings, or other assets of value to society. To understand the actual risk of flooding a spatial climate risk assessment is undertaken using FEMA Natural Hazards and Risk Assessment Program software, Hazus 5.0.

The spatial flood maps produced by the Flood Model are used to forecast physical damages to assets and corresponding economic losses to society for three time horizons (Present day, Mid-Century, End-Century). Economic losses are calculated using functions that relate the depth of flooding to the degree of damage for various categories of buildings (i.e., commercial, residential, institutional etc.). Additional costs, such as social impacts and damages to utility systems or critical facilities, have been accounted for with a factor scaling from emerging climate risk literature.

Hazus models were run for three climate planning horizons (Present day, Mid-Century, End-Century) and varying storm severities to approximate the direct economic losses in the project area. Hazus losses are calculated using functions that relate the depth of flooding to the degree of damage for various categories of buildings (i.e. commercial, residential, institutional etc.). Additional costs, such as social impacts and damages to utility systems or critical facilities, have been accounted for with a factor scaling from emerging climate risk literature.

Hazus 5.0 was released in April 2021 and relies on building, infrastructure, and population inventories from the 2010 U.S. Census. The considerable development seen in the Southwest and Buzzard Point neighborhoods in recent years is not represented by Hazus' inventory. Outdated inventories underestimate the scale of damage incurred by the neighborhood in the face of flooding.

Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security. FEMA coordinates resources to adaptation, mitigation and response to natural disasters.

Hazus

Hazus is a nationally standardized risk modeling tool from FEMA, that estimates economic impacts of earthquakes, hurricanes, floods, and tsunamis.

Expected Annual Damages

Expected annual damage (EAD) is the expense that would occur in any given year if monetary damages from all hazard probabilities were spread out equally over time.

Identified Risk

Risk models show expected damage costs of 1.2 million dollars per year under current climate conditions. With more extreme weather in the future, expected annual damage costs increase to 6.5 million dollars per year by the end of the century. Low return period events, meaning those that have a high probability of occurring, cause less damages than more extreme events, but contribute more to economic losses over time due to their high frequency.

Setting a Level of Protection to Mitigate Flood Risk

The neighborhood flood risk composition, the character of the spatial topography, and the community planning goals are analyzed together to identify a relevant level of risk mitigation, a so called "design storm". The design storm dictates the sizing of the proposed new BGI network to mitigate the flood risk. A design storm can be defined in several ways. In relation to rainfall-driven flood mitigation there are generally three overarching approaches that can also be combined:

1. District-wide protection level: One protection level is set for an administrative unit (a District, municipality, country, or similar) typically based on a high-level climate risk assessment
2. Land-use protection level: Protection levels are defined for different types of land-uses or zones, e.g., hospitals, roads, residential, etc.
3. Area-specific protection level: Protection levels are defined for areas based on an area-specific climate risk assessment. This means, that within a municipality, areas (often "catchments") can have different protection levels although they are within same administrative boundaries.

For most cities the design storm is defined as a combination of option 1 and 2. Offering same level of protection throughout the administrative boundaries are the most politically popular approach, while allowing land-use based protection levels for critical infrastructure such as metro lines, hospitals, sub-stations, etc.

A design storm is most often identified based on a climate risk assessment and/or a scenario-based cost-benefit analysis. The latter provides a socio-economic optimum between costs, benefits (reduced risk), and co-benefits for several plans designed for different protection levels.

The Southwest and Buzzard Point Flood Resilience Strategy is very much a pilot project for the District. For this pilot project the design storm is identified based on a neighborhood-wide climate risk assessment. This assessment illustrates that the highest risk for Southwest & Buzzard Point is concentrated around smaller (more frequent storms) up to the 20-yr storm in 2080. Larger storms do not significantly increase risk in the neighborhood. For this reason, a 20-yr storm in 2080 (3.34 inches in one hour) is set as an overarching design storm for Southwest & Buzzard Point with supplementary recommendations to increase this protection level for critical infrastructure in the neighborhood.

This recommendation takes into account the useful life of BGI solutions, the "one-off costs" of infrastructure construction, the capacity of the community to fund and maintain the infrastructure, and lastly the stormwater management capabilities of the proposed BGI network. By sizing flood reduction projects for this design storm, the Strategy ensures that present-day high-intensity rainfalls are addressed—and that the BGI Network will continue to be effective as these events become more frequent and intense due to climate change. This design storm strategy also provides a framework that the District can consider when evaluating and sizing BGI projects in other neighborhoods.

It is recommended that Washington Metropolitan Area Transit Authority (WMATA) and Pepco detail their risk and take appropriate measures to mitigate rainfall-driven flooding (as well as other climate-related impacts) to the metro station "Waterfront" and the Pepco Substation on 1st Street, respectively.

A climate risk assessment for other neighborhoods in the District might suggest other design storms than the one identified for Southwest & Buzzard Point. However, this design storm strategy can still provide a framework that the District can consider when evaluating and sizing BGI projects in other neighborhoods. Ultimately, our commendation is to revisit the design storm for Southwest & Buzzard Point once a District-wide analysis has been undertaken to ensure an equitable level of protection across the District.

Figure 23: Different Ways to Define a New Protection Level

Source: Ramboll

Cloudburst Soccer Field in Carlsberg City
Place: Copenhagen, Denmark.
Source: Ramboll.

SECTION 4: DESIGNING THE BLUE-GREEN INFRASTRUCTURE NETWORK

Blue-Green Infrastructure Best Practices

The existing conditions in the Project Area (demographics, community assets, critical facilities, etc.) help guide development of stormwater management projects that respond to the community's priorities. Blue-Green Infrastructure (BGI) is a stormwater management technique that addresses flooding concerns while also improving parks and streetscapes. The following pages provide an overview of BGI. The specific design elements for the Southwest & Buzzard Point neighborhoods can be found in Section 5.

BGI Concept

The concept of BGI is to acknowledge that traditional stormwater infrastructure—discharging rainwater into pipes—is not an adequate solution in the context of dense urban environments, especially as climate change is projected to increase extreme weather events. Traditional grey infrastructure alone is a single-purpose solution that does not provide additional co-benefits to communities or allow for the needed flexibility in designing for future climate conditions.

Rather than only relying on grey infrastructure, BGI connects urban hydrological functions (blue) with vegetation systems (green) in civic spaces thereby mimicking nature's own way of managing rainwater. BGI is designed to provide hydraulic functions such as conveyance (transport), detention (temporary storage), retention (permanent storage), filtration (natural cleansing), infiltration, water re-use, etc. The hydraulic functions vary site-to-site based on soil conditions, design objectives, water opportunities and challenges, and other factors.

BGI has the potential to reintroduce water as a resource for urban life while also providing critical benefits to communities by improving parks and open space, traffic calming, enhancing biodiversity and natural habitat, and reducing the urban heat island effect.

BGI can be a stand-alone solution or an add-on to existing or new grey infrastructure. Combining BGI with traditional stormwater infrastructure can reduce the demand on below-grade pipes and create more flexibility in the stormwater management system to absorb and cope with future climate conditions.

Principles of a BGI Network

The principle of the BGI network is to design a connecting series of projects that either convey or detain water during heavy rain events. The BGI network is designed based on flood modeling, benefit-cost analysis, and maximization of co-benefits. BGI projects are connected by how they convey and detain water as part of the overall network plan.

Conveyance of water occurs on paths and terrain that is designed to move water through the public realm. These paths can vary from small, temporary streams to large channels, depending on the necessary capacity.

Detention areas are urban spaces that are designed to hold excess water during extreme rain events, reducing the peak stormwater flow in traditional gray infrastructure. Detention areas can be permanent water bodies, or they can be usable public spaces that are designed to flood during extreme rain events. Detention areas can fill with water during extreme events, slowly releasing water into the storm sewer system after the peak flow has receded.

Combined BGI and grey infrastructure can be designed to include overflow mechanisms triggered automatically as rainfall intensities increase to ensure a flexible new network for stormwater management fit for the future. We call this a "the flexible design storm approach".

Figure 24: Conceptual System of Connected BGI

Source: Ramboll

BGI Hierarchy

BGI projects can be designed at a variety of scales. The volume of water that a given BGI project—and the overall network—is designed to handle depends on the neighborhood topography, the catchment size and location in the catchment, land-use of the neighborhood, and the agreed flood reduction ambitions.

Green infrastructure projects designed for smaller, more frequent rain events may be familiar to District residents already. These projects include stormwater facilities incorporated into development parcels such as green roofs, permeable pavers, and rain gardens.

Larger rain events require more substantial stormwater interventions that are integrated into the urban landscape to convey and detain a larger volume of water. These projects could include segments of parks or rights-of-way that are designed for temporary stormwater management.

Extreme rain events require even larger volumes for conveyance and detention of stormwater. These projects could include detention in entire park areas and water features that are unusable during extreme storm events to mitigate flooding of neighborhood assets.

The location in the catchment, upstream or downstream, influences the size of the BGI. The further downstream a project, the more stormwater the BGI will need to convey and/or detain.

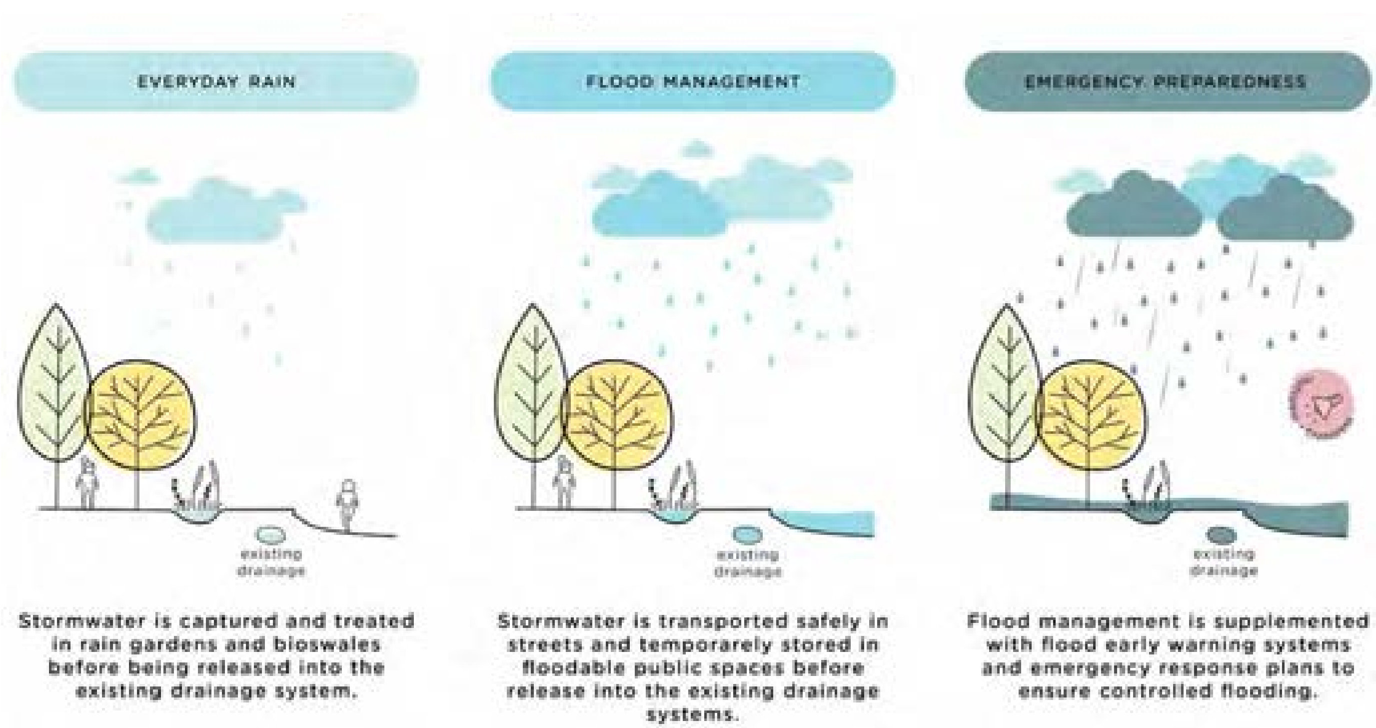


Figure 25: Flexible Design Storm Approach

Source: Ramboll

Conveyance

Conveyanve paths on terrain are designed to move water through the public realm.

Paths can vary from small, temporary streams to large channels, depending on necessary capacity.

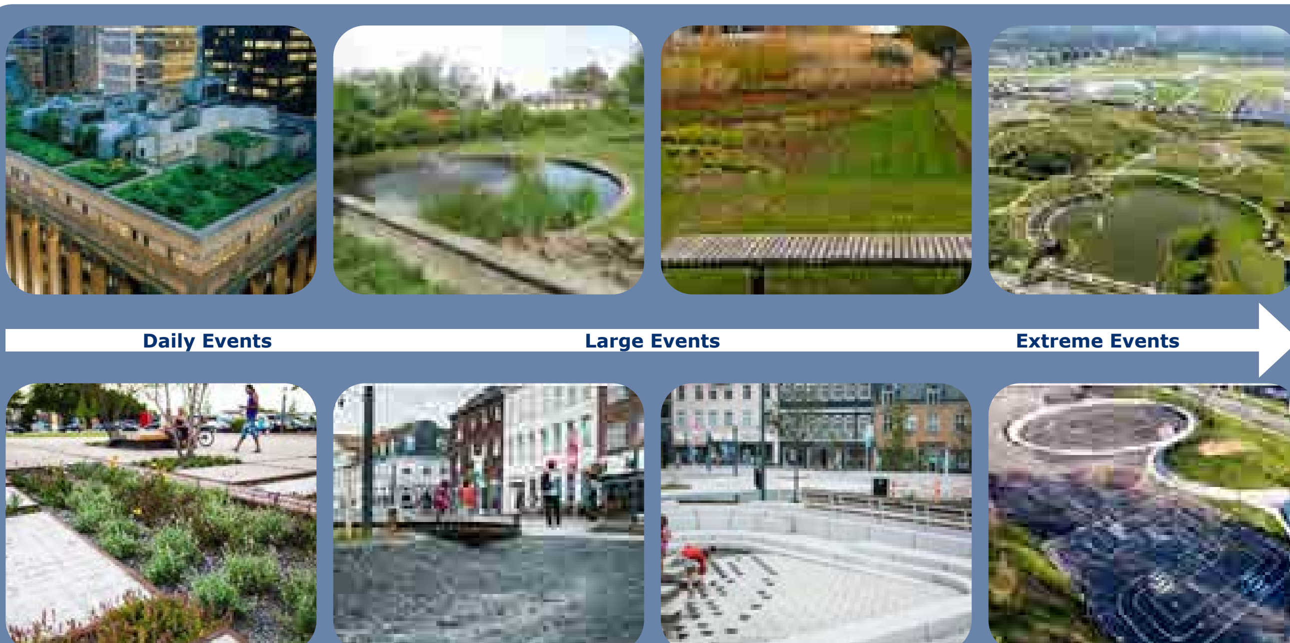
Detention

Detention areas are urban spaces designed to reduce peak stormwater flow.

Detention areas can be permanent waterbodies or they can usable public spaces that are designed for temporary storwage during extreme rain events.

Figure 26: BGI Network Principles

Source: Ramboll



Stormwater managed within development parcels through green roofs, permeable surfaces, and green infrastructure

Small scale interventions that are integrated in the urban landscape to convey and provide storage for large rain events

Controlled and temporary flooding of parks and open spaces during more extreme rain events

Figure 27: Hierarchy

Source: Ramboll

BGI Examples

Tanner Springs, Portland, OR

Tanner Springs Park in Portland, Oregon, is situated in an area that was once a wetland. Due to urbanization the wetlands were slowly filled, and Tanner Creek was rerouted. Today, the park serves as a multi-purpose detention pond and recreational area with art performances on the floating deck, and grass areas and paddle pools for everyday recreation.

Retention Street, Copenhagen, DK

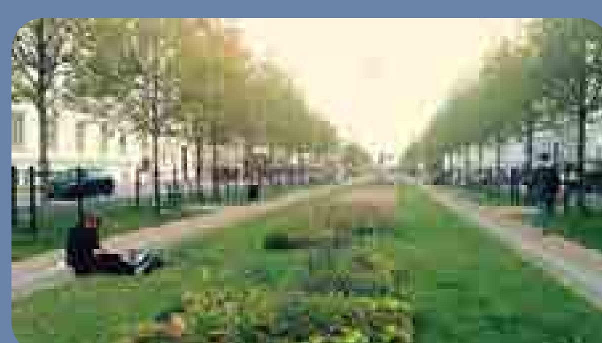
In this retention street in suburban Copenhagen rain gardens separate the sidewalk and bike path from the main road and increase road traffic safety, while filtering and retaining rainwater.

Freiburg Zollhallenplatz, Freiburg, Germany

Rain gardens serve as local retention in Freiburg Zollhallenplatz in Germany, where rainwater is cleansed and filtered before it reaches the groundwater. No stormwater is discharged to the sewer system, even during heavy rainfall.

Sankt Annæ Plads, Copenhagen, DK

Sankt Annæ Plads in old city-center Copenhagen has been turned into a cloudburst street, where rainwater from roofs and from the roads on each side is conveyed to a wide lowered grass area in the middle. From here stormwater is discharged through an underground overflow system to the harbor in extreme rain events.



Blue-Green Infrastructure in Southwest and Buzzard Point

The year-long planning process has led to the development of a BGI Network for Southwest and Buzzard Point that factors in a wide range of inputs. While this process culminates with a conceptual design for Lansburgh Park and King Greenleaf Park, the intent of the network is to implement several BGI projects to complete the network. It is understood that implementation of the full network will occur over the course of several years. Implementation will depend upon successful completion of the first pilot project at Lansburgh Park to demonstrate the benefits of BGI. Criteria for completing future projects will also depend upon the District securing local and outside funding.

A BGI Network consists of BGI solutions ("typologies") that transport (convey) and/or temporarily store (detain) stormwater. To effectively develop a BGI Network to mitigate flooding to the recommended design storm and facilitate the prioritized community benefits in Southwest and Buzzard Point an area-specific toolbox of relevant BGI typologies is developed. For this Strategy the typologies primarily focus on District-owned spaces that can be more easily redesigned than privately or federally owned spaces.

BGI Typologies

A BGI Network consists of solutions that transport (convey) and that temporarily store (detain) stormwater. Based on the existing conditions research, community input, and flood modeling, the project team developed a series of typologies that carry out the conveyance and detention functions. These typologies were designed based on conditions within the Project Area, but also with consideration for general conditions in the District. The typologies developed for this Strategy should also be applicable in other neighborhoods with similar conditions.

This Strategy primarily focuses on District-owned spaces that can be more easily redesigned than privately owned spaces or federally owned spaces. Within the Project Area, the Strategy uses two types of typologies: Rights-of-way (ROW) and Parks (or "Public Space"). In addition to conveying and/or detaining stormwater, a typology is informed by the local character and designed to be scalable and replicable across the neighborhood and throughout the District.

The District of Columbia has been a leader in the US in the building of green infrastructure (GI) for over a decade. Besides the now standard applications of GI that dot most of the District's streets, there are a few examples of GI projects that take on a more integrated BGI shape. This includes Canal Park in Capitol Riverfront in the Navy Yards area or the lowered median on Maine Street in Southwest, which has an overflow to the existing underground stormwater network. In other words, the District has already embarked on a BGI pathway and the BGI Network for Southwest & Buzzard point is accelerating these efforts.

Stormwater Median on Maine Avenue in Southwest

Toolbox of Hydraulic Elements

Each of the BGI Typologies is designed from a common toolbox of hydraulic elements linked to the prioritized hydraulic functions. For the Southwest and Buzzard Point neighborhood the following four hydraulic functions are applicable in relation to the development of the BGI Network: conveyance (transport), detention (temporary storage), retention (permanent storage), and filtration (natural cleansing). The toolbox provides a user-friendly narrative to communicate how BGI projects could be adapted to unique, site-specific conditions within the Project Area and elsewhere in the District. The hydraulic elements in the toolbox include:

1. Bioswales
2. Raingardens
3. Cleansing Biotopes
4. New Stormwater Pipes
5. Storage Cells
6. Floodable Multi-Functional Space
7. Floodable Road

The first step in developing location-specific typologies is to identify Right-of-Way (ROW) and Park types that are representative throughout the neighborhood and to the District in general. Then, hydraulic elements are assigned to each type according to the available space and their proposed hydraulic functions in the BGI Network.

Each of the developed typologies are applicable in multiple locations throughout the Project Area and elsewhere in the District to ensure that this Strategy provides a roadmap for incorporating BGI throughout Washington, D.C. That said, similar BGI Networks developed based on other neighborhood characteristics may identify additional typologies applicable in the District.

Figure 28: Hydraulic Elements and Functions for Southwest and Buzzard Point

Source: Ramboll

Prioritizing Community Co-benefits

In addition to reducing flood risk, BGI projects can be designed to contribute to increased quality of life in cities. These positive impacts of BGI, beyond the flood mitigation impacts, are called co-benefits. BGI can be designed to improve air and water quality, reduce noise, improve mental and physical well-being, reduce the urban heat island effect and the loads to the wastewater treatment plant, improve the quality of the aquatic environment by treating stormwater runoff, increase carbon storage through planting of new trees, and many more aspects.

In developing the ROW and Parks Typologies for Southwest and Buzzard Point eight community co-benefits have been prioritized: (1) increased recreation space, (2) improved air quality, (3) opportunities for physical activity, (4) carbon storage, (5) energy savings through micro-climate regulation, (6) increased traffic safety, (7) job creation, and (8) increased thermal comfort through micro-climate regulation.

Figure 29: Co-Benefits Quantified in the Co-Benefit Assessment

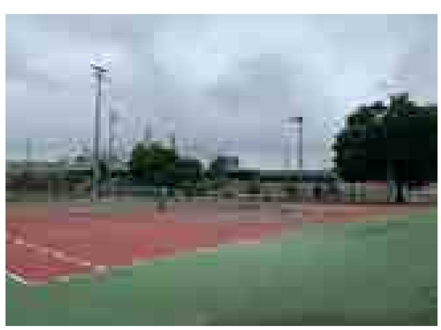
Source: Ramboll

Typologies Developed for Parks and Public Spaces

The following typologies are based on the common theme of using public open space to detain stormwater. Floodable parks and other open spaces present a great opportunity for large retention/ detention spaces within urban areas. They can be located throughout the catchment area and can be designed at various scales, depending how much space is available, compatible uses, and the volume of water that needs to be detained. Ideally, floodable parks are located in naturally low-lying areas (to minimize excavation) downstream in a catchment. They can include either temporary storage volume or permanent water features.

Each of the Park Typologies are designed to manage everyday rain events while maintaining the recreational functions of the park. In other words, during typical rainfall events, park users may not even notice that their park has been transformed into a stormwater management facility. In fact, some park resources, such as athletic fields and open lawns, will be more usable due to improved drainage. Some fields remain soggy after rainstorms under current conditions but will drain more quickly once the BGI project is completed.

During extreme rain events, the Park Typologies are designed to detain larger volumes of stormwater through temporary, controlled inundation of select areas of the park. Hydraulic elements such as raingardens, bioswales, and cleansing biotopes are integrated into the overall park design for stormwater quantity and quality control. Floodable parks are designed to detain water during extreme rain events, while the existing storm sewer system is at capacity. As the storm sewers drain, the floodable parks slowly empty into the existing drainage system. Floodable parks may require some cleaning or routine maintenance after an extreme rain event.



Floodable Passive Park

Floodable Passive Parks are generally areas of parks that are not programmed for specific athletic activities. These could include open lawns, constructed wetlands, sculpture gardens, or walkways.

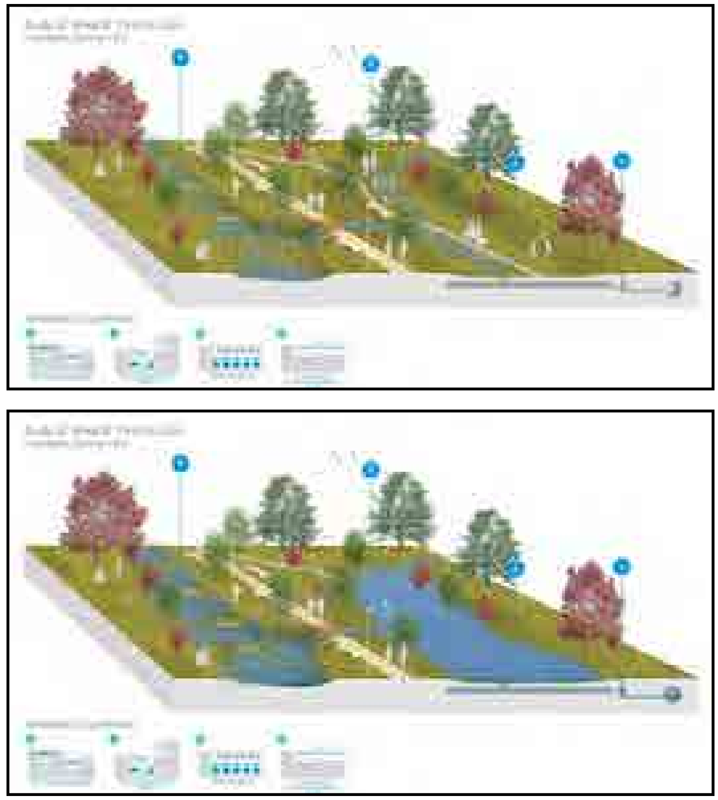


Figure 30: Floodable Passive Park

Source: Ramboll

Floodable Athletic Fields

Floodable Athletic Fields could include grass, turf, or hardscape sports facilities (e.g., football fields, soccer fields, tennis courts, basketball courts, etc.). The field is excavated to be at a lower elevation than surrounding park space, so that it can detain large amounts of stormwater during extreme rain events. Because the fields would be flooded during heavy rains regardless, designing them to purposely flood temporarily during extreme events would not disrupt organized sporting events more than they would anyway. Also, the large capacity of these fields should only be required during rare storm events (i.e., once every 10 or 20 years). The fields are designed with drainage systems that are connected to the existing storm sewer system so that they can adequately drain after the storm passes. These drainage systems should also improve drainage during everyday rains so that athletic fields are more usable immediately after minor rain events.

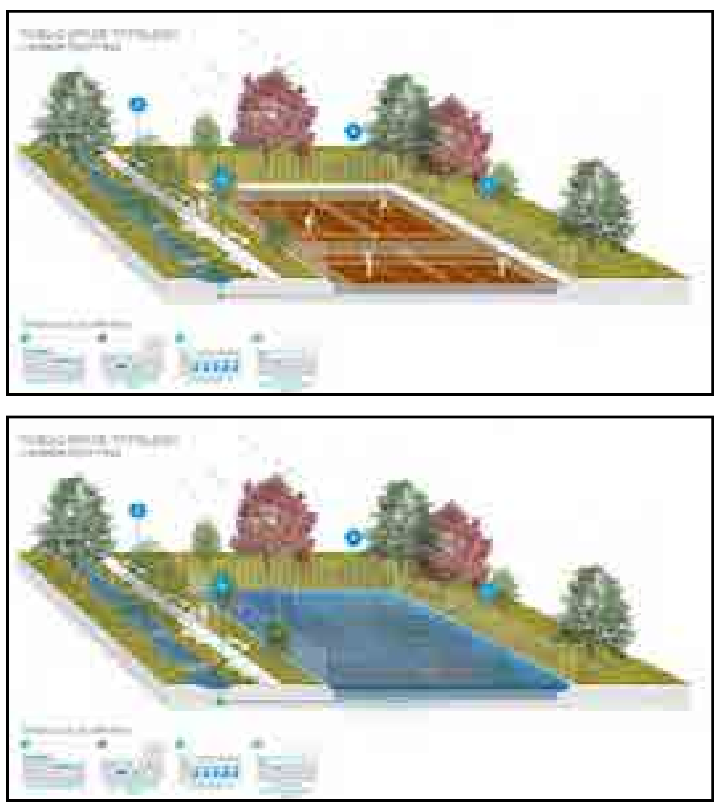


Figure 31: Floodable Athletic Fields

Source: Ramboll

Floodable Wet Plaza

Floodable Wet Plazas are urban open space elements that generally include hardscape, rather than lawns or grassy areas. Wet plazas incorporate different levels for visual interest and to create space for detention of stormwater. The lowered portions of the plaza can be used for temporary storage and/or as permanent water features.

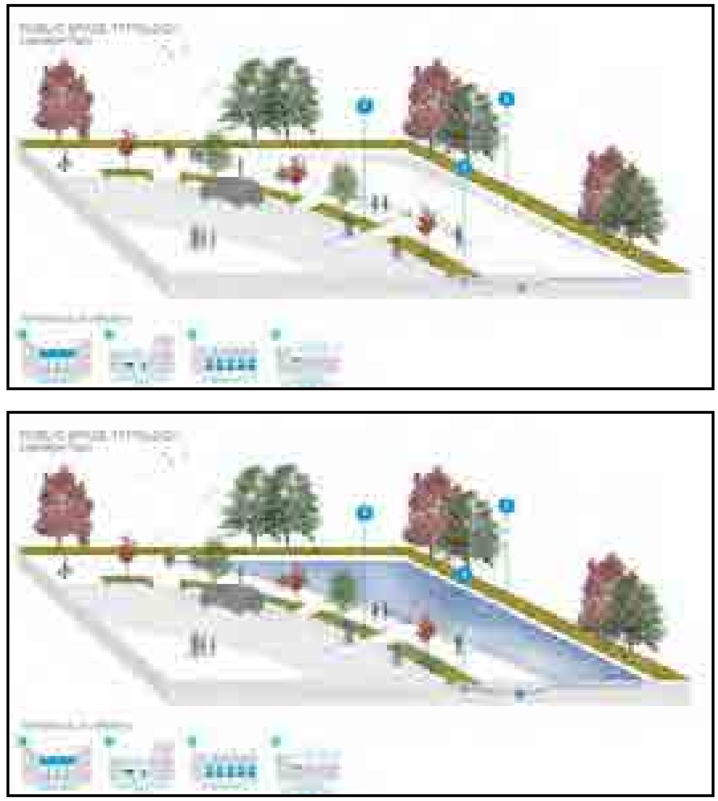


Figure 32: Floodable Wet Plaza

Source: Ramboll

Floodable Parking Lot

Floodable Parking Lots are very similar the Wet Plazas, except that instead of public civic space, they use existing parking lots. The advantage of Floodable Parking Lots is that they are less expensive than installing large, below grade detention systems. In addition, the parking lot can incorporate improved design elements, such as bioswales and planted medians. By installing drainage to the storm sewer system, Floodable Parking Lots may have improved drainage during everyday rain events, mitigating nuisance flooding. During extreme rain events, the parking lots would be used for detention of stormwater. This typology must be carefully designed to ensure that it does not receive a depth of water that would cause damage to cars.

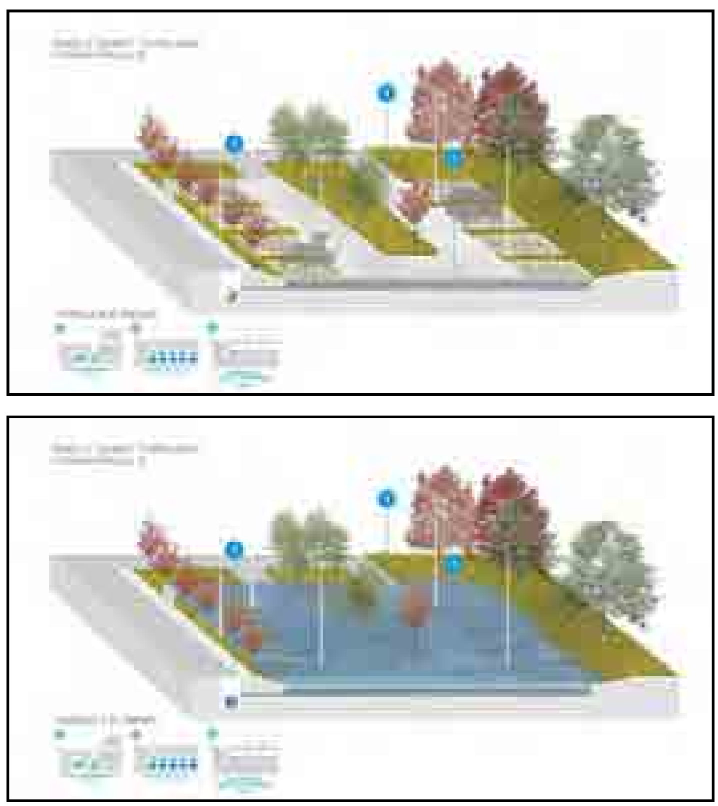


Figure 33: Floodable Parking Lot

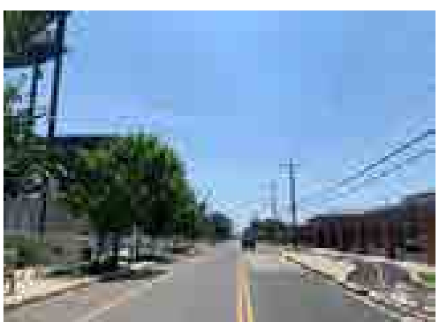
Source: Ramboll

Right-of-Way (ROW) Typologies

During extreme rain events, water naturally flows downhill, increasing in volume toward the bottom of the catchment area. While Parks Typologies are designed to detain water, Right-of-Way typologies are designed to move water through the catchment area so that it can be stored in a controlled way. Without this controlled conveyance of stormwater, extreme rain events will cause flooding of streets and buildings, interrupting evacuation routes, damaging buildings, and stranding drivers in dangerous conditions.

Each Right-of-Way typology includes a combination of hydraulic elements that hold water and convey it downhill. These hydraulic elements include bioswales, raingardens, underground storage cells, and new stormwater pipes to move water underground where surface measures are not appropriate. Under existing conditions, extreme rain events create a risk of flooding roadways, which can damage property and interrupt travel routes. By creating a controlled system of conveying water, the BGI Network helps to mitigate flood risks.

The potential co-benefits of each Right-of-Way Typology include increased traffic safety, improved air quality, micro-climate regulation, and job creation.






Green Stormwater Street

Green Stormwater Streets incorporate vegetation (perennials, shrubs, trees) and small-scale engineered systems (bioswales, raingardens, permeable pavement) to detain, slow, filter, and cleanse stormwater runoff from impervious surfaces, such as streets and sidewalks. Green Stormwater Streets are proposed as upstream conveyances to Cloudburst Conveyance Roads, Stormwater Detention Boulevards, and retention/detention areas located in parks. Stormwater from everyday rain events should be collected by hydraulic elements within the right-of-way, cleansed by bioswales and raingardens, and then discharged toward downstream solutions and/or the existing storm sewer system.

Green Stormwater Streets are generally smaller scale rights-of-way, so they require flexibility in terms of which hydraulic elements can be incorporated. In some cases, parking lanes can be enhanced with permeable pavement, existing grassy swales can be replaced with rain gardens, and back-of-sidewalk lawns can incorporate bioswales. In other cases, there may not be enough space within the right-of-way to incorporate all of these hydraulic elements. Even with these limitations, Green Stormwater Streets bring great value to improve mobility within the Project Area through traffic calming.

Figure 34: Green Stormwater Street

Source: Ramboll

Cloudburst Conveyance Road

Cloudburst Conveyance Roads are similar to Green Stormwater Streets, in that they incorporate vegetation and small-scale engineered systems to detain, slow, filter, and cleanse stormwater runoff. However, conveyance roads would be placed further downstream in the catchment area and therefore require greater capacity than stormwater streets. As water collects and is conveyed in the catchment area, the volumes increase.

In addition to bioswales, raingardens, and permeable pavement, Cloudburst Conveyance Roads also incorporate a V-shaped profile of the roadway. Rather than directing water to the curbs, as a typical crown would do, the inverted crown holds water within the roadway so it can be conveyed downstream. As with the Green Stormwater Street, the Cloudburst Conveyance Road can incorporate each of the hydraulic elements, when there is adequate space within the right-of-way; or, on narrower roads, there may not be enough space to incorporate all of the hydraulic elements.

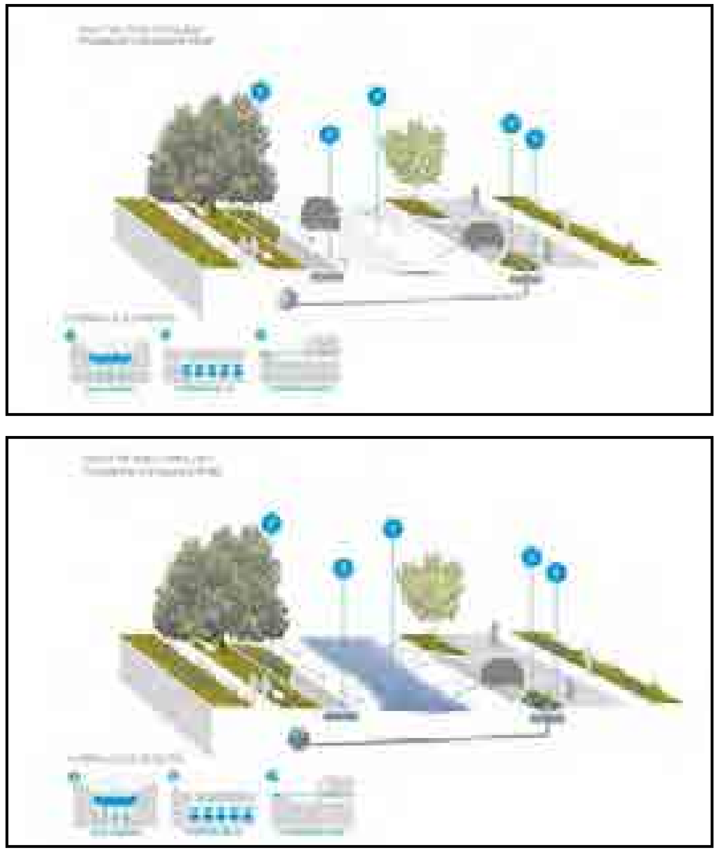


Figure 35: Cloudburst Conveyance Road

Source: Ramboll

Stormwater Detention Boulevard

Stormwater Detention Boulevards are used to channel and direct cloudburst runoff. These streets can be designed with a V-shaped profile (with a center median) and raised curbs to ensure that water will flow in the middle of the road, away from buildings. In addition, rain gardens within the parking lane and bioswales back-of sidewalk can be established so that water runs in urban rivers and green strips, rather than impacting adjacent buildings and infrastructure. Stormwater Detention Boulevards are typically implemented on larger streets that can be utilized to channel large volumes of stormwater in case of extreme rainfall events.

This typology is applicable to wide roadways that have existing center medians (or space to add such a median). The center median can be converted to a bioswale to capture and convey stormwater from everyday rainfall events. In the event of extreme rainfall, the entire V-shaped road profile can be used to effectively convey water to a downstream detention facility or water body. Additionally, Stormwater Detention Boulevards can include raingardens and bioswales where space permits, to collect and cleanse stormwater runoff. In Southwest & Buzzard Point, the Stormwater Detention Boulevard was designed with M Street in mind. However, it could also be applicable to many other wide boulevards in the District with center medians.

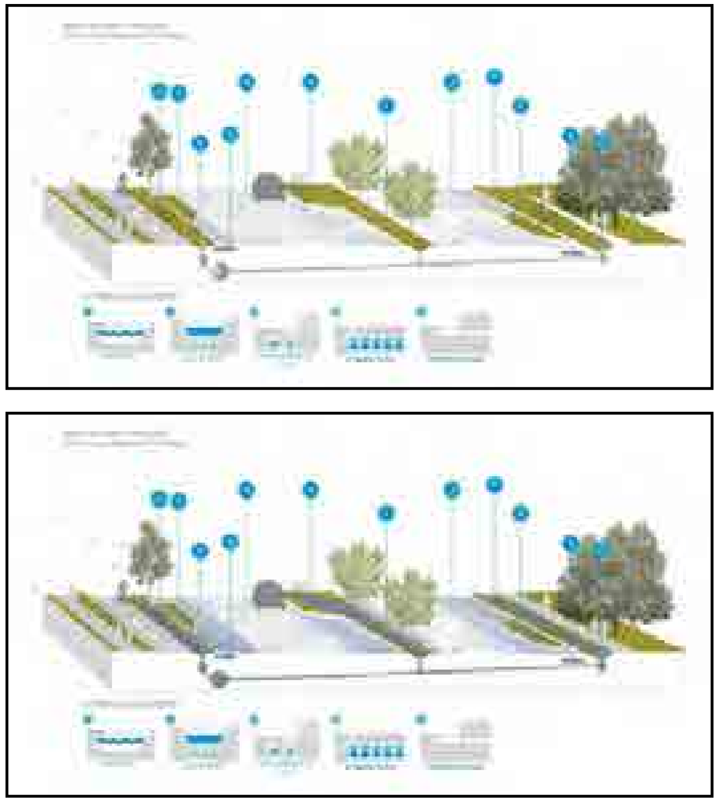


Figure 36: Stormwater Detention Boulevard

Source: Ramboll

Proposed Rendering of Lansburgh
Source: Moody Graham.

SECTION 5: BGI NETWORK FOR SOUTHWEST AND BUZZARD POINT

The process for creating the BGI Network begins by analyzing how water naturally flows and collects within the Project Area. A fundamental piece to the BGI network is a Neighborhood-wide “Water Balance” for stormwater management. This water balance combines information regarding the existing stormwater network capacity, rainfall data for the design storm, land-use information to evaluate runoff volumes and velocities, conveyance and/or detention capacities estimated for the developed BGI Typologies, and connectivity between proposed projects. It is in this water balance we ensure that all projects are sized, and connected appropriately, and needs for additional underground storage cells or new stormwater pipes identified and sized accordingly.

The water balance represents the entire BGI Network but is made up of sub-catchment areas where stormwater collects during rain events. Each sub-catchment area (also known as a “Cloudburst Branch”) is an independent area in the BGI Network that consists of connected upstream projects that detain water and convey water to the end recipient (typically a Floodable Multi-Purpose Space or a larger water body). A water balance is developed for each of the Cloudburst Branches making up the BGI Network for Southwest and Buzzard Point in an overall integrated manner.

The Cloudburst Branch delineations are illustrated in a BGI Cloudburst Branch Diagram showing directionality of conveyance projects and links between series of projects as they move downstream within a given Cloudburst Branch or sub-catchment. As water moves downstream through the Cloudburst Branch, the sizing of individual projects increases, eventually arriving at detention basins in parks, parking lots, or to the Washington Channel or Anacostia River. The BGI Cloudburst Branch Diagram resembles the Stormwater Flowlines (see Figure 21 on page 50) indicating a successful terrain-based BGI Network development for Southwest and Buzzard Point.

The BGI Network does not cover the entire Southwest and Buzzard Point neighborhood. The Washington Channel edge from the Wharf and to the intersection with the Anacostia River at the Fort McNair premises is already draining naturally to the Channel. Additionally, recent investments as part of the developments undertaken in the Wharf has included substantial new BGI features. Similarly, the southeastern part of Buzzard Point along Water St is still undergoing significant development which also includes new BGI projects. This area already drains naturally to the Anacostia River. It is assumed that these two waterfront areas of the Project Area are already sufficiently resilient in relation to near future extreme rainfall events. It is recommended, that their stormwater management capacity be reevaluated in relation to future updates to the Strategy.

In addition to this science-based approach, the BGI Network is also a result from significant community feedback and discussions with District and Federal agencies. Meetings with residents, representatives of civic groups and property owners helped identify opportunities at specific sites within the Project Area. The community events and public workshops were critical for gathering input from members of the public. At these events, community members reviewed draft concepts and provided feedback about the types of co-benefits that were most important to them. In addition, community members provided direction on design elements that should be included in Lansburgh Park, 2nd Street, and Delaware Avenue. Finally, agency representatives provided input to ensure that the overall BGI Network Plan and conceptual designs are compatible with District and federal regulations through a serious of meetings with District and federal agencies. This feedback is important because it helps to ensure that design ideas are feasible and aligned with agency priorities, which will reduce roadblocks in implementing the proposed BGI projects.

Catchment Areas

Critical to the calculations of storage requirements and the design of a mixed BGI system across the site is the delineation of catchments. Catchments can be delineated both in accordance with the existing underground stormwater infrastructure or based on the natural overland flows. Often a mix of the two will be relevant in relation to designing the BGI system, as it is connected to the existing (and future) underground stormwater system and will need to respect existing watersheds, flow directions and outlet capacities.

These steps combined leads to the BGI Network Plan made up of 30 individual BGI projects supported by six new stormwater pipes connecting the BGI Network to the existing drainage system. In total the BGI Network will be able handle 11 million gallons of stormwater.

The Conceptual BGI Network Plan shows the location of all proposed BGI projects and pipes divided into BGI Typologies. The Network Plan shows each of these locations in a diagrammatic way. Eventually, the intent of this Strategy is to provide a roadmap for the District to implement more BGI Projects in the future. As part of this Strategy, conceptual designs for three key locations were developed for Lansburgh Park, Delaware Avenue, and 2nd Street.

Figure 37: **BGI Project Diagram**

Source: Ramboll

Figure 38: Conceptual BGI Network Plan

Source: Ramboll

Project ID	Project Name	Typology	Water Volume (cf)	Cost Estimate
ROW-1	G-street (from 4th Pl to 3rd St)	Green Stormwater Street	57,510	$7,020,000
ROW-2	H St (Delaware Ave to Randall Field)	Cloudburst Conveyance Road	10,128	$1,550,000
ROW-2a	1st St (6th St to Delaware Ave)	Green Stormwater Street	55,173	$6,640,000
ROW-2b	Delaware Ave (1st st to H St)	Green Stormwater Street	9,945	$1,280,000
ROW-3	Delaware Ave (from I St to K St)	Green Stormwater Street	7,134	$970,000
ROW-4	Delaware Ave (from K St to M St)	Cloudburst Conveyance Road	23,317	$3,570,000
ROW-5	Delaware Ave (from M St to Canal St)	Green Stormwater Street	20,336	$2,760,000
ROW-6	Town Center Parks Walkway	Green Stormwater Street	25,634	$2,960,000
ROW-7	M St (from 4th St to 6th St)	Stormwater Detention Boulevard	17,759	$2,900,000
ROW-8	M St (from 4th St to Delaware Av)	Stormwater Detention Boulevard	43,923	$7,180,000
ROW-9	M St (from Capital St to 1st St Walk)	Stormwater Detention Boulevard	28,029	$4,580,000
ROW-9a	M st (from 1st st walk to Delaware Ave)	Stormwater Detention Boulevard	9,976	$2,360,000
ROW-10	Canal St (from N St to P St)	Cloudburst Conveyance Road	33,423	$4,920,000
ROW-11	P St (from 2nd St to 4th St)	Green Stormwater Street	11,612	$2,350,000
ROW-11a	3rd St (from P St to O St)	Green Stormwater Street	10,885	$1,260,000
ROW-12	2nd St (from P St to R St)	Green Stormwater Street	27,351	$3,530,000
ROW-13	2nd St (from R St to T St)	Green Stormwater Street	8,226	$3,160,000
ROW-14	2nd St (from T St to V St)	Cloudburst Conveyance Road	31,603	$4,470,000
ROW-15	1St (from S St SW to river)	Cloudburst Conveyance Road	57,177	$7,390,000
ROW-16	5th Ave (Fort McNair)	Cloudburst Conveyance Road	72,557	$10,240,000
Park-1a	Lansburgh Park West	Floodable Athletic Field	124,618	$5,180,000
Park-1b	Lansburgh Park East	Floodable Passive Park	68,840	$2,860,000
Park-2	Randall Field	Floodable Athletic Field	176,296	$7,240,000
Park-3	Jefferson Field	Floodable Athletic Field	44,230	$1,970,000
Park-4a	King Greenleaf Park South	Floodable Athletic Field	262,119	$4,480,000
Park-4b	King Greenleaf Park North	Floodable Athletic Field	27,976	$3,320,000
Park-5	James Creek Marina	Floodable Parking Lot	172,749	$8,580,000
Park-6	Southwest Library Playground	Floodable Playground	34,055	$1,450,000
Park-7	Parking lot on Delaware Ave	Floodable Parking Lot	50,641	$3,930,000
Park-8	Green space b/w G St and Delaware Ave	Floodable Playground	19,411	$670,000
Pipe-1	Park-1 to system	Pipe discharge		
Pipe-2	Park-2 to system	Pipe discharge		
Pipe-3	Park-2 to Pipe-2	Pipe discharge		
Pipe-4	Park-3 to system	Pipe discharge		
Pipe-5	Park-5 to river	Pipe discharge		
Pipe-6	Park-8 to ROW-2	Pipe discharge		

Blue-Green Infrastructure Projects

Project Descriptions

G Street (from 4th Place to 3rd Street)
Project ID: ROW-1

Typology: Green Stormwater Street

A series of connected bioswales and raingardens on G Street are designed to convey water toward large detention facilities in Randall Field. This project would include raingardens strategically placed in the parking lane and the middle of the existing but lowered traffic circles to manage stormwater while improving pedestrian safety and limiting loss of parking spaces. Bioswales would be installed outside of the sidewalks, where practical. Examples could include alongside Amidon Field and within existing swales in front of condo buildings on G Street. Installation of stormwater facilities on private property would require approval by (and, potentially incentives to) private property owners. In addition, stormwater facilities should be sited to avoid removal of existing trees.

H Street (from Delaware Avenue to Randall Field)
Project ID: ROW-2

Typology: Cloudburst Conveyance Road

This section of H Street will convey water from Delaware Avenue into Randall Field. H Street terminates at the Randall Field parking lot, which is designed to be a floodable parking lot. H Street is located toward the bottom of the catchment area, just before emptying into detention areas in Randall Field. This project creates an opportunity to improve the public roadway used to access Randall Field, and directly in front of Culture House and adjacent to the Rubell Museum.

I Street (from 6th Street to Delaware Avenue)
Project ID: ROW-2a

Typology: Green Stormwater Street

The Green Stormwater Street along I Street is designed to convey water from the top of the catchment area in the direction of Delaware Avenue. Beginning adjacent to the Southwest Duck Pond, a series of connected bioswales and raingardens are designed to convey water toward Delaware Avenue. Potential locations for bioswales could include adjacent to the Duck Pond, in front of Amidon Elementary School, and coordinated with the Town Center Parks Master Plan. In addition, this project could include coordination with the redevelopment of Greenleaf Gardens by DC Housing Authority. I Street SW is also identified in the 2015 Southwest Neighborhood Plan as an art street and, therefore, the front plaza at Randall Park presents an opportunity to integrate public art with proposed stormwater projects as it abuts the new Rubell DC museum.

Delaware Avenue (from Canal Street to H Street)
Project IDs: ROW-2b, ROW-3, ROW-4, ROW-5

Typologies: Green Stormwater Street, Cloudburst Conveyance Road

Each of these four segments of Delaware Avenue have distinct conveyance purposes.

ROW-2b (from I Street to H Street): This one-block segment is intended to convey water from I Street (ROW-2a) toward H Street (ROW-2) and then into detention facilities in Randall Field. The wide right-of-way along Delaware Avenue can be used to create bioswales without damaging existing trees.

ROW-3 (from I Street to K Street): This one-block segment is intended to convey water from I Street (ROW-2a) toward detention facilities in the northern part of Lansburgh Park (Park-2a). The wide right-of-way along Delaware Avenue includes grassy swales in front of Greenleaf Gardens and Friendship Baptist Church. Both of these areas create opportunities for conveyance functions, by providing incentives to property owners.

ROW-4 (from M Street to K Street): This section of Delaware Avenue provides conveyance from M Street (ROW-8) to Lansburgh Park (Park-1a). As with other sections of Delaware Avenue, the wide right-of-way creates a significant opportunity to install bioswales. These include in front of Greenleaf Gardens, Lansburgh Park, and the Metropolitan Police Department parking lot.

ROW-5 (from M Street to King Greenleaf Park): The Green Stormwater Street on this segment of Delaware will convey water from M Street to detention facilities at King Greenleaf Park. With a relatively narrow roadway and established trees lining the street, this project will require coordination with private property owners.

Town Center Parks Walkway

Project ID: ROW-6

Typology: Green Stormwater Street

The Town Center Parks walkway is in the process of being procured, designed, and built, as a partnership between DGS and the Southwest BID. Coordination with that effort provides an opportunity to incorporate BGI into the ongoing design project. The objective of this project is to convey water from the top of the catchment area, toward I Street, and into detention facilities at the Southwest Library Playground.

M Street

Project IDs: ROW-7, ROW-8, ROW-9, ROW-9a

Typology: Stormwater Detention Boulevard

M Street is designed as a Stormwater Detention Boulevard, making use of the wide right-of-way and center median to provide additional storage and conveyance capacity. A particular advantage of the Stormwater Detention Boulevard on M Street is that it can be used to divert stormwater away from WMATA vents—these vents flood during heavy rainstorms, causing flooding on tracks below grade. The vents are currently protected by sandbags, which provide limited protections. By directing water toward the center median, rather than the curbs, these vents should not receive stormwater that causes damage to WMATA assets.

There are four segments of M Street, each with distinct conveyance functions:

ROW-7 (from 4th Street to 6th Street): This segment of M Street connects to the existing stormwater median on Maine Avenue. The segment conveys water from the top of the catchment to the existing stormwater pipe at the intersection of M Street/Maine Avenue and 6th Street. In addition to the stormwater median, there may also be opportunities to install bioswales behind the sidewalk in select locations—and in coordination with private property owners.

ROW-8 (from 4th Street to Delaware Avenue):

ROW-9 (from Capital Street to 1st Street Walk):

ROW-9a (From 1st Street Walk to Delaware Avenue):

Canal Street

Project ID: ROW-10

Typology: Cloudburst Conveyance Road

Canal Street is designed to function as a Cloudburst Conveyance Road transporting the stormwater captured on 2nd St to storage solutions in King Greenleaf Park. Construction of BGI on Canal Street is a long-term implementation goal slated to take place after renovations of King Greenleaf Park are complete. Wide sidewalk green strips and open spaces north of P Street can be converted to bioswales to promote infiltration and channel runoff away from assets. The network of bioswales and supporting drainage infrastructure along Canal St will discharge into the Floodable Athletic Field in King Greenleaf.

P Street

Project ID: ROW-11

Typology: Green Stormwater Street

P Street, an already vegetated and mobility-focused streetscape, is opportune for small-scale engineered systems (bioswales, raingardens, permeable pavement) to detain, slow, filter, and cleanse stormwater runoff from impervious surfaces. Small renovations for hydraulic elements within the right-of-way will reduce ponding in the street and bike lanes and enhance the urban landscape of this residential block. Solutions on P Street are to be connected with the downstream Green Stormwater Street solutions on 3rd Street. Construction on P Street is a long-term implementation goal and should be concurrent with that on 3rd Street.

3rd Street

Project ID: ROW-11a

Typology: Green Stormwater Street

Like P Street, 3rd Street is well-vegetated with mature trees. Existing tree pits can be built out into raingardens to detain more runoff. Bioswale installation along sidewalks on 3rd Street is proposed in collaboration with residential property owners. Below grade drainage infrastructure on 3rd Street will connect to upstream infrastructure on P Street and discharge stormwater to the parking lot on Delaware Avenue during extreme events. This requires downstream construction of the parking lot on Delaware Avenue to be completed in advance. Connection of pipe infrastructure into the parking lot will also require coordination with the private property owner.

2nd Street

Project IDs: ROW-12, ROW-13, ROW-14

Typologies: Green Stormwater Street and Cloudburst Conveyance Road

There are three project segments on 2nd Street to accommodate differing flow paths and available space. 2nd Street reaches a local high point at the intersection with R Street, north of which runoff drains to King Greenleaf Park and south of which drains to James Creek Marina and the Anacostia River conveying runoff both north and south. 2nd Street runs along the eastern perimeter of Fort McNair and features wide sidewalks and grass strips. Coordination with city agencies presents an opportunity to re-imagine mobility, pedestrian access, and landscape design on 2nd Street.

ROW-12 (from R Street to P Street) is modeled as a Green Stormwater Street that uses small-scale nature-based solutions to channel water along the existing street grade to the north. The Green Stormwater Street solutions will then connect into conveyance mechanisms on Canal Street (ROW-10) and discharge into storage areas in King Greenleaf Park. Small rain events can be managed by bioswale and raingarden features in the ROW, and larger, more extreme rain events will be conveyed to storage areas to avoid property damage and risk to residents. The function of ROW-12 is dependent on ROW-10 and is to be constructed after the downstream BGI network.

ROW-13 (from R Street to T Street) is also a Green Stormwater Street but conveys stormwater in the opposite direction. Here, BGI in the ROW will help convey water from the local high point at R Street and 2nd Street to the south where it will connect into ROW-14. Bioswales and raingardens are proposed for existing grass strips and permeable pavement for the separated bike lane. Construction is dependent on the downstream BGI network (ROW-14 and ROW-15) and should be done concurrently or sequentially.

ROW-14 (from T Street to V Street) extends from T Street down to the southernmost end of 2nd Street where it connects into James Creek Marina and outfalls into the Anacostia River. Designed as a Cloudburst Conveyance Road, this segment can convey large volumes of stormwater from the upstream network. In addition to roadside bioswales and raingardens, this segment will feature a V-shape road profile to assist in transporting water to the outfall when sewer networks are surcharged. Construction of ROW-14 is set as mid-term planning goal to begin when James Creek Marina renovations are complete.

1st Street

Project ID: ROW-15

Typology: Cloudburst Conveyance Road

The Cloudburst Conveyance Road on 1st Street is designed to drain runoff from the top of the catchment area on S Street out to the Anacostia River. Using vegetated roadside features and V-shape road profiles, the road will convey water out to the river during extreme storm events. The catchment area is small and not projected to experience frequent precipitation-based flooding, and so the project is lower priority and slated for long term implementation.

5th Avenue

Project ID: ROW-16

Typology: Cloudburst Conveyance Road

The 5th Avenue Cloudburst Conveyance Road is proposed for stormwater management inside Fort McNair. Conveyance is proposed along the existing flow path to direct runoff away from assets and toward the floodable parking lot in James Creek Marina. DOD management of implementation is suggested to expedite approvals. The project is independent of other BGI network components and can be pursued for near-term construction.

Lansburgh Park

Project IDs: Park-1a and Park-1b

Typology: Floodable Passive Park

The objective of the conceptual design for Lansburgh Park is to maximize stormwater management strategies, while also providing co-benefits for park users and the neighborhood as a whole. Design concepts were considered for their ability to serve multiple functions—Blue-Green Infrastructure components are intended to provide other benefits for the community, such as improved park space for underserved communities and reduction in urban heat island effect. Lansburgh Palk is located at the bottom of the catchment area and receives runoff from conveyance projects on M Street, Delaware Avenue, and overland flows. BGI features include a floodable basketball court, floodable dog park, floodable play lawn, bioswale corridors, and shaded sculpture grounds and art portal. In addition, the conceptual design is intended to restore elements of the original L'Enfant Plan, which has been interrupted by urban renewal in the Southwest Neighborhood. Funding for the Lansburgh Park project has been secured from FEMA. The site is publicly owned and is proposed a near-term implementation goal to be coordinated with DPR as a demonstration project for the neighborhood. For more information refer to the Pilot Project section.

Randall Field

Project ID: Park-2

Typology: Floodable Athletic Field

Coordination with planned DPR work at Randall Field presents an opportunity for innovative stormwater management additions. Existing athletic fields at Randall can be lowered to provide stormwater detention during extreme events. The large capacity of these fields should only be required during rare storm events (i.e., once every 10 or 20 years). The fields are designed with drainage systems that are connected to the existing storm sewer system so that they can adequately drain after the storm passes. Randall Field is located at the bottom of the catchment area and will detain stormwater conveyed from ROW-1 and ROW-2. The project is therefore proposed for near-term implementation to allow for upstream projects.

Jefferson Field

Project ID: Park-3

Typology: Floodable Athletic Field

At Jefferson Field, the existing tennis courts and pickleball courts would be converted into floodable athletic courts. They would be lowered to be below the surrounding grade. During extreme rain events, stormwater would be piped into these courts from G Street, then distributed into dry basins. The courts will be designed using the Floodable Athletic Fields typology . They include pipes to inlet water into the dry basin, underdrains to drain water out, and sub-surface storage cells to increase storage capacity. By providing underdrains and sub-surface storage, drainage for these facilities will be improved during everyday rain events as well, reducing ponding in the courts. The design also includes providing bioswales around the edges of the grassy area of the park. These bioswales would not encroach upon the existing soccer field and baseball diamond. Rather, they would be sited in order to reduce ponding from frequent rain events on the active athletic fields.

Figure 39: Conceptual Diagram of BGI at Randall Field

Source: Moody Graham

King Greenleaf Park and Recreation Center

Project ID: Park-4a, Park-4b

Typology: Floodable Athletic Field

King Greenleaf Recreation Center has an existing baseball field and lawn space that can be converted to a floodable dry basin. By excavating the field and re-landscaping (with traditional grasses and clays) at a lower surface elevation, the area will serve its recreational purpose while providing additional detention during extreme events. The floodable baseball field will receive stormwater from surface BGI and underground pipes during high volume events. The field is at a low-point, and existing topography and flow paths will support overland runoff to the dry basin. The project is proposed for a near-term implementation goal.

Recreational courts on the north end of the Recreational Center offer an additional detention space for long-term cloudburst planning. The courts were recently refinished, so BGI improvements are suggested in 10+ years when routine renovations take place. At that time, lowering the hardscape courts will provide additional detention area for the conveyance from Delaware Avenue.

James Creek Marina

Project ID: Park-5

Typology: Floodable Parking Lot

James Creek Marina is the southernmost detention area in the Strategy. A Floodable Parking Lot accompanied by a network of bioswales and raingardens will offer storage to the conveyance features on 2nd Street and 5th Street. Adjacent to the Anacostia River, outfall connectivity can help drain the lot after large storm events. Coordination with the National Park Service is required for implementation.

Southwest Library Playground

Project ID: Park-6

Typology: Floodable Playground

The Southwest Public Library is a new community landmark designed to enhance neighborhood experience and connect users with nature. The existing playground in the front of the property presents an opportunity to further improve community livability and natural habitat. Re-designing the playground, currently a synthetic rubber surface, to permeable surfaces with detention potential will support stormwater management in the north of the Project Area. The Floodable Playground can detain flows from the Town Center Parks Walkway and should be coordinated with the Walkway redesign. Implementation should be pursued in the short term.

Parking Lot on Delaware Avenue

Project ID: Park-7

Typology: Floodable Parking Lot

The River Park Parking Lot on Delaware Avenue was identified for surface floodwater detention. Renovations for the parking lot are a long-term implementation goal to support stormwater management. During extreme rainfall events, the lot can receive stormwater from P Street and 3rd Street to maintain roadway service for emergency response and evacuation. Detaining water in the parking lot will also protect surrounding residential buildings from asset damages and public endangerment. Gray infrastructure will drain to the sewer network to prevent ponding over certain depths.

Green Space between G Street and Delaware Avenue

Project ID: Park-8

Typology: Floodable Playground

The private green space adjacent to Randall Field, between G Street and Delaware Avenue, is an additional site for stormwater detention. Strategically situated between the G Street Green Stormwater Street and the Randall Field dry basins, this green space would hydraulically connect the BGI network and allow water to be conveyed from the right-of-way to the detention areas. Existing grass areas can be excavated and redesigned as raingardens and bioswales to enhance stormwater management capacity. The property is critical for drainage from G Street but requires coordination with the private condominium that owns the property for implementation. The project is proposed for mid-term implementation (5-10 years) in coordination with upstream and downstream BGI projects.

Phasing Construction of BGI Over Time

A Construction Phasing Plan was developed to provide an informed estimate of when each BGI project may be implemented over time. This plan is based on an array of factors, which are summarized below. It should be emphasized that the actual timeframe for a given project is subject to funding availability, timing of relating capital projects, site ownership, and other site-specific factors. The criteria for prioritizing future BGI project include:

1. Potential for risk reduction: Projects that will have a greater impact on reducing damages due to rainwater flooding should be implemented before projects that would have a smaller impact on flooding and fewer co-benefits.
2. Feasibility: Site control, available funding, and coordination with DC and federal agencies are all critical factors in implementing BGI projects. This plan acknowledges that many BGI projects will require outside grant funding, participation by multiple local agencies, and coordination with private property owners in some cases.
3. Timing of other site improvements: BGI projects that are located on sites that have been recently upgraded, may have a lower priority (since the District has recently allocated public funds to those sites). By contrast, sites that are planned for regular maintenance or upgrades in the near future should be prioritized for BGI projects that are coordinated with planned work in the public realm.
4. Location in the catchment area: Downstream BGI projects receiving larger volumes of water should be prioritized first followed by immediately upstream projects, so that the temporary incomplete sections of the BGI network functions effectively until the full network has been constructed.
5. Coordination with other capital projects: The most efficient way to implement BGI projects is to combine them with other capital improvements. This requires coordination between property owners and the District, as well as between different District agencies to create more efficient improvements in the public realm.

Based on the above criteria, each BGI project has been assigned a general timeframe, as follows:

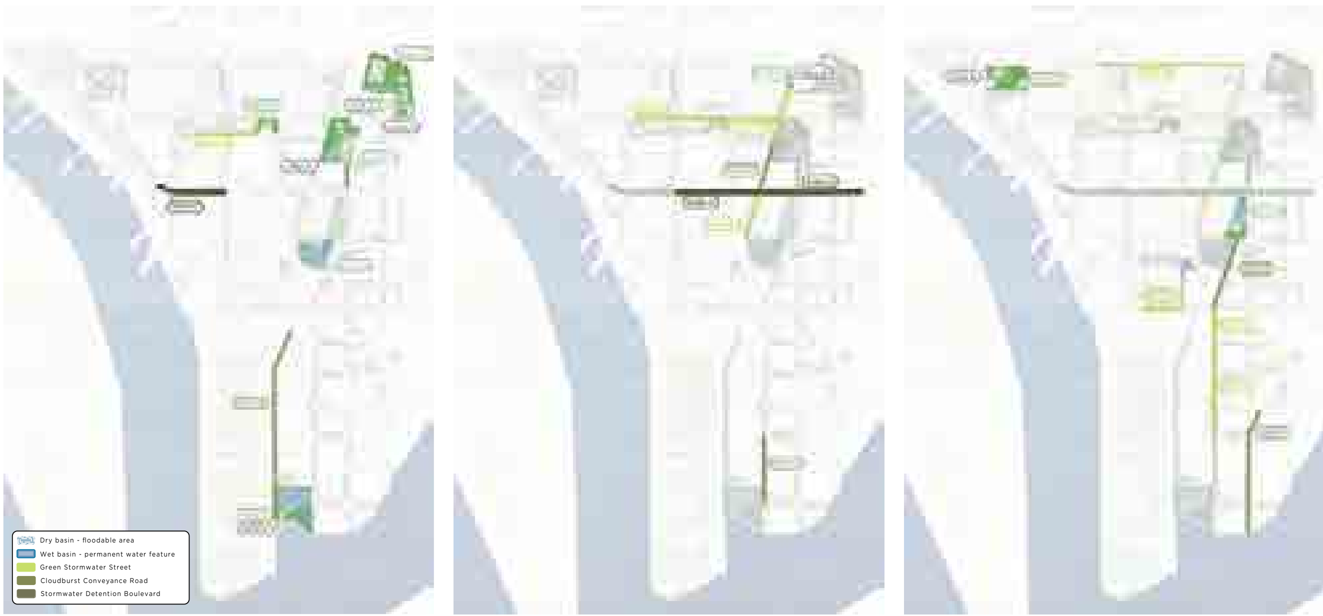
- Short-term: 1 to 5 years
- Medium-term: 5 years to 10 years
- Long-term: 10 years or more

Note that these timeframes are not intended to be set in stone or to bind the District to implement specific projects in a given timeframe. The specific timing will depend upon coordination between agencies and availability of funding.

PROJECTS WILL BE PHASED ACCORDING TO PLACEMENT IN THE CATCHMENT AND OTHER PLANNED CONSTRUCTION.

5 YEARS | 10 YEARS

SHORT	MEDIUM	LONG
Downstream floodable multi-functional space typologies, stand-alone projects, and high-risk area.	Projects immediate upstream from constructed floodable multi-functional space typologies.	Upstream projects and lower risk areas.



SHORT

ID	TYPOLOGY	PROJECT NAME
Park-1	FLOODABLE ATHLETIC FIELD	LANSBURGH PARK WEST
	FLOODABLE PASSIVE PARK	LANSBURGH PARK EAST
Park-2	FLOODABLE ATHLETIC FIELD	RANDALL FIELD
Park-4a	FLOODABLE ATHLETIC FIELD	KING GREENLEAF PARK SOUTH
Park-5	FLOODABLE PARKING LOT	JAMES CREEK MARINA
Pipe-1	PIPE DISCHARGE	PARK-1 TO SYSTEM
Pipe-2	PIPE DISCHARGE	PARK-2 TO SYSTEM
Pipe-3	PIPE DISCHARGE	PARK-2 TO PIPE-2
Pipe-5	PIPE DISCHARGE	PARK-5 TO RIVER
ROW-6	GREEN STORMWATER STREET	TOWN CENTER PARKS WALKWAY
ROW-7	STORMWATER DETENTION BLVD.	M ST (FROM 4TH ST TO 6TH ST)
ROW-16	CLOUDBURST CONVEYANCE ROAD	5TH AVE (FORT MCNAIR)

MEDIUM

ID	TYPOLOGY	PROJECT NAME
Park-8	FLOODABLE PLAYGROUND	GREEN SPACE BTW G ST AND DEL. AVE
Park-6	FLOODABLE PLAYGROUND	SOUTHWEST LIBRARY PLAYGROUND
Pipe-6	PIPE DISCHARGE	PARK-8 TO PARK-2
ROW-2	CLOUDBURST CONVEYANCE ROAD	H ST (DELAWARE AVE TO RANDALL FIELD)
	GREEN STORMWATER STREET	1ST ST (6TH ST TO DELAWARE AVE)
	GREEN STORMWATER STREET	DELAWARE AVE (1ST ST TO H ST)
ROW-3	GREEN STORMWATER STREET	DELAWARE AVE (FROM I ST TO K ST)
ROW-4	CLOUDBURST CONVEYANCE ROAD	DELAWARE AVE (FROM K ST TO M ST)
ROW-5	GREEN STORMWATER STREET	DELAWARE AVE (FROM M ST TO CANAL ST)
ROW-8	STORMWATER DETENTION BLVD.	M ST (FROM 4TH ST TO DELAWARE AV)
ROW-9	STORMWATER DETENTION BLVD.	M ST (FROM CAPITAL ST TO 1ST ST WALK)
	STORMWATER DETENTION BLVD.	M ST (FROM 1ST ST WALK TO DELAWARE AVE)
ROW-14	CLOUDBURST CONVEYANCE ROAD	2ND ST (FROM T ST TO V ST)

LONG

ID	TYPOLOGY	PROJECT NAME
Park-3	FLOODABLE ATHLETIC FIELD	JEFFERSON FIELD
Park-4b	FLOODABLE ATHLETIC FIELD	KING GREENLEAF PARK NORTH
Park-7	FLOODABLE PARKING LOT	PARKING LOT ON DELAWARE AVE
Pipe-4	PIPE DISCHARGE	PARK-3 TO SYSTEM
ROW-1	GREEN STORMWATER STREET	G-STREET (FROM 4TH PL TO 3RD ST)
ROW-10	CLOUDBURST CONVEYANCE ROAD	CANAL ST (FROM N ST TO P ST)
ROW-11	GREEN STORMWATER STREET	P ST (FROM 2ND ST TO 4TH ST)
	GREEN STORMWATER STREET	3RD ST (FROM P ST TO O ST)
ROW-12	GREEN STORMWATER STREET	2ND ST (FROM P ST TO R ST)
ROW-13	GREEN STORMWATER STREET	2ND ST (FROM R ST TO T ST)
ROW-15	CLOUDBURST CONVEYANCE ROAD	1ST (FROM S ST SW TO RIVER)

Figure 40: Construction Phasing Plan

Source: Ramboll

Lansburgh Park and King Greenleaf Park Pilot Project

Lansburgh Park

Context and Neighborhood Connection

The L'Enfant Plan of Washington, D.C. highlights how much the street network has changed around Lansburgh Park. In the L'Enfant Plan, Delaware Avenue continues uninterrupted from Fort McNair all the way north to the Capitol building. First Street is a north-south artery. K Street and L Street extend through the area currently occupied by Lansburgh Park.

One other notable feature on the L'Enfant Plan is James Creek, following the path of present-day Canal Street and forming the eastern border of Fort McNair. The presence of James Creek in the L'Enfant Plan is a reminder of where the low-lying areas are located—and where water is likely to collect during extreme rain events.

The current street plan, overlaid with the L'Enfant Plan streets, shows how the intended connections were interrupted when Lansburgh Park was constructed as part of the urban renewal of the Southwest neighborhood in 1964. Delaware Avenue is no longer a primary diagonal route from Buzzard Point to the Capitol. Instead, because Delaware only extends from N Street to H Street, it has the feel of a neighborhood street. 1st Street is cut off by Lansburgh Park but is replaced within the park by First Street Walk. Similarly, K Street and L Street also terminate at the west side of the park, before continuing on the east side. The redesign of Lansburgh Park provides an opportunity to recreate the sense of connection that was intended by the L'Enfant Plan.

In addition to honoring the L'Enfant Plan, strengthening the connection from K Street into the park serves other purposes as well. Notably, the K Street connection can be viewed as an extension of the Town Center Parks Master Plan. This plan focuses on the pedestrian walkway that extends from the Southwest Duck Pond to the Southwest Library. The District, in coordination with the Southwest Business Improvement District, is currently working with a consultant on design and construction of the Town Center Parks plan. The redesign of Lansburgh Park is also an opportunity to link the north-south connection through the park (1st Street Walk) to the proposed Art Corridor on I Street and the Rubell Museum.

Lansburgh Park Existing Conditions

With its ample areas of open turf fields, a dog park and basketball courts, Lansburgh Park provides plenty of opportunities for stormwater management through the redesign of spaces. However, the park is also rich with existing elements and infrastructure that is important to the community and that will not be changed. The proposed design for Lansburgh Park preserves these existing elements and enhances them with the new design. The pavilions located along 1st Walk are part of the original design by Leroy Skillman. These structures are historically relevant and are the subject of a recent application for landmark status and will not be affected by the proposed park redesign.

There are also many existing heritage and special trees on the site. The proposed design for Lansburgh Park should preserve as many existing trees as possible and should also be mindful of the critical root zone to avoid damaging existing trees.

There are also several newer recreational assets in the park that are important to community members—and should be preserved. These include the basketball court, dog park, community garden, and murals. Where possible, the proposed design seeks to enhance these design elements. Among the improvements suggested by members of the public include improving site lines into the park, along 1st Walk and from Delaware Avenue. To achieve this, the proposed design should avoid vegetation that blocks viewsheds from I Street and M Street. In addition, the existing mound blocks sight lines from Delaware Avenue, creating perceptions of safety issues in Lansburgh Park.

Figure 41: L'Enfant Plan

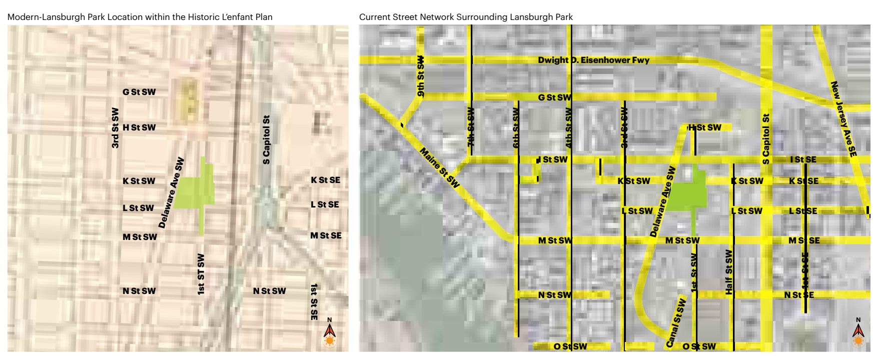


Figure 42: Lansburgh Park in the Contect of the L'Enfant Plan

Source: Moody Graham

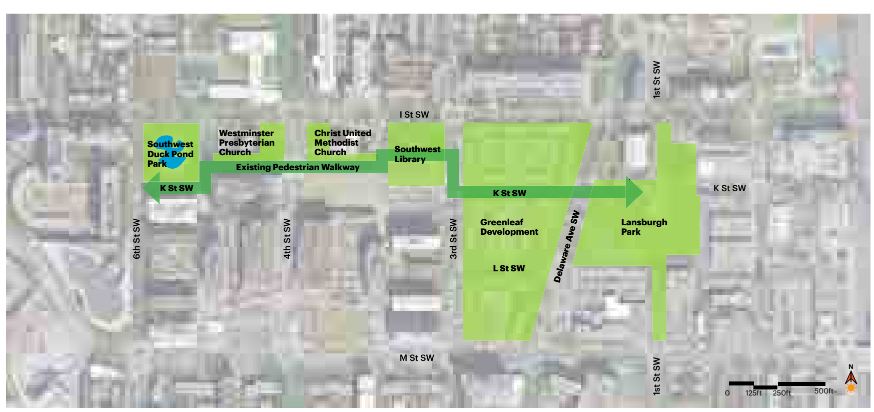
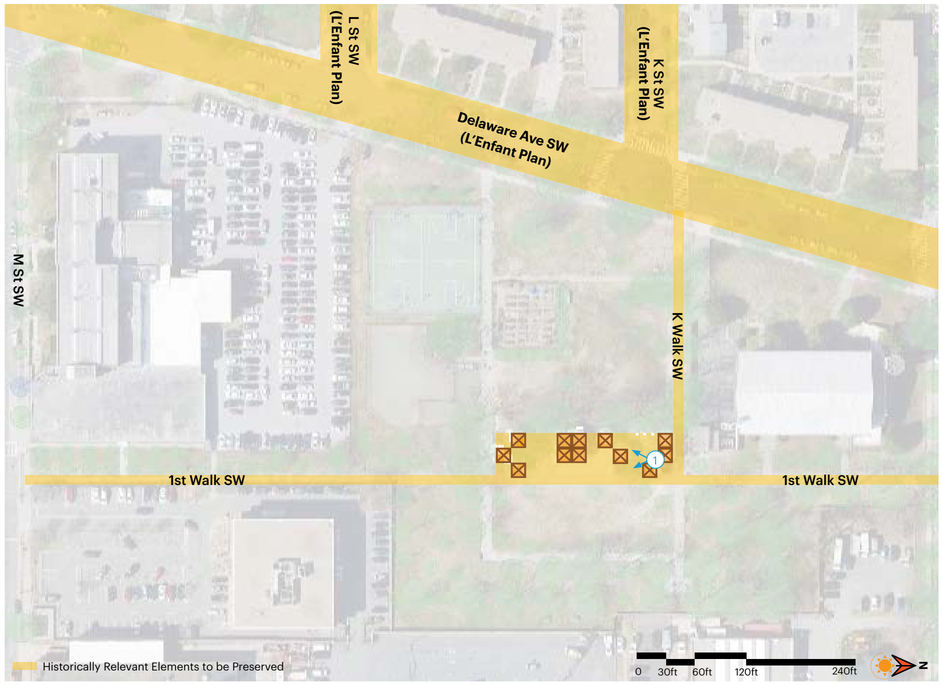


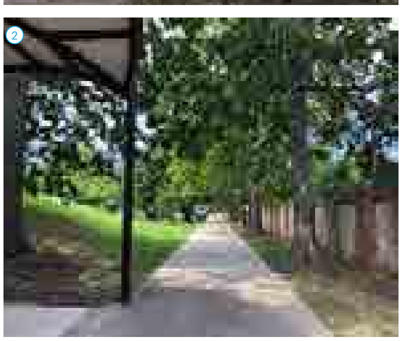
Figure 43: Connection from Lansburgh Park, to the Town Center Parks, and the Duck Pond

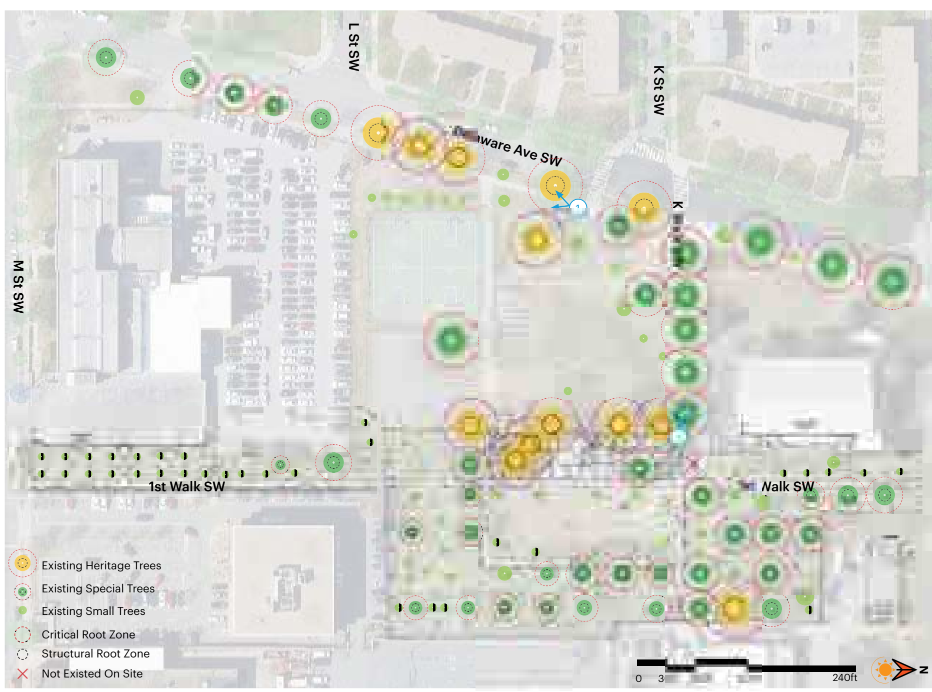
Source: Moody Graham

Historically Relevant Elements to be Preserved



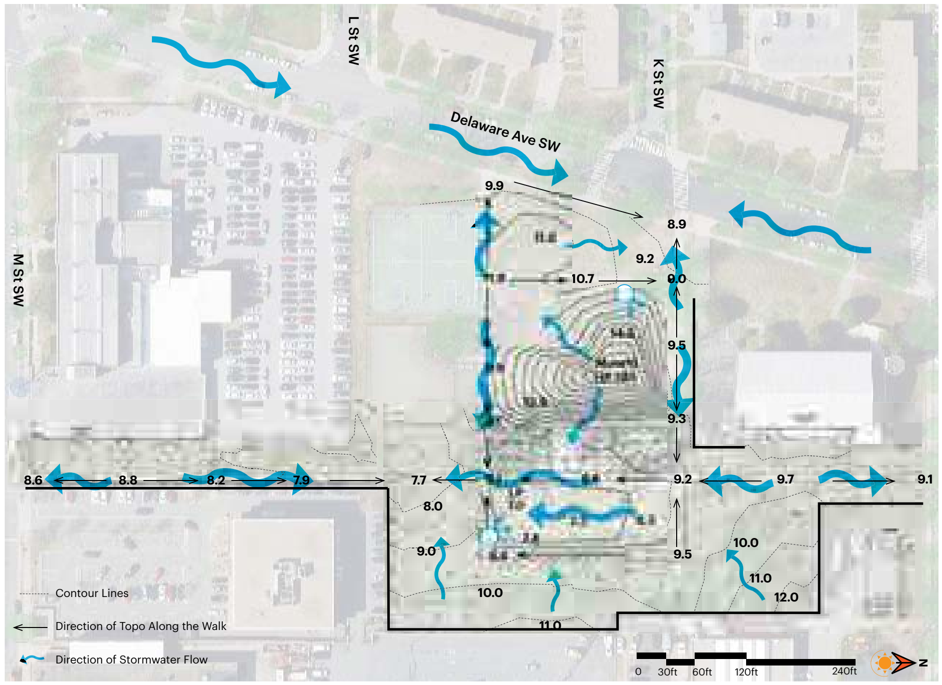
Existing Heritage and Special Trees





Existing Topography and Spot Grades

xisting topography blocks entrance views to the park



Existing Park Program

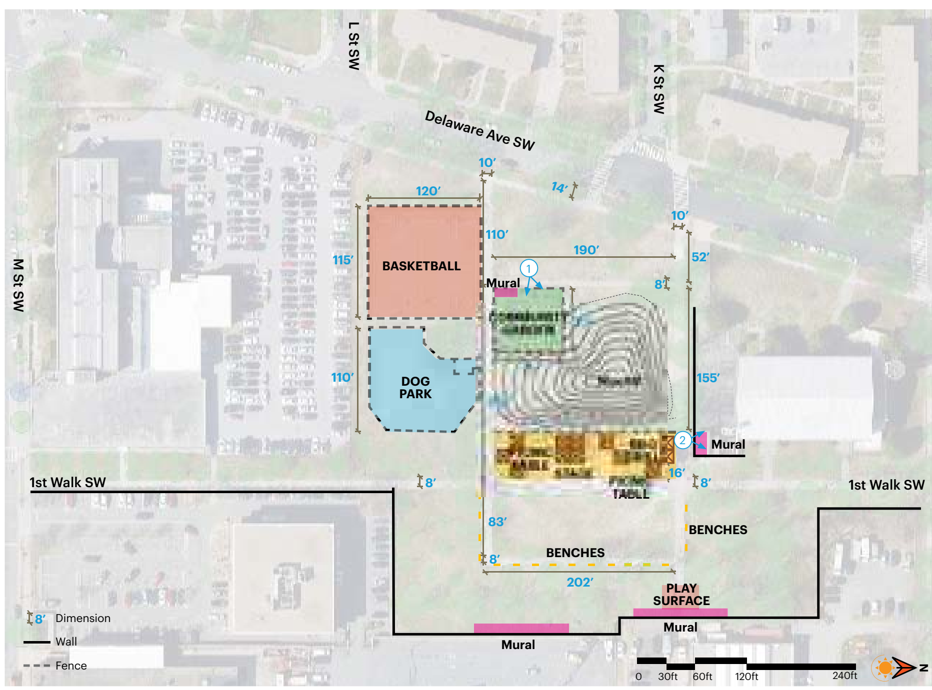


Figure 44: Lansburgh Park Existing Conditions Diagrams

Source: Moody Graham

Opportunities and Constraints

In addition to analyzing existing conditions, the project team also gathered input from the community during public workshops and through on-site interviews. Based on this feedback, the team developed a series of Opportunities and Constraints to guide conceptual design for the park:

Opportunities

- Invested and engaged community.
- Popular community garden.
- Existing art murals and proximity to Rubell museum.
- Existing depression with low points creates opportunities to detain stormwater.
- Proximity to Greenleaf Development and continuous green pedestrian corridor planning.
- Existing historical structures to remain and be revitalized by inserting new program.

Constraints

- Existing topography creates difficulties in conveying stormwater from nearby streets to the low point in the park.
- Existing mounds create separation between the park and streets, enhancing the quiet and peaceful environment but also blocks the view corridor and creates safety concerns.
- Existing mature trees limit the potential locations for swales.
- Existing historical structures to be preserved.
- Preservation of L'Enfant street plan.

Lansburgh Park

Kiela - Resident across the street:

No matter what you design, **please don't forget the community.** They changed the kids playground to a dog park. It is good for the dogs, but the existing kids playground is too small. It would be great to have **more places for kids.**

Andica - Nearby Resident:

I really enjoy the **peacefulness** here. I can always hear **birds singing. We come here to grill.** But that **stage we do not use much.**

I like the dog park here. **I also love the fruits trees and blackberry vines on the community garden.**

John - Nearby Resident:

It is a nice park. Benches are good. A lot of people come for parties and play music under the trellis. I have seen the **lawn get flooded and very mushy several times.**

Community Engagement Feedback :

The mound **block the view corridor** and create some **safety concerns.**
The entry along the 1st walk is too hidden. People would not know there is a park from south and north entry point.
The gateway from Delaware Ave is also not open and welcoming enough.

Figure 45: Community Feedback and On-Site Interviews

Source: Moody Graham

REOCCURRING RESPONSES: WHAT WOULD YOU LIKE TO SEE IN LANSBURGH PARK?

•Improve safety and make it feel more welcoming

•Extend the number of usable hours of the park with lighting

•Extend the growing season of the community garden by incorporating a cistern

•Improve the usability of the dog park by adding trees for shade

•Remove the fewest number of trees possible

•Provide spaces for a diverse range of family gatherings

•Keep the existing mound but alter it so that it provides a specific value as well as visual interest

•Solve the constantly muddy conditions of the dog park area

•Remove as much fencing as possible and shorten fences when possible

•Minimize the presence of mosquitos

•Feature edible fruit trees

• Solve the un-level pavement issues

• Replace the existing benches

• Prevent police officers from parking their vehicles within the park

• Make sure the light features are Dark-Sky compliant and that they don't negatively affect wildlife

• Use plants and to frame view corridors (L'Enfant)

• Better connect to other nearby parks and public spaces (including the Randall Rec Center the Rubell Museum)

• Incorporate a wildlife study

• Trash is an ongoing maintenance concern

•Have all of the elements in the park work independently and cohesively

PROGRAMMATIC PRIORITIES: RANKING THE OPTIONS FOR LANSBURGH PARK

1. **Flexible Space & Relaxation**
2. **Access to Nature**
3. **Gathering & Event Space**
4. **Art & Expression**
5. **Kids' Play Area**

Figure 46: Community Engagement Event Analysis

Source: Moody Graham

Lansburgh Park - Precedent Images

Playful Spaces for Nature-Based Stormwater Conveyance

Lansburgh Park Conceptual Design

The objective of the conceptual design for Lansburgh Park is to maximize stormwater management strategies, while also providing co-benefits for park users and the neighborhood as a whole. Design concepts were considered for their ability to serve multiple functions—Blue-Green Infrastructure components are intended to provide other benefits for the community, such as improved park space for underserved communities and reduction in urban heat island effect. In addition, the conceptual design is intended to restore elements of the original L'Enfant Plan, which has been interrupted by urban renewal in the Southwest Neighborhood.

Stormwater Allee and K Street Extension

The K Street Stormwater Allee will become the primary entrance to Lansburgh Park along Delaware Avenue. This wide allee is intended to recall the original grid of the L'Enfant Plan by providing a wide entryway into the park. This corridor is also designed to convey and detain stormwater, serving a critical function in the BGI Network. The pathway is a linear axis with integrated bioswales. The walkway is pervious and bioswales provide storage capacity for stormwater. The bioswales convey water toward the Floodable Play Lawn in the eastern portion of the park.

Floodable Basketball Court and Dog Park

The existing basketball courts and dog park will remain, but they are redesigned so that they also serve a stormwater function. Both of these assets will be lowered approximately 3 feet below the surrounding grade. Lowered athletic fields and courts will be designed to be ADA compliant. During extreme events, stormwater from M Street will be conveyed along the 1st Street Walk Bioswale Corridor, then distributed into these dry basins. The basketball courts and dog park will be designed using the Floodable Athletic Fields typology. They include pipes to inlet water into the dry basin, underdrains to drain water out, and sub-surface storage cells to increase storage capacity. By providing underdrains and sub-surface storage, drainage for these facilities will be improved during everyday rain events as well, reducing ponding in the courts and muddy conditions in the dog park. The sub-surface storage cells have the added benefit of storing the initial flow of stormwater, meaning that the surface volumes will only collect water during extreme rain events.

Floodable Play Lawn

The Floodable Play Lawn in the eastern portion of the park is at a lower elevation than surrounding grades under the existing conditions. However, it lacks additional drainage, which leads to ponding and soggy conditions, even during everyday rainstorms. Under the proposed redesign, this area would be further lowered below the surrounding grade to create additional storage capacity. The grassy areas would be tiered to create visual interest, a variety of spatial experiences, and storage areas for different size storms. The edges of these tiers will be made of large stones, which also serve as seating areas.

Water will be piped to the Floodable Play Lawn from the Pebble Walk and from the northern section of 1st Street Walk. Pipes will inlet water into the dry basin, with underdrains to drain water out, and sub-surface storage cells to increase storage capacity. The underdrains and sub-surface storage cells will improve drainage during everyday rains as well, reducing the ponding that currently occurs in the play field.

The Floodable Play Lawn also includes an educational platform, adjacent to the existing pavilion structures. This platform and walkway will include educational signage to provide information about BGI facilities and how the redesigned Lansburgh Park functions as a stormwater facility. In addition to this educational signage, the educational platform can also serve as a muti-use stage area for small performances. Viewers would be able to observe from the tiered levels of the Floodable Play Lawn.

Figure 47: Lansburgh Park Illustrative Plan

Source: Moody Graham

Proposed Site Feature Notes

1. Stormwater Allee and K Street Extension
2. Existing Community Garden - No Change
3. Cistern to Extend the Growing Season of the Community Garden
4. Expanded Orchard - Fruit and Nut Trees
5. Sunken Basketball Courts - Lower than Surrounding Grade for Stormwater Storage Capacity
6. Sunken Artificial Turf Dog Park - Lower than Surrounding Grade for Stormwater Storage Capacity
7. L Street Extension with Walkway and Trees
8. 1st Street Walkway with Flowering Tree Canopies and Bioswales
9. Art Portals at 1st Street Park Entries
10. Existing Historic Pavilions
11. Historic Community Stage Pavilion
12. Theater Deck to Expand Audience Capacity, Provide Flexible Play, and Serve as an Outdoor Classroom
13. Floodable Play Lawn, a Multi-Level Multi-Use Space - Lower than Surrounding Grade for Stormwater Storage Capacity
14. Mural and Sculpture Walkway Among Existing Special and Heritage Trees
15. Existing Mural
16. Proposed Sculpture Location
17. Outdoor Classroom Storage Shed

Note: See subsequent pages for stormwater diagram and trees to remain diagram.

Bioswale Corridors (1st Street Walk and L Street Extension)

1st Street Walk and the extension of L Street are both used as corridors for bioswales to convey water into the detention areas within Lansburgh Park. The southern portion of 1st Street Walk conveys water from M Street to the dry basins at the dog park and basketball courts. The bioswales along the L Street extension also convey water to the dry basins at the dog park and basketball courts. The northern portion of 1st Street walk conveys water from I Street to the Floodable Play Lawn. These corridors include planted bioswales and an improved concrete walkway that welcomes neighbors into portions of the park that are currently underutilized due to perceived safety issues.

The pathways are designed with flowering trees, new lighting, and benches, with sightlines into the park emphasized to improved visibility and safety.

Shaded Sculpture Grounds and Art Portal

The Shaded Sculpture Grounds are intended to enhance tree cover in Lansburgh Park, increasing stormwater retention and reducing urban heat island effect. Ideally, the District will seize the opportunity to create a connection with the new Rubell Museum across the street and build on the 2015 Southwest Neighborhood Plan idea of creating an art corridor on I Street by including sculptures and playable art in the park.

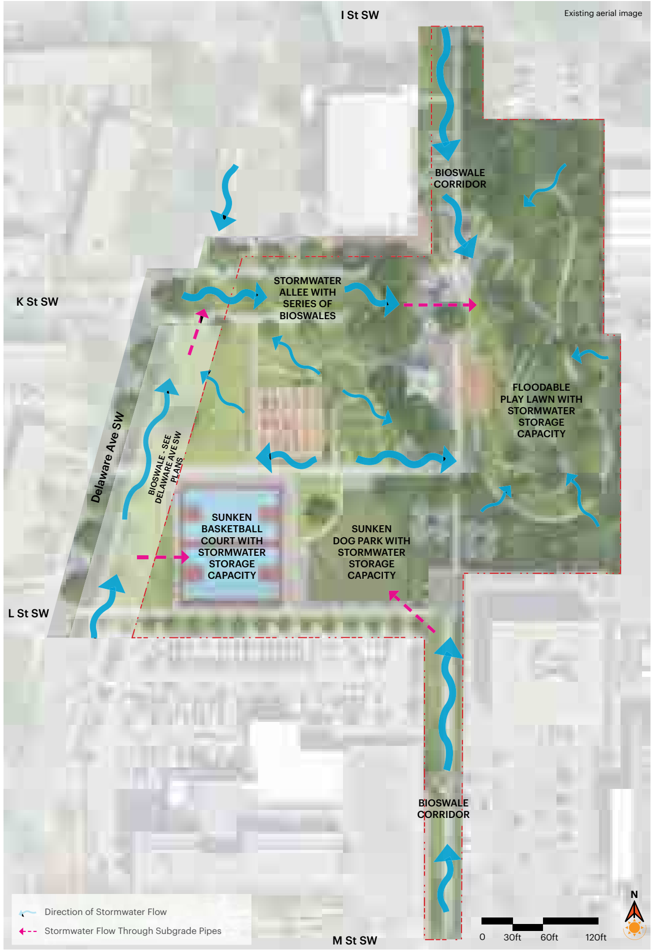


Figure 48: Proposed Drainage Strategy

Source: Moody Graham

Figure 49: Existing Tree Strategy

Source: Moody Graham

Lansburgh Park - Site Sections

Figure 50: Section Revealing BGI: Floodable Dog Park

Source: Moody Graham

Figure 51: Section Revealing BGI: Floodable Play Lawn to Existing Heritage Trees

Source: Moody Graham

Lansburgh Park - Vignette Visualizations

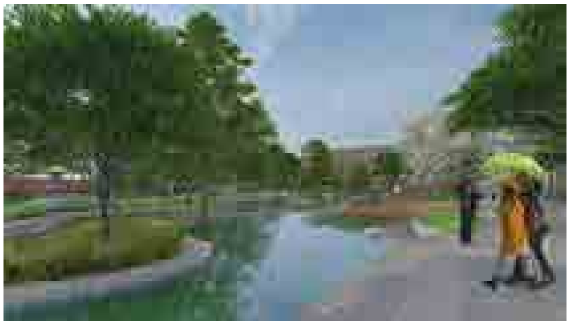
Floodable Play Lawn


Dry Conditions

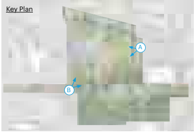

Estimated Mid-Capacity Storage


Estimated Maximum Capacity Storage


Dry Conditions


Storm Conditions

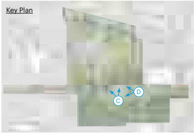
Pedestrian Corridors



K Street SW Pedestrian Extension: Stormwater Allee

1st Street SW Pedestrian Extension: Bioswale Corridor and Flowering Tree Canopy

Theater Deck and Community Stage



Theater Deck at Existing Community Stage - During Performance

Theater Deck at Existing Community Stage - Flexible Use

Figure 52: Vignette Visualizations

Source: Moody Graham

King Greenleaf Recreation Center Conceptual Design

The northern section of King Greenleaf Recreation Center includes basketball courts, tennis courts, and pickle ball courts. These would be converted into floodable athletic fields. They would be lowered so they are below the surrounding grade. Lowered athletic fields and courts will be designed to be ADA compliant. During extreme rain events, stormwater would be piped into these courts from M Street, then distributed into these dry basins. The courts will be designed using the Floodable Athletic Fields typology. They include pipes to inlet water into the dry basin, underdrains to drain water out, and sub-surface storage cells to increase storage capacity. By providing underdrains and sub-surface storage, drainage for these facilities will be improved during everyday rain events as well, reducing ponding in the courts.

The southern section of King Greenleaf Recreation Center includes the baseball field, football field, and additional unprogrammed lawn areas. These athletic fields and lawn areas are at slightly lower elevations than the surrounding grade, under existing conditions. They would be further excavated to increase surface storage area and sub-surface storage cells. The unprogrammed lawn area that is just north of the football field would be at the lowest elevation—during moderate storm events, this unprogrammed area would detain stormwater. The active athletic fields would only be used for surface detention during the most extreme rain events. Stormwater would be piped into these floodable athletic fields from Delaware Avenue and Canal Street, then distributed into these dry basins. The fields will be designed using the Floodable Athletic Fields typology. They include pipes to inlet water into the dry basin, underdrains to drain water out, and sub-surface storage cells to increase storage capacity. By providing underdrains and sub-surface storage, drainage for these facilities will be improved during everyday rain events as well, reducing ponding and wet field conditions.

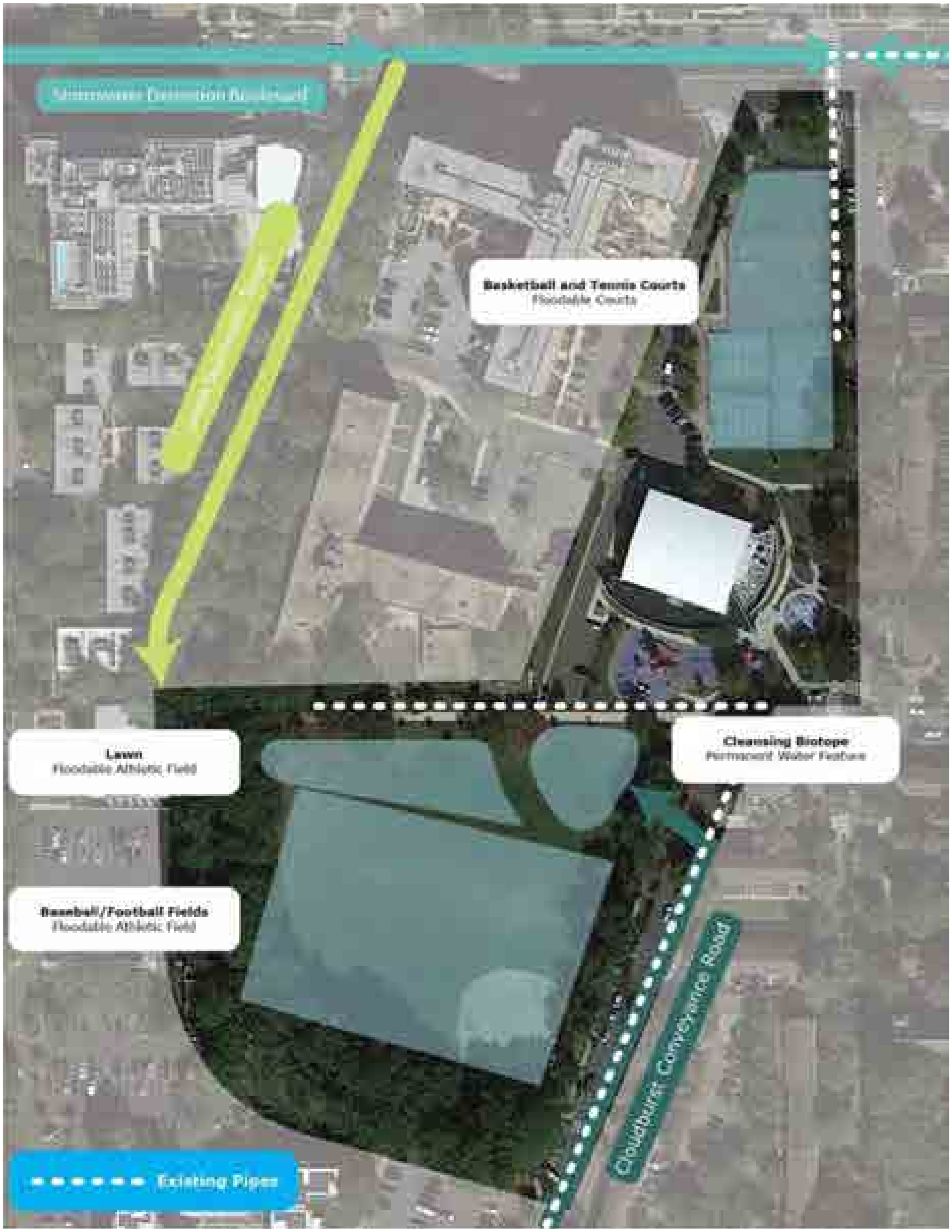


Figure 54: King Greenleaf Park Conceptual Site Plan

Source: Ramboll

2nd Street Pilot Project

2nd Street Conceptual Design

The conceptual design for 2nd Street is intended to achieve two primary functions. First, to convey stormwater to BGI detention areas and to the Anacostia River in a controlled manner that mitigates flood risk to surrounding properties. This conveyance is achieved using a variety of facilities, including surface bioswales and rills, as well as below-grade pipes, where necessary. The second function is to improve the streetscape for pedestrians and bicyclists, while maintaining roadway capacity for drivers and on-street parking. In general, the design focuses on the west side of 2nd Street. For much of the length of the roadway, the east side of the street has recently been upgraded, including green infrastructure facilities. Given this recent work, the proposal would upgrade the west side of the right-of-way with new BGI facilities and upgraded bicycle and pedestrian pathways.

The proposal for 2nd Street is to utilize existing open space between the Fort McNair wall and existing roadway curb for stormwater conveyance along 2nd Street and out toward the Anacostia River.

The existing bike lanes would be relocated from the roadway to a shared-use trail closer to the Fort wall. Pedestrian and bike lanes are distinguished by different surface materials and buffered from traffic by a vegetated bioswale.

Where this shared use path encounters crossing traffic, such as at existing intersections, pedestrian crosswalks, and Fort access gates, the trail expands into a Shared-Use Plaza zone. Here, cars, bikes, and pedestrians may pass safely. The plazas are appointed with benches, bike racks, and bus shelters.

Within the Shared-Use Plaza water from the bioswales is captured and continues flowing south towards the Anacostia River within a sculptural Rill, or channel.

The design is made up of three different BGI projects. These projects are based on two factors. One factor is that the length of 2nd Street is captured by two different catchments areas. The northern catchment area includes 2nd Street from P Street to R Street. This segment of 2nd Street flows to the north and will convey stormwater to the proposed detention facilities at King Greenleaf Park. The southern catchment area runs from R Street to the Anacostia River. Stormwater would be detained and treated using bioremediation in James Creek Marina, before flowing into the river.

The second factor is that the roadway is made up of different typologies, depending on the location within the catchment. The principle is that segments of the right-of-way that are further upland within the catchment area do not need to convey as much stormwater as segments that are further downstream. Therefore, the upland segments use the Green Stormwater Street typology, which is designed to convey less stormwater. Downstream segments use the Cloudburst Conveyance Road typology, which is designed to convey more stormwater.

A description of each of the three segments follows:

2nd Street from P Street to R Street

The northernmost segment of 2nd Street flows to the north, based on existing surface grades. This segment of the right-of-way is based on the Green Stormwater Street typology. Between R Street and Q Street, the proposed design includes a shared use path with designated space for bicyclists and pedestrians on the west side of 2nd Street. The shared use path would be separated from the vehicular lanes by a bioswale. The existing, on-street bike lane would be relocated to the shared use path, with the bioswale placed in the area currently used for the existing bike lane. The shared use path path is adjacent to the bioswale. This bioswale in this location is designed to be similar to recently installed facilities on Potomac Avenue SW in Buzzard Point.

Between Q Street and P Street, the design is largely the same in section. The one difference is that the wall to Fort McNair on this block is set back further from the street. This allows for a wider bioswale and potentially additional plantings along the wall, creating a buffer between the bicycle path and the wall. The design for 2nd Street also allows for the opportunity to incorporate post and panel temporary flood barriers at the high point along R Street. These flood barriers could be installed in advance of coastal storm events to protect the community north of R Street from storm surge and riverine flooding. Currently, the flood protection plan in this area relies on the deployment

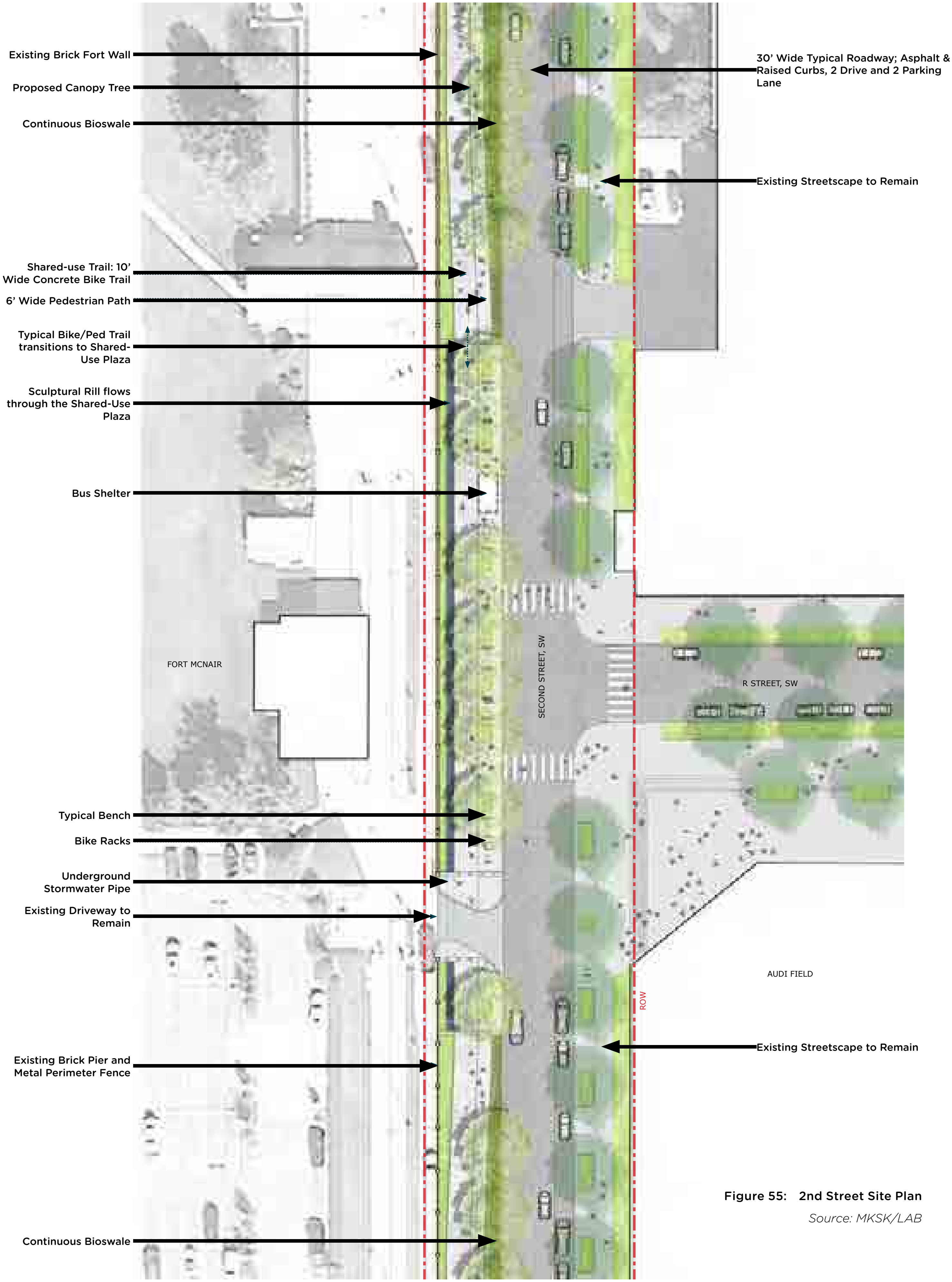


Figure 55: 2nd Street Site Plan

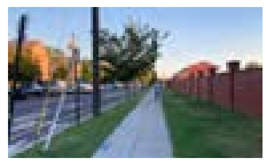
Source: MKSK/LAB

of sandbags. The post and panel flood barriers would provide a more permanent solution and should be studied during the redesign of 2nd Street.

2nd Street from R Street to T Street

South of R Street, the existing surface grades will direct stormwater to the south, toward the Anacostia River. This section of 2nd Street is also designed based on the Green Stormwater Street typology. The typical condition for this segment is generally the same as the segment to the north—the bike lane is relocated to the shared use path, the bioswale is placed in the location of the existing bike lane. In addition, this section includes bus stops and entrances to Fort McNair. At these key locations, the design includes shared use plazas to accommodate additional pedestrians waiting for public transit. While the shared use path will continue, the bioswale will pass underneath the path and will transform into a rill, or a small stream. The rill will be located adjacent to the Fort McNair wall, allowing a continuous plaza space for bus shelters, pedestrians, and bicyclists.


Pedestrian and Bike Trail Connection into Shared-Use Plaza


EXISTING WEST-SIDE; FORT MCNAIR


EXISTING EAST-SIDE; AUDI FIELD

2nd Street from T Street to James Creek Marina

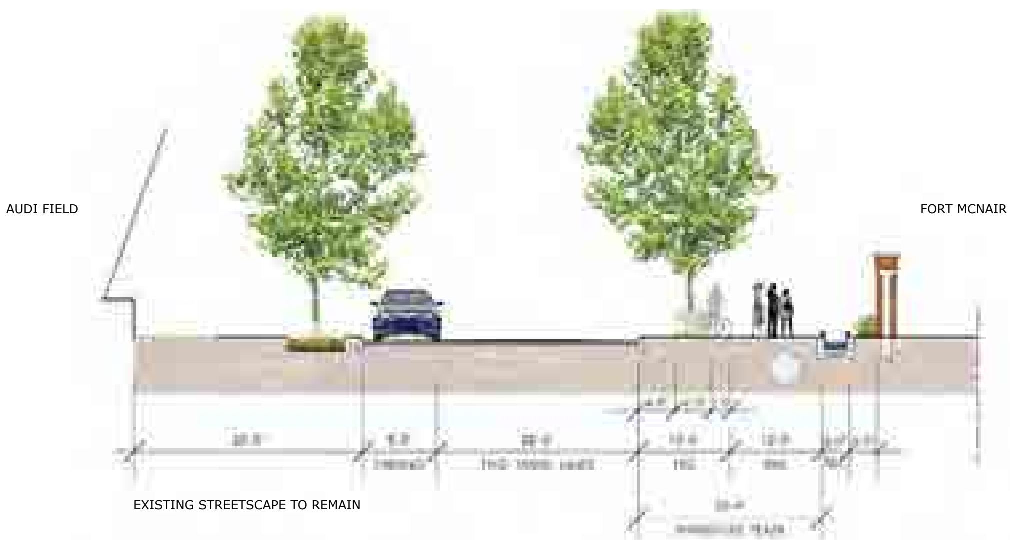
The final segment of 2nd Street, from T Street to the James Creek Marina, is designed based on the Cloudburst Conveyance Road typology. This typology is intended to move larger amounts of stormwater at the bottom of the catchment area. Outside of the carriageway, the design of this segment of 2nd Street is very similar to the segment to the north (from R Street to T Street)—the east side of the right-of-way will remain as-is. On the west side, the typical condition is the shared use path separated from vehicular traffic with a bioswale. At key locations, such as bus stops, the design includes the shared plaza with rill to accommodate pedestrian traffic and convey stormwater.

The key distinction of the Cloudburst Conveyance Road is that the carriageway itself is also designed to convey water during extreme rain events. The carriageway would be regraded, in one of two ways. The first option is to regrade the road into a V-shape (instead of the typical inverted V) in order to capture water within the carriageway. The second option is to regrade the road to pitch in one direction, toward the bioswale. The objective is to create a cross section with a larger volume to convey water at the bottom of the catchment area. The V-shaped roadway cross section does not currently comply with the DDOT Design and Engineering Manual (DEM). The pitch of the roadway will be resolved during the design process by DDOT.

At the intersection of 2nd Street and V Street, stormwater would be conveyed into a new dry basin in the James Creek Marina parking lot and a series of bioswales within James Creek Marina. Finally, a new conveyance pipe will convey water from the bioswales into the Anacostia River.

2nd Street Existing Street Section

2nd Street Proposed Plaza Section



2nd Street Proposed Trail Section

Figure 56: 2nd Street Site Sections

Source: MKSK/LAB

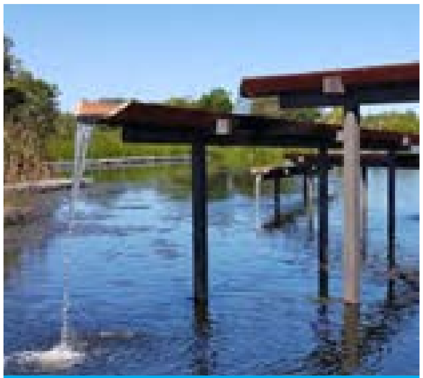
Delaware Avenue Pilot Project

Delaware Avenue Conceptual Design

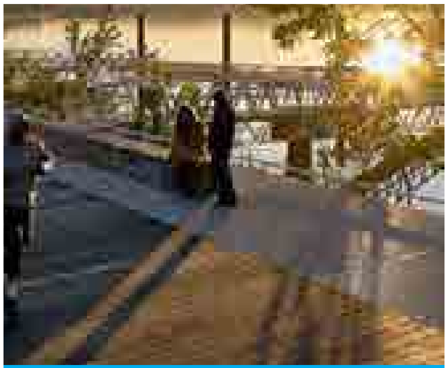
The Delaware Avenue proposal utilizes the street's wide right-of-way to capture storm water within new bioswales, and in extreme storm events, conveys the excess towards larger detention areas within the adjacent Lansburgh Park. The roadway is 40' wide, but there is an additional 60' of public right-of-way beyond the curb on both sides of the street. On both sides, proposed bioswales are filled with trees and shrubs - increasing neighborhood canopy coverage and biodiversity.

On the west side near the Greenleaf housing community, these bioswales are proposed to be compact, like canals, with straight sides retained by gabion walls. This efficiency will save space that can be occupied by the future renovated building entrances, seating, decks and play areas for residents and the public.

On the east side, the park, the bioswales are winding and more open. Their sculpted forms will merge with the existing mounds and softer lines of the park, creating spaces to sit and gather along the existing sidewalk – a landscaped entrance to the renovated park. Some of the proposed design elements are not included in DDOT's standard design elements for public space. Any such design elements that are included in the final design would require special maintenance agreements between DDOT and DPR, as well as DDOT and DC Housing.


STORMWATER DOWNSPOUTS


GREENLEAF DEVELOPMENT PLAY AREA


BRIDGE - METAL GRATE
DIAMOND TEAGUE PARK - WASHINGTON, DC


GABIAN WALL - WITH BENCH SEATING


WINDOW-DECK WITH SEATING


BRIDGE OVER BIORETENTION

Figure 57: Precedent Images, Delaware Avenue, G Street to M Street

Source: MKSK/LAB

DELAWARE AVE NORTH OF M STREET
EXISTING CONDITIONS

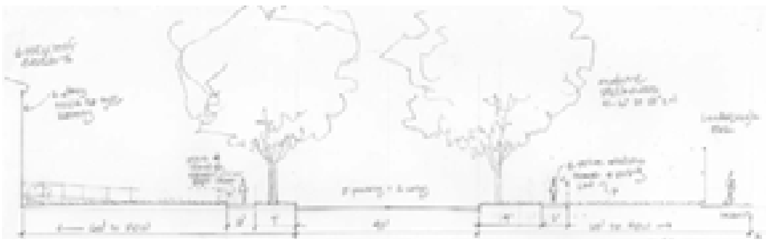
OPPORTUNITIES

- Generous ROW Setbacks (~160 ft.)
- Some Govt. Services encroaching into ROW with Parking Lots (could reclaim as green space)
- New greenleaf dev. as opportunity to introduce "small streets strategy"

CONSTRAINTS

- Maintain access across/through Detention Basins to Residential Blocks

LEGEND
Fence
METRO Vent
4 ft Grass Median
8-12 ft Grass Median
4 ft Brick Median
LID Median
Ex. Bioswale Area



EXISTING SECTION THROUGH DELAWARE AVE WITH EXISTING RESIDENTIAL BLOCK AND PARK

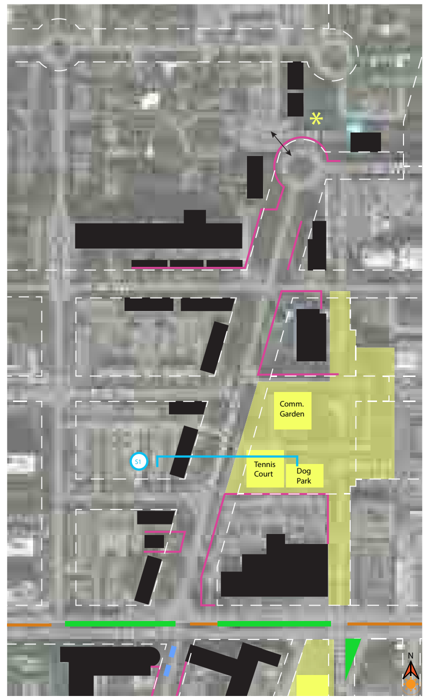


Figure 58: Existing Condition, Delaware Avenue, G Street to M Street

Source: MKSK/LAB

DELAWARE AVE SOUTH OF M STREET
EXISTING CONDITIONS

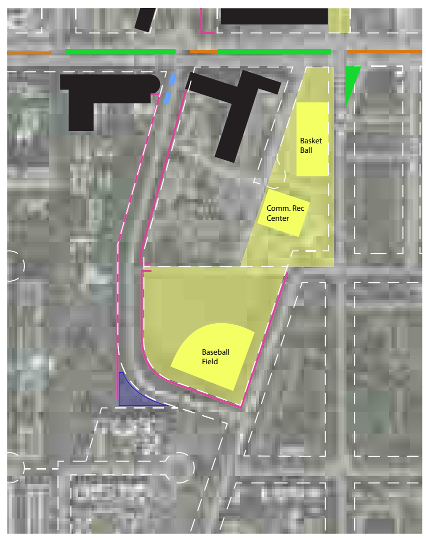
OPPORTUNITIES

- Potential to reclaim under-utilized parking lane to green space as primary parking occurs in private gated parking lots
- Few curb cuts (most to private parking lots); opportunities for continuous strategies

CONSTRAINTS

- Narrow ROW Setbacks at Back-of Sidewalk
- Mature Trees to Preserve

EXISTING SECTION THROUGH DELAWARE AVE WITH EX. BIOSWALE AND PARK



LEGEND
Fence
METRO Vent
4 ft Grass Median
8-12 ft Grass Median
4 ft Brick Median
LID Median
Ex. Bioswale Area

Figure 59: Existing Condition, Delaware Avenue, M Street to Canal Street

Source: MKSK/LAB

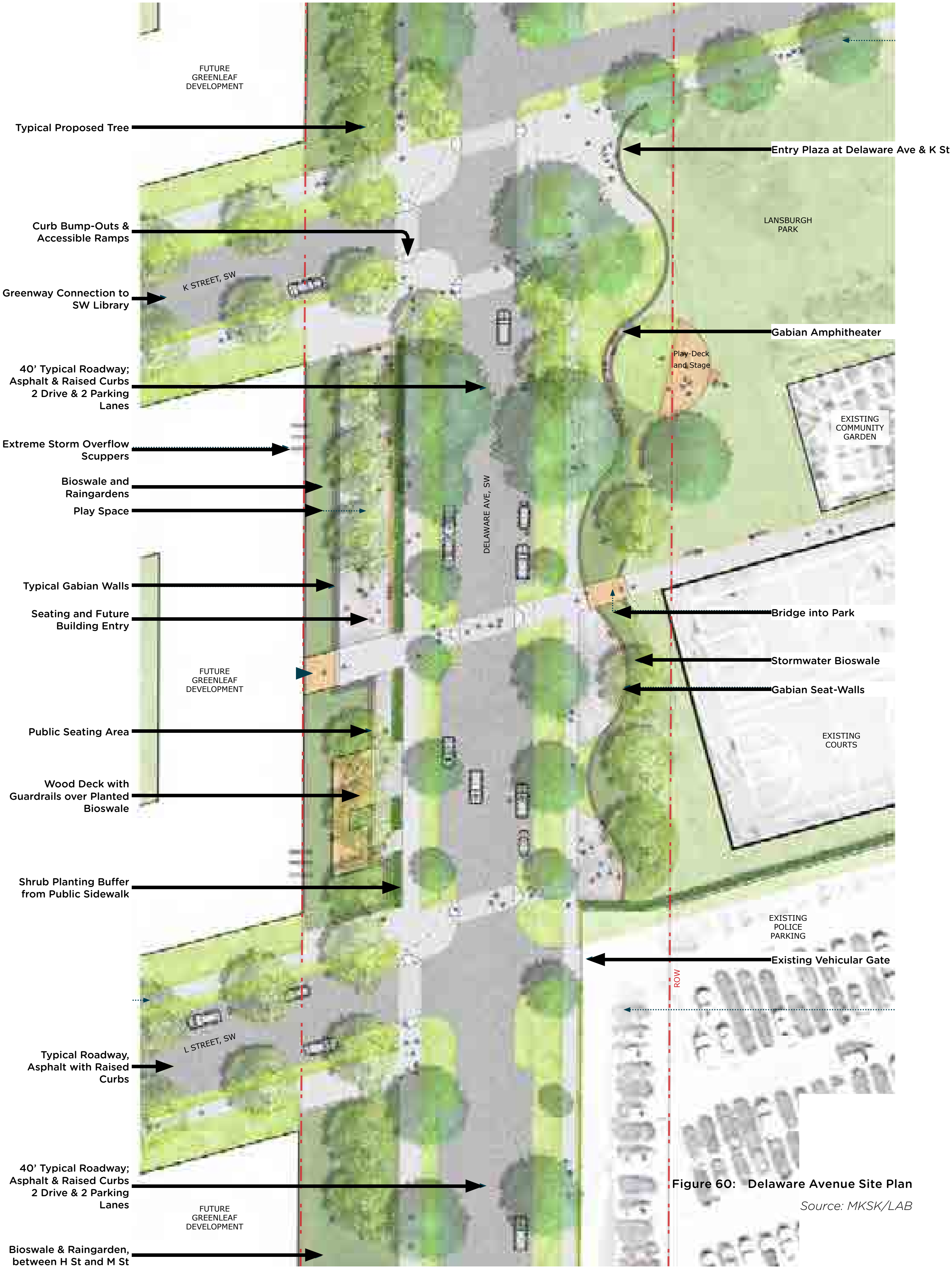


Figure 60: Delaware Avenue Site Plan

Source: MKSK/LAB

Delaware Avenue
Proposed Street Section

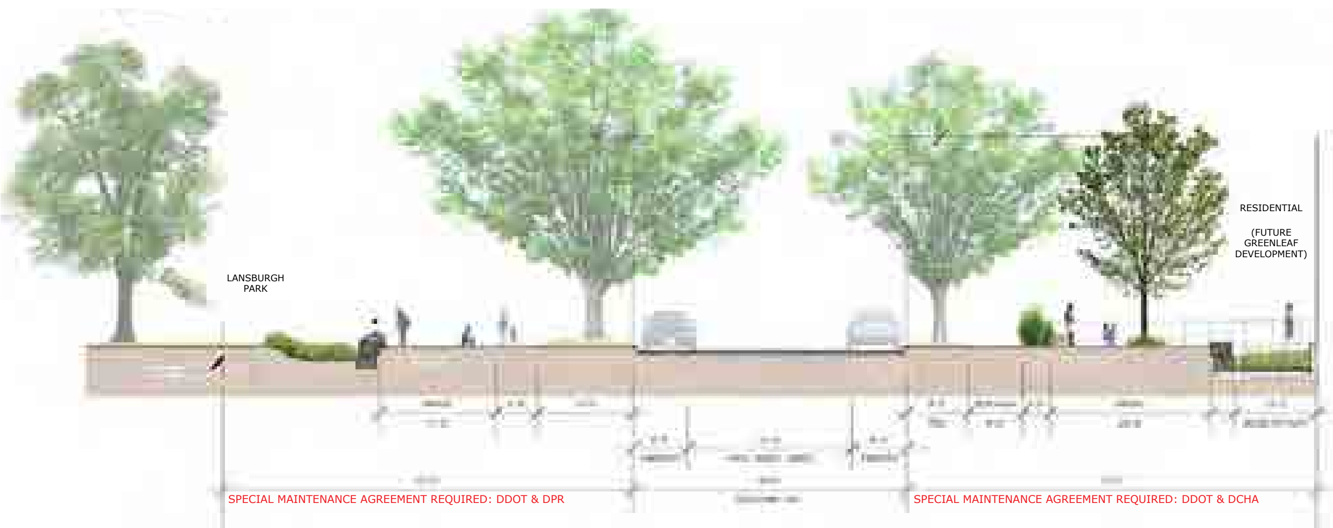


Figure 61: Delaware Avenue Site Sections

Source: MKSK/LAB

Verdensparken
Place: Oslo, Norway.
Source: Ramboll.

SECTION 6: MEASURING EFFECTS AND EVALUATING COSTS

Analyzing Costs and Benefits of the BGI Network

A benefit-cost analysis (BCA) measures the positive and negative financial impacts of a project. Costs include the design, construction, and maintenance of a mitigation project, while benefits include avoided costs/losses from flooding and co-benefit gains. Avoided costs include physical damages to properties, loss of service/function (e.g., temporary or permanent business closures, temporary disruptions to transportation services, water, and electricity), displacements costs, or emergency management costs. Co-benefits include social and environmental benefits such as the avoided costs associated with mental stress and anxiety or improvements to the natural environment. Costs and benefits are measured regardless of who pays for or receives them (i.e., the federal government, District government, or residents and property owners).

The success of the BGI network at mitigating flood risk and improving community livelihood is gauged by the Benefit-Cost Ratio (BCR). A successful project is a cost-effective project, meaning its costs are lower than the benefits that the project creates. When BCR exceeds 1.0, the project is deemed cost-effective.

Costs

BGI Network implementation requires a community investment in capital construction as well as in operation and maintenance. While BGI is typically less expensive to construct than gray infrastructure for flood mitigation, maintenance costs trend higher. To ensure project success, maintenance funding and responsibility should be accounted for at the time of construction for the useful life of the project.

The costs of the complete BGI Network are developed based on the BGI Network Water Balance containing all 30 individual BGI projects, and the six new stormwater pipes. The Water Balance with costing for constructions and maintenance is set up in Excel. It is partially automated to allow for easy changes to initial project parameters such as, e.g., run-off coefficients, design storm definitions, assumptions for surface-based flow, and maintenance costs.

Cost estimates are based on estimator judgement and DDOT and DOEE design standards. DDOT data was derived from 2021 program actual costs and confirmed by DDOT.DC.GOV Price Index Data. Supplementary costs for earthworks and landscaping were sourced from the DOEE Stormwater Best Management Practices Green Infrastructure Construction Price Calculator for Bioretention. Additional construction fees include pre-construction surveying, traffic diversion, rerouting utilities, and contractor OH&P are factored as a percentage of total construction costs. Construction Management Services, Engineering Design Services, and contingency costs are also calculated as percentages of total costs.

The total non-discounted costs of constructing the BGI Network is estimated to USD 120.8 million. The total annual maintenance costs approximate USD 2.8 million. It should be noted that cost estimates in the Strategy are highly conservative, based on a 100% construction cost without co-financing with other capital projects. However, it is recommended that BGI projects be implemented in coordination with related capital projects by DC agencies (e.g., DDOT, DPR) to reduce overall construction costs significantly. In order to develop the estimated maintenance cost, the project team assumed that maintenance would amount to approximately 2.5% of total construction costs, based on conservative industry standards.

Benefits

The benefits portion of the BCA quantifies the avoided risk to infrastructure and the enhanced socioeconomic and environmental conditions in the Project Area. Combining a traditional asset-based approach with an expanded view of the co-benefits of BGI makes for a more holistic business case for Southwest and Buzzard Point. Analyses that consider asset-based risk assessments alone direct flood mitigation measures to areas with higher property values and concentrated wealth, thereby prioritizing continued investment in wealthy areas. This approach favors resilience-building in higher income neighborhoods at the expense of lower income neighborhoods; and fails to account for the value of community assets in lower income neighborhoods and equip them with climate resilience strategies. This cycle reinforces climate inequity and injustice. By supplementing the infrastructure-focused risk assessments with a thorough existing conditions understanding and inclusion of co-benefits in the BGI Typologies a more equitable Strategy has been developed. An example of this is the prioritized location of significantly upgraded park space as part of the BGI Network Plan and the proposal of a new park at James Creek Marina. By applying this approach all residents within Southwest

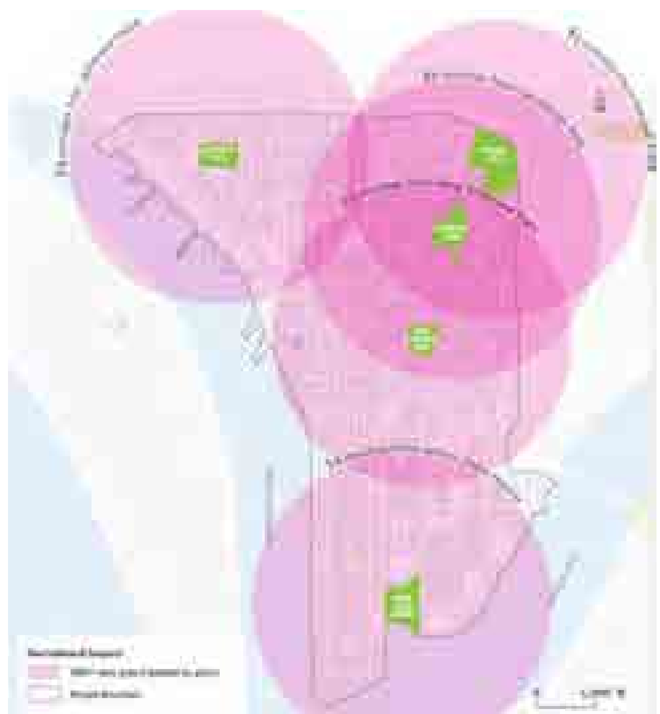


Figure 62: Areas where the quality of the existing green space is improved

Source: Ramboll

and Buzzard Point have a quality recreational space within approximately 6 minutes of walking within a significant concentration of investment into upgraded recreational space (and stormwater detention) around public housing complexes at Lansburgh Park and King Greenleaf Park. The BCA is designed to also capture such added value created in Southwest and Buzzard Point as a "side-effect" to the BGI Network Plan.

Risk Reduction Benefits

The primary benefit of the BGI Network is realized in avoided risk to assets and residents. Expected annual damages are reduced across all return period storm events with implementation of the Strategy.

The Strategy detailed in Section 4 mitigates flood risk of a 20-year storm event in 2080 and all lesser storms within the BGI Network area. There is still flooding anticipated in more severe events and in areas outside the BGI Network catchments. As mentioned, the BGI Network does not extend to The Wharf or to the southeast-most corner of Buzzard Point, as both have been recently renovated with new BGI to support drainage to the Channel and to the Anacostia River. Flooding in these catchment areas is likely managed by recent District projects, but due to uncertainty on the level of protection of these designs, they are left out of the Flood Models and subsequent BGI Network development.

Modeling Residual Risk

20-year Rain Event in 2080
Existing vs. BGI Plan Conditions

Yellow/orange represents flooding that has been removed after implementation of the BGI plan

Under certain assumptions, flooding can be removed for rainfall events with intensities up to a 20-year event in 2080s climate conditions based on the proposed conceptual design of a BGI network.

100-year Rain Event in 2080
Existing vs. BGI Plan Conditions

There is still flooding in more severe events and in areas not captured within the catchments of the proposed measures (ROWs and Parks). Flooding from a 100-year rain event is shown in blue.

Figure 63: Post-Mitigation Flood Models for the 20 and 100-year rain events under 2022 and 2080 climate conditions

Source: Ramboll

Co-benefits

In addition to reducing flood risk, BGI projects can be designed to contribute to increased quality of life in cities through the use of nature-based solutions. These positive impacts of BGI, beyond the flood mitigation impacts, are called co-benefits. Using BGI to reduce flooding can also improve air and water quality, reduce noise, improve mental and physical well-being, reduce the urban heat island effect and the loads to the wastewater treatment plant, improve the quality of the aquatic environment by treating stormwater runoff, increase carbon storage through planting of new trees, and many more aspects.

Including co-benefits in a BCA provides a better understanding of the positive impacts of multi-functional and nature-based climate adaptation solutions and a more realistic business case for resilience. In addition, the analysis of co-benefits can be connected to other municipal goals and sustainability visions, thus ensuring more holistic planning across municipal sectors. Relevant co-benefits are identified based on community input, and neighborhood-wide challenges and opportunities. The assessment of potential added values is based on the size and quality of the new/modified areas (e.g., conversion of gray to green surfaces or significant improvements to existing green space), as well as the number of new trees in parks and along roads, number of households within upgraded areas, or the size of construction and maintenance budgets.

The co-benefits analysis is completed using Ramboll's Nature-based Solutions (NBS) Value tool. The tool contains a large database with best-practice studies and valuation methodologies for added values related to nature-based solutions. For this project, eight relevant co-benefits have been identified and six of these quantified in the NBS Value tool. The six co-benefits that are quantified using the NBS value tool are:

1. Recreation
2. Air Quality
3. Physical Activity
4. Carbon Storage
5. Energy Savings
6. Traffic Safety

Nature-based Solutions (NbS)

The EU Research and Innovation policy agenda on Nature-based Solutions and Re-naturing Cities defines NbS to societal challenges as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions."

Several co-benefits are tied directly to the implementation of more trees throughout the neighborhood, and especially along streets. The increased traffic safety is a result of BGI placed in the ROW typologies as traffic calming elements. Complete streets and stormwater management solutions are compatible elements of redesigned streets so that the new right-of-way contributes to both improved traffic safety outcomes, as well as helping to reduce flood risk. Additionally, construction costs of the BGI Network include upgrading the bike infrastructure in the Southwest and Buzzard Point to include separated bike lanes on the highlighted street sections. In addition to the six quantified co-benefits three additional benefits were examined.

Job creation: It is assumed that the project will create a number of new jobs – both temporary for construction but also on the longer term, due to these new green urban areas attracting both people and local businesses. An American study shows, that $1M spend on flood protection measurement creates 40 full-time equivalent (FTE) jobs (25 construction and 15 retail). Using this approach for Southwest and Buzzard Point, with an investment of $ 120.8 million into the BGI Network could result in the creation of 151 FTE construction jobs and 91 FTE retail jobs. The construction jobs would be available (yearly) for the investment period of 20 years, whereas the retail jobs are expected to remain for an extended period beyond the investment horizon of 20 years.

Thermal comfort: Heat waves and cold waves are among the most dangerous of natural hazards, but rarely receive adequate attention because their death tolls and destruction are not always immediately obvious. While the BGI Typologies have considered extreme heat and extreme cold the impact of their design is not included in the quantification of co-benefits. This would require an assessment of the reduction of loss of lives do to the improved micro-climate and thermal comfort.

Stormwater treatment: As part of the BGI Network we have included natural treatment of runoff for the everyday rainfall. For catchments of roughly 240 acres that largely drain untreated to the Washington Channel and Anacostia River today the BGI Network will ensure treatment of daily rain events before discharge. Additionally, a catchment area of about 58 acres in the northeast of the Project Area will be disconnected from the wastewater treatment plant and drain to Washington Channel in the future as part of the BGI Network.

Benefit Cost Ratio

The Benefit Cost Ratio, or BCR, divides the net present value of a project's benefits by its costs, and informs decision-makers on financial feasibility. When BCR exceeds 1.0, communities can expect to see a return on their investment. The BCA for the Southwest and Buzzard Point Strategy has a BCR of 1.30. This indicates, theoretically, that for every $1 invested in construction, maintenance, and reinvestments, the community will see returns of $1.30 in avoided risks and co-benefits. The BCR demonstrates at a high level, that the Strategy is financially sound. To pursue additional federal funding, the District should consider performing project-specific benefit-cost analyses to confirm feasibility, return on investment, and support funding applications.

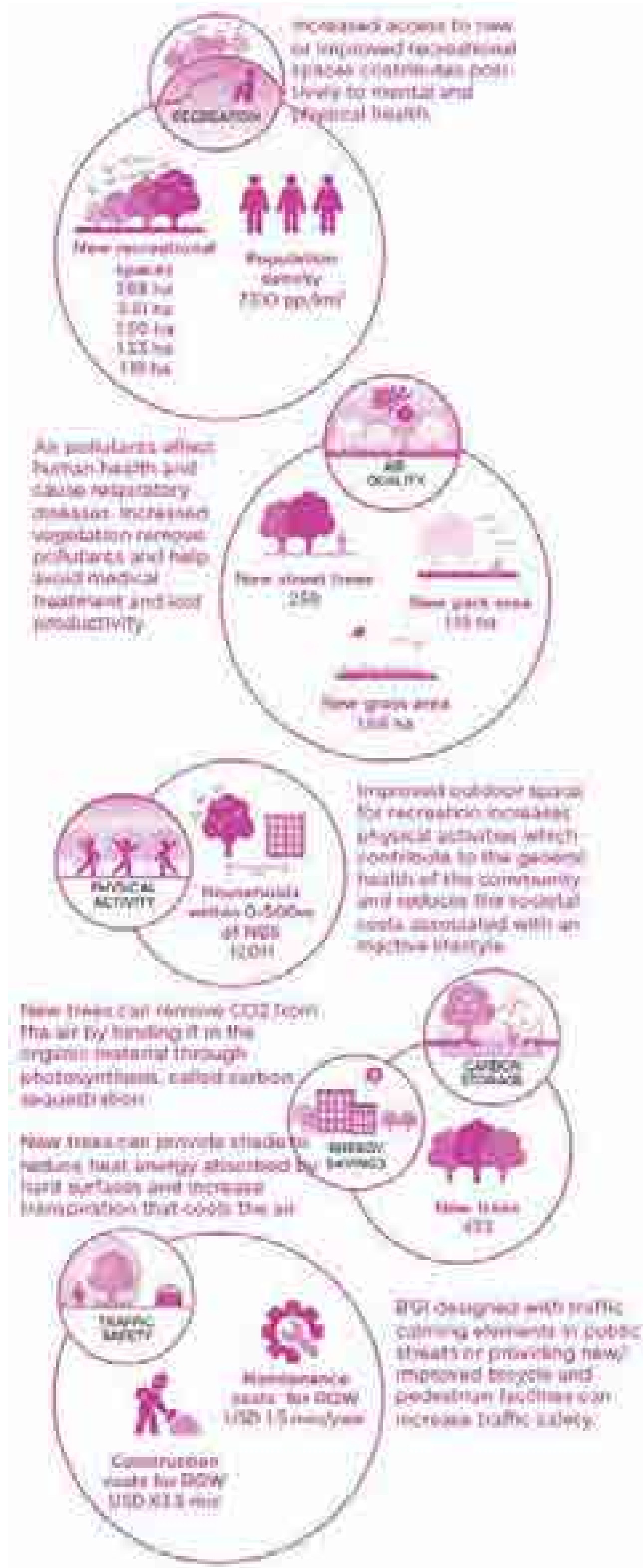


Figure 64: Overview of parameters used to quantify co-benefits in the NBS Value Tool for inclusion in the BCA

Source: Ramboll

Figure 65: Street sections where separated bike-lanes are proposed as part of the BGI Network Plan

Source: Ramboll

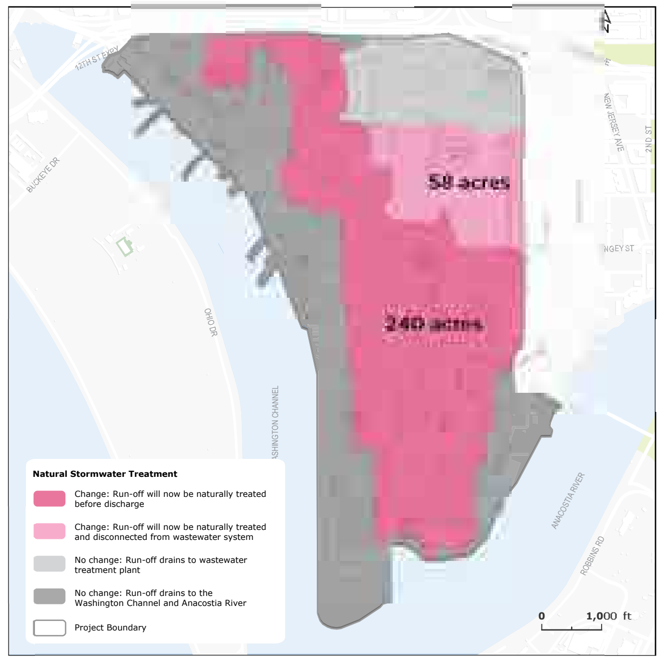


Figure 66: Areas where natural treatment will improve existing water quality conditions as result of the BGI Network

Source: Ramboll

Bishan Park
Place: Singapore.
Source: Ramboll.

SECTION 7: CONCLUSIONS AND NEXT STEPS

Next Steps to Implement the Southwest and Buzzard Point Flood Resilience Strategy

The Southwest and Buzzard Point Flood Resilience Strategy outlines an actionable rainwater-driven flood mitigation plan with design concepts and resources to apply for funding. The pilot project for Lansburgh Park and King Greenleaf Park is funded through the FEMA BRIC program and local funds and will proceed toward implementation in 2023. HSEMA, in partnership with DOEE and DDOT, has applied for funding to further study and design the 2nd Street project. District agencies should use this Strategy to continue applying for funding from FEMA and other federal agencies for the remaining BGI projects.

A high degree of coordination among DC agencies (DOEE, DPR, DGS, DDOT, and DC Water) will be required for successful implementation of the Strategy. DOEE should work with fellow agencies to update the Construction Phasing Strategy to align with other capital projects. It is recommended that, to the extent possible, BGI projects be implemented as part of other capital construction work. Ownership shall be evaluated on a case-by-case basis, Park Typology implementation may be managed by DPR and for ROW typologies by DDOT. It is recommended that BGI project implementation in the network be tracked and documented.

To solve interior flood risk in DC, multiple DC government actions will need to be taken, from making sure new construction accounts for the risk, to making sure proprety owners have coverage, and existing buildings are retrofitted (potentially throuhg DC's FloodSmart Homes Program). One of the most important things the government can do, however, is to build infrastructure that removces the possibility of water from affecting daily life in these neighborhoods, while also providing cobenifits like new play spaces and reduced heat island effects.

This report outlines at a high level the multiple projects that can be implemented in Southwest and Buzzard Point. While all of these projects need further refinement before they can begin construction, DOEE has focused on Lansburgh Park and 2nd Street as the two projects to move forward initially. The Lansburgh Park and King Greenleaf Park pilot project has federal funding to begin construction. Even after the first pilot project is implemented, the District should proceed to implement all projects listed here in order to get the full flood risk reduction benefit.

Additional Project Recommendations in Southwest and Buzzard Point

Additional BGI projects were assessed for implementation in Southwest and Buzzard Point but were not included in this Strategy. These include public waterfront access to the Washington Channel on P Street and daylighting of James Creek in key locations. It is recommended that these projects be further explored with technical feasibility study, community engagement, and benefit cost analysis.

Applying Lessons Learned throughout the District

Building equitable and sustainable flood resilience in the District will require a citywide strategy. It is recommended that DC, follow suit of global partners like Copenhagen, and conduct a citywide Catchment Area Study, risk assessment, and BGI masterplan. A citywide BGI masterplan with aligned policy measures can unify DC agencies on a path toward food resilience. Policy measures ensure that agency capital projects support the Strategy and its implementation.

Remiseparken
Place: Copenhagen, Denmark.
Source: Ramboll.