- Key staff of the City in charge of the operations and maintenance of the City's stormwater management system and the implementation of improvements to the system are well qualified and capable of effectively managing the responsibilities of such operations, maintenance and implementation.
- The methodology used to develop the capital improvement program for the City's stormwater management system, the timing of the implementation of the program and the cost of its improvements was an appropriate methodology for such purposes.
- Improvements to be made to the City's stormwater management system have been or are expected to be designed in accordance with usual and customary engineering practices and involve proven technology and proven configurations of that technology.
- The projected cost and time periods for implementing the improvements to the City's stormwater management system to be financed with proceeds of the Series 2017 Bonds are reasonable.
- In the opinion of the Consulting Engineers, the City's issuance of the Series 2017 Bonds in the aggregate principal amount set forth in the Official Statement related to the Series 2017 Bonds, at the time and for the purposes described in this Engineer's Report, is an advisable undertaking.

AECOM recommends that the City proceed with the issuance of the Series 2017 Bonds; continue the implementation of the capital improvement program for the Stormwater Utility and as necessary, the adoption of rate adjustments in anticipation of future issuance of additional Stormwater Revenue Bonds.

Exhibit 4

RESOLUTION NO. 2018-30570

A RESOLUTION OF THE MAYOR AND CITY COMMISSION OF THE CITY OF MIAMI BEACH, FLORIDA, ACCEPTING THE URBAN LAND INSTITUTE (ULI) FINAL EVALUATION REPORT OF THE CITY'S STORMWATER MANAGEMENT STRATEGY, WHICH REPORT WAS FUNDED BY 100 RESILIENT CITIES, AND IS ATTACHED HERETO AS EXHIBIT A.

WHEREAS, at the January 2018 Sustainability & Resiliency Committee meeting Commissioner Mark Samuelian introduced an item to review the City of Miami Beach's Stormwater Resilience Program; and

WHEREAS, the City is interested in obtaining a third-party assessment of the current program; and

WHEREAS, the City is a member of the 100 Resilient Cities (100 RC) Network, an organization dedicated to support cities as they face growing fiscal and development pressures due to climate change, urbanization and globalization; and

WHEREAS, the Urban Land Institute is a 100 Resilient Cities platform partner and is dedicated to creating thriving communities across the globe with expertise in land use, planning and real estate; and

WHEREAS, through the City's membership in 100 Resilient Cities Network, 100 RC has graciously agreed to fund the Stormwater Resilience Program review effort; and

WHEREAS, the Urban Land Institute Technical Assistance Advisory Panel Review was held from April 16-19, 2018, in Miami Beach, Florida.

NOW, THEREFORE, BE IT DULY RESOLVED THAT THE MAYOR AND CITY COMMISSION OF THE CITY OF MIAMI BEACH, FLORIDA, hereby accepts the Urban Land Institute (ULI) Final Report evaluating the City's Stormwater Management Strategy, which report was funded by 100 Resilient Cities, and which report is attached hereto as Exhibit A.

PASSED and **ADOPTED** this 17 of October, 2018.

Dan Gelber, Mayor

ATTEST:

10/30/18

Rafael E. Granado, City Clerk

MIAMI BEACH INCORPORATED MARCH 26TH 1915

APPROVED AS TO FORM & LANGUAGE & FOR EXECUTION

City Attorney

8/27/18

Date

MIAMIBEACH

COMMISSION MEMORANDUM

TO: Honorable Mayor and Members of the City Commission
FROM: Jimmy L. Morales, City Manager
DATE: October 17, 2018

SUBJECT: A RESOLUTION OF THE MAYOR AND CITY COMMISSION OF THE CITY OF MIAMI BEACH, FLORIDA, ACCEPTING THE URBAN LAND INSTITUTE (ULI) FINAL EVALUATION REPORT OF THE CITY'S STORMWATER MANAGEMENT STRATEGY, WHICH REPORT WAS FUNDED BY 100 RESILIENT CITIES, AND IS ATTACHED HERETO AS EXHIBIT A.

RECOMMENDATION

Adopt the Resolution.

ANALYSIS

At the January Sustainability and Resiliency Committee, Commissioner Samuelian introduced an item to review the city's stormwater resilience program. Staff advised that with the support of the Rockefeller Foundation's 100 Resilient Cities (100 RC) Network, the Urban Land Institute (ULI) has been invited to assess the City of Miami Beach's current stormwater management strategy. SRC reviewed the project scope and forwarded to the full Commission in March for approval. In April a multidisciplinary global team convened in Miami Beach to review our program.

The Urban Land Institute (ULI) is the oldest and largest network of cross-disciplinary land use and real estate experts in the world dedicated to creating thriving communities around the globe. Their goal is to make cities better places to live for people from all walks of life. ULI is also a 100 RC platform partner, part of a professional network that provides resilience-building tools and services to 100 RC cities.

ULI panels are intensive, on-site engagements conducted by volunteer panelists that provide strategic advice to governments and organizations on a wide variety of land use challenges. This four-day event convened senior practitioners from a variety disciplines, such as urban planning, engineering, science, finance, insurance etc. Panelists spent hours in reading background material, attending staff orientations and tours, conducting stakeholder interviews, and hosting a public listening session. The final onsite deliverable was a panel presentation to the city at a public meeting. At that meeting the panel shared their recommendations on:

Program vision:

- Integrate stormwater management into the larger resilience strategy
- Enhance trust, trust the public, increase transparency
- Elevate aesthetics and function to perpetuate city's cultural relevance
- Actively use green and open spaces for sponge function
- Increase long term financial and comprehensive protection

- Go big on the resilience brand – distinguish yourself from your coastal competitors

Program principles:

- Maintained urgency,
- incrementalism & evaluation,
- transparency,
- ecological health,
- financial pragmatism,
- co-benefits, social equity,
- cultural identity,
- living with water.

CONCLUSION

It is recommended that the City Commission accept the Urban Land Institute Final Report (attached) for staff implementation. Certain recommendations may require additional Commission approvals and will be vetted through the committee process.

Legislative Tracking

Office of the City Manager

ATTACHMENTS:

Description

- Resolution
- Exhibit A: Urban Land Institute Advisory Services Panel Report - Miami Beach
- ULI Presentation

A ULI Advisory Services Panel Report

Miami Beach Florida

April 16–19, 2018

Urban Land Institute

A ULI Advisory Services Panel Report

Miami Beach
Florida

Stormwater Management and Climate Adaptation Review

April 16–19, 2018

Urban Land Institute

PIONEERED BY THE ROCKEFELLER FOUNDATION
100 RESILIENT CITIES

About the Urban Land Institute

THE URBAN LAND INSTITUTE is a global, member-driven organization comprising more than 42,000 real estate and urban development professionals dedicated to advancing the Institute's mission of providing leadership in the responsible use of land and in creating and sustaining thriving communities worldwide.

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

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

Peer-to-peer learning is achieved through the knowledge shared by members at thousands of convenings each year that reinforce ULI's position as a global authority on land use and real estate. In 2017 alone, more than 1,900 events were held in about 290 cities around the world.

Drawing on the work of its members, the Institute recognizes and shares best practices in urban design and development for the benefit of communities around the globe.

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

Cover: Katharine Burgess/ULI.

2001 L Street, NW
Suite 200
Washington, DC 20036-4948

About ULI Advisory Services

THE GOAL OF THE ULI ADVISORY SERVICES program is to bring the finest expertise in the real estate field to bear on complex land use planning and development projects, programs, and policies. Since 1947, this program has assembled well over 600 ULI-member teams to help sponsors find creative, practical solutions for issues such as downtown redevelopment, land management strategies, evaluation of development potential, growth management, community revitalization, brownfield redevelopment, military base reuse, provision of low-cost and affordable housing, and asset management strategies, among other matters. A wide variety of public, private, and nonprofit organizations have contracted for ULI's advisory services.

Each panel team is composed of highly qualified professionals who volunteer their time to ULI. They are chosen for their knowledge of the panel topic and screened to ensure their objectivity. ULI's interdisciplinary panel teams provide a holistic look at development problems. A respected ULI member who has previous panel experience chairs each panel.

The agenda for a three-day panel assignment is intensive. It includes an in-depth briefing day composed of a tour of the site, meetings with sponsor representatives, and interviews with 15 to 30 community representatives, followed by two days of formulating recommendations. Long nights of discussion precede the panel's conclusions. On the final day on site, the panel makes an oral presentation of its findings and conclusions to the sponsor. A written report is prepared and published.

Because the sponsoring entities are responsible for significant preparation before the panel's visit, including sending extensive briefing materials to each member and arranging for the panel to meet with key local community members and stakeholders in the project under consideration, participants in ULI's panel assignments are able to make accurate assessments of a sponsor's issues and to provide recommendations in a compressed amount of time.

A major strength of the program is ULI's unique ability to draw on the knowledge and expertise of its members, including land developers and owners, public officials, academics, representatives of financial institutions, and others. In fulfillment of the mission of the Urban Land Institute, this Advisory Services panel report is intended to provide objective advice that will promote the responsible use of land to enhance the environment.

ULI Program Staff

Paul Bernard
Executive Vice President, Advisory Services

Thomas W. Eitler
Senior Vice President, Advisory Services

Beth Silverman
Vice President, Advisory Services

Paul Angelone
Director, Advisory Services

Cali Slepin
Associate, Advisory Services

James A. Mulligan
Senior Editor

Laura Glassman, Publications Professionals LLC
Manuscript Editor

Brandon Weil
Art Director

Anne Morgan
Lead Graphic Designer

Kurt Wisthuff, Arc Group Ltd
Graphic Designer

Craig Chapman
Senior Director, Publishing Operations

Urban Resilience Panels

THE URBAN LAND INSTITUTE HAS JOINED with 100 Resilient Cities (100RC)—pioneered by the Rockefeller Foundation—as a platform partner, supporting cities in the 100RC network in their efforts to be more resilient and to design and implement comprehensive resilience strategies. Together, they acknowledge 100RC's definition of *resilience*: the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience. Implied in that definition is the ability not just to recover and bounce back but also to bounce forward and thrive. The platform partnership will host ULI panels within 100RC cities, thereby creating a powerful nexus of knowledge and resources. ULI will also support 100RC cities through other means, such as collaborative local projects and outreach with ULI's network of District Councils and National Councils.

Since 2014, ULI has undertaken a series of Advisory Services panels across the United States to assess how cities can better prepare for changes deriving from global climate change and foster more resilient approaches to land use. Advisory Services panels are intensive, on-site workshops led by a dedicated team of ULI members, who work with a host city to address complex land use challenges. Panelists complete site tours, briefings, and stakeholder outreach and engagement, followed by intensive research, deliberation, and collaboration, to produce a series of recommendations for the host city. The environmental vulnerabilities faced by panel host cities have ranged from rising sea levels and exacerbated drought and air temperatures to more extreme conditions, such as floods and wildfires.

The objective of these panels is to offer strategic guidance that will assist in cities' formulation of plans and policies and that will, in turn, make their communities more resilient and create stronger responses to and recoveries from both peak events and the long-term stresses arising from climate change. These panels also build from ULI member knowledge of land use, real estate, and development to help cities foster an environment in which the private sector can productively contribute to resilience building. In summary, the guidance from these panels is intended to offer cities strategies to more effectively address the impacts of climate change on a day-to-day basis, support an environment conducive to investment, and make infrastructural investments that will not only improve preparedness but also strengthen social cohesion, economic development opportunities, and environmental performance.

ULI Program Staff

Billy Grayson
Executive Director, Center for Sustainability and Economic Performance

Katharine Burgess
Senior Director, Urban Resilience

Leah Sheppard
Associate, Urban Resilience

Erica Ellis
Intern, Urban Resilience

Rachael Hartofelis
Intern, Urban Resilience

Julie Medley
Executive Director, ULI Southeast Florida/Caribbean

Mallory Barker
Associate, ULI Southeast Florida/Caribbean

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KATHARINE BURGESS/ULI

The Miami Beach panel spent an intensive three-and-half days in Miami Beach, researching, interviewing residents and stakeholders, and presenting its recommendations.

Acknowledgments

THE URBAN LAND INSTITUTE WISHES TO THANK the city of Miami Beach for hosting this panel and the Rockefeller Foundation's 100 Resilient Cities initiative for sponsoring this panel. In particular, ULI thanks Mayor Dan Gelber and City Manager Jimmy Morales for initiating this panel and offering the panelists and the ULI team access to Miami Beach staff, knowledge, and resources. In addition, a special thank you for hosting ULI and facilitating the panel's work is extended to the chief resiliency officer and assistant city manager, Susanne Torriente, and the deputy resiliency officer, Amy Knowles, who led preparation for the panel and ensured the panel's access to critical information and viewpoints, showing a very clear commitment to the city and resilience.

Many other dedicated staff members from the city of Miami Beach provided excellent support to the panel during preparation and the panel's visit, including Eric Carpenter, assistant city manager; David Martinez, capital improvements director; Roy Coley, public works director; Thomas Mooney, planning department director; Elizabeth Wheaton, environment and sustainability director; Maria Hernandez, Miami Beach Convention Center project director; Kayla Martinez, environmental and sustainability office associate; Cynthia Casanova, Parks and Recreation; Nestor Navarro, GIS manager; Naima de Pinedo in the Office of the City Manager; and Grace Castro, special events manager, and Denis Wolpert from the Bass Museum of Art.

The panel would also like to thank the 100 Resilient Cities initiative for its generous financial support of the panel, which made the project possible, and for all the services provided to the city through its engagement with the network. Staff from 100RC who provided leadership and support to the Miami Beach team and ULI on this project included Jeb Brugmann, Smita Rawoot, and Eric Wilson. Wilson has also been an important resource and guide for the city of Miami Beach throughout the Greater Miami and the Beaches Resilience Strategy process.

The panel also extends its thanks to the many stakeholders from Miami Beach who participated in the panel through the interview process and who attended the public listening session and final presentation. This group included residents, community and civic leaders, local designers, environmental activists, academics, business leaders, real estate developers, and many others. Throughout the week the panel was continuously impressed with the level of passion and involvement from the community and its interest in stormwater management and resilience.

Contents

ULI Panel and Project Staff

Panel Chair

Joyce Coffee
President
Climate Resilience Consulting
Chicago, Illinois

Panel Members

Juanita Hardy
Senior Visiting Fellow, Creative Placemaking
Urban Land Institute
Washington, D.C.

Jeff Hebert
Vice President for Adaptation and Resilience
The Water Institute of the Gulf
Baton Rouge, Louisiana

Phillip Kash
Principal
HR&A Advisors
Washington, D.C.

Greg Lowe
Global Head of Resilience and Sustainability
Aon
London, United Kingdom

Walter Meyer
Founding Principal
Local Office Landscape Architecture and
Adjunct Professor, Parsons The New School
New York, New York

Christian Nyerup Nielsen
Senior Director, Climate Adaptation, Landscape and
Flood Risk Management
Ramboll Water
Copenhagen, Denmark

Mark Osler
Associate Vice President and Coastal Science and
Engineering Practice Lead
Michael Baker International
Alexandria, Virginia

Greg West
President and CEO, ZOM
Chair, ULI Southeast Florida/Caribbean
Miami, Florida

ULI Project Staff

Katharine Burgess
Senior Director, Urban Resilience

Julie Medley
Executive Director, ULI Southeast Florida and Caribbean

Nicole Martinez
Contributing Writer

Mallory Barker
Associate, ULI Southeast Florida and Caribbean

Leah Sheppard
Associate, Urban Resilience

Erica Ellis
Intern, Urban Resilience

Rachael Hartofelis
Intern, Urban Resilience

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Panelists tour Miami Beach, led by Elizabeth Wheaton, the city's environment and sustainability director.

Executive Summary

INCORPORATED IN 1915 on a seven-mile stretch of porous substrate land along the Atlantic Ocean, the city of Miami Beach has nearly 100,000 residents and welcomes millions of visitors annually. A coastal barrier island, home to significant tourism and magnificent art deco architecture, the city is a cultural and touristic center that is extremely vulnerable to weather and the sea. For instance, the region is one of the most at risk to sea-level rise in the country and is vulnerable to three sources of flooding: coastal flooding including king tides, flooding caused by rainfall, and flooding from groundwater.

The city of Miami Beach has shown an impressive commitment in the last few years to addressing these flooding vulnerabilities, including identifying the funding for and beginning execution of a projected $600 million stormwater management program, sourcing financing independently of federal and state funds. Referred to throughout this report as the stormwater management program, this program comprises infrastructural investments and policy changes related to climate adaptation as relevant to stormwater, king tides, and sea-level rise. As of early 2018, the city is about 15 percent into this ten-year program that includes infrastructural updates as well as updates to both land use and development codes, as follows:

- Improving drainage systems;
- Elevating roads and public seawalls;
- Installing pumps to replace aging gravity stormwater pipes;
- Replacing much of the water, wastewater, and other utilities;
- Increasing seawall height;
- Increasing base flood elevation;

The city of Miami Beach is located on a barrier island off the southeast coast of Florida.

- Establishing a freeboard above Federal Emergency Management Agency (FEMA) base flood elevation;
- Introducing additional commercial height standards;
- Increasing setbacks and open space for single-family homes; and
- Requiring sea-level rise review criteria for land use boards.

The Miami Beach Rising Above website provides information about many of these infrastructural investments and policies, as well as other initiatives relevant to climate adaptation. The city is also participating in the Rockefeller Foundation's 100 Resilient Cities (100RC) initiative and will be authoring a resilience strategy in coordination with city of Miami and Miami-Dade County efforts.

WIKIPEDIA

Miami Beach is well known for one of the most notable ensembles of historic art deco architecture in the United States.

The Panel's Assignment

With the support of the 100 Resilient Cities initiative, the Urban Land Institute was invited to assess the city's current stormwater and climate adaptation strategy. At an Advisory Services panel held over the course of three days, ULI-member experts from around the globe convened to both assess the current framework and propose additional efforts to further bolster the city's existing strategy. The city asked the panel to address the following questions:

- Is the city of Miami Beach on the right track in its approach to mitigate flooding caused by tidal and rain events?
- Is the city of Miami Beach on the right track in terms of elevating roads, harmonization, placemaking, and aesthetics?
- Is the city of Miami Beach's neighborhood and project boundary map and strategy for project prioritization and sequencing sound?
- What other investments in public infrastructure improvements could occur where construction is already underway?
- How can the city best communicate with residents and stakeholders about potential solutions and costs and otherwise engage community in the ongoing stormwater and flood management program?

In addition, panelists were asked to identify possible future opportunities, including the following:

- How can the city ultimately advance climate adaptation in private development, including residential and commercial development, including perhaps adaptation strategies such as raising buildings?
- What strategies could be used to involve the private sector, public/private partnerships, or both in the design, funding, and delivery of stormwater management and flood mitigation strategies?
- How might the city use its upcoming business case analysis to advance future climate adaptation and stormwater management decision making?

In summary, the Advisory Services panel was tasked with examining Miami Beach's current stormwater management and climate adaptation strategy to assess its efficacy while making recommendations for future planning and development of the resilience strategy, which will address flooding, among other issues.

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Elevated streets, along with pumps placed in public rights-of-way and green spaces, are an integral part of the city's stormwater management strategy.

For clarification, in this report the panel uses the following terms:

- *Stormwater management strategy* refers to the $600 million funded program of work already underway that includes infrastructural improvements such as the introduction of pumps and elevated streets and development code updates and addresses risks including stormwater management, king tides, and sea-level rise.
- *Miami Beach Rising Above* refers to the website, communications collateral—such as email, PR materials, brochures, newsletter, and app—and branding developed after the launch of the stormwater management strategy, which has also more broadly addressed Miami Beach's climate adaptation efforts.
- *Resilience strategy* refers to the current strategy being developed through the 100 Resilient Cities initiative, which is likely to address water management and other related resilience factors alongside other issues relevant to social, environmental, and economic resilience. A 100RC Resilience Strategy is a roadmap or call to action addressing a city's people, projects, and priorities that is the product of six to nine months of consultation.[1] This strategy will be coordinated with strategies created by the city of Miami and Miami-Dade County, which are also a part of the 100 Resilient Cities network.

The recommendations of this report are not only meant for Miami Beach but are also intended to be considered within the development of Greater Miami and the Beaches Resilience Strategy. Although Miami Beach has sought this service, certainly much of south Florida and other communities in the United States and abroad can learn from the report.

This report is based on the panelists' work during the week of the Advisory Services panel and the final presentation on April 19, 2018. The recorded presentations can be accessed on the Miami Beach Rising Above website, www.mbrisingabove.com.

Elizabeth Wheaton of the city of Miami Beach explains to panelists how the stormwater management system functions.

Panel Recommendations

The panel's assessment centered on studying Miami Beach's environment, land use, and development patterns in the context of flooding vulnerability and the stormwater management program currently underway. In addition to meeting with Miami Beach officials and hosting a public listening session, the panelists conducted anonymous interviews with local community and neighborhood association leaders, business owners, developers, preservationists, and academic professionals to make these determinations and reviewed materials provided by the city, ULI, and other interested parties.

First, the panelists assessed Miami Beach's stormwater management strategy and identified its strengths and opportunities for improvement. They agreed that Miami Beach's proactive approach in triaging the problem and acting upon solutions is commendable. The city has been extremely process oriented, taking careful steps to understand the scientific data and implement solutions.

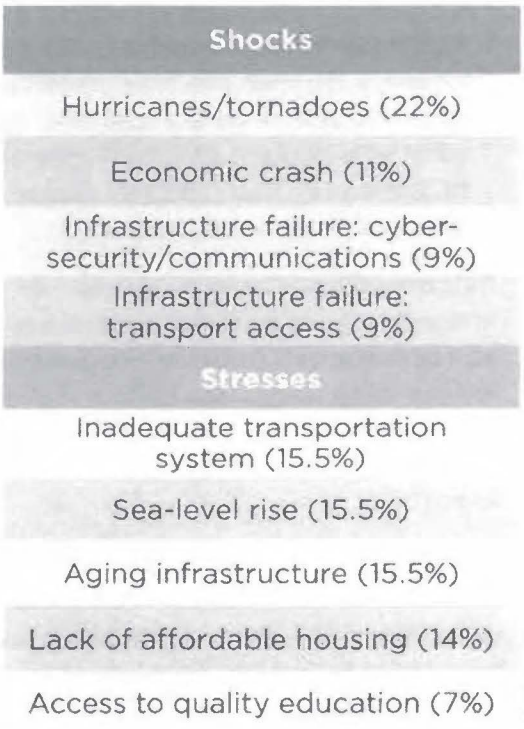
The city's decision to elevate the most problematic roads while upgrading and enhancing its stormwater pumping system is an essential part of its strategy for incremental adaptation, which can be built on over time. The city successfully implemented fundraising strategies to finance

these projects, which were not opposed by residents or commercial business owners. The city's planning includes a flooding risk estimate that prioritizes the city's implementation plan according to an area's vulnerability to flooding.

The panelists were also impressed by Miami Beach's collaborative relationship with regional entities, including the neighboring jurisdictions, and the city's decision to assess its strategy and recalculate its approach midstream and over time. The city's willingness to implement continuous learning and remain adaptable as it searches for solutions suggests that Miami Beach has the opportunity to enhance its broader resilience to flooding and climate impacts with a more integrated approach.

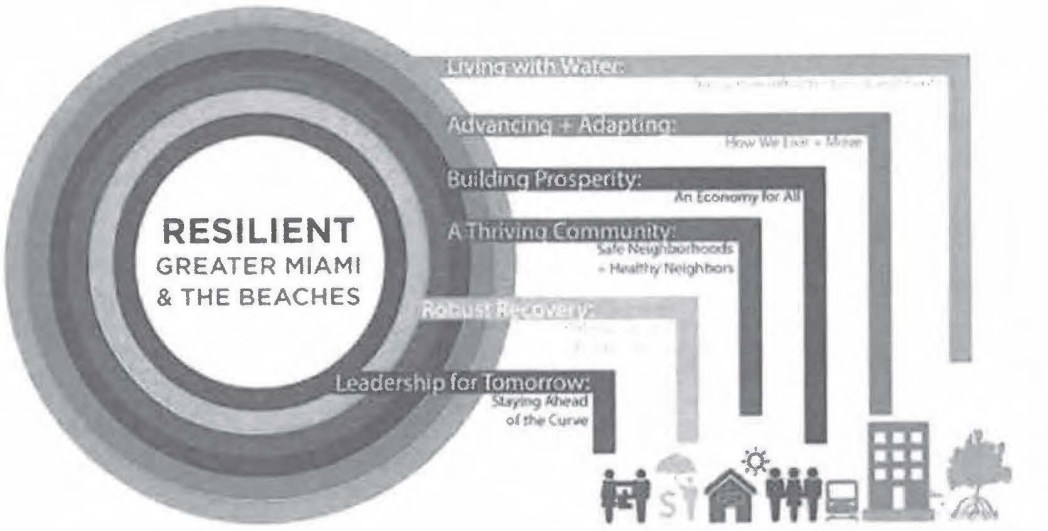
In short, the city acted with courage to fix sunny-day and stormwater flooding. The panel was particularly impressed that the city has taken the following actions:

- **Applied good practice for initial stormwater pump rollout and street elevations:** These infrastructural investments have made a noticeable difference for neighborhoods that once regularly experienced sunny-day flooding, such as Sunset Harbour.
- **Designed using climate change risk estimates:** Miami Beach designs to climate change projections from the Southeast Florida Climate Compact—the regional climate governance structure for Broward, Miami-Dade, Monroe, and Palm Beach counties—and plans for high tides.[2] The compact is one of the leading examples of U.S. regional collaboration, and the city should be applauded for its collaboration with the compact and for using forward-looking rather than historic data for infrastructure decision making. The city also monitors flood levels itself and compares observations to these projections.
- **Raised funds through fees and bonds rather than relying on state or federal funding:** Importantly, unlike many other U.S. cities at such risk, the city of Miami Beach has entirely funded its stormwater management program without contributions from federal and state programs. In fact, the implementation of a stormwater fee represented an opportunity that the city could pursue without oversight or approval from even the county, although permitting and regulations are followed. The city's property values—some of the highest in the southeastern region of the United States—have allowed the city to rapidly pursue mitigation and establish funding sources that are likely to remain stable even in the face of changes in federal and state policy. Therefore, preserving property values is critical to ensure funding availability for future stormwater and resilience investments and is a topic explored in this report.
- **Crafted thoughtful communication materials and vehicles on the overall resilience program:** The Miami Beach Rising Above initiative offers excellent communication materials on the city's investments in stormwater management and climate adaptation, which explain key issues in a tone accessible to a range of stakeholders.



CITY OF MIAMI BEACH

As a part of the city's work with 100RC, the city participated in a resilience diagnostic to identify and prioritize its stresses and shocks.



CITY OF MIAMI BEACH

Miami Beach's resilience strategy includes six "discovery areas," which are key issues identified in the 100RC resilience assessment. This panel's recommendations are primarily relevant to the living-with-water discovery area.

- **Collaborated both interagency and within regional partnerships:** As noted above, south Florida and Miami Beach offer a tremendous example of regional collaboration, particularly because of the Southeast Florida Climate Compact, in which the city of Miami Beach actively participates, including current participation on the Steering Committee. Beyond this, Miami Beach has closely coordinated with the city of Miami and the Miami-Dade County resilience offices through 100 Resilient Cities.
- **Implemented multiple levers, including policy changes:** The stormwater management program not only funded infrastructural investments, but the city also revised land use policies to support the desired outcomes. Future efforts including the resilience plan and Miami Beach Rising Above should continue to follow this precedent.
- **Examined program cost/benefit:** Through this Advisory Services panel, Miami Beach welcomed outside experts to critique and offer strategies to continue to iterate and improve the stormwater and resilience program underway.

The panelists agreed that the city's stormwater management strategy, although a good start, is not currently sufficient to address the extent of risk faced by the city and does not reflect its cultural leadership. Accordingly, the panel proposes a series of opportunities for improvement, which should be incorporated into an expanded strategy that seeks to more broadly address resilience beyond stormwater management. Key opportunities explored in this report include the following:

- **Integrating flood management within the larger resilience strategy:** Integrating the stormwater management plans with broader goals in the emerging resilience strategy will enable the city to embrace a more comprehensive and holistic plan for "living with water." This is critical given the extent of flooding and climate risk faced now and in the future. This strategy should also include investing in technology, such as enhanced modeling, to better inform the city on the varied types of flooding risks and the cost/benefit of different interventions to address them.
- **Enhancing public trust, trusting the public, and increasing transparency:** Although city staff currently spends significant time and effort on community outreach, past efforts have not been as successful as they could have been. The early stages of the stormwater management program were implemented in emergency

PIXABAY

Although already well known as a beachfront destination, Miami Beach has the opportunity to distinguish itself as a coastal community with its resilience efforts.

response mode and formed residents' initial impressions, leaving many feeling they were not provided with meaningful opportunities for input. Since that time, the city has broadened its resilience work and engagement, particularly through its work under the umbrella of 100 Resilient Cities. Future efforts should better integrate public comment and outreach into the decision-making process, provide significant opportunities for the public to weigh in, and increase transparency of the city's investments, the cost/benefit, and the likely timeline of various climate adaptation investments. Future efforts should also report on bay water quality monitoring, individual projects' progress against planned timelines, and outreach efforts.

- **Elevating public aesthetics and function to perpetuate the city's cultural relevance:** Flood mitigation should not be implemented independent of public aesthetic concerns. Future investments in stormwater management and resilience should also seek to improve health and quality of life and build from the culture of arts, heritage, and placemaking in Miami Beach.
- **Actively using green and open space:** Green and open space offer an important opportunity to manage and infiltrate water, given their permeability and sponge functions—meaning the ability to absorb water naturally. Green infrastructure and open space also offer opportunities to enhance overall quality of life and improve collateral public benefits from investment in infrastructure.
- **Increasing long-term financial and comprehensive protection:** A comprehensive resilience strategy will increase both infrastructural and financial protection, considering how the city can leverage a range of funding sources and be strategic about its approach to risk.
- **Embracing the resilience brand—distinguishing Miami Beach from coastal competitors:** Miami Beach has the opportunity to be an international leader in resilience and climate adaptation. Embracing this opportunity and communicating about it will distinguish the city from its coastal competitor cities and potentially help residents, businesses, and other stakeholders appreciate the value of the proactive alternative Miami Beach has chosen.

The panel's recommendations were guided by a key set of principles, set out in the next section, that considered both the city's and its residents' and businesses' priorities, as well as the impressions of and reactions to the implemented stormwater plan thus far. Following the introduction of these principles, this report contemplates an integrated solution for future stormwater management and resilience work addressing the following elements:

- Infrastructure;
- Physical design and typology;
- Creative placemaking;
- Governance;
- Financing;
- Regulations; and
- Communications.

Strategies for each of these elements are explored in detail in individual sections of this report.

Guiding Principles

MIAMI BEACH IS CURRENTLY CHARTING a course that could become a model for global cities adapting to sea-level rise. The city's commitment to taking a proactive approach to resilience has already positioned it as a world leader in the climate adaptation space. A next step will involve more fully embracing dynamic and holistic solutions and communicating these better to residents, businesses, other stakeholders, and the city's many visitors. Because the city's competitors, particularly for tourism and coastal living, are also coastal, Miami Beach has the chance to differentiate itself from other cities by embracing the brand it defined in its Miami Beach Rising Above living-with-water communications and proactively preparing for a changing climate and the related impacts.

The panel developed the following guiding principles to advance future stormwater management and resilience work. These principles are relevant to all of the recommendations in this report.

Maintaining Urgency

Miami Beach began its stormwater management and climate adaptation strategy with unusual speed and a "get it done" attitude. As the program evolves, future phases should strive to be more transparent and collaborative with residents while maintaining the initial sense of urgency set for the program. Investing in climate adaptation infrastructure to protect against flooding is critical for the city's near-term and long-term future. In light of current and growing risks, the program needs to continue to innovate, and by maintaining this urgency, Miami Beach will continue to be in the lead compared to its fellow at-risk coastal communities.

KATHARINE BURGESS/ULI

Pumps and generators installed in the Sunset Harbour neighborhood are a visible part of the city's stormwater strategy.

Using Incrementalism—Phases and Evaluation

Resilience entails both being ready to bounce back after a shock event and being able to regularly adjust and recalibrate to changing environmental, social, and economic conditions. It is important that the city has implemented the first crucial resilience strategy phase and is evaluating it.

CITY OF MIAMI BEACH

The delivery plan for the Greater Miami and the Beaches Resilience Strategy includes a variety of strategies for community involvement, assessment, and analysis.

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Maintaining the quality of Biscayne Bay is critical for the sustainability of both the city and its surrounding ecosystems.

Moving forward, the stormwater management plan must be designed for incremental evaluation and change to respond to the availability of new technologies, data sets, and economic and physical realities. A key new technology may be the addition to the city's tool set of a physical model that, for instance, helps identify the best solutions and define benefits for the riskiest areas, which is explored in more detail in the "Infrastructure" section of this report.

Technologies and strategies in use should be regularly evaluated and modified in a continuous improvement process and considered against the principles described in this document. Moreover, a key aspect of incrementalism is offering opportunities for input from affected community members to ensure that all are part of the solution, which is also a way to build transparency.

Ensuring Transparency

Initial stages of the stormwater management plan were swiftly implemented with some public presentations but relatively minimal opportunities for public input and comment—and without clear information about the costs and benefits. As a result, many residents deeply distrust the flood-related decisions the city has made and feel unfairly inconvenienced or concerned about changes occurring near their properties. As the stormwater management plan advances and the city continues with its resilience plan, agencies must ensure a transparent process with robust two-way communications.

Ample collateral communications are currently prepared for Miami Beach Rising Above, including excellent materials explaining the technologies the city has put in place to address flooding. All stakeholders need more information on the larger vision of risks and solutions and the costs and benefits of the proposed interventions, as well as the expected timeline of various investments and the basic science behind the plans. Materials should also give comparative context for what Miami Beach's future would be if proactive adaptation were not carried out.

Residents and businesses should also be presented with clear information on how to adapt properties as well as given toolkits on likely costs and strategies to invest in climate adaptation at the scale of the single-family home and large and small-scale multifamily buildings. Although the local government can provide some of these resources and collateral information on how to adapt private property at the building level, this is also an opportunity for private sector leadership from the design, real estate, and building technology sectors.

In addition, the financial and regulatory markets are becoming more and more sophisticated about the physical impacts of climate change; for instance, Moody's and Standard & Poor's investor services are including exposure to climate hazards in their city bond credit evaluations. Accordingly, Miami Beach needs to be forthright about what scenarios of climate change suggest about its future exposure as well as about what changes it has already observed and how it is applying solutions to this knowledge. Comparing itself to other coastal communities and sharing information about the investments in adaptation the city has made will be crucial and can help the city differentiate itself from competitors.

Respecting the City's Ecological Endowment

Biscayne Bay is a precious resource for Miami Beach and the whole region—and a shared responsibility for all of Miami-Dade County. The city's stormwater management plan must respect this tremendous natural capital.

Miami Beach has taken care to remove trash and sediments from the pump stations. However, with the introduction of

more pumps and generators, a risk exists that the quest for peak-event preparedness eclipses the need for sustainability and respectful use of natural resources.

The stormwater management plan must recognize this potential tension, ensure a commitment to the natural environment, and communicate these values to residents, who are currently concerned about this possibility. Ensuring frequent monitoring, such as in-pump water quality monitoring that is reported to the public in real time, will be one aspect of the solution. Regional cooperation will also continue to be a part of the solution for enhanced water quality because 8,000 outfalls exist countywide.

Maintaining the ecological treasures of the area is not only important because of residents' values: the beach and the ocean are the primary draw for Miami's many tourists and therefore represent an important component of economic development.

Exercising Financial Pragmatism

Miami Beach is admirably financing its stormwater improvements without state and federal support through increased stormwater fees and the issuance of bonds. In future, the city should continue to self-finance, assuming that minimal support will be available from the federal and state governments.

The city would also be unwise to assume that federal programs such as the National Flood Insurance Program (NFIP) will continue indefinitely, so Miami Beach should be prepared for the impact on residents and the tax base if NFIP were to change significantly. Miami Beach is lucky to have an extraordinarily strong tax base and economy, and it is far better placed than cities across the country to finance the ambitious infrastructural improvements that the island needs. Elements of the recommendations in this report focus on maintaining this tax base to ensure the increasing funds that will be needed to enhance resilience.

Recognizing Co-benefits

Investing in new stormwater infrastructure presents an opportunity to advance Miami Beach's other quality-of-life and economic development goals. For example, raised streets represent the opportunity to implement complete streets investments such as bike lanes and improved sidewalks, which are in line with the city's current Street Design Guide.

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Complete street infrastructure, as seen here in Vancouver, British Columbia, could be integrated with planned road elevations to maximize the efficiency of the city's infrastructure investments and provide co-benefits.

Other co-benefits include decreased impacts from extreme storm events, faster rebounds for affected areas, improved resident health because of more welcoming physical spaces that encourage walkability and bikeability, more opportunities for public art, and reduced congestion due to alternative transportation modes.

Prioritizing Social Equity

Although Miami Beach is a very wealthy city overall, many households have significant needs: according to 2016 U.S. Census Bureau figures, 16.7 percent of residents live below the poverty line. The city needs to ensure that low-income populations are given priority for investments in stormwater management because the most vulnerable are the least likely to have needed resources of their own.

The city will also be a stronger and more resilient community when there are more housing options affordable for people at a range of income levels. Currently, 50 percent of renters are rent-burdened, and 38 percent of homeowners are house-burdened. A household is burdened if it pays more than 35 percent of its income on shelter. In addition, the median income of $49,444 obscures the inequality shown by the mean income, which jumps to $95,728 because it accounts for the highest incomes.[3]

Diversity, including income diversity and racial diversity, makes for culturally relevant and vibrant places and helps employers find candidates for a range of positions and needs. While the goal of enhancing affordable housing and income diversity reaches beyond the remit of a stormwater management program, it is a critical goal to inform the city's broader resilience work.

Preserving Cultural Identity

Miami Beach is known internationally for its distinctive art deco architecture, world-class beaches, and thriving arts scene, including Art Basel. These cultural characteristics feed thriving hotel, tourism, and restaurant industries and drew 16 million people to the Greater Miami metropolitan area in 2016.

The stormwater management and climate adaptation strategy should strive to maintain this unique sense of place and build from it; even pumps and generators can be made more aesthetically pleasing if designed in partnership with local artists. That being said, to adapt to the future, residents, businesses, and city stakeholders need to take a broader and more flexible view of what cultural and built identity comprises, rather than preserving the entire built environment exactly as is.

Living with Water

Water has always been a key part of Miami Beach's identity: the beautiful beaches and bay are cherished by residents and draw visitors from around the world. Thanks to the stormwater management and resilience work already underway, the city is also a leader—regionally, nationally, and increasingly globally—in adapting to rising sea levels, king tides, and increased precipitation. The city has made significantly more progress than peer cities around the world.

Now is the time to capitalize on this leadership as efforts mature and climate-related coastal pressures grow for people around the world. "Living with water" could become part of Miami Beach's tourism and economic development

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The idea of living with water could become part of Miami Beach's branding in the future.

branding as well as its resilience and stormwater management strategies. More information on the appropriate technologies and the mindset of living with water are found in the "Infrastructure" section of this report.

Taking a Long-Term and Regional Perspective

The city of Miami Beach has made impressive investments in climate adaptation and stormwater management. Immediate, incremental investments in stormwater management and climate adaptation are a good start, but more is needed to secure the city's long-term future, given flood vulnerability and both observed and predicted sea-level rise. Building from initial efforts and taking a more holistic approach to adaptation that can be incrementally evaluated and strengthened are critical. No matter what climate change scenario one refers to, a consensus exists that the world's current population is enjoying a more stable climate than it will experience not only in the coming decades, but also well into the next century.

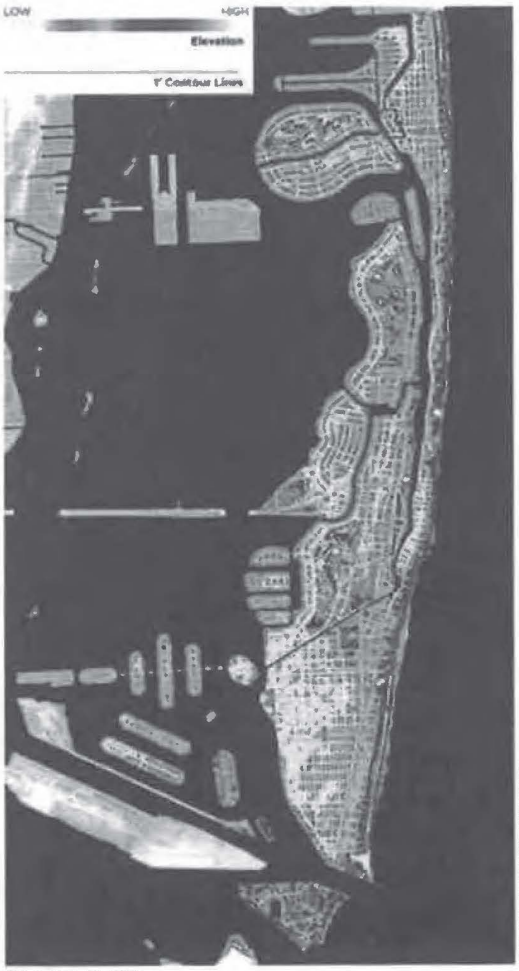
Taking this longer-term view, sharing it with residents, and encouraging other communities in the regional economy to do so should be part of the city's overall program of work. Compared to the alternative lack-of-action scenario, the costs and inconveniences that lie ahead for Miami Beach should be understood in the context of the impact of growing flood-related risks.

Background

SOUTH FLORIDA'S STORMWATER vulnerabilities start from the ground upward. The geology of south Florida is fossilized coral limestone, which serves as the foundation for Miami Beach's road construction. Many of the streets in the city have about eight inches of crushed limestone and asphalt topping. When water rises through this porous limestone—whether caused by stormwater or high-tide events, such as the annual king tides—the limestone element experiences water cycling that degrades the structural integrity of the base and shortens the lifespan of the city's roads. Consequently, the city frequently experiences flooding that significantly hampers accessibility during these high-tide and stormwater events.

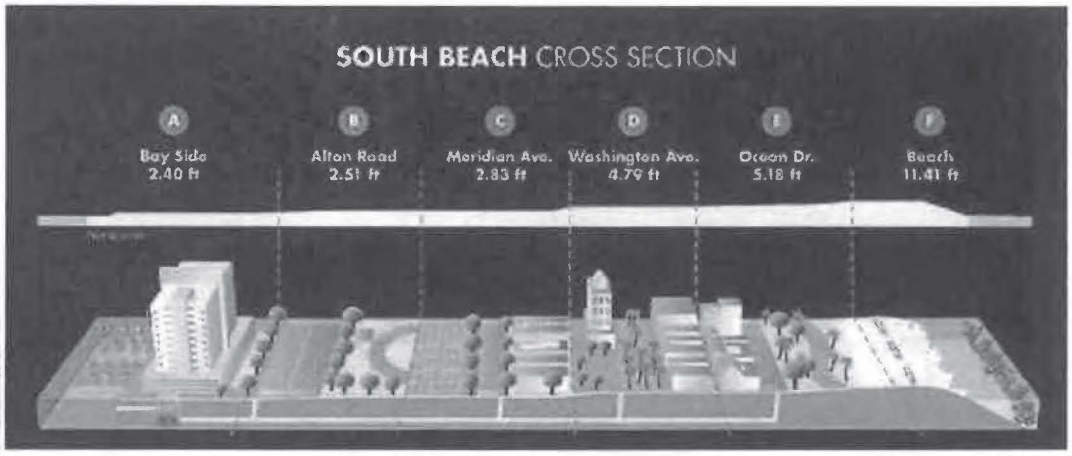
South Florida has experienced numerous peak events and storms over the years, which have led to local innovations in resilience and preparedness with global impact. Decades of crippling storms in the early 20th century led to the 1957 South Florida Building Code, which was adopted in Dade and Broward counties. Although the south Florida code was strong, it had enforcement issues. After Hurricane Andrew in 1992, Miami-Dade County implemented an unprecedented series of wind resilience codes as a reaction to the storm's widespread destruction. In addition, the county required licensure of building code enforcement officials to amplify regulation. The policies were integrated into the Florida Building Code, approved in 2002, the state's first overarching code.[4]

Platted in a traditional grid, Miami Beach has a building typology that mixes residential, multifamily, commercial, hotel, and historic buildings. Each typology contributes financially to Miami Beach; taxes paid by residential, multifamily, and commercial properties represent a significant portion of city revenue, while historic buildings are cultural assets that largely drive tourism investment in the region. Many of Miami Beach's buildings are likely to need to be



ELEVATION
Miami Beach

Miami Beach's low elevation, as shown on this map, is one of its key vulnerabilities. The bayfront coast is notably vulnerable.



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Over 20 percent of the properties in Miami Beach lie below 3.7 feet NAVD, and 93 percent are within the FEMA-designated Special Flood Hazard Area.

adapted to remain resilient, but current regulations present significant challenges for city officials. Nearly 30 percent of property located in Miami Beach sits within its historic districts. These properties in particular are at a greater risk of damage from sea-level rise; 67 percent of those properties are partially or fully at an elevation lower than 3.7 feet NAVD (North American Vertical Datum of 1988). As a whole, 93 percent of Miami Beach properties are in the Special Flood Hazard Area.

The city's assessed property value totals $37.4 billion, representing over 13 percent of the county's property values on only 0.4 percent of the land. However, this statistic obscures the fact that Miami Beach faces income inequality: the poverty rate is 16.7 percent.[5] Furthermore, the vast majority of the city's properties are insured under the National Flood Insurance Program. Any changes in the NFIP would therefore significantly impact Miami Beach because of the high level of coverage. One mitigation step Miami Beach has taken is joining and aggressively participating in the NFIP Community Rating System, which recognizes floodplain management strategies as a form of risk reduction. Through this program, residences and businesses save $6.5 million annually.

As a result of the high property values, property taxes in Miami Beach make up over half the operating budget, at 53 percent. The city's secondary revenue source is tourism, at 12 percent. The city has a $610.9 million operating budget and a $59.8 million capital budget. In addition, the city's current bond ratings are stable and well rated across the board. The city's Stormwater Revenue Bonds of 2017 in the amount of $156.5 million were rated by Moody's Investors Service as Aa3 with a "stable outlook" and by Standard & Poor's Financial Services as AA– with a "stable outlook."

Current Stormwater Management Program

MIAMI BEACH'S POROUS GEOLOGY and the threats of sea-level rise and regular sunny-day flooding present existential threats, which are top of mind for many in the community. This section introduces Miami Beach's efforts to address stormwater management and tidal flooding, as well as other relevant work led by the city. This high-level introduction summarizes information presented to panelists at the beginning of the panel. More information can be found on the Miami Beach Rising Above website, www.mbrisingabove.com.

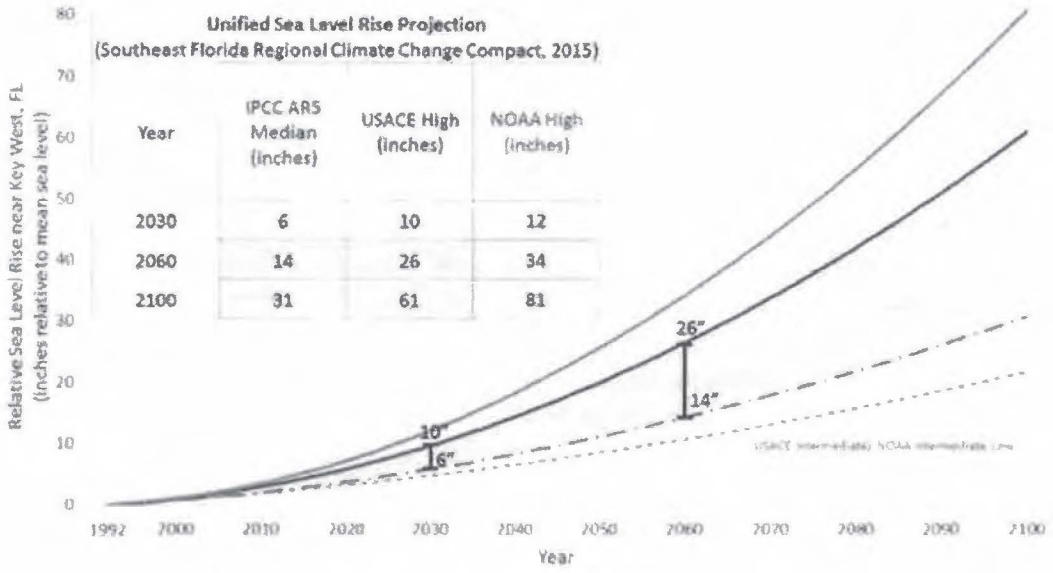
Miami Beach has had policies, plans, and infrastructure in place to address stormwater management since the 1990s. The program in effect today was kick-started in 2013, when the city began an aggressive stormwater plan that identified its most at-risk neighborhoods and used a 30-year projection timeline for sea-level rise in an effort to identify a strategy going forward. Road elevation was a key component of the new strategy. In simple terms, the city came to the decision on road elevations as follows:

- At the beginning of the stormwater management program, Miami Beach officials identified that the mean high-water elevation figure being used to design new stormwater projects—0.6 feet NAVD—did not account for higher stormwater and tide events.
- To correct these measurements, the city assessed every tidal event over the last several years and identified that the highest-elevation non-storm-related event occurred at 1.7 feet NAVD.
- Using that figure, the city created a 30-year planning horizon that accounted for a 12-inch projected increase in sea level, arriving at a base elevation of 2.7 feet NAVD. Under these guidelines, Miami Beach identified that the crown of area roads would need to be elevated to 3.7 feet NAVD, and its approach was to identify the city's most vulnerable areas and prioritize those regions successively.

Newly installed stormwater infrastructure can be seen here in Sunset Harbour.

Since making these design decisions, the city has since observed 2.2 feet NAVD high-tide elevations in 2016 and 2017, indicating that the earlier estimates are unlikely to be sufficient if trends continue, particularly for a 30-year window.

As part of this effort, the city also made key improvements to existing stormwater management systems, effectively implementing a road elevation strategy that retrofitted existing or installed new pumps and treatment systems to improve flooding and address water quality issues. These updated pumps were installed with generators to prevent overflow flooding during power outages. At the time, the city aimed to tackle the harmonization of private property with the elevated citywide pump infrastructure, but that topic remains highly debated to this day.



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The Southeast Florida Regional Climate Change Compact developed unified sea-level-rise projections for the region in 2015, which Miami Beach adopted for its planning in 2016.

Policy

In 2013, the city began its most ambitious stormwater management program yet, to tackle sunny-day flooding faster and more aggressively. The city committed to investing nearly $600 million to raise roads to a 3.7-foot NAVD and improve stormwater drainage in the most vulnerable areas: the plan projected that nearly 60 percent of Miami Beach–owned roads will be elevated to meet the elevation goal of 3.7 feet NAVD.

CAROL BERNEY / FLICKR

Sunny-day flooding, pictured here near Washington Avenue in Miami Beach, is a persistent threat that the stormwater management program seeks to address.

Focusing initially on this component, the city passed a resolution to modify the design criteria for tailwater elevation to 2.7 feet NAVD for all tidal boundary conditions. By December 2014, the city was able to pass a resolution that raised the standard seawall height to 5.7 feet NAVD with an additional cap of two feet, and this resolution was subsequently amended in 2015 to require seawalls to be designed to reach 5.7 feet NAVD with an interim condition of 4.0 feet NAVD in consideration of existing homes. In 2015, the city also approved the sale of over $100 million in stormwater bonds in an effort to finance the stormwater management program.

In addition, the city made strides in updating land use and development codes, establishing a minimum of one-foot and maximum of five-foot freeboard elevation for every building in the city. Regulations pertaining to the calculation of building height and minimum elevations of required yards in single-family districts were also implemented under this plan. More recently, sea-level rise and resilience criteria must be considered by the city's land use boards.

In its initial effort, the city created a sequencing chart laying out a capital improvement program by neighborhood with a funding timeline. This sequencing chart is based

upon identifying which neighborhoods are most vulnerable and also have neighborhood improvement projects already underway. To finance this project, the city can bond $100 million per fee increase, with fees set at $7 per residential unit per month. The city also received modified tax increment financing from the county.

Miami Beach is installing a total of 42 monitoring wells in nested sets of three at 14 different locations throughout the city to develop a comprehensive groundwater program. This plan accounts for groundwater as a key component of flooding in the stormwater management master plan and considers its direct interaction with surface waters and sea-level-rise effects. The city has already completed substantial drainage and road elevation improvements to a number of vulnerable areas, and the plan provides for flexibility among residents. For example, residents in lower-elevation areas are given the option of connecting their storm drains into the citywide system, which has achieved 50 percent resident buy-in.

Water Quality

As one of 30 permitted entities to discharge stormwater in Miami-Dade County, Miami Beach manages 4 percent of the 8,000 outfalls within the county. As part of the city's stormwater master plan, officials set out to improve its discharge management to prevent trash and sediment from being discharged into waters. Streets are swept daily, removing 450,000 pounds of material that would have eventually flowed into the bay. Miami Beach has upgraded its pump station maintenance so that refuse is being disposed of properly. The city uses a vacuum truck to extract and discharge large trash and sedimentation at a regional landfill, with some city pumps being cleaned as frequently as every week. Nonetheless, the city receives frequent expressions of concern and criticism from residents who believe the drainage pumps are contaminating the bay.

Further complicating the issue is that several of the city's pump systems are managed by the state, and the city frequently interfaces with state officials who put the burden of proper disposal of their state-owned pumps on the city.

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The current program has installed new drainage pipes throughout the city, such as this one on Alton Road.

This creates a situation in which Miami Beach is maintaining both state and city pumps.

Historic Preservation

Historic districts in Miami Beach are highly vulnerable and highly valuable. Most of the properties within these districts were built at low elevations, and design guidelines have yet to adapt for sea-level rise. Moreover, the city takes a district versus individual property approach to historic preservation; rather than identifying a neighborhood's most important buildings, the Historic Preservation Ordinance designates an entire neighborhood as a protected district, applying stringent design and build regulations to properties located within that district. Miami Beach currently has 14 historic districts, with over 44 percent of assessed property value found within a historic district.

Currently, the city is upgrading existing guidelines to better adapt historic buildings for sea-level rise. The city is retaining an architectural firm to lead a team with experience in historic guidelines, urban planning, and climate change and is considering tangible ways to adaptively use building first floors, given their flood vulnerability.

Environmental Resources and Green Infrastructure

Enhancing and using natural resources is a critical component of Miami Beach's resilience strategy and broader work in planning policy. Potential exists for natural resources

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Miami-Dade County Beach Erosion Control and Hurricane Surge Protection Project deposited 18,500 truck-hauls of sand in Miami Beach in 2016 alone. Depicted are the beach before (left) and after the protection project.

to play a more prominent role in the city's stormwater management strategy and urban design aesthetic.

Current environmental resources and sustainability projects underway include the following:

Environmental resources

- The Miami-Dade County Beach Erosion Control and Hurricane Surge Protection Project has been ongoing since the 1970s. It provides storm protection and erosion control and a variety of environmental, recreational, and economic co-benefits.
- In 2015, the city of Miami Beach established a citywide Coastal Dune Management Plan to outline the framework and specifications the city will use to foster and maintain a healthy, stable, and natural dune system. As a result of the plan, the dune system successfully protected the city from storm surge and substantial sand loss, demonstrating the value of natural infrastructure in resilience.
- In partnership with the Florida Department of Transportation, the city is currently upgrading the stormwater system and elevating Indian Creek Drive. This project will protect a hurricane evacuation route from tidal flooding and improve water quality going into the adjacent Indian Creek Waterway, which is part of the Biscayne Bay aquatic preserve. To enhance this project, the city is proposing the first in-water hybrid shoreline that includes a mangrove planter waterward of a new elevated seawall.
- Farther north, the Brittany Bay Park shoreline project has been redesigned to incorporate mangrove and wetland species by pulling the seawall into the park to create a living shoreline inside the existing park footprint. This project includes a walkway and waterway overlooks to connect the public with the natural environment.
- The Muss Park Seawall Enhancement project included the construction of a seawall, designed strategically to protect existing mangroves that had naturally recruited

along the shoreline. This project pulled the seawall back into the park around the mangrove and created additional space to plant more red mangroves.

- The beachwalk corridor is an alternative transportation pathway that will connect the city north–south from Government Cut to 87th Terrace. Through the implementation of the beachwalk, the city has been able to expand its alternative transportation network while also reinforcing the adjacent coastal dune system.
- Miami Beach's transportation master plan prioritizes pedestrians and emphasizes that trees enhance walkability. The city has completed a GIS inventory of all trees in parks and public rights-of-way and is currently seeking proposals to develop a street tree management plan.
- In 2015, the city established a Tree Preservation Program to permit the removal of trees on public and private property. Applicants are required to mitigate tree canopy lost through replanting or contributing to the Tree Preservation Trust Fund.

Sustainability

- In 2015, the city completed its first greenhouse gas inventory that included assessment of government operations and community-wide emissions. The built environment is the largest source of greenhouse gas emissions. In 2016, the city passed a green building ordinance that requires Leadership in Energy and Environmental Design (LEED) Gold certification or Living Building Challenge certification for new construction over 7,000 square feet or ground-floor additions to existing structures that encompass over 10,000 square feet of additional floor area. If an applicant chooses not to pursue green building certification, it is required to pay a percentage of its construction valuation into a sustainability fund that will be used for environmental and sustainability-related public improvements.
- The city is focusing on green infrastructure as an innovative approach to resilience. However, because of the existing regulatory requirements, the city notes that gray infrastructure is easier to build and finance. City officials are working closely with regulatory agencies to overcome challenges to the implementation of green infrastructure and are seeking grant and nontraditional funding to realize these projects.

Communications

The city of Miami Beach has implemented a communication strategy for Miami Beach Rising Above intended to inform residents of its progress on overall resilience planning efforts. The city regularly shares key information on its stormwater and flooding challenges and plans and is correctly focusing on reaching all stakeholders in the city. These methods include the following:

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The Brittany Bay Park project will create a living shoreline that includes walkways and overlooks for members of the public to enjoy.

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The Miami Beach Rising Above website is a central resource for sharing Miami Beach's climate adaptation research, planning, and opportunities for involvement.

- Regular communications in the city's printed magazines for residents;
- Hosting community meetings throughout the city's neighborhoods;
- Strong engagement on social media channels; and
- The city's Rising Above website, which is the cornerstone of this effort and includes critical information regarding the Miami Beach Rising Above program. Residents and business owners can log in and obtain specific information about their properties, read about the scientific reports that have led the city to adopt these resolutions, use an innovative adaptation calculator, and sign up for updates on public meetings and town hall sessions.

Sunset Harbour, which was a pilot site for stormwater improvements, has recently seen substantial commercial growth and new development.

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Neighborhood Case Studies

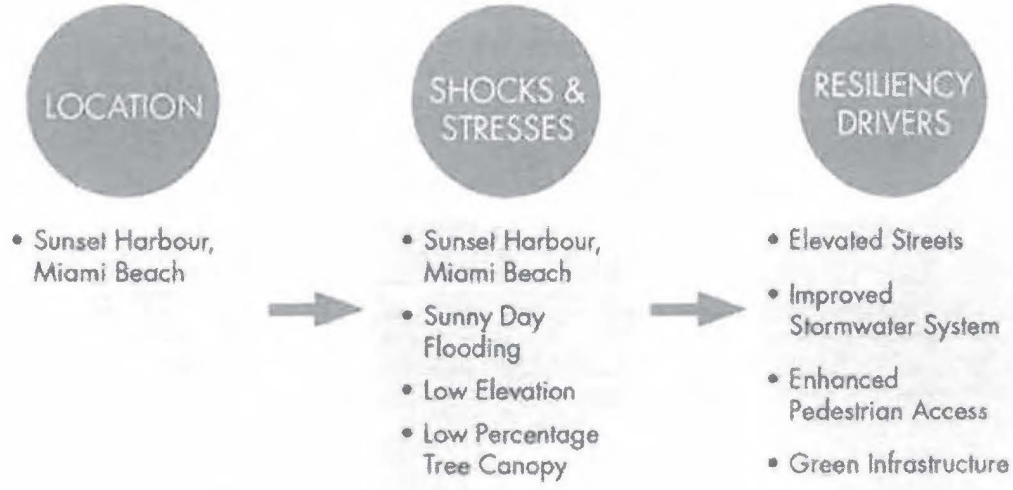
Miami Beach's sequencing model approach has been implemented in key areas across the city. In an effort to help panelists understand firsthand how these improvements have been carried out, city staff led tours for panelists to key areas at various stages of investment, including those described in the following sections.

Sunset Harbour

The Sunset Harbour area of Miami Beach was once plagued by intense flooding during high-tide and stormwater events. As the area began to grow commercially, the city realized that a substantial road elevation project would need to be implemented to protect those assets. The result includes one of the city's most ambitious road elevation projects and a buzzing commercial area. The city anticipates that private infrastructure will adapt incrementally along with its own public infrastructure plan.

Dade Boulevard, the main thoroughfare running through Sunset Harbour, was raised about 30 inches, with a new pump station installed along the canal that runs parallel to the street. Roads in Sunset Harbour were also raised, and split-level sidewalks were installed to alleviate flooding for businesses that have yet to raise their structures. As designed, higher-elevation sidewalks spill excess water into the street drainage, whereas their lower counterparts have separate drains that have been installed to absorb overflow and protect commercial properties from flooding. The city notes that removing street parking was integral to completing this project. Now, most visitors to Sunset Harbour park in one of two parking garages located in the area.

A recent storm event led the city to make upgrades to the generator systems powering the pumps within Sunset Harbour. Formerly, the pumps relied on power from Florida Power & Light, one of the largest electrical companies in Florida. If a storm event caused a power outage, then the pumps would be unable to run. Instead, the city installed a permanent generator and is currently considering beautification improvements to these pump stations.



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The Sunset Harbour elevation project incorporates resilience drivers to respond to local shocks and stresses.

Palm and Hibiscus Islands

Palm and Hibiscus Islands represent one of the residential areas with the highest land values in Miami Beach and a key part of the city's tax base. The islands have undergone substantial neighborhood improvements and boast some of the most engaged and active residents in the city. Debates on recent projects have been vigorous and can delay construction.

In addition to roadway elevation, the city has installed yard drains to which property owners can connect their drain pipes in an effort to communally manage runoff. Other infrastructure improvements include sanitary sewer rehabilitation, relining of pipes, and replacement of lateral connections. In addition to upgrading the stormwater system, the city is installing a pedestrian lighting system on the islands and will underground franchise utilities on Hibiscus Island. The overhead-to-underground utility conversions have been a point of contention among city residents.

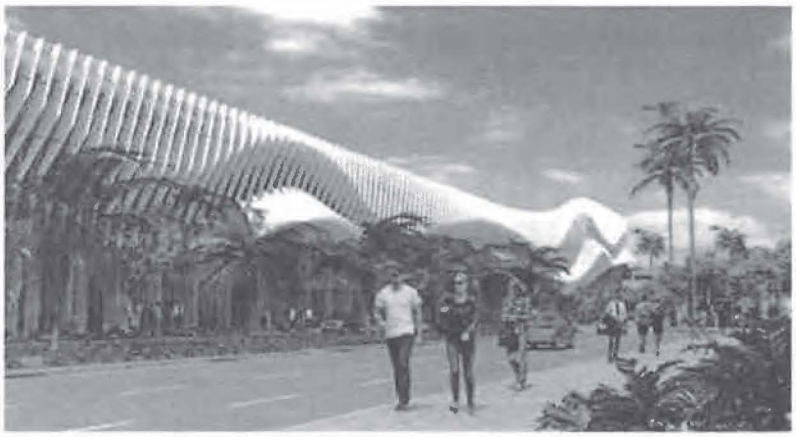
MARC AVERETTE | FLICKR

Hibiscus Island is a manmade island in Biscayne Bay with highly desirable property.

Miami Beach Convention Center

The epicenter of economic impact in Miami Beach, the Miami Beach Convention Center was long slated for renovation and improvement. Comprising 25 acres in the center of Miami Beach, the new Convention Center project master plan incorporates two new public parks and increases green space by 12 acres. The Convention Center is a $620 million project being referred to as the city's new civic heart because a six-acre public park is being constructed in the center, surrounded by several existing and important public spaces, the Holocaust Memorial, and the Botanical Garden as well as the existing City Hall. The building was also required to remain open to support major economic drivers such as Art Basel Miami Beach.

The Convention Center site is also the location of two of Miami Beach's largest pump stations and is therefore a significant component of the city's overall stormwater plan. The pumps located on the Convention Center campus will interconnect runoff from two separate and adjacent



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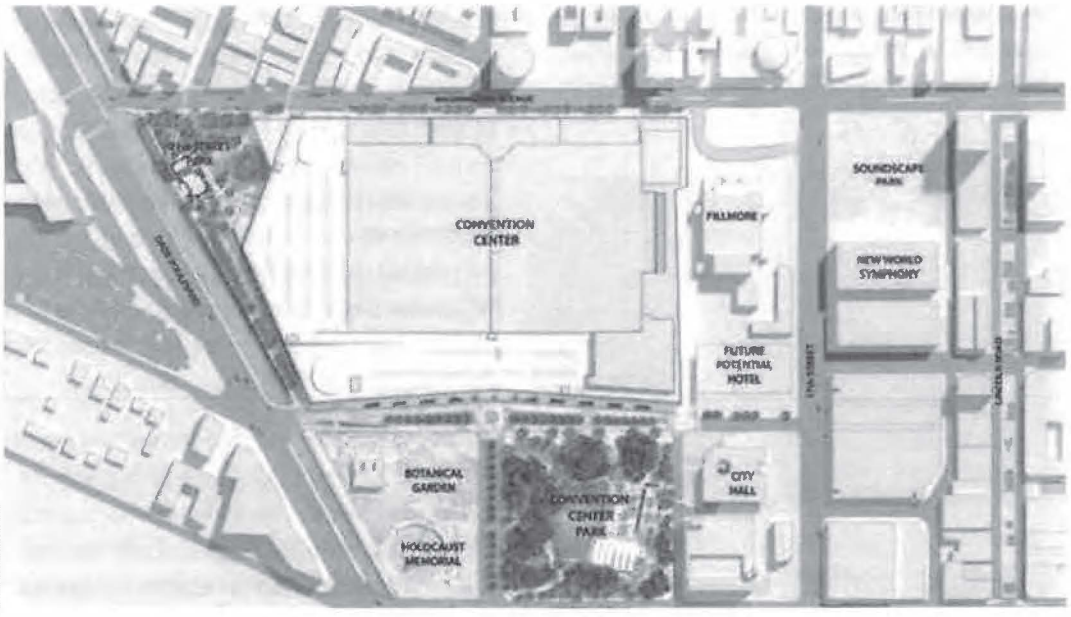
The Miami Beach Convention Center was a $620 million renovation on a 25-acre site in the heart of the city.

neighborhoods and drain the entire area reaching up to Lincoln Road, a popular tourist spot. In this area, roads were elevated to 6.1 feet NAVD, and the building was raised by four inches to meet current FEMA flood elevation requirements, although officials note the building could have been raised more if not for the city's requirement to remain open throughout the three-year construction period. In response to water contamination issues, the pump stations include measures such as vortex treatment systems for stormwater quality. The design for the area will increase the pervious area by 245 percent. Mangroves and mahogany trees will be installed along the Dade canal to create a living shoreline, and a new 3.5-acre open space will include bicycle paths, public art, and restoration of the oldest public building in Miami Beach, the historic Carl Fisher Clubhouse.

Renovation of the Convention Center was designed on a 30-year time frame for resilience, and all critical emergency systems and generators have been raised to the second floor of the building, 23 feet above sea level. Approached incrementally, the renovation of the Convention Center was designed to enhance residents' quality of life while sustaining and facilitating continued tourism investment.

Flamingo Park Historic District

Located in the heart of South Beach, the Flamingo Park Historic District embodies a variety of architectural styles and is greatly admired by preservationists. The western portion of the area sits at an extremely low elevation, and much of the area's prewar and early postwar construction make road elevation and adaptable use quite challenging. However, some progress has been made, and recently a raised street elevation was completed for 11th Street to the immediate east and west of Meridian Avenue, one of



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The Convention Center renovation incorporated two public parks, a living shoreline, and two of the city's largest pump stations.

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North Beach, as seen here in 2008, is considered a prime area for future development opportunities.

the district's main thoroughfares. The city also elevated the sidewalk and proposed that property owners raise their front yards to accommodate the elevation increase.

The city recognizes that many of its efforts within the Flamingo Park Historic District are innovative, but a climate adaptation plan is likely to require the raising of historic buildings, which is extremely costly and challenging to execute under current guidelines. Moreover, the placement of stormwater infrastructure in the area, such as pumps or generators, requires review by the historic preservation board. In addition to reformulating the historic preservation ordinance, city officials are considering new methods for maintaining this district, such as the installation of a mature tree canopy.

Tatum Waterway and the North Beach Master Plan

As one of the last remaining development frontiers in Miami Beach, North Beach is poised for a major redevelopment that incorporates many neighborhood improvements to promote walkability: updated mobility schemes, reimagined height and density designations, and wider sidewalks.

Within North Beach lies the Tatum Waterway, one of the city's poorest neighborhoods, that sits on one of the lowest base elevations in Miami Beach. During high-tide events, bay water overflow is severe. As a result, the city installed one of its first pump stations in this neighborhood, using an axial flow pump system instead of a submersible pump, while incorporating plants for beautification. Because seawall overflow is a significant issue here, the city must determine whether a mandatory assessment is needed to raise private seawalls throughout the area.

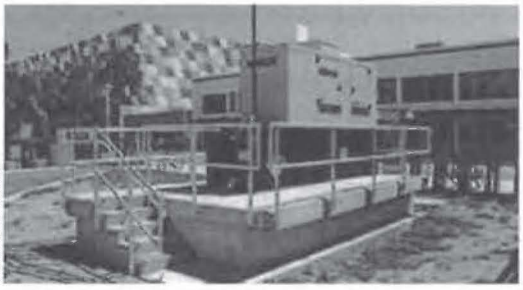
The following sections of the report discuss the panel's recommendations regarding individual elements of an integrated solution for future stormwater management and resilience work.

Infrastructure

MIAMI BEACH HAS MADE A COURAGEOUS START to combat sunny-day flooding and stormwater through its existing stormwater management program. The city should be commended for its timely action, investment in physical infrastructure, identification of self-funding sources for physical infrastructure to address flooding, decision to include sea-level rise and increased precipitation in planning, and close collaboration with the Southeast Florida Regional Climate Compact and the regional participants in the 100 Resilient Cities initiative.

However, Miami Beach is significantly at risk, so more infrastructural advancement and investment are necessary. The city is vulnerable to three distinct sources of flooding:

- Coastal flooding including king tides;
- Flooding caused by rainfall; and
- Flooding from groundwater.



KATHARINE BURGESSDALI

Miami Beach's investment in stormwater infrastructure can be seen throughout the city in its new, elevated pumps.

WIKIPEDIA

Sunny-day flooding is a common problem; here, Brickell Bay Drive, in nearby Miami, flooded during a normal high tide in 2016.

Current flood management practice is rightly focused on alleviating flooding as a whole and clearing the surface water as efficiently as possible. However, future holistic flood risk management should differentiate contributions from the three discrete sources, understand how each source influences the others, and strategize accordingly. Any strategy should include increased collaboration with the local community and education about the mechanics of flooding and how the city's infrastructure investments are addressing existing and future risk. In addition, all investments should seek to serve multiple purposes to achieve the highest possible benefit/cost ratios and maximize ownership and support from the citizens, companies, and organizations in the city.

To build a more holistic strategy and increase the city's preparedness for the increasingly severe impacts of climate change, the city should strive to incorporate the following recommendations:

- Improve the flexibility and robustness of the current system.
- Enable more informed decision making and risk management through enhanced modeling.
- Implement blue and green infrastructure to advance a more integrated and holistic approach to living with water.
- Ensure appropriate modeling, study, and funding availability for green and blue infrastructure projects.
- Implement living-with-water pilot projects.
- Create tools and highlight opportunities for living-with-water projects at the building level.
- Consider a level-of-service (LOS) concept to guide future decision making.

- Address water quality concerns.
- Improve communications about and education on engineering and infrastructural solutions.

More information about all of these recommendations follows, starting with recommendations related to the two primary elements of the city's current approach—floodwater pumps and elevated roads—and moving to new options informed by a robust optimization model.

Improve Flexibility and Robustness of Current System

The city's current plan for stormwater infrastructure, including pumps and elevated streets, is well tested and thoroughly designed but lacks flexibility—the system is not designed to adapt. This lack of flexibility is the Achilles's heel of the current system. Indeed, the system is costly to install, operate, and maintain and is—at this stage—not

Green and Blue Infrastructure

Green and blue infrastructure are approaches to water management that incorporate natural processes to manage and treat water. Rather than speeding water underground or away from a site or road, green and blue infrastructure slow water down and integrate it into natural systems, often conveying it and treating it through landscape amenities.

These terms can refer to a wide variety of different processes and approaches at the site or regional scales that can function in many different climates and habitats.

- *Green infrastructure* manages water through natural processes, slowing water to be absorbed and filtered through a combination of vegetation and soils. Approaches include living shorelines, mangrove plantings, rain gardens, bioswales, cisterns, and many other technologies that can be implemented independently or together in a "rain chain," funneling water from one source to another.

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A rain garden acts as a sponge, helping water permeate the ground naturally while also nurturing the landscaped plants.

DAVE PAPER / FLICKR

Planting of mangrove trees is a green infrastructure strategy that can provide protection from storm surge while enhancing the biodiversity of the ecosystem.

- *Blue infrastructure* works with the natural hydraulics of the aquifer and can refer to new canals, wetlands, and retention on urban plazas and other public facilities managing water during extreme rain events.

At the scale of a real estate project, green infrastructure may refer to design features that will capture and slow the release of water after routine and peak rain events. Green infrastructure may also refer to public works projects implementing landscape systems in parks, rights-of-way, and elsewhere to create a community-wide or citywide network for water conveyance.

Green and blue types of technologies have many benefits compared to traditional gray infrastructure such as pumps and pipes: the former are more affordable, offer opportunities for enhanced green space, can be implemented incrementally, and have public health benefits. Cited benefits of green and blue infrastructure have included improved water quality, reduced water use, flood risk mitigation, improved wildlife habitat, enhanced real estate value, enhanced recreational spaces, cost savings, and opportunities for green jobs.

completely guaranteed to function during all peak events because of reliance on a generator-backed power system. Not all pumps are backed by standby generators, and even these will not necessarily provide sufficient robustness. Nor does the system provide ample collateral benefits to the local community.

Furthermore, how long the system will continue to function well is unclear, taking into account development in climate change projections, maintenance of systems, and so on.

Going forward, the city should identify a broader range of strategies, including blue infrastructure, green infrastructure, and seawall improvements, together with its committed pumping systems and elevated streets, to both introduce more flexibility in managing water and offer more visible collateral benefits to the local community.

Trends in Hydraulic Design

The hydraulic design of drainage systems is linked with many uncertainties, especially considering the life span of the structures. These uncertainties should be addressed in a structured way split topic by topic. Opportunities to improve include integrating the following:

- Factors to accommodate for increase in extreme precipitation caused by climate change during the lifetime of the pipes: these factors should be derived using the most updated data and provide recommendations for a factor for design criteria and for stress test (this would often be a factor 1.2–1.4 for design criteria rainfalls and as much as 1.8 for the extreme rainfalls—corresponding to an expected increase in rain intensity of 20 to 80 percent, depending on return period);
- Factors to accommodate for building out and densification on private and public property 1.0–1.2, which is directly related to the ongoing trend to pave and build and to connect more impervious areas to the drainage system; and
- Factors to accommodate for general uncertainties in model and rain statistics 1.2–1.3 (uncertainties on dimensions, levels, state of repair).

First and foremost, the current stand-alone pump and pipe solutions are not particularly flexible to changes in boundary conditions, power outages, and exceeding of design criteria. Opportunities to improve include the following:

- Implement storage volume upstream to retain runoff and reduce peaks at pumping stations; for example, use storage in public parks, porous sub-base of roads, private cisterns, swales, and tree strips, many of which can be implemented with green and blue infrastructure.
- Improve design and increase capacity of gravitational overflows from pump stations by installing flap weirs designed to extreme events.
- Implement a monitoring system for tracking infiltration to pipe systems (and for calibration of hydraulic models).

The city should consider implementing electrical and infrastructure enhancements to mitigate extreme weather, to supplement a generator-backed pump system that presents issues with power backup supplies. The system also needs to be "safe to fail," allowing controlled flooding in the case of some extreme events.

Street elevation is another key component of the city's current strategy. Raised land has been a tested successful solution to alleviate tidal flooding in new development and, to a lesser extent, in retrofit solutions. Where street elevations are determined to be the best flood mitigation solution, the city could improve and further optimize this strategy to local areas with more information on geology and groundwater, which is explored further in an upcoming section on modeling. Opportunities to improve include the following:

- Revisit the criteria and time span for the solution (through community and risk modeling, explored in a subsequent section).
- Better understand the context with groundwater and the aquifer.
- Explore solutions related to porous geology.

KATHARINE BURGESS/ULI

Barceloneta, a restaurant in Sunset Harbour, is surrounded by elevated streets and now has patio seating at the original street elevation.

- Test the impacts on lower-lying property through detailed hydraulic models.
- Analyze alternative uses for low-lying property.
- Revisit options such as channeling road drainage to the pumped system.
- Consider the cost/benefit, including elevated streets and pumps, as well as the ongoing operations and maintenance costs for the pumps.
- Ensure best-in-class stormwater treatment before discharge to the bay.

Use Enhanced Modeling for Better-Informed Decision Making

The situation regarding flooding in Miami Beach is extremely complex, and quantifying the likely effects of events and suggested solutions, including pumps as well as green and blue infrastructure, is currently difficult. The city must take more actionable steps to ensure that its efforts are driven by hard data that is consistently being updated to reflect current conditions, including the complex interplay between the three different sources of flooding extant in the city. To address this, the city should create an integrated, hydrodynamic computer model that simulates the physics of flooding caused by the three sources:

- Coastal flooding, including king tides;
- Precipitation; and
- Groundwater.

This model would provide a physics-based tool to quantify the relative contribution of coastal flooding, precipitation, and groundwater to the flooding mechanics at all locations across the island. Changing climate conditions and other boundary conditions such as new infrastructure and buildings could be simulated with this tool, showing how flood risk evolves in the future, based on estimates of future conditions. Importantly, this risk relates not just to protection of physical property from damage but likely costs of damages and repairs.

Such a model would be state of the art, and the tool is not yet commonly used by cities. By adopting such a tool, Miami Beach would continue to be a leader in climate adaptation and offer a model for many other cities to rep-

Who Makes Hydrological Models?

Federal government: The most widely used models come from publicly available sources that are free to use. Federal agencies such as the U.S. Army Corps of Engineers have been making such software for decades. The software is divided by usage, with coastal areas using different programs. Governments and researchers use all of the publicly available programs often.

Researchers: Research institutes, universities, and even private researchers are the source of many models. The larger institutes have more widely used models; but universities and local researchers sometimes develop models for use within their region. These are often not publicly available, except from larger institutes, which usually require subscriptions or licenses.

Private sector: Private sector firms specializing in modelling software often offer the most developed models, including software that integrates different types of systems (tides, groundwater, etc.). The software requires paid licenses.

licate. However, the city will need to develop staff capacity to make the best and most efficient use of such a tool and will require external expertise to procure technology.

Any flood mitigation could be input into this tool, including pumps as well as green and blue infrastructure, the results simulated, and the benefits of this action would be clearly quantified. These quantified benefits could then be compared with the costs to implement and thus enable informed economic choices about the city's future. Importantly, this tool would allow the city to clearly quantify and communicate the outcomes of any chosen mitigation action.

In addition to the flood risk calculation tool, the city can calculate the value of the co-benefits and build the business case on a complete cost/benefit analysis. A clear cost/benefit analysis is an important tool for decision making, and this integrated water model is the best possible way to simulate current and future conditions, and directly quantify the benefits expected from any given mitigation action.

Digital Elevation Models

A digital elevation model (DEM) is a digital three-dimensional elevation model that shows the terrain's surface. These can sometimes be referred to as digital terrain models or digital surface models. Digital surface models, however, usually include the objects on the land, such as buildings or trees. They are most often created using satellites, radar, remote sensing, or other aerial techniques instead of by direct physical survey. A DEM is the foundation of most hydrological models for flooding and drainage, and accurate modeling depends on its quality.

The quality of a DEM is ultimately determined by the scale and type of survey technique. A model that is more detailed, and uses newer technology, will be considered more useful and accurate. However, such models are more expensive to survey, and the file sizes are more difficult to manage.

The city currently has a pipe-network model that allows it to simulate the hydraulic load in the drainage systems and on the pumps during heavy rainfalls. In addition, the city is logging water levels and groundwater tables in boreholes. These assumptions and others relevant to the feasibility of a model include the following:

- The city's pipe network is currently about 90 percent modeled and can be exported.
- Geology can be modeled as an equivalent porous medium, and an additional geophysical survey will take place at project level.
- Digital elevation is mapped in a detailed DEM (in grid cells about four feet by four feet).
- Logging of groundwater and water level in the bay is continuing.
- Five to eight rain gauges will be installed close to existing SCADA (Supervisory Control and Data Acquisition) points for calibration.
- Eight clamp-on meters or channel-flow meters will be rented and installed for a six- to eight-month period.

As a next step, the city should couple the pipe-network model with a digital elevation and groundwater model to make more informed decisions regarding flood risks. This digital model would function as a comprehensive simulation incorporating physics related to groundwater and stormwater levels, which would allow the city to quantify and compare risk when making decisions related to resilience. An integrated model of digital elevation of this nature would require a geophysical survey of parts of the island, but its implementation is relatively cost-effective, fairly easy to execute, and can be carried out and implemented in the model over time, for example, when detailed information is required in relation to detailed design on project level.

Established computer programs could independently model these scenarios. To begin work implementing a model, the city would likely require both the purchase of modeling software (which would represent both a fixed upfront cost and an ongoing license and maintenance fee) and a separate engagement of consulting expertise to build, calibrate, and verify the model.

Engagement of a third party to provide quality control review of the model is also recommended. The city might consider engaging a consultant to serve as an owner's representative during the procurement process for identifying both the model and the associated consulting services. This engagement would be similar to the common practice of hiring someone in this role to oversee large construction projects on behalf of a government owner.

This owner's representative should have technical knowledge of complex, integrated hydraulic modeling and provide the city with the expertise to parse and compare the proposed products and consultants' proposals. This owner's representative may possibly be able to provide the third-party quality review but is not required to have this capacity.

Over the medium to long term, the city should consider adding a member of staff, such as a "flood risk model manager" position, to monitor the city's use of the tool. The flood risk model manager would track use of the model, ensure that the information is up to date, and become the city's in-house "guru" on the tool. Many members of staff should be literate and comfortable with the tool and be able to input scenarios for modeling and subsequent decision making.

The end goal is a model that accurately represents the interplay among the coastal, precipitation, and groundwater flooding sources, as well as the ground elevations, pipe networks, pump facilities, and land use throughout the entire city. It will be an accurate digital model of the city, which can be used to simulate any flood mitigation proposal under consideration.

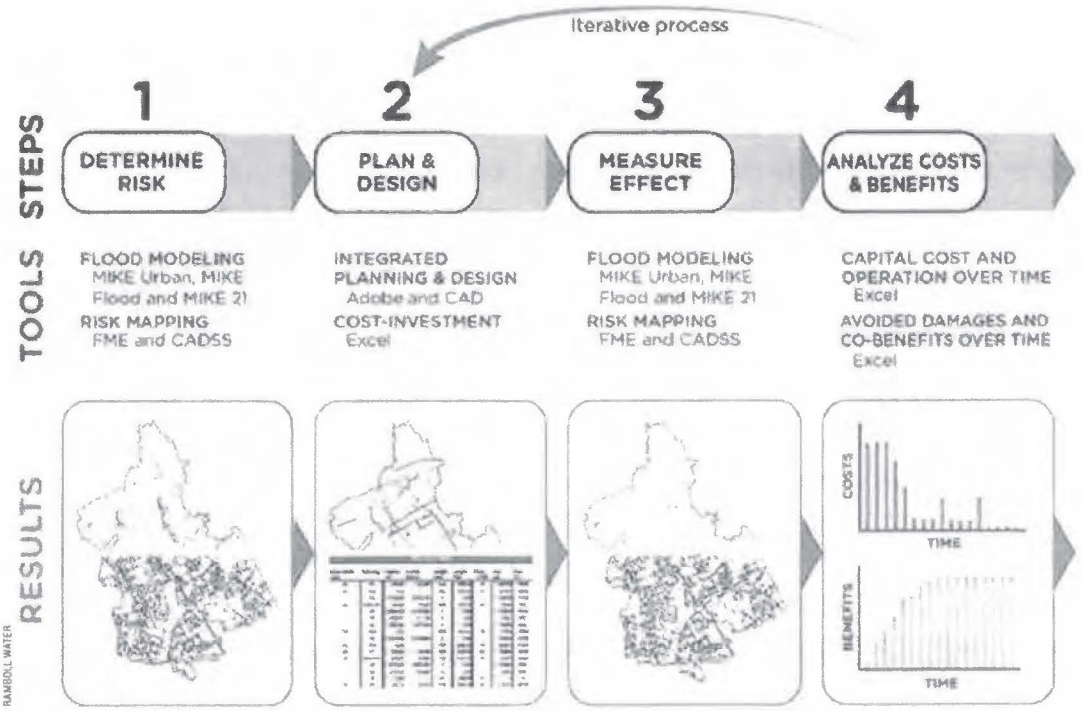
After procuring and implementing this digital model, the city of Miami Beach could then make informed decisions (risk/benefit-based management) regarding flood protection strategies. A more comprehensive model would do the following:

- Calculate risk for various impacts, such as different types of storm conditions or volumes of rainfall or levels of king tides;
- Enable the city to be more informed before investing in specific civil works actions, such as raising a seawall, implementing more pumps, or building more blue/green infrastructure;
- Help formulate optimal socioeconomic protection levels and define collateral benefits;
- Work in "safe-to-fail" limits to infrastructure, allowing for effects of extreme events;
- Create safer guidelines for densification, climate change, system data, and rain statistics; and
- Allow flexibility for climate change, system data, and rain statistics.

As an example, if the city could create large-scale retention in park areas, thereby reducing the flood risk further downstream, the model would be able to predict the benefit/cost ratio of such an investment, including the following elements:

- Capital and operational expenditures;
- Reduced damages;
- Reduced investments in underground infrastructure; and
- Co-benefits in terms of health effects, increased property value, and so on.

Another scenario would be to model reduced saltwater flooding. Under a given management scenario, it would be possible to eliminate sunny-day flooding caused by upwelling of groundwater during high tides. But what would the



RAMBOLL WATER

The modeling process requires a layered approach in terms of both programs and iterative steps.

optimum mix of street elevation and pump capacity be now and in the future? With this tool and updated climate scenarios, the city could accurately simulate all three sources of flooding in the city, answering these vital questions.

Building and using the model is likely to take a year or so. The city's ongoing use and upkeep of the model would include keeping the model calibrated by monitoring flow rates and levels in pump stations and selected manholes.


CITY OF MIAMI BEACH

Planting mangroves is a natural way to protect the shoreline.

Implement Blue and Green Infrastructure

With the knowledge of an enhanced hydraulic model, the city can better explore a more diverse array of options for flood mitigation from all three flooding sources. Green and blue infrastructure will be key options to explore and integrate into the current strategy, particularly given the opportunities for co-benefits.

Broadening Miami Beach's strategy beyond pumps and street elevation to integrate green and blue infrastructure and other innovations in resilience could lead Miami Beach to become a worldwide model of living with water. With this approach, resilient infrastructure should not only clear water away during tidal flooding and peak rain events but also identify opportunities to improve quality of life through vibrant public spaces, water features, and water recycling. Blue and green infrastructure should be key components of this strategy and offer many opportunities for co-benefits related to public space, aesthetics, water quality, and recreation.

The city should consider the following strategies:

- Living shorelines;
- Mangrove plantings;
- Rain gardens and bioswales;
- Porous pavement;
- Cisterns;
- Tree strips and cells;
- Multifunctional use of parks and plazas; and
- Changes in land use to allow more of the preceding options.

A more integrated living-with-water approach will not only include the incorporation of more types of flood mitigation infrastructure, but will also require more structured collaboration and potential cofunding of infrastructural investments across city departments. Strategies to introduce this type of interagency planning could include the following:

- Ensure fluency with the outputs of the hydraulic model and the opportunities for better understanding the impact of different flood mitigation mechanisms and

Living with Water: New Technologies, Attitudes, and Design Aesthetics

Miami Beach has the opportunity to be a world leader in the concept of living with water. This theme could be a core component of the stormwater management and resilience strategies, as well as the city's economic development, tourism, and placemaking strategies. The approach entails not only the use of different technologies to manage water, but also different attitudes about convenience, mobility, health, and aesthetics. Notably, living with water would entail embracing green and blue infrastructure that can manage water using natural systems.

The visual effects of blue and green infrastructure are very different from pumps or pipes that send influxes of water out of sight and out of mind. Adopting a living-with-water approach would therefore require that Miami Beach residents, businesses, and stakeholders change some of their comfort levels about ponding, minor flooding, and visibility of water in the public realm. Notably, water is likely to be more visible after storm events and take longer to subside. Aesthetics are also different: instead of monotone manicured lawns, a green infrastructure palette typically includes more wild-looking native plants that can, although will not necessarily always, look unkempt when they are at peak ecological function. These plantings can be part of beautifully textured compositions that would contribute to Miami Beach's sense of place, but they would not necessarily chime with aesthetic norms of mowed lawns and English-style gardens.

If implemented successfully, living with water could be more than an infrastructural approach and become part of Miami Beach's tourism and economic development branding. For instance, tourists could come to Miami ready to ride amphibious vehicles or tour newly implemented natural coastlines and mangroves; small businesses interested in climate adaptation would relocate here to find peers and clustered work environments for climate technology and green infrastructure. However, to ensure that the city maintains this resilience leadership, prioritizing the minimization of greenhouse gas emissions from fossil fuels in the stormwater and flood resilience solutions implemented will also be key to maintaining a reputation as a climate leader.

A bioswale helps filter the runoff at ECO Modern Flats in Fayetteville, Arkansas.

infrastructural cost/benefit analysis across different agencies.

- Prepare two or three integrated/interagency master plans per district, developed through charrettes with communities and agencies.
- Integrate stormwater master plans at the highest level of city planning to ensure harvesting of budget synergies with other investment plans and projects and the least possible nuisance for the citizens.
- Build the clear business case based on the cost of doing nothing, the traditional solution, and the living-with-water approach, generating co-benefits that in many cases exceed the reduced damages and other tangible outcomes.
- Invest in high-quality pilot projects to generate enthusiasm and ownership of the living-with-water concept.
- Examine the land use ordinance to plan for future flood mitigation needs and potential changes to built environments.

Ensure Appropriate Resources for Green and Blue Infrastructure

The city is currently advancing some blue and green infrastructure projects that align with the living-with-water vision, including living shorelines and green infrastructure in park design. However, the funding sources are independent of those currently being used for the stormwater management program, and some are grant based or otherwise not as reliable as those in use for the stormwater program. These green infrastructure investments are also not necessarily being modeled and considered in conjunction with the stormwater management program underway. A more holistic approach should not only offer funding for innovative green and blue infrastructure strategies but also ensure that their contributions are effectively measured and studied in the context of overall flood mitigation efforts.

Implement Living-with-Water Pilot Projects

Miami Beach should create iconic pilot projects that involve the community to determine the best future approaches for resilience and to test and explore the living-with-water concepts. These pilot projects should represent exciting opportunities to both enhance resilience and introduce co-benefits related to green infrastructure, public space, and quality of life. Pilot projects are excellent opportunities for community engagement and for broadening public understanding of the goals of the stormwater management program.

Communities in Miami Beach that experienced the first phases of stormwater investment were complimentary about how the program has improved sunny-day flooding and eliminated the many related inconveniences they once experienced on a regular basis. However, these same citizens showed clear concern about how the pump program had been implemented, citing concerns about reduced quality of public spaces or low-quality streetscapes—and even questionable public safety near pumps that block vision and views. These responses represent a clear missed opportunity: communities that experienced early phases of investment are the best candidates to become ambassadors for the program and to inspire and excite neighborhoods that will receive investment later. Launching pilot projects that represent innovative approaches and respond to community interests will better serve the city and help generate community buy-in for the program.

Iconic pilot projects could include the following:

- Green and blue infrastructure designed into iconic public parks, or even pocket parks;
- Raised streets, including coordination with other desired infrastructure investments, such as bike lines or bike-share stations;
- Centralized stormwater retention;
- Retention on private property (e.g., the development of a "climate neighborhood");

Ecological Design for Bishan Park, Singapore

One of the largest parks in central Singapore has undergone an ecological renovation. Originally constructed in 1988, the 62-acre park was built around a portion of the Kallang River, which had been channeled through a constructed canal. The canal, however, was at maximum 75 feet wide, making for limited drainage, and its concrete construction created a physical division within the park. Because water is a critical resource for the island of Singapore, the large park was seen as an opportunity for collection. In 2009, Ramboll Water partnered with the Public Utilities Board (PUB) and the National Parks Board to restructure the park, hoping to make it more dynamic and ultimately more efficient for stormwater. The project became a case for PUB's Active, Beautiful, Clean Waters program, which seeks to transform existing areas into ones that serve both form and function—beauty, recreation, and stormwater collection.[6]

The project centered on restructuring the Kallang River, taking it out of its concrete casing and making it a more natural river system. It took nearly a dozen experimental trials to come to a decision about the right bio-engineering standards both to create the system and to prevent soil erosion.[7] Hydraulic models also helped the teams plan. The new river follows a floodplain concept and allows for widening up to 330 feet into the park, permitting 40 percent more conveyance capacity. It also connects to the city's greater drainage system.[8]

The park was planned to provide multiple benefits. Landscaping was carefully considered to maintain and encourage rich biodiversity, and bridges and stepping stones help integrate recreation and learning. In addition, new playgrounds seek to engage families, including the water playground, an active, partially inundated play area that won the Singapore Design Award.[9] Outdoors, the park encourages active learning, providing materials for self-guided trails. Many local schools visit it for this purpose and have even created their own trails throughout. To create a truly varied recreational experience, users can also book particular areas or visit a number of on-site businesses and restaurants. Importantly, much of the park was built with accessibility in mind, including the playground areas.[10]

Implementing the new river system actually cost Singapore 15 percent less than constructing the concrete canal, showing that sometimes a slew of benefits can actually come at lower cost.[11] And today, more than 3 million people visit the area annually.[12] Bishan Park is an exceptional example of how an area can fulfill PUB's Active, Beautiful, Clean Waters program, integrating design elements with critical function.

RAMBOLL WATER

The cleansing biotope helps filter the water before it is returned to the drainage system in the park.

RAMBOLL WATER

The Kallang River was removed from its concrete encasing and now can widen up to 330 feet in flood conditions, increasing conveyance by 40 percent.

- Retention in the sub-base of streets;
- Cleansing biotopes, which are assemblages of plants in a filter medium, for example wetland cells, that can cleanse water, absorb nutrients, and provide filtration;
- Private landowner adoption of indoor and outdoor adaptation strategies; and
- City action on private seawalls and other barriers.

Create Tools for Building-Level Living-with-Water Projects

Building owners are an important part of the solution to living with water and have a responsibility to design their projects for flood waters. They should be encouraged to follow the city's leadership by implementing flood water management strategies on and in their properties. The city can also provide them with further resources and toolkits on climate adaptation segmented for different property types; this possibility is explored in more detail in the "Communications" section of this report.

Consider Level of Service in Future Decision Making

The city of Miami Beach requested the panel's thoughts about the current phasing and sequencing of the storm-water management work. To date, the strategies for pumping and roadway elevations have largely been based on the amount of surface water that is expressed and the roadways relevant to a specific design elevation. Moving forward, the city might consider instead pivoting to a level-of-service model that considers flooding disruption in terms of likely flood frequency, depth, and duration.

To decide on the socioeconomic optimum level for flood management, different options should be calculated in terms of the following:

- Reduced damages;
- Capital expenses;
- Operating expenses;
- Savings on other capital expenses such as upgrades of sewers and wastewater treatment plants; and
- Co-benefits.

The optimum LOS concept would consider how flooding disruptions inconvenience the community at a district scale. This approach then integrates community preference on level of mitigation into the decision-making process, working across agencies and integrating public engagement into the process.

This LOS strategy may mean conducting direct cost analysis, or cost/benefit analysis, to compare and find the optimum net present value of a plan. For example, if local stakeholders are interested in protection beyond the 100-year storm, this strategy could factor in the likely costs and determine whether there is appetite to fund the intervention.

Address Water Quality Concerns

Water quality frequently presents an issue within storm-water infrastructure, and the city has thus far done a very good job at implementing solutions to uphold the area's water quality. However, the city should take this work to the next level, including state-of-the-art systems such as green infrastructure and cleansing biotopes.

Pumped systems including a traditional grid, sand trap, and vortex have a tendency to underperform and fail during extreme events. Moreover, the citizens and stakeholders of Miami Beach are clearly concerned about water quality and the potential water quality implications of the pump system.

Going forward, the city should implement state-of-the-art treatment systems through green infrastructure that will absorb pollutants while increasing flexibility. Upstream green infrastructure should be a key aspect of the living-with-water plan but also include outlets with cleansing biotopes for treatment and polishing of water quality by filtering, sorption, and sedimentation.

Level-of-Service Approach to Flood Protection

Climate projections are showing a strong trend toward more extreme weather. Most scientists and experts generally agree on the magnitude of the sea-level rise, whereas the extreme rainfalls are harder to predict, especially because of their often very local character—both statistically and in short-term forecasts. The threats are imminent, but in many cases the traditional planning approach is insufficient or not fit for the purpose.

Thus, many cities are moving toward a flood protection planning approach based on a cost/benefit analysis, which combines the calculated risk of doing nothing with the benefits and costs related to adapting. The cost/benefit analysis also allows monetization of the co-benefits from investing in green infrastructure. The concept can be framed as the level-of-service (LOS) approach. The LOS approach refers to the planning method, in which cities clearly define the maximum level or frequency of floods acceptable during a given time period. It has the potential to reduce damages and nuisance, environmental, and health-related issues.

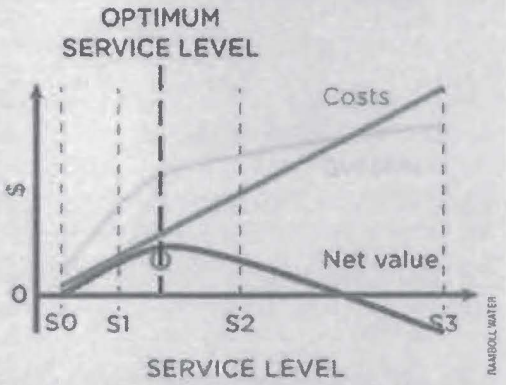
In Copenhagen, for instance, the city guarantees that no flooding will occur during a ten-year storm, while four inches of flooding is allowed during a 100-year storm. (Both measures factor in the expected impact of climate change.) The city provides flood control on public right-of-way and drainage from private property up to a ten-year storm. Beyond this, or if the private landowner wants a higher level of protection than four inches, it is up to the individual landowner. Furthermore, the city guarantees that the plans will improve—or have no negative impact on—the quality of the receiving waters.

This level of service is based on socioeconomic calculations of the capital investments, operation, and maintenance of a suggested plan over time, compared to the benefits of reduced damages and downtime of businesses, improved connectivity, and co-benefits from green solutions.

The LOS concept has some clear advantages when compared to traditional planning and design approaches:

- Strong business case to support investments in flood protection;
- Clear definition of responsibility between the city and its citizens and companies; and
- LOS based on actual flood events regardless of the reason—rainfall, storm surge, groundwater, or malfunction of system.

In order to calculate and implement the optimum level of service for the city of Miami Beach, an integrated and dynamic hydraulic model including runoff from rainfall, groundwater and infiltration, sea level, and overland flow needs to be built. This should be combined with a spatial model of assets, land use, and socioeconomic information to calculate the risks and benefits. To ensure the best business case, all relevant strategies and visions for the city should be incorporated into the adaptation design and subsequent business case.



The approach requires finding the optimal service level of flood protection where benefits and costs are maximized.

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Pollutants from upstream can contaminate the water around Miami Beach.

CITY OF MIAMI BEACH

The city removes pollutants from its waterways three times a week.

Beyond implementing further infrastructural investments to protect water quality, the city should prioritize transparently communicating the outcomes to local constituencies. For example, the city currently has 80 sampling locations: making the data publicly available would be one opportunity that could facilitate innovation with the potential interest and involvement of local activists and citizen scientists.

Improve Communications about Engineering and Infrastructural Solutions

How are local stakeholders currently connecting and digesting the best information available? Flood vulnerability in Miami Beach is a complex issue, and evolving weather patterns and available data mean that new information is often available, changing the context behind decision making.

Local stakeholders clearly articulated that the outreach process that led to the current stormwater management system was not sufficient. Stakeholders particularly noted the minimal opportunities for community input and a tone that did not welcome input. The outreach process also did not provide enough time or interagency coordination opportunities to streamline the stormwater management investments with other desired infrastructural upgrades.

More information on the overall communication strategy for the future resilience and stormwater management strategies is available later in this report. On the infrastructure and engineering side, the panel recommends the following:

- Consider adding a "climate science translator" role to city staff to map best state of science into basis of design criteria, inform all city design decisions, and help communicate vulnerabilities, risk, and mitigation opportunities to the public, including what will happen in a do-nothing scenario.
- Continually monitor different areas for changing conditions and strategize about how to communicate new information to residents and businesses as new information becomes available.
- Ensure that communications are clear regarding the anticipated time frame for implemented infrastructure and the overall cost/benefit analysis and rationale behind implementing different types of technology and infrastructure.

Were Miami Beach to not stay on the vanguard of infrastructure planning and implementation related to stormwater management and climate adaptation, the prospects for a continued high quality of life are unlikely. Thus, continuing to evolve and mature the city's infrastructure strategy is imperative.

Physical Design and Typology

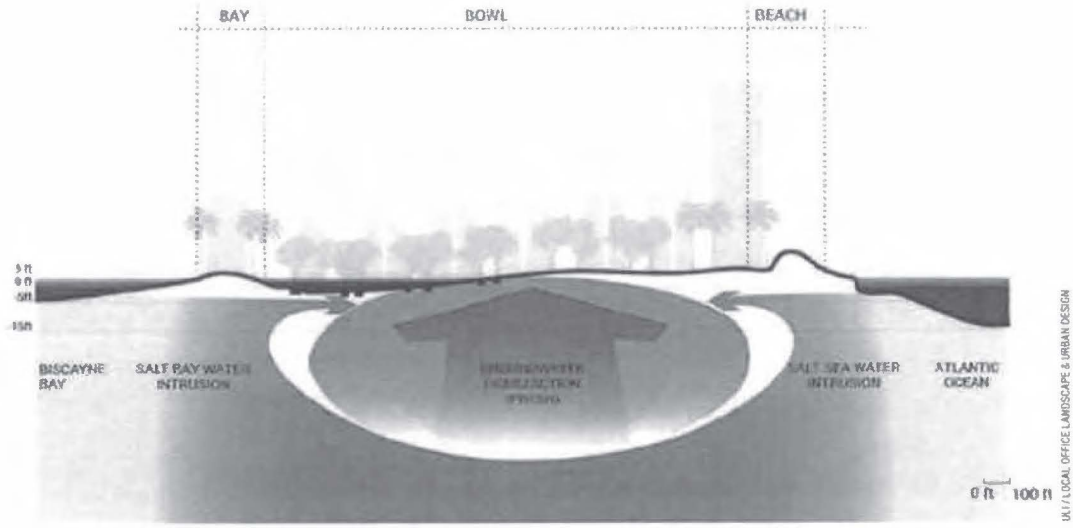
MIAMI BEACH'S PHYSICAL TYPOLOGY presents a unique opportunity to craft a more innovative and cost-effective solution than the present stormwater management system. This more holistic strategy could better respond to natural topography and land and water conditions, incorporating green infrastructure, parks, open spaces, and opportunities for the incorporation of renewable energy that will increase preparedness for peak events and power failure.

The following recommendations, as well as ideas and examples of how to achieve this goal, are discussed in more detail below:

- Select design and infrastructure interventions that respond to the city's beach/bowl/bay typology.
- Look to golf courses as underused green spaces for water management.
- Consider modifying road specifications for permeability.
- Pursue opportunities with solar and renewables.
- Consider long-term options for neighborhood design and green space.

Select Interventions Responding to the City's Beach/Bowl/Bay Typology

The island of Miami Beach follows a beach/bowl/bay typology. The beach dunes are at a higher elevation than the center of the city, which is its lowest base elevation area. However, design analyses completed during the panel noted that the bay side of the island is also slightly elevated, which creates a bowl in the center of the island that is currently a major challenge for the city. Moreover, an analysis of the water levels within this bowl reveals a freshwater bubble, mostly rainwater, that is interfacing with rising tides. This fact explains why flooding is especially prevalent within this area: the freshwater runoff from leaky pipes is creating optimal conditions for flooding.



An illustration of the beach/bowl/bay typology that results in a freshwater "bowl" in the center of the island.