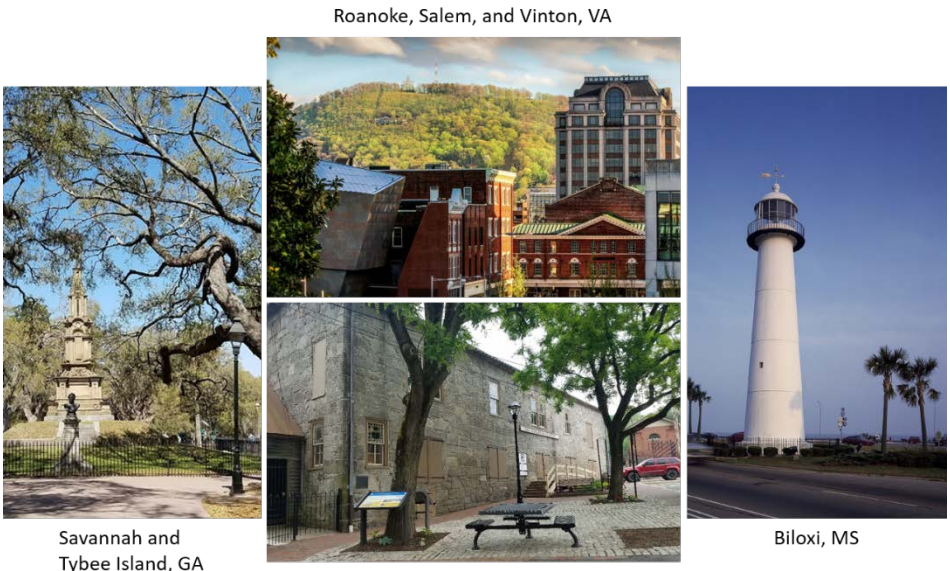
Mitigation Actions and Opportunities to Address Community Flood Risk

Summary Report

December 10-11, 2019



ResilientAmerica Program
The National Academies of Sciences, Engineering, and Medicine

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INTRODUCTION

The Resilient America Program (RAP) of The National Academies of Sciences, Engineering, and Medicine visited select communities in the southeastern region of United States that recently experienced flood-related disasters to learn about mitigation efforts at the local level. Specifically, this project investigated the range of mitigation actions and investments taking place in communities, the challenges communities face mitigating floods, and what communities need that will enable them to make investments in mitigation.

The RAP facilitated discussions (July-September 2019) with diverse stakeholders in four communities—Biloxi, MS; Ellicott City, MD; Roanoke and Vinton, VA; and Savannah and Tybee Island, GA—about their flood mitigation efforts, successes, and challenges.

Specific project goals were to better understand:

- the risks and impacts of floods on communities,
- actions communities are taking to mitigate future floods,
- flood mitigation success stories, best practices, and lessons learned in communities,
- challenges communities continue to face related to flood mitigation,
- what communities need in order to enable them to make informed decisions about flood mitigation, and
- how communities are funding their flood mitigation activities.

The RAP convened a two-day flood mitigation event in Atlanta, GA (December 10-11, 2019), which brought together stakeholders from the four communities that participated in Resilient America's community dialogues on flood mitigation, experts and community practitioners, and representatives from local, state, and federal agencies to engage in an interactive discussion focused on solutions and actions for mitigating and building resilience to flood risk. The objectives of this event were to: (1) share information learned during the community meetings and provide opportunities for peer-to-peer learning among community stakeholders; (2) explore ways communities are addressing some of their flood mitigation challenges; and (3) learn about federal and state resources available to communities for mitigation. This report provides a summary of the event.

All images that appear in this report are from presenter PowerPoint presentations.

URBAN FLOODING: HOW FLOODING HAS EVOLVED AND IS IMPACTING COMMUNITIES

Dr. Lauren Alexander Augustine, Executive Director, Gulf Research Program, National Academies of Sciences, Engineering, and Medicine
Dr. Gerald E. Galloway, Glenn L. Martin Institute Professor of Engineering, University of Maryland

Dr. Lauren Alexander Augustine discussed some of the findings of the National Academies of Sciences, Engineering, and Medicine's recent report *Framing the Challenge of Urban Flooding in the United States*.[1] There are four dimensions of urban flooding:

1. The physical dimension represents the built and natural environments.
2. The social dimension represents the people, where they live, who in the community is impacted, what those impacts look like, etc.
3. The information dimension looks at a variety of issues such as what data are needed to understand the flood risk, how to communicate risk, how people interpret information about risk, etc.
4. The actions and decisions dimension considers what needs to be done about urban flooding, how decisions are made, how flooding is managed, etc.

A lot of flood risk markers are starting to converge. More and more people are moving to flood-prone areas like the coast, weather patterns are changing, and infrastructure is aging. Infrastructure is an especially daunting problem, but there is no political will or funding to fix aging infrastructure. Planning to address urban flooding is challenging especially since the data needed to understand it are lacking.

Dr. Gerald Galloway co-authored a recently published report *The Growing Threat of Urban Flooding: A National Challenge*[2] that considered several questions including: What is urban flooding? Where is it occurring? What are the consequences of urban flooding? What do we need to do about it?

This report was based on a national survey of municipal flood and stormwater managers and professionals, and found:

- 83% of respondents experienced urban flooding in their communities.
- 65% of respondents indicated that most of the damages from these floods were not covered by the National Flood Insurance Program (NFIP) because the community was located well outside the areas of the FEMA floodplains and located in areas that were not considered at risk for floods.
- 41% of respondents indicated that their communities do not have funding to address their urban flooding problem.

[1] National Academies of Sciences, Engineering, and Medicine. 2019. *Framing the Challenge of Urban Flooding in the United States*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25381.
[2] Galloway, G. and Brody, S. 2018. *The Growing Threat of Urban Flooding: A National Challenge*. University of Maryland, College Park and Texas A&M University, Galveston Campus. Accessed February 3, 2020. https://cdr.umd.edu/sites/cdr.umd.edu/files/urban-flooding-report-online.pdf.

- 32% of respondents stated that there is a lack of political will to address the urban flooding problem.
- Respondents believed only 34% of elected officials and 28% of the public were concerned about urban flooding in their communities.

Some of the report's conclusions include:

- Urban flooding is a local government issue, but it is everyone's problem. How do we put communities in a better position to be able to deal with urban flooding?
- The division of responsibility for urban flooding is fragmented. There is too much stove-piping within government and between agencies and organizations. There is no coordinated approach for dealing with urban flooding.
- Infrastructure is aging and inadequate, and it is getting worse.
- There is no federal agency charged with coordinating the federal support of urban flooding.
- The economic and social impacts of urban flooding are immense. The lowest income groups are being hit hardest.
- Government is not communicating the urban flooding risk very well, but the data needed to understand the risk are lacking.

One problem that exacerbates urban flooding is a lack of affordable housing. There is not enough, if any, affordable housing outside of high-risk areas for a good portion of the population. The people least able to deal with and recover from flooding are living in the areas most at risk for flooding.

Q&A

Who is responsible for solving the urban flooding problem?

Dr. Galloway reiterated that within the federal government, there is no single agency in charge of urban flooding. The Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineers (USACE), and U.S. Department of Housing and Urban Development (HUD) each have a role, for example. What do we need to do to get all these agencies together to share information and work together on this issue? How do we establish a linkage between communities that are dealing with the problem and the federal government that has the money to address the problem? During the Obama Administration, there was concern about what to do about climate change. Governors, tribal leaders, and mayors were brought together to develop recommendations on what the Administration should do.[3] [4] This kind of initiative is needed to bring the importance of the urban flooding problem to the attention of decision makers. Community stakeholders need to come together and tell their mayors and governors

[3] The White House. November 2014. *President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience: Recommendations to the President*. Accessed February 3, 2020. https://obamawhitehouse.archives.gov/sites/default/files/docs/task_force_report_0.pdf.

[4] "State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience." *The White House*. Accessed February 1, 2020. https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/resilience/taskforce.

how difficult the urban flooding problem is and request that these decision makers address this problem in their annual budgets.

What is the status of political involvement and engagement on the urban flooding problem?

Based on the communities she has visited, Dr. Augustine stated that there is political will in many communities to deal with urban flooding. Dr. Galloway asked, "Political will for whom?" In many communities, the wealthier neighborhoods are repaired and fixed, but lower-income neighborhoods continue to be neglected. Inequity is a factor when it comes to political will.

There is often a lot of political will to move vulnerable populations out of flood-prone areas. But these vulnerable populations may not want to relocate or cannot afford to relocate. How do we solve this issue?

Dr. Augustine stated that people are attached to where they live and where they are from. The need to displace large groups of people is becoming more and more a reality. Figuring out this displacement issue is a big challenge and needs to be addressed. Dr. Galloway added that HUD has a role and needs to step in and be a partner. And communities need to start making better decisions about where they build.

Communities are already funding projects (e.g., repairing stream infrastructure, cleaning debris from storm drains) that help manage flooding for lesser storms (e.g., 10- or 25-year storms) which can help create more resilient watersheds and slowly build resilience toward bigger storms. Are there communities across the country that are working on strategies to manage lesser storms to create more resilient watersheds?

Dr. Augustine stated that a lot of coastal communities are doing this, especially those that experience frequent nuisance flooding. Maricopa County, AZ is an example of a community that is starting to approach flooding this way. In Snohomish County, WA, the County Commissioner once said, "Don't bring me a $2 million solution when I only have a $250,000 budget." This highlights the importance of management. Communities need to effectively manage their budgets to start chipping away at the problem.

Dr. Galloway concluded that true resilience is knowing what your risk is and recognizing that even if you do not currently have resources to mitigate that risk, you can make sure you know what you can do to prepare for it.

Other Resources

- *Urban Flood Hazards: Challenges and Opportunities*. Discussion Paper (draft)[5]

[5] Association of State Floodplain Managers, Inc. 2019. "Urban Flood Hazards: Challenges and Opportunities." Discussion Paper (draft). Accessed January 31, 2020. https://www.floods.org/ace-images/UrbanFloodHazardAreasDiscussionPaperDRAFT6_19_2019.pdf.

PANEL 1 – ADDRESSING MITIGATION CHALLENGES: LIVING WITH FLOOD RISK

Moderated by Arrietta Chakos, Principal, Policy Advisor, Urban Resilience Strategies

CITY OF CHARLESTON SEA LEVEL RISE STRATEGY

Mr. Mark Wilbert, Chief Resilience Officer, City of Charleston

Charleston is a world-renowned destination known for its friendly locals, beautiful coastal setting, thriving culinary scene, rich architecture, and unique history. The city has about 150,000 people in a region of one million people. The region is growing rapidly, with a lot of newcomers moving into the region.

Many cities along the coast are dealing with three interrelated challenges: affordable housing, transportation, and flooding. In Charleston, these three challenges are colliding, but the city's number one challenge is flooding.

Founded 350 years ago, Charleston is situated on a peninsula along the coast and is built on top of centuries of fill. Some of the city's major critical infrastructure and its four major hospitals are built on top of this fill and are located in areas that flood frequently.

The city is focused on finding solutions that address the threats posed by rising seas, increased coastal flooding, and extreme weather events. Some efforts include major infrastructure drainage projects, including check valves,[6] and the restoration of 19th century underground tunnels to manage stormwater (see Figure 1).

Figure 1. 19th century underground tunnels that manage stormwater in Charleston.

[6] More information about Charleston's Check Valve Program is available at: "Check Valve Program," Charleston SC, Accessed February 3, 2020, https://www.charleston-sc.gov/1995/Check-Valve-Program.

Charleston has numerous flood initiatives underway. The city is focusing significant efforts toward improving the drainage system.[7] It received a Bloomberg Philanthropies grant to work on flood adaptation measures.[8] TIDE eye[9] is a web and mobile-friendly tool for keeping an eye on local Charleston weather and tides, as well as their impact on traffic and road closures. And Sea Level Rise Viewer[10] is an interactive map that helps users better visualize the lasting impacts of rising tides. Since 1980, the number of high tides that reached or exceeded 7 feet has been increasing:

- 1980s – 9.3 events/year
- 1990s – 18.8 events/year
- 2000s – 21.4 events/year
- 2010s – 41.0 events/year

In 2019, the city experienced over 80 of these high tide events (the previous highest number in a year was 52 events). Sea level rise is causing regular, high tide, "sunny day" flooding to become more common in the city.

One challenge Charleston is facing is how to keep its critical infrastructure operational in the face of frequent flooding. Living with water requires Charleston to make difficult choices and thoughtful planning decisions, and take bold action. For example, 20 historic homes have been elevated—this would never have been considered just a few years ago—with over 100 additional historic homes on the list to be raised.

Charleston is providing opportunities for community members to help the city become resilient.[11] Though local government is committed to addressing flood mitigation and adaptation, the city is trying to get greater community buy-in. Local residents are becoming more educated about flooding and how they can better adapt to the increasing frequency of flood events. Addressing the city's flood challenges is going to take the entire community.

The City of Charleston's *Flooding and Sea Level Rise Strategy*[12] is focused on flood mitigation and adaptation, and is informed by the latest science-based findings and data from National Oceanic and Atmospheric Administration (NOAA). The strategy targets long-term solutions through five critical components (see Figure 2). Land use is one of the biggest challenges of the future for cities.

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[7] "Stormwater Management." *Charleston, SC.* Accessed January 31, 2020. https://www.charleston-sc.gov/2144/Stormwater-Management.
[8] "Tailored Alerts on Tidal Flooding." *Bloomberg Philanthropies*. Accessed January 31, 2020. https://mayorschallenge.bloomberg.org/ideas/charleston/.
[9] "TIDEeye." *Charleston IT/GIS Division*. Accessed January 31, 2020. https://gis.charleston-sc.gov/tideeye/.
[10] "Charleston Sea Level Rise Viewer." Accessed January 31, 2020. https://gis.charleston-sc.gov/interactive/slr/.
[11] "You Can Help!" *Charleston SC*. Accessed January 31, 2020. https://www.charleston-sc.gov/1978/You-Can-Help.
[12] Charleston, South Carolina. 2019. *Flooding and Sea Level Rise Strategy*. Second Edition. Accessed January 31, 2020. https://www.charleston-sc.gov/DocumentCenter/View/20299/Flooding-and-Sea-Level-Rise-Strategy-2019-web-viewing?bidId.

Figure 2. The five critical components of the Charleston Flooding and Sea Level Rise Strategy.[13]

Charleston recently completed several planning projects. It participated in the Dutch Dialogues™[14] process in 2018 and 2019; [15] the final report *Dutch Dialogues™ Charleston*[16] was recently published. This study brought together water experts and Charleston stakeholders to conceptualize a way for the city to live with water. The study focused on four areas in the city (see Figure 3) and identified three main challenges:

1. Increasingly severe and frequent flooding from intense rainfall, rising sea levels, and storm surge.
2. Development pressure in low-lying, risky, and ecologically sensitive areas.
3. The historic character and identity of the region are threatened by water.

[13] Ibid., p. 3.
[14] "Dutch Dialogues," *Waggonner & Ball*, Accessed February 3, 2020, https://wbae.com/projects/dutch_dialogues.
[15] "Dutch Dialogues," *Charleston, SC*. Accessed January 31, 2020. https://www.charleston-sc.gov/1974/Dutch-Dialogues.
[16] Waggonner & Ball, The Water Institute of the Gulf, Kingdom of the Netherlands. *Dutch Dialogues™ Charleston.* Accessed January 31, 2020. https://www.dutchdialoguescharleston.org/.

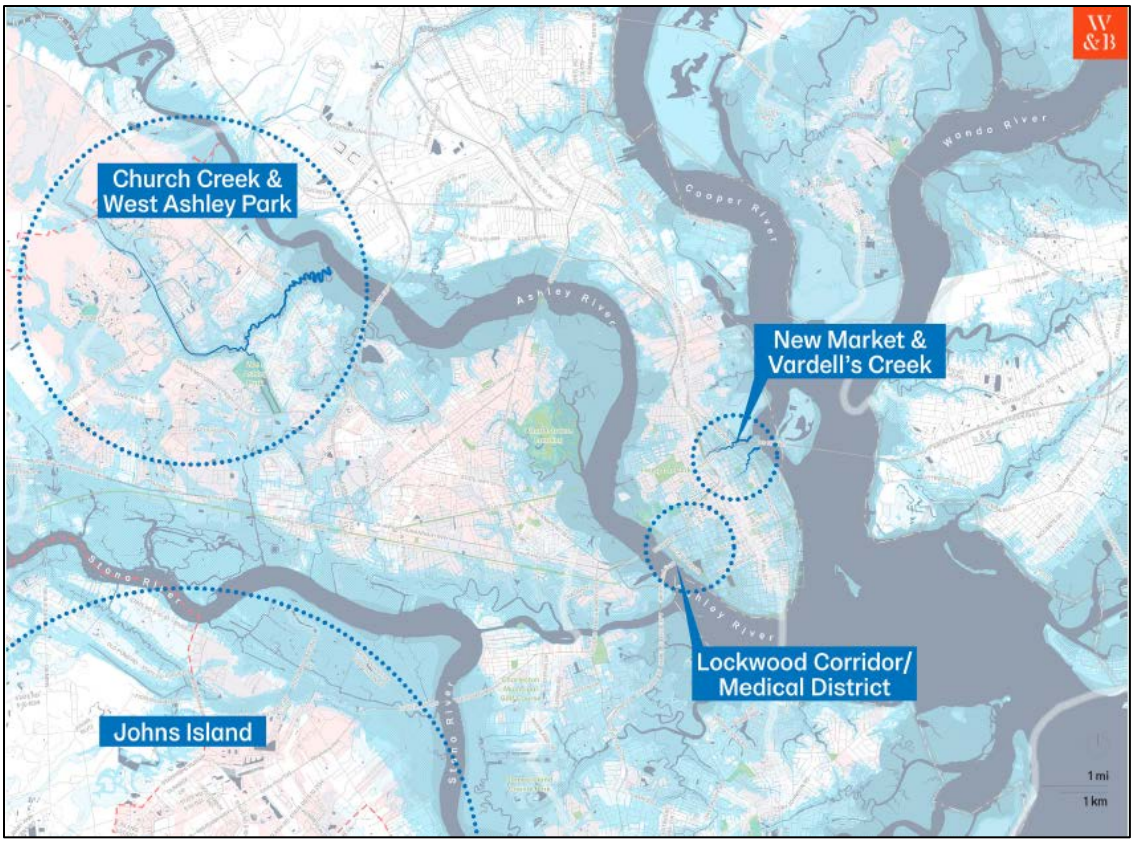

Figure 3. The Dutch Dialogues™ focused on four areas in the City of Charleston.[17]

Several recommendations came out of the Dutch Dialogues™ process including:

- Natural systems matter.
- Safety first and topography matters: multiple lines of defense, redundancy, risk assessments, sustainable inhabitation, multi-benefit infrastructure (green and grey).
- Preparedness—not reaction; humility—not hubris to reduce risks, impacts, and costs.
- Adapt development to water systems; avoid adapting water systems to development.
- Embrace uncertainty. Projects must be adaptable.
- Property at risk of flooding is a depreciating asset for the owner, the community, and the city.
- Costs come before benefits.

Since 1990, Charleston has spent $235 million on flood mitigation projects. The city is committed to keeping itself accountable to achieving the initiatives that are outlined in its sea level rise strategy. Department heads have been put in charge of each of the five critical components (i.e., infrastructure, governance, resources, land use, and outreach) and are responsible for reporting on their status along key performance indicators once a month to the mayor. Progress on each initiative can be tracked online.[18]

[17] Image source: Waggonner & Ball, The Water Institute of the Gulf, Kingdom of the Netherlands. *Dutch Dialogues™ Charleston,* p. 20. Accessed January 31, 2020. https://www.dutchdialoguescharleston.org/.
[18] "Champions of the Five Critical Components: Track Progress on Our Initiatives!" *City of Charleston*. Accessed January 31, 2020. http://bit.ly/TrackOurProgress.

Charleston's other recently completed projects include:

- All Hazards Vulnerability & Risk Assessment[19]
- Hazard Mitigation Plan[20]
- U.S. Army Corps of Engineers Charleston Peninsula Flood Risk Management Study[21]
- Stormwater Program Management Team and update of the city's 1984 Master Drainage and Floodplain Management Plan[22]
- Comprehensive Plan[23] update and zoning update

NORFOLK: RESILIENT COASTAL COMMUNITY OF THE FUTURE

Ms. Christine Morris, Resilience Consultant (former Chief Resilience Officer for the City of Norfolk)

> *"Resilience is the capacity of individuals, communities and systems to survive, adapt and grow in the face of stress and shocks and even transform when conditions require it."*
>
> - From 100 Resilient Cities

Creating a resilient Norfolk means reorienting the city toward becoming a coastal community of the future. The City of Norfolk was part of the Rockefeller 100 Resilient Cities (100RC) program.[24] [25] Each 100RC city developed a resilience strategy. Through an extensive community engagement process, the city identified three main resilience challenges:

1. Coastal resilience (the city faces increasing sea level rise and flood risks)
2. Economic resilience (the city has an overreliance on two industries)
3. Neighborhood resilience (there are concentrations of poverty across the city and communities are disconnected from one another)

[19] "All Hazards Vulnerability & Risk Assessment." *Charleston SC.* Accessed January 31, 2020. https://www.charleston-sc.gov/1975/All-Hazards-Vulnerability-Risk-Assessmen.
[20] "Hazard Mitigation Plan." *Charleston SC*. Accessed January 31, 2020. https://www.charleston-sc.gov/1976/Hazard-Mitigation-Plan.
[21] "Charleston Peninsula, South Carolina: A Coastal Flood Risk Management Study." *U.S. Army Corps of Engineers*. Accessed January 31, 2020. https://www.sac.usace.army.mil/Missions/Civil-Works/Supplemental-Funding/Charleston-Peninsula-Study/.
[22] "Storm Drainage Mapping," Charleston, SC, accessed February 3, 2020, https://www.charleston-sc.gov/1513/Storm-Drainage-Mapping
[23] "Comprehensive Plan." *Charleston SC*. Accessed January 31, 2020. https://www.charlestoncounty.org/departments/zoning-planning/comp-plan.php.
[24] "About Us," 100 Resilient Cities, Accessed February 3, 2020, http://www.100resilientcities.org/
[25] "Norfolk's Resilience Challenge." *100 Resilient Cities*. Accessed January 31, 2020. https://100resilientcities.org/cities/norfolk/.

From these challenges, Norfolk developed three major resilience goals that are highlighted in its resilience strategy:[26]

- Goal 1: Design the coastal community of the future
- Goal 2: Create economic opportunities by advancing efforts to grow existing and new industry sectors
- Goal 3: Advance initiatives to connect communities, deconcentrate poverty, and strengthen neighborhoods

To create its coastal community of the future, Norfolk engaged community stakeholders to develop *Vision 2100*,[27] a strategy to ensure Norfolk's success as a water-based community into the future. This strategy identified four areas of the city: economic engines, adaptation areas, new urban centers, and neighborhoods of the future (see Figure 4). Vision 2100 has been incorporated into the city's comprehensive plan[28] to guide land use decisions.

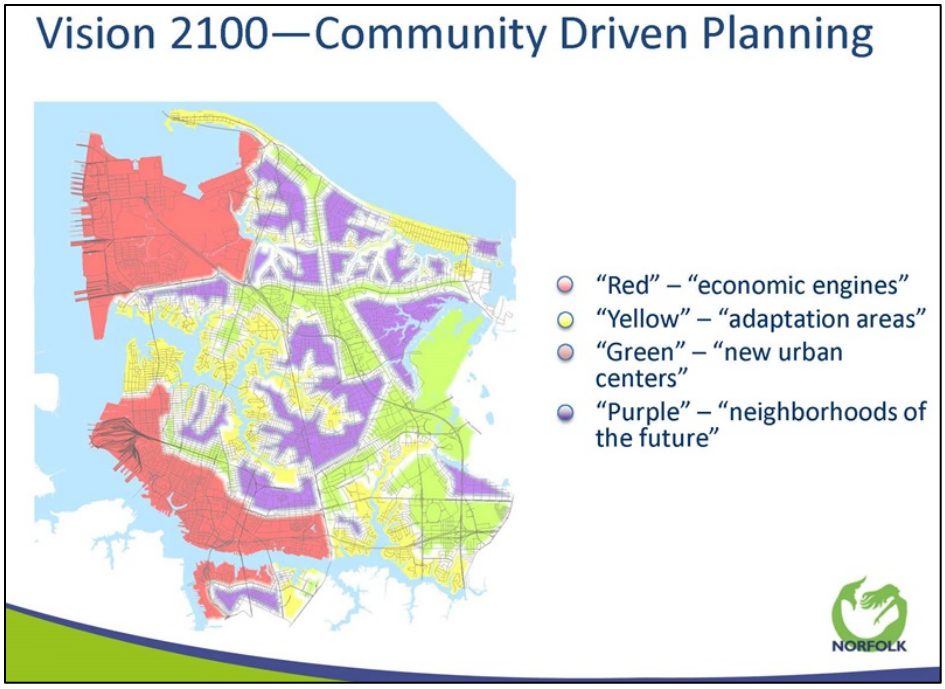

Figure 4. The four key areas of the City of Norfolk.

The city used these four areas to design a resilient zoning ordinance.[29] All development within the city has to meet a resilience quotient, which is measured on a point system.[30]

[26] "Office of Resilience: Norfolk Resilient City." *City of Norfolk*. Accessed January 31, 2020. https://www.norfolk.gov/3612/Office-of-Resilience.
[27] City of Norfolk. *Norfolk Vision 2100*. Accessed January 31, 2020. https://www.norfolk.gov/DocumentCenter/View/27768/Vision-2100---FINAL?bidId=.
[28] City of Norfolk. *plaNorfolk2030: The General Plan of the City of Norfolk*. Accessed January 31, 2020. https://www.norfolk.gov/DocumentCenter/View/2483/plaNorfolk2030?bidId=.
[29] "Norfolk's Zoning Ordinance." *The City of Norfolk*. Accessed January 31, 2020. https://www.norfolk.gov/3910/Zoning-Ordinance-Rewrite.
[30] City of Norfolk. *Norfolk's Zoning Ordinance Executive Summary*. Accessed January 31, 2020. https://www.norfolk.gov/DocumentCenter/View/36605/Zoning-Ordinance-Executive-Summary?bidId=.

In 2014, Norfolk participated in the Dutch Dialogues™ process.[31] The city learned that it has to be able to hold the water where it falls; the vision was to create spaces in the city to hold water. One way the city will achieve this is by daylighting its creeks.

In 2016, the Commonwealth of Virginia won a $121 million HUD National Disaster Resilience Competition grant;[32] $115 million is going to the Ohio Creek Watershed Project[33] in Norfolk (construction began in December 2019). This project will design a coastal community of the future. For example, every property in certain areas must have a rain barrel, every public space (including the streets and intersections) will be designed to hold water, and the wetlands will be cleaned up so they can hold more water.

In 2019, Norfolk received a $30 million HUD Choice Neighborhoods Initiative Implementation grant[34] to fund the city's St. Paul's Initiative.[35] [36] This project will redevelop a public housing area that has about 2,000 units. This area is located at the bottom of a watershed and floods heavily. It is also located across from downtown Norfolk but is completely cut off from the downtown by a six lane road. These neighborhoods will be reconnected to the city and redesigned to handle water (e.g., the creek will be daylighted). The project will also incorporate mixed income housing (one-third at market rate, one-third workforce housing, and one-third highly subsidized housing). Families in St. Paul's will receive assistance in job training, education, housing, and health and wellness. Families have been given housing choice vouchers (i.e., to stay or leave the neighborhood); 70% of people are opting to leave.

Norfolk and Virginia Beach partnered with the U.S. Navy on a joint land use study[37] that focused on sea level rise impacts. This study was recently completed and identified two priority areas impacted by sea level rise: the Chesapeake Bay side and an area around Hampton Roads that accesses the naval station from Norfolk. The city will work with the U.S. Navy to find funding for this project.

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[31] "Dutch Dialogues." *Hampton VA*. Accessed January 31, 2020. https://hampton.gov/3466/Dutch-Dialogues.
[32] "Virginia to receive more than $120.5 million from National Disaster Resilience Competition." 2016. *Mark R. Warner*. Accessed January 31, 2020. https://www.warner.senate.gov/public/index.cfm/pressreleases?ID=00E5BB28-7149-4D4F-9713-D3295A87D0B3.
[33] "Ohio Creek Watershed Project." *The City of Norfolk*. Accessed January 31, 2020. https://www.norfolk.gov/3867/Ohio-Creek-Watershed-Project.
[34] "Norfolk Awarded $30 Million Choice Neighborhoods Initiative Implementation Grant." *Norfolk Redevelopment Housing Authority*. May 13, 2019. http://www.nrha.us/newsandevents/pressreleases/norfolk-awarded-30-million-choice-neighborhoods-initiative-implementatio.
[35] "St. Paul's Initiative." *The City of Norfolk.* Accessed January 31, 2020. https://www.norfolk.gov/4379/St-Pauls-Initiative.
[36] "St Paul's Area Transformation." *The City of Norfolk.* Accessed January 31, 2020. https://www.stpaulsdistrict.org/.
[37] "Norfolk-VA Beach Joint Land Use Study." *Hampton Roads Planning District Commission.* Accessed January 31, 2020. https://www.hrpdcva.gov/departments/joint-land-use-studies/norfolk-va-beach-joint-land-use-study/.

Norfolk just completed a U.S. Army Corps of Engineers study.[38] Though the city wanted green infrastructure, these types of projects do not meet the benefit-cost ratio requirement. The recommended project includes pumps, floodwalls, tide gates, and a levee.

Norfolk's Retain Your Rain initiative provides homeowners with an app that calculates how much rainwater runoff is generated by their house's roof.[39] The city hosts several kinds of events to teach people how to manage flooding, for example, how to install rain gardens and rain barrels. The city also has an entrepreneurial ecosystem initiative that is focused on enticing companies that have innovations related to flood water retention and flood management to start businesses in the city.

FINANCING RESILIENCE

Moderated by Dr. Janice Barnes, Founder, Climate Adaptation Partners

Dr. Janice Barnes suggested looking at the problem of flooding differently. When cities put financing first, the overall approach to solving the problem changes. This is a new way of thinking about how to pay for flood mitigation. The types of questions asked are different: How does flooding interrupt city services or revenue? Where does the money come from? How does that impact my annual budget? Environmental impact bonds are one way to structure this approach.

INTRODUCTION TO ENVIRONMENTAL IMPACT BONDS

Mr. Benjamin Cohen, Director of Urban and Coastal Resilience, Quantified Ventures

Quantified Ventures[40] is an outcomes-based capital firm that drives transformational health, social, and environmental impact. Outcomes-based financing is repayment on a bond, loan, or other type of investment based on achievement of environmental, social, or economic outcomes. It can help make existing funding more efficient because funding is tied to performance and outcomes of projects. Outcomes-based financing can also tap into a broader set of beneficiaries (i.e., stakeholders) who have a vested interest in the project's outcomes.

Local governments find it challenging to fund all their priority projects, and need to find more and new sources to pay for these projects. At the same time, there is a growing base of ESG (environmental, social, and governance) investors who want to align their financial returns with environmental and social returns.

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[38] "Norfolk Coastal Storm Risk Management." *US Army Corps of Engineers*. March 21, 2018. Accessed January 31, 2020. https://www.nao.usace.army.mil/NCSRM/.

[39] "Retain Your Rain." *The City of Norfolk*. Accessed January 31, 2020. https://www.norfolk.gov/3700/Retain-Your-Rain.

[40] More information about Quantified Ventures is available at: "Home," Qualified Ventures, Accessed February 3, 2020, https://www.quantifiedventures.com/.

The local government municipal green bond market totaled $25 billion in the first half of 2019. This was almost twice what it was the first half of 2018. Thus, there is a growing base of impact capital that can be leveraged by structuring outcomes-based solutions.

Local government should think about its community's challenges from a systems-based, holistic view. For example, when considering projects to fund, local government should think about all the potential stakeholders who could be involved and how to best leverage existing sources of funding, plans, or initiatives. Identifying a range of stakeholders who could benefit from a project as well as other initiatives that could be linked to the project are examples of how environmental impact bonds (EIBs) are innovative and can support a more holistic approach to project financing.

EIBs are a type of outcomes-based investment. They are municipal bonds that are issued by local governments, but instead of having a set interest rate, part of the repayment is based on how successfully the project achieves a predefined environmental, social, or economic outcome (see Figure 5).

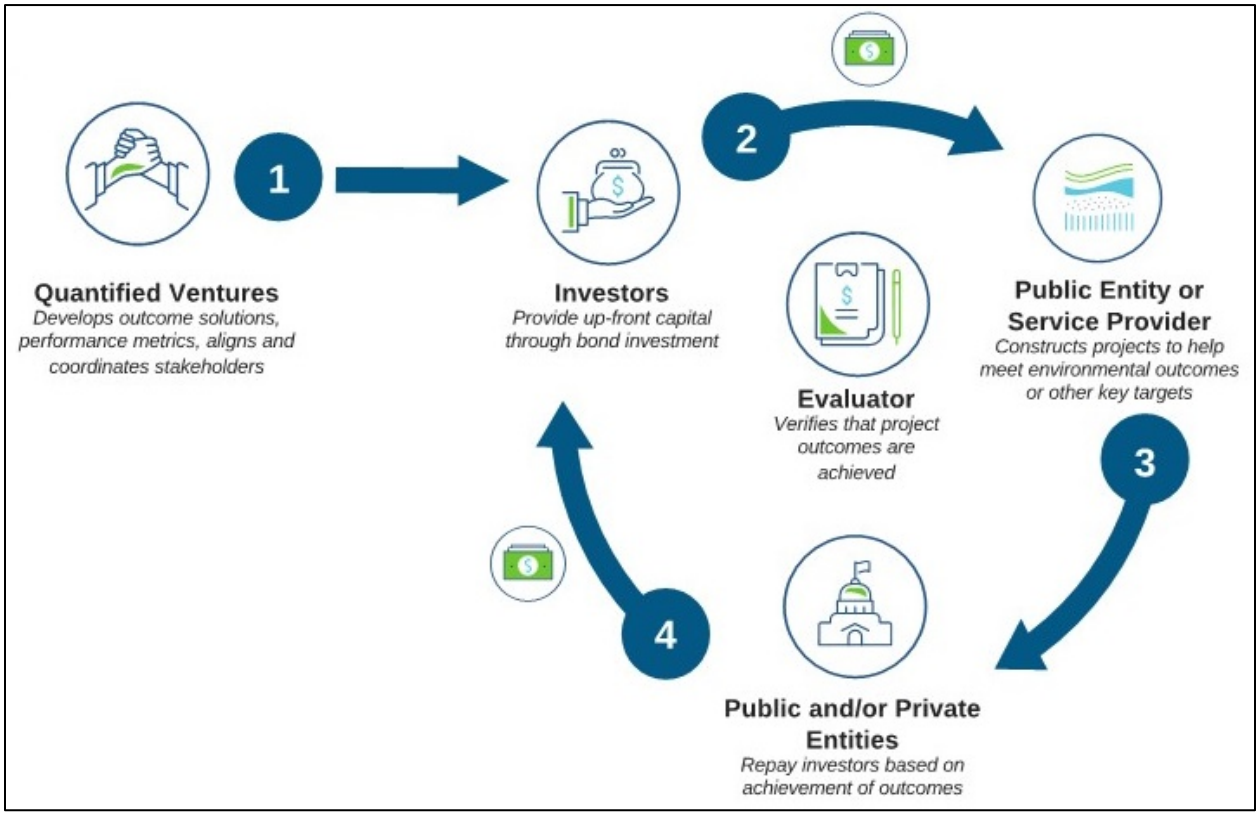

Figure 5. High level view of how Quantified Ventures' EIB works.

There are several benefits of outcomes-based financing such as EIBs (see Box 1). For example, it transfers performance risk of innovative projects to investors. If a project achieves a higher than expected performance, investors receive an additional payment; if a project does not perform as expected, the investors are essentially subsidizing the issuer (i.e., the local government), taking a risk, and innovating.

Box 1
Benefits of Outcomes-based Financing

- Transfer performance risk of innovative projects to investors
- Access new sources of investment capital
- Showcase partners and their projects, attracting internal and external support
- Engage diverse and new stakeholders benefitting from projects, potentially to contribute financing for them
- Measure and track outcomes through embedded performance evaluation
- Build an evidence base to inform future project planning

EIBs differ from green bonds in a few key ways. With green bonds, investments do not vary based on the outcomes, but with EIBs outcome performance is measured and can be tied to investment terms. In addition, green bonds focus on certification of environmental purposes under recognized standards whereas EIBs focus on measurement, reporting, and valuation of an actual environmental benefit produced. A lot of investors want more than investing in a project that was labeled as a green project; they want to see the actual impacts of their investments.

Mr. Cohen provided case studies of some of Quantified Ventures EIB projects including green stormwater infrastructure in Atlanta,[41] coastal wetland restoration in Louisiana,[42] recreation infrastructure (a bike trail) in Ohio,[43] and wildfire mitigation in Colorado.[44]

For example, in Atlanta, the EIB project financed six green infrastructure projects in underserved neighborhoods. These communities are located downstream from the city center and experience a lot of flooding and water quality challenges. The projects were designed to help the city manage stormwater, reduce local flooding, alleviate water quality impacts, increase community access to greenspace, minimize the impact of gentrification, and provide workforce development opportunities. Quantified Ventures worked with the Atlanta Department of Watershed Management to identify the different types of benefits that could come from these projects—to the local neighborhoods, to the Department of Watershed Management, and to city government—and assign economic value to those benefits; an economic analysis was undertaken on flood risk reduction and water quality.

Quantified Ventures has been advising the State of Louisiana Coastal Protection and Restoration Authority on how to use EIB financing to help fill capital gaps for projects in their Coastal Master Plan. The plan has about $15 billion worth of projects, most are wetlands or marsh restoration projects along the coast. But the state only has $9 billion to $12 billion of

[41] For more information about the Atlanta Green Stormwater Infrastructure Project, visit https://www.quantifiedventures.com/atlanta-eib.
[42] For more information about the Lafourche Parish Wetlands Environmental Impact Bond, visit https://www.quantifiedventures.com/wetlands-environmental-impact-bond.
[43] For more information about the Athens, OH Outdoor Recreation Environmental Impact Bond, visit https://www.quantifiedventures.com/outdoor-recreation-environmental-impact-bond.
[44] For more information about the Southwest Colorado Wildfire Mitigation Environmental Impact Fund, visit https://www.quantifiedventures.com/wildfire-mitigation-environmental-impact-fund.

publically available funding for these projects (mostly from Deepwater Horizon settlement funds). The EIB project is trying to tap into a broader set of beneficiaries to help pay for these projects (e.g., oil, shipping, and fishing industries), and identify ways these beneficiaries can help finance these projects based on project outcomes they would benefit from. Several of these large companies already have grant programs for coastal and wetland restoration, so part of the planning is to identify how to be more strategic with these funds and instead divert them to support bond financing.

EIB financing can also work in rural areas by leveraging payments from other beneficiaries of a project. For example, Quantified Ventures is working with stakeholders in Athens, OH to construct an 88-mile mountain biking trail in a national forest. This area is located in the Appalachian region in one of the poorest parts of Ohio where there is a lot of economic distress. The project is located on U.S. Forest Service (USFS) land, but the USFS cannot finance the project since existing funds are being diverted for wildfires. The project is designed to benefit the local community by helping this area become a destination for mountain bikers all over the country. An outcomes-based approach has enabled multiple stakeholders to come together to help support the financing of this project. The total project cost is about $11 million; $3.6 million will be supported through an EIB that is backed by the City of Athens and Athens County. The remaining funds will be leveraged from the USFS, smaller villages near the trailheads (e.g., they will forego their parking revenue to support payment of the bond), and the mountain biking industry. Project benefits include increased tourism, increased tax revenues, job development, and environmental restoration.

In southwest Colorado, Quantified Ventures is supporting a regional wildfire mitigation program around the San Juan National Forest through forest health treatments. Though the USFS conducts wildfire mitigation efforts in the San Juan National Forest, nonfederal lands adjacent to the park boundaries are not being treated and are at high risk for wildfires; thus, the entire region is still at risk. Because the region experienced a wildfire in 2018 and local communities suffered an economic impact, local stakeholders (e.g., city and county governments, electric and water utilities, local tribes) recognize the importance of this project. Rather than an EIB, this project will create an environmental impact fund (EIF). The EIF is issued to capitalize a fund that will disperse revolving loans to pay for forest health treatments. These loans will be repaid by local entities based on the risk reduction outcomes of the project. Thus, money will recycle back into the fund and provide an ongoing source of capital to fund these types of forest treatments into perpetuity and potentially expand to other areas of the region where needed. EIFs are a way to create self-sustaining funds.

PANEL 2 – USING SCIENCE AND DATA TO INFORM DECISION-MAKING

Moderated by Dr. Lauren Alexander Augustine, Executive Director, Gulf Research Program, National Academies of Sciences, Engineering, and Medicine

A VISION FOR A MORE RESILIENT IOWA: THE IOWA WATERSHED APPROACH

Dr. Larry Weber, Professor, Civil and Environmental Engineering and Edwin B. Green Chair in Hydraulics, University of Iowa

Formed in 2009, the purpose of the Iowa Flood Center[45] (IFC) is to give Iowans access to the latest technology and resources to help them prepare for floods and become more resilient. The IFC does this through a number of activities, including providing accurate, science-based information to help Iowans better understand flood risks; developing hydrologic models for physically-based frequency estimates and real-time flood forecasting; establishing community programs to improve flood monitoring; developing strategies to mitigate and prevent future flood damage; and developing Iowa's workforce in flood-related fields.

In addition to the 140 USGS sensors, the IFC has deployed over 250 stream sensors across the state that monitor river levels every 15 minutes. One hundred more sensors have been requested. The IFC also deployed 20 hydrologic stations that measure rainfall, soil moisture, and soil temperature.[46] Though the National Weather Service provides forecasting at about 100 locations throughout the state, the IFC runs its own streamflow forecast model—a real-time, spatially explicit, hydrologic model that describes Iowa as 600,000 hillslopes and stream segments. Thus, the IFC calculates streamflow at 600,000 locations with a 10-minute update based on Next Generation Weather Radar (NEXRAD)[47] rainfall estimates.

One way the IFC provides accurate, science-based information is through the Iowa Flood Information System[48] (IFIS) (see Figure 6). The IFIS is a web-platform to access community-based flood conditions, forecasts, visualizations, community inundation maps (see Figure 7), and flood-related information and applications. IFIS is open to the public and widely used by residents, business owners, emergency managers, and other state and federal agencies responsible for flood-related programs.

[45] More information about the Iowa Flood Center is available at https://iowafloodcenter.org/.
[46] Sara Steussy, May 22, 2013. "Iowa Flood Center Deploys Rain Gauges," Iowa Flood Center, Accessed February 12, 2020, https://iowafloodcenter.org/iowa-flood-center-deploys-rain-gauges/.
[47] More information about NEXRAD is available at: "NEXRAD Products," NOAA's NCEI, Accessed February 3, 2020, https://www.ncdc.noaa.gov/data-access/radar-data/nexrad-products.
[48] More information about the Iowa Flood Information System is available at http://ifis.iowafloodcenter.org/ifis/.

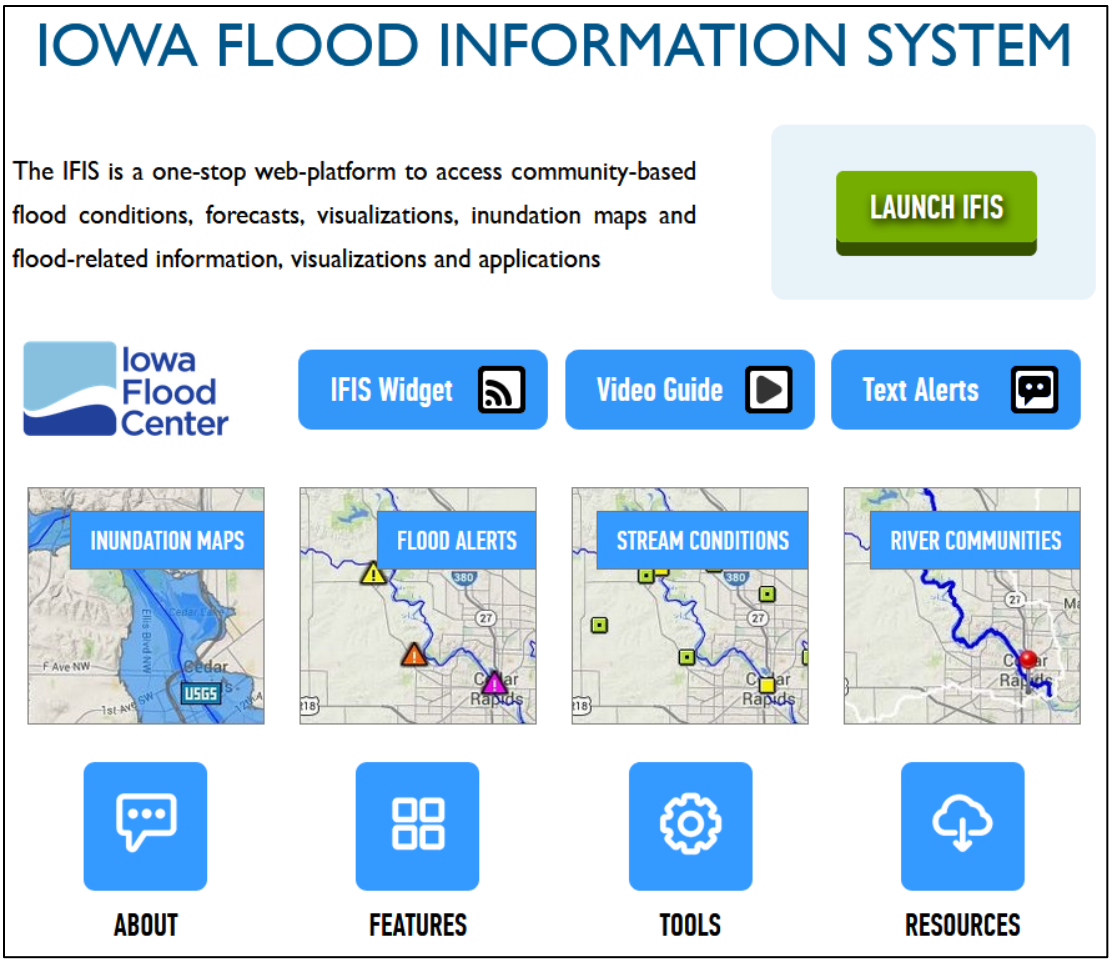

Figure 6. Homepage of the Iowa Flood Information System (http://ifis.iowafloodcenter.org/ifis/).

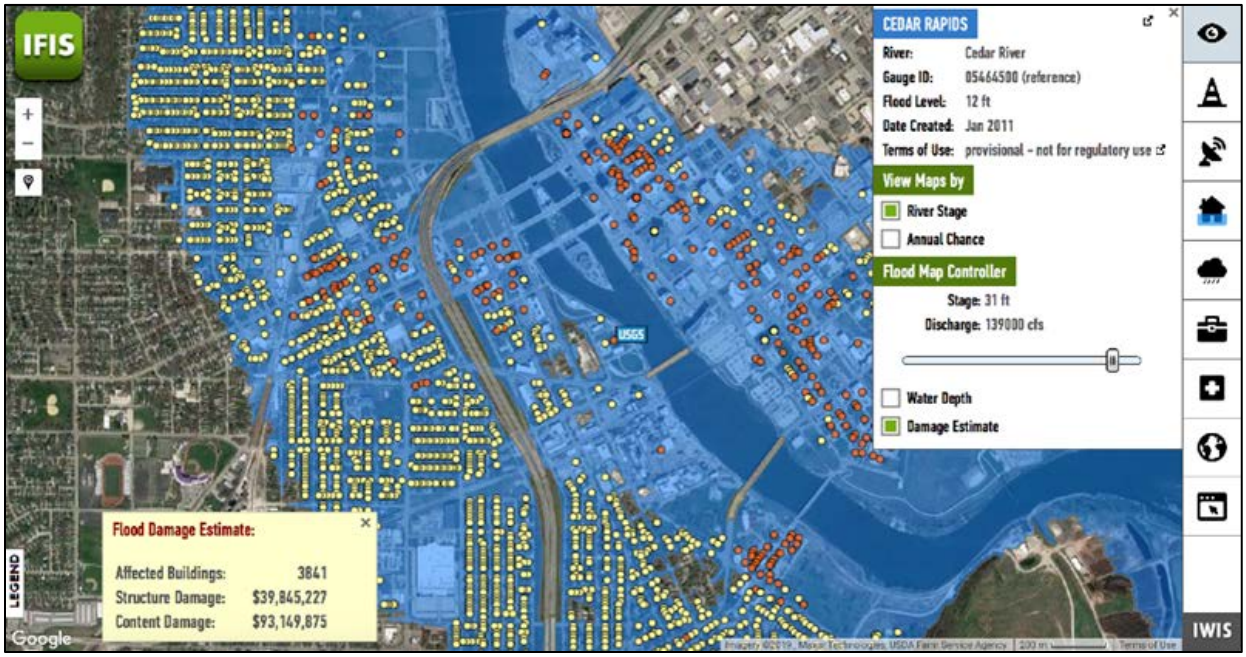

Figure 7. Example of a community flood scenario map for damage estimates.

Data from the IFIS was leveraged by the State of Iowa and the Iowa Economic Development Authority in their grant application for the National Disaster Resilience Competition (2016 – 2021), for which they were awarded over $96 million for the Iowa Watershed Approach[49] (IWA) program, of which $40 million will support the design and construction of urban flood mitigation projects and another $40 million will support the design and construction of conservation practices (e.g., wetlands, ponds, storm water detention, re-connected floodplains) on rural private lands for the benefit of communities downstream. The IWA has about 600 projects under design. The IWA program hosts its own information system, which joins water quantity and quality measurements to inform decisions on best management practices and community flood resilience.

Other Resources

- Iowa Water Quality Information System[50] (IWQIS)
- Iowa Nutrient Center[51]

VALIDATING OPERATIONAL FLOOD FORECAST HYDRO MODELS USING SENSORS AND CITIZEN SCIENCE

Dr. Jon Derek Loftis, Assistant Research Scientist, Lead, StormSense Project, Virginia Institute of Marine Science

Sponsored by the Virginia Institute of Marine Science (VIMS),[52] the StormSense[53] Project works to advance the field of emergency preparedness by providing forecast flooding from storm surge, rain, and tides to the public. In order to collect data for forecast flooding, over 40 water level sensors have been installed in Newport News, Norfolk, and Virginia Beach, VA, as well as the lower Chesapeake Bay. Each sensor transmits data on water conditions to the StormSense cloud via the Internet of Things (IoT),[54] instead of satellite uplink or mobile broadband. As a result, datasets are transmitted not only at a faster rate, but also at a lower cost. StormSense sensors cost approximately $3,000 in comparison to USGS sensors, which cost about $33,000.

To test their accuracy, some StormSense ultrasonic sensors (sound-based measurement) were co-located with USGS radar sensors (electromagnetic wave-based measurement). Over a period of twelve months, data collected by four separate StormSense sensors were compared with data collected from their corresponding USGS sensors. On average, the relative difference between the two different types of sensors (i.e., ultrasonic versus radar) was 1.18 cm.

[49] More information about the Iowa Watershed Approach is available at https://iowawatershedapproach.org/.
[50] More information about the Iowa Water Quality Information System is available at https://iwqis.iowawis.org/.
[51] More information about the Iowa Nutrient Center is available at https://www.cals.iastate.edu/inrc/.
[52] "Homepage," VIMS, Accessed February 3, 2020, https://www.vims.edu/
[53] More information about StormSense is available at https://www.vims.edu/people/loftis_jd/StormSense/index.php.
[54] The Internet of things (IoT) is "a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction." "Internet of things," Wikipedia 2020, last updates February 1, 2020, Accessed February 3, 2020, https://en.wikipedia.org/wiki/Internet_of_things.

Funding for sensors was made possible through a combination of grants and local capital improvement programs. Grant awards totaling $284,000 were used to purchase sensors; whereas, CIP budgets paid $337,500 to install and maintain them.

VIMS integrated StormSense's measurements into Tidewatch Charts [55](a 36-hour tidal forecasting system), which is translated into the Tidewatch Forecast Map.[56] Forecast efforts of the StormSense Project go beyond fluvial systems to take into account the multi-directional flow from tides and storm surge that compound the flooding impacts of rainfall. Instead of using hydrologic transport models, Tidewatch forecasts are driven by a hydro-dynamic model called SCHISM[57] (Semi-implicit Cross-scale Hydroscience Integrated System Model). Tidewatch Map covers all the coastal ocean along with the Gulf of Mexico since many of Virginia's substantial flood events and wind events have come from the Gulf. It incorporates atmospheric data, surge data, building elevations, sea level rise, and land subsidence. Tidewatch Map ingests 2.4 GB of atmospheric data (e.g., wind direction, wind magnitude, and relative air pressure fluctuations) at 3-km spatial resolution and 1-hour temporal resolution to predict storm surge-induced flooding through coastal Virginia up to 36 hours in advance. Each 36-hour run takes 1.25 hours using a high performance computing platform and an additional three hours to process the data for web display.

Tidewatch models were validated using citizen science. Using social media and the Sea-Level Rise app, citizens captured and shared photos of flooding conditions (i.e., geospatial data). Geospatial data were then input into a GIS database and converted into contours so that it could be compared to the Tidewatch models for vertical and horizontal accuracy. The forecasted models compared well with citizen science geospatial data (horizontal accuracy), as well as StormSense sensor data (vertical accuracy).

Citizens can subscribe to the StormSense Project to receive SMS, emails, and/or text alerts when water levels reach a pre-established, critical threshold. In this way, project data can help the public make more informed decisions related to flood preparedness.

Other Resources

- Embracing the Salt and Adapting to Sea Level Rise[58]
- Reporters, Scientists, and Citizens Team to Map Virginia's Highest Tide[59]

[55] More information about Tidewatch Charts is available at https://www.vims.edu/bayinfo/tidewatch/index.php.
[56] More information about the Tidewatch Forecast Map is available at http://cmap2.vims.edu/SCHISM/TidewatchViewer.html.
[57] More information about SCHISM is available at http://ccrm.vims.edu/schismweb/.
[58] "Embracing The Salt And Adapting To Sea Level Rise," *Science Friday*, May 17, 2019, Accessed February 12, 2020, https://www.sciencefriday.com/segments/embracing-the-salt-and-adapting-to-sea-level-rise/.
[59] Wright, D. December 13, 2017. "Reporters, Scientists, and Citizens Team to Map Virginia's Highest Tide." Esri. https://www.esri.com/about/newsroom/blog/mapping-virginias-highest-tide/.

- National Disaster Resilience Competition[60]
- King Tides: Using an app to measure rising sea levels[61]

OPEN-STORM

Dr. Brandon P. Wong, Postdoctoral Research Fellow, Department of Civil and Environmental Engineering, University of Michigan

The State of Michigan faces several water-related challenges from impaired water quality (e.g., polluted stormwater runoff, combined sewer overflows, and extreme riverbank erosion) to severe flooding. When Detroit flooded in 2014, it was the most expensive flood event that year, totaling over $1 billion in damages. Despite being one of the most intense rainfalls on record, the areas that were most impacted were located outside the 100-year floodplain.[62] Our understanding of localized flooding in urbanized areas stands to be improved by data. Today, the USGS maintains the largest monitoring network nationwide and serves as the gold standard for collecting consistent and reliable flood-related data. However, despite the network of over 8,000 USGS river and stream gages across the country, some communities and counties do not have enough gages to monitor water levels, especially in urbanized areas where river and stream gages may not always be nearby.

Started by Professor Branko Kerkez and the Real-Time Water Systems Lab[63] at the University of Michigan, Open-Storm[64] is an open-source platform for real-time monitoring and control of urban watersheds.[65] Open-Storm serves as a blueprint to measure and control urban water systems in real-time using a variety of sensors placed in community-identified, flood-prone areas in the Great Lakes region. For example, the Open-Storm platform combines online weather forecasts with wireless sensors to detect the rise and fall of water levels in stormwater basins and to automatically activate the valves of each basin to collectively optimize the storage and treatment capacities of the watershed as a whole (see Figure 8).

[60] "National Disaster Resilience," HUD Exchange, Accessed February 3, 2020, https://www.hudexchange.info/programs/cdbg-dr/resilient-recovery/

[61] "King Tides: Using an app to measure rising sea levels," *CBS This Morning*, January 4, 2020, Accessed February 12, 2020, https://www.youtube.com/watch?time_continue=5&v=CTZKK1jM2i8&feature=emb_logo.

[62] For more information about the 2014 Detroit flood, see: "Story to remember, 2014: August flooding in metro Detroit," *Crain's Detroit Business*, December 2014, Accessed February 3, 2020, https://www.crainsdetroit.com/article/20141222/NEWS/141229993/aftermath-of-august-flooding-10-billion-gallons-of-sewer-overflows.

[63] More information about the Real-Time Water Systems Lab is available at: "Home," Real-Time Water Systems Lab," Accessed January 29, 2020, http://www-personal.umich.edu/~bkerkez/.

[64] "About," Open-Storm, Accessed January 29, 2020, http://open-storm.org/.

[65] Matthew Bartos, Brandon Wong, and Branko Kerkez, 2018. "Open storm: a complete framework for sensing and control of urban watershed." *Environmental Science: Water Research & Technology*, 4(3):346-358. https://doi.org/10.1039/C7EW00374A.

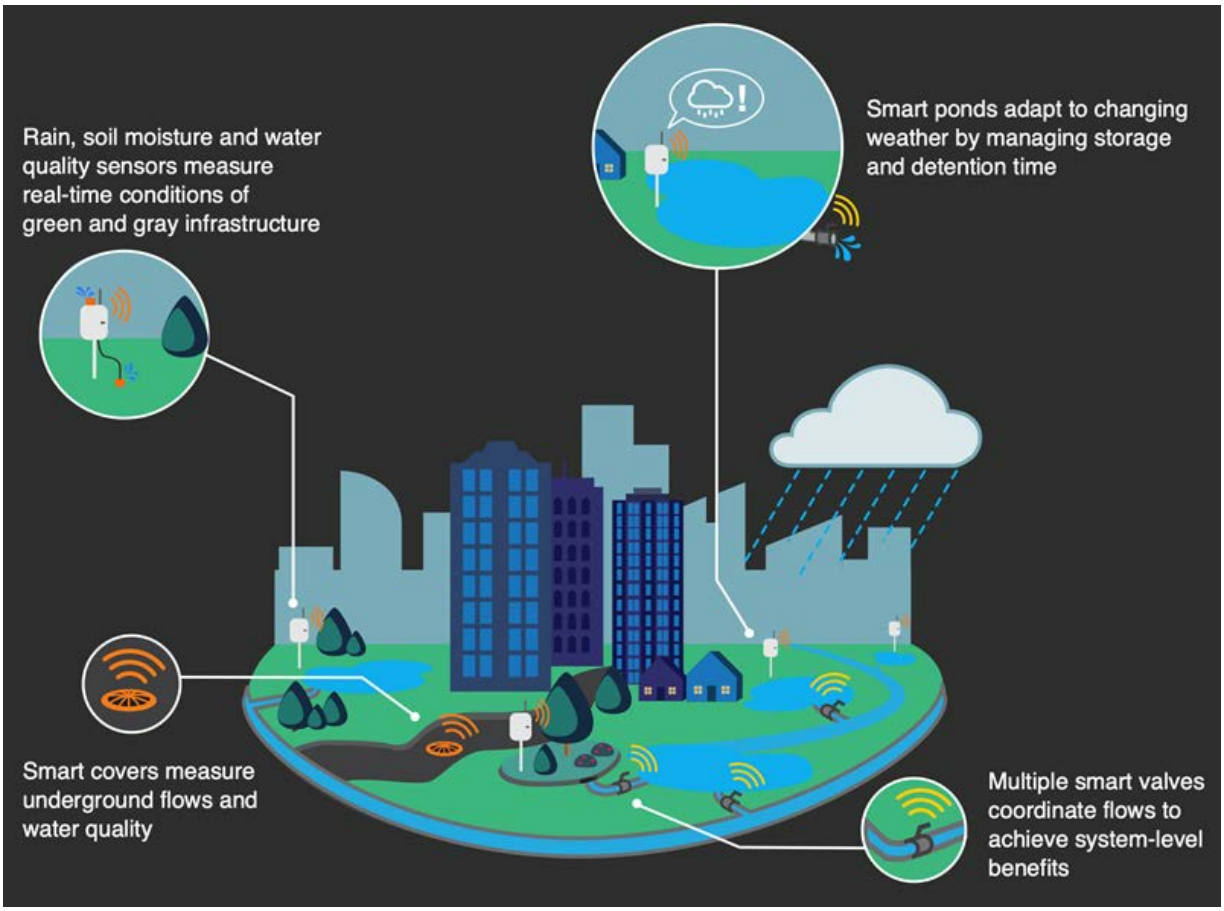

Figure 8. A graphic that depicts the variety of smart sensors and their uses in the Open-Storm project.

The technologies that underpin Open-Storm follow an "Internet of Things" approach. The same electronics found in today's smart phones are combined with solar panels, a variety of sensors, and weather forecasts to deliver data to the web instantaneously. Data streams can then be pushed to devices like smart phones in real-time, enabling on-the-ground decision making. For example, automatic flood alerts can help emergency responders coordinate where to go during flood events and determine what resources are required (see Figure 9).

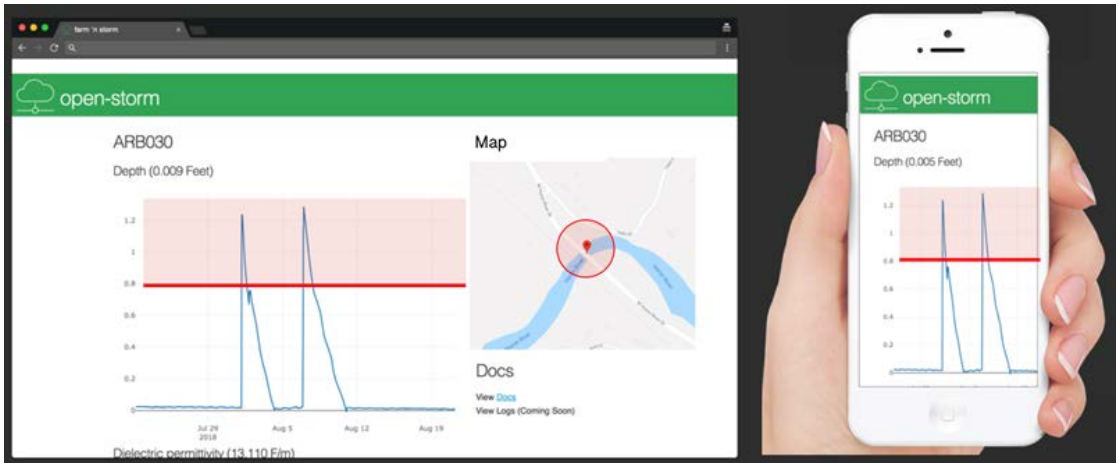

Figure 9. Automatic flood alert data displayed on a smart phone.

Last summer, the Real-Time Water Systems Lab received funding from the state to pursue instrumenting over an additional 750 square miles. Leveraging the lessons learned and the technologies developed through Open-Storm, a small team of students and county engineers installed fifty sensors at critical locations that were identified by community members and watershed managers (see Figure 10). This high-resolution data enables watershed managers to see how storm runoff pulses throughout the watershed and adapt their management strategies accordingly.

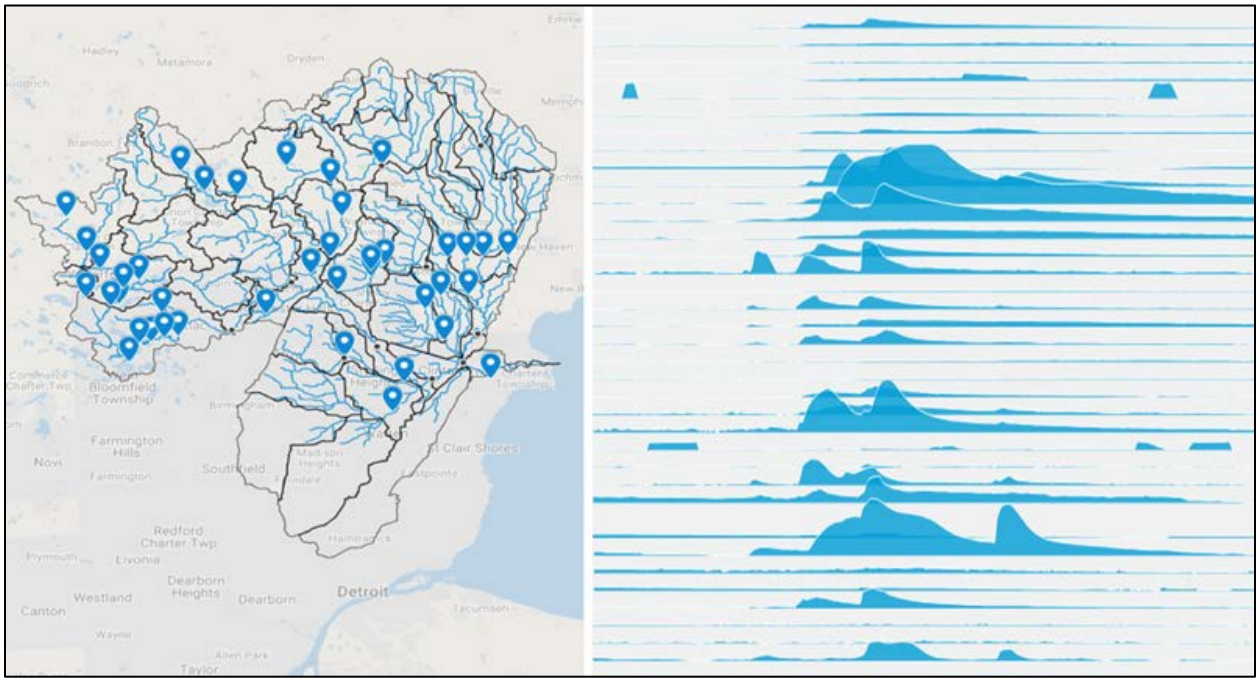

Figure 10. The locations of Open-Storm sensors (left); a screenshot of the water level at each sensor during a rainstorm (right).

In combination with the network of USGS gages along streams and rivers, Open-Storm technologies are helpful in monitoring local flood risk in urbanized areas like parking lots and commercial centers. The team behind Open-Storm is also broadening out to the regional scale to conduct pilot programs in areas such as upstate New York and northern Ohio to explore how these technologies might benefit local communities throughout the Great Lakes.

USING SCIENCE AND DATA TO INFORM DECISION MAKING

Dr. Jeffrey Warren, North Carolina Policy Collaboratory, University of North Carolina, Chapel Hill

The North Carolina Policy Collaboratory[66] is an environmental research collaborative that was established by the state legislature to conduct research on natural resources management and provide policy recommendations to the North Carolina General Assembly. The Collaboratory is a statewide initiative that outsources to and manages the policy and research initiatives of the

[66] More information about the Collaboratory is available at: "About," The North Carolina Policy Collaboratory, Accessed January 29, 2020, https://collaboratory.unc.edu/about/.

17-campus University of North Carolina system. Since its inception in 2016, Collaboratory projects have explored a range of topics such as energy storage, PFAS (per- and polyfluoroalkyl substances), oyster aquaculture, and flood resilience.

North Carolina has a perpetual risk of flooding from tropical and subtropical storms. This was evident with the occurrence of three, billion-dollar storms hitting North Carolina: Hurricanes Matthew, Florence, and Dorian. Because of this, in 2019, the North Carolina General Assembly approved $2 million in funding for the Collaboratory to conduct a flood resilience study. From this study, an implementation plan will be provided to the General Assembly with recommendations for how to advance flood resilience in North Carolina.

Flood resilience is advanced through a number of strategies including: 1) identify and reduce the present and future likelihood and extent of flood hazards; 2) assess and reduce the present and future impact and vulnerability of flooding; and 3) enable rapid return to normal functions by individuals, public services, and commerce.

With this in mind, the flood resilience project[67] is composed of five research teams each working on a different aspect of the project: the built-upon environment, natural systems, public health, finance, and buyouts. Examples of some of these projects, include:

1. In the built-upon environment, the research team is analyzing energy infrastructure and utilizing data from Duke Energy Inc. that shows where substations have been flooded or where storms have taken down power lines. The team is also modeling the vulnerability of solar power infrastructure to flooding. North Carolina has the second highest number of solar deployments in the United States and most are located in the southeastern coastal plains of the state, an area that has a high incidence of flooding.
2. With natural systems, the team is conducting research on stormwater and wetlands. A legal team is looking into the recent EPA re-designation of WOTUS[68] (water of the United States) laws to understand how North Carolina's wetlands will be impacted.[69]
3. North Carolina has one of the highest numbers of people per capita in the United States that uses private water wells. During flooding, these wells can become contaminated with floodwaters, but many people do not know they need to disinfect their wells. The public health team will conduct modeling to identify areas where wells are at risk of floodwater contamination and develop a program to educate people on how to properly decontaminate wells after floods.

[67] More information about the Flood Resiliency project is available at: "Legislative Studies," The North Carolina Policy Collaboratory, Accessed January 29, 2020, https://collaboratory.unc.edu/current-projects/legislative-studies/.

[68] "About Waters of the United States," EPA, Accessed February 3, 2020, https://www.epa.gov/nwpr/about-waters-united-states.

[69] More information about the re-designation of WOTUS laws is available at: "EPA and Army Deliver on President Trump's Promise to Issue the Navigable Waters Protection Rule – A New Definition of WOTUS," Environmental Protection Agency, January 23, 2020, Accessed January 30, 2020, https://www.epa.gov/newsreleases/epa-and-army-deliver-president-trumps-promise-issue-navigable-waters-protection-rule-0.

4. The finance team has a dataset that includes every residential mortgage that is held in the state, the value of the structure, and the outstanding mortgage. The team will use this data to look at community, financial institution, and state government risking.

Resilient America Program: Flood Mitigation and Community Engagement Project

Dr. Charlene Milliken, Senior Program Officer, Resilient America Program, National Academies of Sciences, Engineering, and Medicine

Resilient America provided a broad overview of its community engagement work and a summary of what it learned through its flood mitigation and community engagement project. This project encompassed three main activities: community visits, stakeholder meetings, and an annual event. The goal of this project was to better understand flood mitigation at the community level by investigating:

- the risks and impacts of floods on communities.
- actions communities are taking to mitigate future floods.
- challenges communities continue to face related to flood mitigation.
- what communities need to enable them to make informed decisions about flood mitigation.
- how communities are funding their flood mitigation activities.
- success stories, best practices, and lessons learned.

Four communities participated in the community engagement work (see Figure 11): Biloxi, MS; Ellicott City, MD; Roanoke and Vinton, VA; and Savannah and Tybee Island, GA.

Figure 11. Communities that participated in Resilient America's Flood Mitigation and Community Engagement project.

For each community, Resilient America facilitated a series of discussions with diverse stakeholder groups in order to capture a range of perspectives on flood experiences and mitigation efforts. Box 2 shows the different types of stakeholder groups that participated in the discussions.

Box 2
Examples of Stakeholder Groups that Participated in the Project

- local and county government (e.g., elected officials, public works, economic development, floodplain management, engineering, planning and zoning, infrastructure, stormwater management, etc.)
- state and federal government
- nonprofits and community- and faith-based organizations
- academia (e.g., researchers, scientists)
- emergency management and first responders
- natural environment and sustainability groups
- historic preservation societies
- small businesses
- real estate agencies
- insurance agencies

Communities are undertaking a range of flood mitigation efforts including infrastructure projects, flood preparedness campaigns, flood mitigation planning activities, and the development of tools, dashboards, and apps. Communities also participate in FEMA's National Flood Insurance Program (NFIP), the Community Rating System, and the property acquisition program.

Some of the common challenges that communities are grappling with include:

- Addressing the needs of at-risk populations to mitigate floods: Lower-income populations often live in the most flood-prone areas but they cannot afford to move out of these areas, buy flood insurance, or elevate their homes.
- Mental health issues: Some individuals who live in communities that have faced devastating floods may experience mental health issues such as anxiety or post-traumatic stress disorder symptoms during hurricane season or major rain events. Communities need information about how to address these types of mental health issues.
- Effective communication: Communities often struggle with how to effectively communicate flood risk to different groups in the community.
- Impacts of development on flooding*:* New development is increasing the flood risk to surrounding neighborhoods and communities.
- Property acquisitions and green spaces*:* Maintaining acquired properties can be costly for local governments.

- Economic impacts: Implementing flood mitigation efforts can have an economic impact; for example, local governments can no longer collect tax revenues from acquired properties.
- Maintaining technology: Technology needed for flood mitigation such as river gauges may be costly to maintain.
- High cost of flood insurance*:* Many homeowners cannot afford flood insurance.
- Outdated FEMA flood maps: Communities often make decisions based on the FEMA flood maps, but those maps are outdated.
- Predicting and preparing for flash floods: It is challenging for communities to prepare for flash floods because they happen quickly and it is difficult to predict when or where they will occur.
- Need for watershed planning: Watershed plans are needed to coordinate flood mitigation efforts across communities that share a watershed.
- Overcoming political obstacles: In some cases, there is a lack of political will to advance flood mitigation efforts in communities.

Community stakeholders shared several lessons learned and best practices based on their flood experiences and mitigation efforts.

- Building and cultivating relationships with diverse community stakeholders is critical.
- It is important to tailor communication and outreach efforts to different groups within the community.
- Engaging the community in flood mitigation efforts is important for building trust and gaining community buy-in.
- Many communities have experienced and learned from major flood disasters. Communities that are at risk but have yet to experience a major flood disaster should learn from others.
- Communities should try to find a balance between short-term solutions and the need for long-term strategies.
- Communities need to have effective advanced warning systems.
- Local, state, and federal governments rely on nonprofits to provide services to community members during disasters and post-recovery. Governments should fund and reimburse nonprofits for these efforts.
- Communities should maintain flood documentation and recordkeeping.

PANEL 3 – COMMUNITY ACTIONS FOR MITIGATION

Moderated by Jane Cage, Principal, InsightFive22 and Senior Advisor for Homeland Security and Emergency Management, Innovative Emergency Management

ELLICOTT CITY, MD

Mr. Mark DeLuca, Deputy Director, Howard County Bureau of Environmental Services, Ellicott City, MD

Ellicott City was founded as a mill town in the 18th century on the banks of the Patapsco River and is surrounded by steep granite slopes (some over 100 feet). The granite is covered by a relatively thin layer of soil and becomes quickly saturated, leading to heavy stormwater runoff that flows directly onto Main Street. Floodwaters run through Historic Ellicott City and into the Patapsco River. Four streams drain the western portion of Ellicott City, and in the 1800s these streams were channelized where they converge in Historic Ellicott City to form a single stream that is only 20 feet wide, just before draining into the Patapsco River (see Figure 12).

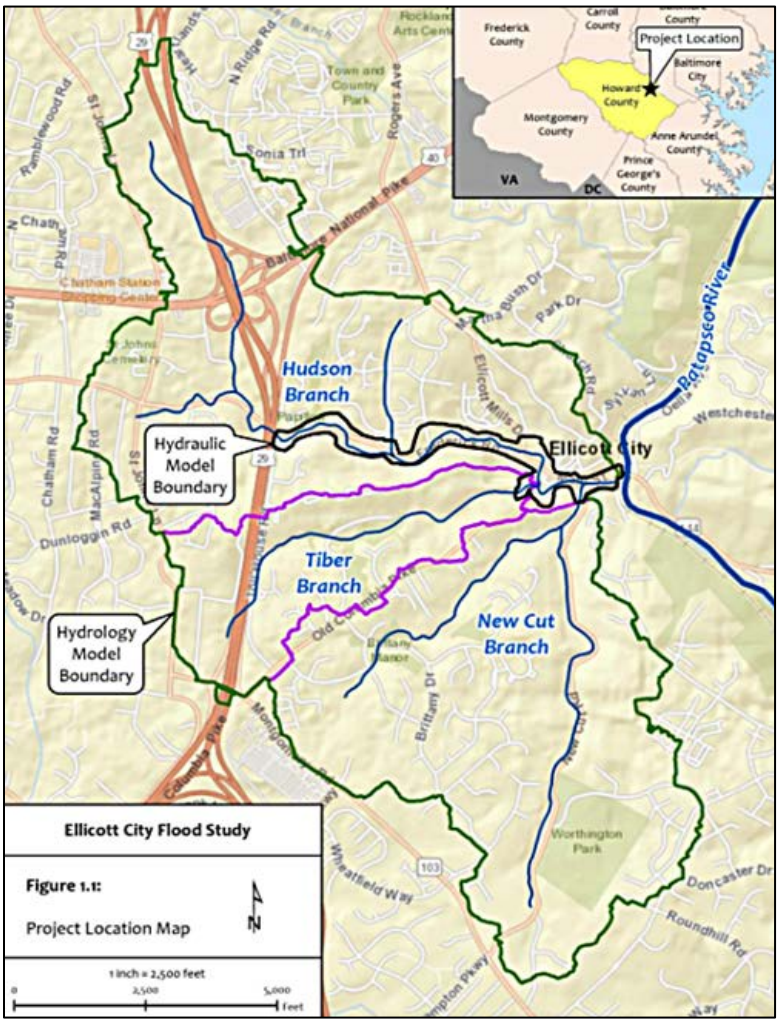

Figure 12. A map from the Ellicott City Flood Study that shows 4 streams converging at the bottom of the Patapsco River valley, where Historic Ellicott City is located.

Ellicott City has top-down and bottom-up flooding. Historically, the community has experienced riverine flooding as a result of tropical storms and hurricanes. These types of floods are locally known as "bottom-up" floods because river levels top the banks of the Patapsco River and flooding starts at the bottom of the Patapsco River Valley. Ellicott City is better equipped to handle bottom up flooding because these events develop more slowly and allow people time to prepare.

Flash flooding from stormwater runoff that runs into the city from higher elevations is "top-down" flooding. The 2016 flood[70] and 2018 flood[71] were both top-down floods that resulted from intense, fast-building rainstorms. It is difficult for Howard County to mitigate and prepare for these flash floods because of the velocity of the water, the unpredictability of where they will occur, and the speed at which floodwaters rise.

Following the catastrophic 2016 flash flood, the county conducted baseline modeling of the Tiber watershed, which was peer-reviewed by the USACE (Figure 13). The county then began to develop mitigation strategies and implementation timelines. The 2016 floods generated a lot of community enthusiasm to rebuild. By late 2017, Ellicott City was on track to finalize its infrastructure repairs from the 2016 flood and start mitigation projects; 95 percent of businesses had reopened in the downtown.

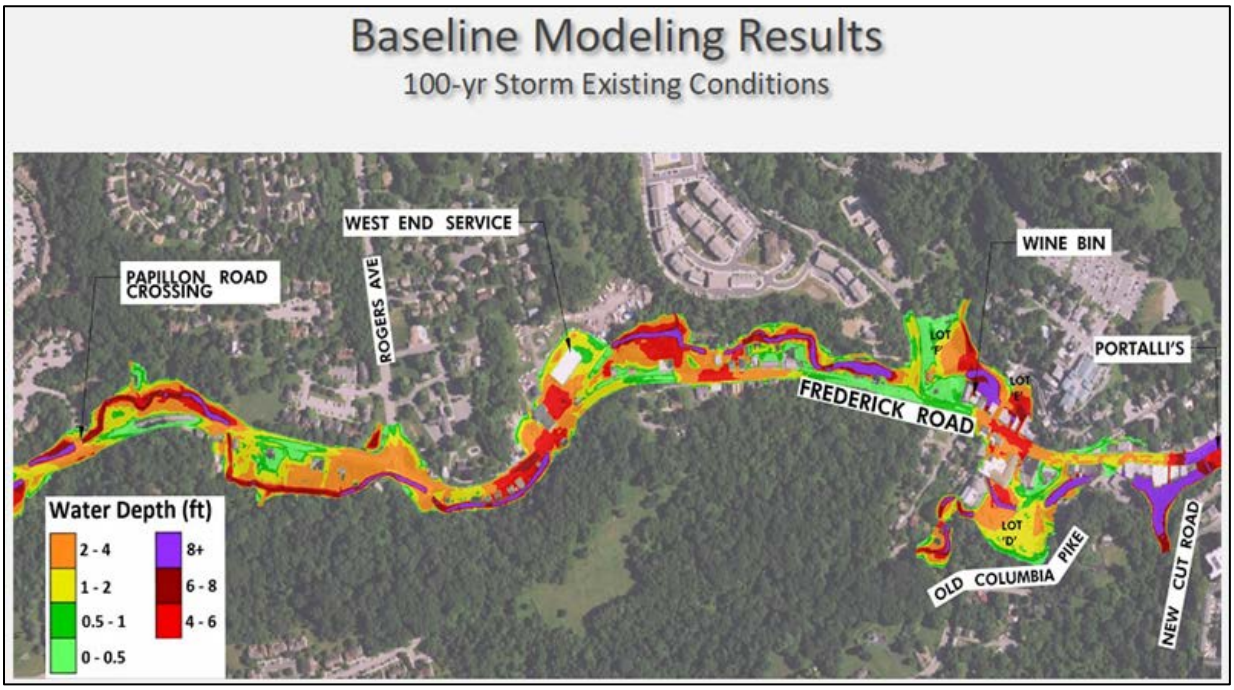

Figure 13. A map of the baseline modeling results from a flood study after the 2016 flood.

[70] "Ellicott City Historic Rain and Flash Flood – July 30, 2016." *National Weather Service*. Accessed February 3, 2020. https://www.weather.gov/lwx/EllicottCityFlood2016.
[71] "May 27th, 2018 Flooding – Ellicott City & Catonsville, MD." *National Weather Service*. Accessed February 3, 2020. https://www.weather.gov/lwx/EllicottCityFlood2018.

However, in May 2018, Ellicott City was struck by another catastrophic flash flood. The new county administration developed a long-term mitigation strategy.[72] The county's plan includes a project to divert the Hudson Branch into a tunnel so that water flow misses vulnerable sections of historic downtown, and includes retention and conveyance projects in the upper and middle sections of the watershed, respectively. In addition, the county implemented smaller projects such as flash flood warning signs (see Figure 14), designated areas for safe parking, and audible alert systems. The county also provided flood-proofing grants to help businesses and residents rebuild.

Figure 14. High ground access signs in Historic Ellicott City.

The county recognizes the need to move away from 100-year and 500-year flood terminology when communicating with the public because this terminology leads some people to believe that these types of floods are once in a lifetime events. The county also recognizes the need to distinguish between rain events and flood events, since each produces different impacts.

HAZARD MITIGATION CHALLENGES – BILOXI, MS

Ms. Christy LeBatard, Director of Engineering, City of Biloxi, MS

The City of Biloxi has a population of about 45,000 people, and the downtown (the historic area known as "the point") sits on a peninsula. Most of the city is located in the 100-year floodplain. On August 29, 2005, Hurricane Katrina, a category 3 hurricane, made landfall on the Mississippi Gulf Coast. This event changed how the city would approach development moving forward. After Katrina, FEMA produced new flood maps with new flood zones and elevation requirements, which the City of Biloxi adopted. At the time, there was a lot of buy-in and political support for some of the hazard mitigation changes that Biloxi implemented because

[72] The post-2018 flood mitigation strategy is part of a larger public safety initiative called the Ellicott City Safe & Sound Plan. More information about the plan is available at: "Home," Ellicott City Safe & Sound, Accessed February 10, 2020, https://www.ecsafeandsound.org/.

the city was so devastated by Katrina. But 14 years later, the city is experiencing challenges due to some of the earlier decisions it made and is having to deal with the impacts those earlier decisions have had on the city as it continues recuperating from Katrina.

Previously, in the old part of Biloxi, existing elevations varied from 6 to 12 feet. With the new base flood elevation (BFE), the new elevation requirements are from 17 to 21 feet. On top of this, the city adopted an additional one foot of freeboard to the FEMA BFE requirements; the city is currently looking into adding another one foot of freeboard.

These elevation requirements are difficult for many people to meet. The old part of Biloxi includes a lot of low-income housing, as well as million dollar homes, commercial development, and casinos. Excluding the casinos, many of these buildings are still not up to code because of the cost to meet the elevation requirements.

Before Hurricane Katrina, the population of the Biloxi Peninsula (where downtown is located) was about 17,000, but today it is about 8,000. After Katrina, people did not return to the peninsula because the cost to build is too high. Besides the casinos, the Waffle House diner is the only commercial business that has returned to the Biloxi Peninsula; it is the only elevated Waffle House in the United States. When a city is trying to recover from a devastating disaster, it needs its population to return and rebuild. A city cannot recover if its community members do not return. It is challenging to balance hazard mitigation with the economic needs of the city. If people do not return, the city cannot collect taxes, for example. The adoption of new elevation requirements have made it cost-prohibitive for many residents and businesses to return (see Figure 15).

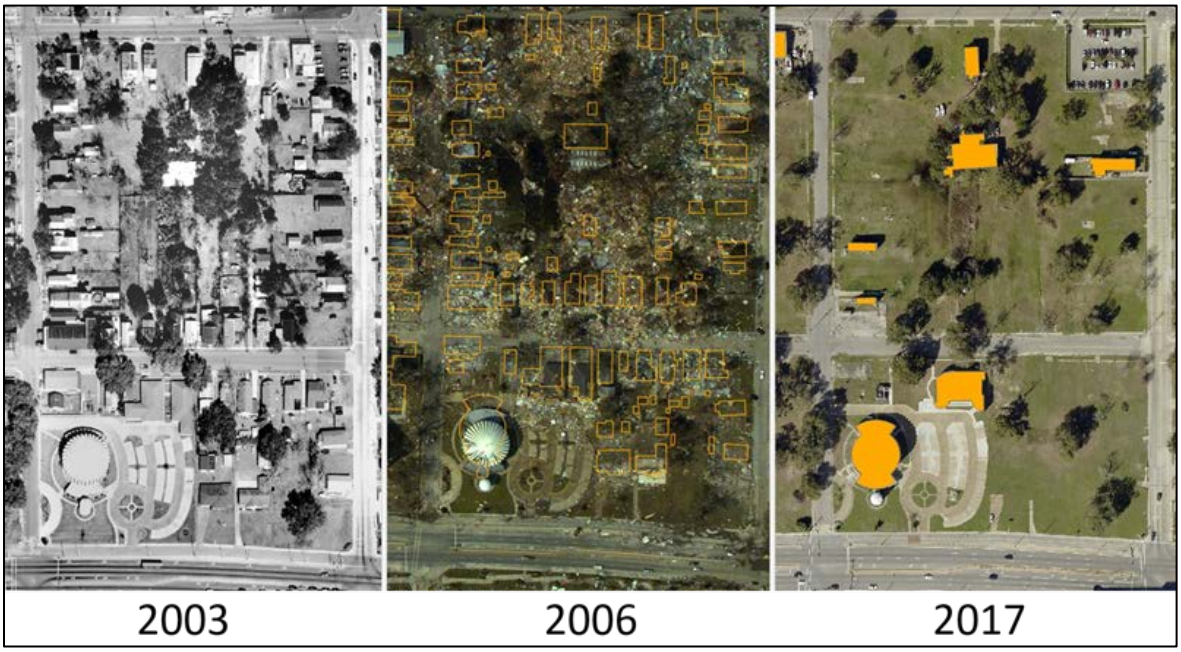

Figure 15. Aerial images of a city block in Biloxi that demonstrates the loss of residential properties after Hurricane Katrina. Pre-Hurricane Katrina in 2003 (left) had about 60 homes; one year after Katrina in 2006 (center) with yellow outlines where homes used to be located; in 2017 (right), the yellow areas show the only six remaining homes.

The new elevation requirements also pose accessibility challenges for some people (e.g., the elderly) who would need to install costly elevators to access their homes. Elevations are also changing the aesthetics of the city because facilities such as public restrooms and critical infrastructure also need to be elevated (see Figure 16). Elevating protects public infrastructure but people do not want these elevated structures in their neighborhoods.

Figure 16. Lift station not located in a flood zone (left) compared to a lift station located in a flood zone that had to be elevated (right). Both are in residential areas.

The Bonnet Carré spillway protects the City of New Orleans from flooding by releasing floodwaters from the Mississippi River which then flow into Lake Pontchartrain and thence into the Mississippi Sound of the Gulf of Mexico. In 2019, the spillway opened for a total of 143 days, releasing 10 trillion gallons of Mississippi River water. This caused massive harm to the economy and fisheries throughout all the communities of the Mississippi and eastern Louisiana coastal counties and cities, decimated the oyster industry along the Mississippi Gulf Coast, and almost wiped out the seafood industry. A hazard mitigation measure in another state is negatively impacting the Mississippi Gulf Coast economy.

Cities adopt hazard mitigation measures, and they work. But, in some cases, there can be downsides to implementing hazard mitigation activities.

WHERE COAST & RIVER MEET – TYBEE ISLAND, GA

Mr. Alan Robertson, Project Manager of Beach Renourishment and Dune Restoration, Savannah/Tybee Island, GA

Tybee Island is a small, barrier island located within the Savannah River Watershed (see Figure 17) and has a population of about 3,000 residents. During the summer, Tybee Island can get 50,000 visitors over a weekend. The island is bordered on the north by the Port of Savannah Shipping Lane, a 48-foot channel artificially managed by the USACE. In terms of flood hazards, the channel impedes natural sand drift and exposes the island to dramatic ship wakes. Both of these hazards have contributed to beach erosion that makes Tybee Island more vulnerable to storm surge. The back side of the island is comprised of tidal saltmarshes; spring tides can get as high as 10 feet and storm tides as high as 12 feet.

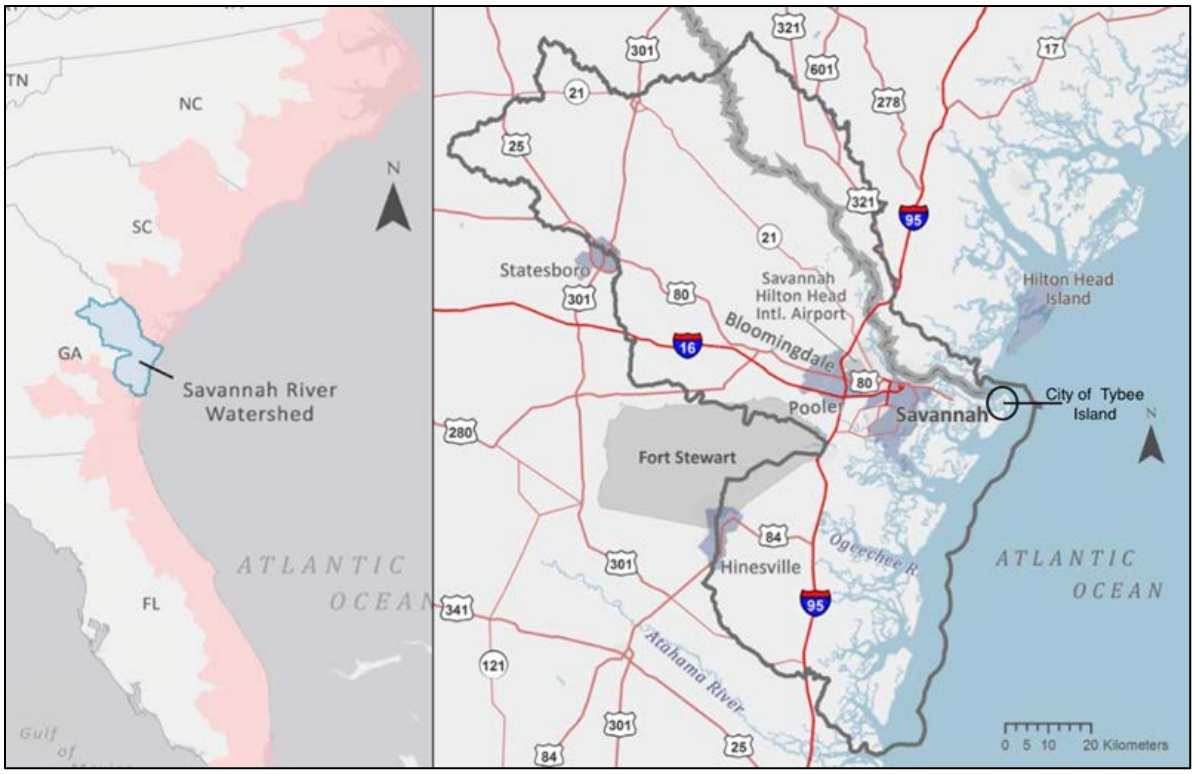

Figure 17. Map of the Savannah River Watershed and Tybee Island, GA.

Hurricanes and "sunny day flooding"[73] are major concerns for Tybee Island. The city was significantly impacted by Hurricanes Matthew (2016) and Irma (2017). Hurricanes Florence (2018), Michael (2018), and Dorian (2019) hit the island as tropical storms. Most of the flooding from these storms occurred on the back side of the island rather than the ocean side. Sunny day floods are frequent, result from high tides on the back side of the island, and can close off access to the island for a few hours. The beach is publicly owned so local government can mitigate flooding and storm surge; however, the back side of the island is privately owned.

Figure 18 shows a map of Tybee Island that was used in the assessment of its dune field, a mitigation measure to protect from storm surge. The areas marked in green represent the dune field; those marked in red represent access points to the beach. While the dunes themselves are quite hardy, the access points are vulnerable.

[73] Sunny day flooding is another term for tidal flooding, which does not result from precipitation, see: "Tidal flooding," Wikipedia 2019, last updated December 12, 2019, Accessed February 3, 2020, https://en.wikipedia.org/wiki/Tidal_flooding

Figure 18. Map of Tybee Island; areas marked in green represent the dune field and those marked in red represent access points to the beach.

In terms of flood mitigation efforts, the State of Georgia awarded Tybee Island a $5 million grant to pursue flood mitigation actions for the beachside of the island. The University of Georgia Marine Extension Service conducted a sea level rise study and developed the *Tybee Island Sea Level Rise Adaptation Plan* for the city.[74] The USACE is currently re-nourishing the beach, and the city is building and stabilizing the sand dunes. Regarding mitigation actions for the back side of the island, the city was recently awarded a National Fish and Wildlife Foundation grant[75] to conduct an assessment of the river and marsh and will work with the University of Georgia to better understand what can be done to mitigate flooding on the back side of the island (see Figure 19).

[74] Evans, J. M., Gambill, J., McDowell, R. J., Prichard, P. W., and Hopkinson, C. S. 2016. *Tybee Island Sea Level Rise Adaptation Plan.* *https://eos.ucs.uri.edu/seagrant_Linked_Documents/gaus/Tybee_Report_52016_small%20%201%20.pdf*.

[75] More information about the NFWF National Coastal Resilience Fund is available at: "National Coastal Resilience Fund," NFWF, Accessed February 3, 2020, https://www.nfwf.org/programs/national-coastal-resilience-fund

Figure 19. Flooding on the back side of Tybee Island.

Mr. Robertson shared three lessons learned: have a plan in place for mitigation actions, build community consensus for mitigation actions, and be prepared for public pushback on mitigation actions. First, because the city had a sea level rise plan in place that included a list of recommendations for mitigation actions, the city was able to take action when it received funding. Second, it is important for local government to obtain public input and community consensus on flood mitigation efforts, including what actions need to be taken, why, and how. Third, local government should prepare for pushback from community members who may not realize how mitigation actions will affect them personally, as homeowners (e.g., sand dunes may obstruct their beach view or access).

ROANOKE, VA

Leigh Anne Weitzenfeld, Water Quality Administrator, Stormwater Utility, City of Roanoke, VA

The City of Roanoke is located in a valley surrounded by mountains. Roanoke County surrounds the city, and the City of Salem is located to the west and the Town of Vinton to the east. The Roanoke River bisects the city and is fed by 11 surrounding tributaries (see Figure 20). Due to the mountainous topography, many of the tributaries and even the Roanoke River can experience flash flooding. The downtown area can experience substantial flooding during extreme intensity precipitation events. It is a natural low area that once was a wetland or salt lick and gave Roanoke its first name of Big Lick.

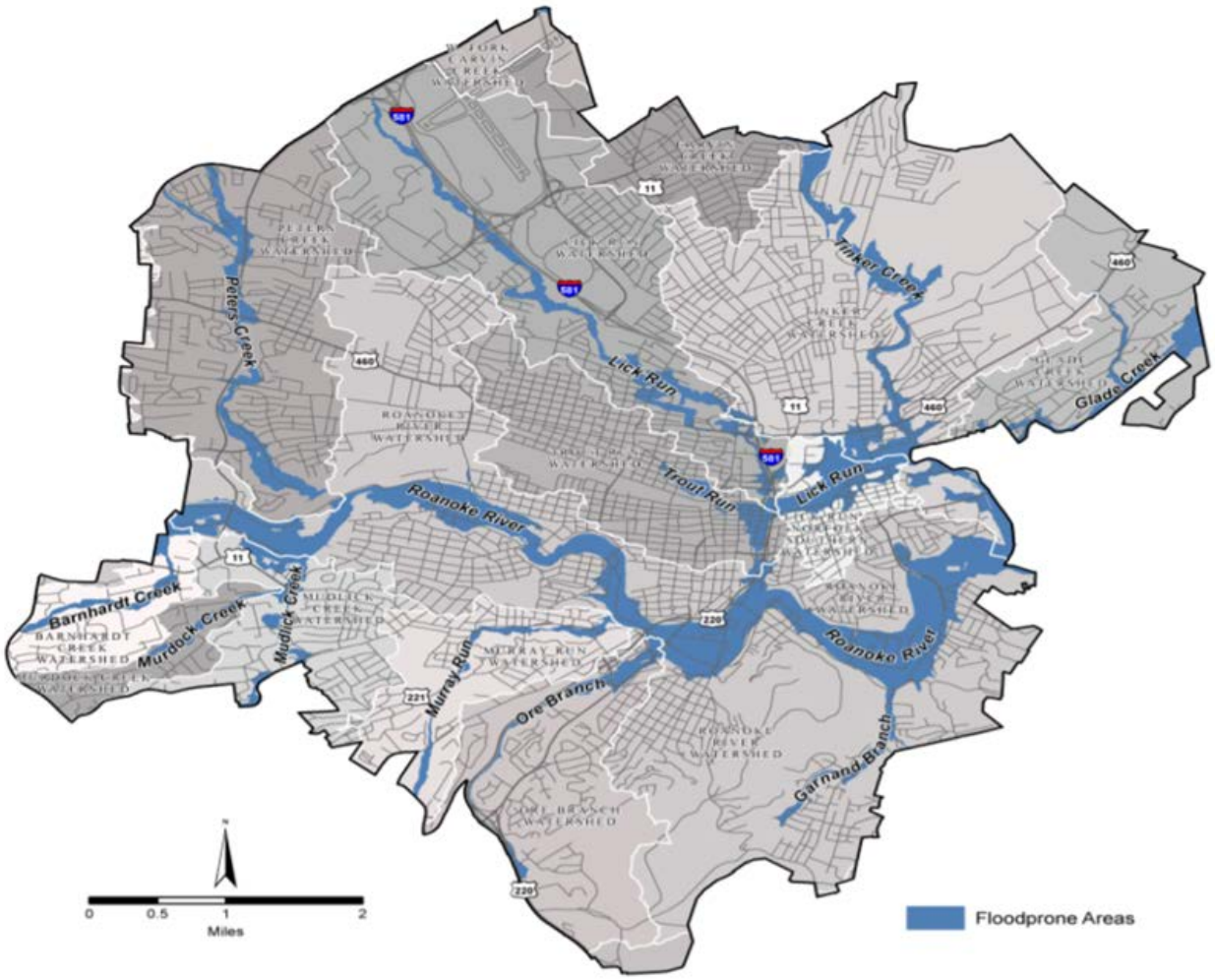

Figure 20. A map showing the City of Roanoke and the many tributaries that feed the Roanoke River.

In May 2018, a house located in the floodway near the confluence of Mud Lick Creek and the Roanoke River was severely flooded (the basement and two of three above-ground floors of the home were inundated) (see Figure 21). In October 2018, two weeks after the family had completed renovations and repairs and had moved back into the home, Hurricane Michael struck and severely flooded the house again. The homeowner did not want to wait the two years it would take to get FEMA funds and could not afford to pay the mortgage, flood insurance, and rent. To address this, the City of Roanoke created its own mitigation program, the Stormwater Utility Flood Mitigation Program,[76] to supplement the FEMA grants. In this property acquisition program, the homeowner covers 75 percent of the cost (usually flood insurance proceeds) and the city's stormwater utility fee covers 25 percent.

[76] More information about Roanoke's property acquisition program is available at: City of Roanoke, *Roanoke City Council Regular Session,* Roanoke, VA, pp. 18-21, March 2019, Accessed January 30, 2020, https://www.roanokeva.gov/AgendaCenter/ViewFile/Item/613?fileID=10331

Figure 21. The first substantially flood-damaged home in Roanoke, which also prompted the city to implement an innovative approach to property acquisitions.

The city has built and cultivates partnerships with Virginia Tech's Department of Civil and Environmental Engineering, the USGS, and the National Weather Service in Blacksburg, VA. There is a water quality monitoring station and hobo sensors in the city. Through these partnerships, the city now has access to enough data to start modeling all of the flooding events of 2018. The USGS partnership resulted in nine precipitation gauges being installed throughout the city that the public and the Office of Emergency Management can access. The partnership with Virginia Tech resulted in the *SHARKS* app (*S*tream *H*ydrology and *R*ainfall *K*nowledge *S*ystem), which provides different parameters of rain and flood events.[77]

The city implemented the Roanoke River Flood Reduction Project in the late 1990s and early 2000s, and built bench cuts to protect the city from a 25-year flood. The city also built a greenway along the Roanoke River. The city will have new maps when the LOMR (Letter of Map Revision) is completed.

Roanoke's future flood mitigation goals include:

- Continuing to look at watersheds holistically for water quality, floodplain, and stormwater management.
- Conducting a climate vulnerability and risk assessment.

[77] The SHARKS app is available at: "Sharks," BigBadCrad, Accessed January 27, 2020, https://bigbadcrad.shinyapps.io/SHARKS/

- Conducting an economic valuation of the floodplains and related open space to be able to make better development decisions.

PANEL 4 – STATE MITIGATION PROGRAMS AND RESOURCES

Moderated by Dan Burger, Chair, Charleston (SC) Resilience Network

GEORGIA HAZARD MITIGATION ASSISTANCE (HMA) PROGRAMS OVERVIEW

Mr. Terry Lunn, Mitigation Division Director, Georgia Emergency Management Agency

The most important activity of Georgia Emergency Management and Homeland Security Agency's (GEMA/HS) Hazard Mitigation Department (HMD) is to coordinate the update of the state's hazard mitigation plan,[78] which ensures that the State of Georgia is eligible to receive the full range of disaster assistance through the Stafford Act. The HMD also administers disaster (e.g., Hazard Mitigation Grant Program[79]) and non-disaster (e.g., Flood Mitigation Assistance Program, Pre-Disaster Mitigation Program) grants, coordinates with USDA's Natural Resources Conservation Service on emergency watershed protection grants,[80] provides technical assistance to local governments (e.g., planning and project grant applications), and supports the Georgia Silver Jackets Program.[81] In addition, HMD works closely with Georgia Environmental Protection Division Floodplain Management[82] in support of Risk MAP and resilience workshops.

The Hazard Mitigation Assistance Program is a federally-funded, state-administered program. HMD has developed mandatory pre-applications for each type of hazard mitigation project which are utilized to determine initial eligibility (e.g., How much money is the community requesting? Is it cost-effective? Is it a technically feasible program to be funded?). Applying communities must participate in the NFIP. Because of this pre-application process, HMD has been 100 percent successful in getting local projects funded.

Of the mitigation projects that have received funding, property acquisitions and structure demolitions are the most prevalent. Other types of mitigation projects that have been funded include structure elevations, generators for critical facilities, flood risk reduction projects (e.g., drainage improvements, dam rehabilitation projects), community safe room construction, initiative projects (Hazard Mitigation Grant Program only), and state and local plan updates.

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[78] Georgia Emergency Management and Homeland Security Agency. 2019. *Georgia Hazard Mitigation Strategy*. Accessed January 27, 2020, https://gema.georgia.gov/hazard-mitigation-planning.

[79] More information about Georgia's Hazard Mitigation Grant Program is available at https://gema.georgia.gov/hazard-mitigation-grant-program.

[80] More information about USDA Natural Resources Conservation Service Emergency Watershed Protection Program is available at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/.

[81] More information about Georgia Silver Jackets is available at https://silverjackets.nfrmp.us/State-Teams/Georgia.

[82] More information about Georgia Environmental Protection Division Floodplain Management is available at Georgia Environmental Protection Division Floodplain Management.

The GEMA/HS website provides a variety of hazard mitigation resources[83] to help local communities update their plans and develop mitigation projects, including FEMA mitigation planning guides; GEMA/HS mitigation planning documents; hazard mitigation and long-term recovery planning; HMA pre-applications; laws, regulations, and policies; safe rooms; Georgia Hazard Mitigation Strategy; and other resources.

Other Resources

- U.S. Army Corps of Engineers – Communities of Practice
- Georgia Flood Map Program

MITIGATION ACTIONS AND OPPORTUNITIES TO ADDRESS COMMUNITY FLOOD RISK

Mr. Brian Shoun, State CRS Coordinator, Georgia Department of Natural Resources

The Georgia Floodplain Management Unit[84] carries out four main activities: community assistance, outreach and training, flood maps, and information clearinghouse. The Georgia Flood Map Program[85] allows homeowners to learn about their flood risk (e.g., see a map that shows how deep 100- and 500-year floods would be on their properties) and flood insurance.

Many people still do not realize there is a flood risk or understand it. There are three ways community members understand flooding:

1. It is the city's responsibility to fix the problem.
2. The flooding is caused by someone who lives upstream (and it is the city's responsibility to fix it).
3. It is hard to imagine it will flood as much as indicated on the FEMA flood map.

There are two kinds of flooding: EPA flooding (i.e., water quality and storm drainage) and FEMA flooding. Though the floods are the same, there are different ways to fund them. While communities in Georgia grapple with a variety of issues related to flooding, one of the biggest challenges is funding mitigation actions.

Examples of local funding sources for flood mitigation in Georgia include a general fund from property taxes, general obligation bonds, a special assessment or tax district, Special-Purpose Local-Option Sales Tax (SPLOST), a downtown development authority, and stormwater utilities.

At the state level, there are six main entities that provide funding for mitigation actions:

- Georgia Emergency Management Agency (GEMA)
- Department of Natural Resources (DNR)

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[83] "Hazard Mitigation Resources." *Georgia Emergency Management and Homeland Security Agency.* Accessed on February 3, 2020. https://gema.georgia.gov/hazard-mitigation-resources.

[84] More information about Georgia Department of Natural Resources Environmental Protection Division's Floodplain Management Unit is available at https://epd.georgia.gov/watershed-protection-branch/floodplain-management.

[85] To access the Georgia flood map, visit http://www.georgiadfirm.com/.

    - Coastal Incentive Grant Program[86]
    - 319[87]
    - Small Business Environmental Assistance Program[88]
    - Regional Water Plan Seed Grant[89]
    - Recreational Trails Grant Program[90]
- Department of Community Affairs (DCA)
    - OneGeorgia[91]
    - Community Development Block Grants[92]
    - Appalachian Regional Commission[93]
    - Downtown Development Revolving Loan Fund[94]
- Georgia Environmental Finance Authority (GEFA)
    - Georgia Fund[95]
    - Clean Water State Revolving Loan Fund[96]
    - Water and Sewer Loans[97]
    - Environmental Emergency Loans[98]
- Georgia Main Street Program[99]
- Georgia Development Authority[100]

Examples of federal funding sources include:

- Small Business Administration[101]

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[86] More information about the Coastal Incentive Grant Program is available at https://coastalgadnr.org/CIGApplying.
[87] More information about Section 319(h) Georgia's Nonpoint Source Implementation Grant is available at https://epd.georgia.gov/outreach/grants/section-319h-georgias-nonpoint-source-implementation-grant.
[88] More information about the Small Business Environmental Assistance Program is available at https://epd.georgia.gov/outreach/outreach-educational-programs/small-business-environmental-assistance.
[89] More information about the Regional Water Plan Seed Grant Funds is available at https://epd.georgia.gov/outreach/grants/regional-water-plan-seed-grant-funds.
[90] More information about the Recreational Trails Program is available at https://gadnr.org/RTP.
[91] More information about OneGeorgia is available at https://www.dca.ga.gov/community-economic-development/funding-programs/onegeorgia-authority.
[92] More information about Community Development Block Grants is available at https://www.dca.ga.gov/community-economic-development/funding-programs/community-development-block-grants-cdbg.
[93] More information about the Appalachian Regional Commission is available at https://www.dca.ga.gov/community-economic-development/funding-programs/appalachian-regional-commission-arc.
[94] More information about the Downtown Development Revolving Loan Fund is available at https://www.dca.ga.gov/community-economic-development/funding-programs/downtown-development-revolving-loan-fund-ddrlf.
[95] More information about the Georgia Fund is available at https://gefa.georgia.gov/georgia-fund.
[96] More information about the Clean Water State Revolving Fund is available at https://gefa.georgia.gov/clean-water-state-revolving-fund.
[97] More information about water and sewer financing is available at https://gefa.georgia.gov/water-and-sewer-financing.
[98] More information about environmental emergency loans is available at https://gefa.georgia.gov/georgia-fund.
[99] More information about Georgia Main Street program is available at http://www.georgiamainstreet.org/.
[100] More information about the Georgia Development Authority is available at https://www.gdaonline.com/.
[101] More information about SBA funding programs is available at https://www.sba.gov/funding-programs.

- United States Department of Agriculture (e.g., water and wastewater, community facilities, rural economic development)[102]
- United States Army Corps of Engineers (e.g., Silver Jackets, small flood damage reduction projects)
- United States Department of Commerce Economic Development Administration (e.g., public works)[103]
- National Resources Conservation Services Emergency Watershed Protection Program[104]

In addition, other sources of funding for mitigation actions include:

- Coastal Area District Development Authority[105]
- Southeast Rural Community Assistance Project, Inc.[106]
- Georgia Community Loan Fund, Inc.[107]
- Georgia Cities Foundation Revolving Loan Fund[108]
- Environmental Education in Georgia[109]
- National Coastal Resilience Fund[110]
- Rural Community Assistance Partnership[111]
- National Rural Water Association[112]

MARYLAND'S DISASTER RISK REDUCTION EFFORTS: MITIGATION ACTIONS & OPPORTUNITIES TO ADDRESS COMMUNITY FLOOD RISK

Mr. Kyle Overly, Director of Risk Reduction, Maryland Emergency Management Agency

In recent years, communities in Maryland have been experiencing changes in their flood risk: small rain events are becoming major rain events with hyper-localized flooding and flooding is occurring in places where it has never occurred in the past. Based on these changes, the Maryland Emergency Management Agency[113] (MEMA) reassessed its responsibility to enable communities to address their changing risk by considering three overarching questions:

[102] More information about USDA resources is available at https://www.usda.gov/ and https://www.rd.usda.gov/programs-services/all-programs.
[103] More information about EDA resources is available at https://www.eda.gov/.
[104] More information about the Natural Resources Conservation Service Emergency Watershed Protection program is available at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/.
[105] More information about Coastal Area District Development Authority is available at https://cadda-sba.org/.
[106] More information about SERCAP, Inc. is available at http://sercap.org/.
[107] More information about Georgia Community Loan Fund is available at https://www.guidestar.org/profile/01-0678290.
[108] More information about Georgia Cities Foundation Revolving Loan Fund is available at https://www.georgiacitiesfoundation.org/Programs-Services/Revolving-Loan-Fund.aspx.
[109] More information about Environmental Education in Georgia is available at http://eeingeorgia.org/.
[110] More information about the National Coastal Resilience Fund is available at https://www.nfwf.org/programs/national-coastal-resilience-fund.
[111] More information about Rural Community Assistance Partnership is available at https://www.rcap.org/.
[112] More information about the National Rural Water Association is available at https://nrwa.org/.
[113] More information about MEMA is available at https://mema.maryland.gov/Pages/default.aspx.

1. Why do we do things the way we do?
2. What is the role of emergency management?
3. How do we fit into a broader discussion on how to make communities safer?

MEMA recognized the need to shift away from a reactive model of emergency management (i.e., consequence management) to a more proactive one. Driving this shift was a change in philosophy from viewing hazard mitigation as individual components (working independently) to complementary components (working in coordination) to address community flood risk.

In the past 4-5 years, MEMA has embraced disaster risk reduction as a framework for how the agency can best coordinate the various hazard mitigation components. Under this framework, MEMA goes beyond mitigation by working to remove programmatic barriers, building partnerships and aligning statewide efforts, maximizing funding streams for widespread community impact, proposing policy changes and legislation, and informing future investment and statewide priorities (see Figure 22).

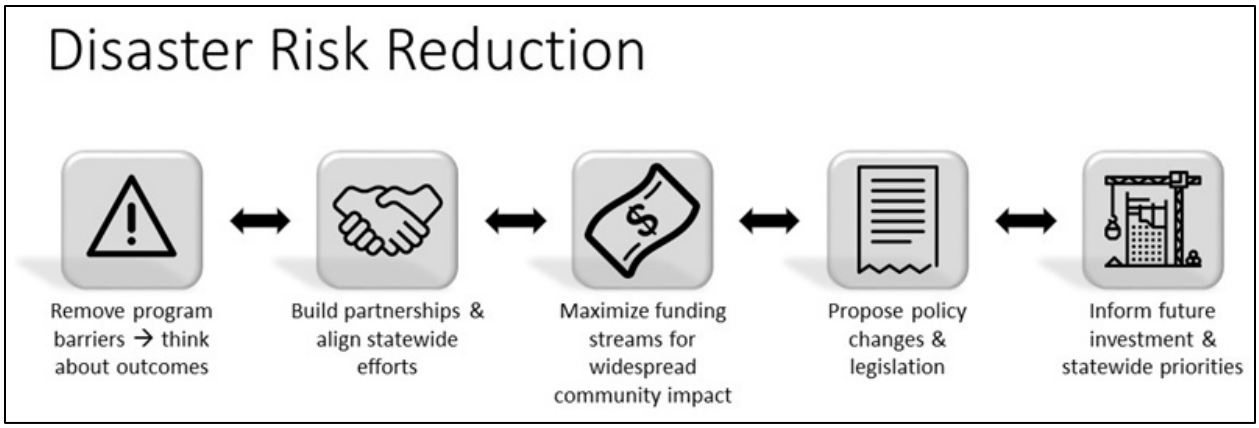

Figure 22. MEMA Disaster Risk Reduction Actions.

Removing programmatic barriers: Instead of having communities conform their priorities to fit the eligibility criteria of any given program, MEMA encourages them to agree on what mitigation actions they believe would improve the lives of their community members. This forces communities to think more broadly about the underlying issues that give rise to their flood risk.

Building partnerships and aligning statewide efforts: MEMA is partnering with nonprofits to pursue joint funding for projects that have traditionally been outside the purview of emergency management. The agency is also partnering with the private sector to reduce risk at the community level, which not only helps businesses avoid interruptions in their operations, but also helps communities maintain access to important resources and services.

Maximizing funding streams for widespread community impact: Pursuing projects that are broader and/or less traditional requires MEMA to look at different funding streams and connect them in a meaningful way to make the biggest impact for the community.

Proposing policy changes and legislation: Throughout their coordination activities, MEMA notes which programmatic barriers are most suitable to being changed through policy and legislation. The agency leverages partnerships with nonprofits, state and federal government agencies and personnel, and the private sector, to gain greater community buy-in and thus have a larger impact.

Informing future investment and statewide priorities: All of the aforementioned activities go toward informing future investment and statewide priorities. For example, if the Maryland Department of Transportation is building a highway network, then MEMA would seek a seat at the table to provide guidance on how its construction could avoid increasing community flood risk.

MEMA has encountered a few challenges in carrying out the disaster risk reduction framework:

- administrative burdens and funding delays that are time costly and have stifled progress on risk reduction efforts;
- a lack of community capacity to participate in risk reduction efforts;
- a lack of vision to pursue projects that meet community needs on a broader scale;
- difficulty getting buy-in from smaller communities that are struggling economically;
- combining funding streams and projects; and
- slow progress and implementation.

However, MEMA has experienced a number of successes, including establishing the Disaster Risk Reduction Working Group, gaining momentum through local projects, receiving support from elected officials, and having policy influence and advocacy at the national level.

Establishing the Disaster Risk Reduction Working Group: Last year, MEMA established the Disaster Risk Reduction Working Group comprised of 23 executive-level state agencies. As a group, agencies share an interest in pursuing a broad approach to risk reduction that addresses community flood risk. Working group members are currently preparing for the Disaster Recovery Reform Act and its funding reauthorization (i.e., the new FEMA Building Resilient Infrastructure and Communities (BRIC) program). [114] The working group is also looking at addressing the special needs of individuals with disabilities before and after disasters.

Gaining momentum through local projects: Many communities have had success with their local projects. Ellicott City is leading the way on risk reduction with Howard County's new Flood Mitigation Plan.[115] Fredrick City has built a park to retain water, which has reduced its flooding substantially. Ocean City has installed backflow prevention, which has reduced flooding in the lower areas of the city. MEMA would like to capitalize on their accomplishments by spreading momentum for disaster risk reduction throughout the state.

[114] More information about BRIC, including webinars, is available at: "Building Resilient Infrastructure and Communities," FEMA, Accessed February 3, 2020, https://www.fema.gov/drra-bric

[115] For more information about Howard County's Flood Mitigation Plan, visit https://www.howardcountymd.gov/News/ArticleID/1526/News05139b.

Receiving support from elected officials: One of Maryland Governor Larry Hogan's top priorities is resilience. With his support for disaster risk reduction, MEMA has been contacted by state delegates and other legislatures for guidance on how to make their communities more safe and resilient.

Having policy influence and advocacy at the national level: In addition to support from the governor, MEMA has benefited from the political influence and advocacy that their executive director, Russell Strickland, has had at the national level. This includes advocating for regulation that supports mitigation action; influencing legislation on FEMA's BRIC program; and being active with the National Governors Association (NGA).[116]

MEMA sees the disaster risk reduction framework as an opportunity for both emergency managers and communities to pursue mitigation actions that not only reduce hazards, but also reduce vulnerability on a broader scale and ultimately make a meaningful impact for communities.

PANEL 5 – FEDERAL MITIGATION RESOURCES, FUNDING, AND TECHNICAL ASSISTANCE

Moderated by David Thomas, Senior Policy Advisor, Mitigation Directorate, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency

Mr. David Thomas began the session by thanking Biloxi, Ellicott City, Roanoke and Vinton, and Savannah and Tybee Island for participating in the Resilient America flood mitigation project. All of the cities deeply care about their communities; flood mitigation preparedness, response, recovery, and mitigation; and the challenges that vulnerable populations face. Communities know what their risks are and are working hard to address those risks.

After having participated in all the community visits with the Resilient America Program, Mr. Thomas wanted to clarify that anyone in an NFIP community can obtain flood insurance, and that pre-disaster mitigation grants are available to any community with a hazard mitigation plan, not just those communities that have experienced a disaster. He also informed the group that FEMA's Building Resilient Infrastructure and Communities (BRIC) Program[117] is in development, but should be announcing a funding opportunity in late summer or fall 2020.

FEMA HAZARD MITIGATION ASSISTANCE GRANTS

Mr. Richard Flood, Federal Emergency Management Agency, Region IV

Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to human life and property from natural hazards. Mitigation addresses risk from natural hazards and finds

[116] More information about the NGA is available at: "About," NGA, Accessed February 3, 2020, https://www.nga.org/about/.
[117] More information about BRIC is available at https://www.fema.gov/drra-bric.

long-term solutions. The goal of mitigation is to break out of the cycle of disaster damage, reconstruction, and repeated damage.

Mitigation planning is the first step in the mitigation process. Mitigation planning:

- Identifies potential projects relative to hazard risk, including structural and regulatory tools (e.g., ordinances and building codes).
- Is required in order for states and communities to receive project funding through FEMA's Hazard Mitigation Assistance grants.

States, tribal governments, and territories can apply for Hazard Mitigation Grants (HMG). HMG sub-applicants can include state agencies, tribal governments and agencies, private nonprofits, tribal governments and agencies, and local governments (townships, cities, counties). However, private individuals, businesses, church organizations, etc., cannot apply directly for HMGs but states and local government can apply on their behalf.

FEMA's hazard mitigation assistance (HMA) grants programs[118] include:

- Pre-Disaster Mitigation Grant Program (PDM)[119]
- Flood Mitigation Assistance program (FMA)[120]
- Hazard Mitigation Grant Program (HMGP)[121]

The goal of PDM is to reduce overall risk to people and property from future hazard events. It funds mitigation projects and plans that address natural hazards. PDM is a nationally competitive program but there is also set-aside funding for states.

FMA is funded by the National Flood Insurance Program (NFIP),[122] and its goal is to reduce or eliminate claims made under NFIP. Communities must be participating in, and be in good standing with, the NFIP to be eligible. The mitigation action must benefit NFIP-insured properties; likewise, any property being modified with FMA funds must be NFIP-insured. FMA only funds flood hazard mitigation activities. FMA funds can be used to complete the flood portion of local and state mitigation plans. FEMA prioritizes FMA grant funding based on agency priorities.

[118] For more information about FEMA's hazard mitigation assistance grant programs visit https://www.fema.gov/media-library-data/1441133724295-0933f57e7ad4618d89debd1ddc6562d3/FEMA_HMA_Grants_4pg_2015_508.pdf.
[119] "Pre-Disaster Mitigation Grant Program." FEMA. Accessed February 1, 2020. https://www.fema.gov/pre-disaster-mitigation-grant-program.
[120] "Flood Mitigation Assistance Grant Program." FEMA. Accessed February 1, 2020. https://www.fema.gov/flood-mitigation-assistance-grant-program.
[121] "Hazard Mitigation Grant Program," FEMA, Accessed January, 31, 2020, https://www.fema.gov/hazard-mitigation-grant-program.
[122] "NFIP," FEMA, Accessed February 3, 2020, https://www.fema.gov/national-flood-insurance-program.

Section 404 of the Stafford Act[123] authorizes HMGP. It is made available when requested by a governor after a Presidential Disaster Declaration, and it is the main post-disaster hazard mitigation funding program. HMGP is intended to reduce the loss of life and property due to natural disasters and to implement mitigation measures (that have been identified in local mitigation plans) during recovery from a disaster. Communities submit applications to the state, and the state is responsible for prioritizing and selecting projects to submit to FEMA. FEMA reviews projects for eligibility. HMGP is then administered by the state or an eligible Native American Tribal Nation.

There have been recent changes to HMGP:

- Advance Assistance[124]
- Program Administration by States[125]
- Strategic Funds Management[126]
- There is now a greater emphasis on building codes.

Resources

- Building Resilient Infrastructure and Communities[127]
- National Disaster Recovery Framework[128]
- Community Recovery Management Toolkit[129]
- Strategic and Operational Planning Guides[130]
- Disaster Financial Management Guide[131]

[123] "Robert T. Stafford Disaster Relief and Emergency Assistance Act," FEMA, Accessed February 3, 2020, https://www.fema.gov/robert-t-stafford-disaster-relief-and-emergency-assistance-act-public-law-93-288-amended.

[124] For more information about Advance Assistance for HMGP, visit https://www.fema.gov/media-library/assets/documents/32755.

[125] For more information about Program Administration by States, visit https://www.fema.gov/media-library-data/1424368115734-86cfbaeb456f7c1d57a05d3e8e08a4bd/FINAL_PAS_FAQ_13FEB15_508complete.pdf.

[126] For more information about Strategic Funds Management, visit https://www.fema.gov/media-library/assets/documents/30301.

[127] "Webinar Series 2019: Building Resilient Infrastructure and Communities," FEMA. Accessed January 31, 2020, https://www.fema.gov/drra-bric.

[128] "National Disaster Recovery Framework (second edition)," FEMA, last updated October 22, 2018, Accessed January 31, 2020, https://www.fema.gov/national-disaster-recovery-framework

[129] "Community Recovery Management Toolkit," FEMA, last updated October 2, 2019, Accessed January 31, 2020, https://www.fema.gov/community-recovery-management-toolkit

[130] The intended audience for the links on this page are for individuals, families, communities, the private and nonprofit sectors, faith-based organizations, and federal, state, local, tribal and territorial governments. "Strategic and Operational Planning," FEMA, last updated January 28, 2020, Accessed January 31, 2020, https://www.fema.gov/plan#wcm-survey-target-id

[131] "Disaster Financial Management Guide," FEMA, Accessed January 31, 2020, https://www.fema.gov/media-library/assets/documents/182432

- Office of Intergovernmental Affairs: Recovery through Federal-State-Local Partnership[132]
- Economic Development Administration: Funding Opportunities[133]

SUPPORTING RISK REDUCTION THROUGH THE NATIONAL DISASTER RECOVERY FRAMEWORK

Ms. Wynne Kwan, Community Planning & Capacity Building Coordinator, Federal Emergency Management Agency, Region III

When a disaster hits, there are many complex recovery challenges that communities have to work through which require a high level of coordination. To address these challenges, communities need to reestablish partnerships and relationships that had been built prior to the disaster. The National Disaster Recovery Framework[134] (NDRF) establishes a coordinating structure for multi-stakeholder disaster recovery efforts. It provides guidance and training for all the federal interagency partners that are supporting post-disaster recovery efforts in a community, and it focuses on how best to restore, redevelop, and revitalize the health, social, physical, economic, natural, and environmental fabric of the community. The NDRF also incorporates partnerships with nonfederal community stakeholders (e.g., private sector, nonprofits, families).

The NDRF is based on three key concepts:

1. Leadership at every level. At the federal level, the coordinating leader is the federal disaster recovery coordinator (FDRC). Every region in FEMA has an FDRC.
2. Recovery Support Function coordinating structure.
3. Preparedness, resilience, and mitigation planning through pre- and post-disaster planning.

Recovery Support Functions[135] (RSFs) are the NDRF's coordinating structure for providing recovery support to local governments. They bring all stakeholders together to problem-solve. RSFs improve community access to resources and foster coordination among state and federal agencies. RSFs serve as a vehicle for information sharing before and after a disaster. Post-disaster, RSFs coordinate timelines, activities, and resources across federal agency partners. They also leverage funding opportunities and other resources across nonfederal organizations and partners. Other potential recovery partners include academia, the private sector, state agencies, regional organizations, nonprofits, faith-based organizations, and foundations.

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[132] United States, White House Office of Intergovernmental Affairs, *Recovery through Federal-State-Local Partnership*, United States, Washington, D.C., 2018, Accessed January 31, 2020, https://www.whitehouse.gov/wp-content/uploads/2019/03/DisasterRecovery.pdf

[133] "Funding Opportunities," The Economic Development Administration, Accessed January 31, 2020, https://eda.gov/funding-opportunities/

[134] FEMA. 2016. *National Disaster Recovery Framework*. Second Edition. https://www.fema.gov/national-disaster-recovery-framework.

[135] For more information about Recovery Support Functions, visit https://www.fema.gov/recovery-support-functions.

There are six RSFs (see Table 1) and within each is a coordinating agency and primary and supporting agencies and organizations that build a network of resources (e.g., technical assistance, steady state funding programs) that can be brought to bear in a post-disaster situation.

Table 1
Recovery Support Functions

Recovery Support Function (RSF)	Lead Coordinating Agency
Community Planning and Capacity Building[136]	Department of Homeland Security/FEMA
Economic Recovery[137]	Department of Commerce
Health and Social Services[138]	Department of Health and Human Services
Housing[139]	Department of Housing and Urban Development
Infrastructure Systems[140]	U.S. Army Corps of Engineers
Natural and Cultural Resources[141]	Department of the Interior

FEMA's Interagency Recovery Coordination groups (IRCs) work with states and communities pre- and post-disaster on a variety of issues (e.g., recovery and resiliency planning, implementation of post-disaster recovery strategies, technical expertise and training) and coordinate with federal partners to identify resources for communities and funding gaps community may have.

There are a number of resources from federal agencies that support community recovery.

- Community Planning and Capacity Building Recovery Resources[142]
    - Community Recovery Management Toolkit[143] (a compilation of guidance, case studies, tools, and training to assist local communities as they are in the midst of managing recovery post-disaster

[136] "Community Planning and Capacity Building Recovery Support Function," FEMA, April 2016, Accessed January 31, 2020, https://www.fema.gov/media-library-data/1466705670641-82c846c9cfe2db88a70bf2475d5785bf/RSF_CPCB_41416.pdf

[137] "Economic Recovery Support Function," FEMA, Accessed January 31, 2020, https://www.fema.gov/pdf/recoveryframework/economy_rsf.pdf

[138] Health and Social Services Recovery Support Function," U.S. Department of Health and Human Services, last updated January 16, 2019, Accessed January 31, 2020, https://www.phe.gov/about/oem/recovery/Pages/hss-rsf.aspx

[139] "Housing Recovery Support Function," FEMA, Accessed January 31, 2020, https://www.fema.gov/media-library-data/1466718036445-e2026c3a5907bf0cb86e75b3a3c51757/RSF_Housing_0623_508.pdf

[140] "Infrastructure Systems Recovery Support Function," FEMA, Accessed January 31, 2020, https://www.fema.gov/media-library-data/1466718036457-e2026c3a5907bf0cb86e75b3a3c51757/RSF_Infrastructure_Systems_0623_508.pdf

[141] "Natural and Cultural Resources Recovery Support Function (NCR RSF) Overview," U.S. Department of the Interior, Accessed January 31, 2020, https://www.doi.gov/recovery/about-recovery/ncr-rsf-overview

[142] "Community Planning and Capacity Building," FEMA, last updated October 1, 2019, Accessed January 31, 2020, https://www.fema.gov/community-planning-and-capacity-building

[143] "Community Recovery Management Toolkit," FEMA, last updated October 3, 2020, Accessed January 31, 2020, https://www.fema.gov/community-recovery-management-toolkit

- Disaster Financial Management Guide (draft)[144] (will help jurisdictions establish and implement sound disaster financial management practices)
- Recovery through Federal-State-Local Partnerships[145] (identifies a range of disaster resources available to states, tribes, and local communities to assist in recovery)

HUD resources:

- Community Development Block Grant (CDBG) Program[146]
- Distressed Cities Technical Assistance[147]
- Capacity Building for Community Development and Affordable Housing Program (Section 4)[148]
- Rural Capacity Building for Community Development and Affordable Housing Program (RCB)[149]
- Neighborhood Stabilization Program (NSP)[150]
- Brownfields Economic Development Initiative (BEDI)[151]

EPA programs and resources:

- Green Streets, Green Jobs, Green Towns (G3) Grant Program[152]
- Smart Growth – Funding Opportunities and Technical Assistance[153]
- Water Infrastructure and Resiliency Finance Center[154]
- Water Finance Clearinghouse[155]
- Watershed Academy[156]

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[144] "Disaster Financial Management Guide." (Draft). FEMA. September 12, 2019. Accessed January 31, 2020. https://www.fema.gov/media-library-data/1567781906291-4445608f37ae19a3c587af8a191e867c/Disaster_Financial_Management_Draft.pdf.

[145] White House Office of Intergovernmental Affairs. *Recovery through Federal-State-Local Partnerships*. December 2018. https://www.whitehouse.gov/wp-content/uploads/2019/03/DisasterRecovery.pdf.

[146] "Community Development Block Grant (CDBG) program," HUD, Accessed February 3, 2020, https://www.hudexchange.info/programs/distressed-cities/ https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs

[147] "Distressed Cities Technical Assistance," HUD Exchange, Accessed February 3, 2020, https://www.hudexchange.info/programs/distressed-cities/

[148] "Section 4 Capacity Building for Community Development and Affordable Housing Program," HUD Exchange, Accessed February 3, 2020, https://www.hudexchange.info/programs/section-4-capacity-building/

[149] "Rural Capacity Building for Community Development and Affordable Housing Program (RCB)," HUD, Accessed February 3, 2020, https://www.hud.gov/program_offices/spm/gmomgmt/grantsinfo/fundingopps/fy18rcb

[150] "Neighborhood Stabilization Program," HUD, Accessed February 3, 2020, https://www.hudexchange.info/programs/nsp/

[151] "Brownfields Economic Development Initiative," HUD Exchange, Accessed February 3, 2020, https://www.hudexchange.info/programs/bedi/

[152] "Green Streets, Green Jobs, Green Towns (G3) Grant Program," EPA, Accessed February 3, 2020, https://www.epa.gov/G3/green-streets-green-jobs-green-towns-g3-grant-program

[153] "Smart Growth Technical Assistance Programs," EPA – Smart Growth, Accessed February 3, 2020, https://www.epa.gov/smartgrowth/smart-growth-technical-assistance-programs

[154] "Water Infrastructure and Resiliency Finance Center," EPA, Accessed February 3, 2020, https://www.epa.gov/waterfinancecenter

[155] "Water Finance Clearinghouse, EPA – Water Data, Accessed February 3, 2020, https://www.epa.gov/waterdata/water-finance-clearinghouse

[156] "Watershed Academy," EPA, Accessed February 3, 2020, https://www.epa.gov/watershedacademy

- Healthy Watersheds Consortium Grants (HWCG)[157]
- Drinking Water State Revolving Funds (DWSRF)[158]
- Brownfields Grant Program[159]
- Five Star and Urban Waters Restoration Grant Program (RFP)[160]
- Building Blocks for Sustainable Communities[161]

USACE programs and resources:

- Engineering with Nature Initiative (EWN)[162]
- Silver Jackets[163]
- Flood Risk Management Program[164]
- Planning Assistance to States[165] – technical assistance to help with comprehensive planning for development, utilization, and conservation of water and related land resources

Economic Development Administration program and resources:

- Public Works[166] (helps communities expand and upgrade physical infrastructure)
- The Comprehensive Economic Development Strategy (CEDS)[167] supports local organizations with short and long-term planning efforts
- Local Technical Assistance and University Center Programs[168] (fills knowledge and information gaps that may prevent leaders in the public and nonprofit sector in distressed areas from making optimal decisions on local economic development issues)
- EDA Funding Opportunities[169]
- EDA and Disaster Recovery[170]

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[157] "Healthy Watersheds Consortium Grants (HWCG)," EPA, Accessed February 3, 2020, https://www.epa.gov/hwp/healthy-watersheds-consortium-grants-hwcg

[158] "Drinking Water State Revolving Fund (DWSRF)," EPA, Accessed February 3, 2020, https://www.epa.gov/dwsrf

[159] "Brownfields," EPA, Accessed February 3, 2020, https://www.epa.gov/brownfields

[160] "2020 Five Star and Urban Waters Restoration Grant Program RFP," EPA – Urban Water Partners, Accessed February 3, 2020, https://www.epa.gov/urbanwaterspartners/2020-five-star-and-urban-waters-restoration-grant-program-rfp

[161] "Building Blocks for Sustainable Communities," EPA – Smart Growth, Accessed February 3, 2020, https://www.epa.gov/smartgrowth/building-blocks-sustainable-communities

[162] "Engineering With Nature," U.S. Army Engineer Research and Development Center, Accessed February 3, 2020, https://ewn.el.erdc.dren.mil/

[163] "Silver Jackets," National Flood Risk Management Program, Accessed February 3, 2020, https://silverjackets.nfrmp.us/

[164] "Flood Risk Management Program," USACE, Accessed February 3, 2020, https://www.iwr.usace.army.mil/Missions/Flood-Risk-Management/Flood-Risk-Management-Program/

[165] "Planning Assistance to States," USACE – Public Services, Accessed February 3, 2020, https://www.nae.usace.army.mil/Missions/Public-Services/Planning-Assistance-to-States/

[166] "Public Works Program." U.S. Economic Development Administration. Accessed February 2, 2020. https://www.eda.gov/pdf/about/Public-Works-Program-1-Pager.pdf.

[167] "The Comprehensive Economic Development Strategy (CEDS)," EDA – CEDS, Accessed February 3, 2020, https://www.eda.gov/ceds/

[168] "Local Technical Assistance and University Center Programs," EDA, Accessed February 3, 2020, https://www.eda.gov/pdf/about/Local-TA-and-UC-Program-1-Pager.pdf

[169] "Funding Opportunities," EDA. Accessed February 3, 2020, https://eda.gov/funding-opportunities/

[170] "EDA and Disaster Recovery," EDA, Accessed February 3, 2020, https://eda.gov/disaster-recovery/

Department of the Interior programs and resources:

- Technical Preservation Assistance for Existing National Historic Landmarks[171]
- National Park Service Rivers, Trails, and Conservation Assistance Program[172] supports community-led natural resource conservation and outdoor recreation projects.
- Land and Water Conservation Fund (LWCF) Grants[173]
- Federal Lands to Parks Program[174]

Department of Agriculture programs and resources:

- National Urban and Community Forestry Program[175]
- Water and Waste Disposal Loan and Grant Program[176]
- Community Facilities Direct Loan & Grant Program[177]

USGS Flood Resiliency Resources

Mr. Brian McCallum, Assistant Director for Data, U.S. Geological Survey, South Atlantic Water Science Center

The mission of the U.S. Geological Survey (USGS)[178] is to serve the Nation "by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life."[179]

The USGS National Streamflow Network[180] has over 8,200 real-time, continuous stream gauges across the country that are used to monitor hydrological conditions (see Figure 23).

[171] "Technical Assistance," National Park Service, Accessed February 3, 2020, https://www.nps.gov/subjects/nationalhistoriclandmarks/technical-assistance.htm
[172] "Rivers, Trails, and Conservation Assistance Program," National Park Service, Accessed February 3, 2020, https://www.nps.gov/orgs/rtca/index.htm
[173] "Land and Water Conservation Fund," US Department of the Interior, Accessed February 3, 2020, https://www.doi.gov/lwcf
[174] "Federal Lands to Parks Program," National Park Service, Accessed February 3, 2020, https://www.nps.gov/orgs/1508/index.htm
[175] "Urban and Community Forestry Program," US Forest Service, Accessed February 3, 2020, https://www.fs.usda.gov/managing-land/urban-forests/ucf
[176] "Water & Waste Disposal Loan & Grant Program," USDA –Programs & Services, Accessed February 3, 2020, https://www.rd.usda.gov/programs-services/water-waste-disposal-loan-grant-program
[177] Community Facilities Direct Loan & Grant Program," USDA – Programs & Services, Accessed February 3, 2020, https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program
[178] "Who We Are." U.S. Geological Survey. Accessed February 2, 2020. https://www.usgs.gov/about/about-us/who-we-are.
[179] "Who We Are." U.S. Geological Survey. Accessed February 2, 2020. https://www.usgs.gov/about/about-us/who-we-are.
[180] For more information about the USGS National Streamflow Network, visit https://www.usgs.gov/mission-areas/water-resources/science/usgs-streamgaging-network?qt-science_center_objects=0#qt-science_center_objects.

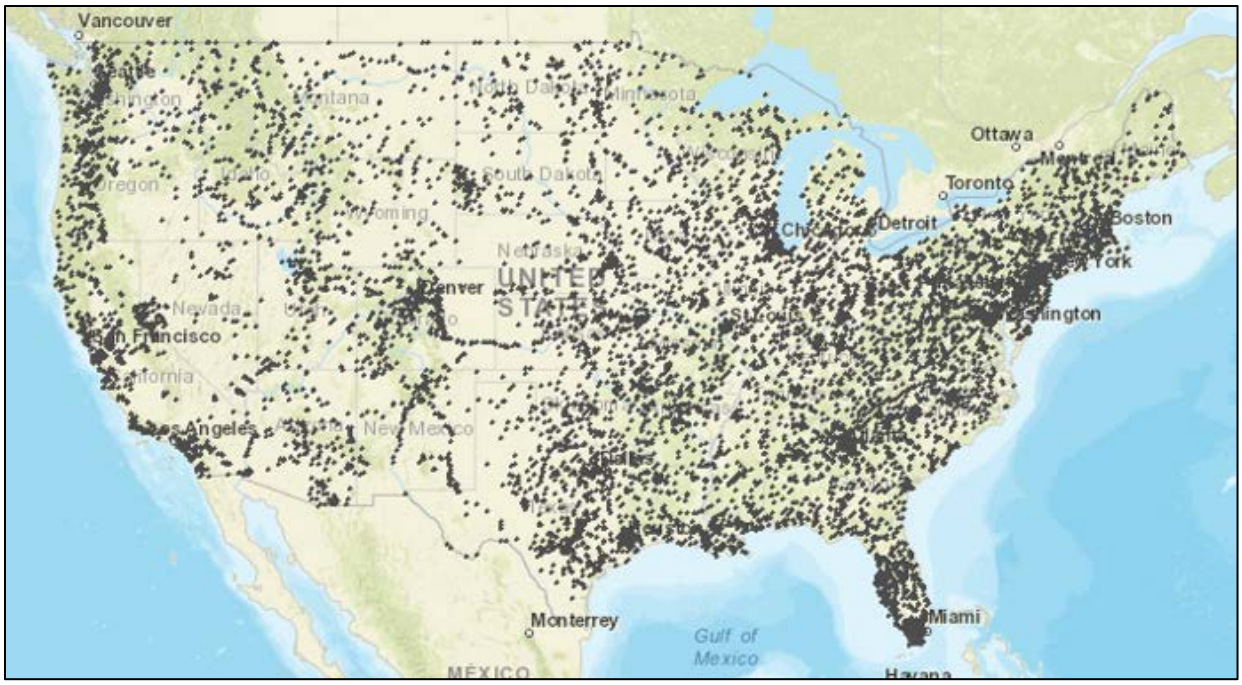

Figure 23. USGS stream gauge network.

Many federal agencies fund USGS stream gauges including USACE, FEMA (which mainly funds temporary or rapid deployment stream gauge efforts), and the Department of the Interior. Major users of USGS stream gauge data include the National Weather Service (NWS) and NOAA; the USGS provides the data and the NWS and NOAA use that data to keep the public informed. The USGS also partners with hundreds of state agencies with water observing systems using cooperative matching funds for stream gauge networks, water-quality sampling, groundwater monitoring, and interpretive studies.

USGS stream gauge data can be accessed through its National Water Information System.[181] All of the gauges collect data to national standards, so gauge data collected in one location in the U.S. is compatible with gauges across the country. This compatibility allows users to see how the conditions captured by a single gauge fits into state, regional, or national hydrological conditions.

Starting with Hurricane Rita in 2005, the USGS began short-term, rapid deployment approaches (e.g., storm surge technology) ahead of approaching storms. For example, submersible pressure transducers are placed along the coastline to measure storm surge. Instead of only capturing a high-water mark with no time reference, this technology allows the USGS to produce a full hydrograph which allows the National Hurricane Center[182] to make storm surge forecasts.

[181] "National Water Information System," USGS, last modified January 30, 2020, Accessed, January 31, 2020, https://waterdata.usgs.gov/nwis

[182] "Homepage," The National Hurricane Center, Accessed February 3, 2020, https://www.nhc.noaa.gov/

The USGS has a number of tools available to the public:

- USGS Hurricane Response[183]
- WaterWatch[184]
- WaterAlert[185]
- WaterNow[186]
- StreamStats[187]
- Flood Inundation Map Libraries[188]

The USGS is moving in a few new directions:

- Next Generation Water Observing Systems[189]
- All gauges will be converted to NAVD (North American Vertical Datum).
- Will be performing a network gap analysis of where more gauges are needed and why.
- Will work on how to visually present data uncertainty.
- Will work on how to estimate water flow at ungauged locations with temporary sensors.

Other resources:

- U.S. Geological Survey Water Science Strategy—Observing, Understanding, Predicting, and Delivering Water Science to the Nation[190]

NATIONAL WEATHER SERVICE (NWS)

Mr. Peter Corrigan, Hydrologist, National Weather Service, National Oceanic and Atmospheric Administration

NOAA includes the National Weather Service (NWS), regional offices, and 13 river forecast centers. NOAA also has national centers: the Storm Prediction Center, National Hurricane Center, Space Weather Prediction Center, Aviation Weather Center, the Weather Prediction

[183] "Hurricane Response," USGS, Accessed January 31, 2020, https://www.usgs.gov/hurricanes
[184] "Water Watch," USGS, last modified January 31, 2020, Accessed January 31, 2020, https://waterwatch.usgs.gov/
[185] "Water Alert," USGS, Accessed January 31, 2020, https://maps.waterdata.usgs.gov/mapper/wateralert/
[186] Water Now," USGS, last modified January 3, 2017, Accessed January 31, 2020, https://water.usgs.gov/waternow/
[187] "StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications," USGS, Accessed February 2, 2020, https://www.usgs.gov/mission-areas/water-resources/science/streamstats-streamflow-statistics-and-spatial-analysis-tools?qt-science_center_objects=0#qt-science_center_objects.
[188] "Flood Inundation Map (FIM) Libraries," USGS, Accessed February 2, 2020, https://www.usgs.gov/mission-areas/water-resources/science/flood-inundation-map-fim-libraries?qt-science_center_objects=0#qt-science_center_objects.
[189] "USGS Next Generation Water Observing System (NGWOS)," USGS, Accessed February 2, 2020. https://www.usgs.gov/mission-areas/water-resources/science/usgs-next-generation-water-observing-system-ngwos?qt-science_center_objects=0#qt-science_center_objects.
[190] Evenson, E.J., Orndorff, R.C., Blome, C.D., Böhlke, J.K., Hershberger, P.K., Langenheim, V.E., McCabe, G.J., Morlock, S.E., Reeves, H.W., Verdin, J.P., Weyers, H.S., and Wood, T.M. 2013. *U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation*. U.S. Geological Survey Circular 1383–G. https://pubs.usgs.gov/circ/1383g/circ1383-G.pdf.

Center, and the Water Center (new). The NWS' operational emphases are on river forecasting and flash flood forecasting. AHPS[191] [192] (Advanced Hydrologic Prediction Service) is one of the NWS' most well-known forecast products.

Recent developments in the hydrologic sciences include:

- MRMS[193] (Multi-Radar, Multi-Sensor) produces large amounts of data on rainfall (e.g., surface precipitation type, rate, hourly accumulations, etc.).
- FLASH[194] (Flooded Locations and Simulated Hydrographs) uses MRMS data to produce flash flood forecasts; the primary goal of FLASH is to improve the accuracy, timing, and specificity of flash flood warnings.
- National Water Model[195] is a revolution in forecasting; it is a hydrologic modelling framework that simulates observed and forecast streamflow over the entire continental United States.
- Flood Inundation Mapping[196] [197] provides guidance for the development of advanced hydrologic prediction service flood inundation mapping.

[191] AHPS is "a web-based suite of accurate and information-rich forecast products. They display the magnitude and uncertainty of occurrence of floods or droughts, from hours to days and months, in advance." From "AHPS." National Weather Service. Accessed February 2, 2020. https://water.weather.gov/ahps/about/about.php.
[192] AHPS products available at https://water.weather.gov/ahps/forecasts.php.
[193] More information about MRMS is available at https://www.nssl.noaa.gov/projects/mrms/.
[194] More information about the FLASH system is available at: "Home," Flash, Accessed January 31, 2020, http://flash.ou.edu/
[195] More information about the National Water Model is available at https://water.noaa.gov/about/nwm.
[196] More information about NWS Flood Inundation Mapping is available at https://water.weather.gov/ahps/inundation.php.
[197] NOAA. 2012. *The National Weather Service: Inundation Mapping Release 2.0.* Accessed February 2, 2020. https://water.weather.gov/ahps/inundation_mapping_user_guide.pdf.

APPENDIX 1. AGENDA

RESILIENTAMERICA ROUNDTABLE

MITIGATION ACTIONS AND OPPORTUNITIES TO ADDRESS COMMUNITY FLOOD RISK

AGENDA

December 10-11, 2019
Atlanta, GA

Meeting goal: To bring together experts and community representatives from across the United States to engage in an interactive discussion focused on solutions and actions for mitigating and building resilience to flood risk. The purpose of the workshop is to:

- Share information learned during community dialogues and provide opportunities for peer to peer learning with community stakeholders, state and federal agencies, and other participants
- Explore ways communities are addressing some of their key mitigation challenges
- Learn about federal and state resources available to communities for mitigation

Tuesday, December 10, 2019	
9:00 – 9:15 a.m.	**Welcome** – **Linda Langston**, Chair, Resilient America Roundtable
9:15 – 10: 00 a.m.	**Featured Discussion: Urban Flooding: How flooding has evolved and is impacting communities** – **Lauren Alexander Augustine**, Executive Director, Gulf Research Program, National Academies of Sciences, Engineering, and Medicine – **Gerald E. Galloway**, Glenn L. Martin Institute Professor of Engineering, University of Maryland
10:00 – 10:15 a.m.	**Break**
10:15 – 11:15 a.m.	**Addressing Mitigation Challenges: Living with Flood Risk** *Moderator: Arrietta Chakos, Principal, Policy Advisor, Urban Resilience Strategies*

	– **Christine Morris**, Resilience Consultant – **Mark Wilbert**, Chief Resilience Officer, City of Charleston
11:15 am – 12:00 p.m.	**Financing Resilience** – **Janice Barnes**, Founder, Climate Adaptation Partners – **Benjamin Cohen**, Director of Urban and Coastal Resilience, Quantified Ventures
12:00 1:00 p.m.	**Working lunch**
1:00 – 2:30 p.m.	**Using Science and Data to inform Decision Making** *Moderator: Lauren Alexander Augustine, Executive Director, Gulf Research Program, National Academies of Sciences, Engineering, and Medicine* – **Jon Derek Loftis**, Assistant Research Scientist, Lead, Storm Sense Project, Virginia Institute of Marine Science – **Jeffrey Warren**, North Carolina Policy Collaboratory, University of North Carolina, Chapel Hill – **Larry Weber**, Professor, Civil and Environmental Engineering and Edwin B. Green Chair in Hydraulics, University of Iowa – **Brandon Wong**, Research Scientist, Department of Civil and Environmental Engineering, University of Michigan
2:30 – 2:45 p.m.	**Break**
2:45 – 3:00 p.m.	**Resilient America Program: Flood Mitigation And Community Engagement Project – What We Learned** – **Charlene Milliken**, Senior Program Officer, Resilient America Program, National Academies of Sciences, Engineering, and Medicine
3:00 – 4:00 p.m.	**Community Actions for Mitigation** *Moderator: Jane Cage, Principal, InsightFive22 and Senior Advisor for Homeland Security and Emergency Management, Innovative Emergency Management* – **Mark DeLuca**, Deputy Director, Howard County Bureau of Environmental Services – **Christy LeBatard**, Director of Engineering, City of Biloxi – **Alan Robertson**, Project Manager of Beach Renourishment and Dune Restoration, Savannah/Tybee – **Leigh-Anne Weitzenfeld**, Water Quality Administrator, Public Works, City of Roanoke

4:00 – 5:00 p.m.	**Community Discussion – Flood Mitigation Activities and Investments** *(Open Discussion)*
5:00 p.m.	**Closing Remarks/Adjourn**
5:30 p.m.	**Reception**
	Wednesday, December 11, 2019
9:00 – 9:15 a.m.	**Welcome and Debrief**
9:15 – 10:30 a.m.	**State Mitigation Programs and Resources** *Moderator: Dan Burger, Chair, Charleston Resilience Network* – **Terry Lunn**, Mitigation Division Director, Georgia Emergency Management Agency – **Kyle Overly**, Director of Risk Reduction, Maryland Emergency Management Agency – **Brian Shoun**, State CRS Coordinator Georgia Department of Natural Resources
10:30 – 10:45 a.m.	**Break**
10:45 – 12:15 p.m.	**Federal Mitigation Resources, Funding, and Technical Assistance** *Moderator: David Thomas, Senior Policy Advisor, Mitigation Directorate, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency* – **Peter Corrigan**, Hydrologist, National Weather Service, National Oceanic and Atmospheric Administration – **Richard Flood**, Federal Emergency Management Agency, Region IV – **Wynne Kwan**, Community Planning & Capacity Building Coordinator, Federal Emergency Management Agency, Region III – **Brian McCallum**, Assistant Director for Data, U.S. Geological Survey South Atlantic Water Science Center
12:15 – 1:15 p.m.	**Working Lunch**
1:15 p.m.	**Adjourn**

APPENDIX 2. SPEAKER & MODERATOR BIOGRAPHIES

Lauren Alexander Augustine, Executive Director, Gulf Research Program, National Academies of Sciences, Engineering, and Medicine
Dr. Lauren Alexander Augustine is the Executive Director for the Gulf Research Program. She is responsible for overseeing all aspects of management and use of the criminal settlement funds from the Deepwater Horizon disaster that were entrusted with the National Academies by the federal government. This includes fulfilling the vision, defining the strategic direction, and leading the development and implementation of this multi-dimensional, science-based program. Since her tenure at the National Academies began in 2002, Lauren has gained experience working in a variety of roles on a broad range of topics pertaining to water, natural disasters, and resilience. Prior to joining the Gulf Research Program in 2018, she served as Director of the Resilient America Program, which supports communities' efforts to build resilience to extreme events using science and diverse stakeholder engagement. In addition, she has formerly served as Country Director for the African Science Academy Development Initiative (ASADI), a decadal program that built scientific capacity in national academies across Africa; as Director of the Disasters Roundtable; and as a study director for the Water Science and Technology Board. Outside of her work at the National Academies, Lauren has served on the World Economic Forum's Global Agenda Council on Risk and Resilience; was a member of the Advisory Board for the American Geophysical Union's Thriving Earth Exchange program; and was a juror for two resilience competitions, Rebuild by Design for recovery after Hurricane Sandy and Resilience by Design in San Francisco. She is also a NATO Expert for the Civil Protection Group. Lauren earned her B.S. in applied mathematics and systems engineering and her M.S. in environmental planning and policy from the University of Virginia, and her Ph.D. in an interdisciplinary program that combined physical hydrology, geomorphology, and ecology from Harvard University.

Janice Barnes, Founder, Climate Adaptation Partners; Resilient America Roundtable member
Dr. Janice Barnes is currently serving as a managing partner with Climate Adaptation Partners. Prior to this Janice was the director of resilience at Waggonner & Ball. Dr. Barnes works with clients to identify their risks and vulnerabilities and to meet their resilience goals. With nearly 30 years of design experience bridging practical applications with empirical research, Janice recognizes critical organizational processes and links these to appropriate design responses. Internationally recognized for this expertise, Janice links environmental, social and economic indicators to advance resilience principles and connect knowledge across communities. Dr. Barnes has a Ph.D. from the University of Michigan, an M.S. in Architecture from the University of Michigan, an M. Arch from Tulane University, and a B.A. from the University of Tennessee.

Daniel Burger, Chair, Charleston Resilience Network; Resilient America Roundtable Member
Daniel Burger is the founding chair of the Charleston Resilience Network (CRN). CRN is a collaboration of public, private, and nonprofit organizations seeking to enhance the capacity of individuals, communities, institutions, businesses and systems within the Charleston region to survive, adapt and grow despite episodic natural disasters and chronic climate hazards. Inspired

by opportunities to connect social and technical science with public policy, Mr. Burger is committed to developing solutions to complex resource management and inter-governmental planning challenges. Since 2004, Mr. Burger has served in senior leadership positions for the South Carolina Coastal Zone Management Program. His efforts have focused on enhancing the delivery of value-added products, policy analysis, and technical planning assistance to stakeholders as well as building the cooperative capacity among governments to manage fragile coastal resources. Mr. Burger currently serves on numerous local, state, and regional advisory boards including Carolinas Integrated Sciences and Assessments (CISA, a NOAA RISA), S.C. Sea Grant Climate Advisory Committee, Charleston Harbor Watershed Resilience Study Committee, Charleston Area Transportation Policy Committee, and the College of Charleston Master of Public Administration Program. Mr. Burger also represents the CRN to the Regional Consortium Coordinating Council (RC3). Mr. Burger is a member of the American Society of Adaptation Professionals (ASAP) and the American Shore and Beach Preservation Association (ASBPA). Prior to his work in South Carolina, Mr. Burger worked to advance environmental public policy and build the capacity of nonprofit organizations in Maryland. Mr. Burger earned an M.P.A. in Public Administration from the College of Charleston and a B.A. in Government and Industrial Sociology from Western Maryland College.

Jane Cage, Principal, InsightFive22; Resilient America Roundtable member
Jane Cage is the principal at InsightFive22. Ms. Cage's professional experience also includes consulting on projects around long-term recovery and resilience. She has been an instructor for FEMA for classes based on community long-term recovery and is certified to teach E0210 and L0205 - Disaster Recovery: The Role of the Local Community and L0209: State Recovery Planning and Coordination. She also serves on the external assessment panel for Colorado State University Center for Risk-Based Community Resilience Planning, a NIST-funded Center of Resilience. After the city of Joplin was impacted by an EF-5 tornado in May 22, 2011, Ms. Cage served as the volunteer chairman of the newly formed Citizens Advisory Recovery Team (CART). As CART leader, she led the group in listening to citizens about their vision for a recovered Joplin. The resulting report became the basis for the long-term recovery plan for Joplin. For over 30 years, Cage worked in the IT channel as an entrepreneur as a partner and COO of Heartland Technology Solutions (HTS), a regional business networking firm with offices in five states. Ms. Cage is a graduate of the National Preparedness Leadership Initiative at Harvard University and the FEMA Emergency Management Institute. Ms. Cage holds a B.A. in Economics and a B.A. in Spanish from Wake Forest University

Arietta Chakos, Public Policy Advisor, Urban Resilience Strategies; Resilient America Roundtable member
Arrietta Chakos is a public policy advisor on urban resilience, working on community resilience strategies and multi-sectoral engagement. Her work as an advisor with the Association of Bay Area Governments focuses on resilience planning the S.F. Bay Area, emphasizing development of common resilience policies and implementation measures. The initiative, sponsored by the Federal Emergency Management Agency and the 100 Resilient Cities Initiative launched by the Rockefeller Foundation, engages communities to accelerate resilience action. Ms. Chakos is a member of the Resilience Roundtable and the Committee to Advise the U.S. Global Change Research Program at the National Academy of Sciences; she chairs the Housner Fellow

committee at the Earthquake Engineering Research Institute. Ms. Chakos served as research director at the Harvard Kennedy School's Acting in Time Advance Recovery Project. She worked extensively in local government directing innovative risk mitigation initiatives, intergovernmental coordination, and multi-institutional negotiations at the City of Berkeley, California.

Benjamin Cohen, Director of Urban and Coastal Resilience, Quantified Ventures
Ben Cohen is the Director of the Urban and Coastal Resilience practice at Quantified Ventures, an impact investment intermediary that specializes in structuring outcomes-based financing, notably Environmental Impact Bonds (EIBs). Ben led the structuring of the first-ever Impact Bond to be publicly offered with the City of Atlanta's Department of Watershed Management. The Atlanta EIB, which closed at the beginning of 2019, financed green infrastructure to manage stormwater and mitigate local flooding and water quality issues in economically distressed neighborhoods. In addition to green infrastructure, Ben also works on outcomes-based investments in coastal wetland restoration, wildfire risk reduction, and workforce development. He previously worked on green infrastructure finance as an MBA intern at Encourage Capital, and has experience in resilience internationally through his work at the UN Development Programme's global climate adaptation team, and as a Fulbright Scholar researching climate vulnerability in Nepal. He is an alum of the dual M.B.A and Master of Environmental Management program at Yale, and also holds a Bachelor's degree in Biology from Williams College.

Peter Corrigan, Hydrologist, National Weather Service
Peter Corrigan is a Senior Service Hydrologist with the National Weather Service (NWS) in Blacksburg, VA. He has worked with the National Weather Service for over thirty years. Previously he held the position of Research Meteorologist and Hydrologist, and he has worked as a Senior Service Hydrologist in multiple locations across the U.S. and in San Juan, Puerto Rico. He graduated from the University of Rhode Island with a B.S. in Geography and Meteorology, and from the University of Delaware with an M.S. in Geography and Climatology.

Mark DeLuca, Deputy Director, Howard County Bureau of Environmental Services
Mark DeLuca is the Deputy Director of Public Works and Chief of Environmental Services for the Howard County. After an 18-year career in the private sector, DeLuca joined Howard County Public Works in 2001 where he has held several key positions in the department, most notably, Deputy Director since 2008. In addition to his deputy director responsibilities, he has served as chief of Environmental Services since 2012, providing strategic oversight to the county's storm water management and flood mitigation programs, illicit discharge program, county landfills, recycling programs, and residential curbside collections services. Mr. DeLuca has also served on many county-citizen workgroups and task forces as technical advisor and department representative, including the Historic Ellicott City Flood Workgroup and the Citizens Advisory Group both formed after the 2016 flood, and the 2017 Citizen Task Force on Adequate Public Facilities. He is a past president of the County Engineers Association of Maryland (CEAM) and continues to represent CEAM on the Maryland Quality Initiative (MdQI) Innovation subcommittee and the Maryland State Workgroup on Connected and Autonomous Vehicles.

Brigadier General Gerald E. Galloway, Jr., USA, Retired, Glenn L. Martin Institute Professor of Engineering, University of Maryland

Gerald Galloway, PE, PhD is a Glenn L. Martin Institute Professor of Engineering, Department of Civil and Environmental Engineering, University of Maryland and acting director of the University's Center for Disaster Resilience. His teaching and research focus is on water resources policy, resilience, and disaster risk management under climate change. He serves as a consultant to several international, federal, state and non-governmental agencies and has been involved in water projects in the US, Europe, Asia and South America. In 1993, he was assigned to the White House to lead the study of the Great Mississippi Flood of that year. From 2008-2018 he was a member of the Louisiana Governor's Advisory Commission on Coastal Protection and Restoration and is currently a Governor's appointee to the Maryland Coast Smart Council. In 2014, he was appointed chair of an international panel of experts to examine the flooding threats to Florence, Italy and by the government of Singapore to a panel of experts advising on sea level rise challenges. From 2016-2019 he co-chaired a National Academy Committee examining the measurement of community resilience. He is an elected member of the National Academy of Engineering, the National Academy of Public Administration, and the National Academy of Construction, and a 38 year veteran of the US Army who retired as a Brigadier General and Dean (Chief Academic Officer) at the US Military Academy at West Point.

Wynne Kwan, Community Planning & Capacity Building Coordinator, FEMA Region III

Wynne Kwan, AICP, LEED AP (BD+C) is the Community Planning and Capacity Planning (CPCB) Coordinator at FEMA Region III in Philadelphia, Pennsylvania. During blue skies, Wynne works with various Federal and non-federal partners to help State, Local, Tribal, and Territorial (SLTT) governments prepare for disaster recovery, through the communication and coordination of guidance materials, tools, training, and other resources that enhance SLTT capacity and resilience. Post-disaster, Wynne coordinates and facilitates support among CPCB partners for the planning, capacity, and resilience building capabilities needed by local or tribal governments. Prior to joining FEMA, Wynne worked as a Community Planner within the Infrastructure Development and Recovery (IDR) Program at DHS-Infrastructure Protection (now the Cybersecurity and Infrastructure Security Agency (CISA)) developing tools and guidance to help SLTT governments better integrate infrastructure resilience planning into existing planning initiatives/efforts. Wynne worked as a consultant providing industrial/economic development strategy, military base planning, environmental planning, and hazard mitigation planning support to international, federal, state, and local government clients.

Linda Langston, Consultant, National Association of Counties; Chair, Resilient America Roundtable

Linda Langston is the former Director of Strategic Relations for the National Association of Counties in Washington, DC and continues in a consultant role. Ms. Langston previously served on the Linn County Board of Supervisors from 203-2016. In Iowa she serves as the Vice Chair of the City of Cedar Rapids Planning Commission. Ms. Langston is a former president of the National Association of Counties (NACo). Her presidential initiative was Resilient Counties, which focused on building communities' capacity to be ready, resilient, agile and adaptive in the face of natural, manmade and economic disasters. Her home county was devastated by flooding in 2008. Also during her time at NACo she served as chairs of the Health Steering

Committee, Healthy Counties Advisory Board, Finance Committee, and Arts and Culture Commission. Her outstanding leadership in arts and culture earned her the 2009 Americans for the Arts' Public Official of the Year Award. Ms. Langston is a member of the Resilient America Roundtable for the National Academy of Sciences and just completed six years on National Advisory Council for the Federal Emergency Management Agency. Born in Chicago and raised in Iowa, Langston graduated from Knox College in Galesburg, Illinois with a degree in history. She is a 2007 graduate of Harvard's Kennedy School of Government for State and Local Officials.

Christy LeBatard, Director of Engineering, City of Biloxi

Christy LeBatard, P.E. is the Director of Engineering as well as City Engineer for the City of Biloxi, MS and has worked for the City for 17 years. She received her Bachelors of Science Degree in Civil Engineering from University of South Alabama in 2002 and her Masters of Business Administration from William Carey College in 2005. At the City of Biloxi, she is responsible for the contract and construction management of various types of projects from conception through design, procurement, construction and close out. Projects include not only water, sewer, and drainage, but also buildings, parks, boardwalks, piers and harbors. She has been instrumental in helping the City manage Hurricane Katrina recovery projects. In her position as Director and City Engineer she manages an annual capital projects budget of over 70 million dollars.

Jon Derek Loftis, Assistant Research Scientist, Lead, Storm Sense Project, Virginia Institute of Marine Science

Dr. Derek Loftis is an Assistant Research Scientist working in the Center for Coastal Resources Management and the Virginia Commonwealth Center for Recurrent Flooding Resiliency at the Virginia Institute of Marine Science (VIMS). Dr. Loftis graduated with a Ph.D. in Marine Science in 2014 from VIMS at the College of William & Mary upon completing his dissertation research focusing on street-level flood forecasting in New York City during 2012 Hurricane Sandy. Dr. Loftis' hydrodynamic modeling research at VIMS focuses on: (1) development of numerical simulations and inundation forecasts for regions prone to flood damage, (2) validation of model accuracy using drones, sensors, citizen science, and satellite remote sensing observations, and (3) engineering resilient solutions to enhance adaptability to future flood events in the interest of protecting human life and valuable infrastructural assets. His research has recently been featured in Esri's ArcUser Magazine (3D Flood Modeling), AWS' Blog (Sensor-Driven Automated Flood Alerting), NPR's Science Friday, and Esri's Blog (Citizen Science Flood Monitoring). Dr. Loftis teaches remote sensing and advanced geographic information systems classes at VIMS and William & Mary, and he is the project lead and a developer of the hydrodynamic model used in the StormSense Project in the Greater Hampton Roads Region of Tidewater Virginia.

Terry Lunn, Hazard Mitigation Manager, Georgia Emergency Management Agency/Homeland Security

Terry Lunn is the Manager of the Hazard Mitigation Department for the Georgia Emergency Management and Homeland Security Agency (GEMA/HS) and is responsible for the coordination and implementation of comprehensive Hazard Mitigation programs in Georgia. Mr. Lunn has worked in support of mitigation programs since 1992 and has been with GEMA/HS since 1995, and has served as the Hazard Mitigation Manager since 1997. His

department delivers high levels of customer service and assistance to local governments in all phases of the Hazard Mitigation grant process, from application development, training and local briefings, to on-site technical assistance.

Brian McCallum, Assistant Director for Data, Georgia South Atlantic Water Science Center
Brian McCallum graduated from the University of Nebraska-Lincoln with a bachelors (1991) and master's degrees (1992) in civil engineering. He worked as a student in the U.S. Geological Survey (USGS) Orlando, Florida office while still in school. In 1993, he started full-time with the USGS Baton Rouge, Louisiana office where he installed and operated an ALERT flood warning system and helped form the Louisiana HydroWatch, a statewide network of monitoring gages with products such as the first-ever Flood Tracking Chart. In 2000, Brian became the Assistant Director of Hydrologic Monitoring for the USGS Georgia Water Science Center in Norcross, Georgia. In 2014, the Georgia office was merged into the South Atlantic Water Science Center, where Brian is now the Assistant Director for Data-Georgia and oversees a program of more than 380 stream gages. He has been active in the National Hydrologic Warning Council and the International Association of Emergency Managers. Since 2014, Brian has been the program coordinator for an extensive collaboration between the United States and Brazil for water resources monitoring. This year he is also leading a national effort in the USGS to merge data feeds into a unified water viewer. Brian loves spending time with family, following Nebraska football, and traveling. He has been married since 1992 and has two daughters.

Charlene Milliken, Senior Program Officer, Resilient America Roundtable, National Academies of Sciences, Engineering, and Medicine
Dr. Charlene Milliken is a senior program officer for the Resilient America Roundtable where she manages the program's portfolio of projects. Before joining the National Academies of Sciences, Engineering, and Medicine in 2015, she worked for seven years in the Department of Homeland Security's (DHS) Science & Technology Directorate (S&T) where she was involved in programs and activities related to community resilience, terrorism, improvised explosive devices, technology transition, strategic communications, risk communication, and social media use during disasters. Most recently, Dr. Milliken was in the DHS S&T Office of University Programs supporting management of the Centers of Excellence Program. While at DHS, she also conducted research and participated in interagency efforts focused on national and homeland security issues. Dr. Milliken was a National Defense and Global Security S&T Fellow through the American Association for the Advancement of Science in 2007-2009. She received a B.A. degree in international relations from the University of Southern California, and earned her Ph.D. in anthropology from the University of Pittsburgh. She conducted her dissertation research in Peru, where she investigated mortuary rituals and ancestor veneration of the ancient Wari civilization.

Christine Morris, Consultant
Ms. Morris is an independent contractor providing consulting services to clients interested in developing robust resilience programs. She served as the first Chief Resilience Officer for the City of Norfolk, VA for the past five years. In October 2015 Norfolk became the third city in the 100 Resilient Cities network to launch a Resilience Strategy. In January 2016 in partnership with the Commonwealth of VA, the City received 120.5 million dollars under HUD's National Disaster

Resilience Competition. In 2019 the Norfolk Resilience Office in partnership with the Norfolk's Housing Authority successfully competed for a 30 million dollar Choice Neighborhood Grant to resiliently revitalize the St. Paul's area of Norfolk. Ms. Morris began working for the city as an Assistant to the City Manager in Markh of 2013 concentrating on areas of workforce development and economic vitality including entrepreneurship and growing local business. She worked with Elevate Early Education to establish the New School, a state-wide demonstration preschool partnership with the University of Virginia. Prior to joining Team Norfolk, she served as Vice President of Initiatives for the Hampton Roads Community Foundation. She holds a BA from the University of Pennsylvania and a Master's degree in International Affairs from George Washington University.

Kyle Overly, Director of Risk Reduction, Maryland Emergency Management Agency
Kyle Overly is an experienced practitioner & educator who is currently the Director of Disaster Risk Reduction at the Maryland Emergency Management Agency (MEMA). In this capacity he is responsible for leading five agency branches and programs including Hazard Mitigation, Risk Analysis & Recovery, Public Assistance, Communications & Outreach, and Non-Governmental Services. As a member of MEMA's senior leadership he assists with shaping the direction of emergency management policy in Maryland and directing the agency towards realizing its overarching vision to shape a Resilient Maryland where communities thrive. Previously Kyle was the Planning Branch Manager for MEMA where he was responsible for leading MEMA's team of preparedness planners, setting state planning priorities, and coordinating planning efforts with local, state, and Federal agencies. Kyle also served as a Preparedness Planner and the Prevention/Protection program manager where he developed Maryland's Prevention/Protection Mission Area, the State's Special Events Program, and supported a number of other statewide efforts. Kyle led efforts to prepare for numerous large events in the State including the 2014 Star-Spangled Spectacular and the 2015 Gubernatorial Inauguration. Prior to joining MEMA Kyle worked in the private sector. In this capacity he led planning projects for clients across the United State ranging from hazard mitigation, evacuation, emergency operations, and medical needs efforts. He also supported clients in their emergency operations centers during Hurricane Irene in 2011 and Hurricane Sandy in 2012. Aside from his practical experience Kyle also teaches undergraduate emergency management and homeland security courses for the University of Maryland system. Kyle holds a Master of Science in Fire & Emergency Management Administration from Oklahoma State University and is a Certified Emergency Manager.

Alan Robertson, Principal, AWR Strategic Consulting
Alan is Principal of AWR Strategic Consulting, a management consulting firm working with a variety of clients on issues of strategy and execution. Among his clients is the City of Tybee Island, where he also resides. He is Project Manager for the City's dune restoration, beach nourishment, and marsh evaluation. Alan led the development of the dune restoration plan, writes grant proposals including those for the State of Georgia's Department of Community Affairs and the National Fish and Wildlife Foundation grants, coordinates with the various regulatory agencies that support the City, and manages the day-to-day execution of the restoration plan in concert with the appropriate City staff. Alan is a member of the Tybee Island Planning Commission and was formerly Chairman of the Master Plan Committee. His first

career was investment management. He was most recently Executive Vice President of Northern Trust Company, Global Head of Sales and Service for Northern Trust Asset Management, a Member of the Operating Group of Northern Trust Corporation, and Board and Audit Committee Member of Northern Trust Investment, N.A. Alan grew up on the Eastern Shore of Maryland, enjoying the Chesapeake Bay and its environs from Ocean City, MD to Virginia Beach, VA. Alan and his family have lived on or near the water for most of their lives, including three years in Hong Kong. He is fortunate to have traveled the world and has explored waters from Alaska to Palau. Alan's work today is a natural extension of his desire to give back while bringing his experience to the opportunities and challenges of living in a Georgia coastal community.

Brian Shoun, State CRS Coordinator, Georgia Floodplain Management, Georgia Department of Natural Resources – Environmental Protection Division

Brian Shoun currently works for the State of Georgia's Floodplain Unit within the Department of Natural Resources, Environmental Protection Division. He provides technical guidance, training, and support to over 600 communities in Georgia concerning floodplain management, flood control, urban flooding, and NFIP rules and regulations. He has 34 years of engineering experience within the fields of stormwater, floodplain, drainage systems, green infrastructure, low impact development, and erosion control. Prior to working for the State of Georgia he worked for five different local governments in Georgia as a County and City Engineer, for 26 years. Since 1993 he has worked through a major flood disaster that flooded 7,500 homes (Alberto 1993), through over ten presidential declared disaster areas, and has worked in recovery, FEMA grants, technical support, and pre-disaster mitigation (concepts, design, construction, and financing). He is registered as a Professional Engineer in Alabama and Georgia and a certified Floodplain Manager by the Association of State Floodplain Managers (ASFPM). He has also served as a committee member for Georgia's Stormwater Management Manual (The Blue Book).

Jeffrey Warren, Research Director of North Carolina Policy Collaboratory, University of North Carolina, Chapel Hill

Dr. Jeffrey Warren is currently serving as the research director for the North Carolina Policy Collaboratory at the University of North Carolina Chapel Hill. As director Dr. Warren is responsible for research oversight at the North Carolina Policy Collaboratory, liaising between researchers in the UNC system and the NC General Assembly on natural resource issues, and making natural resources management recommendations developed by the Collaboratory to the NC General Assembly. Formally trained as a marine geologist, Jeff Warren has spent the past fifteen years in State-level science policy positions, including the coastal hazards policy specialist for the North Carolina Division of Coastal Management (2004 to 2010) and the science advisor for the North Carolina Senate President Pro Tempore (2011 to 2017). Dr. Warren earned his BSc from the University of Arizona (1994), his MSc from Auburn University (1997), and his PhD from the University of North Carolina at Chapel Hill (2006). Dr. Warren's academic research included field sites in the southeastern US, northern Mexico, the East and South China Seas, and Antarctica.

Larry Weber, Executive Associate Dean of the UI College of Engineering, Iowa Flood Center
Dr. Larry Weber is a professor of civil and environmental engineering at the University of Iowa (UI) and a research engineer at IIHR—Hydroscience & Engineering (IIHR). Weber is a Fellow of the American Society of Civil Engineers and holds the Edwin B. Green Chair in Hydraulics in the UI College of Engineering. Weber was the director of IIHR (a world-renowned research institute focused on research, education, and public service in hydraulic engineering and fluid mechanics) for 13 years and co-founded the Iowa Flood Center and the Iowa Nutrient Research Center. Weber's research interests include fish passage facilities, laboratory hydraulic modeling, river mechanics, hydropower, computational hydraulics, water quality, and watershed processes. Weber serves as primary investigator of the Iowa Watershed Approach, a 97 million dollar HUD-funded statewide project that engages with Iowans to move toward a more flood-resilient state, while also improving water quality, creating new habitat, and improving the quality of life and health for citizens. Weber has coauthored 63 peer-reviewed journal articles and has directed more than 170 million dollars of externally supported research funded by federal, state, and private organizations. His awards and honors are many, including the ASCE Hunter Rouse Hydraulic Engineering Award, the Iowa Board of Regents Faculty Excellence Award, and the Johnson County Heritage Trust Conservation Award for grassroots conservation efforts. Weber holds B.S., M.S., and Ph.D. degrees in civil and environmental engineering from the University of Iowa.

Leigh-Anne Weitzenfeld, Water Quality Administrator, Public Works, City of Roanoke
Leigh-Anne Weitzenfeld is the Water Quality Administrator for the City of Roanoke in the Stormwater Division. Leigh-Anne works to restore the health of local streams, educates on key environmental issues, and facilitates partnerships and collaboration with the community to achieve a Clean Water Legacy in the Roanoke Valley. She administers the City's MS4 Stormwater Permit, oversees the TMDL Action Plans (stream pollution diets), serves as the City's Floodplain Manager, and oversees the Community Rating System Program. She has experience with green infrastructure (particularly green roofs) and has been self-employed as a landscape designer. Leigh-Anne holds a Master's degree in Natural Resources from the Center for Leadership in Global Sustainability at Virginia Tech and a Botany degree from North Carolina State University.

Mark Wilbert, Chief Resilience Officer, City of Charleston
Mark Wilbert is the Chief Resilience Officer for the City of Charleston, South Carolina. Mark is focused on leading city staff and citizens in planning for the effects of changing weather, flooding and sea level rise in a thriving city of 150,000 residents in a region with seven million visitors annually. Since becoming Charleston's first Chief Resilience Officer in 2018, Mark has led the development and implementation of the City of Charleston's Flooding and Sea Level Rise Strategy, and has served as city project lead for the recently completed Dutch Dialogues. He also continues as city project lead for the U.S. Army Corps of Engineers Flood Risk Management Study for the Charleston Peninsula and is leading the city team through an All Hazards Risk and Vulnerability Analysis. Prior to assuming his current role, Mark served as the City's Emergency Management Director for five years following active duty service in the U.S. Coast Guard for 35 years, retiring as Captain. During his Coast Guard career he was involved in planning and responding to numerous weather related disasters, September 11th related

events, and several large events including the G-8 Summit in 2004 and the Deepwater Horizon Oil Spill in 2010.

Brandon Wong, Research Scientist, University of Michigan
Dr. Brandon P. Wong is a Research Scientist at the University of Michigan, where he recently completed his PhD. He is a systems engineer with a dual training in Electrical Engineering and Computer Science, as well as Civil and Environmental Engineering. Brandon led the development of the technologies behind open-storm.org, an open source blueprint for smart water systems.

Other Presenters

- Richard Flood, Senior Program Manager, Federal Emergency Management Agency, Region IV
- David Thomas, Senior Policy Advisor, Mitigation Directorate, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency