



# Investing in Green Infrastructure

Florida Stormwater Association

December 5, 2024

# OVERVIEW

- City resilience in the face of complex challenges
- *Resilient Jacksonville* strategy and actions
- Examples of green infrastructure in Jacksonville
- Future green infrastructure projects



**CITY RESILIENCE** is the ability of city systems to **adapt** and **thrive** in the face of **acute shocks** (*sudden, extreme events that threaten a community*) and **chronic stresses** (*long-term pressures that weaken the fabric of a community over time*).





## ACUTE SHOCKS

- Extreme Rainfall Events
- Extreme Heat Events
- Hurricanes / Tropical Cyclones
- Winter Storms / Extreme Cold Events
- Infrastructure Failure or Disruption
- Energy Insecurity / Blackouts
- High Winds
- Wildfires
- Infectious Diseases
- Cyber Attack
- Hazardous Materials Incidents



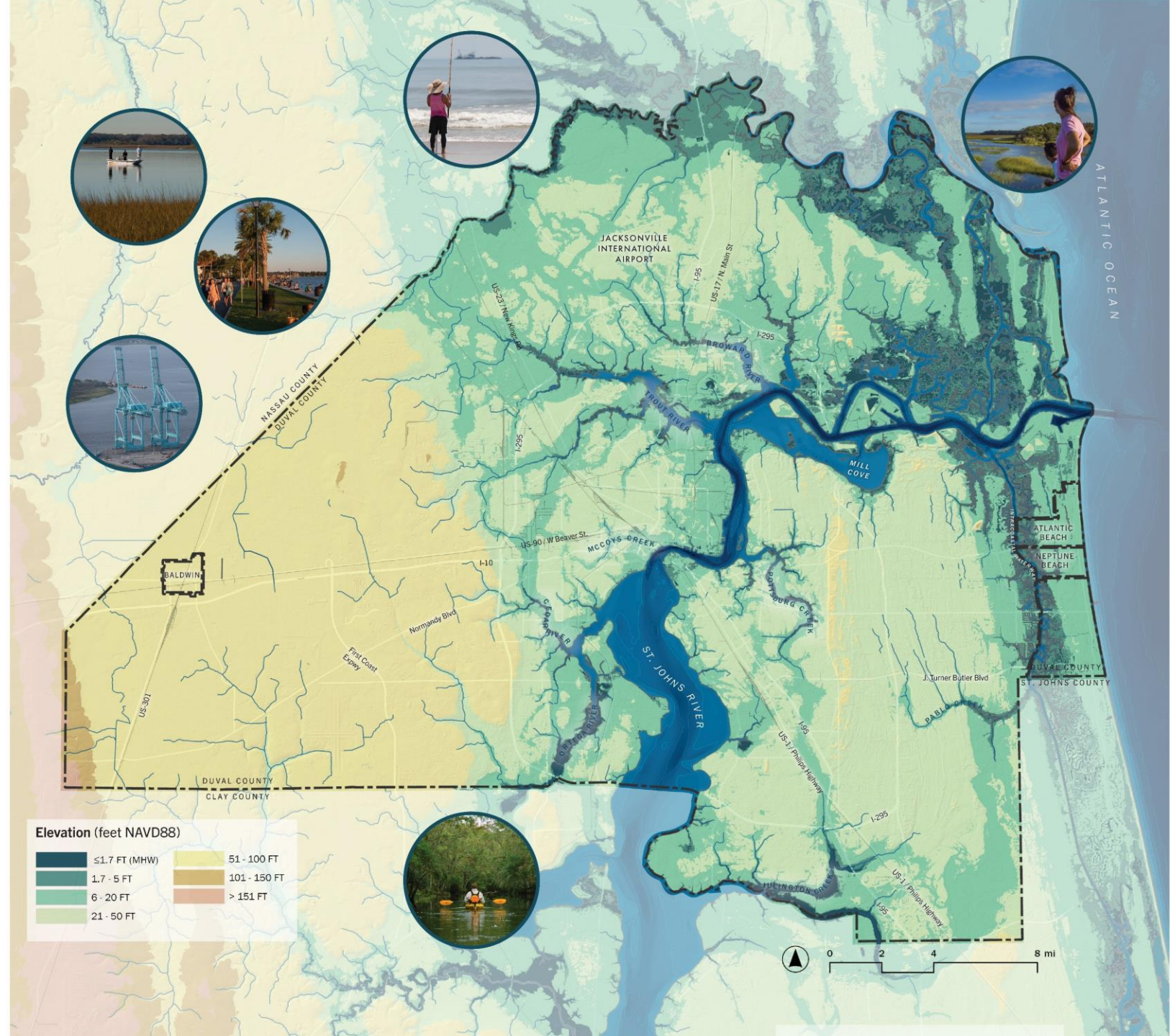
## CHRONIC STRESSES

- Sea Level Rise
- High Tide Flooding
- Heavy Rainfall
- Coastal Erosion
- Saltwater Intrusion
- Groundwater Threats
- Urban Heat Island Effect
- Drought
- Aging Infrastructure
- Economic Downturns
- Poverty
- Social Inequality
- Lack of Reliable Transportation
- Lack of Safe and Affordable Housing
- Food Insecurity & Supply Chain Disruptions
- Lack of Healthcare Access
- Chronic and Infectious Diseases



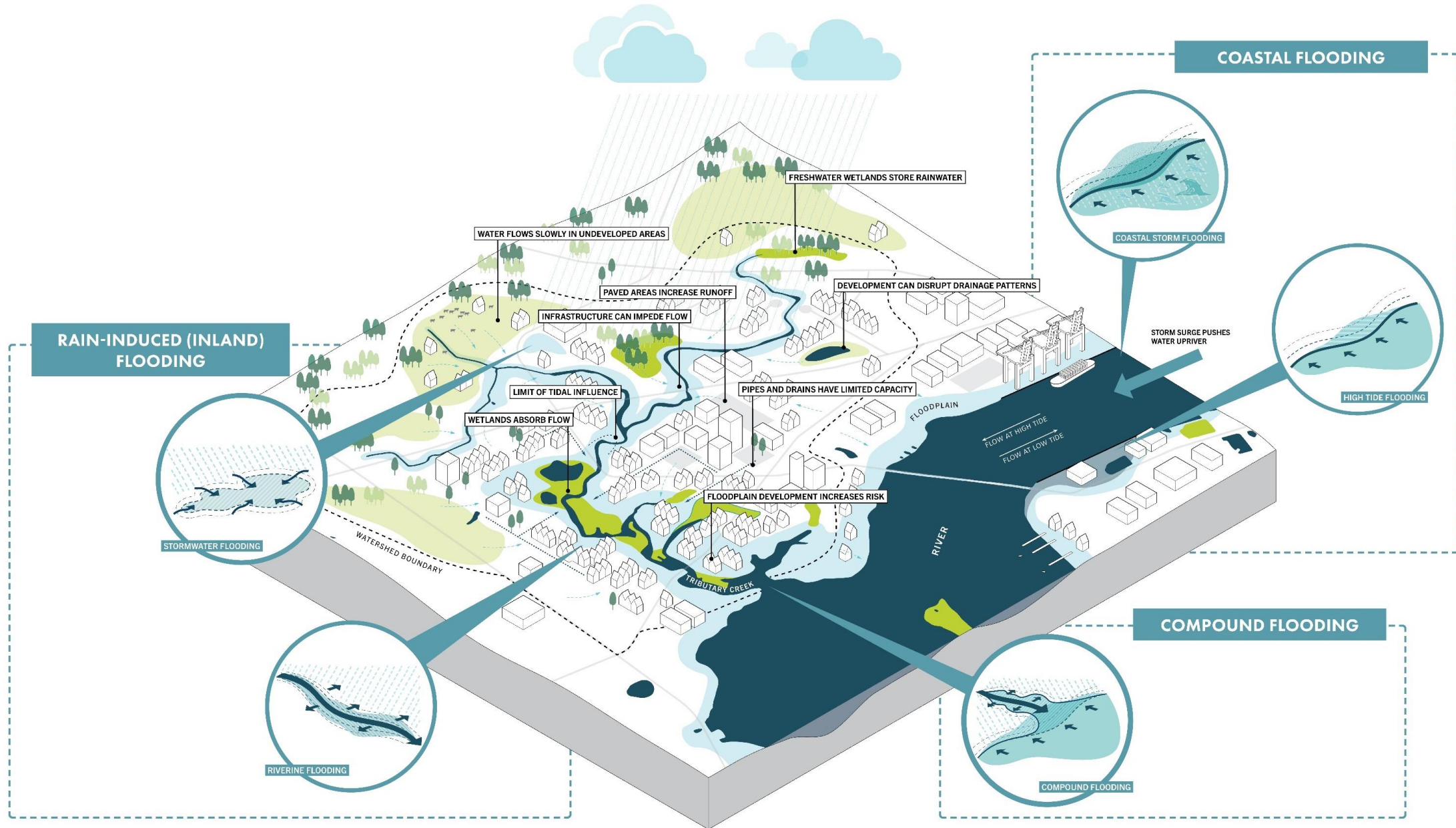
# A CITY SHAPED BY WATER

- Atlantic Coast, St. Johns River, 59 Tributaries
- Over 1,500 miles of shoreline
- Tidal influence up to 100 miles upriver

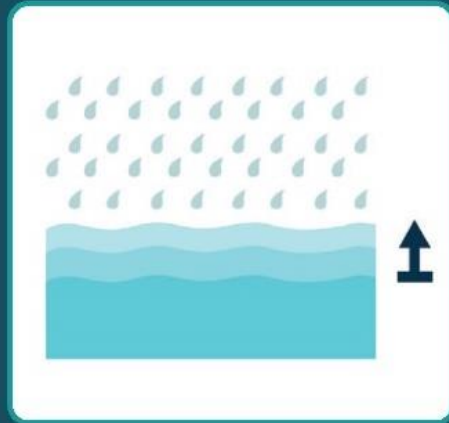




# Jacksonville is exposed to many types of flooding



# HOW WILL CLIMATE CHANGE IMPACT FLOODING?



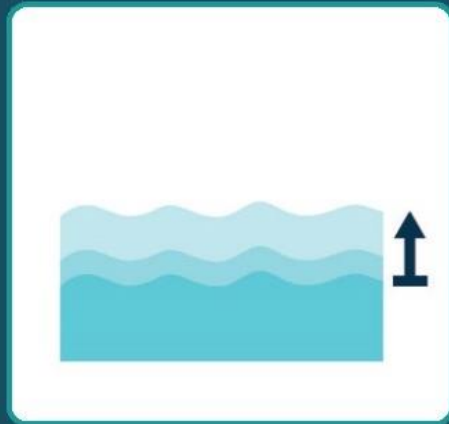
## INLAND (RAIN-INDUCED) FLOODING

Jacksonville will experience more inland flooding due to more intense rainfall events (precipitation) and the associated stormwater runoff.

**1.5-2x** INCREASE IN EXTREME  
PRECIPITATION EVENTS BY 2070

COMPARED TO HISTORIC AVERAGE FOR THE SOUTHEAST US

SOURCE: FOURTH NATIONAL CLIMATE ASSESSMENT, 2018



## COASTAL FLOODING

Jacksonville will experience more coastal flooding due to sea level rise and from stronger coastal storms.

**40-60** ANTICIPATED HIGH TIDE  
FLOODING DAYS IN 2050

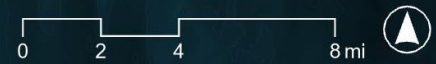
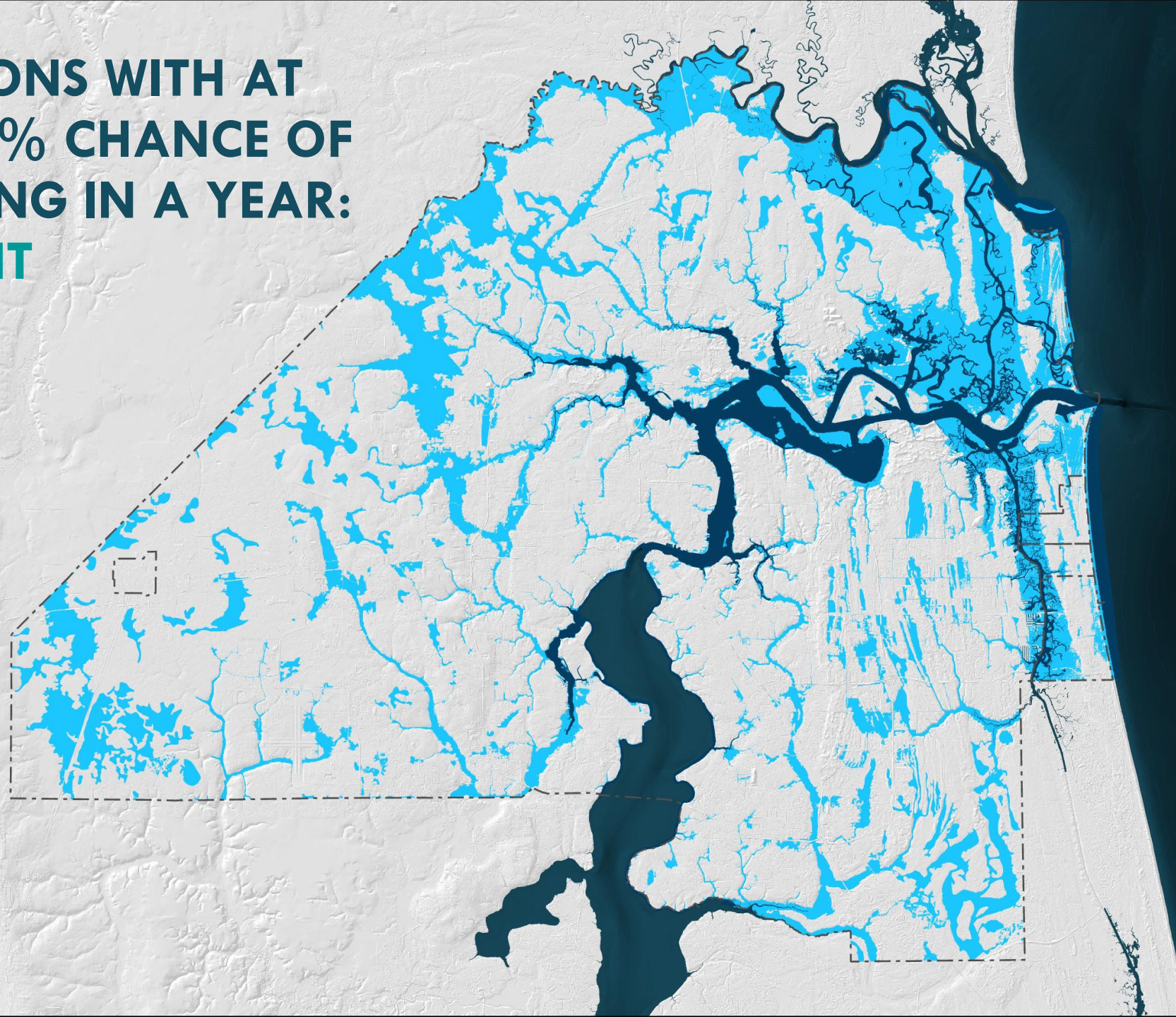
COMPARED TO 4 HIGH TIDE FLOODING DAYS IN 2021

SOURCE: NOAA STATE OF HIGH TIDE FLOODING AND 2022 ANNUAL OUTLOOK FOR MAYPORT, FL



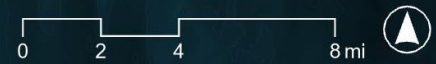
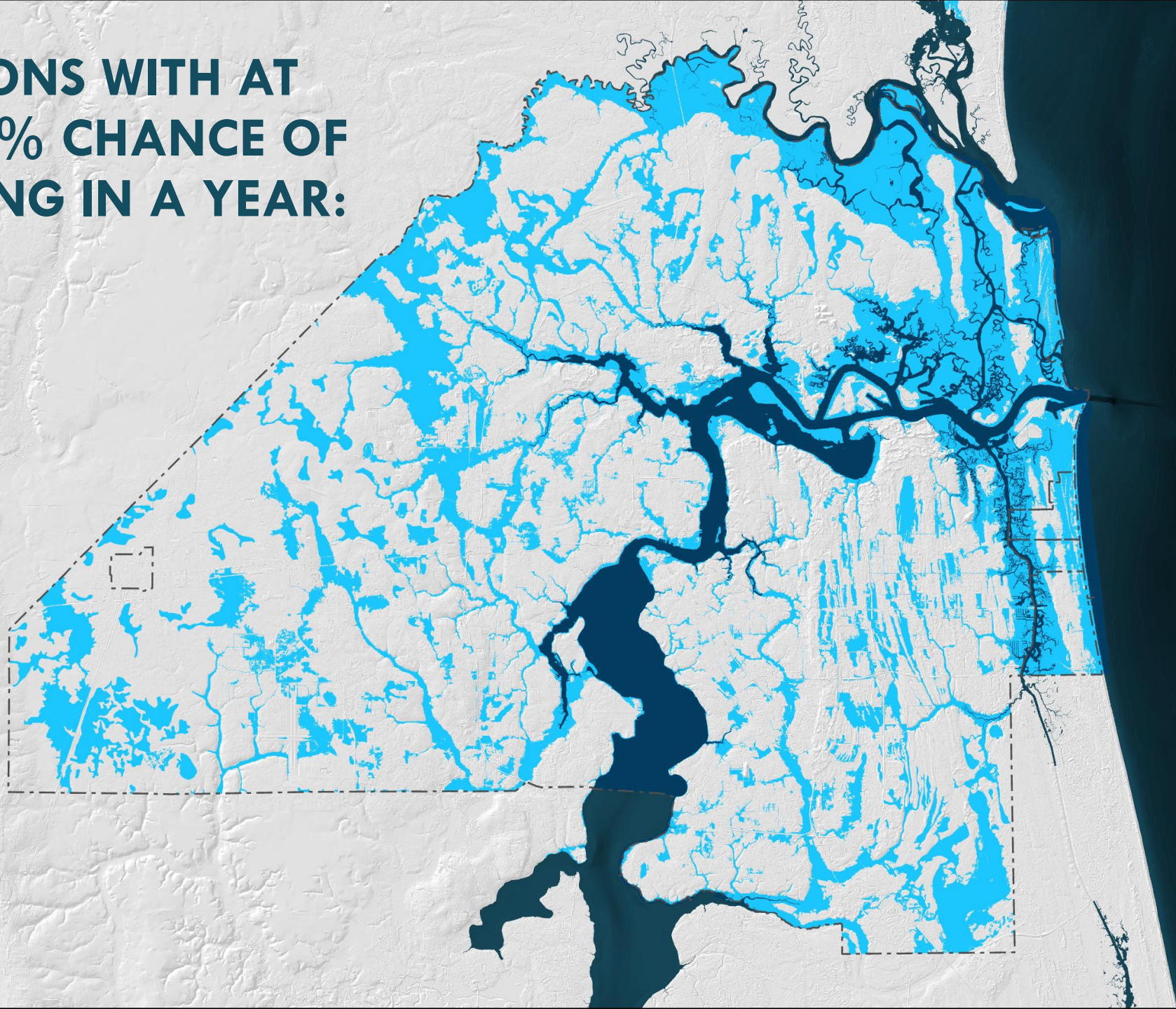


**LOCATIONS WITH AT  
LEAST 1% CHANCE OF  
FLOODING IN A YEAR:  
CURRENT**





**LOCATIONS WITH AT  
LEAST 1% CHANCE OF  
FLOODING IN A YEAR:  
FUTURE**





# A FUTURE WITHOUT ACTION

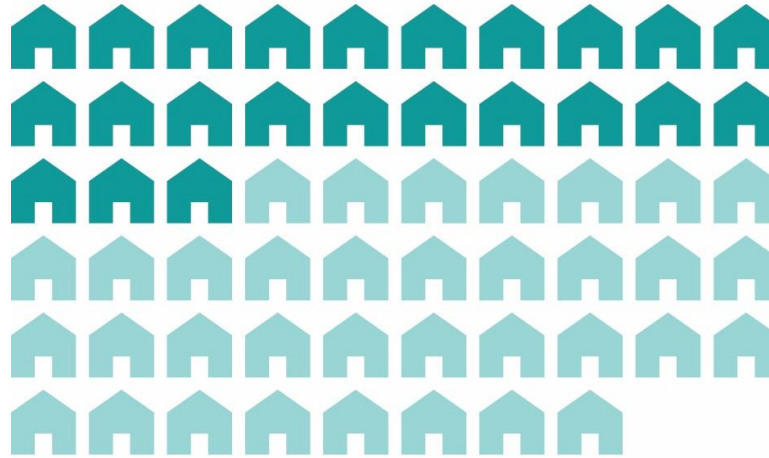
## Residents Exposed to Potential Flooding



 = 10,000 people **TODAY**     = 10,000 additional people in 2070

140,000 -> **430,000**

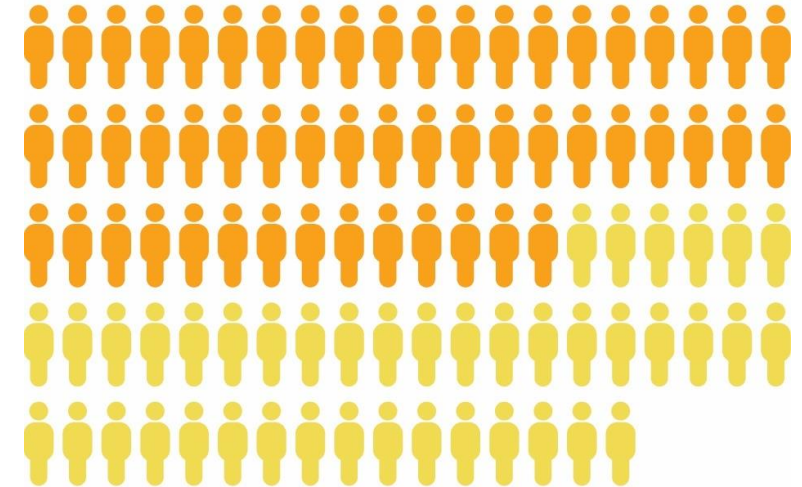
## Assets Vulnerable to Potential Flooding



 = 1,000 assets **TODAY**     = 1,000 additional assets in 2070

23,000 -> **58,000**

## Residents Vulnerable to Extreme Heat



 = 10,000 people **TODAY**     = 10,000 additional people in 2070

536,000 -> **959,000**





Reduced risk of flooding & damage



Neighborhood revitalization  
& economic development



Improved health & quality of life



Environmental education  
& workforce development

# RESILIENCE DIVIDEND

**Designing projects  
for multiple benefits**





# RESILIENT JACKSONVILLE

CITY OF JACKSONVILLE  
October 2023



## SYSTEMS

Adaptation Approaches and Actions that work across multiple sites at a neighborhood, corridor, landscape, or regional scale.



## SITES

Adaptation Approaches and Actions that can be implemented at the scale of a single asset or site.



## PEOPLE

Resilience Approaches and Actions that focus on residents, communities, businesses, organizations, and partnerships.

**GROW RESILIENTLY**

Guide safe and connected development to areas of low flood risk and high resilience potential.

**TRANSFORM**

Redesign infrastructure and the built environment to make space for water, reduce urban heat, and improve connections between places.

**PRESERVE**

Conserve and enhance valuable open space and ecosystems and limit development in areas of high flood risk.

**PROTECT**

Fortify critical city systems against future threats.

**PREPARE**

Plan in advance of a threat to improve the response of city systems during an emergency.

**ACCOMMODATE**

Alter or retrofit vulnerable buildings and the built environment at the parcel level to adapt to heat and manage water.

**RELOCATE**

Offer voluntary, incentivized, or gradual retreat where fortification and accommodation are not efficient or effective.

**SUPPORT**

Invest in the health and quality of life of Jacksonville residents.

**THRIVE**

Ensure shared prosperity for Jacksonville's people and businesses for the long-term.

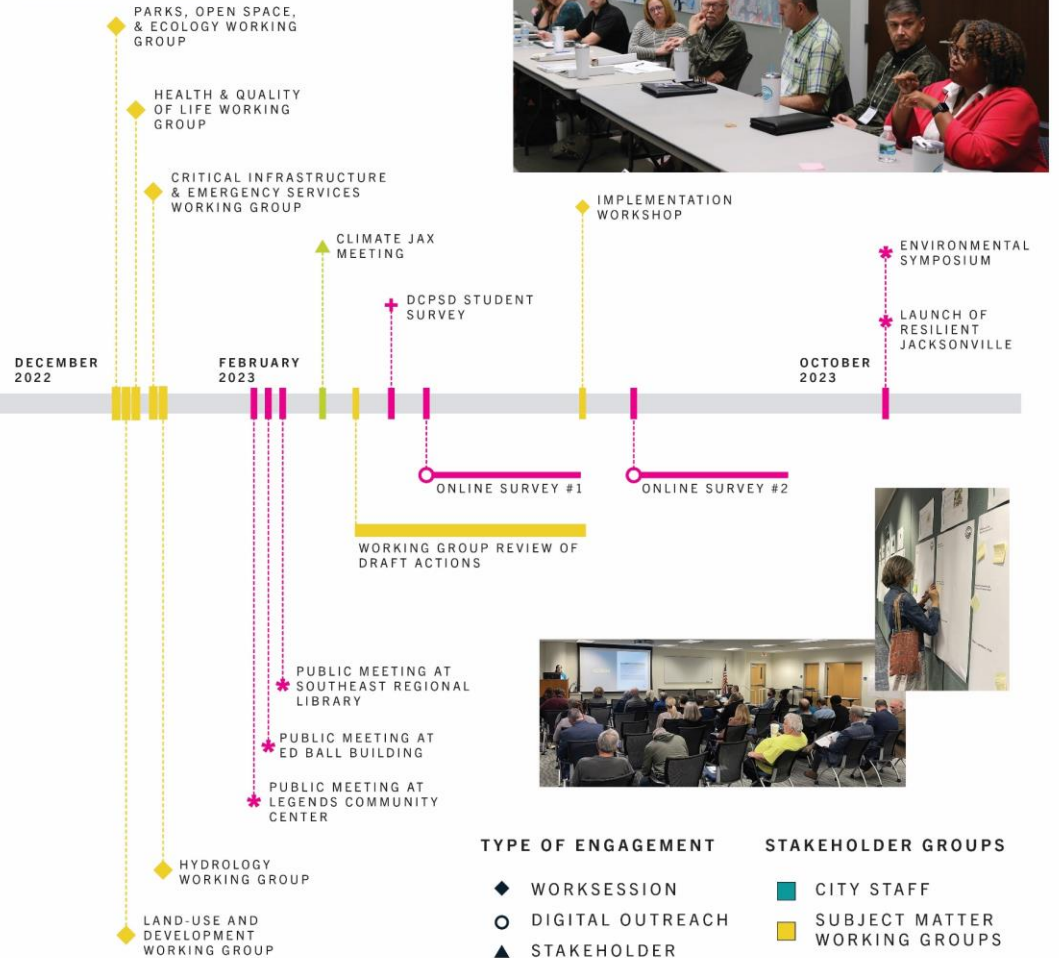
**COLLABORATE**

Strengthen partnerships and coordination among city departments, between government agencies, with civic organizations, and in support of regional coalitions.



# COLLABORATIVE DEVELOPMENT OF ACTIONS

- 45 Actions
- 90 Sub-Actions
- Implementation details, partners, funding mechanisms, timelines, and costs



TYPE OF ENGAGEMENT	STAKEHOLDER GROUPS
◆ WORKSESSION	■ CITY STAFF
○ DIGITAL OUTREACH	■ SUBJECT MATTER WORKING GROUPS
▲ STAKEHOLDER MEETING	■ COMMUNITY, NGO, & BUSINESS LEADERS
* PUBLIC MEETING / OPEN HOUSE	■ BROADER PUBLIC
+ SURVEY	



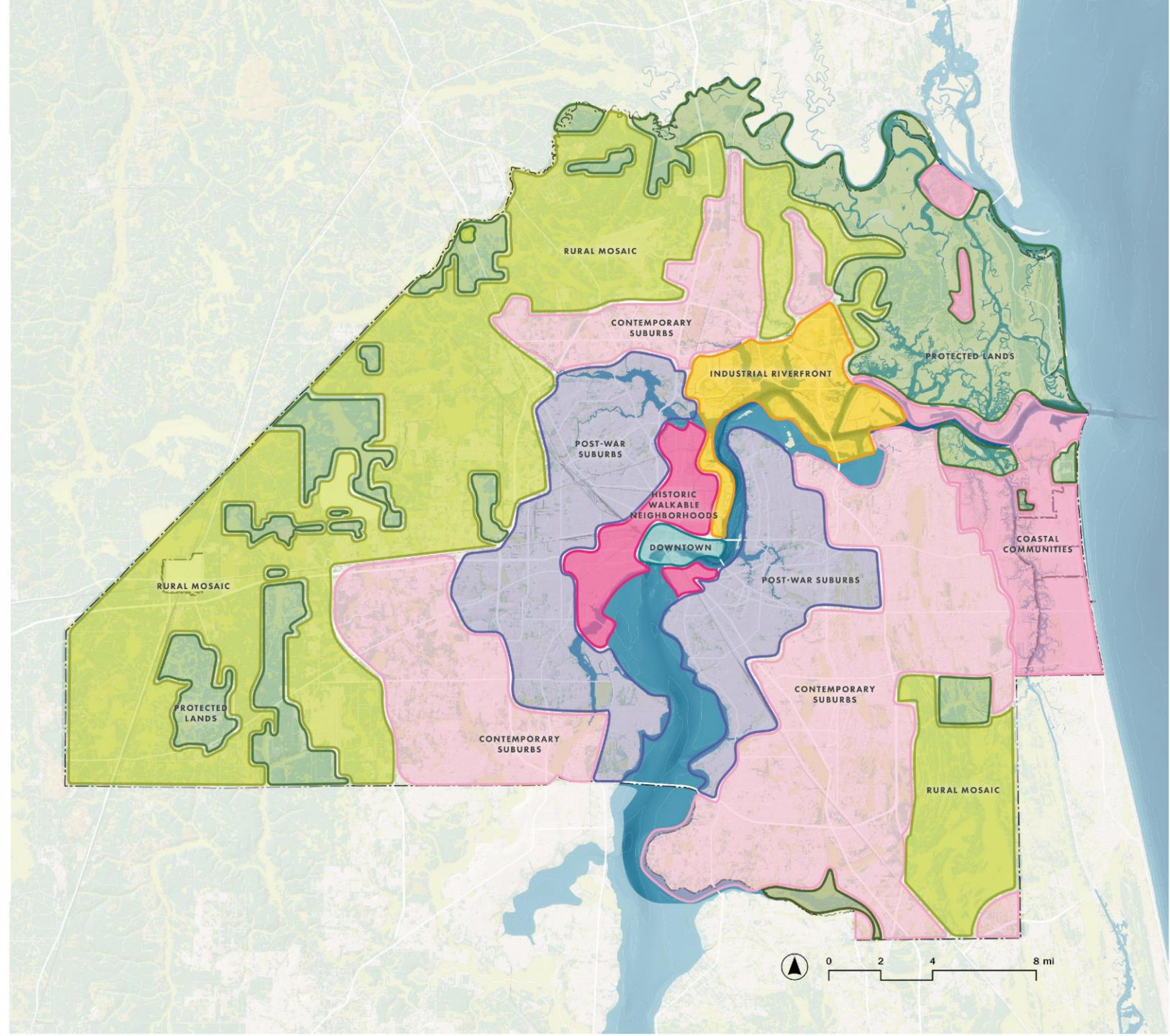
# PLACE-BASED STRATEGIES

Defining where different adaptation approaches make sense



# DEVELOPMENT TYPES

-  Downtown
-  Historic Walkable Neighborhoods
-  Post-War Suburbs
-  Contemporary Suburbs
-  Industrial Riverfront
-  Coastal Communities
-  Rural Mosaic
-  Protected Lands



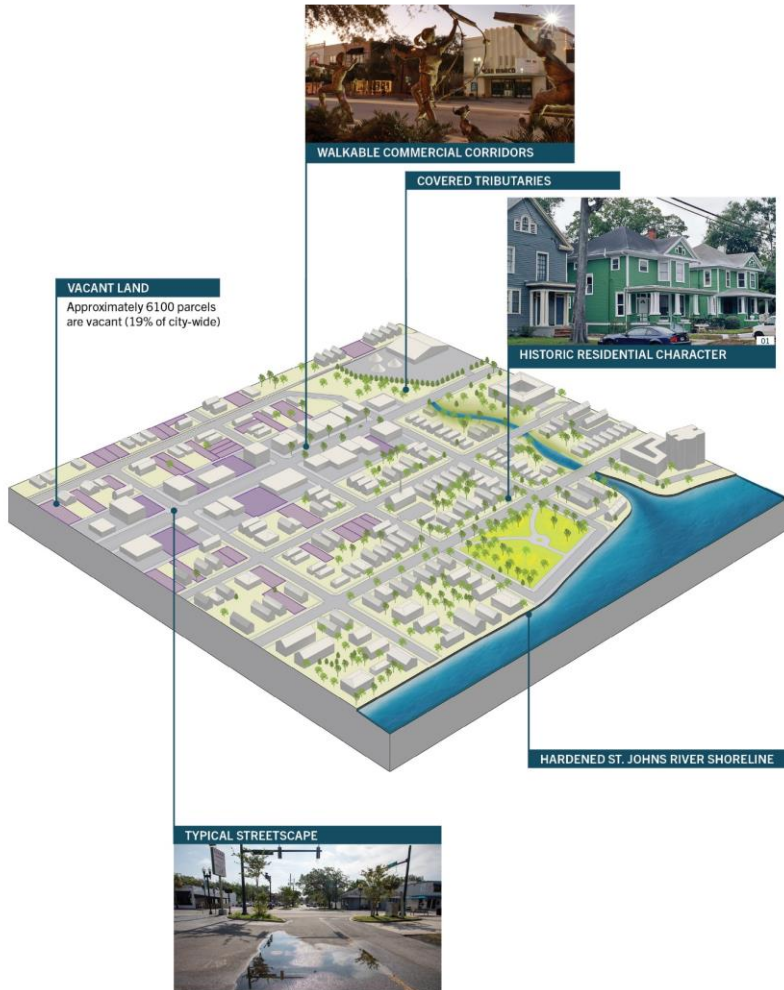
# DEFINING DEVELOPMENT TYPES

*What characteristics influence a neighborhood's vulnerability to climate threats?*

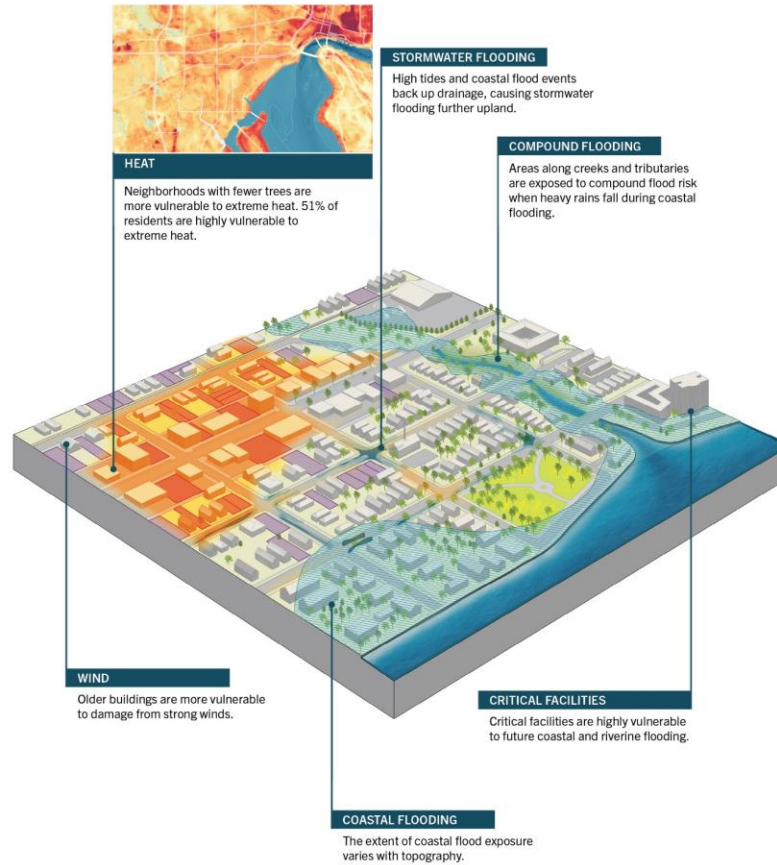
	Age/Era of Development	Density of Development	Street + Roadway Network	Residential + Commercial Urban Form	Stormwater + Wastewater Infrastructure	Use of + Relationship to Waterbodies	Impervious + Vegetated Cover
<b>URBAN</b>	Historic / pre-WWII	High density	Gridded, connected, walkable	Mixed Use	Curbs and Gutters + Sewered	Oriented to Waterfront	Significant impervious surface with limited tree canopy
<b>SUBURBAN</b>	Post-WWII to 1978	Medium density	Mostly gridded, mostly connected, somewhat walkable	Long Linear Commercial corridors	Curbs and Gutters +Septic/Sewered mix	No Access to water	Older, large mature tree canopy and small lots
<b>SUBURBAN</b>	1978 to today	Low density	Curvilinear, disconnected, designed for motorized transit	Regional Commercial hubs	Ditches + Ponds + Septic/Sewered mix	Adjacent to Open Water/Wetlands	Large lots of lawn and impervious surface with new small trees
<b>RURAL</b>	Primarily undeveloped	Rural residential	Primarily highways, interstates and state roads	Makes use of regional commercial hubs	Ditches + Septic Tanks	Adjacent to open water / wetlands	Older, more dense vegetation and less impervious surface



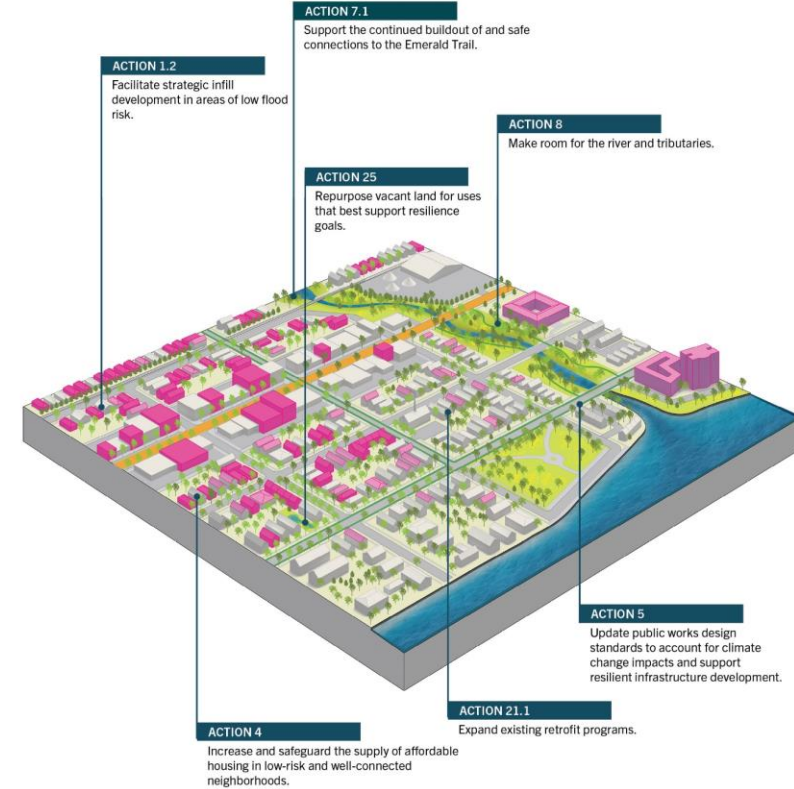
# HISTORIC WALKABLE NEIGHBORHOODS



Scale: Tile above represents approximately 0.1 sq miles.



■ Floodplain  
■ Stormwater Flooding  
■ Urban Heat



■ Resilient development  
■ Improved evacuation routes  
■ Resilient streetscape  
■ Building retrofits

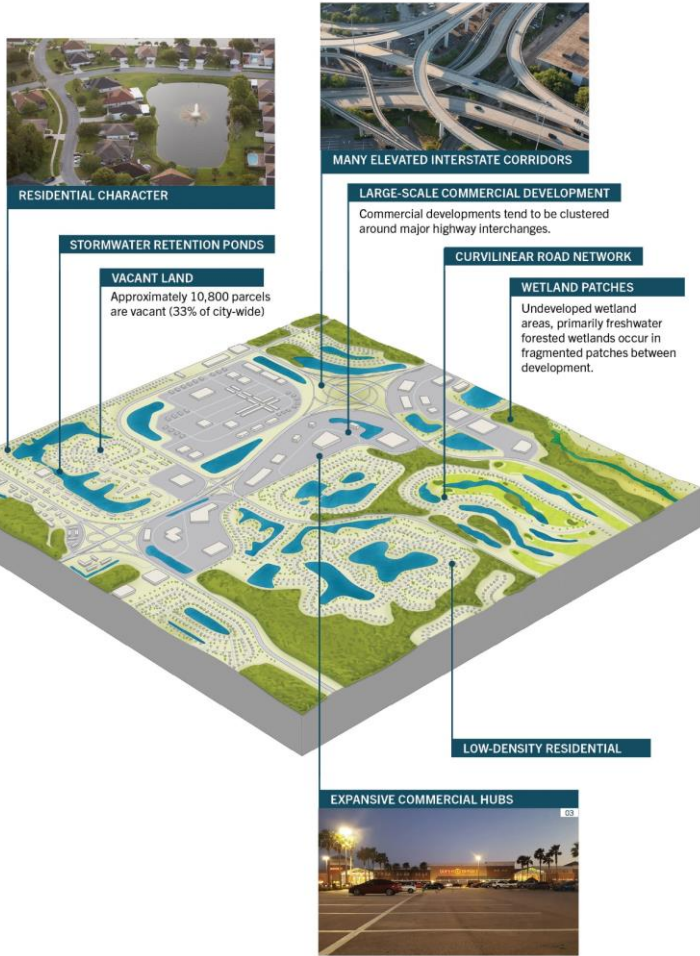
## Character

## Risks

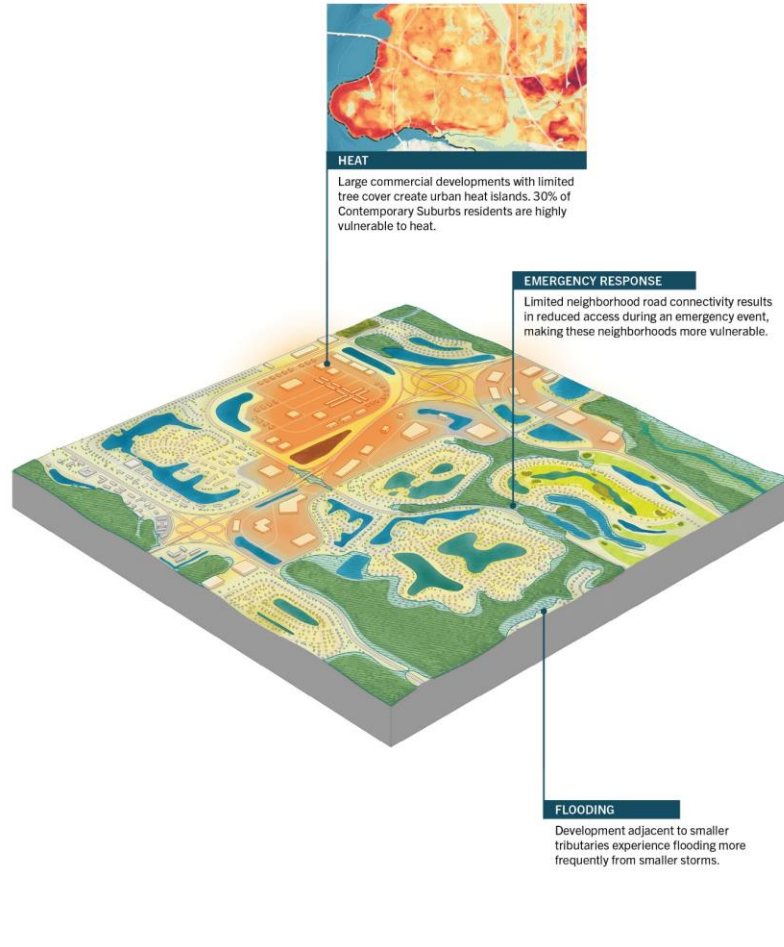
## Opportunities



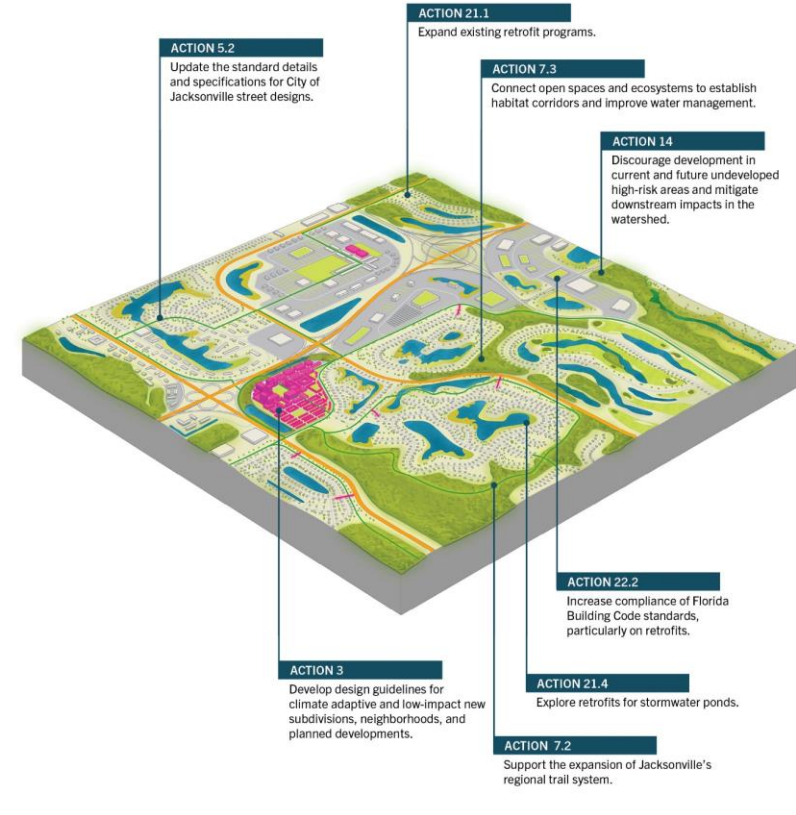
# CONTEMPORARY SUBURBS



Scale: Tile above represents approximately 12 sq miles.



Floodplain  
Stormwater Flooding  
Urban Heat



Resilient parking garage  
Improved evacuation routes  
Resilient streetscape or greenway  
Solar panels or green roof  
Subdivision additional access

## Character

## Risks

## Opportunities

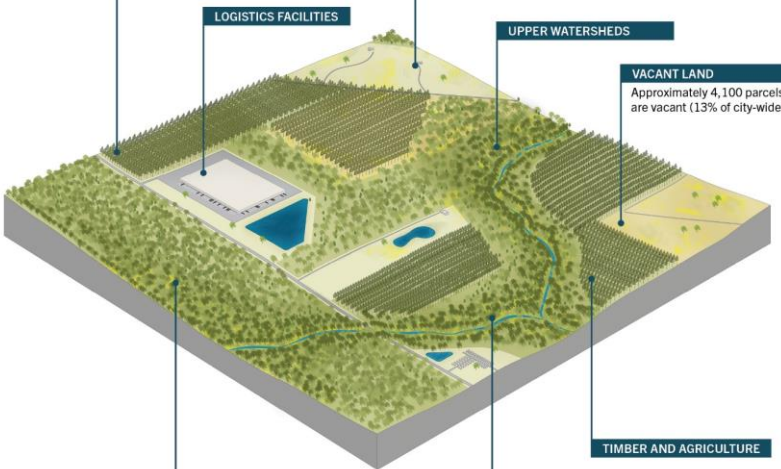
# RURAL MOSAIC



WORKING LANDS



LOW DENSITY RESIDENTIAL AND HISTORIC SITES



OUTDOOR RECREATION

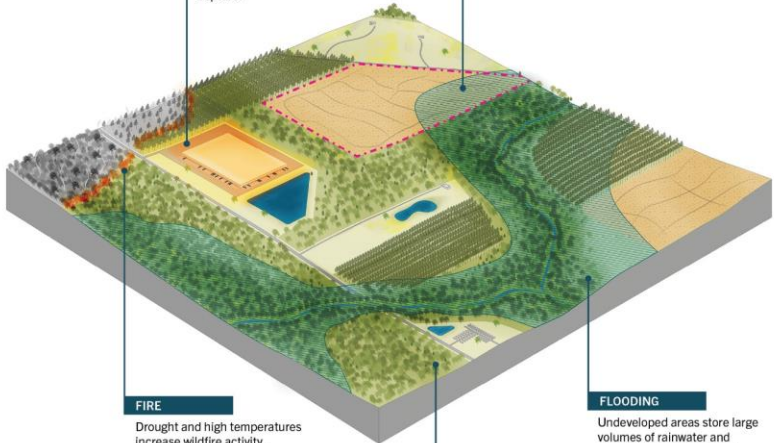
Scale: Tile above represents approximately 2 sq miles.



**HEAT**  
Only 2% of residents are vulnerable to heat due to the cooling abilities of trees and open spaces. However, impervious surfaces and structures increase heat capture.

**CONVENTIONAL DEVELOPMENT**

New development is often sited in floodplains and with disregard for existing woodland and wetlands.



- Floodplain
- Wildfire
- Urban Heat

**ACTION 1.1**

Update the city's land development regulations.

**ACTION 3**

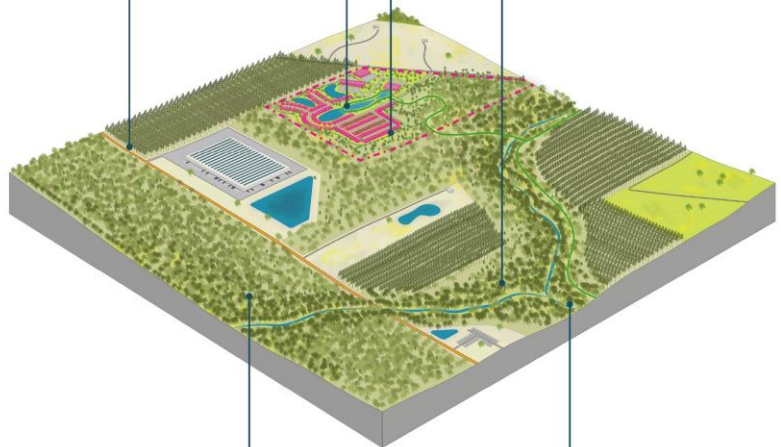
Develop design guidelines for climate adaptive and low-impact new subdivisions, neighborhoods, and planned developments.

**ACTION 2**

Ensure infrastructure investments are aligned with land use priorities for growth and conservation.

**ACTION 12.2**

Support strategic land acquisition for conservation.



**ACTION 14**

Discourage development in current and future undeveloped high-risk areas and mitigate downstream impacts in the watershed.

**ACTION 13.2**

Manage invasive species and nuisance animals.

- Resilient development
- Improved evacuation routes
- Greenway trail
- Solar panels or green roof

## Character

## Risks

## Opportunities



# RESILIENCE ACTIONS

A comprehensive approach to  
improving resilience





## 5 | Update public works design standards to account for climate change impacts and support resilient infrastructure development.

Public works design standards set a precedent for the safety and resilience of public infrastructure and establish a baseline of resilience for any city investment. Prioritizing the resilience of infrastructure is critical, not only to avoid costly repairs but also to minimize the wide-ranging consequences of natural disasters for the livelihoods and well-being of residents.<sup>4</sup> Integrating climate change data into public works design standards and the Capital Improvement Plan prioritization process will ensure that retrofits and new construction performed by the Department of Public Works are resiliently designed and built to withstand flooding, high winds, heat, and other extreme weather.

Resilient design standards will also guide the development of community services, jobs, retail, and affordable housing in low-risk areas with existing infrastructure, transit networks, and underutilized sites, and reduce the amount of capital spent on repairing infrastructure. In addition, actions intended to improve infrastructure resilience—for example, a park that is “designed to flood” and provide additional water storage capacity during heavy rainfall events—can often yield additional benefits during non-emergency conditions.<sup>5</sup> The multiple benefits derived from interventions like this are often referred to as the “resilience dividend,” which represents the many benefits that accrue by investing in actions that strengthen the city’s resilience. Extensive research from the National Institute of Building Sciences has repeatedly shown that investments in mitigation provide substantial benefits over cost. Their study of federal mitigation grant programs found a \$6 benefit for every dollar invested.<sup>6</sup>



Credit: Montgomery County DEP

### Shocks and Stressors Addressed

Flooding / Sea Level Rise / Chronic Flooding / Urban Heat Island Effect

### Implementation Partners

Public Works / JEA / Subdivision Standards and Policy Advisory Committee / Context Sensitive Streets Committee

### Potential Funding Mechanisms

Resilience Office / Fuse Fellows

### Implementation Timeframe



### Relative Cost



## SUB-ACTIONS

### 5.1 Align above-ground and below-ground infrastructure specifications and review processes.

To ensure consistency in design for above- and below-ground infrastructure, it’s important that the committees setting these standards are in close coordination. The City will facilitate the merging of the Subdivision Standards and Policy Advisory Committee (SSPAC) and the Context Sensitive Streets Committee to allow for holistic planning and streamlined decisionmaking. Additionally, to save on costs and materials and improve sustainability citywide, the City and JEA will closely coordinate projects and maintenance, collaborate to improve standards and specifications, and implement resilient standards where applicable.

### 5.2 Update the standard details and specifications for City of Jacksonville street designs.

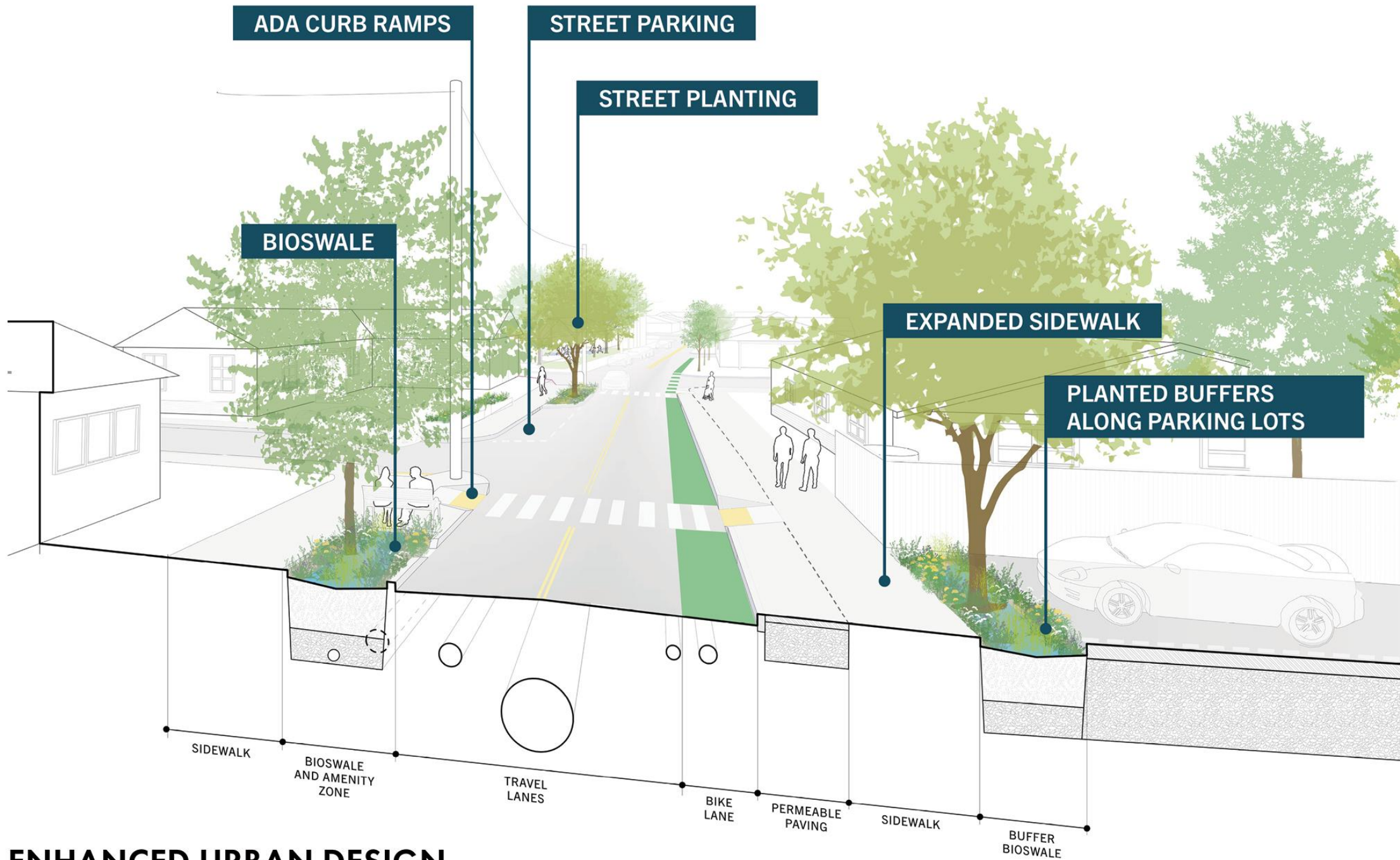
If you laid all of Jacksonville’s City-managed roads in a straight line, you could get from Downtown to Los Angeles and halfway back—a total of over 3,400 miles. Each road has the potential to provide significant resilience benefits beyond transportation. The City will undergo a streetscape design update that will comprehensively look at the various types of roadways in Jacksonville and provide standards for roadway design and upgrades that provide additional quality of life, stormwater management, and urban heat reduction benefits. These redesigns could include multiple components, such as multimodal active transportation with lanes and pavement

markings for buses and bicyclists. They could also include light-colored roadways to reduce urban heat absorption and additional street trees to provide shade, absorb stormwater, and lower air temperatures. Redesigns could both benefit pedestrians through the installation of safe and accessible sidewalks and include permeable paving to reduce runoff and promote infiltration. Updating the City’s streetscape design standards is an opportunity to make significant improvements to meet resilience goals.

### 5.3 Incorporate green infrastructure features into drainage specifications.

Though not a catch-all solution for drainage, green infrastructure features can take pressure off the city’s drainage system while simultaneously providing multiple benefits by filtering, storing, and even infiltrating stormwater (the process by which water flows into and through the soil). Development of design guidelines for green infrastructure features as part of a drainage guidebook is one mechanism that can be used to implement citywide standards around green infrastructure installation (e.g., determining what an urban bioswale should look like in specific parts of the city). In addition to establishing design guidelines and standard details—and separate from the regular flow capacity the city relies on from the traditional drainage system—the City can set targets for how much water different parts of Jacksonville should be able to temporarily retain during and after one or more major rainfall events.

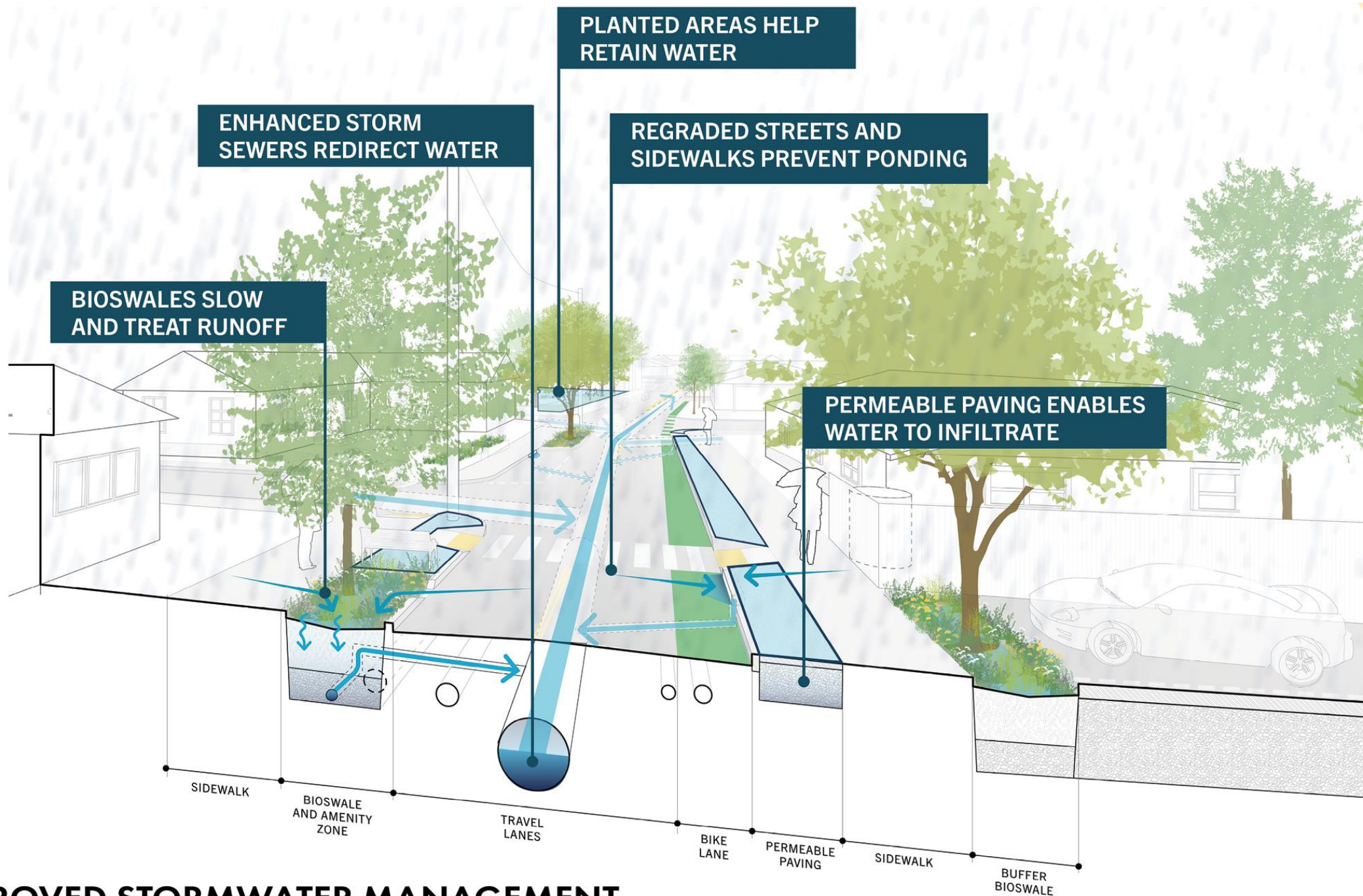




# ENHANCED URBAN DESIGN







# IMPROVED STORMWATER MANAGEMENT

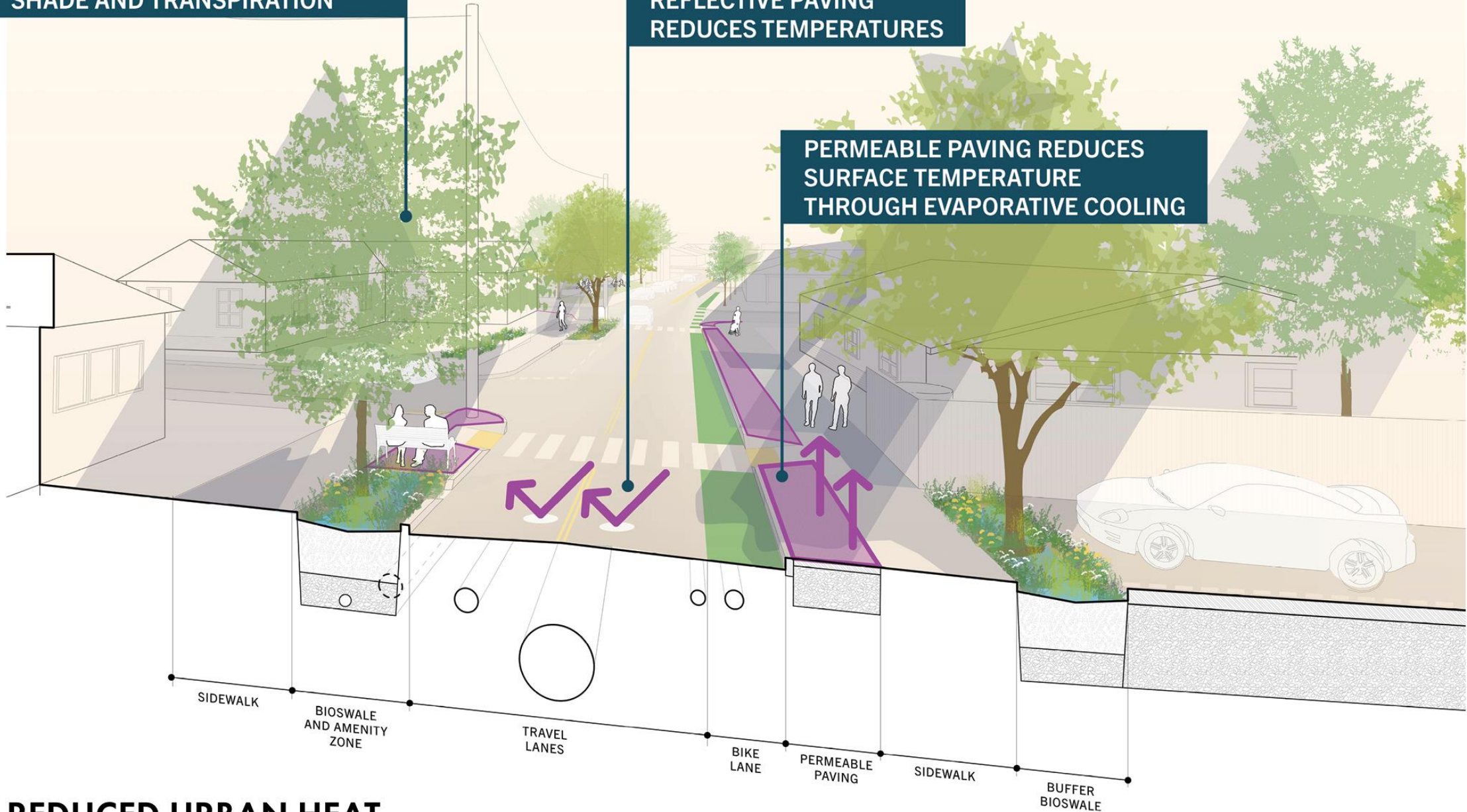




TREES AND OTHER VEGETATION  
COOL SURROUNDINGS THROUGH  
SHADE AND TRANSPIRATION

LIGHTER, MORE  
REFLECTIVE PAVING  
REDUCES TEMPERATURES

PERMEABLE PAVING REDUCES  
SURFACE TEMPERATURE  
THROUGH EVAPORATIVE COOLING



**REDUCED URBAN HEAT**





8 | **Make room for the river and tributaries.**

Rivers and tributaries naturally carry and hold rainfall runoff from their watershed. Providing more room along riverbanks for floodable open spaces can reduce flood risk by systematically holding more water in the riparian corridor, limiting assets at risk in the floodplain, and improving health and quality of life by providing connective recreational and ecological corridors. In planning for new structures along the St. Johns River and tributaries, the City will support the restoration of natural, historic floodplains by making investment decisions and prioritizing projects that make room for flood water, avoiding placing structures in the floodplain, and actively returning areas of the floodplain to natural space that can provide Jacksonville residents benefits such as flood risk reduction, improved water quality, urban heat reduction, and recreation areas.

**Action Description**

The Office of Resilience will collaborate with the Parks Department and the Department of Public Works to limit the use of City funds along tributaries to water-dependent structures, like docks, piers, boat ramps, or elevated walkways. The City agencies will further encourage the addition of vegetated buffers along rivers, wetlands, and stormwater ponds; replace hardened shorelines with green or hybrid infrastructure where feasible; and limit new bulkhead permits on private property.

**Shocks and Stressors Addressed**

Flooding / Chronic Flooding / Groundwater Threats

**Implementation Partners**

Parks / Public Works / Groundwork Jacksonville / St. Johns Riverkeeper

**Potential Funding Mechanisms**

Resilient Florida / National Fish and Wildlife Foundation

**Implementation Timeframe**



**Relative Cost**



**EXAMPLE  
MCCOYS CREEK RESTORATION**

The McCoys Creek Recreation and Restoration Project, currently underway, exemplifies the efforts of Action 8: Make Room for the River. Like many creeks in Jacksonville, much of the historic McCoys Creek was channelized underneath highways or hidden behind dense overgrowth. The creek suffered from water quality and acute flooding issues. Through City, nonprofit, community, and stakeholder collaboration, the project is making a significant impact in improving resilience, ecology, and quality of life in Jacksonville.

The City of Jacksonville has committed \$105.4 million to restore McCoys Creek through natural channel design and mitigate the ongoing and frequent flooding in nearby neighborhoods.<sup>8</sup> Groundwork Jacksonville, a local nonprofit, has partnered with the City to engage residents and community stakeholders to craft a vision plan and

design for McCoys Creek that reduces flooding, improves water quality, restores fish and wildlife habitats, expands recreational opportunities and access through a multimodal greenway, and establishes wayfinding that honors McCoys Creek's rich social and cultural history.

The McCoys Creek project is a great example of the resilience dividend: by building a larger project with multiple benefits, many funding sources can be combined and leveraged, rather than used piecemeal. Combining the expertise of multi-disciplinary teams with community engagement, feedback, and values has led to a project with broad support and extensive benefits. While still under construction, this project is already demonstrating flood risk reduction benefits, evidenced by its ability to mitigate against the impacts of Hurricane Ian in fall 2022.

**EXAMPLE  
RIBAULT RIVER CORRIDOR PROJECT**

The Ribault River Corridor Project demonstrates ways in which Jacksonville can maintain environmental health at the neighborhood scale and prioritize investments that expand access to waterways and seek to address the needs of individual communities. For this project—located on the banks of the historic Ribault River—LISC (Local Initiative Support Corporation) Jacksonville and the St. Johns Riverkeeper partnered with community and academic leaders to identify community

assets, social and environmental vulnerabilities, and community-defined investments for parks and waterway access, housing, infrastructure, and environmental quality. Different from McCoys Creek which is highly urbanized, the Ribault River Corridor Project will help determine how creek restoration can work on a larger scale and identify elements that are transferrable to many other tributaries throughout Jacksonville.



9 | **Develop a green stormwater infrastructure program across Jacksonville based on the best available science and data.**

The growing trend of “cloudburst” rain events that drop many inches of rainfall in a short period of time is a phenomenon impacting every part of Jacksonville. These increasingly regular events can overwhelm the city’s drainage systems and worsen flooding. Oftentimes, cloudbursts are not named storms, not always easy to predict, and may arrive as one single heavy rain event or many sustained days of rain when the ground is saturated and storage systems are full. Like many other cities experiencing these types of events, Jacksonville’s drainage systems, including underground pipes, stormwater ponds, and open-air drainage ditches on the side of the road, can be overwhelmed by the frequency and severity of such rainfall events. Simply put, there is often too much water and not enough places for it to go. Green stormwater infrastructure can help relieve the pressure that heavy rainfall puts on Jacksonville’s drainage system by capturing and holding water before it reaches the storm drain system and absorbing overflow during rain events. Green infrastructure also improves water quality, mitigates extreme heat, expands natural space, and creates a healthier environment for residents.

**Action Description**

Up until now, Jacksonville and other cities across the U.S. have sought to address stormwater flooding by looking at historical data to identify where it has already been happening. Analyzing reported flood data from 630-CITY, for example, is a useful first step to identify key areas that experience repeat stormwater flooding, but the City recognizes the need for more sophisticated estimates that can more accurately project future flood risk from both heavy rainfall events and compound flood events (events when different types of flooding, such as storm surge and heavy rain, occur at the same time). Using new estimates of flood risk and mapped outputs from Jacksonville’s upcoming compound flood analyses, the City will establish a new program focused on green stormwater infrastructure, identify locations with the greatest need for these types of interventions, and invest resources accordingly.

**Shocks and Stressors Addressed**

Stormwater Flooding / Urban Heat Island Effect

**Implementation Partners**

Resilience / Public Works / Parks

**Potential Funding Mechanisms**

Resilient Florida / USACE Silver Jackets

**Implementation Timeframe**



**Relative Cost**



CASE STUDY  
**GREEN CITY, CLEAN WATERS**  
Philadelphia, PA | 2011

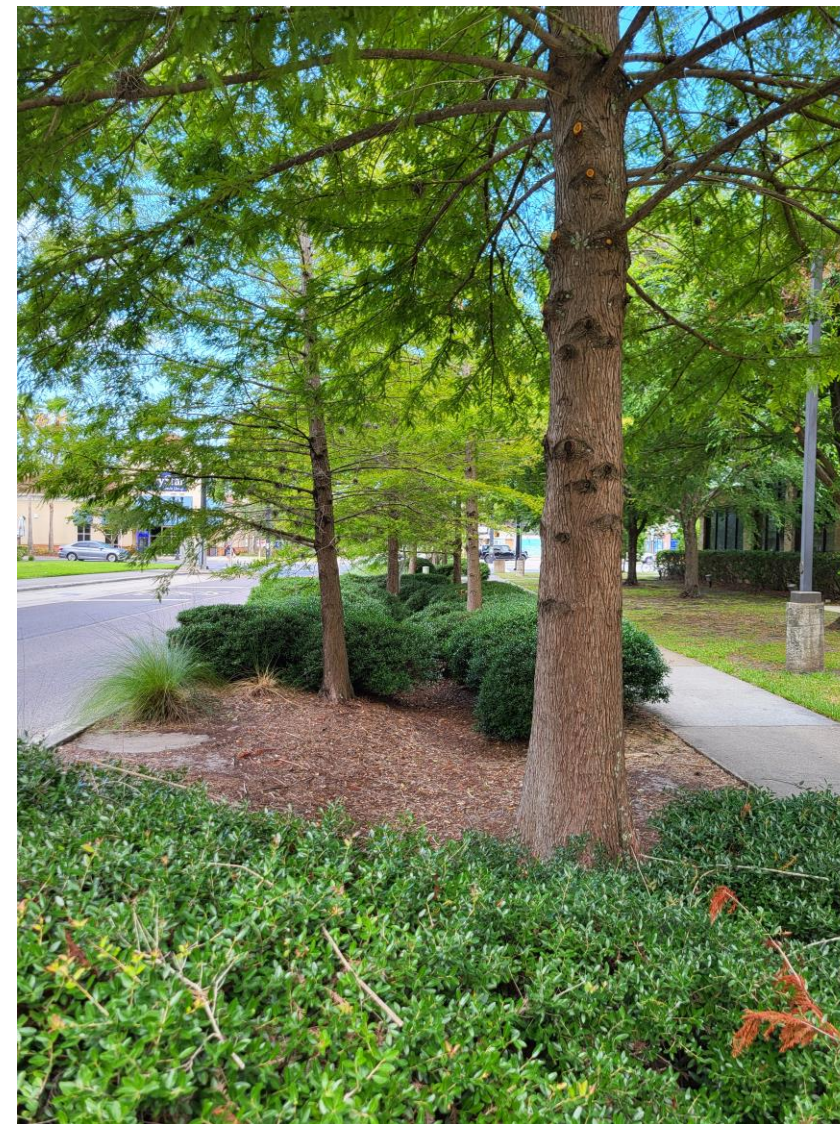
Credit: Philadelphia Water Department

Green City, Clean Waters is a comprehensive 25-year plan developed by the Philadelphia Water Department (PWD) to implement green stormwater infrastructure (GSI) citywide. The primary goal of this program is to reduce water pollution by utilizing GSI such as rain gardens, swales, and stormwater tree trenches to store stormwater runoff before it reaches the sewers and causes an overflow of polluted waters into the city’s rivers. PWD has partnered with other city departments, agencies, private developers, and organizations to install GSI at recreation centers and schools, as well as in parking lots. Green City, Clean Waters is also looking into opportunities for GSI to be coupled with future renovations, such as upgrades to athletic fields.

In the program’s first decade of implementation, nearly 800 sites across the city have incorporated GSI, resulting in more than 2.7 billion gallons of polluted water kept out of local waterways. These efforts yield additional environmental benefits like reduced stormwater flooding, improved air quality, energy conservation, ecological support, and reduced impacts from extreme heat. They also provide economic and social benefits such as improved opportunities for recreation, increased property values, investment in local businesses, and reductions in crime.



# LaSalle Street Bioswale







## 12 | Preserve ecologically important areas with the capacity to manage water and mitigate extreme heat.

Jacksonville’s ecosystem diversity is impressive—its habitats include marine and estuarine, intertidal, subtidal, estuarine wetlands, freshwater wetland, rivers and streams, ponds and lakes, coastal beaches, coastal uplands, scrub and prairie, and upland and pine forests. Each ecosystem plays a role in a resilient Jacksonville. Establishing mechanisms for preserving and protecting existing natural areas, especially wetlands and flood-prone areas, can provide many benefits for the city. Ecologically important areas are defined as supporting native plant communities and wildlife, providing environmental benefits such as improved air and water quality, and reducing risks associated with natural disasters and climate change. Specifically, they help to purify air and water, lower air temperatures, stabilize soil which reduces erosion, reduce flood risks and impacts, recharge the aquifer, and provide important habitat. Strategic land preservation is critical to improving Jacksonville’s resilience and maintaining its identity as a spacious city with the largest urban park system in the nation.



### Shocks and Stressors Addressed

Flooding / Extreme Heat / Wildfires / Air Quality / Water Quality

### Implementation Partners

Parks / SJRWMD / North Florida Land Trust

### Potential Funding Mechanisms

SJRWMD

### Implementation Timeframe



### Relative Cost



## SUB-ACTIONS

### 12.1 Protect existing park and preserve lands in perpetuity.


Protecting lands in perpetuity allows important ecological areas to grow without risk of development. Within the city limits, there are many protected parklands, including state parks, wetland mitigation banks, and the Timucuan Ecological and Historical Preserve National Park. The City of Jacksonville manages more than 400 park and recreational sites providing many services to residents. Some of these are preserve lands, which are larger, natural areas with specific types of recreational use. The services these existing parks and preserve lands provide Jacksonville include benefitting mental and physical health, naturally absorbing and filtering rainwater, recharging the aquifer, providing safe and natural places for riparian flooding, improving air quality, and storing carbon, among others. Furthermore, according to the Natural Areas Conservancy’s 2022 Cooling Study, which included 12 U.S. cities (two in Florida), forested natural areas are 3–9°F cooler on average and are the coolest type of greenspace in cities.<sup>9</sup> Some of Jacksonville’s parks and preserve lands are threatened by development pressures. Removing existing parkland from the city’s green space network is counterproductive to achieving citywide resilience as it results in a loss of the benefits listed above. To prevent the loss of Jacksonville’s park and preserve lands for the next century, the Parks Department

will develop a program to add important preserve lands and existing parks into long-term conservation easement agreements. Additionally, the Office of Resilience will develop a citywide policy to limit the sale of existing City-owned park and preserve lands and will work with the Planning and Development Department to add restrictions to the land-use code to prevent the conversion of City park land into other types of land uses.

### 12.2 Support strategic land acquisition for conservation.

Acquiring lands that support important ecological functions and provide citywide benefits is an effective strategy for long-term conservation. The Office of Resilience, in partnership with the Parks Department and Real Estate Division, will identify and pursue methods for acquiring strategic areas of land. This may include large natural areas or contiguous parcels of natural areas, areas adjacent to existing park land, properties experiencing repetitive flooding, or areas of land within future floodplains. The City can partner with other organizations such as the North Florida Land Trust, Florida Forever Program, the St. Johns River Water Management District, and the Timucuan Parks Foundation to leverage resources to apply to grants for land acquisition.





# THE PRESERVATION PROJECT JACKSONVILLE

**TIMUCUAN PARKS FOUNDATION**

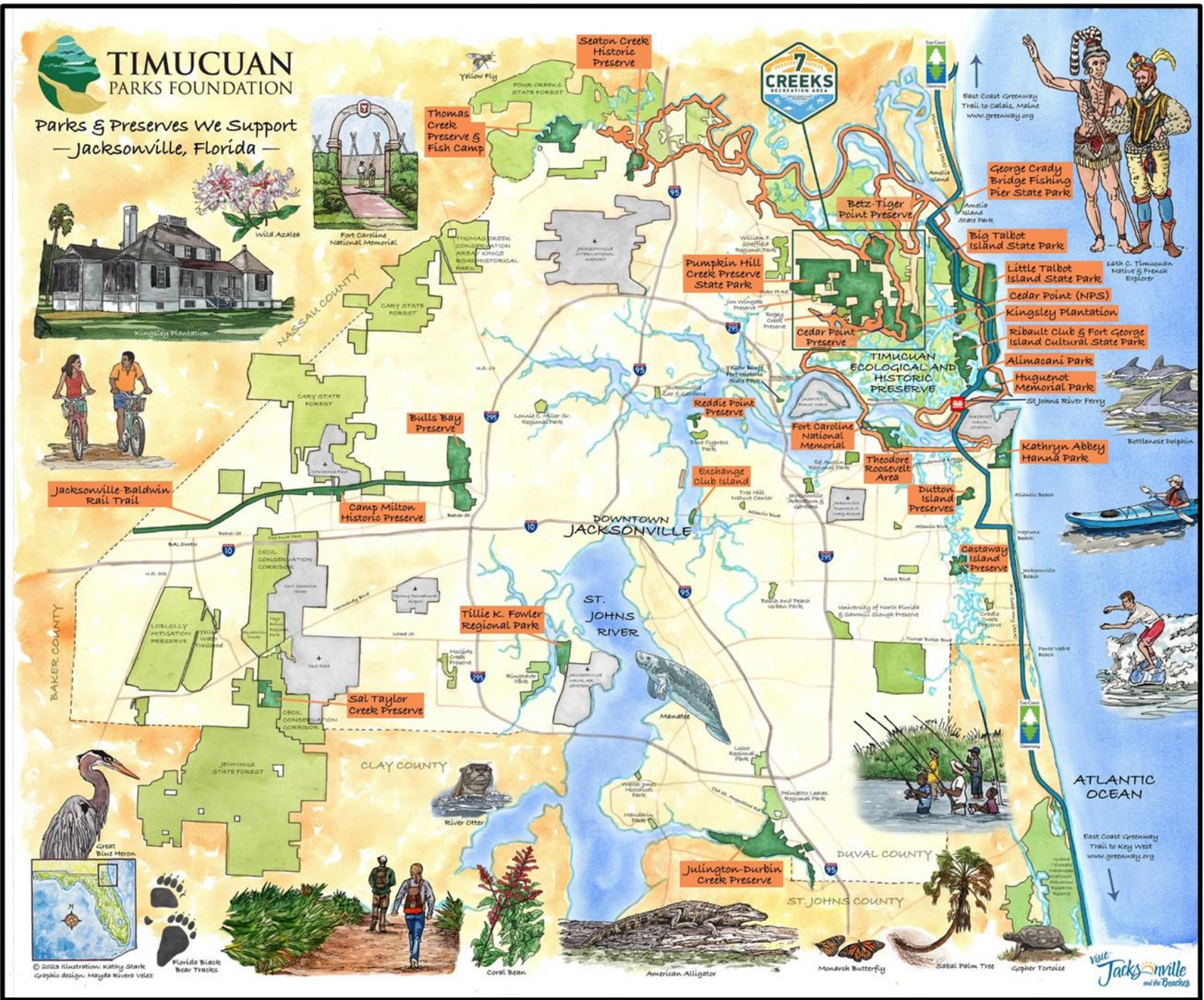
Parks & Preserves We Support  
— Jacksonville, Florida —



Jacksonville Baldwin Rail Trail



© 2023 Illustration: Kathy Stark  
Graphic design: Mayda Rivera Velez







## 17 Identify shorelines where natural and nature-based solutions can provide long-lasting ecosystem service benefits.

Natural and nature-based solutions, when implemented strategically, have the capacity to provide multiple resilience benefits. As defined by the U.S. Army Corps of Engineers, natural and nature-based features refer to landscape features that produce flood risk management benefits. Projects such as oyster reef installation, salt marsh restoration, dune establishment, and hybrid gray-green infrastructure have the potential to mitigate impacts from coastal hazards, improve ecosystem health, and even lower long-term costs of shoreline maintenance. For example, oyster reefs can serve as breakwaters as they absorb the force of waves, slow coastal erosion, create habitat, and provide water filtration that enhances surrounding ecosystems. Restoration of salt marsh can also contribute to many of these benefits. The Parks Department, in partnership with the Office of Resilience, will prioritize sites for nature-based shoreline stabilization opportunities, develop solutions for coastal erosion within the City's park system, and identify additional opportunities to implement nature-based solutions that yield multiple public benefits. Additional partnerships with the University of Florida and homeowner associations can facilitate the identification of potential private property natural and nature-based opportunities. To facilitate a data-driven process, the Parks Department will combine results from the *Resilient Jacksonville Vulnerability Assessment* with federally funded research and analyses.



Credit: University of North Florida

### Shocks and Stressors Addressed

Coastal Erosion / Chronic Flooding / Water Quality

### Implementation Partners

Parks / Resilience / USACE

### Potential Funding Mechanisms

Resilient Florida / NFWF Coastal Resilience Fund

### Implementation Timeframe



### Relative Cost



## SUB-ACTIONS

### 17.1 Conduct research and analyses to identify waterfront edges most suitable for natural and nature-based solutions.

With 59 tributaries, the St. Johns River, and the Atlantic Ocean, Jacksonville has hundreds of miles of waterfront edges. Many of these edges may be suitable for natural and nature-based solutions, particularly to address shoreline erosion. The City will pursue a Living Shoreline Suitability Model, as was developed for the Tampa Bay Area by the Florida Fish and Wildlife Research Institute, and will use the results in conjunction with the vulnerability assessment to prioritize sites for stabilization solutions like oyster reefs, living breakwaters and/or salt marsh restoration.<sup>13</sup> Hybrid gray-green approaches may also be suitable where some degree of hardening is needed, but additional habitat area might provide cascading benefits.

### 17.2 Address shoreline erosion in coastal parks.

Hurricanes and tropical events can cause large-scale erosion to Jacksonville's coastal parks and beaches. Past projects, like the Duval County Shore Protection Project implemented by the Jacksonville District of the U.S. Army Corps of Engineers, have successfully renourished hurricane-eroded beaches, adding sand to provide recreation and tourism opportunities as well as shorebird and marine turtle habitat.<sup>14</sup> Renourished beach and dune systems also provide protection to life and property from storm surge and waves during hurricanes and nor'easters. New partnerships, like the University of North Florida's work with the National Park Foundation, Groundwork Jacksonville, and Stericycle, are bringing oyster reefs to protect sensitive areas in the Timucuan Preserve from erosion.<sup>15</sup> The City and its partners will continue to search for new and innovative ways to address shoreline erosion.

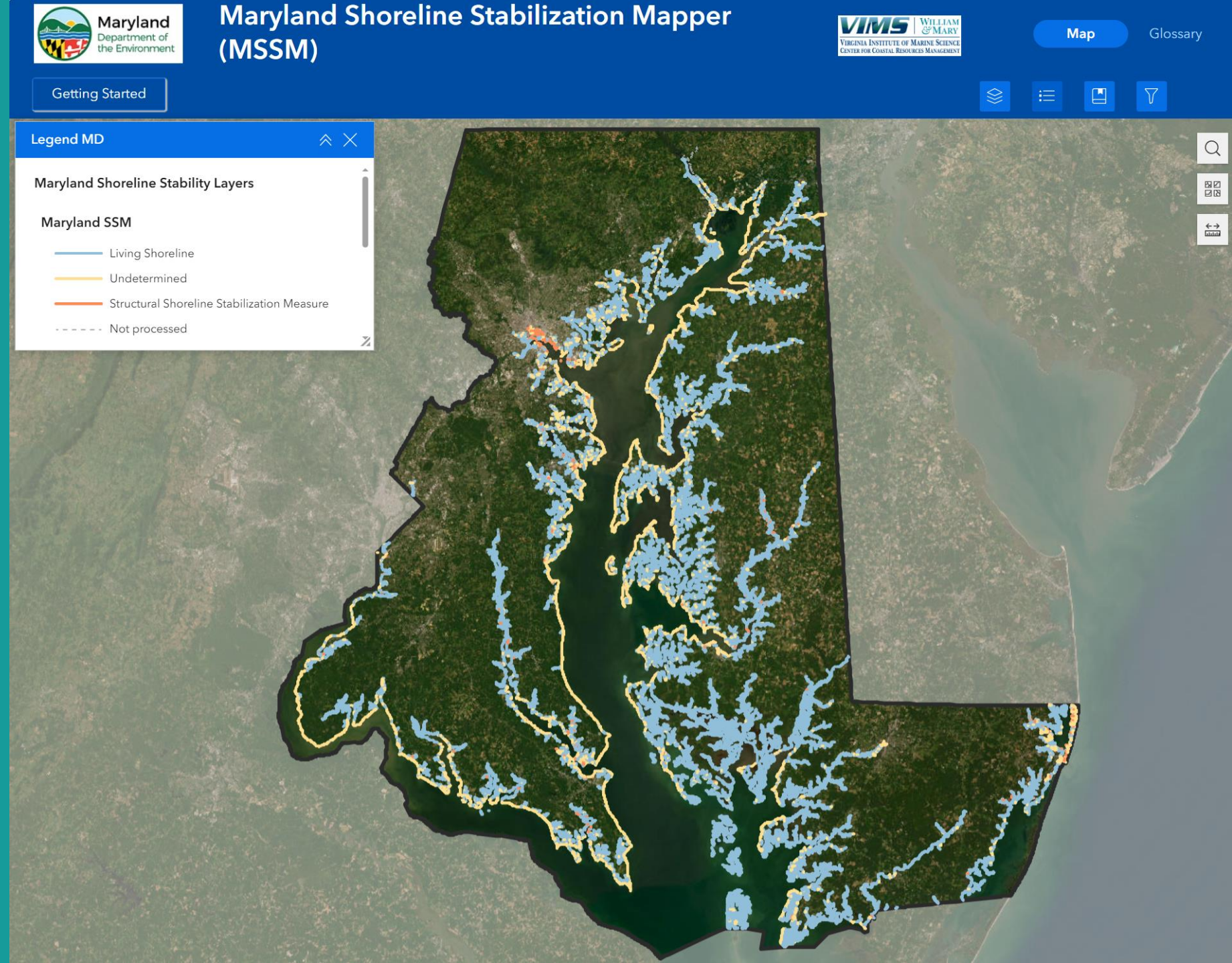
### 17.3 Identify sand and sediment resources for natural and nature-based solutions.

Natural and nature-based solutions like beach nourishment and marsh creation can help protect communities and ecosystems while providing recreational benefits to residents, beachgoers, and local businesses. These approaches rely on sand and other sediments which, in the future, may become increasingly expensive as readily available sources of suitable material become depleted. The City of Jacksonville will coordinate with partners such as the U.S. Army Corps of Engineers to identify long-term solutions for supporting beach nourishment, thin layer placement of dredged materials, and other coastal protection measures.



# Shoreline Suitability Model

- Developed by Virginia Institute of Marine Science
- Adapted for Tampa Bay, Perdido Bay, and Pensacola Bay
- Green vs. Gray





24 | **Invest strategically in existing parks to increase stormwater management capacity and reduce urban heat.**

Jacksonville has over 400 City parks distributed across the city. These sites provide many services for the community and can be improved to increase their capacity to provide even more stormwater management and urban heat reduction. Several of Jacksonville’s parks contain pools and splash pads—facilities that can help prevent heat-related illness during high heat days. Continued investment in and expansion of these resources is important for the well-being of Jacksonville’s residents. Green infrastructure such as rain gardens, bioretention ponds, and vegetated swales have the capacity to improve water storage capacity and water quality, provide ecological benefits, and improve public safety. Interventions such as rain cisterns, subsurface storage cells under active recreation, and permeable paving in parking lots can significantly increase the storage capacity of a park while maintaining, and often enhancing, the existing park uses. Interventions like the removal of underutilized impervious surfaces and planting of shade trees can improve areas with a high risk of heat exposure. Tree and other native vegetation planting can help cool and provide shade. Investments in park facilities such as green roofs, white roofs, and lighter, more reflective hardscapes can decrease urban heat. Additional investment in ongoing maintenance of existing features will help maximize the resilience potential as well.



**Shocks and Stressors Addressed**

Flooding / Extreme Heat / Water Quality

**Implementation Partners**

Parks / Public Works

**Potential Funding Mechanisms**

CIP / Resilient Florida

**Implementation Timeframe**



**Relative Cost**



SUB-ACTIONS

**24.1 Align resilience actions with the forthcoming Master Recreation Improvement Plan.**

The Parks Department is undergoing a comprehensive Recreation Master Plan effort that includes public outreach as well as cataloging and assessing existing park land and facilities. The Plan will make recommendations for how to improve parks, assess which facilities and parks are used by the community, and take stock of the overall condition and needs for each park site. The Plan will guide short-, medium-, and long-term investments and park modernization efforts. The Parks Department will incorporate resilience objectives, such as reducing urban heat and stormwater flooding and improving community and ecosystem health, into the assessment of existing parks and prioritization of future investments. Relevant resilience actions identified in *Resilient Jacksonville* will be included in the Master Recreation Improvement Plan to coordinate implementation of the two plans.

**24.2 Create multi-beneficial park amenities with intentional stormwater retention.**

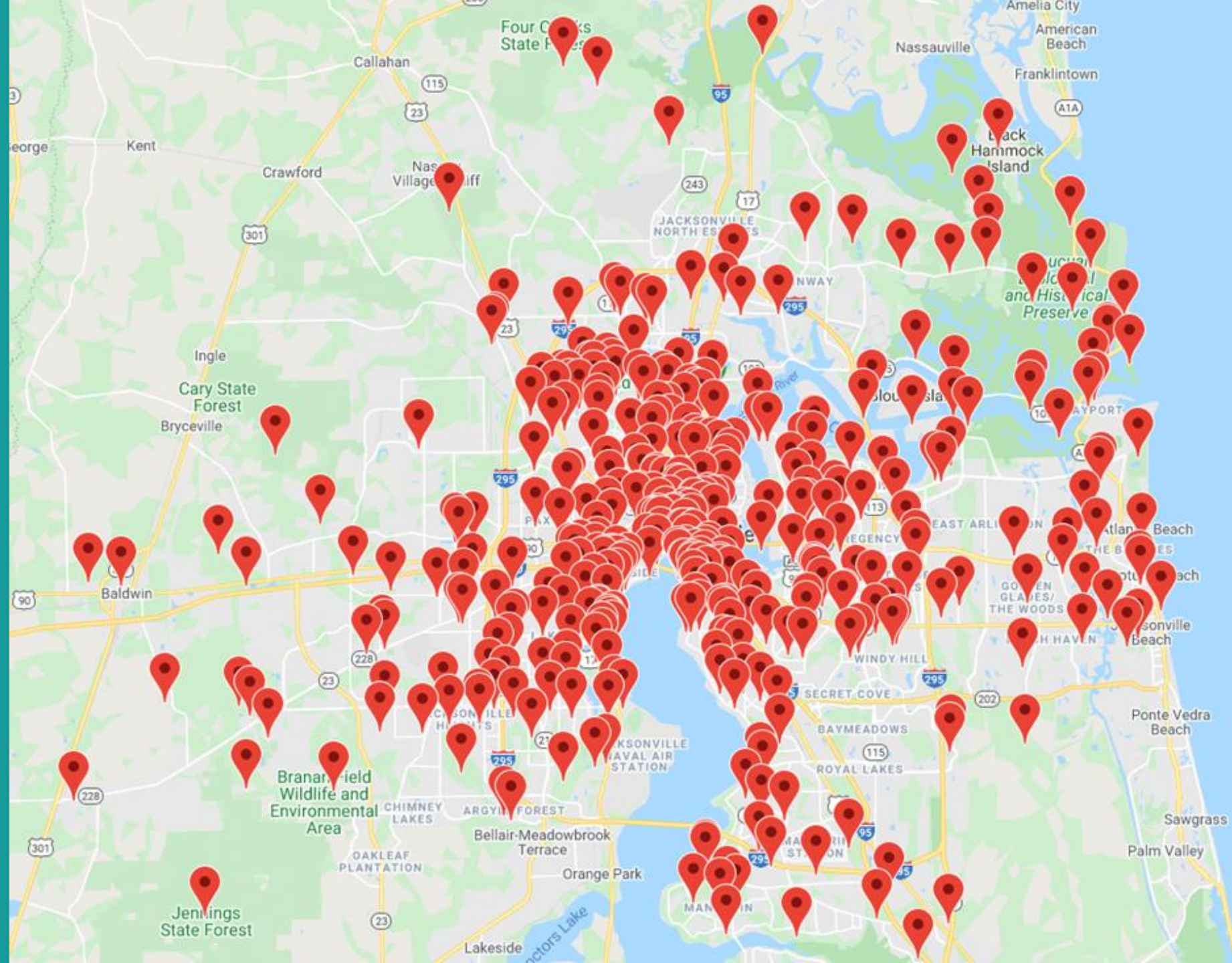
The Office of Resilience will work with the Parks Department to prioritize park upgrades that include amenities that provide multiple benefits to the community, rather than serving a single use or function. For example, when a sports field needs to be regraded and renovated, the City will consider incorporating below-grade water storage to provide improved stormwater management, reduce flood risk to neighboring areas, and speed up the time it takes for the field to dry and be playable again after a rain event. Another example is incorporating resilience benefits into parking lot renovations through designs with vegetation and trees to provide shade, biodiversity, and bioretention, as well as use of permeable paving for rainwater management. Upgrading existing parks can improve resilience by reducing flood risks and lowering urban heat effects while providing additional benefits such as improved places to gather, trails for active recreation, and increased adjacent property values. These resilience benefits extend beyond the boundaries of an individual park: parks located on higher ground within a watershed are often key to retaining water during storm events to reduce the amount of water within the storm system, while parks in floodplains or with higher groundwater can be designed to maximize accommodation and retention of stormwater. The City will consult the best available flood and heat data from the vulnerability assessment to identify parks that have the greatest capacity for water storage and can benefit most from improvements that address extreme heat.





# COJ Parks

- Largest park system in continental US
- Over 400 parks and facilities
- Ideal locations for green infrastructure





# Parks are ideal locations for green infrastructure

## Practices Include:

- Native trees
- Protected habitat
- Constructed wetlands
- Retention pond
- Rain garden
- Bioswale
- Green roof
- Cistern
- Porous asphalt
- Permeable pavement



- 1 Bioswale
- 2 Stormwater trees
- 3 Permeable pavement parking lot
- 4 Porous asphalt basketball court
- 5 Rain garden
- 6 Protected habitat
- 7 Native trees
- 8 Retention pond/  
Constructed wetlands
- 9 Cistern
- 10 Green roof

Green stormwater infrastructure (like the features highlighted here) in local parks is an efficient way to reduce flooding; improve water quality and wildlife habitat; provide opportunities for education and employment; increase biodiversity, access to nature and green space, and community resiliency; and much more. For more information and for an interactive version of this poster visit [www.nrpa.org/GreenInfrastructure](http://www.nrpa.org/GreenInfrastructure).

*Managing Stormwater Naturally!*



# FLORIDA DWIGHT PARK BIORETENTION





# S LINE MULTIUSE TRAIL BIOSWALE





# BEACH AND PEACH URBAN PARK STORMWATER POND





# RIVERFRONT PARK GREEN ROOF







## 40 | Establish an Office of Resilience to facilitate the ongoing implementation of Resilient Jacksonville.

To guarantee that the recommendations set forth in *Resilient Jacksonville* are coordinated and well-positioned for implementation, the City will establish and adequately staff an Office of Resilience. The office will be responsible for the ongoing implementation of *Resilient Jacksonville* by leading coordination across City departments and with external partners and collaborating with local academic partners to organize a system that tracks implementation progress. The office will also prioritize the development, sharing, and application of the best available data and science on climate projections, flood and heat risk, and other shocks and stressors to inform decisions across City government. The Office of Resilience will also ensure that the use of resilience data is managed ethically and accessed through the appropriate channels.



### Shocks and Stressors Addressed

All Shocks and Stressors

### Implementation Partners

COJ / The Water Institute / JU

### Potential Funding Mechanisms

General Fund / FUSE Fellows

### Implementation Timeframe



### Relative Cost



### 40.1 Facilitate interdepartmental and interagency collaboration throughout City government and with external partners.

The main purpose of establishing the Office of Resilience is to ensure all aspects of City government are well-coordinated, and that decisions are made holistically rather than in silos. The development of this Strategy began a process of inter-agency collaboration, and the success of *Resilient Jacksonville* will rely on the creation of collaborative processes that continue into implementation. By filling this role, the Office of Resilience can ensure that investments make the best use of taxpayer dollars and are aligned with resilience goals—that infrastructure is designed and built to withstand future conditions and that city staff are able to build stronger relationships across departments. Additionally, this office can help articulate a cohesive vision in partnership with other outside agencies to ensure that all key entities in Jacksonville are moving towards a shared future.

### 40.2 Use the best available science and data to inform decisions.

Just as *Resilient Jacksonville* was developed using the latest and most comprehensive science and data, continuing to develop and use the best available data will be critical for achieving the many goals set forth in this Strategy. The Office of Resilience will serve as the agency in charge of maintaining and deploying robust climate and vulnerability datasets across all departments and helping to contextualize data for city leaders to use in decision-making processes. More specifically, over the next two years, the Office of Resilience will be developing a compound flood model in conjunction with The Water Institute that will provide the City with the most advanced flood data in the state. This work will identify the most flood-prone areas of the city and guide project development. As new datasets become available—whether it be the compound flood model or future national climate assessments—the Office of Resilience will be responsible for updating policies and procedures that reflect the most accurate data.





# COMPOUND FLOOD MODEL

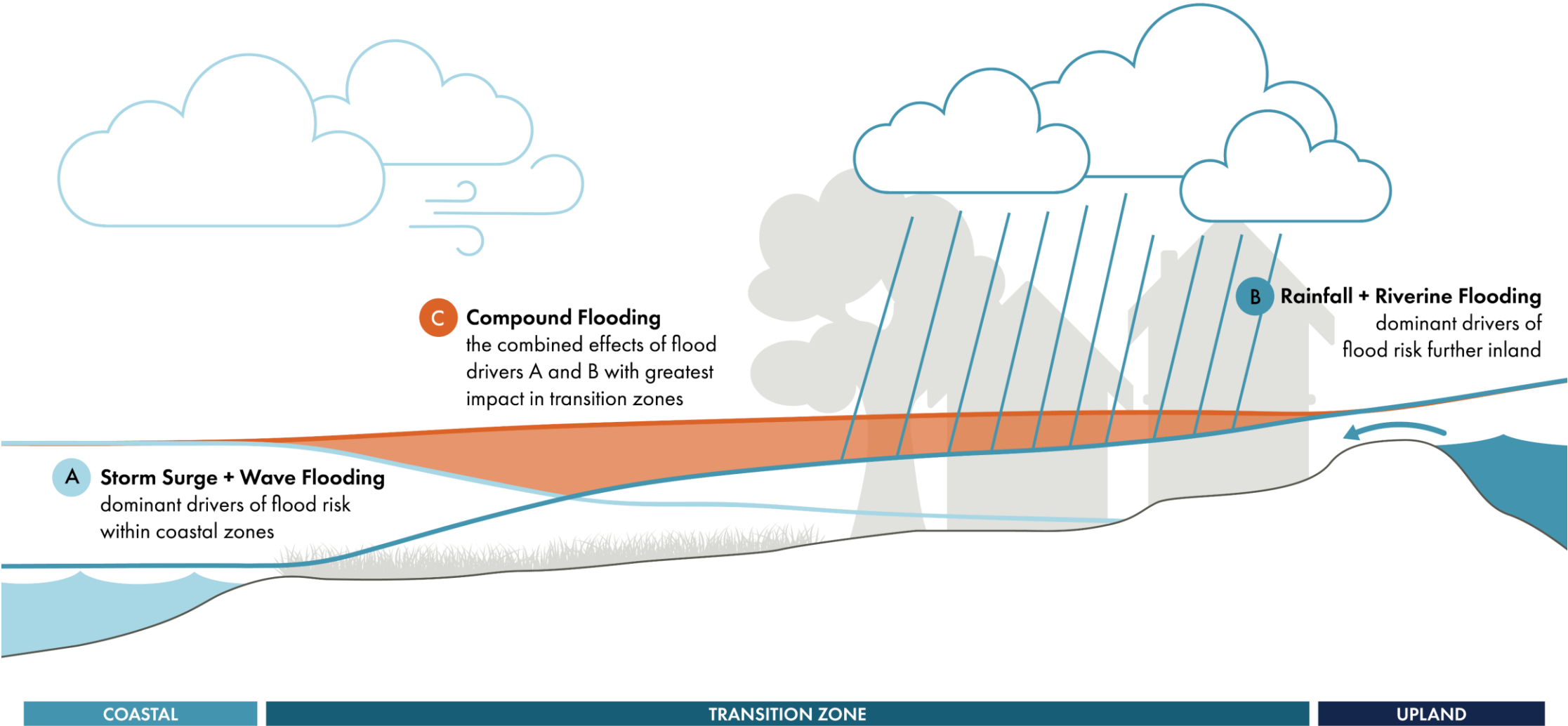
Identifying risk using best available  
science and data





# COMPOUND FLOODING

IN COASTAL TRANSITION ZONES



*Compound flooding occurs when rainfall, riverine flooding, and coastal flooding interact to produce combined flood hazards.*





### **Quantify compound flood hazards**

Develop probabilistic compound flood model to better understand flood risks.



### **Forecast flooding in real time**

Design FloodID support dashboards to facilitate dynamic disaster preparedness and response.



### **Develop data and model catalog**

Deploy Jacksonville EnDMC to support efficient and centralized data sharing.



### **Guide implementation of Resilient Jacksonville**

Estimate flood consequences and improve decision making, policy, and resilient infrastructure design.

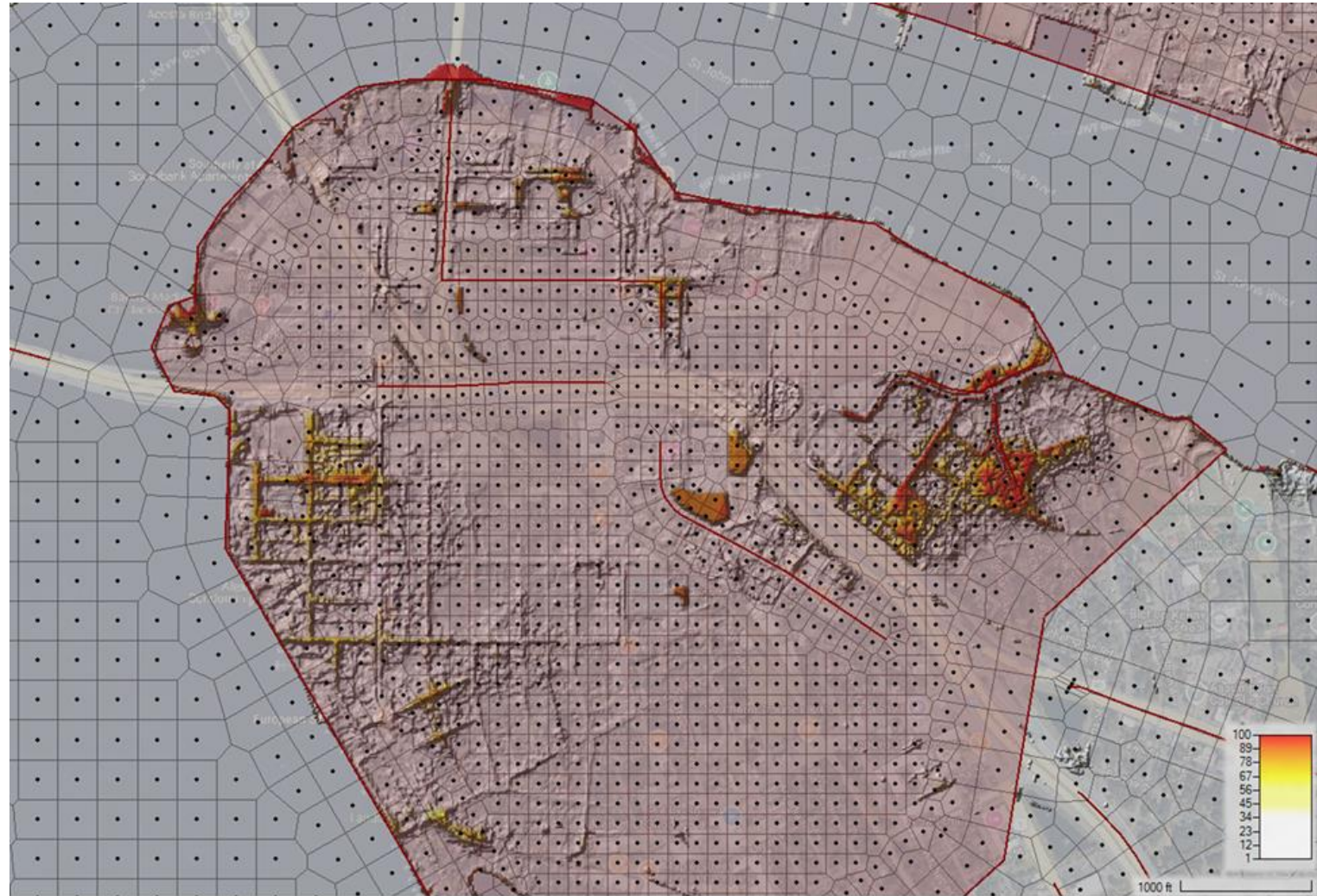


**cutting edge science and data**

**TO SUPPORT A MORE RESILIENT JACKSONVILLE**

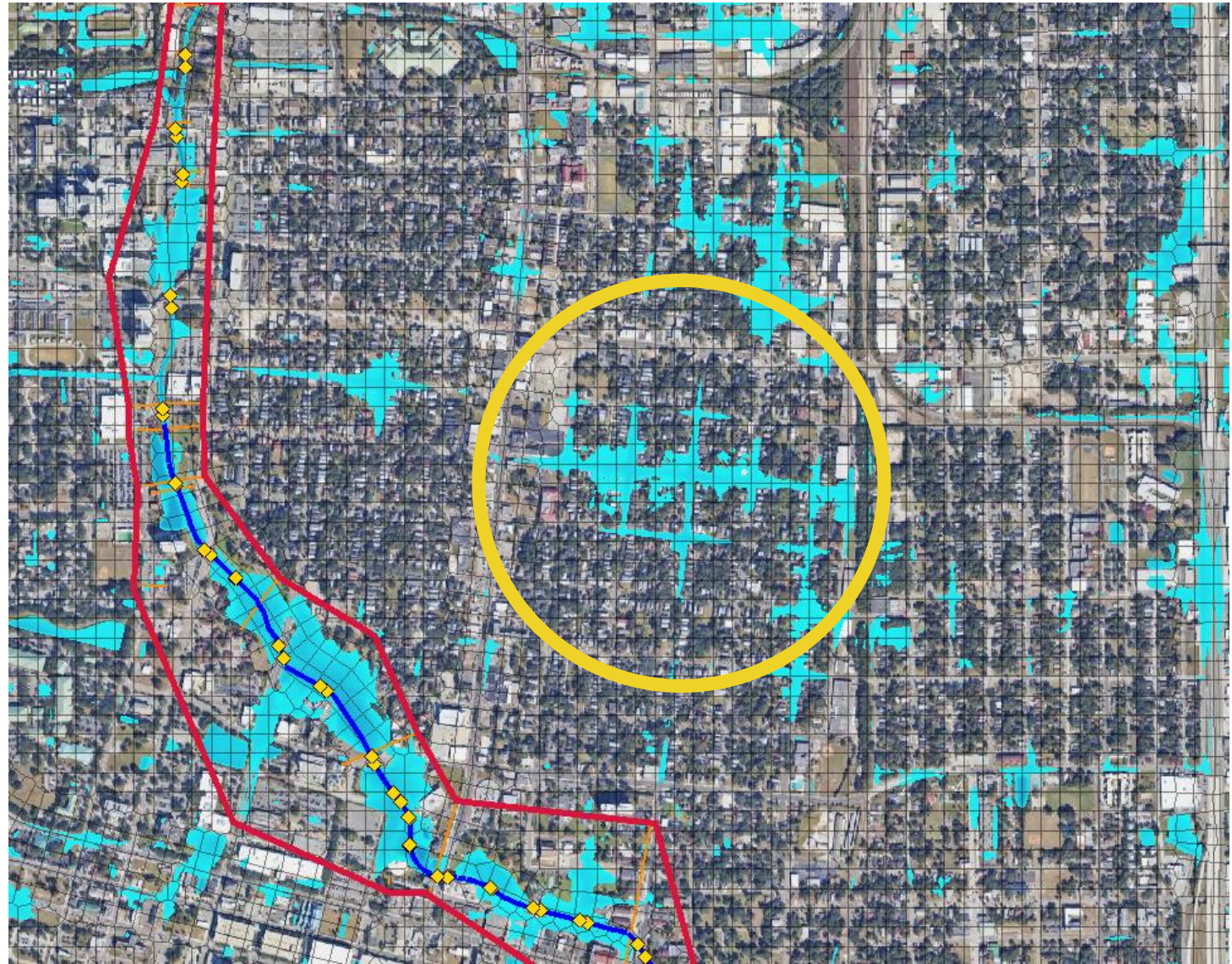


New detailed  
models better  
capture  
complex flood  
dynamics



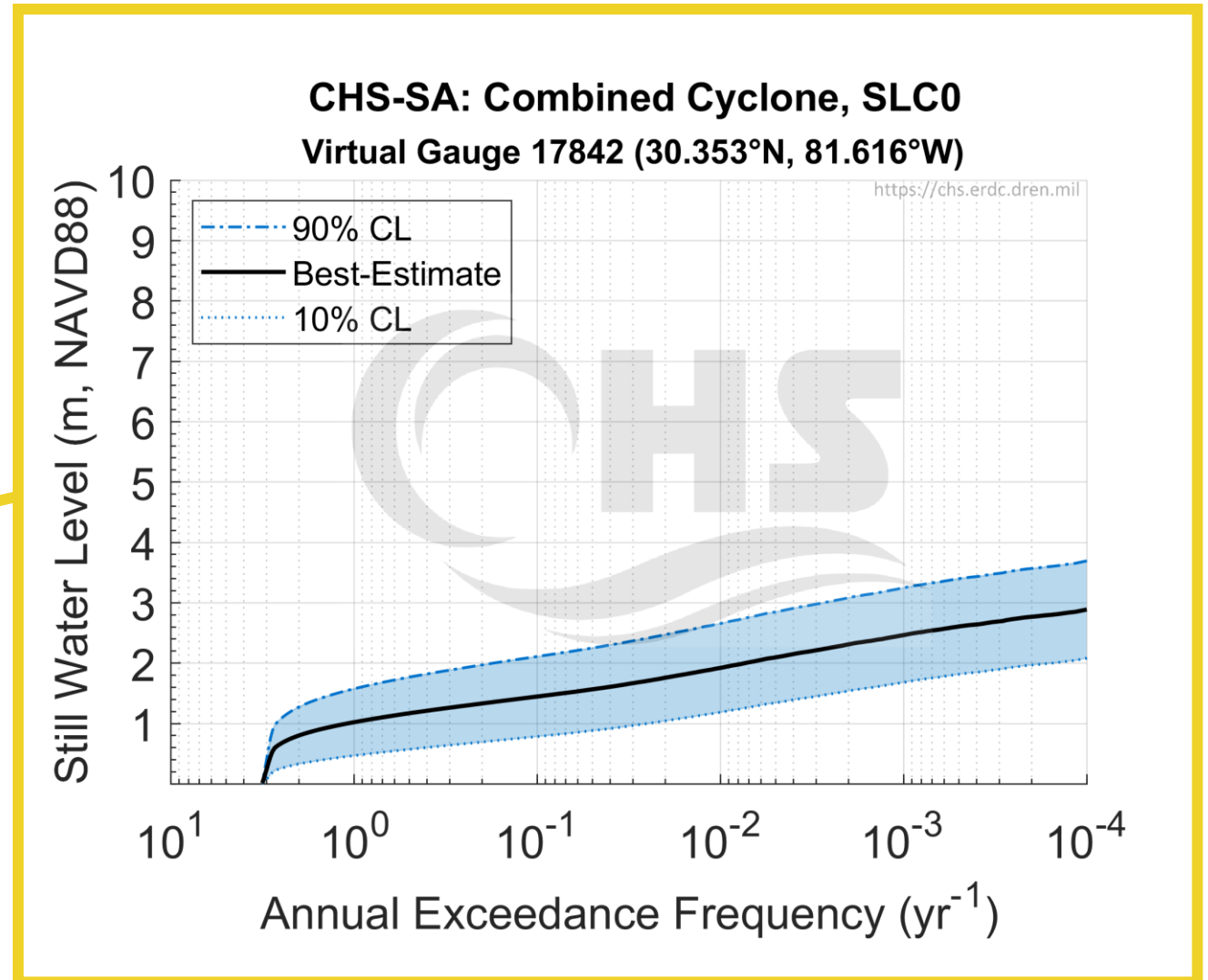
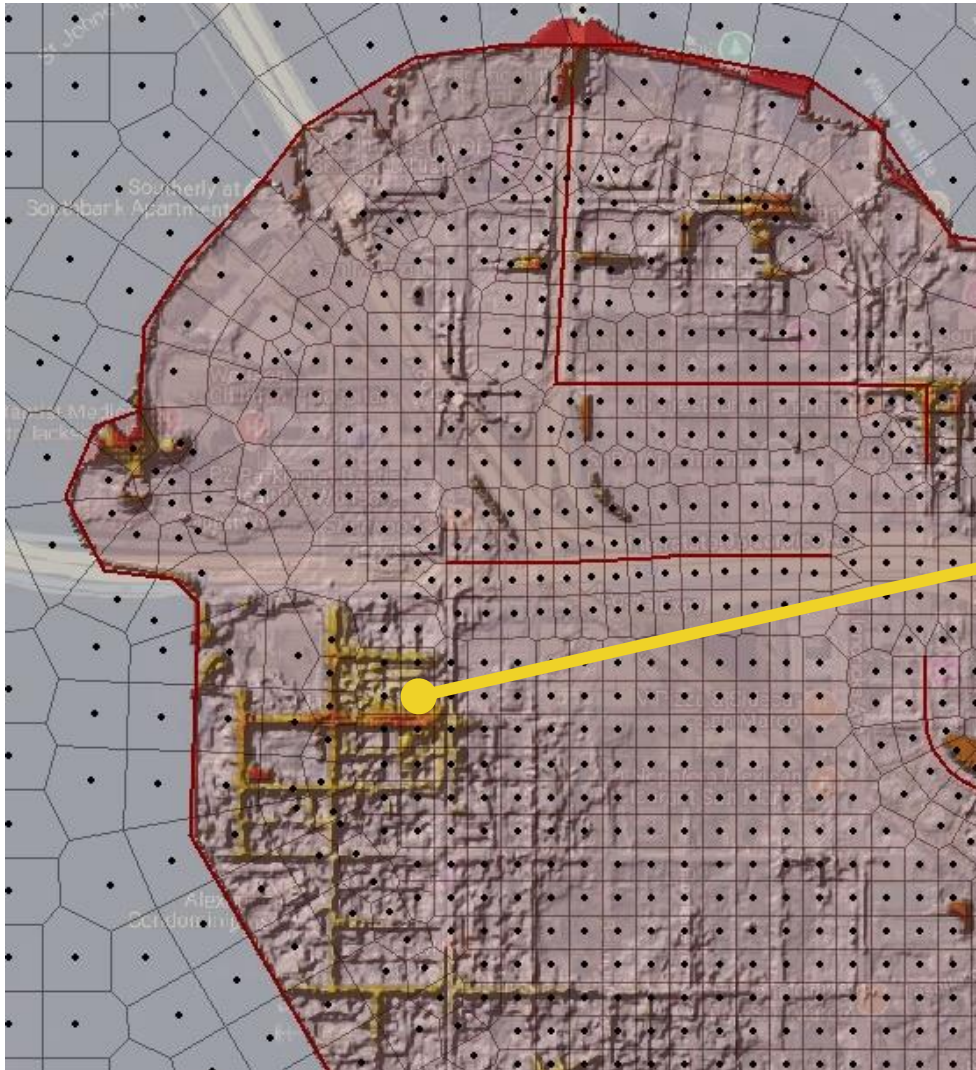


Compound flood model captures localized flooding not included in existing flood data



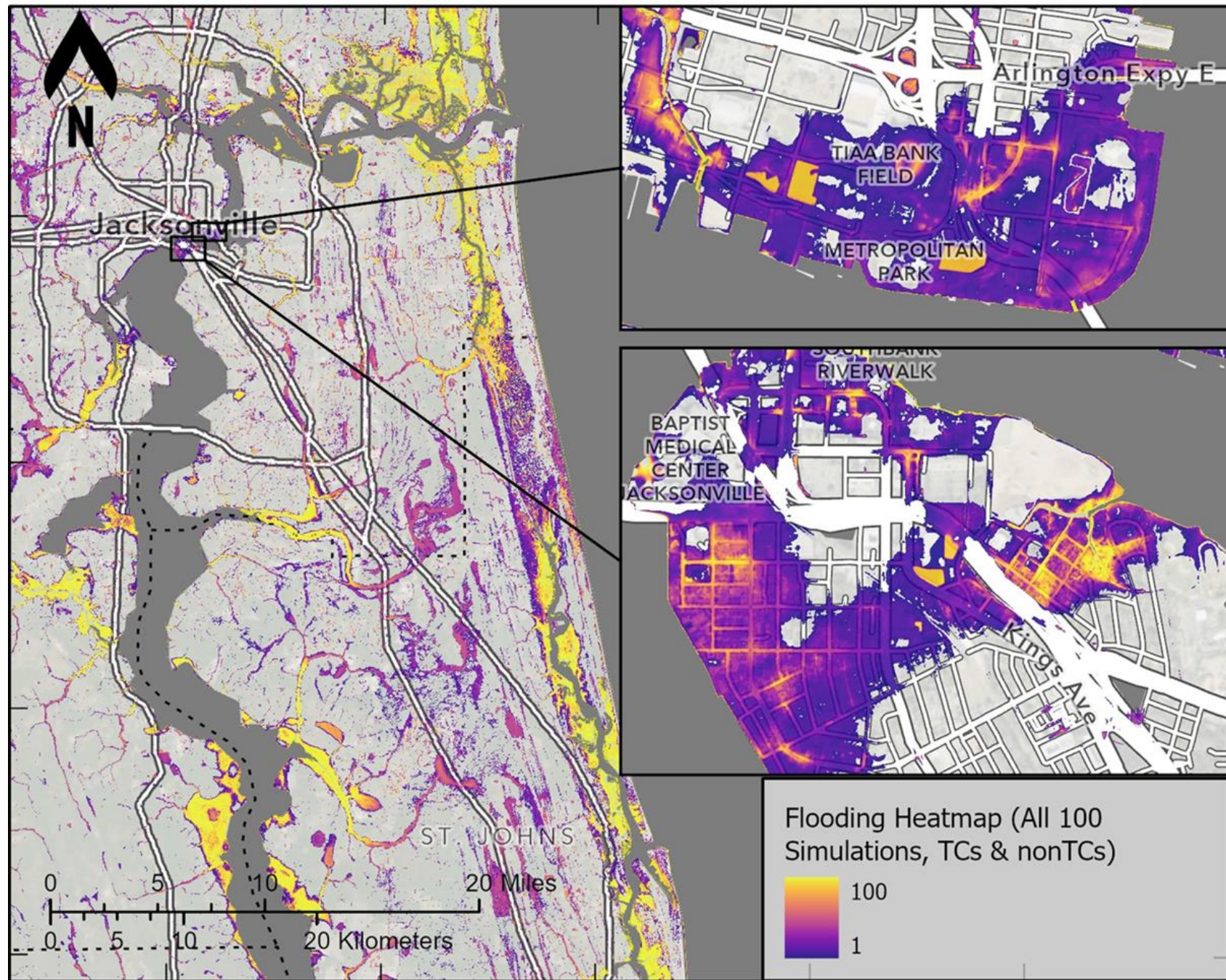


# ESTIMATING COMPOUND FLOOD FREQUENCY AND SEVERITY



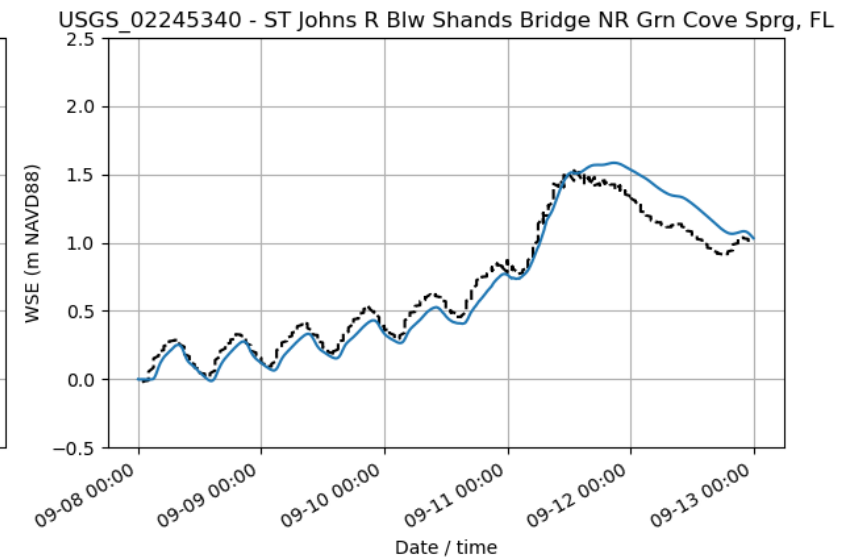
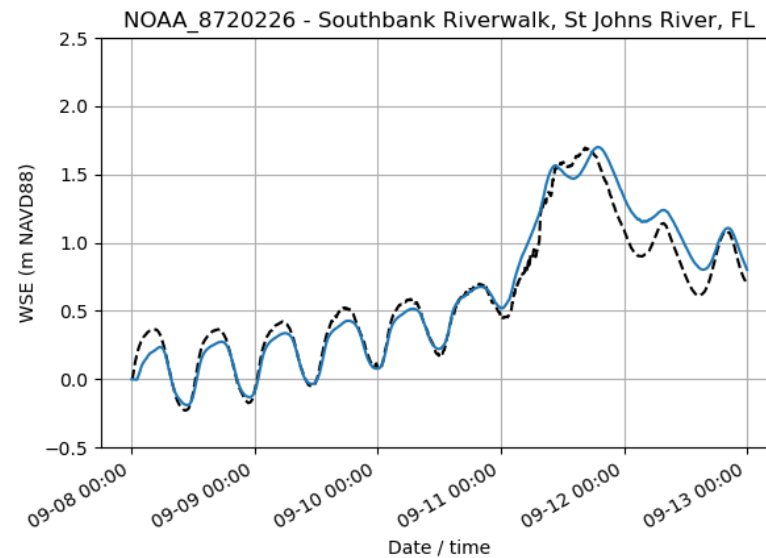
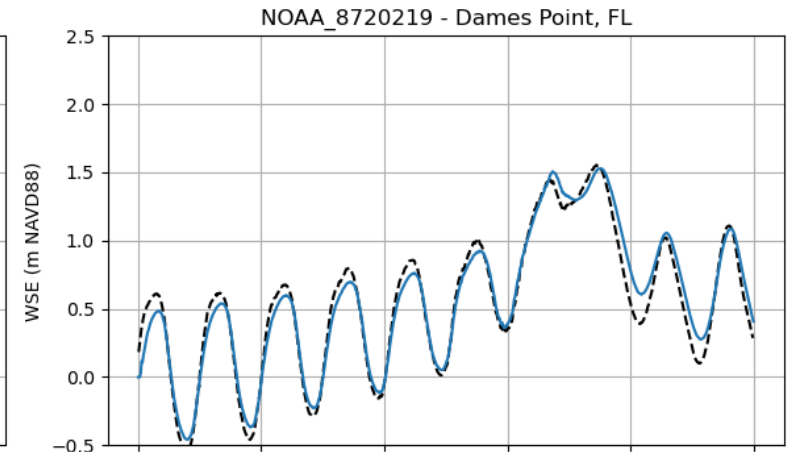
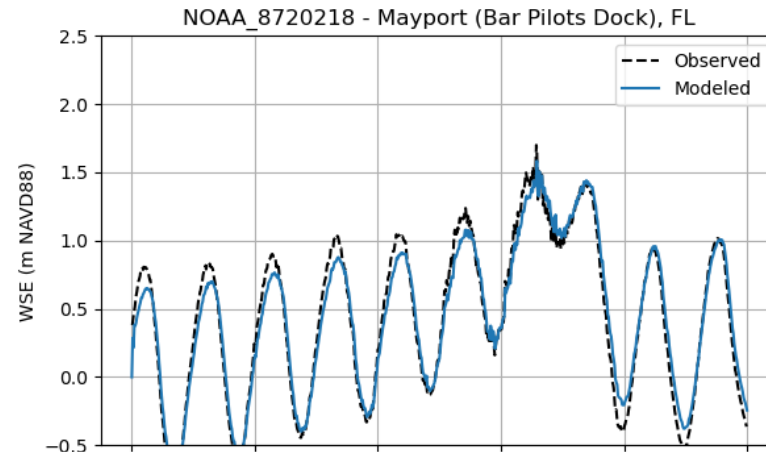
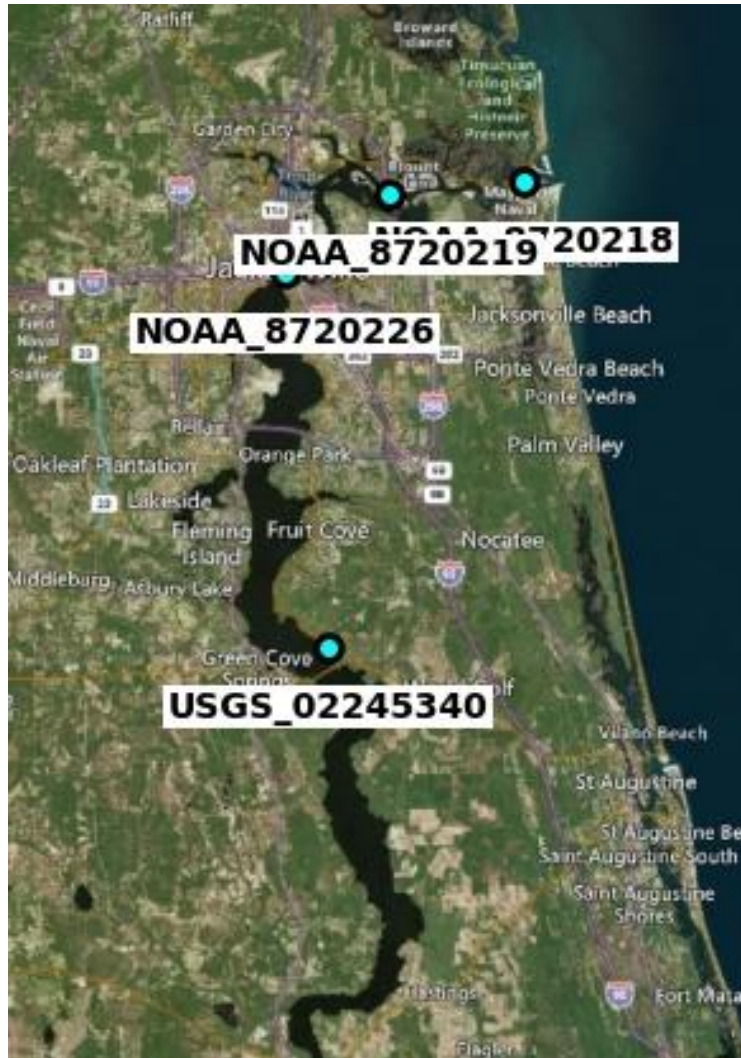


# VISUALIZING RESULTS



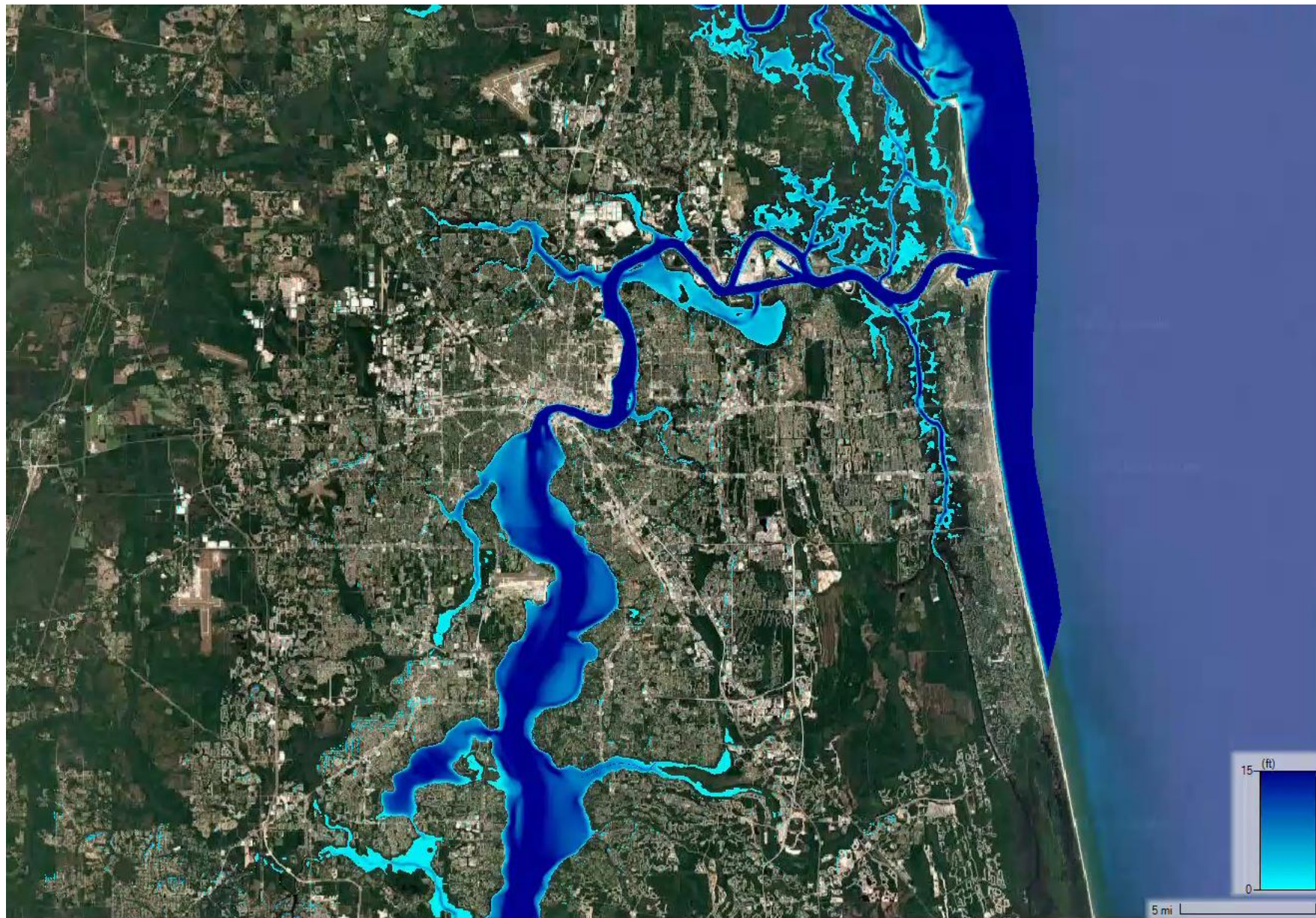


# MODEL PERFORMANCE: HURRICANE IRMA





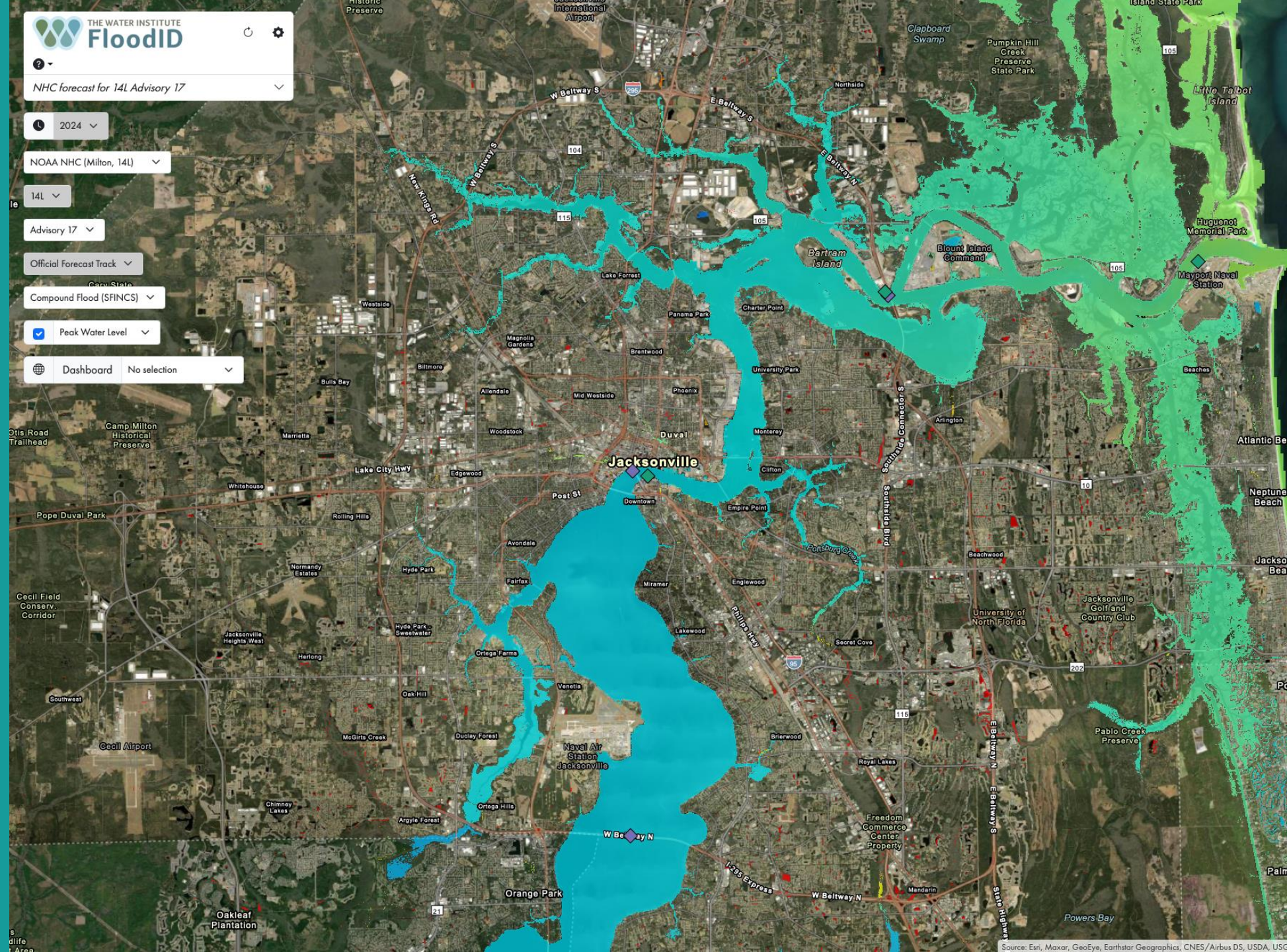
# New modeling captures complexity of Hurricane Irma





# FLOOD ID

- SFINCS Model
- Real-time forecasting
- Flooding extent, duration, and water depth





**METEOROLOGICAL FORECAST: WIND AND PRESSURE FIELDS**

**METEOROLOGICAL FORECAST: RAINFALL**

**TROPICAL STORM SURGE MODELING**

**COMPOUND FLOOD MODELING**

**FLOOD EXTENT, DEPTH, AND TIMING VISUALIZATION**

**DECISION SUPPORT TOOLS**

Leverage NOAA atmospheric pressure and wind velocity, which drive the coastal storm surge response

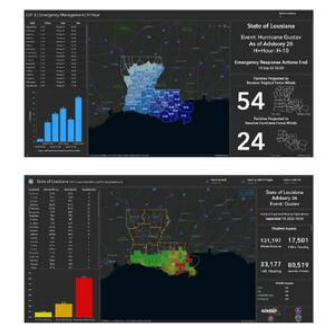
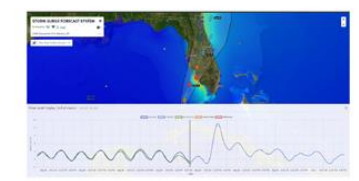
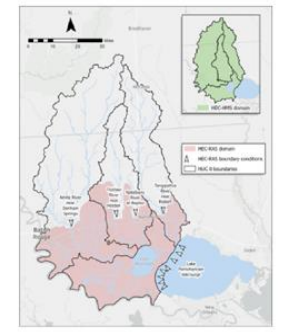
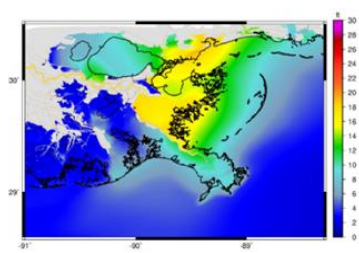
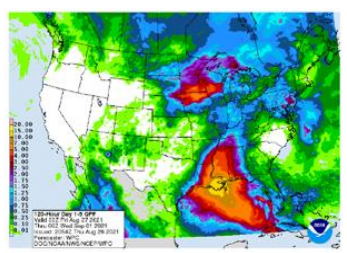
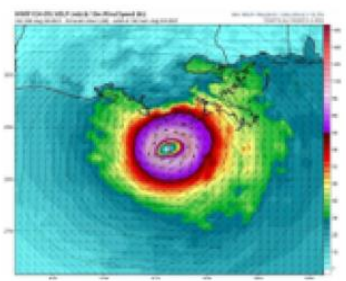
NOAA rainfall forecasts appropriate to combine with pressure and wind forecast for estimating compound flooding

Using pressure/wind forecast data to estimate storm surge and wave conditions, extents and timing

Using rainfall and streamflow data, as well as storm surge forecasts to estimate compound flooding

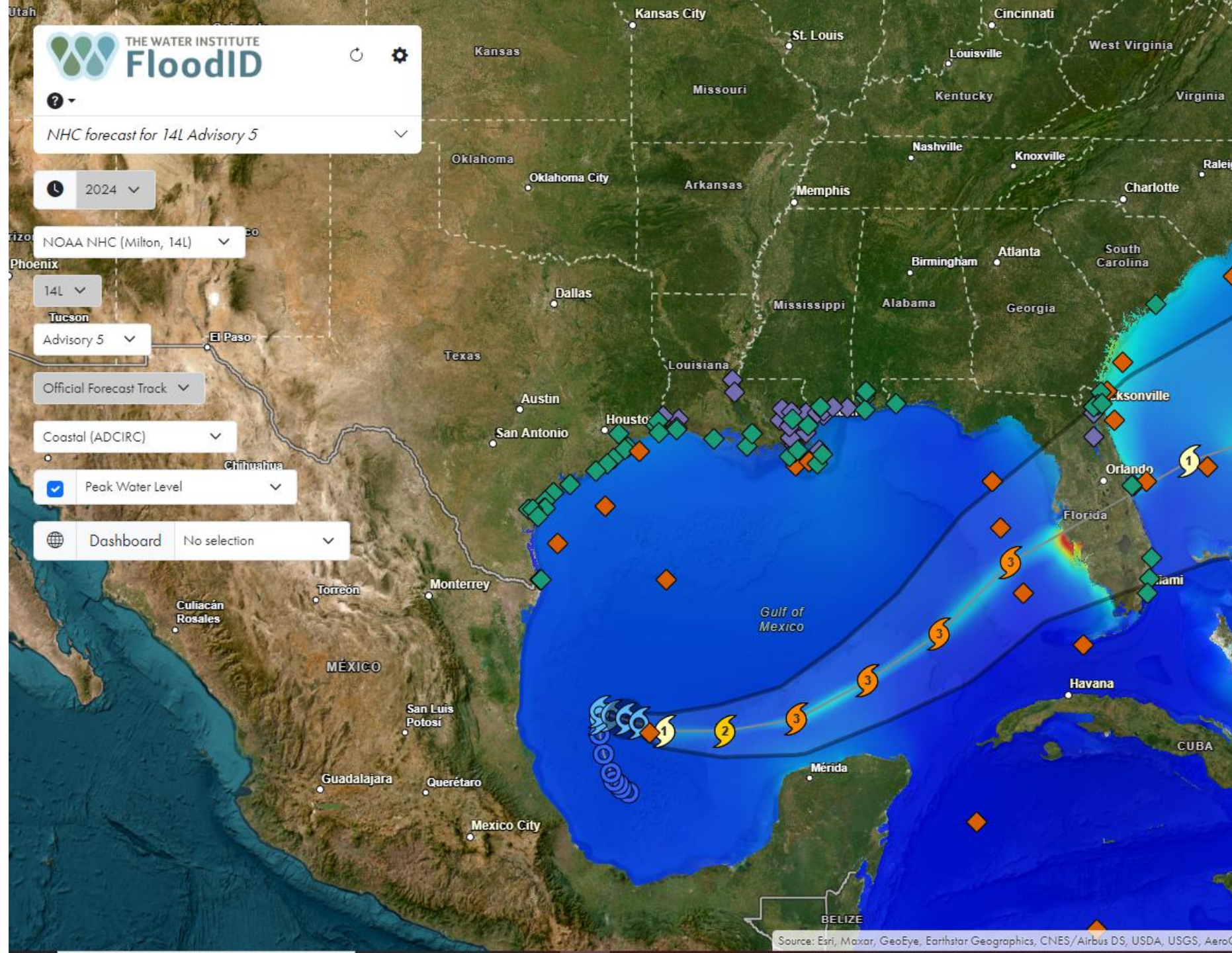
Visualize the outputs from tropical storm surge modeling and compound flood modeling

Custom set of decision support tools to meet stakeholder-specified needs





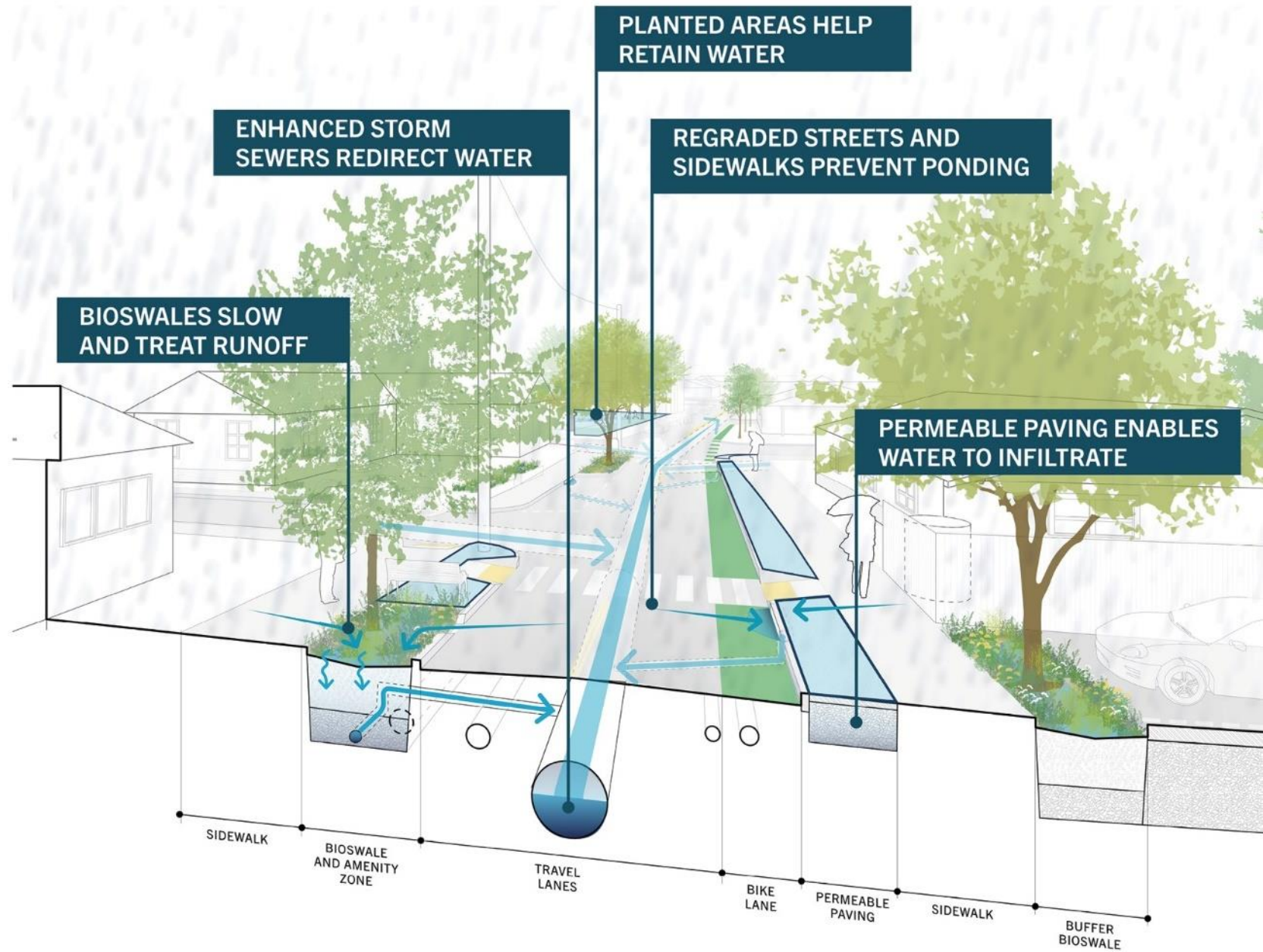
# EMERGENCY RESPONSE: Supporting real-time decision making





# ENGINEERING & DESIGN:

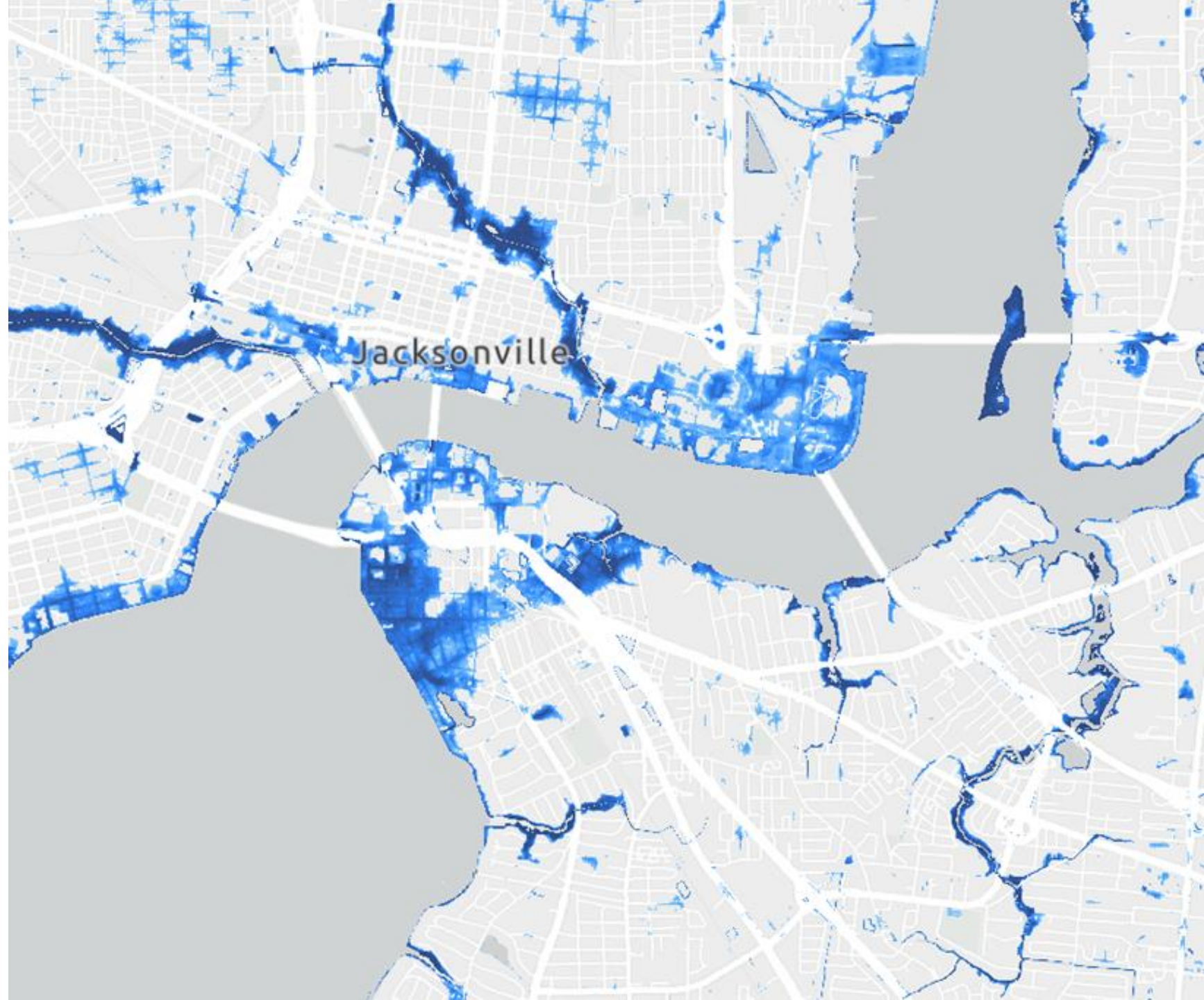
Supporting resilient  
infrastructure  
design





## **PLANNING:**

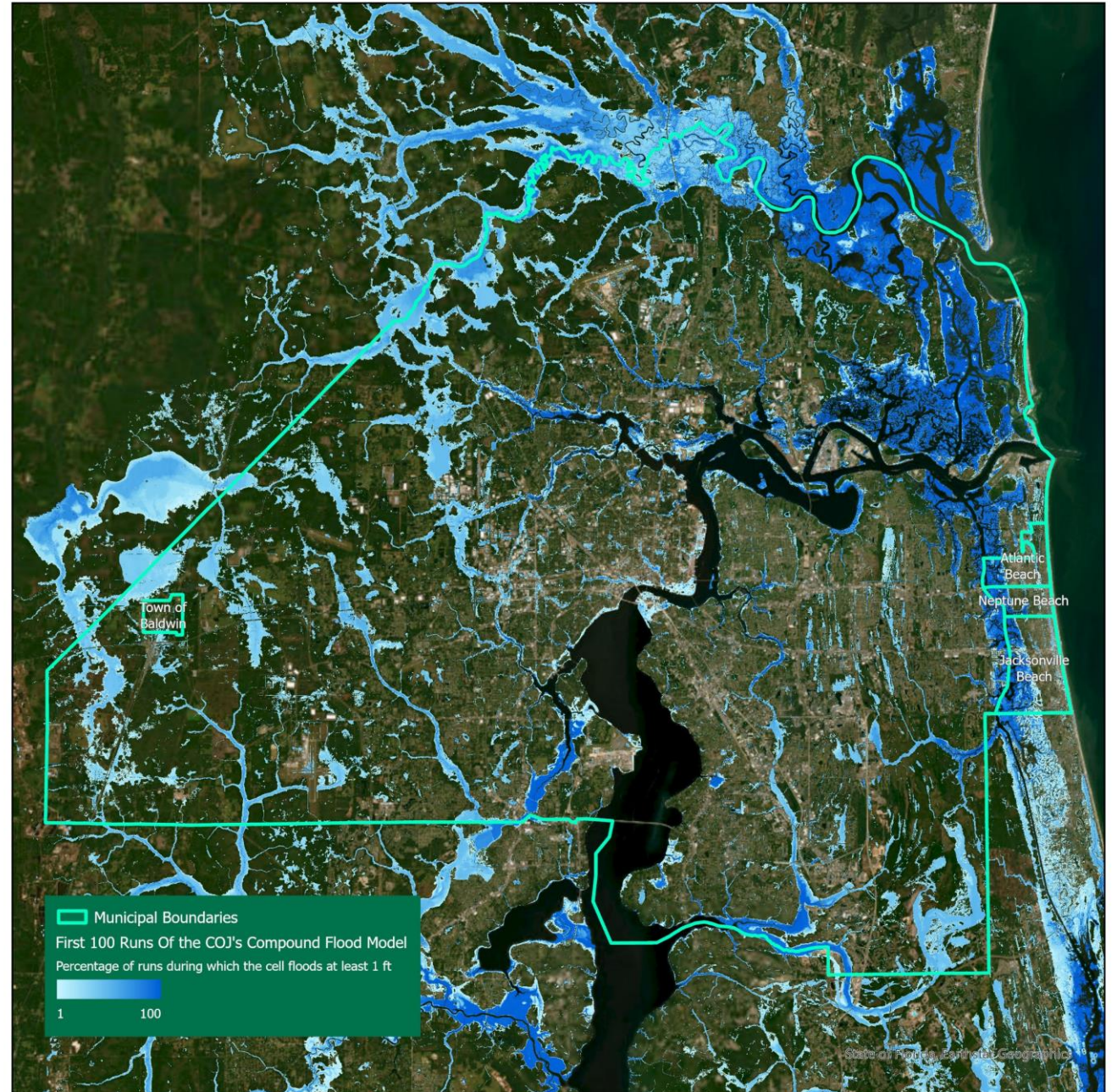
Guiding future growth in areas that are low risk and well-connected to infrastructure





# PLANNING GREEN INFRASTRUCTURE:

Site selection for projects on public properties across the city





# **GREEN INFRASTRUCTURE**

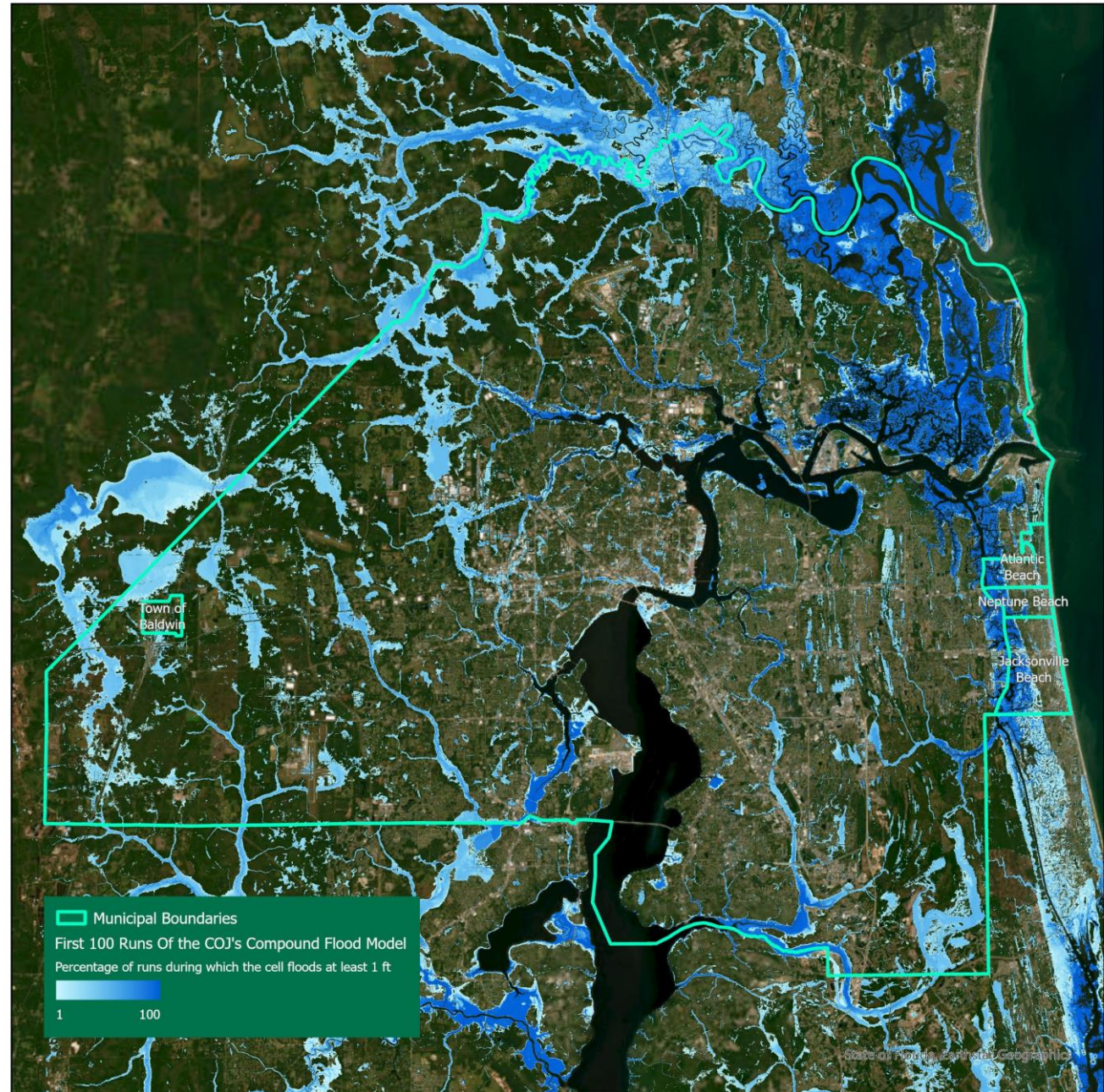
**Investing in public properties to  
mitigate heat and manage stormwater**





# Site Selection

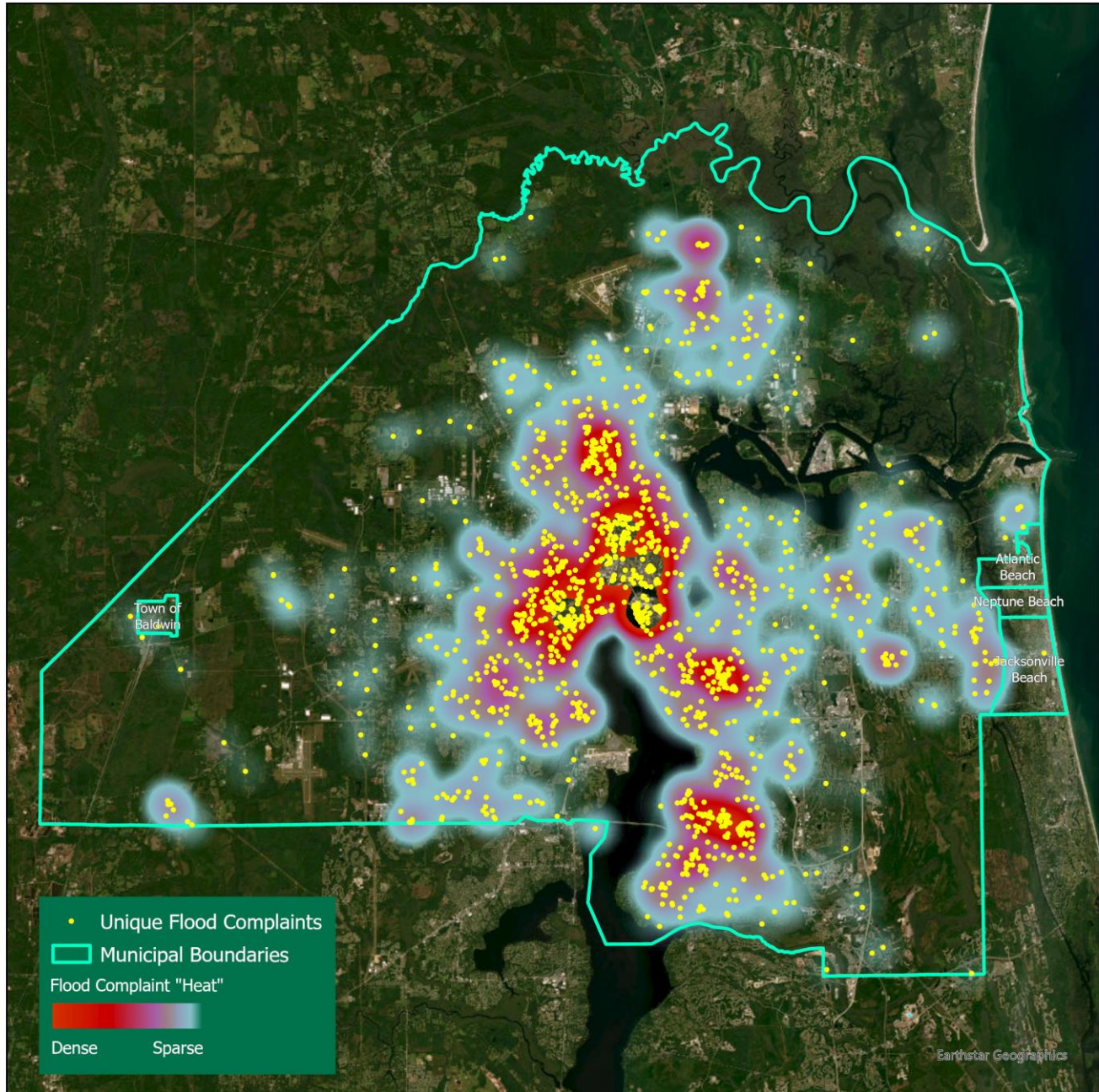
- First 100 runs of compound flood model
- 630-CITY flooding complaints
- Flooding data from vulnerability assessment





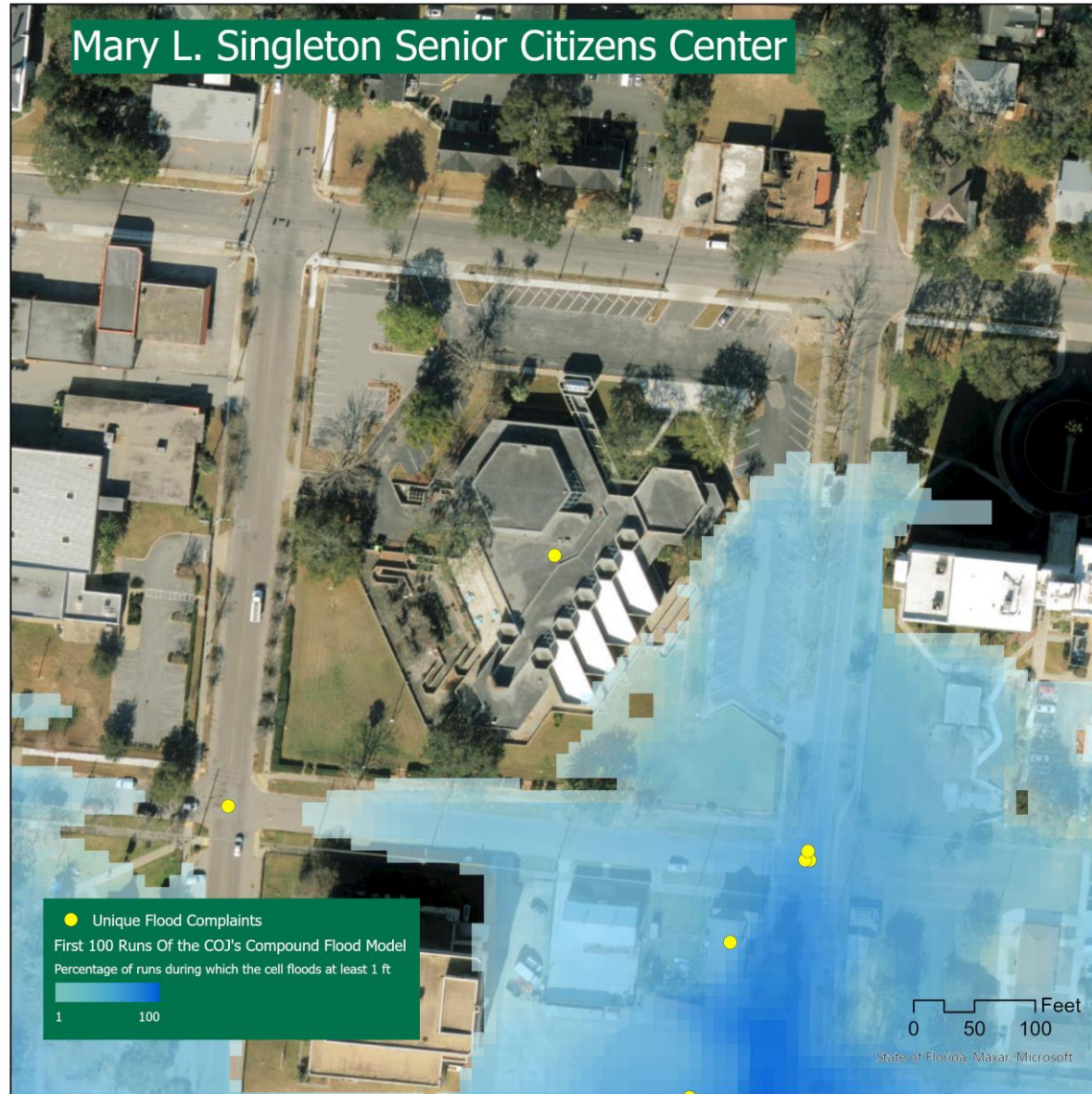
# Site Selection

- First 100 runs of compound flood model
- 630-CITY flooding complaints
- Flooding data from vulnerability assessment





# MARY SINGLETON SENIOR CENTER





# CONCLUSIONS

- Green infrastructure reduces flooding and extreme heat
- *Resilient Jacksonville* strategy includes green infrastructure
- Public parks are ideal locations for pilot projects
- Compound flood model will guide site selection for future projects







**DOWNLOAD THE STRATEGY  
AND FOLLOW OUR PROGRESS**

**[resilientjacksonville.com](https://resilientjacksonville.com)**