



SEA LEVEL RISE IN TAMPA

# Living With Water™

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WAGGONNER  
& BALL





- I Who We Are
- II Louisiana Delta
- III Tidewater Virginia
- IV South Carolina Low Country



# Waggoner & Ball Projects





# The Historic New Orleans Collection

New Orleans, Louisiana





# Tulane University School of Business

New Orleans, Louisiana





# Beijing City International School

Beijing, China





# Flooded City, 2005

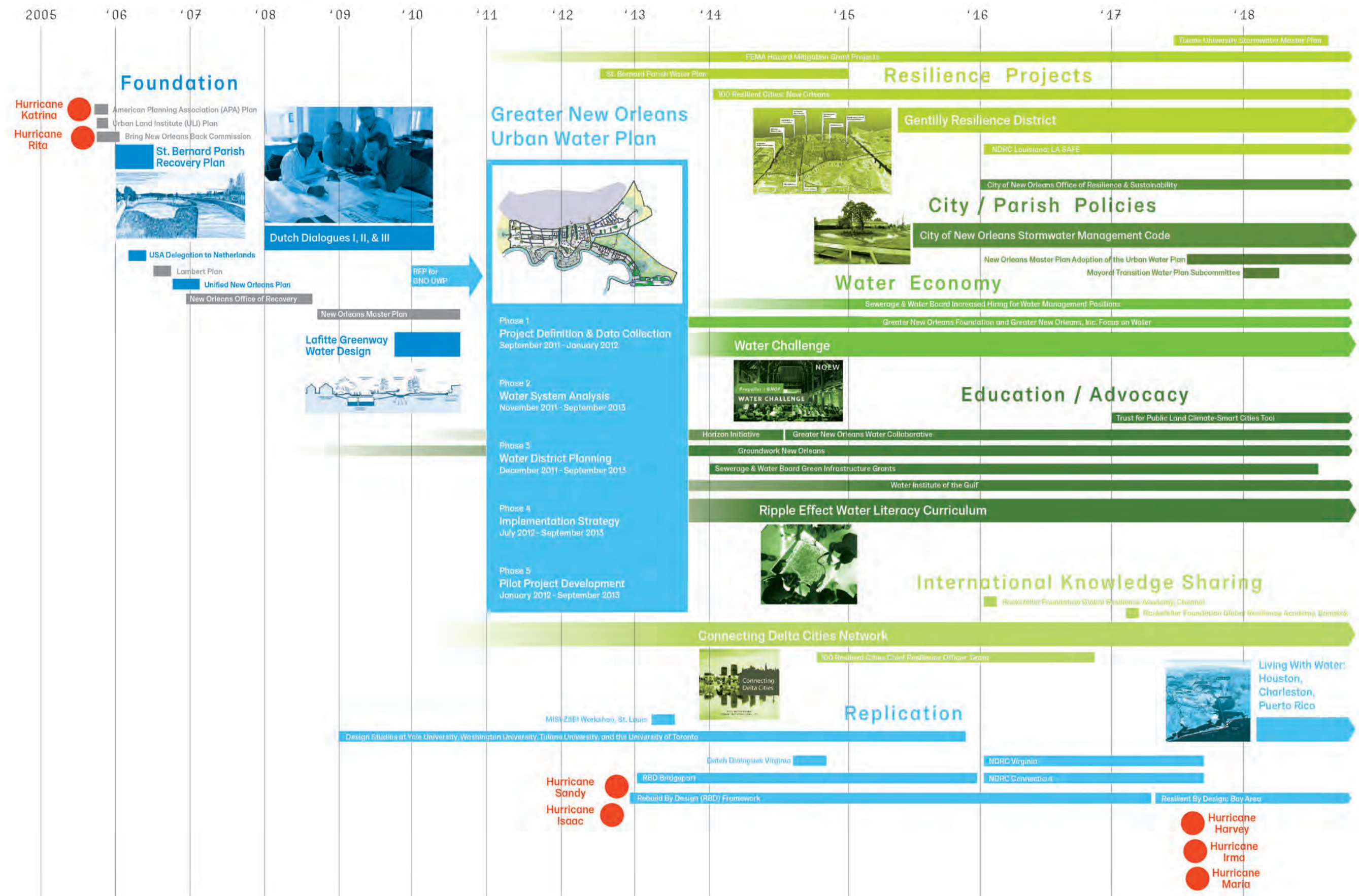
New Orleans





# Living With Water New Orleans

## Post-Katrina Catalytic Plans



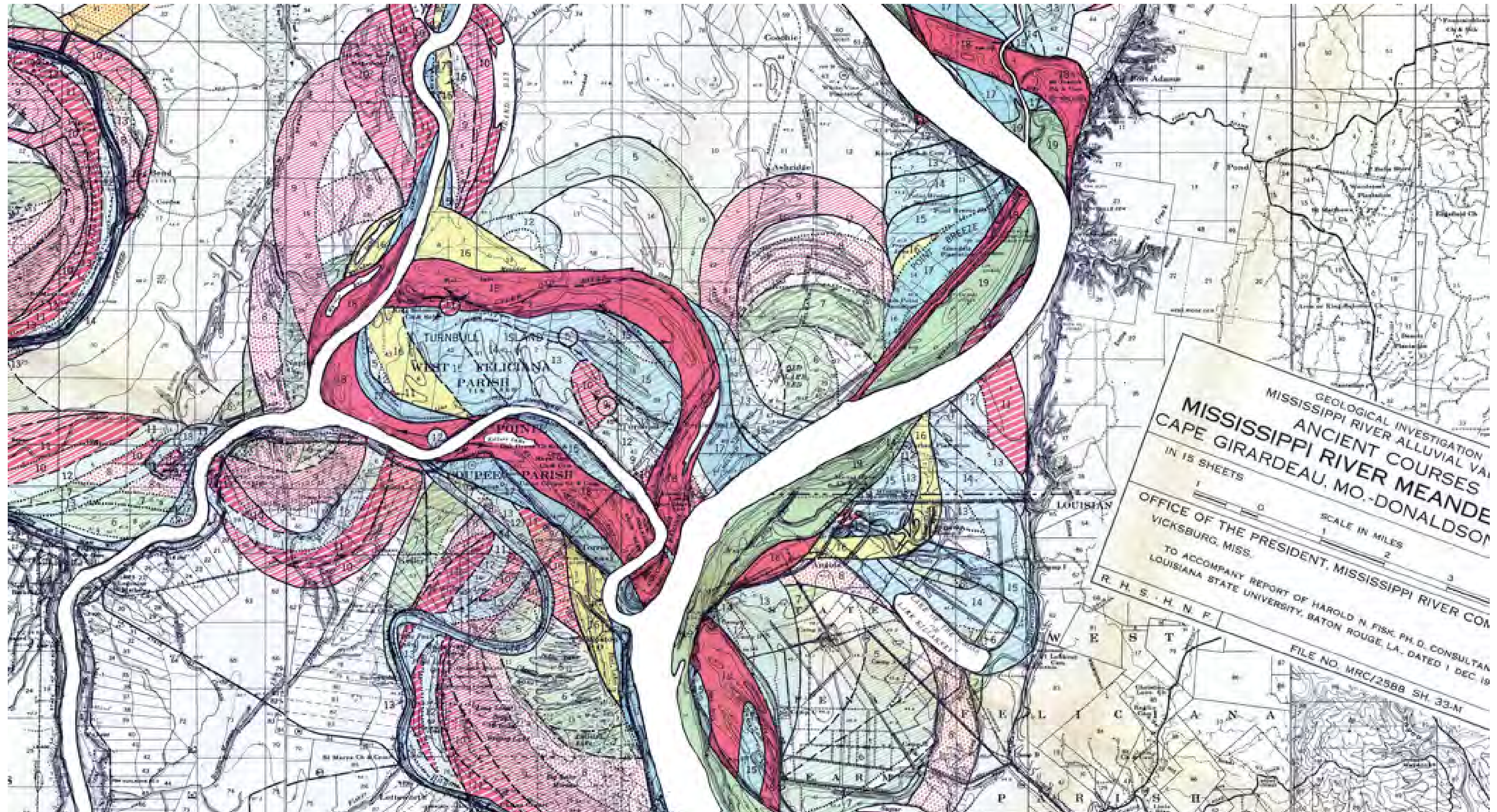


# Louisiana Delta





# Fisk Maps of the Mississippi River

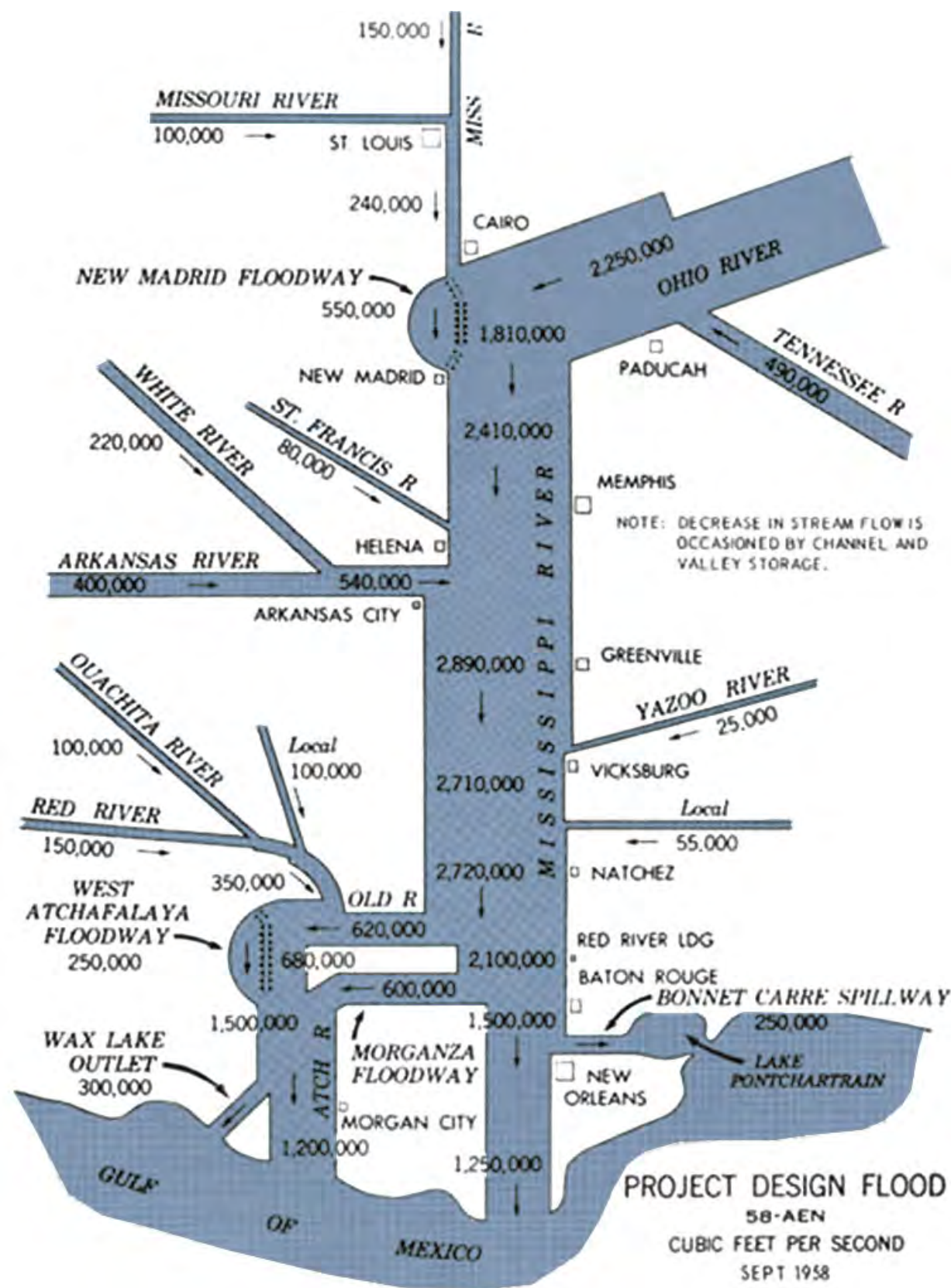


source: "Geological Investigation of the Alluvial Valley of the Lower Mississippi River



# Flood Control

Mississippi River & Tributaries Project



source: U.S. Army Corps of Engineers, 1958



# Coastal Condition

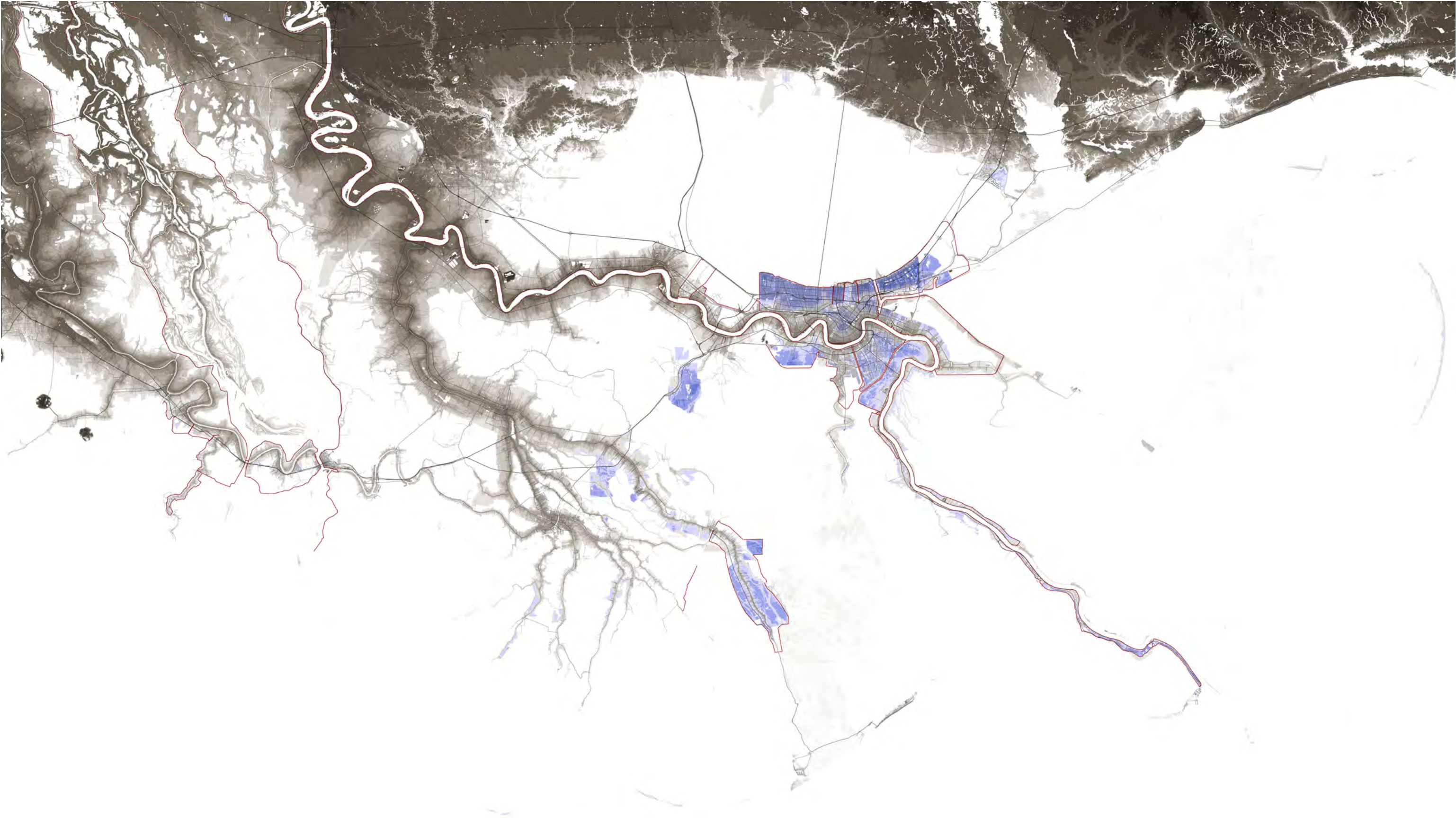
Louisiana





# High + Low Landscape

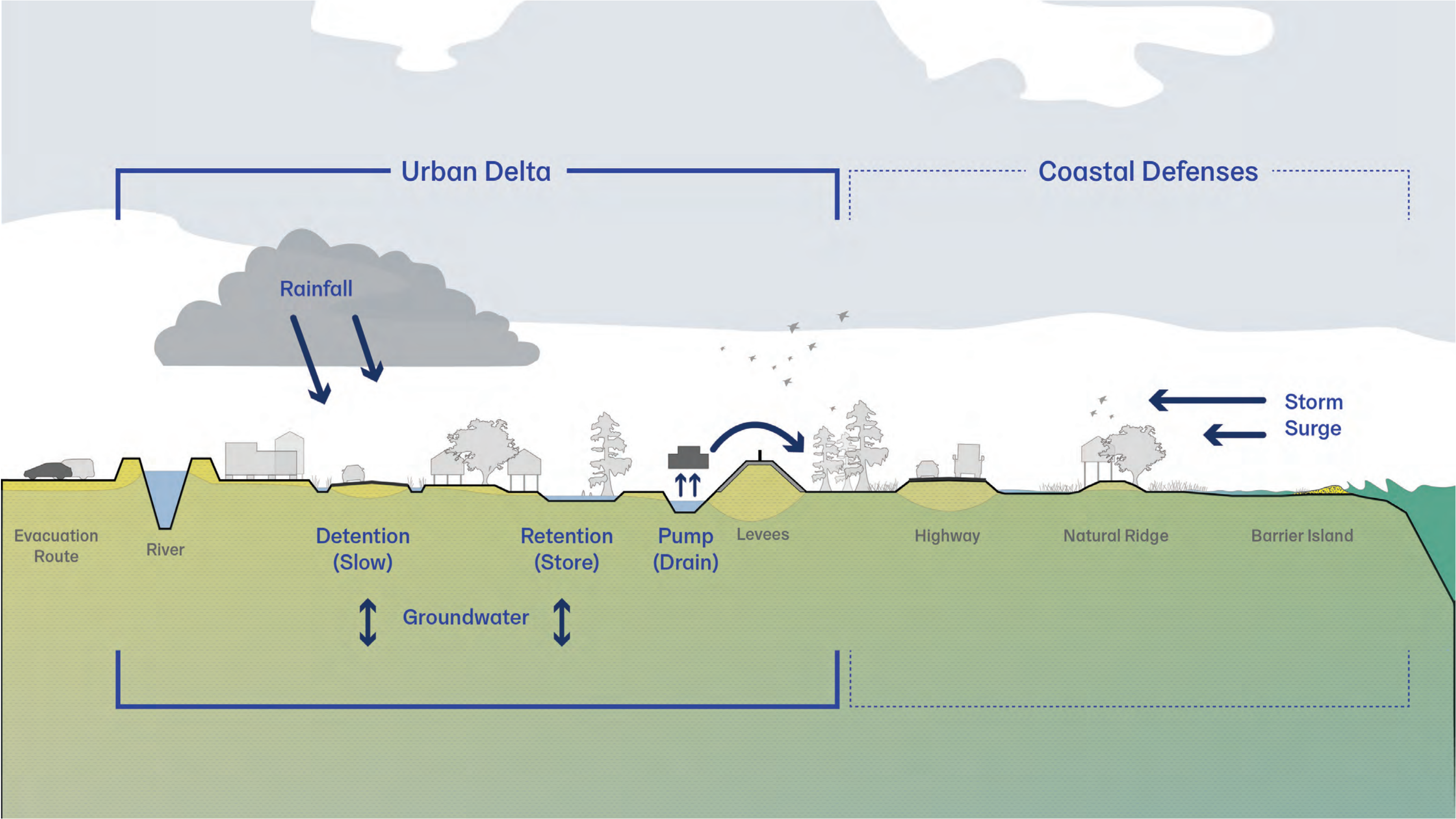
Louisiana





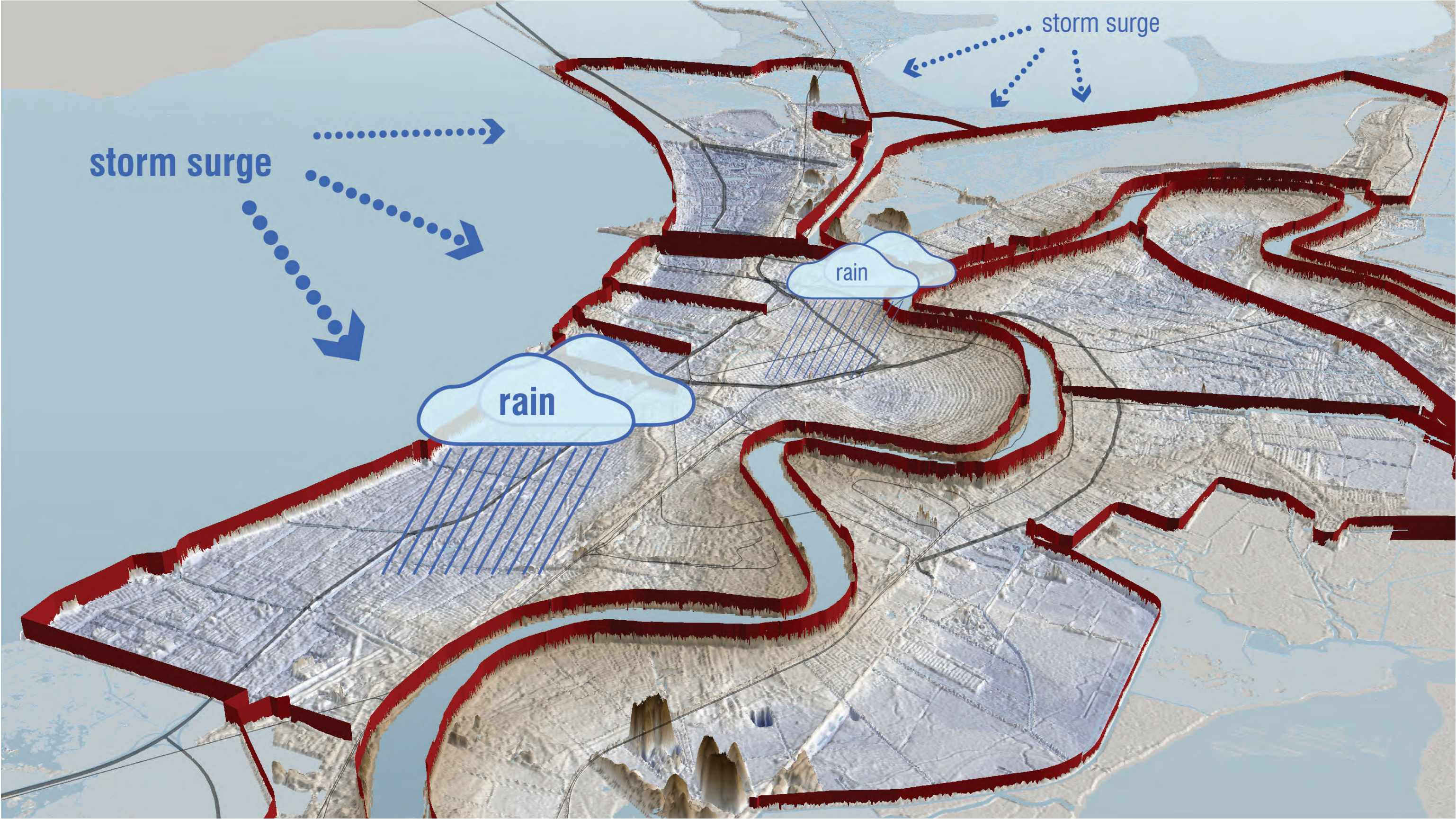
# Multiple Lines of Defense

Louisiana Delta





Forces of Water  
New Orleans





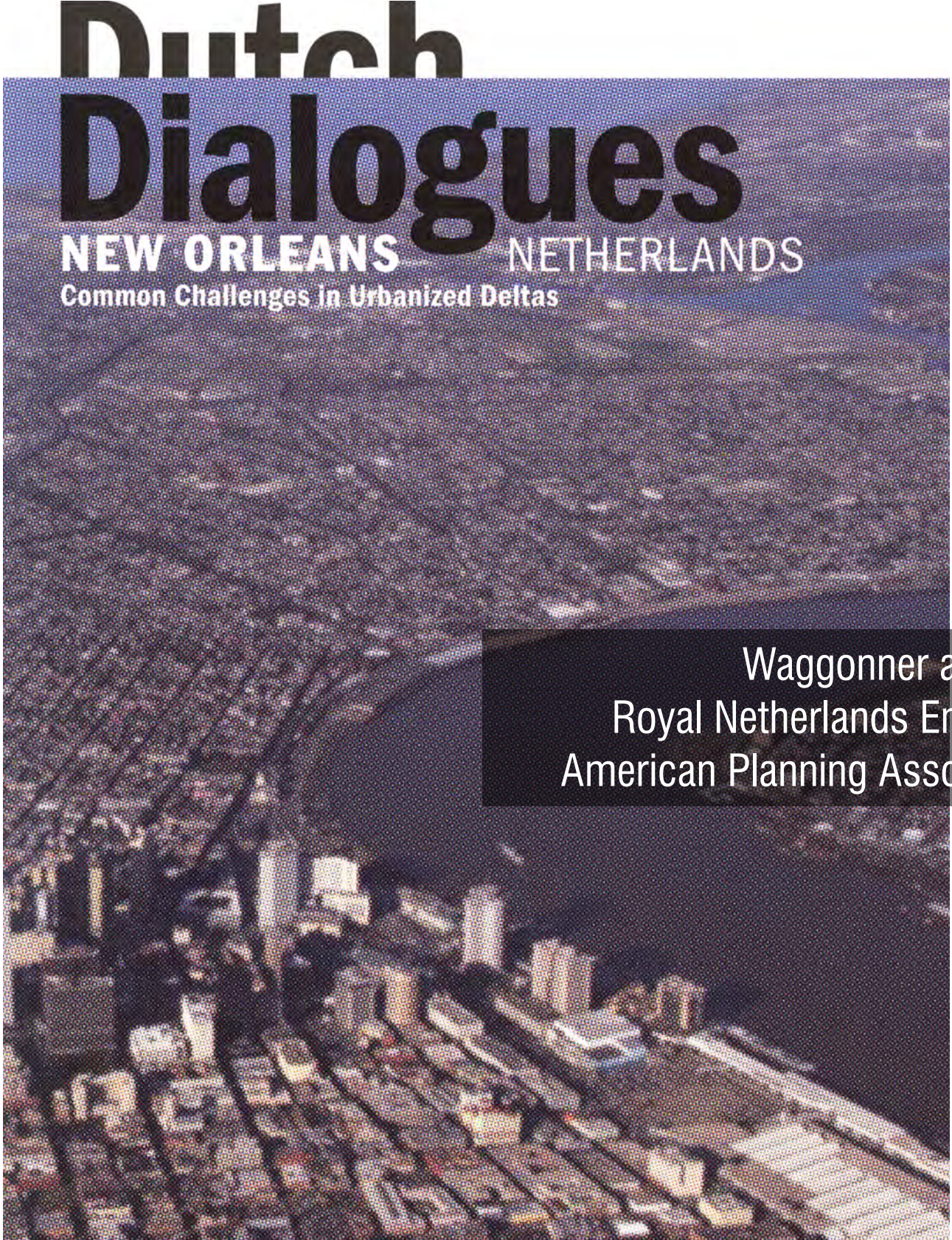
Hurricane Katrina  
New Orleans



source: Ralph Madison

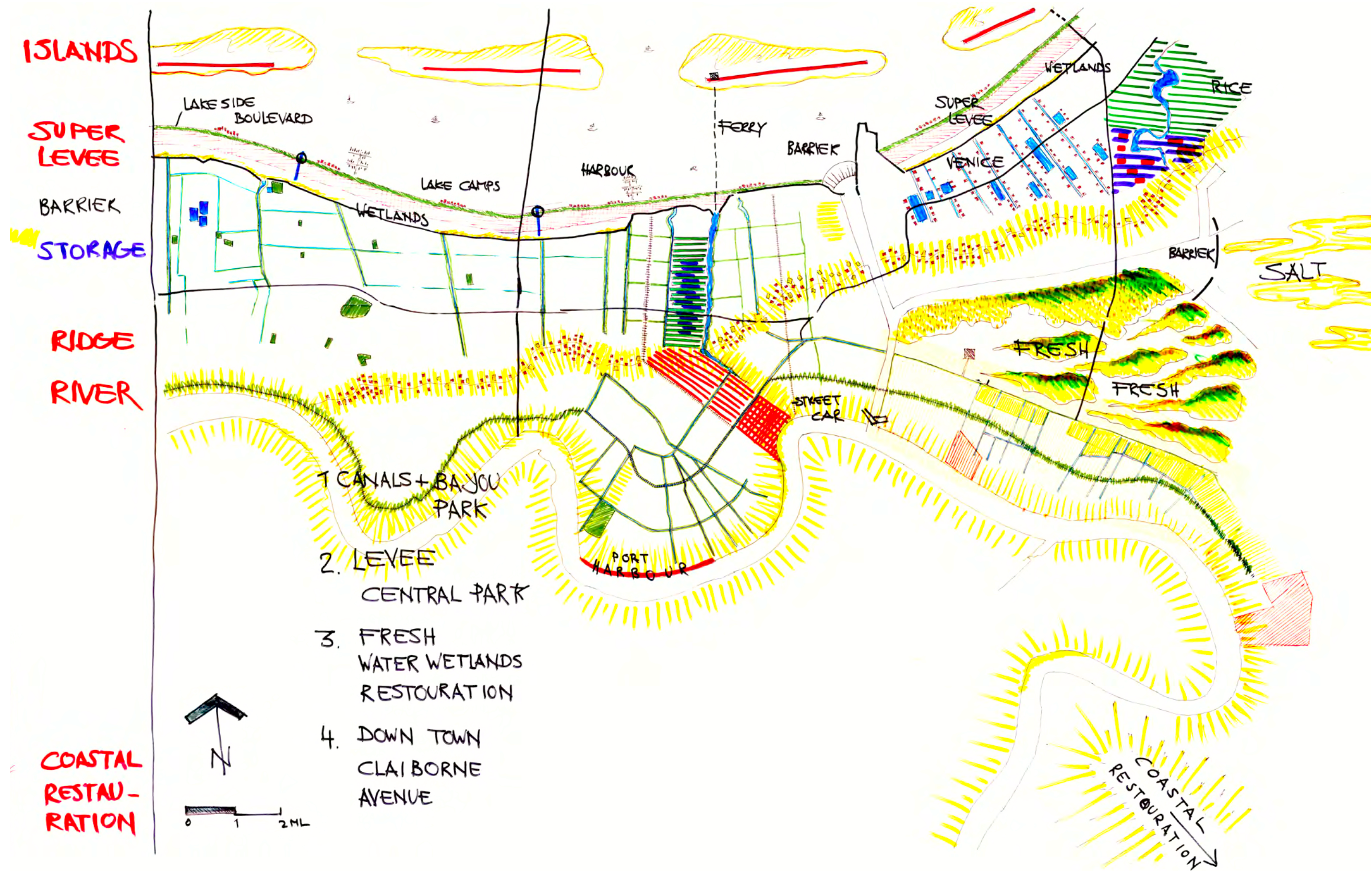


Dutch Dialogues  
New Orleans

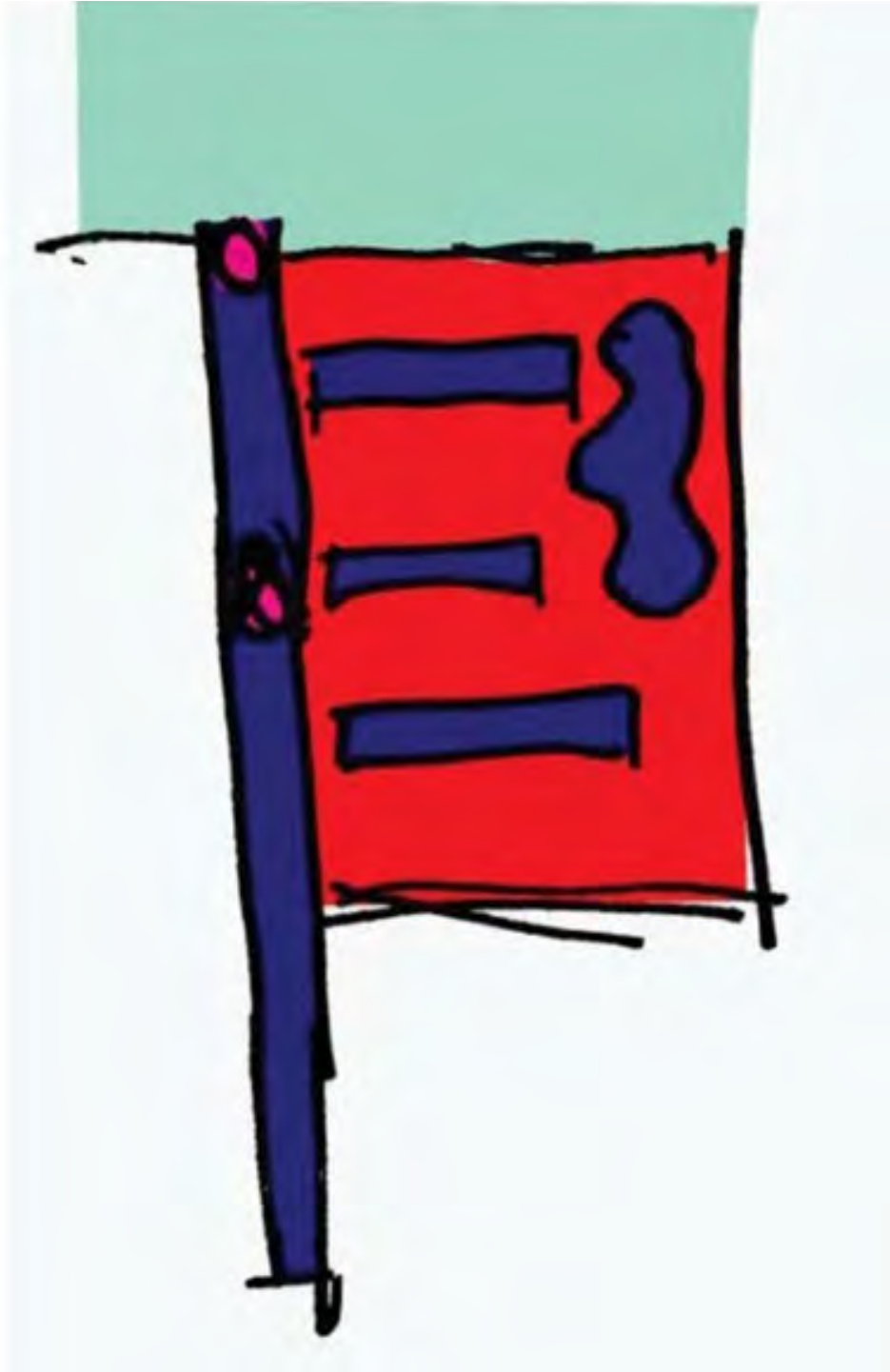


source: "The Commonwealth Approach" via "Dam[ned] Landscapes"





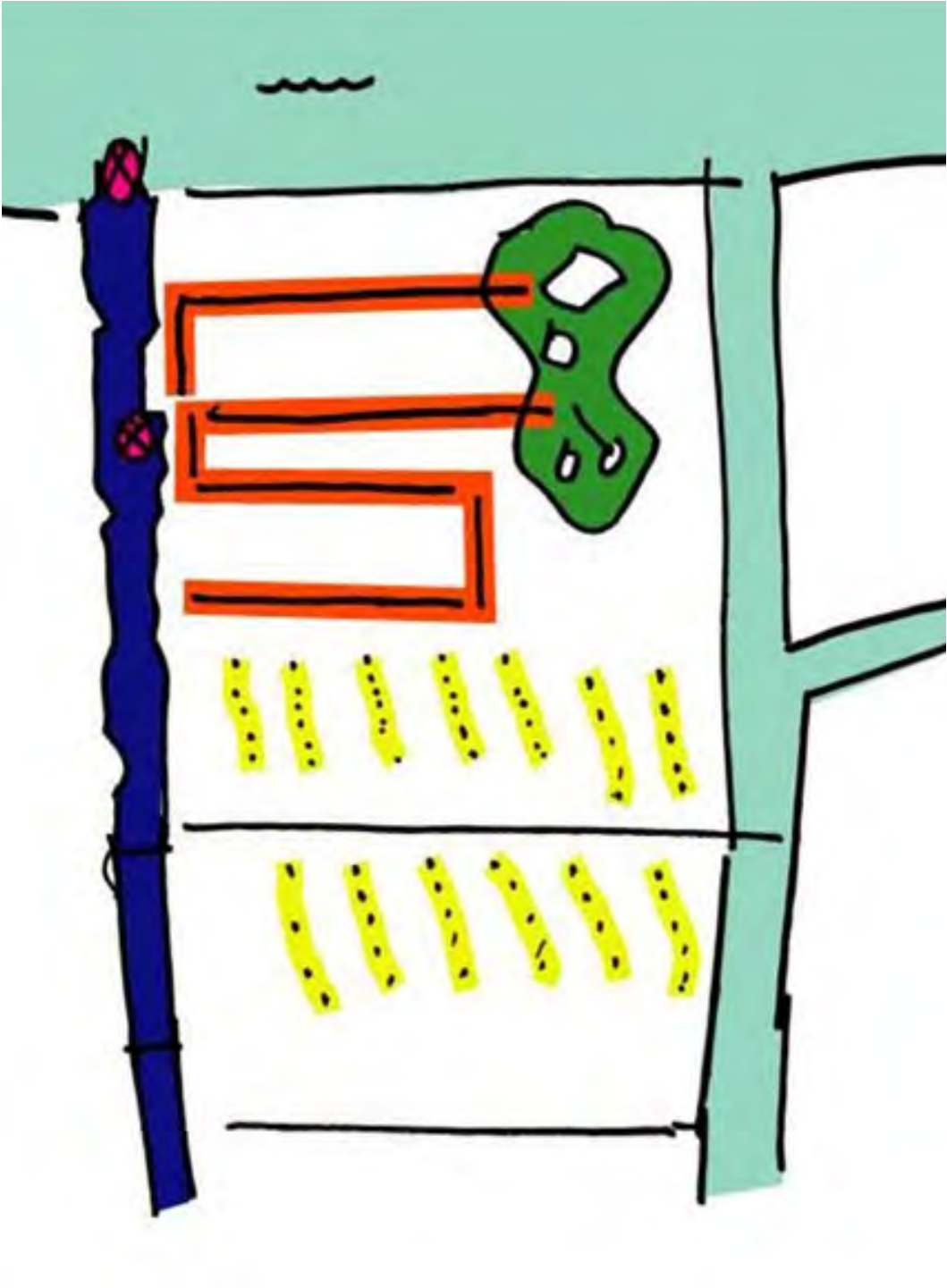




**Concept:**  
More Internal Water

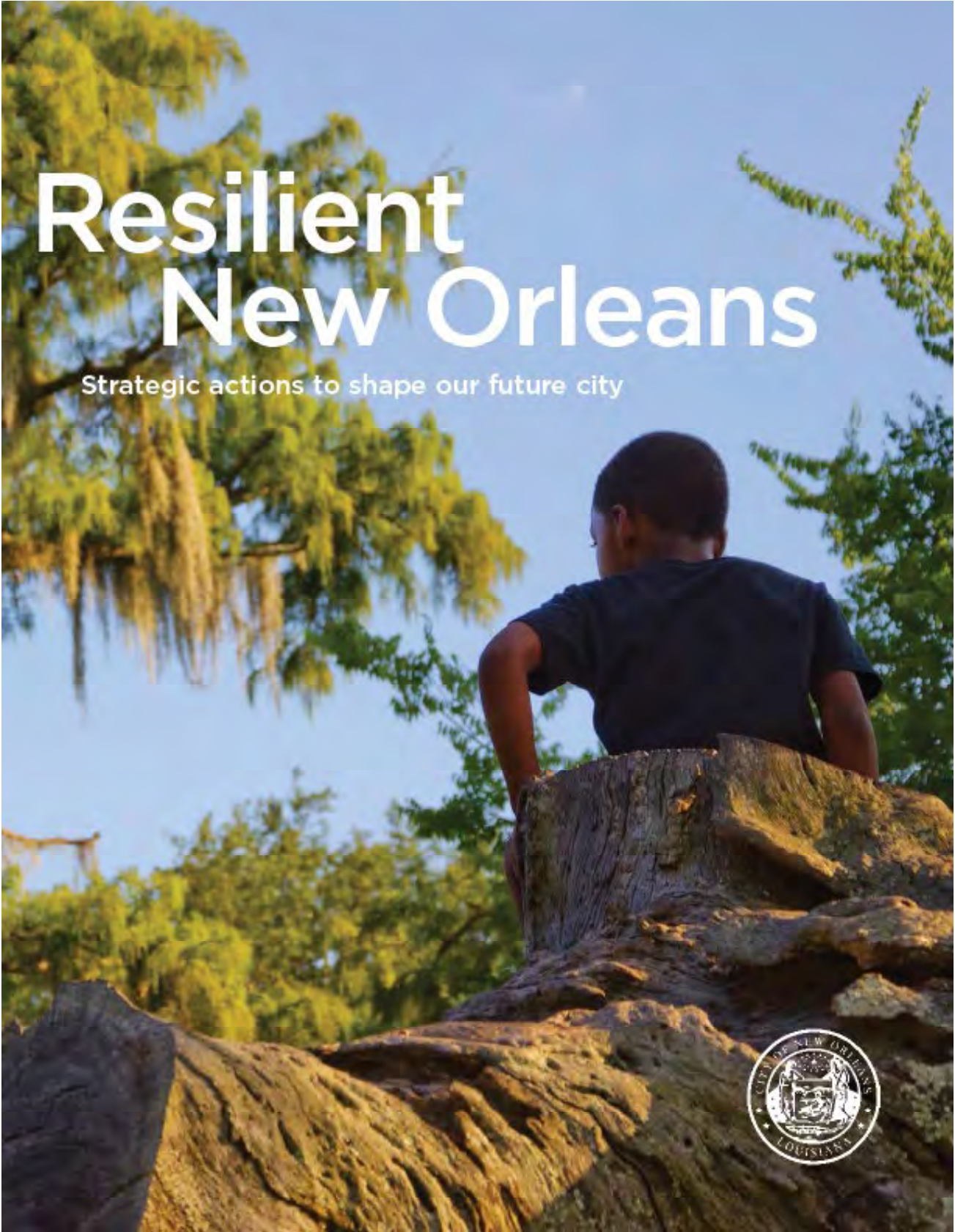
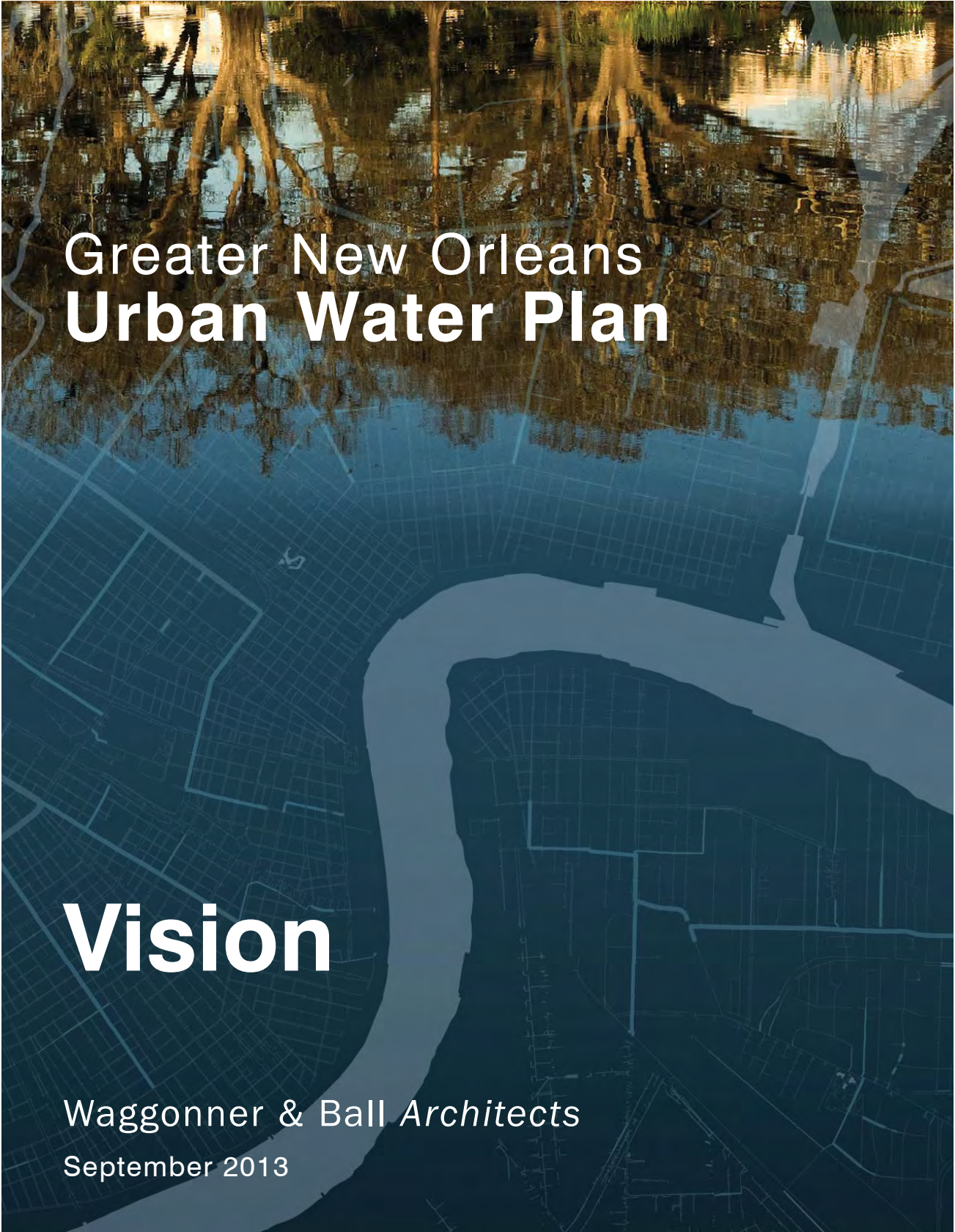


**Concept:**  
Circulating



**Concept:**  
Different Water Identities







# Problems Identified

## Greater New Orleans Urban Water Plan



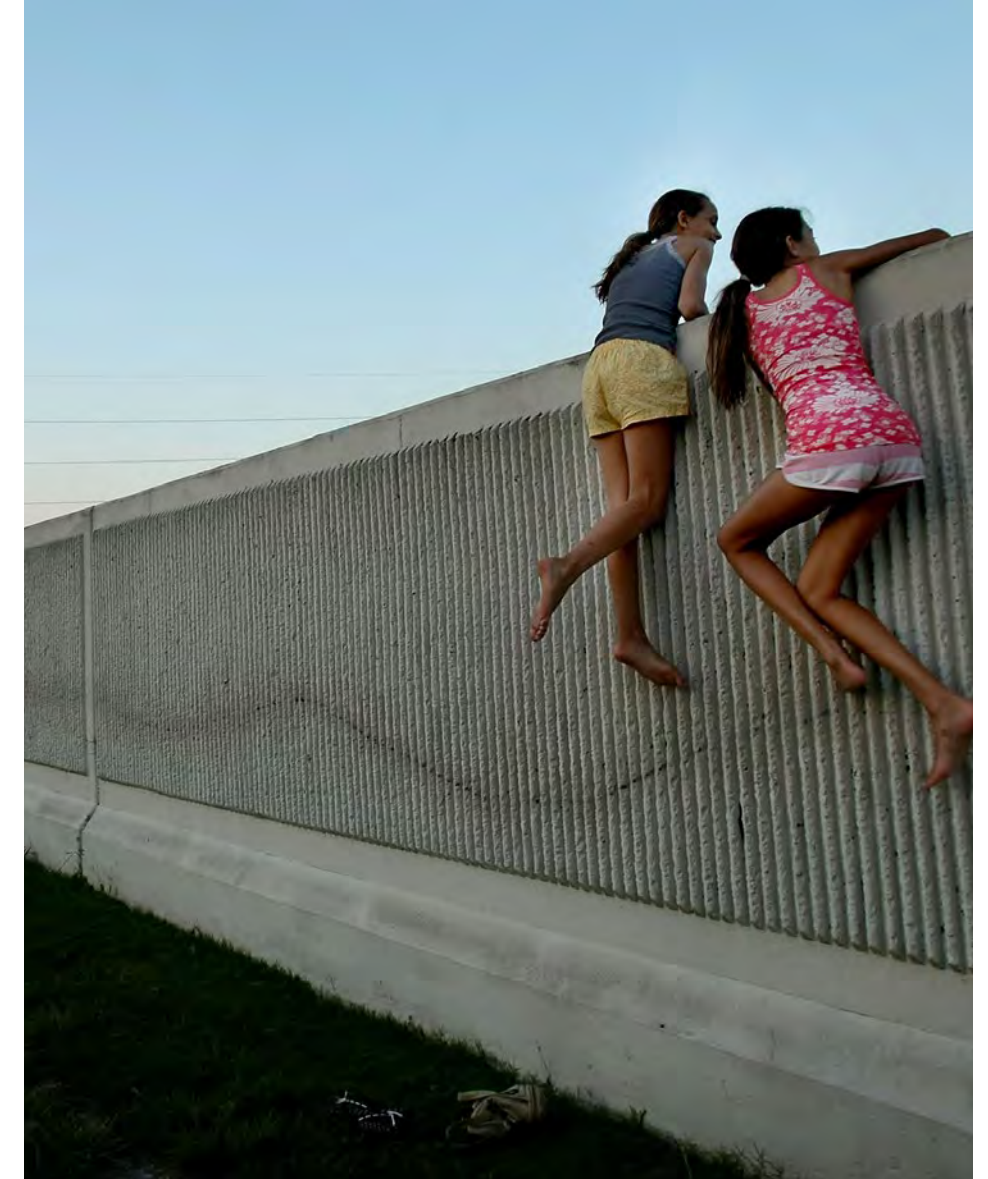
**1** **Flooding** is caused by runoff & overwhelmed drainage systems.

Credit: Waggonner & Ball



**2** **Subsidence** results from excessive groundwater pumping.

Credit: Waggonner & Ball

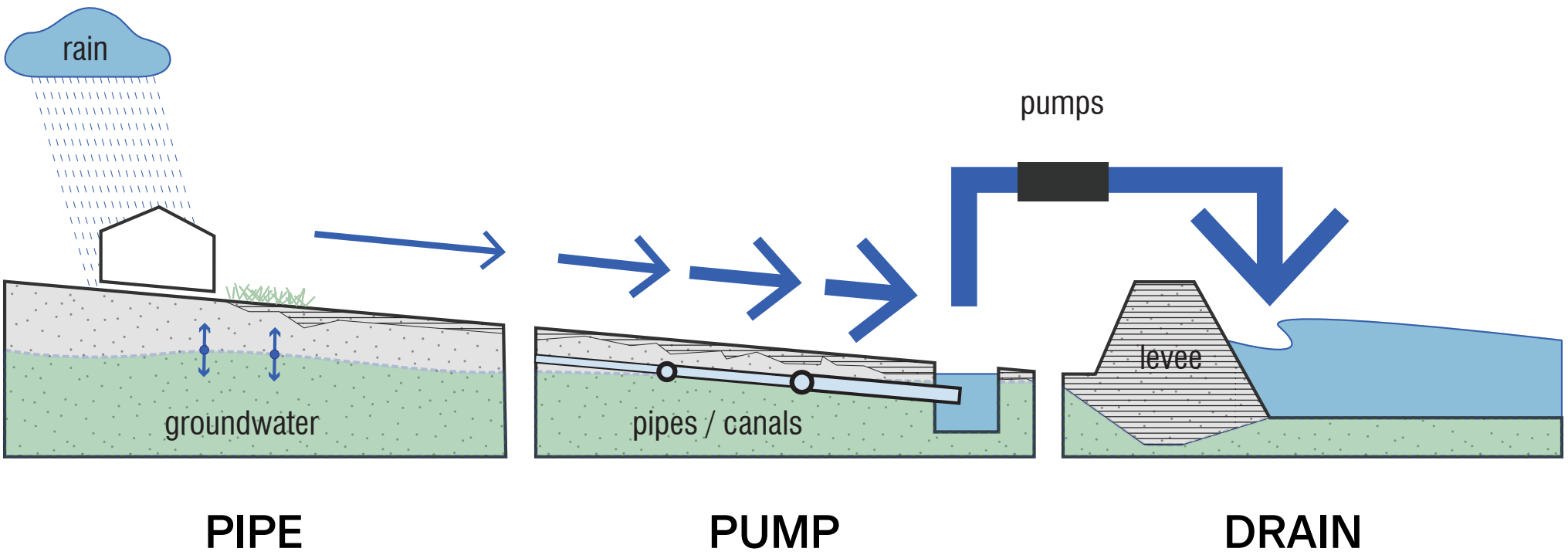


**3** **Water assets wasted** behind walls, buried underground, or pumped out of sight.

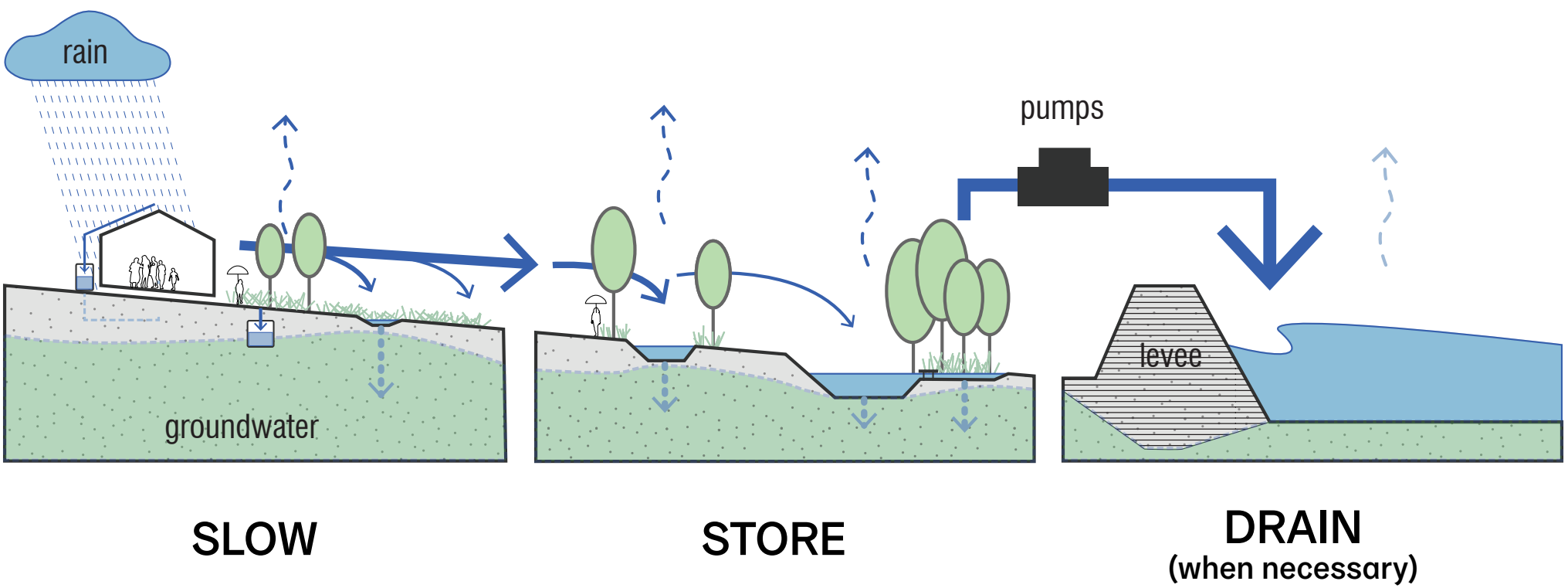
Credit: Mario Tana



Engineered Approach

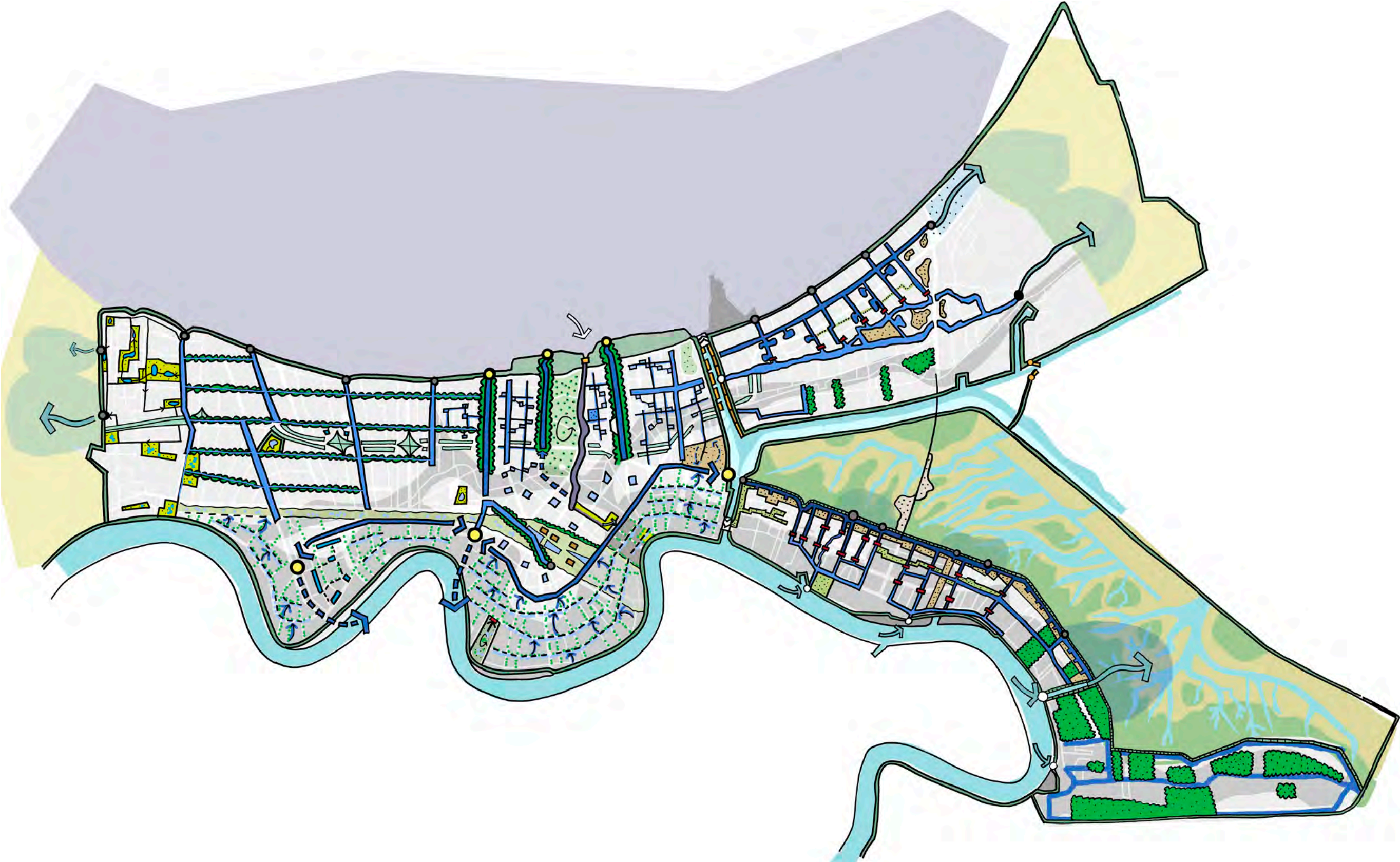


Living with Water





Living Water System  
Greater New Orleans Urban Water Plan



source: H + N + S



# Regional Costs vs. Benefits

Greater New Orleans Urban Water Plan

A grayscale photograph of a park where the ground is completely flooded. Two children are wading through the water, which is up to their knees. Large trees and a park pavilion are visible in the background.

**\$6.2 Billion**

## Implementation Costs

- detention/retention features
- storage basins
- drainage improvements

**\$20.6 Billion**

A horizontal bar chart consisting of four colored segments: a light green segment on the left, followed by a dark green segment, then a medium green segment, and a small lime green segment on the far right. The light green segment represents the \$6.2 billion in implementation costs, and the remaining three segments together represent the \$20.6 billion in economic benefits.

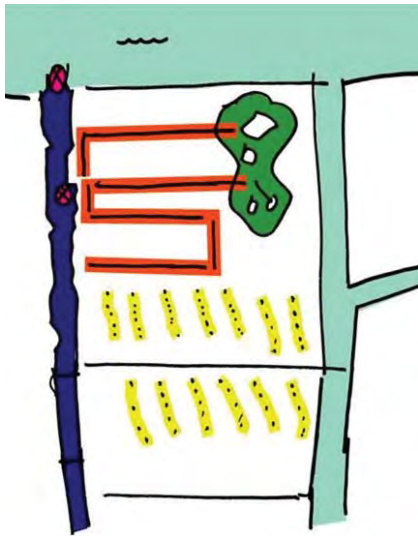
## Economic Benefits

- direct and indirect job growth
- reduced flooding-induced damages
- reduced subsidence-induced damages
- improved insurability
- improved property values



# Funded Projects

HUD NDRC City of New Orleans



Dutch Dialogues  
Concept



Urban Water Plan  
System Integration



Gentilly Resilience District

\$141 million awarded



# Blue Green Corridors

Gentilly Resilience District





# Mirabeau Water Garden

Gentilly Resilience District





|                      |                                 |
|----------------------|---------------------------------|
| <b>\$54 million</b>  | <b>State of Connecticut</b>     |
| <b>\$92 million</b>  | <b>State of Louisiana</b>       |
| <b>\$120 million</b> | <b>Commonwealth of Virginia</b> |
| <b>\$141 million</b> | <b>City of New Orleans</b>      |
| <b>\$1 billion</b>   | <b>Total awarded nationally</b> |



# Coastal Condition, 1820

LA SAFE



Coastal Condition  
1820

- Water
- Wetlands

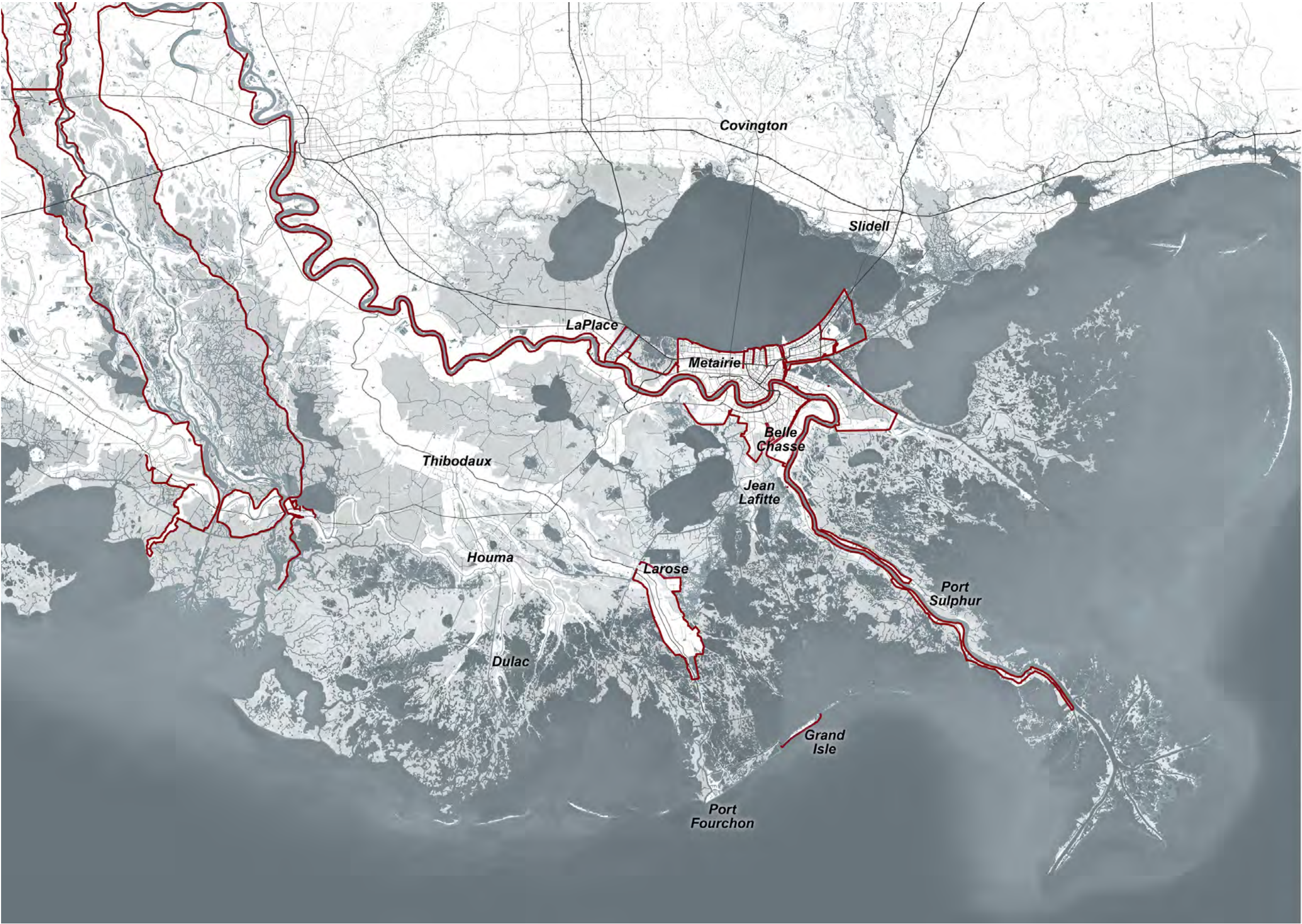
0 5 10 20 Miles

Sources: David Rumsey Map Collection  
US Census TIGER/Line 2010, USGS National Hydrography Dataset, NOAA, Atlas: The Louisiana Statewide GIS, Esri, TomTom, Tele Atlas North America, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



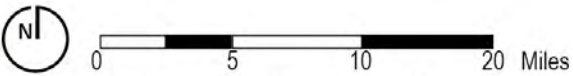
# Coastal Condition, 2017

LA SAFE



Coastal Condition  
Today

- Water
- Wetlands
- Levees



Sources: CPRA Coastal Master Plan 2017 and USGS  
US Census TIGER/Line 2010, USGS National Hydrography Dataset, NOAA,  
Atlas: The Louisiana Statewide GIS, Esri, TomTom, Tele Atlas North America,  
DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,  
AeroGRID, IGN, and the GIS User Community



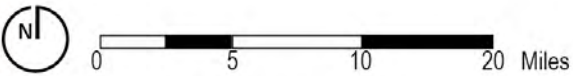
# Coastal Condition, 2067 (No Action)

LA SAFE



Coastal Condition  
2067 - No Action

- Water
- Wetlands
- Wetlands Created
- Levees

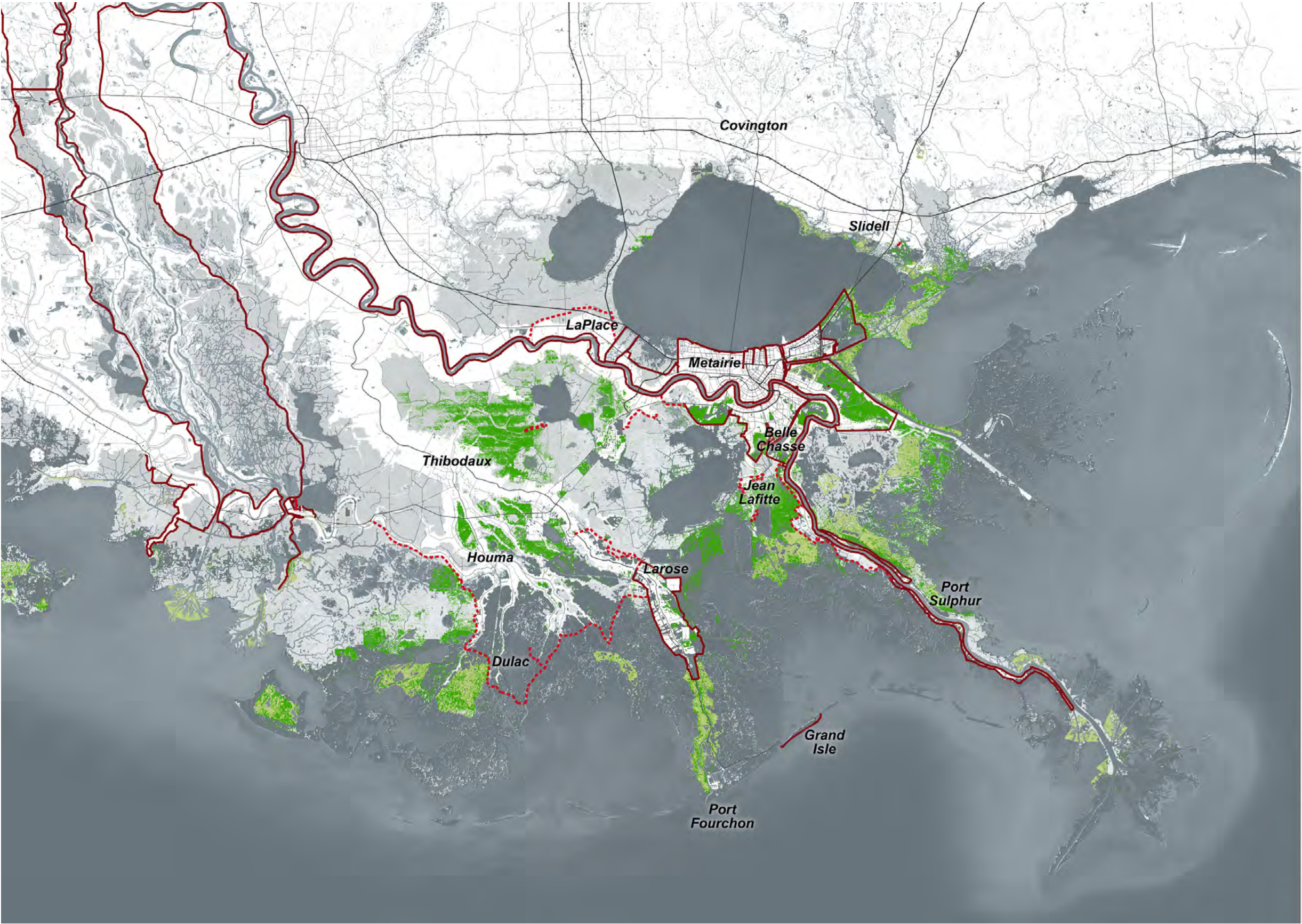


Sources:  
US Census TIGER/Line 2010, USGS National Hydrography Dataset, NOAA, Atlas: The Louisiana Statewide GIS, Esri, TomTom, Tele Atlas North America, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



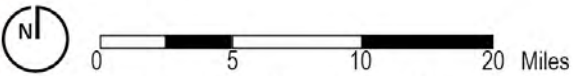
# Coastal Condition, 2067 (With Action)

LA SAFE



Coastal Condition  
2067 - CPRA Master Plan

- Water
- Wetlands
- Wetlands Sustained
- Wetlands Created
- Levees
- CPRA Proposed Levees

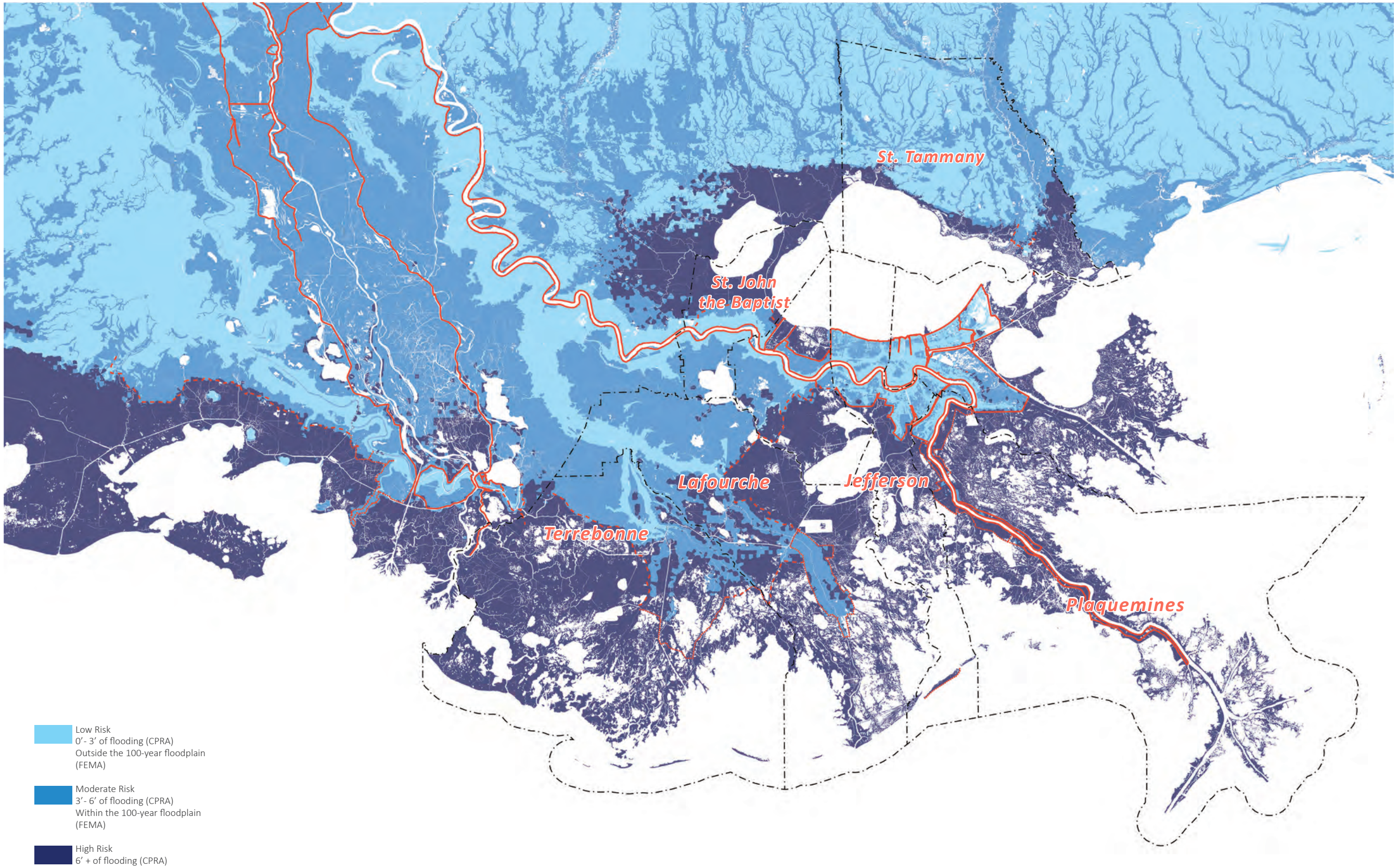


Sources: CPRA Coastal Master Plan 2017 and USGS  
US Census TIGER/Line 2010, USGS National Hydrography Dataset, NOAA,  
Atlas: The Louisiana Statewide GIS, Esri, TomTom, Tele Atlas North America,  
DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,  
AeroGRID, IGN, and the GIS User Community



# Regional Risk Zones

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# 50-Year Vision by Risk Zone

LA SAFE



**Low Risk**  
0' - 3' projected flood depths

## Design New Growth Corridors and Urban Centers

Low risk areas have development opportunities to receive populations and economic activity from more flood-prone environments.



**Moderate Risk**  
3' - 6' projected flood depths  
Within the 100-year floodplain

## Protect Assets and Establish Resilient Neighborhoods

Areas conducive to maintaining current population levels and economic trends provided such communities orient future development and mitigation activities in alignment with future flood risk projections.



**High Risk**  
6'+ projected flood depths

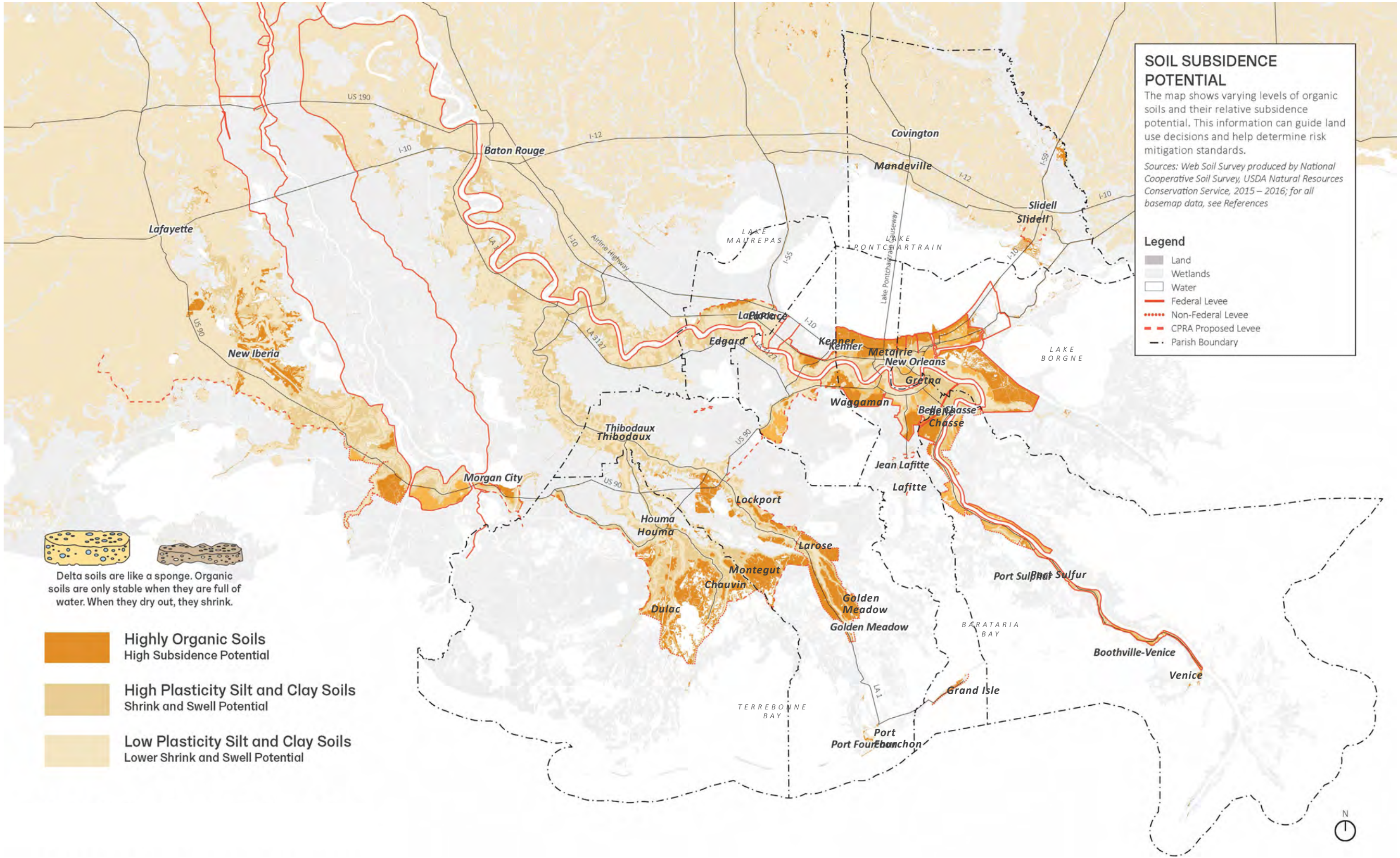
## Enhance Economic Engines and Adapt to Rising Waters

Areas that can expect to experience population decline and economic losses, up to and including full community-scale resettlement, as environmental conditions deteriorate and repetitive severe flood events take place.

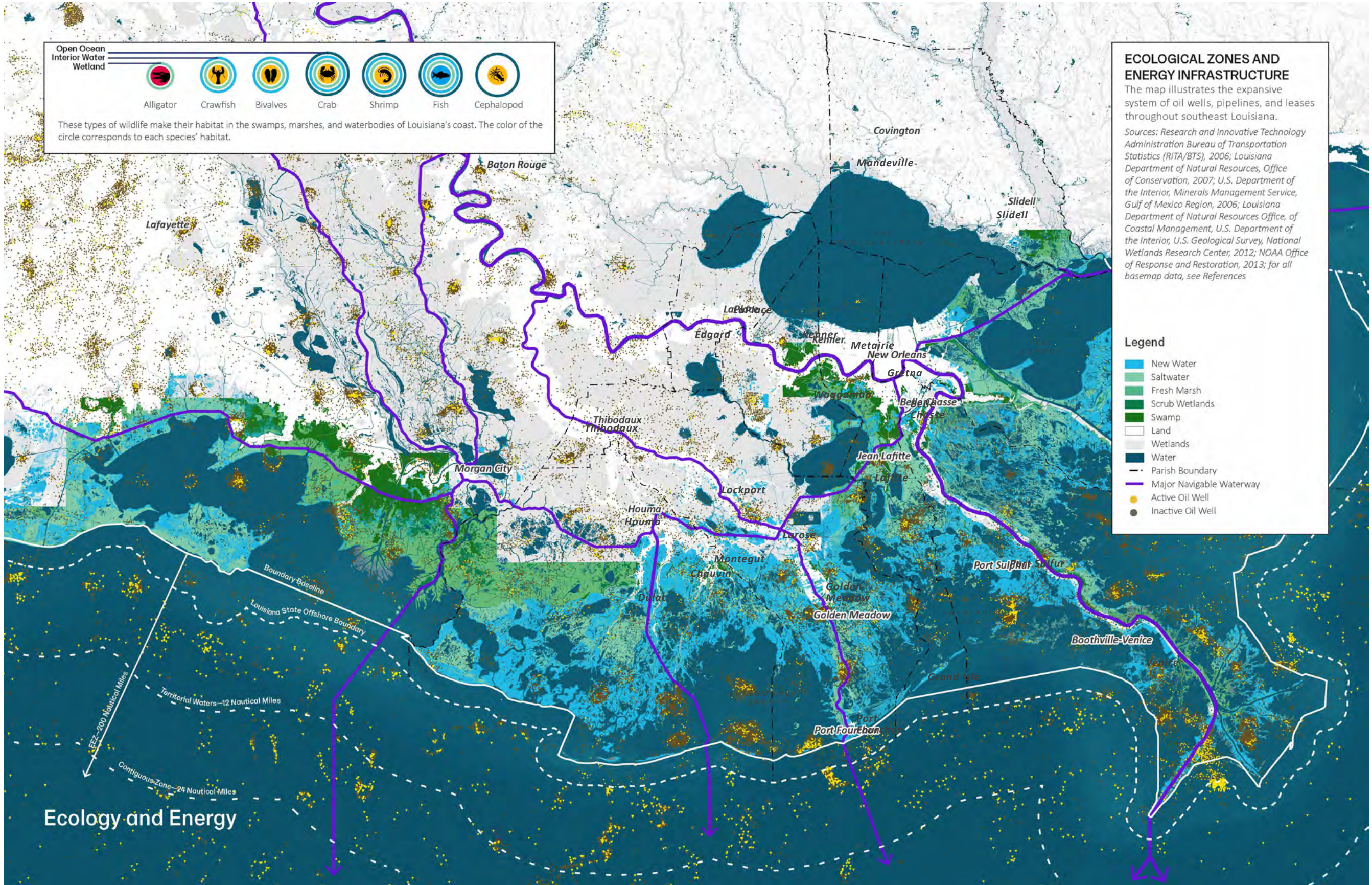


# Subsidence Potential

LA SAFE











**Goal 1: Manage Flooding and Subsidence**



**Goal 2: Direct Growth to Low Risk Areas**



**Goal 3: Improve Mobility throughout the Parish and Region**

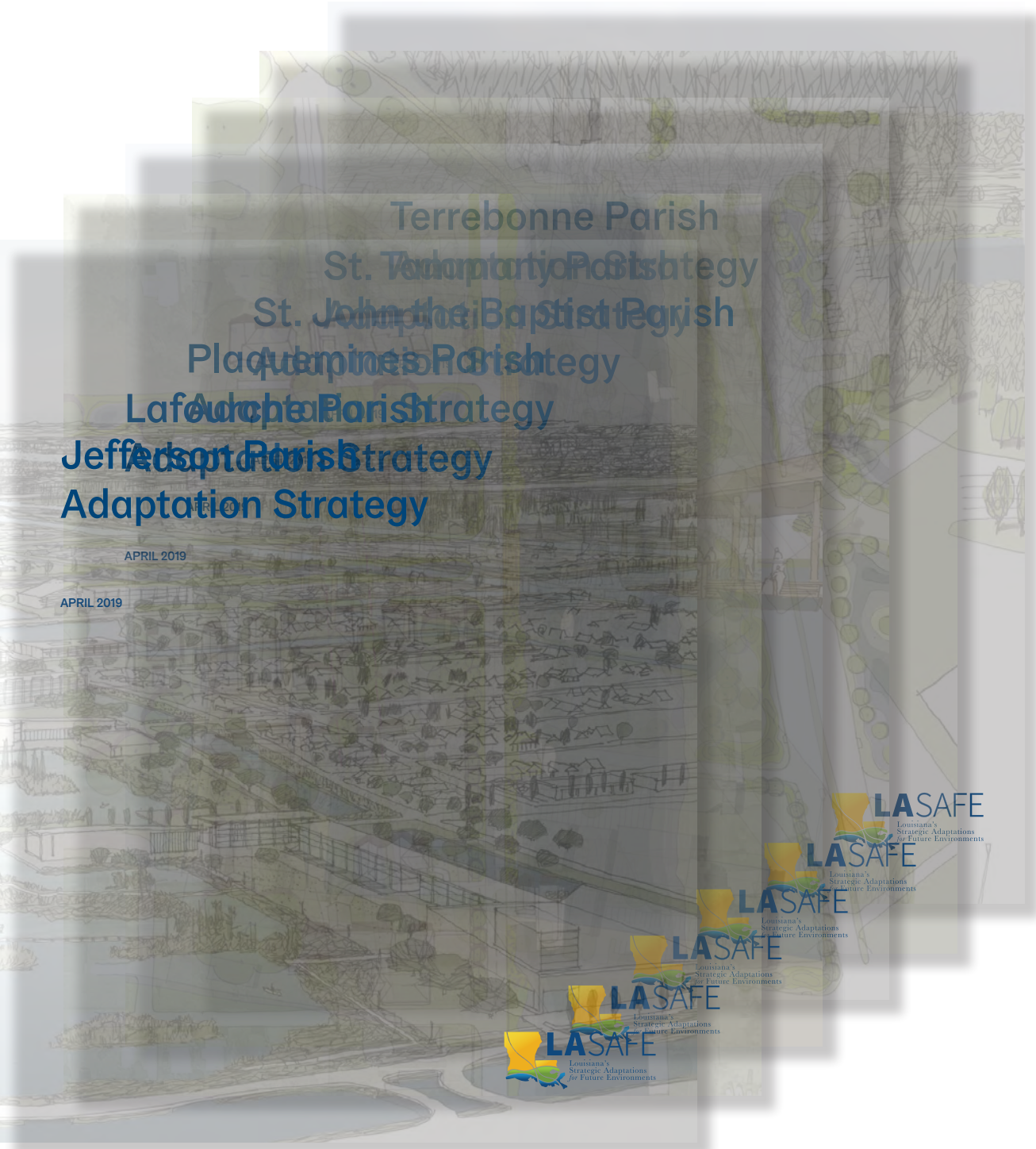
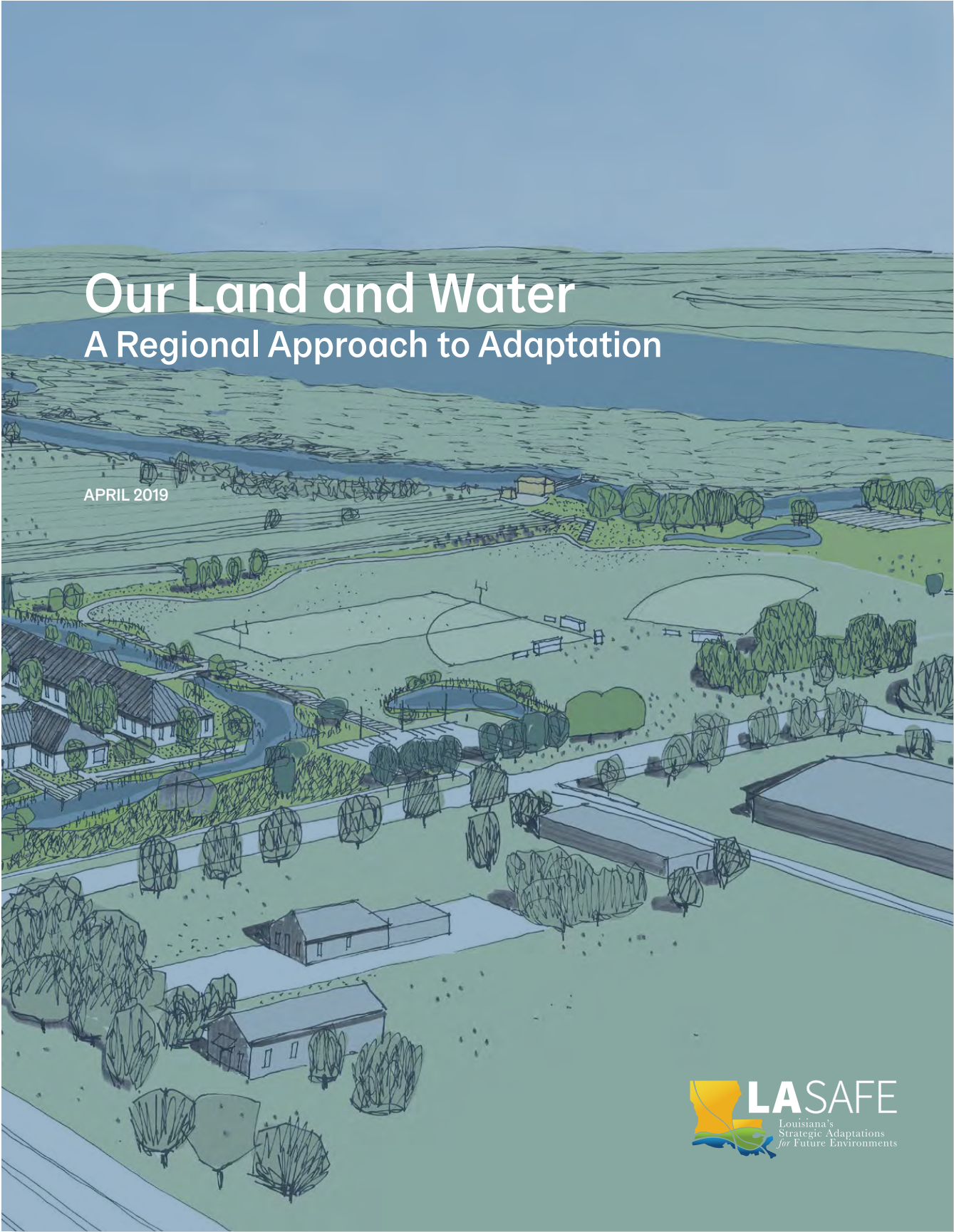


**Goal 4: Strengthen and Diversify Local Economies**

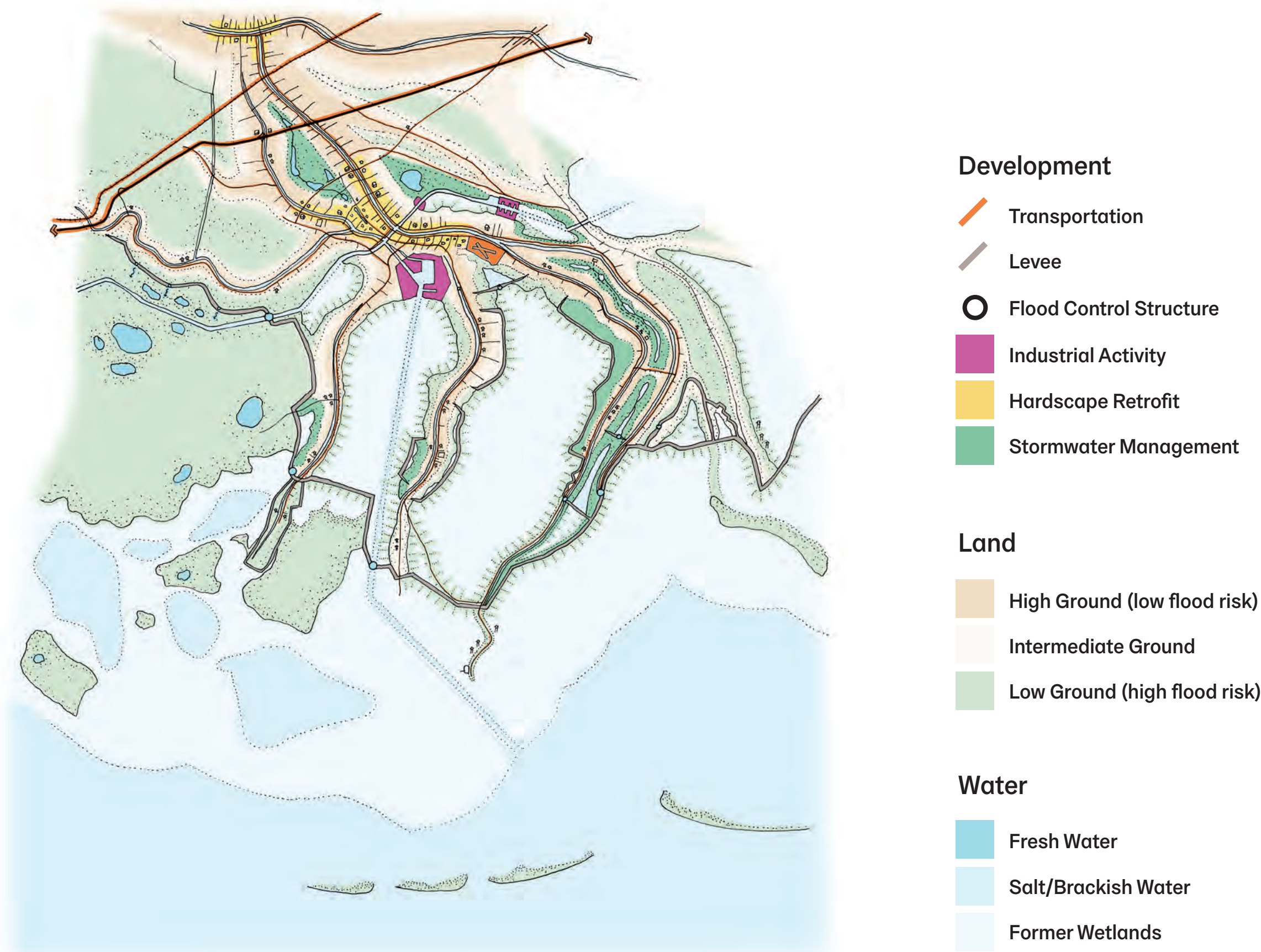


**Goal 5: Protect and Promote Historic and Cultural Assets**











# Houma Seafood Market & Harbor of Refuge

LA SAFE - Terrebonne Parish



Precedent images from Delcambre and Westwego Fish Markets

- 1 New Harbor of Refuge and Boat Docks
- 2 New Boat Launch
- 3 Picnic Area with Pavilions and Tables
- 4 Covered Pavilion and Fishing Dock
- 5 Seafood Market in Modified Existing Building
- 6 New Raised Convenience Store and Restrooms



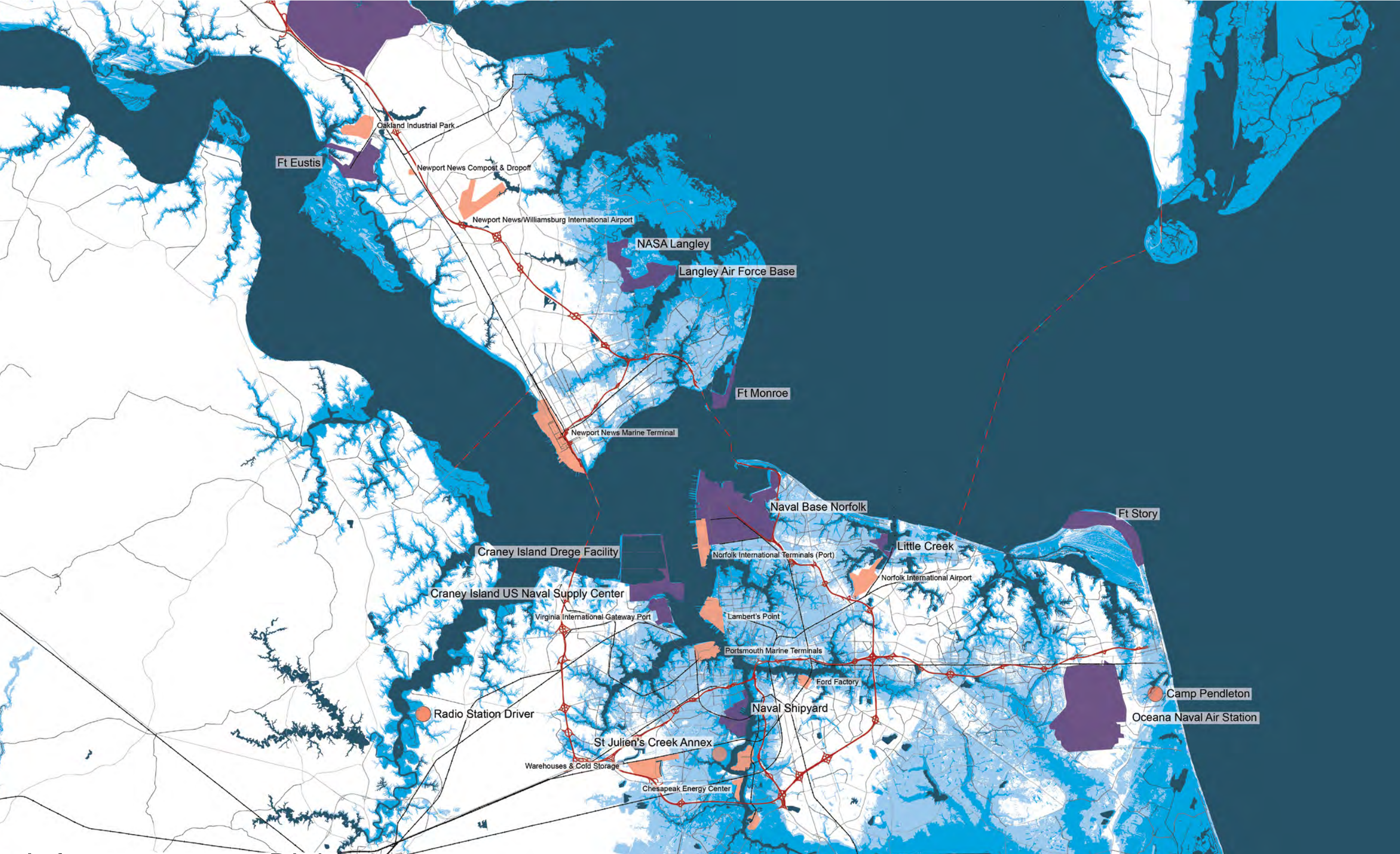
# Tidewater Virginia





# Infrastructure at Risk

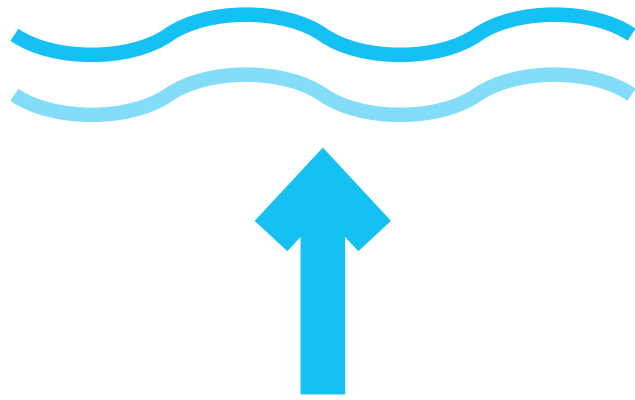
Dutch Dialogues Virginia





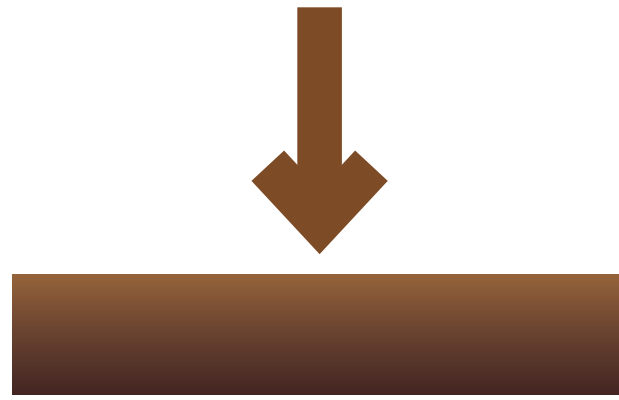
# Relative Sea Level Defined

Norfolk, Virginia



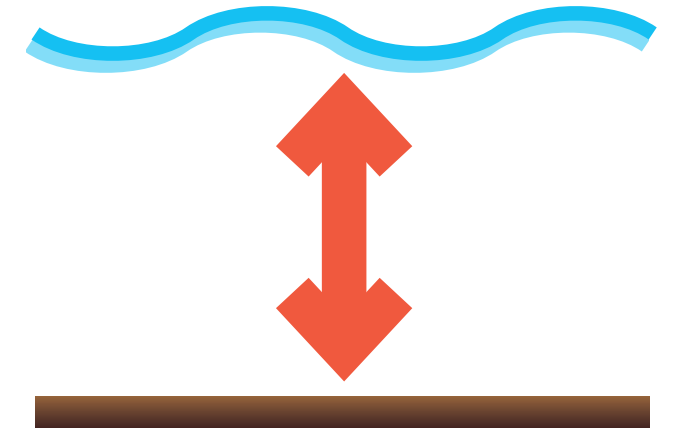
**Rising  
Tides**

**+**



**Sinking  
Land**

**=**



**Relative  
Sea Level**

## Eustatic Global Sea Level Rise:

- Melting Glaciers
- Thermal Expansion
- 1.8 to 3.1 mm/year



## Land Subsidence:

- Geologic  
(Salisbury Embayment + Chesapeake Bay  
Meteorite Impact Crater)
- Decaying Organics
- Reclaimed Land

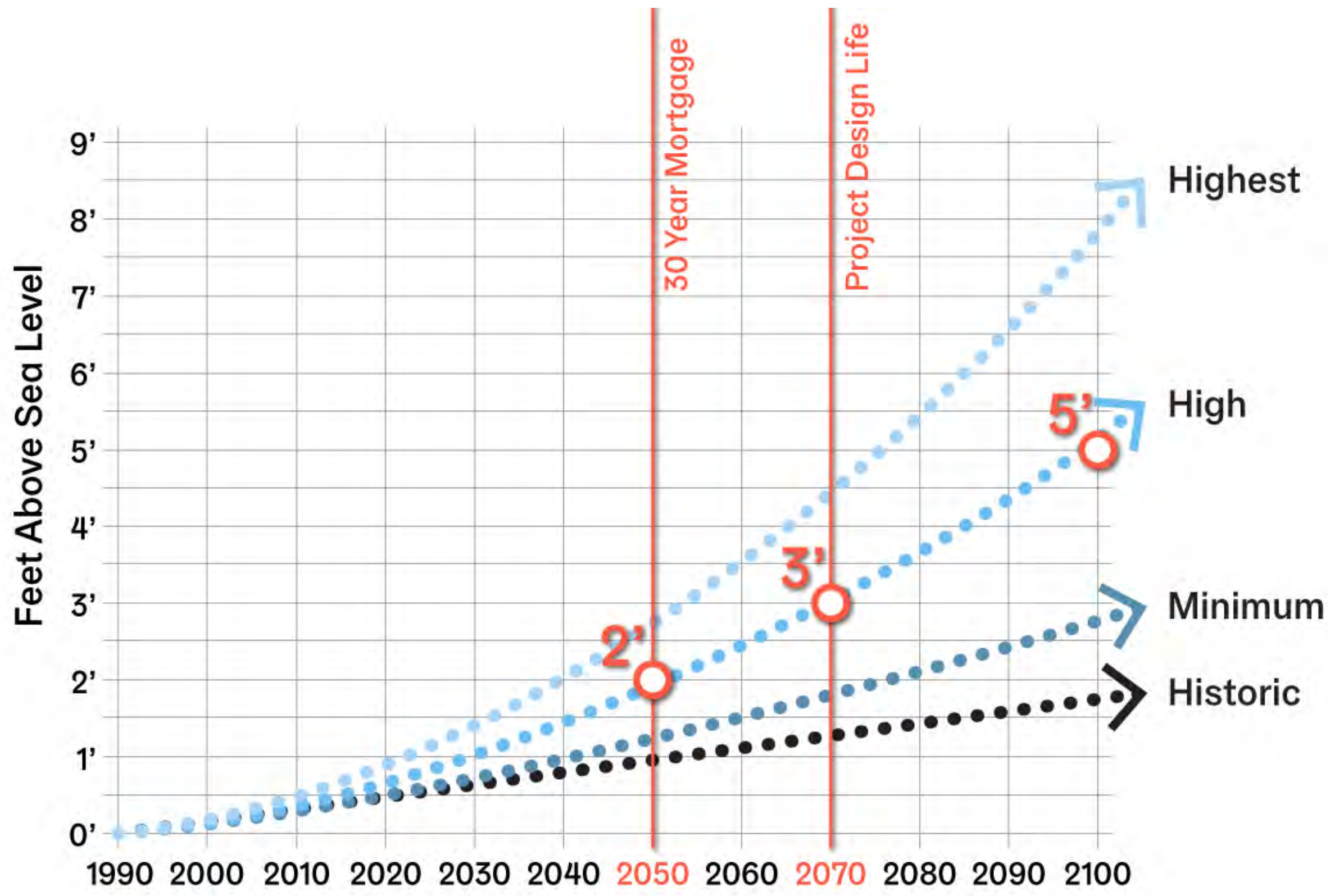
## Sewell's Point:

- +1.45 Feet/Century
- Among the largest  
documented rises  
in the world



# Relative Sea Level Rise Projections 2014

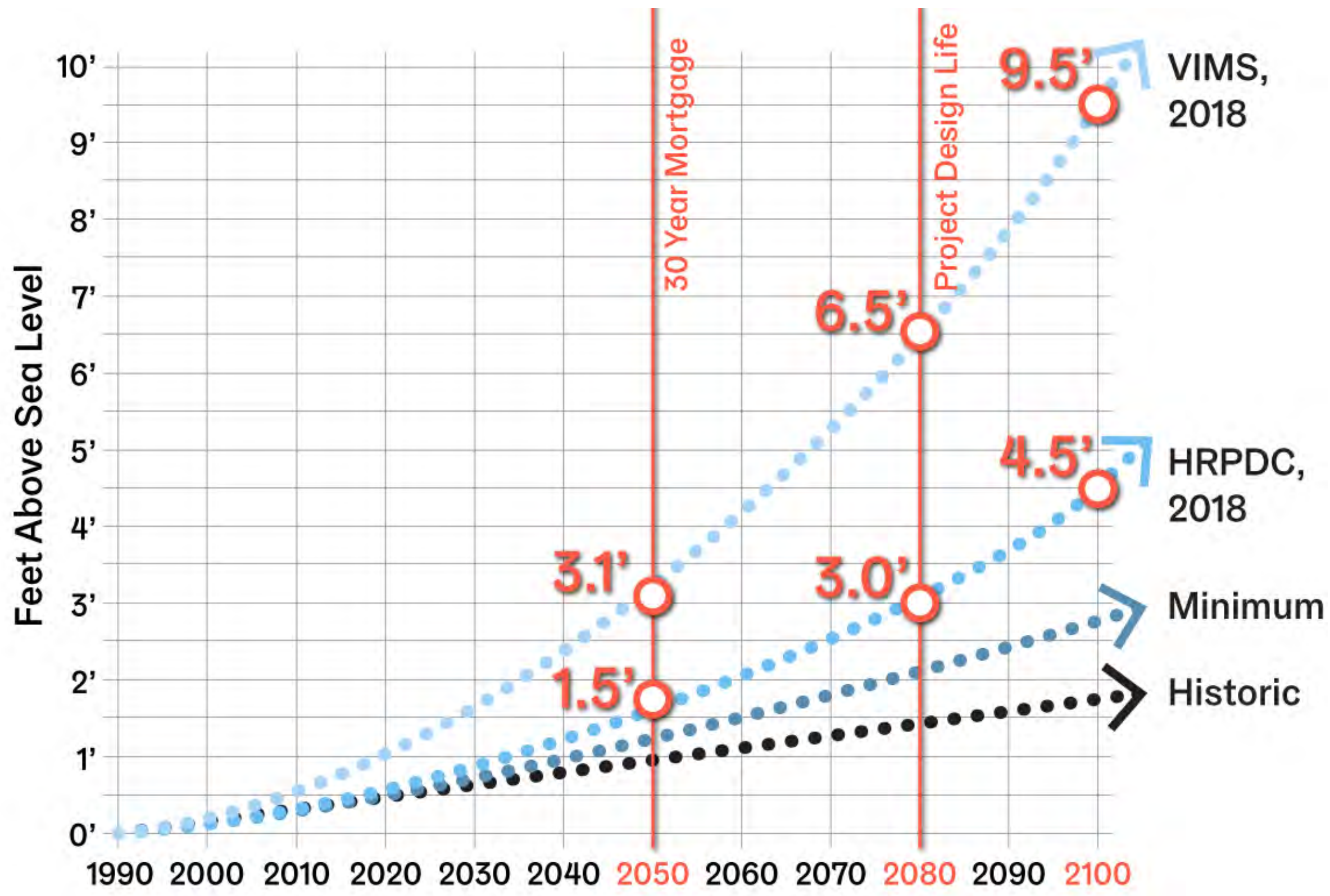
Southeast Virginia





# Relative Sea Level Rise Projections 2018

Southeast Virginia



source: Virginia Institute of Marine Science, Hampton Roads Planning District Commission



Norfolk 1877



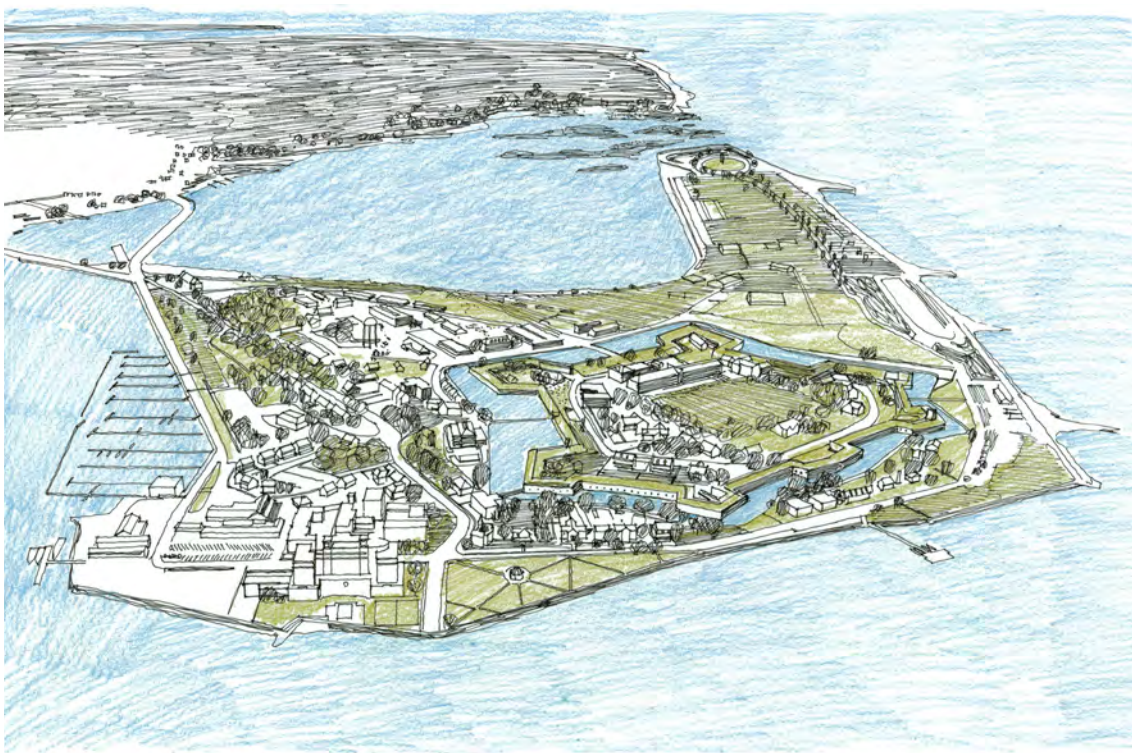


# Norfolk Flood Risk

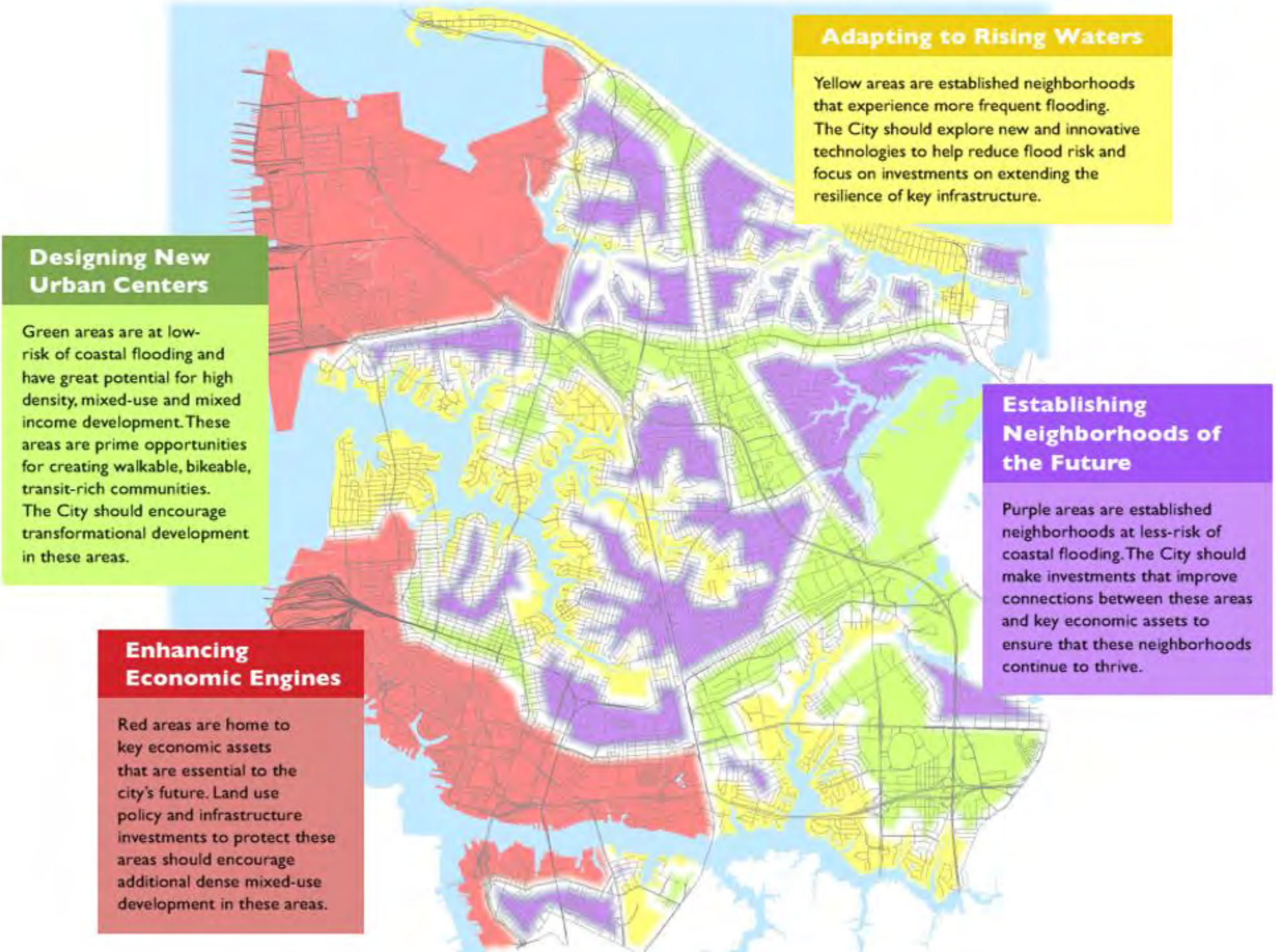




Newmarket Creek  
Dutch Dialogues Virginia









Press Release

December 3, 2020

## City of Hampton Fights Flooding with Issuance of Virginia's First Environmental Impact Bond

***Hampton to Undertake Three Major Flood Resilience Projects with \$12 Million in Innovative Outcome-Based Financing***

Media Contact:

Matt Lindsay, [lindsay@quantifiedventures.com](mailto:lindsay@quantifiedventures.com), 202.425.1792

High-Resolution project renderings and a recording of the December 3 online press event are available at [this link](#)

[Read the MSRB Issue Detail and Bond Official Statement](#)



Lake Hampton, credit: Waggonner&Ball



Big Bethel Blueway, credit: Waggonner&Ball



North Armistead, credit: Waggonner&Ball



# Norfolk Ohio Creek Stormwater Plan





Ohio Creek  
Norfolk, Virginia



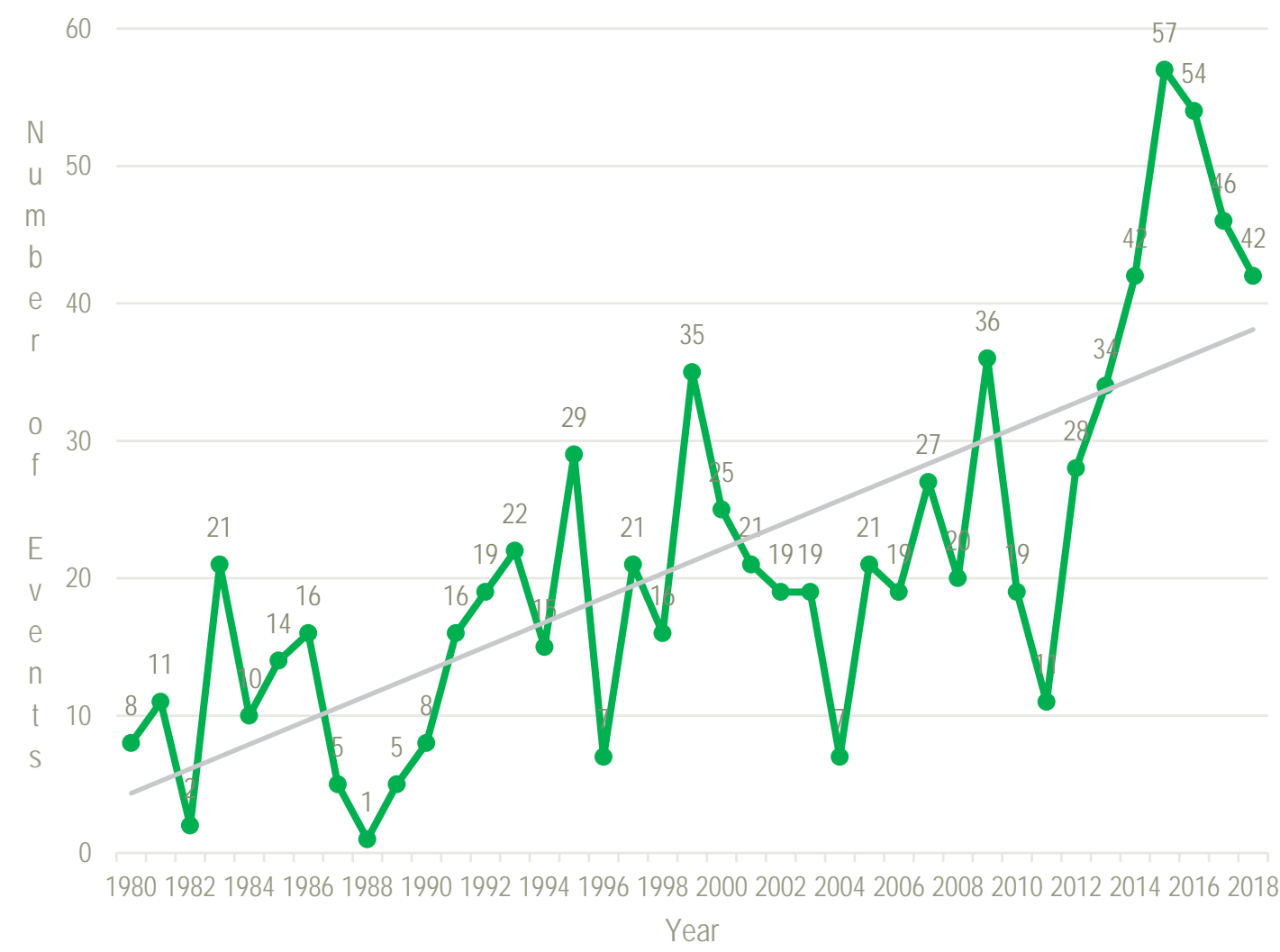


A scenic landscape photograph of a marshy area. In the foreground, a body of water reflects the sky and surrounding greenery. To the right, a rocky shore is covered with numerous white oyster shells. Lush green trees and bushes frame the scene, with a person partially visible on the right. The text "South Carolina Lowcountry" is overlaid in white on a semi-transparent orange rectangle in the upper left.

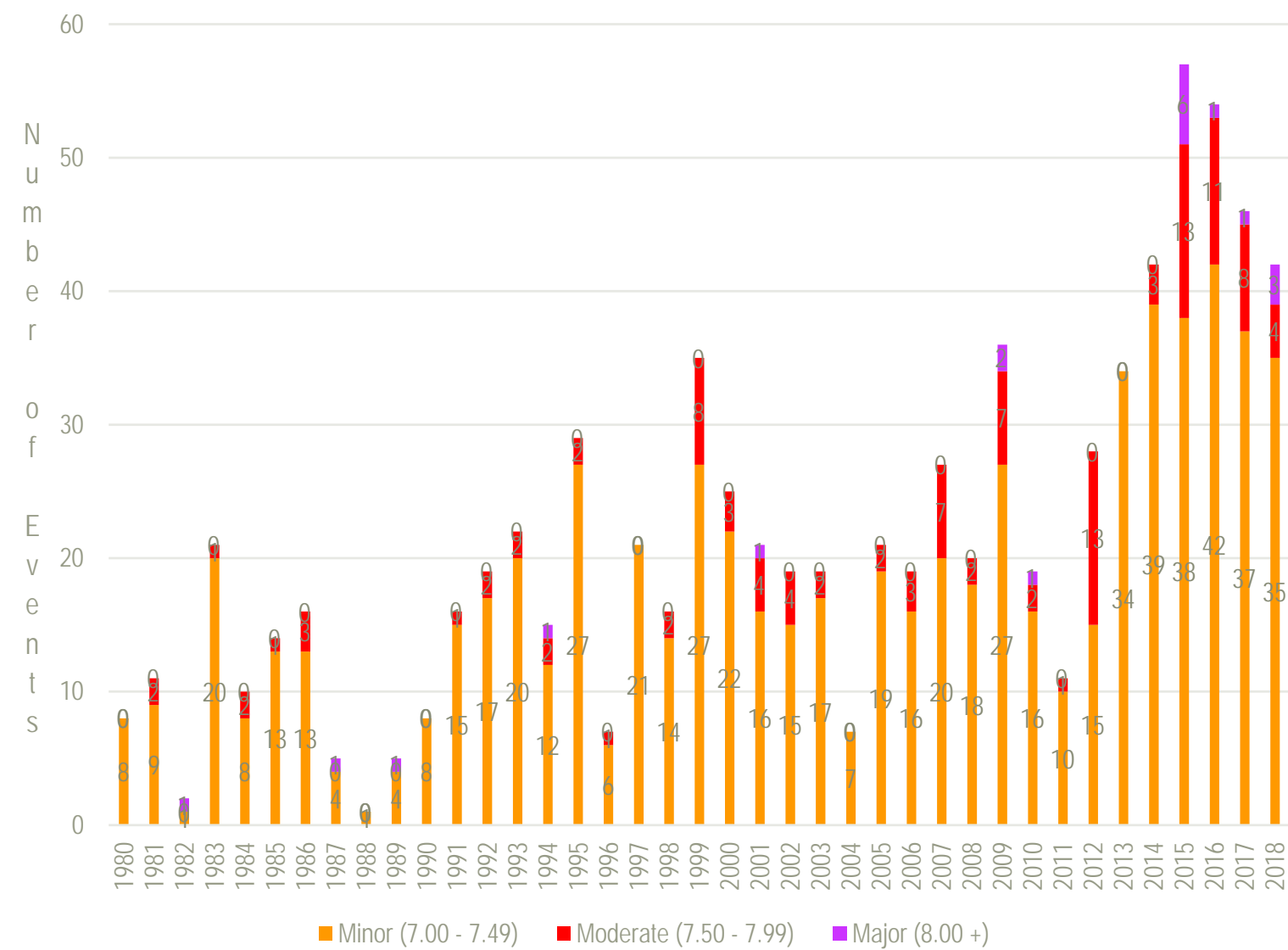
# South Carolina Lowcountry



Charleston Harbor, SC Coastal Flood Events by Year (7.00 ft MLLW or higher)



Charleston, SC Coastal Flood Events by Category

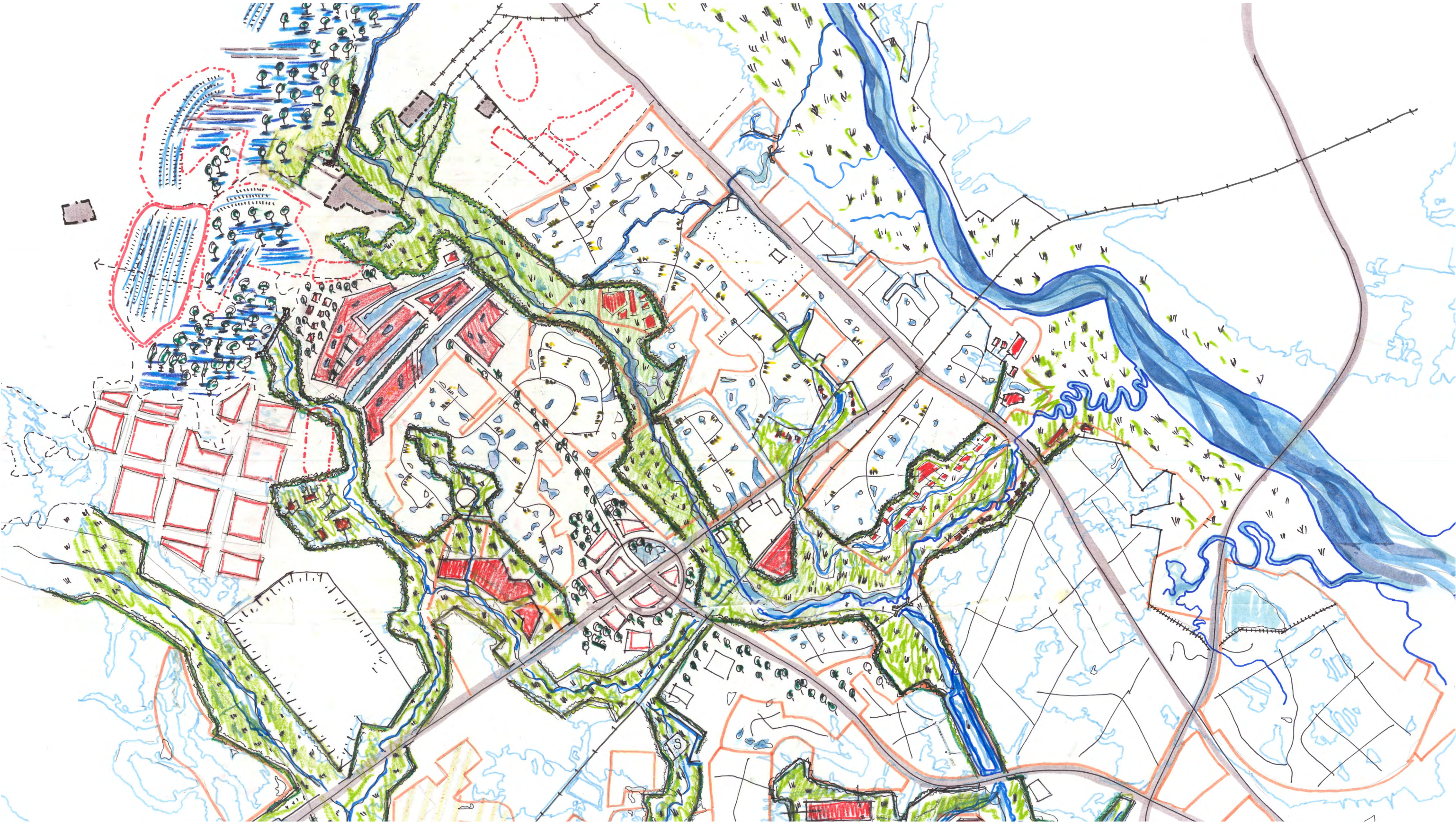








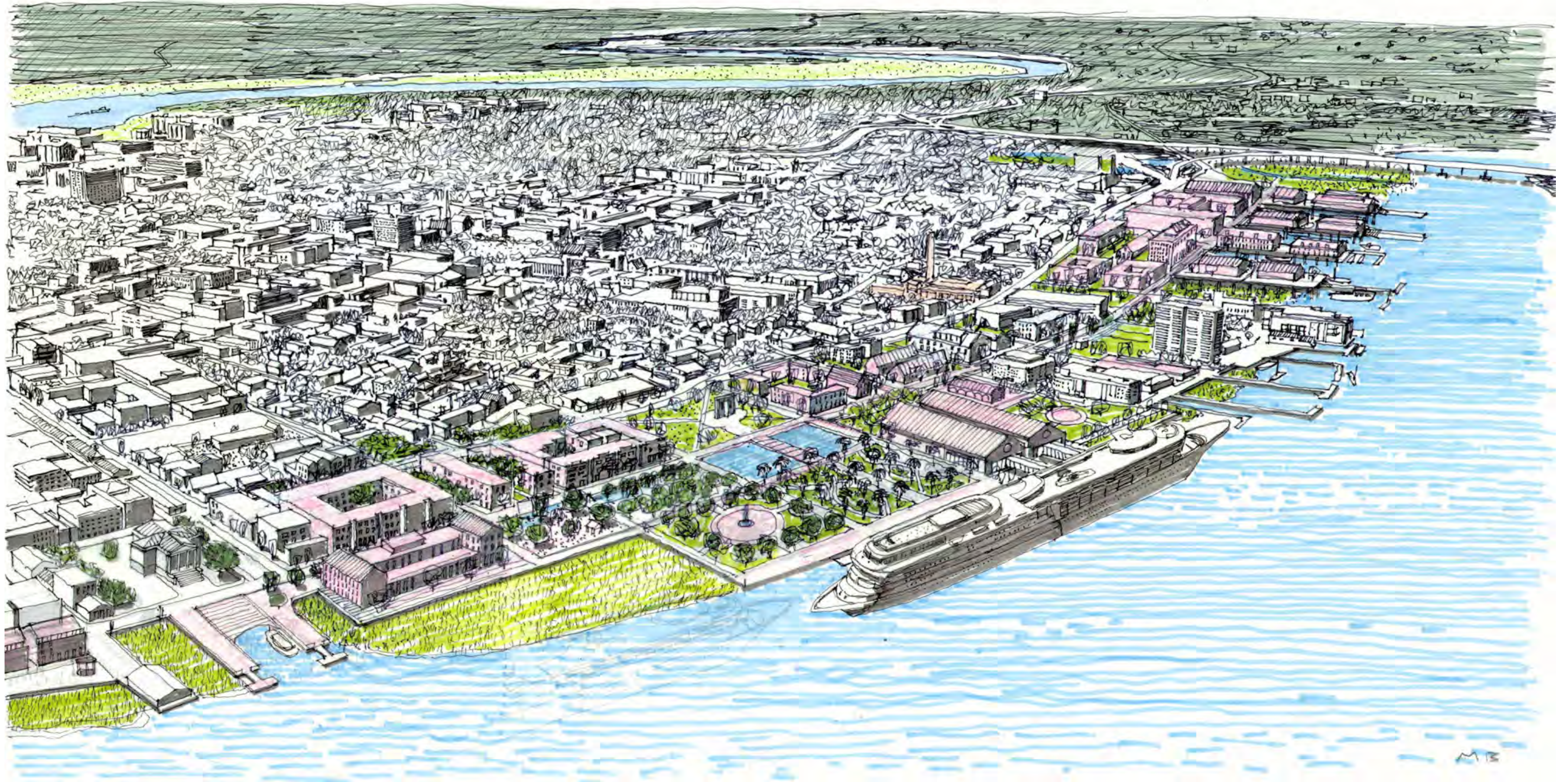
Lowcountry Vision  
Church Creek Basin



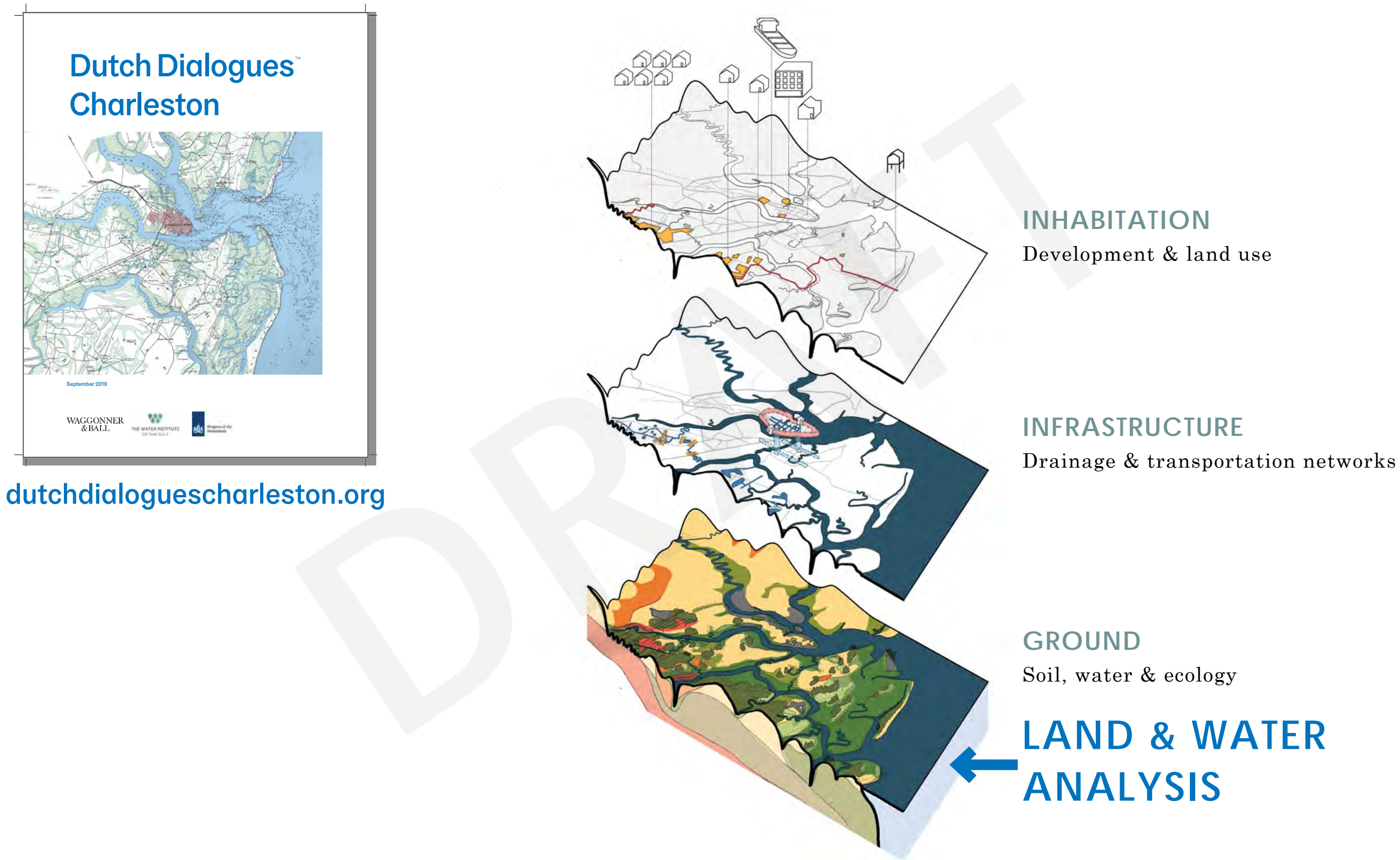


# Cooper River

Dutch Dialogues Charleston









# WATER DATUMS

## 2/3 OF CHARLESTON

Inside the urban growth boundary is in the 100 Year Floodplain

## 10.2 INCHES OF RAIN

Over 24 hours every 100 years

## 17 FEET STORM SURGE

Maximum possible category 3 storm surge

## 3 FT OF SEA LEVEL RISE

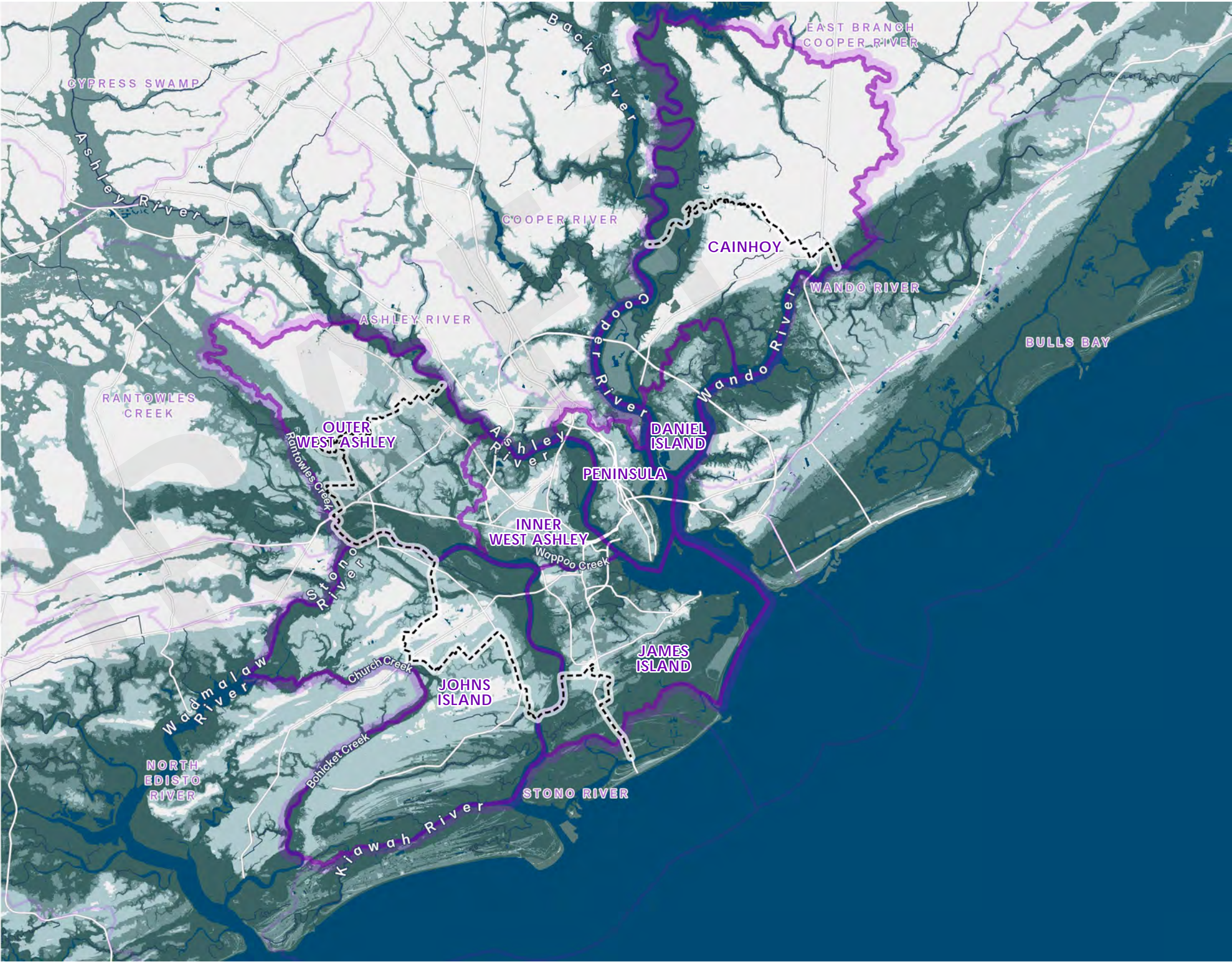
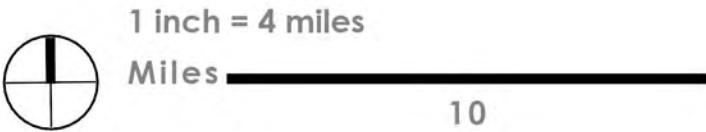
By 2080

## 7 WATERSHED AREAS

Peninsula, Inner West Ashley, Outer West Ashley, James Island, Johns Island, Daniel Island and Cainhoy

Watersheds Neighborhood

- Urban Growth Boundary
- Water





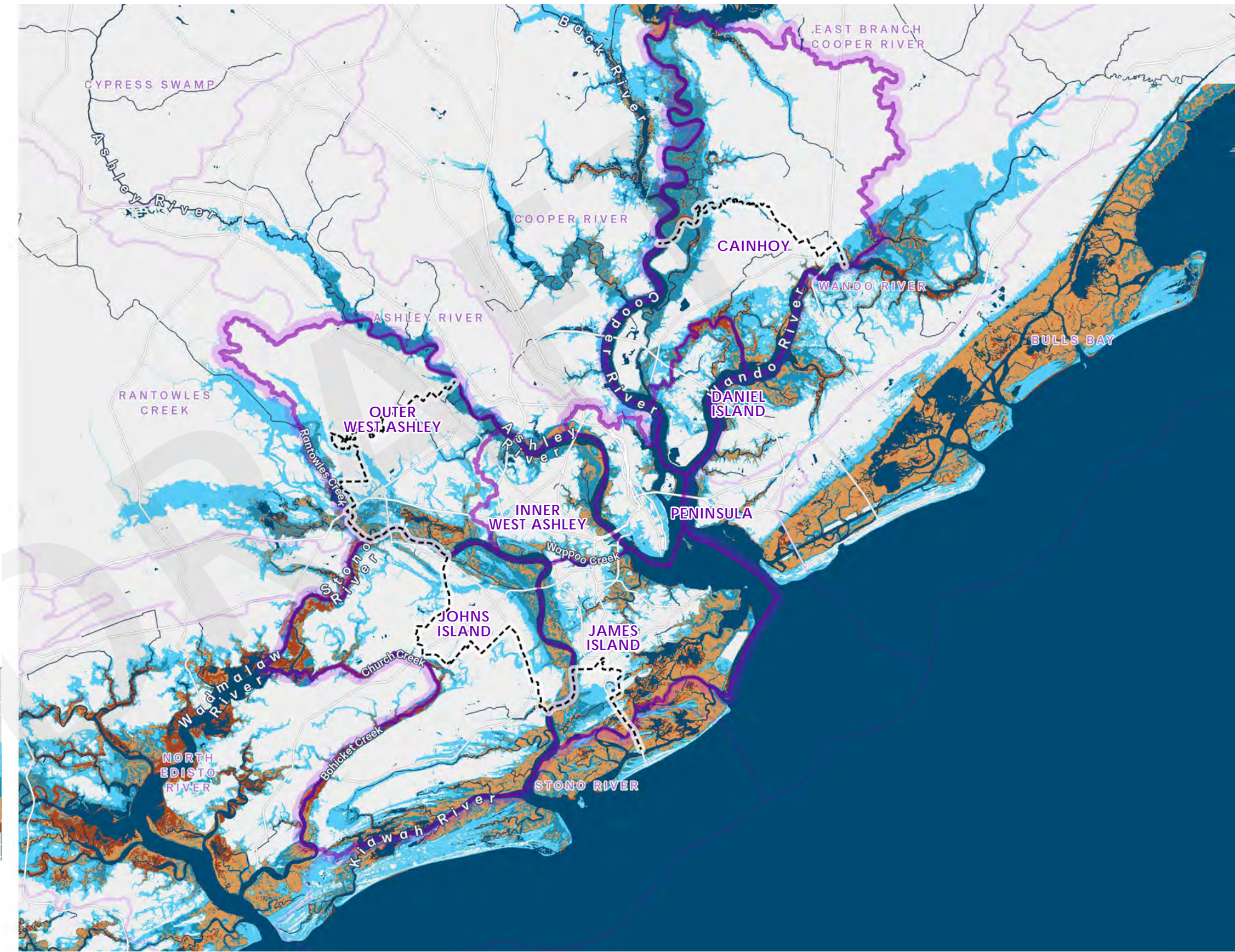
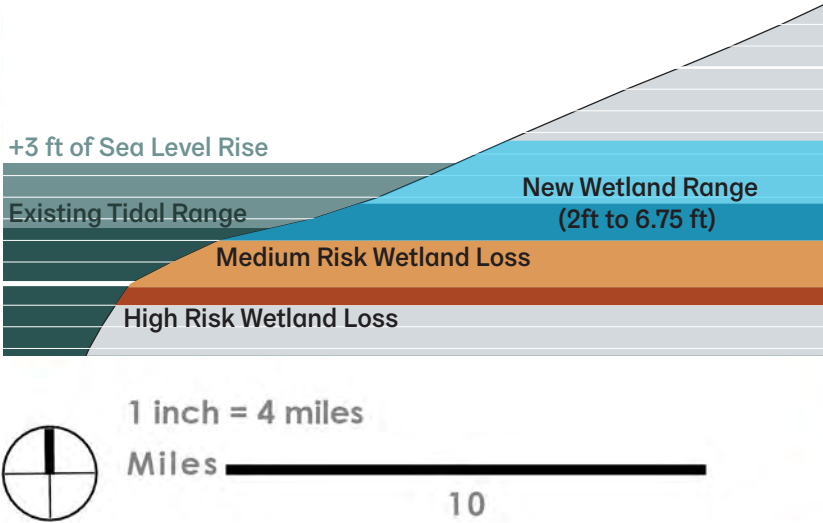
# MARSH MIGRATION WITH 3 FT OF SEA LEVEL RISE

This map show marsh migration; which zones are most at risk and which zones could become herbaceous wetlands in the future.

map sources: USGS, MRLC

≈ 2 TO 6.75 FT (NAVD)  
WETLAND MIGRATION ZONE

≈ -1 TO 3.75 FT (NAVD)  
EXISTING WETLAND RANGE





# TREE CANOPY

This map shows tree canopy density as of 2015 and tree canopy loss and gain from 2000-2015.

map sources: Global Land Cover Facilities

Legend

Tree Canopy (2015)

Dense

Sparse

Canopy Change (2000-2015)

High Gain

High Loss

Watersheds Neighborhood

Urban Growth Boundary

-----

Water

Water

Wetland

1 inch = 4 miles

Miles

10





# SOIL HYDROLOGIC GROUPS

Soil hydrologic groups define a soil’s capacity to absorb water.

sources: USDA

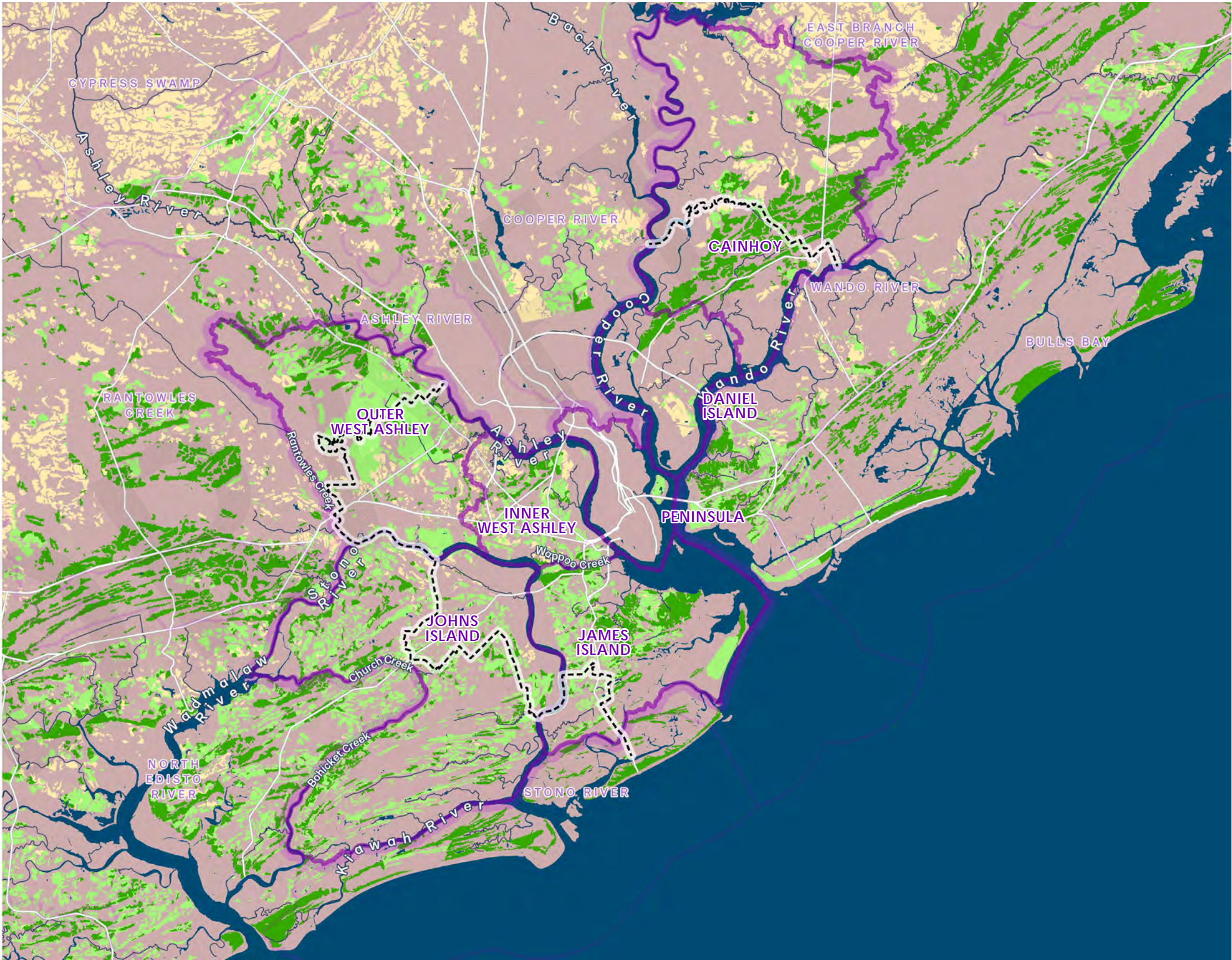
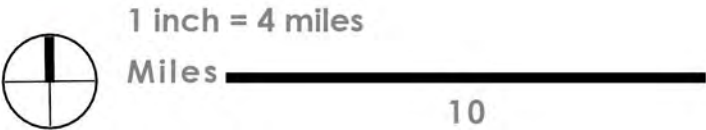
- A: ABSORBS THE MOST WATER
- B: ABSORBS SOME WATER
- C: ABSORBS LITTLE WATER
- D: POORLY DRAINED AND/OR ABSORBS BASICALLY NO WATER

Watershed Neighborhood

Other Watersheds

Urban Growth Boundary

Water





# ELEVATION ZONES

## HIGH GROUND

High ground is defined as land outside of the 100 year floodplain and above the max category 3 storm surge. High ground has the lowest flood risk, and the greatest capacity for stormwater detention and infiltration in Charleston.

## ADAPT ZONE

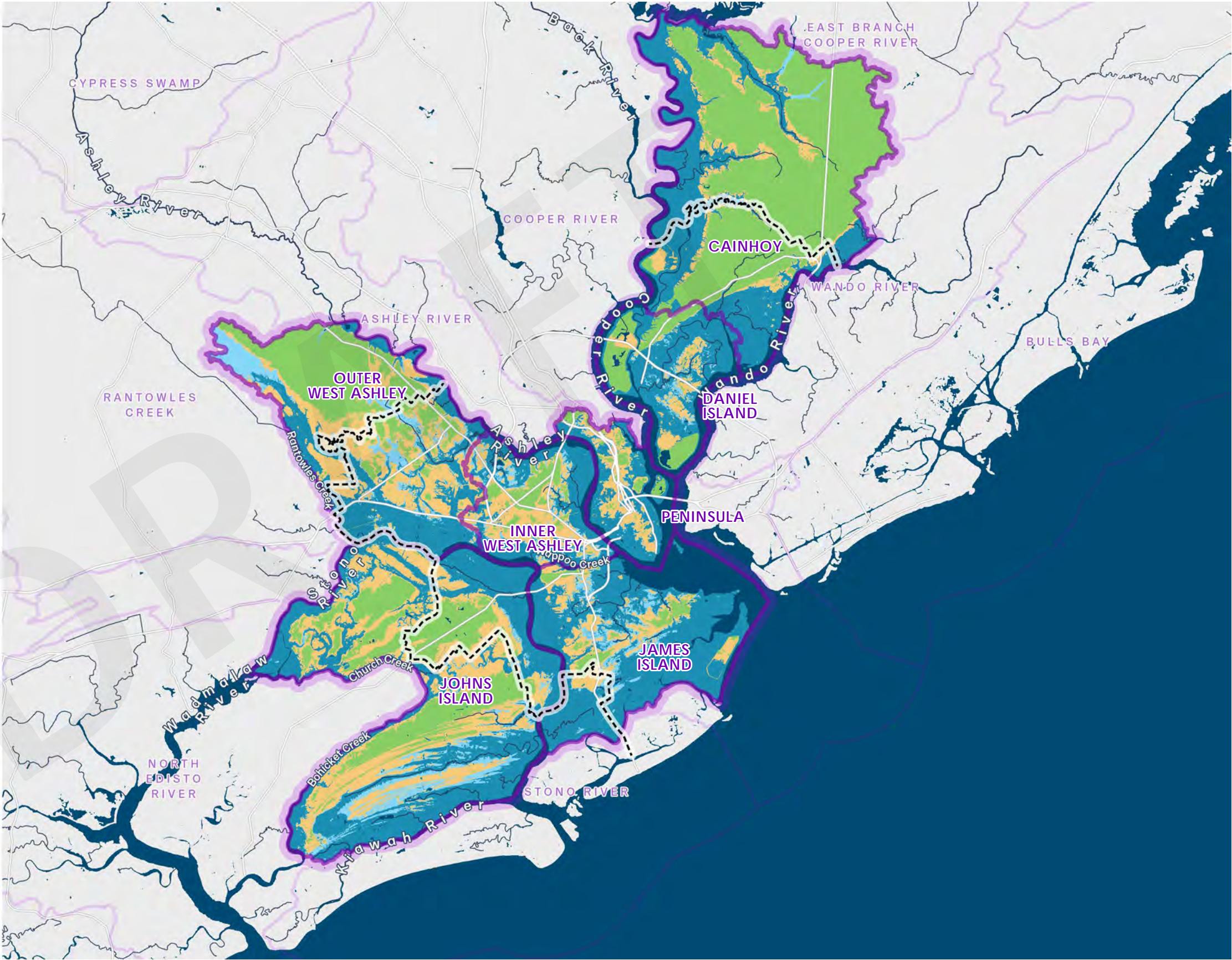
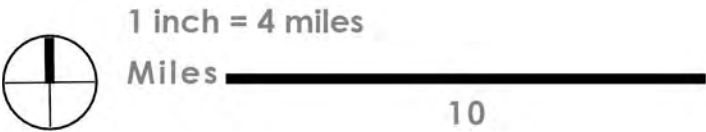
The adapt zone consists of land outside of the 100 year floodplain, that is still within the maximum storm surge of a category 3 hurricane. Flooding in this zone is infrequent but not impossible.

## COMPOUND FLOOD RISK

This zone encompasses areas within the floodplain above the tidal flood risk zone, where flood risk comes from a mixture of rainfall, runoff and tidal conditions.

## TIDAL FLOOD RISK ZONE

This zone encompasses the lowest land in Charleston, . Nearly 100% of this zone is in the 100 year floodplain. Flooding is frequent and can come solely from tidal events independent of precipitation.



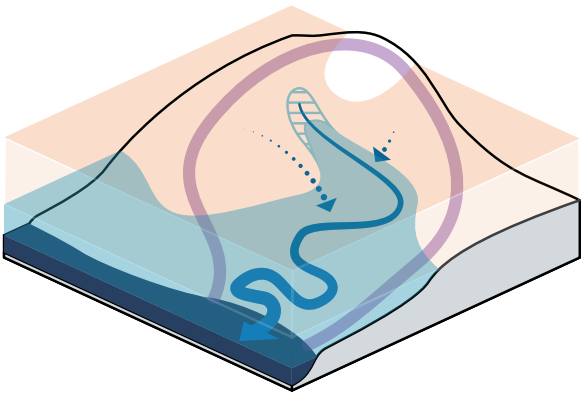


# WATERSHED TYPE

WATERSHED TYPOLOGY INFLUENCES POTENTIAL FLOOD RISK

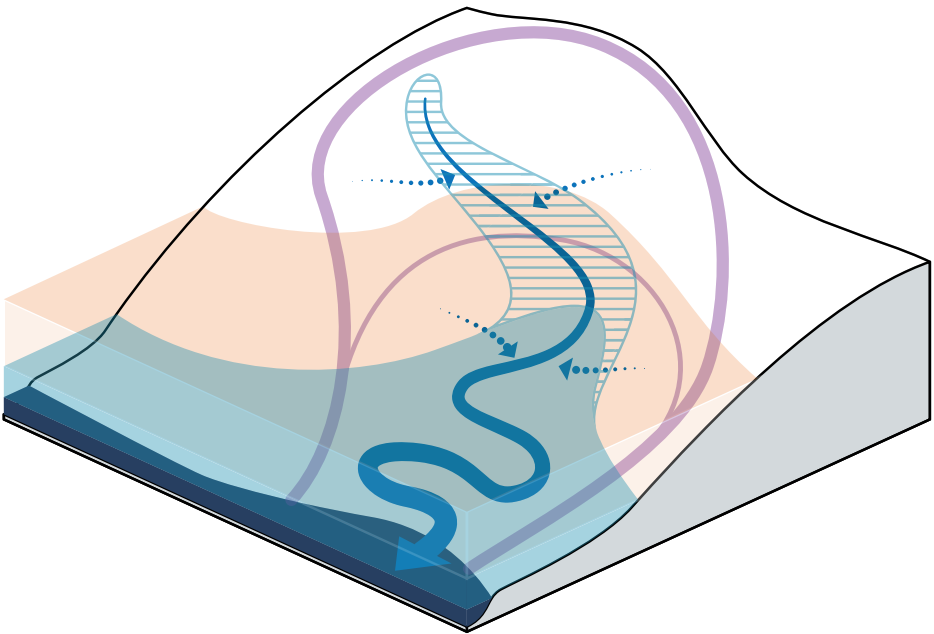
## SMALL WATERSHEDS

- DITCHES OR SHEETFLOW
- LESS RUNOFF ACCUMULATION
- LESS COMPOUNDING DRAINAGE BACKUP

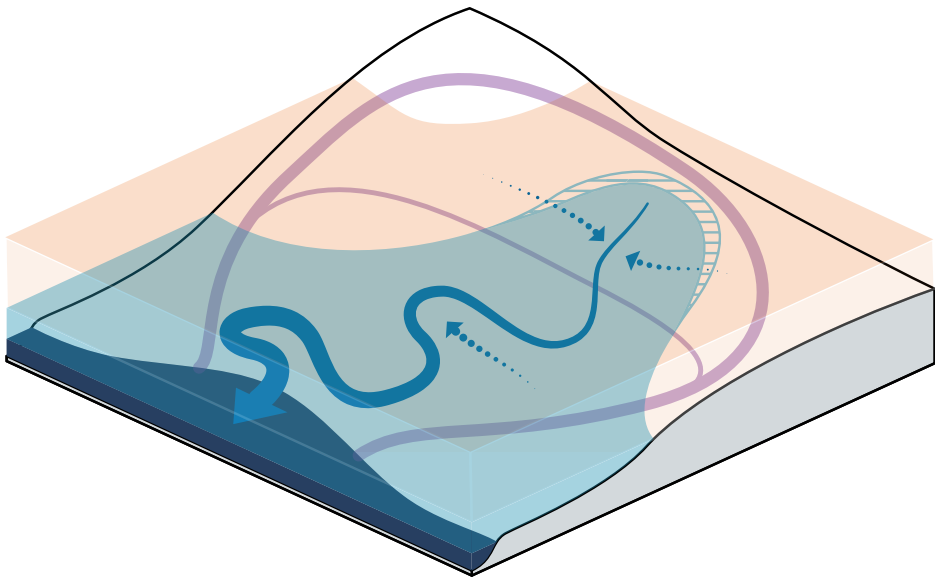


## LARGE WATERSHEDS

- WELL DEFINED WATERWAYS
- UPSTREAM & DOWNSTREAM SUBWATERSHEDS



LARGE INLAND

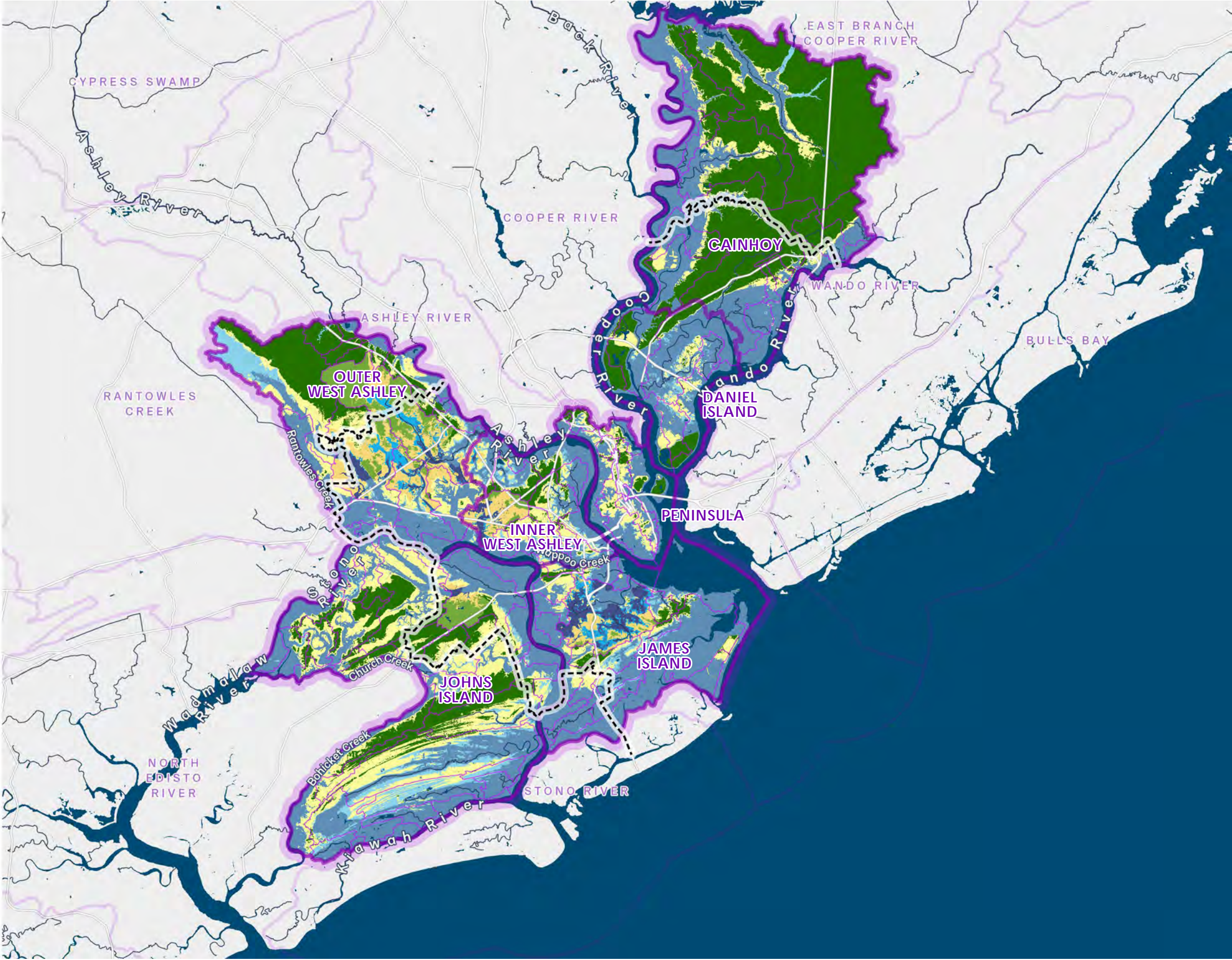
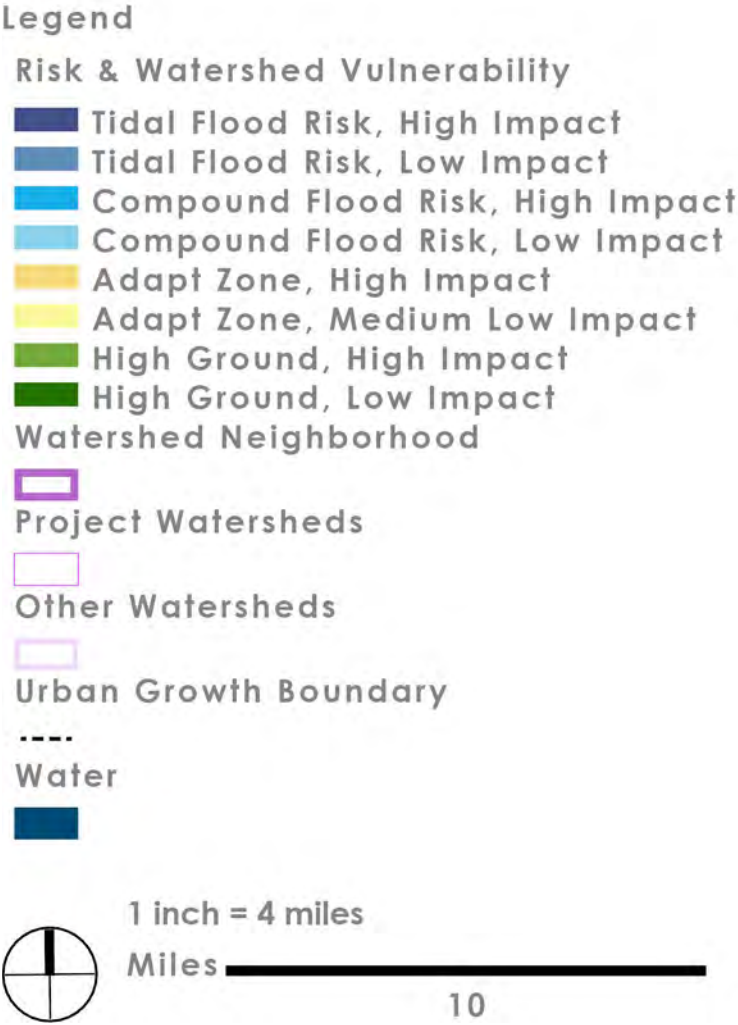


LARGE TIDAL

- Runoff
- Drainage Path
- Watersheds
- Subwatersheds
- Tidal Flooding
- Compound Flooding
- Maximum Storm surge



# ELEVATION ZONES & WATERSHED IMPACT





## GROW

Responsibly increase development and population density. Growth makes the most sense in areas with low impact and low risk. Growth has to occur in tandem with water management.

## DEFEND

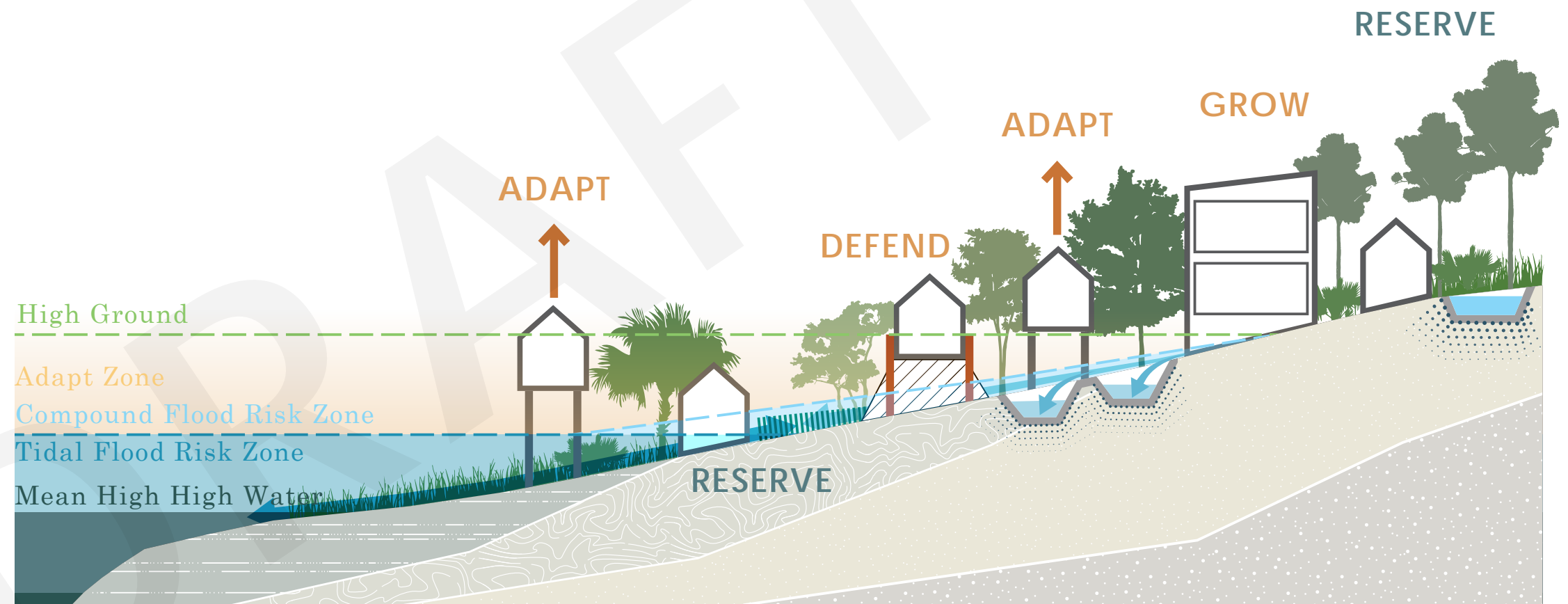
Protect infrastructure with engineered measures such as berms and flood walls. Defense measures, like berms and flood walls should be reserved for areas with the highest risk, and lowest impact (e.g. where the displacement of floodwater will not exacerbate risk elsewhere.)

## ADAPT






















Retrofit vulnerable existing infrastructure to be resilient to water risks. Adapt wherever possible, raising structures reduces risk with limited to no increase in watershed impacts. However adaptive capacity is limited by building typology.

## RESERVE

Restore and preserve natural ecosystems. Reserve is applicable to all zones. Ecosystems providing stormwater benefits and essential wildlife habitats exist throughout Charleston and need to be preserved.





|         | Tidal Flood Risk Zone                                                               |                                                                                       | Compound Flood Risk                                                                   |                                                                                       | Adapt Zone                                                                            |                                                                                       | High Ground                                                                           |                                                                                       |
|---------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|         | High Impact                                                                         | Low Impact                                                                            | High Impact                                                                           | Low Impact                                                                            | High Impact                                                                           | Low Impact                                                                            | High Impact                                                                           | Low Impact                                                                            |
| GROW    |                                                                                     |                                                                                       |                                                                                       |                                                                                       |   |   |   |   |
| DEFEND  |  |  |                                                                                       |  |                                                                                       |                                                                                       |                                                                                       |                                                                                       |
| ADAPT   |  |  |  |  |  |  |                                                                                       |                                                                                       |
| RESERVE |  |  |  |  |  |  |  |  |



# Peninsula Alignment Zone

US Army Corps of Engineers 3x3x3 Analysis







# Water literacy begins with our youngest citizens.



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## Vision

We envision a future where all citizens have the knowledge and creativity they need to strengthen their communities and live with water in an era of climate change and sea level rise.

## Mission

Ripple Effect prepares our youngest citizens to be tomorrow's environmental leaders by redefining environmental education through place-based teaching, learning, research, and design.





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