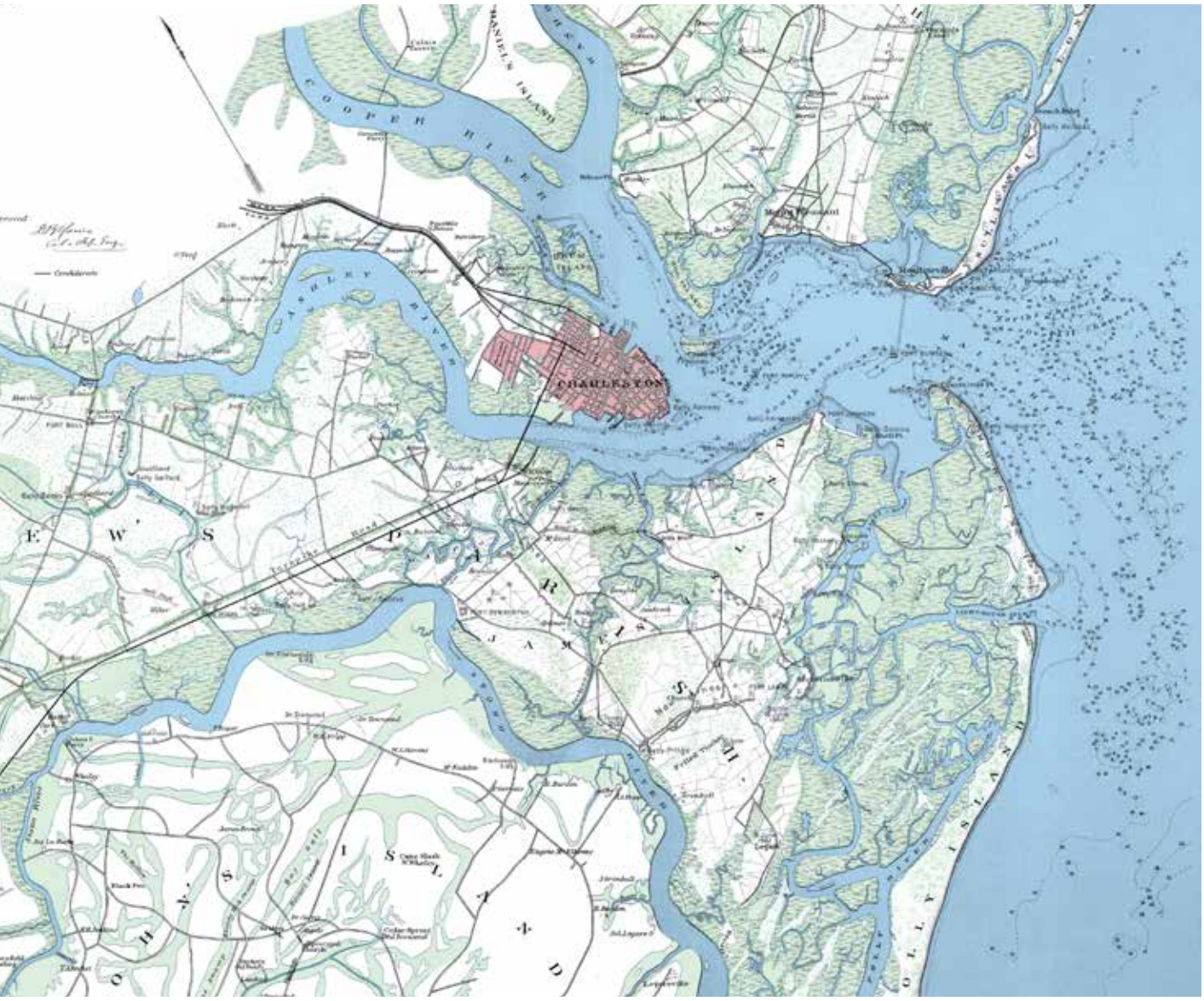
Dutch Dialogues™ Charleston



September 2019

WAGGONNER & BALL

THE WATER INSTITUTE OF THE GULF

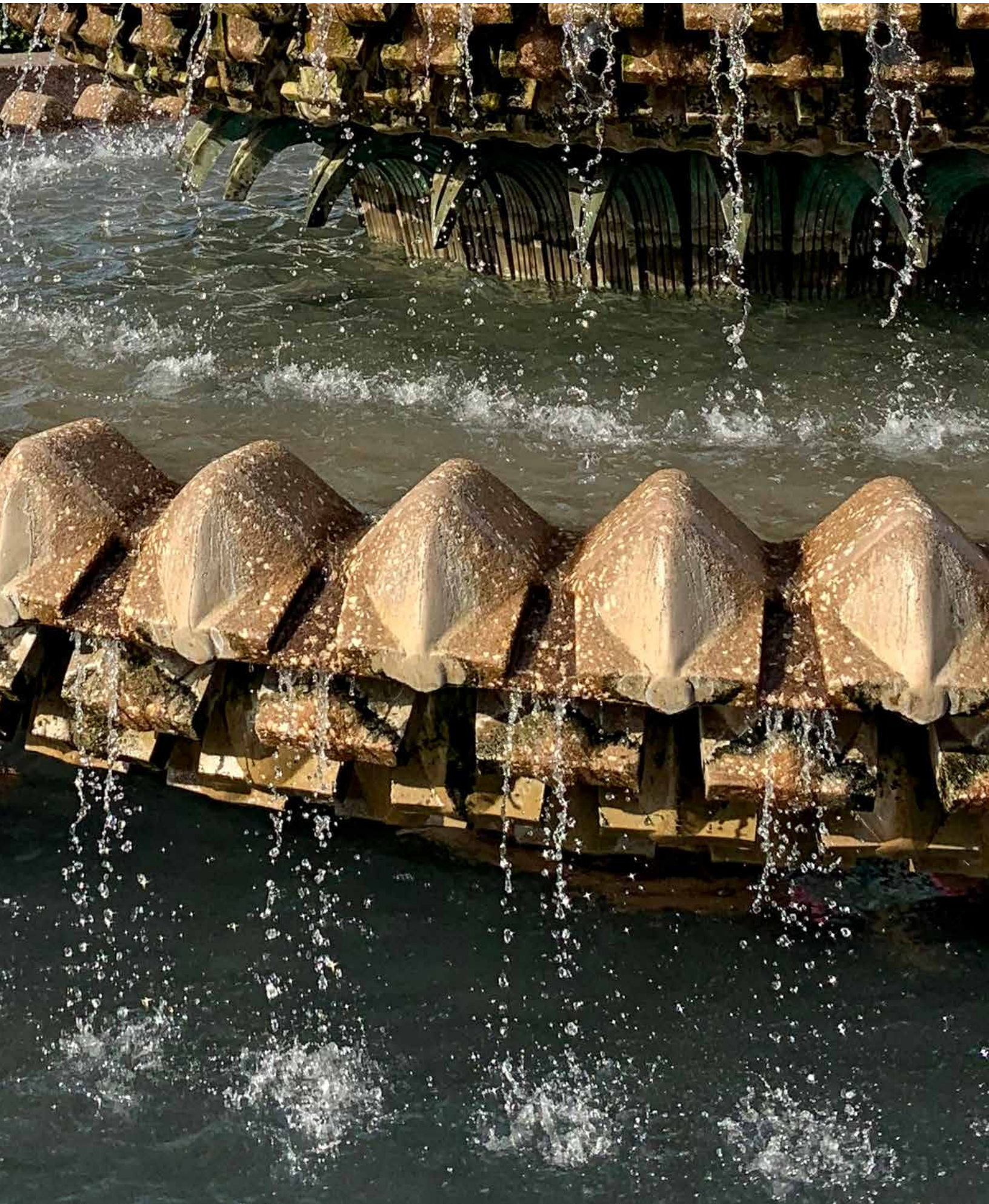
Kingdom of the Netherlands

Church Creek

West Ashley Park

Johns Island

Pineapple Fountain



Lockwood St. Dropshaft
Credit: City of Charleston

Pedestrians on the High Battery

> **“We have a bias: to work with the natural and ecological systems that are here. If you ignore them, Mother Nature eventually will win. And make human safety your primary focus. Natural and human -- make those systems work together.”**

Dale Morris
Director of Strategic Partnerships, The Water Institute of the Gulf

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HISTORIC CHARLESTON FOUNDATION

WAGGONNER & BALL

THE WATER INSTITUTE OF THE GULF

Kingdom of the Netherlands

AMERICAN FLOOD COALITION

Charleston Water System

CDC.C CLEMSON DESIGN CENTER CHARLESTON

MUSC Medical University of South Carolina

The Nature Conservancy

Foreword

Dutch Dialogues Charleston is an effort by many individuals, organizations, partners, and professionals who offered time and resources to co-create for Charleston a pathway to resilience and reduced flooding while maintaining its historic beauty and iconic identity.

Charleston is and will remain a water city and thus our focus is properly on water: surge, tidal, rainfall, stormwater, drainage, surface, groundwater, and combinations thereof. Charleston's long-term survival will, in a large part, be determined by how the community manages its flood and sea-level rise risks. While social, economic and equity challenges were beyond our scope, we touched upon some to highlight opportunities to address those through the context of water.

The Dutch Dialogues do not produce engineering plans or project lists but instead principles and pathways. Our key, universal values are Safety First, Respect Natural Systems, Reduce Human and Economic Loss. Our recommendations are grounded in science, inspired by community, based in design and informed by our humility about things we do not yet know. We believe that principles and visions should inform planning, engineering and investment.

Water is not something to exploit or control; it is something to respect, manage and embrace. Acknowledging and accepting the water system's primacy, however, yields sober choices but also aspirational options. As Chinese philosopher Lao Tzu observed, "If you don't change direction you may end up where you are heading." What follows in this report is, we believe, a pathway towards a safer Charleston.

Long-term planning to manage the risks and the opportunities provided by the Lowcountry's dynamic water systems is essential. The Netherlands and Louisiana regularly update detailed coastal master plans to guide and prioritize investment in protection and restoration based upon available resources and cutting-edge science. Texas, Virginia, New Jersey and Florida are moving in that direction too; South Carolina should follow. Many cities – Amsterdam, New York, New Orleans, Miami, Rotterdam, Copenhagen, Boston, Norfolk, Virginia Beach, London, Houston, Ho Chi Minh City, San Francisco – are grounding local and regional planning efforts in their physical water systems. In these places, the water system is becoming primary again, as it must in Charleston.

While we call this process Dutch Dialogues, our team of experts is not primarily Dutch. It is comprised of experienced designers, landscape architects, architects, engineers, planners, geographers, and others – some Dutch, most not – who understand that a new approach to water is needed. The Dutch operate their "polder landscape" through structured collaboration, shared values, science, planning and investment. Multiple benefits are pursued. Limits and trade-offs, not unbridled manipulation of physical systems, are clarified and understood. Preparedness and humility have replaced reaction and hubris. Long-term, structured investment is essential: inscribed above the world's oldest stock exchange, in Amsterdam, are these words: "The Costs come before the Benefits."

That said, we are humbled that the core group of Dutch participants for the Charleston effort have worked at the highest levels of Dutch water practice. That speaks, perhaps, to the beauty of Charleston as a "place," the complexity of its water challenges and the inevitable losses if the status quo prevails.

We hope and trust that our work will add to the already-rich ideas and expertise we discovered in the Lowcountry.

Dale Morris and **David Waggonner**
on behalf of the Dutch Dialogues
Charleston Team

> **“We’re known as a city to be the number one in hospitality in the world. That means, stay a while, come and find a place for you here. We haven’t done that with water. We need to treat water respectfully and be an advocate for water. This is a community effort, and we have to share this cultural mindset.**

Mayor John Tecklenburg
City of Charleston

Acknowledgements

There are numerous side-bars in this report of additional information that support the narratives. These are intended to aid the reader’s understanding of key concepts and relevant examples.

To thank everyone who helped or engaged is likely impossible. Special thanks and recognition are nevertheless due to many, including (in no hierarchical order):

The funders and sponsors of Dutch Dialogues Charleston: American Flood Coalition, City of Charleston, Medical University of South Carolina, Historic Charleston Foundation, Charleston Water System, The Nature Conservancy, and the Clemson Design Center;

Mayor John Tecklenburg, who encouraged us “to do the right thing,” and Council Members Seekings, Jackson and Griffin who engaged, grounded and even nudged us when we became sidetracked;

Winslow Hastie and Holland Williams of Historic Charleston Foundation;

The Royal Netherlands Embassy, whose financial support enabled the travel of the Dutch experts;

Ray Huff, B.D. Wortham-Galvin, and Mimi Rose of the Clemson Design Center and the students of the Resilient Urban Design program housed there;

Dennis Frazier of the Medical University of South Carolina;

Pastor Paul Rienzo and members of the Crosstowne Christian Church;

Latonya Gambrell, members of the Eastside Community Development Commission, and leadership of the Coastal Community Foundation who pointed us to them;

The College of Charleston, and in particular professors Norm Levine, Scott Harris and Phil Dustan;

Rick Devoe and Sarah Watson of SC Sea Grant;

Elizabeth Fly of the Nature Conservancy;

Dan Burger of the Charleston Resilience Network;

Dedicated staff of the City of Charleston: Mark Wilbert, Katie McKain, Jacob Lindsey, Mandi Herring, Christopher Morgan, Robert Hauck, Eric Pohlman, Kinsey Holton, Matt Fountain, Aaron Holley, Jacob Kronsberg, Steve Kirk, Amy Wharton, Steven Julka;

Many local Charleston engineers, not the least of which Jared Bramblett, Rick Karkowski, Joshua Robinson, Brian Durham, Betty Nierman, Robert Horner;

Josh Dix of the Charleston Realtors Association;

The Baton Rouge Area Foundation whose leadership supports the Charleston-Baton Rouge and South Carolina- Louisiana connections;.

…and the many others upon which we leaned, cajoled, questioned and joined to our teams.

Contents

Report produced by Waggonner & Ball with text contributions from The Water Institute of the Gulf.

Executive Summary

As explained in the Foreword, Dutch Dialogues (DD) Charleston is an effort by many to co-create for Charleston a pathway to resilience that reduces flooding while ensuring its historic beauty and iconic identity will endure. The effort was led by Waggonner & Ball Architecture / Environment, The Water Institute of the Gulf, and the Royal Netherlands Embassy. Moffatt & Nichol, Arcadis, and numerous Charleston academics, researchers and private-sector experts volunteered their time.

A brief DD history, the Charleston DD scope, our team's approach to water in the Lowcountry and "what we heard" through this DD effort follow this introduction. Next are summary narratives of the design process, design inquiries and key recommendations for each of the four focal areas.

Each of the narratives in this report has a distinct "voice." This voice derives from the focal area Team Leader and is influenced and infused by the thinking of the focal Team. We thought it important to allow these diverse, distinct voices to be heard.

The flood and elevation maps at the beginning of each narrative must be studied in order to understand current and future flood risks and our recommendations.

Johns Island and Church Creek are distinct water systems in which landscape functions have been, or will be, negatively constrained by land development and land usage. There are ways to prevent further degradation of these functions or improve their performance, but these will require new zoning, building, land-use regulations and market-based mechanisms to ensure that future development mitigates the increasing flood risks for current and future inhabitants.

The peninsula's Eastside (New Market Creek and Vardell's Creek) neighborhoods and the Medical District have similar, and substantial, flood risks, although flood impacts differ substantially. Nevertheless, floods and high-water will eventually overwhelm both areas unless the City substantially invests in both green and gray infrastructure for these areas (and other areas on the peninsula too): drainage, pumps, perimeter protection, flood plain and creek restoration, bioswales, complete streets, stormwater infiltration and detention in public spaces.

Dutch Dialogues Timeline

> **“Charleston is a city that is built over time, exists over time as a palimpsest. Written over, written better, drawn better, made better, becoming more beautiful.”**

David Waggonner
Principal, Waggonner & Ball Architecture/Environment

The narratives include both regional and peninsula-wide perspectives, adding a landform and systems coherence to the overall report.

Our recommendations are found at the end of each narrative. Some recommendations are pressing, to address immediate research and risk-limitation needs. Some are policy and regulatory changes needed to facilitate the transition to a more resilient Charleston. Others are for alternative modes and tools that Charleston needs to adapt to rising seas, higher tides, and extreme weather.

At the end of each narrative are one- and-two-page “side bars” which contain important data, projections, policy suggestions, examples and similar information of relevance to Charleston’s goal to “live with water.” Other important “side bars” are found in the appendices.

The Appendices contain a summary of the May 2019 Dutch Dialogues Colloquium, which informed the starting point for the July 2019 Workshop. The Colloquium summary provides essential “problem definition” information and highlights some of the ongoing flood risk mitigation efforts already underway.

Also found in the appendices are a list of the DD Team, the many individuals who contributed informational side bars, a list of those local citizens, stakeholders and experts invited to participate in the Workshop and Colloquium, a brief summary of the Louisiana Coastal Protection and Restoration Masterplan, which is an ongoing science, policy, prioritization and investment-based effort, along with a brief summary of the corollary LA SAFE community adaptation strategy, and Norfolk’s Vision 2100 and Resilient Zoning Ordinance.

Any flaws or oversight in this effort stem from scope, resource, or time constraints. The strengths of the report derive from the knowledge, commitment, and concern of the Charleston citizens, stakeholders, scientists, City agencies and leaders who worked with the Dutch Dialogues team throughout this intense, creative and productive engagement.

Grounded in Science, Driven by Design

Dutch Dialogues Charleston Scope

Charleston's future depends upon how well the City and surrounding counties invest to adapt and preserve physical assets, underlying economies of medicine, education, tourism and trade, and enhance residents' quality of life. Given Charleston's abundant natural and man-made assets, creatively linking spatial planning, integrated water management, infrastructure and development will yield a compelling vision for Charleston's future.

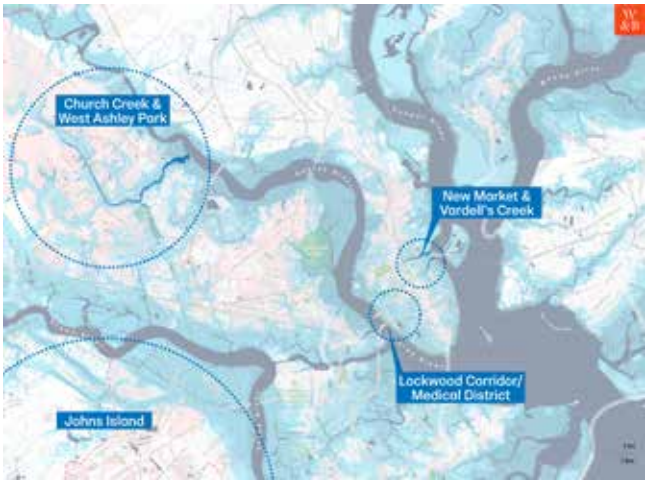
To create that vision, the Historic Charleston Foundation and the City of Charleston have launched Dutch Dialogues Charleston, a collaborative effort involving national and international water experts working alongside Charleston's local teams to conceptualize a Living With Water™ future. This new way of thinking about water, land, and people with multiple benefits will provide near- and long-term value to Charleston.

Many U.S. coastal cities, like Charleston, are experiencing the limits of "pump and drain" due to recurrent, more severe storms with extreme precipitation, increased river discharge and sea level rise. Dutch Dialogues Charleston researches, explores, designs and proposes integrated ways to mitigate and adapt to flood and other risks threatening the City and Lowcountry environs. These Dialogues should demonstrate the need for a comprehensive, realistic and inspirational Charleston Regional and Urban Water Plan to guide investment and (re)development in both nature-based and man-made water infrastructure improvements in the coming decades and provide a road map for flood risk mitigation.

Dutch Dialogues Charleston is directed and coordinated by Waggonner & Ball, LLC, The Water Institute of the Gulf and the Royal Netherlands Embassy, Washington, DC, alongside key Charleston-region partners from January through late-summer 2019. The areas of focus include:

Lockwood Corridor/Medical District

is a critical provider of essential services, a regional economic driver, and is currently impaired by recurrent tidal and storm-related flooding.



Map of Dutch Dialogues Charleston Focus Areas

New Market & Vardell's Creek Area

is experiencing significant growth and requires comprehensive land use and water planning to address the low elevation, stormwater flooding, unmet housing needs, and broader neighborhood development patterns.

Johns Island

requires a set of best water management practices to mitigate current and predicted flood risk. This multi-jurisdictional area with many infrastructure and growth-related challenges demands a regional perspective.

Church Creek & West Ashley

is urbanized, underutilized, and constrained and serves primarily as a drainage conduit and cause of flooding. Settlement patterns, geography, land use, water storage and discharge needs, and upland opportunities will influence proposed interventions to lower flood risk and enhance post-event resiliency while ensuring the vitality and viability of the area.

For more information: https://dutchdialoguescharleston.org

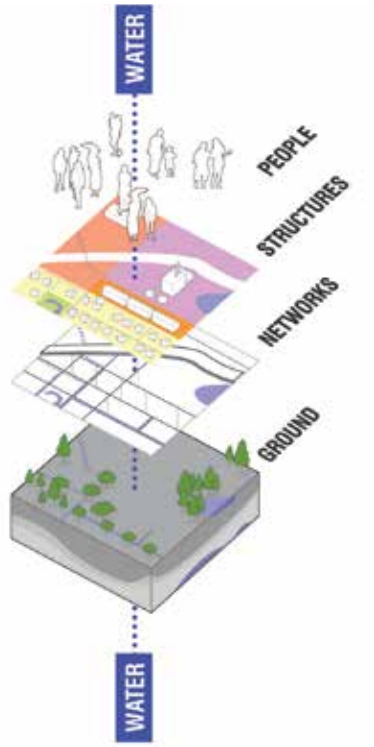
Recovery & Resilience through Collaboration

Dutch Dialogues History

Recovery requires cooperation. Resilience requires vision. These are two of the important lessons learned in the immediate aftermath of Hurricane Katrina as coastal Louisiana and neighboring regions struggled to address multiple storm-related environmental challenges (coastal surge, subsidence, urban storm water, aging pump and water-management infrastructure) and their related long-term social, economic, and quality-of-life consequences.

Recognizing that recovery efforts in the crucial time after a disaster event are often addressed as discrete, disconnected problems, David Waggonner of Waggonner & Ball, Dale Morris of the Royal Netherlands Embassy (now at the Water Institute), and Paul Farmer, former CEO of the American Planning Association, co-developed a series of stakeholder-focused workshops, the Dutch Dialogues, modeled on the Dutch approach of developing actionable solutions through integrated water management and flood infrastructure planning with a preference for multi-benefit investments. The New Orleans Dutch Dialogues, hosted between 2008 and 2010, seeded the Greater New Orleans Urban Water Plan, a large portion of the New Orleans Resilience Plan, and was instrumental to the $141 million Gentilly Resilience District project. Dutch Dialogues were also held in St. Louis in 2013 and in Tidewater (Norfolk), Virginia in 2015, the latter providing crucial input for Norfolk's successful $121 million National Disaster Resilience award. The workshop model has been successfully deployed in exploratory engagements in Los Angeles and Miami, and with Rebuild by Design in Bridgeport, Connecticut.

The design driven methodology led to over $310 million in federal funding for New Orleans, Norfolk, and Bridgeport. It transformed how these cities approach economic (re)development in relation to water, catalyzed water entrepreneurship and job creation through resilience building and stimulated citizens to become part of the region's systemic effort to reduce flooding. Dutch Dialogues begins the process of transforming water from threat to asset.



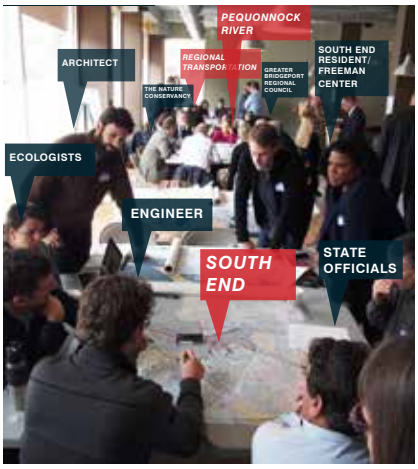
Planning involves all layers of place, from subsurface aquifers to patterns of human inhabitation.

$50 million
Rebuild by Design, Bridgeport, CT

$121 million
National Disaster Resilience award, Norfolk, VA

$141 million
Gentilly Resilience District, New Orleans, LA

Federal funding outcomes or proposals developed through Dutch Dialogues



Team structures maximize knowledge sharing and involve a full spectrum of stakeholders, from government officials to local residents.

Stakeholder Engagement Summary

Citizen and stakeholder engagement are embedded in the Dutch Dialogues (DD) process. The DD Team conducted numerous meetings with key Charleston-area citizens, stakeholders, public leaders, academics, researchers and local professionals over the course of this engagement.

The earliest discussions about a Dutch Dialogues occurred with Mayor Tecklenburg and leaders, members and subject matter experts of the Charleston Resilience Network (CRN) in the Fall of 2017. In August 2018, Water Institute, Waggonner & Ball, and Embassy staff conducted meetings with the Mayor, the American Flood Coalition, College of Charleston, Historic Charleston Foundation, South Carolina Sea Grant and leaders of City agencies and key staff. DD Team leaders were given in-depth briefings on the City's history, geography, geology, hydrology, planning, transportation and development. Meetings with the Charleston Trident Association of Realtors, Metro Chamber of Commerce, Charleston Home Builders Association, the Medical University of South Carolina, key leaders of engineering companies (Weston & Sampson, Davis & Floyd, Thomas & Hutton) and the Coastal Community Foundation were held. The Team extensively toured and explored the 4 focal zones / neighborhoods on foot and had detailed explorations of Church Creek, the Charleston Medical District, and Eastside neighborhoods.

A Charleston Delegation visited the Netherlands in October 2018, together with city / state government and Baton Rouge Area Foundation delegation from Baton Rouge, Louisiana. This trip was led by Water Institute staff with support from the Royal Netherlands Embassy. Numerous flood control projects – large and small, urban and rural, surge, tidal, riverine and stormwater were visited. Water management governance, investment policies and key Dutch approaches and practices were explored for their relevance to Charleston and Baton Rouge.

Presentation at Public Event

Mayor Tecklenburg with Members of the Dutch Dialogues Team
Credit: The Post and Courier

Public Open House
Community members review design team's work.
Credit: Marquel Coaxum

Drawing as a Tool
Prioritizing graphics to share information at a well attended public presentation.

The Dutch Dialogues Charleston were officially announced in January 2019 in Church Creek. More discussions were held with local engineering companies (Davis & Floyd, Thomas & Hutton, Weston & Sampson), Charleston Medical District senior leaders and facilities staff, CRN, SC Sea Grant, The Nature Conservancy, Professor Norm Levine and leading researchers at the College of Charleston and the Clemson Design Center / Graduate School of Urban Design, City Planning / Engineering / Resiliency staff, City Council members, and the US Army Corps of Engineers. More site and walking tours were conducted.

In February 2019, DD Team members were connected to the Westedge Foundation, visited the West Edge development, and in March 2019 DD Team member Janice Barnes participated in two meetings, at the Foundation's request, with West Edge leadership and Board in April 2019.

Dale Morris, DD Team leader, visited Charleston in March 2019 for follow-up meetings with City leaders, Church Creek developers, CRN, Nature Conservancy, Charleston Medical District staff, Davis & Floyd, Coastal Conservation League, Charleston Preservation Society, Charleston Trident Association of Realtors, Dr. Phil Dustan of the College of Charleston, Johns Island developers and community leaders, City Planning and Stormwater departments, and the Metro Chamber of Commerce. Another extensive walking tour of the Eastside and CMD was conducted.

Also in March 2019, Team leader David Waggonner presented the Dutch Dialogues approach at Historic Charleston Foundation's lecture series, as well as results from these processes elsewhere and ambitions for Charleston.

The Dutch Dialogues Colloquium was held May 1-2 in Charleston, preceded by a full day of site tours of the focal zones neighborhoods. Please see the Colloquium Summary and Colloquium invitee and attendee list in the appendix of this Report.

The Colloquium provided community leaders, stakeholders, professionals and concerned citizens with the opportunity to interact with Charleston leaders, key DD Team staff, Dutch experts, and with each other on the many flood risk challenges, needs, and opportunities in the City and broader SC Lowcountry. The Colloquium established the design intentions, parameters and goals for July 2019 Design Workshop. In mid-May 2019, DD Team Leader Dale Morris participated in a Historic Charleston Foundation public event on the financing of flood protection infrastructure.

The DD Design Workshop was held July 15–19, 2019. This report captures the process and output of that Workshop, grounded in the rich, detailed information gathered from the engagements, meetings and research compiled and conducted over the previous 12 months. During the Workshop, two public Open Houses were held, one in West Ashley's Crosstowne Church and one at the Clemson Design Center in the Eastside. Two lengthy briefings on Amsterdam's Rainproof program were held, one open to the public and one for key City staff and leaders. The Workshop encompassed numerous stakeholder meetings, including with the Eastside Community Development Corporation, homeowner and community associations in West Ashley and Johns Island, Brittlebank Park users, Medical District leaders and users, County and State Government staff, land development and homebuilder sectors, and the US Army Corps of Engineers.

Please see the appendix for lists of Workshop invitees, participants, DD Team, City staff and local professionals and experts activated during the Workshop.

Workshop Drawing
Team member draws over a large format map.
Credit: Marquel Coaxum

Workshop Review
Team members discuss in-progress work.
Credit: Marquel Coaxum

Workshop Discussion
Broad conversations across a range of issues.
Credit: Marquel Coaxum

What We Heard*

Water & Environment

Leverage nature to protect and defend against flooding

Involve partnerships to advance

Tree planting campaign, using local species, connected to forests and marsh lands

Don't increase risk; do no harm

Protect citizens and neighborhoods

Access to water as public right

Acknowledge shared but different histories

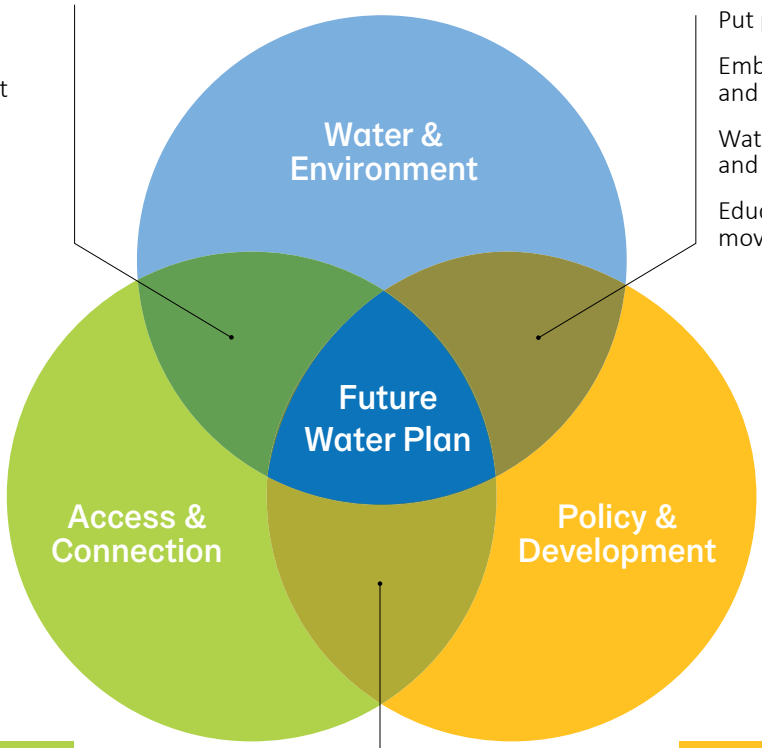
Value current and future residents

Put people and communities first

Embrace water as cultural value and regional asset

Water as connector of people and nature

Education and proactive movements



Access & Connection

Places to meet in nature with families, friends, and pets

Free time spent on or near waterways walking, biking, kayaking, swimming, paddle-boarding, fishing

Marsh-way: linear park allowing public access to marshes

Trail and bikeway along Long Branch, Lake Dotterer, Church Creek waterways, and around peninsula

Accommodate growth without exacerbating flooding

Mandate low impact development throughout city to prevent adverse impacts

Use watershed approach

Protect long term health of community based on science

Policy & Development

Development must be part of solution and engage

Tough decisions need to constrain negative impacts of development

Privatize the risk so risk reduction is not left solely to public sector/ government

Update building code

Find common ground

Embrace policy changes, like TDR

Risk has been socialized, but gain has been privatized for new developments

No risk to new or existing development

Advance existing growth/ comprehensive planning

Identify places we cannot afford to develop

Respect West Ashley and Johns Island plans

* comments recorded and grouped by the DD team according to emergent themes

Design Team Studying Historic Development Models of the City
Credit: Marquel Coaxum

Team Geologist Taking Water Samples

Design Team Site Visit to West Ashley Park

Design Team During Workshop
Waggonner & Ball team member leading discussion.

Multidisciplinary Team
Designers, engineers, and other experts collaborate to work across disciplines.
Credit: Marquel Coaxum

Participants at Community Engagement Event
Credit: Marquel Coaxum

Community Engagement Event at Crosstowne Church
Credit: Marquel Coaxum

Workshop Drawing
Waggonner & Ball team member explaining drawings.
Credit: Marquel Coaxum

Design Team During Workshop
Credit: Marquel Coaxum

Final Presentations
Credit: Marquel Coaxum

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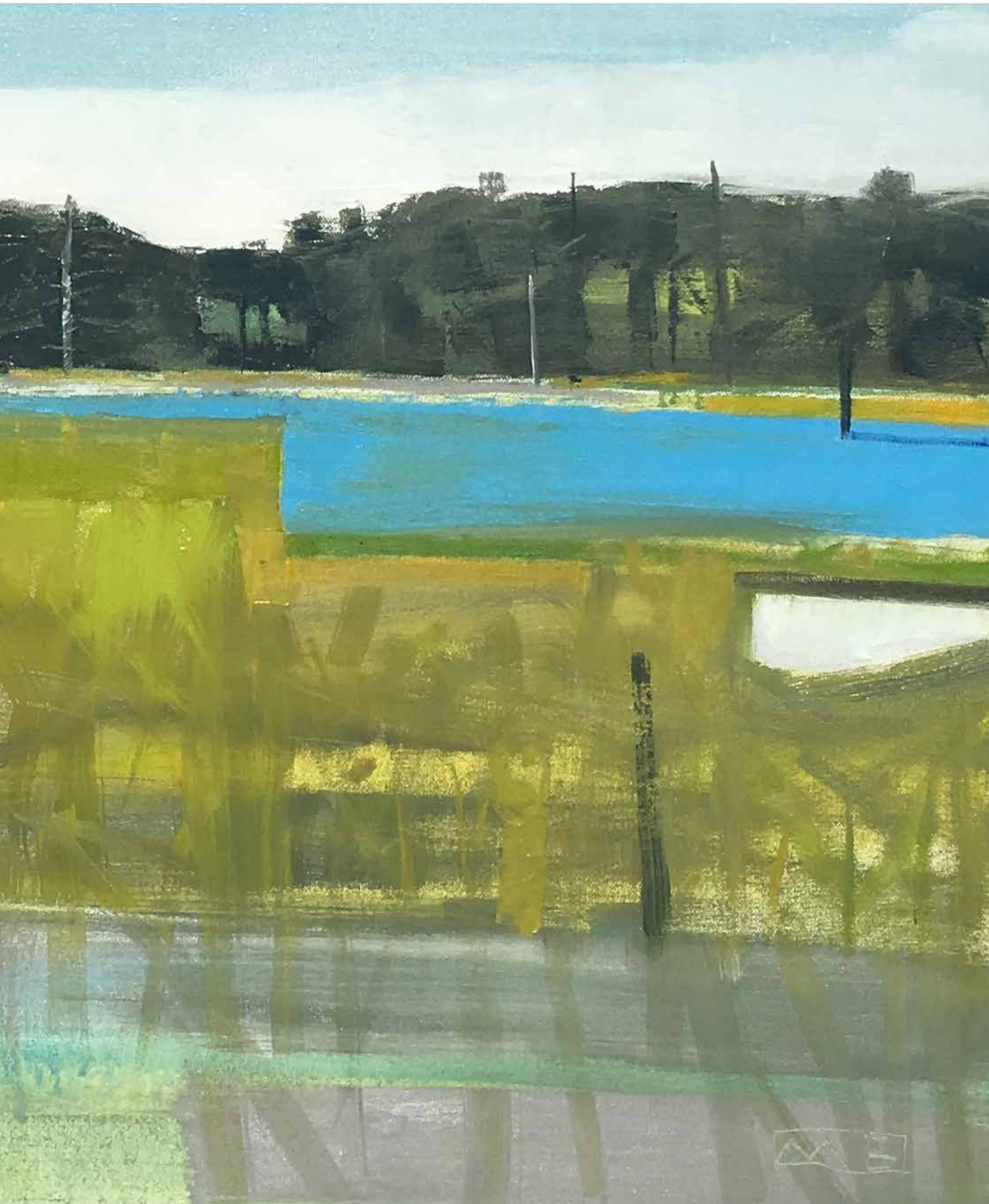
Lowcountry Water

Edisto
Abstraction of the colors, textures, and forms of the regional coastal environment.
Credit: Mac Ball



History

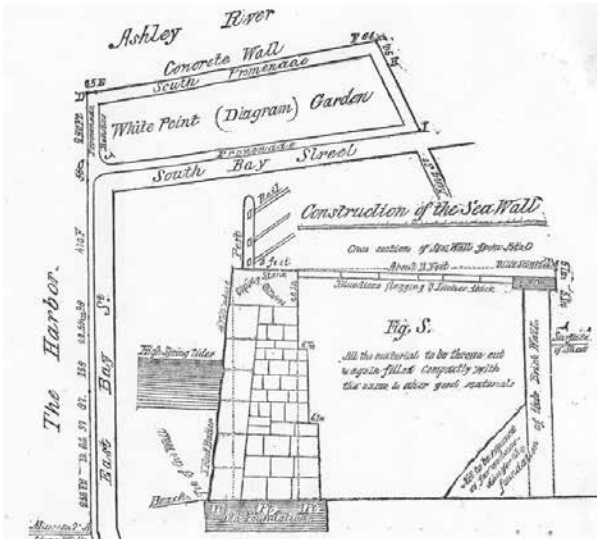
According to legend, the Atlantic Ocean formed where the Ashley, Cooper and Wando Rivers meet.

Charleston is defined by history and nature. It's character and culture have been developed over 300 years of inhabitation and are sustained by vibrant ecology.

A confluence of three tidal rivers shaped the city and region from the beginning. The rivers brought bounty—and risk—from the sea. During the hurricane surge of 1713, the waters of the Ashley and Cooper become one on the peninsula, and early fortifications protected the city from water as much as from military and commercial threats. Charleston's most famous defensive structure—the Battery—continues to keep out the sea. Other 19th century infrastructure is still in use. Brick vaulted sewers, the city's original drains, used the tides to flush waste, though now gravity drainage is vulnerable to rising seas.

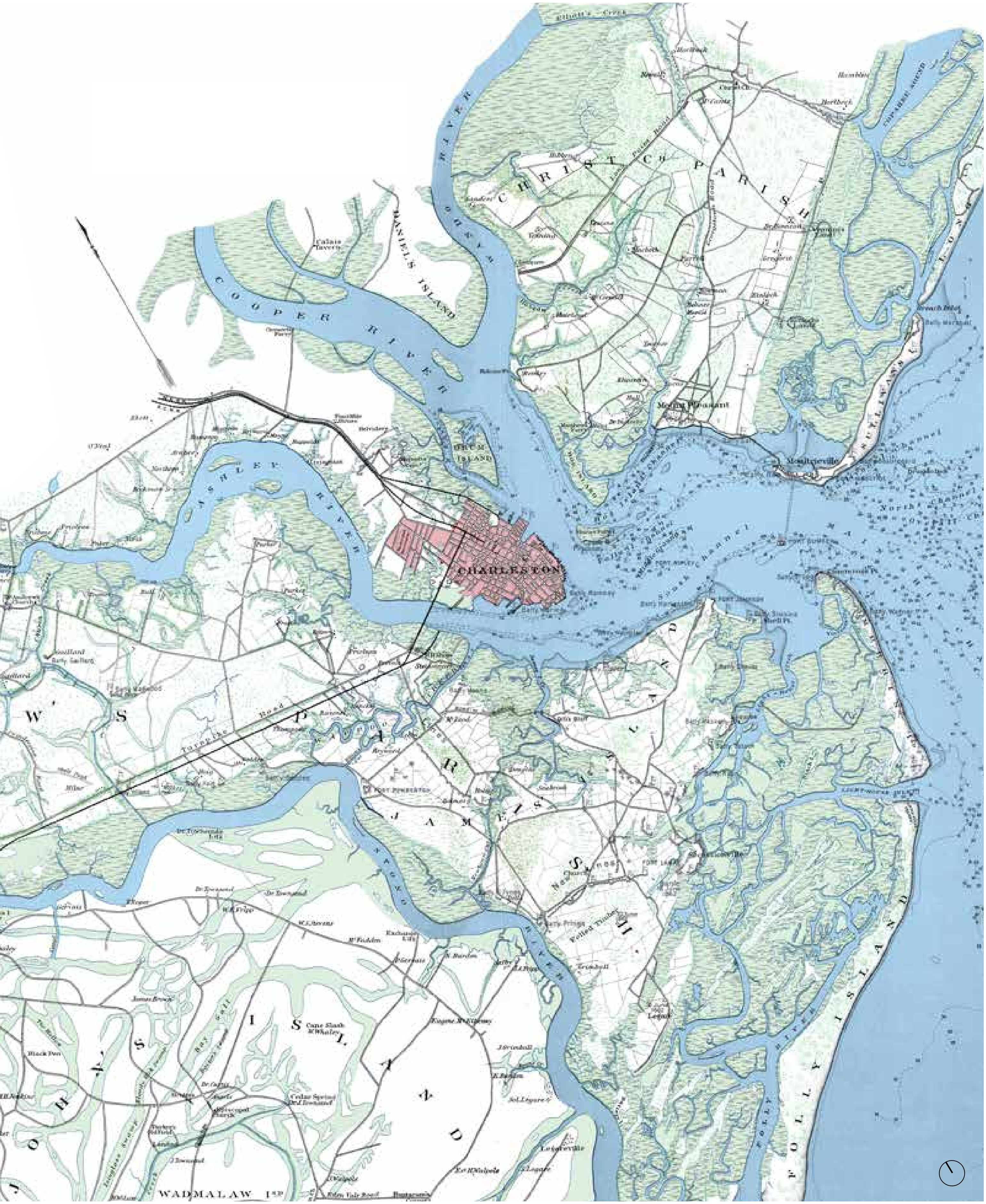
History, however, can be a guide: not the past systems that buried and walled off water, but the inherently resilient natural ones that absorb, regenerate, and adapt. Tidal wetlands can rise with water levels, to a point, and buffer waves. Barrier sands shift and soften surge. Native topsoil soaks up rain like a sponge.

Some hard infrastructure has been and will always be needed to sustain settlements in the Lowcountry, but water and wetlands determined historic patterns of living and building. **Land that was once naturally wet, will be again.**



Fortification from the Sea
High Battery plan and cross section.
Image Credit: Parker Survey, 1855

Charleston's Defenses: Natural & Man-Made
1863 Civil War map of Charleston's Defenses, drawn by William Walker, Confederate States of America Army.
Credit: US Army Corps of Engineers
Colorized by Waggonner & Ball


COOPER RIVER
ASHLEY RIVER
DANIEL'S ISLAND
CHRIST CH PARISH
DRUM ISLAND
CHARLESTON
Mount Pleasant
Moultrieville
JAMES ISLAND
JOHNS ISLAND
FOLLY ISLAND
FOLLY RIVER
STONO RIVER
WADMALAW ISD

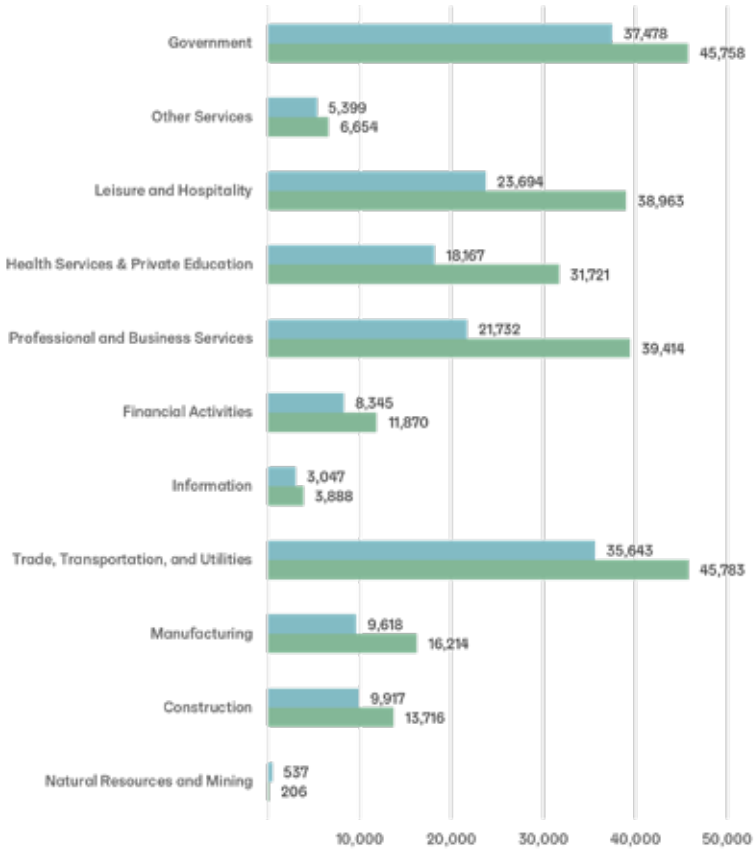
Change

Charleston faces growth pressure in the built environment and climate changes in the natural environment.

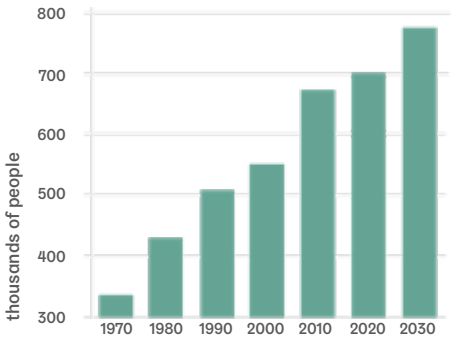
The Lowcountry is desirable and dynamic, and with new energy comes pressure to grow and change. The desire to live and work near the center has proven powerful enough to create new land: the peninsula's creeks have been almost entirely filled in and built over. Soft edges turn hard. Similar development pressure threatens creeks and lowlands on sea islands and in suburbs, to the detriment of environmental resilience, natural landscape function and flood safety.

The consequences of a growing population are compounded by environmental change, especially related to water. Sea level rise is accelerating, causing more frequent tidal flooding. Rainfall rates are increasing as the warming atmosphere holds more water, and Charleston has been impacted by a 100-year rainfall event each of the last three years.

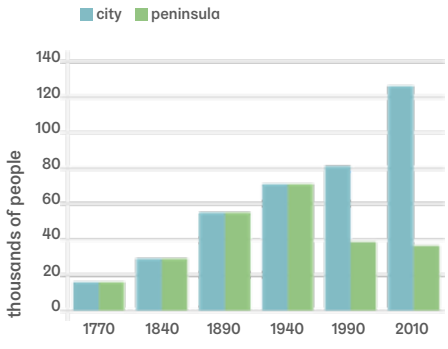
Growth comes with benefits and challenges. **Change presents a choice: harness adaptive energy, or be inundated by it.**



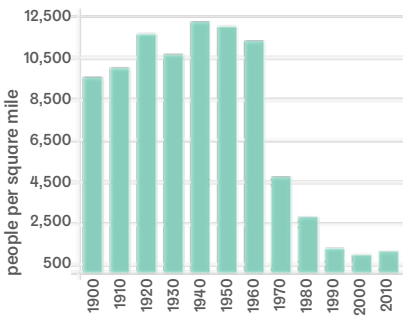
Charleston County Employment 1998 & 2018
Source: Charleston Regional Data Center



Regional Population

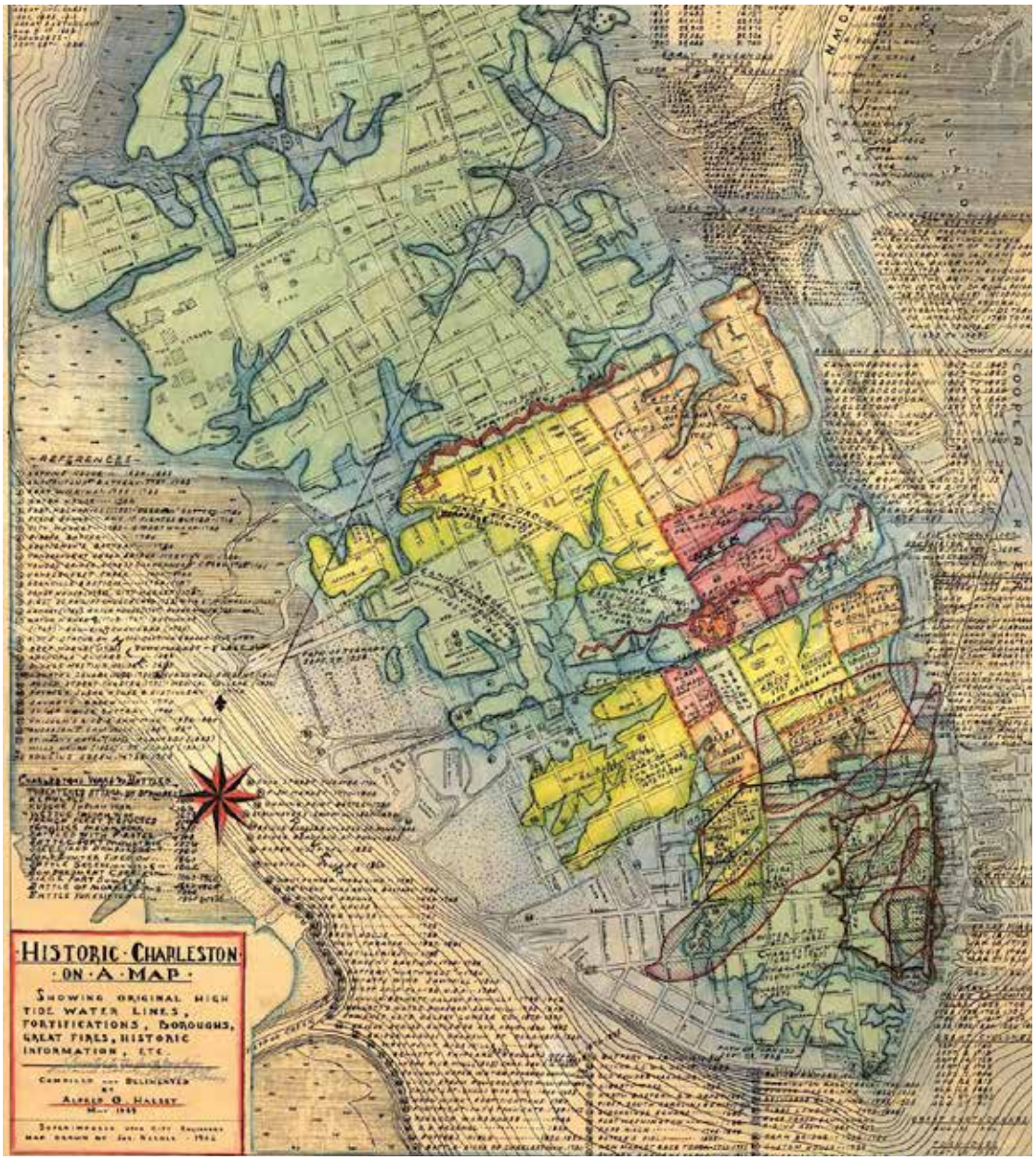


City of Charleston
Historic Population Growth

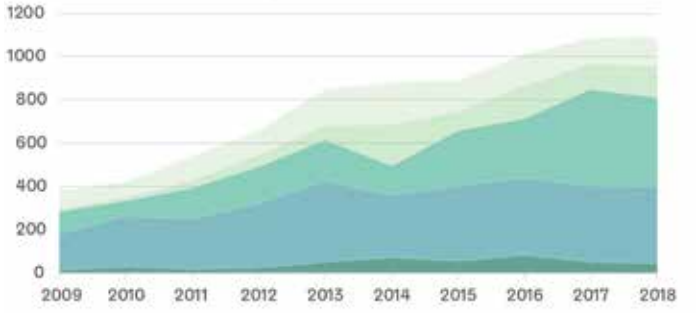


City of Charleston
Historic Population Density

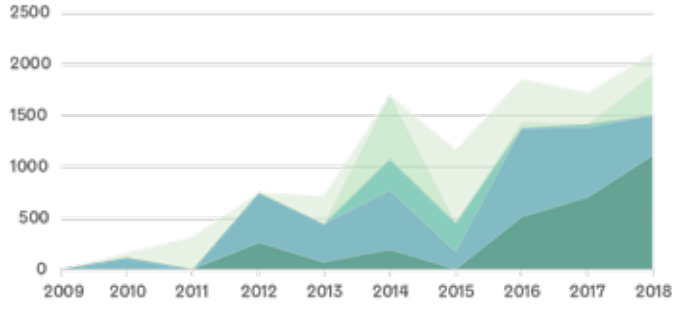
Source: US Census Bureau and City of Charleston Estimates



Halsey Map of 1949
Charleston street grid overlaid on top of the peninsula's original natural edge.



Single Family Permits



Multi-Family Permits

Peninsula West Ashley Johns Island James Island Daniel Island

Risk Levels

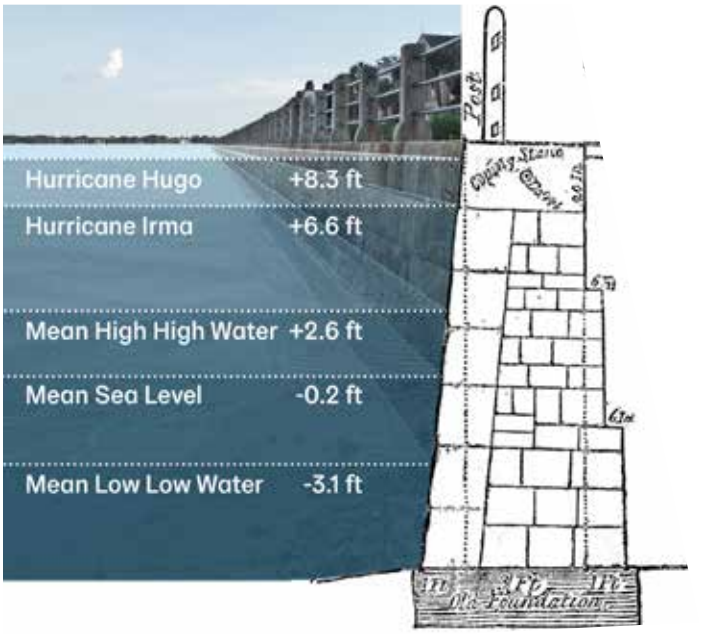
Some degree of water risk has always affected Charleston. The impacts depend on magnitude and management.

Risk has many sources. Water from the sea, water from the sky, and decision making about where and how to build.

Most stormwater drainage in Charleston flows by gravity to the sea, and some drains backflow when the tide is high. King tides, the highest annually, return sea water to filled-in creeks, now streets. While the City has installed 22 one-way check valves on the peninsula and in West Ashley to prevent tidal backflow, and plans to install more, pipes full of seawater or closed by valves cannot drain runoff. If heavy rain falls at high tide, the city floods. Nuisance flooding is predicted to become a daily occurrence. **Risk and elevation are inextricably linked.**

Traditional defenses against water can amplify risk. Sea walls and filled developments create immovable points in a landscape that wants to flow and change. Hard edges compound risk: natural ebbs and flows are contained, and once-benign water becomes a flood.

Water threatens the safety of typical developments and the viability of standard development practices. Water, if unmanaged, also threatens **asset value, equity and affordability: property at risk of flooding is a depreciating asset for owner, community, and for the City.** Development in areas of known risk becomes tomorrow's buyout.

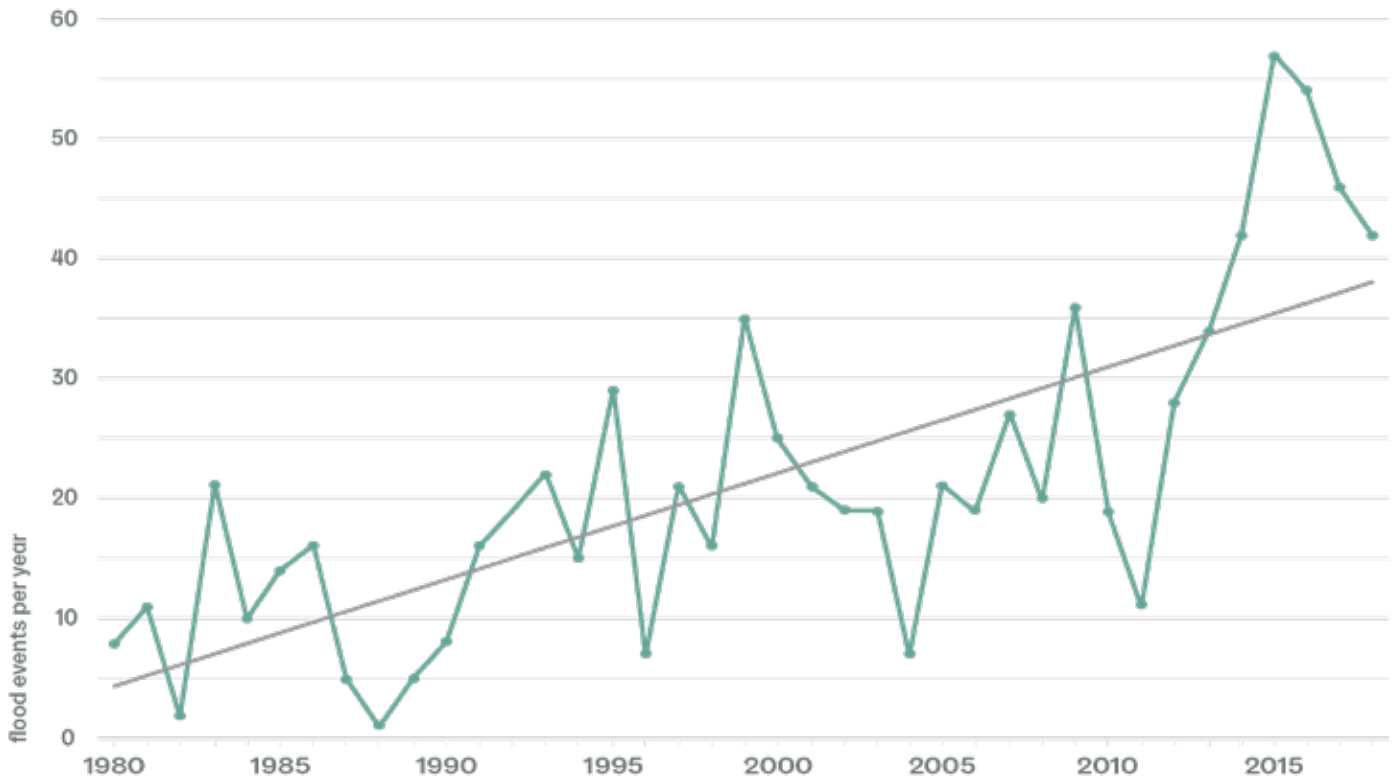


Tides & Storm Surge on the High Battery

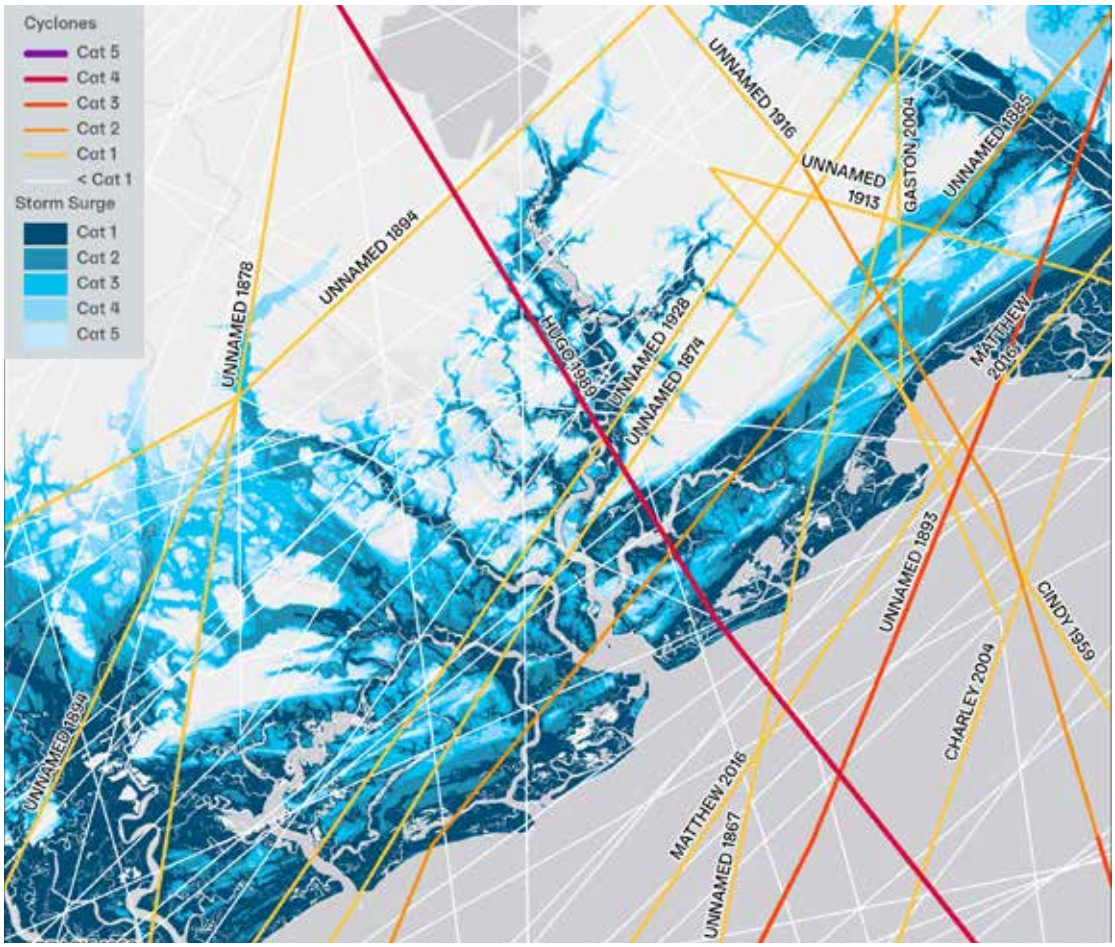
Forces of Water
Range of climate challenges facing Charleston.
Image Credit: City of Charleston 2019 Flooding and Sea Level Rise Strategy Plan

Charleston Precipitation Event Classifications

	2-Year 50% Chance	5-Year 20% Chance	10-Year 10% Chance	25-Year 4% Chance	50-Year 2% Chance	100-Year 1% Chance	500-Year 0.2% Chance
1 hr	2.09 in	2.58 in	2.99 in	3.53 in	3.97 in	4.42 in	5.56 in
24 hrs	4.42 in	5.46 in	6.46 in	7.87 in	9.02 in	10.2 in	13.3 in



Flood Events
Charleston Harbor flood events (7 ft MLLW or higher)
Source: Sea Level Rise Strategy for Charleston



Storm Surge Risk and Historic Cyclone Paths
Credit: Waggonner & Ball

Challenges

How can Charleston overcome flooding and grow safely while preserving culture, history and environmental quality?

Retrofits and adaptation are a form of growth from within. Adaptation requires creativity to meet practical challenges, and collaboration to do so as self-sufficiently, by city and region, as possible.

Funding must simultaneously prioritize short term action and long term planning. There exists a pressing need for action in response to immediate needs. Sometimes data is incomplete. Projects must be prioritized according to greatest system benefit, but must not overly depend on other actions or features in order to have an impact.

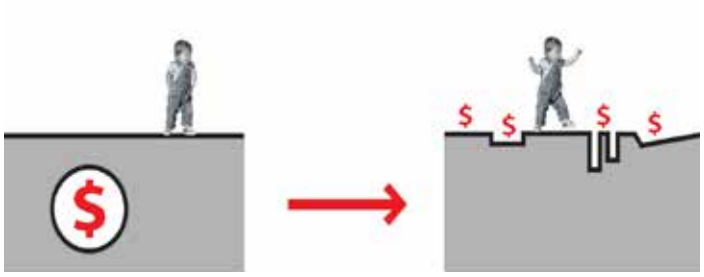
Charleston must adapt to water—live with water—in some areas, and make space for water in others. Residents and visitors alike need to understand the critical importance of high and low ground, and the water system that connects them. Key consideration should be given to when and where water is to be kept out, and when and where to let it in.

Charleston grew as a city on the water, because of water. **The City's future, like its past, depends on water, and requires a new approach in the midst of challenge and change.**

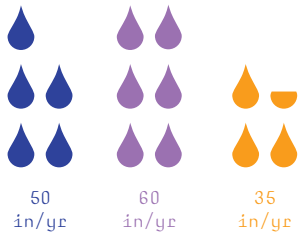
1 Increasingly severe and frequent flooding from intense rainfall, rising sea levels, and storm surge

2 Development pressure in low-lying, risky, and ecologically sensitive areas

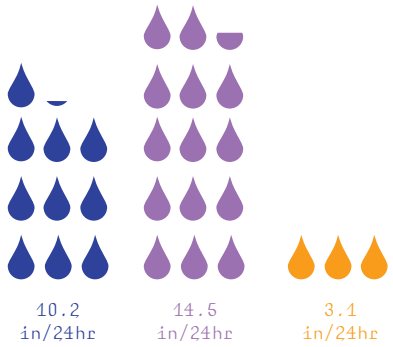
3 Region's historic character and identity threatened by water



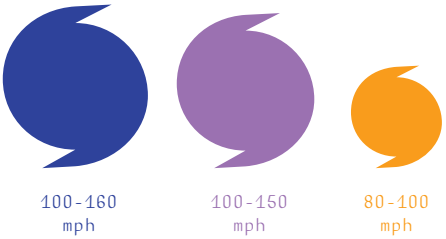
Same-Cost Approaches to Water Challenges
Narrowly defined projects may succeed on narrow evaluation, but risk missing greater value.
Image credit: Urbanisten



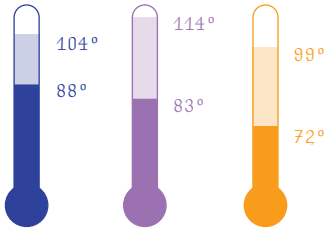
Annual Rainfall



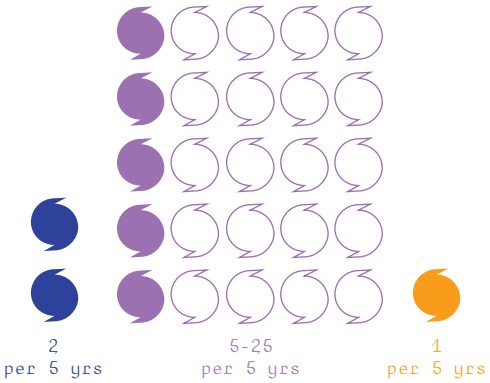
Peak Rainfall
(100 yr storm)



Peak Windspeed



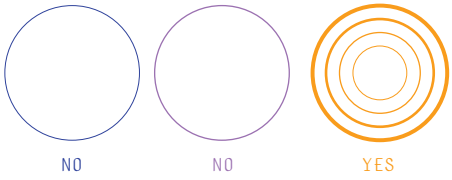
Average High &
Record Temperature



Historical Storm Occurrence

Maximum Storm Surge

Protection Factor



Layered Protection

South Carolina Louisiana Netherlands

SOURCES
http://www.dnr.sc.gov/climate/sco.php
https://en.climate-data.org/europe/the-netherlands/north-holland/amsterdam-3330/#climate-graph
http://www.environmentandsociety.org/arcadia/north-sea-flood-1953
http://bibliotheek.knmi.nl/klimaatrapporten/supplementsto06scenarios.pd
https://www.ncdc.noaa.gov/climatenormals/clim60/states/Clim_LA_01.pdf

Risk Comparison

Natural threats are greater in South Carolina and Louisiana, yet factors of protection are orders of magnitude greater in the Netherlands.

A Layered Approach

A layered planning approach begins with Charleston's most basic layer: its physical ground, the land and water upon which infrastructure and inhabitation, history and culture, are based.

Safety first. Safety is increased through elevation and redundancy. Multiple lines of defense begin outside the city, in the landscape, and are also structured from within. Sustainable inhabitation is connected to deep geology.

Elevation is salvation from inundation. Elevation is critical in low-lying place, and awareness of place translates to informed action. Charleston has areas of stable, relatively high ground, a critical asset in high water.

Know where you are. The Ashley and Cooper are tidal rivers. Shorelines shift across a low landscape, and plants and habitat move with them, if allowed. Healthy ecology supports a healthy economy and can provide protective benefits. Sustainable infrastructure aligns with ecological function. Water in the region must be understood as a holistic system, man-made and natural in tandem.

Work at multiple scales. Focus on the smallest scale, with an understanding of larger watershed and system functions. Conflicts between and within layers are acknowledged—culture and technology sometimes produce misalignments—and design solutions begin by asking what lies underneath.

Pursue multiple benefits. Single-purpose infrastructure is a poor investment.

No regrets. Make sure action taken now will not compromise future opportunities. Projects should fit within a comprehensive planning vision, but should be able to operate independently with success. Plans must be adaptable over time.



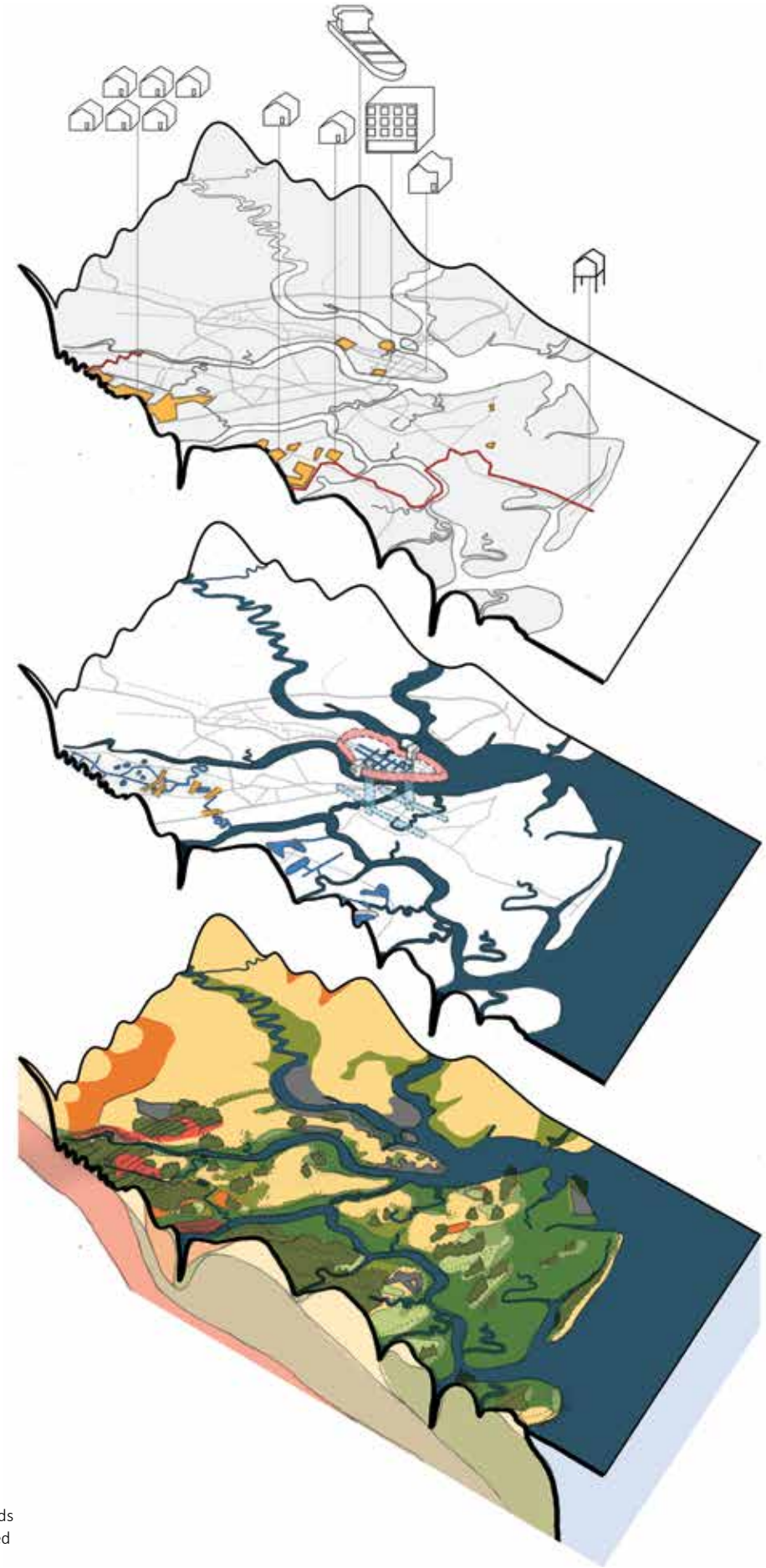





Development & Land Use

Drainage & Infrastructure Networks

Soils & Ecology



Layers of Charleston
Ground is fundamental; infrastructure ultimately depends on its foundation; and buildings and people are sustained by deep connections to landscape and place.

Lessons from Louisiana

Insights from people and communities have grounded Waggonner & Ball's planning and design work in Louisiana, and have informed a series of guiding principles applicable to Charleston and coastal contexts:

- Value the past, study how people lived here before us. Don't hold to it so tightly that you can't adapt.
- Adaptation is different in every place. With adaptation, mitigation has impact.
- Culture is pivotal.
- Topography matters.
- Design is a matter of scale. Scale is a question for design. Use the smallest scale that works.
- The polymaths were of another era. Today we need teamwork and collaboration.
- Learn from others. 300 or 350 years in America is not so long.
- Respect and reinforce the inherent patterns.
- Landscape is a process that grows and can heal. Trees shelter and protect us.
- People react. Nature feeds and rests in its rhythm. We are not separate from it.
- Water is essential, our source, the fresher the better.
- Make space for water.
- Make water visible. Include it in civic space.
- Balance land with water. Value both.
- Use mapping and design to inform community.
- Meet people where they are. Listen.
- Truth and trust are fundamental for consensus.
- Get people facing in the same direction.
- Action requires alternatives.
- People must see another way for themselves, in their terms.
- Everyone needs something they can do.
- Think 3 steps ahead, take one.
- Learning is mostly by trial and error.
- Don't do anything you wouldn't do twice.
- Failure favors inaction. Convincing ourselves of status quo and why change is difficult assures failure.
- Performance is beautiful. Value it. Measure it. Track its impacts. Check your course.
- Operation and maintenance are impossible without design and planting or construction.
- Changes to infrastructure take a long time and these investments determine places for generations. Their design is more than engineering.
- Be prepared. Disasters are opportunities for those who are. As in war, one can learn a lot in floods. People seek alternatives as well as meaning afterwards.
- It will take all generations working together.
- Develop an industry that integrates environment and adaptation.
- Appreciate those who do the work and nurture them, pay them.
- Educate the children.
- Inform everyone.
- Even with money you must organize to implement.
- You have to love somewhere and give what you can to it.
- Embrace uncertainty. Engage the present.

Communication is Key
Planning principles and design ideas must be communicated clearly to have an impact. Waggonner & Ball's collateral and branding strategy for the Gentilly Resilience District in New Orleans captured local history, community input, and future vision.

Golden Rules from the Netherlands

Change Attitudes

Embrace water and its spatial quality. It demands and is a tool for inclusiveness.

Cooperate

"God created the world, but the Dutch created the Netherlands." Living safely with water is a collective responsibility and needs collective solutions. Have a larger perspective, in time, scale, purpose, systems and the environment.

Don't Accept Solutions that Only Work

Single-purpose solutions fail the test of time. They are expensive to build and maintain, and lose public support over time. Instead, seek solutions for water challenges that add other values – economic, environmental, recreational, mobility related, and social. A design-based approach identifies these other values and their salience to the communities that form a city. Dare to think outside of the box, create a vision beyond narrowly-bound programming or funding constraints. Have a vision: from inspiration comes funding, and from funding comes inspiration.

Have Courage to Think Big and the Guts to Act Small

A compelling long-term vision must be shared and understood, but small projects must be quickly implemented to prove to citizens that the vision is achievable.

Overall Recommendations

Charleston is at a critical juncture in its history and development. Pressures brought by its coastal location, desirable environment, and economic position push against its low-lying land, fragile infrastructure, and rising flood threat. As it reaches decision points, it needs a vision that allows it to see several steps ahead to anticipate changes it will face, to build consensus, to use and connect all scales, and to invest wisely to develop a sustainable water system, and thus a sustainable city, for the 21st century.

Slow – Store – Drain

All flood risk mitigation, water management programs, and projects must start with and achieve these goals. All other relevant City Capital Improvement Projects must contribute to these goals too: street maintenance, reconstruction and public spaces (like schools, public buildings and especially parks).

Develop a City-wide Water Plan

A comprehensive City-wide Water Plan is needed to guide Charleston's transition. The Water Plan will provide a comprehensive assessment of flood risk, storage, infiltration and drainage performance and set-forth water assignments per drainage basin. The Water Plan would also identify preferred land-use, projects, pilots, policy and regulatory changes needed to achieve water assignments. If a City-wide Water Plan is not possible at this time, the City should incrementally develop Water Plans per major areas – Peninsula, Sullivan's Island, James Island, Johns Island, Daniel Island and West Ashley. The Peninsula-wide Water Plan should have priority.

Update Comprehensive Plan

The Comprehensive Plan, building codes, site preparation protocols and other policies that govern private property use should be updated to mandate, or at least encourage, on-site water storage, certainly for new developments or substantially modified redevelopments. Likewise, infiltration of rainfall and stormwater should be required on "high-ground" properties that have proper soils. High-ground infiltration will increase drainage system performance and lower runoff stress on lower grounds. Infiltration will balance groundwater plus provide environmental, sub-surface and subsidence, and shrink-swell management benefits. Storage and infiltration targets should be derived from a water assignment in each drainage basin as established in a Water Plan.

Conduct a Charleston Groundwater Assessment

A comprehensive Charleston Groundwater Assessment is needed. The Team is concerned that sea level rise is going to impair substantially shallow drainage systems, decreasing their efficiency and performance and thereby increasing flood risk. This would ideally be embedded within the City-wide Water Plan, or major area Water Plans, per above.

Manage Water on Public Properties

The City's street maintenance and improvement plan, as well as regulations for public spaces including schools and parks, must include requirements to infiltrate and store stormwater. This should be piloted ASAP—perhaps starting in Eastside—but should eventually become a standard component of every street reconstruction or maintenance project. Please see the Eastside Chapter for street water management examples.

Reduce Fill

In areas of new development occurring in flood zones, marshy, intertidal or otherwise low-lying areas, eliminate, or substantially reduce, the placement of fill or other structures that decrease the infiltration and absorption performance of these areas.

Engage Private Sector Leadership

The financial impacts of flooding upon Lowcountry business operations – large and small-- are substantial and growing. Flood events impact business operations, logistics, continuity, insurability, employee retention and welfare, and overall profitably. While some Charleston-based land developers, homebuilders, realtors, Lowcountry Local First, leadership of the Charleston Metro Chamber of Commerce and Charleston Medical District institutions openly and conscientiously engaged in the Dutch Dialogues effort, other business sectors did not.

Successful flood risk and community resilience efforts demand a fully engaged private sector that contributes awareness, leadership, innovation and support. The Metro Chamber or another local business organization should immediately create a structured platform through which business leaders (a) engage with like-minded CEOs, CFOs, human resource and facility managers to assess and coordinate flood risk reduction efforts within sectors, (b) discuss and propose flood mitigation projects and their prioritization, and (c) serve as a sounding-board for policy changes under consideration by elected leaders.

Improve Regional Governmental Coordination

The City of Charleston and Tricounty region should lead / coordinate a regional—Myrtle Beach to Hilton Head / Savannah—Coastal Commission or similar intergovernmental entity. The primary goal of this Commission would be to advocate to the State Flood Commission, relevant state agencies and the state legislature for a long-term, integrated SC Coastal Protection and Restoration Masterplan. That Plan would identity, research, prioritize, and engineer policies, projects and revenue sources to protect the SC coastal communities, coastal resources and environments, coastal tourism and other economic drivers, and those otherwise dependent upon the SC coast, both coastwide and upstate.

Develop Rainproof Charleston

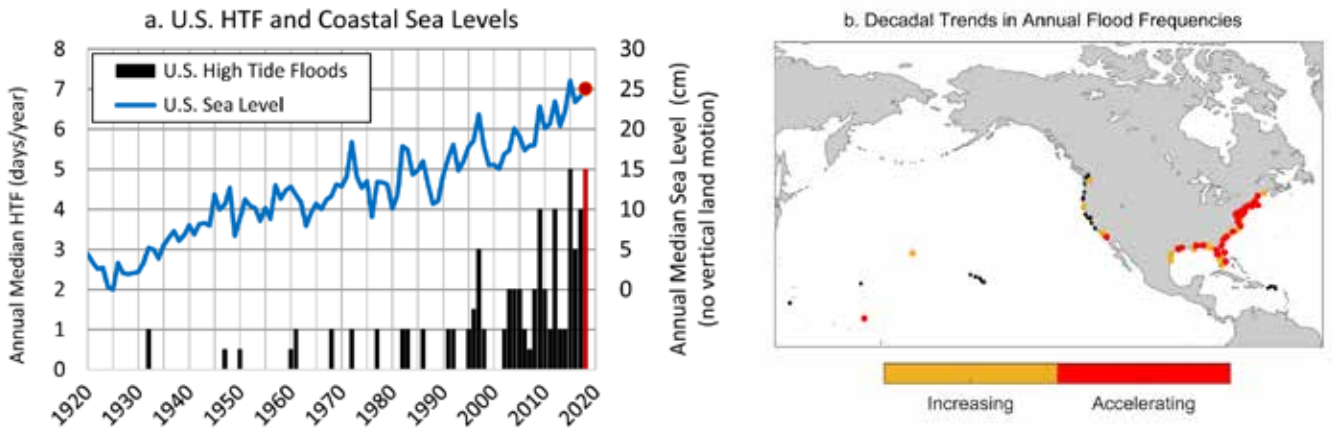
The City should develop, or at a minimum pilot, a “Rainproof-type” program. The Team noted overwhelming public agreement and enthusiasm for this during the Colloquium and Workshop. Some community leaders and stakeholders have agreed to help develop and implement a Rainproof program. We underscore that everyone in Charleston should understand their flood risk and their responsibility to contribute, in small and large ways, to making Charleston less flood prone. A Rainproof program will engage citizens and landowners in the effort to achieve water assignments and, more importantly, create the culture of flood awareness and responsibility necessary for Charleston to survive and thrive in its wet future.

Flexible, Market-Based Implementation

Flexible water assignment implementation within a drainage basin should be permitted. Market-based tools—including stormwater credits, green infrastructure implementation credits, enhanced permitting, green roofs, conservation and stormwater easements—to achieve the water assignments are encouraged. These must be developed and adopted through regulatory or legislative authorities.

National Oceanic & Atmospheric Administration (NOAA)

Nuisance Flooding: The New Normal



Decadal Trends in Annual Flood Frequencies
Map credit NOAA Technical Report NOS CO-OPS 090*

A June 2019 report from the National Oceanic and Atmospheric Administration (NOAA) describes historical and recent measurements of High Tide Flooding (HTF) in the US. The trend is alarming with approximately 2/3rds, or 65 of 98 tidal gauges, showing either "significant acceleration" in or "linearly increasing" HTF. The cause: relative sea level rise. Geographically, per the map below**, these impacts are distributed along the entire US east coast.

HTF impacts are diverse, and run from nuisance to severe: flooded roadways, business disruption, increasing shallow groundwater levels and degraded subsurface infrastructure and utilities, beach erosion, disrupted or impaired performance of stormwater, sewer and freshwater distribution systems, salination of important coastal farmlands and ecosystems, and reduced property values.

Even during low tides, stormwater drainage systems are becoming challenged, unable to efficiently perform as designed "causing rainwater to flood streets and neighborhoods until the tide lowers." Extreme rainfall coinciding with high tides make the problems substantially worse. NOAA assumes that these impacts "are nearly certain to get worse this century," and "will soon become chronic without adaptation."

In 2019, the overall US HTF trend is 100% greater than in the year 2000, with the southeast Atlantic coast up 190% and the northeast Atlantic coast up 140%.

Looking forward to 2030 and 2050, the trends are sobering. NOAA assumed two relative sea-level rise scenarios (intermediate low and intermediate) and projects that the median number of HTF days in the northeast Atlantic 2030 will be between 15 and 25 days in 2030 and between 40 and 130 days in 2050, and in the southeast Atlantic, which includes Charleston, will be between 7 – 15 days in 2030 and between 25 – 70 days in 2050. In short, by 2030 Charleston may experience HTF once a month and once every 10 days or more by 2050.

Charleston's future is dependent upon aggressive investment and adaptation to mitigate HTF impacts. Without such investment, a robust future for Charleston is in doubt.

*NOAA Technical Report NOS CO-OPS 090: https://tidesandcurrents.noaa.gov/publications/Techrpt_090_2018_State_of_US_HighTideFlooding_with_a_2019_Outlook_Final.pdf

Waggonner & Ball Architecture/Environment

Greater New Orleans Urban Water Plan

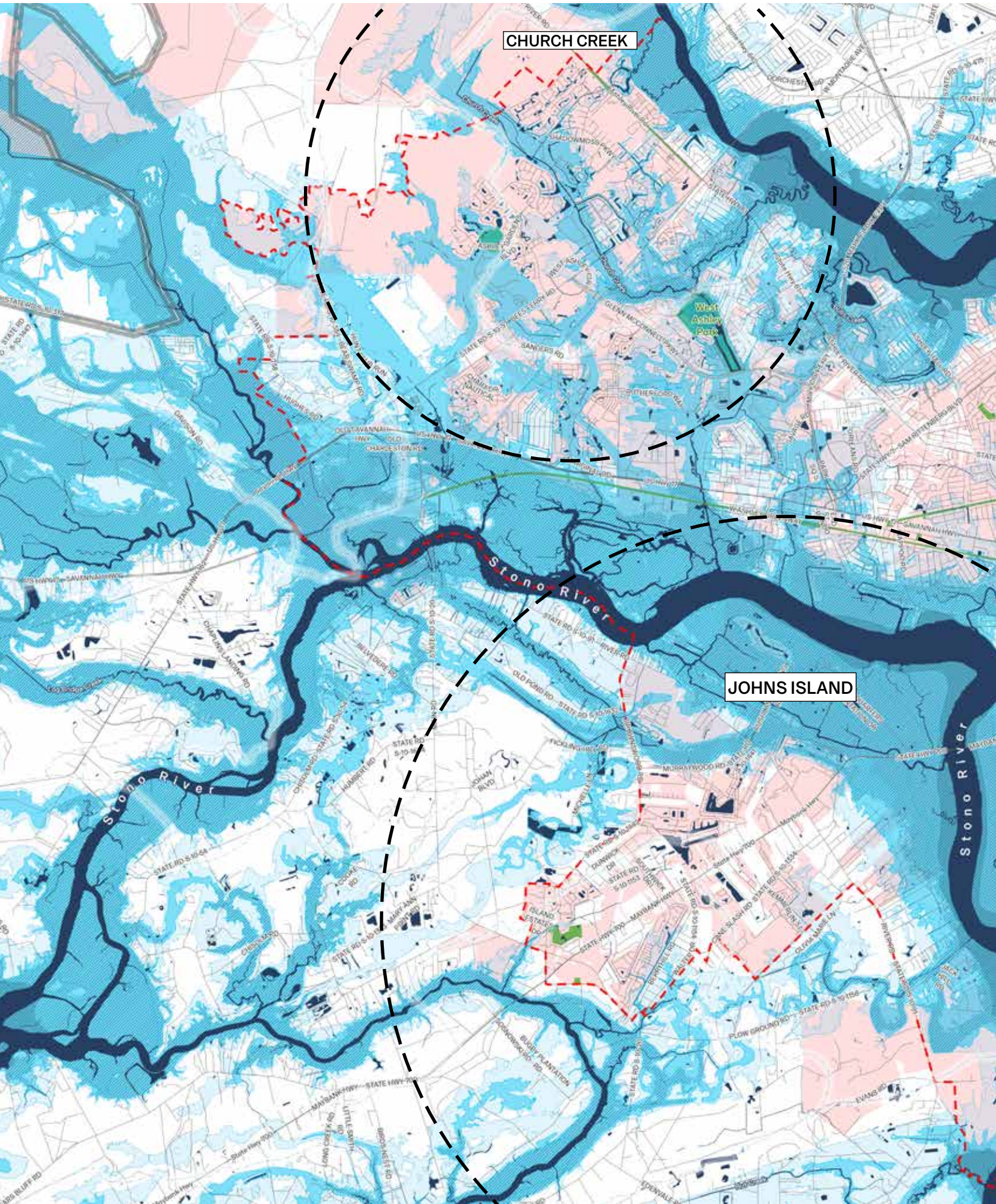
The New Orleans region has been surrounded and defined by water since its founding over 300 years ago. Now partially below sea level on the Mississippi River delta, the area is fortified by a perimeter levee protection system designed to reduce risk from a 100-year storm event. However, flooding from frequent rainfall and land subsidence from current drainage practices remain critical challenges.

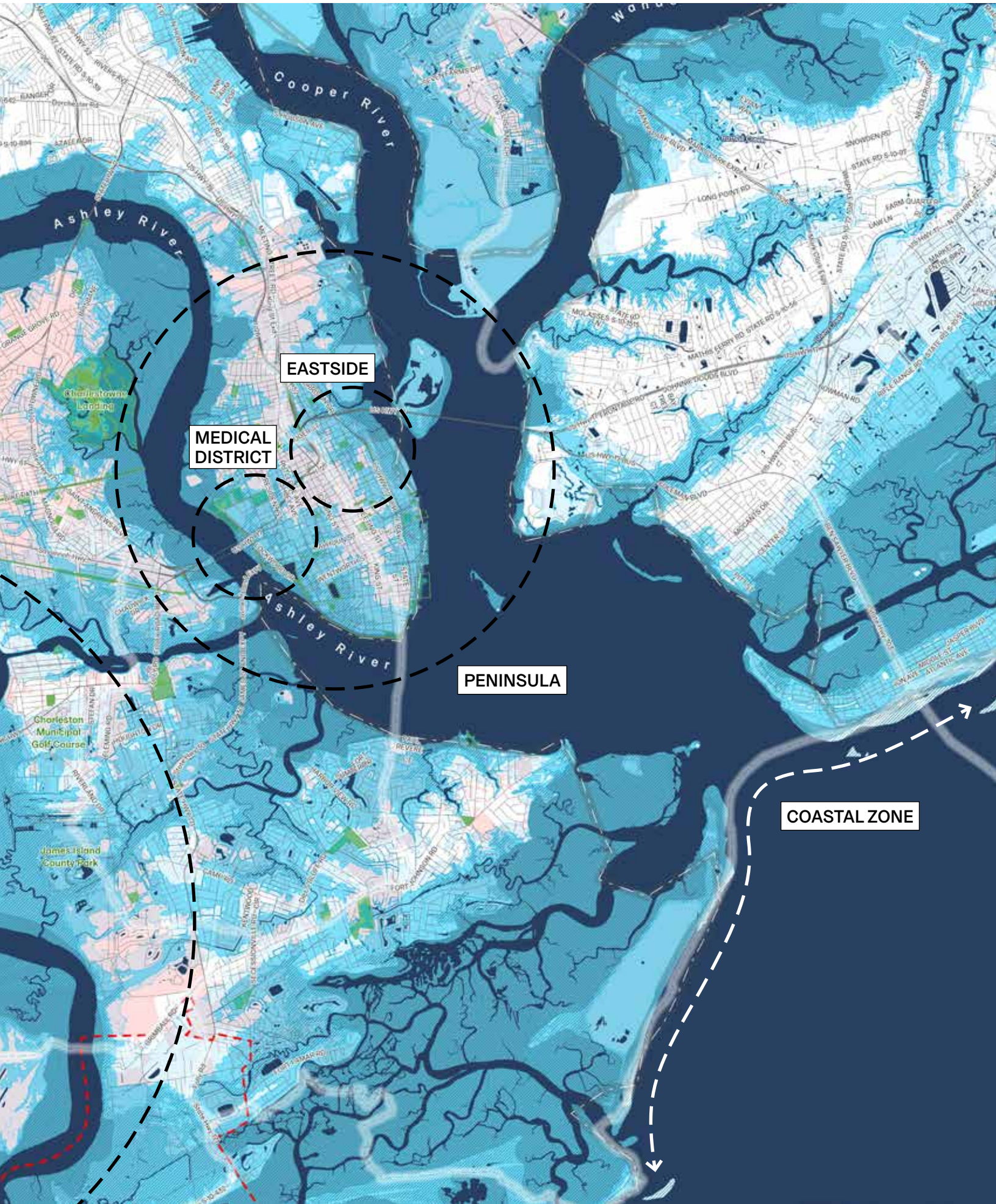
The Greater New Orleans Urban Water Plan is a water-based landscape and urban design proposal that illustrates how the region can live with water rather than fight against it. It employs a multi-layered, ground-up approach that is science-based, place-based, and adaptable. The multi-scaled, actionable strategy, which spans four volumes and over twenty district and demonstration reports, is available for public download at livingwithwater.com.

Regional Vision
The Greater New Orleans Urban Water Plan is a holistic, integrated, comprehensive water-base plan is the first of its kind for an American city.

2 Focus Areas

Design Workshop
Participants at the Dutch Dialogues Charleston design workshop.
Credit: Marquel Coaxum


CHURCH CREEK
JOHNS ISLAND
Stono River
Stono River
Stono River
West Ashley Park


Cooper River
Ashley River
EASTSIDE
MEDICAL DISTRICT
Ashley River
PENINSULA
COASTAL ZONE
Charleston Municipal Golf Course
James Island County Park

Coastal Zone

> “Natural and nature based protection—green infrastructure—are no brainer, no regret efforts, and are almost always a good place to start.”

Piet Dircke
Global Leader Water Management, Arcadis

Contributors

Piet Dircke, Roelof Stuurman, Mark van Auken, Keith Bowers

Contents

Coastal Plain

LEGEND

- Urban Growth Boundary
- Surrounding Cities
- County Boundary

WATER WETLANDS

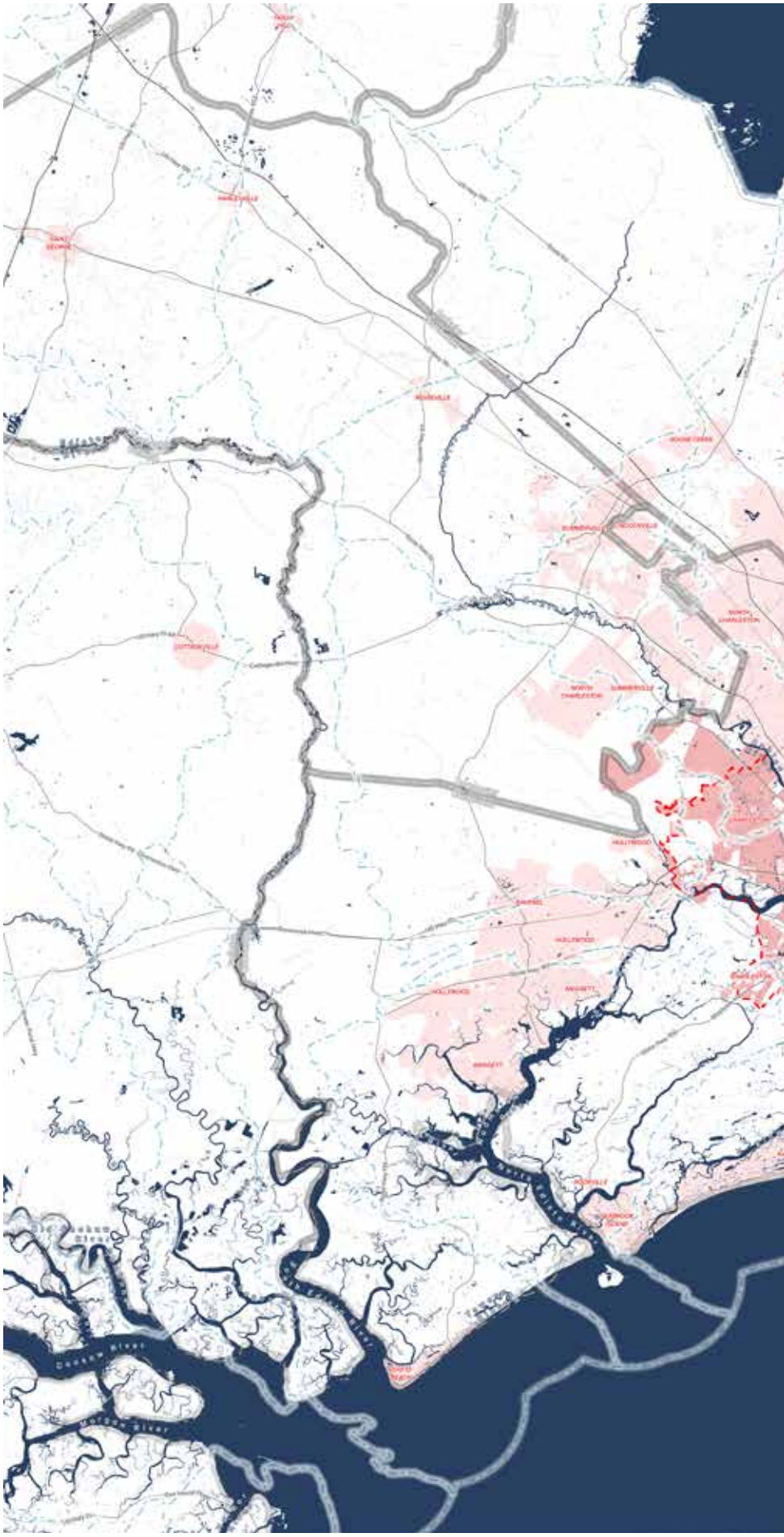
- Water

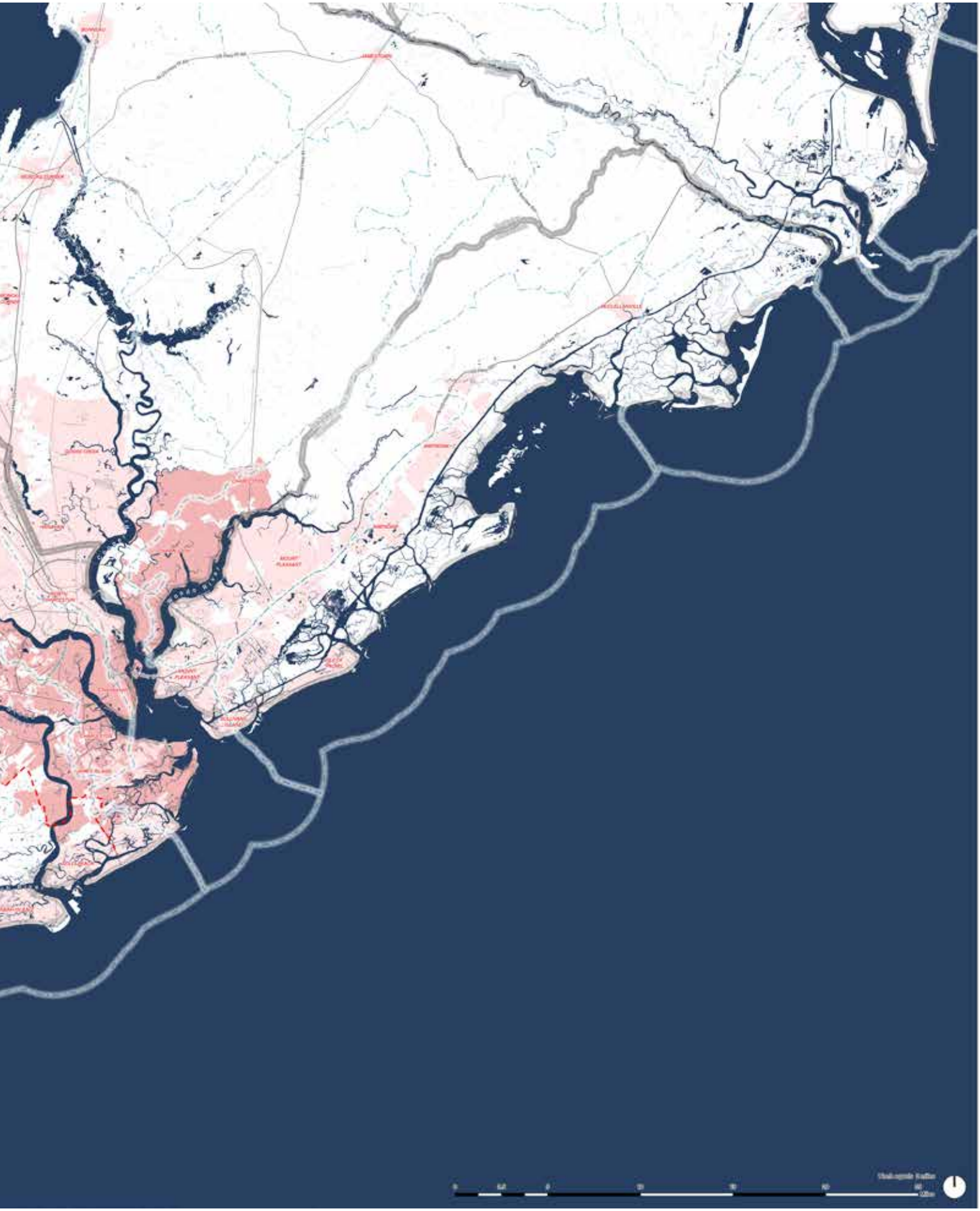
WATERSHED

- Watersheds

ROADS RAIL

- Rail
- Road





Metro Charleston

LEGEND
- Park
- Urban Growth Boundary
- Charleston City Limits
- County Boundary

WATER WETLANDS
- Water

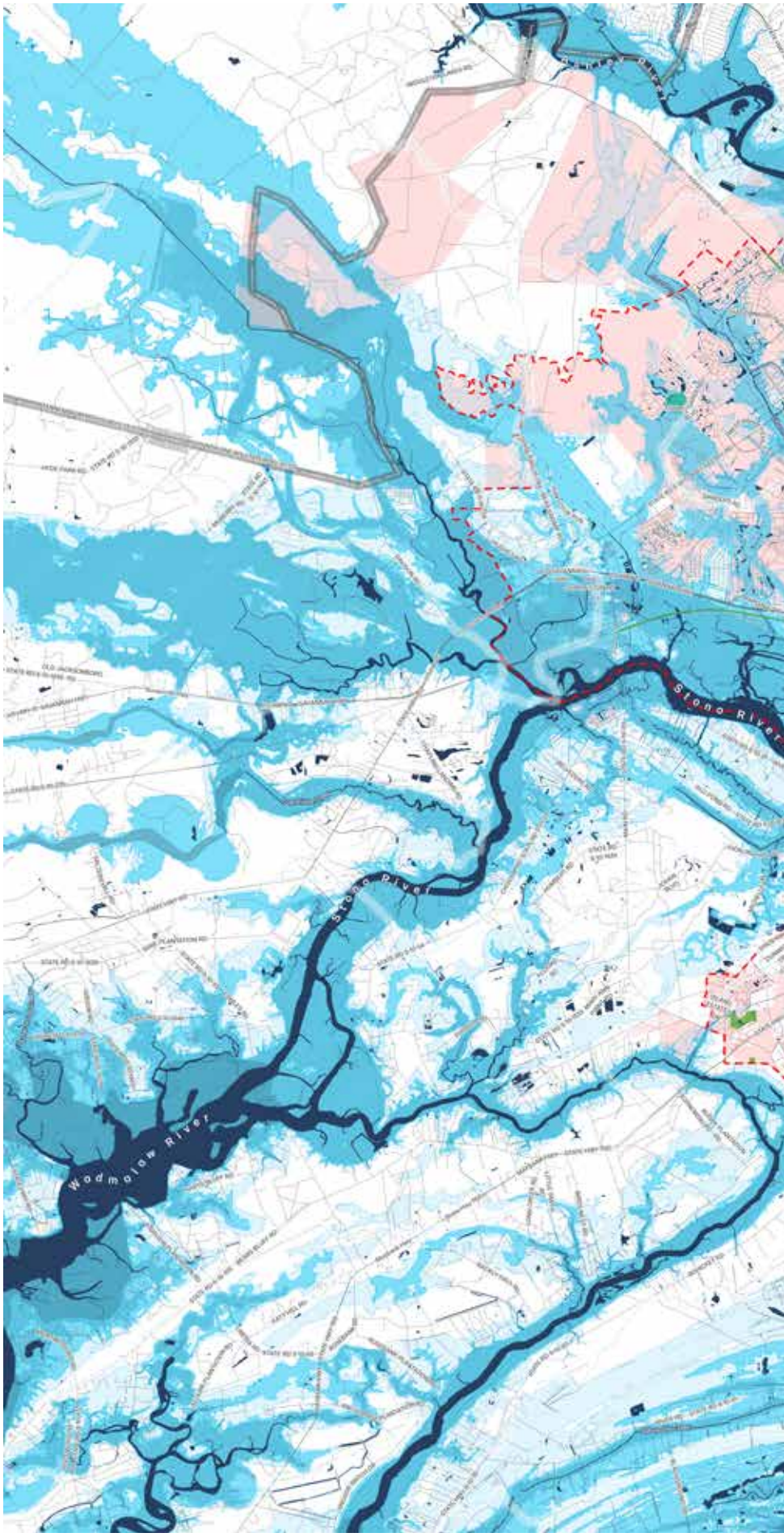
WATERSHED
- Watersheds

SEA LEVEL RISE
- 3' Sea Level Rise

DFIRM
- coastal floodzone, floodway
- 100 year floodplain
- 500 year floodplain

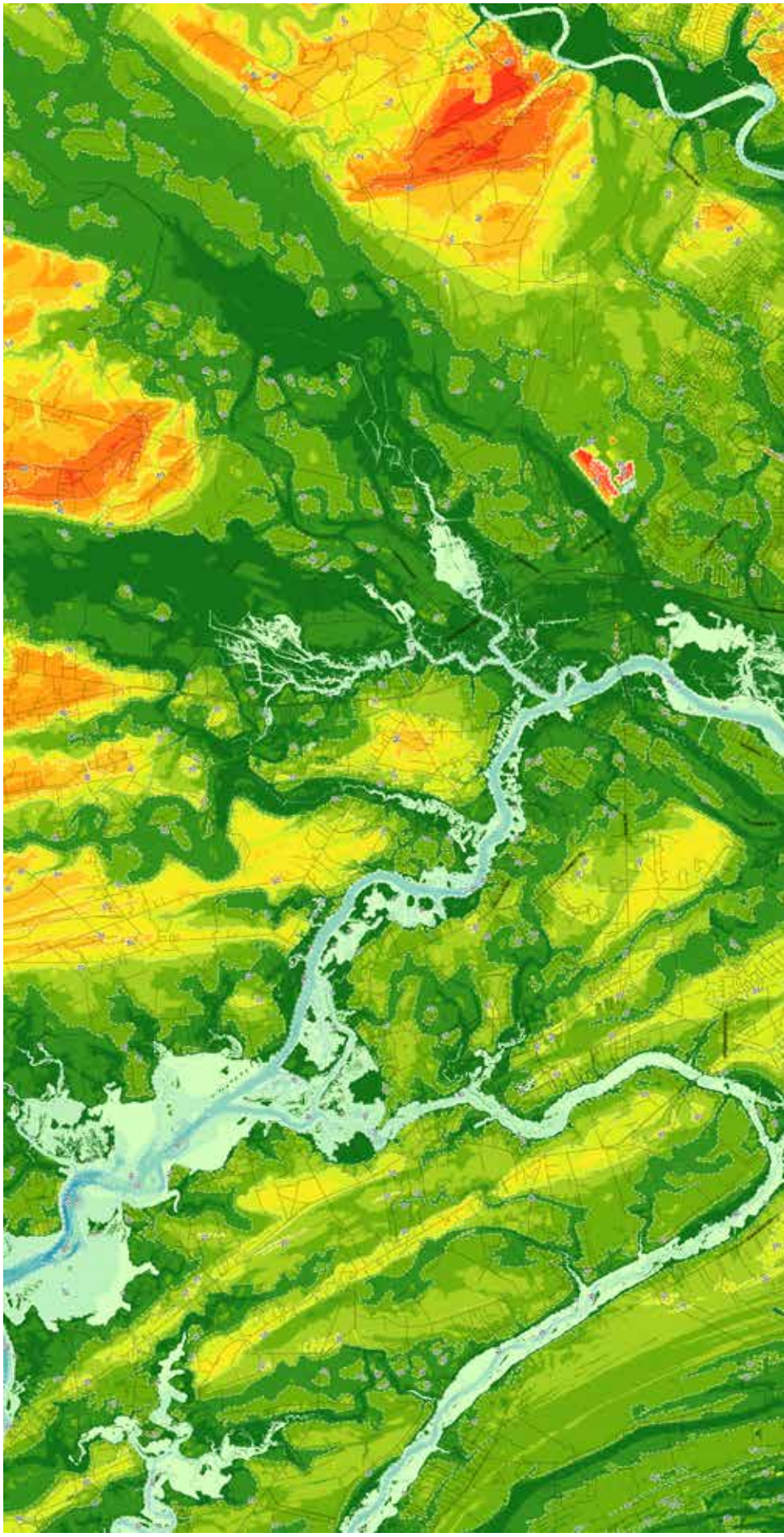
ROADS RAIL
- Rail
- Road

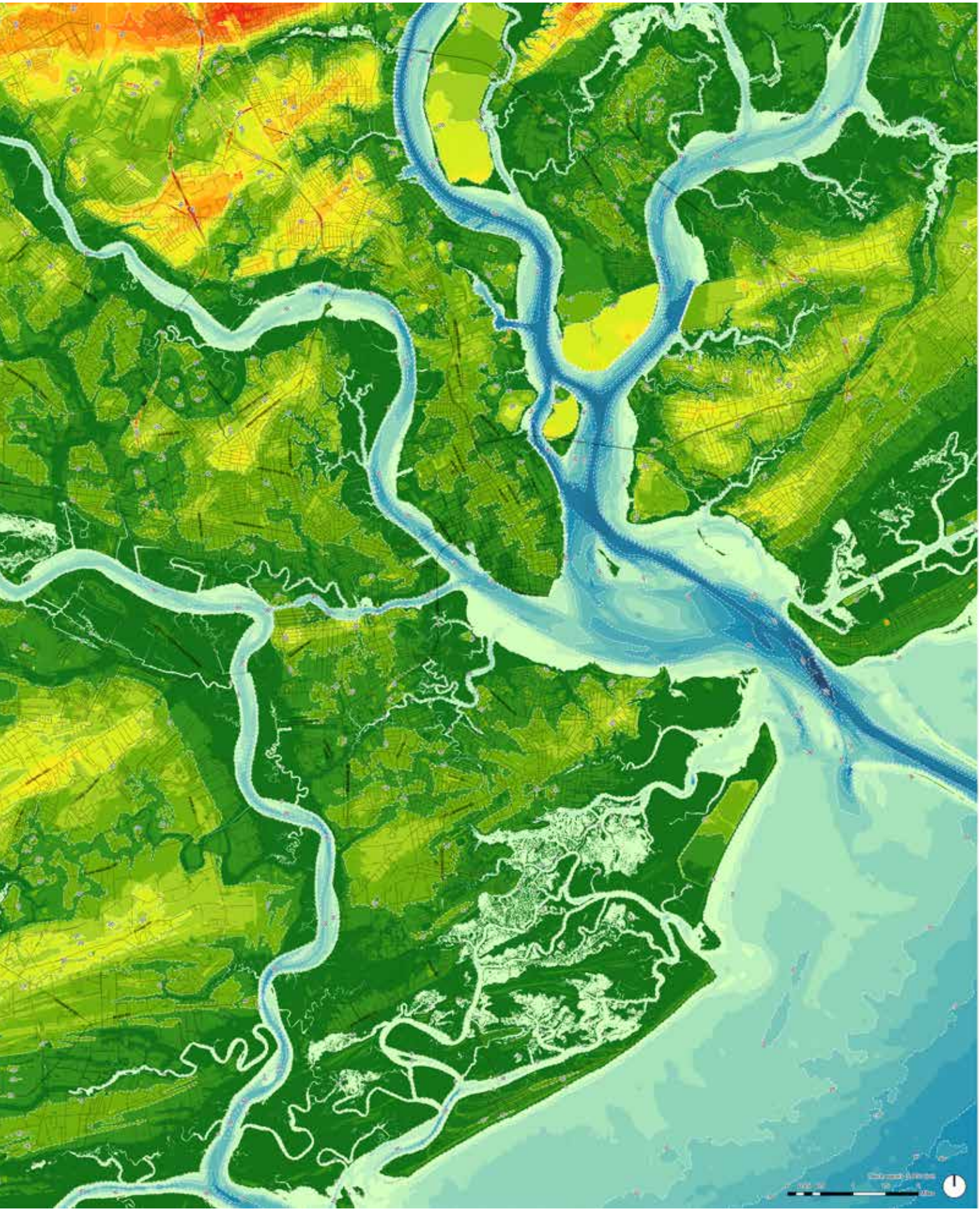
Road
- major
- minor




Wando River
Cooper River
Ashley River
Ashley River
Stono River
Stono River
Kiawah River

Metro Charleston Elevation





Coastal Zone

Coastal Protection

The Charleston region could opt for regional coastal protection grounded in an integrated coastal masterplan for hurricane risk reduction. The Netherlands constructed a coastal protection system between 1958 and 1997, coastal Louisiana has been building and integrating coastal protection system components for some time, while Tidewater / Hampton Roads, Virginia, Houston-Galveston, the Greater New York region, and Greater Boston, are studying ways to add a mix of coordinated structural and non-structural infrastructure to defend again coastal surge from hurricanes, Nor'easters, and tropical storms.

A regional plan would focus on hurricane risk reduction through coastal protection infrastructure and environmental restoration integrated with local measures to manage increased rainfall and sea level rise over the term of a regularly updated masterplan. A regional plan would combine nature-based and civil-engineering structures, with multiple lines of defense across major regional watersheds. These would create redundancy to ensure the most sustainable and resilient overall protection.

Advantages & Disadvantages

Advantages of the regional approach are that it will address:

- Major chronic, catastrophic and underlying threats, including coastal erosion and ecosystem degradation at the regional scale, over a long time-period.
- All areas in the region, including smaller areas that are unable to cost-share but will benefit from regional-scale investments.
- The natural water system and landscape, unconfined by administrative or political boundaries.

Urban Beach
Sandy area along the battery on the peninsula shows that Charleston is a coastal city.

Dutch Delta Plan 2050
Credit: Rijkswaterstaat

Urbanized Areas

Coastal Dune High Ground

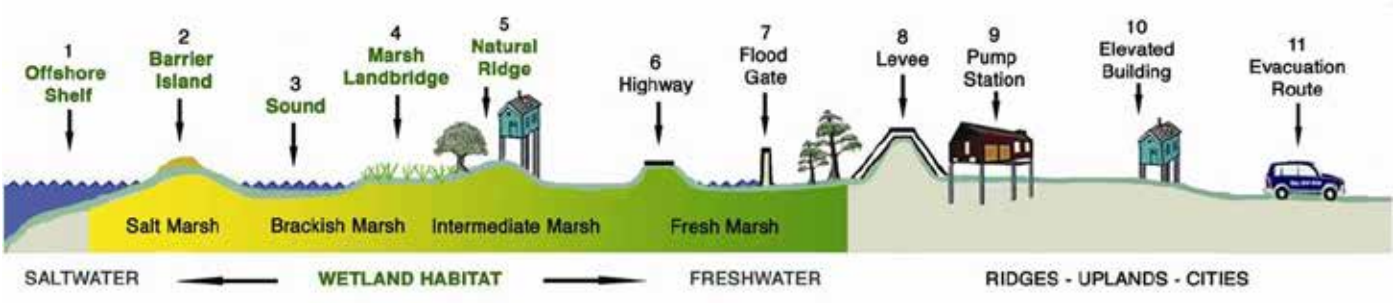
Bottomlands

Tidal Wetlands

Barrier Islands

Tidal Wetlands

Historic City



Louisiana's Multiple Lines of Defense
Credit: Louisiana CPRA

Disadvantages of a regional approach are that it requires:

- Robust implementation; the system is only as strong as its weakest link, requiring gates and barriers where open water crosses the (primary) lines of defense.
- Substantial inter- and intra-governmental cooperation and coordination.
- Additional measures, often related to stormwater drainage and local sea level rise adaptation.
- Reliable, steady investment, for long-term design, construction, operations and maintenance (O&M) funding. O&M costs are generally estimated at between 2%- 4% per year of the original cost of construction.
- Trade-offs between protection and environmental considerations. Some environmental impacts can often be mitigated post construction, for a price.

Elements of a Theoretical Regional System

A Hurricane Risk Reduction System for Charleston would consist of broad elements from offshore to inland areas.

- Reinforcing / strengthening / and possibly reestablishing of barrier islands.

New Orleans Inner Harbor Navigation Channel Surge Barrier

Dutch Sand Engine
This Building with Nature project distributes sand along the Dutch coast with the forces of wind and water
Credit: Rijkswaterstaat

Top
Example of a flood resilient home
Credit: Aamodt/Plumb Architects

Above
Coastal flood defense in the beach resort of Katwijk, a combination of a sea dike, underground, beach-front parking garage, covered by a natural dune with a pedestrian zone and a nature reserve
Credit: Arcadis

- A robust intertidal and coastal marsh zone, buffering land and sea, with coastal marsh restoration, increased oyster banks and similar “building with nature” components.
- Pockets of resilient, elevated communities, able to adapt to storm, surge and sea level rise outside of the primary coastal defense system.
- A coastal defense alignment, behind which all infrastructure and buildings will be protected against the impacts of storm surge at the defined risk reduction level. This line would consist of coastal ridges, dunes, berms, sea dikes, levees and, where necessary (due to spatial constraints), floodwalls. Note: the Dutch have begun using more multifunctional flood protection structures in which primary flood protection and other economic, environmental, mobility or social benefits are combined.
- Gates / Barriers integrated into the coastal defense line to limit storm surge impacts that would occur via open water channels. To lessen ecosystem impacts and ensure normal riverine and tidal exchange and shipping access, movable gates would be required. These are complex structures and can be vertical lift gates or navigable barriers or a combination thereof.

Top
Vertical lifting gate in Hartelkering, Netherlands.
Credit: Rijkswaterstaat

Above
The Maeslant barrier in the Port of Rotterdam spans the 1,375-foot wide shipping channel.
Credit: Rijkswaterstaat

A Charleston Regional Hurricane Risk Reduction System?

A Charleston system would have to contain all elements previously described above. During the Dutch Dialogues Workshop, we noted important challenges.

- The jetties aligning the ship channel into Charleston Harbor negatively impact coastal geomorphology, causing erosion and land loss on the western (Morris Island) side and sand accretion on the eastern (Sullivan's Island) side. Sand nourishment / supplementation on western side would be needed.
- The narrows between Morris Island and Sullivan's Island near Fort Sumter exceed a mile in width. Full hurricane protection for the Peninsula and Port would require an extended land bridge combined with a navigable storm surge barrier. Such a barrier would be comparable to the conceptual designs made for the Verrazano Narrows in New York and for Bolivar Roads / Galveston TX. These designs combine both vertical lift and floating sector gates.
- While such barriers are feasible, designing, constructing and maintaining them would be complex and expensive. Residual stormwater and some tidal risks would remain and not all ecosystem and environmental impacts could be mitigated.
- Two additional, smaller barrier structures would be needed on the Wadmalaw and Stono rivers.
- The system alignment would be controversial. Deciding who and what to include "inside" the system and who to exclude "outside" the system would be politically difficult. These political considerations must also align with the physical system constraints-- geographic, geologic, hydrologic, hydraulic-- and economic considerations that come into play.

Evaluation

A regional hurricane and surge protection system for Charleston would be very difficult to achieve and only at a very high price. Certain landform components to the west are missing and thus hurricane surge would still flow around John's Island and penetrate inland via the Stono and Wadmalaw rivers unless surge gates were added there, too.

Residual post-construction risk would thus remain high depending upon storm tracks. To mitigate that residual risk, a complete surge protection system would require a mix of barriers which would present substantial environmental impacts. The system would be quite costly (+/- $25 billion) and would likely not pass stringent benefit-cost ratios needed for federally supported projects.

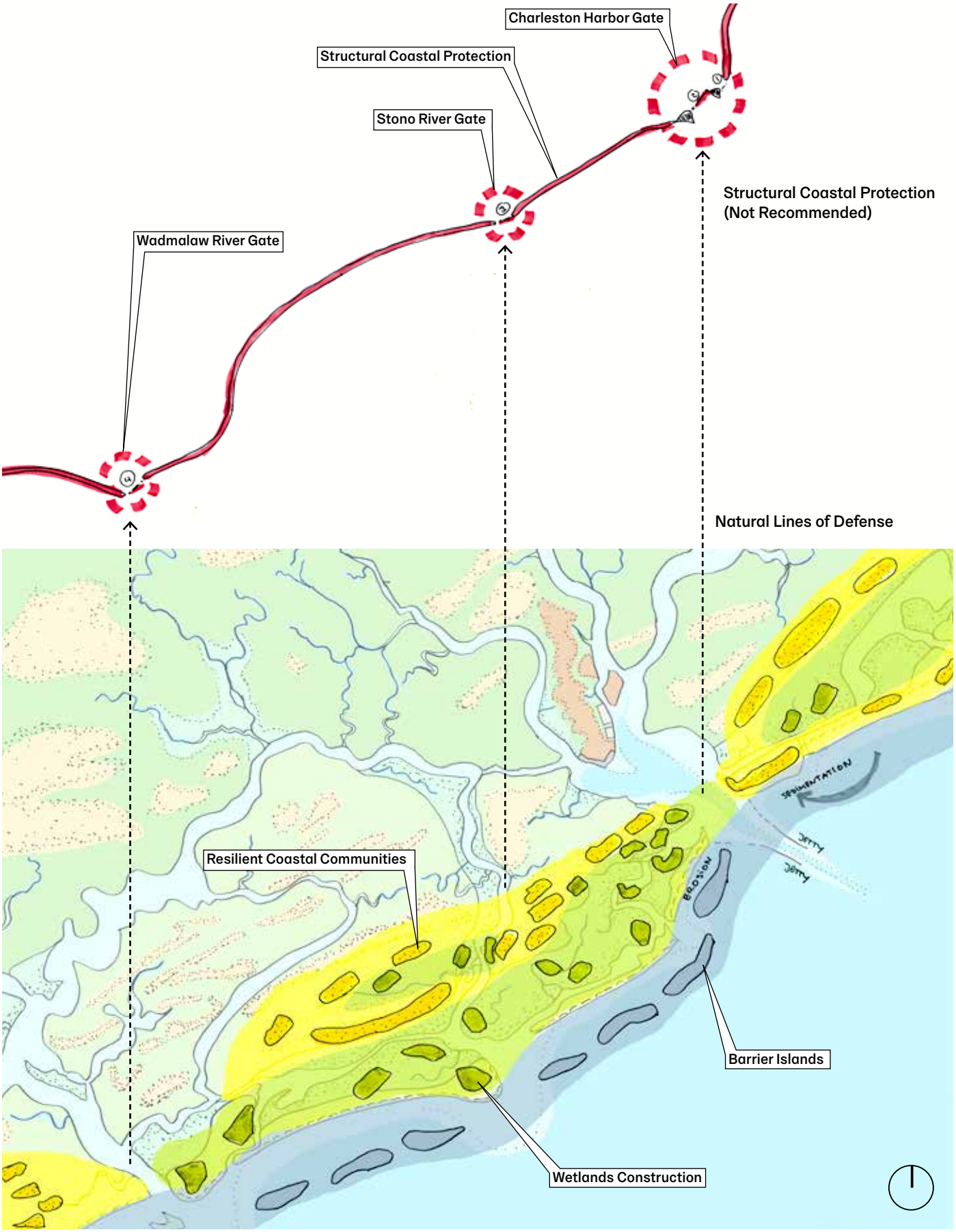
Oddly, the current effort to explore and possibly build a Peninsula-focused flood protection system – being studied in the USACE 3x3x3 project – would further reduce the benefit-cost ratio of a coastal surge reduction system. Note, too, that the coastal surge reduction system would mitigate only the regional hurricane surge risk but not the recurrent stormwater, tidal flooding and sea-level rise risks present throughout the region.

Nevertheless, natural and nature-based solutions to improve the coastal wetland / marsh / beach / dune and barrier island ecosystems are "no regret" measures that will strengthen the coastline, reduce storm surge, improve environmental quality and enhance Charleston's overall resilience. These nature-based solutions should be pursued, no matter what, as they will reduce flood risk, improve natural systems and environmental quality and support the delivery of other essential ecosystem services.

Structural Coastal Protection
A levee provides access and protects against flooding
Credit: Ecopedia

Resilient Design and Construction
Kenogami House in Saguenay, Quebec is energy efficient and elevated to avoid flooding
Credit: Alain Hamel

Offshore Coastal Defense
The Sand Engine in the Netherlands creates a larger buffer against storms while building land for public recreation
Credit: Rijkswaterstaat / Jurriaan Brobbel


Charleston Harbor Gate
Structural Coastal Protection
Stono River Gate
Wadmalaw River Gate
Structural Coastal Protection
(Not Recommended)
Natural Lines of Defense
Resilient Coastal Communities
Barrier Islands
Wetlands Construction
SEDIMENTATION
JETTY
JETTY
EROSION
Multiple Lines of Defense

Coastal Zone Recommendations

The coast – its history and ecology – is the foundation of the region's identity. Humans and nature in synergy can preserve, protect, and strengthen one another.

Region-wide Engineered Hurricane Protection is Not Recommended

A regional, coastal hurricane and surge risk reduction system consisting of man-made surge barriers is not feasible at this time. Such a system would be costly, politically difficult to align, have substantial environmental impacts unlikely to meet benefit-cost ratios, carry substantial and expensive operations and maintenance costs, and divert resources from important coastal restoration investments that provide immediate and long-term benefits. *Note: this hurricane surge system is not the perimeter protection system under consideration for the Charleston peninsula.*

Use Nature-based Adaptation Strategies

The City and County should identify and allocate municipal, county, state, federal and private or non-profit resources to natural and nature-based projects in the City / County / region that restore and improve the natural protective and adaptive processes of sand dunes, barrier islands, coastal marshes, wetlands and intertidal ecosystems that reduce storm surge impacts and allow for long-term sea-level rise adaptation.

Dutch Dialogues Team at the Low Battery

Dr. Scott Harris, Associate Professor, College of Charleston

A Primer on Lowcountry Geology

Fieldwork
College of Charleston students taking salt marsh core samples.
Image Credit: Scott Harris

The Lowcountry landscape has been created through cycles of sea level highstands (interglacial warm periods) and lowstands (glacial periods or Ice Ages) over the last several hundred thousand years, stacking one barrier island complex upon another until the modern marine inundation. The Lowcountry formed as active beach ridges and estuaries and the modern barrier island system mimics these ancient systems. The modern Lowcountry coast-- harbors, estuaries, inlets, tidal rivers, ancient sea islands, hammock islands and uplands-- is a complex arrangement of modern and ancient barrier islands resting on the ancient marls recently mined for phosphates.

Topographically, the landscape reflects the geological history of the region. In the modern period, beaches form as the active culmination between the processes of waves, tides, winds, plants and animals with the coastal sediments, sands, and rocky hardgrounds offshore. When more sediment is supplied to the coastal system, beach dunes can expand and grow, creating vegetated ridges parallel to the coastline. When starved of sediment, storms can wash across the islands and ridges and cover the marsh systems. Because of its high tidal range and relatively low wave heights, the Lowcountry contains many inlets (such as Light House, Stono, and Charleston Harbor) separated by barrier islands of various sizes (Morris, Folly, Kiawah, Seabrook). This coastal geometry is common in the large coastal bight stretching from Georgetown, SC, to Charleston, to Jacksonville, FL. Farther north and south, higher wave energies and lower tidal ranges form longer beach strands with few to no inlets, such as South Carolina's Grand Strand and Florida's Space Coast.

Lowcountry inlets, channels, creeks, and estuaries send huge volumes of water twice a day back and forth from the ocean. While some tidal systems are perpendicular to the coast, extending inland (Cooper, Ashley, and Stono rivers), others run parallel to the coast and drain the areas between uplands and the modern barrier islands (Kiawah and Folly rivers). Each of these rivers has accumulating marshes and swamps. In some areas, hammock islands rise a few feet above the marsh and are being slowly inundated by sea level.

Geologically, three primary time periods have formed the Lowcountry's foundational sediments. The underlying base deposits of the Ashley Formation (among others) are between over a hundred feet below the surface to several tens of feet above sea level. These deposits are exposed in mine tailings, tidal channels, creeks, and inland ditches. Above these formations are interglacial coastal systems – sand ridges and muddy, sandy lowlands – in which the muddy marsh and estuarine deposits have compacted over time and pose little threat of additional compaction. Above that are modern barrier islands, marshes, and swamps

which have been drowning the interglacial coastal systems for over five-thousand years. The loose unconsolidated muds and sands fill the river basins and creeks, creating geologically unstable conditions.

The topography, geology, and modern coastal environments define the near-surface hydrology of the region. Ancient and modern beach ridges have a high capacity for infiltration, while the lower areas between ridges tend to accumulate water, producing the upland swamps and wetlands common throughout the Lowcountry. Where many beach ridges are stacked together, the groundwater table generally sits closer to the land surface, draining slowly at the edges and maintaining high water tables except in times of extreme drought. The wide, relatively flat areas of ancient marshes and estuaries are usually slow to infiltrate water due to high water tables, and water must take long pathways to the modern river systems. Extreme wind and storm driven tidal surges are common and often destructive, depending on elevation and position. River and creek systems enable the inland transport of large volumes of water during these events, flooding the marshes and low-lying inland communities. Surge can be mitigated when low-lying areas are surrounded by healthy marshes and oyster reefs, which attenuate wave action and decelerate surge. As sea-levels rise marshes will be unable to keep up and turn into open water, increasing wave energy and surges into low-lying areas.

Johns Island

The landscape of Johns Island is dominated by long, wide ridge systems (Maybank Highway) with multiple smaller ridges separated by former estuaries (e.g. Plowed Ground Road) that formed in both beach- and river-parallel systems. These ridge and swale systems, where infiltration can be very high, often have accumulations of upland peats in the narrow areas between the smaller ridges ranging from a few feet to over ten feet thick. These deposits are highly compressible, absorb and filter large volumes of water, and buffer the flow to other lowland areas. The high ridge systems are high infiltration areas with large capacity to store water.

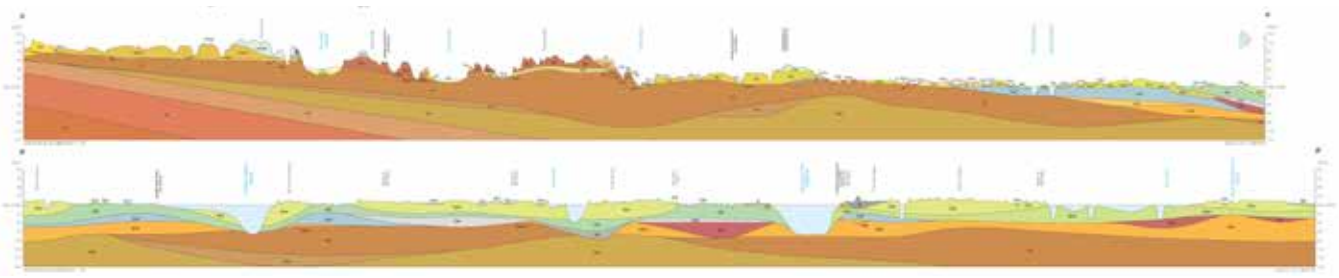
Church Creek

The Church Creek region consists of a set of irregularly spaced and oriented high areas separated by several sets of ancient tidal creek systems and phosphate mining areas, flanked by modern estuaries and thick mud accumulations. In general, this area was once a large bay (harbor) and tidal creek system, that has been reoccupied through many interglacial periods by successively lower tidal creek systems and interspersed uplands. Being mostly a high plane with circuitous drainages along ancient creek systems, coupled with limited infiltration and high ground water table, it is easy to identify why water floods these low areas.

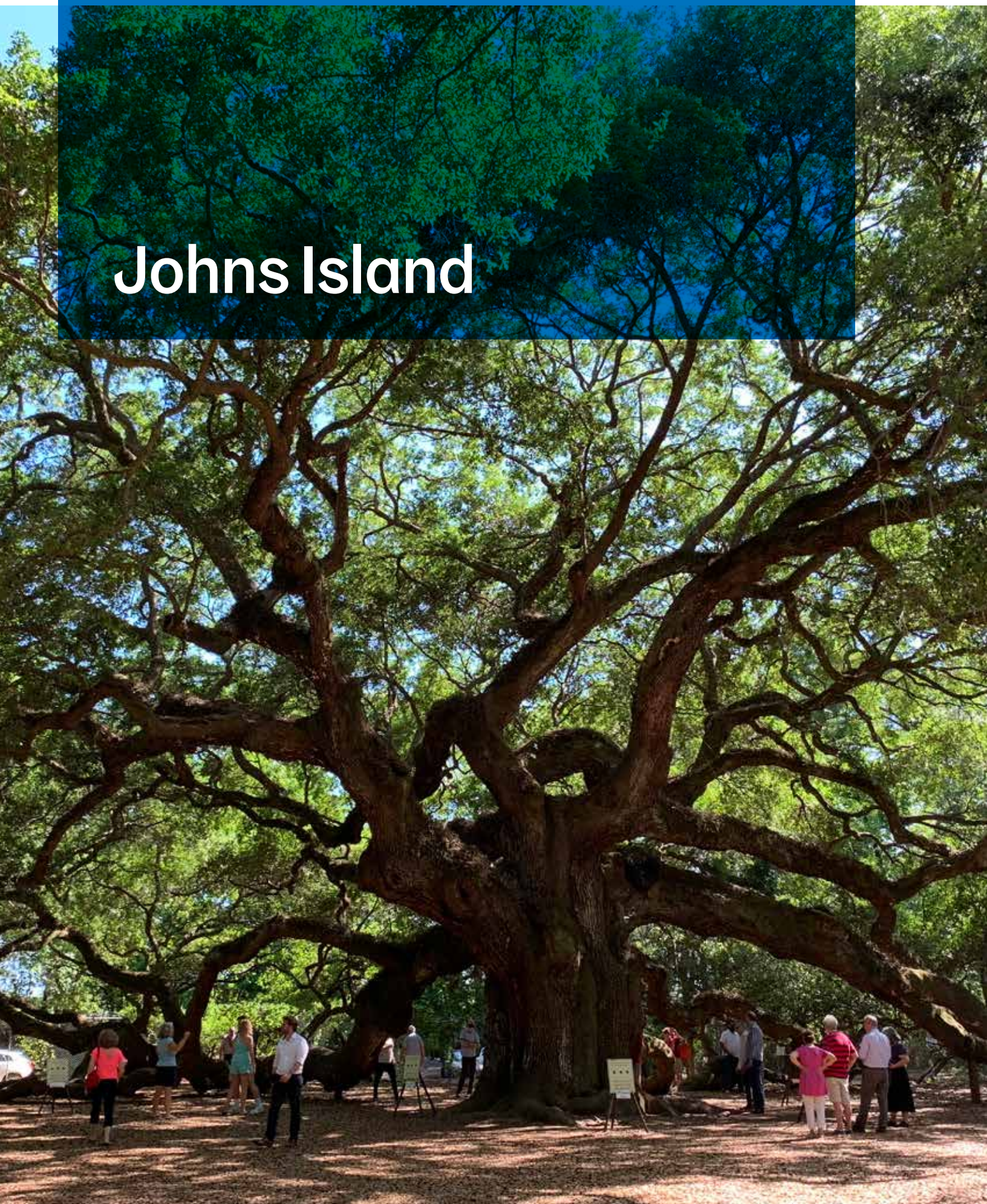
Charleston Peninsula

The Charleston Peninsula has a similar geological history to the West Ashley region, but is reduced in size by the shifts in the Cooper and Ashley rivers through the Ice Ages. Ancient swamp and estuarine deposits beneath the city are mostly compacted, with dense sand deposits scattered in the ancient channels of streams feeding the Ashley and Cooper rivers. With such a narrow width between the deeper channels of the rivers, modern streams have been able to penetrate the Peninsula more deeply as sea level has risen. Backfilling the edges with estuarine muds as sea level has encroached, the backfilled ancient stream valleys create areas underlain by uncompacted muds which are easily compressed and subside.

Geological Section of the Charleston Region
Credit: Weems, R.E., Lewis, W.C., and Lemon, E.M., Jr, U.S. Geological Survey



Johns Island



> “Tide levels, surge levels and storm return periods fundamentally guide our thinking on Johns Island.”

Yttje Feddes
Feddes Landscapes

Contributors

Andy Sternad, Yttje Feddes, Scott Harris, Johnny Martin, Keith Bowers, Jan Peelen, Scott Hemmerling, Bill Whalen, Chris Mack, Adam Clinch, Betty Nierman, Danny Forsberg, Conor Morris, Nick Bilgri

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Water & Development

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- Urban Growth Boundary
- Charleston City Limits
- County Boundary

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- Water

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- 3' Sea Level Rise

DFIRM

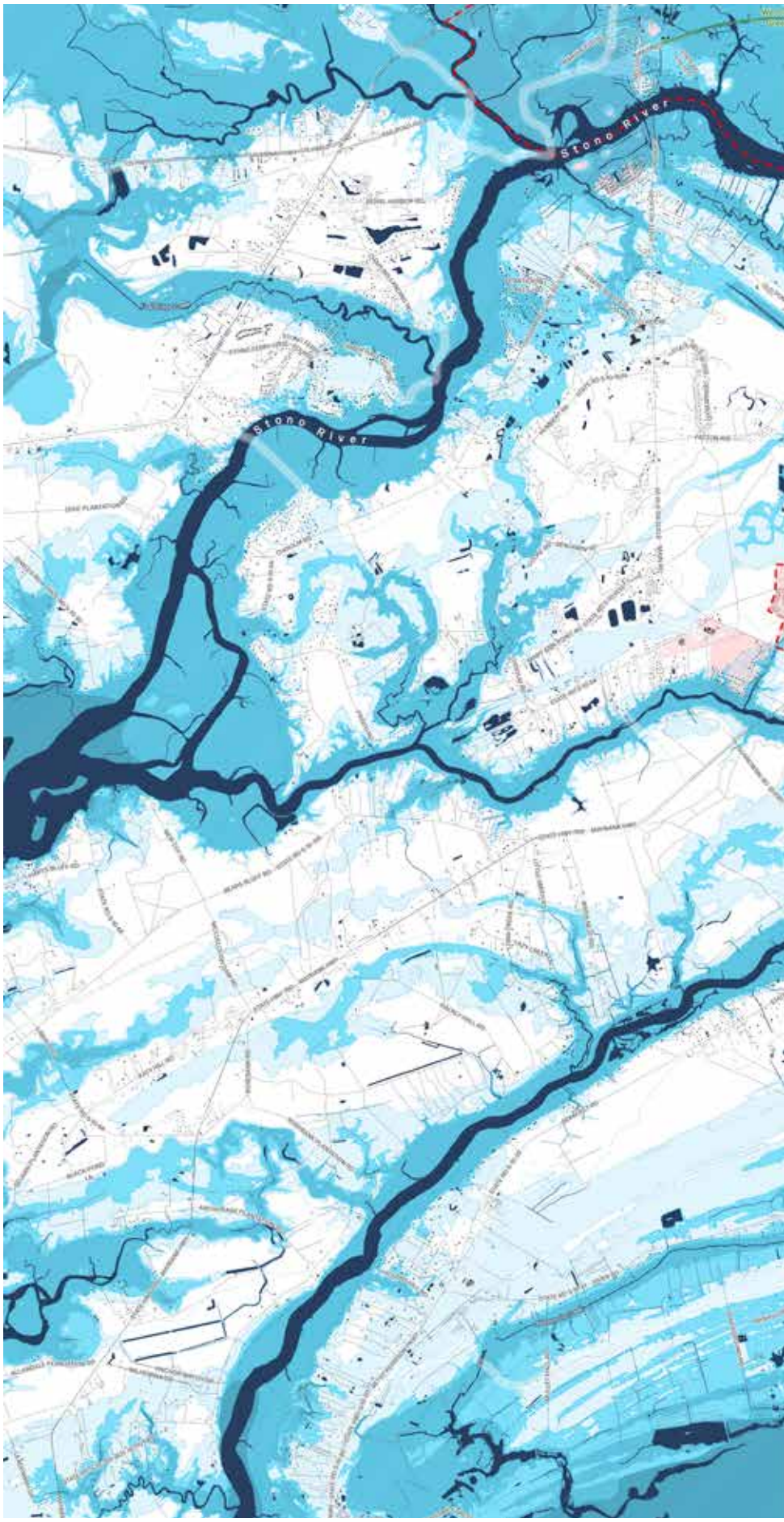
- coastal floodzone, floodway
- 100 year floodplain
- 500 year floodplain

ROADS RAIL

- Rail

Road

- major
- minor




Stono River
Ashley River
Stono River
Kiawah River
Stono River

Surface Elevation

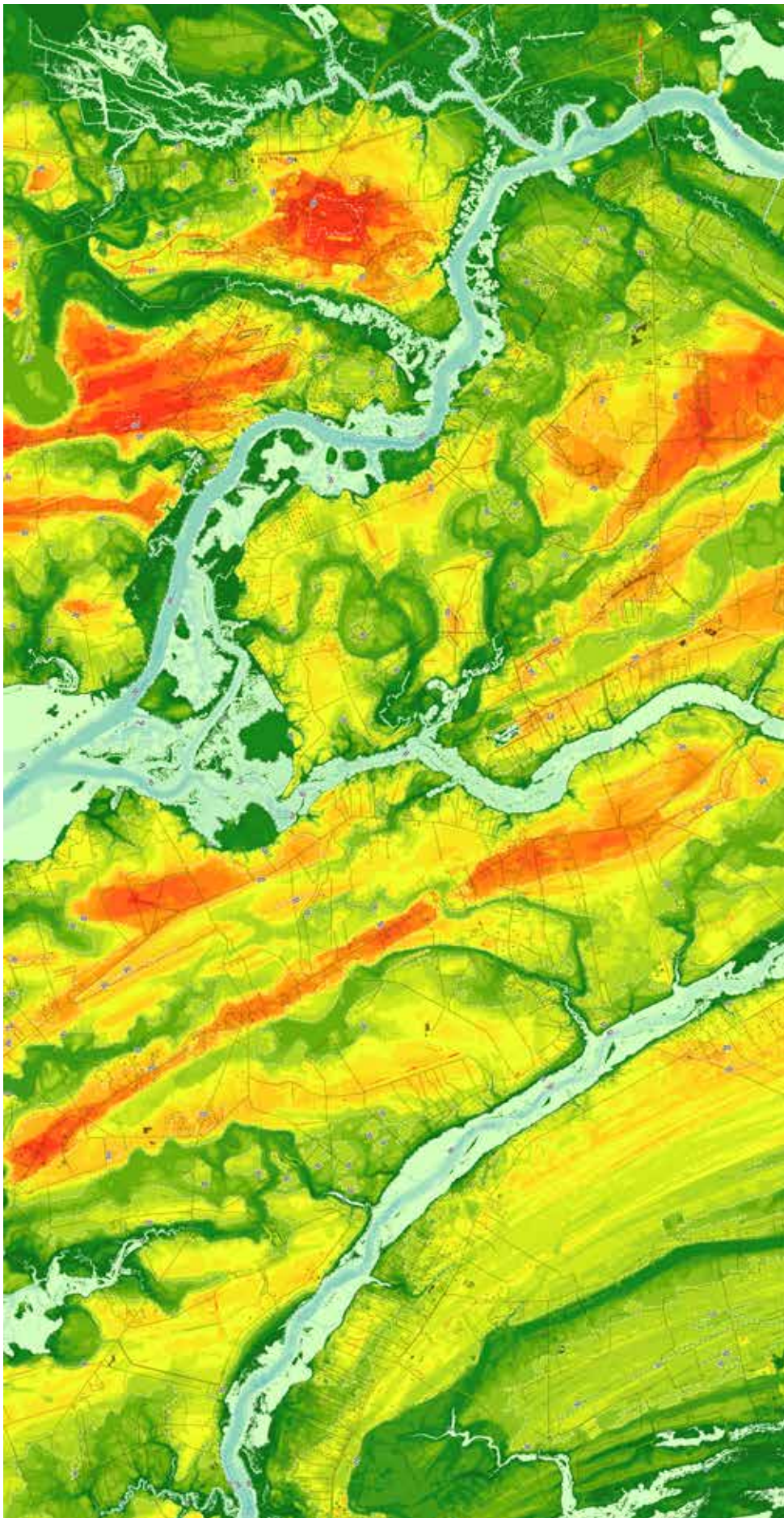
LEGEND

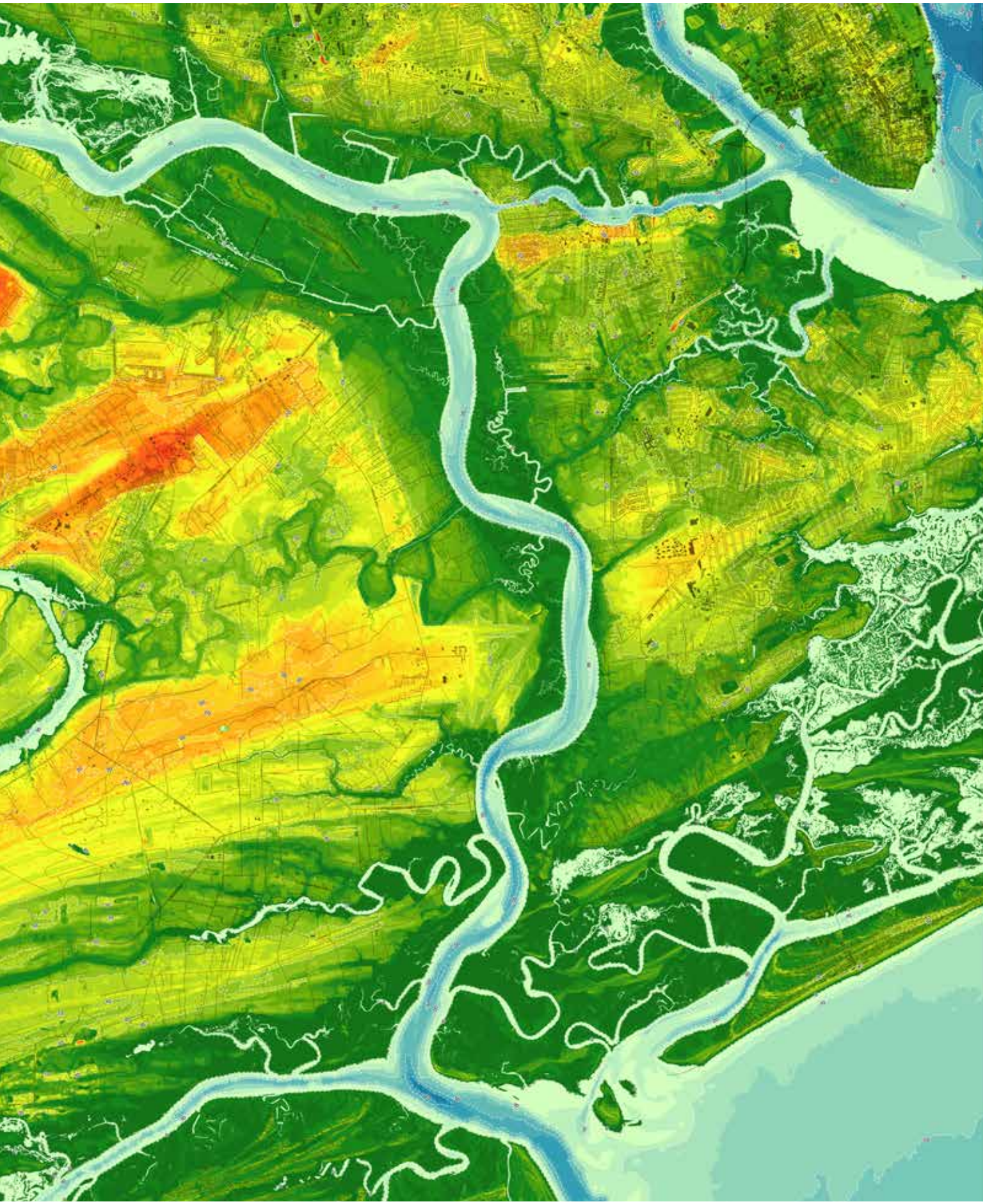
Topography 0'-30'

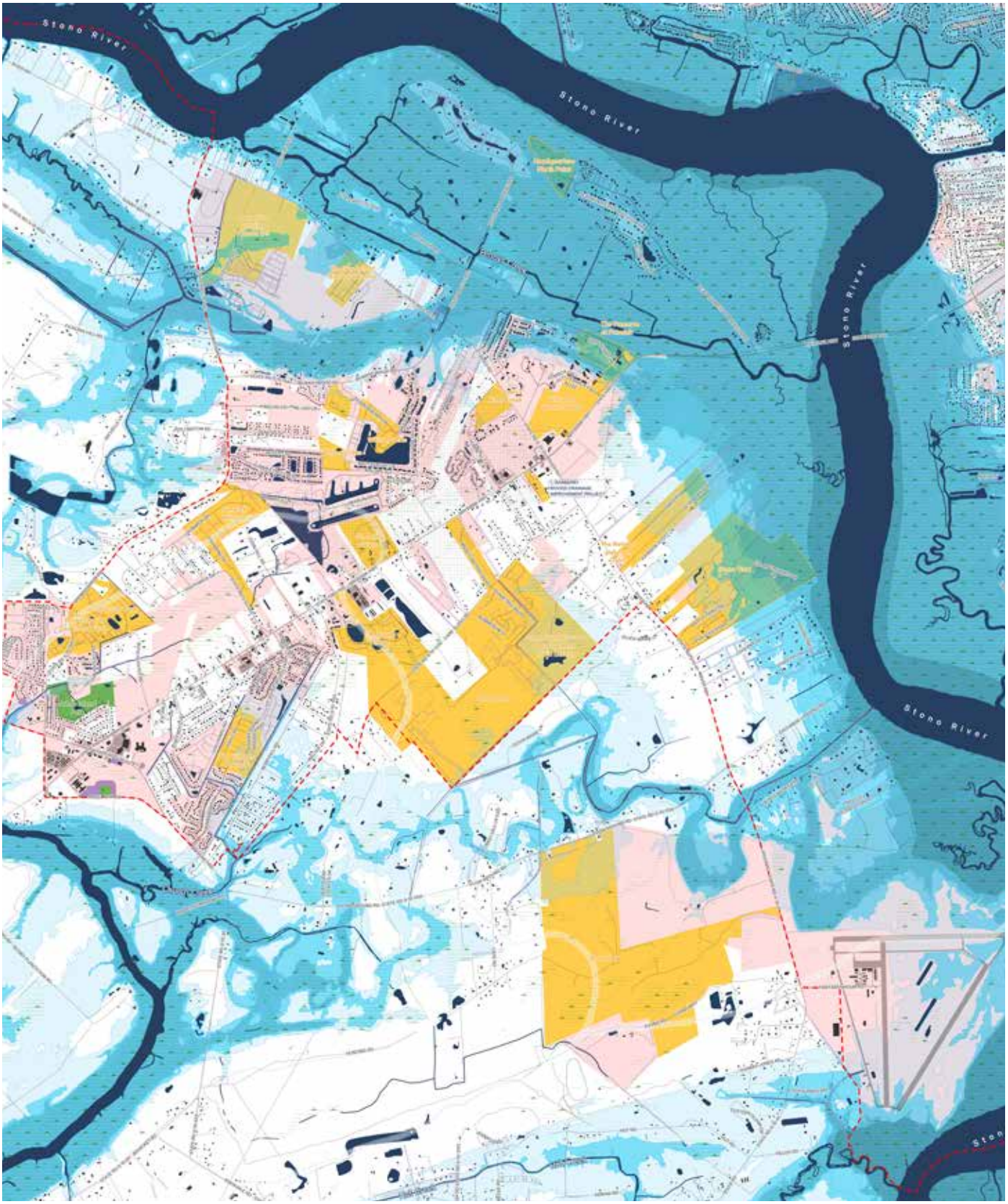
- ≤30
- ≤28
- ≤26
- ≤24
- ≤22
- ≤20
- ≤18
- ≤16
- ≤14
- ≤12
- ≤10
- ≤8
- ≤6
- ≤4
- ≤2

Bathymetry

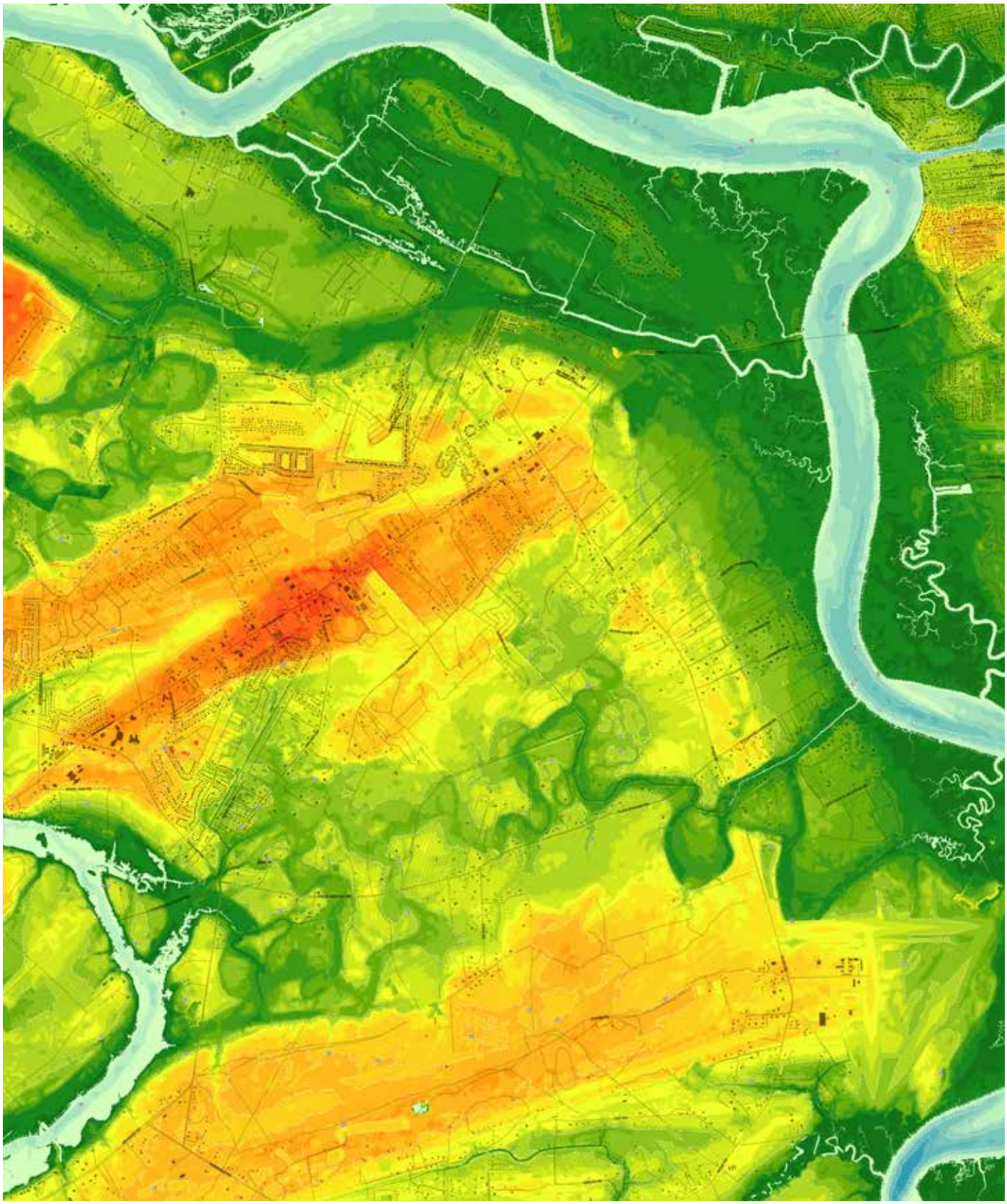
- ≤0
- ≤-5
- ≤-10
- ≤-15
- ≤-20
- ≤-25
- ≤-30
- ≤-35
- ≤-40
- ≤-45
- ≤-50
- ≤-55
- ≤-60
- ≤-65
- ≤-70
- ≤-75
- ≤-80







Floodplain and Development
Floodplain is the light blue overlay and development sites are the yellow parcels



Elevation
Green is the lower ground, red is the higher ground.

Natural & Historic Character

New Development

Sea Island Context

Johns Island is the 4th largest Island on the US East Coast with a rich, diverse ecology and culturally significant history. The Island is under substantial development and transportation pressure, which add to its significant stormwater, tidal and surge risks. Johns Island functions as a natural storm surge buffer for much of the Charleston region west of the Ashley River; **its protective role in the Lowcountry's landscape, like that of other sea and barrier islands, cannot be overstated.**

Johns Island is also naturally resilient, working to regenerate and protect itself in a layered system of sands and sediment, water courses, and marsh and upland vegetation. The dunes and sand ridges, which run parallel to the coast, naturally migrate, accrete and dissipate over time. The accretion, migration and dissipation processes are influenced by coastal forces of wind, waves, surge and erosion and are constantly underway. **The ridges and dunes are compacted into stable formations and are naturally robust.** The Maybank Corridor and parts of Bohicket and River Roads run atop and follow these high ground ridges. Johns Island has an incredible forest canopy, productive soils, and rich ecological systems, all of which benefit the island's current and historic inhabitants.

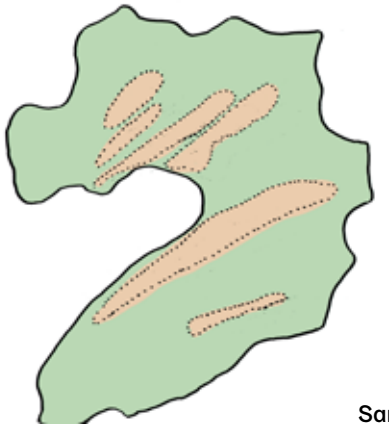
The Lowcountry's saltmarsh is an ecological keystone habitat for water, plants, fish and other crucial species and for the Gullah Geechee culture and people. Historic homes and properties are abundant. This ecology and community are also home for more recent residents, often concentrated in newer developments in which the widespread use of fill for elevation and drainage routing often impair watershed functionality and the Island's hydrology connecting ridge to river. The removal or covering of native topsoil and coastal forests and trees further reduce natural water infiltration and storage capacity.

Water Challenges

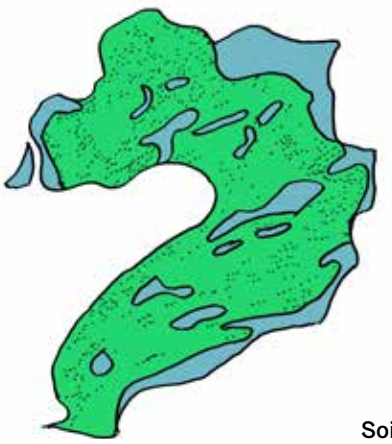
A pressing challenge on Johns Island is stormwater management: ponding, pooling,

Residents and citizens, whether recent arrivals or long-term inhabitants, should not be put in risky surge, tidal or drainage zones.

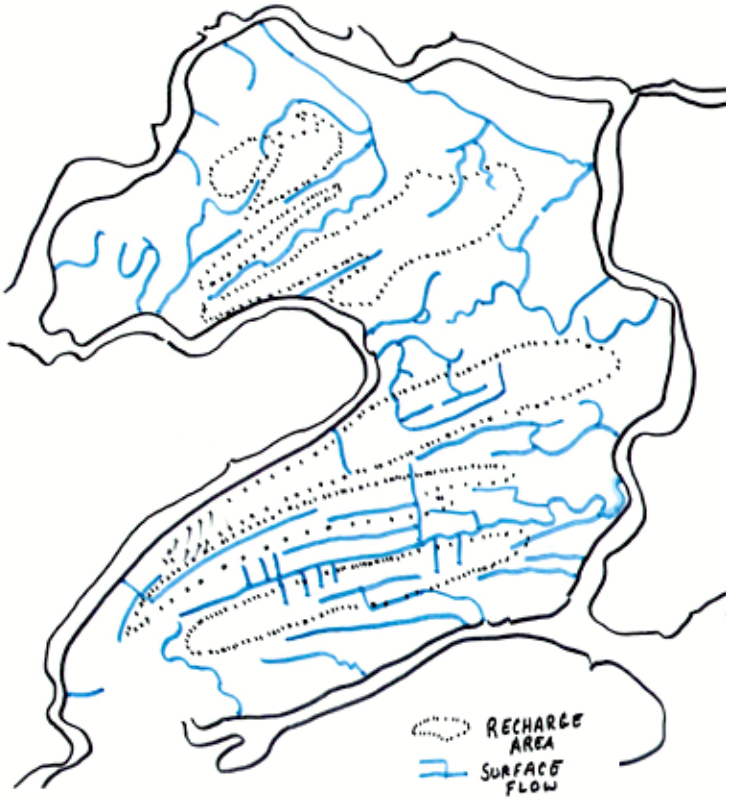
Forest Canopy



Sand Ridges



Soil Infiltration



Johns Island Waterways & Infiltration Areas
Natural streams and man-made ditches weave between sand ridges.

infiltration, and drainage. While drainage codes and guidelines are crucial management tools to address these problems, a critical determinant of their magnitude is mean sea level, which increased by 6" between 1990 and 2016 in Charleston Harbor (NOAA Tides & Currents). Higher tides can slow or even reverse drainage outflows, and **managing water in the soil and where it falls becomes all the more vital**. Drainage regulations, overland drainage siting and maintenance regimes, and development patterns must be updated to reflect current (and rising) tidal levels and account for future anticipated sea level rise. If these higher water levels are ignored, and overland drainage channels are undermaintained, the drainage infrastructure may fail to mitigate the direct, harmful consequences of stormwater management on the Island's ecology and people.

Another primary and long-term risk on Johns Island is storm surge, which also will be exacerbated by rising sea levels. Residents and citizens, whether recent arrivals or long-term

Water Flow Through Ecological Zones

inhabitants, should not settle or build in risky surge, tidal or drainage zones.

Tide levels, surge levels and storm return periods fundamentally guide our thinking on Johns Island. All planning must be based in two- and three-dimensional perspectives (levels, section and cross section), not the traditional one-dimensional (plan) view.

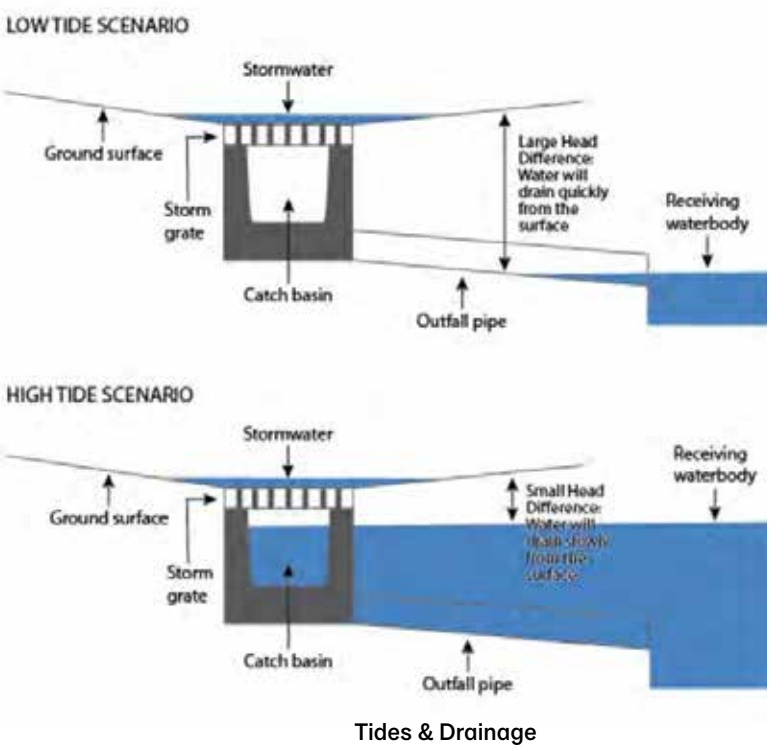
Elevation Zones

The Team identified four planning or safety zones – **wet, ecological, transition, community** – based upon elevation above local mean sea level (MSL).

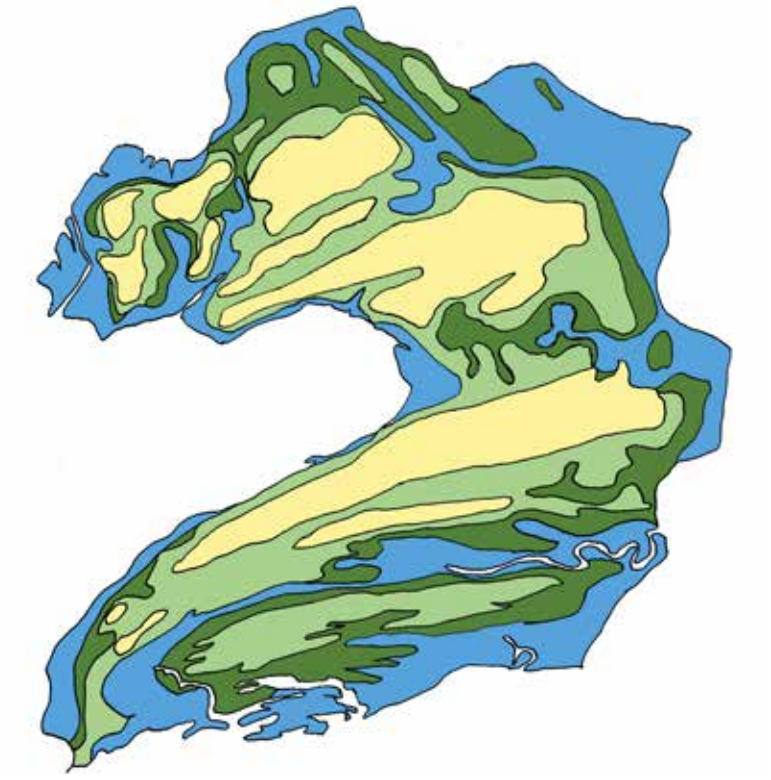
The first wet zone is from zero to six feet above MSL, which coincidentally correlates with the impacts of the 10-year storm return period. As noted in the NOAA Coastal Surge / HTF summary, 10-yr design storms are quickly becoming the 2-yr design storms. Similarly, rainfall amounts associated with the previous 10-yr storm are now associated with the 2-yr storm.

We recommend prohibiting future development in the wet zone. Marsh in this zone is essential for storm surge protection. In addition, marshland warrants robust ecological protection and restoration, possibly through the addition of living shorelines, although sediment accretion and marsh migration must be studied and encouraged. Sea walls and bulkheads should not be used, as they ultimately cause erosion and undermine natural lines of coastal defense. Adding access points for Johns Island residents to the river and marshes would provide recreation and health benefits and opportunities to educate citizens about the marsh ecosystem's role in surge protection.

The ecological zone exists from six to ten feet above MSL. This is primarily saltmarsh and low coastal forest, providing ecological connections, ecosystem services and water storage / sponge functions between the Island's lowland and highland. Only limited and adapted development should occur in the ecological zone, such as low density, pile-elevated, single-family homes-- with access provided by elevated roads (at +8 feet or

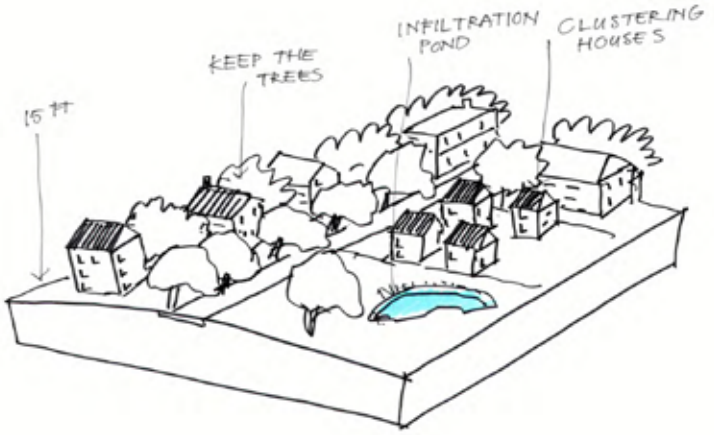


Tides & Drainage
Tidal impact on water levels and "wet pipe" regulations
Credit: Adam Clinch, ARCADIS



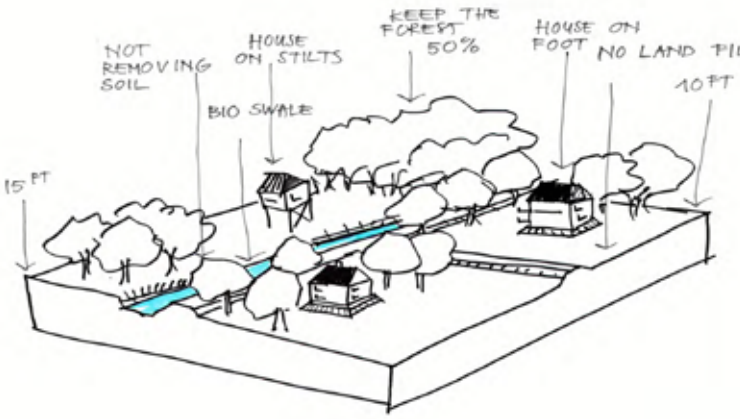
Elevation Zones
Development pressure should be steered away from low, vulnerable areas and ecological assets.

>15’



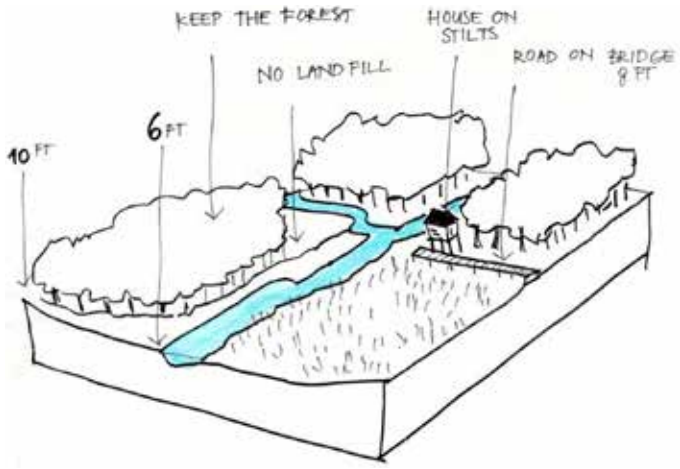
Community Zone

10<15’



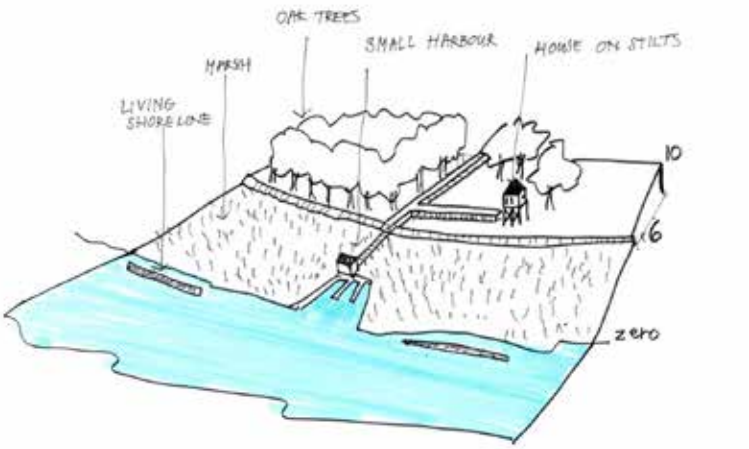
Transition Zone

6<10’



Ecological Zone

0<6’



Wet Zone

more) and bridges-- with little-to-no landfill and no large-scale removal of existing soils and trees. Maintaining the existing coastal forest is essential: the average forest canopy should be maintained at 50% or more of land cover in this zone.

The ecological zone carries substantial flood risk and can expect to get wet in a 100-year storm which, mathematically, means a 1% chance of flooding in any year and a 26% chance that a home with a 30-yr mortgage will flood once over the mortgage term. Those living in this zone should be fully aware of the risk they assume by living there.

The transition zone is defined as areas between 10-15ft above MSL. **In the transition zone, development is possible**, including clustered, elevated homes. Development here must respect the dynamic nature of the landscape, with fluctuating water levels and sufficient, maintained overland drainage channels, and the need for tailored flood risk reduction strategies. Fill should be sparingly used, primarily for road construction or to elevate only certain homes. The coastal forests in this zone should not be further degraded as trees are essential for storing and managing stormwater.

The community zone, at 15 feet and more above MSL, is on historic and stable sand ridges, the most prominent of which are along Maybank Ridge and Upper Burden Creek. **This is stronger, higher, safer, and thus more valuable ground**, although it is neither scarce nor abundant. Clustered development combined with stormwater infiltration could be encouraged in this zone, especially where the soils readily infiltrate and store water. The existing water systems-- channels, swales, creeks, ditches -- in these zones must also be protected and maintained, and not further compromised, filled, or eliminated. These systems store and infiltrate stormwater, providing stormwater management and hydrologic balance. Clear rules to protect these hydrologic features must be developed and enforced.

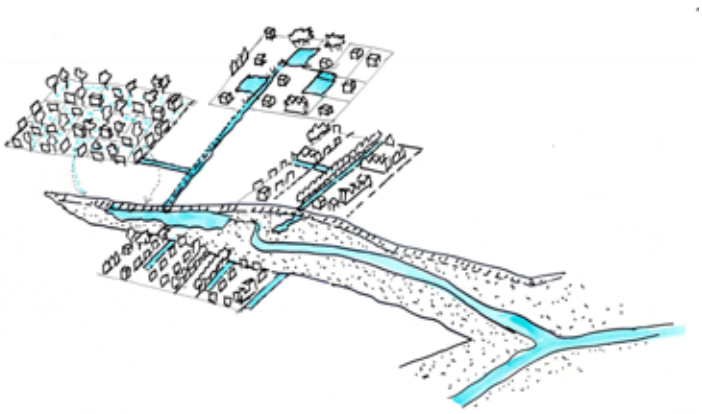
Zone	Approx. Land Elev. (NAVD)	Allowable Development Density	Allowable Foundation Types	Fill Allowed	Potential Stormwater BMPs
Wet Zone	0 – 6’	None	N/A	No	Living Shorelines/Buffers
Ecological Zone	6 – 10’	Limited (Single)	Elevated	Roadways Only	Promote Buffers/Open Systems/Space/ Storage Only
Transition Zone	10 – 15’	Moderate	Elevated/ Limited Slab on Grade	Limited	Closed Systems/ Open Space/Storage and Green Infrastructure/ Infiltration
Community Zone	> 15’	Moderate to Urban	Mix	Limited to Moderate	Green Infrastructure/ Infiltration and Limited Closed Systems

Elevation Zones
Four different zones are described relative to development strategies

With sea level rise, the odds change. The hundred-year storm today, with 2-feet of sea level rise, becomes a fifty-year storm, or one with a 2% annual chance of occurrence. 3-feet of sea level rise means the 100-year storm becomes a twenty-five-year storm. In short, increasing storm, surge, flood and occurrence are forecast in Charleston's future.

Connections across the four zones are essential, as are other connections: between the salt marshes and freshwater zones, between the groundwater and surface water, between the tree canopy and tree roots, and between Johns Island residents and the natural systems – the "Island Life" – they want to embrace and sustain.

Critical infrastructure—evacuation routes, fire stations, utilities, hospitals—all need immediate, targeted, science-based, near-term planning for future surge, water level, storm frequency and rainfall increase. This is true even if residential and commercial development regulations are adjusted to reflect the new levels over time.



Drainage Network
Johns Island needs a drainage network that connects multiple ecologies and land uses.

Zone	Approx. Land Elev. (NAVD)	Approx. Infiltration Rate	Approx. Depth to WT	Approx. WT Elev (NAVD)	Approx. Available Storage*
Wet Zone	**0 – 6'**	**1 in/hr**	**0 – 1'**	**5'**	**1"**
Ecological Zone	**6 – 10'**	**3 in/hr**	**1 – 3'**	**6'**	**7"**
Transition Zone	**10 – 15'**	**6 in/hr**	**3 – 5'**	**8'**	**14"**
Community Zone	**> 15'**	**6 in/hr**	**> 5'**	**10'**	**18"**

Soil Infiltration Characteristics
30 percent porosity is assumed. The 100-year/24-hour rainfall event equals 10.3".
Source: SCS Soil Survey.

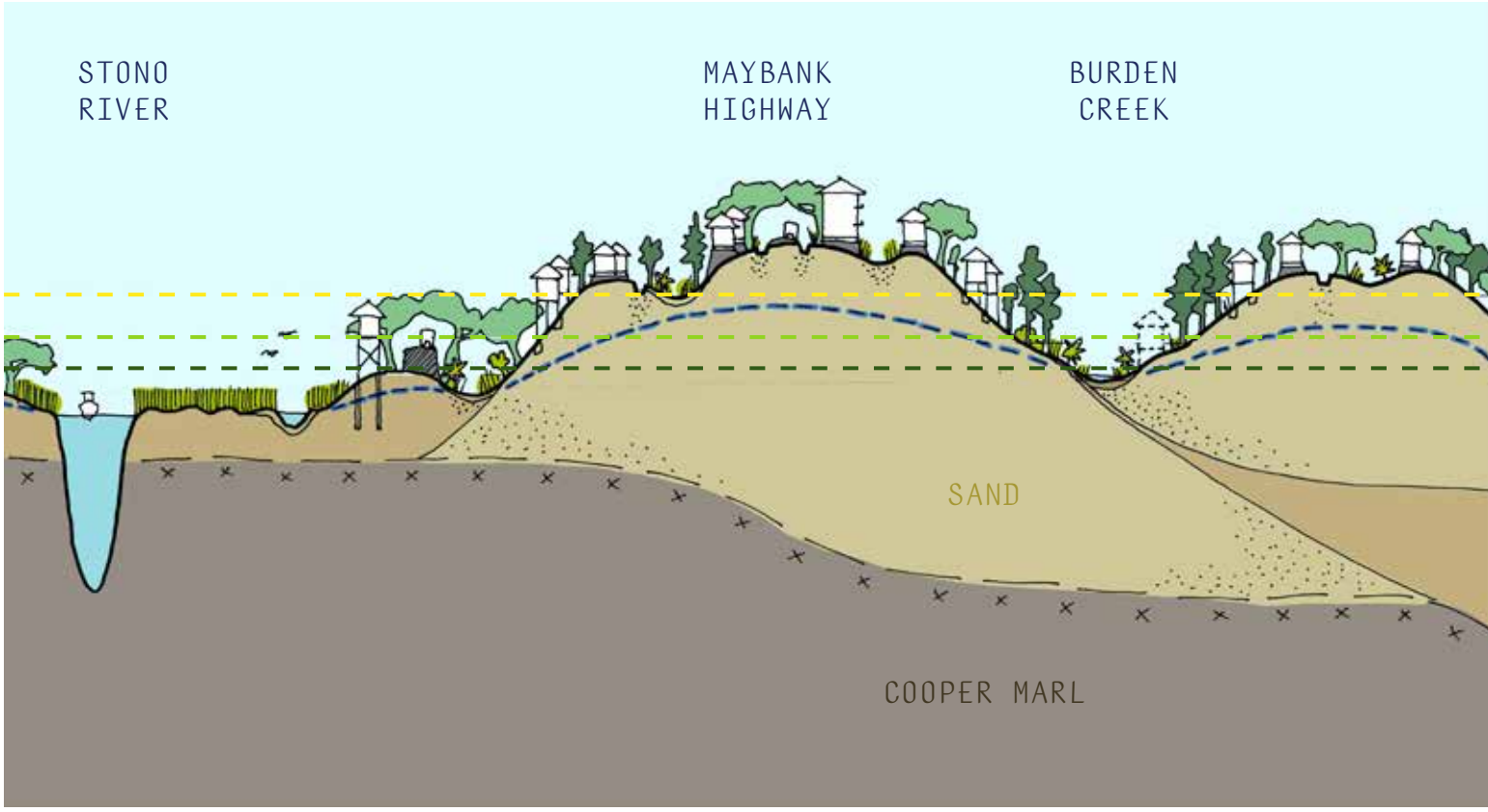
Policy & Regulation

Market-based strategies to achieve land-use recommendations should be supported via common-sense policy and regulations, including transfer of development rights, low-impact development, conservation easements, stormwater credits, and deployment of green infrastructure measures. Without such requirements and market-based mechanisms supporting them, Johns Island residents will carry substantially higher flood risks and potential for catastrophic or steady and likely irreversible physical and financial losses.

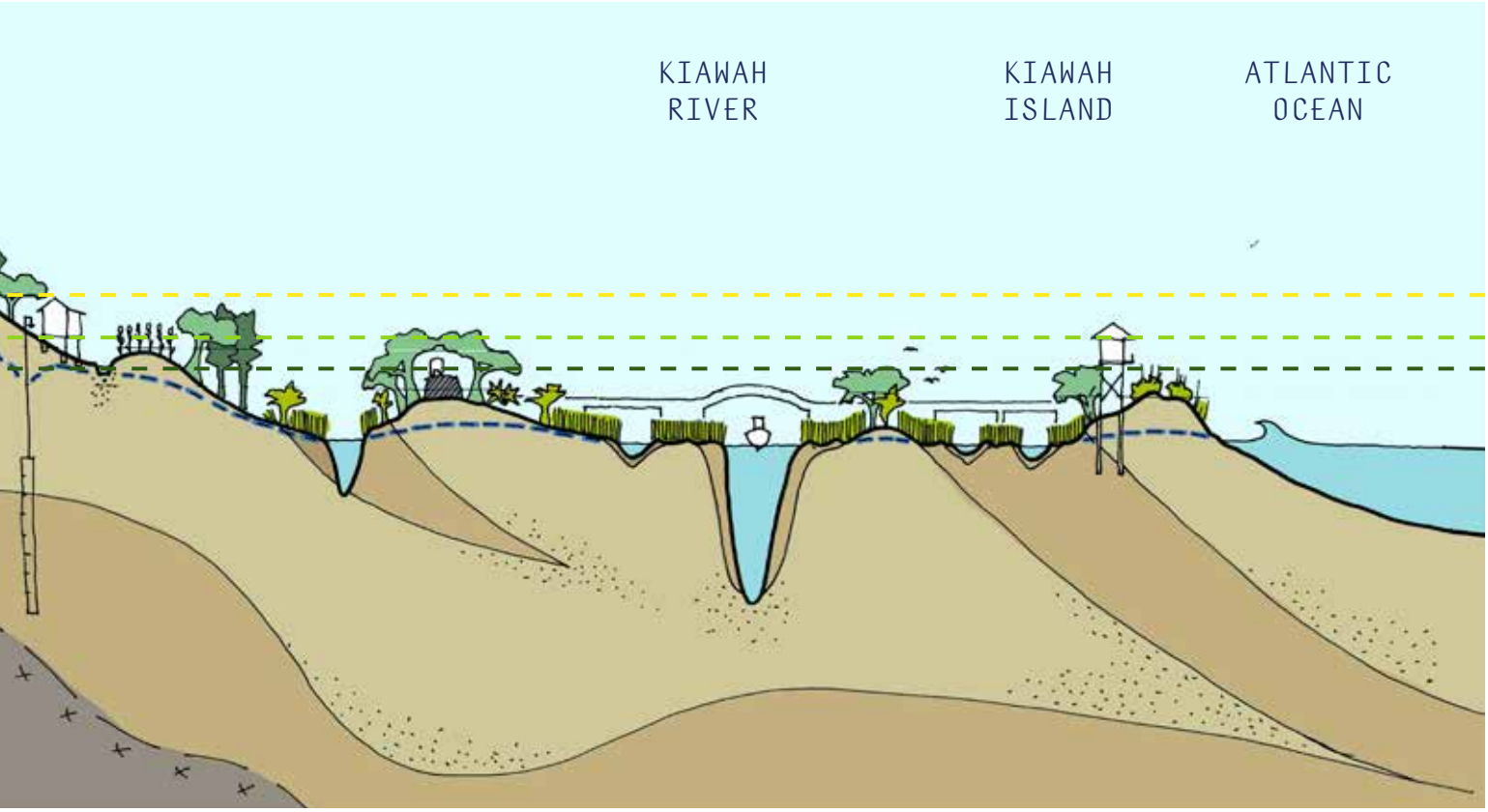
A primary goal is to reinforce the land, soil and water system's natural tendencies to store, manage and drain the area's stormwater. Our team acknowledges both the advantages and disadvantages of deploying wet pipes. The addition of bioswales, infiltration ponds, and restoration of former creek beds should be strongly encouraged. They should be designed and constructed to also provide amenity to connect new and existing neighborhoods with linear park-like and natural spaces and to connect residents to the landscape and ecology in which they live.

This new approach on Johns Island will require time to be carefully designed, developed and implemented. More science-based research is recommended to refine levels for each zone as a basis for all future planning, design, retrofits, and regulatory decision making. While implementation of this approach can be phased, **immediate conservation of the Island's existing ecological assets should begin now**: they cannot be replaced once gone. Development of a Johns Island Watershed Master Plan – a blue-green framework, across the entire Island, which would entail coordination with County officials and that informs or is integrated into an updated Johns Island Master or Zoning Plan is strongly recommended.

Elevation Zones
Recommendations for building on Johns Island are directly tied to stable geology and elevation.



Development on the High Ground
The densest development is located on the highest ground.



Johns Island Vision Plan
Zones are developed based on elevation floodrisk and ecology.


STONO

Johns Island Recommendations

The island is an irreplaceable ecological and cultural asset, a character setting resource for the region. If unmanaged, the features that draw residents to the island could be lost to growth and environmental change. The unique environment of Johns Island, and its inhabitants' safety, require unique consideration to sustain its many values.

Do No Harm

Do not place future residents in risky surge, intertidal or overland drainage zones.

Conserve & Protect Natural and Cultural Assets

Protection, restoration and maintenance of the existing marsh, wetland and coastal forest features across the island must be secured through revisions to land-use planning and protocols. These environmental features are essential attractions of the Islands' aesthetic and provide crucial flood risk mitigation. Maintaining them is, therefore, a community wide interest. Connecting new and existing developments to these environmental features would be beneficial and create more awareness of their essential functions and fragility. The Gullah Geechee community, its heritage and future are crucial Charleston-region assets and must be protected too.

Respect Elevation

The City Stormwater Management processes and its development and zoning regulations must be regularly updated to reflect the current and projected mean and high-water levels. Water levels will increase over time and so will flood risk on the Island unless properly mitigated. Costs will be incurred and the spectrum of benefits must be optimized.

The Dutch Dialogues Team developed four Johns Island conceptual planning zones. Certain practices should be either (a) prohibited, restricted or allowed only under certain circumstance or (b) encouraged to achieve smart growth, flood risk mitigation, connectivity or environmental protection / restoration goals. The four zones are Wetland, Ecological, Transition and Community. Please refer to the Johns Island Chapter for more detailed recommendations and guidelines.

The City / County should immediately create a near-term plan to elevate evacuation routes and protect critical facilities / infrastructure on the Island. Planning should be based upon the likely water-level, storm frequency, precipitation amount and surge levels projected in 30 years. The City / County should build and expand the number of community (flood) evacuation centers on high ground for Island residents.

Update Johns Island Plan with a Regional Perspective

Revise or re-animate the existing Johns Island Community Plan, based upon new weather, water level and flood-risk information, to guide the Island's future. As a tactical matter, any development plan should include two- and- three-dimensional visual sections and cross sections so citizens and decisionmakers can understand surge, tidal and flood risks of development. Risk communication in the plan is key.

The City / County should develop an Island-wide watershed masterplan, from River Road and Maybank Highway in the east to Kiawah and Seabrook.

Maintain and Improve Overland Drainage

Do not further compromise overland drainage channels; ensure these channels are maintained. Infiltrate stormwater on the high ground and ridges. Low-lying areas provide crucial space for surface water storage.

Use Market-Based Tools

Market-based policies are especially relevant for Johns Island: stormwater credits, smart growth, transfer of development rights, conservation easements, green infrastructure incentives, etc. City Council should develop, legislate and adopt such tools as soon as possible.

Tidal Creek Outlet

Johnny Martin, Coastal/Hydraulic Engineer, Moffatt & Nichol

Storm Frequencies & Storm Surge Levels

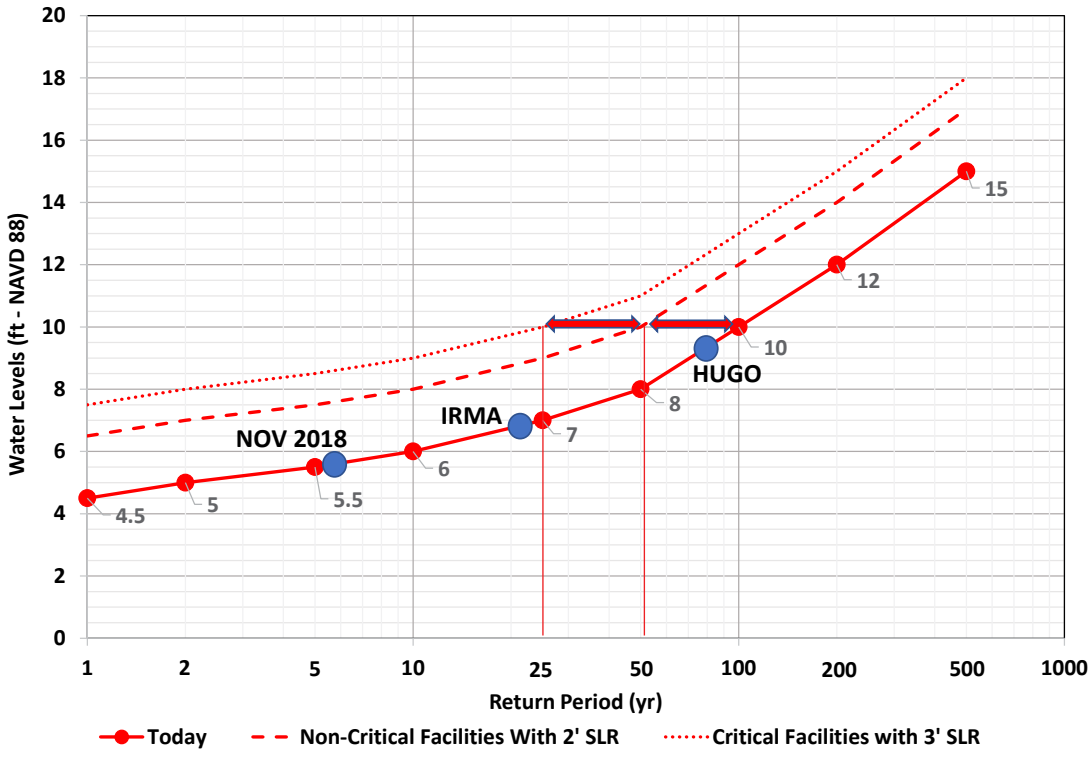
The community of Johns Island is currently largely undeveloped but is experiencing development pressures as the regional community is looking to provide a mix of housing stock including affordable homes as well as higher end properties. Given that the area is just on the verge of significant development pressure, the opportunity exists to develop smart planning tools to assist in determining the level/types of development that should be allowed within various elevation zones based on existing and future risk of flooding from storm surge. It should be noted that the graphs below only consider coastal storm surge flooding and that rainfall flooding should also be considered.

The solid red line on the graphic below outlines the current storm surge water levels vs. return period to show the coastal flooding risk to Johns Island based on current FEMA studies and measured water levels. The graphic also shows some historical events for perspective. For example, the peak water level experienced during Hurricane Hugo is currently estimated to be roughly an event that would happen on average once every 80 years.

The dashed and dotted lines demonstrate how under various sea level rise scenarios, a given water level will happen much more often than under current conditions (e.g. the 10ft water level shifts from having a return period of 100 years to a return period of 50 years). The 2 ft SLR scenario is currently being used for planning of non-critical facilities in the region while the 3 ft SLR scenario is currently being used for critical facilities.

The graphic on the right shows our teams initial recommendation of development zones to encourage safe development and keeping people out of harms way. The development zones consist of the “wet zone” (elevations between 0 to +6 ft NAVD), the “ecological zone” (elevations between +6 to +10 ft NAVD), the “transitional ecological zone” (elevations between +10 to +15 ft NAVD), and the “community zone” (elevations higher than +15 ft NAVD).

The team has designated land elevations below 6 ft NAVD to be in the “wet zone”. This zone is within the normal tide zone as well as up to the currently estimated water level that happens on average once every 10 years. Nonetheless,



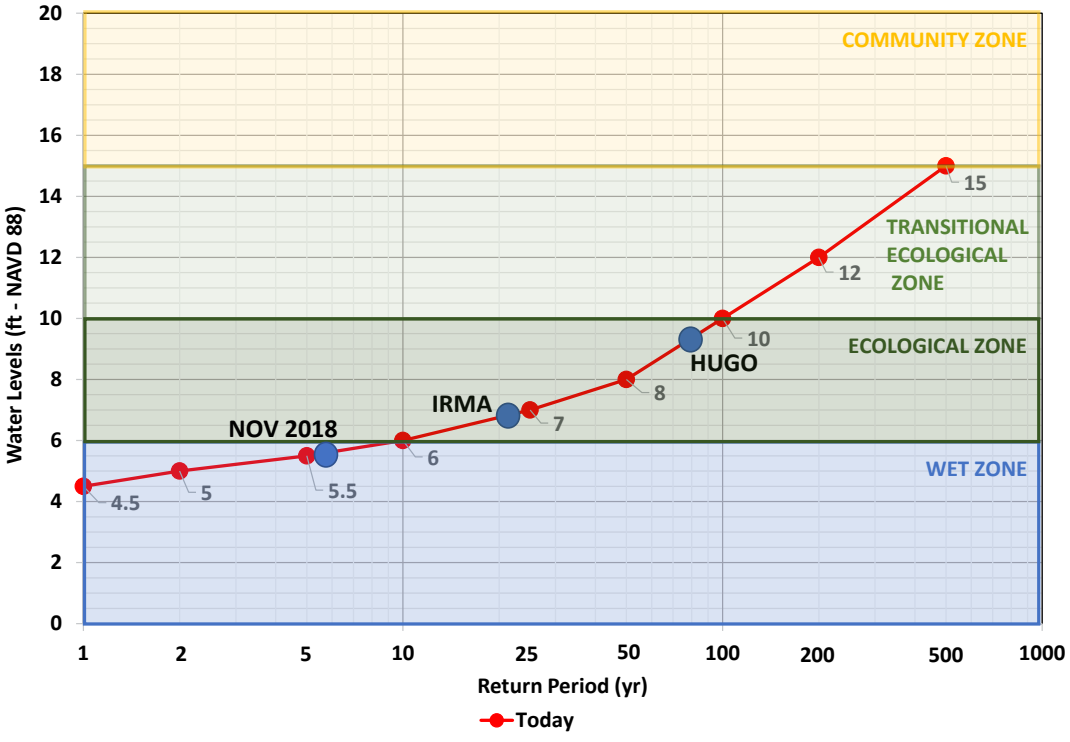
Water Levels for Johns Island (FEMA) vs. Return Period with Sea Level Rise

the recent behavior of king tides (shown on the graphic as the Nov 2018 event) demonstrates that these water levels can be experienced much more often than once every 10 years. Looking at the 2 ft and 3 ft SLR scenarios, the wet zone peak elevation of +6 ft NAVD will happen many times a year. For these reasons, no development is recommended to be allowed in this zone.

The ecological zone (denoted as land elevations between +6 to +10 ft NAVD) currently is estimated to be inundated during events that happen on average between once every 10 to 100 years. However, under the 2 ft and 3 ft SLR scenarios, these water levels will occur in this range from multiple times per year (elevations +6 to +7) to once every 25-50 years (elevation +10). For this reason, only limited development is recommended in this zone with elevated structures only being allowed.

The transitional ecological zone (denoted as land elevations between +10 to +15 ft NAVD) currently are estimated to be inundated during events that happen on average between once every 100 to 500 years. However, under the 2 ft and 3 ft SLR scenarios, these water levels will occur in this range from once every 25 to 50 years (elevations +10 to +11) to once every 100 to 300 years (elevations +14 to +15). For this reason, low-moderate development density is recommended in this zone with a mix of elevated and slab-on grade structures being allowed (depending on elevation).

The community zone (denoted as land elevations higher than +15 ft NAVD) currently is estimated to be inundated during events that happen on average every 500 years. However, under the 2 ft and 3 ft SLR scenarios, these water levels will occur from once every 200 to 500 years. For this reason, moderate to high development density is recommended in this zone with a mix of elevated and more slab-on grade structures being allowed.



Water Levels for Johns Island (FEMA) per Elevation Zones

Roelof Stuurman, Geohydrologist, Deltares

Water-Neutral Site Preparation

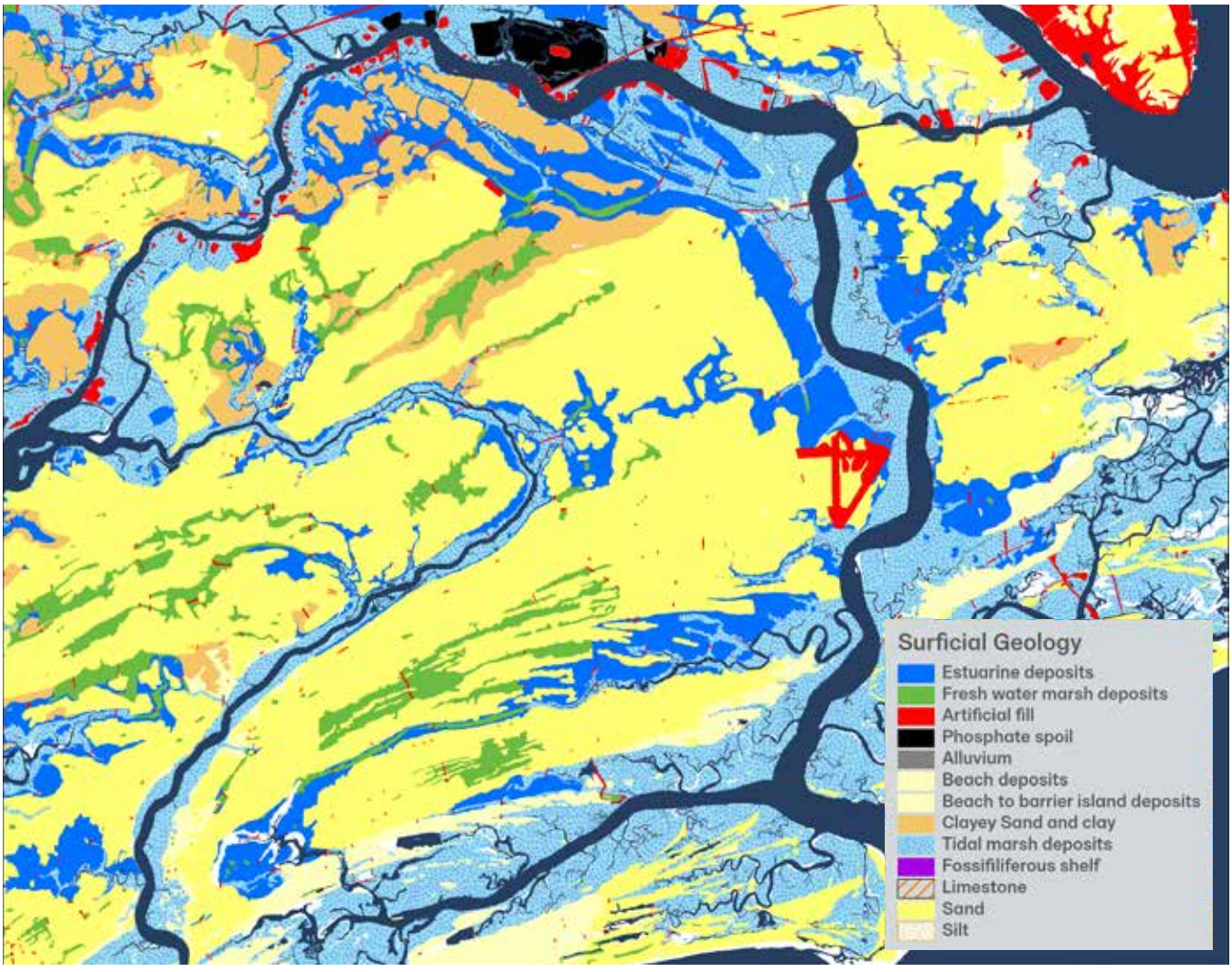
Most lowland soils are very old forest soils, developed over thousands of years. The top layer of this soil is an organic layer that acts, under natural circumstances, as a sponge. This sponge effect is improved by the natural forest morphology (less wind, relative high humidity).

Site development practices often remove, harm or destroy this organic layer, which in-turn creates ponding and fast storm drainage run-off. Lower layers of the organic soil column are unable to absorb intensive rainstorms, especially after dry periods.

A new development paradigm, one that would retain as much existing forest, soil and the organic top-layer as possible, is needed.

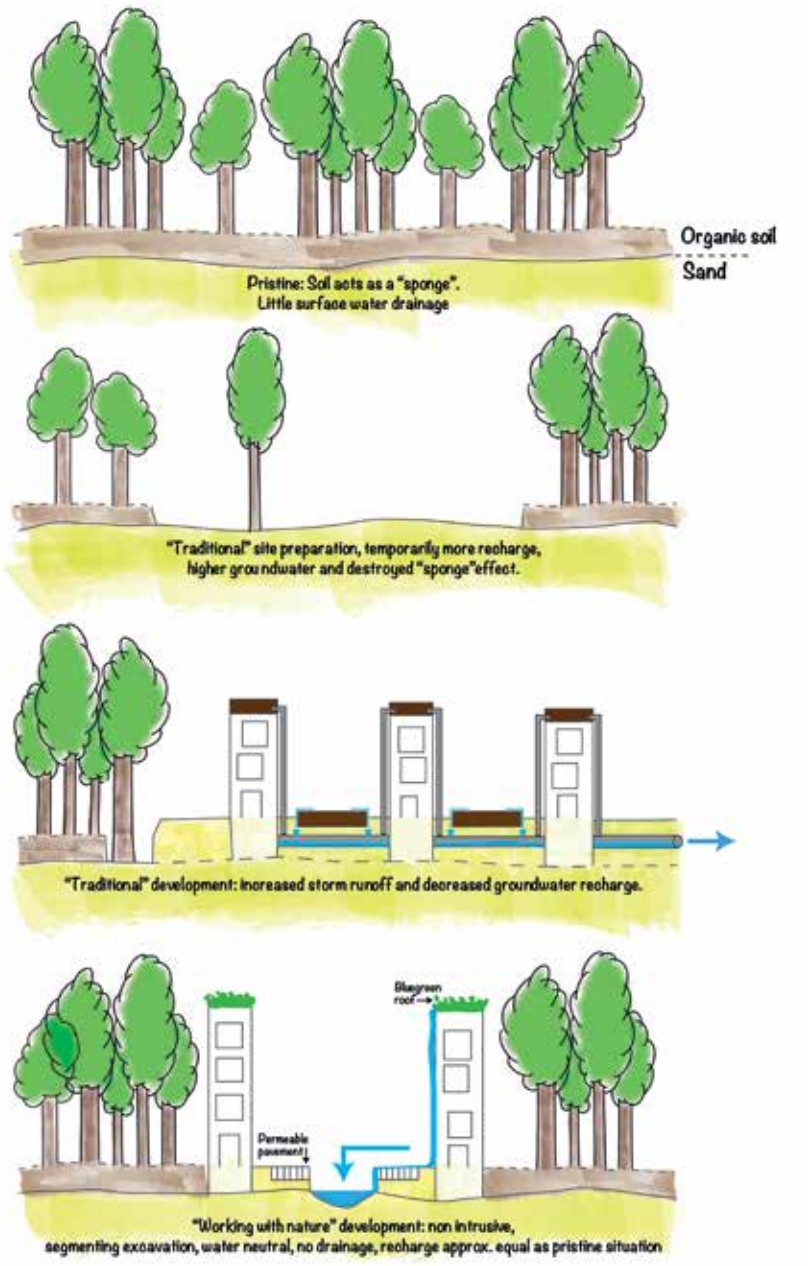
This should ensure that sites in which fill is used are in equilibrium with the existing soils. Additionally, site development should be "water neutral," in which surface water drainage and groundwater infiltration are, as much as possible, equal to the pre-development (pristine coastal forest) conditions. Sites should also be developed with future conditions in mind, including climate change and sea level rise.

Surficial (near surface) Geology
Sand lies just below the surface, and native topsoil encourages infiltration.



Valuable Soil

Right: Native topsoil is perfectly adapted to its wet environment, and should be preserved.



Johns Island Development

Below: Standard site clearing practices remove valuable native topsoil.
Credit: *Post & Courier*

Colleen McHugh, Dutch Dialogues Team

Conservation Easements

A conservation easement is a voluntary legal agreement that imposes permanent limitations to development on a privately-owned property for the purposes of preserving its ecological, recreational, scenic, agricultural, historical, and/or open space value. In exchange for preserving land as open space, the property owner may receive tax benefits, incentives, or monetary compensation.

Conservation easements may provide a useful adaptation tool for some areas of Charleston and other parts of coastal South Carolina facing sea level rise and other climate and flood related risks. Conservation easements could be used to prohibit development in all or part of properties that are at high risk of sea level rise and flooding or that serve critical ecological and water management functions. Such conservation easements could be tailored to meet adaptation goals for specific shoreline zones. For example, conservation easements could require a development setback or prohibit building in "Wet Zones." In "Transitional Zones," easements could stipulate partial conservation of forest lands and limits to impervious surfaces. Several states, such as Virginia and California, are exploring rolling conservation easements, the provisions of which would "roll" upland as sea level rises and the coast erodes, while allowing for certain activities in the near term. Such rolling easements could accommodate future risk as well as facilitate the migration of wetlands and other important ecological buffer zones.

Considerations

Conservation easements are enabled by state laws in all 50 states. The South Carolina Conservation Easement Act of 1991 provides specifications for the allowable purposes and holders of a conservation easement in the state. The South Carolina Conservation Bank and other land trusts are already successfully using conservation easements to conserve open land across the state.

Conservation easements are typically less expensive than outright land acquisition and may be more politically palatable than regulatory tools. They also provide a high degree of flexibility, allowing the property owner and

easement holder to tailor the terms to meet each party's specific goals for the land and to address current and future risk. However, this flexibility also comes with the potential drawback of creating a patchwork of preserved lands in areas with many different landholders. Therefore, conservation easements may be a more appropriate tool where larger land parcels are owned by fewer individual owners.

Case Study

The Maryland Department of Natural Resources (DNR) has proactively integrated climate change adaptation considerations into its conservation easement program, adding provisions to increase coastal ecosystem resilience and reduce vulnerability to coastal hazards. Maryland DNR used the first-ever Coastal Resilience Easement in 2013 to preserve 221 acres near the Blackwater National Wildlife Refuge, prohibiting development and protecting areas for wetland migration.

For more information

- Stanford Center for Ocean Solutions, Coastal Adaptation Policy Brief: Conservation Easements
- South Carolina Conservation Easement Act of 1991
- South Carolina Conservation Bank
- The Nature Conservancy: Conservation Easements
- Maryland's Coastal Zone Enhancement Plan: https://coast.noaa.gov/czm/enhancement/media/md309-2016.pdf

Rick Pruetz, FAICP

Transferable Development Rights (TDR) Primer

Transferable development rights (TDR) is a market-based way of implementing planning goals. Traditionally, TDR allows additional development potential in places where growth is wanted when developers pay for the reduction or elimination of development potential in places less suitable for growth. Most TDR programs preserve farmland, historic landmarks and a variety of environmentally-significant resources including wetlands, woodlands, habitat, steep slopes and coastal areas. Recently, jurisdictions are using TDR to promote compact communities capable of mitigating greenhouse gas emissions and adapting to wildfires, flooding, sea level rise and other growing hazards.

A local government spells out the mechanics of its TDR program within its adopted land use regulations. In a classic TDR code, the jurisdiction defines and/or maps the area where it wants less or no development, called the sending area, and those places where extra development is wanted, called the receiving area. Owners of sending and receiving area land are free to choose whether or not to take advantage of the TDR option offered by the dual zoning established by the TDR ordinance.

Sending area property owners who decline to participate can continue to use their land in accordance with the underlying zoning. However, if they choose to participate, these property owners typically record a conservation easement that permanently reduces on-site development potential but continues to allow whatever land uses are consistent with the program's goals. In many environmental programs, property owners often have the option of transferring ownership to a conservancy or public agency. In return for recording easements or transferring title to sending sites, the participating property owners are issued a commodity called transferable development rights, or TDRs, which they sell to developers in the receiving areas. Compensation from the sale of these TDRs motivates sending site owners to voluntarily participate.

Developers of receiving area property also have a choice. The ordinance allows a prescribed amount of development potential for developers who decline the TDR option.

West Ashley Park
Additions to the park were created through deals similar to TDRs

However, developers can choose to exceed this baseline by buying TDRs from sending area property owners. When a TDR program works, the extra development potential made possible by TDR generates sufficient additional revenue to motivate developers.

Although the logic is simple, TDR is more complex than traditional zoning and requires observance of important success factors. For example, developers must want to exceed baseline levels of development or they will have no reason to buy TDRs. Similarly, the TDR ordinance must be capable of producing a TDR value that is attractive to buyers and sellers. If TDRs cost too much, receiving area developers will not buy them and if sending area property owners do not feel adequately compensated, they will not sell TDRs. TDR ordinances can create a viable market by adjusting the number of TDRs available to sending sites and/or the additional development allowed per TDR to receiving sites. Consequently, by paying attention to local real estate economics, jurisdictions can create TDR programs that achieve important community goals at little public expense.

Rick Pruetz, FAICP, is a researcher and planning consultant who has studied TDR for decades.
Email: rickpruetz@outlook.com
Website: www.SmartPreservation.net

Church Creek

> “We all like to live near the water, if it is safe.”

Robbert de Koning
Robbert de Koning Landscape Architects

Contributors
Robbert de Koning, Joshua Robinson, Lauren Grimley, Lex Agnew, Mandi Herring, Donald del Cid, Ryan Smith, David Wood, Erin Stevens, Bill Whalen, Mark Wilbert, Eric Pohlman, Diane Perkins, Nolan Williams

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3' Sea Level Rise

DFIRM

coastal floodzone, floodway

100 year floodplain

500 year floodplain

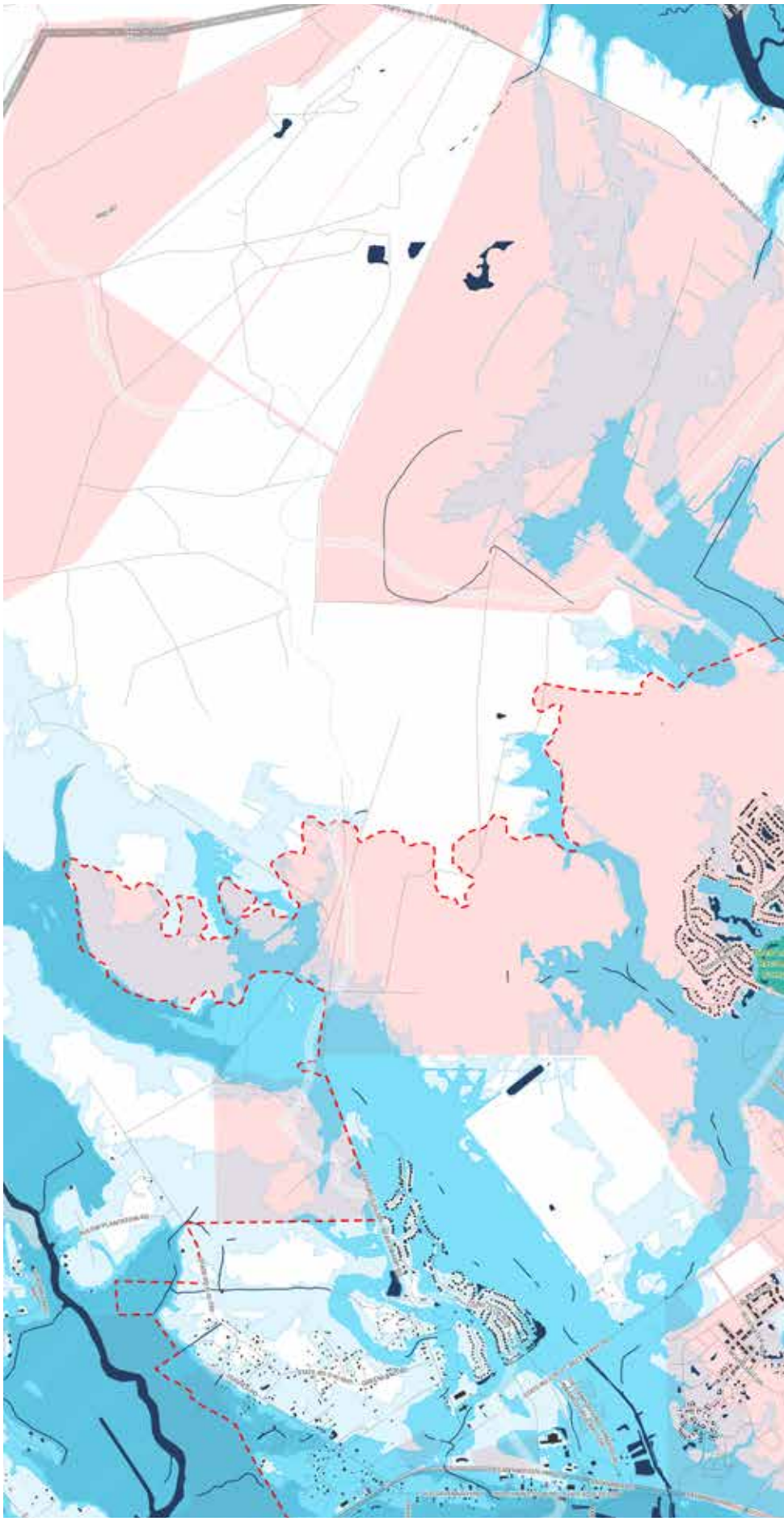
ROADS RAIL

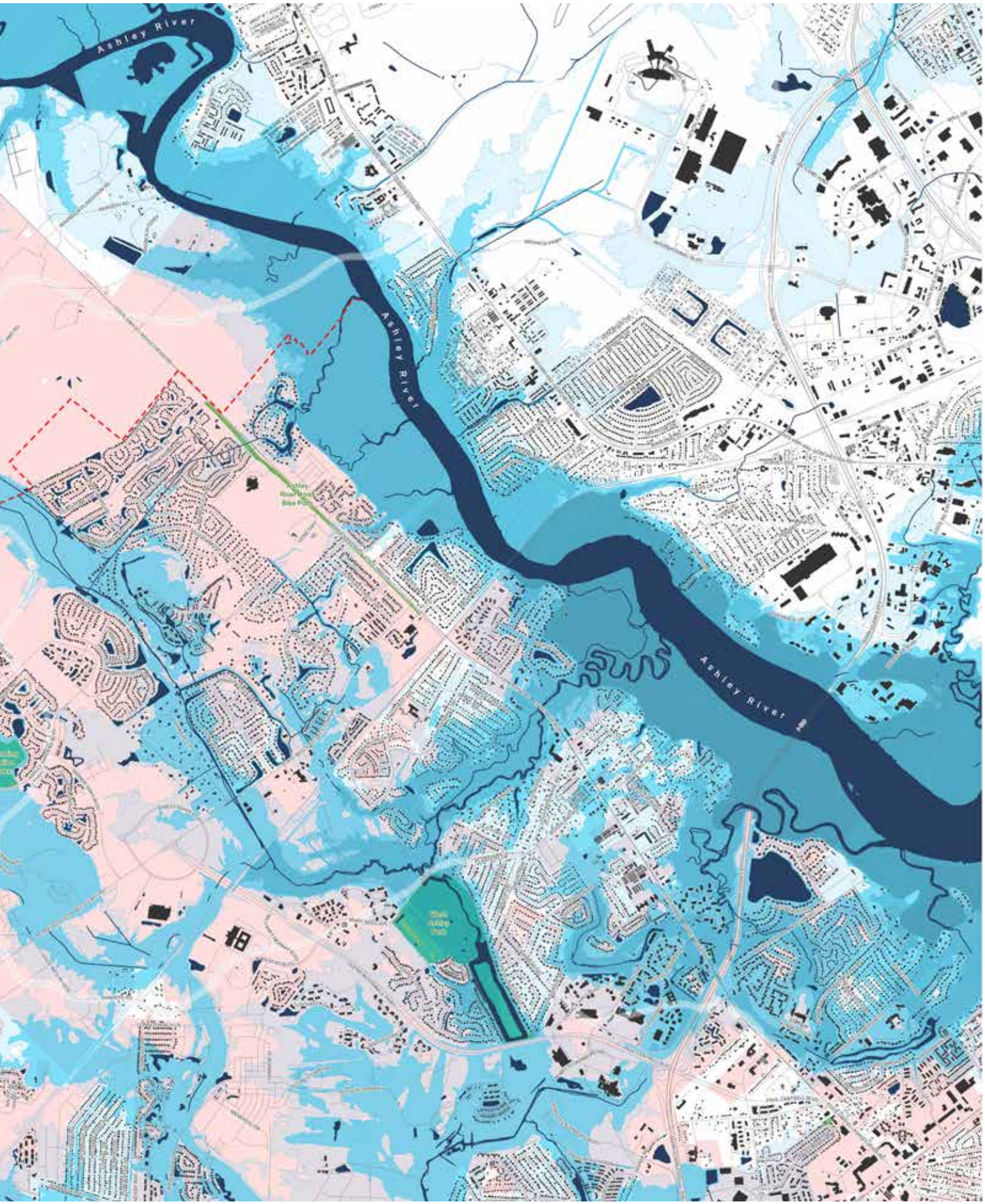
Rail

Road

major

minor




Ashley River
Ashley River
Ashley River

Church Creek Elevation

LEGEND

Topography 0'-30'

- ≤30
- ≤28
- ≤26
- ≤24
- ≤22
- ≤20
- ≤18
- ≤16
- ≤14
- ≤12
- ≤10
- ≤8
- ≤6
- ≤4
- ≤2

Bathymetry

- ≤0
- ≤-5
- ≤-10
- ≤-15
- ≤-20
- ≤-25
- ≤-30
- ≤-35
- ≤-40
- ≤-45
- ≤-50
- ≤-55
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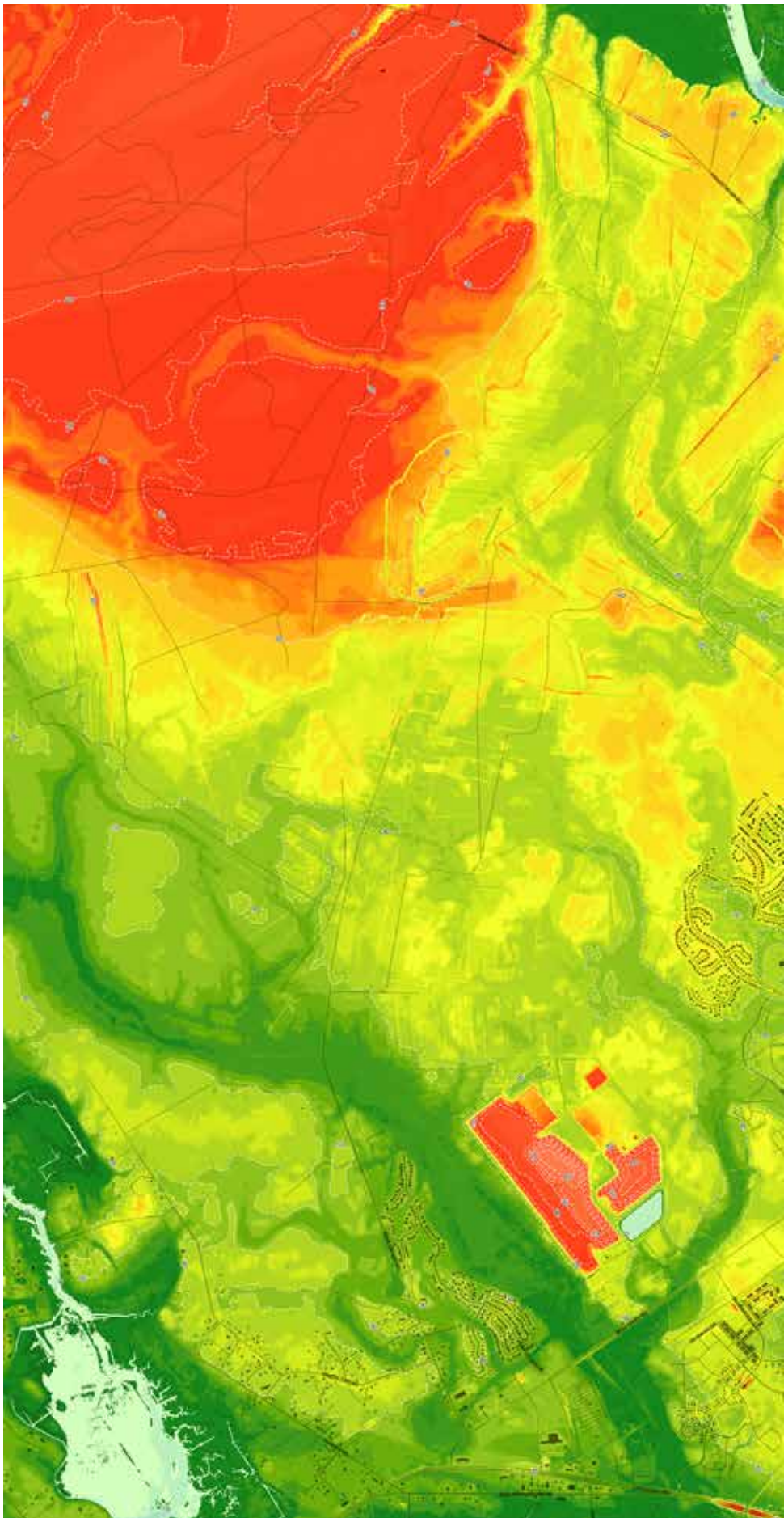
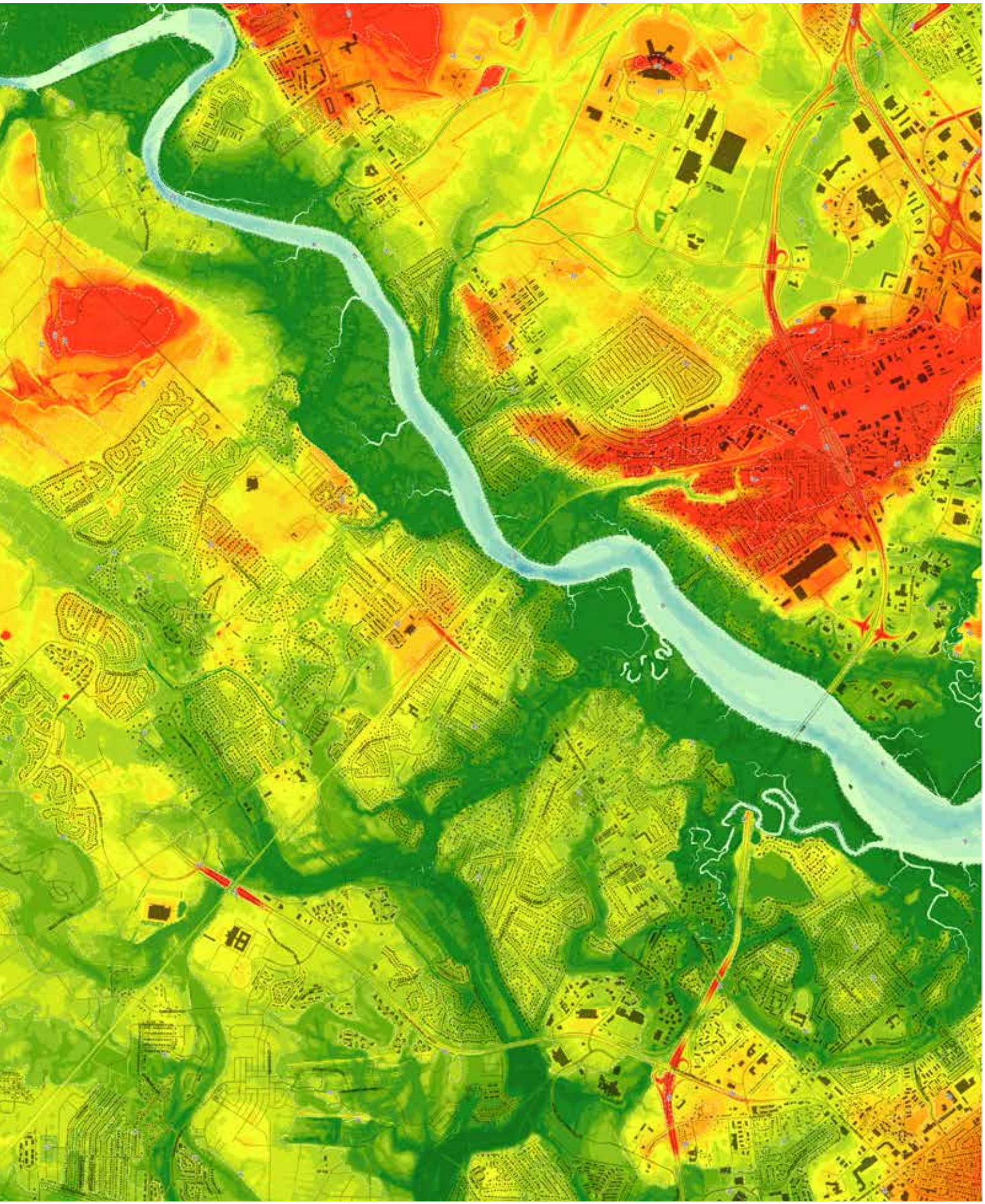
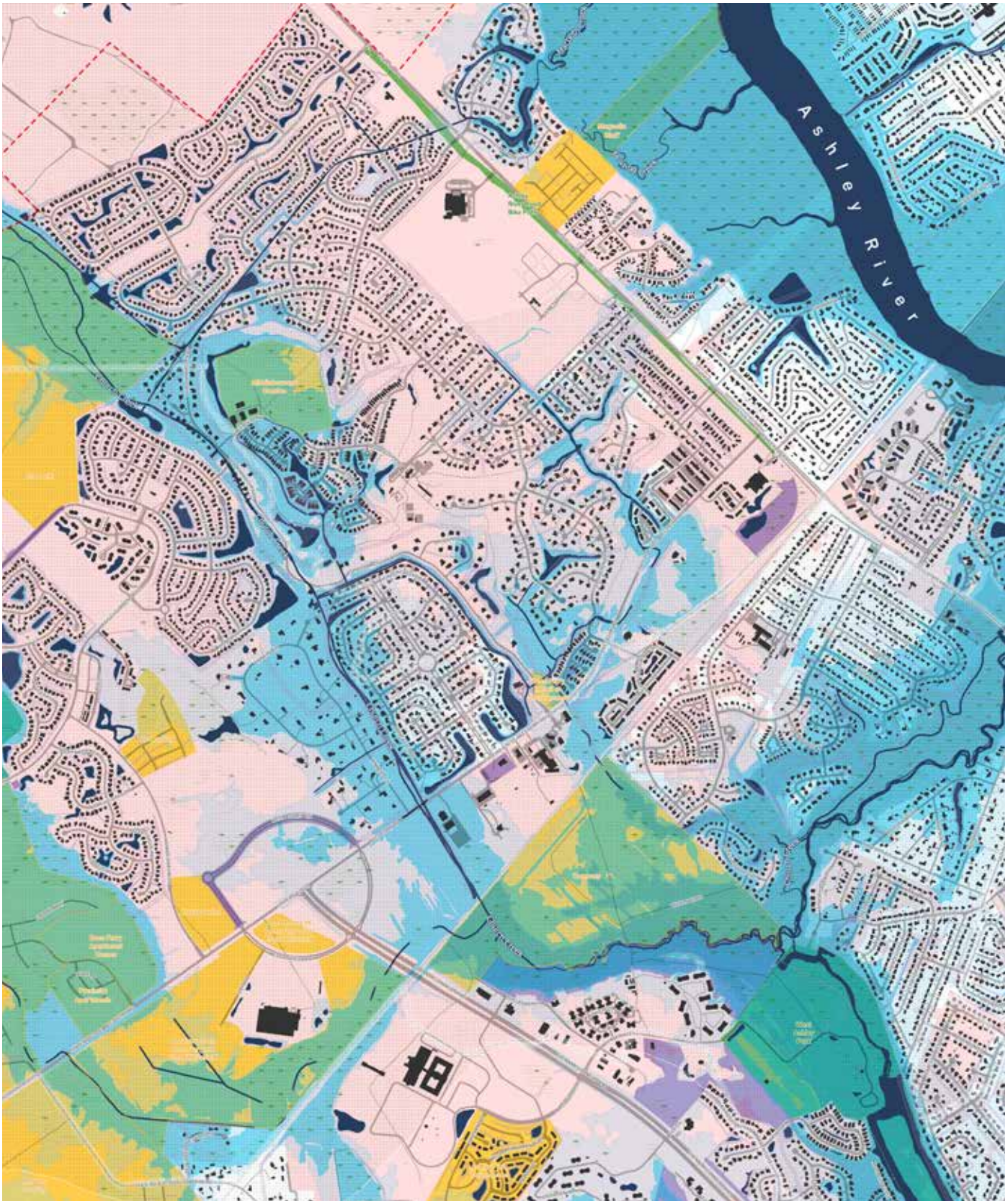
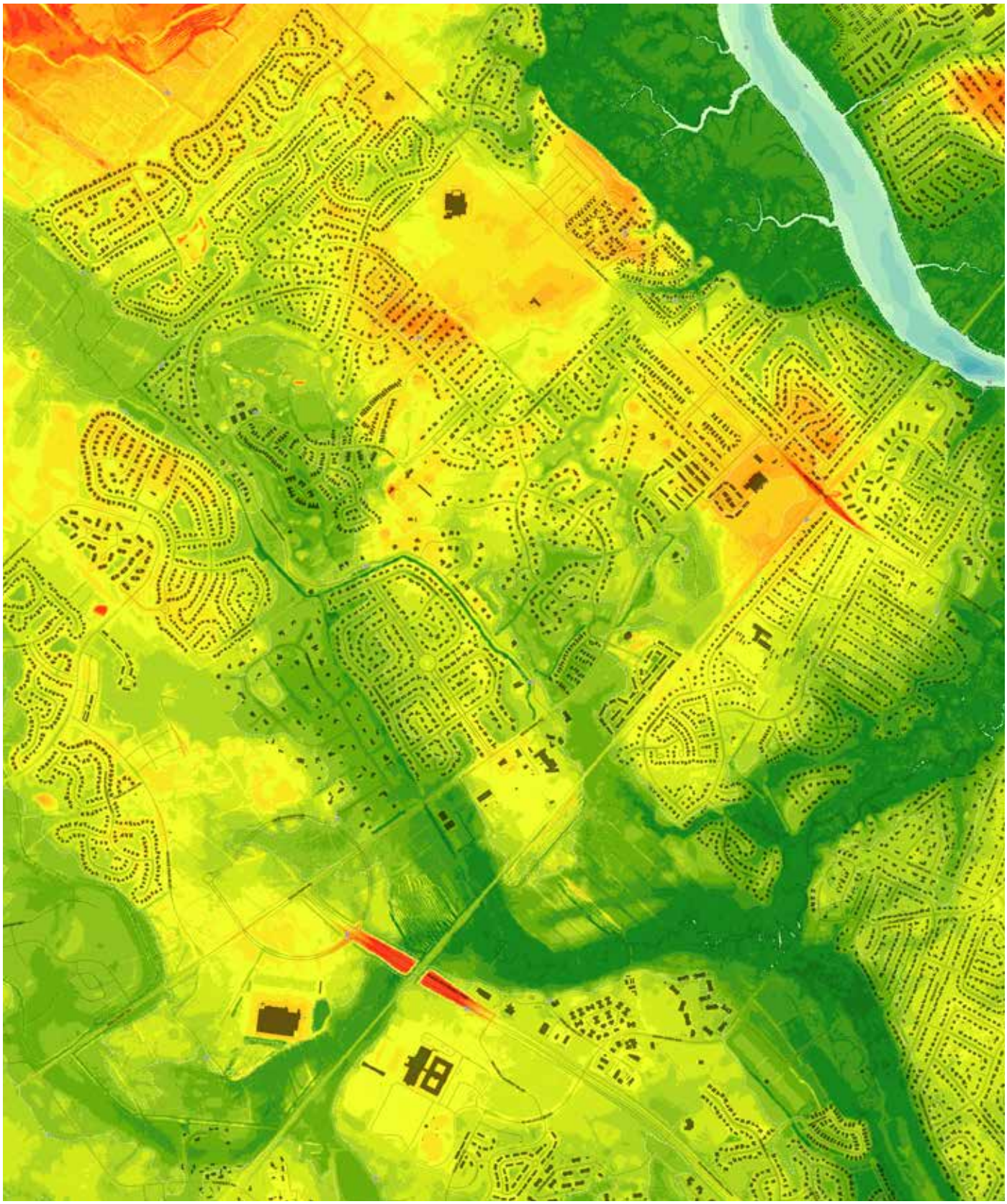
- ≤-70
- ≤-75
- ≤-80







Floodplain and Development
Floodplain is the light blue overlay and development sites are the yellow parcels



Elevation
Green is the lower ground, red is the higher ground. Striations are typically where phosphate mining occurred (southeast of West Ashley Circle is an example of that pattern)

Church Creek

Landscape Context

The West Ashley / Church Creek area, unlike Johns Island or the Peninsula, is upland (but still low-lying), upstream, and influenced by fluvial conditions more than coastal ones. Ecologically, Church Creek and much of West Ashley is a water basin. The sponge-like functioning of the basin is compromised by constraints upon its water systems and by land-use and development patterns. **While Church Creek is lower in elevation than both Johns Island and the Peninsula, the issues of hurricane storm surge and sea level rise are less urgent here**.

Before human settlement, Church Creek was a sinuous waterway that had multiple branches and outlets. It was reminiscent to the nearby Angel Oak tree, with its vascular system that spreads out in a multitude of winding paths. Just as the Angel Oak gives life, form and energy to Johns Island, the long forgotten Church Creek landscape provides the same for West Ashley. The Creek's natural functions are needed to restore health, safety and balance to the Ashley and Stono River watersheds. Ignore these, and more flood disruption and devastation along these floodplains will occur.

The Church Creek basin has been irreparably shaped by human activity. The basin, once a lowland swamp between the Stono and the Ashley Rivers, was first drained for rice cultivation. The second wave of alteration came after the Civil War when it was further drained and cleared for phosphate mining. After phosphate extraction had subsided, the basin became a suburb. The system of ditches that drained the swamp became the drainage system for neighborhoods. The remaining swamp was developed, constricting an already unnatural drainage system.

North of the railroad, Church Creek is now entirely artificial, a man-made ditch that runs behind backyards, under culverts and through the old phosphate mines. This section suffers the worst flooding. Culverts constrict flow and homes are built directly along channels and old creek beds. **South of the railroad the creek is tidal and still largely natural.** Flood risk in this lower zone stems primarily from tidal impacts.

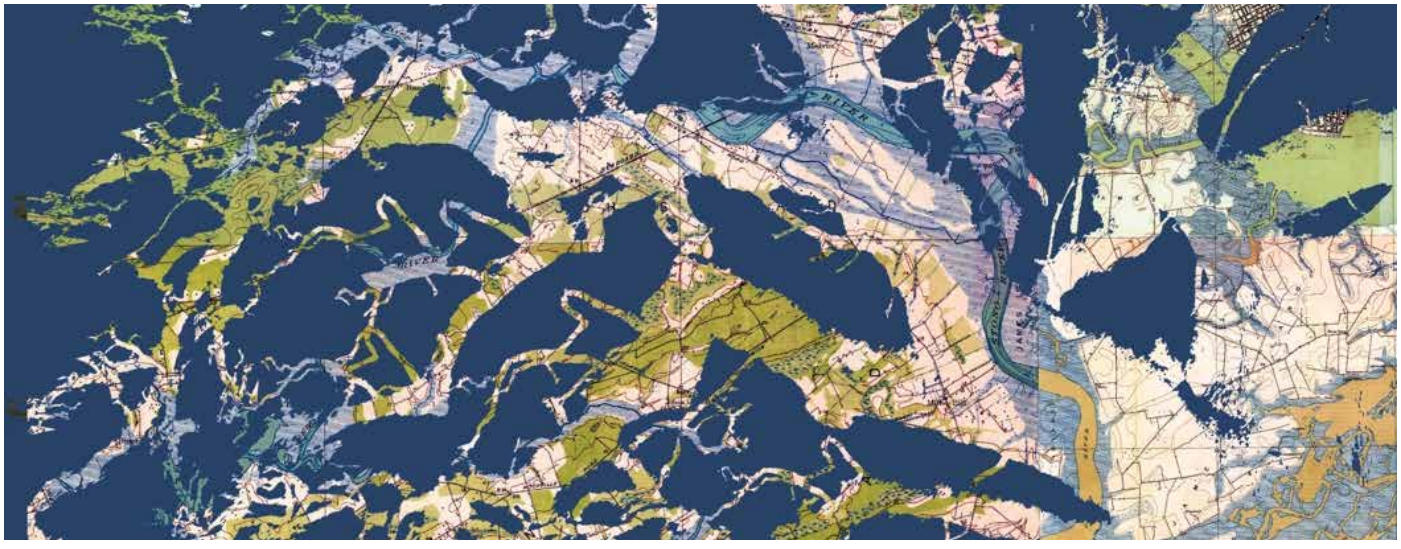
Development in the Basin

The flood challenge in Church Creek is partly about the water system and partly about occupation and land-use planning. Development pressure is high and most of the remaining developable space in the basin will be built out soon. Most of the basin is incredibly low in elevation. Homes in the floodplain may be only slightly lower than homes outside of it. Homes along the tidal portion of the creek are at an additional risk from tides and sea level rise. Neighborhoods' ability to store water is challenged. Even as developmental regulations become more strict, existing homes retain substantial tidal flooding and stormwater risks.

There are things to embrace and things to change in the Church Creek basin. The tidal landscape can be used to accrete land and resilient waterfront development. The retrofitted creek, and the historical phosphate mines, must become functioning pieces of a basin-wide stormwater system. New, elevated homes have limited some flood risk but are disconnected from each other and the landscape. Without water and development working together problems are often transferred downstream.

1919 USGS Map of Church Creek

Angel Oak



Vascular systems found at multiple scales in nature

Tidal Landscape
At the mouth of the creek the floodplain widens and becomes tidally influenced.

Retrofitted Creek
Large portions of the creek were artificially created over the last 150 years.

Constricted Flow
Originally the creek was connected to the Stono River, but the connection is currently blocked by a dam constructed for phosphate mining.

Historic Phosphate Mine Spoil
The upper Church Creek Basin has been significantly altered by phosphate mining beginning around the end of the Civil War.

Shadowmoss Buyout Properties
Recently, homes within the floodplain were purchased and demolished by FEMA.

Bees Ferry Road
One of the significant bottlenecks in the Creek's drainage.

Upper Church Creek Development
Development along the upper portion of the creek constricts it's flow.

Low Homes in the Lower Basin
New slab-on-grade developments near the mouth of the creek.

Flooding at Bees Ferry Road and Church Creek Intersection
Crosstowne Church (pictured) has flooded multiple times in the last 5 years.

Working With Nature

The Church Creek Team pursued an ecological planning approach combined with an integrated understanding of the water system that embraces the neighborhood's environmental, historic, and cultural landscapes.

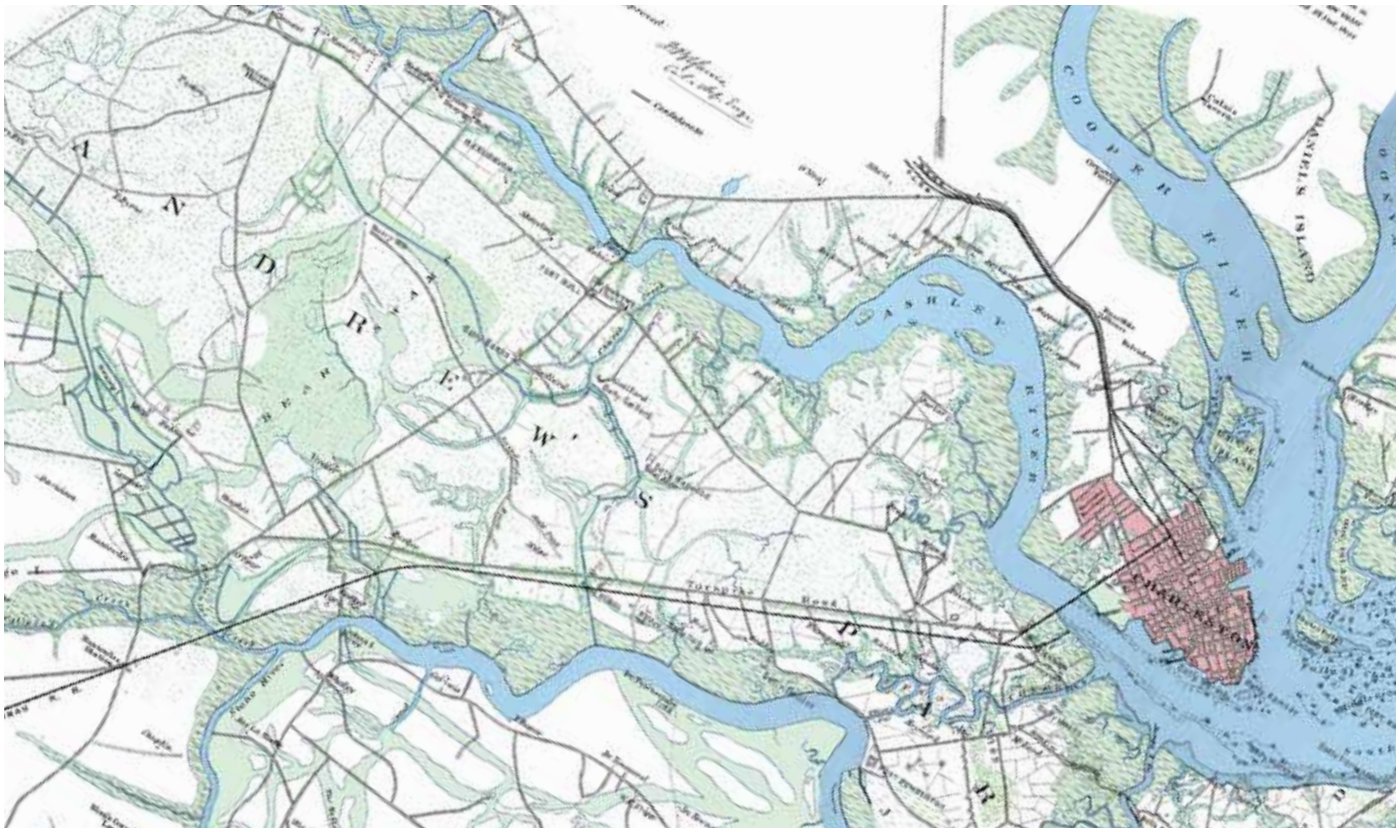
In both natural and engineered water systems, we are confronted with the force and energy of water. When you fight force with force, you often lose. **We thus recommend a strategy borrowed from the martial arts**: to "stop the boxing" and instead **embrace natural forces**, using Judo-like techniques to harness and redirect water to manage challenges and **strengthen the functions of the landscape**.

Looking beyond Church Creek to the wider West Ashley system, the area used to be one large basin (or sponge), with the wetlands, marshes, creeks, and tidal floodplains connected to the Ashley and Stono Rivers. While that system has been irreparably lost, the new system must restore its function. The retrofitted ditch becomes a system of flexible floodplains. The old phosphate mine is restored to a swamp, holding water instead of needlessly shedding runoff into neighborhoods downstream. Lake Dotterer at West Ashley Park gets safely reconnected to Church Creek and to the Stono River. **Mimicking the natural systems builds a robust retain-store-drain flood mitigation strategy**.

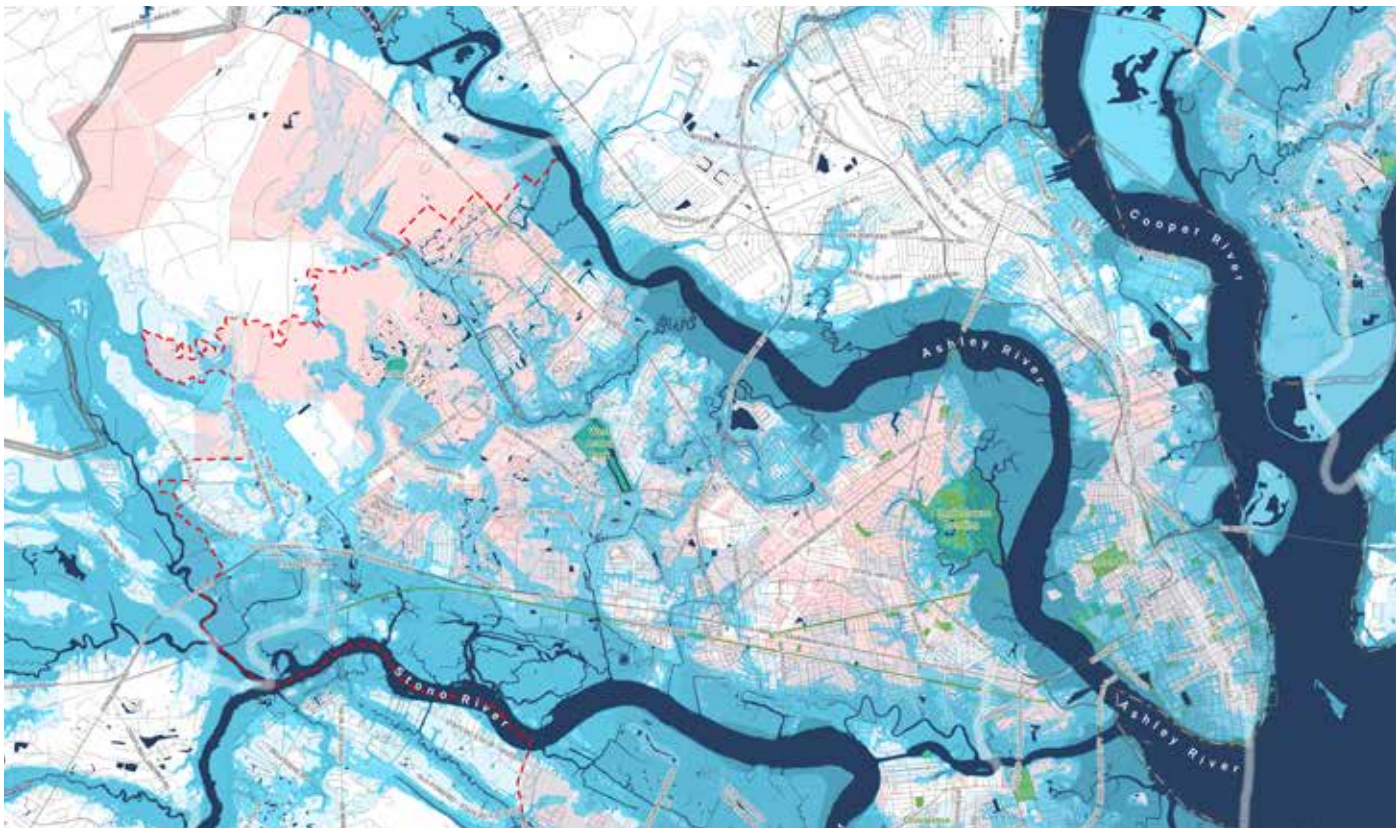
Pre-Development
The basin is a sponge, water can flow in a multitude of directions.

Early Development
Swamp is drained for mining, waterways become disconnected and channelized.

Present Condition
Much of the remaining swamp is developed, constricting drainage.



1863 Map of Charleston
Church Creek basin is labeled "Bear Swamp."
Image Credit: USGS

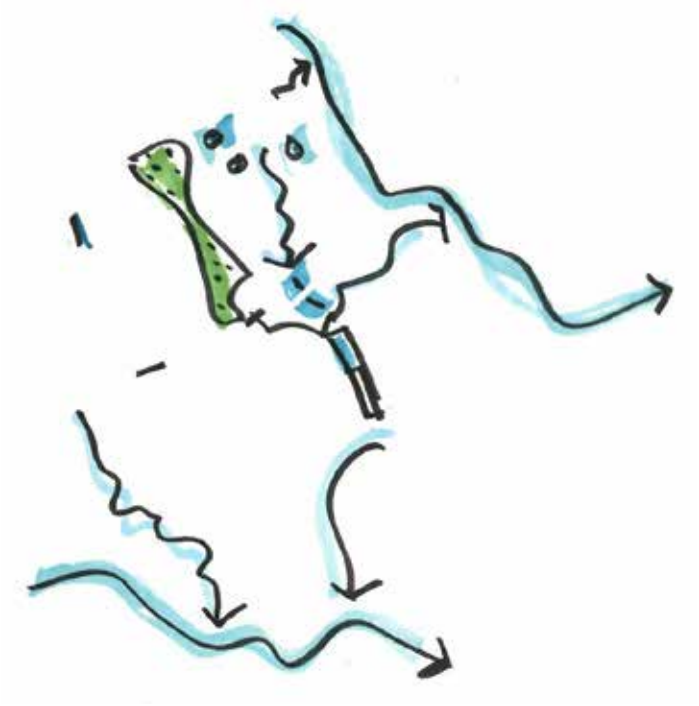


Present Day Map of Charleston
Much of what was swamp is now floodplain.

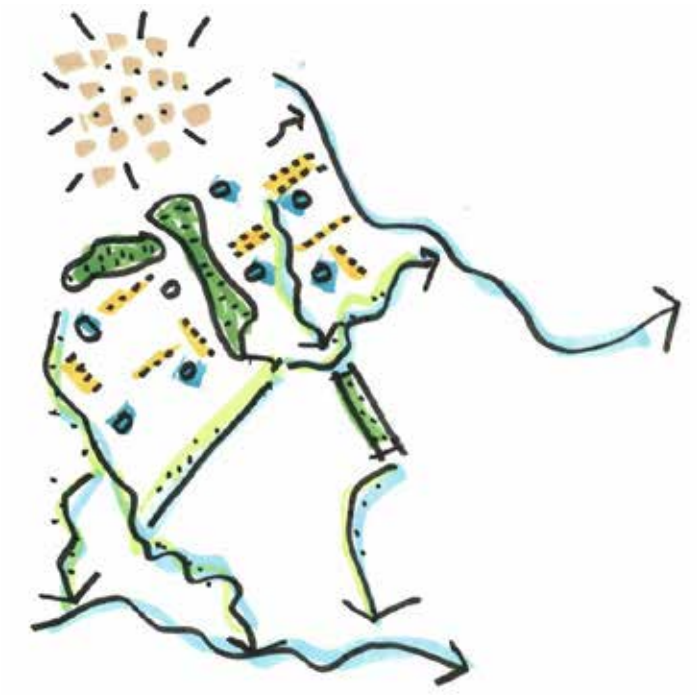
Retain, Store, Drain

An integrated Church Creek water system will retain and store water. **Retain water on high ground wherever possible and infiltrate that water into the soils and groundwater system**. New development should be required to store 100% of its water assignment, possibly through an incremental approach. Space for water via in-line detention and retention must become more robust. Flood plains and intertidal zones naturally grow and shrink to accommodate varying levels of water in wet and dry periods, and those in the Church Creek water system must be given space to do so. **When the water system is full it must enable efficient downstream discharge**. This may require buyouts or enactment of targeted development restrictions. During the Colloquium, citizens asked if "restoring the past would help secure the future?" Retain – Store – Drain is a way to do that.

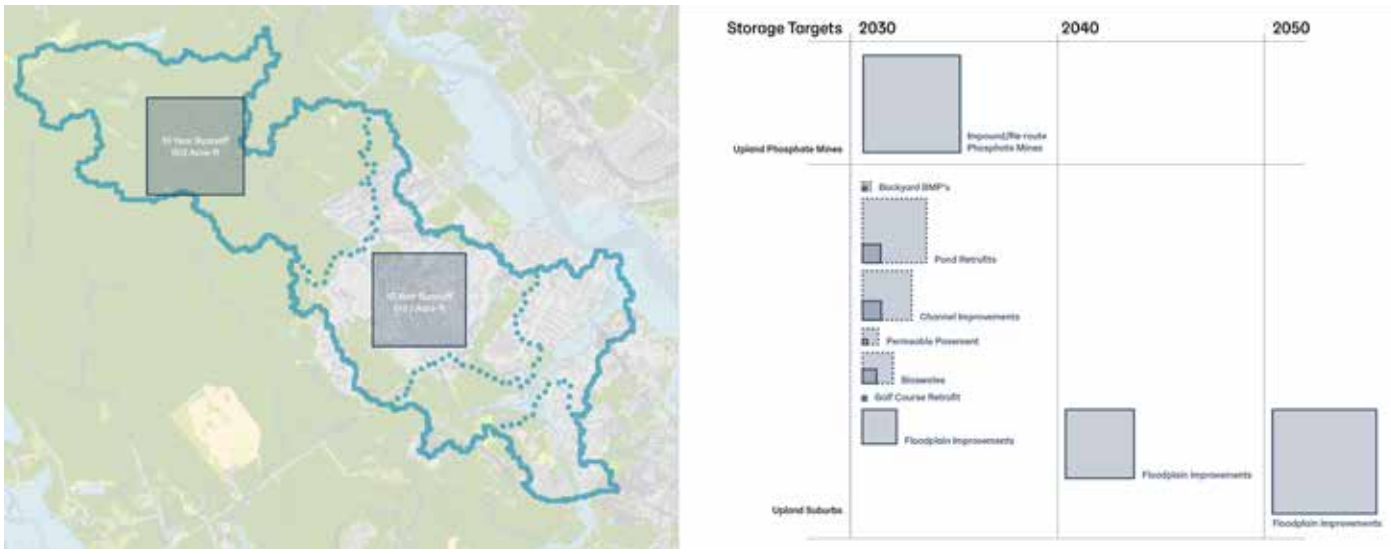
Pursuant to a water plan, the City should develop a water assignment toolbox specific to Church Creek / West Ashley. This plan and toolbox – with regulatory support – would (a) assess and quantify and (b) highlight for citizens and developers how the various floodplain improvements, pond retrofits, discharge enhancements, bioswales, blue and green networks achieve the critical water assignment.



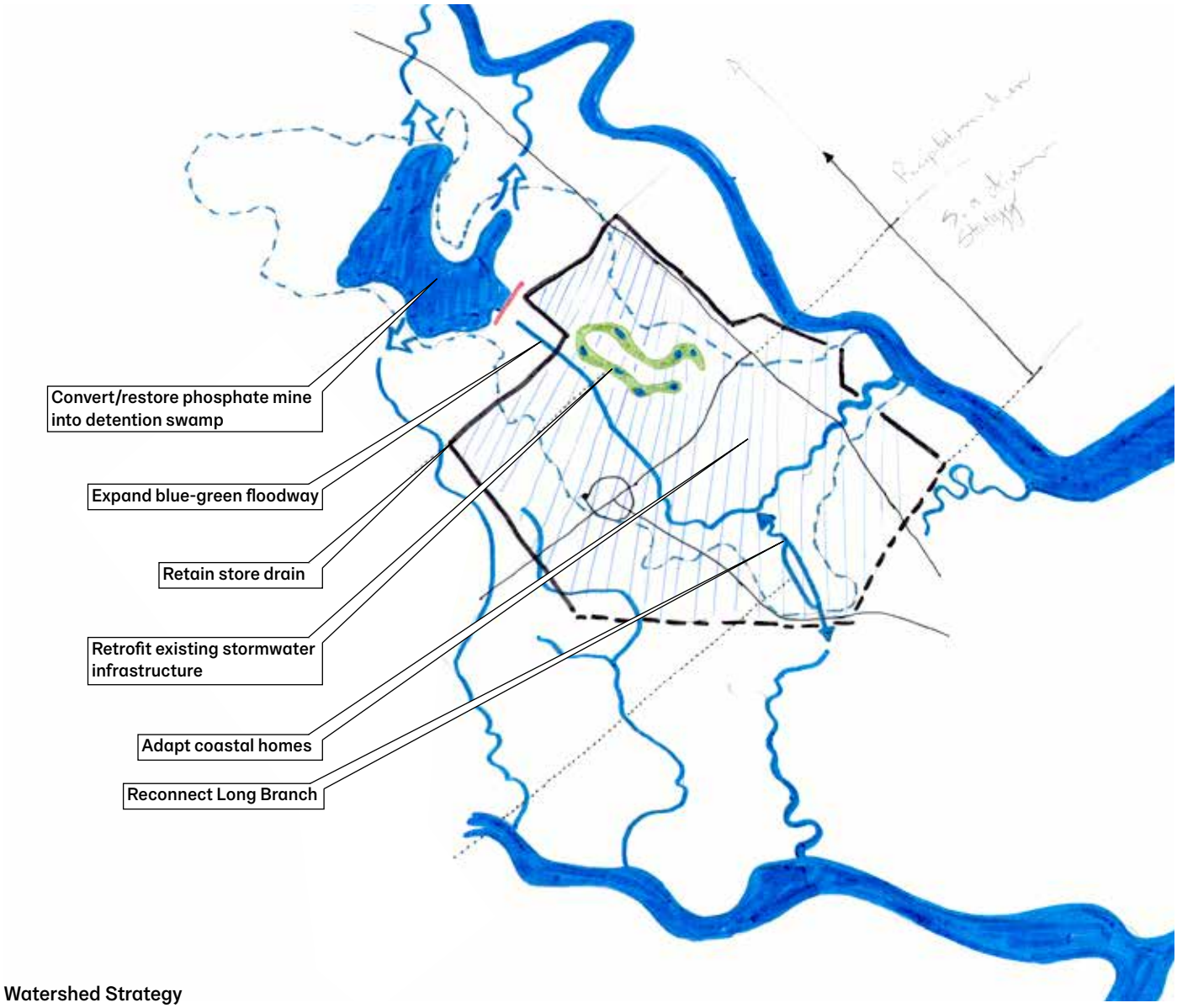
Present Condition
Limited storage, disconnected flow, constricted waterways



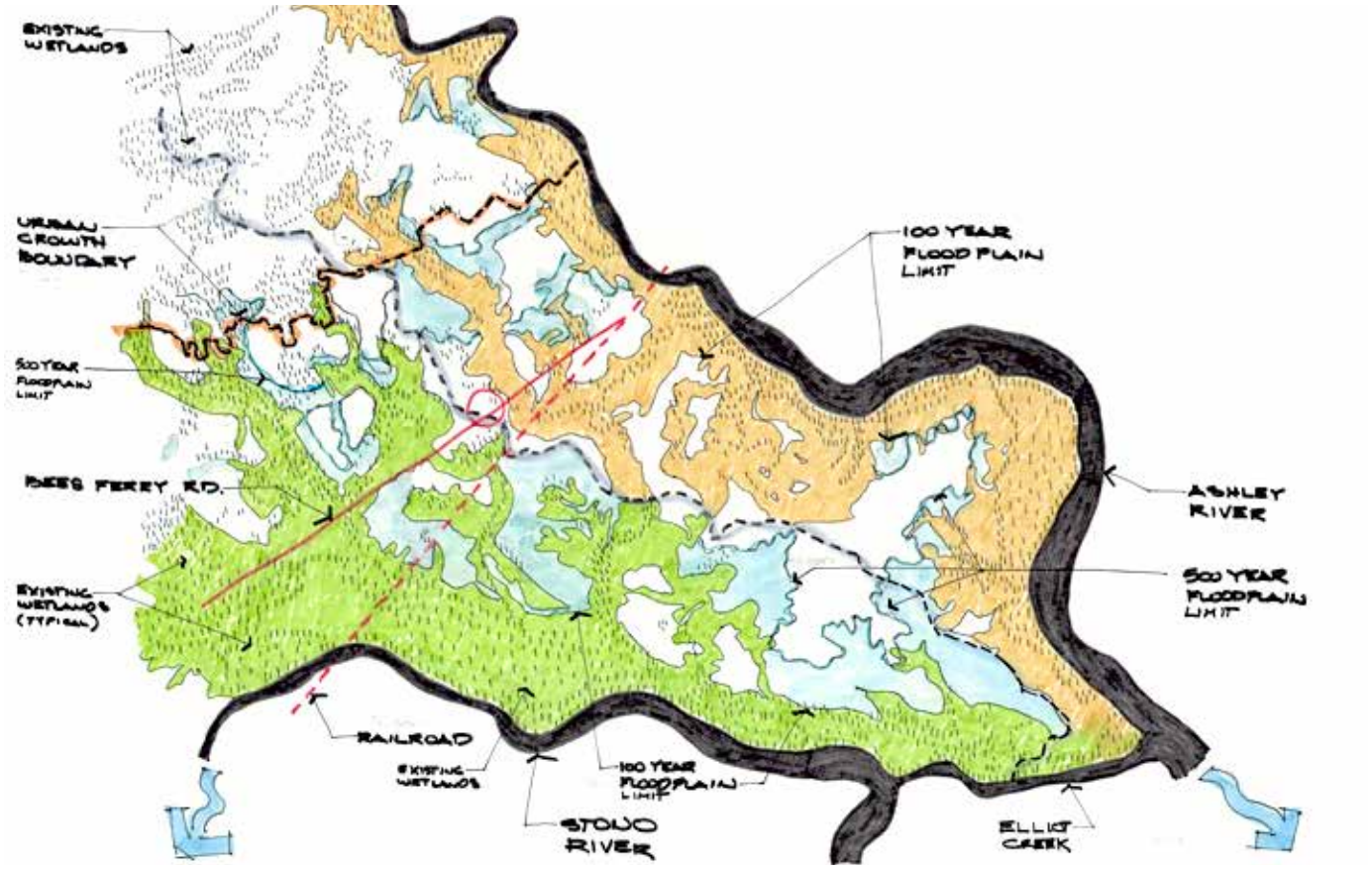
Proposed Condition
More Storage, interconnected and flexible flow, enlarged floodplain



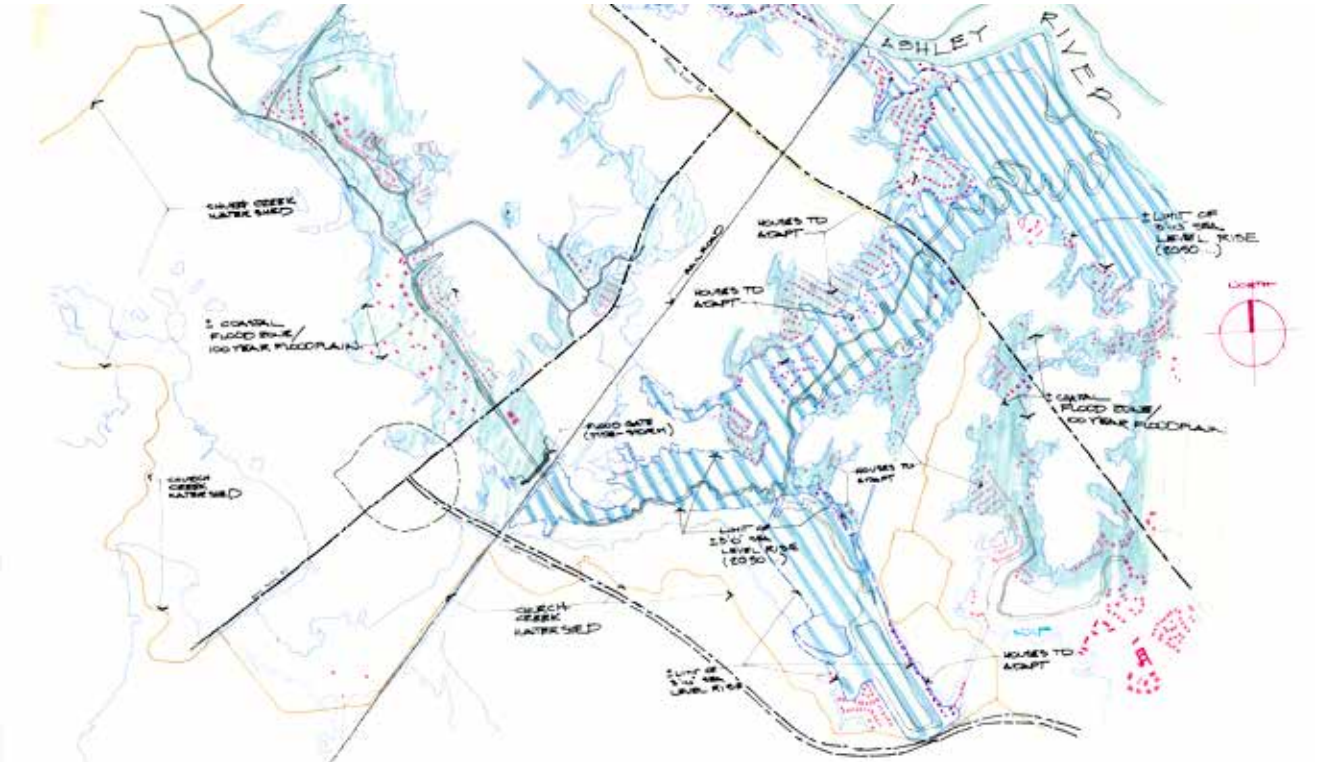
Water Assignment Toolbox
Preliminary rubric for evaluating retain store drain tactics developed in the workshop.



Watershed Strategy

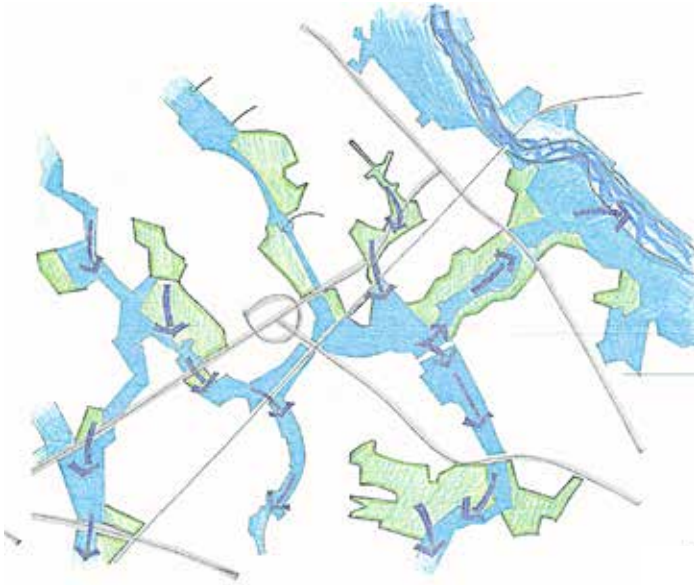


Floodplains
Orange flows into the Ashley River, green flows into the Stono River.



Homes in Risk Zones
There are over 700 homes in the Church Creek basin floodplain.

Present Floodway: Constricted Disconnected



Proposed Floodway: Expanded Interconnected Flexible

Flowing to the Ashley River

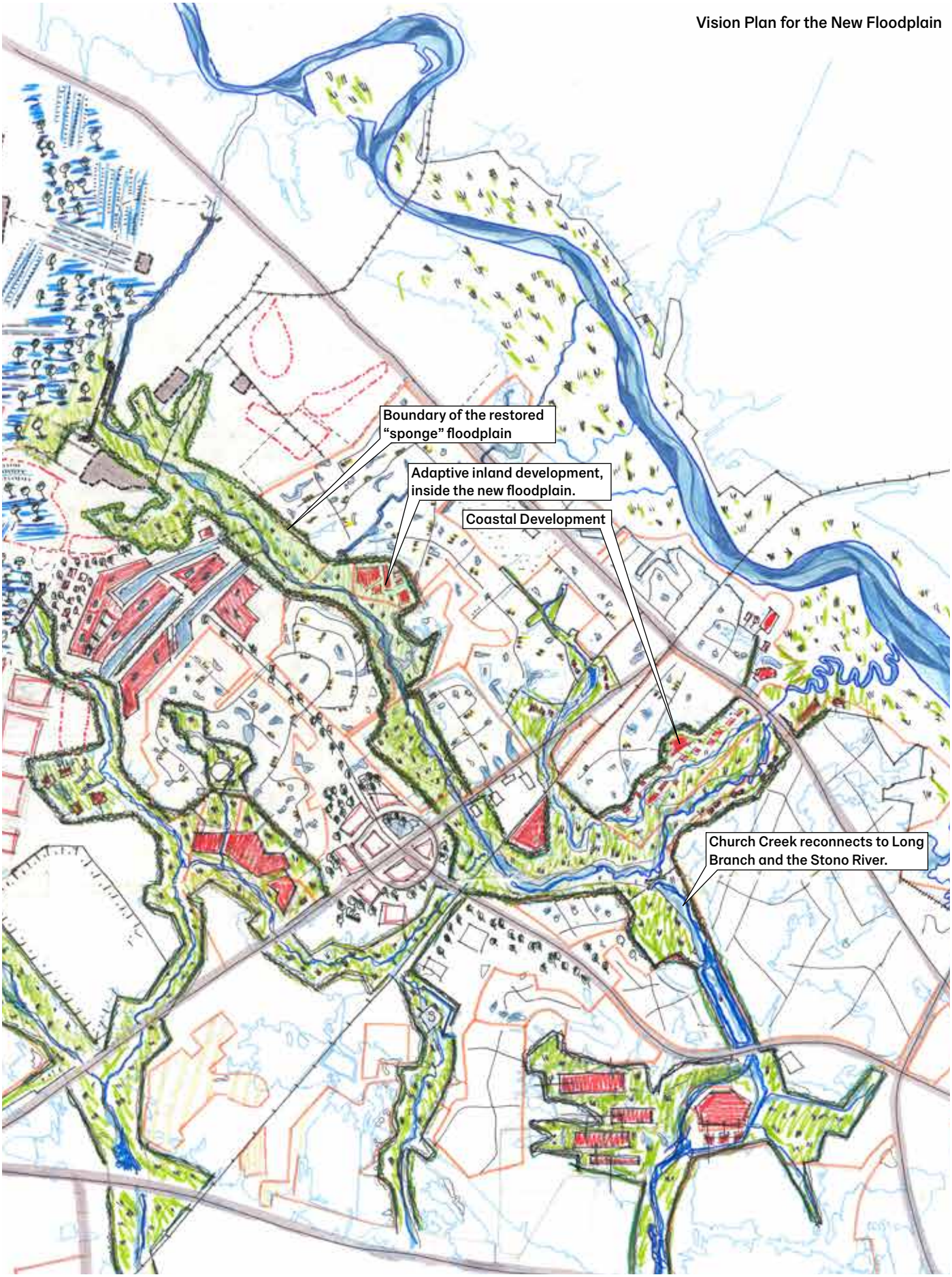
Flowing to the Stono River

Expanded Flexible Floodway

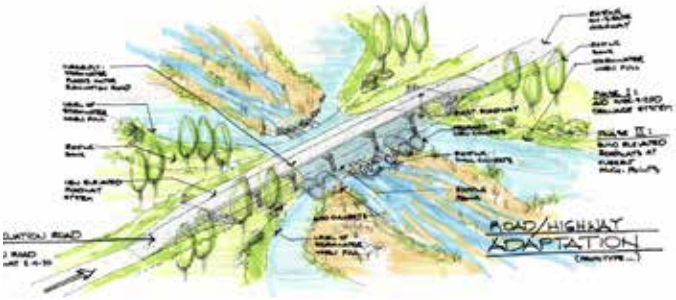
This area already has a legacy blue-green system—almost an afterthought, residual to overall development patterns and sorely constrained. To improve discharge flexibility, the blue-green system could be restored to enable outflows to both the Ashley and Stono Rivers, most likely as it functioned in the past. This watershed systems approach should identify and create more places to detain, infiltrate, distribute and discharge the water. **Adding coherence, flexibility and an expansion of the existing blue-green system is a retrofit of development—not its repudiation**.

Enlarging water system capacity via greener, more natural and flexible floodplains would reduce flooding. Some housing patterns and occupation would have to adapt. Many homes built before stronger regulation was instituted are most at risk. Adaptation to housing patterns can be done safely, in tailored and financially responsible ways, over time and through effective planning and communication.

Vision Plan for the New Floodplain



Inland Development

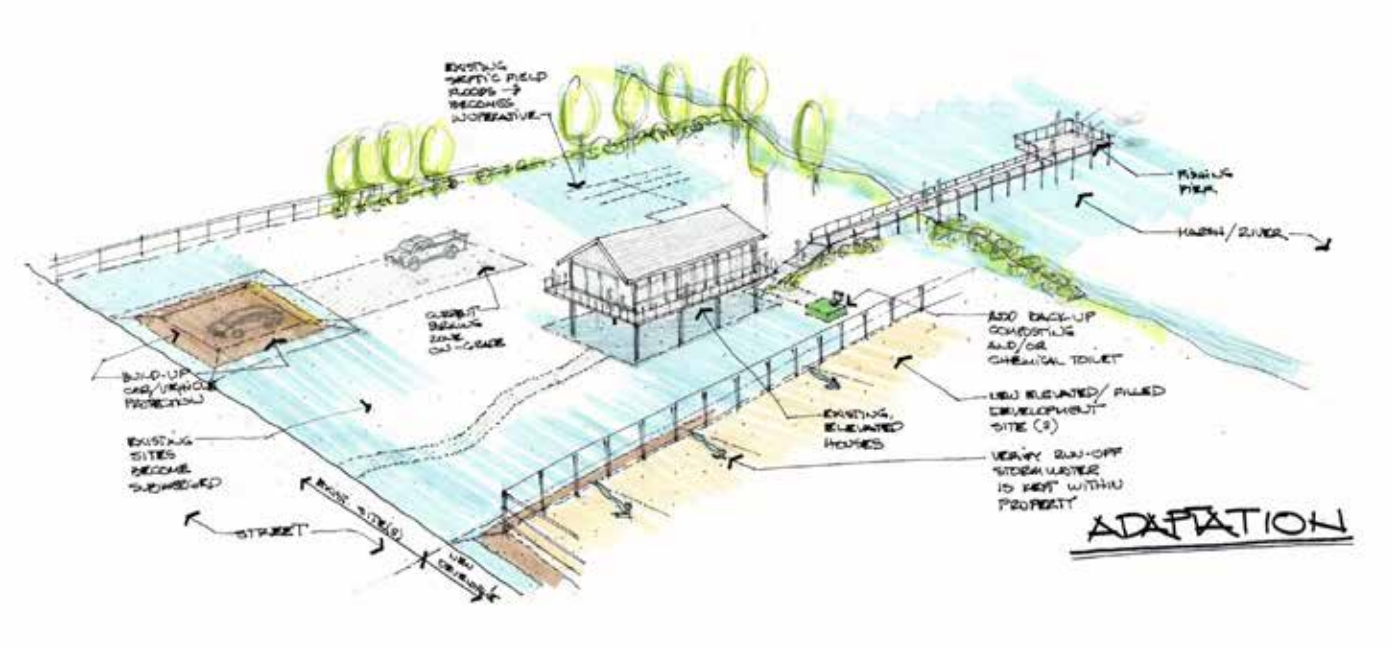


Retrofitted Road Overpasses

New Development

Our proposed blue-green network might be supplemented with new or repurposed developments (red areas in opposite drawing) within the floodplain. This development pattern establishes a vision and direction for the region and can be achieved over the next decade or two. We suggest starting on this vision as soon as possible, through a process that includes new developments in the pipeline and those already on the drawing board.

Sea level rise will extend the floodplain inland. Some development here – we all like to live near the water—is acceptable if properly elevated. An old Cajun saying is relevant: Elevation is Salvation from Inundation. **But this development will have to adapt to the water system, not the other way around**. A new type of water-centric development could be a cultural and economic asset for Charleston. Connectivity for cars, bikes and pedestrians– via possible new linear parks—could reinforce this living with water vision.



Coastal Development

Cultural Landscape

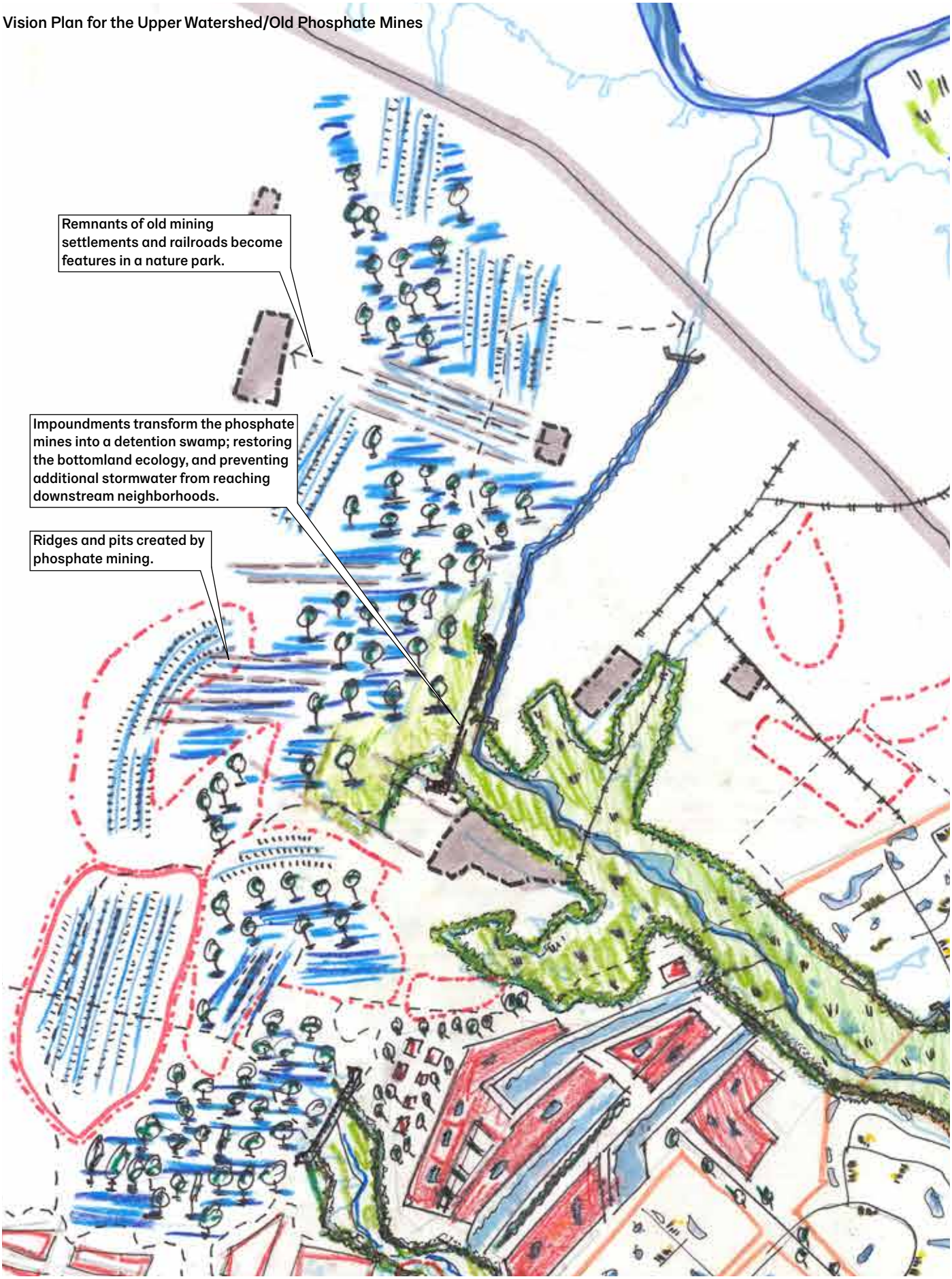
After the Civil War, the phosphate/fertilizer industry radically transformed the Lowcountry landscape. Phosphate was extracted by digging trenches that exposed the underlying marl. The first trenches were dug by hand, and later by steam shovels. The larger trenches are still visible in the topography. Much of Church Creek basin was clear cut for phosphate mining. Fertilizer production continued in the Charleston region until the mid-20th century.

Today, that cultural landscape is both hidden from sight and the impetus for West Ashley's stormwater issues. The phosphate mines that first drained the swamp now lie overgrown and out of reach. They are a fascinating landscape of trenches, mounds, and industrial remnants that occupy around a third of the Church Creek watershed. **Transforming that landscape into a stormwater park could both restore a historic ecological condition and turn a hidden history into a public amenity.**

Phosphate Mining
Early phosphate trenches were dug by hand, while later trenches were dug with steam shovels.

Present Day
Traces of mining settlements, and excavation trenches remain scattered throughout the Charleston area.
Photo credit: Andrew Whitaker, The Post and Courier

Vision Plan for the Upper Watershed/Old Phosphate Mines



Church Creek Recommendations

The Church Creek basin, formerly swamp, is rapidly becoming a fully built out suburb, intensifying stress on local drainage. Solutions to chronic flooding lie in restoring natural systems that complement existing infrastructure.

Judo, Not Boxing

Stop fighting and trying to control nature, but instead embrace its energy and power. Align future (re)development to the functions of the basin's water systems; do not assume to align the basin's water system to development. Create better connections between the creeks and other water systems in West Ashley, including where possible interconnections between the Ashley and Stono rivers. This creates water management redundancy and resiliency and is how the water systems functioned before development.

Develop Watershed-Based Plans

Develop a West Ashley Water Plan (ideally as part of a City-wide Water Plan) built from existing, watershed assessment(s) of the Church Creek Basin. Develop water storage assignments for each drainage basin and sub-basin. Require new development to meet 100% of the assignment.

Protect & Sustain Intertidal Zones

Eliminate, or substantially reduce, the placement of fill or other structures that impair the performance of the intertidal marsh and upland creek systems. Do not further reduce their ability to shrink and enlarge with varying water levels. These systems, if unimpeded, naturally accrete and deposit organic material sediments which yield (natural) storm surge mitigation and adaptation to sea-level rise. The regenerative capacities of healthy intertidal zones are a key flood risk management tool. Build with Nature.

Detain & Infiltrate

Explore all opportunities to add in-line and nearby stormwater and creek detention capacity along Church Creek's canals, streams, tributaries and distributaries. Encourage existing developments to participate; require all new developments to meet a certain detention level. The Dutch Dialogues Team identified locations in which such detention could be expanded.

Encourage the infiltration of stormwater into "high-ground" areas of Church Creek and developments to and in the north of the basin.

Integrate Parks, Water Storage & Historical Landscapes

Consider a new West Ashley (Church Creek and nearby) park system and trail amenity formed from the area's remaining phosphate-mine and related rail alignments.

Weir at West Ashley Park

Dutch Dialogues Team

Green Infrastructure Policy Tools

Wider implementation of green infrastructure (GI) best management practices will help to slow and store stormwater where it falls, an important component of an integrated water management strategy across Charleston. Initial rough "water assignment" calculations made during the Dutch Dialogues workshop for the Peninsula show a need to accommodate a significant amount of rain water within the built environment to achieve a design goal of "net zero stormwater runoff" and mitigate flood risk during heavy rain events (approximately 1,284 acre feet or 64 Marion Squares at 3 feet of storage depth for a 10 year/24 hour rain event; or 624 acre feet or 31 Marion Squares at 3 feet of storage depth for 25 year/1 hour cloudburst storm).

Achieving this level of stormwater management and GI adoption will require Charleston to use multiple policy levers and a comprehensive, strategic planning approach. For an accessible, comprehensive guide to GI, see Georgetown Climate Center's Green Infrastructure Toolkit. A brief description of policy tools that Charleston may consider follow below.

Incentives

Development incentives such as density bonuses or expedited permits can be a useful tool to encourage GI installation in areas planned for significant growth and larger scale new developments. Charleston has incorporated such incentives into the zoning code for the Upper Peninsula Zoning District, providing height and density bonuses for decreasing stormwater runoff and impervious surfaces as well as installing vegetated green roofs. The City should extend such GI incentives to other parts of the city, such as Johns Island, and expand them to incorporate more holistic guidelines for green development.

The City of Houston's newly released Incentives for Green Development study may serve as a useful case study for Charleston. This study concluded that existing development rules and design criteria act as a barrier to GI implementation and recommends "enacting an integrated set of green stormwater infrastructure development rules that harmonize parking, landscaping, open space, drainage design, detention design, and stormwater quality design requirements." This study compared detailed cost estimates for conventional development designs under existing rules to cost estimates under a proposed suite of integrated green infrastructure design rules, and found that the latter should reduce overall costs for developers which would, in turn, increase GI deployment.

Financial incentives – grants, subsidies, rebates, and tax abatements – provide other useful tools to encourage stormwater management and GI installation for new and existing development. Houston's incentives study includes recommendations for exploring tax abatements. Financial incentives may also be combined with stormwater fees. The Philadelphia Water Department, for example, charges its customers a stormwater fee based on impervious surface area on their property. Philadelphia provides various subsidies, grants, and rebates for residential and non-residential properties that install GI features and reduce runoff – including a reduction in the customer's stormwater fee.

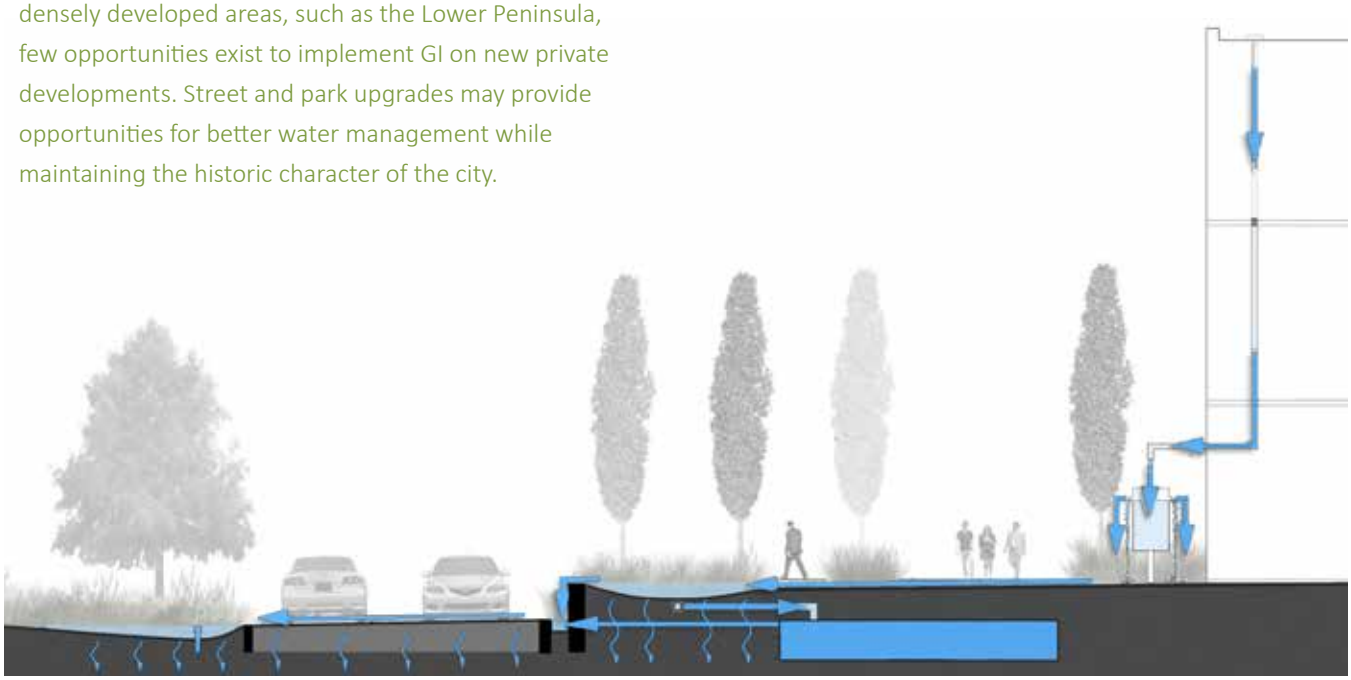
Regulation

Beyond incentives, Charleston may consider requirements for stormwater management in the zoning code, building code, or through a stormwater ordinance. Norfolk's Zoning Ordinance, for example, includes a Resilient Quotient System, requiring developments to earn a certain number of points by including different resilient design measures and stormwater management features. Article 23 of the New Orleans Comprehensive Zoning Ordinance includes a requirement that all new developments or significant reconstructions manage the first 1.25 inches of stormwater onsite. Such regulatory tools will ensure more widespread implementation of GI and stormwater management practices than a purely incentives-based approach. However, they may prove politically challenging to enact.

Planning & Government Operations

Implementation of GI should be strategic, not simply opportunistic. Charleston should adopt a comprehensive citywide planning approach to GI via an integrated water management strategy or Urban Water Plan, and incorporate GI into other City plans.

Charleston, in partnership with other local and state agencies, should incorporate GI and improved drainage features into street design standards, and the construction and maintenance of City facilities and parks. In some densely developed areas, such as the Lower Peninsula, few opportunities exist to implement GI on new private developments. Street and park upgrades may provide opportunities for better water management while maintaining the historic character of the city.



On Site Water Storage
Waggonner & Ball's Greater New Orleans Foundation captures the first eight inches of rainfall on site, exceeding a local 1 hour, 100-year rainfall.
Credit: CARBO Landscape Architecture

Strategies to Slow and Store Water
The Greater New Orleans Foundation includes features to slow and store water, such as native plants, pervious paving, a rain garden, subsurface storage, and a pervious asphalt parking lot.
Credit: Waggonner & Ball / Alise O'Brien

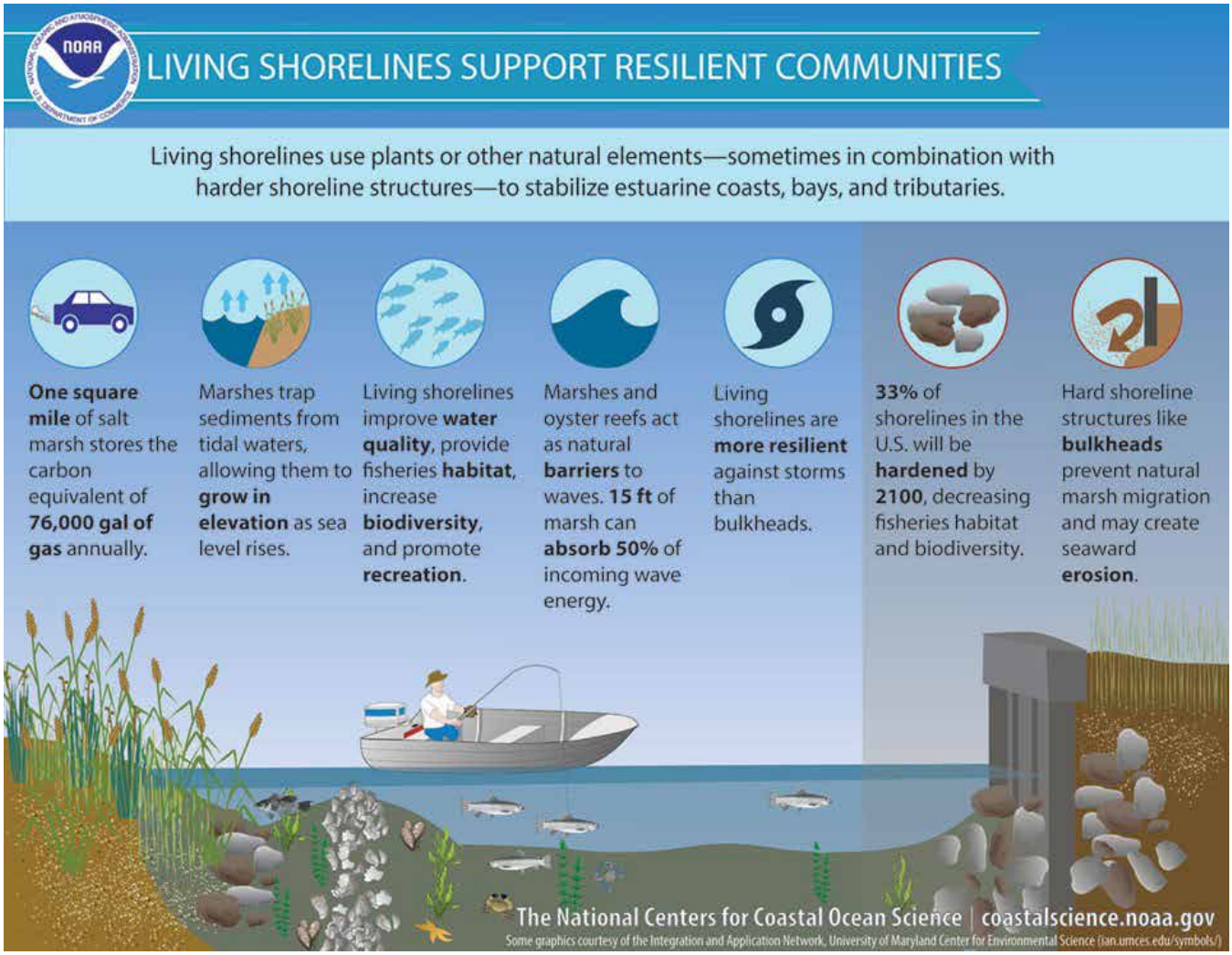
Lisa Vandiver, Marine Habitat Restoration Specialist, NOAA Restoration Center

Marsh Restoration & Sea Level Adaptation

Wetlands provide natural buffers against extreme weather events by protecting communities from coastal inundation and storm surge, reducing wave damage and floods, and stabilizing shorelines from erosion. Wetland protection and restoration should be a critical component of community efforts to adapt to climate change and mitigate flood risk.

Tidal wetlands have been dredged, filled, or impounded throughout the southeastern US. These activities reduce tidal flow, resulting in degraded or complete loss of wetland functions. Of particular note in the Charleston region are the historic rice field structures – trunks, dikes, and canals – that are scattered throughout the coastal landscape. During the 17th and 18th centuries, these features were built within wetland habitats to create rice fields and control flooding and drainage for agricultural production. Rice production began to phase out over time and became practically obsolete following the end of the Civil War with the loss of slave labor. Today, evidence of the historic rice production era can be found throughout Charleston, either as derelict dikes and canals dotted throughout the coastal landscape, or as managed impoundments that now provide valuable wetland habitat for waterfowl. The unmanaged dikes and canals often fall into disrepair, continuing to restrict tidal flow and degrade salt marsh habitat functions. Such areas provide an opportunity for cost effective approaches to restore salt marsh habitat, while reconnecting communities to the valuable services they provide for the region.

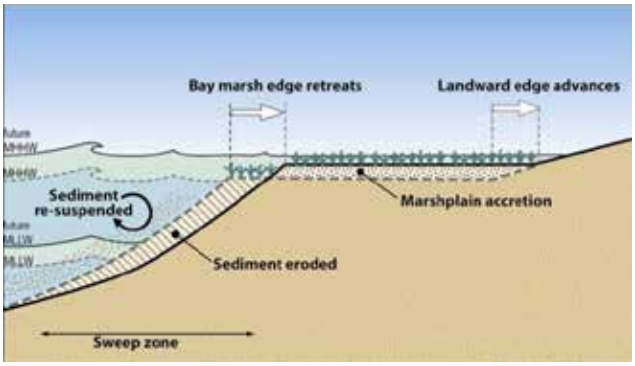
Although reconnected tidal flow restores salt marsh ecosystem function, these actions also make surrounding areas more resilient to the impacts of climate change and sea level rise. The extent, duration, and timing of tidal flow dictates the sediment deposition and erosion processes, which allow salt marshes to naturally adjust to rising sea levels. Restoring tidal flow enhances these sediment-trapping processes, and promotes the reestablishment of salt marsh vegetation. These two components of a healthy salt marsh provide the foundation for carbon accumulation over time, which graudally builds up marshes vertically, protecting them from sea level rise. Restored salt marsh



Living Shorelines
https://serc.carleton.edu/vignettes/collection/42858.html

habitats are able to keep pace with rising sea levels while also buffering human communities from the impacts of extreme weather events. Degraded salt marsh habitats cannot; their restoration should be a priority.

Scientists Jenny Davis and Carolyn Currin from NOAA's National Centers for Coastal Ocean Science Beaufort Lab worked with The Nature Conservancy to develop this tool.



Marsh Migration
https://serc.carleton.edu/vignettes/collection/42858.html

For more information, see:
https://www.fisheries.noaa.gov/topic/habitat-conservation#overview

and

https://coastalresilience.org/project/living-shoreline-explorer/

Matt Fountain, Director of Stormwater Management, City of Charleston

Stormwater Utility Credits

Stormwater Utility Fee credits are a local tool through which property owners and developers are incentivized to implement stormwater best management practices (BMPs) in exchange for a reduced stormwater fee. Stormwater credit programs help the local utility achieve key stormwater goals through a collaborative approach with private property owners, thereby achieving better overall stormwater management. Such programs are common and vary in implementation, reflecting the need to tailor the creditable BMPs to existing local conditions.

In a typical stormwater credit program, property owners and developers who deploy stormwater BMPs beyond those required by regulation would pay reduced stormwater fees. The lower fees recognize the additional stormwater benefits their site provides to the utility. Activities that earn credits typically reduce local flooding, improve the water quality in an impacted area, or provide additional stormwater education and outreach. Green infrastructure is often deployed to achieve the additional water quality and stormwater detention and retention improvements.

A credit program can also encourage existing, or grandfathered, properties to provide stormwater controls and achieve the fee reduction, even if such controls were not required at the time of development.

A more recent, market-based addition to stormwater credit programs are Tradable Stormwater Credits. This initiative values stormwater retention volumes – or water quality improvements – tracked as tradable certificates. Credits are generated by the installation of stormwater systems beyond what regulations require. Developers can generate credits by installing more retention than required, or by a property owner voluntarily installing more retention to generate credits for sale.

The ability to buy and sell credits encourages the most cost-effective compliance methods within a drainage basin, which then allows for a higher overall level of basin-wide stormwater retention. Tradeable certificates also incentivize market-driven development patterns. Ideally, stormwater retention is used in areas most appropriate for green infrastructure while development occurs in areas that make the most efficient use of the property. Certificates thus incentivize the deployment of stormwater BMPS across an entire drainage basin rather than incentivizing BMPs on each individual property, thereby improving the basin's overall drainage efficiency.

Cities such as Philadelphia, Richmond and Norfolk, VA, Buffalo, NY, Portland, ME, the District of Columbia, municipalities across in Minnesota, and many other localities are deploying effective stormwater credit programs. Charleston should adopt a program too.

Front Yard Initiative
Homeowner BMP incentive program in New Orleans

Meghan Finnegan, Dutch Dialogues Team

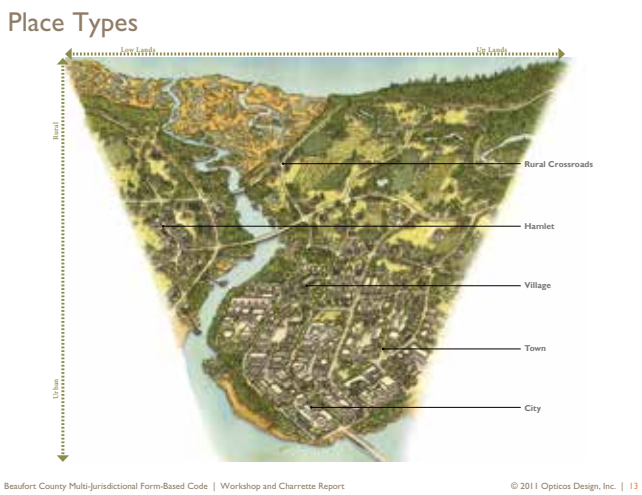
Beaufort County Form-Based Code

Urban communities are growing although traditional zoning, which makes diverse, walkable, urban spaces either illegal or difficult to achieve. For example, mixed-use buildings that hug the sidewalk in Cleveland, OH are possible only through special zoning exceptions. In New York City, 40% of Manhattan's buildings would violate the city's current zoning because they're too tall, or have too many apartments or businesses. Many cities, however, are pursuing a new approach to zoning, prioritizing people and public space rather than buildings and land use.

The definition of Form Based Code is a land development regulation that fosters predictable built results and a high-quality public realm by using physical form (rather than separation of uses) as the organizing principle for the code; a regulation, not a mere guideline, adopted into city, town, or county law.

In Beaufort, South Carolina, the implementation of a Form Based Codes (FBC) have helped it adapt well to new growth. For the past two decades, Beaufort County had experienced extensive growth, pressuring infrastructure and public services, and negatively impacting the natural environment and quality of life. The County partnered with Opticos Design to create a new code to channel growth into existing urbanized areas, preserve rural character and natural resources. After substantial community engagement and input, an FBC was adopted in 2017. The result was a single, precedent-setting, shared regulatory framework to implement the community's vision and goals, regardless of jurisdictional boundaries.

The Beaufort FBC is successful because of its unique characteristics. First, the county, cities and towns must abide by the code. Its clear language and step-by-step instructions make it exceptionally easy to understand. With illustrations, examples and clear definitions, the code makes potential conflicts easy to avoid. Gone is "unpredictable" Planned Unit Development zoning; a unique transect ensures new development matches the characteristics of the communities. Public realm standards for streets and civic spaces provide tools to create good buildings and great neighborhoods. Ultimately, the Beaufort FBC is site specific, created for the good of the community. The salience of the Code's shared goals ensures its acceptance and success.



Beaufort County Transect

The Beaufort Code serves as a precedent for environmental resource standards. Section 8 of the code addresses stormwater, the purpose being "to control the adverse effects of post-development stormwater runoff." The code calls out specific elements of the Stormwater Manual, specifically those on impervious surfaces and best management practices (BMPs). Specific BMPs must be chosen based off the site's location in the transect, depending on the site's watershed. Bioswales, underground water storage, and green infrastructure are all options outlined within the code to meet stormwater quality and volume controls. With a clear outline of requirements and measurable interventions, the Beaufort Code demonstrates how FBCs can be used to effectively mitigate stormwater flooding with best management practices.

City of Beaufort, Department of Planning and Zoning: http://www.cityofbeaufort.org/DocumentCenter/View/976/The-Beaufort-Code?bidId=

Policy

Developer Community Recommendations

The Charleston Trident Association of REALTORS® (CTAR) and The Charleston Home Builders Association's (CHBA) Engineering Taskforce, consisting of engineers from multiple disciplines, reviewed proposed flood solutions offered during the Dutch Dialogue Charleston sessions. The CHBA and CTAR have outlined the following recommendations:

1. The most cost-effective strategy to address immediate flooding is a stronger focus on existing drainage system maintenance. This entails dedicating financial resources to identifying all existing systems, cataloging those systems, and performing regular maintenance. We note that a large percentage of citizen complaints are related to older developments where drainage has failed, not been serviced, is unknown to the municipality, not the responsibility of the municipality, or a combination of these factors.
2. Equally important is to structure improved drainage system maintenance by and between the City of Charleston, Town of James Island, Charleston County, and the S.C. Department of Transportation. Without intergovernmental cooperation, including legal rights and easements to service these systems, even best planned drainage projects fail when the system relies on multiple municipalities or agencies that fail to communicate.
    - The South Carolina Department of Transportation has a large role to play in this realm.
    - Staffing: more workers are needed to perform drainage system maintenance across all jurisdictions.
3. We support a comprehensive analysis of all regional watersheds and drainage basins. This "water plan" analysis would then inform the development of a master drainage plan before new land use planning decisions are made. Watershed and drainage basin studies are crucial because each system has unique characteristics. For example, standards unique to Church Creek are not necessarily applicable to watersheds / basins on James Island or Johns Island. Applying a one-size-fits-all standard would likely result in poor outcomes.
4. Master drainage plans should include interconnected

systems. Not all watersheds can rely on independent drainage systems during flood events; interconnecting systems would likely reduce flood risk. Incorporating tidal gate systems would enhance water storage and flow management.

5. We recommend the adoption of policies that are financially palatable for the housing community, such as transfers of development rights (TDR) rather than down-zoning or cost-prohibitive new standards. The city must be mindful of the unintended consequences of stringent flood mitigation policies, which could exacerbate the housing affordability crisis and undermine municipal revenues with reduced densities. By developing a TDR program with neighboring municipalities, the city could avoid litigation and strengthen smart growth principles.

6. We support the deployment of low-impact development (LID) practices to lower flood risk and increase infiltration. LID practices, however, often require extra maintenance, shorter service intervals, and if improperly executed, can exacerbate drainage problems. We strongly recommend careful design of requirements, with proper attention given to soil analysis, excavation requirements and landscaping materials. If not properly installed and maintained, LID systems – such as rain gardens, infiltration trenches and bioswales – can cause soil medium buildup, lack of infiltration, and negatively affect water quality. In some cases, LID requires more land area, thus reducing density and affordability. LID systems should be linked to secondary drainage systems in case large water volumes overwhelm their capacity. LID systems are an important, but not exclusive, solution to small-scale flood risk mitigate projects.

7. More catch basins on residential streets would reduce neighborhood flooding. We acknowledge this will increase maintenance requirements.

8. Provide incentives for progressive approaches to flood mitigation (e.g. tax incentives or expedited permitting for designs which include rain barrels or other water capture devices).

9. Increase staff in the planning, zoning, and stormwater/drainage management departments to ensure better feedback, timely responses, and higher quality products. Provide higher pay to retain the talent that is currently here. We believe the City does not have a lack of talent, but instead a lack of capacity as departments are overwhelmed by their workload. The City should explore how other municipalities use public-private partnerships in which developers collectively support department staff additions to facilitate and coordinate projects.

10. Greater cooperation between the public and private sectors is essential to quality planning. Designers and developers should collaborate on standards, ordinance, and code changes to blend both theoretical and practical approaches.

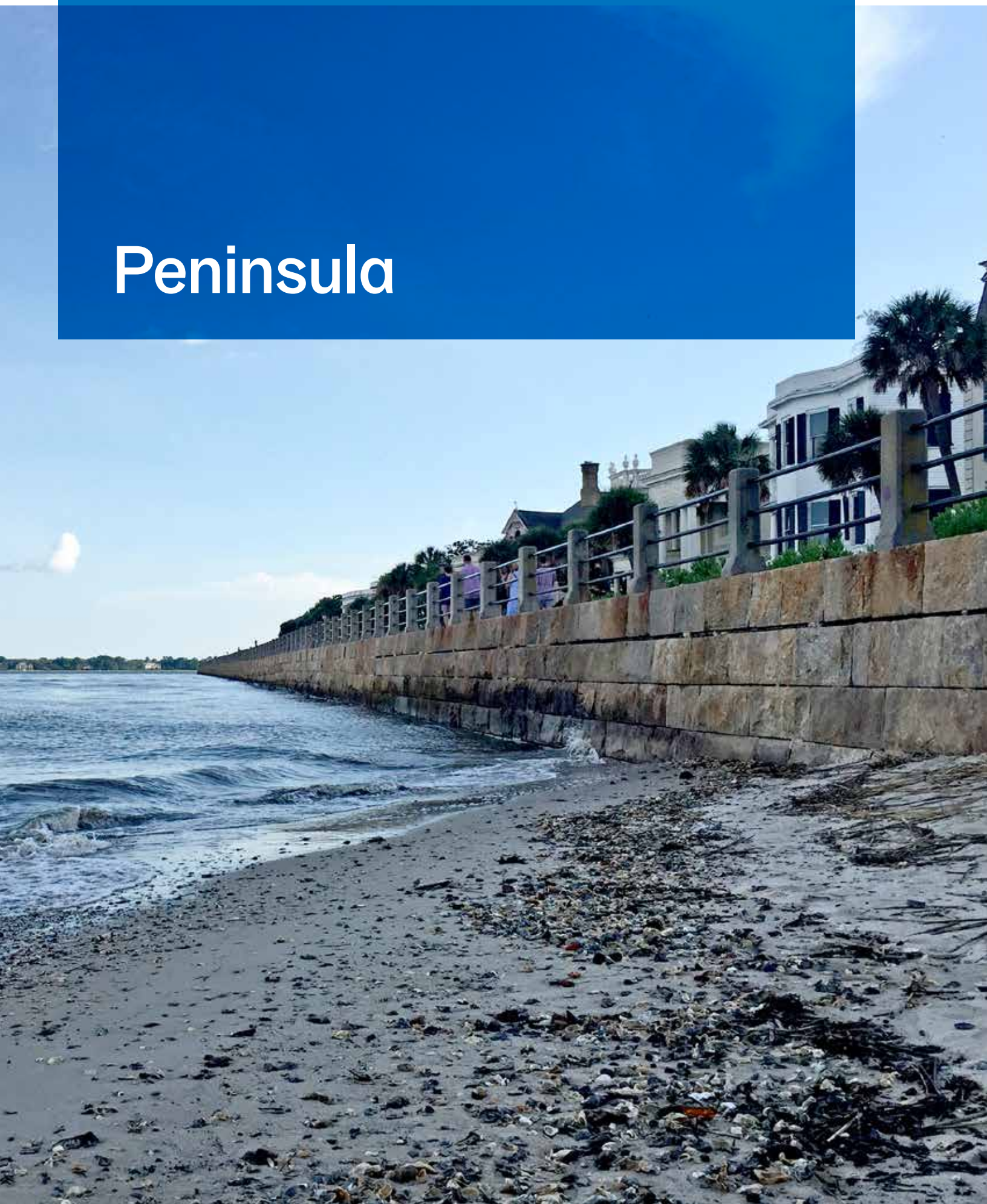
11. Smart Growth. Promote density to enhance sustainability and discourage sprawl, which will ease traffic and reduce the amount of impermeable surfaces. Smart growth enables development where it is most resilient.

12. The formation of a regional planning body is needed. Flooding issues do not entirely originate within the City or the County; water does not adhere to jurisdictional boundaries. A regional planning entity – with authority to consider coastal, intertidal, and riverine flood impacts – could be housed within existing bodies such as OneRegion or the Council of Governments. The ability to bring the private sector, planning, and zoning departments together to collectively develop and implement a region-wide watershed approach will best serve the Tricounty area.

13. Promote Conservation Planning throughout the city and region. Conservation Planning has been successfully done on James Island, in limited exposure, and other parts of the country. Conservation Planning maintains unit quotas, but allows for smaller lot sizes in the correct placement on a larger parcel. Allowing developers to maintain project size and create more green space with resilient design will enhance the project's and community's sustainability.

14. Service level standards and protocols should be essential components of the Stormwater Drainage Manual and the Comprehensive Plan update.

Peninsula



> “Topography matters, and it must be an essential factor in any future development.”

Pieter Schengenga
H+N+S Landscape Architecture

Contributors

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WATERSHED
- Watersheds

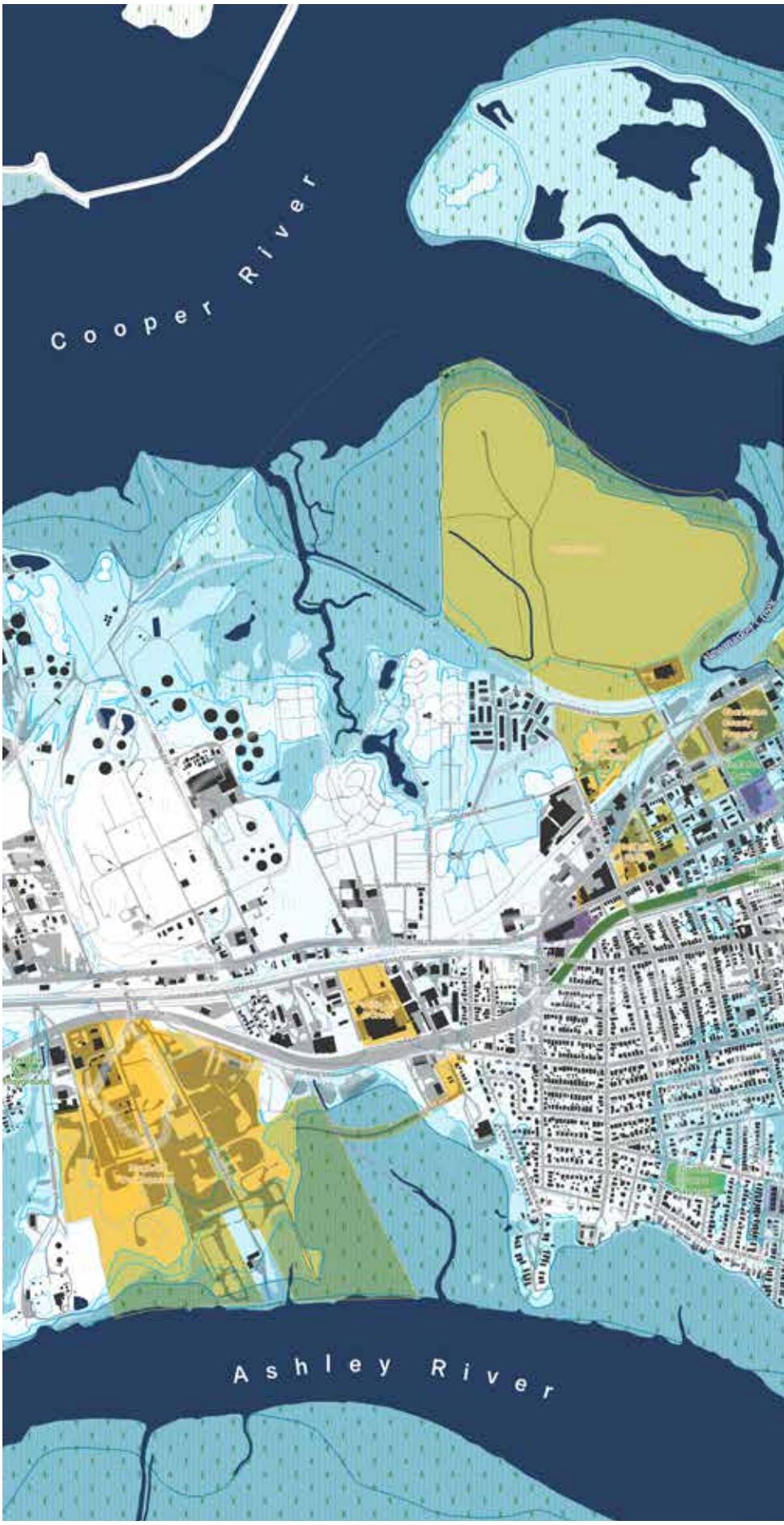
WATER MANAGEMENT PROJECTS
- Projects

SEA LEVEL RISE
- 3' Sea Level Rise

DFIRM
- coastal floodzone, floodway
- 100 year floodplain
- 500 year floodplin
- Street Flooding

ROADS RAIL
- Rail

Road
- Major
- Minor
- Local




Alberta Loop Lake Park

Peninsula Elevation

LEGEND

Topography 0'-20'

- ≤2
- ≤4
- ≤6
- ≤8
- ≤10
- ≤12
- ≤14
- ≤16
- ≤18
- ≤20

Bathymetry

- ≤0
- ≤-5
- ≤-10
- ≤-15
- ≤-20
- ≤-25
- ≤-30
- ≤-35
- ≤-40
- ≤-45
- ≤-50
- ≤-55
- ≤-60
- ≤-65
- ≤-70
- ≤-75
- ≤-80

The Peninsula

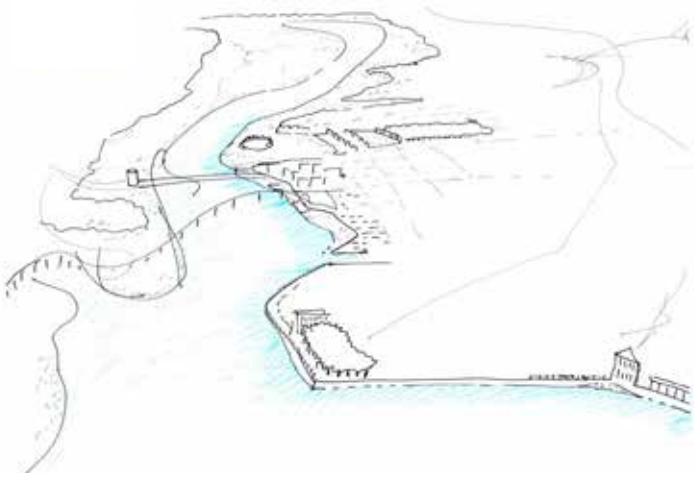
Peninsula Water Identity

The Peninsula is the foundation of Charleston's identity. To the Dutch Dialogues Team, key qualities stand out.

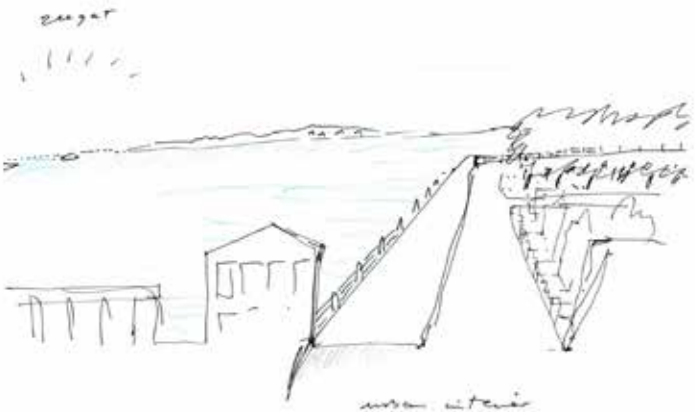
First is Charleston's historic urban quality, starting with the High Battery, where the city embraces the sea. The seawall provides protection and amenity: an urban space for citizens where the city, the rivers, and the sea meet.

Another is Charleston's houses and gardens, which combine in a fantastic typology. South and west-facing side verandas create a beautiful relation between inside and the outside; they provide shade, access to cooling breezes, and connection to the outdoors. Fences and garden walls allow views from the street deep into the lush gardens, supporting the urban form and enabling the city to "breathe." **This transparency is fundamental to Charleston's spatial quality**, with endless variations in both the wealthiest and the poorest parts of the city.

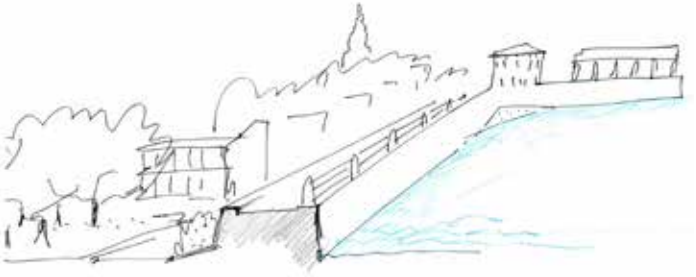
Then there is the **urban grid and tree canopy**. The streets are for connectivity, spaces to move along but also to linger in, shaded by trees. The trees provide shelter and create perspective and depth, for both individuals and for creating an identity for the city. The street grid gives views; many principal streets offer perspectives to the water. While many corridors and water views are blocked today, **this historic grid might inspire**, from inside the city and around its perimeter, **reconnection to the water.**



South of Broad
The High and Low Battery define southern edge of the historic city, hospital district and Citadel beyond



High Battery
Looking south towards the Ashley River from the Historic Charleston Foundation



High Battery
Looking north towards the Historic Charleston Foundation and City Center

Waterfront Park
Promenade and greenspace built on former docklands provides public access to water.

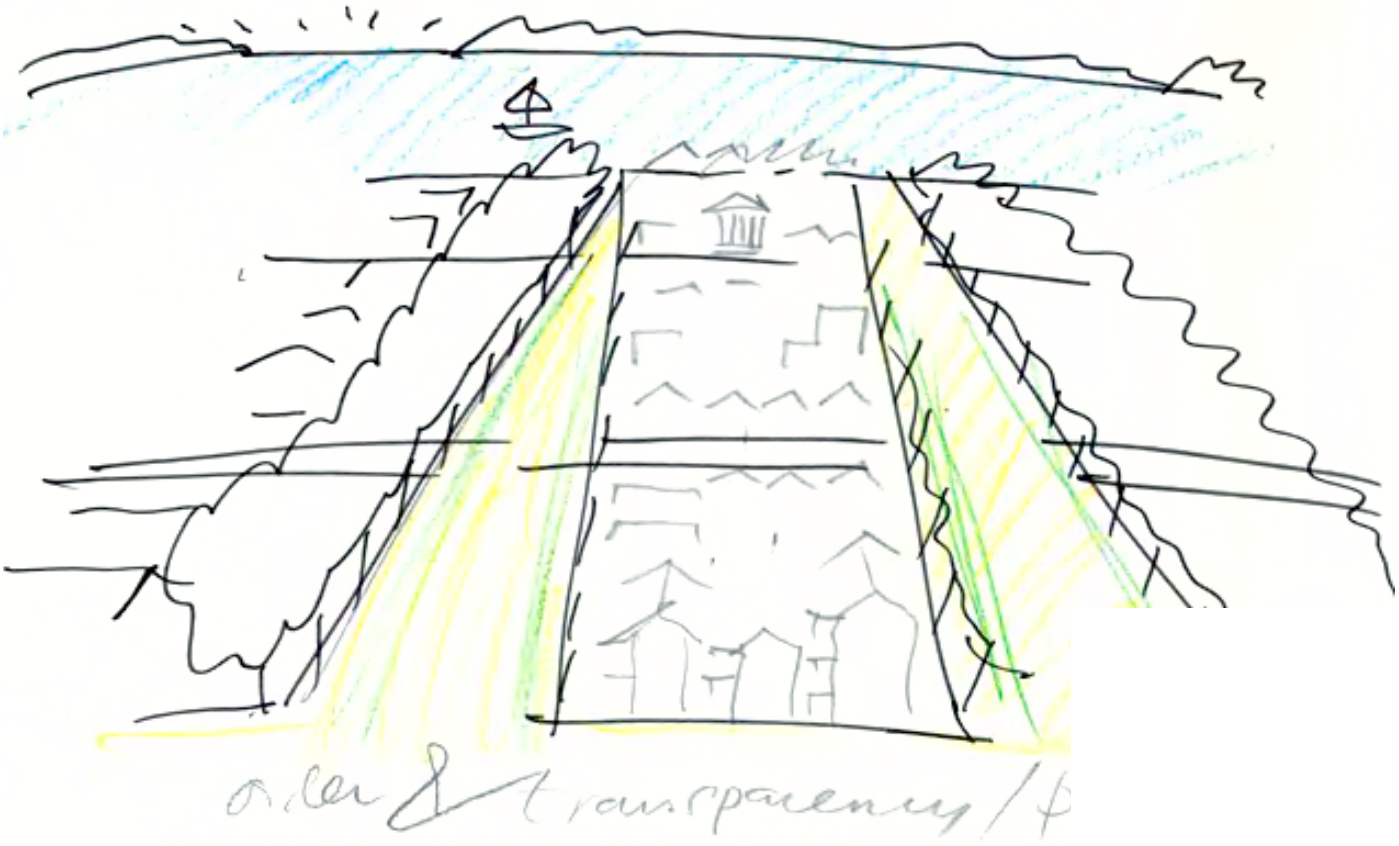
Low Battery during Storm Surge
The Low Battery is susceptible to over-topping during tidal events. Plans to raise it to match the High Battery are in the works.
Image Credit: Charleston Post and Courier

Newmarket Creek
Remnants of a tidal creek are in close proximity to new development.

Lowcountry Low Line
This former rail corridor is becoming a bike path and park.

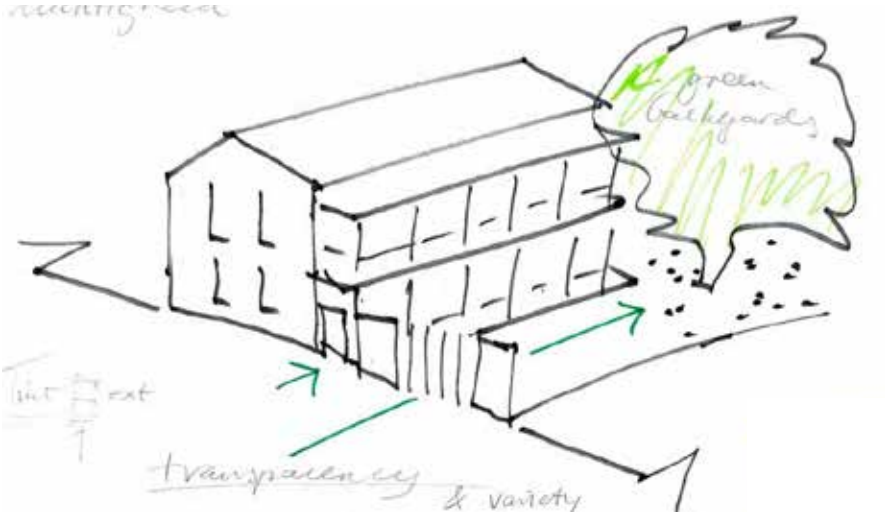
Public Pier and the End of Waterfront Park
The peninsula has multiple access points to the Cooper and Ashley River.

Charleston Single
The false front doors opens to a side gallery.



Historic Grid
Street grid with views and connection to water

Historic Aerial
1872 rendering illustrates the urban grid and extent of waterfront development



Charleston Homes
Vernacular house typology with south or west facing verandas and gardens or courtyards

Urban Tree Canopy
Street trees provide shade and rain interception

Morphology & Risk

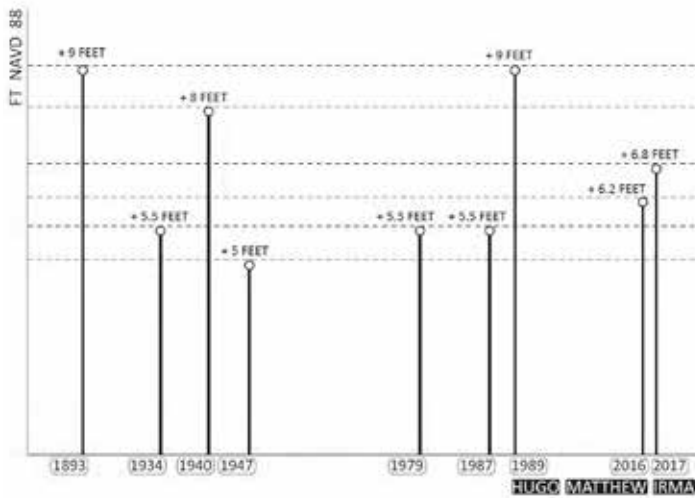
Meeting and King Streets are the Peninsula's backbone, stretching north and south on naturally high ground with cross streets radiating east and west to the water. On the nearby map, note the creeks and marshes, some of which had already been filled when this map was drawn, while others are still visible. These creeks extend far into the city, while wet edge marshes ring much of the Peninsula. Overlaying a map of current flood-prone areas shows a clear relationship to these now-filled creeks and marshes. **Topography matters, and it must be an essential factor in any future development.**

The Peninsula has multiple flood hazards: stormwater, insufficient and inefficient drainage, tidal and storm surge exposure, and compound flooding when the distinct hazards occur together. The flat topography, dense occupation, and pervasive impervious surfaces amplify those risks, and sea level rise and the likelihood of more regular, more intense rainstorms will too. Tidal and surge risks are the focus of the US Army Corps of Engineers 3x3x3 study (see summary at the end of this chapter).

Elevating critical infrastructure and roads will help, in the near term. As seas rise, however, so will groundwater. Relying solely upon the existing drainage system to manage stormwater without groundwater control will fail. There is a need for a City-wide urban water plan that includes a groundwater assessment to underpin a management strategy. **Without a groundwater management strategy, groundwater will eventually overwhelm the drainage system.**

An urban water plan would set forth a science-based strategy to manage coherently all peninsula water systems over time, increase infiltration capacity, and improve drainage efficiency via a retain-store-discharge strategy, noted elsewhere. **A water plan would underpin land use, development, building code, zoning, and other regulatory policies to elevate or otherwise protect critical infrastructure and peninsula residents.**

Halsey Map, 1949
Charleston street grid overlaid on top of the peninsula's original natural edge.



Historic Storm Surge
High tide levels during historic storm events.

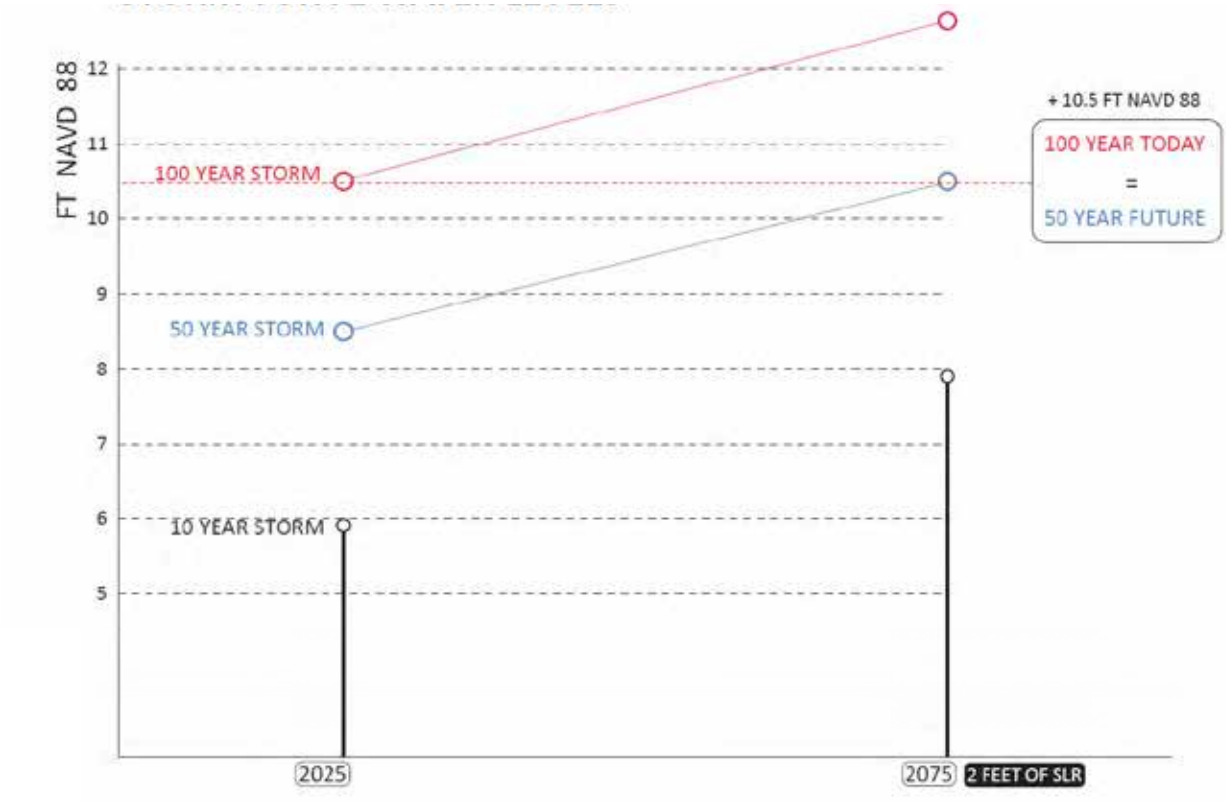
The peninsula geological profile nearby (west to east) shows the Pleistocene deposits, the soft marsh and fill. These soils are structurally weak and are why the Peninsula's perimeter is compacting, subsiding, and flooding. The underground (both deep and shallow) drainage systems are visible. The shallow stormwater drainage pipes are quickly losing discharge capacity as the river water levels rise. Recent subsidence rates in these areas vary between 5 millimeters and 30 millimeters per year. **The peninsula edges are thus suffering dual impacts: subsidence and sea level rise** (higher mean water levels).

System Design Principles

The Peninsula may have to transition to an **"urban polder"** system, including the construction of perimeter protection against tidal impacts and surge, and programs for surface water management and groundwater control.

The alignment of any perimeter protection or floodwall must be logical and practical. It **could be used to improve surface water management** by creating space for temporary stormwater storage when the shallow stormwater system cannot function. Water in this zone could also be used as part of a groundwater management strategy.

There are many low areas in the street grid and neighborhoods. These low spots create additional flood and impact risks when they align with entrances to critical infrastructure, such as hospitals, emergency management equipment, primary road intersections, and evacuation routes. **Elevating these "critical low spots" as part of the city's streets rebuilding and repaving programs must be a priority.** When adding new connectivity components, e.g., Lowcountry Rapid Transit, or when key properties are being built or rebuilt, elevating and creating redundant building/facility access should be a design requirement. These simple adaptation efforts, progressively phased and built, will increase the city's overall resilience.



Future Storm Surge Risk
Storm surge potential with 2 feet of sea level rise.

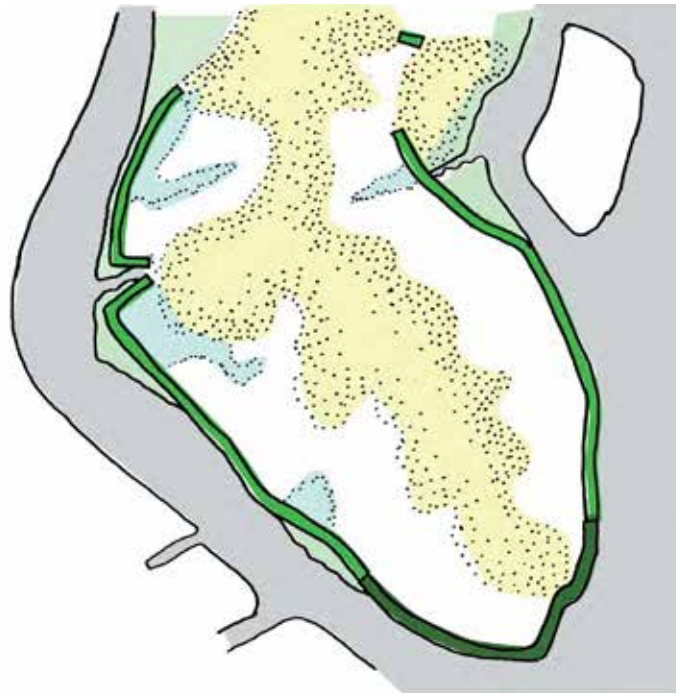
The existing and planned deep drainage tunnels additions are significant, adding considerable and much needed capacity. Creating more interconnectivity in these deep tunnels, and exploring how they might store stormwater and drain it should be explored, certainly in the Spring-Fishburne and Calhoun West projects.

The shallow drainage system has the most challenges, as previously noted. Recent and planned capacity improvements and the installation of tidal check valves at the system's river outfalls must remain a priority. These are essential, near-term additions for flood risk mitigation, but at some future point, with sea level rise, they will become ineffective.

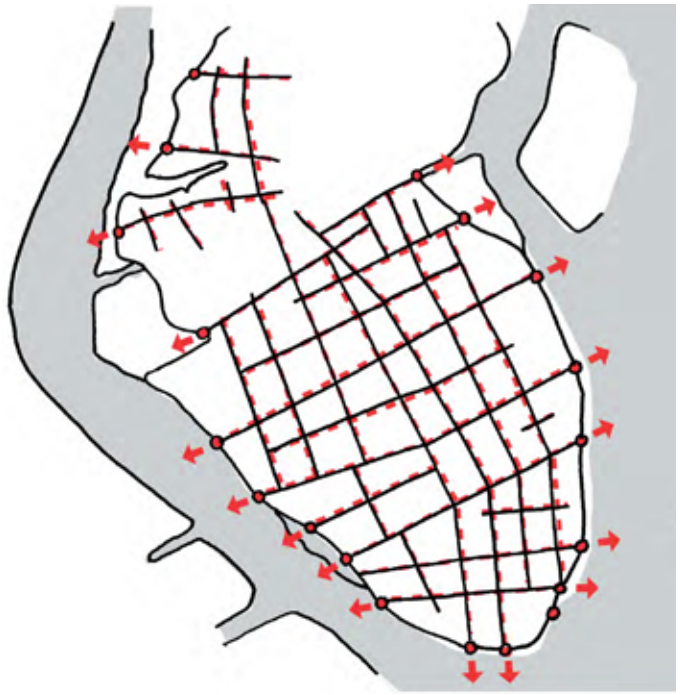
A new approach would be to think of the Peninsula's water management system as having three distinct parts. First, the deep tunnel system, which originates along the elevated peninsula backbone and stores and discharges large volumes of stormwater. Second, a new system that works within the planned perimeter protection system, and manages runoff and groundwater from low-lying, near-perimeter neighborhoods. Third, a comprehensive peninsula-wide water storage plan in public spaces and on commercial and residential properties.

The first part, on higher ground, is the existing deep-tunnel system supplemented with a new retain-store-drain approach. This system would be complementary to, but bypass, the shallow drainage system in the discharge phase, adding to the deep-tunnel system's ability to store and drain water.

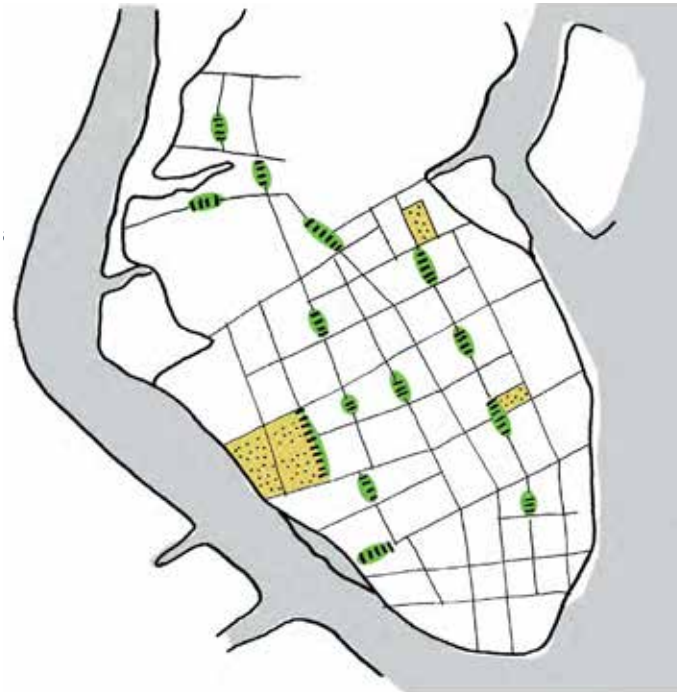
New water storage, drainage, and pumping components could be added to low areas just inside or close to the planned perimeter protection system as part of the City's preferred plan. These new areas would collect, store, and manage stormwater from nearby neighborhoods and manage shallow groundwater. The additions would substantially increase storage capacity in low areas and enable more efficient use of the large, deep-tunnel systems.



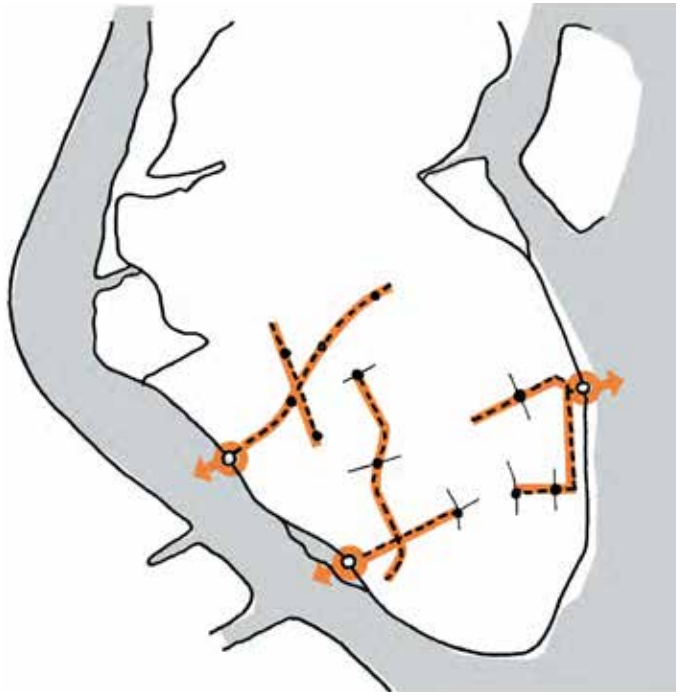
1. Perimeter Protection
Alignment of levee or floodwall



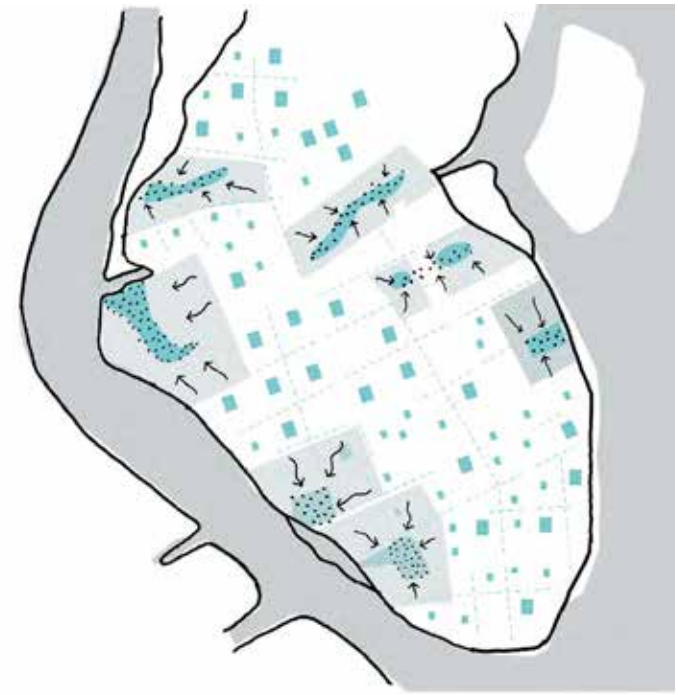
4. Tide Control
Check valves at drainage outfalls are required in the near term to manage increasing tides



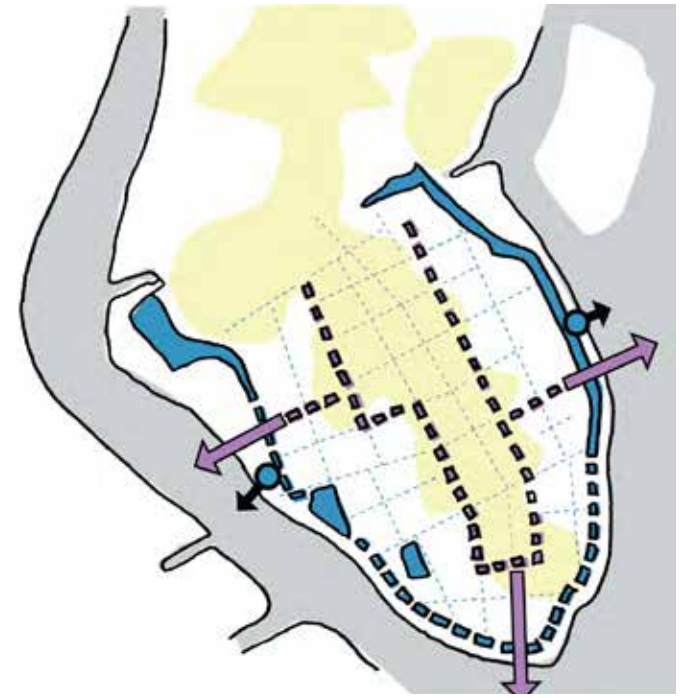
2. Elevate
Raise key intersections, roads and critical infrastructure



3. Deep Tunnels
Leverage deep tunnel system investment



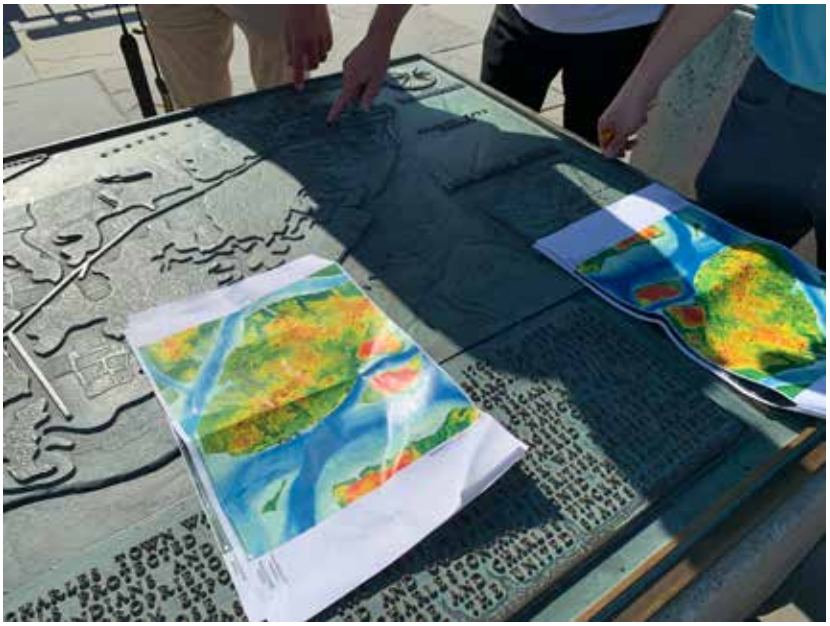
5. Slow and Store
Runoff interception and detention in public spaces, private parcels, right of ways, and former creeks



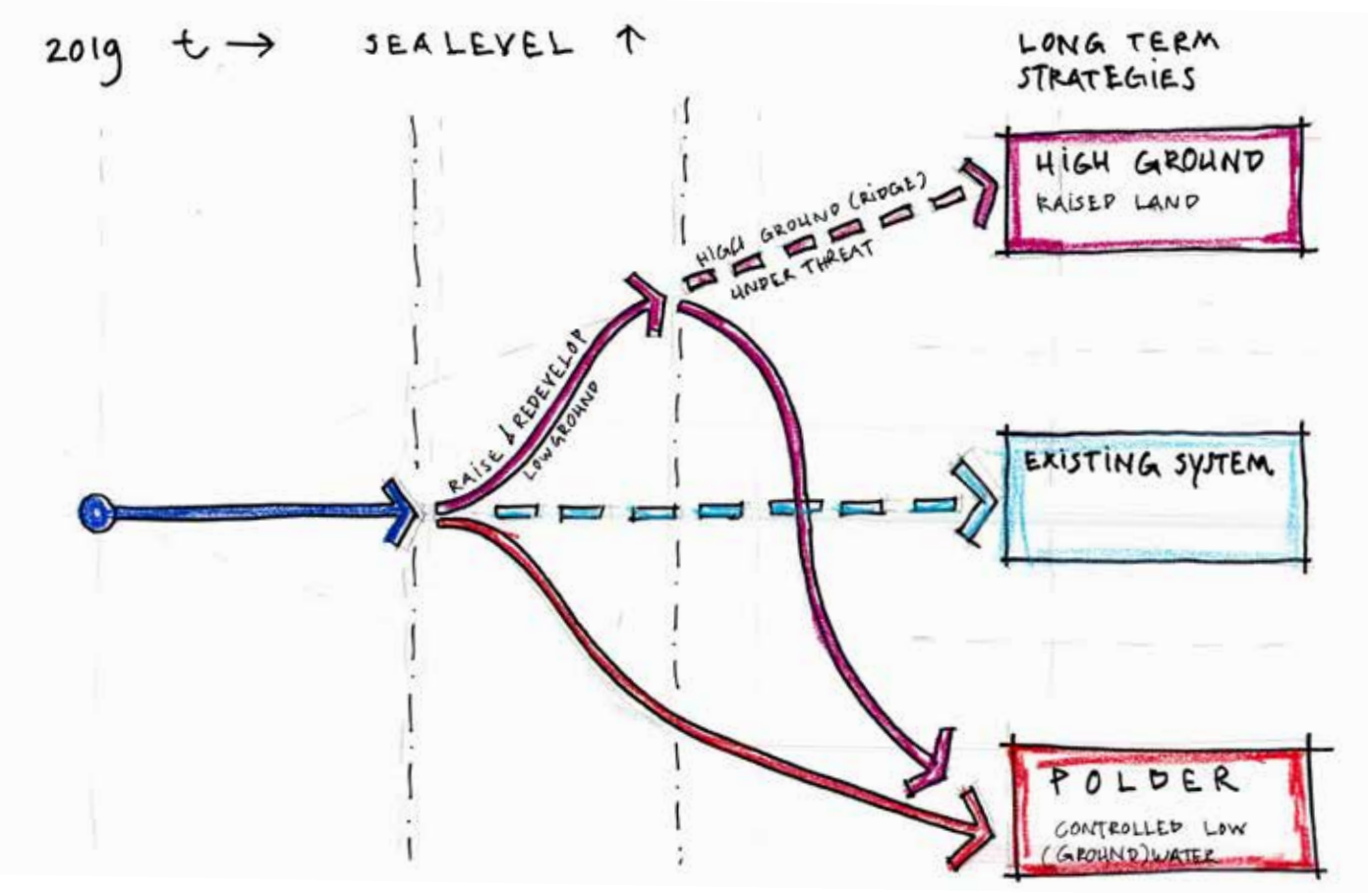
6. New Drainage Strategy
Drainage from the high ground is collected and discharged directly into river. Waterways and canals store and discharge water collected behind perimeter protection while balancing groundwater

To these, you would add requirements for public spaces, streets, parking lots, and parks to store stormwater, supported by an aggressive Amsterdam "Rainproof" type program in which commercial and residential property owners are encouraged to manage some stormwater on their properties. **All layers work together to create a more robust stormwater management system.**

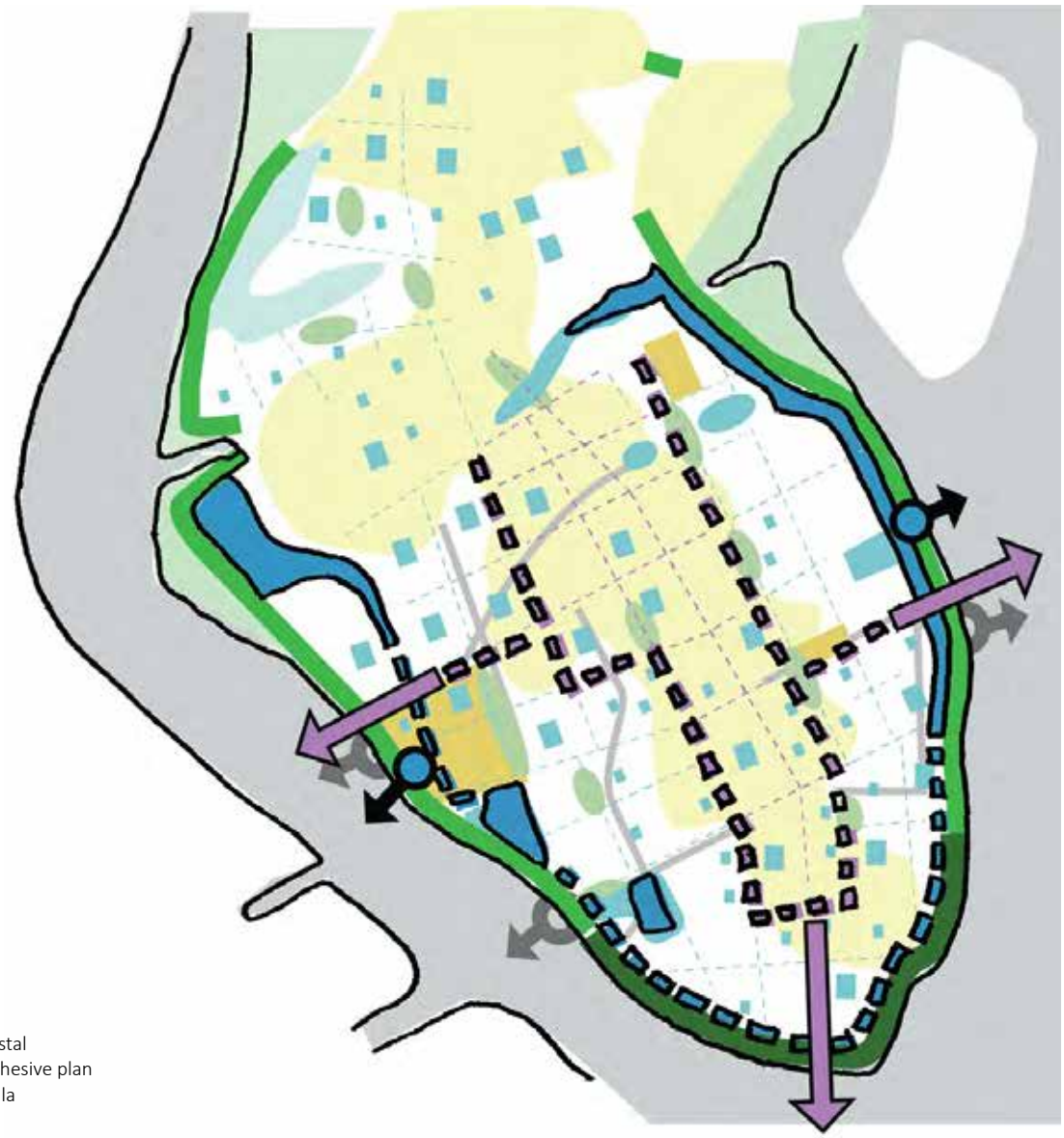
This long-term vision creates an adaptation structure, or a renovation plan, from which to build a more resilient peninsula. On timing and salience: **the decisions the City and the US Army Corps of Engineers make soon about the alignment and structure of the Peninsula's perimeter defense will influence, or possibly constrain, water storage possibilities needed inside that protection system.** City officials must proceed with a long-term strategy for both peninsula perimeter protection and peninsula-wide stormwater management.



Peninsula Topography Map on top of Historic Model

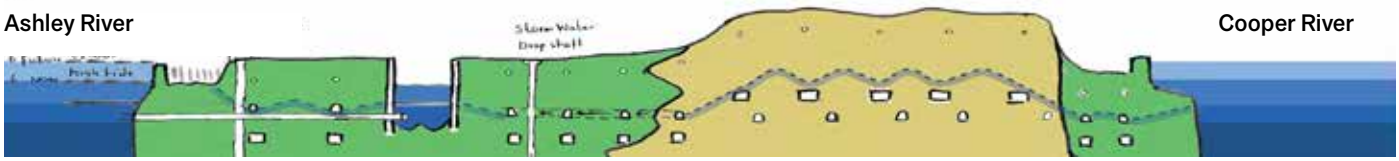


Climate Adaptation Timeline
Transition strategy to address Sea Level Rise and extreme weather over time

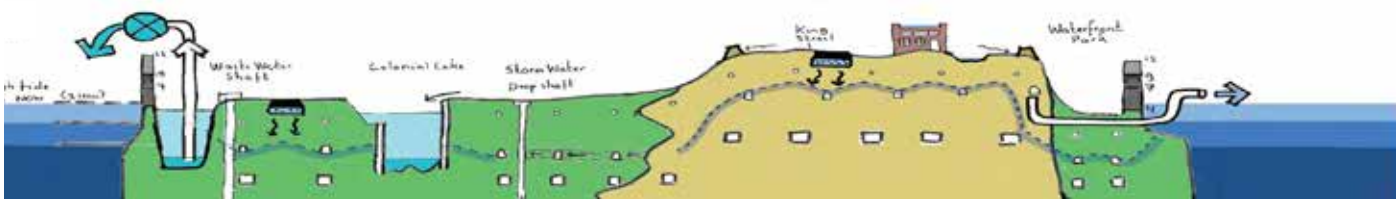


Integrated System Design
Stormwater, groundwater and coastal protection strategies merged in cohesive plan for the historic Charleston Peninsula

Existing



Proposed



Section Profiles
Existing and proposed design sections

Peninsula Recommendations

30 years since the dedication of Riley Park, now is the time to bring water into the park and into the city.

Emphasize Historical Connections

Back to the Future. The historical street grid, in which the city connected high-ground to low-ground and to the rivers with its transparency, order, and canopy of trees, should be reinforced. Topography matters. High ground is of prime value.

Decouple High and Low Ground Water Systems

Managing stormwater at the top of the watershed will alleviate pressures for immediate drainage on low ground. Decoupling high and low drainage systems should be examined. A peninsula-wide groundwater management assessment is needed; otherwise groundwater will likely overwhelm the drainage system due to imbalances between surface water levels and pressure on the shallow groundwater.

Perimeter Protection Must Be Multifunctional - and Beautiful

The importance of the Perimeter Protection Study cannot be overstated, and any perimeter protection alignment must be logical, practical, and forward-looking. Special care is needed to ensure that perimeter protection intersects in a logical, sensitive ways with the Historic District. Certain alignments will create important stormwater storage opportunities and help manage groundwater. All alignments should take a multiple benefit approach that contributes to Charleston's unique character and exceptional quality of place.

Work at All Scales – from Dips to Deep Tunnels

If a perimeter protection is chosen in which more stormwater storage is possible, decoupling the new deep-tunnel system from the shallow drainage systems near the perimeter could improve the efficiency of the deep tunnel systems. Increasing interconnectivity between the deep-tunnel systems should then be assessed to create additional stormwater management and storage opportunities.

"Dips" and "swales" in peninsula streets should be strategically eliminated. Such dips encourage stormwater ponding, impair mobility and access to critical facilities and reduce resilience. When eliminating street dips, add water storage alongside and under the repaired streets to ensure previously impounded stormwater can drain without creating risk elsewhere.

Work Towards a No-Regrets Polder Approach

The recommended long-term strategy is an integrated water system with perimeter protection that allows the peninsula to be operated as a polder, or low-lying hydrologic unit. As sea levels rise, so will the need to store water to pump over the perimeter defense line. Current investments should be made with this future reality clearly in mind so that the water system necessary for the future can be implemented without regrets or wasted resources.

> “From our gardens, from our own property, to our public spaces, to our sidewalks and streets, we have to think of a creating a place for water. Being a friend for water, being an advocate for water, giving it a place to reside, giving it a place to rest rather than just hurrying up and pushing it out to the harbor. Reusing it wherever we can, making the best that we can of this resource.”

Mayor John Tecklenburg
City of Charleston

Waterfront Park
Low-lying public space has the potential to better live with water.

Maarten Kluijver, Coastal Engineer, Moffatt & Nichol

Decoupling High Ground Peninsula Drainage

Charleston's storm drainage network is a complex, dense set of concrete pipes, box culverts, and brick arch tunnels that has been expanded over the last century. As the city developed lower, coastal areas of the peninsula, upstream, high ground drainage basins on the peninsula's central ridge were connected to newer lower lying drainage basins at the coastal edge.

With increasing urbanization and impervious surface area, the system is often overwhelmed by ever-increasing volumes of rainwater. Sea level rise will worsen the problem, as the coastal basins and drainage outfalls are vulnerable to backflow as high tides exceed the street and catch basin elevations of the drainage system. Recent check valve installations help to prevent backflow, but water in the system cannot drain as designed during high tides, and spills or backs up into the streets.

Flooded streets and properties pose numerous problems: access limitations to hospitals, medical district facilities, and hospitality providers, traffic restrictions, and physical flood damage to public and private properties and contents therein. Recently completed and ongoing drainage infrastructure improvements, including the deep drainage tunnel additions, will improve overall system performance but will increasingly need pumps to operate. These updates reinforce the City's reliance on the dense, interconnected network of storm sewer infrastructure.

The Peninsula Team investigated a decoupling of the higher ground peninsula drainage system and to make it a standalone gravity-based system. Such a high ground drainage system could discharge rainfall runoff using gravity flows uninfluenced by tides. Because high ground runoff would not be carried through the low ground drainage system after decoupling, the capacity of both the low- and- high-ground systems would increase. This increased capacity will reduce the potential for street flooding during rainfall events that occur during high tides.

A desktop-level analysis led to a preliminary delineation of a new high ground drainage system, generally encompassing the peninsula's central southern ridge above an elevation of approximately +9ft NAVD88. This would require decoupling existing pipes and infrastructure in this high ground and an upgrade of the King Street storm sewer, which would then serve as gravity outfall for the high ground system. This new system, with a drainage area of approximately 300 acres, would reduce the catchment area of existing drainage basins, meaning each basin would be able to operate more efficiently. The Team estimated that the Meeting Street basin would achieve a reduction (preliminary estimated) of 73%. See table below for preliminary estimates.

A final note regarding the surface characteristics of the various basins. The peninsula's high ground has the highest percentage of hardened surface (including urban and light industrial rooftops) and relatively less vegetation and green space. Decoupling this drainage basin, which has a high direct rainfall runoff coefficient, will increase performance of the entire peninsula system.

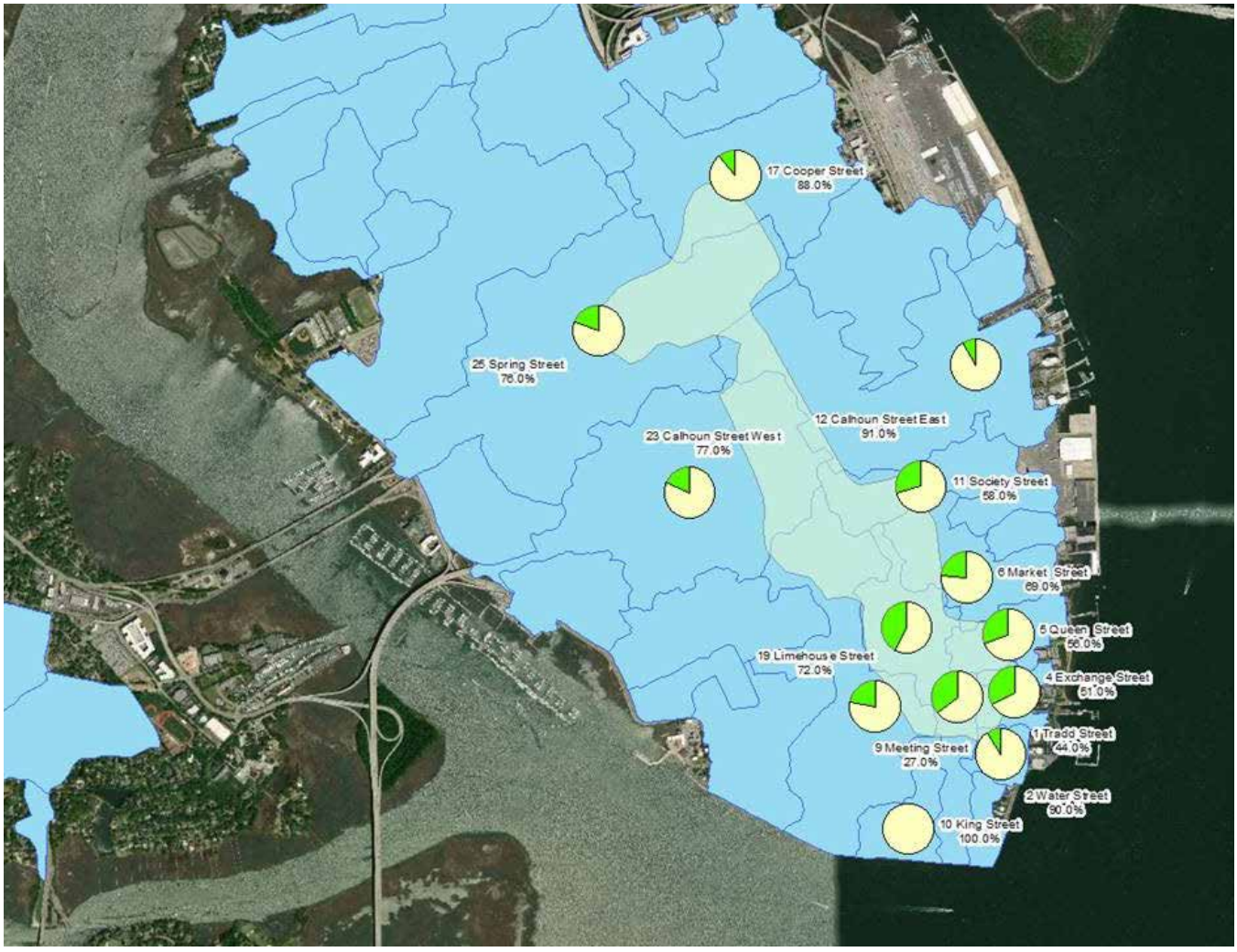
The Team recommends further study and an engineering assessment of this concept during the development of an Urban Water Plan for the peninsula.

A decoupled system offsets approximately 300 acres from existing drainage, and achieves an estimated 73% reduction in the Meeting Street basin.

Right: Water Offsets
Decoupling high ground drainage offsets runoff from 307 acres on the surrounding low ground.

Affected Drainage Areas	Existing Drainage area [acres]	New drainage area [acres]	Percent reduction
New "High-ground" Drainage area	-	300	-
Tradd Street	8	4	56%
Water Street	15	13	10%
Exchange Street	10	5	49%
Queen Street	29	16	44%
Market Street	58	40	31%
Meeting Street	76	21	73%
Society Street	48	28	42%
Calhoun Street East	184	167	9%
Cooper Street	131	114	12%
Limehouse Street	146	105	28%
Calhoun Street West	206	159	23%
Spring Street	282	214	24%

Note: Drainage areas are preliminary and based on desktop level assessment. Further analysis is needed to refine estimates and investigate delineation of basins and drainage performance thereof.



Steven Slabbers, Bosch Slabbers Landscape Architects

Perimeter Protection, Outside the Box

Water City
Charleston has an historic relationship to water

As a landscape architect, I appreciate Charleston's Peninsula because you always experience the water. There is a glimpse of the glittering water at the end of the road. You can feel the water. You can almost touch it. Charleston also has an iconic atmosphere: beautiful houses, gorgeous gardens, historic streets. The atmosphere is in these built structures and elements and its relationship with water. Water is a core quality of the Peninsula, mostly for the better but more recently, for the worse.

As explained elsewhere, we see the Peninsula eventually becoming a polder, providing perimeter protection against the outside water. There is no alternative over the long-term. How high that protection should depend upon how safe you want to be and how much money you can spend. At this moment, nine feet high for the whole perimeter seems quite reasonable, which is the current height of the High Battery. But what's good for today might not be best for tomorrow. With rising sea levels and increasing storm frequency, maybe 10, 11, or even 12 feet high might be more appropriate.

I don't like the term sea wall or floodwall. Walls are built to keep things or people out. We can instead develop a "first defense line" to keep the water out and make it in ways that strengthen the unique relationship of the Peninsula to the surrounding water. If we design the defense line in an uncomplicated, rational manner, it can also become a "connecting and protecting" zone. Less complicated equals less regrettable.

There are many existing perimeter structures upon which to build the defense line, including sea walls, berms, and waterfront parks. They must be strengthened, and other components added, to create the full perimeter system.

Where are the existing lines and structures? And where is it smart to investigate new, more autonomous lines? Because Charleston is the center of the fastest-growing coastal region between New York and Miami it is also wise to think about room for future residents.

This brings me to the first defense line in the Columbus Street Terminal. Charleston has four existing port areas. All over the world, old city-center ports are being relocated to areas with more space and better, less restricted ingress and egress. Port relocation can leave blight or provide inner cities with more space for urban development and less-disruptive land use. From the long-term perspectives of port and population growth in Charleston, is it possible to imagine a first defense line that supplies room for the city, more east of East Bay Street?

To the south, we can follow Waterfront Park, the High Battery, and the planned elevation and reinforcement of the Low Battery.

Peninsula Plan
Autonomous line along the Ashley River,
integrated protection on the Cooper River

For the west side, we imagined two different strategies. First, a strategy in which the levee follows the edge of the Peninsula as tightly as possible, which would be complicated and inelegant. An alternative approach proposes a more autonomous line. This would create entirely new opportunities for access, recreation, and unique scenic river experience. Such a defense line would showcase Charleston's water culture and its picturesque sunsets while providing more room for water storage. It does this without impacting existing properties.

This line, however, will impact the ecological quality of the wetlands within the new system, which is a negative outcome unless mitigated with new marshland growth on the outside. The City Harbor would have to be relocated or reimagined to interact with this new system. These are tough, yet essential choices given the overall water, population, development, and housing challenges on the Peninsula.

Flood Protection

U.S. Army Corps Study

Study Area
USACE map delimiting Charleston Peninsula Boundary

The U.S. Army Corps of Engineers (USACE) is conducting a Charleston Peninsula Coastal Flood Risk Management Study and Feasibility Report. The Study follows standard 3x3x3 protocol, was initiated in October 2018, and has a target completion date of Fall 2021. Note: any decision document from the Study will require subsequent Congressional authorization and appropriation before the recommended project may be implemented.

Project Area

The Charleston Peninsula is approximately 8 square miles, located between the Ashley and Cooper Rivers. The two rivers join off the Battery in Charleston to form Charleston Harbor before discharging into the Atlantic Ocean. The Charleston Harbor is a natural tidal estuary sheltered by barrier islands. The Charleston Peninsula is the historic core and urban center of the City of Charleston and is home to 38,000 people. The shoreline of the peninsula has undergone dramatic changes, predominantly by landfilling of the intertidal zone.

Problem Statement

The Charleston Peninsula experiences coastal storm surge inundation that adversely affects the economic sustainability of Charleston, places populations at risk, and limits or completely restricts access to critical facilities, emergency services, and evacuation routes.

Federal Interest

Preliminary economic analysis indicates that structures in the 100-year floodplain are appraised at $3.5 billion and structures in the 500-year floodplain are appraised at $5.4 billion. Replacement values and solution cost estimates will be developed over the course of the study. The alternatives and their associated cost estimates will be further refined over the course of the study.

Risk Identification

The problems identified for the study include effects resulting from coastal storm surge inundation, posing a damage risk to structures and contents and a risk to human

health and safety. Based on historical storm events, there is a minimal risk to loss of life.

Identified study risks include the use of existing information, assumptions regarding subsurface conditions, locations of underground utilities, and future improvements to the Port of Charleston. All study risks are considered low risk and typical of feasibility studies at the beginning of the study. These risks have been identified and analyzed on the IWR-Assistance for Planning Teams risk register, including consequences, likelihood and uncertainty ratings, and risk management options. The risk register will be updated as the study evolves and new information is made available.

Factors Affecting the Levels of Review

Scope of Review. Issues driving the scope of review include distinguishing between coastal storm surge inundation and interior flooding (rainfall and high tides). Although the peninsula is bounded by two rivers, riverine flooding from interior watersheds is not a driver of the flooding problem. Existing coastal and storm wave models will be used to analyze coastal flooding issues.

Assumptions will be made about subsurface conditions which can vary greatly, especially in areas where fill has been placed for development. Inaccurate assumptions could result in cost increases when implementing the recommended plan. The tentatively selected plan will be evaluated using three sea level rise scenarios per ER 1100-2-8162, but there is no single projection of relative sea level rise that can be used to guarantee a coastal storm risk management project will remain effective throughout the entire 50 year period of analysis.

It is unlikely that the project will be justified by life safety, but life safety issues will be part of the study, i.e., the medical district is susceptible to catastrophic flooding, and evacuation routes are subject to flooding and closure during hurricane or tropical storm events.

Note: “3x3x3” refers to WRRDA 2014 process for this study that stipulates 3 years, $3 million, 3 levels of review.

See USACE Study overview for detailed information: https://www.sac.usace.army.mil/Missions/Civil-Works/Supplemental-Funding/Charleston-Peninsula-Study/

New Orleans HSDRRS
USACE “Hurricane & Storm Damage Risk Reduction System” provides 100-year risk reduction, without consideration for aesthetics. or amenities

London Avenue Canal Floodwall
Dutch and Indonesian delegates visit floodwall in New Orleans with no access to water.

Westerdijk, Rotterdam, NL
Multi-functional flood protection integrates transit, road, pedestrian and bicycle paths, with development sites and park spaces.

Roelof Stuurman, Geohydrologist, Deltares

Subsurface, Subsidence & Groundwater

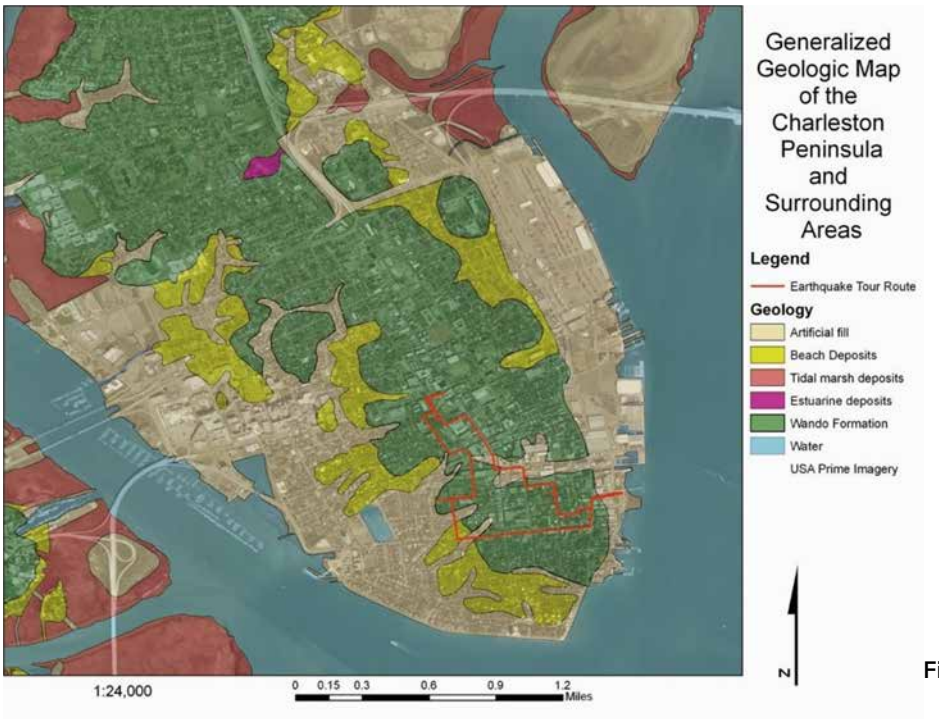


Figure 1

Hydro-geology & Subsidence Vulnerability

The shallow subsurface of the Charleston peninsula is characterized by solid Pleistocene deposits (silt, very fine sands), which are often covered by soft organic-rich marsh soils along the riversides. In the urban area, these marsh soils are covered by uncharacterized fill (figure 1). These heavy fills are still compacting the underlying soft soils.

An important hydrogeological (nearly impermeable) foundation of the urban groundwater system is formed by the Cooper Marls (calcium-rich heavy clay). Below the Cooper Marls is a regional aquifer system. These aquifers and aquitards descend as they move east (figure 2). Besides the (1) local heterogeneous, shallow subsidence caused by compaction of the marsh soils, (2) regional, homogenous deep subsidence processes exist, induced by decreased hydraulic heads (groundwater pressure) in these aquifers. Pumping decreases hydraulics heads at a local, but also regional scale, resulting in compaction of aquifers and overlying and underlying aquitards (confining unit)(figure 2).

Decreased hydraulic heads in the aquifer system below Charleston are extreme. In the past, these aquifers were characterized by artesian conditions (water pressure above surface level); nowadays, the water levels are tens of feet below sea level. The hydraulic head in the deep Middendorf aquifer dropped more than 100 feet (30 meters) between 1990 and 2005. Between 2005 a restoration process started, then stabilized at around 40 feet and started to drop slightly again in 2014 (figure 3).

Other, shallower aquifers suffer decreased hydraulic heads. The hydraulic head in the Florida aquifer (325 feet below the surface) in North Charleston dropped more than 30 feet (9 meters).

Estimated Subsidence Velocities

Relative Sea level rise around Charleston (monitoring location harbor area) is 3.36 mm/year (NOAA). “Relative” means that this rate is the result of subsidence of the depth of the foundation of the monitoring site (in Pleistocene subsurface) and absolute sea level rise. “Relative” sea level rise will be further compounded by shallow compaction processes.

During the Dutch Dialogues Workshop, no subsidence data was available. Discussions with experienced local engineers

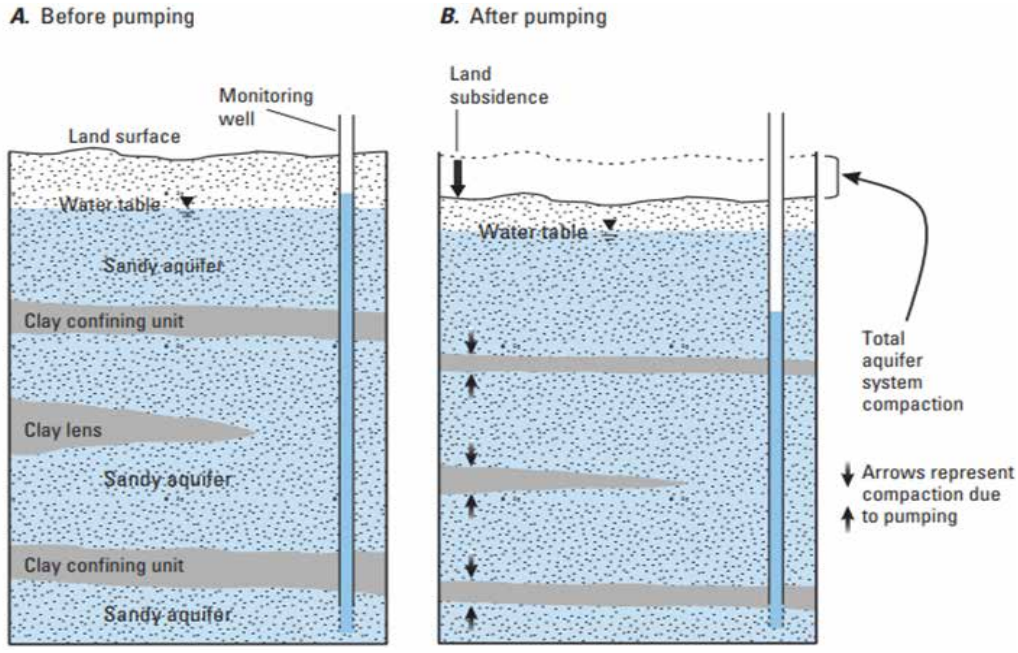


Figure 2
Aquifer-system compaction caused by groundwater withdrawls
Modified from Galloway and others (1999)

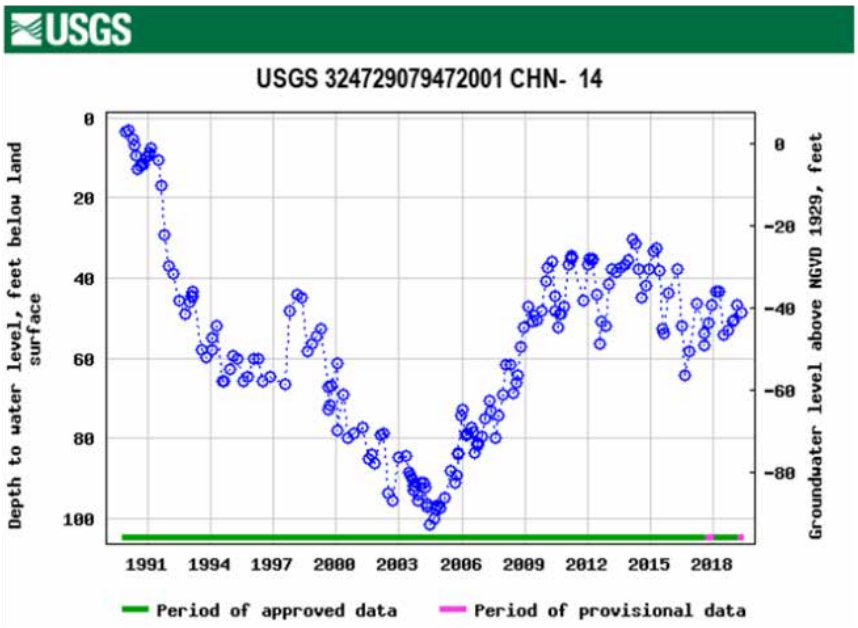


Figure 3
Groundwater Levels at observation well in downtown Charleston
USGS

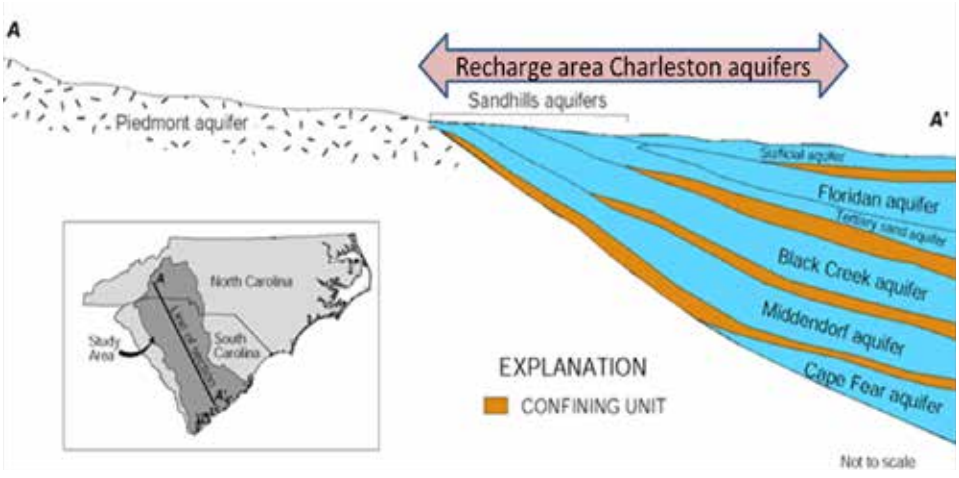


Figure 4
Regional Groundwater System section diagram

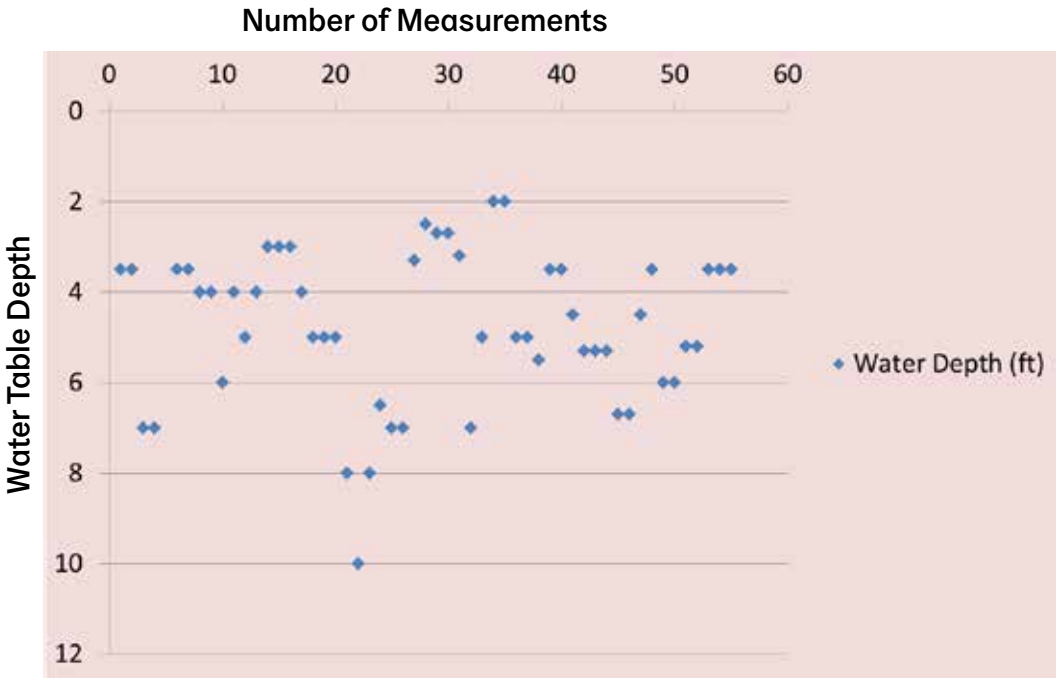


Figure 5
Groundwater report compilation

delivered subsidence estimates for the fill area of 5 (Jackson Park) to 30 (River Dogs Baseball field) mm/year. So, all of the non-piled, fill areas are sinking faster than sea level rises.

The amount of deep subsidence due to decreased hydraulic heads is unknown. Deep subsidence in Norfolk, VA, under similar conditions and drawdowns, is approx. 3 mm/year. So, given measured relative sea level rise of 3.36 mm/year, deep subsidence or local sea level rise is small.

Groundwater

Little is known about groundwater levels and groundwater fluctuations (seasonal, after rainstorms) at the peninsula. However, by analyzing approximately 50 geotechnical reports during the Workshop by Steven Jaume, Department of Geology and Environmental Geosciences, College of Charleston, an estimate of these groundwater depths was determined (figure 5). These reports indicate that groundwater levels are found between approximately 3.5 to 6 feet (105 to 180 cm) below the surface. Seasonal differences were not included, and how groundwater levels were determined is unknown. Better understanding of groundwater fluctuations and groundwater depths will help urban water management in relation to: (1) understanding groundwater storage availability for stormwater infiltration, (2) understanding the optimal target groundwater level to protect (untreated historical) wooden foundations, (3) to reduce shallow subsidence by keeping groundwater levels above organic marsh soils.

Hydrogeological Water System Cross Section

Based on geological information from the geotechnical reports and expert information from experienced local engineers, the subsurface water system can be schematized (figure 6). This cross-section follows Queen Street, passing Colonial Lake. This picture also includes an estimate of the depth of storm drains and wastewater sewer pipes. Wastewater sewer pipes are, in general, approximately 12 feet below surface level and connected to a system of deep (> 100 feet) vertical shafts and tunnels constructed in the solid Cooper Marl. This system ends at the Waste Water Treatment Plant at Plums Island. Treated wastewater is discharged into the nearby river. The storm drainage pipes are typically constructed 1-2 feet below sea level and are often more than 100 years old. The vaulted brick channels discharge by gravity or by pumps into the river. Over time, this storm drainage system became more vulnerable for rising river levels, and is now protected by flap gates or check valves.

Local urban groundwater is likely drained by leaking pipes (waste water as well as storm drainage), and so determines the groundwater level fluctuation. Therefore, the cross-section water table follows the depth of the drainage system. A better understanding of this groundwater level is vital to groundwater management, but also in relation

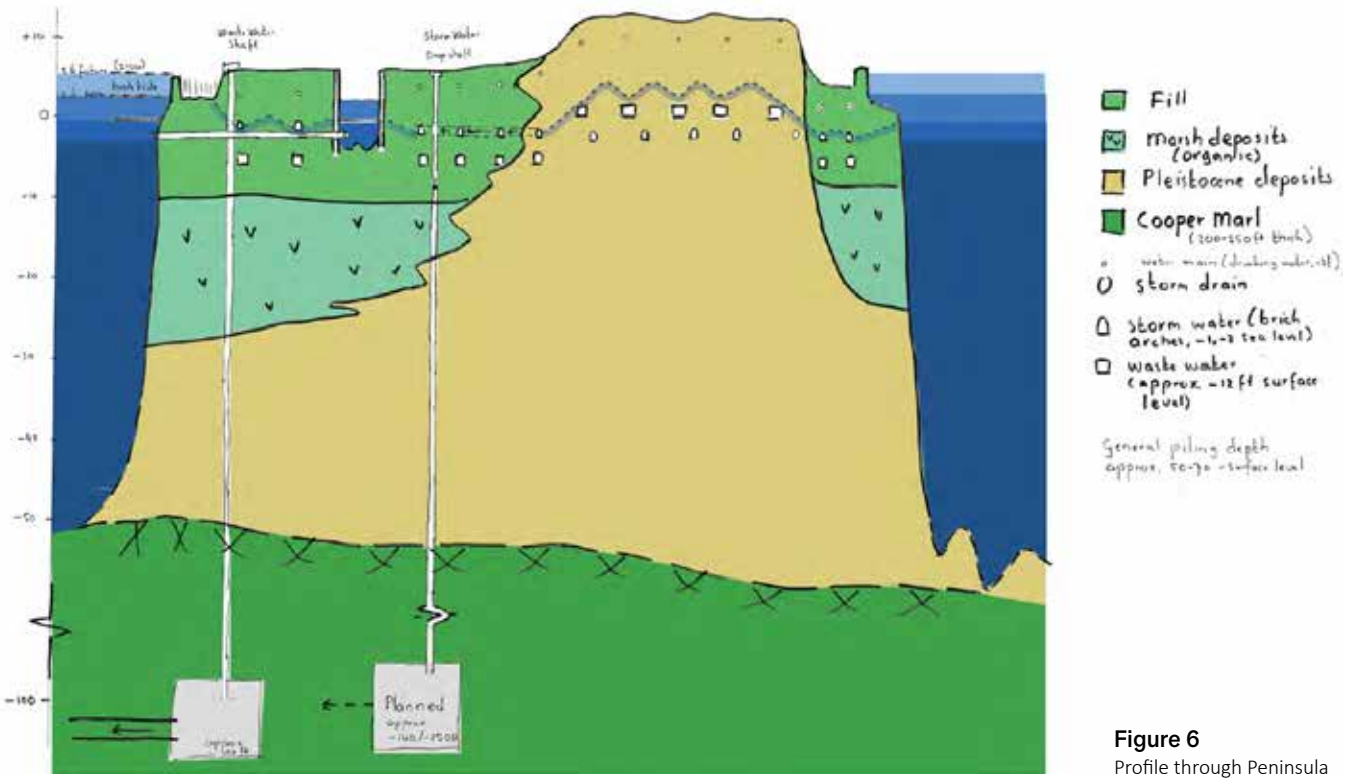


Figure 6
Profile through Peninsula

to storm water management. It is unknown how much drinking water is lost during transport.

Recommendations

1. Design and install an urban groundwater monitoring network to understand the relation between groundwater, river levels, rain storms, and leaking waste water and storm drainage pipes. Approximately 20 locations in the peninsula.
2. Design and install a storm drainage sensor monitoring network. A distributed network around the city's urban system to understand relations with river water levels, rain water, and ground water. Approximately 10 sensors would suffice. Together with the first recommendation, this will become an integrated water observation network.
3. Determine groundwater drainage by the waste water system: dry weather drainage and wet weather groundwater drainage.
4. Start a satellite (InSar) subsidence velocity analysis, e.g., using the Sentinel satellite (passing every week, pixels 5x25 meter, since 2016). This analysis will deliver the sum of shallow and deep subsidence.
5. Start to understand "relative" sea level rise near Charleston better, splitting "deep" subsidence and absolute sea level rise.
6. Start a regional platform to restore the hydraulic heads in the deep aquifers to reduce subsidence and protect fresh groundwater resources against saltwater intrusion. Platform goals would be to better understand the locations, depths, pumping amounts, and use of existing withdrawals.
7. Rethink the waste of dumping fresh water (storm drainage, treated waste water effluent) into a saltwater environment. Perhaps this water can be used for industrial or other purposes.
8. Are there additional benefits possible for the deep shafts and tunnels? For example, by using them for cooling.
9. Construct a 3D (urban) geology model based on existing geotechnical reports that can be used to construct a hydrogeological groundwater model. This groundwater model can be used to evaluate the effects of sea level rise, but also to analyze the impacts of renovation (becoming impermeable for groundwater drainage) of the subsurface pipes system.

Historic Charleston Foundation

Flood Adaptations for Historic Structures

Historic Examples of Building Elevations
Structures from the nineteenth century are elevated several feet, with facades and porches that create a consistent, traditional streetscape.
Credit: City of Charleston

Historic Charleston Foundation

Charleston is undeniably proud of its historic architecture. The city has one of the most important collections of residential and civic architecture in the United States. A pioneer in modern historic preservation, the City created a local historic district that was later designated as a National Historic Landmark District in 1960. Both the local and the nationally recognized district have been greatly expanded over the years; retaining the historic character of individual buildings is key to the preservation of the whole.

Until fairly recently, Charleston's preservation community was adamantly opposed to elevating historic buildings simply because of flood risk. The visual character of a historic building is closely linked to its overall design, including its height, massing, proportion and the overall scale of its architectural features. When an historic building is raised, the process can affect its integrity by altering its proportions and compromising its relationship to adjacent buildings, and to the historic district as a whole. Massive damage from Hurricane Hugo in 1989 demonstrated the dangers for historic buildings within the low-lying areas of the city, yet the event – at the time – seemed isolated.

Today, with escalating rain events, sea level rise, and tidal flooding, we know that water constitutes an increasing threat to our historic district, and our position on elevating threatened buildings has evolved. A key component of historic preservation is adaptability. Therefore, we must accommodate the elevation of historic buildings where warranted in order to ensure their very survival, and improve resiliency for the historic district.

All images this spread credit: City of Charleston

Foundation Design Considerations

Successful Examples

Historically elevated foundation

Extension of column line to pier foundation

Solid foundation at front

Guidelines

- Generally, foundations should be based on historically elevated foundations in Charleston, and also based on neighborhood/context specific examples.
- Foundation components should complement existing façade features:
  - ◊ Visual support of columns
  - ◊ Pilaster expression
  - ◊ Solid foundation wall under main body of house, especially at the street front, and piers at piazza with infill screening
  - ◊ Use traditional masonry materials
  - ◊ Use existing elements as visual references to be repeated and extended throughout foundation design
- Pier infill should be:
  - ◊ Recessed
  - ◊ Use louvers or custom lattice
  - ◊ No "beachy" style horizontal slats or stock lattice

"Beachy" style foundation

Stock Lattice

Charleston Board of Architectural Review Design Guidelines

The City of Charleston Board of Architectural review adopted design guidelines to assist property owners with elevating historic structures in order to adapt to challenges from forces of water. Adopted in July 2019, the guidelines show examples of local buildings in context. Recommended practices are explained and illustrated with photographs. This spread shows selected excerpts from the document.

For more information, see:
https://www.charleston-sc.gov/DocumentCenter/View/18518/BAR-Elevation-Design

Eastside

> “In order to best manage water we need to start on the high ground.”

Ramiro Diaz
Senior Designer, Waggonner & Ball

Contributors

Ramiro Diaz, Steven Slabbers, Colleen McHugh, Maarten Kluijver, B.D. Wortham-Galvin, J.R. Kramer, Allen Davis, Tonya Gore, Arianne Wolfe, Katie McKain, Taylor Schenker, James Ward, Dale Morris, Mark van Auken, Kyle Brooks, Brian Shelton, Krithika Mohan, Austin Viridin

Contents

Eastside

LEGEND

AREAS

- Development Sites
- Public Parcels
- Public Easement
- Park
- Urban Growth Boundary

WATER WETLANDS

- Water
- Wetland

WATERSHED

- Watersheds

WATER MANAGEMENT PROJECTS

- Projects

SEA LEVEL RISE

- 3' Sea Level Rise

DFIRM

- coastal floodzone, floodway
- 100 year floodplain
- 500 year floodplain
- Street Flooding

ROADS RAIL

- Rail

Road

- Major
- Minor
- Local


Newmarket Creek

Eastside Elevation

LEGEND

Topography 0'-20'

- ≤2
- ≤4
- ≤6
- ≤8
- ≤10
- ≤12
- ≤14
- ≤16
- ≤18
- ≤20

Bathymetry

- ≤0
- ≤-5
- ≤-10
- ≤-15
- ≤-20
- ≤-25
- ≤-30
- ≤-35
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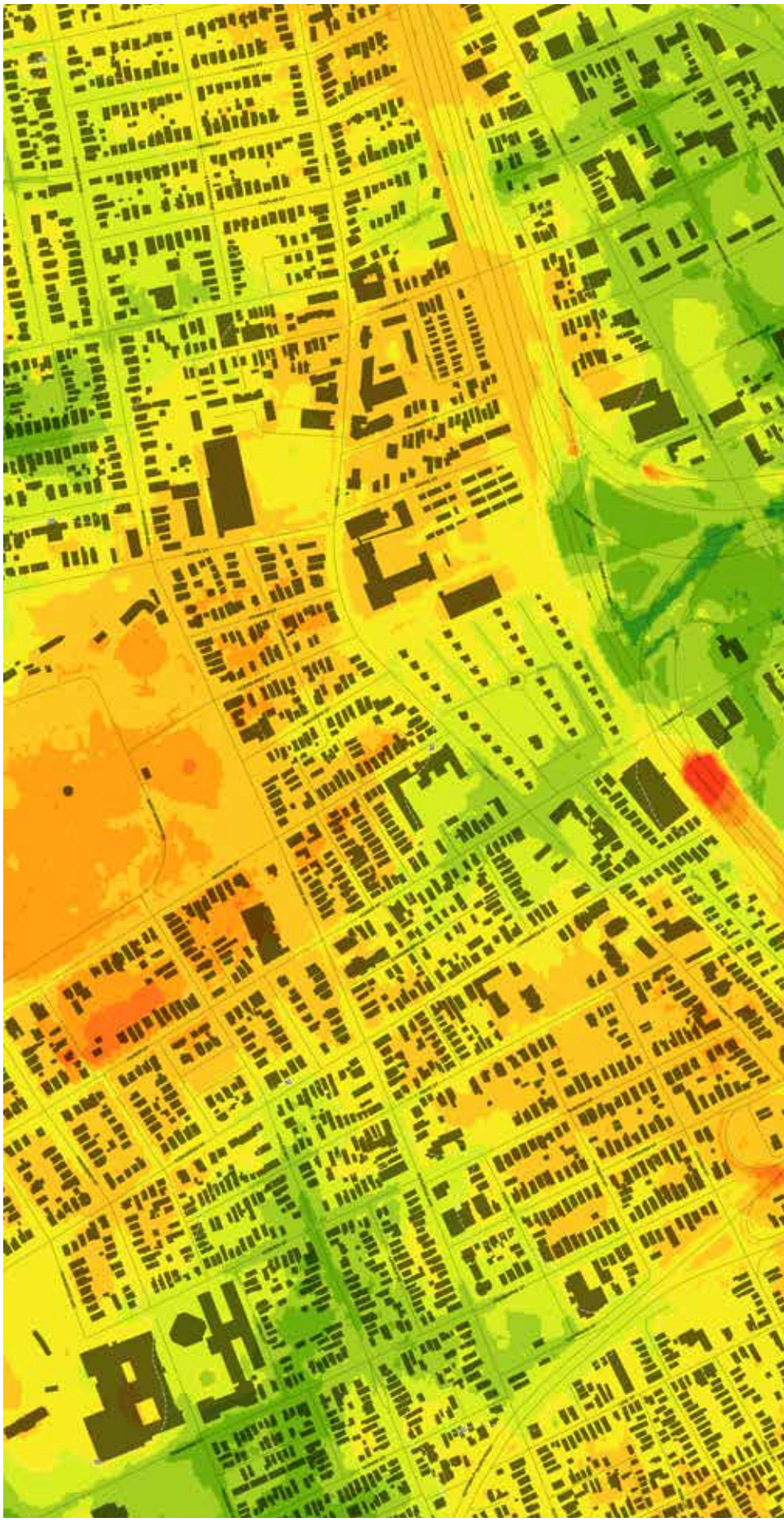
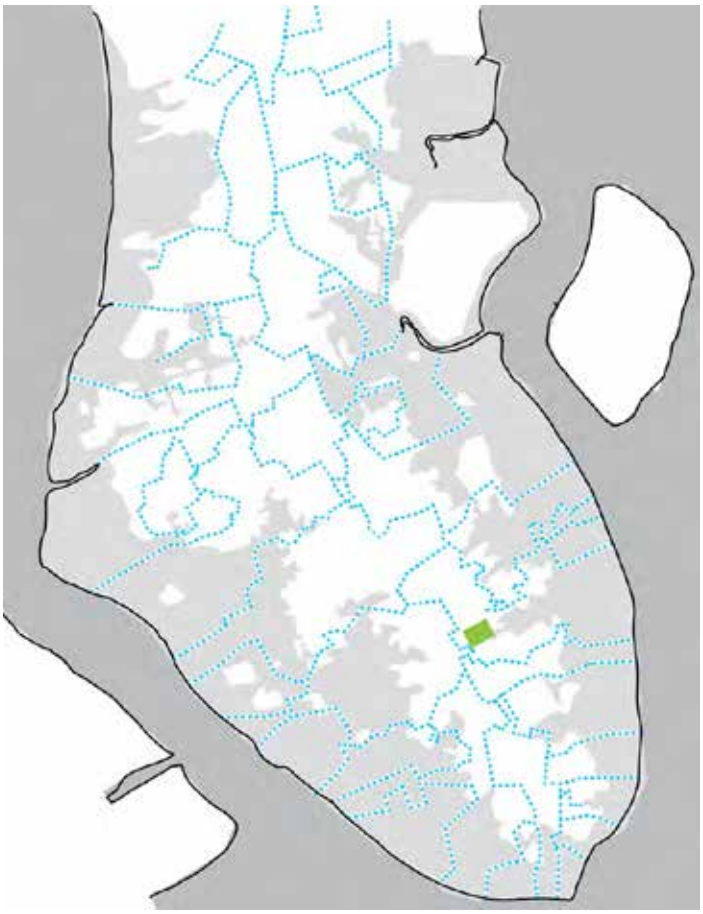
- ≤-75
- ≤-80



Eastside



Watersheds in the Eastside

Topography & Drainage

The peninsula spine is high ground; it has the most significant runoff influence on the low ground. Every drop of water that falls must go somewhere, most often by gravity, either planned through the stormwater systems or unplanned through the streets, neighborhoods, cars, and homes. Because gravity stormwater drainage systems (at low elevations) are tidally influenced, sea level rise will increase flooding impacts if not properly managed. **With the implementation of perimeter protection, stormwater runoff will need to be managed more purposefully and intensively, and eventually pumped**, or there will be flooding. This is particularly true in Eastside neighborhoods.

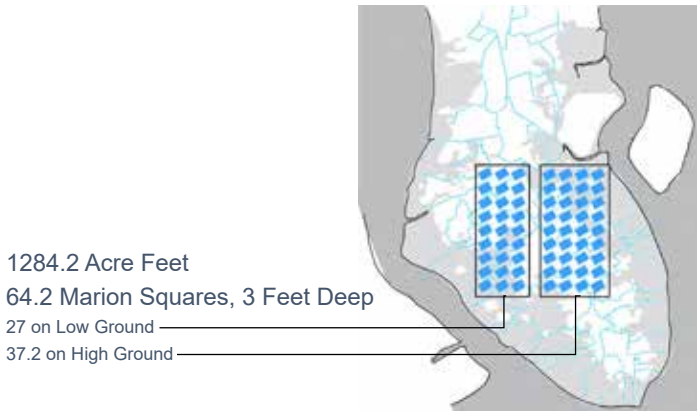
Topographically, Charleston is relatively, but not absolutely, flat. Subtle elevation differences in the streets break the water one direction or another, but always to the drainage system and low-lying areas such as historic creek beds, and eventually to the rivers. The efficiency of the existing drainage system is limited by the catch basin size, pipe size, and outfall size/elevation; relative to rainfall intensity and volume. When the drainage system in each basin is at capacity, the result will be ponding and unmanaged overland flow.

Water Assignment

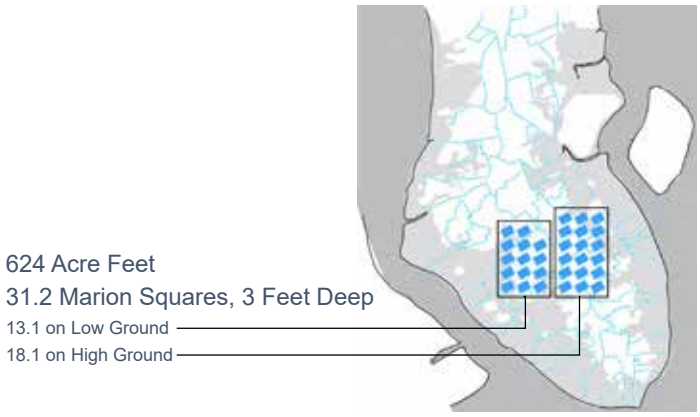
To understand, and eventually prevent, the overfilling of the basins, we think in terms of "the water assignment" in temporal and spatial senses. **The water assignment is the volume of water beyond what the drainage system can handle for any given storm.** Stormwater managers think of water in terms of acre-feet. Imagine the scale of Charleston's Marion Square, and fill that space with three feet of water. This "Marion Square" becomes our spatial reference for the water assignment, which is based upon the typical design storm: a 10-year, 24-hour storm with 6.5 inches of rain. Such rainfall is not overwhelming if it falls evenly over 24 hours, but it still must be managed, or flooding will result. Uneven, intense rainfall, especially at high tide, substantially complicates the flood management challenges.

Design storm parameters, derived from NOAA measurements, are changing, and drastically in some parts of the city. For instance, the rainfall associated with the 10-year storm in Charleston is now occurring approximately once every year or two. Charleston isn't unique in this sense; many East Coast and Gulf Coast cities are also seeing their 10-year design storms occurring on average every two years. **Existing drainage infrastructure is overtaxed everywhere.**

More worrisome is evidence that peak one-hour events, "rain bombs" and "cloudbursts," are also increasing in frequency. When peak rainfall events coincide with high tide, their impacts quickly transition from nuisance to severe.



Water Assignment for a 10-Year (10% annual occurring chance) 24 Hour Storm Event

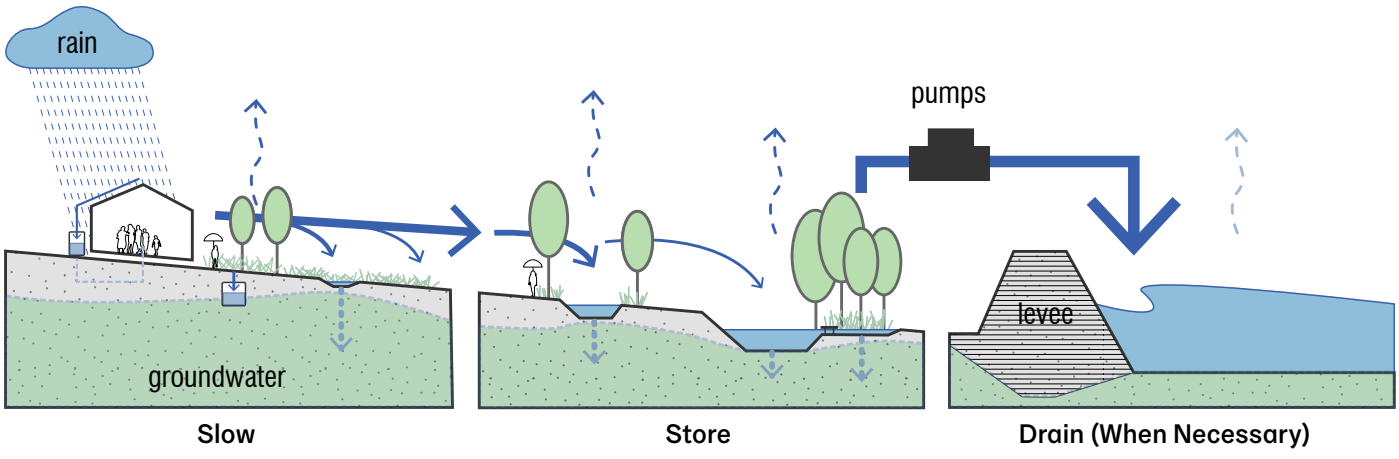


Water Assignment for a 25-Year (4% annual occurring chance) 1 Hour Storm Event

A New Approach

The slow-store-discharge, or retain-detain-drain, approach underpins the Dutch way and the Greater New Orleans Urban Water Plan, and is appropriate for Charleston too. **Infiltrating more water on the high ground changes the runoff coefficient**, making the water assignment easier to achieve. Infiltration rates can be calculated when reliable soil maps and groundwater levels are known. Charleston leaders should commission a detailed, comprehensive groundwater study for the Peninsula to understand soil and groundwater challenges and opportunities.

More infiltration means less water to store/detain, further reducing the water assignment. Stored water can accomplish many things, from reducing heat-island impacts, to providing amenity and environmental quality, adding recreation in blue-green corridors, and, crucial for Charleston's future, balancing groundwater.



Slow-Store Approach to Stormwater Management

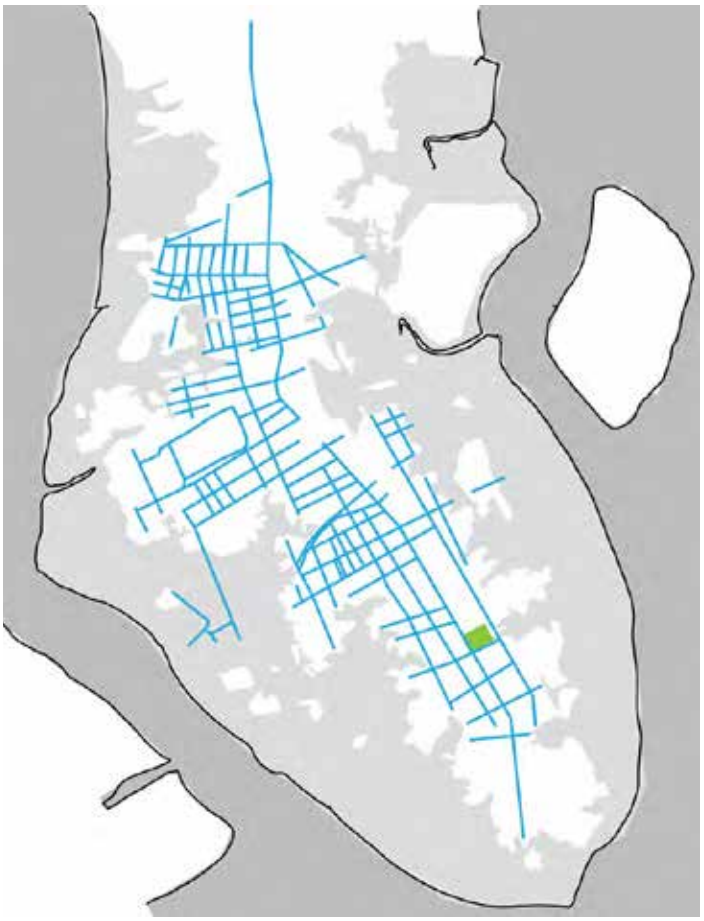
Streets and Rights of Way

Groundwater and drainage networks under the **streets above 8-feet elevation will not be tidally influenced** in the near term. They have the most significant potential to store water.

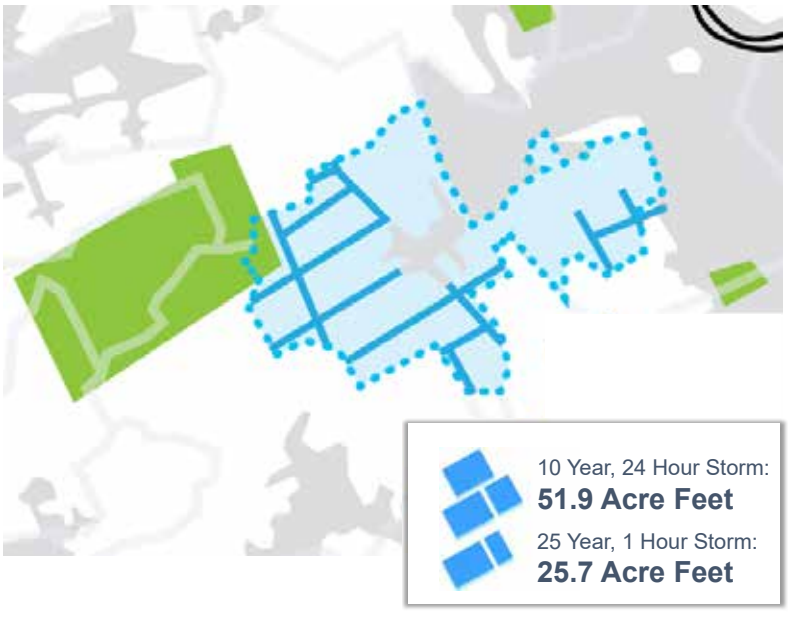
In the Huger/King street watershed, the team calculated a 10-yr storm water assignment for a 10-year 24-hours storm at 2.5 Marion Squares and a 25-yr, 1-hour storm at 1.25 Marion Squares.

A natural ridge east of this intersection does not follow the Lowline; instead, the Lowline is an artificial ridge, like many old railbeds, and is impounding water. Newmarket Creek used to flow to the Cooper River through this area. Thus, it is no surprise that the Huger/King Street intersection regularly floods.

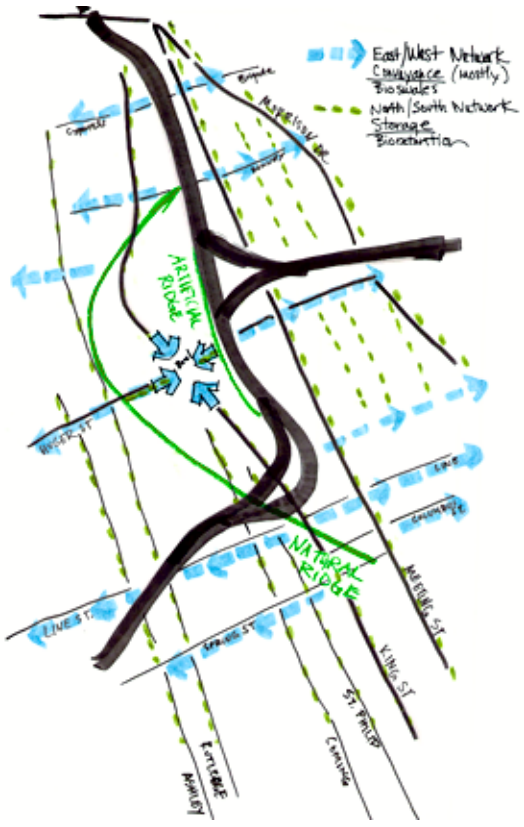
Except for the Peninsula's narrow streets, many water assignment interventions are possible. They can be implemented and added piecemeal as roads are rebuilt or repurposed. Better would be a set of well-researched and **coordinated interventions pursuant to an urban water plan.**



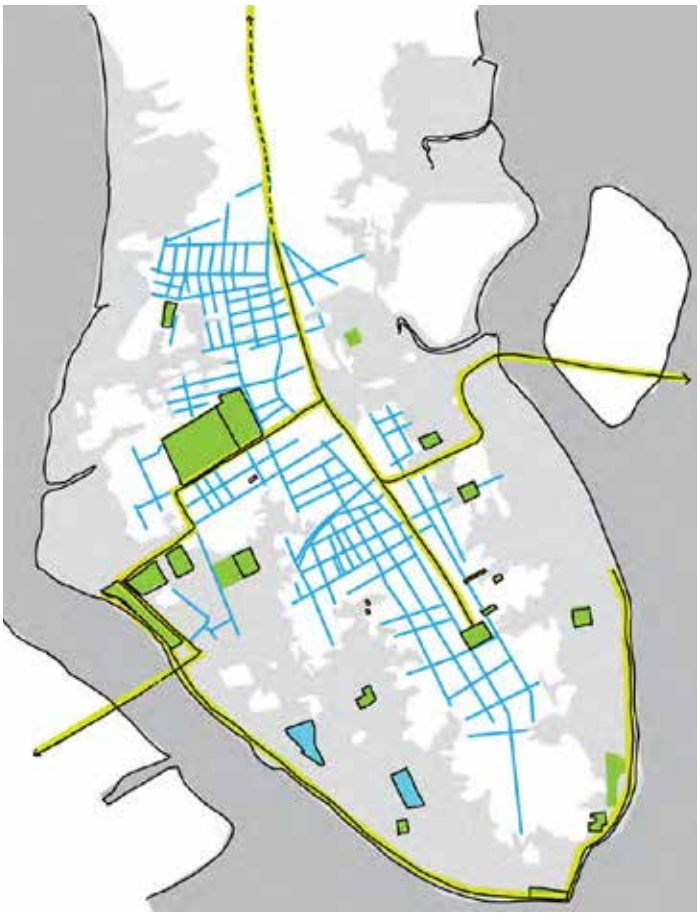
Existing Streets Above +8 Feet Elevation



Water Assignment for the Huger/King Street Watershed



Ridges and Flows of Water



Existing Streets Above +8 Feet Elevation and Public Parcels

How do streets store water?

First: Permeable pavers. The product illustrated below, Permeable Articulating Concrete Block pavers, is easy to install and maintain, can withstand heavy traffic loads, and works well in street-side parking spaces and lots.

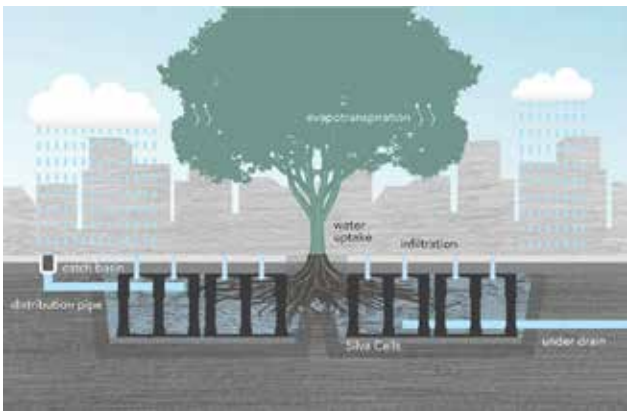
Second: Water storage under the streets. Options abound, and they can store a lot of water. The principle is to create void space below grade for storage, while structurally supporting the surface above.

Third: Plant more street trees, in wells with space for their roots. Structural Soil and suspended pavement systems, such as Silva Cells, create a framework under the sidewalk that ensures softer, looser soil to support tree health, growth, and space for water storage.

Fourth: Bioretention in the street right-of-way to intercept, infiltrate, store, and drain water.

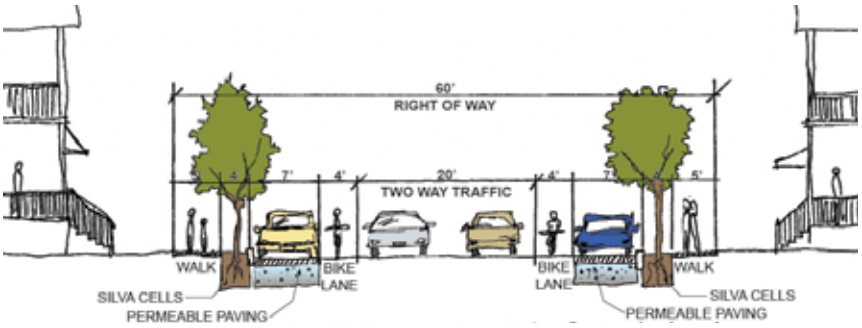
Left: Permeable Articulating Concrete Block Pavers
Photo Credit: PaveDrain

Right: Subsurface storage vaults at Easton Park, New Orleans



Left: Bioretention planters, Bell Street, Seattle

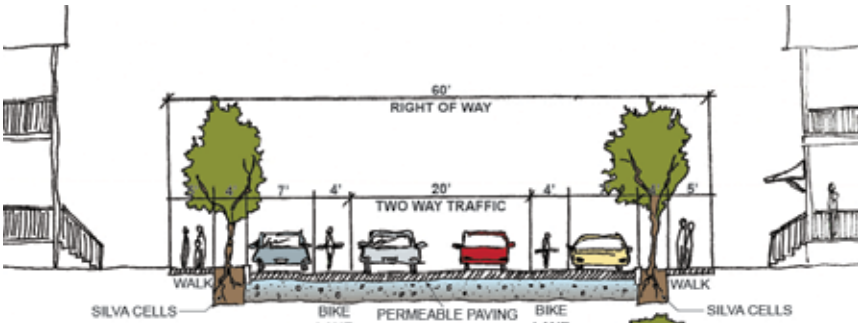
Right: Silva Cell, Tree Well and Suspended Pavement System
Photo Credit: Deeproot



Minimum Intensity Scenario of Retrofitting an Existing Public Right of Way

4% of 10 Year / 24 Hour Storm

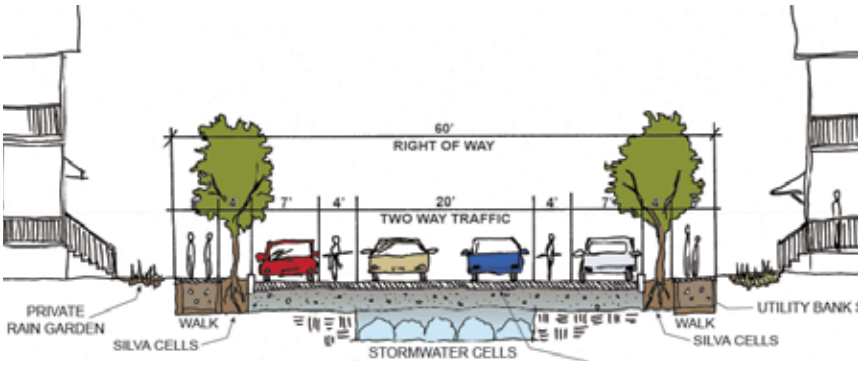
8.5% of 25 Year / 1 Hour Storm



Medium Intensity Scenario of Retrofitting an Existing Public Right of Way

11% of 10 Year / 24 Hour Storm

23% of 25 Year / 1 Hour Storm



Maximum Intensity Scenario of Retrofitting an Existing Public Right of Way

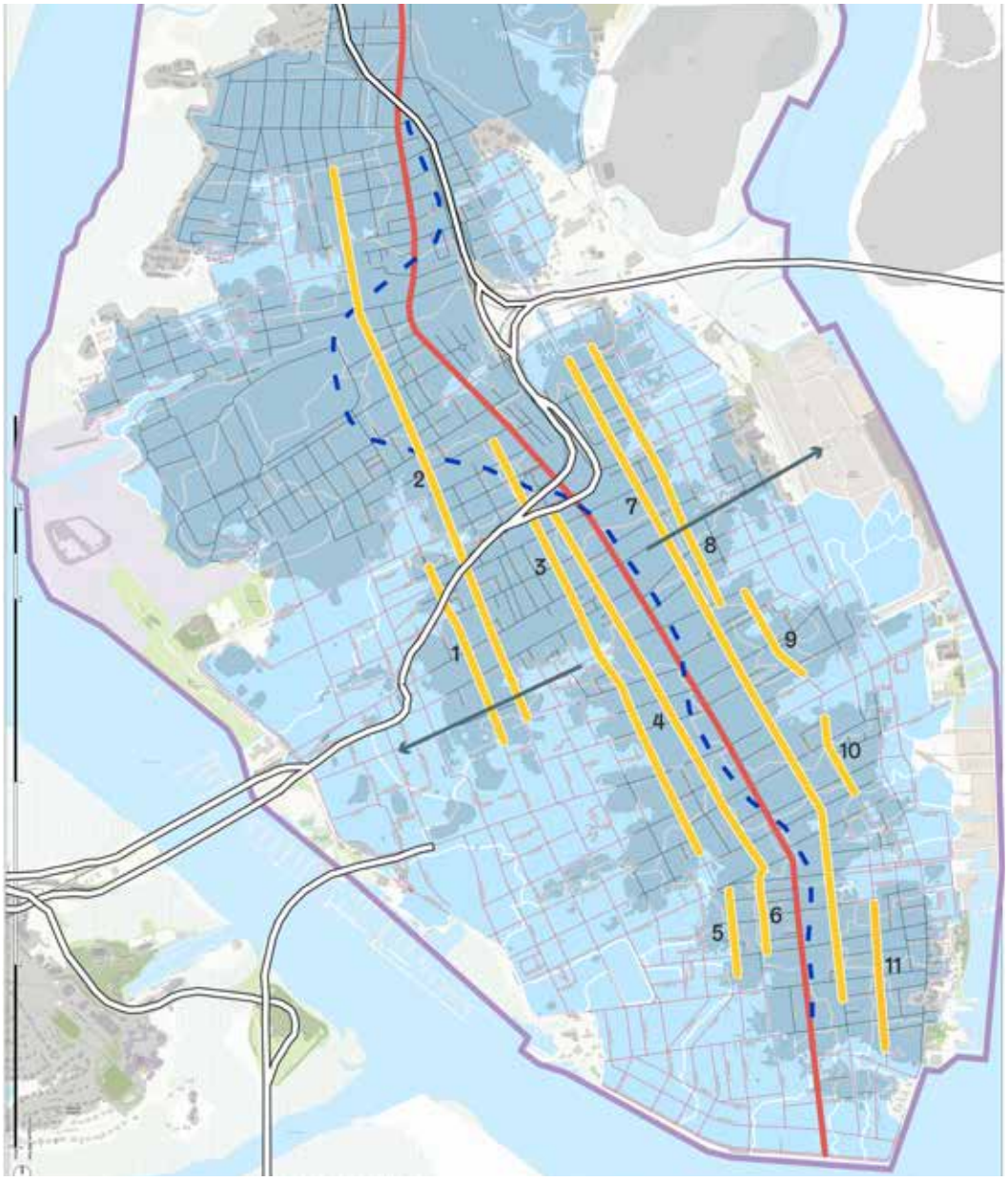
30% of 10 Year / 24 Hour Storm

62% of 25 Year / 1 Hour Storm

Roadway Retrofits

A minimum combination of the above street interventions on only the north/south streets illustrated in the map at right will store approximately **8.5% of the peak water assignment**. A more aggressive scenario, with permeable paving along the entire street section, stores between **23% of the peak water assignment.** While costly upfront, the avoided flood losses can be monetized to offset installation costs. The bonus? Functional, beautiful streets. Adding stormwater cells under the streets to maximize storage, which is possible in high ground areas, can achieve **62% of the peak water assignment**. Increasing storm frequencies and peak rainfall events leave no doubt that street retrofits per the above must become part of the City's long-term water management toolbox.

Bioretention Planter Alongside Bell Street, Seattle, WA

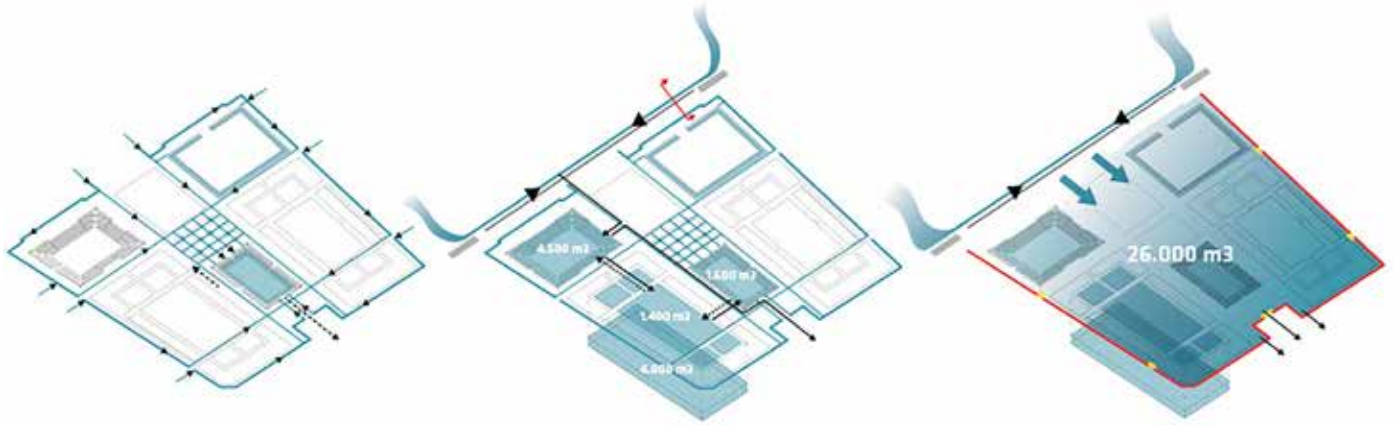


Average values of stormwater storage (ac-ft) created by minimum, medium, and maximum street excavation interventions

West of King St	Min	Med	Max
1 Ashley Ave	1.42	4.24	11.4
2 Rutledge Ave	7.42	16.66	44.85
3 Coming St	5.91	13.28	35.74
4 Saint Philip St	3.43	10.29	27.66
5 Logan St	1.15	1.71	4.13
6 Archdale St	0.06	0.14	0.37
total	19.39	46.32	124.15

East of King St	Min	Med	Max
7 Meeting St	4.32	24.33	64.76
8 Nassau St	3.23	5.01	13.05
9 Elizabeth St	1.46	2.63	12.05
10 Anson St	0.36	0.77	1.99
Anson St (wide)	0.31	0.62	1.73
11 Church Street	1.85	3.17	7.99
total	11.53	36.53	101.57

Examples of Stormwater Management in Large Parcels



Enghaveparken Water Garden System Diagrams
Image Credit: Terdje Natur

Public Parcels

Opportunities exist in public parcels too. The Peninsula has few large parks or open spaces; they must be **optimized for infiltration and detention on the high ground** (Hampton Park), and **storage in lower areas** (Brittlebank Park). Water storage and park usage are not an either-or choice; they can be combined to produce multiple benefits.

Schools and other public facilities, which are abundant and well-dispersed, can be optimized to serve students, residents, and a water assignment function via underground detention, bioswales, green spaces, and water squares.

Water Garden to Slow and Store Run-off in Enghaveparken
Image Credit: Terdje Natur

Left: Existing Conditions at William Enston Housing

Huger and Low Line Opportunities

At the William Enston Homes, an attractive, historic housing development, a swale already exists. Nearby is more space for water storage, including between the trees. Implementing green infrastructure at this site would **mitigate some flooding at King and Huger**, for which the City is already developing drainage improvement plans. Ensuring flow from the Enston Homes bioswale over or through the Lowline would create additional storage and drainage. Expanding the Newmarket Creek watershed and improving flow east of the Lowline would further improve drainage and water storage potential, and also increase environmental quality. During a preliminary discussion at the Workshop, SC DOT indicated a willingness to consider **park and water management features under I-26**. Many other high ground spaces on or near the Lowline can be similarly adapted to manage stormwater.

Opportunities to slow, store and drain runoff while connecting Huger, Enston Homes, the Low Line and Newmarket Creek

Parks and Schools

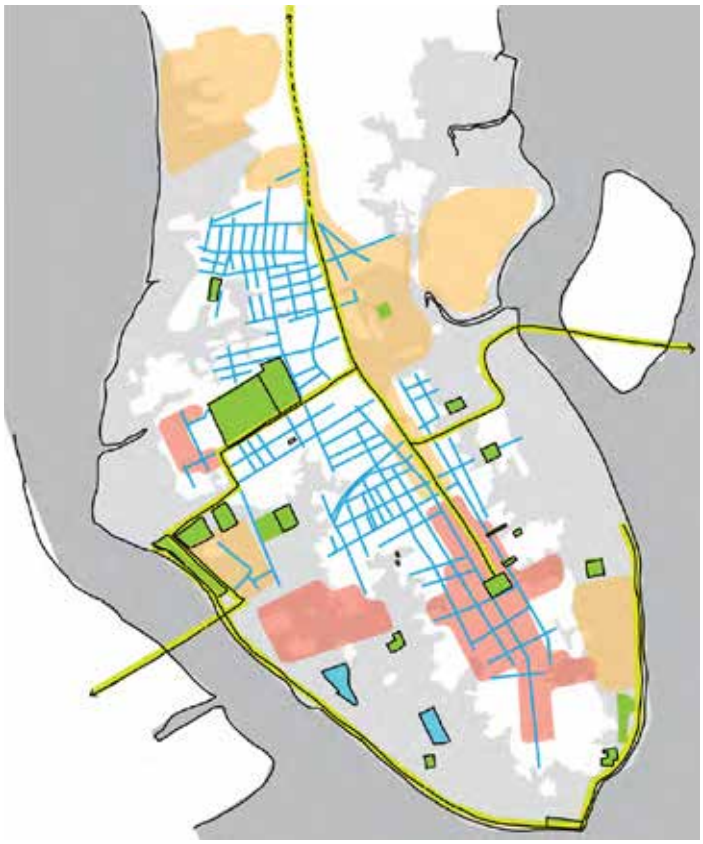
Parks, such as Hampton Park, should not be creating runoff that impacts their adjacent neighborhoods, but often they do. Infiltration, storage, vegetation at the edges, and storage near and under the playing fields will improve Hampton Park's beauty and functionality while reducing runoff.

School properties provide fantastic water management opportunities. Educational programs can **teach and empower students** to understand the wet environment, how water systems work, and what actions they can take to stay safe. James Simons Elementary School and the Charleston Charter School for Math and Science could slow and store runoff at their higher elevations in the watershed, while the Sanders-Clyde Elementary School could utilize its courtyard and surrounding open spaces to reduce flooding along America Street.

Bioretention Features
Brother Martin High School, New Orleans
Waggonner & Ball

Sanders Clyde Elementary School
Potential for water management and educational interventions in courtyard and open spaces

Large public sites with potential to slow and store runoff



Strategic Locations of Green Infrastructure on Private Properties

Private Property

On private property, an essential strategy is to adopt an Amsterdam **"Rainproof-type" program** to encourage commercial and residential property owners to capture and store rainfall. Rain barrels, flow through planters, cisterns, pervious paving, bioswales, blue-and-green roofs: over time and at scale, these stormwater best practices **add storage, value, and interest** to the property.

This type of program can create and infuse a culture of **citizen awareness, responsibility, and action** towards water management. Finally, regulations should be adopted to require new or substantial property (re)development to store water onsite, especially if the construction is occurring on the high ground.

Permeable paving surfaces at a Charleston Single House

Green Roof
Beijing City International School, Waggonner & Ball

Permeable Asphalt
Greater New Orleans Foundation, Waggonner & Ball

Top: Architectural Cistern

Bottom: Flow Through Planter

Discussions with Residents

Discussions with Eastside residents during the Workshop distilled their guiding principles:

Safety and amenity are primary, including loss of life and property, but concerns about health and mobility are distinctly salient.

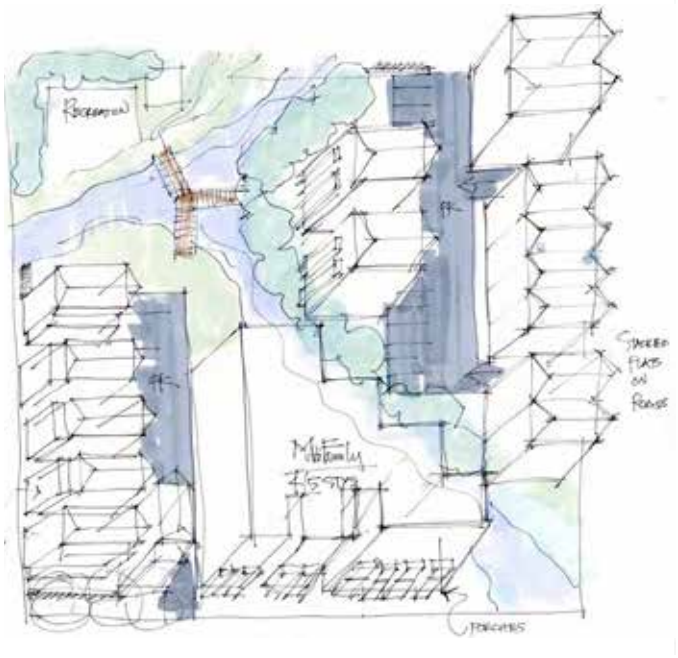
Repeated nuisance flooding is burdening Eastside residents with water in their homes, cars, and streets. If you lose your car in a flood you are not safe. If you can't get to work, you are not safe. If you are trapped in your neighborhood and cannot evacuate, you are not safe.

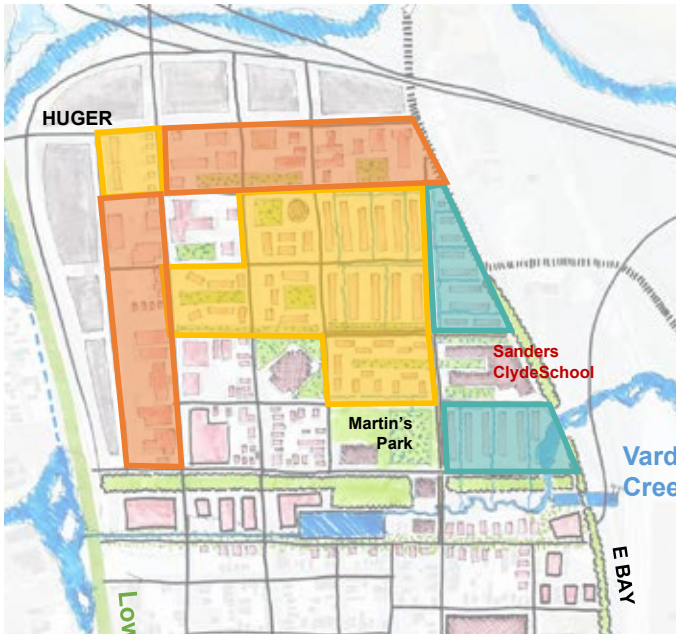
Flood risk investments are needed as soon as possible, should beautify the neighborhood, and **preserve and enhance community institutions.**

Redevelopment Strategies

New or redeveloped affordable housing must be built on higher ground or elevated, and green space around the development must incorporate infiltration and water storage technologies. **Access to affordable housing,** both publicly subsidized and private, for Eastside residents is critical.

Vardells Creek, though mostly hidden, becomes visible during bad storms. Part of Cooper Street is trying to emerge as a wetland. This area should be (re)developed only in ways that allow the creek bed to do what Mother Nature intended: store and drain water. **Do not put people or institutions at further risk** in this area.



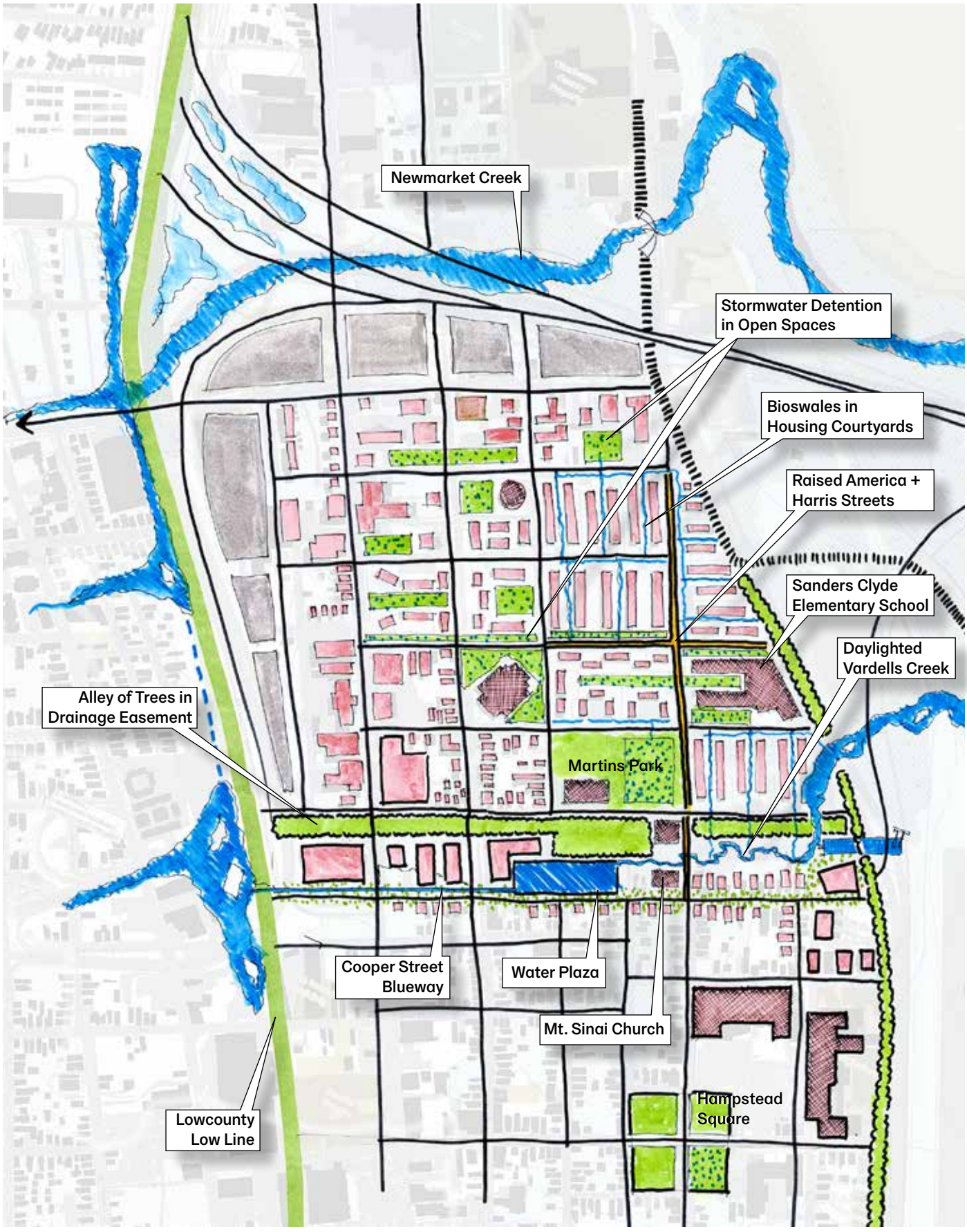


"Living with Water" Redevelopment Strategies
At the scale of the city block (above) and the neighborhood (below).

Public Housing Prone to Flooding
Consider redeveloping as open space, or elevate housing and streets

Public Housing Sites on Higher Ground
Incorporate slow and store water management practices to reduce flooding

Private Development Sites
Incentivize/require maximum stormwater practices



Enlarged Detail of Vision for Green Infrastructure and Elevated Roadways

Vision

Cooper Street to Meeting Street is a physical connection that warrants a visible stormwater management strategy. This can include a bioswale along the edge, permeable pavement, trees, and underground storage (where utility alignments permit). Other options are a large water square and even a tidal-limited creek that **connects the urban water to the river.**

The parking lots near Morrison and East Bay, some of which are in the Cooper Bridge Redevelopment Zone Phase 2, should be repurposed to store stormwater rationally. They presently store it irrationally and dangerously. Water-loving trees would add beauty and water storage. Meet the water assignment so that rainfall infiltrates or is stored in green and blue areas, and not in houses.

Much of the existing public housing in the lowest part of the Cooper Bridge Redevelopment Zone, which is in a flood hazard zone. Streets, cars, and homes have repeatedly flooded, and standing water is widespread even in dry periods. **No future development should occur in the lowest part of this zone.** If public housing is available elsewhere in the neighborhood, residents should be permitted and perhaps encouraged to relocate, with supoort. If relocation is pursued, the vacated space should be purposely adapted to store and manage water. This entire zone is ripe for improvement, conservation, preservation, and adaptation. **Water needs to be positioned as an asset.**

Eastside neighborhood residents greatly impacted our team. They said, “Charleston is the Holy City, and it can remain the Holy City if we take care of it and love it.” As depicted in the photo at right, surrounded by floodwaters, Mt. Sinai church is a powerful metaphor all too real for too many. The church can be raised on the water; the water doesn’t have to raze the church. **If the will is there, there are ways to do this.**

Mt. Sinai Holiness Church of Deliverance with Adjacent Flooding
Photo Credit: Jared Bramblett

Vardell’s Creek During Tidal and Rain Flooding Events
Photo Credit: Jared Bramblett

Vision for Resilient Redevelopment at
Mt. Sinai Church

Vision for Resilient Housing and
Stormwater Management

Eastside Recommendations

The Eastside is a place of history and memory, one whose past can be prologue to a future of continuity and renewal. Solutions to recurring flooding are available at multiple scales, from intersections to school yards and parking areas to the former Cooper River Bridge right-of-way to restorations of Vardell's and Newmarket Creeks. In time, land that is presently highly utilized by the port might be joined with the Eastside to allow a threaded line of coastal defense along with resilient redevelopment. The past and future of the Eastside are integral to the story of Charleston and the peninsula. Respect for community and its history is the basis for all actions here.

Expose & Highlight Waterways

Daylighting Newmarket Creek near the Lowline, in order to create more water storage and better drainage as well as improve environmental quality, should be studied. Newmarket Creek's intertidal zone under Septima Clark should be improved to manage tidal impacts and store stormwater, regardless of whether perimeter protection is pursued.

Prioritize High Ground

Any new housing in this zone must be built on high ground. Any public housing redevelopment in recurrent flood zones must be adapted to reduce stormwater flood impacts on those properties and their residents. Citizens in public housing currently experiencing recurrent flooding should be given the opportunity to move to any new in-neighborhood public housing, with support. Any public housing in low areas that is substantially abandoned or unoccupied should be removed; the space created can be turned into parkland or other types of water storage.

Add Water to Public Spaces

All public spaces – parks, schools, and streets – in Eastside should be assessed for water storage and infiltration opportunities. Additionally, parking areas and other commercial parcels and open space in and/or nearby the Cooper Redevelopment Zone should be studied for water storage and infiltration opportunities. Ideally, these would be pursuant to a citywide or peninsula-wide Water Plan, and foreseen in the City's Comprehensive Plan update and Transportation Plan.

Development Guidelines

Limit development in the lowest portions of the Cooper Redevelopment Zone to avoid putting any people or institutions at risk of flooding. Water storage should be programmed into the right-of-way of the former Cooper River Bridge, and development adapted to assure continuous water management features throughout this zone.

Resilient Vision for the Eastside
Includes redeveloped waterfront with housing, public spaces, and stormwater management

Coordinate Drainage and Perimeter Protection

The City should ensure that if peninsula protection is pursued then robust stormwater runoff management throughout Eastside drainage basins is explicitly and purposefully created. Drainage to the river / outfall should be ensured, likely via pumps and properly designed collecting basins.

Pilots, Projects, Programs, and Partnerships

The City should pilot water storage in streets and street retrofits in the Eastside neighborhood, with a monitoring program to ensure design, management and maintenance regimes are appropriate.

"Rainproof" type pilot projects should be encouraged or mandated within this zone, possibly under the leadership of the Eastside Community Development Corporation (ECDC). The City should support ECDC in the development of a best practices toolbox, supported by a public awareness campaign, about citizen and community efforts to increase water storage and lessen flood impacts.

Curriculum at Eastside and other city schools could be oriented to development of water management and resilience knowledge amongs students and community service to support the Rainproof projects (See information on Ripple Effect later in this chapter).

Education

Ripple Effect Water Literacy Project

New Orleans-based Ripple Effect is a K-12 education nonprofit that provides interdisciplinary, standards-aligned environmental science instruction about real communities impacted by climate change. Ripple Effect works with teachers, scientists, and designers to develop, test, and teach interdisciplinary science curriculum in high-need schools. The goal is to improve student achievement and increase resilience in communities most vulnerable to climate change impacts.

Ripple Effect provides teachers with high-quality environmental science curricula about real-world issues that challenge students to “practice stewardship” now, in preparation for choices and challenges ahead. In the classroom, Ripple Effect raises student achievement and investment in science, builds student empathy and sense of civic responsibility, and primes students for careers where they can make a direct impact on climate change.

For more information: RippleEffectNola.com

Eastside Community Development Corporation (ECDC)

Principles, Questions & Recommendations

The Dutch Dialogues leadership held a special Workshop meeting with members of the Eastside Community Development Corporation (ECDC) on July 16, 2019. ECDC is a "grassroots non-profit organization located in the Eastside community of Charleston SC. We are proud to help and be of service to our community. ECDC's core is Safety, Care, Education, Dependable."

Principles

ECDC members identified these core neighborhood principles:

- Eastside is a vibrant, busy, distinct and culturally important Charleston neighborhood. Please protect it.
- Eastside was the first "suburb" of downtown, and its housing stock is unique, beautiful and significant.
- Eastside is a community. Sundays – when worship, community service and family time are embraced-- are especially important.
- Charleston is a holy city: "We cannot lose the Eastside churches. We need to better protect these areas."
- Eastside is and has always been diverse and welcoming. "You faced more racism outside of this neighborhood than inside."

Issues & Questions

ECDC members raised important issues and unanswered questions:

- Long-time residents know which streets to use and which to avoid during a flood. Please help us inform new Eastside resident of evacuation routes.
- What is the impact of the new, large buildings on neighborhood flooding? Streets that were previously safe and dry now flood. How long before areas that are usually dry during a flood become wet?
- Any new or development of redevelopment in the Eastside should have a robust impact fee to fund investments to alleviate neighborhood flooding.
- Can King Street TIF and Opportunity Zone fund be used to fund Eastside neighborhood infrastructure and flooding improvements?
- Calhoun and East Bay streets no longer flood. What worked there and why? Can that be done along East Bay and Morrison?

Recommendations

ECDC members asked the Design Team to consider some solutions:

- Scale solutions to the neighborhood, including the Grace Bridge redevelopment site and other parks and public properties in the Eastside.
- Stormwater retention and detention on higher ground neighborhood would positively contribute to reducing flooding on low ground.
- Explore opportunities to increase retention and detention capacity at Sanders Clyde ES, the now closed Wilmot Fraser ES and Archer ES, Hempstead Square, parking lots for the Cigar Factory, Trident Tech and the St. Julian Devine Community Center, and even in some green space in more elevated public housing areas.
- Encourage Charleston County School District to start a "Ripple Effect"-like program to engage students in the science and planning of water.
- Create a blue-green corridor connecting Eastside schools, park, and green space to the Lowline, across to Hampton Park, and down to Harmon Field and Brittlebank Park for multi-purpose uses of water storage, biking and connectivity.

For more information, see: https://www.ecdcorp.org/

Daniel Goedbloed, Program Manager, Rainproof Amsterdam

Rainproof Amsterdam

Moisture loving plants in the Harkstraat swale

"To become truly rainproof, you need to improve the 'sponge effect' of the city. That includes the sewer system, but especially includes the public and private spaces such as streets, gardens and rooftops."

Rainproof has been tasked with involving all stakeholders in the rainproof city: this includes the Water Authority and the municipality, along with businesses, property owners, residents, consultants, and research and educational institutions. Using the motto 'Every drop counts', the Rainproof programme seeks to make people aware that they are the co-owners of both the problem and its solutions. Instead of adopting a moralizing tone, the programme invites the community to 'together make the city rainproof, greener, more livable and more beautiful'.

It's raining harder and harder, and our city can't handle it

Make Amsterdam Rainproof.
Visit rainproof.nl to see what you can do.

Amsterdam Rainproof
every drop counts

Together, we can catch those raindrops and make Amsterdam Rainproof

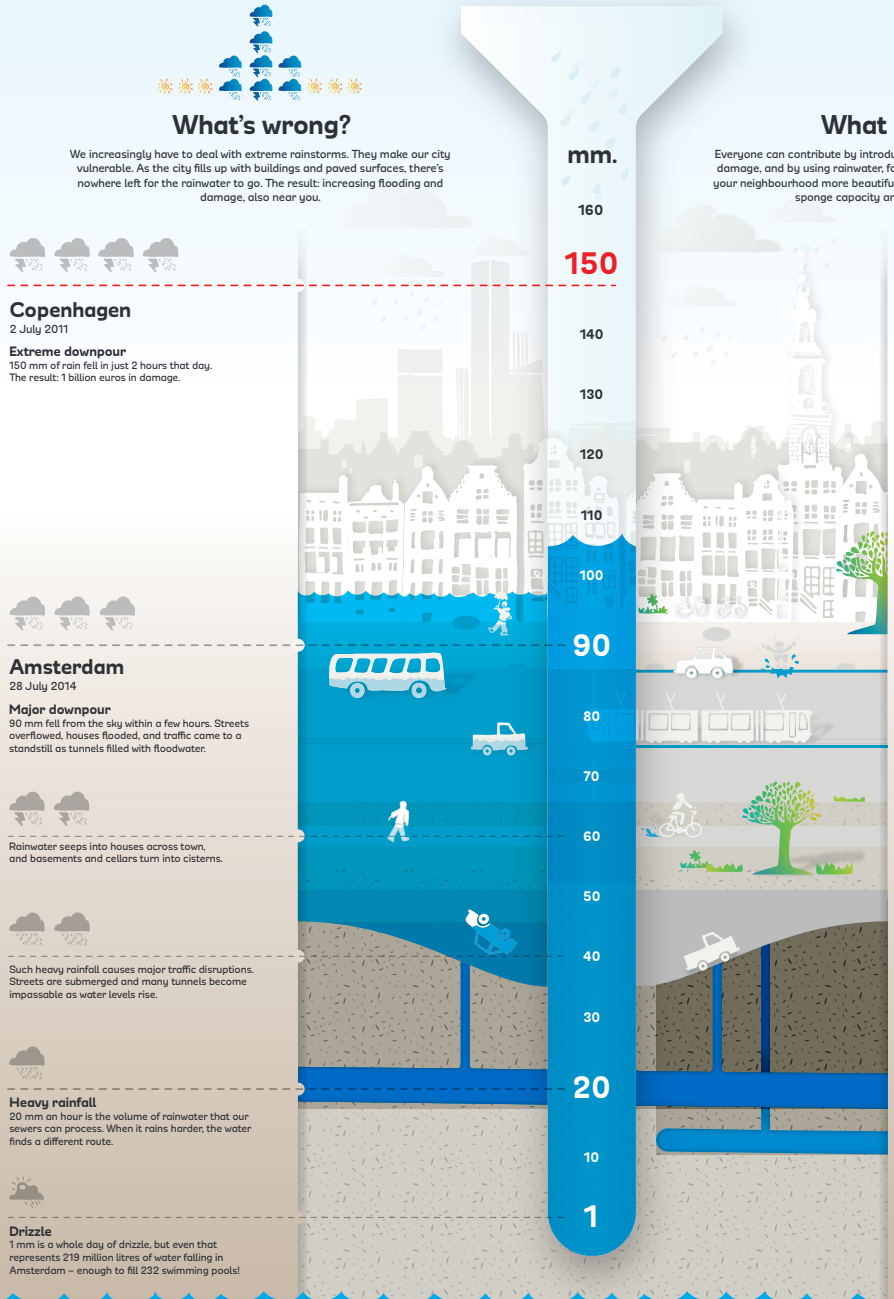
Amsterdam Rainproof
every drop counts

What's wrong?

We increasingly have to deal with extreme rainstorms. They make our city vulnerable. As the city fills up with buildings and paved surfaces, there's nowhere left for the rainwater to go. The result: increasing flooding and damage, also near you.

What you can do

Everyone can contribute by introducing smart solutions, big and small, to prevent damage, and by using rainwater, for example to water your garden. And it makes your neighbourhood more beautiful. Join in! Every drop counts. Increase our city's sponge capacity and make Amsterdam Rainproof.



Copenhagen
2 July 2011

Extreme downpour
150 mm of rain fell in just 2 hours that day.
The result: 1 billion euros in damage.

Amsterdam
28 July 2014

Major downpour
90 mm fell from the sky within a few hours. Streets overflowed, houses flooded, and traffic came to a standstill as tunnels filled with floodwater.

Rainwater seeps into houses across town, and basements and cellars turn into cisterns.

Such heavy rainfall causes major traffic disruptions. Streets are submerged and many tunnels become impassable as water levels rise.

Heavy rainfall
20 mm an hour is the volume of rainwater that our sewers can process. When it rains harder, the water finds a different route.

Drizzle
1 mm is a whole day of drizzle, but even that represents 219 million litres of water falling in Amsterdam – enough to fill 232 swimming pools!

Roof
A green roof helps hold onto rainwater. It suits lots of different roof structures and helps keep the building cooler. It benefits biodiversity, and if you add an extra water storage layer, a blue roof is even better for storing rainwater.

Building
Rainwater capture systems, a green or blue roof, higher thresholds by the front door, and no wooden floors in the basement: all these measures help prevent damage and make your house more rainproof.

Neighbourhood
Less pavement and more green, ditches, little gardens along the building fronts, and waterside plants near your home make your neighbourhood more beautiful. Greenery holds a lot of water and creates a better microclimate.

Garden
If you have a garden, balcony or roof terrace, set up a rain barrel with a tap on the side so you can water your plants for free. Remove some pavement from your garden and replace it with a plant or pond, or lay permeable paving.

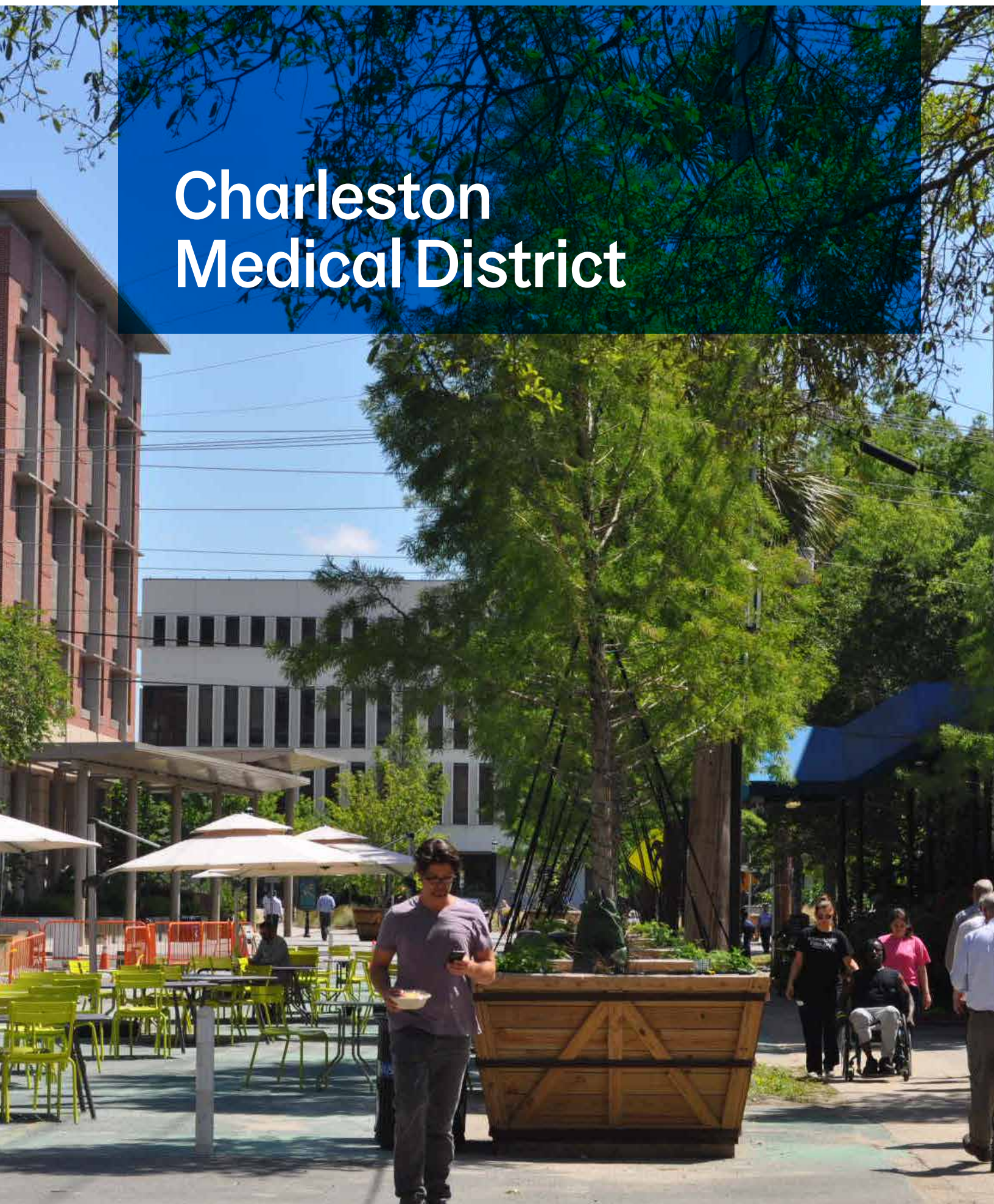
Street
Rainproofing a street is as easy as laying a hollow road and higher kerbs. Urban infiltration strips, swales and open gutters bring rainwater drainage out into the open and make the city more beautiful.

Square
Rainwater-fed fountains, open gutters and more greenery transform a city square into a place to play with water – and make it easier to accommodate heavy rainfall.

Park
Green parks, swales and ponds make key contributions to temporary water storage and slow down rainwater drainage from the surrounding area. They are good for plants and animals and contribute to a cooler neighbourhood.

Make Amsterdam Rainproof. Visit rainproof.nl to see what you can do.

Charleston Medical District



> “Ours is a long-term perspective, combining the world of medicine with the urban world, recognizing that the world of patients and the world of citizens are often the same.”
>
> **Frits Palmboom**
> Palmbout Urban Landscapes

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- Park
- Urban Growth Boundary

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SEA LEVEL RISE
- 3' Sea Level Rise

DFIRM
- coastal floodzone, floodway
- 100 year floodplain
- 500 year floodplain
- Street Flooding

ROADS RAIL
- Rail

Road
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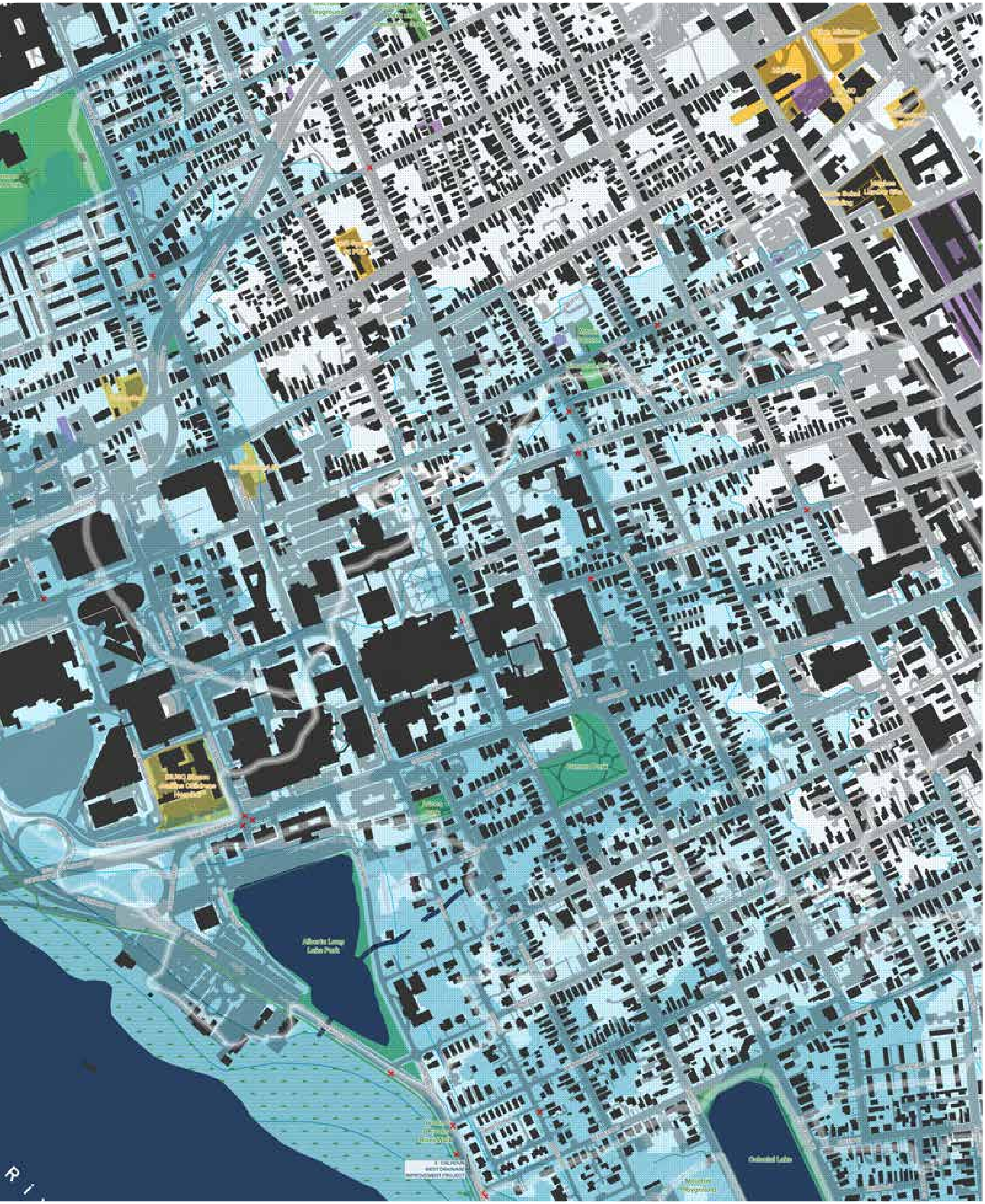

Medical District Elevation

LEGEND

Topography 0'-20'

- ≤2
- ≤4
- ≤6
- ≤8
- ≤10
- ≤12
- ≤14
- ≤16
- ≤18
- ≤20

Bathymetry

- ≤0
- ≤-5
- ≤-10
- ≤-15
- ≤-20
- ≤-25
- ≤-30
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- ≤-40
- ≤-45
- ≤-50
- ≤-55
- ≤-60
- ≤-65
- ≤-70
- ≤-75
- ≤-80

Charleston Medical District

The Charleston Medical District (CMD) is a cluster of critical infrastructure and institutions -- MUSC, Roper Hospital, Veterans Administration facilities-- growing in a constrained physical space that suffers regular tidal, stormwater, and compound flooding, and that is also succeptible to storm surge flooding and sea level rise. Traffic congestion is an everyday challenge. As a result, patient, employee, service delivery, and student access suffer. CMD has a strong existing development plan which assumes the "the patient" is the central character. This focus is essential.

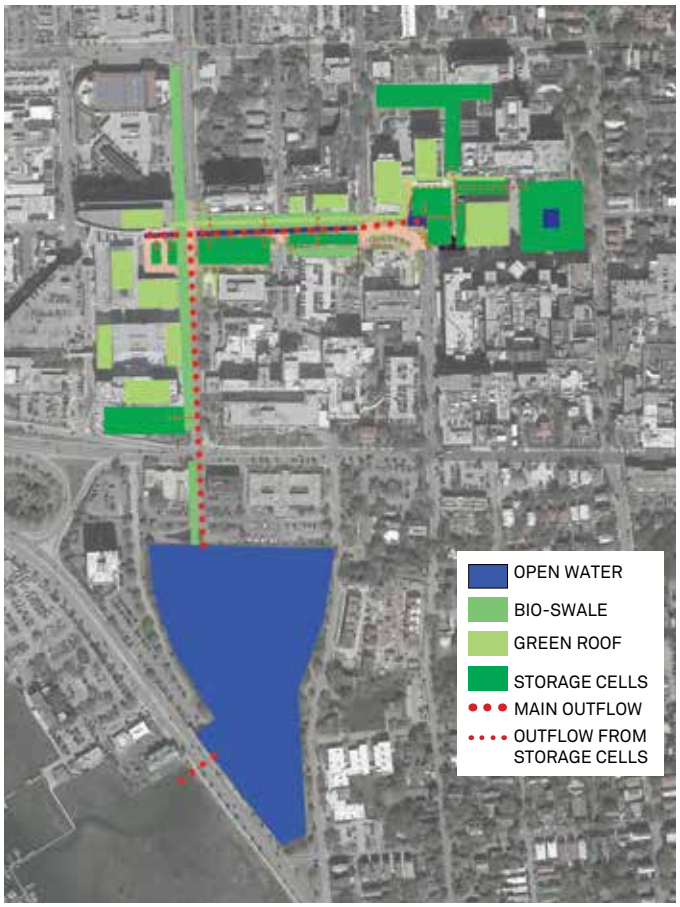
The Team explored a long-term perspective for CMD. In this vision, the world of medicine touches the urban world because the world of patients and the world of citizens are often the same.

CMD's core objective – providing patients with exceptional experiences in a physical environment that aids recovery – can be substantially enhanced and implemented in conjunction with smart water management.

As a complex district, CMD has multiple identities. A pattern of grids is the basis for the City; CMD is a city within the city, sharing grids. Synergy exists within CMD and its institutions, and between nearby neighborhoods. Accessibility is crucial for functioning. Connectivity is how CMD relates to its environment and surroundings. Transparency, order, and porosity of the urban tissue are also key identities.

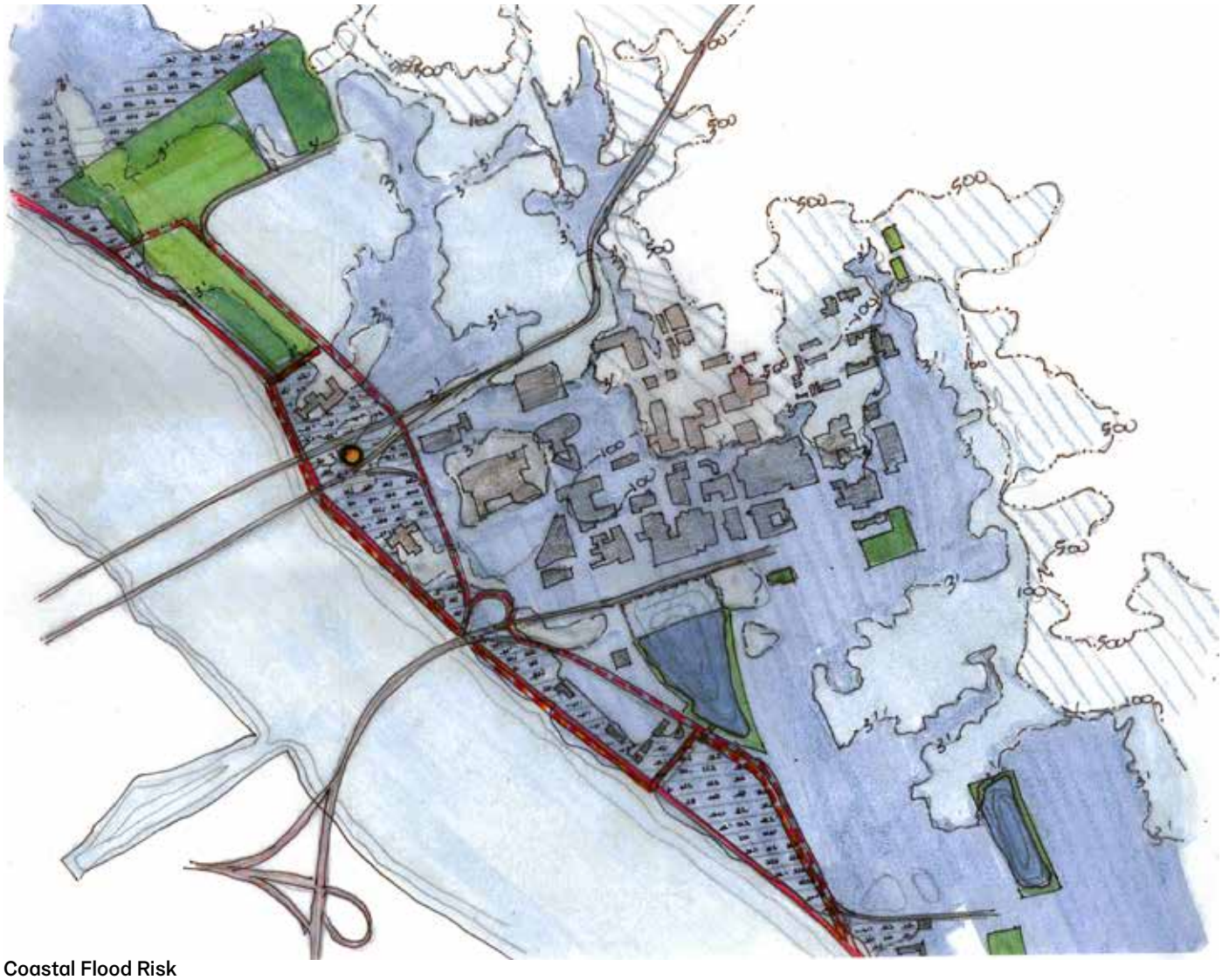
Master Planning

MUSC completed a Facilities Master Plan, which includes essential blue-green elements. Its vision extends north and south, towards WestEdge, with important mixed and multifunctional uses. **A dominant line exists along Courtenay Drive towards Long Lake, nearby marshes and the Ashley River. These nearby waterways are beautiful, underutilized, and undervalued assets**.



MUSC Facilities Master Plan Stormwater Strategy
Credit: MUSC Master Plan

View of Pedestrian Street from MUSC Facilities Master Plan
Credit: MUSC Master Plan



Coastal Flood Risk
100 and 500 Year Floodplain

1. Green Roofs
2. Rain Gardens
3. Pervious Pavers / Structural Cell
4. Water Storage Cell
5. Cistern
6. Underground Garage
7. To Long Lake

MUSC Facilities Master Plan Stormwater Strategy
Credit: MUSC Master Plan

Medical District
Most of the Medical District was built on reclaimed land. The eastern edge of Alberta Long Lake (water body in the foreground) was close to the original shoreline of the peninsula

Doughty St
Existing green street running through the center of the Medical District

Alberta Long Lake
Lake formed by the construction of Lockwood Drive

Parking Lot on Western Peninsula
Floods at High Tide and Rain Events

Tidal Wetlands
Tidal Wetlands north of the baseball stadium

Brittlebank Park
Park along the Ashley River northwest of the medical district

Subsidence at River Dogs Stadium
Sidewalks and parking lot have subsided relative to pile supported buildings due to landfill compaction

Raised Street at West Edge
New streets in West Edge are pile supported and elevated above base flood elevation

Ashley River Bridge Drop Shaft
This drop shaft part of the Spring/Fishburne Drainage Improvement project, brings stormwater to large underground storage tunnels, during flood events
Photo Credit: City of Charleston

Gadsen Creek
Tidal creek course and ecology has been modified over time by landfill and development

Water management is a recent addition to the Master Plan. Elements include integration of water storage in order to manage stormwater, reduce flooding, create amenities, create safety, and maintain pedestrian and vehicular access.

Goals include reinforcing and enhancing these plans, increasing the internal cohesion of the Medical District, and improving MUSC's relationships with nearby neighborhoods. These principles should inform a district-wide plan.

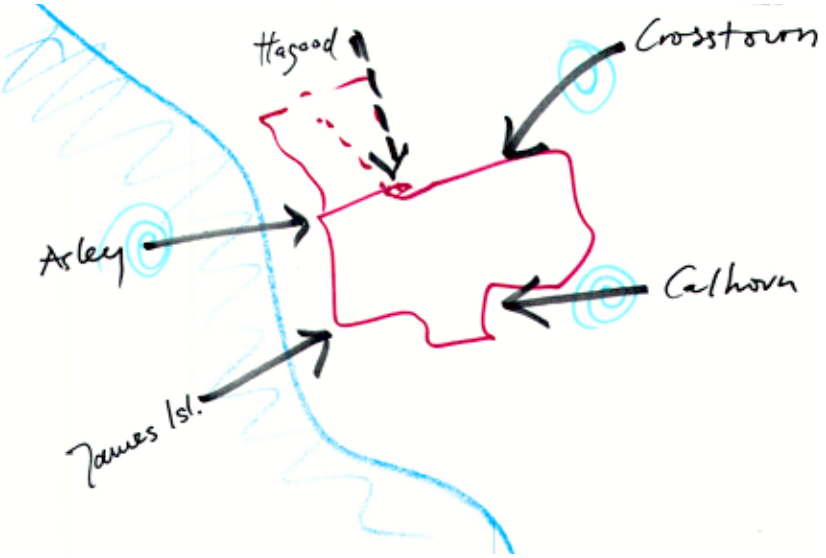
New Front Door for District

We suggest extending the Greenway to Ashley Avenue, which will create a new "front door" for CMD. Water storage, water plazas, water squares, water infiltration, and planting more trees will mitigate flood risk, reduce urban heat, and provide better quality spaces.

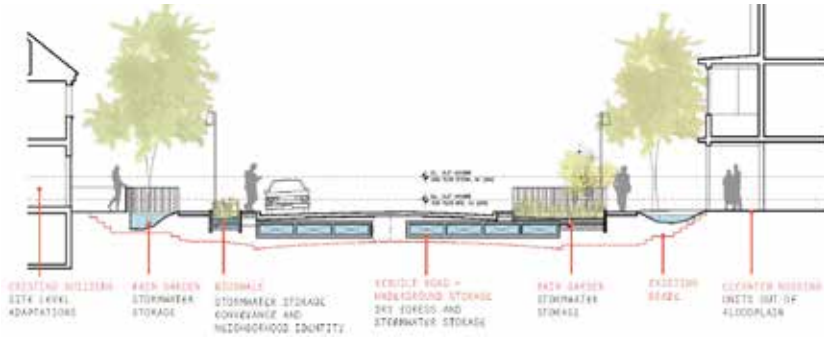
We also suggest development of a new, comprehensive plan to address how buildings are impacted from reoriented entries, as well as patient and service flows, and how constructability issues should be resolved. We recommend using the links of Cherry, Bravo, and McClennan Banks streets as an additional entrance to CMD, with access from the Crosstown highway and Calhoun. The goal is to maintain wise use of public space, and smart integration of existing and new public transit and cycling pathways in CMD. It demands investment and intra-institution coordination and collaboration.

Such a plan would create new, redundant access to CMD for vehicular and emergency vehicle access from the Crosstown. The new entrance to the district would also create urban public space for CMD employees and visitors as well as those nearby and passing through via new cycling or pedestrian pathways. We are reluctant, however, to recommend new access corridors to CMD via residential neighborhoods.

Improving the connectivity of WestEdge, Gadsden Green and nearby, isolated neighborhoods to and from the CMD must be part of this plan. This will improve the area's design and coherence.

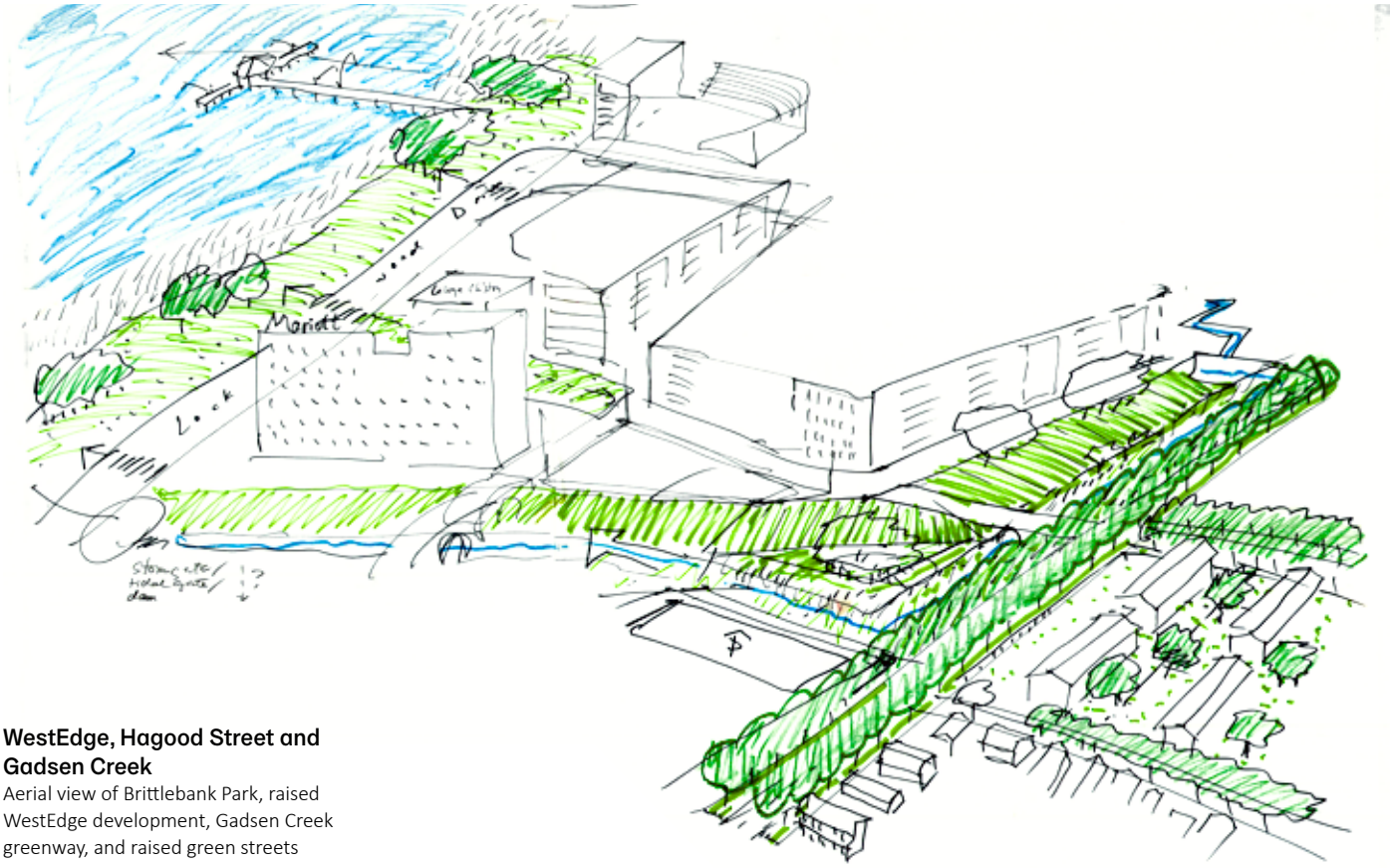


Proposed Network of Redundant Access and Egress

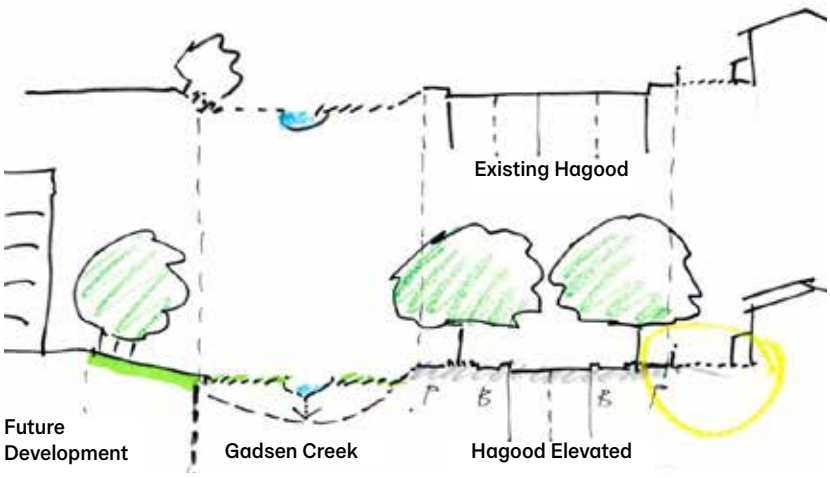


Raised Street Design for Bridgeport, CT
Credit: Waggonner & Ball/YUDW, Resilient Bridgeport

WestEdge Development Raised Street
Current alignment impacts housing and creek



WestEdge, Hagood Street and Gadsen Creek
Aerial view of Brittlebank Park, raised WestEdge development, Gadsen Creek greenway, and raised green streets



Hagood Street and Gadsen Creek
Raised development set back to allow room for creek as asset

Raising Hagood Street to the level of WestEdge and covering Gadsden Creek has been proposed. This might reinforce the "cut-off" and isolated sense that currently exists in nearby neighborhoods. **Any change to Hagood must not impair important water discharge from the neighborhoods**. Ideally, water quality would also be improved. Creating a gentle slope from Westedge to Hagood will mediate the transition and create opportunities for better stormwater infiltration and storage. Maintaining Hagood as a two-lane street enables space for cycling, while tree-covered, pedestrian walkways would connect the neighborhoods and CMD.

The addition of tree cover reestablishes the historic street typology in Charleston, while contributing multiple benefits. These include adding character, shade, reducing urban heat, and slowing down and storing stormwater.

Covering and filling Gadsden Creek is not recommended given that most of the recurrent and nuisance flooding – whether from tidal influences or stormwater – on the peninsula occurs in areas where natural creeks were filled.

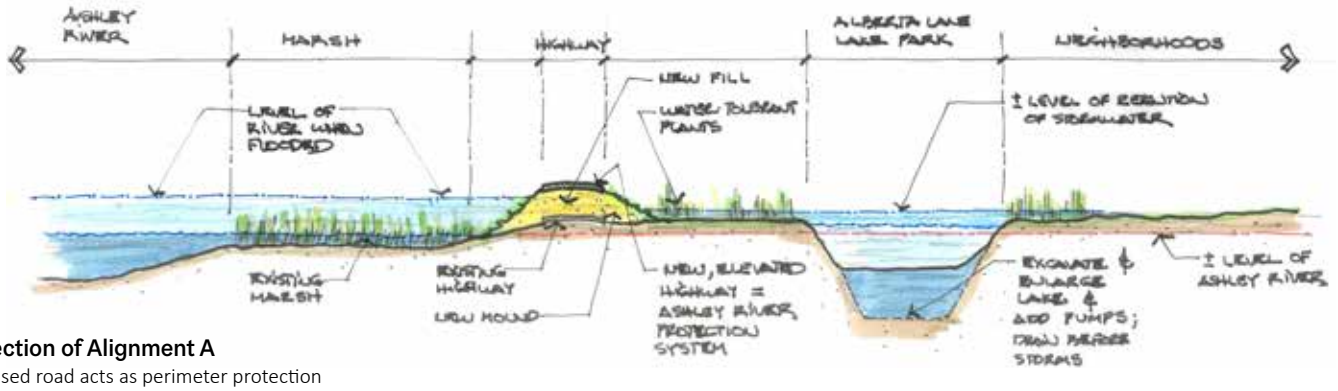
While the current configuration is not a natural creek, it is a natural drainage pathway, moving water from the neighborhood to the Ashley River. **The management of the Gadsden Creek tidal interface with the Ashley River must be given due consideration in any peninsula perimeter protection planning.**

WestEdge, Riley Park, Brittlebank Park, Westside neighborhoods, and possibly Hampton Park should be better spatially and environmentally connected. Brittlebank Park, the Ashley River and its marshes are beautiful, yet underutilized community amenities. Creating better access from Westside to the river, via Westedge and its northern and southern flanks, is a necessary addition to the area's near-term planning. Reinforcing both the north-south and east-west connections in the area north of the Crosstown are important goals.

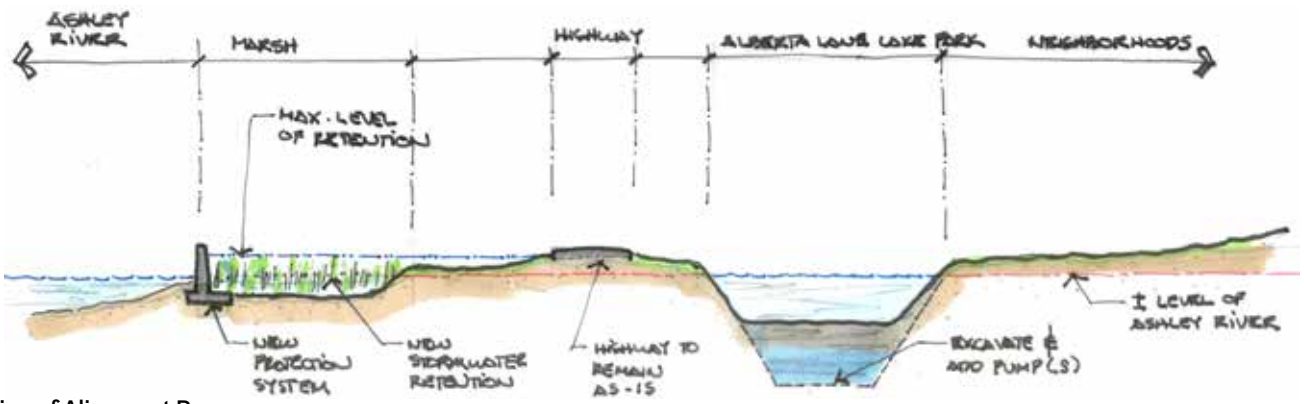
Other Approaches

Looking forward, perimeter protection infrastructure could be used to improve the environment for visitors and residents, and to increase the flood risk reduction in the Lockwood Corridor. **Using the existing Lockwood alignment, a "High Battery" approach could be successful.** Implementing this approach could be difficult, particularly with coordinating existing complex infrastructure and transportation corridors.

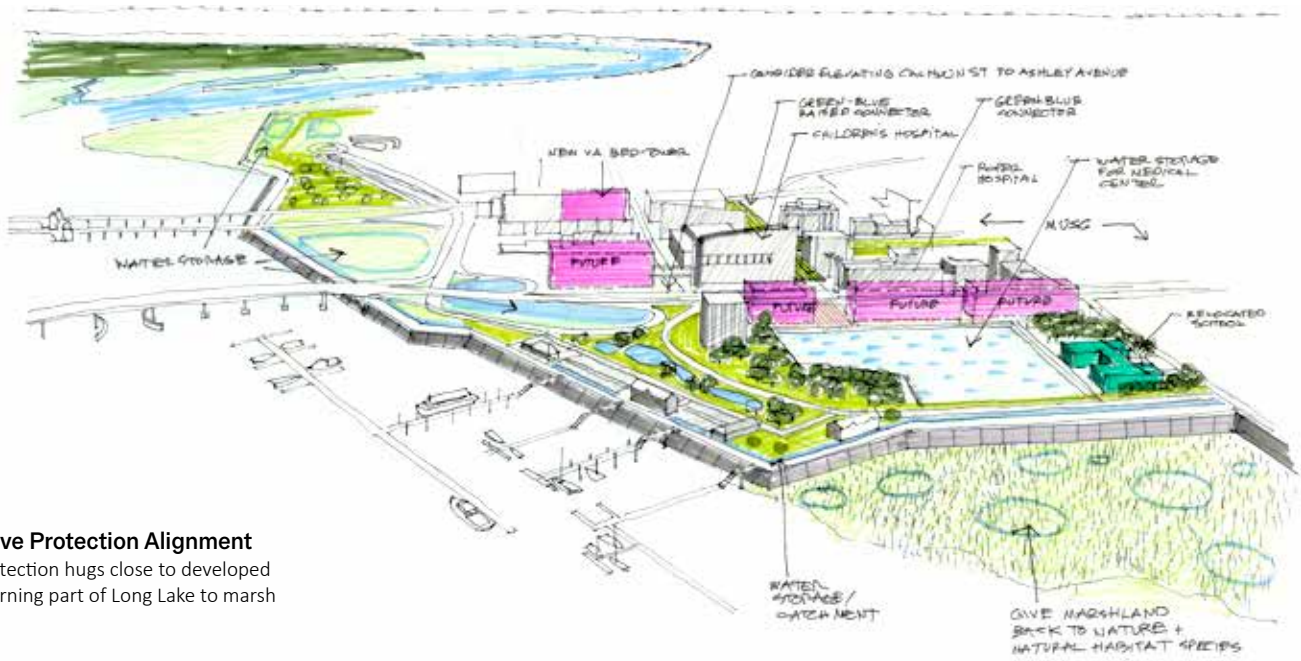
Another approach is to imagine a repurposed Lockwood Corridor and Long Lake. A new parallel line, described nearby as perimeter protection, would run under the bridges and along the harbor. This would create new pedestrian and recreation opportunities with the river, while also allowing non-motorized access from Brittlebank and Westedge down to the Low Battery. An accessible waterfront would encourage CMD staff, patients, and other users to enjoy the riverine landscape. From a water management perspective, **this alignment provides multiple benefits**: space to aggressively manage and store stormwater that the Medical District generates, and to manage surface water as it relates to rising groundwater.



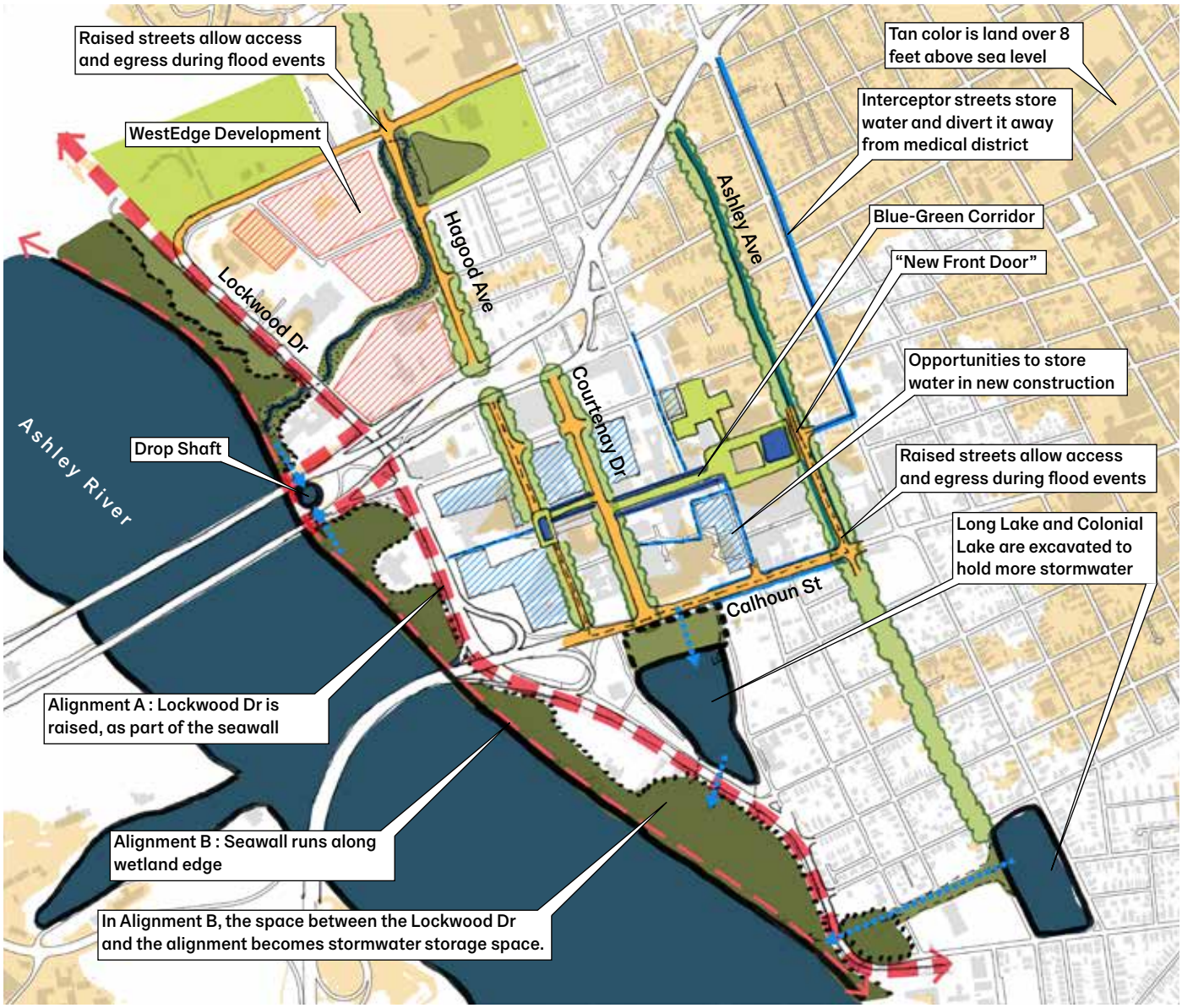
Section of Alignment A
Raised road acts as perimeter protection

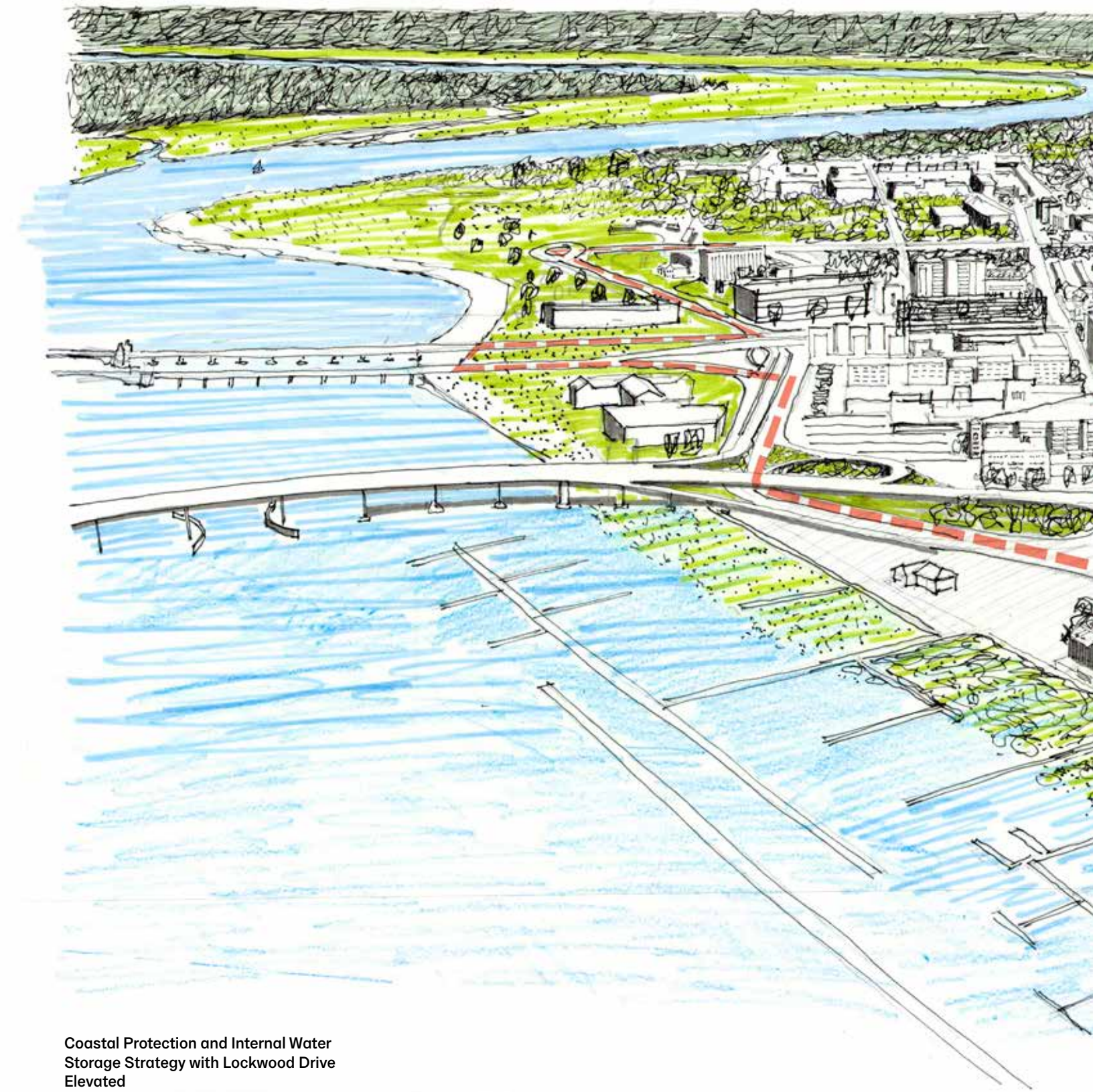


Section of Alignment B
Perimeter protection encloses wetlands, increasing stormwater storage

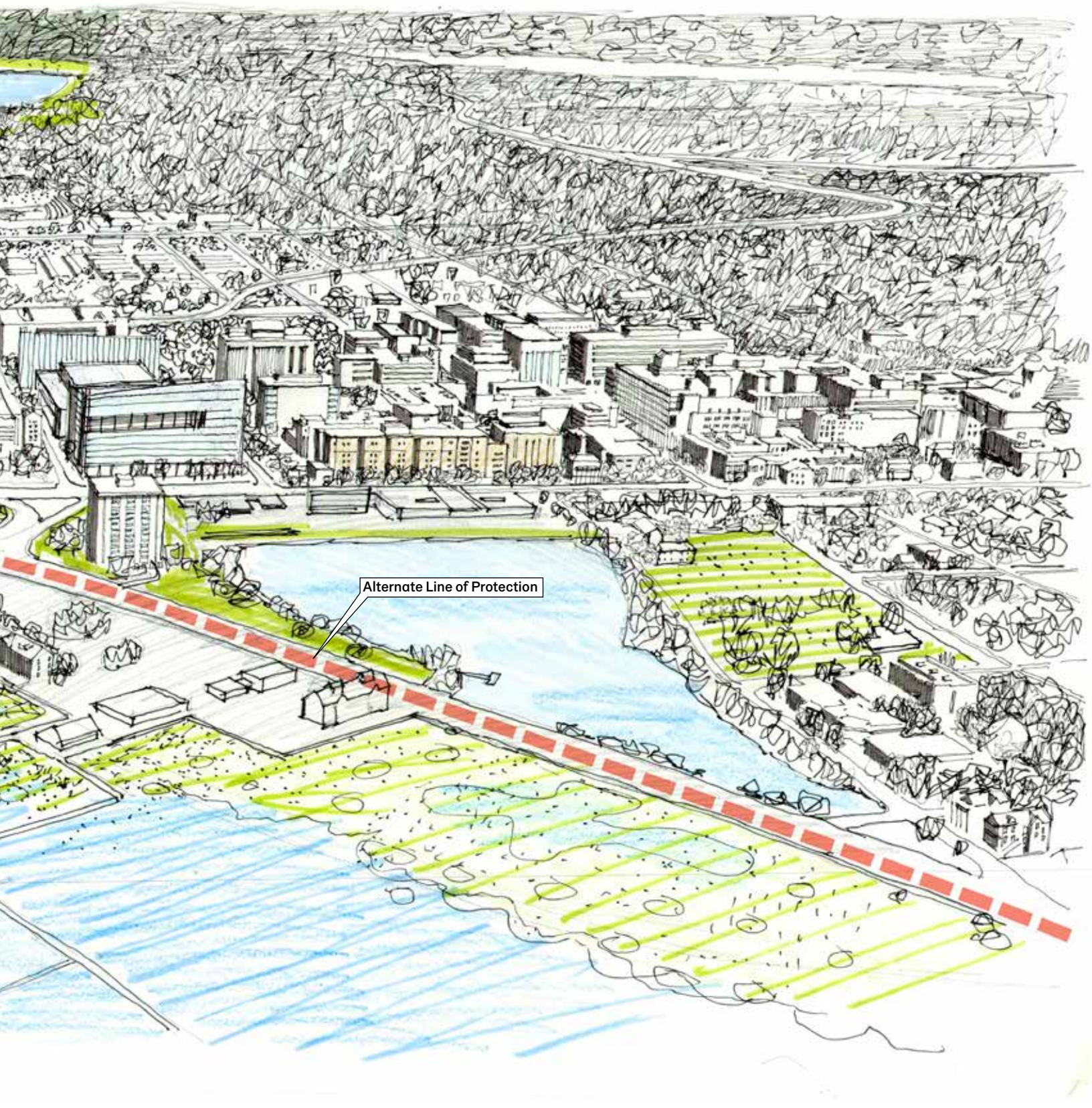


Alternative Protection Alignment
Line of protection hugs close to developed areas, returning part of Long Lake to marsh





Coastal Protection and Internal Water Storage Strategy with Lockwood Drive Elevated


Alternate Line of Protection

Medical District Finance Strategy

The Charleston Medical District (CMD), perhaps more than other parts of the city, presents coherent, aligned institutions with shared goals. The District is unified in the delivery of medical services, and has established clear, well-understood revenue streams.

The CMD also faces substantial flood risk, which threatens its medical service delivery, along with patient, employee, supplier, and visitor access. Millions of dollars of medical equipment are at risk of damage on ground floors of institutions, while flooding causes accelerated deterioration of the District's buildings and physical plant.

CMD institutions are seeking more robust inter- and intra-institution coordination to identify shared flood risks and implement resilience strategies. **The range of institutions in the District must identify and structure their revenue streams in order to fund projects that increase resilience and reduce risks.** The collaboration also needs to recognize and pursue efforts to reduce urban heat, improve traffic and pedestrian flows and connectivity, and create redundant energy supply.

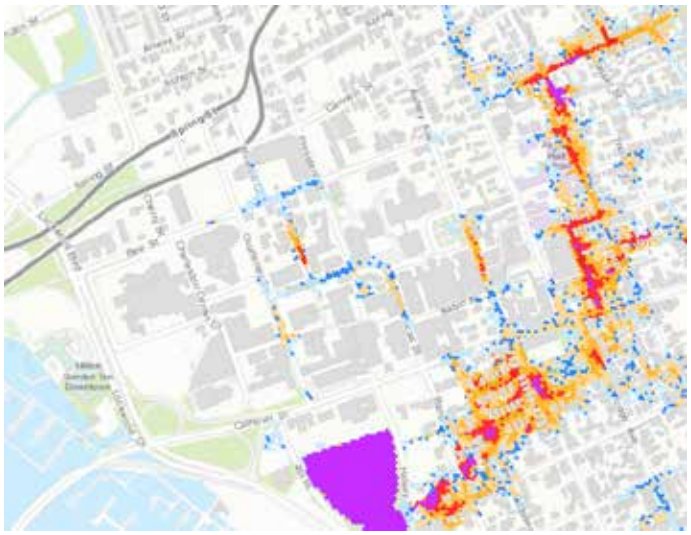
Discussions throughout the project (see the Colloquium Summary in appendices) targeted CMD flood impact costs, considered the baseline scenario, and possible revenue streams or cost-savings to fund resilience / reduce floods projects. During the Dutch Dialogues Workshop, a special "CMD Finance Group" explored possible finance strategies and revenue that would fund projects, such as those identified by the Dutch Dialogues CMD design team. The CMD Finance Group created financing roadmaps and a list of possible flood risk mitigation and resilience pilot projects.

The Finance Team began by assessing the rainfall and tidal flood challenges that impact the medical district on a regular (weekly or monthly) basis. The Team did not address the impacts of less frequent and hard to predict hurricane / tropical storm surge risk, or longer-term sea-level rise issues. The focus was purposefully on recurrent flooding as those have a regular and considerable toll on CMD institutions.

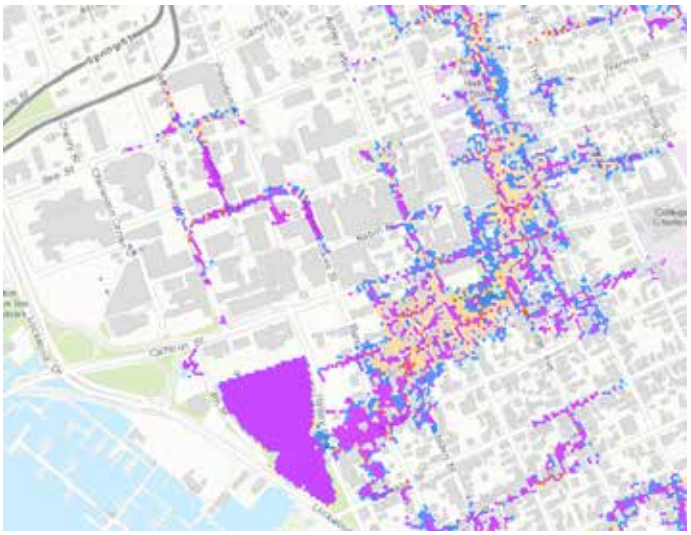
CMD institutions share a collaborative Memorandum of Understanding (MOU) from 2015 that facilitates inter-institution collaboration. This MOU should be further activated and revised to address the recurrent flood impact challenges and opportunities across the District.

CMD institutions and the Finance Team assessed the reach and intensity of CMD health services for the city, the tri-county region, and the rest of the state and surrounding states. **Understanding the patient "catchment areas" substantially enlarges the nature of the challenges facing the CMD.**

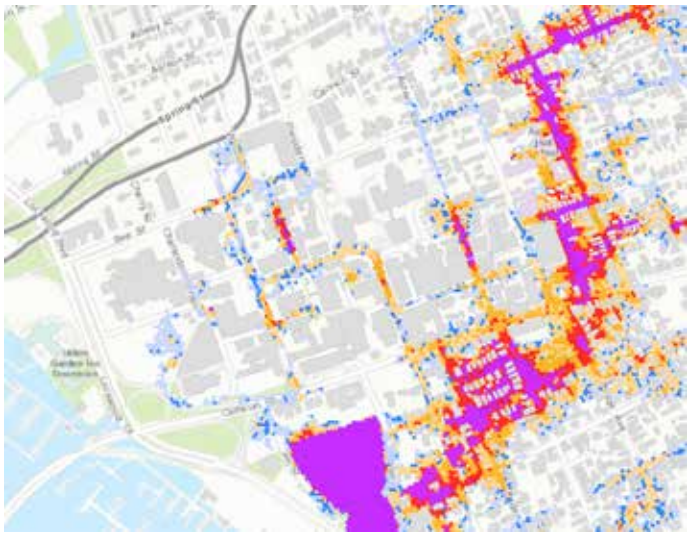
The large catchment area of the District shows the impact of medical service disruption, and the reach of possible finance solutions. The Medical University of South Carolina (MUSC) is the only Level 1 trauma center serving the entire East Coast of South Carolina, a catchment area of about 1.5 million people. Roper Hospital and the Ralph H. Johnson VA Medical Center have similar catchment areas as well. Given the scale of the areas and the types of patients served, we strongly underline that CMD institutions are key critical assets for the entire South Carolina coast. **To maintain this critical infrastructure, the institutions need robust flood protection and investment.** Please see the Vulnerability Analysis summary at the end of this chapter.



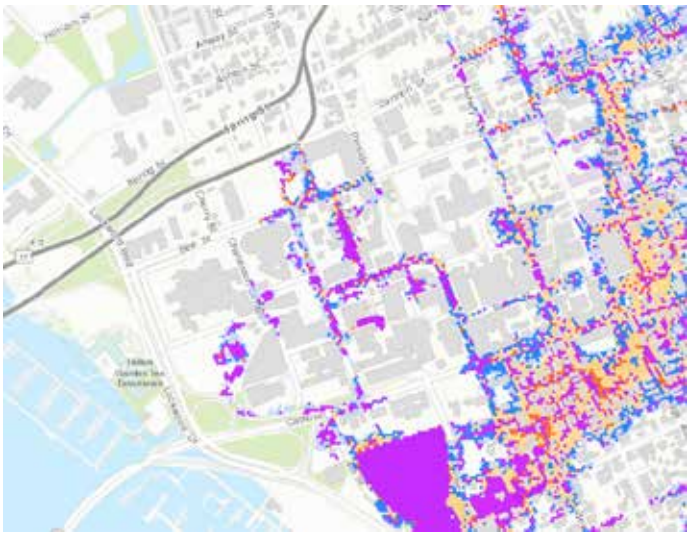
1 Year Storm Event Flooding Depth



1 Year Storm Event Flooding Duration



10 Year Storm Event Flooding Depth



10 Year Storm Event Flooding Duration

Existing Entrances and Vehicular Access in the CMD

Finance Team Considerations

- How rainfall frequency and tidal flooding impact the CMD
- The financial impact (direct and indirect losses, or increased costs) of those events
- How those costs are allocated across and within the institutions, and to employers, employees service providers and the City
- What near-, mid-, and long-term solutions are needed
- What management structures and tools are needed to implement those solutions

The Team identified **near-term** opportunities to improve flood recovery, restore medical service delivery, and create more floodwater storage. **Mid-term**, the Team assessed how to substantially increase water storage and connectivity across CMD, which would reduce medical service disruption. **Long-term**, the Team explored how to enhance patient services and experience with flood-risk mitigation and resilience investments. Co-benefits – green space, infiltration, urban heat reductions – were recognized but not quantified. Serious benefit-cost analyses are needed to capture and possibly monetize those values.

The Team established near-term action items. These include:

- quantifying stormwater flooding impacts and rates of occurrence;
- studying the water storage capacity and other stormwater management uses of Long Lake:
- creating integrated planning between CMD, WestEdge, CARTA and Lowcountry Rapid Transit;
- assessing risks to equipment located on the first floor of CMD institutions;
- evaluating the resilience of funded capital projects.

The Team also explored accelerating the construction of the Ehrhardt Drop Shaft -- an addition to the Spring-Fishburne deep tunnel system, which could be built much less expensively in the near term. Postponing construction to the mid-term will cost several millions of dollars more and prolong exposure to flood risks. **These are substantial opportunity costs of delaying drop shaft construction.** Beyond these lie flood impact costs to the City, and CMD financial losses due to service interruption.

CMD agreed to conduct a detailed benefit-cost analysis to quantify financial losses associated with delayed construction. CMD institutions also agreed to explore how savings from expedited drop shaft construction could be used to accelerate the design and construction of other flood reduction projects, possibly those identified by the CMD design team.

The Finance Team investigated combining CMD cost savings with other funding sources (federal, state, local and private) to maximize the impact of flood risk investment. The Team prioritized direct and indirect funding stream requirements with CMD needs. This financing and investment strategy will directly benefit CMD and nearby properties sharing the same drainage catchment. **This approach should be replicated elsewhere by other commercial sectors and like-minded institutions in the city.**

More analysis is needed of the various finance streams. Beyond those fall solely under CMD institution jurisdiction, a list of possible funding sources is on a following page.

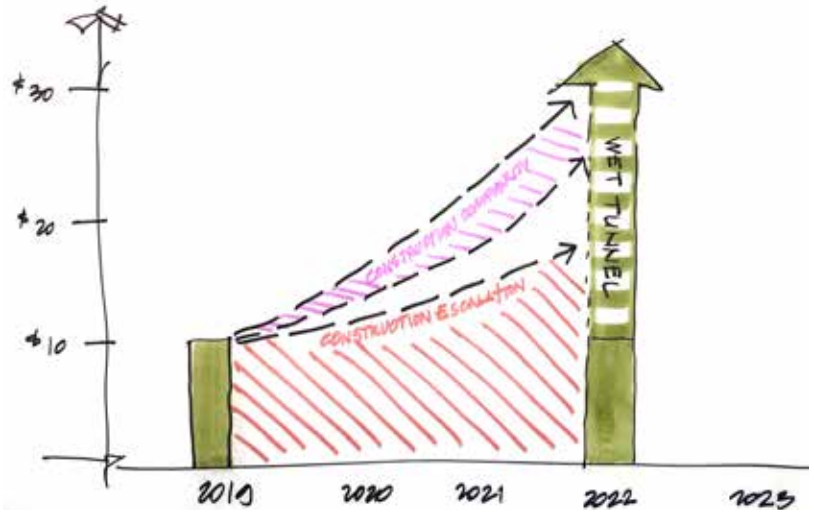
Diagram of CMD Noting Key Assets and Traffic Flows

Near Term
Improved Flood Recovery and Water Storage

Mid Term
Improved Connections and Water Storage

Long Term
Improved Services and Expanded Capacity and Water Storage

Medical District Project Priorities



Opportunity Cost of Ehrhardt Shaft Construction Delays

Federal

- FEMA Pre-Disaster Mitigation Planning Grants for Community Lifelines/BRIC
- FEMA Hazard Mitigation Grant Program
- TIGER, BUILD or other Federal Transportation Authority grants
- National Fish and Wildlife Foundation grants
- Community Development Block Grant / Disaster Recovery
- Department of Veterans Affairs Facility Funding
- HUD Public Housing CIPs

State

- State Transportation Grants
- State Revolving Fund
- State Infrastructure Bank
- MUSC Capital Improvement Programs

Local

- Environmental Impact Bonds
- Revenue Bonds
- Stormwater fee
- City CIP
- Tax Increment Financing (TIF)
- Funds from a to-be-created CMD or broader Resilience Business Improvement District

Private

- Hospitality Tax Share
- Private Development Cost Share
- TNC demo fund
- Roper CIPs
- Charleston Medical District
- CMD GI
- CMD User Fee

Finance Team Efforts & Outcomes

1. Orientation of key issues and site tour of the Medical District with a focus on understanding critical facilities and access points. The team collectively defined locations within the three portfolios of properties of MUSC, Roper Hospital, and the VA where the greatest value [patient service, revenue, grants, etc.] is currently generated.
2. Description of service flow across the campus [where people park or drop off, major buildings/service delivery sites and ongoing negative impacts]
3. A focus on frequent/nuisance-based risks such as rainfall and tidal flooding, not hurricane or sea level rise risks.
4. An overview of flooding locations / key problem areas and current strategies to adapt during those flood events.
5. Solution identification and prioritization to avoid future losses categorized across near, mid and long-term investments.
6. Governance and organizational models needed to coordinate and synthesize these efforts, via the 2015 CMD MOU.
7. Identification of potential funding or financing streams to support investments and pathways to access that funding.
8. A follow-up strategy, not the least of which is the quantification of the current financial impacts of recurrent flooding upon CMD and an identification of how avoid-loss revenue streams can be most effectively deployed.

				Funding				
	Priority	Project	Cost ($M)	Federal	State	Local	Private	Purpose
Short Term	1	VA Pipe/Pump with Green Infrastructure where possible	3 - 5	Out of cycle request; Capital Program - EM for 2020-?		Stormwater bond?		Reduce flooding to improve access
	2	Calhoun Pump with Green Infrastructure where possible	3 - 5	←	→ SIB?	Stormwater bond? CIP fund	← →	
	3	Ehrhardt Shaft	10	CDBG-DR application critical to fund	BUD appropriation	CIP fund design ← →	CMD Green Infrastructure funds to complement road repairs	
	4	Long Lake Dredge Study	0.1-0.2	NFWF / L&W Cons. Fund		Stormwater bond CIP funds feasibility study	Private developer in coordination with CMD	Study to understand potential additional storage and amenity spaces
	5	Greenway Water Storage	10 - 20	HMGP/FMA/BRIC	SIB?		TNC demo fund	Reduce flooding & improve patient/staff experience
Mid Term	6	Bravo/McClennan Road	2.8+			CIP fund road repairs TIF?		Improve access from north to CMD for 'dry feet' during flooding
	6a	M.D. Connector West edge	10	←	→	TIF / bond	Harbor Tower / Bennett Hotel / Comm. Bus. Ex. $1/night program	
	6b	US-17 Crossing SCDOT coord.	3.5	FTA ←	→	BRT / BCDCOG		
Long Term	7	Consolidated Garages & Transit Exchanges	TBD			BCDCOG BRT / LCRT Repurpose/sell County Building 16	Study?	Res. Surface transportation plan for district
	8	Pedestrian Bridge/Porch	30 - 50	PDM/BRIC		PPP	incubator	Alternative circulation in high water or heat
	9	Roper/MUSC Lucas Garage Consolidation	TBD	←	→	PPP MD		Improve parking & open space for water, improve patient experience
	10	CMD Organization MOU	TBD	←	→	MD ← →	FO	Extend collaboration for near-long term planning
	11	Ground Floor Risk Assessment	0.04-0.05	←	→	MID respective entities		Better capture service & capital risk in order to prioritize solutions

Medical District Priority Projects

Medical District Finance Group
Workshop collaboration and brainstorming

Medical District Recommendations

A key driver of economy, health, and safety, adaptations to water must be well-coordinated within the Medical District and in dialogue with surrounding infrastructure investment.

Establish a Flood Resilience Coordinating Committee

CMD, pursuant to its 2015 MOU, should establish within 6-months an inter-institution CMD Flood Resilience Coordinating Committee with authority to develop, coordinate funding, manage, contract and implement flood-risk and resiliency-related projects. CMD institutions should, under the direction of institution CFOs, (a) compile flood-related financial-loss accounting identified during the Dutch Dialogues and (b) pursue internal/ external funding sources through which near-term flood-risk management and other pilots can be designed, engineered and constructed.

Understand the Cost of Doing Nothing

CMD institutions should perform an investment value analysis to assess current risks and recent loss and impact patterns, plus likely escalations of those given recurrent flood trends, against capital and operational commitments.

Develop Real-Time Forecasting Capability

Given the increasing frequencies of flood events and extreme rainfall, CMD and/ or the City should develop, or improve, real-time, web-/application-based flood forecasting tools for CMD emergency vehicles, employees, patients and the public. This tool would overlay current weather, tides, precipitation and CMD streets to give users the timing, duration and projected water levels on/ near CMD streets, and alert users to which streets are likely impaired or impassable. Such tools are in development elsewhere.

Advocate for Multiple-Benefit Perimeter Protection

If a peninsula perimeter protection is eventually built, its alignment from the Low Battery to the Citadel will impact CMD. CMD should advocate, possibly via the above Coordinating Committee, for an alignment that enables future, additional stormwater storage and groundwater management opportunities. See CMD narrative for further explanation.

Anticipate Changing Conditions

Given existing hurricane and storm surges, changes to Gulf Stream patterns, projected increases in extreme rain and tropical storm events, combined with projected sea level rise along the Lowcountry coast within the century, CMD flood risk reduction strategies must incorporate these projected changes and their impacts upon access and operations. Time-bound investment value analyses that assesses current risks and recent loss/impact patterns, and likely escalations thereof, against capital and operational commitments are needed.

Create Resilient Connections

The CMD Greenway along Doughty street should be extended to Ashley Avenue over time and incorporate aggressive above ground water storage and infiltration strategies and, if possible, below ground as well.

Additional “entrances” into and through CMD along Cherry, Bravo and McClennan Banks streets, between Crosstown and Calhoun, would create efficient and ensure redundant access for emergency vehicles, patients and staff to CMD institutions. The City’s Comprehensive Plan update could encompass this entrance while integrating bus-rapid transit, cyclist routes, public and green space, plus water infiltration and storage into this access. SC DOT and CMD would be key partners. This throughway should be properly elevated against tidal and stormwater flood impacts.

Connectivity between WestEdge, Gadsden Green and westside neighborhoods should be reinforced. Connectivity enhancements must not impair current drainage; ideally, they would enhance drainage, water storage and infiltration while improving pedestrian, vehicular and neighborhood access.

The Dutch Dialogues Team cannot recommend the filling or impairment of Gadsden Creek or its drainage functions. The Creek should be beautified, and its functions enhanced.

A Westside planning framework is needed through which the City, CMD, WestEdge, Riley Park, the Citadel, and Westside neighborhoods establish coherent, beneficial environmental and citizen connections to and through these areas. Brittlebank and Hampton Parks, the coastal marshes north and west of this zone, and the Ashley River are underutilized community, water access and water management assets.

Medical District Campus

NEMAC+FernLeaf

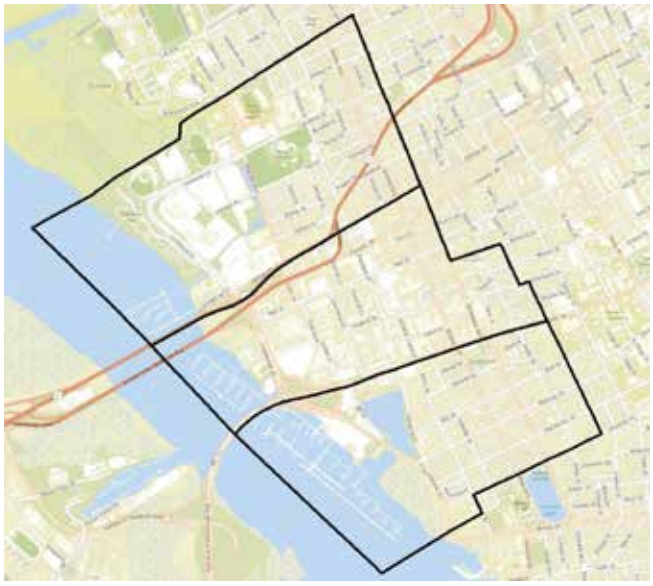
Charleston Vulnerability Assessment Key Data

The City of Charleston is pursuing a thorough analysis to assess its vulnerability to different types of flooding--including major flooding events, storm surge, tidal flooding, and sea level – and other hazards, such as earthquakes, hazardous materials releases, and water supply shortages. The analysis is led by NEMAC+FernLeaf, supported by a team of experts and consultants, using a powerful team-developed tool – AccelAdapt – that examines the vulnerability of the city's public infrastructure, services and socio-economic systems to the various types of flooding facing the city – both now and in the future.

Lockwood Corridor

One of the area's most susceptible to flooding is the Lockwood Drive corridor which includes the Medical Center complex containing the Medical College of South Carolina (MUSC), the Veteran's Administration Medical Center (VAMC) and the Roper Hospital. The corridor covers three census tracts, extending from the new West Edge development in the north, eastward to Rutledge Avenue and Pitt Street, and southward through the Medical Center to Baufein Street. This area contains about 20% of the jobs and employees, and 10% of the government facilities, in the City. Lockwood Drive is a key transportation artery providing essential access to the Medical District and to the business and tourism districts of the Peninsula.

The Lockwood Drive corridor is currently subject to chronic flooding due to low topography from historic filling of wetlands, and the limited capacity of the current storm drain system. Using the Accel-Adapt tool, the Vulnerability Assessment preliminarily indicates that over 90% of the commercial and residential property, government facilities, critical facilities (medical and schools) and parks are located within the 500-year floodplain and nearly the entire corridor could be subject to flooding from a Category 2 hurricane. Critical access points to major medical facilities are vulnerable to flooding from high tides and extreme rainfall events. Most of the corridor is also threatened by a long-term sea level rise of 3 feet. The corridor's vulnerability threatens a large employment and research base, and the delivery of medical services to residents of the city and those in the wider Greater Charleston region. The corridor has a high level of social and economic vulnerability due to low income levels, age and family composition, and dependence on public services, including housing and federally subsidized food programs.



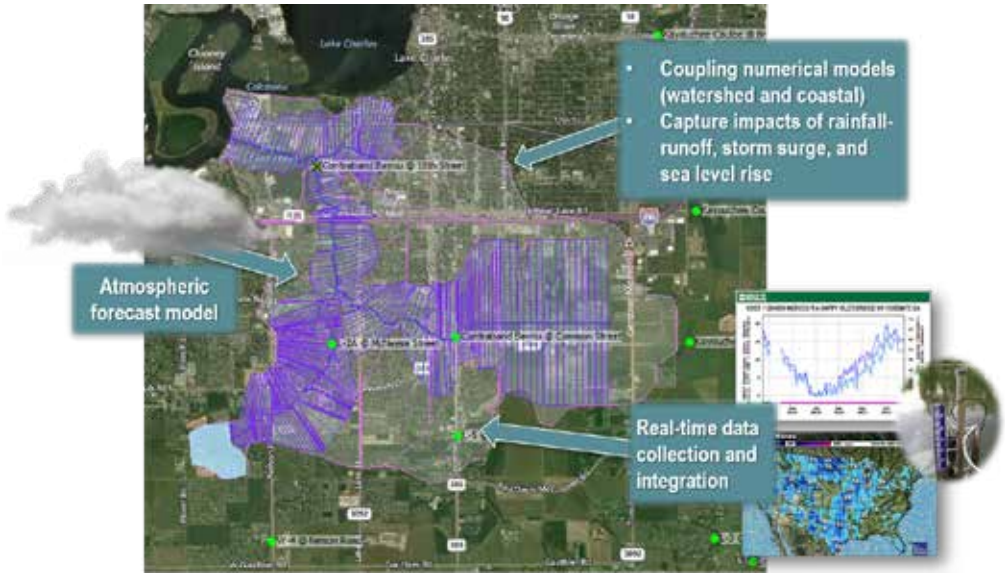
Census Tracts in the Lockwood Drive Corridor
Image Credit: NEMAC+Fernleaf

Beyond evacuations during major storm events, current strategies for addressing current and long term flooding and sea level rise include a storm surge wall being evaluated by the U.S. Army Corps of Engineers, deep shaft drainage structures to contain and discharge stormwater, upgrades to the near-surface stormwater systems, stormwater detention and retention controls, low impact development, relocation of vulnerable equipment and facilities, enhanced flood warning and notification systems, and community capacity building. An essential, related goal is to improve cooperation between the three Medical District facilities to mitigate flood impacts in the District, and advance several key drainage projects in and near the area.

The Vulnerability Analysis will be completed in early 2020 and will contain important information for all city residents, business and institutions.

The Water Institute / Dutch Dialogues Team

Real-Time Forecasting (RTF)



RTF System Inputs
A RTF system, developed by The Water Institute and Deltares, to provide flood-relevant information along Contraband Bayou in Louisiana. This system provides local officials with potential flood risk, inundation, road and other impacts caused by rainfall-runoff and the compounding effects of storm surge and high tides. Such a system would help emergency managers prepare for flood risks in Charleston's Medical District, South of Broad and Eastside neighborhoods.

Real-time forecasting systems (RTF) serve as decision support tools for emergency responders, governments, and residents to minimize risks for people, infrastructure, and the natural environment. RTF can be accompanied by an advance warning system to quickly disseminate flood-relevant information to those whose homes, businesses, facilities, cars and livelihoods may be impacted by floods.

RTF systems combine real-time data, weather forecasts, hydrological or coastal numerical models, and other tools to provide targeted users with a single, reliable predictions and location-specific information. Data availability and data quality strongly influence RTF accuracy, especially those coupled to flood alert systems. These require a robust, real-time monitoring network that measures rainfall and water levels in the stream network. A well-designed RTF system will thoughtfully and efficiently configure and integrate these types of data with the models.

Cities are experiencing floods of various causes: rainfall, tides, waves, surge or all the above. These compounding interactions underscore the need to seamlessly integrate coastal and inland flood models. Flood depths and durations are most commonly estimated by a physics-based, numerical model with land elevations, land use, and drainage information. An example of an RTF system in a small, inland watershed in coastal Louisiana focused on flood warnings is shown above. This was built with e Delft-FEWS (Flood Early Warning System) software which is a platform to import environmental data from several sources and activate that information to drive the numerical model.

Emergency managers must act quickly and purposefully when allocating resources. RTF systems can be configured to provide emergency managers and responders (police, fire, hospitals, ambulances, public health officials, etc.) with real-time flood risk information to accurately target, manage, communicate and adapt responses. Typical flood warning RTF system outputs include flood depth, safety risk, road and building safety, hazard level, and other flood-relevant information. Other RTF systems that have a more ecological purpose can include salinity, water temperature, sediment and nutrient concentration.

RTF systems also provide City planners, finance, budget, citizens, residents and other decision-makers with scenario-development tools to better plan, model and simulate responses to various flood events across the target watersheds and/or coastal regions.

Governance

Does Charleston Need a Flood Coordinator?

Clemson Design Center students supporting the DD team surveyed, in person and by email, several Workshop participants (City staff and citizens) regarding the creation of a regional flood coordinator or "flood czar." The survey lacked the sample size and statistical underpinnings needed to yield a scientifically valid result. The summarized survey answers, nevertheless, provide food-for-thought about structured regional collaboration. Neither survey participant names or verbatim answers were recorded; the results are anonymous.

Question 1

Given the water and flood challenges in the Charleston region, do you think more regional cooperation is necessary or desirable?

- Water knows no boundaries. Regional cooperation is necessary. A regional group should be created to solve regional flood issues.
- We are stewards of the land and everyone, collectively, should work together. Municipalities must work together as neighbors.
- We understand how water flows during a hurricane. When everyone is involved and on the same page we can come up with a good solution.
- The challenge is how you do it, fund it, implement it, and who takes the lead?

Question 2

If necessary or desirable, what form or what mechanisms would you prefer to accomplish that cooperation? Voluntary cross-county collaboration? Formalized collaboration-- for instance a new regional flood platform of governing officials or their staffs? Embedding such a platform in an existing intergovernmental collaborative entity?

- Formalized collaboration is needed; voluntary collaboration has failed.
- We need a regional organization for regional-scale solutions. We need authoritative planning and enforceable zoning at the regional scale.
- Create a new flood council made up of technical members funded and empowered to work independently of political campaigns, budget cycles.
- We need a regional water commission for the City of Charleston, Mt Pleasant, N. Charleston, Charleston County.
- Every party should work together; although competition between municipalities may require a regional, independent entity.
- Stronger than voluntary, because different communities have different needs, esp. in the African American neighborhoods.

Question 3

Do you think Charleston needs a "Flood Czar" to facilitate flood risk planning and investment coordination?

- It would be nice to have one point of contact to help coordinate flood and investment activities.
- We need an independent individual or independent regional not comprised of politicians from the different municipalities.
- Czar staff should not be in City government. The city would benefit if the Czar was not a City position.
- The political climate, especially in the City, is very fluid. If this is a City-appointed position, there is a very real chance that an appointed Czar could be hamstrung or replaced every time there is a change in power.
- This should be an elected position that would operate with County and City and cannot be fired.

Collaborate and Communicate
Dutch Dialogues format provides a model for future collaboration

- We need one individual coordinating & supervising the various flooding and climate change activities, accountable to the mayor. Be careful: if you put the focus on 'flood', then you'll get only engineers and engineering solutions.
- No, we need the existing authorities to work together for a solution. No need to add additional layers to an already complex government.
- I'm not comfortable with having a flood czar. We still need a team to alleviate problems
- Charleston needs regional planning and zoning, empowered and coordinated by a stronger planning department.
- Financing will be the most difficult issue. The city does not have resources to solve the problems on its own. Beyond regional cooperation, state/federal funding is needed.

Question 4

If yes to question #3, where should such a function be located, within the city, county government or an independent entity? If an independent entity, which one or which type?

- Place it in the TriCounty collaboration.
- Someone within each municipality should be the point person, expert. If you do it only at a regional level you will miss the fine grain understanding you need.
- Each city should have one or two representatives. Each member of that commission has a vote to appoint a candidate for the head position, or all candidates can be elected by the members of the community.
- If the Czar is within the City of County, he / she would need authority to fund and regulate. City Citizens would protest because of the cost.

Question 5

Are you comfortable with the level of real-time flood information or preparation? If not comfortable, what kind of information would you like to have?

- Communication and data can be better. The issues are evolving, and we must always gather best data and to make our our practices better.
- City planning is proactive and moving quickly. Other agencies are not understood by the people.
- Real time info/prep is not an issue. National weather center does a good job.
- Use all streams of contact because the elderly is not on social media so they will need TV, or phones calls. We need to reach all groups.
- It would be nice to have access to information from a network of rain gauges, stream/creek flow & level gauges, etc.
- Lots of data is available to the public but I'm not sure if the public is able to understand the data. We have the information but not a way to distribute it to the public.
- No. Maximize what we have, define what is a danger and what is not. Community is not comfortable with the real time information that we have. The city is working on an app that is integrated into Waze.
- I am generally aware of what conditions lead to flooding and which areas to avoid, so I rarely find myself inconvenienced by the flooding.

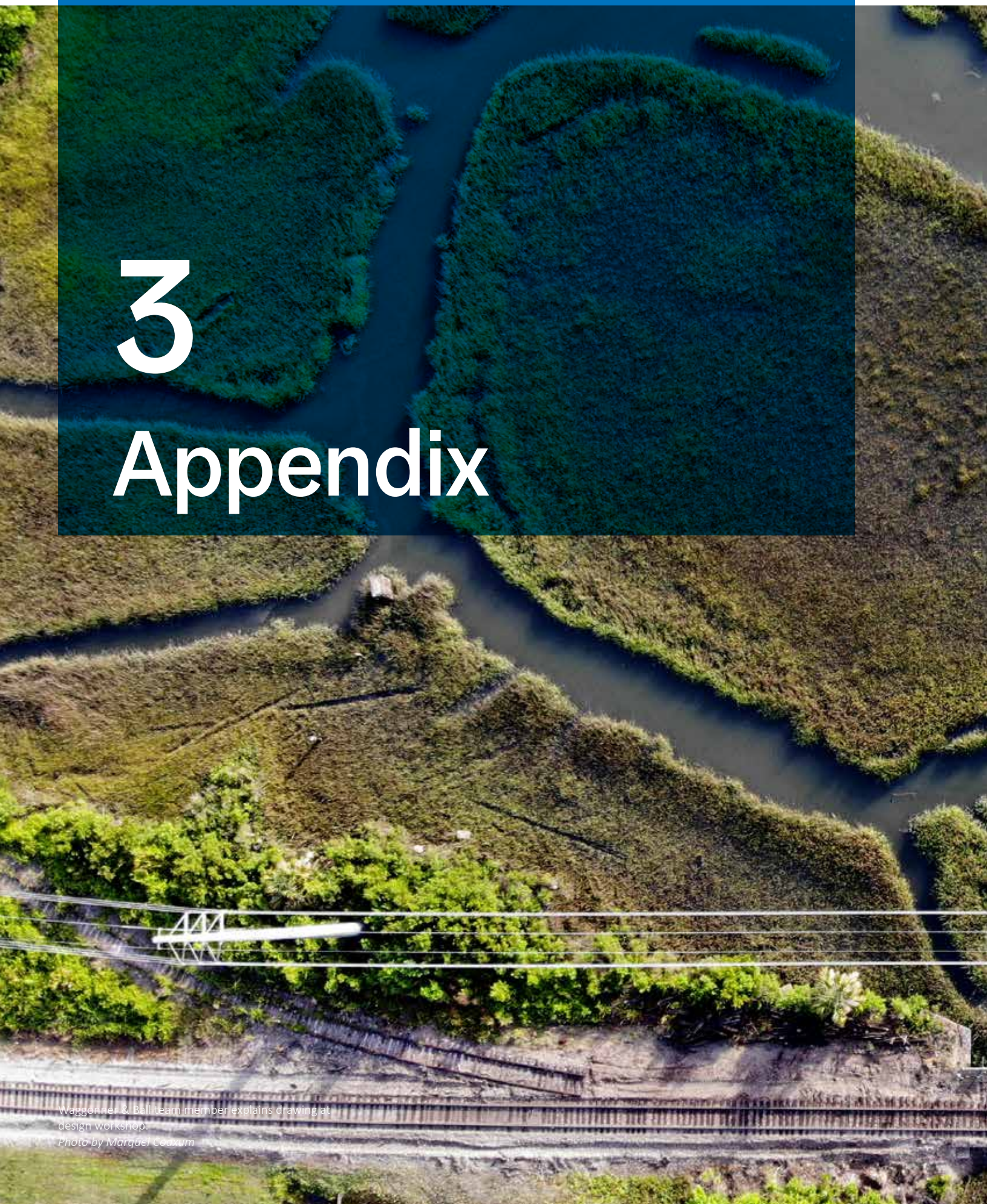
Question 6

What other suggestions do you have to further improve the regional flood risk mitigation efforts, communications, planning and investment in Charleston and the region?

- Stronger cross-collaboration between the public and private sectors.
- Greater education for the general public that starts at the school level. General education for everyone could help prepare everyone to be better planners. Public information and education should be continuous for many years to build understanding and support for the huge multibillion-dollar effort needed to protect Charleston.. When Charleston thrives, we all thrive.
- Need compliance and enforcement of new ideas on development. Slow down on how fast we are building.
- Allow submerged drainage systems.
- Citizen resistance and frustration aren't always about the big storms or big moments. More individuals should take responsibility and manage water; teach them how water can be managed because everyone can do their own part, great or small.
- Rezoning (down zoning) on some properties will likely be required. Transfer of development rights and density seems to be reasonable options but I do not know how those would be created and approved.
- The public is opposed to areas of increased density because it causes traffic, but density is exactly what is needed in some areas. Transportation options must be available that serve the community's needs (offering more frequent service as well as providing late runs) and show that increased density does not necessarily mean more traffic delays.
- Implement recommendations from the Dutch Dialogues. Avoid the lowest, most flood prone areas.
- Need City and County Council members on board to support the various initiatives area wide and not focus solely on their districts.

Coastal Edge
Abstraction of the coastal wetlands found near Charleston, which also exist at the edge of the Medical District.
Credit: Mac Ball

3 Appendix



Waggonner & Ball team member explains drawing at design workshop.
Photo by Marquel Coaxum

Dutch Dialogues Core Team

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Pieter Schengenga H+N+S Landscape Architecture

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Ryan Smith Moffatt & Nichol

Roelof Stuurman Deltares

South Carolina Coast
Abstraction of the colors, textures, and forms of the low country environment.
Credit: Mac Ball

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Ruby Randall

Luther Reynolds City of Charleston

Paul Rienzo Crosstowne Church

John Rivers Rivers Enterprises, Inc.

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David Wood Aecom

BD Wortham Galvin Clemson Design Center

Artemiy Zheltov Shadowmoss Neighborhood Association

Coastal Protection

Louisiana Coastal Master Plan

Following Hurricanes Katrina and Rita in 2005, the Louisiana Legislature created the Coastal Protection and Restoration Authority (CPRA) to coordinate local, state, and federal efforts for comprehensive coastal protection and restoration. To accomplish these goals, CPRA was charged with developing a master plan to guide our work toward a sustainable coast, to be updated every five years.

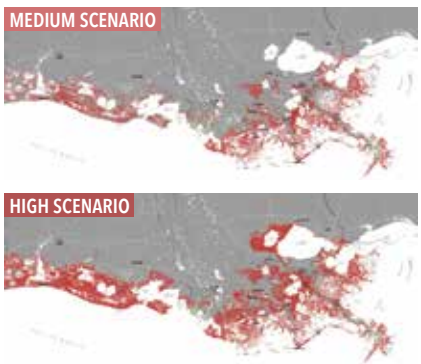
"The 2017 Coastal Master Plan recommends a diversity of projects to build land and reduce flood risk in order to balance short-term needs with long-term goals. The reality is that this plan will not solve all the challenges facing coastal Louisiana.... The master plan is keenly focused on identifying and prioritizing high-performing projects that could be implemented over the next 10 years, while also planning for the next 50."

For more information, see:
cims.coastal.la.gov/our-plan/2017-coastal-master-plan

Excerpts from the 2017 Coastal Master Plan
Credit: CPRA

COMMITTED TO OUR COAST

Our goal is not, and has never been, to rebuild the coast of the 1930s or to maintain our current coastal footprint. We know that is not feasible. The 2017 Coastal Master Plan recommends a diversity of projects to build land and reduce flood risk in order to balance short-term needs with long-term goals. The reality is that this plan will not solve all the challenges facing coastal Louisiana. It will take an unprecedented effort by government, the private sector, and coastal communities to improve the sustainability of our coast. However, Louisiana's people are resilient, and we are up to the challenge.



FACING A FUTURE WITHOUT ACTION. If the latest "worst case" sea level rise estimates prove to be accurate, then coastal communities around the world will all face tremendous risks.

Louisiana will be no different, especially considering the fact that much of our coast is also experiencing some degree of subsidence. We know we have lost at least 1,900 square miles of land since the 1930s, and we know we are going to lose more. In fact, our latest predictions show that if we do nothing, we stand to lose in the range of 2,250 to 4,100 additional square miles of land (for the medium and high environmental scenarios).

WHAT THE PLAN PROVIDES

The master plan is keenly focused on identifying and prioritizing high-performing projects that could be implemented over the next 10 years, while also planning for the next 50. Over the next 50 years, the 2017 Coastal Master Plan includes:

- $18 billion for marsh creation, $5 billion for sediment diversions, and more than $2 billion for other types of restoration projects, providing land building benefits of 800 to 1,200 square miles compared to no action.
- $19 billion for structural risk reduction and $6 billion for nonstructural risk reduction; these projects will save more than $8.3 billion in annual economic damage by year 50 and are expected to pay for themselves three times over the course of implementing the plan.
- Many restoration benefits that will support commercial and recreational fisheries, coastal wildlife, and the diverse habitats which enable us to live, work, and play across the coast.

2017 COASTAL MASTER PLAN

RISK REDUCTION

- STRUCTURAL RISK REDUCTION
- NONSTRUCTURAL RISK REDUCTION

RESTORATION

- MARSH CREATION
- RIDGE RESTORATION
- SHORELINE PROTECTION
- BARRIER ISLAND RESTORATION
- HYDROLOGIC RESTORATION
- SEDIMENT DIVERSION
- SEDIMENT DIVERSION

Small scale hydrologic restoration and oyster reef/living shoreline projects are included programmatically in the 2017 Coastal Master Plan. Consistency of individual projects will be determined on a case-by-case basis. To learn more about the 2017 Coastal Master Plan and recommended projects, please visit cims.coastal.la.gov/our-plan/2017-coastal-master-plan.

TAKING ACTION TODAY FOR TOMORROW'S GOOD. In all, the master plan outlines projects that cost, in present value, approximately $50 billion. These investments will not only provide direct restoration and risk reduction benefits, but will also provide tremendous economic development opportunities for Louisiana and its residents.

The unprecedented investment in coastal restoration and protection will continue to put Louisiana at the forefront of using science and innovation to plan a sustainable future for our coastal communities and our valuable ecosystem. We are proactively preparing for a bright future in an ever-changing landscape.

TELL US WHAT YOU THINK!

DOWNLOAD PLAN:
COASTAL.LA.GOV

EMAIL:
MASTERPLAN@LA.GOV

WRITE:
COASTAL PROTECTION &
RESTORATION AUTHORITY
P.O. BOX 44027
BATON ROUGE, 70804

INTERACT:
CIMS.COASTAL.LA.GOV/MASTERPLAN

CONNECT:

THE COASTAL PROTECTION & RESTORATION AUTHORITY

was formed by the Louisiana State Legislature in 2005 following the devastation brought to our state by Hurricanes Katrina and Rita. CPRA is responsible for hurricane protection and the protection, conservation, restoration, and enhancement of coastal wetlands and barrier shorelines or reefs throughout southern Louisiana's coastal area – the contiguous areas subject to storm or tidal surge. CPRA is boldly addressing the root cause of Louisiana's coastal crisis by pioneering large-scale restoration plans to build coastal habitats and to reconnect the river to its delta, as well as promoting increased coastal protection and community resilience.

Waggonner & Ball Architecture/Environment

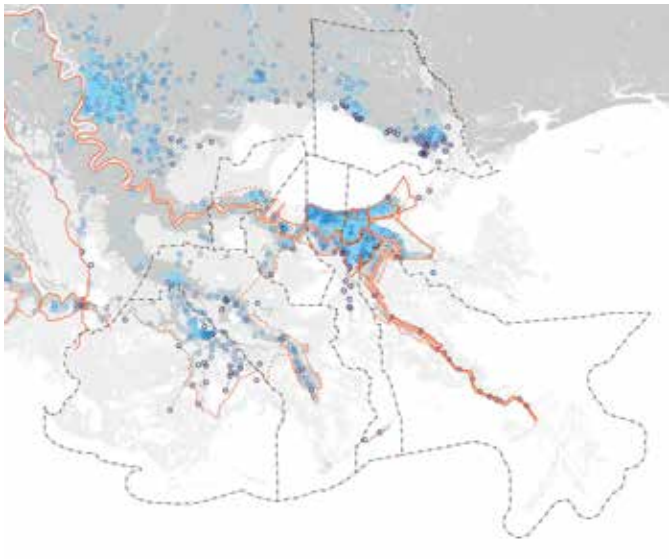
LA SAFE Regional Adaptation Strategy

A precedent for Charleston is the State of Louisiana's Strategic Adaptations for Future Environments (LA SAFE) effort. In collaboration with a multi-disciplinary team of planners, designers and community engagement experts, the goal is to enable coastal communities to be proactive in designing for rapid land loss and shifting social, economic, and ecological conditions. LA SAFE is about community resilience, economic prosperity and a better quality of life for everyone in the state, with a focus on six coastal parishes.

Waggonner & Ball led the design effort with research and analysis of the physical characteristics of the land and the subsequent development of regional and parish-specific adaptation strategies responsive to the specific needs of each area, all within a framework of community engagement. The team developed a range of pilot projects and a planning document based on the discussions with the community and parish officials. Pilot projects are currently in the design phase.

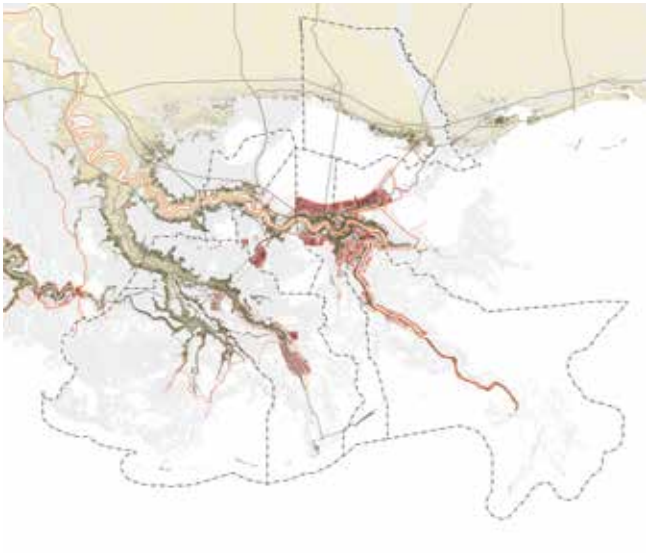
Community Meeting in Terrebonne Parish

Learn more at lasafe.la.gov



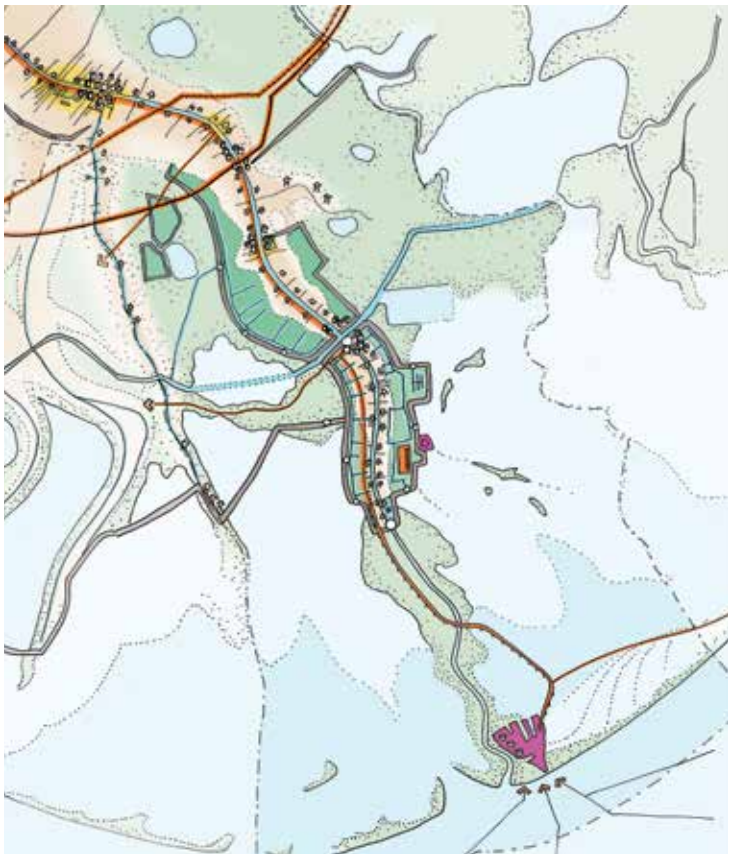
Population at Risk

- 1,000 people
- 355,000 people in Low Risk Zone
- 470,000 people in Moderate Risk Zone
- 80,000 people in High Risk Zone
- Federal Levee
- CPRA Proposed Levee



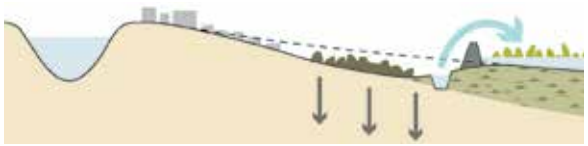
Elevation

- Less than -5'
- Sea level
- Greater than 10'

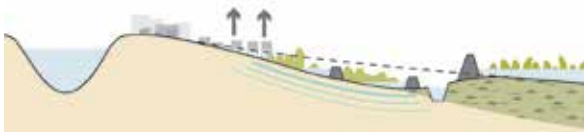


Lafourche Parish 50 Year Vision

Pre-European Settlement



Current Condition - Subsidence



Future With Adaptation

Laplace Canal Park Pilot Project

Meghan Finnegan, Dutch Dialogues Team

Vision 2100 Norfolk, Virginia

Then & Now
Historic creeks, now filled and developed, closely align with tidal and stormwater flood risk.

Background

In 2013, the Rockefeller Foundation selected the City of Norfolk to be one of the initial 33 global cities of its 100 Resilient Cities (100RC) network, recognizing Norfolk's leadership in addressing the potential impacts of climate change – primarily sea level rise-- in the coastal environment.

Norfolk, like many coastal cities, is under stress from sea-level rise, a changing economy, aging (road, flood and other) infrastructure, and a growing population. Existing investment, related to its changing economy, is also under duress. As the City pondered these pressures, it also started to explore – given these pressures – how to prioritize investment, flood protection, across its neighborhoods. Vision 2100 was created to reimagine the City for the 22nd Century through a new resilient framework.

Planning for Vision 2100 stretched across and through the entire City. The process had three phases: awareness, asset mapping and vision development, with citizen engagement at the core. City agencies worked collaboratively. Asset mapping identified key elements that make Norfolk a great place to live, work and play. The City committed itself to preserving and replicating unique and important assets and neighborhoods.

Vision

Vision 2100 outlines citywide actions-- including many related to mobility, transit and affordable housing-- to create a more resilient future. Major investments will target the most resilient areas (defined as those least likely to be affected by sea level rise) while ensuring the viability of at-risk areas for as long as practicable.

Vision 2100 stresses that "every Norfolk resident, business and organization implement innovative strategies to prevent flooding" whether they are directly impacted by sea-level rise or not. Green infrastructure opportunities are encouraged to help the City become a less concrete, greener cityscape. Building materials and quality construction are prioritized, putting responsibility on residents and developers. Resilience is woven throughout Vision 2100.

Vision 2100 divides the city into four distinct areas based on topography, sea level rise projections, existing and future assets and development patterns. The first are Red Areas, home to key assets – downtown area, Naval Station, ports and shipyards, universities and medical facilities- that likely cannot be relocated or recreated elsewhere in the City. These areas contain critical assets and high levels of flood risk. These areas should be secured with major flood-control investments: flood walls, tide gates, enhanced drainage infrastructure, pumps, as well as green infrastructure. Direct public and private investment will be promoted in these areas to increase density, enhancing the investment's impact by reducing flood risk and improving overall safety.

Vision 2100 seeks to achieve balance between protection, access, livability and affordability in these areas.

Yellow Areas have fewer key community assets but at a higher flood risk. Here, the focus is on adaptation to rising waters. New and innovative technologies will be sought, and hopefully "developed locally," to reduce flood risk and focus infrastructure investment to enhance resilience. The City will develop programs to help property owners recoup economic value lost to rising waters. Some Yellow Areas are historic neighborhoods which the City intends to protect.

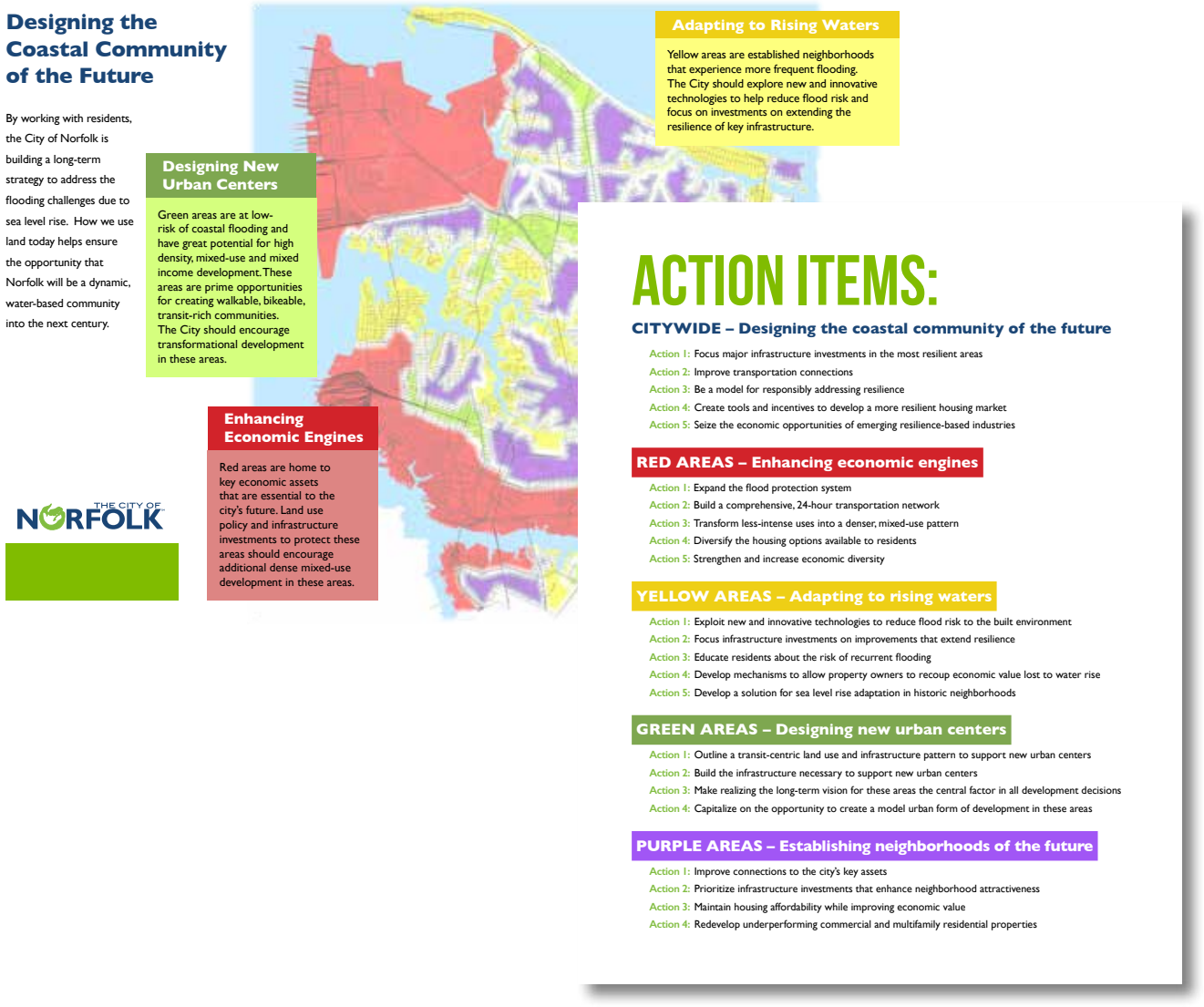
Green Areas have high value uses like hospitals and underdeveloped parcels at lower sea-level rise and flood risks. Here, the goal is to redevelop for transit-oriented, urban centers safe from flood risk and able to accommodate density and increased population. Specific, high-ground locations have already been identified.

Purple Areas have stable neighborhoods at a relatively low flood risk that could benefit from additional connectivity investments. The City aims to maintain housing affordability while redeveloping underperforming commercial and multifamily residential properties. Because these areas are enjoyed by current residents, they are not targets for large scale transformation.

Implementation

The city adopted Norfolk Vision 2100 as an element of its comprehensive land-use plan, ensuring it is an integral element of city policy. Vision 2100 is not a comprehensive plan in and of itself; it supplements the City's comprehensive plans and guides its sea-level rise adaptation planning.

For more information:
https://www.norfolk.gov/documentcenter/view/27768



Meghan Finnegan, Dutch Dialogues Team

Norfolk Resilient Zoning Ordinance

Waterfront Character
Resilience policies must incorporate existing assets.

Norfolk's new zoning ordinance was unanimously adopted by City Council on January 23, 2018 and took effect March 1, 2018. The ordinance was rewritten to strengthen the City's commitment to vibrant neighborhoods, economic diversity, and coastal resilience.

The new zoning ordinance encourages and supports development that makes Norfolk more resilient, both physically and economically, recognizes the four established character districts, is user-friendly and supports streamlined development processes. It allows us to take a proactive and innovative approach to address flooding and position the mermaid city as the coastal community of the 21st Century and a model for other coastal communities to follow

Resilience

The Ordinance contains several pioneering approaches in response to the long-term challenges posed by sea level rise, one of which requires all development within the City to meet a resilience quotient. The requirement is measured on a points system covering three separate resilience elements: risk reduction, stormwater management, and energy resilience. This innovative points system ensures that new development will be more resilient and environmentally-friendly while providing flexibility to builders by allowing them to choose which measures to include in the development. Additionally, new or expanding development must meet minimum requirements for first floor elevations 1.5 – 3 feet above flood level.

The ordinance allows for easier mixing of use in commercial corridors to encourage more vibrant and pedestrian-friendly communities, whether one walks, bikes or drives. Increasing the housing use and diversity also includes provisions for more live-work units, providing a broader range of home occupations. As one example of this, the ordinance allows home- business owners to ask for permission to see clients in their home, something that wasn't previously available. Additionally, the ordinance creates more housing options, such as accessory dwelling units (or in-law suites) in many areas of the city.

Neighborhood Character

The ordinance also reflects the need to preserve and enhance Norfolk's unique development character. Character districts were established to apply different standards to different areas, with four district character districts – Downtown, Traditional, Suburban, and Coastal – each having standards that address their historic and planned development character. Form standards for each character district establish guidelines for how new buildings can be developed while maintaining the integrity of that neighborhood's character. These standards focus on form and not design, including things such as porch or garage locations in residential development and window glazing or parking location in commercial development. Form standards apply to all uses but vary based on character district.

Ohio Creek Neighborhood Plan
Including infrastructure improvements and anticipated policy-based outcomes.

Streamlined Development Processes and Permitting Flexibility

The new zoning ordinance includes clearly defined expectations so that there are no surprises for both applicant and the neighborhood/residents. There is a clear understanding of every step in the process up front, including checklists, meeting guidance and review criteria. There are also clear performance standards for each use making it easy to understand what is expected of a new use at the outset. This improved process empowers the neighborhood and allows all to give their input at the beginning of the process, so that any compromises between the builder and the neighborhood can be agreed upon at the start. Additionally, flexible use regulations will allow expedited approval for certain businesses, removing several uses from the list of those requiring time-consuming approval processes. By applying consistent standards across an entire category of uses, new businesses can navigate the process more efficiently and effectively. Norfolk's zoning ordinance creates policy through the lens of resilience. This ordinance helps shape our city now as well as prepare for future challenges, both natural and socioeconomic. It addresses factors with an innovative approach, guaranteeing that development will be more resilient, while still providing builders options and flexibility to achieve this. The ordinance protects the unique character of Norfolk's neighborhoods while still allowing freedom in design. Clearly defined procedures will increase the efficiency of the process. This resilience-focused zoning ordinance effectively positions Norfolk as the coastal community of the future.

Application to Charleston

Norfolk's resilient zoning ordinance contains elements that should be replicated in other coastal cities, including Charleston. The ordinance established a Coastal Resilience Overlay (CRO) zone, where new development and redevelopment will have to comply with new flood resilience requirements. In the CRO zone, additional requirements include permeable surfaces on new parking and stormwater infiltration requirements. An Upland Resilience Overlay (URO) zone was also created to encourage new development in areas of the city with lower flood risk.

The zoning ordinance includes innovative practices for fostering more flood resistant urban development. For example, the ordinance adds a new resilience quotient system, where developers earn points for adopting different resilience measures that promote flood risk reduction, stormwater management and energy resilience. All development, unless exempted, must go through a site plan review process specifically for resiliency. Developers have flexibility to meet the resiliency quotients in the risk reduction, stormwater management and energy resilience categories. Requirements vary based on the size and number of units in the development proposal.

For more information:
https://www.norfolk.gov/DocumentCenter/View/36605

Colloquium Summary


Dialogues Charleston
Colloquium Plenary

Plenary Setting

Opening, Stage-Setting, and Connected Efforts

Dr. B.D. Wortham-Galvin, Director of the Resilient Design program and the Clemson Design Center, Winslow Hastie, Director of the Historic Charleston Foundation, Mayor John Tecklenburg of the City of Charleston and Dale Morris of The Water Institute of the Gulf opened by anchoring Charleston's challenges to the work of the Colloquium.

They noted that while the Netherlands has hundreds of years of managing water, its most recent strategies move away from "fighting the water" and towards "Living with Water." Smart spatial planning drives investment to facilitate adaptation to storm impacts and climate change while also providing other societal benefits. This Living with Water approach is a mindset of adaptation and efficient investment that Charleston needs.

The Dutch Dialogues are a search for solutions, direction, and a shared, common vernacular to drive policy, action and proactive investment. Pre-event preparation and prevention are always less costly-- in terms of human life, impacts and dollars spent-- than post-event emergency response and recovery.

David Waggonner of Waggonner and Ball, Dr. Norm Levine of the College of Charleston, and Steven Slabbers of Bosch-Slabbers Landscape Architecture then set the stage for the effort. They explained work in the city of New Orleans, Bridgeport, CT and Hampton Roads, VA, as well as research on sea level, seismic risk and heat in the Lowcountry, and the history of water management and spatial adaptation in the Netherlands. They assessed the challenging Lowcountry landform in the context of increasing storms, sea-level rise and aspirational pathways for solutions.

> **"In a recent survey, 3/4 of local businesses report considerable impacts from storms and flooding and 44% reported loss of income. This is economically unsustainable.**

Colloquium Presentations:

1. BD Wortham-Galvin, Clemson Design Center: Welcome
2. Winslow Hastie, Historic Charleston Foundation: Overview of Dutch Dialogues
3. John Tecklenburg, Mayor: Charleston Vision
4. Dale Morris, The Water Institute: Dutch Dialogues / Colloquium Summary and Goals
5. David Waggonner, Waggonner & Ball: Living with Water
6. Norm Levine, College of Charleston: The Physical System
7. Steven Slabbers, Bosch-Slabbers Landscape Architects: Dutch Perspectives: Living with Water in Historic Cities
8. Mark Wilbert, City of Charleston: Flooding and Sea Level Rise Strategy
9. Ken Dierks, NEMAC-Fernleaf: All Hazards Vulnerability and Risk Assessment
10. Wesley Wilson, USACE: USACE 3x3 overview
11. Matt Fountain, City of Charleston Storm Water Program Manager
12. Jacob Lindsey, City of Charleston, Related City Planning Efforts
13. Dan Burger, Charleston Resilience Network
14. Rick Devoe, South Carolina Sea Grant
15. Liz Fly, The Nature Conservancy
16. Ian Scott, Metro Chamber of Commerce
17. Lauren Gellatly, Lowcountry Local First
18. Hugh Roberts, The Water Institute of the Gulf
19. Joannes Westerink, Notre Dame
20. Frans van de Ven, Deltares
21. Jared Bramblett, Davis and Floyd
22. Bob Horner, Weston and Sampson
23. Michael Maher, West Edge

Colloquium Agenda, Speaker Bio Sheet, and all presentations are available at dutchdialoguescharleston.org

Tidal Flooding on Lockwood Drive
Image Credit: Norm Levine

Living with Water in the Netherlands
Image Credit: Steven Slabbers

Every physical landscape, its inhabitation, systems, and uses, is unique. Discovering the context of the place, and how to create or fortify identity through water, is key. This mindset presumes a relationship with and respect for water. Ignoring or constantly fighting the water will not be an effective or affordable long-term strategy.

Charleston's natural and physical systems and landforms are grounded in dunes and islands, and are shaped by waves, winds, currents and interconnected, inland water systems (creeks, rivers, marshes, estuaries). This is indeed "the Lowcountry," with half of all home elevations at less than 10ft above sea level. Like many coastal environments, Charleston's physical, environmental and aesthetic riches are the sources of its most pronounced vulnerabilities. Urbanization-induced landfill has changed the water-land interface but the region's marshes still want to act like marshes, regardless of use or condition. Extreme weather events and tide-driven, sunny day flooding are equally costly and demand equal attention: both impact property, livelihoods, critical infrastructure, economic activity and property values. These impacts are worrisome to citizens, policymakers, emergency responders and investors alike.

Mark Wilbert, Chief Resilience Officer of the City of Charleston, Ken Dierks of Kimley Horn in collaboration with Nemac/Fernleaf, Wes Wilson of the US Army Corps Engineers, Matt Fountain of the City of Charleston Stormwater Management Team and Jacob Lindsey, Planning Director for the City of Charleston, provided overviews of a much larger and diverse set of flood-risk mitigation and adaptation efforts in the City.

Dan Burger of Charleston Resilience Network, Rick Devoe of SC Sea Grant, Liz Fly of The Nature Conservancy, Ian Scott of the Metro Chamber of Commerce and Lauren Gellatly of Lowcountry Local First wrapped-up the Colloquium's Plenary.

Patience and urgency, plus a long-term vision and funding, are necessary to manage Charleston's multi-generational and multifaceted challenges of growth, flooding, transportation, equity and cultural heritage. Scales and layers of time, geography, elevation, occupation and science must underpin solutions. Coastal cities recognize that state and federal governments are unable to respond effectively to local climate change impacts. Natural systems, which can address many of these impacts, should be embraced.

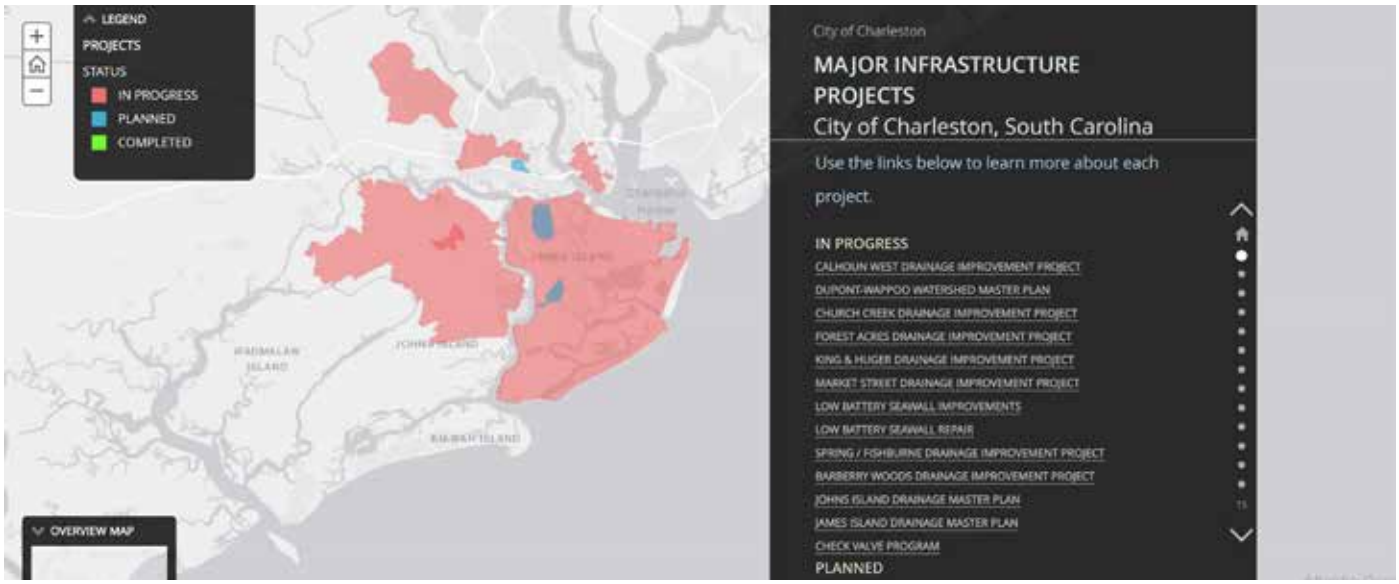
While the Cooper River and the Peninsula work tends toward the retrofitting of existing built environments, West Ashley and Johns Island developments are frequently planned in previously undeveloped areas. Given this, there is a clear, yet shrinking, possibility to "get it right" from the start.

Businesses note that their largest challenges are the ability to attract and retain talent and provide affordable housing to the growing workforce. Talent attraction and affordable housing are intertwined with stormwater and tidal flooding and the growing threat of sea-level rise.

In a recent survey, 3/4 of local businesses report considerable impacts from storms and flooding and 44% reported loss of income. This is economically unsustainable.

Business sees political fragmentation as a challenge, the lack of vision as worrisome, and the desire for more regional cooperation and a single voice to focus attention, resources and information as a necessity.

Dutch Dialogues Team at Angel Oak
Credit: Waggonner & Ball



Online Storymap of Infrastructure Projects in Charleston

Ongoing Flood Risk Mitigation Efforts

City of Charleston Flooding and Sea Level Rise Strategy: The City's 2019 updated Flooding and Sea-level Rise Strategy plans for 2-3 feet of sea-level rise over the next 50 years, and has five distinct focal areas: governance, resources, land use, outreach and infrastructure. An online, active platform keeps residents informed and engaged.

City of Charleston Vulnerability Assessment: The Vulnerability Assessment analyzes the many regional threats and their interactions with populations and assets to highlight the most critical areas. If Charleston does not understand and manage well its many vulnerabilities, investment and people can and will go elsewhere.

City of Charleston USACE 3×3 Study: The US Army Corps 3 x 3 Peninsula Flood Risk Management study is focused upon surge and storm risks on the peninsula and will explore structural and non-structural solutions to mitigate those risks. These responses shall be aligned with other investments in the lower (battery-areas) and mid-peninsula areas and could incorporate locally-preferred alternatives.

City of Charleston Stormwater Management Program: The newly-created Stormwater Management Department is led by a newly-appointed Stormwater Program Manager who will update the 1984 Master Drainage Plan. The Department is a one-stop shop for the City's stormwater management programs, projects, resources and capabilities.

Related Planning Efforts: The City's Planning Department is focused upon future flood risks but also housing, transportation, tourism, the changing economy across the City's neighborhoods. These and other issues are part of the ongoing Comprehensive Plan Update. The Planning Department noted that inspiration from the Netherlands is essential but that Charleston is 17-times less dense than the Netherlands with a tax-base that reflects a more suburban, less urban environment.

Lockwood Corridor and Medical District

Operations Vulnerability

Participants noted that access to health services, patient and personnel safety, and overall well-being are at risk. Many patients had trouble accessing the medical district, including Emergency Rooms, because of flooding. Current flooding will impact where patients seek future medical care, and recent announcements of providers “moving upland” confirm this.

Largest Employer

The District is the single largest area of concentrated employment in South Carolina. Thus, the District’s aggregate economy-- patients, families, medical facility personnel, suppliers and supporting businesses-- is at extreme risk. Many hope / expect that the Vulnerability Analysis will quantify this economic risk. The State is refining its shelter-in-place strategy and hospitals await new guidelines to understand operational impact, since emergency responders lack facilities in the District.

Ecological Vulnerability

Participants expressed concern about the former landfills surrounding and underneath the District and water quality (in WestEdge and at Laurel Island). Similar discussions on the water quality in Ashley River and Long Lake raised additional concern. Habitat loss, tree cover loss and their relation to tourism and human comfort brought forward greater considerations.

Energy Vulnerability

Significant concern exists about the redundancy and reliability of the District’s energy supply. The goal of a district energy strategy is to increase resilience.

Heat Vulnerability

In addition to the work on slowing, storing, redirecting, and adapting to water, complementary solutions would help. Many solutions for water also help to reduce urban heat.

Team collaborations to understand the work area

Aerial Photo of Medical District with Adjacent Waterways

Collaboration Intent

Participants expressed a desire to collaborate more deeply, combine (and increase) local funding and programs where possible, better leverage state (transportation) funding, and gain more control over key transportation arteries in (and near) the District.

Transportation Planning

Many hoped that SCDOT, in addition to its primary task of repaving and reducing congestion, would begin to explore how road improvements could be rethought to reduce flood risk mitigation / enhance resilience. Similarly, several expressed a desire to (re)engineer parking enhancements with stormwater storage and a desire to create more transit opportunities (bus and water taxis) to alleviate congestion and improve access.

Shared Parking

There was significant discussion about how shared parking across the three hospital systems might free-up space for greater stormwater storage. Incentives and citizen engagement to collect and store rainwater, “adopt a drain,” “rainproof” their neighborhoods, become an “evacuteer,” create and manage a nearby “living shoreline” are desired. Similarly, the nearby Charleston Public Housing Authority, the Citadel, West Edge, Riley Ballpark, local businesses and surrounding counties must be part of the collaborative effort.

Connectivity Improvements

Expanding the District’s limited connections to key centers – The Citadel, College of Charleston, Brittlebank Park, Westedge, Riley Field – offer new opportunities.

Communication Campaign

Participants identified the need for greater resilience awareness in the city including structured partnerships to enable others to understand their risks.

Investments and Policy

There is interest in perimeter protection along the Ashley River, which will be addressed by the USACE 3x3 study (and which would likely require additional pumping capacity). The area’s existing density and intense use may preclude large-scale use of green infrastructure.

Further Opportunities

Some wanted to explore storm water storage opportunities in / near Alberta Long Lake combined with enhanced recreation; others were encouraged by plans-in-development to elevate key pedestrian corridors between medical facilities and elevate key utilities at the same time. Still others referenced the Charleston Plan and the need to further coordinate with its directions. There is a desire to require a “resilience component” in any future permitted project to create and deepen a culture of resilience awareness and responsibility.

Newmarket and Vardell's Creeks

Complex and Compact

Two old creeks – one covered, one not-- define its physical boundaries and the area is low and flat. One-third of the adjacent Eastside neighborhood has public housing. "High-ground" in the area is close to the Cooper River (Morrison Drive and East Bay Street), along Huger Street and, on the west-side, abutting the Lowline. There is a considerable amount of mixed-use and market-rate housing development on the Zone's western edge (Meeting Street), some of which extends into the Cooper Bridge Redevelopment Zone. Cultural amenities in the zone include churches, schools, the community center, Martin's Park and green space amongst some of the public housing.

Wet, Flat and Vulnerable

There are four distinct, interrelated water challenges in the Cooper River Redevelopment District and in the nearby Eastside community: stormwater impacts, compromised drainage, high-water (tidal and surge) inundation, and the future sea-level rise impacts upon drainage and possible inundation. Understanding and managing these water risks must be primary for all (current and future) neighborhood development as well as the communication to residents and business of these risks. The drainage system is not well-understood and shallow groundwater levels are likely high.

Lee Street and Nearby

An obvious, if possibly overlooked, opportunity is to repurpose Lee Street and nearby surface parking lots for water storage as leases there are nearing deadline.

Green infrastructure (bioswales etc.) and an immediate opportunity to recreate the blue-green links that previously defined the area are important. Participants are curious if the Port's Columbus Terminal might play a role in perimeter protection, and others wondered whether any peninsula perimeter protection stemming from the USACE 3x3 study will require a pumping system. Many want to explore using the lower Newmarket Creek watershed (under I-26 and Ravenel Bridge) for additional neighborhood water storage and, possibly, a community amenity (park).

Redevelopment and Equity

Parts of the Cooper River Redevelopment District are hotbeds of (re)development that are influencing the neighborhood's identity. Participants believe that respecting and reinforcing the community's identity as (re) development occurs are important. There is uncertainty – within the neighborhood and without-- about the target of redevelopment, amenities the residents need and want, and neighborhood identities to safeguard. This begs for more community outreach, engagement by the City, and a community trust-building effort.

Transit and Connectivity

The Morrison / East Bay corridor and the Meeting Street corridor provide opportunities to reinforce transit nodes (bike, bus, future BRT) in / near the zone. Participants wondered whether a water taxi (linking to lower peninsula, or even to Lockwood Corridor or Mt. Pleasant) would be possible and if / how the future Lowline redevelopment can also create an east-west corridor linking to Hampton Park, Medical District and the Riley Ballpark.

Stewardship and Governance

There is a need to (re)create a water identity in the neighborhoods and provide outreach and resources to enable residents to help manage and have stewardship of stormwater (e.g., adopt a drain, rain barrels, rain gardens, infiltration space). Ownership and maintenance responsibilities of the streets is complex and shared by City and State authorities, which in turn confuses residents and makes street and stormwater management unnecessarily complex.

Top Left, Center and Right: Site tour view, team collaborations and open space and networks sketch made during the Colloquium

Above: Cooper River Bridge Redevelopment District, New Market and Vardell's Creek Floodplains and Sea Level Rise

Johns Island

Ecological Identity and Vulnerability

Johns Island is the 4th largest island on the US east coast. Its strengths are its aesthetic beauty, coastal ecology, mid-island elevation, its treescape, marshes and sandy soils, and the large tracts of undeveloped land that create a distinct, bucolic, languid sense of place. The strengths are vulnerable and diminishing. The island's large farms are also diminishing as is the land stewardship that farmers frequently practice. Development pressure and the Urban Growth Boundary have a tense relationship when it comes to flood risk, as newer development within the Boundary is occurring in low-lying areas.

Flood Vulnerability

The island is reliant upon historic and poorly-maintained overland drainage infrastructure, development-specific (not system- or-island-wide) drainage plans, insufficient or poorly-enforced stormwater regulations and management practices. The Island's explosive development, development-related stormwater impacts (e.g., raising homesites without understanding impacts on nearby communities and drainage system limits), traffic, storm evacuation challenges, and complex relationships between the City and developers adds to the existing flood risk. Sea-level rise and higher mean water levels in the Ashley, Stono and Wadmalaw Rivers and Bohicket Creek will further constrain overland drainage.

Cultural Vulnerabilities

The island's cultural assets – including the Gullah-Geechee community, slave descendants, and its Civil War, Civil Rights movement and native American histories – are rich and distinct. All are threatened by land development, recurrent tidal and stormwater flooding and sea-level rise. There is much to protect and much to lose.

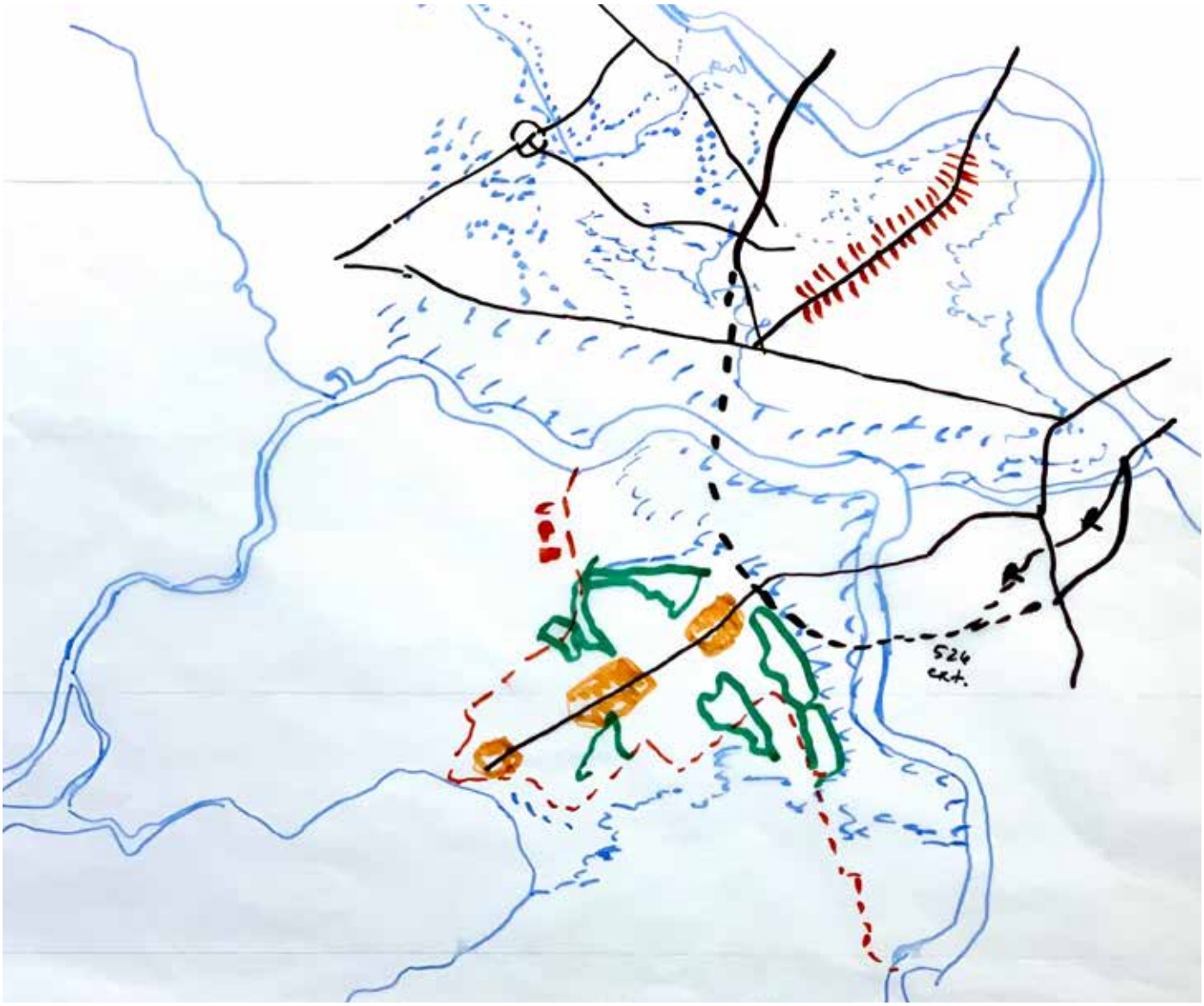
Transportation Planning

Almost every discussion about Johns Island is influenced by transportation and the I-526 extension. Concerns about the value versus the costs in a time of other financial needs tend to be the focus. Opinions pro-and-con are strongly held and expressed.

Green and Gray

Johns Island, "different from the rest of Charleston," is mostly a greenfield development – not a redevelopment-- challenge. There is space for innovation, new water management practices (green and gray), new housing and flood-proofing technologies and low-impact development pilots. Citizens ask: "How do we get this right?" Successful resilient development will occur only if and when it is grounded in the Island's current and future geology, geography and hydrology. Citizens wisely question whether to call "Johns Island affordable if people are buying homes with excessive flood risk?" They wonder whether successful development practices piloted in the Lowcountry could enable developers and leaders in Charleston to share their efforts with other communities facing similar threats. If done right, "resilience" is a brand to showcase Charleston.

Top Left and Right: Site tour of typical development and typical tree treatment



John's Island Site Studies

Church Creek

Church Creek Basin

Participants saw the Church Creek challenge as a retrofit to "understand the past to secure the future." Before human settlement, the area's dominant coastal forests and savannah woodlands lacked arterial water, channels and creeks, and served as a natural basin providing water storage. Higher water-levels in Ashley River, and the loss of Long Branch Creek / Church Creek system connectivity, have further challenged the area's natural storage / drainage functions. The construction of Bees Ferry Road has altered natural drainage patterns, with the Road acting as a dam in places. Housing development has further compromised the area's basin function.

Phosphate Mining

The coastal forests were cut to enable phosphate-mining, the remnants of which – artificial linear mounds and dug channels-- dominate undeveloped parts of the current basin. These mining impacts and more recent suburban development impacts that further deforested the area have substantially altered and diminished the area's hydrology, drainage and natural systems functioning. The drained soils are subject to compaction and subsidence.

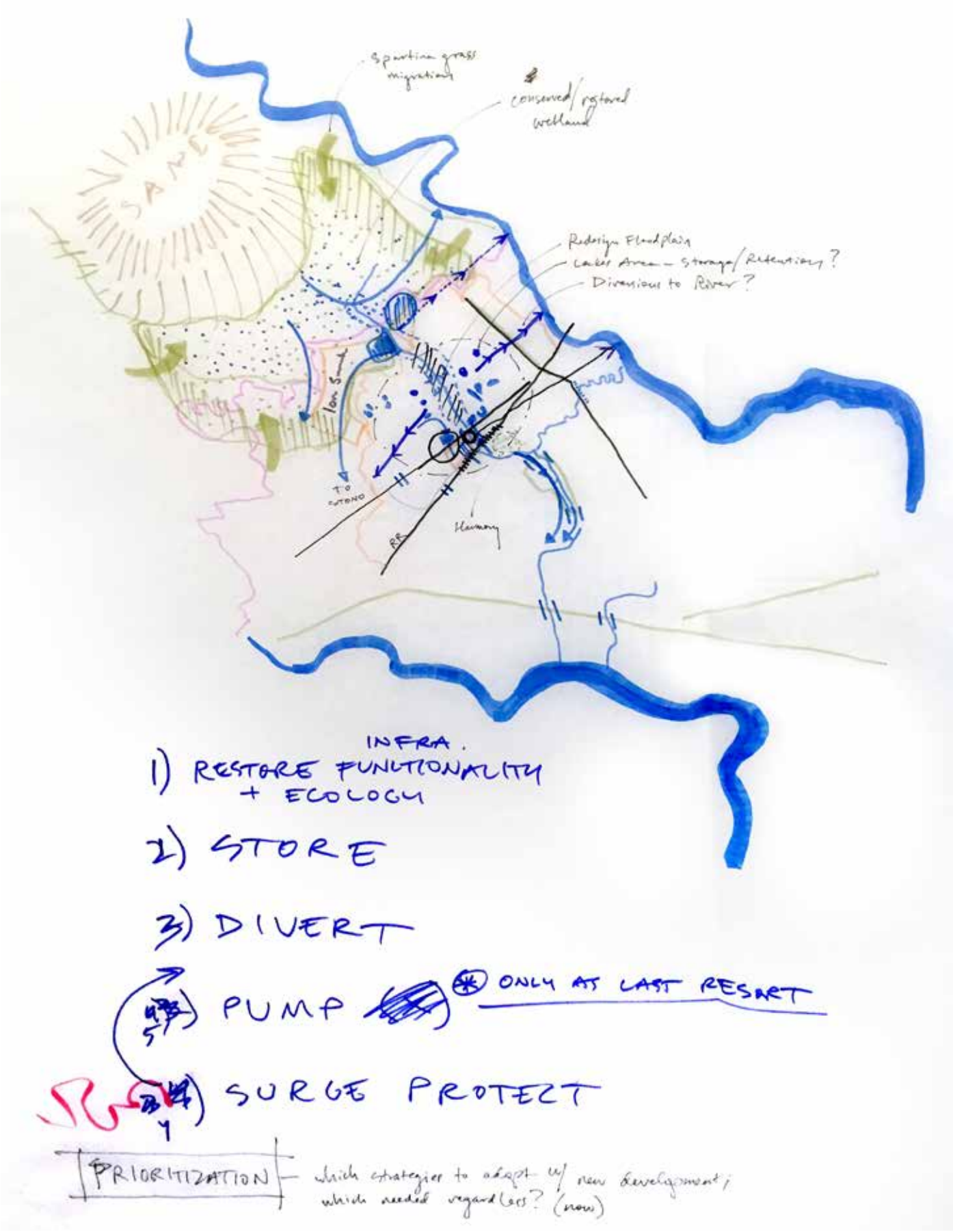
High, Dry and Connected

The participants adopted a "high-dry-and-connected" theme to guide infrastructure improvements and development in the West Ashley area. Planning and development must recognize the benefits and challenges of the human-water relationship while also considering climate and population projections in the Charleston area.

Ongoing Studies/Unrealized Opportunities

Church Creek is home to many studies that can inform new opportunities to secure the future. There is a complex land reclamation project (Harmony) through which the City is gaining land. NOAA / Sea Grant are studying whether and how to reconnect Long Branch Creek / Lake Dotterer to Church Creek (West Ashley Park). How these will impact the water system, water levels and stormwater drainage is unclear. There is a new drainage study, with proposed projects, that is informing current plans. There are a few developers interested in piloting new development and drainage practices, and offering land bank mitigation, to offset their investments. These developers should be encouraged to pilot innovative projects and applauded for their leadership.

Top Left and Right: Shawdowmoss and nearby neighborhood site photos



Church Creek Site Studies and Strategies

Collective Takeaways

1: Participants noted that there were few surprises.
"Many things we thought we knew and assumed turned out to be true." However, the subtleties of the solutions and their interconnectedness appear to be poorly understood. As the Dutch experts strongly encouraged, the City needs to understand these connections and their capacity to address what needs to be done.

2: Solutions exist but funding is needed.
Some are achievable and desired; all presume collective (federal, state, regional, county and local) action and multiple funding sources. Such collective action yields greater opportunities for stacked financing structures and potentially greater overall resilience. A wish without funding remains a wish.

3. There is a clear thirst for action.
Action must rest on an integrated, comprehensive and articulated plan that secures the greatest value for the investments made. While the City is ready for action, it lacks a long-term vision and plan for how to proceed. The number of current parallel studies and their findings, and the large, important and still disconnected drainage projects underway are representative of the challenge.

The outcomes of the USACE 3x3 study will set a datum for seawall expansion. NOAA's remapping of the Gulf Stream will possibly undermine the seawall assumptions. Compound growth in developing areas will exacerbate existing flooding and worsen water quality. Investments upstream in the watershed, across the three intersecting counties and the outcomes of the City's vulnerability assessment need to be aligned in a regional masterplan to guide an effective course of investment. Citizens and businesses in the meantime need short-term plans to address the risks faced as the new hurricane season opens.

4. The City and others must communicate better and share more info on Dutch Dialogues and other studies / actions.
The Community should be further engaged "on their terms and in their places." This includes enabling community members to be ready to respond in the short term as longer-term city-scale solutions are developed. It also serves as a solicitation for citizen involvement in solution-making.

5: South Carolina Department of Transportation (SC DoT) should be engaged more to partner in flood-risk efforts given their control of, and investments in, crucial infrastructure.
Overlapping jurisdictions and authorities can be either obstacles to action or opportunities for enhanced functioning and more robust adaptation.

Dutch Reflections

Charleston's resilience is a complex story that must be explained in a simple way.
Water is fundamental to Charleston's past and its future and it must be directly embraced and acknowledged. Build the story so citizens and businesses understand. Boldly raise community awareness of their risks and their opportunities.

Developers are not leading on resilience.
Whether fearful of leadership or of losing market share to lower-priced developments, the recently completed developments underscore how little effort is made toward a resilient future for Charleston. The City should quantify the financial and livelihood risks to homebuyers of such developments. The City should also adopt stronger building codes to mitigate the various risks that will be quantified in the ongoing Vulnerability Analysis. Until the marketplace demands more, the market response will be insufficient to the challenge.

Recognize that safety comes in various forms such as flood protection, spatial planning and warning systems.
Solutions to flooding fall into four categories: (1) Improve the drainage/protection system, (2) Change the land level by excavating and filling, (3) Adapt homes and buildings to address new water levels and/or (4) Adapt the preparedness level of people. There is no silver bullet: Charleston requires combinations of all four categories.

Understand the difference between engineering solutions for current problems and designing for the future given the information available now.
Engineering solutions address current quantifiable challenges. Designing for the future enables Charleston to project toward 2100 and beyond, with a long-term future imaginable as a new way of living with water.

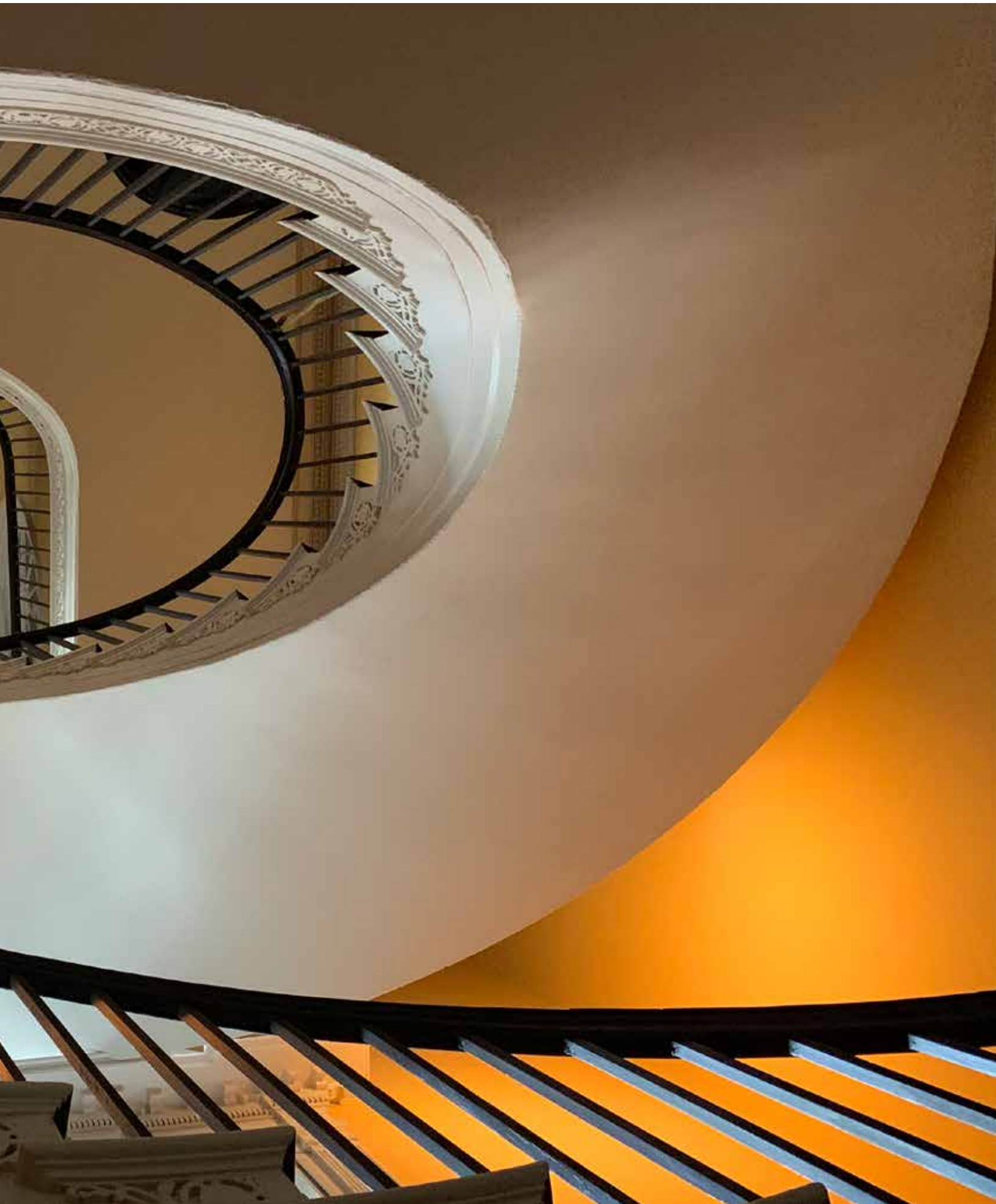
Public Presentation

The Colloquium concluded with a public briefing at the nearby Cigar Factory. Comments by Mayor John Tecklenburg, Winslow Hastie, Dale Morris, Janice Barnes, David Waggonner, Jan Peelen and Taylor Schenker offered perspectives gleaned during the previous workdays and a glimpse into the efforts required in the Design Workshop.

Presentation at the Cigar Factory


WHW
DUTCH
DIALOGUES

Nathaniel Russell House



White Point Gardens


Under the direction of
Maj. Wm H. ECHOLS, C. S. Engrs Corps.
BY
Wm A. WALLER, Draughtsman, C. S. Engrs Corps
Drawn by
John B. Key, 2d Lieut. C. S. Engrs
CHARLESTON, S. C.,
NOV. 28th 1863.
Scale
S A N D R
Approved