



Becoming Resilient in Virginia Beach

September 6, 2024

C.J. Bodnar, PE, and Kristina Searles, PE
Stormwater Engineering Center
City of Virginia Beach Public Works



A Call to Action

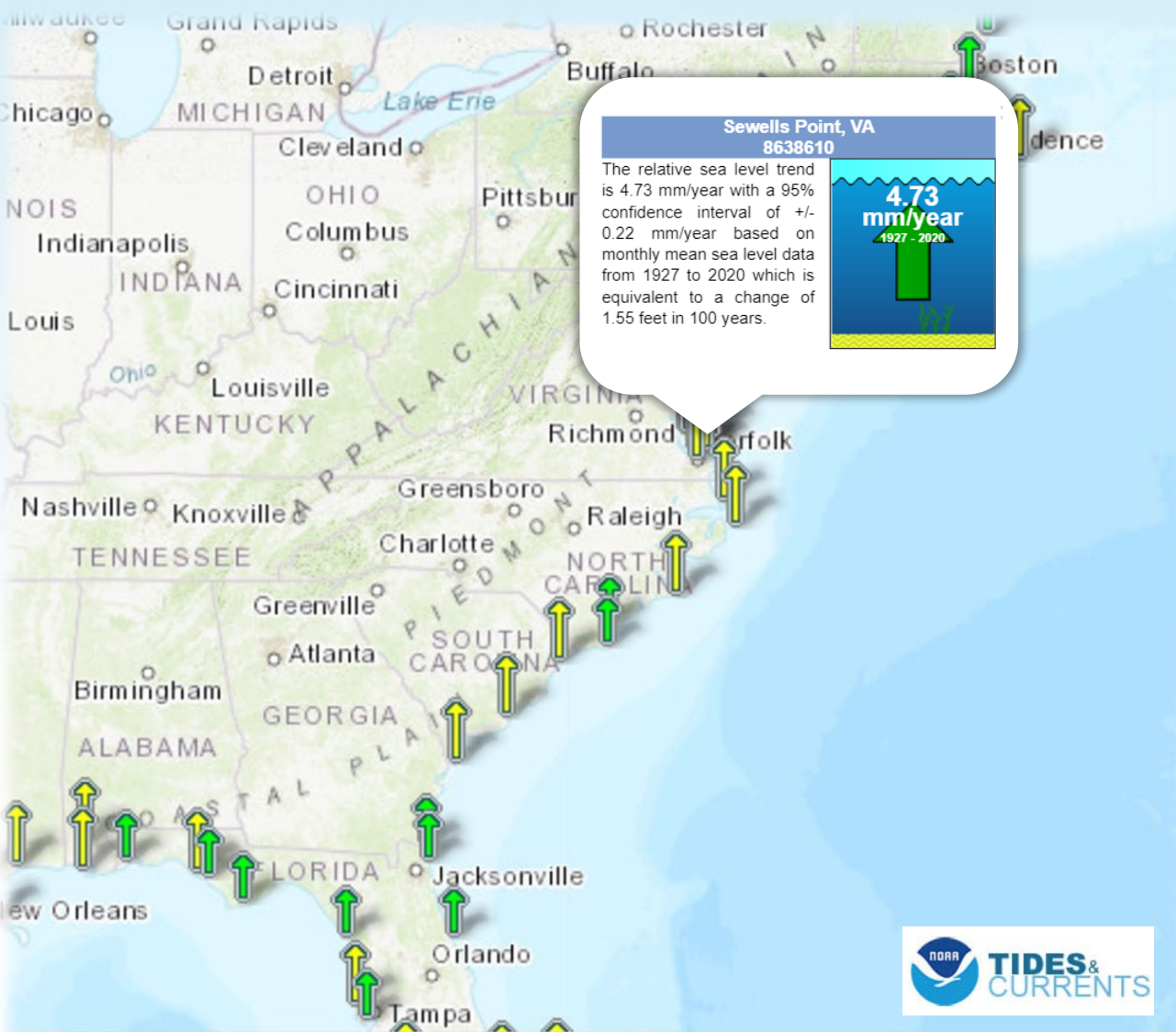


Moody's Questionnaire to VB

- Does the existing/future CIP include spending for mitigation or resiliency?
- Has your governing body discussed the capital or financial implications of rising sea levels?
- Has there been an estimate on potential impacts from rising sea levels or flooding?
- Please discuss how flooding has impacted the city's budget and may impact future budgets?
- Have there been any zoning /long-term planning adjustments downtown and along the waterfront to mitigate future flooding impacts?
- What is management's current view on the potential impact/vulnerabilities in your community from rising sea levels and a heightened risk of extreme weather events?



Relative Rate of Sea Level Rise



Sewells Point, VA
8638610

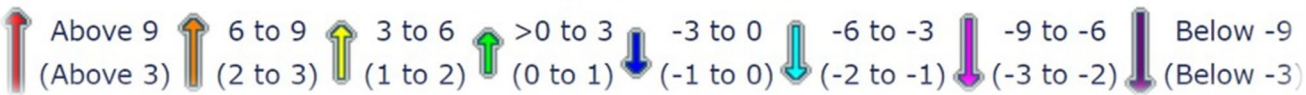
The relative sea level trend is 4.73 mm/year with a 95% confidence interval of +/- 0.22 mm/year based on monthly mean sea level data from 1927 to 2020 which is equivalent to a change of 1.55 feet in 100 years.

4.73 mm/year
1927 - 2020



Relative Sea Level Trends

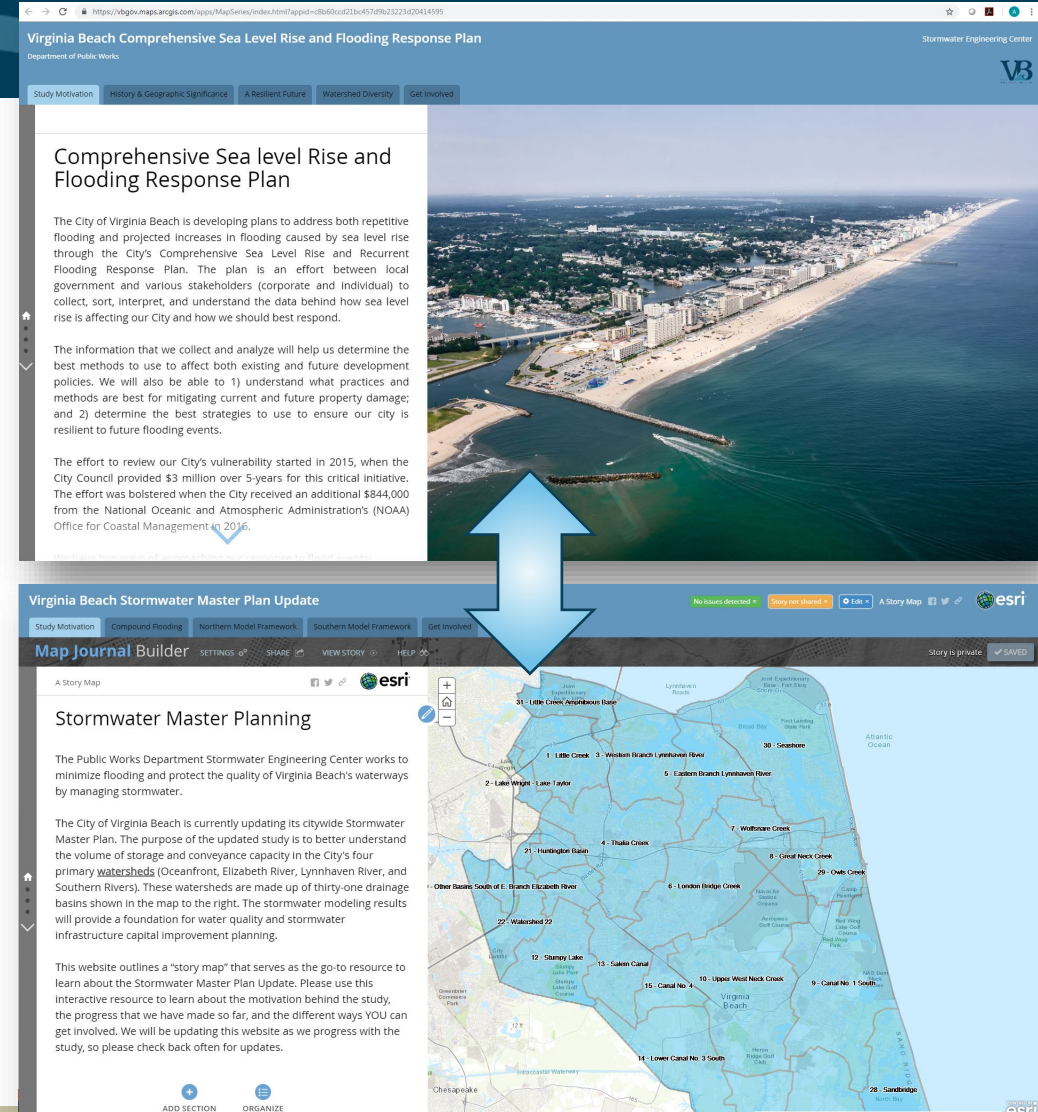
mm/yr (feet/century)



Water Level Recording Station	Record length (years)	Sea Level Rise (feet/century)	Rank
Eugene Island, LA	35	3.2	1
Grand Isle, LA	69	3.0	2
Galveston Pleasure Pier, TX	54	2.2	3
Galveston Pier 21, TX	112	2.1	4
Chesapeake Bay Bridge Tunnel, VA	41	2.0	5
Sabine Pass, TX	58	1.9	6
Ocean City Inlet, MD	41	1.8	7
Rockport, TX	79	1.8	8
Wachapreague, VA	38	1.8	9
Lewisetta, VA	46	1.7	10
New Canal, LA	34	1.7	11
Colonial Beach, VA	38	1.6	12
North Spit, CA	39	1.5	13
Sewells Point, VA	89	1.5	14
Cape May, NJ	51	1.5	15
Duck, NC	38	1.5	16
Apra Harbor, Guam	23	1.5	17
Freeport, TX	36	1.5	18
Bay Waveland, MS	38	1.4	19
Corpus Christi, TX	33	1.4	20

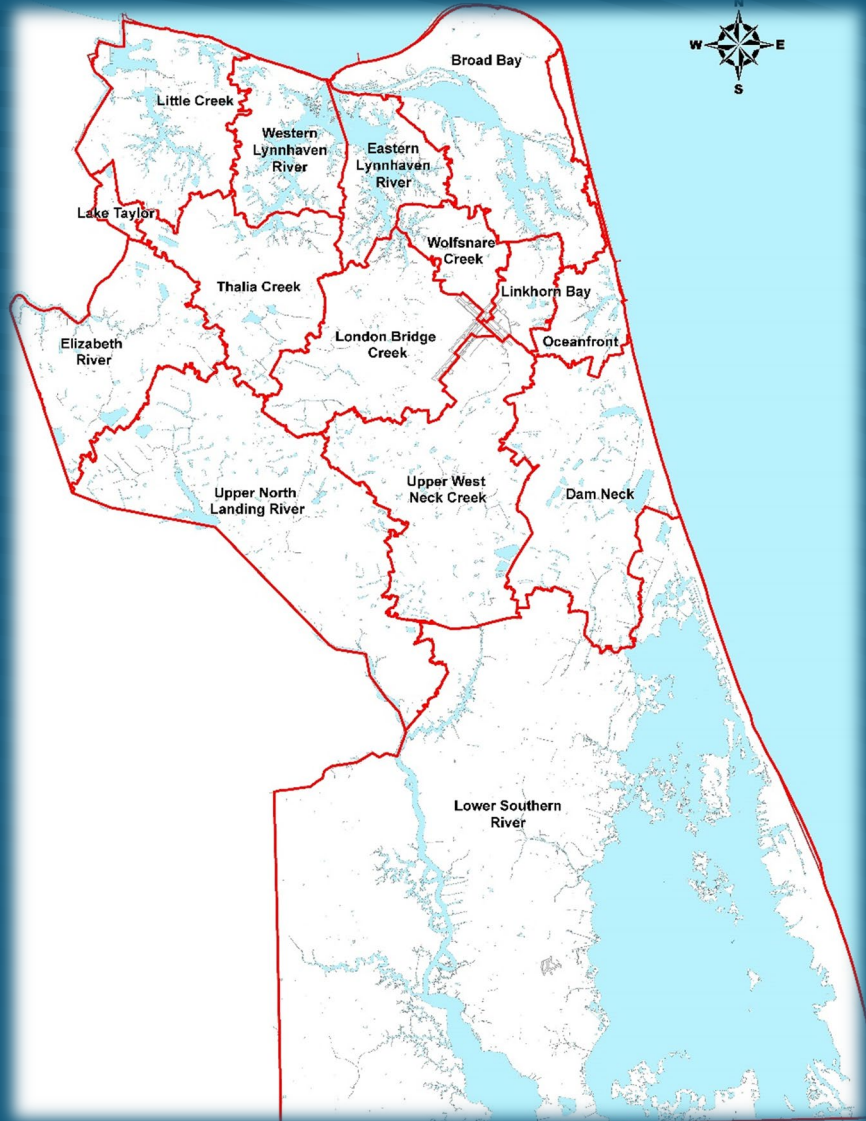
Studies

- Comprehensive Sea Level Rise and Recurrent Flooding Study
 - Assessing existing and future flood vulnerabilities and identifying strategies to ensure our City is resilient to future flooding events
- Master Drainage Study and Stormwater Master Plan
 - Detailed inventory and performance assessment of the City's stormwater system
 - Identification and prioritization of needed improvements to stormwater system



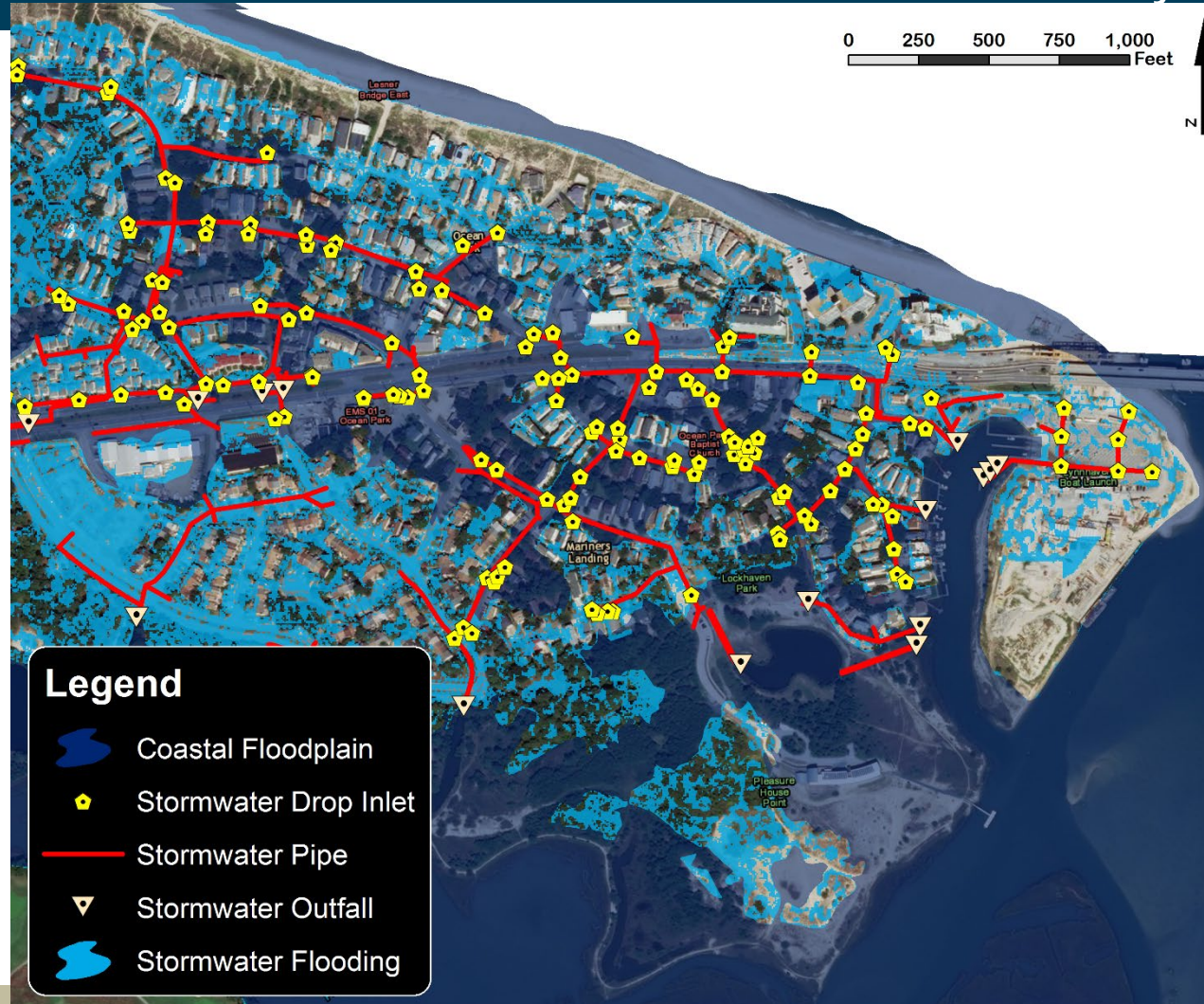
The top screenshot shows the "Virginia Beach Comprehensive Sea Level Rise and Flooding Response Plan" website. It features a navigation bar with tabs: "Study Motivation", "History & Geographic Significance", "A Resilient Future", "Watershed Diversity", and "Get Involved". The main content area includes a title "Comprehensive Sea level Rise and Flooding Response Plan" and several paragraphs of text. To the right is an aerial photograph of Virginia Beach. The bottom screenshot shows the "Virginia Beach Stormwater Master Plan Update" website. It has a navigation bar with tabs: "Study Motivation", "Compound Flooding", "Northern Model Framework", "Southern Model Framework", and "Get Involved". The main content area includes a title "Stormwater Master Planning" and a map of Virginia Beach with various watersheds labeled (e.g., 1 - Little Creek, 2 - Lake Wiggins, 3 - Western Branch Lynnhaven River, etc.). A blue double-headed arrow points from the aerial photo in the top screenshot to the map in the bottom screenshot.

Basin Boundaries and Master Model



Combined Impact on Stormwater Analysis

- Higher coastal water levels diminish stormwater system performance



- Coastal Flooding
- Stormwater Conveyance
- Combined Flooding

Opening Our Eyes – 2016

- September 1 – Tropical Storm Hermine
 - 3-day event
 - 7.15 inches of rain recorded
 - 10-year Storm Event
- September 19 – Tropical Storm Julia
 - 3-day event
 - 15.3 inches of rain recorded
 - Greater than 200-yr Storm Event
- October 8 – Hurricane Matthew
 - 20-hour event
 - 14.1 inches of rain recorded
 - 1000-year Storm Event




As sea levels climb, storms that once might have been an afterthought can have an impact

By DAVE MAYFIELD
THE VIRGINIAN-PILOT | OCT 06, 2017 AT 10:00 AM

Politics & Policy

Climate Change Becomes an Issue for Ratings Agencies

The risk of a ratings downgrade can pressure cities and companies to take steps to mitigate climate risks, such as from sea level rise.

By Kristoffer Tighe 
August 5, 2019

Forgotten Virginia Beach neighborhood cries out for flood relief

By ALISSA SKELTON
THE VIRGINIAN-PILOT | MAY 08, 2017 AT 9:00 AM

Hurricane Matthew showed Virginia Beach what happens when it takes decades for drainage upgrades

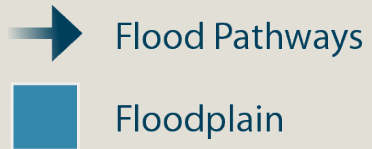
By MECHELLE HANKERSON
THE VIRGINIAN-PILOT | OCT 05, 2017 AT 1:30 PM



Becoming Sea Level Wise

An aerial photograph of a coastal residential development. The image shows a large, winding waterway or canal system that winds through a dense residential area. The houses are mostly single-story or two-story structures with light-colored roofs. In the upper left, there is a large, multi-story apartment complex. The waterway is surrounded by green lawns and trees. The overall scene is a mix of urban development and natural water features.

Coastal Flood Pathways



Little Creek Inlet:

The Little Creek Inlet provides a flood pathway from the Chesapeake Bay into the west side of Virginia Beach.

Elizabeth River Eastern Branch:

The eastern branch of the Elizabeth River is a 9-mile long tidal estuary that provides a flood pathway through Norfolk and Chesapeake into Virginia Beach.

Elizabeth River Southern Branch:

The southern branch of the Elizabeth River connects to the Albemarle and Chesapeake Canal, creating a connection between the Chesapeake Bay and the Currituck Sound through the North Landing River in southern Virginia Beach.

North Landing River:

Storms or sustained winds from the south push water into the City from North Carolina's Currituck Sound.

Back Bay:

Storms or sustained winds from the south push water from the Currituck Sound through the Knotts Island channel, or across the causeway and marshes during severe conditions.

Lynnhaven Inlet:

The Chesapeake Bay enters through the Lynnhaven Inlet and then disperses internally to numerous surrounding bays and tidal rivers – including Lynnhaven River, Lynnhaven Bay, Broad Bay, and Linkhorn Bay.

Rudee Inlet:

The Atlantic Ocean enters Virginia Beach through the Inlet.

West Neck Creek:

Water from the North Landing River feeds into West Neck Creek, which connects with a tributary of the Eastern Branch of the Lynnhaven River, thus providing a flood pathway to central Virginia Beach.

Technical Reports

Water Resources in the Southern Watershed of Virginia Beach

VB Sea Level Wise
A commitment to the future for Virginia Beach

Dewberry

Joint Occurrence and Probabilities of Tides and Rainfall

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Orders 2 and 5A
Final Report

Dewberry

Analysis of Historical and Future Heavy Precipitation

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 8A
Final Report
Date: March 26, 2018
Submitted to: City of Virginia Beach
Department of Public Works

Dewberry

Demographic and Population Vulnerability Analysis

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 12B
October 13, 2018

Dewberry

Hazus Economic Flood Risk Analysis

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Orders 6 and 13B
Draft Report
Date: February 25, 2020
Submitted to: City of Virginia Beach
Department of Public Works

Dewberry

Analysis of Marsh Response to Sea Level Rise

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 3B
Date: March 21, 2018
Final Report submitted to City of Virginia Beach
Department of Public Works

Virginia Beach Sea Level Rise Policy Adaptation Report

VB Sea Level Wise
A commitment to the future for Virginia Beach

Dewberry

Nature-Based Coastal Flood Mitigation Strategies

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 6C
Final Report
Date: May 16, 2019
Submitted to: City of Virginia Beach
Department of Public Works

Dewberry

Individual Building and Site-Level Flood Risk Reduction Strategies

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Orders 4A and 17B
Final Draft Report
Date: May 1, 2019
Submitted to: City of Virginia Beach
Department of Public Works

Dewberry

City-wide Structural Flood Protection Alternatives for Coastal Flood Protection

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 17B
Final Report
Date: March 5, 2020
Submitted to: City of Virginia Beach

Dewberry

Neighborhood-Scale Structural Strategies for Coastal Flood Risk Reduction

City of Virginia Beach, Virginia
CIP 7-030, PWCN-15-0014, Work Order 17B
Final Report
Date: March 25, 2020
Submitted to: City of Virginia Beach

Adapting to the future



Partnering for Broader Outcomes



Multiple Layers of Adaptation



• Natural Mitigations

- Land Conservation
- Beach and Dune Nourishment
- Marsh Restoration
- Living Shorelines
- Maritime Forests
- Aquatic Vegetation
- Shellfish Reefs
- Seagrass Restoration

• Engineered Defenses

- Earthen Levee
- Floodwall
- Seawall
- Gates

• Adapted Structures

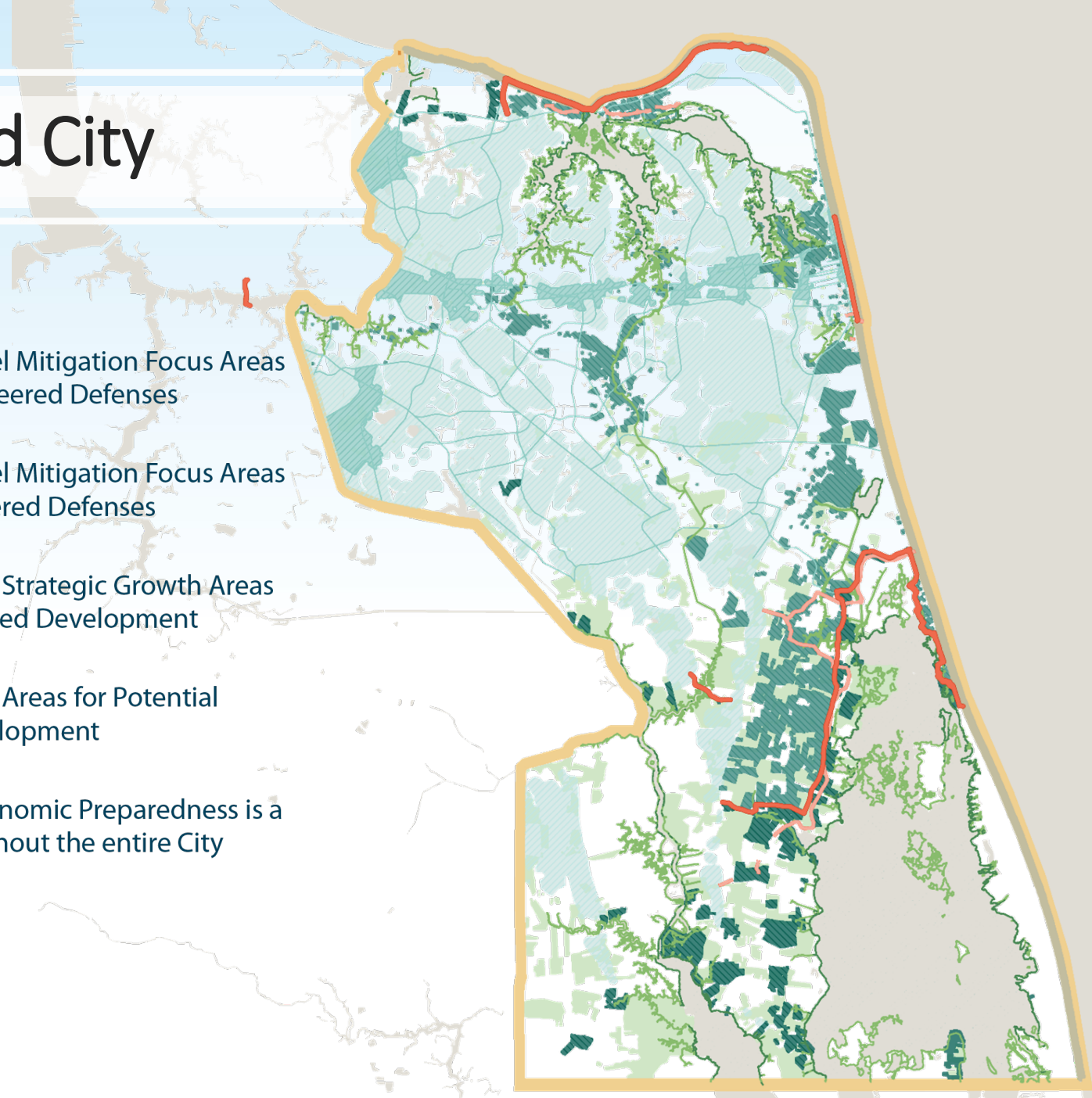
- Wet/Dry Flood Proofing
- Structure Elevation
- Mitigation-Reconstruction
- Voluntary Acquisition
- Floodplain Regulation
- Responsible Development

• Prepared Communities

- Educational Workshops
- Business Outreach
- Community Partnerships
- Military Coordination
- Flood Insurance Expansion

Envisioning an Adapted City

- Living Shoreline and Enhanced Revetment Areas
- Marsh Restoration Areas
- Land Conservation Focus Areas
- Beach and Dune Renourishment Areas
- Potential Large-scale Engineered Defenses
- Potential Neighborhood-scale Engineered Defenses
- Structure-Level Mitigation Focus Areas Outside Engineered Defenses
- Structure-Level Mitigation Focus Areas Inside Engineered Defenses
- 'High and Dry' Strategic Growth Areas for Concentrated Development
- 'High and Dry' Areas for Potential Adapted Development
- Social and Economic Preparedness is a theme throughout the entire City



Watershed Approach

Each watershed has distinct flooding challenges and opportunities





Applying the Adaptation Framework Elizabeth River



Lynnhaven

Oceanfront

Southern Rivers

Integrating Policy and Planning



What

Each layer aims to achieve concrete outcomes that improve Virginia Beach's overall flood resilience.

- Natural Mitigations
- Engineered Defenses
- Adapted Structures
- Prepared Communities

How

In order to achieve those outcomes, the City must integrate policy and planning tools:

- Comprehensive and strategic planning
- Budgeting and financing
- Community outreach
- Building codes and standards
- Partnerships
- Research and analysis
- Land use planning and zoning
- Incentives and support programs
- Program and project management



CITY OF VIRGINIA BEACH, VIRGINIA
DEPARTMENT OF PUBLIC WORKS
ENGINEERING GROUP

DESIGN STANDARDS

MANUAL

JUNE 2020



Resilient Design

- Virginia Beach City Council Unanimously Voted to Adopt more stringent Stormwater Design Standards
- Designs required to account for Sea Level Rise
 - Non-Critical Infrastructure: 1.5 ft.
 - Critical Infrastructure: 3 ft.
- Designs required to increase rainfall depths by 20% over current NOAA Atlas 14 Rainfall depths (inches)

“Adopting higher standards will be more expensive, but keeping the same standards will increase risk. Either way, there is a cost.”

- Hampton Roads Regional Planning District



Adoption of Plan

“We’ll try to make sure it’s not just a document we adopt and don’t pay attention to. It’s really critical for our future.” – Councilwoman Barbara Henley

“Future flooding events will have wide-ranging impacts on our infrastructure, economy, and overall well-being – we must be proactive now” – Councilwoman Jessica Abbott.

The Virginian-Pilot

Virginia Beach approves sea level rise plan, will require developers to take more flooding into account

By PETER COUTU
THE VIRGINIAN-PILOT | JUN 17, 2020 AT 1:00 PM



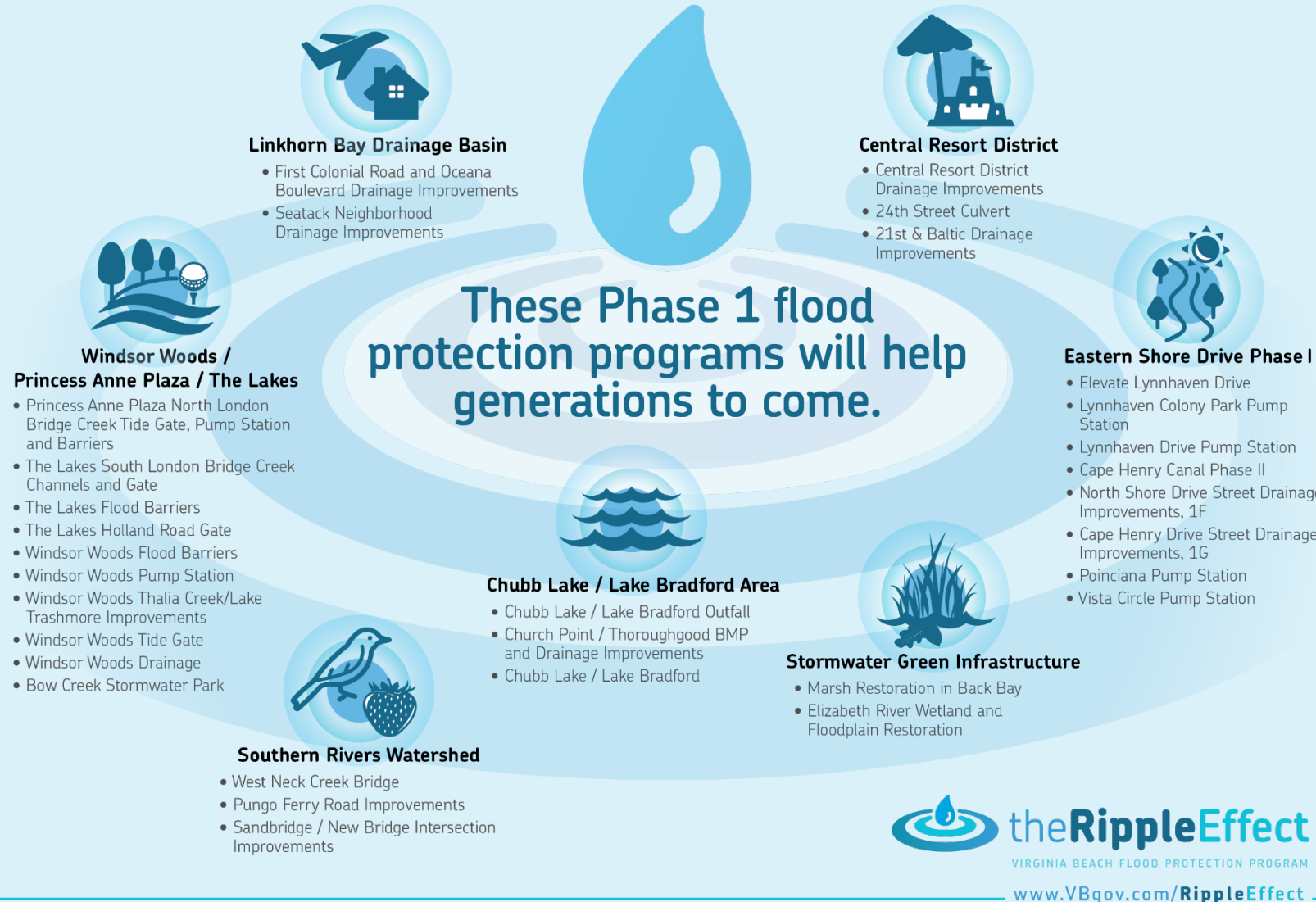
Path Forward



Flood Protection Program



How the **RippleEffect** affects you.



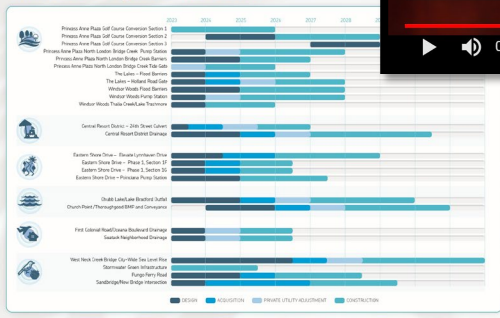
Bond Referendum

During the General Election on November 2, 2021, City of Virginia Beach residents voted to authorize **\$567.5M** in debt to fund the design and construction of Phase 1 projects in the **Citywide Flood Protection Program.**

Education



Phase 1 Projects Timeline



Frequently Asked Questions

How long will it take to complete the flood protection projects?
The timeline for completion of all of the Phase 1 projects ends in 2032, although, about half of the Phase 1 projects will be completed within the next 6 - 7 years (FY27).

How much will the Flood Protection Program cost?
The total cost for all Phase 1 projects included in the Flood Protection Program is \$567,492,850.

How much will my real estate taxes increase to fund the Flood Protection Program?
Depending on the term of the bonds issued (10-year repayment vs. 20-year repayment), the real estate tax dedication needed would be between 4.3 and 6.4 cents per \$100 of valuation.

Rather than increase our taxes, can the City re-prioritize the money we already have to pay for flood protection efforts?
The amount of funding we currently receive for stormwater projects is inadequate to deliver the needed projects in a timely manner. The additional funding received from the bond referendum will allow us to accelerate projects currently underway and begin several new projects. Without this funding, projects will be delayed and more flooding events must be endured without adequate protection.

For more information and FAQs, visit www.VBgov.com/RippleEffect



VBTV RECORDS VB411 In The Know - Flood Protection Program Bond Referendum

Watch later Share

How the **RippleEffect** affects you.

These Phase 1 flood protection programs will help generations to come.

Linkhorn Bay Drainage Basin
Windsor Woods / Princess Anne Plaza / The Lakes
Central Beach District
Eastern Shore Drive Phase I
Southern Watershed
Chubb Lake / Lake Swarthout Area

VBTV RECORDS Flood Protection Program Costs

Watch later Share

VIRGINIA BEACH FLOOD PROTECTION PROGRAM

Approximate Cost Per Property Owner:

\$10 - \$14 per month

ASSESSMENT VALUE OF \$267,600

VBTV RECORDS Flood Protection Program Phase 1 Projects

Watch later Share

How the **RippleEffect** affects you.

These Phase 1 flood protection programs will help generations to come.

Linkhorn Bay Drainage Basin
Windsor Woods Princess Anne Plaza The Lakes
Southern Watershed

MORE VIDEOS

0:31 / 2:40

VBTV RECORDS Flood Protection Program Overview

Watch later Share

FLOODING AFFECTS EVERYONE CITYWIDE.

VIRGINIA BEACH FLOOD PROTECTION PROGRAM

theRippleEffect

MORE VIDEOS

0:06 / 1:19

YouTube

Virginia Beach OKs \$568 Million Bond to Fend off Rising Seas

NATION & WORLD | Posted October 29 | Updated October 29

Virginia Beach voters consider extraordinary spending to counter the rising ocean

The need for money to protect communities against climate change is growing across the globe, and the city could prove to be a testing ground.

BY BEN FINLEY ASSOCIATED PRESS

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VIRGINIA MERCURY

2021 CRIMINAL JUSTICE + POLICING ENERGY + ENVIRONMENT

ELECTION 2021 **ENERGY + ENVIRONMENT**

THE BULLETIN

☰ Huron Daily Tribune

NEWS

Virginia Beach confronts inescapable costs of rising seas

BEN FINLEY, Associated Press
Updated: Oct. 29, 2021 8:51 p.m.

13 NEWSNOW

VIRGINIA BEACH

'It's worth it' | Flood mitigation referendum passes in Virginia Beach

Virginia Beach voters approve \$567 million bond referendum to deal with flooding

BY: SARAH VOGELSONG - NOVEMBER 2, 2021 8:27 PM



Flood Protection Program Funding

**FY 2022–2023
Capital Improvement Program (CIP)**

Adopted on July 1, 2022

\$757.1M

**6-year total
appropriated funding**

Includes \$567.5M from
Stormwater Bond Referendum

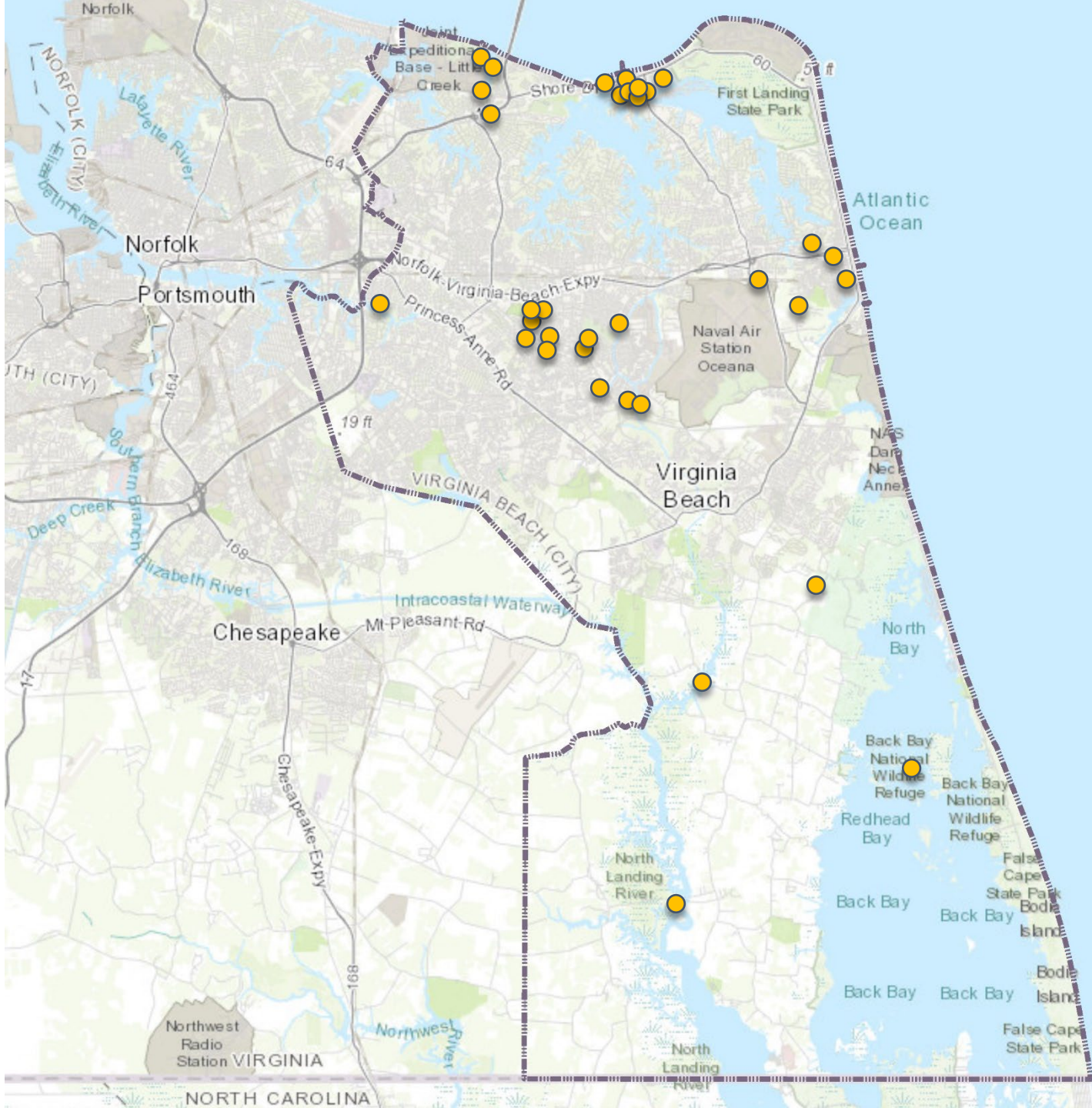
41 total projects and programs

**7 master projects containing
30 of the 41 total projects:**

- Eastern Shore Drive Phase I
- Windsor Woods, Princess Anne Plaza & The Lakes
- Central Resort District
- Stormwater Green Infrastructure
- Lake Bradford/Chubb Lake
- Linkhorn Bay Drainage Basin
- Southern Rivers Watershed

**11 stand-alone projects
and programs**





Flood Protection Program

- Project Locations

Flood Protection Program (FPP) Awarded Grants



	Project	Grant	Amount Awarded
1	Eastern Shore Drive Drainage Improvements	BRIC	25,144,014
2	Elizabeth River Wetland and Floodplain Restoration	CFPF	3,000,000
3	Seatack Neighborhood Drainage Improvements	CFPF	1,925,000
4	First Colonial Road and Oceana Boulevard Stormwater Improvements	CFPF	2,021,662
5	Back Bay Marsh Restoration Construction*	CFPF	5,000,000
6	Back Bay Marsh Restoration Design	NFWF NCRF	135,124
7	Back Bay Marsh Restoration Construction	NFWF NCRF	9,886,400
8	Pungo Ferry Road Improvements**	PROTECT	19,012,917
		Total	66,125,117

*Awarded March 2024, will be appropriated with FY25 CIP

**Awarded April 2024, not yet appropriated

Funding Types:

BRIC = Building Resilient Infrastructure and Communities (FEMA)

CFPF = VA Community Flood Protection Fund (VA DCR)

NFWF NCRF = National Fish & Wildlife Foundation National Coastal Resilience Fund

PROTECT = Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (US DOT)

USACE Regional Coastal Storm Risk Management Study



USACE and City of Virginia Beach sign Feasibility Cost Share Agreement

U.S. ARMY CORPS OF ENGINEERS NORFOLK DISTRICT

Published July 26, 2022



[PRINT](#) | [E-MAIL](#)

NORFOLK, Va. - The U.S. Army Corps of Engineers, Norfolk District, and the City of Virginia Beach signed a Feasibility Cost Share Agreement during an event July 21 to launch the Virginia Beach and Vicinity Coastal Storm Risk Management Study.

Col. Brian Hallberg, Norfolk District commander, and Patrick Duhaney, Virginia Beach City Manager, signed the agreement which outlines the cost-sharing structure of the three-year, \$3 million study authorized by America's Water Infrastructure Act of 2018.

"Ultimately, the study data will help determine additional steps we can take to mitigate the impact of storm-related coastal flooding," said Virginia Beach City Manager Patrick Duhaney. "Understanding where to best utilize limited resources is the first step in working with the Army Corps of Engineers to safeguard our homes, businesses and public infrastructure."

USACE received \$1.5 million federal funding for the study through the Infrastructure Investment and Jobs Act.

The Virginia Beach and Vicinity Coastal Storm Risk Management Study is a comprehensive investigation of flood-risk management problems and solutions in the city. The study will consider past, current, and future flood-risk management and resilience-planning initiatives and projects underway at USACE and other federal, state and local agencies.

"I'm very excited that we've completed this important first step," said Hallberg. "We have a tremendous working relationship with the city, and I know the District team is eager to get this study moving forward."

US Army Corps of Engineers Coastal Storm Risk Management Study

- March 2022 – Authorization Received
- July 2022 – Agreement Signed
- August 2022 – Scoping Meeting
- June 2023 – Study Scope Revisions by CG USACOE
- Alternatives Analysis Underway



Continued Commitment

Reducing flood risks and planning for a vibrant future is an ongoing, iterative process, requiring sustained actions from the City, its partners and residents.



Marsh Restoration in Back Bay



Supporting Stakeholders



The Nature Conservancy



Back Bay



Restoration Foundation
IT'S WORTH SAVING



COMMONWEALTH of VIRGINIA
Office of the Governor



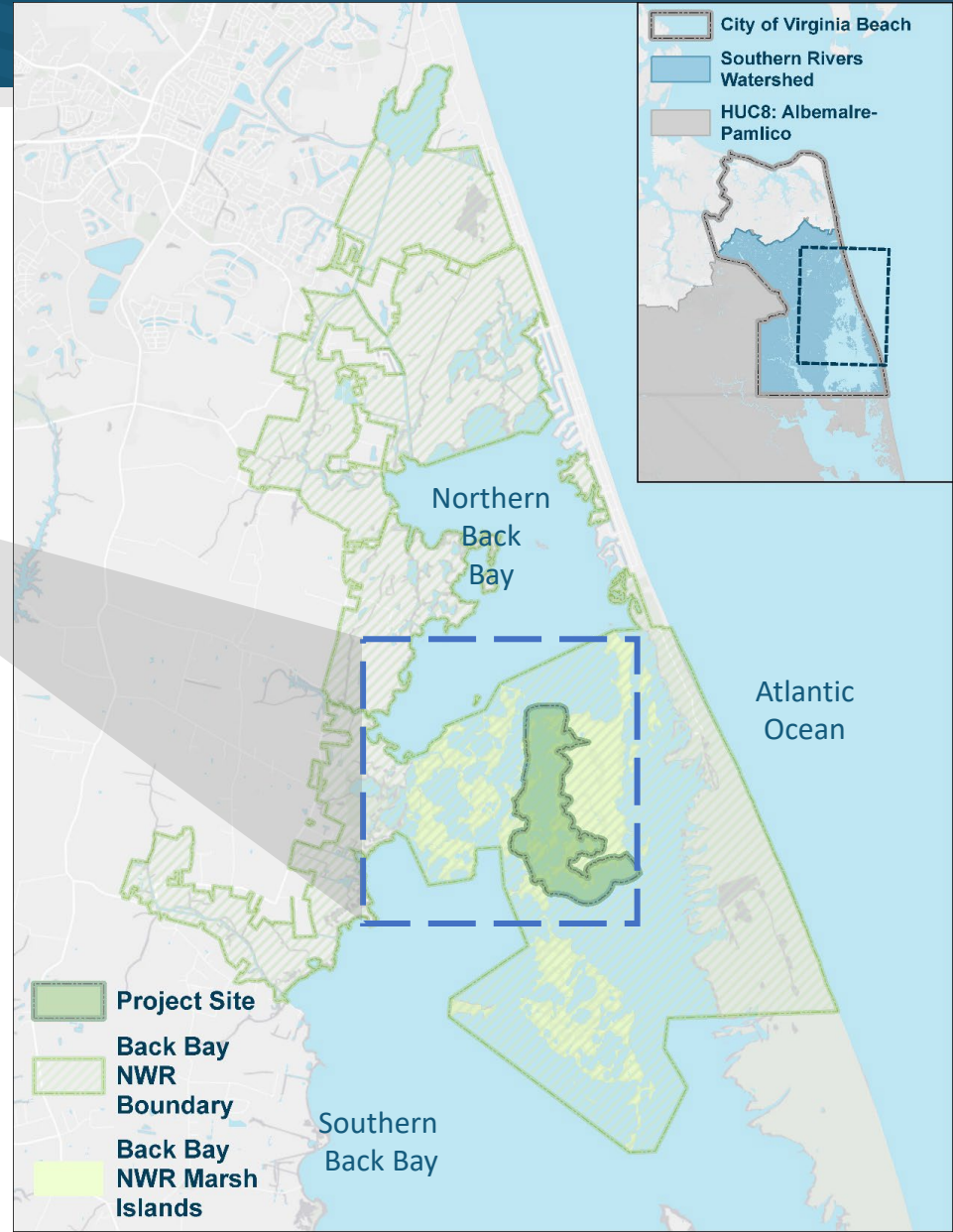
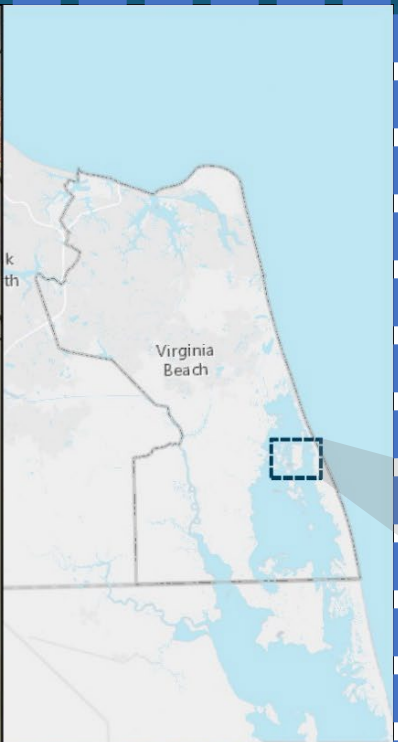
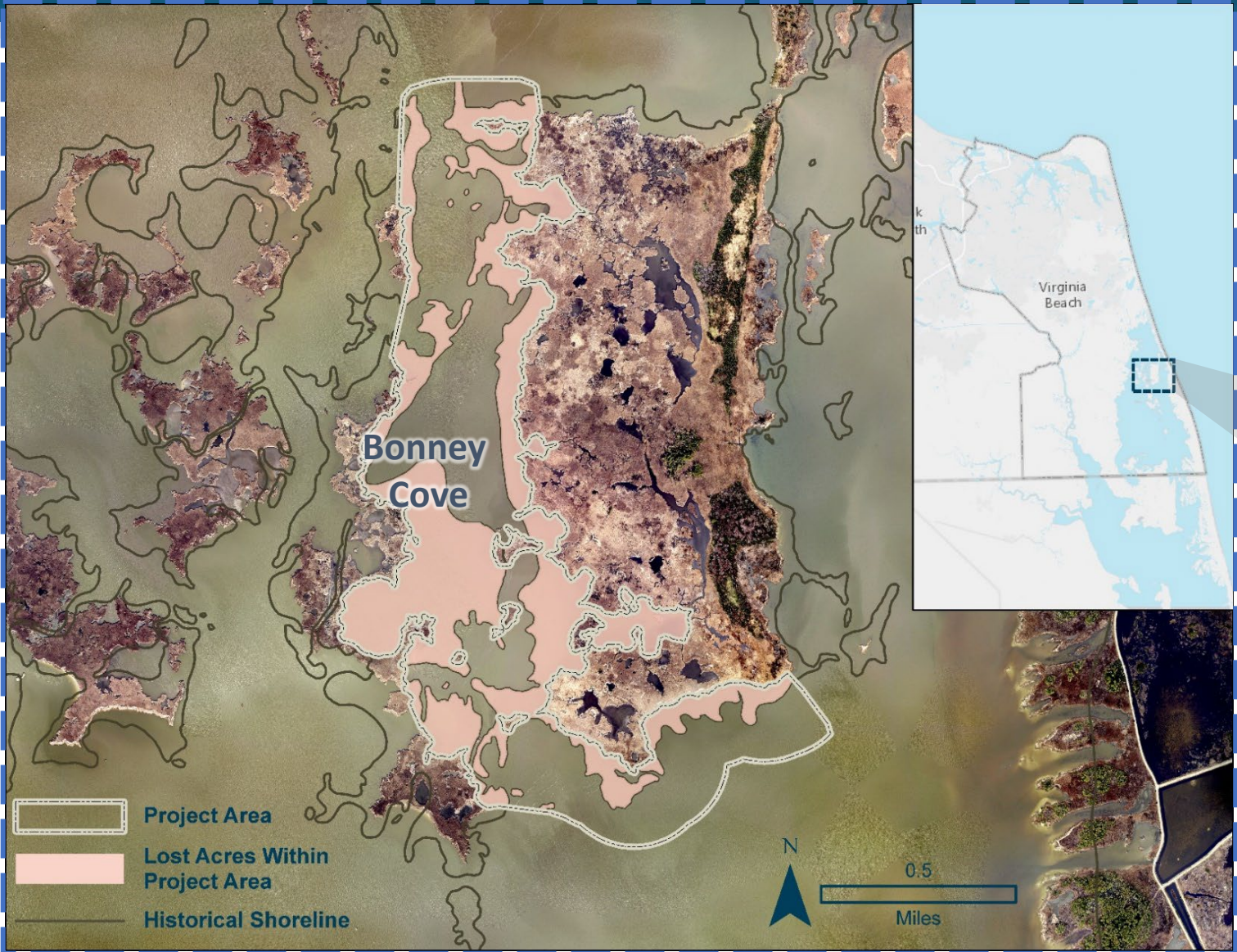
NFWF



Albemarle-Pamlico
National Estuary Partnership



Project Site – Bonney Cove



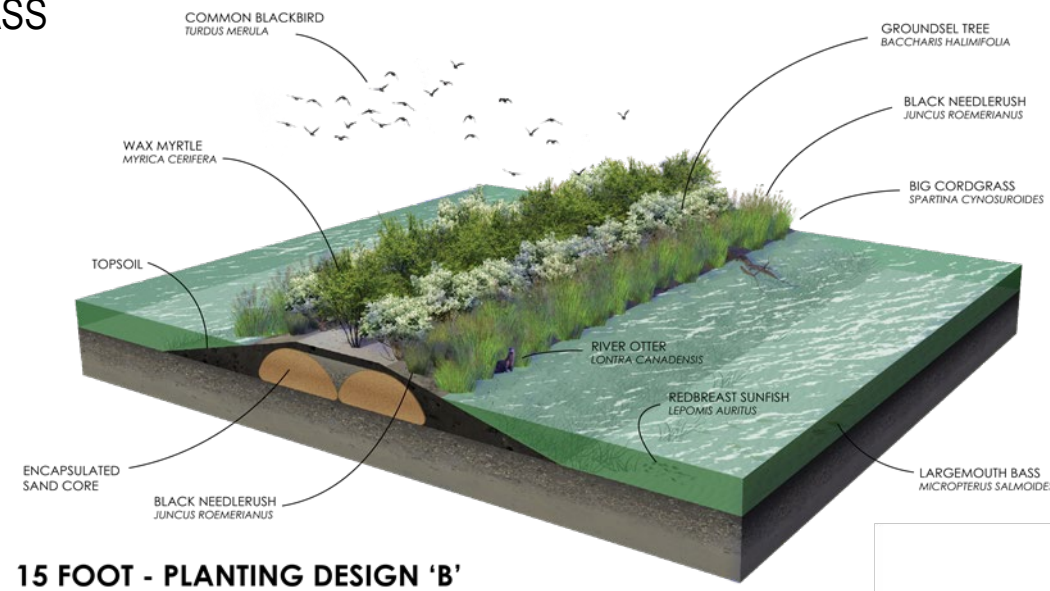
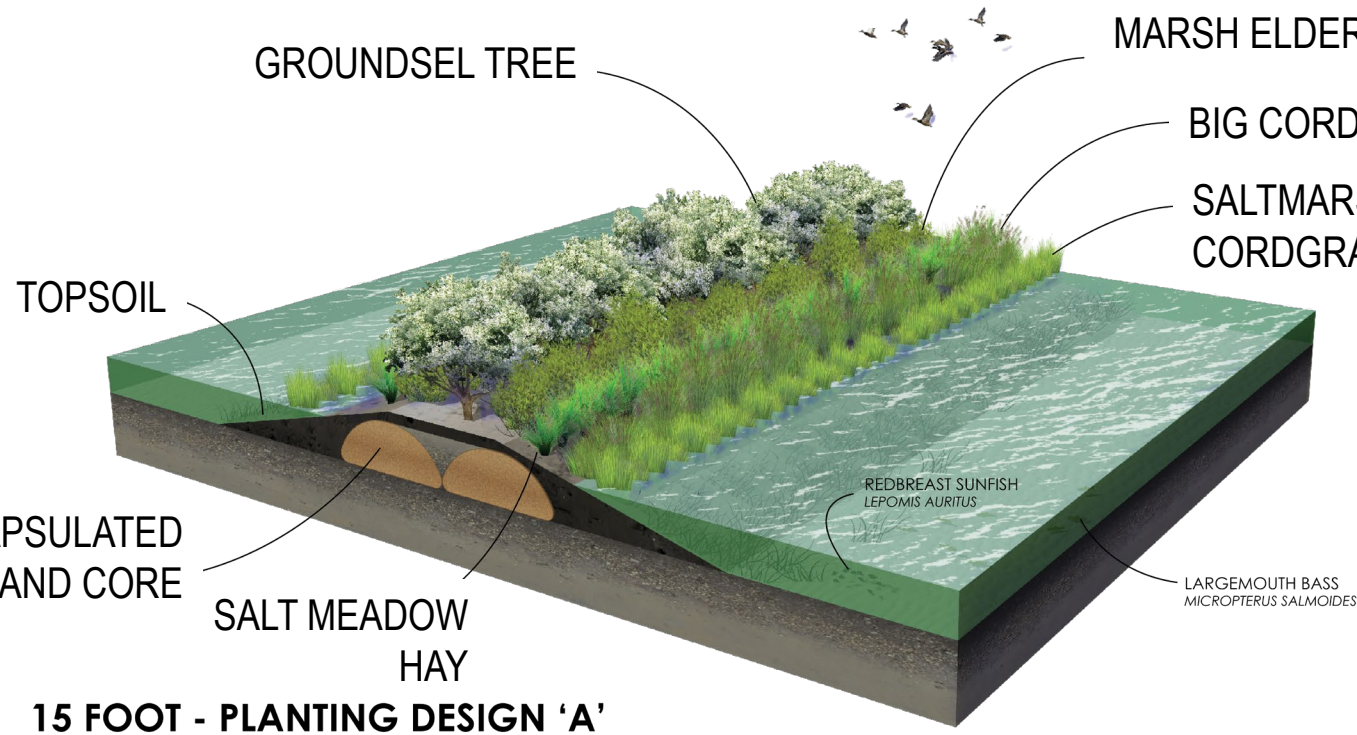
Project Scope



- Create 41 individual marsh terraces totaling approximately ~25,000 linear feet (~47-acre footprint)
 - 15-foot-wide terraces throughout the site
 - 30-foot-wide terraces in the middle of the site
- 33 acres of estuarine wetlands created with over 130,000 native plants
- Create approximately 310 acres of suitable submerged aquatic vegetation habitat between the terraces



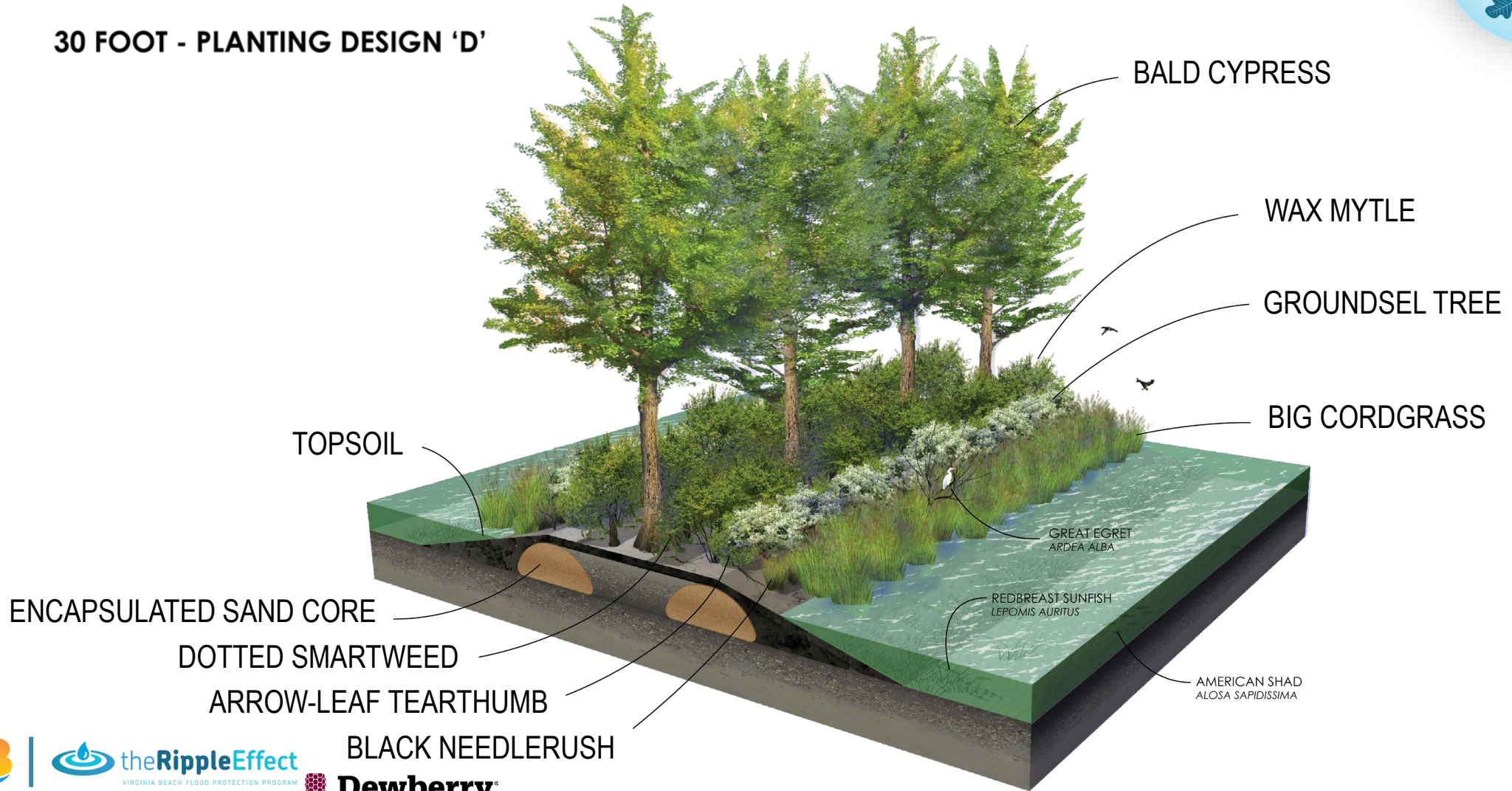
Typical Planting Design Details



Typical Planting Design Details



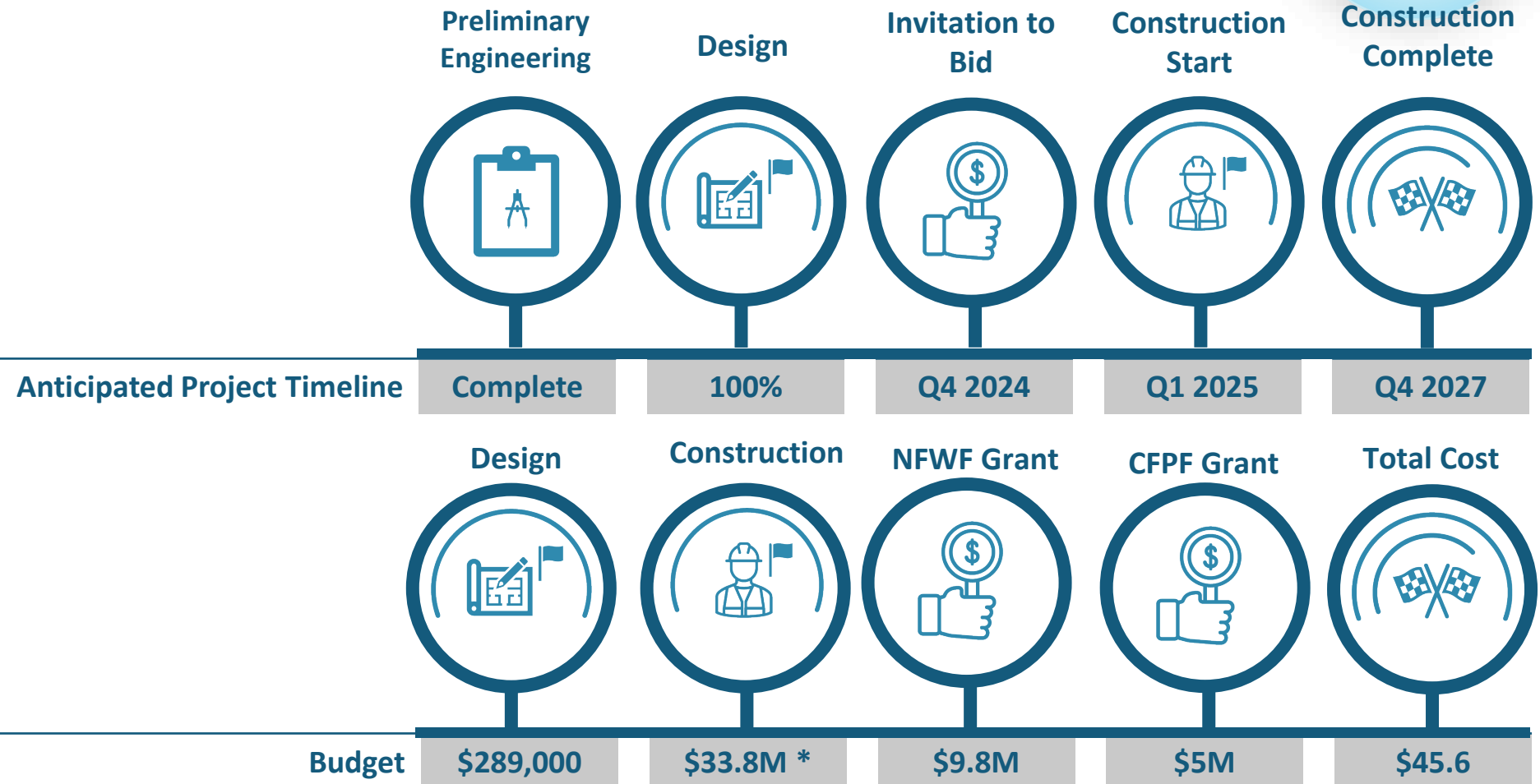
30 FOOT - PLANTING DESIGN 'D'



Dewberry



Anticipated Project Timeline and Budget



*Based off most recent Engineering Estimate.



Elizabeth River Wetland & Floodplain Restoration



Project Team



CITY OF VIRGINIA BEACH



Dewberry



FROEHLING & ROBERTSON

Elizabeth River Project
Making restoration a reality.



The JAMES RIVER INSTITUTE for ARCHÆOLOGY, Inc.



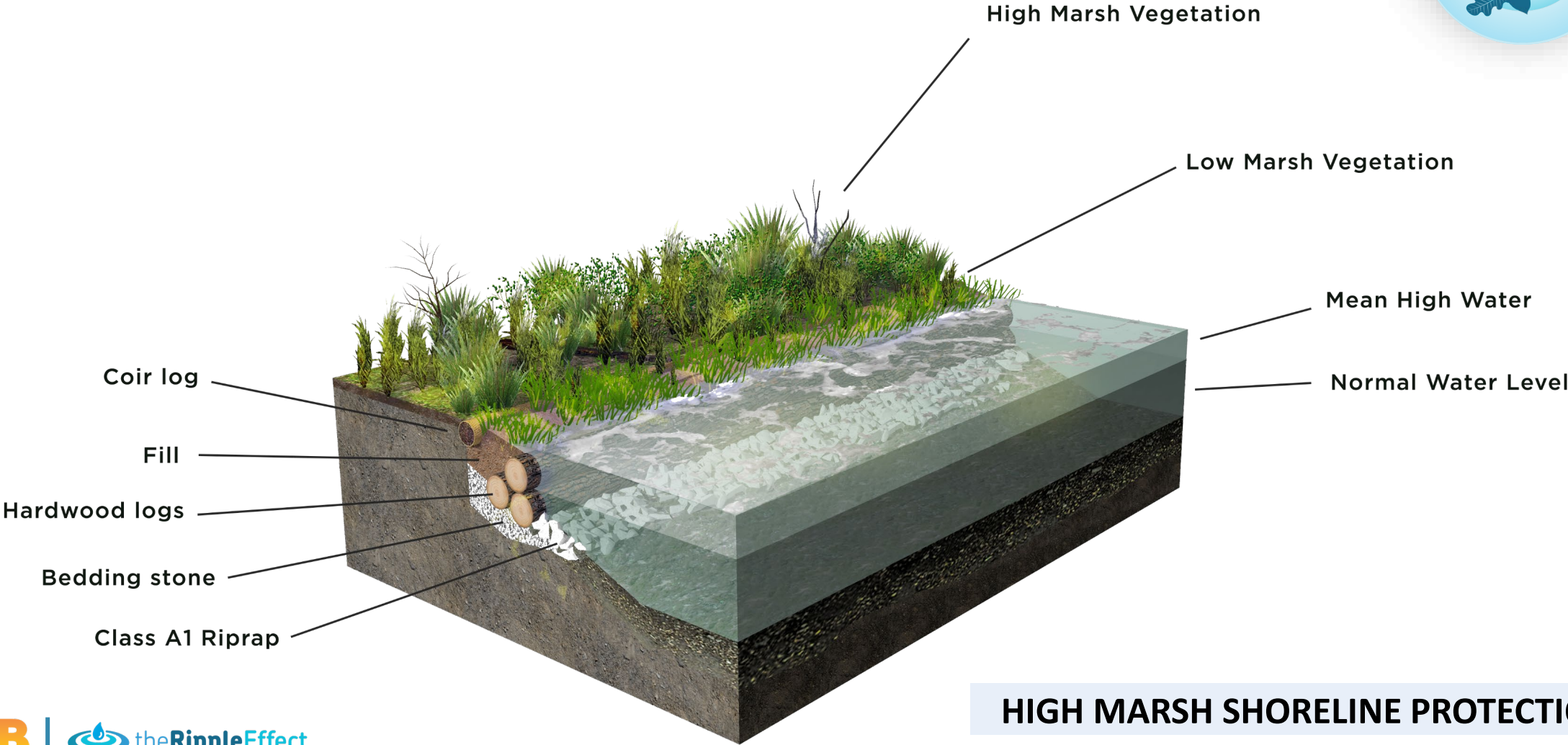
MAP ENVIRONMENTAL INC.



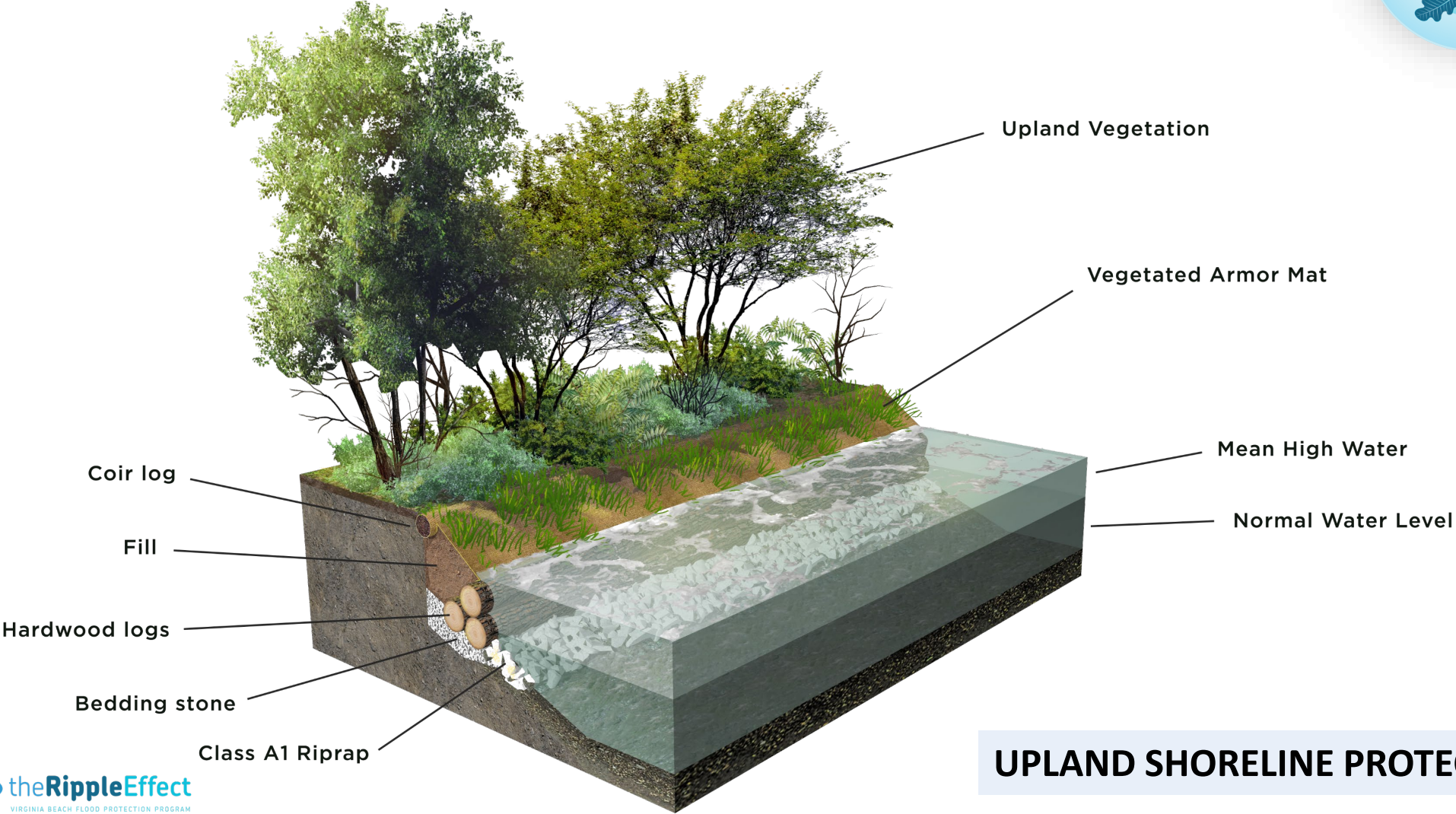
This project received funding from the Virginia Community Flood Preparedness Fund Grant Program through the Virginia Department of Conservation and Recreation (DCR), via **CFPF-21-01-08**.

Project Area

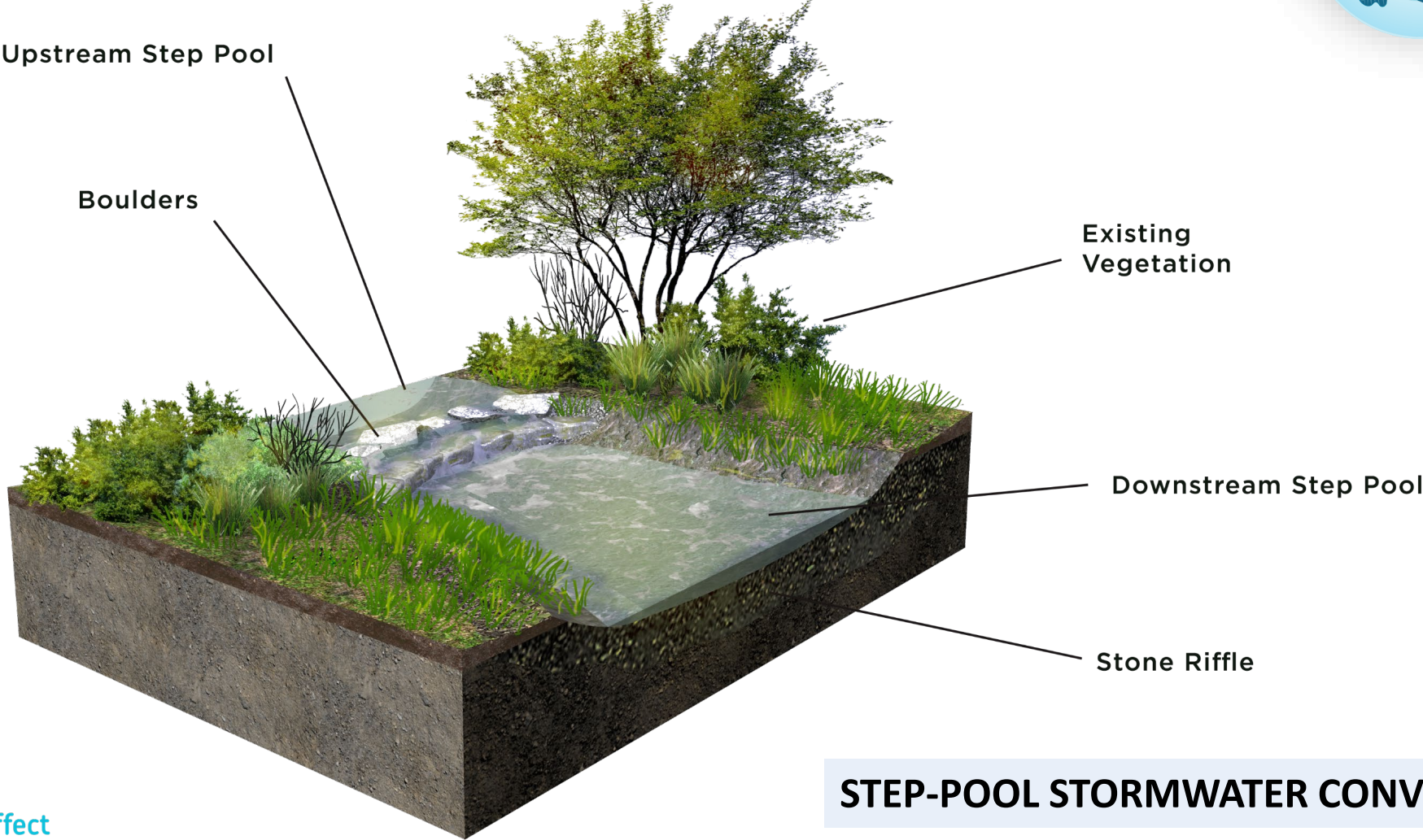




HIGH MARSH SHORELINE PROTECTION



UPLAND SHORELINE PROTECTION



STEP-POOL STORMWATER CONVEYANCE

Design Layout



Design Layout



Existing Site
Conditions



Proposed Site
Conditions



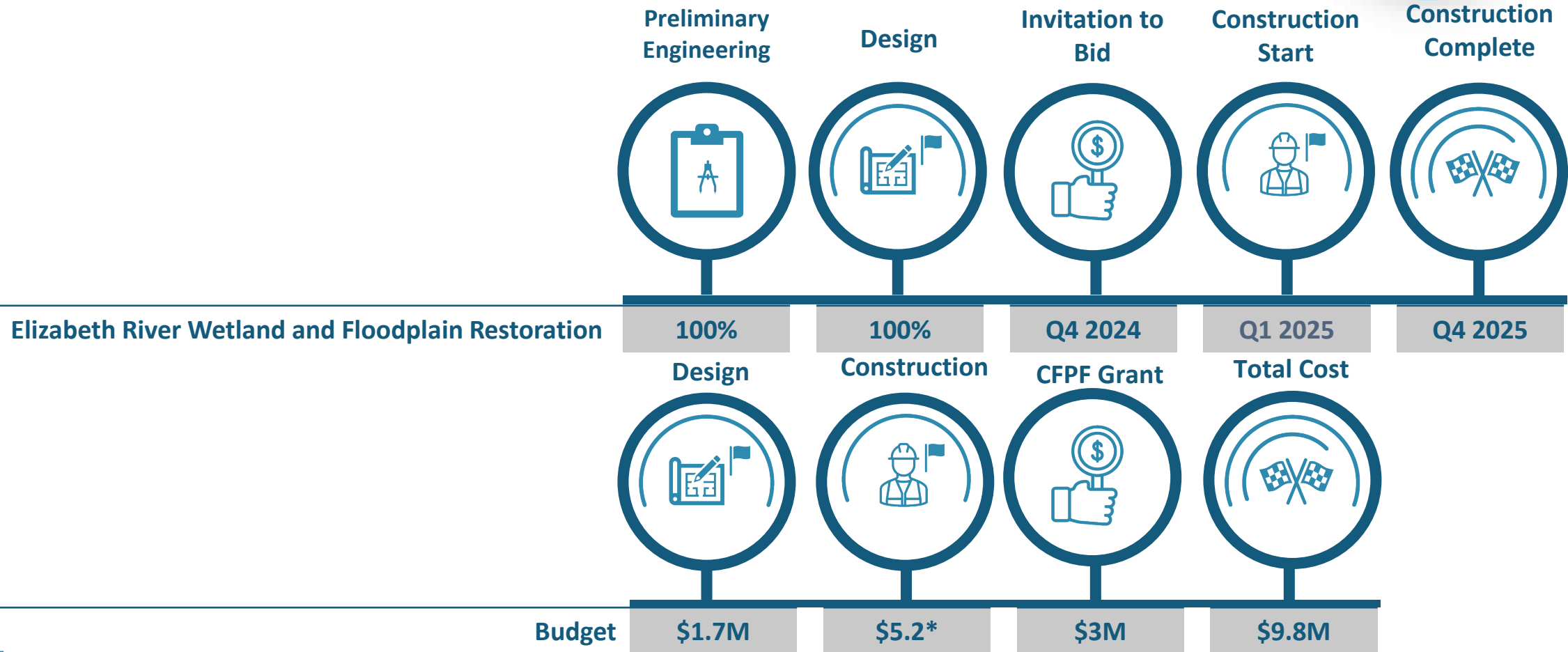
Existing Site
Conditions



Proposed Site
Conditions



Anticipated Project Timeline and Budget



*Based off most recent Engineering Estimate.

Challenges



- Collecting geotechnical data in Back Bay
- Countering misinformation
- Finding the right consultant
- Environmental Permitting

Points of Contact



C.J. Bodnar, P.E.
cbodnar@vbgov.com

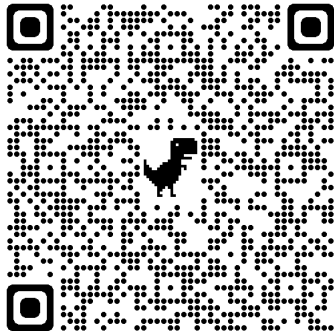
Kristina Searles, P.E.
ksearles@vbgov.com

Mike Tippin, P.E.
mtippin@vbgov.com

More Information – Sea
Level Wise Website



More Information –
Marsh Restoration in
Back Bay



More Information – Elizabeth
River Wetland & Floodplain
Restoration

