CERF 2021
26TH BIENNIAL CONFERENCE

Design Competition: Coastal Virginia

Advancing Towards a Resilient Hampton 2050 by Supporting Population Mobility

VIRGINIA TECH

HAMPTON
ON THE HORIZON

PROJECT TITLE

Advancing Towards a Resilient Hampton 2050 by Supporting Population Mobility

PROJECT TEAM | Virginia Tech

YEAR 2021

DESIGN TEAM

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ABSTRACT

Many coastal communities along the Atlantic Coast are experiencing chronic flooding due to sea level rise. Expected impacts on the population living in flood-prone coastal areas include difficulty to commute to work, school delays and closures, business closures, property damage, and psychosocial problems. Communities have three options to respond to sea level rise: they can protect their assets with structural and non-structural measures, accommodate changes via home elevation and flood-resistant construction, and relocate to higher ground or further inland. For most coastal locations, successful adaptation will include a combination of these three approaches that reflect their place-based characteristics such as socioeconomic, cultural, and historical context. Two primary goals of this design proposal are to characterize impacts of SLR on the natural and built environment in the City of Hampton by 2050 and identify opportunities for future land use and development adjustments via elevation-based zoning and innovative policy mechanisms to accommodate the anticipated land loss due to rising seas. We use geospatial analysis, economic assessment, and urban planning approaches to create design scenarios of redevelopment and land use shifts supporting an incremental transition from the high impact or "Conversion zones" to drier or "Advancement zones: within the same jurisdiction.

SUMMARY OF PROJECT TEAM EFFORT

This project was conducted during the Spring semester at Virginia Tech (January 19 – May 05, 2020) and involved eight students and four faculty from different disciplinary backgrounds. The project team was divided into three groups focused on the geospatial analysis, economic assessment, and evaluation of planning options. Groups of undergraduate (UG) and graduate (G) students were led by a faculty with relevant expertise in Geography (GEOG), Urban Affairs and Planning (UAP), and Economics (ECON).

The whole project team met once a week for project updates and integration, while individual task force groups also gathered independently to work on their specific assignments. During the performance period, the team specifically focused on the problem identification that involved learning and problem-solving activities, data collection and analysis, and integration and interpretation of individual components (figure below).

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Faculty lead | Dr. Thomas Pingel (GEOG)

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PROJECT DESCRIPTION

STATEMENT OF DESIGN PROBLEM

The three selected neighborhoods in the City of Hampton are already experiencing significant recurrent flooding and are at high risk of permanent inundation by 2050 due to accelerated sea level rise. Even though some natural and structural interventions can offer some protection, they may not be feasible for all locations due to their high cost and short-term benefits. Our design problem is grounded in the assumption that some areas of the City of Hampton will be reclaimed by sea level rise by 2050, prompting forced displacement of homeowners and other residents and public and private infrastructure and assets. Our core assumption is that some areas will have to be vacated due to permanent inundation, inclusive of all current land uses that occupy that space. However, we argue that this outcome does not indicate a failure to adapt in place but rather presents an opportunity to re-envision the urban space and create new living and employment opportunities in the areas with lower flood risk while converting reclaimed areas to new recreational open spaces. Our design proposal is driven by the objective of retaining as many displaced households as possible within city limits by identifying and developing new sustainable urban forms in dry, higher-elevation Advancement Zones. The vacated areas would be rehabilitated into the Conversion Zones that would offer new educational and recreation opportunities for the Hampton citizens and visitors.

"There is some renaissance, some reservation from some citizens: hey, I still want to stay in this house, I do not want to leave this neighborhood, I love this neighborhood... but after they get flooded that reservation goes down very quickly. And you have a lot of people who just want to get the heck out. It is not a hard sell."

~ Interview respondent[1]

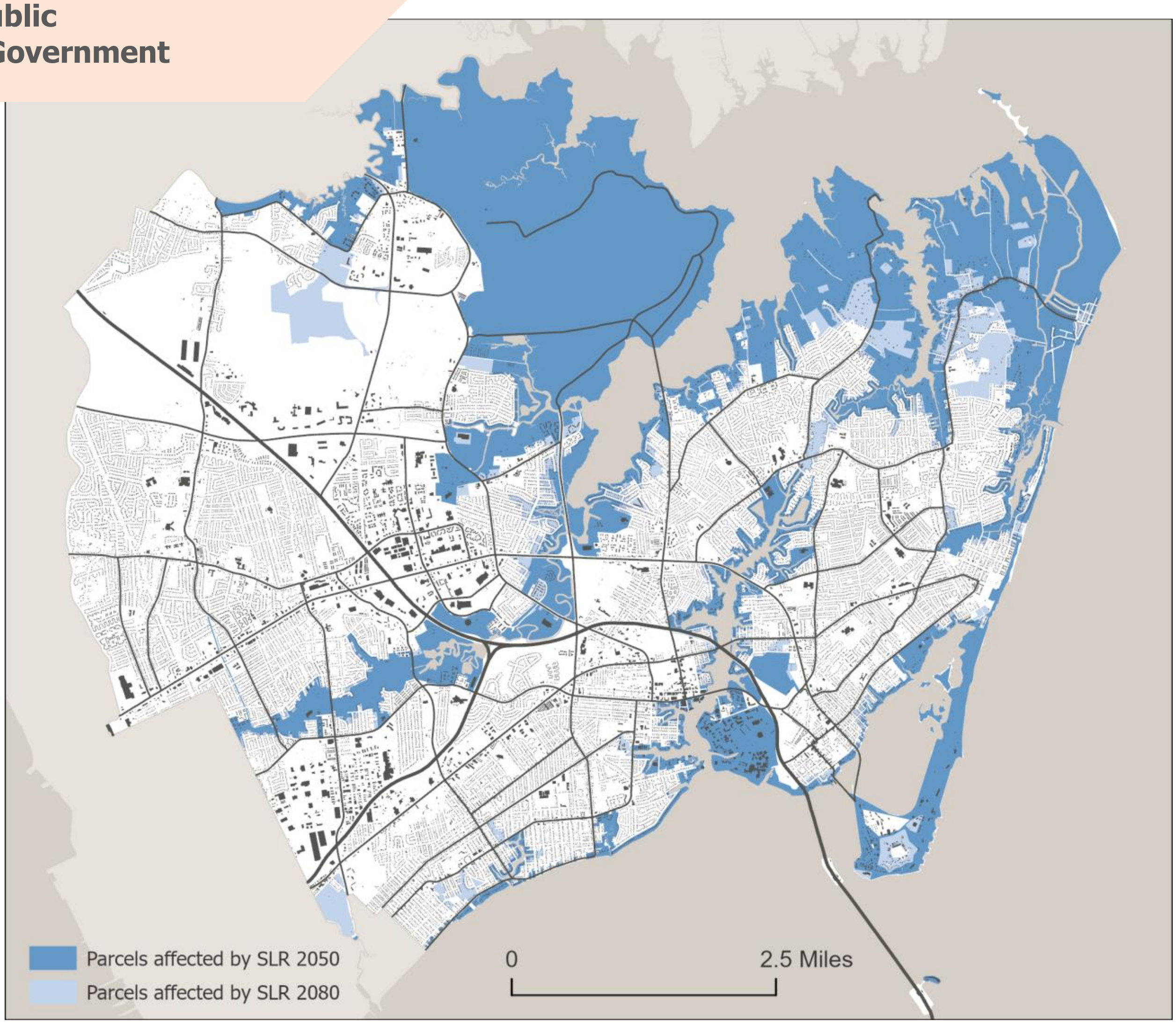
SITE ASSESSMENT

The City of Hampton, is located in Southeast Virginia at the junction of Chesapeake Bay and James River. It was established in 1610 and has a prominent cultural, economic, historic, and geopolitical significance for the region[2]. It is also a home to some of the vital assets such as the now decommissioned military installation Fort Monroe, NASA Langley Research Center, Langley Airforce Base, historic downtown, and public beaches. According to the 2019 American Community Survey estimates[4], Hampton has a total population of 134,510, with 15% of individuals age 65 and over, prevalently Black population (49.9%), median household income of $56,287, and 15.2% residents living in poverty. The socioeconomic characteristics vary between different neighborhoods and stem from their historic context, from rural areas in fringes that are wealthier and whiter, to older urban neighborhoods in downtown Hampton and historic districts that are more diverse, have older housing stock, and a legacy of other urban issues.

Hampton is highly exposed to coastal flooding with its 227 miles of shoreline along waterways and the Chesapeake Bay and 124 miles of navigable waterfront[5]. High flood risk in this geographic area stems from accelerated relative SLR, land subsidence, low elevation, and flat topography. According to the Virginia Institute of Marine Science[6], the predicted SLR for 2050 is 1.7 ft (intermediate scenario) with a possible 2.2 ft increase in sea levels (high scenario). Such change in the baseline water levels would increase tidal and storm surge flooding and result in more severe damage along all waterways. In Hampton, SLR-driven recurrent flooding is already causing significant impacts on the people's livelihoods, such as school delays and closures; difficulty to commute to work; business closures and canceled appointments, home and yard damage, negative impacts on home value, and neighbors selling homes and moving out[7].

3,342 Residential
127 Commercial
22 Industrial
37 Public
113 Government

PARCELS AFFECTED by 2050 SLR

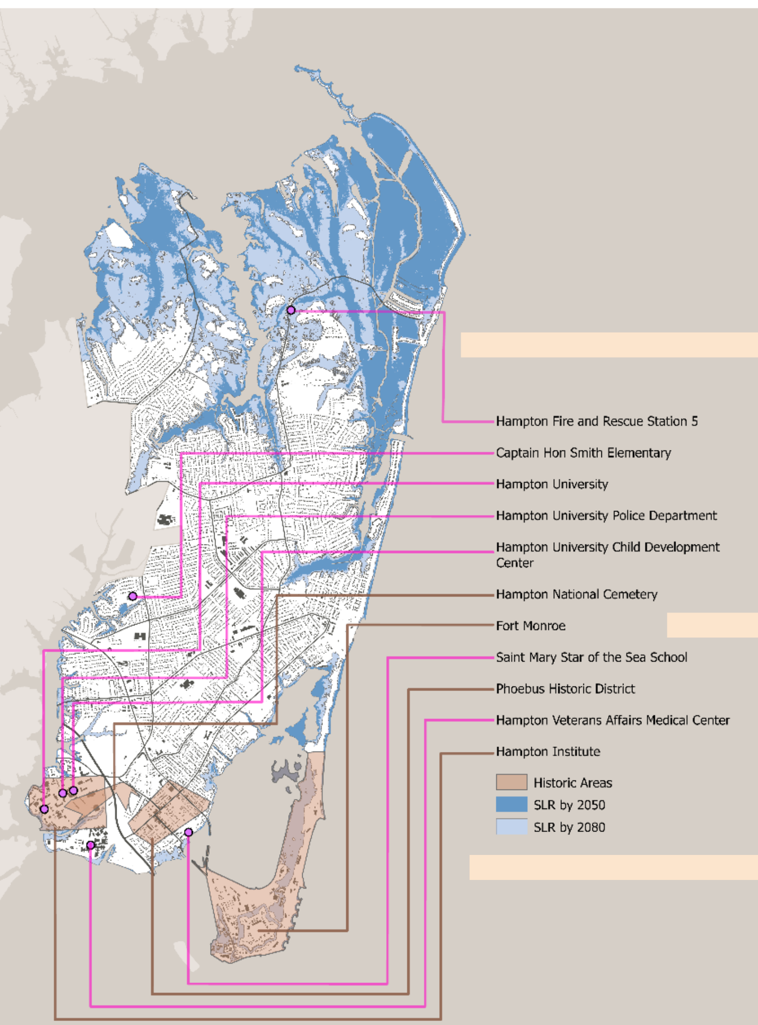


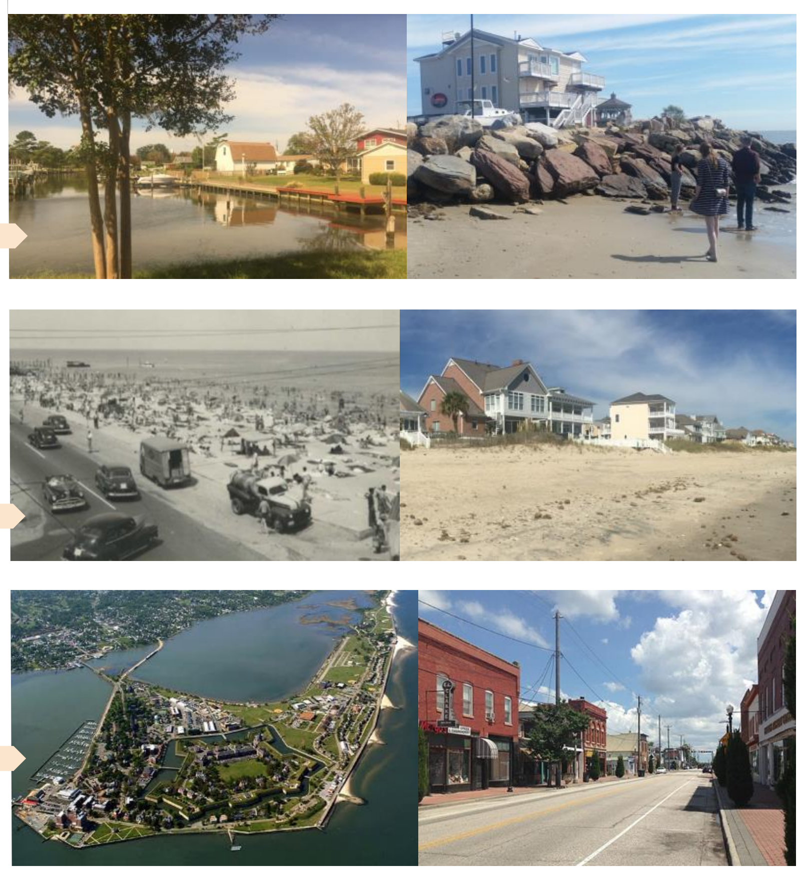
Within Hampton, this proposal focused on three specific neighborhoods that are experiencing the shared challenge of coastal flooding but have significantly different resilience options due to their unique socio-economic, historical, cultural, and physical characteristics. Even though all three neighborhood clusters will be affected by SLR, Fox Hill and Grandview will experience the most significant flood impacts that will lead to pervasive property damage and limited accessibility.

Phoebus and Fort Monroe | Historic district with a main street shopping area | Decommissioned military installation ▪ currently national monument and one of the key tourist attractions | Active marina |Historic Chamberlain hotel ▪ currently retirement community | Other historic properties[6]

Buckroe and Salt Ponds | Historic beach resort area | Public man-made beach | Residential communities | Many homes built as summer vacation bungalows | Value oceanfront views[6]

Grandview and Fox Hill | Rural residential communities | Fishing village culture | More remote and self-sufficient | Comfortable with some flooding | Wetlands and ghost forest[6]





GRANDVIEW AND FOX HILL

BUCKROE AND SALT PONDS

PHOEBUS AND FORTH MONROEL

Hampton communities have three options to respond to SLR and related tidal and storm surge flooding[7]:

Protection

Accommodation

Relocation

Protection | the use of natural features (e.g., wetlands restoration and living shorelines) or engineering physical barriers (e.g., shoreline armoring, seawalls, and levees).

Accommodation | the use of design and construction options that help coping with the exposure but no not try to hold back the water (e.g., home elevation, installation of flood vents, or use of flood-resistant construction materials).

Relocation | a permanent voluntary movement of the whole or part of a community from the original to a new location due to sudden or gradual climate change impacts[8]

Relocation has been increasingly considered an effective adaptation and resilience strategy for situations where risk is accelerating and causes repetitive damage. If implemented as a voluntary and preventive measure, it can help move people and property out of harm's way while at the same time creating new opportunities for creative repurposing of built to open space. Even though relocation is the most complex and difficult resilience strategy, it is supported by the increasing number of coastal residents who cannot cope anymore with flood impacts.

According to the survey of homeowners in flood-prone Hampton Roads neighborhoods[9], 38% would consider moving somewhere else due to coastal flooding, 50% would consider doing so in the future, and only 11% would not consider moving at all. Specifically, in Hampton, a majority of surveyed homeowners would consider relocating if insurance would not cover the flood damage (72%), if crime becomes worse (68%), if they could not access services and amenities due to flooding (59%), and if they would be offered with financial compensation or buyout (57%)[6].

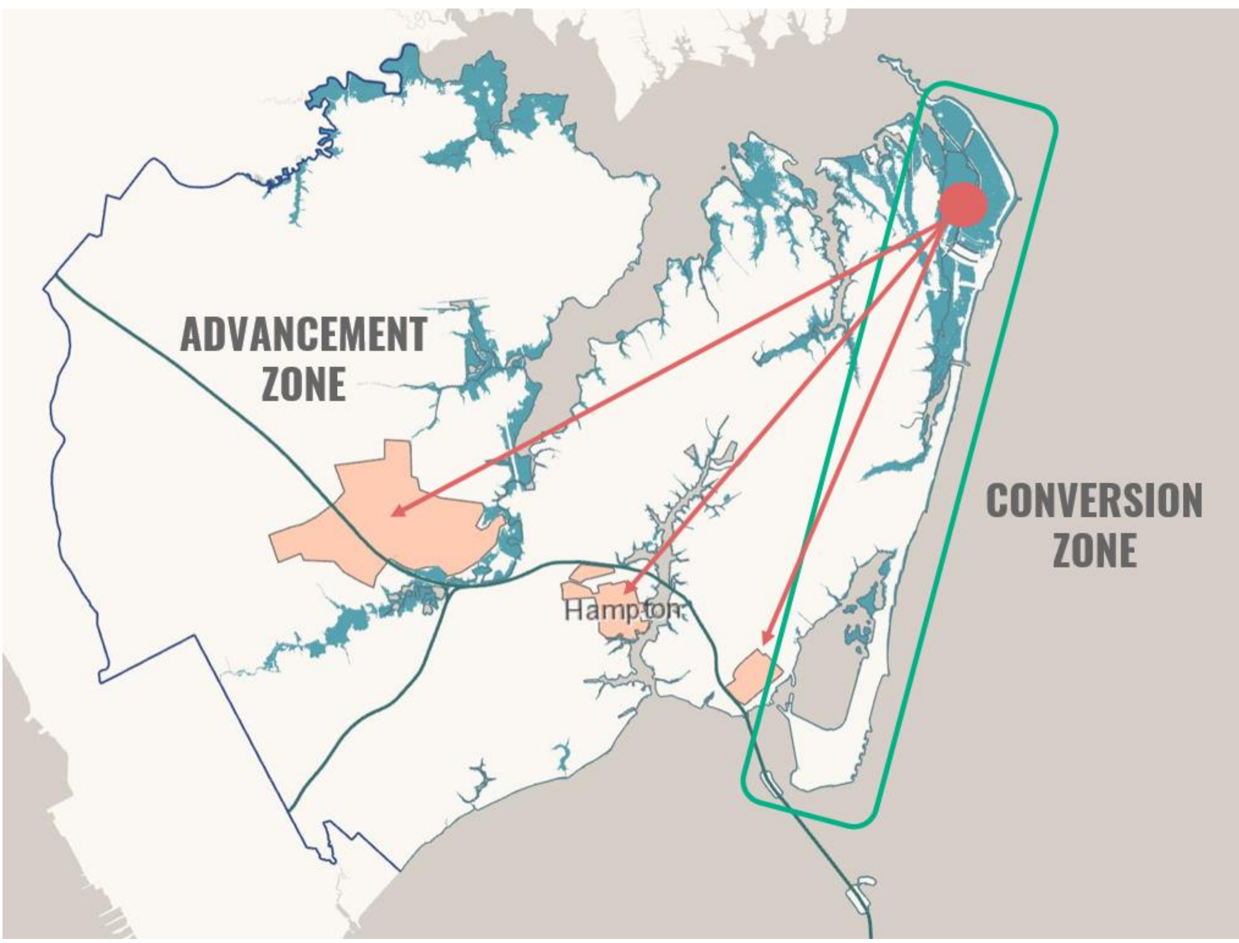
RECOMMENDED DESIGN SOLUTION

Our recommended design solution revolves around the following key assumptions. Some areas of Hampton will become permanently inundated by 2050 and therefore be rendered uninhabitable. Residents and the built environment in this SLR-inundation corridor will have to relocate incrementally.

Most people prefer to relocate closer to their original location, in the area where they have existing social networks and favored amenities. Municipalities affected by SLR also prefer to keep residents within their administrative boundaries to preserve the community's tax base and socio-economic stability. Local relocation of the affected population would represent a win-win outcome both for relocatees and the municipality. For that to happen, the City of Hampton would have to secure new development in dry areas, away from flooding, where residents of SLR-affected neighborhoods could move to.

Advancement Zone | Zone of new development/redevelopment where residents affected by chronic SLR could relocate. The same areas could also attract new residents from outside Hampton.

Conversion Zone | Zone of permanent SLR inundation that would be subject to relocation and converted into public open spaces for education, recreation, and tourism.



Even though this approach would require profound land use, planning, and policy changes, in the long-term, it would lead to thriving and stable urban conditions that would co-evolve with the advancing flooding. Such an approach would rely on various planning tools, such as Transfer of Development Rights (TDR), rolling easements, intensification, and vertical growth. If done wisely, it would bring new opportunities for urban revitalization grounded in the inclusive and equitable urban mix-use designs fostering socioeconomic health and wellbeing of the community.

PHOEBUS TODAY

PHOEBUS TOMOROW

ADVANCEMENT ZONE

The key beneficial features of the Advancement Zone
Form-based re-zoning to create walkable communities
Alignment with the Hampton's Master Plan (densification, mixed-use growth, etc.)
Reduced risk to SLR and other coastal hazards
Consideration of anticipated demand to prioritize available supply
Match between socio-economic profile of relocatees with housing types
Provision of desirable urban features for new prospective residents

The vision for Advancement Zone is based on identification and redevelopment of underutilized parcels in the drier parts of the city to increase residential density (compact development) and diversify the existing housing typology. This first step targets industrial properties, brownfield sites, decaying buildings, and vacant parcels within the Advancement Zone. Those areas would provide new low-rise, mid-rise, high-rise developments, and townhouse communities with an abundance of affordable housing options.

Advancement Zone would include a range of housing options that would appeal to residents of various sociodemographic groups, from families with children and young professionals, to empty nesters and retired individuals.

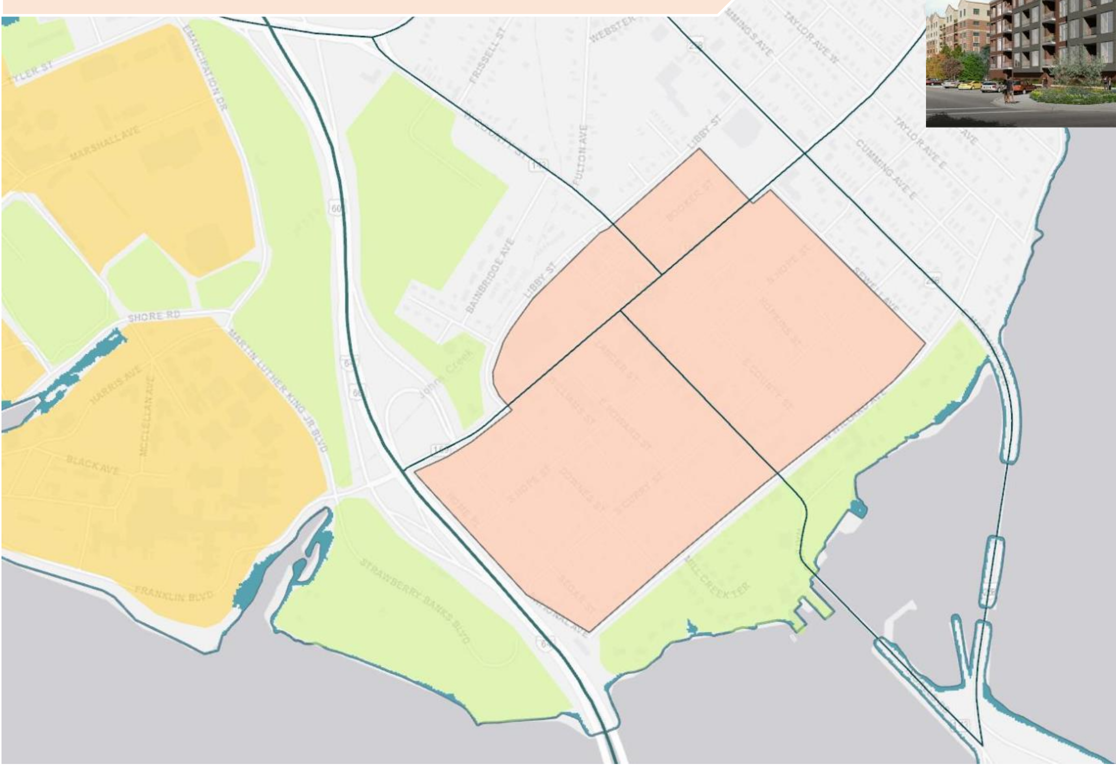
For many residents of selected Hampton neighborhoods, access to water is an essential consideration of the decision to stay or leave their community. Therefore, the Advancement Zone would be spatially connected with the coastline via new multi-modal transportation options that would allow residents to live in safer locations while still enjoying the beachfront amenities. The parcels identified for new development/redevelopment are located in Phoebus, Downtown Hampton, and Coliseum Central.

Number of residents new housing would accommodate	
Phoebus	1,600
Downtown Hampton	1,100
Coliseum Central	440

The majority of development in **Phoebus** that would create new housing options for the people relocating from the flood-prone locations would be between S Mellon St. and S Willard Ave. Selected floor area ratios and residential units per acre in this area (marked in peach color below) are consistent with examples in other urban spaces (specifically Fairfax) and would accommodate new 1,600 residents.

Phoebus is also the only neighborhood that includes both the Advancement Zone and Conversion Zone. These circumstances would present an ideal option for those residents impacted by SLR who prefer to stay in the same community and preserve local social networks and proximity to marina, Fort Monroe, and commercial area in downtown Phoebus. New strategic mixed-use development would bring more local investment and opportunities for Phoebus' residents, stimulating economic growth, quality of life, and social conditions.

PHOEBUS



Based on existing Business Strategic Plan

Expansion in scale

Compliant to Climate Change & Conversion Demand

Waterfront Park

Connections to Hampton University and Veteran Hospital

Walkable Community

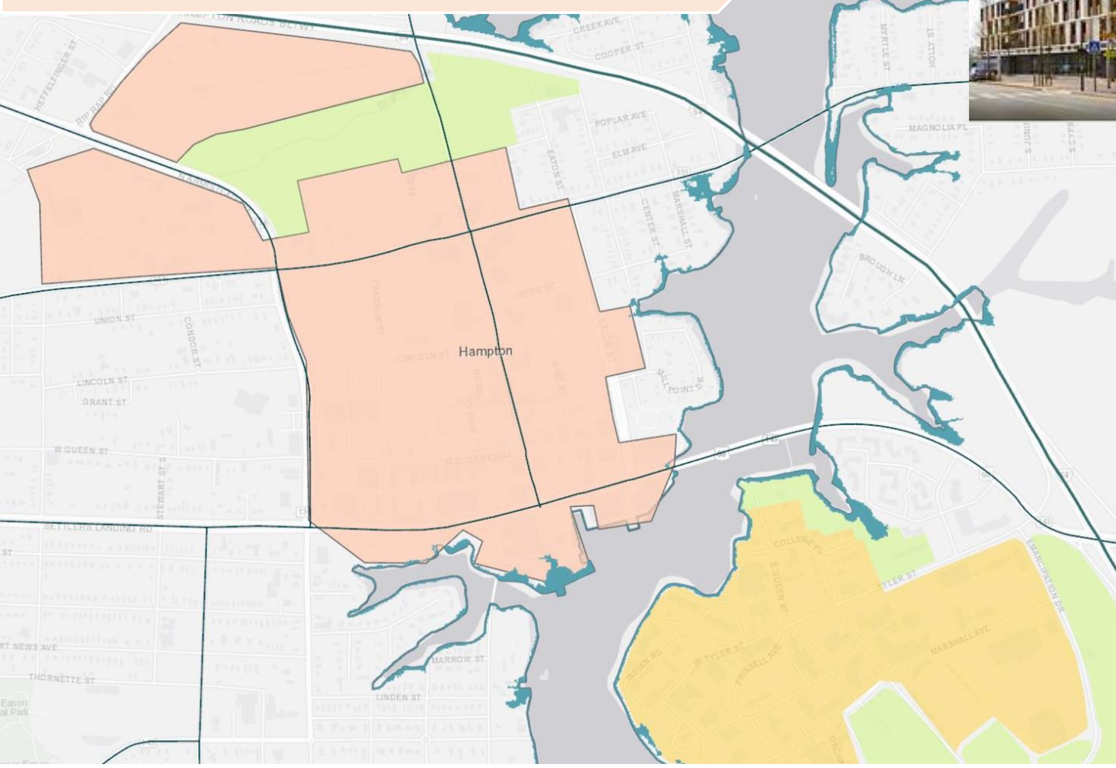
Downtown Hampton has a number of deteriorating and vacant properties that could be redeveloped to provide the new housing and preserve the net number of residents within the municipal boundaries.

36.28 acres
Mixed-Use Development
Floor Area Ratio 1.0
(1,580,370 sq ft)
30 Dwelling Units/acre
(3 Stories)
~1088 Residential Units

2.99 acres
Low-Rise Apartments
Floor Area Ratio - 0.5
(65,122 sq ft)
16 Dwelling Units/acre
(1 story)
~24 Residential Units

Well-designed mixed-use housing with shared public spaces and pedestrian friendly infrastructure would improve public health and safety, social capital, and socio-economic conditions in downtown Hampton. It would also bring new foot traffic outside the business hours that would support local stores and service providers.

DOWNTOWN HAMPTON



Parks on the Former Rail Yard

Redevelop Brownfield near the Rail

Walkable Community

Downtown Business Corridor

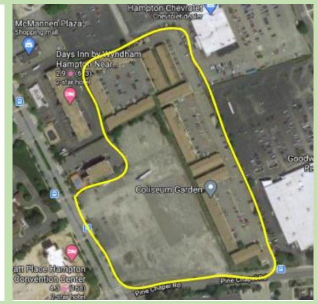
Connections to Hampton University

Total of 1100+ units

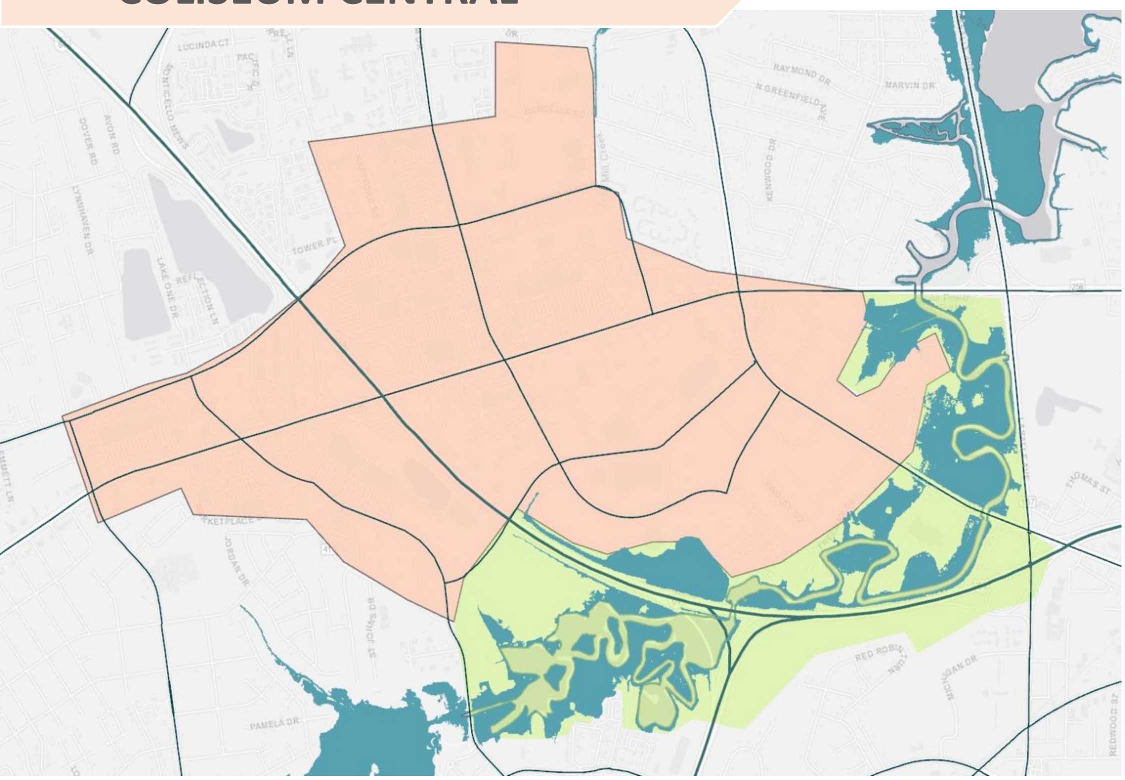
Coliseum Central is a thriving car-centric community with a number of water features in the floodplain, new development, and vibrant shopping district. Our proposal identified a few lots in this area that could be repurposed for new mixed-use development.

164,185 sq ft (3.77 acres)
Townhomes
Act as a transition zone between single structure residential area
Provide easier access by widening and extending Barrack St to connect Convention Center Blvd/Pine Chapel Rd
Add sidewalks with trees and bioswales

360,735 sq ft (8.28 acres)
Low- to mid-rise apartments
Connect buildings with green space
Modern look to begin transition to a more urban aesthetic
Aligned with the City's "urban core" concept



COLISEUM CENTRAL



Car-centric community

Parks on Newmarket Creek

Coliseum Central shopping district

Basin & Floodplain

Utilizing Developable Parcels

440 + Units

"By reducing the need for vehicle travel, mixed-use development also brings shared community space. Plazas, parks, and sidewalks foster interaction among community members—interaction that wouldn't be safe or possible under a sprawled, car-centric design model. Mixed-use, public transit-friendly neighborhoods benefit local economies by increasing foot traffic."

~ Word Resources Institute

HAMPTON
ON THE HORIZON

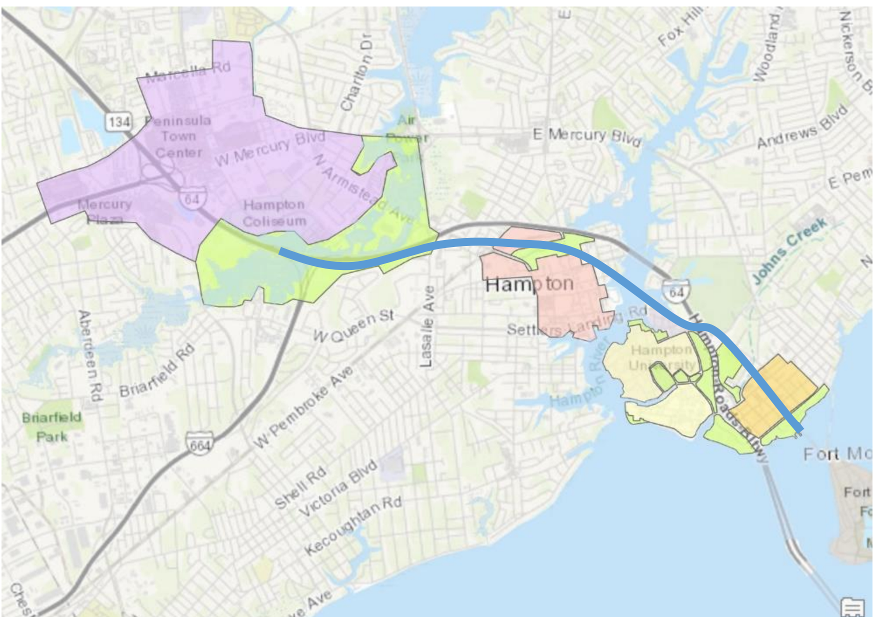
CONNECTIVITY

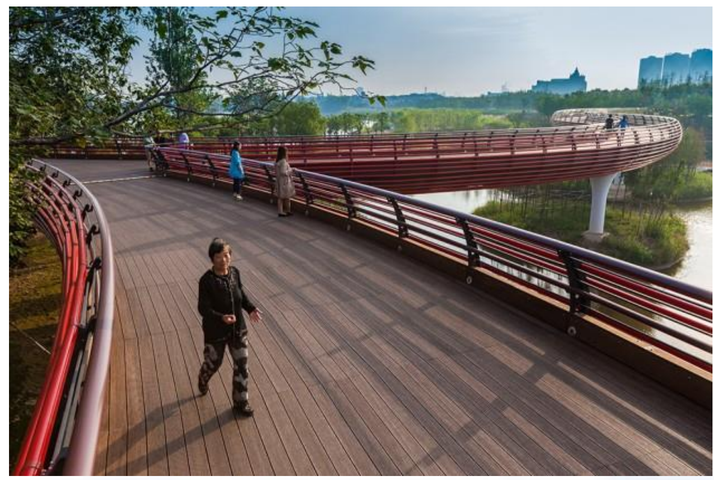
The important feature of our concept is that it would promote connectivity between individual locations within the Advancement Zone with the coastal Conversion Zone via flood-proof multimodal access with emphasis on bicycle and pedestrian mobility.

General Benefits of Greenways

Creating value and generating economic activity
Improving bicycle and pedestrian transportation
Improving health through active living
Reducing pollution and supporting biodiversity
Protecting people and property from flood damage
Enhancing cultural awareness and community identity
- Greenways, Inc.

Current condition





https://landezine.com/a-resilient-landscape-yanweizhou-park-in-jinhua-city-by-turenscape/

HAMPTON
ON THE HORIZON

CONVESION ZONE

KEY CONSIDERATIONS

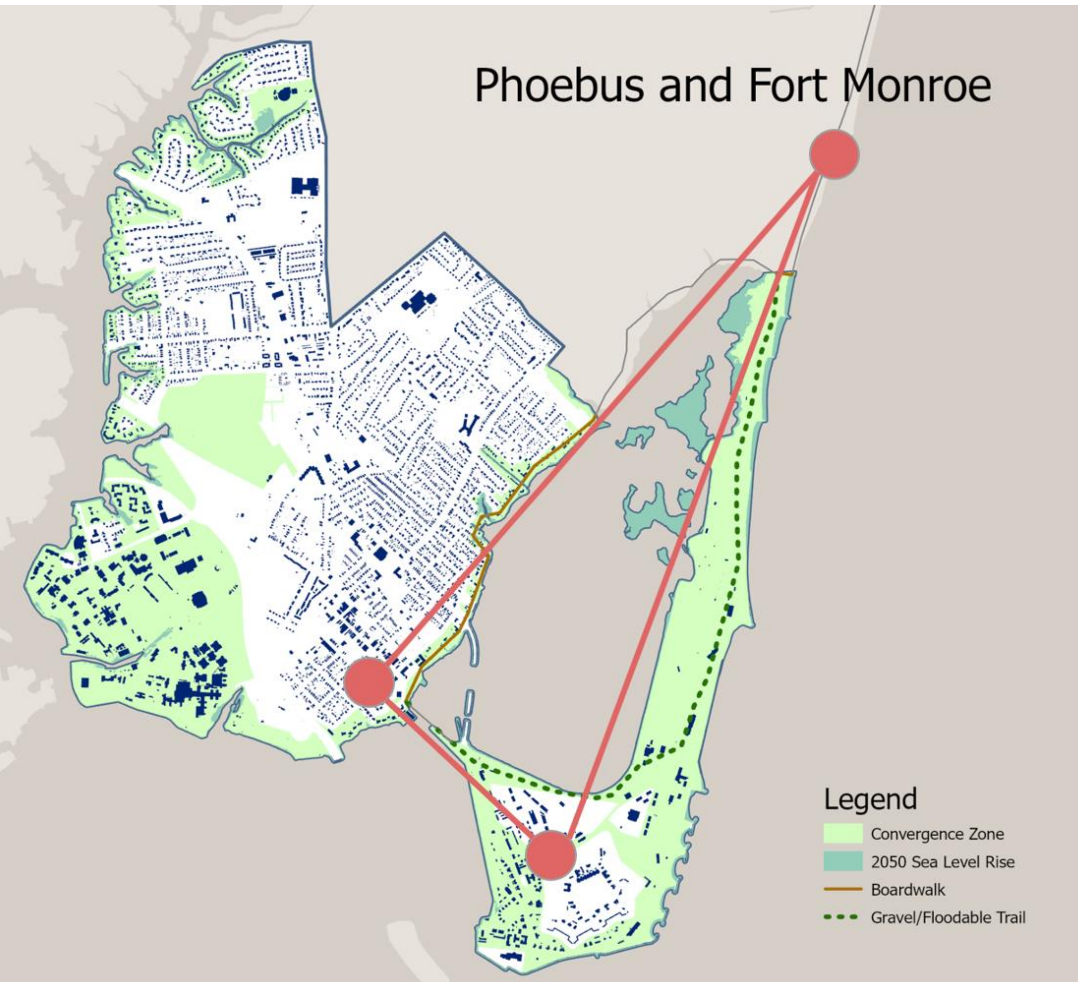
- New recreational opportunities (e.g., walking, biking, fishing, learning)
- Flood protection (primary and secondary, mostly natural features)
- Preserving access to the water and beach (as important for place attachment)
- Supporting local, regional, and state tourism - year-round to seasonal
- Improving public access to diverse users to improve their health and wellbeing
- Centered on ecosystem-based adaptation for multiple ecological benefits
- Attracting investment and new businesses

KEY FEATURES

- Wetlands (migration, restoration, new construction)
- Living shorelines and secondary flood protection (e.g. shoreline stabilization)
- Public recreational area - walking, jogging, and biking trails connected to existing infrastructure with easy access in all three neighborhoods
- Solar canopy - solar panels installed above the trails and parking lot for energy generation
- Shading elements - extending use of trails during urban heat events and summer
- Aesthetically pleasing - providing safe, well-lit, and attractively looking spaces

The vision for the Conversion Zone is grounded in easy access, connectivity, and inclusive amenities. Namely, all three neighborhoods would be strategically connected with walking and biking trails with multiple access points for existing local amenities and landmarks. In Phoebus and Fort Monroe, vacated residential lots would be replaced with an elevated boardwalk and floodable trail that could be easily restored at low cost after each subsequent flood event.

The trail would loop around Mill Creek, connecting downtown Phoebus with Fort Monroe's historic attraction and Buckroe. This approach would give users access to tangible destinations such as the brewery on Fort Monroe or restaurants and shops in Phoebus. This approach would also shift focus away from the more vulnerable shoreline to the creek itself, and open new opportunities for fishing, canoeing, and stand-up paddling in calmer bay water.

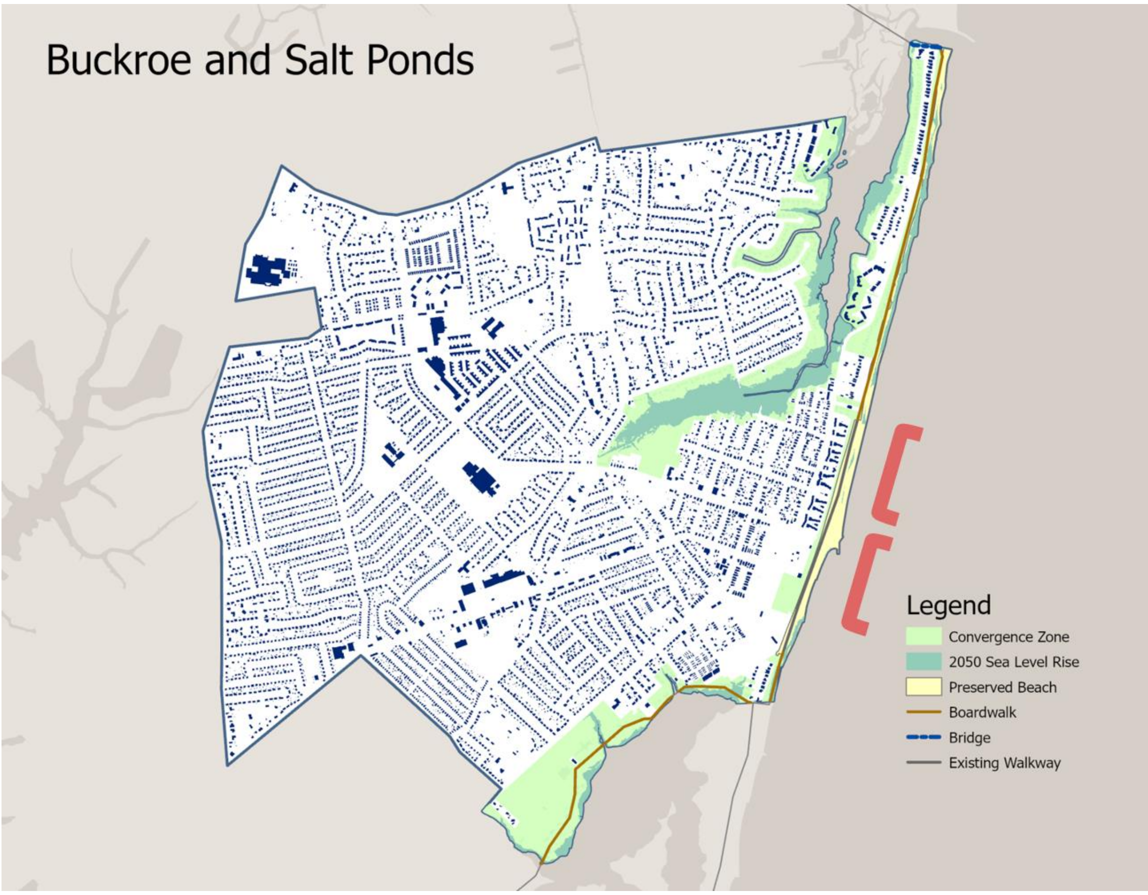


"Interaction with people and the ability to support and build healthy community connections is a value they see happening mostly organically. Festivals, running and biking clubs, sports leagues, and gathering space were all mentioned as part of community building."

~ Stephanie Lovely[10]

The trail would use existing biking and pedestrian infrastructure in Buckroe and Salt Ponds with improvements to provide more cohesive linear connectivity along the shoreline. It would be aligned with the existing plans to upgrade the seawall, boardwalk, and streetscape of beachfront and Buckroe Park.[11]

Another important feature that would be implemented in this neighborhood are breakwaters that would offer additional protection from the wave activity and storm surge during episodic events. Regardless of their design, breakwaters would also slow down the beach erosion and facilitate the use of this space for a broader range of recreational activities that were not possible due to rough waters. Use of living or floating breakwaters would also provide additional ecological benefits, such as habitat for marine life and shoreline birds.



"Recreation in the coastal zone can affect residents' sense of place, social interactions, health and overall quality of life. Coastal ecosystems are likely to contribute to social interaction through the provision of common space that is aesthetically pleasing, attracts residents and provides a convenient setting for casual contact. They also tend to improve both physical and mental health"

~ Cox et al. 2014[12]

Foxhill and Grandview will experience the most profound transformation due to their high risk of permanent SLR inundation. AT the same time, this area has great potential to reinvent their space and generate new educational, recreation, and tourism opportunities that are aligned with the growing public support for environmental education and experiential learning. Consequently, the newly acquired space would serve as a new advancement area for marsh migration and natural unstructured recreational spaces.

The new trail/boardwalk would extend from the Buckroe and Salt Ponds all the way to the new educational and cultural heritage center that would be designed as a flood-proofed zero-carbon signature building in a natural setting. The boardwalk would be elevated above the marsh and numerous creeks as needed. It would also offer gathering, well-lit safe spaces for learning, observing, and gathering.

"Spending at least two hours a week in local parks, greenways, and other natural spaces significantly improves physical health and psychological wellbeing[13]. Studies have shown that time spent in green natural settings lower blood pressure and stress hormone levels, reduce nervous system arousal, enhance immune system function, increase self-esteem, reduce anxiety, and improve mood."

~ Robbins 2020[14]

ECONOMIC ASSESSMENT: Inaction vs Action Scenarios

Economic analysis is important not only to the City of Hampton Officials, but also for all Hampton's residents to understand what they may financially gain or lose as the city adapts to sea level rise. The first analysis, the No Action Scenario, considers only the costs, assuming no actions are taken to prepare for 2050's projected sea level rise. The second analysis is the Action Scenario, which calculated the costs and benefits of relocating residents from moving out of the inundation zone (i.e., the Convergence zone) to the Advancement Zones.

This benefit-cost analysis should be interpreted as very general and preliminary, given time, budget, and team constraints. It simply covers what we consider the main interventions corresponding to our envisioned action plan, imposes a variety of simplifying assumptions, especially on the temporal flow of interventions, and relies to a large extent on borrowing estimates from other, similar projects and existing literature.

No Action: Costs of inundation **Action:** Benefits & costs above & beyond "no-action"

KEY ASSUMPTIONS

- Stakeholders: Residents of Hampton (incl. Municipal government)
- Direct / primary impacts only (no "trickle-down" effects)
- Only flows into and out of local economy count - internal transactions are neutral
- Three scenarios for temporal sequencing of effects (to show bounds):
- Starting Point (SP): Everything happens on Jan. 1, 2022
- Intermediate Point (IP): Everything happens on Jan. 1, 2035
- End Point (EP): Everything happens on Jan. 1, 2050
- One-time losses / benefits (e.g. homes) are counted only once,
- Recurring losses / benefits (e.g. lost property taxes) are counted annually
- All monetary values are discounted back to 2021 at a rate of 2.5%

No Action Scenario Costs (billion $'s)			
Loss Category (million $)	**SP (2021)**	**IP (2035)**	**EP (2050)**
Homes	626.17	454.24	313.64
Property Tax	162.78	75.37	3.89
Commercial Buildings	574.55	416.79	287.78
Commercial Property Tax	115.64	53.54	2.76
Industrial Building	1.69	1.22	0.84
Industrial Property Tax	0.34	0.16	0.01
Roads	29.24	21.21	14.64
Beach Recreation	1,603.24	742.33	38.30
Wetlands	471.13	218.14	11.26
Open Space	102.80	47.60	2.46
Critical Facilities	977.83	709.34	489.77
Total/Scenario	**4.67**	**2.74**	**1.17**

ESTIMATED COSTS AND BENEFITS UNDER ACTION SCENARIO

- Beach preservation & maintenance (cost, recurring)
- New natural wetlands (cost, recurring)
- New Greenway (multi-use trail)
    - Construction cost (cost, one-time)
    - Annual maintenance (cost, recurring)
    - Capitalization gain to local homeowners (benefit, one-time)
    - Annual benefits to trail users (benefit, recurring)
- 3,000 new homes (different housing configurations) in the advancement zones
    - Construction cost (cost, one-time)
    - Annual property maintenance for new homes (cost, recurring)
    - Annual homeowners' benefit (expressed through rental rates) (benefit, recurring)
    - Annual property taxes (otherwise lost under "no-action") (benefit, recurring)
- New cultural center
- Construction cost (cost, one-time)
- Annual maintenance (cost, recurring)
- Annual benefits to visitors (benefit, recurring)
- Solar panels to cover multi-use trail

SP (2022) Scenario (billion $'s)			
	Cost	**Benefits**	**Overall (million $)**
Beach Preservation	213.00	32.16	-180.85
Wetlands	0.00	138.94	138.94
Greenway	15.84	488.82	472.98
New Homes	674.32	1,324.55	650.23
Cultural Center	16.43	61.38	44.95
Solar Panels	40.39	90.39	50.00
Overall Net Benefits (Billion $)			**1.18**
IP (2035) Scenario (billion $'s)			
	Cost	**Benefits**	**Overall (million $)**
Beach Preservation	133.17	20.11	-113.06
Wetlands	0.00	86.87	86.87
Greenway	11.42	353.83	342.41
New Homes	458.24	613.29	155.05
Cultural Center	8.45	28.42	19.97
Solar Panels	27.38	41.85	14.47
Overall Net Benefits (Billion $)			**0.51**
EP (2050) Scenario (billion $'s)			
	Cost	**Benefits**	**Overall (million $)**
Beach Preservation	5.09	0.77	-4.32
Wetlands	0.00	3.32	3.32
Greenway	7.60	241.20	233.60
New Homes	281.54	31.65	-249.90
Cultural Center	1.92	1.47	-0.46
Solar Panels	16.75	2.16	-14.59
Overall Net Benefits (Billion $)			**-0.03**

In sum, and assuming costs and benefits will be spread over the scenario time frame and not occur at the very end of our time window (as assumed in the EP scenario), this design project has potentially positive net benefits from taking the action as envisioned in this project. The earlier implementation takes place, and the longer benefits such as those related to recreational opportunities have time to accrue, the more likely benefits will outpace costs in the long run. This economic analysis did not capture all important details in back-of-the-envelope computations, such as the exact timing of interventions, details related to new development and uncertainties regarding future policy decisions. We primarily envision this economic exercise as a starting point for a consideration of potential cost and benefit line items, and ongoing discussion regarding their detailed characteristics and implementation.

Acknowledgement

Design team is thankful to Shadaye Byfield, multimedia journalism major undergraduate student, for her assistance with logo development.

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APPNENDIX

Economic analysis valuation and sources

Approach

- Consult existing sources (journal articles, reports, official web sites, etc.)
- Utilize GIS and input from other teams to obtain specific values for calculations
- Extract unit values (costs or benefits) for comparable locations/situations ("benefit transfer method")
- Apply unit values to Hampton - aggregate over units (households, buildings, etc.)
- Insert total value into the temporal scenario (e.g. "SP:" occurs Jan. 1. 2022)
- Add up all discounted benefits & costs to obtain estimated net present value for "no-action" and "action" scenario

Housing

Location	Unit	Value (2019)	Source
Hampton City, Virginia (County)	**Avg. Home Value**	$192,049	CERF

Taxes

Location	Unit	Value	Source
Hampton City, VA	Real Estate Taxes	$1.24 per $100 of assessed value	https://hampton.gov/572/Real-Estate-Taxes

Real estate taxes. (n.d.). Retrieved March 12, 2021, from https://hampton.gov/572/Real-Estate-Taxes

Value of Wetland (Salt Marshes)

Location	Unit	Value per acre	Present Value per person per acre (2021)	Total Occupied Housing Units (2019)	Source
NJ, PA, DE, MD	Salt Marsh-willingness to pay to avoid losses	0.165	**$0.18**	55633	Moeltner et al. (2019)/ u.s. Census

Moeltner, K., Balukas, J. A., Besedin, E., & Holland, B. (2019). Waters of the United States: UPGRADING wetland valuation VIA benefit transfer. *Ecological Economics, 164*, 106336. doi:10.1016/j.ecolecon.2019.05.016

Public Open Spaces

Location	unit	Price from article	Price present value using mean	source
North Carolina	WTP/per household/year	10.97 – 21.79 per 300 acres of land	**$0.0764**	Cho et al. 2005

Cho, S., Newman, D. H., & Bowker, J. (2005). Measuring rural homeowners' willingness to pay for land conservation easements. *Forest Policy and Economics, 7*(5), 757-770. doi:10.1016/j.forpol.2005.03.007

Beach Value

South Carolina	**Willingness to Pay per ft of Beach Width per mile for homes within 800m of shoreline (1983)**	**Present value**	Source
	$36.3 per ft	**$70.77**	Pompe & Rinehart (1995) whitehead (2008)
North Carolina	**WTP Recreation (2008) per length**		
	$.19	**$.25**	

Pompe, J. J., & Rinehart, J. R. (1995). Beach quality and the enhancement of Recreational property values. *Journal of Leisure Research, 27*(2), 143-154. doi:10.1080/00222216.1995.11949739

Whitehead, J. C., Dumas, C. F., Herstine, J., Hill, J., & Buerger, B. (2008). Valuing beach access and width with revealed and stated preference data. Marine Resource Economics, 23(2), 119-135. doi:10.1086/mre.23.2.42629607

Corporate Tax Rate

Location	Commercial Poperty Tax Rate	Source
Virginia Beach	**0.96% (.0096)**	2019 50-State Property Tax Comparison Study by the Lincoln Institute of Land Policy and the Minnesota Center for Fiscal Excellence

Commercial

unit	general retail in 2019	present value	Source
Value of Commercial Space per Sq mile	15.37	**16.14**	2019 Hampton Roads Real Estate market review by Old Dominion University

Industrial

Unit	location	2018 value	present value	Source
value per square foot	Chesapeake	5.9	**6.34**	2019 Hampton Roads Real Estate market review by Old Dominion University

Critical Facilities

Facility	**# of Facilities**		**Present Value**	**Source**
Schools	5	$242.96 per square foot (Average Middle school size- 118,500 square feet). Per School- 28,800,000	29,520,000 per school	https://spaces4learning.com/articles/2015/07/01/school-costs.aspx
Universities	1	26 Academic Buildings (med size 55,820; 130.61 per sqft) 7 admin B.(med size 37,500; 60 per sqft) 1 12,000 seat stadium (50 mil) 21 dorms (med size 110,000;144.22 per sqft)	Academic Buildings: 194,295,828 Admin Buildings: 2,306,250 Stadium: 50,000,000 Dorms: 333,148,200 Total Cost: 579,750,278	https://cxre.co/real-estate-investment/understanding-the-owners-costs-of-commercial-build-outs/#BASIC_OFFICE_SPACE_51_TO_61SQUARE_FOOT https://evstudio.com/cost-per-square-foot-of-college-building-types-by-region/ CollegeConstructionReport2015.pdf

Post Offices	1	Size 1200 sqft? (100 per sqft)	120,000	https://evstudio.com/construction-cost-per-square-foot-for-a-post-office/
Cemeteries	4	Hampton National Cemetery: 27.071 acres Hampton National Cemetery (VAMC): 0.2 acres Parklawn Memorial Cemetery: 27.9 acres Clark Cemetery: 2.32 acres	80,000 per acre	https://www.cem.va.gov/cems/nchp/hampton.asp#ed https://www.cem.va.gov/cems/nchp/hamptonvamc.asp https://www.theforesightcompanies.com/blog/starting-a-cemetery-with-no-experience-has-not-gone-well/#:~:text=An%20investment%20of%20%2480%2C000%20per,in%20less%20than%20five%20years. https://www.planning.org/pas/reports/report16.htm
Hospitals	2	United States Air Force Hospital Langley: 60 beds Hampton Veterans Affairs Medical Center: 46 beds	500,000 per bed	https://hhbc.in/how-to-build-hospitals-fast-in-a-cost-effective-way/ https://www.fixr.com/costs/build-hospital#:~:text=roughly%20300%2C000sq.-,ft.,and%20space%20for%20120%20beds. https://www.va.gov/directory/guide/facility.asp?id=57#:~:text=Hampton%20VA%20Medical%20Center%2C%20a,of%20more%20than%20220%2C000%20veterans.
EMS/ fire station Stations	4	Small fire station: 8,000 sqft	190 per square foot	https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osRenovationNeedsOfUSFireStations.pdf

				https://www.sehinc.com/news/nine-major-trends-shaping-modern-fire-station-design#:~:text=Forty%20years%20ago%2C%20fire%20station,over%20the%20past%20decade%20especially. https://www.wbdg.org/FFC/AF/AFDG/ARCHIVES/firestationfacilities.pdf
Police Stations	1	Average cost to build police station ~6,000,000	6,000,000	https://www.cityofhomer-ak.gov/sites/default/files/fileattachments/memo/22471/memo_17-082_1_very_conceptual_cost_estimate_-_two_sites_6m-9m_-_revision_corrected_05.23.17.pdf https://evstudio.com/construction-cost-per-square-foot-for-a-police-station/ https://www.kbbi.org/post/qa-why-does-new-police-station-cost-75-million#stream/0
Daycares	1	Average building/land cost: 205,000	205,000	http://www.buildingchildcare.net/uploads/pdfs/Child-Care-Facility-Dev-Budget-Guide.pdf

Roads:
Gives the construction cost of roads per mile in rural and urban settings and depending on the number of lanes. We based our value off of a two-lane undivided road in a rural setting (which was $2-3 million per mile).

American Road & Transportation Builders Association. (2020, May 15). Frequently Asked Questions. Retrieved from https://www.artba.org/about/faq/

No-Action Scenario. The purpose of the no-action scenario is to determine the baseline economic cost of sea-level rise from 2021 to 2050. The no-action economic assessment estimated the values by using data from similar locations and relevant studies. Geographic Information System (GIS) analysis was used to determine the size of beaches, wetlands, and public open spaces, as well as the number of and size of commercial and residential parcels, critical facilities, and miles of road lost during inundation. All of the values were recalculated using the discount rate of 2.5% to estimate the 2021 value, and was adjusted for the difference between the size of locations as needed.

Discounting Factor. ERG (2013) recommended finding discounting factors either at the federal or state level. Virginia Department of Planning and Budget (2017) weighed the pros and cons of using a 2.5%, 3%, or 5% rate, regarding an impact assessment on air pollution. The smaller the percentage, the more money is worth in the future. I.e. 1 billion in 2050 is 87 million today at a 5% rate, whereas 1 billion in 2050 is $291 million today at a 2.5% rate. It gets more extreme as the time increases. We wanted to use a discounting factor that was provided by the state and felt that using a lower rate would be ideal to communicate to the city what a true worst-case scenario would look like.

Residential, Commercial and Industrial. In the study area, the average value of housing units is $192,049 (CERF, 2020). The value per square foot of a commercial space (e.g. general retail) is estimated to be $15.37, and the value per square foot of an industrial complex is estimated to be $5.90 (E.V. Williams Center for Real Estate, 2019).

Property and Commercial Tax Rate. The tax rate for private homes is $1.24 per $100 of assessed value in Hampton Virginia (City of Hampton, n.d.). The tax loss of private homes was determined by multiplying the tax rate, by the number of homes lost and the average home value. The commercial property tax rate was determined to be 0.96% (50-State Property Tax Comparison Study, 2019), and was multiplied by the commercial value.

Public Open Space. According to Cho et al. (2005) the average household in North Carolina is willing to pay 10.97 – 21.79 USD per 300 acres of land per year for public open spaces. This data was used to calculate the willingness to pay for public open space in the study area by calculating the value per acre and adjusting the costs to the size of public open space and number of homes.

Wetlands. According to Moltner et al. (2019), the willingness to pay to avoid losses of wetland (i.e. salt marshes) was determined to be $0.17 per person per acre in New Jersey, Pennsylvania, Delaware, and Maryland.

Beach. The value of beaches were split into two groups, the value for homes within half a mile of the shore, and the willingness to pay per foot of beach width. In South Carolina, the average house within 800 meters (approximately 0.5 mile) from the shoreline is willing to pay $606 per foot of beach width (Pompe & Rhinehart, 1999). Additionally, the average recreational value per foot of beach width in North Carolina is $0.19 per mile (Whitehead et al., 2008). These values were recalculated into present day values, and adjusted to account for the beach size and number of homes within the study area.

Roads. The value of the roads were determined using the construction costs of roads per mile in rural and urban settings, and further valued by the number of lanes (American Road & Transportation Builders Association, 2020). The cost of road loss in the study area was determined using the value of a two lane undivided road in a rural setting, which was $2-3 million per mile.

Critical Facilities

Schools. An article from Spaces4Learning was used to determine the construction cost of the average middle school per square feet along with the average school size which is 118,500 square feet and $242.96 per square foot.

Universities. The university values were estimated from a real estate agency named CXRE and by finding the amount of buildings on campus and estimating the square footage. In addition, a college construction report from 2015 was used. Once the square footage was obtained construction costs were used for academic buildings, administrative buildings, dorms, and a 12,000 seat stadium. The total cost came out to $579,750,278.

Post Office. Post offices' typically cost more to build than an average building so specific construction costs per square footage were found to calculate the value. This estimation came from an engineering and architecture studio called EVstudio. The estimated square footage used was 1,200 square feet with $100 per square foot.

Cemeteries. It is estimated that a cemetery costs about $80,000 per acre to build and maintain due to individual plots of land. The cemetery estimation was calculated by finding all acres of cemeteries and multiplying by 80,000. Foresight consulting was the source used to estimate costs and the National Cemetery Administration from the U.S. Department of Affairs was used to estimate the size of the cemeteries.

Hospitals. The hospitals' value was found by using a per bed formula construction cost with $500,000 per bed. The formula was taken from HOSPACCX, an architecture and design consulting agency. The hospital beds were found from the Veterans Affairs website. It did not take into consideration the extra buildings that the Hampton Veterans Affairs Medical Center has.

EMS/Fire Stations. To estimate the value of the EMS and fire stations, the average size of a small fire station was used multiplied by the construction cost per square foot. The estimated costs were taken from the National Fire Protection Association and various local news articles. Which came out to a small fire station being 8,000 square feet and $190 per square foot.

Police Stations. Using articles for new police stations from New Homer, Arkansaw, Alaska, and EVstudio was used to estimate the average cost to build a police station which came to $6,000,000.

Daycares. Since there were not many sources regarding daycare costs, a facility budget guide from the Low Income Investment Fund was used. the building and land cost came out to $205,000.

Formulas. Based on the values described above, the loss categories were calculated as follows:

1. Beach Value: (WTP per ft of width * households within 0.5mi * ft beach width loss) + (WTP Recreation * households within 0.5mi) /1,000,000
2. Roads: miles of roads lost * value of roads per mile (millions)
3. Wetlands: (recreational value per person per acre * number of households in hampton * 2.41 * acres lost) / 1,000,000
4. Public Open Space: (WTP per person per acre * number of households in hampton * 2.41 * acres lost) / 1,000,000
5. Critical Facilities: (number of schools * average value of middle school) + (number of fire/police stations * average price of fire/police station + (number of hospital beds * value of single hospital bed) + (value of hampton university buildings) + (number of cemetery acres * value of cemetery acres) + (square feet of post office * value of sq ft of post offices) + (number of daycares * average value of a daycare) did not divide by one million, all inputted values were adjusted to represent one million.
6. Homes: (number of residential parcels lost * median value of Homes in Hampton VA) / 1,000,000
7. Property Tax: (((Hampton tax rate per 100 dollars * median value of homes in Hampton) / 100) * number of residential parcels lost) / 1,000,000
8. Commercial Property: (value of commercial general retail space per sq ft * sq ft lost) / 1,000,000
9. Commercial Property Tax: (commercial property tax rate * sum commercial property value lost) / 1,000,000
10. Industrial Property: (value of industrial space per sq ft * sq ft lost) / 1,000,000
11. Industrial Property Tax: (value of commercial property tax rate * sum of industrial property value lost) / 1,000,000