

Planning for Sea Level Rise and Storm Surge to Protect Coastal Municipalities and Ecosystems



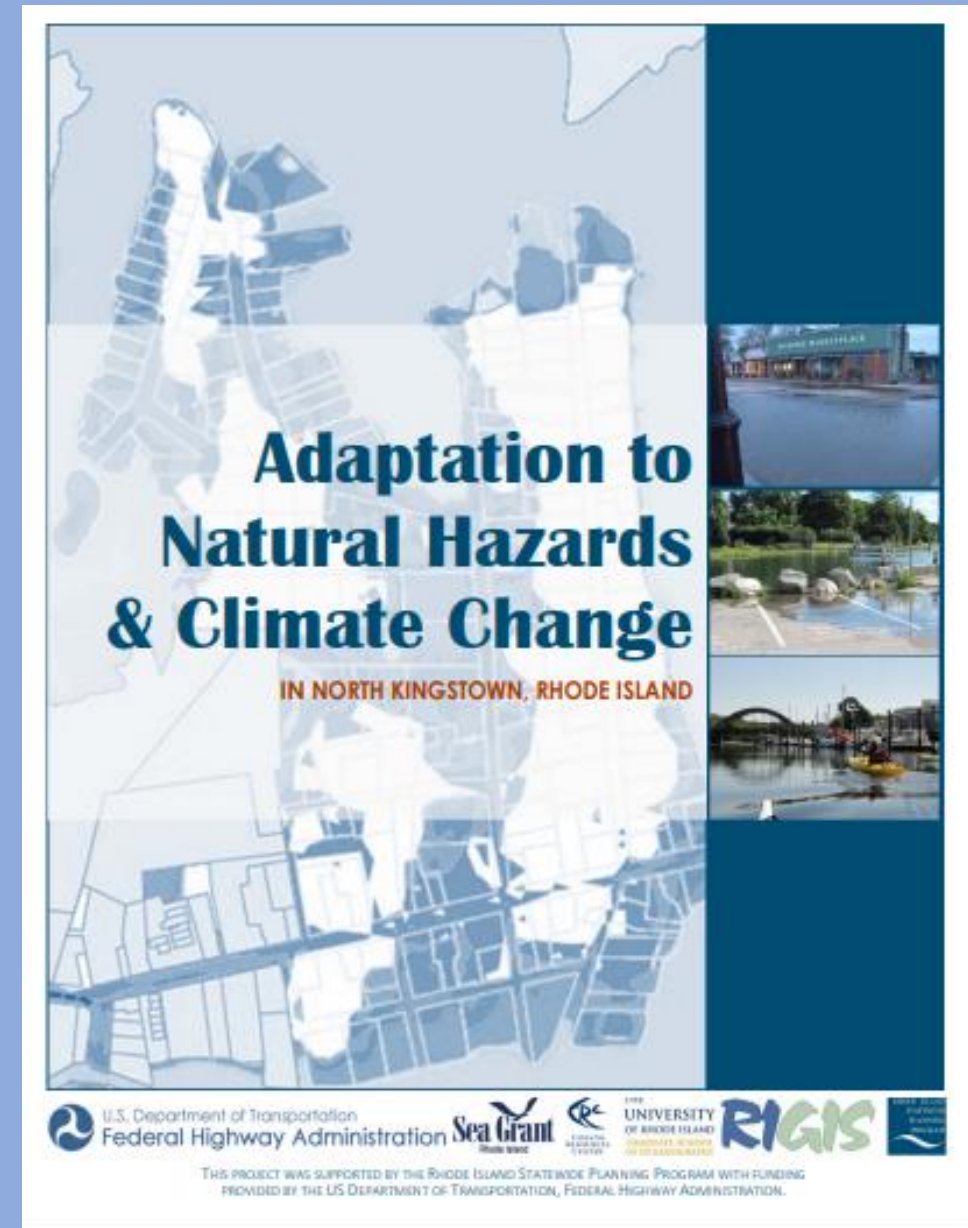
<https://maineimaging.smugmug.com/Aerials/Rhode-Island/Warren-RI-aerial-photos/>

Information Gathering Project

**Kelly Medeiros
MESM - URI
28 August 2018**

Project

- Information gathering
 - Deliverables:
 - Summaries of resources
 - A 2-3 page overview of information gathering
 - Presentation to start discussion
- Provided with resources
- North Kingstown Adaptation Report
- Started the Search ...
- Summarized the plans/reports



Coastal Climate Change Vulnerability Assessment And Adaptation Plan

City of Gloucester, MA
June 29, 2015



Climate Change Vulnerability, Risk Assessment and Adaptation Study

Town of Hingham, MA
June 29, 2015



COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON AND CHARLESTOWN

FINAL REPORT

October 2017



Mayor Martin J. Walsh



Dutch Dialogues VIRGINIA

LIFE at SEA LEVEL



CITY REPORT 2015

NORFOLK

Milan * New York City * Quito
 Melbourne * Rome * Thessaloniki
 Rotterdam * Athens * Paris
 Dakar * Juarez * Boston
 Dallas * Vejle * Norfolk, Virginia
 Medellín * Bangkok * Rio de Janeiro
 Barcelona * Los Angeles
 Rome * Chicago * Da Nang
 New Orleans * Kigali * Huangshi
 Singapore * Lisbon * Mexico City
 Cali * Santiago de los Caballeros
 Belgrade * Ramallah * Glasgow
 Montreal * Mandalay * Accra
 London * El Paso * Bangalore
 Surat * Jacksonville * San Juan
 Durban * Sydney * Pittsburgh
 Amman * Semarang * Enugu
 Porto Alegre * San Francisco
 Deyang * Santiago, Metropolitan
 Region * Ashkelon * Wellington
 City * St. Louis * Toyama * Byblos
 Arusha * Christchurch * Tulsa
 Chennai * Oakland * Bristol
 Santa Fe * Berkeley * Boulder



NORFOLKVISION2100

OPPORTUNITY. COLLABORATION. VISION.

Opportunity The challenge of sea level rise provides opportunity to transform Norfolk into a resilient waterfront community	Collaboration Collective leadership drives innovative solutions and new ways of thinking	Vision Norfolk is THE coastal community of the future
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WAGGONNER & BALL

Overall City/Town Project Approach

- Step 1: Estimate a climate baseline
 - Storm surge, SLR curve, precipitation, temperature, weather, sea level rise levels
 - SLR modeling
 - Determine SLR elevations
 - Set planning horizons - 2030 and 2050
- Step 2: Assessing risk
 - Prioritizing risk – vulnerability vs risk
 - Sensitivity vs probability
- Step 3: Develop solutions
 - Gather data – GIS
 - Public input
 - Assess risk
 - Recommend solutions
 - Complete coastal resilience plan

Summaries

- Title and link to resource
- Project team
- Short summary of goals
- Outlined methods and strategies
- Additional resource links

**Planning for Sea Level Rise and Storm Surge to Protect Coastal Municipalities and Ecosystems
Information Gathering Project - KCMedeiros**

5 August 2018

City of Gloucester Coastal Climate Change Vulnerability Assessment and Adaptation Plan

Project Team:

Andre Martecchini, Nasser Brahim and Indrani Ghosh – Kleinfelder

Kirk Bosma – Woods Hole Group

City of Gloucester Working Group |

Resources:

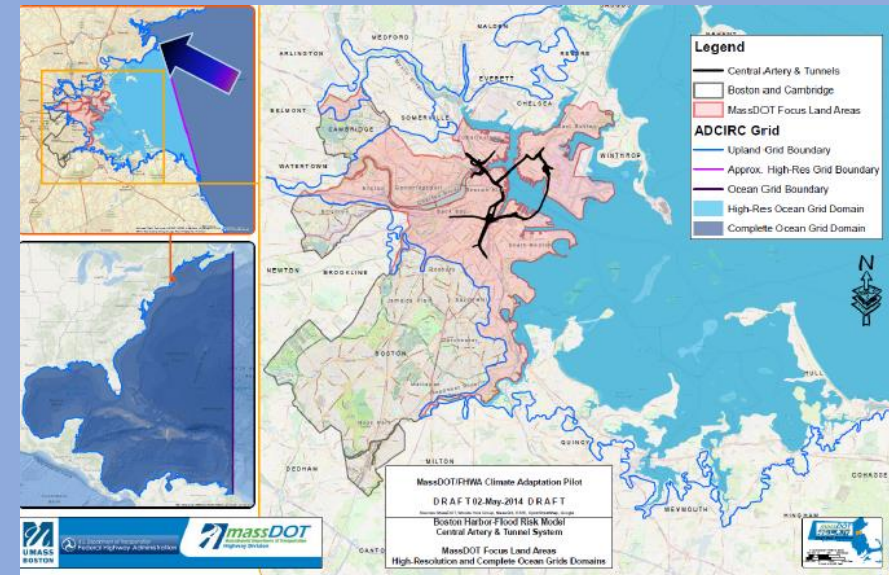
- 1) *Public meeting slides 6/16/15* <http://gloucester-ma.gov/DocumentCenter/View/3412>
- 2) *Adaptation Plan 6/29/15* <https://gloucester-ma.gov/DocumentCenter/View/3416>

Local officials for the City of Gloucester have identified floods caused by hurricanes, nor'easters, severe rainstorms and thunderstorms to be the most serious natural hazard. The project objectives include developing appropriate sea level rise and storm surge scenarios, understanding vulnerability of municipal infrastructure and natural resources to sea level rise and storm surge, developing potential short-, mid- and long-term adaptation strategies producing high quality products that will not only move the project forward but help with public outreach and education programs. There is a phased project approach with 3 phases 1) Sea Level/Storm Surge Scenario Development, 2) Mapping Inundation Modeling Vulnerability/Risk Assessment and 3) Develop Adaptation Strategies and Public Outreach

Gloucester

Phased project approach

- 1) Sea Level/Storm Surge Scenario Development,
- 2) Mapping Inundation Modeling Vulnerability/Risk Assessment
- 3) Develop Adaptation Strategies and Public Outreach



Gloucester

Planning Horizons

The models were not developed as “worst case” but developed as “worst likely” scenarios for three planning horizons

- 2013 to present
- 15 years out -2030 (Total Relative SLR “Highest” – 0.66 ft)
- 55 years out –2070 (Total Relative SLR “Highest” – 3.39 ft)

Gloucester

Infrastructure Strategies:

- Raise waterfront structures
- Permanent flood barrier – raising elevations of roads
- Hurricane barrier system (examples from New Bedford, Stamford and Providence)
- Marsh restoration
- Beach and dune restoration
- Concrete Permanent Flood Wall
- Glass Flood Wall
- Self-Regulating Tide Gates
- Decorative Permanent Flood Wall
- Green flood-proofing with Landscape Berms

Gloucester

Zoning Strategies:

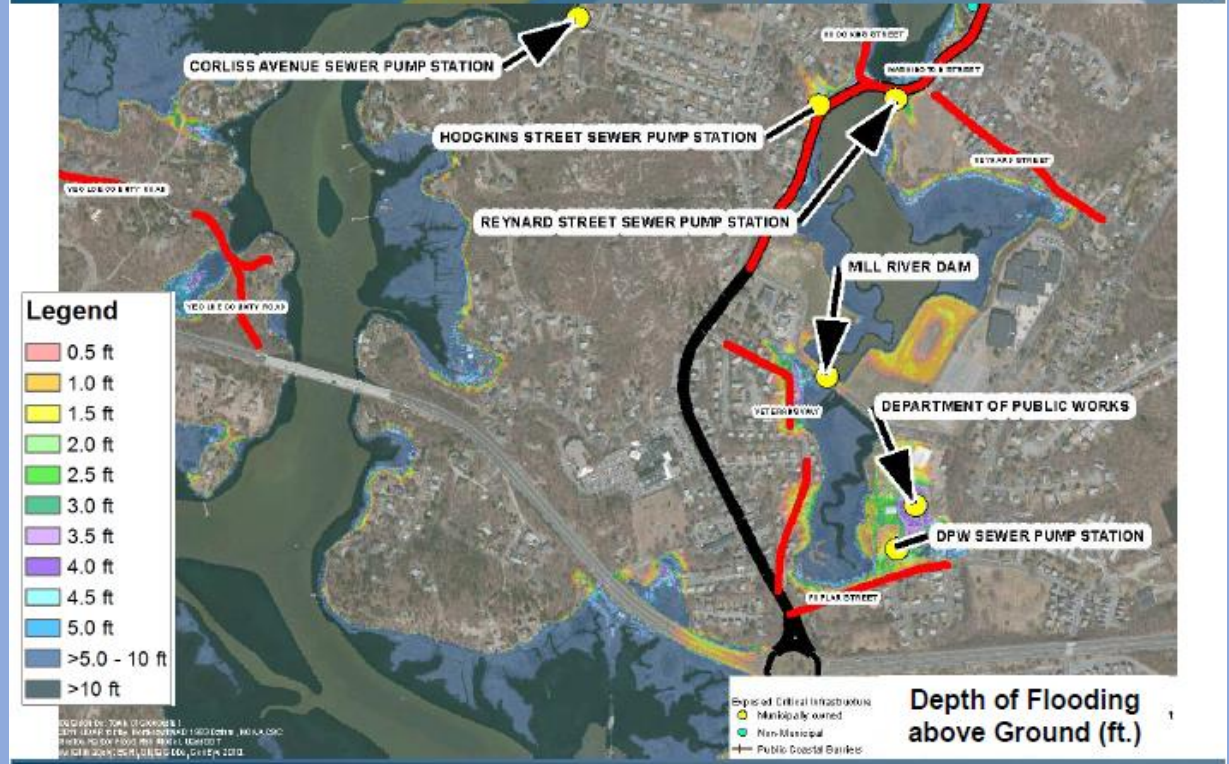
- Provide performance standards
- Clearer definitions
- Increase buffer zones
- Provide incentives
 - Freeboard incentive” -“...the Town of Hull adopted a “freeboard incentive” that reduces building department application fees by \$500 if an elevation certificate is provided to verify that the building is elevated a minimum of two feet above the highest federal and state requirement for the flood zone.”
- Develop an environmental impact evaluation
- Land acquisition through rolling easement programs – “retreat policy”
- Update hazard mitigation plans

Route 128 at Washington Street 2030: 1% Annual Probability (≈100 yr Recurrence)



<https://gloucester-ma.gov/DocumentCenter/View/3416>

Route 128 at Washington Street 2070: 1% Annual Probability (≈100 yr Recurrence)

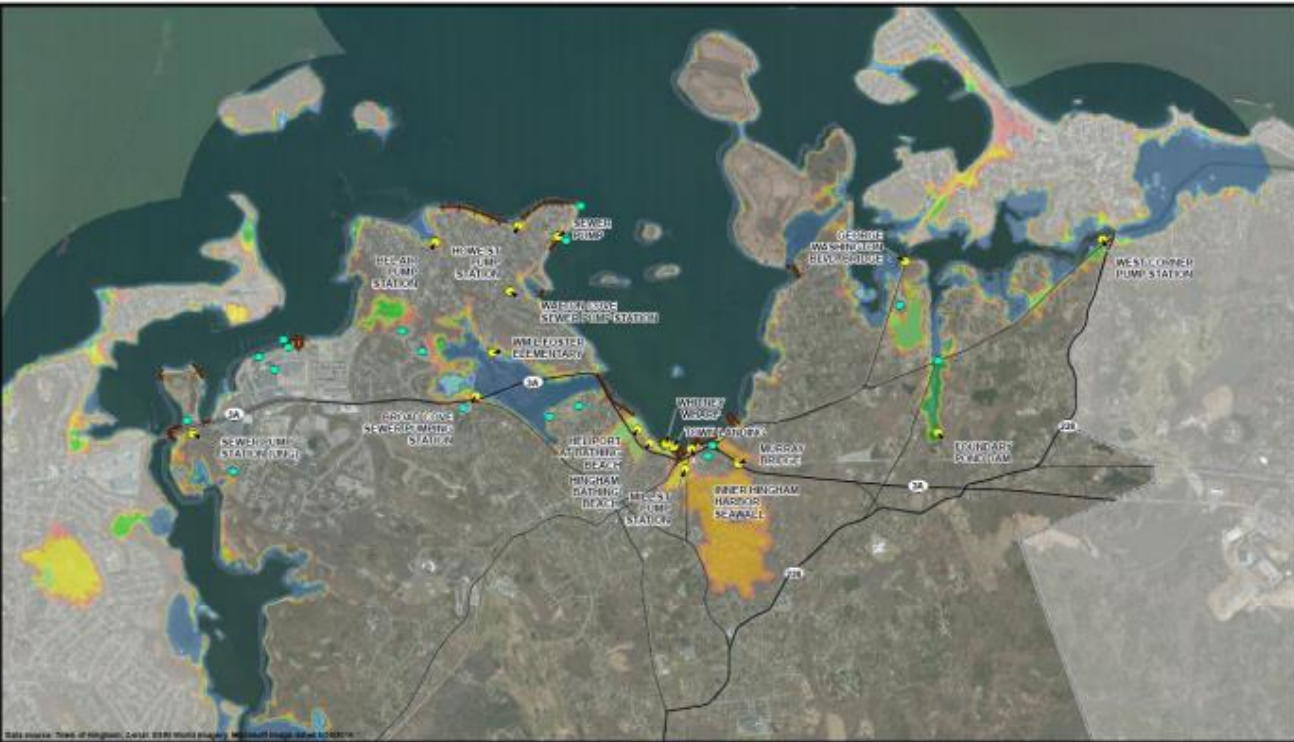


Hingham

Goals:

- 1) Identify areas of the town that are vulnerable to the combined effects of sea level rise and storm surge from extreme storm events
- 2) Assess the vulnerability of municipally-owned public infrastructure and natural resources
- 3) Identify adaptation strategies that will help to mitigate the long-term effects of sea level rise and storm surge
- 4) Educate the public, town officials and state legislators about those potential impacts





PROJECT NO. 2010020
 DRAWN: APR 2010
 DRAWN BY: KPH
 CHECKED BY: NB
 FILE NAME: 00yr_2010.mxd

2030 - DEPTH OF FLOODING AT 0.2% ANNUAL PROBABILITY (~500 YR RECURRENCE)

C2M Resiliency Grant
 Hingham, Massachusetts

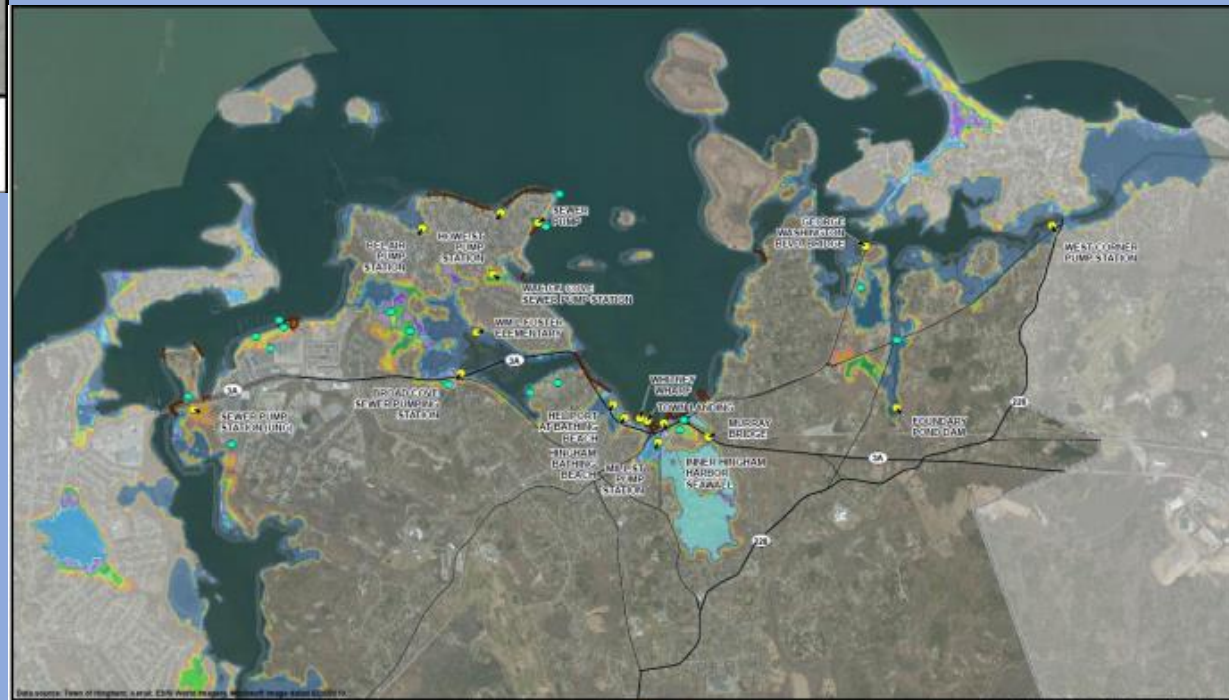
LEGEND
 Exposed Critical Infrastructure:
 - Municipally owned (Yellow circle)
 - Non-Municipal (Green circle)
 - Public Coastal Barriers (Black line)
 Depth of flooding above ground for 0.2% risk (in feet):
 - Dry (White)
 - 0.5 ft (Light Yellow)
 - 1 ft (Yellow)
 - 1.5 ft (Light Green)
 - 2 ft (Green)
 - 2.5 ft (Light Blue)
 - 3 ft (Green)
 - 3.5 ft (Light Blue)
 - 4 ft (Blue)
 - 4.5 ft (Dark Blue)
 - 5 ft (Dark Blue)
 - 5-10 ft (Dark Grey)
 - > 10 ft (Black)

KLEINFELDER
 Bright People. Bright Solutions.
 www.kleinfelder.com

PROJECT NO. 2010020
 DRAWN: APR 2010
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 FILE NAME: 00yr_2010.mxd

FIGURE A-7

<https://www.hingham-ma.gov/DocumentCenter/View/1082/Hingham-Climate-Change-Vulnerability-Risk-Assessment-and-Adaptation-Final-Report-PDF>



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 Hingham, Massachusetts

LEGEND
 Exposed Critical Infrastructure:
 - Municipally owned (Yellow circle)
 - Non-Municipal (Green circle)
 - Public Coastal Barriers (Black line)
 Depth of flooding above ground for 1% risk (in feet):
 - Dry (White)
 - 0.5 ft (Light Yellow)
 - 1 ft (Yellow)
 - 1.5 ft (Light Green)
 - 2 ft (Green)
 - 2.5 ft (Light Blue)
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PROJECT NO. 2010020
 DRAWN: APR 2010
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 CHECKED BY: NB
 FILE NAME: 00yr_2010.mxd

FIGURE A-8

Hingham

Infrastructure Strategies:

- Raise and improve existing waterfront structures
- Incentivize or “compel” private seawall owners to meet adjoining structures
- New seawalls
- Raise roadways (3D modeling)
- Increase culverts – more tidal flushing
- Naturally evolve – “wait and see”
- Beach and dune restoration
- Green resilience for fringing marsh areas
- Thin layer deposition, marsh expansion, living shorelines



<https://www.hingham-ma.gov/DocumentCenter/View/1082/Hingham-Climate-Change-Vulnerability-Risk-Assessment-and-Adaptation-Final-Report-PDF>

Hingham

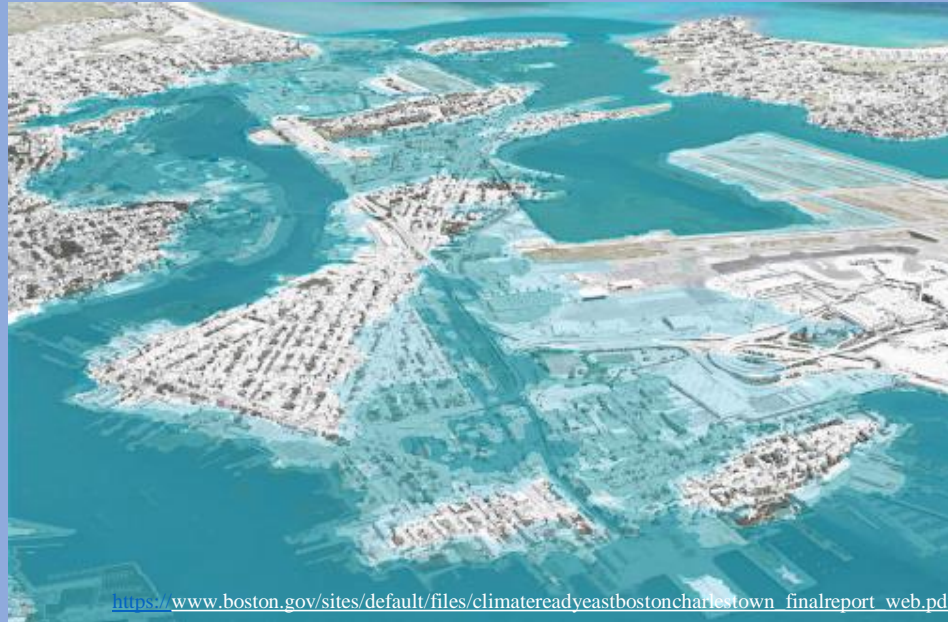
Wetlands and Zoning Strategies:

- Provide performance standards
- Clearer definitions
- Increase buffer zones
- Establish a Coastal Management Zone district
- Provide incentives
 - Freeboard incentive” -“...the Town of Hull adopted a “freeboard incentive” that reduces building department application fees by \$500 if an elevation certificate is provided to verify that the building is elevated a minimum of two feet above the highest federal and state requirement for the flood zone.”
- Allow for cluster development
- Land acquisition through rolling easement programs – “retreat policy”
- Assess becoming a Green Community
- Evaluate the hazard Mitigation Plan
- Develop a regular/inventory report
- Develop a Coastal Flood Operations Plan



East Boston and Charlestown, MA

Most vulnerable areas to coastal flooding because they are currently at risk from the “1% annual chance coastal flooding”.



Definition: “**1% annual chance**” is defined as having a 1 in 100 chance of being equaled or exceeded in any given year and is the primary coastal flood hazard delineated in FEMA flood maps. A 1 percent annual chance event could occur multiple times in a given year, decade or century. Climate Ready Boston uses “1 percent annual chance flood” instead of “100 year flood event” due to potential misinterpretation.

East Boston and Charlestown, MA

Proposals:

- Elevated waterfront parks
- Enhanced harbor walks
- Improved connections to the waterfront
- Natural wetland buffers
- Increased tree canopy to address higher temperatures
- Hardscaped seating stairs and furnishings
- Compatible, resilient, mixed-use redevelopment with smaller footprints
- Varying building heights and density



https://www.boston.gov/sites/default/files/climatereadyeastbostoncharlestown_finalreport_web.pdf



East Boston and Charlestown, MA

Zoning Code and Article 80 Development Revision Suggestions:

- Establish Flood Protection Overlay District
- Establish Interim Planning Overlay District
- Transfer of priority parcels
- increase open space requirements
- Require information on project location relative to coastal flood pathways
- Add standards for project review approval in the Flood Protection Overlay Districts



https://www.boston.gov/sites/default/files/climatereadyeastbostoncharlestown_finalreport_web.pdf

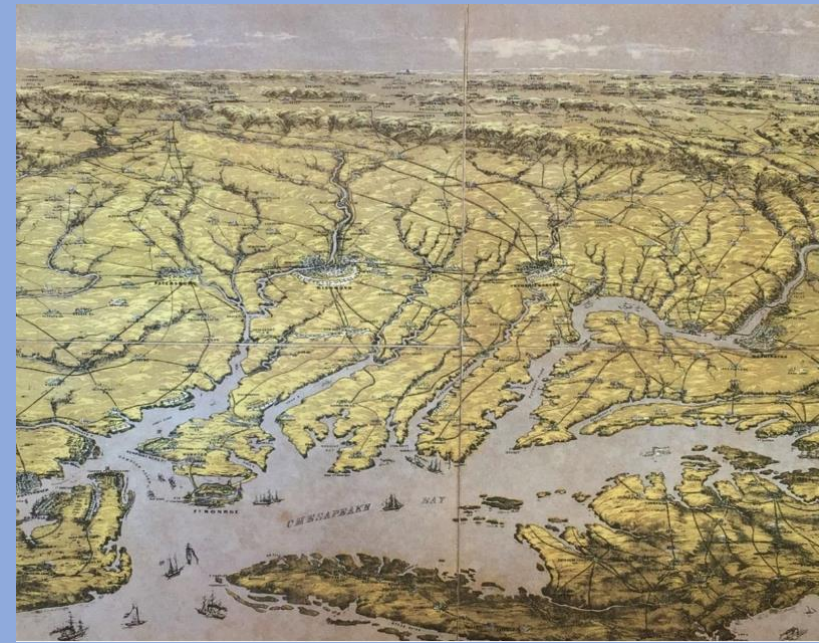
It is recommended that this project be designed and operated to the standards set by the Army Corps of Engineers and FEMA so the project will be eligible for federal funding if there are repairs needed in the future.

Norfolk, VA

Design the “coastal community of the future”.

Strategies:

- 1) Collectively create a vision for the future for the City
- 2) Access, identify and implement innovative infrastructure for managing water
- 3) Create a place where people want to live, work and play
- 4) Redesign tools and regulations to achieve the above goals

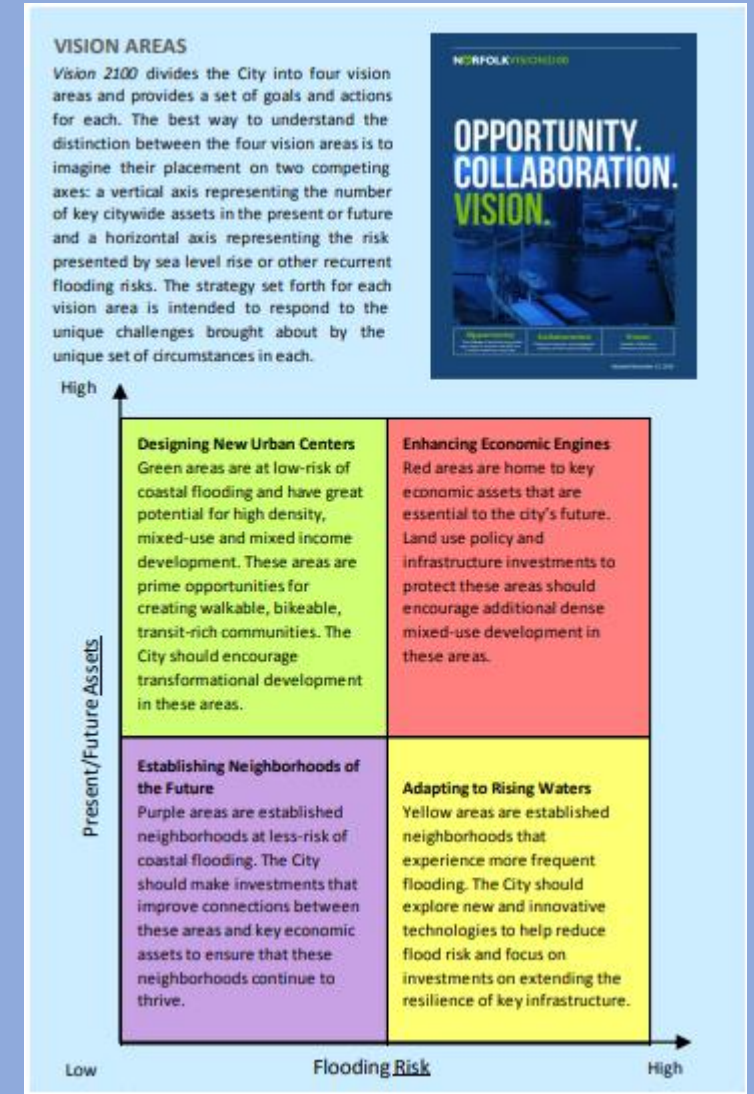


<https://wparch.com/dutch-dialogues-va-life-at-sea-level/>

Norfolk, VA

Strategy 1: The City is developing the vision for the future using a design-based dialogues.

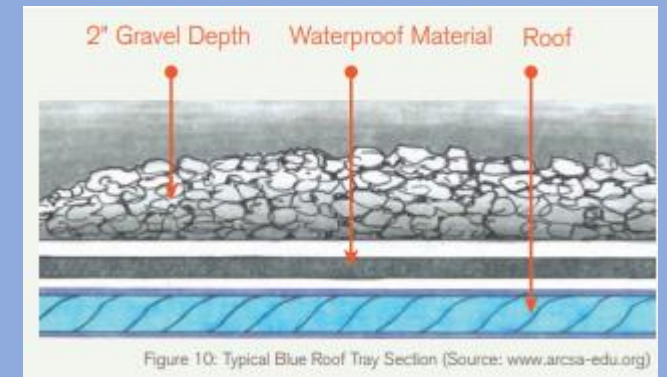
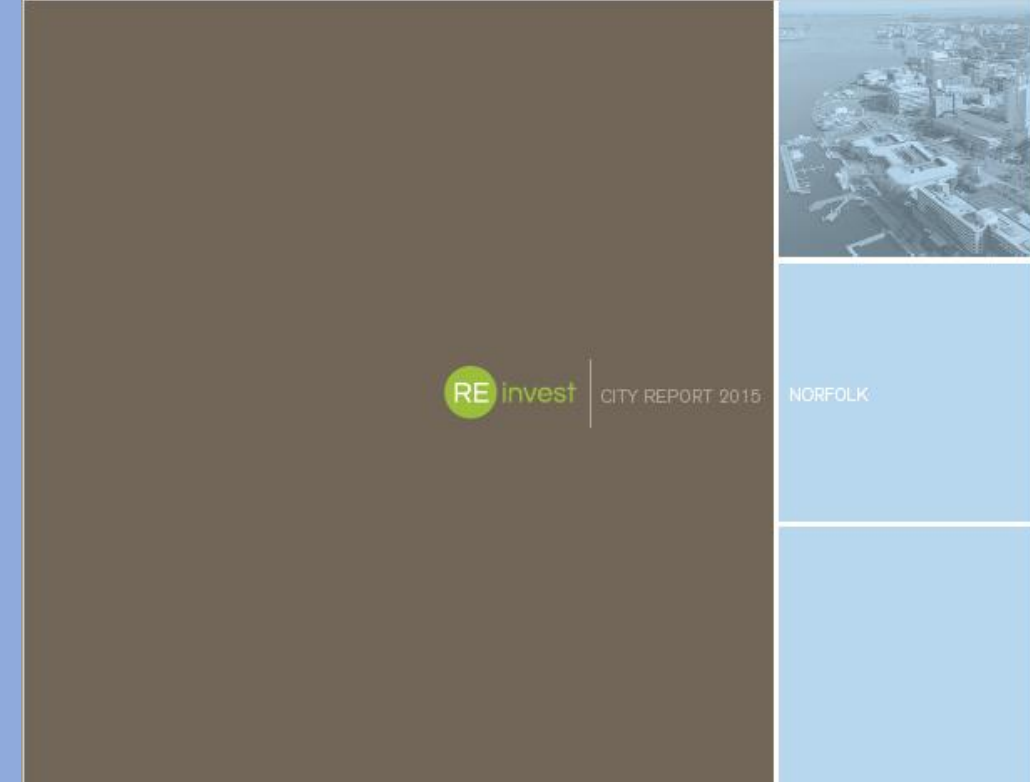
- Action: Launch Vision2100
 - a citizen led discussion to identify future land use decisions for the City
- Action: Develop “next-generation” water management strategies – hosted Virginia Dutch Dialogues (June 2015)



Norfolk, VA

Strategy 2: Hard and soft infrastructure and creative funding solutions will be developed to implement new innovative approaches to managing water.

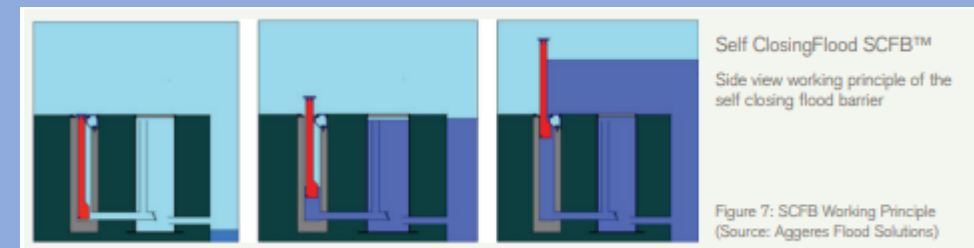
- Action: *RE.invest* provided new design ideas for flood control
- Action: Manage living with water
- Action: Participate in Structures of Coastal Resilience initiative.
 - New design concepts including “fingers of high ground” creating areas that can be developed even with the reality of sea level rise. This is included in Vision2100 planning.
- Action: Partner with the Army Corps of Engineers on flood risk study



RE.invest

Suggested practices:

- Blue Roofs
 - Non-vegetated point source controls that detain stormwater that can reduce the urban heat island effect and are inexpensive options (implemented by New York City)
- Raised Planter Boxes
 - Flow-through stormwater treatment facilities adjacent to buildings and disconnected downspouts – provide temporary retention during storm events
- Green Alleys
 - Alleys designed in order to help manage stormwater, reduce urban heat island effects and conserve energy
 - Replacement of asphalt to permeable pavement and a PVC pipe near the bottom of the storage media could create additional storage within the watershed to delay entry into the system.



RE.invest

Suggested practices:

- Permeable Pavement
 - Non-traditional pavement surfaces that allow stormwater runoff to filter through voids in the surface into a stone reservoir below where this water can either be retained or allow to replenish the groundwater
 - Pervious concrete, porous asphalt and interlocking pavers
- Stormwater Tree Trench
 - Subsurface trench with a stone reservoir for stormwater runoff retention and conveyance along with sections of engineered soil for growth of trees
 - Collects surface runoff via inlets and overland flow and conveys surface flow to subsurface trench and is stored temporarily in the voids and provides water to the trees
- Surface Depression Storage
 - Medians and grassy areas should be excavated to a 6 inch depth in order for stormwater runoff to pond temporarily in medians and grassy areas



Norfolk, VA

Strategy 3: Continue to develop protected coastline and downtown through infrastructure investment to keep it an attractive place to live and visit.



Norfolk, VA

Strategy 4: Create government processes and regulatory actions that support resiliency.

- Action: Planning Department to re-write the zoning codes
- Action: Incorporate lessons and technical assistance from a 100RC land use workshop to report in Leveraging Land Use Regulation to Achieve City Resilience Goals
- Action: Use Better Block demos to test design ideas. These are already driving permanent improvements
- Action: Update the Long-Term Recovery Plan
- Action: Develop a new rapid housing recovery model in the wake of disaster



Dutch Dialogues VIRGINIA

LIFE *at* SEA LEVEL



“But with sea level rise and increased storm intensity, we need to expand our thinking and our solutions and develop creative new infrastructure systems at both the edge and within the city. We need to think differently about how we build, how we connect, and how we live with and embrace the water.”

- Plan
- Prepare
- Mitigate
- Communicate

Dutch *Dialogues*: Virginia

- Sponsored by Royal Netherlands Embassy
- Participants:
 - Dutch urban designers, engineers, landscape architects, planners and academics and government officials
- Major Strategies:
 - Rain gardens
 - Cisterns
 - Living shorelines
 - Marshes, streams and berms

Dutch Dialogues

- A phasing approach should be considered
- Coalition or compact should be developed for the communities that will be most impacted
- Retain, restore and drain

Design ideas:

- *Architectural embankment*
 - Combine architectural and urban development to protect areas behind the embankment
- *Folding the ground level*
 - Higher berm to protect behind industrial areas
- *Landscaping the shorelines*
 - Picking up the quality of existing shoreline and trying to design shoreline that will be ready
 - Work with green and grayscapes for berm development
 - Water storage is critical
 - Systems that are developed to create an intervention with water are key to the design for the future.

Town of Stonington

Coastal Resilience Plan

August 2017



OLD SAYBROOK

Connecticut



BEVERLY COASTAL RESILIENCY PLAN

JUNE 30, 2017

Overview

- Infrastructure and governing strategies are fairly standard across plans
- Process and implementation status varies
- Cost benefit analysis is critical – some towns/cities are more prepared than others
- Assess the success of the process of developing strategies
- Important to reach out to more towns/cities that have already started implementing strategies
- Continuous monitoring and adaptation as time goes on

