COASTAL RESILIENCE IN RHODE ISLAND

Introduction to STORMTOOLS & RI Adaptation in Progress









Coastal Risk in Rhode Island







1938 Hurricane High Water Mark

> Wickford, RI Brown Street

Superstorm Sandy October 2012 4-foot storm surge

> Wickford, RI Brown Street Parking Lot

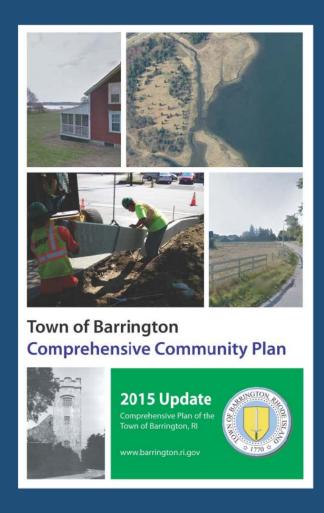
High Tide March 3, 2018

East Bay Bike Path Bristol, RI

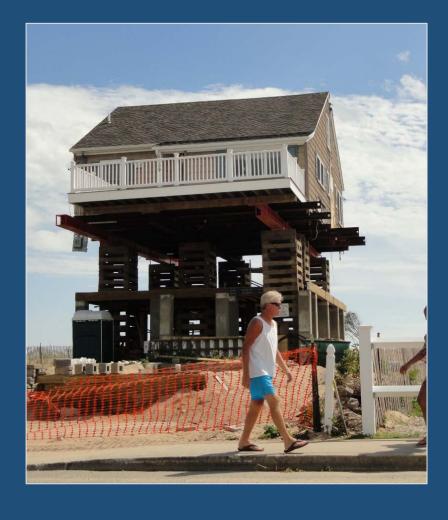
Know Your Risk

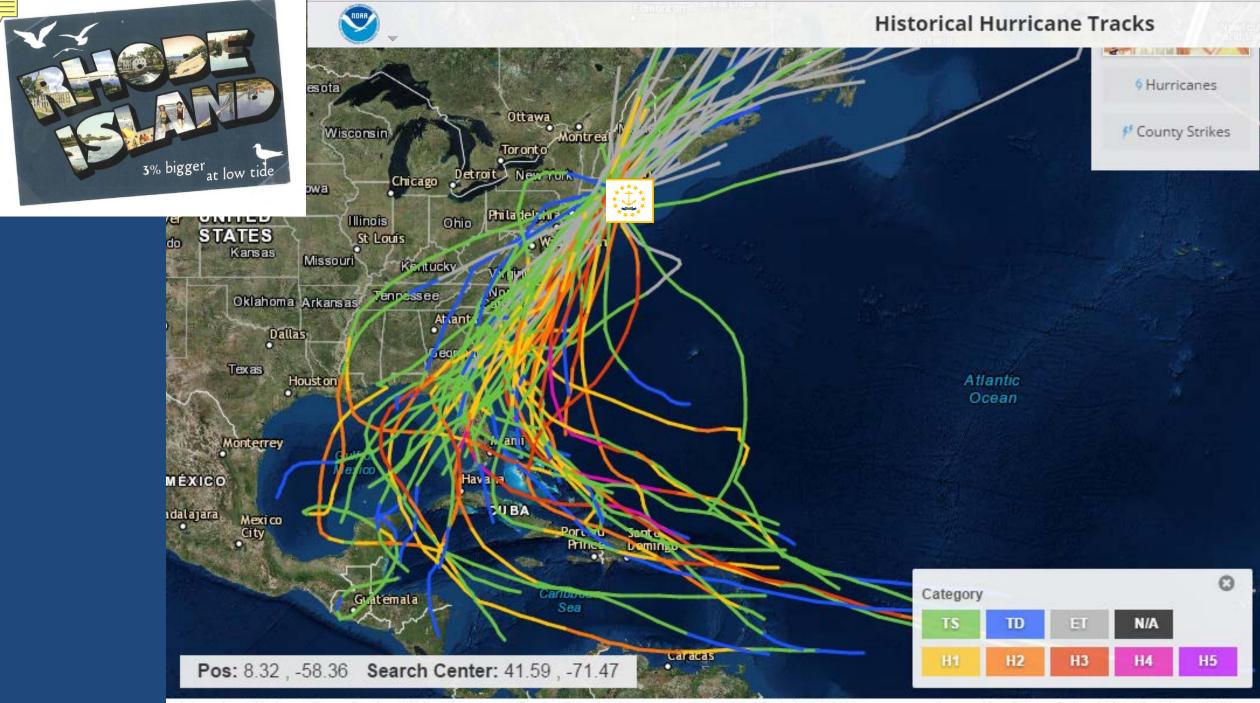
Port smouth

Make a Plan



Take Action



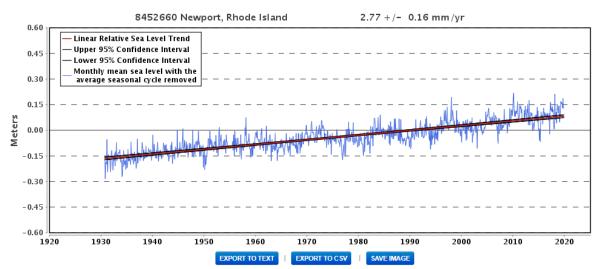




Sea Level Rise

PAST

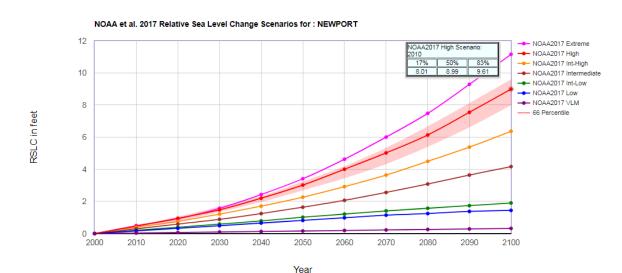
Relative Sea Level Trend 8452660 Newport, Rhode Island



The relative sea level trend is 2.77 millimeters/year with a 95% confidence interval of +/- 0.16 mm/yr based on monthly mean sea level data from 1930 to 2018 which is equivalent to a change of 0.91 feet in 100 years.

FUTURE

Gauge/Grid Selected: NEWPORT NOAA2017 V.Lh. 0.00322 feetly 66 Percentille Confidence Range for the High Scenario is shown All values expressed in feet Lines shown are the result of interpolation between values plotted













STORMTOOLS for Beginners

Advanced STORMTOOLS

Coastal Environmental Risk Index

Rhode Island e911 Exposure Assessment

STORMTOOLS Design Elevation (SDE) Maps

STORMTOOLS

RI Shoreline Change Special Area Manangement Plan

STORMTOOLS is a method to illustrate and display storm inundation, with and without sea level rise, for different types of storms that could occur along Rhode Island's coast line.

www.beachsamp.org/stormtools

or

https://stormtools-mainpage-crc-uri.hub.arcgis.com/

STORMTOOLS' Sea Level Rise Scenarios

ArcGIS ♥ STORMTOOLS for Beginners Modify Map & Sign In ■ Details | ■ Basemap | ■ Share ♣ Print - | ➡ Measure Find address or place Legend Will 1-FOOT of SEA LEVEL RISE affect my property? Will 2-FEET of SEA LEVEL RISE affect my property? Will 3-FEET of SEA LEVEL RISE affect my property? Will 5-FEET of SEA LEVEL RISE affect my property? Will 7-FEET of SEA LEVEL RISE affect my property? Will 10-FEET of SEA LEVEL RISE affect my property? Will 12-FEET of SEA LEVEL RISE affect my property?

STORMTOOLS – Storm Surge Scenarios

ArcGIS ♥ STORMTOOLS for Beginners Modify Map & Sign In ■ Details | ■ Basemap | ■ Share 🖶 Print 🕶 | 🛗 Measure | Find address or place 1 About Content ELegend Legend Is my property vulnerable to a 100-year return period (1% annual chance) COASTAL STORM, and how DEEP will the Stafford Springs Adjacent Lowlying Area Management

STORMTOOLS - Seekonk River to Blackstone River

ArcGIS ♥ STORMTOOLS for Beginners Modify Map & Sign In ■ Share 🖶 Print 🗸 📮 Measure Find address or place 1 About Content Legend Contents ▶ ☐ Rhode Island Addressed Structures ☑ Will 1-FOOT of SEA LEVEL RISE affect my property? ✓ Will 2-FEET of SEA LEVEL RISE affect my property? ✓ Will 3-FEET of SEA LEVEL RISE affect my property? ☑ Will 5-FEET of SEA LEVEL RISE affect my property? ☑ Will 7-FEET of SEA LEVEL RISE affect my property? ☑ Will 10-FEET of SEA LEVEL RISE affect my property? ☑ Will 12-FEET of SEA LEVEL RISE affect my property? ☐ Is my property vulnerable to a 100-year return period (1% annual chance) COASTAL STORM, and how DEEP will the water be? T III 🙀 ... ☐ Is my property vulnerable to a 100-year return period (1% annual chance) COASTAL STORM with 2 Feet Sea Level Rise ▶ @ Imagery Hybrid

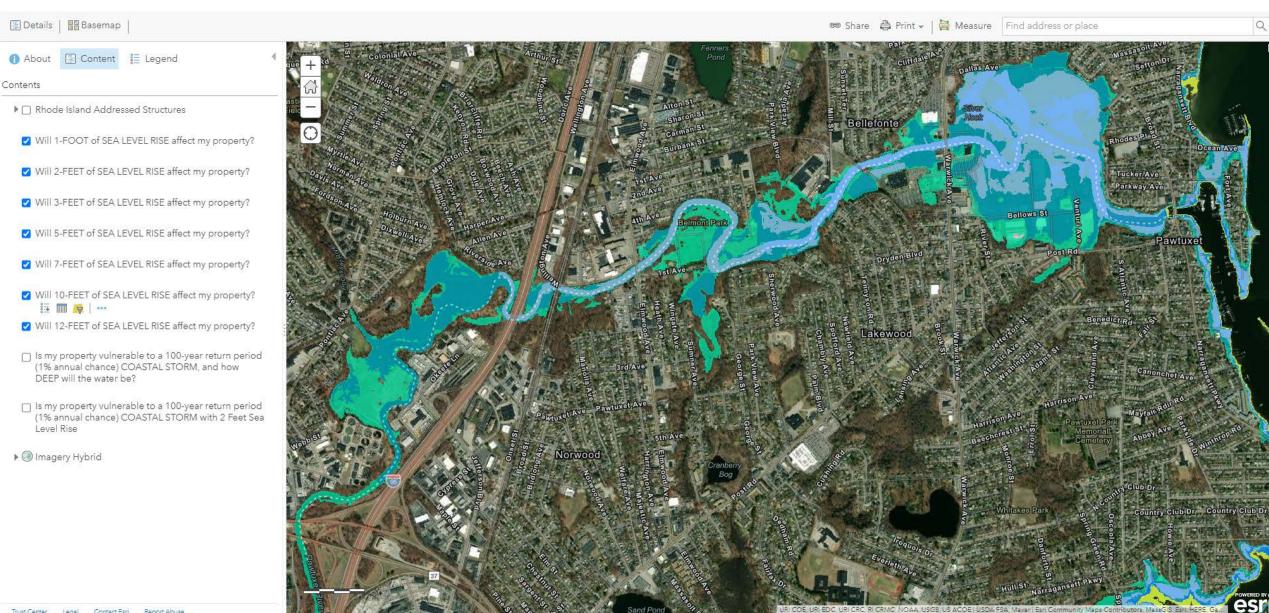
URI COE, URI EDC, URI CRC, RI CRMC, NOAA, USGS, US ACOE | USDA FSA, Maxar | Esri Community Maps Contributors, MassGIS, BuildingFoot...

STORMTOOLS – Woonasquatucket River

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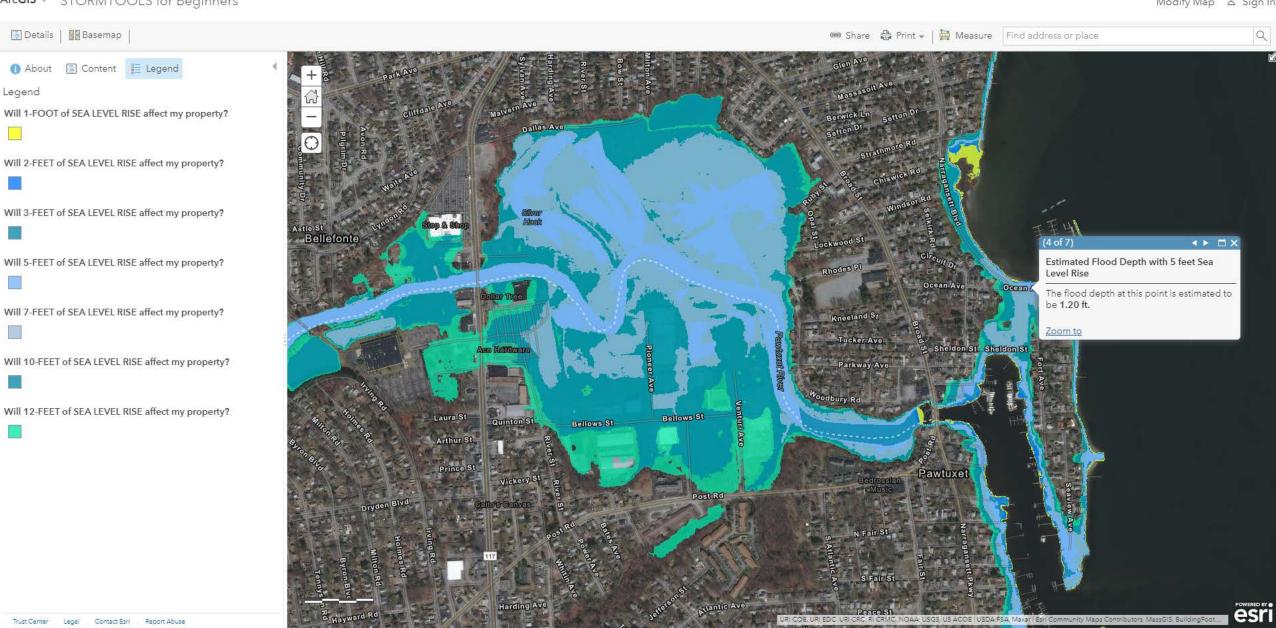
STORMTOOLS – Pawtuxet River

ArcGIS V STORMTOOLS for Beginners Modify Map & Sign In



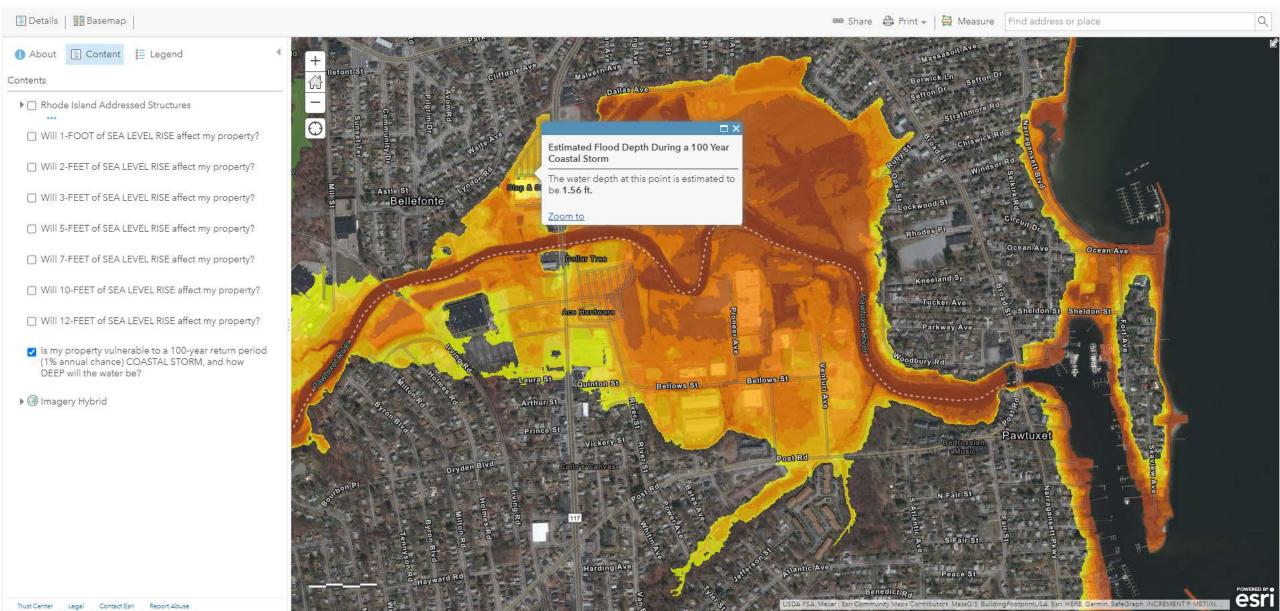
STORMTOOLS – Pawtuxet River

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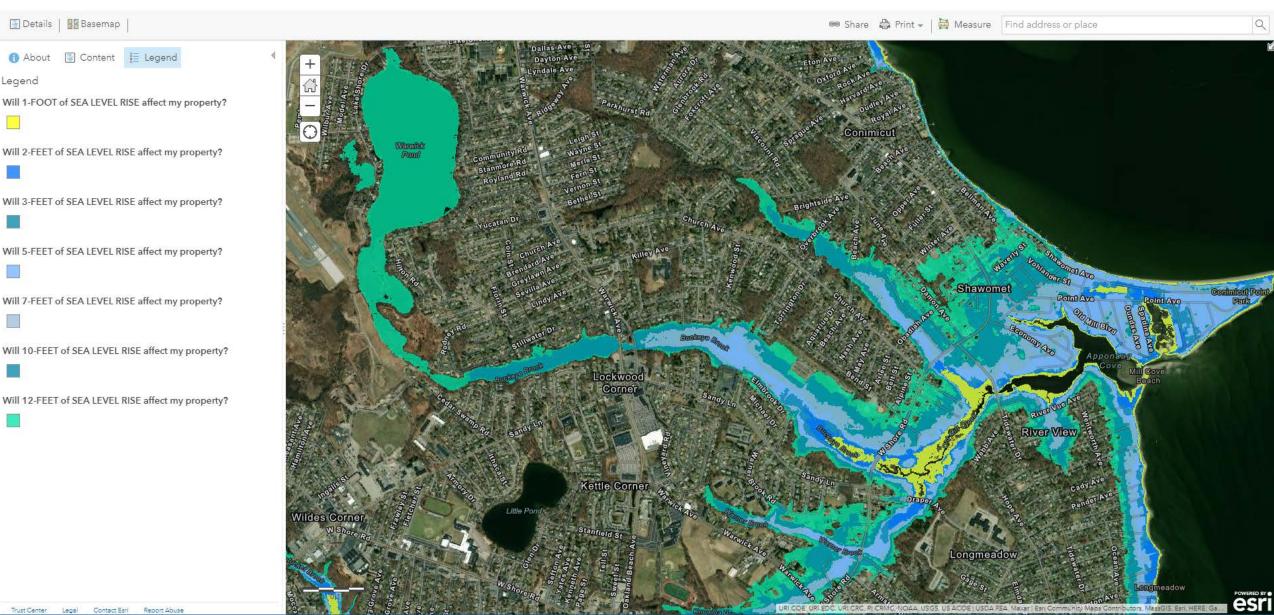
STORMTOOLS - Pawtuxet River

ArcGIS V STORMTOOLS for Beginners



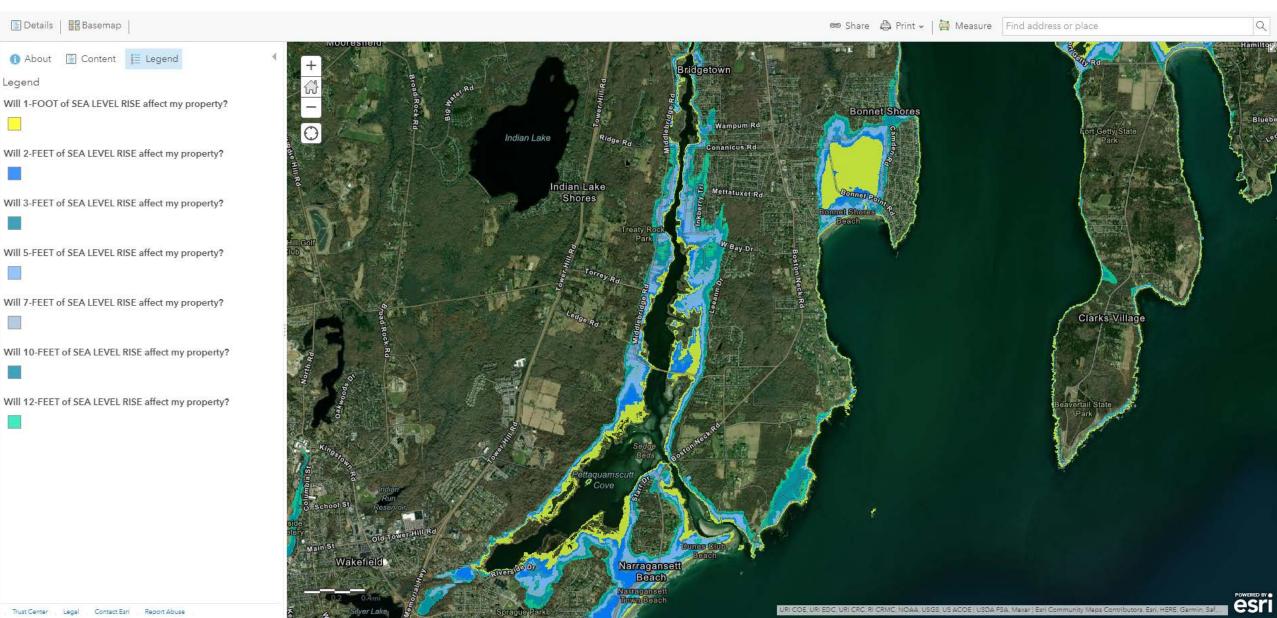
STORMTOOLS – Buckeye Brook

ArcGIS v STORMTOOLS for Beginners



STORMTOOLS – Narrow River

ArcGIS v STORMTOOLS for Beginners



STORMTOOLS – Pawcatuck River

ArcGIS V STORMTOOLS for Beginners

Modify Map 2 Sign In

Details Basemap Measure Find address or place

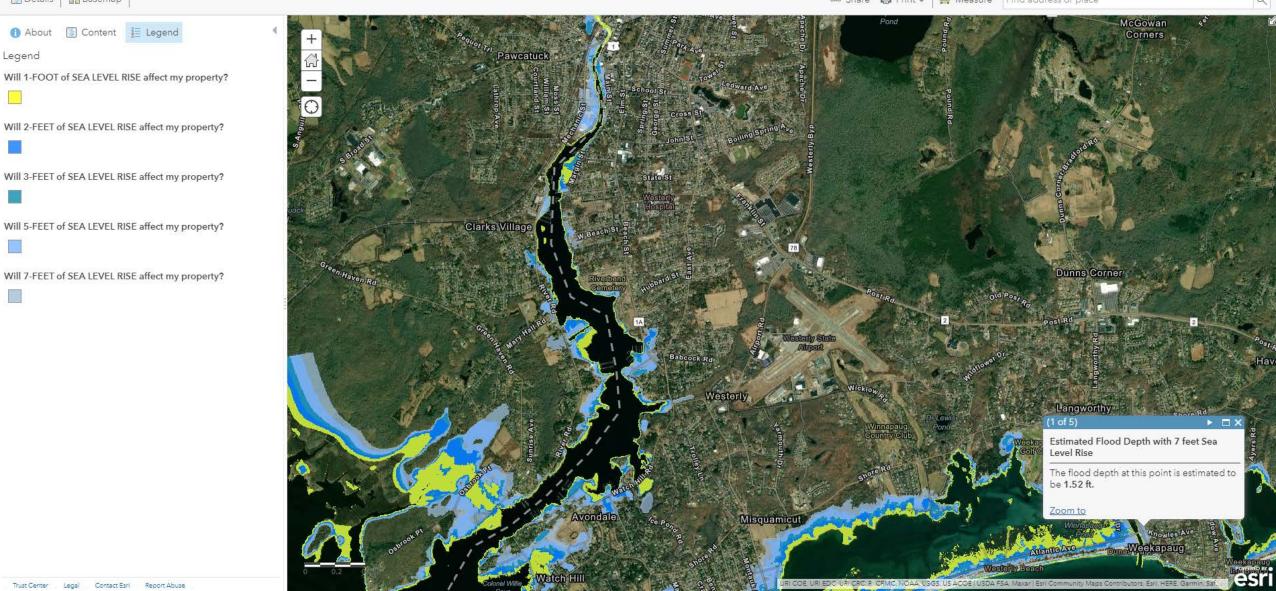
Pond

Pond

McGowan

McGowan

McGowan



Coastal Hazard Application

Welcome to the RICRMC Coastal Hazard Application WORKSHEET and ONLINE VIEWER!

Please download and print the RICRMC Coastal Hazard Application WORKSHEET from the link below, and use the ONLINE VIEWER to access the maps and other information required for completion of the WORKSHEET.





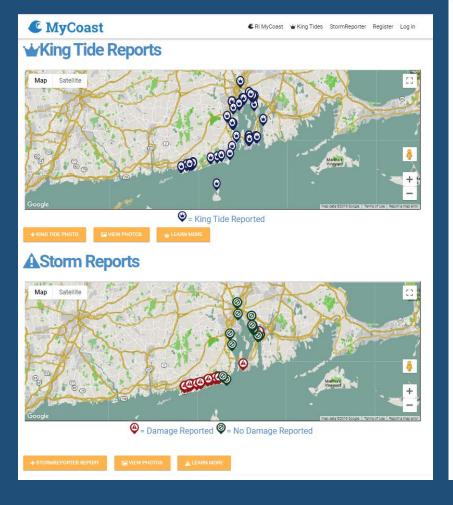
Coastal Hazards Application Online Viewer

The list of projects below must complete the RICRMC Coastal Hazard Application WORKSHEET to be filed in addition to and with your standard CRMC application (http://www.crmc.ri.gov/applicationforms.html).

Any of the following new projects, including tear downs and rebuilds, located on a coastal feature or within the 200-foot contiguous area:

- 1. construction of new residential buildings as defined in § 1.1.2;
- 2, construction of new commercial and industrial structures as defined in § 1.1.2:
- 3. construction of new beach pavilions as defined in § 1.1.2;
- 4. construction of any new private or public roadway, regardless of length;
- 5. construction of any new infrastructure project subject to §§ 1.3.1(F), (H), and (M); and
- 6. construction of any new subdivisions with six (6) or more lots, any portion of which is within 200 feet of a shoreline feature.

Online PHOTOBANK: MyCoast Rhode Island





King Tide Report by Janet Freedman

Oakland Beach | Kent County

VIEW ON STORMTOOLS



04/09/2020 | 10:06 am

(0 hours 23 minutes after high tide)



Weather Overview



Wind Speed: 12 MPH Wind Direction: 164° Temperature: 48°F

Rainfall (Calendar Day): 0.47" Rainfall (Past 24 Hours): 0.03"

(Click here for full weather details)

Tidal Overview

Data from East Greenwich (2.9 miles away)

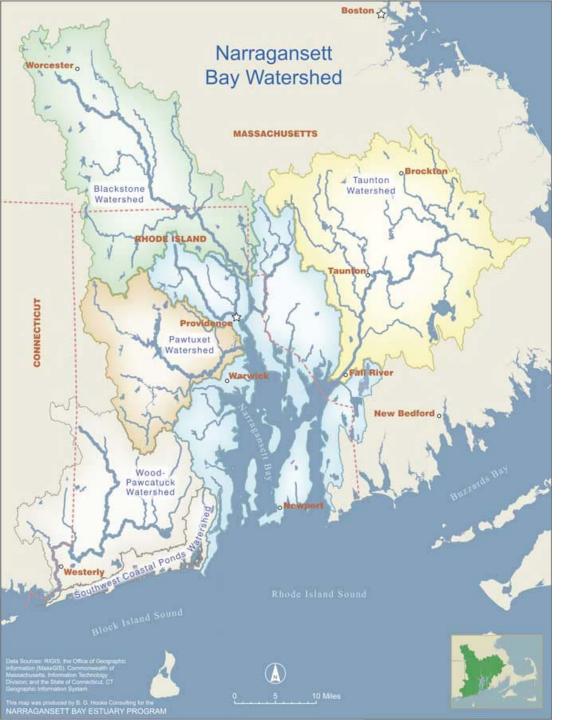
Water Level: Not yet available Predicted tide: 9:43 am, 4.9'

An integrated modeling system for the Pawtuxet River and Watershed flood management

M Reza Hashemi, <u>reza hashemi@uri.edu</u>
Sheets 212
Department of Ocean Engineering & Graduate School of Oceanography



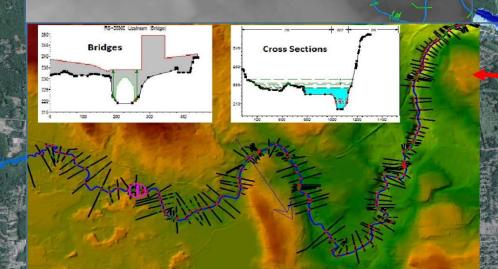


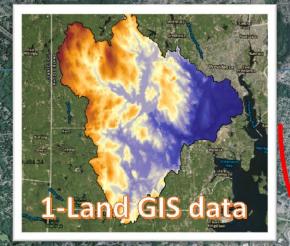


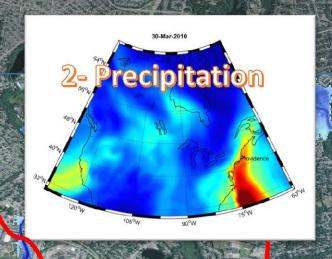
- The Narragansett Bay watershed includes 4 river basins:
 - **Taunton River Basin** 338,871 acres (529 square miles)
 - **Blackstone River Basin** 303,734 acres (475 square miles)
 - **Coastal Narragansett Basin** 300,124 acres (469 square miles)
 - **Pawtuxet River Basin** 148,404 acres (232 square miles)
- The Narragansett Bay Watershed lies 40% in Rhode Island and 60% in Massachusetts (NBEP)
- Objectives of Pawtuxet River/Watershed study:
 - Developing a validated web/GIS-Based watershed/river model for the Pawtuxet watershed, flood prediction along the river flood plains
 - 2. Impact of the Scituate and Flat River Reservoirs on other structures on flooding as well as climate change
 - 3. Paving the way for a real-time forecasting system for this river, and other rivers in RI, adding it to STORMTOOLS
- **Results:**
- Link to open access journal article (Flood Risk Management)

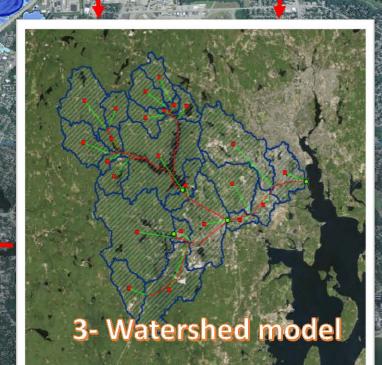
Overview of the modeling system

4-Web/GIS-based river model









Summary

- Web-based river/watershed model of Pawtuxet river (integrated to STORMTOOLS) has been developed
- II. Scituate reservoir always reduces the flood impact.
- III. Scituate reservoir dam can be managed/modified to control flooding (considering water supply).
- IV. Some (not all) of the diversion dams in the Pawtuxet river increase the flooding extent.
- V. Debris can significantly increase the flooding risk in this area.
- VI. Now, it is feasible to setup an ensemble flood forecasting model for the entire floodplain of the river and present the results on an online map.

Recommendations

- I. Operational flood forecasting model for the Pawtuxet watershed/river
- II. Consequence of possible catastrophic dam failure during major floods (water quality, flooding,..)
- III. Simulating the impacts of climate change on the watershed-river flooding risk
- IV. Installing a river gauge downstream of the Scituate reservoir, and a precipitation/temperature gauge on the watershed
- V. Effective management of the Scituate reservoir for flood control

ORIGINAL ARTICLE



Flood risk in past and future: A case study for the Pawtuxet River's record-breaking March 2010 flood event

Soroush Kouhi¹ M. Reza Hashemi^{1,2} Rozita Kian¹ Malcolm Spaulding¹ Matthew Lewis³ | Isaac Ginis²

Correspondence

M. Reza Hashemi, Department of Ocean Engineering, University of Rhode Island, South Kingstown, RI. Email: reza_hashemi@uri.edu

Funding information

Rhode Island Coastal Resources Management Council, Grant/Award Number: CFDA 14.228; U.S. Department of Homeland Security, Grant/Award Number: 2015-ST-061-ND0001-01; U.S. Department of Housing and Urban Development, Grant/Award Number: B-10-DF-44-0001

Abstract

In March 2010, a sequence of three major rainfall events in New England (United States) led to a record-breaking flooding event in the Pawtuxet River Watershed with a peak flow discharge of about 500-year return period. After development of hydrological and hydraulic models, a number of factors that played important roles in the impact of this flooding and other extreme events including river structures (reservoirs, historical textile mill dams, and bridges) were investigated. These factors are currently omitted within risk assessments tools such as flood insurance rate maps. Some management strategies that should be considered for future flood risk mitigation were modeled and discussed. Furthermore, to better understand possible future risks in a warmer climate, another extreme flood event was simulated. The synthetic/hypothetical storm (Hurricane Rhody with two landfalls) was created based on the characteristics of the historical hurricanes that severely impacted this region in the past. It was shown that while the first landfall of this hurricane did not lead to significant flood risk, the second landfall could generate more rain and flooding equivalent to a 500-year event. Results and the methodology of this study can be used to better understand and assess future flood risk in similar watersheds.

climate change, flood risk, HEC-RAS, hurricane, river flooding

1 | INTRODUCTION

River flooding is a major cause of catastrophic loss in the United States and around the world. Table 1 shows catastrophic loss by cause for about two decades in the United States (1996-20161). Losses of 91.9% were caused by weather-related events including tornadoes, hurricanes, and winter storms in which flooding has a significant contribution. Previous studies indicated that the risk of riverine flooding is increasing due to climate change

(Booij, 2005), sea level rise (Le, Nguyen, Wolanski, Tran, & Haruyama, 2007) (for the rivers draining to the open seas and the ocean), and growth in populations/ urbanization (Campbell et al., 2018; Suriya & Mudgal, 2012) in flood zones.

In the United States, Federal Emergency Management Agency (FEMA, https://www.fema.gov/) generates Flood Insurance Rate Maps (FIRMs) for the assessment of flood risk in the flood zone. FIRMs provide a general guidance to estimate the river and coastal storm risk to

J Flood Risk Management, 2020;e12655 wilevonlinelibrary.com/journal/ifr3 1 of 20

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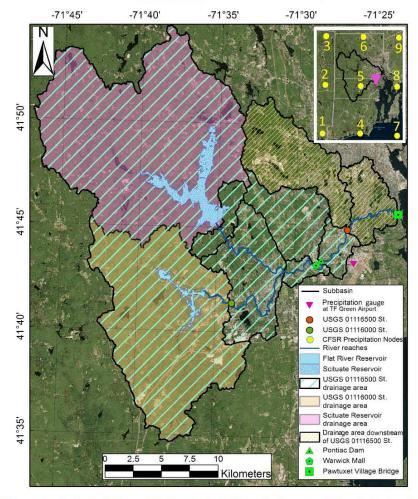


FIGURE 1 Map of the Pawtuxet River watershed. The watershed and subbasins borders are shown in black. The locations of the USGS stream gauges, meteorological station, reservoirs, and a few river structures are also shown. Locations of CFSR nodes to extract hindcast rainfall data are shown on the top right subfigure. CFSR, Climate Forecast System Reanalysis; USGS, United States Geological Survey

South and North Branches, and drains to the Providence River in upper Narragansett Bay. Two USGS stream gauges are located in the watershed: the USGS 01116500 on the Main Branch at Cranston and the USGS-01116000 on the South Branch at Washington (see Figure 1). Table 2 provides more details about drainage areas in this watershed.

2.2 | River structures and their role in flooding

In the aftermath of March 2010 event, the affected communities, stakeholders, and flood management authorities were looking for main causes of this catastrophe and what could have been done to reduce the impacts of this

¹Department of Ocean Engineering, University of Rhode Island, South Kingstown, Rhode Island

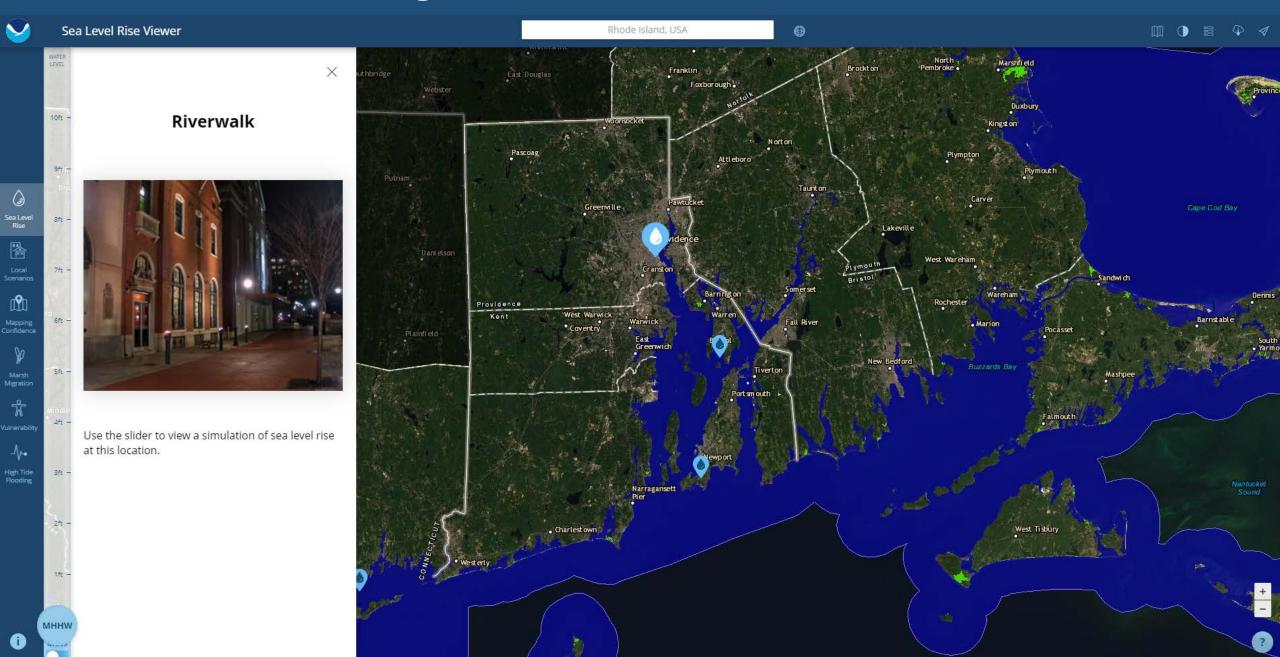
²Graduate School of Oceanography, University of Rhode Island, South Kingstown, Rhode Island

³School of Ocean Sciences, Bangor University, Bangor, UK

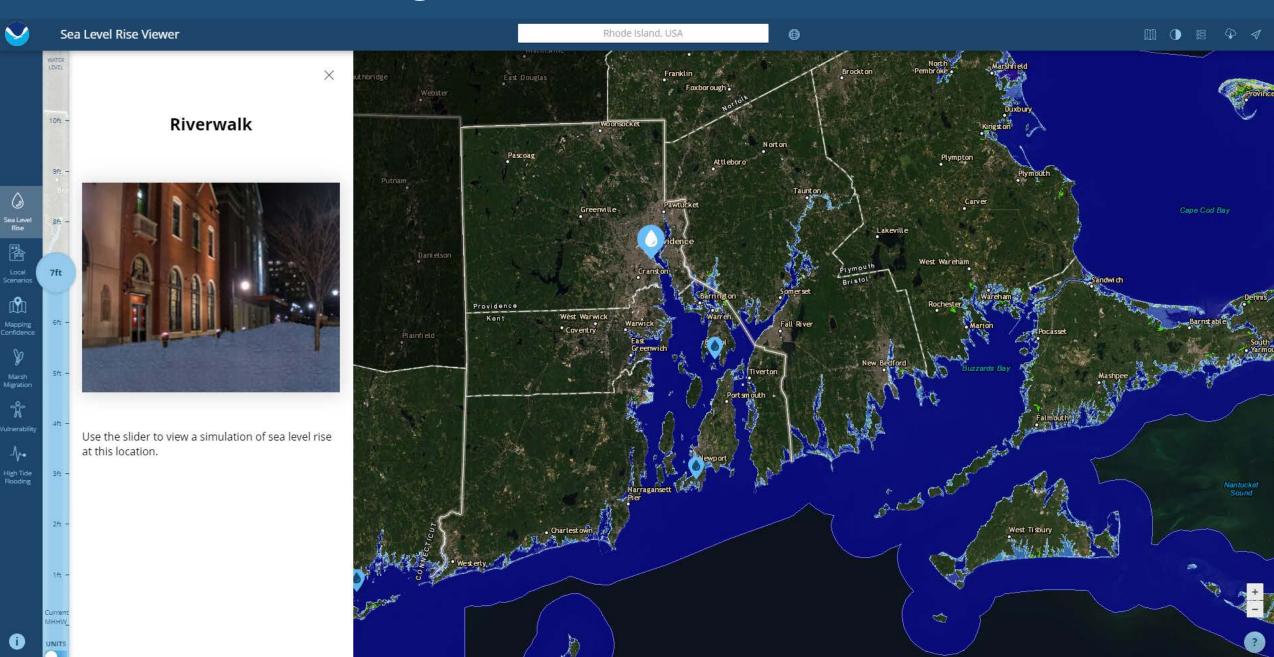
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^{© 2020} The Authors, Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.

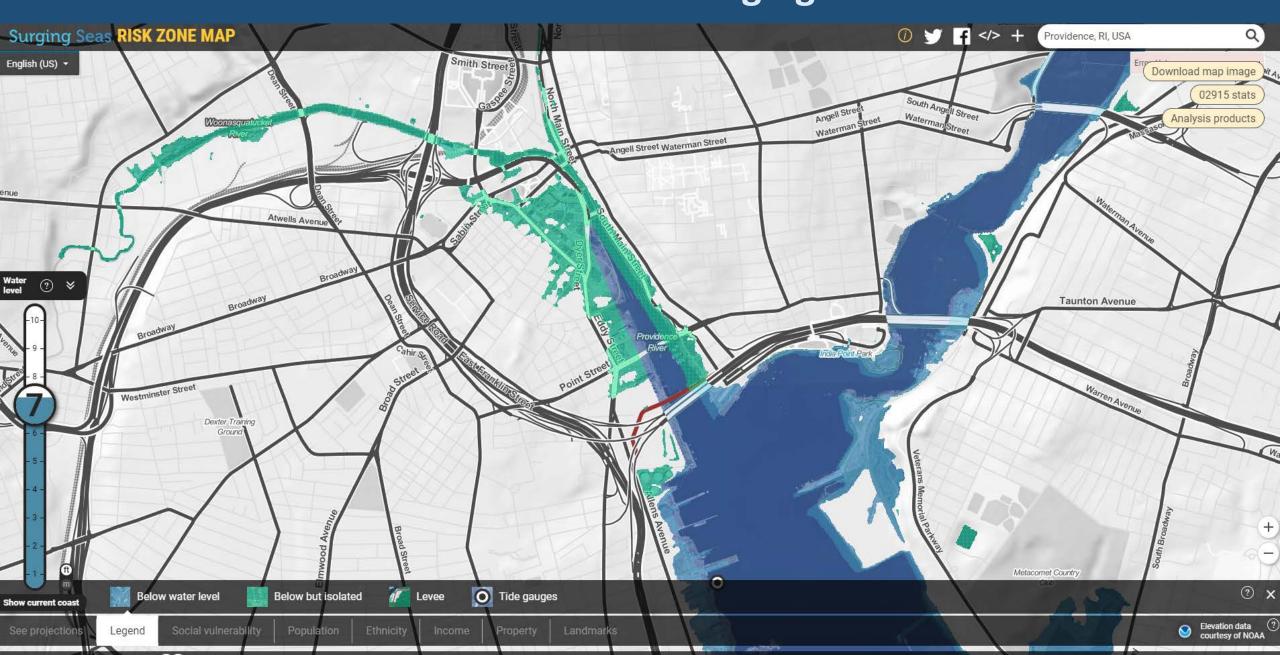
NOAA Digital Coast – Sea Level Rise Viewer



NOAA Digital Coast – Sea Level Rise Viewer

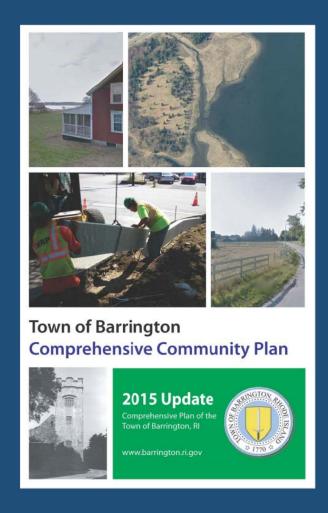


Climate Central – Surging Seas

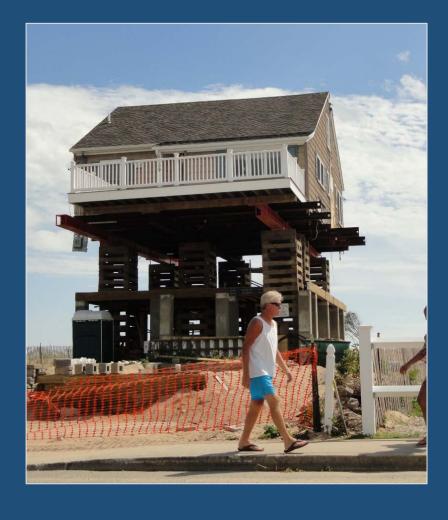


Know Your Risk

Make a Plan

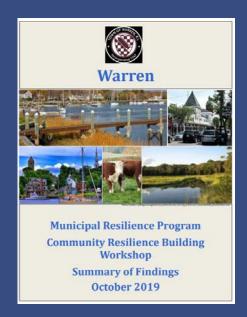


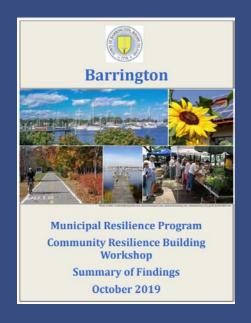
Take Action

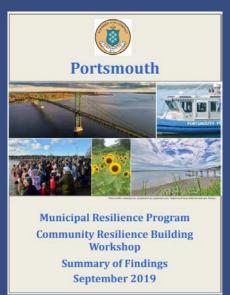


MAKE A PLAN Municipalities Plan for Resilience https://www.riib.org/mrp

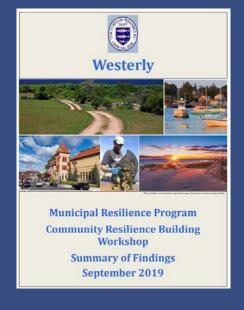












MAKE A PLAN - Business Tools

http://climatechange.ri.gov/businesses/small-biz.php

Printable Guides

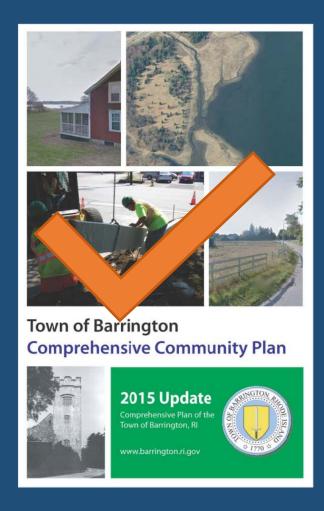
Small Business Resilience Project (less than 50 employees)



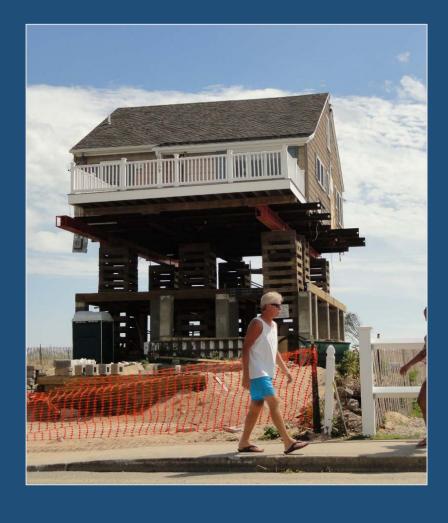
- Restaurant/Food Guide
- Retail Guide
- Lodging & Accommodations Guide
- Mater-Dependent Guide
- Image: Manufacturing Guide
- Service Provider Guide
- Construction Guide
- Real Estate / Property Management Guide

Know Your Risk

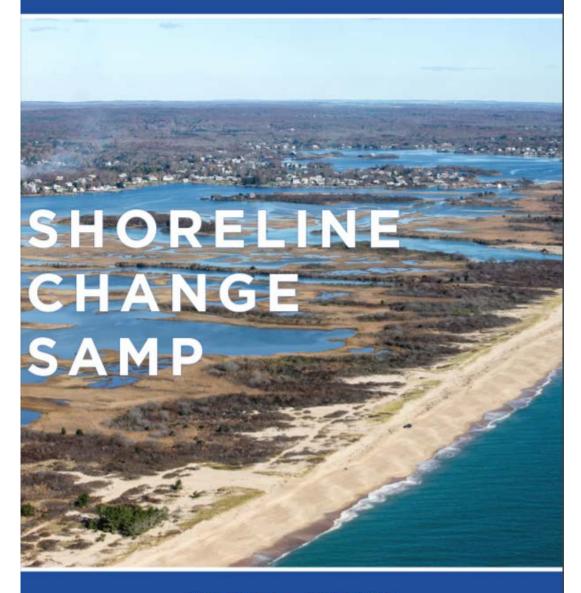
Make a Plan



Take Action



RHODE ISLAND COSTAL RESOURCES MANAGEMENT COUNCIL SHORELINE CHANGE SPECIAL AREA MANAGEMENT PLAN (SAMP)



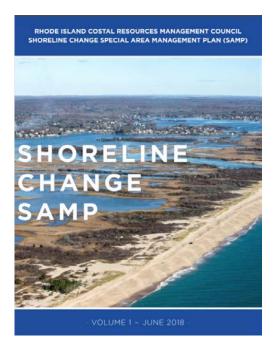


Chapter 7: Adaptation Strategies and Techniques for Coastal Properties





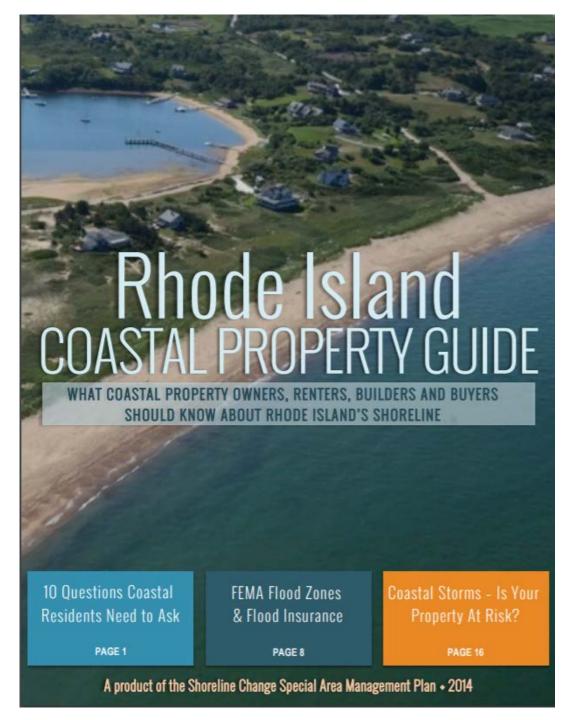




Chapter 7: Adaptation Strategies and Techniques for Coastal Properties

Table 1. Summary table of coastal property adaptation tools and techniques

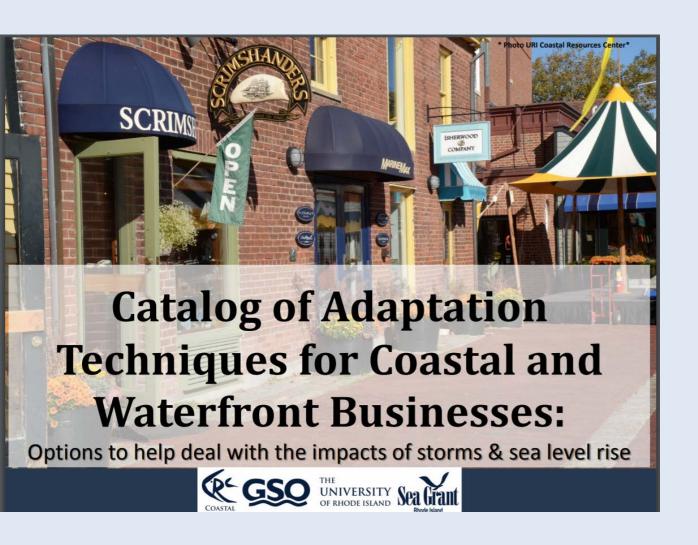
Strategy	Existing or New Construction	Protection, Accommodation or Retreat	Site or Structure
Site selection	New	Accommodation or Retreat	Site or structure
Distance inland	Existing or new	Retreat	Site or structure
Elevation	Existing or new	Accommodation	Site or structure
Terrain management			
Site grading	New	Accommodation	Site
Site layout	New	Accommodation	Site
Drainage	Existing or new	Accommodation	Site or structure
Natural or nature-based n	neasures		
Coastal bank protection	Existing or new	Protection	Site
Living breakwaters	Existing or new	Protection	Site
Dune restoration	Existing or new	Protection	Site
Beach nourishment	Existing or new	Protection	Site
Coastal wetland or enhancement	Existing or new	Protection	Site



10 Questions Coastal Residents Should Ask About Coastal Property

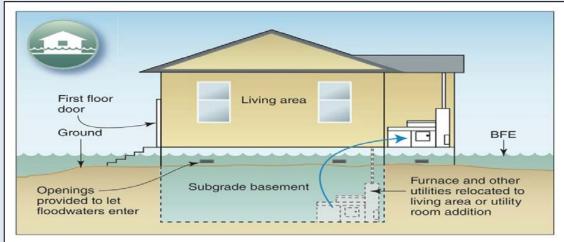
	Question	Page
1	What kinds of coastal features are on or near the property, and what kinds of setbacks or regulations apply?	
2	Are there restrictions on the property due to the adjacent CRMC water classification?	6
3	Is the property in a flood zone according to FEMA maps?	8
4	If I am in a flood zone, do I have to obtain flood insurance? How can I find out what my flood insurance premiums will be?	10
5	How will erosion and sea-level rise impact the property and surrounding area?	12
6	Can I install structures along the shore to protect the property and buildings from erosion or flooding?	14
7	How will coastal storms and flooding affect the property and structures? Will I be allowed to rebuild in the event of a flood or storm that partially or completely destroys the building?	16
8	How do I determine if the buildings on the property meet the current design and construction standards for the flood zone?	20
9	What kinds of septic systems are permitted in the coastal zone? Can I repair or replace a damaged septic system?	
10	Can I make the existing building more resilient? How do I build a new resilient structure?	24

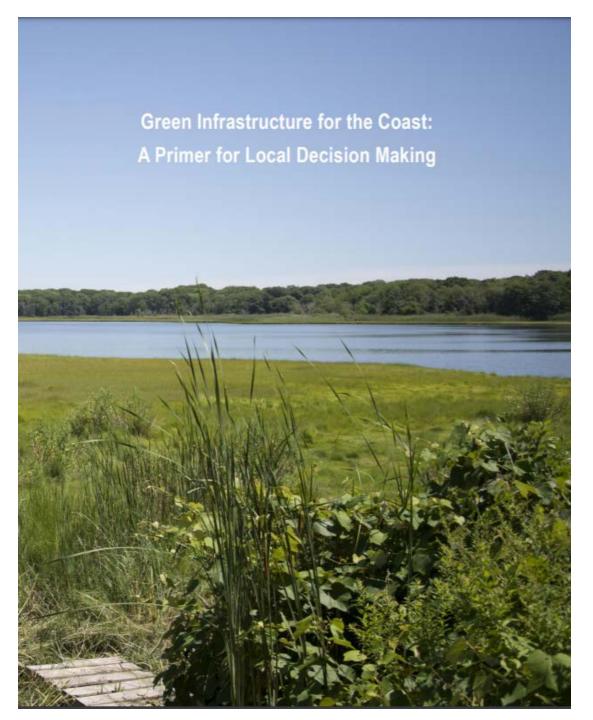




Accommodating Flood Waters

Methods for allowing flood water to enter and exit a structure while minimizing damage are commonly used to accommodate flood waters. Examples: Elevating a structure, installing flood vents and raising utilities and electrical system components.





10 Guiding Questions on Coastal Green Infrastructure

- 6 Q1 How is Green Infrastructure Applied on the Coast?
- 8 Q2 What are the Benefits of Implementing Coastal Green Infrastructure?
- 10 Q3 What is an Integrated Design Process: and How Does it Enhance Outcomes?
- 12 Q4 What are some Key Design Considerations?
- Q5 Why is Planning for Maintenance Critical to the Design Process?
- 16 Q6 How Do You Start to Frame Decision Making About Green Infrastructure?
- 18 Q7 What are the Considerations for Appropriate Plant Selection?
- 20 Q8 How Do Municipalities Fund Green Infrastructure?
- 22 Q9 What are the Barriers to Adopting Green Infrastructure? What are the Solutions?
- 24 Q10 Where Can I Get Additional Information and Support?

SHORELINE ADAPTATION, **INVENTORY AND DESIGN**



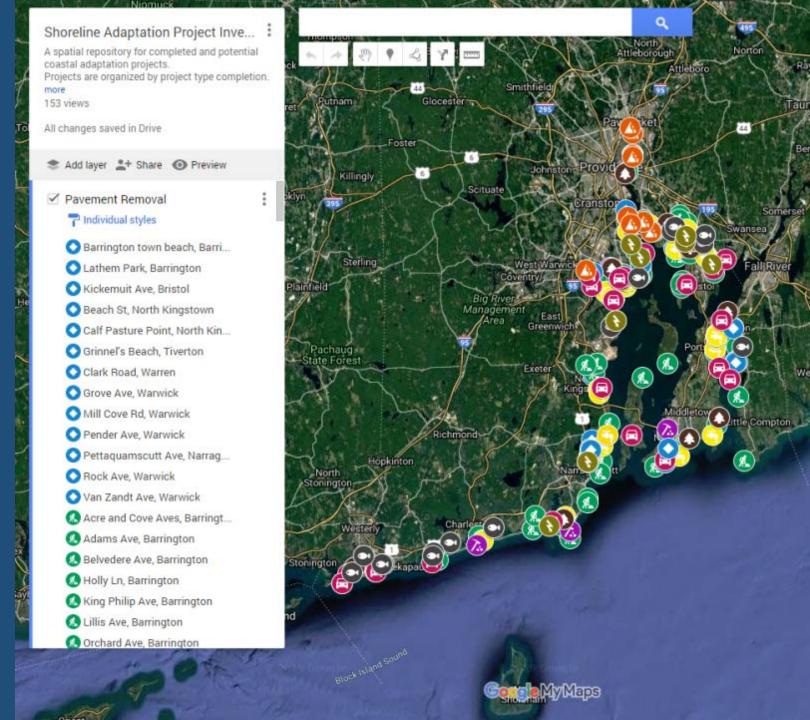
NARRAGANSETT BAY





PROJECT INVENTORY

- **Pavement Removal**
- **Stormwater Management**
- **Structure Removal**
- **Natural Feature Restoration**
- **Road Relocation / Limit Vehicle** Access
- **Bank Re-Grading / Stabilization**
- **Culvert Redesign**
- **Utility Removal / Relocation**





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