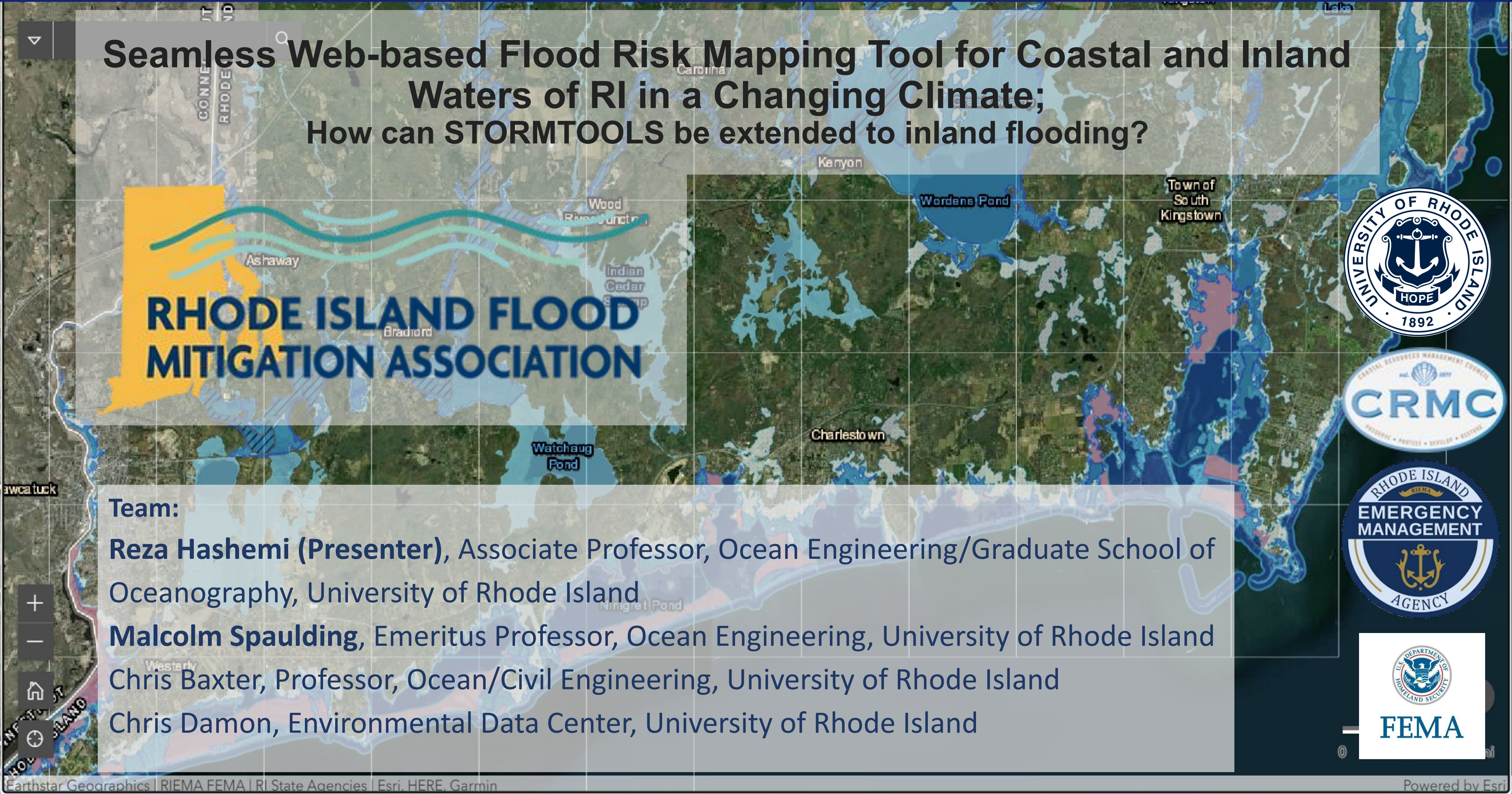
# Seamless Web-based Flood Risk Mapping Tool for Coastal and Inland Waters of RI in a Changing Climate;

## How can STORMTOOLS be extended to inland flooding?

RHODE ISLAND FLOOD MITIGATION ASSOCIATION





**Team:**

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**Malcolm Spaulding**, Emeritus Professor, Ocean Engineering, University of Rhode Island

Chris Baxter, Professor, Ocean/Civil Engineering, University of Rhode Island

Chris Damon, Environmental Data Center, University of Rhode Island


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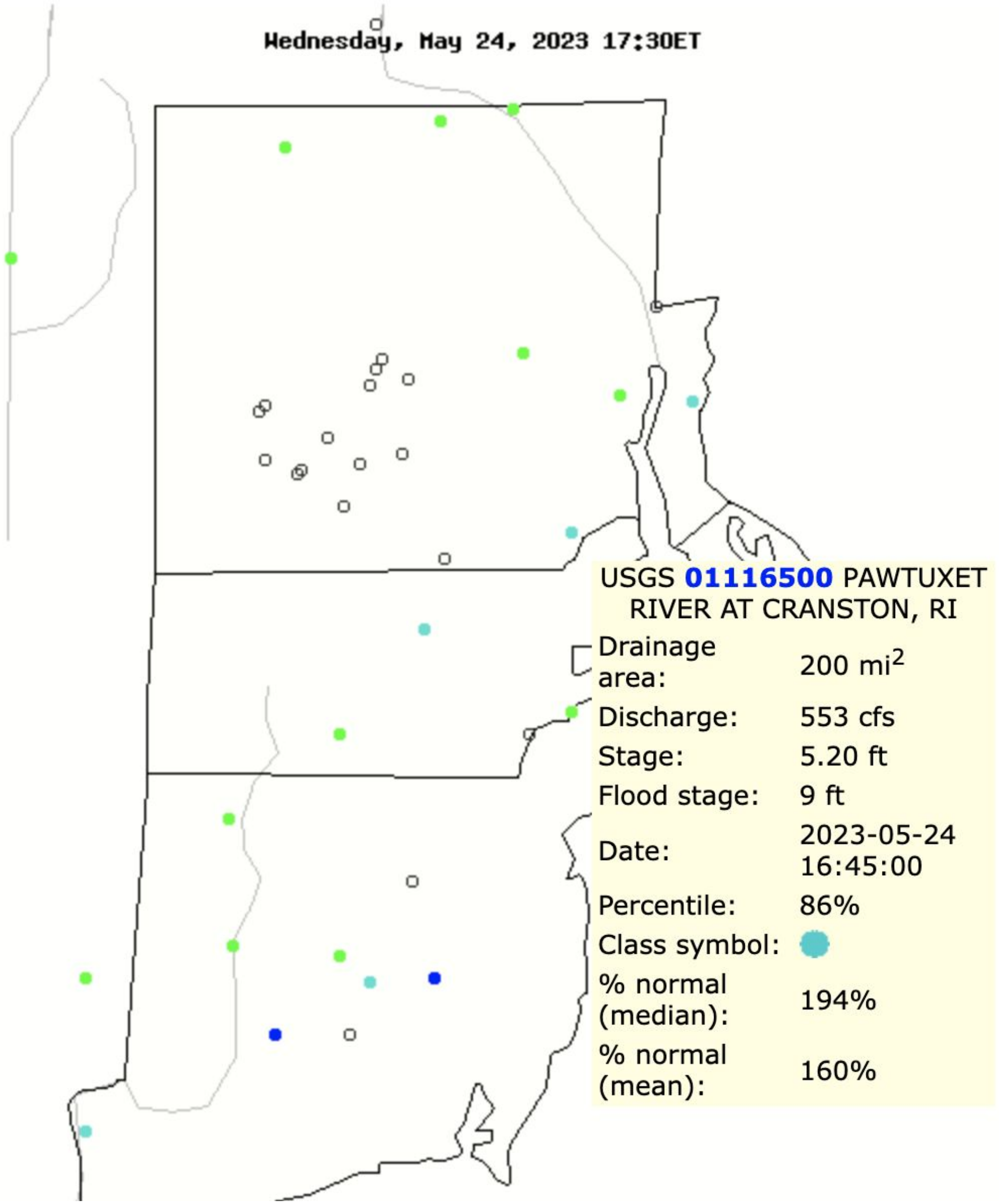
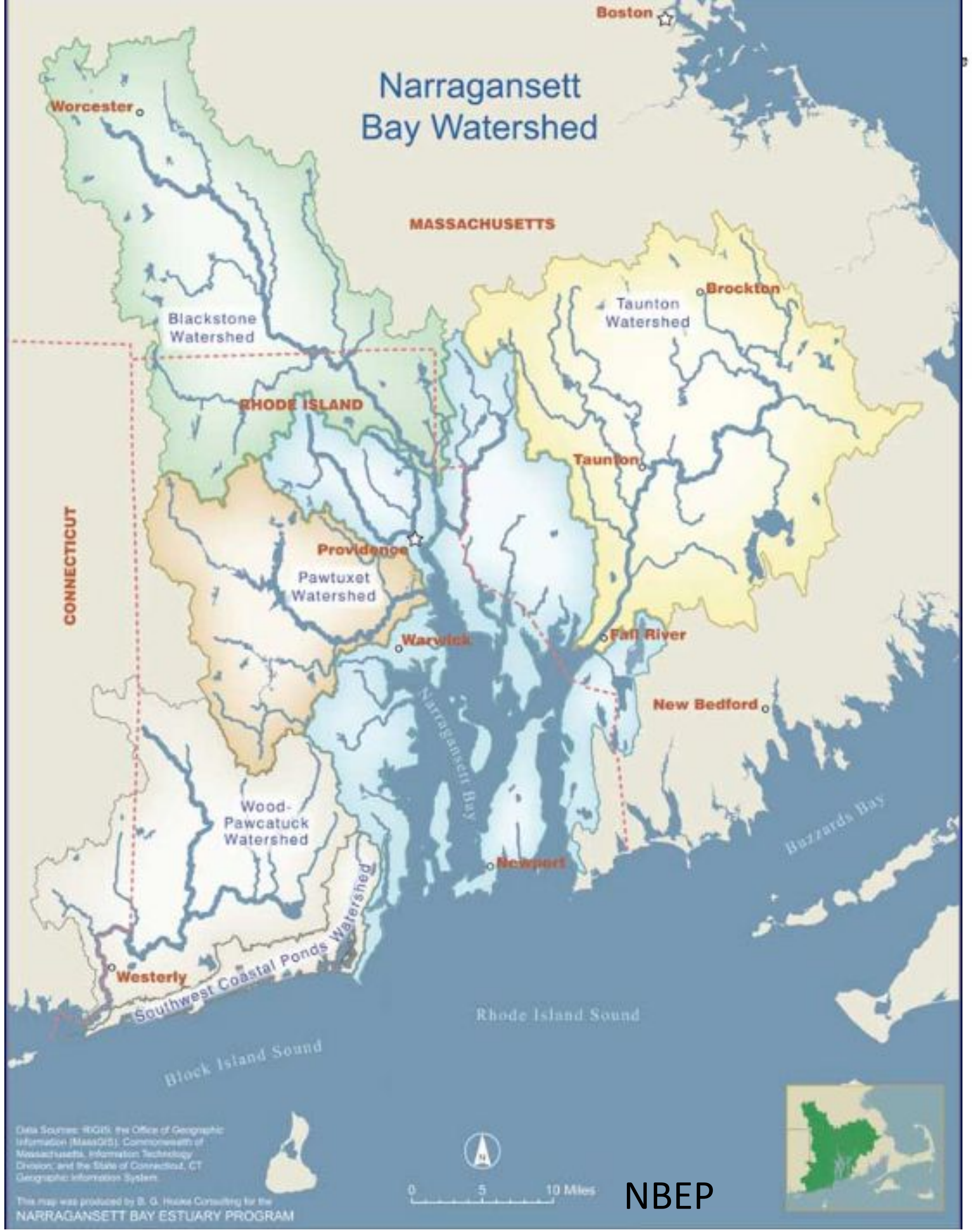
CRMC

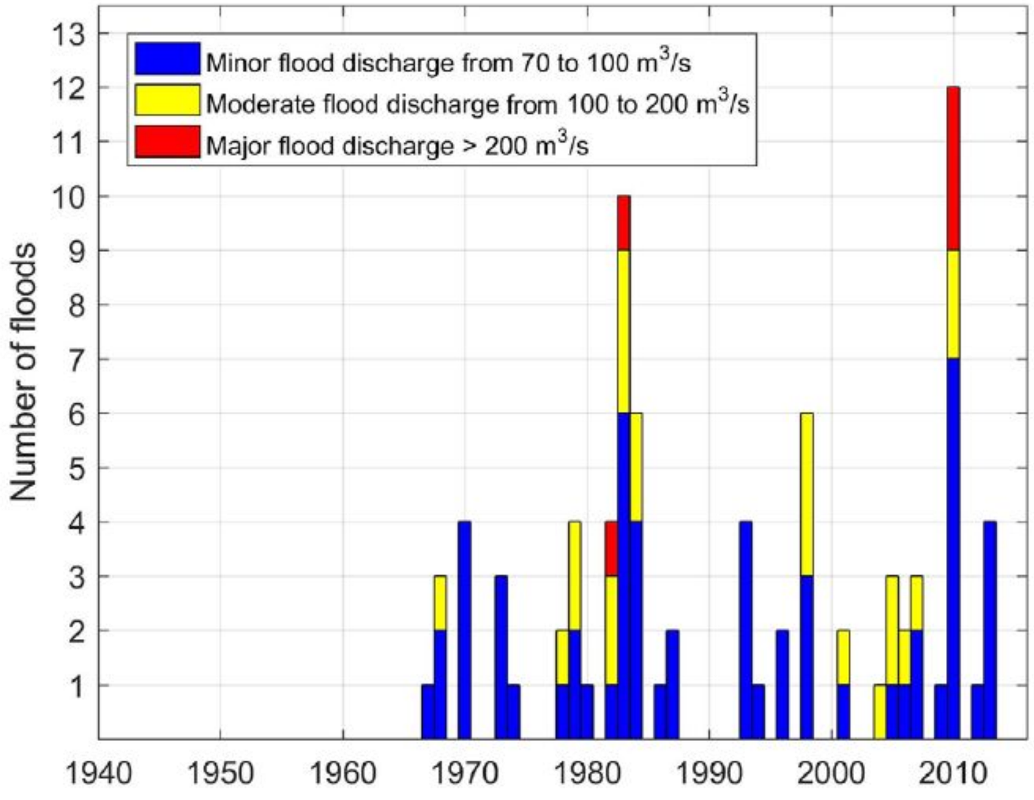
RHODE ISLAND EMERGENCY MANAGEMENT AGENCY

FEMA

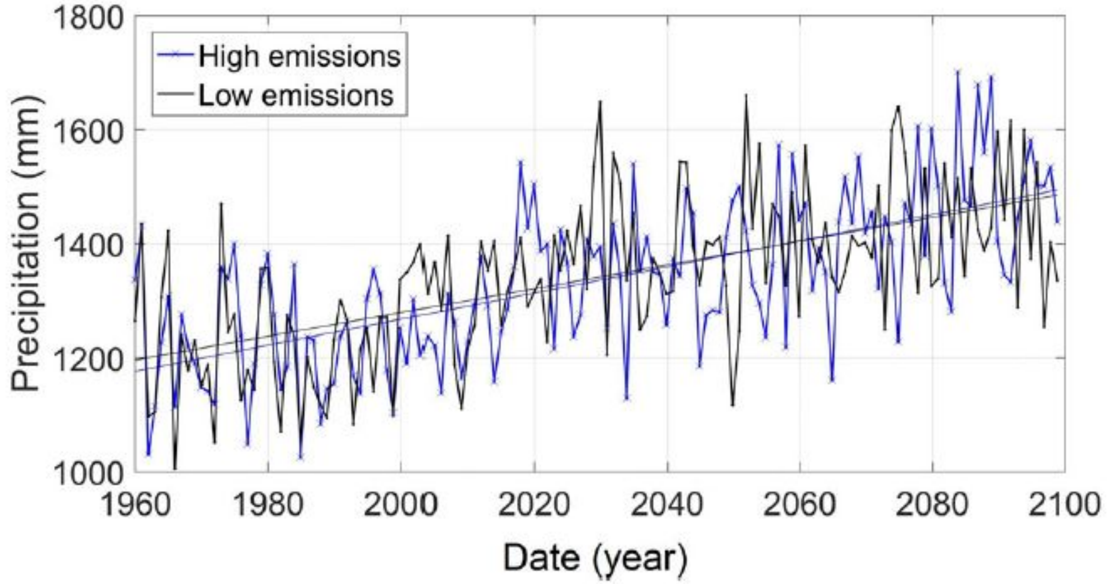

Wednesday, May 24, 2023 17:30ET
USGS 01116500 PAWTUXET RIVER AT CRANSTON, RI
Drainage area: 200 mi²
Discharge: 553 cfs
Stage: 5.20 ft
Flood stage: 9 ft
Date: 2023-05-24 16:45:00
Percentile: 86%
Class symbol:
% normal (median): 194%
% normal (mean): 160%


Narragansett Bay Watershed
Boston
Worcester
MASSACHUSETTS
Blackstone Watershed
Taunton Watershed
Brockton
RHODE ISLAND
Taunton
CONNECTICUT
Providence
Pawtuxet Watershed
Warwick
Fall River
New Bedford
Narragansett Bay
Wood-Pawcatuck Watershed
Newport
Buzzards Bay
Southwest Coastal Ponds Watershed
Westerly
Rhode Island Sound
Block Island Sound
0 5 10 Miles
NARRAGANSETT BAY ESTUARY PROGRAM
NBEP

# Rainfall in past and future in a changing climate




Historical flood frequency per year at the USGS 01116500 in Cranston from 1940 to 2017. The colour of the bars show the severity of the floods based on the flowrate. USGS, United States Geological Survey

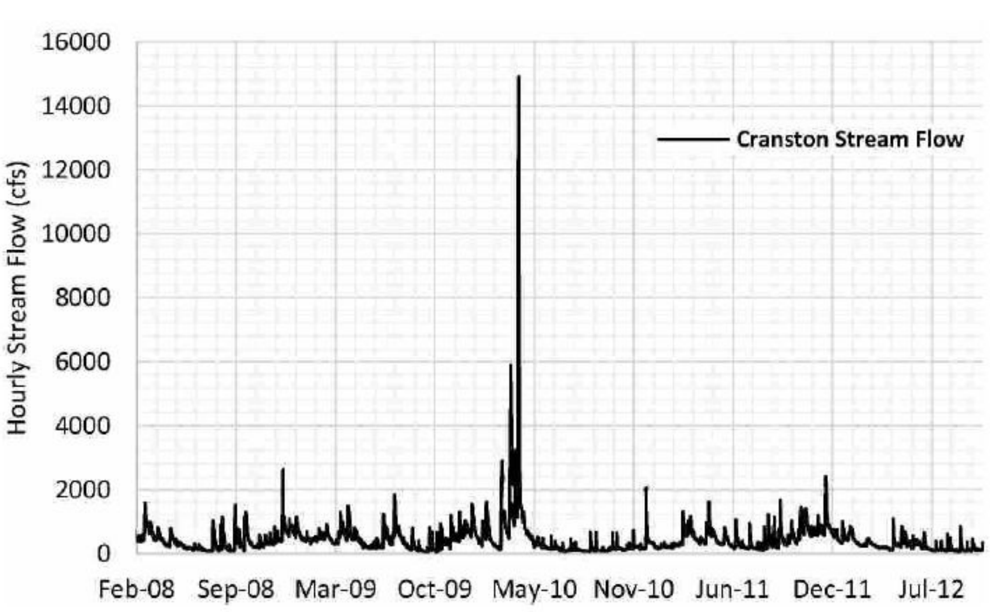



Rhode Island annual precipitation from 1960, and projected to 2099. Two projections are shown corresponding to low and high emissions scenarios (Hayhoe et al., 2007). The straight lines show linear trendlines for each scenario

*Kouhi, S., Hashemi, M. R., Kian, R., Spaulding, M., Lewis, M., & Ginis, I. (2020). Flood risk in past and future: A case study for the Pawtuxet River's record-breaking March 2010 flood event. Journal of Flood Risk Management, 13(4), e12655.*

**Table 17.** March–April 2010 flood peak and annual exceedance probability at active streamgages in Rhode Island.

[Values in **bold** typeface indicate new peak of record. AEP, annual exceedance probability determined from weighted estimates in table 7. ft³/s, cubic feet per second; %, percent; R, river; Ave., Avenue; Rd., Road; RI, Rhode Island; nr, near; --, not determined]




*(a)*

| U.S. Geological Survey streamgage | | Start of record | 2010 Flood peak | | | | Previous record peak | |
|---|---|---|---|---|---|---|---|---|
| Number | Name | | Date | Gage height, (feet) | Discharge (ft³/s) | AEP (%) | Discharge (ft³/s) | Date |
| | | | n | | | | | |
| 011 | | | 1/2010 | **10.79** | **2,600** | 1 | 2,190 | 10/16/2005 |
| | | | in | | | | | |
| 011 | | | 0/2010 | 8.29 | 1,800 | 2 | 1,870 | 10/15/2005 |
| 011 | | | 1/2010 | 12.05 | 5,260 | 4 | 6,290 | 10/15/2005 |
| 011 | | | 1/2010 | 14.50 | 14,900 | 4 | 32,900[a] | 08/19/1955 |
| | | | , and Hunt River Basins | | | | | |
| 011 | | | 0/2010 | **6.26** | **2,040** | 1 | 1,990 | 10/15/2005 |
| 011 | | | 0/2010 | **9.00** | **1,750** | 2 | 1,530 | 10/15/2005 |
| 011 | | | 0/2010 | **2.55** | **249** | 4 | 180 | 10/20/1996 |
| 011 | | | 4/2010 | **6.57** | **1,330** | 2 | 1,110 | 06/17/2001 |
| 011 | | | 0/2010 | **5.32** | **1,020** | 0.2 | 762 | 08/11/2008 |
| 01116000 | South Branch Pawtuxet River at Washington, RI | 1940 | 03/31/2010 | **9.22** | **5,480** | 0.2 | 1,980 | 06/06/1982 |
| 01116500 | Pawtuxet River at Cranston, RI | 1939 | 03/31/2010 | **20.79** | **14,900** | 0.2[c] | 5,440 | 06/07/1982 |
| 01117000 | Hunt River near East Greenwich, RI | 1940 | 03/30/2010 | **5.61** | **2,380** | 0.2 | 1,680 | 10/15/2005 |

Source: Alisa Richardson

Source A.P.

# Climate Change is affecting the extreme rainfalls & inland flooding In RI

hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ri

URI | Settings | Journals and Sear... | Course_developm... | Grants | personal | conference | Python

**Data description**

**Data type:** Precipitation depth **Units:** English **Time series type:** Partial duration

**Select location**

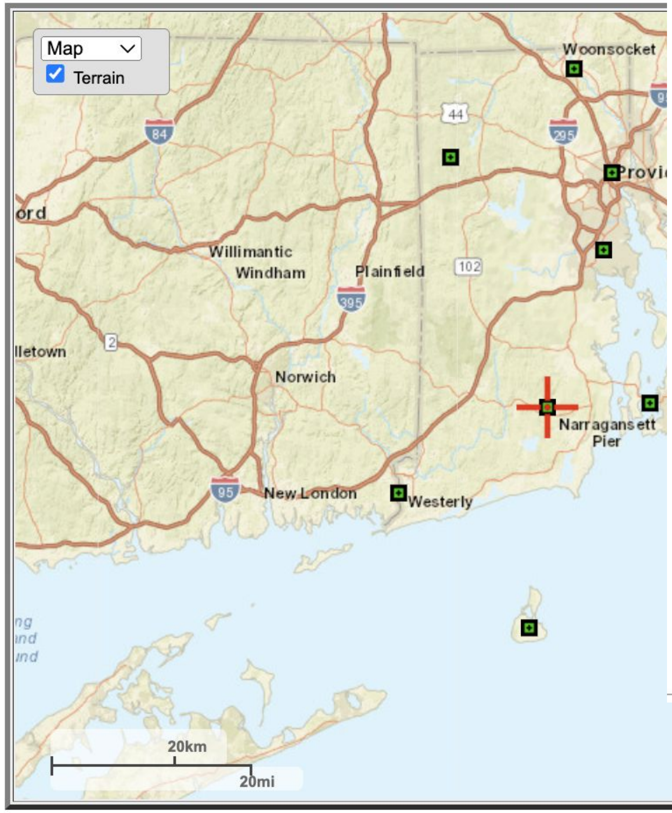
**1) Manually:**

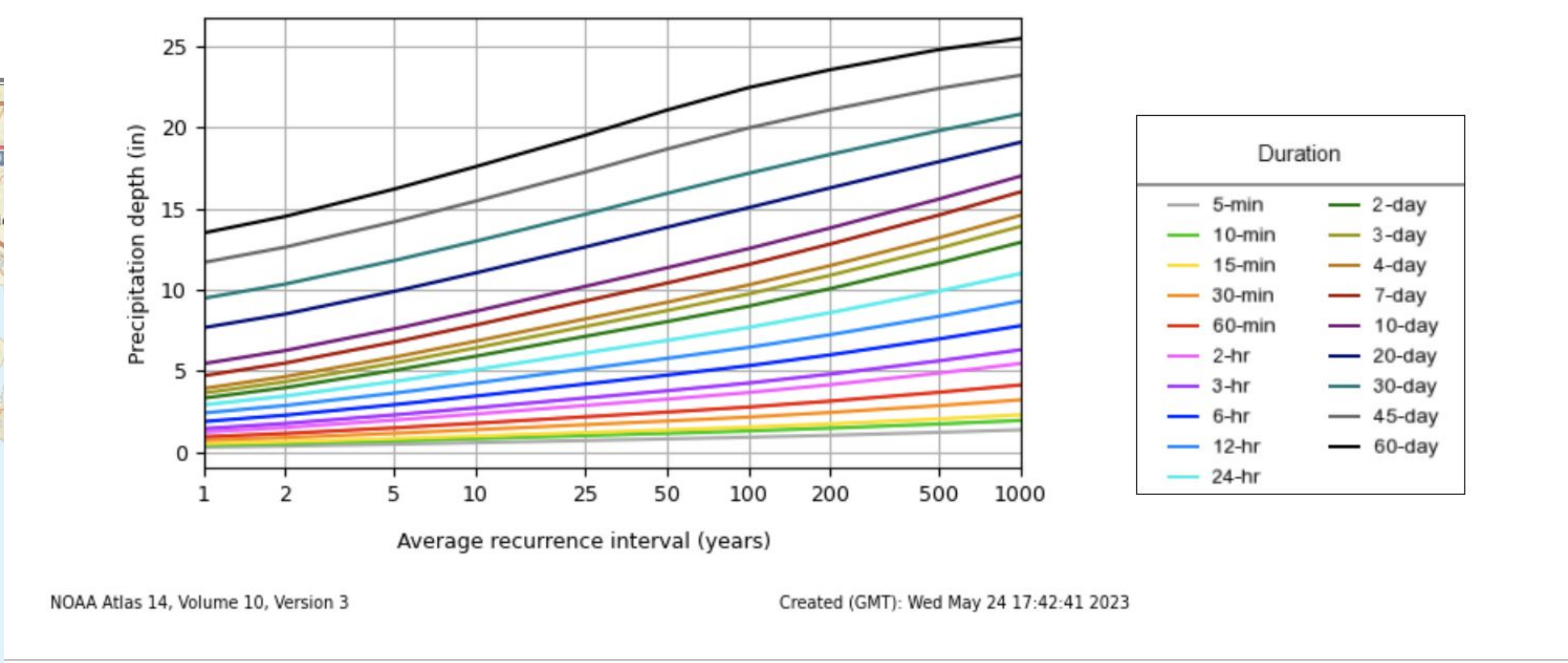
**a) By location** (decimal degrees, use "-" for S and W): Latitude: Longitude: Submit

**b) By station** (list of RI stations): KINGSTON (37-4266)

**c) By address** Search

**2) Use map:**




* Source: ESRI Maps
** Source: USGS

**POINT PRECIPITATION FREQUENCY (PF) ESTIMATES**

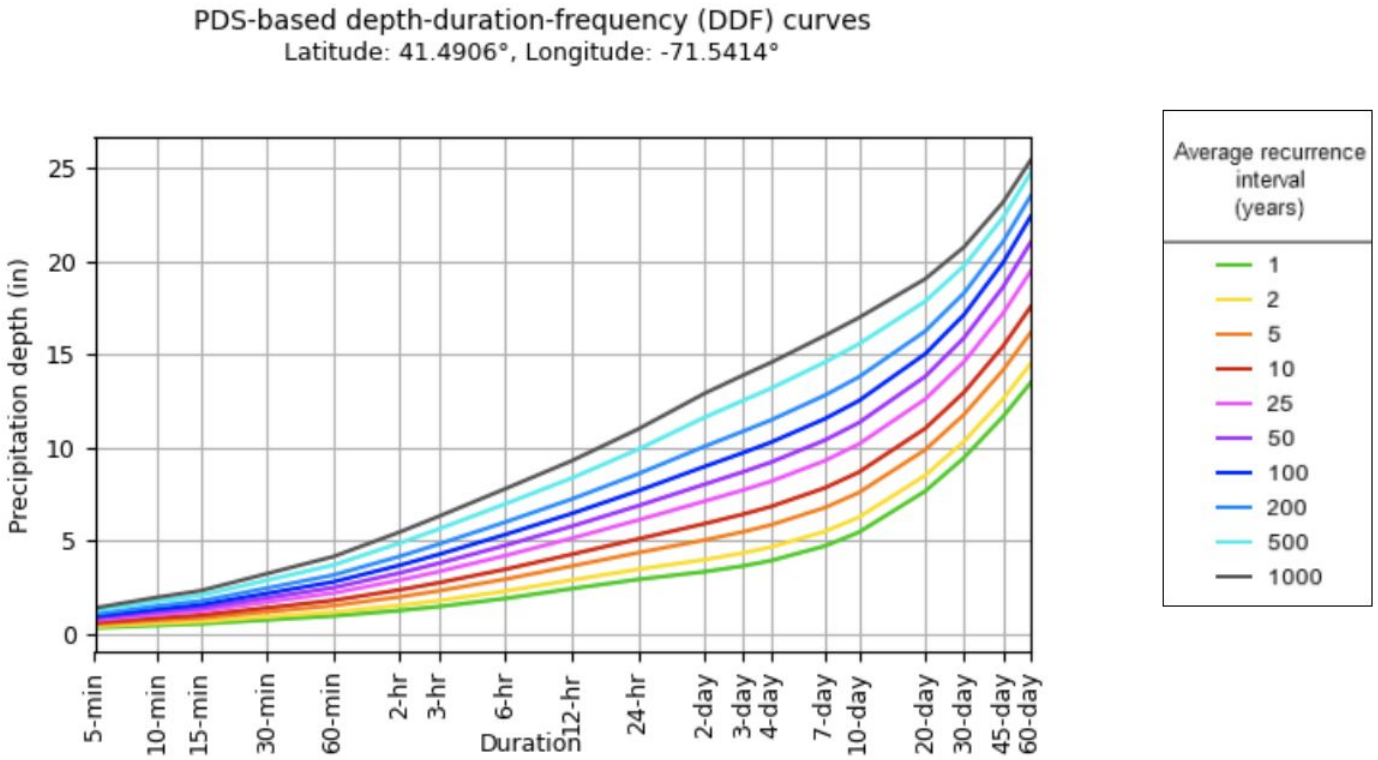
**WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION**

**NOAA Atlas 14, Volume 10, Version 3**

PF tabular | PF graphical | Supplementary information

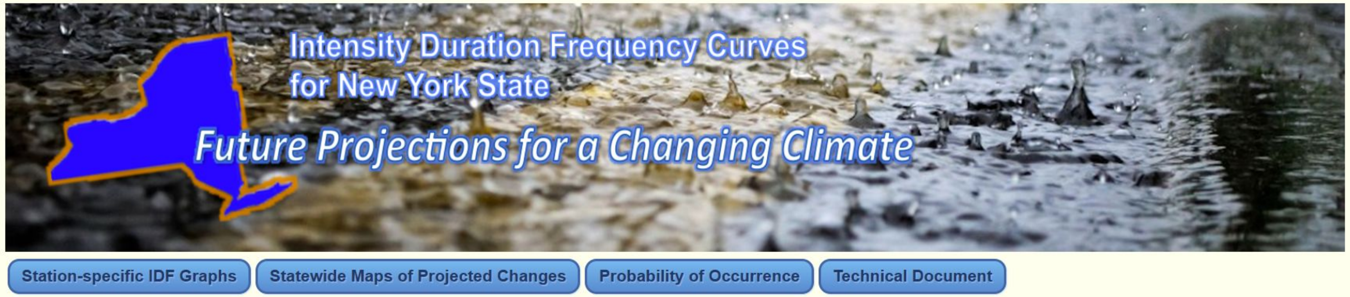
Print page

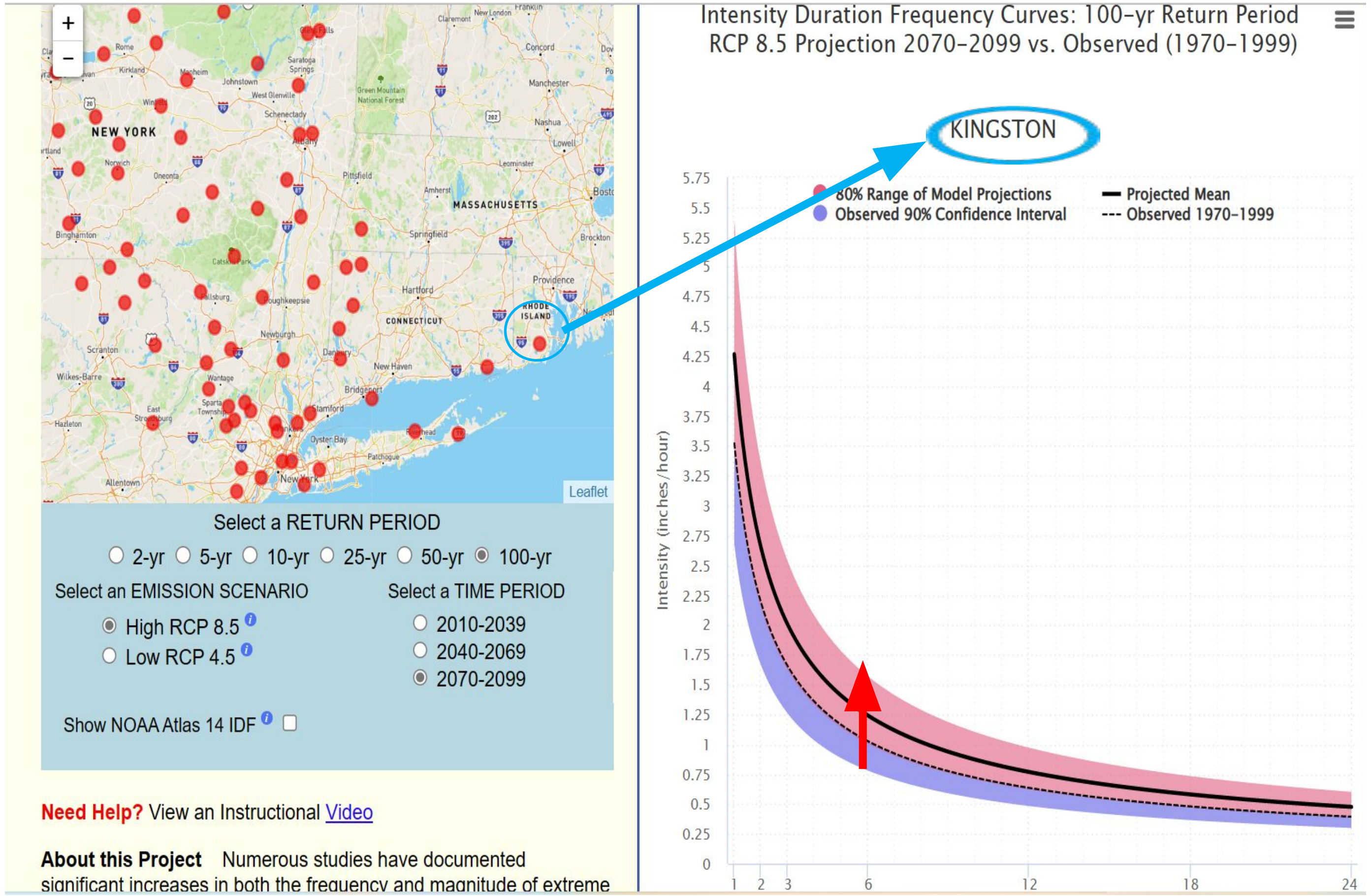
Curves | PF estimates with confidence intervals



Northeast Regional Climate Center, Cornell University,

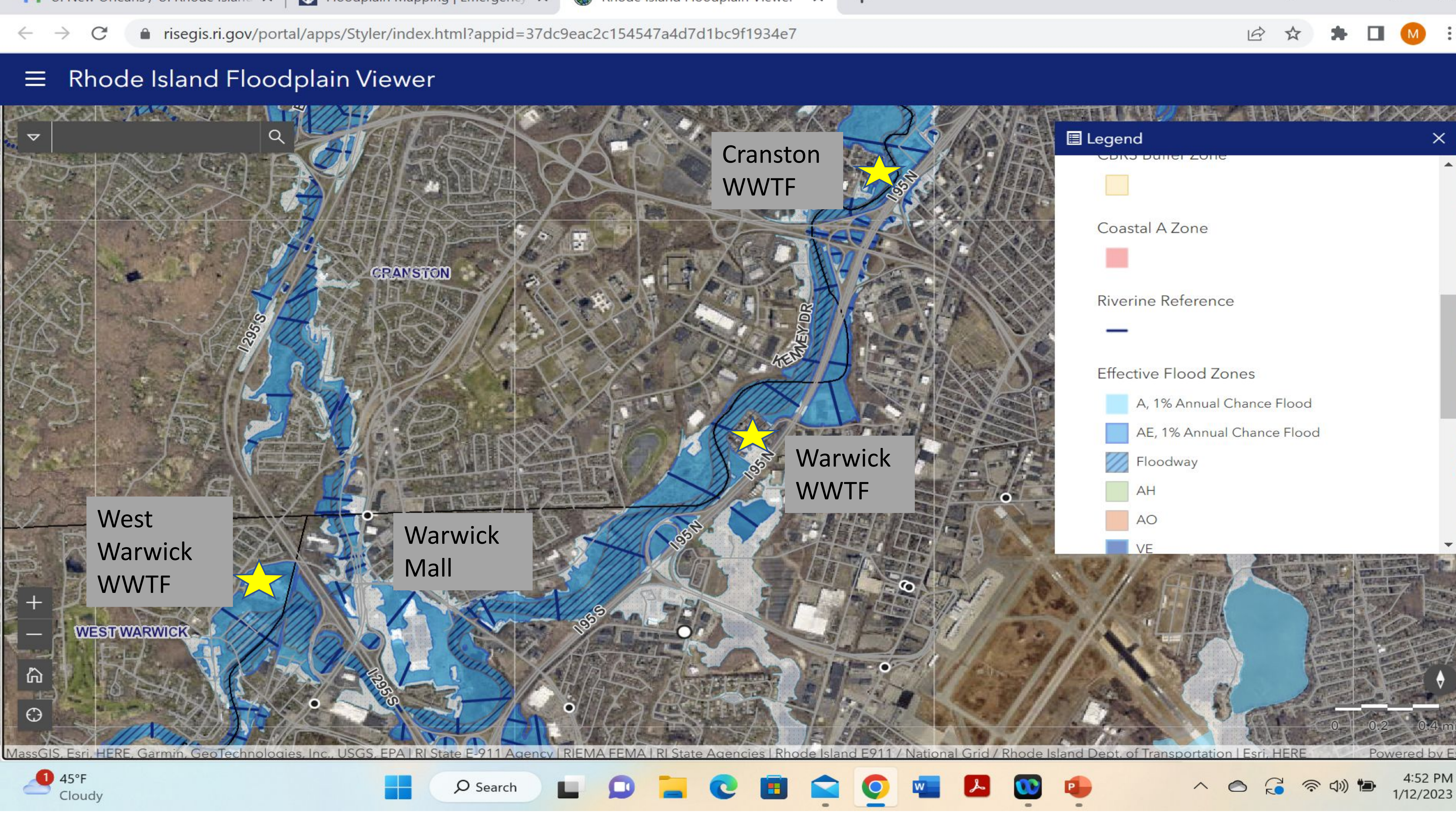
# Change in Rainfall Intensity




| Duration (hrs) | Projected 2040-2069 Intensity Ensemble Member 10th | Mean | 90th | Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds Low CI | Mean | High CI |
|---|---|---|---|---|---|---|
| 1 | 3.45 | 3.95 | 4.64 | 2.68 | 3.53 | 3.51 |
| 2 | 2.14 | 2.45 | 2.88 | 1.66 | 2.19 | 2.17 |
| 3 | 1.62 | 1.85 | 2.18 | 1.26 | 1.65 | 1.64 |
| 6 | 1.00 | 1.15 | 1.35 | 0.78 | 1.02 | 1.02 |
| 12 | 0.62 | 0.71 | 0.84 | 0.48 | 0.63 | 0.63 |
| 18 | 0.47 | 0.54 | 0.63 | 0.36 | 0.48 | 0.48 |
| 24 | 0.38 | 0.44 | 0.52 | 0.30 | 0.39 | 0.39 |

| Duration (hrs) | Projected 2070-2099 Intensity Ensemble Member 10th | Mean | 90th | Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds Low CI | Mean | High CI |
|---|---|---|---|---|---|---|
| 1 | 3.46 | 4.27 | 5.40 | 2.68 | 3.53 | 3.51 |
| 2 | 2.14 | 2.65 | 3.35 | 1.66 | 2.19 | 2.17 |
| 3 | 1.62 | 2.00 | 2.53 | 1.26 | 1.65 | 1.64 |
| 6 | 1.00 | 1.24 | 1.57 | 0.78 | 1.02 | 1.02 |
| 12 | 0.62 | 0.77 | 0.97 | 0.48 | 0.63 | 0.63 |
| 18 | 0.47 | 0.58 | 0.73 | 0.36 | 0.48 | 0.48 |
| 24 | 0.39 | 0.48 | 0.60 | 0.30 | 0.39 | 0.39 |


risegis.ri.gov/portal/apps/Styler/index.html?appid=37dc9eac2c154547a4d7d1bc9f1934e7
Rhode Island Floodplain Viewer
Cranston WWTF
Warwick WWTF
West Warwick WWTF
Warwick Mall
CRANSTON
WEST WARWICK
I 295 S
I 95 N
I 95 S
JEMEY DR
Legend
Coastal A Zone
Riverine Reference
Effective Flood Zones
A, 1% Annual Chance Flood
AE, 1% Annual Chance Flood
Floodway
AH
AO
VE
MassGIS, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA | RI State E-911 Agency | RIEMA FEMA | RI State Agencies | Rhode Island E911 / National Grid / Rhode Island Dept. of Transportation | Esri, HERE
45°F
Cloudy
Search
4:52 PM
1/12/2023

# Climate Change is also affecting Sea Levels & Coastal flooding

# RI CRMC Coastal Hazard Application

RI CRMC Beach SAMP

STORMTOOLS Home | STORMTOOLS for Beginners | Advanced STORMTOOLS | STORMTOOLS Design Elevation (SDE) | More

Step 4: Shoreline Change

## Step 5A. Other Site Considerations: CERI

### 5A. COASTAL ENVIRONMENTAL RISK INDEX (CERI)

For development applications along Rhode Island's South Coast, identify the risk and potential damage profile of a property using the map to the right.

The maps to the right illustrate projected risk to residential structures for a 100-year storm event with sea level rise scenarios. Risk is represented by the percent of damage a structure is expected to receive assuming a worst-case scenario -- two story house with a basement located within the flood zone.

0-25% Damage - Moderate Risk
25-50% Damage - High Risk
50-75% Damage - Severe Risk
75-100% Damage - Extreme Risk

TECHNICAL PAPERS:

100yr, SLR0 | 100yr, SLR2 | 100yr, SLR3 | 100yr, SLR5 | 100yr, SLR7 | 100yr, SLR10

Home | STORMTOOLS Coastal Environme... | Open in Map Viewer | Modify Map | Sign In

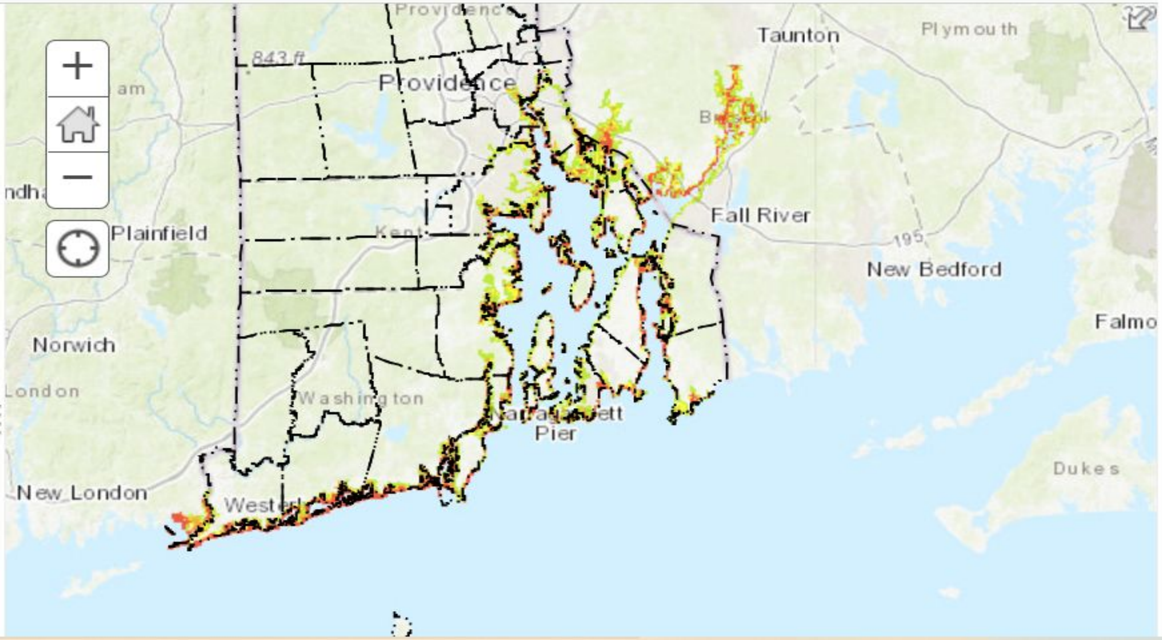
Details | Basemap | Share | Print | Measure | Find address or place

Legend

**Municipal Boundaries**

**CERI Maximum Structural Risk Potential**

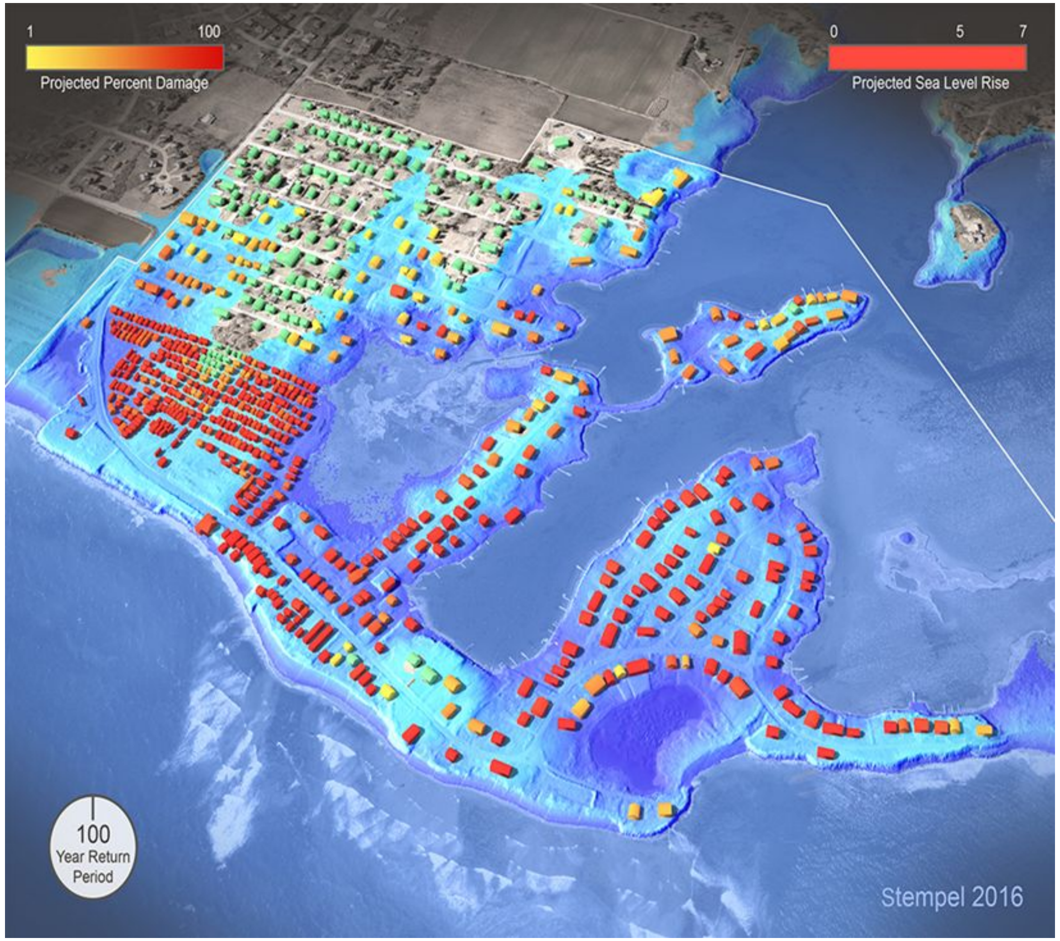
- Inundated By 2100
- Moderate
- High
- Severe
- Extreme

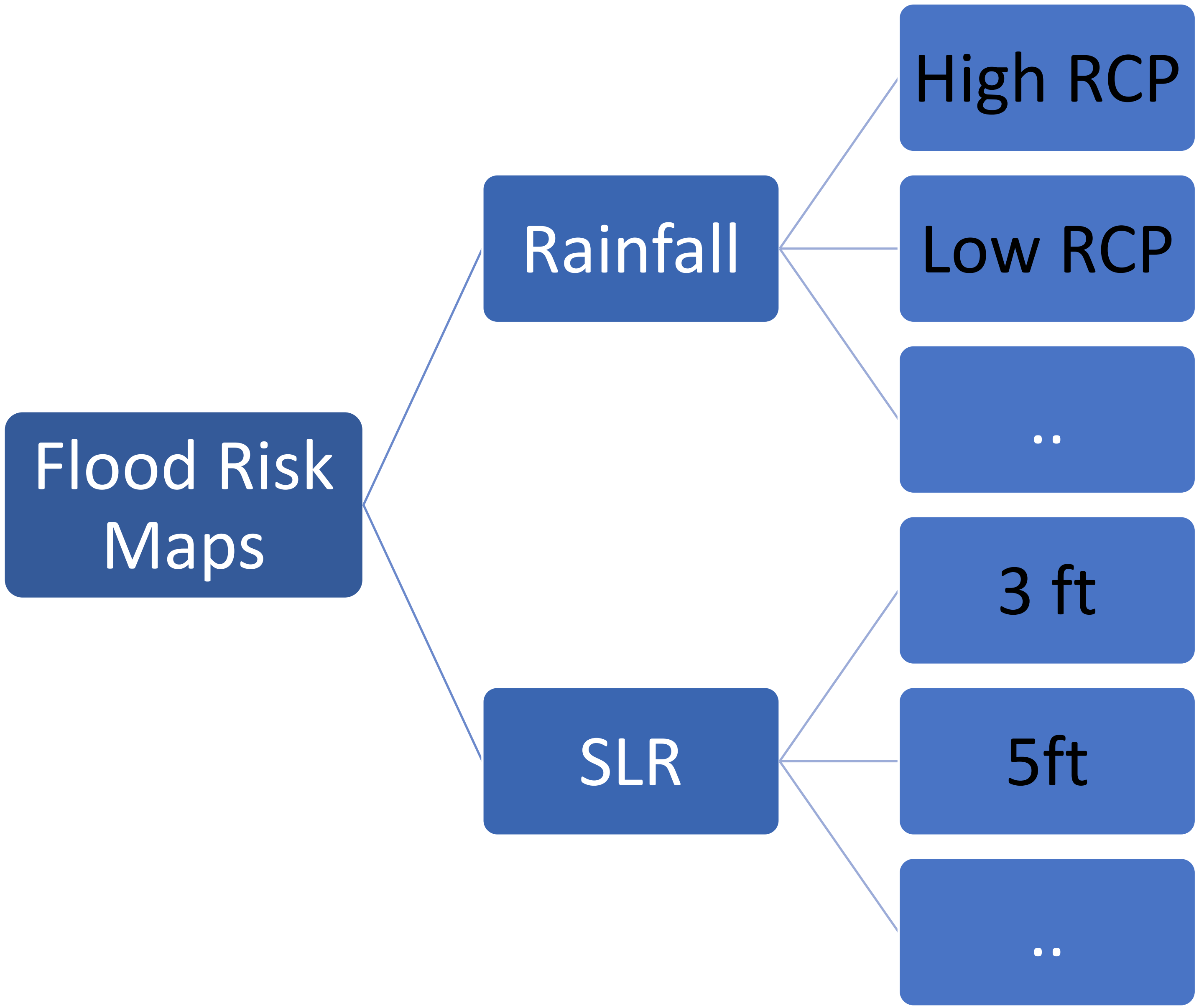


# CERI East Matunuck, 100 yr, no and 7 ft SL

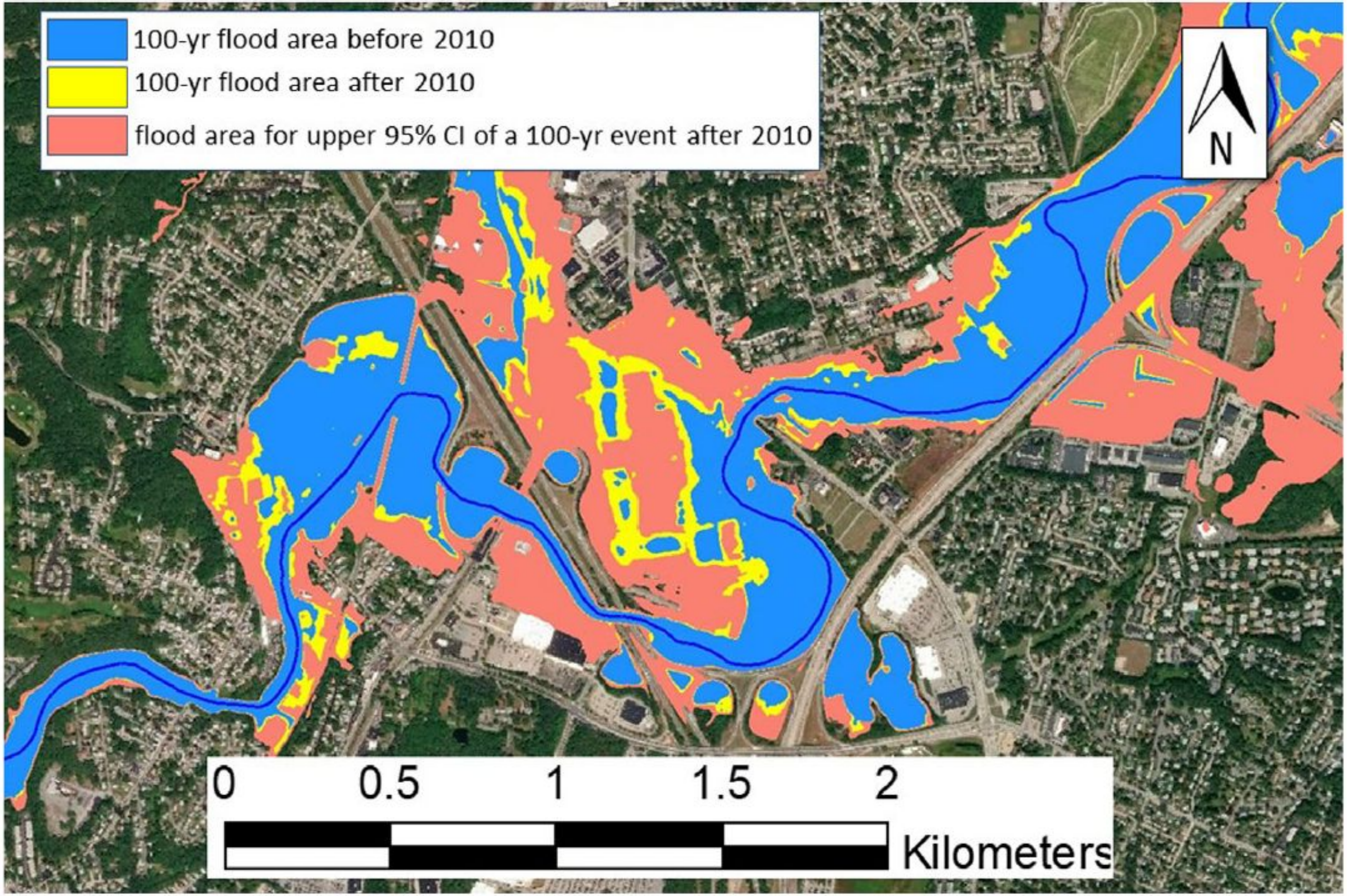
No SLR


7 ft SLR

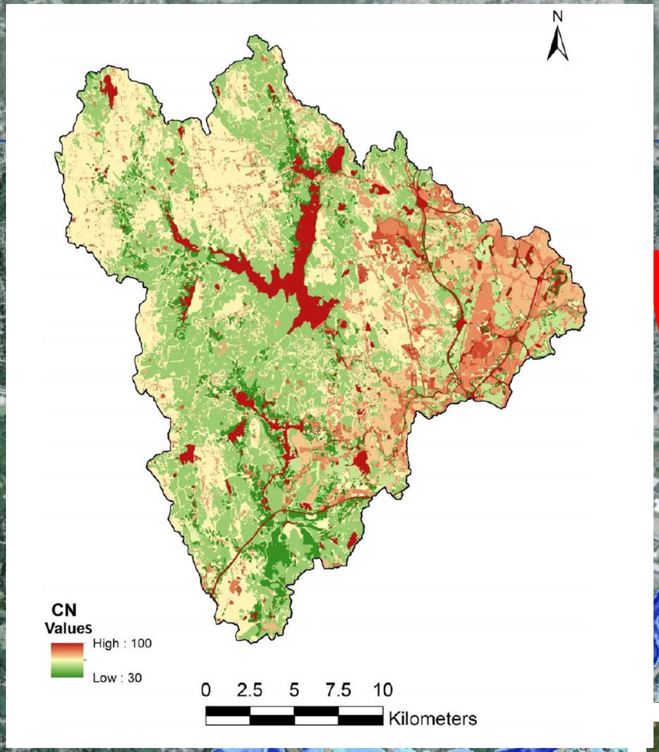


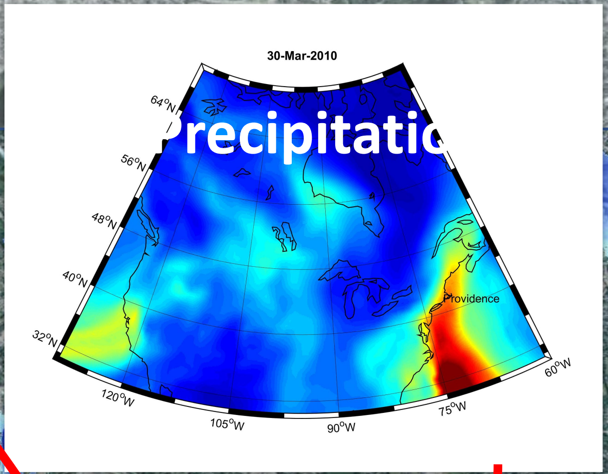


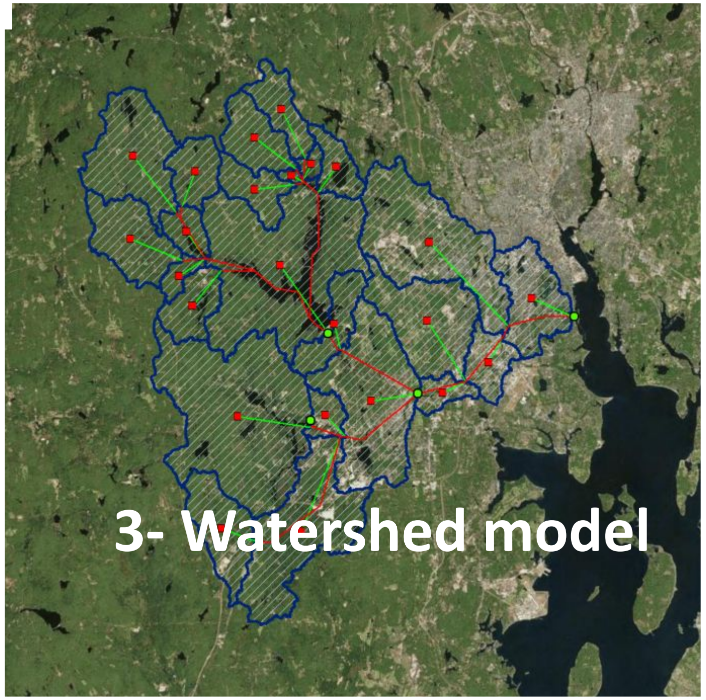

The Representative Concentration Pathways (RCPs) describe four different 21st century pathways of greenhouse gas (GHG) emissions and atmospheric concentrations, air pollutant emissions and land use.

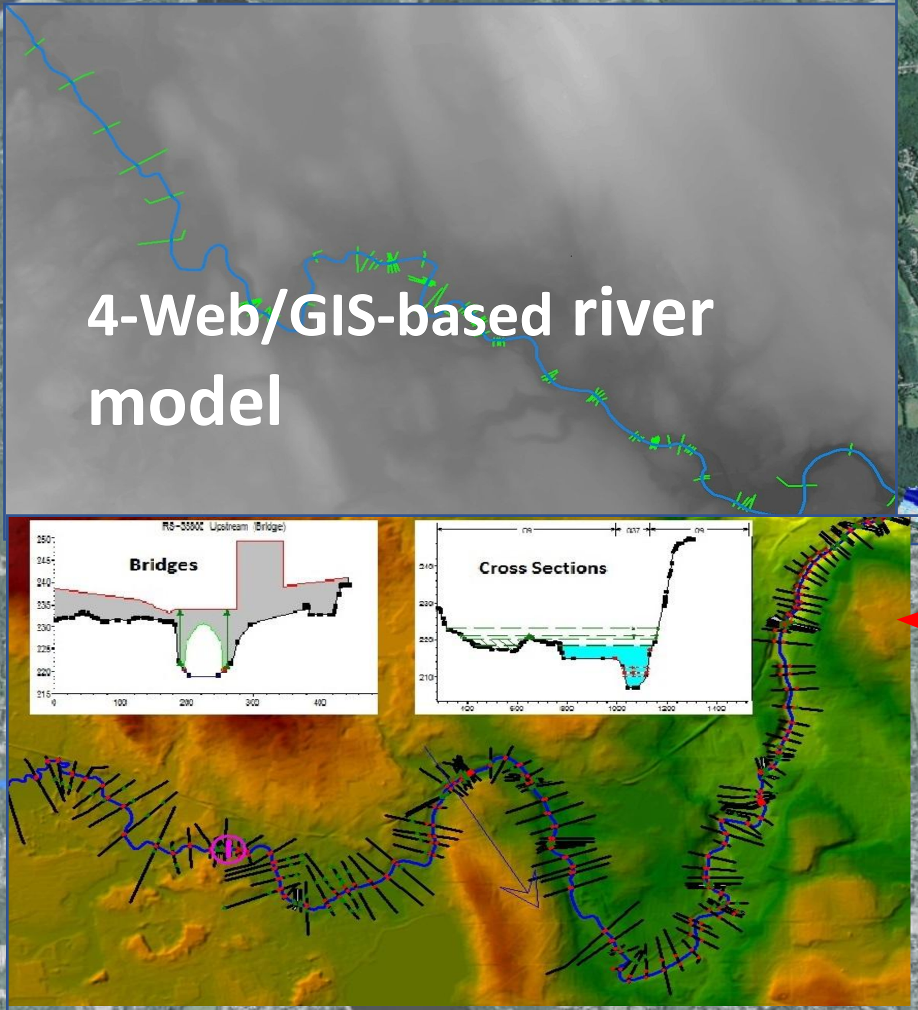

100-yr flood area before 2010
100-yr flood area after 2010
flood area for upper 95% CI of a 100-yr event after 2010
N
0
0.5
1
1.5
2
Kilometers

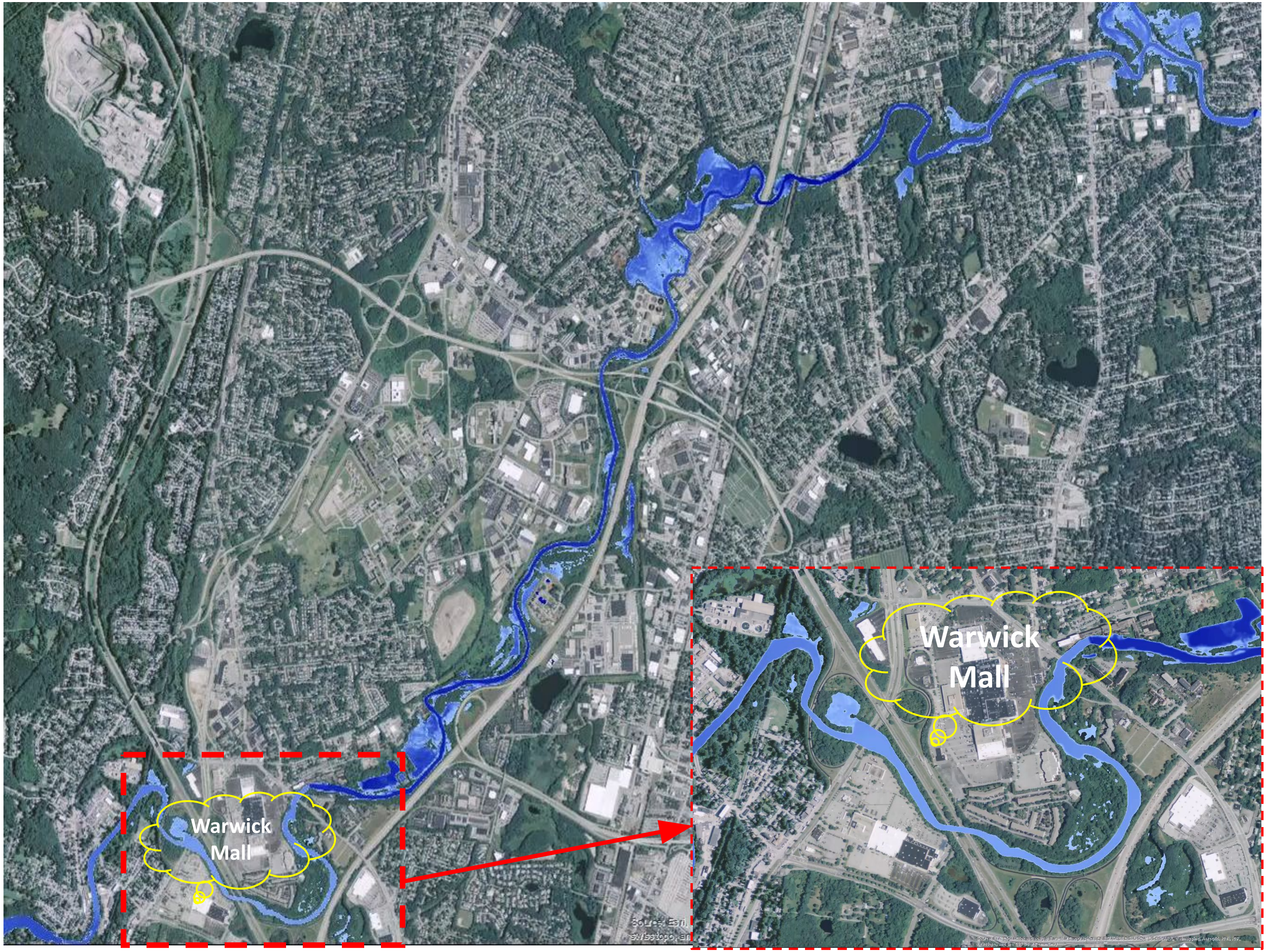
# Overview of the modeling system



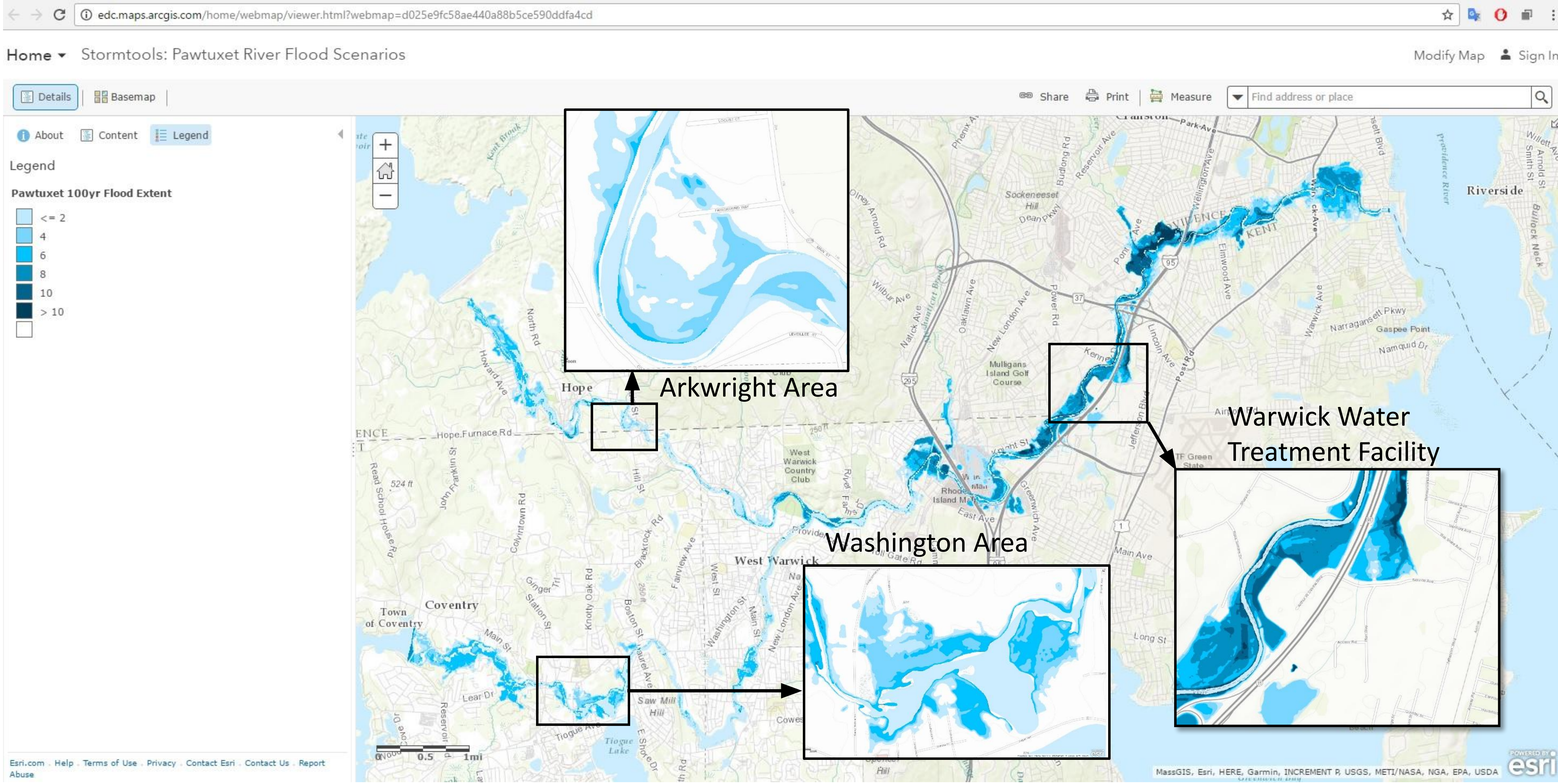




Warwick
Mall
Warwick
Mall

# Web-based maps for Pawtuxet River



# Study Goals (proposal to FEMA)

- To develop and incorporate watershed models that predict the impact of climate change (or precipitation changes) on riverine flooding and how these impact present-day FEMA flood zones.

- To leverage existing STORMTOOL initiatives to develop a seamless flood risk assessment tool for preparedness and mitigation of flood risk in RI considering the future changes in climate (precipitation and SLR). Also, disseminate the results to permitting agencies and RI communities.

- To provide an effective statewide flood mapping tool for planning hazard mitigation projects and increasing public awareness about the impacts of climate change (extreme rainfall and SLR) on flood risk.

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DOI: 10.1111/jfr3.12655

ORIGINAL ARTICLE

CIWEM Chartered Institution of Water and Environmental Management | Journal of Flood Risk Management | WILEY

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

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**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.

**KEYWORDS**

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

# Thanks!
# Questions?

Three different methods were used to downscale future daily precipitation extremes at each station under two IPCC climate change scenarios (RCP4.5 and RCP8.5). The first method employs quantile–quantile mapping to bias correct a really adjusted precipitation extremes obtained from dynamically downscaled climate model simulations. **These simulations consist of regional climate models (RCMs) run at 50-km resolution and driven by atmosphere–ocean general circulation models (AOGCMs) from Phase 5 of the Couple Model Intercomparison Project (CMIP5).** The second method, a variation of the delta method, computes differences in simulated precipitation extremes between CMIP5 future and historical periods, and applies these differences toward observed precipitation extremes. The third method combines quantile–quantile mapping with a unique approach for downscaling daily precipitation extremes from historical analogs. This analog approach involves a multi-step procedure in which the occurrence of extreme precipitation on a given CMIP5 model day is first predicted based on the observed probability of extreme precipitation on that day's closest historical analog days. Then, if extreme precipitation occurred on the selected analog day(s), the precipitation observations associated with the historical analog day(s) are used to ascribe precipitation amounts on the corresponding model day. Across all three downscaling methods, 49 unique sets of extreme precipitation projections were generated for each climate scenario–time period combination. These 49 simulations form an ensemble of projections that is summarized by an ensemble mean, and the ensemble member corresponding to the 10th and 90th percentiles of the 49 simulations.