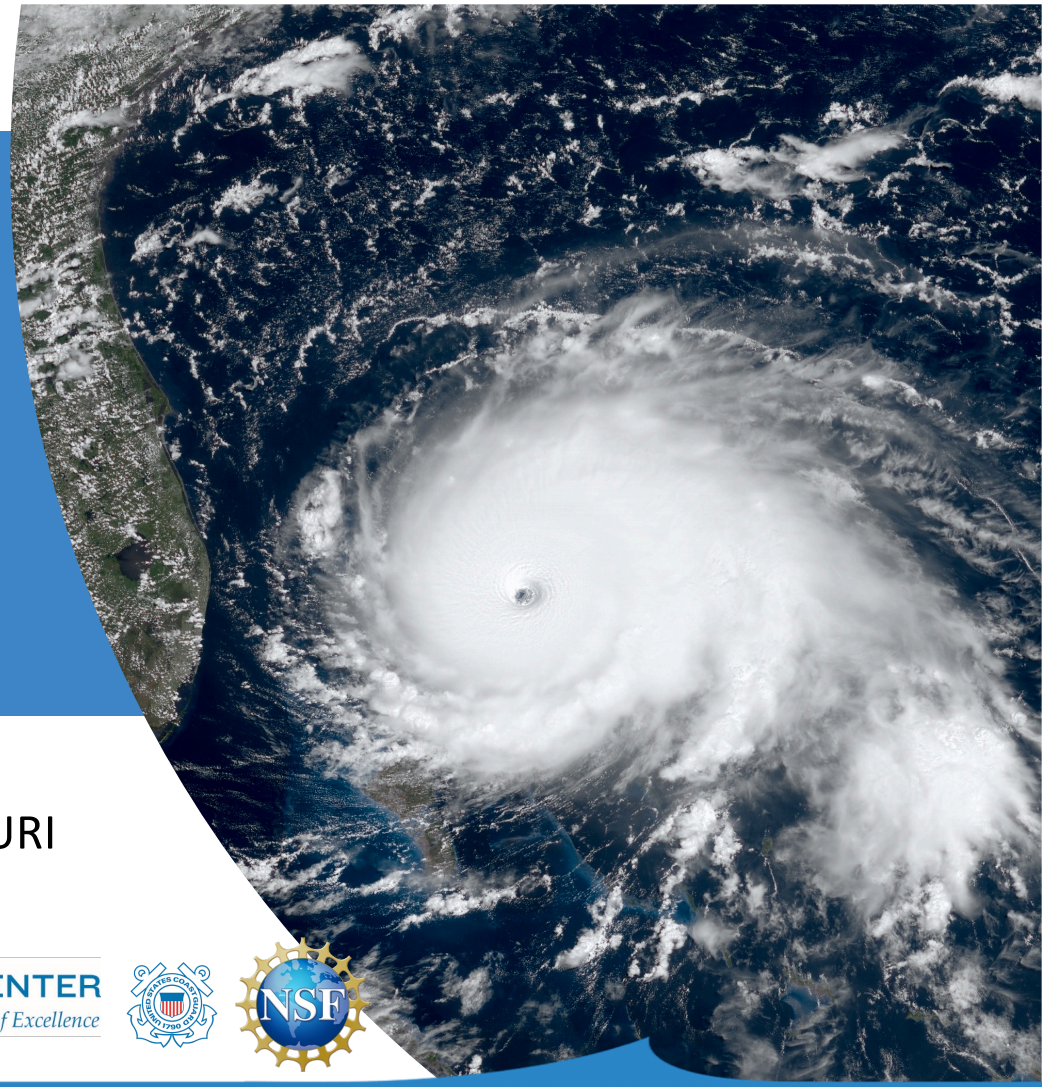
Coastal Hazard Modeling & Decision-support Systems for RI:
--
A review of tools from URI & In-depth look at CHAMP



Dr. Austin Becker, Chair of Marine Affairs, URI

THE UNIVERSITY OF RHODE ISLAND DEPARTMENT OF MARINE AFFAIRS

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY

COASTAL RESILIENCE CENTER
A U.S. Department of Homeland Security Center of Excellence

This material is based upon work supported by the U.S. Department of Homeland Security under Grant Award Number 2015-ST-061-ND0001-01. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S Department of Homeland Security.

Complex Challenges Require Diversity of Expertise

Emergency Management & Outreach



Pam Rubinoff
URI Coastal Resources Center



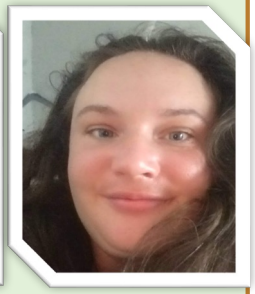
Eliza Berry
URI Coastal Resources Center



Sam Adams
URI Dept. of Marine Affairs & URI Public Safety

Storm Modeling



Isaac Ginis, Ph.D.,
Reza Hashemi, Ph.D., Pranav Sai, Sarah Bednarski
URI School of Oceanography

GIS Interface for End-Users






Peter Stempel
Penn State

Chris Damon
Aimee Mandeville
Greg Bonynge
URI Environmental Data Center

Social Sciences






Austin Becker, Ph.D.,
Kyle McElroy, Noah Hallisey,
Jon Nelson, Ph.D.
URI Dept of Marine Affairs

Coastal Hazard Decision Support at URI

CHAMP

STORMTOOLS

MyCoast

- Supports:
  - Local-scale emergency management and resilience planning
  - Land developers assessing flood risks
  - Critical infrastructure managers
  - Community engagement in resilience planning
  - Citizen Science
- Medium term goal:

Develop a center at URI that brings these tools together, incorporate new technology as it develops, and enhance them with community input to support sustainability and resiliency.

CHAMP: **C**oastal **H**azards, **A**nalysis, **M**odeling, and **P**rediction **S**ystem

Developed with emergency managers





- **Real-time** storm response and recovery preparation (RI Emergency Management)
- State and local hazard mitigation **planning**
- Floodplain **management**
- **Facility planning** (RI Dept. of Environmental Management and Dept. of Health)

CHAMP projects to date

RI CHAMP

- Providence critical infrastructure (all)
- Statewide:
  - Health facilities with DOH
  - Wastewater facilities with DEM
  - Drinking water infrastructure with DOH
- Warren (launching 1/2025)
  - Road low point analysis with RIDOT
  - Integration of riverine flooding

Newport Military Installation Resilience Review (MIRR)

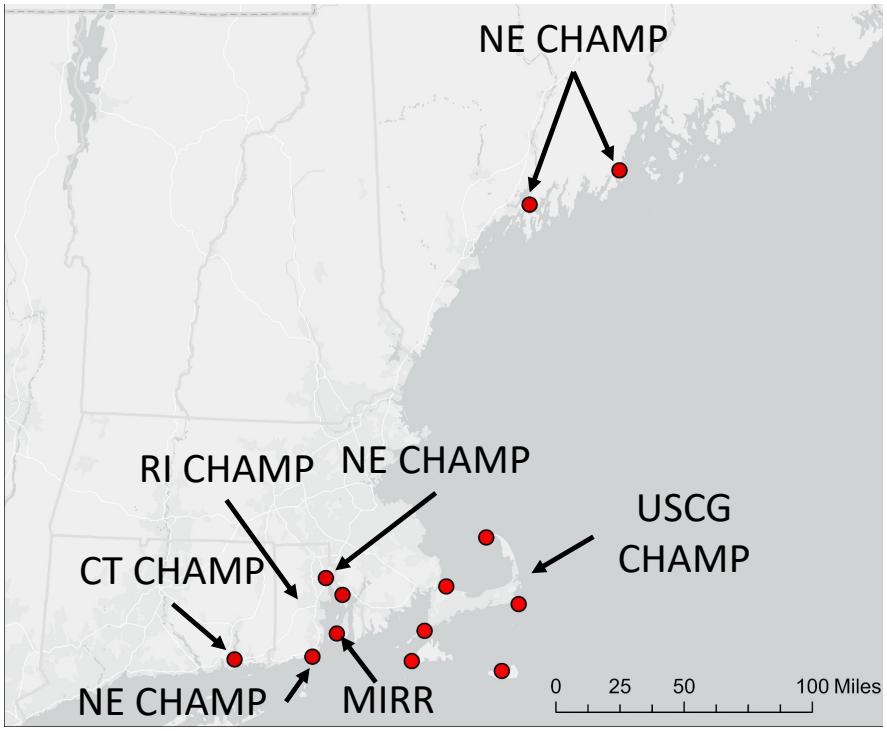
- Assets at facilities inside and outside the fenceline with Newport, Portsmouth, Middletown, and Navy Station Newport

NE CHAMP (Underway)

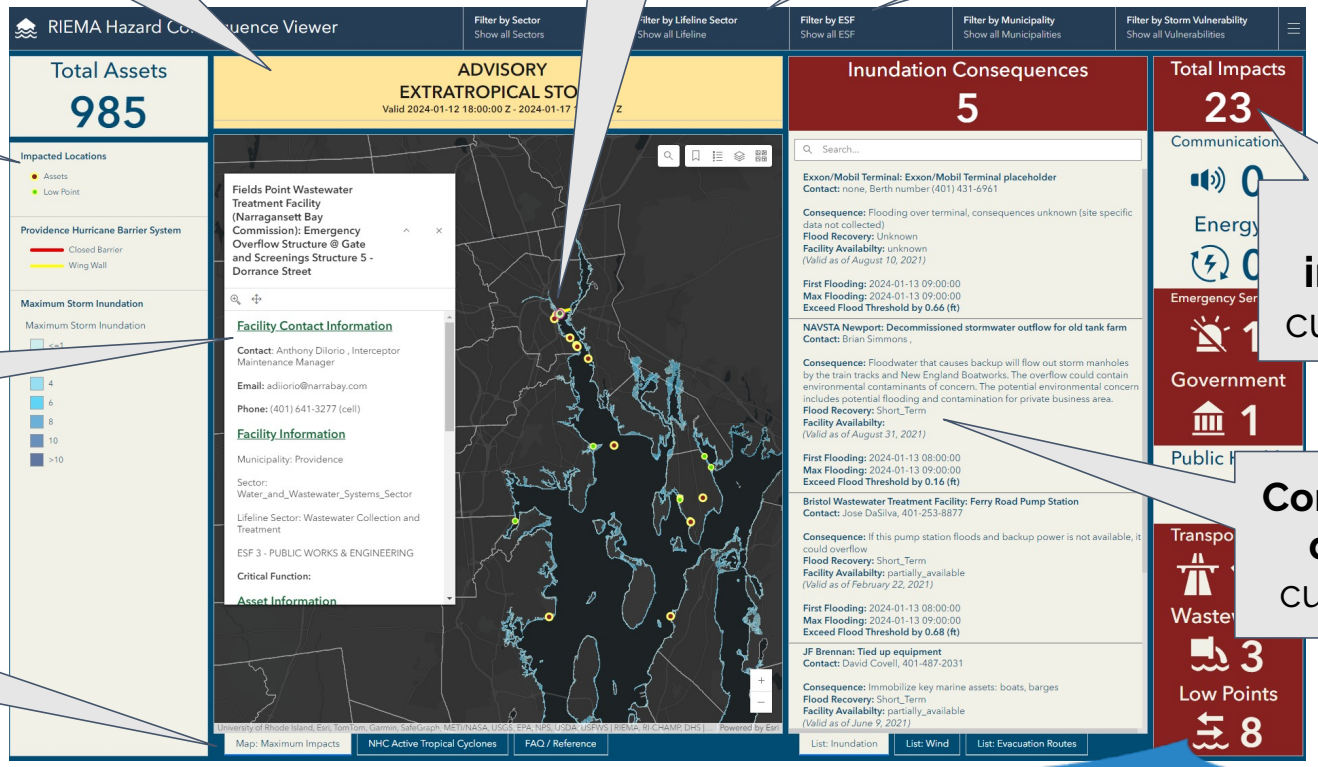
- Galilee, Providence, Bath and Rockland (ME)

USCG CHAMP (Underway)

CT CHAMP (Underway)



CHAMP Interactive Dashboard



Map legend

Current scenario

Impacted assets and facilities

Map controls Zoom, layers, base map

Filter by ESF or municipality

Asset details and consequences

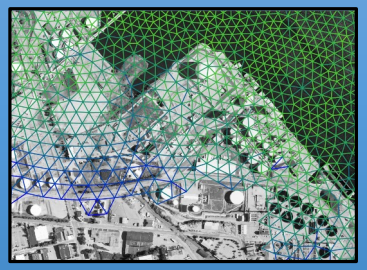
Total impacts in current view

Consequence details in current view

Tab selection Max inundation or FAQ

CHAMP System Overview – Four Components

ADCIRC Storm Model
NetCDF surge and wind file(s)



Infrastructure Assets Consequence Threshold (IACT) Database





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ArcGIS Data Store

ArcGIS Server
ArcGIS Image Server

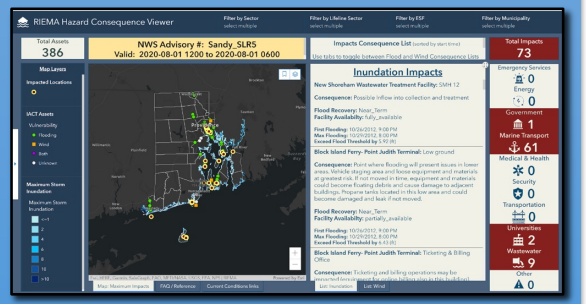
python® scripting and arcpy.mapping

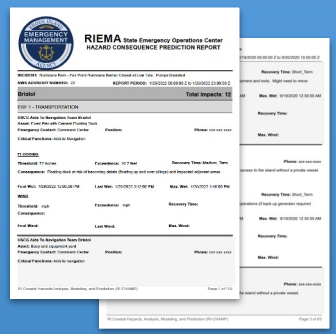
Reporting

Impact Analysis

Map and Image Services

Outputs - RI-CHAMP Dashboard & Reports





MANUSCRIPT: Stempel, P., Ginis, I., Ullman, D., Becker, A., & Witkop, R. (2018). Real-Time Chronological Hazard Impact Modeling. *Journal of Marine Science and Engineering*, *6*(4), 134.

Leveraging State-of-the-Art ADCIRC Storm Modeling

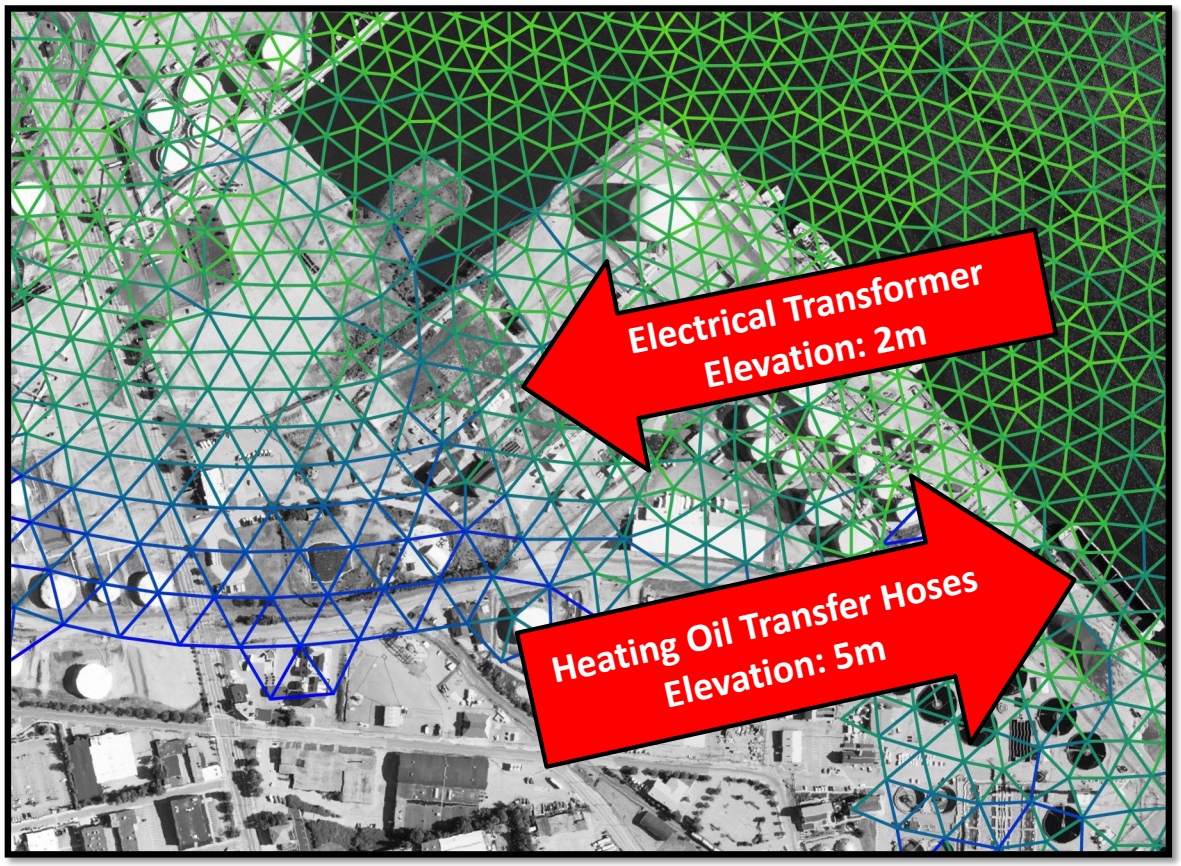
High-resolution ADCIRC modeling
(~20-40m unstructured grid)

+

Ground-truthed, locally derived,
consequences data

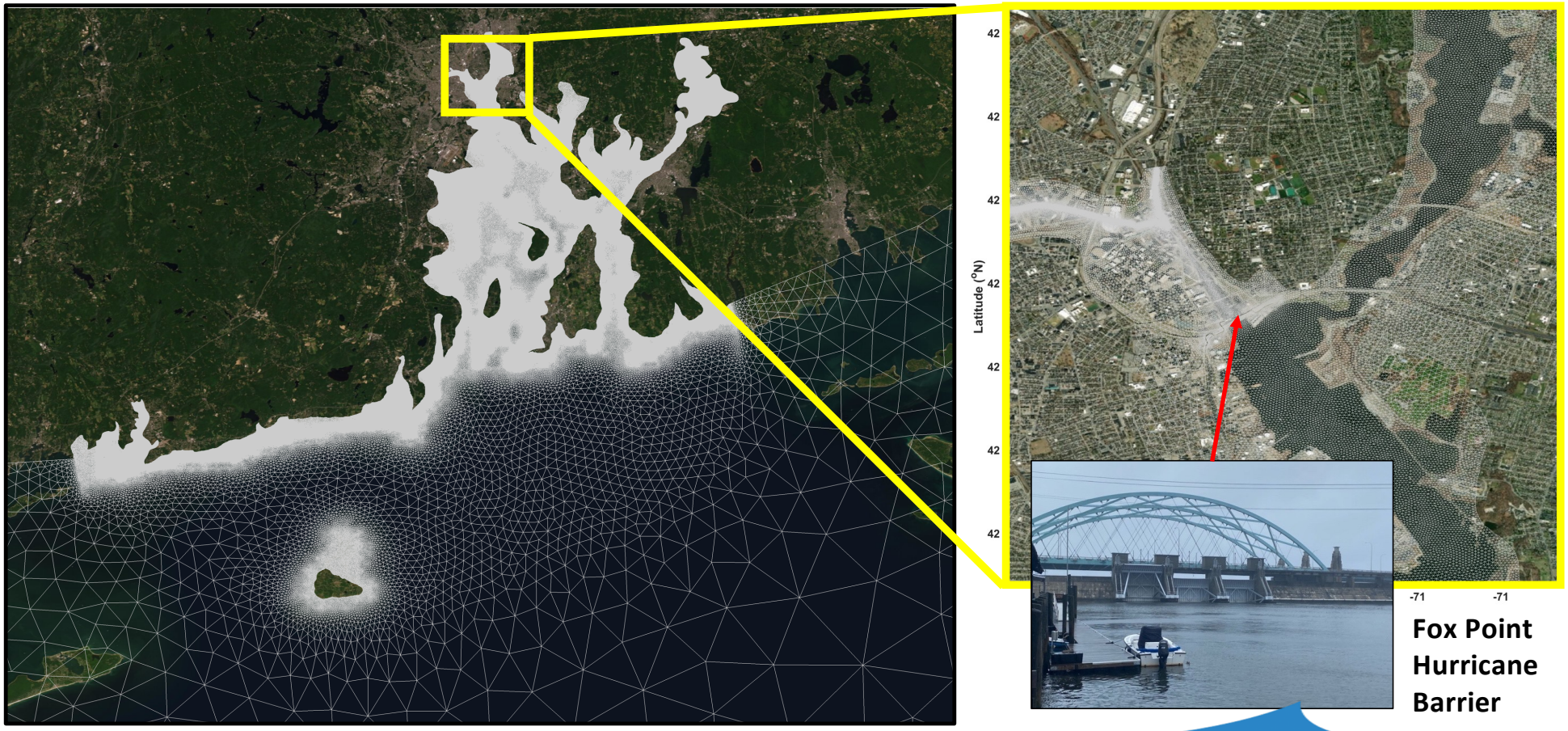
=

~2 meter FLOOD RES0LUTION
POWERFUL IMPACT PREDICTION



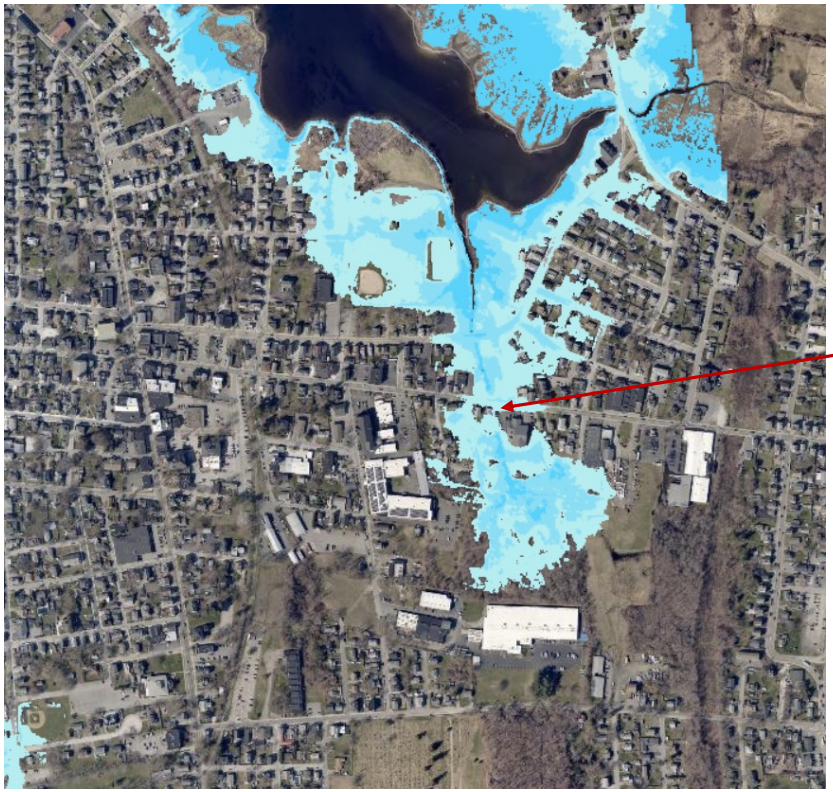
Providence, RI

State-of-the-Art ADCIRC Storm Modeling



Results: Real-time forecast of December 2022 Nor'easter

CHAMP Flood Map - Warren, RI

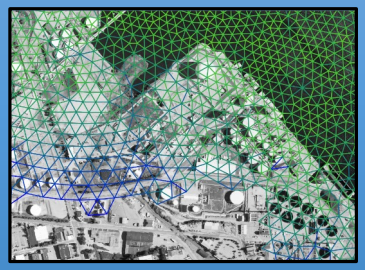


Child Street Warren, RI



CHAMP System Overview

ADCIRC Storm Model
NetCDF surge and wind file(s)



Infrastructure Assets Consequence Threshold (IACT) Database



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ArcGIS Data Store

ArcGIS Server
ArcGIS Image Server

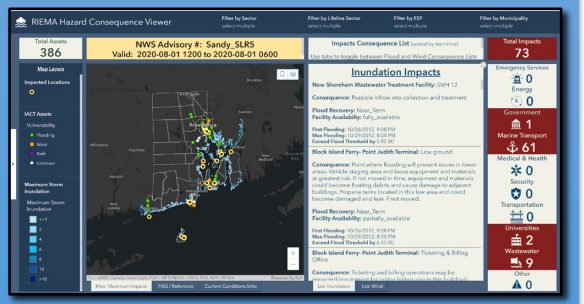
python® scripting and arcpy.mapping

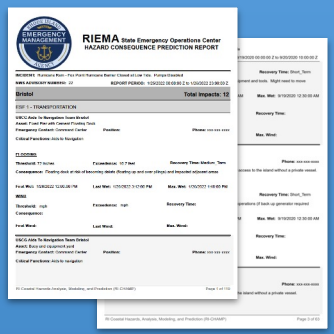
Reporting

Impact Analysis

Map and Image Services

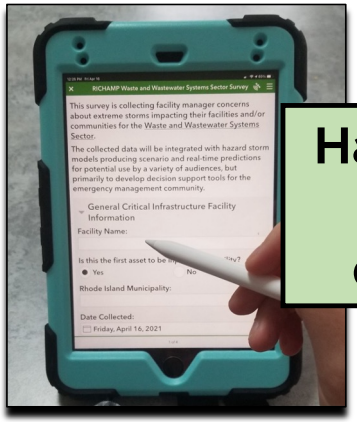
Outputs - RI-CHAMP Dashboard & Reports





Stempel, P., Ginis, I., Ullman, D., Becker, A., & Witkop, R. (2018). Real-Time Chronological Hazard Impact Modeling. *Journal of Marine Science and Engineering*, *6*(4), 134.

Data Collection from Subject Matter Experts



Hazard Consequence Thresholds (HCTs) complement other quantitative assessment tools



Specific, local, flexible

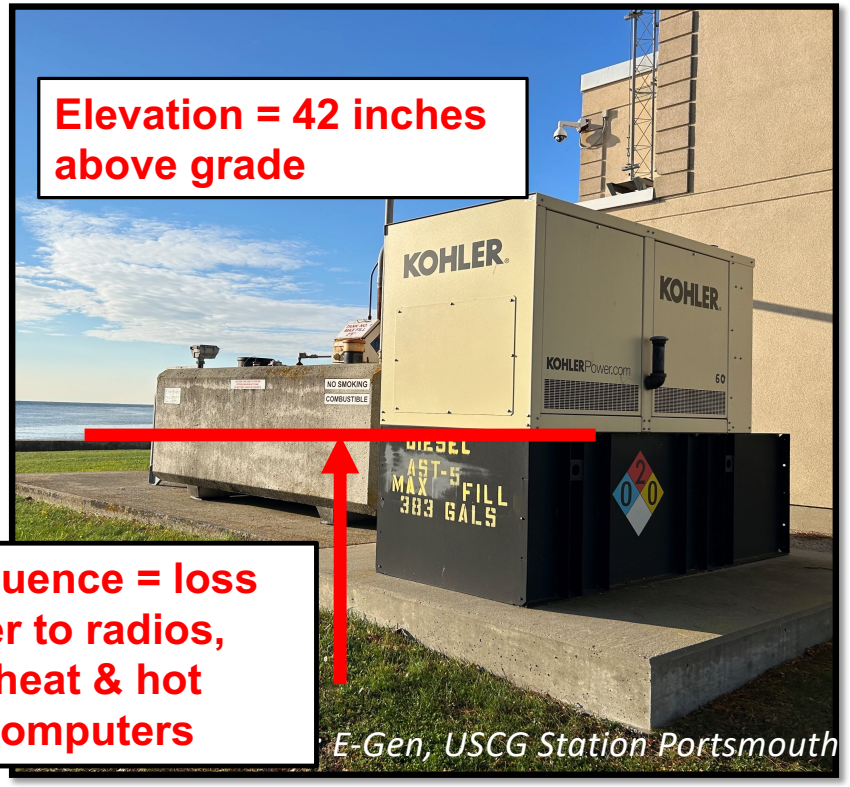
Infrastructure facility managers:

- Know their own local **vulnerabilities**
- Need to **understand model outputs on their own terms**
- Participation increases the **credibility and value** of the storm models outputs

To Date: Data collected at ~450 infrastructure facilities

The Infrastructure Asset Consequence Thresholds (IACT) Database

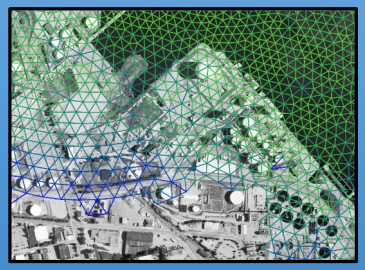
- **Asset Name:** *Electricity Generator*
- **Asset x/y location:** Lat/Long
- **Thresholds** at which flood and/or wind would impact the asset
- **Consequences** of that asset being impaired
- **Estimated time of recovery:** Weeks
- **Mitigation steps:** Sandbags
- **Emergency point-of-contact:** Statio Officer of the Day



Examples: transformers, utility rooms, antennas, road low points, HVAC, tanks, clarifiers, docks, cold storage . . .

CHAMP System Overview

ADCIRC Storm Model
NetCDF surge and wind file(s)



Infrastructure Assets Consequence Threshold (IACT) Database



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ArcGIS Data Store

ArcGIS Server
ArcGIS Image Server

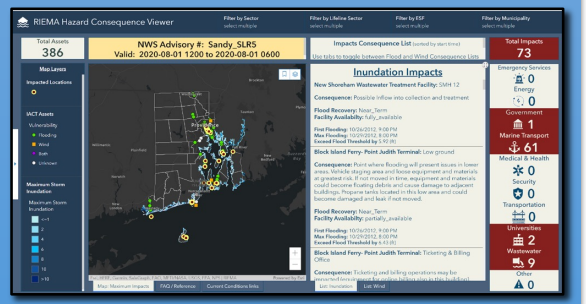
python® scripting and arcpy.mapping

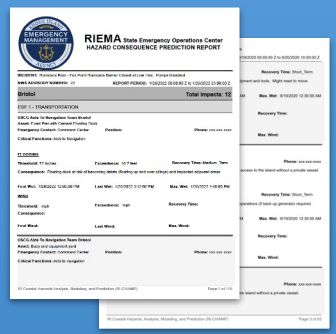
Reporting

Impact Analysis

Map and Image Services

Outputs - RI-CHAMP Dashboard & Reports

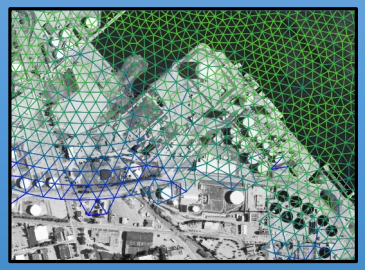




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CHAMP System Overview

ADCIRC Storm Model
NetCDF surge and wind file(s)



Infrastructure Assets Consequence Threshold (IACT) Database





Survey123

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ArcGIS Image Server

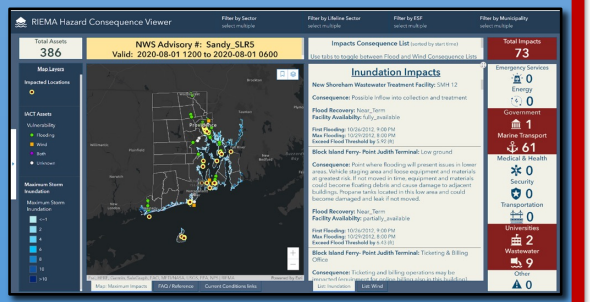
python® scripting and arcpy.mapping

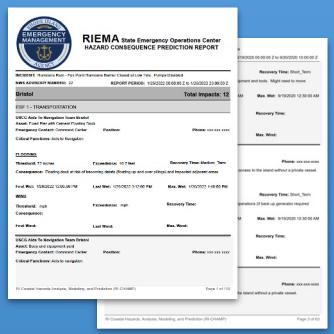
Reporting

Impact Analysis

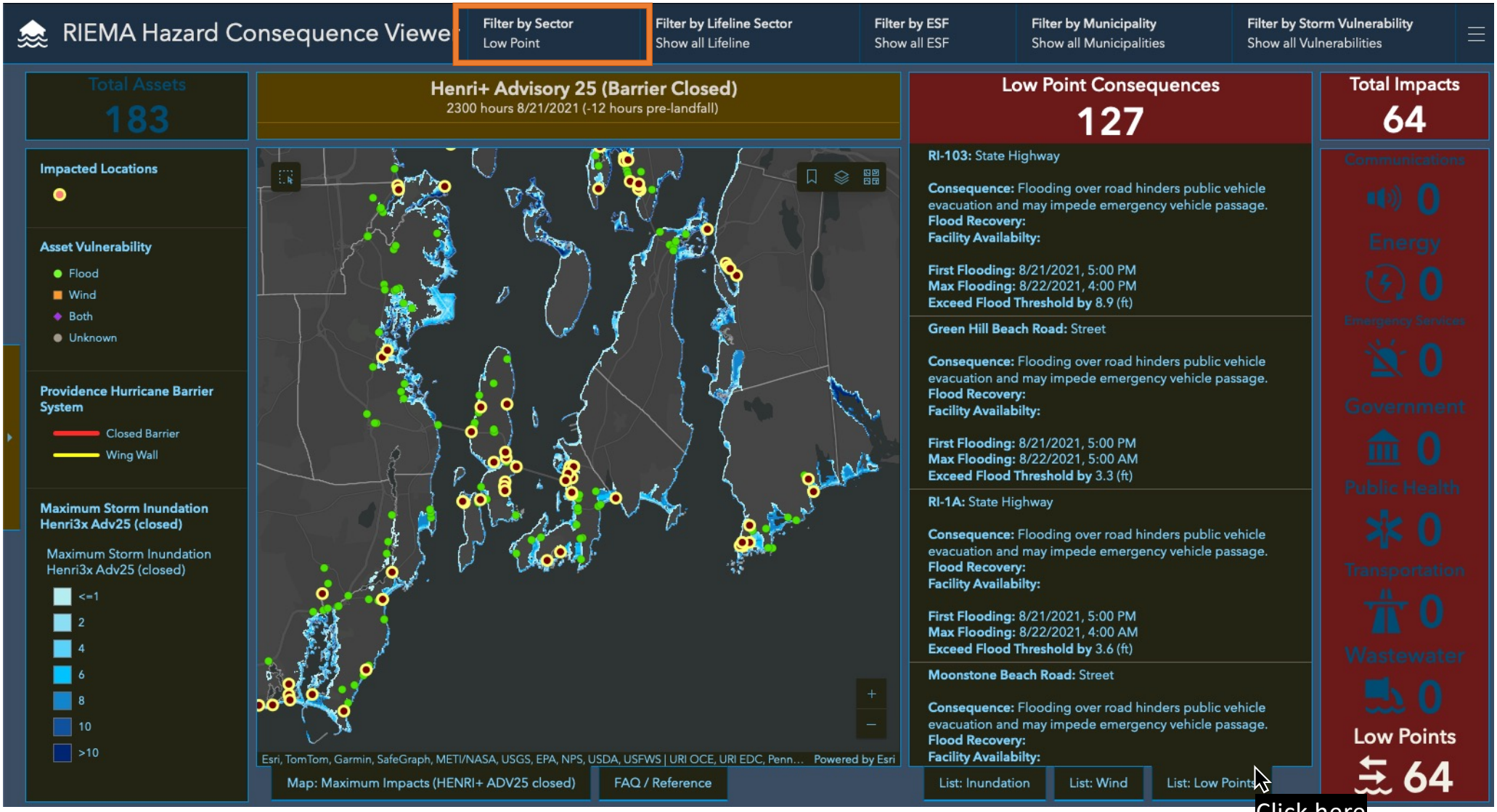
Map and Image Services

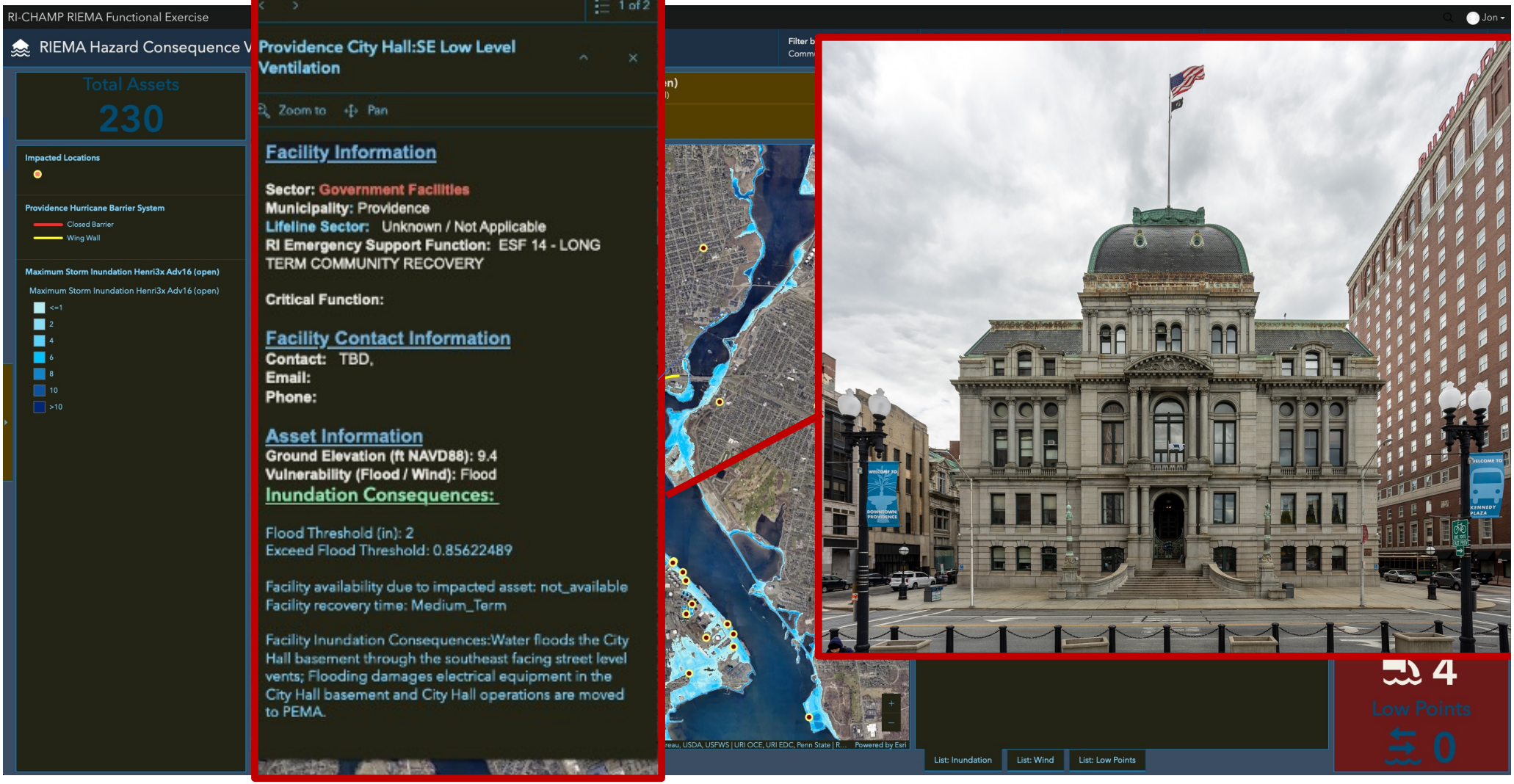
Outputs - RI-CHAMP Dashboard & Reports





MANUSCRIPT: Stempel, P., Ginis, I., Ullman, D., Becker, A., & Witkop, R. (2018). Real-Time Chronological Hazard Impact Modeling. *Journal of Marine Science and Engineering*, *6*(4), 134.


RIEMA Hazard Consequence Viewe
Filter by Sector
Low Point
Filter by Lifeline Sector
Show all Lifeline
Filter by ESF
Show all ESF
Filter by Municipality
Show all Municipalities
Filter by Storm Vulnerability
Show all Vulnerabilities
Total Assets
183
Impacted Locations
Asset Vulnerability
Flood
Wind
Both
Unknown
Providence Hurricane Barrier System
Closed Barrier
Wing Wall
Maximum Storm Inundation Henri3x Adv25 (closed)
Maximum Storm Inundation Henri3x Adv25 (closed)
<=1
2
4
6
8
10
>10
Henri+ Advisory 25 (Barrier Closed)
2300 hours 8/21/2021 (-12 hours pre-landfall)
Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, USFWS | URI OCE, URI EDC, Penn... Powered by Esri
Map: Maximum Impacts (HENRI+ ADV25 closed)
FAQ / Reference
Low Point Consequences
127
RI-103: State Highway
Consequence: Flooding over road hinders public vehicle evacuation and may impede emergency vehicle passage.
Flood Recovery:
Facility Availabilty:
First Flooding: 8/21/2021, 5:00 PM
Max Flooding: 8/22/2021, 4:00 PM
Exceed Flood Threshold by 8.9 (ft)
Green Hill Beach Road: Street
Consequence: Flooding over road hinders public vehicle evacuation and may impede emergency vehicle passage.
Flood Recovery:
Facility Availabilty:
First Flooding: 8/21/2021, 5:00 PM
Max Flooding: 8/22/2021, 5:00 AM
Exceed Flood Threshold by 3.3 (ft)
RI-1A: State Highway
Consequence: Flooding over road hinders public vehicle evacuation and may impede emergency vehicle passage.
Flood Recovery:
Facility Availabilty:
First Flooding: 8/21/2021, 5:00 PM
Max Flooding: 8/22/2021, 4:00 AM
Exceed Flood Threshold by 3.6 (ft)
Moonstone Beach Road: Street
Consequence: Flooding over road hinders public vehicle evacuation and may impede emergency vehicle passage.
Flood Recovery:
Facility Availabilty:
List: Inundation
List: Wind
List: Low Points
Click here
Total Impacts
64
Communications
0
Energy
0
Emergency Services
0
Government
0
Public Health
0
Transportation
0
Wastewater
0
Low Points
64


RI-CHAMP RIEMA Functional Exercise
RIEMA Hazard Consequence V
Total Assets
230
Impacted Locations
Providence Hurricane Barrier System
Closed Barrier
Wing Wall
Maximum Storm Inundation Henri3x Adv16 (open)
Maximum Storm Inundation Henri3x Adv16 (open)
<=1
2
4
6
8
10
>10
1 of 2
Providence City Hall:SE Low Level Ventilation
Zoom to
Pan
Facility Information
Sector: Government Facilities
Municipality: Providence
Lifeline Sector: Unknown / Not Applicable
RI Emergency Support Function: ESF 14 - LONG TERM COMMUNITY RECOVERY
Critical Function:
Facility Contact Information
Contact: TBD,
Email:
Phone:
Asset Information
Ground Elevation (ft NAVD88): 9.4
Vulnerability (Flood / Wind): Flood
Inundation Consequences:
Flood Threshold (in): 2
Exceed Flood Threshold: 0.85622489
Facility availability due to impacted asset: not_available
Facility recovery time: Medium_Term
Facility Inundation Consequences:Water floods the City Hall basement through the southeast facing street level vents; Flooding damages electrical equipment in the City Hall basement and City Hall operations are moved to PEMA.
Jon
4
Low Points
0
List: Inundation
List: Wind
List: Low Points

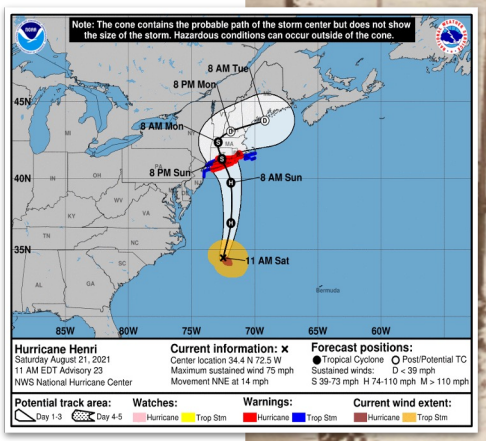
Real-time & Planning Applications

Near-Real Time Storm Forecast Models

- Used for an actual storm threatening the area
- May include multiple track iterations
- Basis for near-real-time consequence predictions
- Updated at set intervals (e.g., every 6 hrs)

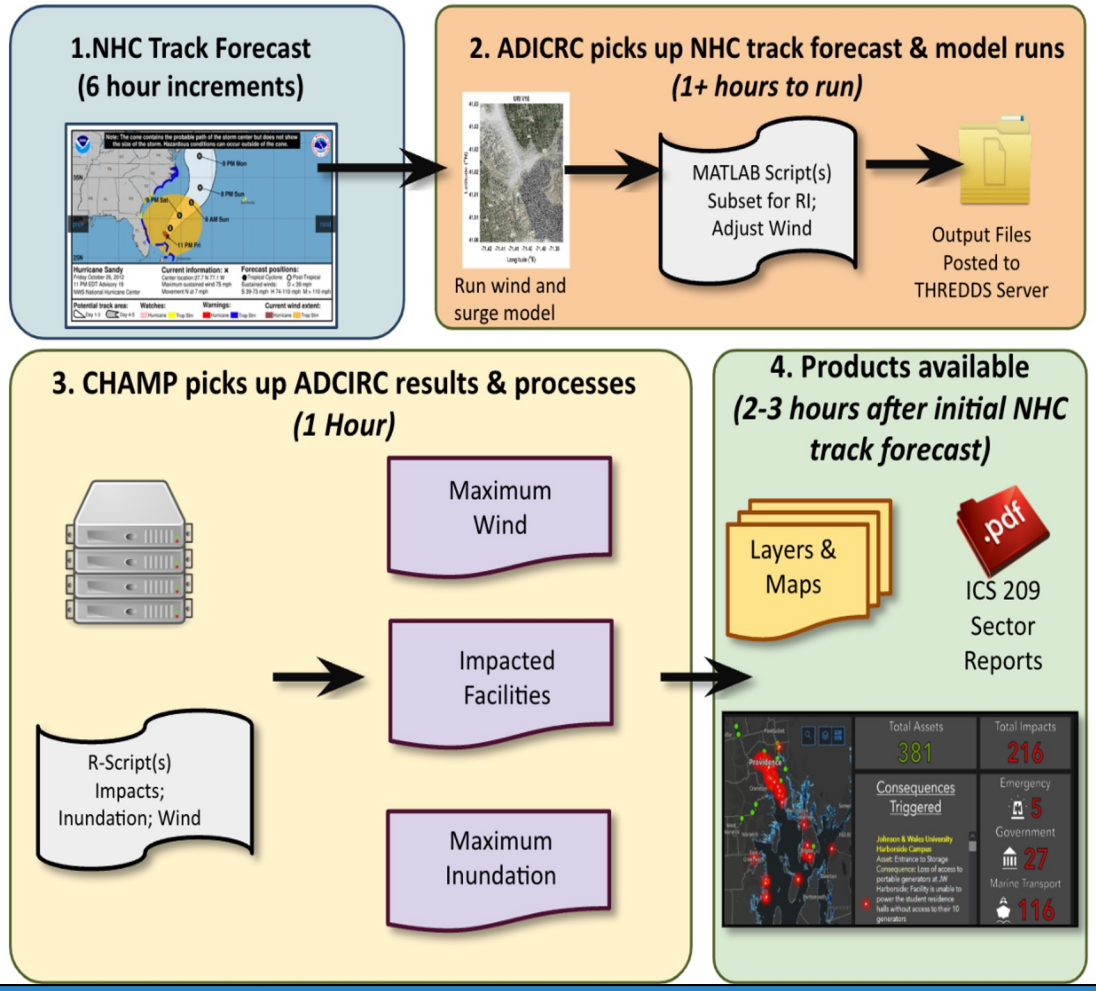
Storm Simulations

- Used for planning purposes
- Simulate actual historical storm or a hypothetical model
- Can include sea level rise

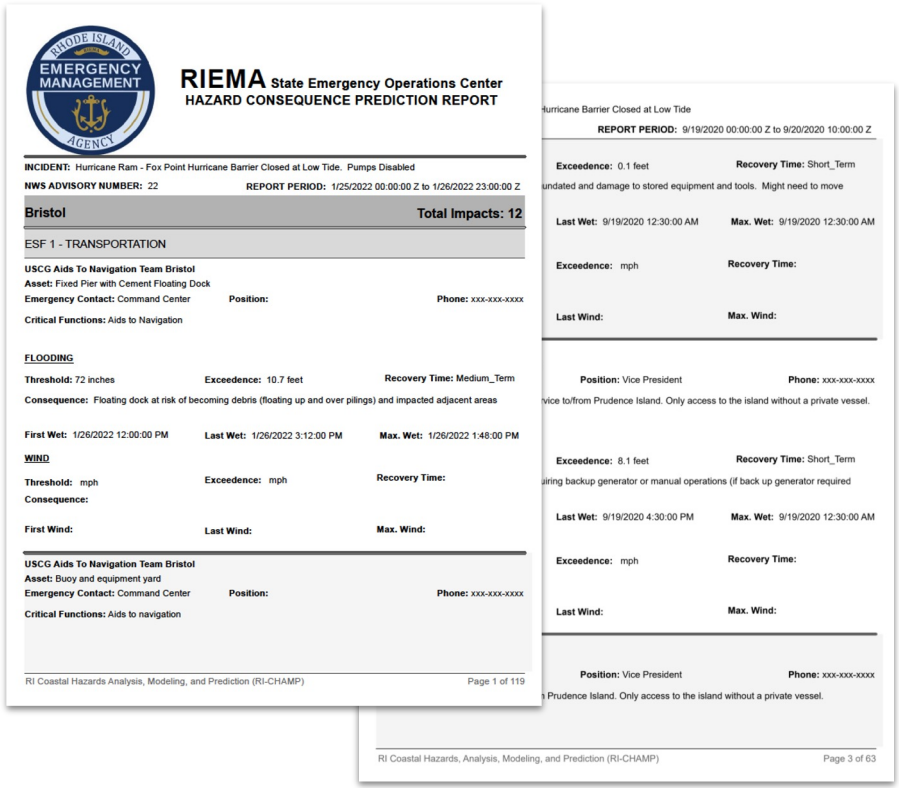


Operational Mode in RI Emergency Management Agency

Time	Event
00:00	**1. National Hurricane Center (NHC) Issues a Tropical Storm Advisory**
00:01	**2. ADCIRC System Picks Up NHC Forecasted Track & model runs to forecast wind/surge based on track forecast**
01:15	ADCIRC Run Completed
01:30	ADCIRC results (water level & wind) posted to THREDDS server
01:31	**3. CHAMP picks up ADCIRC results and ADCIRC results processing initiated**
01:50	High resolution inundation maps completed
02:10	**4. Products available - Asset impacts/consequences & maps are posted to the CHAMP dashboard**



Customized Impact Prediction Reports for Current Storm



RIEMA State Emergency Operations Center
HAZARD CONSEQUENCE PREDICTION REPORT

INCIDENT: Hurricane Ram - Fox Point Hurricane Barrier Closed at Low Tide. Pumps Disabled
NWS ADVISORY NUMBER: 22 **REPORT PERIOD:** 1/25/2022 00:00:00 Z to 1/26/2022 23:00:00 Z

Bristol **Total Impacts: 12**

ESF 1 - TRANSPORTATION

USCG Aids To Navigation Team Bristol
Asset: Fixed Pier with Cement Floating Dock
Emergency Contact: Command Center **Position:** **Phone:** xxx-xxx-xxxx
Critical Functions: Aids to Navigation

FLOODING
Threshold: 72 inches **Exceedence:** 10.7 feet **Recovery Time:** Medium_Term
Consequence: Floating dock at risk of becoming debris (floating up and over pilings) and impacted adjacent areas
First Wet: 1/26/2022 12:00:00 PM **Last Wet:** 1/26/2022 3:12:00 PM **Max. Wet:** 1/26/2022 1:48:00 PM

WIND
Threshold: mph **Exceedence:** mph **Recovery Time:**
Consequence:
First Wind: **Last Wind:** **Max. Wind:**

USCG Aids To Navigation Team Bristol
Asset: Buoy and equipment yard
Emergency Contact: Command Center **Position:** **Phone:** xxx-xxx-xxxx
Critical Functions: Aids to navigation

RI Coastal Hazards Analysis, Modeling, and Prediction (RI-CHAMP) Page 1 of 119

Hurricane Barrier Closed at Low Tide
REPORT PERIOD: 9/19/2020 00:00:00 Z to 9/20/2020 10:00:00 Z

Exceedence: 0.1 feet **Recovery Time:** Short_Term
undated and damage to stored equipment and tools. Might need to move
Last Wet: 9/19/2020 12:30:00 AM **Max. Wet:** 9/19/2020 12:30:00 AM
Exceedence: mph **Recovery Time:**
Last Wind: **Max. Wind:**

Position: Vice President **Phone:** xxx-xxx-xxxx
vice to/from Prudence Island. Only access to the island without a private vessel.

Exceedence: 8.1 feet **Recovery Time:** Short_Term
iring backup generator or manual operations (if back up generator required
Last Wet: 9/19/2020 4:30:00 PM **Max. Wet:** 9/19/2020 12:30:00 AM
Exceedence: mph **Recovery Time:**
Last Wind: **Max. Wind:**

Position: Vice President **Phone:** xxx-xxx-xxxx
Prudence Island. Only access to the island without a private vessel.

RI Coastal Hazards, Analysis, Modeling, and Prediction (RI-CHAMP) Page 3 of 63

- PDF format
- Organized by
  - Facility
  - CI Sector
  - ESF
- Summary of dashboard results

Customized Risk Assessment Reports for Planning

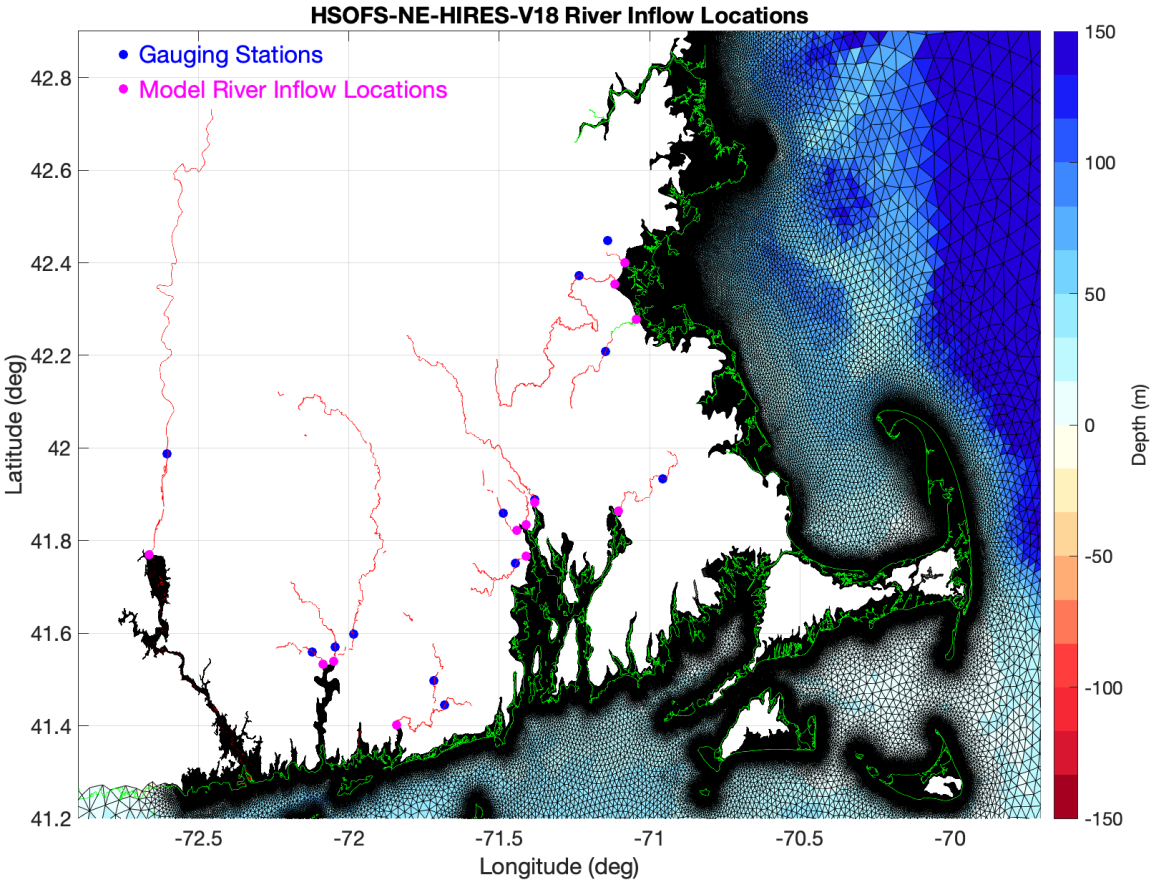


- Hard copy & electronic formats
- Facility scale
- Summary of assets at risk
- Flood & wind impacts to specific assets

Integrating hydrological models

- Presently have 12 rivers configured for Rhode Island
- For hindcast simulations, discharges for these rivers available from USGS at gauging stations
- For forecasts, will utilize output from National Water Model
- New project soon launching to focus on Warren, RI

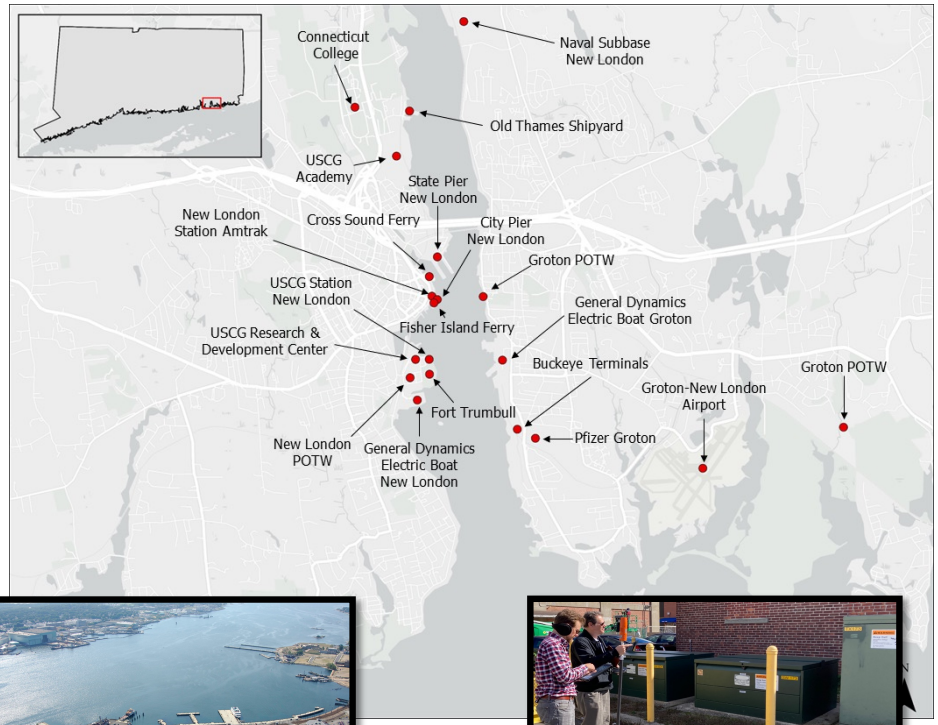
Most rivers in Southern New England are relatively short, increasing the likelihood that effects of river flooding and wind-driven storm surge can interact.



COASTAL RESILIENCE CENTER

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2025 - USCG & CT-CHAMP Demonstration Projects

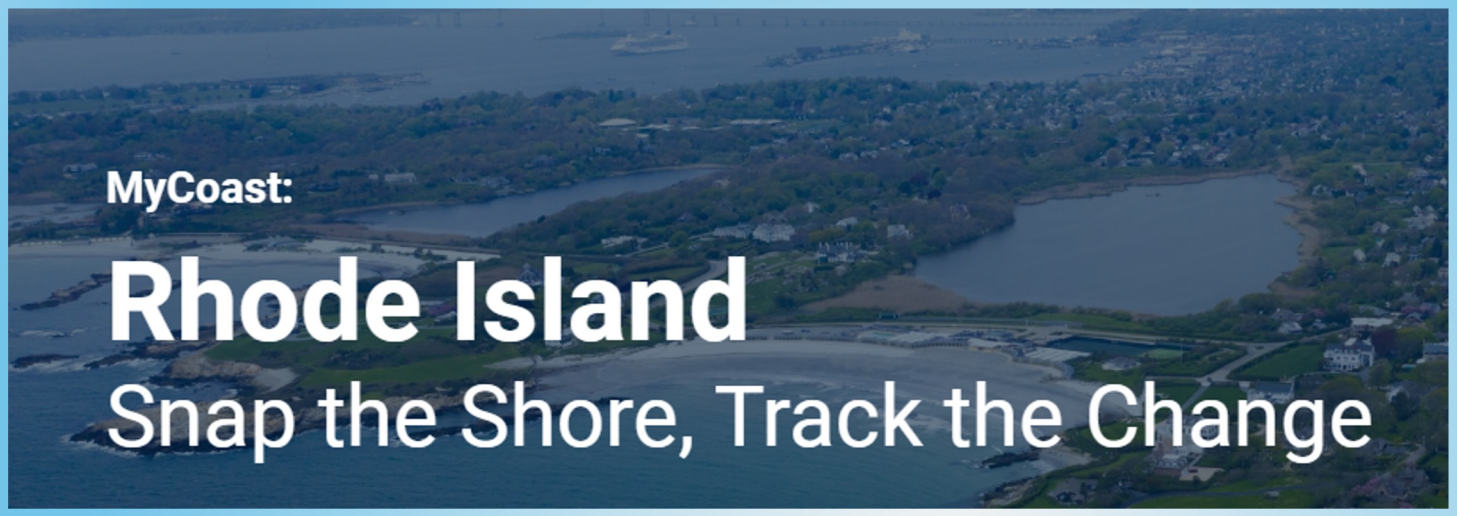




COASTAL RESILIENCE CENTER
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Summary and next steps

- CHAMP in service for Rhode Island for emergency management and infrastructure resilience planning
- Scaling/expansion underway in New England
- Piloting integration of storm surge and riverine flooding in Warren
- Funding sought for sustained operations and maintenance



- **Collect and analyze photos** of shorelines across the Ocean State.
- Capture the impact of **flood hazards today**, and to illustrate **possible future conditions**.
- **Link photos and data** about weather and tides to see the full picture.
- **Support stakeholders** (e.g., government agencies, business owners, and residents) to understand shoreline change and make informed decisions.
- **Validate storm models** (including CHAMP, STORMTOOLS)

Help Chronicle Our Changing Coast

How it Works

1



You Add Your Picture or Report

Take your picture via our mobile app (below) or submit it via your browser when you get back to your computer.

2



We Fetch Background Data

Our servers retrieve weather and tidal information to add context to your photo.

3



Your Report Informs Decisions

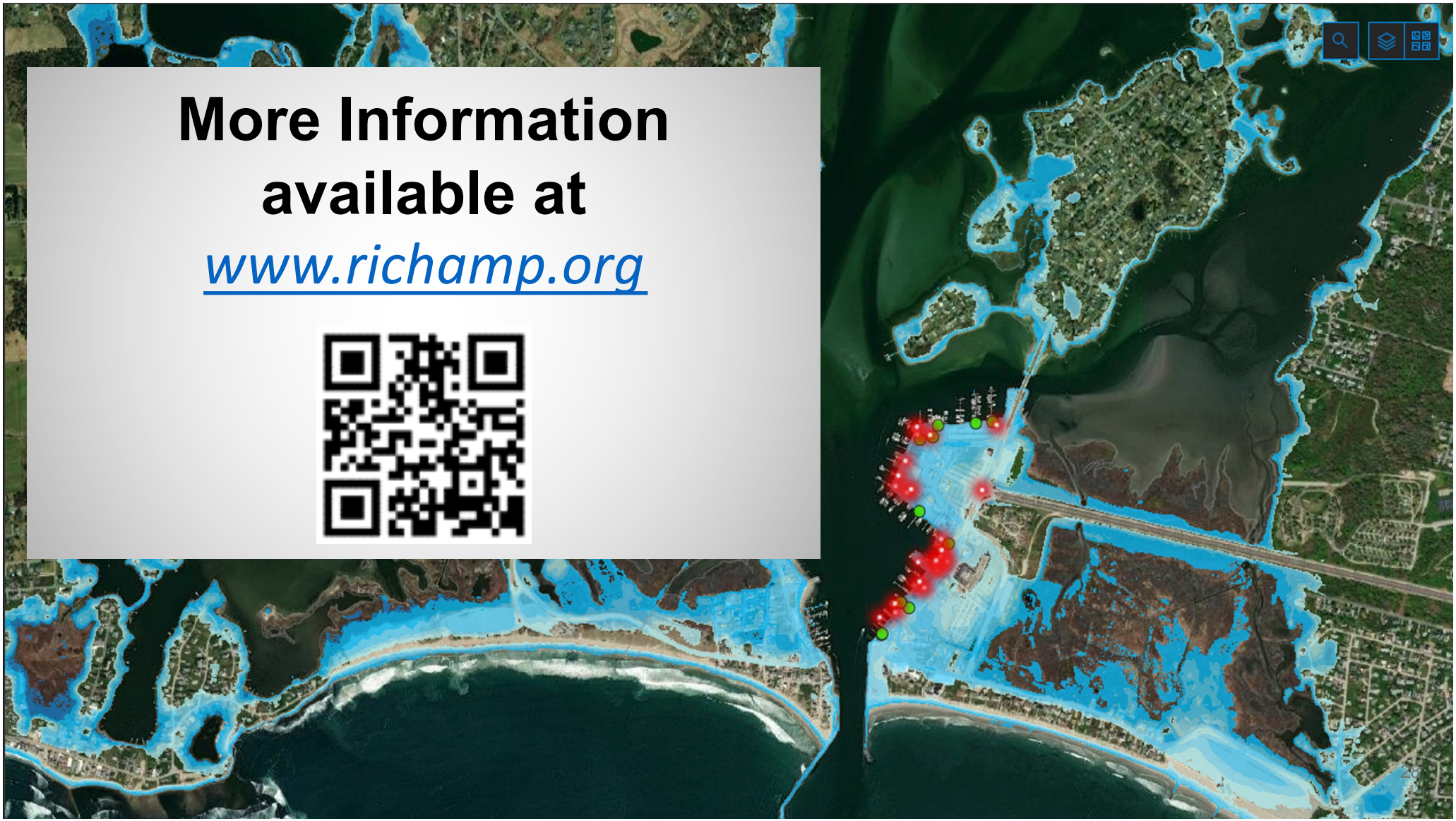
Coastal leaders and groups can use your data to make better decisions.

Testimonials

"URI's Real Time 3-D Storm Impact Modeling will allow Emergency Managers to determine the potential impacts to critical infrastructure. It also will allow states to strategically plan to mitigate those storm impacts." ***Tom Guthlein, Executive Administrator, RIEMA***

"... CHAMP has ***introduced capabilities that have long been sought yet remained unfulfilled due to a lack of understanding and belief that such a product could be made . . .*** *Future funding for completion of this project is an absolute imperative." - Erik P. Ulmen, PMP, Protective Security Advisor, RI, US Department of Homeland Security, Cyber and Infrastructure Security Agency (CISA)*

"While work to complete the project is ongoing, RIDOH and its partners in the Healthcare Coalition of RI have deepened their understanding of the hazards and consequences that face this infrastructure. RIDOH and its partners are eager to continue participation in this project and to explore ways to leverage the data collected in support of RI's healthcare system." ***Nicholas Larmore, Center for Emergency Preparedness and Response, RIDOH***


More Information
available at
www.richamp.org