PREPARING FOR RESILIENCE

BARRINGTON, WARREN AND BRISTOL
MIXED-USE CLIMATE RESPONSE DEMONSTRATION SITE

ACCOMPLISHMENTS
Summer 2019 through Fall 2021

View of Belchers Cove in Warren, RI after a king tide. Photo credit: RI Sea Grant.

COASTAL INSTITUTE

THE UNIVERSITY OF RHODE ISLAND

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EXECUTIVE SUMMARY

The University of Rhode Island (URI) Coastal Institute, through the *Climate Response Demonstration Site* initiative, has been collaborating with Barrington and Warren since 2016 and more recently with Bristol (2021), to study and "demonstrate" adaptation actions that could be adopted by the three towns, as well as other coastal municipalities, to achieve community resiliency and ecosystem sustainability. Public outreach and interactions with town and state governments, community groups, conservation organizations, academia and others have been essential components to the collaborative activities of the Bristol County Mixed-Use Demonstration Site program. This document, the second of two, reports on accomplishments and activities of the Mixed-Use Climate Response Demonstration Site team during the past two years; the first accomplishments report covered the period from project initiation in 2016 to mid-2019. The Demonstration Site team is truly collaborative, consisting of URI personnel with climate science and resilience expertise and planners from the three towns. Some highlights of recent accomplishments and ongoing activities of the team include the following.

- Bristol was welcomed and now all three Bristol County (RI) East Bay communities are affiliated with the Mixed-Use Demonstration Site. Collectively, the communities have similar coastal flood threats and highly vulnerable neighborhoods, infrastructure, and ecosystems, thus actions to enhance community resilience and ecosystem sustainability are common and shared.
- The Coastal Institute, following discussions initiated during Demonstration Site workshops and follow-up work sessions with state agencies and multiple RI coastal towns, prepared an authoritative report on how the state might move toward developing a comprehensive set of guidelines to assist with voluntary buyout initiatives. Buyout refers to a managed retreat strategy whereby neighborhoods (residences and businesses) in highly vulnerable flood-prone areas could voluntarily apply for financial assistance to relocate or retreat to areas of higher elevation, then restoring the abandoned land to wetlands and open space for floodplain management. With presentations on the report's findings before the Rhode Island Governor's Executive Climate Change Coordinating Council, it is hoped that buyouts will continue to be a topic of focus at the state level.
- Concerns about current and future implications of transportation corridor flooding on emergency services, evacuation routes, and isolation of neighborhoods during storms has been continually expressed by town officials and the public during the many workshops and meetings convened by the Demonstration Site program. With major roads in the three towns under state jurisdiction, recent Demonstration Site-facilitated discussions with the towns and state offices, namely the RI Department of Transportation and RI Division of Statewide Planning, focused on future adaptation actions to build resilience of the transportation network.
- A Demonstration Site graduate student intern completed an impressive mapping and data analysis for the three towns to expand upon the STORMTOOLS modeling (https://www.beachsamp.org/stormtools/) and develop a detailed inventory of potential impacts on the town's transportation networks and residential housing stock. This coastal flood risk analysis, consisting of a geodatabase and hundreds of GIS maps, will assist town officials in medium and long-term planning decisions in response to sea-level rise and storm surge flooding.

- Outreach and information sharing was somewhat hampered by the COVID pandemic, but our accomplishments did include several presentations to various town committees, participation in the Barrington-Warren "Community Resilience Building Workshop," sponsored by the RI Infrastructure Bank and The Nature Conservancy, and a public Bristol walking tour of flood-prone areas. To more widely share our program accomplishments and learn from others, at the *Restore America's Estuaries* 2020 national conference we gathered scientists and program managers from each New England state to present their collaborative programs to enhance climate resilience of communities and ecosystems.

The final section of this report provides thoughts on future activities of the Bristol County Mixed-Use Demonstration Site program, with some to continue and expand existing efforts related to transportation, buyouts, exciting student engagement opportunities, and outreach and information exchange, while others propose new areas to pursue. These topics include enhancing coastal resilience reporting to town officials and the public, coastal access, and historic and cultural preservation. All efforts of the Demonstration Site program emphasize the urgency to plan now for catastrophic flooding and implement appropriate adaptation measures.

ACKNOWLEDGEMENTS

Funding for the Bristol County Mixed-Use Climate Response Demonstration Site has been provided by the URI Coastal Institute, the Sounds Conservancy, and generous support from an anonymous donor with a dedication to conservation of Rhode Island coastal communities and resources. Teresa Crean, affiliated with the URI Coastal Resources Center and RI Sea Grant, was provided with financial support from the URI Coastal Institute for her involvement in Demonstration Site activities. Teresa Crean is leaving URI to begin a new career challenge – she is gratefully acknowledged for her dedication, leadership, and sharing of an unparalleled knowledge of climate resilience. Her capacity for positivity in the face of extreme challenges is a model for us all.

Teresa Crean, formerly of the URI Coastal Resources Center and Rhode Island Sea Grant.

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INTRODUCTION

Hurricane Sandy caused extensive property damage as it marched up the Atlantic seaboard. October 2012. Source: https://earthobservatory.nasa.gov/images/79553/goes-view-of-hurricane-sandy

Barrington, Warren and Bristol, representing all of Rhode Island's Bristol County, is a region of coastal Rhode Island that is among the most vulnerable to flooding associated with sea-level rise and storm surge. During periodic high tides (i.e., spring tides) and minor storms, areas of all three towns experience flooding, impacting homes, businesses, infrastructure, and transportation. Consider that future flooding with a modest 2-ft rise in sea-level (projected by about 30 years from now), compounded by a major storm (a 100-year return period storm), could result in inundation of nearly one-third of Bristol County buildings (see table below). And remember, there is a chance of a 100-yr coastal storm or a less powerful storm with significant Narragansett Bay flooding potential, occurring at any time in the future. Even a relatively minor 25-yr storm at today's sea-level, could flood 15% of buildings within the three towns (estimates based on RI STORMTOOLS, e911 Exposure Assessment; https://rhode-island-e911-exposure-assessment-crc-uri.hub.arcgis.com/).

	2ft SLR + 100 yr storm Exposed Buildings	**Total Buildings (Town)**	**Percent (Town)**
Barrington	3446	6576	52%
Warren	1602	4568	35%
Bristol	705	8053	9%
TOTAL	5753	19197	32%

SOURCE: RI STORMTOOLS, e911 Exposure Assessment

The towns recognize the immediate urgency to act and are implementing and investigating strategies that will enhance resiliency as sea-level continues to rise and storms intensify in response to global warming. The URI Coastal Institute, through the *Climate Response Demonstration Site* initiative, has been collaborating with Barrington and Warren since 2016 and more recently with Bristol (2021), to study, test, and "demonstrate" adaptation actions that could be adopted by the towns to achieve the goals of community resiliency and ecosystem sustainability. Public outreach, widespread interactions (municipal and state governments, community groups, conservation organizations, academia, consultants, others), and university student mentorship have also been important components to the collaborative activities of the Demonstration Site program. The Climate Response Demonstration Site initiative is designed to

include the range of Rhode Island's coastal landscape types as responses to climate change and adaptation strategies will often vary depending on coastal setting, development type and intensity, thus the selection of natural, urban, and mixed-use sites. The Barrington-Warren-Bristol Mixed-Use Demonstration Site is characterized by moderate-to-high density residential development, commercial and business areas, a rich history, maritime industry and heritage, parks and recreation areas, outstanding natural resources, and cultural and socioeconomic diversity. The other Demonstration Sites are Napatree Point Conservation Area (Watch Hill, RI), the "natural site," and the recently initiated "urban watershed" site represented by Providence's Roger Williams Park and surrounding neighborhoods and waterways.

Like the Mixed-Use site, led by a team of town planners and URI personnel and students, the other Demonstration Sites also work collaboratively with multiple partners. Teams for both sites include faculty and students from the URI College of the Environment and Life Sciences and colleagues from numerous affiliations (e.g., natural area site – Watch Hill Conservancy, Watch Hill Fire District; urban watershed site – Roger Williams Park, The Nature Conservancy, Providence Stormwater Innovation Center, others).

This document reports on the activities and accomplishments of the Mixed-Use Demonstration Site during the past two-plus years (summer 2019 through fall 2021). A previous document reported on activities from initiation of the Mixed-Use site in 2016 through spring 2019 (https://ci.uri.edu/preparing-for-resilience-barrington-and-warren-mixed-use-climate-response-demonstration-site-fall-2019/). Here, the continued efforts of the Mixed-Use Demonstration Site team are presented, highlighting the following;

- Expansion of the program to include Bristol
- Buyouts as a component to managed retreat
- State agency collaborations regarding transportation resilience
- Participation in the town's Municipal Resilience Program
- GIS analysis of potential flood risks from sea-level rise and storm events
- Student engagement
- Community outreach and information sharing
- Proposed future activities

ACCOMPLISHMENTS AND ONGOING ACTIVITIES

Bristol Welcomed

The Mixed Use Demonstration Site included Barrington and Warren when the program was initiated. It always made sense, from a geographic or regional perspective that Bristol, with similar geography, climate change risk, and land use, should be included, but our intent was to begin small as this new initiative was developed. Over the past several years we have developed collaborative relationships with Barrington and Warren planners and learned of the specific climate adaptation topics that are of most relevance to these communities and begun the process of working collaboratively with the towns to investigate adaptation measures that will enhance community and ecosystem resilience. Now with Bristol included, all three East Bay towns of

Bristol County are part of the Mixed-Use Demonstration Site. Initial activities with Bristol, following our kick-off correspondence with the Bristol town planner in spring 2021, include the following.

Bristol Flood Risk GIS Analysis. Initiated May 2021 and completed September 2021.

- As detailed in the "GIS Coastal Flood Risk Analysis" section of this accomplishments report, a URI graduate student, Patrick MacMeekin, supported by the Mixed-Use Demonstration Site, conducted a geospatial (GIS) analysis of roadways projected to be flooded and structures damaged by sea-level rise and storm surge. This information is useful as the town evaluates, for example, vulnerability of emergency and evacuation routes and considers resilience measures that are appropriate for flood-prone neighborhoods.
- This effort followed the GIS mapping and analysis methods that the Demonstration Site completed for Warren and Barrington.

Bristol Hazard Mitigation Plan, 5-Year Update

- Presentation at a Bristol public workshop on the Hazard Mitigation Plan. "Coastal Resilience in Rhode Island: An Introduction to STORMTOOLS" (Teresa Crean; October 21, 2021)
- Led a public walking tour of Bristol's flood-vulnerable areas in association with the Hazard Mitigation Plan 5-year update (Teresa Crean; October 30, 2021)

Walking tour of flood-prone areas in Bristol, October 2021. Source: D. Williamson, Bristol.

Buyouts

Buyout refers to a managed retreat strategy whereby a collection of properties in highly vulnerable flood-prone areas could voluntarily apply for financial assistance to relocate or retreat to areas of higher elevation. Ecosystem restoration is an important component of buyout programs and could include conversion of the abandoned site to wetlands that are expected to migrate landward as sea-level rises, or to public parks with facilities designed to withstand flooding associated with sea-level rise and storms, or other strategies to reclaim open space for floodplain management.

The topic of buyouts received much interest at an earlier (October 2018) Barrington-Warren Demonstration Site workshop conducted on land use resilience strategies. As reported in the previous Demonstration Site accomplishments report (https://ci.uri.edu/preparing-for-resilience-barrington-and-warren-mixed-use-climate-response-demonstration-site-fall-2019/) we convened and facilitated several work sessions bringing together multiple state agencies and program offices, RI communities, academic institutions, and consultants to exchange information on buyouts, discuss past buyout experiences and challenges (i.e., following the March 2010 flood, 2012 Superstorm Sandy), and next steps toward developing a statewide centralized program with a consistent process and guidelines for implementing voluntary buyouts.

The Roger Williams School of Law, Marine Affairs Institute and RI Sea Grant Legal Program, has published a paper that reports on federal programs that fund buyouts, describes the use of buyouts in Rhode Island, and discusses equity issues related to existing buyout programs and suggests some solutions toward more equitable buyout programs (https://docs.rwu.edu/law_ma_seagrant/100/).

Also informative, the Georgetown Climate Center (Georgetown University Law) provides an overview of the voluntary buyout process and examples of programs administered by state and local governments.
https://www.georgetownclimate.org/adaptation/toolkits/managed-retreat-toolkit/voluntary-buyouts.html

Since the previous accomplishments report, the buyout topic has been an important focus area of the Mixed-Use Demonstration Site, as follows.

Convened a meeting on "Buyouts in RI: The Role of Federal Agencies," March 5, 2020

- Invited speakers from USDA-NRCS, FEMA, and US Army Corps of Engineers
- Attendees included:
  RI Emergency Management Agency
  RI Office of Housing and Community Development
  RI Infrastructure Bank
  RI Coastal Resources Management Council
  Roger Williams University, Marine Affairs Institute and RI Sea Grant Legal Program
  URI Coastal Institute
  Towns of Barrington, Cranston, East Providence, Johnston, South Kingstown, Warren, Westerly

- Organized by the URI Coastal Institute Demonstration Site; facilitated by Teresa Crean (URI Coastal Resources Center and RI Sea Grant)

Report "Voluntary Buyouts in Rhode Island: Property Acquisition and Reclamation of Land in Flood-Prone Areas," July 2020

- This URI Coastal Institute Mixed-Use Demonstration Site report is a comprehensive summary of the 2019-2020 statewide discussions that were organized by the Demonstration Site. Included here is the Abstract or Summary excerpted from the report. The full report is available at https://ci.uri.edu/files/Demo_Buyout_Summary.pdf

> "Property buyouts, also referred to as land acquisition for easements, is one of many floodplain adaptation strategies that can be implemented to minimize risk of asset losses in flood-prone areas. Structures in flood-prone areas are purchased and demolished, and the site is remediated to serve as open space that accommodates future flood conditions. Purchase of flood-prone properties has been applied in Rhode Island, notably after the March 2010 floods, Tropical Storm Irene (2011), and Superstorm Sandy (2012). The process is complex and takes many steps to complete, relying on federal, state, and municipal coordination with both property owners and tenants of these properties. Establishing a consistent and predictable process in Rhode Island has the potential to leverage federal funds, ensure a timely response to property owners and tenants, prioritize investments, promote efficiency and economies of scale, and limit legal challenges. This summary documents a series of work sessions in 2019-2020 exploring how buyouts have been pursued in Rhode Island and concludes with considerations for how the state might move toward a comprehensive set of guidelines to assist with future voluntary buyout initiatives."

Buyout Presentations before the RI Executive Climate Change Coordinating Council (RI EC4) and the RI EC4 Science and Technical Advisory Board. June 24, 2020 and September 17, 2020, respectively

- The report on "Voluntary Buyouts in Rhode Island" served as a catalyst to continue discussion and consensus-building on the topic of buyouts, with particular attention to the development of a state administered program. The EC4, created by the *Resilient Rhode Island Act,* is composed of 12 participating state agencies and addresses all aspects related to building resilience to the impacts of climate change (http://climatechange.ri.gov/state-actions/ec4/). The Rhode Island Governor's Office and EC4, with its broad state agency representation, coupled with the municipalities and stakeholders, will be quite influential as future discussions are pursued on all topics of resilience, including buyouts.
- Powerpoint presentation to the EC4 (June 24, 2020), presented by Teresa Crean (https://ci.uri.edu/files/Demo_EC4_Presentation.pdf)

Warren's Market-to-Metacom Managed Retreat Project

Warren is studying the feasibility of an exciting forward-looking project that proposes residences and businesses in the highly vulnerable flood-prone Market Street neighborhood be relocated to

Metacom Avenue – a planned redeveloped corridor with residential housing, commercial businesses, and open space within a high ground area free of chronic flooding. An important aspect of managed retreat includes restoration of the flood-prone area that is abandoned. Ecosystem restoration could include conversion of the site to wetlands, public parks with habitats and facilities that can withstand flooding associated with storms and sea-level rise, or other strategies to provide open space for floodplain management. Learn more about this voluntary buyout plan at the town's website (https://www.townofwarren-ri.gov/town_government/town_manager/index.php)

- The Market-to-Metacom project is the vision of Bob Rulli (Warren Director of Planning and Development) and Kate Michaud (Warren Town Manager), with initial plans being developed with funding support from US EPA's Southern New England Program and collaboration with the consulting firm Fuss and O'Neill.
- The Demonstration Site program has participated in the three community outreach workshops facilitated by the Warren Director of Planning and Development and Fuss and O'Neill; May 12, July 14, and September 16, 2021. The GIS mapping and analysis of flood risk in the Market Street neighborhood, conducted by a Demonstration Site supported graduate student (see "GIS Coastal Flood Risk Analysis" section of this report), proved useful to the Town Planner and the Fuss and O'Neill firm during their planning analyses and will likely continue to be of value as the redevelopment project moves forward.
- The Demonstration Site program looks forward to further collaboration as Warren proceeds with this bold project.

Roadway flooding in the Market Street neighborhood of Warren, RI. Source: J. Freedman, RICRMC.

Transportation

Identifying transportation corridors most vulnerable to flooding from sea-level rise and storm surge in Barrington and Warren and discussing alternatives for future adaptation actions were a focus of the Demonstration Site beginning in Fall 2018, as presented in the previous

accomplishments report (https://ci.uri.edu/preparing-for-resilience-barrington-and-warren-mixed-use-climate-response-demonstration-site-fall-2019/). These earlier transportation-related activities included focused workshops in Barrington and Warren and the University of Pennsylvania School of Design graduate program site visits and report, facilitated by the Demonstration Site program, which provided recommendations for building a more resilient transportation network.

Studying transportation resilience continues to be of critical importance to the towns. With major roads in the three towns under state jurisdiction, recent Demonstration Site efforts have focused on facilitating discussions with state offices, such as the RI Department of Transportation and RI Division of Statewide Planning. The goals of facilitated meetings with Barrington-Warren-Bristol and state officials were to discuss the need for long-range planning to address resilience of vulnerable roadways, identify the need for site-specific transportation resilience planning studies, and identify transportation projects to be considered for federal funding through the State Transportation Improvement Program (http://www.planning.ri.gov/planning-areas/transportation/tip.php). The following meetings were organized and facilitated by the Demonstration Site program.

Meeting with RI Chief Resiliency Officer, RI Statewide Planning Associate Director and Assistant Chief, Barrington and Warren planners. February 17, 2020

Meeting with RI DOT, Barrington and Warren planners. September 10, 2020

Meeting with Warren, RI DOT and RI Statewide Planning. December 23, 2020

Municipal Resilience Program

The RI Climate Resilience Action Strategy, known as Resilient Rhody and under the leadership of the RI Infrastructure Bank, was released by the Governor in July 2018 and provides "implementable actions to better prepare the state for impacts" associated with climate change (http://climatechange.ri.gov/documents/resilientrhody18.pdf). As part of this Strategy, the RI Infrastructure Bank, in cooperation with The Nature Conservancy, is administering the Municipal Resilience Program (MRP) aimed at working with municipalities to identify priority resilience strategies. Based primarily on deliberations of a workshop of town officials, state agencies, conservation organizations, climate resilience experts, and others, followed by preparation of a report that details priority resilience efforts, towns are certified as "Resilient Rhody Communities." With this designation, municipalities are able to apply for MRP action grants through the RI Infrastructure Bank – funds to support climate resilience projects. The Barrington, Warren and Bristol workshop reports that summarize the climate-related hazards and recommended actions to improve resilience are found on the RI Infrastructure Bank website (https://www.riib.org/mrp), along with descriptions of the projects that have been funded by action grants, to date.

The Mixed-Use Demonstration Site served no formal role in the MRP process, aside from participating in the combined Barrington-Warren workshop. However, we do expect that our collaborations with the towns through our workshops, meetings and outreach activities as outlined in our previous accomplishments report and those herein, contributed to the MRP workshop deliberations and summary report preparation.

Demonstration Site actions related to the MRP process in the mixed-use communities follow.

Letter (https://ci.uri.edu/files/Warren_Barrington_Support.pdf) *from the Coastal Institute to the RI Infrastructure Bank in support of the Barrington-Warren proposal to participate in the Municipal Resilience Program and to ultimately be certified as a "Resilient Rhody Community."* March 29, 2019.

Participated in the combined Barrington-Warren Community Resilience Building Workshop. September 24, 2019.

Meeting with Barrington and Warren to discuss the MRP report findings and opportunities to collaborate. February 4, 2020.
This MRP debrief proved useful as the Demonstration Site team formulated the 2020 and 2021 work plans. The following ideas for future pursuit included;

- Convene a second Transportation Workshop with the goal of engaging RI DOT and the RI Division of Statewide Planning in transportation resilience discussions. Note in the above section of this report on Transportation, we have facilitated several meetings with these state agencies, with positive outcomes, which are critical to developing a long-range plan for improving transportation resilience.
- Buyouts is an important resilience strategy to continue pursuing at the state level. Warren's buyout planning, specifically the abovementioned, Market-to-Metacom proposal, could serve as a pilot for addressing buyouts and relocation of both commercial and residential properties.
- Online tracking of climate adaptation projects is important so the public and board members from the towns are aware of progress that has been made and future plans toward enhancing resilience of residences, businesses, infrastructure, and ecosystems from the impacts of sea-level rise and flooding.
- Aggressively continue outreach and education on climate change and resilience topics, targeting the following five levels of audiences; elected officials, decision-makers/town boards, property owners, general public and middle school/high school students. Messages, especially to youth audiences, should provide positive elements – highlight actions being taken to enhance community and ecosystem resilience.
- Annual "State of the Town" presentations and reports should include updates on all resilience and adaptation actions that have been taken. The Demonstration Site could assist with organizing this information.

See the final "Future Directions" section of this report for more discussion of the above items.

Teresa Crean served as a facilitator of the Bristol Community Resilience Building Workshop. July 2020.

- Note that Teresa Crean served this role in accordance with her URI Coastal Resources Center/RI Sea Grant affiliation, not in her capacity with the Mixed-Use Demonstration Site team. However, resilience knowledge gained through her Demonstration Site leadership role was likely beneficial to her facilitator tasks.

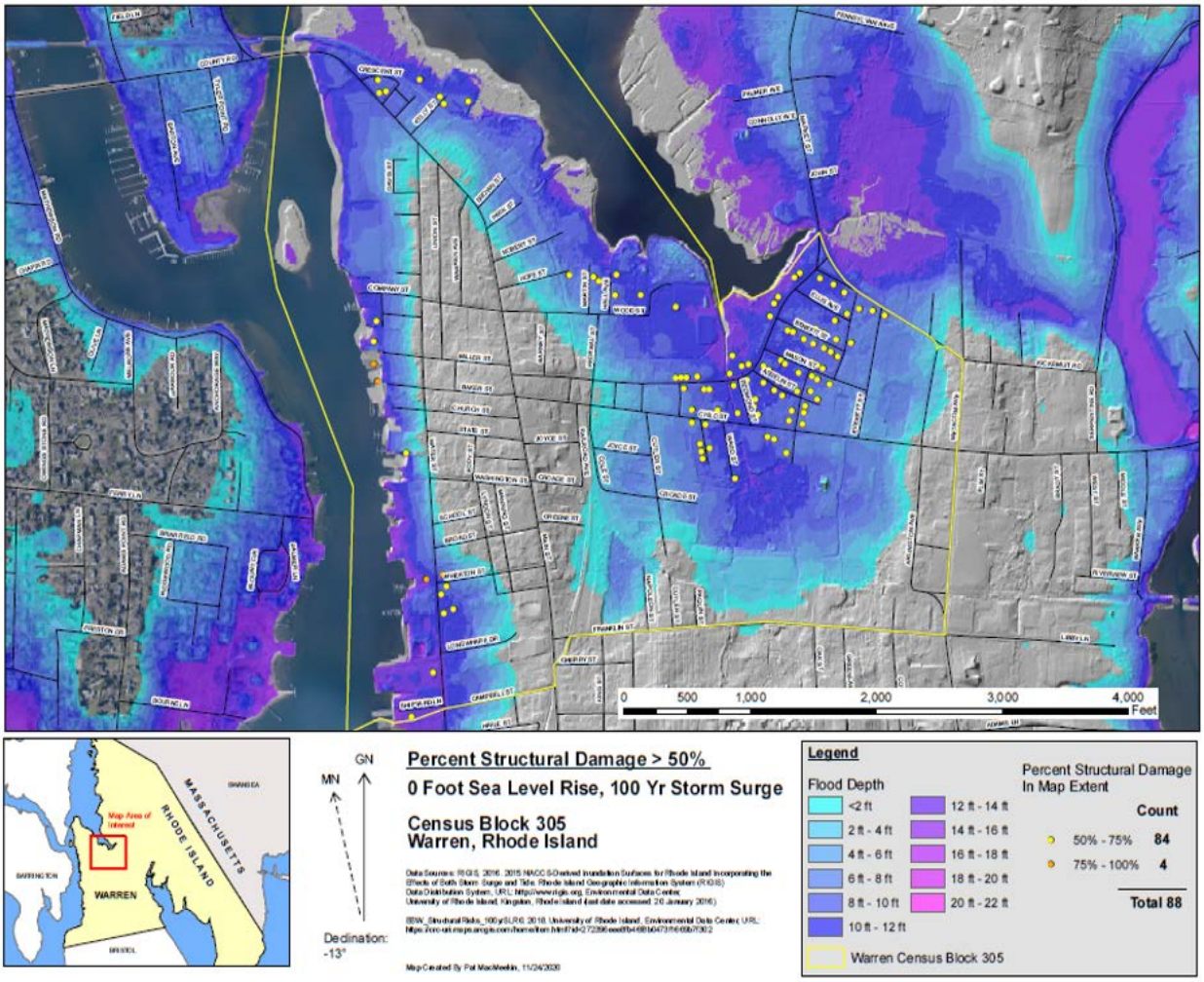
GIS Coastal Flood Risk Analysis

A major reason for selecting the Narragansett Bay communities of Barrington, Warren, and Bristol as the Mixed-Use Demonstration Site was that statewide inundation (STORMTOOLS) modeling revealed how the area's low topography and high-density development leads these communities to be especially vulnerable to flooding from sea-level rise and storm surge. Recognizing a need for more detailed and clearly presented information about flood impacts to these communities, the Demonstration Site launched a mapping and data analysis project in Fall 2020 to expand upon the STORMTOOLS modeling and develop a detailed inventory of potential impacts on each town's transportation network and residential housing stock. The goal of this project was to develop a suite of maps and data products, using ArcGIS software, to assist town officials in medium and long-term planning decisions in response to sea-level rise and storm surge flooding. The following accomplishments resulted;

- development of a comprehensive geodatabase for each town, which included flood inundation data layers, transportation assets, structure information, and an array of public GIS data (e.g., parcels, elevation, etc.) to assist in mapping
- identification of roads inundated by floodwaters, noting the depth of flooding, and statistics on the linear length of affected roads. These analyses were conducted for numerous flood scenarios that combined multiple sea-level rise forecasts with different storm intensities (e.g., 100-yr storm, 25-year storm);
- calculation of the extent of flooding to structures in each town that would be damaged based on an extreme 100-yr storm with current sea-level, 2-ft, and 5-ft of sea-level rise;
- mapping the spatial density of potential structural damage to identify hotspots or areas with a concentration of dwellings at risk of flooding – areas that town officials may want to consider targeting for adaptation options, such as property buyouts or other resilience strategies.

Details of the project methods and findings are found in a written report (see below) and all GIS data and hundreds of individual maps were provided to the towns. Warren has posted the map products on their website (https://www.townofwarren-ri.gov/town_government/departments/planning_and_comm_development/index.php).

An example of the mapping products shows Warren's census block 305 with flooding associated with a major storm (100-yr storm) under current sea-level conditions. It is projected that large segments of Warren's road network could be flooded and significant damage (greater than 50% damage) to over 192 residential structures could result. A moderate sea-level rise of 2-ft combined with a 100-yr storm would nearly double the number of damaged structures in this area.



Flooding analysis for a portion of Barrington and Warren, showing the depth of flooding modeled for a 100-yr storm and greater than 50% damage to structures within Warren's Market St. and Water St. neighborhoods. Source: P. MacMeekin and N. Vinhateiro, URI.

Final Report, "Geospatial Analysis of Sea-level Rise in Warren, RI,"(https://ci.uri.edu/geospatial-analysis-of-sea-level-rise-in-warren-rhode-island/). January 2021.

- This project was led by URI graduate student, Patrick MacMeekin, with mentor Nathan Vinhateiro and other members of the Demonstration Site team.
- See the following section on "Student Engagement" for details on Mr. MacMeekin's actions related to this project.

Instruction Manual, "Geospatial Analysis of Sea-level Rise for Rhode Island Municipalities; Analysis of Roads and Structures." (https://ci.uri.edu/files/Instructions-for-Geo-Analysis-of-SLR-in-Rhode-Island.pdf), June 2021.

- This document, produced by Patrick MacMeekin and Nathan Vinhateiro, provides detailed instructions for other municipalities that may want to replicate the GIS analyses that were conducted for Warren, Barrington, and Bristol.

Student Engagement

The Demonstration Site program provides an opportunity for university students to become immersed in exploring strategies that will improve the resilience of the built environment and sustainability of natural ecosystems – topics of extraordinary global and local importance. Moreover, Demonstration Site student interns work closely with program managers, policy-makers, and scientists on issues currently confronting the towns; a critical element of experiential learning and career preparation. During the previous Demonstration Site reporting period we had extensive student involvement, including several semester-long university classes focusing on Barrington-Warren climate resilience topics. Student interns were also supported by the Coastal Institute on focused projects.

Due to the COVID pandemic, student engagement during the current reporting period was limited to a single URI graduate student intern, Patrick MacMeekin. Patrick recently graduated with a Master's of Environmental Science and Management. Patrick's outstanding accomplishments as a student intern were related to the GIS flood risk analysis discussed in the previous section. During Patrick's student internship he had the opportunity to work closely with the planners and resilience officers of Warren, Barrington, and most recently Bristol, while also collaborating with the scientists and GIS analysts affiliated with STORMTOOLS, the URI Environmental Data Center, and constant interaction with the Mixed-Use Demonstration Site team. His intern experience provided excellent exposure to topics of climate resilience science, management, and planning. Dr. Nathan Vinhateiro, Coastal Institute Assistant Director is acknowledged for his role as mentor during Patrick's internship.

Patrick MacMeekin, graduate student intern (September 2020 through June 2021) and Coastal Institute associate (July 2021 through December 2021)

- Project was initiated in Warren (September 2020), Barrington (February 2021) and Bristol (May 2021)
- Presentations and frequent meetings with town officials were conducted throughout the process

Certificate of Appreciation from the Town of Warren, April 23, 2021

- Patrick's accomplishments and excellence in serving the planning needs of Warren are recognized

Community Outreach and Information Sharing

Warren, Barrington and Bristol and all coastal communities in Rhode Island are diligently working to seek options to enhance the resilience of residences, businesses, infrastructure and coastal ecosystems that are currently experiencing and facing a future of rising sea-level, more intense storms, flooding, changes in precipitation patterns, and health risks, among other consequences associated with global warming. The Demonstration Site program is dedicated to working collaboratively with town officials and boards, state agencies, conservation organizations, the public, and others to identify, study, and demonstrate the feasibility of

resilience actions. An essential aspect of the Demonstration Site program is to share our findings and expertise with the local communities and beyond. Wide-ranging and often costly decisions will be needed as resilience options are proposed and it is important that the taxpayers are knowledgeable of the threats associated with climate change, the economic costs of implementing resilience measures, and the societal costs of failing to act proactively. Our more recent outreach, education, and information sharing activities follow.

Public Presentation, Barrington Farm School. "Climate Change Impacts in Coastal Rhode Island," January 26, 2020, Presenter; Peter August (URI, Dept. of Natural Resources Science)

Public Workshop on Stormwater Issues. Presentation and Panel Participant, Warren, RI. March 30, 2020. Presenter: Teresa Crean (invited by RI State Representative Lauren Carson)

Warren Steering Committee for the Hazard Mitigation and Flood Management Plan. July 2020 and ongoing. Invited Member, Teresa Crean.

Restore America's Estuaries, 2020 National Coastal and Estuarine Summit. September 29, 2020.

- Organized a dedicated session on "*Collaborative Programs to Enhance the Resilience of Communities and Ecosystems to Climate Change*," with presentations from program managers and scientists from each New England coastal state. (Facilitated by Nathan Vinhateiro and the Coastal Institute's Demonstration Sites) https://www.youtube.com/watch?v=EWYO4_LCPEE
- Presentation "*Climate Response Demonstration Sites in RI: A Collaborative Forum to Enhance Resilience of Local Communities*" Presenter: Peter August (URI Dept. of Natural Resources Science) and others. See above link.

Salt Marsh Migration in Warren. Meeting with Warren Land Conservation Trust, Warren Planning Office, and Save The Bay, January 15, 2021

- Purpose of the meeting was to demonstrate and test a new GIS tool to identify upland parcels that could be considered for protection by the Land Trust. Presenters; Michael Bradley (URI Environmental Data Center) and Charles Roman
- This project provides an online Salt Marsh Coastal Parcel Planning Tool for RI showing potential wetland migration under sea-level rise scenarios and identifies opportunities for conservation of the upland migration corridors (https://www.edc.uri.edu/ri-salt-marsh-conservation-project/).

Presentation before the Barrington Resilience and Energy Committee. September 28, 2021

- Topic was the GIS flood risk analysis. Presenters: Patrick MacMeekin (URI graduate student) and Teresa Crean.

Public Workshop, Bristol Hazard Mitigation Plan. October 21, 2021

- Presentation on "Coastal Resilience in RI; Introduction to STORMTOOLS," Presenter, Teresa Crean.

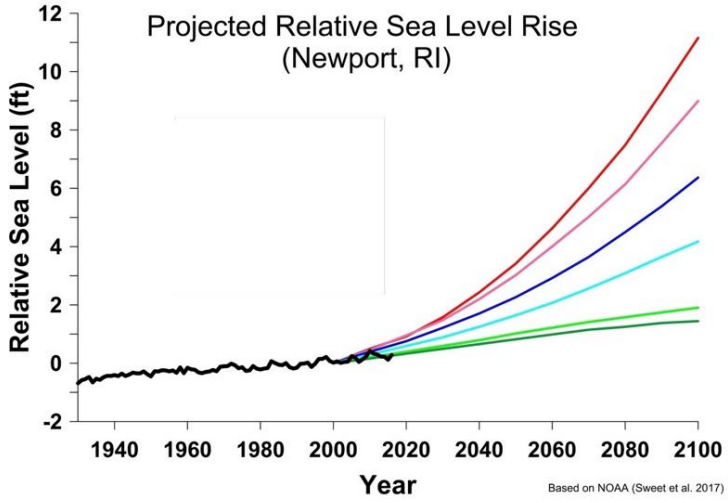
Bristol Coastal Flood Risk Public Walking Tour, October 30, 2021

- Tour was associated with the Bristol Hazard Mitigation Plan Update. Organized and led by Teresa Crean.

FUTURE DIRECTIONS

Collaborative discussions with the three towns, scheduled at the start of each calendar year, have been and will continue to be essential to development of annual work plans that are responsive to the resilience needs of the communities. The following is an ambitious list of topics, provided in no particular priority order, to consider pursuing over the next 12-24 months; some continue ongoing activities while others propose new initiatives.

All Rhode Island coastal communities are currently experiencing flooding and shoreline changes associated with sea-level rise, modest storms, and even periodic extreme high tides (King tides), while future projections by NOAA and the international community of climate scientists (United Nations Intergovernmental Panel on Climate Change, IPCC, https://www.ipcc.ch/about/) point to higher rates of sea-level rise, more intense storms and resulting impacts on the landscape and socioeconomic make-up of the coastal zone. Scientists, engineers, managers, policy-makers and other disciplines, globally, are identifying actions to slow global warming and are recommending adaptation strategies that are necessary to enhance the resilience of coastal communities and ecosystems faced with increased threats of inundation and storm surge. All previous, ongoing, and proposed activities of the Demonstration Site program draw from this growing body of information and emphasize the urgency to plan now for the anticipated future conditions and implement appropriate resilience-building measures.



Observed (black line) and future projected sea-level for Newport, RI. Colored lines show projected sea level trends ranging from global society aggressively curbing greenhouse gas emissions (green lines) to little or no attempts to reduce greenhouse gas emissions (pink and red lines). Data Source: NOAA 2017

Coastal Resilience Updates

The three towns have many completed and ongoing coastal resilience accomplishments and ongoing activities that should be reported to town leaders and citizens in formats that are easily available and updated in a consistent manner. The Demonstration Site program could collaborate with the towns to compile all resilience activities, mapping products, and reports and create a town website that tracks and periodically updates (annual or more often) this information. Annual summary presentations could be created and posted (powerpoint or storymaps) and available for town managers and planners to present before their Town Council, Boards, Commissions, and the public. A dedicated page on the town website with a resilience database and summary presentations would serve to institutionalize coastal resilience as a topic of priority importance.

It is noted that the RI CRMC, with multiple partners, has created a "Shoreline Adaptation Inventory and Design" program -- a statewide inventory of completed and potential shoreline adaptation projects (http://www.crmc.ri.gov/coastalresilience.html). Review and/or collaboration with this adaptation inventory database should be pursued.

Transportation and Buyout Strategy Sessions

The Demonstration Site program plans to continue pursuing discussions related to resilience of the town's transportation network and buyouts as a necessary managed retreat strategy. Future collaborations among the three Bristol County towns and state officials from RI DOT and RI Statewide Planning will benefit from the abovementioned flood risk maps, recently prepared by the URI student intern, of roadway flood depths and distance of flooded roads under different scenarios of sea-level rise and storm surge. As an example from the flood-vulnerable Wampanoag Trail in Barrington, the table provides some of the alarming roadway flood depths projected to occur under different scenarios of sea-level rise and storm surge.

Floodwater depth on road surface (feet) – Intersection of Primrose Hill Rd and Wampanoag Trail, Barrington (RI)				
Sea-level Rise Scenario	Mean Higher High Water	1 Year Storm Return Period	25 Year Storm Return Period	100 Year Storm Return Period
2 Ft	--	0.73	8.91	12.66
5 Ft	0.58	3.73	11.91	15.90
7 Ft	2.58	5.73	13.91	18.00
10 Ft	5.58	8.73	16.91	24.57

Regarding buyouts, using Warren's *Market-to-Metacom Redevelopment Project* as a model planning approach for relocating residents and businesses in flood-prone neighborhoods to higher ground areas of the town, it is proposed that the Demonstration Site program participate in

each towns ongoing discussions to identify critical flood-prone areas and relocation or other adaptation options.

Outreach

Information sharing has been a fundamental aspect of the Mixed-Use Demonstration Site initiative. Understanding the climate change threats that face the communities and knowledge of the range of adaptation options to enhance community resilience are critical to making informed decisions. Outreach should include all types of audiences, but it is proposed that a particular effort be made to target the town decision- and policymakers (town councils, boards, commissions, working groups, etc.), elected officials, and youth groups (middle and high school). Tackling climate change issues will be ongoing throughout this century and beyond, therefore, it is especially important that the world's youth appreciate the impacts of climate change on ecosystems and society and has knowledge of approaches to slow global warming, enhance community resilience, and promote ecosystem sustainability. Climate change-related decisions made now will influence the entire lives of today's youth.

Outreach could include topic-focused presentations (e.g., global warming science, buyouts, transportation issues, habitat restoration, resilience practices, etc.) and field trips visiting flood-prone areas of the towns and touring existing or planned resilience efforts, among other outreach formats. The recent walking tour of Bristol in association with the town's Hazard Mitigation Plan update was quite successful. Presentations to statewide, regional and national audiences on the Demonstration Site program will also be pursued.

Young future researchers at the Graduate School of Oceanography Science Saturday. Source: Mike Salerno.

Student Engagement

The Coastal Institute expects to continue funding and mentoring graduate students to work with the Mixed-Use Demonstration Site team. As our work plan for the next 12-24 months is developed specific focus areas for graduate student interns will be identified.

We are excited to report that RI Sea Grant's *Senior Integrated Coastal Resilience Capstone* will concentrate on Bristol County during the upcoming Spring 2022 semester. In brief, the Senior Capstone combines students and faculty mentors from the URI departments of Ocean Engineering, Landscape Architecture, Environmental and Natural Resource Economics, and Marine Affairs to work collaboratively with local community professionals to address, in a multidisciplinary manner, issues of sea-level rise, flooding and coastal resilience. The towns and Demonstration Site team will work closely with the students and faculty during the planning and execution of this semester-long program. The Capstone will likely include topics related to coastal resilience zoning policies and legal context, economic cost-benefit analyses, design of

resilience projects, and problem-specific application of the STORMTOOLS CERI (Coastal Environmental Risk Index).

The "Envision Resilience Challenge," with private funding, has announced that in Spring 2022 it will focus on Narragansett Bay. The mission of the Challenge is "*to inspire the communities to imagine a future that is adaptive in the face of sea-level rise by bringing together the insights of local experts, the innovative thinking of graduate students and the stories of people who call the communities home*" (excerpted from: https://www.envisionresilience.org/). Participating academic institutions in the Challenge design studio will be URI, RI School of Design, Roger Williams University, Syracuse University, Northeastern University, and University of Florida. Barrington/Warren/Bristol is one of several Narragansett Bay areas to be part of the project. The Demonstration Site Team looks forward to collaborating with this venture. The initial project conducted by the Envision Resilience Challenge was on Nantucket. Please visit the website for more details on both the Nantucket and pending Narragansett Bay projects.

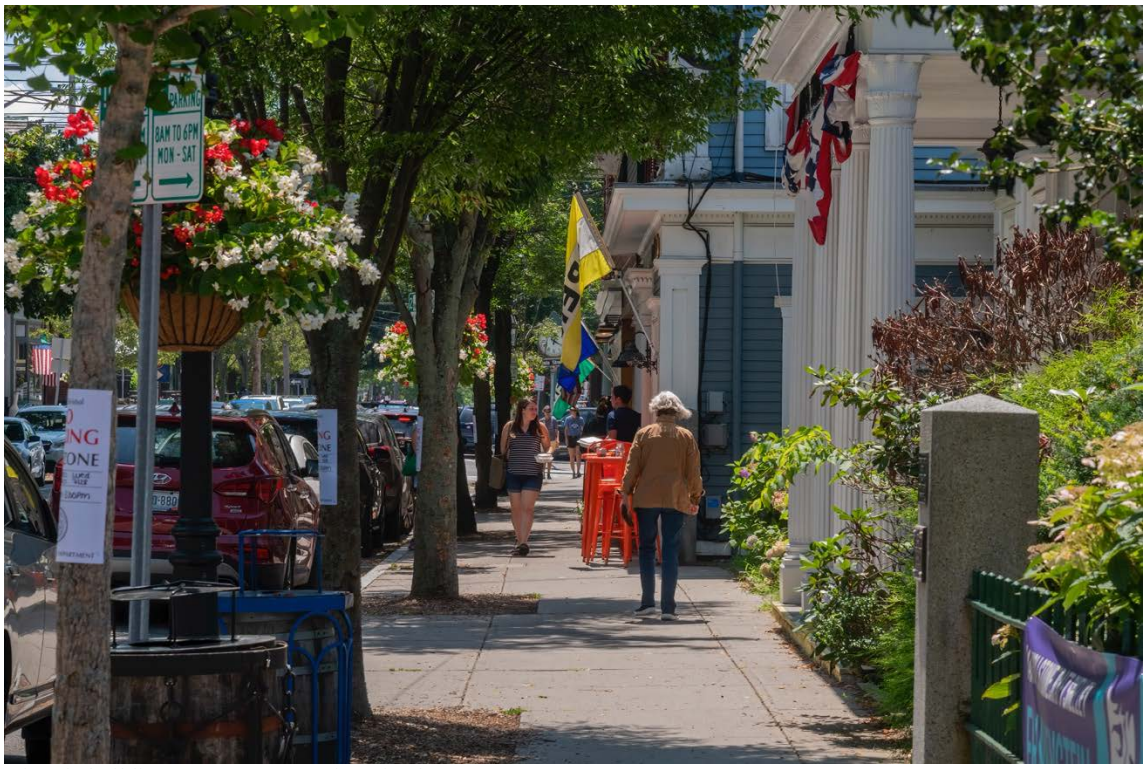
Coastal Access

A recent initiative of the Coastal Institute's Climate Response Demonstration Site program has been the development of new monitoring and outreach to identify and define public access to the RI coast (https://ci.uri.edu/access/). The goals are concentrated on helping the public locate access points and understand their shoreline privileges, and providing decision-makers with up-to-date science about the interplay of coastal processes and shoreline access. With town interest and collaboration, the Demonstration Site proposes to build a comprehensive inventory of shoreline access points in Bristol County. Recent work by RI Coastal Resources Management Council (RI CRMC) and RI Sea Grant has resulted in the development of state-wide guides to public coastal recreation sites in both print and digital (mobile) platforms. We intend to build on this work and include data from recently-designated sites, RI DEM (Department of Environmental Management) properties, public boat launches, coastal greenways, and town harbor management plans. The database could be developed as a web map for use by the public and include site-specific information (e.g. use category, parking, amenities) and a photo-library linked to the sites. An important new aspect of this initiative is to examine public access sites that are at risk of impingement or other limitations due to sea-level rise and extreme storms.

A public access location along Bristol Harbor, RI.

Preserving Historic and Cultural Heritage

Bristol County has a rich historic and cultural heritage, with an extraordinary collection of historic structures and designated historic districts, many on the National Park Service's National Register of Historic Places. It seems especially important to use the best-available science to identify the many significant historic resources that are located in flood-prone areas. Given consensus from the towns, the URI Coastal Institute could collaborate with a student intern and faculty mentor from the Roger Williams University School of Architecture, Art and Historic Preservation to identify flood threats to specific structures and historic districts under different flood-risk scenarios such as 3-ft, 7-ft and greater sea-level rise and storm surge (as obtained from the flood-risk assessment maps discussed above in this report). With this knowledge, structures with the potential to be flooded in the near-term (perhaps within the next few decades) could be given high priority for preservation planning and action, while for others the planning stage could be initiated. The student intern, with extensive input from the town planners, town Historic District Commissions, various local and state preservation societies, the National Park Service, and others as appropriate, could begin the process of developing guidelines for identifying structures for managed retreat, flood-proofing, or other preservation measures. There is an extensive literature on practices to build flood-resilience of historic buildings, with this National Park Service document as an example (https://www.nps.gov/orgs/1739/upload/flood-adaptation-guidelines-2021.pdf).



Historic buildings on Hope Street in Bristol, RI.

URI Coastal Institute's Grant Program

The Coastal Institute's grant program welcomes applications from coastal researchers, managers, practitioners, policy-makers, and other relevant professions, that are interested in initiating or adding to an ongoing project or activity that is focused on coastal ecosystem management (https://ci.uri.edu/grants/). These modest grants are not intended to provide full support for a project, but rather will kick-start an idea (catalyst grant) or complement activities of an existing project (leveraging grant). In recognition of the science and coastal management accomplishments that the Mixed-Use, Natural Areas, and newly initiated Urban Watersheds Climate Response Demonstration Sites have realized, there is consideration to dedicate a portion of the Coastal Institute's grant funds to Demonstration Site projects. Barrington, Warren, and Bristol partners and others could request funds for partial support of any of the proposed activities identified here, as well as other projects that will contribute to the overall mission of the Demonstration Site initiative. For example, student interns could be supported, experts from other regions with an expertise in resilience practices could be invited to speak and interact with the team, components of a comprehensive study to evaluate the socio-economic outcome of implementing resilience measures vs. doing nothing could be outlined, an environmental monitoring program could be designed with a focus on estuarine water level and storm surge, groundwater level and seawater intrusion, habitats, post-storm damage assessment, and other monitoring attributes, and components of a program of information sharing with other RI and southern New England coastal communities could be developed, to name just a few possible thoughts that would benefit from some initial financial support.