Downtown Mystic Resiliency and Sustainability Plan

Town of Groton, Connecticut

Prepared By:
GZA GeoEnvironmental, Inc.

Prepared For:
Town of Groton

JANUARY 2024

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ACRONYMS

ASCE/SEI	American Society of Civil Engineers / Structural Engineering Institute
BFE	Base Flood Elevation
CDA	Community Development Agency
CIRCA	Connecticut Institute for Resilience and Climate Adaptation
CRRA	Community Risk and Resiliency Act
CT DEEP	Connecticut Department of Energy and Environmental Protection
CT DEMHS	Connecticut Division of Emergency Management and Homeland Security
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GCM	Global Climate Model
GHCN	Global Historical Climate Network
HAT	Highest Astronomical Tide
HDSC	Hydrometeorological Design Studies Center
IPCC	Intergovernmental Panel on Climate Change
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MSL	Mean Sea Level
NACCS	North Atlantic Coast Comprehensive Study
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
RCP	Representative Concentration Pathway
RSLC	Relative Sea Level Change
SFHA	Special Flood Hazard Areas
SLR	Sea Level Rise
USACE	United States Army Corps of Engineers

ACKNOWLEDGEMENT

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EXECUTIVE SUMMARY

Overview

Mystic, Connecticut is a historic village located in the eastern part of the Town of Groton and the western part of the Town of Stonington, spanning across the Mystic River. Although its location along the banks of the Mystic River has helped the area prosper, it also makes Mystic vulnerable to climate change impacts. In response to Mystic's climate change vulnerability, the Town of Groton began the Downtown Mystic Resiliency and Sustainability Plan development process in 2022. The study area (see Figure 1) is located on the Town of Groton side of Downtown Mystic to the west of the Mystic River. The goal set for the Plan was to protect natural and manmade resources; sustain the local economy; and provide possible risk mitigation strategies for property owners, the Town, and regional stakeholders. This goal was accomplished by first conducting a vulnerability analysis focused on three main climate change impacts: coastal flooding (rising sea levels and increasing storm surge), flooding caused by increasing rainfall volumes and intensity, and extreme heat. Once the vulnerability analysis was completed adaptation strategies designed to reduce the area's risk to these hazards, using 2050 projections as a guiding benchmark, were developed. These strategies focused on measures including maintaining the study area's cultural and historical resources and economy, maintaining water quality in the Mystic River, maintaining emergency response accessibility, and protecting infrastructure. Public outreach was conducted throughout the entire plan development process and included a variety of public meetings, conversations with local property owners, a survey, and a meeting to address needs of local business owners. Stakeholders were also invited to provide written feedback to the draft recommendations before they were finalized.

Recommendations

A prioritization methodology was developed and applied to identify sixteen (16) high priority adaptation recommendations. The three highest ranking recommendations are:

- Install backflow preventers on stormwater outfalls
- Develop an approach to elevate low-lying roadways
- Evaluate Pearl Street stormwater improvement alternatives

Although the highest-ranking recommendations address flood vulnerability, the high priority recommendations also include several that address extreme heat, including increasing shade through tree cover and canopies and implementing temporary pop-up cooling measures during outdoor summer events. The recommendations section also includes best practices for private property owners and three low priority recommendations, the feasibility of which should continue to be evaluated in the future but that pose such significant barriers that they should not be the immediate focus of the Town's implementation plans.

The development of this plan was just the first step towards achieving a more resilient Mystic. As the Town and local and regional stakeholders shift into plan implementation, continued public outreach and education about these issues will be essential to garner the local support needed to put the recommendations into action. A variety of funding opportunities may be pursued to help provide financial support, as are described in Chapter 7. The flooding events experienced in Mystic as the plan was being finalized in January 2024 were a reminder of the criticality of this work. Sustained and robust action will be needed to keep up with these more common impactful storm events. This plan provides the roadmap needed to maintain the "magic of Mystic" while also protecting the community that makes it the special place it is.

1.0 PLAN OVERVIEW

1.1 PLAN PURPOSE

Mystic, Connecticut is a historic village located in the eastern part of the Town of Groton and the western part of the Town of Stonington, spanning across the Mystic River. Originally part of the ancestral lands of the Pequot Tribe, the land was colonized by European settlers in the early 1700s. The location of Mystic along the river supported a robust maritime economy, and it was home to many captains, ship builders, and merchants. Over time, Mystic became a densely developed area but maintained its history and maritime culture. Today, Mystic has many businesses and has become a popular tourist destination; it was rated one of 10 best summer travel destinations by USA Today in 2023. As a result, Mystic is a significant economic driver for both its municipalities as well as the region. However, Mystic also supports many residences and a year-round population. Many of its homes date to the 1800s and are included in both state and national registers as well as a historic district.

Although its location along the banks of the Mystic River has helped the area prosper, it also makes Mystic vulnerable to climate change impacts. Although "living with water" has always been inherent to Mystic, those waters are now rising. The area is also facing flooding from extreme precipitation events as well as increasing heat impacts from rising global temperatures. In response to these hazards, the Town of Groton began the Downtown Mystic Resiliency and Sustainability Plan development process in 2022. The study area (see Figure 1) is located on the Town of Groton side of Downtown Mystic to the west of the Mystic River. The purpose of this project was to understand the area's vulnerability to climate change hazards and develop adaptation strategies to reduce it, all through a process informed by community engagement. The goal set for the final plan was to protect natural and manmade resources; sustain the local economy; and provide possible mitigation strategies for property owners, the Town, and possibly regional stakeholders.

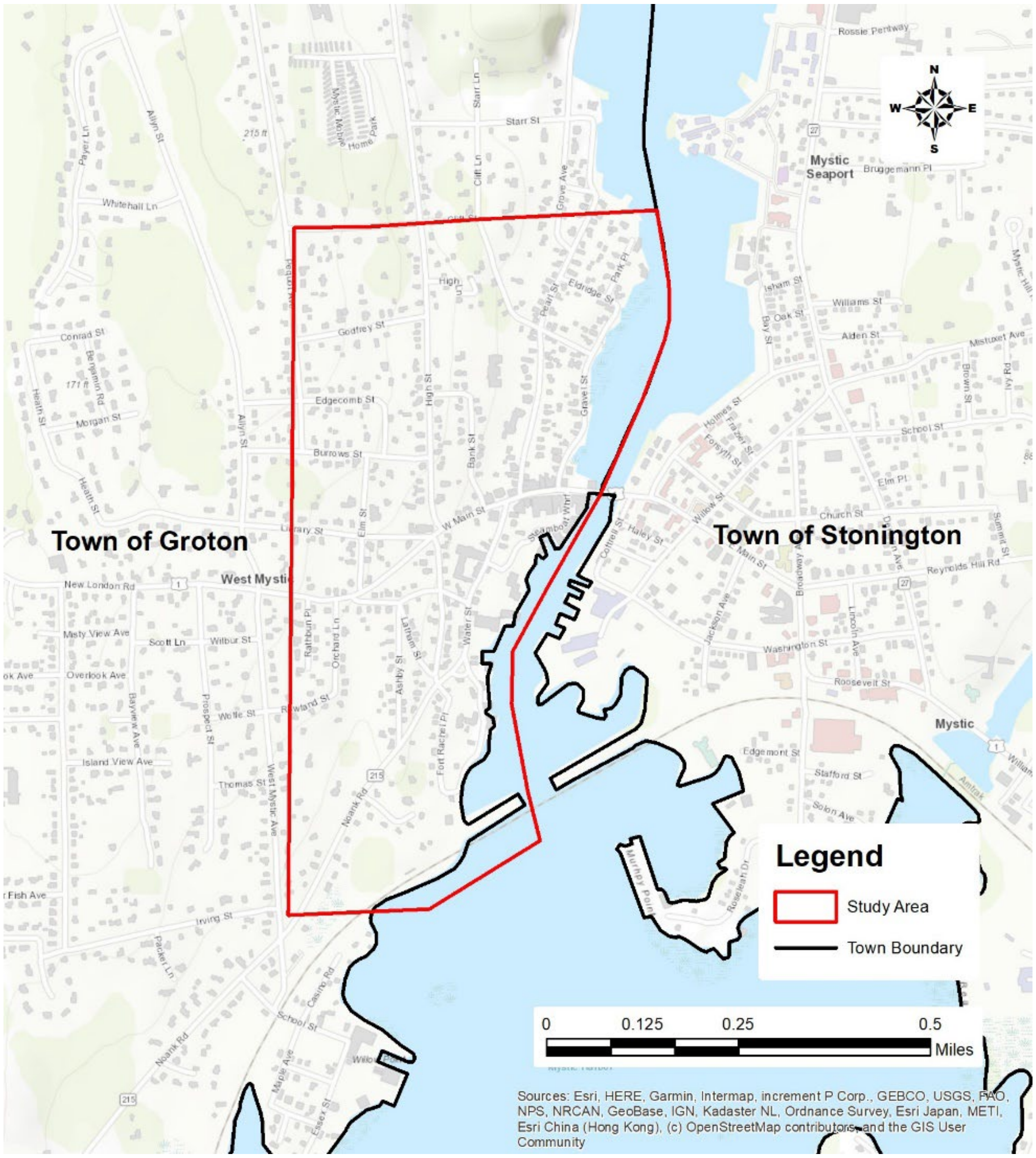

Figure 1: Downtown Mystic Study Area

This document is the final deliverable of the planning process and will be a crucial resource for the Town's efforts to build a more sustainable and resilient future for Downtown Mystic. The document provides the results of a vulnerability analysis conducted to assess the impacts of the following effects of climate change:

- Rising sea level
- Increasing storm surge
- Increasing rainfall depths and intensity
- Increasing temperatures

It also presents comprehensive strategies and measures to guide decision makers with future resilience planning and regulation with the following areas of focus:

- Maintaining the study area's cultural and historical resources and economy
- Maintaining water quality in the Mystic River
- Maintaining emergency response accessibility
- Protecting infrastructure

1.2 TOWN OF GROTON PLANNING TEAM, ADVISORY COMMITTEE AND STAKEHOLDERS

The main contributors of this plan include the following:

Town of Groton Planning Team

- **Jonathan Reiner**, Office of Planning & Development Services (OPDS) Director
- **Deborah Jones**, OPDS Assistant Director
- **Megan Granato**, OPDS Sustainability and Resilience Manager

Town of Groton Project Advisory Committee

- **Frank Bohlen**, UCONN Marine Sciences Professor Emeritus and representative of the Groton Resiliency and Sustainability Task Force
- **James O'Donnell**, Executive Director of the Connecticut Institute for Resilience and Climate Adaptation (CIRCA)
- **Chad Frost**, Principal with Kent + Frost Landscape Architecture
- **Todd Brady**, Managing Director of Coastal Funding Co., LLC, and representative of the Groton Historic District Commission
- **Eric Ott**, Town of Groton Resident (retired from the Connecticut Department of Energy and Environmental Protection [DEEP])

- **Mark Berry**, Director of Groton Parks and Recreation
- **Greg Hanover**, Director of Groton Public Works
- **Captain James Bee**, Director of Groton Emergency Management
- **Delia Morrison**, Director of Groton Finance

GZA GeoEnvironmental, Inc.

- David M. Leone, CFM, P.E.
- Alexander M. Roper, WEDG
- Wayne Cobleigh, CPSM

1.3 PLAN APPROACH AND METHODOLOGY

1.3.1 PLAN METHODOLOGY

Climate resilience is the ability to maintain function despite external stresses imposed by the interactions of climate change and natural hazards. Climate resilience is achieved by evolving in a way that leaves a community better prepared for future climate change related impacts. It can be achieved through a combination of 1) land use planning; 2) zoning and building codes; 3) public outreach and education; 4) emergency response preparedness; 5) strong social networks; and 6) infrastructure design, among others.

The preparation of the plan included the following steps:

Step 1: Develop asset inventory within the study area.

Step 2: Characterize the hazards and existing and projected (2050) conditions in the study area.

Step 3: Assess vulnerability of identified key assets to hazards.

Step 4: Facilitate public and stakeholder outreach.

Step 5: Review and identify resilience and adaptation strategies, actions, and measures for hazards, with a focus on providing resilience to impacts to be experienced by 2050.

Step 6: Identify implementation recommendations (prioritization)

Although noted as step 4 above, public outreach was conducted as an ongoing activity throughout the project in support of completing the other five steps outlined above. Section 1.4 provides more details on the project's public outreach approach. Terminology used in this plan is defined in **Attachment 1**.

1.3.2 QUALITY ASSURANCE PROJECT PLAN

As required by the LISFF, GZA developed a Quality Assurance Project Plan (QAPP). The purpose of the QAPP is to establish quality control procedures for data collection to ensure the project produces reliable data that can be used to meet the project's overall objectives and goals. The QAPP includes data quality objectives and data quality assurance objectives for primary, secondary, and workshop/ survey data collected during the planning process. Primary data includes data that was collected on-the-ground, specifically data collected during the site visits. Secondary data includes data that was collected by reviewing published geospatial, natural hazard, and modeling data, specifically data that was used in support of the vulnerability assessment. The workshop/ survey data includes data that was collected during the public workshops and a mid-project survey. GZA submitted the QAPP to NFWF and had a meeting with NFWF representatives to discuss the contents of the QAPP and suggested revisions. The final QAPP was approved on December 21, 2022.

1.3.3 VERTICAL DATUM

Elevations in the plan are in the North American Vertical Datum of 1988 (NAVD88).

1.4 PUBLIC OUTREACH APPROACH AND OVERVIEW

The Town and GZA facilitated online and in-person public education and outreach to gather public and community stakeholder input during the planning process for the project.

The Town first utilized the Greater Groton website to host a project webpage (Downtown Mystic Resiliency & Sustainability Plan | Greater Groton) as a platform to share information, request input, and highlight progress made during the project. This online tool served as a key social media link to the community that enabled the Town to: 1) host an interactive mapper, 2) advertise project updates and stakeholder meetings, 3) request and post images of flooding impacts, 4) host the mid-point project survey, and 5) provide an alternative means of gaining input from those not able to attend the public meetings.

The Town and GZA also used social media websites and in-person canvassing to spread awareness of the project and public workshops. Examples of online sites utilized included the Town's website, Facebook site, and Instagram account as well as local online newspapers including *The Day*.

The Town and GZA used stakeholder outreach meetings as a platform to share information and gain support of key stakeholders. GZA worked with the Town and steering committee to arrange three in-person workshops at key milestones in the project, across which approximately 150 people attended. The activities conducted, topics covered, and public input received during public workshops are described below. Several outreach events were also conducted outside of the three in-person workshops. Those events are described below as well.

1.4.1 PUBLIC WORKSHOP #1

The first public workshop was held on November 1, 2022, and served as an introduction to the project. Participants included Mystic stakeholders (residents, business owners, etc.) from both Groton and Stonington . During the first workshop, the

Town presented the project overview and purpose and a preliminary overview of the assets and hazard inventories, which included projections of sea level rise (SLR) and heat for 2050. GZA provided an overview of the schedule, example recommendations from similar plans, and next steps including the proposed approach for site visits. Workshop participants then worked in small groups on three (3) topics and responded to questions for each topic that included: 1) flooding; 2) heat; and 3) next steps. Participants identified causes of flooding in Downtown Mystic, including:

- Downpours
- Clogged drains
- Tidal flooding including high tides and king high tides
- Heavy precipitation/ stormwater flooding
- Coastal storms
- Combination of all of the above

Participants also identified locations in Downtown Mystic that have been impacted by flooding in the past, including:

- Gravel Street
- Pearl Street
- Fort Rachel Place
- West Main Street
- Water Street
- River Road
- Steamboat Wharf / parking lot
- Mystic Museum of Art parking area
- West Mystic

Participants noted that they have observed an increase in the number of days over 90^{o} F in recent years. Participants indicated that the rising temperatures affected business owners, residents, and community members in the following ways:

- Algae blooms in coves during August
- Increased use of air-conditioning
- Drought
- Increased use of water
- More difficult to successfully maintain gardens, farms, and produce

Attachment 2 includes a full list of participant responses from Public Workshop #1.

1.4.2 PUBLIC WORKSHOP #2

The second public workshop was held on May 2, 2023, and served as an intermediate progress update for the project. Participants included stakeholders from the Downtown Mystic study area and surrounding area. GZA and the Town presented the results of the asset inventory, flood hazard characterization, and vulnerability assessment. Several stations were set up with results of the flood hazard characterization and vulnerability assessment, manned by representatives from the Town of Groton, GZA, and CIRCA. Workshop participants moved between stations and asked questions to representatives about the results. Additionally, a survey was conducted, which asked participants to select which approaches or alternatives they would prefer to build resilience against extreme heat and flooding hazards. The results of the survey were eventually used to develop the adaptation strategies described in Sections 5 and 6 of this plan. **Attachment 3** summarizes the results of the mid-point survey.

1.4.3 PUBLIC WORKSHOP #3

The third and final public workshop was held on January 4, 2024, and served as a presentation of the adaptation measures and recommendations. Over 110 participants attended the workshop, including residents, Town Councilors, and representatives from local boards and commissions. In similar fashion to the second public workshop, posters were displayed in the meeting area to present results to the attendees. The posters included results of the vulnerability assessment as well as adaptation measures for intense precipitation and coastal flooding and best practices for heat resilience. GZA and the Town presented the recommended adaptation measures for coastal flooding, intense precipitation flooding, and extreme heat. A question-and-answer session followed the presentation, where several residents and stakeholders provided their input on the recommendations and prioritization, which was later considered when finalizing the recommendations.

1.4.4 PRESENTATION TO THE WOMEN'S CIRCLE OF THE MYSTIC CONGREGATIONAL CHURCH

On May 8, 2023, the Town of Groton Sustainability and Resilience Manager presented an overview of the project and its progress to date to the Women's Fellowship of the Mystic Congregational Church, which is located in the Stonington portion of Mystic. CIRCA's Director of Resilience Planning also provided a presentation, explaining climate change basics and anticipated impacts. The combination of the two presentations gave the participants an understanding of climate change from the global to the local scale.

1.4.5 GROTON STAFF BROWN BAG PRESENTATION

The results of this project will impact staff and operations across Town departments. In order to raise awareness about the project, OPDS staff hosted a brown-bag presentation on September 19, 2023. The presentation provided an overview of the approach being taken, progress to date, and the results of the mid-project survey. Over 20 staff from OPDS, Public Works, Parks and Recreation, Information Technology, Human Resources, and the Town Manager's Office attended.

1.4.6 LOCAL BUSINESS OUTREACH WEBINAR

The Town of Groton partnered with the Greater Mystic Chamber of Commerce to co-host an online event titled "Weathering the Storm: An Online Forum for Mystic Businesses" on November 15, 2023. The event was publicized through direct mailings to store owners, the Chamber's electronic newsletter, door to door canvassing of businesses on West Main Street, and online platforms. During the event the Town's Sustainability and Resilience Manager presented an overview of past flooding impacts to Mystic businesses, shared resources that local businesses can use to increase their resilience, and led conversation to hear from business owners and employees about their flooding-related challenges and ideas.

1.4.7 TOWN COUNCIL PRESENTATION

On December 12, 2023, the Town's OPDS Director and Sustainability and Resilience Manager presented a project overview to the Town Council. The presentation covered the project approach, major climate impacts being addressed, results of the vulnerability assessment, and draft resilience action ideas. All Town Council meetings are open to the public and recordings are posted on the Groton Municipal Television YouTube page.

1.4.8 PUBLIC OUTREACH TAKEAWAYS

Takeaways from each of the public outreach events helped to inform the decision-making process in the Plan. The project team used the public feedback on causes and locations of flooding in the study area to highlight focus areas in the plan. Further, the results of the midpoint survey were used in the prioritization methodology. Support for certain adaptation measures was considered when scoring the public support for a given recommendation. Finally, comments on the recommendations and prioritization were incorporated in the final version of this Plan, to ensure that final recommendations would be met with public support.

2.0 ASSET DATA COLLECTION AND INVENTORY

2.1 DOWNTOWN MYSTIC OVERVIEW

The study area is located in the eastern portion of the Town of Groton, CT (see Figure 1) along the western bank of the Mystic River approximately 2.5 miles upstream of the Fishers Island Sound. The northern portion of the study area includes approximately Clift Street south to West Main Street, and Pequot Avenue east to the Mystic River. The southern portion of the study area includes West Main Street south to the railroad line, and West Mystic Avenue east to the Mystic River. The study area includes approximately 1.1 miles of shoreline along the Mystic River. Downtown Mystic has seen several changes in landscape over its history, including the placement of fill to convert an inlet of the Mystic River to land supporting Pearl Street and expand the land south of West Main Street immediately west of the Bascule Bridge. Historic maps from 1868 and 1912 are shown in Figure 2.

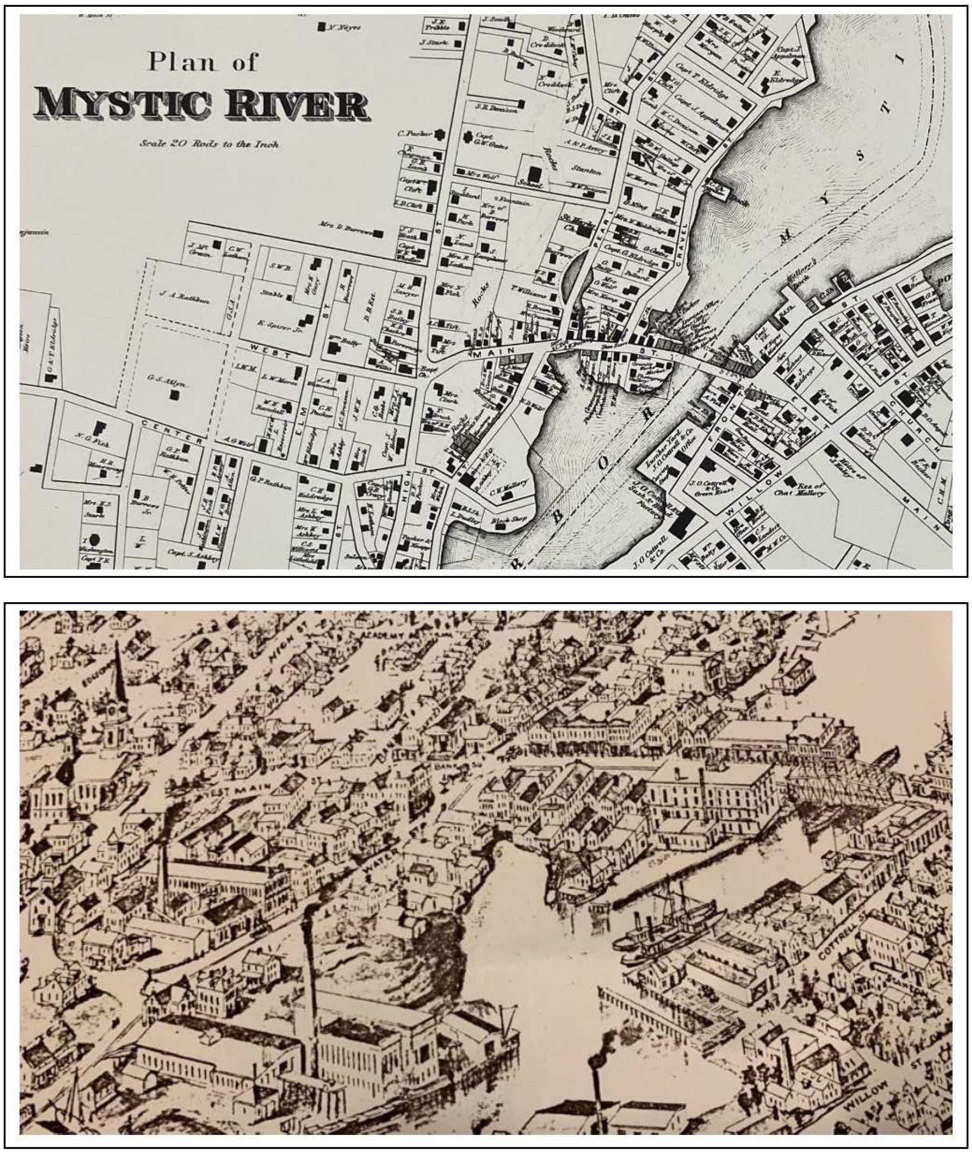

Figure 2: Historic Maps of Downtown Mystic in 1868 (bottom image) and 1912 (top image)

2.2 DOWNTOWN MYSTIC EXISTING CONDITIONS OVERVIEW

The first step of the planning approach is to understand the existing conditions of the study area in terms of land use, environmental justice, shoreline and topography, zoning, buildings and structures, essential facilities, historic structures and places, infrastructure, transportation systems, and high value assets.

2.2.1 EXISTING LAND USE

The study area covers approximately 147 acres of Downtown Mystic. There are five different land uses in the study area, shown on Figure 3. The land use with the greatest percentage of the study area is residential, followed by commercial, vacant land, apartments, and industrial. The low-lying areas in the study area, which are most susceptible to flooding, are mostly residential and commercial.

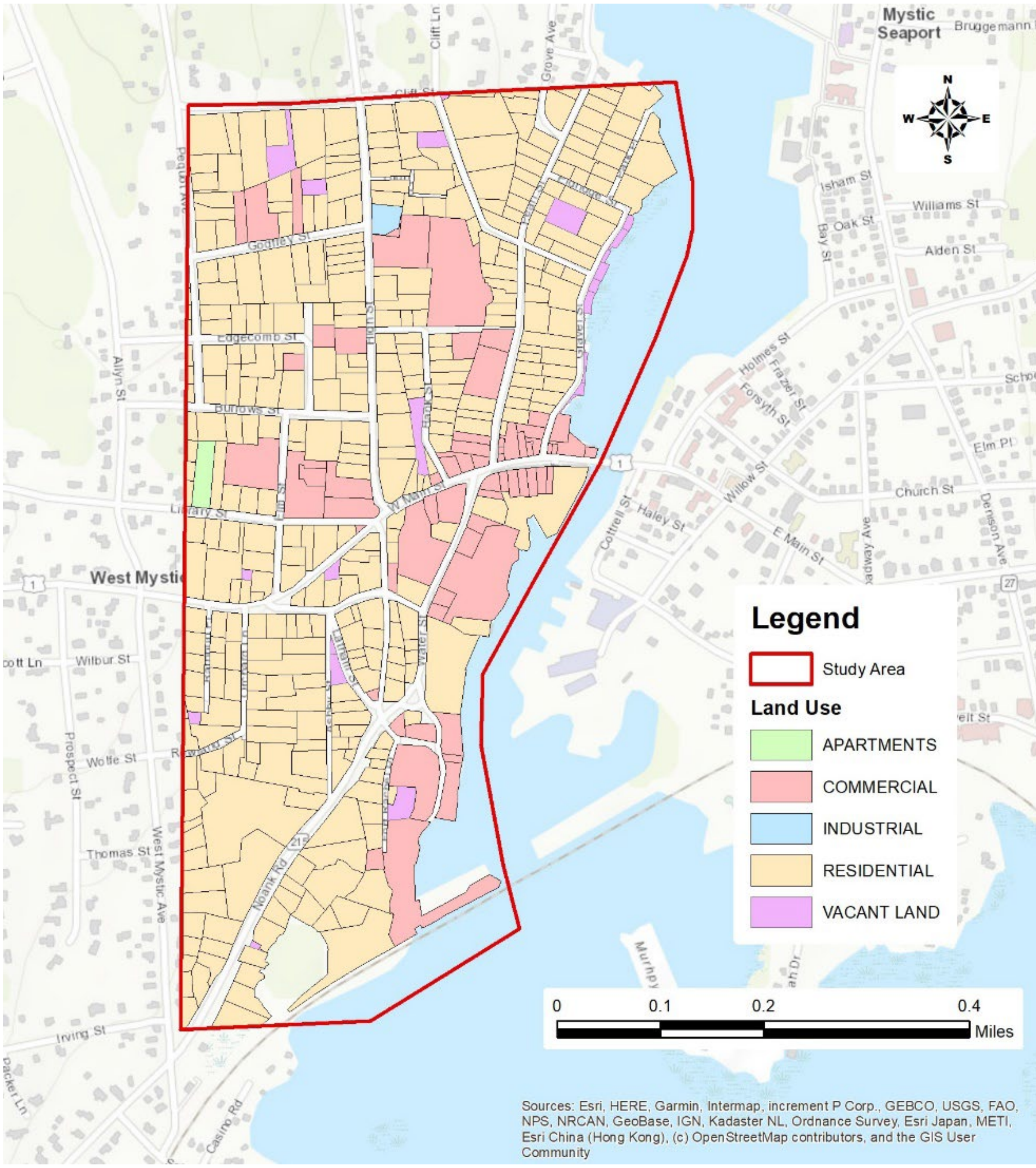

Figure 3: Downtown Mystic Land Use

2.2.2 ENVIRONMENTAL JUSTICE

Per the Connecticut General Statutes (CGS) section 22a-20a, an environmental justice community is defined as:

- *a distressed municipality, as designated by the Connecticut Department of Economic and Community Development (DECD); or*
- *defined census block groups where 30% of the population is living below 200% of the federal poverty level.*

The Connecticut DECD applies a nine-factor methodology[1] to determine distressed municipalities rankings for 169 municipalities on an annual basis. Based on the results of this analysis, the DECD identifies 25 towns with the highest scores as designated distressed municipalities. In 2022, Groton received a ranking of 22, making the Town an environmental justice community.

Although the entirety of the Town has this designation, the Mystic area of Groton is amongst the most affluent areas of Town. Data from the EPA EJSCREEN Tool (epa.gov/ejscreen) show that the median household income for the block group that includes the study area is $122,188. The population is predominately white, with 4% people of color. Forty-six percent of the population is over the age of 64, which is in the 98th percentile for the state.

2.2.3 SHORELINE AND TOPOGRAPHY

Based on review of aerial imagery and photographs, the majority of the study area shoreline north of West Main Street is masonry bulkhead. The area near West Main Street appears to be sheet piles, and the area south of West Main Street is stone bulkhead. There are approximately 1.1 miles of shoreline within the study area. Aerial imagery of the shoreline is shown in Figure 4 and field photos of the shoreline are shown in Figure 5.

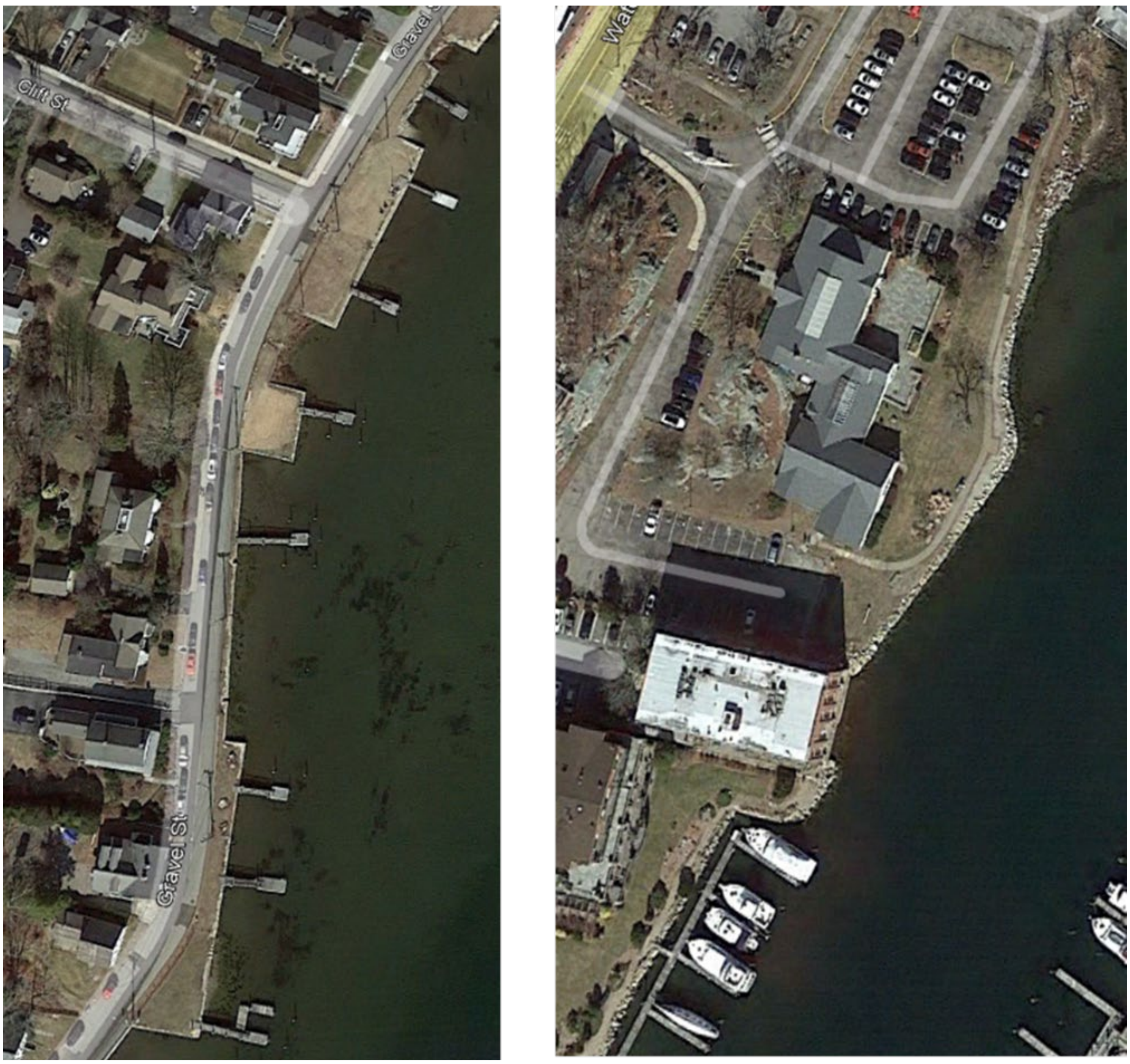

Figure 4: Aerial Imagery of Shoreline Showing Masonry Bulkhead (Left) and Stone Bulkhead (Right)

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[1] Environmental Justice Communities (ct.gov)

(Shoreline off Gravel Street North of West Main Street)

(Shoreline at Northern Boundary of Study Area off Park Place)

Note: Google Earth Imagery (February 2020) showing study area north of West Main Street (Left) and south of West Main Street (Right

Figure 5: Field Photos of Downtown Mystic Shoreline

Topography in the study area ranges from approximately 0 to 200 ft, NAVD88. The highest portion of the study area is generally in the northwest corner, with a fairly steep slope from west to east approaching the lowest area located along the shoreline of the Mystic River (see Figure 6). Low areas include the vicinity of Pearl Street eastward and portions of West Main Street, which have elevations as low as approximately 3 ft, NAVD88. There is a steep change in terrain to the west of Pearl Street, with elevations going from 3 ft, NAVD88 on Pearl Street to around 54 ft, NAVD88 at the top of the bedrock outcropping.

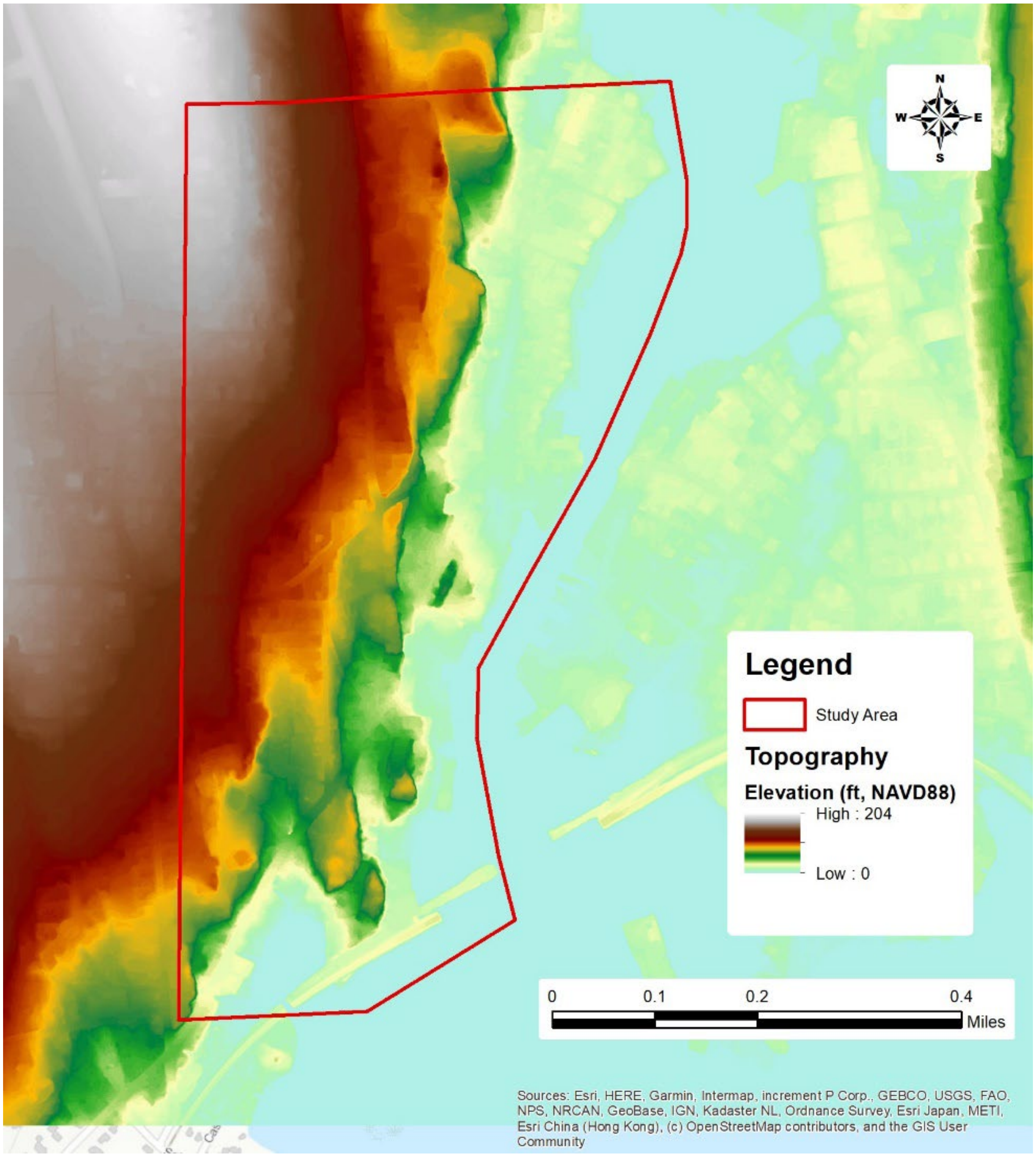


Figure 6: Downtown Mystic Topographic Map

2.2.4 ZONING

The study area zoning classification is Residential (R-7 and R-12) and Mystic Downtown District (MDD) (Figure 7), reflecting the mixed-use of the area as a hub of relatively dense residential development and local commercial activity. The eastern area is also in the Coastal Area Management overlay zone. Per the Town of Groton's Zoning Regulations (Effective 11/15/21, Revised 7/14/2023), the specifications for each type of zoning include:

- Residential-7 (R-7) District: encompasses the densest residential area that surrounds the mixed-use core of historic Mystic Village. The area is covered by the Mystic River Historic District, and buildings, existing and new, must adhere to historic district design standards. Dimensions in this district are designed to encourage one- and two-unit dwellings that support the denser, historic residential patterns of Mystic Village; Minimum lot area: 7,000 SF;

- Residential-12 (R-12) District: encompasses residential neighborhoods throughout the Town. What these diverse neighborhoods share are generally smaller lots, often walkable and bikeable internally and to nearby resources. Future development and redevelopment in this zoning district will enhance these benefits by encouraging one- and two-unit dwellings in walkable, bikeable, sewered, residential neighborhoods near or adjacent to mixed-use centers, other retail and services, parks, schools, and major roads and transit; Minimum lot area: 12,000 SF;

- Mystic Downtown District (MDD): is designed to maintain and enhance this special village by establishing specific standards to ensure a mix of compatible uses, concentrated development, pedestrian friendly circulation, shared parking and public spaces, and the compatibility with existing historic character. The area is also covered by the Mystic River Historic District, and buildings, existing and new, must adhere to historic district design standards.

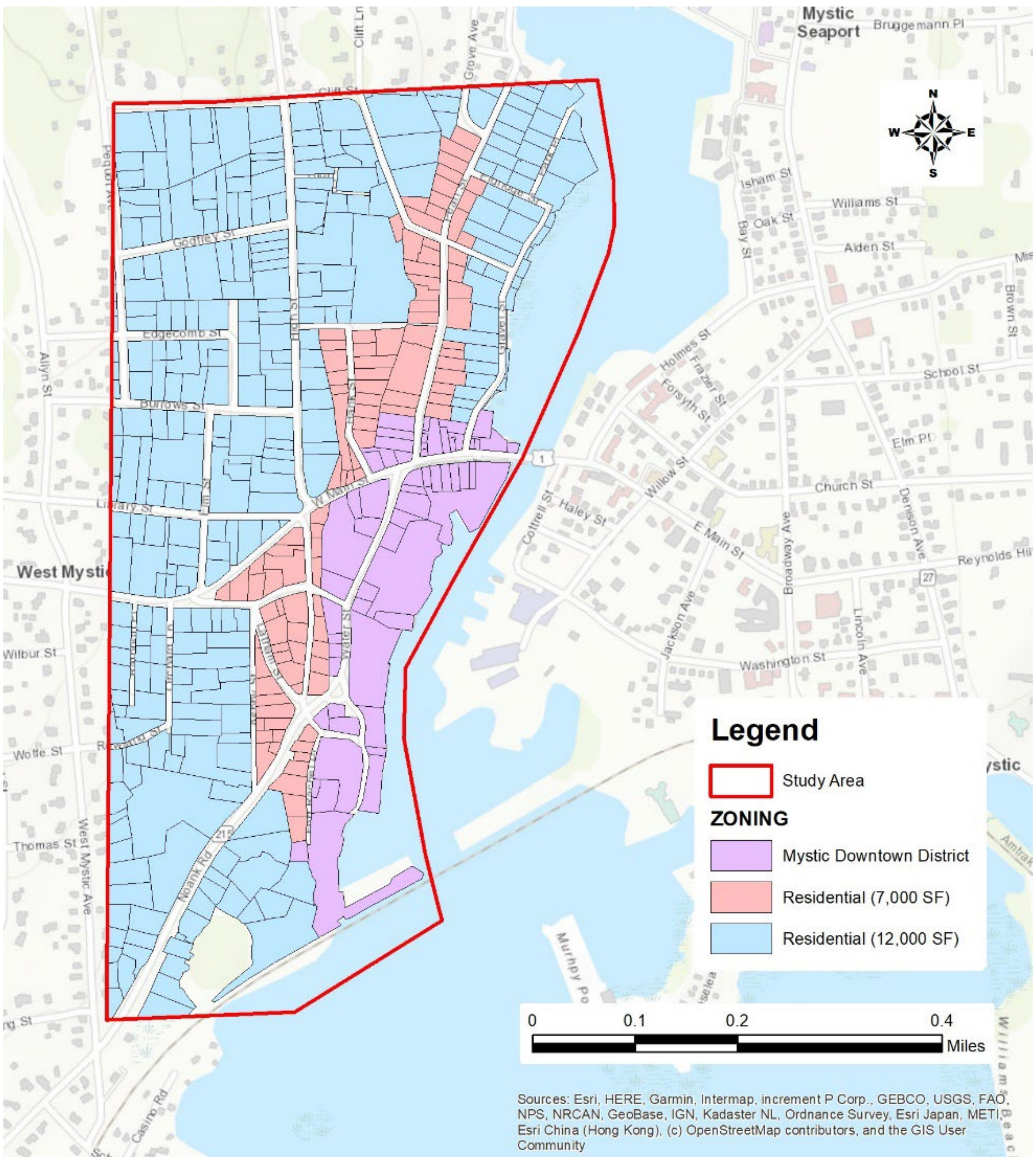


Figure 7: Downtown Mystic Zoning Districts

2.2.5 BUILDINGS AND STRUCTURES

The study area includes 536 parcels and approximately 718 buildings (see Figure 8). Buildings take up about 15% of the study area (22 acres). The buildings located on West Main Street are mostly commercial mixed-use properties, and the buildings in the areas north and south of West Main Street are mostly residential.

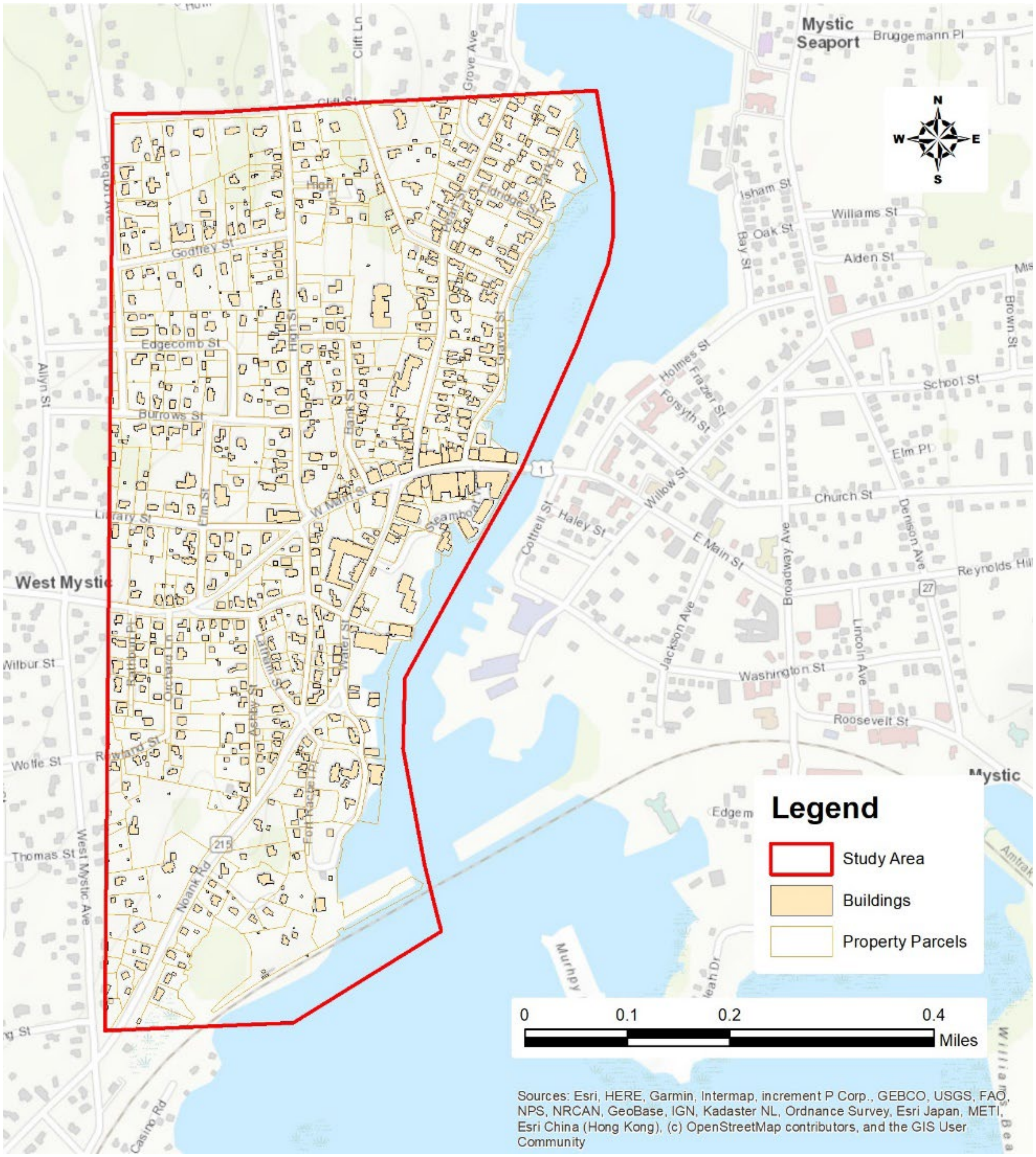


Figure 8: Downtown Mystic Buildings & Structures

The total assessed value for each parcel (per Town of Groton assessor's data) is shown, by ranges, on Figure 9. Assessed values range from $100 for a piece of small undevelopable vacant land to $11,108,900 for the parcel containing the Academy Point at Mystic assisted living facility. Other parcels with high assessed values include the Steamboat Inn and the property at 8 West Main Street, which is multiple use residential/ commercial.

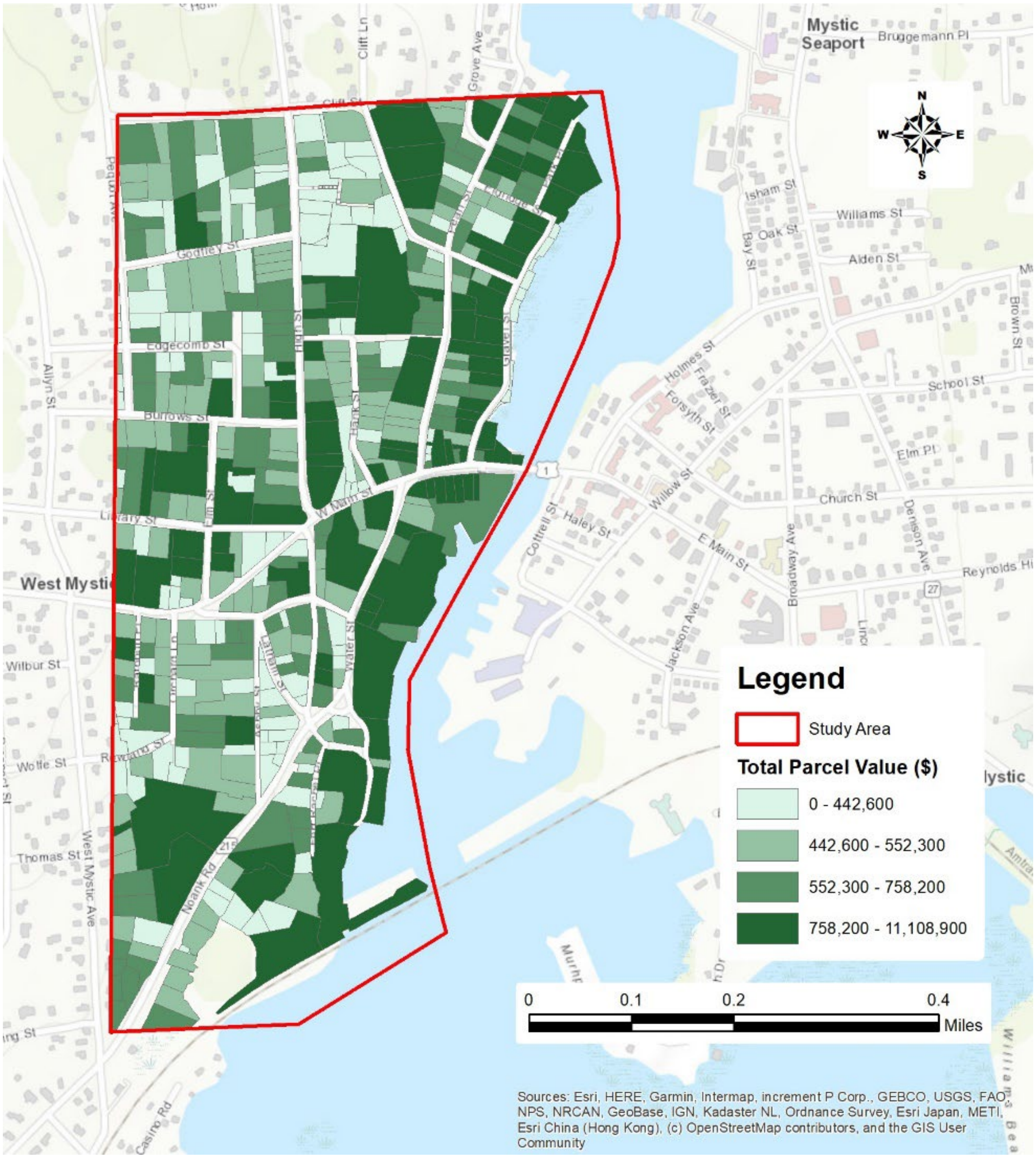


Figure 9: Downtown Mystic Assessed Total Parcel Value

2.2.6 ESSENTIAL FACILITIES

Essential facilities are defined as those facilities essential to public safety and welfare. They include buildings and other structures that continue to provide services (such as emergency response and recovery) during extreme conditions including flooding, wind, snow, or earthquakes. Essential facilities located within or in close proximity to the study area are shown in Figure 10.

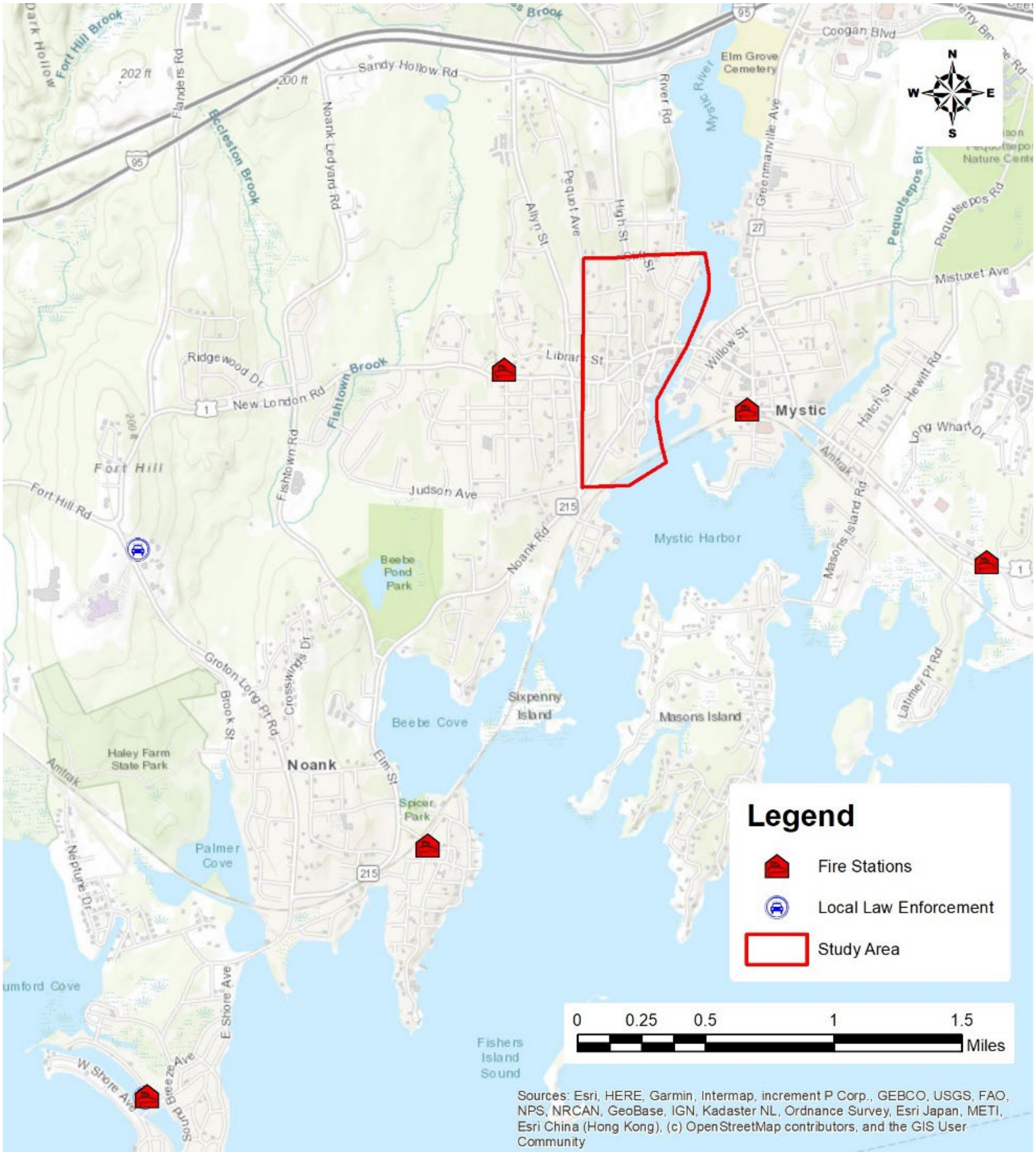


Figure 10: Downtown Mystic Essential Facilities

The only essential facility within the study area is the Groton Police Department's community policing building located on Water Street. There are fire stations and police stations within close proximity. The Mystic Fire District Hook and Ladder Company is located approximately 0.3 miles west of the study area. The nearest police station is the Groton Town Police Department, located approximately 1.8 miles southwest of the study area. The nearest hospital is the Pequot Medical Center in Groton, approximately 4.5 miles west of the study area.

2.2.7 HISTORIC STRUCTURES AND PLACES

Most of the study area is located within the Mystic River Historic District, a district on the National Register of Historic Places. Established in 1979, the Mystic River Historic District was noted to contain over 260 houses of 19th century vintage, and generally representative of 19th century architecture and style. The Mystic River Historic District contains a total of 617 historic properties (see Figure 11). The properties are designated as either: Inventoried, National Register, National Register Non-Contributing, or State Register. These national and state registers and their boundaries are different than the Town-regulated Mystic Historic District. The Town of Groton Historic District Commission was established to review alterations, demolition, or construction of buildings and other structures for the purposes of preservation of historic resources.

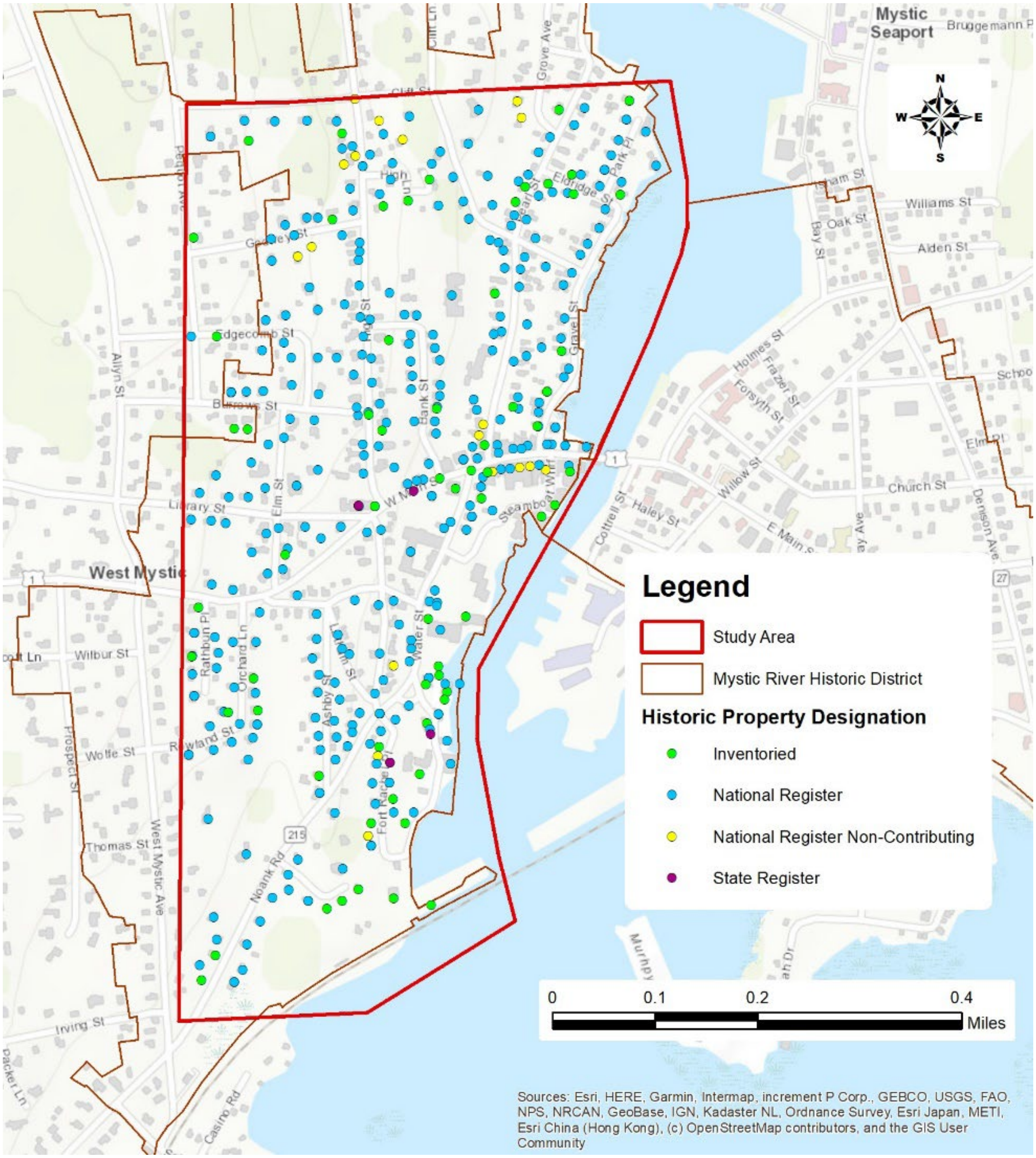


Figure 11: Downtown Mystic Historic Properties

2.2.8 INFRASTRUCTURE

The infrastructure assessed in the study area includes coastal structures (e.g., seawalls, bulkheads) and lifeline systems (e.g., sanitary sewer and stormwater drainage system).

Coastal Structures

The western bank of the Mystic River located within the study area is largely compromised of bulkheads. The shoreline to the north of West Main Street appears to be masonry bulkhead (see Figure 5). The area south of West Main Street is stone bulkhead. Around West Main Street and the drawbridge, numerous buildings directly abut or overhang the riverbank. The railroad embankment at the southern end of the study area is stone bulkhead. The railroad embankment and bridge may provide protection for Tuft's Cove and the study area by dissipating wave energy, but it is unknown if the structure was designed to withstand extreme flooding.

Lifeline Systems

Lifeline systems are those public and private utility facilities that are vital to maintaining or restoring normal services to areas before, during, and after a flood. Lifeline systems located in the study area include both sanitary and storm sewer systems:

- Sanitary Sewer System (see Figure 12, based on Town of Groton GIS data)
    - 30,578 feet of sewer pipes
    - 171 sewer manholes
    - 11 sewer grinder pumps
    - 1 sewer pump station
- Stormwater Drainage System (see Figure 13, based on Town of Groton GIS data)
    - 19,922 feet of drainage pipes
    - 23 stormwater outfalls
    - 185 catch basins
    - 41 stormwater manholes
    - 2 stormwater oil separators

Figure 12: Downtown Mystic Sanitary Sewer Locations

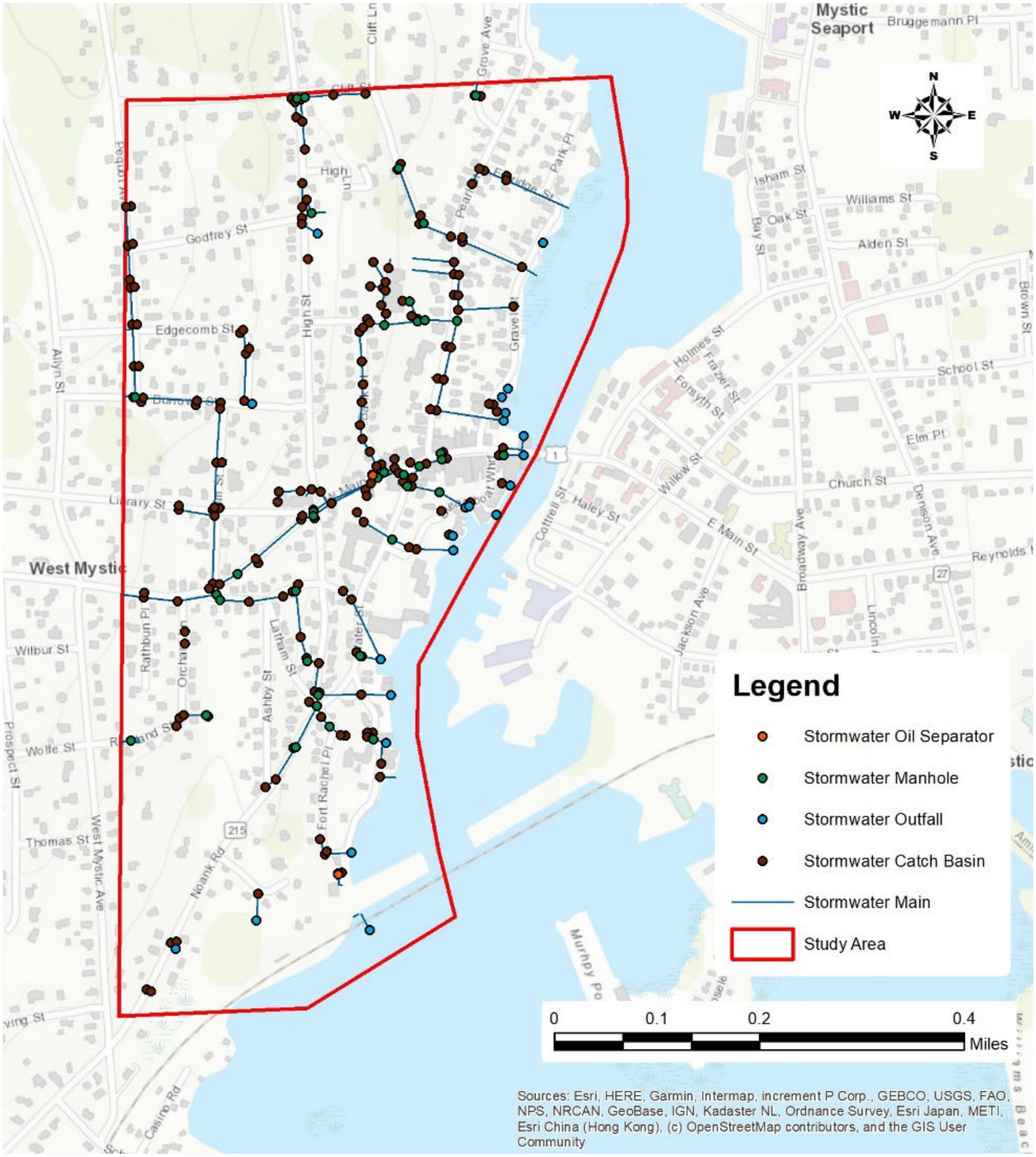


Figure 13: Downtown Mystic Stormwater Drainage System

2.2.9 TRANSPORTATION SYSTEMS

Transportation systems located in and adjacent to the study area include roadways and bridges. The roadways in the study area include West Main Street (State Route 1), Gravel Street, Pearl Street, Clift Street, Eldridge Street, Park Place, Bank Street, High Street, Godfrey Street, Edgecomb Street, Burrows Street, Library Street, Elm Street, New London Road, Water Street, Noank Road, Fort Rachel Place, Ashby Street, Latham Street, Rathbun Place, Rowland Street, Pequot Avenue, Grove Avenue (Mystic), and Orchard Lane. There are approximately 1.05 miles of state highway and 4.37 miles of Town roads presented on Figure 14. Note that there are no bridges within the study area, and the Mystic River Bascule Bridge that connects Groton and Stonington is considered out of the study area.

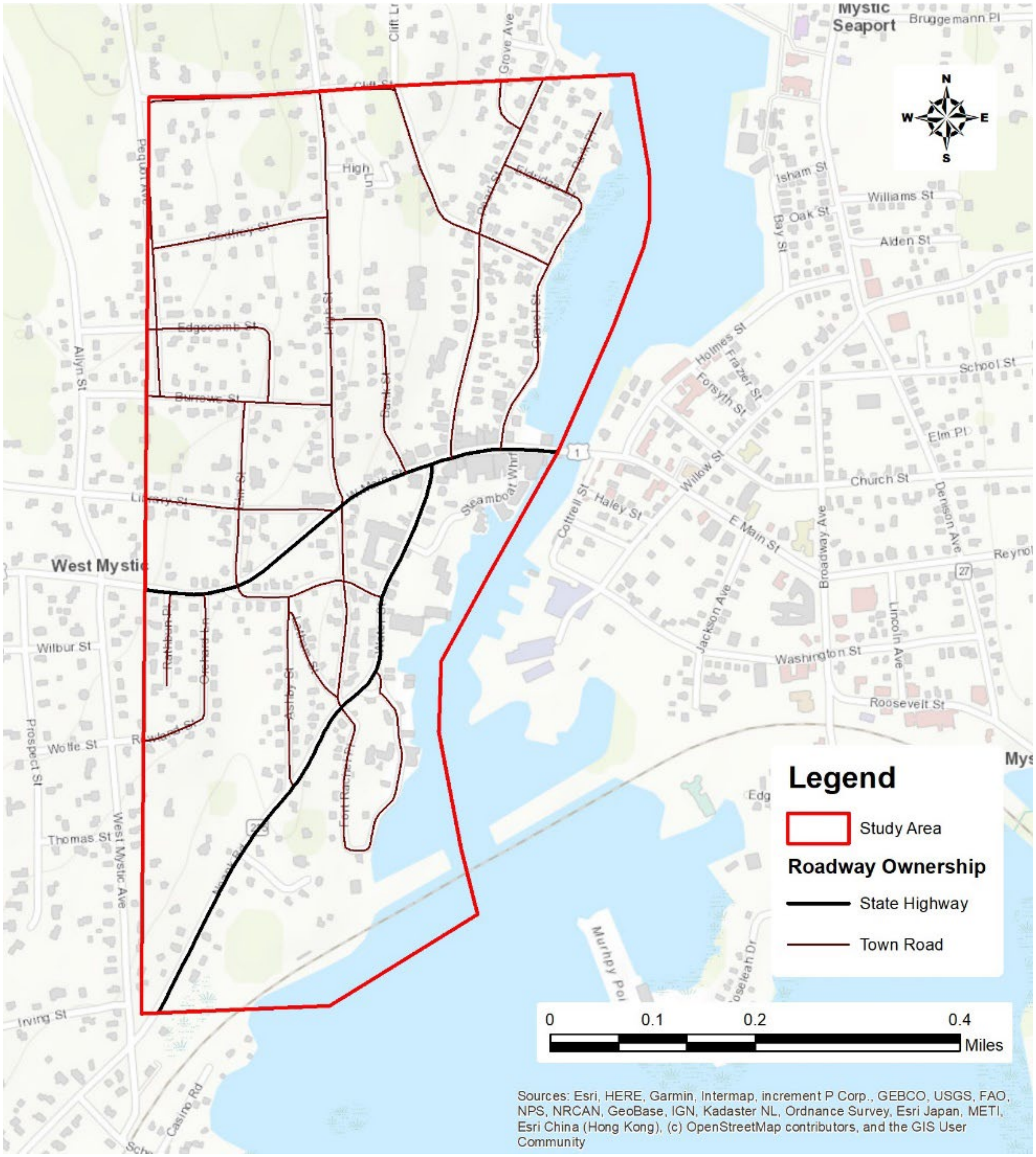


Figure 14: Downtown Mystic Roadways

2.2.10 HIGH VALUE ASSETS

High value assets and properties are shown in Figure 9. The highest value asset in the study area is the Academy Point at Mystic, an assisted living facility. The property at 14 Godfrey Street, which was formerly the Mystic River Residential Care assisted living facility, is another high value asset. Other high value assets include multiple uses, but are primarily commercial buildings at 12 Water Street, 1 West Main Street, and 8 West Main Street.

2.2.11 NATURAL AND RECREATIONAL RESOURCES

Natural resources in the study area are summarized on Figure 15. There are approximately 4.5 acres of tidal wetlands located at the southern border of the study area on the Mystic River, plus the Mystic River itself is an important natural resource. Recreational resources are summarized on Figure 16. There are three owner types of the open space in study area: municipal, private, and state. Open space in the study area includes the Water Street Dock and Boat Launch, Bank Street Corner, Mystic Academy Park, and Daniel Burrows Cemetery.

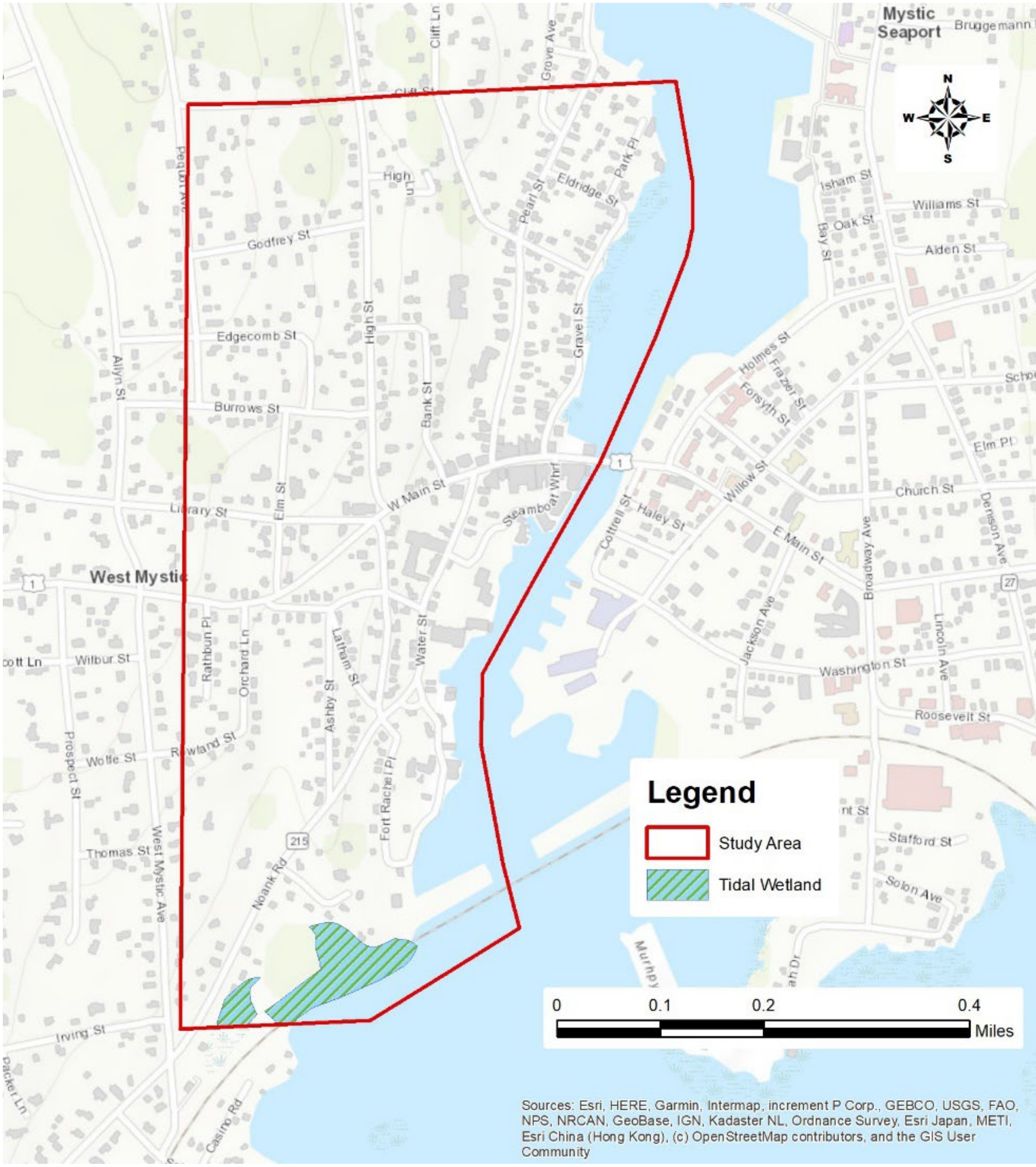


Figure 15: Downtown Mystic Natural Resources

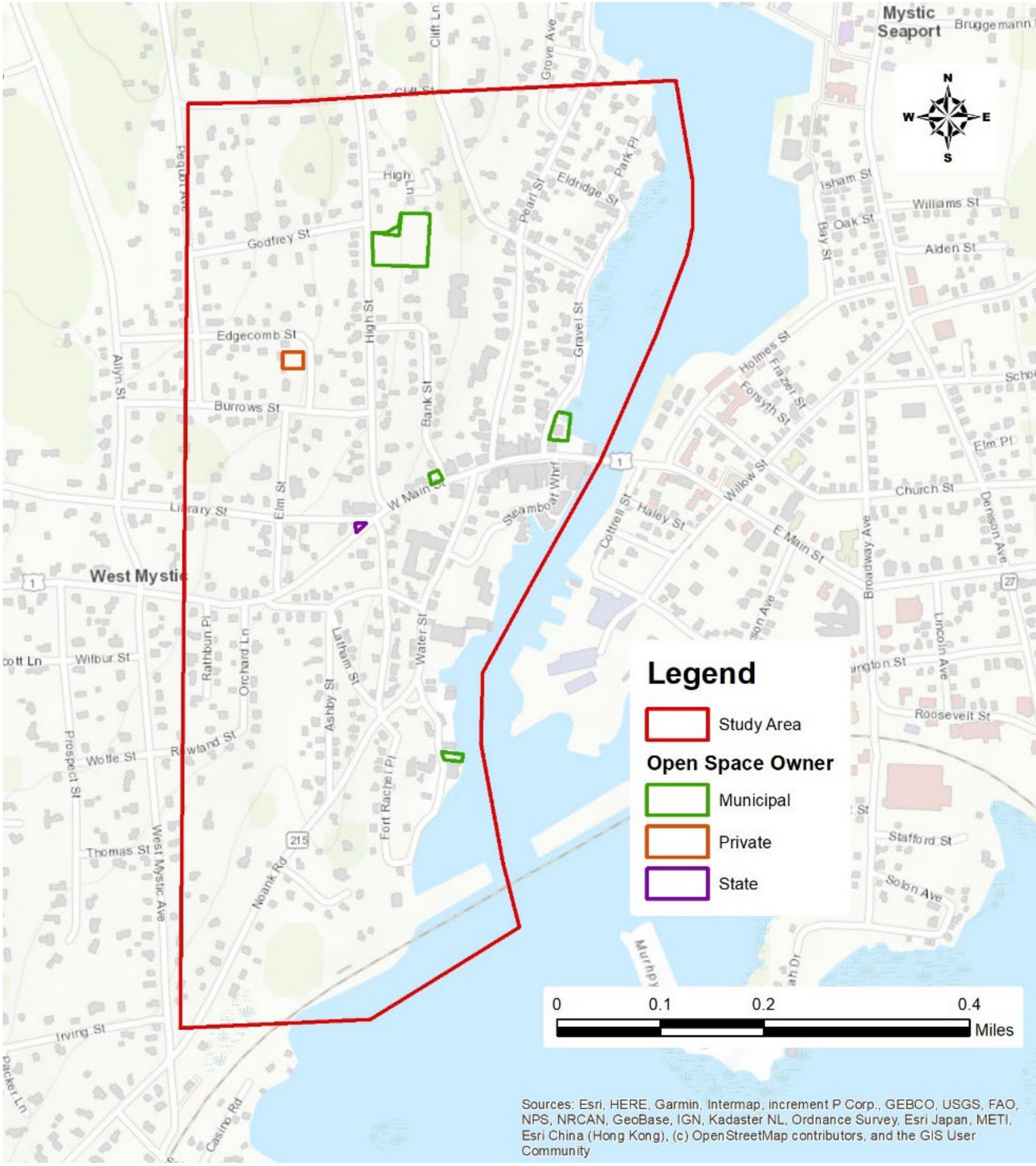


Figure 16: Downtown Mystic Open Space & Recreational Resources

CUSH, Inc. (Clean Up Sound and Harbors[2]) released the following report card assessment of the environmental health of the Mystic River in 2023: "*Received a C (76%), a full grade lower than in 2021 (85%). Although this was a decrease, the 14-year trend indicates this site is variable, and often in the B-range. The hypoxia score [dissolved oxygen level] tends to be low, and chlorophyll is generally good.*"

[2] "Mystic River and Wequetequock Cove Report Card 2008 to 2022." https://cushinc.org/

2.3 DOWNTOWN PROPERTIES ASSESSMENT

2.3.1 DOWNTOWN FIELD VISITS OVERVIEW AND APPROACH

GZA and Town of Groton staff conducted field visits to the study area on January 4 to 5, 2023 and March 2, 2023. During the field visits, GZA observed structures and properties located within the present-day regulatory floodplain (i.e., Federal Emergency Management Agency's [FEMA] 100-yr floodplain) to further the project team's understanding of the study area's setting relative to natural hazards and climate change interactions. The field visits consisted of interviewing available property owners about the presence and location of utilities or critical building contents, as well as discussing the history of flooding at the property. The team also noted building construction type, the presence of below grade floors, and number and type of openings. The information gathered from the field visits is used in later sections as follows:

- Develop representative categories of Downtown Mystic properties.
- Incorporate the observed history of how flooding impacts different locations of Downtown Mystic with current flood mitigation strategies to develop recommendations for property owners to increase their resilience to flooding.

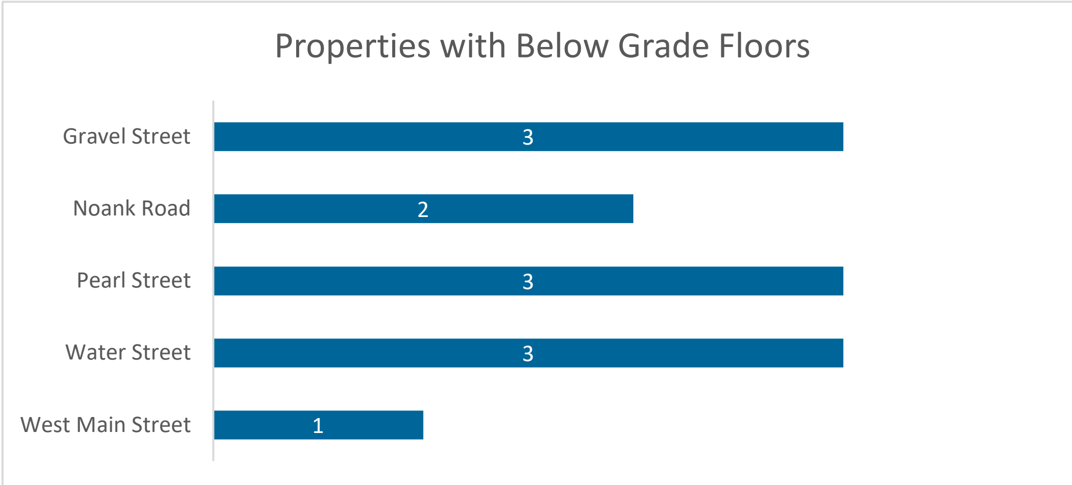
2.3.2 DOWNTOWN FIELD VISIT IMPLEMENTATION AND RESULTS

GZA was able to access 56 of the 105 properties within the regulatory floodplain during the field visits. If the property was not accessible, the team filled out the surveys with available information from the Town's assessor's data. GZA documented and provided the Town with the detailed results of the downtown surveys that provides the comprehensive results for each of the properties evaluated during the three-day field assessment. The number of properties accessed by street are presented below.

An overview of the key findings that were used to inform the identification of resilience and recovery opportunities and recommendations are presented below.

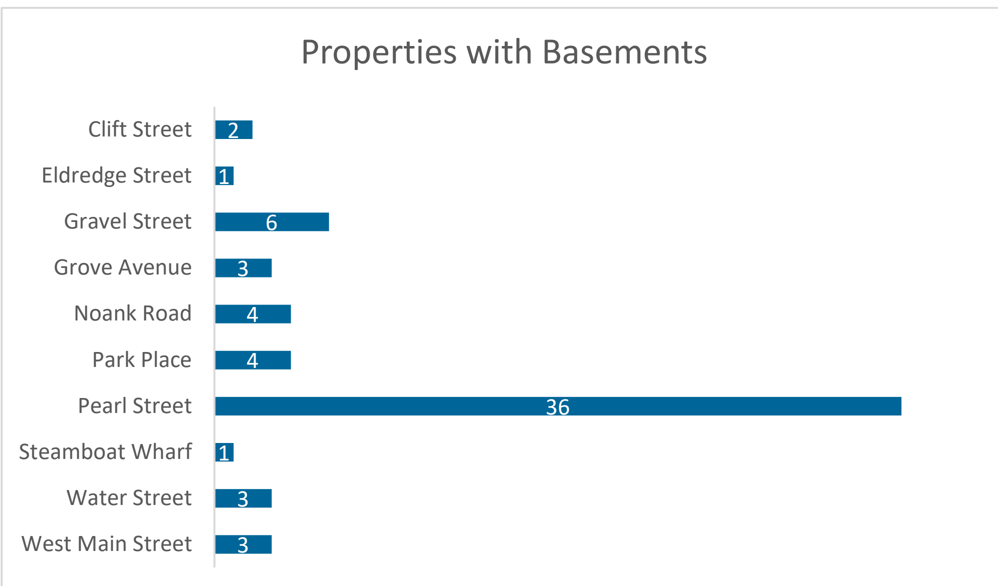
Properties with Finished Floors "Below-Grade"

Twelve (12) properties in the Downtown Mystic survey area's regulatory floodplain have finished floors that are below street grade, according to the property owners. The locations of these properties by street are presented below.



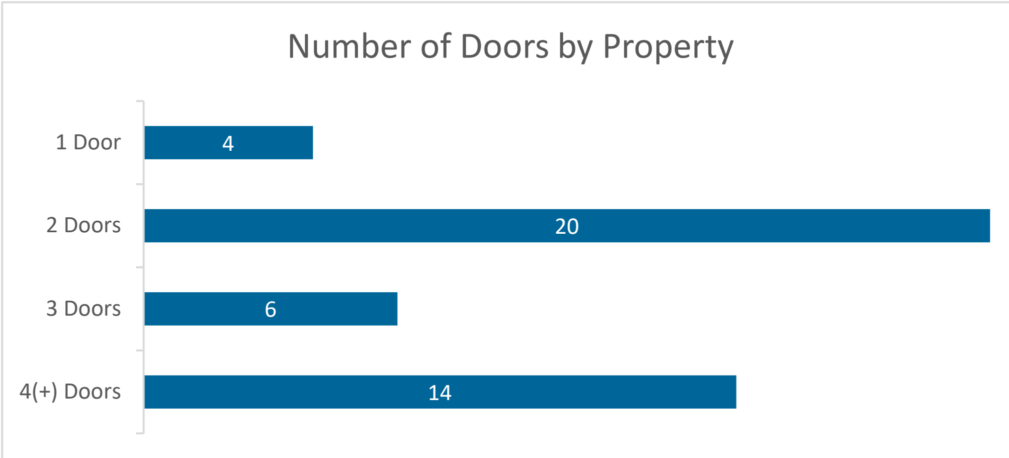
Properties with Basements

Sixty-three (63) properties in the Downtown Mystic survey area's regulatory floodplain appeared to have subgrade basements. Below is an overview of the number of properties by street location.



Number of Doors by Property

Most properties in the Downtown Mystic survey area's regulatory floodplain appeared to have one to two first story doors that provide access to the building and may be vulnerable to flooding, as presented below.



Representative Properties

Downtown Mystic has mixed-use zoning and a number of different property and building types. Each different property/building type can have unique characteristics and challenges that will have different resilience and adaptation improvement options. Based on our review of existing data and our site visit, four (4) representative property types were identified that cover the majority of the study area's building composition:

1. Residential properties
2. Commercial properties
3. Marinas
4. Infrastructure

Representative Properties: Residential

As noted above, there are several residential properties within the Downtown Mystic regulatory floodplain that have basements and door entrances that are vulnerable to flooding. Although property owners are facing flood vulnerabilities, many have implemented actions towards resiliency.

Photos 1 and 2: Example of basement openings (indicated by the orange arrows) that may be vulnerable to flooding.

The majority of properties with below grade floors appeared to have unfinished basements. Utility systems (electrical, mechanical, gas) typically appeared to be either above grade or elevated above the floor if located below grade. Further, several homeowners have sump pumps installed in their basements in response to repeated flooding. Although actions like elevating utilities and installing sump pumps may provide resilience against nuisance type flooding, they likely do not have the capacity to withstand extreme coastal flooding.

Photos 3 and 4: Example of sump pump and raised utility system.

The annotated photograph below (taken during field reconnaissance) shows building openings on a typical residential structure that may be vulnerable to flooding:

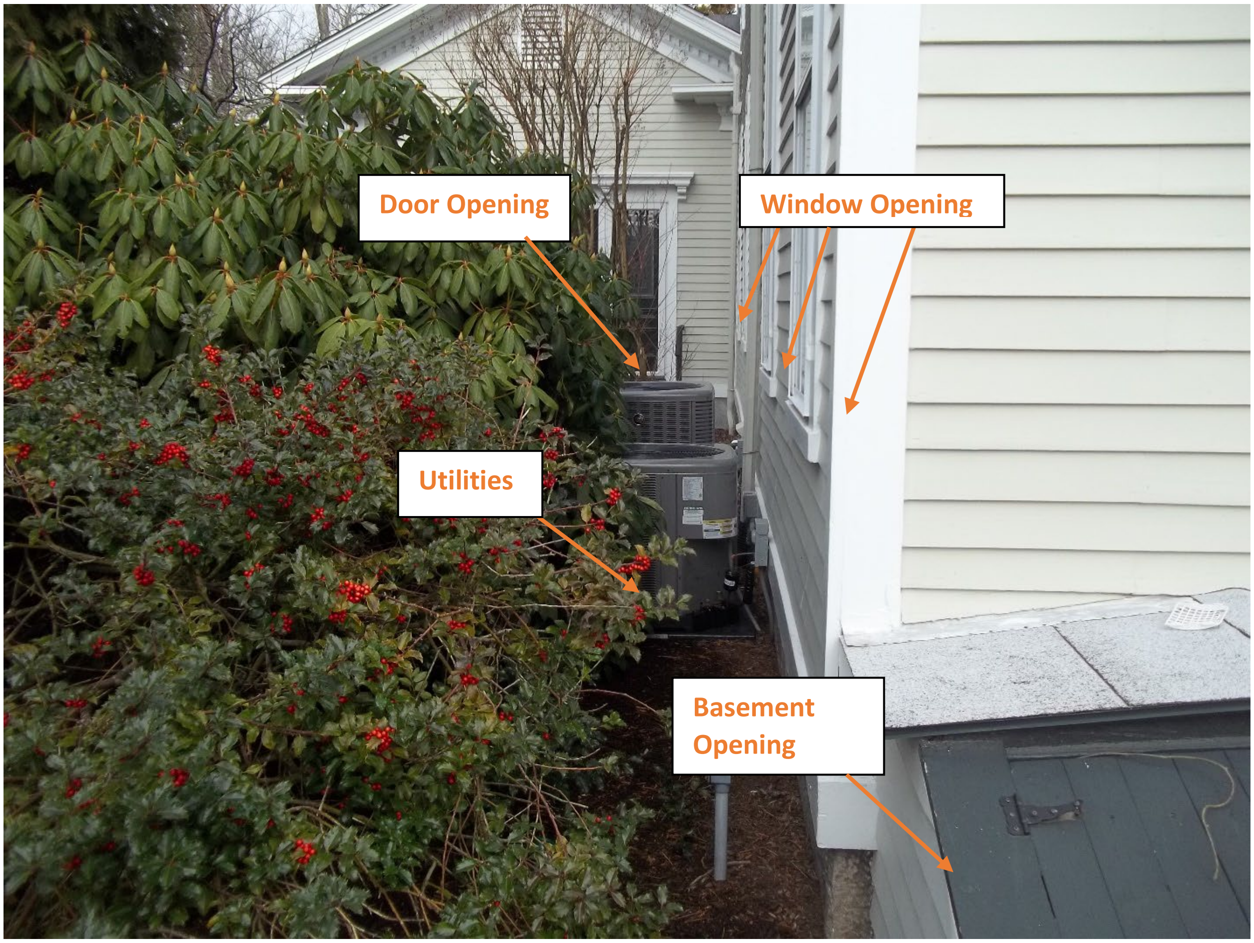


Photo 5: Residential structure with potential vulnerabilities annotated.

Representative Properties: Commercial

There are many commercial properties within Downtown Mystic that appeared to have vulnerable building openings. The majority of commercial properties along West Main Street did not appear to have below-grade floors or basements. However, businesses located elsewhere in the floodplain have basements that may be vulnerable to flooding. Even if the commercial properties do not have a basement, the doors and windows on the ground level may be pathways for flood entry. Further, many of the businesses have utilities that are not elevated and may be vulnerable to flooding.

Photos 6 and 7: Example of building openings that may be vulnerable to flooding.

The annotated photograph below shows building openings on a typical commercial structure that may be vulnerable to flooding:

Photo 8: Typical commercial building with annotated points of potential vulnerability

Representative Properties: Marinas

The marinas in the Downtown Mystic study area are located on the Mystic River. Similar to the residential and commercial properties, the marinas have buildings with openings vulnerable to coastal flooding. The marinas appear to be better equipped to sustain flooding due to the nature of their location and business. Although the marinas have indoor areas with vulnerable doors and windows, some utilities have been raised above the ground level.

Photos 9 and 10: Example of raised utility systems.

The annotated photograph below shows building openings on marinas that may be vulnerable to flooding:

Photo 11: Overview of marina building with potential vulnerabilities annotated.

Representative Properties: Infrastructure

The lifeline systems within the Downtown Mystic Study Area includes the sanitary sewer system and stormwater drainage system. The Gravel Street Pump System is part of the sanitary sewer system and may be vulnerable to coastal flooding. There are eight door openings at the pump station and additional utility openings that may be vulnerable to flooding. Reports from residents on roads including Pearl Street, Water Street, and Grove Avenue (Mystic) indicate that stormwater catch basins flood during high water levels in the Mystic River, possibly due to a lack of tide gates or backflow preventers at the stormwater outfalls.

Photos 12 and 13: Gravel Street Pump Station (left) and Stormwater Catch Basin on Grove Ave (Mystic) (right)

The annotated photograph below shows building openings on a lifeline system related structure that may be vulnerable to flooding:

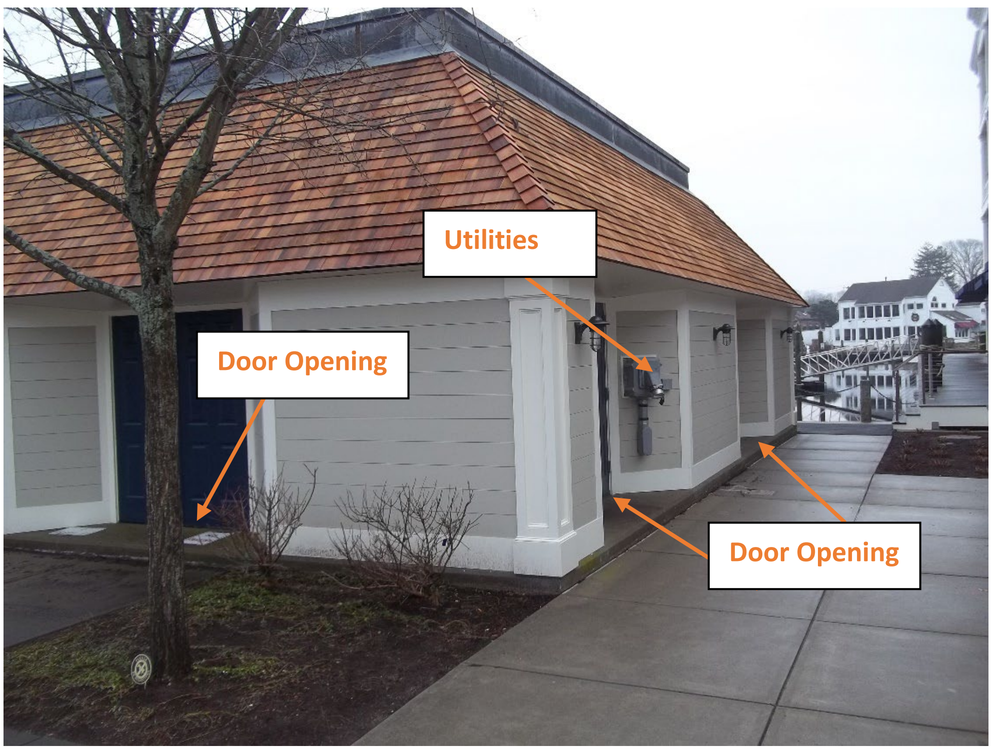


Photo 14: Lifeline System Structure with potential vulnerabilities annotated.

3.0 HAZARDS CHARACTERIZATION

A hazard is a threat (natural or human) that has the potential to cause loss of life, injury, property damage, socio-economic disruption, and/or environmental degradation. Hazard probability is the likelihood or chance that the hazard will occur. The hazards addressed in this plan are natural hazards resulting from climate change: SLR, increasing storm surge, increasing precipitation, and increasing temperatures. The hazards from SLR, increasing storm surge, and increasing precipitation are grouped as flood hazards. Flood hazards result from the hydrostatic and hydrodynamic loads from stillwater, currents, and wave action. It should be noted that although hazards are described separately, they do not necessarily occur separately or independently. Risks and damages from natural hazards may be worsened if multiple hazards occur simultaneously.

It should be noted that in addition to the flood hazards presented below, the project team interviewed several homeowners in the Downtown Mystic Study Area to better understand the history of flooding in the area. As shown in Figure 2, much of the development along the western bank of the Mystic River has been added on fill atop former wetlands. According to residents, these areas along Pearl Street and Gravel Street are frequently flooded. Additionally, areas along the base of the bedrock outcropping to the west of Pearl Street are frequently flooded by intense precipitation flooding.

3.1 COASTAL FLOODING AND SLR

SLR and storm surge are coastal flood hazards that have been characterized using several different data sources, which are summarized below. Due to the inherent uncertainty associated with climate projections and flood estimation, multiple sources of SLR projections are included to inform the approach used in this plan.

3.1.1 TIDES (PRESENT DAY)

Tides are the daily rise and fall of the Earth's waters by long-period waves that move through the ocean in response to astronomical gravitation forces, predominantly exerted by the moon and sun. A National Oceanic and Atmospheric Administration (NOAA) tide station is located on the Mystic River approximately 0.5 miles southwest of the Study Area (see Figure 17). The NOAA tide station (ID 8460751) only provides a detailed record of water levels from March- September 2015. Another nearby tide station, at New London, CT (ID 8461490), approximately 6.5 miles west of the Study Area (see Figure 17), has a record of water levels from 1938 to 2023. Tidal datums are developed based on observed water level data during the current National Tidal Datum Epoch, the 19 years between 1983 and 2001. This period was adopted by the National Ocean Service (NOS) as the official time segment over which sea level observations are averaged to obtain mean values for datum definition.

Figure 17: NOAA Tide Stations

The tides at New London are semidiurnal which means that during each lunar day (24 hours and 50 minutes) there are two high tides and two low tides. The elevations of the high and low tides vary over the daily cycle and lunar cycle (see Figure 18).

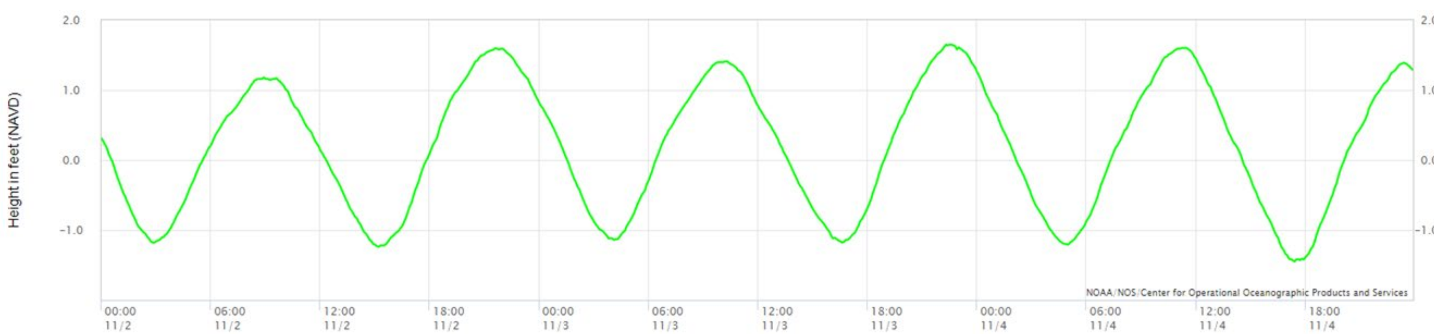


Figure 18: Tidal Elevations at New London Tide Station Showing Differences in Elevations of High and Low Tides during Successive Tidal Cycles

Tidal datums are used to define tide elevations and include:

- Mean High Water (MHW) which is the average of all the high tides over the National Tidal Datum Epoch
- Mean Low Water (MLW) which is the average of all the low tides over the National Tidal Datum Epoch
- Mean Higher High Water (MHHW) which is the average of the higher of the two high tides during each tidal day observed over the National Tidal Datum Epoch
- Mean Lower Low Water (MLLW) which is the average of the lower of the two tides over the National Tidal Datum Epoch
- Mean Sea Level (MSL) which is the arithmetic mean of all hourly heights over the National Tidal Datum Epoch

- The Mean Range of Tide which is the difference between the Mean High Water and the Mean Low Water
- Highest Astronomical Tide (HAT) which is the highest predicted astronomical tide expected to occur over the National Tidal Datum Epoch

The tidal datums at New London are indicated in Table 1.

Table 1: Tidal Datum Elevations for New London Tide Station relative to NAVD88 Datum

Tidal Datum	Elevation (ft); NAVD88
Highest Astronomical Tide (HAT)	2.0
Mean Higher-High Water (MHHW)	1.2
Mean High Water (MHW)	0.9
Mean Sea Level (MSL)	-0.3
Mean Low Water (MLW)	-1.6
Mean Lower-Low Water (MLLW)	-1.8

Comparing the tidal datums to the minimum study area elevation of approximately 3 feet, the study area is at least 1.0 feet above the Highest Astronomical Tide.

3.1.2 OBSERVED SLR AT TIDE GAUGE

SLR is the rise of global ocean waters. Relative Sea Level Change (RSLC) is the change in the difference in sea level relative to the adjacent land mass and is unique to a given geographic location. RSLC is caused by several factors, including: 1) ground settlement due to post-glacial isostatic adjustment; 2) warming of ocean waters, resulting in volume expansion; 3) increase in ocean volumes due to melting Arctic and land ice; 4) ocean density gradients due to the infusion of lower density fresh water; and 5) changes to global ocean circulation patterns (e.g., the Gulf Stream and Labrador Current).

Over the last century, sea levels along the northern East Coast have risen faster than the global mean rate. Figure 19 shows the RSLC at New London since 1938. The observed RSLC trend is 2.76 millimeters (mm) per year (2.76 mm/year = 0.11 inch/year), with a 95% confidence interval of +/- 0.21 mm per year.

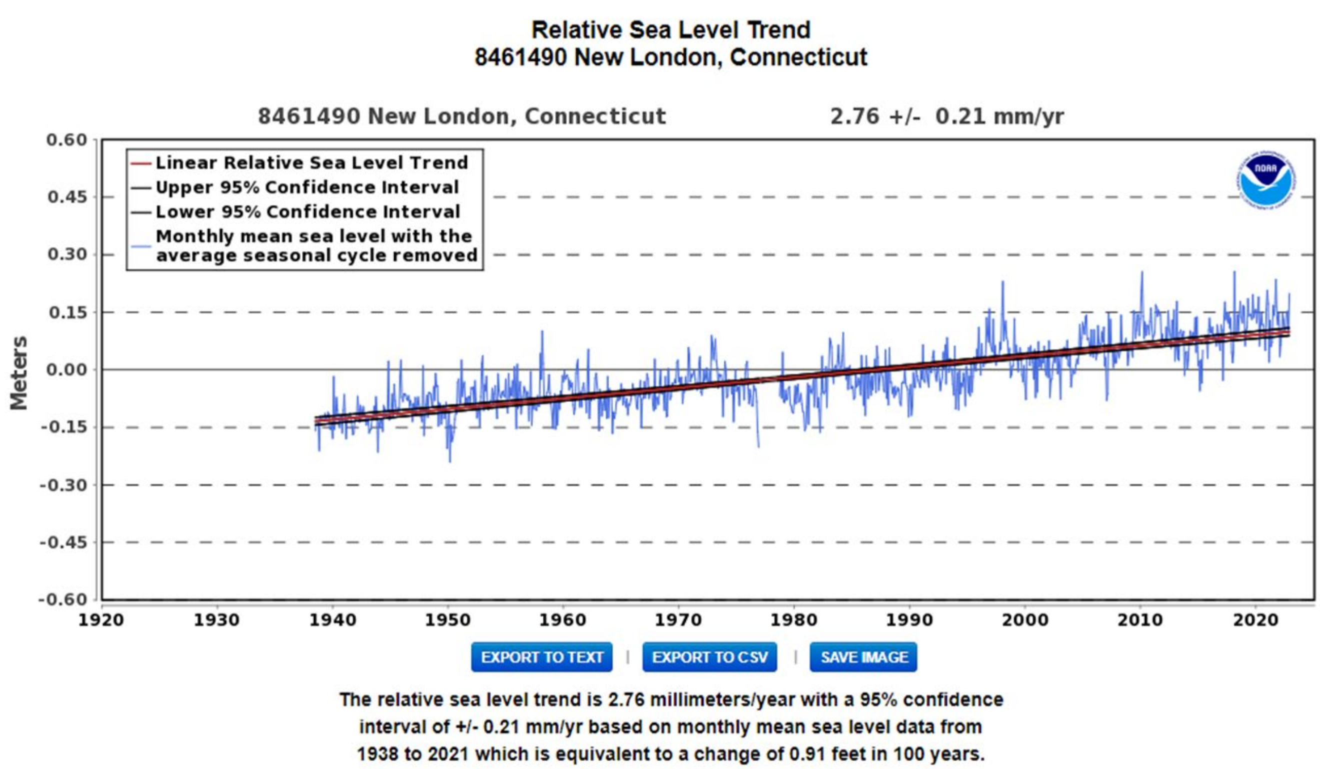


Figure 19: Observed Relative SLR at New London, CT since 1938

3.1.3 TIDE GAUGE EXTREME WATER LEVELS

Extreme water levels recorded at the New London tide gauge are plotted in Figure 20. Tropical storms and hurricanes have historically resulted in the largest storm surge flooding affecting the Downtown Mystic area. The most recent extreme water level was during Hurricane Sandy in 2012. The maximum reported extreme water level is from 1938, from the 1938 New England Hurricane. The approximate peak water levels at the New London tide station during the 1938 Hurricane was 8.72 feet.

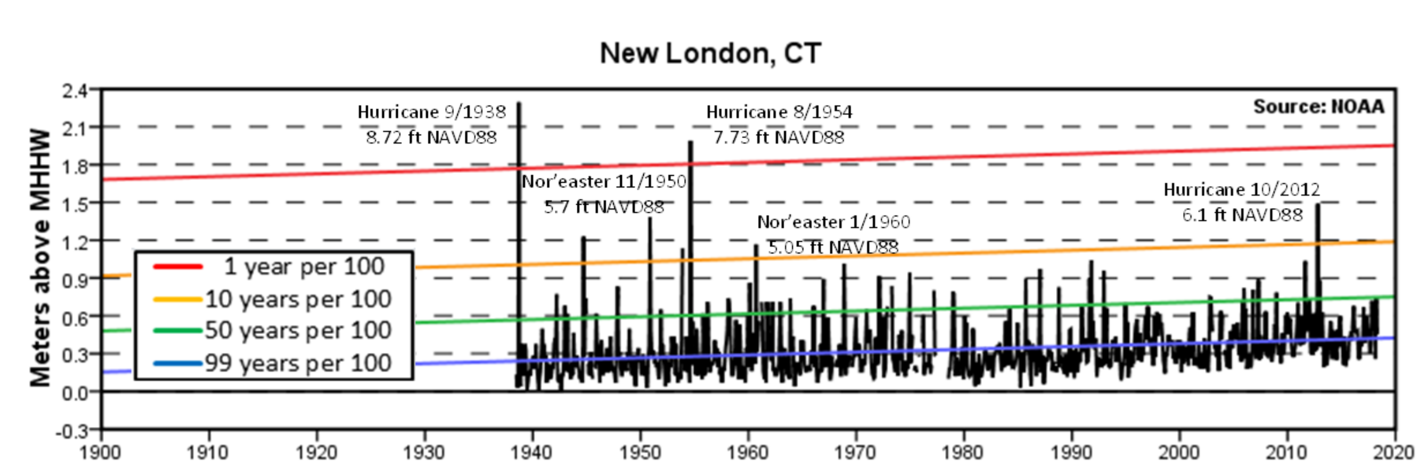


Figure 20: Extreme Water Levels and Exceedance Probability Lines at New London, CT

Figure 20 also shows the 100-year water level (see red line), also called the 1% water level, which was computed using statistical analysis from the tide gauge. The red line slopes upward to account for the observed SLR at the gauge. The 1-year through 100-year water levels for year 2020 are summarized in Table 2.

Table 2: New London Water Level Elevations

Recurrence Interval (years)	Annual Exceedance Probability	Water Level (ft)
1	~100%	2.4
2	50%	3.5
5	20%	4.3
10	10%	4.8
20	5%	5.6
50	2%	6.6
100	1%	7.4

3.1.4 REGULATORY FLOODPLAINS

24.4.4.2 FEMA FLOOD INSURANCE PRODUCTS

The study area flood zone is mapped on FEMA Flood Insurance Rate Map (FIRM) Panel 0526J for New London County, Connecticut (Map Number 09011C0526J, revised August 5, 2013). The calculations for the mapping are summarized in the Flood Insurance Study (FIS) for New London County, Connecticut (revised April 3, 2020).

The FIRM (Figure 21) shows that a portion of the study area is in a Zone AE, which is the Special Flood Hazard Area (SFHA) subject to inundation by the 1% annual chance flood (i.e., 100-year flood, also called the Base Flood). The Base Flood Elevation (BFE) is 11 feet for the majority of the study area, with the exception of the area near Tuft's Cove, which has a

BFE of 10 feet. The study area also includes a shaded Zone X, which is an area subject to inundation by the 0.2% annual chance flood (i.e., 500-year flood), an area of 1% annual chance flood with average depths of less than 1 foot or drainage areas less than 1 square mile, or areas protected by levees from the 1% annual chance flood. Since the study area does not have levees and the drainage area is greater than 1 square mile, the Zone X is likely either the 0.2% annual chance flood and/or an area of 1% annual chance flood with average depths less than 1 foot.

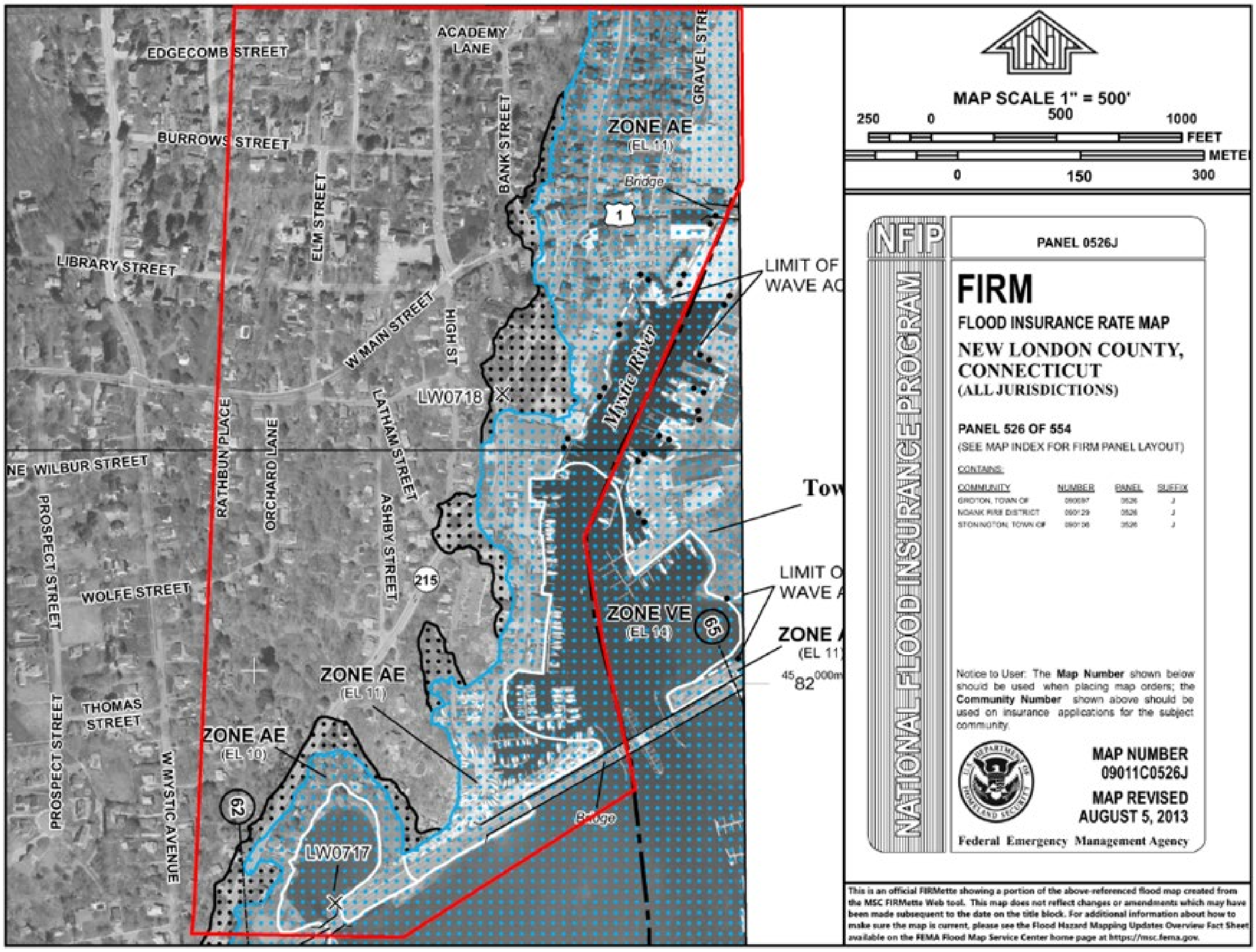


Figure 21: FEMA Flood Insurance Rate Map for New London County, CT Panel 0526J (Revised August 5, 2013)

Beyond the shoreline of the study area, the Mystic River is in a Zone VE, and subject to wave action from the Fishers Island Sound (see Figure 21). The Zone VE has a BFE of 14 feet. The study area, however, is beyond the limits of moderate wave action. Moderate wave action is defined as waves with heights between 1.5 and 3 feet. Note that the AE zone on the FIRM may include waves less than 1.5 feet high.

The FIS provides more detailed information on water levels near the study area. The stillwater levels for FEMA FIS transect 62, the closest transect to the study area located near the outlet of the Mystic River, is summarized in Table 3. Note that the transect has wave information, but it has not been included in this plan because the study area is beyond the limit of moderate wave action.

Table 3: FEMA FIS Stillwater Elevations near Downtown Mystic

Recurrence Interval (years)	Annual Exceedance Probability	Water Level (ft)
10	10%	4.9
50	2%	7.7
100	1%	9.8
500	0.2%	18.4

FEMA influences construction in existing SFHAs through its role in administering the NFIP. This includes the incorporation of minimum federal floodplain management standards into state and local building codes. As an NFIP participant, the Town of Groton incorporated the NFIP's minimum standards into Section 7.2 Flood Protection Regulations of the Town's Zoning Regulations (Revised November 15, 2021) that were designed to:

- prevent or minimize loss of life, injuries, property damage, and other losses, both private and public;
- promote the health, public safety, and general welfare of the people; and
- help control and minimize the extent of floods and reduce the depth and violence of flooding.[3]

3.1.4.2 TOWN OF GROTON ZONING

Section 7.2 of the Town's Zoning Regulations and those requirements outlined in the Connecticut State Building Code serve as the primary floodplain management requirements for the Town. As per the Town's flood protection requirements, Flood Hazard Areas include all SFHAs identified by FEMA in its flood insurance study (FIS) for New London County, Connecticut, dated August 5, 2013, and accompanying FIRMs noted above.

The local and state requirements include some standards that are higher than the minimum NFIP standards for new construction and substantial improvements for non-residential and residential structures located in FEMA SFHAs located on the FEMA FIRMs. For example, per Section 7.2-4(A)(1), all new construction, substantial improvements, and repair to structures that have sustained substantial damage which are residential structures shall have the bottom of the lowest floor, including basement, elevated one (1.0) foot above the base flood elevation (BFE).

3.1.5 CIRCA SLR PROJECTIONS

Pursuant to the State of Connecticut's Public Act No. 18-82, *An Act Concerning Climate Change Planning and Resiliency*, the Connecticut Department of Energy and Environmental Protection (CT DEEP) adopted SLR projections in 2018 for the Long Island Sound. The CT DEEP adopted the sea level change scenarios published by NOAA in Technical Report OAR CPO-1.[4] In May 2018, CIRCA[5] released Floodplain Building Elevation Standards that provides guidance on implementation of SLR.

CIRCA published planning guidance for coastal Connecticut that provides SLR projections through the end of the century. SLR projections from CIRCA are based on 2012 NOAA Global SLR Scenarios for the United States National Climate Assessment. CIRCA recommends that Connecticut plan for the upper end of the range of values projected of SLR or up to 20 inches (1.67 feet) of SLR higher than the national tidal datum in Long Island Sound relative to 2000 by 2050 and that it is likely that sea levels will continue to rise after that date (see Figure 22). CIRCA also recommends that the scenarios be updated at least every 10 years, or more frequently, to incorporate the best available science and new observations. Connecticut SLR projections are summarized in Table 4.

[3] Section 7.2.1 of the Town's Zoning Regulations (effective October 1, 2019 (revised November 15, 2021)
[4] Global Sea Level Rise Scenarios for the United States National Climate Assessment. NOAA, 2012
[5] Floodplain Building Elevation Standards- Current Requirements & Enhancement Options for Connecticut Shoreline Municipalities, UCONN School of Law Center for Energy & Environmental Law, May 2018.

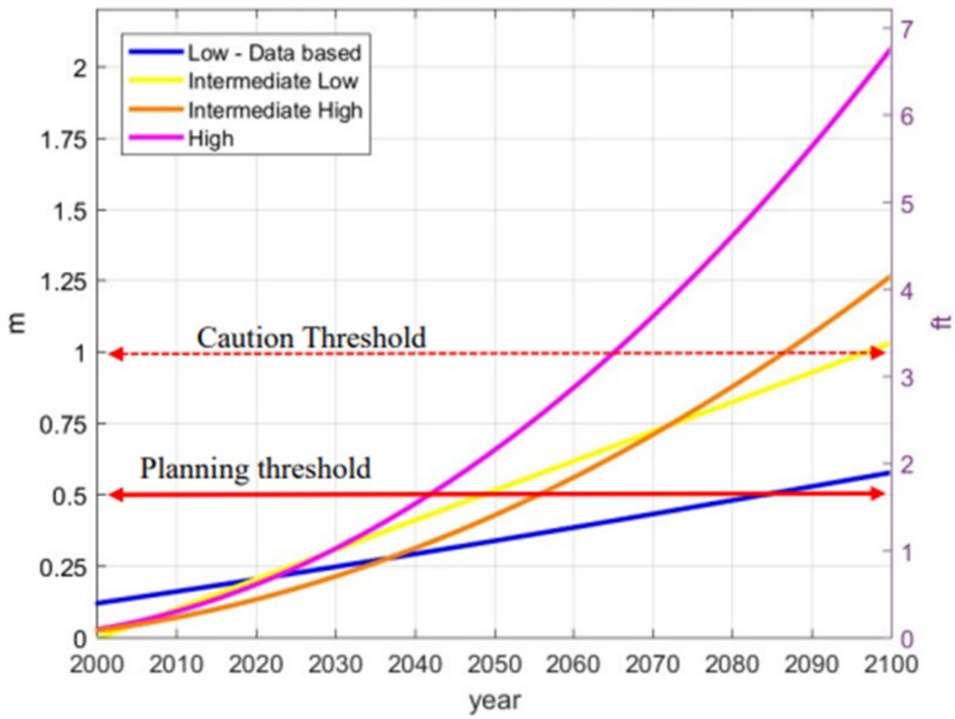


Figure 22: CIRCA SLR Projections

Table 4: CIRCA SLR Projections, in feet

Year	2030	2040	2050
Sea Level Rise	1.03	1.36	1.67

3.1.6 CIRCA FLOOD ELEVATION PROJECTIONS

CIRCA provided the planning team with flood depth raster files based on coastal modeling they performed. The depth raster files provided flood depths at a given location for the present day and future (with 20 inches of SLR) floods. Since the data did not have singular flood elevations associated with them, the vulnerability assessment was conducted using the inundation boundary, rather than comparing flood elevations with asset elevations.

In comparison to FEMA data, CIRCA shows substantially less flood inundation area for the 100-year flood, as CIRCA modeling uses different methodology and employs different assumptions than the FEMA analysis. FEMA does not provide an inundation area for the 10-year flood. Therefore, CIRCA's information is judged to be the best available data for lesser flood return periods such as the 10-year event.

3.1.7 USACE NORTH ATLANTIC COAST COMPREHENSIVE STUDY

The USACE published the North Atlantic Coast Comprehensive Study (NACCS): Resilient Adaptation to Increasing Risk in 2015. The USACE NACCS used a more robust hydrodynamic computer modeling approach as compared to FEMA's analysis. The results of the USACE NACCS are available at specific model "save point" locations. Stillwater elevations and wave heights are available at each save point.

Table 5 presents predicted stillwater elevations for USACE NACCS save point 8369, which is located on the Mystic River east of the Study Area. Note the 100-year flood level is about the same as what the FEMA FIRM presents (i.e., 9.6 feet in the NACCS versus 9.8 feet for the FEMA FIRM).

Table 5: NACCS Water Level Elevations at Mystic River near Downtown Mystic, in NAVD88

Recurrence Interval (years)	Annual Exceedance Probability	Water Level (ft)
1	100%	3.5
2	50%	4.4
5	20%	5.5
10	10%	6.4
20	5%	7.2
50	2%	8.5
100	1%	9.6
200	0.5%	10.8
500	0.2%	12.3

3.1.8 NOAA SLR PROJECTIONS

NOAA has developed standard ranges of RSLC for use on federal projects in the United States. NOAA's methodology is summarized in "Global and Regional Sea Level Rise Scenarios for the United States," published in 2022. NOAA's analysis concluded the range in Global Mean Sea Level (GMSL) rise for 2100 is 1.1 meter to 2.1 meters. NOAA discretized the range by 0.5-meter increments and named them as six scenarios ranging from Low to High. For each scenario, regional RSLC was calculated as summarized in Table 6.

Table 6: NOAA 2022 Projected Sea Level Change at New London, in feet

Year	Low Scenario	Int-Low Scenario	Intermediate Scenario	Int-High Scenario	High Scenario
2000	0	0	0	0	0
2020	0.38	0.42	0.42	0.43	0.42
2030	0.60	0.65	0.68	0.72	0.71
2040	0.83	0.92	0.98	1.07	1.10
2050	1.04	1.18	1.30	1.50	1.61
2060	1.22	1.44	1.67	1.99	2.30
2070	1.35	1.68	2.09	2.63	3.18
2080	1.47	1.91	2.58	3.33	4.20
2090	1.59	2.14	3.18	4.17	5.35
2100	1.71	2.34	3.86	5.04	6.47

Note: Projections were obtained from the NASA Interagency Sea Level Rise Scenario Tool. Projections are relative to 2000 as base year.

The NOAA 2022 projections presented above are associated with different likelihoods of occurrence based on different emissions trajectories. The NOAA 2022 Intermediate-Low projection has a high likelihood of occurrence (37% to >99% by 2100). The NOAA 2022 Intermediate projection has low to moderate likelihood of occurrence (<1% to 23% by 2100). The NOAA 2022 High scenario is a worst-case scenario with a low likelihood of occurrence. A comparison of water levels with SLR is presented in **Attachment 4**.

3.1.9 GROUNDWATER

The relationship between groundwater, sea level, and recharge is complex and continues to be studied. According to a 2012 USGS investigation[6] in New Haven, CT, a modeled scenario with SLR and no increase in recharge resulted in about a 1:1 increase in groundwater levels near the coast with SLR. Preliminary studies indicate that groundwater levels in coastal areas

[6] Bjerklie, D.M, et. al, 2012, Preliminary Investigation of the Effects of Sea-Level Rise on Groundwater Levels in New Haven, Connecticut, Open-File Report 2012-1025.

can be expected to rise with SLR.

3.2 INTENSE PRECIPITATION

Intense precipitation is also referred to as urban flooding or cloudburst flooding. This type of flood is a result of direct precipitation, usually high intensity and often highly localized, upon poorly drained or impervious surfaces, and of sufficient intensity to exceed the capacity of the local storm drain network. The flooding from intense precipitation depends on topography, land use, and the capacity and condition of the stormwater system. The topographic data in Figure 6 shows the study area is bordered by high ground to the north and west. Precipitation on these areas from beyond the study area boundaries can therefore contribute to flooding. Intense precipitation at the study area has been characterized using several different data sources, which are summarized below.

3.2.1 RAINFALL GAUGE DATA

The closest climate gauge to the study area with a long historical record is the Norwich Public Utility Plant in Norwich, CT (GHCND:USC00065910), shown on Figure 23. The gauge is located approximately 12.7 miles northwest of the study area and has data from 1956-2023. Statistical analysis was performed on the data from 1960-2020.

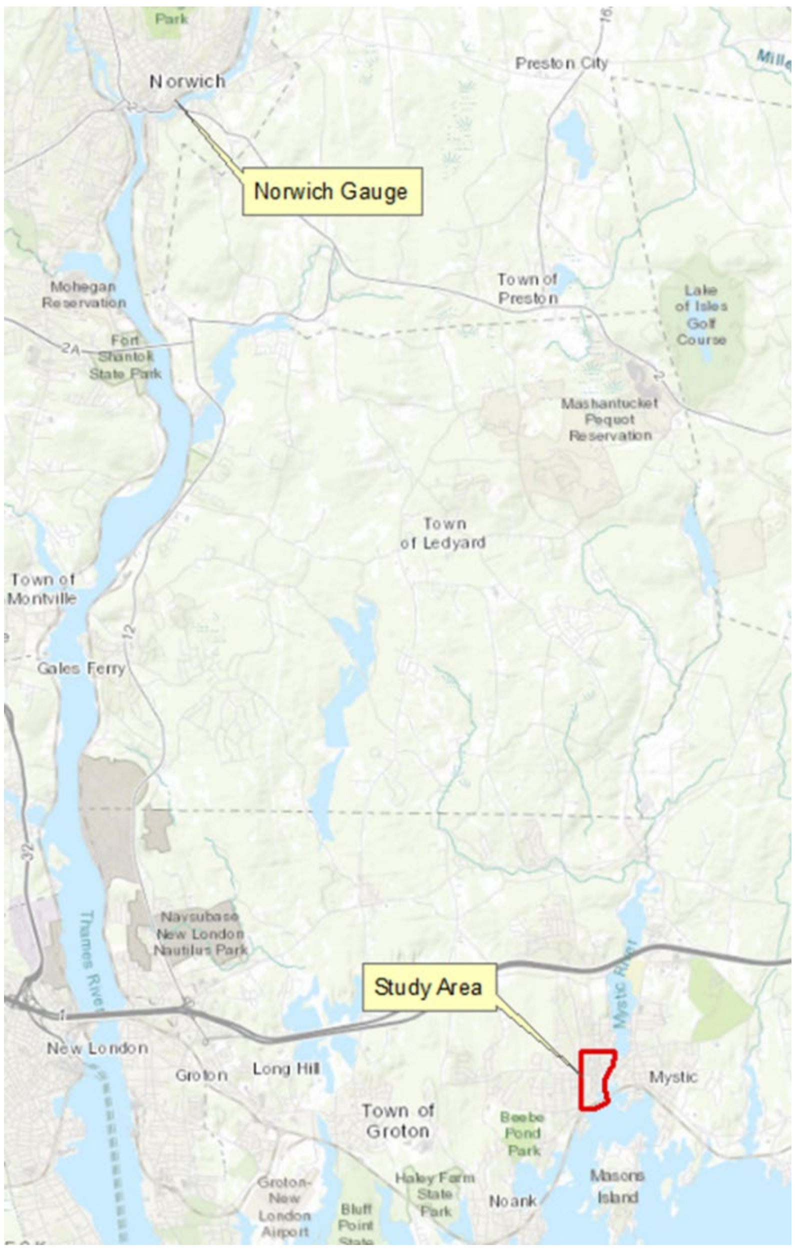


Figure 23: Climate Gauge Location

The gauge is part of the Global Historical Climate Network (GHCN), which is comprised of climate records from numerous sources that have been integrated and subjected to a common suite of quality assurance reviews. Precipitation trends were analyzed at the Norwich Public Utility Plant gauge. The following graphs were developed using daily data:

- Total Annual Precipitation (Figure 24)
- Maximum Daily Precipitation (Figure 25)
- Number of Days with Greater Than 2 Inches of Precipitation (Figure 26)
- Number of Days with Greater Than 4 Inches of Precipitation (Figure 27)

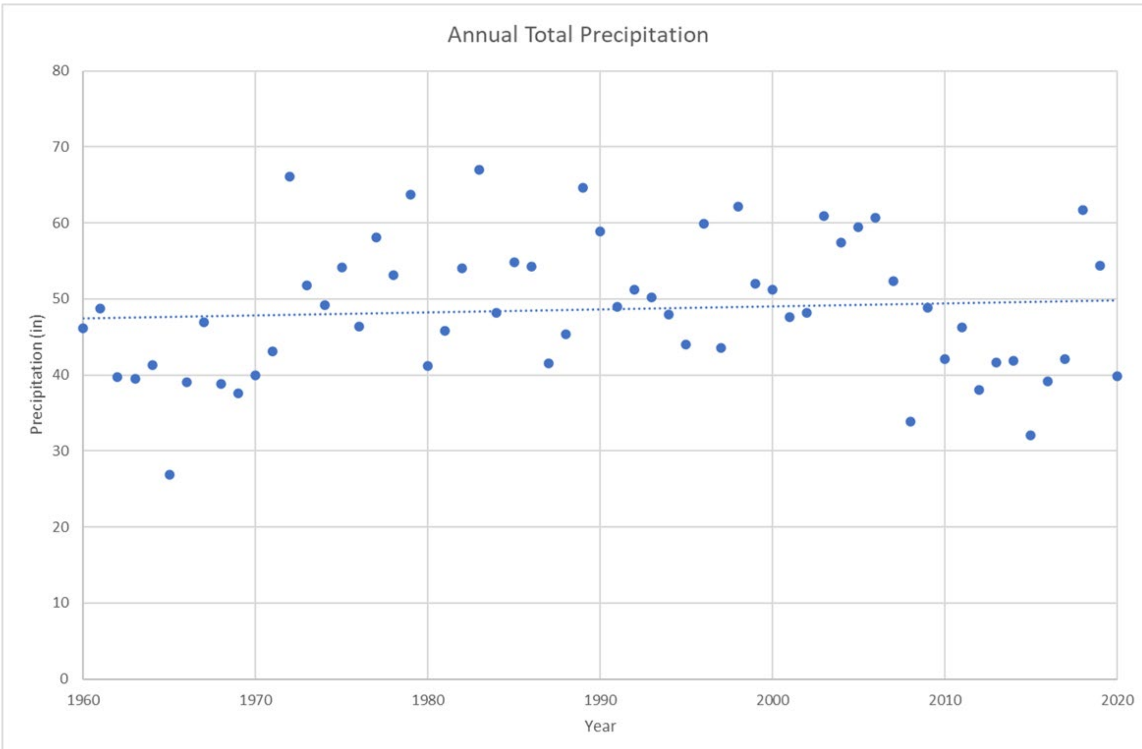


Figure 24: Annual Total Precipitation

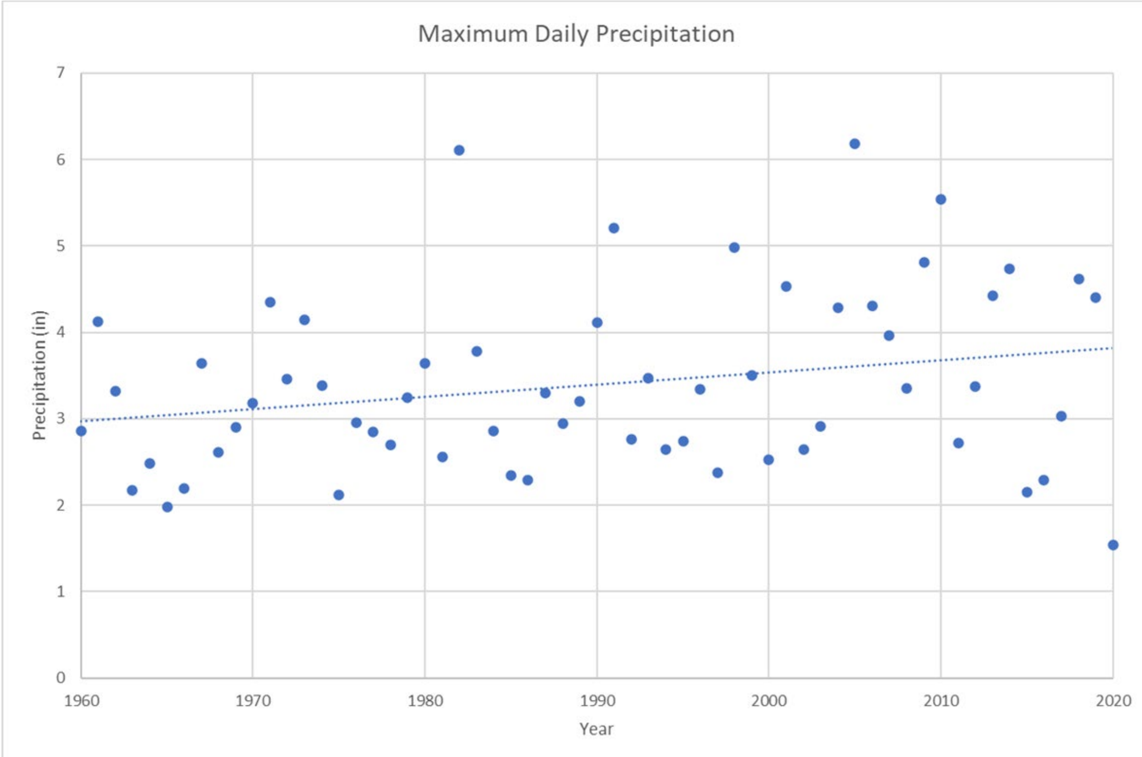


Figure 25: Maximum Daily Precipitation

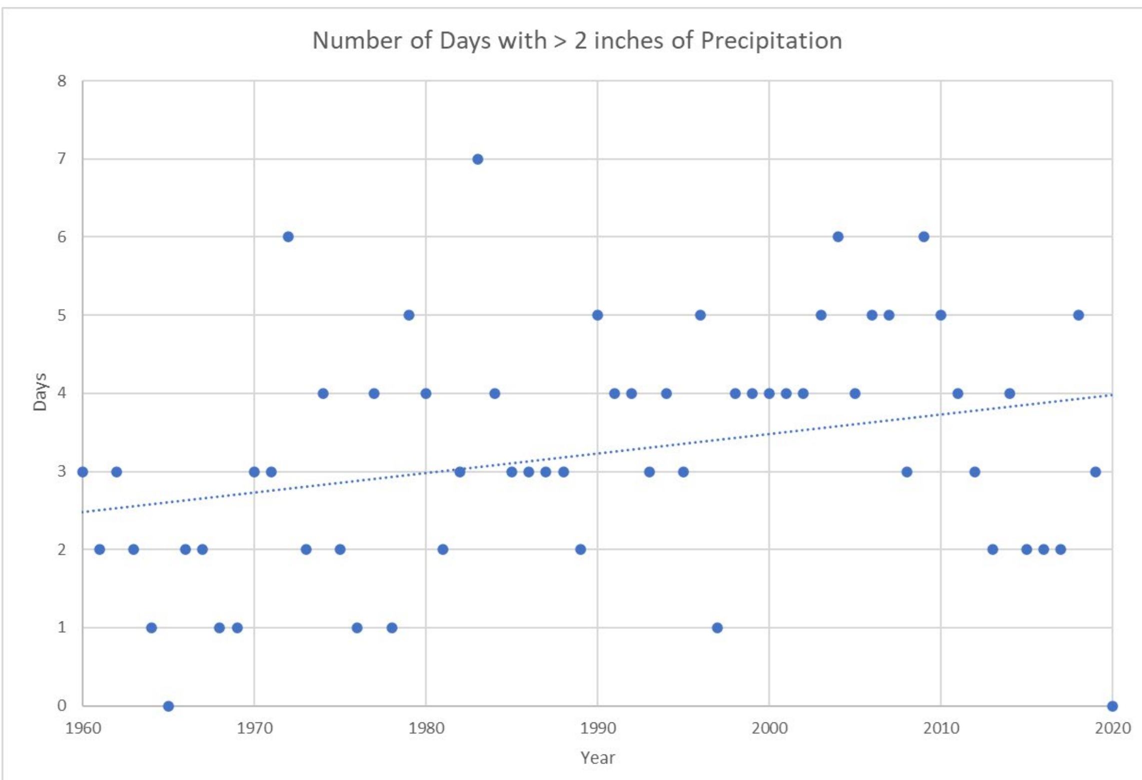


Figure 26: Number of Days with Greater than 2 Inches of Precipitation

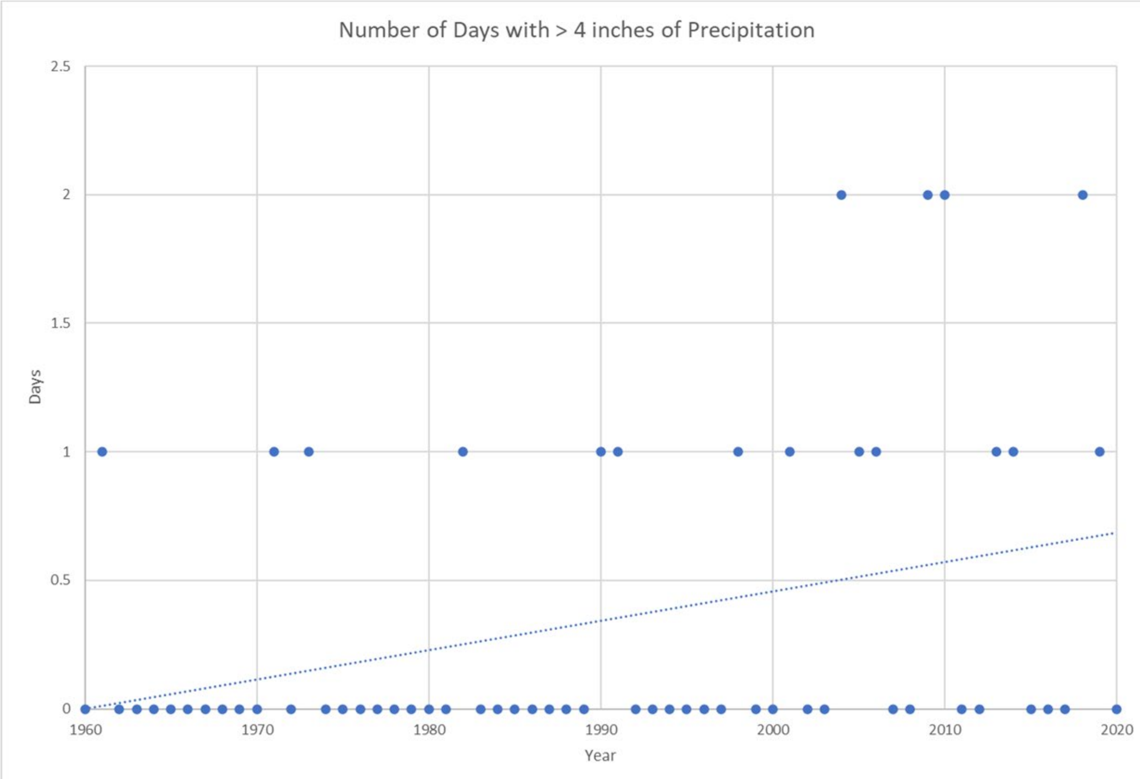


Figure 27: Number of Days with Greater than 4 Inches of Precipitation

A best-fit straight-line trend line was added to each graph. The gauges show that the total annual precipitation and maximum daily precipitation are slightly increasing over time. The number of days with greater than 2 inches and 4 inches are also increasing over time. This aligns with the observation from the CIRCA's 2019 *Connecticut Physical Climate Science Assessment Report*.

3.2.2 NOAA ATLAS 14 PRECIPITATION FREQUENCY STUDY

The most up-to-date publication on design rainfall for the study area is NOAA Atlas 14 Volume 10, published by the Hydrometeorological Design Studies Center within the Office of Water Prediction of the NOAA National Weather Service. The publication, last updated in 2019, contains precipitation depths for selected storm durations and recurrence intervals in the Northeast United States. The precipitation depths were calculated using regional frequency analysis from 7,629 climate gauges. The precipitation depth-duration-frequency estimates for Downtown Mystic are presented in Table 7.

Table 7: Point Precipitation Frequency Estimates for Downtown Mystic, in inches

Duration	Average Recurrence Interval (years)									
	1	2	5	10	25	50	100	200	500	1,000
10-min	0.5	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.7	1.9
15-min	0.6	0.7	0.9	1.0	1.2	1.4	1.5	1.7	2.0	2.2
30-min	0.8	0.9	1.2	1.4	1.7	1.9	2.2	2.4	2.8	3.1
1-hr	1.0	1.2	1.6	1.8	2.2	2.5	2.8	3.1	3.6	4.0
2-hr	1.3	1.6	2.0	2.4	2.9	3.3	3.6	4.1	4.7	5.3
3-hr	1.6	1.9	2.4	2.8	3.3	3.8	4.2	4.7	5.5	6.1
6-hr	2.0	2.4	3.0	3.5	4.2	4.8	5.3	6.0	6.9	7.6
12-hr	2.5	2.9	3.7	4.3	5.2	5.8	6.5	7.3	8.4	9.4
1-day	2.9	3.4	4.4	5.1	6.1	6.9	7.7	8.7	10.1	11.3
2-day	3.2	3.9	4.9	5.8	7.0	7.9	8.9	10.0	11.8	13.2
3-day	3.5	4.1	5.3	6.2	7.5	8.5	9.5	10.8	12.6	14.1

3.2.3 CIRCA PRECIPITATION PROJECTIONS

According to the *Connecticut Physical Climate Science Assessment Report*, published August 2019 by CIRCA, precipitation depth is projected to increase in the future. The study projected that the 24-hour 100-year precipitation depth would increase approximately 91 percent from baseline period of 1970-1999 to the period 2040-2069. The upper bound of this increase is 145 percent. The study projected that in the later part of the 21st century, the 24-hour 100-year precipitation depths could then decrease. Table 8 presents the CIRCA precipitation projections for the 24-hour mean, 10, 20, 50, and 100-year precipitation depths.

Table 8: CIRCA Projected Changes in 24-hour Maximum Precipitation

Event	1970-99 Reference	2040-69 Changes	2070-99 Changes
Mean	2.8±0.1	0.7±0.2 (27%)	0.6±0.2 (22%)
10-year	4.1±0.2	2.0±0.8 (49%)	1.3±0.8 (31%)
20-year	4.7±0.2	2.8±1.3 (59%)	1.7±1.2 (36%)
50-year	5.7±0.3	4.3±2.4 (76%)	2.4±2.2 (42%)
100-year	6.6±0.4	5.9±3.7 (91%)	3.1±3.2 (49%)

3.2.4 PRECIPITATION STATISTICAL ANALYSIS- FUTURE PROJECTIONS

The U.S. Climate Resilience Toolkit Climate Explorer provides temperature projections through the end of the century. The tool, hosted by the National Environmental Modeling and Analysis Center (NEMAC), visualizes climate projections from the Coupled Model Intercomparison Project Phase 5 (CMIP5) for two emissions scenarios. Climate projections are downscaled using the Localized Constructed Analogs method and presented as graphs that compare future precipitation depths to historical depths. The following graphs are included for precipitation projections:

- Total Annual Precipitation (Figure 28)
- Number of Days with Greater Than 2 inches (Figure 29)
- Number of Days with Greater Than 3 inches (Figure 30)

Figure 28: Total Annual Precipitation Projections from The Climate Explorer

Figure 29: Number of Days with Greater than 2 Inches of Precipitation Projections from The Climate Explorer

Figure 30: Number of Days with Greater than 3 Inches of Precipitation Projections from The Climate Explorer

Total annual precipitation is projected to increase by 4.37 inches by 2050 for the higher emissions scenario, compared to the observed value from 1961-1990. Days with greater than 2 inches of precipitation are projected to increase by 1.4 days by 2050, and days with greater than 3 inches of precipitation are projected to increase by 0.3 days by 2050.

3.3 EXTREME TEMPERATURE- HEAT

Since the pre-industrial era (1880-1900), the global average surface temperature has increased 2 degrees Fahrenheit. Increasing temperatures is one of the key indicators of climate change, spawning the term "global warming." The increasing temperatures at Downtown Mystic have been characterized using several different data sources, which are summarized below.

3.3.1 TEMPERATURE GAUGE DATA

Temperature gauge data was evaluated at the Norwich Public Utility Plant in Norwich, CT. This is the same gauge that was used for the precipitation analysis, which is located approximately 12.7 miles northwest of the study area. Statistical analysis was performed on the daily data from 1960-2020. The following graphs were developed using daily data:

- Average Daily Maximum Temperature (Figure 31)
- Average Daily Temperature (Figure 32)
- Number of Days with Maximum Temperature Less Than or Equal To 32°F (Figure 33)
- Number of Days with Maximum Temperature Greater Than or Equal To 90°F (Figure 34)
- Number of Days with Maximum Temperature Greater Than or Equal To 95°F (Figure 35)

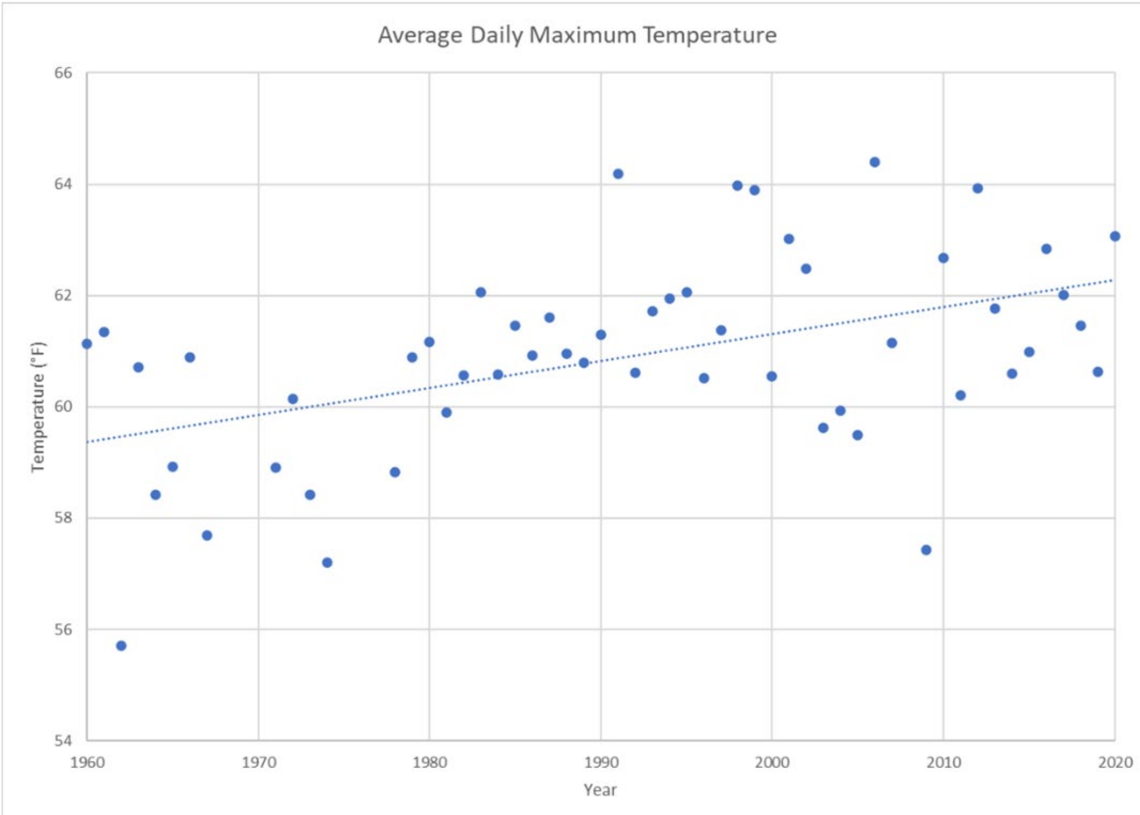


Figure 31: Average Daily Maximum Temperature

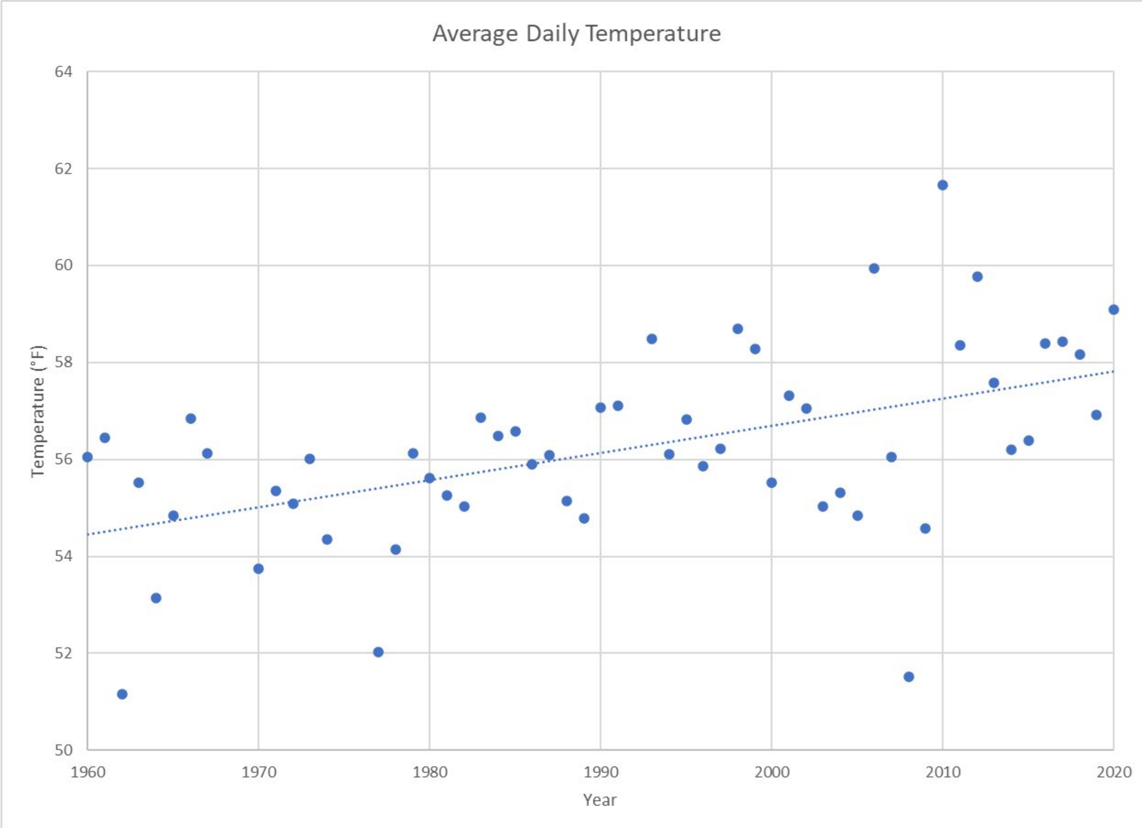


Figure 32: Average Daily Temperature

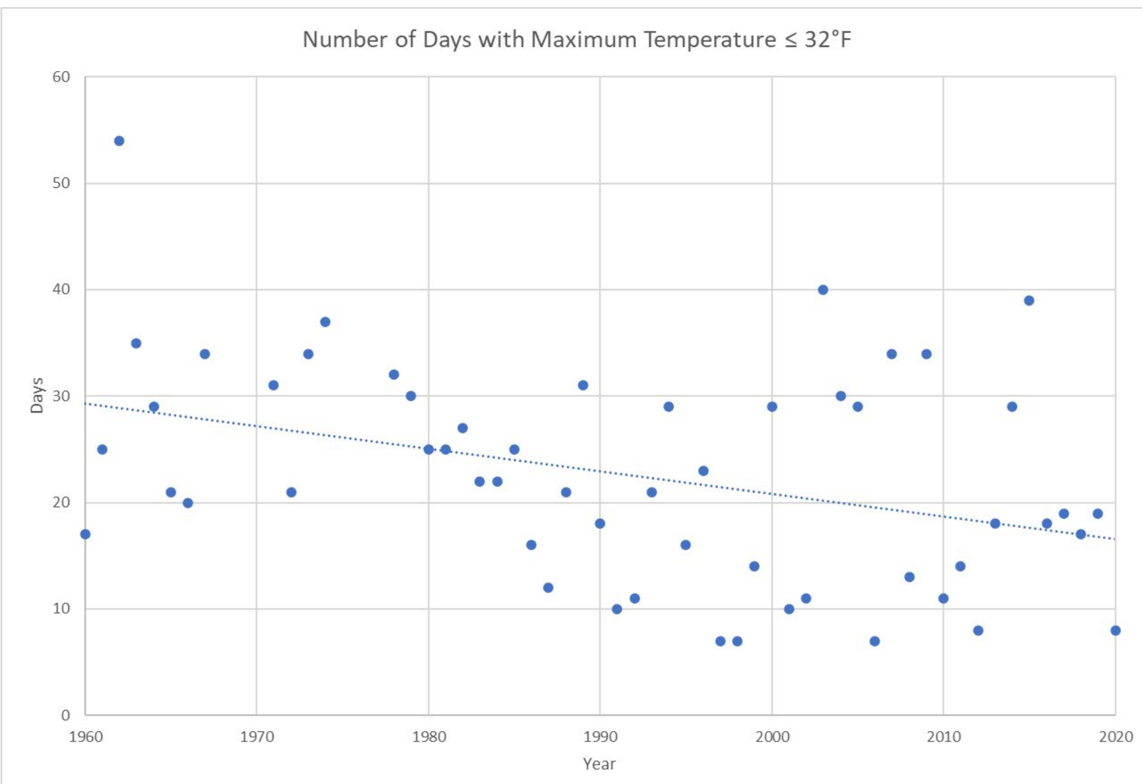


Figure 33: Number of Days with Maximum Temperature Less Than or Equal to 32°F

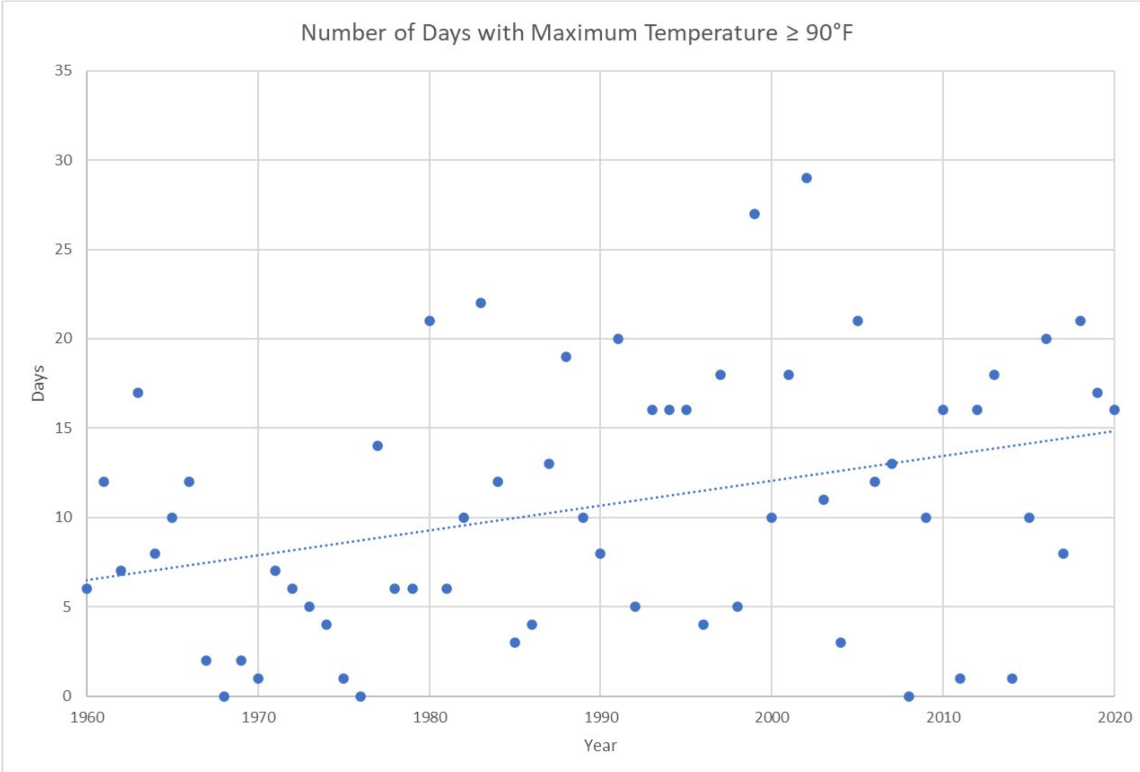


Figure 34: Number of Days with Maximum Temperature Greater Than or Equal to 90°F

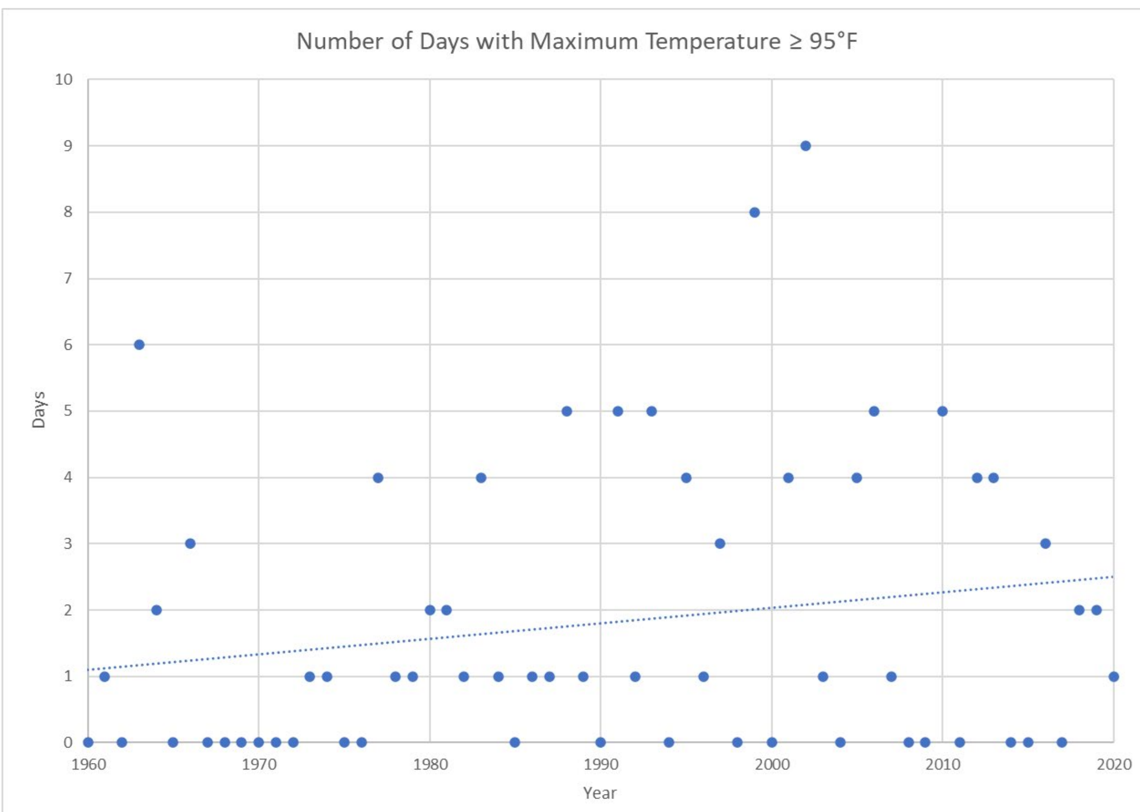


Figure 35: Number of Days with Maximum Temperature Greater Than or Equal to 95°F

The data shows that both daily maximum and average daily temperatures are rising. The data shows that the Norwich gauge has reported about a 3°F increase in daily maximum temperature and about a 3.4°F increase in average daily temperature between 1960 and 2020. Further, the number of days per year with maximum temperature less than or equal to 32°F decreased by about 12 days over the analysis period. Additionally, the number of days per year with maximum temperature greater than or equal to 90°F increased by about 8 days over the same time period.

3.3.2 NOAA SUMMARY FOR CONNECTICUT

In 2022, NOAA published State Climate Summaries consisting of observed and projected climate change information. For Connecticut, the summary includes the following key takeaways:

- Since 1950, the greatest number of hot days occurred over the last two multiyear periods (2010–2014 and 2015–2020) (see Figure 36)
- The number of warm nights in Connecticut has been steadily increasing since the 1950s; the most recent multiyear period (2015–2020) had the second-highest average (see Figure 36)
- The number of very cold nights has been below average since the mid-1980s. The lowest multiyear average occurred during the 2010–2014 period (see Figure 36)

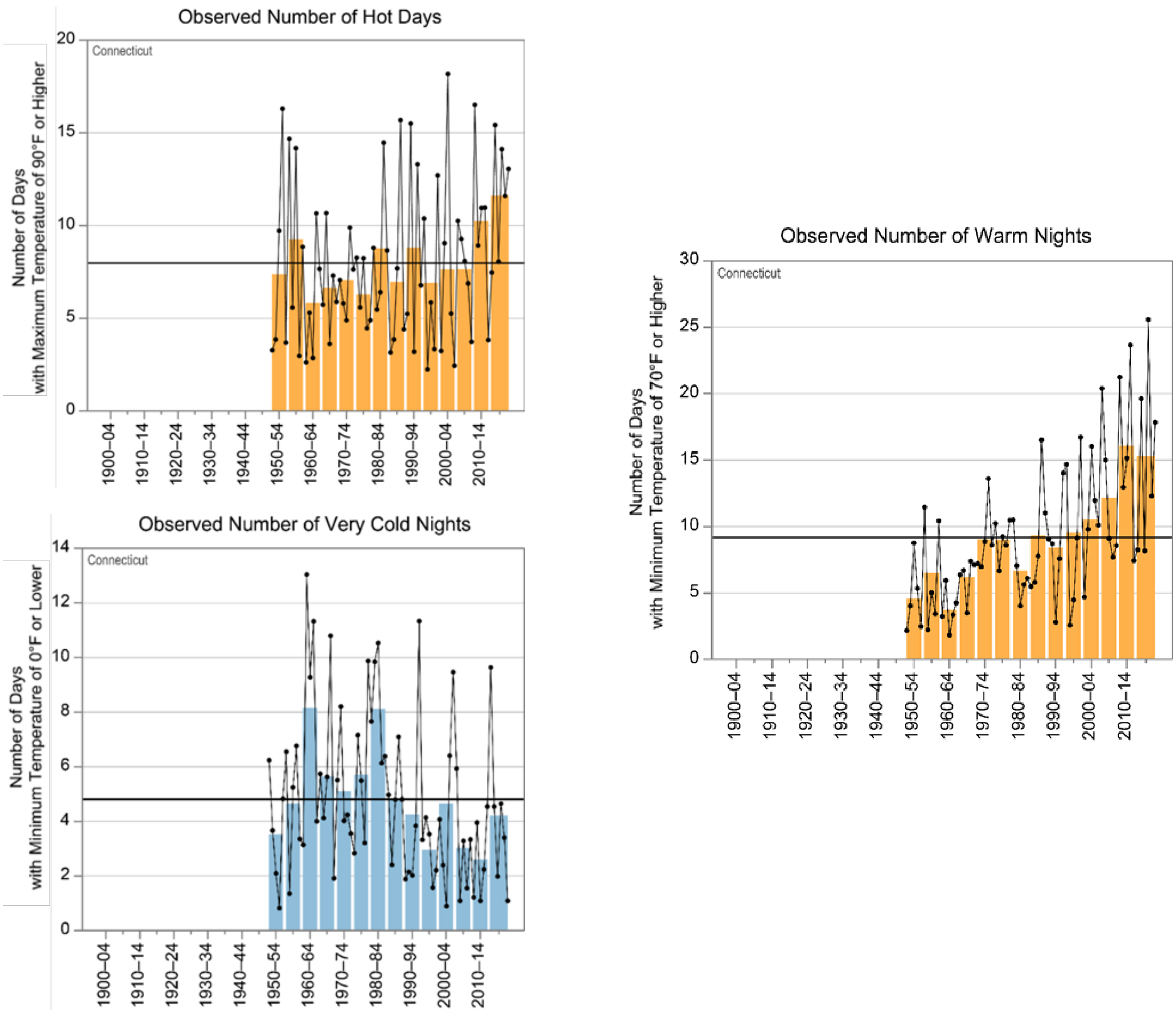


Figure 36: Temperature Data for Connecticut

Note: Figure is from NOAA National Centers for Environmental Information, State Summary of Connecticut. Values were averaged over 5-year periods. The dark horizontal line represents the long-term average.

The summary discussed why extreme heat is a particular concern for urban areas due to urban heat island. The urban heat island effect is the rise in temperature resulting from heat-retaining asphalt and concrete, lack of vegetation, and man-made heat from buildings, cars, etc.

3.3.3 HEAT STATISTICAL ANALYSIS – FUTURE PROJECTIONS

Temperature projections from the U.S. Climate Resilience Toolkit Climate Explorer were compared to historical observed values. The following graphs are included for temperature projections:

- Average Daily Maximum Temperature (Figure 37)
- Number of Days with Maximum Temperature Less Than 32°F (Figure 38)
- Number of Days with Maximum Temperature Greater Than 90°F (Figure 39)
- Number of Days with Maximum Temperature Greater Than 95°F (Figure 40)

Figure 37: Average Daily Maximum Temperature Projections from The Climate Explorer

Figure 38: Number of Days with Maximum Temperature Less than 32°F Projections from The Climate Explorer

Figure 39: Number of Days with Maximum Temperature Greater than 90°F Projections from The Climate Explorer

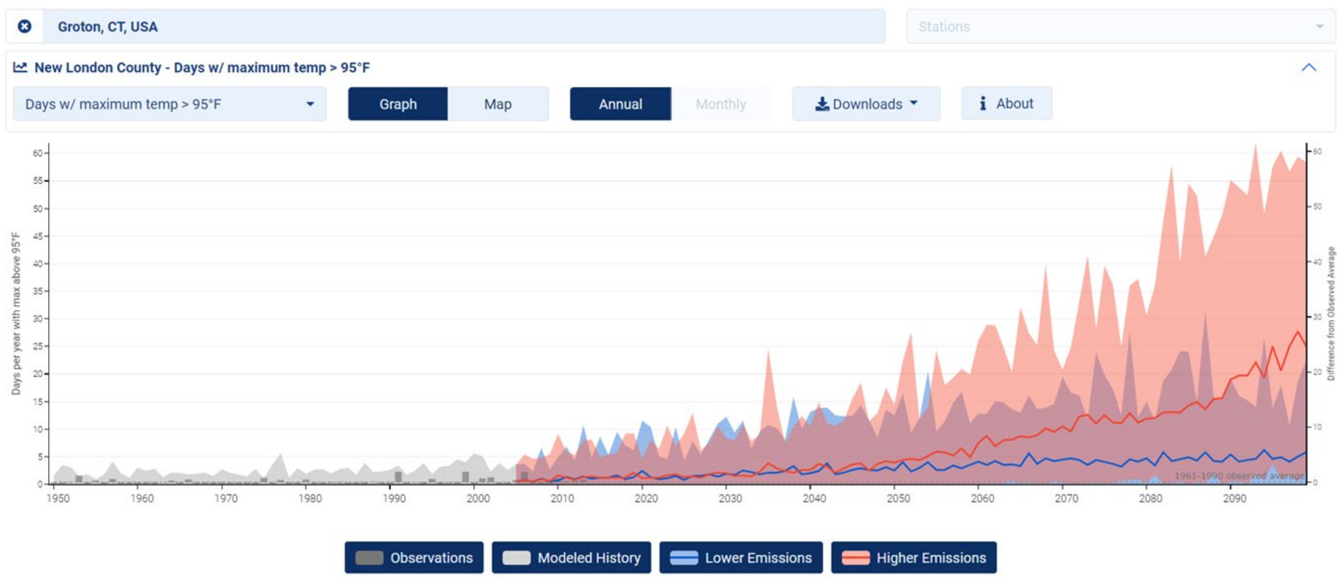


Figure 40: Number of Days with Maximum Temperature Greater than 95°F Projections from The Climate Explorer

Daily maximum temperature is projected to increase by 5.3°F by 2050 for the higher emissions scenario, compared to the observed value from 1961-1990. The number of days with a maximum temperature less than 32°F is projected to decrease by 13.8 days by 2050. Days with maximum temperatures greater than 90°F are projected to increase by 17 days by 2050, and days greater than 95°F are projected to increase by 4.7 days by 2050.

Even though this plan included an evaluation of how temperature extremes may affect future warming, it is important to highlight that humidity also plays an important role in how humans are impacted by heat. As is stated in CIRCA's August 2019 *Connecticut Physical Climate Science Assessment Report,* future studies will need to be completed to better understand the relationship between temperature extremes and humidity to better quantify the extent these risks may pose to human health over time.

3.4 KEY TAKEWAYS

A summary of key takeaways regarding hazards at the study area are summarized below:

- <u>Coastal Flooding and Tides</u>:
  There are a number of different estimates for flood elevations and SLR available for the Study Area:
    - Current tide data indicates the mean higher high-water (MHHW) elevation is approximately 1.2 feet;
    - Per Connecticut General Statutes (CGS) Section 25-68o(b), the adopted sea level change scenario for Connecticut is 0.5 m (1 foot 8 inches) higher than the national tidal datum in Long Island Sound by 2050.;
    - The FEMA 100-year flood stillwater elevation of the Mystic River near the study area is 9.8 feet for the 100-year storm. FEMA flood data is widely used for regulatory purposes (zoning, building codes, etc.);
    - The BFE is 11 feet for the majority of the study area, with the exception of the area near Tuft's Cove, which has a BFE of 10 feet;
    - The USACE NACCS study provides similar estimates of the 100-year flood (9.6 feet);
    - CIRCA's 100-year flood data is less conservative than that shown by FEMA and the USACE;
    - CIRCA's 10-year flood data is the best available data for lesser flood return periods. FEMA and USACE do not provide inundation limits for the 10-year flood.

  As a result of the above, the FEMA 100-year flood and the CIRCA 10-year flood are used in the vulnerability assessment in Section 4.

- <u>Intense Precipitation</u>:
    - Current precipitation data indicates the 10-year return period, 24-hour duration storm is 5.1 inches and the 100-year, 24-hour duration storm is 7.7 inches.
    - CIRCA projects that the 10-year and 100-year precipitation depths will increase relative to the 1970-1999 reference by 2.0 and 5.9 inches, respectively, by the middle of the century;
- <u>Extreme Heat</u>:
  Daily maximum temperature, days with maximum temperatures greater than 90°F, and days with maximum temperatures greater than 95°F are all projected to increase by 2050, while days with maximum temperature less than 32°F are projected to decrease by 2050.

4.0 CLIMATE CHANGE VULNERABILITY ASSESSMENT

FEMA defines "vulnerability" as "*a description of which assets, including structures, systems, populations and other assets as defined by the community, within locations identified to be hazard-prone, are at risk from the effects of the identified hazard(s).*"[7] Furthermore, FEMA defines "risk" for the purpose of hazard mitigation planning as "*the potential for damage or loss created by the interaction of natural hazards with assets.*" To illustrate these concepts, consider the following examples. An uninhabited, undeveloped area along the Mystic River would have low vulnerability to flooding or extreme heat because no people or assets are present which could be harmed or damaged. On the other hand, a developed area could have high vulnerability to flooding or extreme heat because people and/or assets may be harmed. The degree of vulnerability depends on what is present in the area, the severity of the hazard (including the probability of its occurrence), and how the hazard affects the area.

The previous section (Section 3) characterized the coastal flood, intense precipitation, and temperature hazards within the study area, now and in the future. This section (Section 4) evaluates these hazards in the context of the people and assets located in the Downtown Mystic study area. This information allows us to understand the study area's vulnerability and to assess the potential benefits of climate adaptation strategies discussed later in this report (in Sections 5 and 6).

4.1 FLOODING AND SLR VULNERABILITY ASSESSMENT

The study area's vulnerability to coastal flooding and intense precipitation flooding was evaluated by completing an inventory of essential community facilities, buildings and structures, historic properties, infrastructure, high value assets, and natural and recreational resources in the study area and generally comparing their location and elevation to available flooding data.

Vulnerability to coastal flooding was assessed for the 10-year and 100-year recurrence interval floods. The 100-year flood is assessed using the FEMA BFE, and the 10-year flood is assessed using CIRCA data, as geospatial data for the FEMA 10-year flood elevation was not available. The future vulnerability for the 10-year and 100-year flood was assessed using 20 inches of SLR, in accordance with recommendations from CIRCA.

Vulnerability was qualitatively characterized as follows:

- High: indicates a high probability of occurrence and a moderate or greater consequence.
- Moderate: indicates either (1) a high probability of occurrence and a consequence of minor significance; (2) a moderate probability of occurrence and a moderate consequence, or (3) a low probability of occurrence and a moderate consequence.
- Low: indicates a low probability of occurrence and a minor consequence.

As previously noted, portions of the study area are at a low elevation and/or have been developed in areas of fill atop former wetlands. These areas of fill are located in areas naturally prone to flooding, and the sources of that flooding may be complex. Research has found that SLR can cause groundwater levels to rise. Flooding from shallow groundwater levels is not separately described in this report because unlike the other flooding hazards, maps and data characterizing the hazard do not exist for this area. However, flooding from rising groundwater is a confounding factor that may be adding to the patterns of inundation experienced in the study area.

4.1.1 VULNERABILITY OF ESSENTIAL FACILITIES

Essential facilities are those facilities essential to public safety and welfare and include buildings and other structures that continue to provide services (such as emergency response and recovery) during extreme weather including flooding, wind, snow, or earthquakes.

The only essential facility within the study area is the Groton Police Department's community policing building located at 9 Water Street, shown on Figure 10, and summarized in Table 9. The majority of the Town of Groton's essential facilities are

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[7] FEMA, Local Mitigation Planning Policy Guide, April 2022 (https://www.fema.gov/sites/default/files/documents/fema_local-mitigation-planning-policy-guide_042022.pdf)

located outside of the study area.

The approximate minimum ground elevation[8] at this facility is about 15 feet. The coastal flooding vulnerability was evaluated using the current FEMA 100-year recurrence interval coastal flood (i.e., 100-year flood), the predicted 100-year flood elevations through the year 2050 (using CIRCA SLR projections), and both the present day and future (2050) CIRCA 10-year flood. The vulnerability to intense rainfall (1-year, 1-hour duration event) was also qualitatively evaluated relative to the runoff patterns presented in Figure 41.

Table 9: Flood Vulnerability Profile of Downtown Mystic Essential Facility

Facility	Approximate Minimum Ground Elevation (feet)	Flooded by Current 10-year Flood	Flooded by 2050 10-year Flood	Coastal Flood Vulnerability		Intense Rain Flood Vulnerability
				Current (100-year BFE elev. = 11.0 feet)	2050 (100-year BFE elev. = 12.7 feet)	
Groton Police Department Community Policing Building	15	No	No	Low	Low	Moderate

[8] Connecticut Statewide LiDAR 2016

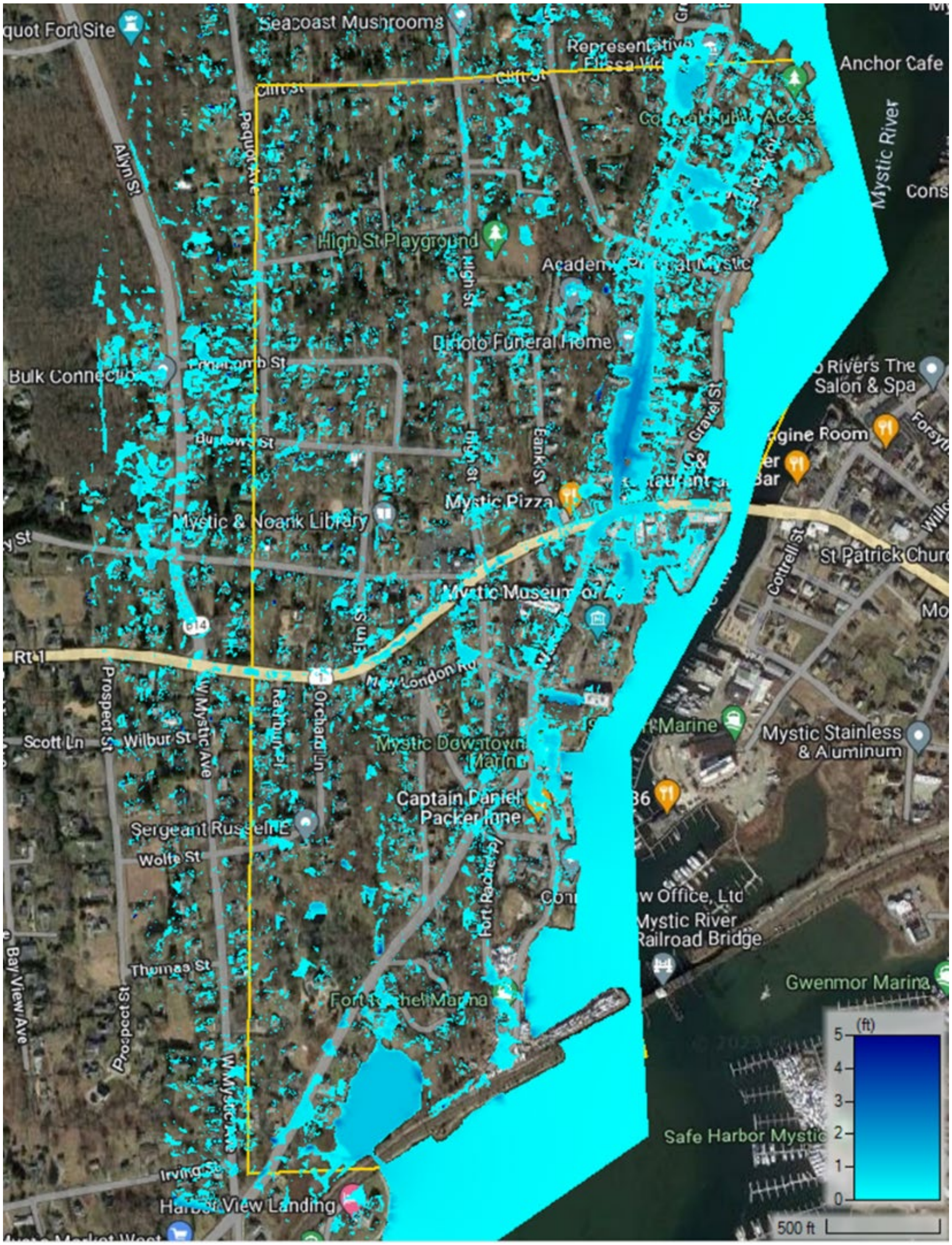

Figure 41: Stormwater Runoff Modeling for the 1-year, 1-hour Precipitation Event

Coastal Flood Vulnerability

The Groton Police Department Community Policing Building is located above the present day and future 100-year flood hazard (see Figure 42). The coastal flooding vulnerability of the essential facility was also evaluated relative to the present day and future (2050) 10-year flood. As noted in Figure 43 and as can be inferred from Table 10 since the building is above the 100-year flood, the Community Policing Building is located outside of the 10-year flood hazard area, and thus has a low coastal flood vulnerability.

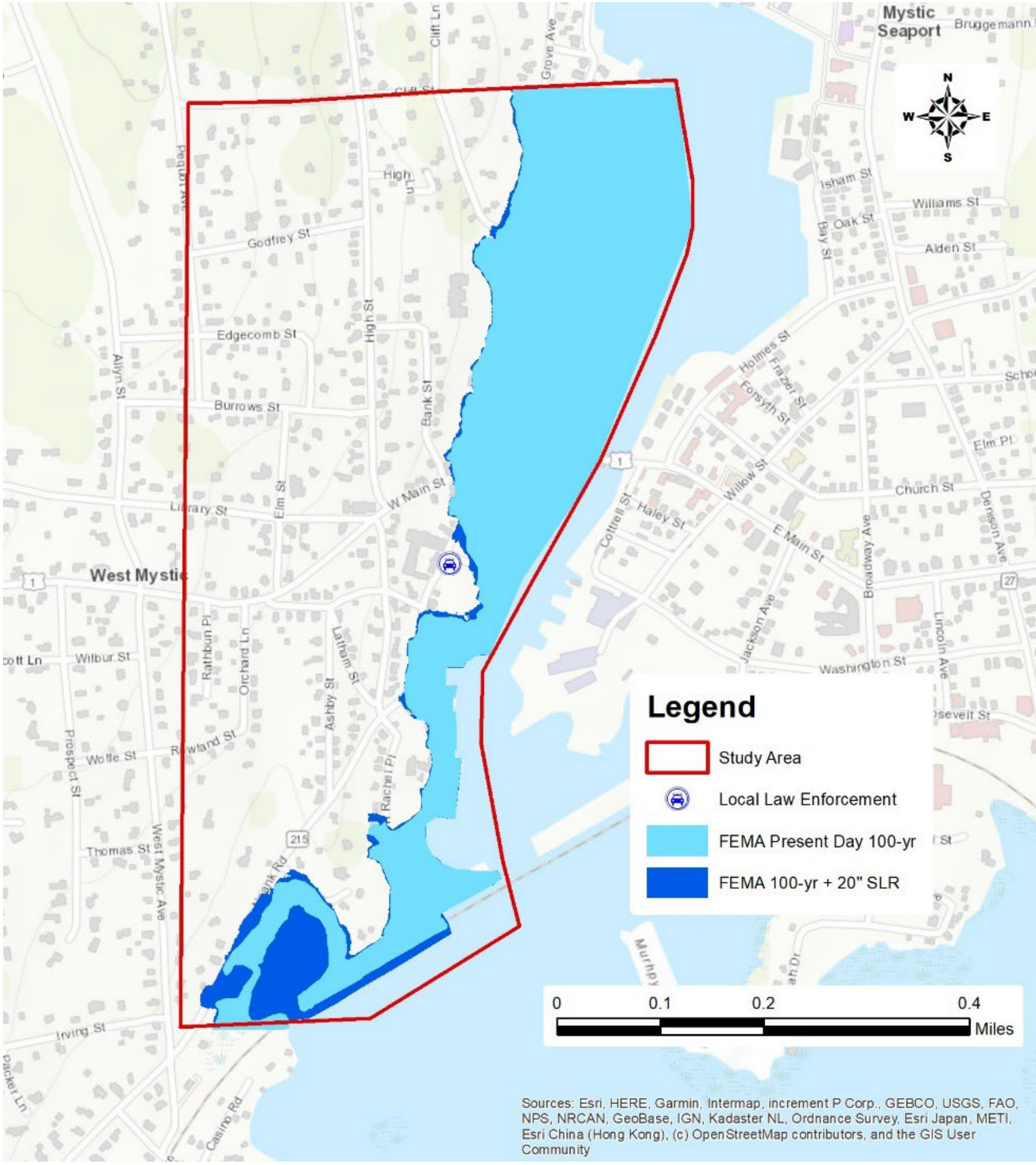

Figure 42: Essential Facilities Vulnerability Assessment

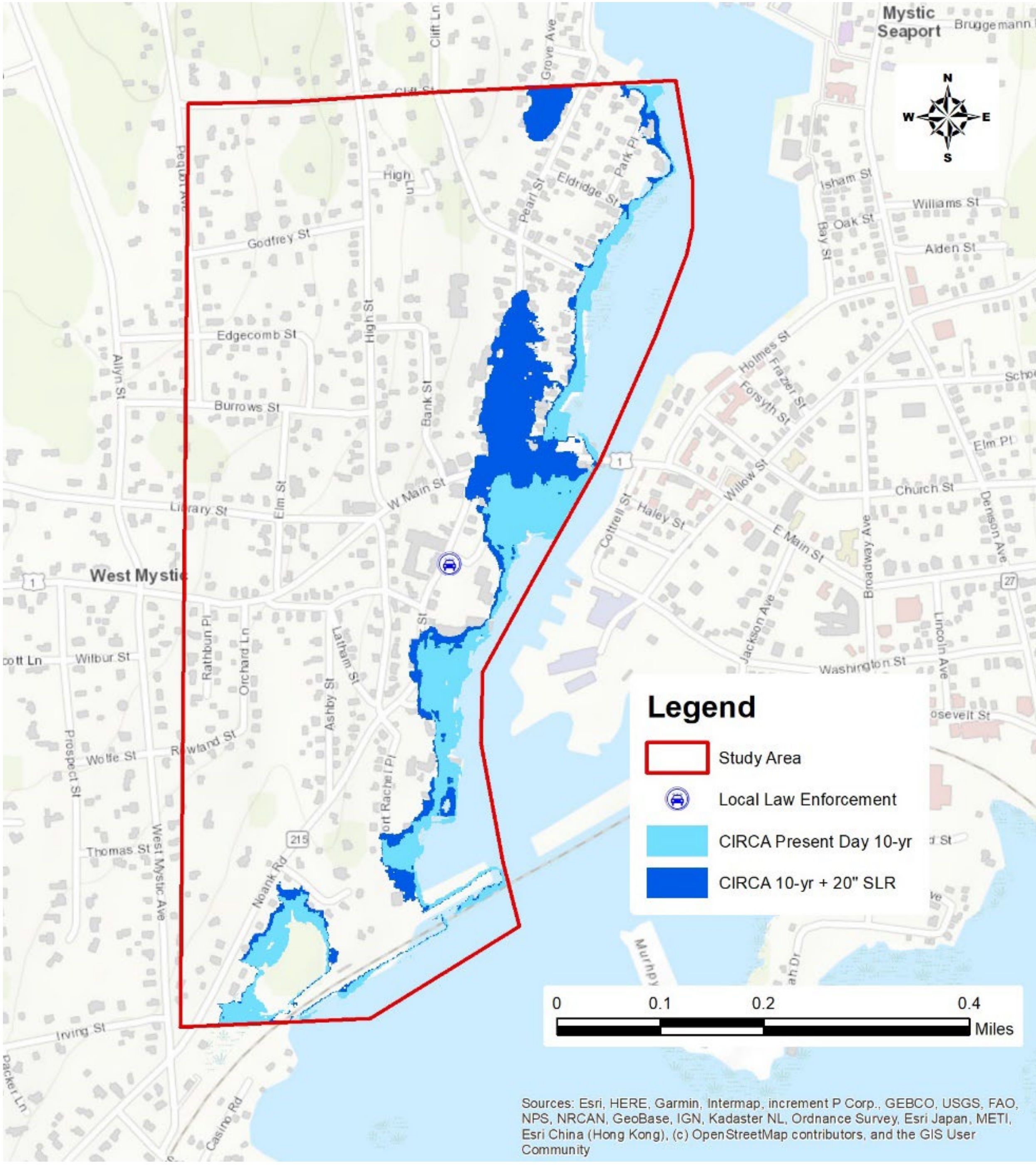

Figure 43: Essential Facilities Vulnerability Assessment

Intense Precipitation Vulnerability

The Community Policing Building does not appear to be impacted by stormwater, as runoff will travel down Water Street to the low point near West Main Street. However, this may cause difficulty in accessing the building from the north and east directions if these roadways flood.

4.1.2 VULNERABILITY OF BUILDINGS AND STRUCTURES

There are approximately 718 buildings and structures located within the Downtown Mystic study area. Note that these structures include occupied buildings as well as detached garages, sheds, etc. The number of structures located within the present day and future (2050) 10-year and 100-year inundation areas are summarized in Table 10.

Table 10: Flood Vulnerability Profile and Number of Structures Exposed to Coastal Flooding

Asset	CIRCA Current 10-year	CIRCA 2050 10-year	FEMA Current 100-year	FEMA 2050 100-year
Buildings and Structures (#)	41	96	212	223
Vulnerability Profile	High	High	Moderate	Moderate

Coastal Flood Vulnerability

As shown above and in Figure 44, the number of structures impacted by the 100-year flood (currently 11 feet) increases by about five percent when considering projected SLR (projected 12.7 feet in 2050). This is a result of the topography of the study area, which features a steep increase in elevation near the study area's west side and confines the areal extent of additional flooding. Note that flood-exposed properties will be subjected to a greater flood depth in the future. For example, the most developed portion of West Main Street is subjected to a flood depth of 5 to 6 feet during the present day 100-year flood; that depth increases to 7.7 to 8.7 feet by 2050.

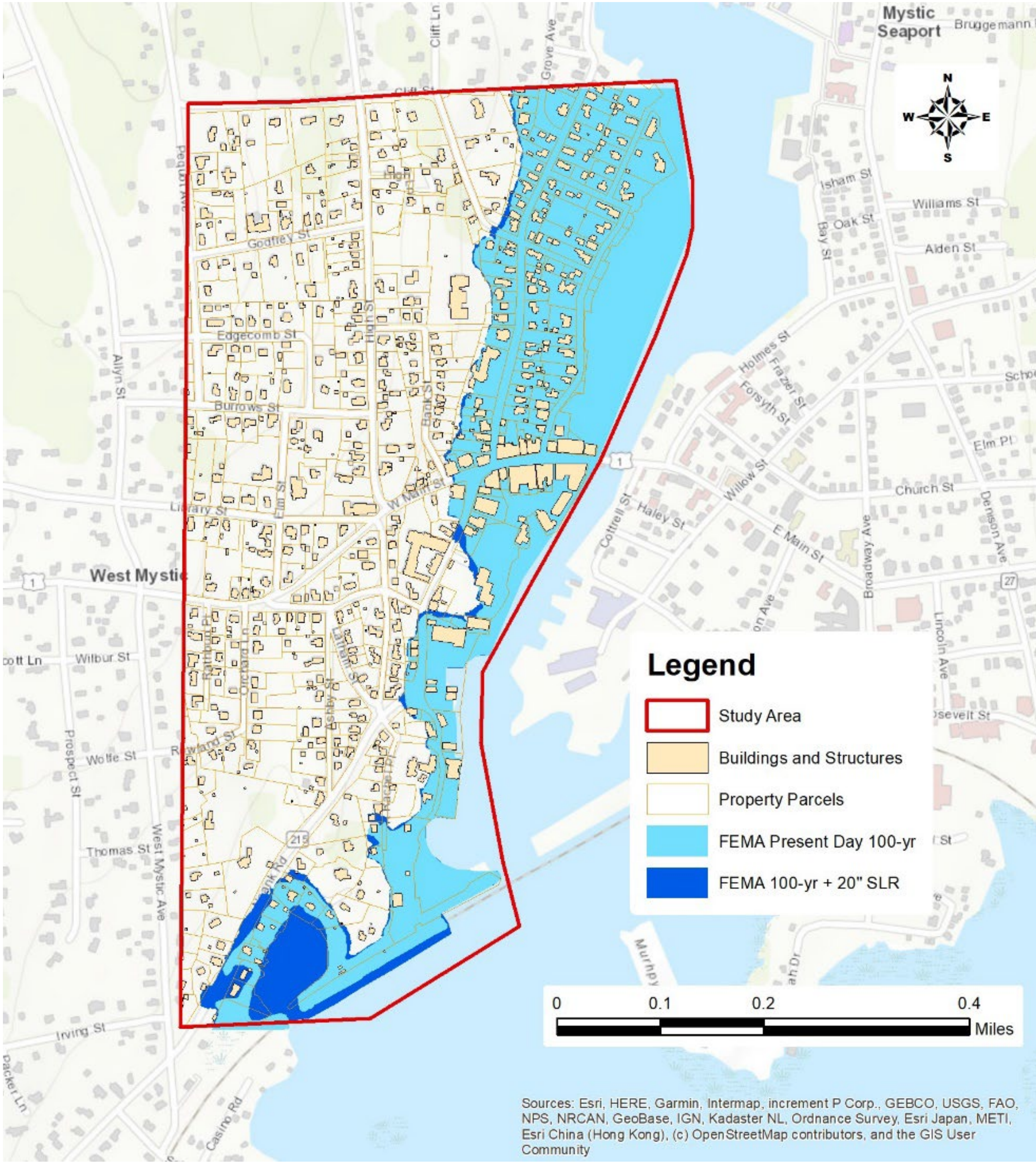

Figure 44: Buildings and Structures Vulnerability Assessment

As shown in Figure 45, the number of structures impacted by the 10-year flood more than doubles from present-day with the addition of projected SLR for 2050. The impacted structures are subjected to a flood depth of 0.3 to 1 foot during the present day 10-year flood; that depth increases to 0.3 to 2 feet by 2050.

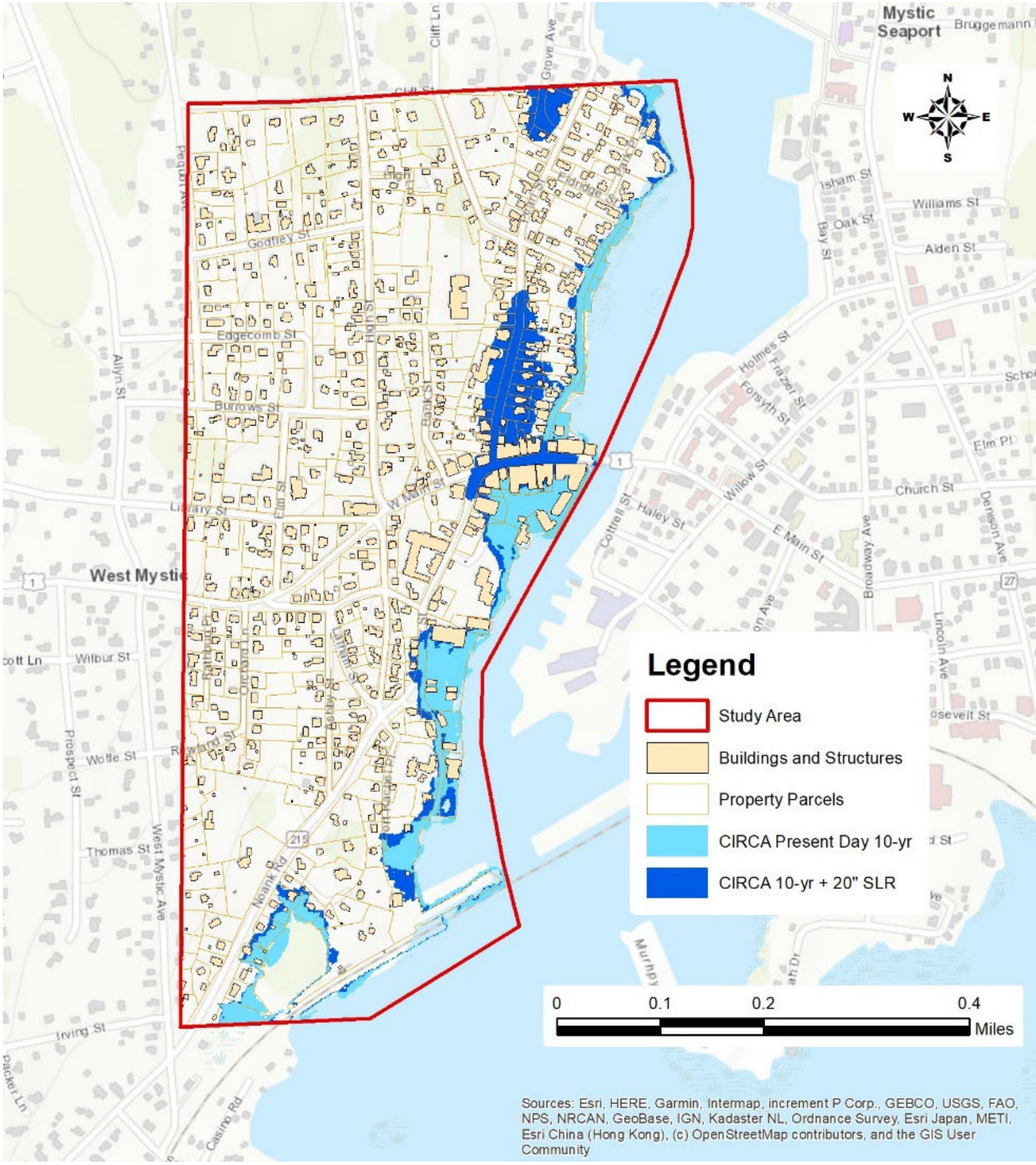

Figure 45: Buildings and Structures Vulnerability Assessment

The buildings and structures located within the present and future 10-year flood hazard area are considered to have high vulnerability to flooding. The 10-year flood is a relatively frequent event and the depth of flooding anticipated has the potential to cause significant damage to structures, which is anticipated to worsen in 2050. Approximate building value for the structures exposed to the floods are presented in Table 11.

Table 11: Building Value of Structures Exposed to Coastal Flooding

Asset	CIRCA Current 10-year	CIRCA 2050 10-year	FEMA Current 100-year	FEMA 2050 100-year
Buildings and Structures ($)	56,419,000	76,684,000	100,916,000	104,186,000

The buildings and structures located within the present and future 100-year flood hazard area are considered to have moderate vulnerability to flooding. The 100-year flood has a relatively low probability of occurrence, though buildings that experience such flooding are likely to have significant damage, as presented in Table 12.

Intense Precipitation Vulnerability

Buildings and structures located in low lying areas of the study area are considered to have moderate vulnerability to intense precipitation flooding. Intense precipitation has a relatively high probability of occurrence, but the impact of intense precipitation on buildings and structures is generally expected to result in minor damages. However, intense precipitation flooding could have a more significant impact if a building's critical facilities are located in low lying areas.

4.1.3 VULNERABILITY OF HISTORIC PROPERTIES

There are approximately 617 historic structures located within the Downtown Mystic study area (per the National and State Registers). The number of historic properties located within the present day and future (2050) 10-year and 100-year inundation area are summarized in Table 13. Note, most of the study area is located within the Mystic River Historic District, a district on the National Register of Historic Places (i.e., most of the vulnerable properties noted in Table 12 are in the Mystic River Historic District). Please refer to Section 4.1.2 for discussion of building vulnerability in general for the study area.

Table 12: Flood Vulnerability of Downtown Mystic Historic Properties

Asset	CIRCA Current 10-year	CIRCA 2050 10-year	FEMA Current 100-year	FEMA 2050 100-year
Historic Properties (#)	18	58	154	158
Vulnerability Profile	High	High	Moderate	Moderate

Coastal Flood Vulnerability

As shown in Figure 46, the number of historic structures impacted by the 100-year flood does not significantly increase with SLR. As mentioned previously, this is largely a result of the topography of the study area. However, the currently impacted structures will be exposed to a greater flood depth in the future. The historic properties located within the present and future 100-year flood hazard area are considered to have moderate vulnerability to flooding. The 100-year flood is a relatively infrequent event, but the depth of flooding anticipated has the potential to cause significant damage to structures.

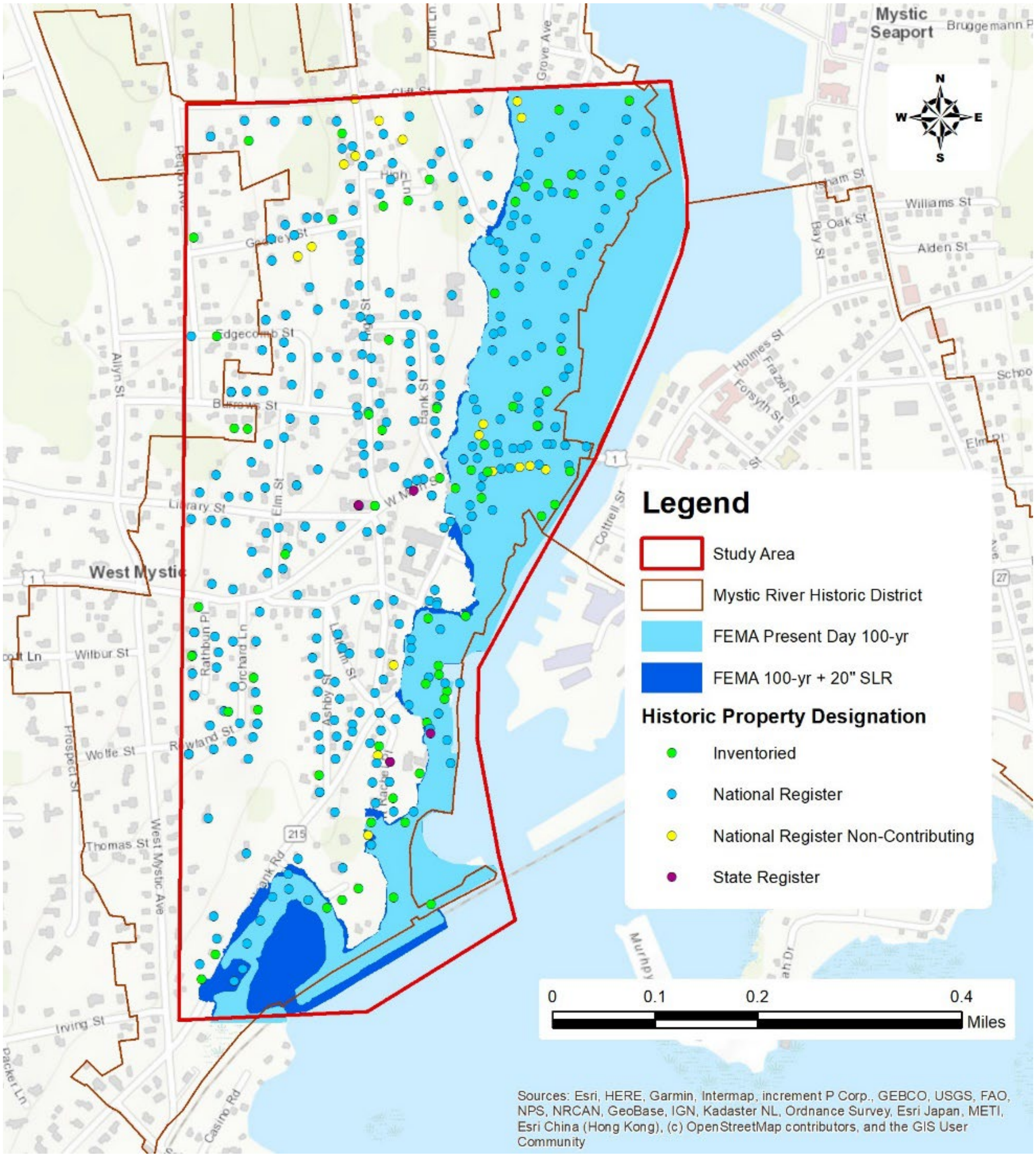

Figure 46: Historic Properties Vulnerability Assessment

As shown in Figure 47, there are 18 historic properties vulnerable to the present day 10-year flood and 58 properties vulnerable to the future (2050) 10-year flood. These historic properties are considered to have high vulnerability to coastal flooding.

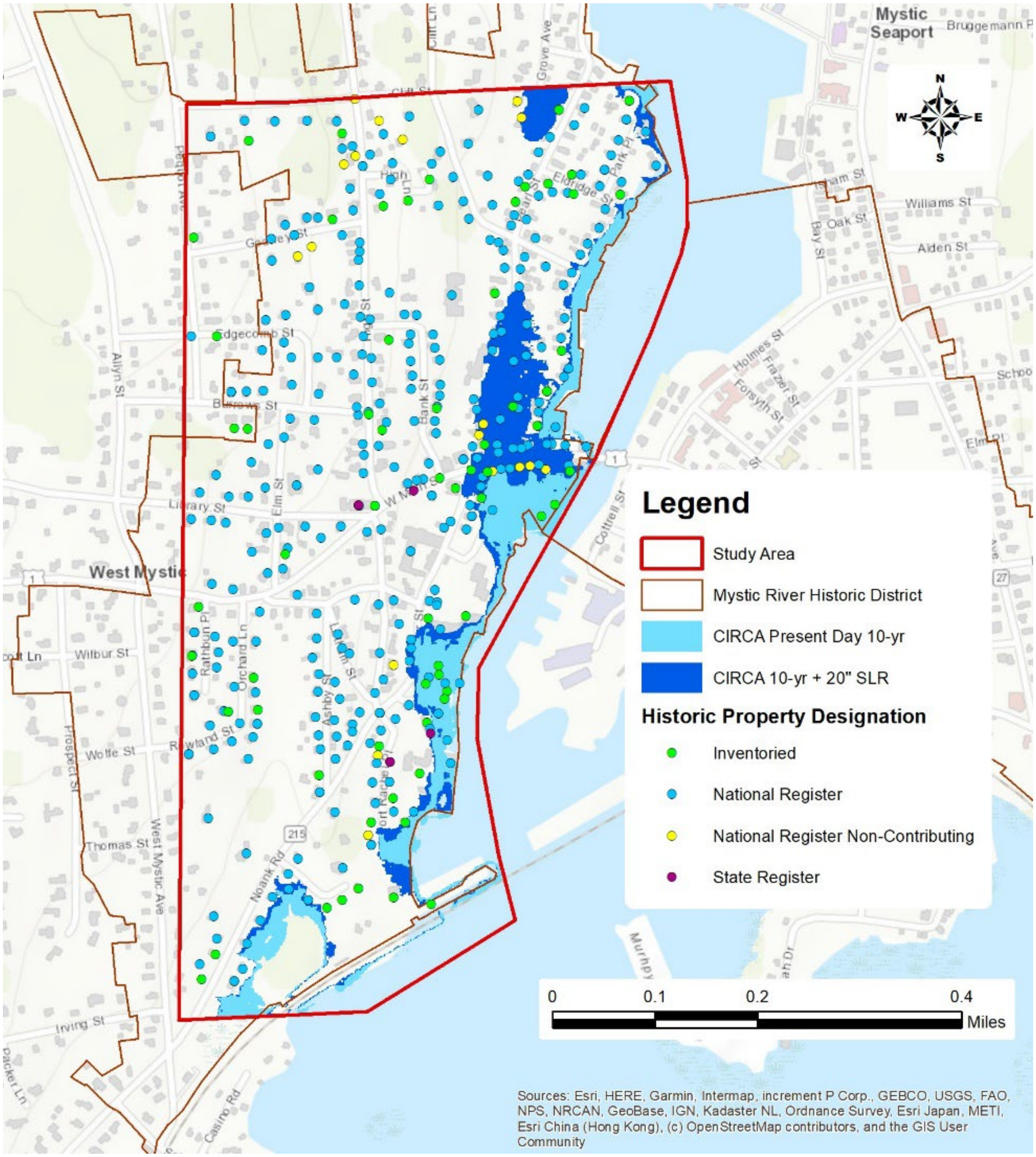

Figure 47: Historic Properties Vulnerability Assessment

Intense Precipitation Vulnerability

Historic properties located in low lying areas of the study area are considered to have moderate vulnerability to intense precipitation flooding. Intense precipitation has a relatively high probability of occurrence, but the impact of intense precipitation on buildings and structures is generally expected to result in minor damages.

4.1.4 VULNERABILITY OF INFRASTRUCTURE

The infrastructure assessed in the study area includes lifeline systems (e.g., sanitary sewer and stormwater drainage systems) and transportation systems.

Lifeline Systems

Lifeline systems are described in Section 2 and shown in Figure 12 and Figure 13. Table 13 below presents the flood risk profile for each independent lifeline system.

Table 13: Flood Vulnerability Profile of Downtown Mystic Lifeline Systems

Facility	Approximate Minimum Ground Elevation (feet)	Flooded by Current 10-year Flood	Flooded by 2050 10-year Flood	Coastal Flood Vulnerability		Intense Rain Flood Vulnerability
				Current (100-year BFE elev. = 11.0 feet)	2050 (100-year BFE elev. = 12.7 feet)	
Stormwater Drainage System	Underground	Yes	Yes	High	High	High
Sanitary Sewer System	Underground	No	No	Moderate	Moderate	Moderate
Gravel Street Pump Station	5	Yes	Yes	High	High	Moderate

Intense Precipitation Vulnerability

Intense rainfall most directly impacts the stormwater drainage system because the system's purpose is to drain runoff. Community feedback suggests the existing stormwater drainage system may be inadequate, particularly in the southern portion of Pearl Street near West Main Street and portions of West Main Street. There are stormwater catch basins located along Pearl Street, regularly spaced on both sides of the roadway approximately 170 feet apart. However, the furthest stormwater catch basin to the south on Pearl Street is approximately 275 feet from the intersection of West Main Street, a location of historical flooding. From preliminary runoff modeling (see Figure 41), much of the ponding at Pearl Street appears to come from runoff from the steep elevation change to the west. The portion of Pearl Street that is regularly flooded has an elevation of approximately 3 feet, NAVD88, which is much lower than elevation 54 ft, NAVD88 at the top of the bedrock outcropping. Runoff appears to also be impacting the portion of West Main Street at the Pearl Street intersection as well as immediately to its east and west. The area near the intersection with Pearl Street is a low point where the downward sloping West Main Street and Water Street converge before the downtown area.

Increased rainfall intensity in the future may result in the system reaching or exceeding its maximum capacity more frequently. Pipes that are undersized will surcharge (i.e., flow full and under pressure) and this will exacerbate flooding in the areas which the pipes typically drain. If pipes are not designed to handle surcharge pressures, the pipes can be damaged.

The typical design storm for stormwater drainage systems is 10-years per the Connecticut DEEP Stormwater Quality Manual[9]. Similarly, the Town of Groton Zoning Regulations[10] sets a minimum standard that all site development plans comply with the design criteria identified in the Connecticut Stormwater Quality Manual, which suggests the 10-year storm as a design measure. However, the Town of Groton Road and Drainage Standards[11] require that storm drainage system have a pipe design of a 25-year storm frequency.

As noted in Section 2, the frequency and intensity of heavy precipitation are projected to continue to increase over the 21st century. In terms of the stormwater drainage system design, the practical consequence is that the return-period based design storm is a moving target, changing with time as formal guidance such as NOAA Atlas 14 precipitation depths are periodically updated. For example, CIRCA guidance[12] suggests that the 10-year storm in 2040-2069 (6.1 inches) will be greater than the 50-year storm in 1970-1999 (5.7 inches). Further, CIRCA estimates that the present day 10-year event will

[9] Connecticut DEEP, Connecticut Stormwater Quality Manual, Chapter 7.3, 2004.

[10] Town of Groton, CT, Zoning Regulations, Section 7.3 Stormwater Management Plan and Low Impact Design, Rev. November 15, 2021.

[11] Road and Drainage Standards for Town of Groton, Connecticut, September 2002.

[12] CIRCA, UCONN ASG, Connecticut Physical Climate Science Assessment Report, August 2019.

have a recurrence interval of only 3 years in 2040-2069. The practical consequence in terms of performance is that the stormwater drainage system will be more frequently overwhelmed by intense precipitation, leading to localized flooding and ponding. This is particularly the case where the storm drain outfalls may also be submerged due to coastal flooding or high tides (with SLR).

Coastal Flood Vulnerability

The study area's stormwater drainage system is also vulnerable to compound effects of rainfall and coastal flooding (see Figure 48). The system discharges stormwater into the Mystic River via outfalls. The pipe network is therefore directly connected with the River. Coastal flooding that reaches the elevation of the outfall will fill the drainage pipes, thereby reducing the system's capacity and possibly causing pipes to backflow. Saltwater intrusion may cause corrosive damage. The outfalls are not currently equipped with tide gates, flap valves, or other measures to prevent backflow flooding. Historical and recent accounts of flooding indicate that locations on Pearl Street and Grove Ave (Mystic) have experienced backwater flooding from storm drains during high tide events.

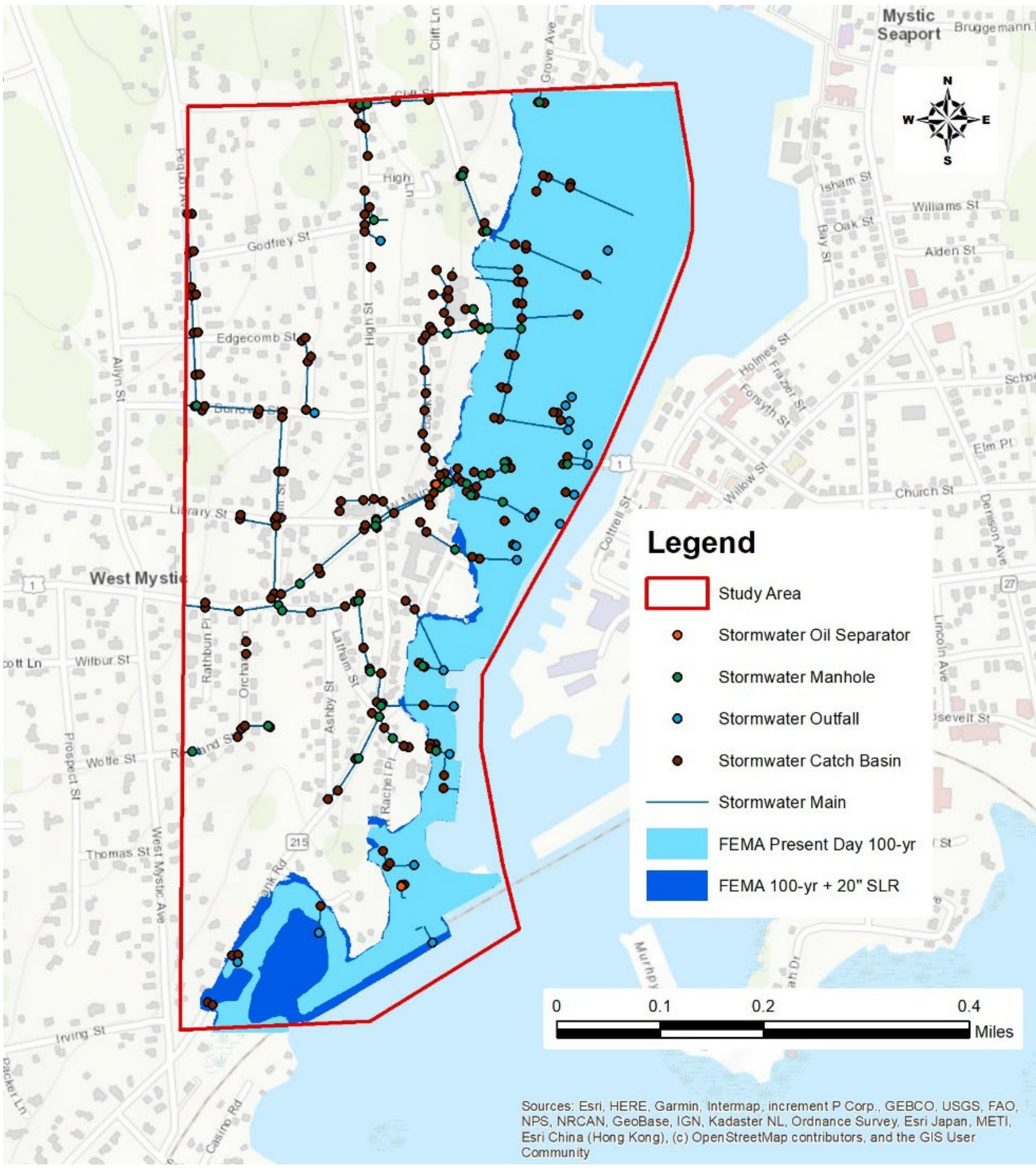

Figure 48: Stormwater Drainage System Vulnerability Assessment

For these reasons above, the stormwater system is considered highly vulnerable to coastal and precipitation flooding, including from the 10-year flood (see Figure 49).

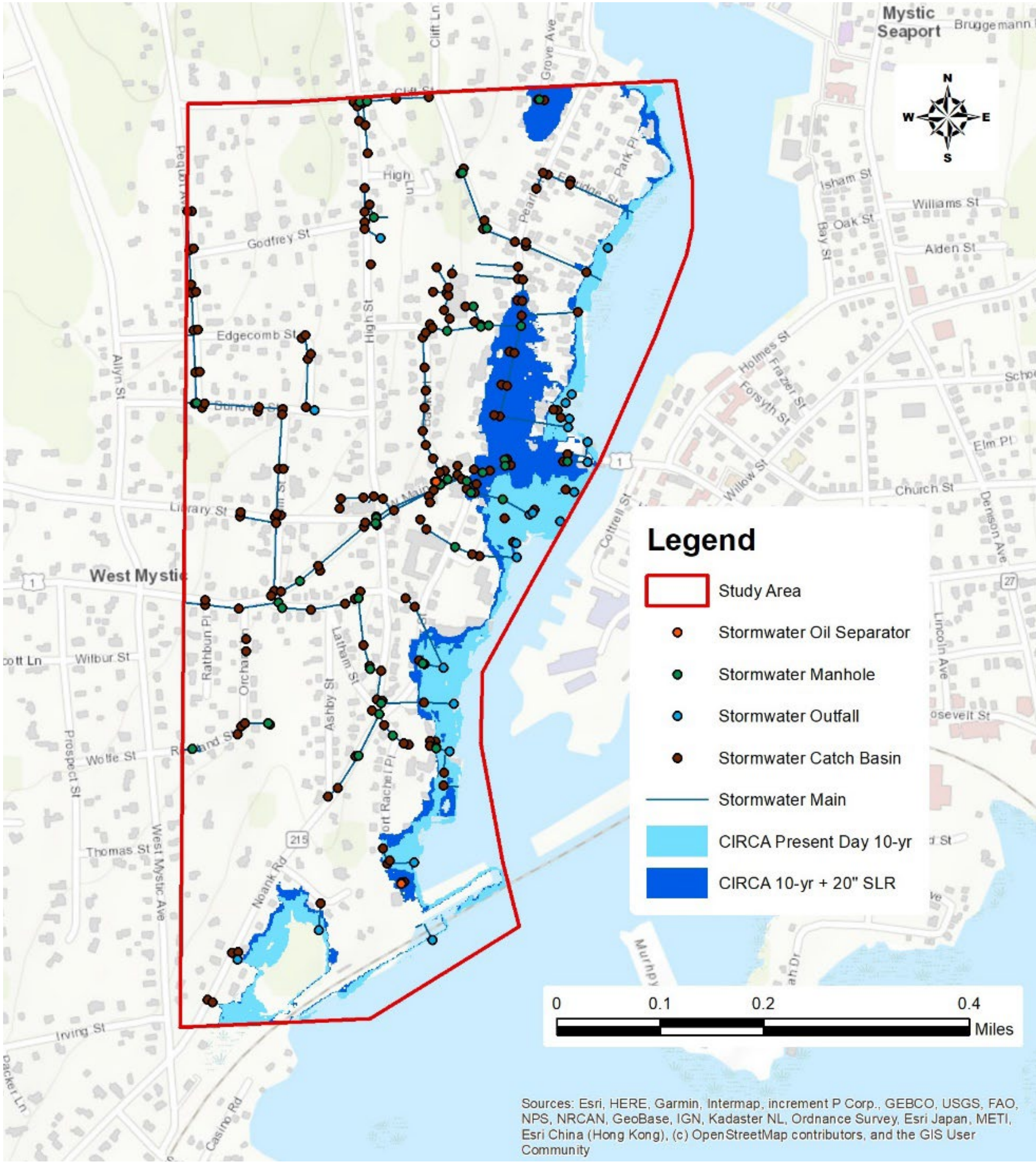

Figure 49: Stormwater Drainage System Vulnerability Assessment

Table 14 summarizes the number of stormwater outfalls and catch basins located within the present day and future (2050) 10-year and 100-year inundation area.

Table 14: Flood Vulnerability Profile and Number of Stormwater Infrastructure Exposed to Coastal Flooding

Lifeline System	CIRCA Current 10-year	CIRCA 2050 10-year	FEMA Current 100-year	FEMA 2050 100-year
Stormwater Outfalls (#)	15	15	20	20
Stormwater Catch Basins (#)	19	40	61	63

The sanitary sewer system is generally located below grade within the study area. The sanitary sewer main and grinder pumps are designed as a closed system, so surface flooding should not impact them. However, deficiencies in the systems may lead to vulnerability. The sanitary sewer system and water distribution system are vulnerable to coastal flooding via water infiltration (groundwater seeps through cracks, leaky pipe joints, or deteriorated manholes) and corrosive damage from saltwater. Sanitary sewer systems are also vulnerable via unauthorized inflow (stormwater enters through illegally connected rain leaders, basement sump pumps, or drains). These issues could represent significant consequences, though the probability of their occurrence is judged to be low to moderate. Thus, the vulnerability of the sanitary sewer system is also judged to be moderate.

The Gravel Street Pump Station is located adjacent to the Mystic River at approximately elevation 5 and is exposed to present and future coastal flooding (see Figure 50 and Figure 51). Since flood depths at the pump station are several feet for the 100-year flood in the present day, its vulnerability is judged to be high. There are currently no flood doors at the pump station, but it is reportedly flood-protected with concrete walls extending above the BFE. The pump station is expected to be less vulnerable to rainfall-runoff flooding, which would generally result in shallow, nuisance type flooding.

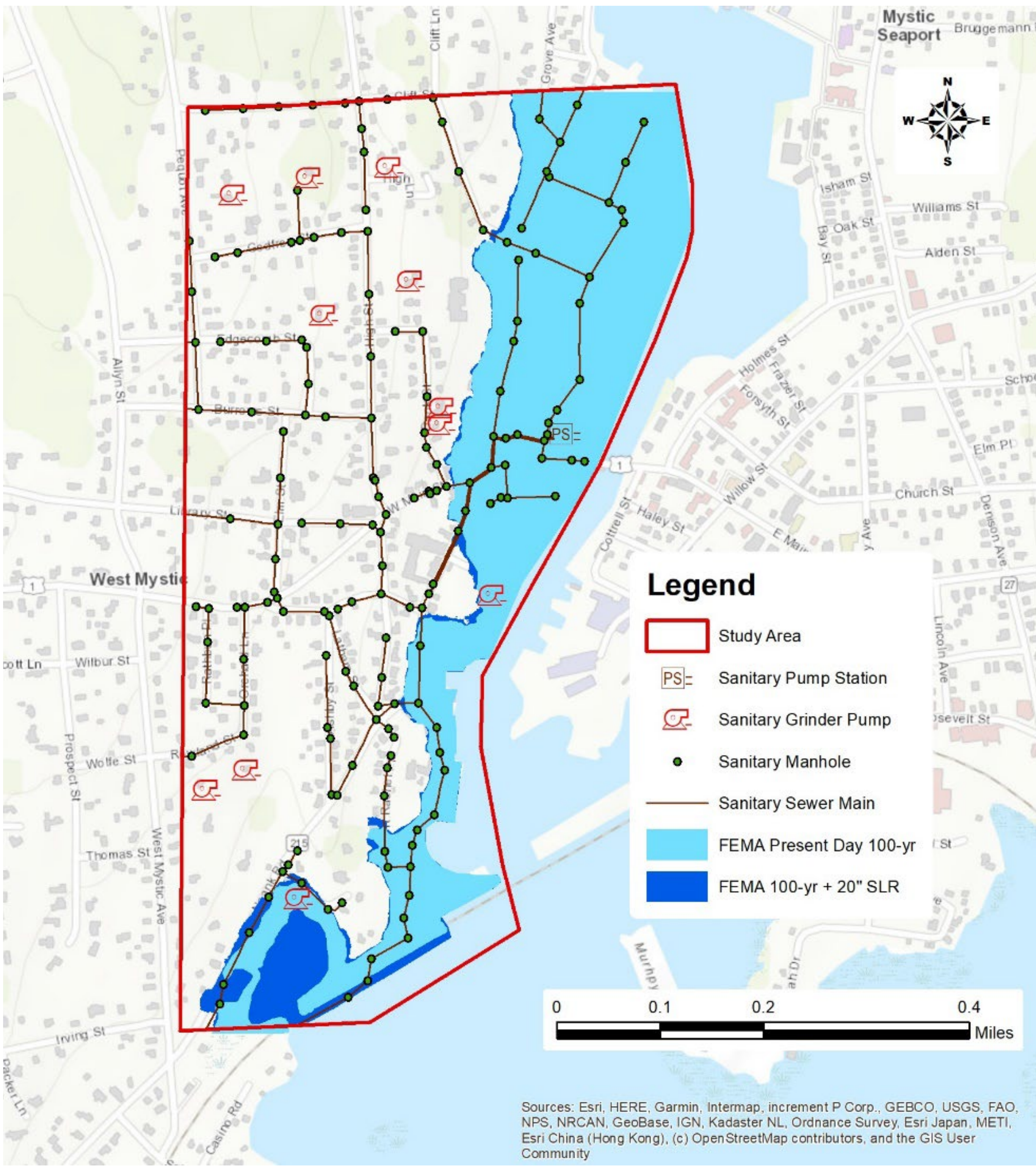

Figure 50: Sanitary Sewer Vulnerability Assessment

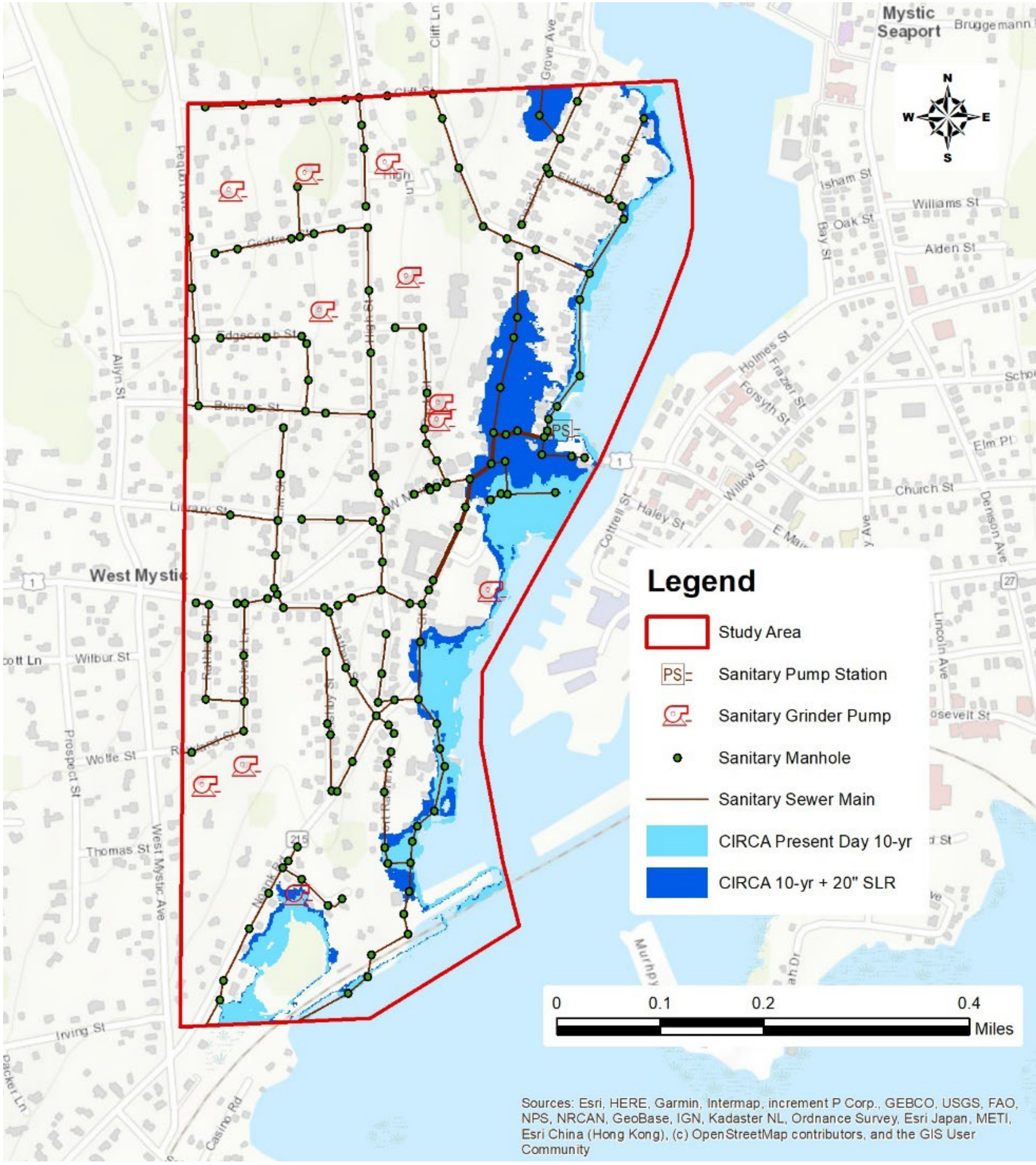

Figure 51: Sanitary Sewer Vulnerability Assessment

Transportation Infrastructure

4.1.5 VULNERABILITY OF TRANSPORTATION SYSTEMS

Transportation systems are described in Section 2 and shown in Figure 14. Table 15 summarizes the length of roadway located within the present day and future (2050) 10-year and 100-year inundation area.

Table 15: Flood Vulnerability Profile and Length of Roadways Exposed to Coastal Flooding

Transportation System	CIRCA Current 10-year	CIRCA 2050 10-year	FEMA Current 100-year	FEMA 2050 100-year
Roadways (miles)	0.50	0.93	1.52	1.66

Roadways in the study area that have a reported history of flooding include: West Main Street, Pearl Street, Gravel Street, Noank Road, Fort Rachel Place and Water Street. The flood vulnerability for these roads is provided in Table 16. The coastal flooding vulnerability was evaluated relative to the current FEMA FIRM BFE (11 feet) as well as the predicted 100-year flood elevations through the year 2050 (using CIRCA SLR projections).

Table 16: Flood Vulnerability Profile of Downtown Mystic Roads

Roadway	Approximate Minimum Ground Elevation (feet)	Flooded by Current 10-year Flood	Flooded by 2050 10-year Flood	Coastal Flood Vulnerability		Intense Rain Flood Vulnerability
				Current (100-year BFE elev. = 11.0 feet)	2050 (100-year BFE elev. = 12.7 feet)	
West Main Street	5	No	Yes	High	High	High
Pearl Street	3	Yes	Yes	High	High	High
Gravel Street	3	Yes	Yes	High	High	Moderate
Noank Road	11	No	No	Moderate	High	Moderate
Water Street/ Fort Rachel Place	5	Yes	Yes	High	High	High
Clift Street	7	No	No	High	High	Moderate
Eldridge Street	6	No	No	High	High	High
Park Place	8	No	No	High	High	Moderate

Coastal Flood Vulnerability

The minimum elevations for West Main Street, Pearl Street, Gravel Street, and Water Street are all well below the present-day FEMA BFE of 11 feet, NAVD88. Such flood depths would be capable of significantly damaging or washing out the roadway. Therefore, and in combination with the observed flooding reported by the community, these roads are considered highly vulnerable to coastal flooding both currently and in the future.

- The flooding of Gravel and West Main Streets are likely to be particularly disruptive. Gravel Street provides access to the Gravel Street Pump Station. West Main Street is the main road through Downtown Mystic and provides access to neighboring Stonington, where some essential facilities are located (see Figure 52).
- The flooding of Pearl Street and Water Street/ Fort Rachel Place is also likely to be disruptive because these roads provide access to several businesses, residences, public parking, and community and recreational resources.
- The minimum elevation of Noank Road is approximately equal to the present day BFE, but below the projected 2050 100-year flood elevation.
- Portions of the Downtown Mystic transportation system are vulnerable to the 10-year flood, as well (see Figure 53).

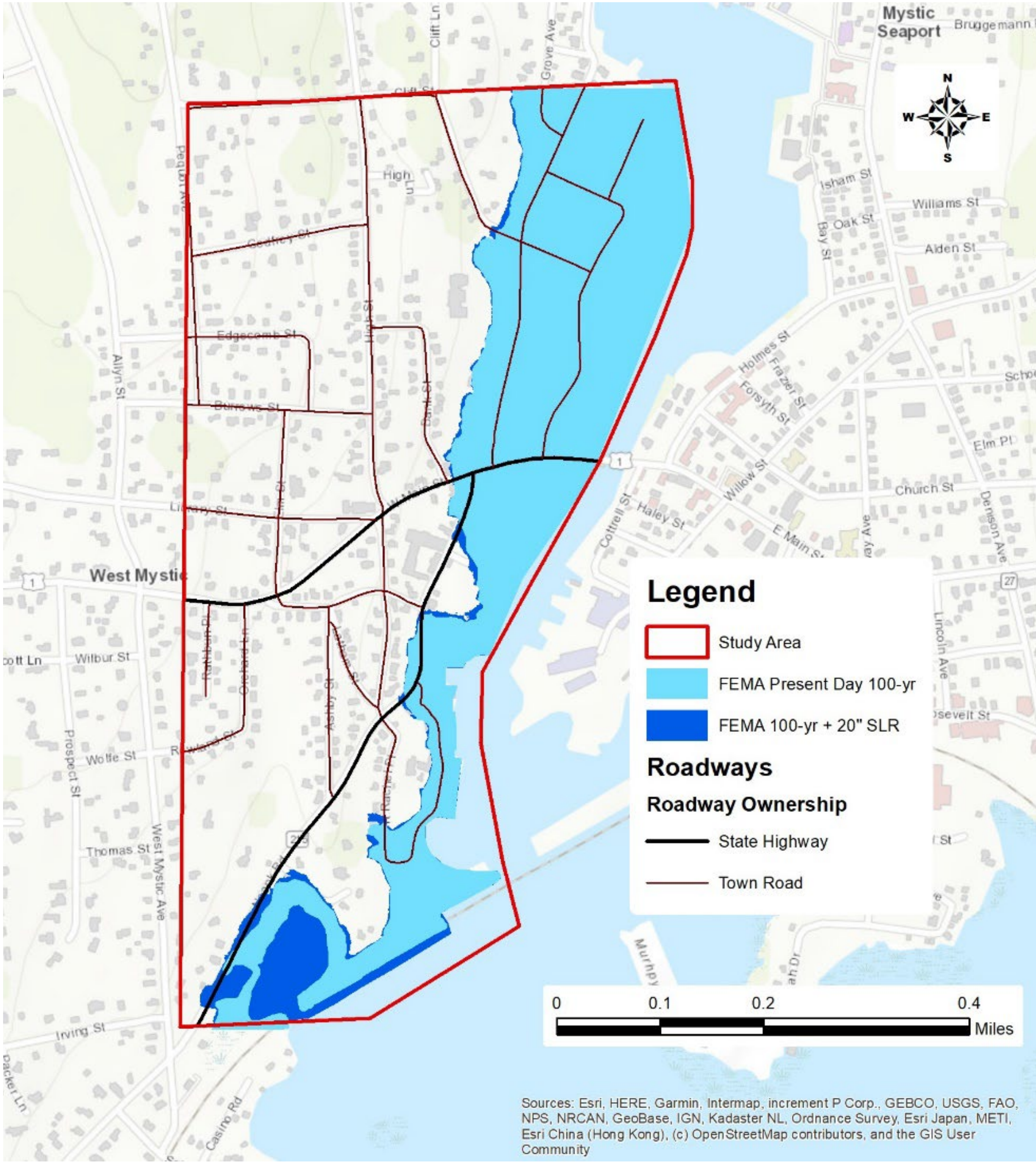

Figure 52: Downtown Mystic Transportation Vulnerability Assessment

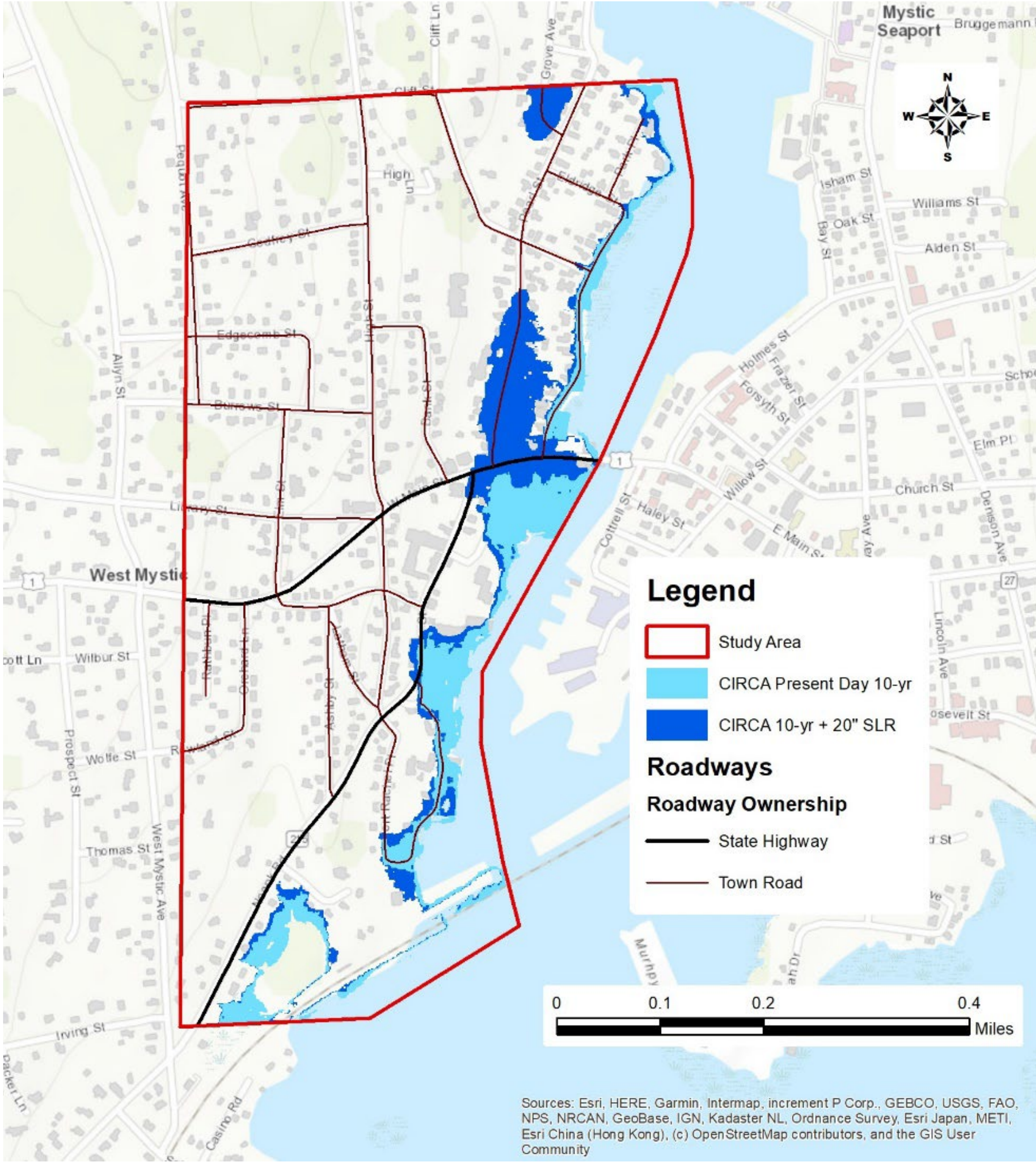

Figure 53: Downtown Mystic Transportation Vulnerability Assessment

Intense Precipitation Vulnerability

Many of the roads that are vulnerable to coastal flooding are also subject to intense precipitation flooding.

- Pearl Street has experienced stormwater flooding in the past and preliminary runoff modeling (see Figure 41) indicates that it is vulnerable to stormwater flooding due to its low elevation.
- Gravel Street is less vulnerable to runoff flooding, as stormwater generally drains to the Mystic River.
- Low lying portions of West Main Street and Water Street near the low point where the roads converge with Pearl Street are vulnerable to stormwater flooding.
- The portion of Clift Street east of Pearl Street is low lying and vulnerable to stormwater flooding, but the portion to the west is at higher elevation and does not experience significant stormwater flooding.
- Eldridge Street is low lying and collects stormwater runoff.
- The stormwater near Park Place runs off to the adjacent Mystic River, and is not likely to be flood prone.

4.1.6 VULNERABILITY OF HIGH VALUE ASSETS

High value assets within the study area (Figure 9) include:

- the Academy Point at Mystic, an assisted living facility
- 14 Godfrey Street, formerly Mystic Residential Care
- Factory Square, Steamboat Inn, and 8 West Main Street, all multiple use facilities, comprised of primarily commercial buildings.

Note that the five properties with the highest parcel value (ranging from $3,728,000 to $11,109,000 in total value) were included in the vulnerability assessment. The flood risk for the high value assets is provided in Table 17.

Table 17: Flood Vulnerability Profile for High Value Assets

Asset	Approximate Minimum Ground Elevation (feet)	Flooded by Current 10-year Flood	Flooded by 2050 10-year Flood	Coastal Flood Vulnerability		Intense Rain Flood Vulnerability
				Current (100-year BFE elev. = 11.0 feet)	2050 (100-year BFE elev. = 12.7 feet)	
Academy Point at Mystic	37	No	No	Low	Low	Low
Factory Square	18	No	No	Low	Low	Low
Steamboat Wharf/ Inn	6	Yes	Yes	High	High	Moderate
8 West Main Street	7	No	Yes	High	High	Moderate
14 Godfrey Street	150	No	No	Low	Low	Low

Coastal Flood Vulnerability

Academy Point at Mystic is located on high ground at the top of the outcropping near Pearl Street, and is well above the present day and future 100-year flood elevations (see Figure 54). Similarly, 14 Godfrey Street is located at a high elevation above the flood elevations. The Factory Square building is located in the lower lying area near Downtown Mystic but is still above the present and future 100-year flood elevations. Access to Factory Square commercial areas may be an issue, however, as Water Street will be affected by flooding. The Steamboat Inn is located below the BFE and is highly vulnerable to coastal flooding. 8 West Main Street is located across West Main Street from Steamboat Wharf and is also highly vulnerable to coastal flooding. During the December 2022 event, West Main Street was flooded. The Mystic Army Navy Store reported that cars driving through flood waters created small waves that damaged (or compounded damage to) its storefront.

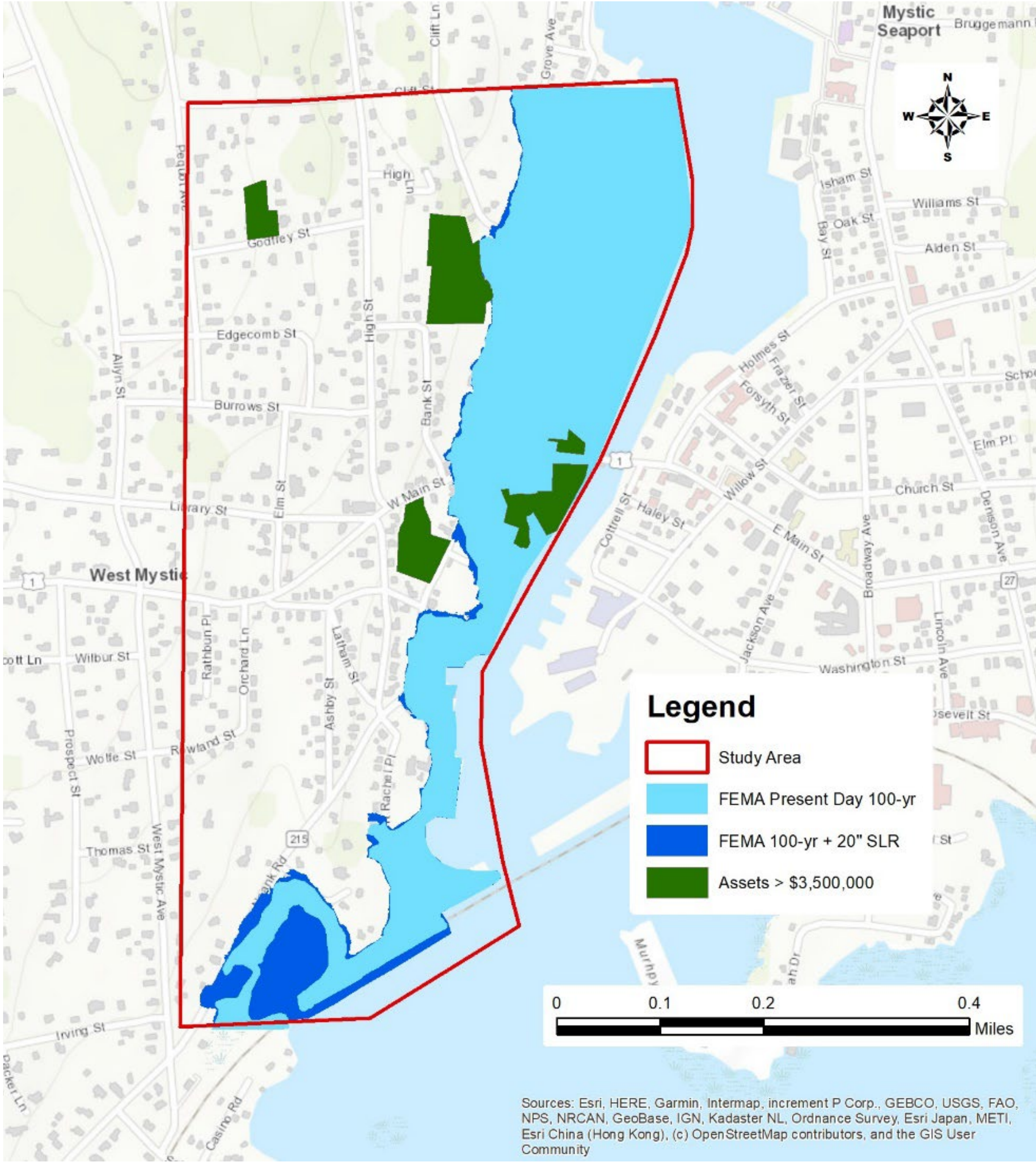

Figure 54: High Value Asset Vulnerability Assessment

Similar to the 100-year flood, the Steamboat Inn and 8 West Main Street are located within the 10-year flood inundation area (see Figure 55). These two properties are vulnerable to the present and future 10-year floods, and the Academy Point at Mystic, Factory Square Building, and 14 Godfrey Street appear to be unimpacted by these floods.

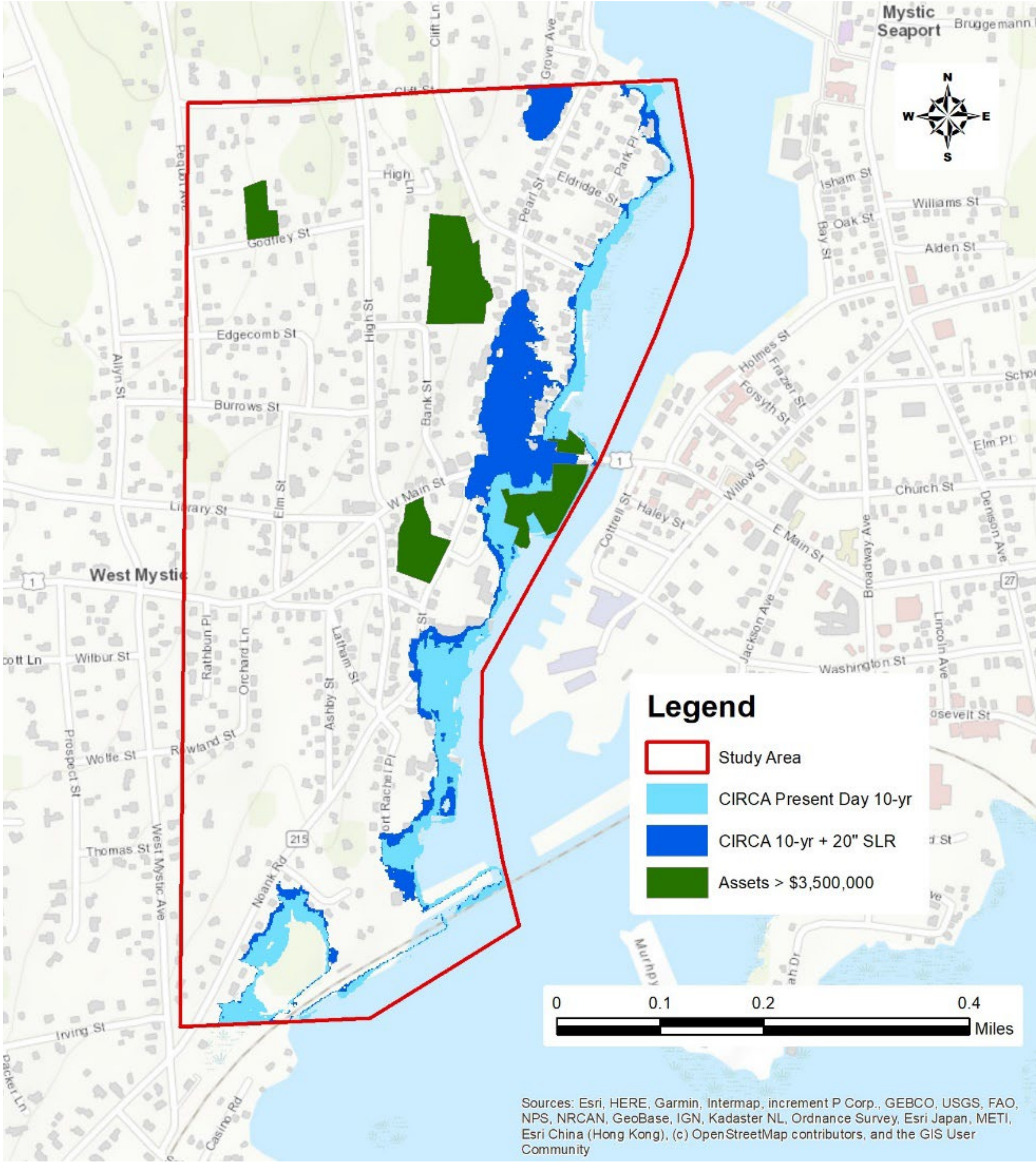

Figure 55: High Value Asset Vulnerability Assessment

Intense Precipitation Vulnerability

Neither Academy Point at Mystic nor 14 Godfrey Street are expected to be significantly impacted by stormwater flooding, as runoff will travel away from the high elevations they occupy. The Factory Square Building does not appear to be impacted by stormwater, as runoff will travel down Water Street to the low point near West Main Street. However, this runoff may interfere with access to the building from the north and east. The stormwater near the Steamboat Inn is expected to drain to the Mystic River, but flooding of West Main Street and the parking lot behind the Inn could limit access to these areas during a storm. Some ponding on West Main Street in front of the 8 West Main Street building may occur, and stormwater to the north of the building is expected to drain to the Mystic River.

4.1.7 NATURAL AND RECREATIONAL RESOURCES

Natural resources in the study area are shown on Figure 15 and recreational resources are shown on Figure 16. Flood vulnerability for the existing natural and recreational resources is provided in Table 18.

Table 18: Flood Vulnerability Profile for Natural and Recreational Resources

Roadway	Approximate Minimum Ground Elevation (feet)	Flooded by Current 10-year Flood	Flooded by 2050 10-year Flood	Coastal Flood Vulnerability		Intense Rain Flood Vulnerability
				Current (100-year BFE elev. = 11.0 feet)	2050 (100-year BFE elev. = 12.7 feet)	
Water Street Dock	2	Yes	Yes	Moderate	Moderate	Low
Bank Street Corner	16	No	No	Low	Low	Low
Mystic Academy Park	67	No	No	Low	Low	Low
Daniel Burrows Cemetery	120	No	No	Low	Low	Low
Tidal Wetlands	0 to 2	Yes	Yes	High	High	Low

Coastal Flood Vulnerability

The Water Street Dock is at a low elevation (about 2 feet), and will be inundated by the 100-year flood (see Figure 56). The Dock is judged to have moderate vulnerability to coastal flooding because the dock is exposed to frequent flooding, but does not provide essential functions.

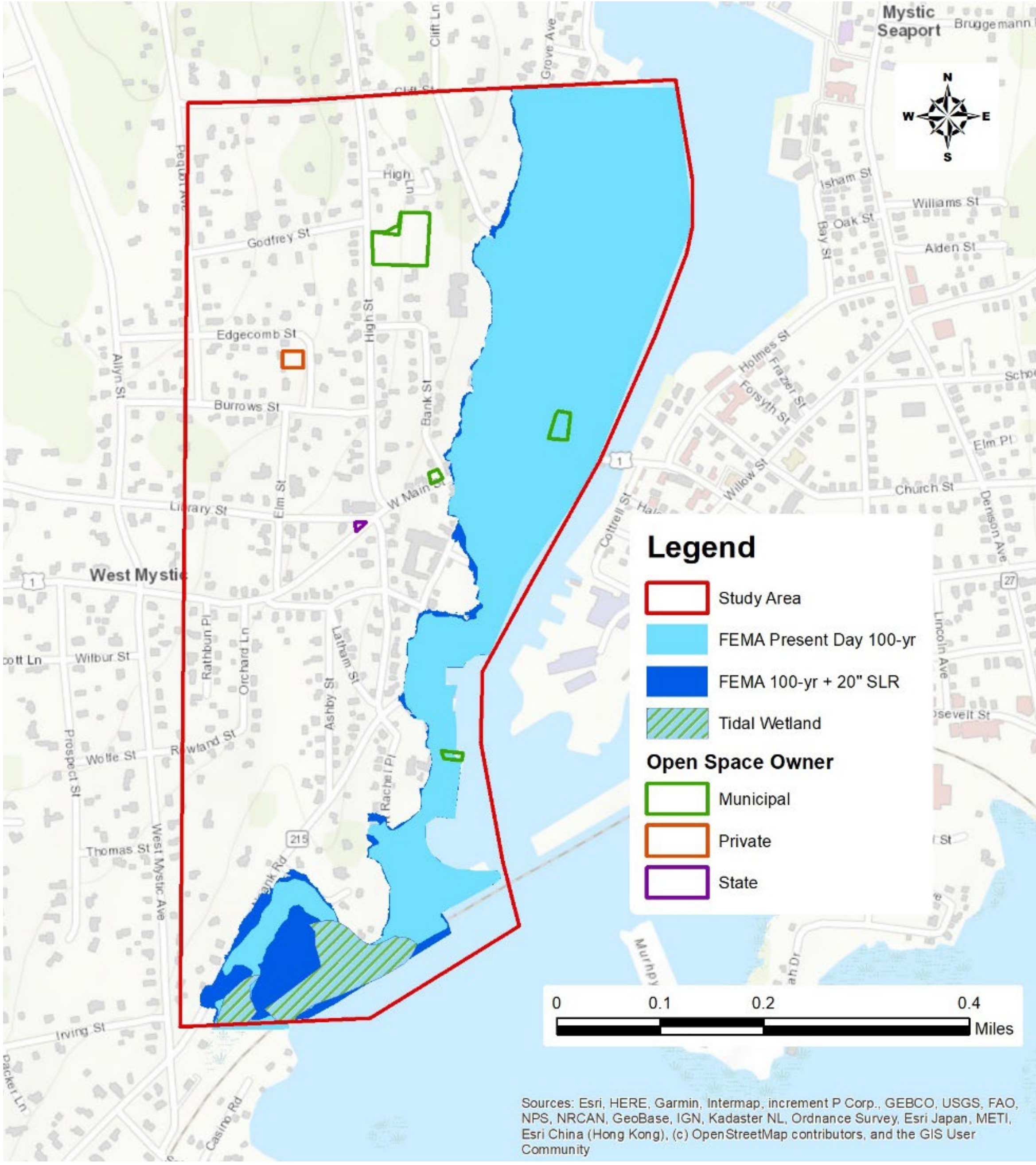

Figure 56: Open Space & Recreational Resources

The Bank Street Corner, Mystic Academy Park, and Daniel Burrows Cemetery are located above the present day and future 10-year and 100-year flood elevations (see Figure 57). A low vulnerability has been assigned to these recreational resources.

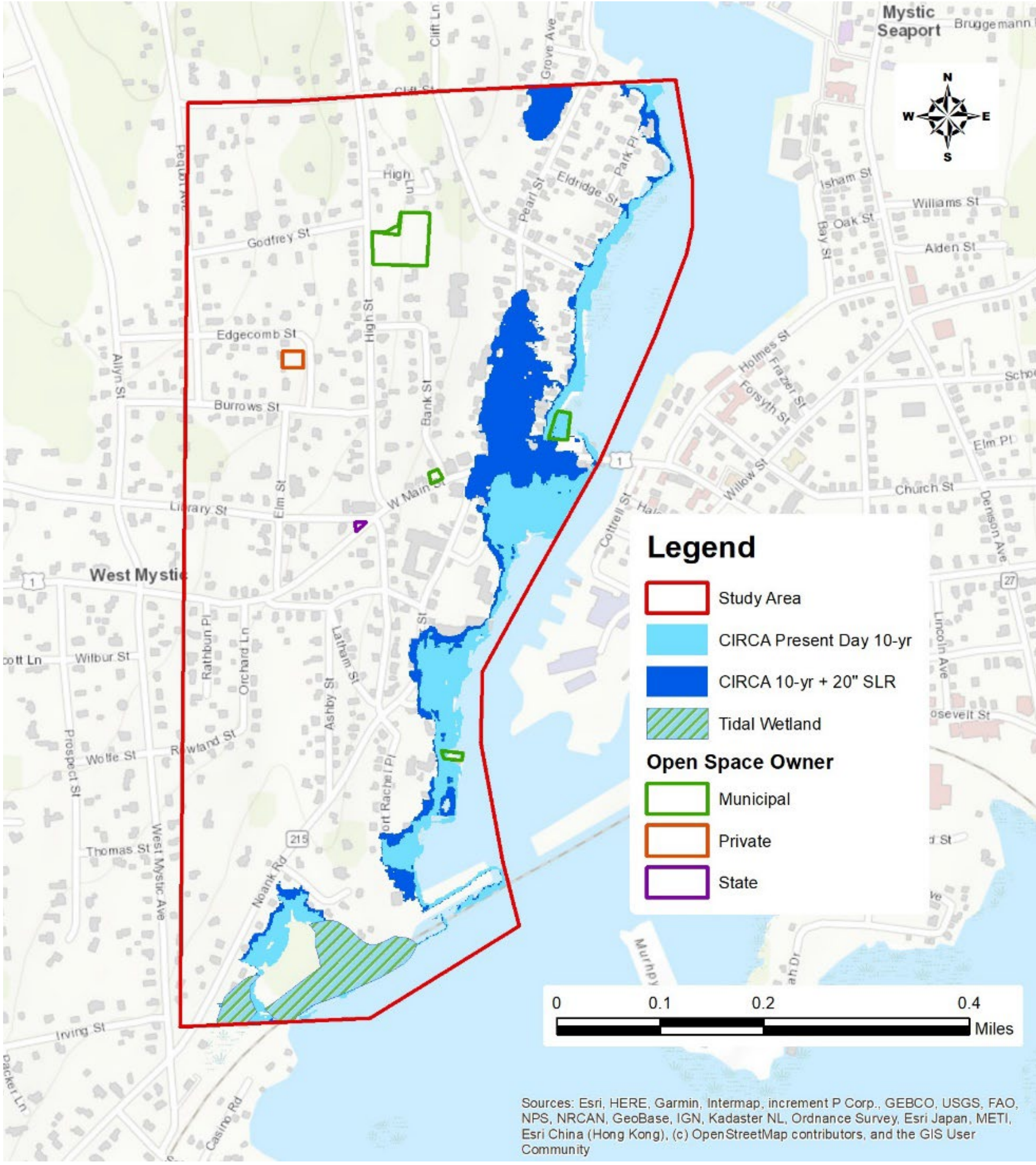

Figure 57: Open Space & Recreational Resources

The tidal wetlands located at the southern boundary of the study area are at slightly above the MSL of the Mystic River (0.3 feet). Extreme water levels can drown marshes if inundated for too long. Therefore, the tidal wetlands have a high vulnerability to the present day and future (2050) 10-year and 100-year floods (see Figure 56 and Figure 57).

Intense Precipitation Vulnerability

Stormwater runoff is not expected to impact the Bank Street Corner, Mystic Academy Park, or Daniel Burrows Cemetery in a significant manner. The dock is not expected to be impacted by stormwater, as runoff will sheet flow to the Mystic River. Stormwater is not expected to impact the wetlands, as they are likely already acclimated to different stormwater runoff volumes in Tuft's Cove and stormwater volume is a small fraction of the volume generated by a coastal flood.

Mystic River Vulnerability

While the River itself is anticipated to be able to withstand the direct effects of coastal flooding and intense precipitation, it is noted that the indirect effects, particularly due to increased stormwater contributions, may degrade the water quality of the River. Therefore, potential adaptation measures discussed in Sections 5, 6, and 7 consider preserving the water quality in the River as an important consideration.

4.2 EXTREME TEMPERATURE VULNERABILITY ASSESSMENT

4.2.1 PEOPLE, INFRASTRUCTURE, AND NATURAL RESOURCES

The study area's vulnerability to increasing temperatures was evaluated with a literature review of publications that discuss the impacts of increasing temperatures. The documents reviewed include the following:

- Heatwave Guide for Cities, by Red Cross Red Crescent Climate Center, 2019.
- U.S. Climate Resilience Toolkit, by U.S. Federal Government, 2019.
- Fourth National Climate Assessment, Volume II, U.S. Global Change Research Program, 2018.

The impacts most applicable to the study area are summarized in Table 19.

Table 19: Impacts of Increasing Temperatures and Applicability to Study Area

Impacts of Increasing Temperatures	Applicability to Study Area
During heat waves, people are more prone to dehydration, heat exhaustion, heat stroke, loss of consciousness, and other medical emergencies. People who are the most vulnerable include elderly, people working outside, infants, people with pre-existing medical conditions, and pregnant and lactating people. If people live alone, they are also more vulnerable because they may not get help. Lower income families are also more vulnerable because they may not have air conditioning in their home/car, they may have labor-intensive jobs, and they may have limited access to healthcare. Outdoor events and recreational activities may experience more heat-related medical incidents going forward.	People[13]
Heat and sunshine can intensify ground-level pollution by mixing with nitrous oxide gases (from sources like car exhausts) to create ozone, a pollutant. People who are most vulnerable to poor air quality include young children, the elderly, and people with pre-existing medical conditions, such as asthma.	People
During heat waves, high energy use may overwhelm the electricity grid which can result in blackouts.	Infrastructure; People
Heat waves can trigger water use restrictions.	People
Heat waves can reduce the number of hours outdoor workers can be employed safely and reduce the productivity of offices without adequate cooling.	People; Economy
More warm days can expand the season for mosquitos, such as those that carry Eastern Equine Encephalitis and West Nile viruses, and other disease vectors.	People
More energy will be required to cool homes and businesses, causing higher utility bills. Note that this may be offset by reduced heat costs due to milder winters.	Infrastructure; People
A longer warm season combined with nutrient pollution (i.e., fertilizer, yard waste, detergents that reach the stormwater system) can increase the risk of harmful algal blooms in water bodies.	Mystic River
Heat waves can accelerate the degradation of asphalt roads, buckle railroad tracks, and cause thermal expansion of bridges.	Infrastructure

The major impact discussed in the publications was the health effects of heat waves. Therefore, addressing heat waves is an important consideration for the study area's growth. The study area has the benefit of the Fishers Island Sound and Mystic River waterbodies providing a moderated thermal response. However, the downtown area along West Main Street

[13] Demographics of the study area show 46% of the population is over the age of 64, which is in the 98th percentile for the state.

is urbanized by buildings and asphalt cover with little to no tree cover. The lack of trees and presence of asphalt may result in exacerbating high temperatures.

The location of Mystic directly on the Mystic River and nearby the Fishers Island Sound prompted some local stakeholders to express that heat was not a significant issue for the area. However, the results of the mid-project survey (**Attachment 3**) show that people who live in Mystic as well as those who visit it are already feeling the impacts of the rising temperatures. The Town of Groton worked on an extreme-heat focused study in the summer of 2023, which also included a survey, of which fourteen (14) respondents reported living in Mystic (though not necessarily in this project's study area). Of those respondents, eight (8) indicated that heat is already causing them to limit the time they spend outside and the activities they do. Three (3) respondents noted that heat is already causing them to be affected by energy impacts (high cost, power outages, etc.) whereas two (2) noted experiencing mental impacts, such as anxiety and irritability, as a result of extreme heat. The reality of heat impacts in Mystic was also reiterated by a local business employee, who commented during a public meeting that people will sometimes enter their store during the summer to look for respite from the high temperatures, clearly struggling from heat health impacts.

Increasing temperatures for the study area were evaluated in Section 3.3.1 using nearby temperature gauge data and climate projections. Based on the temperature projections from circulation models, the following trends are projected for the study area:

- Daily maximum temperature is increasing by about 10 degrees Fahrenheit per century
- Number of days with maximum temperature above 90°F is increasing by about 50 days per century

Because these trends are based on historic observations, they do not consider different emissions trajectories. Scientists concluded in the Fourth National Climate Assessment that by 2050, regardless of emissions trajectories, annual average temperatures are expected to rise 5.3°F – which is a larger rise than that predicted from the temperature gauge data near the study area. Beyond 2050, the extent of the temperature increase depends on the emissions. This suggests the trends from the temperature gauge data are a low estimate for the increasing temperatures at the study area. Table 20 shows that these trends are expected to result in increased illness from both heat and pollution, increased energy usage during warm seasons, longer season for disease vectors (like mosquitos), more nutrient pollution, and heat-related degradation of road pavement.

4.3 KEY TAKEAWAYS

4.3.1 COASTAL FLOOD VULNERABILITY

- Several structures in the study area have moderate to high vulnerability to coastal flooding. Over 200 structures are located within the 100-year flood hazard area, and those structures within the 10-year flood inundation area are judged to have high vulnerability.
- Fifty-four (54) historical properties are located within the present day 100-year flood hazard area, and an additional four (4) are located within the future 100-year flood hazard area. Eighteen (18) of these properties are exposed to the present day 10-year flood hazard, and fifty-eight (58) will be exposed to the future 10-year flood hazard. The properties exposed to the present day and future 10-year flood hazard are judged to have high vulnerability, and the properties within the 100-year flood hazard area and not the 10-year are judged to have a moderate vulnerability to coastal flooding.
- The stormwater drainage system has high vulnerability to coastal flooding. Coastal flooding will affect the stormwater drainage system by filling the outfalls and drainage pipes unless tide gates/valves are installed to prevent reverse flows.
- The Gravel Street Pump Station has a high vulnerability to coastal flooding.
- West Main Street, Pearl Street, Water Street/ Fort Rachel Place, and Gravel Street all have high vulnerability to coastal flooding.
- The Steamboat Inn is a high value asset that has high vulnerability to present day and future coastal flooding.
- The Water Street Dock is a recreational resource that has a high vulnerability. The dock elevation is below the flood elevations, and would likely be impacted by coastal flooding.

4.3.2 INTENSE PRECIPITATION VULNERABILITY

- The stormwater drainage system has high vulnerability to increasing intense precipitation. Increasing intense precipitation is expected to overwhelm the drainage system more frequently. Members of the community have observed that parts of the study area are not adequately drained, suggesting the existing drainage system is not adequate. Increasing intense precipitation is expected to exacerbate these problems.
- Pearl Street and Water Street both meet West Main Street at a low elevation that receives runoff from the study area, and have high vulnerability to intense precipitation. Pearl Street is expected to flood more frequently; however, Gravel Street provides access to the Gravel Street Pump Station. Noank Road is expected to have high vulnerability in the future (by 2050) due to SLR.

4.3.3 EXTREME TEMPERATURE VULNERABILITY

- The study area has high vulnerability to increasing temperatures, particularly in the form of heat waves. During heat waves, people are more prone to dehydration, heat exhaustion, and other medical emergencies. Heat and sunshine can also intensify ground-level pollution. Addressing heat waves is an important consideration for the study area's growth.

5.0 AN INTRODUCTION TO TYPES OF RESILIENCE AND ADAPTATION APPROACHES AND MEASURES

Climate change adaptation is the process of taking action to prepare for, and adjust to, both the current and projected future impacts of climate change.[14] This section introduces the breadth of the types of approaches and measures that are used to adapt to flooding and extreme heat hazards associated with climate change. The specific resiliency action recommendations for Downtown Mystic, which draw on the approaches and measures introduced in this chapter, are presented in Chapter 6.

5.1 TYPES OF COASTAL FLOOD AND INTENSE RAINFALL HAZARDS APPROACHES AND MEASURES

Section 5.1 provides an overview of approaches and measures for reducing vulnerability to coastal flood and intense precipitation hazards. Approaches can be categorized in a number of ways; in this plan, they are categorized in three ways:

1. Protect,
2. Accommodate, or
3. Managed Retreat.

Subsequently, measures of implementation are categorized as:

A. Non-structural,
B. Structural, or
C. Nature/natural-based.

The approaches and means of implementation are summarized in Table 20 and are more fully described in 5.1.1 and 5.1.2.

Table 20: Summary of Example Approaches and Measures of Implementation to Reduce Flood Vulnerability

3 Types of Approach	3 Types of Implementation
Protect Prevent water from reaching asset.	**Non-structural** With measures such as new or modified policies that do not necessarily directly alter inundation area.
Accommodate Allow water to reach site but protect asset from water damage.	**Structural** With structures that alter inundation area or otherwise serve as a physical barrier.
Managed Retreat Relocate or remove asset.	**Natural** With nature-based features that may alter inundation area.

5.1.1 DESCRIPTION OF APPROACHES: PROTECT, ACCOMMODATE, RETREAT

The flood resiliency and adaptation approaches are defined as follows:

Protect is a range of interventions designed to hold back flooding from inundating developed areas. Protections can be

[14] EPA, Climate Adaptation and EPA's Role (https://www.epa.gov/climate-adaptation/climate-adaptation-and-epas-role)

implemented on a small scale (e.g., an individual building can be dry floodproofed) or a regional scale. A regional strategy of Protect is typically applied to flood hazards and implemented through a series of flood protection projects such as levees and floodwalls, which provide perimeter flood protection along and near the flood source. This strategy is or has been used in many flood-prone areas of the U.S., such as New York City and New Orleans. These flood protection projects can be integrated with public green space to provide recreation and natural resource access. The appropriate "level" of flood protection (i.e., "how high would a levee or floodwall be?") is a function of technical and regulatory feasibility, compatibility with other uses, cost, prevented losses, and impact on insurance cost. Protect strategies can also be applied to flood hazards from rainfall through the development of effective stormwater systems and drainage.

Accommodate involves allowing the hazard to occur, but protecting infrastructure, property and natural resources from damage through permanent and interim measures implemented on an ongoing basis. A strategy of Accommodate typically includes actions such as elevating or wet floodproofing buildings, developing emergency/flood response plans, and post-storm repair and cleanup.

The Accommodate measures identified above are typically implemented at lower incremental upfront costs than the costs from Protect and Retreat and are sometimes easier to implement. However, their long-term costs will generally be higher, and their long-term efficiency and benefits are often less.

Lastly, Managed Retreat is managed withdrawal from hazardous areas, most often characterized by a change in land use and managed relocation of people and structures. An example of Managed Retreat is the voluntary acquisition and demolition of existing buildings within a flood hazard-prone area and transformation of the area to a public natural resource. A common issue for Managed Retreat-based strategies is that they often run counter to other practical, social, or economic values. For example, relocating the Gravel Street Pump Station to outside of the study area is not a feasible alternative.

5.1.2 DESCRIPTION OF MEASURES: NON-STRUCTURAL, STRUCTURAL, AND NATURE BASED SOLUTIONS

Flood resiliency measures can be further categorized as 1) Non-Structural; 2) Structural; and 3) Natural and Nature-Based measures. These classifications are consistent with federal guidance from FEMA and USACE.

Non-structural measures reduce human exposure or vulnerability to a hazard without altering the nature or extent of the hazard. Non-structural measures are consistent with the resiliency strategies of Accommodate and Managed Retreat. Some non-structural measures do include small-scale construction, but do not include regional or large-scale flood protection measures. Therefore, these small-scale construction options are more suitable for implementation at the individual building or neighborhood level scale. Examples of non-structural measures (consistent with the USACE National Floodproofing Committee guidance) include elevating, relocating, and floodproofing buildings; small-scale berms and floodwalls; flood warning systems; flood emergency response plans; and land use regulations.

Structural measures are designed to alter the characteristics of the flood hazard and reduce its probability in the location of interest. These measures are consistent with a resiliency strategy of Protect. Traditional flood protection structures include levees, floodwalls, storm surge barrier gates, revetments, and nearshore breakwaters.

The purpose of these measures is to reduce flood inundation extent. Structural measures in this context (as opposed to small-scale berms and floodwalls considered non-structural measures) refer to significant projects performed at a large scale that will often result in accreditation in FEMA Flood Insurance Rate Maps (FIRMs). These measures also require maintenance (e.g., embankments must be mowed, concrete structures occasionally require resurfacing, rock revetments require rock replacement and repositioning, etc.) to perform their function over their intended service life.

Natural measures are features that are created and evolve over time through the natural actions of physical, biological, geological, and chemical processes. Nature-Based measures are features that "mimic" natural features but are created by human design, engineering and construction to provide specific services such as coastal risk reduction. Nature-based features are acted upon by the same physical, biological, geological, and chemical process that affect natural features, and therefore may require special considerations for maintenance to reliably perform (e.g., vegetation may need to be replanted, soil may need to be replaced, etc.). Natural and nature-based features include natural and constructed oyster reefs, marshes, and wetlands; green stormwater management approaches (rain gardens, bioretention facilities, bioswales, etc.); permeable pavement; and roof stormwater management approaches (green roofs, rain barrels, cisterns, etc.).

5.1.3 PUBLIC FEEDBACK

During the second public workshop and online survey, participants were asked to select adaptation approaches they thought should be further considered for Downtown Mystic. A breakdown of their responses is provided in Table 21. Respondents were not limited by the number of approaches they could select, which is why the percentages sum to more than 100%.

Table 21: Survey Respondent Support for Adaptation Approaches

Approach	Number of Responses	Percentage of Respondents in Support
Protect	69	68%
Accommodate	54	53%
Retreat	45	44%

The ranking of the approaches (Protect being most popular, followed by Accommodate and then Retreat) was consistent across respondents who lived and/or worked in the study area as well as those who visit the study area but do not live or work there. Of the respondents who live and/or work in the study area, 73% thought Protect should be further considered, 51% thought Accommodate should be further considered, and 41% thought Retreat should be further considered. Of the respondents who visit the study area, 68% thought Protect should be further considered, 56% thought Accommodate should be further considered, and 48% thought Retreat should be further considered.

The survey also asked respondents to indicate which adaptation measures they thought should be further considered. The results are presented in Table 22. The respondents were not limited by the number of responses they could select.

Table 22: Survey Respondent Support for Adaptation Measures

Measure	Number of Responses	Percentage of Respondents in Support
Non-Structural	47	46%
Structural	53	52%
Nature-Based	86	84%

The ranking of adaptation measures differed between those who live and/or work in the study area versus those who visit it. Whereas those who live and/or work in Downtown Mystic preferred Nature-Based measures (92%) followed by Non-Structural (51%) and Structural (49%) those who visit the area preferred Nature-Based measures (84%) followed by Structural (56%) and Non-Structural (42%).

5.2 HEAT HAZARDS ADAPTATION APPROACHES

Climate change-induced hazards relating to increased temperatures and extreme heat can threaten the well-being of residents and visitors to the study area, at least on a seasonal basis. The adaptation approaches discussed in this section address the vulnerabilities summarized in Table 19 by either reducing exposure to the hazard, reducing sensitivity to the hazard, or increasing the ability to recover from the hazard. The approaches can be categorized as for people or for infrastructure. The following key references were used to identify these approaches:

- "Heat Islands" website by the United State Environmental Protection Agency, https://www.epa.gov/heatislands, accessed April 2021.
- "Sports for Climate Action", second issue of "Sustainability Essentials – A Series of Practical Guides for the Olympic Movement," by the International Olympic Committee and the United National Climate Change, 2018.

5.2.1 APPROACHES FOR PEOPLE

People-based adaptation approaches achieve resiliency without the need to construct new infrastructure, which can be costly and require time for permitting, construction, etc. People-based adaptation approaches can be categorized as short-term (i.e., can be implemented in the near future) or long-term (i.e., can be implemented in the later future).

Examples of short-term, people-based approaches include cooling measures (access to fans, drinking water, and cooling centers), heat-health education and messaging, administrative controls (shifting strenuous activities to cooler times of the day), and personal protective equipment.

Some approaches are considered long-term because either they take longer to implement or because the vulnerability they address is a secondary effect of increasing temperatures (for example, longer mosquito season). Examples of long-term, people-based adaptation approaches include education campaigns, development of long-term heat response plans, and monitoring heat conditions and impacts over time (i.e. data-driven approaches). Community-building approaches, such as encouraging people to check in family, friends, and neighbors (especially those who live alone and are elderly or disabled), can help ensure that people impacted by heat receive the medical attention they need.

5.2.2 INFRASTRUCTURE APPROACHES

Infrastructure changes are another way to build resiliency in the study area. Infrastructure changes can reduce the impacts to infrastructure condition, reduce people's exposure to hazards, or otherwise help to modify people's behavior in a manner that increases overall resiliency. Examples of infrastructure changes include the following:

- Add shade
  - Use vegetation for shade[15](vegetation provides cooling effects as well as aesthetic and ecological benefits).
  - Add shade-providing structures, such as awnings and canopies.
- Add infrastructure to support cooling and/or human health needs
  - Water fountains and bottle-filling stations for freely available drinking water.
  - Splash-pads or pools.
  - Buildings that can act as a cooling center (i.e., has air conditioning).
  - Medical/first aid facilities.
- Construct buildings to withstand extreme heat and reduce energy use
  - Heat-resistant materials
  - Light-colored roofing materials
  - "Cool" pavements, which absorb more solar energy and evaporate less water than traditional materials.

[15] A 2015 study found that intercepting solar radiation (i.e., providing shade) is the most effective way to reduce heat load on people. ("Designing urban parks that ameliorate the effects of climate change", Landscape and Urban Planning Volume 138, Robert D. Brown et. al, June 2015).

- Design considering the orientation of buildings/structures with regard to the sun.
- Reduce stress on the electricity grid by adding energy efficiency measures (i.e., natural ventilation) and renewable energy (solar, wind, coastal, geothermal).

5.2.3 PUBLIC FEEDBACK

During the second public workshop and online survey, participants were asked to indicate the short and long term heat adaptation approaches for people they thought should be further considered. Similar to the selection of adaptation approaches and measures described above, respondents were able to select all of the options they thought were worth considering. The results are presented in Table 23.

Table 23: Public Support for Heat Adaptation Approaches

Approach	Number of Responses	Percentage of Respondents in Support
Short-Term Approaches		
Cooling measures	57	61%
Heat-related health education and messaging	42	45%
Increased administrative controls	50	54%
Improved access to personal protective equipment	21	23%
Long-Term Approaches		
Public education	32	34%
Community-building	41	43%
Long-term planning	40	42%
Improved medical care access	45	47%
Data-driven approaches	51	54%

Most of the approaches received approximately the same level of support, with slight preference given to cooling measures and administrative controls as short-term strategies and data-driven approaches as a long-term strategy. Interestingly, public education received less interest than the other long-term strategies.

5.3 KEY TAKEAWAYS

- Mitigation approaches can be categorized as Protect, Accommodate, or Managed Retreat.
- Mitigation measures can be categorized as Structural, Non-Structural, or Natural / Nature-Based.
- The Protect approach received the highest percentage of support from the mid-point survey.
- Nature-Based measures received the highest percentage of support from the mid-point survey.
- Heat adaptation measures can be implemented through a people-based approach or an infrastructure approach.
- Cooling measures received the highest percentage of support from the mid-point survey.

6.0 RESILIENCE ACTION RECOMMENDATIONS

This section takes the adaptation approaches and measures introduced in Chapter 5 and hones them into recommendations that are specific to the Downtown Mystic study area. The list of recommendations was developed based on the project team's understanding of the project area and actions taken in similar coastal areas that may be successful in Mystic, the expertise of the project's steering committee, and the ideas and insights of the public shared during meetings and through the mid-project survey. The recommendations were developed in response to the climate impacts anticipated to occur by the year 2050.

A ranking system was used to identify the high priority recommendations. The ranking system applied five factors, each of which had equal weight:

- Vulnerability reduction
- Technical feasibility (including cost)
- Maintaining cultural and historical resources and the economy
- Maintaining or improving water quality
- Public support and benefit

A full table showing the scores for each action by factor is provided in **Attachment 5**.

Section 6.1 shares the list of high priority resilience action recommendations. These actions will be pursued by the Town through Capital Improvement Plans (CIPs, which are part of the Town budget process) and grant funding within the next five to ten years.

Section 6.2 shares best practices for property owners to help them protect their homes or commercial buildings from flood damages.

Section 6.3 shares the list of low priority resilience action recommendations. These actions will be revisited in the future, but pose such significant cost, time, and logistical barriers that they should not be the focus of the Town's immediate actions as the transition is made from planning into implementation.

Section 6.4 highlights the continued education, outreach, and partnership-building that will be essential for any of the actions described in this section to be successful.

It is important to note that there is no one single solution to protecting Downtown Mystic from flooding and heat. Even a downstream flood barrier across the Mystic River that would help protect from tidal storm surge would not permanently protect the study area beyond 2050 from the ongoing incremental effects of SLR, and possibility of storms that may exceed design criteria. As one local business owner commented during the field assessments performed at the start of this project, "in Mystic, you live with water." That sentiment will continue to be true. The strategy of the high priority actions listed in Section 6.1 will be to keep up with the rise in the water while also helping reduce the impact of extreme heat.

It is also important to note that "no action" is also an option that needs to be considered with intention, as opposed to occurring by default due to lack of interest or motivation. As each of the recommended actions are pursued the potential costs and benefits versus the price of doing nothing will be evaluated, which includes the financial toll of damages from natural hazard impacts that could have been avoided. Costs of inaction are typically underestimated when working on climate change, and present very different tradeoffs when they are fully considered. The National Centers for Environmental Information reports that between January 1, 2023 and October 10, 2023 there were 24 confirmed weather/climate disaster events with losses exceeding $1 billion each to affect the U.S., resulting in 373 lives lost.[16] In the past 5 years, on an average

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[16] NOAA National Centers for Environmental Information (NCEI). 2023. *Billion-Dollar Weather and Climate Disasters*.

annual basis, 18 events have exceeded the $1 billion loss threshold in the U.S. Adaptation measures such as the ones discussed in this plan are specifically designed to mitigate a significant portion of such potential losses. For some actions that require particularly high upfront investments, the tradeoff between the cost of taking action and the cost of inaction will be re-evaluated over time, as costs and benefits may evolve as the impacts of climate change worsen. The recommendations made in this plan should not be considered as a static list, but a resource that will need to be iteratively reviewed and adjusted as actions are completed and conditions change.

6.1 HIGH PRIORITY RESILIENCE ACTION RECOMMENDATIONS

Each of the high priority resilience action recommendations are described below:

1. Install backflow preventers on stormwater outfalls: There are 20 stormwater outfalls within the study area. Stormwater outfalls are the end points of the stormwater drainage system, where water collected throughout the system discharges into the Mystic River. When the Mystic River rises, water can enter the stormwater drainage system through the outfalls and move through the system "in reverse." If enough water enters the system, flood waters can come up through the catch basins, causing inundation on the adjoining land. Backflow preventers such as tide gates can be installed at stormwater outfalls and control flow so it is only allowed in one direction (downstream). Multiple accounts from homeowners in the Grove Avenue (Mystic) area indicate that sunny day flooding (flooding without rain) occurred during the December 2022 event. This is likely due to high tides in the Mystic River entering the stormwater system and backflowing to the stormwater catch basins. Installation of the backflow preventers would not likely cause a significant disruption to the typical functionality of the stormwater system, as they are installed at or near the outfall. However, they would require regular inspection and maintenance. Before being installed, design and permitting would need to be completed.

2. Develop an approach to elevate low-lying roadways: Raising low-lying roadways, such as portions of Gravel Street, Pearl Street, and Water Street, would likely alleviate flooding from small events. Elevating Pearl Street would reduce the risk of intense precipitation flooding by diverting runoff from roads and draining any ponding more quickly. Depending on the height, elevating Gravel Street and Water Street would have the potential to help reduce coastal flooding from the Mystic River. It should be noted that the areas impacted by flooding are highly developed and interconnected and that localized drainage patterns must be considered, as elevated roadways could lead to worsened flooding in other areas. Connections to other roadways, driveways, and parking lots must be evaluated when raising roadways. This option is unlikely to be a feasible way to provide significant protection against severe coastal floods, given the difference between the elevation of some of the low-lying roads (i.e., as low as elevation 3 or 4 feet) relative to the flood elevation associated with a 100-year flood (12.7 feet). However, it could potentially help reduce impacts from nuisance flooding and smaller, more frequent, storms (such as the 10-year storm). A feasibility analysis would need to be conducted to develop the approach to be used to ensure net benefit, and extensive coordination with property owners along the roads would need to be conducted. Additionally, Water Street and West Main Street are state-owned roads, so raising of these roadways may be infeasible. Phasing, in which road heights are raised incrementally over time, should be considered.

3. Evaluate Pearl Street stormwater improvement alternatives: The hydrology, or the distribution and movement of water, along Pearl Street is very complex. Once an open water inlet, the land beneath Pearl Street is fill material. Several people who live and work on Pearl Street described water coming up through their basements during large storm events, suggesting that there may be a tidal connection to the Mystic River. Water may also back-flow into Pearl Street through four stormwater outfalls during large events. Aside from coastal influence, the stormwater

https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73 drainage system on Pearl Street receives runoff from approximately 44 acres[17]. A preliminary report developed by URS Greiner in 1997 noted that the current stormwater system is inadequate to convey the runoff from a 2-year storm without roadway flooding. It also explained that the lack of elevation change between Pearl Street and the Mystic River makes it so that "through the use of conventional storm drainage facilities, it is not possible to construct a system to accommodate the design storm" (which is the 25-year storm per Town stormwater regulations) for the portion of Pearl Street south of Clift Street.

The report outlines several options that could be further considered, including:

- installing larger pipes in several areas (though depending on the area, it would be impossible to do so while meeting the Town's Road and Drainage Standards with regards to pipe slope, pipe cover and design storm)
- adding a new outlet pipe and outfall, which would require private property easements
- installing a stormwater pumping station
- separating the drainage from the area west of Pearl Street through a new catchment and pressure conduit system

A detailed hydrological and hydraulic study that could inform the benefit to be achieved by these and/or additional options needs to be conducted to determine which options are feasible and would produce meaningful reductions in stormwater flooding. A detailed hydrological and hydraulic study would estimate the amount of inflow to the stormwater system and evaluate the capacity of the existing system to design flows. Enhanced stormwater management was the most popular flood resiliency strategy in the mid-project survey, with 73% of respondents voting that it should be further considered. This action should also be considered in concert with the evaluation of roadway elevation described above. Elevating Pearl Street may provide additional clearance, which could help Town standards be met.

4. Reduce pressure on the Pearl Street stormwater system through installation of green infrastructure in the upper watershed: The most cost-effective way to reduce stormwater flooding on Pearl Street may be to reduce the drainage entering the system from the contributing drainage area, which (per the URS Greiner report) includes land to the west as far as Pequot Avenue. Green infrastructure options, such as bioretention facilities and bioswales (see Figure 58), allow for retention of stormwater until eventually infiltrating into the groundwater after an intense precipitation event[18]. The upper watershed is a primary candidate for green infrastructure installation because it is higher in elevation and is anticipated to have more clearance between its ground surface elevation and groundwater to enable infiltration, and because much of the runoff generated from the upper watershed eventually makes its way to the more flood-prone areas of Downtown Mystic. Sub-actions associated with this approach include:
    a. Perform green infrastructure education/outreach to private landowners: Providing educational outreach for property owners in the upper watershed area could encourage the use of green infrastructure on private property. The Town could explore how to provide economic incentives for residential green infrastructure to increase buy-in. An example of a residential rain garden is presented in Figure 59.

[17] URS Greiner, Inc. 1997. *Reconstruction of Pearl Street Preliminary Design*.
[18] Benefits of Green Infrastructure | US EPA

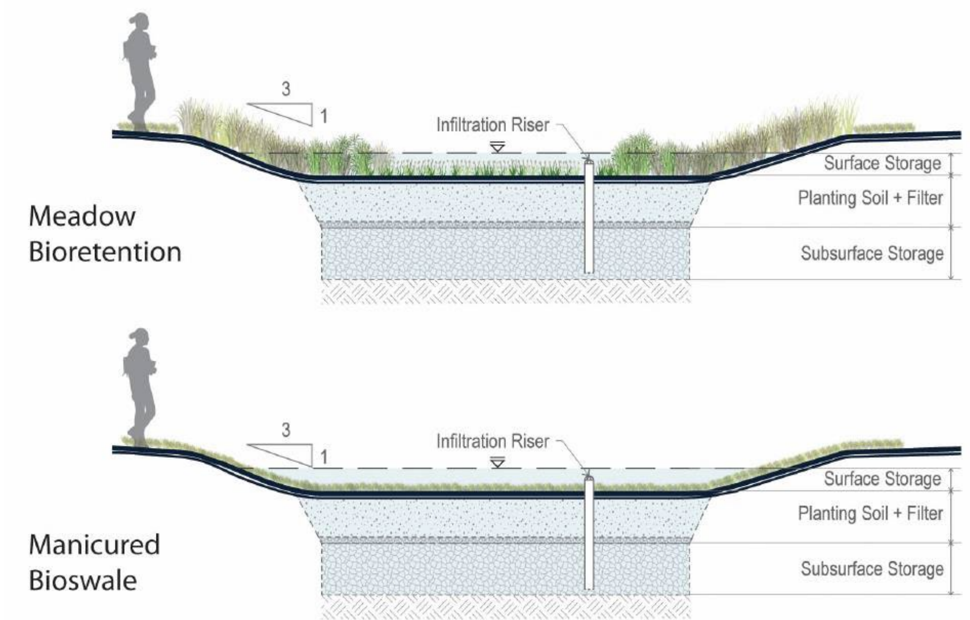

Figure 58: Examples of green infrastructure

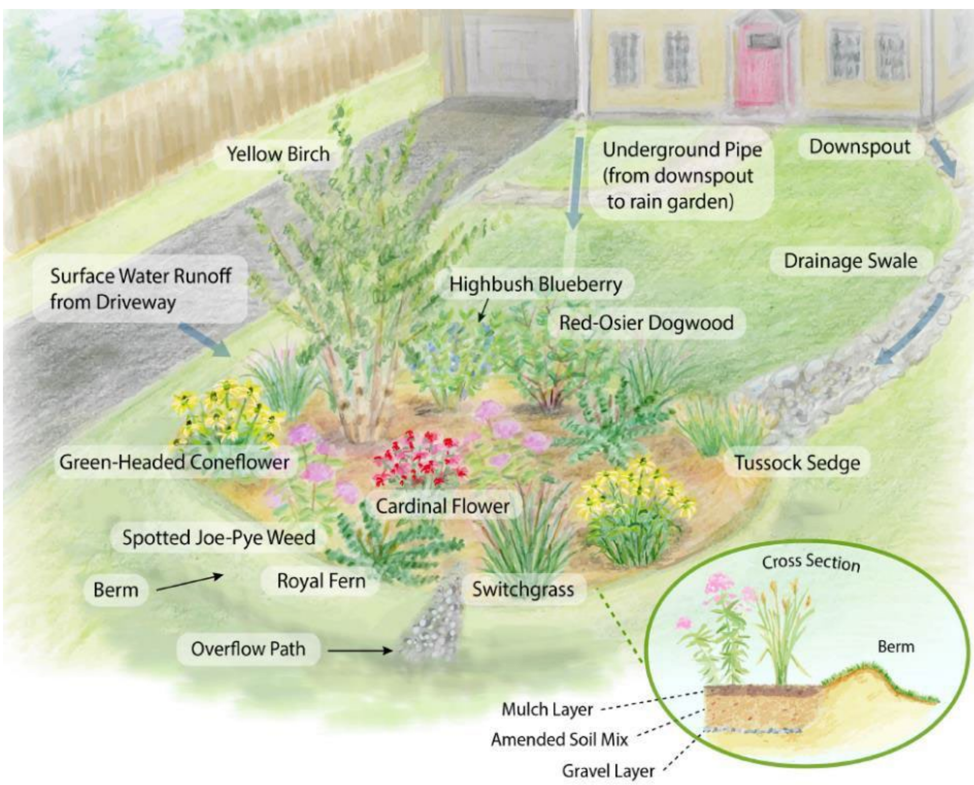

Figure 59: Residential rain garden (Stormwater Solutions for Homeowners, mass.gov)

b. Implement green infrastructure at Mystic Academy Park and Town-owned road rights-of-way: Mystic Academy Park is the one large area of open green space owned by the Town in the study area. Five catch basins on High Street are discharged onto the Aquarion property immediately next to the Park; routing the drainage into a bioretention system built within the Park would help improve water quality and retain the water. Rights-of-way along roads may also provide opportunities for bioswales.

Nature-based approaches, which include green infrastructure, was the most selected adaptation measure in the mid-project survey, suggesting that a public campaign to increase green infrastructure may be successful.

5. Evaluate the feasibility of adopting a stormwater authority: Resiliency action recommendations #3 and #4 above present ways to improve the existing stormwater system. A stormwater authority (or utility) may be established in a certain area (watershed, municipality, etc.) as a means for collecting revenue from the properties that are contributing to the loading of the stormwater system. These types of stormwater authorities use a variety of different techniques to assign fees, from flat rates to a fee based on the amount of impervious area on a property. Often, the fees amount to only a few dollars per month per property, which when distributed over a large area can produce hundreds of thousands of dollars or more of usable revenue for stormwater improvements. A pilot project was recently implemented in New London, Connecticut and has been used to fund stormwater pumps to mitigate flooding in its downtown. Challenges to the implementation of a stormwater authority are mainly administrative and political. An equitable system for establishing the fees must be developed and public education and outreach must be performed so users of the stormwater system understand their role in contributing to flooding issues and how they can help mitigate them.

6. Pursue partnership opportunities with the State Department of Transportation to assess state-owned stormwater infrastructure: West Main Street is a state road, and as a result, the state owns and manages its associated stormwater drainage network. One of the outfalls connected to the network is located adjacent to the Steamboat Wharf Condominiums. Residents have observed pollutants and sediment entering the Mystic River from that outfall for over a decade. The Town should seek opportunities to engage the state in evaluating the condition of the existing system and identifying possible ways (which could also improve public education and outreach) to improve the quality of the water that drains from it.

7. Stockpile materials and procure sump pumps, generators, etc. for responding to flooding: One of the ideas suggested multiple times during the project was to stockpile materials needed to prepare for, or respond to, flooding events. Some property owners asked about the availability of sand bags whereas others explained that they don’t have the space to store a generator and trying to find one to rent prior to a forecasted storm is next to impossible. The Town of Groton could purchase and stockpile equipment that could be loaned during flood events to both residential and commercial property owners. The upfront and maintenance costs would be borne by the Town, however, it would lead to an overall increase in resilience for the main commercial district in the study area, the business and building owners of which may not otherwise be able to procure equipment. Providing access to such equipment during flood events would help businesses bounce back more quickly after a flood event, reducing the amount of time lost recovering from flooding, and reducing the impact of flooding on commercial activity in Downtown Mystic.

8. Increase shade through additional tree cover or canopies: It is acknowledged that space around the West Main Street corridor is very limited for adding trees or built shade structures. However, adding green space and vegetation is one of the most effective ways to reduce heat island effects and provide cover. Small footprint tree boxes could be considered to reduce the potential for root zone conflicts with existing utilities. This strategy is also consistent with reducing stormwater impacts, as trees and tree boxes can help to reduce the quantity of runoff and improve runoff water quality. Groton’s Parks and Recreation Department is implementing a street tree inventory

and community forest management plan project; recommendations from that effort and the suite of recommended tree species to be used for future planning should be followed. Built structures such as canopies also could provide shade, albeit without the stormwater benefits. In addition to the West Main Street area, there exists potential for additional shade structures at Mystic Academy Park in the upper watershed area. Maintenance would be required (e.g., cleaning and repair of canopies; removal of leaf litter, etc.) and should be considered during project planning.

9. Strengthen building standards: The Town of Groton Zoning Regulations are robust when it comes to construction in flood hazard areas. For residential buildings in the A and AE zones (1% annual chance of flooding, or "100 year floodplain") all new construction, substantial improvements, and repair to structures that have substantial improvements are required to have the bottom of the lowest floor, including basement, elevated one (1.0) foot above BFE, which is 11 feet in most of the study area. Electrical, plumbing, machinery, and other equipment that service the structure must be elevated 1.0 foot above the BFE as well. Commercial, industrial, or non-residential structures within those zones must be elevated to the same standard as residential structures or be floodproofed to 1.0 foot above the BFE. Additional regulations apply. These zones cover a significant portion of the study area; see Figure 21.

   However, changes could be enacted to further strengthen these regulations. CIRCA's "Zoning for Resilience" training program suggests considering the following options:
   - Further strengthening the definition of "substantial improvement" by lowering the cost threshold below 50% or lengthening the lookback period over which the improvements are made, which is currently one year.
   - Using overlay zones to add additional protections to specific areas (such as a watershed). Overlay zones could be used to add regulations to protect natural resources, such as riparian buffers. Some municipalities, such as South Kingstown, Rhode Island, have created coastal overlay zones that integrate SLR projections instead of solely basing boundaries on FEMA maps.

   In addition to these flood-specific approaches, the standards could also be strengthened to reduce the impacts of extreme heat. Examples include requiring new construction to use heat-resistant materials, light-colored roofing materials, and "cool" pavements and creating energy efficiency standards for heating and cooling systems. To increase shade, regulations could encourage partial shading of outdoor spaces.

10. Dry floodproof Gravel Street pump station: The Gravel Street pump station is part of the sanitary sewer system, which is described as being a "lifeline system" in section 2.2.8. The consulting firm Wright-Pierce evaluated the Town's flood-vulnerable pump stations, including the Gravel Street pump station, in 2022 and recommended floodproofing actions. The recommended actions include installing a flood door (a structural evaluation will need to be conducted first), ensuring tank components are water-tight, protecting or relocating equipment, and considering replacing the fuel tanks that support the emergency generator. If a flood door is not installed, temporary flood barriers would provide protection while allowing access to all openings during periods of non-flooding. Public Works personnel would need to be on site to deploy temporary barriers at the pump station before a flood event. Examples of deployable flood barriers are shown in Figure 60 to Figure 62. Partial funding for pump station resiliency upgrades was approved as part of the Town's FYE2024 capital improvement budget.

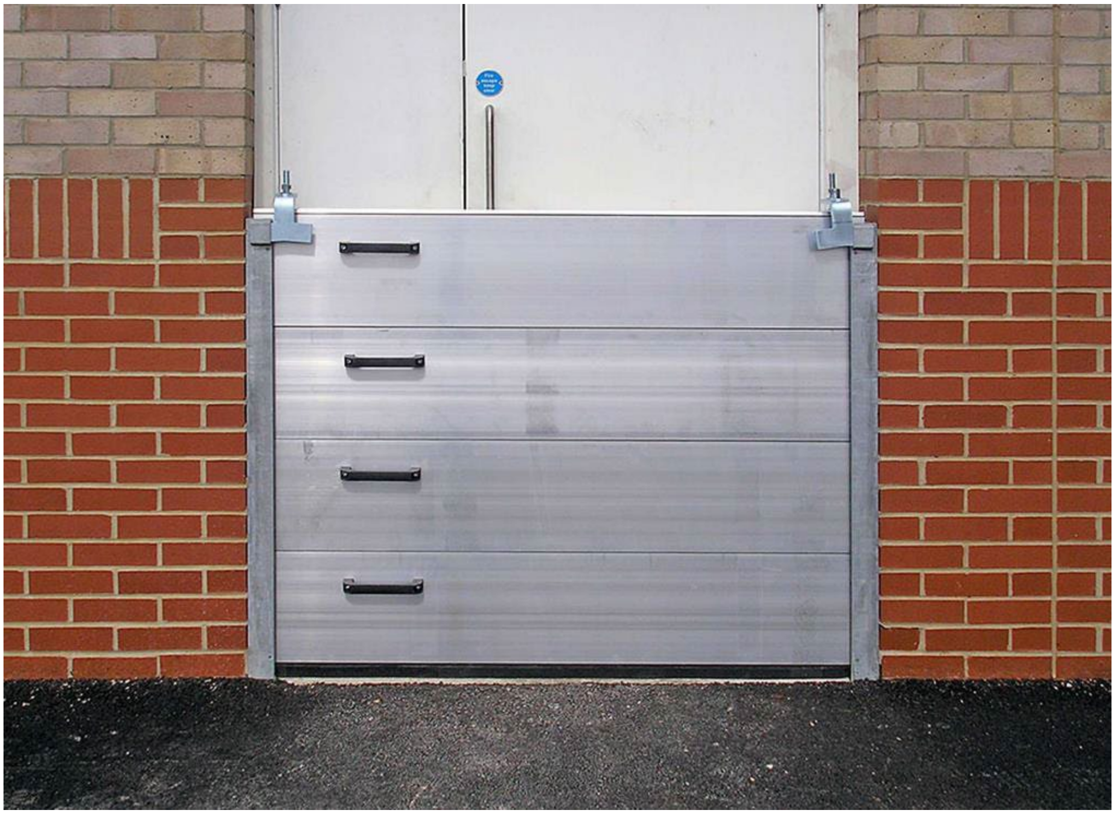

Figure 60: Temporary flood barrier example: Stoplog System (for openings such as doorways)

Figure 61: Temporary flood barrier example: AquaFence

Figure 62: Temporary flood barrier example: bladder dam

11. Implement temporary, pop-up cooling measures: Expanding the network of cooling locations on a temporary basis in targeted areas with significant foot traffic can reduce heat exposure for residents, employees, and visitors. These measures will be particularly important during large outdoor events, such as the Mystic Outdoor Art Festival. Outdoor pop-up measures can include tents, umbrellas, and misting stations. These measures could be quickly assembled when heat advisory or excessive heat warnings are anticipated to be issued by the National Weather Service. These measures do require labor to deploy and, in some cases, staff. Equipment must also be stored and maintained when not in use. Potential locations for temporary cooling measures include the area on the corner of West Main Street and Water Street in front of Bank Square Books or the John Kelly parklet. This action is an example of both the "cooling measures" and "increased administrative controls" options that were popular with respondents of the mid-project survey.

12. Increase reach of and public participation in emergency warning systems: It is critical that people are made aware of flood hazards so that they can remain safe. The town should pursue signage on Gravel St, Pearl St, and Water St to indicate that they may flood. Although Mystic residents know to avoid these areas during storms, visitors from out of town may not. The Town uses a variety of tools to issue emergency notifications, including direct messaging through phone and email as well as through local news outlets, the internet, and social media. The Town participates in the CT Alerts system, which is operated by the State of Connecticut. Signing up for CT Alerts is one of the quickest and easiest disaster preparation actions to complete. However, the results of the mid-project survey showed that only 47% of respondents who live or work in Mystic and 57% of respondents who visit Mystic had enrolled in the system. The Town should run an information campaign to increase participation in this system as well as encourage other disaster preparations. The FEMA *2023 National Household Survey on Disaster*

Preparedness: Key Findings[19] report should be used as a resource to help inform campaign development.

13. Assist local businesses with resiliency planning: The local business community is at the core of what makes Mystic a special place to live in and visit, and it will be critical to help local businesses and property owners prepare for, and respond to, climate change impacts. Taking action before a disaster can be very economically beneficial for businesses and property owners; research conducted by the Critical Infrastructure Resilience Institute found that businesses avoided $4.57 in losses for every $1.00 invested on resilience actions related to Superstorm Sandy and Hurricane Harvey. However, with so much to manage keeping the doors open day to day, spending time to prepare for future issues can seem like a luxury that many local businesses and property owners do not have time to address. The Town should assist by bringing in added capacity through interns or fellows to directly support local businesses and property owners in resilience-building planning and action. The lessons learned through these interactions could then inform a storm preparedness and response plan to be created by the Town that identifies critical actions that will be needed post-response to help reduce business disruption.

14. Develop a post-disaster response/recovery plan: According to FEMA, "the purpose of a post-disaster redevelopment or recovery plan is to facilitate pre-disaster planning in a way that guides long-term recovery efforts [five years or more] following a disaster." Post-disaster response and recovery planning can help ease decision-making and action in the aftermath of catastrophic events. Having these plans in place can also help ensure that rebuilding is done in a resilient way that fits the community vision by integrating social and economic drivers[20].

15. Partner with CIRCA for a heat study: Researchers at CIRCA have been studying extreme heat in Connecticut municipalities. The Town should continue conversations started the previous summer as to whether Groton (and Mystic) could be the location of a future study. This would provide additional data needed to inform heat education and outreach campaigns as well as preparation and response strategies, and is an example of a data-driven approach that 54% of mid-project survey respondents thought should be further considered.

Table 24 provides an overview of the high priority resilience action recommendations with rough cost estimates. The following scale is used in the relative cost column:

- $ less than $250,000
- $$ $250,000 - $1,000,000
- $$$ $1,000,000 - $10,000,000
- $$$$ more than $10,000,000

[19] FEMA. 2023. *2023 National Household Survey on Disaster Preparedness: Key Findings*. https://fema-community-files.s3.amazonaws.com/2023-National-Household-Survey.pdf

[20] FEMA. *Building Community Resiliency by Integrating Hazard Mitigation: Planning for Post-Disaster Redevelopment*. https://www.fema.gov/sites/default/files/2020-07/post-disaster-redevelopment-planning.pdf

Table 24: Summary of high priority resilience action recommendations

Action #	Description	Protect, Accommodate, Retreat	Non-Structural, Structural, Nature-Based	Benefits	Challenges	Relative Cost
1	Install functional backflow preventers on stormwater outfalls	Protect	Structural	Reduces total flow in stormwater mains during combined coastal and intense precipitation events, reduces sunny day flooding	Requires annual or more frequent maintenance and permitting for work in and under water	$$
2	Develop an approach to elevate low-lying roadways	Protect	Structural	Helps reduce roadway inundation, improving emergency access	Area is highly developed, BFE is many feet above existing roadways	Study: $ Implementation: $$$
3	Evaluate Pearl Street stormwater improvement alternatives	Accommodate	Non-structural	Develops scalable recommendations to improve capacity or flow, reducing flooding	Requires survey data and elevation information for stormwater system	$
4	Reduce pressure on stormwater system through green infrastructure					
4a	Outreach to local landowners	Accommodate	Nature-Based	Reduces peak runoff during storm events, improves water quality	Requires buy-in and funding from private landowners	$
4b	Green infrastructure on Town-owned lands	Accommodate	Nature-Based	Reduces peak runoff during storm events, improves water quality	Limited space available, unknown subsurface conditions	$$
5	Evaluate feasibility of a stormwater authority	Accommodate	Non-structural	Establishes a revenue source dedicated to stormwater improvements	Requires education and outreach to overcome potential political barriers	$
6	Pursue partnership opportunities with state DOT.	Accommodate	Non-structural	Improve water quality in Mystic River by evaluating stormwater discharge.	State ownership of infrastructure could lead to challenges.	$
7	Stockpile emergency	Accommodate	Non-structural	Aids property owners who	Up-front costs to create	$-$$

	response materials			cannot procure or store equipment themselves, increases resilience of commercial district	and administer to be borne by the Town, demand may be greater than need, requires developing new processes to lend materials	
8	Increase shade through tree cover or canopies	Protect	Nature-Based or Structural	Mitigates heat island effects, trees provide water quality co-benefits	Space is limited, trees may increase maintenance (leaf cleanup, etc.)	$$
9	Strengthen building standards	Protect or accommodate	Non-structural	Variety of approaches can be used to provide additional protections	Political push-back	$
10	Dry floodproof Gravel Street pump station	Protect	Structural	Protects critical function of pump station equipment during floods, maintaining service	Temporary barriers would require personnel on-site to deploy	$$
11	Implement cooling measures	Accommodate	Structural	Helps people avoid health impacts of extreme heat	Space is limited	$
12	Increase public participation in emergency warning systems	Accommodate	Non-structural	Helps ensure people will receive emergency notifications before a disaster	Campaign will need to overcome barriers to participation	$
13	Assist local businesses with resiliency planning	Accommodate	Non-structural	Potentially helps businesses re-open more quickly after a disaster by having planned and prepared	Local business owners have very limited time	$
14	Develop a post-disaster response/recovery plan	Accommodate	Non-structural	Facilitates resilient recovery and rebuilding	Requires time and effort from a variety of stakeholders	$
15	Partner with CIRCA on a heat study	Accommodate	Non-Structural	Informs heat education campaigns and future extreme-heat preparation and response strategies	Academic expertise and technical equipment are needed	$

6.2 BEST PRACTICES FOR PROPERTY OWNERS

As sea levels rise and storms worsen, strategies currently used by property owners (residential and commercial) may no longer be sufficient. This section describes a number of best practices that should be considered to build additional resilience. Although employing these approaches in historical buildings may provide unique challenges, there are paths forward. Helpful resources include the Cape Cod Commission's *Flood Area Design Guidance for Cape Cod* and the National Park Service (US Department of Interior) *Guidelines on Flood Adaptation for Rehabilitating Historic Buildings*.

1. Install sump pumps in basements to remove floodwaters: Sump pumps are generally automatically-triggered when groundwater levels get high enough to approach basement floor elevations. Sump pumps can discharge to adjacent land surfaces or (if permissible) be connected to the stormwater system (with a backflow preventer). During the field assessments, several homeowners in the area reported having sump pumps installed in their basement, but several did not and reported basement flooding. Sump pumps can be used for floodwaters caused by either coastal or intense precipitation flooding. Note that sump pumps are generally more useful for minor floods or to reduce flood duration, not necessarily as a flood prevention measure.

2. Relocate or elevate critical equipment: It is important to keep critical equipment and machinery above flood elevations to avoid damage or destruction of important systems (i.e., HVAC). Relocation of critical equipment would involve moving machinery away from low lying areas on the property or in the building. Moving electrical panels to higher elevations or elevating HVAC equipment off the ground would improve resilience to flooding. Some machinery could potentially be relocated into attic or rooftop spaces.

3. Wet Floodproofing: Wet floodproofing prevents or reduces damage from flooding by allowing flood waters to enter and exit the structure without the use of pumps or other manually activated devices. In accordance with National Flood Insurance Program (NFIP) and building code regulations, wet floodproofing can be performed under certain circumstances, and is limited to enclosures used solely for parking of vehicles, building access, or storage. Wet floodproofing involves using water and corrosion resistant construction materials and flood vents.

4. Dry Floodproofing: Dry floodproofing makes property more resistant to flooding through the use of flood barriers at building penetrations below the design flood elevation. Dry floodproofing is typically limited to about 3 feet of flood depth. It can be accomplished through the use of permanent or temporary flood barriers. Temporary flood barriers are deployed when a storm event is forecasted, then removed after floodwaters have receded. Examples of deployable flood barriers are shown in Figure 60 to Figure 62. Dry floodproofing of residential structures comes with two significant caveats per FEMA guidance[21]: (1) dry floodproofing cannot be used to bring a Substantially Improved or Substantially Damaged home into compliance with the requirements of floodplain management regulations; and (2) dry floodproofing measures can fail during floods larger than the design flood or if the measures are not adequately designed and constructed to withstand flood forces. Installing deployable, temporary flood barriers to protect building openings in the West Main Street area could be a feasible option reduce interior flood damages. Permanent flood barriers would require a more regional approach. Temporary flood barriers would ideally protect all building openings, including the storefront windows along West Main Street as well as the rear entrances of the buildings. The businesses would need somewhere to store the deployable barriers when not in use and need to train staff how to properly install the barriers. GZA interviewed several business employees during the field reconnaissance that indicated temporary flood barriers (i.e. sandbags) have already been used during floods. Other deployable measures that could help include stoplog or flood panel systems for doorways and windows. Deployable measures that require permanent features such as anchor points or panel slots must comply

[21] FEMA. 2014. *Homeowner's Guide to Retrofitting: Six Ways to Protection Your Home From Flooding* (FEMA P-312, 3rd Edition. https://www.fema.gov/sites/default/files/2020-08/FEMA_P-312.pdf

with historical preservation goals and requirements.

5. Increase Building Elevations: This measure is the raising of existing structures to an increased height. Although it was not a popular option in the mid-point survey, it may be the best option some property owners have to protect their buildings. Cape Cod Commission's *Flood Area Design Guidance for Cape Cod* report explains that strategies including elevating all buildings in a neighborhood to a consistent height, maintaining street level interest, and installing layers of landscaping and fencing can help improve the visual appeal of elevated buildings. The Town of Groton's zoning regulations require that all for residential buildings in the A and AE zones, all new construction, substantial improvements, and repair to structures that have sustained substantial damage which are residential structures shall have the bottom of the lowest floor, including basement, elevated one (1.0) foot above the BFE. Most of the study area has a BFE of 11 feet, which would set the minimum elevation of the bottom of the lowest floor at 12 feet (not including projected SLR). If substantial improvement requirements do not apply (such as if the property owner is voluntarily opting to elevate the structure), and FEMA funds are not supporting the project, the property owner can apply their own discretion as to the design elevation. However, elevating to heights below the BFE will provide less protection and may not yield reductions in flood insurance rates.[5]

6.3 LOW PRIORITY RESILIENCE ACTION RECOMMENDATIONS

These actions, though popular with some Mystic residents, each pose such significant barriers to implementation that they should not be the immediate focus of plan implementation. These actions will be revisited periodically as conditions change to reevaluate their potential.

1. Downstream Flood Barrier in the Mystic River / Floodplain: This idea consists of constructing a flood barrier with a closeable gate and adjoining earthen embankment on the Mystic River downstream of the study area to protect the region including and beyond the study area from storm surge. It is important to note that a flood barrier would not provide permanent protection from incremental SLR. The railroad embankment near the southern end of the study area was mentioned during outreach, since it already acts somewhat as a barrier between Downtown Mystic and the Fishers Island Sound. Elevations of the top of the embankment currently range from approximately 14 feet at the Mystic River Railroad Bridge to approximately 9 feet at Tufts Cove. The top of the Mystic River Railroad Bridge is higher than the present day and future 100-year flood elevation; however, the grade at Tufts Cove is not. Therefore, additional embankments or walls would be needed to extend the flood protection elevation (Figure 63). This alternative would need to consider how the flood barrier affects the areas south of the barrier. Additionally, pump stations may be needed to accommodate incoming river flow during periods when the gate is closed. The usage of the embankment as an active railroad and associated ownership issues may make this option infeasible. It is unknown if the embankment soil material is capable of holding back significant flood waters.

Figure 63: Potential layout of Mystic River flood barrier (on top of present day FEMA flood zones)

This type of project would require the cooperation of the USACE, which built a number of similar systems in New England in the 1960s as a direct response to the destruction caused by Hurricane Carol in 1954. Mystic was one of the sites considered at that time, but was likely rejected either because the benefit:cost ratio (a required consideration of USACE and FEMA programs) was not favorable or because the required local cost share could not be provided[22]. These two obstacles would likely still apply today. It is unlikely that a favorable benefit:cost ratio would be met for the project, and if it were, the Town of Groton would have to provide an impracticable amount of funding as a share of the project cost as well as continued funding to operate and maintain it. Compared to the projects constructed in the 1960s, similar projects today would be hampered by much more expansive and extensive environmental impact studies, more challenging permitting and property rights negotiations, and higher property values (which would make easement and construction access more difficult)[23].

2. <u>River Wall or Levee Along the Mystic River:</u> To protect the study area, the levee or floodwall would need to tie into high ground at the southwest corner of the study area (e.g., on Noank Road near Tufts Cove) and at high ground north of the study area near the intersection of River Road and Starr Street. Alternatively, the levee or floodwall

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[22] USACE. 2007. *Hurricane Barriers in New England and New Jersey – History and Status After Four Decades*. https://apps.dtic.mil/sti/pdfs/ADA473784.pdf

[23] Morang, Andrew. 2016. *Hurricane Barriers in New England and New Jersey: History and Status after Five Decades*. J. of Coastal Research, 32(1):181-205. https://doi.org/10.2112/JCOASTRES-D-14-00074.1

could extend beyond the study area, protecting additional areas. No matter the design flood elevation, a levee, floodwall, or elevated bulkhead introduces significant hurdles: (a) waterfront access or views may be obstructed by the barrier and interior drainage needs to be provided or improved, (b) construction of a levee, floodwall, or elevated bulkhead needs to be evaluated for worsening flood conditions nearby, for example the Town of Stonington along the eastern shore of the Mystic River; (c) the levee/floodwall/bulkhead will not prevent backflow through storm sewers, and tide gates would be required along drainage outfalls (d) the extent of riverfront means the wall or levee would need to be miles long; and since most of the riverbank area is privately owned, agreements between the Town and private owners to construct the barrier (and maintain it in the future) would need to be reached. For example, property owners on Gravel Street would have to agree to the wall blocking access to the land they own on the river-side of the road. A potential layout of the Mystic River floodwall/ levee is presented in Figure 64.

Figure 64: Potential layout of Mystic River floodwall / levee (on top of present day FEMA flood zones)

3. Stormwater retention/detention storage systems: Stormwater retention/ detention systems like detention ponds or subsurface tanks are generally located in low-lying areas to allow runoff to naturally drain to them. These systems provide storage for stormwater to be temporarily retained instead of ponding on roadways or private properties. Given the flooding that occurs on Pearl Street, the applicability of detention/retention systems was evaluated. However, the immediate area is largely developed and impervious. There is not enough space above ground for a detention pond (which also limits the potential for green infrastructure components like rain gardens). Other

utilities below ground such as the sanitary sewer system would make it extremely challenging, if not impossible, to accommodate subsurface storage. The feasibility of this system is also dependent on groundwater elevations and soil conditions. If this action was to move forward, it would likely require the purchase of privately-owned land.

6.4 EDUCATION, OUTREACH, AND PARTNERSHIP-BUILDING

In order to be successful, the recommendations presented in this report will need to be supported through extensive community outreach and education. In addition to public meetings, webinars, trainings, and other traditional outreach approaches, it will be helpful to have a “boots on the ground” approach to disseminate information. The Groton Community Policing Office could serve as an information conduit; investing in the continuity of this building and its operations will be important. Public information installations, such as through art, displays of past storm surge level, etc. should also be considered. Non-profit partners, such as Groton Conservation Advocates and the Alliance for the Mystic River Watershed, may be able to help expand the reach of outreach approaches and create larger community conversations.

7.0 CLIMATE ADAPTATION, SUSTAINABILITY, AND RESILIENCE FUNDING PROGRAMS

Many funding sources are available to potentially offset costs of implementation of the recommended climate adaptation and resiliency measures. Please note that the following funding information is subject to change as these programs are modified and ended, and as new programs and regulations may be implemented.

7.1 FEDERAL RESILIENCE FUNDING PROGRAMS

The Bipartisan Infrastructure Law (BIL) is a five-year (covering fiscal years 2022-2026) federal infrastructure funding program that includes $23.3 billion in funds for Natural Disaster Mitigation and Prevention. BIL provides direct funding to states and grants for municipalities and not-for-profit organizations. Depending on the funding program, the grants may pay for 75% or more of the costs for eligible climate resilience projects. This legislation creates a once in a generation level of federal funding assistance, but the legislation ends September 30, 2026. If not expanded or renewed, projects funded through fiscal year 2026 can be completed through fiscal year 2029. Three years is an aggressive schedule to advance a project from a plan into design, permitting and obtain funding for construction given the delays inherent in using government grant programs.

Examples of commonly pursued federal grant funding programs for flood mitigation and climate adaptation projects identified in this Plan include[24]:

- FEMA Building Resilient Communities and Infrastructure (BRIC),
- Hazard Mitigation Grant Program (HMGP),
- Flood Mitigation Assistance (FMA) Fiscal Year 2023 Notices of Funding Opportunities for Hazard Mitigation Assistance Grants | FEMA.gov;
- U.S. Department of Housing and Urban Development (HUD) Disaster Recovery and Resiliency Grants including Community Development Block Grant – Disaster Recovery (CDBG-DR);
- NOAA and National Fish & Wildlife Federation (NFWF) National Coastal Resiliency Funds and Long Island Sound Futures Funds;
- US. Department of Commerce Economic Development Administration (EDA) Disaster Recovery Grants; and
- US DOT Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Grants.
- Connecticut Sea Grant Program's sustainable and resilient community extension educator team website has a list of current and upcoming federal, state and philanthropic grant opportunities on their website at Current and upcoming grant opportunities | Connecticut Sea Grant (uconn.edu)

The Report of the Financing and Funding Adaptation and Resilience Working Group Prepared for the Governor's Council on Climate Change (GC3) dated November 2020, Table 1 on page 60, entitled "Existing State Financing and Funding Mechanisms for Climate Adaptation and Resilience" provides a comprehensive summary of funding programs applicable to the projects recommended in this Plan. This table summarizes which funds are applicable for pre-disaster projects and post-disaster projects, as well as which phases of a project costs are eligible (planning, design, permitting, construction).

This GC3 Report is online at https://portal.ct.gov/-/media/DEEP/climatechange/GC3/GC3-working-group-reports/GC3_Financing_funding_Adaptation_Resilience_Final_Report_111320.pdf

Note that funding under these federal grant programs have a set aside for up to 40% of the benefits of the funding for environmental justice communities under the Justice 40 program. In addition, federal grant funding from HUD, EPA, DOT, FEMA,NFWF and NOAA typically allows for construction of projects to be completed up to 3 years after the fiscal year of the grant award. So, a construction grant awarded in FY2026 may be completed up to September 30, 2029.

[24] GZA has summarized the federal grant funding programs on its website at https://service.gza.com/infrastructure with specific updates on programs available to municipalities in Connecticut.

It is important to note that accepting federal funding for flood mitigation / adaptation projects may increase the performance standards required for a project in order to comply with higher state or local floodplain management standards. Such standards may include using a 1 percent annual chance event with SLR and freeboard considerations (e.g., 1 to 3 feet), or using a 0.2 percent annual chance event with SLR and freeboard considerations (e.g., up to 2 feet). Depending on the project, the requirements of the state, as applied through the permit review process, may require even more robust performance standards. For example, the State of CT requires elevation to the 0.2 annual chance event plus two feet to account for sea level rise for residential structures in a floodplain.

The proposed Federal Flood Risk Management Standard (FFRMS), if approved in 2024, would apply to any Federally Funded Project (for example flood mitigation or climate adaptation projects when FEMA determines that the project uses FEMA funds for new construction, substantial improvement, or to address substantial damage to a structure or facility). This proposed rule change requires FEMA to first determine whether the proposed action falls within the definition of an "action subject to the FFRMS". According to FEMA, the rule will also apply to hazard mitigation projects involving structure elevation, dry floodproofing and mitigation construction. A summary of the FEMA's Proposed FFRMS Rule and changes to both eight-step process and the standard that applies to FEMA's actions can be found at the Association of State Floodplain Managers (ASFPM) website[25]. The FFRMS Rule is referenced in Executive Order 13690 by President Obama. President Trump discontinued EO 13690 and President Biden reinstated it. EO 13690 and the FFRMS rule applies to federal agencies beyond FEMA. Federal agencies are evaluating the proposed rule and will need to show how they are going to implement any changes in their decision-making process concerning flood resiliency, and how they will implement the new standard in their agencies. Applicants to federal grant and loan programs should plan to comply with the rule for projects initiated on the effective date of the rule.

7.2 STATE FUNDING PROGRAMS

Connecticut also has increased its available state grant funding for resilience projects due in part to the federal funding the State will receive for spending through September 30, 2026. Grant funding received from the Connecticut DEEP Climate Resilience Fund (DCRF) is limited to planning, design and permitting climate adaptation projects and requires the grantee to commit to pursue federal grant funding for advancing projects into construction with non-federal matching funds at 25-50%. Note that DCRF grants have a set aside for up to 40% of the benefits of the funding for environmental justice communities. A date for Round 2 DCRF Track 2 project development grants to pursue design and permitting of projects identified in this Plan has not been announced as of January 2024.

It is very important to note that the State of Connecticut defines via C.G.S. Sec 25 that flood mitigation and climate adaptation projects funded with federal or state grant or loan are a *Proposed State activity* and defines *critical activity* as including but not limited to the siting of housing for the elderly, schools or residences in the 0.2 percent floodplain in which the Commissioner [of DEEP or its representative] determines that a slight chance of flooding is too great. As a result, state permitting and design of flood mitigation and climate adaptation projects funded by state grants or loans to protect residential structures are typically regulated to a state flood protection standard of the 0.2 percent annual chance flood elevation with an additional freeboard requirement to account for SLR of up to 2 feet. These regulatory requirements may significantly increase the design flood elevation requirements proposed to mitigate the flood risks of existing structures in the floodplain, though DEEP's interpretation of these rules may change over time.

On January 17, 2024, the Connecticut Green Bank announced in a webinar that it will expand their Smart-E Loan program into environmental infrastructure per C.G.S 22-6 to help homeowners become more resilient by reducing flood impacts. New eligible upgrades that homeowners can obtain Smart-E loans for include:

1. Elevate electrical, mechanical, and battery storage service equipment,
2. Install high impact glass windows,
3. Install storm shutters,
4. Floodproof basement windows

[25] www.floods.org - search for FFRMS

5. Storm hardening of HVAC service equipment, and
6. Inspection of anchor systems for solar panels.

The Connecticut Green Bank (www.ctgreenbank.com) indicated at its January 17, 2024, Winter Quarterly Webinar plans to expand the Smart-E Loan Program again in 2024 to add additional flood resiliency measures for homeowners in G.G.S. 22-6 which will be subject to public comment when introduced as proposed legislative changes. The Connecticut Green Bank also indicated at this webinar plans to offer financing of Resilience Hubs, facilities which can operate during power outages, which may be a method for the Town to finance an emergency equipment rental facility for homeowners and business needing emergency power supplies in the event of a power outage to provide power for sump pumps.

Examples state grant funding, non-federal matching fund investment methods and financing programs include:

- **Long Island Sound Resilience Grant Writing Assistance Program** which is administered by University of Connecticut's Sea Grant Program to enable municipalities in the Long Island Sound Coastal Area to retain a qualified grant writing contractor to assist in preparing grant applications for projects that benefit the resiliency and sustainability of Long Island Sound and its communities. A link to the RFP which is available on a rolling basis until funds are spent and list of pre-qualified grant writing consultants are online at New 2023 Long Island Sound Resilience Planning and Updated Grant Writing Support Opportunities | Connecticut Sea Grant (uconn.edu)

- **The CIRCA Resilient Connecticut Phase III Program** funding is now available to municipalities in central and eastern Connecticut through 2024 due to funding received from the State of Connecticut. A contract for consultants to assess concept projects in several municipalities in Eastern Connecticut over the next three years was awarded effective October 25, 2023. Several consultants, including GZA, have been prequalified to work on projects with funding and management by CIRCA to help municipalities advance climate adaptation projects through feasibility analysis, conceptual design, cost estimating and benefit cost analysis to improve the competitiveness of the projects for federal and state grant applications for design, permitting and construction. Alternatively, municipalities can hire the CIRCA approved consultants directly with municipal or other grant funds if the consultant had agreed in the Resilient Connecticut Phase III Procurement to allow their CIRCA contract rates to also be available directly to municipalities.

- **The DEEP Climate Resilience Fund (DCRF)**[26] has completed one round of grant awards totaling $8.8 million announced in June 2023, which included Town of Groton. Connecticut DEEP is expected to open a second round of grant applications in 2024 after the contracts for the first round are completed. Note that 40% of the grant funds for the DCRF are designated for benefitting distressed communities and environmental justice communities. Connecticut DEEP indicated that an estimated 93% of the first round of grant funds benefitted distressed communities. The Town has been awarded a DCRF grant in round 1 and is awaiting transfer of funds from the State. DEEP Commissioner Katie Dykes indicated at the *2023 CIRCA Summit: A Climate Resilience Roadmap for Connecticut, December 1, 2023*[27] that the DCRF will be continued in 2024 and that DEEP will allow future use of the DCRF by municipalities for non-federal matching funds for pursuit of federal climate resiliency grants for advancing projects into construction.

- CT DEMHS has **Emergency Management Performance Grant (EMPG)** funds from FEMA they plan to make available to municipalities as a grant application in March 2024, which was presented by Douglas Glowacki, CT DEMHS, during a November 1, 2023 Connecticut Association of Flood Managers Annual Conference. The EMPG provides state, local, tribal and territorial emergency management agencies with the resources required for implementation of the National Preparedness System and works toward the National Preparedness Goal of a secure and resilient nation.

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[26] https://portal.ct.gov/ConnecticutClimateAction/Executive-Order/DEEP-Climate-Resilience-Fund#:~:text=Applicants%20can%20seek%20up%20to,change%20increases%20weather%2Drelated%20risks
[27] https://resilientconnecticut.uconn.edu/2023-circa-summit/

The EMPG's allowable costs support efforts to build and sustain core capabilities across the prevention, protection, mitigation, response and recovery mission areas. Up to $30,000 per municipality is available in 2024.

- Public Act No. 19-77, **An Act Authorizing Municipal Climate Change and Coastal Resiliency Reserve Funds**, effective July 1, 2019 enables municipalities "upon the recommendation of the chief executive officer of a municipality and approval of the budget-making authority of the municipality, the legislative body of any municipality, as defined in section 7-369 of the general statutes, may, by a majority vote, [to] create a Climate Change and Coastal Resiliency Reserve Fund." The Town can, " upon the recommendation of the chief elected official and budget-making authority of such municipality and the approval of the legislative body of such municipality [for example the Town of Groton's Selectman- Town Council- Representative Town Meeting] of any part, or the whole, of such reserve fund may be used and appropriated to pay for *municipal property losses, capital projects and studies related to mitigating hazards and vulnerabilities of climate change including, but not limited to, land acquisition*." According to a CIRCA publication, *Branford's Coastal Resiliency Reserve Fund - Planting Seeds for the Future*, "the Town of Branford's climate resiliency reserve fund was highlighted among the factors that supported a AAA rating of the Town's long-term General Obligation Bond by S&P Global Ratings in a 2019 report for investors[28]. It is clear that the approach towns and states use to manage the long-term financial risks of climate change will continue to factor into borrowing costs and investors' willingness to purchase their debt." The Town of Groton can take advantage of P.A. 19-77 to establish a dedicated reserve fund that can be managed for growth over time for a future need or to access funds in response to a natural disaster or as a source of matching funds for state and federal climate resiliency grants.

- P.A. 21-115 **An Act Concerning Climate Change Adaptation**, allows municipalities to create a **stormwater authority**. P.A. 21-115 indicates the purposes of the stormwater authority shall be to:

  1. Develop a stormwater management program (including, but not limited to):
     - For construction and post-construction site stormwater runoff control, including control detention and prevention of runoff from development sites
     - For the control and abatement of stormwater pollution from existing land uses and the detection and elimination of connections to the stormwater system which threaten public health, welfare, or the environment
  2. Provide public education and outreach, as well as establish procedures for public participation
  3. Provide for the administration of the stormwater management program
  4. Establish the geographic boundaries of the stormwater utility district
  5. Recommend to the legislative body of the municipality the imposition of a fee on the interests in real property as the revenues to be used in carrying out the powers of the district. The utility may plan, layout, acquire, construct, reconstruct, repair, maintain, supervise, and manage stormwater control systems.

NEXT STEPS

- Review technical guidance and resources from Connecticut DEEP on grant application strategies for success that are available at the Connecticut Association of Flood Managers (CAFM) website.[29]

- Evaluate establishing a Climate Change and Coastal Resiliency Reserve Fund to create a governance process for managing a dedicated source of municipal funding for investing in addressing "*municipal property losses, capital projects and studies related to mitigating hazards and vulnerabilities of climate change including, but not limited to, land acquisition."*

- As of October 16, 2023, a **second round of the Long Island Sound Resilience Grant Writing Assistance Program** is

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[28] https://resilientconnecticut.uconn.edu/wp-content/uploads/sites/2761/2021/05/CIRCA-branford-4page-spread-FINAL.pdf

[29] www.ctfloods.org at the events page for the CAFM 10th Annual Conference November 1, 2023. The Climate Resilience Fund Presentation by DEEP is at: https://ctfloods.org/wp-content/uploads/2023/11/Watson_2023-11.01-CAFM-DEEP-DCRF.pdf

available, which enables the Town to hire qualified consultants to provide technical and administrative grant writing services up to $9,950 per grant application. There is no grant request deadline, and a municipality can apply for multiple grants. If the proposed climate resiliency project is approved by University of Connecticut Sea Grant and funds are available, the grant writing consultant is paid directly by University of Connecticut on behalf of the grant applicant.[30] The funding is available to municipalities advancing the planning, design, permitting and construction of projects and increasing the competitiveness of municipalities applying for federal grants to benefit the sustainability and resiliency of Long Island Sound and watersheds impacting the Sound.

- Leverage the University of New Hampshire Sustainability Institute Fellowship Program to help the Town in resilience-building for local businesses.
- Evaluate Town Capital Improvement Plan project possibilities for the next fiscal year budget.

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30 https://longislandsoundstudy.net/about/grants/grants-and-grant-writing-assistance-opportunities/long-island-sound-resilience-grant-writing-assistance-program/

ATTACHMENT 1: TERMINOLOGY

Floodplain: Any land area susceptible to being inundated by water from any source as the "floodplain."

Base Flood: A flood having a 1% chance of being equaled or exceeded in any given year. The base flood is the national regulatory standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development.

Base Flood Elevation: The elevation shown on the Flood Insurance Rate Map (FIRM) for Zones AE, AH, A1-30, or VE that indicates the water surface elevation resulting from a flood that has a 1% chance of occurring in any given year. In coastal areas, BFEs are calculated by taking into account: 1) the storm surge stillwater elevation, 2) the amount of wave setup, 3) the wave height above the storm surge stillwater elevation, and 4) the wave runup above the storm surge stillwater elevation (where present).

Coastal Barrier Resources Act (CBRA) Boundaries: The Coastal Barrier Resources Act (CBRA) established the John H. Chafee Coastal Barrier Resources System (CBRS), a defined set of geographic units along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts. Most new Federal expenditures and financial assistance (including flood insurance) are prohibited within the CBRS, with some exceptions. The U.S. Fish and Wildlife Service is responsible for administering CBRA.

Community Rating System: A FEMA initiative, established under the National Flood Insurance Program (NFIP), to recognize and reward communities that have implemented floodplain management measures beyond the minimum NFIP requirements. Under the CRS, those communities that choose to participate may reduce the flood insurance premium rates in the community from 5 to 45% based on the types of activities they perform.

Flood: A condition of partial or complete inundation of normally dry land areas from: (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source

FEMA Flood Insurance Study (FIS): The official report which usually accompanies the Flood Insurance Rate Map (FIRM), provided by FEMA that contains additional technical information on the flood hazards shown on the FIRM

Floodproofing: Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures, and their contents.

LiMWA: The Limit of Moderate Wave Action (LiMWA) is the demarcation between areas with waves greater and lower than 1.5 feet height.

Special Flood Hazard Areas: Flood hazard zones are lettered based on the level and type of flood risk:

> Zone V/VE: An area of high flood risk subject to inundation by the 1% annual-chance flood event with additional hazards due to storm-induced velocity wave action (a 3-foot or higher breaking wave).
>
> Zone A/AE: An area of high flood risk subject to inundation by the 1% annual-chance flood event.
>
> Zone AO: An area of high flood risk subject to inundation by 1% annual-chance shallow flooding where average depths are between one and three feet.
>
> Shaded Zone X: Areas of moderate flood risk within the 0.2% annual chance floodplain; or areas of 1% annual chance flooding where average depths are less than 1 foot, where the drainage area is less than 1 square mile, or areas protected from this flood level by a levee.
>
> Unshaded Zone X: Areas of low flood risk outside the 1%- and 0.2%-annual chance floodplains.
>
> Zone D: Areas where flood hazards are undetermined, but flooding is possible.

Coastal AE Zones: coastal areas within the 1% annual chance (base) flood, with waves between 1.5 to 3 feet height. These are areas that will be exposed to both flood, moderate wave forces and other wave effects.

Sea Level Rise: An increase in sea level caused by a change in the volume of the world's oceans due to temperature increase, deglaciation (uncovering of glaciated land because of melting of the glacier), and ice melt.

Stillwater Elevation: The projected elevation of floodwaters in the absence of waves resulting from wind or seismic effects. In coastal areas, stillwater elevations are determined when modeling coastal storm surge; the results of overland wave modeling are used in conjunction with the stillwater elevations to develop Base Flood Elevations.

Storm Surge: Storm surge is the water, combined with normal tides, that is pushed toward the shore by strong winds during a storm. This rise in water level can cause severe flooding in coastal areas, particularly when the storm coincides with the normal high tides. The height of the storm surge is affected by many variables, including storm intensity, storm track and speed, the presence of waves, offshore depths, and shoreline configuration

Wave Set-Up: The increase in the water level caused by the onshore mass transport of water that happens due to waves breaking during a storm. Wave setup is affected by the wave height, the speed at which waves approach the shore, and the slope of the shore.

Wave Run-Up: The rush of water that extends inland when waves come ashore. Wave runup effects are computed as a part of the overland wave analysis and are added to the stillwater elevations computed from the storm surge model when developing Base Flood Elevations in coastal areas.

ATTACHMENT 2: PUBLIC WORKSHOP #1 RESPONSE

Discussion Topic 1: Flooding

How often have you observed flooding in downtown Mystic?	What caused the flooding?
Downtown 2-3 times/ year	Downpours
Gravel Street routinely (3x/week)	Clogged Drains
Fort Rachel often (Water St) (monthly)	Storms
Willowpoint River Road (often)	High tides
Frequently with high tide	King tide
Sometimes monthly	Named storms
3-4 times/ year	Tide
9ish	rain
Frequently- with storms	High tides
More often in past year	Heavy rain
High tide almost all of the time near park (higher than MHW)	Combination of all
Full moon flooding	Tides
Estimated 1/month	Some rainfall
Lack of info on what to do when floodings	Tides normally
During hurricanes	Is there a tide gate?
Periods of high tides	Tides, coastal storms, rainfall
Nor'easters- add to surge	Tides

Do you see flooding as a problem?	Do you remember any specific event being more significant than others?
Yes! Unanimous	Superstorm Sandy
Yes	Tropical storm Irene
Yes	Sandy
Absolutely!	Hurricanes
Yes!	Nor'easters (winter storms)
Yes- salt water damage to cars	Rain events (bombs)
Yes- dock piers stone seawalls damaged	Sandy
Yes- impacts ability to reach certain properties	Sandy
Also impacts septic systems	Heavier storms
Yes, and growing	Sandy
	MLK day 2022- storm + tide
	Storm flooded Pearl St
	Storm pipe backflow
	Any "big" storm
	During fall moon
	What is economic impact to entire town not just in flood plain

Where in downtown Mystic have you observed flooding?	Are there places in downtown Mystic where you have observed flooding repeatedly in the same locations?
West Mystic	All listed in previous questions
Gravel St	All listed in previous questions
W Main St	All listed in previous questions
Fort Rachel (Water St)	Seaport marina
Pearl St	Art center
repeatedly (Stonington- Cottrell, Holmes)	All listed in previous questions
Main St	All listed in previous questions
Holmes St	Water St
Cottrell St	River Rd
Fort Rachel Ave	Gravel St
Gravel St	Impact on zoning and building guidelines based on outlooks
Art center parking area	
Bank square	
Stonington side- Cottrell area and neighborhood	
River Rd	
Gravel St	
Water St	
Steamboat wharf/ parking lot	
Gravel St	
Pearl St	
Fort Rachel	
Water St	
River Rd	
Downtown/ Main St	
Areas outside study has same issues	
Willow point	
Noank (village)	
96 needs phase 2	

Were the flooding events reasonably predicted?	What sources provided you with reliable predictions?
Sometimes- weather is unpredictable here	Local news
High tides	Weather channel
Predicted storms but not severity (Sandy)	Phone apps
Yes	TV weather (ch 8)
Tides more so than rain events	Phone warnings
If you're looking at the right source	Weather channel
But no Sandy- that wasn't predicted effectively	Common sense
Yes storm surge	Routine
Full moon	Hurricane Info
High tides	NOAA
Storms	weather.com
	Local tv forecasters not always accurate
	Online websites
	NOAA sources- SLOSH models
	Local news
	High water infiltration into residential basements
	Local news

Did the recent "streetscape" project and the associated utility work improve flooding resilience?	To what extent has flooding affected your business or property?
No	Water in basement, new problem; increase in home owners insurance cost
Not clear about streetscape project?	House was lost in Sandy
No	Yes, should we move because of flooding
Yes, have noticed that downtown Mystic seems to drain better	Insurance/ or lack of it
Not familiar	Always concerned about loss
No	Heavy rainfall events have had big impact on our property (out of downtown)
	N/A
	Limited access

Discussion Topic 2: Heat Questions

Have you noticed that summer months are warmer than in the past in Mystic?	What summer months appear to be warmer?
Yes! Last 2 years	July and August
More 90 degree days	August in past, July more recently
Noticed more humidity	No change in drought conditions
Warmer in the fall months	Can't see a pattern
Winters not as cold	July, August
Yes	No rain in summer
Yes! Installed AC years ago	June-September
Heat sink of water lowers temp 10° in summer	July especially this year
Yes	August
Yes hotter, more humid	August
	July has always been hot, but even hotter now

Have you observed an increase in days over 90°F in recent years?	To what extent has increasing temperatures (i.e., days over 90) affected your business or property?
Yes, last few years	Gardens/ farms/ produce
Yes	Drought
Yes, but even lower temperatures fell hotter because of humidity	Increase in AC use- power use and $
Yes	Increased air conditioning capacity
Yes	Run AC more
Yes	Algae bloom in coves during August
Yes, hotter for longer	Temptation to water plants and lawn more
	More high priced lawn equipment to keep up with growth
	Electric costs for AC
	Don't get out much
	Running AC more
	Equipment in the house
	Farm business- high temperatures/ drought affects our farm animals
	Increase in AC use- increased electrical consumption
	Changes in landscaping/ vegetable garden- dead lawn, increased use of water
	Higher energy bills
	AC on more

Discussion Topic 3: Discussion Questions

What ideas would you like to see this study explore to increase the resiliency of the area to climate change including increasing temperatures and flooding?

Increase trees (shade and water absorption
Green roofs
Porous surfaces
Change development specifications- multi family developments vs single family homes leaving more open space
Land use policies for managing flood risk
Preserve wetlands (expand wetland area) - natural flood protection
Towns working together
New construction regulations/ zoning ordinances
Surge protection strategies (RR bridge)
Natural infrastructure/ living shorelines in suitable locations
Added permeable surfaces, pumps, rain gates to make water drain faster
Be ready to get wet- floodproofing
Emissions
More permeable surfaces
Sponge areas in parking lots
Preserve zoning for open space for plans & nature to absorb stormwater
Look at what other states have done
Seek ideas from other success

With a predicted 1.7-foot rise in MSL expected by 2050, how would you increase the flooding resilience of 1) downtown Mystic 2) your property?	With days over 90°F expected to increase by 2050, how would you increase the heat resilience of 1) downtown Mystic 2) your property?
Land use policy	Plant trees
Increase porous surfaces	Misters
Look at specific properties for impact	Change type of landscaping/ vegetation
What are options for roads being passable during storms	Rain gardens, French drains, other stormwater management
Storm drain information	
New construction regulations (elevations)	
Costs of elevating home- grant for mitigating costs	
Limit density and new construction in floodplain areas	
Increase staff for oversight of violations and misuse of floodplain areas	
Don’t put things in harms way- responsible development	
Insurance	
Elevate if possible	

ATTACHMENT 3: PUBLIC WORKSHOP #2 AND MID-POINT SURVEY RESULTS

Number of Submissions	Responses	Percentage
online	66	
paper_live/work	16	
paper_visitor	23	
TOTAL	*105*	

Relationship to the Study Area	Responses	Percentage
live in Downtown Mystic and don't work	10	9.5%
live in Downtown Mystic and work at home	8	7.6%
live in Downtown Mystic and work at a Downtown Mystic business	1	1.0%
live in Downtown Mystic and work elsewhere	11	10.5%
unknown	3	2.9%
visit but don't live or work in Downtown Mystic	64	61.0%
work in Downtown Mystic but don't live there	8	7.6%
TOTAL	*105*	

RESIDENTS: How long have you lived and/or worked in Downtown Mystic?	Responses	Percentage
one year or less	1	2.4%
one to five years	6	14.6%
five to ten years	4	9.8%
more than ten years	28	68.3%
unknown	2	4.9%
TOTAL	*41*	

VISITORS: How often have you visited Downtown Mystic in the past 2 years?	Responses	Percentage
once or twice	1	1.6%
several times per year	6	9.4%
monthly	5	7.8%
weekly	48	75.0%
unknown	4	6.3%
TOTAL	*64*	

RESIDENTS: Has flooding and/or heat impacted you, your property, and/or the Downtown Mystic business you work at?	Responses	Percentage
yes	26	63.4%
no	12	29.3%
unknown	3	7.3%
TOTAL	*41*	

VISITORS: Have heat and/or flooding impacted your visits to Downtown Mystic?	Responses	Percentage
yes	31	47.7%
no	32	49.2%
unknown	2	3.1%
TOTAL	*65*	

RESIDENTS: Which impacts have you experienced?		
Mystic River / coastal flooding	20	74.1%
heavy precip / stormwater flooding	19	70.4%
extreme heat and humidity	6	22.2%
# respondents who answered the question	*27*	

RESIDENTS: How have you been impacted?		
property / business flooded	12	57.1%
temporary relocation	5	23.8%
business closure	4	19.0%
travel challenges	14	66.7%
vehicle damage	1	4.8%
heat exhaustion or stroke	0	0.0%
# respondents who answered the question	*21*	

RESIDENTS: Have you done any of the following research actions to prepare for climate hazards?		
looked up flood zones / SLR projections	23	69.7%
checked tide gauges	16	48.5%
researched evacuation routes	9	27.3%
evaluated alternative parking locations	16	48.5%
signed up for CT Alert	16	48.5%
considered purchasing or increasing flood insurance	8	24.2%
# respondents who answered the question	*33*	

VISITORS: How have your visits been impacted?		
skipped or shortened visits due to flooding	17	50.0%
skipped or shortened visits due to heat	9	26.5%
business closures	14	41.2%
travel challenges	23	67.6%
# respondents who answered the question	*34*	

VISITORS: Have you done any of the following research actions to prepare for climate hazards?		
looked up flood zones / SLR projections	39	69.6%
checked tide gauges	30	53.6%
researched evacuation routes	19	33.9%
evaluated alternative parking locations	14	25.0%
signed up for CT Alert	32	57.1%
# respondents who answered the question	*56*	

Are you concerned about how cliamte change is affecting, and will continue to affect, Downtown Mystic?		
yes	92	87.6%
no	9	8.6%
unknown	4	3.8%

TOTAL	*105*	

If yes, what is your level of concern?

slightly concerned	10	10.8%
moderately concerned	39	41.9%
very concerned	44	47.3%
TOTAL	*93*	

Which of the following topics are you concerned about as they relate to Downtown Mystic?

damage to personal property	23	24.7%
negative impacts to property value	22	23.7%
negative impacts to businesses and local economy	76	81.7%
first responder concerns	68	73.1%
sustained loss of utilities	74	79.6%
negative impacts to cultural and historical resources	73	78.5%
# respondents who answered the question	*93*	

Rank the following community assets from most important for protection (1) to least important for protection (7)

roads and sidewalks	3.71
public utilities	2.16
natural and recreational resources	4.28
historical and cultural resources	4.17
homes and personal properties	3.42
businesses and civic resources	4.17
marinas	6.06

Which flood protection approach would you like to see emphasized?

protect	69	67.6%
accommodate	54	52.9%
retreat	45	44.1%
# respondents who answered the question	*102*	

Which flood resiliency measure would you like to see emphasized?

non-structural	47	46.1%
structural	53	52.0%
nature-based	86	84.3%
# respondents who answered the question	*102*	

Of the strategies below, which would you most like to be further considered?

floodproof buildings	19	18.6%
tide gates on stormwater outfalls	39	38.2%
floodwall	28	27.5%
enhanced stormwater management system	74	72.5%
elevate buildings	13	12.7%

increased required site grade or elevation of new builds	58	56.9%
new construction flood features that "bounce back"	55	53.9%
flood emergency response plan required for new assets	29	28.4%
post-storm repair and cleanup plan	39	38.2%
stricter building and zoning requirements	57	55.9%
# respondents who answered the question	*102*	

Of the building-specific strategies below, which would you like to be further considered?		
restrict new buildings to areas not expected to be flood-prone	58	56.9%
elevate new construction	42	41.2%
elevate existing buildings	15	14.7%
investigate a regional flood protection approach	63	61.8%
require new construction to accommodate flooding	43	42.2%
# respondents who answered the question	*102*	

Which of the short-term strategies related to increasing temps and extreme heat would you like to see emphasized?		
cooling measures	57	61.3%
heat-related health education and messaging	42	45.2%
increased administrative controls	50	53.8%
improved access to PPE	21	22.6%
# respondents who answered the question	*93*	

Which of the long-term strategies related to increasing temps and extreme heat would you like to see emphasized?		
public education	32	33.7%
community building	41	43.2%
long-term plan	40	42.1%
medical care access	45	47.4%
data-driven approaches	51	53.7%
# respondents who answered the question	*95*	

Which cooling-related infrastructure changes would you like to see further evaluated?		
increased vegetation and trees	75	75.8%
water fountains and bottle filling stations	59	59.6%
shade structures	57	57.6%
cooling centers	35	35.4%
heat-resistant materials	45	45.5%
cool pavements	50	50.5%
energy efficiency	65	65.7%
restricted use of fossil-fueled equipment	49	49.5%
blackout curtains in homes	9	9.1%
community splash pad	20	20.2%

ATTACHMENT 4: WATER LEVELS WITH RELATIVE SLR

Water Levels with Sea Level Rise
Intermediate Scenario

Time Period	Water Level + Projection	Water Level for Tide / Recurrence Storm (feet, NAVD88)								
		MHHW	2-Year	5-Year	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year
Current	Tide Gauge	1.2	3.5	4.3	4.8	5.6	6.6	7.4		
	FEMA				4.9		7.7	9.8		13.5
	USACE		4.4	5.5	6.4	7.2	8.5	9.6	10.8	12.3
2050	Tide Gauge + CIRCA	2.9	5.2	6.0	6.5	7.3	8.3	9.1		
	Tide Gauge + NOAA	2.5	4.8	5.6	6.1	6.9	7.9	8.7		
	FEMA + CIRCA				6.6		9.4	11.5		15.2
	FEMA + NOAA				6.2		9.0	11.1		14.8
	USACE + CIRCA		6.1	7.2	8.1	8.9	10.2	11.3	12.5	14.0
	USACE + NOAA		5.7	6.8	7.7	8.5	9.8	10.9	12.1	13.6

	SLR (feet)
Data Source	2050
CIRCA	1.7
NOAA 2022 Report	1.3

ATTACHMENT 5: RECOMMENDATION PRIORITIZATION MATRIX

Recommendation	Scoring by Criteria (1 to 10, low to high)					Weighted Score (1 to 10, low to high)	Rank
	Vulnerability Reduction	Technical Feasibility	Maintaining Cultural & Historical Resources & Economy	Maintaing Water Quality	Public Support & Benefit	Total Score	
Install functional tide gates and backflow preventers on stormwater outfalls	7	8	7	7	8	**7.4**	**1**
Develop an approach to evaluate raising low-lying roadways	7	9	7	5	8	**7.2**	**2**
Evaluate Pearl Street stormwater improvement alternatives.	6	8	6	8	8	**7.2**	**3**
Reduce pressure on stormwater system through green infrastructure.	8	6	5	8	8	**7.0**	**4**
Evaluate the feasibility of adopting a stormwater authority.	7	10	7	7	4	**7.0**	**5**
Pursue partnership opportunities with state DOT.	6	10	6	6	6	**6.8**	**6**
Stockpile emergency response materials.	6	7	7	5	8	**6.6**	**7**
Increase shade through additional tree cover or canopies.	8	3	7	6	9	**6.6**	**8**
Strengthen building standards	7	7	5	5	8	**6.4**	**9**
Dry floodproof Gravel Street Pump Station	8	7	5	5	7	**6.4**	**10**
Implement temporary, pop-up cooling measures	6	5	7	5	8	**6.2**	**11**
Increase public participation in emergency warning systems.	6	7	6	5	7	**6.2**	**12**
Assist local businesses with resiliency planning.	4	8	7	5	6	**6.0**	**13**
Develop a post-disaster response/recovery plan.	6	6	6	6	6	**6.0**	**14**
Partner with CIRCA on a heat study.	6	6	6	5	6	**5.8**	**15**
Downstream Flood Barrier in the Mystic River / Floodplain	8	3	8	4	3	**5.2**	**16**
River Wall or Levee Along the Mystic River.	7	3	8	3	3	**4.8**	**17**
Install retention/detention storage systems (including subsurface storage systems).	6	1	6	5	5	**4.6**	**18**
No action.	1	10	1	5	2	**3.8**	**19**