SOUTHEASTERN CONNECTICUT COUNCIL OF GOVERNMENTS

MULTI-JURISDICTION
HAZARD MITIGATION PLAN UPDATE

FEMA APPROVAL PENDING ADOPTION (APA) ISSUED NOVEMBER 16, 2017
ADOPTED DECEMBER 2017

MMI #3570-09

Prepared for:

SOUTHEASTERN CONNECTICUT COUNCIL OF GOVERNMENTS
5 Connecticut Avenue
Norwich, Connecticut 06360
860-889-2324
http://www.seccog.org

The preparation of this document has been financed in part through funds provided by the Connecticut Department of Emergency Services and Public Protection under a grant from the Federal Emergency Management Agency. The contents of this document reflect the views of the SCCOG and its member municipalities and tribal governments and do not necessarily reflect the official views of the Connecticut Department of Emergency Services and Public Protection. The document does not constitute a specification or regulation.

Prepared by:

MILONE & MACBROOM, INC.
99 Realty Drive
Cheshire, CT 06053
203-271-1773
www.miloneandmacbroom.com

ACKNOWLEDGMENTS & CONTACT INFORMATION

This plan update was prepared under the direction of the Southeastern Connecticut Council of Governments (SCCOG). The following individual should be contacted with questions or comments regarding the plan:

Mr. James S. Butler, AICP, Executive Director
Southeastern Connecticut Council of Governments
5 Connecticut Avenue
Norwich, Connecticut 06360
860-889-2324 Phone
860-889-1222 Fax
jbutler@seccog.org

Representatives from the 22 municipalities and two tribes that comprise the SCCOG were involved in plan development. The following individuals led the efforts of each municipality. Their time and knowledge were indispensable in preparing this plan update. Additional personnel from each municipality and tribes also involved in plan development are listed in the plan annex for each municipal or tribal entity.

Name	Position	Affiliation
Glenn Pianka	First Selectman	Town of Bozrah
N. Reed Gustafson	Building Official	Town of Colchester
Gary Goeschel	Planning Director	Town of East Lyme
William Eyberse	Emergency Preparedness Director	Town of Franklin
Mario Tristany	Town Planner	Town of Griswold
John Connelly	Jewett City Borough Warden	Borough of Jewett City
Barbara Goodrich	Director of Planning	City of Groton
Jon Reiner	Planning Director	Town of Groton
Joe Sastre	Emergency Management Director	Town of Groton
Phil Chester	Town Planner	Town of Lebanon
Russell Shaw	Emergency Management Director	Town of Ledyard
Thomas Sparkman	First Selectman	Town of Lisbon
Jeffrey King	Emergency Director	Mashantucket Pequot Tribal Nation
Frank Gavigan	Director of Emergency Preparedness	Mohegan Tribe
Ron McDaniel	Mayor	Town of Montville
Sybil Tetteh	City Planner	City of New London
Shawn Murphy	First Selectman	Town of North Stonington
Gene Arters	Emergency Management Director	City of Norwich
Robert Congdon	First Selectman	Town of Preston
Don Bourdeau	Public Works Director	Town of Salem
Catherine Osten	First Selectman	Town of Sprague
Jeff Callahan	Borough Warden	Borough of Stonington
Keith Brynes	Town Engineer	Town of Stonington
Abby Piersall	Planning Director	Town of Waterford
Mike Licata	Emergency Management Director	Town of Windham

The consulting firm of Milone & MacBroom, Inc. (MMI) prepared the subject plan update, building upon the initial work completed by DELTA Environmental Services, Inc. and Wilbur Smith Associates in 2005 and the plan update prepared by MMI in 2012. Over time, there have been many changes regarding planning requirements for local, multi-jurisdictional, and tribal hazard mitigation plans. Thus, this plan has been reformatted and updated from the original plan. The following individuals at Milone & MacBroom, Inc. should be contacted prior to plan adoption with questions or comments regarding the plan:

Mr. David Murphy, P.E, CFM, Associate
davem@miloneandmacbroom.com

Mr. Noah Slovin, CFM, Environmental Scientist
noahs@miloneandmacbroom.com

Milone & MacBroom, Inc.
99 Realty Drive
Cheshire, Connecticut 06410
203-271-1773 Phone
203-272-9733 Fax

EXECUTIVE SUMMARY

Southeastern Connecticut Council of Governments
Multi-Jurisdiction Hazard Mitigation Plan Update

The primary purpose of a Multi-Jurisdictional Natural Hazard Mitigation Plan (HMP) is to identify natural hazards and risks, existing capabilities, and activities that can be undertaken by a community to prevent loss of life and reduce property damages associated with identified hazards. The Disaster Mitigation Act of 2000 requires local communities to have a FEMA-approved mitigation plan in order to be eligible to receive Pre-Disaster Mitigation Program grants and Post-Disaster Hazard Mitigation Grant Program funds under the Hazard Mitigation Assistance program. The subject HMP is an update to the Southeastern Connecticut Council of Governments (SCCOG) Region's previous HMP. The SCCOG Region is comprised of 24 jurisdictions including two federally-recognized Native American tribes.

Situated on the Connecticut coastline bordering Long Island Sound, with major and minor rivers draining through upland areas to the coast and a variety of development patterns ranging from densely populated cities to sparsely-populated rural areas that are predominantly State forest, the landscape of the SCCOG Region has many different features that make it vulnerable to an array of natural hazards. These hazards include, but are not limited to, areas susceptible to inland flooding; coastal flooding, shoreline change, and erosion; hurricanes and tropical storms; summer storms; tornadoes; winter storms and nor'easters; earthquakes; wildfires; and dam failures. These hazards are each addressed in the 2014 *Connecticut Natural Hazards Mitigation Plan Update*. This plan discusses each of these natural hazards with respect to location, extent, and impact (including likelihood of occurrence and potential for loss of life and property), with the understanding that a particular hazard effect (i.e., damage from falling trees) can be caused by a variety of hazard events (e.g., high winds, lightning, heavy snow and ice) that can be caused by a variety of storms (e.g., hurricanes, tropical storms, and winter storms).

The primary hazard in the region is flooding from inland and coastal sources. The major watercourses in the region include the Thames River which bisects the lower portion of the region; the Quinebaug River, which drains a large portion of Northeastern Connecticut and Massachusetts before emptying into the Shetucket River; the Shetucket River, which drains most of eastern Tolland and western Windham County; the Yantic River, which has many floodprone and repetitive loss properties along its reach in Bozrah and Norwich; the Pawcatuck River, which drains from Rhode Island and forms the State border with Stonington and North Stonington, and smaller rivers such as the Mystic River that drain directly to Long Island Sound.

Subsequent to the approval of the last edition of the HMP, the most significant hazard event to affect the region was Hurricane Sandy in October 2012. This storm caused coastal flooding that resulted in approximately $2.6 million in flooding damage (primarily from storm surge) and wind damage in the SCCOG region.

A number of significant floods have occurred in the region as a result of tropical storms, hurricanes, and nor'easters. A broad area south of Interstate 95 is below the elevation of the 1% annual chance coastal flood event, and Special Flood Hazard Areas (SFHAs) continue inland along the major watercourses noted above. Much of the coastal SFHA is residentially developed.

Jurisdictions in the region have a number of capabilities in place to prevent flood damage including regulations and codes preventing encroachments and development near SFHAs and floodways. The SCCOG region intends to maintain and strengthen compliance with the NFIP regulations by continuing to administer the local flood damage prevention regulations and enforcing the requirements of the regulations. The SCCOG Region has been limited in its ability to be proactive with mitigation activities over the past several years due to limited municipal budgets, despite the influx of Hurricane Sandy disaster relief appropriations. However, additional home acquisitions and demolitions, elevations, and other mitigation projects are desired by member jurisdictions.

Tropical Storm Irene (August 28, 2011) was the region's most significant recent wind event prior to Hurricane Sandy. Falling tree branches downed power lines in all of the SCCOG municipalities, with power outages lasting more than a week in some communities.

While flooding is generally restricted to areas along watercourses and along the coastline, wind damage occurs anywhere in the region. The amount of damage incurred from wind action is variable. Typically, wind damage occurs more often in the shoreline communities. Most damage is caused by falling limbs and/or debris bringing about damage to public and private property. Although hurricanes and tornadoes are infrequent, they represent extreme wind events alongside select nor'easters. *HAZUS-MH* simulations predict that minimal wind damage will occur in the region for events with top wind speeds less than 65 miles per hour. Utility line maintenance and underground installation, tree trimming, and selective wind load retrofits are all recommended for SCCOG jurisdictions; many of these programs are currently in place.

Major winter nor'easters have the potential to occur every few years and produce above-average snowfall amounts and moderate to excessive wind damage. Snow loads are a particular concern for many SCCOG communities after the heavy snowfall that occurred in January 2011. Many SCCOG communities developed plans to inspect and clear roofs of snow during the winter months.

Heavy accumulating snowfall in January 2011 caused a number of homes, businesses, and barns to collapse in some of the SCCOG communities. Only nine months later, heavy wet snow from Winter Storm Alfred brought down many tree limbs, causing significant power outages only two months after Tropical Storm Irene.

While there are many geologic faults in the region, only the Honey Hill and the Lake Char fault are considered to be potentially active. Major earthquakes have not occurred in Connecticut in since the 18th century. Southeastern Connecticut is unlikely to experience a damaging earthquake in any given year. However, as the earthquake in Virginia reminded the United States in August 2011, east coast earthquakes can be felt for a great distance. Earthquake mitigation in the region will continue to include use of codes and control of development, although redundancy of critical facilities is recommended as well.

The region is considered to have areas of low and moderate risk for wildfires. SCCOG communities report that they consider their level of fire response to be adequate. Those areas of moderate risk include limited-access forests and other areas such as coastal marshes that are distant from the public water system, since tanker trucks must be relied on to fight a fire. Provision of water for fire suppression is recommended in remaining vulnerable areas.

Several high and significant hazard dams exist in the SCCOG region as inventoried through the Connecticut Department of Energy & Environmental Protection's (CT DEEP) Dam Safety Section. Failure of Class B or C dams can cause moderate to great economic loss and possibly loss of life. Many of these dams have Emergency Action Plans (EAPs) that delineate downstream areas at risk of inundation should the dam suddenly fail. Additional EAPs are desired for other dams in the region.

Governments in the region continue to possess and maintain a variety of formal and informal hazard mitigation capabilities. The plan update identifies and assesses these existing capabilities, and proposes new strategies that address identified gaps in current mitigation efforts. Each jurisdiction and tribal government also updated its list of mitigation strategies and actions that each will attempt to achieve over the next five years.

Each SCCOG jurisdiction has a community annex attached to this plan that discusses specific vulnerabilities to the examined natural hazards and prioritizes potential strategies and actions into a local implementation strategy. It is understood that not all mitigation actions may be able to be completed in the next five years depending on the ability to obtain grant funding, availability of local funding and staff time, and/or permission from pertinent property owners. At a minimum, each community must participate in an annual plan maintenance process to review local goals, objectives, and the status of proposed strategies and actions.

Annualized loss estimates from natural hazards have been prepared for each jurisdiction based on local loss information or information presented in the 2014 *Connecticut Natural Hazards Mitigation Plan.* These estimates are summarized for each community in the table below and range from approximately $8,600 per year for the Mohegan Tribe to nearly $3.3 million per year in Norwich. The total estimated annualized loss due to natural hazards for the SCCOG region is estimated at $21.8 million. Details regarding these loss estimates are provided in Sections 3 through 10 and in each pertinent annex.

Annualized Loss Estimates by Hazard for Each Community

Jurisdiction	Dam Failure	Earthquakes	Flooding*	Hurricanes & Tropical Storms (Wind)	Severe Winter Storms	Summer Storms (Thunderstorms)	Tornadoes	Wildfires	Total
Bozrah	$3,129	$4,965	$161	$189,046	$4,145	$367	$812	$2,242	$204,867
Colchester	$19,140	$30,368	$7,229	$1,156,298	$25,354	$2,243	$4,965	$5,504	$1,251,101
East Lyme	$22,822	$36,210	$166,082	$1,378,735	$30,232	$2,674	$5,920	$3,811	$1,646,486
Franklin	$2,289	$3,633	$3,253	$138,312	$3,033	$268	$594	$2,186	$153,568
Griswold	$10,082	$15,997	$20,876	$609,093	$13,356	$1,181	$2,615	$3,811	$677,011
Groton, City of	$11,191	$17,756	$87,235	$676,090	$14,824	$1,311	$2,903	$347	$811,657
Groton, Town of	$36,593	$58,060	$159,769	$2,210,697	$48,474	$4,288	$9,492	$3,127	$2,530,500
Jewett City, Borough of	$4,154	$6,590	$950	$250,934	$5,502	$487	$1,077	$78	$269,772
Lebanon	$8,705	$13,812	$2,103	$525,904	$11,532	$1,020	$2,258	$6,064	$571,398
Ledyard	$17,929	$28,446	$19,094	$1,083,112	$23,750	$2,101	$4,651	$3,856	$1,182,939
Lisbon	$5,167	$8,199	$2,080	$312,175	$6,845	$605	$1,340	$1,827	$338,238
Mashantucket Pequot Tribal Nation	$393	$624	$16,407	$23,748	$521	$46	$102	$415	$42,256
Mohegan Tribe	$125	$198	$420	$7,556	$165.68	$15	$32	$67	$8,579
Montville	$7,196	$11,417	$24,911	$434,727	$9,532	$843	$1,867	$4,640	$495,133
New London	$23,313	$36,989	$86,135	$1,408,384	$30,882	$2,732	$6,047	$616	$1,595,098
North Stonington	$6,310	$10,011	$135,667	$381,187	$8,358	$739	$1,637	$6,086	$549,995
Norwich	$48,235	$76,531	$141,820	$2,913,989	$63,895	$5,652	$12,512	$3,172	$3,265,806
Preston	$5,630	$8,932	$7,569	$340,096	$7,457	$660	$1,460	$3,464	$375,268
Salem	$4,945	$7,845	$4,865	$298,718	$6,550	$579	$1,283	$3,251	$328,036
Sprague	$3,554	$5,640	$16,077	$214,737	$4,709	$416	$922	$1,480	$247,535
Stonington, Borough of	$1,107	$1,756	$26,220	$66,853	$1,466	$130	$287	$34	$97,853
Stonington, Town of	$20,984	$33,294	$128,638	$1,267,697	$27,797	$2,459	$5,443	$4,304	$1,490,616
Waterford	$23,248	$36,887	$121,362	$1,404,498	$30,797	$2,724	$6,031	$3,677	$1,629,224
Windham	$10,237	$47,756	$3,535	$1,818,356	$92,266	$10,034	$18,068	$10,057	$2,010,309
SCCOG Total	**$296,477**	**$501,918**	**$1,182,456**	**$19,110,942**	**$471,443**	**$43,573**	**$92,319**	**$74,116**	**$21,773,245**

*Includes inland, coastal, and ice jam flooding

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Section **Page**

Tables

TABLE OF CONTENTS (Continued)

Section **Page**

TABLE OF CONTENTS (Continued)

Section **Page**

Figures

TABLE OF CONTENTS (Continued)

Appendices

Community Annexes

Individual community annexes are separate documents that provide community specific detailed hazard mitigation information. A community annex should be kept with the Multi-Jurisdictional plan in each community. Copies of the Multi-Jurisdictional hazard mitigation plan with all 23 community and tribal annexes are located in the SCCOG office. The 23 annexes include the following communities and tribal entities:

LIST OF ACRONYMS

AEL	Annualized Earthquake Losses
ARC	American Red Cross
ASFPM	Association of State Floodplain Managers
BCA	Benefit Cost Analysis
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
BOCA	Building Officials and Code Administrators
CLEAR	Center for Land Use Education and Research (University of Connecticut)
CM	Centimeter
CRS	Community Rating System
CT NHMP	Connecticut Natural Hazards Mitigation Plan
DEEP	Department of Energy & Environmental Protection
DEMHS	Department of Emergency Management and Homeland Security
DFA	Dam Failure Analysis
DMA	Disaster Mitigation Act
DOT	Department of Transportation
DPW	Department of Public Works
EAP	Emergency Action Plan
ECC	Emergency Communications Center
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
GIS	Geographic Information System
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HURDAT	Hurricane Database (NOAA's)
HURISK	Hurricane Center Risk Analysis Program
ICC	International Code Council
IPCC	Intergovernmental Panel on Climate Change
KM	Kilometer
KT	Knot
LID	Low Impact Development
LOMC	Letter of Map Change
MM	Millimeter
MMI	Milone & MacBroom, Inc.
MPH	Miles per Hour
NAI	No Adverse Impact
NCDC	National Climatic Data Center

LIST OF ACRONYMS (Continued)

NESIS	Northeast Snowfall Impact Scale
NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act
NOAA	The National Oceanic and Atmospheric Administration
OPM	Office of Policy and Management
POCD	Plan of Conservation and Development
PDM	Pre-Disaster Mitigation
RFC	Repetitive Flood Claims
RLP	Repetitive Loss Property
SCCOG	Southeastern Connecticut Council of Governments
SFHA	Special Flood Hazard Area
SLOSH	Sea, Lake and Overland Surges from Hurricanes
SRL	Severe Repetitive Loss
SSURGO	Soil Survey Geographic
STAPLEE	Social, Technical, Administrative, Political, Legal, Economic, and Environmental
TNC	The Nature Conservancy
USD	United States Dollars
USDA	United States Department of Agriculture
USGS	United States Geological Survey

LIST OF GENERAL MULTI-JURISDICTIONAL PLAN UPDATES

The previous HMP has been revised and updated in several ways to be compatible with new planning requirements as well as to present hazard information in a straight-forward manner. General formatting updates to the Multi-Jurisdictional HMP are presented below.

Section 1 – Introduction & Implementation – This section has been updated from the previous HMP to include changes to the SCCOG region (addition of Lebanon and Windham, loss of Voluntown), changes regarding the NFIP and existing grant programs, coordination with the statewide 2014 Connecticut HMP, coordination with neighboring communities, and current information regarding the current planning process and progress monitoring.

Section 2 – Regional Profile – This section has been updated form the previous HMP and includes updated information regarding the SCCOG region, disaster declarations, land use, geology, climate, drainage basins, demographics, development trends, regional planning efforts, and sheltering.

Sections 3 through 10 – Individual Hazards – The Setting, Hazard Assessment, Regional Historic Record, Existing Capabilities, Vulnerability and Risk Assessment, and Potential Mitigation Strategies and Actions sections were all updated from the previous plan based on regulatory changes, new studies, and information collected over the last five years. In particular, each Vulnerability section includes estimation of annualized loss for the respective hazard based on data published in the statewide 2014 Connecticut HMP, local loss information, or HAZUS-MH simulations.

Section 11 – Regional Strategies and Actions – Section 11.1 reviews the previous regional strategies and actions relative to the capacity of SCCOG to complete such recommendations. The majority have been delisted and deferred to local officials or other parties. Section 11.2 presents regional strategies actions to be completed by SCCOG over the next five years. Section 11.3 is updated with a new STAPLEE analysis to prioritize the regional strategies and actions, and other information pertinent to the STAPLEE.

Section 12 – Resources and References – Section 12.2 has been updated to include the Connecticut Association of Flood Managers. Section 12.3 has been updated with new references as necessary.

LIST OF GENERAL ANNEX UPDATES

Each community and tribal annex to the previous HMP has also been revised and updated in several ways to be compatible with new planning requirements as well as to present hazard information in a straight-forward manner. Each annex has been given the same general layout as the Multi-Jurisdictional HMP such that Section 3 in both the main HMP and each annex discusses inland flooding.

Section 1 – Introduction – Similar to the previous HMP annexes, these sections discuss the purpose of the annex, setting, and plan development process. This information has been updated as appropriate.

Section 2 – Community Profile – This section takes much of the information previously offered under the "Setting" section of each annex and provides a more detailed look at the physical features, development trends, government structure, and capabilities of each community or tribe.

Sections 3 through 10 – Individual Hazards – These sections present updated specific information pertinent to each community or tribe. Similar to the Multi-Jurisdictional HMP, each hazard is discussed in a separate chapter. Potential mitigation strategies and actions are discussed in these sections where appropriate, with the reader being directed to Section 11 for a complete list of actions.

Section 11 – Mitigation Actions – One objective in the development of this update was to thoroughly review the 2012 lists of mitigation actions for each jurisdiction – which were greatly expanded relative to the actions listed in 2005 – and appropriately relegate many of them to ongoing capabilities and other functions. A more concise list was developed for each jurisdiction.

1.0 INTRODUCTION

1.1 Background and Purpose

The goal of emergency management activities is to prevent loss of life and property. The four phases of emergency management include Mitigation, Preparedness, Response and Recovery. What sets them apart is the distinction that hazard mitigation is to eliminate or reduce the need to respond. The term *hazard* refers to an extreme natural event that poses a risk to people, infrastructure, or resources. In the context of disasters, pre-disaster hazard mitigation is commonly defined as any sustained action that reduces or eliminates long-term risk to people, property, and resources from hazards and their effects.

The primary purpose of a hazard mitigation plan (HMP) is to identify natural hazards and risks, existing capabilities, and activities that can be undertaken by a community to prevent loss of life and reduce property damages associated with the identified hazards. Public safety and property loss reduction are the driving forces behind this plan. However, careful consideration also must be given to the preservation of history, culture and the natural environment of the region.

This HMP update was prepared specifically to identify hazards and potential mitigation measures in the municipalities and tribes of Southeastern Connecticut Council of Governments (SCCOG). SCCOG's initial HMP was approved by the Federal Emergency Management Agency (FEMA) in October 2005 and the subsequent update was approved in 2012. Both are on file at the FEMA Region I office as well as at SCCOG. The HMP is relevant not only in emergency management situations but also should be used within the region's land use, environmental, and capital improvement frameworks. While an update of the previous HMP, this HMP has been expanded to include the Towns of Lebanon and Windham, which were not members of the SCCOG at the time of the previous HMP iteration. In addition, the Town of Voluntown is no longer part of the SCCOG and thus is not included in this HMP update. This HMP update has also been reformatted where necessary to be consistent with current FEMA planning requirements.

The Disaster Mitigation Act

The Disaster Mitigation Act of 2000 (DMA), commonly known as the 2000 Stafford Act amendments, was approved by Congress and signed into law in October 2000, creating Public Law 106-390. The purposes of the DMA are to establish a national program for pre-disaster mitigation and streamline administration of disaster relief. The DMA requires local communities to have a FEMA-approved mitigation plan in order to be eligible to apply for and receive Hazard Mitigation Assistance (HMA) grants.

The HMA "umbrella" contains three competitive grant programs deigned to mitigate the impacts of natural hazards. This HMP update was developed to be consistent with the general requirements of the HMA program as well as the specific requirements of the Hazard Mitigation Grant Program (HMGP) for post-disaster mitigation activities, as well as the Pre-Disaster Mitigation (PDM), Flood Management Assistance (FMA). *Note that HMA programs are funded at the discretion of Congress.* These programs are briefly described below.

> ***Mitigation Funding***
> *Applications for hazard mitigation grant funding are administered under the Unified Hazard Mitigation Assistance program. More information on this and the following programs can be found at FEMA's website, http://www.fema.gov/*

Pre-Disaster Mitigation (PDM) Program

The PDM program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. In Connecticut, the PDM program is administered by the Connecticut Department of Energy and Environmental Protection (DEEP), formerly known as the Department of Environmental Protection (DEP) until its consolidation with another agency in 2011.

The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through pre-disaster mitigation planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities. PDM funds should be used primarily to support mitigation activities that address natural hazards. In addition to providing a vehicle for funding, the PDM program provides an opportunity to raise risk awareness within communities. This plan update is supported by funds applied for by SCCOG under the PDM Program.

Hazard Mitigation Grant Program (HMGP)

The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. In Connecticut, the HMGP is administered by the Connecticut Department of Emergency Services and Public Protection (DESPP), formerly known as the Department of Emergency Management and Homeland Security (DEMHS) until its consolidation with another agency 2011.

The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented

during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster. Several SCCOG municipalities applied for HMGP grants subsequent to Hurricane Sandy in 2012.

Flood Mitigation Assistance (FMA) Program

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). In Connecticut, the FMA program is administered by DEEP.

FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities. Three types of grants are available under FMA. These are planning, project, and technical assistance grants. FMA funds have not been utilized in the SCCOG communities over the past two years.

Changes Since 2012

The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) programs and made the following significant changes to the FMA program:

Effective August 15, 2013, acquisitions and elevations will be considered cost-effective if the project costs are less than $276,000 and $175,000, respectively. Structures must be located in Special Flood Hazard Areas (the area of the 1-percent-annual-chance flood). The benefit-cost analysis (BCA) will not be required.

- The definitions of repetitive loss and severe repetitive loss properties have been modified;
- Cost-share requirements have changed to allow more Federal funds for properties with repetitive flood claims and severe repetitive loss properties; and
- There is no longer a limit on in-kind contributions for the non-Federal cost share.

The NFIP provides the funding for the FMA program. The PDM and FMA programs are subject to the availability of appropriation funding, as well as any program-specific directive or restriction made with respect to such funds.

One important change to the PDM, HMGP, and FMA programs since the adoption of the 2012 edition of this plan is that "green open space and riparian area benefits can now be included in the project benefit cost ratio (BCR) once the project BCR reaches 0.75 or greater." The inclusion of environmental benefits in the project BCR is limited to acquisition-related activities.

Table 1-1 presents potential mitigation project and planning activities allowed under each FEMA grant program described above as outlined in the most recent HMA Unified Guidance document. Many of the strategies and actions developed in this plan fall within the above list of eligible activities.

Table 1-1: Eligible Mitigation Project Activities by Program

Eligible Activities	HMGP	PDM	FMA
1. Mitigation Projects	✓	✓	✓
Property Acquisition and Structure Demolition	✓	✓	✓
Property Acquisition and Structure Relocation	✓	✓	✓
Structure Elevation	✓	✓	✓
Mitigation Reconstruction	✓	✓	✓
Dry Floodproofing of Historic Residential Structures	✓	✓	✓
Dry Floodproofing of Non-residential Structures	✓	✓	✓
Generators	✓	✓	
Localized Flood Risk Reduction Projects	✓	✓	✓
Non-localized Flood Risk Reduction Projects	✓	✓	
Structural Retrofitting of Existing Buildings	✓	✓	✓
Non-structural Retrofitting of Existing Buildings and Facilities	✓	✓	✓
Safe Room Construction	✓	✓	
Wind Retrofit for One- and Two-Family Residences	✓	✓	
Infrastructure Retrofit	✓	✓	✓
Soil Stabilization	✓	✓	✓
Wildfire Mitigation	✓	✓	
Post-Disaster Code Enforcement	✓		
Advance Assistance	✓		
5 Percent Initiative Projects	✓		
Miscellaneous/Other(1)	✓	✓	✓
2. Hazard Mitigation Planning	✓	✓	✓
Planning Related Activities	✓		
3. Technical Assistance			✓
4. Management Cost	✓	✓	✓

Source: Table 3 – HMA Unified Guidance document, February 27, 2015

1.2 Hazard Mitigation Goals

The previous HMP identified two goals, three policies, and seven objectives that guided the SCCOG Hazard Mitigation Committee in the development of the original HMP. Those goals, policies, and objectives continue to be valid for each community and tribe in the SCCOG region for this plan update. The original ten items have been summarized into the list below.

The primary goal of this hazard mitigation plan update is to prevent or minimize the loss of or damage to life, property, infrastructure, and natural, cultural, and economic resources from natural disasters. This includes the reduction of public and private damage costs. Limiting losses of and damage to life and property will also reduce the social, emotional, and economic disruption associated with a natural disaster.

Updating, adopting, and implementing this HMP is expected to:

- ***Increase access to and awareness of funding sources for hazard mitigation projects.*** Certain funding sources, such as the PDM and HMGP, may continue to be available if the HMP is in place and approved. Many of the SCCOG communities have limited budgets. Some potential mitigation activities are expensive and cannot be performed by SCCOG communities without outside assistance and grant funding.
- ***Identify mitigation initiatives to be implemented if and when funding becomes available.*** This HMP will update the mitigation recommendations, which can then be prioritized and acted upon as funding allows.
- ***Connect hazard mitigation planning to other community planning efforts.*** This HMP can be used to guide development in the SCCOG region through regional and inter-municipal coordination as well as interdepartmental coordination within SCCOG communities.
- ***Improve the mechanisms for pre-disaster and post-disaster decision making efforts.*** This plan emphasizes actions that can be taken now to reduce or prevent future disaster damages. If the actions identified in this plan are implemented, damage from future hazard events can be minimized, thereby easing recovery and reducing the cost of repairs and reconstruction. Like many communities, SCCOG communities have historically focused on hazard preparation and response rather than mitigation.
- ***Improve the ability to implement post-disaster recovery projects*** through development of a list of mitigation alternatives ready to be implemented.
- ***Enhance and preserve natural resource systems.*** Natural resources, such as wetlands and floodplains, provide protection against disasters such as floods and hurricanes. Proper planning and protection of natural resources can provide hazard mitigation at substantially reduced costs.
- ***Educate residents and policy makers about natural hazard risk and vulnerability.*** Education is an important tool to ensure that people make informed decisions that complement the region's ability to implement and maintain mitigation strategies. It is a preventive pre-disaster measure that is less costly than most structural projects.
- ***Complement future Community Rating System (CRS) efforts.*** Implementation of certain mitigation measures may increase a community's rating with the NFIP program and thus the benefits that it derives from FEMA. The Town of East Lyme, the Borough of Stonington, and the Town of Stonington each participate in the CRS, and SCCOG plans to assist communities review and prepare materials for entering the program in 2018.

Overall, priorities for SCCOG and its jurisdictions have not changed since the approval of the 2012 HMP. The Council of Governments, municipalities, and two tribes continue to desire progress with minimizing the impacts of all hazards by focusing on emergency services and preparedness; maintenance of power utility infrastructure and tree trimming; and strict control of development and redevelopment in areas of flood risk. However, some of the coastal jurisdictions have increased their attention to climate change and coastal resilience concepts in response to Tropical Storm Irene, Hurricane Sandy, and the funding that has resulted from both events.

1.3 Identification of Hazards and Document Overview

1.3.1 Identification of Hazards

As stated in Section 1.1, the term *hazard* refers to an extreme natural event that poses a risk to people, infrastructure, or resources. The 2012 HMP determined that the most significant hazard in the SCCOG region is flooding, with winter storms, hurricanes, and earthquakes also presenting significant concerns. Wildfires, landslides, and coastal erosion were concerns in particular communities but not considered to be region-wide threats. Drought was also a minor concern as the relative abundance of rainfall and ample water supply in SCCOG communities has made serious droughts a rare occurrence.

Additional hazards were reviewed in full to bring the updated plan into concurrence with the State of Connecticut HMP and other local HMPs in Connecticut. Based on a review of the 2014 Connecticut Natural Hazard Mitigation Plan and other local plans in Connecticut, the list of hazards includes the following:

- Inland Flooding
- Coastal Flooding (including effects of sea level rise and shoreline change)
- Hurricanes and Tropical Storms
- Summer Storms and Tornadoes
- Winter Storms
- Earthquakes
- Dam Failure
- Wildfires

These are the same hazards that were addressed in the previous SCCOG Hazard Mitigation Plan. They were reviewed during the development of the *2014 Connecticut Natural Hazards Mitigation Plan* (CT NHMP - adopted January 2014), and the 2012 SCCOG HMP contributed to the Hazard Identification and Risk Assessment (HIRA) presented in that document. Thus, the plans are consistent. The only hazard given attention in the *2014 Connecticut Natural Hazards Mitigation Plan* but not addressed in the HMP Update is drought; however, this is the lowest-ranked hazard of those discussed in the state's plan, with a medium-low composite risk score for New London and Windham Counties. In addition, the statewide and countywide annual estimated loss (AEL) in the state plan for this hazard is $0. As such, its inclusion was considered not necessary in the SCCOG HMP Update.

This document has been prepared with the understanding that a single *hazard effect* may be caused by multiple *hazard events*. For example, flooding may occur as a result of frequent heavy rains, a hurricane, or a winter storm. Thus, Tables 1-2, 1-3, and 1-4 on the following pages provide summaries of the hazard events and hazard effects that impact the SCCOG region and include criteria for characterizing the locations impacted by the hazard, the frequency of occurrence of the hazard, and the magnitude or severity of the hazards. In order to better identify current vulnerabilities and potential mitigation strategies associated with other hazards, each hazard has been individually discussed in a separate chapter in this Multi-Jurisdictional plan. Specific community details are discussed in each individual community annex.

Table 1-2: Effects of Natural Hazards

Natural Hazard	Causes						
	Hurricanes and Tropical Storms	Sea Level Rise and Shoreline Change	Summer Storms and Tornadoes	Winter Storms	Wildfires	Earthquakes	Dam Failure
Inland Flooding	X		X				X
Flooding from Poor Drainage	X	X	X				
Coastal Flooding	X	X		X			
Storm Surge	X			X			
Coastal Erosion	X	X		X			
Wind	X		X	X			
Falling Trees/Branches	X		X	X			
Lightning	X		X				
Hail			X				
Snow				X			
Blizzard				X			
Ice				X			
Fire/Heat					X		
Smoke					X		
Shaking						X	
Dam Failure						X	X
Power Failure	X		X	X	X	X	

Table 1-3: Hazard Event Ranking

Natural Hazards	Location	Frequency of Occurrence	Magnitude/ Severity	Rank
	1 = small 2 = medium 3 = large	0 = unlikely 1 = possible 2 = likely 3 = highly likely	1 = limited 2 = significant 3 = critical 4 = catastrophic	
Winter Storms	3	3	2	8
Hurricanes	3	1	3	7
Summer Storms and Tornadoes	2	3	2	7
Earthquakes	3	1	2	6
Wildfires	1	2	1	4

- ❑ Each hazard may have multiple effects; for example, a hurricane causes high winds and flooding.
- ❑ Some hazards may have similar effects; for example, hurricanes and earthquakes may cause dam failure.

Location
1 = small: isolated to specific area during one event
2 = medium: multiple areas during one event
3 = large: significant portion of the city during one event

Frequency of Occurrence
0 = unlikely: less than 1% probability in the next 100 years
1 = possible: between 1 and 10% probability in the next year; or at least one chance in next 100 years
2 = likely: between 10 and 100% probability in the next year; or at least one chance in next 10 years
3 = highly likely: near 100% probability in the next year

Magnitude/Severity
1 = limited: injuries and/or illnesses are treatable with first aid; minor "quality of life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%
2 = significant: injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities for more than one week; property severely damaged <25% and >10%
3 = critical: injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged <50% and >25%
4 = catastrophic: multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%

Table 1-4: Hazard Effect Ranking

Natural Hazard Effects	Location 1 = small 2 = medium 3 = large	Frequency of Occurrence 0 = unlikely 1 = possible 2 = likely 3 = highly likely	Magnitude/ Severity 1 = limited 2 = significant 3 = critical 4 = catastrophic	Rank
Nor'easter Winds	3	3	2	8
Snow	3	3	2	8
Blizzard Conditions	3	3	2	8
Falling Trees/Branches	3	3	2	8
Hurricane/Tropical Storm Winds	3	1	3	7
Ice	3	2	2	7
Thunderstorm and Tornado Winds	2	2	2	6
Flooding from Dam Failure	1	1	4	6
Shaking	3	1	2	6
Lightning	1	3	1	5
Flooding from Poor Drainage	1	3	1	5
Riverine Flooding	2	2	1	5
Falling Trees/Branches	3	3	2	5
Hail	1	2	1	4
Fire/Heat	1	2	1	4
Smoke	1	2	1	4

- ❑ Some effects may have a common cause; for example, a hurricane causes high winds and flooding.
- ❑ Some effects may have similar causes; for example, hurricanes and nor'easters both cause heavy winds.

Location
1 = small: isolated to specific area during one event
2 = medium: multiple areas during one event
3 = large: significant portion of the city during one event

Frequency of Occurrence
0 = unlikely: less than 1% probability in the next 100 years
1 = possible: between 1 and 10% probability in the next year; or at least one chance in next 100 years
2 = likely: between 10 and 100% probability in the next year; or at least one chance in next 10 years
3 = highly likely: near 100% probability in the next year

Magnitude/Severity
1 = limited: injuries and/or illnesses are treatable with first aid; minor "quality of life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%
2 = significant: injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities for more than one week; property severely damaged <25% and >10%
3 = critical: injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged <50% and >25%
4 = catastrophic: multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%

1.3.2 Document Overview

The Multi-Jurisdictional plan and each community annex are similarly laid out, with the Multi-Jurisdictional plan discussing each hazard from a regional perspective and each community annex taking a more detailed look at each natural hazard for that particular community. The HMP and its annexes include a general discussion of the SCCOG region and each community, including the physical setting, demographics, development trends, governmental structure, and sheltering capacity. Next, each chapter of this HMP and its annexes that is dedicated to a particular hazard event is broken down into six different parts. These are: *Setting; Hazard Assessment; Historic Record; Existing Capabilities; Vulnerabilities and Risk Assessment; Potential Mitigation Strategies and Actions; and Status of Mitigation Strategies and Actions*. These are described below.

- ***Setting*** addresses the general areas (locations) that are at risk from the hazard. General land uses are identified.
- ***Hazard Assessment*** describes the specifics of a given hazard, including general characteristics and associated effects. Also defined are associated return intervals, probability and risk, and relative magnitude.
- ***Historic Record*** is a discussion of past occurrences of the hazard and associated damages when available.
- ***Existing Capabilities*** gives an overview of the measures that SCCOG or its member communities has undertaken in the past or is currently undertaking to mitigate the given hazard. These may take the form of ordinances and codes, home elevations and acquisitions, structural measures such as dams, or public outreach initiatives.
- ***Vulnerabilities and Risk Assessment*** focuses on the specific areas at risk to the hazard. Specific land uses in the given areas are identified. Critical buildings and infrastructure that would be affected by the hazard are identified. Hazards of a regional nature, such as hurricanes, have a risk assessment specifically addressed in the Multi-Jurisdictional plan, while the risk assessment for hazards that are more community specific, such as inland flooding, are discussed in more detail within each community annex.
- ***Potential Mitigation Strategies and Actions*** identifies mitigation alternatives, including those that may be the least cost effective or inappropriate for the region or community.
- ***Status of Mitigation Strategies and Actions*** provides a summary of the recommended courses of action for each community that is included in the STAPLEE analysis described in Section 11.3.

This section of the Multi-Jurisdictional document concludes with an updated strategy for implementation of the HMP, including a schedule and a program for monitoring and updating the plan. Discussion of technical and financial resources is included in a reference section at the end of this Multi-Jurisdictional plan (Section 12).

1.3.3 Loss Estimates

Loss estimates from natural hazards have been prepared for each community within the SCCOG Region, as well as for the region as a whole. These estimates were generated using one or more of the following three resources:

- **HAZUS-MH:** FEMA's Hazard Loss Estimation software (version 4.0) was used to model losses caused by riverine flooding, coastal flooding, hurricanes, and earthquakes.
- **Public Assistance Grants:** Losses due to individual events were calculated from FEMA Public Assistance (PA) grants received by NFIP communities (federal reimbursement is 75-percent of the total damages incurred).
- **2014 Connecticut Natural Hazards Mitigation Plan Update:** Loss estimates for Connecticut Counties, as presented in the 2014 CT NHMP Update, were used to estimate losses for individual communities based on the relative populations of each community compared to the populations of the counties (2010 Census).

Loss estimates developed using the above methods are presented, when applicable, within each hazard-specific section of this document and its annexes, providing a range of possible loss scenarios.

1.4 Documentation of the Planning Process

Mr. James Butler of SCCOG coordinated the development of the original Multi-Jurisdictional Hazard Mitigation Plan as well as both HMP updates. Because the plan is an update of the previous plan, the timeline was somewhat compressed and meetings were held to a minimum.

Members of the public were involved with the development of the two previous HMPs and were given continued opportunities to be involved. Residents, business owners, and other stakeholders in the SCCOG region were invited to the public information meetings noted below via news releases and information posted on various Patch and Facebook websites. Copies of these news releases are located in Appendix A.

The data collection, evaluation, and outreach program for each community and tribe is discussed in the community annexes. The following is a list of meetings that were held as well as other efforts to develop the update:

1.4.1 Public Information Meeting- November 28, 2016

The plan update project was presented and public comments solicited. A press release was sent to community leaders, area newspapers, and local "Patch" news websites advertising the meeting. Copies of the press release and subsequent media announcements are presented in Appendix A. Approximately eight members of the public attended the meeting. Representatives from SCCOG and MMI also attended the public information meeting. Meeting minutes are presented in Appendix B.

1.4.2 Public Information Meeting – December 1, 2016.

The update project was presented and public comments solicited a second time. Press releases, area newspapers, and local "Patch" news websites advertised the meeting. Copies of the press release and subsequent media announcements are presented in Appendix A. Two members of the public attended the meeting. A representative from SCCOG and MMI also attended the meeting. Meeting minutes are presented in Appendix B.

1.4.3 Community Data Collection Meetings

Meetings were scheduled through electronic mail and phone calls and an agenda was sent to each community prior to the meeting such that pertinent information (such as information regarding annual plan reviews and completed projects) could be prepared in advance. A summary of the data collection meetings is presented in Table 1-5.

Table 1-5: Individual Meetings Attended by City/Town/Tribal Representatives

Date	City / Town / Tribal Nation	Number of Local Representatives Attending
12/12/2016	Town of Bozrah	1
12/15/2016	Town of Colchester	6
1/26/2017	Town of East Lyme	7
12/15/2016	Town of Franklin	2
1/26/2017	Town of Griswold & Borough of Jewett City	3
11/8/2016	City of Groton	4
11/22/2016	Town of Groton	2
12/15/2016	Town of Lebanon	4
12/12/2016	Town of Ledyard	2
11/30/2016	Town of Lisbon	1
3/6/2017	Mashantucket Pequot Tribal Nation	5
3/6/2017	Mohegan Tribe	1
11/17/2016	Town of Montville	5
11/8/2016	City of New London	5
11/30/2016	Town of North Stonington	3
11/30/2016	City of Norwich	3
12/12/2016	Town of Preston	1
1/26/2017	Town of Salem	1
11/17/2016	Town of Sprague	1
11/9/2017	Stonington Borough	1
11/9/2017	Town of Stonington	2
11/23/2017	Town of Waterford	7
12/15/2016	Town of Windham	1

Each section of the existing HMP annex for that community or tribe was reviewed at its individual data collection meeting. The review and update process was conducted as presented in Section 1.7 with the exception that implementation documents from the previous planning period were generally not available (see Section 1.7 for details). Questions asked included those pertinent to the update of a HMP

as presented in Section 1.8. In addition, the goals and strategies and actions of the previous HMP were evaluated with officials of each community and tribe to determine if they remain valid or if they needed to be revised. More information regarding these meetings is presented in each community and tribal annex, with an evaluation of previous strategies and actions discussed in Section 2.7 of each community and tribal annex.

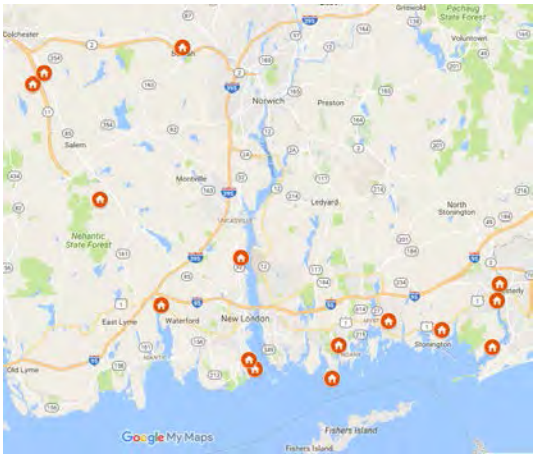
1.4.4 Local Public Perception of Natural Hazard Risk

A public survey was posted online through the website www.surveymonkey.com. The primary goal of the survey was to educate local officials of the general public awareness regarding natural hazards, with the secondary goal being to collect information that may lead to potential mitigation strategies. The survey was posted from October 17, 2016 to March 14, 2017. The survey was advertised on the SCCOG website, local Patch websites, and on the SCCOG Facebook page. The responses provide an indication of the public perception regarding the level of risk, awareness of natural hazard mitigation planning, and emergency response in the SCCOG region. Some write-in responses were accepted for publication, although some were deleted as being inapplicable to the needs of the study.

Sixteen residents of the SCCOG region responded. Individual communities were represented as shown in the following table and map:

Table 1-6: Locations of Survey Respondents

Community	Number of Respondents
Bozrah	1
Colchester	2
Groton, Town of	4
New London	2
Salem	1
Stonington, Town of	4
Waterford	2



Locations of Survey Respondents

A total of 81% of respondents were aware their community maintained a HMP.

Participants were asked which recent events, if any, have generated awareness of natural hazards. Table 1-7 summarizes the responses. The majority of respondents reported that Superstorm Sandy in October 2012 raised their awareness of natural hazards.

Table 1-7: Contributors to Awareness of Natural Hazards

Events	Number of Participants Selecting
Winter Storms of February 2013 and January 2015	5
"Superstorm" Sandy in October 2012	9
"Winter Storm" Alfred in October 2011	3
Hurricane/Tropical Storm Irene in August 2011	5
The Snowstorms of January 2011	2
The floods of March 2010	4

Other events noted by respondents were Hurricane Gloria, 1978 storms, and sea level rise in general. Four respondents claimed that they have not become more aware of natural hazards, either because they were already aware or because they have not noticed any recent changes in hazard events.

The next question asked responders to rate hazards on a scale of 1 (low threat or concern) to 3 (high threat or concern), indicating the level of threat or concern each presents to their homes or to the functions of their businesses. Responses are presented in Table 1-8.

Table 1-8: Potential Hazard Threat Based on Survey Response

Hazard	Number of Participants Selecting			Average Rating
	Low Threat or Concern (1)	Moderate Threat or Concern (2)	High Threat or Concern (3)	
Flooding from Rivers	8	3	2	1.54
Flooding from the Coast	4	4	5	1.69
Flash Flooding / Flooding from Poor Drainage	2	7	4	2.15
Wave Action (coastal)	9	2	2	1.46
Sea Level Rise	4	6	4	2.00
Hurricanes and Tropical Storms	0	6	8	2.57
Tornadoes	9	3	1	1.38
Other High Wind	2	7	5	2.21
Severe Thunderstorms	5	8	1	1.71
Winter Storms	3	4	7	2.29
Earthquakes	11	1	1	1.23
Wildfires and Brush Fires	9	3	0	1.25
Dam Failure	12	0	1	1.15

The hazards considered to pose the highest threat or concern to the majority of respondents include hurricanes and tropical storms, winter storms, high wind events, flash flooding and flooding from poor drainage, and sea level rise. One respondent also noted drought as a hazard of concern.

The follow-up question asked which hazards have affected the participant's selves or businesses. Table 1-9 summarizes these results.

Table 1-9: Impact on Responder or on Responder's Business

Hazard	Number of Participants Selecting
None; I have not been impacted	0
Flooding from Rivers	2
Flooding from the Coast	4
Flash Flooding / Flooding due to Poor Drainage	5
Wave Action (coastal)	2
Sea Level Rise	3
Hurricanes and Tropical Storms	8
Tornadoes	0
Other High Wind	3
Severe Thunderstorms	3
Winter Storms and Blizzards	9
Earthquakes	1
Wildfires	0
Dam Failure	0

A majority of respondents reported being affected by winter storms and blizzards, and hurricanes and tropical storms, with fewer respondents being affected by the other hazards.

Eleven participants entered answers when asked if any specific areas of SCCOG were vulnerable to any of the above hazards. Their responses are summarized in the table below.

Table 1-10: Specific Areas Vulnerable to Hazards

Location	No. of Mentions
Amtrak Tracks	1
Bank Street, New London	1
Broad Street, New London	2
Carli Boulevard and Fran Lane, Colchester	1
Church Street, Stonington	1
Coast (general)	2
Groton Long Point (general)	4
Groton Long Point Bridge	1
Hunts Brook, Waterford	2
Jordan Village	1
Mago Point, Waterford	1
Main Street, Old Mystic	1
Mason's Island, Stonington CT	1
Mystic	3
Noank	1
Norwichtown	1
Osbrook Point Road, Pawcatuck	1
Riverside Drive, Pawcatuck	1
Stillman Avenue, Pawcatuck	1
Stonington Borough (general)	2
Yantic River	1

The next question asked if responders had noticed an increase in utility maintenance activities due to increased pressure on utility companies to harden utility lines and manage vegetation following the wind and snow events of 2011. Eleven respondents said they had noticed an increase in maintenance while 3 said they had not. Tree trimming was the activity noted in the comments.

Responders were asked what their thoughts on flood insurance, especially with regards to increasing insurance premiums, were. The results are presented in Table 1-11. A majority of respondents indicated that they would be supportive of looking for ways to reduce the cost of flood insurance.

Table 1-11: Concerns with Flood Insurance Rates

Actions	Number Selecting
I do not have flood insurance and have no opinions about it	3
I currently have flood insurance and am not concerned about changes in the premiums	0
I currently have flood insurance and will be looking for ways to reduce my premiums	2
I would be supportive of looking for ways to reduce the cost of flood insurance policies for all policyholders	9

Survey-takers were asked about their feelings about planning for climate change and sea level change. Most responders believed that it was appropriate to plan for sea level rise to accelerate, with more than one foot of rise experienced by 2100. Furthermore, most responders believed that it is appropriate to plan for storm events to become more severe and more frequent in the future.

Table 1-12: Planning for Sea Level Change

Statement	Number Selecting
It is appropriate to plan for sea level rise to continue at the current rate, with less than a foot of rise by 2100	5
It is appropriate to plan for sea level rise to accelerate, with more than one foot of rise by 2100	7
It is appropriate to plan for sea level rise to accelerate dramatically, with several feet of rise by 2100	2

Table 1-13: Planning for Changing Storm Patterns

Statement	Number Selecting
It is appropriate to plan for storm events to occur more frequently	1
It is appropriate to plan for storm events to become more severe	1
It is appropriate to plan for storm events to become more severe and more frequent	8
It is appropriate to plan for storm events to occur at a similar frequency and severity as in the past	4

Responders were asked to rank, on a scale of one-to-ten, activities intended to restore daily life after a hazard event based on which was most important (1) to them and which was least (10). Ratings for each activity were averaged, and results are presented in Table 1-14. Addressing injuries and casualties, reopening roads, and restoring lines of communication were considered by respondents to be the three most important recovery activities.

Table 1-14: Importance of Recovery Activities

Activity	Average Rating	Relative Importance (Least → Most)
Address Injuries and Casualties	2.92	
Re-open Roads	3.42	
Restore Communication (Telephones, Cell Phones, Internet)	4.08	
Restore Water Service	4.50	
Restore Wastewater Collection and Disposal (Sewer or Septic System)	4.67	
Make Home Livable	6.25	
Reopen Businesses	6.58	
Repair Damaged Buildings	6.75	
Restore Parks, Beaches, and other Natural Resources	7.27	
Resume Tourism Activities	8.18	

When asked "What are the most important things that your municipal government and leaders can do to help residents and businesses be prepared for a disaster and become more resilient over time?" respondents answered as presented in Table 1-15. The responses suggest that conducting projects in the community to mitigate for hazards and to minimize impacts from disasters are the most desired type of municipal mitigation measure, followed by making it easier for residents, businesses, and organizations to take their own mitigation and resiliency actions.

Table 1-15: Most Important Municipal Mitigation Measures

Measure	Number Selecting
Conduct projects in the community, such as drainage and flood control projects, to mitigate for hazards and minimize impacts from disasters	11
Make it easier for residents, businesses, and organizations to take their own actions to mitigate for hazards and become more resilient to disasters	7
Enact municipal regulations, codes, and ordinances - such as zoning regulations and building codes - designed to protect residents and businesses from natural hazards and disasters	5
Provide technical assistance to residents, businesses, and organizations to help them reduce losses from hazards and disasters	4
Provide outreach and education to residents, businesses, and organizations to help them understand risks and be prepared	3
Improve warning and response systems to improve disaster management	1

Respondents were asked if they have taken any steps to reduce risks to their family homes or businesses. The results are summarized in Table 1-16. Responses varied, with the highest number of responders reporting that they maintain a disaster supply kit and participate in public meetings overseeing local planning processes. Other respondents have taken measures to reduce snow build-up on roofs, and cut back or removed vegetation near overhead utility lines and roofs.

Table 1-16: Personal Mitigation Measures Taken

Measure	Number Selecting
Elevated my home or business to reduce flood damage	1
Floodproofed my business to reduce flood damage	1
Installed storm shutters or structural/roof braces to reduce wind damage	2
Taken measures to reduce snow build-up on roofs	4
Cut back or removed vegetation from my overhead utility lines or roof	4
Replaced my overhead utility lines with underground lines	1
Managed vegetation to reduce risk of wildfire reaching my home or business	2
Developed a disaster plan for my family, home, or business	2
Maintain a disaster supply kit for my family, home, or business	5
Participated in public meetings to discuss the Plan of Conservation and Development or open space plans	5
Participated in public meetings to discuss and approve changes to zoning or subdivision regulations	1
I have not taken any of these actions	1

Additional actions shared in comments include:

- Volunteered for Climate Change Task Force and Local Land Trust
- Replaced Old Roof

Participants were asked what one action could be taken in their community to reduce risks of hazards and disasters. Responses included:

- Streamline processes (including grants) for work to protect properties from hazards
- Protect roads from post-flooding damage
- Allow for flooding (which is inevitable) but allow for unimpeded run off [drainage]
- Supply convenient food and water in the case of extended power outages
- Provide means of communication and transport after flooding.
- Encourage more volunteerism for emergency services
- Define a community supply stockpile for food, water and basic shelter. Don't rely on retail supply chains.
- Set aside the future coastal floodplain as open space area
- Improve infrastructure to prevent erosion and support drainage
- Clean out all waterways, rivers and ponds
- Better repairing of dams

Additional comments and questions included:

- What do elected officials plan to do regarding sea level rise, and how will it be paid for?
- Where does the Hazard Mitigation Plan reside?

- Maintain supplemental local power systems for battery operated devices.
- Develop a standard communications system (website, radio) detailing what is open, closed, or impassible, and where food and water supplies are located.
- Coordinate with Stonington's Coastal Resiliency Plan
- Communities: take a closer look at the public safety side of hazards and have plans to increase efficiency and staffing during and after disasters
- Make the plan real and realistic.
- Communities must know available resources for the first hours or days after a major event when the community will be isolated.
- Address sea level rise regionally and not just at the town level.

Finally, nine participants provided additional contact information for follow-up. These respondents were emailed when the draft plan was made available for public review on the SCCOG website in August 2017. A copy of the email is presented in Appendix A. No comments were received on the plan to date.

Results of the public survey are included in Appendix B.

1.4.5 Draft Plan Review

Members of each jurisdiction involved in the planning process will be sent an electronic version of the Multi-Jurisdictional plan, their community annex, and the community annexes of their neighboring communities to review and comment. Communities will be encouraged to share the review draft with other committees and solicit their comments prior to compiling the final draft of the HMP.

Final opportunities for the public to review the HMP update will be implemented in advance of the public hearings to adopt this plan which will be scheduled in each SCCOG community following conditional approval of the HMP by FEMA. The drafts sent for State review and FEMA review will be posted on the SCCOG website and individual community websites, if possible, for public review and comment. Comments received from the public will be incorporated into the final draft where applicable.

Upon receiving conditional approval by FEMA, a public hearing will be scheduled at which time any remaining public comments may be addressed. If any final HMP modifications result from the comment period leading up to and including the public hearings to adopt the HMP update, these will be submitted to the Connecticut DEMHS and FEMA with a cover letter explaining the changes. It is not anticipated that any major modifications will occur at that phase of the project.

1.5 Coordination with Neighboring Communities

SCCOG and its member communities have coordinated with neighboring municipalities both within and without the SCCOG region in the past relative to hazard mitigation and emergency preparedness and continue to do so. The following is a list of the communities that lie outside of the SCCOG region but adjacent to SCCOG municipalities.

Table 1-17 : Non-SCCOG Municipalities Adjacent to SCCOG Communities

City / Town	Hazard Mitigation Plan Status
Adjacent Connecticut Municipalities	
Town of Old Lyme	Single Jurisdiction Plan via RiverCOG (2014)
Town of Lyme	
Town of East Haddam	Multi-Jurisdictional Plan via RiverCOG (2014)
Town of East Hampton	
Town of Marlborough	Multi-Jurisdictional Plan through CRCOG (2014)
Town of Hebron	
Town of Columbia	Multi-Jurisdictional Plan via Former WinCOG (2016)
Town of Coventry	
Town of Mansfield	
Town of Chaplain	Multi-Jurisdictional Plan via NECCOG (2015)
Town of Scotland	
Town of Canterbury	
Town of Plainfield	
Town of Voluntown	
Adjacent Rhode Island Municipalities	
Town of Hopkinton	Single Jurisdiction Plan (2012), Update in Progress
Town of Westerly	Single Jurisdiction Plan (2012)

Communities outside of the region were included in the development of the annexes to the extent practicable, including having the option to attend the public meetings and participate in the online survey. However, SCCOG communities generally do not have shared hazard mitigation interests with their immediate neighbors that require direct coordination without facilitation by SCCOG.

SCCOG communities were given ample opportunity to review and comment on the Multi-Jurisdictional plan and community annexes during plan development. For example, SCCOG member communities within the southeastern Connecticut region were invited to review the mitigation strategies formulated by their neighboring SCCOG member municipalities.

1.6 Implementation Strategy and Schedule

The SCCOG will be responsible for coordinating adoption of this HMP in its member communities and tribes. The SCCOG understands that this multi-jurisdictional plan will be considered current for five years from the date that the first SCCOG community adopts the plan. Thus, communities that choose to delay adoption of this plan will not impede mitigation activities of other SCCOG communities. However, communities that delay adoption will not be eligible for certain funding programs administered by FEMA until they formally adopt the plan.

Each community annex identifies the responsible party for HMP implementation at the local level. The SCCOG will work with local HMP coordinators to pursue mitigation actions at the local level by offering its expertise and assistance to identify and pursue the potential technical assistance and funding sources identified in Section 12.

Individual mitigation actions (Section 11 of this Multi-Jurisdictional document and in each community annex) of this HMP will be implemented by the municipal and tribal commissions and departments that oversee these activities. The STAPLEE matrix in Appendix A of each community and tribal annex outlines current recommendations for each community and tribe. An implementation strategy and schedule is also identified for each action, detailing the responsible department and anticipated time frame for completing the mitigation action if funding is available.

Upon adoption at the local level, this HMP will be made available to other community and tribal departments as a planning tool to be used in conjunction with existing documents and regulations. It is expected that revisions to other community and tribal plans and regulations such as the Plan of Conservation and Development, department annual budgets, and Zoning and Subdivision Regulations may reference this plan and its updates. The local coordinators will be responsible for ensuring that the actions identified in each annex are incorporated into local planning activities.

Local leaders will be responsible for assigning appropriate community and tribal officials to update local planning documents, regulations, and emergency operations plans to include the provisions from this HMP if it is determined that such updates are appropriate. The local coordinators will be responsible for determining the extent of the revisions. However, should a general revision be too cumbersome or cost prohibitive, simple addendums to these documents will be added that include the provisions of this HMP. The Plan of Conservation and Development (and similar tribal plans) are the documents most likely to benefit from the inclusion of mitigation-related goals and recommendations, as discussed in Section 2.8.

Information and projects in this HMP will be included in the annual budget and capital improvement plans as part of implementing the projects recommended herein. This will primarily include the annual budget and capital improvement project lists maintained by each community and tribe.

1.7 Progress Monitoring and Public Participation

The following instructions shall be followed by the local coordinators of this HMP as identified in each community and tribal annex. The local coordinators will be responsible for monitoring the successful implementation of this HMP in their community or tribe. The local coordinator will provide the linkage between the multiple departments involved in hazard mitigation at the local level relative to communication and participation. As the plans will be adopted by each local government, coordination is expected to be able to occur without significant barriers.

Site reconnaissance for Specific Recommendations – Local coordinators, with the assistance of appropriate department personnel, will annually perform reconnaissance-level inspections of sites that are subject to specific recommendations. This will ensure that these recommendations remain viable

and appropriate. Examples include home acquisitions or elevations, structural projects such as culvert replacements, roadway elevations in coastal areas, and water main extensions for increased fire suppression capabilities. The worksheet in Appendix C will be filled out for specific project-related recommendations.

The local coordinator will be responsible for obtaining a current list of repetitive loss properties (RLPs) in the community each year. This list is available from the Connecticut DEEP. The RLPs shall be subject to a windshield survey at least once every two years to ensure that the list is reasonably accurate relative to addresses and other basic information. Some of the reconnaissance-level inspections could occur incidentally during events such as flooding when response is underway.

Annual Reporting and Meeting – Each local coordinator will be responsible for having an annual meeting to review the plan. Matters to be reviewed on an annual basis include the goals and objectives of the HMP, hazards or disasters that occurred during the preceding year (for example, the recent devastation from Tropical Storm Irene), mitigation activities that have been accomplished to date, a discussion of reasons that implementation may be behind schedule, and recommendations for new projects and revised activities. Results of site reconnaissance efforts will be reviewed also. A meeting should be conducted in spring each year, at least two months before the annual application cycle for pre-disaster grants under the HMA program[1]. This will enable a list of possible projects to be circulated to applicable local departments to review and provide sufficient time to develop a grant application. The local coordinator shall prepare and maintain documentation and minutes of this annual review meeting.

Post-Disaster Reporting and Metering – Subsequent to federally declared disasters in the State of Connecticut, a meeting shall be conducted by each local coordinator and representatives of appropriate departments to develop a list of possible projects for developing an HMGP application. The local coordinator shall prepare a report of the recent events and ongoing or recent mitigation activities for discussion and review at the HMGP meeting. Public outreach shall be solicited for HMGP applications at a *separate* public meeting.

Continued Public Involvement – Continued public involvement will be sought regarding the monitoring, evaluating, and updating of the HMP. Public input can be solicited through community meetings, presentations on local cable access channels, and input to web-based information gathering tools. Public comment on changes to the HMP may be sought through posting of public notices and notifications posted on local websites and the SCCOG website.

1.8 Updating the Plan

Updates to this HMP will be coordinated by SCCOG. SCCOG will update this Plan if at least one of its member communities expresses an interest in keeping the plan current with FEMA. SCCOG understands that this HMP will be considered current for a period of five years from the date of adoption of the first community to adopt the plan. SCCOG will be responsible for compiling the funding required to update the HMP in a timely manner such that the current plan will not expire while the plan update is being

[1] PDM and FMA applications are typically due to the DEMHS in October of any given year.

developed. This will ensure that the opportunity to apply for funding is available should an untimely disaster occur.

To update the Plan, the SCCOG or its consultant will coordinate the appropriate group of local officials consisting of representatives of many of the same departments solicited for input to this HMP. In addition, local business leaders, community and neighborhood group leaders, relevant private and nonprofit interest groups, and the neighboring municipalities will be solicited for representation, including representatives from communities adjacent to SCCOG communities but not part of SCCOG. These communities were outlined in Table 1-6.

The project recommendation worksheets prepared by the local coordinators and annual reports described in Section 1.7 above for each municipality will be reviewed. In addition, the following questions will be asked of each community and tribe:

- Do the mitigation goals and objectives still reflect the concerns of local residents, business owners, and officials?
- Have local conditions changed so that findings of the risk and vulnerability assessments should be updated?
- Are new sources of information available that will improve the risk assessment? For example, revised coastal digital flood insurance rate maps (DFIRMs) (see Section 4) will be released and adopted during the time between this plan update and the next plan update.
- If risks and vulnerabilities have changed, do the mitigation goals and objectives still reflect the risk assessment?
- What hazards have caused damage locally since the last edition of the HMP was developed? Were these anticipated and evaluated in the HMP or should these hazards be added to the plan? For example, Tropical Storm Irene occurred just prior to this update, and the effects were important considerations.
- Are current personnel and financial resources at the local level sufficient for implementing mitigation actions?
- For each mitigation action that has not been completed, what are the obstacles to implementation? What are potential solutions for overcoming these obstacles?
- For each mitigation action that has been completed, was the action effective in reducing risk? For example, acquisition and demolition of floodprone structures would generally be considered to be effective if performed properly.
- What mitigation recommendations should be added to the plan and proposed for implementation?
- If any proposed mitigation actions should be deleted from the plan, what is the rationale?

Future HMP updates may include deleting recommendations as projects are completed, adding recommendations as new hazard effects arise, or modifying hazard vulnerabilities as land use changes. For instance, with reference to Table 11-1 of each community and tribal annex, several mitigation actions were removed from the HMP while preparing this update because they were successfully completed, while others were subsumed by more specific mitigation actions. In addition, the list of shelters and critical facilities should be updated as necessary or at least during each HMP update.

2.0 REGIONAL PROFILE

2.1 Physical Setting

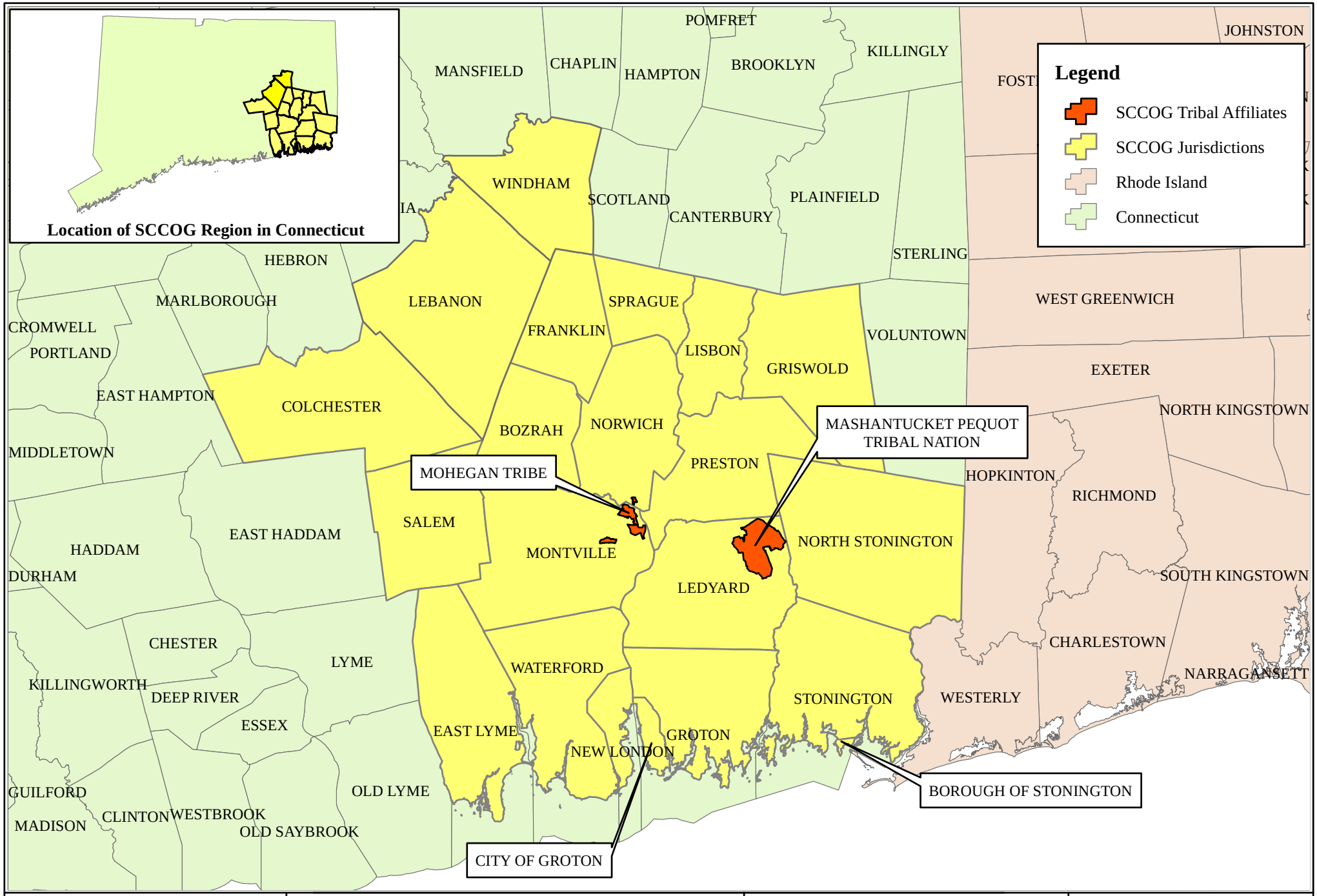
The Southeastern Connecticut Council of Governments (SCCOG) is the regional planning organization consisting of 22 municipalities in the southeastern corner of Connecticut. The planning region comprises all but three municipalities in New London County and includes one town in Windham County. The member communities include the towns, cities and boroughs of: Bozrah, Colchester, East Lyme, Franklin, Griswold, City of Groton, Town of Groton, Jewett City, Lebanon, Ledyard, Lisbon, Montville, New London, North Stonington, Norwich, Preston, Salem, Sprague, Stonington, Stonington Borough, Waterford, and Windham. Two federally recognized Native American tribes, the Mashantucket Pequot Tribal Nation and the Mohegan Tribal Nation, are affiliate members of the SCCOG.

In 2014, the SCCOG's boundary was re-designated by act of the Connecticut General Assembly. As part of this re-designation, the SCCOG gained the towns of Lebanon and Windham, and lost the town of Voluntown. In June 2014, the SCCOG voted to amend its MPO boundary to add Lebanon and Windham, and to remove Voluntown. The Governor approved of this redefinition as required by federal regulation in June, 2015.

The communities of Waterford, East Lyme, City and Town of Groton, New London, Stonington, and the Borough of Stonington are bordered by Long Island Sound to the south, while other adjacent communities to SCCOG communities were listed in Table 1-6. Refer to Figure 2-1 for a map showing the regional location of SCCOG.

Coastal towns including East Lyme, Waterford, New London, Groton and Stonington lie almost entirely in the region of Connecticut called the "Coastal Slope," a zone that begins approximately 12 miles north of the coastline and extends toward the continental shelf. In this zone, the plane of hilltop elevation decreases at a slope of about 50 feet per mile, about twice the slope of zones further inland. The topography in the SCCOG region generally increases in elevation moving from the shoreline of Long Island sound inland to the north. Many areas remain below 200 feet above sea level, while higher hills can reach over 500 feet; the highest point in the region is the peak of Gates Hill in Lebanon at 660 feet. Major rivers, including the Thames, the Quinebaug, and the Shetucket, create further hydrographic divides in the region necessitating major bridge crossings.

The location of SCCOG communities in southeastern Connecticut places its residents at risk of damage from a variety of natural hazards. SCCOG communities are at risk of experiencing inland flooding, hurricanes, summer storms, tornadoes, hail, severe winds, lightning, heavy snow, earthquakes, dam failure, and wildfires similar to other communities in the region. While the presence of Long Island provides a buffer against wave action from coastal flooding, storms approaching from the southeast can bypass Long Island and cause a direct hit on the SCCOG coastline. Thus, coastal flooding and erosion is a particular concern for coastal SCCOG communities.



SOURCE(S):
CT DEEP GIS Data
RI GIS Data
NYS GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 2-1: Regional Location of SCCOG

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION: Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-05
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-1.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 30,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

According to information on the FEMA website, Connecticut has received 20 Major Disaster Declarations since 1954. Table 2-1 presents information related to recent declarations in New London County. Recent disasters include a tropical storm, a heavy snow storm, and severe storms that produced widespread inland flooding.

Table 2-1: Disaster and Emergency Declarations in SCCOG Region

Disaster Number	Event	Date of Event(s)	Individual Assistance	Public Assistance	HMGP
FEMA-DR-4213	Severe Winter Storm and Snowstorm	1/26 -1/29/2015		X	X
FEMA-DR-4106	Severe Winter Storm and Snowstorm	2/08 - 2/12/2013		X	X
FEMA-DR-4087	Hurricane Sandy	10/27 - 11/08/2012	X	X	X
FEMA-DR-4046 / EM-3342	Winter Storm Alfred	10/29 – 10/30/2011		X	X
FEMA-DR-4023	Tropical Storm Irene	8/27 – 9/1/2011	X	X	X
FEMA-DR-1958	Snowstorm	1/11 – 1/12/2011		X	X
FEMA-DR-1904	Severe Storms and Flooding	3/12 – 5/17/2010	X	X	X
FEMA-DR-1700	Severe Storms and Flooding	4/15 – 4/27/2007	X		X
FEMA-EM-3266	Snow	2/11 – 2/12/2006		X	
FEMA-DR-1619	Severe Storms and Flooding	10/14 – 10/15/2005		X	X
FEMA-EM-3200	Snow	1/22 – 1/23/2005		X	
FEMA-EM-3192	Snow	12/5 – 12/7/2003		X	
FEMA-EM-3176	Snowstorm	2/17 – 2/18/2003		X	
FEMA-DR-1092	Blizzard	1/7 – 1/13/1996		X	
FEMA-EM-3098	Severe Winds, Blizzard, Record Snowfall	3/13 – 3/17-1993		X	
FEMA-DR-916	Hurricane Bob	8/19/1991		X	
FEMA-DR-747	Hurricane Gloria	9/27/1985		X	
FEMA-DR-661	Severe Storms, Flooding	6/14/1982	X	X	
FEMA-EM-3060	Blizzards and Snowstorms	2/7/1978		X	
FEMA-DR-42	Hurricane, Torrential Rain, Floods	8/20/1955			
FEMA-DR-25	Hurricanes	9/17/1954			

Notes: *Individual Assistance* includes assistance to individuals and households.
Public Assistance includes assistance to State and local governments and certain private non-profit organizations for emergency work and the repair or replacement of disaster-damaged facilities.

2.2 Land Use

The land area of the region is 616.6 square miles based on Geographic Information System (GIS) town boundary data available from the Connecticut DEEP. 4.3 square miles fall within the Tribal Nation jurisdictions not included in this Plan. Nearly 85% of the SCCOG area is largely undeveloped, consisting of forests, wetlands, lands in agricultural use, active and passive recreation, and dedicated open space. Table 2-2 presents the 2006 land cover data for the SCCOG region as prepared by the University of Connecticut's Center for Land Use Education and Research (CLEAR).

Table 2-2: 2006 Land Cover in the SCCOG Region

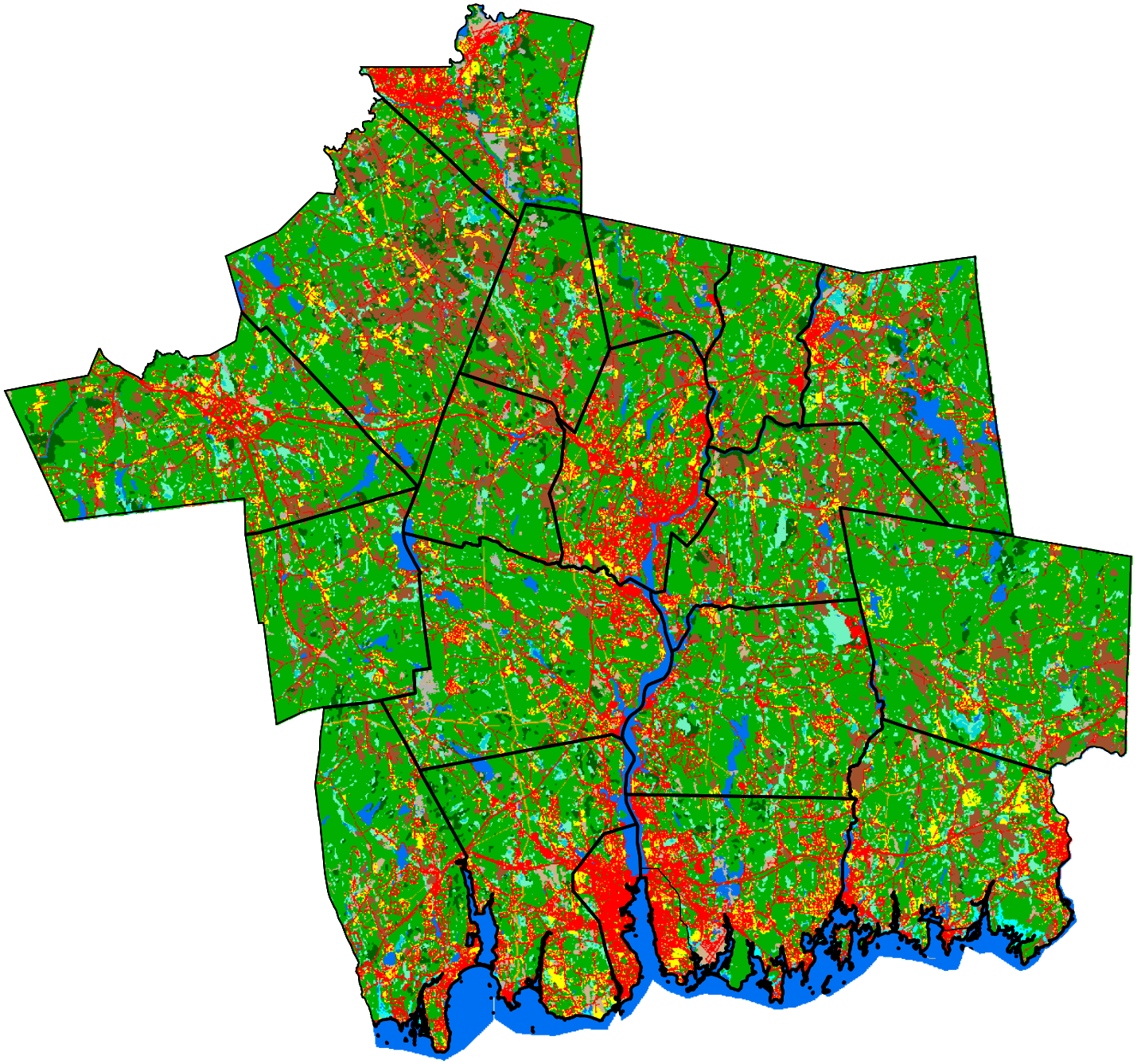
Category	Area (acres)	Percentage
Developed	61,228	15.5%
Turf & Grass	23,562	6.0%
Other Grasses	8,437	2.1%
Agricultural Field	32,516	8.2%
Deciduous Forest	208,434	52.7%
Coniferous Forest	15,004	3.8%
Water	14,768	3.7%
Non-Forested Wetland	2,303	0.6%
Forested Wetland	20,001	5.1%
Tidal Wetland	1,694	0.4%
Barren	5,692	1.4%
Utility ROW (Forest)	1,933	0.5%
Total	**395,572**	100.0%

Source: UConn CLEAR

Figure 2-2 presents generalized land cover based on the 2006 CLEAR land cover data. Areas shown as turf and grass are maintained grasses such as residential and commercial lawns or golf courses.

In May 2012, SCCOG released updated land use calculations based on 2011 data collected from jurisdictions within SCCOG at that time. This project analyzed the land use at over 95,000 parcels and utilizes more recent Geographic Information System (GIS) software and techniques than those utilized during the 2006 CLEAR study. Table 1 from this document is presented herein as Table 2-3. Figure 2-3 presents 2011 land use data as reprinted from the 2012 SCCOG *Land Use – 2011 – Southeastern Connecticut Region* document. **It is important to note that this data does not include land-use for the towns of Windham and Lebanon**, which were not members of SCCOG at the time of that report. The totals listed below do include Voluntown, which was still a member of SCCOG at the time of the report. Nevertheless this information provides a useful regional overview.

As noted in Table 2-3, approximately 22% of the region consists of residential development, approximately 2% is commercial, and approximately 2% is industrial. Approximately 35% of the existing land area is considered to be developed (including the above categories), 24% is considered to be designated open space or agriculture, and approximately 40% is considered to be undeveloped land.



SOURCE(S):
2010 UConn CLEAR

N

Figure 2-2: Land Cover of SCCOG Region, 2010

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-2.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

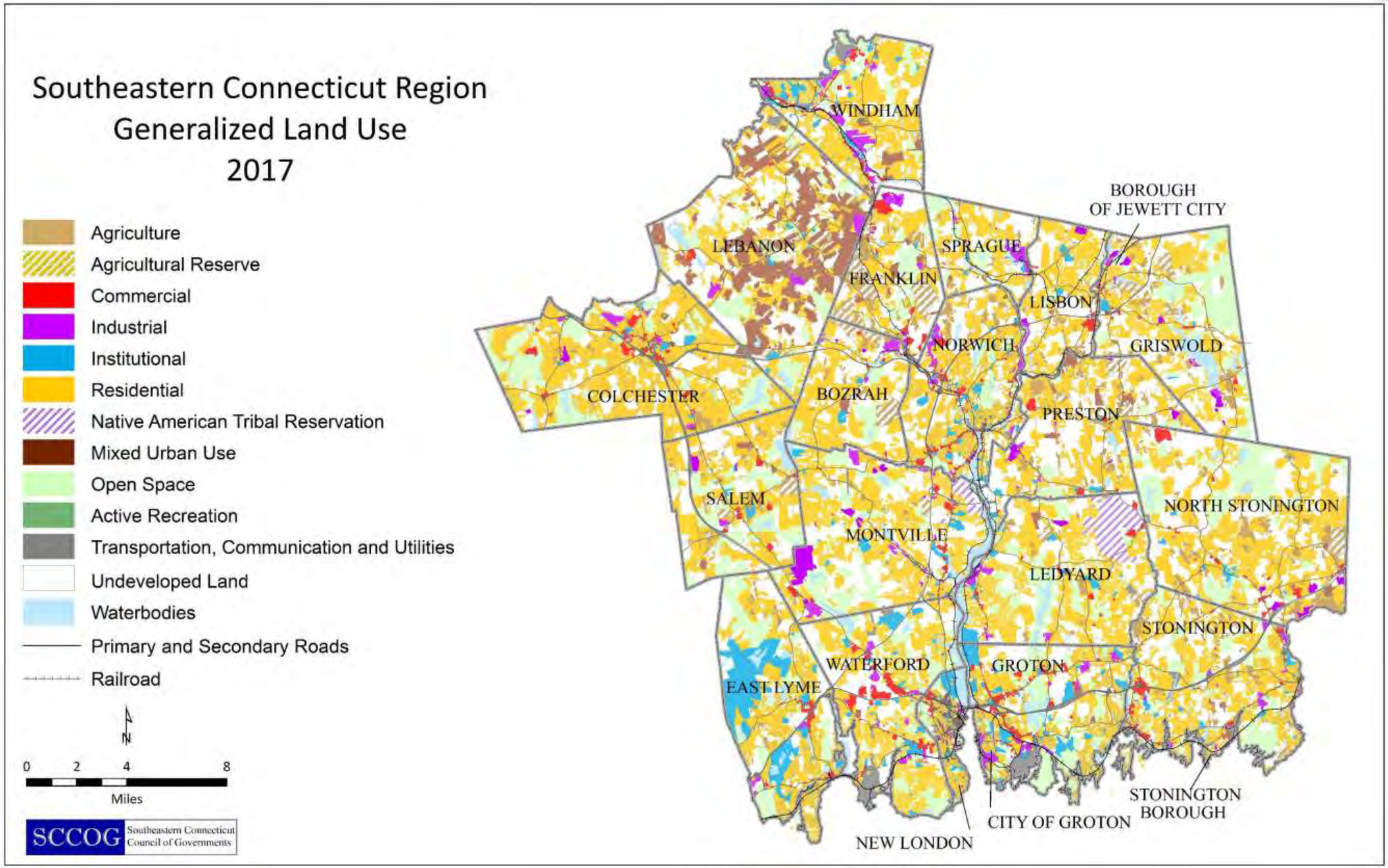


Figure 2-3. Existing Land Use in Southeastern Connecticut, 2016.
Source: Municipal Land Use Data.

Table 2-3: 2011 Land Cover in the SCCOG Region

Category	Acres:	% of Total
Low And Very Low Density Residential	55,783	**15.0%**
Medium And High Density Residential	25,545	**7.1%**
Industrial Intensive	4,274	**1.2%**
Industrial Extractive	2,171	**0.6%**
Commercial	6,794	**1.9%**
Institutional	11,408	**3.2%**
Mixed Urban Use	105	**0.03%**
Transportation Communication And Utility (TCU)	20,549	**5.7%**
Total Developed Land	**126,629**	**35.3%**
Open Space (W/ Cemeteries)	57,777	**16.1%**
Active Recreation	8,479	**2.4%**
Agriculture (Includes Agricultural Reserves)	20,451	**5.7%**
Total Designated Open Space	**86,707**	**24.2%**
Native American Tribal Reservation	2,736	**0.8%**
Undeveloped	142,780	**39.8%**
Total Acres In Region	**358,852**	**100.0%**

Source: SCCOG

The coastal areas and regions adjacent to major watercourses are predominantly developed, whereas the outer regions are characterized by mixtures of forest, wetland, and agriculture. The highest developed density in the region is located along the Quinebaug River and the Thames River corridor. Jewett City in the Town of Griswold, Norwich, New London, and the City of Groton were the municipalities with the highest development density in the region, although Windham also has a heavily developed section in Willimantic. As noted in Table 2-3, over 44% of developed land in the SCCOG region in 2011 was residential with 31% of all residential development in the medium to high density range (defined as greater than 1 dwelling unit per acre). The remaining developed land in the region is a mix of commercial, industrial, institutional, mixed urban, and transportation, communication, and utility uses.

The majority of region's land cover is designated as deciduous forest, with developed areas accounting for the next largest percentage of land use. State forests are found throughout the region and include the Pachaug State Forest in Griswold, the Salmon River State Forest in Colchester, Rocky Neck State Park and Nehantic State Forest in East Lyme, and the Hopeville State Forest in Griswold. The northeastern corner of the SCCOG region is particularly undeveloped and is dominated by the Pachaug State Forest.

2.3 Geologic Setting

2.3.1 Geology

Geology is important to the occurrence and relative effects of natural hazards such as earthquakes and coastal erosion. Thus, it is important to understand the geologic setting and variation of bedrock and surficial formations in the SCCOG region. Geologic information discussed in the following section was

acquired in Geographic Information System (GIS) format from the United States Geological Survey and the Connecticut DEEP.

In terms of North American bedrock geology, the region is located in the northeastern part of the Appalachian Orogenic Belt, also known as the Appalachian Highlands, which extend from Maine southward to Mississippi and Alabama. The Appalachian Highlands were formed when Pangaea assembled during the late Paleozoic era. The region is generally characterized by deformed sedimentary rocks cut through by numerous thrust faults.

Bedrock Geology
Connecticut bedrock geology is comprised of several "terranes." Terranes are geologic regions that reflect the role of plate tectonics in Connecticut's natural history.

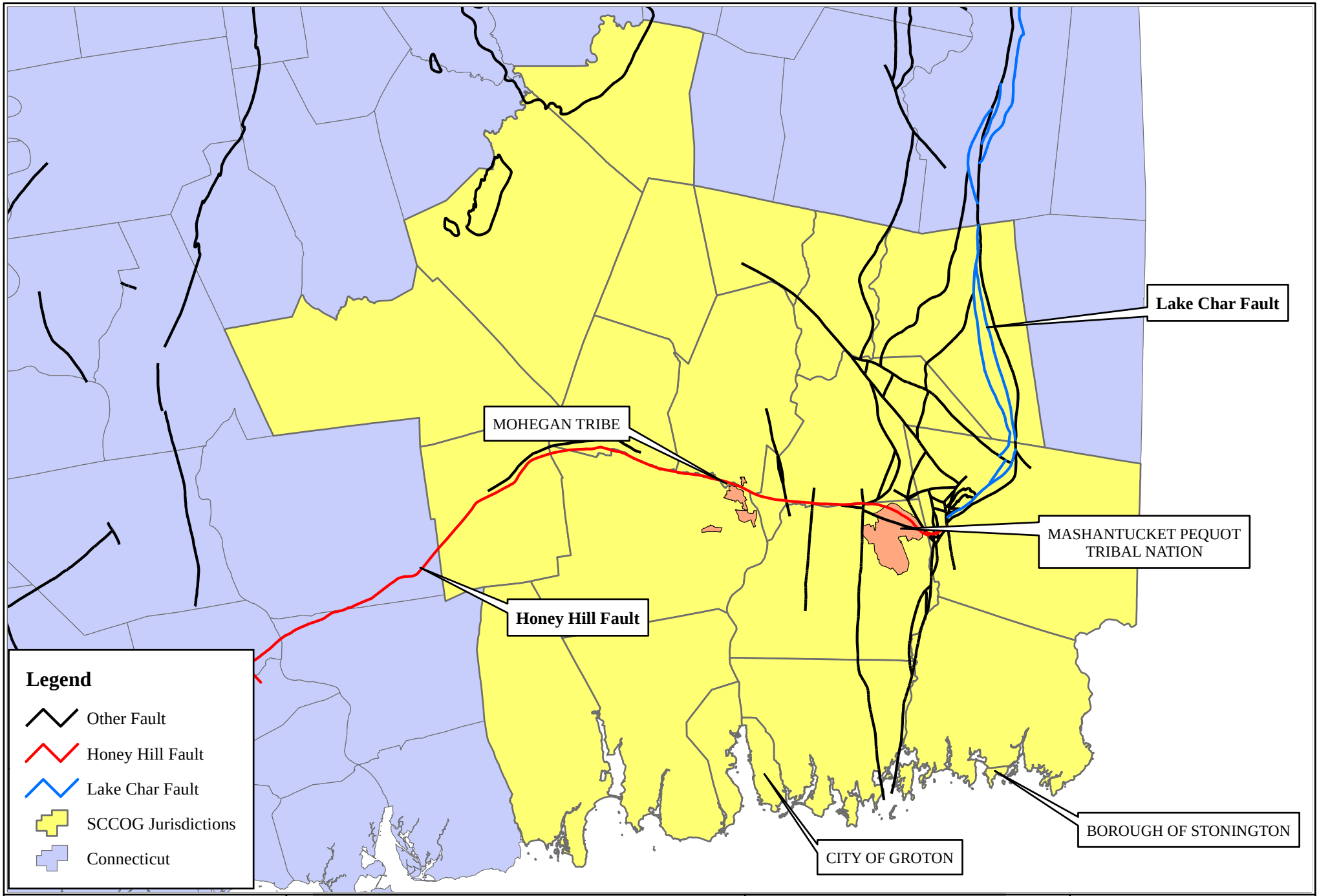
The SCCOG region contains a number of different bedrock formations that have been extensively mapped by the State of Connecticut Geology and Natural History Survey. These formations are aligned in tight, alternating bands trending west to east along the coastline and extending approximately 16 miles inland from the coast. The bedrock formations then transition into wider, north-south trending bands throughout the northern towns in the region. The area in northwestern Windham is part of the Willimantic Window, an area where underlying rocks of the Avalonian Terrane are exposed beneath the surrounding Iapetos Terrane.

There are numerous faults within the SCCOG region. The two most significant fault lines are the Honey Hill Thrust fault and the Lake Char Fault which comprise the Lake Char-Honey Hill Fault complex in southeastern Connecticut. This fault system is composed of the north-south trending Lake Char and the east-west trending Honey Hill Fault. These two faults meet and conjoin around a sharp 90° bend north of Ledyard. The Willimantic Window is also bounded by a thrust fault. Refer to Figure 2-4 for a depiction of mapped fault lines in the SCCOG region.

The Honey Hill Thrust Fault runs west-east through Salem, along the boundary between Bozrah and Montville, and along the boundary between Preston and Ledyard. The Lake Char fault is oriented north-south and crosses through the center of Griswold, and curves to the southwest through the northwest corner of North Stonington where it connects to the Honey Hill Thrust Fault near a series of intercrossed minor fault lines along the western boundary of North Stonington. The Lake Char Fault is a diagonal line formed by the collision of two Paleozoic land masses, and is one of the oldest fault lines on Earth.

Glaciers have formed in the northern hemisphere several times over the past few million years, with the most recent occurrence being approximately 12,000 years ago. The southernmost portion of the more recent glaciations covered the area that is now the SCCOG region. The result of the recent glacial recession is that the SCCOG region is covered by a variety of sand and gravel deposits. As the glaciers receded, mineral deposits were left behind by the melting ice forming glacial till, and meltwaters carved valleys and left stratified drift deposits behind when they receded.

Till areas contains an unsorted mixture of clay, silt, sand, gravel, and boulders deposited by glaciers as a ground moraine, while surficial materials in stratified drift areas are more homogenous. Refer to Figure 2-5 for a generalized depiction of surficial materials in the SCCOG region.



SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

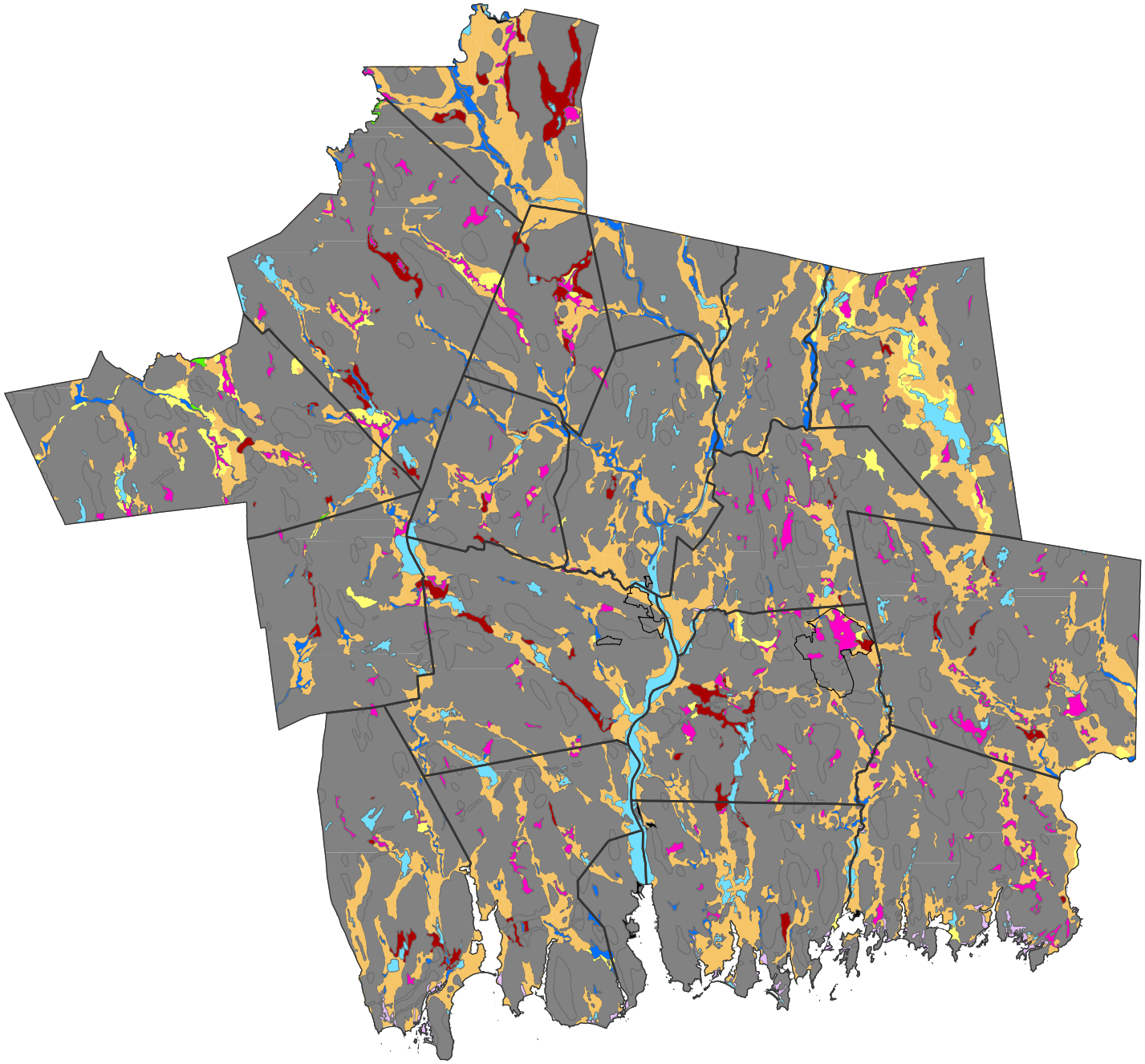
Figure 2-4: Fault Lines in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-4.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com



Legend

- SCCOG Jurisdictions

Surficial Geology

- Alluvium
- Artificial Fill
- Fines
- Gravel
- Salt Marsh
- Sand and Gravel
- Sand
- Swamp
- Till
- Water

SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 2-5: Surficial Geology in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-5.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

The surficial geology of the SCCOG region is important to natural hazard mitigation for several reasons:

- First, areas of stratified materials are generally coincident with current and historical floodplains. These materials were deposited at lower elevations by glacial streams, and these valleys were later inherited by the larger of our present day streams and rivers.
- Second, stratified drift areas are often important sources of public water supply necessary to fight wildfires and other fires caused by natural hazards such as lightning or earthquakes.
- Third, areas of till typically contain higher amounts of surficial materials that are less susceptible to erosion.
- Finally, the amount of stratified drift also has bearing on the relative intensity of earthquakes and the likelihood of soil subsidence in areas of fill.

2.4 Climate and Climate Change

2.4.1 Current Climate Conditions

The SCCOG region has an agreeable climate characterized by moderate but distinct seasons. The mean annual high temperature is approximately 60 degrees Fahrenheit in Connecticut as reported by NOAA for the period 1981-2010. Summer temperatures rise in the mid-80s, and winter temperatures dip into the upper 20s to mid-30's Fahrenheit. Extreme conditions can raise summer temperatures to near 100 degrees and winter temperatures to below zero.

Additionally, according to NOAA, median snowfall inland is approximately 46 inches per year, while median snowfall along Long Island Sound is approximately 22 inches per year. Mean annual precipitation is 54.8 inches per year as measured in Norwich, and is typically evenly distributed throughout the year. By comparison, average annual statewide precipitation based on more than 100 years of record is much lower at 44.8 inches.

2.4.2 Climate Change

The continued increase in precipitation only heightens the need for hazard mitigation planning as the occurrence of floods may change in accordance with the greater precipitation.

It has been shown that average annual precipitation in Connecticut has been increasing by 0.95 inches per decade since the end of the 19th century (Miller et al., 1997; NCDC, 2005). In recent years, much of this increase is attributed to extreme storms. Winter has also produced extreme storms in recent years, such as the winter of 2010-2011 which saw upwards of 80 inches of snowfall in parts of Connecticut. The increase in precipitation, along with sea level rise and the potential for increased heavy snowfall during the winter months, must be accounted for in regional planning.

According to the 2017 Connecticut State Water Plan climate change analysis, climate models project an increase in temperature for all calendar months. Projected temperature changes appear relatively consistent across calendar months and percentile levels, for each of the scenarios. In other words, both summer and winter temperatures are projected to increase by similar amounts; and a similar shift is observed for both extreme cold and extreme hot months. Precipitation projections are more variable, although consistently projecting a generally wetter future for all four scenarios. The largest

precipitation increases are projected for the wetter months (higher percentiles), including extreme wet months. It follows, then, that the seasonality plots show that winter and spring precipitation changes are projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Small decreases in extreme dry month precipitation are projected for the "hot/dry" scenario.

Many storm drainage systems and culverts in the SCCOG region were likely designed using rainfall data published in "Technical Paper No. 40" by the U.S. Weather Bureau (now the National Weather Service) (Hershfield, 1961). The rainfall data in this document dates from the years 1938 through 1958. These values are the standard used in the current *Connecticut DOT Drainage Manual* (2000) and have been the engineering standard in Connecticut for many years. According to these data, the 24-hour rainfall amount in New London County is as follows:

Table 2-4 : U.S. Weather Bureau *Technical Paper No. 40* 24-Hour Rainfall Amounts

Return Frequency (Years)	2	5	10	25	50	100
Rainfall Amount (inches)	3.4	4.3	5.0	5.7	6.3	7.1

This engineering standard was based on the premise that extreme rainfall series do not change through time, and therefore historical data reflect current conditions. Recent regional and state-specific analyses have shown that this is not the case: the frequency of 2-inch rainfall events has increased, and storms once considered a 1-percent-annual-chance event are now likely to occur twice as often. A 2016 paper (Barrett and Salis, 2016) finds that flow rates during peak annual floods, as well as floods with recurrence intervals of 5, 10- and 20- years, have been increasing between 1962 and 2012. Average observed rates are from 0.9 to 1.8 percent per year.

The NRCC has partnered with the Natural Resources Conservation Service (NRCS) to provide a consistent, current regional analysis of rainfall extremes (http://precip.eas.cornell.edu/) for engineering design. The availability of updated data has numerous implications for natural hazard mitigation as it can be used to reevaluate drainage systems, culverts, and bridges. This dataset lists the 24-hour rainfall amount in select SCCOG communities as follows, demonstrating a significant increase in rainfall over the TP-40 data for the larger storm events:

Table 2-5: NRCC 24-Hour Rainfall Amounts

Return Frequency (Years)	2	5	10	25	50	100
	Rainfall Amount (inches)					
Colchester	3.25	4.01	4.69	5.79	6.78	7.96
Norwich	3.35	4.13	4.85	6.00	7.05	8.30
Groton Long Point	3.35	4.15	4.88	6.06	7.13	8.40

On November 3, 2015, the Connecticut Department of Transportation (CT DOT) Office of Engineering put out a bulletin (number EB-2015-2) directing that updated precipitation frequency estimates from the *NOAA Atlas 14* released on September 30, 2015 be used in planning and design. This newest data puts the 24-hour rainfall amount in Norwich as follows, generally increasing the magnitude of smaller storm events but not increasing the larger storm events to the extent of the NRCC data:

Table 2-6: *NOAA Atlas 14* 24-Hour Rainfall Amounts

Return Frequency (Years)	2	5	10	25	50	100
Rainfall Amount (inches)	3.44	4.34	5.08	6.10	6.89	7.67

As climate continues to change, the SCCOG communities must consider not just the past and present, but also potential future conditions. As the expectation is that the precipitation magnitude associated with smaller, more frequent storms is expected to increase, design standards will likely need to continue to increase to compensate. Furthermore, with the expectation that the precipitation magnitude associated with larger, less frequent storms is also expected to increase, more efficient and effective stormwater management controls will be necessary to mitigate flash and poor drainage flooding.

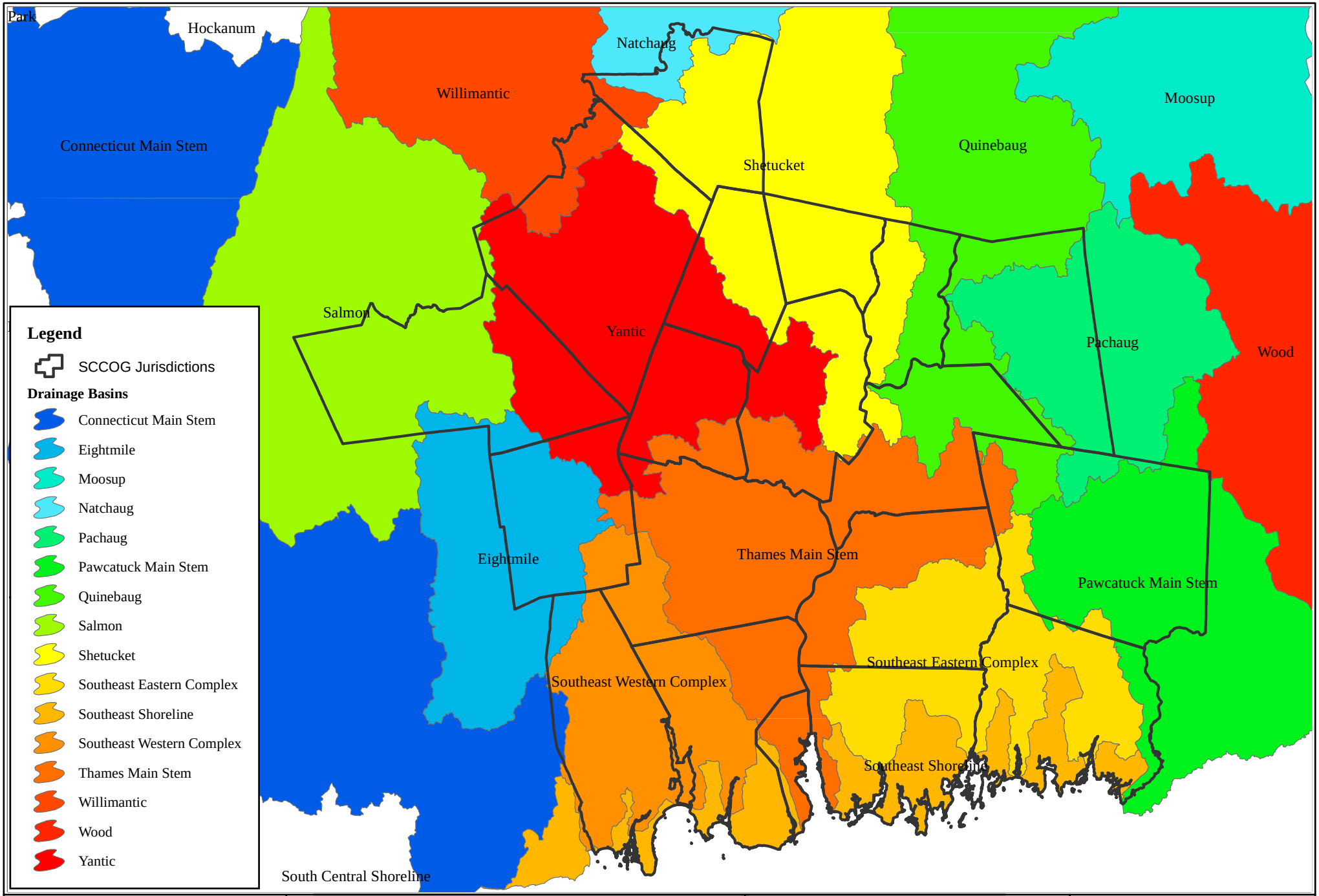
2.5 Drainage Basins and Hydrology

The SCCOG region lies within 16 regional watersheds as defined by the Connecticut DEEP. The majority of these regional basins drain to the Thames River as shown on Figure 2-6. The remaining basins drain either to the Connecticut River, the Pawcatuck River, or directly to Long Island Sound. Table 2-4 presents the characteristics of the regional basins.

Table 2-7: Regional Drainage Basins in the SCCOG Region

Regional Basin	Basin Number	Drains To
Pawcatuck River	1000	Long Island Sound
Wood River	1100	Pawcatuck River
Southeast Shoreline	2000	Long Island Sound
Southeast Eastern Complex	2100	Long Island Sound
Southeast Western Complex	2200	Long Island Sound
Thames River	3000	Long Island Sound
Willimantic River	3100	Shetucket River
Natchaug River	3200	Shetucket River
Moosup River	3500	Quinebaug River
Pachaug River	3600	Quinebaug River
Quinebaug River	3700	Shetucket River
Shetucket River	3800	Thames River
Yantic River	3900	Thames River
Connecticut River	4000	Long Island Sound
Salmon River	4700	Connecticut River
Eightmile River	4800	Connecticut River

The Southeast Shoreline includes primarily minor streams near the coast of Long Island Sound. The two Southeast Complex areas include slightly larger streams such as the Four Mile River, Pattagansett River, Jordan Brook, the Mystic River, Copps Brook, and Anguilla Brook, although these streams are not as large as those listed in Table 2-4. Watercourses are discussed in more detail in each community annex. The SCCOG region has approximately 40 miles of shoreline along Long Island Sound, and numerous additional miles of shoreline along its many tidal estuaries. As a result of the presence of both coastal and riverine floodplains, the southeastern region is faced with significant flood hazards.



SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 2-6: Regional Drainage Basins in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-6.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

2.6 Population and Demographic Setting

According to the 2010 U.S. Census, the SCCOG region's population is 286,711 persons, an increase of 16,716 persons over the 2000 U.S. Census value of 269,995 persons. These figures include all municipalities falling within the 2016 boundaries of the SCCOG region, but exclude the relatively small permanent populations of the Mohegan Tribal Nation and Mashantucket-Pequot Tribal Nation. The City of New London has the highest population density of the region's independent municipalities (while the borough of Jewett City has the highest population density of any SCCOG jurisdiction). Table 2-5 presents the 2000 and 2010 U.S. Census populations for the SCCOG region, the 2010 land area of each jurisdiction based on U.S. Census Bureau, and the resulting 2010 population density for each jurisdiction.

Table 2-8: 2000-2010 Population of the SCCOG Region

Geographic area	2000 Population	2010 Population	Population Change	% Change	Land area (sq mi, 2010)	Population Density per square mile of land (2010)
Bozrah	2,357	2,627	+270	+11.5%	19.96	131.60
Colchester	14,551	16,068	+1,517	+10.4%	48.98	328.00
East Lyme	18,118	19,159	+1,041	+5.7%	34.00	563.60
Franklin	1,835	1,922	+87	+4.7%	19.49	98.60
Jewett City	3,053	3,487	+434	+14.2%	0.70	4,948.30
Griswold	7,754	8,464	+710	+9.2%	34.00	248.90
Groton city	10,010	10,389	+379	+3.8%	3.08	3,368.90
Groton	29,897	29,726	-171	-0.6%	27.95	1,063.54
Lebanon	6,907	7,308	+401	+5.8%	54.10	135.10
Ledyard	14,687	15,051	+364	+2.5%	38.22	393.80
Lisbon	4,069	4,338	+269	+6.6%	16.29	266.30
Montville	18,546	19,571	+1,025	+5.5%	41.95	466.50
New London	25,671	27,620	+1,949	+7.6%	5.62	4,918.70
North Stonington	4,991	5,297	+306	+6.1%	54.25	97.60
Norwich	36,117	40,493	+4,376	+12.1%	28.06	1,443.00
Preston	4,688	4,726	+38	+0.8%	30.82	153.40
Salem	3,858	4,151	+293	+7.6%	28.92	143.50
Sprague	2,971	2,984	+13	+0.4%	13.25	225.20
Stonington borough	1,032	929	-103	-10.0%	0.35	2,658.70
Stonington	16,874	17,616	+742	+4.4%	38.31	459.83
Waterford	19,152	19,517	+365	+1.9%	32.77	595.60
Windham	22,857	25,268	+2,411	+10.5%	26.70	946.37
Total SCCOG	**269,995**	**286,711**	**+16,716**	**+6.2%**	**597.77**	**479.63**
New London County	259,575	274,067	+14,492	+5.6%	665	412.13
Windham County	109,196	118,593	+9,397	+8.6%	521	227.63

Notes: Individual areas do not necessarily add to totaled value due to rounding.
Borough populations are subtracted out of the municipalities to which they are subordinate.
Tribal populations (only members actively living on the reservations) are subtracted out from surrounding communities.

Source: U.S. Census Bureau

Demographic trends for the SCCOG region are similar to many other areas in Connecticut and are closely tied to the State's economy. The suburbanization that characterized the United States after World War

II from the late 1940s through the 1970s, with the construction of new roads and the enhanced availability of the automobile and federally-funded housing programs, yielded a boost in population size. The completion of Interstate 95 in Connecticut in 1956 and of Interstate 395 in 1958 played a major role in the increase of the region's year-round population. This increasing population trend has been and continues to be evident in many areas subject to metropolitan expansion along the eastern seaboard since the 1940s.

The SCCOG region includes populations who are elderly and/or possess disabilities. As expected, the more populated areas include a higher percentage of individuals who may require special assistance or different means of notification before and during natural hazards. In addition, the population in the region is aging. These needs will be discussed in subsequent sections.

2.7 Development Trends

As noted in Section 2.2, development in the SCCOG region is concentrated near major rivers and Long Island Sound, with the highest population densities occurring near the mouth of the Thames River (New London and the City of Groton). The more densely populated and developed areas near Long Island Sound and the Thames River comprise the commercial and industrial center of the region, while residential uses are spread in various densities throughout the remaining SCCOG communities. As shown in Table 2-6, the recent economic downturn has resulted in a reduction of new residential development since 2005.

The southeastern Connecticut region has a strong economic base for commercial and industrial development that includes businesses in defense technology, healthcare, biotechnology, marine research, and tourism. Examples of some of the larger employers in the region include the Foxwoods Resort Casino, General Dynamics Electric Boat, Mohegan Sun Casino, Pfizer, Lawrence & Memorial Hospital, William W. Backus Hospital, Millstone Power Station, Connecticut College, Mystic Seaport Museum, United States Coast Guard Academy, and York Correctional Institution.

Tourism plays a large role in the region's economy. Major commercial developments that have a significant impact on the regional economy include Foxwoods Resort Casino in Mashantucket, the Mohegan Sun Resort in Mohegan, and the Mystic Seaport, Mystic Aquarium, and Olde Mistick Village in Stonington. Other tourist attractions in the region include the Nautilus Memorial/Submarine Force Library and Museum in Groton, the Lyman Allyn Art Museum in New London, the Slater Memorial Museum in Norwich, the Eugene O'Neill Theater Center in Waterford, and the Mashantucket Pequot Museum in Mashantucket. New commercial developments have been limited in recent years due to the economic downturn of 2008-2009, and new industrial development has been negligible.

Table 2-9: Net Gain in Housing Units in the SCCOG Region Since 2005

Place	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Bozrah	9	12	8	2	1	4	2	3	1	2	0	44
Colchester	95	66	58	21	23	35	18	25	34	31	32	438
East Lyme	127	180	116	27	20	32	28	39	37	363	106	1075
Franklin	3	3	4	1	0	29	1	1	2	3	0	47
Griswold	71	87	27	23	28	14	10	8	9	11	4	292
Groton	153	112	90	82	42	38	17	20	57	40	22	673
Lebanon	37	36	15	9	7	7	6	2	5	6	2	132
Ledyard	53	37	18	5	9	12	11	24	43	16	13	241
Lisbon	4	18	9	7	3	3	8	5	6	4	5	72
Montville	67	32	35	45	14	31	7	10	12	11	8	272
New London	77	66	52	33	27	35	28	32	41	41	41	473
North Stonington	27	16	19	4	10	2	4	3	5	8	7	105
Norwich	218	145	80	17	181	43	9	46	27	42	4	812
Preston	41	18	22	2	9	7	7	8	10	0	11	135
Salem	28	13	11	9	9	11	7	6	3	16	9	122
Sprague	16	7	6	10	6	4	1	2	7	0	0	59
Stonington	79	101	64	19	20	19	23	27	33	19	236	640
Voluntown	7	9	8	6	3	2	3	2	1	4	5	50
Waterford	56	38	64	27	9	11	14	12	16	14	8	269
Windham	66	20	19	13	14	71	7	6	6	10	9	241
Total	**1234**	**1016**	**725**	**362**	**435**	**410**	**211**	**281**	**355**	**641**	**522**	**6192**

Source: Connecticut Department of Economic and Community Development

The SCCOG prepared a proposed development map as part of its 2017 Regional Plan of Conservation and Development (POCD). This map is reprinted here as Figure 2-7. The map shows that future urban/high-intensity uses will continue to be concentrated along the Thames and Yantic Rivers, the shoreline of Long Island Sound, the Pawcatuck River, and downtown Colchester, Jewett City, and Willimantic. Low and medium-density suburban uses will abut the urban uses and branch out along established State and local primary roads. Many areas, particularly along inland watercourses and water bodies, are denoted as proposed conservation areas. More information regarding growth in individual communities is presented in each community annex.

The presence of sewers and water systems can serve as a predictor of growth patterns in rural and suburban areas; where sewers are built, development typically follows. The absence of public water and sewer systems is a major factor in the dispersed development patterns seen in the region. Jewett City, Norwich, Montville, New London, and the City of Groton have waste water treatment plans along the Quinebaug and Thames Rivers, and Windham has a facility on the Shetucket River. East of the Thames River, only Pawcatuck (Stonington), the Borough of Stonington, the Town of Groton, and Mystic have municipal sewage treatment facilities. East Lyme and Waterford have areas of sewer service that direct flow to New London's waste water treatment plant. The 2017 Regional POCD notes that sewer planning has traditionally been conducted at the municipal level in the region.

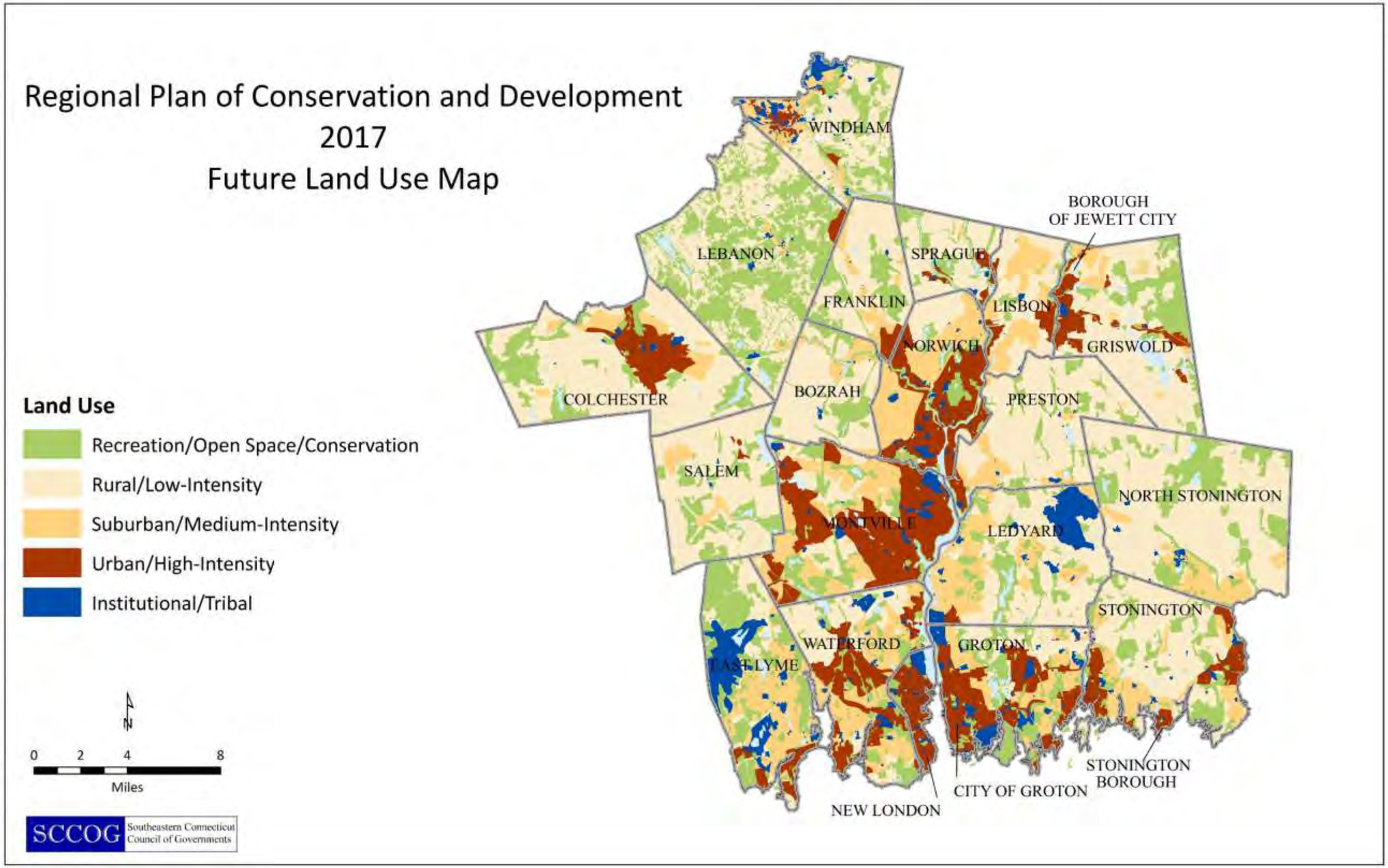


Figure 2-7. Future Land Use Plan Map.

Despite the presence of sewers, on-site subsurface septic systems remain an important method of disposal in the region. Septic systems that serve most of the low-density, seasonal residences on the coast discourage further development in these areas. On Black Point in East Lyme and Mason's Island in Stonington, where traditionally seasonal residences are now being occupied year-round, septic systems are becoming overwhelmed more often than before, and extension of sewers to such areas are one potential solution which could lead to increased development density, and therefore more exposure to natural hazard damage. A balance will need to be struck between improving groundwater quality and preventing additional shoreline development that could be at increased risk for natural hazard damage.

The 2017 Regional POCD also notes that approximately one-third of the SCCOG region is served by public water supplies, supplying water to approximately 75% of the region's population. Two planning processes are underway to address resiliency of public water systems: The Eastern Water Utility Coordinating Committee is conducting regional water supply planning, and the Connecticut Department of Public Health and the University of the Connecticut Institute for Resilience and Climate Adaptation are conducting a resiliency study of public water systems. Results and recommendations from these studies are not yet available, but are expected to be available at the time of the next SCCOG HMP Update.

The 2017 Regional POCD also notes that the rate of new housing construction in Southeastern Connecticut appears to be finally rising following the recent economic downturn, although not to early 2000's levels. The plan notes that 30% of the housing stock in the region pre-dates 1950, and 69% of the housing stock in the region pre-dates 1980. In addition, the Connecticut State Data Center predicts relatively modest growth of approximately 8,000 people in the region through 2025, and Connecticut Department of Labor projections for employment suggest an increase in approximately 13,000 jobs in Eastern Connecticut through 2027.

In general, increasing population and increased development increases the region's overall vulnerability to natural hazards. However, new buildings are constructed to more recent building codes (and generally away from floodprone areas) and are considered to be less vulnerable to natural hazards than older buildings.

2.8 Governmental Structure

This section provides an overview of SCCOG, as well as a general description of the types of local agencies that handle hazard mitigation in the region.

SCCOG

The Southeastern Connecticut Council of Governments (SCCOG) is a public agency. It was formed through local initiative to provide a basis for intergovernmental cooperation in dealing with a wide range of issues facing southeastern Connecticut. The Council was organized in October 1992 through the adoption of ordinances for this purpose by the twenty towns, cities, and boroughs of the region. It succeeded its predecessor agency, the Southeastern Connecticut Regional Planning Agency (SCRPA), which had been in existence since January 1961.

SCCOG is the second largest of Connecticut's fifteen regional planning organizations. It is the only regional planning organization in the state which counts two federally recognized Native American Tribes as non-voting affiliate members. SCCOG also has liaison representation from the United States Naval Submarine Base and the United States Coast Guard Academy.

SCCOG operates under the provisions of Sections 4-124i through 4-124p of the Connecticut General Statutes. Duties assigned to councils of government include making a plan of conservation and development for the region; assisting municipalities within the region, as well as state and other public and private agencies; and performing a variety of advisory review functions. Under federal transportation law, SCCOG functions as the region's Metropolitan Planning Organization (MPO), responsible for coordinating transportation planning in southeastern Connecticut. In addition to its statutorily assigned duties, SCCOG's functions include providing a basis for intergovernmental cooperation, aiding in the solution of regional issues, serving as a technical resource to its member municipalities, and providing a collective voice for the region.

The policy board of the SCCOG consists of the municipal chief elected officials from its 22 member municipalities. The Regional Planning Commission (RPC) functions as a subunit of the Council and is composed of one representative from the planning commission of each member municipality. In addition to the RPC, the Council has several standing committees including the Executive Committee, the Legislative Committee, and the Nominating Committee. The Council's Bylaws allow other committees to form as needed.

SCCOG funding is derived from several sources. SCCOG annually receives dues from each of its municipal members assessed on a per capita basis. The Council receives federal and state funds to conduct planning and transportation studies for the region. SCCOG also offers technical assistance to local planning commissions in its member municipalities and tribal governments on a fee basis.

In addition to the regional council of governments, the municipalities and tribal governments in the region have various departments and commissions responsible for overseeing development and coordinating hazard response. In particular, these governments are tasked with making information available to the public. The following sections briefly describe typical municipal departments which are involved with natural hazard mitigation.

Emergency Management Office

The typical mission of the local Emergency Management Office is to maximize survival of people, prevent and/or minimize injuries, and preserve property and resources in its jurisdiction by making use of all available manpower, equipment, and other resources in the event of natural or technological disasters or national security threats. In addition to coordinating activities during disasters, the Emergency Management Office typically coordinates all early warning activities and is involved in educating the public on how to react during emergency situations.

Department of Fire / Rescue / EMS

Local governments in the region have either full-time or volunteer fire companies. Larger cities or towns generally have several fire houses in different areas of the city or town to assure rapid emergency response. All municipalities have municipal offices where elected officials help maintain order during emergency situations. The Fire Department is one of the primary agencies involved with hazard mitigation through emergency services and public education.

Police Department

Police departments are found in most of the suburban and urban municipalities and tribes but not in all rural towns. Day-to-day duties of a Police Department include crime prevention, criminal investigations, traffic enforcement, motor vehicle accident investigations, and patrols. Duties related to natural hazard mitigation include planning and coordination of personnel, equipment, shelters, and other resources necessary during an emergency. Communication and coordination with the Fire Department is critical before, during, and after natural hazard emergencies. Many of the less-populated SCCOG towns have resident state troopers in lieu of a municipal police department.

Public Works / Highway Departments

All of the SCCOG region's communities have a Public Works Department or Highway Department whose responsibilities include construction and maintenance of roadways, sidewalks, and drainage systems; maintenance of all parks and school properties; street sweeping, sanding, and snow removal; the preservation, care and removal of trees within the Town's rights-of-way and/or public places; and maintenance of Town vehicles and equipment.

As is common throughout Connecticut, Public Works Departments are often charged with implementing numerous structural projects that are related to hazard mitigation. Specifically, roadway/infrastructure maintenance and complaint logging/tracking are the two primary duties of the Public Work Department. The Public Works Department also typically tracks, plans, prepares for, and responds to flooding, inundation, and/or erosion of roads and infrastructure such as the sewer pumping station and the wastewater treatment plants. The Public Works Department also conducts snow removal and deicing on roads; tree and tree limb removal in rights-of-way; and maintains and upgrades storm drainage systems to prevent flooding caused by rainfall.

Because of the duties described above, the Public Works Department is often one of the first responders during emergencies. The Public Works Department must maintain access for the Police and Fire Departments to respond to emergencies.

Building Departments

Local Building Departments administer a building inspection program adhering to and enforcing all code requirements of the State of Connecticut relating to building construction. The tribal governments also have building departments who utilize the international building code. Additional responsibilities include administering and enforcing all related codes for the safety, health, and welfare of persons and

properties in the jurisdiction, supervising departmental policies and procedures, and providing technical assistance to local officials.

The Building Official has a unique responsibility when it comes to hazard mitigation as he or she is responsible for overseeing a number of codes such as those related to wind damage prevention as well as those related to inland and coastal flood damage prevention. Although other departments and commissions may review development plans and develop or revise regulations, many important types of pre-disaster mitigation are funneled through and enforced by the Building Department. For example, the Building Department enforces A- and V-zone standards for floodproof construction and building elevations, maintains elevation certificates, and enforces building codes that protect against wind and fire damage. Thus, the types of mitigation that are administered by the Building Department include prevention and property protection. Typically, the building department provides hazard mitigation assistance at the time of the building permit application.

The primary role of the Building Department during disaster situations is to provide damage assessment, inspect damaged buildings and issue permits for temporary structures and actions necessary to maintain safety standards. Two examples of publications that provide such assistance are:

- Federal Emergency Management Agency. "Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding", June 1998.
- Federal Emergency Management Agency. "Protecting Building Utilities From Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems", November 1999.

Engineering Department

Many towns have Engineering Departments and/or a Town or City Engineer who plans, directs, and coordinates engineering contracts and construction projects, including bridges, sanitary, and marine development. As such, the Engineer will often need to review issues related to drainage, flood conveyance, and flood mitigation and related elements of structural hazard mitigation, and the Engineer usually works closely with Public Works and Highway personnel. Typically, either the Engineer or the Public Works / Highway Superintendent will have a list of floodprone areas in the community.

Planning and Zoning / Land Use Department

The Planning and Zoning or Land Use Department of a jurisdiction enforces the local zoning and subdivision regulations, provides staff assistance to the planning and Zoning Commission, and performs long term planning activities related to land use and community development. This department typically drafts, updates and implements the goals and objectives of the local Plan of Conservation and Development. The planning office provides assistance to local Health Departments and Building and Engineering Departments.

In most cases, the local planning department includes the administrator of the local flood regulations under the NFIP. This person also has access to map information showing the location and extent of

FEMA Special Flood Hazard Areas (SFHAs) in the community. This mapping is important in raising the public's awareness of natural hazards in the community.

Because the Planning Department typically directly assists the applicable commissions with administration of the Zoning Regulations, Subdivision Regulations, and Inland Wetland Regulations, the department is responsible for elements of almost all six facets of mitigation (prevention, property protection, natural resource protection, structural projects, emergency services, and public education). For example, wetlands preservation is one of the purest forms of hazard mitigation due to the natural functions and values of wetlands including stream bank and shoreline stabilization and flood water storage.

In coastal communities, the Planning and Zoning / Land Use Department typically assists the local Harbor Management Commission in administering any Waterway Protection Line Ordinances, as well as reviewing coastal site plan applications for certain development types within the coastal management area defined by the State.

Flood and Erosion Control Board

These boards can be created pursuant to the authority of Public Act No. 509 of the General Assembly, now Sections 25-84 through 25-94 of the Connecticut General Statutes. Typically, the Flood & Erosion Control Board's role in hazard mitigation is very important. They are authorized to "plan, lay out, acquire, construct, reconstruct, repair, supervise, and manage a flood or erosion control system" meaning "any dike, berm, dam, piping, groin, jetty, sea wall, embankment, revetment, tide-gate, water storage area, ditch, drain, or other structure or facility" that is useful in preventing or reducing damage from floods or erosion.

Parks and Recreation Department

The Parks and Recreation Department typically oversees town open space parks. This responsibility includes the properties acquired by the town for hazard mitigation purposes and converted to open space.

Attorney

A jurisdiction's Attorney's office plays a critical role in hazard mitigation. The office typically reviews and helps to administer grant applications and projects under the HMA programs such as HMGP and PDM.

Citizen Volunteer Organizations

Many SCCOG communities have a Citizens Emergency Response Team (CERT). The members of these teams have received training in many areas involving disaster situations such as first aid, sheltering management, and traffic control and commodities distribution along with other related tasks. These groups fill voids that exist especially during large scale incidents where standard public safety staffing cannot fulfill all the necessary operations.

Additional Groups

In addition to Town offices, the American Red Cross (ARC), the Salvation Army and the local health districts provide services related to mitigation and emergency management. The ARC and the Salvation Army help provide shelter and vital services during disasters and participates in public education activities. The local Health Districts become involved with water supply and sanitation issues that may arise during and after emergencies and natural disasters.

2.9 Review of Existing Regional and Local Plans

Public Information is one of the most important types of hazard mitigation measure which, like prevention and resource protection, can be most effectively implemented in conjunction with other hazard mitigation projects. This section discusses regional plans prepared by SCCOG that are pertinent to natural hazard mitigation. Review of local jurisdiction plans may be found in the respective community annexes. Each of the regional plans is freely available on the SCCOG website.

Land Use – 2011 – Southeastern Connecticut Region (2012)

The SCCOG region completed a land use study in May 2012 that analyzed parcel data from all member municipalities. Much of these data were discussed in Section 2.2. The study concluded that the amount of developed land and designated open space in the region have been steadily increasing over the last three decades, while the amount of undeveloped land has been steadily decreasing over the same period.

Regional Plan of Conservation and Development (2017)

The SCCOG region has an established Regional Plan of Conservation and Development (POCD), which was assembled with contributions from local boards and commissions, citizens, and citizen groups. The purpose of the POCD is "to promote with the greatest efficiency and economy the coordinated development of its area of operation and the general welfare and prosperity of its people." Large scale development projects are required to reference the regional and State Plan of Conservation and Development to ensure consistency with established planning guidelines. The Regional POCD discusses natural hazard threats to the region (winter storms, hurricanes, flooding, wind, climate change, and rising sea level) and presents resiliency goals for the region. Specifically, the Regional POCD recommends that SCCOG develop data for use by the region's towns that identify areas of future risk, and develop a plan for near- and mid-term actions to adapt to the effects of climate change. The Regional POCD also recommends that its member municipalities facilitate the elevation of at-risk properties by re-calibrating zoning regulation height limits and that they discourage new development in floodprone areas.

According to the 2017 Regional POCD, the SCCOG region has numerous historical sites. The highest concentrations of historic sites occur in Norwich, New London, and Mystic, and many are located near water such as Mystic Seaport. The State Historic Preservation Office (SHPO) recently conducted an

analysis of historic properties in shoreline communities with regard to vulnerability to natural hazards. More information on historic resources is presented within each municipal annex.

Regional Resilience Guidebook and Regional Resilience Vision Project (2017)

The Nature Conservancy, in conjunction with SCCOG and the Southeastern Connecticut Enterprise Region (SeCTer) developed a Regional Resilience Vision, which seeks to help southeastern Connecticut residents prepare for disaster events and a changing climate. The project was funded by a 2015 grant from the Connecticut Community Foundation, and focused on the towns of East Lyme, Groton, Montville, New London, Norwich, Ledyard, Salem, Stonington, and Waterford.

The vision for the project was assembled in conjunction with municipal staff, land use and economic planners, public and private utilities, major employers, academic institutions, and other stakeholders. In order to prioritize major focus areas of the project, the core project team recruited a team of planners representing each municipality and boroughs within the planning area. This team then derived six planning sectors which would for the framework of the resilience workshops. The six sectors identified are water, food, ecosystem services, transportation, energy, and regional economy. All of these sectors were deemed important areas in which to focus the resiliency efforts.

The Nature Conservancy held two workshops, which were used to derive the challenges facing the region, as well as possible solutions. In the first workshop, participants were given six planning sectors, listed above, and were asked to identify challenges associated with each planning sector caused by weather events, climate change, and other factors. Dialogue between the various stakeholders listed above ensured that various interests were considered when identifying challenges. In the second workshop, stakeholders were tasked with providing potential solutions to each of the challenges identified in each planning sector. The potential solutions were then consolidated into "overarching" solutions, which could have more broad application.

The table below is a summary of the solutions presented in the Southeastern Connecticut Regional Resilience Guidebook. Potential mitigation actions relevant to all-hazards or individual hazard mitigation are noted as such. In some cases, the solution can be used to inform mitigation actions.

Table 2-10: Solutions Cited in the Southeastern Connecticut Regional Resilience Guidebook

Category	Solutions	Potential Direct or Indirect Mitigation Action?
Water	Assess current public and private water supply and distribution capacity	Yes
	Build upon past projects and foster future opportunities across the region to utilize green infrastructure and improve gray infrastructure to enhance capture and infiltration of runoff	Yes
	Develop a regionally specific decision support process to help municipalities assess and plan for flooding, efficient water use/reuse, and nonpoint source pollutions, simultaneously	Yes

Table 2-10: Solutions Cited in the Southeastern Connecticut Regional Resilience Guidebook (Cont'd)

Category	Solutions	Potential Direct or Indirect Mitigation Action?
Food	Explore cooperative funding, sourcing, and distribution models to meet demands for local foods among area residents, schools, and other institutions	No
	Scope feasibility of large scale municipal composting, regional processing facility, and cooperative distribution system	No
	Look to streamline regulatory requirements across multiple state agencies	No
	Create greater housing opportunities in currently developed areas and take steps to promote agricultural careers among the next generation	No
	Explore ways to accommodate the uncertainty of future environmental conditions in farm planning	No
	Reduce flood risk to farmers through dam removal, soil erosion control measures, and watershed management	Yes
	Conduct a food-shed mapping effort across the region to determine sources and quantities of locally produced food	No
Ecosystems	Strengthen collaborative leadership that champions benefits of ecosystem services from municipal to regional scale	No
	Catalogue financial mechanisms and incentives for property owners to maintain and enhance natural infrastructure and associated services	No
	Monetize services provided by natural assets when making economic growth and development decisions across the region	No
	Define ways to incorporate ecosystem services directly into permitting requirements for MS4 and other initiatives	Yes
	Integrate natural infrastructure into zoning codes to reduce conflicts between development and community resilience	Yes
	Conduct outreach and education for residents and business owners on where and what natural alternatives could be considered alongside standard hard engineering approaches	Yes
Transportation	Prioritize state and local funding for infrastructure improvements that contribute to overall community resilience	Yes
	Collaborate on largest regional transportation vulnerabilities and share planning, engineering, and monetary resources across municipalities to enhance regional resilience	Yes
	Integrate green infrastructure and natural assets into transportation upgrades and retrofits through design standards and codes	Yes
	Establish mutual aid agreements with nearby urban centers (Hartford, Worcester) to reduce risk to transit-dependent residents during emergencies	No
Energy	Identify steps to further strengthen and possibly redesign the distribution system in partnership with municipalities	Yes
	Improve communications among stakeholders within the energy system	No
	Target and incentivize consumer behavior to improve overall energy resilience	No
	Routinely update state building codes with energy efficiency standards	Yes
	Update existing response plans with a specific emphasis on speeding up the recovery of energy infrastructure	Yes

Table 2-10: Solutions Cited in the Southeastern Connecticut Regional Resilience Guidebook (Cont'd)

Category	Solutions	Potential Direct or Indirect Mitigation Action?
Economy	Conduct fiscal impact study of extreme weather and sea level rise scenarios to strengthen commitments from community leaders and elected officials	Yes
	Improve coordination of disaster recovery between public and private stakeholders	Yes
	Reduce long-term over-reliance on high value, residential property for tax revenue	No
	Prioritize compact mixed use areas by infilling downtown and village centers outside of flood hazard areas	Yes
	General diversification of the economy to increase collective revenue streams and reduce the demands on local ecosystems	No
Cross-Sector Resilience	Develop a regionally specific decision support process to help municipalities assess and plan for flooding, efficient use/reuse, and nonpoint source pollution, simultaneously	Yes
	Integrate natural infrastructure into zoning codes to reduce conflicts between development and community resilience	Yes
	Collaborate on largest regional transportation vulnerabilities and share planning, engineering, and monetary resources across municipalities to enhance regional resilience	Yes
	Conduct fiscal impact study of extreme weather, drought, and sea level rise scenarios to strengthen commitments from community leaders and elected officials	Yes
	Build upon past projects and foster future opportunities across the region to utilize green infrastructure and improve gray infrastructure to enhance capture and infiltration of runoff	Yes
	Conduct a food-shed mapping effort across the region to determine sources and quantities of locally produced food	No
	Monetize services provided by natural assets when making economic growth and development decisions across the region	No
	Prioritize state and local funding for infrastructure improvements that contribute to overall community resilience across the region	Yes
	Identify steps to further strengthen and possibly redesign energy distribution system through partnerships across multiple municipalities	No

Regional Water Priority Planning Document (2010)

This map depicts critical areas where development of new water sources or infrastructure needs to occur in the SCCOG region. The eight priority projects include:

- Thames River interconnection (completed, activated 2008);
- New source development in Windham to service Franklin, Sprague, Lisbon, Preston, Bozrah, Mohegan Tribe, and Colchester (near term, high priority);

- New London supply development including a lower level intake in Lake Konomoc and new source development to service Waterford, East Lyme, Montville, and Salem (near term, high priority);
- East Lyme / New London operable interconnection (completed, activated 2015);
- New source development in North Stonington to service Stonington, Westerly Water Department, and Mashantucket Pequot Tribal Nation (near term, high priority);
- Groton / Aquarion Water Company emergency interconnection (completed, activated 2013);
- Ledyard / Preston emergency interconnection (mid-term, medium priority); and
- Mohegan-Pequot Bridge crossing between Preston and Mohegan Tribe (long term, medium priority).

Individual community annexes will have more information regarding local water needs, as this can affect emergency response to natural hazard damage.

Regional Emergency Support Plan (2011)

The SCCOG region coordinates with the Northeastern Connecticut Council of Governments (NECCOG) for regional emergency response. Together, these entities and their member communities have developed an emergency support plan that outlines regional emergency support functions for its members. The plan provides a basis for jurisdictions to collaborate in planning, communication, information sharing, and coordination before, during, or after an emergency of regional significance. The document is intended to support local Emergency Operations Plans that are critical to local emergency response and is strategic in scope. Much of the document consists of an all-hazards risk assessment which analyses the impacts of natural hazards such as blizzards, ice storms, ice jams, heat waves, drought, flooding, tornadoes, land subsidence, landslides, dam failure, and hurricanes could contribute to a regional emergency and provides guidance for members to coordinate regionally regarding a variety of support functions, including in the absence of a declaration of a State of Emergency by the Governor of Connecticut.

SCCOG also conducted a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis in 2008 in coordination with the Northeastern Region Council of Governments and the Windham Region Council of Governments. The major weaknesses in emergency response in eastern Connecticut were found to be the lack of intra-district long-distance communication due to radio and cell phone dead zones; general communication issues between municipalities, social service agencies, and non-profits; an inability to directly notify various disciplines, and lack of funding for emergency preparedness.

Local Plans of Conservation and Development

Each Connecticut municipality is required to prepare a POCD every ten years. The POCD requirements are similar to those described above for regional POCDs. One of the recommendations in each annex of the 2012 HMP was for the local municipality to incorporate elements of the 2012 HMP Update into its local planning efforts. Note that such incorporation was suggested in the 2015 HMP Update for Lebanon and Windham, but was not specifically listed as a strategy or action. Table 2-8 summarizes the status of incorporation of natural hazard information into local POCDs:

Table 2-11: Status of Incorporation of Natural Hazards into Local POCDs

Geographic area	Year of Current POCD	Year of Next POCD	Current POCD Incorporates Natural Hazard Information?
Bozrah	2015	2025	Partially. Only addresses flooding.
Colchester	2015	2025	Yes.
East Lyme	2010	2020	Partially. Only addresses flooding and wildfires.
Franklin	2013	2023	Partially. Only addresses poor drainage flooding.
Jewett City, Borough of	2007	2017	Partially. Only addresses wildfires.
Griswold	2007	2017	Partially. Only addresses wildfires.
Groton, City of	2008	2018	No.
Groton, Town of	2016	2026	Yes.
Lebanon	2010	2020	No.
Ledyard	2010	2020	Partially. Only addresses flooding and wildfires.
Lisbon	2016	2026	Partially. References 2012 HMP strategy.
Montville	2010	2020	Partially. Only addresses impediments to development.
New London	2007	2017	Partially. Only addresses flooding.
North Stonington	2013	2023	Partially. Only recognizes need for resiliency.
Norwich	2013	2023	Partially. Only addresses sea level rise.
Preston	2014	2024	Partially. Only addresses wildfires.
Salem	2012	2022	Partially. Only addresses wildfires.
Sprague	2012	2022	Partially. Only addresses flooding.
Stonington, Borough of	2012	2022	Partially. Only addresses flooding.
Stonington, Town of	2015	2025	Yes.
Waterford	2015	2025	Yes.
Windham	2007	2017	Partially. Does not identify natural hazards.

More information on local POCDs can be found in each municipal annex. Based on Table 2-7, four communities have met the incorporation of natural hazards requirement in their POCDs, and two have not met the requirement (although it is noted that both the City of Groton and the Town of Lebanon have not updated their POCD since 2008 and 2010, respectively). The remaining 16 SCCOG jurisdictions have partially addressed the incorporation strategy. The 2017 Regional POCD provides an excellent example of how to incorporate natural hazard information into a POCD. This requirement has been incorporated into the strategies and actions of the 18 SCCOG jurisdictions as appropriate.

2.10 Review of Public Information

Statewide Public Information

Many State government websites contain information pertinent to natural hazards. The Connecticut DEEP also hosts the State Hazard Mitigation Plan online at (http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325652) which provides additional information on the effects of natural hazards in the State. The CT NHMP will be updated by 2019.

Local Public Information

During the preparation of the original HMP in 2004-2005, the Hazard Mitigation Committee identified the need for a continued and expanded program of public information. Such a program could include providing educational information to the homeowners and business owners in the flood hazard areas. A public education and information component should be included in all hazard mitigation projects undertaken in the region. The availability of information and increasing public awareness continues to be a goal of member communities in the SCCOG region.

Libraries can be an effective location of a hazard information center. Town Halls and other public facilities can also serve as information centers. A wide range of hazard mitigation documentation should be compiled for public review. Making available free pamphlets on preparedness for natural hazards is relatively inexpensive way to ensure that the public in informed about basic preparedness measures.

Real estate disclosure is another method where localized hazards identified. This is a procedure where sellers of real estate are compelled to provide notice to buyers of known hazards affecting the property to be conveyed. Most mortgages require the purchase of flood insurance if the property is located within the FEMA SFHA. This extra expense may dissuade some buyers from purchasing the property, but also provides an additional level of assurance to the owner that they will have assistance recovering from a flood event.

FEMA and CitizenCorps have published disaster planning guides known as the "Are You Ready?" series (http://www.ready.gov/are-you-ready-guide). These are considered among the best of the planning guides that are available from disaster-related planning and response organizations. Key publications from the series should be available to all region residents. In addition, public and private school and adult education programs can offer education classes that include hazard identification and hazard mitigation components.

2.11 Review of Regulatory Structures

The SCCOG, as a regional planning organization, does not have or administer any regulations. Instead, members voluntarily agree to abide by regional recommendations when possible.

Hazard prevention includes identification of risks and the use of land-use regulatory and other available management tools to prevent future damage. The municipalities in the southeast region have planning and zoning tools in place that incorporate floodplain management. Planning and zoning regulations, inland wetlands and watercourses regulations, harbor management regulations and building departments' enforcement of Building Codes are all important existing regulatory mechanisms that address hazard prevention and incorporate floodplain management. Additional details for each of the communities can be found in the respective annexes. The following are examples of how hazard prevention can be accomplished through existing programs:

Planning and Zoning

Planning and Zoning Regulations or similar land use regulations can be tailored to be consistent with hazard mitigation planning. Establishment of Flood Overlay Districts, Coastal Resource Zones, and River Corridor Preservation Zones are all techniques that can potentially be employed to limit additional development in hazardous locations.

Open Space Preservation

Community planning that includes open space acquisition and preservation can be established or revised in a manner that is consistent with hazard mitigation planning. For example, acquisition of floodplain and river corridor properties should be encouraged as a municipal priority.

Floodplain Development Regulations

The modification of floodplain management regulations to include more restrictive development standards is consistent with hazard mitigation planning. The NFIP Community Rating System gives credit to communities that exceed the minimum floodplain management requirements of the NFIP. Requirements include elevating structures higher than the 1-percent annual-chance base flood elevation, which is an example of a more stringent standard. Many jurisdictions have incorporated NFIP regulations into their standard Zoning or Subdivision Regulations. A full review of each community's regulations is presented in the respective community annex.

Stormwater Management

Stormwater management regulations that limit any potential increase in the discharge of stormwater and that preserve floodplain storage are examples of the use of stormwater management in a manner consistent with hazard mitigation planning. Communities should conduct catch basin surveys in order to identify and prioritize potential replacements of catch basins and overall stormwater drainage improvements. The identification and improvement of drainage systems and culverts that have inadequate capacity, helps reduce flooding risks and also prevents further damage to roadways.

Wetlands Protection

Wetlands areas generally serve as critical flood storage areas. By limiting wetlands development not only are important natural resource areas protected but additional floodplain development is also limited. All SCCOG members have wetland regulations of some type.

Erosion and Sediment Control Regulations

Effective implementation of Sediment and Erosion controls include utilization of detention basins and use of other Best Management Practices to slow the velocity and limit increase in runoff. Strict adherence to the requirements is an effective hazard mitigation tool. Some municipalities do not have separate erosion and sediment control regulations and instead require compliance with the 2002 State of Connecticut Sedimentation and Erosion Control guidelines.

2.12 Overview of Emergency Services, Critical Facilities, Sheltering, and Evacuation

Aspects of emergency services typically addressed in hazard mitigation include the following:

- Emergency communication;
- Emergency warning and response;
- Emergency sheltering; and
- Critical facilities protection.

Hazard mitigation capabilities related to emergency services can be combined with other types of capabilities and measures to form successful projects, or remain as stand-alone projects. Emergency communication is a critical aspect of the hazard response programs currently in place in the SCCOG region. In the event of an emergency, the municipalities within the region establish an Emergency Operations Center (EOC) within each town and mobilize their response agencies.

Interagency communications among the communities, State agencies and independent utilities in the SCCOG region requires continued coordination to establish and maintain the critical communication links. A need for improved and continued coordination has been identified during this study. Many municipalities within the region expressed interest in a reverse 9-1-1 emergency communication system at the time of the 2005 HMP. The State of Connecticut operates a "CT Alerts Everbridge" reverse 9-1-1 system for emergency communication and response. This reverse 9-1-1 system can automatically call telephones in affected areas throughout participating municipalities, efficiently replaying important information. This type of system is increasingly considered an effective tool in warning and instructing residents during the event of an emergency. Tribal governments are not officially part of the State system. The Mashantucket Pequot Tribal Nation, for example, currently utilizes its own reverse 9-1-1 system on tribal lands although it has access to the State system through employees who work for other municipalities in the region.

Inter-municipal cooperation is an important aspect of emergency services within the region. Mutual aid agreements as well as regional dispatch centers allow for successful assistance between communities in the region in the event of emergencies. Several municipalities in the region expressed the need in 2005 for improving redundancy within the emergency communications systems in order to provide alternate communication in the event of a loss of land line or cell phone service. While some improvements have been made, many municipalities still feel improvements are warranted.

Emergency response cannot be successfully conducted without proper training and equipment. Police, fire fighters, and paramedics maintain emergency response training. This includes maintaining and updating emergency equipment and emergency response protocols. Fire hydrant surveys are regularly conducted in each community to ensure that they are working properly. All communities, particularly inland and rural communities utilize dry hydrants and seek areas where additional dry hydrants may be installed.

The use of fire and rescue boats are necessary in several SCCOG communities (particularly along the coast). In addition to offering additional protection of certain critical facilities, structures, and other assets, (such as the commercial fishing fleet in Stonington) which are located in geographically isolated areas along the coastline, access to such specialized equipment may allow for additional lives to be saved in an emergency.

A dry hydrant is a permanently installed hydrant into an existing lake, pond, stream, or water body and is available to be connected to a pump truck. It is a non-pressurized pipe system that allows firefighters access to water sources from roadways. It is relatively inexpensive with minimal maintenance and may be of use and more cost effective than other water resource alternatives.

Critical Facilities

Numerous "critical facilities" including hospitals, medical centers, fire and police departments, and municipal buildings are located throughout the region. Critical facilities include William W. Backus Hospital in Norwich, Lawrence & Memorial Hospital in New London, Pequot Medical Center in Groton, Windham Hospital in Windham, and medical centers in the surrounding towns such as East Lyme, Ledyard, North Stonington, and Colchester. Every jurisdiction has a fire department and most jurisdictions have a police department, however, several of the smaller rural towns have resident troopers through the Connecticut State Police. Other critical facilities include public water and sewer infrastructure and treatment plants, electrical and natural gas transmission lines and the Millstone Power Station, regional airports, ferries, and major highways in the region.

Some of the SCCOG region's critical facilities have been identified as being located in flood hazard areas. Facilities that may not be accessible during emergency situations include the Griswold Firehouse on Route 138 (Voluntown Road), the Town of Stonington's Sewer Plant, the Yantic Village Fire Station and Department of Public Works in Norwich, and the Mystic Fire Department, Quiambaug Fire Department, Mystic Post Office, and Mystic Train Station in Stonington. Critical facilities in each jurisdiction are discussed within each annex of this plan.

Health care, assisted living and senior living facilities that are located in flood zones are often good candidates for flood proofing. In addition, the facilities in flood zones and those that may be cut off from flooding are recommended to develop site-specific evacuation plans. Specific locations of these vulnerable populations are detailed in the individual community annexes.

In 2017, SCCOG conducted an analysis of 19 critical facilities located in or adjacent to areas of flood risk to determine methods of making them more resilient to flood, snow, and wind risks under climate change. The following facilities were included in the assessment:

Table 2-12: Facilities Included in SCCOG Critical Facility Resiliency Assessment

Municipality	Facility	Address	In FEMA Zone	Adjacent FEMA Zone
Stonington Borough	Fire House and EOC	100 Main St	AE	VE-14
	Borough Hall and Public Works	26 Church St	AE	500-yr
Stonington Town	Old Mystic FD	21 North Stonington Rd	500-yr	AE
	Quiambaug FD	50 Old Stonington Rd	AE	X
	Mystic FD	34 Broadway	AE	X
Groton Town	GLP Police and Fire	5 Atlantic Ave	AE	X
	Town Hall	45 Fort Hill Road	X	500-yr
Groton City	City Hall	295 Meridian St	X	500-yr
	Public Works	295 Meridian St	500-yr	X
New London	Fire HQ and EOC	289 Bank St	500-yr	AE/VE
Waterford	Quaker Hill Fire Co.	17 Old Colchester Rd	500-yr	AE
Montville	Chesterfield Fire Co.	1606 Hartford New London Tpke	X	AE
Norwich	Yantic Fire Co. No. 1	151 Yantic Rd	AE	Floodway
	Occum FD	44 Taftville Occum Rd	AE	500-yr
	Public Works	50 Clinton Ave	500-yr	AE
Preston	Public Works	423 Route 2	X	A
Sprague	Town Hall	1 Main St	AE	Floodway
	Public Works	1 Main St	AE	Floodway

Results of the assessment are discussed in the annexes for Stonington Town, Stonington Borough, Groton Town, Groton City, New London, Waterford, Montville, Norwich, Preston, and Sprague.

Shelters

Emergency shelters are considered to be an important subset of critical facilities as they are needed in emergency situations. These are not to be confused with safe rooms or individual storm shelters, such as designated rooms in certain buildings that are meant to provide increased levels of protection from winds. A primary shelter should have the ability to operate with a standby source of power such as an emergency generator. While FEMA's mitigation programs are not typically able to fund generators (only under HMGP), other funding programs are available for purchase of generators. The most notable example is the "Emergency Operations Center and Emergency Shelter Generator Grant Program" administered by Connecticut Department of Emergency Management and Homeland Security (DEMHS). This program specifically targets emergency operations centers and shelters, and awards can only be made for municipal facilities.

The ARC has published a guidebook entitled "Standards for Hurricane Evacuation Shelter Selection" (ARC Publication #4496). The publication provides guidelines for selecting shelters relative to resilience from storm surges, flooding, and hurricane winds. While the publication recognizes that not all communities are able to identify an ideal shelter, it urges communities to consider as many of the criteria as possible. The ARC also has formal standards for shelters regarding space and internal facilities, but these standards are unrelated to structural resilience. The organization of shelter staff, supplies and notification is described in the community EOPs, along with responsibilities of each individual involved in

emergency response. Shelters in SCCOG communities are listed in Table 2-9 based on communication with local officials and/or other available information. Note that in most cases the "capacity" represents a seated capacity and not bedding-down capacity.

Table 2-13: Shelters in the SCCOG Region

City / Town / Tribe	Number of Local Shelters	Capacity of Local Shelters
Bozrah	3	>100
Colchester	2	800
East Lyme	3	2,300
Franklin	3	318
Griswold	3	525
Groton, City of	1	250
Groton, Town of	2	1,400
Lebanon	1	*
Ledyard	1	>100
Lisbon	1	150
Mashantucket Pequot Tribal Nation	3	400
Mohegan Tribe	1	50
Montville	2	>100
New London	3	3,750
North Stonington	1	>100
Norwich	15	33,000
Preston	1	100
Salem	2	>100
Sprague	2	600
Stonington, Borough of	0	0
Stonington, Town of	2	1,300
Waterford	5	5,500
Windham	4	*

* Sheltering capacities are not immediately available for Lebanon and Windham.

Note that the Mashantucket Pequot Tribal Nation has mutual aid agreements through SCCOG to house regional shelterees in the casino or hotel. This additional shelter space is not listed in Table 2-9. The Mohegan Tribe can also provide additional regional sheltering space during a widespread emergency although no agreements are currently in place.

Upgrading emergency shelters is an important hazard mitigation measure that includes contacting the local ARC or other local emergency aid groups for technical assistance and updating supplies. Supplies include the number of emergency beds, food, and clothes. Communication equipment should be updated and working properly. Emergency shelters should not be sited within the floodplain. Community officials should take steps to relocate existing emergency shelters within the floodplain, or to properly protect the shelter with measures such as flood proofing or elevating the structure if possible.

The U.S. Army Corps of Engineers prepared the Connecticut Hurricane Evacuation Study and Technical Data Report in 1994. The primary purpose of the study was to provide the state, local emergency

management agencies, and evacuation decision-makers with data necessary to plan for and evacuate areas vulnerable to hurricane flooding. The study focused on coastal communities. The study estimated that there were more than 150,000 residents living in Categories One and Category Two hurricane evacuation zones and a total of more than 280,000 residents living in Categories Three and Category Four hurricane evacuation zones. These numbers reflect the number of residents in 25 coastal communities located in Fairfield, New Haven, Middlesex and New London counties.

The 1994 study provides data for each of these coastal communities regarding vulnerable populations, medical/institutional facilities, and shelter needs. Although the study is outdated, it still provides useful data regarding the extents of hurricane impacts within a given community. In general, estimated shelter capacities for individual communities were inadequate for the estimated evacuees. In some cases, jurisdictions in the SCCOG region have added shelters to address these shortfalls, but in others there remain gaps between shelter space and number of evacuees.

Transportation

Southeastern Connecticut possesses a transportation network of highways, rail lines, bus service, air service, passenger ferry service, and shipping corridors. Major highways throughout the region include Interstate 95, Interstate 395, Route 2, and Route 32. Interstate 95 serves the east/west corridor in the region and is the most heavily traveled thoroughfare in the region. It is the main highway for travelers along the Atlantic coast from Florida to Maine, and the volume to capacity ratio of the highway is slowing approaching 1.0 indicating the need for improvements to mitigate congestion (SCCOG Fiscal Year 2015 Long Range Regional Transportation Plan). I-395 serves a north-south corridor in the region, with highest traffic volumes concentrated in the Montville section due to development and expansion of the Mohegan Sun Casino and Hotel complex. Throughout the region many roadways are affected by flooding due to roads being within floodplains, having poor drainage, and/or inadequate culvert sizes. Individual community annexes identify such problem areas.

Rail lines extend to several of the communities allowing people to travel via train. Amtrak provides passenger rail service with stops at New London and Mystic. The Amtrak rail line travels east-west from Boston to New York. Freight service is offered by the New England Central Railroad and the Providence and Worcester Railroad. The New England Central Railroad is located on the west side of the Thames River and offers north-south freight service.

The southeastern region has a public bus system, SEAT, which serves the municipalities of East Lyme, Griswold, Groton, Ledyard, Montville, New London, Norwich, Stonington, and Waterford. SEAT runs routes throughout the region including to the two area casinos. Many community members as well as casino employees rely on this public transportation.

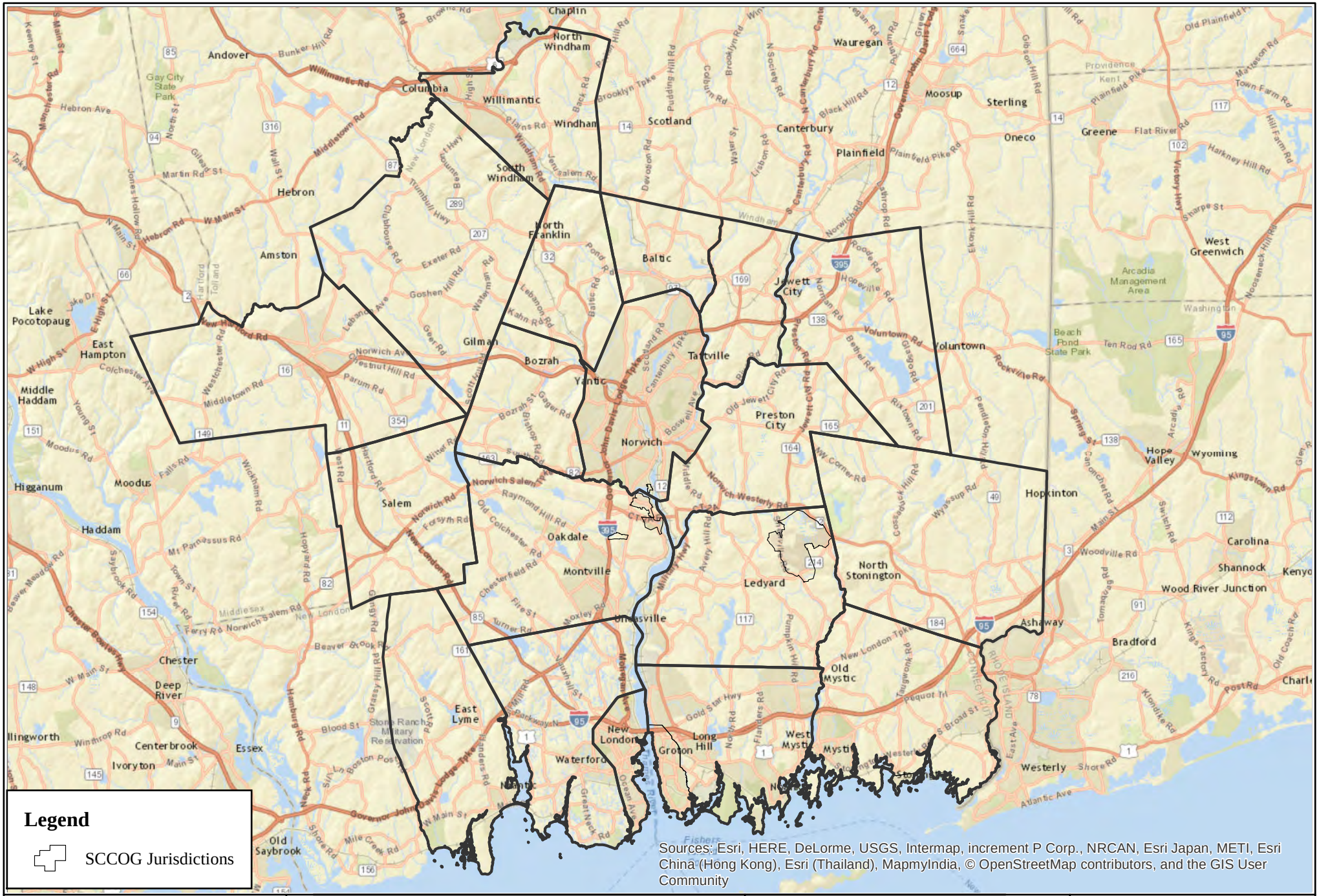
Air service throughout the region is offered by the state owned Groton-New London Airport and Windham Airport, private airports in Griswold and Stonington, a heliport in Colchester, and two military airports. Groton-New London Airport is in a flood zone which may pose a potential impact on the arrival and departure of aircraft during a significant storm event.

Significant marine transportation exists in Long Island Sound, comprising passenger ferries, commercial shipping, and pleasure boating. The Admiral Shear State Pier in New London, which is adjacent to the Central New England Railroad pier, functions as the region's most important commercial marine facility. The State Pier is Connecticut's only major deep-water seaport within a multi-use Foreign Trade Zone. In an effort to reduce congestion on I-95, the State Pier may be utilized in the future to ship non-time sensitive goods along the Connecticut coast to the port of New Jersey. Ferry service out of New London becomes increasingly busy during the summer months and is available to Long Island, Fishers Island, Martha's Vineyard, MA; and Block Island, RI. Long Island Sound and Fishers Island Sound have numerous harbors and inlets that are used extensively by pleasure craft during the summer months. A few of the harbors along the southeastern region's coastline that offer protection during storms include Stonington Harbor, Mystic Harbor, the Thames River, and the Niantic River.

Evacuation Routes

Most SCCOG communities do not have a specific evacuation route map during emergencies. In general, local emergency personnel direct traffic from local roads to primary highways such as Interstate 95, Interstate 395, Route 2, Route 32, Route 49, Route 85, and Route 169. Evacuation routes should not include roads that can become submerged during coastal storms and riverine flooding. Any changes in shelter status, shelter locations, or roadway routing may require modifications to the evacuation map. Many of the coastal communities have installed evacuation signs in strategic locations that direct residents out of coastal flood zones. Refer to Figure 2-8 for a depiction of major roadways.

The State of Connecticut's Department of Emergency Services and Public protection (Emergency Management & Homeland Security) website provides an Evacuation Route Map to Host Communities that is applicable to the southeast region of Connecticut. The map was last updated in July 2011 and was created to address how evacuation should proceed if necessitated by an emergency at the Millstone Power Generation Facility in Waterford. The map was again being updated at the time of this report. Host Communities for affected regions of East Lyme, Waterford, Montville, New London, Ledyard, Town of Groton and City of Groton include New Haven, East Hartford, Storrs, Windham, Stonington and Norwich. Many of the affected communities include areas susceptible to coastal flooding and/or flooding from storm surge, suggesting that a similar plan could be used to address a large scale evacuation due to a major hurricane.



SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 2-8: Major Roads in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure2-8.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

2.13 Historic and Cultural Resources

Recognizing that historic and cultural resources are increasingly at risk to natural hazards and climate change, the State Historic Preservation Office (SHPO) embarked on a resiliency planning study for historic and cultural resources beginning in 2016. Working with the State's Councils of Government and municipalities throughout the planning process, numerous examples were identified where historic and cultural resources were specifically at risk now, could be at risk in the future, and could help generate consensus for resiliency actions. Historic resources are difficult to floodproof, elevate, or relocate without potential loss of their historicity. Therefore, a thorough understanding of the site-specific options for each set of historic resources is necessary prior to disasters that could damage these resources, in order to avoid damage during recovery.

SCCOG hosted a historic resources resiliency planning meeting in June 2016, with several SCCOG communities attending. During winter 2016-2017, individual meetings were held with the shoreline SCCOG communities of East Lyme, Waterford, New London, Groton City, Groton Town, Stonington Town, and Stonington Borough. Reports were issued to these communities in August 2017. These reports outline eight strategies that can be employed to make historic and cultural resources more resilient. They are:

- Strategy: Identify Historic Resources
- Strategy: Revisit Historic District Zoning Regulations
- Strategy: Strengthen Recovery Planning
- Strategy: Incorporate Historic Preservation into Planning Documents
- Strategy: Revisit Floodplain Regulations and Ordinances
- Strategy: Coordinate Regionally and with the State
- Strategy: Structural Adaptation Measures
- Strategy: Educate

A best practices guide for planning techniques to make historic resources more resilient was distributed in September 2017. This guide can be used by all jurisdictions in Connecticut when undertaking development of hazard mitigation plans.

SCCOG has already taken steps toward the strategy "Strengthen Recovery Planning." Specifically, SCCOG developed a model municipal ordinance for disaster recovery. The model ordinance mentions historic resources and buildings. A copy can be found in Appendix E.

To build upon SCCOG's involvement in the historic resources resiliency planning process, one new regional mitigation action is offered for SCCOG to conduct:

- Using the products of the SHPO grant, SCCOG will conduct a review of (1) historic structures in flood risk zones and (2) structures that are not yet designated as historic but could be in the future, and are also at risk of flooding and sea level rise.

3.0 INLAND FLOODING

3.1 Setting

According to FEMA, most municipalities in the United States have at least one clearly recognizable floodprone area around a river, stream, or large body of water. These areas are often outlined as Special Flood Hazard Areas (SFHAs) and delineated as part of the NFIP. Floodprone areas are addressed through a combination of floodplain management criteria, ordinances, and community assistance programs sponsored by the NFIP and individual municipalities.

Many communities also have localized flooding areas outside the SFHA. These floods tend to be shallower and chronically reoccur in the same area due to a combination of factors. Such factors can include ponding, poor drainage, inadequate storm sewers, clogged culverts or catch basins, sheet flow, obstructed drainage ways, sewer backup, or overbank flooding from minor streams.

Flooding (both inland and coastal) was the primary hazard addressed in the previous two editions of this HMP. In general, the potential for inland flooding is widespread across the SCCOG region, with the majority of major flooding occurring along established SFHAs. The areas impacted by overflow of river systems are generally limited to river corridors and floodplains. Indirect flooding that occurs outside floodplains and localized nuisance flooding along tributaries is also a common problem in different inland areas. The frequency of inland flooding in the region is considered likely for any given year, with flood damage potentially having significant effects during extreme events.

This section provides a general overview of riverine flooding as well as nuisance flooding in the SCCOG region. Coastal flooding is discussed in Section 4.0. Specific flooding details for individual towns and cities can be found in their respective annexes.

3.2 Hazard Assessment

Flooding is the most common and costly natural hazard in Connecticut. Flooding is typically produced as a result of other natural hazards, including hurricanes, summer storms, and winter storms. The state typically experiences floods in the early spring due to snowmelt and in the late summer/early autumn due to frontal systems and tropical storms. Localized flooding caused by thunderstorm activity during the summer months can also be significant. Flooding can also occur as a result of ice jams or dam failure and flooding may also cause landslides and slumps in affected areas. According to FEMA, there are several different types of inland flooding:

- **Riverine Flooding**: Also known as overbank flooding, it occurs when channels receive more rain or snowmelt from their watershed than normal, or the channel becomes blocked by an ice jam or debris. Excess water spills out of the channel and into the channel's floodplain area.
- **Flash Flooding:** A rapid rise of water along a water channel or low-lying urban area, usually a result of an unusually large amount of rain and/or high velocity of water flow (particularly in hilly areas) within a very short period of time. Flash floods can occur with limited warning.

- **Shallow Flooding:** Occurs in flat areas where a lack of a water channel results in water being unable to drain away easily. The three types of shallow flooding include:
  - **Sheet Flow:** Water spreads over a large area at uniform depth.
  - **Ponding:** Runoff collects in depressions with no drainage ability.
  - **Urban Flooding:** Occurs when man-made drainage systems are overloaded by a larger amount of water than the system was designed to accommodate.

Flooding presents several safety hazards to people and property and can cause extensive damage and potential injury or loss of life. Floodwaters cause massive damage to the lower levels of buildings, destroying business records, furniture, and other sentimental papers and artifacts. In addition, floodwaters can prevent emergency and commercial egress by blocking streets, deteriorating municipal drainage systems, and diverting municipal staff and resources.

Furthermore, damp conditions trigger the growth of mold and mildew in flooded buildings, contributing to allergies, asthma, and respiratory infections. Snakes and rodents are forced out of their natural habitat and into closer contact with people, and ponded water following a flood presents a breeding ground for mosquitoes. Gasoline, pesticides, poorly treated sewage, and other aqueous pollutants can be carried into areas and buildings by floodwaters and soak into soil, building components, and furniture.

Floodplains are lands along watercourses that are subject to periodic flooding; floodways are those areas within the floodplains that convey the majority of flood discharge. Floodways are subject to water being conveyed at relatively high velocity and force. The floodway fringe contains those areas of the 100-year floodplain that are outside the floodway and are subject to inundation but do not convey the floodwaters at a high velocity.

In order to provide a national standard without regional discrimination, the 1% annual chance flood, or "100-year flood", has been adopted by FEMA as the base flood for purposes of floodplain management and to determine the need for insurance. The SFHA is coincident with the base flood. This flood level has a 1% chance of being equaled or exceeded each year.

The risk of having a flood of this magnitude or greater increases when periods longer than one year are considered. For example, FEMA notes that a structure located within a 1% annual chance flood hazard area has a 26% change of suffering flood damage during the term of a 30-year mortgage. Similarly, a "500-year flood" has a 0.2 percent chance of occurring in a given year. The 0.2% annual chance flood hazard area indicates an area of moderate flood hazard. These areas are distributed to the public on Flood Insurance Rate Map (FIRM) panels and first became available in digital format (DIRM) in New London County in July 2011. The most recent FIRM and FIS updates for New London County were published on August 5, 2013, and reflect some noticeable changes from the previous HMP. Windham County FIRM panels date back to 1998. Digital representation of flood zones mapped on these panels are available as "Q3 Flood Data" and are presented in that format in this Plan.

FEMA uses a variety of flood zones to delineate areas of annual chance flood hazard. These flood hazard zones differentiate between areas of riverine flooding and shallow flood hazards. Table 3-1 describes

the various zones related to inland flooding depicted on the FIRM panels for the SCCOG region. As noted in the table, the majority of inland flooding issues in the SCCOG region result from riverine flooding.

Table 3-1: FIRM Zone Classification in SCCOG Region

Zone	Description
A	An area inundated by 1% annual chance flooding, for which no base flood elevations (BFEs) have been determined. This level of mapping is common for small inland streams in the SCCOG region.
AE	An area inundated by 1% annual chance flooding for which BFEs have been determined. This area may include a mapped floodway. This level of mapping is common for larger streams and rivers in the SCCOG region and in coastal areas.
AH	An area inundated by 1% annual chance flooding (usually an area of ponding), for which BFEs have been determined. Flood depths range from one to three feet. The only occurrence of this zone in the SCCOG region is in a headwater swamp of Sherman Brook in Colchester.
Area Not Included (Zone ANI)	An area that is located within a community or county that is not mapped on any published FIRM. Two such areas occur in the SCCOG region: A small area along Latimer Brook in Montville, and the Eastern Pequot Tribal Nation lands in North Stonington.
Open Water	An area of undesignated flood hazard. A body of open water, such as a pond, lake, ocean, etc. that is located within a community's jurisdictional limits that has no defined flood hazard. In the SCCOG region, these areas primarily occur along the Thames River.
VE	An area inundated by 1% annual chance flooding with velocity hazard (wave action). BFE's have been determined. In the SCCOG region, these areas are located along Long Island Sound and along the Thames River.
X	An area that is determined to be outside the 0.2% annual chance floodplains. This zone covers nearly all inland, non-floodprone areas in the region.
X Protected by Levee	An area that is determined to not be affected by the 0.2% annual chance flood through the presence of a functional levee system. Only one such area occurs in the SCCOG region and it is located north of Shaw's Cove in New London.
0.2% Annual Chance Flood Hazard (Zone B or Zone X500)	An area inundated by the 0.2% annual chance flood for which elevations are determined. These areas are generally mapped adjacent to Zone AE.
1% Annual Chance Flood Hazard Contained in Channel (Zone 100IC)	A SFHA designation that in the SCCOG region only occurs along Gardner Brook in Bozrah. This indicates an area where the 1% annual chance flooding is contained within the channel banks and the channel is too narrow to show to scale. An arbitrary channel width of three meters is shown. BFE's are not shown in this area, although they may be reflected on the corresponding profile.

Flooding can occur in some areas with a higher frequency than those mapped by FEMA. This nuisance flooding occurs during heavy rain events with a much higher frequency than those used to calculate the 1% annual chance flood event and often in different areas than those depicted on the FIRM panels. These frequent flooding events occur in areas with insufficient drainage; where conditions may cause flashy, localized flooding; and where poor maintenance may exacerbate drainage problems.

During large storms, the recurrence interval level of a flood discharge on a tributary tends to be greater than the recurrence interval level of the flood discharge on the main channel downstream. In other words, a 1% annual-chance ("100-year") flood event on a tributary may only contribute to a 2% annual-chance ("50-year") flood event downstream. This is due to the distribution of rainfall throughout large watersheds during storms and the greater hydraulic capacity of the downstream channel to convey floodwaters. Dams and other flood control structures can also reduce the magnitude of peak flood flows.

The recurrence interval level of a precipitation event also generally differs from the recurrence interval level of the associated flood. An example would be Tropical Storm Floyd in 1999, which caused rainfall on the order of a 250-year event (0.4-percent annual chance) while flood frequencies were slightly greater than a 10-year event (10-percent annual-chance) on the Naugatuck River in Beacon Falls, Connecticut. Flood events can also be mitigated or exacerbated by in-channel and soil conditions, such as low or high flows, the presence of frozen ground, or a deep or shallow water table, as can be seen in the historic record detailed in Section 3.3.

3.2.1 Climate Change

Flood risk is typically determined through a review of historic events (as will be done in section 3.3). However, research increasingly points to "non-stationarity" in hydrologic patterns. For example, a 2016 paper (Barrett and Salis, 2016) finds that flow rates during peak annual floods, as well as floods with recurrence intervals of 5, 10- and 20- years, have been increasing between 1962 and 2012. Average observed rates of increasing magnitude are from 0.9 to 1.8 percent per year. Therefore, when planning for inland flood hazards, it is essential to consider not just the past and present, but also potential future conditions.

3.3 Regional Historic Record

The SCCOG region has experienced various degrees of inland flooding in every season of the year throughout its recorded history. Similar to other locations in the northeast, melting snow combined with early spring rains has caused frequent spring flooding. Numerous flood events have occurred in late summer to early autumn resulting from storms of tropical origin moving northeast along the Atlantic coast. Winter floods result from the occasional thaw, particularly during years of heavy snow or periods of rainfall on frozen ground. Other flood events have been caused by excessive rainfalls upon saturated soils, yielding greater than normal runoff. Ice jams are also an issue in certain communities, such as Sprague and Norwich.

Major Historic Floods of Note

According to the 2013 FEMA FIS for New London County, the notable historical inland floods in the 20th century occurred in November 1927, March 1936, September 1938, August 1955, and June 1982. The year 1955 was a devastating year for flooding in Connecticut. Connie was a declining tropical storm (described in Section 5.0) when it hit Connecticut in August 1955, producing heavy rainfall of four to six inches across the state. The saturated soil conditions exacerbated the flooding caused by Tropical Storm

Diane five days later, the wettest tropical cyclone on record for the northeast. The storm produced 14 inches of rain in a 30-hour period, causing destructive flooding conditions along nearly every major river system in the state. The August and October 1955 floodwaters combined caused over 100 deaths, left 86,000 unemployed, and caused an estimated $500 million in damages (1955 United States Dollars, or USD) in Connecticut. To put this damage value in perspective, consider that the total property taxes levied by all Connecticut municipalities in 1954 amounted to $194.1 million.

Effects of these notable floods in New London County are noted below:

- Tropical Storm Diane in August 1955 caused the greatest flood in recorded history along the Quinebaug River. The peak discharge caused by that storm was 40,700 cubic feet per second (cfs), greater than the 0.2% annual chance flood discharge defined in the FIS. Serious flooding was also reported along the Shetucket River.
- The hurricane of September 1938 caused some of the worst flooding in the history of New London County. According to FEMA, the 1938 hurricane, which struck at high tide, resulted in the greatest disaster in Connecticut's history up until that time because of the combined effects of flooding, winds, and storm surge. The greatest flood in recorded history on the Shetucket River occurred as a result of this storm. Flooding in Norwich had an estimated recurrence interval of 0.3% annual chance flood, while areas to the west had flooding equivalent to a 1% annual chance flood.
- A tropical storm in November 1927 caused severe flooding along the Pawcatuck River. The flood has been estimated to have been a 0.5% annual chance flood.
- The two floods of March 1936 had peak discharges of 22,800 cfs and 25,000 cfs on the Quinebaug River. A peak discharge of 2,240 cfs was recorded for the Pachaug River near Jewett City. These are greater than the 1% annual chance flood discharge defined in the FIS. These floods were caused by extra-tropical storms.
- A winter flood in 1979 was equivalent to the 1% annual chance flood in Colchester.
- A major riverine flooding event occurred in June 1982 in East Lyme and Montville. The flood was caused by heavy rainfall. This event is the flood of record for the Fourmile River.
- On January 29, 1994, a major ice jam occurred along the Shetucket River downstream of Route 97 in Baltic (a section of Sprague). Floodwaters behind the jam overtopped a local flood control berm and inundated 31 houses and four businesses. One home was seriously damaged when ice broke the foundation. The USACE estimated damages at $526,000 and estimated that the flood stages experienced would occur once every 12 years.

Significant Floods, 2007-2012

The following are descriptions of more recent examples of floods in and around the region as described in the National Climatic Data Center (NCDC) Storm Events Database and based on correspondence with municipal officials. Note that inland flooding was not necessarily limited to the described areas. Information on disaster declarations was taken from articles within FEMA's Connecticut Disaster History database.

- **April 15-16, 2007**: A Nor'easter brought heavy rain and high winds that caused widespread and significant river, stream, and urban flooding or low-lying and poor drainage areas throughout Connecticut. Significant river flooding lasted through April 23rd. While only 1.76 inches of rain was reported in Groton, heavier rainfall occurred in the northwestern part of New London County. The Yantic River rose 1.42 feet above flood stage in Norwich.
- **December 12, 2008**: A low pressure system produced a prolonged period of rain across southern Connecticut. A total of 4.5 inches of rain fell in New London County. Major flooding occurred along the Yantic River in Norwich, with the river reaching 2.82 feet above flood stage and remaining above flood stage for nearly 18 hours.
- **July 1, 2009**: Isolated severe thunderstorms produced up to 6.5 inches of rainfall that resulted in flash flooding in Groton, Ledyard, Mystic, and North Stonington. Over 100 basements were pumped out. Approximately 50-60 cars were flooded in the Mystic Aquarium parking lot. A dam in Stonington breached due to the heavy rain.
- **March 14, 2010:** A Nor'easter produced an extended period of heavy rainfall across the area that resulted in widespread flooding across portions of New London County. A total of 2.74 inches of rainfall was reported in Groton and 4.7 inches of rainfall was reported in Norwich. Moderate flooding (1.63 feet above flood stage) occurred on the Yantic River in Norwich. Numerous roads were closed in Mystic and Pawcatuck due to the flooding.
- **March 29-30, 2010:** A second Nor'easter produced an extended period of heavy rainfall across southeastern Connecticut. Major flooding occurred along the Quinebaug River at Jewett City, which crested at 23.26 feet, 5.76 feet above flood stage. Many roads were damaged in Jewett City and throughout Griswold. Floodwaters along a small tributary to Wequetequock Cove destroyed a bridge and most of the nearby road and flooded several homes. Numerous homes experienced basement flooding in Groton, Stonington, and North Stonington. Numerous roads were closed and/or washed out in Stonington and North Stonington. The Yantic River crested at 13.23 feet (4.23 feet above flood stage) on March 30, causing major flooding in Norwich. A total of 8.6 inches of rainfall was reported in Mystic. The USGS estimated that flooding ranged from the 4% annual chance flood to the 0.2% annual chance flood along rivers in the region. The Connecticut Department of Transportation noted that the 0.2% annual chance flood level was reached at eight different locations in New London County.
- **August 27-28, 2011:** As a result of Tropical Storm Irene (Federal Disaster declaration #4023), minor inland flooding occurred in coastal communities. The most significant flooding was coastal in nature and is described in Section 4.3.
- **June 25, 2012**: Heavy rainfall caused isolated flash flooding in New London County, closing route 12 at Stoddards Wharf Road in Massapeag.

Recent Significant Floods

Since adoption of the previous HMP in October 2012, a number of other flood events have occurred:

- **June 7, 2013**: The remnants of Tropical Storm Andrea tracked up the eastern seaboard resulting in a prolonged period of heavy rain, which caused flash flooding in portions of Fairfield and New London Counties. In Groton, South Road was closed at the railroad underpass due to flooding. Total

reported rainfall amounts in New London County ranged from 4.12 inches in Yantic to 6.64 inches in Gales Ferry.

- **July 25, 2013**: The redevelopment of showers and storms over the same area of Southeast Connecticut led to a period of persistent heavy rain over New London County, which resulted in flash flooding. The township of Norwich was hit the hardest with WSR-88D Dual-Pol Storm Total Accumulation estimates of 5 to 8 inches, verified by observations received on the ground. During this event, a vehicle was stranded in flood waters on Huntington Avenue in Norwich; West Town Street at I-395 in Norwichtown was impassable due to flooding; a vehicle was stranded in flood waters at the intersection of White Plains Road and Hansen Road in Norwich, and an office complex at 12 Case Street in Norwich was evacuated due to flooding. Also in Norwich, the Yantic River exceeded bankfull at the intersection of Sturtevant Street and Pleasant Street, downstream of the river gauge, resulting in flooding. The public reported a storm total rainfall of 7.88 inches. Mesonets from the neighboring towns of Yantic, Oakdale and Montville reported total rainfall amounts of 5.25 inches, 3.17 inches and 1.96 inches respectively. Additionally, between 12:00 and 12:15 pm, the mesonet in Yantic reported 1.15 inches of rainfall in 15 minutes. Sholes Avenue, Pleasant Street, and West Town Street in Norwich were closed due to flooding. Residents in the area also experienced basement flooding. Several motor vehicles were stranded in flood waters as well and occupants were rescued by the local fire department. The exit ramp of I-395 at exit 82 (West Town Street) was closed due to flooding in Norwich. Golden Road near Route 32 in Norwich was closed due to flooding.
- **September 2, 2013**: Scattered thunderstorms produced between 2 and 2.5 inches of rainfall, causing flash flooding in Fairfield and New London Counties. There were six to eight inches of flowing water on portions of Route 12 from the U.S. Naval Submarine Base south to Groton. South Road at the railroad underpass in Groton was closed due to flooding.
- **March 30, 2014**: Several inches of rain fell across Southern Connecticut. Storm total rainfall reported across New London County ranged from 3.20 inches in New London to 4.90 inches in Mystic. The Yantic River at Yantic exceeded its flood stage of 9.0 feet to crest at 10.10 feet. Numerous roads in Norwich were under 2 feet of water as a result. Snake Meadow Brook in overflowed its banks, flooding and ultimately closing North Sterling Road in Moosup for several hours.
- **July 4, 2014**: As a cold front slowly moved across the area, moisture from Tropical Cyclone Arthur passing to the south and east converged along the boundary resulting in heavy rain and isolated flash flooding in New London. A vehicle became trapped after 4 feet of water accumulated at the intersection of Thames Street and Eastern Point Road in Groton, resulting in a water rescue. The lower Pawcatuck River exceeded bankfull flooding Mechanic St. in Pawcatuck Township.
- **September 10, 2015**: A wave of low pressure riding along a cold front stalled just south of Long Island. It brought heavy rain and isolated flash flooding to New London County, Connecticut. A roadway collapse was reported on Mullen Hill Road between Ellen Ward Road and Gallup Lane in Manitock Spring. Storm total rainfall from the Groton Airport ASOS was 2.53 inches. Cars were stranded on Water Street in New London due to flash flooding. Bank Street was closed due to flash flooding in New London.

Federal Disaster Declarations

Three events have occurred in the SCCOG region in the last decade that have caused flood damage of sufficient extent (as well as other damages) that Presidential Disasters were declared.

- March 12-16, 2010: A nor'easter (Federal Disaster #1904) led to over $6.6 million in Public Assistance funding to be requested by communities, governments, and non-profits in the SCCOG area.
- August 27 - September 1, 2011: Tropical Storm Irene (Federal Disaster #4023) led to nearly $5.8 million in Public Assistance funding to be requested. Irene caused both flooding and high wind damage. An exact breakdown is not immediately available. For planning purposes, the damage values are assumed to be one-third flooding related and two-thirds wind related. Thus, flooding from Tropical Storm Irene caused approximately $1.9 million of damage in the SCCOG region.
- October 27 - November 8, 2012: Hurricane Sandy (Federal Disaster #4087) caused flooding that created approximately $2.6 million of damage in the SCCOG region.

Losses due to these disasters are reviewed in further detail in section 3.5.2.

3.4 Existing Capabilities

Jurisdictions in the SCCOG region have a variety of programs, policies, and mitigation measures that are designed to reduce or eliminate the effects of flooding. These include federal flood insurance programs, regulations, codes, and ordinances preventing encroachment and development near floodways, monitoring efforts, and emergency services. Large scale structural projects have also constructed to reduce flooding damages. Recent and ongoing flood mitigation is described below.

3.4.1 Participation in the NFIP

Jurisdictions in the SCCOG region have voluntarily participated in the NFIP since 1977. These communities have incorporated the NFIP regulations into their own municipal codes, regulations, and tribal policies; plan to continue participating in the NFIP; and will continue to comply with the requirements of the NFIP.

SFHAs in New London County are delineated on a Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) published on August 5, 2013. The county-wide FIS and FIRM supersede the studies for individual towns in the county. Windham County FIS and FIRM panels date back to 1998; coverage includes the Town of Windham, the only municipality in SCCOG located outside of New London County. Some communities also participate in the Community Rating System. Table 3-2 presents the history of NFIP participation in the SCCOG region including the date of identification for the initial Flood Boundary and Floodway Maps (FBFM) or Flood Hazard Boundary Maps (FHBM) that preceded each community FIRM. Each SCCOG community utilizes the current effective FIRM to delineate floodprone areas under the NFIP. Table 3-2 also lists the status of each SCCOG jurisdiction in the Community Rating System, a voluntary FEMA program for local governments which provides discounts on flood insurance for their constituents.

Table 3-2: NFIP Participation in SCCOG Jurisdictions

Community or Tribe[1]	Initial NFIP Map Identified	Initial FIRM Identified	Current Effective Map Date	Community Rating System Status[2]
Bozrah	05/31/1974	09/30/1981	07/18/2011	-
Colchester	08/02/1974	06/15/1982	07/18/2011	-
East Lyme	09/13/1974	06/15/1981	08/05/2013	Class 8
Franklin	11/01/1974	12/01/1981	07/18/2011	-
Griswold	02/28/1975	01/03/1985	07/18/2011	-
Jewett City, Borough of	12/10/1976	04/03/1985	07/18/2011	-
Groton, City of	02/21/1975	05/15/1980	08/05/2013	-
Groton, Town of	02/21/1975	04/15/1977	08/05/2013	-
Groton Long Point Association	04/11/1975	03/18/1980	08/05/2013	-
Noank Fire District	02/21/1975	09/17/1980	07/18/2011	-
Lebanon	01/24/1975	06/06/1988	07/18/2011	-
Ledyard	02/21/1975	04/01/1981	08/05/2013	-
Lisbon	01/31/1975	02/15/1985	07/18/2011	-
Mashantucket Pequot Tribal Nation	02/21/1975	04/01/1981	07/18/2011	-
Mohegan Tribe	10/18/1974	07/02/1980	07/18/2011	-
Montville	10/18/1974	07/02/1980	08/05/2013	-
New London	06/28/1974	05/02/1977	08/05/2013	-
North Stonington	09/13/1974	04/03/1985	07/18/2011	-
Norwich	05/31/1974	06/15/1978	07/18/2011	-
Preston	08/16/1974	03/04/1985	07/18/2011	-
Salem	02/21/1975	02/03/1982	07/18/2011	-
Sprague	05/10/1974	01/03/1985	07/18/2011	-
Stonington, Borough of	11/29/1977	11/01/1979	08/05/2013	Class 8
Stonington, Town of*	10/18/1974	09/30/1980	08/05/2013	-
Waterford	07/26/1974	02/04/1981	08/05/2013	-
Windham	04/12/1974	02/03/1982	11/06/1998	-

1 Tribal lands are identified along with their surrounding communities as initial FEMA designations occurred prior to their lands being identified as sovereign.

2 Class as of October 1, 2016. A "Class 9" rating in the CRS indicates that residents in the SFHA in that community gain a 5% discount on flood insurance, a "Class 8" rating gives a 10% discount, etc.

*The Town of Stonington is actively pursuing reinstatement into CRS

As of March 31, 2017 there were 4,301 flood insurance policies within the SCCOG communities paying a total annual premium of $6,419,081, or an average of $1,492 per policy per year. The total amount of insurance in force is $1.12 billion, or an average of $260,638 per policy. The total number of paid losses (claims paid) since 1978 is 2,110 totaling $29,445,889. This information is summarized in Table 3-3, below.

Table 3-3: NFIP Policy and Loss Statistics (as of 3/31/2017)

Community	Total Losses (since 1/1/1978)	Total Payments (since 1/1/1978)	Policies In Force	Insurance In-Force	Premium In-Force
Bozrah	6	$6,296	6	$1,485,000	$4,162
Colchester	3	$1,171	22	$5,433,400	$12,997
East Lyme	237	$4,306,998	421	$118,822,500	$428,605
Franklin	14	$47,837	4	$1,098,300	$3,545
Griswold	7	$24,088	14	$3,343,000	$12,238
Groton City	78	$1,014,379	124	$29,987,800	$215,117
Groton, Town of	365	$4,303,487	789	$225,363,800	$1,413,614
Jewett City	4	$15,557	6	$1,665,000	$4,091
Lebanon	2	$0	23	$5,913,300	$15,785
Ledyard	20	$179,662	53	$12,594,500	$27,478
Lisbon	7	$15,576	12	$2,737,500	$18,255
Montville	12	$67,734	40	$11,552,800	$44,041
New London	176	$2,367,403	301	$71,478,100	$336,071
North Stonington	15	$173,689	20	$5,343,300	$17,854
Norwich	254	$2,252,037	269	$44,068,900	$322,326
Preston	5	$46,882	15	$3,384,600	$10,384
Salem	2	$1,627	7	$2,325,000	$5,562
Sprague	18	$128,477	26	$4,652,100	$38,423
Stonington, Borough	59	$921,464	282	$76,618,800	$528,587
Stonington	296	$3,682,886	945	$240,375,300	$1,646,639
Waterford	112	$1,137,556	303	$82,856,400	$391,781
Windham	6	$33,651	25	$9,221,200	$58,368
TOTAL SCCOG	**1,698**	**$20,728,454.80**	**3,707**	**$960,320,600**	**$5,555,923**

In the past, the physical alteration of a river through the construction of dams and levees was the standard response to a flooding problem. These manmade physical controls cannot always be relied upon. They are also relatively expensive, sometimes costing more to construct than the value of the property that they were intended to protect. That is why the contemporary philosophy as embodied in NFIP regulations is to prevent inappropriate development from occurring within the floodplain.

Unfortunately, many areas in the SCCOG region are somewhat problematic as development has already occurred within floodplain areas. In fact, while federal policy and regulations restrict to some extent new development in the floodplain, their overall impact has historically been to maintain the level of the existing development there through the NFIP. The NFIP will pay for repairs to a structure in floodplain area numerous times such that the payments encourage property owners to keep improving structures in the floodplains. In fact, only recently has the flood insurance pricing system begun to differentiate between the different levels of risk for pre-FIRM properties, where before a pre-FIRM property owner who was damaged by floods annually paid the same premiums as a pre-FIRM property owner who was located in a relatively low risk section of the floodplain.

The unintended consequences of these policies have been coming into greater attention lately with the unusual number of natural disasters occurring in recent years, and efforts are underway to alter these

policies. As part of such efforts, FEMA is taking steps to make the NFIP more actuarially sound. The Biggert-Waters Flood Insurance Reform Act of 2012 began raising insurance premiums based on actuarial rates of risk. The Homeowner Flood Insurance Affordability Act of 2014 repealed some aspects of the initial act, modified others, and made additional changes to the NFIP. A suite of policy changes went into effect April 1 of 2016, including increased insurance rates and the addition of a surcharge to all policies. As a result, many property owners in the SCCOG region have experienced increases to their flood insurance premium costs.

Another way to discourage continued maintenance of floodplain development is for the Federal government, through FEMA, to purchase property subject to ongoing flood damage rather than pay for repairs, which may be less expensive for the Federal government over the long term. This has been done to some extent through the PDM, FMA, and HMGP programs, although funding is often limited. The effects of such programs are discussed later in this section.

Flood insurance remains the most fundamental tool available for property owners to recover from damaging flood events. Nearly 5,000 homeowners in the SCCOG region purchase flood insurance. Although only a few communities currently participate in the CRS, one of the recommendations of this HMP is for communities to participate in the future.

3.4.2 Regulations, Codes, and Ordinances

Each community annex discusses regulations, codes, and ordinances adopted by the local governing body that are dedicated to or related to flood damage prevention. Development or alterations within the SFHA are generally restricted by local regulations and must conform with standards related to safety and the impact on floodwaters. Generally, the NFIP requires that all new construction or substantial improvements within the floodway fringe (the area of the floodplain outside of the floodway) is permitted if the building is adequately floodproofed and has the lowest floor at or above the base flood elevation (level of the 1% annual chance flood). Local freeboard requirements can require the elevation of the lowest floor or lowest structural member to be higher than the base flood elevation.

Development within the floodway is more restricted and generally limited to a small list of water-dependent activities that do not result in an increase in the base flood elevation more than one foot at any place in the community. These minimum standards have been locally adopted or exceeded to be in compliance with NFIP regulations such that properties within that jurisdiction are eligible for flood insurance under the NFIP. Refer to Table 3-4 for a summary of floodplain management in the SCCOG jurisdictions.

Table 3-4: Floodplain Management in SCCOG Communities

Community	FP Management Ordinance	FP Management Zoning	Substantial Improvement Timeframe	Freeboard Requirement?
Bozrah	No	Section 10.8	1 year window	None
Colchester	Section 64	Section 9.3	1 year window	1 foot
East Lyme	Page 99	Section 15	10 year window	None
Franklin	No	Section 9.14	1-year window	None
Griswold	Section 151	Section 11.4	1-year window	None
Jewett City, Borough of	Yes	No	Unknown	Unknown
Groton, City of	Section 73	Section 4.7	50% for project, or two flood events at 25% within 10 years	None
Groton, Town of	No	Section 6.6	1-year window	1 foot (coastal only)
Groton Long Point Association	No	Section 10	50% for project, or two flood events at 25% within 10 years	1 foot
Lebanon	"Ord. on FP Management"	Section 4.11	5-year window	None
Ledyard	Section 73	Section 12.3	1-year window	None
Lisbon	No	Section 10.15	1-year window	"Above"
Montville	No	Section 16.4	1-year window	None
New London	Ch.6 Article III S:6.41-49	Section 830	10-year window	2-feet
North Stonington	10	Section 307	Project	1 foot
Norwich	Section 3.4	Section 3.4	1-year window	1.5 feet
Preston	No	Section 13.23	1-year window	None
Salem	Page 95	Section 3.13	1-year window	None
Sprague	No	Section 15.14	1-year window	None
Stonington, Borough of	No	Section 3.3.2	3-year window	1 foot
Stonington, Town of	No	Section 7.7	5-year window	1-foot
Waterford	No	Section 25.3	Life of structure	1-foot
Windham	No	Section 52	5-year window	None

Substantial Improvement is defined as any reconstruction, rehabilitation, addition, or other improvement of a structure which costs 50% or more of the market value of the structure prior to the start of construction of the improvement, without regard for the timing of the construction. Triggering this threshold requires the project to meet all current floodplain management requirements. Thus, under the minimum standard it is possible for multiple improvements to be done to a property without addressing flood risk, thereby increasing the overall risk to a property. Communities sometimes strengthen this requirement by attaching a timeframe, and counting the total costs of improvements to that property within that timeframe against the substantial improvement threshold.

Many SCCOG communities also have a policy of "no-net-increase in runoff." No zoning permits for residential or commercial construction, major additions, tennis courts, or pools are issued until the local

departments review drainage and grading plans to ensure that adjacent and/or downstream properties are not adversely affected.

Stream Channel Encroachment Line Program

The previous HMP discussed the State of Connecticut's Stream Channel Encroachment Line (SCEL) program, established in the late 1950's. Under this program, proposed developments in floodplains mapped by the SCEL process required a special permit from the Connecticut DEEP. As of October 1, 2013, the SCEL program has been repealed (Connecticut Public Act 13-205) in favor of the floodplain management programs and mapping promulgated by FEMA.

While it was in existence, four sections of river in the SCCOG region had floodplains delineated by the SCEL program: The Yantic River from the Bozrah / Norwich municipal boundary upstream to Reservoir Road in Lebanon; The lower reaches of the Yantic River from the Bozrah / Norwich municipal boundary downstream to the Falls Mill Dam No. 2 (Upper Dam) located south of Sherman Street; The Shetucket River from the Occum Pond Dam in Norwich located upstream of Bridge Street upstream to the location of the former Baltic Dam in Sprague upstream of Scotland Road (Route 97); and the Shetucket River from the Greenville Dam (upstream of 8th Street) to the confluence with the Thames River.

Local Land Trusts

Local land trusts are charged with keeping an inventory of all open space land and often advise the local communities concerning open space acquisitions and the appropriate use of existing land holdings. State law also enables certain trusts to accept donations of land, easements and other grants in furtherance of these purposes. Many SCCOG communities have identified land within SFHAs that could be converted to open space. Grant funding under the HMA programs can be used for this purpose provided the project is cost-effective.

Education and Outreach

SCCOG communities provide education and outreach to their residents. Information is available on local websites, local libraries, the SCCOG website, and in pamphlets available at local community buildings. Information includes a variety of potential measures for protecting personal property from flooding.

3.4.3 Emergency Response

The National Weather Service issues a flood watch or a flash flood watch for an area when conditions in or near the area are favorable for a flood or flash flood, respectively. A flash flood watch or flood watch does not necessarily mean that flooding will occur. The National Weather Service issues a flood warning or a flash flood warning for an area when parts of the area are either currently flooding, highly likely to flood, or when flooding is imminent.

Local emergency management personnel are responsible for monitoring local flood warnings. SCCOG jurisdictions can access the National Weather Service website at http://www.weather.gov/ to obtain the latest flood watches and warnings before and during precipitation events.

SCCOG communities receive regular weather updates through DESPP email alerts and can also access the United States Geological Survey website (https://waterdata.usgs.gov/ct/nwis/rt) to monitor real-time precipitation totals and river stage changes.

When flooding occurs, local communities respond to flooding as necessary by closing roads, pumping out basements, or rescuing stranded motorists. During extreme flood events, inter-municipal and regional coordination is essential as widespread areas may be damaged. Local communities follow their Emergency Operations Plans as possible. Many SCCOG communities also have a bridge scour monitoring program that goes into effect during heavy rainstorms.

3.4.4 Structural Projects

Property protection projects can address hazards at individual or multiple structures. Such measures can include acquiring floodprone properties and converting the parcel to open space, elevating or floodproofing floodprone structures, constructing flood detention basins, enlarging culverts and bridges to prevent backwater flooding, or large scale projects such as constructing levees or flood control dams. Small scale projects are discussed in Section 3.6. The discussion below focuses on the large-scale flood protection projects that have been constructed to reduce inland flooding in the SCCOG region. Each annex will have more information regarding projects in that community.

There have been several structures built to reduce flooding in the SCCOG region. These structures are described in the 2013 Revised FEMA FIS for New London County, as well as the 1998 FEMA FIS for the Town of Windham:

- The USACE constructed the Mansfield Hollow flood control dam on the Natchaug River following the 1938 floods. The dam was finished in 1952. The dam is designed to reduce the volume of the 1938 flood by approximately half. Though the reservoir reduces the frequency and severity of floods, there still remains a flood hazard on downstream floodplains.
- Several small detention and water supply reservoirs in the upper portions of the Willimantic River basin have a minor effect on flood peaks downstream along the Willimantic and Shetucket rivers.
- The USACE constructed flood control dams in the upper Quinebaug River basins through the mid-1960s. Dams are located at Hodges Village Lake in Oxford, Massachusetts; Buffumville Lake at Oxford and Charlton, Massachusetts; Westville Lake at Southbridge, Massachusetts; East Brimfield Lake at Fiskdale, Massachusetts; and West Thompson Lake at North Grosvenordale, Connecticut.
- The USACE constructed a 0.36-mile levee in Pawcatuck, Connecticut (a part of Stonington near Westerly, Rhode Island) in 1962 and 1963. The levee, pictured to the right, protects an industrial area and surrounding residential area located on Mechanic Street (approximately 28 total acres). However, the levee does not

protect against the 1% annual chance flood event.

- Two small reservoirs were constructed by the Soil Conservation Service (now the Natural Resources Conservation Service, NRCS), in 1963 and 1964 on Spaulding Pond Brook in Norwich. These reservoirs provide moderate control of upland runoff.
- The USACE completed the Shetucket River Channel Improvement Project in January 1959. A 700-foot reach of the Shetucket River was deepened and widened, and the raising of the Laurel Hill Avenue Bridge (Route 12) in Norwich significantly improved the flood-carrying capacity of the river below the Greenville Dam.

3.5 Vulnerabilities and Risk Assessment

This section discusses specific areas at risk to flooding within the SCCOG region. Inland flooding problems are widespread throughout the region. As shown in the historic record, inland flooding can be caused from a variety of sources and can impact a variety of river corridors and cause severe damages in the region. Inland flooding due to poor drainage, ice jams and other factors is also a persistent hazard in the region and can cause minor infrastructure damage, expedite maintenance, and create nuisance flooding of yards and basements.

3.5.1 Vulnerability of Private Properties

Extreme events along defined floodplains often result in damage to insured structures. The most extreme damage associated with inland flooding has historically occurred to homes and businesses along the Yantic River, Mystic River and Latimer Brook corridors resulting from extreme rainfall events. Significant flooding can also take place within the floodplain of smaller tributaries throughout the region. In addition, inland areas can be flooded as a result of coastal storms when flooding passes the initial velocity zone (Zone VE, see Section 4). The potential impacts of flooding in all jurisdictions in the region are high with potential dollar damages as a result of serious flooding being very significant.

Buildings located in SFHAs include residential, commercial, industrial, and critical facility structures. Most of the structures that are threatened by flooding are located within the 1% annual chance floodplain, but some are also in the coastal velocity zone. Location in the velocity zone poses an increased threat to structures due to high wind and potential wave damage, as well as inundation by flood waters. Maps depicting the 1% and 0.2% annual chance SFHAs are included in each community annex.

According to the 2013 Revised FEMA FIS for New London County and the 1998 FEMA FIS for the Town of Windham, a total of 73.38 square miles of land in the SCCOG region is located within areas susceptible to flooding from the 1% or 0.2% annual chance flood. Table 3-5 summarizes the total area of land within each FEMA-delineated floodplain area.

Table 3-5: Area of SFHAs in the SCCOG Region

Flood Zone	Area (acres)
0.2% Annual Chance Flood Hazard	15,104.61
1% Annual Chance Flood Hazard Contained in Channel	0.22
1% Annual Chance Flood Hazard – Zone A	15,570.02
1% Annual Chance Flood Hazard – Zone AE	13,532.14
1% Annual Chance Flood Hazard – Zone AH	8.60
1% Annual Chance Flood Hazard – Zone VE	2,750.36
X – Protected by Levee	37.01
Total	**47,002.96**

The software platform *ArcGIS* was previously utilized along with 2008-2009 aerial photography to determine the number of properties located within the various SFHAs within the SCCOG region. Table 3-6 summarizes the number of structures at risk of flooding in each SCCOG jurisdiction based on the 1% annual chance floodplain mapped by FEMA.

Table 3-6: Number of Structures within the 1% Annual Chance Floodplain

Jurisdiction	Zone A	Zone AE	Floodway in Zone AE	VE	Total
Bozrah	3	7	3	-	13
Colchester	35	3	4	-	42
East Lyme	8	314	12	24	358
Franklin	10	2	1	-	13
Griswold / Jewett City	15	81	7	-	103
Groton, City of	-	95	0	110	205
Groton, Town of	17	925	0	101	1,043
Lebanon	36	67	-	-	103
Ledyard	71	41	3	-	115
Lisbon	5	42	2	-	49
Mashantucket Pequot Tribal Nation	0	0	0	-	0
Mohegan Tribe	-	0	-	-	0
Montville	21	67	8	-	96
New London	0	155	-	43	256
North Stonington	62	6	10	-	78
Norwich	0	271	118	-	389
Preston	29	19	2	-	50
Salem	3	3	1	-	7
Sprague	4	43	12	-	59
Stonington, Borough of	0	211	-	80	291
Stonington, Town of	12	1,204	25	140	1,381
Waterford	5	269	5	31	310
Windham	25	60	10	-	95
Total SCCOG Region	**361**	**3,885**	**223**	**529**	**5,056**

Notes: A "-" indicates that this type of SFHA does not exist within the jurisdiction.

Note that most of the data in Table 3-6 was collected prior to the realignment of the SCCOG borders in 2014. Counting was performed for Lebanon and Windham using 2016 aerial photography.

More than 5,000 properties in the region are at risk of being affected by a 1% annual chance inland flood. Many of the jurisdictions in the region will benefit from pursuing and encouraging potential mitigation measures for floodprone properties. Note that some of these structures may not actually be at risk based on elevation, though they lie within the SFHA boundary. Nevertheless this information provides an important context for understanding the extent of flood risk at a regional level.

The list of repetitive loss properties (RLPs) in the SCCOG region was obtained from Connecticut DEEP. A total of 43 repetitive loss properties (RLPs) associated with inland flooding are located in the SCCOG communities. The majority of these properties are residential with the remainder being commercial properties. General areas containing RLPs are depicted on the maps in each community annex, and the RLPs related to inland flooding are summarized by jurisdiction and flooding source in Table 3-7. The greatest numbers of RLPs affected by inland flooding are located along the Yantic River in Norwich. The majority of the structures are mapped within the 1% annual chance floodplain except for a few properties that appear to be affected by poor drainage or urban flooding. Such properties are mapped within the 0.2% annual chance floodplain or are located outside of mapped floodplains.

Table 3-7: Inland Flooding Repetitive Loss Properties in the SCCOG Region (As of July 31, 2016*)

Town	Number of Properties			Total Payments
	Total	Residential	Non-Residential	
East Lyme, Town of	10	10	0	$1,343,357.18
Franklin, Town of	2	2	0	$47,836.72
Groton, City of	4	4	0	$124,993.10
Groton, Town of	5	5	0	$112,383.63
Ledyard, Town of	3	3	0	$35,226.66
Montville, Town of	2	2	0	$41,778.98
New London, City of	16	15	1	$1,149,113.94
North Stonington, Town of	2	2	0	$36,517.99
Norwich, City of	21	10	11	$1,475,790.11
Stonington, Borough of	2	2	0	$140,965.29
Stonington, Town of	17	15	2	$830,448.43
Waterford, Town of	10	10	0	$171,991.64
Total	**107**	**93**	**14**	**$5,510,403.67**

SCCOG recognizes that many private properties may suffer flood damage that is not reported because the structures are not insured under the NFIP, or because the owners fear an increase in flood insurance rates if they report a claim (a misconception because flood insurance is federally subsidized). These residents and business owners are likely repairing structures on their own. Flood mitigation as recommended in this plan will likely help many of these property owners.

3.5.2 Loss Estimates

HAZUS-MH Vulnerability Analysis

HAZUS-MH is FEMA's loss estimation methodology software for flood, wind, and earthquake hazards. The software utilizes year 2010 U.S. Census data and a variety of engineering information to calculate potential damages (specified in year 2010 United States Dollars or USD) to a user-defined region. The software was utilized to perform a basic analysis to generate potential damages in the SCCOG region from a 100-year combined riverine and coastal flood event within each jurisdiction. The coastal flooding module of *HAZUS-MH* was not run for inland communities.

Note that the FEMA Flood Map Modernization (MapMod) program has not been performed in Windham, and therefore Digital Flood Insurance Rate Maps (DFIRMS) are not available. The HAZUS-MH flooding module was only run in communities with DFIRMs; no results are presented here for Windham.

Note that the HAZUS-MH software was only utilized for those streams in each jurisdiction that include AE Zones, as shown on a DFIRM. As shown in Table 3-2, many streams in the region are mapped through approximate methods (Zone A), so the software did not generate data for these streams. Windham does not have a DFIRM, so the software was not utilized in that community.

Hydrology and hydraulics for the streams and rivers were generated for *HAZUS-MH* through the Flood Information Tool (FIT). The FIT utilizes FEMA cross sections for each watercourse and Digital Elevation Model (DEM) data to calculate potential flood depths in the user-specified areas. For this study, DEM data prepared by the University of Connecticut's Center for Land Use Education and Research (CLEAR) and DFIRM data for New London County published in July 2013 were utilized. The DEMs were based on the 2000 LiDAR survey of Connecticut. Summary reports for the 1% annual chance flood event in each jurisdiction are included in Appendix D. The following paragraphs discuss the results of the *HAZUS-MH* analysis.

Each jurisdiction was run separately in *HAZUS-MH*. FEMA default values were used for each census tract in each *HAZUS-MH* simulation. Note that for communities with coastal flooding areas the 1% annual chance coastal floodplain was combined with the riverine analysis. This is because for Zone AE areas in the SCCOG region it is very difficult to determine where the riverine 1% annual chance floodplain ends and the coastal 1% annual chance floodplain begins because of the many tidal coves and water courses near the shoreline. The individual model runs are summarized throughout this section.

Table 3-6 presents the expected damages for each SCCOG jurisdiction. The *HAZUS-MH* simulation estimates that during a combined 1% annual chance riverine and coastal flood event more than 1,670 buildings will be damaged in the region from inland and coastal flooding. Comparing the number of damaged buildings to the building counts in Table 3-6, this suggests that **approximately two-thirds (66%) of the buildings in the riverine and coastal 1% annual chance floodplain will *not* be damaged during the 1% annual chance event**. It is expected that the **one third (34%) of the buildings would experience at least minor (1% to 10%) damage**. There are possible reasons for the discrepancy, including:

- The DEM used is based on the 2000 LiDAR flight and may be more accurate than the USGS topographic maps originally utilized to generate the SFHA boundaries as modified by the MapMod program... Thus, areas that would be flooded based on the mapped floodplain may actually be elevated above the 1% annual chance flood elevation and therefore would not be simulated as being damaged by *HAZUS-MH*.
- The HAZUS-MH software may be underestimating the potential flooding damage in the region.

Table 3-8: HAZUS-MH Flood Scenarios – Building Stock Damages

SCCOG Jurisdiction	1-10% Damage	11-20% Damage	21-30% Damage	31-40% Damage	41-50% Damage	Substantial Damage	Total
Bozrah	7	2	1	0	0	0	10
Colchester	0	0	0	0	0	0	0
East Lyme	7	65	30	10	4	16	132
Franklin	0	0	0	0	0	0	0
Griswold	0	0	0	3	3	4	10
Groton, City of	1	35	16	2	0	9	63
Groton, Town of	2	159	127	47	23	62	420
Lebanon	0	0	0	0	0	0	0
Ledyard	2	1	2	1	0	1	7
Lisbon	1	0	0	0	0	0	1
Mashantucket Pequot Tribal Nation	0	0	0	0	0	0	0
Mohegan Tribe	0	0	0	0	0	0	0
Montville	1	3	2	1	1	2	10
New London	0	45	16	3	2	9	75
North Stonington	1	0	0	0	0	0	1
Norwich	38	44	22	11	8	69	192
Preston	0	0	0	0	0	0	0
Salem	0	0	0	0	0	0	0
Sprague	10	17	9	4	0	0	40
Stonington, Borough of	0	46	36	14	6	27	129
Stonington, Town of	2	177	191	53	17	49	512
Waterford	6	47	27	2	3	9	94
Total	**78**	**641**	**479**	**151**	**67**	**257**	**1673**

HAZUS-MH utilizes a *subset* of critical facilities known as "essential facilities" that are important following flooding events. These include fire stations, hospitals, police stations, and schools. Not all SCCOG jurisdictions were expected to have damage to essential facilities following a 1% annual chance flood event. A total of 11 essential facilities were expected to have at least moderate damage and loss of use. Those jurisdictions that could potentially experience damage to essential facilities are listed below:

- Bozrah: One school would experience at least moderate damage and subsequent loss of use.
- Griswold: The police station would experience at least moderate damage and subsequent loss of use.

- Groton (Town of): Two fire departments and the police station would experience at least moderate damage and subsequent loss of use.
- New London: One fire department would experience at least moderate damage and subsequent loss of use.
- Norwich: One fire department would experience at least moderate damage and subsequent loss of use.
- Sprague: The police department and one school would experience at least moderate damage and subsequent loss of use.
- Stonington (Town of): Two fire departments would experience at least moderate damage and subsequent loss of use.

The *HAZUS-MH* software estimated the amount of debris that would be caused by inland and coastal flooding. Finishes include items such as drywall and insulation, structural items include materials such as wood and brick, and foundations include materials such as concrete slabs, blocks, and rebar. Results are presented in Table 3-10. The *HAZUS-MH* simulation estimated that a significant amount of debris (over five-thousand tons) would be generated in East Lyme, Griswold, Groton Town and Groton City, Norwich, and Stonington Town and Borough, and Waterford.

Table 3-9: HAZUS-MH Flood Scenarios – Debris Generation (Tons)

SCCOG Jurisdiction	Finishes	Structural	Foundations	Total	Estimated Cleanup Truckloads (25 Tons / Truck)
Bozrah	77	10	7	92	4
Colchester	14	2	1	16	1
East Lyme	2,844	3,475	2,303	86,261	345
Franklin	7	2	1	9	-
Griswold	890	2,647	2,130	5,668	227
Groton, City of	3,215	3,040	1,404	7,659	306
Groton, Town of	7,551	9,131	6,074	22,756	910
Lebanon	47	26	17	89	4
Ledyard	190	156	102	448	18
Lisbon	23	20	16	59	2
Mashantucket Pequot Tribal Nation	-	-	-	-	-
Mohegan Tribe	6	-	-	7	-
Montville	260	139	97	496	20
New London	2,121	1,602	995	4,717	189
North Stonington	7	1	1	8	-
Norwich	5,744	12,904	9,910	28,558	1,142
Preston	126	109	69	305	12
Salem	5	5	-	-	-
Sprague	514	121	82	718	29
Stonington, Borough of	4,037	5,758	3,562	13,358	534
Stonington, Town of	8,695	6,188	4,160	19,043	762
Waterford	2,115	2,330	1,509	5,954	238
Total	**38,488**	**47,666**	**32,440**	**196,221**	**4,743**

HAZUS-MH calculated the potential sheltering requirement for the 1% annual chance flood event. Results are presented in Table 3-11. The model estimates that over tree thousand households will be displaced due to a 1% annual chance flood affecting watercourses in the region. Displacement includes households evacuated from within or very near to the inundated areas.

Table 3-10: HAZUS-MH Flood Scenarios – Shelter Requirements

SCCOG Jurisdiction	Number of Displaced Households	Short-Term Sheltering Need (Number of People)
Bozrah	24	47
Colchester	7	3
East Lyme	334	511
Franklin	1	0
Griswold	113	208
Groton, City of	255	518
Groton, Town of	508	1,102
Lebanon	17	6
Ledyard	40	23
Lisbon	8	3
Mashantucket Pequot Tribal Nation	-	-
Mohegan Tribe	1	0
Montville	48	24
New London	228	515
North Stonington	5	1
Norwich	684	1,586
Preston	16	7
Salem	11	2
Sprague	105	201
Stonington, Borough of	174	396
Stonington, Town of	904	1,944
Waterford	255	352
Total	**3,738**	**7,449**

The predicted sheltering requirements for inland and coastal flood damage have been compared to the shelter information described in Section 2.11 to determine adequacy. In general, all of the communities have sufficient sheltering capacity based on the comparison of *HAZUS-MH* shelter requirements and existing shelter capacities, except that the City of Groton and both the Town and Borough of Stonington each appear to be under-represented in shelter capacity. The Town of Groton has a sheltering capacity very near its estimated need during a 1% annual-chance storm. Sheltering capacities in Lebanon and Windham are not quantified, but are likely sufficient given the small number of people estimated too require shelter under these flood conditions. Emergency managers within these communities have worked to identify sheltering capacities that are believed appropriate for accommodating the populations that are understood to likely require shelter during a flood event.

HAZUS-MH also calculated the predicted economic losses due to the 1% annual chance flood event. Economic losses are categorized between building-related losses and business interruption losses. Building-related losses (damages to building, content, and inventory) are the estimated costs to repair

or replace the damage caused to the building and its contents. Business interruption losses are those associated with the inability to operate a business because of the damage sustained during the flood and include lost income, relocation expenses, lost rental income, lost wages, and temporary living expenses for displaced people. Results are presented in Table 3-9, with the majority of losses occurring in Groton, Norwich, and Stonington.

Table 3-11: HAZUS-MH Estimated Direct Losses from Flooding Scenarios

	Direct Losses (Millions of Dollars)		
SCCOG Jurisdiction	**Estimated Total Building Losses**	**Estimated Business Interruption Losses**	**Estimated Total Losses**
Bozrah	4.15	0.01	4.16
Colchester	0.46	Minimal	0.46
East Lyme	66.25	0.1	66.35
Franklin	0.49	Minimal	0.49
Griswold	51.29	0.05	51.34
Groton, City of	75.01	0.21	75.22
Groton, Town of	194.77	0.65	195.43
Lebanon	1.58	Minimal	1.58
Ledyard	6.8	0.05	6.84
Lisbon	0.7	Minimal	0.7
Mashantucket Pequot	Not Calculated	Not Calculated	Not Calculated
Mohegan	0.17	Minimal	0.17
Montville	7.38	0.02	7.4
New London	58.84	0.43	59.27
North Stonington	0.55	Minimal	0.55
Norwich	252.81	1.47	254.28
Preston	2.93	Minimal	2.93
Salem	0.46	Minimal	0.46
Sprague	12.15	0.04	12.19
Stonington, Borough of	79.77	0.2	79.97
Stonington, Town of	333.03	1.58	334.61
Waterford	48.55	0.07	48.62
Total	**1198.14**	**4.88**	**1203.02**

A 1% annual chance riverine and coastal flood, as simulated by HAZUS-MH, would generate more than $1.2 billion in flooding-related damages in the SCCOG region. The vast majority of the estimated economic losses is due to damage to buildings, contents, and inventory. Estimated damages to business operation accounts for less than 0.5% of all economic damage, including lost income, relocation costs, rental income, and lost wages. Although these losses account for only a small portion of total economic impacts, they can cause ripple effects throughout the economy putting small businesses at risk of closure.

Public Assistance Reimbursements

Loss estimates for flooding can also be generated from the value of Public Assistance grants received by municipalities and other entities within the SCCOG region. According to information from the FEMA

Public Assistance Funded Projects Summary (Open Government Initiative), there were four flood events since 1999 that resulted in federal disaster declarations in southeastern Connecticut. Each of these resulted in reimbursement requests to FEMA. These expenses included debris removal, emergency protective measures, and repairs to damaged infrastructure and buildings experienced by local governments and non-profits. A summary for the SCCOG region is presented in Table 3-12 below.

Table 3-12: Public Assistance Reimbursements Related to Flooding

SCCOG Jurisdiction	Local Government Cost	Other Local Agency Cost*	Total Cost
Bozrah	None	None	None
Colchester	$119,668.69	$9,912.25	$129,580.94
East Lyme	$534,625.41	$446,999.07	$1,001,624.48
Franklin	$36,467.80	None	$36,467.80
Griswold	$364,657.13	None	$364,657.13
Groton, City of	$793,923.80	$308,129.81	$1,102,053.62
Groton, Town of	$655,207.05	$234,409.38	$889,616.44
Jewett City, Borough of	$9,912.25	None	$9,912.25
Lebanon	$37,848.71	None	$37,848.71
Ledyard	$207,670.17	$53,100.83	$260,771.00
Lisbon	$30,246.24	None	$30,246.24
Mashantucket Pequot Tribal Nation	$295,317.80	None	$295,317.80
Mohegan Tribe	$7,556.34	None	$7,556.34
Montville	$400,063.05	$17,069.59	$417,132.64
New London	$384,770.29	$76,006.01	$457,776.30
North Stonington	$2,357,743.20	$4,100.00	$2,361,843.20
Norwich	$1,455,203.16	$58,157.92	$1,513,361.08
Preston	$78,578.47	$36,031.24	$114,609.71
Salem	$86,826.72	None	$86,826.72
Sprague	$230,081.29	None	$230,081.29
Stonington, Borough of	$28,894.91	$17,768.11	$46,663.01
Stonington, Town of	$520,739.20	$94,955.35	$615,694.55
Waterford	$1,643,152.54	$16,341.05	$1,659,493.60
Windham	$36,729.88	$11,360.32	$48,090.20
Total	**$10,315,884.10**	**$1,384,340.93**	**$11,717,225.05**

*Other agencies = Fire Districts, Schools, Housing Authorities, and other Non-Profit Agencies

Tropical Storm Irene and Hurricane Sandy caused both flooding and wind damage. An exact breakdown is not immediately available. The damage values herein are assumed to be one-third flooding related and two-thirds wind related.

Note that federal reimbursement of PA-eligible projects is only typically 75% of the cost. The figures presented in Table 3-13 are the total costs of projects, and are taken to reflect a portion of the damages incurred by each storm event. Damages to private property are not part of the Public Assistance information, so use of these figures alone likely underestimate losses.

Losses incurred during these disaster events were caused by both coastal and inland flooding. The relative proportions of damages caused by each flood source during each event cannot be effectively extracted, and vary from storm to storm. This vulnerability analysis does not attempt to differentiate between coastal and inland storm damages in this case, and reports flood loss estimates as one category.

Based on the information in Table 3-13, flooding losses reimbursed through the FEMA Public Assistance Program have totaled $11.7 million for the SCCOG region since 1999. The annualized loss due to flooding for the SCCOG region over the 18 years of record in the Public Assistance report is therefore $650,956.95.

NFIP Payments

Based on the information from the NFIP presented in section 3.4.1 and Table 3-3, a total of $20,728,454.80 has been paid out to NFIP-insured properties since (1978) (39 years). The annualized loss due to flooding based on this data is $531,498.84.

Potential Losses Based on Connecticut Natural Hazards Mitigation Plan

An additional estimate of regional impact has been determined based on the data presented in the 2014 CT NHMP. The percentage of the population of each SCCOG community as compared to the population of its county (New London or Windham) was used to adjust the flood losses reported to the National Climatic Data Center (NCDC) over 20 years as reported in Table 2-40 of the 2014 CT NHMP. The annualized loss estimate for flooding based on the NCDC damages is presented in Table 3-14.

Table 3-13: Loss Estimates Based on 2014 CT NHMP Based on NCDC Damages

SCCOG Jurisdiction	Annualized Loss Estimate	SCCOG Jurisdiction	Annualized Loss Estimate
Bozrah	$3,361.74	Mohegan Tribe	$134.37
Colchester	$20,562.03	Montville	$7,730.60
East Lyme	$24,517.55	New London	$25,044.78
Franklin	$2,459.56	North Stonington	$6,778.51
Griswold	$10,831.28	Norwich	$51,818.42
Groton, City of	$12,022.67	Preston	$6,047.81
Groton, Town of	$39,312.03	Salem	$5,311.99
Jewett City, Borough of	$4,462.27	Sprague	$3,818.59
Lebanon	$9,351.96	Stonington, Borough of	$1,188.83
Ledyard	$19,260.59	Stonington, Town of	$22,542.99
Lisbon	$5,551.29	Waterford	$24,975.68
Mashantucket Pequot Tribal Nation	$422.30	Windham	$11,344.02
		Total	**$318,851.85**

Summary

Flooding is the most persistent hazard to affect the region. Based on the historic record, information from municipal officials, and *HAZUS-MH* simulations of the 100-year flood events, areas within SFHAs and other areas adjacent to SFHAs are vulnerable to flood damages. These can include direct structural damages, interruptions to business and commerce, emotional impacts, and injury or death.

Several sets of loss estimates are available for including flooding, including the HAZUS-MH output for the 1% annual chance combined inland and coastal flood event, the public assistance reimbursements since 1999, the NFIP Payments since 1978, and the population-based damage annualized loss estimates based on the 2014 CT NHMP. This information can be used to estimate annualized losses due to flooding.

- The HAZUS-MH output is not appropriate for calculating annualized loss it represents damage from one event magnitude.
- The Public Assistance reimbursements alone only reflect damage to governments and non-profits, and not to private structures. However, the NFIP Payment information is typically geared towards private properties with typically minimal overlap with the Public Assistance reimbursements. Combining the annualized loss from the Public Assistance reimbursements with the annualized loss for the NFIP Payment information provides an estimated annualized loss due to inland and coastal flooding of $1,182,455.79.
- The estimated annualized loss due to flooding based on the NCDC losses reported in the 2014 CT NHMP as modified by population is $318,851.85.

The annualized loss estimate based on the Public Assistance reimbursements and the NFIP Payment information is greater than the annualized loss calculated from the data in the 2014 CT NHMP. The greater figure is utilized herein as an estimate of annualized losses in the region due to inland and coastal flooding.

3.6 Potential Mitigation Strategies and Actions

A number of measures can be taken to reduce the impact of a flood event. These include measures that prevent increases in flood losses by managing new development, measures that reduce the exposure of existing development to flood risk, and measures to preserve and restore natural resources. These are listed below under the categories of ***prevention***, ***property protection***, ***structural projects***, ***public education and awareness***, ***natural resource protection***, **and** ***emergency services*****.** All of the recommendations discussed in the subsections below are recommended for SCCOG communities in the respective annexes where appropriate.

3.6.1 Prevention

Prevention of damage from flood losses takes the form of floodplain regulations and redevelopment policies that restrict the building of new structures within defined areas. These are usually administered

by building, zoning, planning, and/or code enforcement offices through capital improvement programs and through zoning, subdivision, floodplain, and wetland ordinances. It also occurs when land is prevented from being developed through the use of conservation easements or conversion of land into open space. Prevention may also include maintenance of existing mitigation systems such as drainage systems.

Open Space Preservation: Municipal departments should identify areas for acquisition to remove the potential for flood damage. Acquisition of heavily damaged structures (particularly RLPs) after a flood may be an economical and practical means to accomplish this.

Planning and Zoning: Zoning and Subdivision ordinances (or their tribal equivalent) should regulate development in flood hazard areas. Flood hazard areas should reflect a balance of development and natural areas although ideally they will be free from development. Policies can also require the design and location of utilities to areas outside of flood hazard areas and the placement of utilities underground.

It is important to promote coordination among the various departments that are responsible for different aspects of flood mitigation. Coordination and cooperation among departments should be reviewed every few years as specific responsibilities and staff change.

Floodplain Development Regulations: Development regulations encompass subdivision regulations, building codes, and floodplain ordinances. Site plan and new subdivision regulations should include the following:

- Requirements that every lot have a buildable area above the flood level;
- Construction and location standards for the infrastructure built by the developer, including roads, sidewalks, utility lines, storm sewers, and drainageways; and
- A requirement that developers dedicate open space and flood flow, drainage, and maintenance easements.

Building codes should ensure that the foundations of structures will withstand flood forces and that all portions of buildings subject to damage are above or otherwise protected from flooding. Floodplain ordinances should at minimum follow the requirements of the NFIP for subdivision and building codes. These could be included in the ordinances for subdivisions and building codes or could be addressed in a separate ordinance.

Build upon Existing FEMA Mapping: FEMA encourages communities to use more accurate topographic maps to expand upon the FIRMs published by FEMA. The FEMA maps represent a "snap shot in time" and do not reflect all changes caused by development and other activities during the past few decades. Many municipalities today have contour maps of one- or two-foot intervals that show more recently constructed roads, bridges, and other anthropologic features. SCCOG municipalities could consider is using more detailed town topographic maps (if available) to develop a more accurate flood hazard map using the published FEMA flood elevations. An alternate approach would be to record high water marks and establish those areas inundated by a recent severe flood to be the new regulatory floodplain.

Adoption of a different floodplain map is allowed under NFIP regulations as long as the new map covers a larger floodplain than the FIRM. The FEMA Region I office has more information on this topic. Contact information can be found in Section 11.

Reductions in floodplain area or revisions of a mapped floodplain can only be accomplished through revised FEMA-sponsored engineering studies or Letters of Map Change (LOMC).

It should be noted that the community's map will not affect the current FIRM or alter the SFHA used for setting insurance rates or making map determinations; it can only be used by the community to regulate floodplain areas. The FIRM (or DFIRM) is the only map allowed for setting flood insurance rates. Therefore, it has been more straightforward for SCCOG communities to use the FEMA maps as the basis for regulating floodplain development.

Floodplain development, grading, and other actions have likely changed the characteristics of the floodplains. For that reason, improvements to the existing maps must eventually be made and approved by FEMA. However, it is FEMA's policy to prioritize communities that have specific demonstrable problems with their mapping. Therefore, communities in the SCCOG region must bring any known issues to FEMA's attention.

Stormwater Management Policies: Development and redevelopment policies to address the prevention of flood damage must include effective stormwater management policies. Developers should be required to build detention and retention facilities where appropriate. Infiltration can be enhanced to reduce runoff volume, including the use of swales, infiltration trenches, vegetative filter strips, and permeable paving blocks. Generally, post-development stormwater should not leave a site at a rate higher than under predevelopment conditions.

Standard engineering practice is to avoid the use of detention measures if the project site is located in the lower one-third of the overall watershed. The effects of detention are least effective and even detrimental if used at such locations because of the delaying effect of the peak discharge from the site that typically results when detention measures are used. By detaining stormwater in close proximity to the stream in the lower reaches of the overall watershed, the peak discharge from the site will occur later in the storm event, which will more closely coincide with the peak discharge of the stream, thus adding more flow to the peak discharge during any given storm event. Developers should be required to demonstrate whether detention or retention will be the best management practice for stormwater at specific sites regarding the position of each project site in the surrounding watershed.

Drainage System Maintenance: An effective drainage system must be continually maintained to ensure efficiency and functionality. Maintenance should include programs to clean out blockages caused by overgrowth and debris. Culverts should be monitored, repaired, and improved when necessary. The use of GIS technology can greatly aid the identification and location of problem areas.

Wetlands: Inland Wetlands and Watercourses Commissions (or their tribal equivalent) typically administer Wetland Regulations. The regulations simultaneously restrict development in floodplains, wetlands, and other floodprone areas. Many mitigation projects take place in wetland areas or the

upland review zone and therefore are under the jurisdiction of the Wetland Commission. Thus, close coordination with this agency is required.

Since regulations related to flood damage prevention often lie within several different regulations and ordinances, SCCOG jurisdictions should develop a checklist that cross references the regulations and codes related to flood damage prevention that may be applicable to a proposed project and make this list available to potential applicants.

3.6.2 Property Protection

Steps should be taken to protect existing public and private properties from flood damage. Measures for public property protection include relocation of structures at risk for flooding (either to a higher location on the same lot or to a different lot outside of the floodplain), purchase of flood insurance, and relocating valuable belongings above flood levels to reduce the amount of damage caused during a flood event.

General Improvements: FEMA offers suggestions to homeowners in a variety of mitigation pamphlets and documents regarding potential home improvements that can mitigate flooding:

- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the high water mark (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- Install a septic backflow valve to prevent sewer backup into the home.
- Install a floating floor drain plug at the lowest point of the lowest finished floor.
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets to at least 12 inches above the high water mark.

Standard Flood Protection Techniques: Techniques applicable to property protection include home elevation, construction of barriers, dry floodproofing, and wet floodproofing techniques.

- Home elevation involves the removal of the building structure from the basement and elevating it on piers to a height such that the first floor is located above the 100-year flood level. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first floor level. Home elevations have occurred in many areas along Long Island Sound in Connecticut.
- Barriers include levees, floodwalls, and berms that are useful in protecting areas subject to shallow flooding. Such structural projects are discussed in Section 3.6.6.

Floodproofing is only recommended for non-residential properties.

Dry floodproofing refers to the act of making areas below the flood level watertight.

Wet floodproofing refers to intentionally letting floodwater into a building to equalize interior and exterior water pressures.

- For dry floodproofing, walls may be coated with compound or plastic sheathing. Openings such as windows and vents should be either permanently closed or covered with removable shields. Flood protection should extend only two to three feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water.
- Wet floodproofing should only be used as a last resort. If considered, utilities and electrical appliances should be moved away or elevated above the 100-year flood elevation.

All of the above property protection mitigation measures will continue to be useful for SCCOG residents to prevent damage from inland and nuisance flooding. Local officials should consider outreach and education in these areas where appropriate.

Insurance: Although flood insurance does not prevent damage from occurring or remove structures from harm's way, it does provide an excellent means of recovering from losses. Changes to the NFIP insurance products in the 1990s added mitigation insurance coverage ("increased cost of compliance") at a very low cost. This coverage can provide people a portion of the additional financial resources needed to rebuild their repetitively flooded or substantially damaged homes and businesses to comply with local floodplain management regulations and building standards, therefore reducing the cost and amount of future flood damages.

Owners of the RLPs located in the areas subject to inland flooding in the SCCOG region may wish to consider any or all of the possible methods of property protection. For some of the structures, elevation may be cost prohibitive such that floodproofing may be more advisable. For other RLPs, the best option may be to move important equipment from walk-out basements and garages to higher levels of the structures. In situations such as raised ranches, it may not be possible to floodproof the lower level or move equipment because of the type of home. For such properties, frequent and repeated flood events may prove too costly, and property acquisition by the local government may be the best option. This has occurred in the past along the Yantic River in Norwich as described in that community's annex.

3.6.3 Emergency Services

A natural hazard mitigation plan addresses actions that can be taken before a disaster event. In this context, emergency services that would be appropriate mitigation measures for flooding include:

- Forecasting systems to provide information on the time of occurrence and magnitude of flooding;
- A system to issue flood warnings to the community and responsible officials;
- Emergency protective measures, such as an EOP outlining procedures for the mobilization and position of staff, equipment, and resources to facilitate evacuations and emergency floodwater control; and
- Implementing an emergency notification system that combines database and GIS mapping technologies to deliver outbound emergency notifications to geographic areas or specific groups of people, such as emergency responder teams.

Each of these mitigation measures are already in place in each local jurisdiction. Additional proposals common to all hazards in this Plan for improving emergency services are recommended in Section 11.1.

3.6.4 Public Education and Awareness

The primary objective of public education is to provide an understanding of the nature of flood risk and the means by which that risk can be mitigated on an individual basis. Public information materials should encourage individuals to be aware of flood mitigation techniques, including discouraging the public from changing channel and detention basins in their yards and dumping in or otherwise altering watercourses and storage basins. Individuals should be made aware of drainage system maintenance programs and other methods of mitigation. The public should also understand what to expect when a hazard event occurs, and the procedures and time frames necessary for evacuation.

Educating local officials is an important concurrent step for increasing awareness. Citizens will most often contact local officials, such as the building department, for advice regarding home mitigation efforts. Technical assistance for local officials, including workshops, can be helpful in preparation for dealing with the massive upheaval that can accompany a severe flooding event. Research efforts to improve knowledge, develop standards, and identify and map hazard areas will better prepare a community to identify relevant hazard mitigation efforts.

Public education in the areas of storm damage potential, mitigation activities, and preparedness are a high priority for flooding and each of the other hazards in this HMP. SCCOG communities should develop an intensive and effective public education campaign. In addition to educating the public, professional groups such as builders, developers, architects and insurance agents must also be educated to broaden their perspectives and increase their awareness of their role in flood hazard mitigation. Finally, local officials must continue education and training in their areas of expertise as related to flooding hazards. This is necessary to maintain knowledge of new technologies and techniques that can be implemented to help reach flood mitigation goals in the SCCOG region.

Based on the above guidelines, a number of specific proposals for improved public education are recommended to prevent damage from flooding. These are listed in Section 3.7.

3.6.4 Natural Resource Protection

Floodplains are a valuable natural resource that provides many benefits including storage of floodwaters, open space and recreation, water quality protection, erosion control, and preservation of natural habitats. Retaining the functions of floodplains can not only reduce the frequency and consequences of flooding but also minimize stormwater management and nonpoint pollution problems. Application of natural resource planning to floodplains can help local governments meet mitigation, recreation, and preservation objectives at substantially reduced overall costs.

Projects that improve the natural condition of areas or restore diminished or destroyed resources can reestablish an environment in which the functions and values of these resources are again optimized. Acquisitions of floodprone property with conversion to open space are the most common of these types of projects. Administrative measures that assist such projects include the development of land reuse policies focused on resource restoration and review of community programs to identify opportunities for floodplain restoration.

SCCOG jurisdictions should continue with an aggressive agenda for acquiring flood prone properties and those that provide valuable recreational and flood storage potential that will benefit the greatest number of residents. Land acquisition can take the form of outright purchases or the less expensive purchase of easements or development rights. Often land acquisition in hazard areas can be combined in recent planning vernacular as "multi-objective floodplain management."

Measures for preserving floodplain functions and resources typically include:

- ❑ *Adoption of floodplain regulations to control or prohibit development that will alter natural resources*
- ❑ *Development and redevelopment policies focused on resource protection*
- ❑ *Information and education for both community and individual decision makers*
- ❑ *Review of community programs to identify opportunities for floodplain preservation*

Based on the above guidelines, the following specific natural resource protection mitigation measures are recommended to help prevent damage from inland and nuisance flooding:

- ❑ Pursue additional open space properties in floodplains by purchasing RLPs and other floodprone structures and converting the parcels to open space;
- ❑ Pursue the acquisition of additional municipal open space properties;
- ❑ Selectively pursue conservation objectives listed in the Plan of Conservation and Development and other more recent planning studies and documents; and
- ❑ Continue to regulate development in protected and sensitive areas, including steep slopes, wetlands, and floodplains

3.6.5 Structural Projects

These projects include the construction of new structures or modification of existing structures (e.g., floodproofing) to lessen the impact of a flood event. Stormwater controls such as drainage systems, detention dams and reservoirs, and culvert resizing can be employed to lessen floodwater runoff. On-site detention can provide temporary storage of stormwater runoff. Barriers such as levees, floodwalls, and dikes physically control flooding to protect certain areas from floodwaters. Channel alterations can be made to confine more water to the channel and accelerate flood flows. Care should be taken when using these techniques to ensure that problems are not exacerbated in other areas of the impacted watersheds. Individuals can protect private property by raising structures and constructing walls and levees around structures.

Channelization of rivers, construction of flood control dams, and other large-scale projects for inland flood mitigation are generally considered to be inappropriate in the SCCOG region and are not recommended. However, a number of areas would benefit from improved drainage and flood conveyance as discussed in each local annex. A variety of projects are under investigation or are underway throughout the region to mitigate flood damage by undertaking changes to man-made improvements. It is SCCOG's broad goal to complete certain projects and to actively identify and pursue funding mechanisms to complete future construction projects to mitigate flood damage.

The Northeast Regional Climate Center (NRCC) has recently issued updated extreme rainfall data for New York and New England, and the Connecticut DOT has released new rainfall data for design purposes as discussed in Section 2.3.2. This data is meant to replace the old Technical Paper No. 40 data that was the standard for culvert and bridge design for many years. As rainfall extremes have been increasing over time, culverts and bridges installed several decades ago may no longer pass their design storm. This information is necessary for local authorities to prioritize capital improvement projects.

Through the course of investigating potential structural projects in the region, it was determined that some hazards within the individual communities in the region often involve roads and corridors owned and operated by the State of Connecticut. The State Department of Transportation recommends that problems involving state roads/structures be reported every time they occur so that DOT can coordinate an evaluation of the problem. State of Connecticut agencies are also able to apply for hazard mitigation funding and should be encouraged to do so by local communities and the State.

4.0 COASTAL FLOODING AND SHORELINE CHANGE

4.1 Setting

Coastal flooding is typically associated with hurricanes and tropical storms, nor'easters, or other storm events that are discussed elsewhere this HMP. It is a well-documented natural hazard that threatens the region frequently and in many locations. A review of the DFIRM in each the coastal communities of East Lyme, Waterford, New London, City of Groton, Town of Groton, Borough of Stonington, and the Town of Stonington reveals that the shoreline of southeast Connecticut consists of AE (1% annual chance flood) and VE (1% annual chance flood with wave velocity hazards) zones. The FEMA mapping implies some level of flooding for vast areas south of Interstate 95 during 100-year coastal flood events. Flooding at tidal creeks can occur where the 100-year coastal flood zones extend far inland from the shoreline and merge with inland flood zones, cutting off access via critical roadways in the process.

Sea level rise is affecting coastal and tidal areas and land areas located at elevations close to sea level. As such, the entire SCCOG shoreline is vulnerable to sea level rise and vulnerable areas extend inland along low-lying areas. The timing of the impacts from sea level rise will vary with distance from the shoreline.

Coastal erosion is a concern in some locations as it generally occurs during coastal flooding events. Coastal erosion and shoreline change are generally possible anywhere along the shoreline although they have been exacerbated by increased rates of sea level rise and are occurring far more rapidly in the low-lying areas between rocky shorefronts where tidal marshes tend to be present.

4.2 Hazard Assessment

4.2.1 Definitions

The shorefront of southeastern Connecticut is varied, containing most categories of the coastal resources found in Connecticut as described by DEEP:

Beaches and Dunes are defined in the Coastal Zone Management Act (CMA) as "beach systems including barrier spits and tombolos, barrier beaches, pocket beaches, land contact beaches and related dunes and sand flats." Spits are projections of sand attached at one end to an island or the mainland but are separated from it by a body of water or marsh.

Beaches have been further described as moderately sloping shores composed of water worked sand, gravel or cobble deposits, or areas of sandy beach fill. The beach is located between mean low water elevation and bluffs/escarpment. Dunes consist of wind deposited sands positioned landward of and elevated above the beach. Beaches are generally considered to be erosion prone, but they were initially formed by the deposition of sand by currents and wave action. The characteristics of the beach are a result of the balance between erosional and depositional forces.

Modified Beaches and Dunes are defined by the CMA as "beach systems temporarily stabilized by an erosion control structure positioned between the dune ridge and the beach." The erosion control structure may be a seawall, revetment or bulkhead.

Modified beaches and dunes are also considered to be erosion prone. The effectiveness of the stabilization structures varies, but generally stabilization structures are effective in either slowing the erosion process or shifting it to another area of the shoreline, rather than elimination. Therefore, erosion control is most effective when used to protect small areas of developed shorefront.

Modified Bluffs and Escarpments are "coastal bluffs and escarpments that have been temporarily stabilized by erosion control structures (revetment, bulkhead or seawall) positioned seaward of the marine cliff or escarpment." Coastal bluffs and escarpments are steep seaward sloping marine cliffs.

Rocky Shorefronts are defined by the CMA as "shorefronts composed of bedrock, boulders and cobbles that are highly erosion resistant and are an insignificant source of sediments for other coastal landforms." Rocky shorefronts may include nearly vertical rock cliffs, or gently seaward sloping rock and boulder lands.

Islands are defined in the CMA as "a land mass of bedrock or till encircled by coastal waters."

Tidal Wetlands include areas both designated and undesignated. Designated wetlands are those wetlands that have been inventoried and mapped by the DEEP as defined by vegetation and are subject to the state Tidal Wetland Regulations. Undesignated tidal wetlands include other areas with wetland vegetation. They have been unregulated by the State Tidal Wetland Program, until passage of recent amendments (Public Act 91-308) to the Connecticut Tidal Wetlands Act, which requires that undesignated tidal wetlands also be regulated.

Tidal wetlands encompass tidal marshes and tidal mudflats. Both are result of the accumulation of fine-grained sediments. Tidal marshes are formed when the sediments accumulate as high as the mid-tide level, which is the intermediate point between high and low tides. Tidal mudflats are where the sediments are below the mid-tide elevation. Generally, tidal marshes are vegetated, while tidal mud flats are not.

Tidal wetlands have been considered by the State and Federal governments worthy of special attention for the following reasons:

- Marine Food Production – Tidal Wetlands are one of the most productive of the world's ecosystems. Two-thirds of all commercially harvested fish and shellfish depend on the marsh-estuarine system at some point in their life cycle.
- Wildlife Habitat – Tidal wetlands are important as breeding, nesting and feeding grounds.
- Flood Control – The serve as a natural buffer, protecting upland and developed areas from storm tides and absorbing wave damage.
- Recreation – Tidal wetlands provide opportunities for hunting and fishing.

- Pollution Control – Tidal wetlands serve as an important basin in which organic pollutants are filtered and converted to nutrients.
- Sedimentation – Tidal wetlands absorb silt and organic matter which otherwise would obstruct channels and harbors.

4.2.2 Coastal Flooding

As shown in the figures in the annexes for East Lyme, Waterford, New London, City and Town of Groton, and the Borough and Town of Stonington, areas inundated by the 1% annual chance flood extend along the entire shoreline of the SCCOG region. As noted in Table 3-1, the 1% annual chance coastal flood inundation areas are associated with Zone AE and Zone VE floodplains. Most of the region's velocity zones are located along the immediate Long Island Sound and Fishers Island Sound shoreline, though some areas are included along the mouths of the major rivers such as the Thames River.

Significant coastal flooding is typically associated with severe storms such as hurricanes, tropical storms, and nor'easters. These storms are discussed in more detail in other chapters. The United States Army Corps of Engineers (USACE) and FEMA have mapped hurricane surge zones in Connecticut for Category 1, 2, 3, and 4 hurricanes. This mapping is entitled the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) mapping. Each affected shoreline community has a map in its respective community annex. In many locations, the Category 1 and 2 surge zones are coincident with the coastal flood zones mapped by FEMA. However, Category 3 and 4 storms are believed to have the potential to drive surges further inland. Hurricanes are discussed in detail in Section 5.0 of this Plan.

Even without the occurrence of hurricanes, tropical storms, nor'easters, or other storm events, astronomical higher tides and "king tides" will cause shallow flooding of different parts of coastal communities every single year. Meanwhile, sea level rise (discussed below) is already known to be exacerbating coastal flooding, and erosion of the shoreline will allow it to affect populations and structures that previously enjoyed a higher degree of protection.

In summary, coastal flooding can occur as a result of astronomical higher tides acting alone or concurrent with storms; as a result of nor'easters, hurricanes and tropical storms; or simply as a result of persistent strong winds. In addition, coastal flooding will increase in frequency and magnitude as sea level rises.

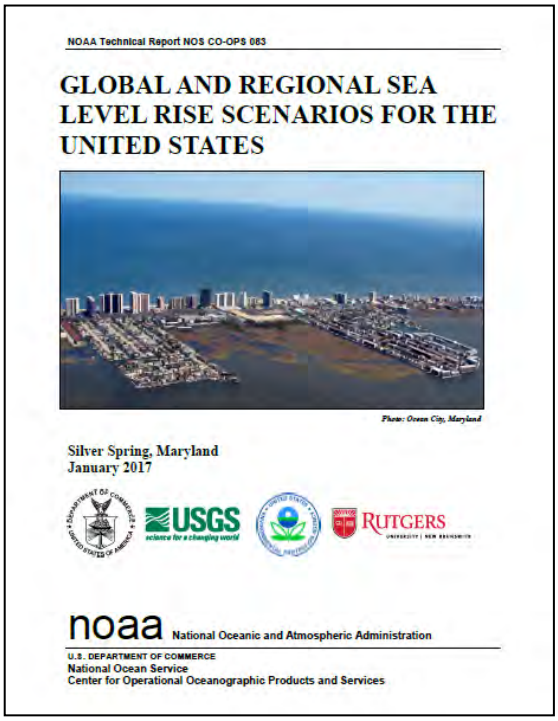
4.2.3 Sea Level Rise

Historic and Future Rise

Although erosion and shoreline change have long been recognized as coastal hazards nationwide, it is only in recent decades that the chronic problem of sea level rise has been projected to be closely connected to the acute threats of erosion and shoreline change. Indeed, continued increases in the rate of sea level rise will increase the incidence, severity, and adverse effects of erosion and shoreline change as well as flooding.

In its landmark 2001 report, the Intergovernmental Panel on Climate Change (IPCC) concluded projected that global sea level may rise nine to 88 centimeters (0.30 - 2.89 ft) during the 21st century. According to the most recent update, *Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013*, these predictions have been revised to a rise of **28 to 98 cm (0.9 to 3.2 ft)** by 2100 relative to 1986-2005 levels.

The January 2017 NOAA Technical Report titled *Global and Regional Sea Level Rise Scenarios for the United States* builds on and updates their December 2012 Report, and is the current reference for sea level rise planning in the United States. The report's updated global mean sea level range for the year 2100 is between **0.3 and 2.5 meters (1.0 to 8.2 feet)** above current levels.



Sea level rise is not consistent around the world, and is affected by local variations in currents, temperature, and changes in land surface elevation. It has long been expected that the rate of sea level rise in Connecticut will be slightly higher than the global projections due to the effects of regional subsidence. However, more recent studies have asserted that changes in ocean circulation will increase the relative sea level rise along the Atlantic coast even more.

The NOAA report finds that sea level along the Northeast Atlantic Coast is projected to be greater than the global average for almost all future scenarios. In Connecticut specifically, sea level rise is projected to be 0 to greater than 1 meter (3.3 feet) higher than the rise in global mean sea level.

The basis for evaluating sea level rise in this HMP is the historic sea level rise for the Connecticut shoreline over the last 100 years as adjusted by local observations. Water level data from tide gauges (refer to Figure 4-1 below) demonstrate that in the late 19th century and early 1900s sea level was rising at a rate of one millimeter (mm) each year. Throughout most of the 20th century, the rate has been rising at two mm per year. More recently, tide gauge data was augmented by satellite altimeter readings, which indicate that between 1990 and 2008 the rate increased to three mm per year. In addition, subsidence along the Connecticut coast may have effectively caused an additional rise of three inches on a localized basis.

Scientific studies have resulted in a wide range in the projected long-term sea level rise to the year 2100. A conservative approach to determine likely "short-term" rise from the present time to 2040 can be developed by using the historic rise over the last century and assuming that the threefold acceleration rate will continue in the short term projected into the future. As noted above, the observed rate over the last century is one to three mm/year resulting in a conservative estimate of an additional rise of five inches to seven inches by 2040. Land subsidence at some local shoreline areas is 0.01 inch per year, which increases the estimated rise to eight inches to 10 inches by 2040.

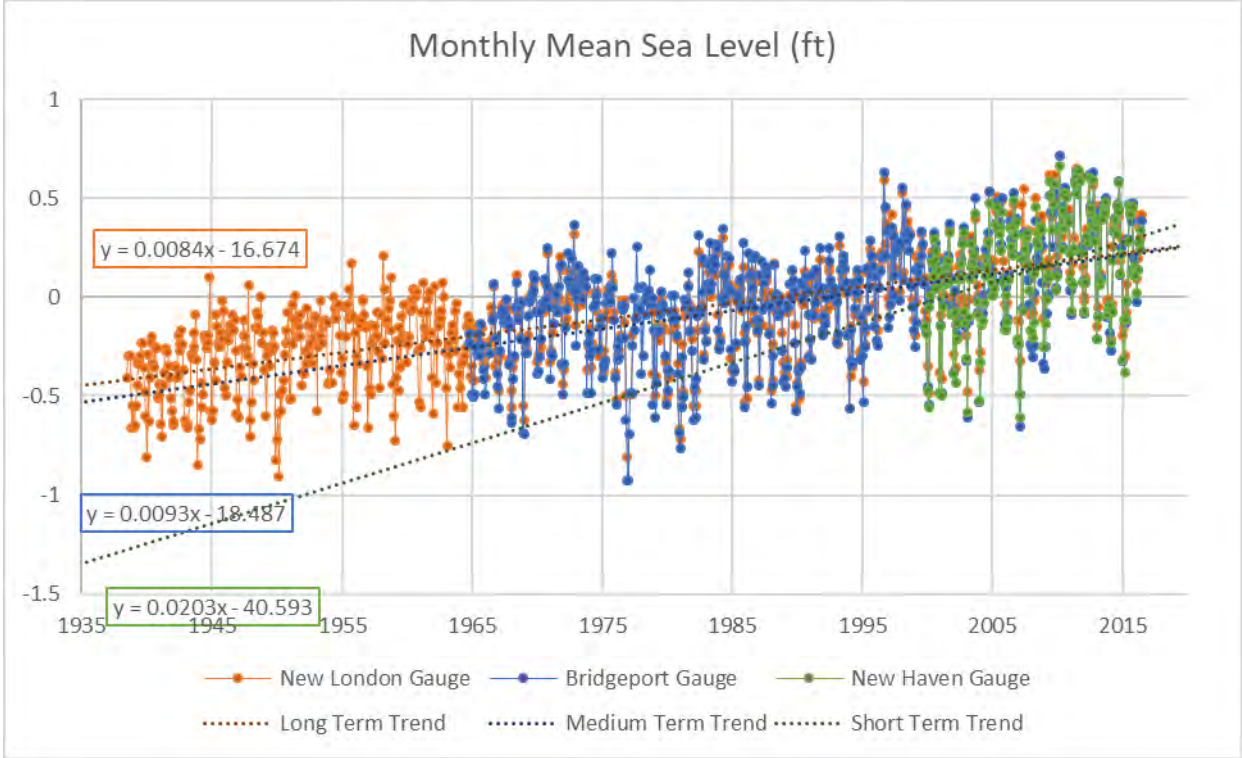


Figure 4-1: Observed Sea Level Data from Tide Gauges in Connecticut

The wide range of governmental and scientific projections reflects the fact that sea level rise and climate change in general will be affected by a wide number of factors, and their combined effect and timing of impact can have a variety of possible outcomes. These averages are global averages and must be further adjusted by local conditions and factors as they become understood.

Impacts

A continued increase in the rate of rising sea levels will inundate low areas, increase erosion of beaches and tidal marshes, increase the incidence of flooding from storm surges, and enable saltwater to advance upstream and intrude further into estuaries and aquifers.

Rising sea level affects both the natural and the human-made environments. Future sea level rise could result in the disappearance of a large percentage of tidal wetlands in the SCCOG region unless they can advance as quickly as the rising level. Saltwater advancing upstream along estuaries can alter the point at which flocculation leads to sedimentation and the creation of shoals.

As sea level rises, storm surges from hurricanes and nor'easters will reach further inland as they will be starting from a higher base level. It has been projected that by the end of the 21st century, it is possible that a Category 1 hurricane storm surge will be similar to what is now mapped as a Category 3 hurricane storm surge.

Similarly, FEMA coastal base flood elevations would progressively rise along with sea level. This means that the 1% annual chance and 0.2% annual chance flood levels will affect lands that are currently at unaffected elevations. This would exacerbate the problem of coastal and near-coastal inland flooding within the region.

As sea level rises, drainage systems become less effective. Thus, rainstorms will have the potential to cause greater flooding. Many coastal areas in the SCCOG region report increased problems with inadequate storm drainage south of Interstate 95 and in several coastal areas. As sea level rises, these areas will likely continue to experience decreased drainage capacity and increased flooding.

4.2.4 Erosion and Shoreline Change

The Connecticut shoreline continues to erode since the end of the last glaciation approximately 12,000 years ago, slowly giving way to the advancing Atlantic Ocean. This net loss of land is due partly to active erosion of beaches and tidal marshes and partly to passive submergence caused by natural component of relative sea level rise. The erosion and submergence together cause a net loss of land resulting in shoreline change.

While erosion itself is natural, it has the potential to damage coastal property and infrastructure. Coastal erosion and shoreline change can result in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources, and wildlife habitats. In addition, erosion can expose septic systems and sewer pipes, contaminating shellfish beds and other resources; release oil, gasoline, and other toxins to the marine environment; and sweep construction materials and other debris out to sea. Public safety is jeopardized when buildings collapse or water supplies are contaminated.

According to the USGS, four possible erosional outcomes can occur during a storm and storm surge event:

- "Swash" occurs when the maximum elevation of wave runup is higher than the beach but still lower than the base of the dune or bluff, if one is present. This results in the erosion of the beach.
- "Collision" occurs when the maximum elevation of wave runup is higher than the base of the dune or bluff but lower than the top of the dune or bluff. Collision results in severe erosion of the dune or bluff.
- "Overwash" occurs when the maximum elevation of wave runup is higher than the top of the dune or bluff. Overwash can result in damage to structures behind the dune or bluff.
- Finally, "inundation" occurs when the base tide and surge level is higher than the beach and dune. This is the most hazardous of the four outcomes with regard to flood damage.

Any of these outcomes are possible in the SCCOG region. They may be expected at sandy beaches and in rockier areas. Processes are somewhat different at the marsh fronts. Erosion events in a coastal setting are dependent upon many factors including sea level rise, surrounding conditions, storm events, and human alteration of drainage and currents.

Many beaches in the SCCOG region have experienced varying rates of erosion over the years. Most of the beaches are considered generally stable, but significant erosion occurs during storm events such as Hurricane Gloria, Tropical Storm Irene, and Hurricane Sandy.

As noted above, it has been documented that sea level rise has occurred at an accelerated rate over the last 100 years. Some coastal states along the eastern seaboard have reported subsidence or drowning of tidal wetlands because they can no longer accumulate peat fast enough to stay above sea level. In Connecticut, the effect of sea level rise depends on location. Sea level rise appears to be altering the zonation of plant communities in southeastern Connecticut, where the tidal range averages 0.75 meters. Studies have documented that at least two marsh systems are currently not keeping up with sea level rise. On Connecticut's western shore, with a tidal range of up to two meters, extensive areas of low marsh vegetation have been drowned (e.g., Five-Mile River, Norwalk).

Another ramification of the projected sea level rise is the tendency for marsh systems to migrate landward. As sea level rises, marshes that are able to stay above the rising water level will tend to move inland. For developed areas where seawalls, lawns, and other structures are at the very edge of the marsh, landward movement is limited.

Complicating matters, the salt marshes of the entire eastern seaboard have been faced with a dilemma that is currently being termed by some scientists as "sudden wetland dieback." Although there is dispute between scientists surrounding what exactly is occurring, it is known that the health of salt marshes and the zonation of the vegetation that resides within the marshes are threatened. Results of salt marsh dieback include the development of tidal flats and pockets of holes in the absence of the various salt marsh grasses.

In summary, erosion and shoreline change can result in significant economic and emotional loss in the current land use system of fixed property lines and ownership. However, attempting to halt the natural process of erosion with seawalls and other hard structures can shift the problem, subjecting other property owners to similar losses. The challenges are to (1) slow erosion where possible without adversely affecting nearby resources, and (2) site coastal development in a manner that allows natural physical coastal processes such as erosion to continue.

4.3 Regional Historic Record

Coastal Flooding

The SCCOG region experiences coastal flooding associated with astronomical high tides and coastal storms such as nor'easters, tropical storms, and hurricanes. Low pressures and strong winds that cause tidal flooding frequently accompany these weather events. Detailed discussions of hurricanes and nor'easters are provided in Sections 5.0 and 7.0 of this Plan, respectively. The region has shared in the devastation of all the major storms that have struck Long Island Sound in the past century. Many of these hurricanes and nor'easters have caused coastal flooding in the region.

The hurricanes of 1938 and 1954 caused some of the worst coastal flooding in the history of New London County. According to FEMA, the 1938 hurricane, which struck at high tide, resulted in the greatest disaster in Connecticut's history up to that time because of the combined effects of flooding, winds, and storm surge. The 1938 hurricane had a maximum tidal elevation of 8.8 feet in the region, just shy of the coastal base flood elevation which is between 11 and 15 feet (V Zone) and between nine and 12 feet (AE Zone). The 1954 hurricane entered Connecticut in the vicinity of New London and created storm surge almost as high as the 1938 hurricane. Both storms caused tidal surges along the Niantic and the Thames Rivers and along other smaller tributaries to these rivers and Long Island Sound. Significant tidal effects were felt upstream on the Thames River in Norwich and Montville. As noted in the community annexes, many communities experienced millions of dollars in damages from these events.

In more recent memory, flooding and winds associated with hurricanes and storm events have caused extensive shoreline erosion and related damages. Hurricanes Gloria and Bob caused very little water damage but resulted in extensive wind damage. Hurricane Gloria caused dock damage, structural damage to sea walls, retaining walls, and bulkheads, and beach erosion throughout the SCCOG region. Fortunately, the hurricane struck at low tide, limiting the damage caused by storm surge. Storm surge associated with Hurricane Bob was also relatively minimal (only five feet) as measured in New London.

Tropical and extra tropical storms have produced periods of locally heavy rainfall that has resulted in the flooding of coastal areas. These events have been recorded on June 4-7, 1982, May 16, 1989, October 31, 1991, December 10-12, 1992, and May 27-June 2, 1994. Emergency Management records show that widespread street and storm drain system flooding were associated with these events producing significant basement flooding. Other nor'easters and blizzards have also resulted in coastal and river flooding. Some of these events that resulted in multiple NFIP damage claims were in February of 1987, March of 1978, January of 1979, March of 1980 and March of 1984. Also, in December of 1992 the nor'easter storm named Beth brought high waters and damage to coastal areas.

Even during lesser storm events and high tides, coastal flooding occurs in the region. Many of the coastal roads have been identified by SCCOG communities as sites of chronic coastal-related flooding where inundation occurs at least once every year and sometimes more frequently. For example, a king tide occurring on a sunny day (October 28, 2015; refer to the picture on the right) caused water to flow onto, and inundate, many sections of roads in the Groton side of Mystic. The residents of many of these neighborhoods have become accustomed to the chronic flooding but remain very concerned nevertheless.

Tropical Storm Irene

When Hurricane Irene moved up the Atlantic coast in late August 2011, it caused severe and widespread flooding in North Carolina, New York, Vermont, Massachusetts, and other states, leading to a series of federal disaster declarations. In Connecticut, the storm made landfall as a tropical storm. The USGS installed storm surge sensors along Long Island Sound in advance of the storm. Storm surges of three to five feet were experienced throughout the region, with the higher surges in the western part of the SCCOG region. These surges resulted in minor to moderate flooding of low-lying areas in the SCCOG region (such as flooding in Mystic) with most damages being as a result of tree damage and extended power outages. Ultimately, the State of Connecticut received federal disaster declaration #4023 as a result of Irene.

Hurricane Sandy

Hurricane Sandy formed in the Caribbean on October 22, 2012. The storm struck the New Jersey and New York region the hardest on October 29, 2012, and also caused extensive flooding along the Connecticut coast. According to the National Hurricane Center, the storm caused an estimated 147 deaths, including five in Connecticut. The most significant damage to the SCCOG region occurred due to storm surge flooding along the coastline, as well as high winds. FEMA Public Assistance records indicate that some SCCOG jurisdictions, such as Norwich and New London, received $500,000 to $1,000,000 in federal money to aid with the cleanup. The picture to the right is from the Stonington side of Mystic.

4.4 Existing Capabilities

Coastal Flooding

Many of the existing programs, policies, and mitigation measures utilized in the region for inland flood mitigation are also applicable to coastal flood mitigation. Participation in the NFIP is an important program for mitigating coastal flooding damages and was described in Section 3.4.1. Local regulations are described in Section 2 of each community annex. Sections of these codes and regulations are dedicated to flood damage prevention. The State Building Code was modified in 2016 to require additional protections for structures in coastal floodplains, essentially requiring freeboard in coastal A and VE zones even if it is not required by local flood damage prevention regulations.

As explained elsewhere in this HMP, the National Weather Service issues a flood watch or a flash flood watch for an area when conditions in or near the area are favorable for a flood or flash flood, respectively. A flash flood watch or flood watch does not necessarily mean that flooding will occur. The National Weather Service issues a flood warning or a flash flood warning for an area when parts of the area are either currently flooding, highly likely to flood, or when flooding is imminent.

In April 1994 FEMA, USACE, NOAA, and the Connecticut Department of Emergency Management and Homeland Security (then the Office of Policy and Management) completed the Connecticut Hurricane Evacuation Study Technical Data Report that includes an evacuation map atlas and an inundation map atlas. This study provides information on the extent and severity of potential flooding from hurricanes (based on the SLOSH mapping), the associated vulnerable population, capacity of shelters, estimated sheltering requirements, and evacuation time. The State and coastal municipalities in the SCCOG region use the study and maps to plan for possible evacuations. Note that CT DEMHS updated the shelter information in 2006 and the SLOSH mapping was last updated by USACE in 2008.

Many SCCOG communities have completed participation in a hurricane evacuation sign project. Gauges and signs have been installed at various locations throughout the region. The signs provide elevations above sea level from the ground up to twelve or sixteen feet above sea level. The signs indicate areas of town that would be inundated by hurricane-related flooding. Although installation of the signs will not provide protection to structures, they will allow residents to take steps to protect their safety and movable possessions.

The shoreline of the SCCOG region contains many coastal flood control structures to prevent coastal flooding and erosion. Seawalls and bulkheads can be found in many of the residentially developed coastal neighborhoods. Specific projects include the New London hurricane barrier in Shaw's Cove (constructed by the USACE between 1978 and 1985), construction of breakwaters at Stonington Harbor, and construction of seawalls, bulkheads, and groins in multiple locations along the shoreline. Many potential structural projects have not been pursued to date, however, because it is questionable whether an acceptable cost-benefit ratio exists for the projects. The potential environmental impacts of structural projects are often also a concern.

In summary, the region primarily attempts to mitigate coastal flood damage and flood hazards by controlling and restricting activities in floodprone areas, elevating homes, maintaining hard structures in good condition, and providing signage and warning systems.

Sea Level Rise

The TNC Coastal Resilience Tool for Shoreline Communities can be found at: http://coastalresilience.org/tools/apps/

The Nature Conservancy has released a number of Coastal Resilience tools for shoreline communities as part of its Coastal Resilience project. The purpose of the Coastal Resilience project is to provide communities, planners, businesses, and officials with easy access to information on projected changes in sea level and coastal storm impacts in order to assist in coastal planning and management decisions. This tool delineates areas likely to receive coastal flooding taking into account the potential impacts of sea level rise. This is an excellent tool for local planners to utilize when making long-term development decisions.

In October 2011, the Coastal Resilience project released the Marshes on the Move tool. This tool provides modeling guidance for resource managers and planners, describing the parameters and issues involved in using wetland migration models that depict the possible responses of coastal wetlands to

sea level rise. This work is a collaborative effort between the National Oceanic and Atmospheric Administration and The Nature Conservancy. The SCCOG region participated in related work that resulted in a journal article published in Environmental Research Letters entitled "Governments Plan for Development of Land Vulnerable to Rising Sea Level: Southeastern Connecticut." In general, these projects concluded that tidal wetland migration would only occur in areas that are currently undeveloped and do not have structural protection measures or are hemmed in by existing development.

In general, the SCCOG communities have traditionally lacked existing policies and mitigation measures that are specifically designed to address sea level rise and coastal change, although this lack of capacity is shifting rapidly. The 2012 edition of this plan noted that "although specific plans to address sea level rise are lacking, important pieces are in place in the form of individual community regulations and codes that have been enacted to minimize storm, erosion, and flood damage. The Town of Groton is proceeding with sea level rise and coastal resilience planning which is described in the annex plan for the Town." Since that time, the Town of Groton has completed a Plan of Conservation and Development and Municipal Coastal Program that are largely dedicated to issues of climate and coastal resilience; and Hurricane Sandy appropriations have been leveraged to develop local community coastal resilience plans for Stonington and Waterford. These plans are advancing the discussion of appropriate policies and procedures for developing coastal resilience through flood mitigation and adaptation, and are also proposing specific actions and projects to build resilience. More information can be found in the annexes for these towns. In the meantime, SCCOG anticipates that its other member jurisdictions along the shoreline (East Lyme, New London, City of Groton, and the four Thames River municipalities with tidal water exposure) may look for ways to pursue forward-thinking coastal planning.

Erosion and Shoreline Change

The use of shoreline flood and erosion control structures is discouraged by the DEEP. However, as noted in the state's *Coastal Management Manual*, a structural solution may be permitted when (1) it is demonstrated that it would protect a water-dependent use, infrastructural facilities, or an inhabited structure; (2) there is a clear demonstration of the need for protection; and (3) the use of the proposed structure is unavoidable because it is demonstrated that there is no feasible less environmentally damaging nonstructural alternative. With regard to preexisting structures that were constructed to reduce coastal erosion, examples include the handful of groins, jetties, seawalls, and bulkheads along the southeastern Connecticut shoreline.

Just like coastal resilience planning, statewide capabilities have been increasing sharply relative to pursuing methods that can slow or halt erosion of the shoreline. In 2012, the Connecticut General Assembly passed Public Act 12-101, An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures. This legislation set forth initiatives to address sea level rise, revise the regulatory procedures applicable to shoreline protection, and promote living shorelines.

The CT DEEP, CIRCA, and CT Sea Grant have individually and collectively spent considerable effort over the last five years providing technical assistance and guidance on the use of living shorelines in both

narrow terms[2] (constructed tidal marshes) and broad terms (constructed tidal marshes, beaches, dunes, and bioengineered banks). The American Water Resources Association (AWRA) hosted a living shoreline conference in Connecticut in December 2015, and Sea Grant hosted a three-part living shoreline design workshop spanning several months in 2015 and 2016. CIRCA provided a green infrastructure training in 2017 that included living shorelines. SCCOG community leaders and staff participated in some of these activities, and some of the SCCOG communities anticipate use of living shorelines and other soft shoreline stabilization methods in the coming years and decades.

4.5 Vulnerabilities and Risk Assessment

This section discusses general areas at risk to coastal flooding within the region. The community annexes discuss specific areas in more detail. As shown by the historic record, coastal flooding is generally associated with large storms that have a regional impact and therefore can affect many roads and neighborhoods, cause widespread severe damage along the shoreline, and impede transportation throughout southeastern Connecticut.

4.5.1 Vulnerability of Coastal Areas

Over the years, the character of the SCCOG shoreline has become more of a year-round community with the conversion of many seasonal cottages to year-round dwellings. This has intensified the risks to life and property for shoreline residents. Beachfront properties are susceptible to damage, not only as a result of flooding, but also because the dynamic nature of the beach system results in shoreline erosion in some locations. Low-lying coastal roadways can also be flooded and the frequency of flooding will certainly increase with sea level rise. This situation can present a serious risk to the safety of certain neighborhoods, such as Mason's Island in Stonington, where only one mode of vehicular egress is available.

Damage from coastal flooding would not be limited to developed areas. With regard to undeveloped areas, all of the tidal marshes in the SCCOG region are vulnerable to sea level rise. They will continue to erode as marshes spend more time inundated. The marshes will continue to be "squeezed" where they cannot migrate inland and, even where sufficient land is available for migration, sea level rise could be too fast for migration to occur.

As noted in Section 4.4, TNC and several partner agencies have developed a hazard planning tool and a risk assessment process designed to help communities identify and prioritize steps to reduce risks in a community. TNC has been promoting this tool in coastal Connecticut communities, with a focused effort in Waterford, East Lyme, and Stonington. TNC hosted an "Eastern Connecticut Climate Risk Assessment Workshop" in the Waterford Town Hall auditorium on January 11, 2012. This workshop was

[2] Connecticut DEEP has developed a working definition of "living shoreline" through research of other coastal states, NOAA, and UConn. The current working definition of living shorelines according to CTDEEP is "A shoreline erosion control management practice which also restores, enhances, maintains or creates natural coastal or riparian habitat, functions and processes. Coastal and riparian habitats include but are not limited to intertidal flats, tidal marsh, beach/dune systems, and bluffs. Living shorelines may include structural features that are combined with natural components to attenuate wave energy and currents."

geared toward assisting with planning and hazard mitigation efforts. During the day-long event, planners and municipal officials were introduced to the coastal resilience tool and encouraged to complete a vulnerability assessment survey. The results of the survey were later forwarded to aid the development of the annexes to the 2012 HMP update.

4.5.2 Vulnerability of Private Properties

Based on correspondence with the State of Connecticut NFIP Coordinator, a total of 54 RLPs have been identified that are located near coastal water bodies in the region, up from the 26 identified in 2012. These repeat claims demonstrate the persistent nature of the coastal flood hazards throughout the region. Maps indicating the approximate location of the repetitive flood insurance losses are included in each community annex. A summary of the RLPs related to coastal flooding are listed in Table 4-1.

Table 4-1: Repetitive Loss Properties Affected by Coastal Flooding in the SCCOG Region (As of July 31, 2016)

Town	Number of Properties	Property Type*	Flooding Source
East Lyme	13	R	Niantic Bay, Niantic River, Long Island Sound
Groton, City of	3	R	Eastern Point Bay, Thames River
Groton, Town of	1	R	Mystic Harbor
New London	16	1 C, 15 R	Thames River, Long Island Sound
Stonington, Borough of	2	R	Fishers Island Sound
Stonington, Town of	13	1 C; 12 R	Mystic River, Mystic Harbor, Stonington Harbor, Pequotsepos River, Quiambaug Cove, Fishers Island Sound, Pawcatuck River, Lamberts Cove
Waterford	6	R	Niantic River, Jordan Cove, Alewife Cove, Long Island Sound
Total	**54**	**2 C, 52 R**	

* R = Residential; C = Commercial

The software platform ArcGIS was utilized to determine the area of floodprone areas and the number of properties located within the various floodplains within the region. As noted in Table 3-5 and Table 3-6, there are 529 properties located in the 2,481 acres mapped as Zone VE in the SCCOG region. Several critical facilities also lie within hurricane surge zones and in coastal SFHAs.

It is recognized that many private properties may suffer coastal flood damage that is not reported because the structures are not insured under the NFIP. These residents and business owners are likely repairing structures on their own. Coastal flood mitigation as recommended in this HMP will likely help many of these property owners.

4.5.3 Loss Estimates

Section 0 described how the 2014 CT NHMP data, NFIP policy data, FEMA PA reimbursement data, and *HAZUS-MH* software were utilized to determine annualized estimated losses from combined riverine and coastal flood events.

4.6 Potential Mitigation Strategies and Actions

4.6.1 Coastal Flooding

Many potential mitigation strategies for coastal flooding are essentially the same as those for inland flooding and are not restated in this section under the headings for prevention, property protection, structural projects, emergency services, public education, and natural resource protection. Potential strategies that are more applicable to coastal flooding than inland flooding are presented below.

V-Zone Standards – In recognition of increased flood losses in coastal environments (often due to increased development), the Association of State Floodplain Managers (ASFPM) has adopted a No Adverse Impact (NAI) floodplain management philosophy. These policies focus on individual- or community-level responsibility and mitigation of flood risk. NAI should be viewed as a set of principles to follow when designing or evaluating development activities. Implementation of NAI principles can be accomplished through planning initiatives, regulatory programs, individual- or community-based projects, and public education and outreach.

The NFIP and the accompanying locally adopted floodplain management ordinances set forth specific design requirements aimed at minimizing damage to buildings in mapped V zones caused by waves and storm-induced erosion. These requirements state that new, substantially damaged, or substantially improved structures that are built in V zones must, among other requirements, be elevated on piers, piles, or other open foundation type, with the lowest horizontal structural component elevated to or above the flood elevation. The area below the flood elevation is to be kept free of obstructions, used only for building access, parking, or storage. The intent of this requirement is to allow floodwaters and damaging waves to pass beneath a building without transferring any additional loads onto its foundational components.

One of the best mitigation options available, as identified by the ASFPM NAI principles, is to exceed the minimum NFIP requirements by constructing (or retrofitting) buildings located in sections of coastal A-zones to meet V-zone standards. Exceeding minimum regulatory requirements may increase costs for initial construction and maintenance, but these costs could more than be offset by long-term benefits.

Freeboard Standards – Application of freeboard standards to coastal flood zone elevations is typically viewed as more effective than applying freeboard standards to inland flood zones. Freeboard standards require structures to be elevated higher than the level that FEMA requires. When used alone, freeboard standards provide additional certainty that flood levels will not damage a structure. When use in combination with V-zone standards described above, freeboard standards can provide an additional level of flood damage prevention.

Freeboard standards can be found statewide in New York (where two feet of freeboard is required for new construction) and a few other states, but it is not required by the State of Connecticut unless hazard mitigation grant funds are used for elevating structures. Several communities in the SCCOG region (see Table 3-4) require freeboard as does the State Building Code. Municipalities in Connecticut are entitled to adopt freeboard standards.

Evacuation Procedures and/or Improvement of Satellite Shelters – Viable evacuation routes can increase a community's disaster resistance. General evacuation routes were discussed in Section 2.10. The primary routes to the shelters are concentrated in coastal flood and storm surge zones, and portions of these roads may be impassable during a coastal hazard event such as a hurricane or nor'easter. The concept of an evacuation route being vulnerable to flooding is contradictory to the objectives of hazard mitigation (reducing property damage and the loss of life). Therefore, coastal residents must evacuate as soon as possible after receiving a warning, or risk evacuation during a storm. Evacuating communities must be prepared in advance to provide necessary supplies to the host communities that will house evacuees.

4.6.2 Sea Level Rise, Shoreline Change, and Erosion

Land use planning in coastal areas must take into account the phenomenon of sea level rise. IPCC published the landmark paper "Strategies for Adaptation to Sea Level Rise" in 1990. Three basic types of adaptation were presented in the report: *retreat*, *accommodation*, and *protection*. These three responses are applicable to erosion and shoreline change as well.

- *Retreat* – Retreat refers to the eventual abandonment of the coastal zone, allowing nature to take its course. This allows for existing coastal ecosystems to shift landward. Retreat may be motivated by excessive economic or environmental impacts of hard or soft measures of protection. Retreat may be implemented through anticipatory land use planning, regulation, and building codes or could be motivated through economic incentives. As a general rule, retreat is feasible in some parts of the SCCOG region but is not feasible in the most densely-developed areas.

- *Accommodation* – Accommodation allows for the continued use of land at risk but does not prevent the land from flooding. Measures associated with accommodation may take the form of elevating buildings on piles and establishing other means of flood hazard mitigation. Accommodation may evolve without any governmental action but could be assisted by strengthening flood preparation and flood insurance programs. Protective measures are implemented by authorities currently responsible for water resource and coastal protection. Policies should be developed with the ultimate goal to protect coastal property values, or they will be at risk of not being accepted by the community. Because erosion rates are relatively low where structures are already present, accommodation is feasible in the SCCOG region.

- *Protection* – Protection is the construction of structures meant to protect land from inundation and flooding. These may be hard structures such as dikes and sea walls or soft solutions including beach nourishment. Of the hard structures, three main structures are utilized to hold back the sea. These are seawalls, bulkheads, and revetments. Seawalls are designed to withstand the full force of waves and are used if significant wave impact at the project site is expected to be greater than three feet. Bulkheads are designed to retain fill and generally are not exposed to severe wave action. Revetments are designed to protect shorelines against erosion by currents and light wave action. In general, utilization of structures to hold back the sea results in large-scale elimination of wetlands, beaches, mud flats, and other coastal habitat. As shoreline erosion advances toward the structure, if sediment is not replaced at an adequate rate, the coastal fringe will eventually disappear under the water surface. This is why beaches in front of bulkheads and seawalls tend to disappear over time.

As noted in the EPA publication "Rolling Easements" (Titus, 2011), accommodation is viable in many communities, but no longer considered sustainable for the long term; eventually protection or retreat will be the default. This is an important concept because communities will need to understand that there is a limit to how far into the future accommodation will be practical. Many of the recent and current trends in adaptation planning (circa 2008 to the present) appear to be taking this into account.

Beach Replenishment involves importing sand to an eroding or eroded beach from sediment-rich areas, such as a harbor undergoing dredging. The slope and width of a beach affects wave setup and runup, and can have a direct impact on flood elevations. Overall, beaches can reduce flood risks and erosion hazards while creating public recreation opportunities, aesthetic value, and in the right conditions support unique habitats. Unlike hard shoreline protection measure, beach replenishment avoids addition of potentially dangerous hard debris to the high energy coastal area.

Dune Management stabilizes these natural flood barriers to protect against surges while maintaining important natural resources. FEMA describes dunes as "important first lines of defense against coastal storms" that can "reduce losses to inland coastal development." The Lake Huron Centre for Coastal Conservation lists the benefits of dunes as including shore protection, water purification, biological diversity, erosion control, and acting as a source of sediment for natural beach replenishment.

Hybrid Techniques incorporate non-structural approaches for erosion control in combination with more traditional approaches, such as a rock structure, to support vegetation growth. Hybrid techniques are typically applied in areas of higher wave energy. One example of a hybrid living shoreline that has been constructed in Connecticut in the last few years is a reef ball project near Lords Point in Stratford. The reef ball rows were installed in the intertidal zone and are believed to be trapping sediment on the landward side of the intertidal zone, thus supporting new marsh grasses.

Tidal Wetland Management creates or supports the natural flood mitigation capabilities of this rare ecosystem. Tidal Wetlands have been found to reduce wave energy and decrease water surface elevations at their inland edges during storm surges. Preservation of tidal wetlands also prevent development in hazardous areas and support important habitat.

Elevation of Roads and Land is another form of protection from sea level rise. Elevation has the important advantage that many types of drainage systems will continue to work properly as the same or greater head gradient will exist between the drainage system and sea level. Elevation of road surfaces can be achieved in connection with repaving or re-grading of roads. In some communities, continued elevation of roads parallel to water bodies can create a diking effect, protecting areas landward of the road. In these cases, care must be taken that road elevation does not cause excessive runoff and flooding problems in other areas that become diked by the elevated roadways. Many SCCOG communities have elevated roads as discussed in their community annexes, and it is anticipated that this type of mitigation will continue.

5.0 HURRICANES AND TROPICAL STORMS

5.1 Setting

Several types of hazards may be associated with tropical storms and hurricanes including heavy or tornado winds, heavy rains, and flooding. The region includes seven coastal jurisdictions susceptible to both coastal flooding and wind damage during such storms; inland communities are also susceptible to wind damage and inland flooding produced by heavy rainfall. A hurricane striking the region is considered a possible event each year and could cause critical damage to the many of the localities and their infrastructure.

The original HMP grouped mitigation of wind hazards associated with hurricanes, tornadoes, severe thunderstorms, and winter storms. The 2012 HMP update addressed wind hazards separately according to cause, and that format is continued herein. As hurricanes and tropical storms are regional in nature, a regional quantitative vulnerability and risk assessment has been performed and is presented in this chapter. Individual community annexes include qualitative information regarding particular at-risk areas in local jurisdictions.

5.2 Hazard Assessment

Hurricanes are a class of tropical cyclones that are defined by the National Weather Service as warm-core, non-frontal, low pressure, large scale systems that develop over tropical or subtropical water and have definite organized circulations. Tropical cyclones are categorized based on the speed of the sustained (one-minute average) surface wind near the center of the storm. These categories are Tropical Depression (winds less than 39 mph), Tropical Storm (winds 39-74 mph, inclusive), and Hurricanes (winds at least 74 mph).

The geographic areas affected by tropical cyclones are called tropical cyclone basins. The Atlantic tropical cyclone basin is one of six in the world and includes much of the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. The official Atlantic hurricane season begins on June 1 and extends through November 30 of each year although occasionally hurricanes occur outside this period.

Inland Impacts

Inland Connecticut is vulnerable to hurricanes despite moderate hurricane occurrences when compared with other areas within the Atlantic Tropical Cyclone basin. Since hurricanes tend to weaken within 12 hours of landfall, far inland areas are relatively less susceptible to hurricane wind damages than coastal areas in Connecticut. However, the heaviest rainfall often occurs inland. A recent example is Hurricane Irene (described in Section 5.3). Irene caused extensive precipitation within inland Connecticut.

Seven of the 24 SCCOG jurisdictions are considered to have coastal areas, although Connecticut's coastal management boundary extends inland along the Thames River. Thus, the SCCOG region is susceptible to both inland and coastal flooding hazards during hurricanes and tropical storms. All areas within the SCCOG region are near enough to the coast to experience strong winds. Of particular concern are the

blockage of roads and the damage to the electrical power supply from falling trees and tree limbs as was experienced during Irene.

Storm Surge

Abnormal rise of water generated by a storm over and above the predicated astronomical tides is commonly referred to as storm surge. In short, it is the difference between the observed water level and the normal astronomical tide. Storm surge is not the same as storm tide, which is the water level rise due to the combination of storm surge and the astronomical tide. Extratropical storms such as nor'easters have produced some of the highest storm surges and resultant damages on record. However, hurricanes have the potential to produce much higher storm surges because of the vast amount of energy released by these storm systems over a relatively short duration. Hurricane Katrina in 2005 is one of the nation's most infamous examples of damage and devastation caused by storm surge.

In 2011, Tropical Storm Irene struck at high tide during a perigee (full moon) tide resulting in an abnormally high storm surge causing serious coastal damage in Connecticut. The storm surge from Irene destroyed structures and flooded many coastal roads in East Haven and Milford.

A number of factors contribute to the generation of storm surge, but the fundamental forcing mechanism is wind and the resultant frictional stress it imposes on the water surface as it forces water to move inland. The magnitude of storm surge within a coastal basin is governed by both the meteorological parameters of the hurricane and the physical characteristics of the basin. The meteorological aspects include the hurricane's size, measured by the radius of maximum winds; the intensity, measured by sea level pressure and maximum surface wind speeds at the storm center; the path, or forward track of the storm; and the storm's forward speed.

The Saffir/Simpson Scale

The "Saffir-Simpson Hurricane Scale" was used prior to 2009 to categorize hurricanes based upon wind speed, central pressure, and storm surge, relating these components to damage potential. In 2009, the scale was revised and is now called the "Saffir-Simpson Hurricane Wind Scale." The modified scale is more scientifically defensible and is predicated only on surface wind speeds. Storm surge is no longer part of the scale. The National Hurricane Center is considering offering specific warnings regarding storm surge based on Sea, Lake, and Overland Surges from Hurricanes (SLOSH) mapping for areas that could be impacted by a hurricane.

Table 5-1 lists the hurricane characteristics mentioned above as a function of category as well as the expected central pressure.

Table 5-1: Hurricane Characteristics

Category	CENTRAL PRESSURE		WIND SPEED		SURGE	Damage Potential
	Millibars	Inches of Hg	MPH	Knots	Feet	
1	>980	>28.9	74-95	64-83	4-5	Minimal
2	965-979	28.5-28.9	96-110	84-96	6-8	Moderate
3	945-964	27.9-28.5	111-130	97-113	9-12	Extensive
4	920-644	27.2-27.9	131-155	114-135	13-18	Extreme
5	<920	<27.2	>155	>135	>18	Catastrophic

Hurricanes are grouped into five categories based on strength. The following descriptions are from the 2014 *Connecticut Natural Hazard Mitigation Plan Update*.

- **Category One Hurricane:** Sustained winds 74-95 miles per hour (mph) (64-82 knots (kt) or 119-153 kilometers per hour (km/hr)). *Damaging winds are expected*. Some damage to building structures could occur, primarily to unanchored mobile homes (mainly pre-1994 construction). Some damage is likely due to poorly constructed signs. Loose outdoor items will become projectiles, causing additional damage. Persons struck by windborne debris risk injury and possibly death. Numerous large branches of healthy trees will snap. Some trees will be uprooted, especially where the ground is saturated. Many areas will experience power outages with some downed power poles.
- **Category Two Hurricane:** Sustained winds 96-110 mph (83-95 kt or 154-177 km/hr). *Very strong winds will produce widespread damage*. Some roofing material, door, and window damage of buildings will occur. Considerable damage to mobile homes (mainly pre-1994 construction) and poorly constructed signs is likely. A number of glass windows in high-rise buildings will be dislodged and become airborne. Loose outdoor items will become projectiles, causing additional damage. Persons struck by windborne debris risk injury and possibly death. Numerous large branches will break. Many trees will be uprooted or snapped. Extensive damage to power lines and poles will likely result in widespread power outages that could last a few to several days.
- **Category Three Hurricane:** Sustained winds 111-130 mph (96-113 kt or 178-209 km/hr). *Dangerous winds will cause extensive damage.* Some structural damage to houses and buildings will occur with a minor amount of wall failures. Mobile homes (mainly pre-1994 construction) and poorly constructed signs are destroyed. Many windows in high-rise buildings will be dislodged and become airborne. Persons struck by windborne debris risk injury and possibly death. Many trees will be snapped or uprooted and block numerous roads. Near total power loss is expected with outages that could last from several days to weeks.
- **Category Four Hurricane:** Sustained winds 131-155 mph (114-135 kt or 210-249 km/hr). *Extremely dangerous winds causing devastating damage are expected.* Some wall failures with some complete roof structure failures on houses will occur. All signs are blown down. Complete destruction of mobile homes (primarily pre-1994 construction). Extensive damage to doors and windows likely. Numerous windows in high-rise buildings will be dislodged and become airborne. Windborne debris will cause extensive damage and persons struck by the wind-blown debris will be injured or killed. Most trees will be snapped or uprooted. Fallen trees could cut off residential areas for days to weeks. Electricity will be unavailable for weeks after the hurricane passes.

- **Category Five Hurricane:** Sustained winds greater than 155 mph (135 kt or 249 km/hr). *Catastrophic damage is expected*. Complete roof failure on many residences and industrial buildings will occur. Some complete building failures with small buildings blown over or away are likely. All signs blow down. Complete destruction of mobile homes. Severe and extensive window and door damage will occur. Nearly all windows in high-rise buildings will be dislodged and become airborne. Severe injury or death is likely for persons struck by wind-blown debris. Nearly all trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months.

5.3 Regional Historic Record

Through research efforts by the National Oceanic and Atmospheric Administration's (NOAA) National Climate Center in cooperation with the National Hurricane Center, records of tropical cyclone occurrences within the Atlantic Cyclone Basin have been compiled from 1851 to present. These records are compiled in NOAA's Hurricane database (HURDAT), which contains historical data recently reanalyzed to current scientific standards as well as the most current hurricane data.

During HURDAT's period of record (1851-2016), three Category Three Hurricanes, 11 Category Two Hurricanes, 16 Category One Hurricanes, and 43 tropical storms have tracked within a 150 nautical mile radius of New London. The representative storm strengths were measured as the peak intensities for each individual storm passing within the 150-mile radius. The 30 hurricanes noted above occurred in July through October as noted in Table 5-2. Based on the historical record, the months of August and September appear to be the time of highest risk for a hurricane or tropical storm to impact the region.

Table 5-2: Tropical Cyclones by Month within 150 Miles of New London, 1851-2016

Category	July	August	September	October
Tropical Storm[1]	5	13	14	7
One	2	5	6	3
Two	0	4	6	1
Three	0	1	2	0
Total	**6**	**23**	**28**	**10**

[1]One tropical storm occurred in May, one occurred in June, and one occurred in November. Hurricane Irene is counted as a Tropical Storm, and Hurricane Sandy is counted as a Hurricane in this table although both were technically extratropical systems upon approach to New London.

While the SCCOG region has experienced hurricanes and tropical storms as shown in Table 5-1, not all of these storms were damaging events. Many passed out to sea southeast of Long Island Sound and thus produced minimal winds and surges. A description of major tropical cyclones that caused damage near the SCCOG region follows:

- An unnamed hurricane in September 1869 was a Category Three Hurricane when its center made landfall in Rhode Island. The hurricane was fairly compact without strong winds on the west side of the center. Storm surge was reported at 8 feet but mitigated by low tide. Heavy winds downed many trees and left severe damage. All telegraph lines between New York and Boston were cut by the storm.

- The most devastating hurricane to strike Connecticut, and believed to be the strongest hurricane to hit New England in recorded history, is believed to have been a Category Three Hurricane at its peak. Dubbed the "Long Island Express of September 21, 1938," this name was derived from the unusually high forward speed of the hurricane (estimated to be 70 mph). As a Category Two Hurricane, the center of the storm passed over Long Island, made landfall near Milford, Connecticut, and moved quickly northward into northern New England.

  The majority of damage was caused from storm surge and wind damage. Surges up to 18 feet were recorded along portions of the Connecticut coast, and 130 mile per hour gusts flattened forests, destroyed nearly 5,000 cottages, farms, and homes, and damaged an estimated 15,000 more throughout New York and southern New England. The storm resulted in catastrophic fires in New London and Mystic, Connecticut. Totals of 14 to 17 inches of rain were reported in central Connecticut, causing severe flooding. Overall, the storm left an estimated 564 dead, 1,700 injured, and caused physical damages in excess of $38 million (1938 USD).

- The "Great Atlantic Hurricane" hit the Connecticut coast in September 1944. This storm was a Category Four Hurricane at its peak intensity but was a Category One Hurricane when its center passed over eastern Long Island and made landfall in Connecticut near New London. The storm brought rainfall in excess of six inches to most of the state and rainfall in excess of eight to 10 inches in Fairfield County. Most of the wind damage from this storm occurred in southeastern Connecticut although wind gusts of 109 mph were reported in Hartford, Connecticut. Injuries and storm damage were lower in this hurricane than in 1938 because of increased warning time and the fewer structures located in vulnerable areas due to the lack of rebuilding after the 1938 storm.

- Hurricane Carol was a Category Two Hurricane when it made landfall in Connecticut near Clinton in late August 1954. The storm arrived shortly after high tide and produced storm surges of 10 to 15 feet in southeastern Connecticut. Rainfall amounts of six inches were recorded in New London, and wind gusts peaked at over 100 mph. Near the coast, the combination of strong winds and storm surge damaged or destroyed thousands of buildings, and the winds toppled trees that left most of the eastern part of the state without power. Overall damages in the northeast were estimated at one billion dollars (1954 USD), and 48 people died as a direct result of the hurricane. Western Connecticut was largely unaffected by Hurricane Carol due to the compact nature of the storm.

- As explained in Section 3.3, the year 1955 was a devastating year for flooding in Connecticut. Connie was a declining tropical storm over the Midwest when its effects hit Connecticut in August 1955, producing heavy rainfall of four to six inches across the state. The saturated soil conditions exacerbated the flooding caused by Tropical Storm Diane five days later, the wettest tropical cyclone on record for the northeast. The storm produced 14 inches of rain in a 30-hour period, causing destructive flooding conditions along nearly every major river system in the state.

- Hurricane Belle of August 1976 was a Category One Hurricane as it passed over Long Island but was downgraded to a tropical storm before its center made landfall near Stratford, Connecticut. Belle caused five fatalities and minor shoreline damage.

- Hurricane Gloria of September 1985 was a Category Three Hurricane when it made landfall in North Carolina and weakened to a Category Two Hurricane before its center passed over Long Island, New York, making landfall in Connecticut near Bridgeport. The hurricane struck at low tide, resulting in low to moderate storm surges along the coast. The storm produced up to six inches of rain in some areas and heavy winds that damaged structures and uprooted thousands of trees. The volume and spread of debris and loss of power were the major impacts from this storm, with over 500,000 people suffering significant power outages.
- Hurricane Bob was a Category Two Hurricane when its center made landfall in Rhode Island in August 1991. The hurricane caused storm surge damage along the Connecticut coast but was more extensively felt in Rhode Island and Massachusetts. Heavy winds were felt across eastern Connecticut with gusts up to 100 mph and light to moderate tree damage. The storm was responsible for six deaths in the state. Total damage in southern New England was approximately $680 million (1991 USD).
- Tropical Storm Floyd struck Connecticut in 1999. Floyd is the storm of record in the Connecticut Natural Hazard Mitigation Plan due to heavy rainfall that caused widespread flood damage throughout the state. The winds associated with Tropical Storm Floyd also caused power outages throughout New England and at least one death in Connecticut.
- Hurricane Irene peaked as a Category Three storm before it made landfall in North Carolina and tracked northward along the Delmarva Peninsula and New Jersey before the remnants of the eye crossed over New York City on Sunday, August 28, 2011. Anticipating storm surges along the Atlantic coastline, many states and municipalities issued mandatory evacuations on August 26 and 27, 2011. Many coastal towns in the SCCOG region ordered a mandatory evacuation to all residents in anticipation of Hurricane Irene's landfall on Saturday, August 27, 2011. The largest damage was done to electrical lines throughout the State of Connecticut. More than half of the State (over 754,000 customers) was without power following the storm, with some areas not having electricity restored for more than a week. A total of 10 deaths were attributed to the storm in Connecticut.
- Hurricane Sandy struck the Connecticut shoreline as a Category 1 Hurricane in late October 2012, causing power outages for 600,000 customers and at least $360 million in damages in Connecticut. Damages in southeast Connecticut were minor, with only a small number of power outages reported. The most significant damage occurred due to storm surge flooding along the coastline, as well as high winds. FEMA Public Assistance records indicate that some towns, such as Norwich and New London, received $500,000 to $1,000,000 federal money to aid with the cleanup.

5.4 Existing Capabilities

Flooding

Existing mitigation measures appropriate for flooding have been discussed in Sections 3.0 and 4.0. These include the ordinances, codes, and regulations that have been enacted to minimize flood damage, as well as the aggressive programs to elevate and remove floodprone homes throughout the town. In addition, various structures exist to protect certain coastal areas, including bulkheads, seawalls, jetties, groins, and riprap.

Wind

Nearly all of the SCCOG jurisdictions utilize the Connecticut State Building Code which addresses the requirements for wind loading. The two tribal governments utilize building codes which have stricter standards in certain cases than the State Building Code. The 2005 Connecticut State Building Code was most recently amended in 2016 and adopted with an effective date of October 1, 2016. The code specifies the design wind speed for construction in all the Connecticut municipalities, with the addition of split zones for some towns to account for inland areas that are less susceptible to direct wind damage. Table 5-2 presents the residential design wind speed for SCCOG jurisdictions based on the applicable building code. Non-residential design wind speeds vary depending on type of building. The 2016 State Building Code also classifies areas south of Interstate 95 as a Wind-Borne Debris Region in the communities of East Lyme, Groton, New London, Stonington, and Waterford.

Table 5-3: Design Wind Speed in SCCOG Jurisdictions

Jurisdiction	Design Wind Speed (mph)[1]
Bozrah	105
Colchester	100
East Lyme	105
Franklin	105
Griswold	105
Groton[2]	105
Lebanon	100
Ledyard[3]	105
Lisbon	105
Montville[3]	105
New London	105
North Stonington	105
Norwich	105
Preston	105
Salem	105
Sprague	105
Stonington[2]	105
Waterford	105
Windham	100

1. Based on three second gust in Appendix R of the State Building Code.
2. State Building Code does not separate out boroughs.
3. State Building Code does not specifically address Tribal Land.

Connecticut is located in FEMA Zone II regarding maximum expected wind speed. The maximum expected wind speed for a three-second gust is 160 miles per hour in south-central and southeastern Connecticut. This wind speed could occur as a result of either a hurricane or a tornado. The American Society of Civil Engineers recommends that new buildings be designed to withstand this peak three-second gust which is much greater than the design wind speeds noted in Table 5-2.

Jurisdictions in the SCCOG region have actively supported wind mitigation, especially along the shoreline. Typical mitigation activities include encouraging the installation of storm shutters and promoting hurricane preparedness by providing information to the public and encouraging evacuation signage and routes. In addition, the majority of SCCOG jurisdictions require all utilities in new subdivisions to be located underground whenever possible in order to mitigate storm-related wind damages.

Each SCCOG jurisdiction has designated an individual as Tree Warden and administers a tree-trimming program. Tree-trimming on municipally-owned property is conducted on an as-needed basis or following complaints by residents. Most tree-trimming is conducted with clean-up activities following storms. In general, local governments maintain small trees and downed branches and contract with tree companies to deal with larger trees. Local electric companies (Bozrah Light & Power, Eversource, Groton Utilities, Norwich Public Utilities, and tribal utilities) have tree trimming maintenance programs in place.

Prior to hurricane and tropical storm emergencies, SCCOG jurisdictions will activate their local EOCs and open emergency shelters. Although hurricanes that have impacted southeastern Connecticut have historically passed in a day's time, additional shelters could be outfitted following a storm on an as-need basis for long-term evacuees. In addition, the local jurisdictions ensure that warning/notification systems and communication equipment are working properly and prepares for the possible evacuation of impacted areas.

The SCCOG region relies on the CT "Everbridge" Reverse 911 system, radio, cable television, area newspapers, and the internet to spread information on the location and availability of shelters. It is understood that several of these information sources can be cut off due to power failure, so emergency personnel can also pass this information on manually via door-to-door communication and public flyers. This was the primary method of communication during Hurricane Irene, for example.

5.5 Vulnerabilities and Risk Assessment

NOAA issues an annual hurricane outlook to provide a general guide to each upcoming hurricane season based on various climatic factors. However, it is impossible to predict exactly when and where a hurricane will occur. NOAA believes that "hurricane landfalls are largely determined by the weather patterns in places the hurricane approaches, which are only predictable within several days of the storm making landfall."

NOAA has utilized the National Hurricane Center Risk Analysis Program (HURISK) to determine return periods for various hurricane categories at locations throughout the United States. As noted on the NOAA website, hurricane return periods are the frequency at which a certain intensity or category of hurricane can be expected within 75 nautical miles of a given location. For example, a return period of 20 years for a particular category storm means that on average during the previous 100 years a storm of that category passed within 75 nautical miles of that location five times. Thus, it is expected that similar category storms would pass within that radius an additional five times during the next 100 years.

Table 5-4 presents return periods for various category hurricanes to impact Connecticut. The nearest two HURISK analysis points were New York City and Block Island, Rhode Island. For this analysis, these data are assumed to represent western Connecticut and eastern Connecticut, respectively.

Table 5-4: Return Period in Years for Hurricanes to Strike Connecticut

Category	New York City (Western Connecticut)	Block Island, RI (Eastern Connecticut)
One	17	17
Two	39	39
Three	68	70
Four	150	160
Five	370	430

Hurricane Sandy in October of 2012 was a significant reminder that hurricanes track close to Connecticut, and significant damage can be inflicted even by storms that do not make direct landfall over the state. The previous SCCOG HMP noted that it was generally believed, at the time, that New England was long overdue for a major hurricane strike. Importantly, despite major news coverage, over $360 million in damage, and four deaths, Hurricane Sandy was a sub-tropical storm with its eye near Atlantic City, New Jersey, when its effects were felt in Connecticut. Therefore the last major hurricane to impact Connecticut continues to be Hurricane Bob in 1991. As shown in Table 5-3, NOAA estimates that the return period for a Category Two or Category Three storm to strike eastern Connecticut to be 39 years and 70 years, respectively. A Category Two or Three storm striking Connecticut within the next decade would conform to these estimates.

According to the 2014 *Connecticut Natural Hazard Mitigation Plan Update*, hurricanes have the greatest destructive potential of all natural disasters in Connecticut due to the potential combination of high winds, storm surge and coastal erosion, heavy rain, and flooding that can accompany the hazard. The 2014 *Connecticut Natural Hazard Mitigation Plan Update* also notes that some researchers have suggested that the intensity of tropical cyclones has increased over the last 40-50 years, with some believing that there is a connection between this increase in intensity and climate change. While most climate simulations agree that greenhouse warming enhances the frequency and intensity of tropical storms, models of the climate system are still limited by resolution and computational ability. However, given the past history of major storms and the possibility of increased frequency and intensity of tropical storms due to climate change, it is prudent to expect that there will be hurricanes impacting Connecticut in the near future that may be of greater frequency and intensity than in the past.

In general, as the residents and businesses of the state of Connecticut become more dependent on the internet and mobile communications, the impact of hurricanes on commerce will continue to increase. A major hurricane has the potential of causing complete disruption of power and communications for up to several weeks, rendering electronic devices and those that rely on utility towers and lines inoperative. Damage from these types of storms can be from several sources:

- Strong winds can cause debris such as signs, roofing material, and small items left outside become flying missiles during hurricanes. Such debris can cause direct damage to structures, vehicles, and people.
- Parts of trees (limbs) or entire tall and older trees may snap and fall during heavy wind events, potentially damaging structures, utility lines, vehicles, and people. Extensive damage to trees, towers, aboveground and underground utility lines (from uprooted trees, poles, or failed infrastructure) may cause considerable disruption for residents. This is considered the most problematic issue associated with strong winds. Following a major storm, the loss of power to the region's many traffic signals potentially causes expenditures of a great deal of manpower to control and post the intersections for duration of the power outages, and creates vulnerabilities for maintaining emergency communication as many areas have insufficient backup power sources.
- Streets may be flooded or blocked by fallen branches, poles, or trees, preventing egress.
- Downed power lines from heavy winds can also start fires during hurricanes with limited rainfall.
- Some hurricanes may also spawn tornados that cause additional damage.

The SCCOG region is highly vulnerable to hurricane damage from wind and flooding and from any tornadoes accompanying the storm. Wind is considered to be the most frequently occurring natural hazard in the region and its effects can be felt nearly everywhere. All of the damage to the region from historical tropical cyclones has been due to the effects of winds, flooding, and storm surge. Factors that influence vulnerability to tropical cyclones in the region include building codes currently in place, local zoning and development patterns, and the age and number of structures located in highly vulnerable areas of each community. In addition, the coastline is home to private and municipal marinas which are vulnerable to the effects of both wind and flooding.

Recall from Section 2.5 that elderly and persons with disabilities reside in the region. It is possible that populations impacted by a widespread high-wind event such as a hurricane could consist of the elderly and numerous people with disabilities. Thus, it is important for local jurisdictions to be prepared to assist these special populations during wind emergencies. More information regarding these populations is presented in each community annex.

5.5.1 Loss Estimates

HAZUS-MH Analysis

In order to quantify potential hurricane damage, HAZUS-MH simulations were run for historical and probabilistic hurricanes that could theoretically affect the region. The simulated storms estimate the potential maximum damage that would occur (based on year 2014 dollar values using year 2010 census data) based on wind speeds of varying return periods. The three historically based hurricanes include the 1938 hurricane, Hurricane Carol in 1954, and Hurricane Gloria in 1985. A hurricane track for Bob (1991) was not available in the *HAZUS-MH* software. The three historical hurricanes tracks that were simulated are shown in Figure 5-1.

Note that these simulations calculate damage for wind effects alone and not damages due to flooding or other non-wind effects. Thus, the damage and displacement estimates presented below are likely *lower* than would occur during a hurricane associated with severe rainfall and storm surge. Results are presented in Appendix D and summarized below.

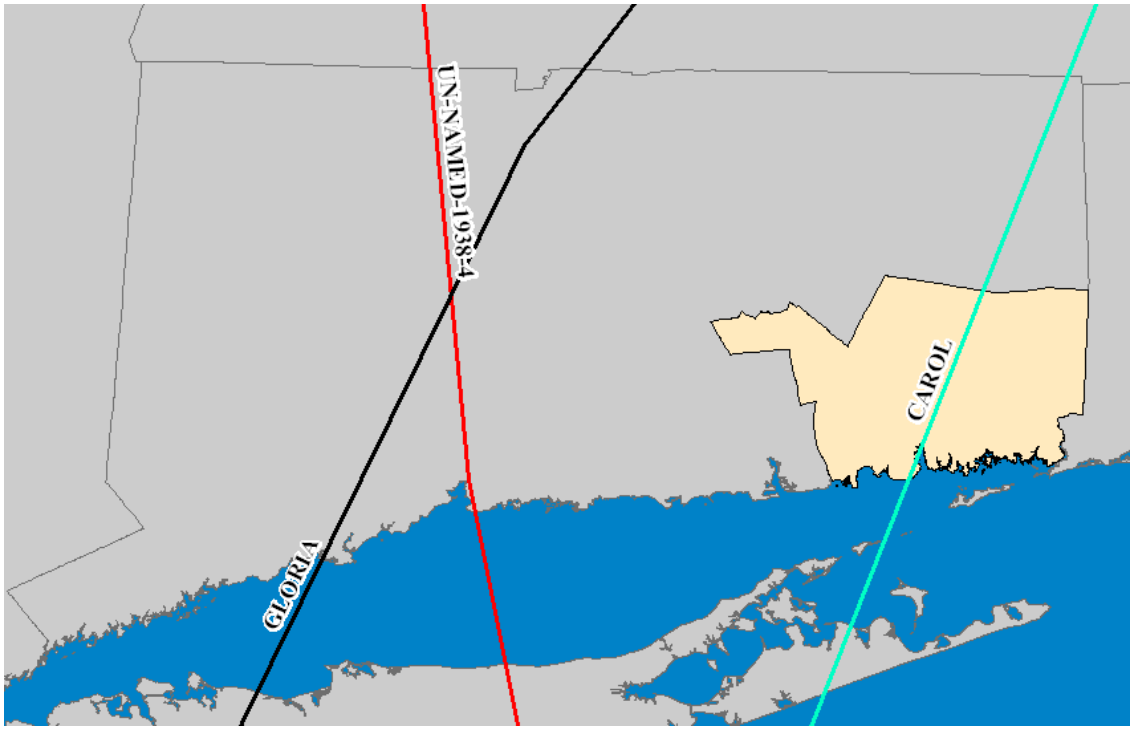


Figure 5-1: Historical Hurricane Tracks for HAZUS-MH Simulations

The FEMA default values were used for each census tract in the *HAZUS-MH* simulations. A summary of the default building counts and values is shown in Table 5-5. Approximately 36.9 billion dollars of building value was estimated to exist in the region.

Table 5-5: HAZUS-MH Hurricane Scenarios Basic Information (millions)

Occupancy	Building Count	Dollar Exposure
Agriculture	437	401,389
Commercial	5,955	5,355,537
Education	278	809,938
Government	298	376,068
Industrial	1,822	1,309,504
Religion	525	501,741
Residential	94,181	28,189,901
Total	**103,496**	$36,944,078

The FEMA *Hurricane Model HAZUS-MH Technical Manual* outlines various damage thresholds to classify buildings damaged during hurricanes. The five classifications are summarized below:

- **No Damage or Very Minor Damage**: Little or no visible damage from the outside. No broken windows or failed roof deck. Minimal loss of roof cover, with no or very limited water penetration.
- **Minor Damage**: Maximum of one broken window, door, or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.
- **Moderate Damage**: Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.
- **Severe Damage**: Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water. Limited, local joist failures. Failure of one wall.
- **Destruction:** Essentially complete roof failure and/or more than 25% of roof sheathing. Significant amount of the wall envelope opened through window failure and/or failure of more than one wall. Extensive damage to interior.

Table 5-6 presents the peak wind speeds during each wind event simulated by *HAZUS-MH* for the region. The number of expected residential buildings to experience various classifications of damage is presented in Table 5-6, and the total number of buildings expected to experience various classifications of damage is presented in Table 5-7. Minimal damage is expected to buildings for wind speeds less than 65 mph, with overall damages increasing with increasing wind speed.

The probabilistic hurricane scenarios modeled in the new version of HAZUS-MH (version 4.0) tend to have lower wind speeds than those modeled for the previous SCCOG HMP. As these scenarios are developed using statistical analysis of the historic record, their parameters will continually change over time. The lower wind speeds in these scenarios reflect the lack of significant hurricanes occurring in the region in recent history.

Table 5-6: HAZUS Hurricane Scenarios – Number of Residential Buildings Damaged

Return Period or Hurricane	Peak Wind Gust (mph)[1]	Minor Damage	Moderate Damage	Severe Damage	Total Destruction	Total
10-Year	41-55	3	0	0	0	5
20-Year	55-79	155	8	0	0	163
Gloria (1985)	89	1,860	150	4	0	2,014
50-Year	82-90	2,431	212	6	2	2,651
Carol (1954)	94	1,058	80	3	1	1,142
100-Year	91-102	7,929	1,059	40	25	9,053
200-Year	99-111	15,428	3,056	213	149	18,846
500-Year	97-128	21,007	6,544	1,005	734	29,290
Unnamed (1938)	124	28,942	9,622	1,340	916	40,820
1,000-Year	106-123	30,968	11,760	1,991	1,374	46,094

Note: 1. Peak wind gusts vary across the region for each event. In general, they are lowest in Colchester and highest along the shore in Groton and Stonington.

Table 5-7: HAZUS Hurricane Scenarios – Total Number of Buildings Damaged

Return Period or Hurricane	Minor Damage	Moderate Damage	Severe Damage	Total Destruction	Total
10-Year	5	0	0	0	5
20-Year	187	8	0	0	195
Gloria (1985)	2,017	161	5	0	2,183
50-Year	2,635	230	8	2	2,875
Carol (1954)	1,166	88	4	1	1,259
100-Year	8,536	1,181	56	26	9,799
200-Year	16,600	3,452	288	151	20,491
500-Year	22,628	7,457	1,320	744	32,149
Unnamed (1938)	31,146	10,925	1,732	927	44,730
1,000-Year	33,304	13,357	2,528	1,390	50,580

The *HAZUS* simulations consider a subset of critical facilities termed "essential facilities" that are important during emergency situations. Note that the essential facilities in *HAZUS-MH* may not necessarily be the same today as they were in 2010. Nevertheless, the information is useful from a planning standpoint. As shown in Table 5-8, minimal damage to essential facilities is expected for wind speeds less than 100 mph. Fire stations and police stations are not simulated to experience more than minor damage for any wind events. Schools are not expected to experience more than minor damage for wind speeds below those of a 200-year wind event. Relatively minor wind events were simulated as having the potential to damage the hospitals in the region, with significant damage occurring beginning with the 100-year event. Emergency operations centers (EOCs) in the region were not simulated as receiving damage under any scenario.

Table 5-8: HAZUS-MH Hurricane Scenarios – Essential Facility Damage

Return Period or Hurricane	Fire Station (Total of 49)	Police Station (Total of 26)	Schools (Total of 132)	Hospitals (Total of 3)
10-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use
20-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use
Gloria (1985)	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	At least moderate damage to 2 hospitals, no loss of use
50-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	At least moderate damage to 2 hospitals, no loss of use
Carol (1954)	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	At least moderate damage to 2 hospitals, no loss of use
100-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, no loss of use	At least moderate damage to 2 hospitals, loss of use >1 day at 1 hospital. 53% of beds available during hurricane, all beds available after one week

Table 5-8: HAZUS-MH Hurricane Scenarios – Essential Facility Damage (Cont'd)

Return Period or Hurricane	Fire Station (Total of 49)	Police Station (Total of 26)	Schools (Total of 132)	Hospitals (Total of 3)
200-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	None or minor damage, loss of use >1 day at 52 locations	At least moderate damage to 2 hospitals, loss of use >1 day at 2 hospitals. 16% of beds available during hurricane, 53% after one week, all after one month
500-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	At least 17 schools with more than moderate damage, loss of use > 1 day at 90 locations	At least moderate damage to 2 hospitals and complete damage to one. Complete loss of use during hurricane. 16% of beds available after 1 week, 53% after 1 month
Unnamed (1938)	None or minor damage, no loss of use	None or minor damage, no loss of use	At least 15 schools with more than moderate damage, loss of use > 1 day at each location	At least moderate damage to 2 hospitals and complete damage to 1. Complete loss of use during hurricane and for at least 1 week. 53% of beds available by 1 month
1,000-Year	None or minor damage, no loss of use	None or minor damage, no loss of use	At least 30 schools with more than moderate damage, loss of use > 1 day at 128 locations	Complete damage, no service for at least one week. 16% of beds available by one month

Note: Damage to EOCs does not occur under any of the modeled scenarios.

Table 5-9 presents the estimated tonnage of debris that would be generated by wind damage during each *HAZUS-MH* hurricane scenario. As shown in Table 5-9, minimal debris is expected for wind speeds less than the 20-year event. Reinforced concrete and steel buildings are not expected to generate debris under any conditions. The majority of the debris that is generated is tree related.

Table 5-9: HAZUS-MH Hurricane Scenarios – Debris Generation (Tons)

Return Period or Hurricane	Brick / Wood	Reinforced Concrete / Steel	Eligible Tree Debris	Other Tree Debris	Total
10-Year	None	None	4	7	11
20-Year	810	None	2,200	7,752	10,752
Gloria (1985)	9,788	None	18,938	91,358	120,145
50-Year	12,639	None	22,579	94,191	129,300
Carol (1954)	5,285	None	9,324	40,909	55,590
100-Year	35,615	None	45,516	195,483	276,426
200-Year	73,643	None	70,093	290,129	434,527
500-Year	147,641	None	109,804	482,296	741,316
Unnamed (1938)	193,521	None	156,334	700,790	1,052,646
1,000-Year	238,566	None	186,103	872,377	1,298,387

Table 5-10 presents the potential sheltering requirements based on the various wind events simulated by *HAZUS-MH*. The predicted sheltering requirements for wind damage are minimal below the 100-year event.

Table 5-10: HAZUS Hurricane Scenarios – Shelter Requirements

Return Period or Hurricane	Number of Displaced Households	Short-Term Sheltering Need (Number of People)
10-Year	None	None
20-Year	None	None
Gloria (1985)	1	None
50-Year	5	None
Carol (1954)	None	None
100-Year	71	11
200-Year	317	55
500-Year	1,505	297
Unnamed (1938)	1,820	377
1,000-Year	2,616	553

Table 5-11 presents the predicted property damage loss due to the various simulated wind events. Property damage loss estimates include the subcategories of building, contents, and inventory damages. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building or its contents.

Table 5-11: HAZUS-MH Hurricane Scenarios – Property Damage

Return Period	Building Losses	Content Losses	Inventory Losses
10-Year	$55,420	$35,640	None
20-Year	$13,754,630	$3,483,210	$280
Gloria (1985)	$98,260,650	$18,379,760	$25,820
50-Year	$119,320,190	$22,859,910	$47,880
Carol (1954)	$58,414,160	$12,754,260	$28,710
100-Year	$294,130,730	$63,039,440	$381,180
200-Year	$614,726,050	$166,560,200	$1,372,390
500-Year	$1,311,636,380	$465,547,380	$5,003,990
Unnamed (1938)	$1,723,702,960	$612,750,270	$5,973,530
1,000-Year	$2,159,092,260	$810,453,170	$8,104,240

Business interruption loss estimates in Table 5-12 include the subcategories of lost income, relocation expenses, rental expenses, and lost wages. The business interruption losses are associated with the inability to operate a business due to the damage sustained during a hurricane and also include temporary living expenses for those people displaced from their homes because of the storm.

Table 5-12: HAZUS-MH Hurricane Scenarios – Business Interruption

Return Period	Income Losses	Relocation Losses	Rental Losses	Wage Losses
10-Year	None	$370	None	None
20-Year	None	$130,000	$138,840	None
Gloria (1985)	$115,870	$3,167,310	$2,428,340	$109,820
50-Year	$332,210	$4,329,310	$3,419,020	$352,370
Carol (1954)	$114,190	$1,370,840	$1,143,610	$111,720
100-Year	$2,149,070	$13,799,240	$10,136,140	$3,527,340
200-Year	$5,300,890	$42,871,660	$24,518,270	$10,337,670
500-Year	$13,036,250	$123,977,150	$59,440,600	$20,783,350
Unnamed (1938)	$13,409,980	$174,573,650	$79,666,280	$23,330,880
1,000-Year	$16,956,470	$230,625,370	$100,345,890	$27,647,700

Table 5-13 summarizes the losses presented in Table 5-11 and Table 5-12. Losses are relatively small for storms with return periods of less than the 20-year but increase rapidly as stronger storms are considered. For example, a 100-year hurricane wind event (slightly stronger than Hurricane Carol in 1954) would cause approximately $387 million in economic losses to the region. Recall that these damage values are based on 2014 dollars.

Table 5-13: HAZUS-MH Hurricane Scenarios – Building-Related Economic Loss

Return Period	Total Property Damage	Total Business Interruption	Total Losses
10-Year	$91,060	$370	$91,420
20-Year	$17,238,130	$268,840	$17,506,970
Gloria (1985)	$116,666,230	$5,821,340	$122,487,570
50-Year	$142,227,990	$8,432,910	$150,660,900
Carol (1954)	$71,197,130	$2,740,350	$73,937,490
100-Year	$357,551,350	$29,611,800	$387,163,160
200-Year	$782,658,640	$83,028,490	$865,687,130
500-Year	$1,782,187,750	$217,237,350	$1,999,425,090
Unnamed (1938)	$2,342,426,760	$290,980,790	$2,633,407,550
1,000-Year	$2,977,649,680	$375,575,430	$3,353,225,110

The probabilistic storm losses in Table 5-13 can be utilized to determine the annualized loss to the region due to hurricane wind. The annualized loss based on the losses incurred during storms with return periods of 10, 20, 50, 100, 200, 500, and 1000 years, is $19.1 million[3]. This includes direct property damage as well as business interruption losses. This figure is based on probabilistic hurricane events and does not address the historic hurricanes modeled in *HAZUS-MH*. Recall that *HAZUS-MH* modeled wind damage only, and did not include damages from flooding caused by hurricanes.

The 2014 CT NHMP presented annualized loss estimates for each county based on the probabilistic storms in HAZUS-MH. As HAZUS was run for the SCCOG region specifically for hurricane wind, an annualized loss estimate based on the older data in the 2014 CT NHMP is not necessary. However, the

[3] Using an equation presented in the HAZUS-MH Technical Manual to calculate annualized loss.

regional HAZUS results were distributed to each SCCOG community based on the population ratio of each jurisdiction to the SCCOG region.

Public Assistance Reimbursements

Loss estimates for hurricane wind can also be generated from the Public Assistance figures received by municipalities and other entities within the SCCOG region, similar to the method used in Section 3.5.2. According to information from the FEMA Public Assistance Funded Projects Summary (Open Government Initiative), there were two hurricane wind events (Irene and Sandy) since 1999 that resulted in federal disaster declarations in southeastern Connecticut. Each of these resulted in reimbursement requests to FEMA. These expenses included debris removal, emergency protective measures, and repairs to damaged infrastructure and buildings experienced by local governments and non-profits. A summary for the SCCOG region is presented in Table 5-14 below.

Table 5-14: Public Assistance Reimbursements Related to Hurricane Wind

SCCOG Jurisdiction	Local Government Cost	Other Local Agency Cost*	Total Cost
Bozrah	None	None	None
Colchester	$207,513.80	None	$207,513.80
East Lyme	$742,462.08	$933,998.13	$1,676,460.21
Franklin	$23,916.91	None	$23,916.91
Griswold	$92,174.92	None	$92,174.92
Groton, City of	$837,172.41	$3,587.04	$840,759.45
Groton, Town of	$621,607.09	$328,072.10	$949,679.19
Jewett City, Borough of	None	None	None
Lebanon	$75,697.42	None	$75,697.42
Ledyard	$122,910.84	$106,201.66	$229,112.50
Lisbon	$14,825.00	None	$14,825.00
Mashantucket Pequot Tribal Nation	$590,635.60	None	$590,635.60
Mohegan Tribe	$15,112.68	None	$15,112.68
Montville	$203,598.45	$34,139.17	$237,737.63
New London	$737,338.60	$86,165.40	$823,504.01
North Stonington	$76,364.23	None	$76,364.23
Norwich	$1,675,741.72	$56,834.21	$1,732,575.94
Preston	$59,988.57	$72,062.48	$132,051.05
Salem	$49,775.78	None	$49,775.78
Sprague	$99,364.76	None	$99,364.76
Stonington, Borough of	$57,789.81	None	$57,789.81
Stonington, Town of	$407,747.46	$19,064.12	$426,811.57
Waterford	$520,396.52	$32,682.11	$553,078.63
Windham	$65,742.75	$15,698.45	$81,441.20
Total	**$7,297,877.40**	**$1,688,504.87**	**$8,986,382.29**

*Other agencies = Fire Districts, Schools, Housing Authorities, and other Non-Profit Agencies

Tropical Storm Irene and Hurricane Sandy had both flooding and wind damage. An exact breakdown is not immediately available. The damage values herein are assumed to be one-third flooding related and two-thirds wind related.

Based on the information in Table 5-14, hurricane wind losses reimbursed through the FEMA Public Assistance Program have totaled $9.0 million for the SCCOG region since 1999. The annualized loss due to hurricane wind for the SCCOG region over the 18 years of record in the Public Assistance report is therefore $499,243.46.

Summary

Hurricanes present a very real and potentially costly hazard to the region. Based on the historic record and *HAZUS-MH* simulations of various wind events, the entire region is at risk to wind damage from hurricanes. These damages can include direct structural damages, interruptions to business and commerce, emotional impacts, and injury and possibly death.

Based on FEMA Public Assistance reimbursements, the annualized estimated loss due to hurricanes and tropical storms is $0.5 million. According to *HAZUS-MH* simulations, the annualized estimated loss is nearly $19.1 million. The HAZUS-MH estimate is utilized herein as an estimate of annualized loss for the SCCOG region as this figure likely takes into account unreported damages to private property that are not part of the Public Assistance information.

5.6 Potential Mitigation Strategies and Actions

Many potential mitigation measures for hurricanes include those appropriate for inland and coastal flooding. These were presented in Sections 3.0 and 4.0. However, hurricane mitigation measures must also address the effects of heavy winds that are inherently caused by hurricanes.

Because damage to trees and resulting power outages and damage to buildings as a result of winds is the most problematic issue facing the SCCOG region during storms with high winds, mitigating damage to utility lines and property and injury or loss of life must be implemented. Mitigation for wind damage is therefore emphasized in the subsections below. In appropriate situations in which there is a public interest, SCCOG jurisdictions should implement specific physical actions to reduce damage to properties associated with wind.

5.6.1 Prevention

Although wind from hurricanes and tropical storms cannot be prevented, a number of methods are available to prevent damage from the storms. SCCOG communities should expand the current program of placing utilities underground and look for opportunities to relocate utilities underground. Continuing or expanding on local tree limb inspections and maintenance is also important.

To prevent damage to watercraft and the potential resulting damage to nearby property, SCCOG communities should remain well-positioned to aid in the removal of watercraft from Long Island Sound prior to hurricanes and tropical storms. Harbor Management Plans should include provisions for such

removal and other aspects of hazard mitigation. Information on best management practices for marinas and yacht clubs is available from both State and Federal agencies.

5.6.2 Property Protection

Potential mitigation measures for property protection during hurricanes include designs for hazard-resistant construction and retrofitting techniques. These may take the form of increased wind and flood resistance as well as the use of storm shutters over exposed glass and the inclusion of hurricane straps to hold roofs to buildings and transfer loads to foundations. In addition, living and working areas can be elevated to allow a storm surge to pass safely underneath. Local Building and Engineering Departments should make literature available to developers during the permitting process regarding various design standards.

As noted in Section 2.11, the ARC has published a guidebook entitled *Standards for Hurricane Evacuation Shelter Selection* (ARC Publication #4496). The publication provides guidelines for selecting shelters relative to resilience from storm surges, flooding, and hurricane winds. Several FEMA publications provide design criteria for shelters, including *Design and Construction Guidance for Community Shelters* (FEMA Publication #361). A reference by the International Code Council (ICC) and the National Storm Shelter Association, *Standard on the Design and Construction of Storm Shelters* (ICC-500), also provides design criteria. In general, recommended design wind speeds range from 160 to 250 miles per hour (mph) in these publications. In contrast, Connecticut's building code for shoreline municipalities requires a resistance to wind speeds up to 120 mph. Thus, a critical facility may be code compliant but unable to withstand the highest hurricane wind speeds, making it an inferior choice as primary shelter if another option can withstand higher wind speeds.

The FEMA PDM program is the current FEMA mitigation grant program best suited to funding wind mitigation projects. The PDM program recognizes four categories of projects for wind damage mitigation in critical facilities as follows:

- "Shutter mitigation" projects protect all windows and doors of a structure with shutters or other systems that meet debris impact and wind pressure design requirements. All openings of a building are to be protected.
- "Load path" projects improve and upgrade the structural system of a building to transfer loads from the roof to the foundation. This retrofit provides positive connection from the roof framing to the walls, better connections within the wall framing, and connections from the wall framing to the foundation system.
- "Roof projects" involve retrofitting a building's roof by improving and upgrading the roof deck and roof coverings to secure the building envelope and integrity during a wind event.
- "Code plus" projects are those designed to exceed the local building codes and standards to achieve a greater level of protection.

The availability of these potential mitigation projects through FEMA's PDM grant program is of interest to the SCCOG region as there may be an opportunity to obtain incremental funding for the local shelters to withstand hurricane force winds.

5.6.3 Public Education and Awareness

Education is a critical component for mitigating wind damage. SCCOG jurisdictions should providing educational opportunities to the local builders, developers and local officials so that future construction and landscaping associated with construction is designed to minimize wind damage and retrofitting of existing structures and maintenance of property are implemented to the benefit of public safety and property loss reduction.

The public should be made aware of evacuation routes and available shelters should a hurricane or tropical storm be forecast to impact the region. This is especially true for those individuals living within hurricane storm surge evacuation zones. Many SCCOG communities completed an evacuation sign installation project several years ago to facilitate evacuation.

Local communities should continue to use various forms of media to notify the public on any and all updates to natural disaster preparedness and damage prevention. Recommendations regarding public education and awareness are common to all hazards in this Plan, and are listed in Section 11.1.

5.6.4 Emergency Services

A HMP addresses actions that can be taken before a disaster event. In this context, emergency services that would be appropriate mitigation measures for hurricanes include diligent use of forecasting to provide appropriate warning time, implementation of Reverse 911 to provide information on the time of occurrence and magnitude of a storm, and early evacuation of neighborhoods and localities.

Severe weather warning is among the SCCOG region's strongest existing capabilities with regard to wind damage mitigation. Most communities in the SCCOG region have implemented Reverse 911 through the statewide CT "Everbridge" system. While warning systems may not be defined as pure mitigation, they are an integral part of the region's overall emergency management strategy and therefore, warrant inclusion here. The region should implement actions to improve the effectiveness of these functions. In particular, improved emergency communication between the region's emergency response agencies and the emergency response coordinators at the local utility companies is critical to improved hazard mitigation efforts in the region.

Response and cleanup capabilities are also strong in most SCCOG communities. Because loss of tree limbs and brush during high wind events is inevitable, each local community must possess methods for cleaning up, tracking, and disposing of such debris. Local budgets typically include a line item for tree clearing and clean-up following typical summer and winter storms. However, smaller SCCOG communities often do not have the resources to clean up after large-scale events and must rely on outside assistance from utility companies. Even larger communities may find that they are overwhelmed following a large-scale event and must rely on outside assistance.

Based on the above guidelines, a number of specific proposals for improved emergency services are recommended to mitigate damage from hurricanes and tropical storms. These are common to all hazards in this Plan and are listed in Section 11.1.

5.6.5 Structural Projects

Structural mitigation for hurricane storm surges is generally focused on hard or soft shoreline protection such as seawalls and living shorelines, respectively. Previous recommendations for coastal flood mitigation provided in Section 4.0 will provide mitigation for coastal flooding caused by hurricanes. However, where seawalls and other structural solutions are permitted, it is important that breaches and damage be repaired promptly to mitigate damage from future storm events.

Structural projects for wide-spread wind damage mitigation are not possible. Note that structural mitigation methods used for *buildings* are classified as *property protection* and were described above.

6.0 SUMMER STORMS AND TORNADOES

6.1 Setting

The entire region is susceptible to damage from summer storms (including heavy rain, flash flooding, wind, hail, and lightning) and tornadoes. Like hurricanes and winter storms, summer storms and tornadoes have the potential to affect any area within the region. Furthermore, because these types of storms and the hazards that result (flash flooding, wind, hail, and lightning) might have limited geographic extent, it is possible for a summer storm to harm one area within a jurisdiction without harming another. Thus, these storms are considered to be less regional in nature and potential vulnerability is discussed within each community annex.

Based on the historic record, it is considered highly likely that a summer storm that includes lightning will occur each year although lightning strikes have a limited effect. Strong winds and hail are considered likely to occur during such storms but also generally have limited effects. A tornado is considered a possible event in New London County each year and could cause significant damage to a small area. Based on the limited historic record of significant tornadoes affecting the SCCOG region, the previous HMP gave tornadoes a lower vulnerability and mitigation priority than other hazards.

6.2 Hazard Assessment

Heavy wind (including tornadoes and downbursts), lightning, heavy rain, hail, and flash floods are the primary hazards associated with summer storms. Flooding caused by heavy rainfall was covered in Section 3.0 of this plan and will not be discussed here.

Tornadoes

NOAA defines a tornado as "a violently rotating column of air extending from a thunderstorm to the ground." The two types of tornadoes include those that develop from supercell thunderstorms and those that do not. While the physics of tornado development are fairly well understood, there are many unknowns still being studied regarding the exact conditions in a storm event required to trigger a tornado, the factors affecting the dissipation of a tornado, and the effect of cloud seeding on tornado development.

Supercell thunderstorms are long-lived (greater than one hour) and highly organized storms feeding off an updraft that is tilted and rotating. This rotation is referred to as a "mesocyclone" when detected by Doppler radar. The figure below is a diagram of the anatomy of a supercell that has spawned a supercell tornado. Tornadoes that form from a supercell thunderstorm are a very small extension of the larger rotation; they are the most common and the most dangerous type of tornado as most large and violent tornadoes are spawned from supercells.

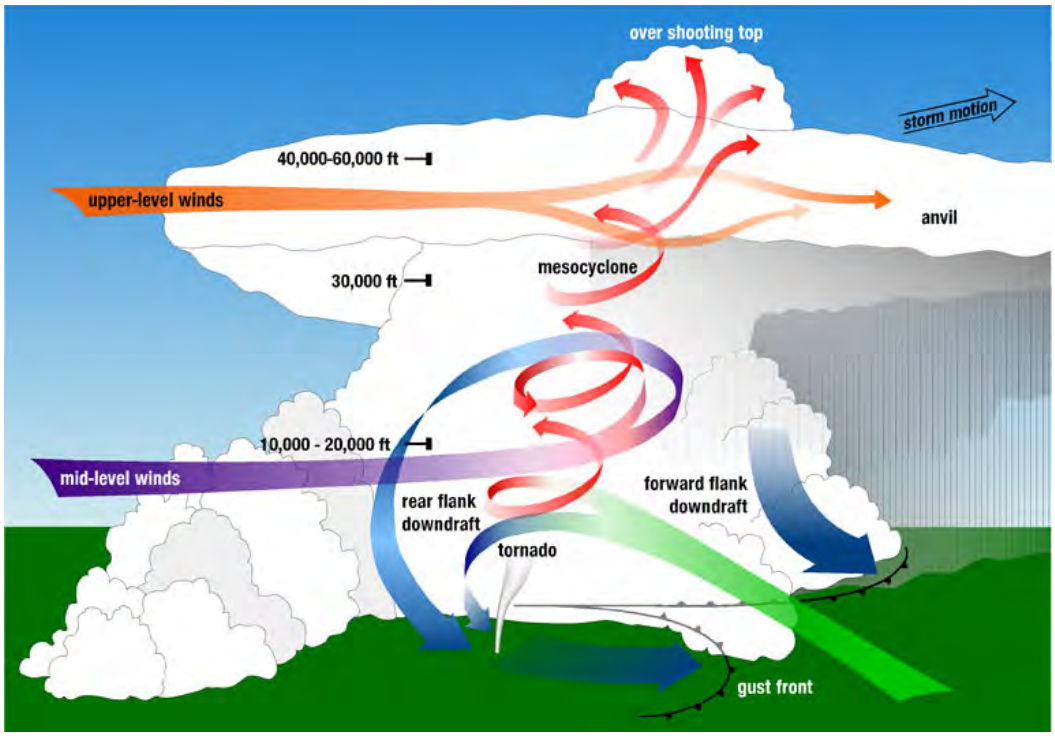


Figure 6-1: Anatomy of a Tornado. Image from NOAA National Severe Storms Laboratory.

Non-supercell tornadoes are defined by NOAA as circulations that form without a rotating updraft. Damage from these types of tornadoes tends to be F2 or less (see Fujita Scale, below). The two types of non-supercell tornadoes are gustnadoes and landspouts:

- A gustnado is a whirl of dust or debris at or near the ground with no condensation tunnel that forms along the gust front of a storm.
- A landspout is a narrow, ropelike condensation funnel that forms when the thunderstorm cloud is still growing and there is no rotating updraft. Thus, the spinning motion originates near the ground. Waterspouts are similar to landspouts but occur over water.

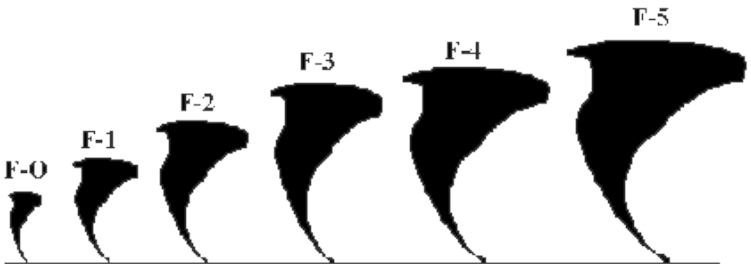
The Fujita Scale was accepted as the official classification system for tornado damage for many years following its publication in 1971. The Fujita Scale rated the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure. The scale ranked tornadoes using the now-familiar notation of F0 through F5, increasing with wind speed and intensity. A description of the scale follows in Table 6-1.

Table 6-1: Fujita Scale

F-Scale Number	Intensity	Wind Speed	Type of Damage Done
F0	Gale tornado	40-72 mph	Some damage to chimneys; branches broken off trees; shallow-rooted trees knocked over; damage to sign boards.
F1	Moderate tornado	73-112 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off for some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel-reinforced concrete structures badly damaged.

According to NOAA, weak tornadoes (F0 and F1) account for approximately 69% of all tornadoes. These tornadoes last an average of five to 10 minutes and account for approximately 3% of tornado-related deaths. Strong tornadoes (F2 and F3) account for approximately 29% of all tornadoes and approximately 27% of all tornado deaths. These storms may last for 20 minutes or more.

Violent supercell tornadoes (F4 and above) are extremely destructive but rare and account for only 2% of all tornadoes. These storms sometimes last over an hour and result in approximately 70% of all tornado-related deaths. Violent and long-lasting tornadoes have caused severe destruction to the Midwest and southern United States and are most common in these regions.



Fujita Tornado Scale. Image courtesy of FEMA.

The Enhanced Fujita Scale was released by NOAA for implementation on February 1, 2007. According to the NOAA website, the Enhanced Fujita Scale was developed in response to a number of weaknesses to the Fujita Scale that were apparent over the years, including the subjectivity of the original scale based on damage, the use of the worst damage to classify the tornado, the fact that structures have different

construction depending on location within the United States, and an overestimation of wind speeds for F3 and greater.

Similar to the Fujita Scale, the Enhanced Fujita Scale is also a set of wind estimates based on damage. It uses three-second gusts estimated at the point of impact based on a judgment of eight levels of damage as compared to 28 specific indicators. Table 6-2 relates the Fujita and Enhanced Fujita Scales.

Table 6-2: Enhanced Fujita Scale

Fujita Scale			Derived EF Scale		Operational EF Scale	
F Number	*Fastest 1/4-mile (mph)*	*3-Second Gust (mph)*	*EF Number*	*3-Second Gust (mph)*	*EF Number*	*3-Second Gust (mph)*
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Official records of tornado activity date back to 1950. According to NOAA, an average of 1,000 tornadoes is reported each year in the United States. The historic record of tornadoes in the region is discussed in Section 6.3. Tornadoes are most likely to occur in Connecticut in June, July, and August of each year.

According to the NOAA Storm Event Database, the highest relative risk for tornadoes in Connecticut is Litchfield (22 events between January 1, 1950 and April 30, 2017) and Hartford (17 events) Counties, followed by New Haven (16 events), Fairfield (13 events), Tolland (11 events), Middlesex (7 events), Windham (3 events), and finally New London (2 events) Counties. The same source shows the adjacent Washington County in Rhode Island as having zero tornado events. The SCCOG region, covering most of New London County and including the Town of Windham, is at a minor risk for tornadoes. The pattern of occurrence in Connecticut is expected to remain unchanged according to the 2014 *Connecticut Natural Hazards Mitigation Plan*, although that documents points out that climate change is expected to increase the frequency and intensity of thunderstorms, in turn increasing the risk and occurrence of associated tornadoes.

<u>Lightning</u>

Lightning is a discharge of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. According to NOAA, the creation of lightning during a storm is a complicated process that is not fully understood. In the initial stages of development, air acts as an insulator between the positive and negative charges. However, when the potential between the positive and negative charges becomes too great, a discharge of electricity (lightning) occurs.

Image courtesy of NOAA.

In-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom. Cloud-to-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom of a second cloud. Cloud-to-ground lightning is the most dangerous. In summertime, most cloud-to-ground lightning occurs between the negative charges near the bottom of the cloud and positive charges on the ground.

According to NOAA's National Weather Service, there is an average of 100,000 thunderstorms per year in the United States. An average of 33 people per year died from lightning strikes in the United States from 2004 to 2013. Most lightning deaths and injuries occur outdoors, with 45% of lightning casualties occurring in open fields and ballparks, 23% under trees, and 14% involving water activities. The historic record of lightning strikes both in the SCCOG region is presented in Section 6.3.

Downbursts

A downburst is a severe localized wind blasting down from a thunderstorm. They are more common than tornadoes in Connecticut. Depending on the size and location of downburst events, the destruction to property may be significant.

Downburst activity is, on occasion, mistaken for tornado activity. Both storms have very damaging winds (downburst wind speeds can exceed 165 miles per hour) and are very loud. These "straight line" winds are distinguishable from tornado activity by the pattern of destruction and debris such that the best way to determine the damage source is to fly over the area.

Downbursts fall into two categories:

- *Microbursts affect an area less than 2.5 miles in diameter, last five to 15 minutes, and can cause damaging winds up to 168 mph.*
- *Macrobursts affect an area at least 2.5 miles in diameter, last five to 30 minutes, and can cause damaging winds up to 134 mph.*

It is difficult to find statistical data regarding frequency of downburst activity. NOAA claims that there are 10 downburst reports for every tornado report in the United States. This implies that there are approximately 10,000 downbursts reported in the United States each year and further implies that downbursts occur in approximately 10% of all thunderstorms in the United States annually. This value suggests that downbursts are a relatively uncommon yet persistent hazard. A few downbursts have occurred in the region as reported in the historic record in Section 6.3.

Hail

Hailstones are chunks of ice that grow as updrafts in thunderstorms keep them in the atmosphere. Most hailstones are smaller in diameter than a dime, but stones weighing more than 1.5 pounds have been recorded. NOAA has estimates of the velocity of falling hail ranging from nine meters per second (m/s) (20 mph) for a one centimeter (cm) diameter hailstone, to 48 m/s (107 mph) for an eight cm, 0.7 kilogram stone. While crops are the major victims of hail, larger hail is also a hazard to people, vehicles, and property.

According to NOAA's National Weather Service, hail caused two deaths and an average of 27 injuries per year in the United States from 2004 to 2013. Hailstorms typically occur in at least one part of Connecticut each year during a severe thunderstorm. Hail storms have occurred in the SCCOG region as reported in the historic record in Section 6.3.

6.3 Regional Historic Record

Connecticut has had 50 confirmed tornado events since 1960. The most vulnerable area of the state is Litchfield County and Hartford County based on historical accounts. Only three tornadoes have been reported in the SCCOG region. Inland areas are generally more vulnerable to tornadoes that coastal areas, since sea breezes have the effect of defusing tornadoes.

An extensively researched list of tornado activity in Connecticut is available on Wikipedia. This list extends back to 1648 although it is noted that the historical data prior to 1950 is incomplete due to lack of official records and gaps in populated areas. Of the three total tornado events affecting the SCCOG Region, one occurred in 1799, one occurred in 1918, and one occurred in 2002. Thus, the frequency of occurrence is very low. Details regarding these tornados are as follows:

- August 2, 1799: A tornado affected the towns of Franklin, Lebanon, and Bozrah, destroying two homes.
- September 18, 1918: A tornado cut a wide path (130 to 160 feet wide) from Groton through Mystic and out into Long Island Sound. Small buildings, roofs, trees, and telephone poles were heavily damaged, and several people received minor injuries from flying debris.
- June 16, 2002: A waterspout formed over Gardner Lake in Montville, causing F1 damage to trees, houses, and cars when it made landfall.

Thunderstorms occur on 18 to 35 days each year in Connecticut. Only 17 lightning-related fatalities occurred in Connecticut between 1959 and 2009. For example, on June 8, 2008, lightning struck a pavilion at Hammonasset Beach in nearby Madison, Connecticut, injuring five and killing one. Hail is often a part of such thunderstorms as seen in the historic record for the SCCOG region. A limited selection of summer storm damage in and around SCCOG jurisdictions taken from the NCDC Storm Events database is listed in each community annex.

6.4 Existing Capabilities

Warning is the most viable and therefore the primary method of existing mitigation for tornadoes and thunderstorm-related hazards in Connecticut. The NOAA National Weather Service issues watches and warnings when severe weather is likely to develop or has developed, respectively. After a series of deadly tornadoes struck Litchfield and New Haven counties on July 10, 1989, killing two persons and causing millions of dollars in damage, Connecticut installed a new type of warning system. The National Oceanic and Atmospheric Administration (NOAA) Weather Radio Specific Area Message Encoder (WRSAME) system allows forecasters at three National Weather Service (NWS) offices to send watches and warnings to specific areas of Connecticut. Warnings can be sent within a few minutes of a Doppler radar indication that at a tornado may be forming within a severe thunderstorm. Tables 6-3 and 6-4 list

the NOAA Watches and Warnings, respectively, as pertaining to actions to be taken by emergency management personnel in connection with summer storms and tornadoes.

Table 6-3: NOAA Weather Watches

Weather Condition	Meaning	Actions
Severe Thunderstorm	Severe thunderstorms are possible in your area.	Notify personnel and watch for severe weather.
Tornado	Tornadoes are possible in your area.	Notify personnel and be prepared to move quickly if a warning is issued.
Flash Flood	It is possible that rains will cause flash flooding in your area.	Notify personnel to watch for street or river flooding.

Table 6-4: NOAA Weather Warnings

Weather Condition	Meaning	Actions
Severe Thunderstorm	Severe thunderstorms are occurring or are imminent in your area.	Notify personnel and watch for severe conditions or damage (i.e., downed power lines and trees). Take appropriate actions listed in municipal emergency plans.
Tornado	Tornadoes are occurring or are imminent in your area.	Notify personnel, watch for severe weather, and ensure personnel are protected. Take appropriate actions listed in emergency plans.
Flash Flood	Flash flooding is occurring or imminent in your area.	Watch local rivers and streams. Be prepared to evacuate low-lying areas. Take appropriate actions listed in emergency plans.

Many SCCOG jurisdictions have weather alert radios in their EOCs. These radios are used in conjunction with the apparatus systems in coastal areas to warn residents of incoming severe weather and for evacuations when necessary.

A severe thunderstorm watch is issued by the National Weather Service when the weather conditions are such that a severe thunderstorm (winds greater than 58 miles per hour, or hail three-fourths of an inch or greater, or can produce a tornado) is likely to develop.

A severe thunderstorm warning is issued when a severe thunderstorm has been sighted or indicated by weather radar.

Aside from warnings, several other methods of mitigation for wind damage are employed in the SCCOG region as explained in Section 5.4 within the context of hurricanes and tropical storms. In addition, the Connecticut State Building Code and the International Building Code includes guidelines for the proper grounding of buildings and electrical boxes.

6.5 Vulnerabilities and Risk Assessment

According to the *2014 Connecticut Natural Hazard Mitigation Plan Update*, New London County and Windham County have the lowest risk to experience tornado damage out of all the counties in the State. As shown in the historic record, tornado activity in the region occurs approximately once every 100

years. However, NOAA states that climate change has the potential to increase the frequency and intensity of tornadoes, so it is possible that the pattern of occurrence in southeastern Connecticut could change in the future.

Given the limited occurrence of tornadoes in Connecticut and the SCCOG region in particular, the magnitude and extent of tornado damage is not sufficient to justify the construction of tornado shelters or safe rooms. Instead, the State has provided NOAA weather radios to all public schools as well as to many local governments for use in public buildings. The general public continues to rely on mass media for knowledge of weather warnings. Warning time for tornadoes is very short due to the nature of these types of events, so pre-disaster response time can be limited. However, the NOAA weather radios provide immediate notification of all types of weather warnings in addition to tornadoes, making them very popular with communities.

The central and southern portions of the United States are at higher risk for lightning and thunderstorms than is the northeast. However, FEMA reports that more deaths from lightning occur on the East Coast than elsewhere. This may be due to the relatively higher population density along the east coast as compared to the Midwest and southern portions of the United States. Lightning-related fatalities have declined in recent years due to increased education and awareness.

In general, thunderstorms and hailstorms in Connecticut are more frequent in the western and northern parts of Connecticut and slightly less frequent in the southern and eastern parts. Thunderstorms are expected to impact the SCCOG region at least 18 days each year. The majority of these events do not cause any measurable damage. Although lightning is usually associated with thunderstorms, it can occur on almost any day. The likelihood of lightning strikes in the SCCOG region is very high during any given thunderstorm although no particular area of the region is at higher risk of lightning strikes. The risk of at least one hailstorm occurring in the region is considered moderate in any given year.

Most thunderstorm damage is caused by straight-line winds exceeding 100 mph. Straight-line winds occur as the first gust of a thunderstorm or from a downburst from a thunderstorm and have no associated rotation. The risk of downbursts occurring during such storms and damaging the region is believed to be moderate for any given year. All areas of the region are susceptible to damage from high winds although more building damage is expected in densely-populated inland areas and coastal neighborhoods.

Experience in the SCCOG region has generally shown that winds in excess of 50 mph will cause significant tree damage. The damage to buildings and electrical and cable utilities due to downed trees has historically been the biggest problem associated with wind storms. Heavy winds can take down trees near power lines, leading to the start and spread of fires. Most downed power lines in the region are detected quickly and any associated fires are quickly extinguished. Such fires can be extremely dangerous during the summer months during dry and drought conditions.

6.5.1 Loss Estimates

The *2014 Connecticut Natural Hazards Mitigation Plan Update* provides annual estimated losses on a countywide basis for several hazards. That Plan does not include any annualized estimated losses in New London County from tornado events, but in neighboring Windham County the annualized loss estimate is $84,682. The annualized number of tornado events in each county is very similar (0.06 in New London County, 0.05 in Windham County). For the purposes of estimated future losses, it was deemed reasonable to extrapolate the Windham County annualized losses to New London County.

Annualized losses due to tornadoes were estimated for each SCCOG community based on each community's population relative to their own county, using the countywide annualized loss estimate of $84,682 as a starting point. The annualized loss estimates for tornadoes are summarized in Table 6-5 below. Based on these figures, the annualized loss due to tornadoes in the SCCOG region is $92,319.41. This estimate for tornado damages is relatively low despite high costs from individual events due to the infrequency of their occurrence. The regional annualized loss was divided by the population ratio of each jurisdiction to its respective county in order to determine annualized losses to each SCCOG jurisdiction.

Annualized losses due to thunderstorms were estimated based on each community's population relative to their own county, and the annualized loss estimate presented in the 2014 CT NHMP for New London County ($38,251) and Windham County ($47,026). The annualized loss estimates for tornadoes and thunderstorms are summarized in Table 6-5, below. Based on these figures, the annualized loss due to thunderstorms in the SCCOG region is $43,573.08. The regional annualized loss was divided by the population ratio of each jurisdiction to its respective county in order to determine annualized losses to each SCCOG jurisdiction.

In summary, the entire region is at relatively equal risk for experiencing damage from summer storms and tornadoes. Based on the historic record, only a few summer storms or tornadoes have resulted in costly damages to the region's jurisdictions. Most damages are relatively site-specific and occur to private property (and therefore are paid for by private insurance). For municipal property, each local government's budget for tree removal and minor repairs is generally limited to handle routine summer storm damage.

Table 6-5: Estimated Annualized Losses from Thunderstorms & Tornadoes

Community	Estimated Annual Costs		
	Thunderstorms	Tornadoes	TOTAL
Bozrah	$366.66	$811.73	$2,245.10
Colchester	$2,242.68	$4,964.95	$13,732.11
East Lyme	$2,674.10	$5,920.06	$16,373.75
Franklin	$268.26	$593.89	$1,642.59
Griswold	$1,181.36	$2,615.35	$7,233.54
Groton City	$1,311.30	$2,903.02	$8,029.20
Groton Town	$4,287.72	$9,492.37	$26,254.07
Jewett City	$486.70	$1,077.47	$2,980.08
Lebanon	$1,020.01	$2,258.15	$6,245.60
Ledyard	$2,100.73	$4,650.70	$12,862.96
Lisbon	$605.47	$1,340.43	$3,707.36
Mashantucket Pequot Tribal Nation	$46.06	$101.97	$282.03
Mohegan Tribe	$14.66	$32.44	$89.74
Montville	$843.17	$1,866.65	$5,162.79
New London	$2,731.61	$6,047.37	$16,725.86
North Stonington	$739.32	$1,636.75	$4,526.95
Norwich	$5,651.78	$12,512.19	$34,606.32
Preston	$659.63	$1,460.32	$4,038.96
Salem	$579.37	$1,282.64	$3,547.55
Sprague	$416.49	$922.05	$2,550.20
Stonington Borough	$129.66	$287.06	$793.95
Stonington Town	$2,458.74	$5,443.28	$15,055.07
Waterford	$2,724.07	$6,030.68	$16,679.71
Windham	$10,033.55	$18,067.90	$28,101.44
SCCOG TOTAL	**$43,573.08**	**$92,319.41**	**$233,466.90**

6.6 Potential Mitigation Strategies and Actions

Most of the mitigation activities for summer storm and tornado wind damage are similar to those discussed in Section 5.6 and are not reprinted here. Public education is the best way to mitigate damage from hail, lightning, and tornadoes. In addition to other educational documents, local Building Officials should make literature available regarding appropriate design standards for grounding of structures.

Both the FEMA and the NOAA websites contain valuable information regarding preparing for and protecting oneself during a tornado as well as information on a number of other natural hazards. Available information from FEMA includes:

- Design and construction guidance for creating and identifying community shelters;
- Recommendations to better protect your business, community, and home from tornado damage, including construction and design guidelines for structures;
- Ways to better protect property from wind damage;
- Ways to protect property from flooding damage; and

- Construction of safe rooms within homes.

NOAA information includes a discussion of family preparedness procedures and the best physical locations during a storm event. Although tornadoes pose a legitimate threat to public safety, as stated earlier their occurrence is considered too infrequent in Connecticut to justify the construction of tornado shelters. Residents should instead be encouraged to purchase a NOAA weather radio containing an alarm feature.

Most communities in the region utilize the State's CT "Everbridge" Reverse 911 emergency notification system to send geographically specific telephone warnings into areas at risk for hazard damage. This is extremely useful for natural hazard mitigation as a community warning system that relies on radios and television is less effective at warning residents during the night when the majority of the community is asleep. This fact was evidenced by a severe storm that struck Lake County, Florida on February 2, 2007 and the recent storms that struck Alabama in spring 2010. These powerful storms, which included several tornadoes, struck at night. In the case of the Florida storm, local broadcast stations had difficultly warning residents due to the lack of listeners and viewers, and encouraged those awake to telephone warnings into the affected area.

7.0 WINTER STORMS AND NOR'EASTERS

7.1 Setting

Similar to summer storms and tornadoes, winter storms have the potential to affect any part of the region. However, unlike summer storms, winter events and the hazards that result (wind, snow, and ice) have more widespread geographic extent. The entire region is therefore susceptible to winter storms and due to its location on the shoreline can have more snowfall totals during ocean-effect snowstorms. In general, winter storms are considered highly likely to occur each year (major storms are less frequent), and the hazards that result (nor'easter winds, snow, and blizzard conditions) can potentially have a significant effect over a large area of the region.

7.2 Hazard Assessment

This section focuses on those effects commonly associated with winter storms, including those from blizzards, ice storms, heavy snow, freezing rain, and extreme cold. Most deaths from winter storms are indirectly related to the storm, such as from traffic accidents on icy roads and hypothermia from prolonged exposure to cold. Damage to trees and tree limbs and the resultant downing of utility cables are a common effect of these types of events. Secondary effects include loss of power and heat.

According to the National Weather Service, approximately 70% of winter deaths related to snow and ice occur in automobiles, and approximately 25% of deaths occur from people being caught in the cold. In relation to deaths from exposure to cold, 50% are people over 60 years old, 75% are male, and 20% occur in the home.

The classic winter storm in New England is the nor'easter, which is caused by a warm, moist, low-pressure system moving up from the south colliding with a cold, dry high-pressure system moving down from the north. The nor'easter derives its name from the northeast winds typically accompanying such storms, and such storms tend to produce a large amount of precipitation.

Severe winter storms can produce an array of hazardous weather conditions, including heavy snow, blizzards, freezing rain and ice pellets, flooding, heavy winds, and extreme cold. The National Weather Service defines a blizzard as having winds over 35 mph with snow with blowing snow that reduces visibility to less than one-quarter mile for at least three hours. Along the coast, wind driven waves can batter the shore, causing flooding and severe beach erosion. Coupled with a high tide, the low pressure of a nor'easter can have an effect similar to a storm surge from a hurricane.

Connecticut experiences at least one severe winter storm every five years although a variety of small and medium snow and ice storms occur every winter. The likelihood of a nor'easter occurring in any given winter is therefore considered high, and the likelihood of other winter storms occurring in any given winter is very high.

Until recently, the Northeast Snowfall Impact Scale (NESIS) was used by NOAA to characterize and rank high-impact northeast snowstorms. This ranking system has evolved into the currently used Regional Snowfall Index (RSI). The RSI ranks snowstorms that impact the eastern two thirds of the United States, placing them in one of five categories: Extreme, Crippling, Major, Significant, and Notable. The RSI is

based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. RSI differs from NESIS in that it uses a more refined geographic area to define the population impact. NESIS had used the population of the entire two-thirds of the United States in evaluating impacts for all storms whereas RSI has refined population data into six regions. The result is a more region-specific analysis of a storm's impact. The use of population in evaluating impacts provides a measure of societal impact from the event. Table 7-1 presents the RSI categories, their corresponding RSI values, and a descriptive adjective.

Table 7-1: RSI Categories

Category	RSI Value	Description
1	1-3	Notable
2	3-6	Significant
3	6-10	Major
4	10-18	Crippling
5	18.0+	Extreme

Connecticut experiences at least one severe winter storm every five years although a variety of small and medium snow and ice storms occur nearly every winter. The likelihood of a nor'easter occurring in any given winter is therefore considered high, and the likelihood of other winter storms occurring in any given winter is very high.

RSI values are calculated within a GIS. The aerial distribution of snowfall and population information are combined in an equation that calculates the RSI score, which varies from around one for smaller storms to over 18 for extreme storms. The raw score is then converted into one of the five RSI categories. The largest RSI values result from storms producing heavy snowfall over large areas that include major metropolitan centers. Approximately 203 of the most notable historic winter storms to impact the Northeast have been analyzed and categorized by RSI through March 2017.

7.3 Regional Historic Record

Thirteen major winter nor'easters have occurred in Connecticut during the past 30 years (in 1988, 1992, 1996, 2003, 2006, 2009, 2010, two in 2011, 2013, 2015, 2016 and 2017). According to the NCDC, there have been over 85 major snow and ice events in the state of Connecticut between January 2000 and March 2015, causing over $22.6 million in damages. Notably, the historic Nor'easter of October 2011 (Winter Storm Alfred) caused power outages, cell-phone tower damage, air travel disruptions, loss of livestock, and an estimated $11 million in damages.

Winter Storm Ginger in 1996 caused up to 27 inches of snow in 24 hours and shut down the state of Connecticut for an entire day. Other storms have also been powerful. A 1992 nor'easter, in particular, caused the third-highest tides ever recorded in Long Island Sound and damaged 6,000 coastal homes.

Inland areas received up to four feet of snow. "Winter Storm Alfred" in October 2011 caused power outages of up to ten days in northern Connecticut. Some of the SCCOG communities suffered similar damage from Winter Storm Alfred and Tropical Storm Irene within a two-month period.

According to the NCDC, there have been 134 snow and ice events in the state of Connecticut between 1993 and April 2010, causing over $18 million in damages. Heavy snowfall is relatively rare in the SCCOG region due to the relatively low elevations in the region and the close proximity of the warm waters of Long Island Sound. Similarly, catastrophic ice storms are less frequent in Connecticut than the rest of New England due to the close proximity of the warmer waters of the Atlantic Ocean and Long Island Sound. The most severe ice storm in Connecticut on record was Ice Storm Felix on December 18, 1973. This storm resulted in two deaths and widespread power outages throughout the state.

Examples of recent winter storms to affect New London County selected from the NCDC database include:

- East Coast Winter Storm, March 13-14, 1993 – A powerful storm with record low barometric pressure readings hit the state with blizzard conditions. Gale force winds accompanied by snow drifts several feet deep closed businesses, hindered travel, and forced residents to lose power. Federal aid was given to the state for snow removal.
- Heavy Snowstorm, January 6-7, 1994 – An extended period of snowfall led to a change to sleet and freezing rain along the coastline, which hindered travel, closed schools, led to a loss of power for many residents in southeastern Connecticut, and resulted in downed tree limbs and power lines.
- Ocean-Effect Heavy Snow Storm, April 10, 1996 – Heavy, wet snow fell across most of Southeastern Connecticut where numerous trees and power lines fell.
- Heavy Snow Storm, February 5, 2001 – Wet snow resulted in large-scale power outages because of downed power lines from fallen tree limbs and caused travel in southern Connecticut to become treacherous as numerous traffic accidents occurred.
- Winter Storm, March 4-7, 2001 – A slow-moving, large-scale winter storm subjected southern Connecticut to heavy wet snow and numerous power outages as snowfall totals were around 14 inches in Old Saybrook. Over $5 million in damages were reported throughout the State.
- February Heavy Snowstorm, February 16-17, 2003 – Heavy snow became widespread and was blown by northeast winds 20 to 30 mph causing near blizzard conditions. Travel almost ceased entirely, and widespread minor tidal flooding occurred along the Connecticut shoreline as Old Saybrook saw a total of almost 16 inches of total snowfall.
- Heavy Snow, January 22-23, 2005 – An intense low produced near blizzard conditions, strong and gusty winds, and blowing and drifting snow and caused minor to moderate local tidal flooding along the shoreline.
- Winter Storm, February 14, 2007 – A mix of heavy snow, sleet, freezing rain, strong gusty winds, and minor tidal flooding occurred along the coast of the state throughout the day.
- The snowfall, sleet, freezing rain, and rain that fell on Connecticut during the 2010-2011 winter season proved to be catastrophic for a number of buildings throughout the State. With severely low temperatures coupled with the absence of the removal of snow and ice buildup from roofs of

buildings in Connecticut, numerous roofs collapsed during the winter season. A list of 76 roof/building collapses and damage due to buildup of frozen precipitation was compiled from various media reports from January 12, 2011 to February 17, 2011. As a result of the roof and building collapses, injury to humans, animals, and property took place. The overall storm impacts and damages resulted in Presidential Disaster Declaration #1958 for Connecticut. The winter storms of January and February 2011 are listed as the 18th and 19th storms and given a "Major" description in the NESIS ranking. These storms produced snow, sleet, freezing rain, strong gusty winds, severely low temperatures, and coastal flooding. Snowfall totals for winter 2010-2011 in Southeastern Connecticut averaged around 70 inches.

Although roof collapses were limited in the SCCOG region, several were observed and recorded as noted in Table 7-2.

Table 7-2: Reported Roof Collapse Damage, January-February 2011

Municipality	Description
Bozrah	Kofkoff Egg Farm
Colchester	Butler Construction Equipment
Griswold	Residential homes and mobile homes (several)
Ledyard	Residential home
New London	575 Bank Street building (commercial/residential)
Norwich	Vacant school
Norwich	Vacant school
Norwich	Perry's Carpets
Salem	Barn
Stonington	Connecticut Castings
Voluntown	Barn
Waterford	Shell gasoline service station
Waterford	Aaron's shopping center

In addition, many structures in the SCCOG communities were in danger of collapse and were cleared to prevent collapse or damage, such as the Stop & Shop Supermarket in Montville and 12 homes in Colchester. In general, damage was more severe in the northern and western part of the region.

- Winter Storm Alfred (the "2011 Halloween nor'easter") struck Connecticut on October 29, 2011. This storm compounded the tree damage experienced during Hurricane Irene two months earlier by producing heavy winds and up to 19 inches of snow in the State. The combination of heavy snowfall and downed branches caused widespread power outages throughout Connecticut. Electrical service was lost for over a week in some locations, and over 830,000 people were left without power in Connecticut following the storm. The SCCOG region was spared the brunt of this storm, with most locations receiving only limited snow and tree damage and having power outages up to three days in length.
- 12/29/2012 – A complex low pressure system entering the Ohio Valley on December 28th transferred its energy to a secondary low along the North Carolina coast on the 29th. The secondary low intensified into a nor'easter off the Mid-Atlantic and New England coasts later on the 29th, and brought heavy snow to most of southern Connecticut. Spotters and state DOT measured 8 to 9 inches of snowfall in Southern New London County and 9 to 12 inches of snowfall in Northern New London.

- February 8, 2013 – A fierce nor'easter (dubbed "Nemo" by the Weather Channel) brought blizzard conditions to most of the Northeast, producing snowfall rates of 5 to 6 inches per hour in parts of Connecticut. Three consecutive hours of blizzard conditions dropped 2-3 feet of snow. Winds also gusted over 50 mph at Groton Airport and the storm caused more than 850,000 power outages. All roads in Connecticut were closed for 2 days. This storm was ranked as a "Crippling" storm by RSI. The overall storm impacts and damages resulted in a Presidential Disaster Declaration for Connecticut. Snowfall totals ranged from 15 inches in Stonington to 22 inches in Ledyard Center to as much as 31 inches in Colchester.
- January 26, 2015 – A strong Nor'easter (named Winter Storm Juno) brought heavy snow and strong winds to Southern Connecticut, with blizzard conditions in New London County. Trained spotters and Connecticut DOT reported snowfall of 16 to 26 inches. North winds gusted up to 45 mph at Groton-New London Airport, with blowing and drifting of snow. Groton-New London Airport experienced blizzard conditions, with 1/4 mile visibility in heavy snow and north winds gusting frequently over 35 mph, from about 4 AM until about 9 AM. Nearby Willimantic Airport experienced blizzard conditions, with 1/4 mile visibility in heavy snow and north winds gusting frequently over 35 mph, from about 630 AM until about 930 AM.
- 1/23/2016: Low pressure moving across the Deep South intensified and moved off the Mid Atlantic coast on Saturday January 23rd, bringing heavy snow and strong winds to all of southern Connecticut, and blizzard conditions to some coastal locations. The public and Connecticut DOT reported snowfall ranging from 7 to 8 inches. Groton ASOS (KGON) reported near blizzard conditions from 9 AM until 5 PM, where winds also gusted to 45 mph. The U.S. Coast Guard Academy in New London reported strong northerly winds sustained at 39 mph and gusting to 50 mph between 9 PM and 10 PM. An automated weather station at Stonington also reported strong northeast winds, sustained at 33 mph at 10:10 AM, and gusting to 45 mph at 12:40 PM. The public and Connecticut DOT reported snowfall ranging from 5 to 14 inches. Nearby Groton ASOS (KGON) reported near blizzard conditions from 9 AM until 5 PM.

7.4 Existing Capabilities

Existing programs applicable to winter storm winds are the same as those discussed in Sections 5.0 and 6.0. Programs that are specific to winter storms are generally those related to preparing plows and sand and salt trucks; tree trimming and maintenance to protect power lines, roads, and structures; and other associated snow removal and response preparations.

As it is almost guaranteed that winter storms will occur annually in Connecticut, it is important for municipalities to budget fiscal resources toward snow management. Each SCCOG jurisdiction ensures that all warning/notification and communications systems are ready before a storm and ensures that appropriate equipment and supplies, especially snow removal equipment, are in place and in good working order.

The Connecticut Building Code specifies that a pressure of 30 pounds per square foot (psf) be used as the base "ground snow load" for computing snow loading for different types of roofs. The International Building code specifies the same pressure for habitable attics and sleeping areas, and specifies a

minimum pressure of 40 psf for all other areas. As a result of the winter of 2010-2011, it is anticipated many communities developed and programs and procedures for roof snow removal.

Collectively, the Connecticut DOT and local public works departments conduct the majority of plowing in the region, with the Connecticut DOT restricted to plowing State routes. Tribal authorities maintain roads on tribal lands. Although private communities are responsible for plowing their own roads, some SCCOG municipalities provide these services where it is difficult to discern the division between private and public roads. Specific capabilities of each jurisdiction are listed in each respective community annex.

7.5 Vulnerabilities and Risk Assessment

Winter storm hazards in the region are potentially significant and regularly cause moderate to high levels of costs including power outages and transportation disruption. Actual direct damages are normally limited under most winter storms to impact the region as the SCCOG region receives generally less snowfall than most of the state. However, as mentioned in Sections 5.0 and 6.0, many roadways in the SCCOG region are heavily treed. Many tree limbs on roadways are not suited to withstand high wind and snow or ice loads. During extreme winters, snow loading on roofs is also an issue. Although snowdrifts do occur in the region, they are not a substantial issue.

Winter storms present some potentially unique transportation vulnerabilities. There is a high propensity for traffic accidents during heavy snow and even light icing events. Roads may become impassable, inhibiting the ability of emergency equipment to reach trouble spots as well as the accessibility to medical and shelter facilities. Stranded motorists, especially senior and/or handicapped citizens, are at a particularly high risk during a blizzard.

Recall from Section 2-6 that elderly and persons with disabilities reside in the region. It is almost certain that populations impacted by a winter storm in the region would consist of the elderly and numerous people with disabilities. Thus, it is important for the jurisdictions in the region to be prepared to assist these special populations during winter storms.

Regarding coastal flooding, the same vulnerable populations discussed in Section 4.5 are vulnerable to flooding caused by nor'easters. Further "flood" damage could be caused in individual homes by freezing and breaking of water pipes.

7.5.1 Loss Estimates

2014 Connecticut Natural Hazards Mitigation Plan

The *2014 Connecticut Natural Hazards Mitigation Plan Update* provides annual estimated losses on a countywide basis for several hazards, including winter storms. However, damages were not reported to the NCDC for winter storms affecting New London County as of 2014. The annualized loss estimate for winter storms in Windham County from the NCDC data is reported as $432,441. For the purposes of estimated future losses, it was deemed reasonable to extrapolate the Windham County annualized losses to New London County (as was done for tornadoes).

Annualized losses were estimated for each SCCOG community based on each community's population relative to their own county, using the countywide annualized loss estimate of $432,441 as a starting point. The annualized loss estimates for winter storms are summarized in Table 7-3 below. Based on these figures, the annualized loss due to winter storms in the SCCOG region is $92,319.41.

Table 7-3: Estimated Annualized Losses from Winter Storms Based on NCDC Data

Community	Winter Storm Losses
Bozrah	$4,145.24
Colchester	$25,354.26
East Lyme	$30,231.66
Franklin	$3,032.79
Griswold	$13,355.64
Groton City	$14,824.70
Groton Town	$48,474.17
Jewett City	$5,502.26
Lebanon	$11,531.55
Ledyard	$23,749.50
Lisbon	$6,845.08
Mashantucket Pequot Tribal Nation	$520.72
Mohegan Tribe	$165.68
Montville	$9,532.31
New London	$30,881.77
North Stonington	$8,358.32
Norwich	$63,895.33
Preston	$7,457.32
Salem	$6,550.01
Sprague	$4,708.56
Stonington Borough	$1,465.90
Stonington Town	$27,796.90
Waterford	$30,796.56
Windham	$92,266.35
SCCOG TOTAL	**$471,442.57**

Public Assistance Reimbursements

Loss estimates for winter storms were also generated from Public Assistance reimbursement data. As noted in Table 2-1, there have been eight winter storm events since 2010 that resulted in federal disaster declarations in the SCCOG region. A summary is presented in Table 7-4 below. Recall that federal reimbursement of PA-eligible projects is only 75% of the cost.

Table 7-4: Public Assistance Grants Received for Winter Storm Events

SCCOG Jurisdiction	Local Government Cost	Other Local Agency Cost*	Total Cost
Bozrah	$51,996.33	None	$51,996.33
Colchester	$441,934.88	$3,830.00	$445,764.88
East Lyme	$537,118.59	None	$537,118.59
Franklin	$87,424.80	None	$87,424.80
Griswold	$275,282.04	None	$275,282.04
Groton, City of	$356,918.05	$3,438.00	$360,356.05
Groton, Town of	$589,811.01	$45,186.90	$634,997.91
Jewett City, Borough of	None	None	None
Lebanon	$215,195.81	None	$215,195.81
Ledyard	$316,918.40	$7,302.39	$324,220.79
Lisbon	$139,239.21	None	$139,239.21
Mashantucket Pequot Tribal Nation	$458,515.20	None	$458,515.20
Mohegan Tribe	$318,744.16	None	$318,744.16
Montville	$511,111.97	$25,096.39	$536,208.36
New London	$581,816.81	$135,578.10	$717,394.91
North Stonington	$168,088.44	None	$168,088.44
Norwich	$1,093,203.33	$211,321.75	$1,304,525,09
Preston	$130,409.40	None	$130,409.40
Salem	$154,232.83	None	$154,232.83
Sprague	$109,433.56	None	$109,433.56
Stonington, Borough of	$77,477.21	None	$77,477.21
Stonington, Town of	$429,962.64	$3,403.89	$433,366.53
Waterford	$698,349.52	$10,516.87	$708,866.39
Windham	$385,097.84	$268,892.95	$653,990.79
Total	**$8,128,282.03**	**$714,567.24**	**$7,538,324.19**

*Other agencies = Fire Districts, Schools, Housing Authorities, and other Non-Profit Agencies

Based on this data, the total losses due to winter storms is $7,538,324.19 since 1999. This gives annualized loss estimate of $418,795.79 for the SCCOG region. This figure does not account for most private property damage (which does not qualify for PA funding), nor for costs associated with typical winter activities (PA grants are only awarded following Presidentially-Declared disasters). This figure, therefore, likely underestimates actual winter storm losses and expenditures.

Summary

The entire region is at relatively equal risk for experiencing damage from winter storms, although some areas may be more susceptible. Most damages are relatively site-specific and affect private property, and therefore are paid for by private insurance. Repairs for power outages, a common impact of winter storms, are often widespread and difficult to quantify on the municipal level. For municipal property, budgets for plowing, roof clearing, and minor repairs are generally adequate to handle winter storm damage, although plowing budgets may be depleted in severe winters.

In particular, the heavy snowfalls associated with the winter of 2010-2011 stressed local plowing budgets and raised a high level of awareness of the danger that heavy snow poses to roofs. The snow

associated with Winter Storm Alfred in October 2011 and storm Nemo in February 2013 also had significant regional impacts and raised awareness of snow dangers.

Based on FEMA Public Assistance reimbursements, the annualized estimated loss due to winter storms is $418,795.79 per year. According to the annualized loss estimates generated by population based on the NCDC losses in the 2014 CT NHMP, the annualized estimated loss for winter storms is slightly higher at $471,442.57 per year. The 2014 CT NHMP NCDC winter storm estimates are utilized herein as an estimate of annualized loss for the SCCOG region as this value is higher and possibly takes into account unreported damages to private property that are not part of the Public Assistance information.

7.6 Potential Mitigation Strategies and Actions

Potential mitigation measures for storm surges and flooding caused by nor'easters include those appropriate for flooding. These were presented in Section 4.6 and are not repeated here. Likewise, wind-related mitigation was covered in Sections 5.6 and 6.6. However, winter storm mitigation measures must also address blizzards, snow, and ice hazards. These are emphasized in the following subsections. Note that natural resource protection and structural projects are generally not applicable categories of mitigation.

Prevention

Cold air, snow, and ice cannot be prevented from impacting any particular area. Thus, mitigation should be focused on property protection, infrastructure protection, emergency services (discussed below), and prevention of damage to structures and utilities as caused by breakage of tree limbs. Previous recommendations for tree limb inspections and maintenance in Section 5.6 are thus applicable to winter storm hazards as well. If utilities are underground, then heavy snow, ice, and winter winds cannot directly damage or destroy them.

Property Protection

Property can be protected during winter storms through the use of shutters, storm doors, storm windows, weather stripping, and other means of keeping cold air outdoors and heat indoors.

Where flat roofs are used on structures, snow removal is important as the heavy load from collecting snow may exceed the bearing capacity of the structure. During the extreme winter of 2010-2011, even sloping roofs throughout the State had trouble with snow loads. Heating coils may be used to melt snow from flat roofs, and rakes can be used to physically remove snow. Pipes should be adequately insulated to protect against freezing and bursting. All of these recommendations apply to new construction although they may also be applied to existing buildings during renovations.

Public Education and Awareness

Given the normal cycle of seasons as experienced in New England, including occasional severe winters, people are generally more prepared for the variety of winter storm hazards than they are with regard to other hazards discussed in this HMP. Nevertheless, people are still stranded in automobiles, get caught

outside their homes in adverse weather conditions, and suffer heart failure while shoveling during each winter in Connecticut. Public education should therefore focus on safety tips and reminders to individuals about how to prepare for cold weather.

Emergency Services

Plowing the access to and from critical facilities should be prioritized in each locality. Health and medical facilities, emergency services, and the shelters should be prioritized for plowing. It is recognized that these priorities may not match the expectations of residents as people typically expect their own roads to be cleared as soon as possible.

8.0 EARTHQUAKES

8.1 Setting

Even though earthquake damage has the potential to occur anywhere both in the region and in the northeastern United States, the effects may be felt differently in some areas based on the type of geology. In general, earthquakes are considered a hazard that may occur and would likely cause effects to a large area of the region. Furthermore, the Virginia earthquake of August 2011 reminded the nation that earthquake effects are transmitted great distances on the east coast.

8.2 Hazard Assessment

An earthquake is a sudden rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes can cause buildings and bridges to collapse; disrupt gas, electric, and telephone lines; result in dam failures; and often cause landslides, flash floods, fires, avalanches, and tsunamis. Earthquakes can occur at any time without warning.

The underground point of origin of an earthquake is called its focus; the point on the surface directly above the focus is the epicenter. The magnitude and intensity of an earthquake is determined by the use of the Richter scale and the Mercalli scale, respectively.

The Richter scale defines the magnitude of an earthquake. Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value recorded by a seismograph, which records the varying amplitude of ground oscillations.

The magnitude of an earthquake is determined from the logarithm of the amplitude of recorded waves. Being logarithmic, each whole number increase in magnitude represents a tenfold increase in measured strength. Earthquakes with a magnitude of about 2.0 or less are usually called microearthquakes and are generally only recorded locally. Earthquakes with magnitudes of 4.5 or greater are strong enough to be recorded by seismographs all over the world.

The effect of an earthquake on the Earth's surface is called the intensity. The Modified Mercalli Intensity Scale consists of a series of key responses such as people awakening, movement of furniture, damage to chimneys, and total destruction. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It is an arbitrary ranking based on observed effects. A comparison of Richter magnitude to typical Modified Mercalli intensity is presented in Table 8-1.

Table 8-1: Comparison of Earthquake Magnitude and Intensity

Richter Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II - III
4.0 to 4.9	IV - V
5.0 to 5.9	VI - VII
6.0 to 6.9	VII - IX
7.0 and above	VIII - XII

According to the Northeast States Emergency Consortium, earthquakes in the northeast do not necessarily occur along fault lines. Connecticut is located near the middle of the North American tectonic plate. As such, earthquakes with epicenters in Connecticut are referred to as intraplate activity.

Bedrock in Connecticut and New England in general is highly capable of transmitting seismic energy; thus, the area impacted by an earthquake in Connecticut can be four to 40 times greater than that of California. In addition, population density is up to 3.5 times greater in Connecticut than in California as a whole, potentially putting a greater number of people at risk.

The built environment in Connecticut includes old, non-reinforced masonry that is not seismically designed. Those who live or work in non-reinforced masonry buildings, especially those built on filled land or unstable soils are at the highest risk for injury due to the occurrence of an earthquake.

8.3 Regional Historic Record

Connecticut has the oldest record of earthquakes in the United States. The earliest settlers learned of seismic activity from the Native Americans dating back to 1568 in Moodus. According to the Northeast States Emergency Consortium and the Weston Observatory at Boston College, there were 139 recorded earthquakes in Connecticut between 1668 and 2011. Of those closest to the southeastern region, more than 60 were in the Moodus/East Haddam area in south-central Connecticut. The vast majority of these earthquakes had a magnitude of less than 3.0. As shown in the historic record below, strong, damaging earthquakes are relatively infrequent in Connecticut.

The following is a description of the 12 levels of Modified Mercalli intensity from the USGS:

I. Not felt except by a very few under especially favorable conditions.
II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V. Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Damage total. Lines of sight and level are destroyed. Objects thrown in the air.

The most severe earthquake in Connecticut's history occurred at East Haddam on May 16, 1791. Stone walls and chimneys were toppled during this quake and the USGS has estimated the damage as being an Intensity VII. Additional instances of seismic activity occurring in and around Connecticut are provided below based on information provided in USGS documents, the Weston Observatory, the 2010 *Connecticut Natural Hazard Mitigation Plan Update*, other municipal hazard mitigation plans, and newspaper articles.

- A devastating earthquake near Three Rivers, Quebec on February 5, 1663 caused moderate damage in parts of Connecticut.
- Strong earthquakes in Massachusetts in November 1727 and November 1755 were felt strongly in Connecticut.
- In April 1837, a moderate tremor occurred at Hartford, causing alarm but little damage.
- In August 1840, another moderate tremor with its epicenter 10 to 20 miles north of New Haven shook Hartford buildings but caused little damage.
- In October 1845, an Intensity V earthquake occurred in Bridgeport. An Intensity V earthquake would be approximately 4.3 on the Richter scale.
- On June 30, 1858, New Haven and Derby were shaken by a moderate tremor.
- On July 28, 1875, an early morning tremor caused Intensity V damage throughout Connecticut and Massachusetts.
- The second strongest earthquake to impact Connecticut occurred near Hebron on November 14, 1925. No significant damage was reported.
- The Timiskarning, Ontario earthquake of November 1935 caused minor damage as far south as Cornwall, Connecticut. This earthquake affected one million square miles of Canada and the United States.
- An earthquake near Massena, New York in September 1944 produced mild effects in Hartford, Marion, New Haven, and Meriden, Connecticut.
- An Intensity V earthquake was reported in Stamford in March 1953, causing shaking but no damage.
- On November 3, 1968, another Intensity V earthquake in southern Connecticut caused minor damage in Madison and Chester.
- Recent earthquake activity has been recorded near New Haven in 1988, 1989, and 1990 (2.0, 2.8, and 2.8 in magnitude, respectively), in Greenwich in 1991 (3.0 magnitude), and on Long Island in East Hampton, New York in 1992.
- The most recent noticeable earthquake to occur in Connecticut happened on March 11, 2008. It was a 2.0 magnitude with its epicenter three miles northwest of the center of Chester.
- A magnitude 5.0 earthquake struck at the Ontario-Quebec border region of Canada on June 23, 2010. This earthquake did not cause damage in Connecticut but was felt by residents in Hartford and New Haven Counties.

- A magnitude 3.9 earthquake occurred 117 miles southeast of Bridgeport, Connecticut on the morning of November 30, 2010. The quake did not cause damage in Connecticut but was felt by residents along Long Island Sound.
- A magnitude 5.8 earthquake occurred 38 miles from Richmond, Virginia on August 23, 2011. The quake was felt from Georgia to Maine and reportedly as far west as Chicago. Many residents of Connecticut experienced the swaying and shaking of buildings and furniture during the earthquake although widespread damage was constrained to an area from central Virginia to southern Maryland. According to Cornell University, the August 23 quake was the largest event to occur in the east central United States since instrumental recordings have been available to seismologists.
- An earthquake with a magnitude 2.1 was recorded near southeastern Connecticut on November 29, 2013. The earthquake did not cause damage but was felt by residents from Montville to Mystic.
- A magnitude 2.7 quake occurred beneath the town of Deep River on August 14, 2014.
- A series of quakes hit Plainfield, Connecticut on January 8, 9, and 12, 2015. These events registered magnitudes of 2.0, 0.4, and 3.1, respectively. Residents in the Moosup section of Plainfield reported minor damage such as the tipping of shelves and fallen light fixtures.

8.4 Existing Capabilities

The Connecticut Building Code and the International Building Code include design criteria for buildings specific to each municipality as adopted by BOCA. These include the seismic coefficients for building design in each jurisdiction. Tribal governments use similar coefficients from their building codes. Each jurisdiction has adopted these codes for new construction, and they are enforced by local Building Officials.

Due to the infrequent nature of damaging earthquakes, land use policies in the SCCOG region do not directly address earthquake hazards.

8.5 Vulnerabilities and Risk Assessment

According to Cornell University, the earth's crust is far more efficient at propagating seismic waves in the eastern United States than in the west, so even a moderate earthquake can be felt at great distances and over a larger region. The cause of intraplate earthquakes remains a fundamental mystery and this, coupled with the large areas affected, results in the August 2011 earthquake in Virginia to be of particular interest to seismologists.

Surficial earth materials behave differently in response to seismic activity. Unconsolidated materials such as sand and artificial fill can amplify the shaking associated with an earthquake. In addition, artificial fill material has the potential for liquefaction. When liquefaction occurs, the strength of the soil decreases, and the ability of soil to support building foundations and bridges is reduced.

Liquefaction is a phenomenon in which the strength and stiffness of a soil are reduced by earthquake shaking or other rapid loading. It occurs in soils at or near saturation and especially in finer textured soils.

Increased shaking and liquefaction can cause greater damage to buildings and structures and a greater loss of life.

As explained in Section 2.3, a notable area of the region is underlain by sand and gravel deposits. Figure 2-4 depicts surficial materials in the region. Structures in these areas are at increased risk from earthquakes due to amplification of seismic energy and/or collapse. The best mitigation for future development in areas of sandy material is the application of the most stringent building codes or the possible prohibition of new construction. However, many of these areas occur in floodplains associated with the major rivers and streams in the region so they are already regulated. The areas that are not at increased risk during an earthquake due to unstable soils are the areas in Figure 2-4 underlain by glacial till.

During a strong earthquake, ground shaking can result in areas of steep slopes to collapse resulting in landslides. Seismic activity can also break utility lines, such as water mains and electric and telephone lines, and stormwater management systems. Damage to utility lines can lead to fires, especially in electric and gas mains. Dam failure can also pose a significant threat to developed areas during an earthquake. For this HMP, dam failure has been addressed separately in Section 10.0.

The potential damage from an earthquake in the region is also high as a result of the age and type of many buildings, making them vulnerable. Older, poorly designed buildings are more at risk of experiencing damage from an earthquake than newer, well-designed buildings.

According to the 2014 *Connecticut Natural Hazard Mitigation Plan Update*, Connecticut is at a low or moderate risk for experiencing an earthquake of a magnitude greater than 3.5 and at a moderate risk of experiencing an earthquake of a magnitude less than 3.0 in the future. No earthquake with a magnitude greater than 3.5 has occurred in Connecticut within the last 35 years, and the USGS currently ranks Connecticut 43rd out of the 50 states for overall earthquake activity. Thus, it is generally believed that the State is a low-risk area.

Earthquake probability maps were generated using the interactive web-based mapping tools hosted by the USGS. These maps were used to determine the probability of an earthquake of greater than magnitude 5.0 or greater than magnitude 6.0 damaging the region. Results are presented in Table 8-2 below.

Table 8-2: Probability of a Damaging Earthquake in the Vicinity of the SCCOG Region

Time Frame (Years)	Equal or Greater than a Magnitude 5.0	Equal or Greater than a Magnitude 6.0
50	3.00%	0.30%
100	8.00%	0.50%
250	20.00%	1.50%
350	20.00%	2.00%

Based on the historic record and the probability maps generated from the USGS database, the state of Connecticut has areas of seismic activity. It is likely that Connecticut will continue to experience minor earthquakes (magnitude less than 3.0) in the future. While the risk of a major earthquake affecting the

region is relatively low over the short term, long-term probabilities suggest that a damaging earthquake (magnitude greater than 5.0) could occur within the region.

Two methods of estimating potential losses due to earthquake damage are considered herein. The first is based upon a statewide loss analysis conducted by FEMA. The 2014 CT NHMP also defined four "maximum plausible scenarios" for earthquake damage for use with the *HAZUS-MH* software. Loss estimates based on these methods are described in the following sections.

Statewide Loss Estimation

The AEL is the expected losses due to earthquakes each year. Note that this number represents a long-term average; thus, actual earthquake losses may be much greater or nonexistent for a particular year.

In the FEMA P-366 report, *HAZUS Estimated Annualized Earthquake Losses for the United States* (April 1, 2017), FEMA used probabilistic curves developed by the USGS for the National Earthquakes Hazards Reduction Program to calculate Annualized Earthquake Losses (AEL) for the United States. Based on the results of this study, FEMA calculated the AEL for Connecticut to be **$6,755,000**. This value placed Connecticut 34th out of the 50 states in terms of AEL. The magnitude of this value stems from the fact that Connecticut has a large building inventory that would be damaged in a severe earthquake and takes into account the lack of damaging earthquakes in the historical record.

The statewide AEL was utilized to determine annualized losses due to earthquake damage for the SCCOG region based on the ratio of the population of each SCCOG jurisdiction to the population of the state. Note that this analysis does not translate well to the two tribal nations which have significant commercial development but limited residential population. Table 8-3 presents the annualized loss estimates for the SCCOG region based on the AEL published by FEMA.

Table 8-3: Annualized Loss Estimates for Earthquakes from Statewide AEL

SCCOG Jurisdiction	Annualized Loss Estimate	SCCOG Jurisdiction	Annualized Loss Estimate
Bozrah	$4,965	Mohegan Tribe	$198
Colchester	$30,368	Montville	$11,417
East Lyme	$36,210	New London	$36,989
Franklin	$3,633	North Stonington	$10,011
Griswold	$15,997	Norwich	$76,531
Groton, City of	$17,756	Preston	$8,932
Groton, Town of	$58,060	Salem	$7,845
Jewett City, Borough of	$6,590	Sprague	$5,640
Lebanon	$13,812	Stonington, Borough of	$1,756
Ledyard	$28,446	Stonington, Town of	$33,294
Lisbon	$8,199	Waterford	$36,887
Mashantucket Pequot Tribal Nation	$624	Windham	$47,756
		Total	**$501,918**

HAZUS-MH Vulnerability Analysis

The 2014 *Connecticut Natural Hazard Mitigation Plan Update* simulated four "maximum plausible" earthquake scenarios (three historical, one potential) within *HAZUS-MH* to generate potential earthquake risk to the state of Connecticut. The same four scenarios were simulated within *HAZUS-MH* to generate potential damages in the SCCOG region from those events using the default year 2010 building inventories and census data. The four events are as follows and located on Figure 8-1:

- Magnitude 5.7, epicenter in Portland, Connecticut, based on historic event
- Magnitude 5.7, epicenter in Haddam, Connecticut, based on historic event
- Magnitude 6.4, epicenter in East Haddam, Connecticut, based on historic event
- Magnitude 5.7, epicenter in Stamford, Connecticut, magnitude based on USGS probability mapping

The results for each *HAZUS-MH* earthquake simulation are presented in Appendix D. These results are considered appropriate for planning purposes for the region. The range of potential impacts from any earthquake scenario is very large, ranging from minor impacts to the maximum possible impacts generated by *HAZUS-MH*. Note that potentially greater impacts could also occur.

Table 8-4 presents the total number of buildings damaged by each earthquake scenario. A significant percentage of building damage is to single-family residential buildings while other building types include agriculture, commercial, education, government, industrial, other residential, and religious buildings. The exact definition of each damage state varies based on building construction. See Chapter 5 of the HAZUS-MH *Earthquake Model Technical Manual*, available on the FEMA website, for the definitions of each building damage state based on building construction. The East Haddam event, in particular, would cause significant damage in Colchester, Salem, and other towns in the western portion of the SCCOG region.

Table 8-4: HAZUS-MH Earthquake Scenarios – Total Number of Buildings Damaged

Epicenter Location and Magnitude	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage	Total
Haddam – 5.7	11,509	3,912	737	143	16,301
Portland – 5.7	8,823	2,906	511	94	12,334
Stamford – 5.7	1,774	399	36	3	2,212
East Haddam – 6.4	26,196	15,859	6,622	4.186	48,681

The *HAZUS* simulations consider a subset of critical facilities termed "essential facilities," which are important during emergency situations. The list of essential facilities in the SCCOG region include nine EOCs, 46 fire stations, 23 police stations, 120 schools, and two hospitals. As shown in Table 8-5, minimal damage to essential facilities is expected for each earthquake scenario.

Table 8-5: HAZUS-MH Earthquake Scenarios – Essential Facility Damage

Epicenter Location and Magnitude	Emergency Operation Centers (Total of 9)	Fire Stations (Total of 49)	Police Stations (Total of 26)	Schools (Total of 132)	Hospitals (Total of 3)
Haddam – 5.7	Minor damage, only one with less than 50% functionality	Minor damage, only two with less than 50% functionality	Minor damage, only three with less than 50% functionality	Minor damage, only six with less than 50% functionality	Minor damage, 67% of beds in service initially, 84% after one week, 96% after 30 days
Portland – 5.7	Minor damage, only one with less than 50% functionality	Minor damage, no loss of use	Minor damage, only two with less than 50% functionality	Minor damage, only five with less than 50% functionality	Minor damage, 70% of beds in service initially, 86% after one week, 97% after 30 days
Stamford – 5.7	None or minor damage	None or minor damage	None or minor damage	None or minor damage	Minor damage, 90% of beds in service initially, 96% after one week, 99% after 30 days
East Haddam – 6.4	Five with at least moderate damage, one completely destroyed, none functional after one day.	22 with at least moderate damage, four completely destroyed, only two functional after one day	22 with at least moderate damage, three completely destroyed, only one functional after one day	76 with at least moderate damage, seven completely destroyed, only six functional after one day	Two with at least moderate damage, 25% of beds in service initially, 47% after one week, 75% after 30 days.

Table 8-6 presents potential damage to utilities and infrastructure based on the various earthquake scenarios. The region's transportation network and utility network were assumed by *HAZUS-MH* to include the following items:

- Highway: 347 major roadway bridges and 276 important highway segments
- Railway: Six important railway bridges, four facilities, and 76 important railway segments
- Light Rail: One facility and six important light rail segments;
- Bus: Five bus facilities;
- Ferry: Two ferry facilities;
- Port: 30 port facilities;
- Airport: Two airport facilities and four runways;
- A potable water system consisting of 11,322 kilometers of distribution lines
- A sanitary sewer system consisting of 12 facilities and 6,793 kilometers of distribution lines
- A total of 4,529 kilometers of natural gas distribution lines;
- A total of four electrical power facilities
- A total of 15 communication facilities.

Table 8-6: HAZUS-MH Earthquake Scenarios – Utility and Infrastructure Damage

Epicenter Location and Magnitude	Transportation Network	Utilities
Haddam – 5.7	Minor damage (no loss of service) to railways, light rail, bus, ferry, port, and airport infrastructure. • Three bridges with at least moderate damage, one out for more than a week. • Minor damage to remaining highway infrastructure. • $69.14 million dollars in bridge damages • Railway: $0.77 million in facility damage • Light rail: $0.20 million in facility damage • Bus: $0.63 million in facility damage • Ferry: $0.20 million in facility damage • Port: $4.59 million in facility damage • Airport: $1.34 million in facility damage	Minor damage to potable water, waste water, natural gas, oil system, electrical power, and communication facilities. • Potable Water: Loss of service to 34 households for one day. 333 leaks and 83 main breaks totaling $1.5 million. • Waste Water: 239 leaks and 60 main breaks totaling $1.07 million with an additional $16.49 million in facility damage • Natural Gas: 68 leaks and 17 main breaks totaling $0.31 million • Electrical: Loss of service to 2,060 households after 1 day, 285 after a week, 35 after a month. Facility damage totaling $13.90 million • Communication: Facility damage totaling $0.05 million
Portland – 5.7	Minor damage (no loss of service) to railways, light rail, bus, ferry, port, and airport infrastructure. • Five bridges with at least moderate damage, one out of service for more than one week. • Minor damage to remaining highway infrastructure. • $47.58 million dollars in bridge damages • Railway: $0.64 million in facility damage • Light rail: $0.12 million in facility damage • Bus: $0.62 million in facility damage • Ferry: $0.12 million in facility damage • Port: $2.81 million in facility damage Airport: $1.29 million in facility damage	Minor damage to potable water, waste water, natural gas, oil system, electrical power, and communication facilities. • Potable Water: 244 leaks and 61 main breaks. No loss of service. $1.1 million in line damage. • Waste Water: 175 leaks and 44 main breaks. $10.53 million in facility damage, $0.79 million in line damage. • Natural Gas: 50 leaks and 13 main breaks. $0.23 million in line damage. • Electrical: Loss of service to 1,940 households after 1 day, 223 after a week, 23 after a month. Facility damage totaling $8.13 million. Communication: Facility damage totaling $0.04 million.

TABLE 8-6 (Continued)
HAZUS-MH Earthquake Scenarios – Utility and Infrastructure Damage

Epicenter Location and Magnitude	Transportation Network	Utilities
Stamford – 5.7	Minor damage (no loss of service) to highways, railways, light rail, bus, ferry, port, and airport infrastructure. • Highway: $2.41 million dollars in bridge damages • Railway: $0.05 million in facility damage • Light rail: $0.01 million in facility damage • Bus: $0.03 million in facility damage • Ferry: $0.01 million in facility damage • Port: $0.32 million in facility damage • Airport: $0.10 million in facility damage	Minor damage (no loss of service) to potable water, waste water, natural gas, electrical power, or communication. • Potable Water: 45 leaks and 11 main breaks totaling $0.20 million • Waste Water: 32 leaks and 8 main breaks totaling $0.15 million with an additional $0.18 million in facility damage • Natural Gas: 9 leaks and 2 main breaks totaling $0.04 million • Electrical: Facility damage totaling $0.11 million. No loss of Service.
East Haddam – 6.4	Minor damage (no loss of service) to railways, light rail, ferry, port, and airport infrastructure. • Highway: At least 122 bridges with moderate damage, 16 completely destroyed, 119 non-functional after one day, 63 still non-functional after one week, $854.39 million dollars in bridge damages • Railway: $2.28 million in facility damage • Light rail: $0.55 million in facility damage • Bus: One facility with moderate damage and out of service for more than a week, $1.96 million in facility damage • Ferry: $0.55 million in facility damage • Port: $12.66 million in facility damage • Airport: $3.81 million in facility damage	Moderate damage to facilities and potential loss of service to many areas. • Potable Water: 3,053 leaks and 763 main breaks totaling $ 13.74 million, more than 32,500 households without water at incident, more than 22,500 without water after one week, all service restored within a month. • Waste Water: 2,188 leaks and 547 main breaks totaling $ 9.85 million. At least moderate damage, totaling $96.27 million, to two facilities. • Natural Gas: 628 leaks and 157 main breaks totaling $2.82 million; • Electrical: More than 29,000 households without electricity at incident, more than 7,500 still without electricity after one week, more than 1,700 households without electricity for more than one month, more than 30 households without power after three months. At least moderate damage to two facilities totaling $73.89 million. • Communication: At least moderate damage to seven facilities totaling $0.29 million.

As shown in Table 8-6, the Stamford scenario (which is the most distant from the SCCOG region) would result in relatively low damages to utilities and transportation elements in the SCCOG region as compared to the other earthquake scenarios. The Portland and Haddam scenarios would produce moderate damages but minor utility loss of service in the SCCOG region, with damages to highway bridges and waste water treatment facilities comprising the majority of damages. The East Haddam scenario would cause significant damages throughout the western portion of the SCCOG region. The

potable water system, wastewater system, and natural gas network will experience breaks leaks that will lead to extended loss of service in some areas.

Table 8-7 presents the estimated tonnage of debris that would be generated by earthquake damage during each *HAZUS-MH* scenario. As shown in Table 8-6, minor debris is expected for the Stamford scenario, while the Haddam and Portland scenarios would each produce a significant amount of debris. The East Haddam scenario would result in catastrophic damages that would require an extensive cleanup.

Table 8-7: HAZUS-MH Earthquake Scenarios – Debris Generation (Tons)

Epicenter Location and Magnitude	Brick / Wood	Reinforced Concrete / Steel	Total	Estimated Cleanup Truckloads (~25 Tons / Truck)
Haddam – 5.7	90,000	90,000	170,000	6,920
Portland – 5.7	70,000	60,000	120,000	4,960
Stamford – 5.7	10,000	None	20,000	720
East Haddam – 6.4	630,000	1,350,000	1,980,000	79,240

Table 8-8 presents the potential sheltering requirements based on the various earthquake events simulated by *HAZUS-MH*.

Table 8-8: HAZUS-MH Earthquake Scenarios – Shelter Requirements

Epicenter Location and Magnitude	Number of Displaced Households	Short-Term Sheltering Need (Number of People)
Haddam – 5.7	539	322
Portland – 5.7	391	238
Stamford – 5.7	41	25
East Haddam – 6.4	6,620	4,033

The predicted sheltering requirements for earthquake damage (not including any resultant fire damage) are relatively minimal for all scenarios with the exception of the East Haddam event. However, it is possible that an earthquake could also produce a dam failure (flooding) that could increase the overall sheltering need in the region. As noted in Section 2.11, estimated capacity of the existing sheltering facilities was more than 40,000 as of 2016. Displacement due to earthquake damage alone could likely be handled by the existing shelters. However, it is possible that sheltering capacity in the SCCOG region may be insufficient during an event such as the East Haddam scenario when one considers damage from the earthquake, fires, and potential dam failures. It is likely that regional shelters will be needed since communities closer to the epicenter of the earthquake will likely have damaged shelters or insufficient space to meet demand.

Table 8-9 presents the casualty estimates generated by *HAZUS-MH* for the various earthquake scenarios. Casualties are broken down into four severity levels that describe the extent of injuries. The levels are as follows:

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life threatening.
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

Table 8-9: HAZUS-MH Earthquake Scenarios – Casualty Estimates

Epicenter Location and Magnitude	Overnight (2 AM)				Afternoon (2 PM)				Rush Hour (5 PM)			
Severity Level	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Haddam – 5.7	104	17	2	3	270	57	8	14	174	37	9	9
Portland – 5.7	76	12	1	2	189	39	5	9	122	26	6	6
Stamford – 5.7	9	1	0	0	15	2	0	0	11	1	0	0
East Haddam – 6.4	1,350	358	53	103	4,137	1,205	191	363	2,612	790	208	233

The casualty categories include commuters, educational, hotels, industrial, other-residential, and single-family residential and are accounted for during the night, in the early afternoon, and during afternoon rush hour. As shown in Table 8-8, minimal casualties are expected for the Stamford scenario and these are all relatively minor injuries. The Haddam and Portland scenarios would result in a moderate amount of casualties with a handful of life-threatening cases and resultant deaths. The East Haddam scenario would produce significant casualties requiring a significant amount of people to be hospitalized with many deaths. It is likely that the hospitals in the region would be overwhelmed with people requiring medical attention and that assistance would be needed in relocating patients to other hospitals in Connecticut, Massachusetts, and Rhode Island.

Table 8-10 and Table 8-11 present the total estimated losses and direct economic impact that may result from the four earthquake scenarios created for the region as estimated by the *HAZUS-MH* software. Capital damage loss estimates include the subcategories of building, contents, and inventory damages. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building or its contents. Business interruption loss estimates include the subcategories of lost income, relocation expenses, and lost wages. The business interruption losses are associated with the inability to operate a business due to the damage sustained during a hurricane and also include temporary living expenses for those people displaced from their homes because of the storm. Note that these damages do not include transportation, utility, or fire damage in Table 8-6.

Table 8-10: HAZUS-MH Estimated Income Losses from Earthquake Scenarios

Epicenter Location and Magnitude	Wage Losses	Capital-Related Losses	Rental Losses	Relocation Losses
Haddam – 5.7	$40.77 million	$30.84 million	$30.91 million	$53.84 million
Portland – 5.7	$27.48 million	$21.03 million	$21.70 million	$37.44 million
Stamford – 5.7	$3.18 million	$2.32 million	$3.02 million	$4.45 million
East Haddam – 6.4	$402.33 million	$298.66 million	$265.92 million	$451.00 million

Table 8-11: HAZUS-MH Estimated Capital Stock Losses from Earthquake Scenarios

Epicenter Location and Magnitude	Structural Losses	Non-Structural Losses	Content Losses	Inventory Losses
Haddam – 5.7	$107.13 million	$359.09 million	$136.73 million	$3.00 million
Portland – 5.7	$76.41 million	$249.50 million	$92.87 million	$2.13 million
Stamford – 5.7	$9.34 million	$19.57 million	$3.79 million	$0.09 million
East Haddam – 6.4	$1,060.07 million	$3,0603.91 million	$1,350.58 million	$41.59 million

Table 8-12 sums the total losses resulting from each of the four earthquake scenarios. Note again that this does not include estimates for fire damages caused by the earthquake as this module is being updated. The total economic impact for the East Haddam scenario is approximately $8.5 billion. The total economic impact for the remaining scenarios is significantly less, with the Haddam scenario resulting in $1.0 billion in total economic impact, the Portland scenario resulting in $0.6 billion of total economic impact, and with the Stamford scenario having $49 million in economic impact.

Table 8-12: HAZUS-MH Estimated Building-Related Losses from Earthquake Scenarios

Epicenter Location and Magnitude	Total Income Losses	Total Capital Stock Losses	Total Transportation Losses	Total Utility Losses	Total Economic Impact
Haddam – 5.7	$156.36 million	$762.31 million	$76.90 million	$33.32 million	$1,028.89 million
Portland – 5.7	$107.65 million	$420.91 million	$53.20 million	$20.80 million	$602.56 million
Stamford – 5.7	$12.97 million	$32.79 million	$2.90 million	$0.68 million	$49.34 million
East Haddam – 6.4	$1,417.91 million	$6,056.15 million	$876.20 million	$196.85 million	$8,547.11 million

Recall that the losses estimated by *HAZUS-MH* are presented in 2014 dollars, which implies that they will be greater in the future due to inflation. Because HAZUS-MH was run for four events in four different locations, and not for a range of magnitudes and intensities, an annualized loss estimate cannot be generated from the results.

Summary

Despite the low probability of occurrence, the potential damage caused by a significant earthquake would result in significant devastation to the region. The annualized loss estimate of $501,918 calculated from the statewide analysis is therefore used herein to estimate potential earthquake damages for the region. However, it is very unlikely that the SCCOG region would be at the epicenter of such a damaging earthquake.

8.6 Potential Mitigation Strategies and Actions

As earthquakes are relatively infrequent, difficult to predict, and can affect the entire region, potential mitigation includes adherence to building codes, education of residents, and adequate emergency response planning.

Aside from emergency preparedness and recovery functions, there are no local programs in place which effectively address earthquake mitigation in the region. Earthquake mitigation in the SCCOG region has been limited to enforcement of locally adopted Building Codes. The Connecticut Building Code

addresses earthquakes for construction of new commercial buildings only. The International Building Code (used by the Mohegan Tribe) has structural requirements for residential buildings as well as commercial and other structures. FEMA has several publications that can assist homeowners and builders in designing structures to withstand the effects of earthquakes and should be made available through local Building Departments:

- "The Home Builder's Guide for Earthquake Design" should be made available to all design professionals, builders and others who are issued permits for new construction.
- "Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide" (FEMA-74, 1994) can also be made available.
- All commercial, industrial and institutional property owners should have an opportunity to obtain a copy of the FEMA publication entitled "Emergency Management Guide for Business and Industry" (FEMA- 141, 1993).

In order to be able to effectively mitigate earthquake damage at the regional level, it is crucial to have an understanding of what is at risk in the event of an earthquake. SCCOG communities should consider the completion of a regional survey to identify the vulnerability of critical facilities such as municipally owned buildings, hospitals, schools, nursing homes, fire stations, and critical infrastructures such as roads, bridges, water lines, etc., that may be unable to withstand earthquake and wind loading. Other long-term goals include surveying all facilities with generators to ensure fuel supplies will be sufficient to withstand potentially long electrical outages following an earthquake (or storm event). Emphasis should be placed on critical infrastructure, shelters and then other sites to ensure structural integrity and backup supplies. This is a recommendation common to all hazards in this plan.

The following potential mitigation measures for earthquakes have been identified:

- Ensure that local departments have adequate backup supplies and facilities for continued functionality in case earthquake damage occurs to these buildings where these critical facilities are housed.
- Ensure that municipal departments and critical facilities have adequate backup power supply generation capabilities.
- Consider preventing residential development in areas prone to collapse such as below steep slopes or in areas prone to liquefaction.
- Continue to require adherence to the local building codes.

In addition, important recommendations that apply to all hazards are listed in Section 11.1.

9.0 WILDFIRES

9.1 Setting

The ensuing discussion about wildfires is focused on the undeveloped wooded, marsh, and shrub/grassland areas of the region, along with the wildland interface, which is low-density suburban-type development found at the margins of these wooded areas. Structural fires in higher density areas are not directly addressed.

9.2 Hazard Assessment

Wildfires are considered to be highly destructive, uncontrollable fires. Although the term brings to mind images of tall trees engulfed in flames, wildfires can occur as brush and shrub fires, especially under dry conditions. Wildfires are also known as "wildland fires."

Nationwide, humans have caused approximately 90% of all wildfires in the last decade. Accidental and negligent acts include unattended campfires, sparks, burning debris, and irresponsibly-discarded cigarettes. The remaining 10% of fires are caused primarily by lightning or downed electrical wires.

Nevertheless, wildfires are a natural process in many ecosystems, and their suppression is now recognized to have created a larger fire hazard as live and dead vegetation accumulates in areas where fire has been prevented. In addition, the absence of fire has altered or disrupted the cycle of natural plant succession and wildlife habitat in many areas. Consequently, federal, state, and local agencies are committed to finding ways to reintroduce fire into natural ecosystems, such as prescribed burning, while recognizing that firefighting and suppression are still important near developed areas.

Connecticut has a particular vulnerability to fire hazards where urban development and wildland areas are in close proximity. The "wildland/urban interface" is where many such fires are fought. Wildland areas are subject to fires because of weather conditions and fuel supply. An isolated wildland fire may not be a threat, but the combined effect of having residences, businesses, and lifelines near a wildland area causes increased risk to life and property. Thus, a fire that might have been allowed to burn itself out with a minimum of firefighting or containment in the past is now fought to prevent fire damage to surrounding homes and commercial areas as well as smoke threats to health and safety of humans and wildlife in these areas.

9.3 Regional Historic Record

According to the 2014 *Connecticut Natural Hazards Mitigation Plan*, Connecticut enacted its first statewide forest fire control system in 1905, when the state was largely rural with very little secondary growth forest. By 1927, the state had most of the statutory foundations for today's forest fire control programs and policies in place, such as the State Forest Fire Warden system, a network of fire lookout towers and patrols, and regulations regarding open burning. The severe fire weather in the 1940s prompted the state legislature to join the Northeastern Interstate Forest Fire Protection Compact with its neighbors in 1949.

Today, most of Connecticut's forested areas are secondary growth forests. According to the Connecticut DEEP, forest has reclaimed over 500,000 acres of land that was used for agriculture as of 1914. However, that new forest has been fragmented in the past few decades by residential development. The urban/wildland interface is increasing each year where urban sprawl extends further out from Connecticut's cities.

The technology used to combat wildfires has significantly improved since the early 20th century. An improved transportation network, coupled with advances in firefighting equipment, communication technology, and training, has improved the ability of firefighters to minimize damage due to wildfires in the state. For example, radio and mobile technologies have greatly improved firefighting command capabilities.

According to the USDA Forest Service Annual Wildfire Summary Report for 1994 through 2003, an average of 600 acres per year in Connecticut was burned by wildfires. For the period 2002 through 2015, the National Interagency Fire Center reports that a total of 3,448 acres of land burned in Connecticut due to 2,334 non-prescribed wildfires, an average of 1.5 acres per fire (Table 9-1). In general, the fires are small and detected quickly, with most of the largest wildfires being contained to less than 10 acres in size. The number one cause of wildfires is arson, with about half of all wildfires being intentionally set.

Table 9-1: Wildland Fire Statistics for Connecticut

Year	Number of Wildland Fires	Acres Burned	Number of Prescribed Burns	Acres Burned	Total Acres Burned
2015	76	159	4	25	184
2014	28	69	4	34	103
2013	76	238	4	37	275
2012	180	417	4	42	459
2011	196	244	7	42	286
2010	93	262	6	52	314
2009	264	246	6	76	322
2008	330	893	6	68	961
2007	361	288	7	60	348
2006	322	419	6	56	475
2005	316	263	10	130	393
2004	74	94	12	185	279
2003	97	138	8	96	234
2002	101	184	13	106	290
Total	**2,334**	**3,448**	**85**	**913**	**4,361**

Source: National Interagency Fire Center

Traditionally, the highest forest fire danger in Connecticut occurs in the spring from mid-March to mid-May. The worst wildfire year for Connecticut in the past decade occurred during the extremely hot and dry summer of 1999. Over 1,733 acres of Connecticut burned in 345 separate wildfires, an average of about five acres per fire. Only one wildfire occurred between 1994 and 2003 that burned over 300

acres, and a wildfire in 1986 in the Mattatuck State Forest in the town of Watertown, Connecticut burned 300 acres.

In the dry spring of 2011, a 25-acre wildfire occurred in East Haddam just west of the SCCOG region. This fire occurred in Devil's Hopyard State Park in late March.

9.4 Existing Capabilities

Existing mitigation for wildland fire control is typically focused on Fire Department training and maintaining an adequate supply of equipment. Unlike wildfires on the west coast of the United States where the fires are allowed to burn toward development and then stopped, the local Fire Departments in the region go to the fires whenever possible. This proactive approach is believed to be effective for controlling wildfires. Each local Fire Department has some water storage capability but primarily relies on the use of the fire ponds, dry hydrants, water tanks, and the local public water systems to fight fires throughout the region.

The Connecticut DEEP Division of Forestry monitors the weather each day during non-winter months as it relates to fire danger. The Division utilizes precipitation and soil moisture data to compile and broadcast daily forest fire probability forecasts. Forest fire danger levels are classified as low, moderate, high, very high, or extreme. In addition, the National Weather Service (NWS) issues a Red Flag warning when winds will be sustained or there will be frequent gusts above a certain threshold (usually 25 mph), the relative humidity is below 30 percent, and precipitation for the previous 5 days has been less than one-quarter inch. Such conditions can cause wildfires to quickly spread from their source area.

During the highest forest fire risk period the CT DEEP sends daily advisories to municipalities, fire departments and the media. The vulnerability to wildfire is reduced by the DEEP's firefighting capability. The agency maintains a trained staff of 70 firefighters for assignment to fires on state property and throughout the region. The group assigned to the Pachaug State Forest, for example, has been very helpful in mitigating the impacts of wildfires in Griswold.

The Connecticut DEEP has recently changed its Open Burning Program. It now requires individuals to be nominated by the Chief Executive Officer in each municipality that allows open burning and to take an online training course and exam to become certified by the Connecticut DEEP as an "Open Burning Official." Permit template forms were also revised that provide permit requirements so that the applicant/permittee is made aware of the requirements prior to, during, and after burn activity. The regulated activity is then overseen by the certified local official.

9.5 Vulnerabilities and Risk Assessment

The most common causes of wildfires are arson, lightning strikes, and fires started from downed trees hitting electrical lines. Thus, wildfires have the potential to occur anywhere and at any time in both undeveloped and lightly developed areas. The extensive forests and fields covering the State are prime locations for a wildfire. In many areas, structures and subdivisions are built abutting forest borders, creating areas of particular vulnerability.

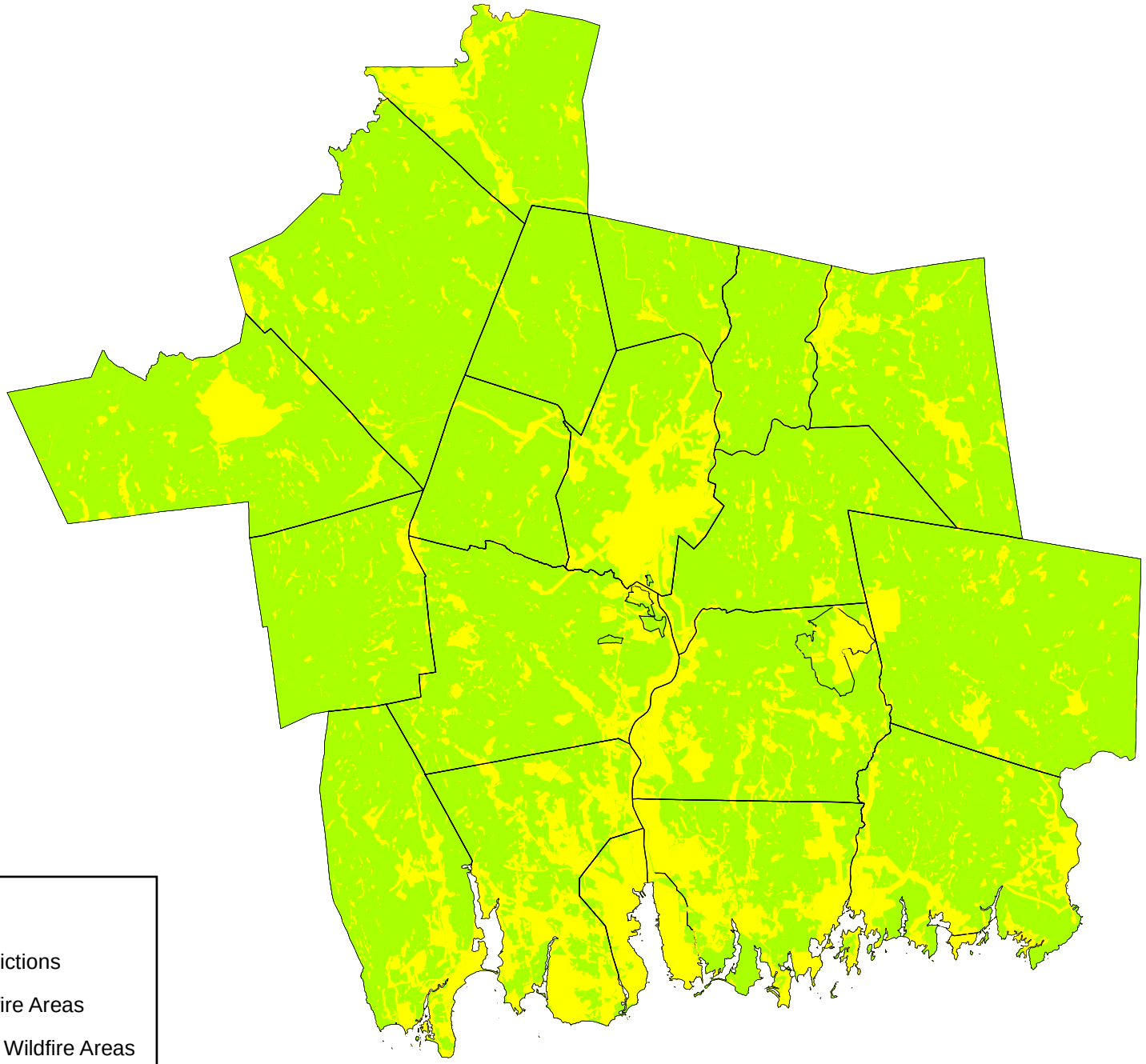
Wildfires are more common in rural areas than in developed areas as most fires in populated areas are quickly noticed and contained. The areas in the SCCOG region most prone to wildfire are those jurisdictions that have large contiguous tracts of forest land within their boundaries. Hemlocks and other coniferous trees throughout the SCCOG region provide good sources of fuel for wildfires. Along the coastline, wildfires in tidal marshes have become problematic in some areas where invasive reeds *(phragmites)* have taken hold. Often the fires start along the railroad tracks resulting from sparks or discarded cigarettes. While these fires have not been known to cause risk to nearby structures, the migration of *phragmites* causes the potential to increase.

The most extreme wildfires in Connecticut's recent history have burned over 300 acres. However, the likelihood of a severe and expansive wildfire developing in Connecticut is lessened by the vast network of water features in the state, which creates natural breaks likely to stop the spread of a fire. It is noted that during long periods of drought, these natural features may dry up, increasing the vulnerability of the state to extreme wildfires.

According to the Connecticut DEEP, the actual forest fire risk in Connecticut is low due to several factors. First, the overall *incidence* of forest fires is limited (216 fires occurred in Connecticut per year from 2002 to 2011, which is a rate slightly higher than one per municipality per year). Secondly, as the wildfire/forest fire prone areas become fragmented due to development, the local fire departments have increased access to those neighborhoods for firefighting equipment. Third, the problematic interface areas are site specific, such as driveways and forest access roads too narrow to permit emergency vehicles. Fourth, the containment of wildfires occurs quickly, with the average wildfire being less than two acres in size. Finally, trained fire fighters at the local and state level are readily available to fight fires in the state, and inter-municipal and inter-state cooperation on such instances is common thanks to a variety of agreements that have been in place for decades.

Public water service is relatively extensive throughout the urbanized and suburban parts of the region. Risk of wildfire increases where significant areas of forested or brushland do not have immediate access to public water supply for fire-fighting. These areas are more predominant in jurisdictions that do not have public water service as shown on Figure 9-1. Most SCCOG communities are comfortable with their ability to respond to wildfires in outlying areas because of available dry hydrants or other water bodies. Therefore, areas surrounding water bodies are also considered to be low risk areas even if public water service is not available.

Should a wildfire occur, it is reasonable to estimate that the average area to burn would be five acres during a drought period and one to two acres during wetter periods, consistent with the State averages. In the case of an extreme wildfire occurring during a drought on forested lands, it is estimated that up to 300 acres could burn before containment due to the limited access of those lands. This is also consistent with actual data in Connecticut. Residential areas bordering such lands would thus be vulnerable to wildfires.



Legend

- SCCOG Jurisdictions
- Low-Risk Wildfire Areas
- Moderate-Risk Wildfire Areas

SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 9-1: Wildfire Risk in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure9-1.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

Recall from Section 2.6 that elderly and persons with disabilities reside in the region. In comparing these figures with the wildfire risk areas described above, it is possible that large populations of the elderly and people with disabilities could reside near wildfire impact areas. Thus, it is important for the local Fire Departments to be prepared to assist these special populations during emergencies, including wildfires.

9.5.1 Loss Estimates

The *2014 Connecticut Natural Hazards Mitigation Plan Update* does not provide annual estimated losses by county for wildfires except on Figure 2-52, where the reported annualized loss for both Windham and New London Counties are reported as being less than $56,050 per year. Table 2-61 of the State Plan indicates that, from 1991 to 2013, New London County experienced 453 wildfire events that burned an average of 0.09 acres per fire, while Windham County experienced 564 wildfire events that burned an average of 0.08 acres per fire. The number of annualized events is therefore 20.59 for New London County and 25.64 for Windham County. The average acres burned in New London and Windham County is 1.81 acres per year and 2.08 acres per year, respectively.

The Town of Mansfield, Connecticut, reports in the 2015 Former WinCOG HMP Update that wildfires cost the Town approximately $2,000 per acre affected. This figure is used here to estimate wildfire-related damage to each SCCOG community based on annualized estimates for the number of acres burned in each community. Population density tends to be *inversely* related to area of land susceptible to wildfires (developed land is less likely to experience a wildfire and more likely to experience a structure fire). Annualized estimates for the number of acres burned in each community were therefore calculated using the inverse of the population density and the total population of the community relative to the county.

Table 9-2, below, lists annual estimated wildfire losses for the SCCOG region, as well as for each SCCOG community, calculated as described above.

Table 9-2: Estimated Annualized Losses from Wildfires

Community	Estimated Annual Costs	Community	Estimated Annual Costs
Bozrah	$2,241.78	Mohegan	$67.25
Colchester	$5,503.56	Montville	$4,640.48
East Lyme	$3,811.02	New London	$616.49
Franklin	$2,185.73	North Stonington	$6,086.43
Griswold	$3,811.02	Norwich	$3,172.11
Groton City	$347.48	Preston	$3,463.55
Groton Town	$3,127.28	Salem	$3,250.58
Jewett City	$78.46	Sprague	$1,479.57
Lebanon	$6,064.01	Stonington Borough	$33.63
Ledyard	$3,855.86	Stonington Town	$4,304.21
Lisbon	$1,827.05	Waterford	$3,676.51
Mashantucket	$414.73	Windham	$10,057.28
		SCCOG TOTAL	**$74,116.07**

Summary

Open space areas, and populated areas adjacent, are considered most at-risk from wildfires. Areas that are not served by public water supplies and not adjacent to large bodies of water may be particularly at-risk of wildfire damages due to firefighting challenges.

Based on these factors, low-risk areas are concentrated around significant population areas, especially along the Thames River and New London Harbor, Niantic Bay, Mystic Harbor, Pawcatuck, Norwich, the Mashantucket Pequot Tribal Nation reservation, Jewett City, Lebanon Town Center, and the region's major highway corridors. More rural and forested areas farther from these centers are designated as moderate-risk. Overall, the SCCOG region has an annualized loss estimate for wildfires of $74,116.07.

9.6 Potential Mitigation Strategies and Actions

Potential mitigation measures for wildfires include a combination of prevention, education, and emergency planning. Educational materials should be made available at all applicable municipal offices. Education of homeowners on methods of protecting their homes is far more effective than trying to steer growth away from potential wildfire areas, especially given that the available land that is environmentally appropriate for development may be forested. Water system improvement is another important class of potential mitigation for wildfires.

The following actions could be implemented to mitigate fire risk:

- Continue to support public outreach programs to increase awareness of forest fire danger, equipment usage, and protecting homes from wildfires.
- Ensure that provisions of local Regulations regarding fire protection facilities are being enforced.
- Extend public water supply and fire protection to areas identified as being particularly at risk.
- Pursue additional sources of fire-fighting water where adequate supplies do not exist, such as the installation of dry hydrants.
- Continue to require that utilities be installed underground.

In addition, specific recommendations that apply to all hazards are listed in Section 11.1.

10.0 DAM FAILURE

10.1 Setting

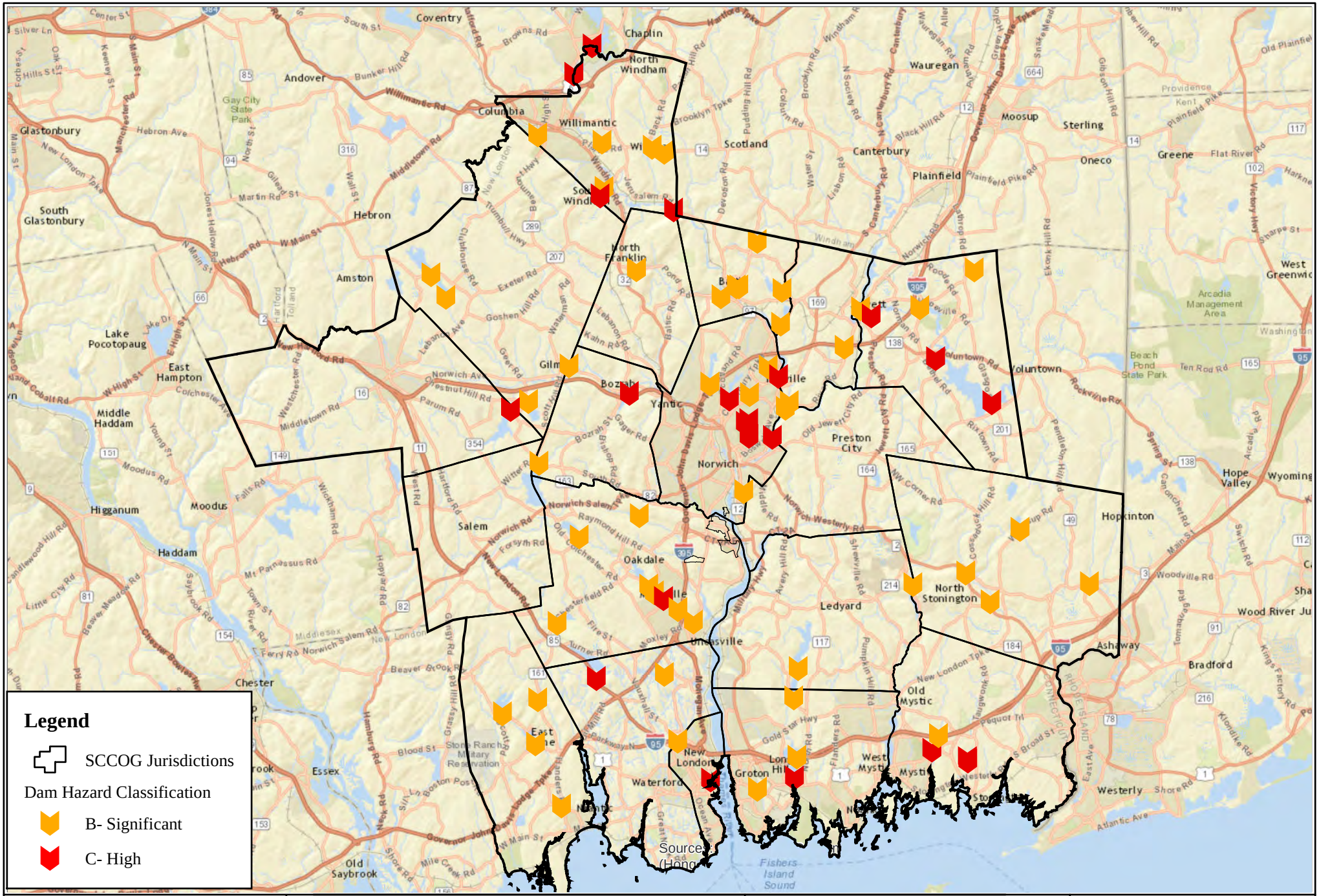
Dam failures can be triggered suddenly with little or no warning and often in connection with natural disasters such as floods and earthquakes. Dam failures often occur during flooding when the dam breaks under the additional force of floodwaters. In addition, a dam failure can cause a chain reaction where the sudden release of floodwaters causes the next dam downstream to fail. With over 250 registered dams and potentially several other minor dams scattered throughout the SCCOG municipalities and two tribal affiliates, dam failure has the potential to occur in any part of the region. While flooding from a dam failure generally has a limited geographic extent, the effects are potentially catastrophic depending on the downstream impact area. Fortunately, a major dam failure is not considered a likely hazard event in any given year (Table 1-4).

10.2 Hazard Assessment

The Connecticut DEEP administers the Dam Safety Section and designates a classification to each state-registered dam based on its potential hazard.

- *Class AA* dams are negligible hazard potential dams that upon failure would result in no measurable damage to roadways and structures and negligible economic loss.
- *Class A* dams are low hazard potential dams that upon failure would result in damage to agricultural land and unimproved roadways, with minimal economic loss.
- *Class BB* dams are moderate hazard potential dams that upon failure would result in damage to normally unoccupied storage structures, damage to low volume roadways, and moderate economic loss.
- *Class B* dams are significant hazard potential dams that upon failure would result in any of the following: possible loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, and schools; damage or interruption of the use of service of utilities; damage to primary roadways and railroads; and a significant economic loss.
- *Class C* dams are high potential hazard dams that upon failure would result in loss of life and major damage to habitable structures, residences, hospitals, convalescent homes, schools, and main highways, with great economic loss.

This HMP section primarily discusses the possible effects of failure of significant and high potential hazard (Class B and Class C) dams only. The Connecticut DEEP published a list of high and significant hazard dams in the State in 2007. According to the list, there are 36 Class B and 17 Class C dams in the region. Class C Dams in the region are listed in Table 10-1, and locations of significant and high hazard dams are illustrated in Figure 10-1.



SOURCE(S):
CT DEEP GIS Data
Mashantucket Pequot Tribal Nation
SCCOG
USGS Topographic Maps

N

Figure 10-1: High and Significant Hazard Dams in the SCCOG Region

SCCOG Multi-Jurisdictional Natural Hazard Mitigation Plan

LOCATION:
Southeastern Connecticut COG

Map By: scottb
MMI#: 3570-09
MXD: H:\3570-05\GIS\Maps\Regional Report\Figure10-1.mxd
1st Revision: 5/25/2012
Revision: 8/15/2017
Scale: 1 in = 25,000 ft

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

Table 10-1: High and Significant Hazard Dams in the SCCOG Region

CT Dam #	Town	Hazard Class 1/21/2016	Name	Owner
1302	Bozrah	C	Fitchville Pond Dam	Private (Commercial)
1305		B	Gardner Lake Dam	CT DEEP
2801	Colchester	C	Deep River Reservoir Dam	Norwich Public Utilities
4501	East Lyme	B	Powers Lake Dam	CT DEEP
4502		B	Darrow Pond	Town of East Lyme
4503		B	Gorton Pond	CT DEEP
4505		B	Pataguanset Lake	CT DEEP
5301	Franklin	B	Gager's Pond	Private
5801	Griswold	C	Glasgo Pond Dam	CT DEEP
5802		B	City Pond	CT DEEP
5803		B	Stone Hill Reservoir	Private (Commercial)
5804		C	Ashland Pond Dam	CT DEEP
5805		C	Pachaug Pond Dam	CT DEEP
5807		B	Hopeville Pond Dam	CT DEEP
5811		B	Aspinook Pond Dam	Private (Commercial)
5902	Groton	B	Ledyard Reservoir	City of Groton
5904		C	Poquonnock Dam	City of Groton
5905		B	Poheganut Reservoir	City of Groton
7101	Lebanon	B	Williams Pond Dam	Town of Lebanon
7104		B	Savin Lake Dam	CT DOAG
7105		B	Brewster Pond Dam	CT DEEP
7108		B	Red Cedar Lake Dam	CT DEEP
7202	Ledyard	*	Long Pond Dam	Private
7207		B	Morgan Pond	City of Groton
7301	Lisbon	B	Lower Blissville Pond	Town of Lisbon
7309		B	Crossing at Lisbon Detention Dam	Private (Commercial)
8601	Montville	B	Congdon Pond Dam	Private (Commercial)
8602		B	Bogue Brook Reservoir Dam	City of New London
8604		B	Picker Pond Dam	Private (Commercial)
8606		C	Oxoboxo Lake Dam	Private (Commercial)
8607		B	Wheeler Pond Dam	Private
8610		B	Red Mill Pond Dam	Private (Commercial)
8613		B	Rockland Pond Dam	Private (Commercial)
8616		B	Stony Brook Reservoir Dam	Norwich Public Utilities
8638		B	Lake Konomoc Dike	City of New London
10201	North Stonington	B	Wyassup Lake	CT DEEP
10202		*	Gallup Pond	Private (Commercial)
10205		B	Clark Falls Dam	Private

Table 10-1: High and Significant Hazard Dams in the SCCOG Region (Cont'd)

CT Dam #	Town	Hazard Class 1/21/2016	Name	Owner
10403	Norwich	C	Taftville Dam #4	Private (Commercial)
10404		C	Fairview Reservoir Dam	Norwich Public Utilities
10405		C	Greenville Hydro Dam	Norwich Public Utilities
10406		B	Taftville Reservoir #1	Norwich Public Utilities
10407		B	Bog Meadow Reservoir	Norwich Public Utilities
10409		B	Taftville Reservoir #3	Norwich Public Utilities
10417		C	Spaulding Pond Dike	City of Norwich
10418		C	Spaulding Pond Site #2 Dam	City of Norwich
10419		C	Spaulding Pond Dam Site #1	City of Norwich
11401	Preston	B	Tunnel Dam	Private (Commercial)
13301	Sprague	B	Baltic Reservoir (West)	Town of Sprague
13302		C	Hanover Reservoir Dam	Private
13303		B	Paper Mill Pond	Private (Commercial)
13304		B	Versailles Pond	Private (Commercial)
13306		B	Harrington Apartments Dam	Private
13312		B	Baltic Reservoir (East)	Town of Sprague
13702	Stonington	C	Silvias Pond Upper Dam	Private
13702		C	Silvias Pond Lower Dam	Private
13703		C	Mystic Reservoir Dam	Private (Commercial)
13708		C	Deans Reservoir Dam	Private (Commercial)
15201	Waterford	C	Lake Konomoc Dam	City of New London
15204		B	Brandagee Lake Dam	City of New London
15205		B	Miller Pond	Private (Commercial)
16301	Windham	C	Scotland Dam	Private (Commercial)

The Mashantucket Pequot Tribal Nation and the Mohegan Tribe do not have high or significant hazard dams on their reservation. Each tribal government believes that its dams are relatively low hazard in comparison with the Connecticut DEEP classifications used for other dams in the region. Tribal dams are discussed briefly in each respective tribal annex.

In addition to dams that exist within the SCCOG region, dams exist upstream of many SCCOG communities as noted in Section 3.4.3. In particular, several flood control dams have been constructed upstream on the Shetucket River and Quinebaug River; and the Mansfield Hollow Lake Dam on the Natchaug River in Mansfield impounds up to 16.1 billion gallons of water for flood control purposes.

10.3 Regional Historic Record

According to the CT DEEP website, approximately 200 notable dam and reservoir failures occurred worldwide in the twentieth century and more than 8,000 people died in these disasters. The following is a listing of some of the more catastrophic dam failures in Connecticut's recent history:

- 1938 and 1955: Exact numbers of dam failures caused by these floods are unavailable, but the Connecticut DEEP believes that more dams were damaged in these events than in the 1982 or 2005 flooding events described below.

- 1961: Crystal Lake dam in Middletown failed, injuring three and severely damaging 11 homes.
- 1963: Failure of the Spaulding Pond Dam in Norwich caused six deaths and six million dollars in damage. This dam failure occurred during a moderate storm.
- June 5-6, 1982: Connecticut experienced a severe flood that caused 17 dams to fail and seriously damaged 31 others. Failure of the Bushy Hill Pond Dam in Deep River caused $50 million in damages, and the remaining dam failures caused nearly an additional $20 million in damages.

More recently, the NCDC reports that flash flooding on April 16, 1996 caused three small dams in Middletown and one in Wallingford to breach. The Connecticut DEEP reported that the sustained heavy rainfall from October 7 to 15, 2005 caused 14 complete or partial dam failures and damage to 30 other dams throughout the state. The October 2005 flooding subsequently resulted in a federal disaster declaration. A summary of damaged dams in the State is summarized in Table 10-2.

Table 10-2: Dams Damaged Due to Flooding from October 2005 Storms

Number	Name	Location	Class	Damage Type	Ownership
-----	Somerville Pond Dam	Somers	--	Partial Breach	DEEP
4701	Windsorville Dam	East Windsor	BB	Minor Damage	Private
10503	Mile Creek Dam	Old Lyme	B	Full Breach	Private
-----	Staffordville Reservoir #3	Union	--	Partial Breach	CT Water Co.
8003	Hanover Pond Dam	Meriden	C	Partial Breach	City of Meriden
-----	ABB Pond Dam	Bloomfield	--	Minor Damage	Private
4905	Springborn Dam	Enfield	BB	Minor Damage	DEEP
13904	Cains Pond Dam	Suffield	A	Full Breach	Private
13906	Schwartz Pond Dam	Suffield	BB	Partial Breach	Private
14519	Sessions Meadow Dam	Union	BB	Minor Damage	DEEP

Dam failures in Connecticut have been of primary concern to the well-being of many communities in according to an American Rivers blog posted on March 31, 2010. Overtopping of the Sylvias Pond Dam in Stonington due to heavy rainfall caused an evacuation of homes downstream in 2009. Additionally, the mayor of the town of Montville evacuated a section of town during the March 2010 floods once it become possible that the Rand-Whitney Dam in town could breach.

With many dams nearing the end of their effective lives, a significant number of dams in Connecticut, New England, and across the United States are likely to grow as potential threats to life and property. Indeed, the Association of State Dam Safety Officials has indicated that dam failures have been documented in every state. From January 1, 2005 through June 2013, state dam safety programs reported 173 dam failures and 573 incidents requiring intervention to prevent failure.

10.4 Existing Capabilities

The dam safety statutes are codified in Sections 22a-401 through 22a-411 inclusive of the Connecticut General Statutes. Sections 22a-409-1 and 22a-409-2 of the Regulations of Connecticut State Agencies have been enacted, which govern the registration, classification, and inspection of dams. Dams must be registered by the owner with the DEEP according to Connecticut Public Act 83-38.

Dam Inspection Regulations require that nearly 700 dams in Connecticut be inspected annually. The DEEP currently prioritizes inspections of those dams that pose the greatest potential threat to downstream persons and properties. Dams found to be unsafe under the inspection program must be repaired by the owner. Depending on the severity of the identified deficiency, an owner is allowed reasonable time to make the required repairs or remove the dam. If a dam owner fails to make necessary repairs to the subject structure, the DEEP may issue an administrative order requiring the owner to restore the structure to a safe condition and may refer noncompliance with such an order to the Attorney General's Office for enforcement. As a means of last resort, the DEEP Commissioner is empowered by statute to remove or correct, at the expense of the owner, any unsafe structures that present a clear and present danger to public safety.

Dams regulated by the DEEP must be designed to pass the 100-year rainfall event with 1 foot of freeboard, a factor of safety against overtopping.

Significant and high hazard dams are required to meet a design standard greater than the 100-year rainfall event.

Owners of Class C dams have traditionally been required to maintain Emergency Operation Plans (EOPs). Guidelines for dam EOPs were published by DEEP in 2012, creating a uniform approach for development of EOPs. As dam owners develop EOPs using the new guidance, DEEP anticipates that the quality of EOPs will improve, which will ultimately help reduce vulnerabilities to dam failures.

Important dam safety program changes have recently occurred in Connecticut. Public Act No. 13-197, *An Act Concerning the Dam Safety Program and Mosquito Control,* passed in June 2013 and describes new requirements for dams related to registration, maintenance, and EOPs, which will be called emergency action plans (EAPs) moving forward. This Act required owners of certain unregistered dams or similar structures to register them by October 1, 2015. The Act generally shifts regularly scheduled inspection and reporting requirements from the DEEP to the owners of dams. The Act also makes owners generally responsible for supervising and inspecting construction work and establishes new reporting requirements for owners when the work is completed.

Effective October 1, 2013, the owner of any high or significant hazard dam (Class B and C) must develop and implement an EAP after the Commissioner of DEEP adopts regulations. The EAP shall be updated every 2 years, and copies shall be filed with DEEP and the chief executive officer of any municipality that would potentially be affected in the event of an emergency. New regulations shall establish the requirements for such EAPs, including but not limited to (1) criteria and standards for inundation studies and inundation zone mapping; (2) procedures for monitoring the dam or structure during periods of heavy rainfall and runoff, including personnel assignments and features of the dam to be inspected at given intervals during such periods; and (3) a formal notification system to alert appropriate local officials who are responsible for the warning and evacuation of residents in the inundation zone in the event of an emergency.

The Connecticut DEEP also administers the Flood and Erosion Control Board program, which can provide noncompetitive state funding for repair of municipality-owned dams. Funding is limited by the State Bond Commission. State statute Section 25-84 allows municipalities to form Flood and Erosion Control

Boards, but municipalities must take action to create the board within the context of the local government such as by revising the municipal charter. More information regarding the Flood and Erosion Control Board program can be found at http://www.ct.gov/dep/lib/dep/water_inland/flood_mgmt/fecb_program.pdf.

10.5 Vulnerabilities and Risk Assessment

The failure of a Class C dam would result in any of the following: loss of life; major damage to habitable structures, residences, hospitals, convalescent homes, schools, and main highways; and a significant economic loss. Failure of a Class B dam would result in slightly less downstream damage including any of the following: possible loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, and schools; damage or interruption of the use of service of utilities; damage to primary roadways and railroads; and a significant economic loss.

The impacts related to the Class C dams in the region are described in each community annex. The descriptions are based on information available at the Connecticut DEEP Dam Safety Section. It is noted that the failure of any of the other dams in the region could also have impacts on human life and property although these impacts would be far lower in scope than those for the Class C and Class B dams.

10.5.1 Loss Estimates

The 2014 Connecticut Natural Hazard Mitigation Plan reports $44,397,208 in damage from seven dam failures in New London County, and $6,525,037 in damage from three dam failures in Windham County, since 1877. This gives countywide annualized dam failure damage estimates of $326,450 and $47,978 for New London and Windham Counties, respectively.

These annualized loss estimates are apportioned by the ratio of the population of each community to that of its county in Table 10-3, below. These figures are consistent with the high cost but relatively small number of dam failure events that have occurred in SCCOG.

Table 10-3: Estimated Annualized Losses from Dam Failure

Community	Estimated Annual Loss	Community	Estimated Annual Loss
Bozrah	$3,129.24	Mohegan	$125.07
Colchester	$19,139.95	Montville	$7,195.94
East Lyme	$22,821.90	New London	$23,312.67
Franklin	$2,289.46	North Stonington	$6,309.70
Griswold	$10,082.18	Norwich	$48,234.62
Groton City	$11,191.18	Preston	$5,629.54
Groton Town	$36,593.18	Salem	$4,944.61
Jewett City	$4,153.66	Sprague	$3,554.49
Lebanon	$8,705.17	Stonington Borough	$1,106.61
Ledyard	$17,928.51	Stonington Town	$20,983.90
Lisbon	$5,167.36	Waterford	$23,248.34
Mashantucket	$393.09	Windham	$10,236.67
		SCCOG TOTAL	**$296,477**

Summary

The SCCOG region, and the State of Connecticut in general, have instituted and carried out strong dam monitoring and maintenance measures. While dam failures may be high hazard events, continued dam management practices can maintain the regions risk status at a relatively low level. This is reflected in the relatively moderate annualized damage estimate of $296,477 calculated above.

10.6 Potential Mitigation Strategies and Actions

The Dam Safety Section of the DEEP Inland Water Resources Division is charged with the responsibility for administration and enforcement of Connecticut's dam safety laws. The existing statutes require that permits be obtained to construct, repair, or alter dams and that existing dams be registered and periodically inspected to assure that their continued operation does not constitute a hazard to life, health, or property. Should a SCCOG jurisdiction have a concern with a particular dam in the region, they should contact the DEEP directly. Tribal governments may also be able to contact DEEP for advice or technical assistance even though their dams are located outside of the Connecticut DEEP's jurisdiction.

The Connecticut DEEP also administers the Flood and Erosion Control Board program, which can provide noncompetitive state funding for repair of municipality-owned dams. Funding is limited by the State Bond Commission. State statute Section 25-84 allows municipalities to form Flood and Erosion Control Boards, but municipalities must take action to create the board within the context of the local government, such as by revising the municipal charter.

FEMA and the Association of Dam Safety Officials have a variety of resources available for dam owners. More information can be found at http://www.fema.gov and http://www.damsafety.org/resources/downloads/

SCCOG jurisdictions should work with dam owners and the Connecticut DEEP to stay up to date on the evolution of any EOPs and DFAs for the high and significant hazard dams in the region should any be produced. The local Building and Engineering Departments should have copies of all existing EOPs and DFAs for dams in their respective communities in their possession, and local emergency personnel should have copies of pertinent areas for evacuation in case of emergency. Whenever possible, copies of these documents (or portions of them that do not provide specific dam vulnerabilities) should be made available at the Town Halls for reference and public viewing.

Each jurisdiction should maximize its emergency preparedness for a potential dam failure. SCCOG jurisdictions should provide assistance to owners of Class A, AA, BB, and unranked dams regarding the resources available to them through various governmental agencies.

SCCOG should consider including future dam failure areas into the CT "Everbridge" Reverse 911 emergency notification system. This technology should be used to warn residents downstream of a dam of an impending dam failure and facilitate evacuation. In the absence of specific DFA mapping, the 500-

year floodplains downstream of a dam could be used to delineate an interim potential dam failure inundation area.

The following specific recommendations are offered for dam failure mitigation:

- Include dam failure areas in the Reverse 911 emergency contact database
- Work with the DEEP to ensure owners of high hazard dams have an EOP.
- Encourage owners of significant hazard dams to develop an EOP.
- Provide assistance regarding resources available to dam owners.

Finally, there are several suggested potential mitigation strategies that are applicable to all hazards in this Plan. These are outlined in Section 11.1.

11.0 REGIONAL STRATEGIES AND ACTIONS

11.1 Status of Regional Mitigation Strategies and Actions from Previous HMP

The general regional strategies and actions from the previous HMP are listed in Table 11-1. These strategies and actions were reviewed with SCCOG to discuss related projects completed to date and the future applicability of the recommendation. Results are presented below. It is important to note that only some of the regional strategies and actions offered in 2012 were possible for SCCOG to conduct. Many of them were offered as a menu of options that could be used in multiple communities, for the SCCOG communities to select from. Therefore, in the table below, the status explanations are provided in the context of whether SCCOG could conduct or complete the action. If one of the jurisdictions elected to undertake a specific mitigation action or incorporated it as a capability, this is noted in the annex.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP

Regional Strategy or Action	Status
Regional Coordination	
Continue to promote inter-jurisdictional coordination efforts for emergency response.	Delisted. This is regularly performed and is a capability.
Continue to promote local and regional planning exercises that increase readiness to respond to disasters.	Delisted. SCCOG provides regional planning services related to emergency response upon request but defers to DEMHS Region 4 to conduct such exercises. SCCOG prepared a model ordinance for disaster recovery that municipalities can adopt.
Continue to evaluate communication capabilities and pursue upgrades to communication and ensure redundant layers of communication are in place within SCCOG communities, between SCCOG communities, and with surrounding regions.	Delisted. SCCOG participates in such studies upon request but defers to DEMHS Region 4 and local emergency managers as to the status and capabilities of such equipment.
Continue to promote regional transportation planning through SCCOG to balance general transportation, shipping, and potential evacuation needs.	Delisted. This is regularly performed and is a capability.
SCCOG should lead a regional study to identify the vulnerability of critical facilities that may be unable to withstand natural hazard damage. Emphasis should be placed on critical infrastructure, shelters and other sites to ensure structural integrity against various hazards and adequacy of backup supplies.	Completed. SCCOG conducted a study in 2017. A total of 18 critical facilities (police, fire, public works, and other municipal buildings) in and adjacent to flood risk zones were evaluated for flood, wind, and snow risks given current conditions and climate change/sea level rise. Individual findings are presented in the annexes for the municipalities that participated.
Develop regional evacuation scenarios that include but build upon the Millstone evacuation plan.	Delisted. SCCOG defers to DEMHS Region 4 and local emergency management officials with regard to regional emergency evacuation scenarios.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Local Emergency Response	
Continue to review and update EOPs at least once annually	Delisted. SCCOG defers to local emergency officials regarding local EOPs. SCCOG prepared a model ordinance for disaster recovery that municipalities can adopt.
Continue to maintain emergency response training and equipment and upgrade equipment when possible.	Delisted. SCCOG does not participate in emergency response, and defers this to local emergency officials.
Encourage local officials to attend DEEP and other training workshops annually. Rotate local staff annually to attend FEMA sponsored training seminars at the Emergency Management Institute (EMI).	Delisted. Encouragement is regularly performed and is a capability. SCCOG staff have attended conferences and events of the Connecticut Association of Flood Managers.
Continue to evaluate emergency shelters, update supplies, and check communication equipment.	Delisted. SCCOG defers to local emergency officials in these matters.
Continue to promote dissemination of public information regarding natural hazard effects and mitigation measures into local governmental and community buildings.	Delisted. This is a capability. SCCOG hosts hardcopies and web links of the HMP and its updates, and encourages local communities to adopt the plan and make it available to the public.
Encourage residents to purchase NOAA weather radios with an alarm feature.	Delisted. SCCOG defers this to local communities.
Post hazard preparedness information on the SCCOG website and local community websites. Include links to established sources at the State of Connecticut and FEMA.	Delisted. SCCOG posts the HMP and its updates on the SCCOG website, but defers posting of hazard preparedness information to local community websites.
Utilize the CT "Everbridge" Reverse 9-1-1 system to telephone warnings into potentially affected areas. Incorporate the 1% annual chance and 0.2% annual chance inland and coastal floodplains based on the recent DFIRM as well as dam failure inundation areas in the database.	Delisted. The Reverse 9-1-1 system is controlled by local communities.
Prevention	
Develop a checklist for land development applicants that cross references the specific regulations and codes related to disaster resilience.	Delisted. SCCOG defers this to local planning departments.
Continue reviewing subdivision applications to ensure proper access for emergency vehicles.	Delisted. This task is typically performed by local emergency management officials. To the extent that SCCOG assists with local reviews, this is a capability.
Continue to require the burying of utility lines for subdivisions and encourage lines to be buried for other projects where appropriate. When major road projects are designed, special consideration should be given to burying overhead lines.	Delisted. SCCOG does not have regulatory authority over local zoning and defers such suggestions to local officials.
Continue to enforce the appropriate building code during the review of new subdivisions and commercial projects.	Delisted. SCCOG does not have enforcement authority over local zoning or subdivisions and defers such suggestions to local officials.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Encourage owners to install and maintain lightning rods on their buildings.	Delisted. SCCOG defers this to local building officials.
Inland Flooding, Coastal Flooding, and Shoreline Change	
Continue to regulate activities within SFHAs to the greatest extent possible within the local land use regulations.	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers. To the extent that SCCOG assists with local reviews, this is a capability.
Consider requiring new buildings in floodprone areas to be protected to the highest recorded flood level regardless of SFHA status.	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers.
If necessary, provide FEMA with any data obtained from other sources that would demonstrate the need to revise the DFIRM, and then petition FEMA to review and revise the local DFIRM.	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers.
Require developers to demonstrate whether detention or retention of stormwater is the best option for reducing peak flows downstream.	Delisted. SCCOG does not have regulatory authority over local zoning and defers this to local officials. To the extent that SCCOG assists with local reviews, this is a capability.
Review local Subdivision Regulations and evaluate the possibility of incorporating changes to place further limitations on areas of impermeable surfaces in new subdivision developments in flood prone areas.	Delisted. SCCOG does not have regulatory authority over local subdivisions and defers this to local officials. To the extent that SCCOG assists with local reviews, this is a capability.
Conduct annual inspection of flood prone areas that are accessible to town officials. Determine if potential flood damage could be stormwater facility related.	Delisted. SCCOG defers such inspections to local floodplain managers.
Incorporate information on the availability of flood insurance into all hazard-related public education workshops.	Delisted. SCCOG defers such workshops to local officials.
Make available FEMA-provided flood insurance brochures at public accessible places such as the local government buildings. Encourage residents to purchase flood insurance.	Delisted. SCCOG defers this outreach to local officials.
Make necessary changes to local floodplain regulations so that all insured residents can be eligible for additional mitigation coverage (coverage for increased cost of compliance with updated federal flood regulations).	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers.
Provide technical assistance to owners of non-residential structures that suffer flood damage regarding floodproofing measures such as wet and dry floodproofing.	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers / building officials.
Pursue elevation of residential properties that suffer flood damage in appropriate areas. RLPs should be prioritized.	Delisted. SCCOG does not have regulatory authority over local floodplain uses and defers this to local floodplain managers.
Apply freeboard standards of one foot or more when requiring structure elevations for renovations and new construction in coastal A zones and V zones.	Delisted. The State Building Code requires freeboard in coastal A and VE zones.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Investigate locations and necessary labor involvement for the pre-event stockpiling of sand bags for use in the flood prone areas.	Delisted. SCCOG defers this to local emergency managers.
Pursue mutual aid agreements with such organizations as the ARC and the Boy Scouts of America to provide volunteer labor during flooding to fill sand bags and assist with other response activities.	Delisted. SCCOG defers this to local emergency managers.
Implement a roadway-specific warning system to alert motorists to the dangers present during times of flooding. Warning may take the form of dedicated signage or traffic control lights.	Delisted. SCCOG defers this to local emergency managers.
Consider having a local Natural Hazards Awareness Week each year. As part of this week, conduct an annual "Flood Fair" so that residents, business owners, insurance and real estate agents, and all interested parties can familiarize themselves with functions of a floodplain, the laws governing development in a floodplain and the associated hazards, mitigation alternatives, and precautions necessary for living in flood prone areas. Invite local insurance agents and the NFIP representatives from FEMA's insurance contractors to educate the public on the program.	Delisted. SCCOG defers this to local officials.
Visit schools (as is currently done under fire prevention) and educate children about the risks of floods (and other natural hazards) and how to prepare for them.	Delisted. SCCOG defers this to local emergency managers.
Establish a relationship with local homeowners associations and other community groups. If there is enough interest, develop a workshop to educate interested residents in flood proofing techniques and strategies for flood prone residential properties. Training would include audits of individual homes and recommendations for flood proofing measures.	Delisted. SCCOG defers this to local officials.
Encourage builders, developers, and architects to become familiar with the NFIP land use and building standards by attending annual workshops.	Delisted. SCCOG defers such encouragement to local officials for attendance at workshops such as those provided by the Connecticut Association of Flood Managers.
Pursue the acquisition of additional municipal open space in SFHAs.	Delisted. SCCOG defers such projects to local floodplain managers.
Pursue acquisition/demolition of floodprone residential properties for open space. RLPs should be prioritized.	Delisted. SCCOG defers such inspections to local floodplain managers.
Selectively pursue conservation recommendations listed in the Plan of Conservation and Development.	Delisted. SCCOG defers such inspections to local officials.
Continue to regulate development in protected and sensitive areas, including steep slopes, wetlands, and floodplains	Delisted. SCCOG does not have regulatory authority over local regulations, and defers to local regulatory authorities.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Continue to aggressively pursue wetlands protection through existing wetlands regulations. Incorporate performance standards into subdivision reviews to include additional protective measures such as conservation easement areas around wetlands and watercourses.	Delisted. SCCOG does not have regulatory authority over local regulations, and defers to local regulatory authorities.
Conduct beach nourishment and vegetation replacement along affected beaches to keep up with erosion.	Delisted. SCCOG defers such actions to local communities and the Connecticut DEEP.
Encourage the use of floodplain storage, diversions, berms, dikes, and other flood control methods in new developments and at existing properties where appropriate.	Delisted. SCCOG defers such encouragement to local officials.
Utilize recently available extreme rainfall data to determine existing sizing of culverts. Encourage bridge replacements and culvert replacements in areas found to be undersized.	Delisted. SCCOG defers such efforts to local officials.
Continue to perform catch basin and culvert surveys to perform maintenance and cleaning and to identify and prioritize structures in need of replacement.	Delisted. SCCOG defers such surveys to local public works departments.
Investigate funding sources and feasibility of improvements to mitigate frequent and repeated flooding problems. Improvements could include elevation of roads and replacement of storm drainage systems. Work with CT DOT to facilitate these actions if State roads are involved.	Delisted. SCCOG defers such work to local public works departments.
Investigate funding sources and feasibility of elevating portions of locally-owned roads with an emphasis on those needed for inland evacuation.	Delisted. SCCOG defers such work to local public works departments.
Upgrade stormwater collection and discharge systems to keep up with rising sea level.	Delisted. SCCOG defers such work to local public works departments.
Maintain existing hard structures along the coast in good condition.	Delisted. SCCOG defers such work to local public works departments and Connecticut DEEP.
Wind Damage from Hurricanes, Tropical Storms, Summer Storms, and Winter Storms	
Implement a region-wide Marina Management Plan addressing wind damage mitigation. Share that plan with the local marinas and yacht clubs and encourage them to develop plans on their own.	Delisted. SCCOG defers such planning to local marinas.
Local Building Departments should make information on wind construction techniques (such as hurricane straps) available to all building permit applicants, obtain literature on wind resistant construction techniques and incorporate that information into the natural hazards reduction information in the local library. The information will also include information on non-structural mitigation.	Delisted. SCCOG defers such efforts to local building officials.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Promote the use of functional shutters for properties located along the coast to guard against window breakage which can result in structural failure. Investigate funding sources to promote this relatively inexpensive type of retrofitting on a large scale.	Delisted. SCCOG defers such efforts to local building officials.
Encourage commercial building owners or managers of buildings with large population clusters to not only develop emergency response plans, but also to identify mitigation opportunities for long range planning.	Delisted. SCCOG defers such efforts to local emergency managers.
Acquire coastal shorefront and convert to open space.	Delisted. SCCOG defers such efforts to local planners.
Consider having a local Natural Hazards Awareness Week each year. As part of this week, conduct an annual workshop so that local building contractors, residents, business owners, insurance and real estate agents, and all interested parties can familiarize themselves with wind associated risks, retrofitting techniques, importance of evacuation, and the understanding of warning mechanisms used in the region.	Delisted. SCCOG defers this to local officials.
Visit schools (as is currently done under fire prevention) and educate children about the risks of wind events (and other natural hazards) and how to prepare for them.	Delisted. SCCOG defers this to local emergency managers.
Develop working relationships with local community organizations such as garden clubs. Encourage organizations to sponsor events to educate the public on wise landscaping techniques, how to locate trees away from utilities, and on the types of trees that are most resistant to wind damage.	Delisted. SCCOG defers this to local officials.
Work through the State to locate NOAA weather radios in commercial buildings with large population clusters. Educate building managers on the proper use of the radios.	Delisted. SCCOG defers this to local emergency managers.
Identify a location or locations in each community for a brush disposal operation for dealing with debris after wind storms. Determine how these trees can be reused within the community (chips, firewood, composting) to reduce costs of exporting.	Delisted. SCCOG defers this to local emergency managers and public works officials.
Develop agreements, if necessary, with land owners and with companies to chop/chip to ensure that plans are in place prior to damage (i.e. like snow plow operations).	Delisted. SCCOG defers this to local emergency managers and public works officials.
Local communities and Boards of Education should conduct engineering surveys for school buildings that are used for shelters and recommend improvements if necessary.	Delisted. SCCOG defers this to local emergency managers and building officials.
Local communities should survey all municipality owned buildings for their ability to withstand wind loading.	Delisted. SCCOG defers this to local emergency managers and public works officials.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Prioritize any wind-related retrofitting, giving those buildings to be used as shelters the highest priority. If analysis reveals that a particular building is better suited as a shelter than one that is currently being used, then consider relocating the shelter to that location.	Delisted. SCCOG defers this to local emergency managers and public works officials.
Ice and Snow from Winter Storms	
Conduct a study to identify municipal buildings, critical facilities, and commercial/industrial buildings that are vulnerable to roof damage or collapse due to snow loads.	Completed. This risk analysis was conducted as part of the critical facility analysis described above. SCCOG defers to local communities to conduct analyses for their remaining buildings.
Develop a plan to prioritize snow removal from the roof of local government buildings (especially critical facilities) and make funding available each budget year for clearing.	Delisted. SCCOG defers to the plans and procedures generated at the local level.
Consider posting the snow plowing routes in local government buildings and on the local website so residents and business owners may better understand their risk during winter travel.	Delisted. SCCOG defers to local officials as to the posting of snow plowing routes.
Continue to identify areas that are difficult to access during winter storm events and develop contingency plans for emergency personnel.	Delisted. SCCOG defers such efforts to local emergency managers.
Provide information for mitigating icing, insulating pipes, and retrofits for flat-roofed buildings in local building departments.	Delisted. SCCOG defers such efforts to local building officials.
Earthquakes	
Ensure that local departments have adequate backup supplies and facilities for continued functionality in case earthquake damage occurs to these buildings where these critical facilities are housed.	Delisted. SCCOG defers such efforts to local emergency managers.
Consider preventing residential development in areas prone to collapse such as below steep slopes or in areas prone to liquefaction.	Delisted. SCCOG does not have regulatory authority over local development and defers such efforts to local officials.
Wildfires	
Continue to support public outreach programs to increase awareness of forest fire danger, equipment usage, and protecting homes from wildfires.	Delisted. SCCOG defers such efforts to local emergency managers.
Ensure that provisions of local regulations regarding fire protection facilities are being enforced.	Delisted. SCCOG defers such efforts to local emergency managers.
Extend public water supply and fire protection to areas identified as being particularly at risk.	Delisted. SCCOG, through its role as a member of the Eastern Connecticut Water Utility Coordinating Committee, is assisting in the preparation of a Coordinated Water Supply Plan for the region which addresses, in part, water supply and fire protection needs. SCCOG defers to utilities regarding the actual extension of mains. This is a capability.

Table 11-1: Status of Regional Mitigation Strategies and Actions from 2012 HMP (Cont'd)

Regional Strategy or Action	Status
Pursue additional sources of fire-fighting water where adequate supplies do not exist, such as through the installation of dry hydrants.	Delisted. SCCOG defers such efforts to local emergency managers.
Continue to require that utilities be installed underground.	Delisted. SCCOG does not have regulatory authority and defers such matters to local officials.
Continue to evaluate areas at risk of wildfire in each community.	Delisted. This is done regulatory (during each regional HMP update) and is a capability.
Dam Failure	
Include dam failure areas in the Everbridge Reverse 911 emergency contact database	Delisted. The Reverse 9-1-1 systems are either managed locally or by the State of Connecticut. SCCOG defers the collection of phone numbers to these parties.
Work with the DEEP to ensure owners of high hazard dams have an EOP and dam failure inundation areas identified. Keep copies available locally for reference.	Delisted. SCCOG defers such efforts to local officials.
Encourage owners of significant hazard dams to develop an EOP.	Delisted. SCCOG defers such efforts to local officials.
Provide assistance to dam owners regarding resources available for inspections and maintenance.	Delisted. SCCOG defers such efforts to local officials.

11.2 Summary of Region-Wide Mitigation Actions

This section offers two actions that could be completed by SCCOG to contribute to the reduction of losses from natural hazards.

1. Conduct an Annual Meeting to Review Hazard Mitigation Plans with Local Officials

Action Description:	Local communities are required to conduct an annual meeting to review the status of their HMP annex, such that progress in meeting the goals of the plan can be measured, and so the meeting minutes and notes can be used to inform the next HMP update. Few SCCOG communities conducted the annual meetings over the last five years. SCCOG should host an annual meeting for local communities to report on their local annual meeting and progress to date.
Lead:	SCCOG
Priority:	TBD
Status:	New
Estimated Cost:	Minimal
Potential Funding Source(s):	Operating Budget
Timeframe:	Annually each October (10/2018, 10/2019, etc.)

2.	Conduct a Workshop to Determine Ways to Increase Individual Resiliency
Action Description:	Survey respondents requested that a study be conducted to identify ways to make it easier for residents, businesses, and organizations to take their own actions to mitigate for hazards and become more resilient to disasters. SCCOG should host a workshop to bring in experts from various fields to discuss ways to improve and promote individual resiliency efforts.
Lead:	SCCOG
Priority:	TBD
Status:	New
Estimated Cost:	Moderate
Potential Funding Source(s):	Grants from CIRCA and/or NOAA
Timeframe:	7/2020 to 6/2021

3.	Conduct a Historic Resources Resiliency Study
Action Description:	One of the findings of the historic resources resiliency study of 2016-2017 was that areas of future risk may arise as structures age and are designated as historic. Using the products of the SHPO grant, SCCOG will conduct a review of (1) historic structures in flood risk zones and (2) structures that are not yet designated as historic but could be in the future, and are also at risk of flooding and sea level rise.
Lead:	SCCOG
Priority:	TBD
Status:	New
Estimated Cost:	Moderate
Potential Funding Source(s):	Grants from SHPO and/or CIRCA
Timeframe:	7/2019 to 6/2021

11.3 Prioritization of Recommended Strategies and Actions

To prioritize recommended mitigation measures, it is necessary to determine how effective each measure will be in reducing or preventing damage. A set of criteria commonly used by public administration officials and planners was applied to each proposed strategy and action in this regional plan and in each annex. The method, called STAPLEE, is outlined in FEMA planning documents such as *Developing the Mitigation Plan* (FEMA 386-3) and *Using Benefit-Cost Review in Mitigation Planning* (FEMA 386-5). STAPLEE stands for the "Social, Technical, Administrative, Political, Legal, Economic, and Environmental" criteria for making planning decisions. The STAPLEE method was also used in the previous HMP.

Overview of the STAPLEE Prioritization Process

Benefit-cost review was emphasized in the prioritization process. Criteria were divided into potential benefits (pros) and potential costs (cons) for each mitigation strategy. The following questions were asked about the proposed mitigation strategies:

- **Social**:
  - Benefits: Is the proposed strategy socially acceptable to the jurisdiction?
  - Costs: Are there any equity issues involved that would mean that one segment of the region could be treated unfairly? Will the action disrupt established neighborhoods, break up voting districts, or cause the relocation of lower-income people? Is the action compatible with present and future community values?
- **Technical**:
  - Benefits: Will the proposed strategy work? Will it reduce losses in the long term with minimal secondary impacts?
  - Costs: Is the action technically feasible? Will it create more problems than it will solve? Does it solve the problem or only a symptom?
- **Administrative**:
  - Benefits: Does the project make it easier for each community to administer future mitigation or emergency response actions?
  - Costs: Does each community have the capability (staff, technical experts, and/or funding) to implement the action, or can it be readily obtained? Can the community perform the necessary maintenance? Can the project be accomplished in a timely manner?
- **Political**:
  - Benefits: Is the strategy politically beneficial? Is there public support both to implement and maintain the project? Is there a local champion willing to see the project to completion? Can the mitigation objectives be accomplished at the lowest cost to the community (grants, etc.)?
  - Costs: Have political leaders participated in the planning process? Do project stakeholders support the project enough to ensure success? Have the stakeholders been offered the opportunity to participate in the planning process?
- **Legal**:
  - Benefits: Is there a technical, scientific, or legal basis for the mitigation action? Are the proper laws, ordinances, and resolutions in place to implement the action?

- Costs: Does SCCOG or the individual municipality have the authority to implement the proposed action? Are there any potential legal consequences? Will the community be liable for the actions or support of actions, or for lack of action? Is the action likely to be challenged by stakeholders who may be negatively affected?

- **Economic**:

  - Benefits: Are there currently sources of funds that can be used to implement the action? What benefits will the action provide? Does the action contribute to community goals, such as capital improvements or economic development?

  - Costs: Does the cost seem reasonable for the size of the problem and the likely benefits? What burden will be placed on the tax base or local economy to implement this action? Should the considered action be tabled for implementation until outside sources of funding are available?

- **Environmental**:

  - Benefits: Will this action beneficially affect the environment (land, water, endangered species)?

  - Costs: Will this action comply with local, state, and federal environmental laws and regulations? Is the action consistent with community environmental goals?

Each proposed mitigation strategy presented in this plan was evaluated and quantitatively assigned a "benefit" score and a "cost" score for each of the seven STAPLEE criteria, as outlined below:

- For potential benefits, a score of "1" was assigned if the project will have a beneficial effect for that particular criterion; a score of "0.5" was assigned if there would be a slightly beneficial effect; or a "0" if the project would have a negligible effect or if the questions were not applicable to the strategy.
- For potential costs, a score of "-1" was assigned if the project would have an unfavorable impact for that particular criterion; a score of "-0.5" was assigned if there would be a slightly unfavorable impact; or a "0" if the project would have a negligible impact or if the questions were not applicable to the strategy.
- Technical and economic criteria were double weighted (x2) in the final sum of scores.
- The total benefit score and cost score for each mitigation strategy were summed to determine each strategy's final STAPLEE score.

Strategies and actions are prioritized in each community annex according to final score. The highest scoring is determined to be of more importance economically, socially, environmentally, and politically and, hence, prioritized over those with lower scoring. Scoring is translated into rankings of "High", "Medium", or "Low" relative to the range of scores for that community. Note that the scoring system inherently favors recommendations that have minimal incremental costs, such hosting meetings or workshops, over costly structural projects. An evaluation matrix with the total scores from each strategy or action can be found in each community annex.

Table 11.2 presents a STAPLEE analysis for the two regional actions described above in Section 11.2.

Table 11-2: STAPLEE Analysis for SCCOG Strategies and Actions

STAPLEE Criteria	Action #1 Conduct an Annual Meeting to Review HMP Status with Local Officials	Action #2 Conduct a Workshop to Determine Ways to Increase Individual Resiliency	Action #3 Conduct a Historic Resources Resiliency Study
Benefits			
Social	1.0	1.0	1.0
Technical (x2)	1.0	0.5	1.0
Administrative	1.0	0.5	1.0
Political	0.5	0.5	0.5
Legal	1.0	0.5	0.5
Economic (x2)	1.0	0.5	1.0
Environmental	0.0	0.0	0.0
Costs			
Social	0.0	-0.5	0.0
Technical (x2)	0.0	0.0	0.0
Administrative	0.0	-0.5	0.0
Political	-0.5	0.0	0.0
Legal	0.0	0.0	0.0
Economic (x2)	0.0	0.0	-1.0
Environmental	0.0	0.0	0.0
Total STAPLEE Score	**7.0**	**3.5**	**5.0**
Priority for SCCOG	**High**	**Low**	**Medium**

An implementation strategy and schedule is included for each strategy and action for each jurisdiction detailing the responsible department and anticipated timeframe for the specific strategies and actions listed throughout each annex. Funding sources for the proposed strategies and actions are also listed. These include the following:

- ❑ Operating and capital budgets;
- ❑ Local land trusts;
- ❑ Eversource for informational materials and utility hardening;
- ❑ Connecticut DOT Local Bridge Program for drainage improvements on State roads;
- ❑ FEMA's Emergency Operation Center (EOC) grant program (when funded);
- ❑ FEMA's Hazard Mitigation Assistance (HMA) grant program;
- ❑ The Public Utility Regulatory Authority microgrid grant and loan program; and
- ❑ Connecticut's Small Town Economic Assistance Program (STEAP).

Discussion of Benefit-Cost Ratio & Estimated Project Costs

Although a community may implement recommendations as prioritized by the STAPLEE method, an additional consideration is important for those recommendations that may be funded under the FEMA mitigation grant programs. To receive federal funding, the mitigation action must have a benefit-cost ratio (BCR) that exceeds one; namely, that the benefits of the project outweigh its costs. Calculation of the BCR is typically conducted using FEMA's Benefit Cost Analysis (BCA) toolkit. The calculation may be complex, vary with the mitigation action of interest, and is dependent on detailed information such as property value appraisals, design and construction costs for structural projects, and tabulations of previous damages or NFIP claims.

Although it is beyond the scope of this plan to develop precise BCRs for each recommendation, projects that are likely to qualify to receive funding are denoted on each community's STAPLEE matrix. When pursuing grants for selected projects, this information can be used to help select the projects that qualitatively have the greatest chance of successfully navigating through the application review process.

Provision of cost estimates for recommendations is not appropriate for a HMP, as this information can be misleading or inaccurate in several years and lead to problems when municipal personnel receive cost estimates from contractors. Potential costs of each recommendation is therefore listed as "minimal", "low", "intermediate", or "high" in Part 2 of each community's STAPLEE matrix. These are defined as follows:

- "Minimal" costs only include printing, copying, or meetings of personnel. Direct expenditures are expected to be less than $1,000 (staff time is not included).
- "Low" costs can typically be handled by existing personnel with few outside expenses. These projects typically cost less than $10,000.
- "Moderate" costs would require less than $100,000 to implement and may include studies, investigations, or small improvement projects.
- "High" costs would require greater expenditures and may require grant funding to successfully complete the project. Such projects typically include capital expenditures for construction or infrastructure.

12.0 RESOURCES AND REFERENCES

12.1 Potential Sources of Funding

The following sources of funding and technical assistance may be available for the projects listed in each community and tribal annex. More information about these agencies is presented in Section 12.2

General Hazard Mitigation

- FEMA Hazard Mitigation Grant Program (HMGP) – *funding for hazard mitigation projects following a presidentially declared disaster.*
- FEMA Pre-Disaster Mitigation Grant Program (PDM) – *funding for hazard mitigation projects on a nationally competitive basis.*
- Connecticut Land Conservation Council – *can provide funding to local land trusts for open space acquisition.*
- AmeriCorps – *teams may be available to assist with landscaping projects such as surveying, tree planting, restoration, construction, and environmental education.*

Beach Replenishment and Erosion Control

- U. S. Army Corps of Engineers – *funding for beach nourishment*.
- U.S. Department of Agriculture – *technical assistance for erosion control.*
- U.S. Fish and Wildlife National Coastal Wetlands Conservation Grant Program - *matching funds at the state level for projects that conserve, restore, and protect coastal wetlands. Nationally competitive.*
- North American Wetlands Conservation Act Grants Program – *funding for projects that support long-term wetlands acquisition, restoration, and/or enhancement. Requires a 1-to-1 funds match.*

Flood Mitigation

- FEMA Flood Mitigation Assistance (FMA) Program – *grants for pre-disaster flood hazard mitigation planning and projects such as property acquisition, relocation of residents, and flood retrofitting.*
- U.S. Army Corps of Engineers – *50/50 match funding for floodproofing and flood preparedness projects.*
- U.S. Department of Agriculture – *financial assistance to reduce flood damage in small watersheds and to improve water quality.*

Hurricane Mitigation

- FEMA State Hurricane Program - financial and technical assistance to local governments to support mitigation of hurricanes and coastal storms.
- FEMA Hurricane Program Property Protection – grants to hurricane prone states to implement hurricane mitigation projects.

Wildfire Mitigation

- Assistance to Firefighters Grant Program – pre-disaster grants to organizations such as fire departments that are recognized for expertise in fire prevention and safety programs.

12.2 Technical Resources

This section is comprised of a list of resources to be considered for technical assistance and potential financial assistance for completion of the actions outlined in this Plan. This list is not all inclusive and is intended to be updated as necessary.

Federal Resources

Federal Emergency Management Agency
Region I
99 High Street, 6th floor
Boston, MA 02110
(617) 956-7506
http://www.fema.gov/

Mitigation Division

The Mitigation Division is comprised of three branches that administer all of FEMA's hazard mitigation programs. The **Risk Analysis Branch** applies planning and engineering principles to identify hazards, assess vulnerabilities, and develop strategies to manage the risks associated with natural hazards. The **Risk Reduction Branch** promotes the use of land use controls and building practices to manage and assess risk in both the existing built developments and future development areas in both pre-disaster and post-disaster environments. The **Risk Insurance Branch** mitigates flood losses by providing affordable flood insurance for property owners and by encouraging communities to adopt and enforce floodplain management regulations.

FEMA programs administered by the Risk Analysis Branch include:

- *Flood Hazard Mapping Program*, which maintains and updates National Flood Insurance Program maps;
- *National Dam Safety Program*, which provides state assistance funds, research, and training in dam safety procedures;
- *National Hurricane Program*, which conducts and supports projects and activities that help protect communities from hurricane hazards; and
- *Mitigation Planning*, a process for states and communities to identify policies, activities, and tools that can reduce or eliminate long-term risk to life and property from a hazard event.

FEMA programs administered by the Risk Reduction Branch include:

- *Hazard Mitigation Grant Program (HMGP)*, which provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration;

- *Flood Mitigation Assistance Program (FMA)*, which provides funds to assist states and communities to implement measures that reduce or eliminate long-term risk of flood damage to structures insurable under the National Flood Insurance Program
- *Pre-Disaster Mitigation Grant Program (PDM)*, which provides program funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event;
- *Severe Repetitive Loss Program (SRL)*, which provides funding to reduce or eliminate the long-term risk of flood damage to "severe repetitive loss" structures insured under the National Flood Insurance Program;
- *Community Rating System (CRS)*, a voluntary incentive program under the National Flood Insurance Program that recognizes and encourages community floodplain management activities; and
- *National Earthquake Hazards Reduction Program (NEHRP)*, which in conjunction with state and regional organizations supports state and local programs designed to protect citizens from earthquake hazard.

The Risk Insurance Branch oversees the *National Flood Insurance Program (NFIP)*, which enables property owners in participating communities to purchase flood insurance. The NFIP assists communities in complying with the requirements of the program and publishes flood hazard maps and flood insurance studies to determine areas of risk.

FEMA also can provide information on past and current acquisition, relocation, and retrofitting programs, and has expertise in many natural and technological hazards. FEMA also provides funding for training state and local officials at the Emergency Management Institute in Emmitsburg, Maryland.

The Mitigation Directorate also has in place several *Technical Assistance Contracts (TAC)* that support FEMA, states, territories, and local governments with activities to enhance the effectiveness of natural hazard reduction program efforts. The TACs support FEMA's responsibilities and legislative authorities for implementing the earthquake, hurricane, dam safety, and floodplain management programs. The range of technical assistance services provided through the TACs varies based on the needs of the eligible contract users and the natural hazard programs. Contracts and services include:

- *The Hazard Mitigation Technical Assistance Program (HMTAP) Contract* – supporting post-disaster program needs in cases of large, unusual, or complex projects; situations where resources are not available; or where outside technical assistance is determined to be needed. Services include environmental and biological assessments, benefit/cost analyses, historic preservation assessments, hazard identification, community planning, training, and more;
- *The Wind and Water Technical Assistance Contract (WAWTAC)* - supporting wind and flood hazards reduction program needs. Projects include recommending mitigation measures to reduce potential losses to post-FIRM structures, providing mitigation policy and practices expertise to states, incorporating mitigation into local hurricane program outreach materials, developing a Hurricane Mitigation and Recovery exercise, and assessing the hazard vulnerability of a hospital; and
- *The National Earthquake Technical Assistance Contract (NETAC)* – supporting earthquake program needs. Projects include economic impact analyses of various earthquakes, vulnerability analyses of

hospitals and schools, identification of and training on nonstructural mitigation measures, and evaluating the performance of seismically rehabilitated structures, post-earthquake.

Response & Recovery Division

As part of the National Response Plan, this division provides information on dollar amounts of past disaster assistance including Public Assistance, Individual Assistance, and Temporary Housing, as well as information on retrofitting and acquisition/relocation initiatives. The Response & Recovery Division also provides mobile emergency response support to disaster areas, supports the National Disaster Medical System, and provides urban search and rescue teams for disaster victims in confined spaces.

The division also coordinates federal disaster assistance programs. This includes the Public Assistance Grant Program (PA), which provides 75% grants for mitigation projects to protect eligible damaged public and private nonprofit facilities from future damage. "Minimization" grants at 100% are available through the Individuals and Family Grant Program. The Hazard Mitigation Grant Program and the Fire Management Assistance Grant Program are also administered by this division.

Computer Sciences Corporation
New England Regional Insurance Manager
Bureau and Statistical Office
(781) 848-1908

Corporate Headquarters
3170 Fairview Park Drive
Falls Church, VA 22042
(703) 876-1000
http://www.csc.com/

A private company contracted by the Federal Insurance Administration as the National Flood Insurance Program Bureau and Statistical Agent, CSC provides information and assistance on flood insurance, including handling policy and claims questions and providing workshops to leaders, insurance agents, and communities.

Small Business Administration
Region I
10 Causeway Street, Suite 812
Boston, MA 02222-1093
(617) 565-8416
http://www.sba.gov/

SBA has the authority to "declare" disaster areas following disasters that affect a significant number of homes and businesses but that would not need additional assistance through FEMA. (SBA is triggered by a FEMA declaration, however.) SBA can provide additional low-interest funds (up to 20% above what an eligible applicant would "normally" qualify for) to install mitigation measures. They can also loan the

cost of bringing a damaged property up to state or local code requirements. These loans can be used in combination with the new "mitigation insurance" under the NFIP or in lieu of that coverage.

Environmental Protection Agency
Region I
1 Congress Street, Suite 1100
Boston, MA 02114-2023
(888) 372-7341

Provides grants for restoration and repair and educational activities, including:

- *Capitalization Grants for State Revolving Funds*: Low interest loans to governments to repair, replace, or relocate wastewater treatment plants damaged in floods. Does not apply to drinking water or other utilities; and
- *Clean Water Act Section 319 Grants*: Cost-share grants to state agencies that can be used for funding watershed resource restoration activities, including wetlands and other aquatic habitat (riparian zones). Only those activities that control non-point pollution are eligible. Grants are administered through the CT DEEP, Bureau of Water Management, Planning and Standards Division.

U.S. Department of Housing and Urban Development
20 Church Street, 19th Floor
Hartford, CT 06103-3220
(860) 240-4800
http://www.hud.gov/

The U.S. Department of Housing and Urban Development offers *Community Development Block Grants (CDBG)* to communities with populations greater than 50,000, who may contact HUD directly regarding CDBG. One program objective is to improve housing conditions for low and moderate income families. Projects can include acquiring floodprone homes or protecting them from flood damage. Funding is a 100% grant and can be used as a source of local matching funds for other funding programs such as FEMA's "404" Hazard Mitigation Grant Program. Funds can also be applied toward "blighted" conditions, which is often the post-flood condition. A separate set of funds exists for conditions that create an "imminent threat." The funds have been used in the past to replace (and redesign) bridges where flood damage eliminates police and fire access to the other side of the waterway. Funds are also available for smaller municipalities through the state-administered CDBG program participated in by the State of Connecticut.

U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742-2751
(978) 318-8520

The Corps provides 100% funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services Program (FPMS). Specific programs used by the Corps for mitigation are listed below.

- *Section 205 – Small Flood Damage Reduction Projects*: This section of the 1948 Flood Control Act authorizes the Corps to study, design, and construct small flood control projects in partnership with non-Federal government agencies. Feasibility studies are 100 percent federally-funded up to $100,000, with additional costs shared equally. Costs for preparation of plans and construction are funded 65 percent with a 35 percent non-federal match. In certain cases, the non-Federal share for construction could be as high as 50 percent. The maximum federal expenditure for any project is $7 million.
- *Section 14 – Emergency Streambank and Shoreline Protection:* This section of the 1946 Flood Control Act authorizes the Corps to construct emergency shoreline and streambank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and non-profit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $1.5 million.
- *Section 103 – Hurricane and Storm Damage Reduction Projects:* This section of the 1962 River and Harbor Act authorizes the Corps to study, design, and construct small coastal storm damage reduction projects in partnership with non-Federal government agencies. Beach nourishment (structural) and floodproofing (non-structural) are examples of storm damage reduction projects constructed under this authority. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $5 million.
- *Section 208 – Clearing and Snagging Projects:* This section of the 1954 Flood Control Act authorizes the Corps to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.
- *Section 206 – Floodplain Management Services:* This section of the 1960 Flood Control Act, as amended, authorizes the Corps to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100 percent federally funded.

In addition, the Corps also provides emergency flood assistance (under Public Law 84-99) after local and state funding has been used. This assistance can be used for both flood response and post-flood response. Corps assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, the Corps can loan or issue supplies and equipment once local sources are exhausted during emergencies.

U.S. Department of Commerce
National Weather Service
Northeast River Forecast Center
445 Myles Standish Blvd.
Taunton, MA 02780
(508) 824-5116
http://www.nws.noaa.gov/

The National Weather Service prepares and issues flood, severe weather, and coastal storm warnings. Staff hydrologists can work with communities on flood warning issues and can give technical assistance in preparing flood warning plans.

U.S. Department of the Interior
National Park Service
Steve Golden, Program Leader
Rivers, Trails, & Conservation Assistance
15 State Street
Boston, MA 02109
(617) 223-5123
http://www.nps.gov/rtca/

The National Park Service provides technical assistance to community groups and local, state, and federal government agencies to conserve rivers, preserve open space, and develop trails and greenways as well as identify nonstructural options for floodplain development.

U.S. Fish and Wildlife Service
New England Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5087
(603) 223-2541
http://www.fws.gov/

The U.S. Fish and Wildlife Service provides technical and financial assistance to restore wetlands and riparian habitats through the North American Wetland Conservation Fund and Partners for Wildlife programs. It also administers the *North American Wetlands Conservation Act Grants Program*, which provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands projects in the United States, Canada, and Mexico. Funds are available for projects focusing on protecting, restoring, and/or enhancing critical habitat.

U.S. Department of Agriculture
Natural Resources Conservation Service (formerly SCS)
Connecticut Office
344 Merrow Road, Suite A
Tolland, CT 06084-3917
(860) 871-4011

The Natural Resources Conservation Service provides technical assistance to individual landowners, groups of landowners, communities, and soil and water conservation districts on land use and conservation planning, resource development, stormwater management, flood prevention, erosion control and sediment reduction, detailed soil surveys, watershed/river basin planning and recreation, and fish and wildlife management. Financial assistance is available to reduce flood damage in small watersheds and to improve water quality. Financial assistance is available under the Emergency Watershed Protection Program, the Cooperative River Basin Program, and the Small Watershed Protection Program.

Regional Resources

Northeast States Emergency Consortium
1 West Water Street, Suite 205
Wakefield, MA 01880
(781) 224-9876
http://www.serve.com/NESEC/

The Northeast States Emergency Consortium (NESEC) develops, promotes, and coordinates "all-hazards" emergency management activities throughout the northeast. NESEC works in partnership with public and private organizations to reduce losses of life and property. They provide support in areas including interstate coordination and public awareness and education, along with reinforcing interactions between all levels of government, academia, nonprofit organizations, and the private sector.

State Resources

Connecticut Department of Economic and Community Development
505 Hudson Street
Hartford, CT 06106-7106
(860) 270-8000
http://www.ct.gov/ecd/

The Connecticut Department of Economic and Community Development administers HUD's State CDBG Program, awarding smaller communities and rural areas grants for use in revitalizing neighborhoods, expanding affordable housing and economic opportunities, and improving community facilities and services.

Connecticut Department of Energy & Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
(860) 424-3000
http://www.dep.state.ct.us/

DEEP is generally responsible for flood hazard mitigation in Connecticut, including administration of the National Flood Insurance Program. Other programs within the division include:

- *National Flood Insurance Program State Coordinator*: Provides flood insurance and floodplain management technical assistance, floodplain management ordinance review, substantial damage/improvement requirements, community assistance visits, and other general flood hazard mitigation planning including the delineation of floodways;
- *Flood & Erosion Control Board Program*: Provides assistance to municipalities to solve flooding, beach erosion, and dam repair problems. Has the power to construct and repair flood and erosion management systems. Certain nonstructural measures that mitigate flood damages are also eligible. Funding is provided to communities that apply for assistance through a Flood & Erosion Control Board on a noncompetitive basis;
- *Inland Wetlands and Watercourses Management Program*: Provides training, technical, and planning assistance to local Inland Wetlands Commissions; reviews and approves municipal regulations for localities. Also controls flood management and natural disaster mitigations;
- *Dam Safety Program*: Charged with the responsibility for administration and enforcement of Connecticut's dam safety laws. Regulates the operation and maintenance of dams in the state. Permits the construction, repair, or alteration of dams, dikes, or similar structures and maintains a registration database of all known dams statewide. This program also operates a statewide inspection program;
- *Rivers Restoration Grant Program*: Administers funding and grants under the Clean Water Act involving river restoration and reviews and provides assistance with such projects;
- *Planning and Standards Division*: administers the Clean Water Fund and many other programs directly and indirectly related to hazard mitigation including the Section 319 nonpoint source pollution reduction grants and municipal facilities program, which deals with mitigating pollution from wastewater treatment plants; and
- *Former Office of Long Island Sound Programs (OLISP)*: Administers the Coastal Area Management (CAM) Act program and Long Island Sound License Plate Program.

Connecticut Department of Emergency Management and Homeland Security
25 Sigourney Street, 6th Floor
Hartford, CT 06106-5042
(860) 256-0800
http://www.ct.gov/demhs/

DEMHS is the lead agency responsible for emergency management and hazard mitigation. Specifically, responsibilities include emergency preparedness, response and recovery, mitigation, and an extensive training program. DEMHS is the state point of contact for most FEMA grant and assistance programs.

DEMHS administers the Earthquake and Hurricane programs described above under the FEMA resource section. Additionally, DEMHS operates a mitigation program to coordinate mitigation throughout the state with other government agencies. Additionally, the agency is available to provide technical assistance to sub-applicants during the planning process.

As the State's home of the *State Hazard Mitigation Officer,* DEMHS is charged with hazard mitigation planning and policy; oversight of administration of the Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, and Pre-Disaster Mitigation Program. DEMHS has the responsibility of making certain that the State Natural Hazard Mitigation Plan is updated every five years.

Connecticut Department of Public Safety
1111 Country Club Road
Middletown, CT 06457
(860) 685-8190
http://www.ct.gov/dps/

Office of the State Building Inspector **-** The Office of the State Building Inspector is responsible for administering and enforcing the Connecticut State Building Code and is also responsible for the municipal Building Inspector Training Program.

Connecticut Department of Transportation
2800 Berlin Turnpike
Newington, CT 06131-7546
(860) 594-2000
http://www.ct.gov/dot/

The Department of Transportation administers the federal Intermodal Surface Transportation Efficiency Act (ISTEA) that includes grants for projects that promote alternative or improved methods of transportation. Funding through grants can often be used for projects with mitigation benefits such as preservation of open space in the form of bicycling and walking trails. CT DOT is also involved in traffic improvements and bridge repairs that could be mitigation related.

Private and Other Resources

Association of State Dam Safety Officials
450 Old Vine Street
Lexington, KY 40507
(859) 257-5140
http://www.damsafety.org

ASDSO is a nonprofit organization of state and federal dam safety regulators, dam owners/operators, dam designers, manufacturers/suppliers, academia, contractors and others interested in dam safety. Their mission is to advance and improve the safety of dams by supporting the dam safety community and state dam safety programs, raising awareness, facilitating cooperation, providing a forum for the exchange of information, representing dam safety interests before governments, providing outreach programs, and creating a unified community of dam safety advocates.

The Association of State Floodplain Managers (ASFPM)
2809 Fish Hatchery Road, Suite 204
Madison, WI 53713
(608) 274-0123
http://www.floods.org/

ASFPM is a professional association of state employees with a membership of over 1,000 that assists communities with the NFIP. ASFPM has developed a series of technical and topical research papers and a series of Proceedings from their annual conferences. Many "mitigation success stories" have been documented through these resources and provide a good starting point for planning. ASFPM also hosts workshops, local and online training sessions, and oversees a national certification program for floodplain managers.

Connecticut Association of Flood Managers
P.O. Box 270213
West Hartford, CT 06105
ContactCAFM@gmail.com
http://ctfloods.org/

CAFM is a professional association of local floodplain managers, consultants, state and regional officials, and staff from non-profit organizations that facilitates training and outreach regarding flood management techniques. CAFM is the local state chapter of ASFPM (above).

Institute for Business & Home Safety
4775 East Fowler Avenue
Tampa, FL 33617
(813) 286-3400
http://www.ibhs.org/

A nonprofit organization put together by the insurance industry to research ways of reducing the social and economic impacts of natural hazards. The institute advocates the development and implementation of building codes and standards nationwide and may be a good source of model code language.

Multidisciplinary Center for Earthquake Engineering and Research (MCEER)
University at Buffalo
State University of New York
Red Jacket Quadrangle
Buffalo, NY 14261
(716) 645-3391
http://mceer.buffalo.edu/

A source for earthquake statistics, research, and for engineering and planning advice.

The National Association of Flood & Stormwater Management Agencies (NAFSMA)
1301 K Street, NW, Suite 800 East
Washington, DC 20005
(202) 218-4122
http://www.nafsma.org

NAFSMA is an organization of public agencies that strive to protect lives, property, and economic activity from the adverse impacts of stormwater by advocating public policy, encouraging technology, and conducting educational programs. NAFSMA is a voice in national politics on water resources management issues concerning stormwater management, disaster assistance, flood insurance, and federal flood management policy.

National Emergency Management Association (NEMA*)*
P.O. Box 11910
Lexington, KY 40578
(859)-244-8000
http://www.nemaweb.org/

A national association of state emergency management directors and other emergency management officials, the NEMA Mitigation Committee is a strong voice to FEMA in shaping all-hazard mitigation policy in the nation. NEMA is also an excellent source of technical assistance.

Natural Hazards Center
University of Colorado at Boulder
482 UCB
Boulder, CO 80309-0482
(303) 492-6818
http://www.colorado.edu/hazards/

The Natural Hazards Center includes the Floodplain Management Resource Center, a free library and referral service of the ASFPM for floodplain management publications. The Natural Hazards Center is located at the University of Colorado in Boulder. Staff can use key words to identify useful publications from the more than 900 documents in the library.

New England Flood and Stormwater Managers Association, Inc. (NEFSMA)
c/o MA DEM
100 Cambridge Street
Boston, MA 02202

NEFSMA is a nonprofit organization made up of state agency staff, local officials, private consultants, and citizens from across New England. NEFSMA sponsors seminars and workshops and publishes the NEFSMA News three times per year to bring the latest flood and stormwater management information from around the region to its members.

Volunteer Organizations - Volunteer organizations including the ARC, the Salvation Army, Habitat for Humanity, and the Mennonite Disaster Service are often available to help after disasters. Service organizations such as the Lions Club, Elks Club, and the Veterans of Foreign Wars are also available. Habitat for Humanity and the Mennonite Disaster Service provide skilled labor to help rebuild damaged buildings while incorporating mitigation or floodproofing concepts. The office of individual organizations can be contacted directly or the FEMA Regional Office may be able to assist.

Flood Relief Funds - After a disaster, local businesses, residents, and out-of-town groups often donate money to local relief funds. They may be managed by the local government, one or more local churches, or an ad hoc committee. No government disaster declaration is needed. Local officials should recommend that the funds be held until an applicant exhausts all sources of public disaster assistance, allowing the funds to be used for mitigation and other projects that cannot be funded elsewhere.

AmeriCorps - AmeriCorps is the National Community Service Organization. It is a network of local, state, and national service programs that connects volunteers with nonprofits, public agencies, and faith-based and community organizations to help meet our country's critical needs in education, public safety, health, and the environment. Through their service and the volunteers they mobilize, AmeriCorps members address critical needs in communities throughout America, including helping communities respond to disasters. Some states have trained AmeriCorps members to help during flood-fight situations such as by filling and placing sandbags.

12.3 References

Association of State Dam Safety Officials, 2010, "Dam Failures, Dam Incidents (Near Failures)," http://www.damsafety.org/media/Documents/PRESS/US_FailuresIncidents.pdf

___, 2010, Connecticut Dam Safety Program, http://www.damsafety.org/map/state.aspx?s=7

Barret, K., and W. Salis, 2017. "Prevalence and Magnitude of Trends in Peak Annual Flow and 5-, 10-. And 20-Year Flows in the Northeastern United States," Journal of Hydrologic Engineering, 22(3). American Society of Civil Engineers

Benson, Adam, 2011, "Norwich seeing building surge", http://www.norwichbulletin.com/carousel/x605400751/Norwich-seeing-building-surge

Benson, J., 2011, "It's Official: 3 to 5 foot storm tide surges during Tropical Storm Irene", The Day, http://www.theday.com/article/20110902/NWS01/110909887/0/SEARCH

Blake, E. S., Jarrell, J. D., Rappaport, E. N., Landsea, C. W., 2006, The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2005 (and Other Frequently Requested Hurricane Facts), Miami, FL: NOAA Technical Memorandum NWS TPC-4, http://www.nhc.noaa.gov/Deadliest_Costliest.shtml

Buck, Rinker, 2010, "Earthquake Reported off Long Island Sound", Hartford Courant, http://articles.courant.com/2010-11-30/news/hc-earthquake-1201-20101130_1_small-quake-minor-earthquake-minor-temblor

Butler, David A., "Geological History of Jamestown, Rhode Island – Building the Northern Appalachian Mountains and New England," http://www.jamestown-ri.info/northern_appalachians.htm, Last assessed 12/30/2010.

City of Norwich, 2012, http://www.norwichct.org/

Columbia University Earth Institute, NASA Goddard Institute for Space Studies, and The Nature Conservancy, 2011, "Downscaled Sea Level Rise Projections for Long Island Sound Across Several Emission Scenarios."

Connecticut Aging Services Division – State Unit on Aging, 2012, "Emergency Preparedness", http://www.ct.gov/agingservices/cwp/view.asp?a=2513&q=423446, Department of Social Services.

Connecticut Department of Economic and Community Development, 2011, "Construction Reports: Housing Production and Permits" 2005 – 2010, http://www.ct.gov/ecd/cwp/view.asp?a=1105&q=251248

Connecticut Department of Emergency Services and Public Protection, 2011, "Safety Planning Information for Neighbors of Millstone Power Station", http://www.ct.gov/demhs/lib/demhs/rept/millstone_ep_book_2011_12_hires.pdf

Connecticut Department of Environmental Protection, 2014, Connecticut's Natural Hazards Mitigation Plan Update.

___, 2007, Natural Hazards Mitigation Plan For 2007-2010.

___, 2007, High Hazard & Significant Hazard Dams in Connecticut, rev. 9/11/07. http://www.ct.gov/dep/lib/dep/water_inland/dams/high_significant_hazard_dams.pdf

___, 1999, Tropical Storm Floyd Heavy Rains and Flooding, September 15-16, 1999, Review Draft, Inland Water Resources Division

___, GIS Data for Connecticut - DEP Bulletin Number 40, revised 2012.

Connecticut Flood Recovery Committee, 1955, Report of the Connecticut Flood Recovery Committee, November 3, 1955, Connecticut State Library, http://www.cslib.org/floodrecov.pdf

Connecticut Geological & Natural History Survey, 1990, Generalized Bedrock Geologic Map of Connecticut, Department of Environmental Protection, http://www.wesleyan.edu/ctgeology/images/CtGeoMap_big.jpg, Assessed 12/30/2010.

Connecticut State Data Center, 2012, Connecticut Census Data, http://ctsdc.uconn.edu/connecticut_census_data.html

Cornell University, 2011, Information regarding the magnitude 5.8 earthquake that occurred 38 miles from Richmond, Virginia on August 23, 2011.

Federal Emergency Management Agency, April 2017, HAZUS® Estimated Annualized Earthquake Losses for the United States. FEMA document P-366.

____, 2012, Community Status Book Report – Connecticut, http://www.fema.gov/cis/CT.html

____, 2012, "Connecticut Disaster History", http://www.fema.gov/news/disasters_state.fema?id=9

____, 2011, "Community Rating System (CRS) Communities and their Classes", http://www.fema.gov/library/viewRecord.do?id=3629

____, 2011, Flood Insurance Study, New London County, Connecticut (All Jurisdictions), Effective July 18, 2011.

___, 2010, Hazard Mitigation Assistance Unified Guidance. http://www.fema.gov/library/viewRecord.do?id=4225

___, 2010, "Tribal Multi-Hazard Mitigation Planning Guidance", http://www.fema.gov/library/viewRecord.do?id=4135

___, 2010, "Wind Zones in the United States", http://www.fema.gov/plan/prevent/saferoom/tsfs02_wind_zones.shtm

___, 2009, "FEMA BCA Toolkit v.4.5.5.0."

___, 2007, "Connecticut Receives More Than $6.4 Million in Federal Disaster Aid", http://www.fema.gov/news/newsrelease.fema?id=38763

___, 2007, Multi-Hazard Mitigation Planning Guidance Under the Disaster Mitigation Act of 2000. March 2004, Revised November 2006 and June 2007.

___, 2007, Using Benefit-Cost Review in Mitigation Planning, State and Local Mitigation Planning How-To Guide Number Five, FEMA document 386-5.

___, 2005, Reducing Damage from Localized Flooding: A Guide for Communities, FEMA document 511.

___, 2003, Developing the Mitigation Plan – Identifying Mitigation Actions and Implementation Strategies, State and Local Mitigation Planning How-To Guide Number Three, FEMA document 386-3.

___, 1999, "In the Aftermath of Floyd, FEMA Offers Suggestions to Reduce Damages from the Next Flood," FEMA Release 1302-15, http://www.fema.gov/news/newsrelease.fema?id=8655

___, 1987, Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials, The Association of State Floodplain Managers.

___, Hazards, Tornadoes, http://www.fema.gov/hazard/tornado/index.shtm

___, Multi-Hazard Loss Estimation Methodology – Earthquake Model: Hazus-MH MR5 Technical Manual.

___, Multi-Hazard Loss Estimation Methodology – Flood Model: Hazus-MH MR5 Technical Manual.

___, Multi-Hazard Loss Estimation Methodology – Hurricane Model: Hazus-MH MR5 Technical Manual.

Floodmaps.com, "Zone Classifications", http://www.floodmaps.com/zones.htm

Flounders, Helene T., 2004, Connecticut Statewide Forest Resource Plan, 2004 – 2013, Connecticut Department of Environmental Protection.

Fox News.com. 2008. Rare Earthquake Strikes Connecticut. http://www.foxnews.com/story/0,2933,336973,00.html. Accessed 8/11/2010.

Glowacki, D. 2005. Heavy Rains & Flooding of Sub-Regional Drainage Basins. Reviewed Draft. Connecticut Department of Environmental Protection, Inland Water Resources Division.

City of Groton, 2012, http://www.cityofgroton.com/main.asp

Hallenbeck, B., 2010, "Co-Gen Plant Puts Tribe on Green Path", http://www.theday.com/article/20100819/BIZ02/308199455/-1/BIZ

Hershfield, David M., 1961, Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U. S. Department of Commerce, Weather Bureau.

Intergovernmental Panel on Climate Change, 2001, Third Assessment Report: Climate Change 2001.

International Code Council, 2009, "International Building Code", http://publicecodes.citation.com/icod/ibc/2009/index.htm

Kafka, Alan L. 2008. Why Does the Earth Quake in New England? Boston College, Weston Observatory, Department of Geology and Geophysics. http://www2.bc.edu/~kafka/Why_Quakes/why_quakes.html. Accessed 8/11/2010.

Kennard, D., 2008, "Fuel Categories", Forest Encyclopedia Network, http://www.forestencyclopedia.net/p/p4/p140/p353/p506

Map and Geographic Information Center, 2012, "Connecticut GIS Data", University of Connecticut, Storrs, Connecticut, http://magic.lib.uconn.edu/connecticut_data.html

The Mashantucket Pequot Museum and Research Center, 2012, http://www.pequotmuseum.org/ExhibitGalleries/MashantucketPequotsToday/

Mashantucket Pequot Tribal Nation, 2011, Draft sections of the 2012 Emergency Management Plan Update.

The Mashantucket (Western) Pequot Tribal Nation, 2012, http://www.mashantucket.com/

Milone & MacBroom, Inc., 2012, Draft Town of Guilford, Connecticut Natural Hazard Mitigation Plan.

___, 2012, Draft Town of East Haven, Connecticut Natural Hazard Mitigation Plan Update.

___, 2012, Draft Multi-Jurisdictional Natural Hazard Mitigation Plan for the Valley Region Council of Governments, Derby, Connecticut.

___, 2012, City of Danbury, Connecticut Natural Hazard Mitigation Plan, Housatonic Valley Council of Elected Officials, Brookfield, Connecticut.

___, 2007, Town of Nantucket, Massachusetts Natural Hazard Mitigation Plan.

___, 2006, Greater Bridgeport Regional Planning Agency Natural Hazard Mitigation Plan, Greater Bridgeport Regional Planning Agency, Bridgeport, CT.

___, 2005, City of New Haven, Connecticut Natural Hazard Mitigation Plan.

Miller, D.R., G.S. Warner, F.L. Ogden, A.T. DeGaetano, 1997, Precipitation in Connecticut. University of Connecticut College of Agriculture and Natural Resources. Connecticut Institute of Water Resources, Storrs, CT.

Muckel, G.B. (editor). 2004. Understanding Soil Risks and Hazards: Using Soil Survey to Identify Areas with Risks and Hazards to Human Life and Property. United States Department of Agriculture, Natural Resource Conservation Service, National Soil Survey Center, Lincoln, NE.

Municipal Code Corporation, 2012, http://www.municode.com/

National Interagency Fire Center, 2012, Fire Information – Wildland Fire Statistics, http://www.nifc.gov/fireInfo/fireInfo_statistics.html

National Oceanic and Atmospheric Administration, Coastal Services Center, 2017, "Hurricane Historical Tracks", https://coast.noaa.gov/hurricanes/?redirect=301ocm

___, National Climatic Data Center, 2012, "Station Snow Climatology", http://www.ncdc.noaa.gov/ussc/USSCAppController?action=station_select&county=true&state=06

___, 2012, "1981-2010 US Normals Data", http://gis.ncdc.noaa.gov/map/cdo/?thm=themeNormals

____, National Hurricane Center, 2011, "Return Periods", http://www.nhc.noaa.gov/HAW2/english/basics/return.shtml

National Oceanic and Atmospheric Administration (NOAA). Enhanced F-scale for Tornado Damage. http://www.spc.noaa.gov/efscale/

___, Severe Weather, http://www.noaawatch.gov/themes/severe.php

___, National Severe Storms Laboratory, 2009, "Tornado Basics", http://www.nssl.noaa.gov/primer/tornado/tor_basics.html

___, 2008, "Lightning Basics", http://www.nssl.noaa.gov/primer/lightning/ltg_basics.html

___, 2006, "Damaging Winds Basics", http://www.nssl.noaa.gov/primer/wind/wind_basics.html

___, 2006, "Hail Basics", http://www.nssl.noaa.gov/primer/hail/hail_basics.html

___, 2004, "Climatography of the United States, No. 20, 1971-2000: Danbury, CT," http://cdo.ncdc.noaa.gov/climatenormals/clim20/ct/061762.pdf

___. 2001, Winter Storms: The Deceptive Killers – A Preparedness Guide. http://www.nws.noaa.gov/om/winter/resources/winterstorm.pdf

___, 1995, A Preparedness Guide.

___. Weekend Snowstorm in Northeast Corridor Classified as a Category 3 "Major" Storm. http://www.noaanews.noaa.gov/stories2006/s2580.htm

___, National Climatic Data Center (NCDC), 2012, Storm Events Database, http://www.ncdc.noaa.gov/stormevents/

___, 2011, "The Northeast Snowfall Impact Scale (NESIS)", http://www.ncdc.noaa.gov/snow-and-ice/nesis.php

___, National Weather Service, Office of Climate, Water, and Weather Services, 2010, "New Weather Fatality, Injury, and Damage Statistics", http://www.nws.noaa.gov/om/hazstats.shtml

___, National Weather Service Columbia, SC Forecast Office, 2010, "Downbursts…", http://www.erh.noaa.gov/cae/svrwx/downburst.htm

___, 2010, Hail…, http://www.erh.noaa.gov/er/cae/svrwx/hail.htm

___, National Weather Service Louisville, KY Weather Forecast Office, 2005, Tornado Classifications, http://www.crh.noaa.gov/lmk/preparedness/tornado_small/classify.php

Neumann, J.E., G. Yohe, R. Nicholls, M. Manion, 2000, Sea-level Rise and Global Climate Change, A Review of Impacts to the U.S. Coasts, Prepared for the Pew Center on Global Climate Change.

New England Seismic Network, 2011, "NESN Recent Earthquakes", Weston Observatory – Boston College, http://aki.bc.edu/cgi-bin/NESN/recent_events.pl

Northeast States Emergency Consortium. Earthquakes. http://www.nesec.org/hazards/Earthquakes.cfm. Accessed 8/11/2010.

Norwich Commission on the City Plan, 2002, *Norwich Plan of Conservation and Development*.

Norwich Harbor Management Commission, 2011, *A Waterfront Vision for the City of Norwich*.

The Paleontological Research Institution, "Geologic History – Mountain Building Part 1: The Grenville Mountains." http://www.priweb.org/ed/TFGuide/NE/geo_history/history_files2/history_pdfs/ne_geohistory1.pdf

Risingsea.net, 2009, "Governments Plan for Development of Land Vulnerable to Rising Sea Level: Southeastern Connecticut", http://risingsea.net/ERL/CT_Southeastern.html.

Robinson, G. R. Jr., Kapo, K. E. 2003. Generalized Lithology and Lithogeochemical Character of Near-Surface Bedrock in the New England Region. U.S. Geological Survey Open-File Report 03-225, U.S. Geological Survey, Reston, VA. http://pubs.usgs.gov/of/2003/of03-225/

Smith, Greg, 2010, "City of Norwich declares state of emergency", http://www.norwichbulletin.com/newsnow/x1176898301/Norwich-schools-closed-due-to-expected-flooding-rain-continues#axzz1ySkprA9P

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Series Classification Database [Online WWW]. Available URL: http://soils.usda.gov/soils/technical/classification/scfile/index.html [Accessed 10 February 2004]. USDA-NRCS, Lincoln, NE.

Southeastern Connecticut Council of Governments, 2012, *Land Use – 2011 – Southeastern Connecticut Region*, http://www.seccog.org/documents.html

___, 2010, "Regional Water Priority Planning Document", http://www.seccog.org/pdfs/Region_water_2011.pdf

____, 2007, *Regional Plan of Conservation and Development*, http://www.seccog.org/documents.html

____, 2004, *Regional Emergency Management Plan for the Southeastern Connecticut Region*, http://www.seccog.org/documents.html

Southeastern Connecticut Council of Governments, Northeastern Region Council of Governments, and Windham Region Council of Governments, 2011, *Regional Emergency Support Plan Version 2.0*, DESPP / EMHS Division, Region 4 Regional Emergency Planning Team.

___, 2008, *RESF SWOT Analysis Summary*, http://www.seccog.org/documents.html

The Mohegan Tribe webpage, 2011, http://www.mohegan.nsn.us/

The Nature Conservancy, 2012, "Future Scenarios Map", Coastal Resilience Planning Tool, http://coastalresilience.org/geographies/long-island-sound/future-scenarios-map

Tornado Project Online. http://www.tornadoproject.com/

United States Army Corps of Engineers, 1994, *Connecticut Hurricane Evacuation Study and Technical Data Report*, http://www.ct.gov/dep/lib/dep/long_island_sound/coastal_hazards/ace1994tdr.pdf

___, 1979-1980, National Program for Inspection of Non-Federal Dams, Phase I Inspection Reports. http://oai.dtic.mil/oai/

United States Census Bureau, 2011, 2010 Census Data, http://2010.census.gov/2010census/popmap/

United States Department of Transportation, 2002, *The Potential Impacts of Climate Change on Transportation*, The DOT Center for Climate Change and Environmental Forecasting. Workshop, October 1-2, 2002, Summary and Discussion Papers.

United States Geological Survey. USGS Water Data for Connecticut.
http://nwis.waterdata.usgs.gov/ct/nwis/nwis

United States Geological Survey, Earthquake Hazards Program. Connecticut Earthquake History. Abridged from Earthquake Information Bulletin, January – February 1971.
http://earthquake.usgs.gov/regional/states/connecticut/history.php. Assessed 8/11/2010.

___, 2010, "2009 Earthquake Probability Mapping",
https://geohazards.usgs.gov/eqprob/2009/index.php

___, 2010, "Magnitude / Intensity Comparison",
http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

___. 2009. Seismic Hazard Map of Connecticut.
http://earthquake.usgs.gov/regional/states/connecticut/hazards.php. Assessed 8/11/2010.

___. 2009. The Severity of an Earthquake. http://pubs.usgs.gov/gip/earthq4/severitygip.html Assessed 8/11/2010.

___, 2009, "Top Earthquake States", http://earthquake.usgs.gov/earthquakes/states/top_states.php

___, 2006, Wildfire Hazards – A National Threat, http://pubs.usgs.gov/fs/2006/3015/2006-3015.pdf

___, 1999, National Assessment of Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Atlantic Coast, U.S. Geological Survey Open-File Report 99-593.

___, Professional Paper 1693, Coastal Bluffs of New England.

University of Connecticut Center for Land Use Education & Research (CLEAR), 2012, "Connecticut's Changing Landscape", http://clear.uconn.edu/projects/landscape/your/town.asp

Wfsb, 2010, "Residents Report Feeling Canadian Earthquake,"
http://www.wfsb.com/news/24007970/detail.html

Wikipedia, 2012, "1869 Atlantic Hurricane Season",
http://en.wikipedia.org/wiki/1869_Atlantic_hurricane_season

___, 2012, "Fort Shantok Archeological District,
http://en.wikipedia.org/wiki/Fort_Shantok_Archeological_District

___, 2012, "Hurricane Irene", http://en.wikipedia.org/wiki/Hurricane_Irene

___, 2012, List of Connecticut Tornadoes, http://en.wikipedia.org/wiki/List_of_Connecticut_tornadoes

___, 2011, "Northeastern United States Blizzard of 1978",
http://en.wikipedia.org/wiki/Northeastern_United_States_blizzard_of_1978

Woods Hole Oceanographic Institute, 2002, Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering: Proceedings of a Workshop Held at the Woods Hole Oceanographic Institution, Woods Hole, MA.

___, 1998, Coastal Landform Management in Massachusetts: Proceedings of a Workshop Held at the Woods Hole Oceanographic Institution, Woods Hole, MA.

3570-09-n2117-rpt-adopted.doc