1.0 Study Area

1.1 Introduction

1.1.1 Study Purpose

The National Hurricane Program (NHP), an interagency group comprised of the Federal Emergency Management Agency (FEMA), the U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA) - National Weather Service (NWS) conducts assessments and provides tools and technical assistance to assist state and local governments in developing hurricane evacuation plans and managing evacuation operations. Through the hurricane evacuation study (HES) process, state and local governments are provided with a range of resources, including regional demographic data, maps, evacuation clearance times, and user-friendly evacuation models. These various data and tools are consolidated and summarized in the Technical Data Report (TDR) for the study area, designed to be the primary source of regional evacuation information for federal, state and local government officials.

The study area for the Connecticut HES TDR includes the communities vulnerable to storm surge within the counties of Fairfield, Middlesex, New Haven, and New London. A map of the study area is depicted in Figure 1-1.

1.1.2 Funding

The Connecticut HES and the completion of the representative TDR was funded by the Federal Emergency Management Agency (FEMA), in coordination with the United States Army Corps of Engineers (USACE) – New England District.

1.1.3 Authority

The authority for the USACE's participation in this study is Section 206 of the Flood Control Act of 1960, as amended (Public Law 86-645). FEMA's participation is authorized by the Disaster Relief Act of (Public Law 93-288). These laws authorize the allocation of federal resources for planning activities related to hurricane preparedness.

1.1.4 Coordination Information

FEMA is responsible for the overall program management of HESs funded through the NHP. Funding is provided from FEMA through an interagency agreement to the USACE, which in turn provides the more detailed, day-to-day management of each study effort. The USACE often engages technical experts to support their efforts and to undertake specific portions of the study process, such as the conduct of transportation analysis and evacuation modeling. State officials support FEMA and the USACE and work closely with the local emergency managers in the study area to ensure that their needs are addressed in the study process.

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None of the states in the New England region have had the benefit of a full-fledged HES as prepared under the direction of the NHP. The NHP, through a USACE contract with Battelle, prepared a transportation analysis report and abbreviated transportation model (ATM) for the state of Maine in 2007. Additionally, Portsmouth, New Hampshire, commissioned a study of hurricane evacuation clearance times for the entire Seacoast Region of the State, which was completed in 2012. Furthermore, various states and local governments throughout the region have initiated their own hurricane related transportation analyses for their own specific jurisdictions, but no comprehensive effort that looks at all aspects of hurricane evacuation within an entire state or the New England region as a whole.

The NHP started the New England HES process in 2012 with the development of Storm Tide Atlases to map the maximum storm tide inundation for the entire New England area. In coordination with FEMA and the USACE, local government officials were then able to draft new evacuation zones, which are the basis for almost all other aspects of this HES. As the mapping was in its final stages of completion, this study effort commissioned a behavioral analysis for Rhode Island, as well as for Connecticut and Massachusetts, to determine the behavioral responses of the evacuating population in response to theoretical storm scenarios. Nonetheless, given recent scares from Earl in 2010 and Sandy in 2012, the behavioral analysis also included New Englander's actual responses during those events. The Transportation Analysis portion of the study effort was kicked off in January of 2014. The USACE and its consultants met with state and local officials to finalize evacuation zones and routes and to begin the process of demographic data collection for evacuation modeling. A final stakeholder meeting presenting the HES, ATM and the draft HURREVAC-ready clearance times was conducted in December 2015.

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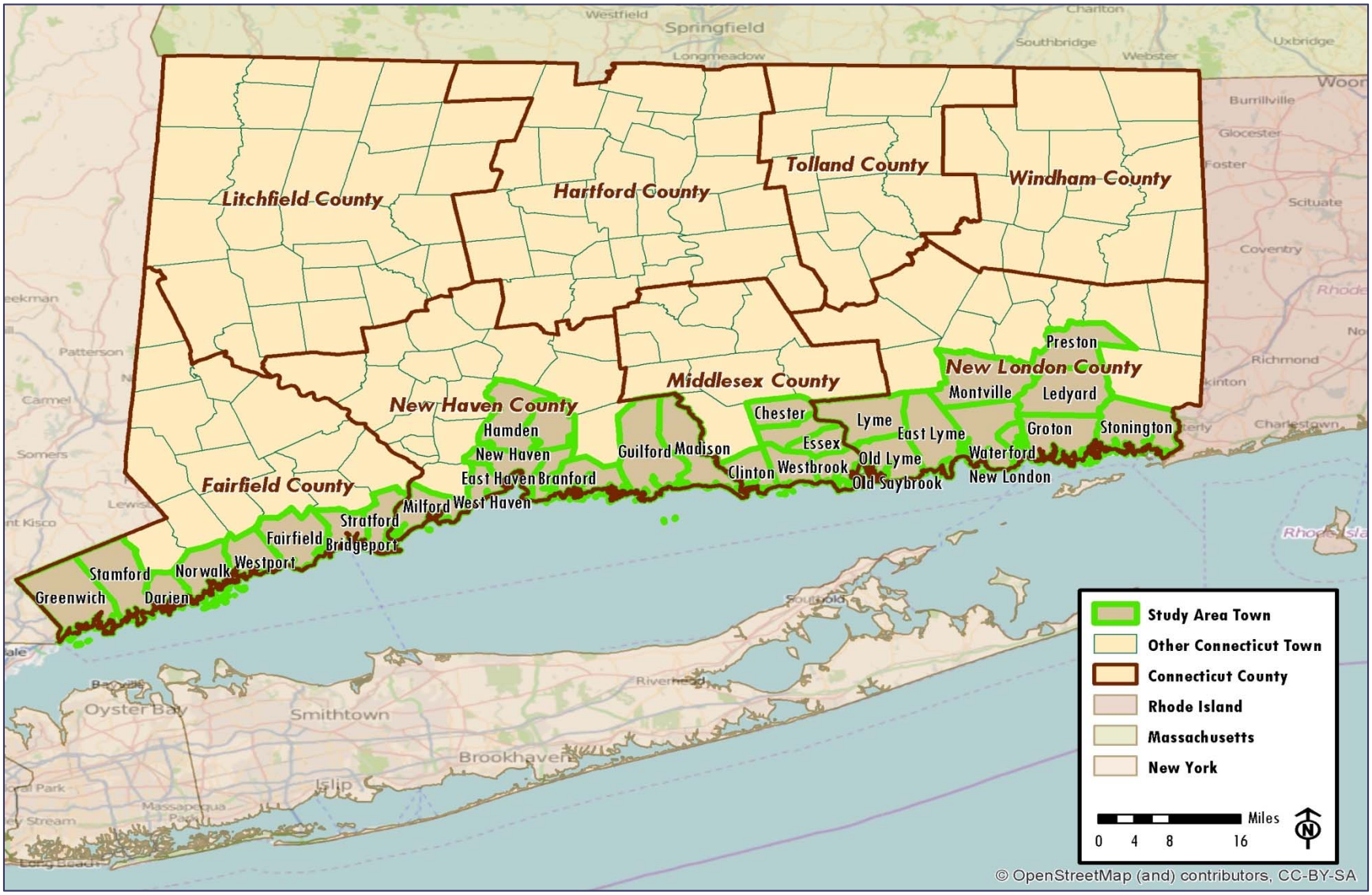

Figure 1-1: Map of Connecticut HES TDR Study Area

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1.2 Description of Study Area

1.2.1 Geography

Connecticut lies in the northeastern part of the United States. The state is bordered by Rhode Island to the east, Massachusetts to the north, New York to the west, and Long Island Sound to the south. The state, at its greatest points, is 110 miles long by 70 miles wide, with a total area of 5,544 square miles (4,845 square miles is land; 698 square miles is water).[1]

The Connecticut HES TDR study area includes Fairfield County, Middlesex County, New Haven County, and New London County. This area is part of the Connecticut Coastal Lowlands which forms a narrow strip of land, 6 to 16 miles wide, that runs along the southern shore of the state at Long Island Sound. Lower than most of Connecticut, the Coastal Lowlands are characterized by lower ridges, beaches, and harbors along the coast.

Fairfield County has a total area of 837 square miles, of which 625 square miles is land and 212 miles is water (U.S. Census Bureau). Fairfield County is surrounded by Litchfield County (north), New Haven County (east), Westchester County, New York (southwest), Putnam County, New York (west), Dutchess County, New York (northwest) and Long Island Sound (south). The Connecticut TDR focuses on the eight coastal communities of Bridgeport, Darien, Fairfield, Greenwich, Norwalk, Stamford, Stratford, and Westport within Fairfield County.

Middlesex County has a total area of 439 square miles, of which 369 square miles is land and 70 square miles is water (U.S. Census Bureau). It is the smallest county in Connecticut by land area and the second-smallest by total area. It is surrounded by Hartford County (north), New London County (east), New Haven County (west) and Long Island Sound (south). The Connecticut HES TDR focuses on the six coastal communities of Chester, Clinton, Deep River, Essex, Old Saybrook, and Westbrook within Middlesex County.

New Haven County has a total area of 862 square miles, of which 605 square miles is land and 257 square miles is water (U.S. Census Bureau). It is surrounded by Hartford County (north), Middlesex County (east), Fairfield County (west), Long Island Sound (south), and Litchfield County (northwest). The Connecticut HES TDR focuses on the nine coastal communities of Branford, East Haven, Guilford, Hamden, Madison, Milford, New Haven, North Haven, and West Haven within New Haven County.

[1] "The Geography of Connecticut," Netstate.com, http://www.netstate.com/states/geography/ct_geography.htm, (May 20, 2015).

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New London County has a total area of 772 square miles, of which 665 square miles is land and 107 square miles is water (U.S. Census Bureau). It is surrounded by Windham County (north), Kent County, Rhode Island (northeast), Washington County, Rhode Island (east), Middlesex County (west), Tolland and Hartford Counties (northwest), and Long Island Sound (south). The Connecticut HES TDR focuses on the eleven coastal communities of East Lyme, Groton, Ledyard, Lyme, Montville, New London, North Stonington, Old Lyme, Preston, Stonington, and Waterford within New London County.

1.2.2 Geology and Topography

Despite Connecticut's small size, it features wide variations in its landscape. In the northwestern portions of the state, it features rolling mountains compared to the coastal landscape found in the southeastern portions. Of specific interest to the Connecticut HES TDR, are the landscape features found within each study area county.

Fairfield County. In Fairfield County, the terrain trends from flat near the coast to hilly and higher in the northern portions. The Taconic Mountains and the Berkshire Mountains ranges of the Appalachian Mountains run through Fairfield County. The Taconics begin in Ridgefield with a portion in rural Greenwich; and, the Berkshires begin in Northern Trumbull, with a portion in rural North Stamford and Ridgefield. The highest elevation is 1,290 feet above sea level along the New York state line south of Branch Hill in Sherman. The lowest point is at sea level.

Middlesex County. In Middlesex County, the terrain trends from mostly level along the Connecticut River and Atlantic coast to gently rolling uplands. The highest elevation, which is close to a triangulation station, is in the Meshomasic State Forest, located at 916 feet above sea level. The lowest point is at sea level. Middlesex County is also the home of Wadsworth Falls.

New Haven County. In New Haven County, the terrain is mostly flat near the coast, with low hills defining the rest of the area, rising significantly only in the northern portions of the county. The highest elevation is close to the northernmost point in the county, found at two areas of approximately 1,050 feet above sea level in Wolcott. The lowest point is at sea level. Notable geographic landmarks include Mount Carmel, West Rock, and East Rock.

New London County. In New London County, the terrain is mostly flat near the coast, becoming more elevated only in northern portions of the county. The highest elevation is Gates Hill in the town of Lebanon at approximately 660 feet above sea level. The lowest point is at sea level.

1.2.3 Bathymetry

Shallow water close to the shore tends to increase the magnitude of hurricane-induced storm surge, thus knowing the offshore bathymetry of the study area is extremely important. Connecticut's location is north of Long Island Sound, and its only access to the Atlantic Ocean is through the East River and Block Island Sound. Nonetheless these factors generally accord the state little protection from storm surge due to the Sound's relative lack of depth and the funneling effect caused by these relatively limited openings to the sea. Overall, the maximum storm tide elevations, according to SLOSH, are as bad in Connecticut as they are along the southern coast of Long Island itself.

Long Island Sound is a tidal estuary of the Atlantic Ocean, lying between the eastern shore of Bronx County, New York City, the southern shores of Westchester County and Connecticut, and the northern shore of Long Island. Long Island Sound stretches 110 miles from the East River in New York City eastward along the south shore of Connecticut to Block Island Sound. A mix of freshwater from tributaries and saltwater from the ocean, Long Island Sound is 21 miles at its widest point and varies in depth from 65 to 250 feet. Major Connecticut communities situated on Long Island Sound include Bridgeport, New London, Stamford, Norwalk, and New Haven.

In addition to Long Island Sound, the Connecticut River divides the state before flowing into Long Island Sound between the towns of Old Saybrook and Old Lyme. At its mouth, large shifting sandbars, created by the large amount of silt from its significantly sized watershed (11,250 mi^2) create a major impediment to ship navigation; hence it is one of the few major rivers in the United States that does not have a major city at its mouth.

1.2.4 Demographics

The State of Connecticut is the third smallest state by area, the 29th most populous, and the fourth most densely populated. With a statewide population estimate of 3,596,677[2], the state capital and third largest city is Hartford, and other major communities include New Haven (New Haven County) and Bridgeport, Greenwich, Norwalk, and Stamford (Fairfield County). Table 1-1 summarizes the county demographics within the study area and Table 1-2 details the housing data associated with the study area.

[2] "American Fact Finder, Connecticut," U.S. Census, 2013 American Community Survey (ACS), 2014 Population Estimate, http://factfinder.census.gov/, (May 15, 2015).

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Table 1-1: Connecticut HES Demographics

Community	Census Data		Population Changes	
	2010	2015	(Number)	(Percent)
Branford	28,026	28,025	-1	0.00%
Bridgeport	144,229	145,587	1,358	0.94%
Chester	3,994	4,128	134	3.36%
Clinton	13,260	13,239	-21	-0.16%
Darien	20,732	20,925	193	0.93%
Deep River	4,629	4,615	-14	-0.30%
East Haven	29,257	29,167	-90	-0.31%
East Lyme	19,159	19,119	-40	-0.21%
Essex town	6,683	6,668	-15	-0.22%
Fairfield	59,404	60,126	722	1.22%
Greenwich	61,171	61,733	562	0.92%
Groton	40,115	40,126	11	0.03%
Guilford	22,375	22,377	2	0.01%
Hamden	60,960	61,443	483	0.79%
Ledyard	15,051	15,051	0	0.00%
Lyme	2,406	2,417	11	0.46%
Madison	18,269	18,287	18	0.10%
Milford	52,759	52,894	135	0.26%
Montville	19,571	19,621	50	0.26%
New Haven	129,779	130,338	559	0.43%
New London	27,620	27,588	-32	-0.12%
North Haven	24,093	24,011	-82	-0.34%
Norwalk	85,603	86,499	896	1.05%
Old Lyme	7,603	7,598	-5	-0.07%
Old Saybrook	10,242	10,258	16	0.16%
Preston	4,726	4,704	22	0.47%
Stamford	122,643	123,995	1,352	1.10%
Stonington	18,545	18,527	-18	-0.10%
Stratford	51,384	51,694	310	0.60%
Waterford	19,517	19,508	-9	-0.05%
West Haven	55,564	55,349	-215	-0.39%
Westbrook	6,938	6,922	-16	-0.23%
Westport	26,391	26,769	378	1.43%
Total	**1,212,698**	**1,219,352**	**6,654**	**0.55%**

Sources: U.S. Census State and County QuickFacts

Table 1-2: Connecticut HES TDR Demographic and Housing Data by Town

Community	2015 Population	Permanent Occupied Housing Units	Mobile Home Units	Vacation / Seasonal Units	Tourist Units
Branford	28,025	12,739	273	591	535
Bridgeport	145,587	51,733	141	165	210
Chester	4,128	1,402	-	37	-
Clinton	13,239	5,295	324	517	297
Darien	20,925	6,760	9	99	-
Deep River	4,615	1,934	-	56	8
East Haven	29,167	11,720	58	256	138
East Lyme	19,119	7,177	5	950	867
Essex town	6,668	2,909	-	151	55
Fairfield	60,126	20,703	131	357	239
Greenwich	61,733	23,286	31	776	531
Groton	40,126	15,813	457	688	1,261
Guilford	22,377	8,287	59	465	120
Hamden	61,443	22,848	-	143	-
Ledyard	15,051	5,634	191	72	302
Lyme	2,417	1,038	20	161	-
Madison	18,287	6,380	46	811	642
Milford	52,894	21,763	182	468	1,298
Montville	19,621	6,960	431	101	825
New Haven	130,338	49,087	53	254	1,077
New London	27,588	10,361	29	170	389
North Haven	24,011	9,104	12	60	143
Norwalk	86,499	1,563	59	89	501
Old Lyme	7,598	33,561	72	288	1,121
Old Saybrook	10,258	3,170	-	1,611	33
Preston	4,704	4,254	-	1,121	403
Stamford	123,995	1,604	23	39	12
Stonington	18,527	47,873	23	430	2,604
Stratford	51,694	8,107	252	667	1,469
Waterford	19,508	20,216	-	173	713
West Haven	55,349	8,001	104	215	152
Westbrook	6,922	21,030	97	111	277
Westport	26,769	2,941	284	812	200
Total	**1,219,352**	**464,961**	**3,416**	**13,225**	**16,549**
Sources: U.S. Census 2009-2013 American Community Survey 5-Year Estimates.					

1.3 Historical Hurricane Activity

Given the relatively high latitude of the entire New England coastline, it would be surprising to some people how frequently tropical cyclones have visited the region, some storms even attaining major (Category 3) hurricane status. Nonetheless, the area is subject to Atlantic basin hurricanes that originate as tropical waves that form off the coast of Africa. Also known as Cape Verde storms, these events are named for the islands from where many of these waves first coalesce into tropical cyclones. These tropical waves traverse the Atlantic Ocean, intensify as they come in contact with the Gulf Stream, and many get entrained in the jet stream, which carries them at relatively high forward speeds to the coast of New England. In fact, those hurricanes that originate off the Southeastern U.S. and Mid-Atlantic states can present local officials in New England with the added challenge of having to plan, order and execute an evacuation with very little lead time. Figure 1-2 below displays the number of tropical systems that have come within 100 nautical miles of the New England area from 1851 to 2008.

The New England Coast is very familiar with hurricanes and tropical storms. According to the NOAA Historical Hurricane Track Database from 1851 to the present, of the 47 tropical cyclones (tropical storm and above) that have come within 100 statute miles of the Southern New England coast, 19 were hurricanes, three of them major (Category 3 and above). The most active decade for tropical cyclone activity was the 1880s with a total of 7 tropical events, but the 1860s, the 1950s and the 1960s were also busy with four storms each. With a search radius of 150 nautical miles the total number of tropical cyclones balloons to 74, many of which were just off shore, but close enough to possibly warrant some degree of protective actions in response to their approach. A few of the major storms to impact the area, including a few not included in the above database, are described in more detail below.

The Great Colonial Hurricane (GCH) – August 1635: The storm was estimated to have been a Cape Verde-type hurricane, probably a Category 4 or 5 hurricane that was likely a Category 3 when it made landfall in the vicinity of eastern Long Island and Connecticut and Rhode Island. Although it made landfall probably east of what is now Groton, there were no specific reports of damage or other impacts to Connecticut itself. Nonetheless, meteorologists believe it to be the strongest tropical cyclone ever to hit the southern New England coast.

The Great September Gale of 1815 – September 1815: This event was the first major storm to hit the New England region in 180 years (see the GCH citation above), and was assessed to be a Category 3 when it came ashore. Although it made landfall around Old Saybrook, Connecticut, much of the documented damage was reported in Providence, Rhode Island.

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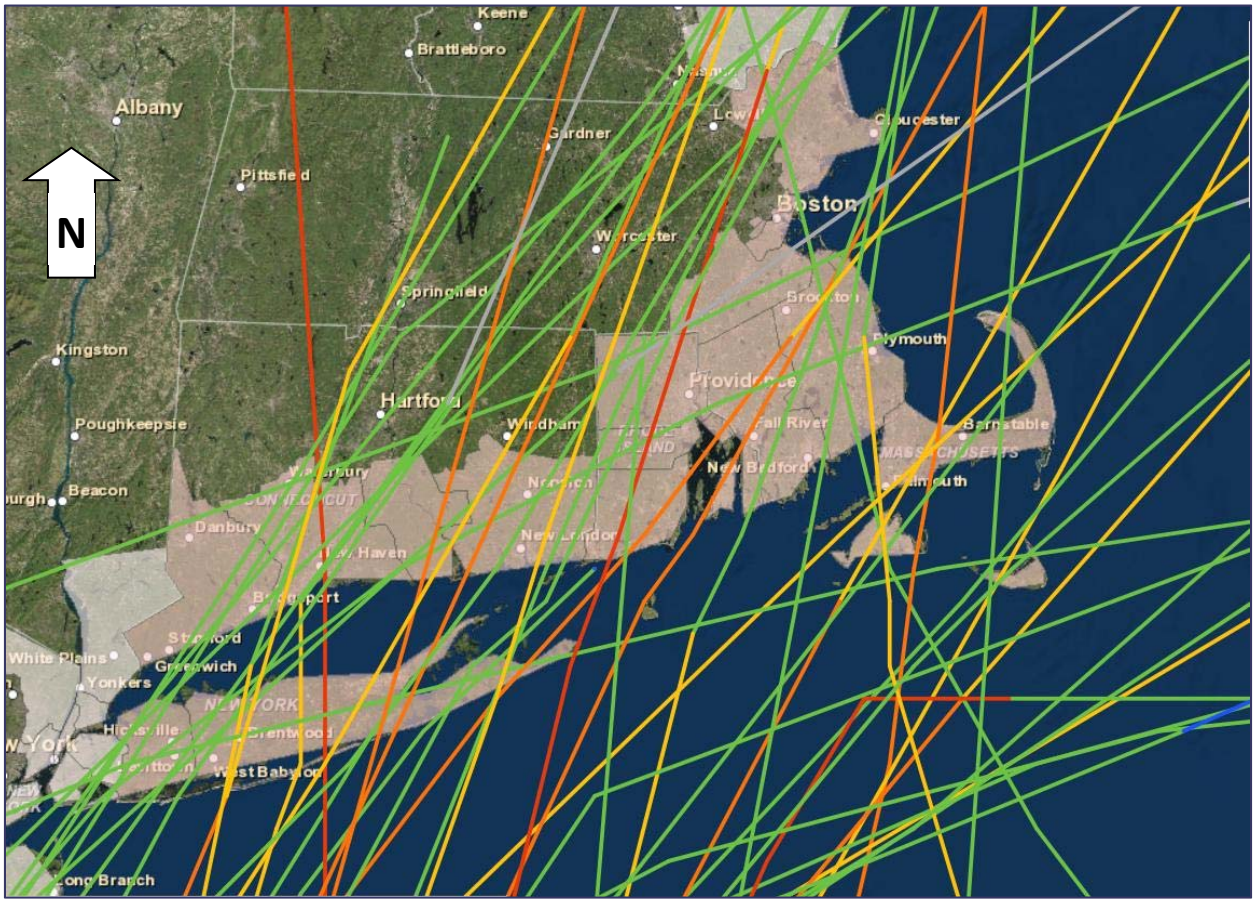

Figure 1-2: Tropical Systems impacting New England (1851 – 2008) (Image created using the National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center's Historical Hurricane Tracker, http://coast.noaa.gov/hurricanes)

The Great New England Hurricane of 1938 – September 1938: This Category 5, which has also been dubbed "The Long Island Express" and the Yankee Clipper, made landfall on September 21, 1938, and was the first major hurricane to strike New England since 1869. The storm formed near the coast of Africa in September becoming a Category 5 hurricane before making landfall as a Category 3 hurricane on Long Island on the afternoon of September 21, and again somewhere between Bridgeport and New Haven, at approximately 4 o'clock the same evening with winds of approximately 115 mph. When it made landfall, the storm was travelling at a forward speed of 47 miles per hour.

Eastern Connecticut was in the right front quadrant of the hurricane, although Long Island acted as a buffer against large ocean surges. Nonetheless, the waters of Long Island Sound rose to all but destroy many small shoreline towns to the east of New Haven. To this day, the 1938 hurricane holds the record for the worst natural disaster in Connecticut's 350-year history. The

Mean Low Water storm tide was 14.1 feet at Stamford, 12.8 feet at Bridgeport, and in New London it was 10.58 feet, which remains a record high.[3]

Buildings were destroyed in the beach towns of Madison, Clinton, Westbrook, and Old Saybrook, as well as along the beach in the town of Old Lyme. At Stonington, the Bostonian, a New York, New Haven & Hartford passenger train became stuck in debris with two passengers drowning while trying to escape as the train crew was clearing the blockage to get the train moving again. Along the Stonington shore front, buildings were swept off their foundations and found two miles (3 km) inland while rescuers found live fish and crabs in kitchen drawers and cabinets in residences in Mystic.

After New London was first swept by the winds and storm surge the waterfront business district caught fire and burned out of control for 10 hours. Meanwhile, many large homes along Ocean Beach were leveled by the storm surge. The 240-ton lightship at the head of New London Harbor was ripped from its permanent moorings and found on a sand bar two miles (3 km) away.

Interior sections of the state suffered widespread freshwater flooding as the hurricane's torrential rains fell on soil already saturated from previous storms. The Connecticut River swelled outside its riverbanks and flooded communities from Hartford south to Middletown.

Hurricane Carol – August 1954: Hurricane Carol was among the worst tropical cyclones on record to affect the New England region. It developed from a tropical wave near the Bahamas on August 25, 1954, and slowly strengthened as it moved northwestward, eventually making landfall on Long Island, New York, and Clinton, Connecticut at the peak of its intensity.

Hurricane Carol struck Connecticut shortly after high tide, which when combined with 10 to 15 feet of storm surge, produced widespread tidal flooding from New London eastward. Coastal communities in Connecticut were nearly wiped out in New London, Groton, and Mystic. Rainfall throughout the impacted areas was relatively light due to the relatively fast forward speed of the storm; nonetheless, New London recorded the heaviest rainfall where up to 6 inches fell. [4]

Strong winds left much of the eastern portion of the state without power. Near the coast, the combination of strong winds and the storm surge reportedly damaged or destroyed thousands of buildings, including 100 homes, as well as a portion of the roof of the New London town hall. Many other homes in Eastern Connecticut were damaged by falling trees. Thousands of people

[3] National Weather Service, New York, NY, The Great New England Hurricane of 1938, 76th Anniversary
[4] Hurricanes Science and Society, 1954- Hurricane Carol; www.hurricanescience.org/history/storms/1950s/carol, accessed May 17, 2015.

evacuated before the storm reached the Connecticut coast, with one reported death attributed to the storm. Because Hurricane Carol was relatively compact in nature, western Connecticut was spared much of the impacts; nonetheless the overall damage tally for the state was estimated at $50 million.[5]

Hurricane Diane – August 1955: Originally a Category 2 storm, by the time Hurricane Diane reached New England, it was an extratropical storm. Nonetheless, it produced heavy rainfall dropping 12.05 inches of rain on Windsor Locks, Connecticut, in a 23 hour period and similar amounts throughout the rest of the state and the region in general. Consequently, damage was the greatest in Connecticut where floods affected two-thirds of the state. Flooding on the Connecticut River was so severe that it in essence cut the state in two, severing most lines of communication between the eastern and western banks. In Waterbury, 30 people were killed in homes that were washed away in the flood waters. In the aftermath, statewide, Diane resulted in 77 deaths, destroyed 563 houses and caused $350 million in damages.

Hurricane Gloria – September 1985: Hurricane Gloria made landfall in Milford, Connecticut, on September 27, 1985, as a Category 1 storm. As it continued northeastward through New England, it became extratropical over Maine on the 28th. Because Gloria made landfall during low tide, its resulting storm surges were relatively low, registering 5 feet in Groton. However, the high waves that accompanied Gloria's arrival did cause severe beach erosion along the New England coast, as well as the loss of many piers and coastal roads.

Gloria's sustained wind peak for the entire New England area was measured in Waterbury Connecticut at 83 mph, with wind gusts reported in Bridgeport of 92 mph. These winds downed thousands of trees, which contributed to two of the three deaths reported in the state, as well as knocked down power lines leaving approximately 727,000 residents without power, many of them for up to a week.[6]

Connecticut received the worst of the hurricane, where tree and structural damage resulted in overall damages estimated at $91 million, the worst of which were reported near Hartford. Because of these significant impacts, the name 'Gloria' has been retired the revolving list of Hurricane names.

Hurricane Bob – August 1991: As Hurricane Bob was making landfall near Newport, Rhode Island, on August 19th, the strong winds of Bob extended westward into Connecticut, registering a peak of 75 mph near Groton with a gust of 100 mph. Although the heaviest wind

[5] James K. McGuire (1954). *The Storm of August 31, 1954* **41** (8). Chattanooga, Tennessee: United States Weather Bureau. pp. 289–292.
[6] Wikipedia, Hurricane Gloria, https://en.wikipedia.org/wiki/Hurricane_Gloria, accessed May 17, 2015.

damage was seen in the southeastern portion of the state near the coast, every county experienced tree falls. Consequently, approximately 315,000 people were left without power in Connecticut.

The highest storm surge was measured at 5 feet in New London, but for the most part coastal flooding was limited to that county. Overall flooding in the state was minor, primarily limited to streams and small rivers, although Norwich measured a rainfall total of 6.22 inches, which was the statewide peak. Total damage in the state was estimated around $40 million and there were a total of six deaths across the state associated with Bob.

Hurricane Earl – September 2010: Hurricane Earl was the first tropical cyclone to threaten the New England region since Hurricane Bob. Although it did not make landfall in New England specifically, nor the United States for that matter, it did cause mass evacuations along the Mid-Atlantic seaboard and parts of the study region. Earl did finally make landfall in Nova Scotia, Canada, but its approach was close enough to warrant decision makers in the New England region to order protective actions for their citizenry and tourists. Nonetheless, according to the behavioral study performed for this study, few respondents in Connecticut recall hearing any evacuation orders issued by government officials; consequently only 8% in the Category 1/2 evacuation zone, and 5% in the Category 3/4 zone indicated that they evacuated.

Hurricane/Tropical Storm Irene – August 2011: Hurricane Irene was a Category 3 hurricane in the Bahamas before eventually weakening to a tropical storm in New England. The storm did not make a direct landfall in New England, but traveled inland through Connecticut and into western Massachusetts and Vermont on August 28, 2011. Despite this inland track, reportedly no shoreline community escaped unscathed, especially in the Cosey Beach area of East Haven where 25 homes were destroyed, including four that were swept out to sea. In the rest of the state, wind and heavy rains (10 inches were measured in Litchfield County), caused widespread flooding. In Connecticut, the toll from Irene included two dead, 132 homes destroyed, 35 communities declared disaster areas, and 830,130 without power, many for an extended period of time.[7]

Hurricane Sandy – October 2012: Hurricane Sandy was a Category 3 hurricane near Cuba before weakening into a tropical storm/post-tropical cyclone. While the storm made final landfall in Atlantic City, New Jersey, on October 29, 2012, New England still felt the impacts of Sandy due to the massive size of the storm. In Connecticut, the storm surge was measured at 9.83 feet above normal tide at Bridgeport and New Haven measured a storm tide of 9.14 feet. Of the coastal communities of Greenwich, Westport, New Canaan, Redding, Milford, East Haven

[7] Devastating Winds Raked Connecticut During Historic Hurricanes, by Jim Shea of the Harford Courant, January 26, 2014.

and New London, all sustained severe damage, but none as bad as Fairfield which logged over 1,000 trees down, 1,000 homes flood-damaged, 5,000 citizens evacuated, six homes washed out to sea and more than two dozen condemned; sand burying main roads and dispersed up to half a mile from the water. In summary, the losses in Connecticut totaled about $1 billion in damages, and resulted in over 6,000 property owners along the coast and another 1,300 inland applying for disaster assistance from FEMA.[8] Given the $50 billion final tally for the entire United States, the name 'Sandy' has been permanently retired. [9]

1.4 Major Analyses

1.4.1 General

The Connecticut HES was initiated in 2011 and was completed in 2015 with the publication of the TDR. It consists of several related analyses that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, timing of evacuations, and sheltering needs for various hurricane threat situations. The major analyses are briefly summarized in the following paragraphs. Detailed descriptions of the analyses and the methodologies of each are contained in subsequent chapters of this report.

1.4.2 Hazards Analysis

The hazards analysis determines the timing and magnitude of wind and storm surge hazards that can be expected from hurricanes of various categories, tracks, and forward speeds. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) numerical model is used by the National Hurricane Center (NHC) to compute the wind speeds and surge heights. The SLOSH output is also used to map storm tide inundation limits that are then used by state and local to delineate evacuation zones. The Hazards Analysis is presented in more detail in Chapter Two.

1.4.3 Vulnerability Analysis

Utilizing the results of the hazards analysis, the vulnerability analysis identifies those areas, populations, and facilities that are vulnerable to specific hazards under a variety of hurricane threats. For this HES, hurricane evacuation zones were delineated for each community in the study area from the SLOSH storm tide inundation limit maps prepared during the Hazards Analysis phase. Population data was used to determine the vulnerable population within each evacuation zone. Further discussion on all aspects of the Vulnerability Analysis is provided in Chapter Three.

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[8] Devastating Winds Raked Connecticut During Historic Hurricanes, by Jim Shea of the Harford Courant, January 26, 2014.

[9] "New England Hurricanes of Note," Massachusetts Emergency Management Agency, http://www.mass.gov/eopss/agencies/mema/hazards/hurricanes/new-england-hurricanes-of-note.html, (May 14, 2015).

1.4.4 Behavioral Analysis

This analysis determines the expected response of the population threatened by various hurricane events in terms of the percentage of the population expected to evacuate, probable destinations of evacuees, public shelter use, and utilization of available vehicles. The methodology used to develop the behavioral data relied on telephone sample surveys of the general population within the study area and interviews with local emergency managers. A behavioral study was completed in 2013 for the Connecticut HES after Hurricane Sandy (2012). A presentation of the Behavioral Analysis can be found in Chapter Four.

1.4.5 Shelter Analysis

The shelter analysis presents an inventory of public shelter facilities, capacities of the shelters, and shelter demand for each jurisdiction. Emergency management offices furnished shelter names, capacities, and other details for their shelter inventory. Shelter demands for the Connecticut HES were calculated using behavioral analysis data. Chapter Five contains information on the Shelter Analysis.

1.4.6 Transportation Analysis

The principal purpose of the transportation analysis is to: 1) determine the time required to evacuate the vulnerable population (clearance times); and 2) evaluate traffic control measures that could improve the flow of evacuating traffic. Complete details on the Transportation Analysis are presented in Chapter Six.

1.4.7 HURREVAC/Decision Tools

HURREVAC is a hurricane evacuation decision-support tool that uses clearance times in conjunction with NHC advisories to assist local officials in arriving at a decision to evacuate or not, as well as advising on when those evacuations, when warranted, should begin. More information on this program may be found at the HURREVAC web-site at www.hurrevac.com. Chapter Seven describes the HURREVAC computer program.