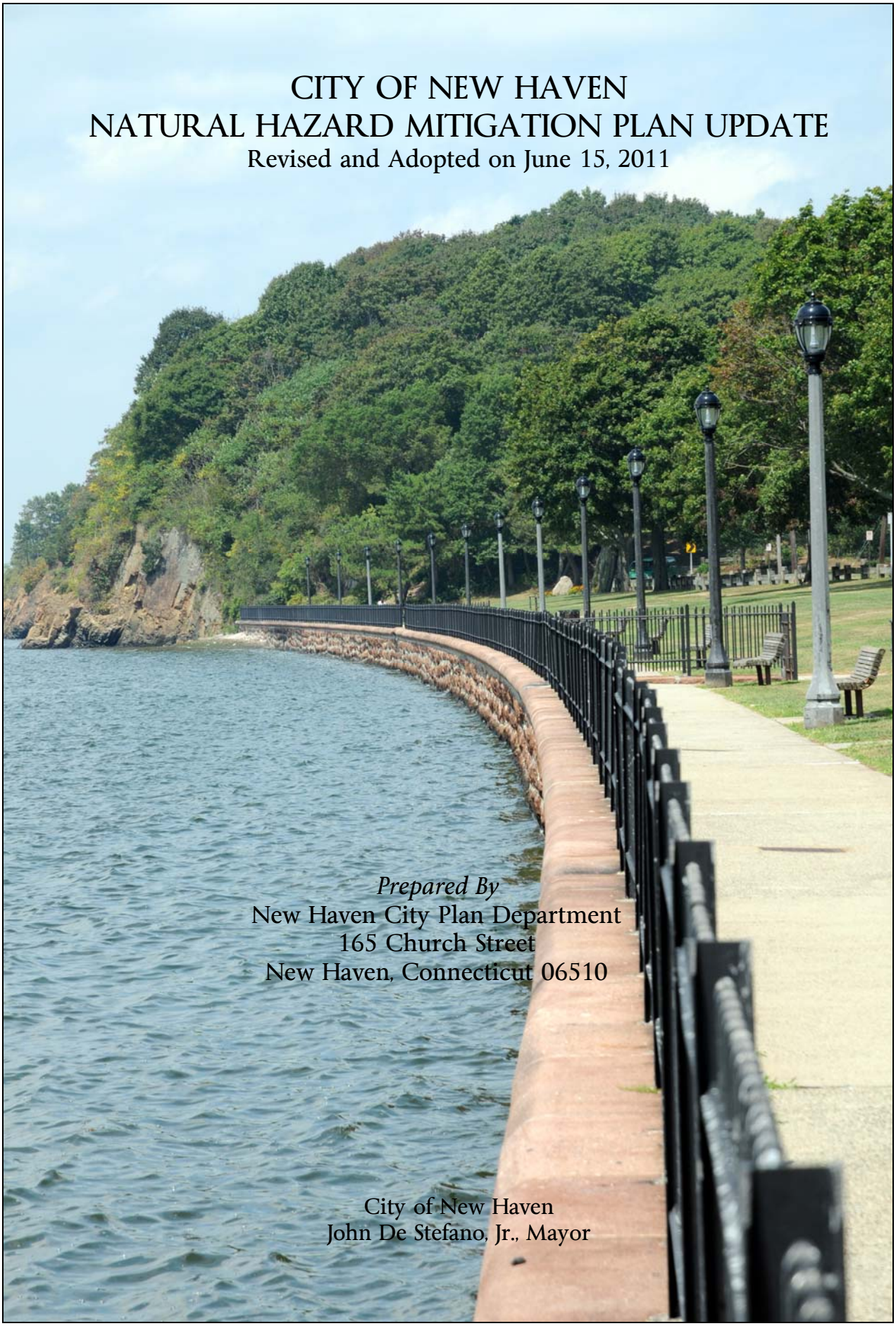
CITY OF NEW HAVEN
NATURAL HAZARD MITIGATION PLAN UPDATE

Revised and Adopted on June 15, 2011



Prepared By
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165 Church Street
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City of New Haven
John De Stefano, Jr., Mayor

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1.0 INTRODUCTION

1.1 Background and Purpose

New Haven's first ever Hazard Mitigation Plan (HMP) was formally adopted by the City and approved by the Federal Emergency Management Agency on October 4, 2005. The current update to this plan is being developed to re-evaluate the mitigation goals and alternatives for the next five years, to asses the work accomplished since 2005 based on the strategy outlined in the previous plan, to frame the recommendations for the next five years, and to outline a strategy for implementation. This plan update is relevant not only in emergency management situations, but is also relevant in community's land use, environmental, and capital improvement frameworks.

The Disaster Mitigation Act of 2000 (DMA) requires local communities to have a Federal Emergency Management Agency (FEMA)-approved mitigation plan, which is updated once every five years in order to be eligible to receive Post-Disaster Hazard Mitigation Grant Program (HMGP) grants and Pre-Disaster Mitigation (PDM) program project grant funds. Once a community has a FEMA-approved hazard mitigation plan, it becomes eligible to apply for HMGP and PDM project funds for mitigation activities (See Section 322 of DMA). DMA is commonly known as the 2000 Stafford Act amendment, which was approved by Congress and signed into law in October 2000 (Public Law 106-390). The purpose of the DMA is to establish a national program for pre-disaster mitigation and streamline administration of disaster relief.

Since 2005, as part of progress monitoring, the New Haven City Plan Department coordinated annual meetings with various city departments for review of the original HMP adopted in 2005. The City is pleased to report that most of the projects detailed in the 2005 report have been completed. In summary, the **accomplishments of the past five years** are as follows:

- **Dean Street Project**. The Dean Street project is complete. To mitigate times of high precipitation and high tide, the City Engineer has decreased the number of outlets on the Morris Creek tide gate from eight to five, added receiving chambers with duckbill flat valves, and added pumping chambers in the area.
- **Morris Creek Channelization**. As part of the improvements to the Tweed New Haven Airport runway, the nearby Morris Creek has been channelized, a stormwater detention area was created, and the State Department of Environmental Protection (DEP) has also restored wetlands in the area.
- **Blake Street Project.** Two bridges were replaced for the Blake Street project. The West River Bridge was replaced with a single span in 2001 in order to eliminate the supporting pier that had been damaged due to scouring action. In addition, the bridge over Wintergreen Brook had its structure rebuilt (abutment replaced) and the channel beneath cleared.
- **Catch Basin Maintenance.** The Engineering Department has hired two contractors to routinely clean out and maintain the City's 11,000 Catch Basins at a rate of 2,000 catch basins per year.
- **Shoreline Stabilization.** The City has obtained DEP permits for stabilization along the East Shore Park Area and Front Street for Dover Beach Park. Phase I of stabilization in these parks is complete. Almost 315 linear feet of missing and dilapidated retaining wall that defined the edge of Front Street Park from the Quinnipiac River was replaced.
- **Front Street.** Front Street between Middletown Avenue and the Grand Avenue area has been rebuilt with new storm drainage structures. The Engineering Department also put in outlets with duckbill valves.
- **Wintergreen at Westville.** The recently completed Wintergreen residential development included the installation of new portable and permanent pumps on site in order to properly drain

the site since it is at a lower elevation than the abutting West River flood wall. In addition, the West River channel adjacent to the Wintergreen residential complex was recently cleared of vegetation and debris to improve flow. The bridge over Wintergreen brook also had its structure rebuilt (abutment replaced).

- **Long Wharf Drive.** ConnDOT has installed duck bill gates on outlets on the main trunk lines from the central city to prevent storm surge. The Federal Emergency Management Agency (FEMA) has recently modified the flood zone designations in this area which includes the rail yards and IKEA (see LOMR to Flood Insurance Rate Maps 090084-00004 C and 0005 D 04/17/08).
- **Morris Creek Tide Gates.** This project involved installation of new tide gates and is now electronically controlled to allow tidal flood to an elevation of 3.7 feet at high tide. This significantly helps the elimination of phragmites. The tide gates are continuously monitored by the airport to prevent flooding.
- **West River Channelization.** The parcel between Valley Street and Whalley Avenue was upgraded as part of the Early Learning Center (495 Blake Street) improvements. The river flow on this parcel has been channelized and cleared of debris and vegetation to improve the flow.
- **Beaver Ponds Feasibility Study.** A feasibility study of various methods to increase storage capacity at Beaver Ponds, which allows the impoundment to hold more sediment from stormwater runoff and more water during heavy runoff events has been conducted
- **Fort Hale Park and Adjacent Areas.** The detailed engineering study (2004) of the Fort Hale area revealed the factors contributing to flooding of a channel located on the south side of the park. One of the two drainage or "splitter" structures that handles runoff from the upgradient neighborhood was found missing. In the recent past, the City installed this missing structure accordingly.
- **Reverse-911 System.** The City's Office of Emergency Management has adopted a reverse notification system for residents (called the reverse-911) through which residents in affected areas or city-wide can be notified about an impending emergency via telephone message.
- **East Shore Park.** In the recent past (after 2005), the City developed an erosion control plan to preserve the park. Phase I of the Erosion control project is complete which includes stabilization of 545 linear feet of eroded shoreline and the placement of rip rap revetment 15-25 feet wide. 155 linear feet of eroded shoreline was stabilized with placement of sand dunes and shoreline plantings 24-40 feet wide. Further work is permitted by DEP but no funding is currently in place.
- **Sinkholes and Settling Issues.** All of the sinkholes and settling issues reported in HMP 2005 have been taken care of by the Department of Public Works as and when funding became available in the past five years.
- **Cleaning of the Brooks.** Since the adoption of HMP 2005, the City's Engineering Department continued to work with the Town of Hamden to keep debris out of Wintergreen Brook, Belden Brook, and Wilmot Brook before they flow into New Haven, where box culverts can become clogged.
- **Hemingway Creek.** The City dredged the lower portion of Hemingway Creek to help improve the flow.
- **Quinnipiac Meadows.** In the recent past (after 2005), a portion of vacant, industrial land in the Quinnipiac Meadows has been transferred to the New Haven Land Trust as part of conservation efforts by the City.

In addition to the afore-mentioned projects, the following additional projects are **currently undertaken** for hazard mitigation as listed below:

- **Save the Sound Project.** In collaboration with Save the Sound, the City is working to implement new self regulatory tidal gates in the West River Area. However, the proposed two-way flow of water through these tide gates might have an impact on Duck Pond near by, causing loss of lawn grass. The City is currently exploring ways to mitigate the loss of lawn grass through the creation of elevated walkways, new plantings, etc., adjacent to the pond.
- **Shoreline Stabilization of River Street.** As part of the implementation of River Street Municipal Development Plan, the City has applied for Federal Economic Development Administration money to stabilize the shoreline from 90 River Street through 34 Lloyd Street (Suraci, Hess property, Capasso Restoration). The properties at 56 and 46 River Street, to the east of Poplar Street, also need new bulkheads. Plans are complete for all of the properties from the foot of James Street to 46 River Street. While funding has been secured to implement these efforts for most of the properties, the improvements to 198 River Street (Bigelow Boiler) and 56 and 46 River Street would have to be pending until funding can be identified for further mitigation work. The City is currently awaiting DEP permits to start the work on those properties that have funding in place. The Seaboard Fuel Oil property (24 and 36 River Street), where the bulkhead is rusted and broken and the parking lot behind eroding, could not be included in this implementation effort as it is privately-owned. (As this property is listed for sale, the City should require the potential buyer to repair the bulkhead here.)
- **Seawalls in Morris Cove.** The residential seawalls close to Pardee seawall in Morris Cove neighborhood have been severely affected by the recent storm that occurred in June 2010. The City is awaiting permit from DEP to repair these walls. While funding from US Army Corps of Engineers was in place until recently, it was taken back as the City could not obtain the necessary permits required to perform the work in time.
- **Long Wharf Park.** There is a 1,200 lineal foot section along the park that remains unprotected and is in a continuous state of erosion. The City is in the process of developing a plan for shoreline protection between Long Wharf and the Land Trust Nature Preserve to prevent erosion and loss of upland material. Design efforts will concentrate on evaluation and development of details for deteriorated existing erosion controls, design of stabilization measures for areas where none currently exist, and upgrading the existing landscape elements in the park. Schematic design work and permit applications with American Corps of Engineers (ACOE) and DEP are scheduled to be completed by May 2011.
- **Morris Causeway and Cove Place Outlet.** An issue has developed over time when the outlet that drains Morris Causeway has been buried due to the movement of sand. Because the sand has accumulated over the pipe, the high tide line has changed this. This now causes a problem as the outlet is now on private property and the portion of land based on riparian rights cuts off direct access to the Cove. Correction of this requires easements and DEP permits, which the City is currently trying to obtain.
- **West Rock Redevelopment.** As part of the West Rock Redevelopment, the Housing Authority of New Haven (HANH) has installed detention ponds and the bridge nearby on Brookside Avenue has been re-built.

Besides adopting these preventive measures for hazard mitigation within the city, the City's floodplain ordinances have also been revised and approved by the City Plan Commission quite recently (in July, 2010). New Haven enacted Flood Damage Prevention as part IV of its Building Code in May 28, 1980, effective June 19, 1980. The City entered the NFIP regular Program on July 16, 1980. An amendment to the zoning ordinance has been proposed In July 2010 and adopted by the Board of Aldermen on October 4, 2010. The City staff also participated in the recent map modernization project initiated by FEMA to revise the Flood Insurance Rate Maps (FIRM) to more accurately identify flood hazard areas and make them electronically available. The Draft FIRMs were shared with the

city for review and comment and became effective on December 17, 2010. These new maps were produced in the North American Vertical Datum (NAVD) 1988 as opposed to the previous FIRMs that were mapped in the National Geodetic Vertical Datum (NAGD) 1929. NAVD was established as the vertical control surveying in United States by the Geodetic Leveling Observations in 1991 due to changes in sea level. While the computed elevation of the base flood may slightly differ in this new datum (may be slightly higher), the elevation of that point relative to another point along the coast did not change.

The **priority projects** for the next five years are listed below. Almost all of these projects were also listed as priorities within the 2005 HMP document. These could not be implemented within the past five years due to budget issues.

- **Brewery Square.** An existing bulkhead located on Ferry Street Bridge heading north, parallel to Front Street (near Brewery Square), is deteriorating. This steel sheet bulkhead is failing and holes are now appearing at the water line. As the tidal flow washes behind the bulkhead, soil migration into coastal waters and bulkhead failure is occurring. This is affecting boardwalks and parking lots in this area and needs immediate attention.
  Estimated Cost: $ 600,000
  Administering Agency:City Department of Engineering
  Time Frame: By 2012
- **Seawalls in Morris Cove.** As mentioned earlier, the residential seawalls near Morris Causeway need immediate attention as they have been severely affected by the recent storm that occurred in June 2010. These need to be repaired as soon as possible to prevent flooding damage to the homes near by.
  Estimated Cost: $ 1.2 million
  Administering Agency: City Department of Engineering
  Time Frame: By 2015
- **Pond Lily Dam.** Due to flooding problems west of the dam, the Town of Woodbridge has requested that the New Haven Land Trust remove the dam. A study is being currently undertaken to identify if the dam is actual cause of flooding.
  Estimated Cost: $ 1 million
  Administering Agency: City Department of Engineering
  Time Frame: 2013 - 2014
- **Dean Street Project (Final Phase).** The City Engineer recommends that for the final phase of this project, the elevation of the berm along Dean Street be raised and a pump station be built in the area.
  Estimated Cost: $ 0.5 million
  Administering Agency: City Department of Engineering
  Time Frame: By 2013
- **Hemmingway and Eastern Streets.** A stream exits from a culvert beneath Hemingway Street. This stream flows in Hemingway Brook. Even slight increased in water elevation in this area floods atleast two residential homes and Hemingway and Eastern streets nearby. The brook at the culvert crossing has been silted in. The City periodically removes the silt to enhance the flow of the brook thus avoiding flooding in the area. However, this is a vicious cycle. Even though the culvert is cleaned periodically, whenever there is a storm trash and debris get collected into the brook and thus clog the culverts once again. One possible solution to completely mitigate this issue is by elevating Hemingway and Eastern streets. Due to lack of funding, this measure could not be adopted in the past five years.
  Estimated Cost: $ 0.5 million

Administering Agency: City Department of Engineering
Time Frame: Currently temporary fix in place, culvert replacement by 2015

- **Stiles Street and Port of New Haven.** A new drainage system has been planned for this area by the Connecticut Department of Transportation (CONNDOT) as part of the I-95 Harbor Improvement Program. Design of this drainage system is complete and the City is awaiting funding assistance from the State to implement this design. This proposed design also includes re-construction of Waterfront Street to overcome drainage problems in this area. Street Drainage problems have been somewhat ameliorated after the on-ramp to I-95 from Stiles Street has been removed in the recent past.
  Estimated Cost: Unknown
  Administering Agency: Connecticut Department of Transportation
  Time Frame: By 2015
- **Middletown Avenue.** The culvert under Middletown Avenue near Foxon Boulevard and I-91 intersection has a low gradient. Sand easily clogs the drainage system and water does not flow out of the system during exceptionally high tides. This was identified as an issue within HMP 2005 and continues to exist even today. Since the problem is associated with varying topographical elevations, no drastic improvements could be made. The only practical solution is to clean the culverts on a regular basis, which was done within the past five years whenever needed. If funding is in place, this street should be elevated to completely mitigate flooding issue here.
  Estimated Cost: $ 0.5 million
  Administering Agency: City Department of Engineering and Department of Public Works
  Time Frame: By 2015

1.2 Documentation of Planning Process

The preparation of the current plan update began in May 2010. This document was submitted for State Department of Environmental Protection (DEP) review in August 2010. A revised plan incorporating DEP's feedback was submitted to FEMA in September 2010.

Ms. Susmitha Attota with the City Plan Department coordinated the development of this plan update. The project team comprised of representatives of City Plan Department, Office of Emergency Management, Department of Engineering, Department of Public Works, Department of Parks, and the Chief Administrator's Office as listed below:

Karyn Gilvarg, City Plan Director, City Plan Department
Richard Miller, Engineering Director, Department of Engineering
Jennifer Pugh, Administrative Assistant, Chief Administrative Office (CAO)
Margaret Targove, Deputy Director, Office of Emergency Management
Robert Levine, Director, Department of Parks and Recreation
Howard Weissberg, Deputy Director, Department of Public Works
Susmitha Attota, Deputy Director of Comprehensive Planning, City Plan Department

Several one-on-one meetings and group meetings were held with the members of the project team in preparation of this plan update. A field visit was undertaken to assess the conditions of flood prone areas within the city. Besides the information gathered from these sources, Barbara Spaulding (Hazard Mitigation Grants and Planning Supervisor) with FEMA DR-1904-CT Joint Field Office was also regularly contacted and her feedback was incorporated in preparing the draft document. At the City Plan Commission's public meeting, key elements of the plan were discussed. The agenda was posted on the city webpage prior to the meeting. This agenda and meeting

minutes can also be now viewed on the city webpage at: http://www.cityofnewhaven.com/uploads/1443%20agenda(1).pdf http://www.cityofnewhaven.com/CityPlan/DecisionLettersCPC/readmore.asp?ID={8686F0DB-174C-4F7E-A686-735001D1B1F3} (OR See Appendix B).

News articles on this meeting are also enclosed in Appendix B. Major concerns were raised on addressing sea-level rise. Since the current plan does not have enough budget to address this in detail, representatives of the City Plan department mentioned that this will be taken care of by the new Office of Sustainability and will also be addressed as one of the key elements in the ten year Comprehensive Plan Update due for adoption in 2013.

A list of the meetings held is given below:

1. Meeting with Barbara Spaulding on Tuesday, May 25, 2010 regarding an overview of update process, content, and timeline,
2. Meeting with Maggie Targove and Jennifer Pugh on Tuesday, June 1, 2010 regarding emergency management services for the city.
3. Meeting and field visit with Richard Miller on Friday, June 11, 2010 to identify and assess the condition of flood prone areas within the city
4. Meeting with Richard Miller on Friday, June 25, 2010 to review the recommendations of the previous plan and discuss the mitigation work adopted and accomplished since then.
5. Meeting with Richard Miller on Tuesday, June 29, 2010 for draft review and feedback.
6. First Project Team Meeting on Tuesday, July 20, 2010 for draft review and feedback; to identify new flood prone areas within the city.
7. Meeting with Barbara Spaulding on Friday, July 23, 2010 for draft review and feedback.
8. Meeting with Richard Miller on Tuesday, August 10, 2010 for the final draft review and feedback.
9. Public informational meeting and City Plan Commission Meeting on Aug 18, 2010 for the adoption of the plan.

Appendix B also lists the purpose and outcome of all the meetings that were held along with field notes and observations.

1.3 Hazard Mitigation Goals

The primary purpose of this hazard mitigation plan update is to evaluate the work accomplished over the past five years based on the goals and strategies outlined in the previous plan and to re-frame the priorities and recommendations for the next five years. The goals outlined in the previous plan remain applicable to the current HMP update as well. The original HMP was prepared to ***reduce 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.

The goals of the previous plan were to:

- **Increase access to and awareness of funding sources for hazard mitigation projects.** Certain funding sources, such as the Pre-Disaster Mitigation Competitive Grant Program and the Hazard Mitigation Grant Program, will be available if the hazard mitigation plan is in place and approved.

- **Identify mitigation initiatives to be implemented if and when funding becomes available.** This HMP will identify a number of 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 community development through inter-departmental coordination.

- **Improve the mechanisms for pre- 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.

- **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 for 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 New Haven's ability to implement and maintain mitigation strategies.

- **Complement future Community Rating System efforts.** Implementation of certain mitigation measures may increase a community's rating, and thus the benefits that it derives from FEMA.

1.4 Identification of Hazards and Document Overview

The term *hazard* refers to an extreme natural event that poses a risk to people, infrastructure, or resources. The following have been identified as natural hazards that can potentially affect the City of New Haven:

- Inland and Coastal Flooding
- Sea Level Rise
- Summer and Winter Storms
- Land Subsidence
- Earthquakes
- Rockslides

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. Despite the cause, the problem of flooding is persistent and demands high expenditures from the City. For this reason, the problems of inland and coastal flooding have been addressed individually in two separate chapters. To identify current vulnerabilities and potential mitigation strategies associated with other hazards, each hazard has also been individually discussed in a separate chapter.

This document begins with a general discussion of the City of New Haven's Community Profile, including the physical setting, demographics, development trends, governmental structure, and sheltering capacity. Next, each chapter of this Plan is broken down into six or seven different parts. These are *Setting*; *Hazard Assessment*; *Historic Record*; *Existing Programs, Policies, and Mitigation Measures*; *Vulnerabilities and Risk Assessment*; *Potential Mitigation Measures, Strategies, and Alternatives*; and *Recommended Actions*. Within these sections, any disaster mitigation work undertaken for the projects listed in the past document are noted and new issues that have come up over the past five years are also listed. A detailed description of these sections is as follows:

- ***Setting*** addresses the general areas 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 Programs, Policies, and Mitigation Measures*** gives an overview of the measures that the City is currently undertaking to mitigate the given hazard. These may take the form of ordinances and codes, structural measures such as seawalls and tide gates, 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 also identified.
- ***Potential Mitigation Measures, Strategies, and Alternatives*** identifies mitigation alternatives.
- ***Recommended Actions*** is a list of the recommended mitigation measures that would be beneficial to protect against a given hazard, based on social, technical, administrative, political, legal, economic, and environmental factors (i.e. the "STAPLEE" method).

This document concludes with a strategy for implementation of the Hazard Management Plan, including a schedule, a program for monitoring and updating the plan, and a discussion of technical and financial resources.

Figure 1-1 Summary of HMP Projects

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2.0 COMMUNITY PROFILE

2.1 Physical Setting

The City of New Haven is located in the southern part of New Haven County, midway along Connecticut's Long Island coastline at the confluence of the Quinnipiac and Mill Rivers. The City is bounded to the south by Long Island Sound; to the west by the City of West Haven and the Town of Orange; to the north by the towns of Woodbridge, Hamden, and North Haven; and to the east by the Town of East Haven. The West River forms much of the southwest border with West Haven. Refer to Figure 2-1 for a location plan of the City, and Figure 2-2 for a more detailed map of the City on a USGS topographic base.

The land of the City is bisected by New Haven Harbor, a protected harbor that is approximately four miles long. The width of the harbor is 1.25 miles at a point between City Point and the East Shore. Water depth varies from very shallow tidal flats, generally along the west side, to the deepwater 35-foot Federal Navigation Channel, which runs north-south through the harbor. The Quinnipiac River, the West River and the Mill River all empty into New Haven Harbor.

The City is 18.9 square miles in size, representing approximately 2.2% of the area of New Haven County and 0.3% of the area of the State of Connecticut. Of this land area, approximately 15.5 square miles are public and private property, which does not include streets, roads, and waterways. Key physical features of the City include two rock ridges called East Rock and West Rock, New Haven Harbor, and the large Quinnipiac tidal marsh.

Figure 2-1 City of New Haven Location Map

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Figure 2-2 USGS Topographic

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2.2 ***Existing Land Use***

Over 70% of all public and private property in the City of New Haven is used for institutional and/or residential purposes. Of these uses, single family homes, largely found in the City's western neighborhoods and the east shore, total 1,764 acres (17.9% of the City as a whole). Refer to Figure 2-3 for a map of land use.

Commercial class property, including office space in the downtown area and throughout the City, represents approximately 15% of all assessed land in New Haven. The City is characterized by smaller commercial districts that developed around neighborhood areas.

Of the 9,483 acres in New Haven, just 804 acres (8%) are classified as industrial. Substantial areas of all industrial space are located in just six neighborhoods. Industrial uses are largely located along Long Wharf, within the east shore neighborhoods and adjacent to Mill River. A significant subset of the industrial sector is the Port of New Haven, located on the east side of the harbor. Port-related uses account for over a quarter of all industrial-class property.

The remaining land use in New Haven is attributable to parks/open space and mixed use. Parks and open spaces account for approximately 1,520 acres. College and University properties, which include the large holdings of Yale University and Southern Connecticut State University, account for 965 acres. Major regional facilities, such as hospitals and government offices, are also present. The chart and map on the following pages depict the existing land uses in the city by acreage and location (See Table 2-1 and Figure 2-3).

The largest concentrations of economic activity are located downtown, in the medical services area of the Hill, Dwight, and West River neighborhoods, and in the industrial sectors east of the central business district. In addition, the City's main arterials and neighborhood commercial districts anchor a diverse retail and commercial services sector.

Floodplain development varies throughout the City and includes residential areas, municipal buildings, commercial structures, shipping and rail facilities, and highway systems. Residential properties located adjacent to the West, Mill, and Quinnipiac Rivers as well as residential areas around New Haven Harbor are at specific risk to flooding. Residential areas in the Morris Cove region have particular problems with flooding

Table 2-1: Table of Existing Land Use in New Haven (less streets and waterways)

Residential	Acres	Sq. Miles	%
Single Family	1764	2.75	17.9%
Two Family	670	1.05	6.8%
Three Family	396	0.62	4.0%
Small Apartment Building	179	0.28	1.8%
Large Apartment Building	260	0.41	2.6%
Special Needs Housing	234	0.36	2.4%
Condos	192	0.30	1.9%
Sub-Total	**3694**	**5.77**	**37.4%**

Commercial and Mixed Use	Acres	Sq. Miles	%
Specialty Commercial	142	0.22	1.4%
Restaurants/Clubs/Taverns	26	0.04	0.3%
Hotels/Motels/Inns	17	0.03	0.2%
General Retail	46	0.07	0.5%
Automotive Sales and Service	59	0.09	0.6%
Bank/Professional/Business Office	135	0.21	1.4%
Mixed Use	119	0.19	1.2%
Commercial Recreation	26	0.04	0.3%
Sub-Total	**568**	**0.89**	**5.8%**

Institutional	Acres	Sq. Miles	%
Cemetery	210	0.33	2.1%
Cultural/Religious/Charitable/Non-Profit	178	0.28	1.8%
Government Offices and Facilities	491	0.77	5.0%
Parks and Open Space	1520	2.37	15.4%
College/University	965	1.51	9.8%
Hospitals/Health Care Facility	34	0.05	0.3%
Schools	330	0.52	3.3%
Sub-Total	**3730**	**5.83**	**37.8%**

Industrial and Transportation	Acres	Sq. Miles	%
Manufacturing and Production	244	0.38	2.5%
Storage and Warehousing	516	0.81	5.2%
Transportation and Utilities	493	0.77	5.0%
Sub-Total	**1253**	**1.96**	**12.7%**

Vacant	Acres	Sq. Miles	%
Vacant Commercial	98	0.15	1.0%
Vacant Industrial	61	0.10	0.6%
Vacant Residential	292	0.46	3.0%
Vacant Undevelopable	182	0.28	1.8%
Sub-Total	**633**	**0.99**	**6.4%**

Total	9879	15.43	100.0%

Figure 2-3 Existing Land Use Map

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2.3 Geology

Geology is important to the occurrence and relative effects of natural hazards such as earthquakes, rockslides, subsidence, and some flooding. Thus, it is important to understand the geologic setting and variation of bedrock and surficial formations in the City.

New Haven is located in the Atlantic Coastal Plain, a broad belt along the eastern seaboard of the United States and the Gulf of Mexico, extending from the mouth of the Rio Grande to Cape Cod. The region is generally characterized by sedimentary rock formations and thick unconsolidated sediment deposits that extend to the continental shelf. Refer to Figure 2-4 for a depiction of bedrock geology and Figure 2-5 for a depiction of surficial geology.

The City of New Haven is unique with regard to bedrock geology. It has elements of three of the four primary geologic regions or "terranes" of Connecticut. Very few municipalities in Connecticut have such a variety of bedrock types and origins. Terranes are geologic regions that reflect the role of plate tectonics in Connecticut's natural history.

- The metamorphic bedrock of the western uplands of Connecticut can be found where New Haven meets Woodbridge. In New Haven, this bedrock is part of the Iapetos Terrane, comprised of remnants of the Iapetos Ocean that existed before Pangaea was formed. The terrane was formed when Pangaea was consolidated.

- The sedimentary rocks and volcanic intrusions of the Connecticut River and Quinnipiac River valleys can be found throughout most of the City of New Haven. This bedrock is part of the Newark Terrane, which formed when Pangaea split apart.

- The metamorphic and igneous bedrock of the eastern uplands of Connecticut can be found in the southern section of the Morris Cove neighborhood. In New Haven, this bedrock is believed to be part of the Avalonian Terrane. This terrane is a remnant from the African continent, which collided with North America during the formation of Pangaea.

One of the most famous faults in Connecticut is the eastern border fault, which separates the central sedimentary rocks from the eastern uplands, representing a split in Pangaea. This fault begins south of New Haven and extends for 130 miles north to Keene, New Hampshire, cutting west to east through the Morris Cove neighborhood. This fault is no longer active.

The faults that formed from the division of Pangaea created pathways for magma to flow to the ground surface. Basalt flows and intrusions now form prominent ridges. Two major volcanic intrusions can be found in New Haven. These are East Rock and West Rock. Both East and West Rocks formed from the same magma. West Rock is an intrusive dike, and actually extends underground through Hamden to East Rock.

Figure 2-4 Bedrock Geology

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Figure 2-5 Surficial Geology

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Surficial geology in the City of New Haven is influenced by bedrock geology as well as by glacial processes. Glacial till covers sections of the metamorphic rock uplands in Westville and Morris Cove, as well as other areas such as the eastern section of the City, the peripheries of East and West Rocks, and the hills located along Prospect Street and Goffe Street.

Most of the City is characterized by stratified sand and gravel ("stratified drift") deposited by glacial melt water streams. Stratified drift can be found from Forest Road, eastward through the downtown area, into Fair Haven. It extends from Hamden to City Point. The oil terminal area along the east side of the harbor and the portion of the Morris Cove neighborhood located along Morris Cove are also underlain by stratified drift. Fill material has been placed on top of stratified drift in many sections of the City, including most of the waterfront. The presence of stratified drift has bearing on the relative intensity of earthquakes, while the presence of fill material directly affects the likelihood of subsidence and soil liquefaction during earthquakes. These topics will be taken up in later sections.

With regard to soil types, the City falls mainly within the Penwood-Manchester-Deerfield soils group, which is known for its level to gentle slopes, well-drained and sandy soils, reddish brown subsoils and broad outwashes. There are three smaller areas, near the East Haven line, in Westville and East Rock, within the Cheshire-Holyoke soils group. In these areas, the slopes increase and the soil is loamier. In the Quinnipiac Meadows, on the east side of the river, Westbrook mucky peat soils are found. These areas are examples of low salt soils that are affected by tidal conditions.

2.4 Climate

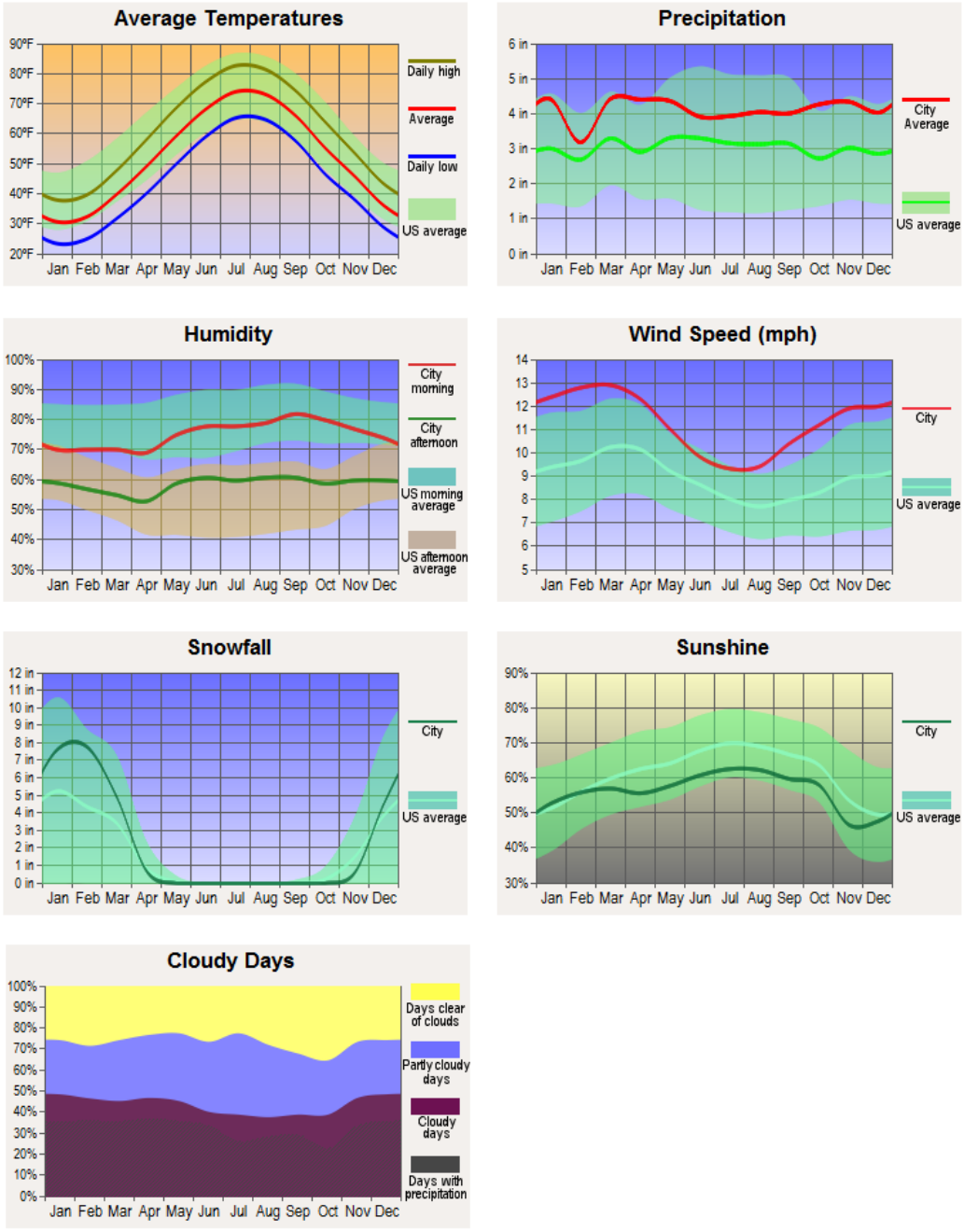
New Haven is well known for an agreeable climate, characterized by moderate but distinct seasons. The average mean temperature is approximately 52 degrees, with summer temperatures in the mid-70s (daily average) and winter temperatures in the mid-30s Fahrenheit. Extreme conditions raise summer temperatures to near 100 degrees and winter temperatures to below zero. Mean snowfall is approximately 52 inches per year. Mean precipitation is 44 inches, which is spread evenly over the course of a year.

By comparison, average annual state-wide precipitation based on more than 100 years of record is nearly the same, at 45 inches. However, average annual precipitation in Connecticut has been increasing by 0.95 inches per decade since the end of the 19th century (Miller et. al., 2002; NCDC, 2005). Likewise, total annual precipitation in New Haven has increased over time. The continued increase in precipitation only heightens the need for hazard mitigation planning, as the occurrence of floods and other hazards may change in accordance with the greater precipitation. The current annual precipitation of New Haven (combined rainfall and snowfall) is 52.73 inches (www.cityinfo.local.com). Figure 2-6 on the following page depicts the average climate in New Haven (Source: www.city-data.com)

Figure 2-6

Average climate in New Haven, Connecticut

Based on data reported by over 4,000 weather stations



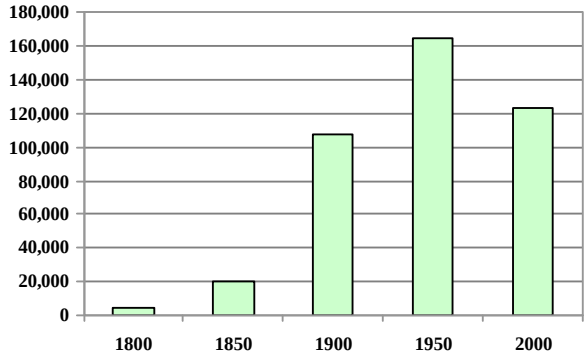
Source: www.city-data.com

2.5 Population and Demographic Setting

Demographic trends for the City are similar to those of many small cities of the northeast United States. Dramatic population increases occurred in New Haven between 1880 and 1920, with the population jumping from 62,882 to 162,655. Most of this population growth was comprised of immigrants from Ireland, Southern Italy and Eastern Europe, as well as African-Americans migrating from the South. After World War I, more restrictive federal immigration policies drastically reduced the flow of European immigrants to New Haven. Instead, immigration came from the south, as African-Americans from southern states and Hispanics from Puerto Rico became the largest sources of post-war immigration. Still, New Haven's population remained relatively stable through the Great Depression to the end of World War II.

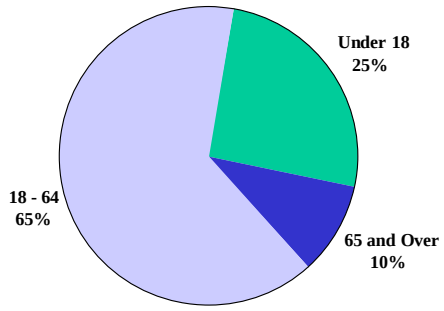
Following the end of World War II, with the construction of new roads and highways, the enhanced availability of the automobile and federally funded housing programs, thousands of the City's middle class citizens migrated to the surrounding suburbs. This out-migration occurred from the late 1940s through the 1970s and into the 1980s.

Figure 2-7: Population of New Haven, 1800 - 2000



According to the Connecticut Department of Public Health's 2007 Population Estimate, there were 123,932 residents in New Haven. New Haven's overall share of the regional population has declined from 24.5% in 1980 to 22.2% in 2007. In New Haven, population density has seen a 19% decrease since 1960, when there were 8,000 people per square mile, compared with 6,500 people per square mile today. In 2000, 25% of the population of New Haven was younger than 18 years of age, 65% was between the ages of 18 and 64, and only 10% was 65 years and older.

Figure 2-8: Population of New Haven by Age, 2000



The Hill and Fair Haven neighborhoods are home to more residents than any other areas in the City. With 15,682 residents in the Hill and 13,683 residents in Fair Haven, these two neighborhoods alone account for almost 25% of the City's total population. The next most populous neighborhoods, East Rock, Westville, and Downtown, account for slightly less than 20% of the City's population. Among the neighborhoods with a residential population base, Wooster Square is the smallest (2,008). The next least populous neighborhoods are the West Rock, West River and Prospect Hill neighborhoods.

In terms of residential density, Dwight is the most densely populated neighborhood in the City, followed by Downtown. The least densely populated neighborhoods are Westville and the East Shore (See Figure 2-9 on the following page).

The projected municipal population in 2010 is 126,432, a 2.0% increase over the 2000 population (approximately 123,000 people). These projections will be affected by the extent of basic economic development, neighborhood revitalization and regional "smart growth" housing strategies. The *Comprehensive Plan of Development* developed by the City of New Haven suggests that population growth will be centered in Downtown and in the harbor area. Similar increases are expected in West Rock and Dixwell, due to larger scale housing initiatives in these areas. The desired/proposed land use for the city as discussed in the City's *Comprehensive Plan* (2003) is depicted in Figure 2-10.

2.6 Development Trends

With its fertile lands perfect for agricultural use, and its strategic location at the mouth of three rivers and Long Island Sound, New Haven was positioned perfectly to become the regional commercial and residential center of Southern Connecticut. Beginning around 1850, New Haven's economic and employment opportunities expanded as the City's manufacturing industries began to flourish. During this era, the City became a national leader in carriage manufacturing and a home to large-scale producers of rubber goods, clocks, pianos, beer, guns and military equipment, and a wide range of other products.

The City experienced its greatest growth in population between 1890 and 1920 as a result of the expansion of these industries and added government demand for equipment needed for the Spanish-American War and World War I.

Historic and more contemporary land use patterns are shaped in relationship to the City's waterfront and riverfront locations. The City Plan Commission's *Harbor Plan* (2002) emphasizes a balance of economic development, environmental sustainability and cultural enrichment along the waterfront. Land use policy in and around New Haven Harbor is framed by the Connecticut Coastal Area Management Act and the New Haven Coastal Management District.

Figure 2-9: Map of City Neighborhoods, Population Densities, and Waterbodies

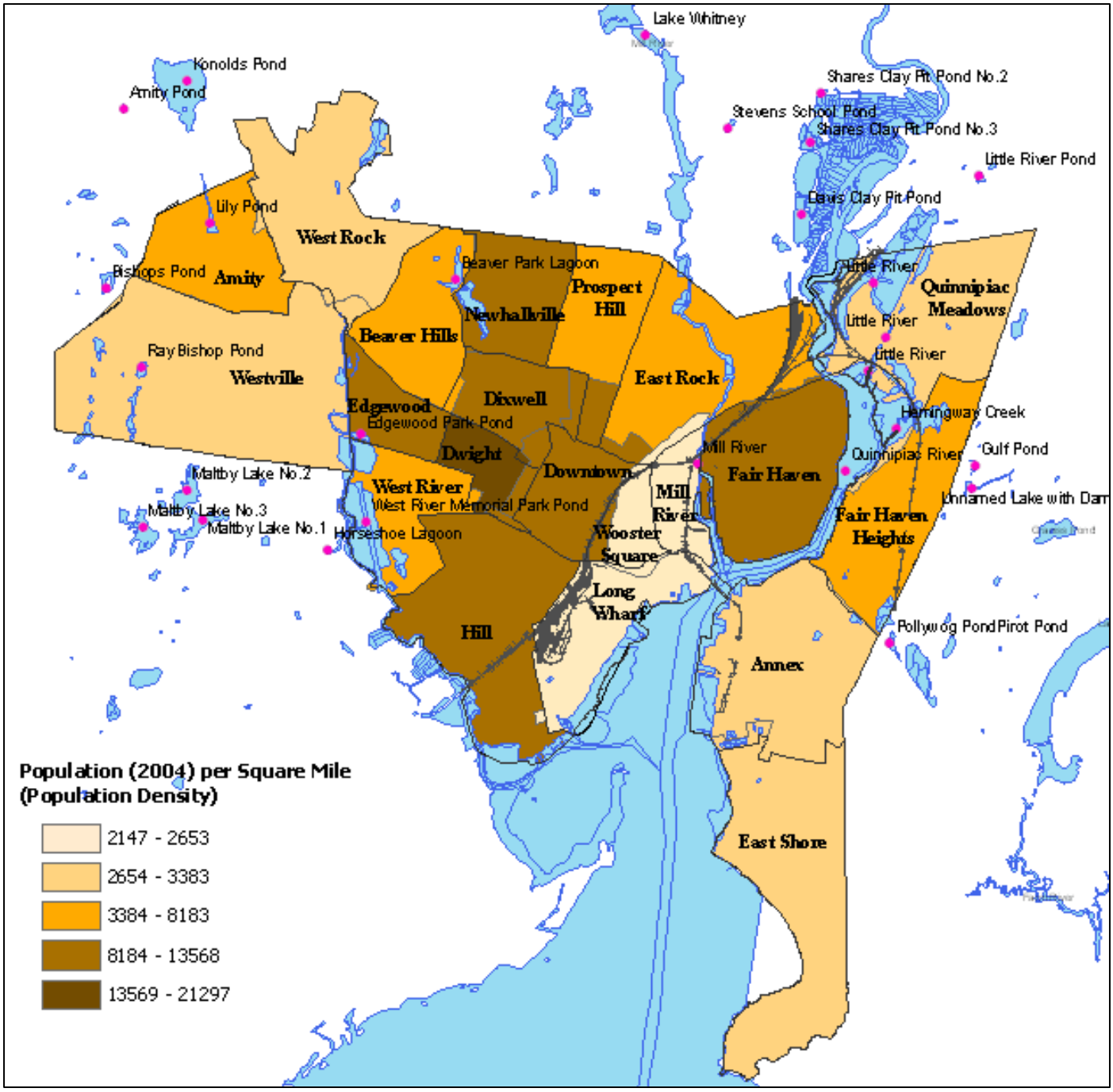
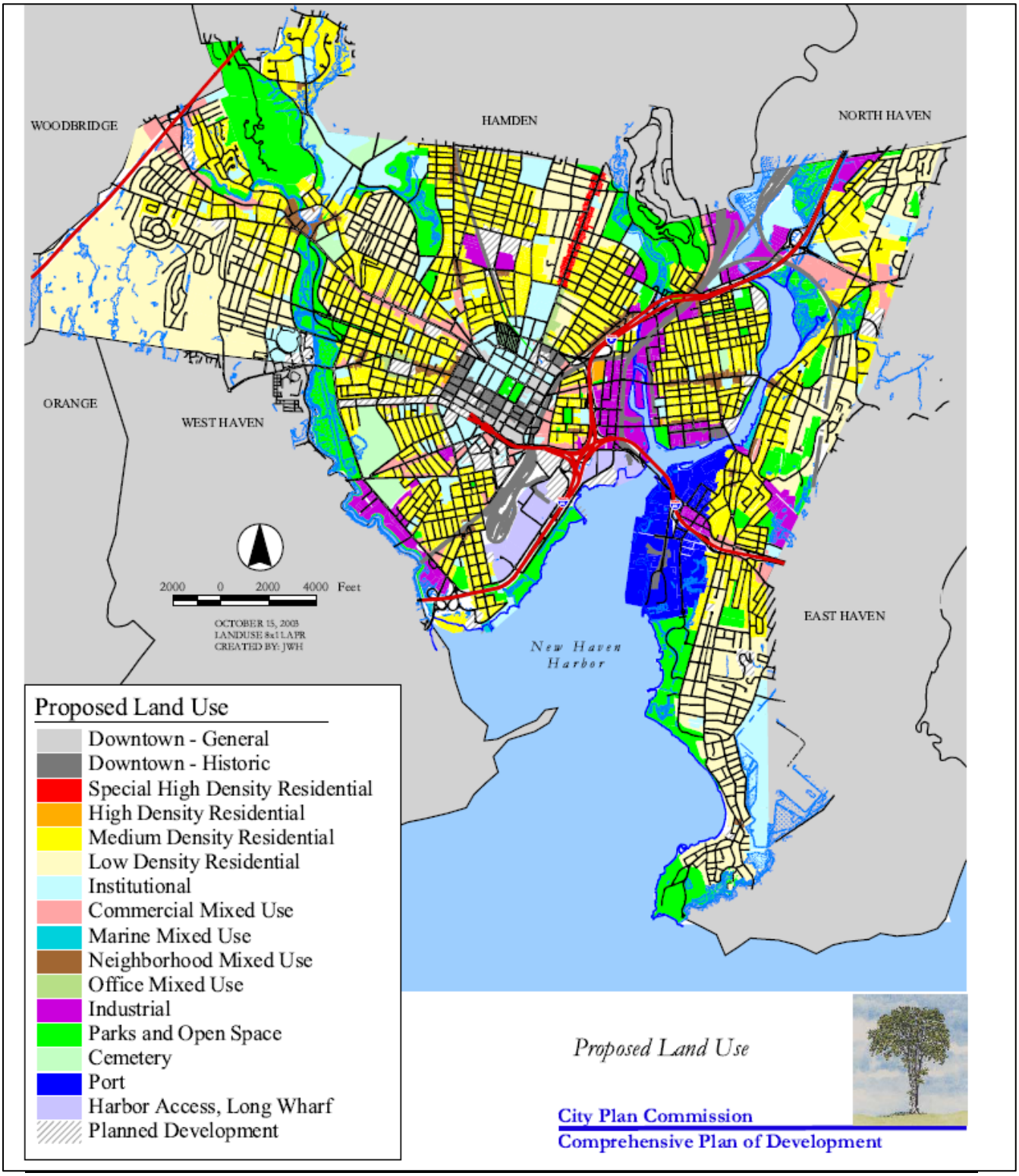


Figure 2-10: Proposed Land Use Map



2.7 Governmental Structure

The City of New Haven has a Mayor-Council form of government. The Mayor is the Chief Executive Officer of the community. The legislative branch is comprised of the Board of Aldermen and the governing branch is comprised of the City Plan Commission. These bodies oversee the actions of the individual City Departments, including City Plan Department which lead the effort to update the HMP 2005.

The City Departments that may play a role in implementing the Hazard Mitigation Plan include the New Haven Office of Emergency Management; the Chief Administrator's Office; the City Plan Department; the Engineering Department / Department of Public Works; and the Department of Parks, Recreation and Trees. In addition, the Fire, Police, and Health Departments are also involved in activities related to hazard response and emergency management. The project team for preparing the HMP update is therefore comprised of representatives of all these departments.

The Connecticut Office of Emergency Management and Homeland Security has five regional offices in Connecticut. The Region II office is located in New Haven. This office coordinates the state's response to disasters, and interfaces with federal disaster assistance agencies to get material and financial help to respond and recover from natural disasters. The area office assists in preparation of the Emergency Operations Plan (EOP) and is the primary interface with the Connecticut office.

The Chief Administrator's Office coordinates interdepartmental activities of City agencies providing public services and oversees the following public service agencies that may be involved in implementation of the Hazard Management Plan: Engineering, Fire, Parks and Recreation, Police, and Public Works.

The City Plan Department facilitates the physical development of the City and encourages the development of sustainable land use, economic and social policy. The department is responsible for developing and updating the *Comprehensive Plan of Development*, as well as other area-specific development plans. The City Plan Department works with City agencies, commissions and boards to provide planning, zoning, and development information and advice, and to assist residents, businesses, and developers in achieving the City's development objectives.

Of these, the City Plan Commission (CPC) would be directly involved in hazard mitigation through implementation of appropriate zoning and planning. The CPC advises the Redevelopment Agency, the Board of Zoning Appeals, the Development Commission and the Board of Aldermen on planning and zoning matters. The CPC reviews site plans, including plans within the Coastal Area Management district and plans for soil erosion and sediment control. The CPC is the City's Inland Wetlands Commission and its Conservation Commission, and has the power to grant Flood Damage Prevention variances.

The Engineering Department provides engineering services such as planning, design, and construction to the City departments, provides technical services for the City's capital improvement projects, and inspects all city-owned bridges and new sewer connections. In addition, the Engineering Department reviews and comments on soil erosion and sediment control applications and assists the general public regarding flood hazards. The mission of the City of New Haven Department of Public Works is to provide effective maintenance management services for the City's infrastructure associated with, but not limited to, public property.

The Department of Parks, Recreation and Trees is responsible for the stewardship of the City of New Haven's entrusted assets. Its responsibility would likely include any properties acquired by the City for hazard mitigation purposes and converted to open space.

2.8 Critical Facilities and Sheltering Capacity

The City's police, fire, medical, governmental, and major transportation facilities are its most important critical facilities because they ensure the public safety and efficiency of community operations both day-to-day and in emergencies. The City's Emergency Operations Center (EOC), located in the basement of the City Hall, serves as the headquarters for emergency management. A list of critical facilities is provided in Table 2-1 on the next page and these facilities are also mapped in Figure 2-11 on page 2-20.

The City is capable of sheltering approximately 5,705 individuals, based on numbers of cots in American Red Cross (ARC) certified facilities. In addition, facilities exist to accommodate the evacuation of nearly 17,705 individuals. A summary of shelter facilities is provided in Table 2-3, following Table 2-2 on the following page.

These buildings have been designated as public shelter facilities by meeting specific ARC guidelines. Amenities and operating costs of the designated shelters including expenses for food, cooking equipment, emergency power services, bedding, etc., are the responsibilities of the community and generally are not paid for by the ARC. They are used on a temporary basis for providing shelter until the threat of a hazard diminishes. Regionally located mass care facilities operated and paid for by the American Red Cross may be available during recovery operations when addition sheltering services are necessary.

Certain shelter facilities are located within the flood zone, as noted in Table 2-2, and thus would not be appropriate in the case of flooding events. Some facilities are equipped with generators and/or kitchens for use in response to emergencies. The Pitkin Tunnel is also identified as a location that can be influenced by ground water. Protective measures to include sand bags can easily mitigate that potential.

In addition to the above-mentioned public facilities, Yale University has a total of 6 shelter locations with a maximum capacity of 3240 as identified in their Shelter Plan.

In case of emergencies, the City will handle its own antennas with vendors that are already in place for the entire communications infrastructure.

FEMA is currently in the process of updating the flood insurance rate maps (FIRMs) for various regions in the State, including New Haven, through its map modernization initiative. For this update, the consultants who were hired conducted a survey of the coastline to identify and determine the boundaries of the flood zone using a hand held global positioning device. The city staff was regularly informed about the status of this process and the staff also provided the requested information on areas of significant flooding within the city, letters of map change, letters of map amendments, and the like to the consultants, to enable them to update these maps accurately. FEMA will provide the draft FIRMs to the city shortly for review and feedback. The final FIRMs would be released later this year (possibly in December), which may include new flood zone boundaries. The base flood elevations are also subject to change as the new flood

maps that will be released later this year will be in accordance with the North American Vertical Datum (NAVD) of 1988 as opposed to previous ones that were mapped in National Geodetic Vertical Datum (NGVD) of 1929. Therefore, the new base flood elevations in each area would be slightly higher than the old ones (by a few inches).

Table 2-2
Critical Public Facilities and Hospitals

Facility	Address	Located in Flood Zone
Emergency Operations Center	200 Orange Street	No
City Hall/Government Center	165 Church Street, 200 Orange Street	No
Yale-New Haven Hospital	20 York Street	No
St. Raphael Hospital	1450 Chapel Street	No
Department of Public Works	34 Middletown Avenue	No
Department of Police Services	1 Union Avenue	No
Union Station (rail, bus)	170 Union Avenue	Yes*
Fire Department Headquarters	952 Grand Avenue	No
Dixwell Fire Station	125 Goffe Street	No
East Grand Fire Station	73 East Grand Avenue	No
Fountain Street Fire Station	105 Fountain Street	No
Hill Fire Station	525 Howard Avenue	No
Lighthouse Fire Station	510 Lighthouse Road	Yes
Whitney Avenue Fire Station	350 Whitney Avenue	No
Woodward Avenue Fire Station	826 Woodward Avenue	No
New Haven Health Department	54 Meadow Street	No
New Haven School Department	54 Meadow Street	No
New Haven Main Library	133 Elm Street	No
Tweed New Haven Airport	155 Burr Street	Yes
New Haven Fire Training Academy	230 Ella T. Grasso Boulevard	Yes
Hill Career High School	140 Legion Avenue	No
James Hillhouse High School	480 Sherman Avenue	No
Wilbur Cross High School	181 Mitchell Drive	Yes*
Nathan Hale School	480 Townsend Avenue	No
Truman School	170 Derby Avenue	No

Table 2-3
Available Sheltering Capacity

NH Regional Fire Training Academy 230 Ella Grasso Blvd. (203) 946-6783	**Evacuation = 275 People** Auditorium = 120 Classrooms = 155	**Shelter = 100 Cots** Auditorium = 45 Classrooms = 55	**Notes** **Flood Zone (on line between 100-500 yr flood zone)** No Generator/No sprinklers

Hill Regional Career High School 140 Legion Avenue (203) 946-5845	**Evacuation = 2,900 People** Gym = 250 Classrooms = 1,925 Auditorium = 725	**Shelter = 830 Cots** Gym = 100 Classrooms = 730	**Notes** Generator
James Hillhouse High School 480 Sherman Avenue (203) 946-0464	**Evacuation = 8,535 People** Gym = 735 Field House = 4,000 Classrooms = 2,800 Auditorium = 1,000	**Shelter = 2,800 Cots** Gym = 275 Field House = 1,475 Classrooms = 1,050	**Notes** Generator
Wilbur Cross High School 181 Mitchell Drive (203) 946-8728	**Evacuation = 4,410 People** Gym 1 / 2 = 1,050 Auditorium = 1,000 Classrooms = 2,360	**Shelter = 1,225** Gym 1 = 250 Gym 2 = 140 Classrooms = 835	**Notes** 120/208 volt Olympian diesel genset. Supports only lights & small motors.
Nathan Hale Middle School 480 Townsend Avenue (203) 946-8669	**Evacuation = 1,585 People** Gym = 390 Auditorium = 115 Classrooms = 1,080	**Shelter = 700 Cots** Gym = 150 Auditorium = 50 Classrooms = 500	**Notes** Generator Adjacent to Tweed Airport

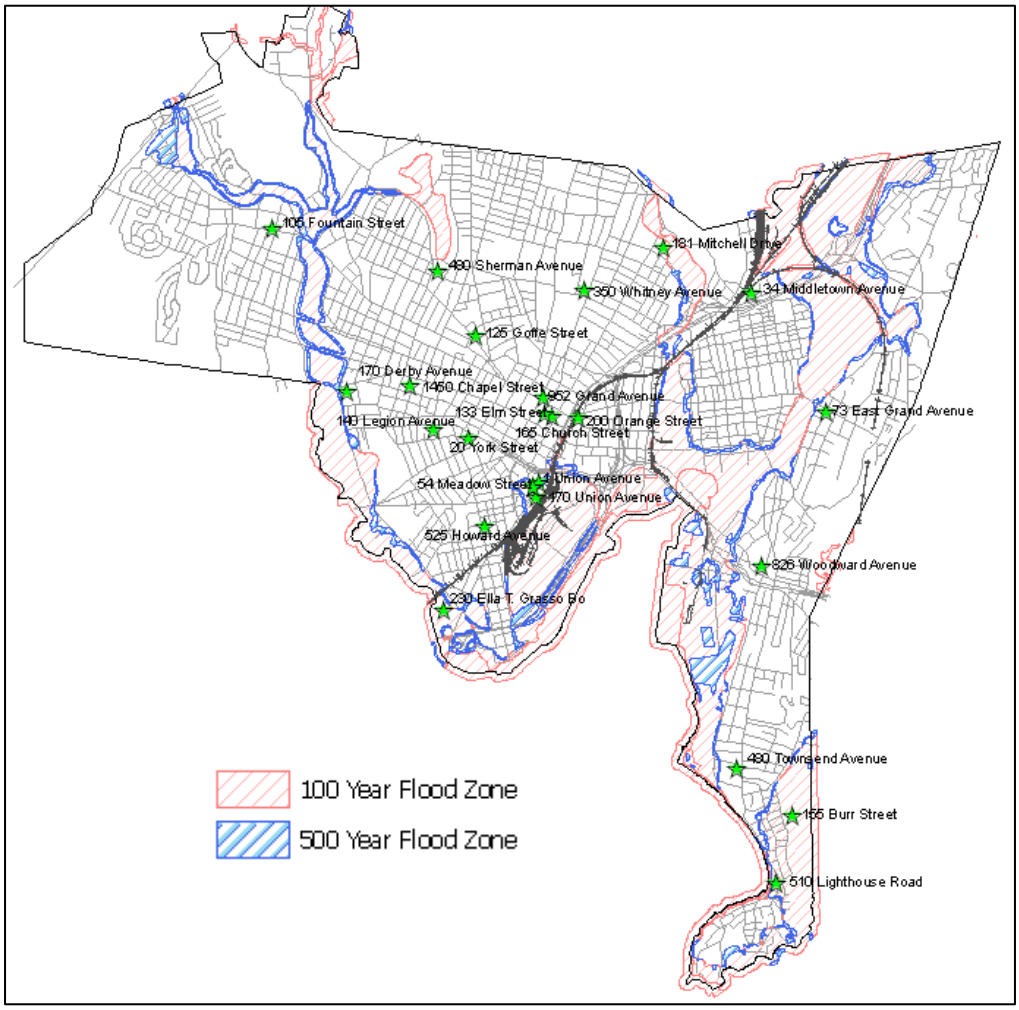
New Haven EOC……..100 Cots / 300 Blankets/20 Special Needs Cots (Located in City Hall basement)

Source: American Red Cross South Central CT Chapter Mass Care/Shelter/Evacuation Facility Overview for the City of New Haven.

The following facilities need State/Region 2approval for opening **(Proposed Sheltering Capacity)**:

Southern CT State University Moore Field House 125 Wintergreen Avenue (203) 392-6003	**Evacuation = 4,740 People** Ground Floor = 2,540 2nd Floor Bleachers = 2,200	**Shelter = 950 Cots** Ground Floor = 950	**Notes: Can be used as a regional shelter** No Generator No Kitchen / Feeding Supplies
Southern CT State University Connecticut Dining Hall 2 Wintergreen Avenue	**Evacuation = 750 People**	Shelter = ZERO	**Notes** Industrial Kitchen Mass Care Feeding, Staging
New Haven Board of Education Central Kitchen Middletown Ave. (203) 946-5345	**Evacuation = ZERO**	**Shelter = ZERO**	**Notes** Generator (limited areas) Industrial Kitchen Mass Care Prep / Staging
Truman Elementary School 114 Truman Street (203) 691-2100	**Evacuation = 1,670 People** Gym = 470 Classrooms = 1,200	**Shelter = 625 Cots** Gym = 175 Classrooms = 450	**Notes** No Generator

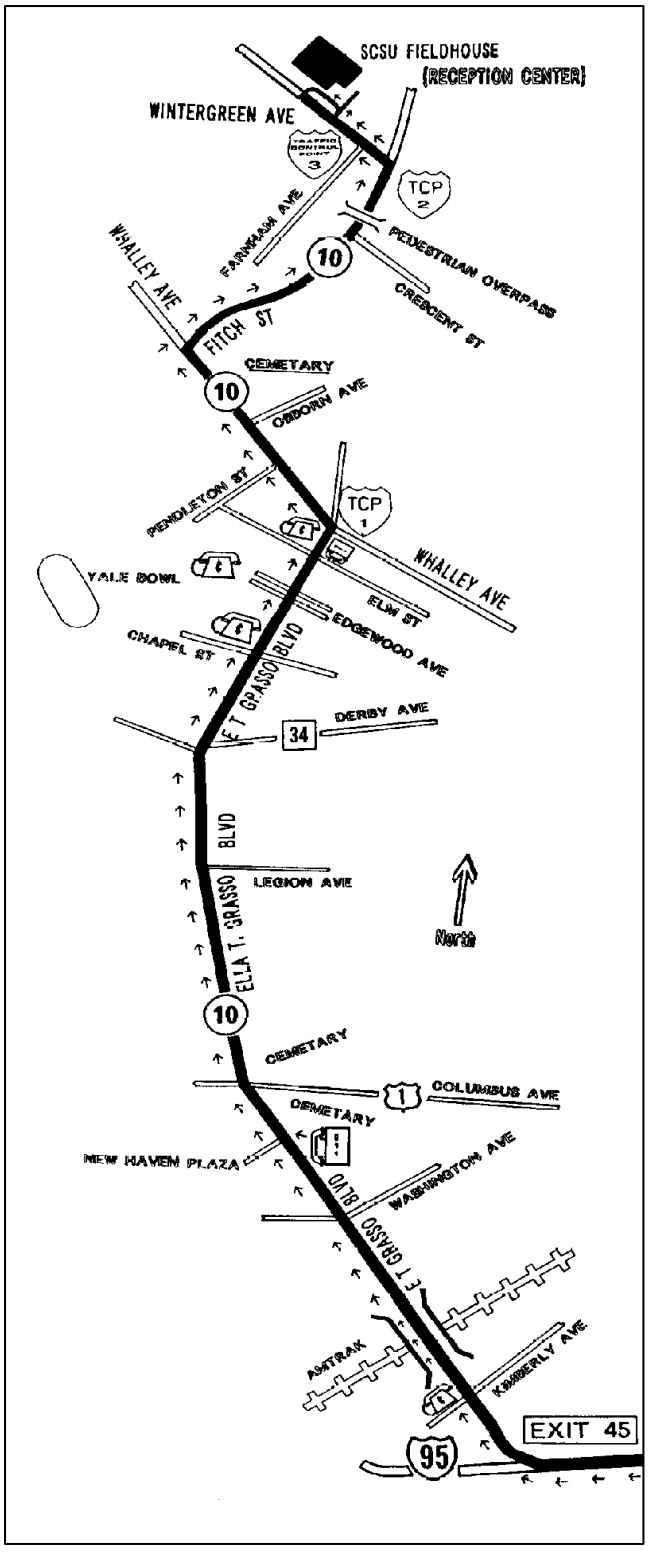
Figure 2-11. Map of Critical Public Facilities and Hospitals in New Haven



According to the City's EOP, New Haven is one of the municipalities designated to shelter evacuees in the event that relocation of the residents living in the vicinity of the state's nuclear power plants becomes necessary. These residents would be housed at Southern Connecticut State University in the event that evacuation was necessary. Planning, preparations and equipment positioning have been accomplished by Northeast Utilities to ensure this can be accomplished. The "New Haven Responsibilities" section of the overall Host Community Plan is included as an annex to the EOP.

The host community evacuation route consists of the entire length of Route 10, including Ella T. Grasso Boulevard, Whalley Avenue, and Fitch Street. This route serves evacuation from water or nuclear power plant. Evacuees would follow Interstate 95 to exit 45 in order to reach Route 10. The evacuation route is shown in Figure 2-12. The three drawbridges in the city—Grand Ave, Ferry, and Chapel Street bridges, which may be used during evacuation are aging and need continuous repairs.

Figure 2-12. New Haven Host Community Evacuation Route



3.0 INLAND FLOODING

3.1 Setting

Inland flooding is a well-documented natural hazard that threatens the City of New Haven. Along with coastal flooding, it is the most common naturally occurring event that disrupts quality of life for many residents. However, a thorough review of records and feedback from residents indicate that inland flooding affects only a few areas of the City with any degree of regularity.

The West River, Mill River, and Quinnipiac River flow south through New Haven and into New Haven Harbor. Small segments of the lower parts of these watersheds are within New Haven corporate limits, and the rivers are tidally-influenced through their lower reaches. Thus, areas impacted by the overflow of their tributaries are generally limited to properties that are adjacent to the rivers. However, indirect flooding that occurs in the floodplains of these rivers is a more common problem, resulting from inadequate drainage and other factors. Figure 3-1 depicts the mapped FEMA Flood Zones in the City of New Haven. These flood zones are subject to change as with the new FIRMs releasing later this year as discussed earlier in Section 2.8.

The three river systems are described below. The only other water body that is not a tributary to these rivers, Morris Creek, is addressed in Section 4.0 as a coastal flood hazard. A sharp line can not easily be drawn to separate areas of inland flooding from areas of coastal flooding. Indeed, the mapped floodplains for coastal and inland areas merge along estuaries and embayments. Any separation or distinction made in this report is mainly for organization purposes.

West River and Tributaries

The West River runs along the westerly side of the City and is heavily impacted by land uses in New Haven and West Haven. Active use of the riverfront for water-dependent purposes is constrained by water depth and bridge clearance. Canoeing and fishing are among the more common in-water activities. Combined sewer overflows impact water quality.

Future development along the West River calls for implementation of the *West River Memorial Park Master Plan (1998)*, according to the *Comprehensive Plan of Development (2003)*. This plan outlines areas for salt marsh restoration, improved soccer and other recreation fields, a circuit path, areas for wildlife refuges and other improvements. The following improvements from the Master Plan were implemented since 2002 to date:

- Phragmities eradication between 2002 and 2004
- Replacement of one existing tide gate with a new tide gate with an opening to allow increased tidal flow into the park in 2004
- Total renovation of the soccer fields and installation of a parking lot in 2005
- Installation of basket ball court in the northern end of the park date in 2005 (approximate)
- Parking lot, walking paths and landscaping installed in the southern end of the park in 2006

The *Comprehensive Plan of Development* has identified the West River tributary system in and around the upper reaches of West Rock, including Wintergreen, Wilmot Farm, and Belden Brooks, as a sensitive environmental area in which care should be taken to preserve environmental assets. The *West Rock Redevelopment Plan* describes a 475-unit residential development spanning 212 acres, which will be developed in phases. It proposes identification of areas for wetland and stream restoration and urges environmentally responsible stormwater management.

Figure 3-1 FEMA Flood Zones in the City of New Haven.

The FEMA Flood Insurance Study (FIS) for the City of New Haven identifies the base flood elevation for Wintergreen Brook at the intersection of Wilmot Road and Wintergreen Avenue as 27.2 feet (all elevations NGVD). The base flood elevation where Wintergreen Brook joins the West River is 18.2 feet. Where the West River flows into the City at Lily Pond, upstream of Lily Pond Dam, the base flood elevation is 80.9 feet. The base flood elevation on the West River just south of Fountain Street is 13.1 feet, and is 12.4 feet just north of Edgewood Avenue. The base flood elevation of the West River merges with the tidal/coastal base flood elevation of 11 feet between Chapel Street and Edgewood Avenue. As discussed earlier in Section 2.8, the City has been working with FEMA regarding the updates to the FIRMs, which are due to be released in December this year. The draft FIRMs were not shared with the City staff yet. Hence it is difficult to know of variations to THE base flood elevations in the new maps.

Although FEMA has requested for an accompanying list of buildings, infrastructure, and critical facilities within these flood zones, they could not be mapped due to recent budget cuts and staff shortage.

Mill River

The Mill River flows south through New Haven into New Haven Harbor. The floodplain for the upper reach of the Mill River within the corporate limits of New Haven includes a large park area, a school, and a large plot of state administered land.

The 100-year flood elevation on the Mill River north of Chapel Street is 11 feet (NGVD). This flood elevation is the same as the coastal flood elevation, and it is consistent for the Mill River through its length in New Haven, implying that the entire reach of the Mill River in the City has a low gradient.

Quinnipiac River and Tributaries

The Quinnipiac River runs south through eastern New Haven, draining into New Haven Harbor. The 100-year floodplain on the Quinnipiac River is largely commercial and industrial throughout its length within the limits of New Haven. The highest densities of residential areas in the Quinnipiac River floodplain are to the northeast at the corporate limits, and the eastern section surrounding Hemingway Creek.

The 100-year flood elevation on the Quinnipiac River north of Ferry Street is 11 feet. As with the Mill River, this flood elevation is the same as the coastal flood elevation, and it is consistent for the Quinnipiac River through its length in New Haven. The base flood elevation of Hemingway Creek where it enters the City from East Haven is also 11 feet, implying coastal inundation during 100-year flood events.

3.2 Hazard Assessment

New Haven lies in the zone of westerly prevailing winds and often experiences cyclonic disturbances that have crossed the country from the west or southwest. It is also exposed to coastal storms, some of tropical origin, that move up the Atlantic coast with heavy rainfall. In late summer and autumn these storms may attain hurricane intensity. Most inland flooding in New Haven is caused by storms with heavy rainfall.

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by FEMA as the base flood for purposes of floodplain management. This flood has a 1% chance of being equaled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. Similarly, a 500-year flood has a 0.2% chance of occurring in a given year. The 500-year floodplain is shown to indicate areas of moderate flood hazard.

While floodplains are lands along watercourses that are subject to periodic flooding, floodways are those areas within the floodplains that actually convey floodwaters. Floodways are subject to water being carried at relatively high velocities and forces. The floodway fringe are those areas of the floodplain outside the floodway which are subject to inundation but do not convey the floodwaters.

FEMA has information to demonstrate areas within the City of New Haven that are vulnerable to flooding. These including Flood Insurance Rate Maps (FIRM), a Flood Insurance Study (FIS), and a Supplement Wave Height Analysis. These FIRMs currently in use were released in October 1977, but later this year updated maps will be released as mentioned in Section 2.8.

In some areas of the City, flooding occurs from heavy rains with a much higher frequency than those mapped by FEMA. These frequent flooding events occur in areas of the City with insufficient drainage; where conditions may cause localized flash floods; and where tidal influences may exacerbate drainage problems.

3.3 Historic Record

Major flooding has occurred on the Quinnipiac River in 1815, 1893, 1938, and 1955. The floods of 1815, 1893, and 1938 are recorded as 25-year floods. The flood of 1938 was a result of the devastating hurricane of September 1938. During the flood of 1938, the Quinnipiac River had a recorded estimated discharge of 6,500 cubic feet per second (cfs). The flood of 1955 is associated with back-to-back hurricanes Connie and Diane. This flood is listed as a 50-year flood.

According to the NOAA National Climactic Data Center, seven flash floods were recorded as occurring in New Haven between 1993 and 2004. Three of these were felt countywide. A flood event is recorded as occurring in January of 1999. One death occurred in New Haven County as a result of these flood events.

On April 16, 1996, six inches of rain fell in 18 hours. This was classified as a greater than 50-year frequency storm. The rainfall, coupled with antecedent moisture conditions from recent snowfall, elevated the water table and caused flooding conditions. Basement flooding and sewer-line backups precipitated numerous complaints from city residents. Within New Haven County, this flood event caused $1.5 million in property damage.

Three flash floods were recorded in New Haven between 2005 and 2010 (NOAA). Connecticut Light and Power reported that about 30,000 customers lost power across the state due to the September 2005 flood.

Two severe storms were also recorded in New Haven between 2005 and 2010; one was in May 2007 (rainwater and flooding) and the other was in April 2010 (rainwater). The 2007 storm caused flooding of properties along Union Street and Forbes Avenue. New Haven was partially reimbursed for the improvements made on these streets after the storm by FEMA. The remaining improvements will be made by CONNDOT's proposed I-95 Harbor Crossing Improvement Program and the City's proposed Waterfront street re-construction.

Flooding occurred on Quinnipiac Avenue due to the failure of a retaining wall, which collapsed due to a high tide during the 2010 storm. This was repaired by the owner of the property afterwards.

Fairfield, Middlesex, New London New Haven and Windham Counties were designated to receive individual assistance following the spring 2010 storm. This means that households were considered affected enough to warrant assistance from FEMA, but public facilities, roads, etc., were not considered affected enough to warrant FEMA assistance. Due to the occurrence of these severe storms, all of the counties within the State of Connecticut have also been made eligible to receive assistance under the Hazard Mitigation Grant Program. Eight properties in New Haven have applied to FEMA to avail this assistance after the spring 2010 storm. The most recent summer storm that occurred in July 2010 has also caused thirty properties in the city to apply for individual assistance (total value: $ 14,154 approximately; source: FEMA).

3.4 ***Existing Programs, Policies, and Mitigation Measures***

Several mitigation measures enable the city to prevent flood damage. These include regulations, codes, and ordinances, as well as some structural features to protect specific areas. The City also provides for drainage system maintenance.

Regulations, codes and ordinances that apply to flood hazard mitigation include:

- Flood Damage Prevention District (CGS, Sec. 7-148, Zoning Ordinance, Sec. 56).
- Interim Site Plan Review Guidelines (CGS Sec. 8-3(g), Zoning Ordinance, Section 64 (f)).
- Soil Erosion and Sedimentation Control Regulations (CGS, Sec. 8-2 and 8-25, Zoning Ordinance, Sec. 58).
- Coastal Site Plan Review as pertaining to the Coastal Management District (CGS, Sec. 22a-109, Zoning Ordinance, Sec. 55 (b) 3).
- Inland Wetlands Ordinance (CGS, Sec. 22a-42a, Zoning Ordinance, Sec. 57).

These ordinances require that a permit be issued for development in flood hazard areas. Specific provisions are made for flood hazard reduction, including rules that regulate construction material and methods, anchoring, location of service facilities, and design specifications for sanitary sewer and water supply systems. These ordinances require that all living space in residential structures be above established base flood elevations. These floodplain ordinances were recently revised by the City Plan staff and approved by the City Plan Commission on July 21, 2010. Accordingly, an amendment to the zoning ordinance was also made. The City will also revise the stormwater regulations of the zoning ordinance shortly.

Site plan standards require that all proposals be consistent with the need to minimize flood damage, that public facilities and utilities be located and constructed to minimize flood damage, and that adequate drainage is provided.

Structurally, the West River and the lower section of Wintergreen Brook have been channelized and the banks protected in the vicinity of Blake Street. This provides protection of the adjacent neighborhood, which is densely developed. Channelization has not been used extensively in other areas of the City.

The Department of Public Works regularly cleans and maintains city-owned culverts, catch basins, and other drainage facilities. The Department also maintains a detailed database of drainage and flooding complaints, and addresses problems as they arise.

Finally, City ordinances provide for an Office of Emergency Management in order to ensure that preparations of the City will be adequate to deal with disasters such as floods.

3.5 Vulnerabilities and Risk Assessment

This section discusses specific areas at risk to inland flooding within the City. Major land use classes are identified, as well as critical facilities.

According to the FEMA Flood Insurance Rate Maps, 11,547 acres of land in New Haven are located within the 100-year flood boundary. This acreage includes areas susceptible to both inland and coastal flooding.

Specific areas of frequent flooding were identified by the Director of Engineering. Many of these areas are included on the map "City of New Haven Flood Prone Areas" (September 1999), which was developed by the City Engineering Department, as depicted in Figure 2-4 in the previous chapter. Most of the identified areas were observed on January 14, 2005.

Within the areas susceptible to inland flooding, the West River tributary system, the area surrounding Hemingway Creek, and the areas along upper Middletown Avenue have high densities of residential populations. The City has had atleast two major flooding events since 2005, one in 2007 and the other in 2010. Flooding was a major problem observed during both these events. Specific areas are discussed in the following sections.

West River and Tributaries

The northern reach of the West River, where it enters the City from the Town of Woodbridge, is characterized by a mix of commercial and residential areas, with some residential areas located along the river. Specific land uses include stores and shops, a hotel, non-profit lands, an electric substation, and a hospital. The northern section of the West River is bordered by large sections of parks and open space. Between Whalley Avenue and Derby Avenue, the City's Edgewood Park encompasses both the 100-year and 500-year flood zones.

Wilmot Brook joins Farm Brook north of the Wilbur Cross Parkway. Belden Brook flows into Wintergreen Brook north of Brookside Avenue, passing east of Katherine Brennan School. Farm Brook flows into Wintergreen Brook south of Brookside Avenue. This area of the West River tributary system is primarily residential, although Wintergreen Brook runs through West Rock State Park.

Brookside Avenue near Wintergreen Brook is identified on the City of New Haven Flood Prone Areas Map, and is partly within the 100-year floodplain. During the recent field visit (2010), it was noted that the culvert/bridge for Wintergreen Brook at Brookside Avenue was at capacity, and that a wooded area upstream of the bridge was flooded. Nearby, where Wilmot Road passes over Wintergreen Brook, a culvert/bridge was at capacity, and a road was flooded. Problems also exist with upstream flooding because of the existence of wetlands and overgrowth in those wetlands.

Southern Connecticut State University's (SCSU) campus abuts the City's Beaver Pond Park, and extends westward to Farnham Avenue. The Beaver Ponds at Fournier Street have been identified by the City Director of Engineering as flood prone areas, due to partially enclosed basins and siltation issues. These ponds are within the 100-year floodplain, and are known to handle large amounts of stormwater. During the field visit (2010), the water levels in the ponds were observed to be several feet below the road. No major problems were observed during and after storm events.

A mixture of park and open space areas and residential units, including single family and apartment units, characterize the Beaver Brook area, which feeds into Wintergreen Brook from the east. The City's Police Academy is located on the west side of Sherman Parkway and the Martin Luther King Jr. School is located on the east side, both of which are partially within the 100-year flood zone. The confluence of Beaver Brook and Wintergreen Brook is characterized by medium/high density residential areas. Industrial buildings are situated to the east of the confluence.

South of West Rock Park, Wintergreen Brook and the West River pass beneath Blake Street and join. This is another area of flood concern identified by the Director of Engineering. Although this area is not identified on the map "City of New Haven Flood Prone Areas," it is within the 100-year floodplain. The downstream section of Wintergreen Brook is channelized, and no flooding was observed during the field visit. Upstream of Blake Street, Wintergreen Brook meanders around a number of homes and yards. No flooding was observed during field visit, but it was noted that some of the housing elevations were such that they could be at risk during moderate intensity storms.

Since the adoption of HMP 2005, the City's Engineering Department continued to work with the Town of Hamden to keep debris out of Wintergreen Brook, Belden Brook, and Wilmot Brook before they flow into New Haven, where box culverts can become clogged. The developers in West Rock neighborhood were also mandated to clean up debris until the Hamden town line. In addition, the West Rock-Brookside development proposes detention basins that control the rate of run-off to the receiving stream, which in turn minimizes the downstream flooding occurrences. In the recent past, developers in Westville (between Blake Street and Whalley Avenue) were required to improve the maintenance requirements suggested by the Engineers in order to ensure that the flood events are controlled.

Two bridges were replaced for the Blake Street project. The West River Bridge was replaced with a single span in 2001 in order to eliminate the supporting pier that had been damaged due to scouring action. In addition, the bridge over Wintergreen Brook had its structure rebuilt (abutment replaced) and the channel beneath cleared.

The recently completed Wintergreen residential development included the installation of new portable and permanent pumps on-site in order to properly drain the site since it is at a lower elevation than the abutting West River flood wall.

South of Blake Street, Edgewood Park and the West River Memorial Park dominate the river floodplain and thus act as protective buffers. The large West River Memorial Park, part of which is within the boundaries of the City of West Haven, lies between Orange Avenue and Derby Avenue, and within both the 100-year and 500-year flood zones. To the east of Route 10, the Evergreen Cemetery lies within the flood zone. The majority of the above area is characterized by residential and park spaces. The parks provide a relative measure of protection from flooding for the surrounding residential areas.

The parcel between Valley Street and Whalley Avenue was recommended for acquisition by the City within the natural resource protection section of the previous HMP (2005). In the recent past, this property was upgraded as part of the Early Learning Center (495 Blake Street) improvements. The river flow on this parcel has been channelized and cleared of debris and vegetation to improve the flow.

In 1919, tide gates were installed 1.1 miles upstream from the confluence of the West River with New Haven Harbor and Long Island Sound. During flood tide, the tide gates close due to the force of advancing water. As the tide ebbs, the tide gates open and seaward flow resumes. Tide gates were originally installed with the intention of enhancing public safety, partially through reducing tidal flooding in the West River. These tide gates have substantially decreased the tidally influenced zone of the West River, creating an area dominated by dense stands of common reed (*Phragmites australis*). These phragmites were eradicated by the Department of Parks between 2002 and 2004.

In an effort to restore ecological diversity to the salt marsh areas of the West River, studies have been and are currently being undertaken to determine the effect of opening the tide gates on the upstream advancement of salt water. As a result manually operated sluice gates have been installed on one of the tide gates to allow for tidal flushing upstream of the Orange Avenue bridge in 2004.

In July 2009, the National Oceanic and Atmospheric Administration (NOAA) awarded 1.5 million through their Marine Habitat Restoration Grants (portion of the Federal Stimulus package) to the West River tidal gate replacement in New Haven and the Bride Brook culvert replacement at Rocky Neck State Park in East Lyme. Connecticut Fund for the Environment and Save the Sound are managing this project. The plan is to replace three of the existing flapper tide gates with self-regulating tide gates (SRT). The new gates will allow more consistent tidal flow (in both directions) into the West River north of the gate, thus improving water quality, fish passage, marsh habitat, and opportunities for recreational use. This project is currently underway.

A feasibility study of various methods to increase storage capacity at Beaver Ponds, which allows the impoundment to hold more sediment from stormwater runoff and more water during heavy runoff events, has been conducted after HMP 2005 was adopted. A study has been conducted in the recent past to prevent floatables from storm system going into the pond. This study recommended hoods and a large separation chamber to capture the floatables. Due to limited funding, this could not be implemented yet.

Due to flooding problems the Town of Woodbridge has requested that the New Haven Land Trust remove the Pond Lily dam. A study is being currently undertaken to identify if the dam is actual cause of flooding.

South of Orange Avenue, the nature of the land use within the flood zone changes dramatically to predominantly commercial and industrial. The area west of Ella T. Grasso Boulevard includes assorted small commercial and industrial uses, a flea market, and New Haven Plaza, which houses several education and social services agencies. The east side of Ella T. Grasso is predominantly composed of commercial and industrial uses as well as the Ernest McClain City Park. The St. Bernard Cemetery lies below Orange Avenue. Just north of the bridge where the Metro-North railroad crosses the West River, the area between the West River and Ella T. Grasso Boulevard is industrial, consisting of several recycling facilities/scrap yards.

The area northeast of the Kimberly Avenue Bridge over the West River is dominated by space-intensive highway ramps. Between the ramps and City Point, Connecticut DOT has a maintenance depot. The City's Fire Fighting Academy is located between Ella T. Grasso Boulevard and the West River. Areas closer to New Haven Harbor are prone to Coastal Flooding events rather than Inland Flooding events, and are addressed in Section 4.0.

Mill River

Several large manufacturers are located in the Mill River area. These include several, vacant brownfield properties. The area also has active freight rail and highway connections. However, for the most part, the banks of the Mill River north of the railroad bridge are dominated by East Rock Park from the Hamden town line to Interstate 91. As a result, few properties in this area are vulnerable to inland flooding along the Mill River.

Tide gates are located on the Mill River just upstream of the I-91 overpass. The tide gates are currently functioning. However, the City Engineer notes that monitoring is needed related to the amount of water coming from Lake Whitney.

Quinnipiac River Estuary

Quinnipiac Meadows is in part identified as an environmentally sensitive area that is characterized by railroads and Interstate 91. On the west side of Interstate 91, the rail yards are home to Amtrak garage facilities, storage, and lay-down areas. Conversely, the Meadows area (in New Haven, Hamden, and North Haven) has become a focal point for both ecological restoration and economic development.

Specific areas that are prone to flooding and cause problems within the City were identified by the City Engineer during the storm on January 14, 2005 and also in the most recent flash floods in 2007 and 2010. As a result, three general areas were considered to be vulnerable to frequent flooding in the previous HMP. This problem of flooding continues to persist within these areas even today whenever a storm occurs. Due to budget constraints, no mitigation measures were adopted to mitigate this issue within the past five years. City efforts in the recent past (after 2005), led to a portion of industrial, vacant land transferred to the New Haven Land Trust.

Upper Middletown Avenue

Minor street flooding was observed in the area of Cranston and Weybosset Streets. This area is identified on the map "City of New Haven Flood Prone Areas," and is partly within the 100-year floodplain with a base elevation equal to the coastal inundation. This area is primarily residential, containing single family homes. Streams do not appear to contribute to flooding; rather, flooding appears to be due to topography and drainage problems. Streets are not curbed, and puddles extend into residential yards. One catch basin appeared to be overwhelmed and partly clogged. This area drains to a large wetland west of Interstate 91. The culvert under Middletown Avenue has a low gradient. Sand easily clogs the drainage system and water does not flow out of the system during exceptionally high tides. This was identified as an issue within HMP 2005 and continues to exist even today. Since the problem is associated with varying topographical elevations, no drastic improvements could be made. The only practical solution is to clean the culverts on a regular basis, which was done within the past five years whenever needed. If funding is in place, this street should be elevated to completely mitigate flooding issue here.

Lower Middletown Avenue

This area is depicted on the map "City of New Haven Flood Prone Areas," and is within the 100-year floodplain with a base elevation equal to the coastal inundation. This area is characterized primarily by industrial warehouses. Streams do not contribute to flooding in this area, which instead appears to be caused by topography and drainage problems. Streets are not curbed in some areas, such that puddles extend into yards. One catch basin in this area appeared to be overwhelmed and partly clogged. This area floods during every heavy rainfall. The drainage ditches in this area are at tide level, and at high tide insufficient head is available for drainage. This was also identified as an issue within HMP 2005. Due to the railroad overpasses that exist at this location, there is no room to make any further improvements here. The possible solution to resolve this issue is to have a drainage system with a control outlet that is connected to an automatic pumping station. Due to lack of funding, no such measure could be adopted in the past five years.

Hemingway Creek

The areas between Quinnipiac Avenue and Hemingway Street near Hemingway Creek are identified on the map "City of New Haven Flood Prone Areas" and they are within the 100-year flood plain with a base elevation equal to the coastal inundation. This was also identified as an issue within HMP 2005 and continues to exist even today. This area is characterized by low and medium density housing, including single family homes, condos, and two- and three-family homes. Street flooding was observed on Quinnipiac Avenue on June 11,2010 post a storm that occurred on June 8, 2010, especially beneath and near the railroad overpass where the street is at a low elevation in relation to the surrounding areas. The previous Plan (HMP 2005) also noted that minor street flooding was observed on Quinnipiac Avenue on January 14, 2005 especially beneath and near the railroad overpass where the street is at a low elevation in relation to the surrounding areas. The culvert for Hemingway Creek was at or over capacity at Quinnipiac Avenue, and only two feet below the road elevation. The upstream side of the culvert was clogged with trash and debris, and the water was brown with silt and sand. The proximity to base level (sea level) and drainage problems appear to cause the flooding in this area.

The culvert for Hemingway Creek was similarly at or over capacity at Hemingway Street, such that the top of the culvert was below the water surface and again only two feet below the road

elevation. The upstream side of the culvert was minimally clogged with trash and debris, and the water was brown with silt and sand.

These problems stem from the fact that the culverts and bridges at the roads in this area are too low, and the sewer crossings in the wetland may be damming the brook, which needs to be cleaned. The wetland in this area acts like a retention basin. Development in the area, including vacant properties and new housing units, are putting greater pressure on the drainage capacity of the watershed. The Hemingway Creek watershed is depicted in Figure 3-2 on the following page.

Nearby, a stream exits from a culvert beneath Hemingway Street. The upstream side of this channel could not be located. The stream does not appear to have a natural channel, and it may only flow during storms. A resident constructed a temporary concrete block wall to keep the water from flooding his/her yard. This stream flows into Hemingway Brook. Even slight increases in water elevation in this area would flood at least two residential homes. The brook at the culvert crossing has been silted in.

The City periodically removes the silt to enhance the flow of the brook thus avoiding flooding in the area. However, this is a vicious cycle. Even though the culvert is cleaned periodically, whenever there is a storm, trash and debris get collected into the brook and thus clog the culverts once again. One possible solution to completely mitigate this issue is by elevating the Hemmingway Street. Due to lack of funding, this measure could not be adopted in the past five years. The City dredged the lower portion of Hemmingway Creek quite recently to help improve the flow.

Figure 3-2 Hemingway Creek Watershed Boundary

Other Areas

Each of the following areas are identified in Figure 2-4 in the previous chapter.

Fair Haven

Minor street flooding occurs on the western shore of the Quinnipiac River estuary along Front Street in Fair Haven, minor street flooding was observed. This area is identified on the map "City of New Haven Flood Prone Areas," and is partly within the 100-year floodplain with a base elevation equal to the coastal inundation. Land use in this area is mixed, and includes the Quinnipiac River Park, stores, warehouses, a yacht club, and some single- and two-family residential areas. Topography and drainage problems appeared to have caused flooding in the past (HMP 2005). However, after the recent installation of new storm drainage structures in this area, no major issues of flooding were observed. The Engineering Department also put in outlets with duckbill valves. The City also obtained DEP permit for shoreline stabilization along Front Street for Dover Beach Park. In the recent past (after 2005), 315 linear feet of missing and dilapidated retaining wall that defined the edge of Front Street Park from the Quinnipiac River was replaced.

The River Street area in Fair Haven is identified on the map "City of New Haven Flood Prone Areas" and is within the 100-year floodplain. The implementation work for the River Street Municipal Development Plan (MDP) parcels began after 2005 and this has mostly improved drainage in the area, except for the area at the end of Poplar Street. This area could not be improved because of contaminated soil and cannot be effectively removed without considerable financial resources. The City is currently pursuing DEP permit for shoreline stabilization at River Street.

As part of the Long Term Combined Sewer Operation (CSO) plan, the area around the Quinnipiac Terrace has also been separated in the recent past (after 2005).

Stiles Street and Port of New Haven

This area is identified on the map "City of New Haven Flood Prone Areas" and is partly within the 100-year floodplain with a base elevation equal to the coastal inundation. Topography and drainage problems cause flooding, and residents have reported frequent inconveniences due to street flooding. The previous HMP (2005) also notes this as a flooding issue for this area.

The Strategic Land Use Plan of the City's Port Authority (2007) indicates that a new drainage system is planned for this area. It will supplement Connecticut Department of Transportation's (DOT) I-95 improvement project's drainage improvements currently planned. (Port of New Haven Strategic Land Use Plan, May 2007; pg. 24-25). Design of the drainage system has already been finalized. The implementation of this design is pending as the City is awaiting funding assistance from the State. Drainage problems were somewhat ameliorated after the on-ramp to I-95 from Stiles Street has been removed in the recent past. However, the old off ramp is still in place, which used to pose problems at its Water Street terminus during severe storms. Currently, this is not in use and would be eventually demolished.

Fort Hale Park and Adjacent Areas

The area near Fort Hale Park within the 100-year floodplain with a base elevation equal to the coastal inundation. In the previous plan (HMP 2005), this was not identified as a flood prone area of the city; however, it was noted as a potential flooding area. Land use in this area consists of the park surrounded by residential areas. The park abuts Coast Guard property. Minor street flooding was observed in this area. North of a small apartment complex, a small wooded area floods and drains into a culvert on the east side of the road in front of the Coast Guard property. Southwest of the small apartment complex, large lawn and wooded areas flooded.

Across Fort Hale Park Road, at the entrance to the park, a stream exits a culvert and flows into the fenced Coast Guard property. The parking lot of the park floods and flows into the stream. The stream has a flat gradient and often overflows. The Coast Guard property was previously a Navy Reserve Center. The City Engineer had conversations with the staff of the Navy Reserve Center in the past regarding the issue of flooding on the street but no action could be pursued due to financial constraints.

A detailed engineering study of the Fort Hale area was conducted in 2004, with a report issued on December 21, 2004. It concentrated on factors contributing to flooding of a channel located on the south side of the park and revealed that only one of two drainage or "splitter" structures handles runoff from the upgradient neighborhood. This indicates that installation of the missing structure would alleviate some of the flooding that occurs in and near the park. A copy of the report is included as Appendix C. In the recent past (after 2005), the City's Engineering Department installed this missing structure within the park.

Flooding of Railroad Tracks near Union Station

The Union Station rail yard is at low elevation due to which the tracks get flooded periodically. The State of Connecticut Department of Transportation maintains the infrastructure in this area. In order to overcome the problem of flooding in this area, a stormwater pumping system was installed by the State in the recent past (after 2005).

3.6 Potential Mitigation Measures, Strategies, and Alternatives

A number of measures can be taken to reduce the impact of an inland 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*.

3.6.1 Prevention

Prevention of damage from flood losses often takes the form of floodplain regulations and redevelopment policies. These are usually administered by building, zoning, planning, and/or code enforcement offices through capital improvement programs and through zoning and subdivision ordinances. While most of these listed below are the same as those outlined in the previous HMP (2005), some were already adopted within the past five years (as noted in the

previous section) and hence removed from this list. Changes have also been made to some preventive measures listed in 2005 to more closely apply to the current conditions and included in the list below.

Coordination among various departments responsible for different aspects of flood mitigation, including the Livable City Initiative (Building Division and Code Enforcement), the Board of Zoning and Appeals, Parks and Recreation, Economic Development, Planning, Public Works, Engineering, Fire and Police, and Emergency Management is also very important in implementing these measures. Coordination and cooperation should be reviewed every few years as specific responsibilities and staff changes.

The City Plan Department, with community input, should identify land that could be acquired and provide necessary easements. Acquisition of heavily damaged structures after a flood may be an economical and practical means to accomplish this. Policies could also include the design and location of utilities in areas outside of flood hazard areas, and the placement of utilities underground.

The following general guidelines are preventive tools that municipalities may have available:

- Planning and Zoning: Zoning ordinances should regulate development in flood hazard areas. Flood hazard areas should reflect a balance of development and natural areas.

- 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 drainage ways; and
    - A requirement that developers dedicate park land and flood flow, drainage, and maintenance easements.

    Building codes should ensure that the foundation of structures will withstand flood forces and that all portions of the building subject to damage are above or otherwise protected from flooding.

- Floodplain ordinances should at minimum follow the requirements of the National Flood Insurance Program for subdivision and building codes. These could be included in the ordinances for zoning and building codes, or could be addressed in a separate ordinance. The City Plan Department recently revised its flood plain ordinances, which were approved by the City Plan Commission on July 21, 2010. Accordingly, the zoning ordinance was also amended and adoption by the Board of Aldermen on October 4, 2010.

- Stormwater Management Policies: Development and redevelopment policies to address the prevention of flood losses should 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 pre-development 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 during the peak discharge during any given storm event. Due to its coastal proximity, the City of New Haven includes the lower portions of its major watersheds. Developers should be required to demonstrate whether detention or retention will be the best management practice for stormwater at specific sites.

- Drainage System Maintenance: An effective drainage system should 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, and repaired and improved when necessary. A development in GIS capability in the Engineering Department would greatly aid this effort.

- Education and Awareness: Other prevention techniques include the promotion of awareness of natural hazards among citizens, property owners, developers, and local officials. 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.

Based on the above guidelines, the following *preventive* mitigation measures specific to problem areas within the City are recommended.

Flooding of Quinnipiac River Estuary

- Re-zone land or provide for conservation easement in the Quinnipiac River estuary to better protect land from inappropriate development.
- Conduct monthly inspections of the storm drain catch basins along Weybosset Street in the vicinity of Cranston Street and Westminster Street.
- Conduct semi-annual inspections of the Cranston Brook culverts.
- Encourage CT DOT to increase inspections and cleanouts of culverts under I-91 and its interchanges in the vicinity of Little River and Cranston Brook, as they can back up water into residential areas.
- Conduct monthly inspections of the storm drain catch basins along Middletown Avenue between the Quinnipiac River and Foxon Boulevard.

Flooding of Hemingway Creek

- Request notification of development proposals in the East Haven portion of the Hemingway Creek watershed in order to monitor and provide comments on proposals that will increase runoff.
- Conduct monthly debris removal from Hemingway Creek in the spring, summer, and fall in order to facilitate drainage of the watercourse.

- Dredge the lower portion of Hemingway Creek in order to accommodate flood waters.

Flooding of West River and Tributaries

- During the redevelopment of the West Rock neighborhood, require developers to demonstrate whether detention or retention will achieve optimum results for stormwater control, in order to avoid adding to peak flows of Wintergreen Brook, Belden Brook, and Wilmot Brook.
- Conduct monthly inspections of the storm drain catch basins along Wilmot and Wintergreen Roads.
- During any development in the Westville neighborhood, require developers to demonstrate whether detention or retention will achieve optimum results for stormwater control, in order to avoid adding to peak flows of West River.
- Utilize riprap to shore up the riverbanks in the vicinity of the fire training school.

3.6.2 Property Protection

The following property protection measures were listed in HMP 2005 and remain the same for the current update as well:

Steps should be taken to protect existing properties, both public, and private where appropriate. Non-structural measures for public property protection include acquisition and relocation of properties at risk. The New Haven Land Trust should be entrusted with the responsibility of acquiring and relocating properties at risk.

Private property owners should be encouraged to purchase flood insurance. In addition, relocating valuable belongings above flood levels can reduce the amount of damage caused to individuals during a flood event.

Non-structural flood protection techniques applicable to structures include the construction of barriers, dry floodproofing, and wet floodproofing techniques. Barriers include levees, floodwalls, and berms, and are useful in areas subject to shallow flooding.

Dry floodproofing refers to the act of making areas below the flood level water-tight. 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 only be two to three feet above the top of the foundation because building walls and floors cannot withstand the pressure of deeper water.

Wet floodproofing should only be used as a last resort. Wet floodproofing refers to intentionally letting floodwater into a building to minimize pressures. Valuable furniture and electrical appliances should be moved away from advancing floodwaters.

3.6.3 Emergency Services

A 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 inland 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; and
- emergency protective measures, such as evacuation and emergency flood-water control.

Currently, the City's Office of Emergency Management has adopted a reverse notification system for residents called the reverse 911 system. With this facility, a telephone message about an impending emergency can be sent to the residents of the entire city or only to those residents in affected areas.

Specific recommendations for emergency services in New Haven include:

Flooding of Quinnipiac River Estuary

- Post notification and place barricades along Middletown Avenue and Foxon Boulevard to avoid using the road during flood events combined with coastal storms or very high tides.

Flooding in Stiles Street Area

- Post notification and place barricades along Forbes Avenue to avoid using the road during flood events combined with coastal storms or very high tides.

Flooding of West River and Tributaries

- Improve access to and from the West Rock neighborhood through Hamden so that residents do not need to evacuate using streets that could be flooded.
- Post notification and place barricades along Springside Avenue to avoid using the road during flood events.

3.6.4 Public Education and Awareness

The 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. The nature of flood risk includes flood levels, associated hazards, and impacts in a specific area.

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 be told what to expect when a hazard event occurs, and the procedures and time frames necessary for evacuation.

The following specific public education and awareness measures are suggested:

Flooding of West River and Tributaries

- Provide educational materials to residents living in the floodplain of Wintergreen Brook along Springside Avenue.

The floodplain maps for the entire city are available for public review at the City Plan Department currently.

3.6.5 Natural Resource Protection

Retaining the natural resources and functions of floodplains can not only reduce the frequency and consequences of flooding, but also minimize stormwater management and nonpoint pollution problems. Through natural resource planning, these objectives can be achieved at substantially reduced overall costs. Floodplains provide a number of natural resources and benefits, including storage of flood waters, open space and recreation, water quality protection, erosion control, and preservation of natural habitats.

Measures for preserving floodplain resources and functions include:

- adoption of floodplain regulations to control or prohibit development that will significantly alter natural resources;
- development and redevelopment policies focused on resource protection;
- information and education for both community and individual decision-makers; and
- review of community programs to identify opportunities for floodplain preservation.

The City Plan Commission recently adopted revised floodplain ordinances for the city and amendments to the zoning ordinance were also made accordingly (See Appendix D).

Measures for restoring diminished or destroyed resources and functions provide for re-establishment of an environment in which these functions can again operate. Measures that involve improving the natural condition of areas or restoring them to their previous natural state include:

- development of land reuse policies focused on resource restoration;
- gathering of information and development of education programs relative to needs and processes; and
- review of community programs to identify opportunities for floodplain restoration.

3.6.6 Structural Projects

Structural projects include the construction of new structures or modification of existing structures to lessen the impact of a flood event. Stormwater controls such as drainage systems, detention dams and reservoirs, and culverts should be employed to lessen floodwater runoff. On-site detention can provide temporary storage of stormwater runoff. Levees, floodwalls, and dikes physically control the hazard 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 this technique to ensure that problems are not exacerbated in other areas of the watershed.

Individuals can protect property by raising structures, and constructing walls and levees around structures. Structures can be modified to keep out stormwater.

Based on the above guidelines, the following specific *structural* mitigation measures are recommended. Some of these guidelines were recommended in HMP 2005 but could not be

implemented due to financial constraints. Therefore, they remain the same for the current update as well and should be pursued for adoption as and when funding becomes available.

Flooding of Quinnipiac River Estuary

- Commission an engineering study to evaluate the feasibility of installing a pumping system and/or tide gate system for the length of Middletown Avenue between the Quinnipiac River and Foxon Boulevard. The study should consider the effects of a rising base level due to sea level change.

Flooding of Hemingway Creek

- Raise the elevation of Eastern Street where it crosses the Hemingway Creek floodplain and replace the bridge. Plan for sea-level change while doing so, as the creek is already at base level where it passes beneath the road.
- Raise the elevation of Quinnipiac Avenue where it crosses the Hemingway Creek floodplain and replace the bridge. Plan for sea-level change while doing so, as the creek is already at base level where it passes beneath the road.

Flooding of West River and Tributaries

- Consider cleaning the culvert on Brookside Avenue, Wilmot Road, and Wintergreen Avenue and perform close inspection of the bridge with repairs where necessary to improve the flow characteristics.

Flooding in Stiles Street Area

- Ensure that drainage is improved as part of the Interstate 95 improvement program and Waterfront Street re-construction. As mentioned in the previous section, the design of the new drainage system proposed at the Stiles Street area has been finalized. City is awaiting funding assistance from the State to implement this design.

3.7 Recommended 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. The method, called STAPLEE, stands for the "Social, Technical, Administrative, Political, Legal, Economic and Environmental" criteria for making planning decisions. The following questions were asked about the proposed mitigation strategies:

- **Social**: Is the proposed strategy socially acceptable to the community? Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- **Technical**: Will the proposed strategy work? Will it create more problems than it will solve?
- **Administrative**: Can the community implement the strategy? Is there someone to coordinate and lead the effort?
- **Political**: Is the strategy politically acceptable? Is there public support both to implement and maintain the project?

- **Legal**: Is the community authorized to implement the proposed strategy? Is there a clear legal basis or precedent for this activity?
- **Economic**: What are the costs and benefits of this strategy? Does the cost seem reasonable for the size of the problem and the likely benefits?
- **Environmental**: How will the strategy impact the environment? Will the strategy need environmental regulatory approvals?

Each proposed mitigation strategy was evaluated and assigned a score (Good = 3, Average = 2, Poor = 1) based on the above criteria. An evaluation matrix with the total scores from each strategy was provided in HMP 2005 and can be found in Appendix D. Each strategy proposed in this update was re-evaluated using the STAPLEE method and prioritized according to the final score. The highest scoring was determined to be of more importance, economically, socially, environmentally and politically and, hence, prioritized over those with lower scoring.

The proposed mitigation strategies for addressing inland flooding are listed below, in order from highest ranking to lowest ranking based on the STAPLEE methodology.

Flooding of Quinnipiac River Estuary

1. Conduct semi-annual inspections of the Cranston Brook culverts.
2. Conserve available land in the mapped floodplain of the Quinnipiac River estuary, and available land that is up to three feet higher in elevation, to allow for landward advancement of the marshes. Allocate money for acquisition.
3. Conduct monthly inspections of the storm drain catch basins along Middletown Avenue between the Quinnipiac River and Foxon Boulevard.
4. Encourage CT DOT to increase inspections and cleanouts of culverts under I-91 and its interchanges in the vicinity of Little River and Cranston Brook, as they can back up water into residential areas.
5. Re-zone land in the Quinnipiac River estuary to protect land from inappropriate development.
6. Post notification and place barricades along Middletown Avenue and Foxon Boulevard to avoid using the road during flood events.
7. Commission an engineering study to evaluate the feasibility of installing a pumping system and/or tide gate system for the length of Middletown Avenue between the Quinnipiac River and Foxon Boulevard. The study must consider the effects of a rising base level due to sea level change.

Flooding of Hemingway Creek

1. Plan for sea-level change at Quinnipiac Avenue and Eastern Street as the Hemingway Creek is already at base level where it passes beneath the road. Presently, the City's Engineering Department is cleaning the culverts at Quinnipiac Avenue and Eastern Street to increase the flow capacity.
2. Conduct monthly debris removal from Hemingway Creek in the spring, summer, and fall.
3. Request notification of development proposals in the East Haven portion of the Hemingway Creek watershed.
4. Raise the elevation of Eastern Street where it crosses the Hemingway Creek floodplain and replace the bridge. Plan for sea-level change while doing so, as the creek is already at base level where it passes beneath the road.

Flooding of West River and Tributaries

1. During any development in the Westville neighborhood, require developers to demonstrate whether detention or retention will achieve optimum results for stormwater control, in order to avoid adding to peak flows of West River.
2. Consider acquiring remaining undeveloped parcels in the upper watershed of West River as open space in order to reduce potential increases in peak flows, including a parcel between Valley Street and Whalley Avenue.
3. Provide educational materials to residents living in the floodplain Wintergreen Brook along Springside Avenue.
4. Utilize riprap to shore up the riverbanks in the vicinity of the fire training school.
5. Post notification and place barricades along Springside Avenue to avoid using the road during flood events.

Flooding of West Rock Neighborhood

1. During the redevelopment of the West Rock neighborhood, require developers to demonstrate whether detention or retention will achieve optimum results for stormwater control, in order to avoid adding to peak flows of Wintergreen Brook, Belden Brook, and Wilmot Brook.
2. Consider cleaning the culvert on Brookside Avenue, Wilmot Road, and Wintergreen Avenue and perform close inspection of the bridge with repairs where necessary to improve the flow characteristics.
3. Conduct monthly inspections of the storm drain catch basins along Wilmot and Wintergreen Roads.
4. Encourage Town of Hamden to clear debris from tributaries.
5. Improve access to and from neighborhood through Hamden.

Flooding in Fort Hale Park and Adjacent Neighborhood

1. Continue the evaluation of drainage into and through the Fort Hale Park area.
2. Consider ways to preserve the Fort along with improving the quality of water in this area.
3. If the study reveals that the drainage system splitter should be completed as planned, install the splitter line to reduce peak discharges through the park.
4. Conduct monthly inspections of the storm drain catch basins along Woodward Avenue in the vicinity of the park and the Coast Guard facility to avoid street flooding.
5. Evaluate critically the feasibility of new residential development in this area and understand the potential flooding impacts associated with such development.

Flooding of Stiles Street Area

1. Post notification on I-95 so that vehicles will not use the Stiles Street off-ramp exit when the area is flooded.
2. Distribute information about safe evacuation to the small residential neighborhood north of I-95 at the Stiles Street off-ramp from I-95 (Exit 50).
3. Ensure that drainage is improved as part of the Interstate 95 improvement program.
4. Post notification and place barricades along Forbes Avenue to avoid using the road during flood events combined with coastal storms or very high tides.

4.0 COASTAL FLOODING

4.1 Setting

Coastal flooding is a well-documented natural hazard that threatens the City of New Haven. Along with inland flooding, it is the most common naturally occurring event that disrupts quality of life for many residents. It affects much of the shoreline in the City, with regular occurrence of at least minor flooding in some areas.

As a shoreline community, New Haven is home to many coastal resources. Tidal wetlands and salt marshes are among the City's most significant environmental assets and integral components of coastal ecology. Tidal wetlands provide nutrients and habitats for shellfish and coastal organisms, and are popular nesting and feeding spots for shorebirds. Much of New Haven's tidal areas were filled in over the last century. In non-filled areas, tide gates have dried much of the remaining salt marsh. Natural tidal areas are still found at Vietnam Veterans Memorial Long Wharf Park ("Long Wharf Park") and along the East Shore. Along the Quinnipiac River, large salt marshes are located from the North Haven town line to the east side.

The lower Mill River and Quinnipiac River areas are the center of the City's aquaculture industry. New Haven harbor is home to high quality and quantity oyster beds and is a central contributor to Connecticut's premier status in the industry. The $62 million Connecticut oyster industry represents 94% of all production in the Northeast. Dockside facilities are located on the rivers.

The *Comprehensive Plan of Development* recognizes eight distinct coastal land areas based on geographic setting. These areas are: West River, City Point, Long Wharf, Canal and Belle Dock, Fair Haven, Quinnipiac Meadows, Port District, and East Shore. These were originally described in HMP 2005 and once again discussed below:

West River

Commercial and industrial uses characterize the southern section of the West River corridor. Future development in this area, according to the *Comprehensive Plan of Development*, will focus on a more compatible mix of retail, commercial, and light industrial uses. Scrap and metal processing and the current outdoor market have been identified as inappropriate uses of the waterfront. While the previous HMP (2005) indicates that the City plans to acquire dedicated riverfront open space, this could not be acquired due to financial constraints. Therefore, the New Haven Land Trust is recommended as the responsible authority for acquiring this land.

City Point

City Point is emerging as one of the City's premier waterfront residential neighborhoods. The mix of land uses is conducive to its coastal environment. Commercial uses, including a marina, a waterfront restaurant, and the Sound School, all relate to the harbor. According to the *Comprehensive Plan of Development*, emphasis for future development focuses on a neighborhood scale waterfront, accomplished by improving access at Howard Avenue and protecting the region from industrial and transportation intensive land uses.

Long Wharf

Long Wharf is the most visible of the City's coastal areas. Along the east side of the highway, all of the land is publicly controlled and/or dedicated open space. Here, the at-grade portion of Interstate 95 and Long Wharf Park provides unparalleled views of the Harbor and the East Shore.

Long Wharf is a sensitive environmental area at risk from coastal erosion. Long Wharf Park is used for occasional waterfront festivals and celebrations, but is generally underused for such a significant public space.

Canal and Belle Dock

Canal Dock is located at the terminus of Canal Dock Road and Long Wharf Drive, between the park and the Maritime Center. According to the *Comprehensive Plan of Development*, the strategy for future development in this area focuses on creation of a critical mass of activity, including a substantial base of residential, commercial, and maritime related activity.

Fair Haven and Mill River

The Fair Haven neighborhood is framed by the lower sections of the Mill River and the Quinnipiac River. Quinnipiac River Park, which was formerly a scrap yard, supports a large, mainly residential neighborhood at Front Street. Along River Street and John Murphy Drive, the Fair Haven waterfront remains a viable commercial/industrial district. Future developments in this area include a linear park extending from Grand Avenue along the Quinnipiac River to James Street along the Mill River. North of Ferry Street, efforts to reinforce and expand the residential community are encouraged.

Quinnipiac Meadows

The Quinnipiac Meadows is an environmentally sensitive area that is heavily impacted by the Northeast Corridor and Interstate 91. The Meadows area is a focal point for ecological restoration and economic development. Although reduced in size, meadows and tidal marsh areas are regaining habitat. North and west of Interstate 91, the focus for future development is on job-creating uses relating to the industrial zoning. Development north of the landfill and/or behind the Route 80 commercial area should be outside of the tidal wetlands. In the recent past (after 2005), a portion of vacant, industrial land in the Quinnipiac Meadows has been transferred to the New Haven Land Trust as part of conservation efforts by the City.

Port District

The Port of New Haven is located on the eastern side of the harbor, generally south of Ferry Street and north of East Shore Park. New Haven Harbor has a long association with waterborne freight transportation, currently connected to the interstate highway system in and around Stiles Street.

New Haven is among the largest ports in the Northeast, handling approximately 9,000 short tons annually. About half of this freight is liquid petrochemical product. In recent years, port terminals have handled a wide diversity of product that is more reflective of the global economy. Port terminals now handle large amounts of steel, aggregate products, lumber, and manufactured goods. The New Haven Port Authority, totaling 366 acres, represents the core port district.

The *Comprehensive Plan of Development* calls for enhancements to the Port District. These improvements include re-establishment of the Waterfront Street Railroad, acquisition of vacant property and stewardship by the Port Authority to advance more efficient land use within the district, and improvement of port aesthetics.

East Shore and Morris Cove

The East Shore, including Morris Cove and Lighthouse Park, is among the City's most desirable residential neighborhoods. East Shore is distinctive both for the quality of the housing stock and for its relationship with the waterfront. The neighborhood's identity is well defined by Pardee Seawall Park along Morris Cove. New Haven's largest public beach, its only carousel, and the historic lighthouse are all located at Lighthouse Point Park.

Plans laid out in the *Comprehensive Plan of Development* call for exceptional stewardship of waterside resources, zoning to prevent incompatible new development, and code enforcement to ensure the long-term viability of the neighborhood. Capital improvements are slated for Lighthouse Park.

4.2 Hazard Assessment

Refer to Figure 3-1 for the areas of New Haven susceptible to coastal flooding based on FEMA flood zones. These flood zones are subject to change with the new FIRMs releasing later this year, as described in Section 2.8. The flood zones are generally based on the 100- and 500-year flood events. As explained in Section 3.0, a 100-year flood event has a 1% chance of occurring in any given year. A 500-year flood has a 0.2% chance of occurring in any given year. Unlike inland flooding, coastal flooding is typically due to hurricanes, nor'easters, or other events that are discussed in subsequent sections of this plan.

In addition, smaller magnitude flood events occur on a more frequent basis. For example, coastal areas and low-lying areas proximal to waters under tidal influence may be susceptible to frequent flooding.

4.3 Historic Record

Most flooding in New Haven is caused by coastal storms that move up the Atlantic Coast with heavy rainfall, according to the FEMA Flood Insurance Study (FIS). This includes tropical hurricanes, which are frequently accompanied by low pressures and strong winds that cause tidal flooding along the shorefront that extends into the tidal and estuarine stream systems.

The FEMA FIS identifies the coastal storm events that had the most effect on New Haven as occurring in 1815, 1938, 1944, 1954, 1955, and 1960. The major unnamed hurricane of September 21, 1938, was estimated to cause 600 deaths in New England. Another unnamed hurricane hit the Connecticut coast in September 1944, and Hurricane Carol struck the Connecticut coast in August of 1954. In the following year, 1955, back-to-back hurricanes Connie and Diane caused torrential rains in Connecticut, with up to 12 inches of rainfall in areas from Connie and an additional 10 to 20 inches of rain in areas.

More recently, flooding and winds associated with hurricanes and storm events have caused extensive shoreline erosion and related damage. In 1985, Connecticut was impacted by

Hurricanes Bob and Gloria, with Gloria directly hitting the New Haven coastline. Tropical and extra tropical storms have produced periods of locally heavy rainfall. 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. Hurricanes are addressed again in Section 5.0.

4.4 Existing Programs, Policies, and Mitigation Measures

The City of New Haven has in place a number of measures to prevent flood damage. These include regulations, codes, and ordinances. These were presented in Section 3.4 in the context of inland flooding.

The City provides for drainage system maintenance, and also maintains structural features to protect specific areas. These include tide gates at the West River, Mill River, and Morris Creek; levees at the tide gates; bulkheads and riprap in numerous locations between Long Wharf and Morris Cove; and the seawall at Morris Cove.

In addition to the ordinances and codes described in Section 3.4, the coastal areas of New Haven are subject to Coastal Area Management District. Coastal area management is governed by the Connecticut Coastal Management Act, as amended by Public Acts 79-535 and 82-250, and by the New Haven Zoning Ordinance, Section 55.

4.5 Vulnerabilities and Risk Assessment

The FEMA flood stage for the New Haven shoreline is currently 11 feet NGVD. This base flood elevation is subject to change as the new FIRMs that will be released later this year would be in accordance with the North American Vertical Datum (NAVD) of 1988 as opposed to previous ones that were mapped in National Geodetic Vertical Datum (NGVD) of 1929 (See Section 2.8). The new flood stage may be slightly higher by a few inches. The water level pertains to the Harbor, as well as the tidally influenced sections of the Quinnipiac, Mill, and West Rivers.

Fair Haven and Mill River

Areas along the Fair Haven shore appear to be deteriorating. Bank protection and bulkheads are in good condition north of Ferry Street along Quinnipiac River Park. However, soil erosion is now occurring along the top of the riprap banks. In the recent past (after 2005), 315 linear feet of missing and dilapidated retaining wall that defined the edge of Front Street Park from the Quinnipiac River was replaced.

An existing bulkhead located on Ferry Street bridge heading north, parallel to Front Street (near Brewery Square), is deteriorating. This steel sheet bulkhead is failing and holes are now appearing at the water line. As the tidal flow washes behind the bulkhead, soil migration into coastal waters and bulkhead failure is occurring. This is affecting boardwalks and parking lots in this area. A preliminary study has been conducted by a consulting firm, in coordination with the City's Engineering Department, to identify ways to correct this failure. The City's Engineering Department is currently working on a cost-effective measure to correct this failure.

Adjacent to the Ferry Street Bridge, the bulkhead at Seaboard Fuel Oil is in poor condition. The steel portion of the bulkhead is rusted and broken, and the parking lot behind is eroding. The wood pilings present are rotted, and the concrete has slumped into pits. This was also indentified

as an issue in HMP 2005. Since this property is privately owned and vacant, no remedial action could be undertaken. The property is now listed for sale. A portion of the property is currently vacant (24 River Street) while the property at 36 River Street is leased. In the near future, the City should require the potential buyer of the property to repair the bulkhead here.

Another eroded wooden bulkhead is present in front of the Hess fuel storage facility and the scrap metal yard. At the sewage outfall at Poplar Street, an old wooden bulkhead is completely eroded and useless. A small beach is present at low tide.

The banks at Criscuolo Park at Mill Street appear to have a partly buried concrete wall that has been riprapped over. Soil erosion is evident at the top of the riprap. The concrete wall was reportedly a remnant of a seawall or bulkhead that previously defined the shoreline. Since this a very old structure built around 12 or 13 years back, it needs restoration and is currently undertaken by a consultant to the Department of Parks. When the project design is complete and all necessary permits are obtained, the City will explore ways to fund this project.

The River Street Municipal Development Plan (the MDP) for the City of New Haven characterizes the shoreline of River Street section of Fair Haven as poorly stabilized with rock and deteriorated sheet steel bulkhead. The MDP recognizes 840 feet of sheet steel bulkhead, mainly found at the southern edge of the Hess terminal, as being in good condition. As part of the implementation of River Street Municipal Development Plan, the City has applied for Federal Economic Development Administration money to stabilize the shoreline from 90 River Street through 34 Lloyd Street (Suraci, Hess property, Capasso Restoration). The properties at 56 and 46 River Street, to the east of Poplar Street, also need new bulkheads. Plans are complete for all of the properties from the foot of James Street to 46 River Street. While funding has been secured to implement these efforts for most of the properties, the improvements to 198 River Street (Bigelow Boiler) and 56 and 46 River Street would have to be pending until funding can be identified for further mitigation work. The City is currently awaiting DEP permits to start the work on those properties that have funding in place. The Seaboard Fuel Oil property (24 and 36 River Street), where the bulkhead is rusted and broken and the parking lot behind eroding, could not be included in this implementation effort as it is privately-owned. (As this property is listed for sale, the City should require the potential buyer to repair the bulkhead here.)

In addition, zoning amendments are proposed as outlined in the River Street MDP to allow for live/work loft space as part of a mixed adaptive reuse of existing older multi-level commercial and industrial structures. These living spaces could potentially be located in high hazard areas, such as coastal flooding zones and hurricane inundation areas. The new ordinances proposed for these coastal properties that were recently adopted by the City Plan Commission require that any new structures along the coastline be elevated above the base flood elevation (See Appendix_ on the Flood Damage Prevention Ordinance and Ordinance Amendment to Section 56 of the Zoning Ordinance).

Long Wharf, Canal Dock, and City Point

Site observations revealed riprap protection in a portion of the Long Wharf park and erosion at other locations along the tidal flats. The area is characterized by beach and flats with a gradual slope. There is a 1,200 lineal foot section along the park that remains unprotected, and is in a continuous state of erosion. The City is in the process of developing a plan for shoreline protection between Long Wharf and the Land Trust Nature Preserve to prevent erosion and loss

of upland material. Design efforts will concentrate on evaluation and development of details for deteriorated existing erosion controls, design of stabilization measures for areas where none currently exist, and upgrading the existing landscape elements in the park. Schematic design work and permit applications with American Corps of Engineers (ACOE) and DEP are scheduled to be completed by May 2011.

The City is also planning to build New Haven's first significant public harbor access facility at the Canal Dock site, which is envisioned to be a waterfront destination point for the community and region. This will encompass small boat sliding seat and fixed seat rowing, paddling, and sailing, marine related education activities, and other water dependent uses. It will also serve as a venue for various City events and festivals with the platform/pier serving a multitude of functions such as arts performance and education as well as boating. The project budget is $34 million and the City expects to bid the first phase of construction Spring 2011. The construction of this facility will be in accord with the construction requirements recommended in the new Floodplain Ordinances that were recently adopted by the City.

Connecticut Department of Transportation (CONNDOT) has installed duck bill gates on outlets on the main truck lines from the central city to prevent storm surge. FEMA has recently modified the flood zone designations in this area, which includes the rail yards and IKEA (see Letter of Map Revision-LOMR to FIRMs 090084-00004C and 0005 D dated 04/17/08).

The area and coastal protection facilities nearby at City Point appear to be in good repair.

West River

Bank erosion was visible along the West River between Interstate 95 and the railroad tracks at the Fire Training Academy. There were no apparent mitigation structures in place, such as riprap or bulkheads. This was also identified as an issue in the previous HMP (2005). This issue was re-examined recently by the project team and noted as minor problem that could be alleviated over time when funding opportunities become available.

East Shore

Although this area has been cited as potentially eroding in HMP 2005, evidence of large-scale or severe erosion was not observed during field observations. Erosion appeared to have occurred, however, along the top of the beach prior to 2005. The elevation of the East Shore park is several feet higher than the tide water level, and the park is very wide. This elevation and width likely provide protection from storm surge for adjacent residential properties. In the recent past (after 2005), the City developed an erosion control plan to preserve the park. Phase I of the Erosion control project is complete. During Phase I, 545 linear feet of eroded shoreline was stabilized with the placement of rip rap revetment 15-25 feet wide. 155 linear feet of eroded shoreline was stabilized with placement of sand dunes and shoreline plantings 24-40 feet wide. Further work is permitted by DEP but no funding is currently in place. The erosion control effort was only for East Shore Park and not the entire East Shore neighborhood.

Morris Cove

The Morris Cove area was substantially developed between 1900 and 1930, though there has also been further infill development as late as the 1980s. The area was originally tidal marsh, and is protected by tide gates and levees that were constructed between 1917 and 1920. The

tops of the levees at Morris Creek are at an elevation of 9.5 feet, and the tide gates regulate the water elevation in Tuttle Brook and Morris Creek to 2.5 feet. Mean high water elevation is 3.7 feet, and the high tide line is at 5.5 feet.

The area floods on a regular basis as a result of the overtopping of Morris Creek and Tuttle Brook and insufficient drainage of runoff. The City receives flooding complaints from residents throughout the year. Overtopping of the creeks can occur as a result of failed tide gates, and/or excessive runoff from the watershed. Most of the watershed is located in East Haven, where recent urban development has increased runoff. Much of the Morris Cove area is located in the 100-year flood zone with a water elevation of 11 feet, although homes in the Morris Cove area would be affected even as waters reach lower elevations. Table 4-1 summarizes the number of homes that would be affected at different water elevations. This information was taken from a study done by the Engineering Department (Appendix E).

Above the levee elevation of 9.5 feet, tidal inundation of the neighborhood would occur. To protect these neighborhoods and prepare for rising sea levels, the previous HMP (2005) recommended levees at Morris Creek which needed to be raised, and improvements to the tide gates. Necessary mitigation work was undertaken since then to mitigate this issue, as described later in this section

Table 4-1
Number of Properties in Morris Cove Area Affected by Flooding at Given Flood Water Elevations

Water Elevation (feet)	Cumulative Number of Properties Affected
3.0	1
3.5	3
4.0	6
4.5	16
5.0	34
5.5	48
6.0	69
6.5	132
7.0	197
7.5	240
8.0	250
8.5	279
9.0	294
9.5	320
10.0	330
10.5	356
11.0	359

Source: City of New Haven Engineering Department

Dean Street in the Morris Cove neighborhood has been identified as a flood prone area on the map "City of New Haven Flood Prone Areas" in HMP 2005. Flooding appeared to be caused by topography and drainage problems. Streets are not curbed in some areas, such that puddles

extend into yards. A site visit in 2005 revealed that the nearby Tuttle Brook contributed to flooding if high tides occurred during heavy rains or if the tide gates fail. Tuttle Brook was observed to be at least two feet lower than the road surface.

Long Island Sound meets the City on the west side of the Morris Cove neighborhood. The wall at Pardee Seawall Park appeared to be in good repair as of 2005. An engineering study and inspection program was commissioned by the Engineering Department in 2005 on this wall. It was characterized as being in "excellent" condition because repairs and maintenance have been conducted. The residential properties south of the Park along the shoreline were determined as likely at high risk to damage from coastal flooding. These structures had direct beach access back then. The seawalls abutting these properties also appeared to be at high risk.

The area at the East Haven Town Line and South End Road was also identified as a problem area in HMP 2005, mainly during high tides and coastal storms. The airport area was listed as the area experiencing flash floods by FEMA. This area is primarily residential. Morris Creek, which is near the airport, was observed to be high during a field visit in 2005. However, the road elevation was several feet higher. It was observed that at least one nearby residential yard and its outbuildings may be flooded during heavy rains and high tides when they occur together. This area also flooded whenever the tide gates, located downstream of the South End Road Bridge, were not working properly. Frequent flooding has also been a problem in the Morris Cove area north of Morris Causeway. The southern portion of the neighborhood, south of Morris Causeway, was also listed as likely to experience difficulty with evacuation (in HMP 2005) should it be necessary, as there are a few evacuation routes out of this neighborhood.

The most recent spring storm that occurred in 2010 majorly impacted the private residential seawalls along the residential properties south of the Park, causing them to fall apart in some cases. The beach that once existed is also gone now and the water from the Sound extends until the edge of the residential properties here. Although the City had funding (from US Army Corps of Engineers) set aside to fix the problem with the seawalls, no mitigation work could be started due to permits that are pending approval with the DEP. Therefore, this funding was also taken back quite recently.

Since 2005, several mitigation measures have been undertaken by the Department of Engineering to prevent flooding in the Dean Street area and the Morris Cove neighborhood, such as:

- Adding receiving chambers with duckbill flat valves and installation of tide gates for pumping rainwater into Morris Creek near Morris Causeway by the airport side
- Installation of tide gates at the Cart Road/Dean Street area to control the flow of water that goes into the creek and to control the amount of tidal flow into the tidal wetland area around the airport in New Haven and East Haven
- Decreasing the number of outlets on the Morris Creek tide gate from eight to five
- Placement of flexible valves for all of the outlets near the Creek
- Replacement of some of the culverts to control the amount of water coming in and going out of the Creek

The lower portion of Morris Creek was also dredged by the airport authority with the funding they received from the FHWA for the airport Runway Project. The recent improvements (after 2005) made at the Tweed New Haven airport also included channelization of Morris Creek and creation of a detention area for stormwater.

While a good portion of Dean Street is controlled by the new pumping outlets that were recently installed, one of the outlets that serves at the intersection of Townsend Avenue and Quinnipiac Avenue drains towards Morris Creek and continues to cause flooding problems in the area. Over the years, this outlet has been buried due to sand accumulation. The City's Department of Engineering is currently attempting to correct this outlet to allow drainage to occur at this location. The City Engineer recommends that for the final phase of the project the elevation of the berm along Dean Street be raised and a pump station be built in the area.

An issue has developed over time when the outlet that drains Morris Causeway has been buried due to the movement of sand. Because the sand has accumulated over the pipe, the high tide line has changed this. This now causes a problem as the outlet is now on private property and the portion of land based on riparian rights cuts off direct access to the Cove. Correction of this requires easements and DEP permits, which the City is currently trying to obtain.

4.6 Potential Mitigation Measures, Strategies, and Alternatives

Potential mitigation strategies for coastal flooding are essentially the same as those for inland flooding, and therefore are not restated in this section. Additional strategies are included and noted where appropriate.

4.6.1 Prevention

The River Street MDP provides an opportunity to prevent flooding and loss associated with flooding in the River Street section of Fair Haven.

The River Street MDP advances a revitalization program for the River Street area through redevelopment, historical restoration, development of a waterfront park and linear trail, improvement of public infrastructure, and implementation of new design controls to create a more appealing environment. Core improvements associated with the River Street redevelopment project are reconstruction of River Street and the construction of shoreline stabilization, both of which provide hazard mitigation opportunities. New buildings or uses within the 100-year flood zone (zone A6) are subject to the Flood Damage Prevention District. Any site development that receives financial assistance from the state is subject to the flood and stormwater management standards specified in section 25-68d of the Connecticut General Statutes (CGS) and section 25-68h-2 through 25-68h-3 of the Regulation of Connecticut State Agencies (RCSA). In addition, the project area is located within the Coastal Area Management District.

The MDP proposes to further improve the River Street drainage system to address local drainage issues. It is anticipated that this effort will include separation of a portion of the sewer system consistent with the citywide sewer separation project through construction of a new storm drainage system.

In addition, side streets located within the project area are proposed for resurfacing. This provides an opportunity to raise street elevations above the coastal base flood elevation of 11 feet, at a minimum.

Proposed shoreline stabilization measures include placement of approximately 1,145 linear feet of new sheet steel bulkhead and placement of approximately 650 linear feet of riprap in the area of

tidal marsh, near 198 River Street and 34 Lloyd Street. The riprap stabilization will be similar to the slope stabilization measures along Criscuolo Park. The City is currently awaiting DEP permits to implement these.

The proposed waterfront trail and linear park will generally match the existing Quinnipiac River Park. The City has allotted $2 million for creation of this park. The park and trail will be designed to City standard (similar to Front Street Park and the design of the new Farmington Canal greenway). This park will provide a buffer from coastal storms and flooding.

In addition to the preventive mitigation strategies mentioned in Section 3.0, it is necessary to repair and maintain coastal infrastructure, such as bulkheads and tide gates, which protect against coastal flooding.

The following specific mitigation measures have been identified as preventive actions. While most of these listed below are the same as those outlined in the previous HMP (2005), some were already adopted within the past five years (as noted in the previous section) and hence removed from this list. Changes have also been made to some preventive measures listed in 2005 to more closely apply to the current conditions and included in the list below.

Flooding in Morris Creek and Morris Cove Neighborhood

- Inspect the Morris Creek tide gates on a monthly basis before the highest tides are anticipated.
- Conduct monthly debris removal from Morris Creek in the spring, summer, and fall.
- Request notification of development proposals in the East Haven portion of the watershed.
- Obtain necessary permits and easements to correct the outlet at Morris Cove.

Flooding and Deterioration of Morris Cove Shoreline

- As sea level rises, continue with beach nourishment and conduct annual inspections of Pardee Seawall.
- Request information annually from homeowners about the condition of their seawalls.
- Repair the existing seawalls near residential homes to the south of Pardee Seawall.

Flooding and Deterioration of Port and Terminal Area

- Request the City's Port Authority to obtain information annually from terminals about their bulkhead and seawall management and encourage terminal owners to repair facilities as needed.

Flooding and Deterioration of Fair Haven and Quinnipiac River Park

- Create River Street linear park, which will act as a buffer from coastal and hurricane storm surge as well as sea level rise.
- Conduct annual inspections of the bulkheads in northern and southern Quinnipiac River Park and repair as needed.
- Fix the pothole that has formed in the bulkhead immediately north of the Ferry Street bridge (Brewery Square).

4.6.2 ***Property Protection***

The following measures are possible mitigation strategies to protect properties within specific areas:

Flooding in Morris Creek and Morris Cove Neighborhood

- Promote raising of homes with first floors below elevation 5.5 feet to be consistent with the current high tide elevation.
- Promote raising of homes with first floors below elevation 8.5 feet to keep up with sea level rise.

Flooding and Deterioration of Morris Cove Shoreline

- Promote raising of homes along the shoreline to keep up with sea level rise.

Flooding and Deterioration of Fair Haven and Quinnipiac River Park

- Conduct annual inspections of the bulkheads in northern and southern Quinnipiac River Park and repair as needed.

Although the above stated measures were also outlined in the previous HMP (2005), some of these measures such as elevating homes along shoreline could not be implemented due to financial constraints.

4.6.3 Public Education and Awareness

The following activities are potential measures to increase public education and awareness about specific problems within the City of New Haven:

Flooding in Morris Creek and Morris Cove Neighborhood

- Distribute evacuation information to residents.

Flooding and Deterioration of Port and Terminal Area

- Post notification on I-95 so that vehicles won't use the off-ramp of Stiles Street exit when the area is flooded.
- Distribute information about safe evacuation to the small residential neighborhood north of I-95 at the Stiles Street ramps.
- Post notification and place barricades along Forbes Avenue to avoid using the road during flood events combined with coastal storms or very high tides.

4.6.4 Natural Resource Protection

Flooding and Deterioration of East Shore Park

- As sea level rises, continue with beach nourishment near the park.

Flooding of Quinnipiac River Estuary

- Conserve available land in the mapped floodplain of the Quinnipiac River estuary, and available land that is up to three feet higher in elevation, to allow for landward advancement of the marshes. Allocate money for acquisition.

4.6.5 Emergency Services

Flooding of Quinnipiac River Estuary

- Post notification and place barricades along Middletown Avenue and Foxon Boulevard to avoid using the road during flood events combined with coastal storms or very high tides.

Flooding and Deterioration of Belle Dock Terminal and Long Wharf

- Obtain a supply of sandbags and other water barriers for use at the viaducts into the Sargent Drive and railroad yard areas.

4.6.6 Structural projects

Physical structures that are capable of lessening the impacts of coastal flooding include seawalls, levees, bulkheads, and causeways. Specific structural mitigation actions identified as potential strategies for the City of New Haven are given below.

Flooding in Morris Creek and Morris Cove Neighborhood

- Repair the outlet at the intersection of Townsend Avenue and Quinnipiac Avenue to improve drainage in this area.

Flooding and Deterioration of Morris Cove Shoreline

- Beach nourishment should be pursued to mitigate for further downward erosion at Pardee Seawall and nearby residential seawalls. Begin allocating funding for beach replenishment. This will help protect the wall and restore the beach.
- The residential seawalls to the south of Pardee seawall need immediate protection.

Flooding and Deterioration of East Shore Park

- Beach nourishment should be pursued to mitigate for landward erosion. Begin allocating funding for beach replenishment.
- Commission an engineering study to evaluate the feasibility of using headland structures to improve the success of beach replenishment.
- Add riprap in select areas, similar to that at Criscuolo Park.

Flooding of Quinnipiac River Estuary

- Commission an engineering study to evaluate the feasibility of installing a pumping system and/or tide gate system for the length of Middletown Avenue between the Quinnipiac River and Foxon Boulevard. The study should consider the effects of a rising base level due to sea level change.

Flooding and Deterioration of Fair Haven and Quinnipiac River Park

- Add riprap to a higher elevation along the central portion of Quinnipiac River Park to keep up with rising sea level and mitigate for existing soil erosion above the riprap; repair existing damage to riprap and seawall.
- Add riprap to a higher elevation in Criscuolo Park to keep up with rising sea level and mitigate for existing soil erosion above the riprap.
- Within the River Street Municipal Development District, repair bulkheads between Ferry Street and Criscuolo Park and raise their elevations when repairs are made to account for changing sea level.
- Encourage remaining private property owners between Ferry Street and Criscuolo Park, and along the Mill River, to repair and maintain bulkheads, raising their elevations when repairs are made to account for changing sea level.
- Encourage private property owners and along the Mill River north of Grand Avenue to armor riverbanks to reduce erosion, while accounting for changing sea level.

Flooding and Deterioration of Belle Dock Terminal and Long Wharf

- Repair bulkheads and raise their elevations when repairs are made to account for changing sea level.
- Add riprap to a higher elevation along Long Wharf Park as needed to keep up with rising sea level and mitigate for soil erosion above the riprap.
- Beach nourishment should be pursued to mitigate for landward erosion if it occurs.
- Raise the elevation of intersections at Long Wharf Drive, Sargent Drive.

While most of the above mentioned measures were also outlined in the previous HMP (2005), these could not be implemented either due to lack of funding or lack of necessary permits.

4.7 Recommended Actions

The following actions have been identified as recommendations, and ranked according to the STAPLEE method. They are given in order from higher ranking to lower ranking, except where two actions are equally ranked as noted.

Flooding in Morris Creek and Morris Cove Neighborhood

1. Inspect the Morris Creek tide gates on a monthly basis before the highest tides are anticipated.
2. Conduct monthly debris removal from Morris Creek in the spring, summer, and fall.
3. Request notification of development proposals in the East Haven portion of the watershed.
4. Distribute evacuation information to residents.
5. Promote raising of homes with first floors below elevation 5.5 feet to be consistent with the current high tide elevation.
6. Promote raising of homes with first floors below elevation 8.5 feet to keep up with sea level rise.

Flooding and Deterioration of Morris Cove Shoreline

1. Beach nourishment should be pursued to mitigate for further downward erosion at Pardee Seawall and nearby residential seawalls.
2. As sea level rises, continue with beach nourishment and conduct annual inspections of Pardee Seawall and other residential seawalls in the area.
3. Request information annually from homeowners about the condition of their seawalls.
4. Promote raising of homes along the shoreline to keep up with sea level rise.

Flooding and Deterioration of East Shore Park

1. As sea level rises, continue with beach nourishment but consider allowing a retreat of the shoreline.
2. Add riprap in select areas, similar to that at Criscuolo Park.

Flooding and Deterioration of Port and Terminal Area

1. Post notification on I-95 so that vehicles will not use the Stiles Street off-ramp exit when the area is flooded.
2. Distribute information about safe evacuation to the small residential neighborhood north of I-95 at the Stiles Street ramps.
3. Ensure that drainage is improved as part of the Interstate 95 improvement program.
4. Post notification and place barricades along Forbes Avenue to avoid using the road during flood events combined with coastal storms or very high tides.
5. Request information annually from terminals about their bulkhead and seawall management.

Flooding of Quinnipiac River Estuary

1. Conduct semi-annual inspections of the Cranston Brook culverts.
2. Conserve available land in the mapped floodplain of the Quinnipiac River estuary, and available land that is up to three feet higher in elevation, to allow for landward advancement of the marshes. Allocate money for acquisition.
3. Conduct monthly inspections of the storm drain catch basins along Middletown Avenue between the Quinnipiac River and Foxon Boulevard.
4. Encourage CT DOT to increase inspections and cleanouts of culverts under I-91 and its interchanges in the vicinity of Little River and Cranston Brook, as they can back up water into residential areas.
5. Re-zone land in the Quinnipiac River estuary to protect land that can not be acquired.
6. Post notification and place barricades along Middletown Avenue and Foxon Boulevard to avoid using the road during flood events combined with coastal storms or very high tides.
7. Commission an engineering study to evaluate the feasibility of installing a pumping system and/or tide gate system for the length of Middletown Avenue between the Quinnipiac River and Foxon Boulevard. The study must consider the effects of a rising base level due to sea level change.

Flooding and Deterioration of Fair Haven and Quinnipiac River Park

1. Create River Street linear park, which will act as a buffer from coastal and hurricane storm surge, as well as sea level rise.

2. Add riprap to a higher elevation along the central portion of Quinnipiac River Park to keep up with rising sea level and mitigate for existing soil erosion above the riprap; repair existing damage to riprap and seawall.
3. Conduct annual inspections of the bulkheads in northern and southern Quinnipiac River Park and repair as needed.
4. Post notification and place barricades along River Street to avoid using the road during flood events combined with coastal storms or very high tides.
5. On City property, repair bulkheads between Ferry Street and Criscuolo Park and raise their elevations when repairs are made to account for changing sea level.
6. Encourage remaining private property owners between Ferry Street and Criscuolo Park, and along the Mill River, to repair and maintain bulkheads, raising their elevations when repairs are made to account for changing sea level.
7. Encourage private property owners and along the Mill River north of Grand Avenue to armor riverbanks to reduce erosion, while accounting for changing sea level.
8. Fix pothole that has formed in the bulkhead immediately north of the Ferry Street bridge.

Flooding and Deterioration of Belle Dock Terminal and Long Wharf

1. Add riprap to a higher elevation along Long Wharf Park as needed to keep up with rising sea level and mitigate for soil erosion above the riprap.
2. Beach nourishment should be pursued to mitigate for landward erosion if it occurs.
3. Obtain a supply of sandbags and other water barriers for use at the viaducts into the Sargent Drive and railroad yard areas.
4. Repair bulkheads and raise their elevations when repairs are made to account for changing sea level.
5. Raise the intersections at Long Wharf Drive and Sargent Drive.

Majority of the above mentioned recommendations were also listed in HMP 2005. Due to lack of funding and/or necessary permits many of these could not be implemented within the past five years.

5.0 HURRICANES

Since there was no hurricane impact on New Haven in the past five years, most of the description on hurricane setting, hazard assessment, storm surge, and historic record remain the same as they were originally described in HMP 2005. Few changes were made to sections on existing policies and vulnerabilities and risk assessment as noted below.

5.1 Setting

Hazards associated with hurricanes include winds, heavy rains, and inland and coastal flooding. As explained in Section 4.1 in the context of coastal flooding, New Haven is a shoreline community with many coastal resources and eight distinct coastal land areas based on geographic setting. While all of these areas are susceptible to hurricane damage such as storm surge and flooding, wind damage can occur throughout the City. Hurricanes therefore have the potential to affect any area within New Haven.

5.2 Hazard Assessment

Hurricanes are a class of tropical cyclones which are defined by the National Weather Service as 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 (1-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 geographical 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.

Coastal Connecticut is particularly vulnerable to hurricanes despite moderate hurricane occurrences when compared with other areas within the Atlantic Tropical Cyclone basin. New Haven's southern facing coastline and the geomorphology of Long Island Sound cause it to be particularly vulnerable to all hurricanes forecasted to track to New England. This is due to the ability of Long Island Sound to amplify hurricane surges. The configuration of Long Island and the Connecticut coast cause a natural funneling influence on ocean waters as they are driven east to west in the Sound by a hurricane. The area's coastline geometry; regional bathymetry; and hurricane direction, intensity, and forward speed are influential parameters that affect resulting hazards.

According to the Emergency Operations Plan (EOP) of New Haven, a hurricane Watch is an advisory for a specific area stating that a hurricane poses a threat to coastal and inland areas. Individuals should keep tuned to local television and radio for updates. A hurricane Warning will be issued when the dangerous effects of a hurricane are expected in the area within 24 hours. For a hurricane Warning, the EOP advises to notify personnel, watch for deteriorating weather conditions, and be prepared for evacuations.

Currently, the City's Office of Emergency Management has also adopted a reverse notification system for residents, called 'reverse 911.' With this facility, a telephone message about an impending emergency can be sent to the residents of the entire city or only to those in affected areas.

Storm Surge

Abnormal high water levels along ocean coasts and interior shorelines are commonly caused by storm events. These higher than expected water levels, known as storm surges, are generally the result of regional scale meteorological disturbances. Storm surge is defined as the difference between the observed water level and the normal astronomical tide. Extra-tropical 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 relatively short duration.

A number of factors contribute to the generation of storm surges, but the fundamental forcing mechanism is wind and the resultant frictional stress it imposes on the water surface. 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, which has been adopted by the National Hurricane Center, categorizes hurricanes based upon their intensity, and relates this intensity to damage potential. The scale uses the sustained surface winds (1-minute average) near the center of the system to classify hurricanes into one of five categories. The details on Saffir/Simpson scale is provided below.

- **Category 1:** Winds 74-95 mph (64-82 kt or 119-153 km/hr). Storm surge generally 4-5 feet above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage. Hurricanes Allison of 1995 and Danny of 1997 were Category 1 hurricanes at peak intensity.

- **Category 2:** Winds 96-110 mph (83-95 kt or 154-177 km/hr). Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings. Hurricane Bonnie of 1998 was a Category 2 hurricane when it hit the North Carolina coast, and Hurricane Georges of 1998 was a Category 2 Hurricane when it hit the Florida Keys and the Mississippi Gulf Coast.

- **Category 3:** Winds 111-130 mph (96-113 kt or 178-209 km/hr). Storm surge generally 9-12 feet above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown

off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 feet above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences within several blocks of the shoreline may be required. Hurricanes Roxanne of 1995 and Fran of 1996 were Category 3 hurricanes at landfall on the Yucatan Peninsula of Mexico and in North Carolina, respectively.

- **Category 4:** Winds 131-155 mph (114-135 kt or 210-249 km/hr). Storm surge generally 13-18 feet above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 feet above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km). Hurricane Luis of 1995 was a Category 4 hurricane while moving over the Leeward Islands. Hurricanes Felix and Opal of 1995 also reached Category 4 status at peak intensity.

- **Category 5:** Winds greater than 155 mph (135 kt or 249 km/hr). Storm surge generally greater than 18 feet above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 feet above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required. Hurricane Mitch of 1998 was a Category 5 hurricane at peak intensity over the western Caribbean. Hurricane Gilbert of 1988 was a Category 5 hurricane at peak intensity and is one of the strongest Atlantic tropical cyclones of record.

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	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

The Saffir/Simpson Hurricane Scale assumes an average, uniform coastline for the continental United States and was intended as a general guide for use by public safety officials during hurricane emergencies. It does not reflect the effects of varying localized bathymetry, coastline configuration, astronomical tides, barriers or other factors that may modify surge heights at the local level during a single hurricane event.

According to Connecticut's Natural Hazard Mitigation Plan, a moderate Category 2 hurricane is expected to strike Connecticut once every ten years, whereas a Category 3 or 4 hurricane is expected before the year 2040. These frequencies are based partly on the historic record, described in the next section.

5.3 Historic Record

Through research efforts by the National Climate Center in cooperation with the National Hurricane Center, records of tropical cyclone occurrences within the Atlantic Cyclone Basin have been compiled dating from 1871. Since 1886, detailed computer files of Atlantic tropical cyclones have been maintained by the National Hurricane Center. During this period of record, 29 hurricanes and 67 tropical storms have passed within a 150 mile radius of Newport, Rhode Island.

In the years between 1900 and 2000, eight direct hits and two hurricanes that did not make landfall (but passed close to the shoreline) were recorded along the Connecticut coast, of which there were four Category 3, two Category 2, and two Category 1 hurricanes (two of the ten struck Connecticut before the Saffir/Simpson scale was developed). Of the four Category 3 hurricanes, two occurred in September and two occurred in August.

The most devastating hurricane to strike Connecticut, dubbed the "Long Island Express of September 21, 1938," was believed to be a Category 3 hurricane. The storm caused surges of 10 to 12 feet along portions of the Long Island and Connecticut Coast, and was estimated to cause 600 deaths in New England. The "Great Atlantic Hurricane" hit the Connecticut coast in September 1944. Hurricane Carol struck in August of 1954. The following year, back-to-back hurricanes Connie and Diane caused torrential rains and record-breaking floods in Connecticut.

More recently, flooding and winds associated with hurricanes and storm events have caused extensive shoreline erosion and related damage. In September of 1985, hurricane Gloria passed over the coastline. Hurricane Bob, in 1991, caused damage along the Connecticut coast, but was more extensively felt in Rhode Island and Massachusetts.

No hurricane events have been recorded in Connecticut within the past five years.

5.4 Existing Programs, Policies, and Mitigation Measures

Existing mitigation measures appropriate for both inland and coastal flooding have been discussed in previous sections. These include ordinances, codes, and regulations that have been enacted and revised to minimize flood damage. Wind loading requirements are addressed through the Livable City Initiative (Building Division and Code Enforcement), which currently uses standards from the 1999 Connecticut State Building Code, which in turn references the BOCA National Building Code 1996. The City adopted the 2003 International Building Code in

December 2005. In addition, various structures exist to protect certain areas, including tide gates, levees, bulkheads, seawalls, and riprap.

5.5 Vulnerabilities and Risk Assessment

This section provides information on areas that would be at risk due to hurricane storm surge. It does not address issues such as flooding that may be associated with heavy rains that often accompany hurricane type storms. Flooding is addressed in both the Inland Flooding and Coastal flooding sections of this plan.

The areas impacted by hurricane storm surge are shown on Figures 5-1 and 5-2. This map was digitized from the *Connecticut Hurricane Evacuation Study Technical Data Report Inundation Map*, dated December 1993. This figure shows the potential surge areas for Category 1 and 2, Category 3, and Category 4 hurricanes, respectively. Inundation areas reflect "worst case" combinations of hurricane direction, forward speed, landfall point, and high astronomical tide.

Figure 5-1 Areas impacted by hurricane storm surge

Figure 5-2 Areas impacted by hurricane storm surge

Inundation areas were derived from application of the National Hurricane Center's "SLOSH" model. The SLOSH model was developed by the National Weather Service and first used for real-time forecasting of surges from hurricanes within selected Gulf of Mexico and Atlantic coastal basins. SLOSH's success in surge forecasting has lead to utilization of the Model for hurricane preparedness planning.

The model calculates storm surge heights for the open ocean and coastal regions affected by a given hurricane. The model also calculates surge heights for bays, estuaries, coastal rivers, and adjacent upland areas susceptible to inundation from the storm surge.

Significant man-made or natural barriers (i.e., dunes, islands, etc.) are represented by the model and their effects are simulated in the calculation of surge heights. The model does not provide predictions based on rainfall amounts or interior freshwater flooding. It is assumed that Flood Insurance Rate Maps will be used to plan for evacuation of non-tidal areas. A detailed description of the SLOSH model is given in the *Connecticut Hurricane Evacuation Study Technical Data Report*.

Based on the model, storm surge from Category 4 hurricanes will cause flooding beyond what would be expected from a 100- or 500-year flood event. Specific areas of note where even Category 1 storm surge areas extend significantly beyond the FEMA flood zone areas include the downtown sector north of the I-95 Interchange, extending west to State Street and north almost to Grand Avenue. Other areas of note include the southern Morris Cove neighborhood and Lighthouse Point Park.

As discussed previously, even hurricanes that track to the east of Connecticut can generate significant flooding at all locations along Connecticut's shore. Vulnerability is further complicated by growing populations and development in coastal areas. In addition to flooding, the force associated with hurricanes and the associated storm surge can cause massive beach erosion and wind damage.

Although FEMA has requested for an accompanying list of buildings, infrastructure, and critical facilities within these areas affected by hurricane storm surge, they could not be mapped due to recent budget cuts and staff shortage.

Public Shelter Demand and Capacity

The City is currently capable of sheltering approximately 5,705 individuals in case of emergencies. In addition, facilities exist to accommodate the evacuation of nearly 17,705 individuals.

Certain behavioral assumptions are incorporated into the calculation of shelter demands. These assumptions are:

- In a Category 1 or 2 scenario, 80% of the population living within Category 1 and 2 evacuation zones and 40% of the population living within Category 3 and 4 evacuation zones, will evacuate. During a Category 3 and 4 evacuation scenario, 90% of the population living within either evacuation zone will evacuate.
- The percentage of the population living outside of evacuation zones assumed to evacuate is 2% for Category 1 and 2 scenarios, and 5% for Category 3 and 4 scenarios.

- Depending on the community's per capita income, evacuees from Category 1 and 2 and Category 3 and 4 evacuation zones will use public shelters at rates of 5% to 10%, and 10% to 20%, respectively, by evacuation zone. The unaffected population that evacuates will use public shelters at rates of 10% to 30% depending upon income.

In addition, the computation of shelter demand assumes an adequate warning period for an approaching hurricane and sufficient public knowledge concerning the locations and availability of public shelter facilities.

Based on sheltering demands of 2,930 and 5,780 for Category 1 and 2 and Category 3 and 4 hurricane scenarios, the City of New Haven has more than adequate facilities to handle the evacuation and sheltering needs based on hurricane storm surge.

5.6 Potential Mitigation Measures, Strategies, and Alternatives

Potential mitigation measures 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. Mitigation for wind damage is therefore emphasized below.

5.6.1 Prevention

As discussed in Section 4.0, the River Street MDP offers opportunities for hazard mitigation. Shoreline stabilization efforts will fortify the River Street area against coastal erosion associated with hurricane storm surge. The waterfront park and linear trail will provide a buffer for the surrounding areas against hurricane storm surge. New buildings and uses will be constructed to current Flood Damage Prevention District and Coastal Area Management District standards, preventing further loss from coastal flooding associated with hurricanes.

The following actions have been identified as potential preventative measures:

- Implement a city-wide tree limb inspection and maintenance program to ensure that the potential for downed power lines is diminished. Unfortunately, due to lack of funds this could not be implemented within the past five years.
- Encourage location of utilities underground.
- Encourage, or consider requiring, the use of storm shutters along the coastline.

5.6.2 Property Protection

Potential mitigation measures include designs for hazard-resistant construction and retrofitting techniques. These may take the form on 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. In addition, living and working areas can be elevated to allow storm surge to pass safely underneath. The Building Department should make literature available to developers during the permitting process regarding these design standards. Although no literature on these design standards exist currently, building standards for dealing with high wind issues can be found in the State Building Code (ICC).

5.6.3 Public Education and Awareness

The public, especially those individuals living within hurricane storm surge evacuation zones, should be made aware of evacuation routes and available shelters. The City's reverse 911 system is also a great way of notifying people in the affected areas in case of emergencies.

5.6.4 Emergency Services

The Emergency Operation Plan should include guidelines and specifications for communication of hurricane warnings and watches, as well as for a call for evacuation. The public needs to be made aware in advance of a hurricane event, of evacuation routes and the locations of public shelters. As mentioned earlier, in the recent past (after 2005) the City adopted the reverse 911 system for notifying the residents in case of emergencies.

The Morris Cove neighborhood is specifically vulnerable to hurricanes. Evacuation from this area can only occur via Woodward and Townsend Avenues. As most residents of Morris Cove are well versed in hurricane evacuation procedures, it may not be necessary to post the hurricane evacuation route for this area.

5.6.5 Structural Projects

Structural mitigation for hurricane storm surges is generally focused on constructing seawalls, which provide better protection than bulkheads. The City of New Haven is not in a position to construct new seawalls. However, previous recommendations for coastal flood mitigation provided in Section 4.0 will provide mitigation for coastal flooding caused by hurricanes. Structural projects for wind damage mitigation are not possible.

5.7 Recommended Actions

The following actions are recommended and listed below in order of higher ranking to lower ranking using the STAPLEE method:

1. The Building Department to make literature available during the permitting process regarding appropriate design standards.
2. Implement a City-wide tree limb inspection and maintenance program to ensure that the potential for downed power lines is diminished.
3. Consider requiring the use of storm shutters along the coastline.
4. Consider placing utilities underground to protect from wind damage.

These recommendations remain the same as those listed within HMP 2005. As discussed earlier, most of these could not be implemented due to lack of funds. However, the City now requires developers of new constructions to place utilities underground, to the extent possible in accordance with recommendation# 4.

6.0 SEA LEVEL RISE

6.1 Setting

Sea-level rise is a phenomenon that affects coastal and tidal areas, and land areas with elevations close to sea level. Land subsidence, caused by the compaction of loose soils such as that found in river delta areas, will affect land elevation. Relative sea-level rise in these areas will be greater.

Within New Haven, areas adjacent to the Harbor and the tidally influenced sections of the West, Mill, and Quinnipiac Rivers are at high risk to impact from sea level rise. These areas include all eight distinct coastal land areas described in the *Comprehensive Plan of Development*. Furthermore, the Morris Cove neighborhood and Tweed-New Haven airport will experience increased flooding with sea level rise, as will the Quinnipiac Meadows area.

6.2 Hazard Assessment

Land use and urban planning in coastal areas must take into account the phenomenon of sea level rise. Sea levels are currently rising along the Atlantic Coast as a result of climate change, which may be attributable to greenhouse gases. Rising sea levels inundate low areas, erode beaches and wetlands, increase flooding from storm surges and rainstorms, and enable saltwater to advance upstream.

Between 1960 and 1995, the coastal population in New Haven county increased by 21%. As coastal population densities increase, greater numbers of people and assets are at risk. For example, increased storm surges due to rising sea levels would impact the railroad station and train yards, Tweed-New Haven airport, and parts of I-95.

Rising sea level affects both the natural and the human-made environment. Future sea level rise could result in the disappearance of a large percentage of Connecticut's coastal wetlands, which are already stressed by development and other activities. Saltwater advancing upstream can alter the point at which flocculation leads to sedimentation and the creation of shoals. Storm surges from hurricanes and nor'easters will reach further inland as they are starting from a higher base.

As sea level rises, drainage systems become less effective. Rainstorms will have the potential to cause greater flooding. New Haven already experiences problems with inadequate storm drainage in areas such as the Morris Cove neighborhood. As sea level rises, these areas may experience increased flooding.

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

FEMA backwater zones, which are currently at an elevation of 11 feet (NGVD) (and may be slightly higher in the new FIRMs due to the change in datum as mentioned in Section 2.8) will progressively rise. This means that the 100-year and 500-year flood levels will affect lands that are currently at unaffected elevations. This will exacerbate the problem of inland and coastal flooding within the City.

6.3 Historic Record

The Intergovernmental Panel on Climate Change (IPCC) concludes that there has been a global mean rise in sea level between 10 and 25 cm (approximately 4 to 10 inches) over the last 100 years (Neumann et. al., 2000). Relative sea level rise in Connecticut in the same time period is estimated as between 1.5 and 3.0 millimeters per year. The IPCC further estimates that global sea level will rise 9 to 88 centimeters during the 21st century.

In Connecticut, the current rates of sea-level rise are 2.54 millimeters (0.10 inches) per year in Bridgeport and 2.03 millimeters (0.08 inches) per year in New London. These trends exceed the global mean trend of sea level rise of around 1.52 ± 0.51 millimeters (0.06 ± 0.02 inches) per year (Environmental Defense, 2004). Including the effects of regional subsidence, sea level is likely to rise two feet along most of the Atlantic Coast in the next 100 years (US DOT, 2002).

6.4 Existing Programs, Policies, and Mitigation Measures

The City of New Haven currently has in place structures that prevent shoreline erosion, such as bulkheads and seawalls. The existing riprap at Criscuolo and Quinnipiac Parks protect the shoreline up to the level of the current high tide. The City's Comprehensive Plan (adopted in 2003) does not address sea level rise. However, the City now has a new Office of Sustainability (opened in 2009), which is currently working on addressing this issue as part of climate change efforts.

6.5 Vulnerabilities and Risk Assessment

In the City of New Haven, the areas susceptible to sea level rise are the areas surrounding New Haven Harbor, the tidal areas of the Quinnipiac and Mill Rivers, and the lower reaches of the West River. In general, areas below an elevation of four to five feet are vulnerable to rising sea level.

Transportation infrastructure in New Haven at risk to adverse affects from sea-level rise includes the railroad station and track yards, the Tweed-New Haven Airport and parts of Interstate-95. Port facilities on the water's edge are particularly susceptible to sea level rise. Docks, jetties, and other facilities are deliberately set at an optimal elevation relative to the water level, and therefore a rise in sea level leaves them at a suboptimal elevation. However, these facilities tend to be rebuilt relatively frequently compared with the time it takes for a substantial rise in sea level.

Commercial, industrial, and residential properties along the coastline are also vulnerable to sea level rise. In general, these are the same areas that were identified in Sections 4.0 and 5.0 in the context of coastal flooding and hurricanes, respectively. The most vulnerable areas are those where topography is relatively flat, such as the Morris Cove neighborhood, areas adjacent to the harbor, and properties along the Quinnipiac River estuary that are accessed from Middletown Avenue.

6.6 Potential Mitigation Measures, Strategies, and Alternatives

The following measures for mitigating sea level rise were originally described in HMP 2005 and mostly remain the same for the current plan update also.

Three fundamental long-term responses to sea level rise are typically reported in the literature, These are *retreat*, *accommodation*, and *protection*.

- ***Retreat*** refers to the eventual abandonment of the coastal zone, allowing nature to take its course. This allows for the existing ecosystems to shift landward. Beach nourishment, which is the stabilization of beach areas with element such as rock and sand, helps to protect the natural area from erosive processes. Retreat may be motivated by excessive economic or environmental impacts 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 not feasible in heavily urbanized areas such as New Haven.

- ***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. All 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.

- ***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 dunes and vegetation. 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.

Elevation of land and structures is another form of protection. 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 with regular repaving of roads. Resurfacing of roads as part of the restoration efforts outlined in the River Street MDP provides an opportunity to mitigate against sea level rise in this section of Fair Haven. In addition, it is recommended that new buildings and uses in the River Street redevelopment area be required to account for sea level rise by adding elevation above the current base flood elevation. Construction of a waterfront park and linear trail provide for retreat from sea level rise by acting as a buffer along the shoreline. The City is currently in the process of implementing some of these recommendations outlined in the River Street MDP. Also, the new Floodplain Ordinances that were recently adopted by the City Plan Commission require elevation of structures along the coastline above the base flood elevation.

In some instances, continued elevation of roads parallel to water bodies can create a diking effect, protecting areas landward of the road. Care should be taken that road elevation does not cause excessive runoff and flooding problems in other areas that become diked by the elevated roadways.

As a general proposition, holding back the sea with structures results in large-scale elimination of wetlands, beaches, mudflats, 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.

Short term responses to sea level rise allow for the development of adequate strategies of response. The first step to be taken is to identify areas at risk to the projected rise in sea level. This can take the form of land surveys and improved mapping. Once this has been accomplished, implications of various responses should be assessed with regard to environmental, economic, social, and legal/institutional impacts. Development of emergency preparedness and evacuation plans allow for improved responses in the cases of winter storms and hurricanes if rapid changes in sea level elevation occur.

6.7 ***Recommended Actions***

Many of the recommendations for mitigating coastal flooding and hurricane storm surges are suitable for mitigation of rising sea level. These are repeated below, with emphasis added (*italics*) for recommendations that will address rising sea level in the long term. Some of the recommended actions outlined in the previous HMP (2005) have already been implemented and not included in the following list. The others have been repeated because they could not be implemented due to lack of funding in the past five years.

Flooding in Morris Creek and Morris Cove Neighborhood

1. Inspect the Morris Creek tide gates on a monthly basis before the highest tides are anticipated.
2. Conduct monthly debris removal from Morris Creek in the spring, summer, and fall.
3. Distribute evacuation information to residents.
3. Promote raising of homes with first floors below elevation 5.5 feet to be consistent with the current high tide elevation.
4. Promote raising of homes with first floors below elevation 8.5 feet to keep up with sea level rise.

Flooding and Deterioration of Morris Cove Shoreline

1. Beach nourishment should be pursued to mitigate for further downward erosion at Pardee Seawall. Begin allocating funding for beach replenishment. This will help protect the seawall.
2. As sea level rises, continue with beach nourishment and conduct annual inspections of Pardee Seawall.
3. Request information annually from homeowners about the condition of their seawalls.
4. Promote raising of homes along the shoreline to keep up with sea level rise.

Flooding and Deterioration of East Shore Park

1. As sea level rises, continue with beach nourishment but consider allowing a retreat of the shoreline.
2. Add riprap in select areas, similar to that at Criscuolo Park.

Flooding and Deterioration of Port and Terminal Area

1. Post notification and place barricades along Forbes Avenue to avoid using the road during flood events combined with coastal storms or very high tides.
2. Request information annually from terminals about their bulkhead and seawall management, encouraging property owners to plan for sea level change.

Flooding of Quinnipiac River Estuary

1. Conduct semi-annual inspections of the Cranston Brook culverts.
2. Conserve available land in the mapped floodplain of the Quinnipiac River estuary, and available land that is up to three feet higher in elevation, to allow for landward advancement of the marshes. The New Haven Land Trust should be made the responsible authority for acquiring these lands.
3. Conduct monthly inspections of the storm drain catch basins along Middletown Avenue between the Quinnipiac River and Foxon Boulevard.
4. Encourage CT DOT to increase inspections and cleanouts of culverts under I-91 and its interchanges in the vicinity of Little River and Cranston Brook, as they can back up water into residential areas.
5. Re-zone land in the Quinnipiac River estuary to protect land that can not be acquired.
6. Post notification and place barricades along Middletown Avenue and Foxon Boulevard to avoid using the road during flood events combined with coastal storms or very high tides.
7. Commission an engineering study to evaluate the feasibility of installing a pumping system and/or tide gate system for the length of Middletown Avenue between the Quinnipiac River and Foxon Boulevard. The study must consider the effects of a rising base level due to sea level change.

Flooding of Hemingway Creek

1. Conduct monthly debris removal from Hemingway Creek in the spring, summer, and fall.
2. Clean the culverts at Eastern Street and Quinnipiac Avenue where it crosses the Hemingway Creek floodplain.
3. Elevate Eastern Street to overcome the issues related to topography and drainage.

Flooding and Deterioration of Fair Haven and Quinnipiac River Park

1. Add riprap to a higher elevation along the central portion of Quinnipiac River Park to keep up with rising sea level and mitigate for existing soil erosion above the riprap.
2. Add riprap to a higher elevation in Criscuolo Park to keep up with rising sea level and mitigate for existing soil erosion above the riprap. (City currently completed the design for this one and waiting for permitting.)
3. Conduct annual inspections of the bulkheads in northern and southern Quinnipiac River Park and repair as needed.
4. Post notification and place barricades along River Street to avoid using the road during flood events combined with coastal storms or very high tides.
5. On City property, repair bulkheads between Ferry Street and Criscuolo Park and raise their elevations when repairs are made to account for changing sea level.

6. Encourage private property owners between Ferry Street and Criscuolo Park, and along the Mill River, to repair and maintain bulkheads, raising their elevations when repairs are made to account for changing sea level.
7. Encourage private property owners along the Mill River north of Grand Avenue to armor riverbanks to reduce erosion, while accounting for changing sea level.

Flooding and Deterioration of Belle Dock Terminal and Long Wharf

1. Add riprap to a higher elevation along Long Wharf Park as needed to keep up with rising sea level and mitigate for soil erosion above the riprap.
2. Beach nourishment should be pursued to mitigate for landward erosion if it occurs.
3. Obtain a supply of sandbags and other water barriers for use at the viaducts into the Sargent Drive and railroad yard areas.
4. Repair bulkheads and raise their elevations when repairs are made to account for changing sea level.
5. Raise the elevation of intersections at Long Wharf Drive and Sargent Drive.

Flooding of Lower West River

1. Utilize riprap to shore up the riverbanks in the vicinity of the fire training school.

7.0 SUMMER STORMS & TORNADOES

7.1 Setting

More than any other hazards already addressed in this plan, summer storms and tornadoes have the potential to affect any area of the City of New Haven. Furthermore, because these types of storms and the hazards that result (wind, hail, and lightning) might have limited geographic extent, it is possible for a summer storm to harm one area within the City without harming another. The entire City of New Haven is therefore susceptible to summer storms and tornadoes. Infact quite recently, on June 24, 2010 and July 21, 2010, two tornadoes struck Connecticut, one of which had an impact on New Haven County as described below under Historic Record section.

7.2 Hazard Assessment

Heavy wind including tornadoes and downbursts; lightning; heavy rain or hail; and flash floods are the primary hazards associated with summer storms. Inland flooding was covered in previous sections of this plan, and will not be discussed in detail here.

A ***severe thunderstorm watch*** is issued by the National Weather Service when the weather conditions are such that a severe thunderstorm (damaging winds 58 miles per hour or more, or hail three-fourths of an inch in diameter or greater) is likely to develop. A ***severe thunderstorm warning*** is issued when a severe thunderstorm has been sighted or indicated by weather radar.

Tornadoes

Tornadoes are spawned by certain thunderstorms. The Fujita scale is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure. The Fujita scale has been accepted as the official classification system for tornado damage prior to 2007. This scale ranks tornadoes as F0 through F6, increasing in wind speed and intensity. The following graphic of the Fujita scale is provided by FEMA. A description of the scale follows in Table 7-1.

Fujita Tornado Scale

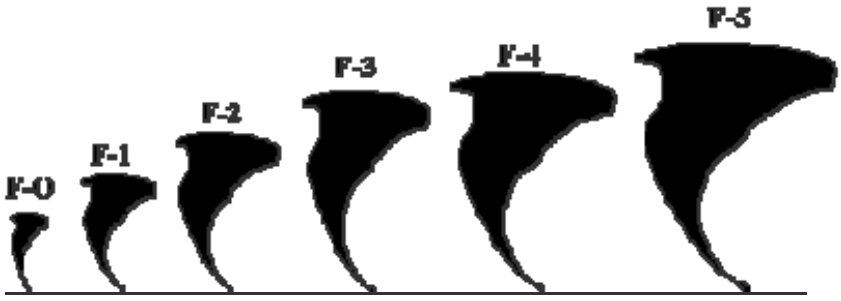


Table 7-1
Fujita Scale

F-Scale Number	Intensity	Wind Speed	Type of Damage Done
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73-112 mph	The lower limit is the beginning of hurricane wind speed; 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 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 re-inforced concrete structures badly damaged.
F6	Inconceivable tornado	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

According to NOAA, weak tornadoes (F0 and F1) account for approximately 69% of all tornadoes. Strong tornadoes (F2 and F3) account for approximately 29% of all tornadoes. Violent tornadoes (F4 and above) are rare but extremely destructive, and account for only 2% of all tornadoes.

The Enhanced Fujita Scale was released by NOAA for implementation on February 1, 2007. According to the NOAA web site, 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.

The Enhanced F-scale is still a set of wind estimates based on damage. It uses three second gusts estimated at the point of damage based on a judgment of eight levels of damage to 28 specific indicators. Table 5-2 relates the Fujita and enhanced Fujita scales.

Table 7-2
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

The historic record of tornadoes is discussed in Section 7.3. The pattern of occurrence in Connecticut is expected to remain unchanged, according to the Connecticut Natural Hazard Mitigation Plan. The highest relative risk for tornadoes in the state will continue to be in the Hartford and New Haven areas. Thus, New Haven County may anticipate a tornado strike once every five years, on average. The City would be struck by a tornado on a less-frequent basis, although the potential for a strike is always present. Overall, the risk to the City of New Haven is believed to be low to moderate for any given year.

Lightning

Thunderstorms occur 18 to 35 days each year in Connecticut, with the City of New Haven experiencing an average of 27 days per year with thunderstorm activity. In general, thunderstorms in Connecticut are more frequent in the western and northern parts of the state, and less frequent in the southern and eastern parts, with New Haven experiencing an intermediate number of storms.

Although lightning is usually associated with thunderstorms, it can occur on almost any day. The likelihood of lightning strikes in New Haven is very high during any given thunderstorm. In addition, several notable areas of New Haven are more susceptible than other communities due to striking elevation changes at West Rock and East Rock, and associated with tall downtown buildings.

Lightning is a circuit of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. 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.

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.

Lightning reportedly kills an average of 87 people per year in the United States, in addition to an average of 300 lightning injuries per year. 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.

Downbursts

A downburst is a severe localized wind blasting down from a thunderstorm. They are more common than tornadoes in Connecticut. These "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris. Depending on the size and location of these events, the destruction to property may be significant. Downbursts may be categorized as microbursts (affecting an area less than 2.5 miles in diameter) or macrobursts (affecting an area at least 2.5 miles in diameter).

It is difficult to find statistical data regarding frequency of downburst activity. However, downburst activity is, on occasion, mistaken for tornado activity in Connecticut, indicating that it is a relatively uncommon yet persistent hazard. The risk to the City of New Haven is believed to be low to moderate for any given year.

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 a pound have been recorded. While crops are the major victims of hail, it is also a hazard to vehicles and property.

Hailstorms typically occur in at least one part of Connecticut each year during a severe thunderstorm. As with thunderstorms, hailstorms are more frequent in the northwest and western portions of the state, and less frequent in the southern and eastern portions. Overall, the risk of at least one hailstorm occurring in the City of New Haven is moderate in any given year.

7.3 Historic Record

The National Climatic Data Center (NCDC) listed 106 thunderstorm and high-wind events for New Haven County between 1950 and 2004. Of these events, 54 had winds at or above 50 knots.

Two injuries were caused by an August, 1998 thunderstorm and wind event, and one death was caused by an event in June of 2000. These storms are not documented as causing any property damage. Twenty major lightning events have been recorded in New Haven County, causing a total of five injuries and $90,000 in damage.

Between 1905 and 1963, hail was recorded in New Haven on an average of just under one day per year. From 1950 to 2004, 26 hail events were reported for New Haven County. In a recent example, a hail event occurred in the City of New Haven on July 18, 1997, resulting in 0.75 inches of hail. No hail events were recorded in New Haven County since 2005 (based on data obtained from NCDC).

A total of 81 tornado events have been recorded in Connecticut since 1950; 14 of these occurred in New Haven County. The tornado events in New Haven County ranged from F0 to F4 on the Fujita scale. These 13 tornadoes caused almost $280 million in damages, injured 137 people, and caused the death of one person. Major tornado events in Connecticut include the Windsor Locks tornado of October 1979, and the Cornwall-to-Hamden tornado of July 1989. According to the National Climactic Data Center, this tornado ranged from an F2 to an F4 on the Fujita scale, injured 90 people, and caused $275 million in damage.

Since 2005, several tornadoes hit various places in Connecticut indicating that there is a high probability of a tornado striking New Haven in any given year. Below is a record of all tornadoes and a description of damages associated with them (Source: Connecticut Tornadoes on Wikipedia):

- **July 12, 2006:** The Westchester tornado that produced F2 damage across the border in New York entered Greenwich at 4:01 PM, producing F1 damage on the north side of town. It may have briefly touched down a second time just north of the Merritt Parkway.
- **May 16, 2007:** Just three months after the switch to the Enhanced Fujita Scale for rating tornadoes, a skipping tornado, rated EF1, tracked 4 to 5 miles (6 to 8 km) from Bethel to Newtown. Widespread wind damage also affected other parts of the state.
- **May 28, 2007:** An EF0 landspout damaged the roof of a barn in Somers, on an otherwise calm day.
- **June 26, 2009:** An EF1 tornado hit the town of Wethersfield. Widespread damage across town especially near the area of Wolcott Hill. Many downed trees caused damages, most notably in Old Wethersfield where a tree split a house in town, and destroyed a front porch. Damage was estimated at around $2.4 million.
- **July 31, 2009:** Significant wind damage was reported across the state, including two EF1 tornadoes. The first tornado caused tree and minor property damage along a 0.5-mile (0.80 km) path through eastern Shelton. The second downed trees along a sporadic 2.75-mile (4.4 km) path in Madison. Many trees were also snapped and uprooted in Fairfield, Milford, Guilford, Chester, Old Lyme and Naugatuck.
- **June 24, 2010:** A tornado briefly touched down in downtown Bridgeport, embedded within a larger area of strong wind damage which downed trees and damaged several buildings. 9 roofs were damaged causing the city to declare a state of emergency. The National Weather service confirmed it as an EF-1 tornado, estimating it to be 100 yards wide with winds of at least 100 mph. The damage was especially concentrated to the east end of Bridgeport and the Lordship section of Stratford. Both areas were declared states of emergencies for at least 24 hours after the storm hit.

- **July 21, 2010:** Several severe storms spread wind damage across the state. Straight-line wind damage was reported throughout the state and there were four locations that the National Weather Service concluded to have tornado touchdowns. One touchdown was reported in Litchfield, and a EF1 tornado was confirmed in Bristol. The Bristol tornado was on the ground for 1.5 miles and had winds at 90mph. A touchdown was also confirmed in Litchfield, Thomaston, the Terryville section of Plymouth and Bristol Wednesday afternoon, the National Weather Service said. The tornado touched down in East Litchfield around Litchfield Road, in Thomaston near D. Welter Way, in Terryville near North Street and in Bristol near Blakeslee and High streets. Tree tops were twisted off and several trees were uprooted. In Bristol, the tornado's path was one and a half miles long and about 25 yards wide. Wind gusts were about 90 mph. The paths in the other three towns were shorter, but all of the touchdowns were caused by the same supercell, meaning there were not four separate tornadoes, but four separate touchdowns from the same tornadic supercell.

7.4 Existing Programs, Policies, and Mitigation Measures

The Connecticut Building Codes include guidelines for Building Officials and Code Administrators (BOCA) Wind Load Criteria that are specific to each municipality. The Emergency Operations Plan (EOP) for the City of New Haven contains information and guidelines for the proper response to a severe summer storm or tornado event. As described in the previous chapters, the City has now adopted a reverse 911 system through which residents in affected areas or city-wide could be notified of impending emergency and other needed information for evacuation.

Tables 7-2 and 7-3 list the National Oceanic and Atmospheric Administration (NOAA) Watches and Warnings, respectively, as pertaining to summer storms and tornadoes observed in the EOP:

Table 7-3
NOAA Weather Watches

Weather Condition	Meaning	Actions
Severe Thunderstorm	Severe thunderstorms are possible in your area.	Notify your personnel, and watch for severe weather.
Tornado	Tornadoes are possible in your area.	Notify your 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 your personnel to watch for street or river flooding.

Table 7-4
NOAA Weather Warnings

Weather Condition	Meaning	Actions
Severe Thunderstorm	Severe thunderstorms are occurring or are imminent in your area.	Notify your personnel and watch for severe conditions or damage (i.e. downed power lines and trees. Take appropriate actions listed in department and City EOP.

Tornado	Tornadoes are occurring or are imminent in your area.	Notify your personnel, watch for severe weather and insure personnel and equipment are protected. Take appropriate actions listed in department and City emergency plans.
Flash Flood	Flash flooding is occurring or imminent in your area.	Notify personnel to watch local rivers and streams. Be prepared to evacuate low-lying areas. Take appropriate actions listed in department and City emergency plans.

7.5 Vulnerabilities and Risk Assessment

The central and southern United States are at higher risk for lightning and thunderstorms than northeast. However, more deaths from lightning occur on the East Coast than elsewhere, according to FEMA. 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 the downburst from a thunderstorm, and have no associated rotation.

The City of New Haven is particularly susceptible to damage from high winds due to its heavily treed landscape and high residential density. However, overall risk is decreased by the lack of mobile home parks in the town.

7.6 Potential Mitigation Measures, Strategies, and Alternatives

Both FEMA and the NOAA websites contain valuable information regarding preparing for a protecting oneself during a tornado, as well as information on a number of other natural hazards. This information is available at:

FEMA
http://www.fema.gov/library/prepandprev.shtm.

NOAA
http://www.nssl.noaa.gov/NWSTornado/

Available information from FEMA includes:

- Design and construction guidance for community shelters.
- Recommendations to better protect from tornado damage for businesses, community, and homes. This includes construction and design guidelines for business and homes, as well as guidelines for creating and identifying shelters.
- Ways to better protect property from wind damage.
- Ways to protect property from flooding damage.
- Construction of safe rooms within homes.

NOAA information includes a discussion of family preparedness procedures and the best physical locations during a storm event.

Specific mitigation steps that can be taken to prevent property damage and protect property are listed in the next section. Some of these remain the same as those outlined in HMP 2005. The City-wide tree limb inspection program that has been recommended within the previous plan

(HMP 2005) could not be implemented due to financial constraints. Therefore, it is once again listed as preventive measure to be adopted within this plan update.

The previous HMP (2005) requires that the utilities should be placed underground. Although the City requires the developers of new constructions to place utilities underground, in some cases this does not become feasible due to the huge expenses involved. However, within this plan update it is once again reiterated that utilities should be placed underground, to the extent possible.

The previous HMP (2005) requires that the Building Department should provide the necessary literature on building design criteria to potential developers. The City's Building Department has adopted the International Building Codes in December 2005. These outline specific design criteria to be followed during the permitting process for construction. The City now requires the developers to follow these codes for building design.

Prevention

- Implement a City-wide tree limb inspection program to ensure that the potential for downed power lines is minimized.
- Place utilities underground, to the extent possible.

Property protection

- Encourage, or consider requiring, the use of storm shutters along the coastline.

7.7 Recommended Actions

The following actions are recommended and listed below in order of higher ranking to lower ranking using the STAPLEE method:

1. Implement a City-wide tree limb inspection program to ensure that the potential for downed power lines in diminished.
2. Encourage the use of storm shutters during severe storms.
3. Utilities should be placed underground to protect from wind damage, to the extent possible.

8.0 WINTER STORMS

8.1 Setting

Similar to summer storms and tornadoes, winter storms have the potential to affect any area of the City of New Haven. However, unlike summer storms, winter events and the hazards that result (wind, snow, and ice) have more widespread geographic extent. The entire City of New Haven is therefore susceptible to winter storms.

8.2 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. Wind driven waves can batter the coastline, 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.

Severe winter storms can produce an array of hazardous weather conditions, including heavy snow, blizzards, freezing rain and ice pellets and extreme cold. The National Weather Service defines a blizzard as winds over 35 mph with snow and blowing snow reducing visibility to near zero.

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.

8.3 Historic Record

According to the NCDC, there have been 162 snow and ice events in the State of Connecticut since 1993, causing over $18 million in damages. Notably, heavy snow in December 1996 caused $6 million in property damage. Two winter storm events in 1997, dated March 31st and April 1st, caused $1 million in damages each. On March 5, 2001, heavy snow caused $5 million in damages, followed by another heavy snow event four days later that caused an additional $2 million in damages. In November of 2002, an ice storm caused $2.5 million in property damage. The last documented blizzard event occurred in January of 1996. These events were recorded for various counties throughout the state.

With regard to major nor'easters, six have occurred in Connecticut during the past 25 years (in 1979, 1983, 1988, 1992, 1996, and 2003). The 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 Ginger in 1996 caused over two feet of snow and shut down the state for 24 hours.

There were 24 snow storm events recorded in New Haven County since 2005 (based on NCDC data). Of these, 16 were recorded as heavy snow events. There was only one ice storm, which occurred quite recently in 2009. This caused one death and three injuries, besides causing power outages and uprooting of trees and power lines in some areas of Northern Fairfield and Northern New Haven Counties.

8.4 Existing Programs, Policies, and Mitigation Measures

Existing programs applicable to coastal flooding and storm surges are the same as those discussed in Sections 4.0 and 5.0. Programs that are specific to winter storms are generally those related to preparing plows, sand and salt trucks, and other associated snow removal and response preparations.

8.5 Vulnerabilities and Risk Assessment

As mentioned for summer storms, the heavily treed landscape in close proximity to densely populated residential areas in the City of New Haven poses problems in relation to blizzard condition damage. Tree limbs and some building structures may not be suited to withstand high wind and snow loads.

In addition, winter storms present some potentially unique vulnerability. 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.

With regard to coastal flooding, the same vulnerable populations discussed in Section 4.0 are vulnerable to flooding caused by nor'easters. Further "flood" damage could be caused by flooding from frozen water pipes.

8.6 Potential Mitigation Measures, Strategies, and Alternatives

Potential mitigation measures for nor'easters include those appropriate for coastal flooding. These were presented in Section 4.0. However, winter storm mitigation measures must address blizzard, snow, and ice hazards. These are emphasized below.

8.6.1 Prevention

Cold air, snow, and ice cannot be prevented from impacting any particular area. Thus, mitigation should be focused on property protection and emergency services (discussed below) and prevention of damage as caused by breakage of tree limbs. Previous recommendations for tree

limb inspections and maintenance in Sections 5.0 and 7.0 are thus applicable to winter storm hazards, as well.

8.6.2 Property Protection

Property can be protected during winter storms through the use of shutters, storm doors, and storm windows. 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. Heating coils may be used to remove snow from flat roofs. Pipes should be adequately insulated to protect against freezing and bursting. All of these recommendations should apply to new construction, although they may also be applied to existing buildings during renovations. As mentioned in the previous chapter, the City adopted the International Building Codes in 2005, which outline some of these as building design criteria.

8.6.3 Public Education and Awareness

The public is typically more aware of the hazardous effects of snow, ice, and cold weather than they are with regard to other hazards discussed in this plan. 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. Such type of information is generally published on the city website before an impending storm to ensure public safety.

8.6.4 Emergency Services

Plowing the access to and from critical facilities, such as hospitals and the shelters that were listed in Tables 2-1 and 2-2, should be prioritized. It has been recognized in the previous plan (HMP 2005) that this may not be a priority to all residents, as people typically expect their own roads to be cleared as soon as possible. Since the City already has the new reverse 911 system in place, it would be best to notify residents about an emergency through this system and prioritize plowing of the route accordingly.

8.7 Recommended Actions

Based on the STAPLEE method ranking, the small number of possible mitigation measures is ranked similarly, and are therefore recommended with equal importance.

9.0 LAND SUBSIDENCE

9.1 Setting

Land subsidence is the collapse of the Earth's surface elevation due to the removal of subsurface support or due to tectonic equilibration. Subsidence thus ranges from broad, regional lowering of the land surface to local collapses. Subsidence may be due to a general settling of the fill material, or due to the decay and subsequent compaction of organic materials, such as tree roots contained in the fill material.

On a regional scale, subsidence is occurring in Connecticut as a result of deglaciation, which increases the relative sea level rise along the entire coast. Local subsidence in the City of New Haven also occurs, as a result of settling and sinkholes in fill material. Section 6.0 covered the effects of relative sea level rise, to which regional subsidence contributes. This section will address the phenomenon of local subsidence.

9.2 Hazard Assessment

Areas within the City that have been built on artificial fill are more susceptible to local subsidence. Settling and the occurrence of sinkholes has been identified by City residents as occurring in the Morris Cove neighborhood, on Beverly Road in Westville, and along Middletown Avenue. Most of the issues related to sinkholes and settling within the city attribute to the city's aging infrastructure, which is more than 100 years old. Damage from local subsidence consists of direct structural damage, property loss and depreciation of land values, as well as business and personal losses that accrue during periods of repair. Generally, subsidence poses a greater risk to property than to life.

With regard to future likelihood of occurrence, settling and subsidence are likely to occur in any area that has been subject to filling, as well as in areas where prior subsidence has already been documented. However, the likelihood of settling and subsidence occurring in any location in the City underlain by natural subsurface materials is low.

9.3 Historic Record

The Department of Public Works maintains a database of complaints that are related to sinkholes and settling. The following information was included as list of complaints in the previous HMP:

- Report of a huge hole and street collapsing at 151 Harrington Avenue (01/03/1990).
- Report that the street is sinking, possible cave-in, at 664 Russell Street (03/20/1990).
- Report of large cave-in, approximately the length of two school buses, at 121 Hemingway Street (06/27/1990).
- Report that the "whole street" is caving in at 14 Boston Avenue (05/25/1993).
- Report that a sinkhole is starting to cave-in by Elm City Auto at 46 Middletown Avenue (07/03/2002).
- Numerous reports from Dean Street in Morris Cove neighborhood show that a large sinkhole is occurring, even after repairs. The area is reported by have sunk greater than eight inches since last repair (October – November 2002).
- Report that a sinkhole is collapsing at the corner of Eden and Dean Streets (06/30/2002).
- Report of a 15 foot deep cave-in at College Street and South Frontage Road (07/21/2004).

The Department has taken care of almost every single issue listed above within the past five years. These locations were re-examined during the preparation of this update and the staff found that no major issues are now found at these locations.

The following information was gathered from City residents at a public meeting held in March 29, 2005:

- A large sinkhole formed at Concord and Dean Streets.
- A nearby foundation has cracked.
- Foundations are failing on Beverly Road.

While the first two have been taken care of in the recent past (after 2005), the third one is difficult to correct as these homes were built on an ice pond that previously existed at this location. The City is currently looking at ways to mitigate this issue.

9.4 Existing Programs, Policies, and Mitigation Measures

The Department of Public Work's complaint database tracks issues related to sinkholes and local subsidence. Problems in streets and on public property are repaired as needed. The City does not have a comprehensive program for addressing or preventing sinkholes and settling, nor is it likely that one would be effective. Most of the issues due to sinkholes and settling are due to the aging infrastructure in the city and these are generally taken care of by the Department of Public Works whenever a complaint is filed.

As noted in the River Street MDP, pilings will be needed for new buildings in the River Street redevelopment area, due to characteristics of local soils. Fortification of this type will prevent buildings from subsidence in the area. The City is currently in the process of implementing the various recommendations outlined in the River Street MDP.

9.5 Vulnerabilities and Risk Assessment

Local subsidence is a small-scale phenomenon that affects a small number of buildings or streets in a limited number of areas. Settling is a relatively slow process, although sinkholes can appear to form quickly as the surface manifestation of settling becomes visible. To date, the majority of the problems have been recorded near Beverly Road, in the Morris Cove neighborhood, and along Middletown Avenue, although any areas built on artificial fill are susceptible and possibly vulnerable. As mentioned earlier, these homes have been built on an ice pond that previously existed at this location. The City is currently looking at ways to mitigate this issue.

9.6 Potential Mitigation Measures, Strategies, and Alternatives

The following mitigation measures were already mentioned in HMP 2005 and remain the same for the current plan update also. Some of these measures were adopted in the past five years such as requiring potential developers to review aerial photographs and improving the tracking of settling problems through new software that will be launched very soon. The others could not be implemented due to financial constraints.

- Improve the tracking of settling problems to distinguish them from potholes and sinkholes caused by failing utilities.

- Apply a categorical classification system to historical complaints from the DPW complaint databases to distinguish settling problems from potholes and sinkholes.
- Identification and mapping of other potentially hazardous settling or sinking sites.
- Require potential developers to review historical atlases, maps, aerial photographs, and/or reports for evidence that subsidence could occur as part of Site Plan Review process.
- Public awareness regarding potential hazards.
- Adjusting local zoning ordinances to account for potentially hazardous conditions, including a new Site Plan Review hazard mitigation checklist.

Restorative actions include site re-grading and repairs to homes and structures, although these are more accurately classified as emergency response than as hazard mitigation.

9.7 Recommended Actions

Given the small number of potential mitigation measures available for addressing settling and sinking, all are recommended.

10.0 EARTHQUAKES AND ROCKSLIDES

According to the latest structural design criteria listed in the 2005 State Building Code, the intensity of an earthquake on a particular region is based on the type of structures impacted unlike the past when the intensity of an earthquake was classified by regional location. Each structure is assigned a seismic use group and a corresponding occupancy importance factor. Seismic Use Group I structures are those that are not assigned in Seismic Groups II and III. Seismic Use Group II structures are those for which failure would result in substantial public hazard due to occupancy. Seismic Use Group III structures are those having essential facilities that are required for post-earthquake recovery and those containing substantial quantities of hazardous substances.

Since there was no major impact of earthquakes or rockslides in New Haven within the past five years, most of the information that has been presented on this topic in the previous plan (HMP 2005) remains the same for the current update also.

10.1 Setting

The entire City of New Haven is susceptible to earthquakes. However, even though earthquakes have the potential to occur anywhere in the City of New Haven, the effects may be felt differently in some areas based on the type of geology.

Only a small number of areas in the City of New Haven are susceptible to rockslides, given that they only occur where slopes are steep and relatively unstable. East Rock, West Rock, and two residential areas are considered to be most susceptible to rockslides.

10.2 Hazard Assessment

Earthquakes

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 phone lines, 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 micro-earthquakes, 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.

The following is an abbreviated description of the 12 levels of Modified Mercalli intensity from the United States Geologic Society.

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, 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. Rail bent.
XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Damage total. Lines of sight and level are destroyed. Object thrown in the air.

Earthquakes in Connecticut are not associated with specific known faults, as opposed to seismic activity in California. Earthquakes with epicenters in Connecticut are referred to as intra-plate 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, potentially putting a greater number of people at risk.

Liquefaction is defined as the transformation of water-saturated granular material from the solid state to a liquid state. Earthquake-induced ground motion can cause the ground to flow and/or lose its strength. Fill material has an increased potential for liquefaction as compared to other surficial materials. As discussed in previous sections, many near-shore areas in New Haven are comprised of fill material.

The built environment in Connecticut includes old, unreinforced masonry that is not seismically designed. People who live or work in unreinforced masonry buildings built on filled land or unstable soils are at the highest risk for injury due to earthquakes, should one occur.

In general, it is difficult to quantify the overall risk or likelihood of an earthquake occurring in Connecticut. Such predictions are not well-published. However, the City of New Haven is unlikely to experience an earthquake in any given year, given the historical record presented in Section 10.3.

Rockslides

Rockslides are a subset of the process known as "mass wasting." Mass wasting includes everything from a roadside slumping problem to massive debris flows in mountainous areas. Rockslides are typically similar to landslides except that the debris is composed of sliding and falling rock. In a city such as New Haven where the bedrock formations are geologically old and stable, and the sand and gravel formations are at low elevations without significant relief, small-scale rockslides are uncommon but can occur.

Rockslides typically occur as loose rock accumulates along the edges of the trap rock (basalt) and sedimentary rock deposits in New Haven. The continuous freezing and thawing of moisture in the fissures of the rock causes the rock to split and separate as the ice expands. Eventually the fragments succumb to the force of gravity. An accumulation of this debris may eventually become unstable "en mass" and form a landslide, although individual rockslides are more common in New Haven. In general, the future likelihood of a landslide occurring in the City of New Haven is low, whereas the future likelihood of a rockslide occurring in New Haven is moderate along the trap rock ridges.

10.3 Historic Record

Earthquakes

According to the USGS Earthquake Hazards Program, Connecticut is a region of very minor seismic activity. This assessment is based on lack of historical and instrumental reports of strong earthquakes. However, earthquakes do occur in this region. Connecticut, Rhode Island, Massachusetts, and New Hampshire regularly register seismic events.

Earthquakes were recorded very early in Connecticut's history. There were 137 recorded earthquakes in Connecticut between 1568 and 1990. 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. In October 1845, an Intensity V earthquake occurred in Bridgeport. An Intensity V earthquake would be a 4.3 on the Richter scale. Another Intensity V earthquake was reported in Stamford in March of 1953. All other seismic activity in Connecticut has ranked less than Intensity V.

North Haven was shaken by a moderate tremor in June 1858, in which residents reported rattling of glasses and a noise "like a carriage crossing a bridge." This was an Intensity IV earthquake, as was the one that was experienced in New Haven in July of 1858.

In 1982 and 1983, two relatively small earthquakes were felt east and west of Bridgeport, respectively. The earthquake in 1982 had a magnitude of 1.1; the 1983 earthquake had a magnitude of 1.8. In August of 1988, an earthquake of magnitude 2.0 is documented in New Haven. In April of 1989, two documentations of earthquakes were made, in West Haven (magnitude 1.6) and southeast of New Haven (magnitude 2.8). In 1990, a magnitude 2.8 earthquake registered north of New Haven. However, a magnitude 3.0 or greater earthquake has not occurred in Connecticut in over 30 years.

Rockslides

Rockslides that occur at the peripheries of East Rock and West Rock within the park land are believed to occur, but there is little record of this because residential areas are rarely affected. In contrast, smaller-scale rockslides with very limited geographic extent that occur along Roosevelt Street and Myron Street are more frequently reported by residents. Therefore, the historic record is focused on these rockslide areas.

In particular, an Alderman for the Morris Cove neighborhood notified the New Haven Public Works Department in May 2000 that large rocks had been sliding from a ridge near Myron Street, comprising a "potentially hazardous situation." Houses on Ira Street are located on the ridge, and retaining walls that were reportedly required to be built with the houses, were not constructed. Up to eight homeowners on Myron Street were potentially affected by the sliding rocks. This represents minor geographic risk in terms of loss of buildings or structures, and little to no risk of loss of life.

10.4 Existing Programs, Policies, and Mitigation Measures

The Connecticut Building Codes include design criteria for buildings specific to municipality, as adopted by the Building Officials and Code Administrators (BOCA). These include the seismic coefficients for building design for New Haven. The Building Department of the City of New Haven has adopted these codes for new construction.

Land use policies in the City of New Haven do not address earthquake hazards or rockslides. This is mainly due to a lack of available space and the mostly built-out nature of the City.

10.5 Vulnerabilities and Risk Assessment

Earthquakes

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. Increased shaking and liquefaction can cause greater damage to buildings and structures, and a greater loss of life.

Major portions of New Haven are underlain by sand and sand over gravel. Figure 2-5 shows surficial materials of the City of New Haven. In addition to sandy areas, there are large portions of the City built on fill. Structures in these areas are at increased risk from earthquakes due to amplification of seismic energy and liquefaction. The best mitigation for future development in these areas may be application of stringent building codes.

The areas that are not at increased risk during an earthquake due to unstable soils are the areas in Figure 2-5 underlain by glacial till and sand and gravel over sand. These areas include the most northwesterly portion of the City, a central peninsula north of the downtown district, and the eastern portion of the City that borders East Haven.

Dam failure can pose a significant threat to developed areas during an earthquake. There are three major dams in New Haven. These are Lily Pond dam, Beaver Pond dam, and Conrad Pond dam. Lily Pond dam and Beaver Pond dam are listed as Class A hazards. Class A represents a low hazard potential. Failure of these types of dams would result in damage to agricultural land and unimproved roadways and minimal economic loss. Lily Pond dam is not actively restricting a large amount of water. Thus, a failure of this dam would likely not introduce greatly increased flows to the area.

Conrad Pond dam is listed as having a Class B – significant hazard potential. Failure of these types of dams are classified to result in the possible loss of life, minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to or interruption of the use of service of utilities; damage to primary highways; and significant economic loss. Conrad Pond dam is located upstream from a large residential area comprised of single family homes. The Conrad Pond dam contains a significant amount of water that could have adverse effects on this residential area.

The classifications listed above are general in nature. The exact damages described would not necessarily occur in every instance.

Rockslides

The rock slide areas within the City were investigated as part of the planning process of the previous HMP. Two areas that were specifically identified were Roosevelt Drive in the northeast section of the City, and Myron Street in the Morris Cove neighborhood. Both of these areas represent minor geographic risks in terms of loss of buildings or structures, and little to no risk of loss of life.

The area of the rockslide on Roosevelt Street is at the end of a cul-de-sac; talus was evident along the road. A major rockslide in this area could potentially affect one home on the north side of Roosevelt Avenue. The rockslide area at Myron Street could introduce debris to a number of residential homes. Major rockslides in this area could have the potential to affect or injure the residents of these homes.

10.6 Potential Mitigation Measures, Strategies, and Alternatives

The following potential mitigation measures have been identified as pertaining to earthquakes and rockslides in the City of New Haven in HMP 2005 and remain the same for the current plan update also:

- Prevent residential development in areas prone to liquefaction.
- Prevent residential development on or below steep slopes.
- In the vicinity of rockslides on Myron Street where private properties may be affected, facilitate collaboration between residents to find a solution to the problem.

- In the vicinity of rockslides on Myron Street where public access is possible, post notification of the hazard and advise residents to avoid the area.
- In the vicinity of rockslides on Roosevelt Street where public access is possible, post notification of the hazard and advise residents to avoid the area.

The above mentioned measures were also listed in HMP 2005. The City could not communicate with residents on Myron Street in the past five years due to other priorities and goals that have taken precedence over this issue.

Based on the STAPLEE method ranking, the small number of possible mitigation measures is ranked equally and are therefore recommended with equal importance.

11.0 GENERAL AND PRIORITY RECOMMENDATIONS

11.1 General Recommendations

The following were general recommendations outlined in HMP 2005 to improve the ability of the City to track hazard complaints and apply mitigation measures. Most of these have already been implemented over the past five years as explained below. For the 2010 plan update, no new recommendations are listed, except for needing increased cooperation among various city departments in implementing various priority projects for hazard mitigation.

2005 HMP general recommendations:

- Consider developing subdivision regulations that will allow for controls of residential development, such as limiting development in the Fort Hale area and controlling development that may be affected by rockslides from steep slopes;
- Implement a complaint tracking database in the Engineering Department that complements the existing DPW complaint database;
- Provide for more accurate categorization of complaints through the complaint tracking database;
- Implement a reverse 911 system that allows the City to alert various segments of the population depending on the nature of the emergency; and
- Create a tool for planning agencies to apply regulations and policies necessary for hazard mitigation.

Although the city does not have sub-division regulations, the Planned Development District (PDD) regulations outlined in the zoning ordinance allow the city to limit development in areas affected by steep slopes.

The City is currently in the process of upgrading the current software for logging complaints, tracking permits and issuing work orders. This will also enhance the cooperation among various departments. This switch to the new software will take place shortly (by the end of this year) thus enabling Engineering Department and DPW along with other city departments to have more accurate categorization and tracking of complaints.

The reverse 911 system has been adopted by the Office of Emergency Management in the recent past (after 2005) to notify residents of affected areas about an impending emergency.

The City Plan Commission has adopted new floodplain ordinances quite recently (as of July 21, 2010) that allow for increased protection against hazards. An amendment to the zoning ordinance was also made accordingly and will be adopted by the Board of Aldermen (BOA) shortly.

11.2 Priority Recommendations

The following recommendations have been identified by the City of New Haven project team as the highest priority projects and/or policies for the next five years. These priority projects are summarized from each chapter of this document. Locations where these recommendations would be applied are depicted on Figure 11-1.

Figure 11-1 Priority Recommendations Location Map

1. *Flooding and Deterioration of Embankment near Ferry Street Bridge (Brewery Square)*

- Fix pothole in the bulkhead immediately north of Ferry Street bridge.
- Conduct annual inspections of the bulkheads in northern and southern Quinnipiac River Park and repair as needed.
- On City property, repair bulkheads between Ferry Street and Criscuolo Park and raise their elevations when repairs are made to account for changing sea level.
- Encourage remaining private property owners between Ferry Street and Criscuolo Park, and along the Mill River, to repair and maintain bulkheads, raising their elevations when repairs are made to account for changing sea level.

Estimated Cost: $ 600,000
Administering Agency: Department of Engineering
Time Frame: By 2012

2. Flooding and Deterioration of Morris Cove Shoreline

- Beach nourishment should be pursued to mitigate for further downward erosion at Pardee Seawall. Begin allocating funding for beach replenishment. This will help protect the wall.
- As sea level rises, continue with beach nourishment and conduct annual inspections of Pardee Seawall.

Estimated Cost: $ 1.2 million
Administering Agency: Department of Engineering
Time Frame: By 2015

3. Flooding and Deterioration of East Shore Park

- As sea level rises, continue with beach nourishment but consider allowing a retreat of the shoreline.
- Add riprap in select areas, similar to that at Criscuolo Park

Estimated Cost: $ 1.2 million
Administering Agency: Department of Parks and Recreation
Time Frame: Ongoing, may complete by 2015

4. Flooding in Morris Creek and Morris Cove Neighborhood

- Inspect the Morris Creek tide gates on a monthly basis before the highest tides are anticipated.
- Immediately repair the residential seawalls near Morris Causeway to prevent flooding damage to the homes near by.

Estimated Cost: $ 3 million
Administering Agency: Department of Engineering
Time Frame: By 2015

5. *Flooding of Pond Lily Dam*

- Install a spillway to the west of the dam to prevent flooding problems at this location, which are also impacting the Town of Woodbridge.

Estimated Cost: $ 1 million
Administering Agency: Department of Engineering
Time Frame: 2013 - 2014

6. *Flooding of Quinnipiac River Estuary*

- Conserve available land in the mapped floodplain of the Quinnipiac River estuary, and available land that is up to three feet higher in elevation, to allow for landward advancement of the marshes. Allocate money for acquisition.
- Re-zone land in the Quinnipiac River estuary to protect land from inappropriate development.

Estimated Cost: $ 1 million
Administering Agency: Department of Parks
Time Frame: Unknown

7. *Flooding of Hemingway Creek*

- Raise the elevation of Quinnipiac Avenue where it crosses the Hemingway Creek floodplain and replace the bridge. Plan for sea-level change while doing so, as the creek is already at base level where it passes beneath the road.
- Conduct monthly debris removal from Hemingway Creek in the spring, summer, and fall.
- Request notification of development proposals in the East Haven portion of the Hemingway Creek watershed.
- Raise the elevation of Eastern and Hemingway Streets where they cross the Hemingway Creek floodplain and replace the bridge. Plan for sea-level change while doing so, as the creek is already at base level where it passes beneath the road.

Estimated Cost: $ 0.5 million
Administering Agency: Department of Engineering
Time Frame: Currently temporary fix in place, culvert replacement by 2015

8. *Flooding/Drainage Problems East of the Quinnipiac River Estuary*

- Conduct routine inspections of the culverts that drain the neighborhoods east of Middletown Avenue, especially where they pass beneath I-91 to the estuary.
- If funding becomes available, raise the elevation of Middletown Avenue to completely mitigate the issue of flooding.

Estimated Cost: $ 0.5 million
Administering Agency: Department of Engineering and Department of Public Works
Time Frame: By 2015

9. Flooding of West Rock Neighborhood

- Clean the culverts at Wilmot Road, Brookside Avenue, and Wintergreen Road
- Conduct routine (industry accepted standard) inspections of the storm drain catch basins along Wilmot and Wintergreen Roads.
- Improve access to and from the neighborhood through Hamden to facilitate evacuations from flooding.

Estimated Cost: $ 800,000
Administering Agency: Department of Engineering
Time Frame: By 2013, currently being addressed by the development under West Rock Hope VI Program

Based on the claims information by state obtained from FEMA website (BureauNet), nearly 296 properties filed for losses to the property as of March 31, 2010. The total payment made by FEMA as part of the flood insurance program was $2,052,927.68. Shoreline properties below 11 feet flood elevation have been mapped as seen in Figure 11-2 on the following page. Of the 850 properties that were identified as being below the current base flood elevation along the shoreline, 799 properties have insurance policies in-force right now.

Based on recent data from National Flood Insurance Program (NFIP), nearly twenty-five properties in New Haven have had repetitive flooding based on data recorded by FEMA as of June 30, 2010. These include ten single family residential uses, one mixed use building, one light industrial (equipment building), three commercial uses, one municipal building, six two-family buildings, one apartment building, and two right of way parcels (See Appendix E). Some of these properties are located in East Shore near Morris Cove neighborhood which is also identified as a priority area for mitigation activities. The combined assessed value of these properties is approximately $ 36,474,760 (See Appendix E). These properties should be elevated above the base flood elevation level by availing assistance with FEMA's pre-disaster mitigation grants.

Areas of significant beach, dune, and shoreline erosion have been mapped by the city in March 2010 to assist FEMA in preparing the new DFIRMs. These areas should also be considered as priority project areas for mitigating hazards over the next five years (See Figure 11-3).

Figure 11-2 Shoreline Properties Below 11 Feet Base Flood Elevation

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Figure 11-3 Areas of Significant Beach, Dune, or Shoreline Erosion

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Although FEMA has requested for an accompanying list of buildings, infrastructure, and critical facilities within these areas of significant beach, dune, or soil erosion, they could not be mapped due to recent budget cuts and staff shortage.

11.3 Specific Sources of Funding

The following sources of funding and technical assistance may be available for the priority projects listed above. Funding requirements and contact information is given in Section 12.0.

Marsh Restoration/Beach Replenishment/Erosion Control

- U. S. Army Corps of Engineers – *funding for beach renourishment*.
- U.S. Department of Agriculture – *technical assistance for erosion control.*
- CT Department of Environmental Protection – *assistance to municipalities to solve beach erosion problems through the Flood and Erosion Control Board Program.*
- 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 Program – *grants for pre-disaster flood hazard mitigation planning and projects.*
- 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.*
- CT Department of Environmental Protection – *assistance to municipalities to solve flooding and dam repair problems through the Flood and Erosion Control Board Program.*

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.*

General Hazard Mitigation

- FEMA Pre-Disaster Mitigation Grant Program (PDM) – *funding for hazard mitigation projects on a nationally competitive basis.*
- Americorps – *teams may be available to assist with landscaping projects such as surveying, tree planting, restoration, construction, and environmental education.*

12.0 PLAN IMPLEMENTATION

12.1 Implementation Strategy and Schedule

The New Haven City Plan Department is authorized to update this Hazard Mitigation Plan every five years, coordinate its adoption by the City of New Haven, and guide it through the FEMA approval process.

As individual recommendations of the plan are implemented, they must be implemented by the City departments that oversee these activities. The Engineering Department, Department of Public Works, and Office of Emergency Management will be primarily responsible for implementing selected projects. These projects are typically included in the City's Capital Improvement Program based on their priority. For major infrastructure projects, when funding becomes available, the residents in the neighboring area are notified about the proposed mitigation activity either through a public meeting or through a notice in the local newspaper. Once the comment and review period is closed, these mitigation activities are implemented. All major infrastructure projects and projects proposed on wetlands or in coastal area go through the City Plan Commission review process before they are implemented.

12.2 Progress Monitoring and Public Participation

Since 2005, the New Haven City Plan Department coordinated annual meetings for review of the plan. Participants in this review included representatives of the Public Works, Engineering, Emergency Services, Chief Administrator's Office, Building, and City Plan Departments.

Matters evaluated included a review of the goals and objectives of the original plan, a review of hazards or disasters that occurred during the preceding year, a review of the mitigation activities that have been accomplished to date, a discussion of why any implementation may be behind schedule, and recommendations for new projects and revised activities.

The City of New Haven World Wide Web site (http://www.cityofnewhaven.com/) includes a page called "Plans and Initiatives" devoted to recent and ongoing projects of the City Plan Department. Documents such as the Comprehensive Plan of Development are posted on the site. A link to the Hazard Mitigation Plan was added in 2006 instructing residents of New Haven to provide comments and recommendations to the City Plan Department. Similar outreach has also been enabled through the City's Office of Emergency Management. This type of progress monitoring and public participation would be continued for the current plan update also.

Besides this, a review of the projects accomplished was also done in the past annually and these annual reports were presented at the City Plan Commission (CPC)'s public meetings. A public notice about this meeting was advertised on the City Plan webpage. Once the reports have been approved by CPC, copies were sent to DEP as annual progress monitoring and evaluation. Whenever funding becomes available to implement major infrastructure projects, the neighboring area residents are notified either through a public meeting or a notice in the local newspaper. These projects are also required to be approved by the CPC before implementation. The same process will be adopted for the projects listed in the current updated plan also.

12.3 Updating the Plan

As currently done, the New Haven City Plan Department will update the hazard mitigation plan once in every five years if a consensus to do so is reached at any of the annual meetings. Updates should include deleting recommendations as projects are completed, adding recommendations as new hazard effects arise, or modifying hazard vulnerabilities as land use changes. In addition, the list of shelters and critical facilities should be updated on a regular basis.

12.4 Technical and Financial Resources

The original HMP (2005) consists of a list of resources to be considered for technical assistance and potentially financial assistance for completion of the actions outlined in the plan. The same list is applicable for this plan update also as shown below (also Refer HMP 2005, Section 12.4).

Federal Resources

Federal Emergency Management Agency
Region I
99 High Street, 6th floor
Boston, MA 02110-2320
(877) 336-2734

Mitigation Division

Administers all of FEMA's hazard mitigation programs, including: National Flood Insurance Program and Community Rating System; prepares and revises flood insurance studies and maps; information on past and current acquisition, relocation, and retrofitting programs; expertise in other natural and technological hazards, including hurricanes, earthquakes and hazardous materials. Financial assistance includes Hazard Mitigation Grant program (post--disaster); Flood Mitigation Assistance Program (pre-and post-flood), Pre-Disaster Mitigation (PDM) grant program; training for local officials at Emergency Management Institute in Emmitsburg, Maryland.

- ***Earthquake Hazards Reduction Assistant Program***: As part of the National Earthquake Hazards Reduction Program (NRHRP), the purpose of the FEMA's State Earthquake Hazards Reduction Program is to provide funds for the development of comprehensive risk reduction programs at the State level and risk reduction measures at the local level to reduce future earthquake damages and losses. The fundamental goal of the program is to reduce earthquake impacts and the subsequent loss of lives, property damages, and economic losses. To accomplish these goals, technical assistance from State programs to local governments in the areas of structural and non-structural mitigation, building codes, and land-use planning ordinances is necessary.

- ***State Hurricane Program***: This program is concerned with reducing the impacts of hurricanes and coastal storms on coastal areas of the United States and its territories as well as reducing the extent of subsequent losses. FEMA provides financial and technical assistance to State and local governments to support their efforts to mitigate the damaging

effects of hurricane and coastal storms. State Hurricane Program funds are to be used for mitigation and preparedness activities related to hurricane hazards. Each participating State receives a Local Assistance allocation of $5,000 in addition to the State Assistance Grant.

- ***Hurricane Program Property Protection - Mitigation Grants***: This element of the Hurricane Program provides grants to hurricane-prone States to implement mitigation projects. Each FEMA Region with States participating in the Hurricane Program receives funds for this activity. The Regional offices solicit the States to undertake projects that reduce the risk of loss of life or injury from damaged structures and reduce the overall cost of hurricane disasters due to property damage. This program is administered by the CT OEM.

- ***Multi-State Groups***: There are three multi-state (regional) consortia that FEMA funds: the Western States Seismic Policy Council (WSSPC), the New England States Emergency Consortium (NESEC), and the Central United States Earthquake Consortium (CUSEC). The mission of all three consortia is to support the National Earthquake Hazard Program (Reduction) funded State earthquake programs. They provide support in areas such as coordination between the States in a region and public awareness and education, and they also reinforce interactions between all levels of government, academia, non-profit associations, and the private section.

- ***Technical Assistance Contracts***: The Mitigation Directorate 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.

    - *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 non-structural mitigation measures, and evaluating the performance of seismically rehabilitated structures, post-earthquake.

- ***Hazard Mitigation Grant Program (HMGP)*:** HMGP is a post-disaster mitigation program that provides funding for hazard mitigation projects in affected counties following presidentially declared disasters. Available funds are based on a percentage of the total damages caused by the particular disaster. Grants from this program are limited to state and local governments and certain non-profit organizations. There is a need to demonstrate a positive cost/benefit analysis and a cost-share requirement of 25% to match the federal funds provided. Grants are competitive within the affected area. This program is administered by the state of Connecticut, Department of Environmental Protection (DEP).

- ***Flood Mitigation Assistance Program (FMA*):** FMA is a pre-disaster mitigation program created by the National Flood Insurance Reform Act of 1994. This program provides both project and planning grants annually for flood hazard mitigation planning and projects with direct demonstrable benefits to the NFIP insurance fund. Administratively, this program is very similar to the HMGP described above.

- ***Pre-Disaster Mitigation Grant Program (PDM*):** PDM is a pre-disaster mitigation program that provides funding for hazard mitigation projects on a nationally-competitive basis. Projects are submitted by states and communities and rated by a national panel. Yearly funding for this grant is in the millions of dollars. There is a need to demonstrate a positive cost/benefit analysis and a cost-share requirement of 25% to match the federal funds provided. This program is administered by the state of Connecticut, Department of Environmental Protection.

Response & Recovery Division

Information on dollar amounts of past disaster assistance including Public Assistance, Individual Assistance, and Temporary Housing; information on retrofitting and acquisition/relocation initiatives. Coordinates federal disaster assistance programs, including 75% grants for mitigation projects to protect eligible damaged public and private non-profit facilities from future damage through the Public Assistance Program, and 100% "minimization" grants through the Individuals and Family Grant Program.

Computer Sciences Corporation
New England Headquarters,
140 Wood Road, Suite 200,
Braintree, MA 02184
(617) 848-1908

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
360 Rainbow Boulevard South, 3rd Floor
Niagara Falls, NY 14303
Disaster Program Director: Win Allred

(716) 282-4612 or 800-659-2955

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. Can be used in combination with the new "mitigation insurance" under the NFIP, or in lieu of that coverage.

Environmental Protection Agency
Region I - JFK Federal Building, Government Center,
Boston, MA 02203
(617) 565-3400

- ***Capitalization Grants for State Revolving Funds:*** Low interest loans to governments to repair, replace, or relocate wastewater treatment plans damaged in floods. Does not apply to drinking water or other utilities.

- ***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 DEP, Bureau of Water Management, Planning and Standards Division.

U.S. Dept. of Housing and Urban Development
330 Main Street
Hartford, CT 06106
(860) 240-4515

CT Dept. of Economic and Comm. Development
505 Hudson Street
Hartford, CT 06106
(860) 566-5310

- ***Community Development Block Grants (CDBG):*** Communities with populations greater than 50,000 contact HUD directly regarding CDGB. One program objective is to improve housing conditions for low and moderate income families. Projects can include acquiring flood prone homes or protecting them from flood damage. Funding is a 100% grant; 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.

U.S. Army Corps of Engineers
Special Studies Branch
424 Trapelo Road
Waltham, MA 02254
(617) 647-8505

Provide 100% funding for floodplain management planning and technical assistance under the Floodplain Management Services Program (FPMS). Various flood protection measures such as beach re-nourishment, stream clearance and snagging projects, floodproofing, and flood preparedness funded on a 50/50 matching basis by Section 22 planning Assistance to States program. They are authorized to relocate homes out of the floodplain if it proves to be more cost effective than a structural flood control measure.

U.S. Department of Commerce
National Weather Service
445 Myles Standish Blvd.
Taunton, MA 02780
(508) 823-2266

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
Rivers and Rails Conservation Program
Regional Office, 15 State Street
Boston, MA 02109
(617) 223-5203

Technical Assistance with open space preservation planning; can help facilitate meetings and identify non-structural options for floodplain development.

U.S. Fish and Wildlife Service
New England Field Office
22 Bridge Street, Unit #1
Concord, NH 03301

Can provide technical and financial assistance to restore wetlands and riparian habitats through the North American Wetland Conservation Fund and partners for Wildlife programs. Also administers the

- **National Coastal Wetlands Conservation Grant Program**: A nationally competitive fund matching program to preserve, restore, and protect coastal wetlands. Funds are administered at the State level.
- **North American Wetlands Conservation Act Grants Program**: 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. Projects must support long-term wetlands acquisition, restoration, and/or enhancement, and require a 1-to-1 match. The program includes both Standard Grants (grant requests between $50,001 and $1,000,000) and Small Grants (funds not to exceed $50,000).

Contacts: *Standard Grants proposals*: David Buie (david_buie@fws.gov), (301) 497-5870; *Small Grants Program proposals*: Keith Morehouse (keith_morehouse@fws.gov), (703) 358-1888. *General office number*: (703) 358-1784.

U.S. Department of Agriculture
Natural Resources Conservation Service (formerly SCS)
CT Office – 344 Merrow Road, Tolland, CT 06084
(860) 871-4011

Technical assistance to individual land owners, 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, 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.

State Resources

Connecticut Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
(860) 424-3706

Bureau of Water Management, Inland Water Resources Division - This division is generally responsible for flood hazard mitigation in Connecticut, including administration of the National Flood Insurance Program.

National Flood Insurance Program State Coordinator - 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.

State Hazard Mitigation Officer (shared role with the Office of Emergency Management) - Hazard mitigation planning and policy; oversight of administration of the Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, and Pre-Disaster Mitigation Program.

Flood Warning and Forecasting Service - Prepares and issues flood, severe weather, and coastal storm warnings. Staff engineers and forecaster can work with communities on flood warning issues and can give technical assistance in preparing flood warning plans.

Flood & Erosion Control Board Program - provides assistance to municipalities to solve flooding, beach erosion and dam repair problems. Certain non-structural 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 non-competitive basis.

Stream Channel Encroachment Line Program - Similar to the NFIP, this state regulatory program places restrictions on the development of floodplains along certain major rivers. This program draws in environmental concerns in addition to public safety issues when permitting projects.

Inland Wetlands and Watercourses Management Program - Provides training, technical and planning assistance to local Inland Wetlands Commissions, reviews and approves municipal regulations for localities.

Dam Safety Program - Charged with the responsibility for administration and enforcement of Connecticut's dam safety laws. 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.

Bureau of Water Management - Planning and Standards Division - Administers the Clean Water Fund and many other programs directly and indirectly related to hazard mitigation including the Rivers Restoration Grant Program, Section 319 Non-point source pollution reduction grants, and municipal facilities program which deals with mitigating pollution from wastewater treatment plants.

Office of Long Island Sound Programs (OLISP) - Administers the Coastal Area Management Act (CAM) program and Long Island Sound License Plate Program.

CT Department of Public Safety
Office of Emergency Management
360 Broad Street
Hartford, CT 06105
(860) 566-5483

OEM is the lead agency responsible for emergency management. Specifically, responsibilities include emergency preparedness, response & recovery, mitigation, and an extensive training program. OEM is the state point of contact for most FEMA grant and assistance programs. OEM administers the Earthquake and Hurricane programs described above under the FEMA resource section. Additionally, OEM operates a mitigation program to coordinate mitigation throughout the state with other government agencies.

Office of the State Building Inspector

Responsible for administering and enforcing the Connecticut State Building Code. Also responsible for the municipal Building Inspector Training Program.

Department of Transportation
2800 Berlin Turnpike
Newington, CT 06131
(860) 594-3236

The Department of Transportation administers the federal Intermodal Surface Transportation Efficiency Act (ISTEA) that includes grants for projects which 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 which could be mitigation related.

Private and Other Resources

The Association of State Floodplain Managers (ASFPM)
4233 W. Belittling Highway
Madison, WI 53711
(608) 274-0123

Professional association of state employees that assist communities with the NFIP with a membership of over 1,000. ASFMP 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.

Natural Hazards Center (303) 492-6818 (M-F, 11:00 AM-6:00 PM Eastern)
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 keywords 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 non-profit 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.

National Center for Earthquake Engineering and Research (716) 645-3391
A source for earthquake statistics, research, engineering and planning advice.

National Emergency Managers Association (NEMA)
c/o Council of State Governments
3650 Iron Works Pike, P.O. Box 11910
Lexington, Kentucky 4057-1910
606-244-8000

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.

New England States Emergency Consortium (NESEC) (800) 445-6332

A clearinghouse for mitigation and preparedness information with cooperation from all of the New England states. NESED presents a unique, non-governmental approach to aid. This agency could secure access to private sources of monetary and logistics support.

Insurance Institute for Property Loss Reduction (IIPLR)
73 Tremont Street, Suite 510
Boston, MA 012109-3910
(617) 722-0200

A non-profit organization put together by the insurance industry to research ways of lessening the impact of natural hazard. IIPLR advocates the development and implementation of building codes and standards nationwide and may be a good source of model code language.

Volunteer Organizations - Volunteer organizations, such as the American Red Cross, the Salvation Army, Habitat for Humanity, Interfaith, and the Mennonite Disaster Service are often available to help after disasters. Service Organizations, such as the Lions, Elks, and VFW are also. Habitat for Humanity and the Mennonite Disaster Service Provide skilled labor to help rebuild damaged buildings 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. That would allow the funds to be used for mitigation and other projects than cannot be funded elsewhere.

Americorps - Americorps is the recently installed National Community Service Organization. Teams of works can assist with landscaping projects such as surveying, tree planting, restoration, construction and environmental education. Some states have trained Americorps members to help during flood-fight situations, such as filling and placing sandbags.

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APPENDIX A
RECORD OF ADOPTION BY CITY OF NEW HAVEN

APPENDIX B
FIELD VISIT IMAGES AND MEETING NOTES

APPENDIX C
UPDATED STAPLEE MATRIX

APPENDIX D
NEW FLOOD DAMAGE PREVENTION DISTRICT ORDINANCE REGULATIONS & ZONING ORDINANCE AMENDMENT

APPENDIX E
NATIONAL CLIMATIC DATA CENTER (NCDC) DATA,
NEW HAVEN COUNTY

&

PROPERTIES WITH REPETITIVE FLOODING EVENTS,
NEW HAVEN, CT