Coastal Hazards Primers

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Introduction

Coastal Hazards include natural events that expose a coastal area to risk of property damage, loss of life and environmental degradation as a result of flooding, high winds and waves, both short- and long-term shoreline erosion, and storm surges. Connecticut's dynamic coast has experienced continuous changes in response to these natural processes. Looking forward, changes in sea level and storm patterns may increase the frequency and severity of existing hazard events, or create new ones.

Flooding

Background

Flooding from severe storms or regular extended precipitation events is a significant natural hazard facing Connecticut's coast. FEMA identifies 22 major disaster declarations occurring in Connecticut between 1954 and 2018, which resulted in severe flooding. Eight of these disasters have occurred in just the last decade. Although Connecticut has no distinct flood season, flood activity has been more prevalent during the late winter/spring melt, late summer/early fall, and early winter.

Coastal flooding can occur as a result of hurricanes, tropical storms, or tropical depressions, which can overwhelm low-lying coastal areas with storm surges. Any of these events can be quite severe, causing millions, and in some cases billions, of dollars in damages and significant loss of property and life.

Flood Mapping

Flood maps are created by using mathematics, physics, engineering, and surveying to model storm and flood events. Accurate flood maps can provide important information for a wide variety of users. Lending institutions and federal authorities use them to identify structures that require flood insurance and to determine federal flood insurance rates. Private insurers, realtors, and citizens in turn, use them to determine flood risks.

State and local governments use flood maps for planning and zoning, preparation of floodplain ordinances, hazard mitigation plans, and emergency response plans. Coastal managers use them to identify "refugia" where coastal wetlands can retreat from rising seas or to assess threatened natural resources. Visit the CT DEEP and FEMA sites on the National Flood Insurance Program (NFIP) for more information about flood mapping.

Flood Management

Early U.S. flood responses used flood mitigation as the primary method of reducing flood hazards. Since the 1960's, people have realized that flood damage mitigation is at least as important as flood mitigation. More recently, due to rising flood losses and continued development in flood-prone areas, the concept of implementing better land use planning and higher building standards have emerged.

Flood Mitigation

Reducing the frequency or intensity of flooding requires preventing floodwaters from reaching flood zones; "hard" and "soft" measures can be used to achieve this. Hard measures include groins, jetties, bulkheads, revetments, seawalls, tide gates, and pumping facilities (used in conjunction with walls or dikes). Soft measures include beach nourishment, wetland restoration, dune management projects, and the creation of "living shorelines".

Fighting the forces of nature can be expensive, harmful to the coastal environment, and prone to long-term failure. Hard protection can increase flood hazards by starving or redirecting sediment. As sea level rises, hard structures can impede the natural migration of tidal wetlands and marshes, reducing their viability as protective measures. Alternatively, beaches and dunes, provide flood protection by absorbing wave energy and providing higher elevations for floods to reach before they affect human-built structures.

Flood Response and Recovery

DEEP’s Land & Water Resources Division coordinates Flood Management and Natural Hazard Mitigation efforts with the state’s Division of Emergency Management and Homeland Security (DEMHS). In response to natural disasters, DEMHS initiates the Disaster Recovery Framework and defines the roles and responsibilities of various state and local municipalities, utility companies, and relief organizations.

Wind

Background

Wind can be hazardous in several ways. Very high winds associated with storm events can directly damage structures and structural components. Strong winds can pick up and propel debris or loose materials, subsequently damaging property. They can also blow trees into structures and roadways and destroy utility infrastructure.

Even normal wind patterns can contribute to coastal hazards. Wind generates surface waves that cause erosion and transport of shoreline materials. Strong onshore winds also contribute to storm surge by means of wind set-up. In addition, wind can cause the movement of sand or other loosely consolidated, fine-grained materials onto and off beaches and dunes.

Terminology

Connecticut can experience several types of damaging winds, defined by The NOAA National Severe Storms Laboratory:

- *Straight Line Winds*: Any thunderstorm wind not associated with rotation, and is used mainly to differentiate from tornadic winds.
- *Downdrafts*: A small-scale column of air that rapidly sinks toward the ground.
- Downbursts: A strong downdraft larger than 2.5 miles across resulting in an outward burst or damaging winds on or near the ground.
- Microbursts: A small concentrated downburst. Microbursts are generally small (less than 2.5 miles across) and short-lived, lasting only 5-10 minutes, with maximum wind speeds up to 168 mph.
- Gust Front: The leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm.

Wind Data for Connecticut

Wind rose graphs documenting wind speed for Connecticut’s coast reflect the following prevalent wind patterns:

- Spring (March – May) winds tend to shift from the winter northwesterly flow to the summer southwesterly flow.
- Summer (June- August) winds from the southwest prevail at approximately 8 – 18 mph.
- Fall (September – November) winds tend to shift from the summer southwesterly flow to the winter northwesterly flow.
- Winter (December – February) winds from the northwest prevail at greater velocities, often in excess of approximately 38 mph.
- In late winter and early spring, when winter storms are most likely, the wind roses indicates a significant component of strong winds from the east.
- The region of the central coastline around New Haven is more unique than other coastal areas. Here, wind direction typically takes a dominant north-south directional flow because of the funneling effect of Connecticut's central valley.

Appendix V of the 2018 Connecticut State Building Code lists the ultimate (V_{ult}) and nominal (V_{asd}) wind speeds for every municipality in the state. These wind speeds are for the 3 second wind gust at 10 meters above ground that structures should be designed to withstand. The nominal values for Connecticut are generally consistent and range from about 90 mph in the northwest corner to about 105 mph in southeast corner.

Erosion

Background

Wind, waves, tides, and sea level rise interacting with the geology of the Connecticut coastline, have been generating erosion for millennia. Erosion can occur gradually over many years or come and go in cyclic patterns. Storms can create massive amounts of erosion, sometimes flattening dunes and gouging beaches in minutes or hours.

Littoral transport, which is the movement of materials in the nearshore area by waves and currents, can help offset the effects of erosion by accreting sand onto the shore. New sediment is delivered from rivers draining into Long Island Sound or released from the naturally-occurring erosion of coastal bluffs and escarpments. These materials and their movement make up the sediment budget of the coast.

Nature & Extent

The Connecticut Coastal Management Program Planning Report no. 29: Shoreline Erosion Analysis and Recommended Planning Process (1979) provides a general description of shoreline composition, configuration, and erosion across Connecticut's coast, which remains relevant today:

- *Greenwich to Norwalk*: Erosion and other significant changes to the shoreline are rare; more pronounced are artificial filling of tidal areas. Erosion effects are most pronounced on small beach areas and areas behind them.
- *Norwalk to Milford*: This area is significantly impacted by erosion due to high density development and highly erodible barrier beaches.
- *Milford to New Haven*: Erosion in beach areas along the north-south trending shoreline has traditionally been a concern and has been aggravated by extensive stabilization of sediment sources in headland areas.
- *New Haven to Guilford*: Most of the shoreline is stable. However, beach shorefront in East Haven and the marshes of Chaffinch Island experience the largest erosion effects in this region.
- *Guilford to Old Lyme*: Erosion of beaches and low bluffs is common. Structural erosion control efforts such as groins and seawall have altered natural shoreline processes and have aggravated the problem by trapping natural sediment needed for beach replenishment. Several large scale changes in barrier beach configuration, notably Menunketesuck Island and Griswold Point, are evident.
- *Old Lyme to Groton*: Generally, no large scale marine erosion effects are evidenced beyond the creation of steep bluffs at the southern ends of headlands (resulting in reduced source materials available to beaches) and along several beach and barrier beach locations.
- *Groton to Stonington*: Only one portion of shoreline is considered significantly affected by erosion, the northerly tip of Sandy Point. Most shoreline is protected due to rocky composition.

Battling Erosion

Attempts to stabilize the naturally dynamic shoreline and control flooding have often complicated erosion problems. Structural protection measures such as seawalls, revetments, bulkheads, groins and jetties may help stop bluffs and stretches of beachfront from eroding, but in nearly all cases they can actually worsen existing erosion or cause new erosion in adjacent sections of the shore.

This typically happens in three primary ways. First, hard structures can deflect wave and wind energy onto immediately adjacent sections of shoreline, exerting additional or new erosion forces. Second, they tend to lock up and/or impede the natural flow of sediment along the coast. Lastly, as sea level rises, hard structures can impede the natural functions of tidal wetlands and marshes, reducing their viability as protective buffers to erosion.

Flood and erosion control projects tend to occur within regulated areas. Connecticut's Coastal Management Act has established legislative goals and policies to maintain the natural relationship between eroding and depositional coastal landforms, to minimize the adverse impacts of erosion and sedimentation on coastal land uses through the promotion of nonstructural mitigation measures, and to promote nonstructural solutions to flood and erosion problems, except in those instances where structural alternatives prove unavoidable.

What can you do when it comes to the threat of erosion in Connecticut?

- Understand that erosion is one of many natural coastal processes inherent with living on the shore.
- Be aware that any construction activities, placement or repair of structures, obstructions, and encroachments, and any work incidental thereto, waterward of the coastal jurisdiction line or within tidal wetlands are subject to State regulation. Visit DEEP's Coastal Permitting page for more information.
- See the Guidance on P.A. 12-101, An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures
- Explore the Connecticut Coastal Management Manual to learn about Connecticut's coastal policies and guidelines.

Precipitation

Background

Precipitation generally takes the form of rain, freezing rain, snow, sleet, and hail. The NOAA National Weather Service (NWS) glossary formally defines for these terms.

All forms of wintry precipitation, such as sleet, freezing rain, snow, and hail can create hazardous conditions on roads and walkways, and damage infrastructure like power lines, buildings and trees from the weight of ice of snow. Non-wintery precipitation is a frequent contributor to flooding events. These are familiar to anyone who lives in Connecticut, not just coastal residents.

Measurement

A 2002 University of Connecticut bulletin, *Precipitation in Connecticut* provides an authoritative summary of data from 73 precipitation gauges across the state and adjacent portions of New York, Rhode Island, and Massachusetts. The record at many gauges begins in 1948, but several have records dating back to the late 19th century. This bulletin denotes:

- The average annual precipitation over the last 100 years shows a generally increasing trend, with high year-to-year variability.
- When averaged over the period of record, total precipitation is distributed evenly throughout the year with slightly higher amounts in the summer than in the winter.
- The proximity of the ocean moderates the snowfall in Connecticut, especially along the coast. The average snowfall in is about 30 inches along the coast, 40 inches inland, and 60 inches in the northwest corner.
- Connecticut has four precipitation regions, two of which include the coastline (Greenwich to Stratford and Milford to Stonington). The regions were created by statistically comparing the extreme precipitation records, grouping those with the least statistical differences, and minimizing the distance between them. Each region has a unique set of precipitation characteristics defined by:
  - Spatial Distribution of Extreme Events;
  - Intensity-Duration-Frequency graphs for 2-, 5-, 10-, 25-, 50-, and 100-year storms;
  - Weekly Distribution of 1-, 6-, and 24-hour Extreme Events.

The NOAA National Climate Data Center provides a searchable index for Weather Observation Station (WOS) data. You can find precipitation data for various stations in Connecticut for 15 minute, hourly, daily, and monthly intervals.

Coastal Effects

Historically, coastal storms have presented a substantial threat to Connecticut's coastline. Coastal storms can be unique because precipitation is often accompanied by other hazards, such as high winds, flooding, or coastal erosion. Henceforth, these events can be expected to take a more significant role in coastal storms with the amplified influence of climate change.

Winter Storms

Categories

Winter storms events in Connecticut can include ice storms, ice jams, blizzards, and major storms known as "Nor'easters".

Major ice storms are rare in Connecticut and even more so along the coast where the waters of Long Island Sound create a warmer winter climate than highland areas of the state. Nevertheless, under the right meteorological conditions, they are possible given the topography and hydrology of the area.

Ice jams are an accumulation of ice in a river that restricts water flow and may cause backwater that floods low-lying areas upstream from the jam. Areas below the ice jam can also be affected when the jam releases, sending water and ice downstream.

A "Nor'easter" is a strong low pressure system affecting the Mid- Atlantic and New England states. A nor'easter gets its name from the continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas. Nor'easters can produce high winds, storm surges, and massive amounts of precipitation. Winter nor'easters are notorious for producing heavy snow, rain, and tremendous waves that crash onto beaches, often causing beach erosion and structural damage.

Criteria

Ice storms in Connecticut occur during a winter storm when warm air overrides cold air (32° F or colder) at the surface. Connecticut's Natural Hazards Mitigation Plan (NHMP) for 2007-2010, identifies three factors required for major ice storms:

1. Temperatures below 28°F;
2. Freezing temperatures extending beyond 12 hours;
3. More than one-half inch of rain.

Wind gusts from nor'easters can exceed hurricane force in intensity. What makes them so strong is the warm and moist air from the Atlantic that feeds the storm, causing it to grow explosively. The 2007-2010 NMHP, identifies the following criteria for coastal flooding consequent to nor'easters:

1. Winds greater than 30 mph lasting more than 12 hours;
2. Wind direction in a range from the northeast to the east-southeast;
3. Astronomical high tides.

Coastal Effects

Since they strike Connecticut frequently, strong winter storms cumulatively cause more coastal flooding, erosion, and annual damage to property than do hurricanes. Serious beach erosion is also caused by smaller winter storms, which can often occur in rapid succession. In addition to flooding, frozen precipitation is a unique hazard associated with winter storms.

For more information about winter storms, including how they form and the types of precipitation they produce, visit the NOAA's National Severe Storms Laboratory page on Winter Weather Basics.

Tropical Storms and Hurricanes

Terminology

Hurricanes, tropical storms, and tropical depressions are different classifications of tropical cyclones. The NWS defines Tropical cyclones as non-frontal, warm-core, low pressure systems that develop over tropical or subtropical water and have definite organized circulations. The classifications are based on the following maximum sustained wind speeds:

1. Tropical Depression – 38 mph (33 knots) or less;
2. Tropical Storm – 39 to 74 mph (34-63 knots);
3. Hurricane –74 mph (64 knots) or higher.

The familiar Saffir-Simpson Hurricane Wind Scale rates the magnitude of a hurricane based on its sustained wind speed:

Category 1: sustained winds between 74-95 mph;

Category 2: sustained winds between 96-110 mph;

Category 3: sustained winds between 111-130 mph;

Category 4: sustained winds between 131-155 mph;

Category 5: sustained winds greater than 155 mph.

Hurricanes above Category 2 are considered major hurricanes due to their potential for significant loss of life and damage. The types of damage associated with these "categories" are relative since lower category storms can sometimes inflict greater damage than higher category storms, depending on where they strike and the particular hazards they bring.

Threats to Connecticut

The principal threat period for Connecticut from a hurricane is from mid-August to mid-October. According to the State of Connecticut Disaster Debris Management Plan, DEMHS considers a Category 3 hurricane the most probable, worst-case natural disaster that the state could experience. Although the US southeast coast and Gulf of Mexico have experienced hurricanes of higher magnitude, Connecticut's characteristics, including population density and highly developed flood-prone areas, make it more susceptible to damages and loss of life from tropical storms and hurricanes.

Historic Hurricanes and Tropical Storms

Name	**Date(s)**	**Intensity**
Unnamed	7/21/1916	Category 1
Great New England	9/21/1938	Category 3
Great Atlantic	9/14-15/1944	Category 3
Carol	8/31/1954	Category 3
Edna	9/11/1954	Category 3
Connie	8/11-12/1955	Tropical Storm
Diane	8/18-20/1955	Tropical Storm
Donna	9/12/1960	Category 2
Belle	8/9-10/1976	Category 1
Gloria	9/27/1985	Category 2
Bob	8/19/1991	Category 2
Bertha	7/12-13/1996	Tropical Storm
Floyd	9/18/1999	Tropical Storm
Irene	8/28/2011	Tropical Storm
Sandy	10/29/2012	Tropical "Super" Storm

Interesting Articles

"The Great New England Hurricane of 1938"

"Worst Hurricanes in New England History"

"2012 in Review: Superstorm Sandy"

Hurricane Response and Recovery

DEMHS has prepared the Connecticut State Response Framework (SRF) and Disaster Recovery Framework (DRF) for state-level support of local and tribal recovery efforts through partnerships with local, state, non-governmental and federal organizations in order to enhance collaboration and continuity of effort between levels of government and to minimize the duration and contain the effort needed for full recovery in affected areas.

Titles 28 and 29, Chapter 517 of the Connecticut General Statutes are the major sources of authority for the State of Connecticut and its political subdivisions to prepare for and respond to natural disasters and other emergencies. Several pertinent mandates include:

- In any type of disaster or emergency, state agencies must first fulfill departmental mandates established by state statutes, regulations or executive orders and then provide support to local authorities. Exceptions are made only in cases of imminent peril to life and health.
- If necessary, the Governor may declare a state of emergency under CGS Section 28-9, and invoke extensive emergency powers to take any action reasonably necessary in light of the emergency. These emergency powers include (but are not limited to) taking operational control of all civil preparedness forces and functions, modifying or suspending statutes and regulations, ordering evacuations, removing debris from public and private land or waters, and seizing property.

Identifying and Measuring Threats

Hurricane response starts with the National Weather Service (NWS). For coastal New England, any tropical cyclone that is near the Bahamas becomes closely watched. Once these become a threat to Connecticut, the NWS begins working closely with DEMHS. The NWS uses the SLOSH model to estimate coastal flood damages according to the latest weather data and will issue coastal flood watches and warnings according to their analysis of the threat. Hurricane Watches and Warnings are issued by the National Hurricane Center (NHC) as follows:

- *HURRICANE WATCH*: An announcement that hurricane conditions (sustained winds of 74 mph or higher) are possible within 48 hours in of the anticipated onset of tropical-storm-force winds.
- *HURRICANE WARNING*: An announcement that hurricane conditions (sustained winds of 74 mph or higher) are expected within 36 hours in of the anticipated onset of tropical-storm-force winds.

Evacuation Orders

The SRF outlines a Hurricane Preparedness Checklist, which defines when DEMHS should recommend protective actions including any potential evacuation timeline and decision point. It also sets forth protocols for communication with municipal officials before and after an evacuation recommendation or order is issued, and the responsibilities to notify media and federal, state, private agencies. The checklist also includes coordination with Coastal Communities on coastal evacuation policies and procedures based on the 2016 New England Hurricane Evacuation Study: Technical Data Report. This includes a Behavioral Response Curve, which indicates time frames for slow, medium, and rapid response times. Based on this curve it a slow response is seven hours from the time residents receive official notification to evacuate. An additional two hours must be added to account for the time it takes to notify the public to evacuate.

The Connecticut Hurricane Evacuation Study also provides a Transportation Analysis with estimated evacuation clearance times and routes for Scenario 1, which includes Category 1 and 2 hurricanes, and Scenario 2 for Category 3 and 4 hurricanes. The response times for these scenarios are presented as slow, medium, and fast response times.

If the NHC does not issue a hurricane warning for the Connecticut coastline, DEMHS will not make evacuation recommendations. In these cases, evacuation decisions are made by local officials based on information from NWS.

Climate Change

What Climate Change Means for Coastal Connecticut

Climate change can be viewed as a "coastal hazards multiplier". There are many aspects of climate change that could influence the severity of coastal hazards, but the primary concerns are the implications of sea level rise, potential changes in storm activity, and the combined effects of the two.

Visit the CT Climate Change page and the Connecticut Institute for Resilience & Climate Adaptation (CIRCA), as well as Adapt CT to learn more about climate change and how Connecticut is working to address it.

Also visit our Coastal Hazards Management page for useful information for home or business owners and municipal officials, as well as links to other resources. Additionally, visit the NOAA Coastal Hazards and Digital Coast pages to learn about the data, tools, and training that NOAA has available to address coastal issues.

Tips

What can you do to be prepared for Coastal Hazards in Connecticut?

- ✓ Find out if you're in a flood zone, and if so, what options are available to you.
- ✓ Make sure your home and family are safe. Visit our Coastal Hazards Management page to learn about resources and ways to manage risk to your property and your community.
- ✓ Monitor weather forecasts and warnings. TV and radio broadcasts are always available, and you can also visit NOAA to get additional information on weather and flooding forecasts, data, tools, and guides.
- ✓ Be aware of traffic hazards by checking CT Travel Smart.
- ✓ Contact the local officials and visit the website for your town to find out what plans or resources your community has developed to address coastal hazards.