

SECTION 4 RISK ASSESSMENT

Risk Assessment	
<p>Requirement: §201.6(c)(2): (The plan shall include) a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.</p>	
Element	B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))
	B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))
	B3. Is there a description of each identified hazard’s impact on the community as well as an overall summary of the community’s vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))
	B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))

44 CFR §201.6(c)(2) outlines specific information that Knox County must consider when completing the risk assessment portion of this mitigation plan. The local risk assessments provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. This plan includes detailed descriptions of all the potential hazards that could affect the jurisdiction along with an analysis of the jurisdiction’s vulnerability to those identified hazards. Specific information about numbers and types of structures, potential dollar losses, and an overall description of land use trends in the jurisdiction are included in this analysis. Because this is a multi-jurisdictional plan, those risks with potential to impact only portions of the County were assessed separately in the context of the plan.

Physical Geography

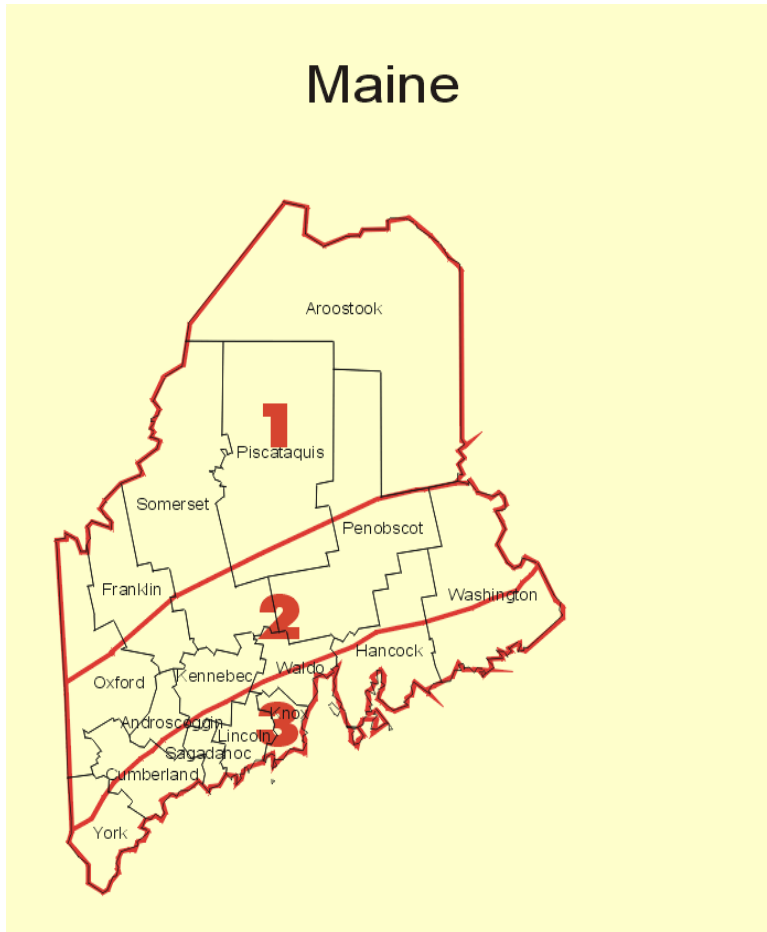
According to the Maine State Hazard Mitigation Plan - 2018, prepared by the Maine Emergency Management Agency, “The present-day landscape is a direct result of glacial erosion and deposition from the large ice sheets that completely covered Maine approximately 14,000 years ago. A variety of glacial deposits cover the state, providing a rich variety in the overall landscape as well as abundant sand and gravel for construction material. Many of these deposits also are excellent sources of ground water (that is, aquifers) for household and industrial water supplies.”

“Maine is a water rich state with five major rivers and 5,779 lakes and ponds. Water accounts for 13.5 percent of Maine’s land cover. Much of Maine is under coastal influence, as the easternmost state in the United States. The State’s tidally influenced coastline stretches 3,478 miles and is characterized by its rugged shape, numerous islands, peninsulas, bays and inlets.”

Climate

Knox County is located in the Coastal Division of Maine’s three climatic divisions. The Coastal Division encompasses a 20-30 mile band along the coast of 4,992 square miles (15%) of the State.

This division is most affected by the ocean, but has minimal elevation change, and thus, minimal climatic impact from any topographic controls.



Climate Divisions of Maine

Temperature: According to the Maine State Hazard Mitigation Plan - 2018, “The mean annual temperature varies greatly across the State of Maine. The mean annual temperature in the coastal region is 43.8 degrees F...July is the warmest month in Maine, with a statewide mean temperature of 65.4 degrees F. Conversely, January is the coldest month on average, with a statewide mean temperature of 13.5 degrees F.”

Precipitation: The Maine State Hazard Mitigation Plan - 2018 states that “Maine averages 42.6 inches of precipitation annually statewide, based on precipitation data collected between 1895 and 2016...On average, the coastal division receives the most annual precipitation, at 46.1 inches...Average monthly precipitation statewide ranges from a low of 2.6 inches in February to a high of 4.0 inches in November.”

Prevailing Winds: The Maine State Hazard Mitigation Plan - 2018 states that “Prevailing wind direction varies across the state with both season and location. Local influences such as orientation of a valley also may play a key role in dictating prevalent wind direction at any one location. Most of the state is under northwest to west-northwest winds throughout much of the year and particularly during the winter. During the summer, southwest to southerly winds may become quite frequent across the state.”

Climate Change

The purpose of this part of the plan is to provide an overview of how climate has changed over time, as documented in various scientific studies, and how that change may be impacting the occurrence and severity of natural hazards in Knox County. Projecting future climate change can be problematic because, as stated in the document “Maine’s Climate Future, 2015 Update,” by the University of Maine, “Climate projections are uncertain for several reasons: natural climate variability, incomplete descriptions of the climate system in computer models, and difficulty in predicting future greenhouse gas emissions” (page 6).

As stated in the Maine State Hazard Mitigation Plan - 2018, “For clarification, the National Aeronautics and Space Administration (NASA) uses the following definitions to describe climate and weather:

Climate: The description of the long-term pattern of weather in a particular area.

Weather: The description of the way the atmosphere is behaving in the short term, from minute to minute, hour to hour, day to day, and season to season.”

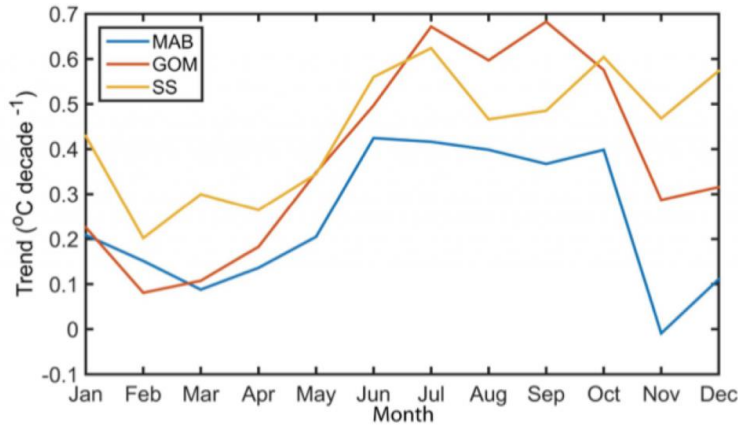
Temperature Changes: Excerpts from the report “Maine’s Climate Future, 2015 Update,” prepared by the University of Maine, include the following:

“Average annual temperature across Maine warmed by about 3.0 degrees F between 1895 and 2014....Although the overall warming trend...is clear, Maine’s temperature signal also features significant year to year fluctuations superimposed on a distinct pattern with periods of relative cold...and warmth...” (page 2).

“Numerical models of the global atmosphere and ocean have been in development for over three decades. The most sophisticated of these models, such as those used by the Intergovernmental Panel on Climate Change (IPCC)...predict that annual temperature will increase another 3.0 – 5.0 degrees F...across Maine between now and 2050” (page 3).

“Maine’s warm season...increased by two weeks from the early 1900s to the 2000s. Global climate models predict that the warm season will increase by an additional two weeks over the next 50 years. Winter is warming at a faster rate than summer.” (page 3).

Surface Seawater Temperature Change: A study completed by Andrew Thomas and the U Maine School of Marine Sciences examined 33 years of sea surface temperatures (SST) data along the NE United States Continental Shelf and found the Gulf of Maine SST to be increasing at a rate of about .4° C/decade. The study postulates “*A warmer shelf means that hurricanes approaching in the late fall are going to be impacting warmer water. We know cold water slows down hurricanes and so hurricanes coming ashore will come ashore more powerful than the same sort of hurricane 20 or 30 years ago*”. (cite: Thomas, A.C., Pershing, A.J., Friedland, K.D., Nye, J.A., Mills, K.E., Alexander, M.A., Record, N.R., Weatherbee, R. and Henderson, M.E., 2017. Seasonal trends and phenology shifts in sea surface temperature on the North American northeastern continental shelf. *Elem Sci Anth*, 5, p.48. DOI: <http://doi.org/10.1525/elementa.240>)



Temperature trends (in degrees Celsius per decade) for the recent 33-year period (1982–2014) in each month, averaged over the surface waters of the Mid-Atlantic (MAB), Gulf of Maine (GOM) and Scotian Shelf (SS). While all months show increasing temperature trends, these data show the large seasonal difference in when, during the year, the largest changes are taking place. (<https://umaine.edu/news/blog/2017/09/05/longer-stronger-summers-gulf-maine/>)

Precipitation Changes: Excerpts from the report “Maine’s Climate Future, 2015 Update,” include the following:

“Since 1895, total annual precipitation has increased by about six inches...or 13%, with most of the additional amount falling in summer and fall. IPCC models predict that precipitation will continue to increase across the Northeast by 5-10% between now and 2050, although the distribution is likely to vary across the climate zones. Model predictions show greater increases in precipitation in interior Maine...whereas measurements to date from the weather stations across the Maine landscape show that precipitation has increased most along the coast” (page 8).

“A significant increase in extreme precipitation events (more frequent and intense storms) has been observed across Maine and other parts of the eastern U.S....we define an extreme precipitation event for this analysis as one in which two or more inches (five or more cm) of precipitation falls within a 24-hour period. Historical measurements show that extreme events vary across the state, occurring most often in the coastal zone and western mountains. The northernmost sites, like Millinocket and Caribou, show fewer extreme events overall, but with similar relative increases over the most recent decade” (page 9).

“In general, the snow season has declined on average across Maine since the late 1800s...On a simplified linear trend, the snowfall has declined by about 15%...although the amount and duration of snow may decline in the future, extreme snowfall events with significant accumulation - strong nor’easters - are likely to increase in frequency” (page 10).

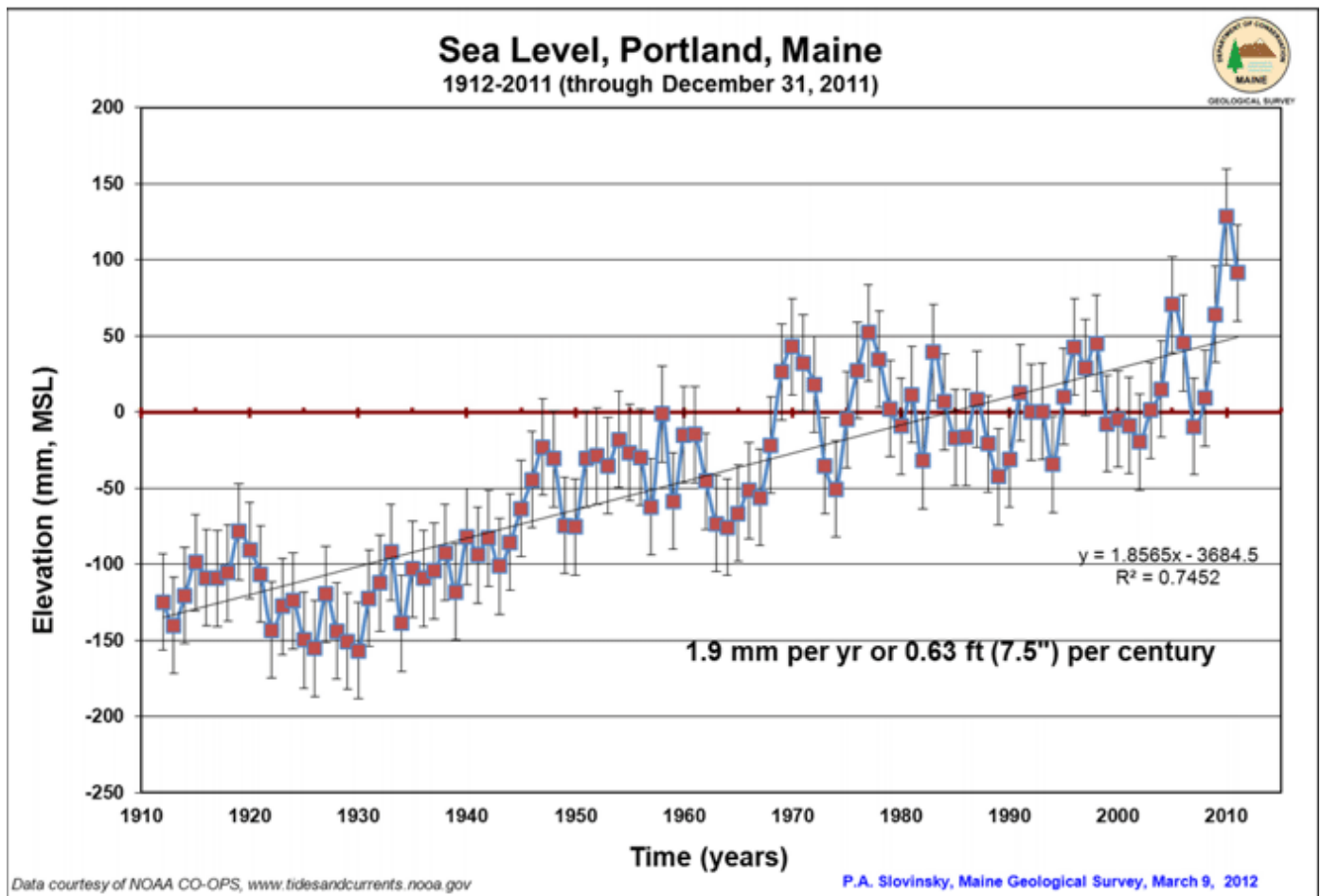
“The Northeast has experienced a greater recent increase in extreme precipitation than any other region in the U.S.; between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events, taxing an already stressed and aging infrastructure” (page 11).

Sea Level Rise. According to the Maine State Hazard Mitigation Plan - 2018, “Global sea level is rising at a rate of 0.07 inches per year (1.9mm), though that rate varies significantly for a specific location based on topography, ocean circulation, and geologic variations. The table below demonstrates documented sea level changes over various time periods based on available data across several locations in Maine, from south to north:

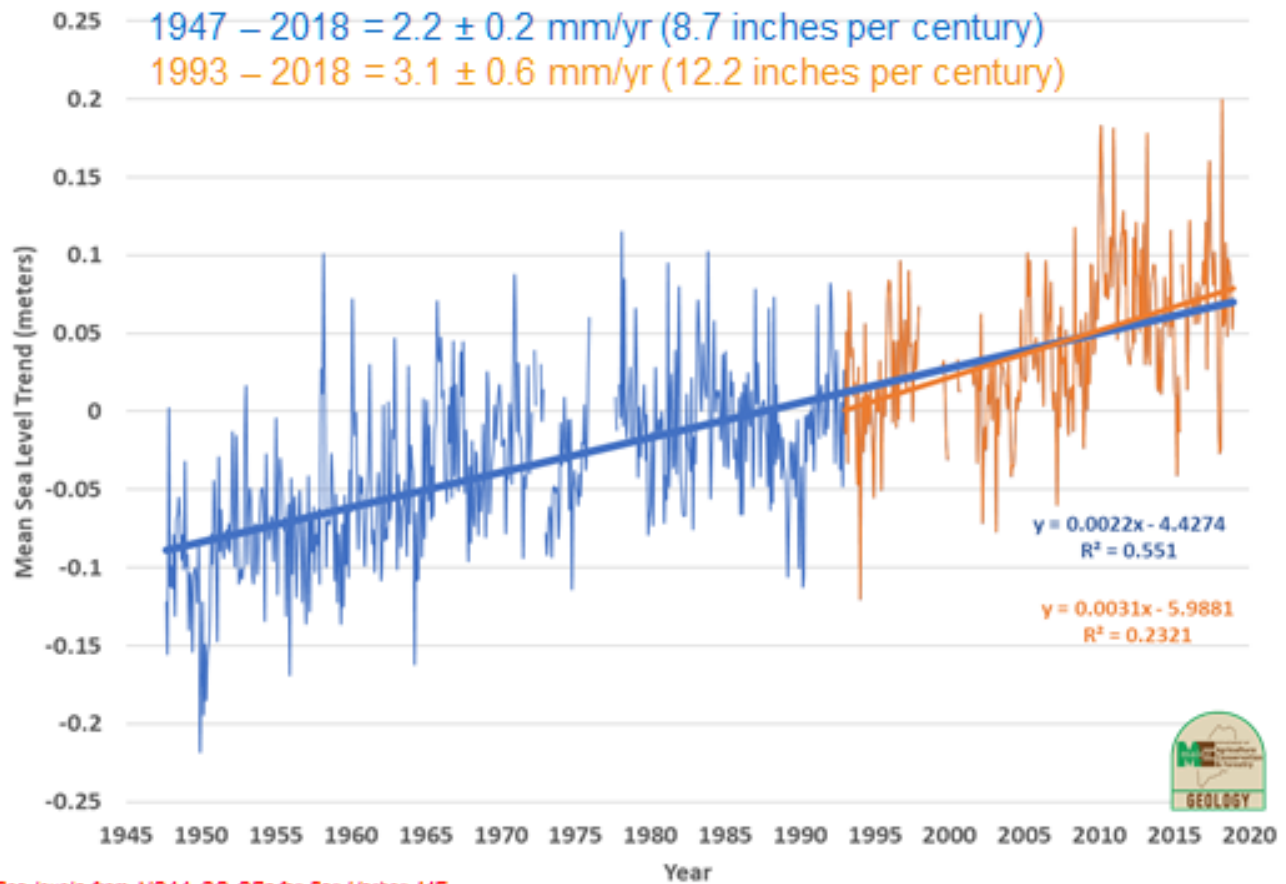
Documented Sea Level Rise across Maine			
Location	Time Period	Total Change (100 year equivalent)	Average Annual Change
Seavey Island, Maine	1926-2001	0.58 feet	1.76 mm
Portland, Maine	1912-2016	0.61 feet	1.86 mm
Bar Harbor, Maine	1947-2016	0.72 feet	2.2 mm
Cutler, Maine	1979-2010	0.77 feet	2.34 mm
Eastport, Maine	1929-2016	0.70 feet	2.12 mm

Source: <https://tidesandcurrents.noaa.gov/sltrends/sltrends.html>”

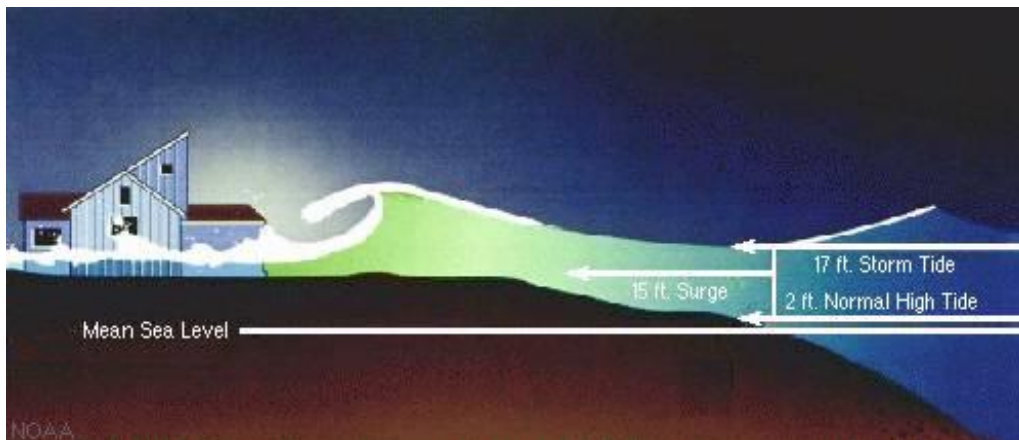
The graphs below, prepared by the Maine Geological Survey, shows sea level rise over time through 2011 in Portland and 2018 in Bar Harbor.



Bar Harbor, ME Sea level Rise Trends (1947-2018)



One of the consequences of sea level rise is the damage that can occur from storm surges. Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm as well as low barometric pressure. This advancing surge combines with the normal tides to create the storm tide. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides. The following illustration shows how storm surge can increase flooding risk.



No one knows for sure how high the sea will rise or how quickly it will occur, but the IPCC has prepared a range of scenarios based on a scientific analysis of a number of variables including glacial ice melt, thermal expansion of water due to global warming, slowing of the Gulf Stream (there has been a 25% reduction during the past decade), and the melting of ice caps in Greenland and Antarctica. Based on the IPCC's projections the Maine Geological Survey (MGS) is using for its studies a conservative, mid-range estimate of two (2) additional feet of sea level rise by the year 2100.

A. Description of natural hazards affecting the jurisdiction.

After reviewing the FEMA and State Plan list of all natural hazards, a summary table was prepared to use as an overview of all the hazards that could potentially affect Knox County. In conformance with the Maine State Hazard Mitigation Plan - 2018, it was decided that because so many of the County's natural hazards tend to occur in seasonal groups, the summary table and hazard "titles" should be revised to reflect that.

Therefore, events such as thunderstorms, lightning, and tornados will all be found under "Severe Summer Storm Events" though it is possible for them to occur separately and at other times of year. Accordingly, blizzards, ice storms, nor'easters, and snowstorms are grouped under "Severe Winter Storm Events" even though nor'easters can occur in other seasons. In considering the effect of each hazard, it became apparent that the most common result was usually flooding. For that reason, "Dam Failure / Breach," though listed separately on the next table for identification purposes, will appear in the flood hazard sections throughout the rest of the plan.

Non-profiled hazards were eliminated from further consideration in the Plan due to a lack of historical evidence, lack of overall countywide severity, or a low likelihood for the event to occur. There is no guarantee that non-profiled hazards would not occur and cause damage.

Knox County Natural Hazard ID – Summary of Hazards

Hazard Type	Sources of Information	Damage History	Location in Plan
Blight/Infestation	Department of Agriculture, Conservation and Forestry; website State Entomological Office historical records Input from residents County and State Hazard Mitigation Plans	Knox County has small-scale wood product related businesses. There are no historical records of major damage to these products that have caused serious economic conditions.	Not included
Dam Failure	MEMA, Dam Safety Program FEMA Disaster Reports Association of Dam Safety Officials Municipal EMA Directors County and State Hazard Mitigation Plans	In the event of High or Significant Hazard Dam failure, a “flash flood” would be the likely result.	Flooding
Drought	Department of Agriculture, Conservation and Forestry National Integrated Drought Info System Historical Records Existing County and State Hazard Mitigation Plans	Severe, multi-year droughts occurred in Maine in the 1960’s, 1980’s, 2000 to 2003 and from 2016-2018. However, the effects of drought, such as wells running dry in some areas, have never been sufficient to create disaster conditions in Knox County, although they have increased the danger of wildfires.	Not included
Earthquake (5.0+ magnitude)	Maine Geological Survey Historical records Existing County and State Hazard Mitigation Plans	All of the earthquakes that occur in Maine are intra-plate earthquakes. Maine is far inland from the boundaries of the North American plate that extends from the Mid-Atlantic ridge on the east to the western boundary of the U.S. Maine is near the middle of the plate and is therefore not subject to the frequent, deep, and large earthquakes that are generated by the edges of the tectonic plates bumping into each other.	Not included
Landslide	Department of Agriculture, Conservation and Forestry, Flood Plain Management State Marine Geologist, ME Geological Survey FEMA Disaster Reports Municipal EMA Directors Newspaper articles Review of Historical Records County and State Hazard Mitigation Plans	Landslides although uncommon in Knox County, have occurred causing roadway and property damage. The most significant landslides occurred in Rockland and Thomaston.	Landslide

Hazard Type	Sources of Information	Damage History	Location in Plan
Erosion	Department of Agriculture, Conservation and Forestry, Flood Plain Management State Marine Geologist, ME Geological Survey FEMA Disaster Reports Municipal EMA Directors Newspaper articles Review of Historical Records County and State Hazard Mitigation Plans	Minor Erosion associated with Severe Summer Storms is noted in the Severe Summer Storm Events hazard profiled in this plan.	Summer Storms
Wildfire: • Wildfire/Urban Interface	Forestry, Fire Protection Division State Fire Marshall's Office Wildfire Loose: The Year Maine Burned Input from residents Committee and local knowledge Existing County and State Hazard Mitigation Plans	Much of Knox County has dense forestland cover. Wildfires have been numerous, though small, in the past.	Wildfire
Flooding (includes coastal, riverine, spring and stormwater run off, heavy rains)	MEMA records Department of Agriculture, Conservation and Forestry, Flood Plain Management FEMA Disaster Reports County EMA Director Municipal EMA Directors Newspaper articles Review of FEMA flood studies, FIRM maps Input from residents Emergency declarations Identification of repetitive losses SLOSH Maps Committee knowledge Existing County and State Hazard Mitigation Plans	Flooding is associated with the effects of ice and snow build-up in the hills and rivers, spring runoff and storms including hurricanes. Several repetitive loss properties and roadways are located in the County. Several coastal communities experience coastal flooding during major storm events - winter and summer. The County contains one major river and many streams and lakes, and is located along the coast.	Flooding

Hazard Type	Sources of Information	Damage History	Location in Plan
Hurricanes	MEMA records FEMA Disaster Reports National Weather Service NOAA website Existing County and State Hazard Mitigation Plans	Direct hits from hurricanes in Knox County are few and so are considered in the Severe Summer Storm Events category. Hurricane Edna was the last major hurricane to hit Knox County in 1954.	Severe Summer Storm Events
Summer Storms • Lightning • Thunderstorms	National Weather Service NOAA website County EMA Director Municipal EMA Directors Committee and local knowledge Input from residents Existing County and State Hazard Mitigation Plans	Knox County is frequently hit with thunderstorms, heavy wind and rainstorms, hail and lightning, and rarely by hurricanes. Summer storms are often accompanied by high winds, road and culvert washouts.	Severe Summer Storm Events
Winter Storms: • Blizzard • Ice Storm • Nor'easters • Sleet Storm	MEMA records FEMA Disaster Reports National Weather Service NOAA website News paper articles County EMA Director Municipal EMA Directors Review of past disaster declarations Input from residents Risk assessments Review of library historical data Committee and local knowledge Records from 1998 ice storm County and State Hazard Mitigation Plans	Knox County is frequently hit by blizzards. The impacts of winter storms include erosion and wind damage, road and culvert washouts. The Knox County coastal communities are more often subject to ice/sleet storms.	Winter Storm Events
Other: Avalanche Subsidence Tsunami	FEMA hazards MEMA and FEMA reports County and State Hazard Mitigation Plans	There are no higher elevations in the County that hold large amounts of snow that would create avalanches. There have been no known cases of subsidence or Tsunami (meteo or seismic origin) in Knox County.	Not included Not included Not included

Profiled Natural Hazard Ratings:

The Knox County Hazard Mitigation Planning Team identified and rated natural hazards. These hazards were identified through a process that utilized input from members of the Hazard Mitigation Planning Team, public input, researching past declared and non-declared disaster declarations in the County, a review of current maps, and a risk assessment completed by the Knox County Emergency Management Agency and the Hazard Mitigation Planning Team. The hazards, and their respective ratings, are shown in the following table.

Rating of Profiled Hazards by Hazard Mitigation Planning Team						
Category/Type of Hazard	Potential Damages	Source	2012 Plan Update		2019 Plan Update	
			Rating	Priority	Rating	Priority
Severe Summer Storm Events (Includes storms in the spring, coastal erosion/landslides associated with storms and Hurricanes)	Downed power lines, blocked roadways. Localized flooding and high wind damage to roads buildings, trees and utility lines. Localized flooding and high wind damage to roads buildings, trees and utility lines	NWS, FEMA, & History Local/State Maine Coastal Program	2.5A	1 (tied)	2.5A	1 (tied)
Severe Winter Storm Events	Downed power lines, blocked roadways, and heavy snow damage. Ice Storm Localized flooding and high wind damage to roads buildings, trees and utility lines	NWS, FEMA, & History Local/State	2.5A	1 (tied)	2.5A	1 (tied)
Flooding	Damages to structures in flood zones, dams, bridges, culverts and roadways	DFIRM	2B	2	2B	2
Wildfire	Timber lost, homes lost, businesses lost. October 1947 Fire	Maine Forest Service/ MEMA	2B	3	2B	3
Landslide	Damage to structures, roads & rail line	County/ Local EMA Records	1.5C	4	2.5C	4

Note: The Hazard Mitigation Team used the 5-year timeframe of the Plan as the basis for estimating the likelihood of various hazards (i.e., how likely is the hazard to occur within the next five years)

Key to Rating

Severity of hazard:

- 3 Severe: Multiple deaths, mass casualties, or millions of dollars in damages
- 2.5 High: Deaths or injuries; or \$100,000s in damages
- 2 Moderate: Single death or several injuries; or \$10,000s in damages
- 1.5 Low: Injuries; or \$1,000s in damages
- 1 Slight: No deaths, single injury; or \$100s in damages

Likelihood of Hazard:

- A. Very Likely
- B. Possible
- C. Very unlikely

Key to Priority: 1. First Priority, 2. Second Priority, 3. Third Priority, 4. Fourth Priority

Profiling Hazards

B1 Type, location, and extent of all natural hazards that can affect each jurisdiction(s).

B2 Previous occurrences of hazard events and probability of future hazard events.

Severe Summer Storm Events

Introduction.

Severe summer storm damages typically involve downed overhead utility lines, flooding from heavy rain, and debris in the roads (since flooding has been covered in another section, it will not be reviewed in this section).

General Definition of Severe Summer Storm Events.

Severe summer storm events are violent weather phenomenon producing winds, heavy rains, lightning, and hail that can cause injuries, and destruction of property, crops, and livestock that usually occur between June and early October.

Types of Severe Summer Storm Events in Knox County.

There are several different types of potential severe summer storm events in Knox County

Summer Storms

- **Hurricane.** An intense tropical cyclone, formed in the atmosphere over warm ocean areas, in which wind speeds reach seventy-four miles per hour or more and blow in a large spiral around a relatively calm center called the “eye.” Storms having Tropical Cyclone features but winds less than 74 MPH are considered Tropical Storms.
- **Lightning.** An electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a “bolt.” This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches a temperature approaching 50,000°F in a split second. The rapid heating and cooling causes thunder.
- **Thunderstorm.** A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air such as a warm or cold front, or a sea breeze. All thunderstorms have lightning and can occur singly, in clusters or in lines.
- **Tornado.** A violently rotating column of air extending downward from a thunderstorm to the ground. The distinctive slender, funnel shaped cloud, with wind velocities of up to 300 miles per hour at the central core, destroys everything along its narrow ground path.
- **Microburst.** A small, extremely intense downdraft which descends to the ground creating strong wind divergence. Microbursts are typically limited to an area less than 2.5 miles across. This weather phenomenon is capable of producing damaging surface winds in excess of 100 mph. Generally, a microburst event will last no longer than 15 minutes.

A. Location of Severe Summer Storm Events.

Knox County is subject to severe summer storm events. The entire County is very susceptible to severe coastal summer storms, especially from the very high winds that are involved in such a storm. The entire County is vulnerable to one or more severe summer storms each year, usually in the form of thunderstorms. Within Knox County, severe summer storms have the most impact on shoreline areas along the coast, including harbor areas, and inland along lakeshores and watercourses like the Saint George River. Areas with steep slopes are also adversely affected by summer storms.

Erosion evidenced in Knox County has been the result of severe storms principally. The location of coastal erosion and landslides (though rare) is found in low-lying shoreline areas, where flooding can also often occur.

B. Extent (severity) of the Hazard.

In the summer, southwest to southerly winds may become quite prevalent across Knox County. Because of the frequent formation of sea breezes, southerly winds prevail along the Mid-Coast during the summer months. Severe summer storms bring high winds that can fell trees and branches onto power lines, causing power, and communication outages. Heavy rains that often accompany thunderstorms can result in flash flooding or erosion. Hail can cause crop damage for farmers and backyard gardeners. Lightning strikes can start fires. Any of these weather events can cause personal injury or property damage.

The impact of summer storms in Knox County is usually restricted to flooding caused by the copious amounts of moisture these storms can carry. Interestingly, the interaction of extra-tropical storms *and* hurricanes can produce events of a significant magnitude such as the floods of October 1996.

The most damaging types of summer storms possible in Knox County are F1 tornados and microbursts with winds in excess of 100 miles per hour, and thunderstorms of more than an inch of rain per hour that can wash out roads and result in flash flooding. For more information on the Enhanced Fujita Scale, see the table below or visit this link: <https://www.weather.gov/oun/efscale>

Enhanced Fujita Tornado Scale (abbreviated)		
Tornado Category	3 Second Gust	Typical Effects
EF0	65-85 mph	Gale tornado (weak); light damage to chimneys; breaks twigs and branches off trees; pushes over shallow-rooted trees; damages signboards; some windows broken.
EF1	85-110 mph	Moderate tornado (weak); Moderate damage: peels surfaces off roofs; mobile homes pushed off foundations or overturned; outbuildings demolished; moving autos pushed off roads; trees snapped or broken.
EF2	111-135 mph	Significant tornado (strong); considerable damage: roofs torn off frame houses; mobile homes demolished; frame houses with weak foundations lifted and moved; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
EF3	136-165 mph	Severe tornado (strong); severe damage: roofs and some walls torn off well-constructed houses; trains overturned; most trees in forests uprooted; heavy cars lifted off the ground and thrown; weak pavement blown off roads.
EF4	166-200 mph	Devastating tornado (violent); devastating damage: well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and disintegrated; large missiles generated; trees in forest uprooted and carried some distance away.
EF5	Over 200 mph	Incredible torbado (violent); Strong-framed, well-built houses leveled; steel-reinforced concrete structures damaged, tall buildings collapse or have severe deformations; some vehicles can be thrown great distances.

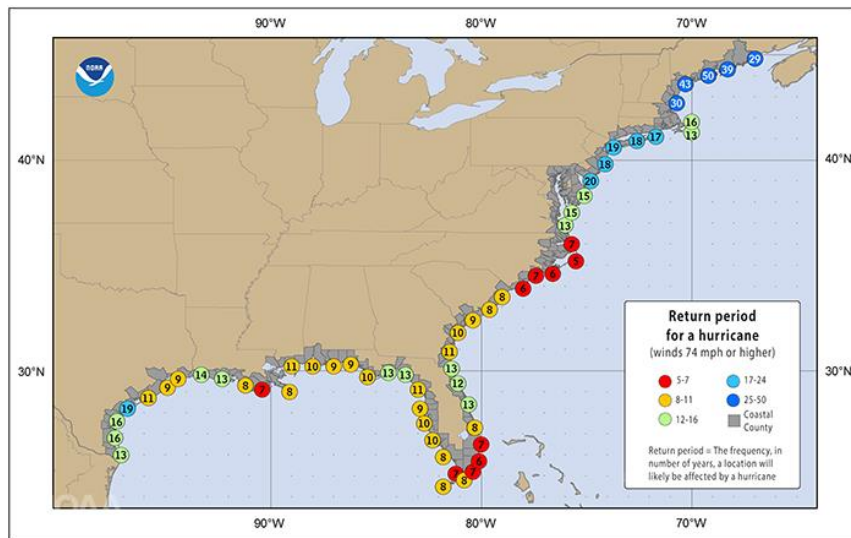
As described in the Maine State Hazard Mitigation Plan, 2018, hurricanes and tropical storms are classifications of tropical cyclones which are relatively large and long lasting, rotating, low pressure weather systems over tropical or sub-tropical waters. Tropical cyclones that can threaten Knox County originate in the Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico. The development phases and progression of a tropical cyclone is captured in the Saffir-Simpson Hurricane Scale shown below and available here: <https://www.nhc.noaa.gov/aboutsshws.php>.

Saffir-Simpson Hurricane Scale		
Category	Definition	Effects
Tropical Depression	Winds up to 38 mph	N/A Tropical disturbances originate in tropical wagtters
Tropical Storm	Winds 39-73 mph	Sustained winds capable of causing structural damage
Hurricane Cagtegrory 1	Winds 74-95 mph	Very dangerous winds will produces some damage
Hurricane Cagtegrory 2	Winds 96 mph-110 mph	Extremely dangerous winds will cause extensive damage
Hurricane Cagtegrory 3	Winds 111-129 mph	Devastating damage will occur
Hurricane Cagtegrory 4	Winds 130-156 mph	Catastrophic damage will occur
Hurricane Cagtegrory 5	Winds 157+ mph	Catastrophic damage will occur

Source: Maine State Hazard Mitigation Plan 2018

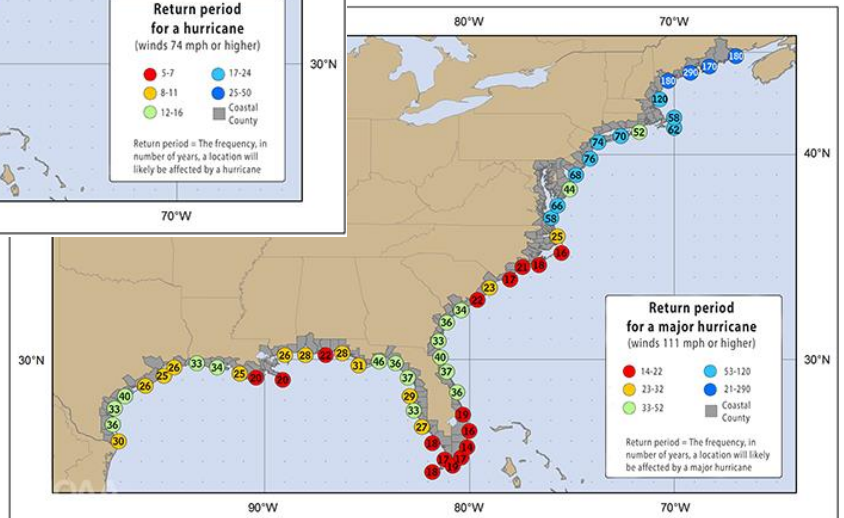
Note: hurricanes with winds greater than 110 mph (Categories 3, 4 and 5) are major hurricanes

According to National Hurricane Center predictive analysis, a hurricane with wind speeds greater than 74 MPH (CAT 1 or 2) can be expected to return within 50 miles of Knox County every 50 years. A Major (CAT 3 or higher) storm could return within 50 miles of Knox County every 290 years.

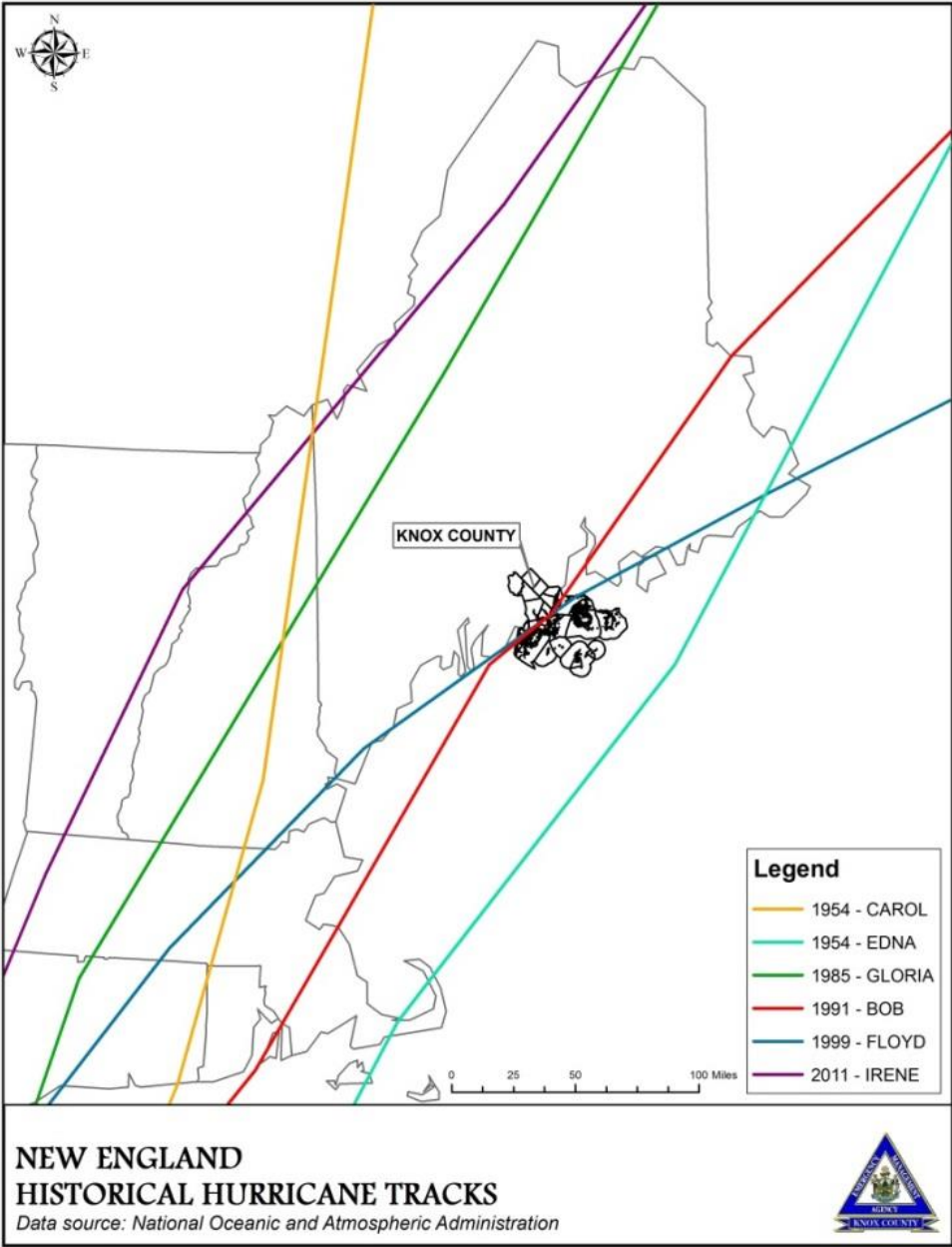


Hurricane Cat 1 & 2

Major Hurricane Cat 3, 4 & 5



Hurricane season in the Atlantic runs from June 1 to November 30, and hurricane threats increase late in the summer as ocean temperatures have warmed. Hurricanes typically weaken before reaching Maine. While unlikely, it is possible for strong storms to reach the state. Hurricane forecasts will have uncertainty due to variables of the hazard which include forward track and approach, storm speed, wind speed, storm size and precipitation and high altitude steering currents. The map below shows some notable storms which have affected Maine and Knox County.



C. Previous Occurrences.

The following table contains a summary of severe summer storms that have occurred in Knox County. Note: Flooding during the spring is often a result of snowmelt, which may be from winter storms.

Historical Summary of Severe Summer Events in Knox County			
Year	Incident Period	Financial Assistance for Knox County and Description/ FEMA Incident Type	Declaration
1954	Sept 2 -15	NA / "Hurricane Edna"	None
1954	Aug 25 - Sept 1	NA / "Hurricane Carol"	None
1985	Sept 16 - Oct 2	NA / "Hurricane Gloria"	None
1991	Aug 16 - 20	NA / "Hurricane Bob"	Presidential FEMA-915-DR <i>(IA only Knox County)</i>
1999	Sept 7 - 19	NA / "Hurricane Floyd"	None
2009	April	NA / Severe Storm	None
2009	June 18 - July 8	\$206,475 Severe Storms, Flooding, and Landslides	Presidential FEMA-1852-DR
2015	Sep 30	\$721,669 Severe Storm, Flooding <i>(*Local Damage Assessments*)</i>	Undeclared
2017	October 29 - November 1	\$226,367* Severe Storm and Flooding	Presidential FEMA-4354-DR

Source: FEMA/MEMA & Local Records. Notes: * This disaster is still open; the figure represents PA Projects approved as of January, 2019. Of the hurricanes listed in this table, only Hurricanes Edna and Bob hit Knox County directly. For the other hurricanes listed, heavy rain, winds and flooding occurred, but not at hurricane-strength levels.

D. Probability of Occurrence.

There are no probability studies available of summer storms; however, based on past experiences, the County can expect thunder and lightning every year. It is expected that a severe summer storm will create damage in Knox County at least once every three years. There have been no EF2-5 tornados documented in Knox County since 1950. Historically, the probability of an F2-5 tornado is low and will not be considered further in the Plan.

Severe Winter Storm Events

Introduction.

Severe winter storm damages typically involve downed overhead utility lines, flooding from heavy rain, ice jams and melt off, and debris in the roads (since flooding has been covered in another section, it will not be reviewed in this section).

General Definition of Severe Winter Storm Events

Severe winter storm events are violent weather phenomenon producing winds, heavy snow, and sleet and ice that can cause injuries, and destruction of property, crops, and livestock. Low temperatures, strong winds, and often large quantities of ice and snow distinguish severe winter storms and weather conditions.

Types of Severe Winter Storm Events in Knox County.

There are several different types of potential severe storm events in Knox County.

- **Blizzard.** Sustained winds and frequent gusts of 35 miles per hour (mph) with heavy falling or blowing snow, persisting for three hours or more, which frequently reduces visibility to less than ¼ mile.
- **Ice Storms.** Rain which freezes upon impact. Ice coating at least one-fourth inch in thickness is heavy enough to damage trees, overhead wires, and similar objects and to produce widespread power outage.
- **Nor'easter.** Nor'easters are extra-tropical coastal storms that can produce tremendous amounts of precipitation and strong winds that can cause coastal flooding damage. When the precipitation is in the form of snow, sleet, or freezing rain, it can damage overhead utility lines and become a highway-driving hazard.
- **Sleet Storm.** Frozen rain drops (ice pellets) which bounce when hitting the ground or other objects. Does not stick to objects, but in accumulated depths of two inches or more, produces hazardous driving conditions.
- **Heavy Snow Storm.** A snowfall of fifteen inches or more within 12 to 24 hours, which disrupts or slows transportation systems and public safety departments' response capability.

A. Location of Severe Winter Storm Events.

The entire County is subject to major snowfall events; however, the northern, inland portion of the County typically will receive greater snowfall amounts. Especially impacted areas includes windswept areas of higher elevations and areas with steep slopes. The entire County can experience a major ice storm, as it did in January 1998, however, the shoreline of coastal communities on the mainland and on the islands, which contain the vast majority of the population, experience freezing rain, sleet, tide surges, flood damage, and ice storms more frequently. The entire County is very susceptible to "Nor'easter" winter storms.

B. Extent (severity) of the Hazard.

During the winter months, Knox County often has heavy snowfall, or snow combined with high winds, freezing rain or ice storms. Significant rainfall also often occurs during winter months. Nor'easters, the most severe form, can occur during the winter, spring, and fall. They rarely develop during the summer. Precipitation amounts can exceed several inches of water equivalent (20-30 inches of snow or more), while wind speeds can be equal to or greater than those for hurricanes that reach Knox County. Loss of electrical power and communication services can occur when utility lines yield under the weight of ice and snow. These conditions can impede the response time of ambulance, fire, police, and other emergency services, especially to remote or isolated residents. The extent of one winter weather event can be exacerbated if it occurs shortly after a previous weather event.

Average seasonal snowfall amounts generally increase north and northwestward from the coastal region. Total seasonal snowfall ranges between 50 and 80 inches in the Coastal Division in which Knox County is located.

Occasionally, Knox County will experience a *Norlun Trough*, as it did in 2016 when two Knox County island towns in Penobscot Bay; Vinalhaven and North Haven, experienced 24 - 26 inches of snow, while nearby mainland areas received single digit snowfall. The WMTW website describes a *Norlun Trough* as follows: "*It's a line where we have instability along it and then air converges and rises and*

we get prolific snow or heavy snow at times. It can last awhile. It doesn't have to move very far. It's kind of like a lake-effect snow band in the winter time where some towns could get a foot and a few towns down only get a few inches."

The snowfall season usually runs from November to April and sometimes into May. Occasionally an early season storm can bring snow in the first weeks of October even along the coast. January is usually the snowiest month and December usually the second snowiest month. The snowpack makes an important contribution to both surface and groundwater supplies, and years with a low snowpack can lead to water shortages by late summer. Melting of the snowpack in April and May is often gradual enough to prevent serious flooding, although there have been times when a quick melt has led to disastrous conditions.

C. Previous Occurrences.

Federally declared winter storm disaster events affecting Knox County since 1978 are shown in the next table. The Maine storm of record occurred in January 1998 and caused \$305,292 in damage throughout Knox County. This storm, which nearly destroyed the electrical transmission system in the State of Maine, caused major damage to the forests, covered many roadways with debris and ice, and caused some limited building damages. However, most winter storms in the County are large snowstorms which over task the highway snow removal operations and cause localized power outages.

In 2008 a series of severe winter storms including an ice storm caused over \$650K in damages to Knox County. This storm, like the "*Great Ice Storm of '98*", forced closure of many roads due to tree and utility debris and ice while also causing widespread power outages.

The next table is a summary of some of the most severe winter storms during the past 47 years:

Historical Summary of Severe Winter Events in Knox County			
Year	Incident Period	Damages	Declaration
1972	March 7	\$12,541 Rain/Snow/Ice, Severe Storms, Flooding	Presidential DR-326
1993	March 13 - 17	\$14,857 Blizzards, Severe Winds and Snowfall, Coastal Storm	Presidential EM-3099
1998	January 5 - 25	\$305,292 Ice Storms " <i>Great Ice Storm of '98</i> "	Presidential FEMA-1198-DR
2005	February 10 - 11	\$173,642 Snow	Presidential EM-3206
2005	March 29 - May 3	\$429,928 Severe Storms, Flooding, Snow Melts, and Ice Jams	Presidential FEMA-1591-DR-ME
2008	December 11 - 29	\$659,827 Severe Winter Storm and Flooding	Presidential FEMA-1815-DR
2010	Feb 23 - Mar 2	\$230,305 Severe Winter Storms and Flooding	Presidential FEMA-1891-DR
2013	Feb 8 - 9	\$337,448 Winter Storm, Snow Storm, Flooding	Presidential FEMA-4108-DR

Historical Summary of Severe Winter Events in Knox County (cont'd)			
Year	Incident Period	Damages	Declaration
2013	Dec 21 - Jan 1 2014	\$338,414 Severe Winter Storm, Ice Storm	FEMA Undeclared Rcvd SBA Declaration #13897/ME-042
2014	Nov 2 - 6	\$213,305 Winter Storm/Heavy Snow (*Local Damage Assessments)	Undeclared
2017	Feb 12 - 14	\$317,688 Severe Winter Storm, Blizzard (*Local Damage Assessments)	Undeclared

Source: FEMA/MEMA & Local Records.

Statewide Storm of Record: The “Great Ice Storm of ’98.”

The storm began January 5th and continued through January 25, 1998. During this time, residents in Knox County and statewide experienced effects from freezing rain, high winds, snow and ice. The combination of peak low-pressure areas, abundant moisture in the atmosphere, and cold temperatures near the ground caused significant rainfall and severe icing. Gusts were reported up to 50 miles per hour and brought much colder air and temperatures dropped to single digits. Wind chills were in the minus twenty to minus forty-degree range. The mixture of precipitation continued into the afternoon of January 25, with significant icing along the coast. Extending from western New York to Maine, below-freezing temperatures combined with record rainfall contributed to the formation of a blanket of solid ice. In some places, more than three inches of ice coated the rural and urban landscape.

On January 13, fifteen of Maine's sixteen counties were declared a federal disaster area, including Knox County, eligible for Infrastructure Support assistance. The Disaster Declaration was amended to cover Individual Assistance on January 15, and Aroostook, the final county, was added. Hazard Mitigation funds to reduce future disaster risks were made available on January 13.

At its peak, more than half of Maine's population was without power, caused by ice that coated lines and branches an inch-thick. Many state and secondary roads were closed because of downed trees on power lines. State, county, and municipal government offices were closed, and innumerable businesses were forced to close and remain closed because of blocked roadways and power outages. As a result, 130 emergency shelters were opened throughout the state. Heat, electricity, refrigeration, running water, and sanitary facilities were all interrupted by the power outage. Maine Public Television and Radio remained unavailable to most viewers for more than a week. Other commercial radio and television stations in South-central Maine lost communication towers and or electrical power and were unable to broadcast. Even the Emergency Alert System failed.

D. Probability of Occurrence.

It is expected that a severe winter storm will create damage in Knox County at least once every three years.

Neither the State of Maine, nor the National Weather Service, maintain data on snowfall and ice accumulation on a town-by-town basis. On average, the length of annual maximum snow cover is about 50 days along the coast

Flooding

Introduction.

Flooding in Knox County takes place at many different intervals. Flooding results from spring thaw, severe storms and heavy rains.

General Definition of Flooding.

A temporary inundation of normally dry land as a result of: 1) the overflow of inland waters; and/or 2) the unusual and rapid accumulation or runoff of surface waters from any source. Note: the nature of Knox County's geology and hydrology is such that flooding is usually fast rising but of short duration.

Types of Flooding in Knox County.

There are several different types of potential flooding in Knox County:

- **Coastal Flooding.** The temporary inundation of beaches and other land areas by the sea, usually as a result of coastal storms. Coastal flooding comes with two significant components: still water and storm surge. The typical high winds associated with coastal flooding exacerbate the flooding by "pushing" more water toward land. A nor'easter can cause a storm surge along the coast of Maine. Fetch, or the distance the wind can blow toward the shore from out at sea is a significant factor in coastal flooding depths. The shape of the ocean floor just offshore is another variable.
- **Dam failure.** The sudden release of water resulting from structural collapse or improper operation of the impounding structure. Dam failure can cause rapid downstream flooding, loss of life, damage to property, and the forced evacuation of people.
- **Flash flood.** A flood event occurring with little or no warning where water levels rise rapidly due to heavy rains, ice-jam release, or rapid snow melt.
- **Ice jam.** An accumulation of floating ice fragments that blocks the normal flow of a river. During a thaw or rainstorm, the rapid increase in discharge from snowmelt and/or rainfall can rapidly lift and break up a thick ice cover and carry it downstream as an ice run. Ice runs can jam in river bends or against the sheet ice covering flatter reaches. The resulting ice jams can block flow so thoroughly that serious flooding may result within an hour of their formation. Failure of an ice jam suddenly releases water downstream. Damages from ice jam flooding usually exceed those of clear water flooding because of higher than predicted flood elevations, rapid increase in water levels upstream, and downstream, and physical damage caused by ice chunks. Moving ice masses can shear off trees and destroy buildings and bridges above the level of the floodwaters.
- **Lacustrine.** (Lake Flooding) occurs when the outlet for the lake cannot discharge the flood waters fast enough to maintain the normal pool elevation of the lake. During a base flood event, normal increases in water surface elevations on most lakes and ponds range from 1 to 5 feet. However, in Maine there are some examples where the base flood event will reverse the flow of the outlet stream. In such instances, river and base flood elevations can rise more than 15 feet above normal pool. While this can impact individual sport camps built near the water's edge, there are no records of major damages so this type of flood will not be further addressed in the Plan.

- **Riverine/riparian.** Periodic overbank flow of rivers and streams, usually the result of spring run off, but can also be caused by major rain storms.
- **Storm surge.** An abnormal rise of water that is generated by a storm, over and above the predicted astronomical tide.
- **Tsunami.** A wave produced by a disturbance that displaces a large mass of water – usually a result of geologic activities such as earthquakes, volcanic eruptions, underwater landslides, or in rare geologic cases, meteor strikes. After such a disturbance, displaced water travels outward from its site of origin as a series of unusually large waves at great speeds (Komar, 1996). All areas with an elevation less than 100 feet and within a mile of the coast could be impacted by a tsunami. Based on information obtained from the Maine Geological Survey, the chances of a catastrophic event are minimal. Moreover, with the presence of the relatively shallow Georges Bank offshore, Maine remains protected from the full force of an Atlantic Ocean tsunami. In Oct of 2008 a rare “*MeteoTsunami*” occurred in the Midcoast town of Boothbay Harbor (FMI, see <https://nws.weather.gov/nthmp/documents/meteotsunamis.pdf>)
- **Urban.** Overflow of storm sewer systems, usually due to poor drainage, following heavy rain or rapid snow melt. The combined sanitary and storm water systems that some urban areas installed years ago cause flooding of sanitary sewerage when riparian floods occur. Runoff is increased due to a large amount of impervious surfaces such as roof tops, sidewalks and paved streets.
- **Beaver Dam Flooding.** Flooding resulting from back-up and overflow of water resulting from beaver dams.

A. Location of Flooding Hazard.

All of Knox County has locations that are susceptible to flooding. Knox County’s susceptibility to flooding is further exacerbated by the wide-ranging weather variables. Due to seasonal (and regional) factors such as heavy rains, rapidly melting snow pack and/or ice jams, major flooding most frequently occurs between December and May. Based on MEMA data, the most flood prone months are April, January and March respectively. Floods can also be caused by severe storm events, including hurricanes, and may be further affected by rises in sea levels. Floods can saturate blueberry barrens, hay fields, and niche farm fields. Flood zones are mapped under the NFIP program. These maps are available at municipal offices.

There is one river located in Knox County. The St. George River flows through the towns of Appleton, Union, Warren, Thomaston, South Thomaston, Cushing and St. George. There are no dams on the St. George River. Flooding from the St. George River happens on occasion, but it is not severe. There are several dams located at the outlets of lakes and ponds that are very small and would not have a major flooding impact. However, on Megunticook Lake there are two dams, Megunticook East and Megunticook West, which the State has classified as High Hazard dams. If these dams were to fail, it would cause major flooding in downtown Camden. The Town of Camden, owner of the dams, has addressed this possibility by developing an Emergency Action Plan, which must be revised every two years, according to State law. Additionally, there is another town-owned High Hazard Dam in Camden, Seabright, which was is regulated by FERC until 2018.

Knox County has approximately 768 miles of coastline, some of which susceptible to coastal flooding. The most susceptible communities to sea level rise and storm surge related coastal flooding are Camden, Cushing, Friendship, North Haven, Owl’s Head, Rockland, Rockport, St. George, South Thomaston, and Vinalhaven. There is a State of Maine Ferry Service at Rockland that services the islands of North Haven, Vinalhaven and Matinicus Island Plantation and this service could be

impacted by coastal flooding. Rare astronomically high “*King tides*” observed and documented during November of 2016 could increase with the potential for future sea level rise. Photo comparisons of King Tide vs. normal high tide levels were obtained locally to support the NWS Coastal Flood Program. Those images are included in Appendix D.

The majority of the flood damage in the County is caused by winter runoff in the springtime, which undercuts or overtops local roads. When Maine has an above average snowfall for the winter and then warmer temperatures and rainfall suddenly arrive in the spring, the snow pack melts off more quickly than the watersheds can handle. This can cause local water bodies to overflow their boundaries and flood nearby road surfaces. Typically, the road damage is not major, although it can absorb the municipal road budget for an entire year and does happen in several towns every year.

Extent (nature) of the Hazard from Dam Failure. Maine dams were constructed incrementally over a period of 300 years. Businesses harnessed the abundant fast flowing rivers and rocky rapids for the development of energy and transportation. Many are low head dams constructed using local materials of stone, timber and earth.

Dam failure is not a frequent occurrence, but it can and does occur. Accordingly, Maine law requires that dams classified as High or Significant Hazard dams must have current Emergency Action Plans (EAPS). By definition, if they failed, High Hazard dams could cause loss of life; Significant Hazard dams could cause significant property damage and Low Hazard dams would generally cause damage only to the owner's property. Usually, dams that produce electricity are regulated by the Federal Energy Regulatory Commission (FERC). The others are regulated by Maine Emergency Management Agency (MEMA).

In Knox County, there are three High Hazard dams, all upstream of the town of Camden. Per their hazard classification, and EAPs, failure of these dams could cause loss of life in Camden, and seriously damage downstream buildings, businesses and the harbor.

Knox County has four Significant Hazard dams, as shown in the next table. Per their hazard classification, and EAPs, if these were to fail, the Lermond Pond Dam would damage the downstream roads in the eastern portion of Union and possibly two homes. Either Henderson Dam could damage the west end roads of Camden. Tolman Pond could damage Mill Street. The County also has 21 low hazard dams and 9 unranked or unclassified dams that are not included in the table.

Knox County High Hazard and Significant Hazard Dams					
MEMA ID	Dam Name	Other Name	Dam Owner	Town	River / Water body
High Hazard Dams					
81A	Megunticook East	Knox # 1	Camden, Town of	Camden	Megunticook
81B	Megunticook West	Knox #2	Camden, Town of	Camden	Megunticook
377	Seabright		Camden, Town of	Camden	Megunticook
Significant Hazard Dams					
85	Lermond Pond	East Union	Richard Morgan	Union	Mill Stream
864 A	Henderson #1		Henderson Lake Association	Camden	unknown
864 B	Henderson #2		Henderson Lake Association	Camden	unknown
524	Tolman Pond	Tolman Rec Dev	Tolman Park Association	Rockport	Oyster River

Source: MEMA

Extent (nature) of Flood Hazard other than Dam Failure. Severe flooding can cause loss of life, property damage, disruption of communications, transportation, electric service and community services, crop and livestock damage, health issues from contaminated water supplies, and loss and interruption of business. Ironically, fire-fighting efforts can be compromised if fire fighters and equipment are responding to a flood emergency.

Generous precipitation (about 46 inches a year) contributes to the flood potential. Low pressure systems over the Eastern Seaboard and the tendency of some storms to follow one another in rapid succession provide heavy, combined moisture. Water abundance is one of the County's most valuable natural resources and can be a hazard.

C. Previous Occurrences.

The next table contains a summary of floods that have occurred in Knox County:

Historical Summary of Flooding Events in Knox County			
Year	Incident Period	Damages	Declaration
1987	Mar 30 - April 12	\$13,062 Severe Storms, Flooding	Presidential FEMA-788-DR
1992	Mar 10 - Apr 6	\$91,712 Flooding, Heavy Rain, Ice Jams	Presidential FEMA-940-DR
1996	April 16 - 17	\$434,989 Flooding and Mudslides	Presidential FEMA-1114-DR (addendum to 1106-DR)
2005	March 29 - May 3	\$429,928 Severe Storms, Flooding, Snow Melts, and Ice Jams	Presidential FEMA-1591-DR-ME
2007	March 16 - 18	\$589,399 Flooding	Presidential FEMA-1691-DR-ME
2007	April 15 - 23	\$375,046 Severe Storms and Inland and Coastal Flooding	Presidential FEMA-1693-DR-ME
2008	April 28 - May 14	\$361,835 Severe Storms and Flooding	Presidential FEMA-1755-DR
2009	December 11 - 29	\$659,827 Severe Winter Storm and Flooding	Presidential FEMA-1815-DR
2009	June 18 - July 8	\$206,475 Severe Storms, Flooding, and Landslides	Presidential FEMA-1852-DR
2010	February 23 - March 2	\$230,305 Severe winter storms, flooding	Presidential FEMA-1891-DR
2015	Sep 30	\$721,669 Severe Storm, Flooding (*Local Damage Assessments)	Undeclared
2017	October 29 - November 1	\$226,367* Severe Storm and Flooding	Presidential FEMA-4354-DR

Source: FEMA/MEMA Note: *This disaster is still open, so this figure represents FEMA totals or Damage Assessments as of Jan, 2019. Flooding during the spring is often a result of snowmelt, which may be from winter storms.

D. Probability of Occurrence.

Floods are described in local flood hazard studies in terms of their extent, including the horizontal area affected, and the related probability of occurrence. Flood studies use historical records to determine the probability of occurrence for different extents of flooding. The most widely adopted design and regulatory standard for floods in the United States is the 1-percent annual chance flood. This is the standard formally adopted by FEMA. The 1-percent annual flood, also known as the base flood, has a 1 percent chance of happening in any particular year. It is also referred to as the “100-year flood.”

The Maine Geological Survey estimates that the ocean has risen about seven (7) inches since 1900, and is currently rising at a rate of about 1/10th of an inch per year. The result has been increased flooding, erosion of coastal bluffs and landslides. The consensus of the scientific community, reflected in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) is that sea level will continue to rise at an accelerating rate through the year 2100. A storm that had a 1% chance of occurring in any one year (the 100-year storm) at the current sea level elevation has a more than 1% chance of occurring in any year at a higher sea level elevation. With sea level rise, more homes, businesses, public infrastructure such as roads, and entire communities will be subject to more devastating coastal floods on a more frequent basis.

Wildfire (also known as Wildland fires)

Introduction.

Much of the County is covered with forests. Wildfires have been numerous, though small, in the past and have the potential to damage or destroy structures, especially in the more rural sections of the County. Wildfires can negatively affect the forestry economy as well.

General Definition of Wildfire.

Wildfire/Wildland fires are defined as those fires that burn vegetative cover: grass, brush, timber or slash (Clayton 1985). Though wildfire is a natural phenomenon and can be ignited by lightning, people have become the greatest cause of fires in the County. Wildland urban interface fires are created where homes meet with highly volatile forest fuels.

Types of Wildfire in Knox County.

There are several different causes of wildfire events in Knox County. The Department of Conservation, Maine Forest Service Forest Protection Division tracks all reported fire occurrences in the state on an annual basis. These are coded by cause: lightning, campfire, smokling, debris burning – which can include backyard burning as well as the agricultural practice of “burning over” blueberry fields, incendiary (includes arson), machinery, railroad children, miscellaneous, and fireworks. The number and acreage of fires by cause is shown in table on the following page.

Number/Acreage of Fires by Cause in Knox County 2014 - 2018											
	Light	Camp	Smoke	Debris	Incend	Mach	RR	Child	Misc	Fireworks	Total
2014		1/0.1				1/0.1			1/4.75		3/4.95
2015		2/4.2	1/0.1	2/0.5		1/0.1		1/0.2	1/0.1		8/5.2
2016	1/0.2	1/0.1		10/12.65	1/0.1	1/0.3			5/0.6	2/0.2	21/14.15
2017		2/0.2		8/4		1/0.1		1/0.1	4/1.55	1/0.1	17/6.05
2018				8/5.2		1/1.5			2/0.6		11/7.3
Total	1/0.2	6/4.6	1/0.1	28/22.35	1/0.1	5/2.1	0	2/0.3	13/7.6	3/0.3	60/37.65

Source: Maine Forest Service, 2019

Note: Fires burn an annual average of about 5.5 acres annually in Knox County.

A. Location of Wildfire.

All parts of the County are subject to wildfire/wildland fires. However the northern portion of the county has the least accessibility to emergency services due to the lack of proper roads. The southern portion of the County has a larger number of homes and businesses within the Wildland-Urban Interface but better access to emergency services. Islands have an increased risk in areas where downed old growth softwood trees and limited access provide a significant fuel load and would delay suppression response.

B. Extent (nature) of the Hazard.

In 2006, Knox County was estimated to have 173,100 acres of forestland, about 74% of the County land area (Maine Land Cover Dataset, 2006). The County's forestland base has remained essentially stable for the last several decades and is close to the estimated acreage of forestland present at the time of European settlement.

The entire County remains at risk for wildfires. Well-distributed rainfall normally reduces forest fire risks, but seasonal variations, rapidly draining soils and unusually dry periods can induce major blazes. In addition, insect damage diseases, severe weather, and residential and commercial developments in wooded areas greatly increase the potential for catastrophic fires. Over time, a considerable fuel supply can accumulate from the ignitable slash of some timber harvesting operations and/or from dead trees left standing on the forest floor after insect infestations. With an increase in drought conditions, wildfires could originate anywhere.

Several demographic factors make Knox County's rural areas less resistant to the threat of wildfires. The in-migration of persons over age 65 and the outmigration of young people (up to age 25) from rural areas often leave an older, more vulnerable population, that usually depend on just volunteer fire departments. As in all of Maine, Knox County's housing stock is aging. When old farm homes and wood frame buildings are located in remote forested areas, it can be very challenging for volunteer firefighters to respond before the structures are destroyed, especially since 90% of all firefighters in Maine are volunteers.

C. Previous Occurrences.

There were 63 reported wildfires in Knox County from 2014 – 2018, an average of slightly more than 12 wildfires annually, which burned about 38 acres total, or an average of about 8 acres per year. The

Maine Forest Service does not have records of a major forest fire (covering 500 or more acres) having occurred in Knox County between 1934 and 2019. Less than 1 % of the fires were caused by nature (lightning). About 99.5% were caused by human-related occurrences, such as machinery, fireworks, smoking, camp fires, etc. Less than 14% of the acres burned were on the islands.

The most severe wildland fire in the County's recent history occurred in October of 1947. Statewide, it burned 17,846 acres, destroyed approximately 400 homes, and caused three deaths on Mount Desert Island. In recent years, there have been about a dozen and a half low-acreage wildfires annually in Knox County, most of which are confined to about an acre in extent.

D. Probability of Occurrence.

Knox County is subject to minor wildland fire events. About 74% of the County is forestland and the accessibility by vehicle to many areas is limited. Wildfire danger areas are shown on the County Base Maps included in this section.

It is expected that low acreage wildland fire events will cause damages in Knox County several times each year; however, they do not rise to the level of the 1947 fire as there have been considerable mitigation efforts through suppression and training. Knox County has an active countywide fire fighters' association, automatic mutual aid, up-to-date fire-fighting resources and communication systems in place. The Maine Forest Service has made exceptional contributions in public education.

Landslide

Introduction

Landslides are uncommon in Knox County, although one occurred in Rockland and one occurred in Thomaston. Unstable coastal bluffs in excess of 20 feet in height will likely be subject to landslides on a more frequent basis as a result of severe storms, flooding and sea level rise.

General Definition of Landslide

A landslide is the downslope movement of earth materials (due to gravity) along a surface of rupture (shear plane).

Types of Landslides in Knox County

The only recorded landslides in Knox County were in the coastal zone. Factors contributing to these landslides include steep slopes, clay sediment layering and water from storm runoff or coastal flooding. No landslides have been recorded inland on hillsides, mountains or other steep areas.

A. Location of Landslide

A landslide took place in Rockland along a portion of Waldo Ave that abuts Rockland Harbor. A landslide took place in Thomaston along a portion of rail line that abuts the riverbank of the St. George River.

B. Extent (nature) of the Hazard.

Coastal landslides are triggered by chronic bluff erosion in areas with mud banks that exceed 20 feet in height. In contrast to the erosion that occurs on the face of a bluff less than 20 feet in height, a

coastal landslide is the result of the internal instability of sediment bluffs and their potential to rapidly move large amount of land down-slope under the influence of gravity. In general, landslide-prone bluffs have the following characteristics:

- A high, steep face;
- Clay sediment;
- Erosion near the high-tide line; and
- A high ground water table.

A Steep Slopes map is included in Appendix A of this plan that shows areas where a landslide potential exists.

C. Previous Occurrences.

A landslide occurred in Rockland in the spring of 1996. That landslide sent two homes and 300 feet of bluff into the harbor. The clay that made up the bluff sheared into blocks, losing its strength as it collapsed. The cost of mitigation was \$848,000. A landslide occurred in Thomaston in the winter of 2010 along a portion of rail line that abuts a riverbank. The landslide/washout was about 45 feet wide by the tracks and up to 150 feet wide by riverfront. That landslide resulted in the temporary closure of a state owned rail line that supports local industry dependent on freight rail and seasonal passenger tourist service. MaineDOT reported engineering and construction costs of \$102,648 for repair of the damaged area and rail line.

D. Probability of Occurrence.

No probability studies have been done, and predictive models do not exist. However, Maine Geological Survey is developing landslide maps along the Maine coast. As these maps are completed, they are presented to the towns for future planning purposes.

Assessing Vulnerability: Overview

Requirement §201.6(c)(2)(ii): (The risk assessment shall include a) description of the jurisdiction’s vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008 must also address NFIP structures that are repetitively damaged by floods.

The Plan should describe vulnerability in terms of:

- A. The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;
- B. An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimates;
- C. Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

iii. For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction’s risks where they vary from the risks facing the entire planning area.

Overall summary of vulnerability to each hazard and impact of each hazard on Knox County (B3)

A. Vulnerability of Knox County to each hazard:

Severe Summer Storm Events. The entire County is vulnerable to thunderstorms, microbursts, tornados, high winds and hurricanes.

Severe Winter Storm Events. The entire County is vulnerable to severe winter storms, including ice storms. As noted earlier in this Assessment, Knox County has been included in a number of Presidential Disaster Declarations for winter storms.

Flooding. With the exception of a few downtown portions of Camden and Rockland, most of the developed areas in Knox County are located outside of designated flood plains, and are thus not very vulnerable to riverine flooding. On the other hand, a large portion of the county is very rural in nature, and is served by a network of rural roads that do not have proper storm drainage systems. These roads are very vulnerable to flooding caused by heavy downpours and/or the blockage of drainage system by ice or debris, even though these roads may not be in an identified flood plain.

Wildfires. Most of Knox County is forested, about 74%, and likely to experience small wildfire/wildland fire events.

Landsides. Those limited areas with unstable coastal bluffs in excess of 20 feet in height may become vulnerable to landslides on a more frequent basis because of severe rain storm events, flooding, and sea level rise.

B. Impacts of each hazard on Knox County Maine:

Severe Summer Storm Events. The damages from summer storms typically involve the washout of roads, downed utility lines and debris clearance. If severe enough, this could result in the loss of income to businesses and individuals due to business closures.

Severe Winter Storm Events. The damage impacts of severe winter storms include road closures (and the subsequent inability of emergency vehicles to provide help), the loss of power for extended periods of time, high costs to local governments for snow removal efforts. If severe and prolonged enough, it could result in loss of income to businesses and individuals due to business closures. Roof collapses, both residential and commercial, are rare but they can occur when snow loads become extreme.

Flooding. The typical damages resulting from flooding in Knox County include damage to roads and their respective drainage systems. Historically, flood damages have included partial or complete road washouts, as well as severe erosion of roadside ditches, resulting in damages to town and personal vehicles. In some cases, entire communities have been partly or completely isolated because the only road serving the town has been become impassable.

Wildfire. The impacts of wildfires include the destruction of woodland forest stands of trees and other vegetation, which when located on steep slopes and/or near watercourses can increase erosion and pollution to water bodies. Loss of income from wood products destroyed and non-commercial properties enrolled in the state tree growth program for private property owners can occur from wildfires. Although uncommon in Knox County, structures in the urban interface including residences can be damaged or destroyed from wildfires. Temporary road closures may be warranted when wildfires are close to roadways or cross over roadways.

Landslide. The impacts of landslides include the damage or destruction of structures located in landslide prone areas, the potential for injury and loss of life, as well as damage to public infrastructure including roadways and utility lines.

Repetitive Loss Properties (B4)

Based on information contained in the Maine State Hazard Mitigation Plan - 2018 prepared by Maine Emergency Management Agency, there is only one repetitive loss property in Knox County. This property is a residential structure that has incurred two losses under the NFIP program. The Federal Privacy Act prohibits disclosure of the addresses, owners or claim information of these repetitive loss properties.

A. The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas:

Severe Summer Storm Events:

- **Buildings.** All buildings in Knox County are vulnerable to summer storms. Damages can include debris like tree limbs; and from high winds, interior water damages due to wind-driven heavy rain.
- **Infrastructure.** Roads and their associated storm drainage systems are the most vulnerable category of infrastructure. They can become temporarily blocked due to heavy rain and debris over a short period. There are approximately 48 roads/road segments in Knox County vulnerable to flooding.
- **Critical facilities.** All critical facilities in Knox County are vulnerable to summer storms in the same manner that individual buildings are vulnerable. However, some of the critical facilities throughout the County have back-up generator systems, which allow building systems to continue operating during a power outage. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Severe Winter Storm Events:

- **Buildings.** All buildings in Knox County are vulnerable to winter storms. Damages can include burst water pipes during power outages due to subfreezing weather and a lack of heat and/or pumps, which require electricity to function, interior water damages due to ice dams forming on roofs, and occasionally, roof collapses due to heavy snow loads.
- **Infrastructure.** Roads and their associated storm drainage systems are the most vulnerable category of infrastructure. There are approximately 48 roads/road segments in Knox County vulnerable to flooding. They can become temporarily blocked due to heavy snow, ice, and debris falling over a short period of time, or ice that can build on their surfaces. Water main breaks due to cold weather can also occur.
- **Critical facilities.** All critical facilities in Knox County are vulnerable to winter storms in the same manner that individual buildings are vulnerable. However, some of the critical facilities throughout the County have back-up generator systems, which allow heating systems to continue operating during a power outage. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Flooding:

- **Buildings.** Very few buildings in Knox County are vulnerable to flood damages. There is only one property identified in Knox County due to repetitive loss; it is a single-family

dwellings in Owls Head. With the exception of downtown portions of Camden and Rockland, most of the developed areas in Knox County are located outside of designated floodplains, and are thus not very vulnerable to flooding.

- **Infrastructure.** Roads and their associated storm drainage systems are the most vulnerable category of infrastructure. There are approximately 48 roads/road segments in Knox County vulnerable to flooding. Much of the county is very rural in nature, and is served by a network of rural roads that do not have proper storm drainage systems. These roads are very vulnerable to flooding caused by heavy downpours and/or the blockage of drainage systems by ice or debris.
- **Critical facilities.** Due to the varied topography within the County and the availability of higher elevation sites within all municipalities, nearly all critical facility structures are located outside of floodplains. Possible exceptions include some wastewater treatment plants, due to the need to locate these facilities at lower elevations. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Wildfire:

- **Buildings.** Buildings in the wildland urban interface within Knox County are vulnerable to wildfires. Damages can include fire damage and destruction.
- **Infrastructure.** Roads are vulnerable to temporary closure when wildfires are nearby or cross roadways.
- **Critical facilities.** Very few critical facilities in Knox County are identified as vulnerable to wildfires in the same manner that individual residential buildings may be vulnerable. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with forested areas in order to determine what assets are potentially impacted.

Landslide:

- **Buildings.** Buildings in the landslide prone areas, as defined previously in this section and as mapped, within Knox County are vulnerable to landslides. Damages can include structure damage and destruction.
- **Infrastructure.** Roads are vulnerable to temporary closure when landslides are nearby or cross roadways. Landslides have affected three road segments with temporary closures. If the landslide includes the roadway itself, the closures may be longer term as reconstruction and realignment efforts are undertaken.
- **Critical facilities.** No critical facilities in Knox County are identified as vulnerable to landslides in the same manner that individual residential buildings may be vulnerable. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with landslide prone areas in order to determine what assets are potentially impacted.

B. Vulnerability of future buildings, infrastructure, and critical facilities

Severe Summer Storm Events:

- **Buildings.** New buildings in Knox County will be less vulnerable to severe summer storms because they are built to meet modern code requirements. State-mandated shoreland

zoning ordinance regulations for areas within 250 feet of the shoreline of the coast, lakes and ponds, and within 75 feet of streams, limit the location of new buildings in areas prone to coastal erosion and storm surges that often result from severe summer storm events. Damages may include roof damage from falling trees and debris. There will be less Interior water damage due to wind-driven heavy rains because the roofs of newer buildings generally are properly designed and roofing materials are more resistant to water infiltration.

- **Infrastructure.** Roads will continue to be the most vulnerable category of infrastructure. New roads can be blocked on a temporary basis due to heavy rainfall, and debris such as tree limbs accumulating on the road surface during a storm event.
- **Critical facilities.** Future critical facilities in Knox County will be vulnerable to summer storms in the same manner that individual buildings will be vulnerable. However, some of them will have back-up generator systems which will allow building systems to continue operating during a power outage. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Severe Winter Storm Events:

- **Buildings.** New buildings in Knox County will be less vulnerable to severe winter storms because they are built to meet modern code requirements. There will be less Interior water damage due to ice dams forming on roofs because the roofs of newer buildings generally are properly vented, which allows the roofs to remain cold. Roof collapses due to heavy snow loads will be very rare because newer roofs are designed to withstand heavy snow loads. State-mandated shoreland zoning ordinance regulations for areas within 250 feet of the shoreline of the coast, lakes and ponds, and within 75 feet of streams, limiting the location of new buildings in areas prone to coastal erosion and storm surges that often result from severe winter storm events. Damages may include burst water pipes in winter, but many newer buildings will be better insulated than older ones, thus being better able to retain heat during longer periods of time when there is a power outage.
- **Infrastructure.** Roads will continue to be the most vulnerable category of infrastructure. New roads can be blocked on a temporary basis due to heavy snowfall, ice building up on the road surface, and debris such as tree limbs accumulating on the road surface during a storm event.
- **Critical facilities.** Future critical facilities in Knox County will be vulnerable to winter storms in the same manner that individual buildings will be vulnerable. However, some of them will have back-up generator systems which will allow building systems including heating systems to continue operating during a power outage. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Flooding:

- **Buildings.** All of the municipalities in Knox County are in the flood insurance program, and all have municipal shoreland zoning ordinances that prohibit the construction of residential, commercial and industrial structures in floodplains.
- **Infrastructure.** State and local road construction standards generally ensure that new roads are properly constructed with adequate storm drainage systems. Road construction exceeding \$100,000 must be designed by a registered professional engineer. Therefore,

roadway flooding should not be as likely or as serious for new roads as it is for old roads in Knox County.

- **Critical facilities.** Because of the requirements of the Flood Insurance Program, as well as state-mandated shoreland zoning and a greater awareness of flooding in all communities, future critical facilities will continue to be located outside floodplain areas. The exception may be wastewater treatment plants, due to the need to locate these facilities at lower elevations. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with coastal flood surge zone hazard areas in order to determine what assets are potentially impacted.

Wildfire:

- **Buildings.** New buildings in Knox County within the Wildland urban interface will be vulnerable to wildfires, as will those constructed at higher elevations on windswept ridgelines. Damages may include scorched exterior walls, roofs or complete destruction.
- **Infrastructure.** Roads will not likely be a vulnerable category of infrastructure. New roads can be blocked on a temporary basis due to wildfires, debris such as burned tree limbs accumulating on the road surface during a wildfire event.
- **Critical facilities.** Only those future critical facilities in Knox County that are located **within** the Wildland urban interface will be vulnerable to wildfires in the same manner that individual buildings will be vulnerable. However, clearing around such facilities will be maintained to reduce the probability of such events. The municipal base maps that are included in this Plan update identify the location of critical facilities. The purpose of these maps is to identify those facilities that overlap with forested areas in order to determine what assets are potentially impacted.

Landslide:

- **Buildings.** New buildings in Knox County will be less vulnerable to landslides, due to the mapping and regulation of such areas through State-mandated shoreland zoning ordinance regulations for areas within 250 feet of the shoreline of the coast, lakes and ponds, and within 75 feet of streams, restricting the location of new buildings in areas prone to landslides.
- **Infrastructure.** Roads near landslide prone areas will continue to be the most vulnerable category of infrastructure. New roads can be blocked on a temporary basis due to landslide activity, and debris such as mud accumulating on the road surface during such an event. State law restricts the construction of new roads in landslide prone areas.
- **Critical facilities.** Future critical facilities in Knox County will not be located in landslide prone areas and will thus not be vulnerable to landslides. The municipal base maps that are included in this Plan update identify the location of critical facilities.

B. An estimate of the potential dollar losses to vulnerable structures and a description of the methodology used to prepare the estimates

This section of the Plan relies on historical damages as the basis for estimating future losses, subject to the following: historical damage estimates have been updated, using the Consumer Price Index shown below; the average annual Consumer Price Index for various years is shown below based on a value of 100 for the years 1982-1984 (Knox County EMA has the capability of performing HAZUS runs and is working towards developing information on its website about this analytical tool).

Consumer Price Index 1982-1984 = 100			
1947 = 22.3	1988 = 118.3	1999 = 166.6	2009 = 214.5
1954 = 26.9	1989 = 124.0	2000 = 172.2	2010 = 218.1
1980 = 82.4	1990 = 130.7	2001 = 177.1	2011 = 224.9
1981 = 90.9	1992 = 140.3	2002 = 179.9	2012 = 229.6
1982 = 96.5	1993 = 144.5	2003 = 184.0	2013 = 233.0
1983 = 99.6	1994 = 148.2	2004 = 188.9	2014 = 236.7
1984 = 103.9	1995 = 152.4	2005 = 195.3	2015 = 237.0
1985 = 107.6	1996 = 156.9	2006 = 201.6	2016 = 240.0
1986 = 109.6	1997 = 160.5	2007 = 207.3	2017 = 245.1
1987 = 113.6	1998 = 163.0	2008 = 215.3	2018 = 250.5

Severe Summer Storm Events.

Hurricane damages are included in the Severe Summer Storm Events category considered in this Plan, and not as a separate category due to low occurrence of hurricanes in Knox County, as noted in the rankings portion of this Plan. Worst-case, real-life damages were used to calculate potential damages from hurricanes. The most recent, devastating hurricane to hit Knox County was probably Edna in September 1954.

Edna produced \$7,000,000 in damages to a coastal swath of Maine including Knox County. The hurricane resulted in eight deaths in Maine and power outages. The damage in 2018 dollars would be about \$65,186,000 ($\$7,000,000 \times 250.5$, the CPI for 2018, divided by 26.9, the CPI for 1954). Knox County comprises 6.6% of the population of the affected area. Prorating the damage based on population, Knox County could have \$4,302,000 in damages from a similar hurricane event ($\$65,186,000 \times .066$). The following Hurricanes also caused damage in Maine: Carol 1954, Gloria 1985, Bob 1991, and Floyd 1999, but these hurricanes did not cause recorded damage in Knox County.

The probability that a Category 1 or higher hurricane will strike Maine during the five-year period covered by this Plan update is low. For coastal communities, there will be wind and flooding damages to structures, flooding damages to roads, and downed power lines. For inland communities, damages will be limited to flooding.

Severe Winter Storm Events

Worst-case, real-life damages were used to calculate potential winter storm damages. It was assumed that historic patterns would hold for the future. The ice storm of 1998, which resulted in a Presidential Disaster Declaration, was one of the worst such storms to affect Knox County. The Ice Storm of 1998 resulted in a total of \$48,000,000+ in damages to the State. The Disaster Declaration did not cover damages to power lines and private structures. Using the Consumer Price Index, the \$47.7 million in the disaster declaration damages in 2018 dollars would be \$73,767,000 ($448,000,000 \times 250.5$, the Consumer Price Index for 2018, divided by 163.0, the CPI for 1998). Knox County comprises 3.1% of the population of the 16-county area. Prorating the damage based on population, Knox County could have \$2,287,000 in damages ($73,767,000 \times .031$) from a similar winter storm event distributed equally across the state.

Flooding

Worst-case, real-life damages were used to calculate potential flooding damages, and it was assumed that historic patterns will hold for the future. For Knox County, the worst recorded flooding was the April Fool's Day flood of 1987, which resulted in a Presidential Disaster Declaration of \$100,000,000 in damages to 14 counties.

Using the Consumer Price Index, the damages in 2018 dollars would be \$220,511,000 ($\$100,000,000 \times 250.5$, the CPI for 2018, divided by 113.6, the CPI for 1987). Knox County comprises 3.4% of the population of the 14-county area. Prorating the damage based on population, Knox County could have \$7,497,000 in damages from a similar flooding event ($220,511,000 \times 0.34$).

Wildfire

This plan uses worst-case, real-life damages to calculate potential wildfire losses, and assumes that historic patterns will hold for the future. The 1947 fire was the worst on record, although it was actually a series of wildfires that flared over Eastern and Southern Maine. The 1947 fire caused an estimated \$30,000,000 in damages to Cumberland, Hancock, Oxford and York Counties. The damage in 2018 dollars would be about \$337 million (multiply \$30 million by 250.5, which is the consumer price index for 2018, and divide by 22.3, which is the consumer price index for 1947). While there is significantly more development in each of these counties today than there was in 1947, fire-fighting capabilities have also increased substantially since that time so there may be no need to further increase the damage estimate. The probability that a wildfire such as the 1947 fire will hit Maine during the five-year period covered by this Plan is not high.

The methodology for calculating potential wildfire losses in Knox County is based on the damages that occurred in the 1947 fire in Cumberland, Hancock, Oxford and York Counties. The population of the four counties is 558,900. Divide \$337 million (the 1947 fire in 2018 dollars) by 558,900 to get a per capita cost of \$603. Multiply the County's estimated 2016 population, 39,717, by \$603 to get potential wildfire damages of \$23,949,000..

Given the lack of a major wildfire (defined as 500 acres or larger) in Knox County over the past eight decades and the relatively low-density development in areas prone to wildfires, the real-life worst-case costs of wildfire damages for Knox County over the next five years would probably be lower. Based upon the median housing price for Knox County (\$203,000 in 2017, according to the Maine State Housing Authority), a worst-case cost might be closer to \$3,248,000, which would be the equivalent of the total destruction of 16 detached housing units.

Landslide

The worst-case, real-life damages of a landslide in Knox County were used to calculate potential damages from such erosion. The worst event occurred in Rockland in the spring of 1996. That landslide sent two homes and 300 feet of bluff into the ocean. The clay that made up the bluff sheared into blocks, losing its strength as it collapsed. The damage costs were \$848,000. That cost in 2018 dollars would be \$1,354,000 ($\$848,000 \times 250.5$, the CPI for 2018, divided by 156.9, the CPI for 1996).

C. General description of land uses and development trends

There has been no known change in vulnerability in Knox County over the past five years. Knox County is located along the Downeast coastline of Maine and is largely rural. Land use within Knox County ranges from densely populated urban areas, like downtown Rockland and downtown Camden, to suburban residential areas, to rural areas with farms, and forestland. The largest community in the County is Rockland with a 2016 estimated population of 7,220. The land uses

within the county generally consist of: residential, resource protection, agricultural, industrial, institutional and commercial areas.

The State of Maine Legislature enacted the Growth Management Act in 1989 (Title 30-A, Chapter 187, subchapter 2) which requires each community to develop a municipal comprehensive plan. The municipal comprehensive plans allow development to occur in appropriate areas taking into account the environment, physical constraints, location of utility services, similarity to existing development, and proximity to flood zone areas. The municipalities must review existing conditions and predict future needs in order to develop their own plans, policies, and ordinances.

Municipalities in Knox County have enacted floodplain management, shoreland zoning, and other land use ordinances. Eighteen communities are participants in the National Flood Insurance Program. The Town of Cushing joined 10 July 2013 and Isle au Haut followed on 28 August 2017.

As shown in the table below, Knox County's overall population has changed very little since the year 2000. Since 2010, only six communities experienced growth (Appleton, Matinicus Isle Plantation, North Haven, Rockport, Union and Vinalhaven). All of the other communities have lost population. A clear trend in the County is that nearly all of the residential growth is occurring in the suburban and some rural communities. Declines in a number of communities may be attributed to the loss of local employment opportunities, which forces some to move to larger labor markets outside Knox County, and/or to move to non-coastal areas where housing costs are typically more affordable. The table below documents the rate of growth for all municipalities in Knox County.

Population Growth 1990 – 2017					
Area	1990	2000	2010	2017 ACS Estimates	2010-2017 % Change
Appleton, Town of	1,069	1,271	1,316	1,358	3.2
Camden, Town of	5,060	5,254	4,850	4,837	-0.3
Cushing, Town of	988	1,322	1,534	1,475	-3.8
Friendship, Town of	1,099	1,204	1,152	1,035	-10.2
Hope, Town of	1,017	1,310	1,536	1,522	-9.1
Isle au Haut, Town of	46	79	73	27	-63.0
Matinicus Isle Plantation	67	51	74	81	9.5
North Haven, Town of	332	381	355	540	52.1
Owls Head, Town of	1,574	1,601	1,580	1,559	-1.3
Rockland, City of	7,972	7,609	7,297	7,204	-1.3
Rockport, Town of	2,854	3,209	3,330	3,356	0.8
St. George, Town of	2,261	2,580	2,591	2,583	-0.3
South Thomaston, Town of	1,227	1,416	1,558	1,453	-6.7
Thomaston, Town of	3,306	3,748	2,781	2,767	-0.5
Union, Town of	1,989	2,209	2,259	2,507	11.0
UT (Unorganized Territories)	0	0	7	8	14.3
Vinalhaven, Town of	1,072	1,235	1,165	1,168	0.3
Warren, Town of	3,192	3,794	4,751	4,706	-0.9
Washington, Town of	1,185	1,345	1,527	1,514	-0.9
Knox County	36,310	39,618	39,736	39,700	-0.9

Source: U.S. Census and American Community Survey 5-Year Estimates 2013-2017

Based on population projections prepared by the Maine Department of Administration and Financial Services for organized municipalities and plantations, Knox County is expected to lose population

over the next 5 to 10 years, as summarized in the table below. The only communities that are projected to increase in population over 2010 Census figures by 2021 are Appleton, Hope, Owls Head, Rockport and South Thomaston. All of the remaining communities are projected to experience modest declines. Based on these projections, there is very little likelihood that many new buildings, infrastructure or critical facilities would be vulnerable to the identified hazards.

Projected Population					
Area	2010	2021	2026	2010-2021 % Change	2021-2026 % Change
Appleton, Town of	1316	1,356	1,368	3.0	0.9
Camden, Town of	4850	4,795	4,746	-1.1	-1.0
Cushing, Town of	1534	1,463	1,425	-4.6	-2.6
Friendship, Town of	1152	1,121	1,102	-2.7	-1.7
Hope, Town of	1536	1,800	1,905	17.2	5.8
Isle au Haut, Town of	73	69	66	-5.8	-4.3
Matinicus Isle Plantation	74	71	70	-4.1	-1.4
North Haven, Town of	355	348	343	-2.0	-1.4
Owls Head, Town of	1580	1,603	1,608	1.5	0.3
Rockland, City of	7297	7,053	6,913	-3.3	-2.0
Rockport, Town of	3330	3,394	3,412	1.9	0.5
St. George, Town of	2591	2,563	2,535	-1.1	-1.1
South Thomaston, Town of	1558	1,642	1,669	5.4	1.6
Thomaston, Town of	2781	2,744	2,714	-1.3	-1.1
Union, Town of	2259	2,183	2,138	-3.4	-2.1
UT (Unorganized Territories)	7	6	6	-14.2	0
Vinalhaven, Town of	1165	1,112	1,084	-4.5	-2.5
Warren, Town of	4751	4,613	4,528	-2.9	-1.8
Washington, Town of	1527	1,494	1,470	-2.2	-1.6
Knox County	39,736	39,430	39,102	-0.8	-0.8

Source: 2010 U.S. Census and Maine Department of Administration and Financial Services

Housing growth has occurred at a faster rate than the growth in population. This is due to the construction of vacation/second homes that are used seasonally, whose residents are not included in the year round population figures. As well, a notable decrease in average household size has occurred over the past twenty years. This decrease is due to the in-migration of retiree-aged households, empty nesters, families headed by single parents, and reduced birth rates, among other causes. Between 2000 and 2010, the largest increases in housing stock have occurred in St. George, Camden, Rockport and Warren.

Housing Unit Growth 1990 – 2010					
Area	1990	2000	2010	# Change 2000-2010	%Change 2000-2010
Appleton, Town of	450	547	646	99	18.1
Camden, Town of	2,654	2,883	3,165	282	9.8
Cushing, Town of	602	778	926	148	19.0
Friendship, Town of	818	849	896	47	5.5
Hope, Town of	542	687	805	118	17.2
Isle au Haut, Town of	136	164	172	8	4.9
Matinicus Isle Plantation	101	135	147	12	8.9
North Haven, Town of	441	488	515	27	5.5

Housing Unit Growth 1990 – 2010					
Area	1990	2000	2010	# Change 2000-2010	%Change 2000-2010
Owls Head, Town of	909	992	1,060	68	6.9
Rockland, City of	3,719	3,752	3,925	173	4.6
Rockport, Town of	1,409	1,677	1,956	279	16.6
St. George, Town of	1,567	1,777	2,107	330	18.6
South Thomaston, Town of	697	804	893	89	11.1
Thomaston, Town of	1,212	1,535	1,385	-150	-9.8
Union, Town of	878	1,052	1,203	151	14.6
UT (Unorganized Territories)	52	67	91	24	35.8
Vinalhaven, Town of	1,038	1,228	1,295	67	5.5
Warren, Town of	1,277	1,534	1,760	226	14.7
Washington, Town of	532	694	797	103	14.8
Knox County	19,009	21,612	23,744	2,132	9.9

Source: U.S. Census

Natural disasters including storms and flooding can temporarily close businesses, which results in a loss of income and economic activity. Most major employers and employment opportunities are located in the service centers of Rockland, Camden, Rockport, and Thomaston, and are generally on or near US Route 1.

The economy of Knox County generally reflects that of the State as a whole, at least in terms of private employment by major industry sector, as shown in the table below. Within Knox County, employment in most of the sectors is within a percentage point or two of State employment figures. The exceptions include wholesale trade (Knox 1.8%, Maine 4.0%), retail trade (Knox 19.7%, Maine 16.2%), and professional and business services (Knox 10.3%, Maine 12.9%).

Knox County Covered Private Employers and Employment March, 2016					
Sector	Knox Co. Covered Employers	Covered Employment			
		Knox Co		Maine	
		#	%	#	%
Natural resources and mining	126	287	2.1	5,724	1.9
Construction	211	839	6.1	24,337	5.0
Manufacturing	96	1,669	12.1	49,570	10.3
Wholesale trade	84	255	1.8	19,301	4.0
Retail trade	253	2,719	19.7	78,489	16.2
Transportation, warehousing	49	292	2.1	15,186	3.1
Utilities	6	64	0.5	1,668	0.3
Information	34	286	2.1	7,461	1.5
Financial services	118	646	4.7	28,850	6.0
Professional and business services	287	1,420	10.3	62,293	12.9
Educational services	32	188	1.4	13,033	2.7
Health care social assistance	150	2,770	20.0	103,718	21.5
Leisure and hospitality	232	1,682	12.2	54,899	11.4
Other/unclassified	179	704	5.1	19,003	3.9
Total	1857	13,821	100.2	483,532	100.7

Source: Maine Department of Labor

iii. Multi-jurisdictional Risk Assessment

As previously stated, the following are hazards for which all areas of the County are subject to the same general risk:

- Flooding
- Severe summer storm events
- Severe winter and storm events
- Wildfires in urban interface areas (Although most areas are at risk from wildfires, it is the less densely developed areas of the smaller communities that face forest acreage losses. This is due to the lack of adequate roads for providing emergency services. In addition, the resources of municipal fire departments for fighting wildfires are extremely limited, due to the small population base and the fact that most firefighters are volunteers.)

Coastal flooding affects limited portions of the coastal communities of Camden, Cushing, Friendship, Isle Au Haut, North Haven, Owls Head, Rockland, Rockport, St. George, South Thomaston, and Vinalhaven. The State of Maine Ferry Terminal at Rockland that serves the islands of North Haven, Vinalhaven and Matinicus Isle Plantation could be impacted by coastal flooding, as could the island ferry facilities.