APPENDIX A. HAZARD ANALYSIS AND RISK ASSESSMENT

The Hazard Analysis and Risk Assessment provides an in-depth study of natural hazard risks for Pawtucket and Central Falls. It is presented in the following distinct sections:

A.1 Overview
A.2 Hazard Identification
A.3 Hazard Profiles
A.4 Vulnerability Assessment
A.5 Summary Findings and Conclusions

A.1. OVERVIEW

The purpose of the Hazard Analysis and Risk Assessment is to identify, analyze, and assess the overall risk of the planning area to natural hazards. It helps determine the potential impacts of hazards to the people, economy, and built and natural environments of the two cities as well as specific vulnerabilities or problem areas. It is a critical element that serves as the foundation to the entire mitigation planning process, which is focused on identifying and prioritizing actions to reduce risk to hazards. In addition to informing the Mitigation Strategy included in this plan, the Hazard Analysis and Risk Assessment can also be used to establish local emergency preparedness and response priorities, for land use and community development planning, and for decision making by elected officials, city staff, businesses, and organizations in the community.

The Hazard Analysis and Risk Assessment completed for the cities of Pawtucket and Central Falls builds on available historical data and information on past hazard occurrences, and projections for anticipated future occurrences. It includes hazard-by-hazard profiles for those hazards deemed to pose significant risk, a geospatial-based exposure and risk assessment for those hazards with geographically-defined boundaries, and culminates in a hazard risk ranking based on the findings and conclusions about the location, probability, potential impact, warning time, and duration of each hazard. The process is designed to assist each City seek the most appropriate mitigation actions to pursue and implement—focusing efforts on those hazards of greatest concern and those assets facing the greatest risk.

Specific information on the methods and data sources used to complete the Hazard Analysis and Risk Assessment are incorporated throughout this section and will be refined as necessary through future updates to this plan.

A.2. HAZARD IDENTIFICATION

This section provides a summary of the initial hazard identification and screening process. The first step in completing a comprehensive risk assessment for mitigation planning purposes is the identification of all natural hazards that can affect the people, economy, and built and natural environments in the planning area. The primary purpose of this step is to ensure that all potential natural hazard threats are considered for inclusion in the plan and to determine which are significant enough to carry forward for more detailed hazard analysis and risk assessment tasks.

Pawtucket and Central Falls are vulnerable to a wide range of natural hazards that threaten life and property which can be defined or categorized in a variety of ways. The hazard identification process completed for this plan began with a review of each City's existing hazard mitigation plan and capturing early input from the Local Planning Team at the project kickoff meeting. This was followed by an extensive evaluation and classification of all potential hazards based on a review of the State of Rhode Island Hazard Identification and Risk Assessment (January 2017), past major disaster and emergency declarations for Providence County, historical and anecdotal data on previous hazard events, and the hazard mitigation plans for neighboring jurisdictions. Readily available information from other official and reputable data sources was also evaluated to supplement information provided through these primary sources.

Table A-1 identifies the 13 definitive types (or groupings) of natural hazards considered for this plan, listed in alphabetical order, and summarizes the rationale for why each was or was not recommended for further study in the risk assessment. While descriptive profiles and vulnerability assessments are to be completed only for the 9 hazards identified as posing significant risk for the planning area, the Local Planning Team shall not be precluded from considering mitigation actions for others if deemed appropriate. It should also be noted that hazards not currently identified for inclusion in the risk assessment may be further studied and/or included during the plan maintenance process as required.

Table A-1: Hazard Identification and Screening Summary

Natural Hazard	Significant Risk for Planning Area?	Rationale for Inclusion or Exclusion from Risk Assessment
Coastal Storm *(includes hurricanes, tropical storms, and nor'easters)*	Yes	• Identified in existing plans, and affirmed as a priority concern by the Local Planning Team • Frequency and severity of previous occurrences in planning area, including multiple major disaster and emergency declarations • Review of NOAA historical records – 30 hurricanes or tropical storms have come within 75 miles of planning area since 1858 • High probability of future events, with potential to cause severe, extensive loss, damage and disruption to the entire planning area
Dam Failure	Yes	• Identified in existing plans, and affirmed as a priority concern by the Local Planning Team • Several high hazard dams are located within and upstream of the planning area • Existing studies suggest that hundreds of homes in planning area are potentially at risk to inundation from dam failures
Drought	No	• Not identified as a hazard of concern in existing plans • Low frequency of previous occurrences, especially for severe to extreme droughts • Potential vulnerability to any physical, social, economic, or environmental impacts in the planning area caused by drought is considered low • Limited ability to implement additional drought mitigation activities beyond existing plans and procedures for emergency water conservation, and the ongoing efforts of the Rhode Island Water Resources Board

Natural Hazard	Significant Risk for Planning Area?	Rationale for Inclusion or Exclusion from Risk Assessment
Earthquake	Yes	• Identified in existing plans – but as low risk • Previous occurrences – moderately damaging earthquakes strike somewhere in the region every few decades • Potential for significant future ground shaking events • Vulnerability older structures (especially unreinforced masonry buildings) and large commercial/industrial structures (old mills, etc.) constructed before modern building codes and/or on fill • Potential local impacts caused by ground liquefaction in low-lying areas near water bodies
Epidemic	No	• Not identified as a hazard of concern in existing plans • Lack of any major previous occurrences • Per the State Hazard Mitigation Plan, the probability of epidemic outbreaks with significant impacts is low • Epidemic is more appropriately addressed through other local plans and procedures, and the ongoing efforts of the Rhode Island Department of Health
Extreme Temperatures	Yes	• History of previous occurrences (both heat and cold) • Potential for increased frequency, duration and severity of extreme heat events due to climate change • Potential life/safety impacts to vulnerable populations in the planning area that could be disproportionately affected
Fire *(includes urban fire and wildfire)*	Yes	• Urban fire identified in existing plan (Pawtucket), and affirmed as a priority concern by the Local Planning Team • Previous occurrences in planning area that have resulted in property damage and destruction • Density of structures and old mill buildings in the planning area exacerbate urban fire hazards (in addition to the presence of chemicals and other accelerants) • Wildland Urban Interface (WUI) areas identified in southeastern Pawtucket
Flood *(includes riverine, coastal, flash, and urban flooding)*	Yes	• Identified in existing plans, and affirmed as a priority concern by the Local Planning Team • Review of existing FEMA Flood Insurance Rate Maps and USACE Hurricane Surge Inundation Areas • Previous occurrences in planning area, including major disaster and emergency declarations but also more frequent, damaging events at a smaller scale • High probability of future events, with potential to cause severe damage and disruption in many locations across the planning area
Landslide	No	• No record of significant previous occurrences in planning area • Low probability of future occurrences based on existing landslide hazard mapping (USGS) • Not addressed in State HIRA for same reason

Natural Hazard	Significant Risk for Planning Area?	Rationale for Inclusion or Exclusion from Risk Assessment
Sea Level Rise	Yes – *but to be included as part of Flood hazard*	• Introduced in existing plan (Pawtucket) • Sea level rise projections and planning guidance from the State's Coastal Resource Management Council • Review of State HIRA, STORMTOOLS, and Climate Central's Risk Finder for sea level rise and coastal flood risk • Sea level rise will increase potential coastal/tidal flood risks for Pawtucket
Severe Weather *(includes severe thunderstorms, high winds, tornadoes, hail, and lightning)*	Yes	• Identified in existing plans, and affirmed as a priority concern by the Local Planning Team • Frequency and severity of previous occurrences in planning area • High probability of future events, with potential to cause extensive damage and disruption to the entire planning area
Severe Winter Storm *(includes snow, blizzards, and ice storms)*	Yes	• Identified in existing plans, and affirmed as a priority concern by the Local Planning Team • Frequency and severity of previous occurrences in planning area, including multiple major disaster and emergency declarations • High probability of future events, with potential to cause extensive damage and disruption to the entire planning area
Soil Hazards *(includes sinkholes, subsidence, and expansion or collapse)*	No	• No record of significant previous occurrences in planning area • Low probability of future occurrences • Not addressed in State HIRA for same reasons

The 9 natural hazards identified above are consistent with all the hazards of concern for the State of Rhode Island as identified in its current *Hazard Identification and Risk Assessment* and *State Hazard Mitigation Plan*. Some of the hazards are interrelated (for example, hurricanes may cause flooding, or drought conditions may increase the likelihood of wildfires), but for hazard identification purposes these individual hazards are distinguished separately. More information on the interrelationship between hazards, potential secondary hazards resulting from a hazard event, and opportunities to mitigate multiple hazard-related risks through common mitigation techniques are addressed in subsequent sections of this plan.

A.3. HAZARD PROFILES

This section provides descriptive information on each of the nine (9) hazards identified as posing significant risk for Pawtucket and Central Falls, including the following key sub-sections:

- **General Description** – Provides brief descriptions of the hazard, its characteristics and potential effects.
- **Location** – Provides information on the geographic areas within the planning area that are susceptible to occurrences of the hazard.
- **Severity/Extent** – Provides information on the potential strength or magnitude of the hazard.
- **Previous Occurrences** – Provides information on the history of previous hazard events in the planning area, including their impacts on people and property.
- **Probability of Future Occurrences** – Describes the likelihood of future hazard occurrences in the planning area. This includes a summary of any anticipated effects that climate change may have on the frequency, duration and intensity of future hazard events. A summary of these effects in the Northeast region and specifically Rhode Island is provided below.

This section concludes with an overall summary of the key findings on the characteristics of each hazard and their potential impacts to the planning area. This information was used to measure relative risk each hazard poses to Pawtucket and Central Falls and helped the Local Planning Team in ranking and generally prioritizing the hazards for purposes of mitigation strategy development.

Natural Hazards and the Anticipated Effects of a Changing Climate

One of the most important factors in assessing natural hazard risk is the consideration of climate change and its potential effects on future events. Traditionally, hazard risk assessments have relied heavily on historical data and information along with the assumption of stationarity – that natural systems will not change with time – in predicting future climate and hazard conditions. However, best available science now tells us that hazard risk will change and, in many cases, will accelerate rapidly. Risk assessments must therefore embrace the reality of non-stationarity and address the how climate change may affect natural hazards. As mentioned above, this has been done for all applicable hazards throughout this section and is specifically summarized in the discussion on the *probability of future hazard occurrences*. A more general overview of the anticipated effects of climate change for the Northeast and specifically Rhode Island is provided below.

Annual average temperatures in the Northeast has increased by 2°F since 1970, with winter temperatures rising twice this much. This warming has resulted in many other climate-related changes including more frequent very hot days, a longer growing season, an increase in heavy downpours (an observed increase of 71 percent since 1958), less winter precipitation falling as snow and more as rain, reduced snowpack, earlier break-up of winter ice on lakes and rivers, earlier spring snowmelt resulting in earlier peak river flows, rising sea surface temperatures, and rising sea level. These trends are projected to continue, with more dramatic changes under higher greenhouse gas emissions scenarios compared to lower emissions scenarios.[1]

[1] United States Global Change Research Program. *Global Climate Change Impacts in the United States*. Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

Rhode Island is already facing the challenges of climate change, including increasing temperatures, more frequent flooding events, rising sea levels, and overall changing precipitation patterns. According to NOAA's summary of state-level climate information in the wake of the *Third U.S. National Climate Assessment*, released in 2014, the following key observations and anticipated effects of a changing climate have been identified for Rhode Island:

- Rhode Island has warmed by more than 3°F over the past century. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century. Increased intensity of heat waves is also projected, but a decreased intensity of cold waves.
- Both mean and extreme precipitation has increased during the last century, with the highest number of extreme events occurring over the last decade. Continued increases in frequency and intensity of extreme precipitation events are projected.
- Sea level has risen more than 9 inches since 1930 at Newport, faster than the global average. It is projected to rise another 1 to 4 feet by 2100. Increases in sea level will likely increase coastal flooding and erosion during winter storms, nor'easters, and hurricanes.

Summary of Major Disaster and Emergency Declarations

Prior to getting into hazard-specific profiles, it is important to note and document past major disaster and emergency declarations that have included Providence County. Major disaster and emergency declarations are issued by the President of the United States at a county level when an event has been determined to be beyond the capabilities and resources of state and local governments to respond and recover. A major disaster declaration is issued when a disaster or catastrophic event requires broader authority and resources to help states and local communities, as well as families and individuals, recover from the damage caused by the event. An emergency declaration is issued to protect property and public health and safety and to lessen or avert the imminent threat of a major disaster or catastrophe.

Since 1953, when presidential declarations first became issued, Providence County has been included in 10 major disaster declarations and 10 emergency declarations as listed in **Table A-2**. Many additional emergencies and disasters have occurred that were not severe enough to require federal disaster relief through a presidential declaration.

Table A-2: Major Disaster and Emergency Declarations for Providence County, Since 1953

Declaration Date	Incident Type	Declaration Type	Description
4/3/2015	Severe Storm(s)	Major Disaster	Severe Winter Storm & Snowstorm
3/22/2013	Severe Storm(s)	Major Disaster	Severe Winter Storm & Snowstorm
10/29/2012	Hurricane	Emergency	Hurricane Sandy
9/3/2011	Hurricane	Major Disaster	Tropical Storm Irene
8/27/2011	Hurricane	Emergency	Hurricane Irene
3/30/2010	Severe Storm(s)	Emergency	Severe Storms & Flooding
3/29/2010	Severe Storm(s)	Major Disaster	Severe Storms & Flooding

Declaration Date	Incident Type	Declaration Type	Description
9/19/2005	Hurricane	Emergency	Hurricane Katrina Evacuation
2/17/2005	Snow	Emergency	Record Snow
3/27/2003	Snow	Emergency	Snow
11/19/1996	Other	Emergency	Major Water Main Break
1/24/1996	Snow	Major Disaster	Blizzard of 96 (Severe Snow Storm)
3/16/1993	Snow	Emergency	Blizzards, High Winds & Record Snowfall
9/16/1992	Toxic Substances	Emergency	Water Contamination
8/26/1991	Hurricane	Major Disaster	Hurricane Bob
10/15/1985	Hurricane	Major Disaster	Hurricane Gloria
2/16/1978	Snow	Major Disaster	Snow & Ice
2/7/1978	Snow	Emergency	Blizzard & Snowstorms
8/20/1955	Hurricane	Major Disaster	Hurricane & Flood
9/2/1954	Hurricane	Major Disaster	Hurricanes

Source: FEMA

A.3.1. COASTAL STORM

A.3.1.1 General Description

Coastal storms include hurricanes and tropical storms, in addition to nor'easters and similar low pressure storm systems with cyclonic flows.

Hurricanes and tropical storms are classified as cyclones and defined as a closed circulation of winds developing around a low-pressure center in which the winds rotate counter-clockwise (in the Northern Hemisphere) and with a diameter averaging 10 to 30 miles across. Tropical cyclones are among the most powerful and destructive meteorological systems on earth. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. The primary damaging forces associated with these storms are high-level sustained winds, heavy rainfall, and tornadoes. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves, and tidal flooding which can be more destructive than wind (and are covered separately in this section under Flood). As these storms move inland, they can cause severe flooding, downed trees and power lines, and widespread structural damage. Once a cyclone no longer has tropical characteristics, it is then classified as an extratropical system. Most hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which extends from June through November.

Nor'easters are extratropical storm systems that, similar to hurricanes and tropical storms, are typically characterized by a large, counter-clockwise wind circulation around a low pressure center that affect the Mid-Atlantic and New England states primarily during winter months. A nor'easter gets its name from the continuously strong northeasterly winds blowing in from the ocean ahead of the storm. They can form over land or water and are notorious for producing high winds, heavy precipitation (rain and snow), and tremendous waves that crash onto beaches, often causing beach erosion and structural damage. Wind gusts associated with these storms can exceed hurricane force (74+ miles per hour) in intensity, and when combined with snow result in blizzard conditions that can paralyze a region. Similar to hurricanes, nor'easters are capable of causing substantial damage to coastal areas due to their associated strong winds, storm surge, and heavy surf. However, unlike hurricanes and tropical storms, nor'easters are typically a winter occurrence and can sit and churn offshore for days, resulting in continuous flooding, various degrees of wave and erosion-induced damage to structures, and erosion of natural resources, such as beaches, dunes, and coastal bluffs.

A.3.1.2 Location

The entire planning area is susceptible to the occurrence of coastal storms including hurricanes, tropical storms, and nor'easters. While the entire planning area is uniformly susceptible to wind-related effects, the area's low-lying flood prone areas are at most risk to inland flooding, including those areas along the Blackstone River which are also more susceptible to the destructive forces of storm surge and tidal flooding (see Figure A-7 under Flood).

A.3.1.3 Severity/Extent

The National Weather Service's Saffir-Simpson Hurricane Wind Scale, shown in **Table A-3**, is used to categorize the strength and magnitude of hurricane events according to sustained wind speed, and provides estimates of potential property damage. New England is also prone to tropical storms and tropical depressions which have wind speeds less than a Category 1 Hurricane (39-73 miles per hour for tropical storms, and 38 miles per hour or less for tropical depressions) but may still cause damage across large areas.

Table A-3: Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
3 (major)	111-129 mph	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA, National Hurricane Center

There is no widely used scale to classify nor'easters. However, the classification scheme developed by Gregory A. Zielinski and presented in **Table A-4** is a useful index to categorize nor'easters (and other severe winter storms) by intensity. It consists of a five-level hierarchy similar to the Saffir-Simpson Hurricane Wind Scale, with a Category 1 storm being the least severe in terms of its intensity and a Category 5 storm being the most severe.

Table A-4: Classification Scheme for Nor'easters

Intensity Index Category	Maximum Snowfall Amounts	Maximum Snowfall Rate	Potential Wind Speeds	Maximum Drifting Potential	Closings/Delays on Communities, Schools, and Travel	Impact on Coastal and Maritime Interests	Nature of Disruption
1	< 10 in.	Very low < 1 in./hr	Weak	Minor < 20 in.	Maybe minor (hours)	Minor	Minimal-nuisance
2	10-20+ in.	Moderate 1+ in./hr	Strong	Moderate 3 ft.	Maybe moderate (hours to a day common)	Minor to moderate	Nuisance-inconvenience
3	20-30+ in.	High 2+ in./hr	Gale force	High 4-6+ ft.	Possibly extensive/ lengthy (several days possible)	Moderate to severe	Inconvenience-crippling

Intensity Index Category	Maximum Snowfall Amounts	Maximum Snowfall Rate	Potential Wind Speeds	Maximum Drifting Potential	Closings/Delays on Communities, Schools, and Travel	Impact on Coastal and Maritime Interests	Nature of Disruption
4	30-40+ in.	Very High 2-3 in./hr	Gale force hurricane	Very High 6-10+ ft.	Probably extensive/ lengthy (up to a week may be common)	Severe	Crippling-paralyzing
5	40-50+ in.	Overwhelming > 3+ in.hr	Gale force hurricane	Exceptional 10-15 ft.	Extensive/ lengthy (up to a week common)	Extreme	Paralyzing

Source: Gregory A. Zielinski, Institute for Quaternary and Climate Studies, University of Maine

For mitigation planning purposes, the maximum probable extent of coastal storms in the planning area is a Category 3 hurricane on the Saffir-Simpson Hurricane Wind Scale; or an Intensity Index Category 4 on Classification Scheme for Nor'easters.

A.3.1.4 Previous Occurrences

According to NOAA historical records, 30 hurricane/tropical storm tracks have come within 75 miles of the planning area since 1858. This includes 19 tropical storms, six (6) Category 1 hurricanes, three (3) Category 2 hurricanes, and two (2) Category 3 hurricanes. **Figure A-1** shows the historical tracks of these storms, some of which are further described below. The figure does not include the tracks of an additional extra-tropical systems, tropical depressions or nor'easters that also came within 75 miles of the planning area.

Hurricanes are relatively rare but have proven to be potentially devastating events in Rhode Island. Hurricane wind damages can be costly for coastal and inland communities, including the cities of Pawtucket and Central Falls, but storm surge along for coastal areas is by far the most destructive force. Though not considered a coastal community, the City of Pawtucket is vulnerable to potential storm surge along the Seekonk and Blackstone rivers as ocean waters are funneled into the upper reaches of Narragansett Bay and past Providence. As further described in section A.3.6 under Flood, Central Falls is at only slight risk to the effects of storm surge, even under the most extreme scenarios (Category 4 hurricane).

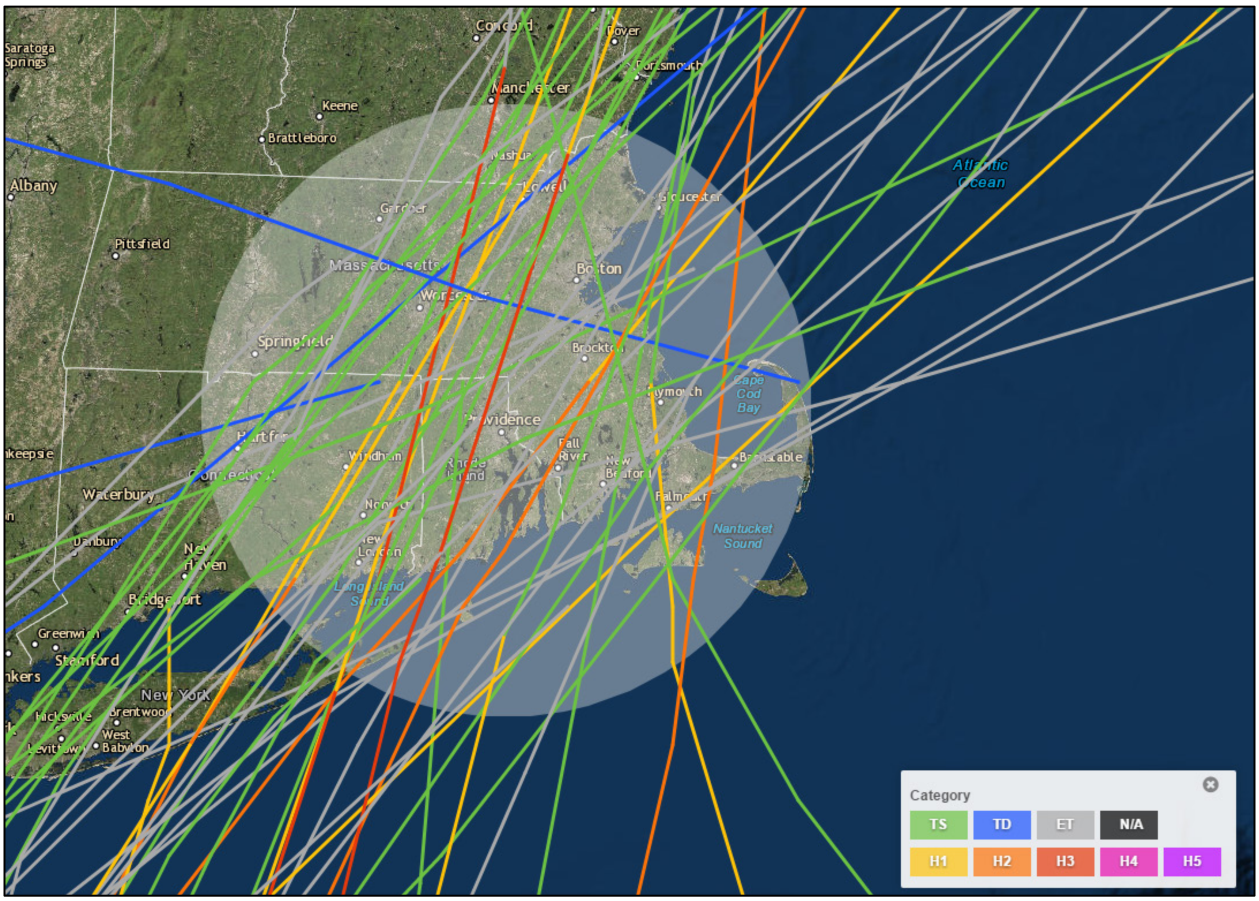
The comparison of hurricanes to nor'easters reveals that the duration of high surge and winds in a hurricane is 6-12 hours, while a nor'easter's duration can be from 12 hours to three days. The amount of damage resulting from a strong hurricane is often more severe than a nor'easter, but Rhode Island has historically suffered more damage from nor'easters because of the greater frequency in which they occur.

Local Impacts

- Pawtucket has suffered property damage from the last few hurricanes due to flooded sewer lines. A significant portion of the city east of the Blackstone River experiences frequent street and basement flooding during heavy rain. This is due to a combination of factors, including the inability of the current combined sewer overflow (CSO) system to handle the runoff during heavy rainfall. The pipes in the CSO system have become clogged with scum buildup over the years, decreasing the capacity of the lines. To help correct this problem, some backflow-prevention valves have been installed where the sanitary line that runs from the house connects to the CSO system.

- The City of Pawtucket recorded wind damage in 1985 (Hurricane Gloria) and 1991 (Hurricane Bob) due to hurricane force winds felling trees and causing damage to residential structures. In 1991, repair costs were in excess of $600,000 just due to felled trees.
- Some residents in Central Falls experienced flooding of their homes in 2011 (Tropical Storm Irene), and many were left without power for days.

Figure A-1: Historical Storm Tracks Since 1958



Source: NOAA

Hazard History

Event descriptions for some of the historic and major coastal storm events impacting the region are provided below. These summaries are based heavily on information available in the NOAA Storm Event Database, FEMA Flood Insurance Study for Providence County, and the State of Rhode Island Hazard Identification and Risk Assessment. Additional local impacts to Pawtucket and Central Falls are included where available.

- October 29, 2012 – Hurricane Sandy, with a wind diameter stretching more than 1,000 miles, became the largest Atlantic hurricane on record and is estimated to be the second costliest in history, only surpassed by Hurricane Katrina in 2005. The storm made landfall as a "post-tropical cyclone" in Atlantic City, New Jersey with sustained winds of 90 miles per hour and a devastating storm surge for communities in the northeast area. Though damage in the planning area was limited, its effects were directly felt throughout Rhode Island with damaging winds and storm surge that caused extensive flooding and erosion along the coast. Sandy caused some property damage and power outages within Providence County, where inland wind gusts ranged from about 55 to 65 mph. More than 122,000 people in the state lost power and it is estimated that more than $39.4 million in support from four federal disaster relief programs has helped Rhode Island recover from this disaster, the majority of which is from the NFIP ($31.1 million). This event resulted in a major disaster declaration for Providence County.
- August 27, 2011 – Hurricane Irene made landfall as a Category 1 hurricane in New Jersey, weakened to a tropical storm, and then traversed New England while producing significant amounts of rain, storm surge, inland and coastal flooding, and wind damage across the region. Gusts of wind up to 71 mph were reported in Rhode Island, and storm surge in Narragansett Bay caused some coastal damage. The storm surge experienced along the coast was generally in the two- to four-foot range with a high of 4.78 feet at Fox Point in Providence. However, most of damage was caused by wind. Sustained winds over a 6 to 12-hour long duration resulted in widespread tree damage and resulted in power outages to roughly half of Rhode Island residents. The highest sustained wind speed was 62 mph at the Physical Oceanographic Real Time System station at Conimicut Light in Narragansett Bay, Rhode Island. This event resulted in a major disaster declaration for Providence County. Damage assessment reports from FEMA put the total public assistance cost at $9,260,898.
- September 6, 2008 – Tropical Storm Hanna resulted in significant wind damage in Southeastern Providence County. The highest sustained wind of 29 mph and gusts of 40 mph were recorded at T.F. Green Airport. Several trees, wires, and a transformer were blown down but the event resulted in no loss of life or injuries, and only $13K in property damage, all from wind. Total rainfall from the storm in southeast Providence County ranged from four to five inches, but no flooding was reported.
- August 18, 1991 – Hurricane Bob was the second named storm and the first hurricane of the 1991 hurricane season, reaching a Category 3 status. The eye of the storm tracked north-northeast between Fall River and Providence, traveling at a speed of 40 mph and creating a 6-10 foot storm surge in Narragansett Bay. Southern New England experienced estimated damages of $1.5 billion, and 60 percent of residents across Southeastern New England lost power. There were also two unconfirmed tornadoes in Rhode Island. This event resulted in a major disaster declaration for Providence County.
- September 27, 1985 – Hurricane Gloria caused extensive damage along the east coast of the U.S. This event was responsible for a total of eight fatalities (two in New England) and approximately $1.94 billion in damage. At one point wind gusts were sustained at 145 mph, causing Gloria to reach a Category 4 status. When it reached New England, it was considered a Category 1 storm, with wind speeds of up to 74 mph. The storm arrived at low tide and resulted in storm surges less than 5 feet above normal, minimizing damage to the

coastline. However, Gloria's winds did cause extensive wind damage in isolated areas along the shore and well inland, resulting in some long-term power outages. This event resulted in a major disaster declaration for Providence County.

- February 5-7, 1978 (Blizzard of 1978) – *covered under Severe Winter Storms (section A.3.8.4).*
- September 21, 1961 – Hurricane Esther caused heavy shore damage at Sakonnet Point in Little Compton and Misquamicut in Westerly.
- September 12, 1960 – Hurricane Donna caused Heavy rain and major flooding in the Blackstone River Valley.
- August 17-20, 1955 – The remnants of Hurricane Diane swept over Rhode Island, but its wind velocities were far below hurricane force. Damage to power lines was high, and at one time 82 percent of Rhode Island's homes were without electricity. Ample warning permitted people to return home from school and work early, and as a result, only two lives were lost. Property damage amounted to $170 million, most resulting from torrential rains, which caused serious river flooding. The Blackstone River crested at 15 feet above normal, and according to FEMA's Flood Insurance Study report, this remains the greatest flood of record on the river due to an average of nearly 12 inches of rain falling over the drainage basin. This event resulted in a major disaster declaration for Providence County.
- September 11, 1954 – Hurricane Edna, a Category 3 hurricane, made landfall near Martha's Vineyard and Nantucket before crossing the eastern tip of Cape Cod, Massachusetts. Hurricane force winds of 75 to 95 mph buffeted all of coastal Rhode Island and knocked out electrical power across many sections of the state. Edna arrived during a rising tide and resulted in severe flooding across Martha's Vineyard, Nantucket, and Cape Cod, where storm surges of over 6 feet were common. Farther west, storm surge values were 4 feet or less, resulting in storm tides that remained below flood stage. Rainfall amounts of up to 7 inches were common, aggravating the already saturated conditions caused by Hurricane Carol ten days earlier and resulting in major flooding in the Blackstone River Valley. The total combined rainfall for Carol and Edna was as much as 11 inches across most of Rhode Island. Edna was responsible for 21 deaths across the region. This event resulted in a major disaster declaration for Providence County.
- August 31, 1954 – Hurricane Carol, a Category 3 hurricane with wind gusts of Category 4 strength, made landfall just west of Rhode Island near Old Saybrook, Connecticut. It was the most destructive hurricane to strike Southern New England since the Great New England Hurricane of 1938. The storm swept into Rhode Island with little warning and came at high tide. The Providence tide gauge recorded a storm surge nearly 10 feet above mean high water and the central downtown area was flooded to a depth of 13 feet, inundating up to 3,500 vehicles. Wind speeds of 90 mph were recorded in Providence, with 115 mph gusts. The storm resulted in 19 fatalities across New England, and an estimated $200 million in property damage. Nearly 3,800 homes were destroyed and the storm left most residents in Rhode Island without power. This event resulted in a major disaster declaration for Providence County.
- September 14, 1944 – Affected Rhode Island and southeastern Massachusetts; $2 million in property damage; no loss of life.

- September 21, 1938 – The most intense hurricane to strike Rhode Island occurred in 1938. Known widely as the "Great New England Hurricane of 1938" or "Long Island Express," it made landfall as a strong Category 3 hurricane on Long Island, New York and moved rapidly through New England. Initially, the hurricane was forecast to curve out into the Atlantic Ocean, and because official forecasts expected mere overcast conditions, residents were unaware of the impending storm. Approximately 600 people died in the storm in New England, most in Rhode Island (262), and up to 100 people elsewhere in the path of the storm. An additional 708 people were reported injured. The hurricane also devastated the forests of the Northeast, knocking down an estimated 2 billion trees in New York and New England. The hurricane produced wind gusts as high as 130 mph, up to 17 inches of rainfall, and a coastal storm surge of 18 to 25 feet from New London, Connecticut to Cape Cod in Massachusetts. The Providence tide gauge reportedly measured a record storm surge of 12.66 feet during the event, which per FEMA's Flood Insurance Study report, caused flood levels of approximately 16 feet on the Seekonk River. Sustained winds of 95 mph were recorded in Rhode Island and virtually the entire state lost electrical power. Total damage is estimated at $6 billion (2004 USD), making it among the costliest hurricanes to strike the U.S. mainland. To date it remains the most powerful, costliest, and deadliest hurricane in New England history, and it is estimated that if an identical hurricane struck today it would cause $39.2 billion (2005 USD) in damage.

A.3.1.5 Probability of Future Occurrences

Coastal storms will continue to be a ***likely*** occurrence in the planning area. Based on historical event data, the annual probability of a hurricane or tropical storm coming within 75 miles of the planning area is 19 percent, though the chance of a major hurricane (Category 3-5) at landfall is much less. According to the State of Rhode Island Hazard Identification and Risk Assessment, the likelihood of occurrence for hurricanes or tropical storms impacting Providence County is between 10 and 100 percent probability in the next 5 years and at least one incident during the next ten years, while nor'easters have an average frequency of one to two events per year.

Long-term global climate models under the Intergovernmental Panel on Climate Change (IPCC) warming scenarios indicate that it is possible that hurricanes and other coastal storms will become more intense, with stronger winds and heavier precipitation throughout the twenty-first century. Although there is insufficient scientific evidence to firmly determine the effects of climate change on future storms, large events are becoming more frequent and research indicates the warming climate may double the frequency of Category 4 and 5 hurricanes by the end of the century, and decrease the frequency of less severe hurricane events.

A.3.2. DAM FAILURE

A.3.2.1 General Description

A dam failure is the structural collapse of a dam that releases the water stored in the reservoir behind the dam. Dam failures can result from natural events, human-induced events, or a combination of the two. A dam failure is usually the result of the age of the structure, inadequate spillway capacity, or structural damage caused by an earthquake or flood. Failures due to prolonged periods of rainfall can result in overtopping (the most common cause), and total failure occurs if internal erosion, overtopping, or damage results in a complete structural breach.

Overtopping occurs when a dam's spillway capacity is exceeded and portions of the dam that are not designed to convey flow begin to pass water, erode away, and ultimately fail.

Other potential causes of dam failure include design flaws, foundation failure, internal soil erosion, inadequate maintenance, or mis-operation. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-laden water that rushes downstream, damaging or destroying everything in its path. The sudden release of water can lead to extensive flooding and has the potential to cause human casualties, economic loss, and environmental damage as the flows are often much larger than the capacity of downstream channels. Flood damage occurs as a result of the momentum of the flood caused by the sediment-laden water, flooding over the channel banks, and impact of debris carried by the flow. An additional hazard concern is the cascading effect of one dam failure causing multiple dam failures downstream due to the sudden release of flowing water. This type of disaster is particularly dangerous because it can occur rapidly, providing little warning and evacuation time for people living downstream.

While dam failures that occur during flood events compound an already tenuous situation and are certainly problematic, the dam failures that occur on dry days are the most dangerous. These "dry day" dam failures typically occur without warning, and downstream property owners and others in the vicinity are more vulnerable to being unexpectedly caught in life threatening situations than failures during predicted flood events.

A.3.2.2 Location

There are seven (7) dams located in the planning area, though as can be seen in **Table A-5**, none of them are classified by the Rhode Island Department of Environmental Management (DEM) as "High" or "Significant" hazard dams where failure or mis-operation will probably cause loss of human life (see section A.3.2.3, *Severity/Extent* for the definition of specific hazard classifications). This includes 2 dams in Central Falls along the Blackstone River, including one dam on Broad Street (Valley Falls) and the other on Roosevelt Avenue (500 block). The other 5 dams are in Pawtucket as further described in the table and below.

Table A-5: State-Regulated Dams in the Planning Area

City/Town	River/Stream	Dam Name	State ID	Hazard
Central Falls/ Cumberland	Blackstone River	Valley Falls Pond	063	Low
Central Falls/ Pawtucket	Blackstone River	Central Falls	064	Low
Pawtucket	Blackstone River	Pawtucket Upper	065	Low
Pawtucket	Blackstone River	Pawtucket Lower	066	Low
Pawtucket	Ten Mile River	Lebanon Mill	293	Low
Pawtucket	Ten Mile River	Ten Mile Reservation	294	Low
Pawtucket	Ten Mile River	Slater Park	702	Low

Source: 2016 State of Rhode Island Dam Safety Program

Of greater concern to Central Falls and Pawtucket are the larger, higher hazard dams located outside and upstream from their jurisdiction. This includes the Woonsocket Falls Dam (Significant Hazard) upstream on the Blackstone River in Woonsocket, and the Hebronville Pond Dam (High Hazard) located upstream on the Ten Mile River in Attleboro, Massachusetts. Brief descriptions are provided below.

1. The Woonsocket Falls Dam was built in 1960 and is owned and operated by the US Army Corps of Engineers. It is classified by DEM as a **Significant Hazard Dam**. The dam was not designed for flood damage reduction but acts as a Mill/Penstock Dam for the Thundermist hydroelectric facility owned and operated for the City of Woonsocket. When conditions warrant, USACE will operate the gates to reduce local isolated flooding upstream. The dam is also monitored by computer sensors and is hooked up to an alarm system, and the city is working on installing some type of flood stage markers in order to monitor the Blackstone River level and buy some more lead time for evacuation. According to a 2015 report by Pare Corporation, the dam is listed in "fair" condition, and suffers from leaks in its upstream wall and is cracking and missing mortar. The report recommended clearing vegetation, repairing masonry and increasing the capacity of the existing spillway.[2]

2. The Hebronville Pond Dam was originally constructed in 1875 and is privately-owned by the Hebronville Mill Limited Partnership. The dam is located immediately upstream of a former mill building which has been converted into residential apartments. It is classified by the Massachusetts Department of Parks and Recreation as a **High Hazard Dam**. According to the Emergency Action Plan (EAP) that was updated in 2013, approximately 300 properties along the Blackstone River in Pawtucket are located in the downstream inundation areas that could be affected in the event of a dam failure. The EAP, which includes inundation maps and a listing of roadways and residences in the inundation areas, along with specific notification and evacuation procedures, is on file with the Pawtucket/Central Falls Emergency Management Agency. According to a 2010 inspection report prepared by Pare Corporation, the dam is listed to be in "fair" condition, with noted deficiencies that included areas of unmaintained vegetation, apparent leakage through the stone masonry wall, and a deteriorated/inoperable sluiceway.

A.3.2.3 Severity/Extent

According to federal guidelines for dam safety, two factors influence the severity of a dam failure: (1) the amount of water impounded, and (2) the density, type, and value of development and infrastructure located downstream. The severity and extent of most dam failures are described by their potential point of inundation; and their hazard potential classifications are identified as follows[3]:

- *Low Hazard Potential* – Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- *Significant Hazard Potential* – Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but

[2] The Sun Chronicle. *Two dams in Attleboro listed as 'poor' and 'high hazard'*. March 8, 2017.
[3] FEMA. *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*. April 2004.

can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

- *High Hazard Potential* – Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

It is important to note that these hazard classifications are not related to the physical condition or structural integrity of the dam (nor the probability of its failure), but strictly to the potential for adverse downstream effects if the dam were to fail.

For mitigation planning purposes, the maximum probable extent of a dam failure in the planning area is a complete failure of a high hazard dam.

A.3.2.4 Previous Occurrences

Rhode Island has experienced many dam failures, mainly resulting from major flood events. Historically, however, the consequences of dam failures have not been well documented. During the major flooding events in March 2010, four dams in Rhode Island were breached and many others were overtopped and close to breaching, which resulted in the inspection of 42 dams throughout the state.

Upon a review of data available from the State of Rhode Island, the National Performance of Dams Program (NPDP) at Stanford University, the Association of State Dam Safety Officials, and NOAA's Storm Events Database, there have been no recorded dam failures causing impacts in the planning area.

A.3.2.5 Probability of Future Occurrences

Dam failures are generally considered infrequent and unlikely occurrences, however, according to the State of Rhode Island Hazard Identification and Risk Assessment, the potential for dam failure is a significant concern given the large number of dams across the state and the fact that there have been dam failure events in the past. Per this assessment, the State estimates the likelihood of occurrence in Providence County as between 10 and 100 percent probability in the next 5 years. It also states that the probability of future dam failure events is not easily measured, but correlates to some extent with the probability of future major flood events coupled with preventative measures, including the routine inspection, maintenance, repair, and proper operation of dams by their owners, and as regulated by DEM's Dam Safety Section.

Due to the relatively low number of dams classified as Significant or High Hazard in proximity to Pawtucket and Central Falls, in addition to current state regulations and DEM's required monitoring and routine inspection and maintenance programs, the probability of future dam failure events is considered a ***possible*** occurrence for the planning area.

It is anticipated that the effects of climate change will not increase the probability of dam failure events, though projected increases in the frequency of heavy precipitation events (as described in section A.3.6.5 under Flood) should continue to be considered in the regulation, construction, operation, and maintenance or repair of dam structures. In Rhode Island, dams that receive construction permits for repair and/or reconstruction are designed to pass at least the one percent annual rainfall event with one foot of freeboard (a factor of safety against overtopping). If smaller rainfall events, such as 10-year and 25-year events, occur more frequently there will be little impact on the ability of the dams to operate safely.

A.3.3. EARTHQUAKE

A.3.3.1 General Description

An earthquake is the sudden motion or trembling of ground caused by an abrupt release of accumulated strain on tectonic plates that comprise the Earth's crust. While these thick plates move slowly and continuously over the interior of the earth, they collide, slide, catch, and hold – but eventually, when the mounting stress exceeds the elastic limit of the rock, faults along or near plate boundaries rupture or slip abruptly and an earthquake occurs. The ensuing seismic hazard effects on the Earth's surface include ground shaking, surface fault ruptures, and ground failures, which have the potential to cause widespread damage to buildings and infrastructure. Liquefaction, which happens when loosely packed, water-logged sediments lose their strength in response to strong shaking, often causes major damage during earthquakes. Earthquakes may also provoke secondary hazards such as tsunamis, landslides, dam failures, or large fires ignited by ruptured gas lines.

The underground point of initial rupture is known as an earthquake's focus or hypocenter, and the point at ground level directly above the hypocenter is known as its epicenter. In general, the severity of the resulting ground motion increases with the amount of energy released and decreases with distance from the epicenter. Larger earthquakes usually begin with slight tremors but rapidly take the form of one or more violent shocks, and are followed by vibrations of gradually diminishing force called aftershocks. While the great majority of earthquakes strike near continental margins or in areas where large plates collide or move past each other, some, including those in the Northeast United States, can occur within plate boundaries.

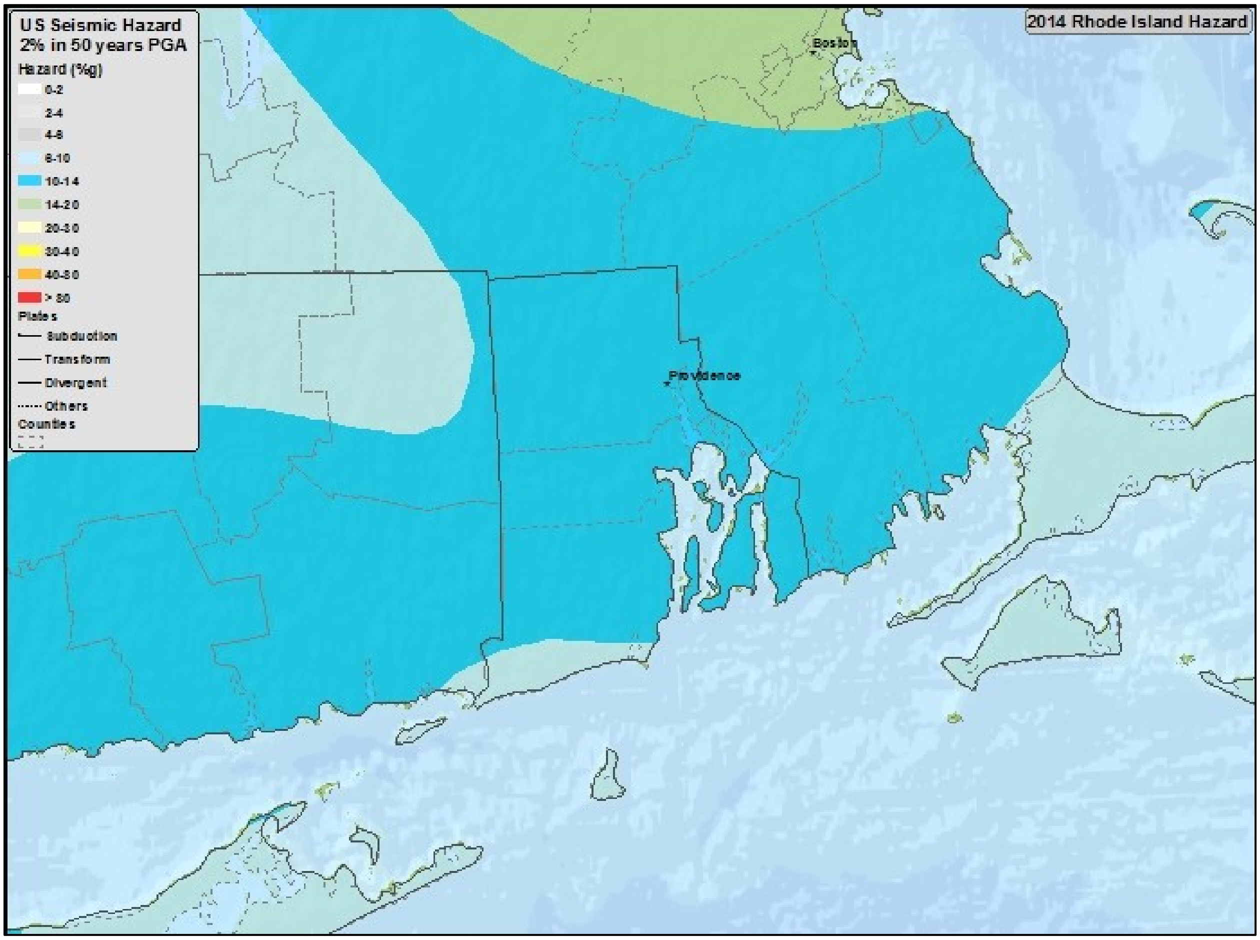
A.3.3.2 Location

The entire planning area is uniformly susceptible to the occurrence of earthquakes. Unlike other areas of the country where earthquakes occur along known fault lines, earthquakes in the Northeast do not correlate with the many known faults that exist in the region. They occur in the middle of plates, far from the plate boundaries.

The planning area (and all of Rhode Island) is located in the North Atlantic tectonic plate and is in a region of historically low seismicity. Only three or four earthquakes of Modified Mercalli Intensity Scale (MMI) V or greater have been centered in Rhode Island, including the most recent 1951 South Kingstown earthquake which had a magnitude 4.6 on the Richter scale. Other past earthquakes centered in Narragansett Bay, which most significantly impacts Newport, Bristol, and Providence counties. Because of this low seismic level there is a general perception that the state has very little risk of sustaining any earthquake-induced damage. However, as further described in this section (under *Previous Occurrences*), areas geographically close to Rhode Island have had moderate seismic activity historically.

Figure A-2 illustrates Rhode Island's earthquake risk based on a 2014 seismic hazard map developed by the United States Geological Survey (USGS) to describe the annual frequency of exceeding a set of ground motions. The figure shows seismic risk zones according to peak ground acceleration, which is expressed as a percentage of the force of gravity (%g). Peak ground acceleration is the amount of earthquake generated ground shaking that, over a specified period, is predicted to have a specified chance of being exceeded. Figure A-2 shows the peak acceleration with 2 percent probability of exceedance in 50 years, a common standard for USGS earthquake hazard maps which are applied in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. Pawtucket and Central Falls are located in a seismic zone with a peak ground acceleration value of 10-14%g, which is considered a low risk zone in terms of potential ground shaking and damage from such an event.

Figure A-2: Seismic Hazard Map for Rhode Island



Source: USGS

A.3.3.3 Severity/Extent

The magnitude of an earthquake is a measure of the amount of energy released as seismic waves at the hypocenter. The Richter Scale classifies earthquake magnitude as determined from measurements recorded by seismographs, and according to a single number on an open-ended logarithmic scale. Each unit increase in magnitude on the Richter Scale corresponds to a ten-fold increase in wave amplitude, or a 32-fold increase in energy.

The intensity of an earthquake is a measure of the strength of ground shaking and its effects on the Earth's surface at a certain location. Intensity is most commonly measured using the Modified Mercalli Intensity Scale, which is based on observed seismic effects versus any mathematical basis. The Scale is composed of 12 increasing levels of intensity (designated by Roman numerals) that range from imperceptible shaking to catastrophic destruction.

Table A-6 summarizes the range of magnitudes and related intensities for earthquakes according to the Richter and Modified Mercalli Intensity (MMI) scales, along with abbreviated descriptions of effects on people, human structures, and the natural environment near the epicenter.

Table A-6: Classification of Earthquake Magnitude and Intensity

<table>
<tr><th colspan="2">Magnitude (Richter Scale)</th><th>Typical Maximum Intensity (MMI Scale)</th><th>Abbreviated Description of Effects (Near Epicenter)</th></tr>
<tr><td colspan="2">1.0 to 3.0</td><td>I</td><td>Not felt except by a very few under especially favorable conditions.</td></tr>
<tr><td colspan="2" rowspan="2">3.0 to 3.9</td><td>II</td><td>Felt only by a few persons at rest, especially on upper floors of buildings.</td></tr>
<tr><td>III</td><td>Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.</td></tr>
<tr><td colspan="2" rowspan="2">4.0 to 4.9</td><td>IV</td><td>Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.</td></tr>
<tr><td>V</td><td>Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.</td></tr>
<tr><td rowspan="2">5.0 to 5.9</td><td></td><td>VI</td><td>Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.</td></tr>
<tr><td rowspan="3">6.0 to 6.9</td><td>VII</td><td>Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.</td></tr>
<tr><td rowspan="5">7.0 and higher</td><td>VIII</td><td>Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned.</td></tr>
<tr><td>IX</td><td>Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.</td></tr>
<tr><td rowspan="3"></td><td>X</td><td>Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.</td></tr>
<tr><td>XI</td><td>Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.</td></tr>
<tr><td>XII</td><td>Damage total. Lines of sight and level are distorted. Objects thrown into the air.</td></tr>
</table>

Source: USGS

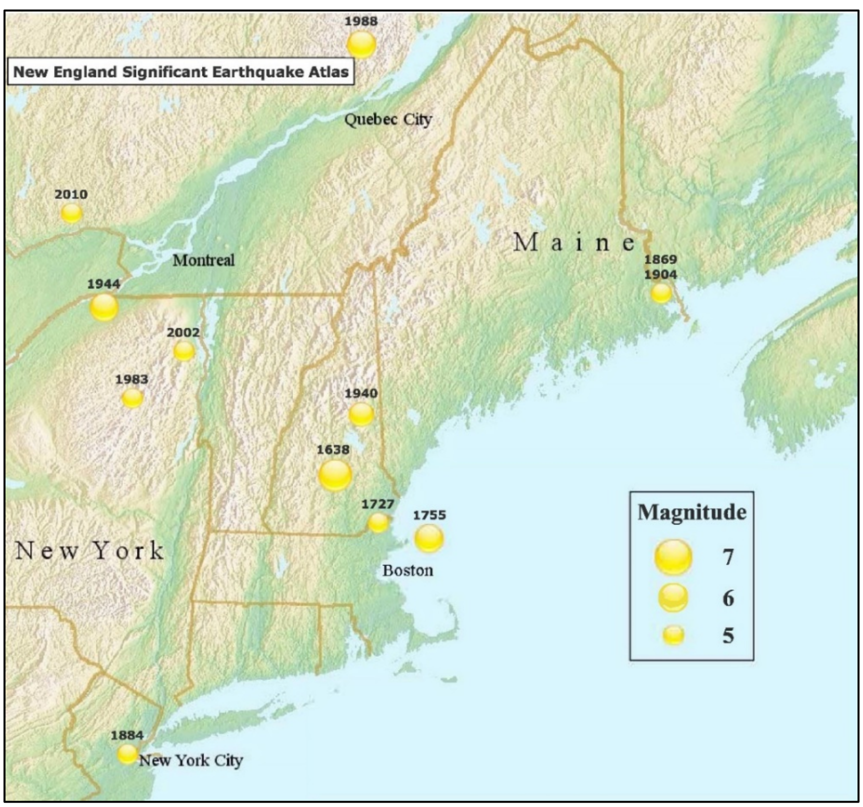
For mitigation planning purposes, the maximum probable extent of an earthquake in the planning area is a 6.5 on Richter Scale and Intensity VII on Modified Mercalli Intensity scale.

A.3.3.4 Previous Occurrences

Earthquakes occur on a regular basis in the Northeast US. According to the Weston Observatory Northeast Earthquake Catalog, more than 5,000 earthquakes have occurred in the region since 1638, including more than 1,500 earthquakes in New England. Generally, most earthquakes that occur in the Northeast US are small in magnitude and cause little to no damage, though ground shaking is felt across large areas due to the geologic composition and rock structure of the region. In terms of potential impacts, this makes the specific location of the epicenter in the Northeast less relevant than in other regions of the US.

Between 1924 and 2016, there were 105 earthquakes in the Northeast measuring a magnitude 4.5 or greater on the Richter scale. Out of these 104 earthquakes, 10 were centered within New England and the other 94 occurred within New York State and the Province of Quebec. Historically, moderately damaging earthquakes strike somewhere in the region every few decades, and smaller earthquakes are felt approximately twice per year. The largest known New England earthquakes occurred in 1638 (magnitude 6.5) in New Hampshire, and in 1755 (magnitude 5.8) offshore from Cape Ann northeast of Boston. The most recent New England earthquake to cause moderate damage occurred in 1940 (magnitude 5.6) in central New Hampshire. Reported damages included toppled chimneys, cracked walls, broken water pipes, fallen plaster, and broken furniture. **Figure A-3** shows the location for some of the most significant historical events per the Weston Observatory's New England Significant Earthquake Atlas.

Figure A-3: Significant New England Earthquakes



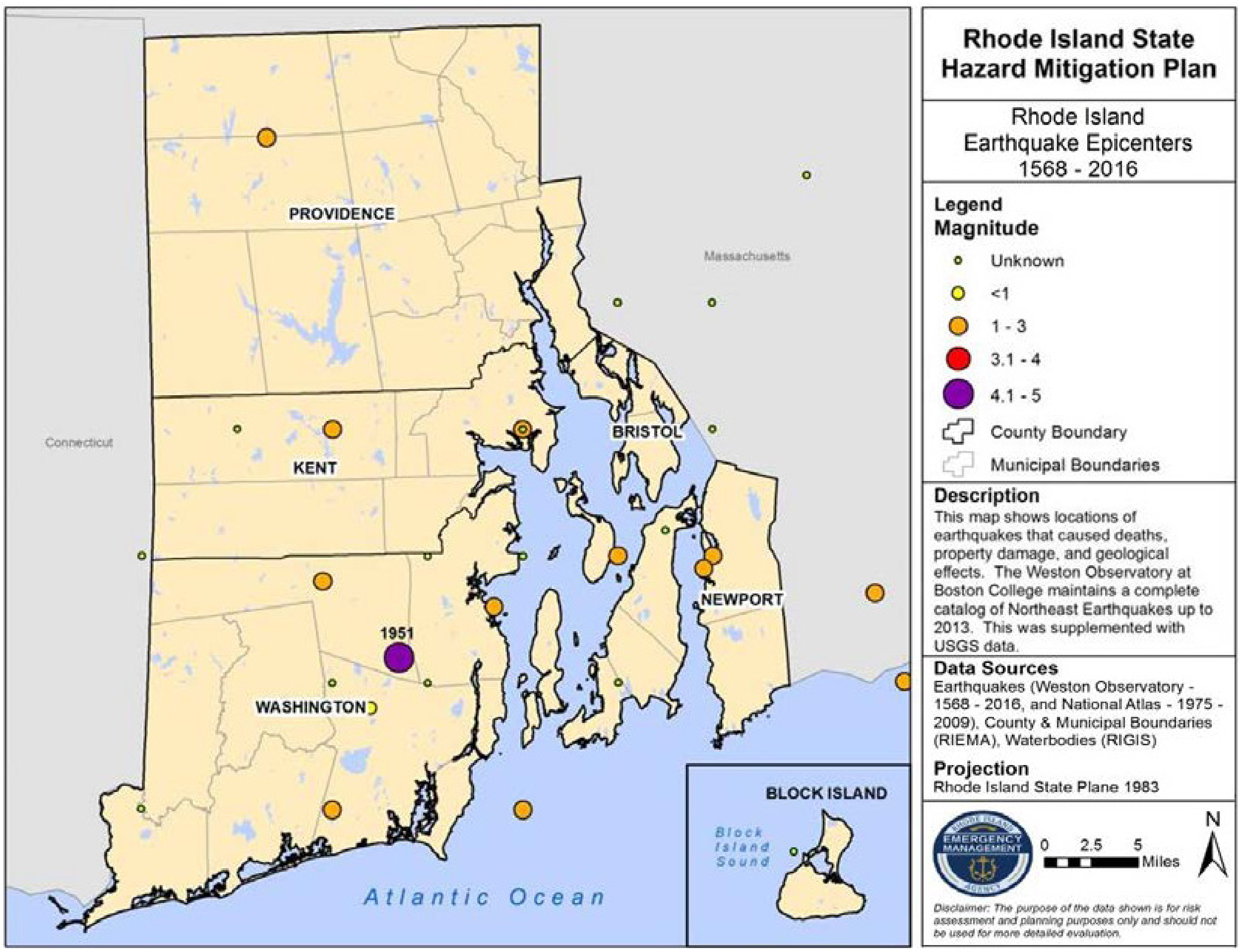
Source: Weston Observatory at Boston College

Local Impacts

As shown in **Figure A-4**, more than 34 earthquakes have been recorded with epicenters in or near Rhode Island since 1568, with no significant activity since 1951. While earthquake events do occur in the state, they do so with much less intensity than elsewhere in the region. In fact, earthquakes are more likely to be felt as a result of an event that occurs in the surrounding region rather than originating within the state. Some of the more significant earthquakes that were felt in the Rhode Island are listed below (under Hazard History), as highlighted in the State Hazard Mitigation Plan.

Based on a review of available data through the USGS and other reliable sources, no damages or casualties associated with these previous earthquake occurrences have been recorded locally in Pawtucket or Central Falls. However past ground shaking events in the region have been felt by residents in both cities.

Figure A-4: Earthquake Epicenters in or near Rhode Island



Source: Rhode Island State Hazard Mitigation Plan; Weston Observatory at Boston College

Hazard History

- June 14, 1973 – A magnitude 5.2 earthquake in western Maine caused some damage in the epicenter region and was reportedly felt over an area of 250,000 square kilometers of New England and Quebec. The intensities in Rhode Island were MMI IV at Charlestown and MMI I-III at Bristol, East Providence, Harmony, and Providence.

- December 7, 1965 – A small earthquake was felt in the Narragansett Bay region with a MMI V. Both windows and doors were reported to be shaking slightly. Some 14 months later, another small earthquake (MMI V) was felt in the lower bay area.
- October 16, 1963 – A magnitude 4.5 earthquake near the coast of Massachusetts caused some cracked plaster (MMI V) at Chepachet, Rhode Island.
- June 10, 1951 – The last earthquake in Rhode Island with a magnitude of 4.0 or greater was centered near North Kingstown.
- September 4, 1944 – Minor intensities were also reported from a shock in the Massena, New York, and Cornwall, Ontario, area. Kingston, Lonsdale, Providence, Wakefield, and Woonsocket reported intensity I-III.
- December 20-24, 1940 – The strong earthquakes centered near Lake Ossipee, New Hampshire, caused some damage in the epicenter area and effects were felt in Newport, Rhode Island. Additional reports included intensity MMI IV effects in Central Falls, Pascoag, Providence, and Woonsocket, and intensity MMI I-III effects in Kingston, New Shoreham, and Wakefield.
- November 1, 1935 – Another widely felt earthquake occurred near Timiskaming, Quebec, Canada. Measured at magnitude 6.25, the shock was felt (MMI IV) on Block Island and at Providence and Woonsocket. The total area affected was about 2,500,000 square kilometers of Canada and the United States.
- November 18, 1929 – The major submarine earthquake (magnitude 7.2) in the vicinity of the Grand Banks of Newfoundland was felt throughout the New England states. Moderate vibrations were felt on Block Island and at Chepachet, Newport, Providence, and Westerly.
- February 28, 1925 – A large area, estimated at over 5,000,000 square kilometers of eastern Canada and the United States (south to Virginia and west to the Mississippi River) was affected by a magnitude 7.0 shock. The epicenter was in the St. Lawrence River region; minor damage was confined to a narrow belt on both sides of the river. Intensity effects were felt on Block Island and at Providence; intensity MMI IV, at Charlestown.
- February 27, 1883 – an earthquake that was centered in Rhode Island was felt from New London, Connecticut, to Fall River, Massachusetts. Within Rhode Island, it was felt (MMI V) from Bristol to Block Island.

A.3.3.5 Probability of Future Occurrences

Earthquakes with a magnitude of 3.0 and greater will remain a ***possible*** occurrence for being felt in the planning area, though based on historical data and existing seismic hazard maps, Pawtucket and Central Falls are considered susceptible to only minor ground shaking and light damages (if any). Moderately damaging earthquakes are only expected to strike somewhere in New England every few decades, and seismologists have estimated that there is about a 50 percent probability of a very damaging magnitude 5.0 earthquake occurring anywhere in the region in a 50-year period. According to the State of Rhode Island Hazard Identification and Risk Assessment, the likelihood of occurrence for an earthquake impacting Providence County is less than one percent probability in the next 5 years. The effects of climate change will have no relation to the probability or magnitude of future earthquake events.

A.3.4. EXTREME TEMPERATURES

A.3.4.1 General Description

According to the National Weather Service, extreme temperatures (including extreme heat and extreme cold) are the number one weather-related killer in the United States.

Extreme heat may be generally defined as temperatures that hover 10 degrees or more above the average high temperature for the region, last for prolonged periods of time, and are often accompanied by high humidity. In Rhode Island, when the outside temperature goes above 90 degrees for three (3) or more days, it is considered a heat wave. Hot temperatures and extreme heat can occur and last for any amount of time, which can vary from one day to several weeks. At certain levels, the human body cannot maintain proper internal temperatures and may experience severe health disorders including heat cramps, heat exhaustion or heatstroke (a life-threatening condition).

Extreme cold may be generally defined as prolonged periods of time with freezing temperatures, often made worse by the impact of wind chill factors (the combined elements of air temperature and wind on exposed skin). At certain levels, the human body may suffer from frostbite or hypothermia, making extreme cold a potential severe and life-threatening hazard to people left unprotected from the elements. Freezing temperatures may cause severe damage to crops and other vegetation, and pipes may freeze and burst in structures that are poorly insulated or without heat. Excessive cold may accompany winter storms, be left in their wake, or can occur without storm activity. Long cold spells may cause rivers and lakes to freeze and lead to ice jams that can act as a dam, resulting in severe flooding.

A.3.4.2 Location

The entire planning area is uniformly susceptible to the occurrence of extreme temperatures. Extreme heat impacts the entire State of Rhode Island, though inland communities such as Pawtucket and Central Falls are at greater risk than coastal areas due to the lack of any moderating or cooling effects from onshore sea breezes. In addition, the more densely populated and urban environments that characterize each city make them more vulnerable to extreme heat due to the "heat island" effect (where built up areas are hotter than nearby rural areas due to human activities). Rhode Island's location in the northeastern United States makes it susceptible to extreme cold, however coastal communities are considered at greater risk due to stronger winds coming off the Atlantic Ocean which result in higher wind chills.

A.3.4.3 Severity/Extent

The National Weather Service's Heat Index is a measure of the effects of the combined elements of air temperature and relative humidity on the human body, particularly for people in higher risk groups (elderly persons, infants and young children, persons with respiratory difficulties, athletes, outdoor workers, and those who are sick or overweight). **Table A-7** summarizes the extent of these effects, and heat alert procedures from the National Weather Service are based mainly on the Heat Index values.

Table A-7: Effects of Extreme Heat on the Human Body

Heat Index	Heat Disorder
80–89° F	Fatigue possible with prolonged exposure and/or physical activity.
90–104° F	Sunstroke, heat cramps and heat exhaustion possible with prolonged exposure and/or physical activity.
105–129° F	Sunstroke, heat cramps or heat exhaustion likely, and heatstroke possible with prolonged exposure and/or physical activity.
130° F and Higher	Heatstroke/sunstroke highly higher likely with continued exposure.

Most recently, the Rhode Island Department of Health established the Northeast Regional Heat Collaborative. The Collaborative examines the relationship between heat and morbidity and mortality in the Northeast and, based on research findings from New England and in collaboration with key partners, the National Weather Service Regional and Local offices in the Northeast are planning to modify the heat advisory threshold in the region. Specifically, under the updated criteria, heat advisories in New England will be issued when either the heat index is forecast to be 95-99°F for 2 or more consecutive days or the heat index is forecast to be 100-104°F for any length of time.[4]

The National Weather Service's Wind Chill Index is used to measure the dangers of frostbite caused by the combined elements of freezing temperatures and wind. **Table A-8** summarizes the extent of these effects. A wind chill index of -5°F indicates that the effects of wind and temperature on exposed flesh are the same as if the air temperature alone were five degrees below zero, even though the actual temperature could be much higher. The NWS issues a wind chill advisory when wind chill temperatures are potentially hazardous and a wind chill warning when the situation can be life-threatening.

Table A-8: Effects of Extreme Cold on the Human Body

Wind (mph)	Temperature (°F) 40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

[4] *State of Rhode Island Hazard Identification and Risk Assessment*. January 2017.

For mitigation planning purposes, the maximum probable extent of extreme temperatures in the planning area is 5 consecutive days with a heat index exceeding 100 degrees, or a wind chill of less than -20 degrees.

A.3.4.4 Previous Occurrences

Extreme temperatures are not a very frequent occurrence in the planning area. As summarized in **Table A-9**, NOAA historical records indicate only 6 reported events in Providence County since 1996, however there were three (3) confirmed fatalities due to extreme heat, including two in Central Falls in 2008.

Table A-9: Previous Occurrences for Extreme Temperatures (1996 – 2017)

Date(s)	Event Type	Description	Casualties (Deaths/Injuries)	Property Damage
2/14/2016	Extreme Cold/ Wind Chill	Arctic high pressure brought strong northwest winds and extremely cold wind chills to southern New England. Many locations reported wind chills between 25 and 35 degrees below zero. Wind chills as low as 32 below zero were reported in Smithfield.	0/0	$0
2/16/2015	Extreme Cold/ Wind Chill	The Smithfield Automated Weather Observing System recorded wind chills as low as 30 below zero during a six-hour time frame.	0/0	$0
7/20/2013	Heat	Heat index values reached 92 degrees in Providence by 8am, peaked at 101 at 2pm and remained there for 3 hours before temperatures fell again. A 90-year old woman died at the Charlesgate Nursing Center in Providence. The woman was not in poor health but lived (and stayed) in a room without air conditioning.	1/0	$0
7/22/2011	Excessive Heat	A strong upper level ridge brought very hot temperatures to Southern New England. A moist southwest low-level flow increased humidity levels such that heat index values rose above 105 degrees for a period of a few hours. The Smithfield Automated Weather Observing System recorded heat indexes of 105 to 107 over a five-hour period.	0/0	$0

Date(s)	Event Type	Description	Casualties (Deaths/Injuries)	Property Damage
7/6/2010	Heat	A strong ridge built into Southern New England resulting in temperatures nearing 100 with high humidity. Heat index values ranged from 100 to 106 degrees for most of Southern New England on the 6th and again on the 7th in a more limited area. Heat index values at the Smithfield Automated Weather Observing System were 100 to 104 degrees.	0/0	$0
6/9/2008	Heat	An elderly couple in Central Falls, RI was found dead in their apartment where temperatures had reached 102 degrees.	2/0	$0
		Total	**3/0**	**$0**

Source: NOAA Storm Events Database

A.3.4.5 Probability of Future Occurrences

Extreme temperatures will continue to be a ***likely*** occurrence in the planning area. It is anticipated that the effects of climate change will result in an increase in the frequency, duration and intensity of extreme heat events, and a decrease in the frequency of extreme cold events. Heat waves are projected to become much more commonplace in a warmer future with potentially major implications for human health, particularly as it relates it more vulnerable populations such as children, seniors, lower income residents, and those already dealing with respiratory or other health problems.

According to the State of Rhode Island Hazard Identification and Risk Assessment, the likelihood of occurrence for an extreme heat event impacting Providence County is 100 percent probability in the next 5 years. Based on history and climatic conditions, the likelihood of occurrence for extreme cold during this same period is considered between 10 and 100 percent probability. Per this same report, extreme heat and hot weather have already increased in frequency and magnitude due to climate change. For example, in 1970, Providence had four days with a maximum temperature over 90°F; however, due to climate change, this number has risen to 22 days. In addition, the number of days over 90°F is projected to continue to grow. Climate change studies estimate that by 2070, Rhode Island could have up to 50 days over 90°F per year.

A.3.5. FIRE

A.3.5.1 General Description

Fire is a combustion or burning, in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke. For the purposes of this plan, the fire hazard includes two types of fire events: urban fires and wildfires.

Urban fires occur primarily in more densely developed areas of cities and towns with the potential to rapidly spread to adjoining structures. These fires damage and destroy homes, schools, commercial buildings and vehicles. A major urban fire or conflagration is a large, destructive, and often uncontrollable fire that spreads substantial destruction. Although they can be ignited by numerous sources, major urban fires are often the result of other hazards, such as storms, earthquakes, gas leaks, transportation accidents, hazardous material spills, criminal activity (arson), or acts of terrorism. Small structural fires, which occur more frequently, can result from mundane events such as cooking, smoking, or electrical equipment/appliance malfunctions. Nationally, the leading causes of urban fires are arson, open flames, and cooking. The leading causes of fire deaths are smoking, arson, and heating, with urban fires causing the most fire deaths and injuries. Between 70 and 80 percent of deaths result from residential fires. People under the age of 5 and over the age of 55 have a much higher death rate than the average population, accounting for more than one-third of all deaths nationally.

A ***wildfire*** is an unwanted, uncontrolled fire burning in an area of vegetative fuels such as grasslands, brush, or woodlands. Other names such as brush fire or forest fire may be used to describe the same phenomenon depending on the type of vegetation being burned. Heavier fuels with high continuity, steep slopes, high temperatures, low humidity, low rainfall, and high winds all work to increase the frequency and severity of wildfire for people and property located within wildfire hazard areas, and particularly for those in rural areas with limited capabilities for rapid fire suppression. When not quickly detected and contained, wildfires have the potential to cause extensive damage to property and threaten human life. Wildfires are part of the natural management of many forest ecosystems, but most are caused by human ignition factors. Nationally, over 80 percent of wildfires are started by negligent human behavior during dry conditions such as improperly discarding cigarettes, burning debris, or not extinguishing campfires in wooded areas. The second most common cause of wildfires is lightning strikes that occur during dry thunderstorms.

A.3.5.2 Location

Urban Fire

The urban fire hazard in Pawtucket and Central Falls involves areas where residential, commercial and/or industrial structures are clustered close together, increasing the possibility of a rapid spread to another structure. Specific areas of concern include locations where closely-spaced wood frame structures and/or adjoining and multi-unit buildings are found such as each city's more densely developed residential districts. Other at-risk areas are characterized by adjoining buildings as found in the commercial corridors and downtown areas of the city. Some specific problem areas of concern include the following:

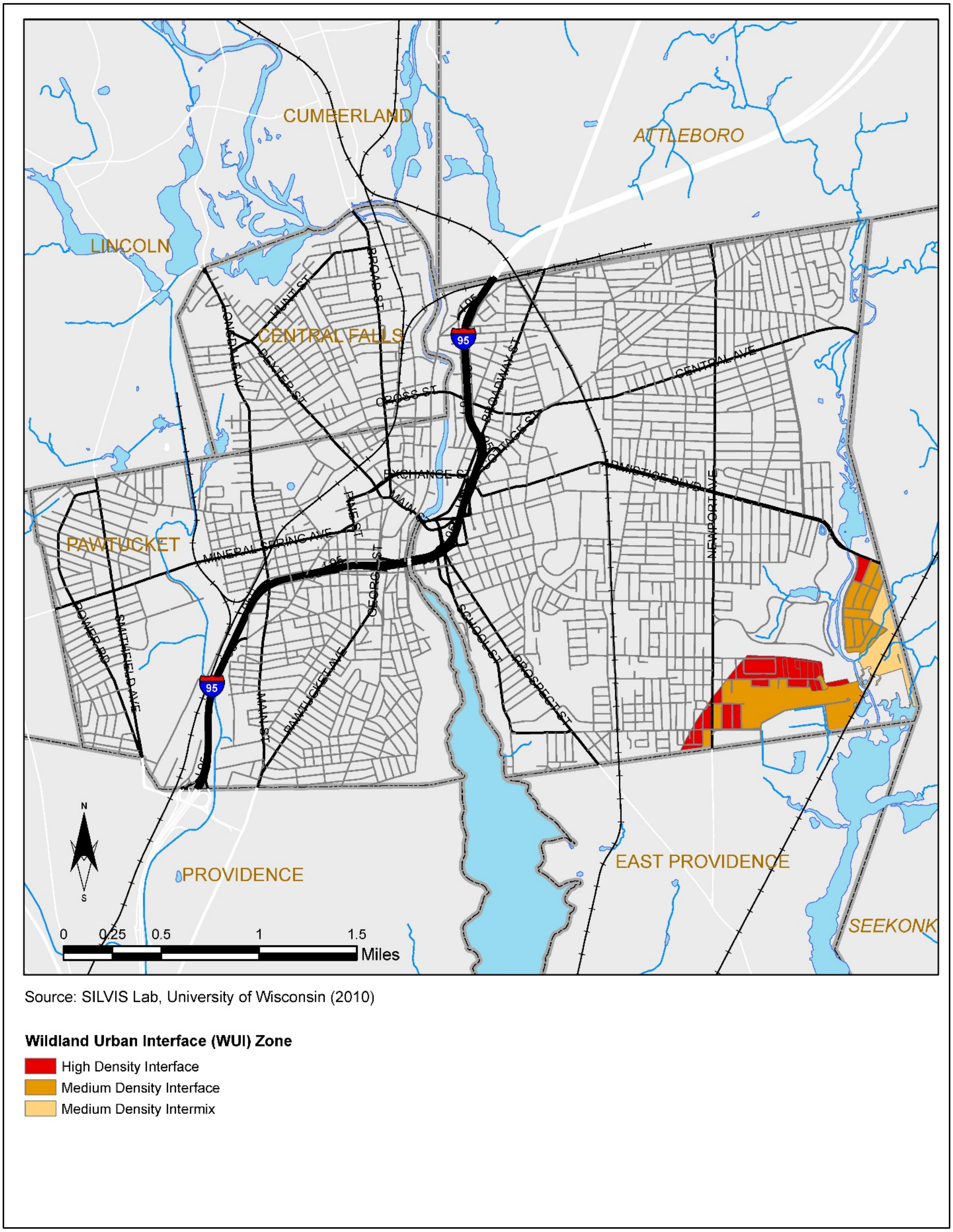
Wildfire

The wildland-urban interface is defined as the area where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. **Figure A-5** illustrates wildfire hazard areas based on the location of wildland-urban interface zones across the planning area as mapped by the SILVIS Laboratory at the University of Wisconsin.[5] These hazard areas include two types of wildland-urban interface areas: intermix and interface. Intermix areas are described as areas where housing and vegetation intermingle; interface areas are described as

[5] Radeloff, V.C., R.B. Hammer, S.I Stewart, J.S. Fried, S.S. Holcomb, and J.F. McKeefry. 2005. The Wildland Urban Interface in the United States. Ecological Applications 15: 799-805.

areas with housing in the vicinity of contiguous wildland vegetation. Although no specific problem areas of concern were identified for either city based on previous wildfire occurrences or identified vulnerabilities, southeastern portions of Pawtucket have been mapped (and confirmed with local staff) as a potential wildland-urban interface zone that includes both intermix and interface areas.

Figure A-5: Wildfire Hazard Areas



Source: SILVIS Lab, University of Wisconsin-Madison

A.3.5.3 Severity/Extent

The magnitude of fire events is often characterized by their size and level of impact. For urban fires this includes the total number and value of structures and other property burned, casualties, and in some cases the number of fire companies responding. For wildfires, this includes the speed of propagation, total number of acres and structures burned, and other resulting impacts to people and property. The magnitude and severity of fire events is greatly dependent on weather, fuel conditions, and existing fire detection, control and suppression capabilities.

For mitigation planning purposes, the maximum probable extent of a fire event in the planning area is a major urban fire affecting multiple large structures; or 100 acres burned along wildland-urban interface.

A.3.5.4 Previous Occurrences

Fires are a very frequent occurrence in the planning area, however detailed historical data and statistics on previous fire occurrences are not readily available. Some limited information from the Pawtucket Fire Department is summarized below in **Table A-10**. In Central Falls. the Fire Department suffered a virus in recent years which wiped out much of their historical data.

Table A-10: Fire Data and Statistics for Pawtucket

Year	Number of Dispatches	# of Structure Fires Extinguished	# of Brush/Grass Fires Extinguished
2016	193	40	7
2015	248	45	11

Source: Pawtucket Fire Department, Dispatch Analysis

Hazard History

- October 13, 2010 – A major fire destroyed over half of the Union Wadding Company mill site in Pawtucket. Approximately 200 firefighters from 8 different communities spent several days extinguishing the fire, with an estimated $2.5 million in damages.
- December 2009 – In Central Falls, there was a 3-story mill building at 444 Roosevelt Avenue which burned to point where it needed to be demolished. That fire was caused by artists using a wood stove for heat.

A major fire burns at the Union Wadding Company Mill in October 2010. *Courtesy of the Sun Chronicle and Ryan Ademan.*

- November 14, 2003 – A major fire at an unoccupied mill complex (Greenhalgh Mill) in Pawtucket spread rapidly to 17 properties causing over $3 million in damages. The fire, fanned by gale force winds, spread rapidly to nearby homes and structures. As the winds fueled the fire and spread large flaming embers into the community, the Pawtucket Fire Department issued a general alarm. Nearly a dozen communities responded with fire equipment and crews, limiting the potential destruction. In total, 17 properties were damaged, with eight totally-destroyed.
- 1995 – a vacant mill complex was destroyed by fire in Pawtucket.


An aerial view of the fire at the Greenhalgh Mills complex in 2003. The raging, wind-whipped fire began at the abandoned textile mill and destroyed several homes and ignited buildings over a 10-block radius. *Courtesy of the Associated Press.*

A.3.5.5 Probability of Future Occurrences

Fires will continue to be a ***highly likely*** occurrence in the planning area, though the magnitude and impact of most events will be contained due to early detection and fire suppression. The potential for larger, destructive urban fires is higher for Pawtucket and Central Falls due to several factors including large concentrations of older, wood frame structures (many without sprinkler systems); numerous areas with adjoining buildings; and the presence of industrial facilities that include but are not limited to buildings with hazardous and flammable materials, and vacant mill sites which have been the source of major local fires in the recent past.

For Central Falls in particular, the urban fire risk is extremely high for the entire city. With reduced manpower and other factors such as the old wooden housing stock of balloon frame structures and their proximity to others makes this a daily threat. The City also factors in the socioeconomic situation within the city which has been found as a contributing reason for greater chances for fires to begin.

It is anticipated that the effects of climate change, including more frequent and prolonged drought conditions, will increase the frequency and intensity of wildfire events; however, the United States Forest Service indicates that it is difficult to project what the exact impacts of climate change may be. Another related factor that is expected to increase the probability of future wildfire events is the introduction of disease, pests, and invasive plants that result in the dieback of mature tree species thus creating increased vegetative fuel loads in forested areas.

A.3.6. FLOOD

A.3.6.1 General Description

Flooding is the most frequent and costly natural hazard in the United States. Nearly 90 percent of presidential disaster declarations result from natural events where flooding was a major cause of human casualties and property damages. Flooding may be generally defined as the partial or complete inundation of normally dry land by the overflow and accumulation of excess water.

Flooding may be classified according to three distinct hazard types:

- ***Riverine floods*** include overbank flooding from a river or stream channel onto adjacent floodplains, and are generally caused by excessive precipitation from large-scale weather systems. A rapid accumulation of heavy localized downpours may also impact smaller streams and creeks to cause flash floods, characterized by a rapid rise in water level and/or high velocity flow with little warning. Other potential causes of riverine floods include ice jams or dam failures.
- ***Coastal floods*** occur along the shorelines and tidal extensions of large water bodies, and are typically caused by the wind-driven waves, storm surge and heavy rainfall produced by hurricanes, tropical storms, nor'easters and other large, low-pressure coastal storms with cyclonic flows. Coastal flood hazards are often exacerbated over the long term by coastal erosion and sea level rise.
- ***Urban floods*** occur where the physical development of a community has decreased the ability of natural groundcover to absorb and retain surface water runoff, and existing drainage systems are incapable of conveying or retaining storm water flow. They are most often caused by isolated, high-intensity rainfall events of relatively short duration (1 to 3 hours). Even when drainage systems are designed to acceptable standards, urban flooding may occur when they are obstructed by debris, sediment or other materials that limit their functional capacity.

A.3.6.2 Location

The principal sources of riverine flooding in the planning area are the Blackstone and Moshassuck rivers and their tributaries. The Blackstone River Watershed comprises a total of 640 square miles, with 382 square miles located in south central Massachusetts and 258 square miles in northern Rhode Island. The Moshassuck River watershed encompasses approximately 23.6 square miles in northeastern Rhode Island. The Moshassuck River is affected by backwater conditions from Providence River, which is tidal, but the stage can be controlled by the Fox Point Hurricane Barrier that separates the Providence River from Narragansett Bay during storm surges. The local source for coastal flooding is the Seekonk River, which begins in Pawtucket where the Blackstone River reaches sea level below Pawtucket Falls. The Seekonk River is a tidal extension of the Providence River and the northern tip of Narragansett Bay, and is subject to coastal flooding and storm surge during hurricanes. Urban floods in the planning area are most typically caused by heavy precipitation events that overwhelm local drainage systems in lower-lying areas of each city.

Riverine Flood
Figure A-6 shows the location of all special flood hazard areas in the planning areas as shown on current FEMA Digital Flood Insurance Rate Maps (DFIRMs). Descriptions for these special flood hazard areas are provided in the *Extent* portion of this section.

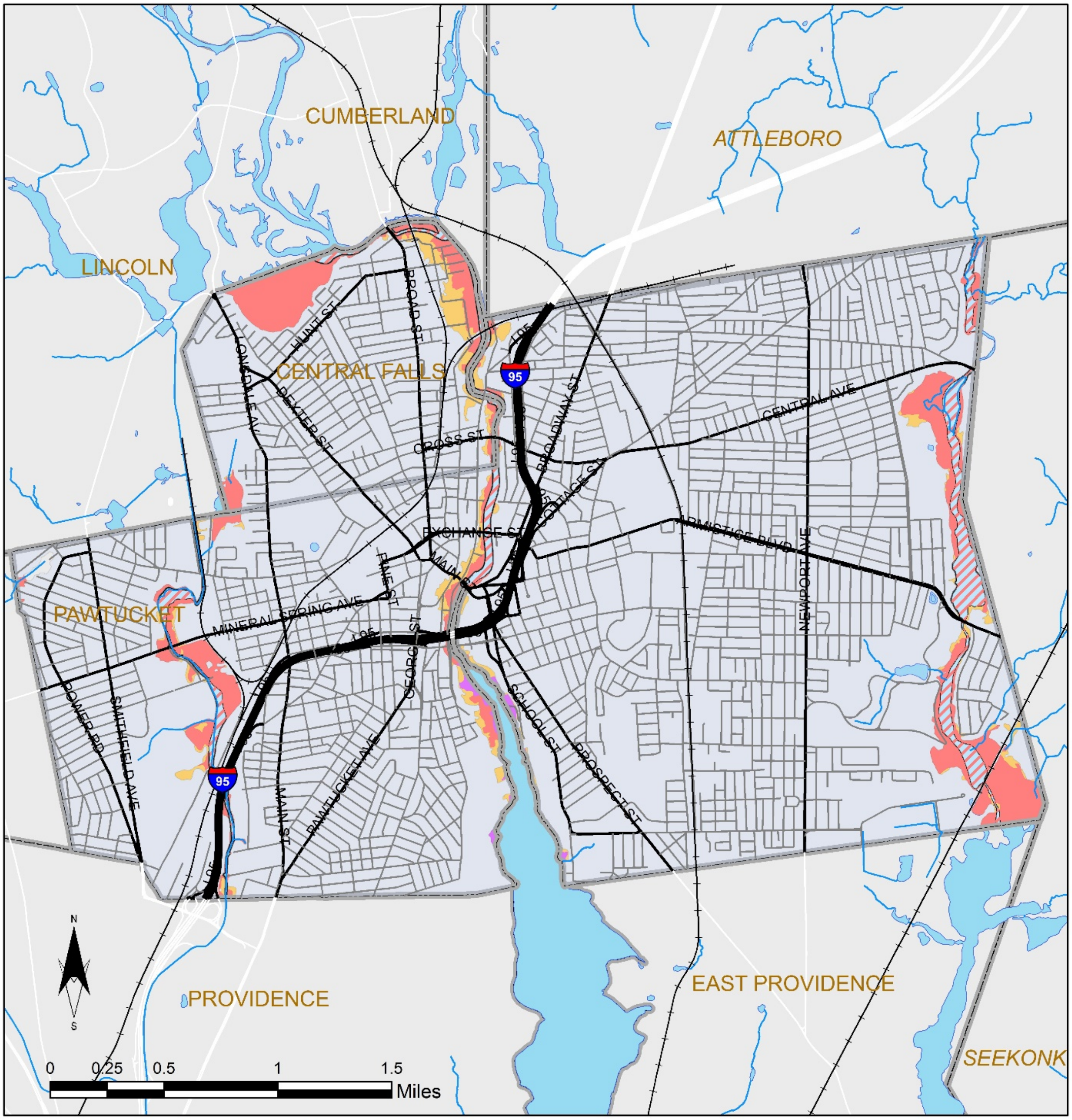
Coastal Flood
Coastal special flood hazard areas as currently mapped on FEMA DFIRMs are included in Figure A-6 as listed above for riverine flood. This includes "VE Zones" which are defined as areas subject to inundation by the 1 percent annual chance flood event with additional hazards due to storm-induced velocity wave action. **Figure A-7** shows the location of all hurricane storm surge inundation areas. This figure illustrates areas that could be inundated by "worst case" scenarios associated with Category 1 through 4 hurricanes striking the coast of Rhode Island.

Another growing concern as it relates to coastal flooding is sea level rise. Although not nearly as significant for the planning area as it is for coastal communities, sea level rise has the potential to increase the severity of tidal flooding as far north as Pawtucket. **Figure A-8** shows potential sea level rise inundation areas for Pawtucket based on Rhode Island's STORMTOOLS online mapping application. The figure shows inland extent and relative depth of inundation from 0 to 7 feet above today's mean higher high water (MHHW), illustrating what this inundation could look like in the future under different scenarios and time horizons. While these projections for future inundation are not severe for Pawtucket, the greater long-term concern associated with sea level rise is that it will amplify the magnitude of episodic coastal flood events.

Urban Flood

Urban floods often strike rapidly, terminate quickly, and occur in areas generally not considered at risk to major flooding (including areas outside of mapped floodplains). Urban floods in Pawtucket and Central Falls have most often occurred as a result of very heavy precipitation that exceeds local drainage capacities, and in some cases, where sediment, brush, trash, or other debris accumulate and impede the conveyance of flood flows through stormwater systems. In addition, trees, ice, and other debris may be washed away and carried downstream to collect on bridges, culverts, and other obstructions. As flood flow increases, significant amounts of this debris often break loose, sending water and debris surging downstream until another obstruction is encountered. However, it is difficult to predict the degree to which, or the specific location where, debris may accumulate.

Figure A-6: Special Flood Hazard Areas



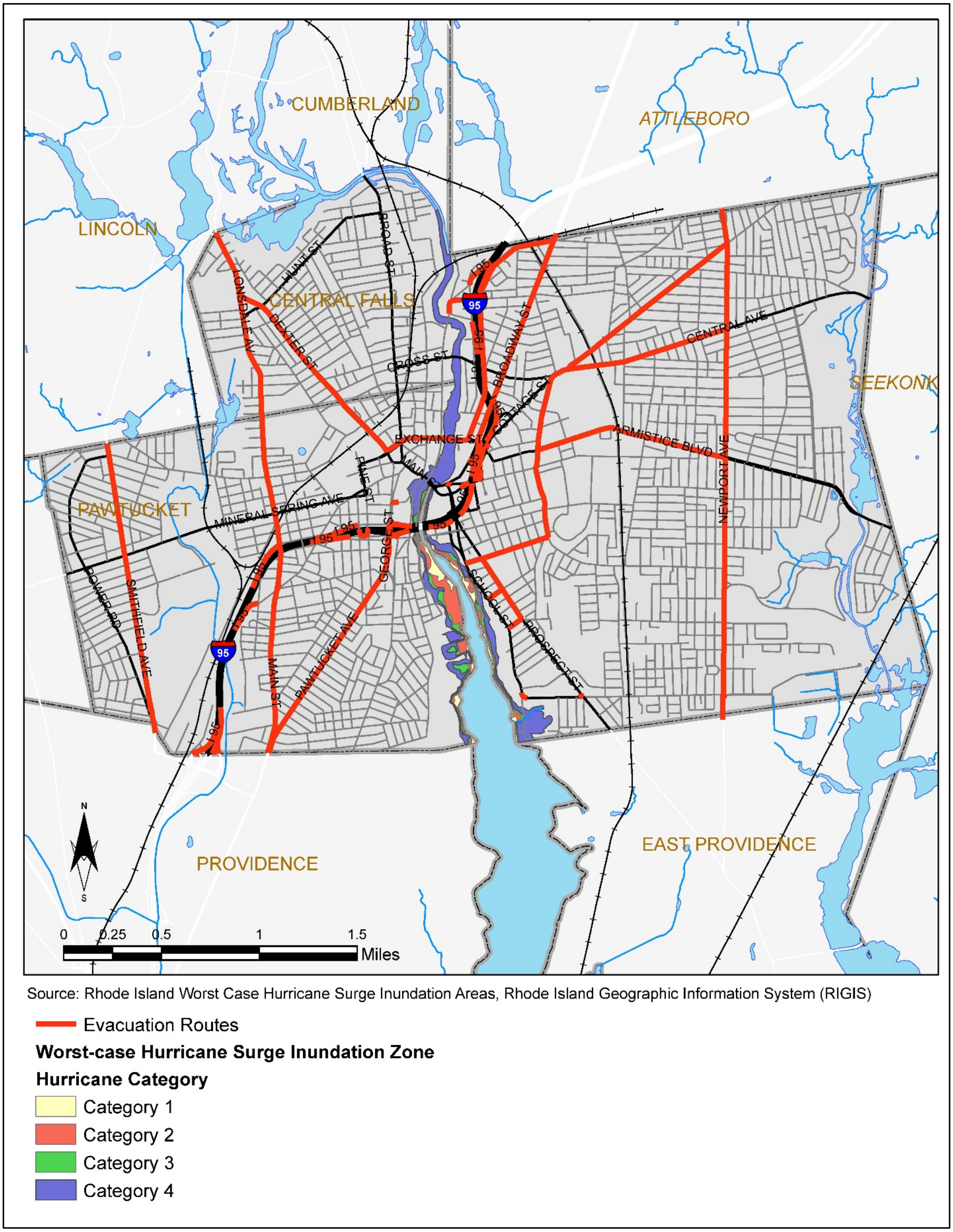
Source: FEMA Flood Insurance Rate Map (FIRM)

FEMA Flood Zones

- Regulatory Floodway
- Zone AE (1% Annual Chance Flood)
- Zone VE (1% Annual Chance Flood with Velocity Wave Action)
- Zone X (0.2 % Annual Chance Flood)

Source: FEMA

Figure A-7: Hurricane Storm Surge Inundation Areas



Source: U.S. Army Corps of Engineers, New England District

Figure A-8: Potential Sea Level Rise Inundation for Pawtucket

Source: RI STORMTOOLS

Principal Flood Hazard Problems

Past flood events in the planning area indicate that flooding can occur during any season of the year, but spring and fall have historically produced those with greatest magnitude and effect. According to the most recent FEMA Flood Insurance Study report (October 2015), the most severe floods have been caused by storms of tropical origin, such as hurricanes, usually occurring in late summer and early fall. Winter and spring flooding is commonly caused by transcontinental storms in combination with snowmelt or ice jams. Mid-spring and fall thunderstorms can also produce limited urban flooding.

Some specific flood hazard problems and areas of concern include the following:

Pawtucket

- A significant portion of the city east of the Blackstone River experiences frequent street and basement flooding during heavy rain. This is due to a combination of factors, including the inability of the current combined sewer overflow (CSO) system to handle the runoff during heavy rainfall. The pipes in the CSO system have become clogged with scum buildup over the years, decreasing the capacity of the lines. To help correct this problem, some backflow-prevention valves have been installed where the sanitary line that runs from the house connects to the CSO system.
- Significant flooding has occurred near the Moshassuck River in the vicinity of Grenville Street and Grotto Avenue and upstream of Mineral Spring Avenue. There are several wooden, multi-family housing units for the elderly on Mineral Spring Avenue that are at risk to flooding. One property, Galego Court (Pawtucket Housing Authority site) includes units subject to flooding, as well as a daycare on site (special population). The backyards of properties along Pinecrest Drive also experience periodic flooding. There are 19 residential structures in the floodplain, most of which are older buildings that have not been brought up to current floodplain standards. Two of the insured structures have reported repetitive losses (more than two significant claims due to floods) since 1978—both cases occurred on Mineral Spring Avenue adjacent to the Moshassuck River. Minor damages were suffered after the last few hurricanes due to flooded sewer lines. Currently, the City is using sand bags to “band-aid” flooding problems.
- Currently, 32 structures in the floodplain are vulnerable to basement flooding, including City Hall, which is situated at the lowest elevation in the city. Slater Mill, a national historic landmark and tourist attraction, is also on the bank of the Blackstone River. The City has contacted officials at Slater Mill to explore possible flood-proofing measures. The City has also made an effort to contact local businesses that are in the floodplain. Pawtucket officials plan to continue this effort if federal grants are available for public education.
- There are various areas in the City that experience repetitive flooding and road washout during heavy rains. A preliminary citywide inventory of streets subject to repetitive flooding and washout is listed below along with the likely cause:
    - Armistice Boulevard in vicinity of DPW Center (drainage)
    - Mineral Spring Avenue (drainage, elevation)
    - Pinecrest Drive, along rear of properties (poor design)
    - Grand Avenue @ the London Avenue intersection (drainage)
    - Grenville St./Grotto Avenue in the vicinity of Moshassuck River (poor design)

- There are four low lying bridges/culverts subject to flooding where branches from fallen trees could clog the drainage flow creating flooding: Interstate 95 over the Moshassuck River; Mineral Spring Avenue culvert over the Moshassuck River; Roosevelt Avenue bridge over the Blackstone River; and Exchange Street bridge over the Blackstone River. Main Street, Central Avenue, Interstate 95 over the Seekonk River, and Division Street are all high bridges that are in good condition and could be used for evacuation over the Moshassuck and Blackstone Rivers.
- Blackstone Falls, a high-rise building for seniors on Grove Street, has seen repeated basement flooding that has required building evacuations. The electrical and mechanical utilities have been elevated but this is still a problem of concern given the vulnerable population that resides there.
- Riverfront Lofts is an old mill site that was converted into a multi-family condominium complex, located on Exchange Court and immediately adjacent to the Blackstone River. The building has seen repeated basement flooding that has resulted in damaged residential living spaces.

Central Falls

- The majority of flooding problems within the city of Central Falls stems from street flooding in poor drainage areas and flooded parking lots in low-lying areas. This is due to a combination of factors, including the inability of combined sewer overflow (CSO) system to handle the runoff during heavy rainfall.
- The main areas in the city prone to flooding are on the east side of the city along the Blackstone River. These streets include River Street, Crown Street, Courtland Avenue, New Haven Avenue, and Roosevelt and High Street businesses. On the west side of the city, Higginson Avenue can be affected by flooding due to topography and poor drainage.
- There are some multi-family homes and other structures located on a few streets that repeatedly flood, including Higginson Avenue, Samoset Avenue, the High Street Underpass by Broadway Transmission & Auto, and the intersections of Broad Street & Madeira Avenue, Perry Street and Beacon Street, and Fales Street and Broad Street.

A.3.6.3 Severity/Extent

Riverine Flood

The severity of a riverine flood event is typically determined by a combination of several major factors, including: stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; the degree of vegetative clearing; and impervious surface. The periodic flooding of lands adjacent to rivers, streams and shorelines (floodplains) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is typically defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude (spatial extent and depths) increases with increasing recurrence interval.

Floodplain areas are delineated according to the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. A more appropriate way of expressing flood frequency is the percent chance of occurrence in any given year (annual probability). For example, the 100-year flood has a 1 percent chance of occurring in any given year, and the 500-year flood has a 0.2 percent chance of occurring in any given year. Statistically, the 1 percent annual chance flood has a 26 percent chance of occurring during a 30-year period, equal to the duration of many home mortgages. Contrary to what the term suggests, a "100-year flood" is not a flood that occurs only once every 100 years. A "100-year flood" can and often does occur in the same location multiple times in a century.

Special flood hazard areas identified on FEMA DFIRMs (as shown in Figure A-6) are defined as the areas that will be inundated by the flood event having a 1 percent chance of being equaled or exceeded in any given year. The 1-percent-annual-chance flood is also referred to as the base flood elevation (BFE), and is the national minimum standard for applying FEMA's NFIP floodplain management regulations and mandatory flood insurance purchase requirements. These areas are shown on FEMA DFIRMs as Zone A (without BFEs determined) or Zone AE (with BFEs determined). Areas that are determined to be inundated by the 0.2-percent-annual-chance flood are considered moderate flood hazard areas and are shown on FEMA DFIRMs as Zone X. Areas outside of all these areas are considered minimal flood hazard areas.

Figure A-6 shows all of the above-mentioned flood hazard areas, in addition to the Regulatory Floodway. The floodway is the most hazardous portion of the mapped flood hazard area and is defined by FEMA as "the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height." Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations.

Coastal Flood

The intensity and duration (or forward speed) of a storm is the most influential factor affecting the severity and impact of storm surges. While hurricanes and tropical storms often move through areas relatively quickly, nor'easters can last for days and multiple tidal cycles, often causing major coastal flooding, erosion and damage from wind-driven wave action.

Special flood hazard areas identified as "VE Zones" on FEMA DFIRMs (as shown in Figure A-6) are defined as areas subject to inundation by the 1 percent annual chance flood event with additional hazards due to storm-induced velocity wave action. Mandatory flood insurance purchase requirements and floodplain management standards apply for these areas.

Figure A-7 shows the location of all storm surge inundation areas for Pawtucket and Central Falls. This figure illustrates areas that could be inundated by "worst case" scenarios associated with Category 1 through 4 hurricanes striking the coast of Rhode Island.

Urban Flood

The severity of urban flooding varies greatly and is highly dependent on rainfall intensity and duration, but is generally limited to minimal, localized damages and/or temporary disruptions to transportation infrastructure. However, the lack of warning associated with urban flood events often creates significant threats to public safety due to flooded roadways, and results in increased damage to property that could have been prevented with more advance notice (particularly for vehicles left unattended in areas susceptible to urban flooding).

For mitigation planning purposes, the maximum probable extent of a flooding event in the planning area is the 1 Percent Annual Chance Flood for all inland FEMA Special Flood Hazard Areas (riverine flood); the worst-case storm surge inundation for a category 3 hurricane (coastal flood); and the 10-year Design Storm Event (urban flood).

A.3.6.4 Previous Occurrences

Floods are a frequent occurrence in the planning area. NOAA historical records include 97 flood events[6] in Providence County since 1996, causing no casualties, and approximately $32.6 million in reported property damages. **Table A-11** includes some recent notable past events with local impacts specific to Pawtucket or Central Falls and/or causing at least $100,000 in total damages. The damage figures associated with these events are believed to greatly underestimate the value of actual flood losses that have occurred but gone unreported and/or unrecorded in NOAA records.

Table A-11: Recent Notable Flood Events[7] (2001 – 2017)

Date(s)	Event Type	Description	Casualties (Deaths/Injuries)	Property Damage
8/6/2016	Flood	A strong cold front moved across southern New England, producing scattered showers and thunderstorms. A few of these storms resulted in wind damage and some minor flooding. McCoy Stadium field and parking lot in Pawtucket was flooding, cancelling the scheduled Pawtucket Red Sox game.	0/0	$15,000
5/31/2015	Flash Flood	A cold front moving across southern New England combined with high precipitable waters and weak flow aloft to initiate showers and thunderstorms that produced flooding and pockets of flash flooding. In Pawtucket, the intersection of Conant and Weeden Street was flooded and impassable.	0/0	$0
10/22/2014	Flood	Low pressure moving up the east coast brought a soaking rain and strong winds to much of southern New England. In addition, both downed leaves from the storm and naturally fallen leaves from before the storm clogged storm drains which resulted in street flooding. In Pawtucket, a car was stuck in flood waters on Whipple Street.	0/0	$30,000

[6] Includes events that were classified as flood, flash flood, or coastal flood.
[7] Includes data for events reported to have occurred in the National Weather Service's Forecast Zone for Providence County, including but not limited to Pawtucket and Central Falls.

Date(s)	Event Type	Description	Casualties (Deaths/Injuries)	Property Damage
9/2/2013	Flood	A nearly stationary warm front draped across southern New England, coupled with a very moist atmosphere, resulted in showers and thunderstorms across the area for the third day in a row. Heavy rain fell within these showers and storms and flash flooding occurred. The emergency room of Memorial Hospital flooded.	0/0	$1.5 million
6/7/2013	Flood	The remnants of Tropical Storm Andrea tracked across Southern New England bringing heavy rain (3-5 inches). This resulted in significant urban flooding, as well as river and small stream flooding. Several basements were flooded along Lockbridge Street in Pawtucket.	0/0	$0
7/28/2012	Flash Flood	Thunderstorms and heavy rains traversed the area, with many locations receiving up to two to three inches in less than an hour. This resulted in flash flooding, particularly in more urban areas. Central Avenue in Pawtucket was flooded with 6 inches of water.	0/0	$30,000
3/29/2010	Flood	A series of climate and weather events in February and March led to the worst flooding event in Rhode Island's recorded history. See *"The Great Rhode Island Flood of 2010"* below this table for more information.	0/0	$27 million
10/15/2005	Flood	A low pressure system interacted with a plume of tropical moisture as the low slowly moved parallel to the Long Island and south Massachusetts coasts, resulting in excessive rain and flooding across Rhode Island. Between 2.5 and 4.5 inches of rain fell from this event. Many roads were closed across the region and approximately 500 evacuations occurred, including along the Blackstone River in Central Falls.	0/0	$200,000

Date(s)	Event Type	Description	Casualties (Deaths/Injuries)	Property Damage
3/22/2001	Flood	Minor to moderate flooding occurred along the Blackstone and Pawtuxet Rivers as a result of melting snow and heavy rainfall. Damage was estimated at three million dollars, and affected nearly 1,400 homes and 37 businesses. The Blackstone River at Woonsocket crested at 11.65 feet on the 23rd (flood stage is 9 feet).	0/0	$3 million
		Total	**0/0**	**$31,775,000**

Source: NOAA Storm Events Database

The Great Rhode Island Flood of 2010

In late February through March 2010, three separate rainfall events resulted in about 17 to 23 inches over much of southern New England, causing major flooding and millions of dollars in damage across Rhode Island, with numerous homes, businesses, and people affected.

Event Summary

On March 29th, 2010, a low pressure system sat just south of Long Island for two days, bringing heavy rain to much of Southern New England. A persistent southerly low-level jet brought very moist air into the area, which resulted in high rainfall rates. A coastal front along the I-95 corridor enhanced rainfall in that area. This event followed a heavy rainfall and record flooding event in mid-March as well as a second lesser rain event about a week prior. Rivers across much of Massachusetts and Rhode Island were still high from those events and warm temperatures in northern Vermont and New Hampshire resulted in a period of snowmelt, that resulted in rises on both the mainstem Connecticut and Merrimack Rivers. All of these factors led to a second record rainfall and major flooding event for Rhode Island.

The Governor's office estimated that tens of thousands of properties were impacted by the flooding and about 4,000 workers were affected when the businesses they worked in were closed during and after the flooding. Numerous schools and many businesses, as well as the state government were closed for at least a day because of the flooding. Four dams in Rhode Island were breached and many others were overtopped and close to breaching, which resulted in the inspection of 42 dams throughout the state. A portion of Interstate 95 was closed for two days after the Pawtuxet River inundated the highway with up to three feet of water. Amtrak service through the state was suspended for several days because portions of the tracks were under up to two feet of water in several locations across the state.

Officials estimated that more than 500 people were evacuated from their homes because of rising water or the threat of rising water. More than 500 Rhode Island National Guardsmen were activated during the flooding, filling sandbags, directing traffic, and aiding in evacuations. Six National Grid substations were flooded and four were close to flooded, disrupting electrical service in Westerly and Warwick. Half a dozen sewage treatment plants through the state were overwhelmed or compromised by the flooding, leading to raw sewage being discharged into area rivers and bays. Shellfishing grounds in the southern part of the state were closed temporarily over concerns of sewage and other contaminants in the water. They reopened about a week and a half later.

Local Impacts

All 39 cities and towns in Rhode Island were affected by this event, but the most damage was seen in Warwick, West Warwick, Coventry, and Cranston. Although the majority of damage was realized by these communities along/downstream of the Pawtuxet River, the Blackstone River raged at a moderate flood level. Six to nine inches of rain fell across Providence County, resulting in rises on both the Blackstone and Moshassuck rivers in addition to several small streams. Numerous streets and basements were flooded across the planning area. In Pawtucket, tenants from lower level units of an apartment building on Exchange Court were asked to evacuate due to flooding. The force of the Blackstone River collapsed approximately 200 linear feet of the retaining wall directly behind City Hall, and another portion further downstream at the parking area to the National Grid facility. This event resulted in a major disaster declaration for Providence County, which encompassed both the mid-March storm and this storm.

Other Notable Historic Events

The second-greatest flood of record occurred in March 1968, the result of about five inches of rainfall combined with snowmelt and nearly 100-percent runoff due to the impermeability of frozen ground. High flows occurred on both Woonasquatucket and Moshassuck Rivers. Flooding on Moshassuck River occurred near Canal and Mill Streets below the USGS gage and along Interstate 95. Gage records showed this flood to be a 38-year event on the Moshassuck River. Flooding resulting from this storm was also extensive on West River, a tributary of the Moshassuck. The magnitude of this flood would have been about ten percent greater if it had not been reduced by the West Hill flood control dam in Uxbridge, Massachusetts. The estimated recurrence interval for this event is 25 years.

The greatest flood of record on the Blackstone River occurred in August 1955 and was the result of Hurricane Diane dropping an average of nearly 12 inches of rain over the drainage basin. This storm has an approximate return interval of 150 years, and the areas below High Street were inundated by several feet of water. Damages from the 1955 flood were estimated at approximately $28 million for Rhode Island, with the Woonsocket area hardest hit in the state. This event resulted in a major disaster declaration for Providence County.

The Seekonk River experienced coastal flooding during the hurricane of September 1938 and Hurricane Carol in 1954. The 1938 hurricane, which had a recurrence interval of approximately 100 years, caused flood levels of approximately 16 feet on the Seekonk River.

Flood Insurance Statistics

According to FEMA flood insurance records and as shown in **Table A-12**, there have been a total of 143 individual losses and more than $2 million in insured damages for the planning area as recorded through the National Flood Insurance Program (NFIP) since 1971. The average claims payment per flood loss during this period was nearly $40,000. However, this information only reflects previous losses as reported through claims under the NFIP, and it is understood that many additional losses have occurred in the planning area that were either uninsured or unreported.

NFIP records have also identified nine "repetitive loss properties" for the area, which are defined by FEMA as an NFIP insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978. According to FEMA database information provided by

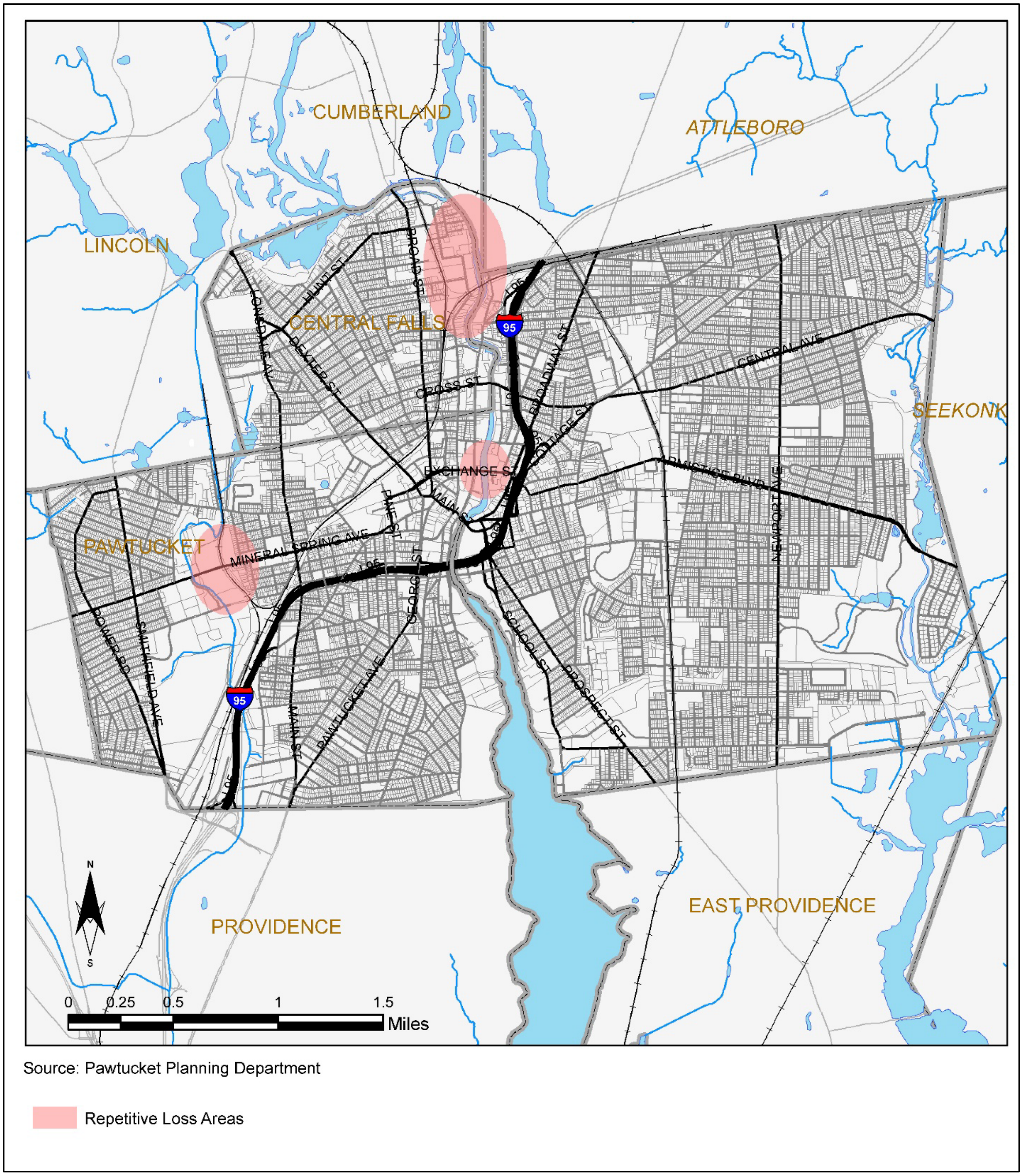
RIEMA these nine properties have accounted for 26 claims totaling $1.75 million. The general location of these properties is illustrated in the map of Repetitive Loss Areas provided in **Figure A-9**.

Table A-12: NFIP Policy Claims and Loss Statistics

Jurisdiction	# of Policies	Total Losses	Closed Losses	Total Payments	Repetitive Loss Properties
Central Falls	57	28	23	$438,404	5
Pawtucket	86	37	29	$1,622,558	4
Total	**143**	**65**	**52**	**$2,060,962**	**9**

Source: FEMA (repetitive loss property data confirmed by RIEMA on November 17, 2017)

Figure A-9: Repetitive Loss Areas



Source: City of Pawtucket Planning Department

A.3.6.5 Probability of Future Occurrences

Floods of varying extent will continue to be a ***likely*** occurrence in the planning area. Riverine and coastal floods will likely be an occasional occurrence in planning area, while urban floods will likely occur more frequently. It is anticipated that the effects of climate change, including sea level rise, will result in an increase in the extent and frequency of storm surge and coastal flooding. Severe urban flooding due to more precipitation and very heavy downpours is also very likely to occur more frequently. According to the 2014 National Climate Assessment, the Northeast experienced a 71 percent increase in very heavy precipitation events from 1958 to 2012, and it is projected that this trend will continue and even worsen under all future emissions scenario. Under the rapid emissions reduction scenario, these events would still occur nearly twice as often. For the scenario assuming continued increases in emissions, these events would occur up to five times as often.[8]

A.3.7. SEVERE WEATHER

A.3.7.1 General Description

Severe weather hazards include high winds, severe thunderstorms, tornadoes, and other extreme weather effects which often accompany such storm systems.

High winds can be generated from several types of weather events, including before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Effects from high winds can include blowing debris, downed trees and/or power lines, and damage to roofs, windows, etc. High winds can cause scattered power outages and are also a hazard for the boating, shipping, and aviation industry sectors. Wind gusts of only 40 to 45 miles per hour can cause scattered power outages from trees and wires being downed. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations which can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 miles per hour are not considered to be hazardous under most circumstances.

Severe thunderstorms are created when air masses of varying temperatures meet, and can occur singularly, in lines, or in clusters, but generally affect a small area when they occur. When thunderstorm winds reach 58 miles per hour, the thunderstorm is considered severe and a warning is issued. Thunderstorms can occur during any season, but are more likely to occur during the spring and early summer months of March through June. They can occur at any time of day, but are more likely to form in the late afternoon and early evening. They can form in less than 30 minutes, giving little warning, and can move through an area very quickly or linger for several hours. The primary damaging forces associated with these storms are straight-line winds, hail, and lightning as described below, but they can also cause flash flooding or spawn tornadoes.

- *Straight-line winds*, which in extreme cases have the potential to cause wind gusts that exceed 100 miles per hour, are storm-induced winds that move in a straight direction (without rotation) and are capable of toppling trees, downing down power lines, and causing moderate to major property damage. Straight-line winds include downbursts, which result from the sudden descent of cool or cold air toward the ground. As the air hits

[8] U.S. Global Change Research Program. *Climate Change Impacts in the United States: U.S. National Climate Assessment*. 2014.

the ground, it spreads outward with incredible force and the potential to cause widespread and tornado-like damage.

- *Hail* is formed in towering cumulonimbus clouds (thunderheads) when strong updrafts carry water droplets to a height at which they freeze. Eventually, these ice particles become too heavy for the updraft to hold up, and they fall to the ground at speeds of up to 120 miles per hour. Hail has the potential to cause minor to moderate property damage, particularly the larger hail stones associated with severe thunderstorms. The size of hailstones is a direct result of the size and severity of the storm.
- *Lightning* remains one of the top three storm-related killers in the United States and is a significant life/safety threat to people, but also has the potential to damage property and ignite both urban and wildland fires. Lightning often strikes outside of areas where it is raining, and may occur as far as 10 miles away from rainfall.

Tornadoes are violent windstorms characterized by a twisting, funnel-shaped cloud extending to the ground. Winds in most tornadoes are 100 miles per hour or less, but in the most violent and least frequent tornadoes, wind speeds can exceed 250 miles per hour. Tornadoes are most often generated by strong thunderstorm activity (but may also be spawned from hurricanes and other coastal storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. Most tornadoes are a few dozen yards wide and touch down only briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several to many miles long.

Tornadoes often develop so rapidly that little, if any, advance warning is possible making them a significant life/safety threat to people. They are more likely to occur during the spring and early summer months of March through June and can occur at any time of day, but are more likely to form in the late afternoon and early evening. Tornadoes in Rhode Island have also occurred July through October with August representing the month that has the most recorded incidents. Tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest.

A.3.7.2 Location

The entire planning area is uniformly susceptible to the occurrence of severe weather including high winds, severe thunderstorms, and tornadoes. While all areas of Rhode Island are at risk from high speed winds, those along Narragansett Bay and Block Island Sound are within highest wind speed area due to their direct proximity to the coast.

A.3.7.3 Severity/Extent

There is a wide range of thunderstorm types as classified by NOAA, including single-cell, multi-cell, squall line, supercell, bow echo, mesoscale convective system, mesoscale convective complex, mesoscale convective vortex, and derecho. Specific definitions aren’t included here, though it’s important to note that any one of these thunderstorm types can be severe. A thunderstorm is classified as "severe" when it contains one or more of the following damaging effects: winds gusting in excess of 58 miles per hour, hail measuring at least one inch in diameter, or a tornado.

The Enhanced Fujita Scale (EF-scale), shown in **Table A-13**, is used to categorize the strength and magnitude of tornado events based on estimated wind speeds and related damage. This represents an update to the original Fujita Scale (F-scale) and has been implemented since February 2007.

Table A-13: Enhanced Fujita Scale

Rating	Wind Speed (3 second gust)	Potential Damage
EF-0	65–85 mph	Light – Causes some damage to siding and shingles.
EF-1	86–110 mph	Moderate – Considerable roof damage. Winds can uproot trees and overturn singlewide mobile homes. Flagpoles bend.
EF-2	111–135 mph	Considerable – Most singlewide mobile homes destroyed. Permanent homes can shift off foundations.
EF-3	136–165 mph	Severe – Hardwood trees debarked. All but small portions of houses destroyed.
EF-4	166–200 mph	Devastating – Complete destruction of well - built residences, large sections of school buildings.
EF-5	Over 200 mph	Incredible – Significant structural deformation of mid- and high-rise buildings.

Source: NOAA

For mitigation planning purposes, the maximum probable extent of severe weather in the planning area is wind gusts exceeding 50 knots, hail measuring at least three-quarters of an inch in diameter, or a tornado occurrence.

A.3.7.4 Previous Occurrences

Severe weather is a frequent occurrence in the planning area. NOAA historical records include 337 severe weather events[9] in Providence County since 1950, causing no fatalities, 38 injuries, and approximately $6.4 million in reported property damages. Most confirmed damages were caused by tornado and severe thunderstorm winds ($5.8 million), though $660,000 in damage was attributed to lightning and $20,000 to hail. It is believed that many additional historic events and/or losses have occurred but gone unreported or unrecorded.

Some notable recent occurrences with specific impacts in the planning area include:

- July 23, 2016 – Strong thunderstorms that produced hail and wind damages moved across much of southern New England. In Pawtucket, a large tree was downed onto a moving car on Main Street. Occupants were trapped in the car but not injured.
- July 2, 2008 – An upper level trough approaching Southern New England set off thunderstorms across much of the area. With cold temperatures aloft, hail was the main threat experienced. However, thunderstorm winds and heavy rainfall also produced some

[9] Includes events that were classified as thunderstorm wind, high wind, strong wind, lightning, hail, or tornado.

damage and complications, with portions of a few roads closed due to fallen trees or flooding.

- June 24, 2008 – A slow moving cold front provided a focus for severe thunderstorms. These thunderstorms produced very heavy rain that resulted in flash flooding, hail, and damaging winds. Quarter to golf ball sized hail damaged several windshields, dented cars and smashed windows in the area surrounding the Pawtucket YMCA. In addition, the amount of hail piled up on the roof of a bank, caused a portion of the roof to collapse. Hail had to be shoveled off the remaining portion of the roof. Property damages were estimated at $20,000.
- September 15, 2000 – Lightning struck a house in Central Falls, igniting a gas line which caused extensive damage to part of the home. Property damages were estimated at $15,000.
- May 25, 1994 – A thunderstorm moving to the east across the state brought a couple reports of large hail (up to 1.75 inches), while marble-sized hail fell at some other locations along with gusty winds.

NOAA historical records include 6 tornado events in Providence County since 1950, causing no fatalities, 23 injuries, and approximately $3.25 million in reported property damages. More information on each of these events is provided in **Table A-14**. Although matching narratives were not found for most events, a review of historical storm tracks as recorded by NOAA suggest that none of these events occurred in or directly impacted Pawtucket or Central Falls.

Table A-14: Previous Occurrences for Tornado in Providence County (1950 – 2017)

Date(s)	Magnitude	Description	Casualties (Deaths/Injuries)	Property Damage
8/16/2000	F0	A weak tornado briefly touched down in a high elevation portion of North Foster. The damage was isolated and limited to only trees.	0/0	$0
9/23/1989	F0	N/A – matching narrative not found in the historical Storm Data Publication.	0/3	$250,000
8/8/1986	F1	N/A – matching narrative not found in the historical Storm Data Publication.	0/0	$250,000
8/7/1986	F2	N/A – matching narrative not found in the historical Storm Data Publication.	0/20	$2,500,000
8/7/1986	F1	N/A – matching narrative not found in the historical Storm Data Publication.	0/0	$250,000
8/26/1985	F1	N/A – matching narrative not found in the historical Storm Data Publication.	0/0	$0
		Total	**0/23**	**$3,250,000**

Source: NOAA Storm Events Database

A.3.7.5 Probability of Future Occurrences

High wind and severe thunderstorm events will continue to be a ***highly likely*** occurrence in the planning area. Tornadoes will continue to be a possible occurrence, though it is unlikely that very strong tornadoes (EF-3, EF-4 or EF-5) will strike the area. According to NOAA, the effects of climate change on future severe weather events cannot be determined at the present time due to insufficient scientific evidence. However, multiple studies cite that the Northeast region of the US will continue experience more very heavy rainfall events which are often associated with severe thunderstorms and other extreme weather events (covered under Flood).

A.3.8. SEVERE WINTER STORM

A.3.8.1 General Description

Severe winter storms can range from a moderate snowfall over a period of a few hours to blizzard conditions (sustained winds or frequent gusts of 35 miles per hour or more) with blinding wind-driven snow that lasts for several days. Heavy accumulations of snow or ice can bring down trees and power lines, disabling electric power and communications for days or weeks, and can paralyze a region by shutting down all air and rail transportation and disrupting medical and emergency services. Severe winter storms are indirectly and deceptively a significant threat to human life and safety, primarily due to automobile accidents, overexertion and exposure. The cost of snow removal, repairing damages, and loss of business can have large economic impacts on local communities.

Severe winter storms may include snow, ice, sleet, freezing rain, or a mix of these wintry forms of precipitation. Heavy accumulations of snow create hazards to transportation, as well buildings with flat rooftops or other vulnerable structures not engineered to withstand heavy snow loads. Sleet – raindrops that freeze into ice pellets before reaching the ground – usually bounce when hitting a surface and do not stick to objects; however, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of ice or freezing rain can cause a significant hazard, especially to trees and power lines. An ice storm occurs when heavy accumulations of freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

A.3.8.2 Location

The entire planning area is uniformly susceptible to the occurrence of severe winter storms. While all areas of Rhode Island are at risk from heavy snow and ice accumulations, those along Narragansett Bay and Block Island Sound are more at risk to the potentially high winds and coastal flood hazards that may accompany severe winter storms.

A.3.8.3 Severity/Extent

NOAA's National Centers for Environmental Information (NCEI) recently developed the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the U.S. The RSI ranks snowstorm impacts on a scale from 1 to 5, as shown in **Table A-15**. RSI values are based on the spatial extent of the storm, the amount of snowfall, and the association of these elements with population and societal impacts. NCEI has analyzed and assigned RSI values to over 500 storms going as far back as 1900 and new storms are added operationally. As such, RSI puts the regional impacts of snowstorms into a century-scale historical perspective. The index is useful for those who wish to compare regional impacts between different snowstorms, and is recommended for classifying major winter storms in combination with the Classification Scheme for Nor'easters presented in section A.3.1.3, as appropriate.

Table A-15: Regional Snowfall Index (RSI)

Category	RSI Value	Description
1	1–3	Notable
2	3–6	Significant
3	6–10	Major
4	10–18	Crippling
5	18.0+	Extreme

Source: NOAA

The Sperry–Piltz Ice Accumulation (SPIA) Index is a scale for rating ice storm intensity, based on the expected storm size, ice accumulation, and damages on structures, especially exposed overhead utility systems. Sid Sperry of the Oklahoma Association of Electric Cooperatives and Steven Piltz from the National Weather Service office in Tulsa, Oklahoma, developed the index together. The SPIA Index uses forecast information to rate an upcoming ice storm's impact from 0 (little impact) to 5 (catastrophic damage to exposed utility systems), as shown below in **Figure A-10**. Per the index developers, it is a tool to be used for risk management and/or winter weather preparedness.

Figure A-10: Sperry–Piltz Ice Accumulation Index

ICE DAMAGE INDEX	* AVERAGE NWS ICE AMOUNT (in inches) *Revised-October, 2011	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
0	< 0.25	< 15	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	0.10 – 0.25	15 - 25	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
	0.25 – 0.50	> 15	
2	0.10 – 0.25	25 - 35	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
	0.25 – 0.50	15 - 25	
	0.50 – 0.75	< 15	
3	0.10 – 0.25	>= 35	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
	0.25 – 0.50	25 - 35	
	0.50 – 0.75	15 - 25	
	0.75 – 1.00	< 15	
4	0.25 – 0.50	>= 35	Prolonged & widespread utility interruptions with extensive damage to main distribution feeder lines & some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
	0.50 – 0.75	25 - 35	
	0.75 – 1.00	15 - 25	
	1.00 – 1.50	< 15	
5	0.50 – 0.75	>= 35	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.
	0.75 – 1.00	>= 25	
	1.00 – 1.50	>= 15	
	> 1.50	Any	

Source: SPIA Index™

For mitigation planning purposes, the maximum probable extent of a severe winter storm in the planning area is a Category 5 on the Regional Snowfall Index; or Intensity Index Category 4 on Classification Scheme for Nor'easters.

A.3.8.4 Previous Occurrences

Severe winter storms are a frequent occurrence in the planning area. NOAA historical records include 171 winter storm events[10] in Providence County since 1996, causing no casualties[11] and approximately $10.3 million in reported property damages. It is believed that additional losses have occurred but gone unreported or unrecorded in NOAA records, and it is also worth noting that one of the most significant financial impacts from winter storms to local communities is attributed to snow removal costs – which are not included in reported property damages.

Snow removal at Pawtucket and Main Street following the Blizzard of 1978, which still serves as the storm of record for the planning area. *Courtesy of Matt Bowling, Blizzardof78.org.*

[10] Includes events that were classified as winter storm, blizzard, heavy snow, or winter weather.
[11] Excluding indirect but storm-related casualties (e.g., automobile accidents, heart attacks while shoveling, etc.)

Some notable recent occurrences for the planning area are provided below. Local impacts to Pawtucket and Central Falls are included where available.:

- February 5, 2016 – Low pressure traveling along a cold front stalled south of southern New England brought heavy rain, which changed over to heavy snow as temperatures dropped. This snow was extraordinarily wet and heavy, bringing down trees and wires across portions of southern New England. A total of 5 to 12 inches of snow fell across northwestern Providence County.
- January 26-28, 2015 (Winter Storm Juno) – An historic winter storm brought heavy snow to southern New England with blizzard conditions for much of Rhode Island. The "Blizzard of January 2015" produced very strong where gusts of 50 to 65 miles per hour were common, and 16 to 30 inches of snow fell across northwestern Providence County. This event resulted in a major disaster declaration for Providence County.
- February 7-8, 2013 (Winter Storm Nemo) – An historic winter storm deposited tremendous amounts of snow across southern New England. The storm also produced a prolonged period of very strong winds with gusts exceeding hurricane force at a few coastal locations. The strong winds, combined with a wet snow, led to extensive power outages from downed trees and wires. A total of 17 to 21 inches of snow fell across southeastern Providence County. This event resulted in a major disaster declaration for Providence County.
- January 12, 2011 – A developing nor'easter coastal storm dumped nearly two feet of snow across portions of Rhode Island in a 24-hour period. This was the second major storm of an above average winter of snowfall. The first occurred December 26 and 27, with several other relatively minor snowfalls in the month of January, and a third major storm February 1 and 2. With only a brief thaw in between the December storm and the January storm, snow piled up across southern New England resulting in numerous roof collapses, towns seeking permission to dump excess snow in area rivers and bays, and numerous disruptions to transportation. The cities of Pawtucket and Central Falls reportedly received 24 inches of snowfall during this event.
- December 26-27, 2010 (Blizzard of 2010) – A strengthening winter storm passed southeast of Nantucket and brought heavy snow and strong winds to much of Rhode Island, resulting in near blizzard conditions at times. Snowfall totals of 8 to 12 inches were observed in southeast Providence County, including 11 inches in downtown Providence. High winds brought down wires on Pawtucket Avenue in Providence.
- December 19-20, 2009 (Blizzard of 2009) – Snow spread across much of Southern New England and blizzard conditions were experienced in several locations. Snowfall totals ranged from 18 to 20 inches across Rhode Island, resulting in numerous flight cancellations out of T.F. Green Airport, school closings, and a struggle by plows to keep the roads clear. A total of 15 to 17 inches of snow fell in southeast Providence County.
- January 22-23, 2005 (Blizzard of 2005) – A major winter storm brought heavy snow, high winds, and coastal flooding to southern New England. In Rhode Island, snowfall totals of 15 to 25 inches were widely observed. Winds gusting as high as 60 mph at times (mainly around greater Providence) created near blizzard conditions at times, making travel impossible during the height of the storm. Officially, the snowfall total at T.F. Green State Airport in Warwick was 23.4 inches, which was the second greatest snowstorm for the Providence area since records began in 1905.

- February 17-18, 2003 – A major winter storm impacted southern New England with heavy snow and strong winds as it tracked southeast of Nantucket. Snowfall totals of one to two feet were widely observed throughout Rhode Island. No significant damage was reported due to the storm, primarily since the snow was fluffy and light with temperatures in the teens and 20s. Impact on travel was minimal, since the storm affected the region on President's Day and most schools were closed that week.
- March 5, 2001 – A major winter storm impacted central and northern Rhode Island with heavy snow and strong winds. The slow-moving storm, which tracked south of New England, dumped more than a foot of snow across Providence County and knocked out power to tens of thousands of customers. Schools and businesses were shut down for three days in some communities.
- April 1, 1997 (April Fool's Day Blizzard) – Heavy snow and strong winds produced blizzard and near-blizzard conditions across most of Rhode Island during the early morning hours on April 1st. Snowfall accumulations set all-time records for April across most of the state, with amounts ranging to nearly 30 inches in the extreme northern portion of the state. The heavy, wet snow made snow removal extremely difficult and highway travel was just about impossible during the height of the storm. Over a thousand tree limbs and some trees were reported down in Providence and some streets were initially left unplowed due to fallen tree limbs and wires. Schools were closed for two days.
- January 7-8, 1996 (Blizzard of 1996) – This storm was one of the most significant winter storms to hit southern New England in the past 20 years. Very heavy snowfall of one to two feet fell across the entire state, which disrupted transportation systems, closed schools, stores, and businesses. Also, the heavy snow accumulation resulted in several roof collapses which damaged homes and businesses during the week following the storm. This event resulted in a major disaster declaration for Providence County.
- March 13-17, 1993 (Blizzard of 1993) – Also referred to as the "Storm of the Century" due to its size and widespread impacts across the eastern US, this major winter storm brought high winds and heavy snow to Rhode Island. This event resulted in a major disaster declaration for Providence County.
- February 1978 (Blizzard of 1978) – The State of Rhode Island's record snowfall of 38 inches occurred from this storm which also produced hurricane-force winds across much of Southern New England. Thousands of Rhode Islanders were without power for weeks and the interstate highways were shut down. This event serves as the storm of record for Rhode Island amongst the number of severe winter storms that the state has experienced over the last several decades. The storm resulted in over 27 inches of snow accumulation in the planning area and resulted in a major disaster declaration for Providence County.

A.3.8.5 Probability of Future Occurrences

Severe winter storms will continue to be a ***highly likely*** occurrence in the planning area. According to the State of Rhode Island Hazard Identification and Risk Assessment, there is a high likely probability that winter hazards will continue to occur and impact Rhode Island, with the probability of a winter storm event occurring within the next 12-60 months near 100 percent. The assessment also notes that Rhode Island can expect to experience several nor'easters, which usually bring coastal erosion and a possibility for blizzard conditions or heavy rainstorms dependent on the temperature.

It is anticipated that the effects of climate change will result in winters that are much shorter with fewer cold days and more precipitation, but less precipitation falling as snow and more as rain. This will result in reduced snowpack, earlier breakup of winter ice on lakes and rivers, and earlier spring snowmelt resulting in earlier peak river flows.

A.4. VULNERABILITY ASSESSMENT

This section provides information on the methods and results of a GIS-based vulnerability assessment for the properties and community assets that are at risk to select, geographically-defined hazards in the planning area. The GIS-based assessment included two distinct analyses: (1) for all parcels and buildings; and (2) for critical facilities or community assets as identified by each City. The approach and methodology for each analysis are provided below.

Methods and Data Sources

Vulnerability Analysis for Parcels and Buildings

The vulnerability of existing parcels and buildings to natural hazards was determined through a GIS-based exposure analysis that combined the City's current tax assessor data records with available hazard data layers used to map and illustrate hazard risk. Each City's existing tax parcel and property value data was used to estimate the number of parcels (developed and undeveloped) and buildings located in identified hazard areas along with their respective assessed values. The parcel data set provides information about the parcel size, land use type, and assessed value among other attribute data. To determine each parcel and building's vulnerability, a GIS overlay analysis was conducted in which hazard extent maps (as described and illustrated in section A.3, Hazard Profiles) were overlaid with the parcel data and existing building footprint data.

To calculate the exposure of parcels and buildings to identified hazards, each City identified the parcels with buildings that are located (completely or partially) within identified hazard zones using the ArcGIS overlay analysis (i.e., select by location using the intersect function). The number of parcels and buildings for specific land use categories (residential, commercial, industrial, etc.) was then totaled, along with the value of buildings and real property values associated with those parcels. These figures provide a strong indication of current hazard vulnerability, as well potential future vulnerability as it relates to vacant and potentially developable parcels across each city.

Vulnerability Assessment for Critical Facilities and other Community Assets

In support of the plan update process, LPT members and staff from each City identified their own unique critical facilities. In general. critical facilities are structures and institutions necessary for a community's response to and recovery from emergencies, and they must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery. For Pawtucket and Central Falls, critical facilities included city halls, emergency operations centers, hospitals, fire stations, police stations, schools, shelters, and libraries. In addition to critical facilities, both cities identified other community assets of important value such as major employers, historic buildings/places, community facilities, private/parochial schools, daycare facilities, and parks/open space/recreation areas.

Once all critical facilities and other community assets were identified by each City, they were identified and mapped in ArcGIS based on the confirmed physical location/address. Similar to the vulnerability analysis for parcels and buildings, each was then overlaid with the identified and mappable hazard zones. For purposes of this analysis it was assumed that the physical location of a critical facility within a hazard area (completely or partially) meant that it is exposed and potentially vulnerable to that specific hazard; however, it is recognized that more site-specific evaluations are required to confirm this assumption. Unlike the vulnerability assessment performed for parcels and buildings, the exposure analysis for other community assets was limited to location only and did not include any information on monetary values as such attribute data was not readily available. This data constraint may be addressed in future updates to this assessment.

Description of Hazard Data Sources

1. Riverine and Coastal Flooding – Hazard location and extent was determined using the current effective FEMA Flood Insurance Rate Map (FIRM) data for the planning area, dated October 2, 2015. The FIRM is the official map on which FEMA has delineated both the special flood hazard areas and the risk premium zones applicable to the community under the National Flood Insurance Program (NFIP). This includes high risk areas that have a 1 percent chance of being flooded in any year (often referred to as the "100-year floodplain"), which under the NFIP, is linked to mandatory purchase requirements for federally-backed mortgage loans. It also identifies moderate to low risk areas, defined as the area with a 0.2 percent chance of flooding in any year (often referred to as the "500-year floodplain"). For purposes of this exposure analysis, the following special flood hazard areas as identified in the current FIRMs were included:

    - Flood Zone AE – 1% Annual Chance Flood Hazard
    - Flood Zone VE – 1% Annual Chance Flood Hazard with Velocity Wave Action
    - Flood Zone X (shaded) – 0.2% Annual Chance Flood Hazard

2. Hurricane Storm Surge – Hazard location and extent was determined using data from the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model as generated by the U.S. Army Corps of Engineers, New England District. Developed to assist emergency management officials in hurricane preparedness and operations, this data layer represents worst-case Hurricane Surge Inundation areas for Category 1 through 4 hurricanes striking the coast of Rhode Island. Hurricane surge values for the four different scenarios included in our analysis were developed by the National Hurricane Center using the PV2 basin SLOSH Model data, and was obtained through the Rhode Island Geographic Information System (RIGIS) in September 2017.

3. Wildfire – Hazard location and extent was determined using data from the Silvis Lab at the University of Wisconsin, which in partnership with the USDA Forest Service, has developed a methodology to spatially identify wildland urban interface (WUI) areas across the US. The WUI is defined as the area where urban development meets vegetated, wildfire prone lands, and the mapping by the Silvis Lab identifies two different types of WUI areas: intermix and interface. Intermix WUI are areas where housing and vegetation intermingle; interface WUI are areas with housing in the vicinity of contiguous wildland vegetation. More information on the data sources and methods used for this mapping is available at http://silvis.forest.wisc.edu/maps/wui.

Hazard Exposure Tables

The results of the vulnerability assessment conducted for existing properties, critical facilities and other community assets are summarized on the following pages, which include a series of exposure tables for those natural hazards with geographically-defined risk areas in each city. For Pawtucket this includes riverine and coastal flooding, hurricane storm surge, and wildfire. For Central Falls this includes only riverine and coastal flooding, as there are no identified hazard zones for hurricane storm surge or wildfire within its jurisdiction.

For all other natural hazards, it is generally assumed that each city's properties, critical facilities and other community assets are uniformly exposed to potential hazard effects (for example, to severe winter storms). However, it is understood that some segments of the population and specific physical assets may inherently be more vulnerable to the effects of these hazards based on their individual characteristics. While this plan does not include an in-depth study of these specific vulnerabilities, they were acknowledged and discussed by the LPT upon completion of this hazard analysis and risk assessment and in the development of the mitigation strategy.

A complete listing of all the detailed hazard exposure tables for each City is provided below:

<u>Pawtucket</u>

- Table A-16: Exposure to Flooding in FEMA Zone AE (1-percent-annual-chance without velocity wave action)
- Table A-17: Exposure to Flooding in FEMA Zone VE (1-percent-annual-chance with velocity wave action)
- Table A-18: Exposure to Flooding in FEMA Zone X (0.2 percent annual chance)
- Table A-19: Exposure to Hurricane Storm Surge (Category 1)
- Table A-20: Exposure to Hurricane Storm Surge (Category 2)
- Table A-21: Exposure to Hurricane Storm Surge (Category 3)
- Table A-22: Exposure to Hurricane Storm Surge (Category 4)
- Table A-23: Exposure to Wildfire (Wildland Urban Interface)
- Table A-24: Exposure of Critical Facilities
- Table A-25: Exposure of Other Community Assets

<u>Central Falls</u>

- Table A-26: Exposure to Flooding in FEMA Zone AE (1-percent-annual-chance without velocity wave action)
- Table A-27: Exposure to Flooding in FEMA Zone X (0.2 percent annual chance)
- Table A-28: Exposure to Hurricane Storm Surge (Category 4)
- Table A-29: Exposure of Critical Facilities
- Table A-30: Exposure of Other Community Assets

Summary of Exposure Analysis

<u>Pawtucket</u>

- It is estimated that there are 227 developed parcels (with buildings) and nearly $285 million in total building value located in FEMA mapped flood zones; including 109 developed parcels which are in the 0.2-percent-annual-chance flood zone (500-year floodplain) and considered at a moderate risk. In total, there are 118 developed parcels located in identified high-risk flood zones, including 60 located in areas with velocity wave action (Zone VE). The potentially at-risk properties include all land use types as shown in tables A-14 through A-16.

- As expected, many of the properties that are in high-risk flood zones identified by FEMA are also in hurricane storm surge inundation zones as mapped by the US Army Corps of Engineers. An estimated 21 developed parcels are considered at risk to storm surge flooding from a Category 3 hurricane, though none are classified as residential (most land use types are identified as transportation and utilities). An additional 69 properties could be inundated by the worst-case scenario Category 4 storm, though only three (3) are classified as residential.
- More than 600 properties (mostly residential) have been identified in areas that are potentially at risk to wildfire due to their location in the mapped Wildland Urban Interface, where urban development meets vegetated, wildfire prone lands.
- The following critical facilities identified by the City of Pawtucket are in identified hazard zones and should be considered potentially at-risk to significant hazard impacts pending more site-specific evaluations:
    - Roosevelt Ave Fire Station @ 137 Roosevelt Ave (500-year floodplain, Category 4 storm surge zone)
    - Pawtucket Police Station @ 121 Roosevelt Ave (500-year floodplain, Category 4 storm surge zone)
    - Pawtucket City Hall @137 Roosevelt Ave (500-year floodplain, Category 4 storm surge zone)
- The following other community assets identified by the City of Pawtucket are in identified hazard zones and should be considered potentially at-risk to significant hazard impacts pending more site-specific evaluations:
    - Historic Places
        - Veterans Park Amphitheater (100-year floodplain, Category 4 storm surge zone)
        - Bridge Mill Power Plant (100-year floodplain, Category 4 storm surge zone)
        - Old Slater Mill Historic Site (100-year floodplain, Category 4 storm surge zone)
        - Main Street Bridge (100-year floodplain, Category 4 storm surge zone)
        - Division Street Bridge (100-year floodplain, Category 1 storm surge zone)
    - Private/Parochial Schools/Day Cares
        - Valley Community School (500-year floodplain)
        - Heritage Park Early Learning Center (100-year floodplain, Category 4 storm surge zone)
    - Parks/Open Space/Recreation Areas
        - Hodgson Rotary Park (100-year floodplain, Category 4 storm surge zone)
        - Town Landing (100-year floodplain, Category 1 storm surge zone)
        - Festival Pier (100-year floodplain with velocity wave action, Category 1 storm surge zone)
        - Max Read Field (Category 3 storm surge zone)

Central Falls

- It is estimated that there are 120 developed parcels (with buildings) and nearly $135 million in total building value located in FEMA mapped flood zones; including 65 developed parcels which are in the 0.2-percent-annual-chance flood zone (500-year floodplain) and considered at a moderate risk. In total, there are 55 developed parcels located in identified high-risk flood zones, but no developed parcels in areas with velocity wave action (Zone VE). Most of the potentially at-risk properties (45) are classified as residential.
- Only nine (9) developed properties in Central Falls could be inundated by the worst-case scenario Category 4 storm. This includes three (3) properties classified as residential and six (6) properties classified as an industrial land use.
- No developed parcels have been identified in areas that are potentially at risk to wildfire.
- None of the critical facilities or other community assets identified by the City of Central Falls are in the geographically-defined hazard areas identified above.

City of Pawtucket – Flood Exposure

Table A-16: Exposure to Flooding in FEMA Zone AE (1-percent-annual-chance without velocity wave action)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	55	0.32%	5	$332,400	0.03%	0.02%	$557,100	0.02%
Commercial	29	3.11%	15	$35,922,000	1.34%	4.32%	$48,999,700	4.01%
Industrial	19	5.90%	14	$9,675,600	2.03%	2.88%	$14,899,200	2.53%
Transportation & Utilities	13	13.68%	4	$1,679,400	14.81%	22.48%	$4,385,600	11.29%
Mixed Use	1	0.59%	2	$1,274,800	0.94%	2.21%	$1,583,000	1.99%
Municipal/Institutional	42	10.85%	13	$31,648,800	3.87%	4.62%	$39,791,000	3.11%
Conservation / Open Space	17	27.87%	5	$2,505,600	2.39%	0.38%	$80,297,400	1.99%
Undeveloped (unprotected)	24	19.05%	0	$0	0.00%	0.00%	$591,100	21.34%
Total	**200**	**1.05%**	**58**	**$83,038,600**	**0.30%**	**1.85%**	**$191,104,100**	**1.87%**

Source: City of Pawtucket GIS Data; FEMA Flood Insurance Rate Map (FIRM)

Table A-17: Exposure to Flooding in FEMA Zone VE (1-percent-annual-chance with velocity wave action)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	56	0.33%	5	$332,400	0.03%	0.02%	$557,100	0.02%
Commercial	29	3.11%	15	$35,922,000	1.34%	4.32%	$48,999,700	4.01%
Industrial	23	7.14%	16	$11,168,200	2.32%	3.33%	$17,273,000	2.93%
Transportation & Utilities	16	16.84%	4	$1,679,400	14.81%	22.48%	$4,385,600	11.29%
Mixed Use	1	0.59%	2	$1,274,800	0.94%	2.21%	$1,583,000	1.99%
Municipal/Institutional	46	11.89%	13	$31,648,800	3.87%	4.62%	$39,791,000	3.11%
Conservation / Open Space	25	40.98%	5	$2,505,600	2.39%	0.38%	$80,297,400	1.99%
Undeveloped (unprotected)	24	19.05%	0	$0	0.00%	0.00%	$591,100	21.34%
Total	**220**	**1.15%**	**60**	**$84,531,200**	**0.31%**	**1.88%**	**$193,477,900**	**1.89%**

Source: City of Pawtucket GIS Data; FEMA Flood Insurance Rate Map (FIRM)

Table A-18: Exposure to Flooding in FEMA Zone X (0.2 percent annual chance)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	64	0.38%	7	$5,662,400	0.04%	0.29%	$7,526,800	0.25%
Commercial	39	4.18%	25	$41,604,300	2.23%	5.00%	$62,386,800	5.10%
Industrial	26	8.07%	28	$13,660,600	4.06%	4.07%	$21,965,800	3.72%
Transportation & Utilities	16	16.84%	5	$1,911,400	18.52%	25.58%	$5,433,200	13.99%
Mixed Use	1	0.59%	2	$1,274,800	0.94%	2.21%	$1,583,000	1.99%
Municipal/Institutional	49	12.66%	36	$50,608,300	10.71%	7.39%	$325,388,600	25.47%
Conservation / Open Space	26	42.62%	6	$2,505,600	2.87%	0.38%	$80,556,400	2.00%
Undeveloped (unprotected)	25	19.84%	0	$0	0.00%	0.00%	$591,100	21.34%
Total	**246**	**1.29%**	**109**	**$117,227,400**	**0.55%**	**2.60%**	**$505,431,700**	**4.95%**

Source: City of Pawtucket GIS Data; FEMA Flood Insurance Rate Map (FIRM)

City of Pawtucket – Storm Surge Exposure

Table A-19: Exposure to Hurricane Storm Surge (Category 1)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Commercial	3	0.32%	0	$0	0.00%	0.00%	$0	0.00%
Industrial	3	0.93%	0	$0	0.00%	0.00%	$0	0.00%
Transportation & Utilities	7	7.37%	2	$1,215,400	7.41%	16.27%	$2,290,400	5.90%
Mixed Use	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Municipal/Institutional	7	1.81%	0	$0	0.00%	0.00%	$0	0.00%
Conservation / Open Space	8	13.11%	0	$0	0.00%	0.00%	$0	0.00%
Undeveloped (unprotected)	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Total	**28**	**0.15%**	**2**	**$1,215,400**	**0.01%**	**0.03%**	**$2,290,400**	**0.02%**

Source: City of Pawtucket GIS Data; Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS)

Table A-20: Exposure to Hurricane Storm Surge (Category 2)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	1	0.01%	0	$0	0.00%	0.00%	$0	0.00%
Commercial	5	0.54%	0	$0	0.00%	0.00%	$0	0.00%
Industrial	5	1.55%	2	$1,492,600	0.29%	0.45%	$2,373,800	0.40%
Transportation & Utilities	7	7.37%	5	$1,911,400	18.52%	25.58%	$5,433,200	13.99%
Mixed Use	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Municipal/Institutional	11	2.84%	0	$0	0.00%	0.00%	$0	0.00%
Conservation / Open Space	10	16.39%	0	$0	0.00%	0.00%	$0	0.00%
Undeveloped (unprotected)	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Total	**39**	**0.20%**	**7**	**$3,404,000**	**0.04%**	**0.08%**	**$7,807,000**	**0.08%**

Source: City of Pawtucket GIS Data; Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS)

Table A-21: Exposure to Hurricane Storm Surge (Category 3)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	1	0.01%	0	$0	0.00%	0.00%	$0	0.00%
Commercial	8	0.86%	3	$512,400	0.27%	0.06%	$886,100	0.07%
Industrial	5	1.55%	2	$1,492,600	0.29%	0.45%	$2,373,800	0.40%
Transportation & Utilities	7	7.37%	5	$1,911,400	18.52%	25.58%	$5,433,200	13.99%
Mixed Use	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Municipal/Institutional	13	3.36%	1	$548,900	0.30%	0.08%	$771,900	0.06%
Conservation / Open Space	11	18.03%	1	$331,300	0.48%	0.05%	$331,300	0.01%
Undeveloped (unprotected)	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Total	**45**	**0.24%**	**12**	**$4,796,600**	**0.06%**	**0.11%**	**$9,796,300**	**0.10%**

Source: City of Pawtucket GIS Data; Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS)

Table A-22: Exposure to Hurricane Storm Surge (Category 4)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	9	0.05%	3	$5,797,300	0.02%	0.30%	$7,520,400	0.25%
Commercial	25	2.68%	19	$37,295,700	1.69%	4.48%	$51,968,600	4.25%
Industrial	14	4.35%	18	$4,321,500	2.61%	1.29%	$6,874,500	1.17%
Transportation & Utilities	9	9.47%	7	$2,375,400	25.93%	31.79%	$7,528,400	19.38%
Mixed Use	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Municipal/Institutional	23	5.94%	15	$32,232,800	4.46%	4.71%	$40,777,800	3.19%
Conservation / Open Space	16	26.23%	7	$9,386,000	3.35%	1.43%	$13,295,700	0.33%
Undeveloped (unprotected)	2	1.59%	0	$0	0.00%	0.00%	$0	0.00%
Total	**98**	**0.51%**	**69**	**$91,408,700**	**0.35%**	**2.03%**	**$127,965,400**	**1.25%**

Source: City of Pawtucket GIS Data; Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS)

City of Pawtucket – Wildfire Exposure

Table A-23: Exposure to Wildfire (Wildland Urban Interface)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	413	2.43%	622	$56,173,600	3.65%	2.92%	$78,874,700	2.65%
Commercial	26	2.79%	24	$19,575,100	2.14%	2.35%	$98,201,000	8.03%
Industrial	7	2.17%	8	$6,472,900	1.16%	1.93%	$11,928,500	2.02%
Transportation & Utilities	10	10.53%	0	$0	0.00%	0.00%	$2,289,800	5.90%
Mixed Use	3	1.76%	3	$405,000	1.42%	0.70%	$685,900	0.86%
Municipal/Institutional	8	2.07%	5	$704,100	1.49%	0.10%	$1,101,100	0.09%
Conservation / Open Space	4	6.56%	0	$0	0.00%	0.00%	$40,264,600	1.00%
Undeveloped (unprotected)	1	0.79%	0	$0	0.00%	0.00%	$139,400	5.03%
Total	**472**	**2.47%**	**662**	**$405,000**	**3.37%**	**0.01%**	**$233,485,000**	**2.29%**

Source: City of Pawtucket GIS Data; SILVIS Lab, University of Wisconsin (2010)

City of Pawtucket – Exposure of Critical Facilities and Community Assets

Table A-24: Exposure of Critical Facilities

Critical Facility Type	Critical Facility ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
Emergency Operation Center	Public Works Building/250 Armistice Blvd								
Hospital	Memorial Hospital of Rhode Island/111 Brewster St								
Library	Pawtucket Public Library/12 Summer St								
Fire Station	Cottage Street Fire Station/385 Cottage St								
Fire Station	Roosevelt Ave Fire Station/137 Roosevelt Ave			x				x	
Fire Station	Columbus Ave Fire Station/2 Columbus Ave								
Fire Station	Newport Ave Fire Station/385 Newport Ave								
Fire Station	West Ave Fire Station/394 West Ave								
Fire Station	Smithfield Ave Fire Station/301 Smithfield Ave								
School	Nathanael Greene School/285 Smithfield Avenue								
School	Shea Senior High School/485 East Avenue								
School	William E. Tolman Senior High School/150 Exchange St								
School	Agnes E. Little School/60 South Bend Street								
School	Fallon Memorial School/62 Lincoln Avenue								
School	Goff Junior High School/974 Newport Avenue								
School	Potter-Burns School/973 Newport Avenue								
School	Flora S. Curtis Memorial School/582 Benefit Street								
School	Henry J. Winters School/481 Broadway								
School	M. Virginia Cunningham School/40 Baldwin Street								
School	Samuel Slater Junior HSl/281 Mineral Spring Ave								
School/Shelter	Francis J. Varieur School/486 Pleasant Street								
School/Shelter	Elizabeth Baldwin School/50 Whitman Street								
School/Shelter	Joseph Jenks Junior High School/350 Division Street								
School/Shelter	Curvin-McCabe/466 Cottage Street								
Law Enforcement	Pawtucket Police Station/121 Roosevelt Ave			x				x	
Law Enforcement	Pawtucket Police Substation/252 Armistice Blvd								
City Hall	Pawtucket City Hall/137 Roosevelt Ave			x				x	

Source: City of Pawtucket GIS Data; FEMA Flood Insurance Rate Map (FIRM); Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS); SILVIS Lab, University of Wisconsin (2010)

Table A-25: Exposure of Other Community Assets

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
Major Employers									
	Hasbro, Inc.								
	The Matlet Group								
	International Packaging Corp.								
	Collette Vacations								
	American Insulated Wire Company								
	Teknor Apex Company								
	RI Textile Company								
Historic Places									
	Sandra Feinstein-Gamm Theater								
	Pitcher-Goff House								
	Pawtucket Lodge of Elks								
	Elisha O. Potter								
	Veterans Park Amphitheater/Roosevelt Ave	x						x	
	Alfred L. Childs House/Childs-Brown House								
	Pawtucket Armory								
	Art's Auto Supply								
	Fuller Tenement House								
	St. Paul's Episcopal Church								
	Riverside Cemetery								
	Lorenzo Crandall House								
	Hope Webbing Company Mill								
	E. A. Burnham House								
	Deborah Cook Sayles Public Library								
	Pawtucket Congregational Church								
	Fifth Ward Wardroom								
	Bridge Mill Power Plant	x						x	

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
	Phillips Insulated Wire Company								
	Pawtucket Times Building								
	Foster-Payne House								
	Joseph Spaulding House								
	James Mitchell House								
	First Ward Wardroom								
	Saint Jean Baptiste Church								
	St. Mary's Church Complex								
	West High School								
	John F. Adams House								
	Nathaniel Montgomery House								
	Charles Payne House								
	Fuller Tenement House								
	Louis Kotzow House								
	Modern Diner								
	Gilbane's								
	Church Hill Grammar School								
	Frederick Scholze House								
	St. Mary's Church Complex								
	Old Slater Mill Historic Site National Hist Dist	x						x	
	Main Street Bridge	x						x	
	Division Street Bridge	x			x				
	Conant Thread Company Mills								
	Liberty Arming the Patriot								
	Pawtucket Post Office								
	Collyer Monument								
	Gately Building								
	Prospect Heights								
	Standard Paper Box Corporation								
Community Facilities									
	Recreation Department/Slater Park								
	Transfer Station/Grotto Ave								

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
	Senior Center/Main St								
Private/Parochial Schools/Day Cares									
	Blackstone Academy Charter School								
	International Charter School								
	Bishop Francis P. Keough Regional High School								
	Smithfield Avenue Nursery School								
	Woodlawn Catholic Regional School								
	Pawtucket Day Child Development Center								
	Puss 'n Boots Nursery School								
	St. Mary School								
	St. Teresa School								
	TLC Day Care Center								
	Darlington Early Childhood Center, Inc.								
	St. Leo the Great								
	St. Cecilia School								
	The Children's Workshop-East Street								
	St. Raphael Academy								
	The Tides School								
	Valley Community School			x					
	Heritage Park Early Learning Center	x						x	
	The Children's Workshop-Bev Hill								
Parks/Open Space/Recreation Areas									
	Ten Mile River								
	Swap for Max Reed Field								
	Turner Reservoir								
	Slater Memorial Park								
	Tomlinson Park								
	Fairlawn Playground								
	McCoy Stadium								
	Newell Avenue Park								
	Berkeley Park								
	John Street Playground								

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
	Goff Lot								
	School Street Lots								
	Hodgson Rotary Park	x						x	
	Slater School Playground								
	Pawtucket Soccer Complex								
	Randall Street Park								
	Town Landing	x			x				
	Pleasant Street Park								
	Payne Park Playground								
	Fairlawn Veterans Memorial Park								
	School Street Traffic Island								
	Ayotte Park Playground								
	Festival Pier		x		x				
	Boys and Girls Club Riverfront								
	School Street CRMC Access Point								
	Potter- Burns Street School								
	Agnes Little School								
	Morley Field								
	Max Read Field						x		
	Oak Hill Tennis Courts								
	Prospect Heights								
	Hank Soars Field								
	Laurel Hill Playground								
	Galego Court Athletic Field								
	Smithfield Avenue Park								
	John B Santos Park								
	Wilkinson Park								
	Collyer Park								

Source: City of Pawtucket GIS Data; FEMA Flood Insurance Rate Map (FIRM); Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS); SILVIS Lab, University of Wisconsin (2010)

City of Central Falls– Flood Exposure

Table A-26: Exposure to Flooding in FEMA Zone AE (1-percent-annual-chance without velocity wave action)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	62	2.45%	45	$10,415,900	1.74%	3.19%	$12,264,200	2.92%
Commercial	1	0.40%	2	$681,300	0.80%	1.21%	$914,800	1.17%
Industrial	5	4.59%	5	$11,376,700	4.27%	12.37%	$12,254,300	9.55%
Conservation / Open Space	13	44.83%	3	$129,800	25.00%	17.11%	$1,382,300	24.04%
Total	**81**	2.78%	**55**	**$22,603,700**	1.86%	4.75%	**$26,815,600**	4.24%

Source: FEMA Flood Insurance Rate Map (FIRM); City of Central Falls GIS Data

Table A-27: Exposure to Flooding in FEMA Zone X (0.2 percent annual chance)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	36	1.42%	41	$10,447,000	1.59%	3.20%	$11,826,600	2.81%
Commercial	3	1.21%	4	$903,300	1.59%	1.60%	$1,335,100	1.71%
Industrial	13	11.93%	15	$65,104,000	12.82%	70.80%	$93,578,400	72.92%
Conservation / Open Space	8	27.59%	5	$183,000	41.67%	24.12%	$622,900	10.83%
Total	**60**	2.06%	**65**	**$76,637,300**	2.19%	16.12%	**$107,363,000**	16.97%

Source: FEMA Flood Insurance Rate Map (FIRM); City of Central Falls GIS Data

Table A-28: Exposure to Hurricane Storm Surge (Category 4)

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	% in Hazard Area	Total Number in Hazard Area	Total Value in Hazard Area	% in Hazard Area	% Value in Hazard Area	Total Value in Hazard Area	% Value in Hazard Area
Residential	2	0.08%	3	$71,700	0.12%	0.02%	$128,600	0.03%

Land Use	Number of Parcels		Number and Value of Buildings				Value of Real Property	
	Total in Hazard Area	**% in Hazard Area**	**Total Number in Hazard Area**	**Total Value in Hazard Area**	**% in Hazard Area**	**% Value in Hazard Area**	**Total Value in Hazard Area**	**% Value in Hazard Area**
Commercial	0	0.00%	0	$0	0.00%	0.00%	$0	0.00%
Industrial	5	4.59%	6	$8,564,500	5.13%	9.31%	$9,089,400	7.08%
Conservation / Open Space	2	6.90%	0	$0	0.00%	0.00%	$99,300	1.73%
Total	**6**	0.21%	**9**	**$8,636,200**	0.30%	1.82%	**$9,317,300**	1.47%

Source: FEMA Flood Insurance Rate Map (FIRM); City of Central Falls GIS Data

City of Central Falls – Exposure of Critical Facilities and Other Community Assets

Table A-29: Exposure of Critical Facilities and Community Assets

Critical Facility Type	Critical Facility ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
Emergency Operation Center	Public Works Building/250 Armistice Blvd								
City Hall	Central Falls City Hall/580 Broad St.								
Library	Adams Public Library/205 Central St.								
School	Captain Hunt Early Learning (PK)/12 Kendall St.								
School	Ella Risk Elementary (K-5)/949 Dexter St.								
School	Veterans Memorial Elementary (K-5)/150 Fuller Ave.								
School	Margaret Robertson Elementary (K)/135 Hunt St.								
School	Calcutt Middle School/112 Washington St.								
School	Central Falls High School (9-12)/24 Summer Street								
School	The Learning Community/21 Lincoln Ave.								
School	Blackstone Valley Prey Mayoral Academy Middle School								
Hospital	Blackstone Valley Community Healthcare/9 Chestnut St								
Law Enforcement	Central Falls Police Department/160 Illinois St.								
Public Works	Central Falls Public Works/1280 High St.								
Fire Department	Central Falls Fire Department/150 Illinois St.								

Source: City of Central Falls GIS Data; FEMA Flood Insurance Rate Map (FIRM); Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS); SILVIS Lab, University of Wisconsin (2010)

Table A-30: Exposure of Other Community Assets

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
Major Employers									
	Central Falls School District								
	The City of Central Falls								
Historic Places									

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
	Central Falls Mill Historic District/between Roosevelt Avenue and Blackstone River								
	South Central Falls Historic District/roughly bounded by Rand, Summit, Dexter and Broad Streets								
	Jenks Park and Cogswell Tower/adjoining 580 Broad Street to the north								
	Valley Falls Mill Complex Office and Bathhouse/1359 & 1361-1363 Broad Street								
	Central Street School/379 Central Street								
	Samuel B. Conant House/104 Clay Street								
	Benjamin F. Greene House/85 Cross Street								
	St. Matthew's Church/Dexter & West Hunt Street								
	Holy Trinity Church Complex/134 Fuller Avenue								
	Central Falls Congregational Church/376 High Street								
	David D. Fales House/476 High Street								
	Conant Threat Company Mills/bounded by Pine, Conant, Carpenter, Coleman, Beecher Streets, and Lonsdale Avenue in Pawtucket; Lonsdale Avenue, Rand and Pine Streets in Central Falls (Pawtucket and Central Falls)								
Parks/Open Space/Recreation Areas									
	Jenks Park/602 Broad St. & Washington St.								
	Governor Lincoln Almond Park/61 Crossman St.								
	River Island Park & Camp Ground/1425 High St.								
	Dexter Plaza/741 Dexter St.								
	Chocolate Mill Overlook/Intersection of Charles Street & Roosevelt Ave.								
	Pierce Park/975 High St.								
	Garfield Street Playground/114 Garfield St.								
	Veterans Memorial Park/416 Hunt St.								
	Sacred Heart Park/Corner of Sacred Heart Ave. & High St.								
	Coutu Memorial Park/Hunt St. and Lewis Street								

Community Asset Type	Community Asset ID (Name/Address)	Exposure to Flooding			Exposure to Hurricane Storm Surge Inundation				Exposure to Wildfire
		Zone AE	Zone VE	Zone X	Cat 1	Cat 2	Cat 3	Cat 4	
	Macomber Stadium/Corner of Blackstone & High Streets								
	Higginson Avenue/Francis Corrigan Sports Complex/ Corner of Lonsdale & Higginson Avenues								

Source: City of Central Falls GIS Data; FEMA Flood Insurance Rate Map (FIRM); Rhode Island Worst Case Hurricane Surge Inundation Areas, Rhode Island Geographic Information System (RIGIS); SILVIS Lab, University of Wisconsin (2010)

A.5. SUMMARY FINDINGS AND CONCLUSIONS

The Hazard Analysis and Risk Assessment completed for the cities of Pawtucket and Central Falls includes both quantitative and qualitative information to help determine the potential impact of each identified hazard on community assets. This information provides significant findings that allow the Local Planning Team to prioritize hazard risks and proposed hazard mitigation strategies and actions.

To assist in this process, the Local Planning Team applied a "Priority Risk Index" (PRI). The PRI is a tool designed to (1) summarize relevant hazard profile information as included in section A.2; and (2) measure the degree of relative risk each hazard poses to the planning area based on that information. The PRI was used to assist the Local Planning Team in ranking and prioritizing hazards based on a variety of characteristics including location, probability, potential impact, warning time, and duration.

The PRI results in numerical values that allow identified hazards to be ranked against one another – the higher the PRI value, the greater the hazard risk. PRI values are obtained by assigning varying degrees of risk to each of the five characteristics, or categories. Each degree of risk has been assigned an index value (1 to 4) and an agreed upon weighting factor, as summarized in **Table A-31**.

To calculate the PRI value for a given hazard, the assigned index value for each category is multiplied by the weighting factor. The sum of all five categories equals the final PRI value, as demonstrated in the below equation:

PRI VALUE =

(LOCATION x .20) + (PROBABILITY x .30) + (POTENTIAL IMPACT x .30) + (WARNING TIME x .10) + (DURATION x .10)

According to the weighting scheme applied for the cities of Pawtucket and Central Falls, the highest possible PRI value is 4.0. Prior to being finalized, PRI values for each hazard were reviewed and accepted by the Local Planning Team.

Table A-31: Priority Risk Index (PRI)

PRI CATEGORY	DEGREE OF RISK			ASSIGNED WEIGHTING FACTOR
	LEVEL	CRITERIA	INDEX VALUE	
Location	Negligible	Less than 1% of planning area affected	1	20%
	Small	1-10% of planning area affected	2	
	Moderate	10-50% of planning area affected	3	
	Large	50-100% of planning area affected	4	
Probability	Unlikely	Less than 1% annual probability	1	30%
	Possible	1-10% annual probability	2	
	Likely	10-90% annual probability	3	
	Highly Likely	90-100% annual probability	4	
Potential Impact *	Minor	Very few injuries, if any. Only minor property damage and minimal disruption to quality of life. Partial or complete shutdown of critical facilities for less than one day.	1	30%
	Limited	Minor injuries only. 10-25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one day.	2	
	Critical	Multiple fatalities/injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one week.	3	
	Catastrophic	High number of fatalities/injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one month.	4	
Warning Time	More than 24 hours		1	10%
	12 to 24 hours		2	
	6 to 12 hours		3	
	Less than 6 hours		4	
Duration	Less than 6 hours		1	10%
	6 to 24 hours		2	
	1 to 7 days		3	
	More than 1 week		4	

* Potential impact is based upon the estimated *maximum probable extent* (magnitude/severity) for each hazard based on historic events or future probability data, as shown in **Table A-32**.

Table A-32: Maximum Probable Extent

HAZARD	MAXIMUM PROBABLE EXTENT
Coastal Storm	Category 3 hurricane on Saffir-Simpson Hurricane Wind Scale; or Intensity Index Category 4 on Classification Scheme for Nor'easters
Dam Failure	Complete failure of a high hazard dam
Earthquake	6.5 on Richter Scale and Intensity VII on Modified Mercalli Intensity scale
Extreme Temperatures	5 consecutive days with heat index exceeding 100°F, or wind chill of less than -20°F
Fire	Major urban fire; or 100 acres burned along wildland-urban interface
Flood (3 Types):	
Riverine Flood	1 Percent Annual Chance Flood for <u>all</u> inland FEMA Special Flood Hazard Areas
Coastal Flood	Worst Case Storm Surge Inundation for Category 3 Hurricane
Urban/Flash Flood	10-year Design Storm Event
Sea Level Rise	Sea level rise of 5 feet by 2100
Severe Weather	Wind gusts in excess of 50 knots, hail measuring at least three-quarters of an inch in diameter, or tornado occurrence
Severe Winter Storm	Category 5 on Regional Snowfall Index; or Intensity Index Category 4 on Classification Scheme for Nor'easters

Table A-33 summarizes the degree of risk assigned for all identified hazards in the planning area based on the application of the PRI tool, along with the calculated PRI values.

Table A-33: Summary of PRI Results

HAZARD	CATEGORY/DEGREE OF RISK					PRI Value
	LOCATION	PROBABILITY	POTENTIAL IMPACT*	WARNING TIME	DURATION	
Coastal Storm	Large	Likely	Catastrophic	More than 24 hours	1 to 7 days	**3.3**
Dam Failure	Small	Possible	Critical	Less than 6 hours	Less than 6 hours	**2.4**
Earthquake	Large	Possible	Minor	Less than 6 hours	Less than 6 hours	**2.2**
Extreme Temperatures	Large	Likely	Critical	More than 24 hours	1 to 7 days	**3.0**
Fire	Small	Highly Likely	Critical	Less than 6 hours	6 to 24 hours	**3.1**
Flood (3 Types):						
Riverine Flood	Moderate	Likely	Critical	12 to 24 hours	1 to 7 days	**2.9**
Coastal Flood	Negligible	Possible	Minor	More than 24 hours	6 to 24 hours	**1.4**
Urban/Flash Flood	Large	Highly Likely	Limited	Less than 6 hours	Less than 6 hours	**3.1**
Sea Level Rise	Negligible	Highly Likely	Minor	More than 24 hours	More than 1 week	**2.2**
Severe Weather	Moderate	Highly Likely	Critical	6 to 12 hours	Less than 6 hours	**3.1**
Severe Winter Storm	Large	Highly Likely	Limited	More than 24 hours	1 to 7 days	**3.0**

The calculated PRI values were used by the Local Planning Team to classify each hazard according to three defined risk levels (Low, Moderate, or High) as shown in **Table A-34**. It should be noted that although some hazards are classified as posing "low" risk, their occurrence of varying or unprecedented magnitudes is still possible and they will continue to be evaluated by the cities of Pawtucket and Central Falls during future updates to this plan.

Table A-34: Conclusions on Hazard Risk

HIGH RISK	Coastal Storm Fire Urban/Flash Flood Severe Weather
MODERATE RISK	Extreme Temperatures Severe Winter Storm Riverine Flood
LOW RISK	Dam Failure Earthquake Sea Level Rise Coastal Flood