

## 12.0 NATURAL HAZARDS AND CLIMATE CHANGE

### 12.1 Vision

[To be developed.]

### 12.2 Introduction

Natural hazards are environmental phenomena that have the potential to impact societies and the human environment.<sup>1</sup> These events are referred to as natural disasters, and they have intensified and become more frequent because of climate change. Climate-related events often refer to natural hazards and disasters that are becoming more prevalent, frequent, severe, or erratic, because of global warming. Current hazard mitigation efforts are aimed at protecting the City's **residents**, resources, property, infrastructure, and general welfare from future disasters. This element of the comprehensive plan addresses Cranston's management of natural hazards and mitigation of climate change impacts.

#### *Ways the City Can Prepare for Climate Change*

Climate mitigation, climate adaptation, and climate resilience are three approaches for addressing climate change impacts.

**Climate change mitigation** refers to activities that help reduce the impacts of climate change by reducing carbon emissions, creating renewable energy sources, storing carbon, and supporting energy efficiency. (*See the Energy Section of this Plan for More Information.*)

**Climate adaptation** refers to actions that can be taken to adjust and evolve the way we live, build, and operate to sustain a safe and productive quality of life despite climate change.

**Climate resilience** refers to the ability of the community to prepare, respond, and recover from climate impacts and climate-related events.

Climate resilience is a newer state-wide initiative in Rhode Island. The first comprehensive climate preparedness strategy, *Resilient Rhody*, was released in July 2018. This strategy identifies critical actions for state agencies, municipalities, and statewide organizations to take in the face of climate change.

[insert any brief description of climate concerns from workshop]

How the City currently respond to natural hazards will have to be adapted as events become more frequent and severe. This element of the Plan addresses Cranston's management of natural hazards and climate change under the following categories:

- Existing conditions including current threats from natural hazards and potential impacts caused by climate change (Section 12.3).
- Challenges and opportunities (Section 12.4).
- Current measures (Section 12.5).
- Community Engagement (Section 12.6).

These are the City’s priorities when considering how natural hazards and climate change influence decision making, based on the concerns and preferences of residents and stakeholders.

[Insert priorities identified by the workshop.]

### 12.3 Future Effects of Climate Change

Because climate change is projected to intensify, this chapter provides a “Future Climate Change Projections” overview rather than an “Existing Conditions” overview. Data on projected climate impacts is provided by *Resilient Rhody* (2018) and NOAA National Centers for Environmental Information’s State Climate Summary for Rhode Island (2022). Cranston’s 2022 Hazard Mitigation Plan Update provides a thorough description of each natural hazard that has impacted or may impact Cranston. These descriptions are included below along with considerations for how each natural hazard may change or increase due to climate change.

#### 12.3.1 High Risk Hazards

The 2022 Hazard Mitigation Plan Update for Cranston provides a ranked list of natural hazards likely to be experienced in Cranston; these rankings were determined based on a public survey issued by the Cranston Hazard Mitigation Committee (HMC). Table 12-1 includes the natural hazard rankings and potential impacts from this HMP update.

Table 12-1: Natural Hazard Risk Ranking and Potential Impacts		
Hazard Type	Level of Concern/Risk Rank	Potential Impacts
Nor’easters	High	Damage to utilities, roads, stormwater infrastructure, buildings, trees, and roofs.
Hurricanes	High	Damage to utilities, roads, stormwater infrastructure, buildings, trees, and roofs.
Flooding	High	Damage to roads, stormwater infrastructure, buildings, dams, water supply lines, and wastewater infrastructure.
Winter Storms	High	Damage to roofs, roads, and buildings. Potential for power outages, emergency services, and local economy.
Ice Storm	High	Potential for automobile accidents, power outages, personal injury, and emergency services.
High Winds	Medium	Damage to trees and buildings. Potential for power outages and emergency services.
Extreme Temperatures	Medium	Damage to utility infrastructure. Concern for power outages and health effects for vulnerable populations.
Lightning/ Thunderstorms	Medium	Damage to buildings, accessory structures, and utilities. Potential for power outages and personal injury.
Microbursts	Medium	Damage to trees and buildings. Potential for power outages, emergency services, and personal injury. Flooding of roadways and stress to stormwater system.
Hail	Low	Damage to buildings and structures. Potential for agriculture/ crop damage.

Table 12-1: Natural Hazard Risk Ranking and Potential Impacts		
Hazard Type	Level of Concern/Risk Rank	Potential Impacts
Drought	Low	Potential for water supply, personal health, fire danger, and agriculture.
Earthquake	Low	Damage to buildings, utility infrastructure, dam failures, gas leaks, and fires. Potential for personal injury.
Tornadoes	Low	Damage to trees, buildings, and utilities. Potential for personal injury from flying debris.
Wildfire/ Brushfire	Low	Damage to buildings. Potential for open fields, forested areas, and grassy areas.

### 12.3.2 Natural Hazards Overview

City of Cranston's 2022 Hazard Mitigation Plan Update provides a thorough description of each natural hazard that has impacted or may impact Cranston and the climate impacts, trend of natural hazards to worsen. Elements of these descriptions are included in the following section along with additional information from NOAA, FEMA, and the statewide climate resilience action strategy *Resilient Rhody*.

#### Nor'easters

Nor'easters are storms along the East Coast that bring precipitation of heavy rain or snow, intense winds, rough seas, and coastal flooding.<sup>2</sup>

#### Historical Events

Cranston has experienced or is threatened by Nor'easters one or twice a year on average. The Blizzard of 1978 was the largest Nor'easter to date in Cranston and left many people without heat and electricity for over a week.<sup>3</sup>

#### Impact and Damage Extent

In the past, Nor'easters have created severe economic, transportation, and human disruption.<sup>4</sup> Nor'easters can damage utilities, roads, stormwater systems, basements or roofs, and natural resources.

#### Climate Change Impacts

Research has suggested an increase in rainfall volume from more frequent and intense Nor'easters.<sup>5</sup> Increase in sea level rise will likely increase coastal flooding and erosion during Nor'easters.<sup>6</sup>

#### Hurricanes

Hurricanes, also referred to as tropical cyclones, are rotating low-pressure weather systems that can reach 74 miles per hours (mph) or above. Storms less than 39 mph are tropical depressions and between 39 and 74 mph are tropical storms.<sup>7</sup> Hurricanes can cause high winds, heavy rain, lightning, tornadoes, and storm surge.

#### Historical Events

Hurricanes have impacted coastal Rhode Island in the past. In October 2012, Hurricane Sandy impacted coastal Rhode Island, but Cranston suffered very few impacts.<sup>8</sup>

### Impact and Damage Extent

Because of Cranston’s coastal location, it could be at risk of damages resulting from hurricanes. Hurricanes have the potential to impact roads, buildings, utilities, infrastructure, and natural resources.

### Climate Change Impacts

The impact of climate change on frequency of storms in the Atlantic Basin is uncertain. However, globally, modeling studies are predicting an increase in hurricane intensity of 2% to 11%.<sup>9</sup> Increase in sea level rise will likely increase coastal flooding and erosion during hurricanes.<sup>10</sup>

### Flooding

There are two main types of flood related hazards that have occurred in Cranston: 1) stormwater flooding and 2) riverine flooding. Stormwater flooding occurs from heavy rain and affects the more urbanized, developed, or impervious coverage of Cranston. Riverine flooding occurs when heavy rainfall or snow melt causes riverbanks and streams to overflow and occurs mostly in the late summer and early spring.<sup>11</sup> A portion of Cranston borders the Narragansett Bay and could be vulnerable to coastal flooding.

FEMA designates riverine flooding by the zones identified in Table 12-2 based on level of risk and recurrence interval. A 100-year flood has a 1% annual chance of recurring, while a 500-year flood has a 0.2% chance of recurring. The geographic boundaries of the flood zone describe what areas may be at risk of experiencing flooding.

<b>Flood Zones</b>	<b>Risk</b>	<b>Floodplain</b>	<b>Annual Chance of Recurrence</b>
Zone VE	High	100-year	1%
Zone A	High	100-year	1%
Zone AE	High	100-year	1%
Zone X	Moderate/Low	500-year	0.2%

Source: FEMA National Flood Hazard

The FEMA Flood Insurance Rate Map (FIRM) below in Figure 12-1 illustrates a select area of Cranston. The hatched areas in blue indicate ‘Zone AE’ and ‘Zone A’, high flood risk, 1% annual chance, with base flood elevations determined for this area. The dotted areas in blue indicate ‘Zone VE,’ high flood risk equivalent to the 1% annual chance flood event, with base floods elevations determined for this area.



Figure 12-1 - FEMA Flood Insurance Rate Map for a portion of Cranston (2015)

### Historical Events

Rhode Island alongside southern New England has experienced a significant increase in both flood frequency and flood severity over the past 80 years.<sup>12</sup> The Great Flood of 2010 was a heavy rainfall event over a five-week period in March that led to I-95 being shut down and damage to hundreds of homes and businesses, including the Warwick Mall. The Pawtuxet River crested at nearly 21 feet.<sup>13</sup>

### Impact and Damage Extent

Flooding can damage roads, stormwater infrastructure, buildings, dams, water supply lines, and wastewater infrastructure.

### Climate Change Impacts



Many climate change models suggest that increases in greenhouse gases will result in precipitation increases.<sup>14</sup> With sea level rise impacts, the Narragansett Bay has seen sea level rise approximately one foot and water temperatures have increased 3° F.<sup>15</sup> Increase in sea level rise will likely the probability for major flooding events and an increase in tidal flooding.<sup>16</sup>

### Winter Storms

Winter storms are defined as a combination of heavy snow, blowing snow and/or dangerous wind chills. Blizzards are winter storms that are the combination of blowing snow and wind.<sup>17</sup>

#### Historical Events

Cranston has experienced annual snowstorms. As mentioned under Nor'easters, the Blizzard of 1978 is regarded as the winter storm of the century.<sup>18</sup> Another strong winter storm that impacted Cranston was the Blizzard of 2013, that occurred in February, leading to extensive power outages and related injuries. 17 to 21 inches of snow fell across southeastern Providence County.<sup>19</sup>

#### Impact and Damage Extent

Heavy snowfall can stress rooftops and slow plowing efforts, as well as cause power outages meaning residents go without heat, and frozen pipes and pipe bursts which impact access to potable water.

#### Climate Change Impacts

Increase in sea level rise will likely increase coastal flooding and erosion during winter storms.<sup>20</sup>

### Ice Storms

Ice storms are storms that result in the accumulation of at least .25' of ice on exposed surfaces.<sup>21</sup>

#### Historical Events

Commonly in New England, ice storms are a part of larger snow events.<sup>22</sup>

#### Impact and Damage Extent

Ice storms can down trees, which can damage homes and infrastructure, and storms can lead to automobile accidents, power and communication system outages, personal injury, and death. These storms also impact the delivery of emergency services.

#### Climate Change Impacts

Ice storms are commonly a part of winter storm or nor'easter events. Both of these events are expected increase in intensity.<sup>23</sup>

### High Winds

High winds can occur during a severe thunderstorm, with a strong weather system, or flow through geographic features such as mountains.<sup>24</sup>

#### Historical Events

High wind events have been recorded in Providence County.<sup>25</sup>

#### Impact and Damage Extent

Strong gusts of wind have led to power outages, downed trees, and damage to vehicles and buildings.<sup>26</sup>

### Climate Change Impacts

The predicted change in storm activity may lead to a change and frequency and intensity of high wind events.<sup>27</sup>

### Extreme Temperatures

Extreme temperatures are broken into extreme heat and extreme cold and have associated warnings, watches, and advisories. Extreme (or excessive) heat warnings are issued within 12 hours of the onset when the expected heat index is expected to be 105 degrees Fahrenheit for at least 2 consecutive days and nighttime air temperatures not expected to fall below 75 degrees Fahrenheit. An excessive heat watch is issued when conditions are favorable for excessive heat in the next 24 to 72 hours. An advisory is issued within 12 hours of the onset and when the maximum heat index temperature is expected to be 100 degrees Fahrenheit or higher for at least two days.<sup>28</sup> Wind chill warnings are issued when temperatures are forecasted to go below 32 degrees Fahrenheit for a long period of time. A wind chill watch is when this forecasted cold reaches 36 hours or more. A wind chill advisory is issued when areas of frost are expected or occurring.<sup>29</sup>

### Historical Events

NOAA's National Weather Service has issued wind chill advisories, watches, and warnings, as well as, excessive heat warnings, watches, and advisories for Cranston.<sup>30</sup>

### Impact and Damage Extent

Temperatures below freezing require more intense heating loads to sustain livable indoor temperatures and emergency assistance to those who are most vulnerable to health impacts caused by cold weather. Both extreme cold and heat can have impact on structures and human health and safety and can cause stress to the power grid.

### Climate Change Impacts

Carbon dioxide and greenhouse gas emissions are driving up the temperatures, especially nighttime lows.<sup>31</sup> Heat waves are projected to increase in intensity while cold waves are projected to become less intense.<sup>32</sup>

### Lightning/Thunderstorms

Thunderstorms are rain showers that contain lightning. In severe thunderstorms, hail, strong wind gusts, or tornadoes occur. Lightning is a spark of electricity generated from differences between positive and negative charges in the cloud and ground. Thunder is a shock wave and sound wave that is caused by lightning.<sup>33</sup>

### Historical Events

Cranston has experienced lightning and thunderstorms as they are a common occurrence in the summer.<sup>34</sup>

### Impact and Damage Extent

Objects that are most vulnerable to the impacts of thunderstorms are nearby trees and tall structures.

### Climate Change Impacts

There is less clarity on how climate change will affect thunderstorms intensity and frequency in Rhode Island, but a study has found that winds associated with thunderstorms are intensifying.<sup>35</sup>

### Microbursts

Microbursts are localized columns of sinking air within a thunderstorm that are less than or equal to 2.5 miles in diameter. There are two primary types of microbursts: 1) wet microbursts and 2) dry microbursts. Wet microbursts are accompanied by a significant amount of precipitation.<sup>36</sup>

### Historical Events

Cranston has experienced microbursts in the past.<sup>37</sup>

### Impact and Damage Extent

Microbursts can reach up to 100 miles per hour in wind speed and can damage buildings and trees.<sup>38</sup>

### Climate Change Impacts

Because microbursts are associated with thunderstorms, more severe thunderstorms may contain microbursts.<sup>39</sup>

### Hail

Hail is a form of precipitation that consists of solid ice that forms within thunderstorm updrafts. Hail falls when it becomes heavier than the strength of the thunderstorm updraft.<sup>40</sup>

### Historical Events

Hailstorms have occurred in Cranston. The hail in Cranston is usually 1 inch or smaller.<sup>41</sup>

### Impact and Damage Extent

Hail can impact aircrafts, buildings, vehicles, and can be deadly to livestock and people.<sup>42</sup>

### Climate Change Impacts

The impact of climate change on hailstorms is highly uncertain. It is generally anticipated that hailstorm frequency and damage potential will decrease in the eastern region of North America.<sup>43</sup>

### Drought

Drought is the absence of water. It is a complex phenomenon that is difficult to monitor and define as it slowly creeps. There are four types of droughts: 1) meteorologic drought, 2) hydrological drought, 3) agricultural drought, and 4) socioeconomic drought. Indices created to assess drought include the Palmer Drought Index and Standardized Precipitation Index [SPI]. The U.S. Drought Monitor tracks conditions in Rhode Island and other time scales.<sup>44</sup>

### Historical Events

Rhode Island has experienced droughts in the past, approximately once every 11 years.<sup>45</sup>

### Impact and Damage Extent

Droughts decrease the availability of drinking and irrigation water and adversely affect water resources, flora, and fauna. Those who use private wells are especially at risk for temporary or permanent loss of water supply.



### Climate Change Impacts

Changing precipitation patterns, such as an increase in precipitation, may mask risks related to episodic and severe drought.<sup>46</sup> Despite this projected increase in precipitation, naturally occurring droughts are projected to be more intense because higher temperatures will increase evaporation rates.<sup>47</sup>

### Earthquakes

An earthquake is caused by slowly moving tectonic plates overcoming friction with one another, shaking the earth's surface.<sup>48</sup>

### Historical Events

Rhode Island is located in an area of "moderate" seismicity and "high" risk. Seismic risk applies to the seismic hazard, location demographics, and regional economics to the vulnerability of the structure of lifeline of the site.<sup>49</sup>

### Impact and Damage Extent

The most vulnerable structures to earthquakes are those built prior to current seismic building standard and masonry structures. Cranston has many older structures were built prior to current building code standards and many nationally and locally recognized historic preservation districts.<sup>50</sup>

### Climate Change Impacts

It is uncertain how climate change will affect earthquake magnitude in Cranston and the surrounding region.<sup>51</sup>

### Tornadoes

Tornadoes are narrow, violently rotating columns of air that extend from a thunderstorm to the ground. A tornado watch is issued by the NOAA Storm Prediction Center when weather conditions are favorable for tornadoes and severe weather. A tornado warning is issued when a tornado has been reported by spotters or indicated by radar.<sup>52</sup>

### Historical Events

There are no historical records of tornadoes in Cranston, but there have been occurrences in Rhode Island.<sup>53</sup>

### Impact and Damage Extent

Tornadoes can bring damage to buildings, trees, and above ground utility lines. Flying debris can be injurious to residents.<sup>54</sup>

### Climate Change Impacts

It is uncertain how climate change will affect tornado outbreaks for region.<sup>55</sup>

## Wildfire/Brushfire

Wildfires are an uncontrolled fire that burns in wildland vegetation. Wildfires can start with a natural occurrence such as lightning or a human-made spark. Weather conditions and the available source of fuel determine how much a wildfire grows.<sup>56</sup> Brushfires are fires fueled by natural cover, including native and non-native species of trees, brush and grasses, and crops along with weather conditions and topography.<sup>57</sup>

### Historical Events

Rhode Island does not typically experience wildfires but does more commonly experience brushfires. Cranston does not experience a significant number of brushfires, but the potential exists given the large areas of forested land in the City.<sup>58</sup>

### Impact and Damage Extent

Wildfires and brushfires can impact buildings and other structures. The timber and forest ecosystems are more susceptible.

### Climate Change Impacts

Longer dry periods and drought conditions may increase the probability of brushfires.<sup>59</sup>

#### 12.3.3 Preliminary Natural Hazard and Climate Change Vulnerability Assessment

Assessing the vulnerability of critical assets to natural hazards and climate impacts can help prioritize future City initiatives, projects, and spending for mitigation actions. Table 12-2 provides a preliminary community vulnerability assessment based on the 2022 HMP Risk Assessment, NOAA, FEMA, and the statewide climate resilience action strategy *Resilient Rhody*. This assessment looks at *potential* impacts to critical assets based on citywide knowledge of natural hazards. It is not a comprehensive vulnerability assessment. In a comprehensive vulnerability assessment, vulnerability is measured by the exposure, sensitivity, or adaptative capacity of critical assets. For this chart, vulnerability did not consider the potential geographic exposure or adaptative capacity of the asset; rather, critical assets were rated based on how sensitive they may be to an event caused by the natural hazard. The assessment assumes a severe event.

A tiered system of vulnerability is used in this preliminary assessment based on the following scale:

- 1: the critical asset is not very sensitive to the impacts of the natural hazard.
- 2: the critical asset may be somewhat sensitive to the impacts of the natural hazard.
- 3: the critical asset is notably or very sensitive to the impacts of the natural hazard

Although populations are included as critical assets in this chart, it is important to note that priority populations may be more vulnerable. This difference in vulnerability is not reflected in this assessment.

**Table 12-2: Preliminary Vulnerability Assessment for Critical Assets**

	Nor'easters	Hurricanes	Flooding	Winter Storms	Ice Storm	High Winds	Extreme Temperatures	Lightning/ Thunder	Microbursts	Hail	Drought	Earthquakes	Tornadoes	Brushfires
<b>Critical Assets</b>														
Flood prone drainage systems, streets, or infrastructure	2	2	3	2	2	1	1	1	1	1	1	3	1	1
Bridges	2	2	3	2	2	1	1	1	2	1	1	3	2	1
Wastewater facilities	1	1	3	1	1	1	1	1	1	1	2	2	2	1
Water supply systems	1	1	3	1	1	1	1	1	1	1	3	3	2	1
Other services/utilities	2	2	2	2	2	2	3	2	2	2	1	3	2	1
Dams	1	1	3	2	1	1	1	1	1	1	3	3	2	1
Critical municipal hazard response facilities	1	1	2	2	1	1	1	2	1	2	2	2	2	1
Populations	2	2	2	2	2	1	3	2	2	1	3	3	3	2
High density residential properties within the floodplain	2	2	3	2	1	2	1	1	2	2	1	3	2	2
Businesses	2	2	2	2	1	2	1	1	1	2	2	2	2	1
State facilities	2	2	2	2	1	2	1	1	1	2	2	2	2	1
Schools within the floodplain	2	2	2	2	1	2	1	1	1	2	2	2	2	1
Natural resources	1	1	2	1	1	2	1	2	1	3	3	1	1	3
Historic resources	2	2	2	1	1	2	1	1	1	1	1	1	2	1

## 12.4 Challenges and Opportunities

### 12.4.1 Challenges

There is a lack of climate action and climate resilience planning for the City of Cranston. Outside of the 2022 Hazard Mitigation Plan Update and Emergency Operations Plan, there are no separate policy action plans that the municipality has adopted aimed at improving resilience related to natural hazards. The 2022 Hazard Mitigation Plan Update has a proposed 2022 mitigation action section as identified by the Cranston Hazard Mitigation Plan Committee. The actions proposed relate to flooding and stormwater management areas and storm damage. There is more opportunity for the City to reduce risk to hazards beyond flooding.

### 12.4.2 Opportunities

Although the City participates in the National Flood Insurance Program (NFIP), there is an opportunity for the City to participate in the Community Rating System (CRS). It previously participated at the lowest classification in this program. If the City was to receive credit for current and additional efforts, flood insurance premiums for the City would be available to property owners.

## 12.5 Current Measures

### 12.5.1 Building Codes

Municipalities within the State of Rhode Island share a single building code (RIGL 23-27.3-100 et. al). Last amended in 2018, the code, which incorporates the International Building Code, takes into account scientific and engineering knowledge and allows for the utilization of modern materials and methods of construction to provide comprehensive construction requirements designed to mitigate the impacts from natural hazards such as high wind events and snow loading. The Department of Inspections enforces The City of Cranston Zoning Code and other related City Ordinances.

## 13 Zoning Ordinance

Enabled by state legislation and intended to provide consistency with the Comprehensive Plan, Cranston's Zoning Ordinance is designed to address a variety of purposes, first and foremost the promotion of public health, safety, and general welfare. Purpose's specific to natural hazards and climate change include:

- Providing for the control, protection and/or abatement of air, water, groundwater, and noise pollution, soil erosion, and sedimentation.
- Providing for the protection of the natural, historic, cultural, and scenic character of the city or areas therein.
- Providing for the protection of public investment in transportation, water, stormwater management systems, sewage treatment and disposal, solid waste treatment and disposal, schools, recreation, public facilities, open space, and other public requirements.
- Promoting safety from fire, flood, and other natural or manmade disasters.

Cranston's zoning ordinance and subdivision regulations also help to mitigate the impacts of natural hazards on new and redevelopment projects. The subdivision regulations contain standards to

prevent soil erosion, sediment control, stormwater management, and site designs to avoid impacting groundwater and aquifer recharge areas. Measures are required to reduce impervious cover and cut and fill on a site which can alter the natural hydrology of the site and ultimately the watershed.

#### 14 Emergency Operations Plan

Cranston has developed a Cranston Emergency Operations Plan (CEOP) in 2018 that provides a plan of action for the City's response to extraordinary emergency situations related to natural, technological, and human-caused hazards. This plan is considered a preparedness document that is meant to be utilized before emergencies and is updated every few years.

##### 14.5.1 National Flood Insurance Program

Cranston has participated in the National Flood Insurance Program (NFIP) since 1984. This program qualifies property owners to purchase insurance against flood losses and requires state and community floodplain management regulations to be adopted and followed to reduce flood-related damages in the City. This plan helps mitigate the effects of flooding on new and improved structures. Overall, the program reduces the economic and societal impacts of natural hazards and climate change by promoting the purchase and retention of general risk insurance, but also of flood insurance specifically. The City of Cranston has adopted the most recent (October 2014) Flood Insurance Rate Maps (FIRM) and Flood Insurance Study (FIS).

<sup>1</sup> FEMA. (n.d.). *Natural Hazards*. Retrieved from <https://hazards.fema.gov/nri/natural-hazards>.

<sup>2</sup> NOAA. (n.d.). *What is a Nor'easter?*. Retrieved from <https://www.weather.gov/safety/winter-noreaster>.

<sup>3</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).

<sup>4</sup> NOAA. (n.d.). *What is a Nor'easter?*. Retrieved from <https://www.weather.gov/safety/winter-noreaster>.

<sup>5</sup> Resilient Rhody. (2018).

<sup>6</sup> NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>

<sup>7</sup> NOAA. (n.d) *What is a hurricane?* Retrieved from <https://oceanservice.noaa.gov/facts/hurricane.html#:~:text=When%20a%20storm%27s%20maximum%20sustained%20winds%20reach%2074,the%20greater%20the%20hurricane%27s%20potential%20for%20p%20property%20damage>.

<sup>8</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).

<sup>9</sup> Resilient Rhody. (2018).

<sup>10</sup> NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>

<sup>11</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).

<sup>12</sup> Resilient Rhody. (2018).

<sup>13</sup> NOAA. *Storm Events Database*. Retrieved from <https://www.ncdc.noaa.gov/stormevents/>

<sup>14</sup> Resilient Rhody. (2018).

<sup>15</sup> Save the Bay: Narragansett Bay. (2022). *Defining and achieving "resilience" in Narragansett Bay*. Retrieved from <https://savebay.org/resilience-in-narragansett-bay/#:~:text=In%20the%20last%20hundred%20years.more%20in%20the%20coming%20decades>.

<sup>16</sup> NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>

<sup>17</sup> NOAA. (n.d.) *Types of Winter Weather*. Severe Weather 101. Retrieved from <https://www.nssl.noaa.gov/education/svrwx101/winter/types/#:~:text=A%20winter%20storm%20is%20a%20combination%20of%20heavy,snow%20and%20wind%20resulting%20in%20very%20low%20visibilities>.

<sup>18</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).

- 19 NOAA. *Storm Events Database*. Retrieved from <https://www.ncdc.noaa.gov/stormevents/>
- 20 NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>
- 21 NOAA. (n.d.) *Types of Winter Weather*. Severe Weather 101. Retrieved from <https://www.nssl.noaa.gov/education/svrwx101/winter/types/#:~:text=A%20winter%20storm%20is%20a%20combination%20of%20heavy,snow%20and%20wind%20resulting%20in%20very%20low%20visibilities.>
- 22 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 23 Jacob Feuerstein. (2022) *Climate change may be fueling increase in major Northeast snowstorms*. The Washington Post. <https://www.washingtonpost.com/weather/2022/02/01/northeast-snow-storm-climate/>
- 24 NOAA. (n.d.) *Wind*. <https://www.weather.gov/safety/wind>.
- 25 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 26 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 27 Resilient Rhody. (2018).
- 28 NOAA. (n.d.). *Heat Watch vs. Warning*. Retrieved from <https://www.weather.gov/safety/heat-ww>.
- 29 NOAA. (n.d.). *Wind Chill Warning vs. Watch*. Retrieved from <https://www.weather.gov/safety/cold-wind-chill-warning>.
- 30 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 31 Resilient Rhody. (2018).
- 32 NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>
- 33 NOAA. (n.d.) *Thunderstorm Basics*. Severe Weather 101. <https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/>
- 34 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 35 Andreas F. Prein. (2023). *Thunderstorm straight line winds intensify with climate change*. Nature Climate Change. Retrieved from [https://www.nature.com/articles/s41558-023-01852-9.epdf?sharing\\_token=s1Nqike\\_cfQoB1zuSZP5NtRgN0jAjWel9jnR3ZoTv00KshIYwoYqe3TrQ9zZ48Vg0CnbelCxxvQfKzHUQh-pozUqokrnYt8NeWzDJ5ADB166sB9vsSHtDAWLCd4VkzSAkR0juFdocm-aWuKCHTSLXljh6bGXT30ePL7n-CAfVX\\_B\\_a4g1tqRmqnzIB0uHt1XMV4rwLohYhSwh2Ew9F69Z1Hzk3z2e2Q0XFE64piWaEKI%3D&tracking\\_referrer=www.washingtonpost.com](https://www.nature.com/articles/s41558-023-01852-9.epdf?sharing_token=s1Nqike_cfQoB1zuSZP5NtRgN0jAjWel9jnR3ZoTv00KshIYwoYqe3TrQ9zZ48Vg0CnbelCxxvQfKzHUQh-pozUqokrnYt8NeWzDJ5ADB166sB9vsSHtDAWLCd4VkzSAkR0juFdocm-aWuKCHTSLXljh6bGXT30ePL7n-CAfVX_B_a4g1tqRmqnzIB0uHt1XMV4rwLohYhSwh2Ew9F69Z1Hzk3z2e2Q0XFE64piWaEKI%3D&tracking_referrer=www.washingtonpost.com)
- 36 NOAA. (n.d.) *What is a Microburst?*. Retrieved from [https://www.weather.gov/bmx/outreach\\_microbursts#:~:text=A%20microburst%20is%20a%20localized%20column%20of%20sinking,than%20or%20equal%20to%202.5%20miles%20in%20diameter.](https://www.weather.gov/bmx/outreach_microbursts#:~:text=A%20microburst%20is%20a%20localized%20column%20of%20sinking,than%20or%20equal%20to%202.5%20miles%20in%20diameter.)
- 37 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 38 NOAA. (n.d.) *What is a Microburst?*. Retrieved from [https://www.weather.gov/bmx/outreach\\_microbursts#:~:text=A%20microburst%20is%20a%20localized%20column%20of%20sinking,than%20or%20equal%20to%202.5%20miles%20in%20diameter.](https://www.weather.gov/bmx/outreach_microbursts#:~:text=A%20microburst%20is%20a%20localized%20column%20of%20sinking,than%20or%20equal%20to%202.5%20miles%20in%20diameter.)
- 39 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 40 NOAA. (n.d.) *Hail Basics*. Severe Weather 101. Retrieved from <https://nssl.noaa.gov/education/svrwx101/hail/>.
- 41 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 42 NOAA. (n.d.) *Hail Basics*. Severe Weather 101. Retrieved from <https://nssl.noaa.gov/education/svrwx101/hail/>.
- 43 Julian C. Brimelow, William R. Burrows & John M. Hanesiak. (2017). *The changing hail threat over North America in response to anthropogenic climate change*. Nature Climate Change. Retrieved from <https://www.nature.com/articles/nclimate3321>.
- 44 NOAA. (n.d.) *Definition of Drought*. Index. Retrieved from <https://www.ncei.noaa.gov/access/monitoring/dyk/drought-definition>.
- 45 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 46 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- 47 NOAA. (2022) *State Climate Summaries 2022 – Rhode Island*. Retrieved from <https://statesummaries.ncics.org/downloads/RhodeIsland-StateClimateSummary2022.pdf>
- 48 FEMA. (n.d.). *Earthquake*. National Risk Index. Retrieved from <https://hazards.fema.gov/nri/earthquake> .....



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- <sup>49</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>50</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>51</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>52</sup> NOAA. (n.d). *Tornado Basics*. Severe Weather 101. Retrieved from <https://www.nssl.noaa.gov/education/svrwx101/tornadoes/>
- <sup>53</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>54</sup> NOAA. (n.d). *Tornado Basics*. Severe Weather 101. Retrieved from <https://www.nssl.noaa.gov/education/svrwx101/tornadoes/>
- <sup>55</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>56</sup> National Geographic. (n.d.) *Wildfire*. Retrieved from <https://education.nationalgeographic.org/resource/wildfires/>
- <sup>57</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>58</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).
- <sup>59</sup> 2022 Hazard Mitigation Plan Update – Cranston, Rhode Island. (2022).