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| Massachusetts Bay Transportation Authority (MBTA) Vulnerability Assessment Report  02/27/2018 |

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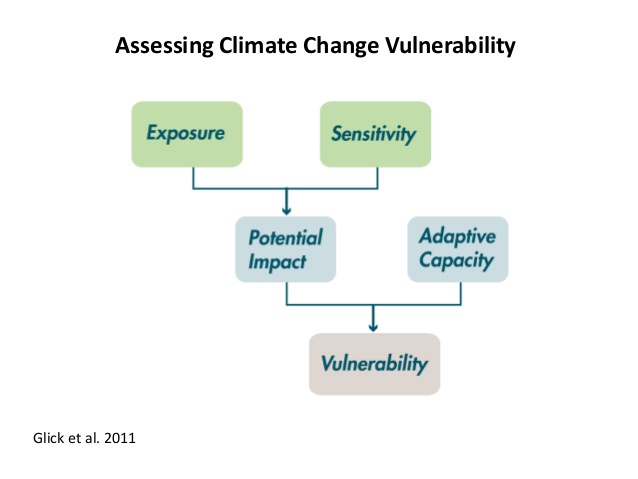
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# Introduction

This report provides a summary of the vulnerability assessment completed by the Massachusetts Bay Transportation Authority (MBTA) using the State Agency Vulnerability Assessment Survey Tool, which was developed as part of the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan. This self-assessment was completed to help identify agency vulnerabilities to climate change and natural hazards and provides the basis for the development of agency-specific priority actions to strengthen resilience and preparedness to climate change and extreme events. This vulnerability assessment report also satisfies the state agency vulnerability assessment required by *Executive Order No. 569 – Establishing an Integrated Climate Change Strategy for the Commonwealth*.

The vulnerability of a state agency to climate change and natural hazards is a function of exposure, sensitivity, and adaptive capacity, as illustrated in the figure below.



This vulnerability assessment involved the agency’s evaluation of the natural hazards identified in the table below, including how those hazards are likely to evolve as a result of climate change. The natural hazards are organized by primary climate drivers, and representative related climate change impacts are also provided.

|  |  |  |
| --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Related Climate Change Impacts** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Beach erosion, marsh migration, inundation of coastal and marine ecosystems, elimination of wetlands |
| Hurricanes/  Tropical Storms |
| Nor’easter |
| Coastal Erosion |
| Precipitation | Extreme Precipitation | Flash flooding, urban flooding, public health impacts from mold, worsened indoor air quality, vector-borne diseases from stagnant water |
| Inland/Riverine Flooding |
| Severe Winter Storm |
| Ice Storms |
| Landslide |
| Dam Failure |
| Temperature | Increase in Average Summer Temperature | Shifting in seasons (longer summer, early spring including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, frequent energy brown-outs from higher energy demands, public health impacts from high heat exposure, poor outdoor air quality |
| Extreme Temperatures/Heat Waves |
| Drought |
| Wildfires |
| Other Extreme Events | Tornadoes | Damage to property, infrastructure, and loss of life |
| Tsunami |
| Earthquake |

This vulnerability assessment report includes the following sections:

* Key Terms: Provides definitions of key terms used for the vulnerability assessment.
* Section 1 General Agency Information: Provides an overview of the agency’s mission along with a summary of the agency’s critical assets, functions, and population groups.
* Section 2 Climate Change Exposure and Sensitivity: Summarizes agency confirmation of natural hazard and climate change impacts that will affect its critical assets, functions, and population groups and the agency’s sensitivity to anticipated future climate conditions.
* Section 3 Agency Capability and Adaptive Capacity: Describes the agency’s adaptive capacity to natural hazards and climate change.
* Section 4 Vulnerability Scores: Provides a summary of vulnerability score for each natural hazard and related climate change impacts that were assessed for a particular critical asset, function, or population group.
* Section 5 Concluding Remarks: Provides a summary of additional concerns or observations regarding the vulnerability of the agency, both in its services and overall mission, to the effects of natural hazards and climate change.

# Key Terms

**Adaptive capacity:** The ability of a system (or, in this case, your agency) to adapt to changing circumstances, both in the short- and long-term. For example, an agency which can operate remotely likely has greater adaptive capacity than an agency which must operate from a flood-prone building. Similarly, a facility that can continue to operate during extended periods of drought due to a resilient water supply system has greater adaptive capacity than one that may encounter water restrictions.

**Assets:** For the purposes of this survey, there are two main types of assets: physical and non-physical. These are defined below.

**Physical assets:** These include any tangible facilities, equipment, landholdings, natural resources, etc. that meet the definition of criticality below by playing a significant role in the operation and mission of your agency.

**Non-physical assets:** This category captures non-tangible resources, such as power, Internet connectivity, or cloud-based data that are essential to your agency’s functions (functions are defined below).

**Climate change:** A statistically significant variation in climate data or patterns over a given period of time, due to either natural climate variability or human activity.

**Climate change adaptation:** Measures taken in response to actual or projected climate change in order to eliminate, minimize, or manage related impacts on people, infrastructure, and the environment.

**Climate change impact:** Consequences of climate change on natural and human systems.

**Climate driver:** The manifestation of a change in climatic conditions through one or more weather variables, such as a change in precipitation or sea level rise, to create an impact.

**Criticality:** This definition is provided to aid agencies with the identification of critical assets or functions for the purpose of this survey. Criticality is based on three parameters: scope, time, and severity.

* Scope describes the geographic area and population that would be affected by the loss or inoperability of an asset or function. An asset or function is considered critical if it serves a region or the entire state, or would affect greater than 10,000 people.
* Time describes the length of time that an asset or function can be inoperable without consequences. An asset or function is considered critical if it is inoperable immediately after a hazard event or one to two days after an event.
* Severity describes the consequences of the loss and inoperability of an asset or function. There are a multitude of consequences, including public health and safety, economic losses, environmental effects, interdependencies, political effects, and psychological effects. An asset or function is considered critical if the consequences include loss of life or severe injuries, significant economic loss, extensive environmental contamination, significant impact on other agencies, significant impact to service delivery, or significant loss of confidence in the agency.

These parameters and examples were taken into consideration when identifying the agency’s critical assets and functions for the purpose of this survey. An asset or function does not need to satisfy all three parameters to be considered critical.

**Exposure:** The extent to which physical and non-physical assets, functions, and population groups are in direct contact with natural hazards or their related climate change impacts. Exposure is often determined by examining the number of people or assets that lie within a geographic area affected by a natural hazard or by determining the magnitude of the climate change impact. For example, measurement of flood depth outside a building or number of heat waves experienced by a county are measurements of exposure.

**Functions:** The programs and services an agency provides to its customers in order to fulfill its mission. These programs and services depend on the mission of your agency and could include activities such as planning, policy development, regulatory enforcement, research, permitting, or outreach/education, or stewardship of critical resources.

**Natural hazard:** Natural events that threaten lives, property, and other assets.

**Natural resources:** These are components of natural systems that exist without human involvement. For the purpose of this survey, key natural resource categories include forested ecosystems, aquatic ecosystems, coastal ecosystems, wetland ecosystems, and old field ecosystems.

**Sensitivity:** Sensitivity refers to the impact on a system, service, or asset when exposed to natural hazards. For example, if a facility is exposed to storm surge, how will its ability to function be affected? When a critical threshold has been identified, the level of sensitivity of your agency, a specific asset, function, or population group served to a hazard indicates how much or to what extent does the occurrence of a hazard exceed the critical threshold for that asset or function such that it would disrupt the ability of the agency/asset/function to continue normal operation. If the critical threshold is not exceeded, then the sensitivity to a certain hazard is low, even if it is exposed.

**Vulnerability:** The overall vulnerability of your agency to a hazard is determined by combining your exposure, sensitivity, and adaptive capacity. Agencies or assets that are highly vulnerable may be highly sensitive to a certain natural hazard or climate change impact, highly exposed, and/or have low adaptive capacity. On the other hand, agencies or assets that have low sensitivity or high adaptive capacity may not be impacted by a natural hazard or climate change impact at all.

# Section 1 General Agency Information

The agency mission statement is provided in this section, as well as the agency’s self-selected critical assets, functions, and population groups (up to ten for each category for the purpose of this vulnerability assessment). Information is also provided regarding the agency’s primary concerns regarding impacts from climate change and natural hazards, as well as interaction with communities and other state agencies.

**Agency Mission Statement**

The MBTA will be a globally premier transit system; committed to providing its customers safe, accessible, cost-effective, resilient, sustainable, dynamic, and responsive service. The MBTA will strengthen and improve the economic health of the region by providing superior and cost- effective service to our customers

**Critical Physical and/or Non-Physical Assets**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Critical Physical/ Non-Physical Assets (refer to the “criticality” definition to aid in identification of critical assets)** | **Reason for Criticality selected from option provided** | **Reason for Criticality if anything other** | **Critical threshold(s), which if exceeded is likely to disrupt normal operation of the program or service.** | **Location** | | **Who Owns / Manages the Asset?** | **If Another Agency, Provide the Point of Contact** |
| **Description of customers / audience served** | **Municipality** |
| Rapid Transit Lines | Provides critical services |  | Any inundation affecting electrification | Residents of Boston metropolitan area that use public transit | Multiple | Massachusetts Bay Transportation Authority |  |
| Maintenance Facilities | Supports critical infrastructure |  | Any flood inundation, loss of power | All users of MBTA transit services | Multiple | Massachusetts Bay Transportation Authority |  |
| Administration Buildings (including Operations Control Center) | Provides critical services |  | Any flooding | All MBTA transit users | Boston | Massachusetts Bay Transportation Authority |  |
| Revenue Vehicles | Provides critical services |  | Flood inundation, loss of power | All MBTA transit users | Multiple | Massachusetts Bay Transportation Authority |  |
| Commuter Rail Lines | Provides critical services |  | Track inundation, loss of tracks or ballast | MBTA commuter rail users | Multiple | Massachusetts Bay Transportation Authority |  |

**Critical Functions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Critical Functions**  **(refer to criticality definition to aid in identification of critical functions)** | **Reason for Criticality selected from option provided** | **Reason for Criticality if anything other** | **Critical threshold(s), which if exceeded is likely to disrupt normal operation of the program or service.** | **Description of customers / audience served** | **Municipality(ies) Served** |
| Asset Management | Number of people served |  |  | All MBTA transit users | Multiple |
| Operations (including passenger transport) | Number of people served |  | Don't Know | All MBTA transit users | Multiple |
| Administration | Number of people served |  | Don't Know | All MBTA transit users | Multiple |

**Critical Population Groups**

|  |  |  |  |
| --- | --- | --- | --- |
| **Critical Population Groups Served** | **Reason for Criticality selected from option provided** | **Reason for Criticality if anything other** | **Municipality(ies) Served** |
| Elderly | Severity of impact to the population group |  | Multiple |
| Disabled | Severity of impact to the population group |  | Multiple |
| Non-English Speakers | Severity of impact to the population group |  | Multiple |
| Low Income | Severity of impact to the population group |  | Multiple |
| Communities of Color | Severity of impact to the population group |  | Multiple |
| Medical Patients | Duration of impact on these population groups |  | Multiple |
| Children | Severity of impact to the population group |  | Multiple |

**Primary Concerns Regarding Impacts from Climate Change and Natural Hazards**

* Impacts to specific facilities
* Impacts to infrastructure controlled by others (e.g. electricity, data, transit and access)
* Response capabilities (i.e. expertise)
* Response capacity (i.e. sufficient resources or personnel)
* Health and welfare of the building occupants
* Likelihood of occurrence of extreme climate events or changes in the future that may not have been experienced in the past
* Ability to assist clients/stakeholders
* Loss of workforce productivity
* Failure to provide critical services
* Failure to meet agency mission or goals

**How Agency Serves Local Communities**

**What impacts would occur to the community if your agency’s operations were temporarily interrupted by a natural hazard or extreme weather event?**

Widespread economic disruption; inability of community members to travel on public transit

**How quickly would those impacts be experienced by the community?**

Immediately

**How might long-term impacts of climate change disrupt community operations?**

Lack of transportation to jobs, schools, hospitals

**What impacts would be experienced by the community?**

See impacts above

**Are any of your agency’s assets designated as shelters or community resources in emergencies or extreme weather events?**

No response

**Agency Interdependencies**

**What other state agencies, regional authorities, or local municipalities could be impacted by loss of your agency’s operations?**

All in the Boston metropolitan area

**Do your operations depend on any other agencies, regional authorities, or local municipalities? If so, which agency/ies?**

Yes, local transportation departments

**Do your operations depend on any private utility company? If so, which company/ies?**

Yes, Eversource, National Grid

**Does your agency depend on the regular delivery or transport of resources or people to and from facilities?**

Yes, fuel delivery, parts, maintenance and construction equipment

# Section 2 Climate Change Exposure and Sensitivity

This section presents the results of the agency’s evaluation of its exposure and sensitivity to natural hazards and climate change. Detail is provided for the agency’s critical assets, functions, and populations identified in Section 1 when possible. For future risk, the agency considered the 2070 planning horizon for its assessment of exposure and sensitivity to future conditions. Reference materials used for considering future conditions included resources provided in the State Agency Vulnerability Assessment Survey Tool for each natural hazard as well as downscaled climate change data available on the Resilient MA Climate Clearinghouse website ([www.resilientma.org](http://www.resilientma.org)).

| **Climate Change Exposure and Sensitivity** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazards** | **Related Climate Change Impacts** | **To the best of your knowledge, list which critical assets, functions, or population groups (as identified in Question 2) have been impacted by each hazard identified in the preceding column *(add additional rows as needed to accommodate your critical items)*** | **To the best of your knowledge, indicate if the critical asset, function or population group served by your agency has been negatively impacted by this hazard in the past.** | **Based on how the natural hazard is likely to change in the future as a result of climate change (see supplemental reference maps identified in the second column), to what extent is the critical asset, function, or population group served exposed to each hazard?**  **High (i.e. all of asset is exposed)**  **Medium (i.e. some of asset is exposed)**  **Low (i.e. asset is minimally exposed)**  **Not Exposed (i.e. no exposure)** | **On a scale of 1 to 5, rate how sensitive the critical asset, function, or population group served is to the natural hazards. Sensitivity should be determined based on whether a critical threshold has been exceeded. If exceeded for a hazard, then assign a “5”. If a critical threshold has not been exceeded, or if a critical threshold has not been identified, a qualitative assessment should be conducted to assign a score based on consideration of the nature of the critical item and the natural hazard and related climate change impacts. In other words, to what degree is the critical item affected or impacted by exposure?**  **N/A = no relevance**  **1 = minimally sensitive if minimum disruption to function/minimal impact to population group served**  **5 = extremely sensitive if significant disruption to function/significant impact to population group served** | **Notes or Explanation (use this column to document information that is specific to a critical item) or Additional Comments** |
| **Sea level Rise and Storm Surge** | **Coastal Flooding (including daily tidal flooding from sea level rise) for *Physical/Non Physical Assets*** | **Beach erosion, marsh migration, inundation of coastal and marine ecosystems, elimination of wetlands** | Rapid Transit Lines | Infrequently | High (i.e. all of asset is exposed) | 5 |  |
| Maintenance Facilities | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Administration Buildings (including Operations Control Center) | No | Medium (i.e. some of asset is exposed) | 4 |
| Revenue Vehicles | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Commuter Rail Lines | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Coastal Flooding (including daily tidal flooding from sea level rise) for *Critical Function*** | Asset Management | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Operations (including passenger transport) | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Administration | No | Medium (i.e. some of asset is exposed) | 4 |
| **Coastal Flooding (including daily tidal flooding from sea level rise) for *Critical Population*** | Elderly | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Disabled | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Non-English Speakers | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Low Income | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Communities of Color | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Medical Patients | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Children | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Hurricanes/**  **Tropical Storms for *Physical/Non Physical Assets*** | Rapid Transit Lines | Infrequently | High (i.e. all of asset is exposed) | 5 |  |
| Maintenance Facilities | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Administration Buildings (including Operations Control Center) | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Revenue Vehicles | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Commuter Rail Lines | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Hurricanes/**  **Tropical Storms for *Critical Function*** | Asset Management | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Operations (including passenger transport) | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Administration | No | Medium (i.e. some of asset is exposed) | 3 |
| **Hurricanes/**  **Tropical Storms for *Critical Population*** | Elderly | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Disabled | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Non-English Speakers | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Low Income | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Communities of Color | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Medical Patients | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Children | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Nor’easter for *Physical/Non Physical Assets*** | Rapid Transit Lines | Infrequently | Medium (i.e. some of asset is exposed) | 5 |  |
| Maintenance Facilities | Infrequently | Medium (i.e. some of asset is exposed) | 5 |
| Administration Buildings (including Operations Control Center) | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Revenue Vehicles | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Commuter Rail Lines | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| **Nor’easter for *Critical Function*** | Asset Management | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Operations (including passenger transport) | Infrequently | High (i.e. all of asset is exposed) | 5 |
| Administration | Infrequently | Low (i.e. asset is minimally exposed) | 2 |
| **Nor’easter for *Critical Population*** | Elderly | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Disabled | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Non-English Speakers | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Low Income | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Communities of Color | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Medical Patients | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Children | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Coastal Erosion for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Low (i.e. asset is minimally exposed) | 3 |  |
| Maintenance Facilities | No | Low (i.e. asset is minimally exposed) | 3 |
| Administration Buildings (including Operations Control Center) | No | Low (i.e. asset is minimally exposed) | 2 |
| Revenue Vehicles | No | Low (i.e. asset is minimally exposed) | 1 |
| Commuter Rail Lines | No | Low (i.e. asset is minimally exposed) |  |
| **Coastal Erosion for *Critical Function*** | Asset Management | No | Low (i.e. asset is minimally exposed) | 3 |
| Operations (including passenger transport) | No | Low (i.e. asset is minimally exposed) | 3 |
| Administration | No | Low (i.e. asset is minimally exposed) | 1 |
| **Coastal Erosion for *Critical Population*** | Elderly | No | Low (i.e. asset is minimally exposed) | 2 |
| Disabled | No | Low (i.e. asset is minimally exposed) | 2 |
| Non-English Speakers | No | Low (i.e. asset is minimally exposed) | 2 |
| Low Income | No | Low (i.e. asset is minimally exposed) | 2 |
| Communities of Color | No | Low (i.e. asset is minimally exposed) | 2 |
| Medical Patients | No | Low (i.e. asset is minimally exposed) | 2 |
| Children | No | Low (i.e. asset is minimally exposed) | 2 |
| **Precipitation** | **Extreme Precipitation for *Physical/Non Physical Assets*** | **Flash flooding, urban flooding, public health impacts from mold, worsened indoor air quality, vector-borne diseases from stagnant water** | Rapid Transit Lines | Infrequently | High (i.e. all of asset is exposed) | 3 |  |
| Maintenance Facilities | Infrequently | High (i.e. all of asset is exposed) | 2 |
| Administration Buildings (including Operations Control Center) | No | Low (i.e. asset is minimally exposed) | 1 |
| Revenue Vehicles | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Commuter Rail Lines | Infrequently | Medium (i.e. some of asset is exposed) |  |
| **Extreme Precipitation for *Critical Function*** | Asset Management | Infrequently | High (i.e. all of asset is exposed) | 3 |
| Operations (including passenger transport) | Infrequently | High (i.e. all of asset is exposed) | 3 |
| Administration | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| **Extreme Precipitation for *Critical Population*** | Elderly | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Disabled | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Non-English Speakers | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Low Income | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Communities of Color | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Medical Patients | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Children | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| **Inland/Riverine Flooding for *Physical/Non Physical Assets*** | Rapid Transit Lines | Infrequently | Medium (i.e. some of asset is exposed) | 5 |  |
| Maintenance Facilities | Infrequently | Low (i.e. asset is minimally exposed) | 5 |
| Administration Buildings (including Operations Control Center) | No | Low (i.e. asset is minimally exposed) | 3 |
| Revenue Vehicles | No | Low (i.e. asset is minimally exposed) | 3 |
| Commuter Rail Lines | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| **Inland/Riverine Flooding for *Critical Function*** | Asset Management | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Operations (including passenger transport) | Infrequently | Medium (i.e. some of asset is exposed) | 4 |
| Administration | No | Low (i.e. asset is minimally exposed) | 2 |
| **Inland/Riverine Flooding for *Critical Population*** | Elderly | Infrequently | Low (i.e. asset is minimally exposed) | 4 |
| Disabled | Infrequently | Low (i.e. asset is minimally exposed) | 4 |
| Non-English Speakers | No | Low (i.e. asset is minimally exposed) | 2 |
| Low Income | No | Low (i.e. asset is minimally exposed) | 2 |
| Communities of Color | No | Low (i.e. asset is minimally exposed) | 2 |
| Medical Patients | No | Low (i.e. asset is minimally exposed) | 3 |
| Children | No | Low (i.e. asset is minimally exposed) | 2 |
| **Severe Winter Storm for *Physical/Non Physical Assets*** | Rapid Transit Lines | Infrequently | Low (i.e. asset is minimally exposed) | 3 |  |
| Maintenance Facilities | Infrequently | Low (i.e. asset is minimally exposed) | 2 |
| Administration Buildings (including Operations Control Center) | No | Low (i.e. asset is minimally exposed) | 1 |
| Revenue Vehicles | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Commuter Rail Lines | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| **Severe Winter Storm for *Critical Function*** | Asset Management | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Operations (including passenger transport) | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Administration | Infrequently | Not Exposed (i.e. no exposure) | 2 |
| **Severe Winter Storm for *Critical Population*** | Elderly | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Disabled | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Non-English Speakers | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Low Income | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Communities of Color | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Medical Patients | Frequently | Low (i.e. asset is minimally exposed) | 3 |
| Children | Infrequently | Low (i.e. asset is minimally exposed) | 2 |
| **Ice Storms for *Physical/Non Physical Assets*** | Rapid Transit Lines | Infrequently | Low (i.e. asset is minimally exposed) | 3 |  |
| Maintenance Facilities | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Administration Buildings (including Operations Control Center) | Infrequently | Low (i.e. asset is minimally exposed) | 2 |
| Revenue Vehicles | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Commuter Rail Lines | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| **Ice Storms for *Critical Function*** | Asset Management | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Operations (including passenger transport) | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Administration | Infrequently | Low (i.e. asset is minimally exposed) | 2 |
| **Ice Storms for *Critical Population*** | Elderly | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Disabled | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Non-English Speakers | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Low Income | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Communities of Color | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Medical Patients | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| Children | Infrequently | Low (i.e. asset is minimally exposed) | 3 |
| **Landslide for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | 1 |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | 1 |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | 1 |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | 1 |
| Commuter Rail Lines | No | Not Exposed (i.e. no exposure) | 1 |
| **Landslide for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | 1 |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | 1 |
| Administration | No | Not Exposed (i.e. no exposure) | 1 |
| **Landslide for *Critical Population*** | Elderly | No | Not Exposed (i.e. no exposure) | 1 |
| Disabled | No | Not Exposed (i.e. no exposure) | 1 |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | 1 |
| Low Income | No | Not Exposed (i.e. no exposure) | 1 |
| Communities of Color | No | Not Exposed (i.e. no exposure) | 1 |
| Medical Patients | No | Not Exposed (i.e. no exposure) | 1 |
| Children | No | Not Exposed (i.e. no exposure) | 1 |
| **Dam Failure for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | N/A |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | N/A |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | N/A |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | N/A |
| Commuter Rail Lines | No | Not Exposed (i.e. no exposure) | N/A |
| **Dam Failure for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | N/A |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | N/A |
| Administration | No | Not Exposed (i.e. no exposure) | N/A |
| **Dam Failure for *Critical Population*** | Elderly | No` | Not Exposed (i.e. no exposure) | N/A |
| Disabled | No | Not Exposed (i.e. no exposure) | N/A |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | N/A |
| Low Income | No | Not Exposed (i.e. no exposure) | N/A |
| Communities of Color | No | Not Exposed (i.e. no exposure) | N/A |
| Medical Patients | No | Not Exposed (i.e. no exposure) | N/A |
| Children | No | Not Exposed (i.e. no exposure) | N/A |
| **Temperature** | **Increase in Average Summer Temperature for *Physical/Non Physical Assets*** | **Shifting in seasons (longer summer, early spring including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, frequent energy brown-outs from higher energy demands, public health impacts from high heat exposure, poor outdoor air quality** | Rapid Transit Lines | Infrequently | Medium (i.e. some of asset is exposed) | 2 |  |
| Maintenance Facilities | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Administration Buildings (including Operations Control Center) | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Revenue Vehicles | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Commuter Rail Lines | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| **Increase in Average Summer Temperature for *Critical Function*** | Asset Management | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Operations (including passenger transport) | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Administration | Infrequently | Medium (i.e. some of asset is exposed) | 1 |
| **Increase in Average Summer Temperature for *Critical Population*** | Elderly | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Disabled | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Non-English Speakers | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Low Income | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Communities of Color | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| Medical Patients | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Children | Infrequently | Low (i.e. asset is minimally exposed) | 1 |
| **Extreme Temperatures/Heat waves for Physical/Non Physical Assets** | Rapid Transit Lines | Infrequently | High (i.e. all of asset is exposed) | 4 |  |
| Maintenance Facilities | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Administration Buildings (including Operations Control Center) | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Revenue Vehicles | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| Commuter Rail Lines | Infrequently | High (i.e. all of asset is exposed) | 4 |
| **Extreme Temperatures/Heat waves for *Critical Function*** | Asset Management | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Operations (including passenger transport) | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Administration | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| **Extreme Temperatures/Heat waves for *Critical Population*** | Elderly | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Disabled | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Non-English Speakers | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Low Income | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Communities of Color | Infrequently | Medium (i.e. some of asset is exposed) | 2 |
| Medical Patients | Infrequently | High (i.e. all of asset is exposed) | 4 |
| Children | Infrequently | Medium (i.e. some of asset is exposed) | 3 |
| **Drought for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Low (i.e. asset is minimally exposed) | 1 |  |
| Maintenance Facilities | No | Low (i.e. asset is minimally exposed) | 1 |
| Administration Buildings (including Operations Control Center) | No | Low (i.e. asset is minimally exposed) | 1 |
| Revenue Vehicles | No | Low (i.e. asset is minimally exposed) | 1 |
| Commuter Rail Lines | No | Low (i.e. asset is minimally exposed) | 1 |
| **Drought for *Critical Function*** | Asset Management | No | Low (i.e. asset is minimally exposed) | 1 |
| Operations (including passenger transport) | No | Low (i.e. asset is minimally exposed) | 1 |
| Administration | No | Low (i.e. asset is minimally exposed) | 1 |
| **Drought for *Critical Population*** | Elderly | No | Low (i.e. asset is minimally exposed) | 1 |
| Disabled | No | Low (i.e. asset is minimally exposed) | 1 |
| Non-English Speakers | No | Low (i.e. asset is minimally exposed) | 1 |
| Low Income | No | Low (i.e. asset is minimally exposed) | 1 |
| Communities of Color | No | Low (i.e. asset is minimally exposed) | 1 |
| Medical Patients | No | Low (i.e. asset is minimally exposed) | 1 |
| Children | No | Low (i.e. asset is minimally exposed) | 1 |
| **Wildfires for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | N/A |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | N/A |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | N/A |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | N/A |
| Commuter Rail Lines |  |  |  |
| **Wildfires for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | N/A |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | N/A |
| Administration | No | Not Exposed (i.e. no exposure) | N/A |
| **Wildfires for *Critical Population*** | Elderly | No | Not Exposed (i.e. no exposure) | N/A |
| Disabled | No | Not Exposed (i.e. no exposure) | N/A |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | N/A |
| Low Income | No | Not Exposed (i.e. no exposure) | N/A |
| Communities of Color | No | Not Exposed (i.e. no exposure) | N/A |
| Medical Patients | No | Not Exposed (i.e. no exposure) | N/A |
| Children | No | Not Exposed (i.e. no exposure) | N/A |
| **Other Extreme Events** | **Tornadoes for *Physical/Non Physical Assets*** | **Damage to property, infrastructure, and loss of life** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | N/A |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | N/A |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | N/A |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | N/A |
| Commuter Rail Lines | No | Not Exposed (i.e. no exposure) | N/A |
| **Tornadoes for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | N/A |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | N/A |
| Administration | No | Not Exposed (i.e. no exposure) | N/A |
| **Tornadoes for *Critical Population*** | Elderly | No | Not Exposed (i.e. no exposure) | N/A |
| Disabled | No | Not Exposed (i.e. no exposure) | N/A |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | N/A |
| Low Income | No | Not Exposed (i.e. no exposure) | N/A |
| Communities of Color | No | Not Exposed (i.e. no exposure) | N/A |
| Medical Patients | No | Not Exposed (i.e. no exposure) | N/A |
| Children | No | Not Exposed (i.e. no exposure) | N/A |
| **Tsunami for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | N/A |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | N/A |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | N/A |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | N/A |
| Commuter Rail Lines | No | Not Exposed (i.e. no exposure) | N/A |
| **Tsunami for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | N/A |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | N/A |
| Administration | No | Not Exposed (i.e. no exposure) | N/A |
| **Tsunami for *Critical Population*** | Elderly | No | Not Exposed (i.e. no exposure) | N/A |
| Disabled | No | Not Exposed (i.e. no exposure) | N/A |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | N/A |
| Low Income | No | Not Exposed (i.e. no exposure) | N/A |
| Communities of Color | No | Not Exposed (i.e. no exposure) | N/A |
| Medical Patients | No | Not Exposed (i.e. no exposure) | N/A |
| Children | No | Not Exposed (i.e. no exposure) | N/A |
| **Earthquake for *Physical/Non Physical Assets*** | Rapid Transit Lines | No | Not Exposed (i.e. no exposure) | N/A |  |
| Maintenance Facilities | No | Not Exposed (i.e. no exposure) | N/A |
| Administration Buildings (including Operations Control Center) | No | Not Exposed (i.e. no exposure) | N/A |
| Revenue Vehicles | No | Not Exposed (i.e. no exposure) | N/A |
| Commuter Rail Lines | No | Not Exposed (i.e. no exposure) | N/A |
| **Earthquake for *Critical Function*** | Asset Management | No | Not Exposed (i.e. no exposure) | N/A |
| Operations (including passenger transport) | No | Not Exposed (i.e. no exposure) | N/A |
| Administration | No | Not Exposed (i.e. no exposure) | N/A |
| **Earthquake for *Critical Population*** | Elderly | No | Not Exposed (i.e. no exposure) | N/A |
| Disabled | No | Not Exposed (i.e. no exposure) | N/A |
| Non-English Speakers | No | Not Exposed (i.e. no exposure) | N/A |
| Low Income | No | Not Exposed (i.e. no exposure) | N/A |
| Communities of Color | No | Not Exposed (i.e. no exposure) | N/A |
| Medical Patients | No | Not Exposed (i.e. no exposure) | N/A |
| Children | No | Not Exposed (i.e. no exposure) | N/A |

# Section 3 Agency Capability and Adaptive Capacity

This section presents the agency’s assessment of existing capabilities related to hazard mitigation and climate change adaptation and identifies specific hazard mitigation, climate adaptation, or emergency response measures that have been identified to intervene and reduce the vulnerability of the agency’s at-risk critical assets, function, or population groups (as identified in Section 1).

**Ability to Withstand Natural Hazards and Climate Impacts**

If the MBTA were exposed to a catastrophic flood event, there would certainly be damage to our system. This is a known vulnerability that we need to address.

**Length for Agency to Return to Essential Functionality Following Severe Extreme Weather Event**

Weeks

**Remote Operation Capability**

No

**Status of Incorporating Natural Hazard Mitigation and Climate Change Adaptation into Programs**

Planning to incorporate

Developing an organization-wide resiliency plan. Also currently identifying vulnerabilities of some key assets, as well as resiliency options.

**Challenges to Improving or Maintaining Ability to Withstand Natural Hazards and Climate Impacts**

Funding is always an issue, of course. We need to institutionalize resiliency such that we consider it in all agency planning and policy. We plan to do this but effecting change throughout an organization presents numerous challenges due to lack of resources and cultural resistance to change.

**Current Capabilities to Accommodate or Recover from Natural Hazards**

We are able to recover from mild to moderate weather-related events. However, if we were to experience a significant coastal flood event at high tide that exposed our tunnels to saltwater, recovery could take weeks to months or longer depending on the extent of damage.

**Plans, Policies, or Procedures to Reduce Potential Risk of Disruption**

We have a new hurricane protection and recovery plan that is in draft format and does not include any capital investment. However, we are developing an organization-wide resiliency plan, conducting a system-wide vulnerability assessment, and trying to identify priority capital investments that will improve high vulnerability/ high impact areas. We will also continue to identify redundant transportation methods in cases for which critical assets are damaged or inoperable. We do not have telecommuting options for the majority of the administrative workforce.

**Plans, Policies, or Procedures in Need of Revision to Better Consider Climate Change**

Yes

Continuity of Operations plans, hurricane preparedness plan, and planning prioritization could explicitly incorporate future extreme weather and climate considerations.

**Adaptive Capacity for Specific Critical Items**

|  |  |  |  |
| --- | --- | --- | --- |
| **Critical Asset, Function, or Population Group** | **Mitigation/Adaptation/Emergency Response Measure** | **Status** | **Effectiveness/ Improvements Required** |
| To be determined |  |  |  |

**Studies or Plans to Support the State’s Hazard Mitigation and Climate Adaptation Program**

Yes

Vulnerability assessments for locations on the blue line, as well as identifying resiliency options. Task Orders in progress

# Section 4 Vulnerability Scores

This section presents the vulnerability scores for each of the agency’s critical assets, functions, and population groups that were evaluated. A vulnerability score is provided for each applicable natural hazard and related climate change impacts that were assessed for a particular critical item, and the scores are presented in summary table for that item. This enables identification of the climate driver/s and natural hazard/s that contribute to the vulnerability of a critical item. This information will be used by the agency to aid in the development of strategies and actions to make the critical item more resilient.

As previously stated, vulnerability to climate change and natural hazards is a function of exposure, sensitivity, and adaptive capacity. To arrive at the vulnerability scores, first the exposure and sensitivity scores determined in Section 2 were combined to arrive at an initial risk rating of low (yellow), moderate (orange), or high (red). Then the adaptive capacity score based on findings in Section 3 was applied to the risk rating to arrive at, a vulnerability score of low (yellow), moderate (orange), or high (red) as shown in the matrix below. If a critical item was determined to not be exposed to a natural hazard or was not assessed by the agency, then a “N/A” (not applicable) value was assigned.

Note that the risk ratings and vulnerability scores are both reported in the summary tables since the adaptive capacity scores developed as part of this vulnerability assessment are preliminary, vary in level of accuracy, and may overstate the adaptive capacity for a particular critical item to a natural hazard and related climate change impacts. Therefore, particular attention should be paid to the risk ratings.

A critical item with a high vulnerability score for one or more natural hazard and related climate change impacts is considered a high priority for future resilience planning and investment. Conversely, a critical item with only low to moderate vulnerability scores suggests that it is already resilient or has minimal exposure or sensitivity to current and projected conditions. Additional detail on the method used to develop the vulnerability scores is provided in Appendix A.

The vulnerability scores reflect an initial high level self-assessment conducted by the agency, and the results contained herein should be considered preliminary. More detailed analyses should be conducted to further the agency’s resilience planning efforts and to refine the preliminary vulnerability assessment results, including closer evaluation of adaptive capacity for each critical item.

|  |  |  |
| --- | --- | --- |
| **Adaptive Capacity**  **Low**  **↓**  **High** | **Sensitivity: Low 🡪 High** | |
| **Moderate Vulnerability** | **High Vulnerability** |
| **Low Vulnerability** | **Moderate Vulnerability** |

**VULNERABILITY SCORE TABLE FOR CRITICAL PHYSICAL/NON-PHYSICAL ASSETS:**

**Rapid Transit Lines**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | High | High |
| Hurricanes/Tropical Storms | High | High |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Moderate | Moderate |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Maintenance Facilities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | High | High |
| Hurricanes/Tropical Storms | High | High |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Administration Buildings (including Operations Control Center)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Low | Low |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Low | Low |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Revenue Vehicles**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | High | High |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Moderate | Moderate |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Commuter Rail Lines**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | N/A | N/A |
| Precipitation | Extreme Precipitation | N/A | N/A |
| Inland/Riverine Flooding | Moderate | Moderate |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**VULNERABILITY SCORE TABLE FOR CRITICAL FUNCTIONS:**

**Asset Management**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | High | High |
| Hurricanes/Tropical Storms | High | High |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Moderate | Moderate |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Operations (including passenger transport)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | High | High |
| Hurricanes/Tropical Storms | High | High |
| Nor’easter | High | High |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Moderate | Moderate |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Administration**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Low | Low |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | N/A | N/A |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Low | Low |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**VULNERABILITY SCORE TABLE FOR CRITICAL POPULATIONS:**

**Elderly**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Disabled**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Non-English Speakers**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Low | Low |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Low | Low |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Low Income**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Low | Low |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Low | Low |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Communities of Color**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Low | Low |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Low | Low |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Medical Patients**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Moderate | Moderate |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | High | High |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

**Children**

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary Climate Driver** | **Natural Hazard** | **Risk Rating** | **Vulnerability**  **Score** |
| Sea Level Rise and Storm Surge | Coastal Flooding (including daily tidal flooding from sea level rise) | Moderate | Moderate |
| Hurricanes/Tropical Storms | Moderate | Moderate |
| Nor’easter | Moderate | Moderate |
| Coastal Erosion | Low | Low |
| Precipitation | Extreme Precipitation | Low | Low |
| Inland/Riverine Flooding | Low | Low |
| Severe Winter Storm | Low | Low |
| Ice Storms | Low | Low |
| Landslide | N/A | N/A |
| Dam Failure | N/A | N/A |
| Temperature | Increase in Average Summer Temperature | Low | Low |
| Extreme Temperatures/Heat Waves | Moderate | Moderate |
| Drought | Low | Low |
| Wildfires | N/A | N/A |
| Other Extreme Events | Tornadoes | N/A | N/A |
| Tsunami | N/A | N/A |
| Earthquake | N/A | N/A |

# Section 5 Concluding Remarks

No response

1. Vulnerability Scoring Method

This appendix presents the method used to develop the vulnerability scores for the state agency critical assets, functions, and population groups that were evaluated as part of this vulnerability assessment. The questions referenced below are from the State Agency Vulnerability Survey Tool, which was developed as part of the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

**Exposure and Sensitivity Scores**

The following exposure and sensitivity scores are used when responses are provided in Section II of the State Agency Vulnerability Assessment Survey for natural hazards for specific critical items.

|  |  |  |
| --- | --- | --- |
| **Item** | **Response** | **Score** |
| **Exposure:** Based on how the natural hazard is likely to change in the future as a result of climate change, to what extent is the critical asset, function, or population group served exposed to each hazard? | Not Exposed | 0 |
| Low | 1 |
| Medium | 2 |
| High | 3 |
| **Sensitivity:** On a scale of 1 to 5, rate how sensitive the critical asset, function, or population group served is to the natural hazards. Sensitivity should be determined based on whether a critical threshold has been exceeded. | N/A | 0 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |
| 5 | 5 |

* Minimum Exposure Score: 0; Maximum Exposure Score: 3
* Minimum Sensitivity Score: 0; Maximum Sensitivity Score: 5

**Risk Rating**

A risk rating is assigned by combining exposure and sensitivity. Thus, the following equation is used to arrive at a risk rating for each critical item:

*Risk Rating = Exposure Score \* Sensitivity Score*

Based on the score ranges used for exposure and sensitivity, there is a possible vulnerability score range of 0-15 as shown below.

* Maximum Risk Rating (Maximum Exposure\*Maximum Sensitivity) = 15
* Minimum Risk Rating (Minimum Exposure\*Minimum Sensitivity/Maximum AC) = 0

The resulting risk rating for each applicable natural hazard and related climate change impacts that are assessed for a particular critical item is reported as low (yellow), moderate (orange), or high (red) as shown in the table below. If a critical item is determined to not be exposed to a natural hazard, a “N/A” (not applicable) value is assigned.

|  |  |
| --- | --- |
| **Score Total** | **Risk Rating** |
| 0-5 | Low |
| 6-10 | Moderate |
| 11-15 | High |

**Adaptive Capacity Score**

An adaptive capacity score range of 1-3 is used, with 1 reflecting low adaptive capacity and 3 reflecting high adaptive capacity. If a mitigation, adaptation, or emergency response measure is identified for a specific critical item in response to Question 15 of the survey (i.e. please identify any specific hazard mitigation, climate adaptation, or emergency response measures that have been identified for a critical item), an adaptive capacity score of 3 is assigned.

If a measure is not identified for a specific critical item in response to Question 15, a general agency adaptive capacity score is developed and assigned by deferring to the agency responses to the five general capability and adaptive capacity survey questions as shown in the table on the following page.

To arrive at the general agency adaptive capacity score, an unweighted average score for the responses to these five questions is used. The general agency adaptive capacity score may not be as accurate as an adaptive capacity score for a specific critical item, but it is used in the absence of better information.

|  |  |  |
| --- | --- | --- |
| **Question** | **Response** | **Score** |
| Question 7: How would you rate your agency’s overall ability to withstand natural hazards and climate impacts in terms of potential physical damage or disruption to its assets, mission, functions, staff, and the public? | Excellent | 3 |
| Good | 2 |
| Satisfactory | 2 |
| Fair | 1 |
| Poor | 1 |
| Question 8: How long would it take your agency to return to essential functionality after a severe extreme weather event, like a hurricane or tornado, that results in significant damage to critical assets and/or functions? | Months | 1 |
| Weeks | 1 |
| Days | 2 |
| Hours | 3 |
| Question 9: Does your agency have any remote operation capability (could services be provided from an alternate location if assets were temporarily damaged?)? | Yes | 3 |
| No | 1 |
| Don't know | 1 |
| Question 10: Is your agency currently incorporating natural hazard mitigation and climate change adaptation into your programs? | Currently incorporating | 3 |
| Planning to incorporate | 2 |
| Not incorporating | 1 |
| Don't know | 1 |
| Question 14: Are there critical agency plans, policies, regulations, or procedures not currently being addressed that could be adjusted to better consider climate change? | Yes | 1 |
| No | 3 |
| Don't know | 1 |

* Minimum Adaptive Capacity Score: 1; Maximum Adaptive Capacity Score: 3

**Vulnerability Score**

Vulnerability is a function of exposure, sensitivity, and adaptive capacity. Thus, the following equation is used to arrive at a vulnerability score for each critical item:

*Vulnerability Score = Exposure Score \* Sensitivity Score / Adaptive Capacity Score*

Based on the score ranges used for exposure, sensitivity, and adaptive capacity, there is a possible vulnerability score range of 0-15 as shown below.

* Maximum Vulnerability Score (Maximum Exposure\*Maximum Sensitivity/Min Adaptive Capacity) = 15
* Minimum Vulnerability Score (Minimum Exposure\*Minimum Sensitivity/Maximum AC) = 0

The resulting vulnerability score for each applicable natural hazard and related climate change impacts that are assessed for a particular critical item is reported as low (yellow), moderate (orange), or high (red) as shown in the table below. If a critical item is determined to not be exposed to a natural hazard, a “N/A” (not applicable) value is assigned.

|  |  |
| --- | --- |
| **Score Total** | **Vulnerability Ranking** |
| 0-5 | Low |
| 6-10 | Moderate |
| 11-15 | High |

|  |  |
| --- | --- |
|  |  |
|  |  |