



MBTA Climate Vulnerability Screening Report

Power, Signal, and Communication Systems on the Red,
Blue, Orange, Green and Silver Lines

STV Incorporated & BSC Group, Inc.

June 29, 2021



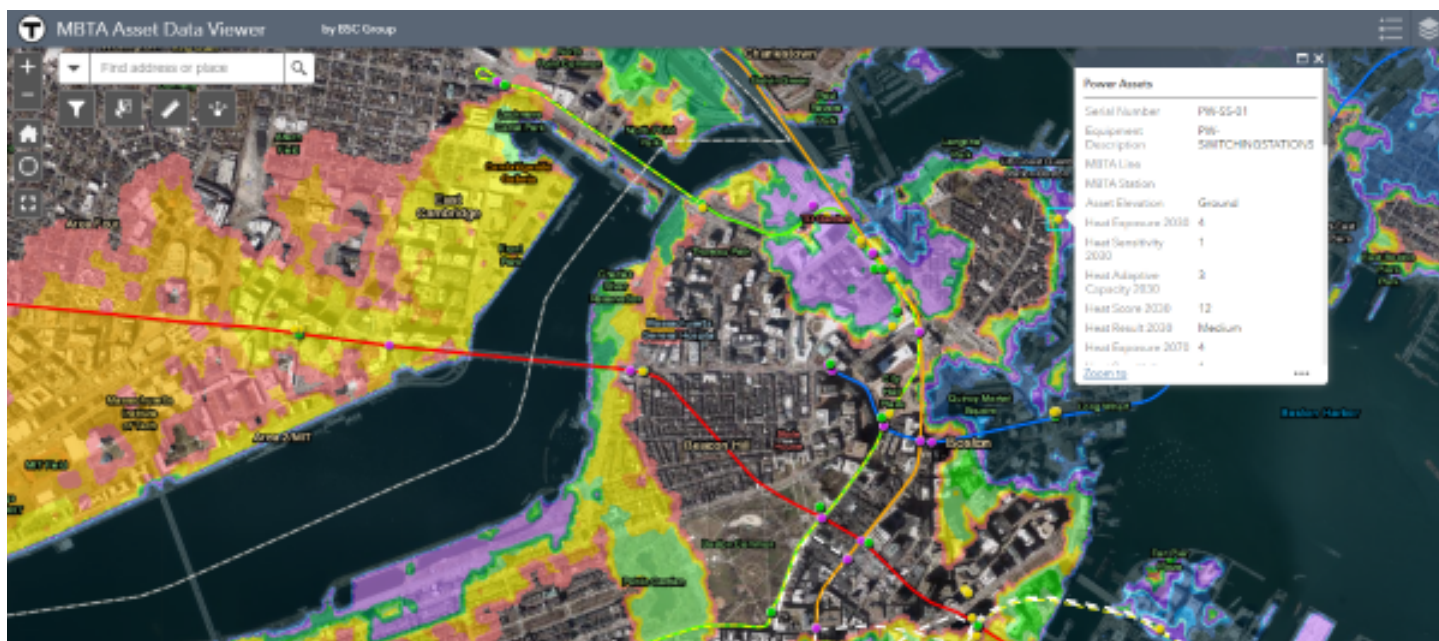
STV Team

- **Marian Barth, PE** - Project Manager
- **Sean Carney** - Traction Power System Specialist
- **Marcela Calderon** - Communications System Specialist
- **Joseph Traum, PE** - Signals Engineer

BSC Team

- **Jeff Malloy** Senior Climate Adaptation Planner
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Phase I Climate Change Vulnerability Assessment (CCVA) Summary

- Asset Data Collection
- Climate Change Data Collection
- Asset Scoring Development
- Preliminary Vulnerability Scoring
- Interactive Web Application with Results



- Performed to give MBTA a snapshot of vulnerabilities on overall systems
- Identify additional needs for more robust assessment
- **Power:** Suppliers and equipment types
- **Signal:** Equipment types

- **Communications:** Equipment includes Security, Radio, IT, Telecom, AFC

Table 1-Comparison of Climate Variables, Scenarios, and Planning Horizons

| Report | Planning Horizons | Emissions Scenarios | Extreme Heat | Sea Level Rise/ Storm Surge | Precipitation | Wind |
|--|--------------------------------------|---------------------|---|--------------------------------------|---|--------------------------------|
| MassDOT FHWA Pilot Project Report ² (2015) | 2013 2030 2070 2100 | 8.5 | N/A | Boston Harbor Flood Risk Model | Kleinfelder for Cambridge CCVA | Bosma et al. ³ |
| Cambridge Climate Change Vulnerability Assessment ⁴ (2015/2017) | 2000 2030 2070 | 4.5 8.5 | Kleinfelder for Cambridge CCVA | Boston Harbor Flood Risk Model | Kleinfelder for Cambridge CCVA | N/A |
| Climate Ready Boston (2016) ⁵ | 2000 2030 2050 2070 2100 | 2.6 4.5 8.5 | Cambridge CCVA; Trust for Public Land Urban Heat Islands | Boston Harbor Flood Risk Model | Boston Water and Sewer Commission; Boston Research Advisory Group ⁶ | Boston Research Advisory Group |
| Braintree Climate Vulnerability Assessment and Action Plan (2017) ⁷ | 2000 2030 2050 2070 2090 | 2.6* 4.5 8.5 | Northeast Climate Science Center, UMASS-Amherst (ResilientMA.org) | MA Office of Coastal Zone Management | Northeast Regional Climate Center; NOAA; MA Climate Change Adaptation Report; Climate Ready Boston | N/A |
| Medford Climate Change Vulnerability Assessment (2019) ⁸ | 2000 2030 2050* 2070 | 2.6 4.5 8.5 | Cambridge CCVA; Northeast Climate Science Center, UMASS-Amherst; Trust for Public Land Urban Heat Islands | Boston Harbor Flood Risk Model | Kleinfelder for Cambridge CCVA | N/A |

² Sea Level Rise only
⁴ Annual exceedance probability
⁵ In regard to Amelia Earhart Dam-related impacts only

Summary of Climate Data

Data Collection and Sources Informed by Metro-Boston regional adaptation efforts

- Boston Harbor Flood Risk Model (BH-FRM)
- Kleinfelder for Cambridge CCVA
- Trust for Public Land Urban Heat Islands
- Boston Water and Sewer Commission
- Boston Research Advisory Group
- ResilientMA MVP Downscaled Data (UMass-Amherst)
- Massachusetts Coastal Zone Management
- Climate Ready Boston



Climate Data: Assumptions and Goals

- **Align** with other MBTA CCVA efforts
- Climate projections selected that could be applied across broad geographic region (i.e. MBTA service footprint)
- **2030** and **2070** Planning Horizons
- Extreme Temperatures – urban heat island not evaluated
- Flooding (Inland/Coastal) - Applies BH-FRM combined with FEMA-FIRM
- **1/3 of assets** outside the extent of BH-FRM
- Reliable models for wind remain undeveloped
- MBTA has a robust snow and ice operations plan
- Assets evaluated on an **“In”** or **“Out”** condition

Climate Exposure Thresholds

| Stressor | 2030 Climate Stressor Threshold | 2070 Climate Stressor Threshold |
|------------------------------|--|--|
| Extreme heat ¹⁸ | 96°F average daily summer heat index (90°F ambient temperature with relative humidity of 50-55%) | 115°F average daily summer heat index (100°F ambient temperature with relative humidity of 50-55%) |
| Sea level rise & storm surge | 1%+ Annual Exceedance Probability, Boston Harbor Flood Risk Model Or 500-year floodplain, FEMA Coastal Flood Insurance Rate Maps | 1%+ Annual Exceedance Probability, Boston Harbor Flood Risk Model Or 500-year floodplain, FEMA Coastal Flood Insurance Rate Maps |
| Inland flooding | 500-year floodplain, FEMA Flood Insurance Risk Maps | Not assessed |
| Wind | 126 mph 3-second gust, ASCE 7 + 5% climate change factor | 130 mph 3-second gust, ASCE 7 + 8% climate change factor |
| Winter Weather | Temperature < 20°F and 24" of snow, Thresholds for Extreme Cold Operations & Level 4 storm per MBTA Snow & Ice Operations Plan | Not assessed |

| Power Equipment Types | Signal Equipment Types | Communication Equipment Types |
|--|--|---|
| Emergency Generator, Light Tower Emergency Generator, Portable Emergency Generator, Stationary Gas Gas Turbine Feeder Station Generation High Voltage Yard Overhead Catenary System Switching Station Traction Power Substation Unit Substation | Hand Throw Switch w/Heater Hand Throw Switch w/o Heater Heat Case Power Switch w/Heater Power Switch w/o Heater Signal Signal Bungalow Signal Case Signal Detector Signal Loops Signal Shelter Signal Trip Track Circuit | Automated Fare Collection Room Bidirectional Amplifiers Communications Room Radio Antenna Switch Location |

Asset Data

- Started with **TRAPEZE** asset database for all Power Signal and Communications (dated 9/25/20)
- **Power:** contained most discrete asset data => preliminary assessment of individual assets

- **Signals:** equipment type, assigned to stations/areas => asset class and region vulnerability
- **Communications:** no asset data available => equipment type vulnerability
- Meetings with internal MBTA departments
- Shared documents: reports, lists, charts, and drawings

| SERIAL_NO | EQP_TYPE | EQP_DESC | MBTA_LINE | MBTA_STATION | ASSET_ELEV | Y_LAT | X_LONG |
|-------------------------|----------|---------------------------|-----------|-------------------|------------|-----------|------------|
| SG-BUNGALOW-AQUARIUM | BUNGALOW | AQUARIUM BUNGALOW | BLUE | AQUARIUM | Below | 42.359619 | -71.051603 |
| SG-BUNGALOW-AIRPORT | BUNGALOW | AIRPORT BUNGALOW | BLUE | AIRPORT | Ground | 42.374815 | -71.029683 |
| SG-BUNGALOW-BEACHMONT | BUNGALOW | BEACHMONT BUNGALOW | BLUE | BEACHMONT | Ground | 42.397561 | -70.992457 |
| SG-BUNGALOW-GVTCENTER | BUNGALOW | GVT CENTER BUNGALOW | BLUE | GOVERNMENT CENTER | Below | 42.359599 | -71.059574 |
| SG-BUNGALOW-MAVERICK | BUNGALOW | MAVERICK BUNGALOW | BLUE | MAVERICK | Below | 42.369484 | -71.039233 |
| SG-BUNGALOW-ORIENT HHTS | BUNGALOW | ORIENT HEIGHTS BUNGALOW | BLUE | ORIENT HEIGHTS | Ground | 42.414459 | -70.991042 |
| SG-BUNGALOW-WONDERLAND | BUNGALOW | WONDERLAND BUNGALOW | BLUE | WONDERLAND | Ground | 42.414459 | -70.991042 |
| SG-BL-CASE-917 | SG-CASE | CASE, BLUE LINE AQUARIUM | BLUE | AQUARIUM | Below | 42.359619 | -71.051603 |
| SG-BL-CASE-918 | SG-CASE | CASE, BLUE LINE AQUARIUM | BLUE | AQUARIUM | Below | 42.359619 | -71.051603 |
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| SG-BL-CASE-923 | SG-CASE | CASE, BLUE LINE AQUARIUM | BLUE | AQUARIUM | Below | 42.359619 | -71.051603 |
| SG-BL-CASE-924 | SG-CASE | CASE, BLUE LINE AQUARIUM | BLUE | AQUARIUM | Below | 42.359619 | -71.051603 |
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| SG-BL-CASE-9012 | SG-CASE | CASE, BLUE LINE AIRPORT | BLUE | MAVERICK | Below | 42.374815 | -71.029683 |
| SG-BL-CASE-9013 | SG-CASE | CASE, BLUE LINE AIRPORT | BLUE | MAVERICK | Below | 42.374815 | -71.029683 |
| SG-BL-CASE-9014 | SG-CASE | CASE, BLUE LINE AIRPORT | BLUE | MAVERICK | Below | 42.374815 | -71.029683 |
| SG-BL-CASE-7-4W | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
| SG-BL-CASE-7-6E | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
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| SG-BL-CASE-7-B6E | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
| SG-BL-CASE-9005 | SG-CASE | CASE, BLUE LINE WOOD ISL | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
| SG-BL-CASE-9029 | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
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| SG-BL-CASE-9038 | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |
| SG-BL-CASE-9040 | SG-CASE | CASE, BLUE LINE ORIENT HI | BLUE | ORIENT HEIGHTS | Ground | 42.374815 | -71.029683 |

Asset Data Limitations

Limited by the existing MBTA data provided

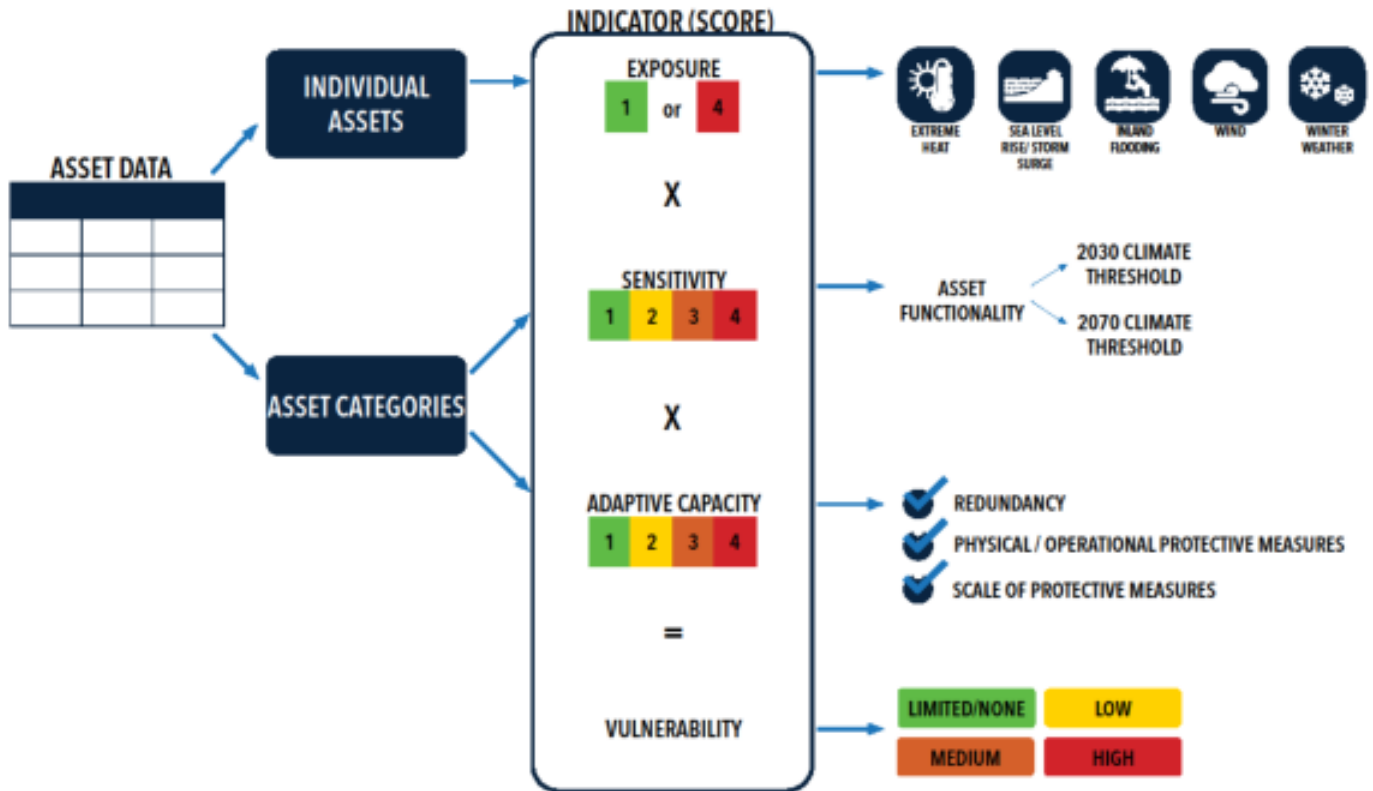
No field observations performed yet to validate

Geospatial assumptions necessary

- Many assets associated to closest station
- Elevations unknown

- Assumption either below ground or at ground

CLIMATE CHANGE VULNERABILITY SCREENING ASSESSMENT



Vulnerability Screening Assessment Methodology

| Exposure (1 or 4) | Sensitivity or Adaptive Capacity (1-4) | | Numerical Vulnerability Score | Vulnerability Category |
|-------------------|--|---|-------------------------------|------------------------|
| 1 | 1 | 1 | 1 | Limited/None |
| 1 | 1 | 2 | 2 | Limited/None |
| 1 | 1 | 3 | 3 | Limited/None |
| 1 | 1 | 4 | 4 | Low |
| 1 | 2 | 2 | 4 | |
| 4 | 1 | 1 | 4 | |
| 1 | 2 | 3 | 6 | Low |
| 1 | 2 | 4 | 8 | Low |
| 4 | 1 | 2 | 8 | |
| 1 | 3 | 3 | 9 | Low |
| 1 | 3 | 4 | 12 | Medium |
| 4 | 1 | 3 | 12 | |
| 1 | 4 | 4 | 16 | Medium |
| 4 | 1 | 4 | 16 | |
| 4 | 2 | 2 | 16 | |
| 4 | 2 | 3 | 24 | Medium |
| 4 | 2 | 4 | 32 | High |
| 4 | 3 | 3 | 36 | High |
| 4 | 3 | 4 | 48 | High |
| 4 | 4 | 4 | 64 | High |

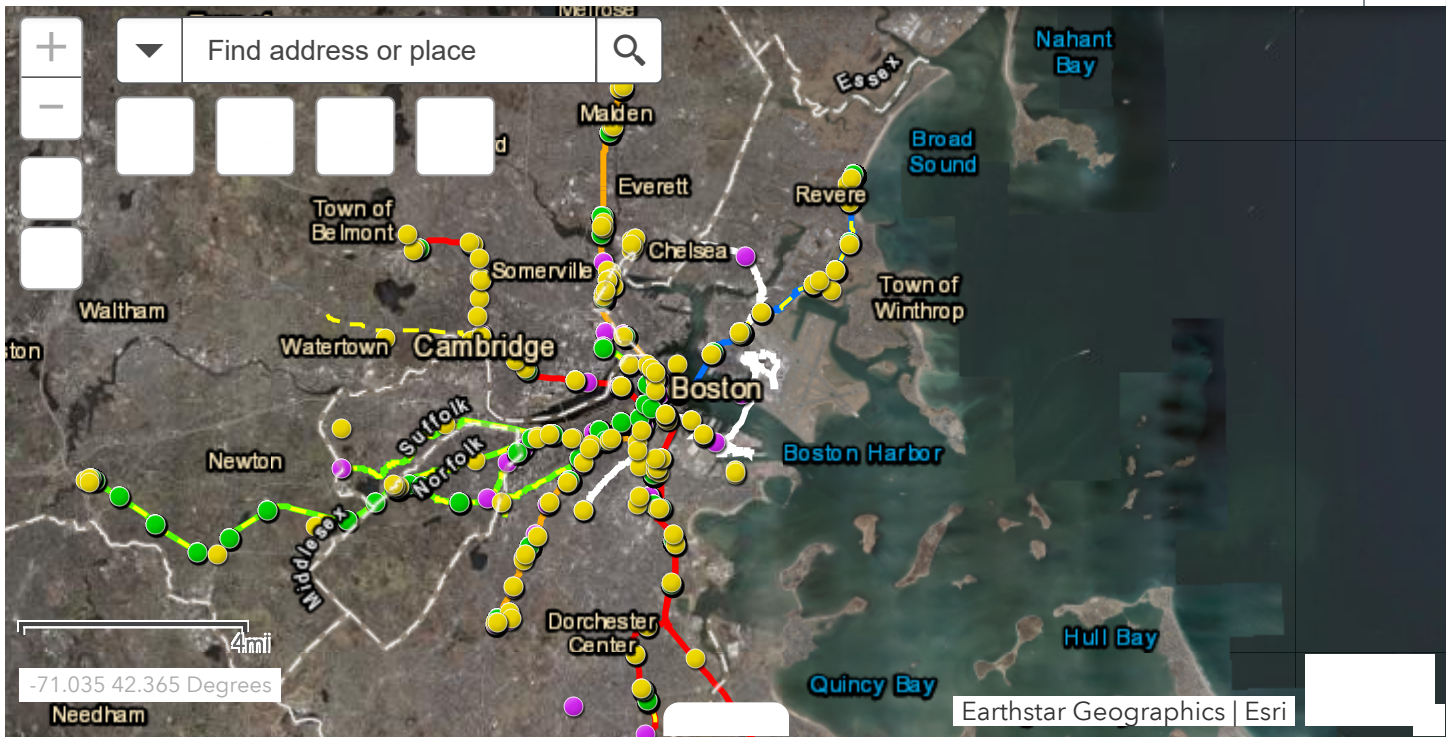
Table 10-Example Power Asset Score

| Asset information | | | | | |
|---|----------|-------------|---------------------------------------|-------------------------|---------------------|
| Serial Number: G940549164 | | | Line/Station: Blue/Beachmont | | |
| Description: Emergency Generator, Beachmont Station | | | Latitude/Longitude: 42.39721/-70.9925 | | |
| Asset Category: Emergency Generator, Stationary | | | Grade location: At/Above Ground Level | | |
| Asset Vulnerability | | | | | |
| Climate Variable (Time Horizon) | Exposure | Sensitivity | Adaptive Capacity | Numerical Vulnerability | Vulnerability Level |
| Extreme Heat (2030) | 4 | 1 | 4 | 16 | Medium |
| Extreme Heat (2070) | 4 | 2 | 4 | 32 | High |
| Sea Level Rise/Storm Surge (2030) | 1 | 4 | 3 | 12 | Medium |
| Sea Level Rise/Storm Surge (2070) | 4 | 4 | 3 | 48 | High |
| Inland Flooding | 1 | 4 | 3 | 12 | Medium |
| Wind | 4 | 1 | 4 | 16 | Medium |
| Winter Weather | 4 | 2 | 2 | 16 | Medium |



MBTA Asset Data Viewer

by BSC Group



ArcGIS Web Application

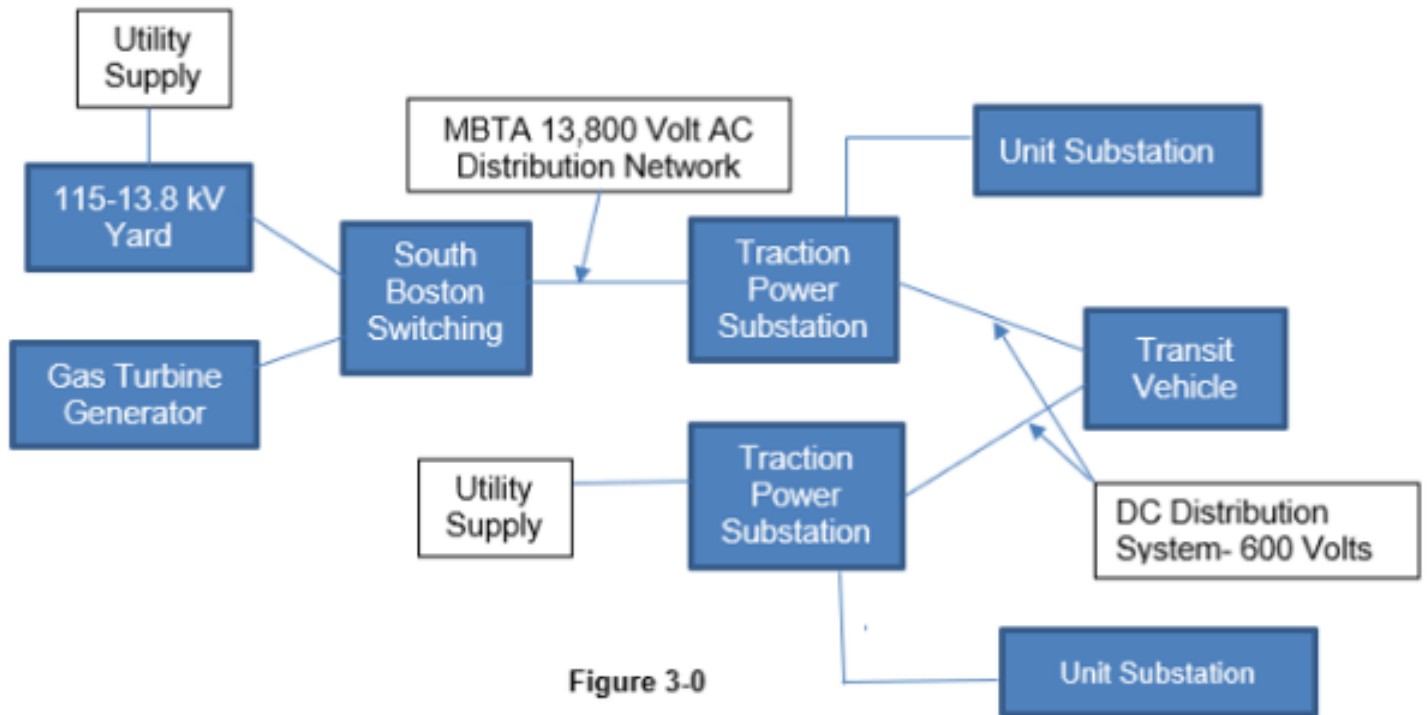


Figure 3-0

Power Systems

There are over 1200 power assets across the system not including that each system has either a hierarchy or web of asset classes that make up the operation of the system.

Key Evaluation Components

1. Generation
2. Utility Supplier (Eversource, National Grid, and Braintree Electric Light Dept.)
3. Transmission
4. Substations/Unit Substations
5. Distribution



Power Generation

MBTA Power Systems can only be as reliable as the power source

- Gas Turbines
- Transmission
- Switching Stations: South Boston, Lincoln, and North Station

Utility Suppliers

- Eversource
- National Grid
- Braintree Electric Light Dept.



Traction Power Substations & Unit Substations

PW-SWITCHINGSTATIONS, PW-TPS, PW-USS

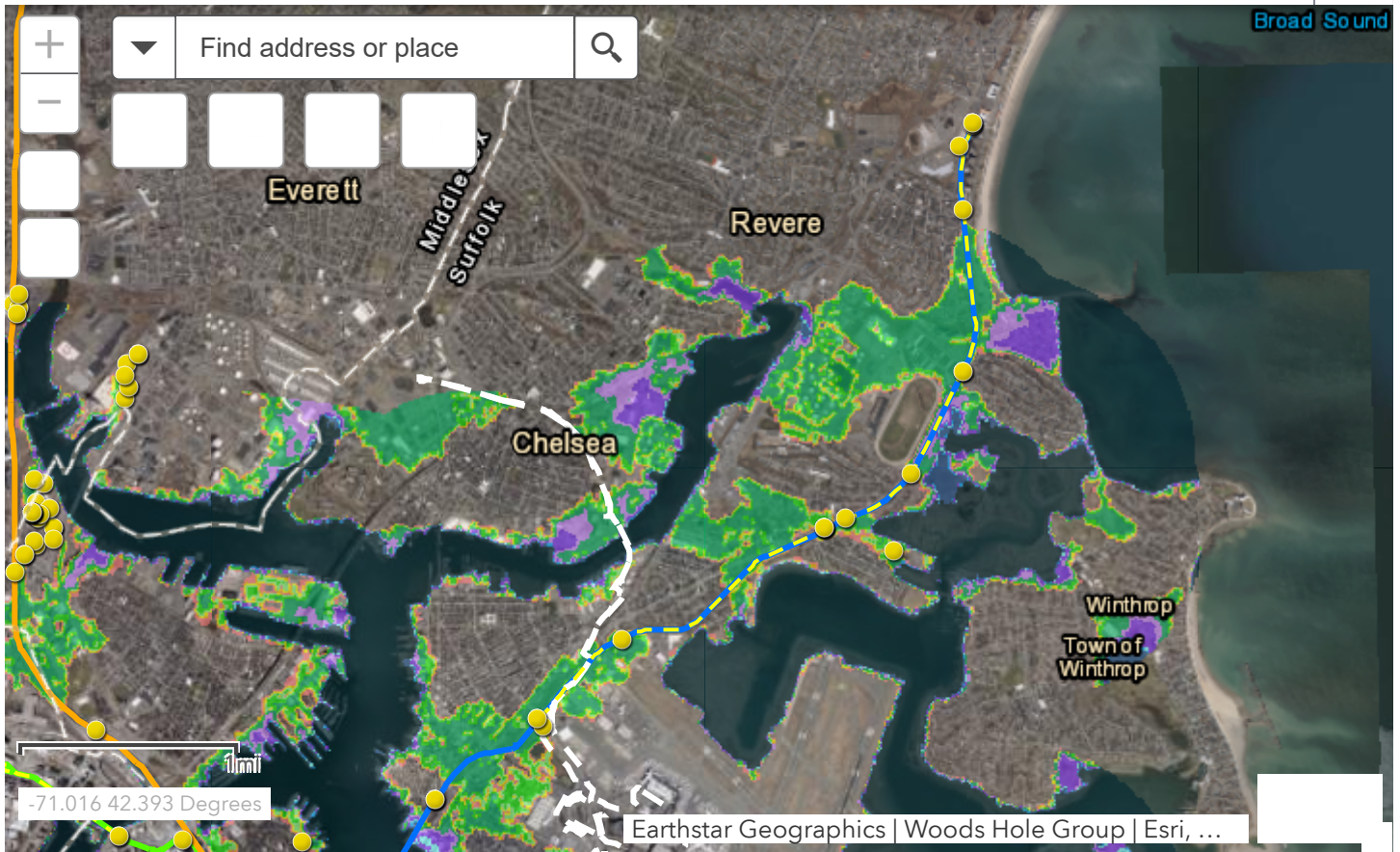
All switching stations exposed to sea level rise by 2070. Lincoln Switching Station exposed by 2030.

21 Traction Power and Unit Substations have 2030 HIGH vulnerability to flooding; increases by **2.5x** in 2070



MBTA Asset Data Viewer

by BSC Group



PW-TPS, PW-USS

21 Traction Power Substations and Unit Substations have 2030 HIGH vulnerability to flooding; increases by **2.5x** in 2070



Overhead Catenary System

PW-OCS

OCS MEDIUM vulnerability 2030, HIGH by 2070





Emergency Power

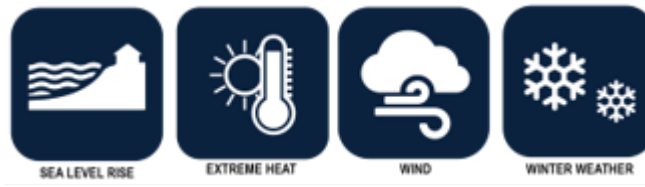
PW-EMGEN-STATIONARY, PW-EMGEN-PORTABLE, PW-XEMGEN-LIGHTTOWER

- Stationary Generators
- Portable Generator
- Generator Light Tower

Wind serves as the highest source of vulnerability for light towers.

All stationary and portable generators increase from MEDIUM to HIGH vulnerability from 2030 to 2070 to extreme heat.

Flood exposure for several generators along the Blue, Red, and Orange Lines.



Signal Systems

Purpose: To Safely and Efficiently control train movements

Vital System – Most important critical system of MBTA

- Safety above all else!
- Failure of any component – “Fail Safe” mode operation

Signal System Assets are related to three Main Wayside Components:

1. Signal Display

2. Train Detection and Control (Speed/Stop Commands)
3. Switch Control and Indication



Signal Systems - Assets

Signal Bungalow (SG-BUNGALOW) / Signal Shelter (SG-SHELTER)

Assets exposed to coastal storm flooding scored HIGH vulnerability in 2030 and 2070. Assets located outside coastal flood areas in 2030 and 2070 received a score of MEDIUM.

These assets have an inherent HIGH vulnerability to extreme temperatures, however will operate as normal with functioning HVAC systems.



Signal Systems - Assets

Signal Case (SG-CASE)

These assets are highly subject to FAIL in extreme heat conditions in 2070. The assets are not climate controlled.

Assets exposed to flooding score HIGH vulnerability in 2030 and 2070. Low adaptive capacity due to accessibility during flood events.



Signal Systems - Assets

Hand Throw Switch with Heater (SG-HTELECTRICLOCKSWI)

Power Switch with Heater (SG-HEATELEMENT)

**Hand Throw Switch without Heater (SG-
HTNOELECTRICLOCKSWI)**

Power Switch without Heater (SG-HTNOSIGNALEQUIPMENTSWI)

Switch Heater Case (SG-HEATCASE)

Power Switch and Hand Throw Switch asset categories are highly vulnerable to flood conditions.



Signal Systems - Assets

Signal Loops (SG-LOOPS)

Signal Detector (SG-DETECTOR)

Signal Trip (SG-TRIP)

Track Circuit (SG-TRK)

- Most Vulnerable to **Flooding, High Water, Snow/Ice Build-up, Wind**

These items have a high tolerance for all climate conditions, however it is the period length of exposure that should be considered.



SIGNAL ITEMS NOT COVERED DIRECTLY BY THIS STUDY

Signals

- Signals Wall Mounted - No flooding issues, Excessive winds
- Signals Pole Mounted - High Water (base only), Excessive winds
- Signals Ground Mounted (Dwarf Signals) - Flooding, High Water

Signal Cables

- Cables mounted to walls or directly underground (no flooding with armor/excessive winds)
- Cable mounted in Conduits and Cable Troughs (no flooding/excessive winds)

Cable Routing Devices

- Cable Termination Cases and Junction Boxes
- Same vulnerabilities as signal cases



Communications

Protect MBTA Security and Communications Equipment Safely and Efficiently

- AFC Rooms
- Communications Rooms
- Bidirectional Amplifiers/Radio Rooms
- Radio Antennas
- Switch Locations



Communications

CM-X-COMMUNICATIONSROOM, CM-X-AFCROOM, CM-X-SWITCH-LOCATIONS

Critical Assets on Security and Communications Systems – critical system of MBTA

- Wide Area Network equipment
- AFC equipment
- Security equipment





Communications

CM-X-ANTENNAS-RADIO, CM-X-RADIO-BDA

Radio Equipment

- Radio Antennas
- Bidirectional Amplifiers





Communications - Vulnerabilities

Flooding/high water cause devices to deteriorate and risk operation failure

Switch Locations and AFC Rooms score HIGH vulnerability to extreme heat by 2030.

17% of system-wide assets score HIGH vulnerability to inland flooding by 2030.

7% of system-wide assets score HIGH vulnerability to coastal flooding by 2030, increasing to 35% by 2070.





MBTA Assets - Summary

Power system is critical to all other systems

- **Lincoln Switching Station** HIGH vulnerability to inland flooding near term
- **All** other switching stations by 2070
- Traction Power Substations



MBTA Assets - Summary

Signal System VITAL to operations

- Signal Cases HIGH for heat and flooding
- Flooding in Red and Blue Line areas



MBTA Assets - Summary

Communications

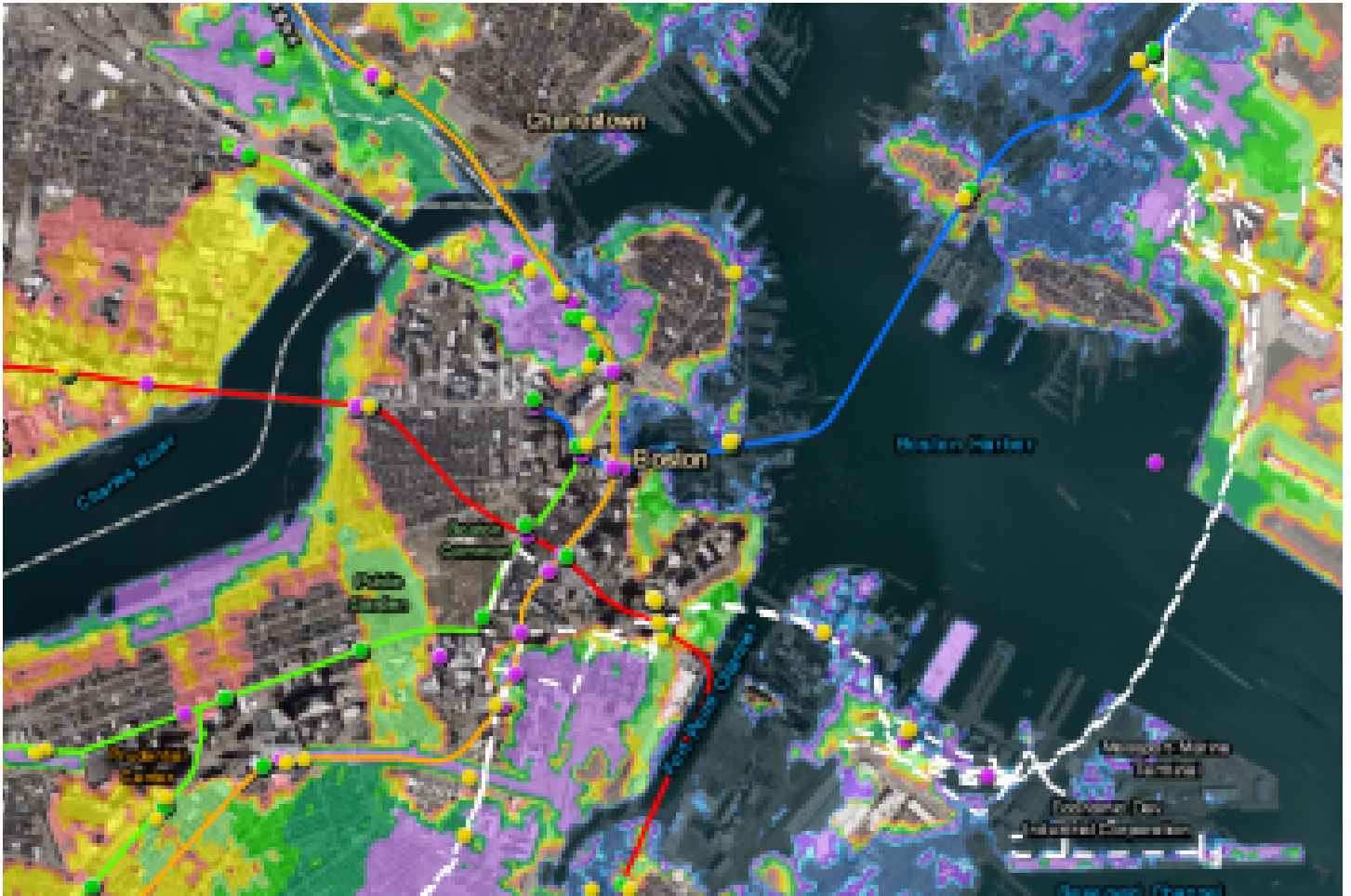
- Heat is stressor for all Switch Locations and AFC Rooms
- Locations along Blue Line, Alewife/JFK on Red Line and Sullivan Square on the Orange Line exhibit flooding risk, further elevation data necessary



Recommendations - Future Analysis

Phase 1 Analysis provides an incomplete picture of true asset vulnerability

- Geospatial Asset Characteristics – More Detail Needed
- Asset Condition Characteristics – More Detail Needed/Existing Adaptive Capacity (e.g. assets on raised platforms above flood elevation, state of good repair)
- Climate Data Projections – Recent and Nuanced Climate Projections
- Context/Site Specific Analysis – Field Truth Assets
- Criticality Analysis based on asset factors such as life safety, operations, system interdependencies, economic impacts and cost to repair
- Estimates of repair costs/cost-benefit analysis



Questions?