# Massachusetts Ambient Air Monitoring Network Assessment

# 2020

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# I. SUMMARY

## Introduction

The Massachusetts Department of Environmental Protection (MassDEP) has prepared this 2020 Ambient Air Monitoring Network Assessment pursuant to 40 CFR 58.10(d). The Federal Clean Air Act established a joint Federal-State partnership for protecting the quality of our nation's air. A key component of this partnership is the national system of ambient air quality monitors. State and local air pollution control agencies maintain a network of air monitoring stations that measure ambient concentrations of pollutants for which the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS). Those pollutants, which are known as "criteria pollutants," include ozone ($O_3$), particulate matter smaller than 10 microns ($PM_{10}$), particulate matter smaller than 2.5 microns ($PM_{2.5}$), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), carbon monoxide (CO), and lead (Pb). The monitoring network is designed to determine if air quality meets the NAAQS as well as to provide data needed to identify, understand, and address ambient air quality problems. EPA promulgates regulations that define minimum monitoring requirements as well as monitoring techniques and procedures.

Monitoring networks are designed to achieve, with limited resources, the best possible scientific data to inform the protection of public health, the environment and public welfare. The number, location, and types of monitors needed to achieve this goal depends on a myriad of factors including demographics, pollution levels, air quality standards, monitoring technology, budgets, and scientific understanding. These factors all change over time. In accordance with EPA monitoring regulations, state and local air pollution control agencies must conduct an assessment of their monitoring networks every 5 years in order to determine:

- if the network meets the monitoring objectives defined in Appendix D of 40 CFR 58.10,
- whether new monitoring sites are needed,
- whether existing sites are no longer needed and can be discontinued, and
- whether new technologies are appropriate for the ambient air monitoring network.

The network assessment must consider the ability of existing and proposed monitoring sites to provide relevant data for air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma). The assessment also must show the impacts of proposals to discontinue any sites on data users other than the agency itself, such as nearby states and tribes or organizations conducting health effects studies. For the criteria pollutant $PM_{2.5,}$ the assessment also must identify needed changes to population-oriented sites.

MassDEP's Air Assessment Branch maintains an ambient air quality monitoring network that consists of 22 monitoring stations located in 18 cities and towns and monitors ambient concentrations of all criteria pollutants. The Wampanoag Tribe of Gay Head (Aquinnah) operates an additional air monitoring station on Martha's Vineyard. MassDEP also monitors meteorological conditions, ambient levels of toxic air pollutants as part of the National Air Toxics Trends Sites (NATTS) network and ozone precursors as part of the Photochemical Assessment

Monitoring Stations (PAMS) network. Ozone precursors are substances that react in the atmosphere to form ground-level ozone.

MassDEP's air monitoring network places an emphasis on monitoring ozone and $PM_{2.5}$ levels. In the past, Massachusetts air quality has been in nonattainment of the ozone standard and has been close to the $PM_{2.5}$ standard. Today, Massachusetts is designated in attainment of all standards, with the exception of Dukes County. Dukes County is designated as nonattainment with the 2008 ozone NAAQS (0.075 ppm). However, Dukes County currently meets the 2008 ozone NAAQS and is designated as attainment with the more stringent 2015 ozone NAAQS (0.070 ppm). The Commonwealth still experiences days with elevated levels of ozone, making ozone monitoring a continued priority. The ozone monitoring network is designed to measure concentrations of ozone and its precursors in-state, as well as provide insight into ozone formation and ozone transport. MassDEP also continues to place priority on monitoring $PM_{2.5}$ concentrations due to the significant health effects posed by $PM_{2.5}$ exposure.

Figure 2-1 shows the location of monitoring stations. All these sites have been approved by EPA as meeting applicable siting criteria, as specified in Subpart B of 40 CFR Part 58. As required by EPA, all criteria pollutants are monitored using Federal Reference Methods (FRMs) or Federal Equivalent Methods (FEMs) and monitors are operated according to the procedures specified in Quality Assurance Project Plans (QAPPs) that have been approved by EPA. MassDEP's monitors meet EPA guidelines and requirements for characterizing micro-scale (up to 100 square meters), middle-scale (a few city blocks), neighborhood (up to 4 square kilometer), urban (a city), and regional (up to hundreds of square kilometers) air quality and for measuring the greatest population exposures, highest exposures and regional transport.

**Update on 2015 Network Assessment**

MassDEP prepared its second Network Assessment in 2015. The 2015 Assessment noted that MassDEP was working to establish a second $NO_2$ near-road site in the Boston Area and an ozone and consolidated $PM_{2.5}$ site in the Pittsfield area. In 2018, MassDEP established a second near-road $NO_2$ monitoring station in Chelmsford (Manning Road), adding to the existing near-road monitoring station in Boston (Von Hillern Street). In 2018, MassDEP also established an ozone monitoring station in Pittsfield (Silver Lake Boulevard, 25-003-0008). MassDEP included $PM_{2.5}$ monitoring at the new station, and in doing so was able to consolidate two former sites in Pittsfield (Center Street and South Street) into a single monitoring station.

EPA's 2015 ozone monitoring regulations reduced the number of required Photochemical Assessment Monitoring Station (PAMS) sites in Massachusetts from four to one. In 2017, MassDEP closed the Newburyport monitoring station, which was originally established as a PAMS site. MassDEP also discontinued PAMS monitoring at the Chicopee and Ware monitoring stations, although MassDEP continues to monitor ozone and other criteria pollutants these sites. MassDEP continues to implement PAMS monitoring at its Lynn monitoring station, which EPA approved as MassDEP's PAMS network site.

MassDEP made several other changes to its monitoring Network since the 2015 Assessment:

- In 2016, MassDEP discontinued filter-based $PM_{2.5}$ monitors at Lawrence and Worcester (Washington Street) as part of trend of relying more on continuous $PM_{2.5}$ monitors.

- In 2017, MassDEP established a site in North Adams to monitor continuous $PM_{2.5}$ and black carbon as a way to monitor wood smoke in the Greylock Valley area.

- In 2018, MassDEP closed the $PM_{2.5}$ monitoring station at Boston – North Street due to a loss of access to the site.

- In 2020, MassDEP established a temporary monitoring station in Weymouth near a natural gas compressor station that is under construction. The station includes a continuous $PM_{2.5}$ monitor, volatile organic compounds (VOCs) sampler and a carbonyl sampler. MassDEP is working to establish a permanent monitoring station in Weymouth, which also will monitor ozone and $NO_2$.

**2020 Network Assessment Results**

MassDEP's review of the Massachusetts monitoring network indicates that the network meets or exceeds EPA's minimum monitoring requirements, that the network is well designed and operated, and adequately characterizes air quality in Massachusetts. While Massachusetts is designated in attainment of the 2015 8-hour ozone NAAQS, MassDEP continues to make ozone monitoring a priority to confirm the overall downward trend in ozone concentrations and to alert the public on days when ozone is elevated. MassDEP also continues to operate a robust $PM_{2.5}$ monitoring network due to the significant health effects posed by $PM_{2.5}$.

MassDEP has reviewed changes in population and pollutant emissions and determined that MassDEP's existing monitoring network is properly designed. Massachusetts population centers remain the same geographically, although overall population has increased (see Figure 3-2); there has been little change in the distribution of vehicle miles travelled across the state (see Figure 4-3); and pollutant emissions have declined fairly uniformly across the state (see Figure 4-4). The absence of major shifts in these factors indicates that adjustment of the basic design of the air monitoring network is unnecessary.

In addition, review of the distribution of sensitive populations (such as children) and of the incidence of various diseases associated with air pollution (such as asthma, respiratory disease, lung cancer, and circulatory diseases), as well as Environmental Justice populations, indicates that the existing network of monitoring sites adequately supports air quality characterization in areas with sensitive populations. However, given the health impacts of $PM_{2.5}$, MassDEP is evaluating opportunities to enhance $PM_{2.5}$ monitoring in Environmental Justice communities.

MassDEP used an analytical tool provided by EPA (NetAssess2020) to evaluate whether any sites are redundant and could be removed and whether any new sites are needed in the monitoring network. The tools evaluates correlations between existing site measurements; distance between sites; the likelihood of the site exceeding a standard; the correlation between site measurements;

removal bias (i.e., the difference between the measured concentrations at a site and those that would be estimated for that site based on data from surrounding sites); and create maps that show the coverage area of each monitor.

MassDEP continues to evaluate opportunities to optimize the monitoring network and provides updates for EPA review and approval through annual Network Plans. MassDEP has taken advantage of opportunities to streamline operations by optimizing travel routes, maintenance schedules, and relying more on automated continuous monitors for most parameters. Two measures implemented since the 2015 Network Assessment include relying more on continuous Federal Equivalent Method (FEM) $PM_{2.5}$ monitors and reducing the workload associated with monitoring PAMS parameters.

## II. NETWORK PURPOSE AND DESCRIPTION

The Massachusetts ambient air quality monitoring network serves several purposes:

- **Provide information about air quality to the public.** MassDEP's website provides near real-time data from continuous monitoring sites, explanations of the health effects of pollution, information about the NAAQS, and the ability to chart historical air quality monitoring data and air quality trends. The network also supports MassDEP's daily air quality forecast and alert system. Both data and forecasts are posted at MassAir at www.mass.gov/air.

- **Verify compliance with National Ambient Air Quality Standards (NAAQS).** EPA specifies the minimum number of monitors that must be located in Massachusetts to demonstrate whether the state is in attainment of each of the criteria pollutants.

- **Assess the effectiveness of current air pollution control regulations and initiatives / support development of policies and regulations aimed at reducing air pollution.** MassDEP uses air monitoring data to develop and track progress of State Implementation Plans (SIPs) that specify the air pollution controls and strategies to attain and maintain the NAAQS and meet Regional Haze requirements.

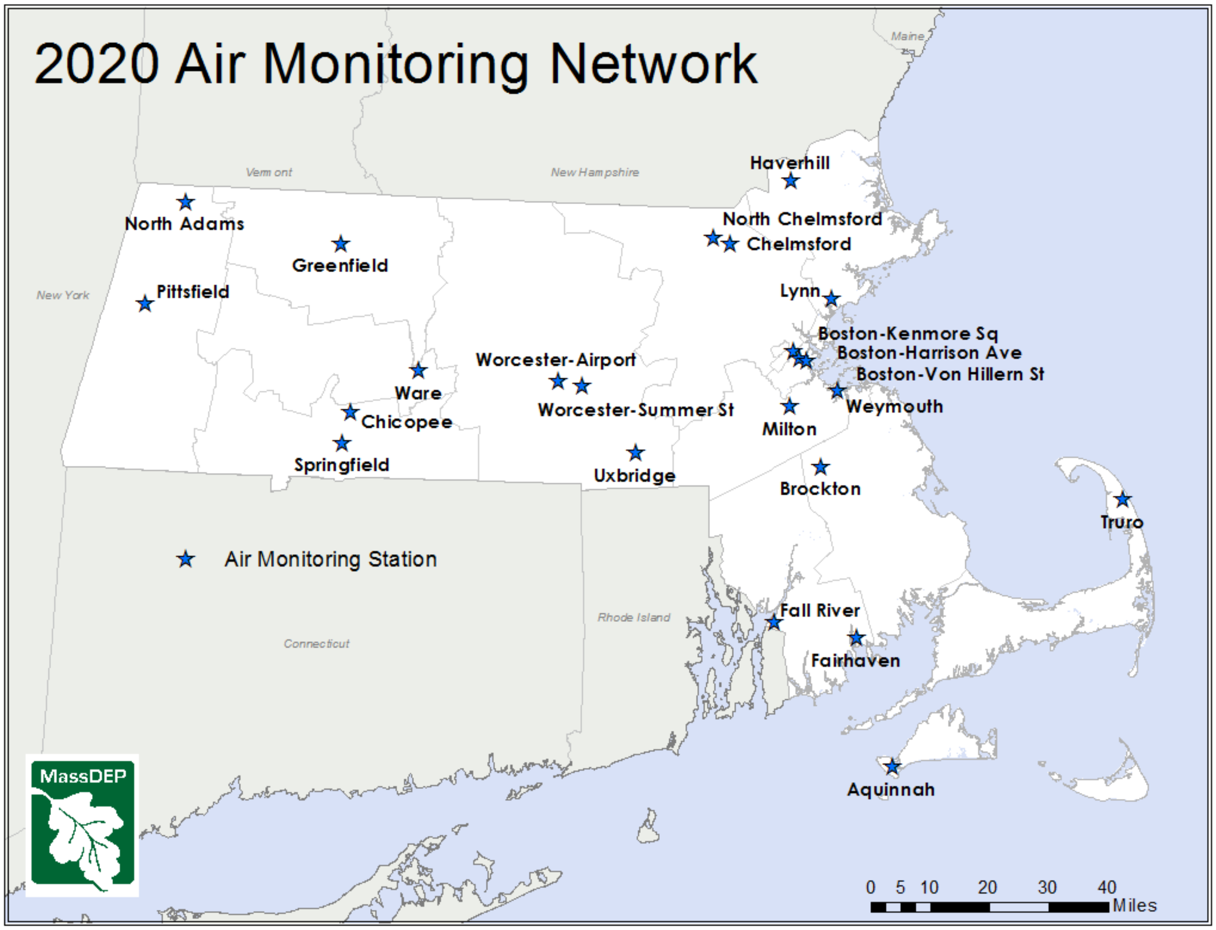
- **Ambient monitoring data are used in conjunction with modeling to characterize the extent of air pollution problems, including transport into and out of the state, as well as to evaluate the impacts of alternative control strategies.** MassDEP's monitoring data are important to regional air pollution control planning efforts. Massachusetts is a member of three interstate regional organizations that coordinate the development of air pollution control plans - Ozone Transport Commission (OTC), Mid-Atlantic/Northeast Visibility Union (MANE-VU), and Northeast States for Coordinated Air Use Management (NESCAUM).

- **Site-specific permitting.** MassDEP staff and consultants use ambient air quality and meteorological monitoring data to make site-specific permitting decisions that ensure that emissions from new or modified facilities do not cause or contribute to violations of NAAQS or consume Prevention of Significant Deterioration increments. In addition, meteorological and toxic chemical monitoring information is used in conjunction with models to estimate if emissions are likely to result in exceedances of MassDEP's Ambient Air Limits (AALs) for toxic pollutants.

- **Research.** Environmental and medical academics, the Massachusetts Department of Public Health, the World Health Organization, conservation groups, environmental advocates, and consultants use ambient air monitoring data to evaluate the public health and environmental impacts of air pollution and to develop and "ground truth" ambient air quality models. Air quality data also are used to better characterize the behavior of contaminants in the atmosphere.

MassDEP operates 22 monitoring stations located in 18 cities and towns. The Wampanoag Tribe of Gay Head (Aquinnah) operates an air monitoring station on Martha's Vineyard. Figure 2-1 shows the location of monitoring stations.

**Figure 2-1**
**Massachusetts Air Monitoring Stations in 2020**




MassDEP operates "continuous" and "intermittent" monitors. Continuous monitors sample and measure the air 24 hours per day and generally report out hourly averages. Intermittent monitors take discrete samples for a specific time period, usually 24 hours, at predetermined intervals, usually every third day or every sixth day. Data is averaged in blocks of 1, 3, or 24 hours, depending on the regulatory requirement.

Some monitors, typically those measuring gaseous pollutants, perform the entire analysis automatically on-site. Others, such as the filter-based samples for lead, particulate matter $\leq$ 10 microns ($PM_{10}$), particulate matter $\leq$ 2.5 microns ($PM_{2.5}$), and volatile organic compounds (VOCs) and toxics, require laboratory analysis.

## Monitor Descriptions

MassDEP operates "continuous" and "intermittent" monitors. Continuous monitors perform complete, automated analysis on-site, measure air quality 24 hours per day, and report the data as hourly means. These are typically used for gaseous pollutants such as sulfur dioxide ($SO_2$), nitrogen oxides ($NO_x$), carbon monoxide (CO), and ozone ($O_3$). Some continuous monitors perform analyses after an hourly sample has been collected, such as Photochemical Assessment Monitoring Station (PAMS) automated gas chromatographs (Auto-GC) and $PM_{2.5}$ Beta Attenuation Monitors (BAMs).

Intermittent monitors obtain discrete samples that are collected by staff and brought to the laboratory for analysis; examples include VOC canisters, carbonyl cartridges and $PM_{2.5}$ filter samples. Depending on the regulatory or analytical requirements, samples may be obtained every day, every third day, every sixth day, or on some other prescribed schedule. The data are averaged in 3- or 24-hour intervals based on EPA requirements for the specific pollutant.

MassDEP is moving toward greater reliance on automated methods such as continuous $PM_{2.5}$ monitors and automated gas chromatographs for VOCs where possible. Advantages of automated analysis in the field include near real-time reporting of ambient air quality data to the public using data loggers and telemetry systems, a continuous record of air quality data 24 hours per day, and fewer labor hours spent retrieving and analyzing samples. However, continuous monitors are expensive, usually require climate-controlled shelters (unlike intermittent samplers that can be placed on rooftops or compact spaces), and can break (requiring back-up equipment).

The Massachusetts network contains the following monitors for criteria pollutants:

- CO: 3 continuous monitors
- $NO_x$: 10 continuous monitors
- $O_3$: 17 continuous monitors (including Aquinnah tribal site)
- $SO_2$: 6 continuous monitors
- $PM_{2.5}$: 16 hourly Federal Equivalent Monitors (FEMs) $PM_{2.5}$ monitors and 11 intermittent Federal Reference Method (FRM) monitors (including collocated units)
- $PM_{10}$: 4 intermittent monitors (including collocated units)

The Massachusetts network contains the following monitors for other pollutants:

- Black carbon (BC): 7 continuous monitors
- Ozone precursors at one PAMS station:
  - Total reactive oxidized nitrogen ($NO_y$): 1 continuous monitor
  - VOCs: 1 continuous automated gas chromatograph (Auto-GC)
  - Carbonyls: 1 intermittent monitor
- NATTS Toxics:
  - VOCs: 1 intermittent monitor
  - Carbonyls: 1 intermittent monitor
  - Polycyclic aromatic hydrocarbons (PAHs): 1 intermittent monitor
  - Metals (including lead): 2 collocated intermittent monitors
- Speciation of $PM_{2.5}$: 2 intermittent monitors measure the individual constituents of $PM_{2.5}$ including elements, sulfates/nitrates, and organic carbon
- $NO_y$: 2 continuous monitors (in addition to PAMS $NO_y$)
- VOCs: 1 intermittent monitor (in addition to PAMS and NATTS VOCs)
- Carbonyls: 1 intermittent monitor (in addition to PAMS and NATTS carbonyls)

- IMPROVE: The National Park Service and Wampanoag Tribe operate two IMPROVE monitors

Meteorological monitors measuring atmospheric conditions that influence air pollution levels:

- Wind speed and direction (WS/WD): 13 monitors
- Relative humidity (RH): 13 monitors
- Precipitation: 2 monitors
- Atmospheric pressure (i.e., barometric pressure): 13 monitors
- Solar radiation: 13 monitors
- Ambient temperature: 13 monitors

The Boston – Harrison Avenue site is the Massachusetts NCore site and was designated a National Air Toxics Trends Station (NATTS) in 2003. The NATTS program specifies the measurement of certain non-criteria air pollutants at trace levels, mostly on an intermittent (every sixth day) basis. The following parameters are measured in association with NATTS monitoring:

- Volatile organic compounds (VOCs)
- Carbonyls (formaldehyde and acetaldehyde)
- Polyaromatic hydrocarbons (PAHs)
- Metals
- Black carbon (BC)

**Quality Control and Quality Assurance**

Whether measurements are continuous or intermittent, all analyzers must be tested to ensure data validity, accuracy and precision, and to ensure that the analyzer is operating properly and can be expected to continue to operate in an acceptable manner. A large portion of MassDEP monitoring staff time is spent calibrating equipment, challenging equipment performance in the field, and reviewing the quality of air monitoring data.

MassDEP's Air Assessment Branch has an active, independent Quality Assurance Section ensuring that proper data collection and analysis procedures are followed, equipment is maintained appropriately, and equipment is calibrated properly using the appropriate test gases. This QA Section performs periodic performance and systems audits at air monitoring sites throughout the network. This is essential to operating the monitoring network, analyzing samples, and producing air quality of sufficient quality to satisfy the needs of users.

## Monitor Siting

Appendix D of 40 CFR Part 58 defines spatial monitoring scales that are useful in describing the purpose of individual monitors at specific locations:

- **Micro scale** – Concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters. An example is the Boston – Kenmore $NO_x$ located near major roadways and within street canyons, where the influence of the emissions is not expected to spread much beyond the immediate area.
- **Middle scale** – Concentrations typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometers. Monitors at this scale characterize local conditions, similar to micro scale, but for a larger surrounding area. Examples include urban $PM_{10}$ monitors.
- **Neighborhood scale –** Concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range. This might be an urban area influenced by a major point source or area sources or the air quality surrounding a defined area of similar conditions. Boston – Harrison Avenue is an example of an urban neighborhood.
- **Urban scale –** Overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale would usually require more than one monitoring site. Ozone networks around Boston, Worcester and Springfield are partially laid out on an urban scale.
- **Regional** – Usually a rural area of reasonably homogeneous geography that extends from tens to hundreds of kilometers. Examples include monitors in Fairhaven, Uxbridge and Truro.

In general, Massachusetts air monitoring stations are sited to characterize one of the following:

- highest expected concentration in an area
- general background levels
- general population exposure
- welfare impacts
- pollutant transport

Most MassDEP monitoring activities are mandated by EPA regulations and guidelines, and MassDEP works very closely with EPA to make sure that Federal air monitoring initiatives are implemented in Massachusetts.

## Monitoring Site Details

A full list of the Massachusetts monitor locations, when they were established, their purpose, what they measure, and the equipment used are presented in Figures 2-2 through 2-5.

**Figure 2-2: Air Monitoring Site Locations**

| Site ID | Site Name | County | Address | City |
|---|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | Suffolk | Kenmore Square | Boston |
| 25-025-0042 | Boston - Harrison Ave | Suffolk | 1159 Harrison Avenue | Boston |
| 25-025-0044 | Boston - Von Hillern | Suffolk | 19 Von Hillern Street | Boston |
| 25-023-0005 | Brockton | Plymouth | 170 Clinton Street | Brockton |
| 25-017-0009 | Chelmsford - EPA | Middlesex | 11 Technology Drive | Chelmsford |
| 25-017-0010 | Chelmsford - Near Road | Middlesex | Manning Road | Chelmsford |
| 25-013-0008 | Chicopee | Hampden | Anderson Road | Chicopee |
| 25-005-1006 | Fairhaven | Bristol | 30 School Street | Fairhaven |
| 25-005-1004 | Fall River | Bristol | 659 Globe Street | Fall River |
| 25-011-2005 | Greenfield | Franklin | 16 Barr Avenue | Greenfield |
| 25-009-5005 | Haverhill | Essex | 685 Washington Street | Haverhill |
| 25-009-2006 | Lynn | Essex | 390 Parkland | Lynn |
| 25-021-3003 | Milton - Blue Hill | Norfolk | 1904 Canton Avenue | Milton |
| 25-003-6001 | North Adams | Berkshire | 86 Holden Street | North Adams |
| 25-003-0008 | Pittsfield | Berkshire | 25 Silver Lake Drive | Pittsfield |
| 25-013-0018 | Springfield | Hampden | 600 Liberty Street | Springfield |
| 25-001-0002 | Truro | Barnstable | 6 Collins Road | Truro |
| 25-027-0024 | Uxbridge | Worcester | 366 E. Hartford Avenue | Uxbridge |
| 25-015-4002 | Ware | Hampshire | Quabbin Hill Road | Ware |
| 25-021-2004 | Weymouth | Norfolk | 6 Bridge Street | Weymouth |
| 25-027-0015 | Worcester - Airport | Worcester | 375 Airport Drive | Worcester |
| 25-027-0023 | Worcester - Summer St | Worcester | 260 Asylum Street | Worcester |
| 25-007-0001 | Aquinnah | Dukes | 1 Herring Creek Road | Martha’s Vineyard |

## Figure 2-3: Air Monitoring Site Descriptions

| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA / MiSA |
|---|---|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | Neighborhood/Micro | Highest Concentration; Population Exposure | 1/1/1965 | Boston-Cambridge-Newton MSA |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton MSA |
| 25-025-0044 | Boston - Von Hillern | Middle | Population Exposure; Highest Concentration | 6/15/2013 | Boston-Cambridge-Newton MSA |
| 25-023-0005 | Brockton | Urban/Neighborhood | Population Exposure | 6/30/2013 | Boston-Cambridge-Newton MSA |
| 25-017-0009 | Chelmsford - EPA | Neighborhood | Population Exposure | 4/1/2005 | Boston-Cambridge-Newton MSA |
| 25-017-0010 | Chelmsford - Near Road | Middle | Population Exposure | 7/1/2018 | Boston-Cambridge-Newton MSA |
| 25-013-0008 | Chicopee | Urban | Population Exposure | 1/1/1983 | Springfield MSA |
| 25-005-1006 | Fairhaven | Regional | Population Exposure | 6/30/2013 | Providence-Warwick MSA |
| 25-005-1004 | Fall River | Neighborhood | Population Exposure | 2/1/1975 | Providence-Warwick MSA |
| 25-011-2005 | Greenfield | Regional/Neighborhood | Population Exposure | 1/1/2014 | Greenfield Town MiSA |
| 25-009-5005 | Haverhill | Regional/Neighborhood | Population Exposure | 7/19/1994 | Boston-Cambridge-Newton MSA |
| 25-009-2006 | Lynn | Urban/Neighborhood | PAMS - Max Precursor $O_3$; Population Exposure | 1/1/1992 | Boston-Cambridge-Newton MSA |
| 25-021-3003 | Milton - Blue Hill | Regional | Upwind Background $PM_{2.5}$; Highest $O_3$ | 4/2/2002 | Boston-Cambridge-Newton MSA |
| 25-003-6001 | North Adams | Neighborhood | Population Exposure | 7/1/2017 | Pittsfield MSA |
| 25-003-0008 | Pittsfield | Regional/Neighborhood | Population Exposure | 7/1/2018 | Pittsfield MSA |
| 25-013-0018 | Springfield | Urban | Highest Concentration; Population Exposure | 5/1/2018 | Springfield MSA |
| 25-001-0002 | Truro | Regional | General Background | 4/1/1987 | Barnstable Town MSA |
| 25-027-0024 | Uxbridge | Regional | Ozone Transport; Population Exposure | 11/1/2008 | Worcester MSA |
| 25-015-4002 | Ware | Urban | Maximum $O_3$; Background other pollutants | 6/1/1985 | Springfield MSA |
| 25-021-2004 | Weymouth | Micro/Neighborhood | Source Impact | 2/4/2020 | Boston-Cambridge-Newton MSA |
| 25-027-0015 | Worcester - Airport | Urban | Population Exposure | 5/7/1979 | Worcester MSA |
| 25-027-0023 | Worcester - Summer St | Urban/Middle | Population Exposure | 1/1/2004 | Worcester MSA |
| 25-007-0001 | Aquinnah | Regional | Regional | 4/1/2004 | Vineyard Haven MiSA |

MSA = Metropolitan Statistical Area
MiSA = Micropolitan Statistical Area

## Figure 2-4: Site Parameters

| Site ID | Site Name | Meteorological | Pollutants |
|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | None | $SO_2$, $NO_2$, $PM_{2.5}$ |
| 25-025-0042 | Boston - Harrison Ave | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $SO_2$, $NO_2$, NOy, CO, $PM_{10}$, $PM_{2.5}$, $PM_{Coarse}$, $PM_{2.5}$Speciation, Black Carbon, VOCs, Carbonyls |
| 25-025-0044 | Boston - Von Hillern | WS/WD, TEMP, RH, BP, SOLAR | $NO_2$, CO, $PM_{2.5}$, Black Carbon |
| 25-023-0005 | Brockton | None | $O_3$, $PM_{2.5}$ |
| 25-017-0009 | Chelmsford - EPA | None | $O_3$ |
| 25-017-0010 | Chelmsford - Near Road | None | $O_3$, $NO_2$, $PM_{2.5}$, Black Carbon |
| 25-013-0008 | Chicopee | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $NO_2$, $PM_{2.5}$, $PM_{2.5}$Speciation |
| 25-005-1006 | Fairhaven | WS/WD, TEMP, RH, BP, SOLAR | $O_3$ |
| 25-005-1004 | Fall River | None | $O_3$, $SO_2$, $PM_{2.5}$ |
| 25-011-2005 | Greenfield | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $PM_{2.5}$, Black Carbon |
| 25-009-5005 | Haverhill | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $PM_{2.5}$ |
| 25-009-2006 | Lynn | WS/WD, TEMP, RH, BP, SOLAR, PRECIP | $O_3$, $NO_2$, $PM_{2.5}$, VOCs, Carbonyls |
| 25-021-3003 | Milton - Blue Hill | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $NO_2$ |
| 25-003-6001 | North Adams | None | $PM_{2.5}$, Black Carbon |
| 25-003-0008 | Pittsfield | WS/WD, TEMP, RH, BP, SOLAR | $O_3$, $PM_{2.5}$, Black Carbon |
| 25-013-0018 | Springfield | None | $SO_2$, $NO_2$, $PM_{2.5}$, Black Carbon |
| 25-001-0002 | Truro | WS/WD, TEMP, RH, BP, SOLAR | $O_3$ |
| 25-027-0024 | Uxbridge | WS/WD, TEMP, RH, BP, SOLAR | $O_3$ |
| 25-015-4002 | Ware | WS/WD, TEMP, RH, BP, SOLAR, PRECIP | $O_3$, $SO_2$, $NO_2$, $PM_{10}$, $PM_{2.5}$, NOy |
| 25-021-2004 | Weymouth | None | $PM_{2.5}$, VOCs, Carbonyls |
| 25-027-0015 | Worcester - Airport | WS/WD, TEMP, RH, BP, SOLAR | $O_3$ |
| 25-027-0023 | Worcester - Summer St | None | $SO_2$, $NO_2$, CO, $PM_{10}$, $PM_{2.5}$ |
| 25-007-0001 | Aquinnah | None | $O_3$ |

## Figure 2-5: Sampling and Analytical Methods

| Parameter | Sample Method | Analytical Method | Sample Frequency | Comments |
|---|---|---|---|---|
| $O_3$ | Continuous monitor | UV Light Photometry | Continuous / Hourly | |
| CO | Continuous monitor | GFC; NDIR Detection | Continuous / Hourly | |
| $SO_2$ | Continuous monitor | UV Fluorescence | Continuous / Hourly | |
| NO/$NO_2$/NOx | Continuous monitor | Chemiluminescence | Continuous / Hourly | |
| NO/$NO_2$/NOx | Continuous monitor | CAPS Spectroscopy | Continuous / Hourly | PAMS |
| NOy | Continuous monitor | Chemiluminescence | Continuous / Hourly | |
| Lead | Low Volume $PM_{10}$ | ICP/MS x-ray fluorescence | One 24-hr sample every 6 days | NATTS |
| $PM_{10}$ | Size Selective, Low Volume | Gravimetric | One 24-hr sample every 6 days | |
| $PM_{2.5}$ | Size Selective, Low Volume | Gravimetric | One 24-hr sample every 3 to 6 days | FRM |
| $PM_{2.5}$ | Continuous monitor | Beta Attenuation | Hourly | FEM |
| $PM_{2.5}$Speciation | Low Volume; Size Selective | ICP/MS x-ray fluorescence, Ion chromatography | One 24-hr sample every 3 days | NCore |
| $PM_{2.5}$Speciation | Low Volume; Size Selective | IMPROVE Protocol | One 24-hr sample every 6 days | IMPROVE |
| Black Carbon | Continuous monitor | Optical Transmittance | Continuous / Hourly | |
| Metals | Low Volume $PM_{10}$ | ICP/MS x-ray fluorescence | One 24-hr sample every 6 days | NATTS |
| PAHs | Quartz Filter, PUF Cartridge | GC/MS | One 24-hr sample every 6 days | NATTS |
| VOCs | Sub-ambient trapping | Auto-GC | Hourly | PAMS |
| VOCs | Passivated Canister | GC/MS | One 24-hr sample every 6 days | NATTS/PAMS |
| Carbonyls | DNPH on Silica Gel Traps | HPLC | One 24-hr sample every 6 days | NATTS |
| Carbonyls | DNPH on Silica Gel Traps | HPLC | Eight 3-hr samples every 3rd day | PAMS |
| Wind Speed/Direction | Continuous monitor | Ultrasonic Sensors | Hourly | |
| Solar | Continuous monitor | Pyranometer | Hourly | |
| Relative Humidity | Continuous monitor | Electronic Sensor | Hourly | |
| Ambient Temperature | Continuous monitor | Electronic Thermistor | Hourly | |
| Barometric Pressure | Continuous monitor | Electronic Sensor | Hourly | |
| Precipitation | Continuous monitor | Tipping Bucket | Hourly | |

$O_3$ = Ozone
UV = Ultraviolet
CO = Carbon Monoxide
GFC = Gas Filter Correlation
NDIR = Non-Dispersive Infrared
$SO_2$ = Sulfur Dioxide
NO/$NO_2$/NOx = Nitric Oxide/Nitrogen Dioxide/Nitrogen

Oxides CAPS = Cavity Attenuated Phase Shift
PAMS = Photochemical Assessment Monitoring Stations
NOy = Total Reactive Oxidized Nitrogen
ICP = Inductively Coupled Plasma
MS = Mass Spectrometry
VOCs = Volatile Organic Compounds Auto
Auto-GC = Automated Gas Chromatography

PAHs = Polycyclic Aromatic Hydrocarbons
PUF = Polyurethane Foam
GC/MS = Gas Chromatography Mass Spectrometry
NATTS = National Air Toxics Trends Station
DNPH = Dinitrophenylhydrazine
HPLC = High Performance Liquid Chromatography

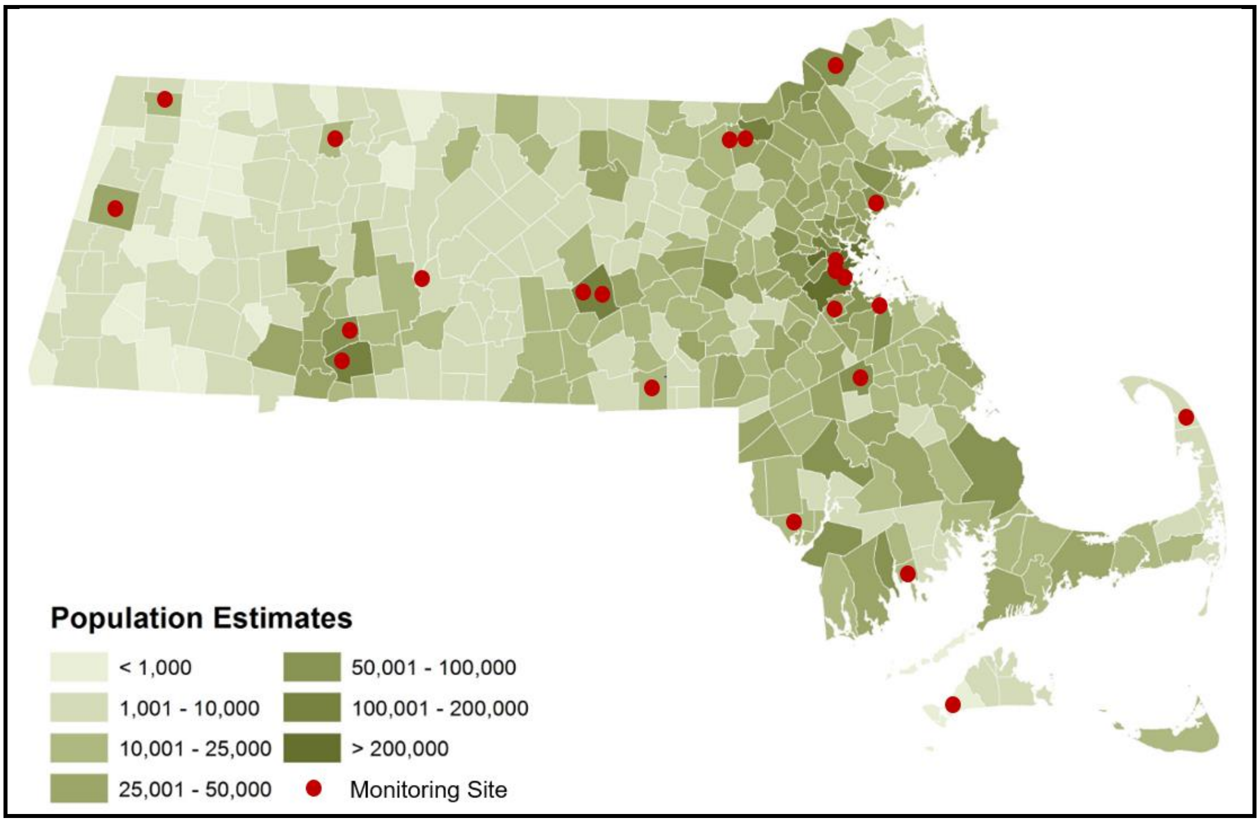
# III. MASSACHUSETTS POPULATION

MassDEP believes the air monitoring network is appropriately designed given the demographic, spatial, and health characteristics of the Massachusetts population:

- There have been no major population shifts Massachusetts in the past 5 years. The shifts that have occurred have moved population closer to areas with existing monitors (e.g., urban areas).
- Sensitive populations are adequately covered by air monitoring, and pollutant levels are well below National Ambient Air Quality Standards.
- EJ areas are well covered by air monitors.

The U.S. Census Bureau estimates that as of 2018, Massachusetts had just over 6.9 million inhabitants in 351 towns/cities and 14 counties. The vast majority of the population is concentrated in the Boston metropolitan area, with additional concentrations in the Springfield and Worcester areas as shown in Figure 3-1 (based on US Census Annual Estimates of the Resident Population).

**Figure 3-1**
**2018 Estimated Population of Massachusetts Municipalities with Air Monitoring Stations**




Source – US Census - Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018.

**Figure 3-1.1**
**Total Population in 2017 by Census Tract**



Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates
https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_B01003&prodType=table

## Population Growth

The U.S. Census Bureau estimates that Massachusetts' population has grown by approximately 5% percent between 2010 and 2018, with the largest percent increases in Suffolk, Nantucket, and Middlesex counties (see Figure 3-2). Rural areas such as Barnstable, Berkshire and Franklin counties seen small population decreases. However, because the total growth in all counties has been small, no county's proportional share of the total statewide population changed by more than + / – 0.6% between 2010 and 2018.

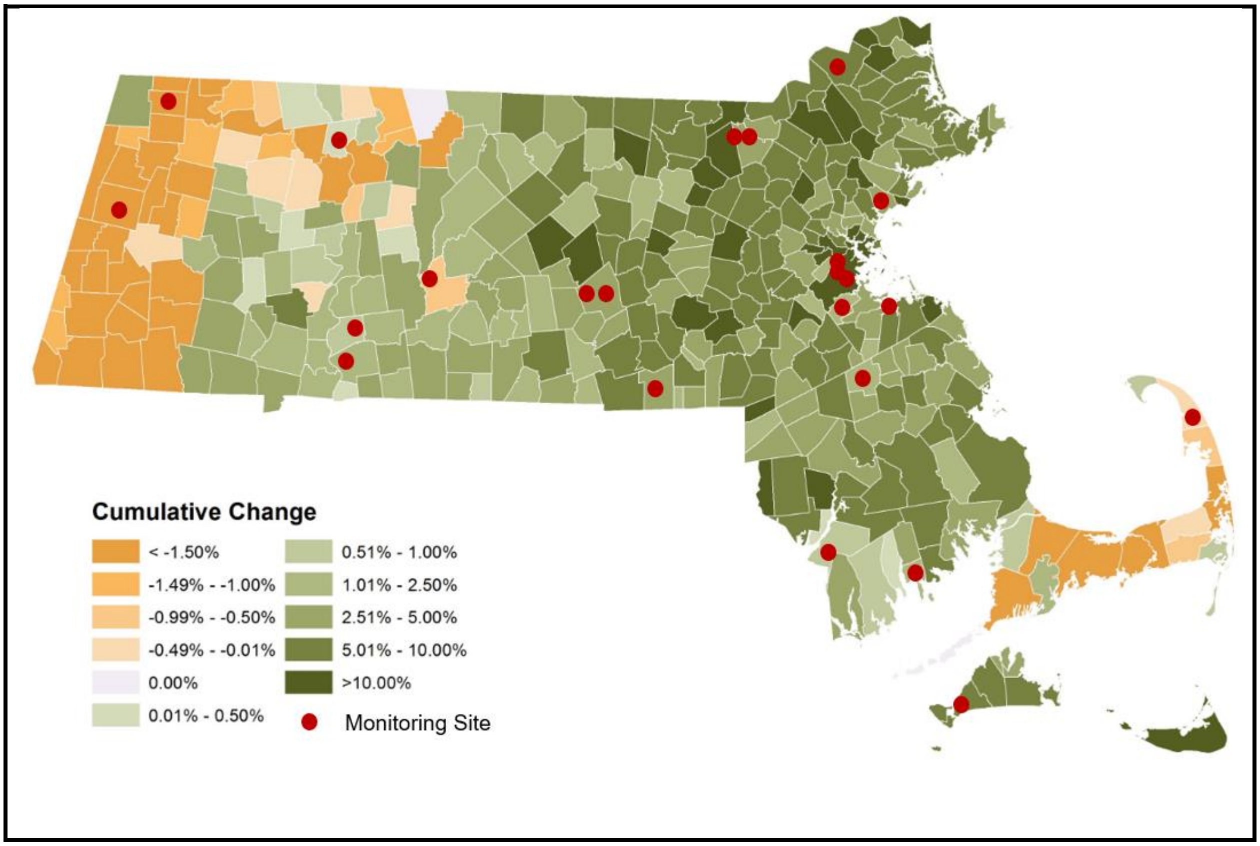
**Figure 3-2**
**Massachusetts Population Change 2010 – 2018**

| County | Population | | | % of State Population | | | Change 2010 - 2018 | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2018 | 2010 | 2015 | 2018 | Total | % |
| Barnstable | 215,893 | 213,811 | 213,413 | 3.3% | 3.1% | 3.1% | -2,480 | -1.1% |
| Berkshire | 131,319 | 127,857 | 126,348 | 2.0% | 1.9% | 1.8% | -4,971 | -3.8% |
| Bristol | 549,177 | 556,878 | 564,022 | 8.4% | 8.2% | 8.2% | 14,845 | 2.7% |
| Dukes | 16,572 | 17,275 | 17,352 | 0.3% | 0.3% | 0.3% | 780 | 4.7% |
| Essex | 745,479 | 777,175 | 790,638 | 11.4% | 11.4% | 11.5% | 45,159 | 6.1% |
| Franklin | 71,366 | 70,902 | 70,963 | 1.1% | 1.0% | 1.0% | -403 | -0.6% |
| Hampden | 464,256 | 469,230 | 470,406 | 7.1% | 6.9% | 6.8% | 6,150 | 1.3% |
| Hampshire | 159,320 | 160,768 | 161,355 | 2.4% | 2.4% | 2.3% | 2,035 | 1.3% |
| Middlesex | 1,507,693 | 1,585,775 | 1,614,714 | 23.0% | 23.3% | 23.4% | 107,021 | 7.1% |
| Nantucket | 10,167 | 10,945 | 11,327 | 0.2% | 0.2% | 0.2% | 1,160 | 11.4% |
| Norfolk | 673,039 | 694,787 | 705,388 | 10.2% | 10.2% | 10.2% | 32,349 | 4.8% |
| Plymouth | 495,930 | 509,146 | 518,132 | 7.6% | 7.5% | 7.5% | 22,202 | 4.5% |
| Suffolk | 725,819 | 782,962 | 807,252 | 11.1% | 11.5% | 11.7% | 81,433 | 11.2% |
| Worcester | 800,401 | 818,380 | 830,839 | 12.2% | 12.0% | 12.0% | 30,438 | 3.8% |
| Total | 6,566,431 | 6,795,891 | 6,902,149 | 100.0% | 100.0% | 100.0% | 335,718 | 5.1% |

Source: U.S. Census Bureau, Population Division
Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018
Release Dates: April 2019

Figure 3-3 shows population change at the municipal level from 2010 to 2018. The figure shows modest population changes, including slight decreases in Western Massachusetts and Cape Cod and increases in Eastern Massachusetts. Generally, these changes would not indicate a need to reconfigure the network, and areas showing population growth have adequate monitoring coverage.

**Figure 3-3**
**Massachusetts Population Change 2010 – 2018**




Source – US Census - Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018.

MassDEP used EPA's Population Served Network Assessment Tool and NetAssess2020 (https://sti-r-shiny.shinyapps.io/EPA_Network_Assessment/) to calculate the population served by each monitor. These tools compute shapes known as Voronoi or Thiessen polygons that are used as an indicator of the area served by each monitor. A Voronoi polygon is the shape formed by the line connecting the points equidistant between a given monitor and each of the other monitors closest to it. The area within the shape created by the lines surrounding the monitor is geographically closer to that monitor than to any other monitor in the network and is therefore considered an approximation of its coverage area. Note that this is a mathematical construct. Geographic features such as hills or valleys, manmade features such as pollution sources, meteorology, and the development pattern of an area could make the actual area represented by a monitor different from its polygon. Nevertheless, these polygons provide a reasonable starting point for looking at the area served by the monitors.

These network assessment tools calculated populations within each polygon and the results are presented in Figure 3-4 (see Section 5 maps showing the polygons). Note that 2018 was the latest population data available.

**Figure 3-4**
**Change in Population in Voronoi Polygon for Each $PM_{2.5}$ Monitor: 2010 to 2018**

| Site ID | Site Name | Population Served | | | % of Total Population Served | | |
|---|---|---|---|---|---|---|---|
| | | 2010 | 2018 | Growth | 2010* | 2018 | Change |
| 25-005-1004 | Fall River | 386,913 | 476,726 | 23% | 6% | 7% | 1% |
| 25-009-2006 | Lynn | 445,800 | 591,026 | 33% | 7% | 9% | 2% |
| 25-009-5005 | Haverhill | 227,031 | 413,740 | 82% | 4% | 6% | 2% |
| 25-013-0008 | Chicopee | 248,630 | 230,123 | -7% | 4% | 4% | 0% |
| 25-015-4002 | Ware | 117,547 | 118,289 | 1% | 2% | 2% | 0% |
| 25-025-0002 | Boston - Kenmore | 883,390 | 1,051,918 | 19% | 15% | 16% | 1% |
| 25-025-0042 | Boston - Harrison Ave | 183,079 | 347,811 | 90% | 3% | 5% | 2% |
| 25-027-0023 | Worcester - Summer St | 440,462 | 730,898 | 66% | 7% | 11% | 4% |
| 25-025-0044 | Boston - Von Hillern | 259,286 | 274,168 | 59% | 4% | 4% | 0% |
| 25-023-0005 | Brockton | 717,147 | 758,288 | 23% | 12% | 12% | 0% |
| 25-011-2005 | Greenfield | 101,945 | 100,576 | -1% | 2% | 2% | 0% |
| 25-003-6001 | North Adams | NA | 43,769 | NA | NA | 1% | NA |
| 25-013-0018 | Springfield | NA | 402,000 | NA | NA | 6% | NA |
| 25-017-0010 | Chelmsford - Near Road | NA | 538,361 | NA | NA | 8% | NA |
| 25-003-0008 | Pittsfield | NA | 105,701 | NA | NA | 2% | NA |
| 25-021-2004 | Weymouth | NA | 265,694 | NA | NA | 4% | NA |

| Site ID | Site Name | 2018 Demographics | | | | $PM_{2.5}$ Monitoring | |
|---|---|---|---|---|---|---|---|
| | | Age < 15 | Age 65+ | Sensitive | Minority | Monitor Type | Probability >35 µg/m$^3$ |
| 25-005-1004 | Fall River | 80,358 | 79,569 | 159,927 | 80,497 | FEM | <10% |
| 25-009-2006 | Lynn | 104,858 | 91,124 | 195,982 | 155,954 | FEM | <10% |
| 25-009-5005 | Haverhill | 83,242 | 50,998 | 134,240 | 152,496 | FRM/FEM | <10% |
| 25-013-0008 | Chicopee | 35,442 | 32,382 | 67,824 | 70,392 | FRM/FEM | <10% |
| 25-015-4002 | Ware | 21,435 | 15,755 | 37,190 | 9,671 | FEM | <10% |
| 25-025-0002 | Boston - Kenmore | 150,018 | 130,916 | 280,934 | 330,106 | FRM | <10% |
| 25-025-0042 | Boston - Harrison Ave | 64,715 | 44,805 | 109,520 | 216,548 | FRM/FEM | <10% |
| 25-027-0023 | Worcester - Summer St | 140,249 | 92,630 | 232,879 | 183,714 | FRM/FEM | <10% |
| 25-025-0044 | Boston - Von Hillern | 44,994 | 29,680 | 74,674 | 180,097 | FRM/FEM | <10% |
| 25-023-0005 | Brockton | 137,536 | 120,203 | 257,739 | 139,654 | FRM/FEM | <10% |
| 25-011-2005 | Greenfield | 15,649 | 15,022 | 30,671 | 9,940 | FRM/FEM | <10% |
| 25-003-6001 | North Adams | 6,495 | 7,806 | 14,301 | 3,572 | FEM | <10% |
| 25-013-0018 | Springfield | 75,991 | 56,132 | 132,123 | 168,692 | FRM/FEM | <10% |
| 25-017-0010 | Chelmsford - Near Road | 107,098 | 68,816 | 175,914 | 122,749 | FEM | <10% |
| 25-003-0008 | Pittsfield | 16,627 | 19,670 | 36,297 | 11,621 | FEM | <10% |
| 25-021-2004 | Weymouth | 47,333 | 42,192 | 89,525 | 50,686 | FEM | <10% |

Source: U.S. Census through NetAssess2020
* As stated in the 2015 Network Assessment which included additional sites that have since been shut down.

Notes about Figure 3-4:

- Changes to the $PM_{2.5}$ network since the 2015 assessment:
    - North Adams, Chelmsford – Near Road, and Weymouth sites were added.
    - Monitors at Milton – Blue Hill, Lawrence, North End, and Worcester – Washington Street sites were discontinued.
    - Springfield and Pittsfield sites were moved to new locations within the same municipal boundaries.
- Most sites experienced significant population gains since 2010. Only two sites experienced population losses: Chicopee (-7%) and Greenfield (-1%).
- The Boston – Kenmore, Brockton and Worcester – Summer Street polygons serve the largest populations. Together these three sites account for 41% of the total population served. North Adams serves the smallest population at about 1%.
- The largest change in total population served and population share is at Worcester – Summer Street (+290,436 and +4%).
- Sensitive populations at all sites account for between 27% to 34% of the populations served. Boston – Kenmore and Boston – Von Hillern showed the lowest sensitive population share (27%), while Fall River, Brockton, Pittsfield and Weymouth showed the highest sensitive population share (34%).
- Boston – Von Hillern serves the highest minority population by percentage (66%) and Boston – Kenmore serves the largest minority population in total (330,106).
- All sites in the network have very low (<10%) probabilities of exceeding the 24-hour $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$.

**Figure 3-5**
**Change in Population in Voronoi Polygon for Each Ozone Monitor: 2018 to 2010**

| Site ID | Site Name | Population Served | | | % of Total Population Served | | |
|---|---|---|---|---|---|---|---|
| | | 2010 | 2018 | Growth | 2010* | 2018 | Change |
| 25-001-0002 | Truro | 114,294 | 127,567 | 12% | 2% | 2% | 0% |
| 25-005-1004 | Fall River | 195,043 | 232,712 | 19% | 3% | 4% | 1% |
| 25-009-2006 | Lynn | 530,743 | 648,062 | 22% | 9% | 10% | 1% |
| 25-009-5005 | Haverhill | 377,233 | 423,004 | 12% | 6% | 7% | 1% |
| 25-013-0008 | Chicopee | 544,158 | 544,158 | 0% | 9% | 8% | -1% |
| 25-015-4002 | Ware | 83,452 | 79,877 | -4% | 1% | 1% | 0% |
| 25-021-3003 | Milton - Blue Hill | 486,526 | 460,672 | -5% | 8% | 7% | -1% |
| 25-025-0042 | Boston - Harrison Ave | 1,372,383 | 1,384,784 | 1% | 22% | 22% | 0% |
| 25-027-0015 | Worcester - Airport | 474,637 | 474,595 | 0% | 8% | 7% | -1% |
| 25-007-0001 | Aquinnah | 40,167 | 59,299 | 48% | 1% | 1% | 0% |
| 25-017-0009 | Chelmsford - EPA | 465,395 | 458,645 | -1% | 8% | 7% | -1% |
| 25-027-0024 | Uxbridge | 446,291 | 446,291 | 0% | 7% | 7% | 0% |
| 25-005-1006 | Fairhaven | 265,898 | 306,157 | 15% | 4% | 5% | 1% |
| 25-023-0005 | Brockton | 501,608 | 551,096 | 10% | 8% | 9% | 1% |
| 25-011-2005 | Greenfield | 105,142 | 101,933 | -3% | 2% | 2% | 0% |
| 25-003-0008 | Pittsfield | NA | 123,680 | NA | NA | 2% | NA |

| Site ID | Site Name | 2018 Demographics | | | | $O_3$ Probability of Exceeding 70 ppb |
|---|---|---|---|---|---|---|
| | | Age < 15 | Age 65+ | Sensitive | Minority | |
| 25-001-0002 | Truro | 16,114 | 34,431 | 50,545 | 12,547 | <10% |
| 25-005-1004 | Fall River | 39,200 | 38,122 | 77,322 | 25,811 | 10%-25% |
| 25-009-2006 | Lynn | 115,184 | 98,302 | 213,486 | 179,593 | 50%-75% |
| 25-009-5005 | Haverhill | 85,646 | 51,886 | 137,532 | 155,146 | <10% |
| 25-013-0008 | Chicopee | 97,034 | 74,899 | 171,933 | 224,822 | >90% |
| 25-015-4002 | Ware | 14,399 | 10,628 | 25,027 | 7,282 | 25%-50% |
| 25-021-3003 | Milton - Blue Hill | 89,968 | 68,119 | 158,087 | 121,186 | <10% |
| 25-025-0042 | Boston - Harrison Ave | 200,278 | 164,999 | 365,277 | 625,171 | <10% |
| 25-027-0015 | Worcester - Airport | 88,739 | 61,561 | 150,300 | 136,172 | 10%-25% |
| 25-007-0001 | Aquinnah | 8,703 | 12,942 | 21,645 | 7,768 | <10% |
| 25-017-0009 | Chelmsford - EPA | 91,900 | 58,353 | 150,253 | 108,362 | <10% |
| 25-027-0024 | Uxbridge | 89,362 | 54,895 | 144,257 | 86,467 | 10%-25% |
| 25-005-1006 | Fairhaven | 53,999 | 48,096 | 102,095 | 57,709 | <10% |
| 25-023-0005 | Brockton | 107,889 | 74,783 | 182,672 | 109,068 | <10% |
| 25-011-2005 | Greenfield | 15,908 | 15,240 | 31,148 | 9,976 | <10% |
| 25-003-0008 | Pittsfield | 19,241 | 23,076 | 42,317 | 12,891 | 10%-25% |

Source: U.S. Census through NetAssess2020
* As stated in the 2015 Network Assessment, which included additional sites that have since been shut down.

Notes about Figure 3-5:

- Changes to the ozone network since the 2015 assessment:
  - Pittsfield site was added.
  - The Newburyport site was discontinued.
- The Roxbury polygon is significantly larger than all other sites, representing 22% of the total population served. The Aquinnah and Ware polygons are the smallest, representing about 1% each. The remainder ranged from about 2% to 10%.
- Seven sites (Truro, Fall River, Lynn, Haverhill, Aquinnah, Fairhaven, Brockton) experienced double-digit positive growth. Lynn experienced the largest growth by total number (117,319).
- Child populations at all sites account for between 13% to 20% of the populations served, and senior populations ranged between 12% to 27%. Truro showed the largest sensitive population by percentage at 40%. Boston – Harrison Ave shows the largest total number of sensitive receptors (365,277); however, it was also the smallest percentage of sensitive receptors as a percentage of the total population served at 26%.
- Boston – Harrison Ave shows the largest population of minorities as both a total number (625,171) and percentage (45%).
- Thirteen of the 16 sites show very low to low probabilities (<10% or 10%-25%) of an exceedance. Only Chicopee showed a probability >90%. Lynn showed the second highest probability at 50%-75%; however, due to the significant influence of ozone transport, Fall River, Fairhaven, Truro and Aquinnah are likely of equal or higher risk of exceeding the ozone standard in comparison to Lynn.

**Figure 3-6**
**Change in Population in Voronoi Polygon for Each $NO_2$ Monitor: 2010 to 2018**

| Site ID | Site Name | Population Served | | | % of Total Population Served | | |
|---|---|---|---|---|---|---|---|
| | | 2010 | 2018 | Growth | 2010* | 2018 | Change |
| 25-009-2006 | Lynn | 681,639 | 753,187 | 10% | 12% | 12% | 0% |
| 25-013-0008 | Chicopee | 331,622 | 374,856 | 13% | 6% | 6% | 0% |
| 25-015-4002 | Ware | 262,804 | 271,701 | 3% | 5% | 4% | -1% |
| 25-021-3003 | Milton - Blue Hill | 1,094,820 | 1,137,954 | 4% | 19% | 18% | -1% |
| 25-025-0002 | Boston - Kenmore | 1,091,887 | 934,098 | -14% | 19% | 15% | -4% |
| 25-025-0042 | Boston - Harrison Ave | 186,988 | 186,988 | 0% | 3% | 3% | 0% |
| 25-027-0023 | Worcester - Summer Street | 799,807 | 860,631 | 8% | 14% | 14% | 0% |
| 25-025-0044 | Boston - Von Hillern | 429,349 | 450,782 | 5% | 7% | 7% | 0% |
| 25-013-0018 | Springfield | NA | 522,583 | NA | NA | 8% | NA |
| 25-017-0010 | Chelmsford - Near Road | NA | 768,618 | NA | NA | 12% | NA |

| Site ID | Site Name | 2018 Demographics | | | |
|---|---|---|---|---|---|
| | | Age < 15 | Age 65+ | Sensitive | Minority |
| 25-009-2006 | Lynn | 132,700 | 116,333 | 249,033 | 165,832 |
| 25-013-0008 | Chicopee | 58,675 | 56,190 | 114,865 | 84,981 |
| 25-015-4002 | Ware | 45,891 | 38,508 | 84,399 | 21,679 |
| 25-021-3003 | Milton - Blue Hill | 212,030 | 174,915 | 386,945 | 250,725 |
| 25-025-0002 | Boston - Kenmore | 126,031 | 114,871 | 240,902 | 297,795 |
| 25-025-0042 | Boston - Harrison Ave | 33,944 | 19,425 | 53,369 | 159,365 |
| 25-027-0023 | Worcester - Summer Street | 163,919 | 109,102 | 273,021 | 207,501 |
| 25-025-0044 | Boston - Von Hillern | 75,528 | 60,569 | 136,097 | 207,683 |
| 25-013-0018 | Springfield | 95,539 | 76,348 | 171,887 | 181,407 |
| 25-017-0010 | Chelmsford - Near Road | 155,249 | 96,824 | 252,073 | 264,697 |

Source: U.S. Census through NetAssess2020
* As stated in the 2015 Network Assessment which included additional sites that have since been shut down.

Notes about Figure 3-6:

- Changes to the $NO_2$ network since the 2015 assessment:
  - The Chelmsford – Near Road site was added.
  - The Newburyport site was discontinued.
  - The Springfield site was moved to a new location within the same municipal boundaries.
- Child populations at all sites account for between 13% to 20% of the populations served, and senior populations ranged between 10% to 15%. Blue Hill shows the largest sensitive population by percentage at 34% and by total number (386,945).
- Boston – Harrison Ave shows the largest population of minorities by percentage (85%); however, Boston – Kenmore shows the largest by total number (297,795).

- The population share for individual monitors may not be as significant for $NO_2$ as traffic counts and congestion since $NO_2$ is primarily a mobile source pollutant in Massachusetts, which limits the utility of the polygon analysis for $NO_2$.

**Figure 3-7**
**Change in Population in Voronoi Polygon for Each $SO_2$ Monitor: 2010 to 2018**

| Site ID | Site Name | Population Served | | | % of Total Population Served | | |
|---|---|---|---|---|---|---|---|
| | | 2010 | 2018 | Growth | 2010* | 2018 | Change |
| 25-005-1004 | Fall River | 720,610 | 902,163 | 25% | 13% | 14% | 1% |
| 25-015-4002 | Ware | 223,576 | 253,751 | 13% | 4% | 4% | 0% |
| 25-025-0002 | Boston - Kenmore | 1,845,482 | 1,853,376 | 0% | 34% | 29% | -5% |
| 25-025-0042 | Boston - Harrison Ave | 1,181,913 | 1,264,640 | 7% | 22% | 20% | -2% |
| 25-027-0023 | Worcester - Summer Street | 833,068 | 867,746 | 4% | 15% | 13% | -2% |
| 25-013-0018 | Springfield | 607,176 | 1,328,609 | 119% | 11% | 21% | 9% |

| Site ID | Site Name | 2018 Demographics | | | |
|---|---|---|---|---|---|
| | | Age < 15 | Age 65+ | Sensitive | Minority |
| 25-005-1004 | Fall River | 148,566 | 158,758 | 307,324 | 129,111 |
| 25-015-4002 | Ware | 40,110 | 33,524 | 73,634 | 29,127 |
| 25-025-0002 | Boston - Kenmore | 300,050 | 246,754 | 546,804 | 556,354 |
| 25-025-0042 | Boston - Harrison Ave | 230,132 | 171,136 | 401,268 | 509,587 |
| 25-027-0023 | Worcester - Summer Street | 166,251 | 110,391 | 276,642 | 202,125 |
| 25-013-0018 | Springfield | 242,876 | 184,840 | 427,716 | 555,225 |

Source: U.S. Census through NetAssess2020
* As stated in the 2015 Network Assessment which included additional sites that have since been shut down.

Notes about Figure 3-7:

- Changes to the $SO_2$ network since the 2015 assessment:
  - The Springfield site was moved to a new location within the same municipal boundaries.
- Springfield shows a significant change in population (+119%) compared to 2010. This may be due to changes in Connecticut's monitoring network. According to the NetAssess2020 tool, the Springfield polygon covers a large portion of Connecticut, including portions of Hartford.
- Child populations at all sites account for between 16% to 19% of the populations served, and senior populations ranged between 13% to 18%. Boston - Kenmore shows the largest sensitive population by total number (546,804); however, all show sensitive populations in the range of 29% to 34% of populations served.
- Springfield and Boston – Harrison Ave show the largest population of minorities by percentage (42% and 40%); however, Boston – Kenmore shows the largest by total number (556,354).
- The population share for individual monitors may not be as significant for $SO_2$ as the location of large stationary sources since $SO_2$ is primarily a point source pollutant, which limits the utility of the polygon analysis.

Since Massachusetts' population distribution has remained largely stable since 2010 and no significant shifts are expected in the future, MassDEP does not believe that it needs to change its network design based on population distribution.

## Sensitive Populations

### Children

The U.S. Census estimates that in 2017 there were 1,383,532 persons under the age of 18 years in Massachusetts comprising 20.4% of the population (down from about 21% in 2013).[1] Figure 3-8 shows the distribution of children by census tract for the state and Boston area. This distribution of children closely matches that of the general population. Figure 3-9 shows asthma prevalence in children throughout the state. Because the state is well covered by ozone and $PM_{2.5}$ monitors, the monitoring network provides good coverage for where children live and where pediatric asthma prevalence may be higher.

### Elderly

The U.S. Census estimates that in 2017 there were 1,049,751 persons 65 years or older in Massachusetts comprising about 15.5% of the population.[2] Figure 3-10 shows the distribution of elders by census tract for the state and Boston area. This distribution closely matches that of the general population as shown in Figure 3-1.1. Because the state is well covered by ozone and $PM_{2.5}$ monitors, the monitoring network provides good coverage for where persons 65 years or older live.

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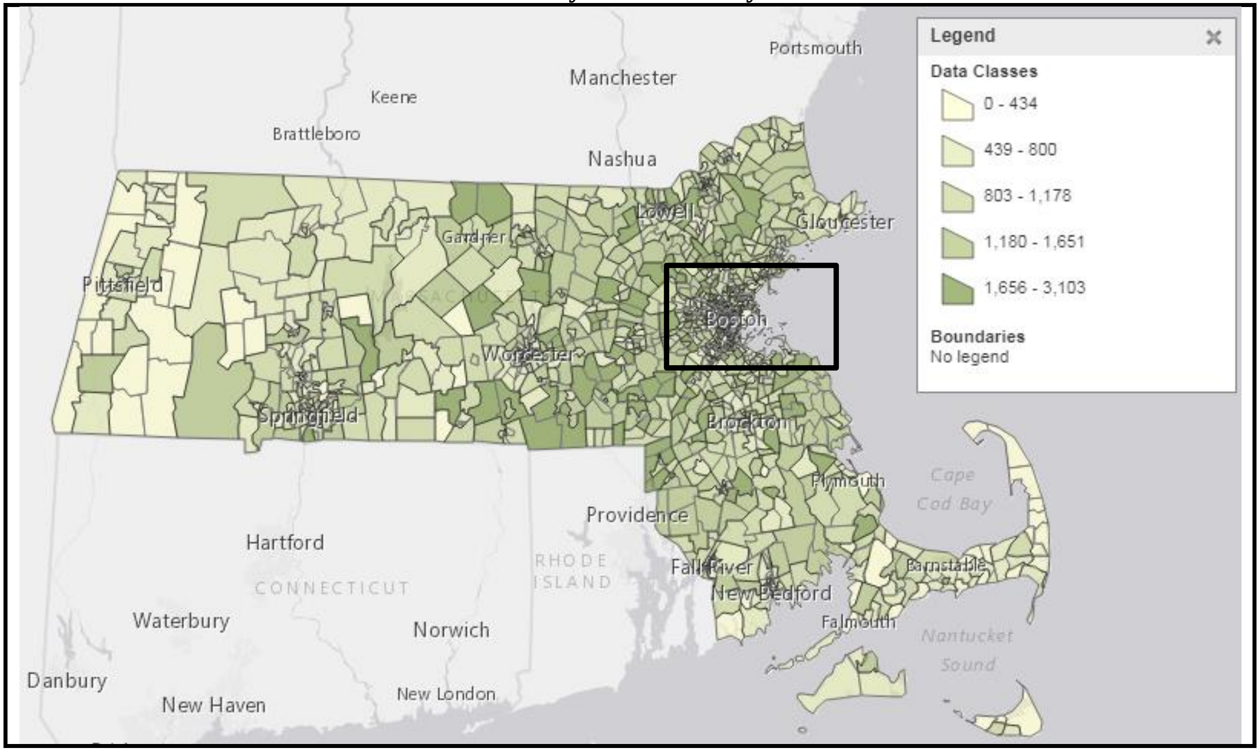
[1] U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_DP05&prodType=table

[2] U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_DP05&prodType=table

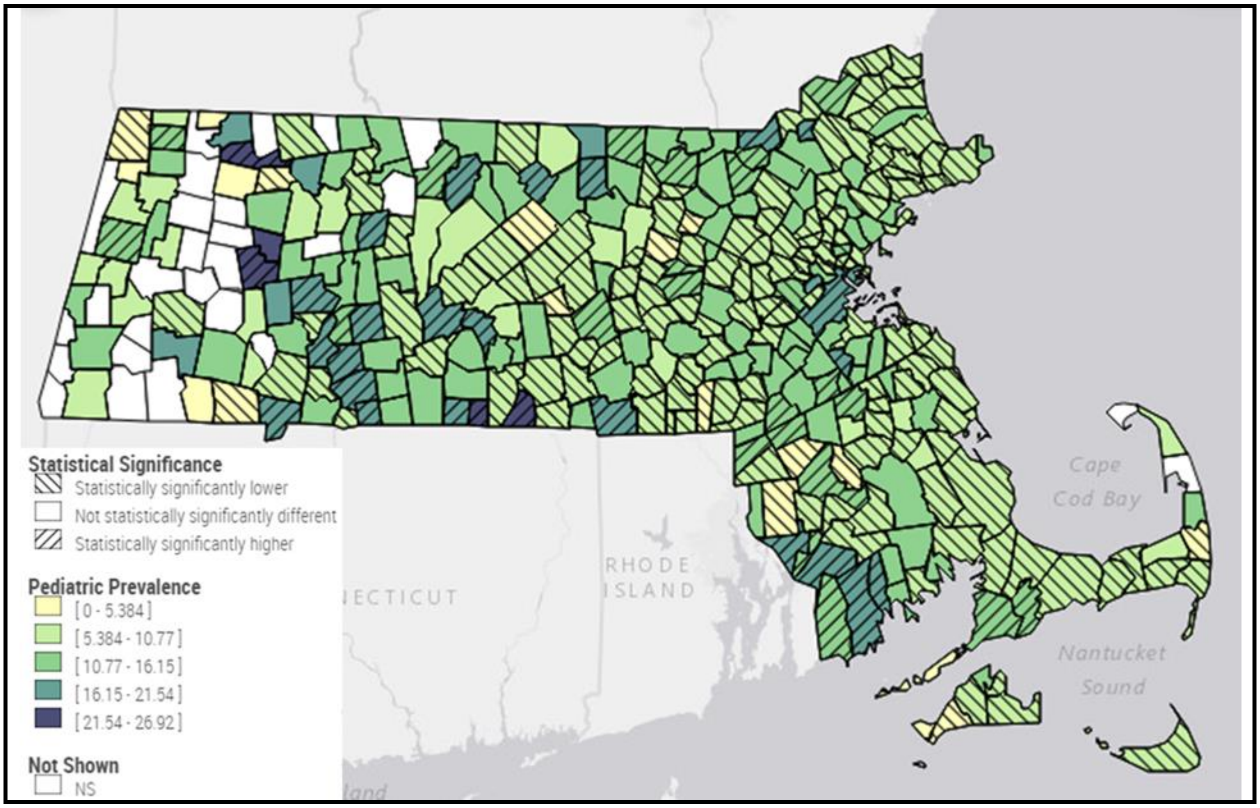
**Figure 3-8**
**Children Under 18 year in 2017 by Census Tract**





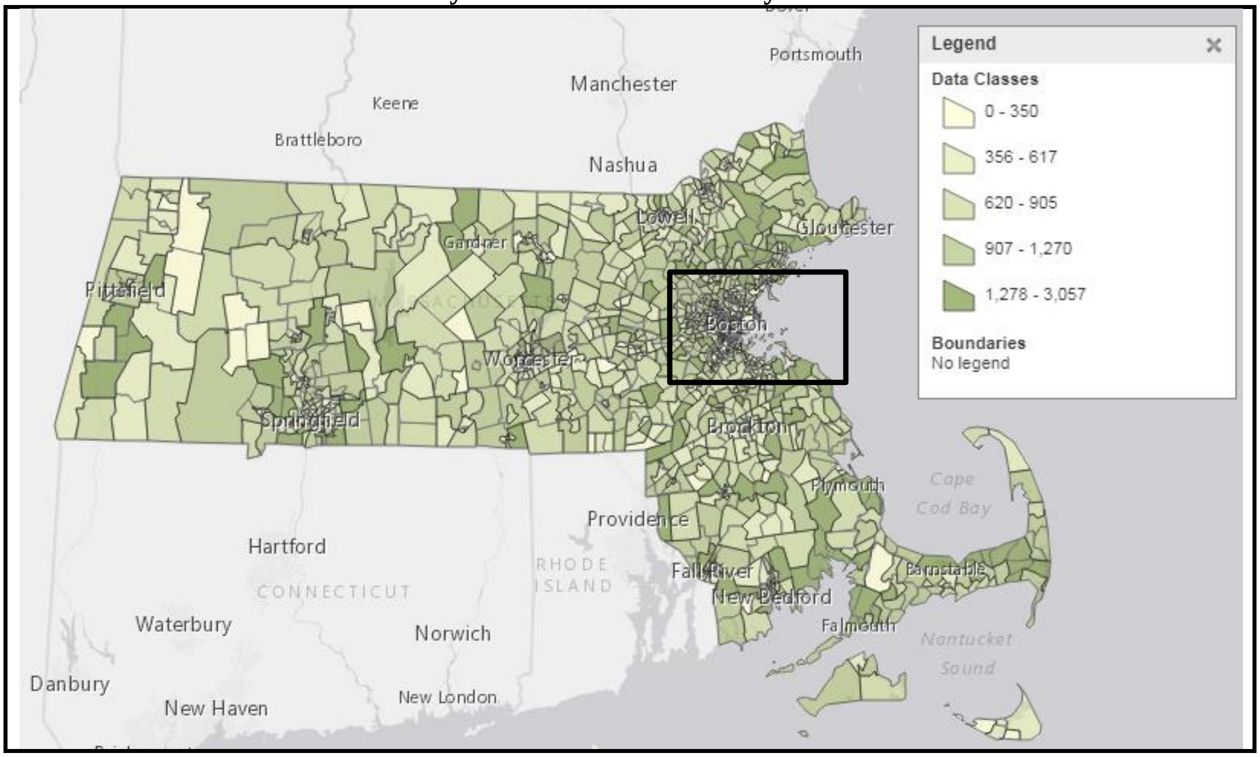
Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates
https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_DP05&prodType=table

**Figure 3-9**
**Pediatric Asthma Prevalence per 100 Students School Years 2016-2017 Ages 5-14**




Source: Massachusetts Environmental Public Health Tracking system
https://matracking.ehs.state.ma.us/Health-Data/Asthma/index.html

**Figure 3-10**
**Persons 65 years and Over in 2017 by Census Tract**





Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates
https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_DP05&prodType=table

**Environmental Justice Populations**

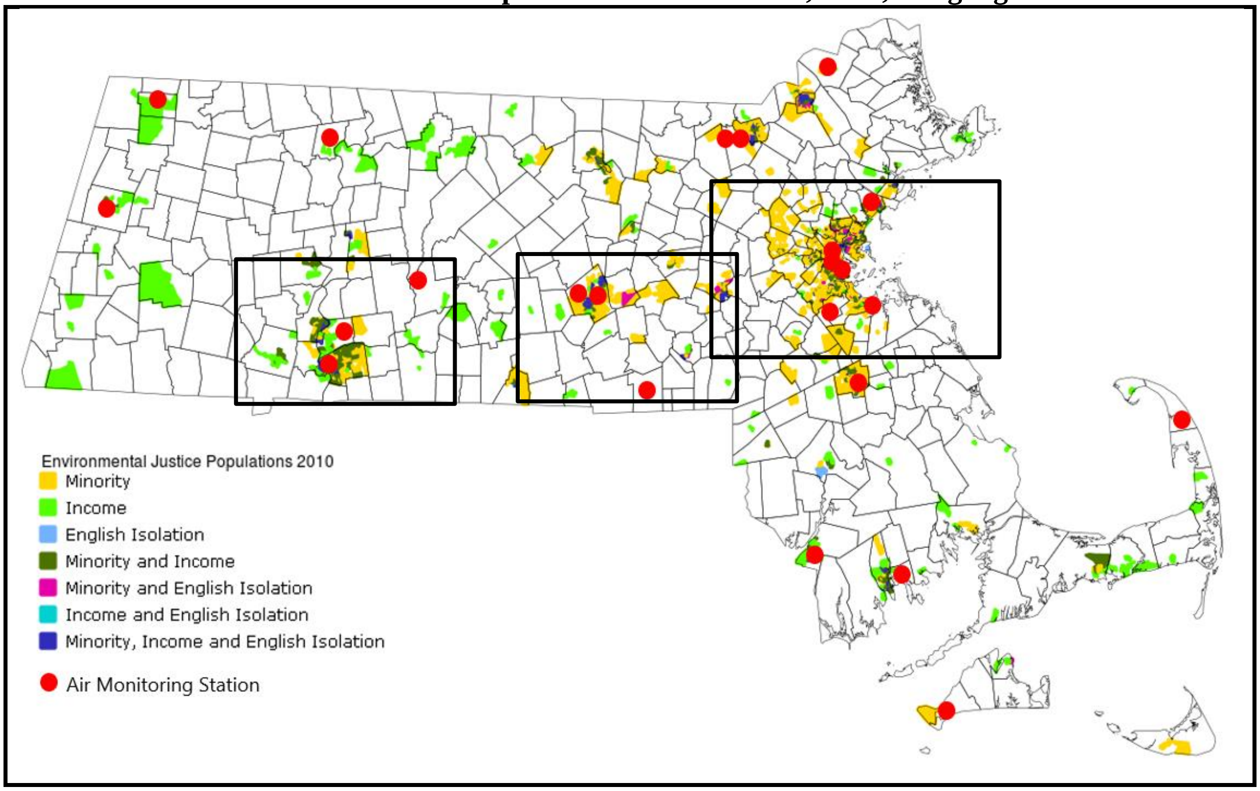
Figure 3-14 shows environmental justice (EJ) communities with monitoring stations overlaid. In Massachusetts a community is identified as an EJ community if any of the following are true:

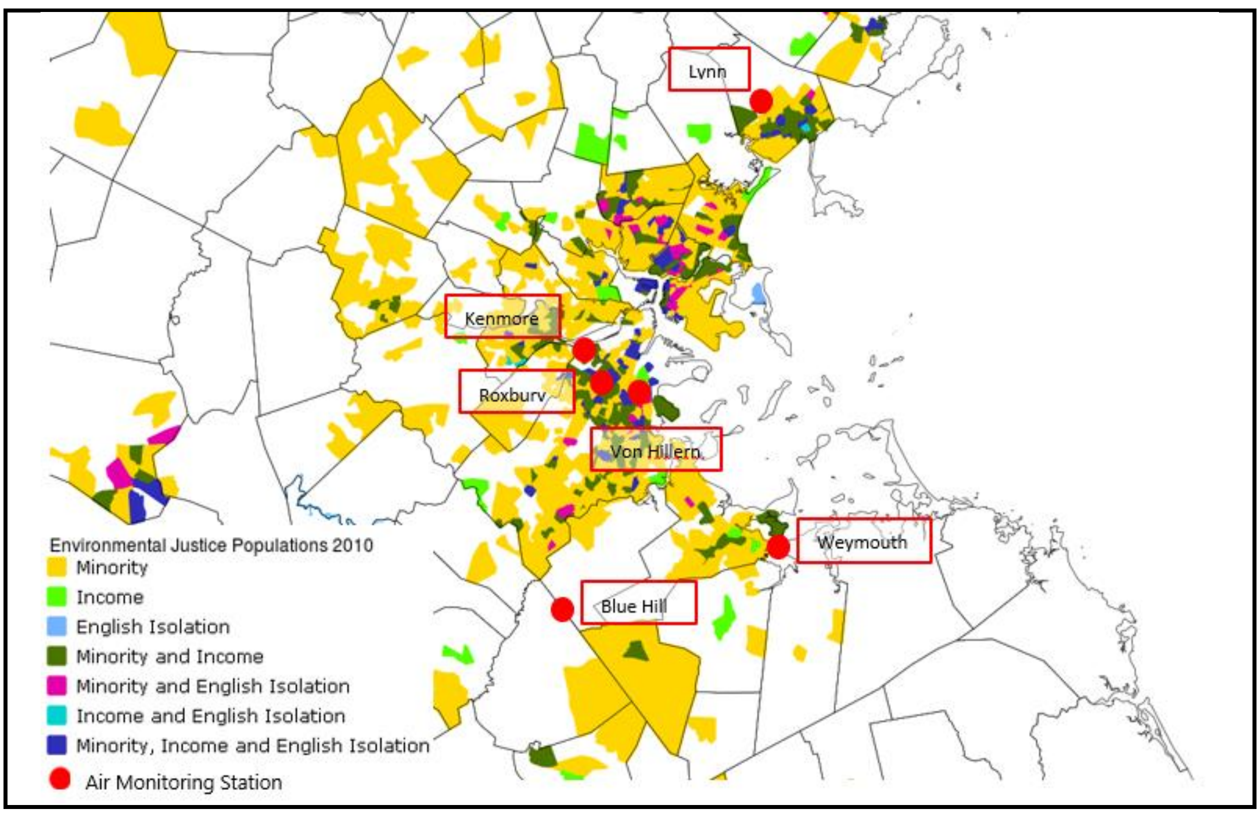
- Block group whose annual median household income is equal to or less than 65 percent of the statewide median; or
- 25% or more of the residents identify as a race other than white; or
- 25% or more of households have no one over the age of 14 who speaks English only or very well.

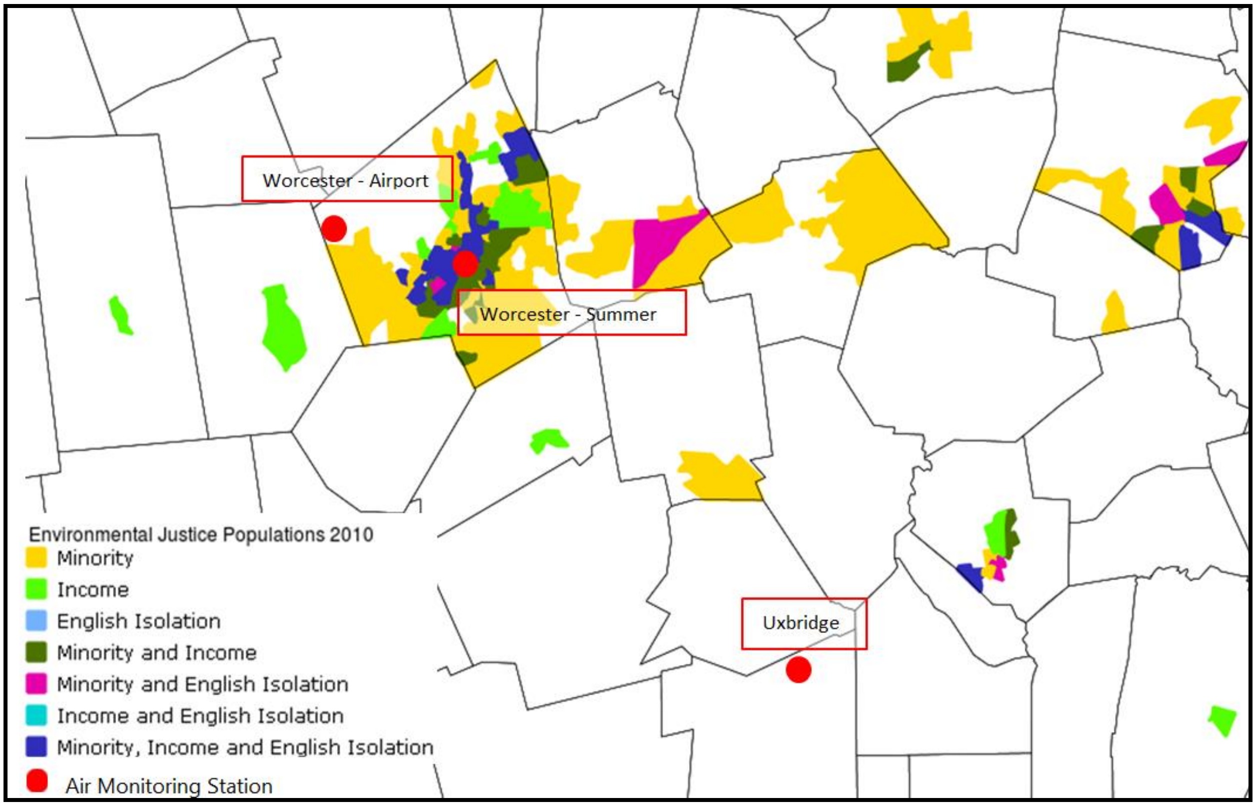
Based on the location of pollutant-specific monitors (as described in Section VI below), the following observations can be made:

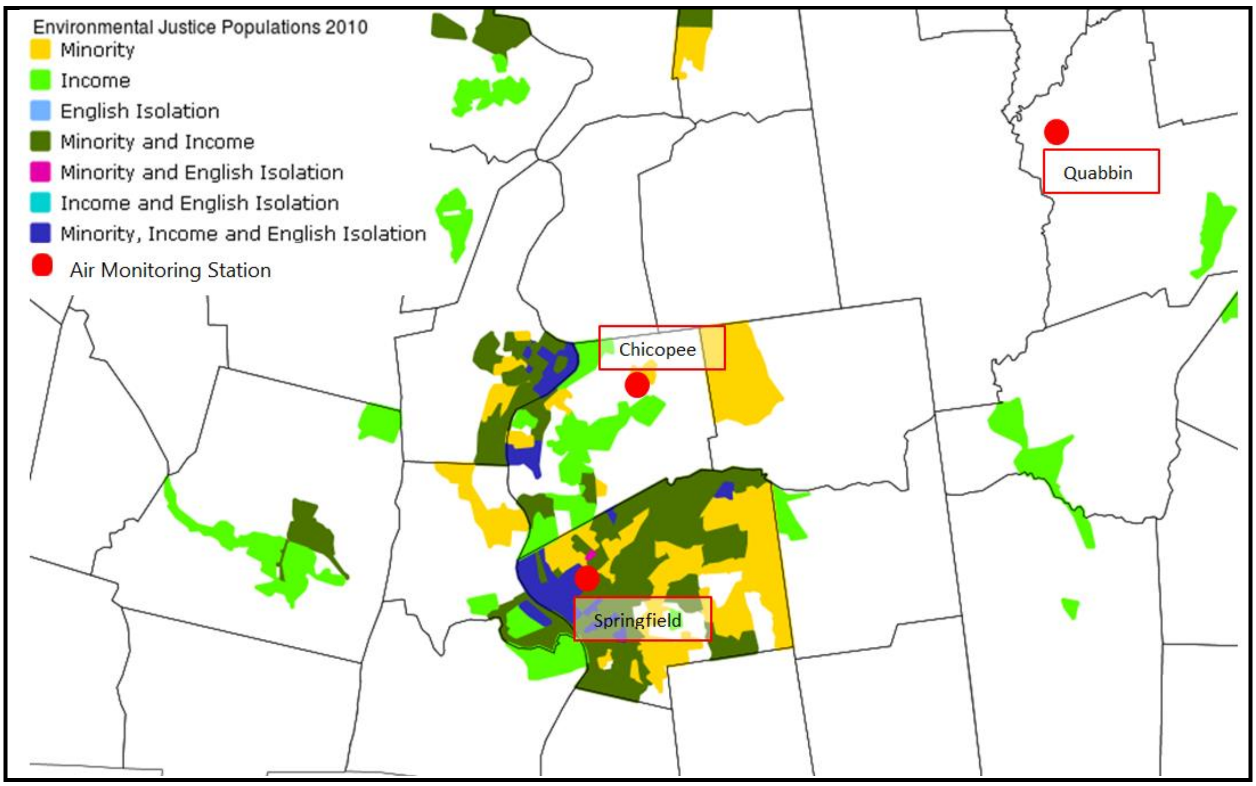
- $PM_{2.5}$ – Most of the larger clusters of urban EJ areas are adequately covered by $PM_{2.5}$ monitors. Urban EJ areas without $PM_{2.5}$ monitors (e.g., Leominster/Fitchburg and Framingham) generally would be expected to experience levels similar to other urban areas. Likewise, rural EJ areas in Western Massachusetts would be expected to experience levels similar to rural monitors in North Adams, Greenfield and Pittsfield. Importantly, $PM_{2.5}$ levels are well below the National Ambient Air Quality Standards statewide.
- Ozone – The state is adequately covered by ozone monitors, and levels do not vary dramatically over small distances.
- $NO_2$ – The near-road monitors at Chelmsford – Near Road and Boston – Von Hillern are designed to measure a maximum exposure level, and therefore generally would cover other areas of the state.
- $SO_2$ – The last coal-fired power station in Massachusetts, Brayton Point in Somerset, discontinued operations in 2017. $SO_2$ values throughout the state have remained very low for several years.
- CO – CO levels are so very low and have not been a concern for many years.

**Figure 3-11**
**Massachusetts EJ Populations 2010 – Income, Race, Language**






Source: MassGIS Environmental Justice Viewer
http://maps.massgis.state.ma.us/map_ol/ej.php

# IV. AIR QUALITY SUMMARY

MassDEP believes that emissions trends in Massachusetts do not suggest a need to change the distribution of monitors throughout the state for the following reasons:

- The decline in emissions has been uniform across the State;
- The number of new major point sources is limited and those that are permitted are well controlled;
- Existing point sources are emitting less;
- The monitoring network is designed to characterize highest concentrations and general background concentrations and population exposures rather than the impacts of individual sources; and
- There has been no significant change in population or distribution of vehicle miles travelled across the state and therefore limited change in the distribution of area and mobile source emissions across the state.

Ozone and $PM_{2.5}$ continue to be important pollutants to monitor and MassDEP maintains an extensive ozone and $PM_{2.5}$ monitoring network. Several ozone monitors are located in the southern and eastern part of the state where ozone transport entering the state is most likely to occur. MassDEP monitors $PM_{2.5}$ and black carbon to characterize wood smoke emissions. Continuous and filter-based $PM_{2.5}$ monitors are located throughout the state. Black carbon monitors are located at Boston – Roxbury, Boston – Von Hillern, Chelmsford – Near Road, Greenfield, North Adams, Pittsfield, and Springfield.

## National Ambient Air Quality Standards

Figure 4-1 shows the National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants: ozone ($O_3$); nitrogen dioxide ($NO_2$); particulate matter ($PM_{10}$ and $PM_{2.5}$); carbon monoxide (CO); sulfur dioxide ($SO_2$); and lead (Pb). EPA has classified Massachusetts as "attainment / unclassified" for all the NAAQS.

**Figure 4-1**

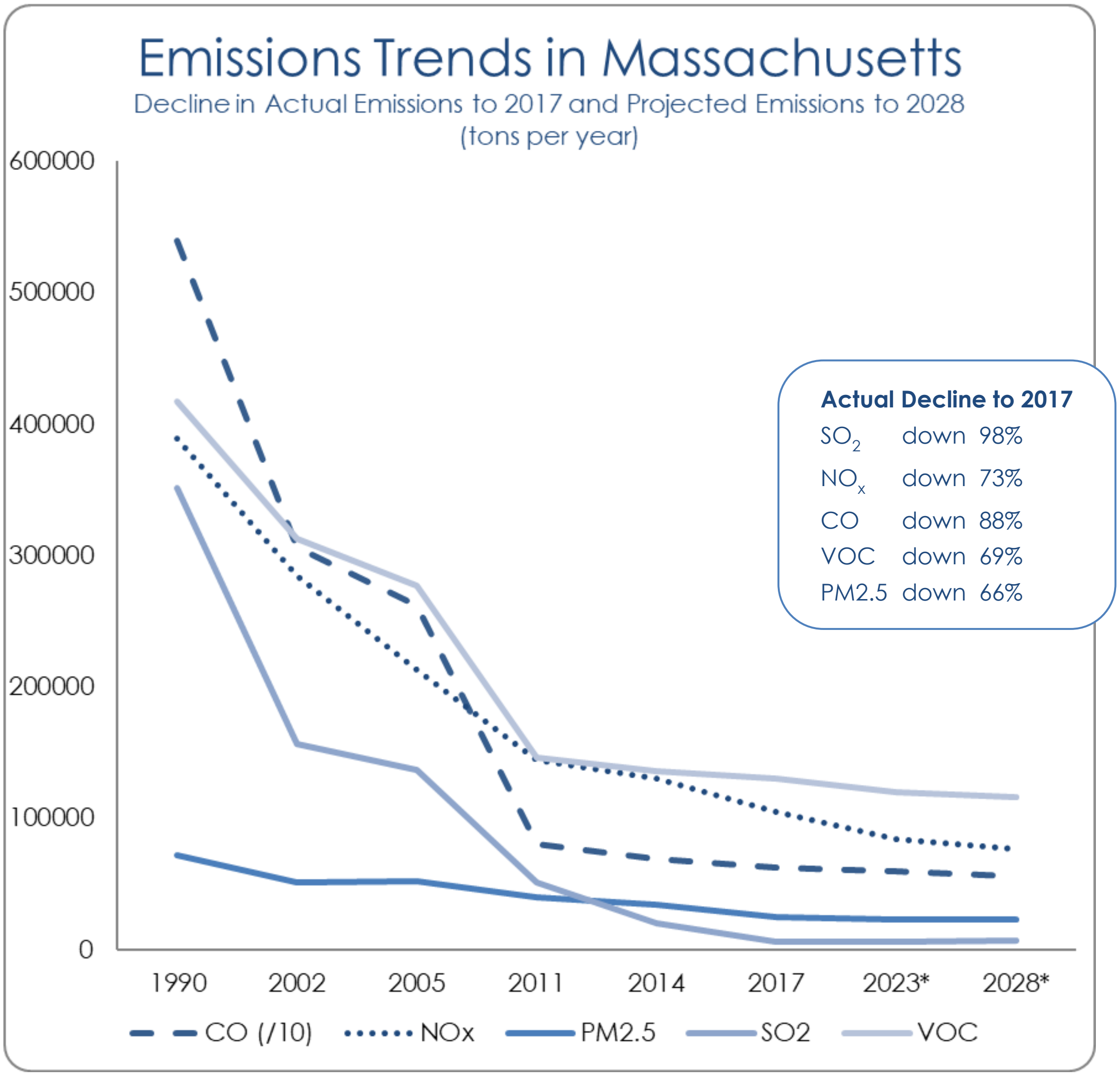
| National Ambient Air Quality Standards | | | | | |
|---|---|---|---|---|---|
| **Pollutant** | | **Primary/ Secondary** | **Averaging Time** | **Level** | **Form** |
| Carbon Monoxide | | primary | 8-hour | 9 ppm | Not to be exceeded more than once per year |
| | | | 1-hour | 35 ppm | |
| Lead | | primary and secondary | Rolling 3-month average | 0.15 μg/m$^3$ | Not to be exceeded |
| Nitrogen Dioxide | | primary | 1-hour | 100 ppb | 98$^{th}$ percentile, averaged over 3 years |
| | | primary and secondary | Annual | 0.053 ppm | Annual Mean |
| Ozone | | primary and secondary | 8-hour | 0.070 ppm | Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years |
| Particle Pollution | $PM_{2.5}$ | primary | Annual | 12 μg/m$^3$ | annual mean, averaged over 3 years |
| | | secondary | Annual | 15 μg/m$^3$ | annual mean, averaged over 3 years |
| | | primary and secondary | 24-hour | 35 μg/m$^3$ | 98$^{th}$ percentile, averaged over 3 years |
| | $PM_{10}$ | primary and secondary | 24-hour | 150 μg/m$^3$ | Not to be exceeded more than once per year on average over 3 years |
| Sulfur Dioxide | | primary | 1-hour | 75 ppb | 99$^{th}$ percentile of 1-hour daily maximum concentrations, averaged over 3 years |
| | | secondary | 3-hour | 0.5 ppm | Not to be exceeded more than once per year |

## Emissions Inventory Summary

Reductions in air pollution emissions since 1990 have led to significant improvements in air quality in Massachusetts. Figure 4-2 shows emissions reductions based on Massachusetts emissions inventory data from 1990 to 2017 (the most recent published inventory) and EPA projections to 2028, which show that the downward trends are expected to continue.

**Figure 4-2**

Source: MassDEP emissions inventories (file: Emissions by Pollutant County 2020.xlsx)



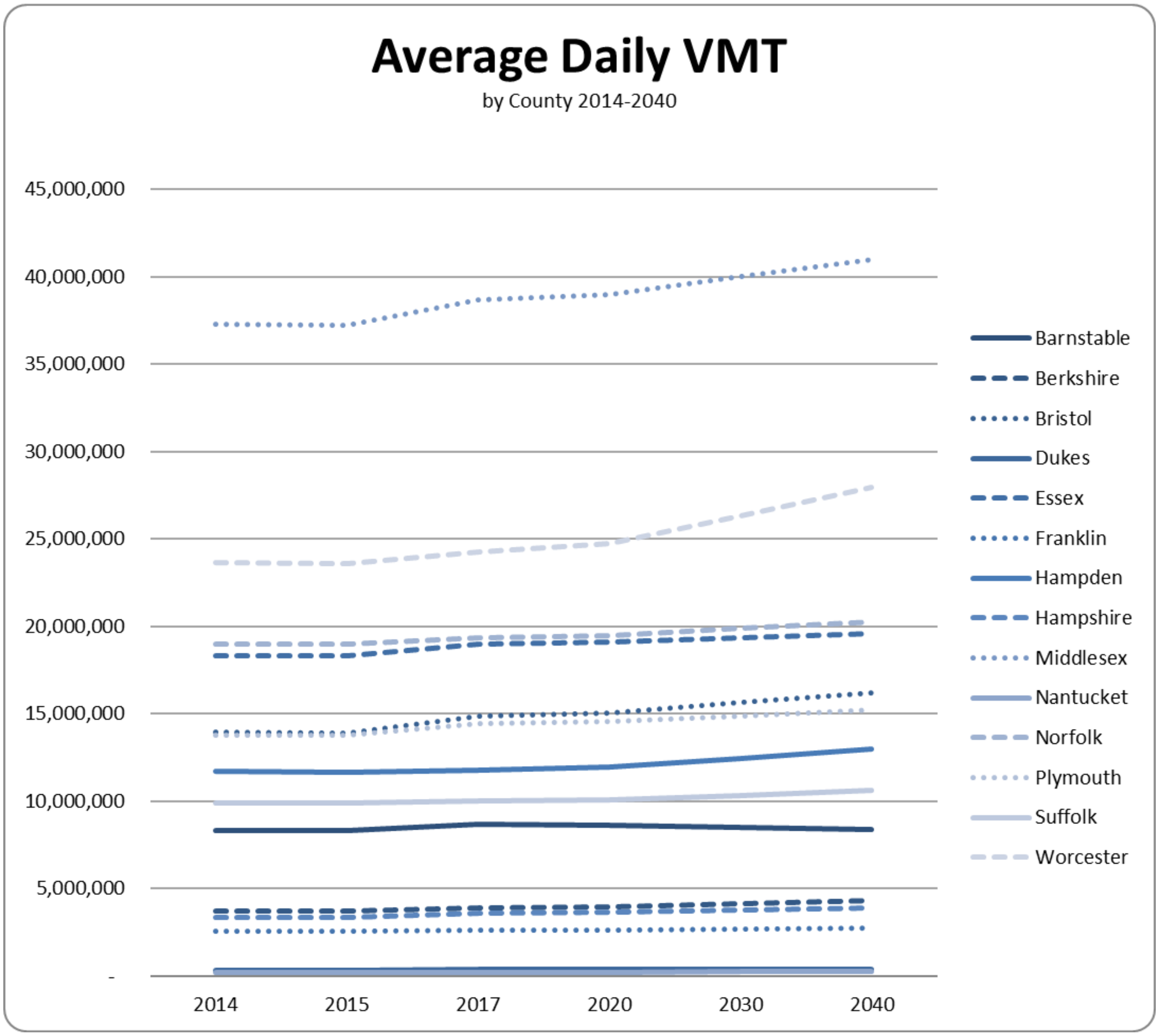

* Projected emissions from EPA 2016 Modeling Platform: ftp://newftp.epa.gov/air/emismod/2016/v1/reports/
Note: CO tons divided by 10 for ease of display with the other pollutants.

Vehicles make up one of the largest sources of VOC and $NO_x$ emissions. Vehicle miles travelled (VMT) indicate the relative distribution and magnitude of those emissions. In the past, as VMT increased, emissions increased. Today, due to new cleaner vehicles in the fleet, VMT does not always result in increased emissions.

Figure 4-3 shows there has been little change in the distribution of VMT across the state, and projections from the Massachusetts Department of Transportation (MassDOT) indicate this general distribution is expected to remain constant into the future. The one exception is Worcester County, where VMT is expected to rise gradually at a higher rate than other areas of the state. This change in VMT in Worcester County is not deemed significant for the purpose of designing the monitoring network.

**Figure 4-3**

Source: MassDOT Planning – emails from Bob Frey 5/15/2017 and 5/2/2019. Underlying sources: Highway Performance Monitoring System (HPMS), MassDOT Traffic Counting Program Data, Massachusetts Statewide Travel Demand Model, MassDOT Planning staff calculations. (file:




VMT Massachusetts by County 2020.xlsx)

## Distribution of Emission Reductions

Figure 4-4 shows that emissions reductions have been relatively uniform across the state.

**Figure 4-4**
**Emissions Reduction by Pollutant and County 1990 – 2017**

| County | Pollutant | 1990* | 2002 | 2005 | 2011 | 2014 | 2017 | % change 1990 - 2017 |
|---|---|---|---|---|---|---|---|---|
| Barnstable | CO | 213,453 | 201,372 | 210,206 | 47,949 | 41,556 | 37,259 | -83% |
| Barnstable | NOx | 18,652 | 23,181 | 12,723 | 8,141 | 7,356 | 5,928 | -68% |
| Barnstable | $PM_{2.5}$ | 3,603 | 4,074 | 3,346 | 1,491 | 1,281 | 913 | -75% |
| Barnstable | $SO_2$ | 63,372 | 28,445 | 28,276 | 1,309 | 512 | 146 | -100% |
| Barnstable | VOC | 19,681 | 21,209 | 15,975 | 8,245 | 7,636 | 7,329 | -63% |
| Berkshire | CO | 98,671 | 54,441 | 27,745 | 30,996 | 26,863 | 24,085 | -76% |
| Berkshire | NOx | 10,665 | 8,349 | 6,105 | 4,364 | 3,943 | 3,178 | -70% |
| Berkshire | $PM_{2.5}$ | 4,315 | 2,414 | 2,393 | 2,631 | 2,260 | 1,612 | -63% |
| Berkshire | $SO_2$ | 10,629 | 1,962 | 2,521 | 707 | 276 | 79 | -99% |
| Berkshire | VOC | 14,161 | 11,139 | 7,869 | 5,676 | 5,256 | 5,045 | -64% |
| Bristol | CO | 447,624 | 188,978 | 160,148 | 58,119 | 50,369 | 45,161 | -90% |
| Bristol | NOx | 62,226 | 28,237 | 23,756 | 12,619 | 11,402 | 9,189 | -85% |
| Bristol | $PM_{2.5}$ | 5,223 | 5,874 | 5,843 | 2,786 | 2,394 | 1,706 | -67% |
| Bristol | $SO_2$ | 103,652 | 48,701 | 41,578 | 20,516 | 8,018 | 2,287 | -98% |
| Bristol | VOC | 32,154 | 24,870 | 19,159 | 11,125 | 10,303 | 9,888 | -69% |
| Dukes | CO | 25,104 | 24,053 | 20,948 | 12,283 | 10,645 | 9,544 | -62% |
| Dukes | NOx | 696 | 4,291 | 2,119 | 2,544 | 2,299 | 1,853 | -57% |
| Dukes | $PM_{2.5}$ | 532 | 895 | 738 | 744 | 639 | 456 | -49% |
| Dukes | $SO_2$ | 229 | 1,557 | 313 | 526 | 206 | 59 | -96% |
| Dukes | VOC | 4,248 | 3,398 | 2,460 | 2,466 | 2,284 | 2,192 | -48% |
| Essex | CO | 606,854 | 264,599 | 233,286 | 90,005 | 78,004 | 69,938 | -88% |
| Essex | NOx | 48,276 | 25,299 | 21,906 | 16,523 | 14,930 | 12,032 | -75% |
| Essex | $PM_{2.5}$ | 6,114 | 3,457 | 4,525 | 4,050 | 3,480 | 2,481 | -59% |
| Essex | $SO_2$ | 56,349 | 20,259 | 17,201 | 6,233 | 2,436 | 695 | -99% |
| Essex | VOC | 50,166 | 30,433 | 26,192 | 16,435 | 15,220 | 14,608 | -71% |
| Franklin | CO | 131,409 | 78,095 | 53,340 | 22,215 | 19,166 | 17,184 | -87% |
| Franklin | NOx | 6,726 | 5,950 | 3,971 | 2,856 | 2,581 | 2,080 | -69% |
| Franklin | $PM_{2.5}$ | 2,914 | 2,342 | 2,324 | 2,140 | 1,839 | 1,311 | -55% |
| Franklin | $SO_2$ | 2,370 | 895 | 1,029 | 567 | 222 | 63 | -97% |
| Franklin | VOC | 12,687 | 8,581 | 30,042 | 4,691 | 4,344 | 4,170 | -67% |
| Hampden | CO | 403,137 | 207,516 | 166,954 | 62,090 | 53,811 | 48,247 | -88% |
| Hampden | NOx | 26,049 | 19,981 | 10,861 | 10,827 | 9,783 | 7,884 | -70% |
| Hampden | $PM_{2.5}$ | 4,830 | 3,940 | 3,858 | 3,400 | 2,921 | 2,083 | -57% |
| Hampden | $SO_2$ | 20,242 | 9,851 | 9,710 | 2,453 | 959 | 273 | -99% |
| Hampden | VOC | 25,328 | 20,105 | 16,192 | 11,505 | 10,655 | 10,226 | -60% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Hampshire | CO | 155,653 | 87,955 | 63,832 | 24,911 | 21,589 | 19,357 | -88% |
| Hampshire | NOx | 7,683 | 5,698 | 4,337 | 3,539 | 3,198 | 2,577 | -66% |
| Hampshire | $PM_{2.5}$ | 2,905 | 2,512 | 2,498 | 2,206 | 1,895 | 1,351 | -53% |
| Hampshire | $SO_2$ | 3,248 | 1,000 | 1,526 | 587 | 229 | 65 | -98% |
| Hampshire | VOC | 12,788 | 9,191 | 6,382 | 4,170 | 3,862 | 3,707 | -71% |
| Middlesex | CO | 1,194,565 | 686,832 | 581,188 | 157,134 | 136,182 | 122,101 | -90% |
| Middlesex | NOx | 62,563 | 49,016 | 43,608 | 26,233 | 23,704 | 19,103 | -69% |
| Middlesex | $PM_{2.5}$ | 12,491 | 7,391 | 7,418 | 5,459 | 4,690 | 3,344 | -73% |
| Middlesex | $SO_2$ | 36,758 | 14,068 | 15,249 | 5,336 | 2,085 | 595 | -98% |
| Middlesex | VOC | 87,722 | 62,071 | 54,218 | 27,230 | 25,217 | 24,203 | -72% |
| Nantucket | CO | 16,927 | 21,379 | 15,134 | 7,082 | 6,138 | 5,503 | -67% |
| Nantucket | NOx | 2,325 | 18,760 | 644 | 1,139 | 1,029 | 829 | -64% |
| Nantucket | $PM_{2.5}$ | 302 | 1,899 | 611 | 270 | 232 | 165 | -45% |
| Nantucket | $SO_2$ | 625 | 10,541 | 99 | 271 | 106 | 30 | -95% |
| Nantucket | VOC | 2,612 | 2,890 | 1,632 | 1,161 | 1,075 | 1,032 | -60% |
| Norfolk | CO | 620,449 | 430,702 | 375,218 | 74,817 | 64,841 | 58,136 | -91% |
| Norfolk | NOx | 27,280 | 28,588 | 25,053 | 13,135 | 11,869 | 9,565 | -65% |
| Norfolk | $PM_{2.5}$ | 5,560 | 3,931 | 3,899 | 2,556 | 2,196 | 1,566 | -72% |
| Norfolk | $SO_2$ | 10,548 | 4,137 | 4,270 | 2,796 | 1,093 | 312 | -97% |
| Norfolk | VOC | 42,215 | 33,557 | 27,741 | 12,847 | 11,897 | 11,419 | -73% |
| Plymouth | CO | 391,226 | 193,139 | 168,608 | 60,471 | 52,408 | 46,989 | -88% |
| Plymouth | NOx | 18,899 | 13,313 | 11,060 | 10,417 | 9,413 | 7,586 | -60% |
| Plymouth | $PM_{2.5}$ | 6,851 | 4,191 | 4,147 | 2,808 | 2,412 | 1,720 | -75% |
| Plymouth | $SO_2$ | 7,606 | 3,005 | 2,723 | 2,463 | 963 | 275 | -96% |
| Plymouth | VOC | 36,613 | 22,757 | 16,980 | 11,279 | 10,445 | 10,025 | -73% |
| Suffolk | CO | 388,528 | 202,518 | 178,554 | 53,251 | 46,151 | 41,379 | -89% |
| Suffolk | NOx | 59,772 | 21,453 | 18,719 | 14,784 | 13,359 | 10,766 | -82% |
| Suffolk | $PM_{2.5}$ | 6,075 | 1,781 | 2,403 | 2,241 | 1,925 | 1,373 | -77% |
| Suffolk | $SO_2$ | 21,869 | 5,787 | 5,367 | 4,388 | 1,715 | 489 | -98% |
| Suffolk | VOC | 25,017 | 20,254 | 18,613 | 11,059 | 10,242 | 9,830 | -61% |
| Worcester | CO | 701631 | 421,181 | 366,744 | 101,129 | 87,645 | 78,582 | -89% |
| Worcester | NOx | 37,342 | 32,895 | 28,065 | 17,606 | 15,908 | 12,821 | -66% |
| Worcester | $PM_{2.5}$ | 10,254 | 6,882 | 7,941 | 7,556 | 6,492 | 4,628 | -55% |
| Worcester | $SO_2$ | 14,381 | 6,159 | 6,837 | 3,600 | 1,407 | 401 | -97% |
| Worcester | VOC | 52,203 | 42,911 | 34,030 | 18,682 | 17,301 | 16,606 | -68% |
| Statewide | CO | 5,395,231 | 3,062,760 | 2,621,905 | 802,452 | 695,368 | 623,465 | -88% |
| Statewide | NOx | 389,154 | 285,011 | 212,927 | 144,727 | 130,774 | 105,391 | -73% |
| Statewide | $PM_{2.5}$ | 71,969 | 51,583 | 51,944 | 40,338 | 34,656 | 24,709 | -66% |
| Statewide | $SO_2$ | 351,878 | 156,367 | 136,699 | 51,752 | 20,227 | 5,769 | -98% |
| Statewide | VOC | 417,595 | 313,366 | 277,485 | 146,571 | 135,737 | 130,280 | -69% |

Source:
2017 data: EPA NEI v.1.0 -- EIS Gateway report download (file: Emissions by Pollutant County 2020.xlsx)
2014 data: EPA NEI v.2 -- EIS Gateway report download
2011 data: MassDEP 2011 Emissions Inventory (http://www.mass.gov/eea/agencies/massdep/air/reports/emissions-inventories.html)
2005 data: State and County Emission Summaries http://www.epa.gov/air/emissions/index.htm
1990 and 2002 data: Air Data: Access to Air Pollution Data Reports and Maps http://www.epa.gov/air/data/geosel.html
* For 1990, VOC, NOx and CO were estimated by multiplying TPSD from Table 1.2 of Section 1 of MA 2014 PEI Report by 312 days (52wks x 6days). Value estimate for 1990 for NOx for Dukes county appears anomalous and so reductions were calculated from 2002 instead of 1990.
Note: Used the county percent from 2011 and applied to 2014 and 2017 statewide values

# V. POLLUTANT NETWORK STATUS

Section V summarizes the status of the ambient air quality monitoring for each of the following pollutants:

- Particulate matter (PM) (including speciation and air toxics)
- Ozone ($O_3$) (including PAMS monitoring)
- Carbon monoxide (CO)
- Lead (Pb)
- Sulfur dioxide ($SO_2$)
- Nitrogen dioxide ($NO_2$) (including $NO_x$, other oxides of nitrogen)

The following topics are covered for each of these pollutants:

- Monitor locations/descriptions/purposes
- Coverage area
- Monitoring data
- Technological issues
- Adequacy of the Monitoring Network including, for ozone and $PM_{2.5}$, Correlations, New Sites Analysis, and Removal Bias Data
- Analysis results

Section V also assesses the Meteorological Network and describes Quality Assurance and Quality Control (QA/QC) activities.

## Particulate Matter (PM)

### Network Description

MassDEP operates PM monitors at 16 locations across the Commonwealth. The National Park Service and Wampanoag Tribe operate PM monitors at two additional locations for the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. At least one monitor is located in each county except for Norfolk and Nantucket. The PM network consists of:

- $PM_{10}$ – 3 sites:
  - All with low volume samplers.
  - One (Boston-Harrison Avenue) with collocated low-volume samplers. Filters from this site are analyzed for toxic elements as part of the National Air Toxics Trends Stations (NATTS) air monitoring program and for lead as required by the NCore program.

- $PM_{2.5}$ – 18 sites:
  - 15 Federal Equivalent Method (FEM) sites, nine of which are collocated with Federal Reference Method (FRM) samplers. Data from all sites in MassDEP's FEM network are currently used to determine compliance with the $PM_{2.5}$ NAAQS. FEMs provide the hourly $PM_{2.5}$ data that appears on MassDEP's website.

  - Ten FRM $PM_{2.5}$ sites. One (Chicopee) with collocated samplers. Five sites are on a 1-in-3 day schedule and five sites are on a 1-in 6 day schedule.

  - Two IMPROVE samplers operated by the National Park Service and Wampanoag Tribe are on a 1-in-3 day schedule.

- $PM_{coarse}$ ($PM_{10}$ – $PM_{2.5}$) – One site in compliance with NCore requirements at the designated NCore site at Boston-Harrison Avenue.

- Speciated $PM_{2.5}$ – Four sites:
  - Two FRM sites (Boston-Harrison Avenue and Chicopee). The speciated $PM_{2.5}$ program is designed to determine some of the chemical constituents (elements, sulfates, nitrates, carbon species) that are contained in $PM_{2.5}$, which can provide information about the sources of the PM.

  - Two IMPROVE sampling sites (Truro and Aquinnah – Martha's Vineyard) that provide speciated $PM_{2.5}$ data. The IMPROVE program measures, at rural locations, parameters that are similar to those measured by the speciation program. The data are used to evaluate the role of fine particulates and their constituents in the degradation of visibility.

Figure 5-1 lists the particulate matter sites, their location, type of monitoring and purpose of the monitoring.

## Figure 5-1
## PM Monitoring Sites

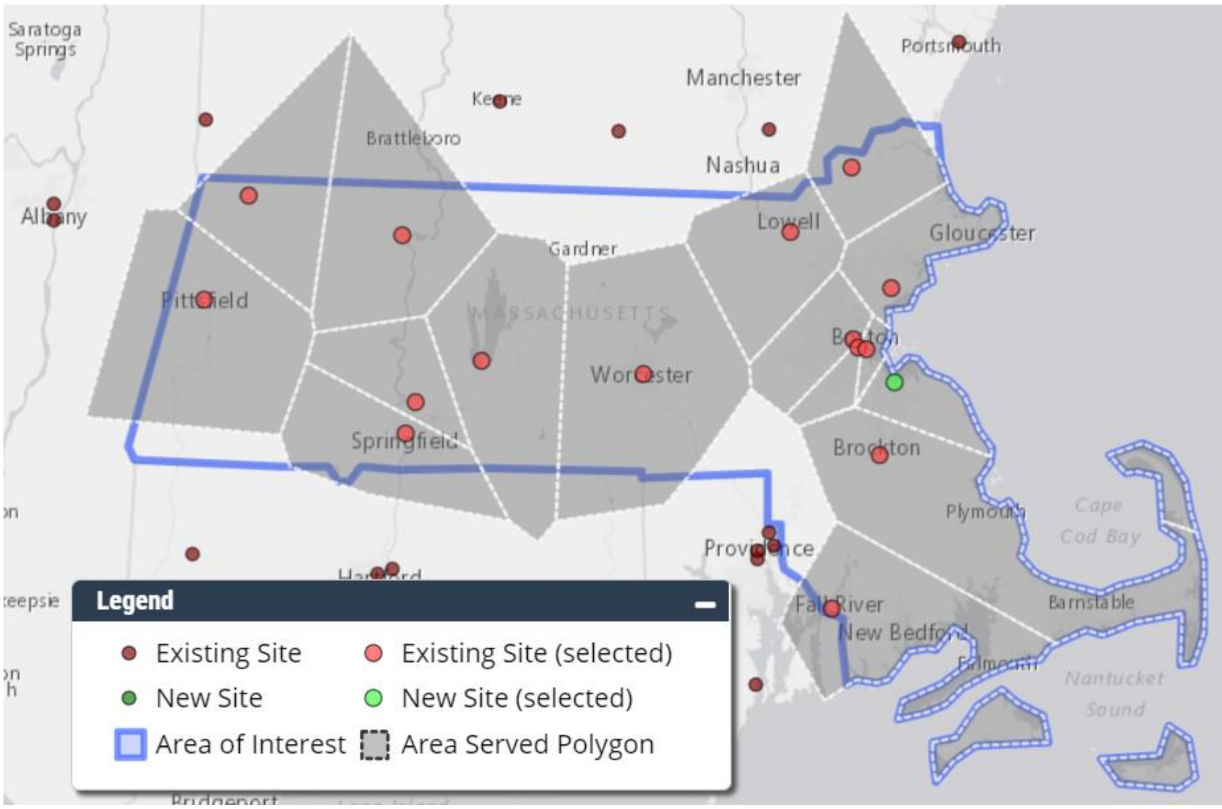
| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA / MiSA | PM Type |
|---|---|---|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | Micro | Highest Concentration; Pop Exposure | 1/1/1965 | Boston-Cambridge-Newton | FRM |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton | $PM_{10}$, FRM, FEM |
| 25-025-0044 | Boston - Von Hillern | Middle | Pop Exposure; Highest Concentration | 6/15/2013 | Boston-Cambridge-Newton | FRM, FEM |
| 25-023-0005 | Brockton | Neighborhood | Population Exposure | 6/30/2013 | Boston-Cambridge-Newton | FRM, FEM |
| 25-017-0010 | Chelmsford - Near Road | Middle | Population Exposure | 7/1/2018 | Boston-Cambridge-Newton | FEM |
| 25-013-0008 | Chicopee | Urban | Population Exposure | 1/1/1983 | Springfield | FRM, FEM |
| 25-005-1004 | Fall River | Neighborhood | Population Exposure | 2/1/1975 | Providence-Warwick | FEM |
| 25-011-2005 | Greenfield | Neighborhood | Population Exposure | 1/1/2014 | Greenfield Town | FRM, FEM |
| 25-009-5005 | Haverhill | Neighborhood | Population Exposure | 7/19/1994 | Boston-Cambridge-Newton | FRM, FEM |
| 25-009-2006 | Lynn | Neighborhood | PAMS - Max Precursor $O_3$; Pop Exposure | 1/1/1992 | Boston-Cambridge-Newton | FEM |
| 25-003-6001 | North Adams | Neighborhood | Population Exposure | 7/1/2017 | Pittsfield | FEM |
| 25-003-0008 | Pittsfield | Neighborhood | Population Exposure | 7/1/2018 | Pittsfield | FEM |
| 25-013-0018 | Springfield | Urban | Highest Concentration; Pop Exposure | 5/1/2018 | Springfield | FRM, FEM |
| 25-001-0002 | Truro | Regional | General Background | 4/1/1987 | Barnstable | IMPROVE |
| 25-015-4002 | Ware | Urban | Highest $O_3$; Background other pollutants | 6/1/1985 | Springfield | $PM_{10}$, FEM |
| 25-021-2004 | Weymouth | Neighborhood | Population Exposure | 2/4/2020 | Boston-Cambridge-Newton | FEM |
| 25-027-0023 | Worcester - Summer St | Urban | Population Exposure | 1/1/2004 | Worcester | $PM_{10}$, FRM, FEM |
| 25-007-0001 | Aquinnah | Regional | Regional | 4/1/2004 | Vineyard Haven | IMPROVE |

MSA = Metropolitan Statistical Area
MiSA = Micropolitan Statistical Area

### Monitor Area Served

Figure 5-2 shows the area served by each $PM_{2.5}$ monitor as defined by Voroni polygons. These polygons were developed using EPA's NetAssess tool. The polygons show that the state is well covered by monitors in Massachusetts or in neighboring states.

**Figure 5-2**
**Area Served – $PM_{2.5}$ FRM and FEM sites**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool https://sti-r-shiny.shinyapps.io/EPA_Network_Assessment/.

Notes: Co-located PM2.5 monitors are treated as a single location. One site (Weymouth - 25-021-2004) was established after the NetAssess2020 tool was compiled; therefore the site was added manually using functions in the NetAssess2020 tool.

## PM MONITORING DATA

### 2019 $PM_{10}$ Data Summary

Figure 5-3 shows a summary of 2019 $PM_{10}$ data. All values are well below applicable NAAQS.

**Figure 5-3**
**2019 $PM_{10}$ FRM Annual Data Summary (µg/m³)**

| City | County | Address | 1ST MAX 24-HR | 2ND MAX 24-HR | 3RD MAX 24-HR | 4TH MAX 24-HR | DAYS MAX >STD | ARITH MEAN |
|---|---|---|---|---|---|---|---|---|
| Boston | Suffolk | Harrison Avenue | 27 | 27 | 22 | 20 | 0 | 10.1 |
| Boston | Suffolk | Harrison Avenue* | 28 | 22 | 20 | 19 | 0 | 9.9 |
| Ware | Hampshire | Skyline Drive | 17 | 15 | 15 | 13 | 0 | 6.0 |
| Worcester | Worcester | Summer St | 52 | 37 | 33 | 27 | 0 | 12.7 |

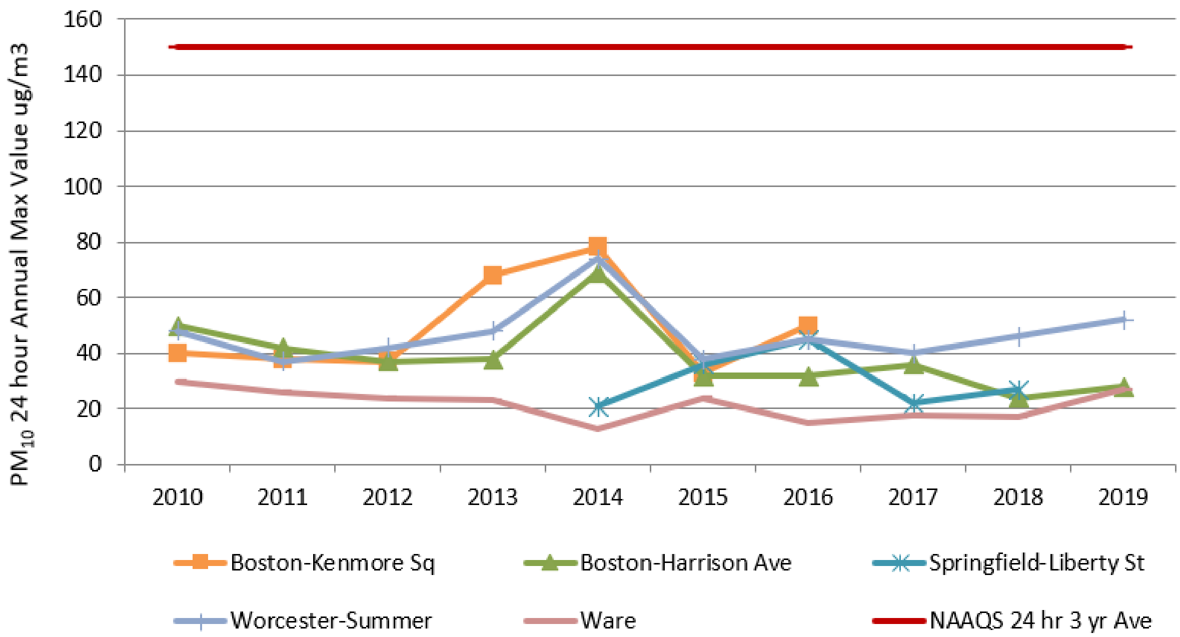
Standard: 24-hour = 150 µg/m3

* = Collocated monitors
1ST, 2ND, 3RD, 4TH 24-HR MAX = 1ST, 2ND, 3RD, and 4TH Highest 24-hr Values for the Year
ARITH MEAN = Annual Arithmetic Mean

### $PM_{10}$ Trends

Figure 5-4 shows trends for each $PM_{10}$ monitor relative to the 24-hour standard of 150 µg/m³.

**Figure 5-4**
**$PM_{10}$ Trends 2010-2019 Annual Arithmetic Mean**



## $PM_{2.5}$ 2019 Data Summary

Figure 5-5 shows a summary of the 2019 FRM $PM_{2.5}$ data. All values are well below applicable NAAQS.

**Figure 5-5**
**2019 $PM_{2.5}$ FRM Annual Data Summary (µg/m$^3$)**

| City | County | Address | 1ST MAX 24-HR | 2ND MAX 24-HR | 3RD MAX 24-HR | 4TH MAX 24-HR | 98$^{TH}$ PECENTILE 24-HR | ARITH MEAN |
|---|---|---|---|---|---|---|---|---|
| Boston | Suffolk | Kenmore Square | 15.0 | 13.3 | 12.9 | 12.7 | 12.9 | 5.67 |
| Boston | Suffolk | Harrison Avenue | 13.5 | 13.2 | 13.0 | 12.1 | 13.0 | 5.22 |
| Boston | Suffolk | Von Hillern Street | 12.0 | 12.0 | 11.7 | 11.6 | 12.0 | 5.66 |
| Brockton | Plymouth | Clinton Street | 12.2 | 11.6 | 11.5 | 9.9 | 11.6 | 4.82 |
| Chicopee | Hampden | Anderson Road | 13.4 | 12.9 | 12.7 | 12.4 | 12.7 | 4.98 |
| Chicopee | Hampden | Anderson Road* | 13.1 | 13.0 | 13.0 | 12.7 | 13.0 | 5.15 |
| Greenfield | Franklin | Barr Avenue | 20.0 | 13.5 | 13.2 | 13.1 | 13.2 | 5.47 |
| Haverhill | Essex | Washington Street | 11.3 | 10.6 | 9.8 | 8.7 | 10.6 | 4.49 |
| Pittsfield | Berkshire | Silver Lake Blvd | 19.0 | 15.7 | 13.2 | 13.2 | 13.2 | 5.32 |
| Springfield | Hampden | Liberty Street | 16.2 | 15.0 | 14.5 | 13.4 | 15.0 | 6.67 |
| Worcester | Worcester | Summer Street | 13.4 | 11.1 | 10.8 | 10.6 | 11.1 | 5.03 |

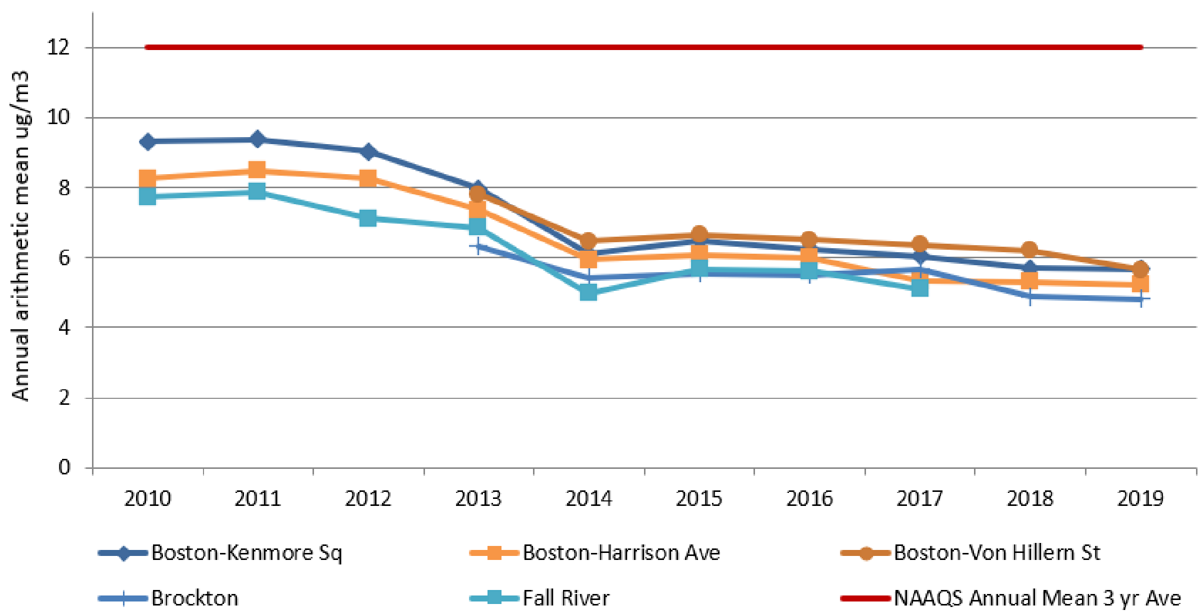
Standards: Annual Mean = 12 µg/m$^3$ (primary)
24-hour (98th percentile) = 35 µg/m$^3$

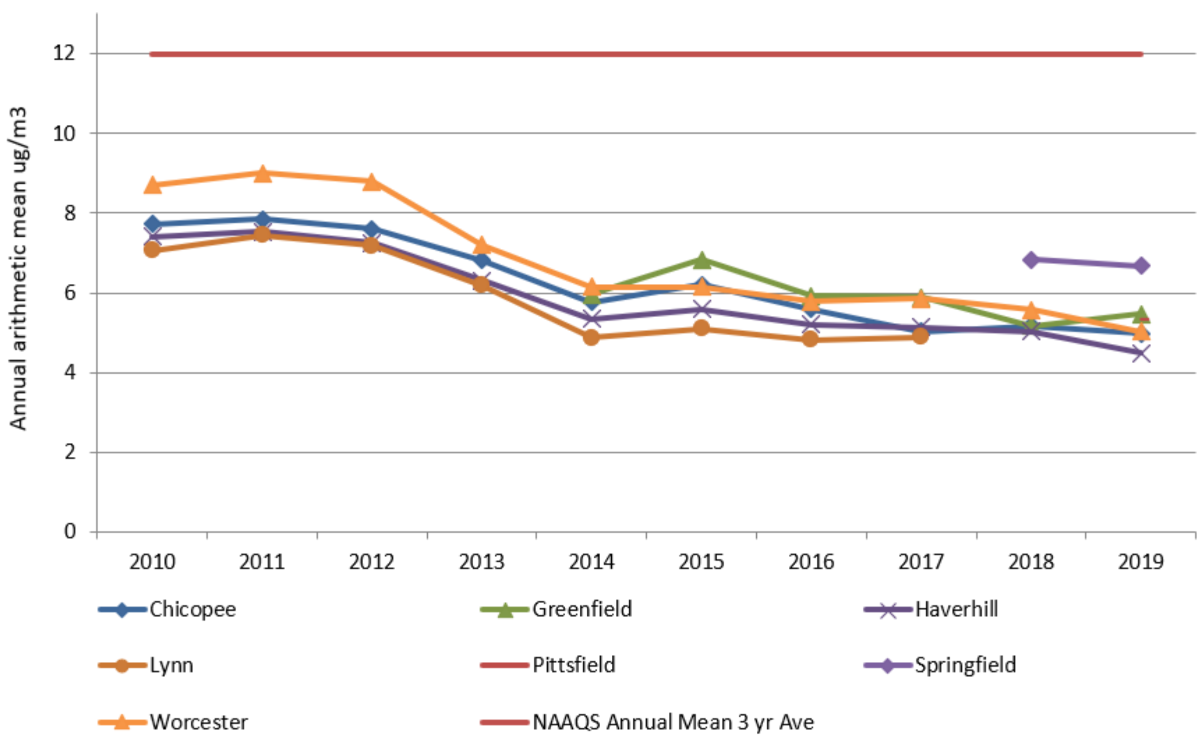
* = Collocated monitors
1ST, 2ND, 3RD, 4TH 24-HR MAX = 1$^{ST}$, 2$^{ND}$, 3$^{RD}$, and 4$^{TH}$ Highest 24-hr Values for the Year
98TH PERCENTILE 24-HR = 98$^{TH}$ Percentile Value for the Year
ARITH MEAN = Annual Arithmetic Mean

## $PM_{2.5}$ Monitoring Data Trends

Figure 5-6 shows trends for each FRM $PM_{2.5}$ monitor relative to the annual standard of 12 µg/m$^3$.

**Figure 5-6**
**$PM_{2.5}$ Annual Arithmetic Mean Trends**



## 2019 FEM $PM_{2.5}$ Data Summary

Figure 5-7 shows a summary of the 2019 FEM $PM_{2.5}$ data. All values are well below applicable NAAQS.

**Figure 5-7**
**2019 $PM_{10}$ FEM 24-Hour Data Summary (μg/m$^3$)**

| City | County | Address | 1ST MAX 24-HR | 2ND MAX 24-HR | 3RD MAX 24-HR | 4TH MAX 24-HR | 98TH PECENTILE 24-HR | ARITH MEAN |
|---|---|---|---|---|---|---|---|---|
| Boston | Suffolk | Harrison Ave | 23.1 | 21.5 | 19.0 | 18.7 | 17.0 | 8.08 |
| Boston | Suffolk | Von Hillern St | 21.7 | 20.7 | 20.4 | 20.3 | 17.3 | 7.57 |
| Boston | Suffolk | Von Hillern St* | 18.9 | 14.4 | 13.8 | 12.2 | 13.8 | 5.60 |
| Brockton | Plymouth | Clinton Street | 19.7 | 17.2 | 15.6 | 15.6 | 13.9 | 6.80 |
| Chelmsford | Middlesex | Manning Road | 20.9 | 17.8 | 17.3 | 17.0 | 14.5 | 6.98 |
| Chicopee | Hampden | Anderson Road | 26.3 | 18.4 | 18.3 | 18.0 | 12.5 | 4.62 |
| Fall River | Bristol | Globe Street | 27.3 | 26.2 | 23.0 | 20.3 | 15.3 | 6.60 |
| Greenfield | Franklin | Barr Avenue | 29.4 | 26.5 | 24.9 | 23.2 | 17.3 | 6.56 |
| Haverhill | Essex | Washington St | 18.6 | 18.2 | 17.0 | 16.2 | 15.1 | 5.64 |
| Lynn | Essex | Parkland Ave | 28.3 | 22.1 | 19.0 | 18.1 | 16.2 | 6.57 |
| North Adams | Berkshire | Holden Street | 18.3 | 17.0 | 16.5 | 16.2 | 15.2 | 6.19 |
| Pittsfield | Berkshire | Silver Lake Blvd | 25.2 | 24.0 | 23.4 | 19.7 | 16.6 | 7.11 |
| Springfield | Hampden | Liberty Street | 31.6 | 27.2 | 26.3 | 21.7 | 16.6 | 7.71 |
| Ware | Hampshire | Skyline Drive | 24.0 | 22.8 | 18.5 | 17.5 | 15.5 | 5.61 |
| Worcester | Worcester | Summer Street | 24.4 | 20.7 | 20.0 | 20.0 | 16.7 | 8.23 |

Standards: Annual Mean = 12 µg/m3 (primary)
24-hour (98th percentile) = 35 µg/m3

* = Collocated monitors
1ST, 2ND, 3RD, 4TH 24-HR MAX = 1$^{ST}$, 2$^{ND}$, 3$^{RD}$, and 4$^{TH}$ Highest 24-hr Values for the Year
98TH PERCENTILE 24-HR = 98$^{TH}$ Percentile Value for the Year
ARITH MEAN = Annual Arithmetic Mean

## $PM_{2.5}$ Design Values

The design value is a statistic that describes the air quality measured by a monitor relative to the NAAQS in order to classify attainment and nonattainment areas, assess progress towards meeting the NAAQS, and develop control strategies. Design values are defined in EPA guidance and are based on the NAAQS in 40 CFR Part 50. They often require multiple years of data that help to ensure a stable indicator. EPA computes and publishes design values for each monitor annually.

The annual $PM_{2.5}$ design value is computed at each site by averaging the daily samples taken each quarter, averaging these quarterly averages to obtain an annual average, and then averaging three years of annual averages. The 24-hour $PM_{2.5}$ design value is computed at each site by determining the 98$^{th}$ percentile of the daily samples collected each year for three years, and then averaging these three numbers. Because design values are computed over a 3-year time period they are more stable than the measurements recorded in any one year.

Several $PM_{2.5}$ monitoring sites include collocated FRM and FEM instruments. At each site with collocated FRM and FEM instruments, the FEM is considered the primary source of data for NAAQS compliance. Sites with only one, either FRM or FEM, the individual instrument is considered the primary monitor by default. Design values are calculated using data from the primary monitor. Boston – Kenmore is the only site with a standalone FRM. All other design values are based on FEM values.

Figure 5-8 shows the most recent design values for each $PM_{2.5}$ FRM monitor. All design values are well below applicable NAAQS.

**Figure 5-8**
**FEM $PM_{2.5}$ 2019 Design Values**

| City | County | Address | 2017-2019 Design Values | |
|---|---|---|---|---|
| | | | 24 Hour Standard 35 µg/m³ | Annual Standard 15 µg/m³ |
| Boston | Suffolk | Kenmore Square | 13 | 5.9 |
| Boston | Suffolk | Harrison Ave | 18 | 7.4 |
| Boston | Suffolk | Von Hillern St | 18 | 7.9 |
| Brockton | Plymouth | Clinton Street | 16 | 5.8 |
| Chelmsford | Middlesex | Manning Road | 15 | 7.2 |
| Chicopee | Hampden | Anderson Road | 13 | 5.0 |
| Fall River | Bristol | Globe Street | 16 | 6.5 |
| Greenfield | Franklin | Barr Avenue | 16 | 5.7 |
| Haverhill | Essex | Washington St | 14 | 5.2 |
| Lynn | Essex | Parkland Ave | 17 | 5.9 |
| North Adams | Berkshire | Holden Street | 15 | 7.1 |
| Pittsfield | Berkshire | Silver Lake Blvd | 17 | 7.4 |
| Springfield | Hampden | Liberty Street | 16 | 7.3 |
| Ware | Hampshire | Skyline Drive | 15 | 5.3 |
| Worcester | Worcester | Summer Street | 16 | 6.5 |

Note: Does not include Chelmsford – Manning Road because three full years of data have not yet been collected.

## PM MONITORING TECHNOLOGY

### $PM_{10}$

MassDEP uses low volume size-selective gravimetric filters. The FRM monitor works by drawing air through a small Teflon filter for 24 hours (midnight to midnight) on the designated sample day, after which the filter is removed from the monitor and transported to the MassDEP Laboratory in Lawrence for weighing. The samples are run every 3rd or 6th day for 24 hours.

**$PM_{2.5}$**

Currently, MassDEP operates 11 FRM filter-based monitors and 16 Beta Attenuation Monitors (BAMs), including collocated monitors, for measuring $PM_{2.5}$ concentrations at locations throughout the state. In Massachusetts, the $PM_{2.5}$ FRM monitor is identical to the $PM_{10}$ monitor with the addition of a cyclone on the air intake to select for particles that are 2.5 micron or below. Filter-based monitors have several disadvantages:

- There is a time delay between sample collection and sample results
- The samples do not provide a continuous analysis of air quality, which could result in missing important $PM_{2.5}$ events.
- There is extra staff time and expense associated with:
  - visiting sites to collect the samples and bring them to the laboratory for analysis
  - conducting the necessary sample management and analysis quality assurance.

BAMs make it possible to collect and report $PM_{2.5}$ concentrations on an hourly basis without having to transport the filters and weigh them in the laboratory. BAM have been designated as a Federal Equivalent Method (FEM), which makes a BAM an acceptable alternate to the FRM monitor. MassDEP is using data from all FEM monitors for comparison to the $PM_{2.5}$ NAAQS. A new scattered light spectrometry monitor was recently designated as FEM for $PM_{2.5}$, $PM_{10}$ and $PM_{coarse}$ measurements. It provides real time, continuous PM measurements by a broadband spectroscopy method, using 90° white-light scattering with Polychromatic LED. MassDEP has begun to implement this new technology in its network.

**$PM_{coarse}$ ($PM_{10}$ – $PM_{2.5}$)**

MassDEP has used the Federal Reference Method (FRM) for $PM_{coarse}$ in compliance with NCore requirements at the NCore site at Boston – Harrison Avenue since January 2011. This method consists of the subtraction of $PM_{2.5}$ values from $PM_{10}$ values at a site that has side-by-side monitors of each type of sampling on the same dates. Harrison Avenue currently has monitors of the appropriate types.

**Speciation**

MassDEP has been collecting $PM_{2.5}$ samples for speciation at the Boston – Harrison Avenue air monitoring station since 2000 and in Chicopee since 2001. Speciation is the analysis of particulate matter collected on Teflon, nylon and quartz filters simultaneously to determine the chemical composition of the particulate matter collected. During each sampling event, the three separate filters are collected and shipped to an out-of-state national contract laboratory for analysis. Each different filter medium is analyzed for a different category of pollutant. These include elements (e.g., metals), sulfates and nitrates, and carbon (total and organic). MassDEP upgraded these sites to the new carbon method (comparable to the IMPROVE method) in 2009. Note that the IMPROVE monitors acquire $PM_{2.5}$ filter samples for speciation analysis using a different protocol than that of the speciation program. At this time, MassDEP does not see a need to change either the speciation or IMPROVE methods.

## ADEQUACY OF THE PM NETWORK

### EPA Requirements

As demonstrated in Figure 5-9, the PM network meets or exceeds federal requirements for $PM_{10}$, $PM_{2.5}$, and speciation.

**Figure 5-9**
**$PM_{2.5}$ Monitor Siting Requirements, including Speciation**

| EPA Requirements for Number of $PM_{2.5}$ Monitors | MSA Population | Most Recent 3-Year Design Value ≥85% of any $PM_{2.5}$ NAAQS | Most Recent 3-Year Design Value <85% of any $PM_{2.5}$ NAAQS or No Design Value |
|---|---|---|---|
| | >1,000,000 | 3 | 2 |
| | 500,000–1,000,000 | 2 | 1 |
| | 50,000–<500,000 | 1 | 0 |

| MSA | 2018 Population | 3 Year Design Values (2019 Maximum for a Monitor in MSA) | | | | > 85% of any NAAQS? | Monitors Needed | Monitors in Network |
|---|---|---|---|---|---|---|---|---|
| | | 24 Hour - 35 µg/m3 | | Annual - 15 µg/m3 | | | | |
| | | Value | % of STD | Value | % of STD | | | |
| Boston-Cambridge-Newton MSA | 4,875,390 | 15.9 (18) | 45% (51%) | 6.5 (7.9) | 43% (53%) | NO | 2 | 7 |
| Barnstable MSA | 213,413 | NA | NA | NA | NA | NA | 0 | 0 |
| Providence-Warwick MSA | 1,621,337* | 16 | 46% | 6.5 | 43% | NO | 1 | 1 |
| Worcester MSA | 947,866 | 16 | 46% | 6.5 | 43% | NO | 1 | 1 |
| Springfield MSA | 631,761 | 15 (16) | 43% (46%) | 5.8 (7.3) | 39% (49%) | NO | 1 | 4 |
| Pittsfield MSA | 126,348 | 16 (17) | 46% (49%) | 7.3 (7.4) | 48% (49%) | NO | 0 | 2 |

* The Massachusetts population in the MSA is 564,022. The remainder of the population resides in Rhode Island.

| Additional $PM_{2.5}$ Monitor Requirements | MSA: Boston-Cambridge-Newton MSA | Worcester MSA | Springfield MSA |
|---|---|---|---|
| At least one monitoring station is to be sited in a population-oriented area of expected maximum concentration. | Boston-Von Hillern | Summer Street | Liberty Street |
| For areas with more than one required SLAMS, a monitoring station is to be sited in an area of poor air quality. | Boston-Kenmore<br>Boston-Harrison Ave<br>Boston-Von Hillern | Summer Street | Liberty Street<br>Chicopee<br>Westover |
| The State, or where appropriate, local agencies must operate continuous $PM_{2.5}$ analyzers equal to at least one-half (round up) the minimum required sites listed in Table D–5 of this appendix. At least one required continuous analyzer in each MSA must be collocated with one of the required FRM/FEM/ARM monitors, unless at least one of the required FRM/FEM/ARM monitors is itself a continuous FEM or ARM monitor in which case no collocation requirement applies. | 6 Continuous<br>4 Collocated | 1 Continuous<br>1 Collocated | 3 Continuous<br>2 Collocated |
| Each State shall install and operate at least one $PM_{2.5}$ site to monitor regional background and at least one $PM_{2.5}$ site to monitor regional transport. These monitoring sites may be at community-oriented sites and this requirement may be satisfied by a corresponding monitor in an area having similar air quality in another State. Methods used at these sites may include non-federal reference method samplers such as IMPROVE or continuous $PM_{2.5}$ monitors | 1 Continuous (Ware) | | |
| Each State shall continue to conduct chemical speciation monitoring and analyses at sites designated to be part of the $PM_{2.5}$ Speciation Trends Network. | 1 | 0 | 1 |

**Correlations, Exceedance Probability, Removal Bias**

EPA recommends three analytical approaches for identifying potentially underserved areas and redundant sites.

1. Identifying potential new sites based on the likelihood of the site exceeding a standard.
2. Evaluating the correlation between site measurements to find redundancies.
3. Estimating the removal bias – the difference between the measured concentrations at a site and those that would be estimated for that site based on data from surrounding sites.

NetAssess2020 is an online tool that provides these analyses. NetAssess2020 was used to implement these approaches for this report. The reference is provided below.

> NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool. The latest data in this version is from 2018. https://sti-r-shiny.shinyapps.io/EPA_Network_Assessment/

Exceedance Probability

NetAssess2020 provides a probability map to help determine where new monitors may be needed. The method is explained in the excerpt below from the NetAssess2020 documentation.

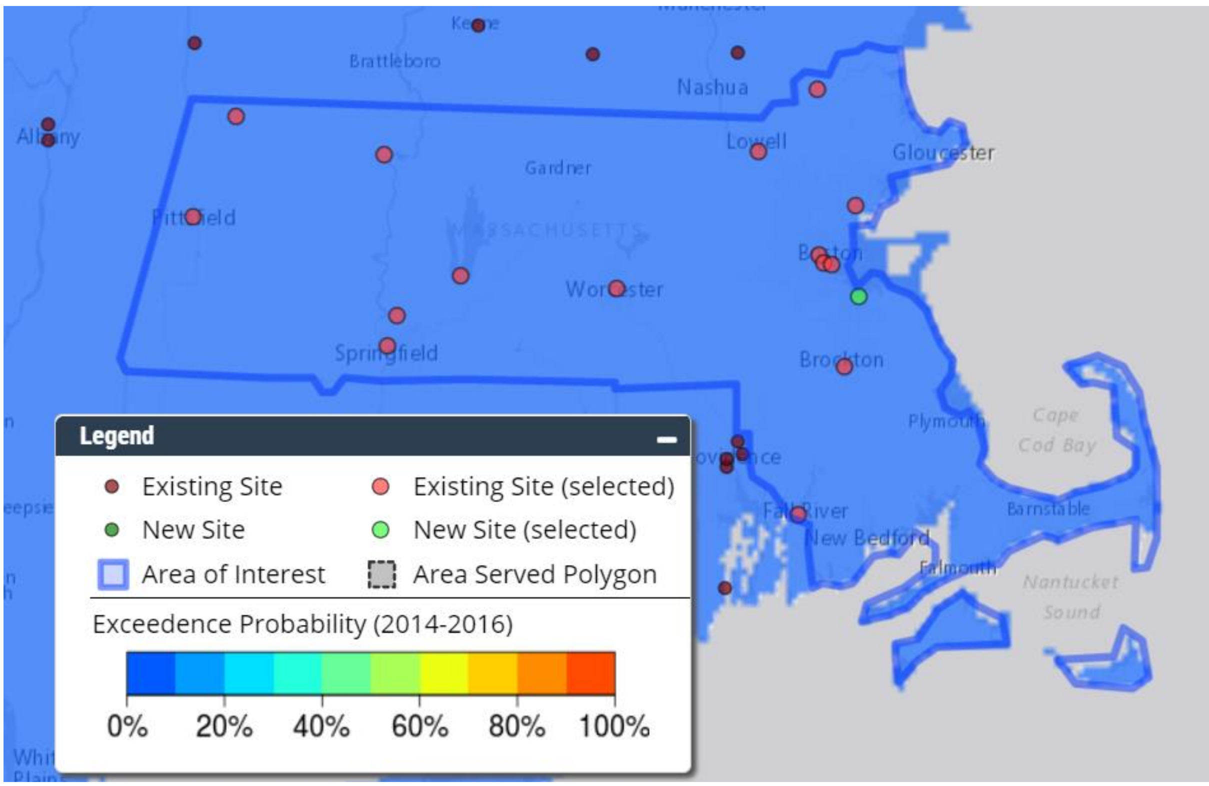
> Exceedance Probabilities
>
> One objective of the network assessment is to determine if new sites are needed. In order to make that decision, it is helpful to have some estimation of the extreme pollution levels in areas where no monitors currently exist. NetAssess2020 provides ozone and $PM_{2.5}$ maps of the contiguous US that can be used to make spatial comparisons regarding the probability of daily values exceeding a certain threshold.
>
> Surface Probability Maps
>
> To clarify, these maps do not show the probability of violating the National Ambient Air Quality Standards (NAAQS). They provide information about the spatial distribution of the highest daily values for a pollutant (not, for example, the probability of the 4th highest daily 8-hour ozone maximum exceeding a threshold).
>
> These maps are intended to be used as a spatial comparison and not for probability estimates for a single geographic point or area. The probability estimates alone should not be used to justify a new monitor. The maps should be used in conjunction with existing monitoring data. If a monitor has historically measured high values, then the probability map gives an indication of areas where you would expect to observe similar extreme values. This information, along with demographic and emissions data, could be used in a weight of evidence approach for proposing new monitor locations.

Data

The surface probability maps were created by using EPA/CDC downscaler data. Downscaler data are daily estimates of ground level ozone and $PM_{2.5}$ for every census tract in the continental US. These are statistical estimates from "fusing" photochemical modeling data and ambient monitoring data using Bayesian space-time methods. For more details on how the data were generated, see the meta data document on the EPA website.

Figure 5-10 shows the probability of exceeding the 35 µg/$m^3$ $PM_{2.5}$ NAAQS. The spatial comparison map indicates all areas of the state have a low probability of daily values exceeding the $PM_{2.5}$ threshold. No areas of high or moderate probability were indicated.

**Figure 5-10**
**Probability of Exceeding the $PM_{2.5}$ 35 µg/m3 Daily NAAQS**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

<u>Site Correlation Analysis</u>

The NetAssess2020 tool was used to provide correlations between monitors. The Correlation Matrix tool calculates and displays the correlation, relative difference, and distance between pairs of sites within a user selected set of air monitoring sites. The correlation matrix graphic displays information about how concentrations at monitors within your Area of Interest compare to one another. Each monitor comparison is represented by a square in the chart.

The blue squares in the bottom-left corner show the correlation between each pair of monitors, with text indicating the number of days used in the calculation. The red squares in the top-right corner show the mean absolute difference in concentrations between each pair of monitors, with text indicating the distance in kilometers between each pair of monitors. The numbers along the diagonal indicate the most recent design value for each monitor.

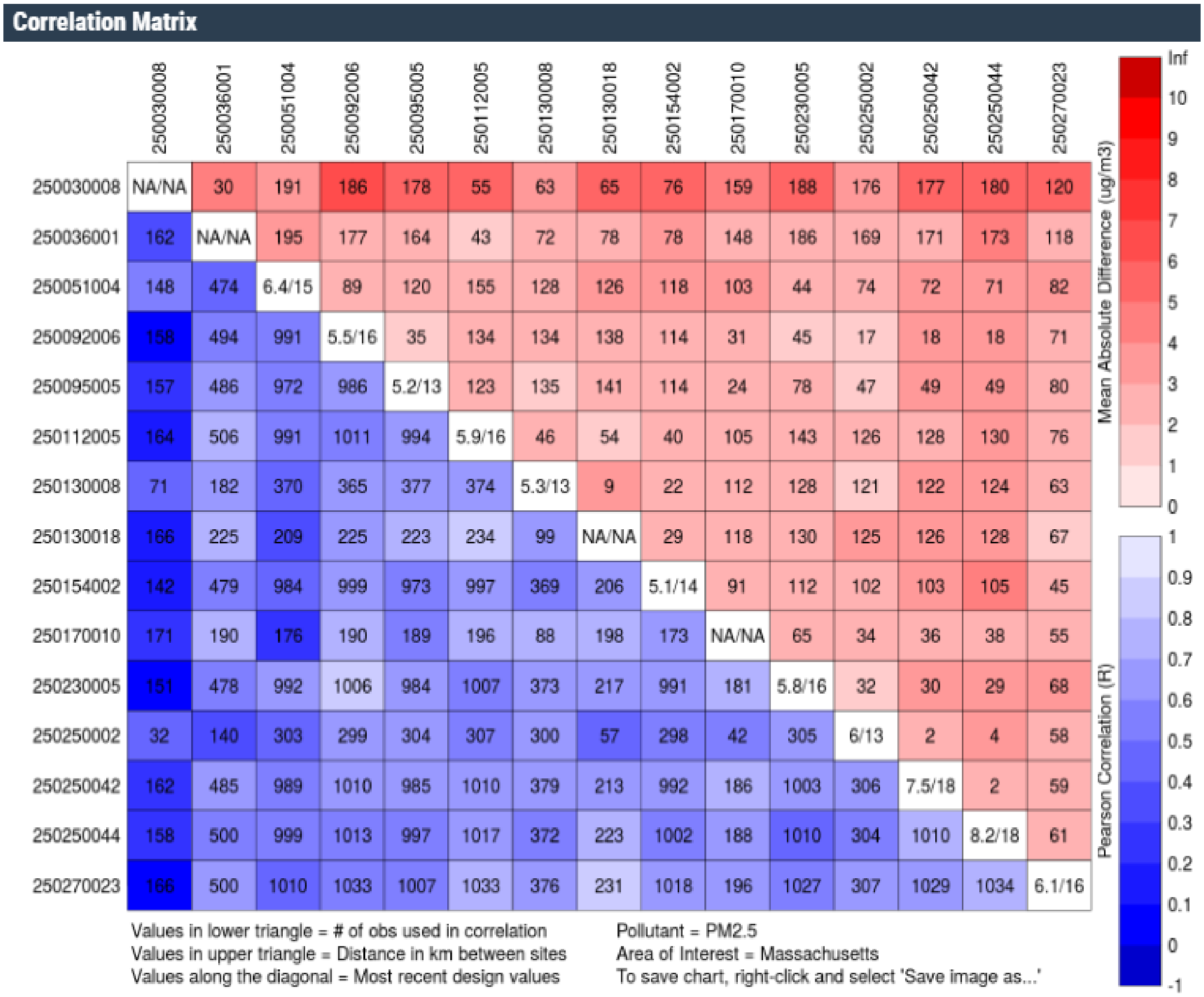
The purpose of this tool is to provide a means of determining possible redundant sites that could be removed. Possible redundant sites would exhibit fairly high correlations consistently across all their pairings and would have low average relative difference despite the distance. Usually, it is expected that correlation between sites will decrease as distance increases. However, for a regional air pollutant such as ozone, sites in the same air shed can have very similar concentrations and be highly correlated. More unique sites would exhibit the opposite characteristics. They would not be very well correlated with other sites and their relative difference would be higher than other site to site pairs.

The Correlation Matrix tool generates a graphical display that summarizes the correlation, relative difference and distance between pairs of monitoring sites. The correlation between two sites quantitatively describes the degree of relatedness between the measurements made at two sites. That relatedness could be caused by various influences including a common source affecting both sites to pollutant transport caused meteorology. The correlation, however, may indicate whether a pair of sites is related, but it does not indicate if one site consistently measures pollutant concentrations at levels substantially higher or lower than the other.

The average relative difference between the two sites is an indicator of the overall measurement similarity between the two sites. Site pairs with a lower average relative difference are more similar to each other than pairs with a larger difference. Both the correlation and the relative difference between sites are influenced by the distance by which site pairs are separated. Usually, sites with a larger distance between them will generally be more poorly correlated and have large differences in the corresponding pollutant concentrations.

Figure 5-11 shows the correlation between the measured air quality at each $PM_{2.5}$ monitoring site based on FRM and FEM data.

**Figure 5-11**
**Correlation Matrix for FRM and BAM $PM_{2.5}$ Monitors**



Correlation Matrix

| | 250030008 | 250036001 | 250051004 | 250092006 | 250095005 | 250112005 | 250130008 | 250130018 | 250154002 | 250170010 | 250230005 | 250250002 | 250250042 | 250250044 | 250270023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250030008 | NA/NA | 30 | 191 | 186 | 178 | 55 | 63 | 65 | 76 | 159 | 188 | 176 | 177 | 180 | 120 |
| 250036001 | 162 | NA/NA | 195 | 177 | 164 | 43 | 72 | 78 | 78 | 148 | 186 | 169 | 171 | 173 | 118 |
| 250051004 | 148 | 474 | 6.4/15 | 89 | 120 | 155 | 128 | 126 | 118 | 103 | 44 | 74 | 72 | 71 | 82 |
| 250092006 | 158 | 494 | 991 | 5.5/16 | 35 | 134 | 134 | 138 | 114 | 31 | 45 | 17 | 18 | 18 | 71 |
| 250095005 | 157 | 486 | 972 | 986 | 5.2/13 | 123 | 135 | 141 | 114 | 24 | 78 | 47 | 49 | 49 | 80 |
| 250112005 | 164 | 506 | 991 | 1011 | 994 | 5.9/16 | 46 | 54 | 40 | 105 | 143 | 126 | 128 | 130 | 76 |
| 250130008 | 71 | 182 | 370 | 365 | 377 | 374 | 5.3/13 | 9 | 22 | 112 | 128 | 121 | 122 | 124 | 63 |
| 250130018 | 166 | 225 | 209 | 225 | 223 | 234 | 99 | NA/NA | 29 | 118 | 130 | 125 | 126 | 128 | 67 |
| 250154002 | 142 | 479 | 984 | 999 | 973 | 997 | 369 | 206 | 5.1/14 | 91 | 112 | 102 | 103 | 105 | 45 |
| 250170010 | 171 | 190 | 176 | 190 | 189 | 196 | 88 | 198 | 173 | NA/NA | 65 | 34 | 36 | 38 | 55 |
| 250230005 | 151 | 478 | 992 | 1006 | 984 | 1007 | 373 | 217 | 991 | 181 | 5.8/16 | 32 | 30 | 29 | 68 |
| 250250002 | 32 | 140 | 303 | 299 | 304 | 307 | 300 | 57 | 298 | 42 | 305 | 6/13 | 2 | 4 | 58 |
| 250250042 | 162 | 485 | 989 | 1010 | 985 | 1010 | 379 | 213 | 992 | 186 | 1003 | 306 | 7.5/18 | 2 | 59 |
| 250250044 | 158 | 500 | 999 | 1013 | 997 | 1017 | 372 | 223 | 1002 | 188 | 1010 | 304 | 1010 | 8.2/18 | 61 |
| 250270023 | 166 | 500 | 1010 | 1033 | 1007 | 1033 | 376 | 231 | 1018 | 196 | 1027 | 307 | 1029 | 1034 | 6.1/16 |



Source: NetAssess2020 v1.1
Note: The Weymouth (25-021-2004) site was added in February 2020, after the NetAssess2020 tool was completed, and correlation data was not available for this assessment.

All monitors exhibit correlations less than 0.9 and most correlations are less than 0.8. Three pairs exhibit correlations between 0.8 and 0.9, as shown in Figure 5-12. The sample sizes (n) for some of these are very small and therefore can be ignored. The relative difference between some pairs is close to the mean relative difference for all sites (0.257) and therefore they are not very similar in magnitude. This leaves the valid highly correlated sites indicated in white in Figure 5-12.

**Figure 5-12**
**Correlation Over 0.8 for FRM and FEM $PM_{2.5}$ Monitors**

| Site 1 | Site 2 | Correlation | Distance (km) | n | Mean Difference |
|---|---|---|---|---|---|
| 25-009-2006 - Lynn | 25-023-0005 - Brockton | 0.8246 | 45 | 1006 | 1.7857 |
| 25-011-2005 - Greenfield | 25-013-0018 - Springfield | 0.8711 | 54 | 234 | 1.9932 |
| 25-013-0018 - Springfield | 25-027-0023 - Worcester | 0.8236 | 67 | 231 | 1.9931 |

Source: NetAssess2020 v1.1

n = Number of observations used in correlation
km = kilometers

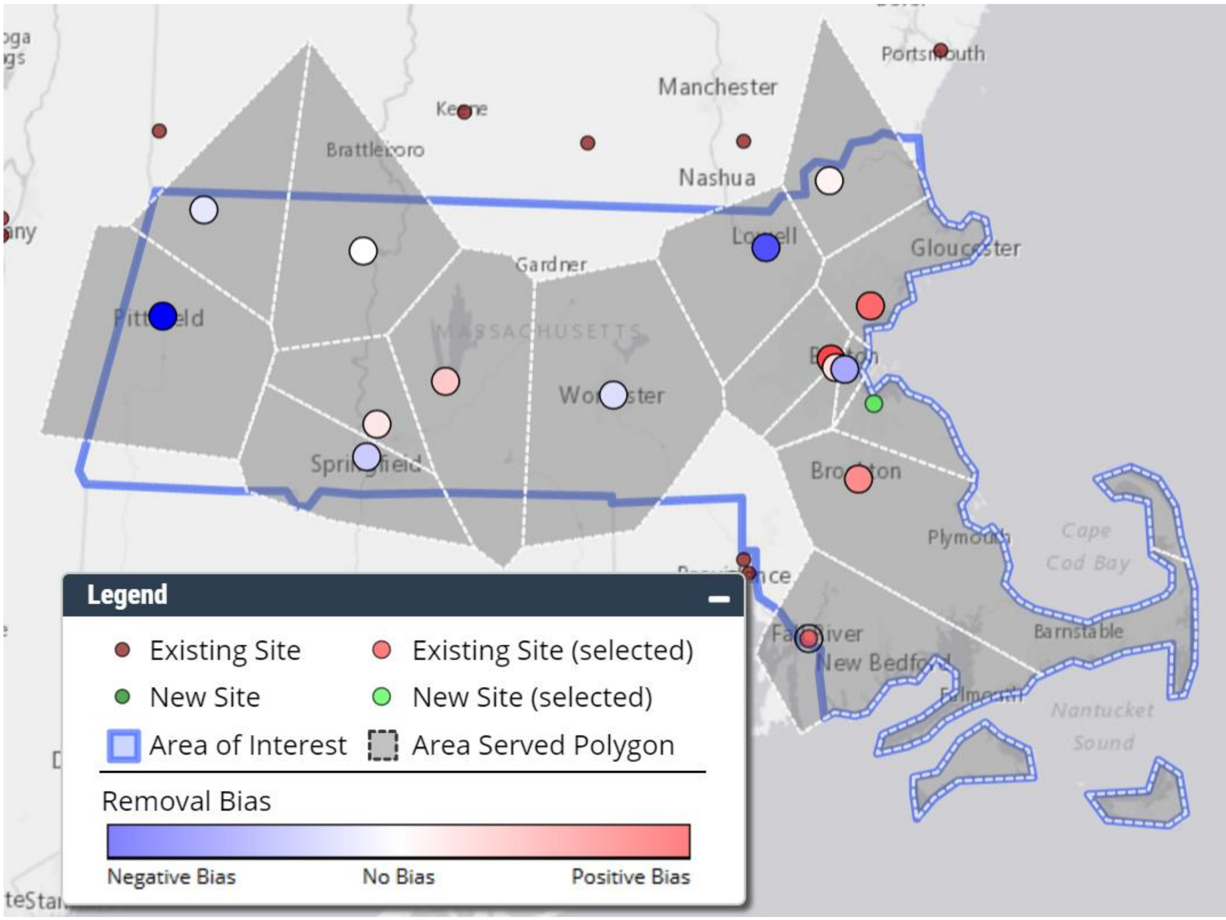
Removal Bias Analysis

Removal bias was calculated among all the $PM_{2.5}$ monitors within the state, treating FRM and FEM as equivalent. Removal bias was calculated with NetAssess2020, which explains the process in its documentation as follows:

> The removal bias tool is meant to aid in determining redundant sites. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the measured concentration. A positive average bias would mean that if the site being examined was removed, the neighboring sites would indicate that the estimated concentration would be larger than the measured concentration. Likewise, a negative average bias would suggest that the estimated concentration at the location of the site is smaller than the actual measured concentration.

If the bias is small, that may indicate that the monitor is redundant and could be removed. Removal bias results are displayed in Figures 5-13 and 5-14.

**Figure 5-13**
**Removal Bias for FRM and FEM $PM_{2.5}$ Monitors**




Source: NetAssess2020 v1.1

**Figure 5-14**
**Removal Bias for FRM and FEM $PM_{2.5}$ Monitors**

| Site ID | Site Name | Mean Removal Bias | Min Removal Bias | Max Removal Bias | Removal Bias Standard Deviation | Neighbors Included |
|---|---|---|---|---|---|---|
| 25-003-0008 | Pittsfield | -2.73 | -13.2 | 6.5 | 5.55 | 7 |
| 25-003-6001 | North Adams | -0.27 | -6.3 | 6 | 2.15 | 4 |
| 25-005-1004 | Fall River | 0.01 | -11.8 | 12 | 3.27 | 7 |
| 25-009-2006 | Lynn | 1.61 | -17.1 | 11.6 | 2.95 | 6 |
| 25-009-5005 | Haverhill | 0.14 | -16.8 | 10.1 | 2.03 | 4 |
| 25-011-2005 | Greenfield | -0.02 | -10.2 | 9.2 | 2.27 | 5 |
| 25-013-0008 | Chicopee | 0.27 | -13.7 | 7.9 | 2.8 | 4 |
| 25-013-0018 | Springfield | -0.56 | -8 | 11.9 | 3.04 | 6 |
| 25-015-4002 | Ware | 0.58 | -9.5 | 11.5 | 2.74 | 8 |
| 25-017-0010 | Chelmsford | -1.88 | -6.3 | 1.9 | 1.7 | 6 |
| 25-023-0005 | Brockton | 1.23 | -11.3 | 8.3 | 2.71 | 9 |
| 25-025-0002 | Boston - Kenmore | 1.99 | -9.1 | 13 | 2.68 | 6 |
| 25-025-0042 | Boston - Harrison Ave | 0.36 | -11.5 | 11.3 | 2.79 | 4 |
| 25-025-0044 | Boston - Von Hillern | -0.94 | -11.4 | 11.2 | 2.86 | 4 |
| 25-027-0023 | Worcester - Summer St | -0.37 | -22.3 | 8.2 | 2.65 | 7 |

Source: NetAssess2020 v1.1
Note: The Weymouth (25-021-2004) site was added in February 2020, after the NetAssess2020 tool was completed, and removal bias data was not available for this assessment.

As shown in Figure 5-14, mean removal bias ranged from -2.73 to 1.99. Fall River (0.01) and Greenfield (-0.02) exhibited values closest to zero. Although redundancies may be indicated by these low values, these sites are located in areas of interest and should be retained.

## ANALYSIS RESULTS

MassDEP's PM monitoring network meets EPA monitoring requirements and objectives and provides good coverage for the state. Monitored PM levels are well below the NAAQS and additional monitors are not needed at this time. However, given the health impacts of $PM_{2.5}$, MassDEP is evaluating opportunities to enhance $PM_{2.5}$ monitoring in Environmental Justice communities.

## Ozone

### NETWORK DESCRIPTION

MassDEP operates 16 ozone monitoring sites in 15 municipalities across the state. There is at least one state-operated ozone monitor located in each county except Dukes (Martha's Vineyard) and Nantucket. The Wampanoag Tribe of Gay Head (Aquinnah) operates an ozone monitor in Dukes County.

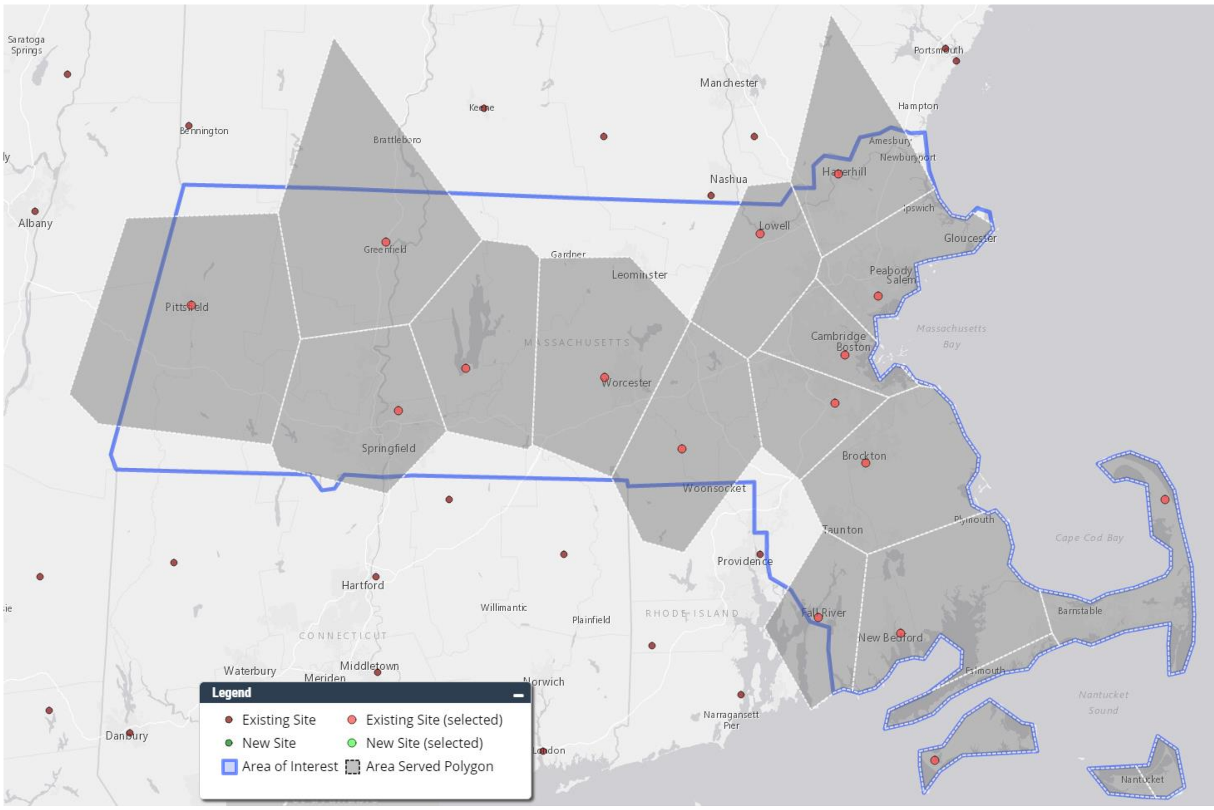
**Figure 5-16**
**Ozone Monitoring Sites, Location, Scale and Purpose**

| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA/MiSA |
|---|---|---|---|---|---|
| 25-001-0002 | Truro | Regional | General Background | 4/1/1987 | Barnstable MSA |
| 25-005-1004 | Fall River | Neighborhood | Population Exposure | 2/1/1975 | Providence-Warwick MSA |
| 25-009-2006 | Lynn | Urban | PAMS - Max Precursor $O_3$; Population Exposure | 1/1/1992 | Boston-Cambridge-Newton MSA |
| 25-009-5005 | Haverhill | Regional | Population Exposure | 7/19/1994 | Boston-Cambridge-Newton MSA |
| 25-013-0008 | Chicopee | Urban | Population Exposure | 1/1/1983 | Springfield MSA |
| 25-015-4002 | Ware | Urban | Max. $O_3$ Conc.; Background for other pollutants | 6/1/1985 | Springfield MSA |
| 25-021-3003 | Milton - Blue Hill | Regional | Upwind Background $PM_{2.5}$; Maximum $O_3$ | 4/2/2002 | Boston-Cambridge-Newton MSA |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton MSA |
| 25-027-0015 | Worcester - Airport | Urban | Population Exposure | 5/7/1979 | Worcester MSA |
| 25-007-0001 | Aquinnah | Regional | Regional | 4/1/2004 | Providence-Warwick MSA |
| 25-017-0009 | Chelmsford - EPA | Neighborhood | Population Exposure | 4/1/2005 | Boston-Cambridge-Newton MSA |
| 25-027-0024 | Uxbridge | Regional | $O_3$ Transport; Population Exposure | 11/1/2008 | Worcester MSA |
| 25-005-1006 | Fairhaven | Regional | Population Exposure | 6/30/2013 | Providence-Warwick MSA |
| 25-023-0005 | Brockton | Urban | Population Exposure | 6/30/2013 | Boston-Cambridge-Newton MSA |
| 25-011-2005 | Greenfield | Regional | Population Exposure | 1/1/2014 | Greenfield Town MiSA |
| 25-003-0008 | Pittsfield | Regional | Population Exposure | 7/1/2018 | Pittsfield MSA |

## OZONE MONITOR AREAS SERVED

Figure 5-17 shows the area served by each ozone monitor as defined by Voronoi polygons. These polygons were developed using NetAssess2020. The polygons show that the state is well covered by monitors in Massachusetts or in neighboring states.

**Figure 5-17**
**Area Served – Ozone sites**




Source: NetAssess2020 v1.1

## OZONE MONITORING DATA

### 2019 Ozone Data Summary

Figure 5-18 shows a summary of 2019 ozone season data (March 1 – September 30).

**Figure 5-18**
**2019 $O_3$ Monitoring Data Summary (ppm)**

| City | County | Address | 1ST MAX 8-HR | 2ND MAX 8-HR | 3RD MAX 8-HR | 4TH MAX 8-HR | 8-HR MAX>0.070 STD |
|---|---|---|---|---|---|---|---|
| Aquinnah (Tribal) | Dukes | Herring Creek Drive | 0.078 | 0.075 | 0.074 | 0.071 | 4 |
| Boston | Suffolk | Harrison Avenue | 0.066 | 0.063 | 0.062 | 0.061 | 0 |
| Brockton | Plymouth | Clinton Street | 0.067 | 0.063 | 0.062 | 0.061 | 0 |
| Chelmsford | Middlesex | Technology Drive | 0.064 | 0.060 | 0.058 | 0.057 | 0 |
| Chelmsford | Middlesex | Manning Road | 0.053 | 0.053 | 0.051 | 0.051 | 0 |
| Chicopee | Hampden | Anderson Road | 0.068 | 0.068 | 0.067 | 0.066 | 0 |
| Fairhaven | Bristol | School Street | 0.069 | 0.063 | 0.062 | 0.060 | 0 |
| Fall River | Bristol | Globe Street | 0.069 | 0.065 | 0.064 | 0.062 | 0 |
| Greenfield | Franklin | Barr Avenue | 0.065 | 0.065 | 0.061 | 0.056 | 0 |
| Haverhill | Essex | Washington Street | 0.062 | 0.057 | 0.056 | 0.055 | 0 |
| Lynn | Essex | Parkland Avenue | 0.077 | 0.067 | 0.066 | 0.065 | 1 |
| Milton | Norfolk | Canton Avenue | 0.070 | 0.063 | 0.062 | 0.059 | 0 |
| Pittsfield | Berkshire | Silver Lake Blvd | 0.066 | 0.066 | 0.060 | 0.060 | 0 |
| Truro | Barnstable | Collins Road | 0.068 | 0.066 | 0.062 | 0.060 | 0 |
| Uxbridge | Worcester | E. Hartford Ave | 0.068 | 0.065 | 0.060 | 0.060 | 0 |
| Ware | Hampshire | Skyline Drive | 0.068 | 0.068 | 0.067 | 0.066 | 0 |
| Worcester | Worcester | Airport Drive | 0.065 | 0.065 | 0.060 | 0.060 | 0 |

Standard: 8-hour = 0.070 ppm

1ST, 2ND, 3RD, 4TH MAX 8-HR = Maximum 8-hour Value for the 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ Highest Day
8-HR MAX > 0.070 STD = Number of Measured Daily 8-hr Maximum Values Greater Than the 0.070 ppm 8-hr Standard

Note: The Chelmsford – Near Road site on Manning Road does not meet ozone siting criteria but is operating for informational purposes. Therefore, it is not a consideration for determining adequacy of the $O_3$ monitoring network.

## Ozone Design Values

The 2015 8-hour NAAQS for ozone is 0.070 parts per million (ppm). The design value is the 3-year average of the annual fourth-highest daily maximum 8-hour ozone concentration. Figure 5-19 shows ozone design values based on 2017-2019 monitored data. All monitors currently attain the 8-hour 0.070 ppm ozone standard except for the tribal monitor on Martha's Vineyard (Dukes County).

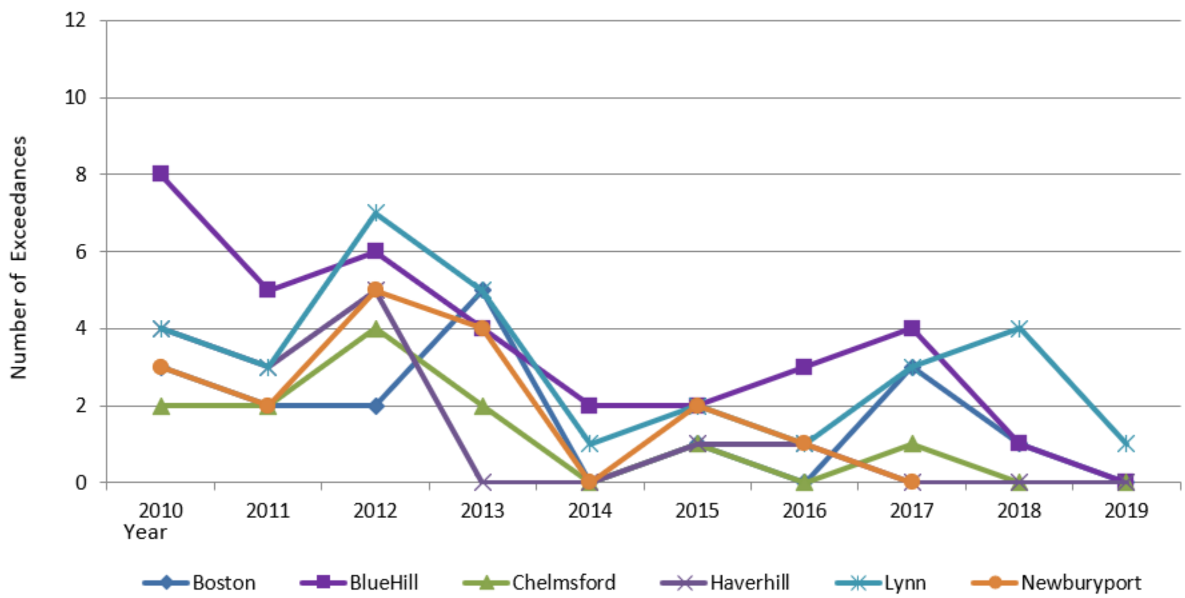
**Figure 5-19**
**Ozone Monitor 2019 Design Values (ppm)**

| City | County | Address | Design Value 2017-2019 |
|---|---|---|---|
| Aquinnah (Tribal) | Dukes | Herring Creek Drive | 0.071 |
| Boston | Suffolk | Harrison Avenue | 0.065 |
| Brockton | Plymouth | Clinton Street | 0.067 |
| Chelmsford | Middlesex | Technology Drive | 0.062 |
| Chelmsford | Middlesex | Manning Road | 0.050 |
| Chicopee | Hampden | Anderson Road | 0.069 |
| Fairhaven | Bristol | School Street | 0.066 |
| Fall River | Bristol | Globe Street | 0.070 |
| Greenfield | Franklin | Barr Avenue | 0.062 |
| Haverhill | Essex | Washington Street | 0.061 |
| Lynn | Essex | Parkland Avenue | 0.068 |
| Milton | Norfolk | Canton Avenue | 0.066 |
| Pittsfield | Berkshire | Silver Lake Blvd | 0.055 |
| Truro | Barnstable | Collins Road | 0.067 |
| Uxbridge | Worcester | E. Hartford Ave | 0.066 |
| Ware | Hampshire | Skyline Drive | 0.066 |
| Worcester | Worcester | Airport Drive | 0.064 |

## 8-hour Ozone Exceedance Trends

Figure 5-20 shows the trends of 8-hour ozone exceedances for each monitor based on the 2015 8-hour standard.

**Figure 5-20**
**8-hour Ozone Exceedance Trends 2010 – 2019**
Based on the 0.070 ppm 8-hour Standard



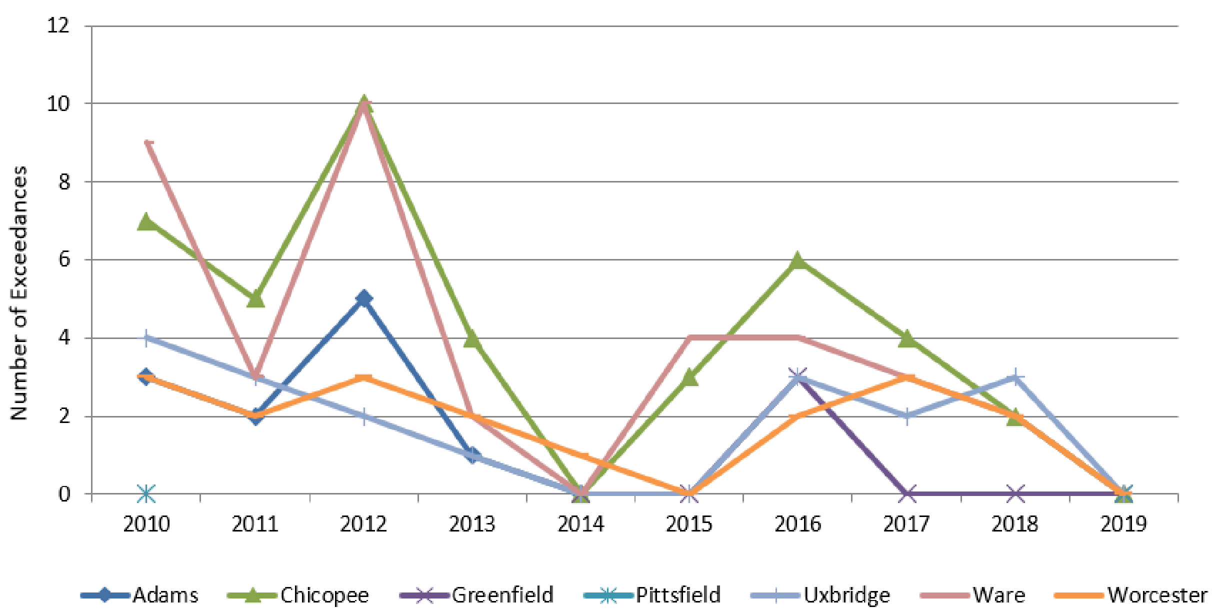
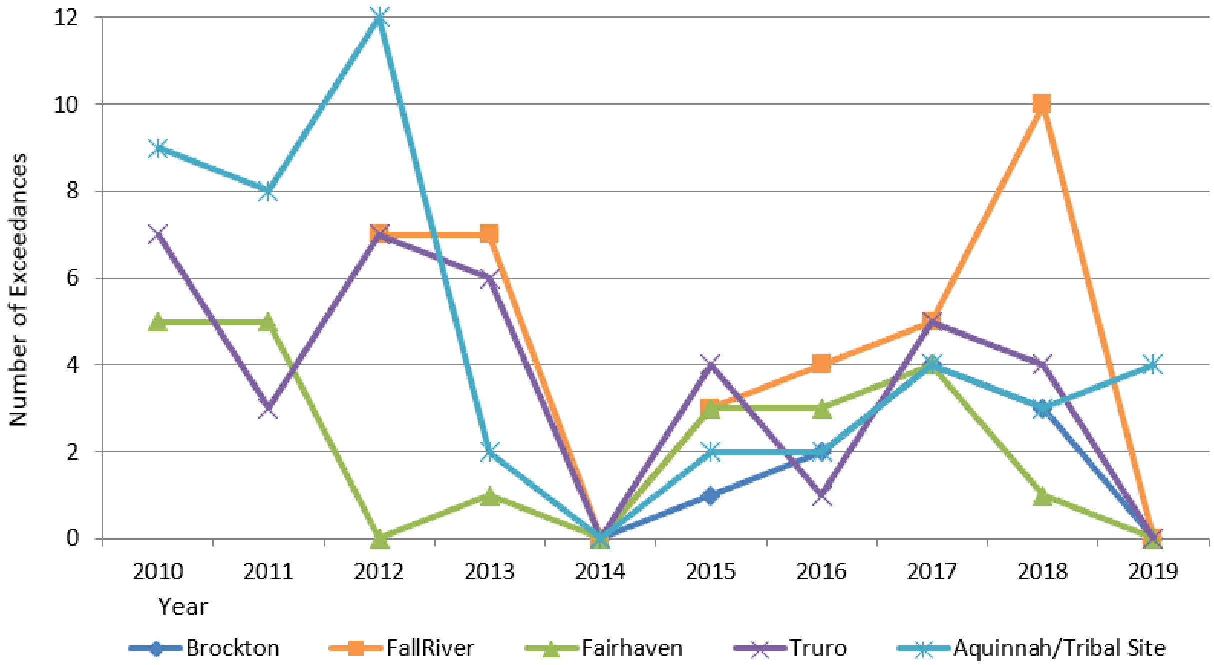



**Figure 5-20 (continued)**
**8-hour Ozone Exceedance Trends 2010 – 2019**
Based on the 0.070 ppm 8-hour Standard




## PAMS MONITORING

Ground-level ozone is unique because it is not emitted directly into the atmosphere from a stack or a tailpipe. Instead, it forms in the atmosphere from the photochemical reactions of other pollutants such as volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$). Ozone formation can occur many miles downwind from the source of the original emissions. These reactions occur in the presence of strong sunlight and are most pronounced during the hottest days of the summer.

PAMS (Photochemical Assessment Monitoring Station) is a special designation for enhanced monitoring stations that gather information on the ozone formation process. Instrumentation at these sites measures pollutants and meteorological parameters that are specific to the photochemical processes by which ozone is created in the atmosphere at ground level. This data makes it possible to assess ozone attainment progress independent of the meteorological variation that occurs between years.

In addition to the standard NAAQS pollutants (ozone, $NO_2$, etc.) that are measured at other sites, other ozone precursors such as VOCs, including hydrocarbons and carbonyl compounds (e.g., aldehydes), are measured at PAMS stations on either an hourly basis or at regular intervals during June, July and August. $NO_x$ (total oxides of nitrogen) measurements (including $NO_x$, NO and $NO_2$) and $NO_y$ (total reactive oxides of nitrogen) are also required at PAMS sites. $NO_y$ characterizes atmospheric nitrogen reactions better than traditional $NO_x$ measurements. The target carbonyl compounds (formaldehyde and acetaldehyde), which have been measured as indicators of photochemical reactions, have received renewed attention regarding their air toxics relevance.

Meteorology is a critical component of ozone formation. Each PAMS site has a full complement of meteorological sensors including wind speed, wind direction, temperature, relative humidity, barometric pressure and solar radiation.

Although Massachusetts is currently in attainment with the ozone NAAQS, MassDEP continues to operate one PAMS site in Lynn (25-009-2006). Based on changes EPA made to the PAMS program, MassDEP discontinued PAMS monitoring in Chicopee (25-013-0008), Newburyport (25-009-4005) and Ware (25-015-4002). MassDEP continues to measure ozone in Chicopee and Ware; however, all measurements were discontinued in Newburyport.

The benefits of continued PAMS monitoring in Lynn include obtaining spatial and temporal trends. MassDEP is in the ozone transport region (OTR) and has collected PAMS data for over 25 years. Continued PAMS measurements can be compared with regional and historic data to demonstrate trends in ozone precursor pollutants as they move through the heavily populated northeast corridor.

When the ozone and PAMS sites were originally established, MassDEP worked closely with EPA to ensure that the proper analyses were done to ensure that each site met the network design requirements. Since population and pollution sources have not significantly changed since the mid-1990s, MassDEP is confident that the ozone sites and the PAMS site still meet the appropriate design criteria.

MassDEP continues to participate in regional and national discussions designed to make sure the PAMS and ozone networks are both efficient and relevant. MassDEP plans to install a ceilometer at the Lynn site and conduct PAMS monitoring in accordance with the approved Implementation Plan and Enhanced Monitoring Plan (EMP) by the June 1, 2021 start date. MassDEP believes the current configuration is sufficient for air pollution forecasting and ozone SIP development and implementation.

**Figure 5-21**
**Location and Description of the PAMS Site**

| Site ID | Site Name | Reason for Monitor | Date Established | Pollutant Measurements | Meteorological Measurements |
|---|---|---|---|---|---|
| 25-009-2006 | Lynn | PAMS - Max. Precursor; Population Exposure | 1/1/1992 | $O_3$, NO, $NO_2$, $NO_X$, $NO_Y$, $PM_{2.5}$, VOCs, Carbonyls | WS, WD, TEMP, RH, BP, SOLAR, PRECIP |

WS = wind speed
WD = wind direction
TEMP = temperature
RH = relative humidity
BP = barometric pressure
SOLAR = solar radiation
PRECIP = precipitation

## OZONE MONITORING TECHNOLOGY

### Ozone

MassDEP uses continuous ultraviolet (UV) light photometry to monitor ambient ozone concentrations. This is the Federal Automated Equivalent Method and there is no reason to change this equipment, although there is current research into the reintroduction of chemiluminescence method.

## PAMS

MassDEP operates an Automated Gas Chromatograph (Auto-GCs) with a flame ionization detector (FID) to measure ozone precursor target hydrocarbon VOCs (volatile organic compounds) at the Lynn PAMS site. This instrument completes an hourly sample collection and analysis cycle to measure target VOCs.

## ADEQUACY OF THE OZONE MONITORING NETWORK

### EPA Requirements

As demonstrated in Figure 5-22, MassDEP's ozone monitoring network meets minimum EPA requirements.

**Figure 5-22**
**Minimum Ozone Monitoring Requirements**

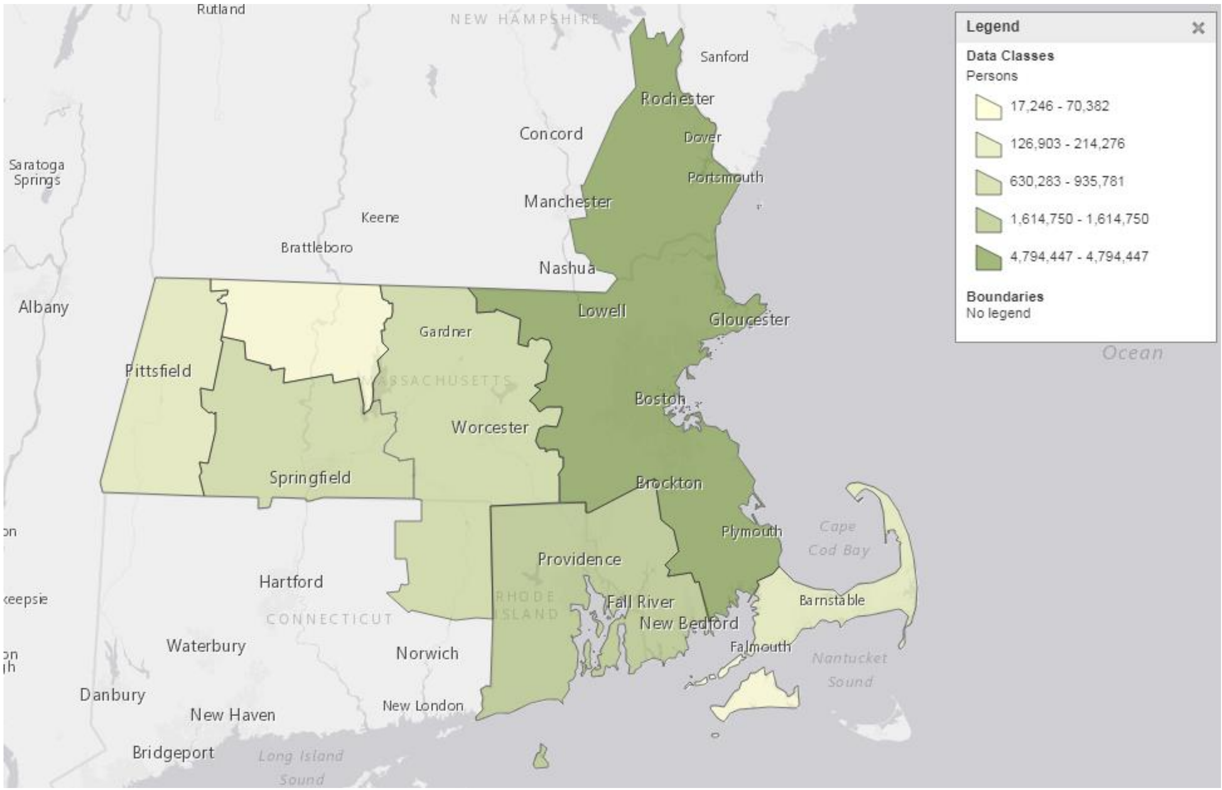
| MSA | 2018 Population | Design Value (max for MSA) | ≥85% of Std? | Monitors Required | Monitors in Network | Maximum Concentration Site |
|---|---|---|---|---|---|---|
| Boston-Cambridge-Newton | 4,875,390 | 0.068 | Yes | 3 | 7 | Lynn |
| Barnstable | 213,413 | 0.067 | Yes | 1 | 1 | Truro |
| Providence-Warwick | 1,621,337 | 0.070 | Yes | 2 | 2 | Fall River |
| Worcester | 947,866 | 0.066 | Yes | 2 | 2 | Uxbridge |
| Springfield | 631,761 | 0.069 | Yes | 2 | 2 | Chicopee |
| Pittsfield | 126,348 | 0.055 | No | 1 | 1 | Pittsfield |

Design Criteria:

If the Design value is ≥85% of the standard:
- MSAs with a population of > 10 million require 4 monitors
- MSAs with a population of 4 - 10 million require 3 monitors
- MSAs with a population of 350,000 - < 4 million require 2 monitors
- MSAs with a population of 50,000 - 349,999 require 1 monitor

If the Design value is <85% of the standard:
- MSAs with a population of > 10 million require 2 monitors
- MSAs with a population of 4 - 10 million require 1 monitor
- MSAs with a population of 350,000 - < 4 million require 1 monitor
- MSAs with a population of 50,000 - 349,999 require 0 monitor

**Figure 5-23**
**Metro/Micro Statistical Areas in Massachusetts**
**Thematic Map of Population Estimate (as of July 1, 2016)**
**Geography: by Metro/Micro Statistical Area**




Source: U.S. Census Bureau. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2016

The benefits of continued PAMS monitoring in Lynn include monitoring spatial and temporal trends. MassDEP is in the ozone transport region (OTR) and has collected PAMS data for over 25 years. Continued PAMS measurements can be compared with regional and historical data to demonstrate trends in ozone precursor pollutants as they move through the heavily populated northeast corridor.

When the ozone and PAMS sites were originally established, MassDEP worked closely with EPA to ensure that the proper analyses were done to ensure that each site met the network design requirements. Since population and pollution sources have not significantly changed since the mid-1990s, MassDEP is confident that the ozone and PAMS sites still meet the appropriate design criteria.

## Exceedance Probability, Correlations, Removal Bias

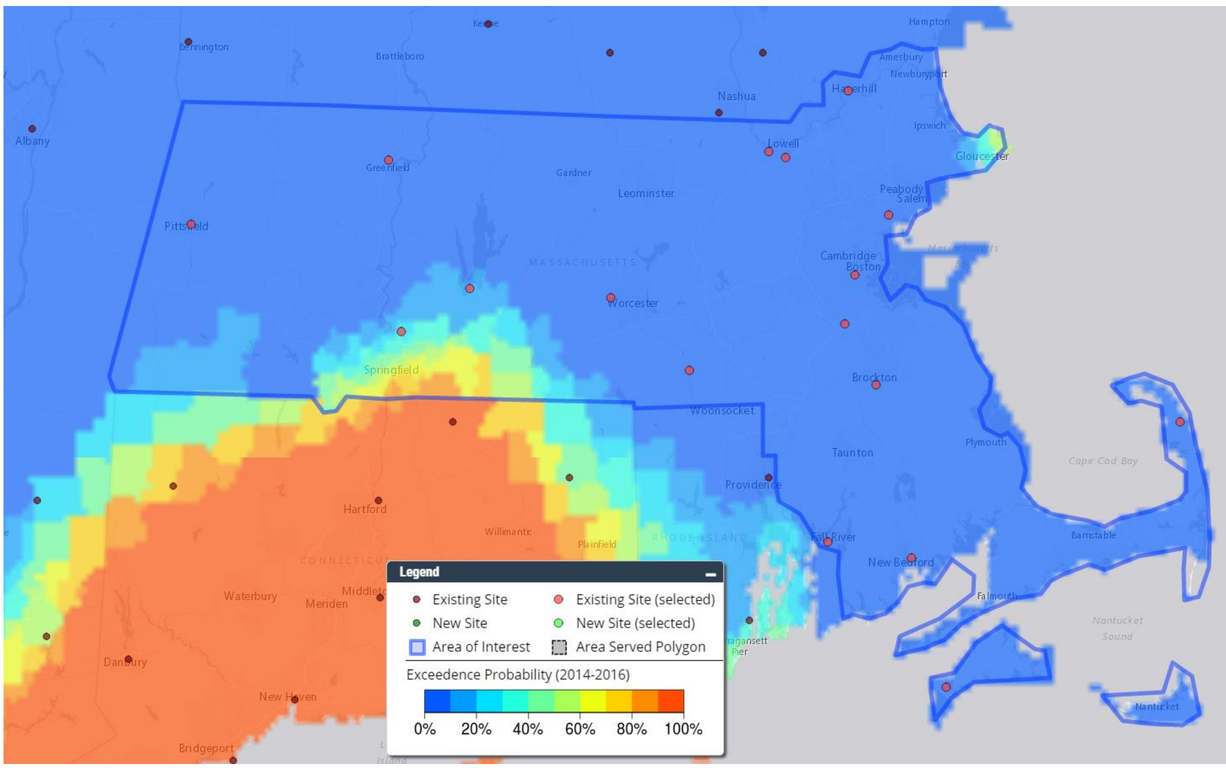
EPA recommends three analytical approaches for identifying potentially underserved areas and redundant sites in the ozone monitoring network. MassDEP used NetAssess2020 to conduct these analyses.

Exceedance Probability

NetAssess2020 provides a probability map to help determine where new monitors may need to be located.

Figure 5-24 shows the probability of exceeding the existing 70 ppb NAAQS. All areas of moderate to high probability are covered by existing monitors and are supplemented by monitors in Connecticut and New York to the south and southwest.

**Figure 5-24**
**Probability of Exceeding the $O_3$ 70 ppb NAAQS**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

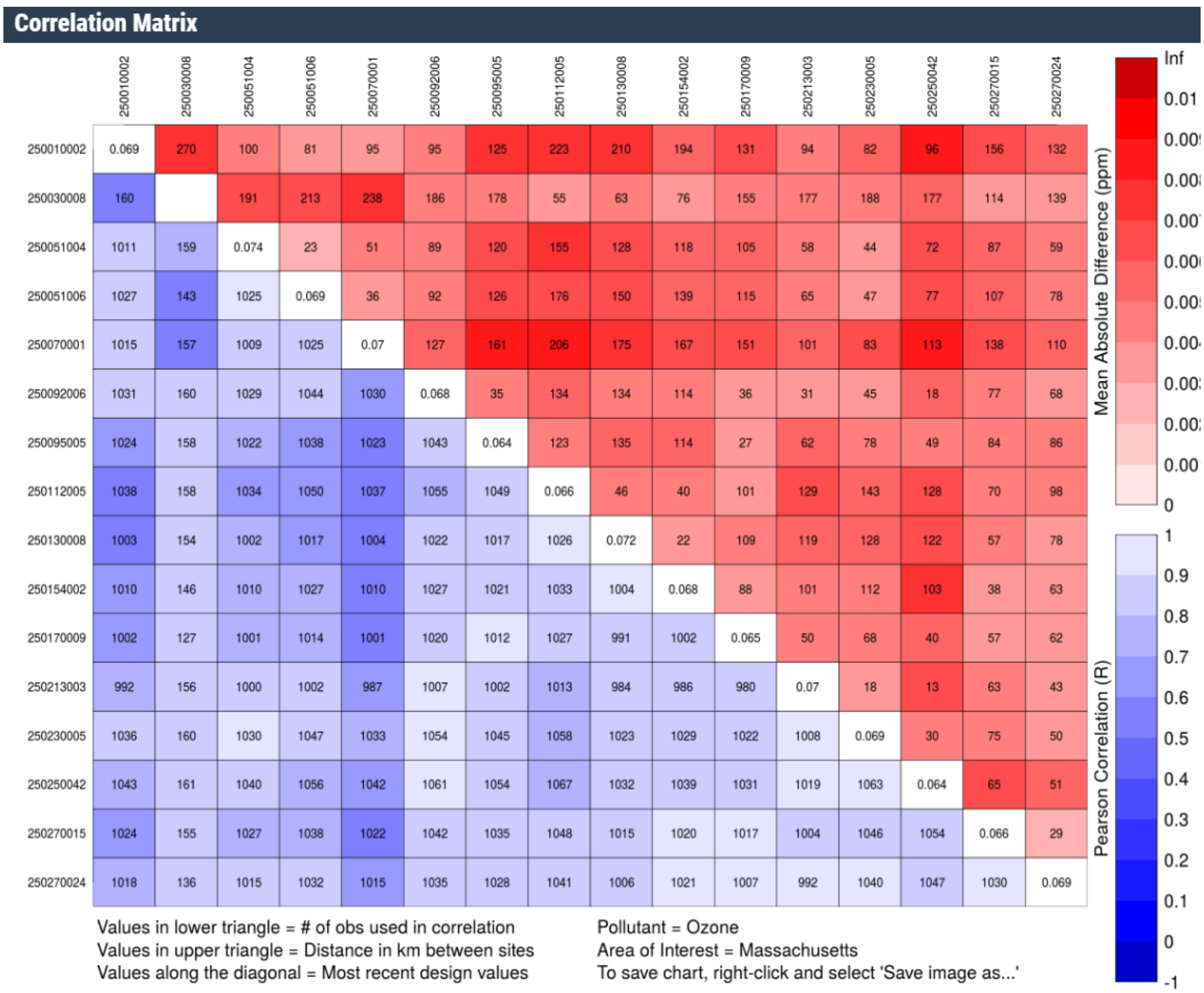
Site Correlation Analysis

The NetAssess2020 tool was used to provide correlations between ozone monitors. The Correlation Matrix tool uses daily summary pollutant concentration data for ozone and fine particles. For ozone, the correlation matrix tool calculates a Pearson Correlation (r) for all valid 8-hour average ozone concentration pairs. If a site has more than one monitor collecting ozone data, the daily maximum 8-hour ozone concentration is the average of all valid results for that site on that date.

Figure 5-25 shows the correlation between ozone measurements at monitoring sites in Massachusetts. Overall, the ozone monitors are highly correlated with an average correlation value of 0.80 and an average mean difference value of 0.005. Figure 5-26 shows highly correlated sites with correlation values greater than 0.90, mean difference less than 0.005 and distance less than 65 km (~40 miles).

The Brockton (25-023-0005) and Uxbridge (25-027-0024) sites appear most frequently in Figure 5-26, with each pairing to another site five times including one pairing between the two sites themselves. No other site appears in Figure 5-26 more than three times.

**Figure 5-25**
**Correlation Between Ozone Monitors in Massachusetts**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

**Figure 5-26**
**Highly Correlated Ozone Monitors in Massachusetts**

| Site 1 | Site 2 | Correlation | Distance (km) | n | Mean Difference |
|---|---|---|---|---|---|
| 25-005-1004 - Fall River | 25-005-1006 - Fairhaven | 0.9359 | 23 | 1025 | 0.0028 |
| 25-005-1004 - Fall River | 25-023-0005 - Brockton | 0.9236 | 44 | 1030 | 0.0033 |
| 25-009-2006 - Lynn | 25-021-3003 - Milton | 0.9218 | 31 | 1007 | 0.0030 |
| 25-009-2006 - Lynn | 25-023-0005 - Brockton | 0.9317 | 45 | 1054 | 0.0030 |
| 25-009-5005 - Haverhill | 25-017-0009 - Chelmsford EPA | 0.9071 | 27 | 1012 | 0.0031 |
| 25-011-2005 - Greenfield | 25-013-0008 - Chicopee | 0.9115 | 46 | 1026 | 0.0041 |
| 25-013-0008 - Chicopee | 25-015-4002 - Ware | 0.9226 | 22 | 1004 | 0.0033 |
| 25-015-4002 - Ware | 25-027-0015 - Worcester Airport | 0.9213 | 38 | 1020 | 0.0030 |
| 25-015-4002 - Ware | 25-027-0024 - Uxbridge | 0.9084 | 63 | 1021 | 0.0033 |
| 25-017-0009 - Chelmsford EPA | 25-027-0015 - Worcester Airport | 0.9027 | 57 | 1017 | 0.0032 |
| 25-017-0009 - Chelmsford EPA | 25-027-0024 - Uxbridge | 0.9185 | 62 | 1007 | 0.0030 |
| 25-021-3003 - Milton | 25-023-0005 - Brockton | 0.9530 | 18 | 1008 | 0.0030 |
| 25-021-3003 - Milton | 25-027-0024 - Uxbridge | 0.9193 | 43 | 992 | 0.0031 |
| 25-023-0005 - Brockton | 25-025-0042 - Boston Harrison Ave | 0.9290 | 30 | 1063 | 0.0046 |
| 25-023-0005 - Brockton | 25-027-0024 - Uxbridge | 0.9239 | 50 | 1040 | 0.0033 |
| 25-027-0015 - Worcester Airport | 25-027-0024 - Uxbridge | 0.9225 | 29 | 1030 | 0.0028 |

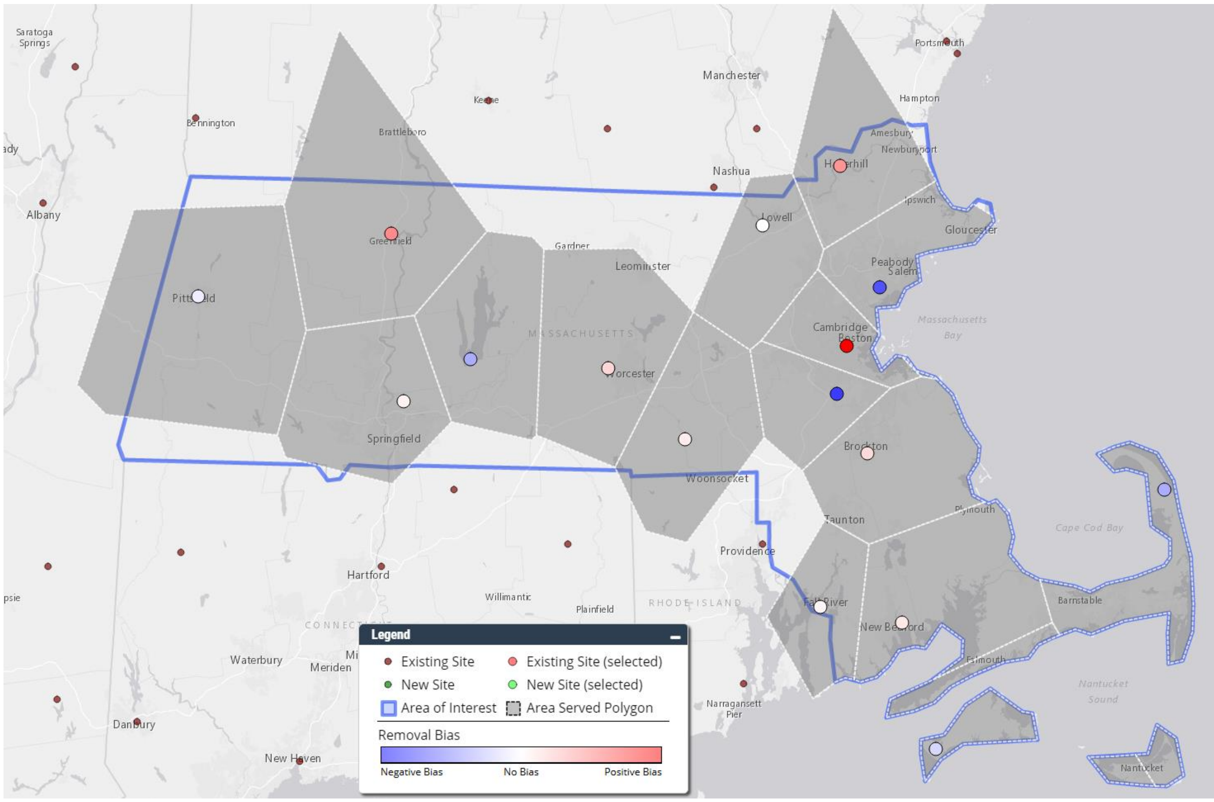
n = Number of observations used in correlation
km = kilometers

Source: NetAssess2020 v1.1

Removal Bias Analysis

Removal bias was calculated with NetAssess2002. Figures 5-27 and 5-28 show the removal bias that would result from eliminating each ozone monitor individually.

**Figure 5-27**
**Removal Bias for Ozone Monitors**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

**Figure 5-28**
**Removal Bias Statistics for Ozone Monitors**

| Site ID | Site Name | Mean Removal Bias | Min Removal Bias | Max Removal Bias | Removal Bias Standard Deviation | Neighbors Included |
|---|---|---|---|---|---|---|
| 25-021-3003 | Milton - Blue Hill | -0.0042 | -0.017 | 0.006 | 0.0034 | 5 |
| 25-009-2006 | Lynn | -0.0037 | -0.016 | 0.008 | 0.0029 | 6 |
| 25-001-0002 | Truro | -0.0018 | -0.019 | 0.019 | 0.0040 | 12 |
| 25-015-4002 | Ware | -0.0018 | -0.023 | 0.013 | 0.0031 | 7 |
| 25-007-0001 | Aquinnah | -0.0009 | -0.035 | 0.024 | 0.0050 | 9 |
| 25-003-0008 | Pittsfield | -0.0004 | -0.010 | 0.007 | 0.0026 | 6 |
| 25-017-0009 | Chelmsford - EPA | 0.0000 | -0.013 | 0.018 | 0.0026 | 7 |
| 25-005-1004 | Fall River | 0.0002 | -0.013 | 0.007 | 0.0028 | 5 |
| 25-013-0008 | Chicopee | 0.0003 | -0.015 | 0.025 | 0.0038 | 6 |
| 25-027-0024 | Uxbridge | 0.0004 | -0.009 | 0.011 | 0.0023 | 7 |
| 25-005-1006 | Fairhaven | 0.0005 | -0.011 | 0.014 | 0.0028 | 4 |
| 25-023-0005 | Brockton | 0.0008 | -0.011 | 0.011 | 0.0022 | 7 |
| 25-027-0015 | Worcester - Airport | 0.0009 | -0.010 | 0.022 | 0.0033 | 5 |
| 25-009-5005 | Haverhill | 0.0023 | -0.010 | 0.021 | 0.0039 | 5 |
| 25-011-2005 | Greenfield | 0.0025 | -0.008 | 0.022 | 0.0036 | 5 |
| 25-025-0042 | Boston - Harrison Ave | 0.0055 | -0.006 | 0.019 | 0.0036 | 4 |

Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

The mean removal bias is generally very small, but the standard deviation is relatively large and the distance between the minimum and maximum are substantial. Therefore, removing any one monitor would not introduce significant bias on average, but would introduce the potential for relatively large errors (imprecision). This analysis therefore does not point to any particular monitor as redundant and a good candidate for removal.

## ANALYSIS RESULTS

MassDEP's ozone monitoring network meets EPA monitoring requirements and objectives and provides good coverage for the state, and there is no need for additional ozone or PAMS monitors at this time. While it is possible that some ozone monitors could be eliminated, MassDEP measures other pollutants at most ozone monitoring sites, providing additional benefits.

## Carbon Monoxide (CO)

### CO NETWORK DESCRIPTION

MassDEP currently operates three carbon monoxide (CO) monitors in Suffolk and Worcester Counties. The network consists of trace-level instruments that measure from 0 to 5 parts per million. Trace-level monitors are used at locations where CO levels are expected to be less than 2 parts per million. Values around the state have been consistently low for quite some time. Figure 5-29 lists the location, purpose, description and EPA scale of each of the CO monitoring stations.

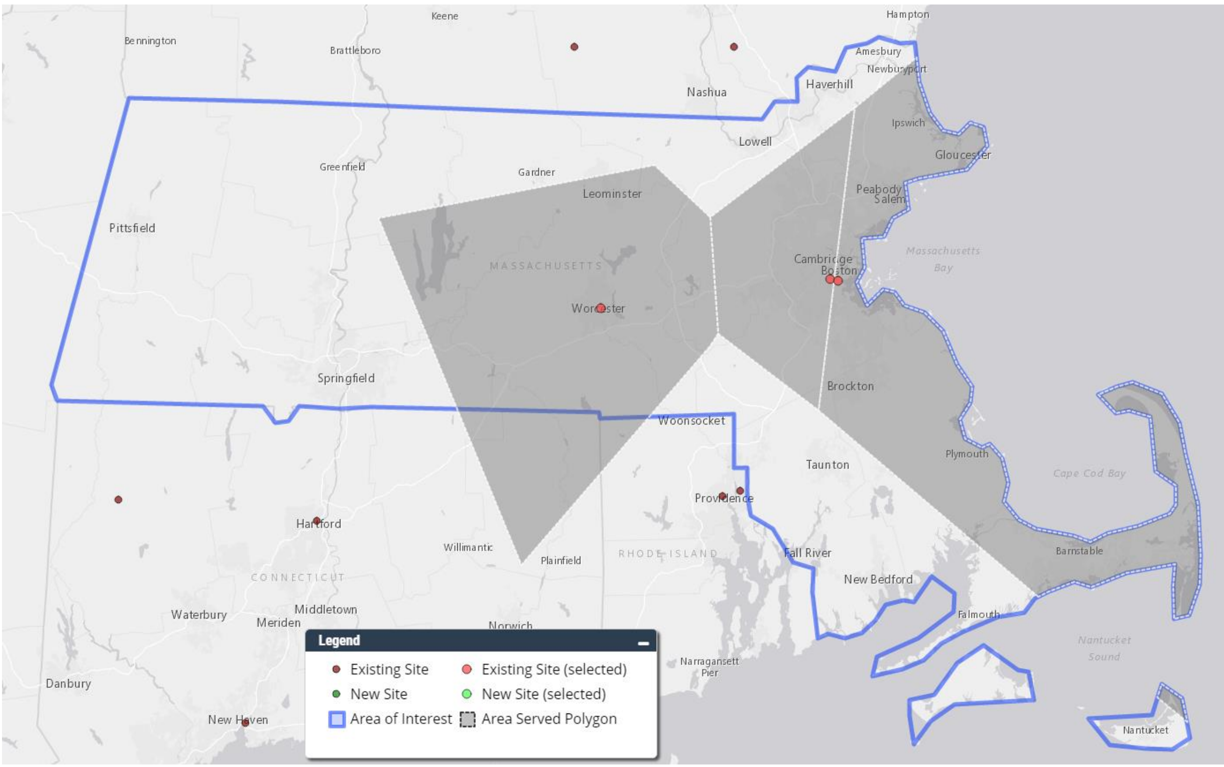
**Figure 5-29**
**CO Monitoring Network Description**

| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA/MiSA |
|---|---|---|---|---|---|
| 25-025-0044 | Boston - Von Hillern | Middle | Population Exposure; Max. Concentration; Near Road | 6/15/2013 | Boston-Cambridge-Newton MSA |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton MSA |
| 25-027-0023 | Worcester - Summer St | Middle | Population Exposure | 1/1/2004 | Worcester MSA |

## CO MONITOR AREAS SERVED

Figure 5-30 shows the area served by each CO monitor as defined by Voronoi polygons. These polygons were developed using NetAssess2020. Due to the very low levels of CO monitored, CO has become much less of a concern for EPA and states, and MassDEP has worked with EPA to gradually reduce its CO monitoring network.

**Figure 5-30**
**Area Served – CO sites**




Source: NetAssess2020 v1.1 Ambient Air Monitoring Network Assessment Tool

## CO DATA

### 2019 Summary Data

Figure 5-31 summarizes 2019 CO data. All values are well below the applicable NAAQS.

**Figure 5-31**
**2019 CO Monitoring Data Summary (ppm)**

| City | County | Address | 1ST MAX 1-HR | 2ND MAX 1-HR | 1ST MAX 8-HR | 2ND MAX 8-HR |
|---|---|---|---|---|---|---|
| Boston | Suffolk | Harrison Avenue | 1.855 | 1.609 | 1.2 | 1.0 |
| Boston | Suffolk | Von Hillern Street | 0.730 | 0.729 | 0.5 | 0.5 |
| Springfield | Hampden | Liberty Street | 1.629 | 1.596 | 1.3 | 1.2 |
| Worcester | Worcester | Summer Street | 1.995 | 1.570 | 1.1 | 0.9 |

Standards: 1-hour = 35 ppm
8-hour = 9 ppm

1ST, 2ND MAX 1-HR = First and Second Highest 1-hr Value
1ST, 2ND MAX 8-HR = First and Second Highest 8-hr Value

### CO Design Values

There are no design values for CO, but only values not to be exceeded. The 8-hour NAAQS for CO is 9 parts per million (ppm) not to be exceeded more than once per year. The 1-hour NAAQS for CO is 35 ppm not to be exceeded more than once per year. Figure 5-32 shows that Massachusetts is consistently well below both the 8-hour and 1-hour CO standards.

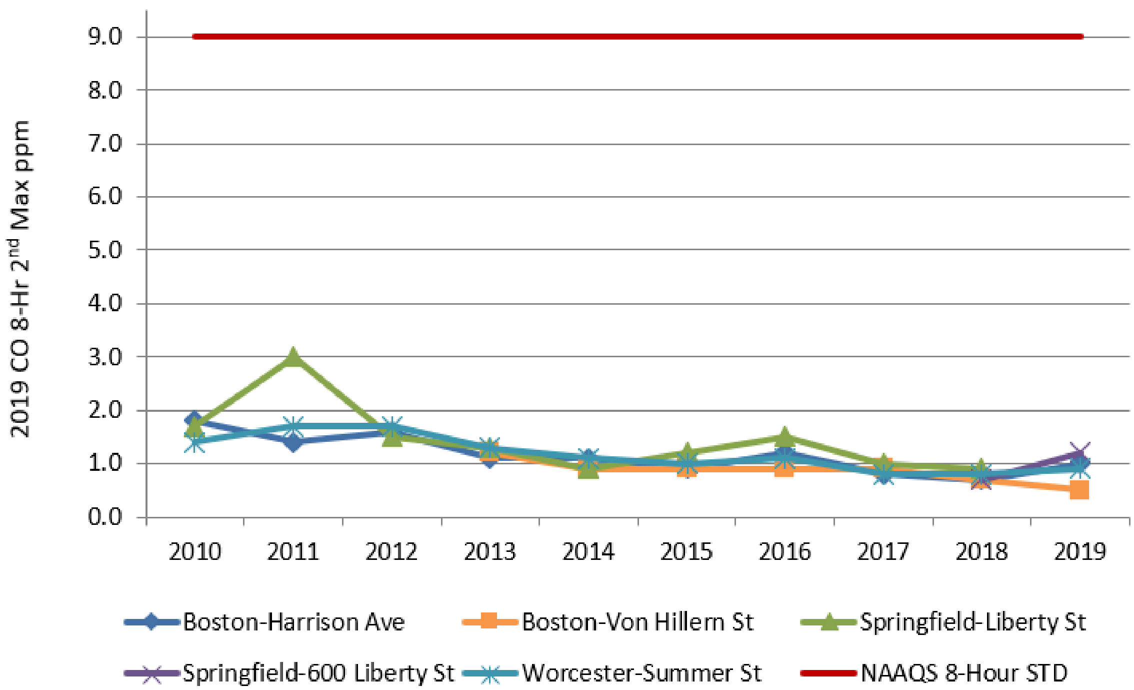
**Figure 5-32**
**2019 Summary Values for CO (ppm)**

| City | County | Address | 2017 – 2019 Maximum Value | |
|---|---|---|---|---|
| | | | 1 Hour (35 ppm) | 8 Hour (9 ppm) |
| Boston | Suffolk | Harrison Avenue | 1.855 | 1.3 |
| Boston | Suffolk | Von Hillern Street | 1.674 | 1.3 |
| Springfield | Hampden | Liberty Street | 2.100 | 1.3 |
| Worcester | Worcester | Summer Street | 1.995 | 1.1 |

## CO Trends

Figure 5-33 shows the trend of each CO monitor relative to the 8-hour standard of 9 ppm.

**Figure 5-33**
**Carbon Monoxide Trends 2010-2019**
2nd Maximum 8-hour Values




## CO TECHNOLOGY

MassDEP uses infrared red (IR) absorption analyzers to monitor low concentration range (trace level) CO. There is no reason to change to another measurement technology at this time.

## ADEQUACY OF THE CO MONITORING NETWORK

### EPA Requirements

MassDEP has sited its CO monitors in compliance with EPA requirements, guidance and approval. Near-road sites in CBSAs having a population of 1,000,000 or more are required to collocate one CO monitor with one $NO_2$ monitor. MassDEP's Boston – Von Hillern site fulfills this requirement.

In addition, continued operation of existing CO sites using FRM or FEM monitors is required until discontinuation is approved by EPA. The discontinuation of the Springfield CO monitor was approved by EPA and the monitor was closed at the end of 2019. The Boston-Harrison Avenue and Worcester - Summer Street monitors represent urban background, and Boston-Von Hillern monitors near-road concentrations.

## ANALYSIS RESULTS

MassDEP's CO monitoring network meets EPA monitoring requirements and objectives and provides adequate coverage for the state given the very low levels of CO monitored, and no additional monitors are needed.

## Sulfur Dioxide ($SO_2$)

### $SO_2$ NETWORK DESCRIPTION

MassDEP currently operates six sulfur dioxide ($SO_2$) monitors in Suffolk, Worcester, Bristol, Hampden and Hampshire Counties. Similar to CO, $SO_2$ concentrations have decreased so significantly that trace instruments are used for monitoring. Figure 5-34 lists the location, purpose and description of the $SO_2$ monitoring stations and their EPA scales for $SO_2$ monitoring purposes.

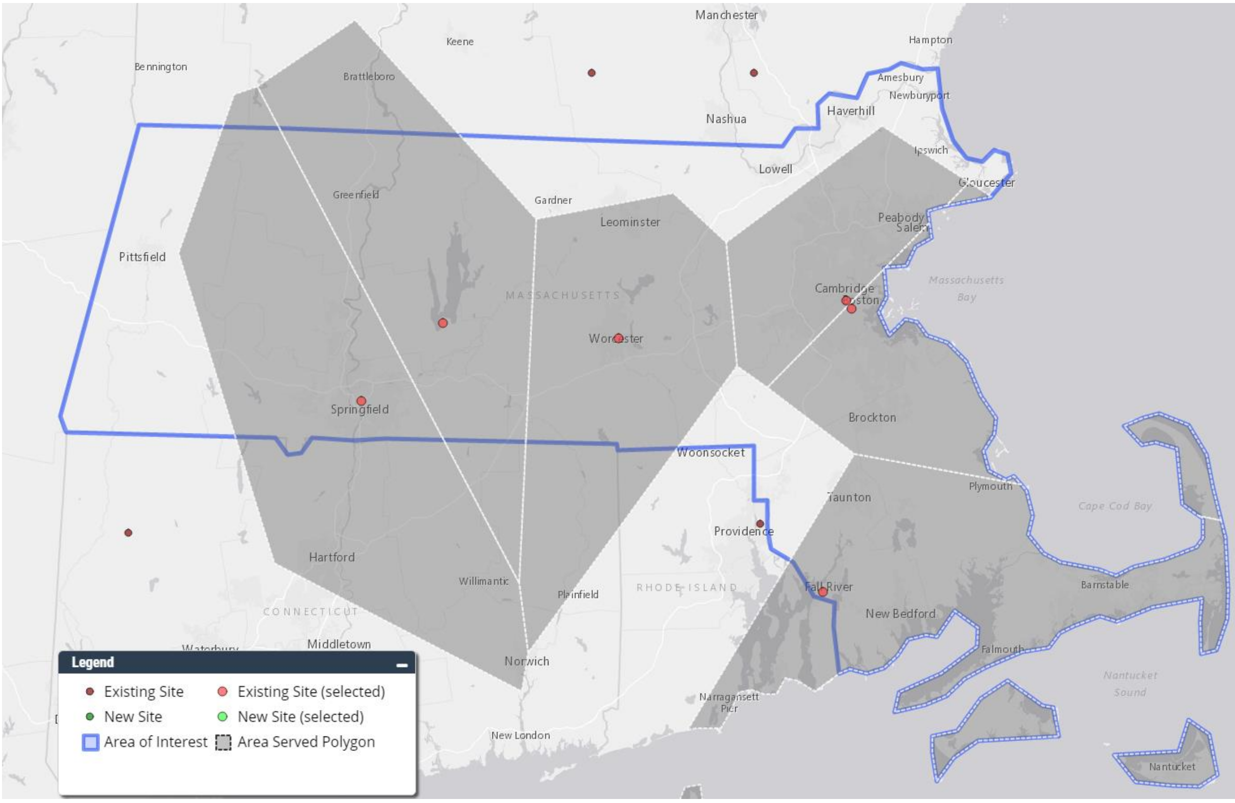
**Figure 5-34**
**$SO_2$ Monitoring Network Description**

| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA/MiSA |
|---|---|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | Neighborhood | Population Exposure | 1/1/1965 | Boston-Cambridge-Newton MSA |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton MSA |
| 25-005-1004 | Fall River | Neighborhood | Population Exposure | 2/1/1975 | Providence-Warwick MSA |
| 25-013-0018 | Springfield | Urban | Population Exposure | 5/1/2018 | Springfield MSA |
| 25-015-4002 | Ware | Urban | Population Exposure | 6/1/1985 | Springfield MSA |
| 25-027-0023 | Worcester - Summer St | Urban | Population Exposure | 1/1/2004 | Worcester MSA |

### COVERAGE AREA

Figure 5-35 shows the area served by each $SO_2$ monitor as defined by Voronoi polygons. These polygons were developed using NetAssess2020. The $SO_2$ monitoring network provides adequate coverage for the state given the low levels monitored. All major $SO_2$ emission sources in Massachusetts have ceased operation. The last coal-fired power station in Massachusetts, Brayton Point Station in Somerset, ceased operations in 2017. $SO_2$ values in the state have remained very low for several years.

**Figure 5-35**
**Coverage Areas for $SO_2$ Monitor**




Source: NetAssess2020 v1.1

## $SO_2$ DATA

### 2019 $SO_2$ Data Summary

Figure 5-36 summarizes 2019 monitoring data for $SO_2$. All values are well below the applicable NAAQS.

**Figure 5-37**
**2019 $SO_2$ Monitoring Data Summary (ppb)**

| City | County | Address | 1ST MAX 1-HR | 2ND MAX 1-HR | 99TH PCTL 1-HR | ARITH MEAN | 1ST MAX 24-HR | 2ND MAX 24-HR |
|---|---|---|---|---|---|---|---|---|
| Boston | Suffolk | Kenmore Square | 3.4 | 2.2 | 1.9 | 0.29 | 1.0 | 0.8 |
| Boston | Suffolk | Harrison Avenue | 2.9 | 1.9 | 1.7 | 0.33 | 0.9 | 0.7 |
| Fall River | Bristol | Globe Street | 5.1 | 3.4 | 3.0 | 0.49 | 1.6 | 1.3 |
| Springfield | Hampden | Liberty Street | 3.0 | 2.9 | 2.5 | 0.28 | 1.8 | 1.5 |
| Ware | Hampshire | Skyline Drive | 1.5 | 1.4 | 1.1 | 0.12 | 0.7 | 0.6 |
| Worcester | Worcester | Summer Street | 2.7 | 2.5 | 2.4 | 0.33 | 1.2 | 1.1 |

Standards: 1-hour = 75 ppb
3-hour = 0.5 ppm (500 ppb)

1ST, 2ND MAX 1-HR = First and Second Highest 1-hr Value
99TH PCTL 1-HR = 99th Percentile of the 1-hr Maximum Value
ARITH MEAN = Annual Arithmetic Mean
1st, 2nd MAX 24-HR = First and Second Highest 24-hr Value

## $SO_2$ Design Values

Figure 5-37 shows the 2019 design values for each $SO_2$ monitor. The annual $SO_2$ NAAQS is 75 ppb measured as the $99^{th}$ percentile of the 1-hour daily maximum concentrations averaged over three years. Design values for all monitors are well below the NAAQS.

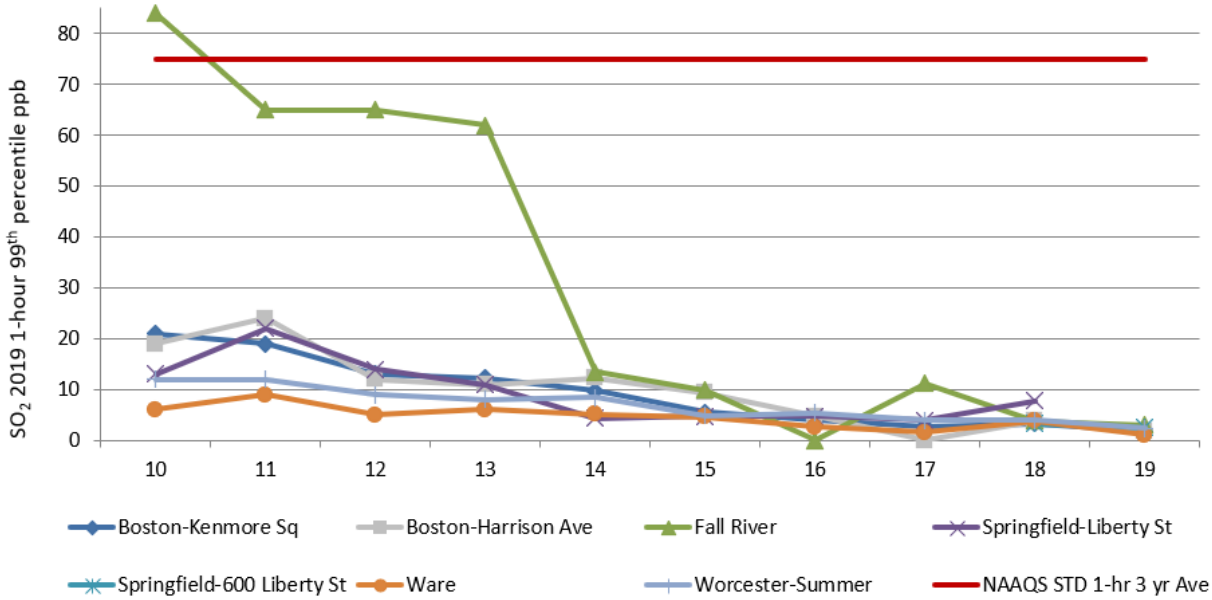
**Figure 5-37**
**2017-2019 $SO_2$ Design Values (ppb)**

| City | County | Address | Design Value 2017-2019 |
|---|---|---|---|
| Boston | Suffolk | Kenmore Square | 3 |
| Boston | Suffolk | Harrison Avenue | 3 |
| Fall River | Bristol | Globe Street | 6 |
| Springfield | Hampden | Liberty Street | 3 |
| Ware | Hampshire | Skyline Drive | 2 |
| Worcester | Worcester | Summer Street | 3 |

### $SO_2$ Trend Data

Figure 5-37 shows the trends for each $SO_2$ monitor relative to the 1-hour standard of 75 ppb.

**Figure 5-37**
**Sulfur Dioxide Trends 2010 – 2019**
1-hour 99th Percentile Annual Average




Note that the Fall River monitor was sited near coal-fired Brayton Point Station in Somerset, which ceased operations in 2017.

### $SO_2$ TECHNOLOGY

MassDEP uses an ultraviolet (UV) fluorescence absorption continuous monitoring technology to measure ambient $SO_2$ trace concentrations. There is no need to change to a different monitoring technology at this time.

### ADEQUACY OF THE $SO_2$ MONITORING NETWORK

### EPA Requirements

The current $SO_2$ monitoring network meets EPA requirements. Figure 5-39 shows the population weighted emissions index (PWEI) and number of $SO_2$ monitors for the state's MSAs.

**Figure 5-39**
**EPA Monitoring Requirements for $SO_2$**

| MSA | MA County in MSA | County Population | MA Population in MSA | $SO_2$ Emissions | PWEI | Monitors Required | Monitors in Network |
|---|---|---|---|---|---|---|---|
| Boston-Cambridge-Newton | Essex | 790,638 | 4,436,124 | 2,366 | 10,496 | 1 | 2 (both in Boston) |
| | Middlesex | 1,614,714 | | | | | |
| | Suffolk | 807,252 | | | | | |
| | Norfolk | 705,388 | | | | | |
| | Plymouth | 518,132 | | | | | |
| Barnstable | Barnstable | 213,413 | 213,413 | 146 | 31 | 0 | 0 |
| Providence-Warwick | Bristol | 564,022 | 564,022 | 2,287 | 1,290 | 0 | 1 |
| Worcester | Worcester | 830,839 | 830,839 | 401 | 333 | 0 | 1 |
| Springfield | Hampden | 470,406 | 631,761 | 338 | 214 | 0 | 2 |
| | Hampshire | 161,355 | | | | | |
| Pittsfield | Berkshire | 126,348 | 126,348 | 79 | 10 | 0 | 0 |

Notes: $SO_2$ emissions measured in tons per year. $SO_2$ emissions for all counties are presented in Figure 4-4.
PWEI = Population weighted emissions index
PWEI = (MA Population in MSA x $SO_2$ Emissions) / 1,000,000

Design criteria:
- MSAs with a PWEI greater than 1,000,000 require 3 monitors
- MSAs with a PWEI between 100,000 and 1,000,000 require 2 monitors
- MSAs with a PWEI between 5,000 and 100,000 require 1 monitor

## ANALYSIS RESULTS

MassDEP's $SO_2$ monitoring network meets EPA monitoring requirements and objectives and provides adequate coverage for the state given the very low levels of $SO_2$ monitored, and no additional monitors are needed. Massachusetts no longer has significant $SO_2$ emissions sources that would warrant $SO_2$ monitoring.

## Nitrogen Dioxide ($NO_2$)

### NETWORK DESCRIPTION

MassDEP operates 10 $NO_2$ monitors in 8 municipalities (see Figure 5-40) located in Suffolk, Norfolk, Essex, Worcester, Hampshire and Hampden Counties. Because $NO_2$ is both a NAAQS pollutant and, along with other oxides of nitrogen, an ozone precursor, MassDEP operates five $NO_2$ sites for NAAQS compliance based on population exposure and operates five $NO_2$ monitors at for ozone monitoring and PAMS purposes. Boston - Von Hillern Street and Chelmsford – Manning Road are required near-road sites for monitoring compliance with the 1-hour $NO_2$ standard.

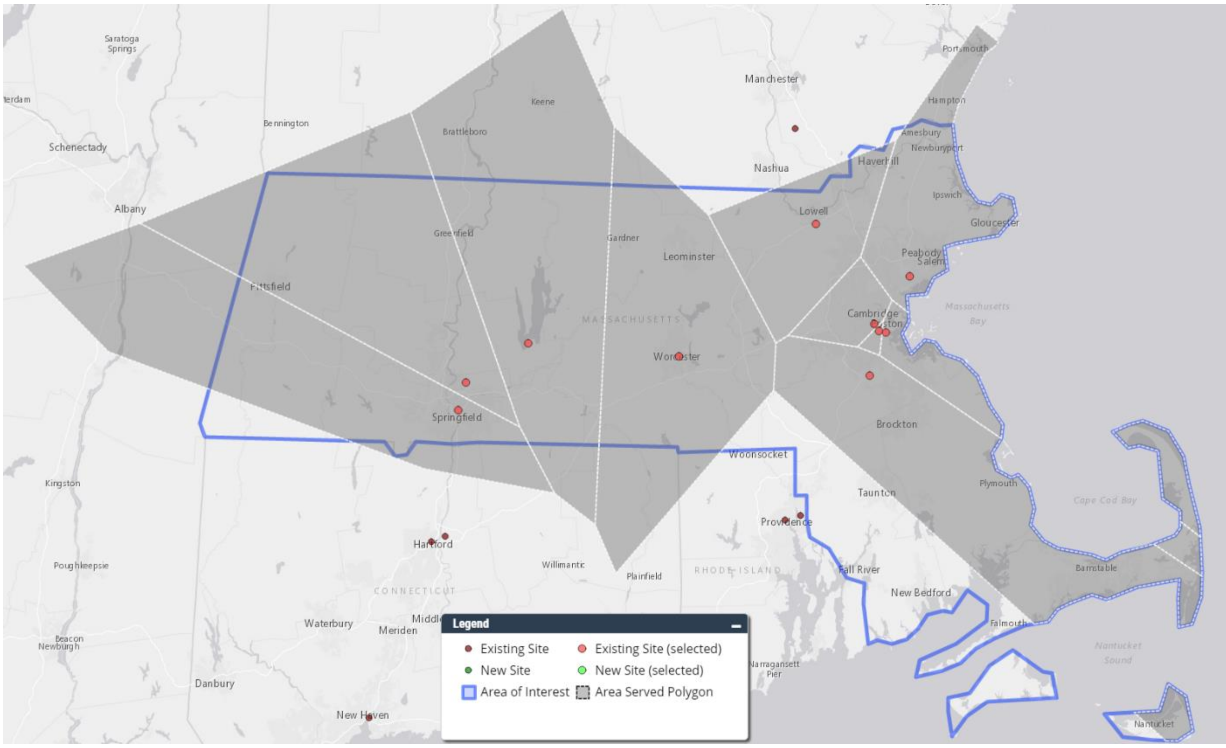
**Figure 5-40**
**$NO_2$ Monitor Site Location, Description and Other Pollutants Monitored**

| Site ID | Site Name | Scale | Reason for Monitor | Date Established | MSA/MiSA |
|---|---|---|---|---|---|
| 25-025-0002 | Boston - Kenmore | Micro | Highest Concentration; Population Exposure | 1/1/1965 | Boston-Cambridge-Newton MSA |
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | 12/15/1998 | Boston-Cambridge-Newton MSA |
| 25-025-0044 | Boston - Von Hillern St | Middle | Population Exposure; Max. Concentration; Near Road | 6/15/2013 | Boston-Cambridge-Newton MSA |
| 25-017-0010 | Chelmsford – Manning Rd | Middle | Population Exposure; Max. Concentration; Near Road | 7/1/2018 | Boston-Cambridge-Newton MSA |
| 25-013-0008 | Chicopee | Urban | Population Exposure | 1/1/1983 | Springfield MSA |
| 25-009-2006 | Lynn | Urban | PAMS - Max. Precursor $O_3$; Population Exposure | 1/1/1992 | Boston-Cambridge-Newton MSA |
| 25-021-3003 | Milton - Blue Hill | Regional | Upwind Background $PM_{2.5}$; Maximum Ozone | 4/2/2002 | Boston-Cambridge-Newton MSA |
| 25-013-0018 | Springfield | Urban | Population Exposure; Highest Concentration | 5/1/2018 | Springfield MSA |
| 25-015-4002 | Ware | Urban | Max. $O_3$ Conc.; background for other pollutants | 6/1/1985 | Springfield MSA |
| 25-027-0023 | Worcester - Summer St | Urban | Population Exposure | 1/1/2004 | Worcester MSA |

## COVERAGE AREA

Figure 5-41 shows the area served by each $NO_2$ monitor as defined by Voronoi polygons. These polygons were developed using NetAssess2020. The $NO_2$ monitoring network provides adequate coverage for the state given that the largest sources of $NO_2$ are roadways, and the network has two near-road sites (Boston – Von Hillern Street and Chelmsford Manning Street) that are sited where the highest concentrations in the state are expected to be.

**Figure 5-41**
**$NO_2$ Monitor Coverage Area**




Source: NetAssess2020 v1.1

## $NO_2$ DATA

### 2019 $NO_2$ Data Summary

A summary of the 2019 $NO_2$ data is shown in Figure 5-42. All levels are well below applicable NAAQS.

**Figure 5-42**
**2019 $NO_2$ Monitoring Data Summary (ppb)**

| City | County | Address | 1ST MAX 1-HR | 2ND MAX 1-HR | 98TH PERCENTILE VALUE | ARITH MEAN |
|---|---|---|---|---|---|---|
| Boston | Suffolk | Kenmore Square | 49 | 48 | 44 | 12.42 |
| Boston | Suffolk | Harrison Avenue | 57 | 55 | 49 | 11.18 |
| Boston | Suffolk | Von Hillern Street | 56 | 53 | 49 | 14.17 |
| Chelmsford | Middlesex | Manning Road | 44 | 44 | 41 | 10.47 |
| Chicopee | Hampden | Anderson Road | 38 | 38 | 32 | 4.45 |
| Lynn | Essex | Parkland Avenue | 46 | 43 | 35 | 5.33 |
| Milton | Norfolk | Canton Avenue | 33 | 33 | 25 | 3.48 |
| Springfield | Hampden | Liberty Street | 46 | 46 | 44 | 10.41 |
| Ware | Hampshire | Skyline Drive | 26 | 26 | 20 | 1.83 |
| Worcester | Worcester | Summer Street | 51 | 49 | 48 | 10.49 |

Standards: 1-hour = 100 ppb
Annual Arithmetic Mean = 53 ppb

1ST, 2ND MAX 1-HR = First and Second Highest 1-hr Value
ARITH MEAN = Annual Arithmetic Mean

## $NO_2$ Design Values

Figure 5-43 shows the 2019 design values for $NO_2$. The annual average $NO_2$ NAAQS is 53 ppb. The 1-hour $NO_2$ NAAQS is 100 ppb calculated as the 3-year average of the annual 98$^{th}$ percentile of the daily 1-hour maximum.

**Figure 5-43**
**2019 Design Values for $NO_2$**

| City | County | Address | 2017-2019 98$^{th}$ Percentile 1-hour Maximum Design Value | 2017-2019 Average Annual Mean |
|---|---|---|---|---|
| Boston | Suffolk | Kenmore Square | 45 | 12.93 |
| Boston | Suffolk | Harrison Avenue | 48 | 11.20 |
| Boston | Suffolk | Von Hillern Street | 46 | 13.78 |
| Chelmsford | Middlesex | Manning Road | 37 | 10.07 |
| Chicopee | Hampden | Anderson Road | 35 | 5.01 |
| Lynn | Essex | Parkland Avenue | 34 | 4.70 |
| Milton | Norfolk | Canton Avenue | 29 | 3.76 |
| Springfield | Hampden | Liberty Street | 38 | 10.33 |
| Ware | Hampshire | Skyline Drive | 21 | 2.09 |
| Worcester | Worcester | Summer Street | 46 | 11.13 |

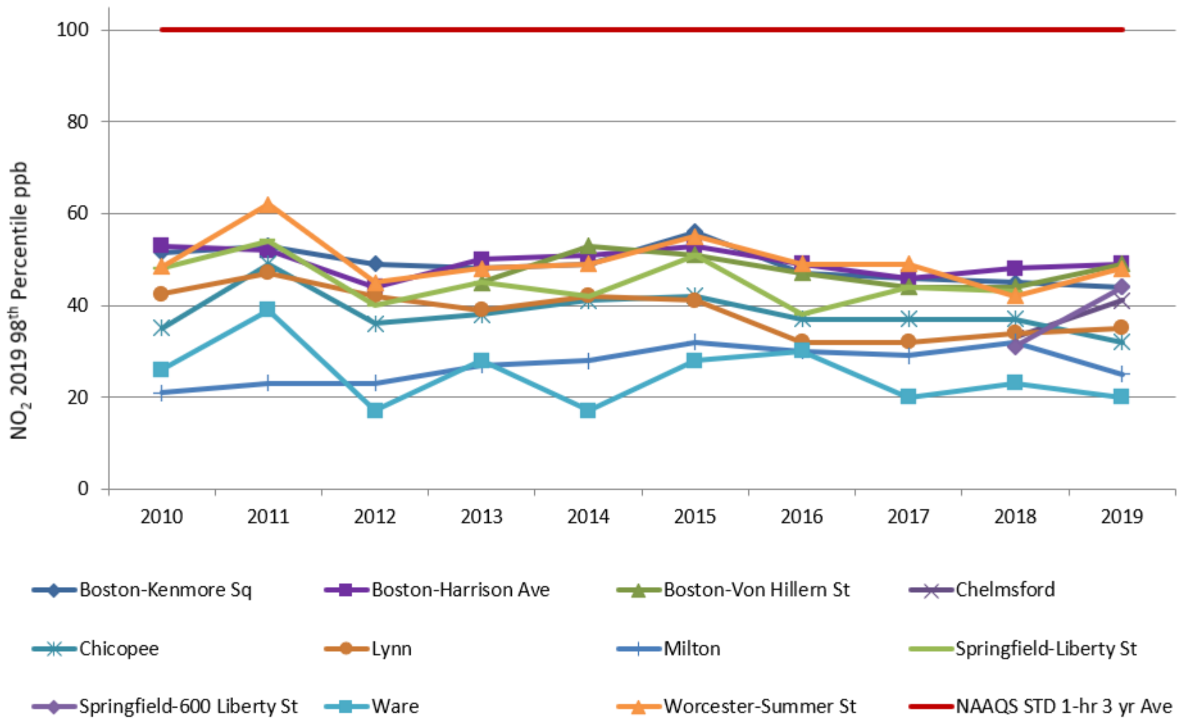
Standards: 1-hour = 100 ppb
Annual Arithmetic Mean = 53 ppb

Note: Chelmsford – Manning Road site does not yet have full three years of data.

### $NO_2$ Trends Data

Figure 5-44 shows trends for each $NO_2$ monitor relative to the 1-hour standard of 100 ppb.

**Figure 5-44**
**Nitrogen Dioxide Trends 2010 - 2019**
**1-hour 98th Percentile Annual Average**




## TECHNOLOGY

MassDEP uses continuous chemiluminescence-based instruments to measure $NO_2$, $NO_x$, $NO_y$ and NOA. Chemilumenescent $NO_x$ monitors measure $NO_2$ indirectly, by subtracting NO (Nitric Oxide) from $NO_x$ (total oxides of nitrogen). Under some circumstances, this difference can include the inadvertent inclusion of other nitrogen compounds. In accordance with PAMS requirements, MassDEP uses one Cavity Attenuated Phase Shift (CAPS) analyzer at the Lynn PAMS site. The CAPS spectroscopy technique provides a direct absorption measurement and relies on producing very long optical paths (up to 2 km) using very high reflectivity mirrors in a sampling cell that is less than 30 cm in length.

## ADEQUACY OF THE EXISTING MONITORING NETWORK

### EPA Monitoring Requirements

In February 2010, EPA promulgated a 100 ppb 1-hour standard for $NO_2$ and established new near-road monitoring requirements for heavily traveled roadways, as well as area-wide monitoring. The number of roadway and area wide monitors required in each MSA depends upon the MSA's population and the Annual Average Daily Traffic counts (AADTs) for major roadways in the MSA. Figure 5-45 shows the number of $NO_2$ monitors required in each Massachusetts MSA.

**Figure 5-45**
**EPA $NO_2$ Monitoring Requirements**

| MSA | MA County in MSA | County Population | MA Population in MSA | 2019 AADT | Required for Near-Road Monitoring | Required for Area-Wide Monitoring | Near-Road Sites | Area-Wide Sites |
|---|---|---|---|---|---|---|---|---|
| Boston-Cambridge-Newton | Essex | 790,638 | 4,436,124 | 329,265 | 2 | 1 | 2 | 4 |
| | Middlesex | 1,614,714 | | | | | | |
| | Suffolk | 807,252 | | | | | | |
| | Norfolk | 705,388 | | | | | | |
| | Plymouth | 518,132 | | | | | | |
| Barnstable | Barnstable | 213,413 | 213,413 | 58,879 | 0 | 0 | 0 | 0 |
| Providence-Warwick | Bristol | 564,022 | 564,022 | 77,414 | 0 | 0 | 0 | 0 |
| Worcester | Worcester | 830,839 | 830,839 | 63,865 | 0 | 0 | 0 | 1 |
| Greenfield Town | Franklin | 70,963 | 70,963 | 1,611 | 0 | 0 | 0 | 0 |
| Springfield | Hampden | 470,406 | 631,761 | 14,733 | 0 | 0 | 0 | 3 |
| | Hampshire | 161,355 | | | | | | |
| Pittsfield | Berkshire | 126,348 | 126,348 | 16,381 | 0 | 0 | 0 | 0 |

Source: AADTs – MassDOT annual traffic data collection program. https://www.mass.gov/traffic-volume-and-classification
Population - US Census-Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018.

Near-road requirements:

- One near-road $NO_2$ monitoring station in each MSA with a population of 1,000,000 or more persons.
- A second near-road $NO_2$ monitoring station is required for any MSA with a population of 2,500,000 persons or more, or in any MSA with a population of 1,000,000 or more persons that has one or more roadway segments with 250,000 or greater AADT counts

Area-wide $NO_2$ requirements:

- One monitoring station in each MSA with a population of 1,000,000 or more persons.
- PAMS sites that are situated in an area of expected high $NO_2$ concentrations may be used to satisfy this minimum requirement

## ANALYSIS RESULTS

MassDEP's $NO_2$ monitoring network meets EPA monitoring requirements and objectives and provides good coverage for the state, and there is no need for $NO_2$ monitors at this time. While it is possible that some $NO_2$ monitors could be eliminated, MassDEP measures other pollutants at all $NO_2$ monitoring sites, providing additional benefit.

# Lead (Pb)

## NETWORK DESCRIPTION

MassDEP monitors lead at the Boston – Harrison Avenue NCore site using a low-volume $PM_{10}$ method for non-NAAQS purposes under the National Air Toxics Trends Site (NATTS) program.

## LEAD MONITORING DATA

### 2018 Pb Data Summary

A summary of the 2019 Pb data is shown in Figure 5-46. All values are well below the NAAQS.

**Figure 5-46**
**2019 Pb Monitoring Data Summary (μg/m$^3$)**

| City | County | Address | 2019 MAX μg/m$^3$ | 2019 MEAN μg/m$^3$ |
|---|---|---|---|---|
| Boston | Suffolk | Harrison Avenue | 0.00460 | 0.00156 |

Standard: 0.15 μg/m$^3$ (rolling 3-month average)

MAX = Maximum 24-hour value
MEAN = Annual Arithmetic Mean

## TECHNOLOGY

MassDEP currently collects Teflon low volume $PM_{10}$ samples at Boston – Harrison Avenue, which is analyzed via X-ray fluorescence by EPA contractors. The samples are collected every 6$^{th}$ day for 24 hours.

## ADEQUACY OF THE MONITORING NETWORK

### EPA Requirements

Because lead levels are well below the NAAQS, EPA no longer requires lead monitoring at MassDEP's Boston NCore site. EPA requires monitoring near lead sources that emit 0.5 tons or greater annually; however, Massachusetts does not have any sources of lead emissions that meet this level.

## ANALYSIS RESULTS

MassDEP is not required to monitor lead for NAAQS purposes. However, MassDEP monitors toxics metals, including lead, at its Boston – Harrison Avenue as part of the National Air Toxics Trends Site program. Levels from this monitoring show lead levels are well below the lead NAAQS of 0.15 μg/m$^3$.

## Meteorology

### NETWORK DESCRIPTION

MassDEP operates the following types of meteorological instruments at its monitoring sites:

- 13 – Barometric pressure (BP)
- 13 – Relative humidity (RH)
- 13 – Solar radiation (Solar)
- 13 – Temperature (TEMP)
- 13 – Wind speed/wind direction (WS/WD)
- 2 – Precipitation (PRECIP)

In addition, there are two acid rain monitors in Massachusetts that are part of the National Atmospheric Deposition Program (NADP):

- Ware – operated by MassDEP
- Truro – operated by the National Park Service

Figure 5-47 describes all the meteorological monitors MassDEP operates.

**Figure 5-47**
**Description of Existing Meteorological Monitoring Network**

| Site ID | Site Name | Scale | Reason for Monitor | Parameters |
|---|---|---|---|---|
| 25-025-0042 | Boston - Harrison Ave | Neighborhood | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-025-0044 | Boston - Von Hillern | Middle | Population Exposure; Max. Concentration; Near Road | WS/WD, TEMP, RH, BP, SOLAR |
| 25-013-0008 | Chicopee | Urban | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-005-1006 | Fairhaven | Regional | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-011-2005 | Greenfield | Regional / Neighborhood | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-009-5005 | Haverhill | Urban | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-009-2006 | Lynn | Urban / Neighborhood | PAMS - Max. Precursor $O_3$; Population Exposure | WS/WD, TEMP, RH, BP, SOLAR, PRECIP |
| 25-021-3003 | Milton - Blue Hill | Regional | Upwind Background $PM_{2.5}$; Maximum Ozone | WS/WD, TEMP, RH, BP, SOLAR |
| 25-003-0008 | Pittsfield | Urban / Neighborhood | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-001-0002 | Truro | Regional | General Background | WS/WD, TEMP, RH, BP, SOLAR |
| 25-027-0024 | Uxbridge | Regional | Ozone Transport; Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |
| 25-015-4002 | Ware | Urban | Max. $O_3$ Conc.; background for other pollutants | WS/WD, TEMP, RH, BP, SOLAR, PRECIP |
| 25-027-0015 | Worcester - Airport | Urban | Population Exposure | WS/WD, TEMP, RH, BP, SOLAR |

## TECHNOLOGY

The Figure 5-48 below summarizes the technology MassDEP uses to measure meteorology. There are no plans to change existing technology.

**Figure 5-48**
**Meteorological Monitoring Technology**

| Parameter | Analytical Method | Sample Frequency | Location |
|---|---|---|---|
| Wind Speed/Direction | Ultrasonic Sensors | Hourly | All Meteorological Sites |
| Solar | Pyranometer | Hourly | All Meteorological Sites |
| Relative Humidity | Electronic Sensor | Hourly | All Meteorological Sites |
| Ambient Temperature | Electronic Thermistor | Hourly | All Meteorological Sites |
| Barometric Pressure | Electronic Sensor | Hourly | All Meteorological Sites |
| Precipitation | Tipping Bucket | Hourly | Ware and Lynn Only |

## ANALYSIS RESULTS

MassDEP has access to adequate meteorological information to forecast air quality, including predicting ozone and $PM_{2.5}$ episodes, modeling emissions from individual sources, evaluating the transport of pollution (particularly ozone and its precursors), and creating wind roses. MassDEP is planning to obtain a ceilometer for the Lynn PAMS site.

# Technology Issues

Key technology issues that MassDEP must address as part of operating the air monitoring network are listed below.

### Calibration

- MassDEP's field calibrators are suitable for ozone and trace-level dilution as appropriate. The equipment is capable of automated quality control checks. MassDEP has an internal ozone generator–photometer.

- MassDEP's lab and field calibrators can generate Minimum Detection Level (MDL) concentrations (CO, $SO_2$, and $NO_y$).

### Zero Air Source

- MassDEP's zero air source is compliant with NCore TAD recommendations. An ultra-pure air cylinder is used for occasional comparison to zero air source. The equipment has the capacity for 20+ LPM of dilution air.

**Data Acquisition System**

- MassDEP's data system is capable of a digital system, remote diagnostics, and remotely enabled checks. MassDEP has invested in a new, upgraded Data Acquisition System and remote communications capabilities, which has improved data polling times and quality and will significantly improve ongoing quality control assessments through real-time and near real-time communications with fields analyzers.

**Gas Cylinder Standards**

- MassDEP's gas cylinders are suitable for trace-level dilutions in accordance with Appendix A of 40 CFR Part 58 audit concentrations and EPA protocol certifications, and meet the special low-level standards needed for MDL concentrations (CO, $SO_2$, and NOy).

**Meteorological Calibration Devices**

- MassDEP's meteorological calibration devices have NIST (National Institute of Standards) traceability for required meteorological parameters. Sonic wind instruments must be shipped to the manufacturer annually for factory calibration.

**Sampling Manifold**

- MassDEP's sampling meets the standards of Appendix E of 40 CFR Part 58, including residence time <20 seconds, only glass or Teflon materials, and probe and monitor inlets of acceptable heights.

**Auditing Equipment**

MassDEP has the following auditing equipment:
- Independent calibrators
- Zero air source and gas standards compatible with trace-level specifications
- Independent meteorological and flow standards
- A new dilution system capable of generating EPA-required concentration levels

**Other**

MassDEP has:
- Automated Gas Chromatograph systems for measuring VOC ozone precursors at the PAMS site and at its laboratory for analyzing field-procured VOC canister samples
- An environmental chamber that houses a robotic weighing device for $PM_{2.5}$ filters
- A real-time website for displaying current air pollution concentrations to the public