Massachusetts 2019 Air Quality Report

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Bureau of Air and Waste
Division of Air and Climate Programs
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ACKNOWLEDGEMENTS

This 2019 Air Quality Report was prepared by the Massachusetts Department of Environmental Protection (MassDEP), Air Assessment Branch (AAB), which collects representative samples of ambient air for a number of pollutants at monitoring stations located across the Commonwealth. All samples are collected in a precise and scientifically sound manner in order to properly characterize the quality of the air in the Commonwealth.

The photo on the cover is a view of the Blue Hill monitoring station in Milton, MA.

This report is available on MassDEP's web site at

https://www.mass.gov/air-monitoring-in-massachusetts

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Table of Contents

Section 1 – Ambient Air Monitoring Program 5

1.1 - Program Overview 5

1.2 - National Ambient Air Quality Standards (NAAQS) 8

1.3 - Pollutant Health Effects and Sources 9

1.4 - Monitoring Network Description 11

Section 2 – Attainment of Air Quality Standards 12

2.1 - Attainment Status Summary 12

2.2 - 2019 Ozone Season 13

2.3 - Daily Ozone and PM Forecasts 16

Section 3 – Massachusetts Air Quality Data Summaries 17

3.1 - Ozone Summary 17

3.2 - Sulfur Dioxide (SO_2) Summary 21

3.3 - Nitrogen Dioxide (NO_2) Summary 24

3.4 - Carbon Monoxide (CO) Summary 27

3.5 - Particulate Matter 10 Microns (PM_{10}) Summary 30

3.6 - Particulate Matter 2.5 Microns ($PM_{2.5}$) Summary 31

3.7 - Speciation 37

3.8 - Interagency Monitoring of Protected Visual Environments (IMPROVE) 37

3.9 - Quality Assurance and Quality Control (QA/QC) 37

Section 4 – PAMS/Air Toxics Monitoring 38

4.1 - Photochemical Assessment Monitoring Stations (PAMS) Monitoring 38

4.2 - Air Toxics Monitoring 38

List of Abbreviations

AAB ....Air Assessment Branch
AQS ....Air Quality System
AQI ....Air Quality Index
BAM ....Beta Attenuation Monitor
BC.........................Black Carbon
BP.........................Barometric Pressure
CAA ....Clean Air Act
CFR.......................Code of Federal Regulations
CO ....Carbon Monoxide
CO_2.......................Carbon Dioxide
FEM......................Federal Equivalent Method
FRM.....................Federal Reference Method
EPA.......................United States Environmental Protection Agency
IMPROVE ....Interagency Monitoring of Protected Visual Environments
MassDEP ....Massachusetts Department of Environmental Protection
NAAQS ....National Ambient Air Quality Standards (for criteria pollutants)
NATTS ....National Air Toxics Trends Station
NCore...................National Core Monitoring Network
NO........................Nitric Oxide
NO_x.......................Nitrogen Oxides
NO_y.......................Total Reactive Oxidized Nitrogen
NO_2 ....Nitrogen Dioxide
NO_3 ....Nitrate
O_3.........................Ozone
PAH ....Polycyclic Aromatic Hydrocarbon
PAMS ....Photochemical Assessment Monitoring Stations
Pb.........................Lead
pH ....Concentration of hydrogen cations (H^+) in solution (an indicator of acidity)
ppb.......................parts per billion by volume
ppm......................parts per million by volume
$PM_{2.5}$ ....Particulate matter ≤ 2.5 microns aerodynamic diameter
PM_{10}.....................Particulate matter ≤ 10 microns aerodynamic diameter
PRECIP..................Precipitation
QA/QC..................Quality Assurance and Quality Control
REL ....Relative Humidity
SIP ....State Implementation Plan
SO_2.......................Sulfur Dioxide
SO_4 ....Sulfate
SUN ....Solar Radiation
SVOC ....Semi-Volatile Organic Compounds
TEMP....................Temperature
TOTAL UV............Ultraviolet radiation
TSA.......................Technical Systems Audit
TSP ....Total Suspended Particulates
$\mu g/m^3$ ....micrograms per cubic meter
VOCs ....Volatile Organic Compounds
WS/WD ....Wind Speed/Wind Direction
WSv/WDv............Wind Speed Vector/Wind Direction Vector

Section 1 – Ambient Air Monitoring Program

1.1 - Program Overview

Introduction

The Massachusetts Department of Environmental Protection (MassDEP) is responsible for monitoring outdoor air quality in Massachusetts, and for developing plans and regulatory programs to reduce emissions of pollutants that adversely affect public health, welfare, and the environment.

MassDEP's Air Assessment Branch (AAB) operates a network of air monitoring stations throughout the Commonwealth. During 2019, MassDEP operated 21 monitoring stations located in 17 cities and towns. MassDEP also received data from the Wampanoag Tribe of Gay Head (Aquinnah), which operates an air monitoring station on Martha's Vineyard.

MassDEP submits ambient air quality data to the national Air Quality System (AQS) database that is administered by the U.S. Environmental Protection Agency (EPA). Continuous monitoring data is sent to the AirNow website, which reports data from all U.S. monitoring stations. MassDEP's MassAir Online website provides air quality information and allows users to point and click on a map of the state to find current air quality data from the MassDEP continuous air monitoring network. MassAir Online is found at www.mass.gov/eea/agencies/massdep/air/quality/. EPA also makes historical AQS data for all U.S. monitoring stations available at https://www.epa.gov/outdoor-air-quality-data.

Why is Air Quality Data Collected?

Ambient air quality data is used for a number of purposes to:

- Provide information about air quality to the public;
- Provide short-term and long-term information regarding air pollution and public health;
- Verify compliance with National Ambient Air Quality Standards (NAAQS);
- Assess the effectiveness of current air pollution control regulations and initiatives;
- Support development of policies and regulations aimed at reducing air pollution;
- Support long-term trend analysis and special research; and
- Fulfill requirements to report ambient air quality data to EPA.

What is Monitored?

MassDEP monitors parameters in the following categories:

Criteria pollutants for which EPA has established NAAQS. The criteria pollutants monitored are:

- sulfur dioxide (SO_2)
- ozone (O_3)
- carbon monoxide (CO)
- nitrogen dioxide (NO_2)
- lead (Pb)

- particulate matter ≤10 microns (PM_{10})
- particulate matter ≤ 2.5 microns ($PM_{2.5}$)

Non-criteria pollutants do not have NAAQS, but can contribute to the formation of ozone and particulate matter and/or be toxic. The non-criteria pollutants monitored include:

- nitric oxide (NO)
- total nitrogen oxides (NOx)
- total reactive oxidized nitrogen (NOy)
- volatile organic compounds (VOCs) – ozone precursors and reaction product chemicals
- black carbon (i.e., soot)
- toxics – health-relevant VOCs, semi-volatile organic compounds (SVOCs), carbonyls and metals

Meteorological parameters monitored include:

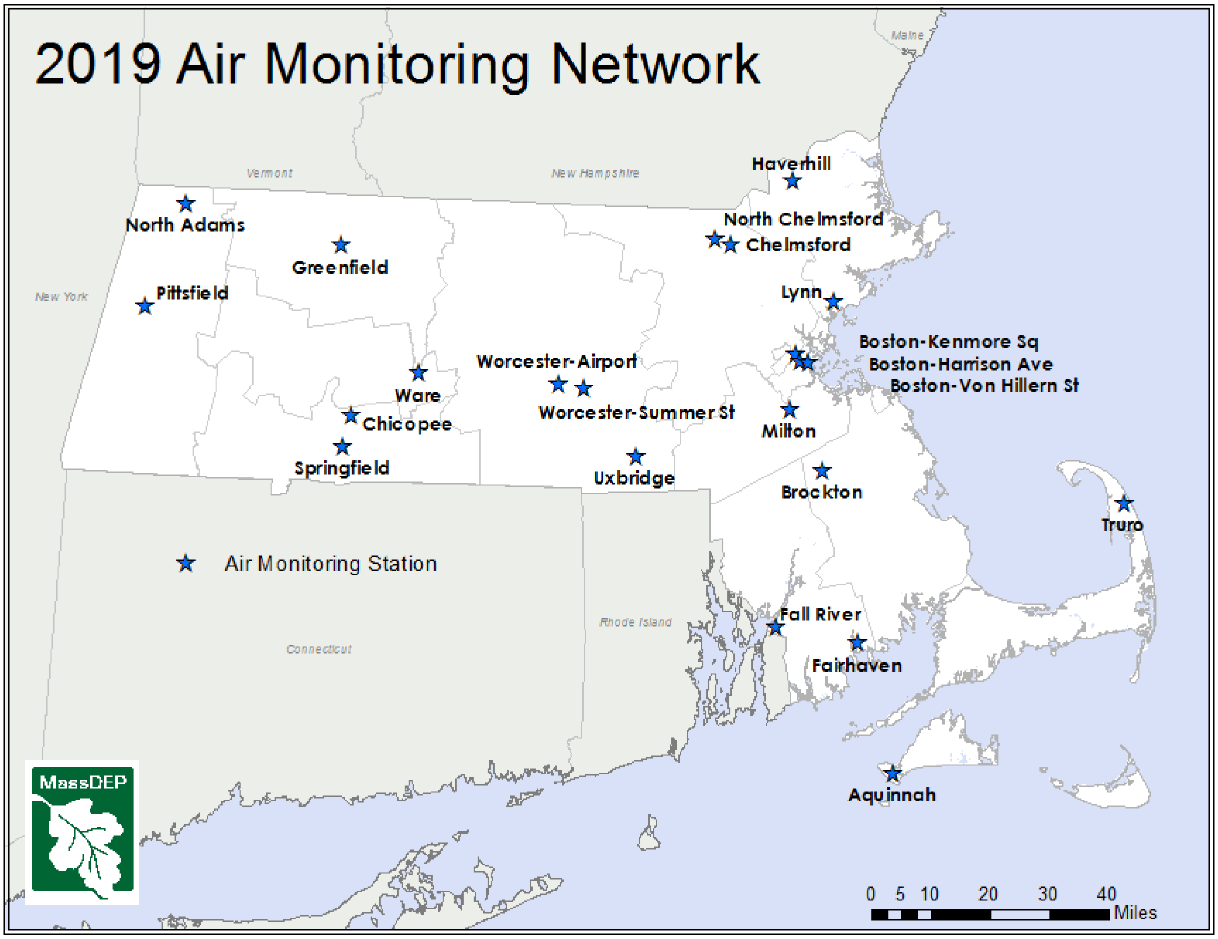
- wind speed/wind direction (WS/WD) and vector (WSv/WDv)
- relative humidity (REL)
- temperature (TEM)
- barometric pressure (BP)
- solar radiation (SUN)
- precipitation (PRECIP)
- ultraviolet radiation (TOTAL UV)

Monitoring Station Locations

Monitoring stations are sited to provide data for various purposes. Some are located where maximum pollutant concentrations are expected, while others are positioned in areas that will provide data that is representative of larger geographical areas. Local topography and pollutant source areas are factors that determine how well a particular monitor's location will represent a region.

Networks of monitors are located throughout the state. These networks are designed to reflect pollutant concentrations for all of Massachusetts. Section III of this report contains data summaries for each pollutant measured and maps showing the monitor locations for each network. Appendix A contains a list of monitoring stations.

The map on page 7 shows Massachusetts cities and towns where air monitors were located during 2019.


2019 Air Monitoring Network
Maine
Vermont
New Hampshire
New York
Connecticut
Rhode Island
Haverhill
North Chelmsford
Chelmsford
North Adams
Greenfield
Pittsfield
Lynn
Boston-Kenmore Sq
Boston-Harrison Ave
Boston-Von Hillern St
Worcester-Airport
Worcester-Summer St
Ware
Chicopee
Springfield
Milton
Uxbridge
Brockton
Truro
Air Monitoring Station
Fall River
Fairhaven
Aquinnah
MassDEP
0 5 10 20 30 40
Miles

1.2 - National Ambient Air Quality Standards (NAAQS)

Below are the current NAAQS for criteria pollutants set by EPA. Primary Standards are designed to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary Standards are designed to protect public welfare, including protection against decreased visibility, damage to crops, vegetation, and buildings.

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/m³	Not to be exceeded
Nitrogen Dioxide		primary	1-hour	100 ppb	98th percentile of 1-hr daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb	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/m³	annual mean, averaged over 3 years
		secondary	Annual	15 μg/m³	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 μg/m³	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		primary	1-hour	75 ppb	99th percentile of 1-hr daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

μg/m³ = micrograms per cubic meter

ppm = parts per million

ppb = parts per billion

1.3 - Pollutant Health Effects and Sources

Ozone (O_3)

- Tropospheric O_3 (ground-level) and Stratospheric O_3 (upper atmosphere) are the same chemical compound, just found at different places in the atmosphere. Stratospheric O_3, found at greater than 30,000 feet above the surface of the earth, is beneficial to all life because it filters out the sun's harmful UV radiation before it reaches the earth's surface. Ground-Level O_3 on the other hand is a health and environmental problem. This report pertains exclusively to ground-level O_3.
- O_3 is a respiratory irritant that can reduce lung function and resistance to infection. It can cause asthma attacks, nasal congestion, and throat irritation. It can inflame and damage (possibly permanently) cells that line the lungs, and aggravate chronic lung diseases. In addition, a number of studies have found a strong link between increases in ground-level O_3 and increased risk of premature death.
- O_3 is toxic to vegetation, inhibiting growth and causing leaf damage.
- O_3 deteriorates materials such as rubber and fabrics.
- Ground-level O_3 is unique in that it is formed by the reactions that occur between certain precursor pollutants in the presence of intense, high-energy sunlight during the hot summer months. The complexity of the process and the amount of time needed to complete these reactions can result in the buildup of ground-level ozone concentrations far downwind from the original source of the precursors.
- Sources of ground-level O_3 precursors, i.e., nitrogen oxides and hydrocarbons, include motor vehicles, lawn and garden equipment, power plants and other industrial sources.

Carbon Monoxide (CO)

- CO binds with hemoglobin in the blood, reducing the amount of oxygen carried to organs and tissues.
- Symptoms of high CO exposure include shortness of breath, chest pain, headaches, confusion, and loss of coordination. The health threat is most severe for those with cardiovascular disease.
- Motor vehicle emissions are the largest source of CO, which is produced from incomplete combustion of carbon in fuels.
- Industrial processes and non-transportation fuel combustion (e.g., boilers, lawn and garden equipment) also are sources of CO.

Sulfur Dioxide (SO_2)

- SO_2 combines with water vapor to form acidic aerosols harmful to the respiratory tract, aggravating symptoms associated with lung diseases such as asthma and bronchitis.
- SO_2 is a primary contributor to acid deposition. Impacts of acid deposition include: acidification of lakes and streams, damage to vegetation, damage to materials, and diminution of visibility.
- SO_2 is a product of fuel combustion (e.g., the burning of coal and oil that contains sulfur). Sources include power plants and business and residential sources burning heating oil.

Nitrogen Dioxide (NO_2)

- NO_2 lowers resistance to respiratory infections and aggravates symptoms associated with asthma and bronchitis.
- NO_2 contributes to acid deposition. Impacts of acid deposition include: acidification of lakes and streams, damage to vegetation, damage to materials, and diminution of visibility.
- NO_2 and nitric oxide (NO) contribute to the formation of ozone.
- NO_2 is formed from the oxidation of NO. Major sources of NO are fuel combustion, space heating, power plants and motor vehicles.

Particulate Matter (PM_{10} and $PM_{2.5}$)

- Particulate matter is tiny airborne particles or aerosols, which include dust, dirt, soot, smoke, and liquid droplets. Fine particulate matter (mostly below 2.5 microns in size) are not only the result of direct emissions, but can be formed in the atmosphere by chemical reactions involving gaseous pollutants.
- The numbers 2.5 and 10 refer to the particle size (actually the particles equal to or less than that size), measured in microns, which are collected by the monitors. Several thousand $PM_{2.5}$ particles could fit on the period at the end of this sentence.
- The small size of these particles allows easy entry into the human respiratory system. Long-term exposure causes the particles to accumulate in the lungs and affects breathing and produces respiratory symptoms. The small particles can migrate through the lungs and into the circulatory system and potentially produce cardio-vascular symptoms, as well as impacts from toxic components contained in the particulate matter.
- Particulate matter causes soiling and corrosion of materials.
- Particulate matter contributes to atmospheric haze that degrades visibility.
- Sources of particulates include industrial process emissions, motor vehicles, incinerators, power plants, and other fuel combustion sources.

Lead (Pb)

- Lead is an elemental metal that is found in nature.
- Exposure to lead can occur by inhalation or ingestion with food, water, soil or dust particles.
- Children, infants, and fetuses are the most susceptible to the effects of lead exposure.
- Lead causes intellectual disability, brain damage, and liver disease. It may be a factor in high blood pressure and damages the nervous system.
- Lead enters the atmosphere from the incineration of lead containing materials and from the manufacture and processing of lead containing products or materials like storage batteries, smelting and removal of lead-containing paint.

1.4 - Monitoring Network Description

The following describes the ambient air monitoring network in 2019.

Network Size	▪ 21 Monitoring Stations ▪ 17 cities and towns with monitoring stations
Number of Continuous Monitors	Continuous monitors measure air quality 24 hours per day. The data are reported as hourly averages. ▪ Criteria pollutant monitors measure pollutants for which NAAQS have been set. ❑ 4 – Trace-level CO monitors ❑ 10 – NO_2, NO and NOx monitors ❑ 16 – O_3 monitors (plus 1 Tribal) ❑ 6 – Trace-level SO_2 monitors ❑ 15 – $PM_{2.5}$ Beta Attenuation Monitors (BAMs) ▪ Meteorological monitors track weather conditions. ❑ 13 – Barometric pressure ❑ 13 – Relative humidity ❑ 13 – Solar radiation ❑ 13 – Temperature ❑ 12 – Wind speed/wind direction ❑ 1 – Wind speed vector/wind direction vector ❑ 2 – Precipitation ❑ 1 – Ultraviolet radiation ▪ Other Monitors ❑ 2 – Total Reactive Oxidized Nitrogen (NO/NOy). ❑ 1 – Photochemical assessment monitoring station (PAMS). PAMS monitors measure VOCs using automated gas chromatographs (GCs) on an hourly basis during the summer. ❑ 7 – Black Carbon.
Number of Intermittent Monitors	Intermittent monitors collect discrete samples for a specific time period. The samples are collected every day, every third day, or every sixth day. The data are averaged in 3-hour or 24-hour intervals. ▪ Criteria pollutant monitors measure pollutants that have NAAQS. ❑ 4 – PM_{10} monitors. ❑ 12 – $PM_{2.5}$ Federal Reference Method (FRM) monitors. ▪ Non-criteria pollutant monitors measure pollutants that do not have NAAQS. ❑ 1 – PAMS. PAMS monitors measure VOCs and carbonyls on a periodic schedule during the summer months. ❑ 1 – Toxics. These monitors measure health-relevant VOCs. ❑ 2 – Speciation. These monitors measure for $PM_{2.5}$, nitrates and organics. ❑ 1 – PM_{10} for metals analysis.

Section 2 – Attainment of Air Quality Standards

2.1 - Attainment Status Summary

The federal Clean Air Act (CAA) contains timeframes and milestones for states to meet and maintain NAAQS for criteria pollutants, which include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. EPA sets NAAQS at levels to protect public health and the environment. The EPA must review each NAAQS every five years and may update the standards based on new scientific information as well as establish new monitoring requirements. Each state is required to monitor the ambient air to determine whether it meets each standard. If monitoring shows that the air quality does not meet a standard, the state must develop and implement pollution control strategies to attain that standard. Once air quality meets a standard, a state must develop a plan to maintain that standard while accounting for future economic and emissions growth. Taken together, these plans and control strategies constitute the State Implementation Plan (SIP).

Carbon Monoxide

Monitored levels of CO in Massachusetts meet the CO standards. Prior to the mid-1980s, Massachusetts was in nonattainment of the CO standards. However, with the adoption of numerous control programs, CO emissions significantly decreased and monitored levels of CO met the standards beginning in 1987. Massachusetts is designated as Unclassifiable/Attainment for the CO standards. Based on EPA's most recent review of the CO standards, in August 2011, EPA retained the existing CO standards. Since EPA did not change the standards, no new designation process was triggered.

Lead

Monitored levels of lead in Massachusetts meet the lead standards. In October 2009, EPA lowered the lead standards (primary and secondary) from 1.5 µg/m³ to 0.15 µg/m³ averaged over a rolling 3-month period. In November 2011, EPA designated all of Massachusetts as Unclassifiable/Attainment for the 2009 standard. Based on EPA's most recent review of the lead standards, in September 2016 EPA retained the existing lead standards. Since EPA did not change the standards, no new designation process was triggered.

Nitrogen Dioxide

Monitored levels of NO_2 in Massachusetts meet the NO_2 standards. In January 2010, EPA established a new 1-hour NO_2 standard of 100 ppb and new near-road monitoring requirements. In January 2012, EPA designated all of Massachusetts as Unclassifiable/Attainment for the 2010 standard. Based on EPA's most recent review of the NO_2 standards, in April 2018 EPA retained the existing NO_2 standards. Since EPA did not change the standards, no new designation process was triggered.

Sulfur Dioxide

Monitored levels of SO_2 in Massachusetts meet the SO_2 standards. In June 2010, EPA established a new primary 1-hour SO_2 standard of 75 ppb. In December 2018, EPA designated all of Massachusetts as Unclassifiable/Attainment for the 2010 standard. Based on EPA's most recent review of the SO_2

standards, in February 2019 EPA retained the existing SO_2 standards. Since EPA did not change the standards, no new designation process was triggered.

Particulate Matter

There are standards for two types of particulate matter: PM_{10} and $PM_{2.5}$. Monitored levels of PM_{10} and $PM_{2.5}$ in Massachusetts meet the respective standards.

In December 2012, EPA lowered the primary annual $PM_{2.5}$ standard to 12 $\mu g/m^3$. In December 2014, EPA designated all of Massachusetts as Unclassifiable/Attainment for the 2012 standard. Based on EPA's most recent review of the PM standards, in April 2020 EPA proposed to retain the existing $PM_{2.5}$ and PM_{10} standards. EPA expects to issue final standards by the end of 2020.

Ozone

In 1979, EPA established an ozone standard (0.12 ppm) based on the maximum 1-hour ozone concentration that occurred each day during the ozone monitoring season. Massachusetts was designated as Nonattainment with this standard.

In 1997, EPA established new 8-hour ozone standards (0.08 ppm) that were designed to be more representative of exposure over time, rather than just the maximum concentration (the 1-hour standard was revoked in 2005). Massachusetts was designated as Nonattainment for these standards at that time. Through a combination of state and regional controls, Massachusetts' air quality attained the 1997 standards by the 2009 attainment deadline.

In 2009, EPA lowered the 8-hour ozone standards to 0.075 ppm. In April 2012, EPA designated Dukes County as Nonattainment for the 2009 ozone standards and designated the remainder of Massachusetts as Unclassifiable/Attainment. Dukes County attained the 2009 ozone standard by the 2015 attainment deadline.

In October 2015, EPA lowered the 8-hour ozone standards to 0.070 ppm. EPA has designated all of Massachusetts as Unclassifiable/Attainment for the 2015 standards. EPA is currently reviewing the ozone standards.

2.2 - 2019 Ozone Season

In 2019, there were five days when the 8-hour ozone standard of 0.070 ppm was exceeded in Massachusetts. Based on the most recent three years of data (2017–2019), one monitoring location, Aquinnah on Martha's Vineyard, violated the 0.070-ppm standard.

While ozone concentrations have trended downward over the past several decades due to air pollution control programs, ozone concentrations vary each year due to varying weather patterns. In general, the chemical reactions that produce elevated ozone concentrations occur when high energy sunlight (present on hot summer days) facilitates the reaction of ozone "precursor" pollutants – VOCs and NOx – which results in ozone formation. Typically, Massachusetts ozone exceedances occur when a high pressure area well south of New England creates a broad southwesterly airflow containing precursors from the upwind coastal urban corridor to New England, where reactions in the atmosphere result in elevated levels of ozone. This typical pattern also moves slowly, promoting heat wave conditions that can last several days, allowing pollutants to build up.

Difference Between Ozone Exceedances and Violations

An ozone exceedance occurs when monitored ozone concentrations exceed the ozone NAAQS. Ozone monitoring data is collected as an hourly average of continuous data which is then used to determine the highest 8-hour average value for the day. An exceedance of the 8-hour standard is an 8-hour averaged value that is greater than 0.070 ppm. An ozone exceedance occurs when a monitor records ambient levels of ozone above the standard. Monitoring an ozone exceedance does not mean that a violation of the ozone standard has occurred, because a violation of an ozone standard (as opposed to an exceedance) is based on three-year averages of data at each monitor.

An ozone violation of the 8-hour standard is determined using the annual 4th-highest daily maximum eight-hour ozone value at each monitor. A violation requires a three-year average of the annual 4th-highest daily maximum eight-hour value that is greater than 0.070 ppm. In other words, the eight-hour values for each day during a year for a specific monitor are ranked from highest to lowest. Then, the 4th-highest value for three consecutive years is averaged. If the three-year average is greater than 0.070 ppm, a violation of the 8-hour standard has occurred at that monitoring site.

Exceedance Days and Total Exceedance Trends

Figure 1 shows the number of 8-hour exceedance days and the total number of exceedances for the past ten years. Note that years 2010-2015 show what exceedances would have been had the 0.070 ppm 8-hour standards been in effect. Figure 2 shows the most recent ozone design values (i.e., the 4th highest 8-hour O_3 value averaged over three years) relative to the 2015 ozone NAAQS. Monitoring sites with less than three years of data, and therefore no three-year averages, are not included in Figure 2.

Figure 1
8-hour Ozone Exceedance Days and Total Exceedances 2010-2019
Exceedances Based on 0.070 ppm 8-hour Standard

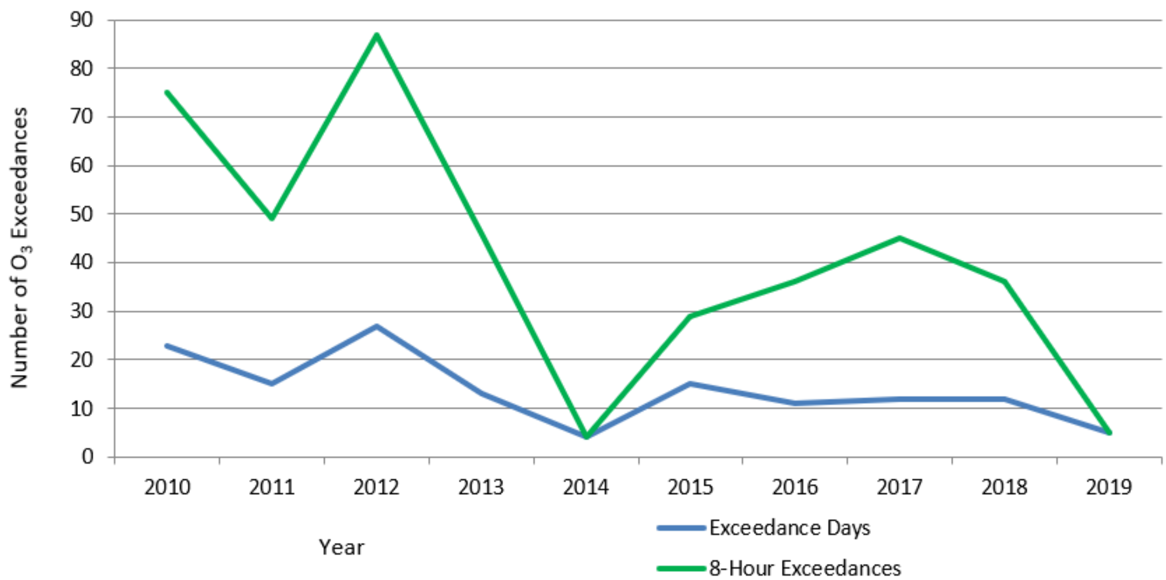
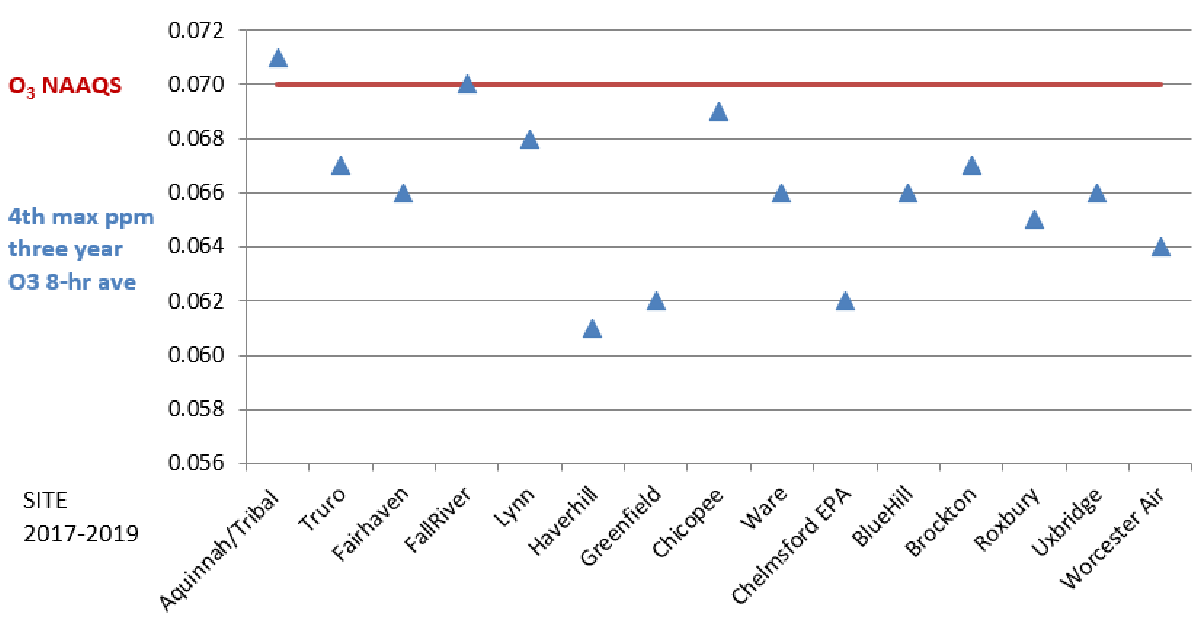


Figure 2
Ozone Design Values (2017-2019)



2.3 - Daily Ozone and PM Forecasts

MassDEP provides the public with daily air quality forecasts for ozone from mid-April through September and for fine particles all year round using weather maps and meteorological factors to predict whether or not conditions will result in elevated pollution levels. The daily air quality forecasts are available from www.mass.gov/eea/agencies/massdep/air/quality/. EPA web sites that contain regional and national pollution forecasts using data that is provided by participating states are located at www.epa.gov/region01/airquality/forecast.html and http://airnow.gov/. The table below describes the ratings used in the daily air quality forecasts.

Air Quality Index (AQI): Ozone		
Index Values	**Levels of Health Concern**	**Cautionary Statements**
0-50	Good	None
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
101-150	Unhealthy for Sensitive Groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.
151-200	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
201-300	Very Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors.

Air Quality Index (AQI): Particle Pollution		
Index Values	**Levels of Health Concern**	**Cautionary Statements**
0-50	Good	None
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101-150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
151-200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
201-300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

Section 3 – Massachusetts Air Quality Data Summaries

3.1 - Ozone Summary

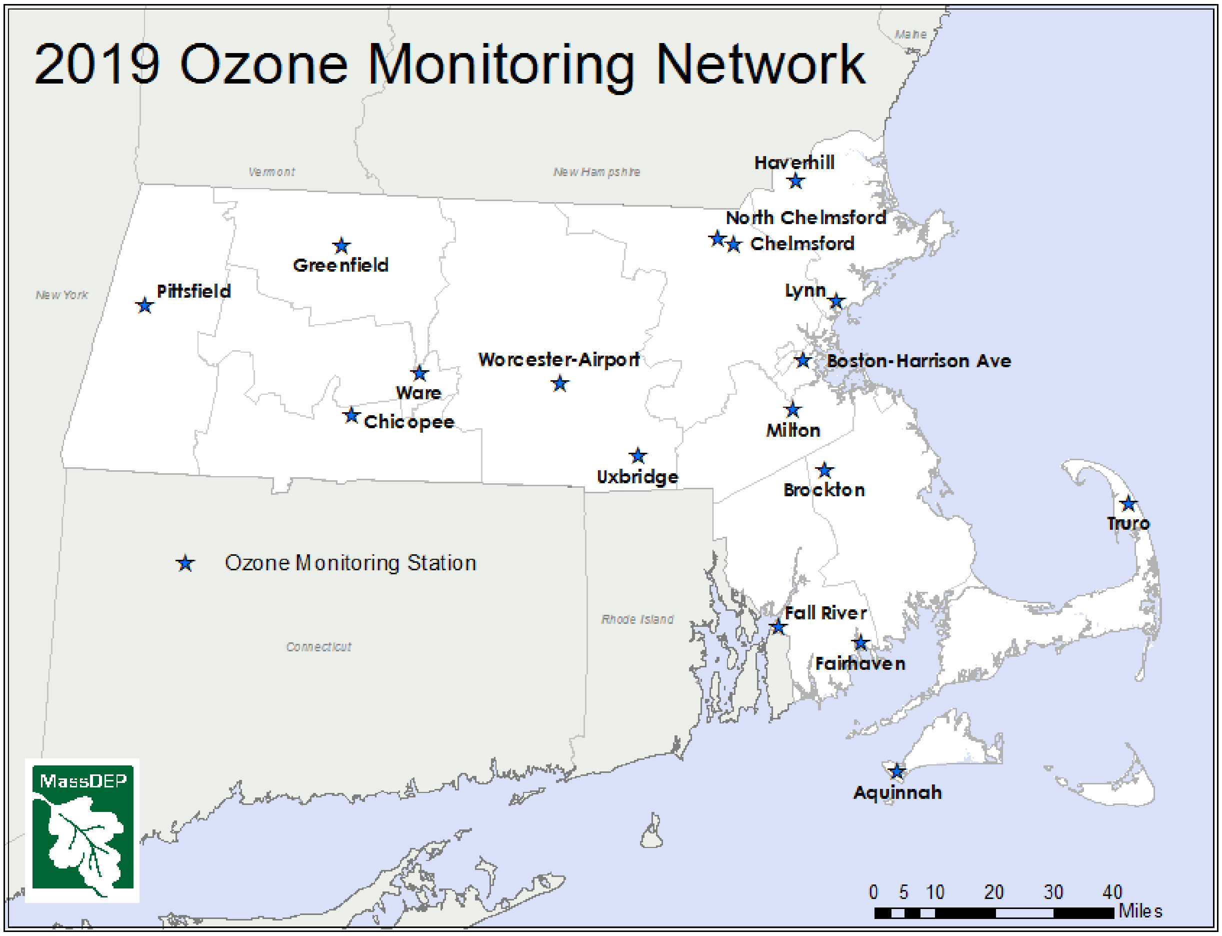
2019 Ozone Data Summary

A summary of the data collected during the 2019 ozone season (March 1 – September 30) is shown below (in parts per million). MassDEP operated 16 ozone monitors during 2019. The Wampanoag Tribe operated one ozone monitor in Aquinnah on Martha's Vineyard.

O_3 2019 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

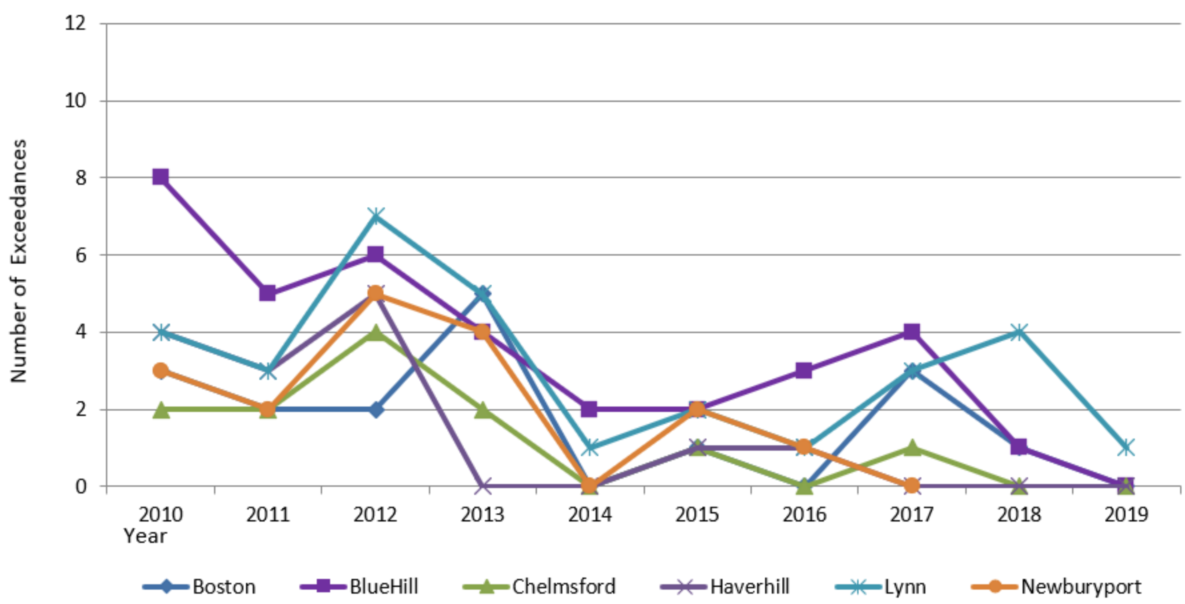
Ozone Monitor Locations



8-hour Ozone Exceedance Trends

Figure 3 shows the trend for each monitor for the past ten years based on the 0.070 ppm 8-hour standard.

Figure 3
8-hour Ozone Exceedance Trends 2010 – 2019
Exceedances Based on 0.070 ppm 8-hour Standard



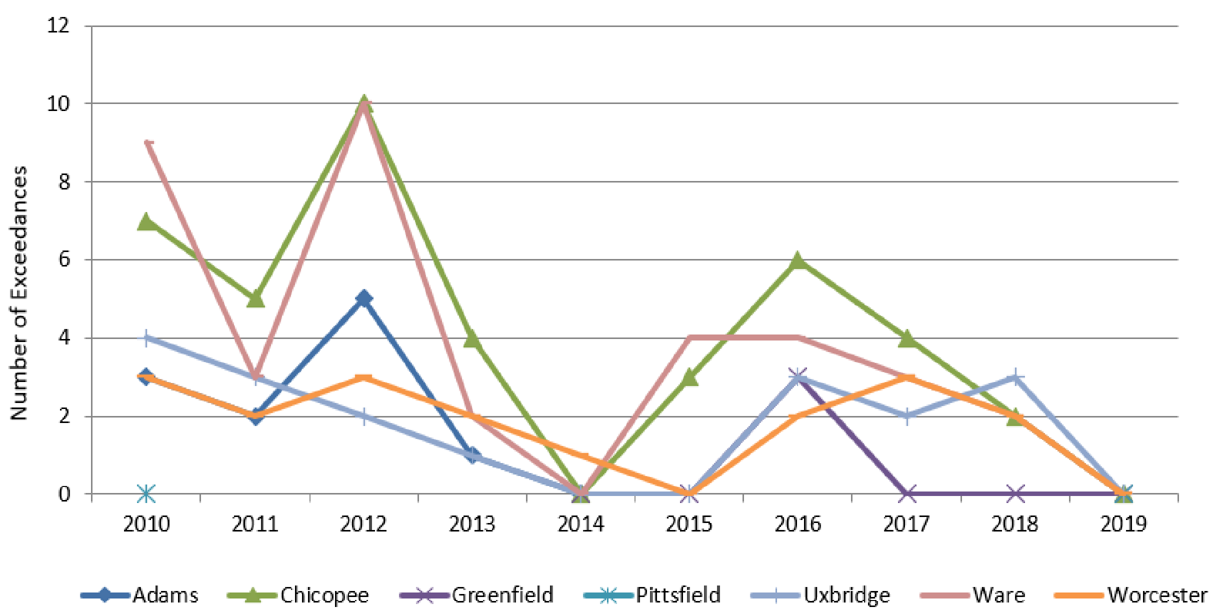
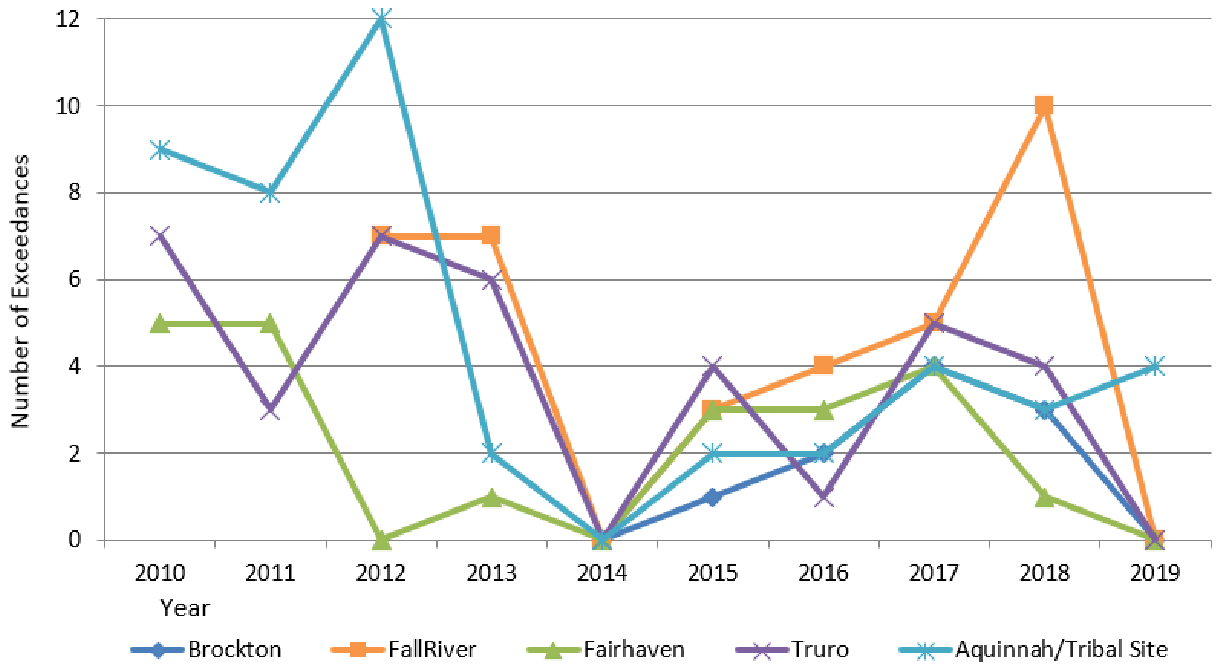


Figure 3 cont.
8-hour Ozone Exceedance Trends 2010 – 2019
Exceedances Based on 0.070 ppm 8-hour Standard



3.2 - Sulfur Dioxide (SO_2) Summary

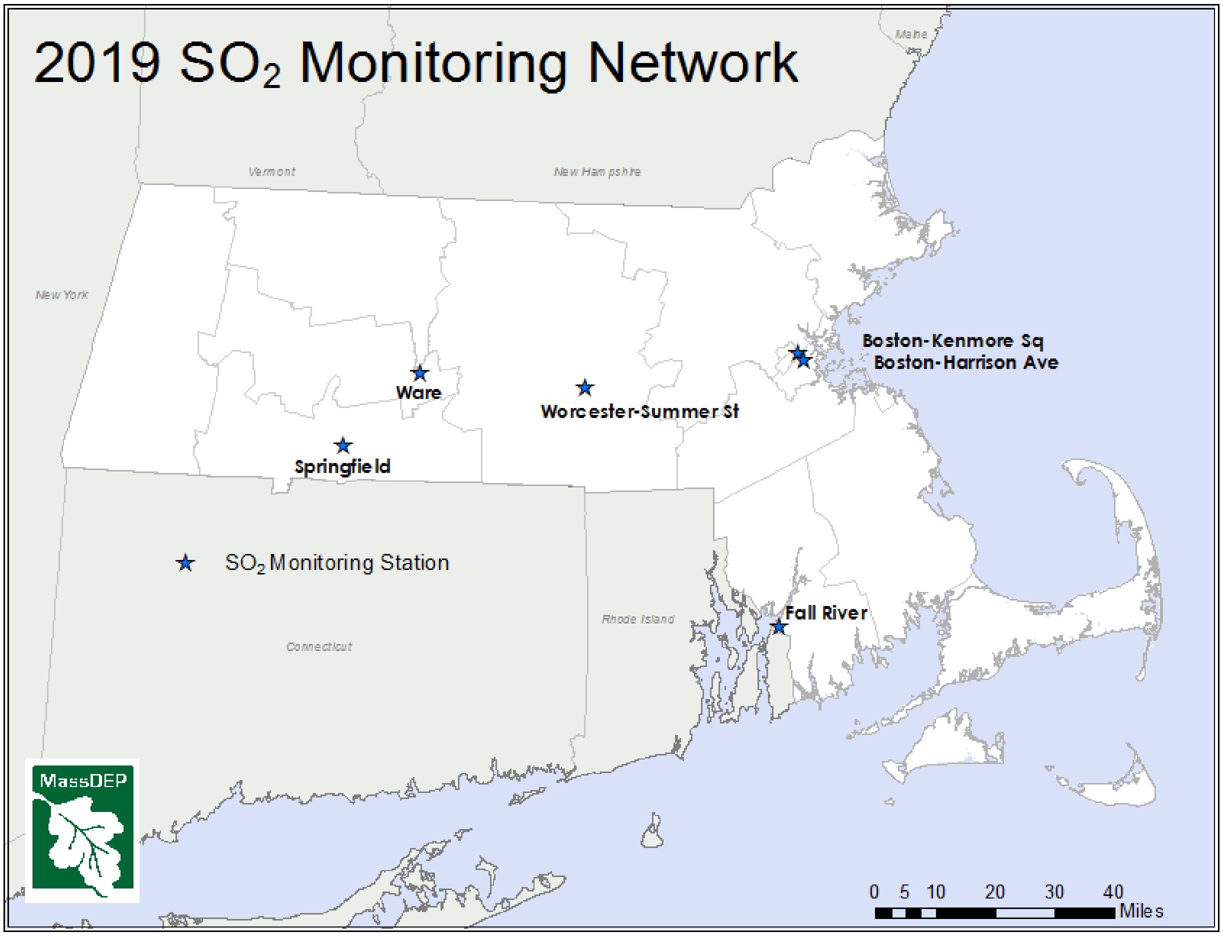
2019 SO_2 Data Summary

A summary of the 2019 SO_2 data is shown below (in parts per billion). MassDEP operated six SO_2 monitors during 2019. All values are well below applicable NAAQS.

SO_2 2019 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 = 99^{th} Percentile of the 1-hr Maximum Value
ARITH MEAN = Annual Arithmetic Mean
1st, 2nd MAX 24-HR = First and Second Highest 24-hr Value

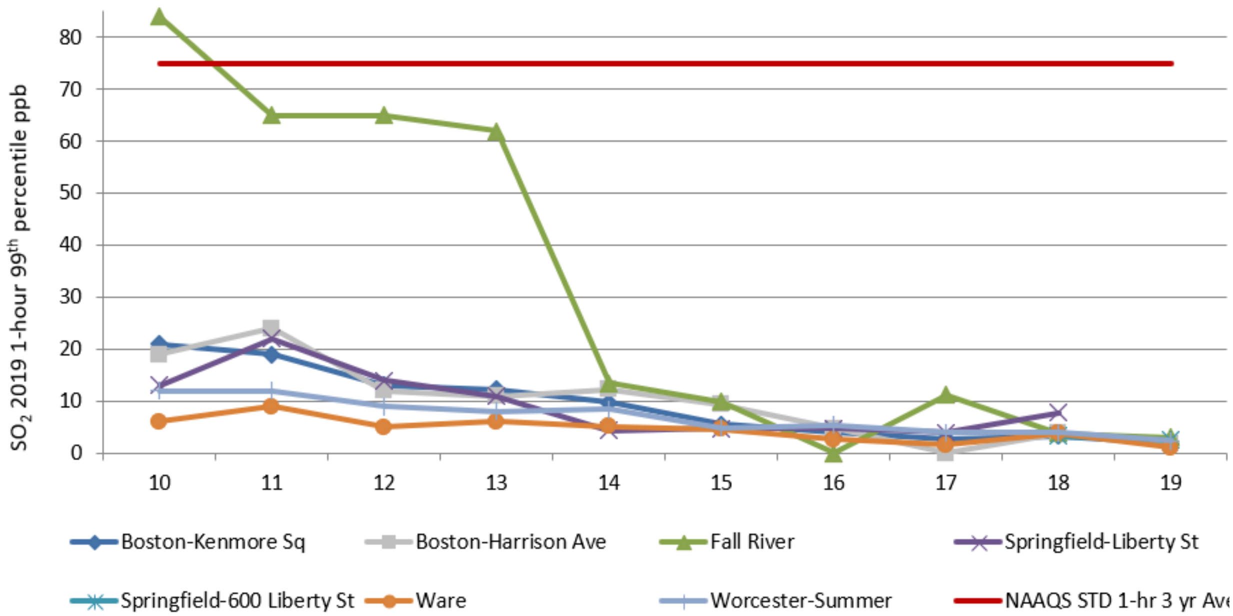
Sulfur Dioxide Monitor Locations



SO_2 Trends

Figure 4 shows the trend of the 1-hour 99th percentile for each SO_2 monitor for the past 10 years relative to the 1-hour standard of 75 ppb.

Figure 4
Sulfur Dioxide Trends 2010 – 2019
1-hour 99th Percentile Annual Average



3.3 - Nitrogen Dioxide (NO_2) Summary

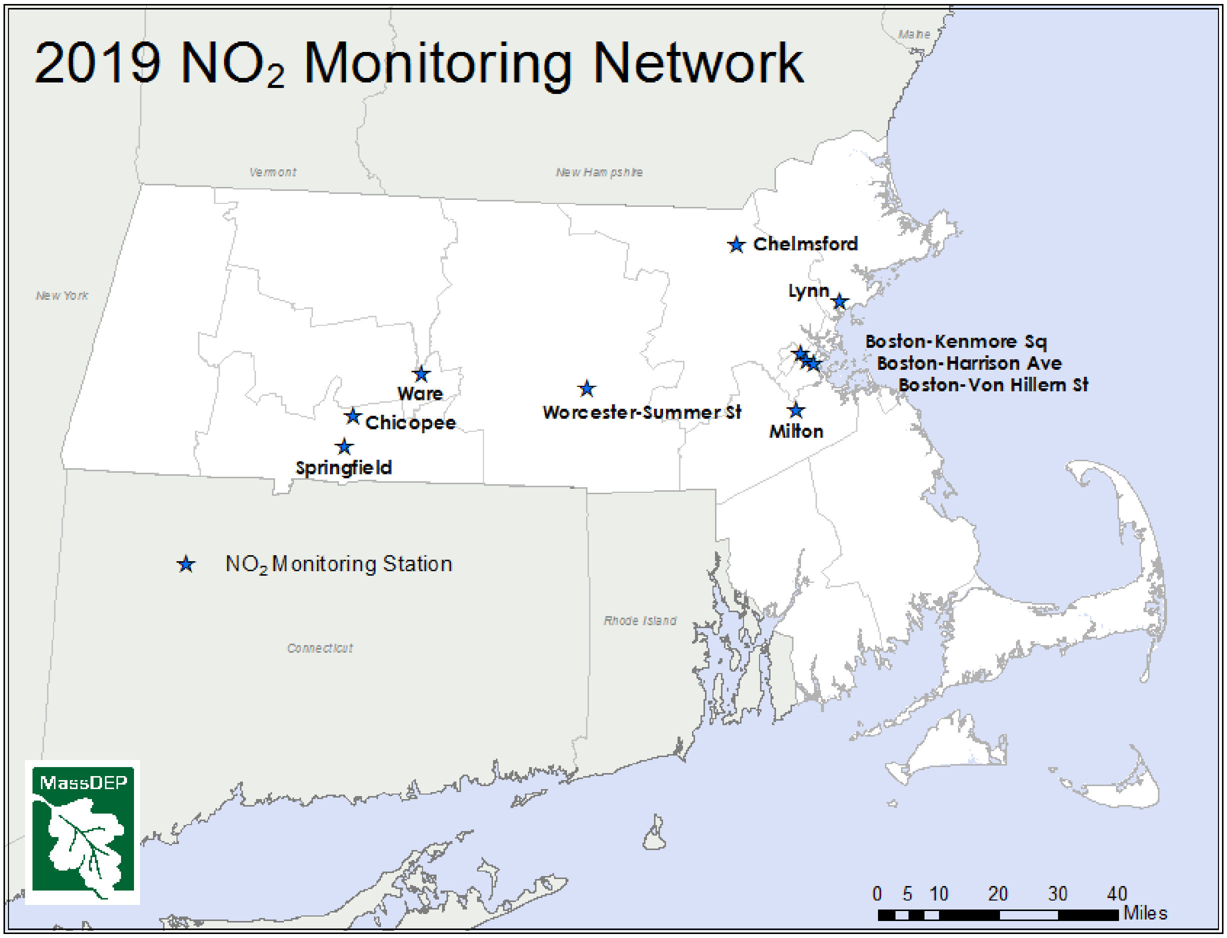
2019 NO_2 Data Summary

A summary of the 2019 NO_2 data is shown below (in parts per billion). MassDEP operated 10 NO_2 monitors during 2019. All values are well below applicable NAAQS.

NO_2 2019 CITY	COUNTY	ADDRESS	1ST MAX 1-HR	2ND MAX 1-HR	98TH PECENTILE 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

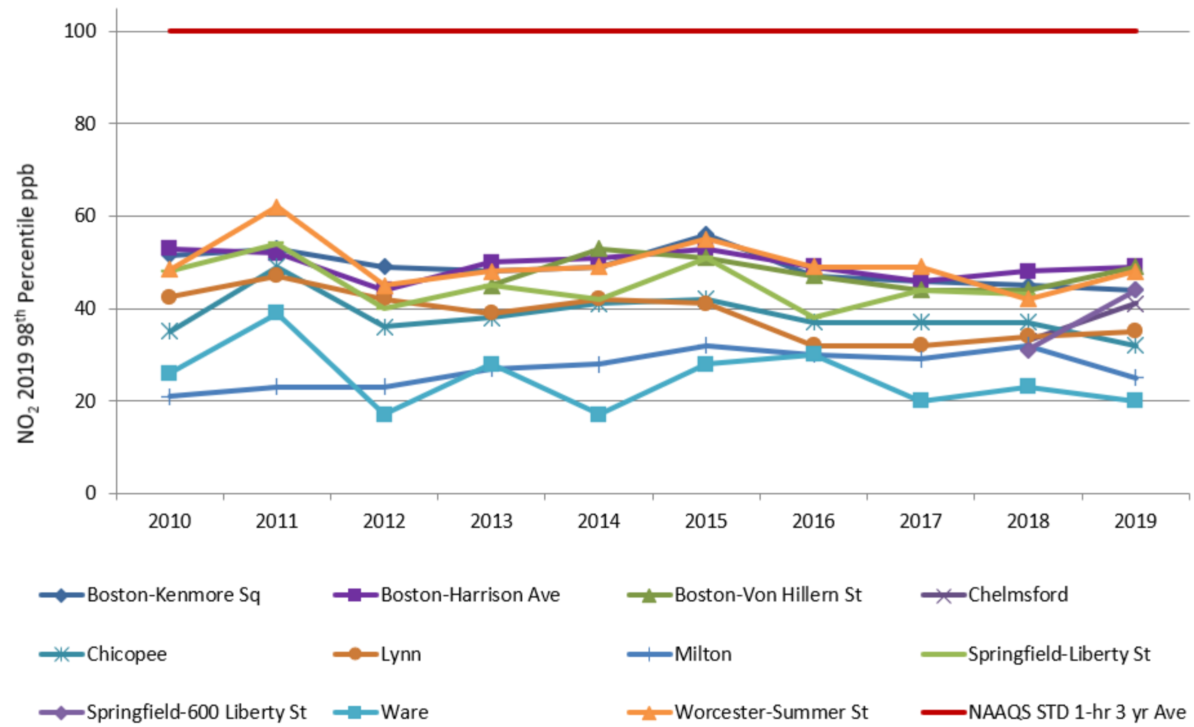
Nitrogen Dioxide Monitor Locations



NO_2 Trends

Figure 5 shows the trend of the 1-hour 98th percentile annual average for each NO_2 monitor over the past 10 years relative to the 1-hour standard of 100 ppb.

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



3.4 - Carbon Monoxide (CO) Summary

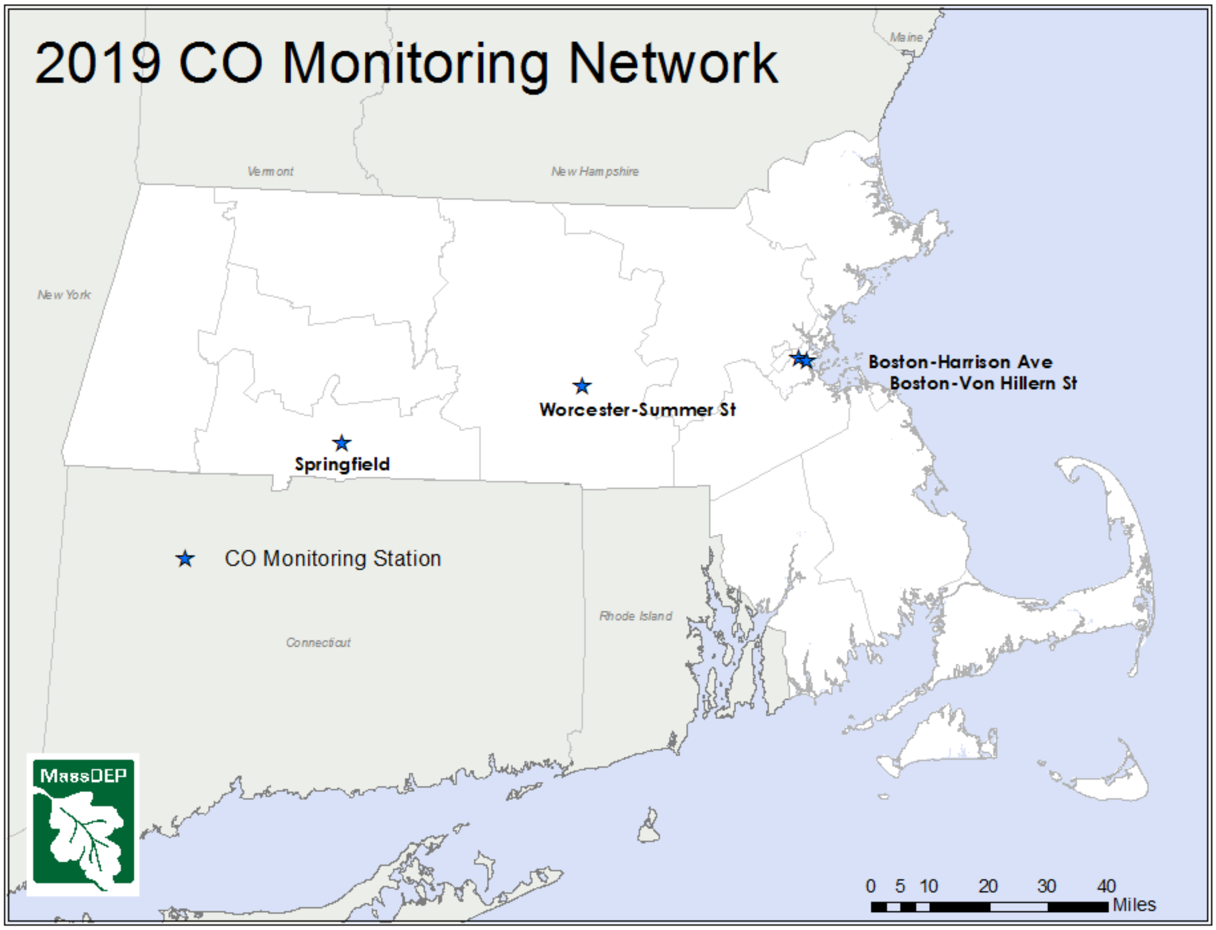
2019 CO Data Summary

A summary of the 2019 CO data is shown below (in parts per million). MassDEP operated four CO monitors during 2019. All values are well below applicable NAAQS.

CO 2019 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

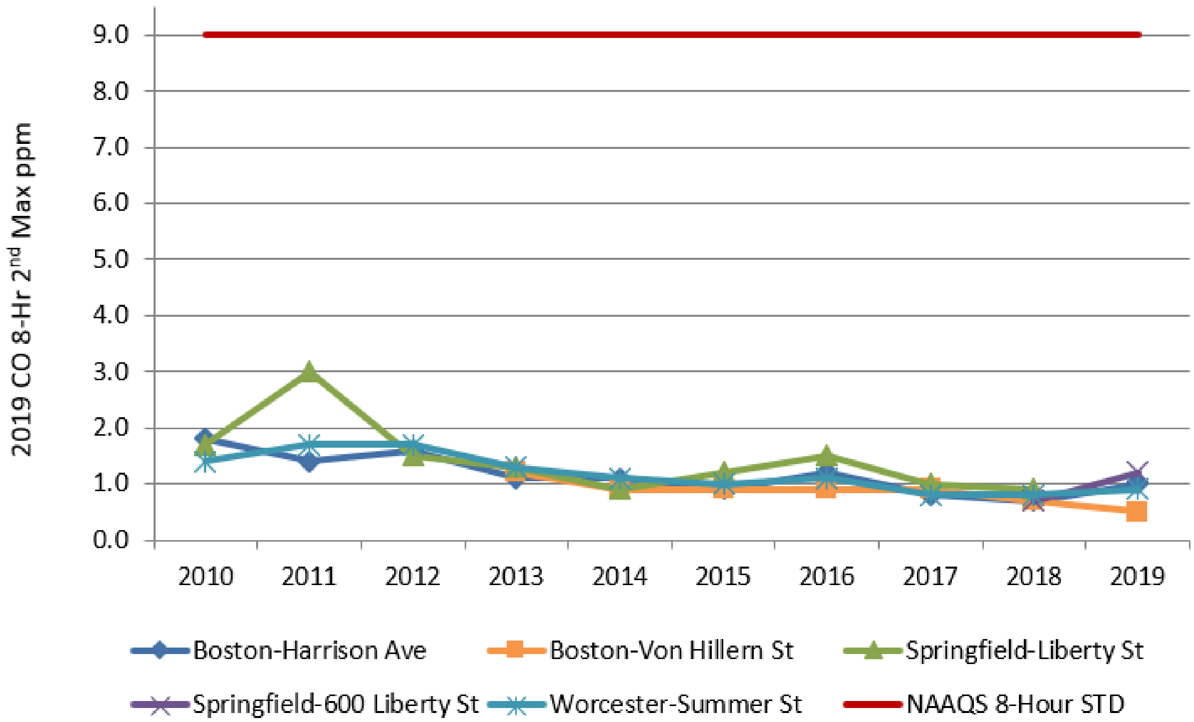
Carbon Monoxide Monitor Locations



CO Trends

Figure 6 shows the trend of the 2nd maximum 8-hour average for each CO monitor over the past 10 years relative to the 8-hour standard of 9 ppm.

Figure 6
Carbon Monoxide Trends 2010 – 2019
2nd Maximum 8-hour Values



3.5 - Particulate Matter 10 Microns (PM_{10}) Summary

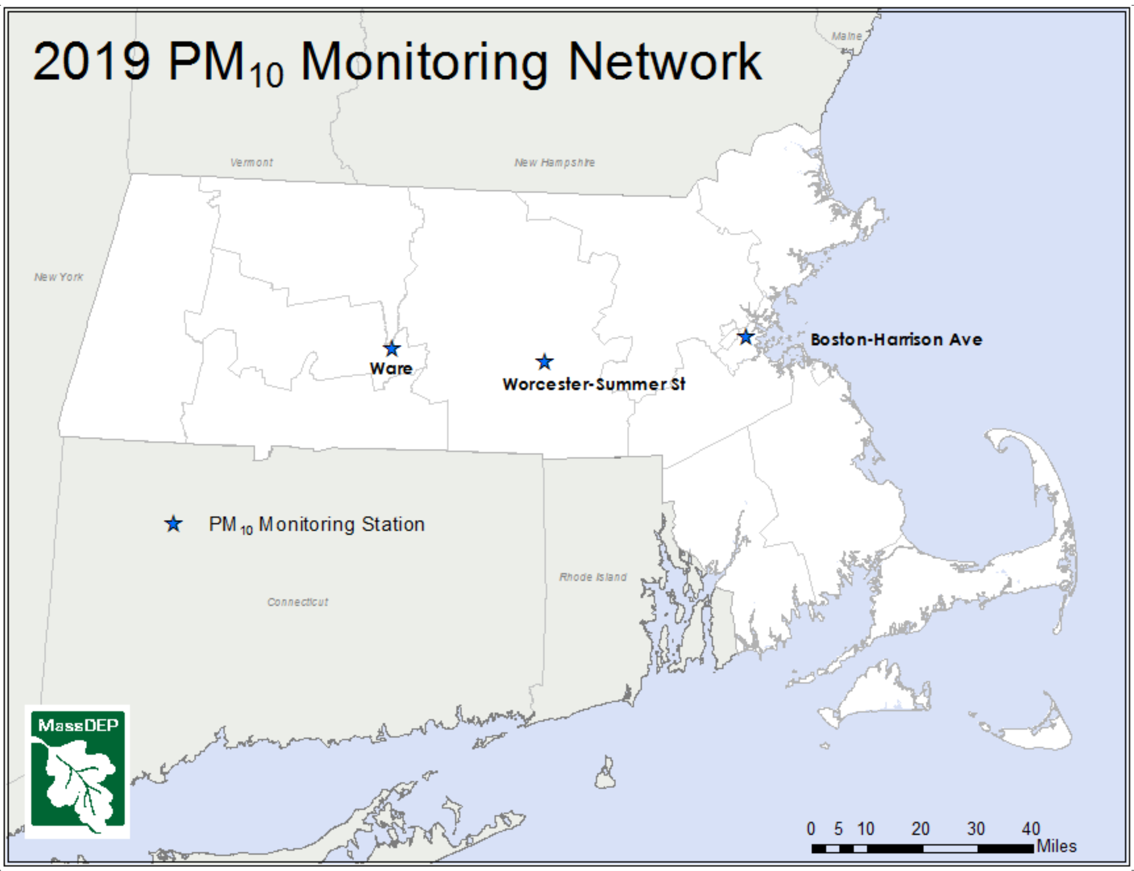
2019 PM_{10} Data Summary

A summary of the 2019 PM_{10} data is shown below (in µg/m^3). MassDEP operated four PM_{10} monitors in 2019. All values are well below applicable NAAQS.

PM_{10} 2019 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

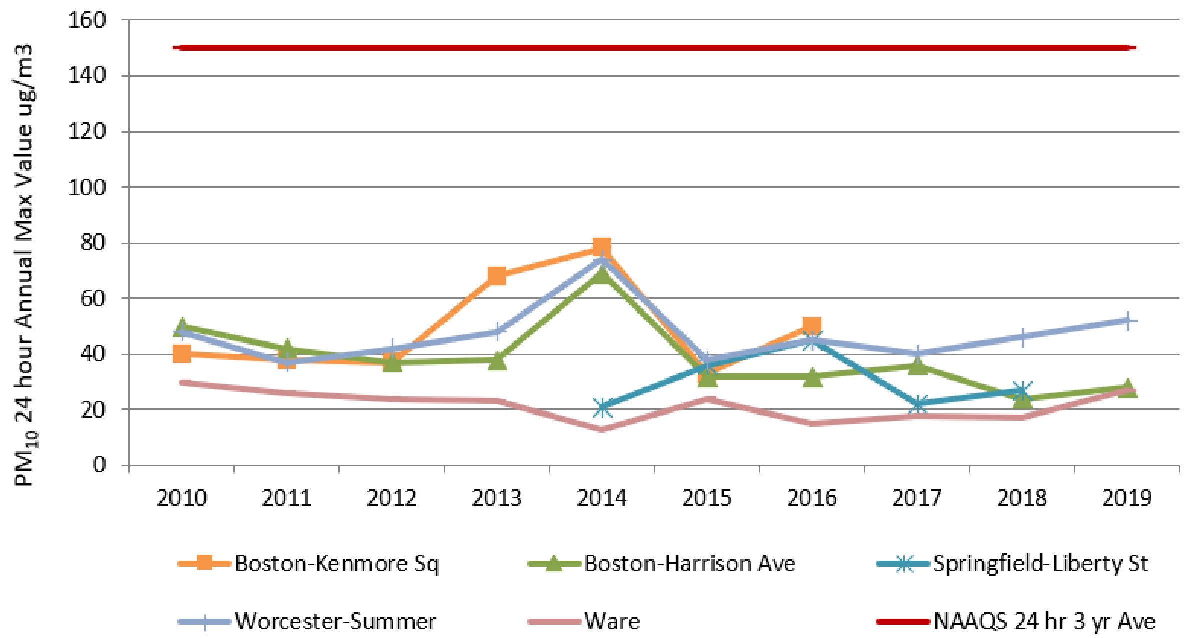
PM_{10} Monitor Locations



PM_{10} Trends

Figure 7 shows the 2019 calendar year 24-hour maximum concentration for each PM_{10} monitor relative to the 24-hour standard of 150 µg/m3.

Figure 7
PM_{10} Trends 2010 – 2019
24-Hour Calendar Year Maximum



3.6 - Particulate Matter 2.5 Microns ($PM_{2.5}$) Summary

During 2019, MassDEP operated 12 Federal Reference Method (FRM) filter-based $PM_{2.5}$ monitors and 15 Federal Equivalence Method (FEM) continuous $PM_{2.5}$ monitors.

FRM monitors require the manual set-up and collection of filters that measure 24-hour samples every three or six days. The filters are weighed prior to placement in the field and then weighed again after the sample is collected to determine the amount of $PM_{2.5}$ collected on the filter.

FEM monitors measure $PM_{2.5}$ on an hourly basis. MassDEP operates FRM and FEM monitors side-by-side at some locations for comparison. In general, FEM monitors provide slightly higher values than FRM monitors, which may be due to measurement of fresh hourly $PM_{2.5}$ samples with FEM versus slightly aged 24-hour samples with the FRM filter method.

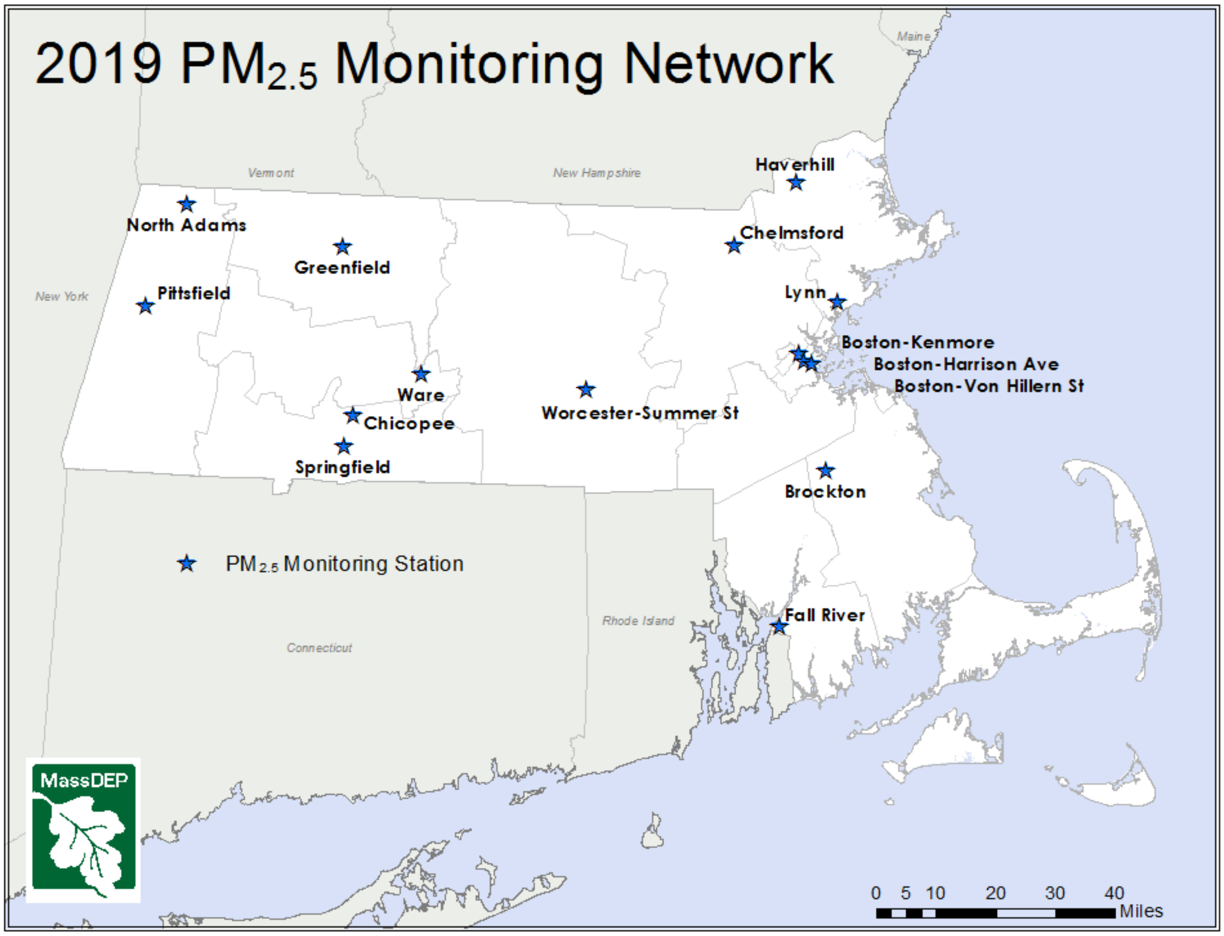
2019 $PM_{2.5}$ FRM Data Summary

A summary of the 2019 $PM_{2.5}$ FRM data is shown below (in µg/m3).

$PM_{2.5}$ 2019 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	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	Center Street	11.2	10.1	7.8	6.9	11.2	4.54
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 = 12.0 µg/m³ (primary) 24-hour (98th percentile) = 35 µg/m3
* = Collocated monitors
1ST, 2ND, 3RD, 4TH 24-HR MAX = 1ST, 2ND, 3RD, and 4TH Highest 24-hr Values for the Year
98TH PERCENTILE 24-HR = 98TH Percentile Value for the Year
ARITH MEAN = Annual Arithmetic Mean

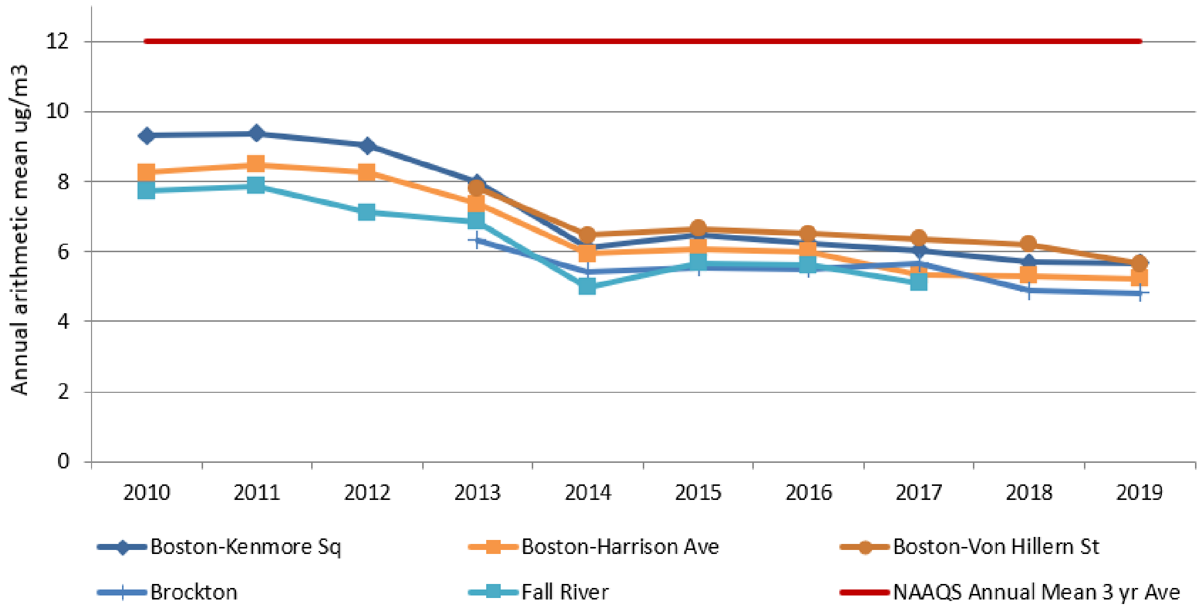
$PM_{2.5}$ Monitor Locations

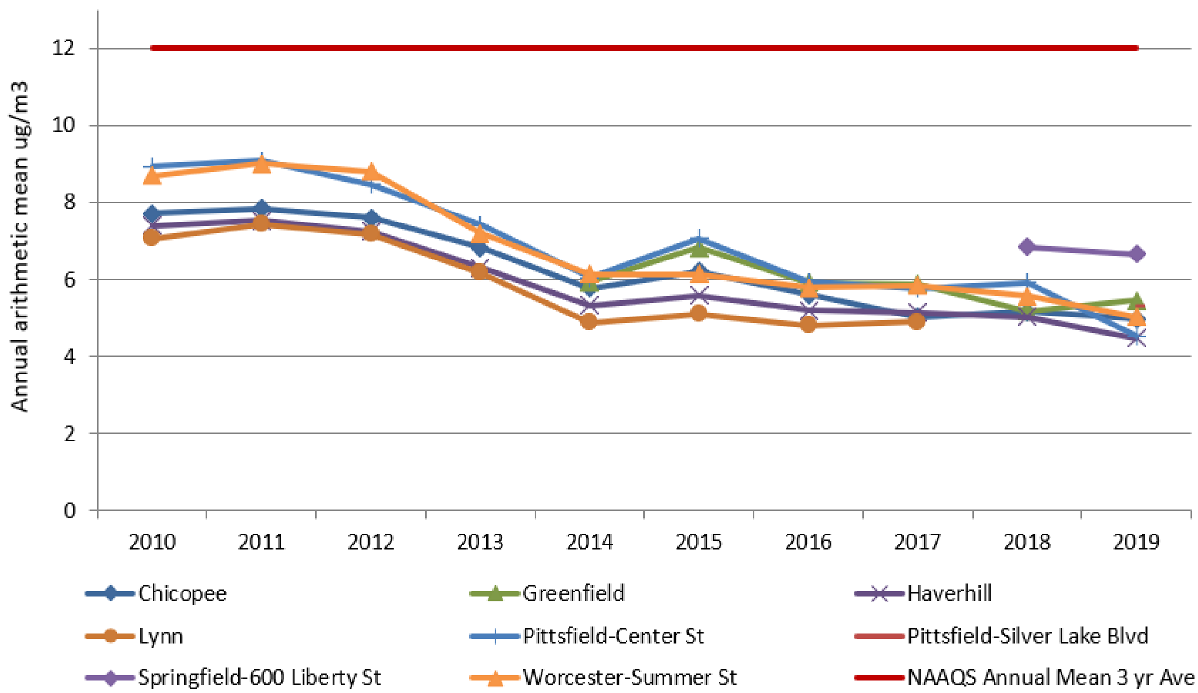


PM2.5 FRM Trends

Figure 8 shows trends of the annual arithmetic mean for each $PM_{2.5}$ FRM monitor over the past 10 years relative to the standard of 12 µg/m3.

Figure 8
$PM_{2.5}$ Trends 2010 – 2019
FRM Annual Arithmetic Mean





2019 $PM_{2.5}$ FEM Data Summary

A summary of the 2019 $PM_{2.5}$ FEM data is shown below (in µg/m3).

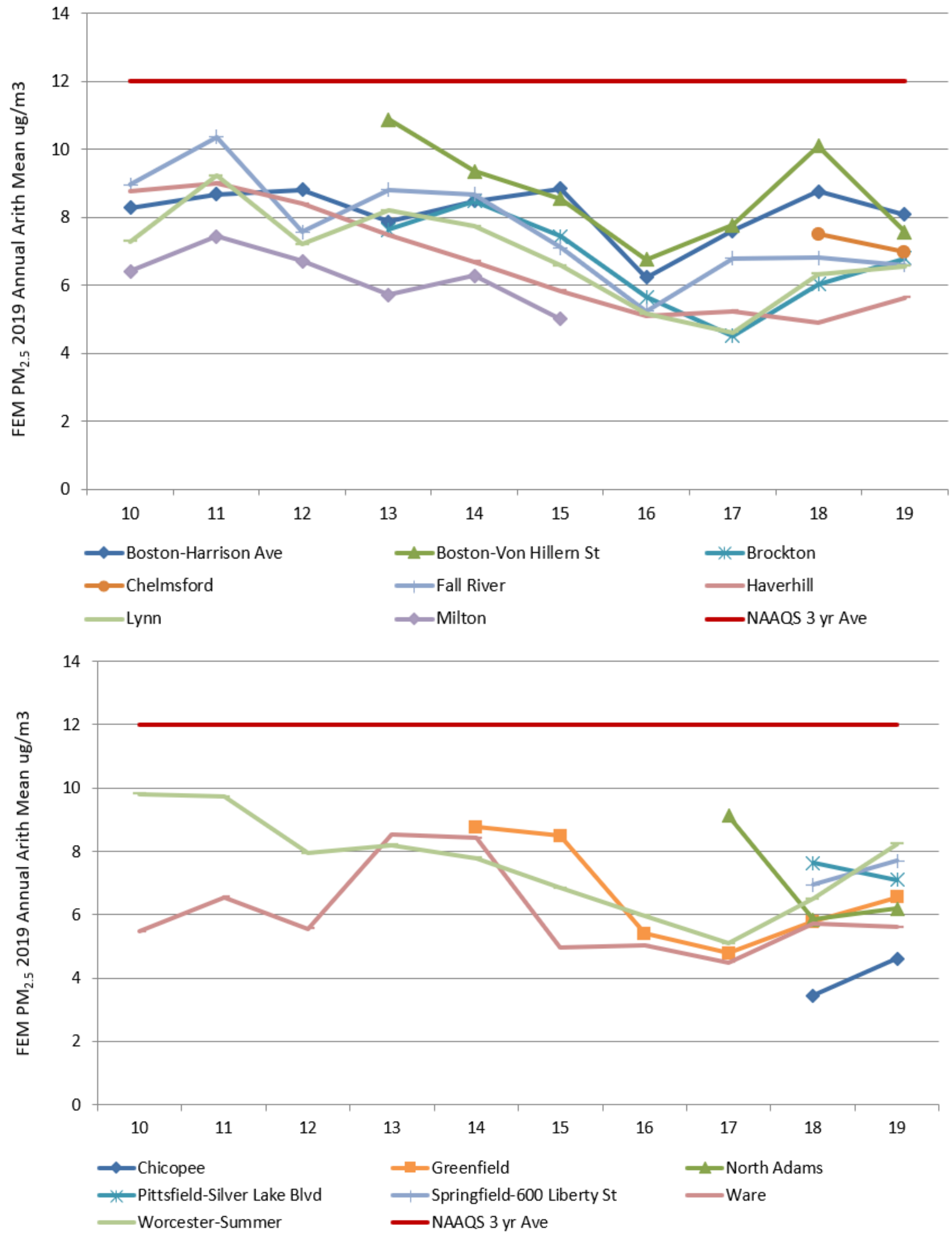
FEM 2019 CITY	COUNTY	ADDRESS	1ST MAX 24-HR	2ND MAX 24-HR	3RD MAX 24-HR	4TH MAX 24-HR	98TH PECENTILE 24-HR	ARITH MEAN
Boston	Suffolk	Harrison Ave	23.1	21.5	19.0	18.7	17.0	8.08
Boston	Suffolk	Von Hillern St	21.7	20.7	20.4	20.3	17.3	7.57
Boston	Suffolk	Von Hillern St*	18.9	14.4	13.8	12.2	13.8	5.60
Brockton	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 = 12.0 µg/m^3 (primary) 24-hour (98^{th} 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

$PM_{2.5}$ FEM Trends

Figure 9 shows trends of the annual arithmetic mean for each $PM_{2.5}$ FEM monitor over the past 10 years relative to the standard of 12 µg/m3.

Figure 9
$PM_{2.5}$ Trends 2010 – 2019
FEM Annual Arithmetic Mean



3.7 - Speciation

MassDEP collects $PM_{2.5}$ samples for speciation in Boston (Harrison Avenue) and Chicopee. Speciation involves analysis of particulate matter to determine its chemical composition and to identity air pollution sources that affect the area around the monitoring station. Pollutants analyzed include elements (e.g., metals), sulfates, nitrates, and carbon (total and organic).

3.8 - Interagency Monitoring of Protected Visual Environments (IMPROVE)

IMPROVE is a nationwide program designed to assess air quality at rural locations where air pollution may affect visibility over long distances (e.g., mountain ranges or scenic vistas). During 2019, the National Park Service operated an IMPROVE sampler at the Truro monitoring site, and the Wampanoag Tribe operated an IMPROVE sampler at its Martha's Vineyard monitoring site. These samplers acquire $PM_{2.5}$ filter samples for speciation analysis to determine effects on visibility. Data can be viewed at the IMPROVE web site at http://vista.cira.colostate.edu/improve/Data/data.htm.

3.9 - Quality Assurance and Quality Control (QA/QC)

In order to ensure that all air quality data is of acceptable and consistent quality, MassDEP has developed standard operating procedures (SOPs) based on federal requirements that include quality control and quality assurance protocols that systematically assess the entire sample collection and data handling system on an ongoing basis. Ambient air monitoring quality assurance requirements are contained in the Federal Regulations at 40 CFR Part 58, Appendix A – E. Each year MassDEP certifies that it is in compliance with the federal requirements. A few of the considerations that affect sample collection data quality are:

- Site Placement
- Intake Probe Material
- Intake Probe Height
- Spacing from roadways and trees

For data processing there are quantitative statistics and qualitative descriptors used to interpret the degree of acceptability and utility of data. Examples of these data quality indicators are:

- Representativeness
- Precision
- Bias
- Detectability
- Completeness
- Comparability

MassDEP's Air Assessment Branch maintains a Quality Assurance Group that ensures samples are collected correctly and conducts performance audits throughout the air monitoring network to verify data validity. There also is a Quality Control Group that reviews daily monitored and historical data for validity, tracks precision results, finalizes monthly values, and submits air quality data to EPA's database in a timely manner. Computer software tools, report queries, and "eyes on" data reviews all are used to validate data before it is submitted to EPA. EPA also conducts its own performance audits on MassDEP samplers and every three years conducts a thorough Technical Systems Audit (TSA). The latest TSA was conducted in 2019.

Section 4 – PAMS/Air Toxics Monitoring

4.1 - Photochemical Assessment Monitoring Stations (PAMS) Monitoring

Ground-level ozone is a secondary pollutant and is not emitted directly to the atmosphere from a stack or tailpipe, but forms in the atmosphere from the photochemical reactions of other pollutants such as VOCs and NOx. 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. The PAMS program was established by the 1990 Clean Air Act Amendments as a way to collect data for assessing NAAQS attainment progress independent of the meteorological variation that occurs between years and for identifying appropriate pollution control strategies. In 2019, MassDEP operated one PAMS station in Lynn.

PAMS is a special designation for enhanced monitoring stations that are designed to gather information on the ozone formation process. Instruments at these sites measure pollutants and meteorological parameters that are specific to the photochemical processes by which ozone is created in the atmosphere at ground level. In addition to the pertinent NAAQS pollutants (ozone, NO_2, etc.), non-criteria pollutants, including VOCs, are measured at PAMS stations on either an hourly basis or at regular intervals during the hottest part of the summer (June, July and August). Meteorology is a critical component of ozone formation and each PAMS site has a full complement of meteorological sensors including wind speed, wind direction, temperature, relative humidity, barometric pressure, solar radiation and at some sites, total ultraviolet light and precipitation.

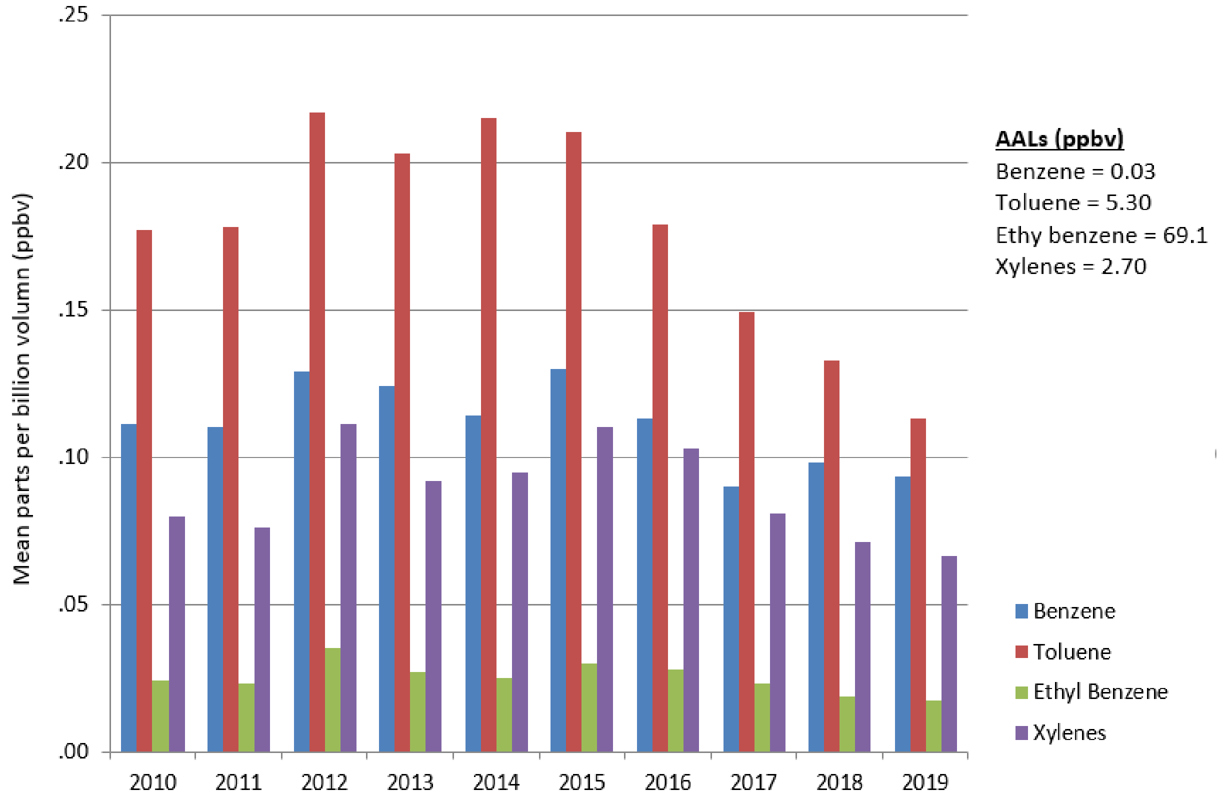
4.2 - Air Toxics Monitoring

Toxic air pollutants are known or suspected to cause cancer or other serious health effects. Air toxics include certain VOCs and toxic metals (e.g., arsenic, cadmium).

The Boston (Harrison Avenue) monitoring site is designated as a National Air Toxics Trends Station (NATTS) designed to collect and quantify a number of toxic air pollutants, including VOCs, metals, carbonyls, black carbon and polycyclic aromatic hydrocarbons (PAHs). Data from this site is compared with data from a network of similar sites across the country to identify transport, trends and site-specific characteristics of these pollutants.

MassDEP also monitors VOCs as part of its PAMS monitoring, some of which are classified as air toxics. Figure 10 summarizes concentrations of benzene, toluene, ethyl benzene, and xylenes measured at the Lynn PAMS site for the past 10 years. Allowable Ambient Limit (AAL) values are presented for reference. AALs are health-based air toxics guidelines developed by MassDEP based on known or suspected carcinogenic and toxic health properties of individual compounds. AAL concentrations were developed for a 70-year lifetime exposure, but are used for comparison with annual averages.

Figure 10
Lynn BTEX Summary 2010 – 2019
24-hour samples



The table below summarizes 24-hour concentrations of target VOCs measured at the Boston (Harrison Ave) and Lynn sites for 2019. Harrison Avenue serves as the central city sampling location and Lynn serves as the area background site.

2019	Boston (Harrison Avenue)		Lynn	
Compounds	Max Value ppb	Mean ppb	Max Value ppb	Mean ppb
1,3-butadiene	0.038	0.016	0.015	0.008
1,1,1-tricholoethylene	0.000	0.000	0.000	0.000
tetrachloroethylene	0.050	0.015	0.050	0.000
trichloroethylene	0.000	0.000	0.000	0.000
Benzene	0.317	0.127	0.250	0.093
Toluene	0.457	0.183	0.314	0.113
ethylbenzene	0.075	0.029	0.038	0.018
Xylenes	0.313	0.113	0.188	0.066

Samples collected at the Harrison Avenue site are analyzed for a suite of metals that are known to be toxic in the environment. The table below summarizes the 2019 metals data.

2019 Metal	Boston (Harrison Avenue)	
	Max Value µg/m3	Mean µg/m3
Antimony	0.00308	0.00139
Arsenic	0.00141	0.00030
Berylium	0.00001	0.00000
Cadmium	0.00026	0.00006
Chromium	0.01400	0.00469
Cobalt	0.00027	0.00008
Lead	0.00460	0.00156
Manganese	0.00759	0.00341
Mercury	0.00002	0.00001
Nickel	0.01570	0.00119
Selenium	0.00061	0.00015

Appendix A
2019 Monitoring Stations

City/Town	Address	Parameters Monitored
Aquinnah*	Herring Creek Road	O_3, $PM_{2.5}$ speciated (IMPROVE)
Boston	Kenmore Square	NO_2, NO, NOx, SO_2, $PM_{2.5}$
Boston	1159 Harrison Ave	O_3, NO_2, NO, NOx, NOy, SO_2, CO, $PM_{2.5}$, PM_{10}, PM_{Coarse}, $PM_{2.5}$ speciated, Black Carbon, VOCs, Carbonyls, metals, PAHs, WS/WD, WSv/WDv, TEMP, SUN, REL, BP
Boston	19 Von Hillern Street	NO_2, NO, NOx, CO, $PM_{2.5}$, Black Carbon, WS/WD, TEMP, SUN, REL, BP
Brockton	170 Clinton Street	O_3, $PM_{2.5}$
Chelmsford	11 Technology Drive	O_3
Chelmsford	5 Manning Road	O_3, NO_2, NO, NOx, $PM_{2.5}$, Black Carbon
Chicopee	Anderson Road	O_3, NO_2, NO, NOx, $PM_{2.5}$, $PM_{2.5}$ speciated, WS/WD, TEMP, SUN, REL, BP
Fairhaven	30 School Street	O_3, WS/WD, TEMP, SUN, REL, BP
Fall River	659 Globe Street	O_3, SO_2, $PM_{2.5}$
Greenfield	16 Barr Avenue	O_3, $PM_{2.5}$, Black Carbon, WS/WD, TEMP, SUN, REL, BP
Haverhill	685 Washington Street	O_3, $PM_{2.5}$, WS/WD, TEMP, SUN, REL, BP
Lynn	390 Parkland Avenue	O_3, NO_2, NO, NOx, $PM_{2.5}$, VOCs, Carbonyls, WS/WD, TEMP, SUN, REL, BP, PRECIP, TOTAL UV
Milton	1904 Canton Avenue	O_3, NO_2, NO, NOx, WS/WD, TEMP, SUN, REL, BP
North Adams	86 Holden Street	$PM_{2.5}$, Black Carbon
Pittsfield	78 Center Street	$PM_{2.5}$
Pittsfield	25 Silver Lake Drive	O_3, $PM_{2.5}$, Black Carbon, WS/WD, TEMP, SUN, REL, BP
Springfield	600 Liberty Street	NO_2, NO, NOx, SO_2, CO, $PM_{2.5}$, Black Carbon
Truro	6 Collins Road	O_3, WS/WD, TEMP, SUN, REL, BP, $PM_{2.5}$ speciated (IMPROVE)
Uxbridge	366 E. Hartford Ave	O_3, WS/WD, TEMP, SUN, REL, BP
Ware	36 Skyline Drive	O_3, NO_2, NO, NOx, NOy, SO_2, $PM_{2.5}$, PM_{10}, WS/WD, TEMP, SUN, REL, BP, PRECIP
Worcester	375 Airport Drive	O_3, WS/WD, TEMP, SUN, REL, BP
Worcester	Summer Street	NO_2, NO, NOx, SO_2, CO, $PM_{2.5}$, PM_{10}