Massachusetts Ambient Air Monitoring Network Assessment 2015

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Bureau of Air and Waste
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CONTENTS

I. SUMMARY

Introduction

The Massachusetts Department of Environmental Protection (MassDEP) has prepared this 2015 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 a National Ambient Air Quality Standard (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 incorporation into 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 currently has 24 monitoring stations located in 19 cities and towns monitors and monitors ambient concentrations of all criteria pollutants. The Wampanoag Tribe of Gay Head (Aquinnah) operates an air monitoring station on Martha's Vineyard. In addition, MassDEP monitors ambient levels of toxic air pollutants and ozone precursors, which are substances that react in the atmosphere to form ground-level ozone, as well as meteorological conditions. MassDEP operates one monitoring site that is part of the National Air Toxics Trends Sites (NATTS) network, four that are part of the Photochemical Assessment Monitoring Stations (PAMS) network, and one that is part of the $PM_{2.5}$ Speciation Trends Network (STN).

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, air quality meets all standards, although the Commonwealth still experiences days with elevated levels of both pollutants. On October 1, 2015, EPA lowered the 8-hour ozone NAAQS from 0.075 ppm to 0.070 ppm, so ozone monitoring will continue to be a top priority. The network is designed to measure the concentrations of ozone and its precursors in-state, as well as provide insight into ozone formation and the transport of ozone and its precursors into and out of the state. MassDEP also expects to continue to place priority on monitoring $PM_{2.5}$ concentrations due to occasional exceedances of the 24 hour $PM_{2.5}$ NAAQS in some parts of the state.

Figure 2-1 shows the location of monitoring stations. All of 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 and the highest exposures.

Update on 2010 Network Assessment

MassDEP prepared its first Network Assessment in 2010. The 2010 Assessment identified new EPA monitoring requirements associated with new NAAQS for SO_2, NO_2, CO and Lead. MassDEP has complied with these requirements by establishing a near-road NO_2 monitoring station in Boston on Von Hillern Street in 2013 (with sampling for NO_2, ozone, $PM_{2.5}$, CO, black carbon), adding lead PM_{10} sampling at the Boston NCore Site (Harrison Avenue), and by completing a year-long lead monitoring study at Nantucket Memorial Airport. MassDEP currently is evaluating a location for a second (phase 2) near-road site in the Boston Area. The third phase of near-road sites in the Worcester and Springfield areas is being re-evaluated by EPA and may be unnecessary. Beyond the next phases of near-road requirements, MassDEP has no additional new EPA monitoring requirements.

The 2010 Network Assessment also identified Franklin and Barnstable counties as potential gaps in the $PM_{2.5}$ monitoring network. In 2014, MassDEP established a new $PM_{2.5}$/ozone monitoring station in Greenfield (Franklin County). This has resulted in better spatial resolution of the $PM_{2.5}$ and ozone networks in Western Massachusetts and also enabled MassDEP to close the Amherst ozone monitor (which had become redundant). MassDEP also established a new $PM_{2.5}$/ozone monitoring station in Brockton in 2013, which added to the continuous $PM_{2.5}$ and ozone monitoring networks and also helped offset the closure of the Boston-Long Island ozone site in 2014 (due to the bridge closure).

MassDEP established an ozone monitoring station in Fall River in 2012 after the loss of the original Fairhaven site in 2012, and then established a new Fairhaven ozone monitoring station in 2013, bolstering the ozone measurement capabilities on the South Coast. MassDEP is currently working on replacing three sites in Berkshire County (including the recently closed Adams ozone site) with a single site in the Pittsfield Area. MassDEP also began ozone monitoring at the EPA laboratory in Chelmsford, which helped offset the closure of the Stow ozone site/upper air profiler in 2011.

2015 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. Air quality in Massachusetts currently attains the 2008 8-hour ozone NAAQS (although Dukes County is still designated as marginal nonattainment), and MassDEP continues to make ozone monitoring a priority to confirm the downward trend in ozone concentrations and to determine attainment status with the new 2015 ozone standard.

MassDEP operates a robust $PM_{2.5}$ monitoring network due to the significant health effects posed by $PM_{2.5}$, the growing use of wood heating, and occasional exceedances of the $PM_{2.5}$ standard in some parts of the state. In 2013 and 2014, MassDEP established $PM_{2.5}$ monitoring sites at key locations (e.g., near-road and rural area affected by wood smoke) where $PM_{2.5}$ levels are expected to be higher than at other monitoring locations.

MassDEP has reviewed changes in population and pollutant emissions, which also confirms that MassDEP's existing monitoring network is properly designed. County-by-county review of the data show that emissions have decreased fairly uniformly across the state. The growth in population also has been fairly uniform across the state. Massachusetts population centers remain the same, although they are larger; the road network is relatively unchanged, although it is carrying more vehicles; and stationary sources of pollution are distributed in roughly the same pattern, although they emit less and there are fewer of them. The absence of major shifts in these factors indicates that adjustment of the basic design of the air monitoring network is unwarranted.

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 distribution of monitoring sites adequately supports air quality characterization in areas with high numbers of sensitive populations.

MassDEP has used the analytical tools developed by EPA and the Lake Michigan Air Directors Consortium (LADCO) for identifying potential new sites for all PM and ozone monitors in the state. These tools address correlations between existing site measurements, distance between sites, and the likelihood of the site exceeding a standard; evaluate the correlation between site measurements and 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 for voronoi polygons that show the coverage area of each monitor. (A voronoi polygon is the shape formed when a line is drawn equidistant between each monitor and each of the monitors closest to it.) These tools show that Barnstable County on Cape Cod and Middlesex and Northern Worcester Counties along Route 2 are potential gaps in the existing $PM_{2.5}$ monitoring network. Asthma rates are higher than the statewide average in these areas, although they are less populated than other areas in the state. There are also EJ populations in the Route 2 area and a high number of elderly in Barnstable County. Since MassDEP meets minimum EPA requirements for $PM_{2.5}$ monitoring and $PM_{2.5}$ levels are not expected to be significantly higher in these areas compared to monitored areas, MassDEP is not proposing changes to the monitoring network at this time. MassDEP will continue to evaluate the need for monitoring stations in these locations.

Looking Forward

MassDEP will continue to optimize the monitoring network and the locations of its sites. MassDEP has streamlined operations by optimizing travel routes, maintenance schedules, and relying on automated continuous monitors for a number of parameters. Two measures implemented from the 2010 network assessment include relying on continuous Federal Equivalent Method (FEM) $PM_{2.5}$ monitors and reducing the workload associated with monitoring PAMS parameters. MassDEP now uses continuous FEM $PM_{2.5}$monitors for compliance with the NAAQS while continuing work to ensure that these monitors and the filter-based FRM monitors agree more closely.

MassDEP consolidated PAMS monitoring by discontinuing canister sampling sites in 2012, two years ahead of EPA's recommendation to discontinue this sampling. MassDEP is operating two Type 2 PAMS sites (Lynn and Chicopee) in 2015 to facilitate quicker turnaround of PAMS ozone season data and enable greater focus on the technical aspects of ozone precursor measurements. The Type 3 PAMS sites (Ware and Newburyport) will be operated less and data from these sites will be processed and submitted as resources allow. Future PAMS monitoring plans will be developed in accordance with monitoring requirements for the new 2015 ozone NAAQS.

To increase automation, MassDEP upgraded its Data Acquisition System (DAS) in 2012. This has involved significant ongoing work to incorporate the new DAS into the existing data system and to train and familiarize staff with the new system. MassDEP is beginning to take greater advantage of the automation features, enhanced quality control and assurance, and improved communications the new system provides. The DAS upgrade will not only save time for field and laboratory staff, but also will improve the timeliness and quality of data.

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 National Ambient Air Quality Standards (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 or not the state is in attainment of each of the criteria pollutants. Currently Massachusetts air quality meets all of the NAAQS.

- **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.

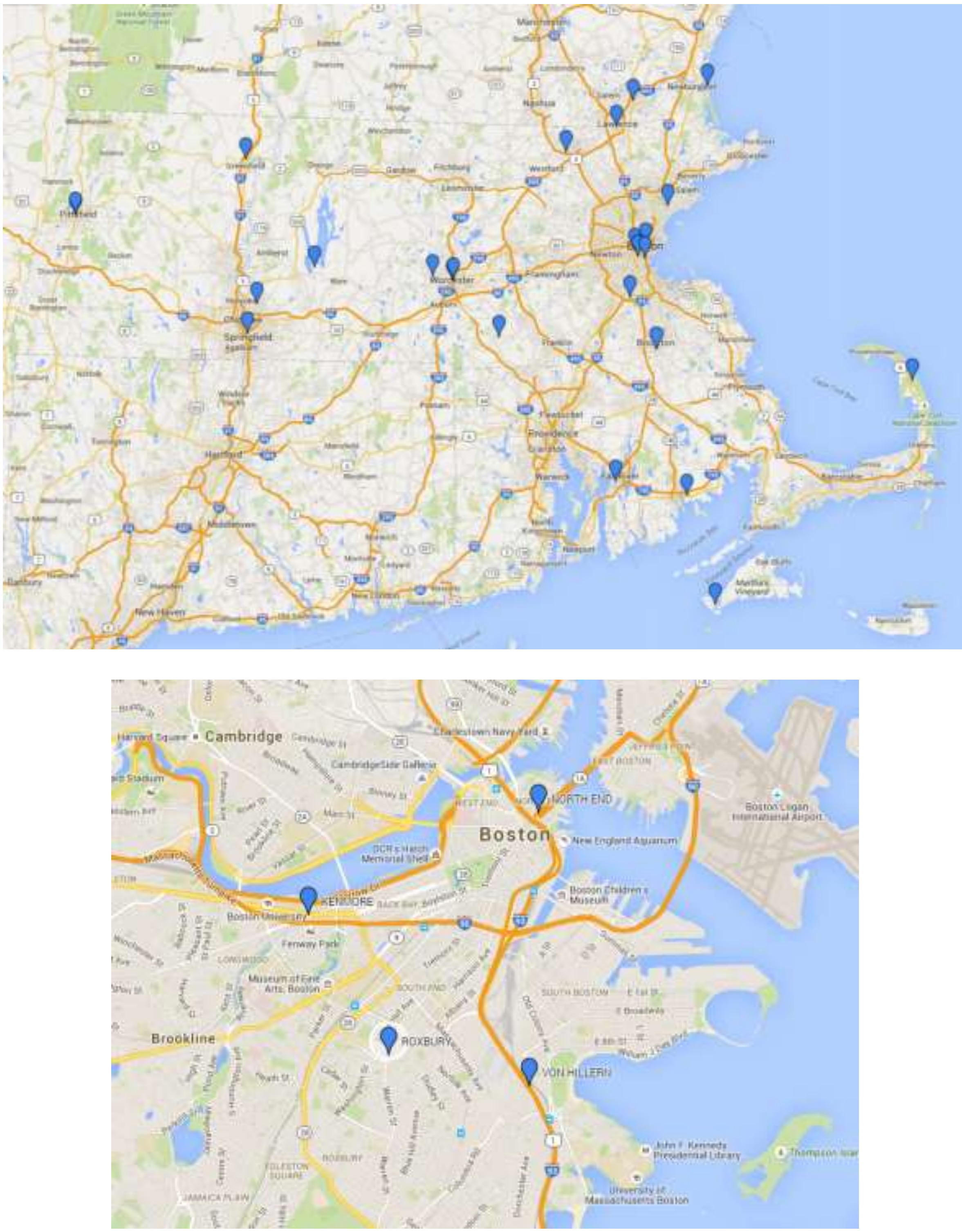
- **Ambient monitoring data are used in conjunction with modeling to characterize the extent of air pollution problems, including transport into and out of the state, as well as to evaluate the impacts of alternative control strategies**. MassDEP's monitoring data are important to regional air pollution 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), Northeast States for Coordinated Air Use Management (NESCAUM), and Mid-Atlantic/Northeast Visibility Union (MANE-VU).

- **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 whether or not emissions are likely to result in exceedances of MassDEP's Ambient Air Limits 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 24 monitoring stations (16 multi-pollutant) located in 19 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
Air Monitoring Stations in Massachusetts



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 ≤ 10 microns (PM_{10}), particulate matter ≤ 2.5 microns ($PM_{2.5}$), and some volatile organic compounds (VOCs) and toxics, require that staff collect samples in the field and bring them back to the laboratory for 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 taken, such as Photochemical Assessment Monitoring Station (PAMS) automated gas chromatographs (AutoGC) and $PM_{2.5}$ Beta Attenuation Monitors (BAMs).

Intermittent monitors take discrete samples that are collected by staff and brought to the laboratory for analysis; examples include volatile organic compounds (VOCs) canisters and $PM_{2.5}$ filter samples. Depending on the regulatory or analytical requirements, samples may be taken 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 that contaminant.

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 real-time or 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 a reduction in labor costs because time does not have to be spent retrieving and analyzing filters and canisters. However, continuous monitors are more expensive and can break (requiring availability of back-up equipment) and usually require climate-controlled shelters (unlike intermittent samplers that can be placed on rooftops or in other compact locations).

The Massachusetts network contains the following monitors for criteria pollutants:

- CO (carbon monoxide): 6 continuous monitors (4 are low-range that detect trace concentrations of CO)
- NO_2 (nitrogen dioxide) / NO (nitric oxide) / NO_x (total nitrogen oxides): 10 continuous monitors
- O_3 (ozone): 15 continuous monitors

- SO_2 (sulfur dioxide): 6 continuous monitors (4 are low-range)
- $PM_{2.5}$: 28 monitors, including 15 intermittent Federal Reference Method (FRM) monitors and 13 hourly Federal Equivalent Monitors (FEMs) $PM_{2.5}$ monitors
- PM_{10}: 5 intermittent monitors
- Pb (lead): 3 intermittent monitors

The Massachusetts network contains the following monitors for other pollutants:

- Ozone precursors at 4 Photochemical Assessment Monitoring (PAMS) stations:
  - NO_y (total reactive oxidized nitrogen): 2 continuous monitors
  - VOCs and carbonyls: 4 continuous monitors using automated gas chromatographs (GCs)
- Black carbon (BC): 5 continuous monitors (BC is a form of light absorbing carbonaceous particulate matter)
- Toxics: 2 intermittent monitors measure toxic VOCs; 1 monitor measures polycyclic aromatic hydrocarbons (PAHs), and 2 collocated monitors measure toxic metals
- Speciation of $PM_{2.5}$: 2 intermittent monitors measure the individual constituents of $PM_{2.5}$ including elements, sulfates/nitrates, and organic carbon
- PM_{10} toxic metals: 1 intermittent monitor
- NO_y: 1 monitor
- VOCs (benzene, toluene, ethylbenzene and xylene): 1 monitor

Meteorological monitors measuring atmospheric conditions that influence air pollution levels:

- Wind speed and direction (WS/WD): 12 monitors
- Relative humidity (RH): 12 monitors
- Precipitation: 2 monitors
- Atmospheric pressure (i.e., barometric pressure): 12 monitors
- Solar radiation: 11 monitors
- Ambient temperature: 12 monitors

The Boston – Harrison Avenue site is the Massachusetts NCore site and also 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:

- Toxic volatile organic compounds (VOCs)
- Polyaromatic hydrocarbons (PAHs)
- Toxic elements (Metals)
- Carbonyls (formaldehyde and acetaldehyde)
- Black carbon

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 that ensures 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. Examples include the Boston – Kenmore Square and Von Hillern Street CO monitors, where the sample inlet is several feet or yards from a travel lane of a roadway and 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 (for example, the Fall River SO_2 monitor) or the air quality surrounding a defined area of similar conditions (for example, Boston-Harrison Avenue as an urban background location or as an ozone monitoring site).
- **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 and extends from tens to hundreds of kilometers. Examples include monitors in Ware 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

MassDEP does not currently operate monitors sited to track pollution from individual point sources. 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 monitoring stations, their locations, when they were established, their purpose, what they measure, and the equipment used are presented in Figures 2-2 through 2-4.

Figure 2-2: Air Monitoring Site Descriptions

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-025-0002	BOSTON	SUFFOLK	KENMORE SQUARE	Middle	Highest Concentration Population Exposure	1/1/1965	Boston CMSA; Boston Metropolitan MSA
25-025-0044	BOSTON	SUFFOLK	VON HILLERN STREET	Middle	Highest Concentration Population Exposure (Near Road)	6/15/2013	Boston CMSA; Boston Metropolitan MSA
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	Middle / Neighbor-hood	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA
25-025-0043	BOSTON	SUFFOLK	150 NORTH STREET	Middle	Population Exposure Maximum Concentration	1/1/2000	Boston CMSA; Boston Metropolitan MSA
25-023-0004	BROCKTON	PLYMOUTH	170 CLINTON STREET	Neighbor-hood	Population Exposure	6/30/2013	Boston CMSA; Brockton MSA
25-017-0009	CHELMSFORD	MIDDLESEX	EPA NERL 11 TECHNOLOGY DRIVE	Urban	Population Exposure	4/1/2005	Boston CMSA
25-013-0008	CHICOPEE	HAMPDEN	ANDERSON ROAD	Urban	PAMS: Springfield Type 2 (Maximum Precursor) Others: Population Exposure	1/1/1983	Springfield MSA
25-005-1006	FAIRHAVEN	BRISTOL	HASTINGS SCHOOL	Regional/ Urban	Population Exposure	6/30/2013	Providence-Pawtucket-Fall River MSA

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-005-1004	FALL RIVER	BRISTOL	GLOBE STREET	Neighbor-hood	Highest Concentration Population Exposure	2/1/1975	Providence-Pawtucket-Fall River MSA
25-011-2005	GREENFIELD	FRANKLIN	VETERANS FIELD	Neighbor-hood / Urban	Highest Concentration Population Exposure	1/1/2014	Springfield MSA
25-009-5005	HAVERHILL	ESSEX	WASHINGTON STREET	Neighbor-hood / Urban	Population Exposure	7/19/1994	Boston CMSA; Lawrence MSA
25-009-6001	LAWRENCE	ESSEX	WALL EXPERIMENT STATION	Neighbor-hood	Population Exposure	4/3/1999	Boston CMSA; Lawrence MSA
25-009-2006	LYNN	ESSEX	390 PARKLAND	Urban	PAMs: Boston Type 2 (Maximum Precursor) Ozone: Population Exposure	1/1/1992	Boston CMSA; Boston Metropolitan MSA
25-021-3003	MILTON	NORFOLK	MILTON MA, BLUE HILL	Urban	$PM_{2.5;}$, & Ozone: Maximum Concentration	4/2/2002	Boston CMSA; Boston Metropolitan MSA
25-009-4005	NEWBURYPORT	ESSEX	261 NORTHERN BLVD	Urban	PAMS Boston Type 3 (Maximum Ozone Concentration) Others: Population Exposure	7/1/2010	Boston CMSA; Boston Metropolitan MSA
25-003-5001	PITTSFIELD	BERKSHIRE	78 CENTER STREET	Neighbor-hood	Population Exposure	12/1/1998	Pittsfield MSA
25-003-0006	PITTSFIELD	BERKSHIRE	1 SOUTH STREET	Neighbor-hood	Population Exposure	12/1/2005	Pittsfield MSA
25-013-0016	SPRINGFIELD	HAMPDEN	LIBERTY STREET	Neighbor-hood	Population Exposure Maximum Concentration	4/1/1988	Springfield MSA
25-001-0002	TRURO	BARNSTABLE	FOX BOTTOM AREA	Regional	General / Background	4/1/1987	No MSA; Downwind Providence-Pawtucket , RI
25-027-0024	UXBRIDGE	WORCESTER	366 E. HARTFORD AVE.	Urban	Ozone Transport (state line upwind) Population Exposure	11/1/2008	Boston CMSA; Worcester MSA
25-015-4002	WARE	HAMPSHIRE	QUABBIN SUMMIT	Neighbor-hood / Urban	PAMS: Springfield Type 3 (Maximum Ozone Concentration) Others: Population Exposure	6/1/1985	Springfield MSA
25-027-0015	WORCESTER	WORCESTER	WORCESTER AIRPORT	Urban	Ozone: Worcester/Springfield Interface Others: Population Exposure	5/7/1979	Boston CMSA; Worcester MSA

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-027-0016	WORCESTER	WORCESTER	2 WASHINGTON STREET	Middle Neighbor-hood	Population Exposure	10/1/2003	Boston CMSA; Worcester MSA
25-027-0023	WORCESTER	WORCESTER	SUMMER STREET	Middle / Neighbor-hood	Population Exposure	1/1/2004	Boston CMSA; Worcester MSA

Figure 2-3: Site Measurements

SITE ID	CITY	ADDRESS	METEOROLOGICAL	POLLUTANTS
25-025-0044	BOSTON	VON HILLERN STREET	WS/WD, TEMP, RH, BP, SOLAR	tCO, NO, NO_2, NO_x, $PM_{2.5}$, Black Carbon
25-025-0042	BOSTON	HARRISON AVENUE	WS/WD, TEMP, RH, BP, SOLAR	O_3, tCO, tSO_2, Pb, NO, NO_2, , NO_x, PM_{10}, $PM_{2.5}$, VOC Toxics, Carbonyls, Black Carbon $PM_{2.5}$ Speciation, PM_{10} Toxcis, PM_{coarse}, NOy, PAHS
	BOSTON	KENMORE SQUARE		tSO_2, NO, NO_2, NO_x, PM_{10}, $PM_{2.5}$, BTEX
25-025-0043	BOSTON	150 NORTH STREET		$PM_{2.5}$, Black Carbon
25-023-0005	BROCKTON	170 CLINTON STREET		O_3, $PM_{2.5}$
25-017-0009	CHELMSFORD	USEPA NERL 11 TECHNOLOGY DRIVE		O_3
25-013-0008	CHICOPEE	ANDERSON ROAD	WS/WD, TEMP, RH, BP, SOLAR	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$, VOC (PAMS), Carbonyls (PAMS), $PM_{2.5}$ Speciation, tCO
25-005-1006	FAIRHAVEN	HASTINGS SCHOOL	WS/WD, TEMP, RH, BP, SOLAR	O_3
25-005-1004	FALL RIVER	GLOBE STREET		O_3, SO_2, $PM_{2.5}$
25-011-2005	GREENFIELD	VETERANS FIELD	WS/WD, TEMP, RH, BP, SOLAR	O_3, $PM_{2.5}$, Black Carbon
25-009-5005	HAVERHILL	WASHINGTON STREET	WS/WD, TEMP, RH, BP, SOLAR	O_3, $PM_{2.5}$
25-009-6001	LAWRENCE	WALL EXPERIMENT STATION		$PM_{2.5}$
25-009-2006	LYNN	390 PARKLAND	FULL MET & PRECIP	O_3, tCO, NO, NO_2, NOx, $PM_{2.5}$, VOC Toxics, VOC (PAMS), Carbonyls (PAMS)
25-021-3003	MILTON	MILTON MA, BLUE HILL	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, $PM_{2.5}$
25-009-4005	NEWBURYPORT	261 NORTHERN BLVD	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, NOA, NO_Y, VOC (PAMS)
25-003-5001	PITTSFIELD	78 CENTER STREET		$PM_{2.5}$
25-003-0006	PITTSFIELD	1 SOUTH STREET		$PM_{2.5}$
25-013-0016	SPRINGFIELD	LIBERTY STREET		CO, SO_2, NO, NO_2, NO_x, $PM_{2.5}$, Black Carbon, PM_{10}, Pb

SITE ID	CITY	ADDRESS	METEOROLOGICAL	POLLUTANTS
25-001-0002	TRURO	FOX BOTTOM AREA	WS/WD, TEMP, RH, BP, SOLAR	O_3, $PM_{2.5}$ IMPROVE, $PM_{2.5}$
25-027-0024	UXBRIDGE	366 E. HARTFORD AVE.	WS/WD, TEMP, RH, BP, SOLAR	O_3
25-015-4002	WARE	QUABBIN SUMMIT	WS/WD, TEMP, RH, BP, SOLAR & PRECIP	O_3, tSO_2, NO, NO_2, NO_x, NOA, NO_Y, PM_{10}, $PM_{2.5}$ IMPROVE, $PM_{2.5}$, VOC (PAMS)
25-027-0015	WORCESTER	WORCESTER. AIRPORT	WS/WD, TEMP, RH, BP, SOLAR	O_3
25-027-0016	WORCESTER	2 WASHINGTON STREET		$PM_{2.5}$
25-027-0023	WORCESTER	SUMMER STREET		tCO, SO_2, NO, NO_2, NO_x, PM_{10}, $PM_{2.5}$
tCO = Trace Carbon Monoxide tSO_2 = Trace Sulfur Dioxide				

Figure 2-4: Sampling and Analytical Methods

PARAMETER	WORKSHEET ABBREVIATION	SAMPLING METHODOLOGY	ANALYTICAL METHOD	SAMPLE FREQUENCY	COMMENTS
Ozone	O_3	Continuous Instrument (field analysis)	Ultra Violet (UV) Light Photometry	Continuous/Hourly	
Carbon Monoxide	CO	Continuous Instrument (field analysis)	Gas Filter Correlation; Non-Dispersive Infrared (NDIR) Detection	Continuous/Hourly	
Sulfur Dioxide	SO_2	Continuous Instrument (field analysis)	UV Fluorescence	Continuous/Hourly	
Nitric Oxide / Nitrogen Dioxide / Nitrogen Oxides	$NO/NO_2/NO_x$	Continuous Instrument (field analysis)	Chemiluminescence	Continuous/Hourly	Same instrument for NO, NO_2, NOx
Total Reactive Oxidized Nitrogen	NO_y	Continuous Instrument (field analysis)	Chemiluminescence	Continuous/Hourly	Same instrument for NO, NO_y, NOx
Lead	Pb	Low Volume on PM_{10}	Xray Fluorescence	1 Every 6th Day/24 hour	Currently Boston/Harrison Ave and Springfield/Liberty Street
Particulate Matter 2.5 microns	$PM_{2.5}$	Low Volume; Size Selective	Gravimetric	1 Every 3rd Day/24 hour	
Particulate Matter 10 microns	PM_{10}	Low Volume; Size Selective	Gravimetric	1 Every 6th Day/24 hour	
Particulate Matter 2.5 microns Hourly	$PM_{2.5}$	Continuous Instrument (field analysis)	Beta Attenuation	Hourly	
Particulate Matter 2.5 microns Speciation	$PM_{2.5}$ SPECIATION	Low Volume; Size Selective	ICP/MS Xray Fluorescence, /Ion Chro matography/ Total Carbon	1 Every 3rd Day/24 hour	Elements, Nitrates/Sulfates, Carbon on 3 filters.
Particulate Matter 2.5 microns Speciation	$PM_{2.5}$ IMPROVE	Low Volume; Size Selective	IMPROVE Protocol	1 Every 6th Day/24 hour	Elements, Nitrates/Sulfates, Carbon on 3 filters. PM_{10} also; Ware and Truro only
Black Carbon	BC	Continuous Instrument (field analysis)	Optical Transmittance	Continuous/Hourly	
Toxic Elements	Toxics Metals	Low Volume/PM10	ICP/MS	1 Every 6th Day/24 hour	Elements; Boston/Harrison Ave. Only
Toxic VOCs	VOC Toxics	Passivated Canister	GC/MS	1 Every 6th Day/24 hour	Lynn, Boston/Harrison Ave Only

PARAMETER	WORKSHEET ABBREVIATION	SAMPLING METHODOLOGY	ANALYTICAL METHOD	SAMPLE FREQUENCY	COMMENTS
Toxic Carbonyls	Carbonyls	DNPH on Silica Gel Traps	HPLC	1 Every 6th Day/24 hour	Lynn, Boston/Harrison Ave Only; Formaldehyde and Acetaldehyde
Toxic Aromatic Compounds	BTEX	AutoSampling Gas Chromatograph	GC-PID	15 Sampling Cycle	Kenmore Square Pilot
Photochemical Assessment Monitoring Stations Volatile Organic Carbons	VOCs (PAMS)	Sub ambient Preconcentration (field analysis)	GC-FID	Hourly	Four PAMS Sites, PAMS Season (June-August) (Ware, Chicopee, Lynn, Newburyport)
Photochemical Assessment Monitoring Stations Volatile Organic Carbons	VOCs (PAMS)	Passivated Canister	GC-FID	1 Every 6th Day/24 hour (Year Round)	Lynn and Chicopee
Polycyclic Aromatic Hydrocarbons	PAHs	Quartz Filter; PUF Cartridge	GC/MS	1 Every 6th Day/24 hour (Year Round)	Boston/Harrison Ave Only
Photochemical Assessment Monitoring Stations Carbonyls	Carbonyls (PAMS)	DNPH on Silica Gel Traps	HPLC	8 3-hour Every 3rd Day (Ozone Season)	Lynn and Chicopee
Wind Speed / Direction	WS/WD	Continuous Instrument (field analysis)	Ultrasonic Sensors	Hourly	
Solar Radiation	Solar	Continuous Instrument (field analysis)	Pyranometer	Hourly	
Relative Humidity	RH	Continuous Instrument (field analysis)	Electronic Sensor	Hourly	
Ambient Temperature	TEMP	Continuous Instrument (field analysis)	Electronic Thermister	Hourly	
Barometric Pressure	BP	Continuous Instrument (field analysis)	Electronic Sensor	Hourly	
Precipitation	Precip	Continuous Instrument (field analysis)	Tipping Bucket	Hourly	Ware and Lynn Only

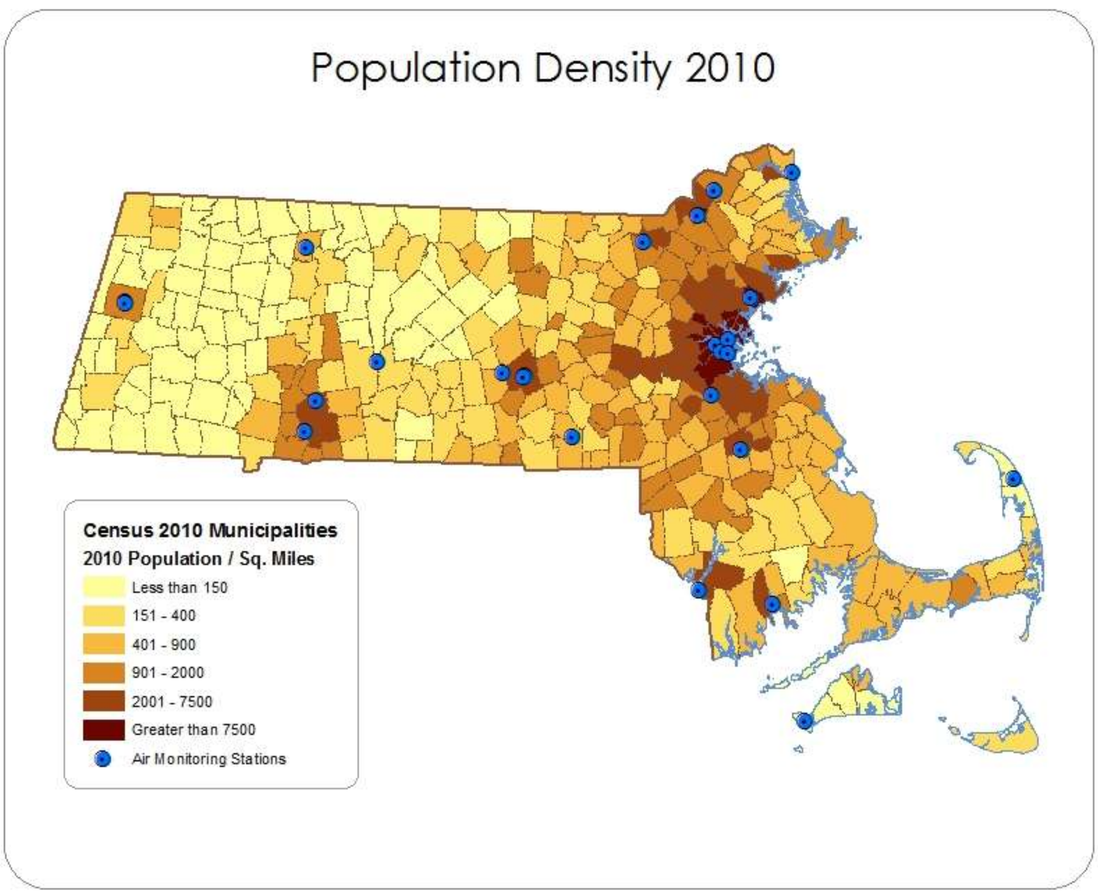
III. Massachusetts Population

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 15 years. The shifts that have occurred have moved population closer to areas with existing monitors (e.g., Worcester, Boston).
- There are no large pockets of sensitive populations that are not covered by air monitoring, with the possible exception $PM_{2.5}$ monitoring on Cape Cod and the northern Worcester/Middlesex County area.
- EJ areas are well covered by air monitors.

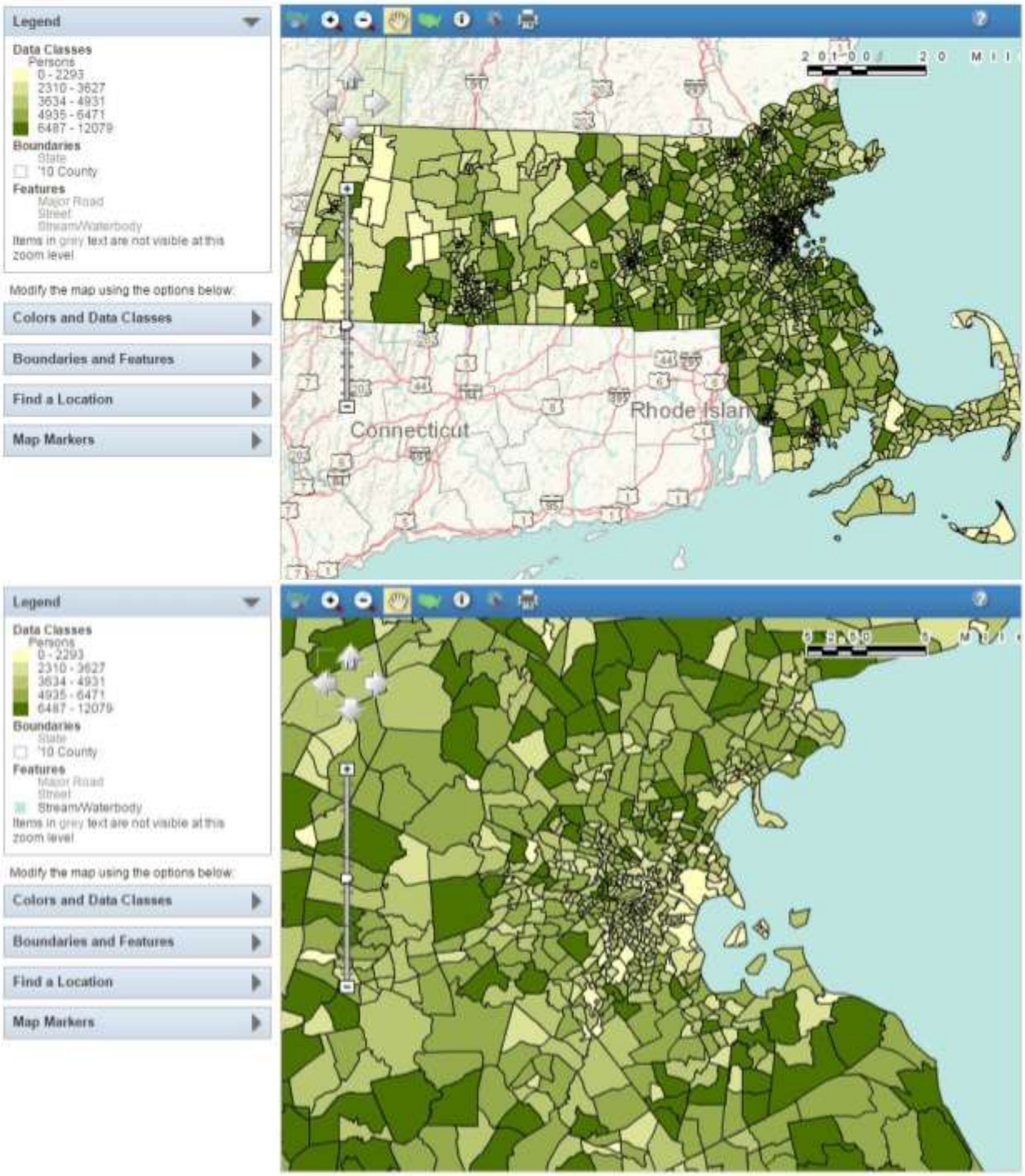
The U.S. Census Bureau estimates that as of 2014, Massachusetts had just under 6.75 million inhabitants in 351 towns/cities and 14 counties. The vast majority of the population is concentrated in the Boston metropolitan area, with additional concentrations in the Springfield and Worcester areas as shown in Figure 3-1 (based on 2010 Census data).

Figure 3-1
Population Density in Massachusetts 2010 by Municipality with Air Monitoring Stations



Source: US Census – MassGIS Data - Datalayers from the 2010 U.S. Census

Figure 3-1.1
Total Population in 2010 by Census Tract



Profile of General Population and Housing Characteristics: 2010, 2010 Demographic Profile Data
http://factfinder.census.gov/bkmk/tm/1.0/en/DEC/10_DP/DPDP1/0400000US25.14000?mapyear=2010&extenttype=extent&zoomlevel=OTHER&minx=-8182369.945141449&miny=5021910.096837344&maxx=-7784897.398058551&maxy=5320320.255262656&mm=&by=&bl=&ft=&fl=&catsetid=HD1%3DHD01%21VD1%3DS001&trans=1.0&sr=255&sg=255&sb=190&er=76&eg=115&eb=0&cc=5&cm=NATURAL_BREAKS&

Population Growth

The U.S. Census Bureau estimates that Massachusetts' population has grown by approximately 6% percent between 2000 and 2014, with the largest percent increases in Middlesex, Suffolk, and Worcester counties (see Figure 3-2). Some counties grew very little (< 0.1%) and 2 counties lost population. 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 + / – 1.6% between 2000 and 2014.

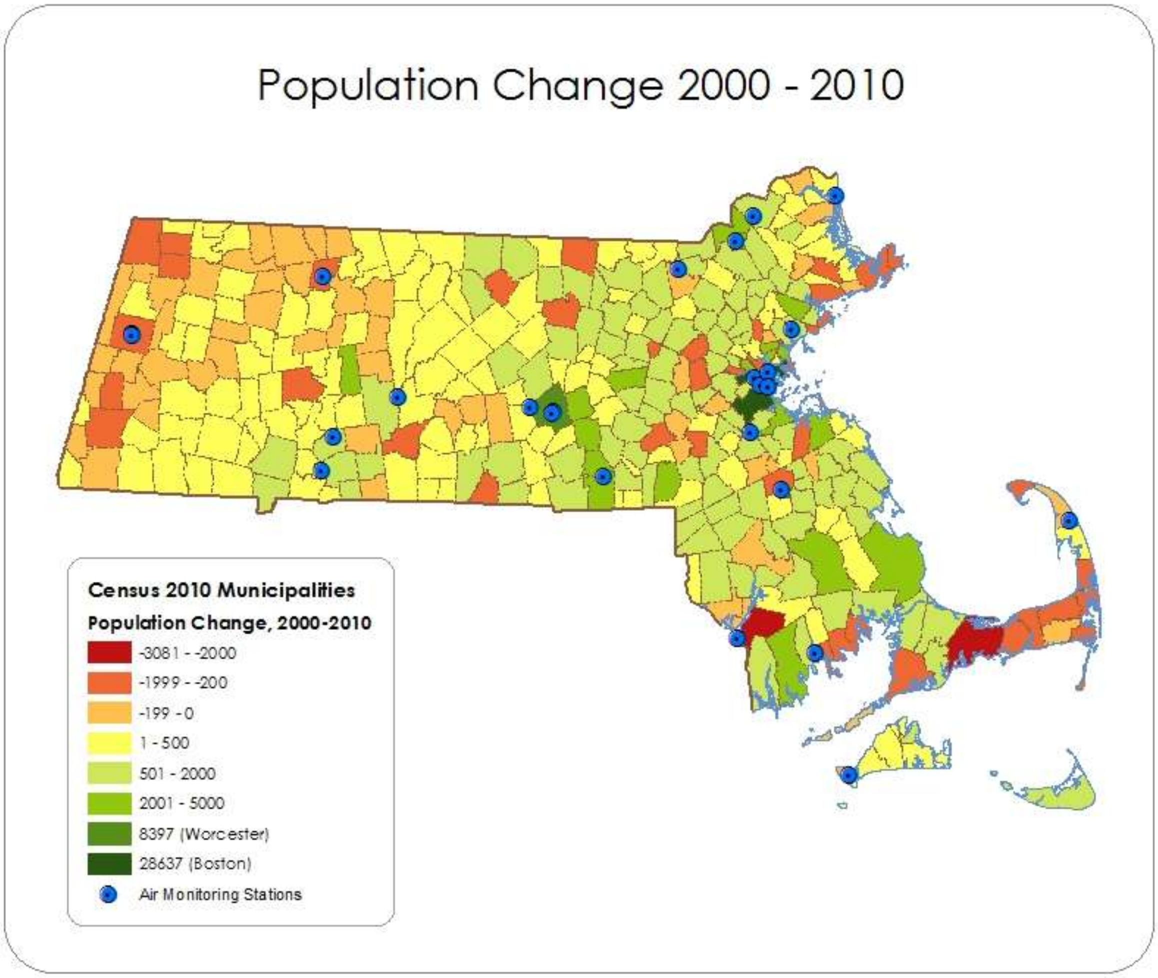
Figure 3-2
Massachusetts Population Change 2000 – 2014

COUNTY	POP 2000	POP 2010	POP 2014	% OF STATE 2000	% OF STATE 2014	CHANGE 2000 - 2014	% CHANGE 2000 - 2014
Barnstable	222,234	215903	214,914	4%	3%	-7,320	-0.1%
Berkshire	134,953	131310	128,715	2%	2%	-6,238	-0.1%
Bristol	534,682	549076	554,194	8%	8%	19,512	0.3%
Dukes	14,987	16553	17,356	0.2%	0.3%	2,369	0.04%
Essex	723,421	745478	769,091	11%	11%	45,670	0.7%
Franklin	71,535	71317	70,862	1%	1%	-673	0.0%
Hamden	456,226	464160	468,161	7%	7%	11,935	0.2%
Hampshire	152,255	159266	160,939	2%	2%	8,684	0.1%
Middlesex	1,466,396	1506852	1,570,315	23%	23%	103,919	1.6%
Nantucket	9,520	10154	10,856	0.1%	0.2%	1,336	0.02%
Norfolk	650,306	672645	692,254	10%	10%	41,948	0.7%
Plymouth	472,822	495856	507,022	7%	8%	34,200	0.5%
Suffolk	689,809	725319	767,254	11%	11%	77,445	1.2%
Worcester	749,973	800184	813,475	12%	12%	63,502	1.0%
MA TOTAL	6,349,119	6,564,073	6,745,408			396,289	6.2%

Source:
US Census – County Totals Dataset: Population, Population Change and Estimated Components of Population Change: April 1, 2010 to July 1, 2014
http://www.census.gov/popest/data/counties/totals/2014/CO-EST2014-alldata.html

Figure 3-3 shows population change at the municipal level from 2000 to 2010, which shows a modest population shift from west to east and from rural/suburban to urban, although there are exceptions. Generally, these changes would not indicate a need to reconfiguration of the network. In addition, population growth has been fairly uniform in each of the "airsheds" served by each monitoring station.

Figure 3-3
Massachusetts Population Change 2000 – 2000



Source:
US Census – MassGIS Data - Datalayers from the 2010 U.S. Census
http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html#CensusStatisticalData

MassDEP used EPA's Population Served Network Assessment Tool and NetAssess (network assessment tool suite developed by LADCO https://ebailey78.shinyapps.io/NetAssessApp/) 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 V maps showing the polygons). Note that 2010 was the latest population data available.

Figure 3-4
Change in Population and Population Proportion in Voronoi Polygon for Each PM2.5 Monitor: 2000 to 2010

Monitor Type	Site Id	Name	2000 POP	2010 POP	% Growth	% Pop Share 2000	% Pop Share 2010	Change Pop Share	Age < 15	Age > 65	Sensitive	Minority	PM2.5 Probability of Exceeding 35ug/m3
FRM/FEM	250035001	Pittsfield	242,130	118,865	-51%	3%	2%	-1%	18707	15610	34317	8300	<25%
FRM/FEM	250051004	Fall River	1,022,655	386,913	-62%	12%	6%	-6%	65699	45829	111528	45248	25%-50%
FRM/FEM	250092006	Lynn	537,074	445,800	-17%	7%	7%	1%	79567	49743	129310	70530	25%-50%
FRM/FEM	250095005	Haverhill	250,578	227,031	-9%	3%	4%	1%	43158	19435	62593	14715	<25%
FRM	250096001	Lawrence	771448	401,640	-48%	9%	7%	-3%	82025	33723	115748	100386	25%-50%
FRM	250130008	Chicopee	403,640	248,630	-38%	5%	4%	-1%	39166	25420	64586	43099	50%-70%
FRM/FEM	250130016	Springfield	269,760	388,639	44%	3%	6%	3%	73121	38540	111661	89305	50%-70%
FRM/FEM	250154002	Ware	328,587	117,547	-64%	4%	2%	-2%	21250	10781	32031	6257	<25%
FEM	250213003	Blue Hill	1,033,412	456,402	-56%	13%	8%	-5%	87627	48289	135916	105933	25%-50%
FRM/FEM	250230004	Brockton	743,271	717,147	-4%	9%	12%	3%	130776	79281	210057	96882	25%-50%
FRM	250250002	Kenmore	776,122	883,390	14%	9%	15%	5%	124065	81668	205733	195759	50%-70%
FRM/FEM	250250042	Roxbury	609,565	183,079	-70%	7%	3%	-4%	33716	12738	46454	117130	50%-70%
FRM/FEM	250250043	North End	114,057	319,656	180%	1%	5%	4%	50420	26791	77211	105710	50%-70%
FRM/FEM	250250044	Von Hillern	NA	259,286	NA	NA	4%	NA	42250	23897	66147	96380	50%-70%
FEM	250270016	Worcester Washington	448,828	319,661	-29%	5%	5%	0%	59301	27630	86931	47727	25%-50%
FRM	250270023	Worcester Summer St	631,664	440,462	-30%	8%	7%	0%	86694	40375	127069	68359	25%-50%
FRM/FEM	250112005	Greenfield HS	NA	101,945	NA	NA	2%	NA	15935	10367	26302	6829	<25%

Source: U.S. Census through NetAssess
Von Hillern and Brockton added since last assessment.

Notes about Figure 3-4:

- Most sites lost population, except for Boston- North End, which tripled in size, and Springfield, which increased by half. Boston-Roxbury decreased to about one quarter of its original population.
- None of the polygons were extremely large, with Boston-Kenmore the largest at 15%. Greenfield and Pittsfield were much smaller than the others. Even though Boston-North End and Springfield had very large increases, their share of the total was similar to other monitors.
- The largest change in population share was for Boston-Kenmore, which also had the largest absolute change and the largest absolute population. Kenmore also had the largest percent of children, elderly, and minority populations.
- Pittsfield, Haverhill, Ware, and Greenfield all had very low probabilities of an exceedance.

Figure 3-5

Change in Population and Population Proportion in Voronoi Polygon for Each Ozone Monitor: 2000 to 2010

Name	Site ID	2000 POP	2010 POP	% Growth	% Pop Share 2000	% Pop Share 2010	Change Pop Share	Age < 15	Age > 65	Sensitive	Minority	Ozone Probability of Exceeding 75ppb	Ozone Probability of Exceeding 70ppb
TRURO	25-001-0002	113,891	114294	0.4%	2.0%	1.9%	-0.1%	14412	30884	45296	8476	70%-80%	80%-90%
FALL RIVER	25-005-1004		195043			3.2%	3.2%	33291	31905	65196	15390	80%-90%	>90%
FAIRHAVEN	25-005-1006	720,839	265898	-63.1%	12.7%	4.3%	-8.3%	46864	40981	87845	34379	70%-80%	>90%
AQUINNAH WAMPANOAG	*25-007-0001*		40167			0.7%		5582	10006	15588	3753	70%-80%	80%-90%
LYNN	25-009-2006	674,996	530743	-21.4%	11.9%	8.7%	-3.2%	94974	79134	174108	98241	50%-70%	80%-90%
NEWBURYPORT	25-009-4005	126,963	130117	2.5%	2.2%	2.1%	-0.1%	22178	20225	42403	5222	80%-90%	80%-90%
HAVERHILL	25-009-5005	932,683	377233	-59.6%	16.4%	6.2%	-10.2%	77208	45668	122876	73996	50%-70%	80%-90%
CHICOPEE	25-013-0008	660,425	544158	-17.6%	11.6%	8.9%	-2.7%	97034	74899	171933	122194	80%-90%	80%-90%
WARE	25-015-4002	62,698	83452	33.1%	1.1%	1.4%	0.3%	14977	11302	26279	5006	70%-80%	80%-90%
CHELMSFORD	25-017-0009		465395			7.6%		93588	59193	152781	82390	50%-70%	80%-90%
BLUE HILL	25-021-3003	786,624	486526	-38.2%	13.8%	7.9%	-5.9%	94585	71909	166494	103904	50%-70%	80%-90%
ROXBURY	25-025-0042	1,168,054	1372383	17.5%	20.5%	22.4%	1.9%	198005	162841	360846	461621	50%-70%	80%-90%
WORCESTER AIRPORT	25-027-0015	446,430	474637	6.3%	7.8%	7.7%	-0.1%	88499	61398	149897	83034	70%-80%	80%-90%
UXBRIDGE	25-027-0024		446291			7.3%		89362	54895	144257	58830	70%-80%	80%-90%
GREENFIELD HS	25-011-2005		105142			1.7%		16370	15705	32075	6918	50%-70%	70%-80%
BROCKTON	25-023-0005		501608			8.2%		98493	67101	165594	81821	50%-70%	80%-90%

Source: U.S. Census through NetAssess
Fairhaven and Newbury sites moved to nearby locations since last assessment.
Adams, Stow, Amherst, and Long Island closed since last assessment.
Uxbridge, Greenfield, Fall River, and Brockton added since last assessment.

Notes about Figure 3-5:

- The Robury polygon was very large with 22.4 % of the total population. The Aquinnah polygon contains < 1% of the population, and the remainder ranged from about 2% - 9%,
- Most site polygons lost population, with Fairhaven and Haverhill dropping by nearly 2/3. Ware increased by 1/3. Roxbury had the largest absolute increase.
- All except Haverhill showed only small changes in populations. Haverhill appears to have lost 10% of its population, but this is due to the addition of the Chelmsford ozone site.
- Roxbury also had the largest populations of children, elderly, and minorities.
- For the 75 ppb NAAQS, probabilities of an exceedance are all greater than 50%, and vary up to 90%. For a hypothetical 70 ppb standard, the probabilities of an exceedance are above 80% at all monitors except for Greenfield.

Figure 3-6
Change in Population and Population Proportion in Voronoi Polygon for Each NO_2 Monitor: 2000 to 2010

Name	Site Id	2000 POP	2010 POP	% Growth	% Pop Share 2000	% Pop Share 2010	Change Pop Share	Age < 15	Age > 65	Sensitive	Minority
LYNN	25-009-2006	607,594	681639	12%	11%	12%	0.3%	128678	98020	226698	145073
NEWBURYPORT	25-009-4005		531456		0%	9%	9.2%	94394	72736	167130	29599
CHICOPEE	25-013-0008	198,265	331622	67%	4%	6%	2.0%	51704	48945	100649	47619
SPRINGFIELD	25-013-0016	315,718	386525	22%	6%	7%	0.7%	72741	53802	126543	89245
WARE	25-015-4002	236,281	262804	11%	4%	5%	0.1%	44372	37174	81546	14322
BLUE HILL	25-021-3003	1,566,767	1094820	-30%	30%	19%	-10.8%	204325	167140	371465	196025
KENMORE	25-025-0002	1,095,886	1091887	0%	21%	19%	-1.9%	157744	139324	297068	247911
ROXBURY	25-025-0042	326,897	186988	-43%	6%	3%	-3.0%	33944	19425	53369	117948
VON HILLERN	25-025-0044		429349		0%	7%	7.4%	71440	56845	128285	142172
WORCESTER SUMMER ST	25-027-0023	937,544	799807	-15%	18%	14%	-3.9%	153639	101399	255038	121364

Source: U.S. Census through NetAssess
Haverhill was closed and not replaced since the previous assessment.
Newbury and Long Island were closed but new sites located nearby.

Notes about Figure 3-6:

- Major changes in population for individual polygons have occurred primarily due to the removal or addition of monitors (e.g., decreases at Roxbury and Blue Hill). Other changes appear to be due to changes in the computation by the NetAssess tool compared to previous tools used (e.g., the increase in Chicopee).
- 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 and Population Proportion in Voronoi Polygon for Each SO2 Monitor: 2000 to 2010

Name	Site Id	2000 POP	2010 POP	% Growth	% Pop Share 2000	% Pop Share 2010	Change Pop Share	Age < 15	Age > 65	Sensitive	Minority
FALL RIVER	25-005-1004	1089051	720610	-34%	22%	13%	-8.9%	119660	127213	246873	71921
SPRINGFIELD	25-013-0016	564721	607176	8%	12%	11%	-0.3%	110182	87000	197182	125670
WARE	25-015-4002	189440	223576	18%	4%	4%	0.3%	35167	28991	64158	18555
KENMORE	25-025-0002	990812	1845482	86%	20%	34%	13.9%	299581	245956	545537	386862
ROXBURY	25-025-0042	1142493	1181913	3%	23%	22%	-1.4%	214168	157598	371766	387201
WORCESTER SUMMER ST	25-027-0023	929703	833068	-10%	19%	15%	-3.6%	159569	105334	264903	123005

Source: U.S. Census through NetAssess

Notes about Figure 3-7:

- Significant changes in population for individual polygons have occurred primarily due to changes in the computation by the NetAssess tool compared to previous tools used (e.g., the increase in Kenmore and decrease in Fall River).

- 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 resulting from coal and residual oil burning in Massachusetts, which limits the utility of the polygon analysis.

Because the population distribution has remained the same over the past ten years and no significant shifts are expected in the future, MassDEP does not believe that it needs to change its network design on the basis of population distribution.

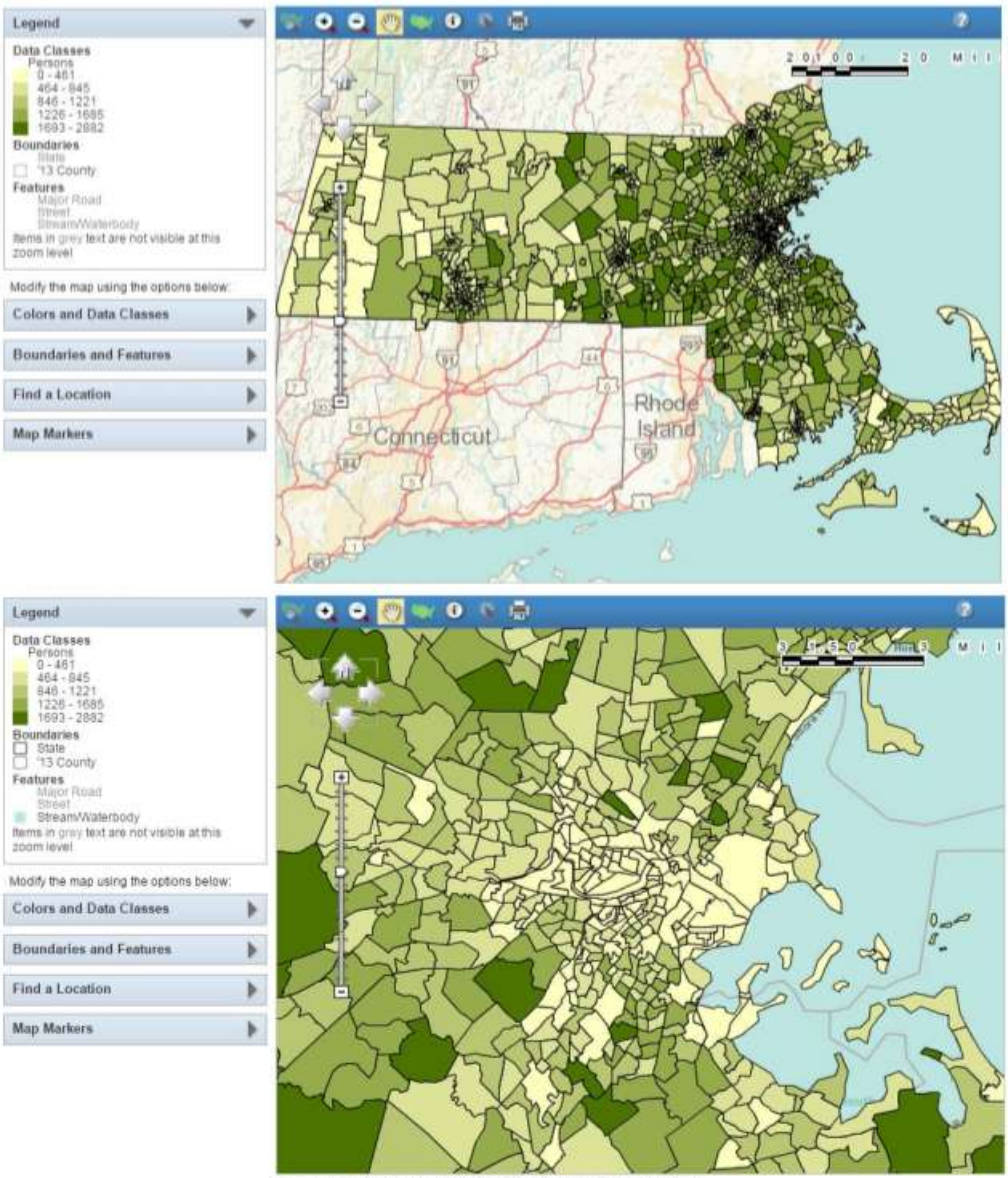
Sensitive Populations

Children

The U.S. Census estimates that in 2013 there were 1,408,050 persons under the age of 18 years comprising about 21% of the population (down from 25% in 2008).[1] Figures 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. The only observable difference appears to be a slightly smaller number of children in the central urban area tracts of Boston than in surrounding suburban tracts. Therefore, conclusions regarding network coverage for the general population apply to the population of children.

[1] Annual Estimates of the Resident Population for Selected Age Groups by Sex for the United States, States, Counties, and Puerto Rico Commonwealth and Municipios: April 1, 2010 to July 1, 2013
Source: U.S. Census Bureau, Population Division. Release Date: June 2014"
http://factfinder.census.gov/bkmk/table/1.0/en/ACS/13_5YR/B09001/0400000US25|0400000US25.14000

Figure 3-8
Children Under 18 yr in 2013 by Census Tract



Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey

Source: POPULATION UNDER 18 YEARS BY AGE, Annual Estimates of the Resident Population for Selected Age Groups by Sex for the United States, States, Counties, and Puerto Rico Commonwealth and Municipios: April 1, 2010 to July 1, 2013
Source: U.S. Census Bureau, Population Division,
Release Date: June 2014. American FactFinder: http://factfinder.census.gov/bkmk/table/1.0/en/ACS/13_5YR/B09001/0400000US25|0400000US25.14000

Elderly

The U.S. Census estimates that in 2010 there were 902,724 persons 65 years or over comprising about 14% of the Massachusetts population.[2] Figure 3-9 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. The only significant difference appears to be a larger number of elders on Cape Cod. Cape Cod is well covered by ozone monitors; however, there are no $PM_{2.5}$ monitors on Cape Cod.

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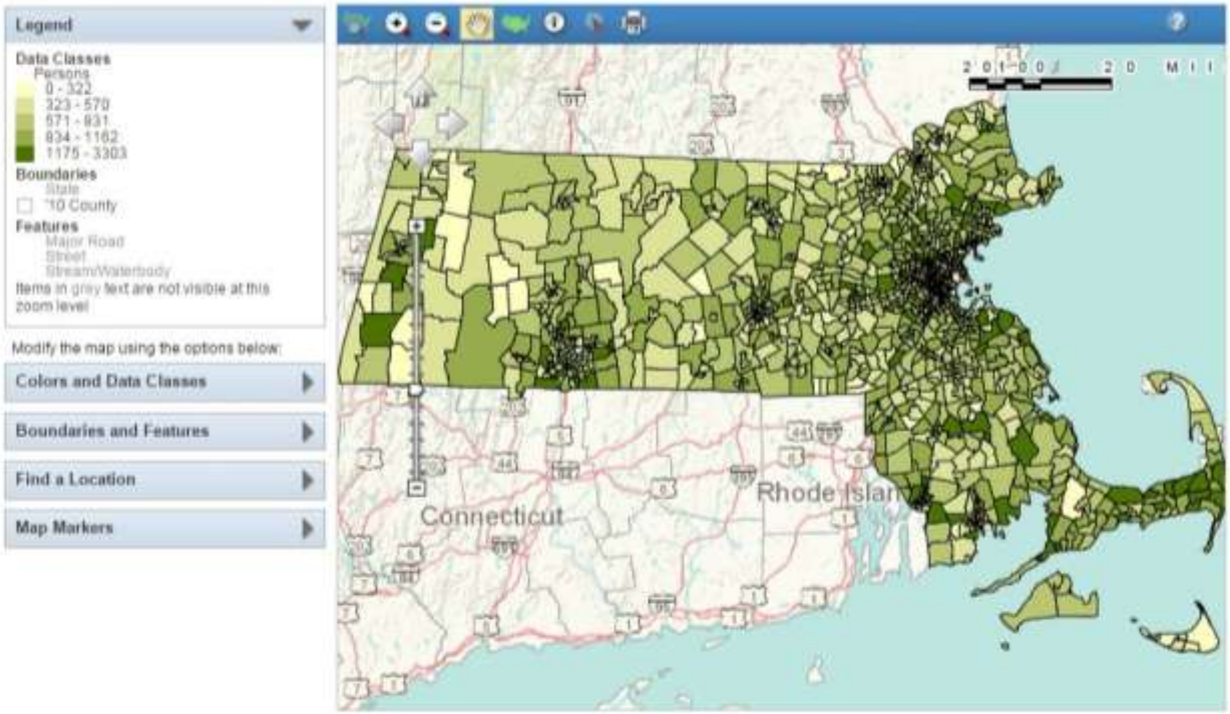
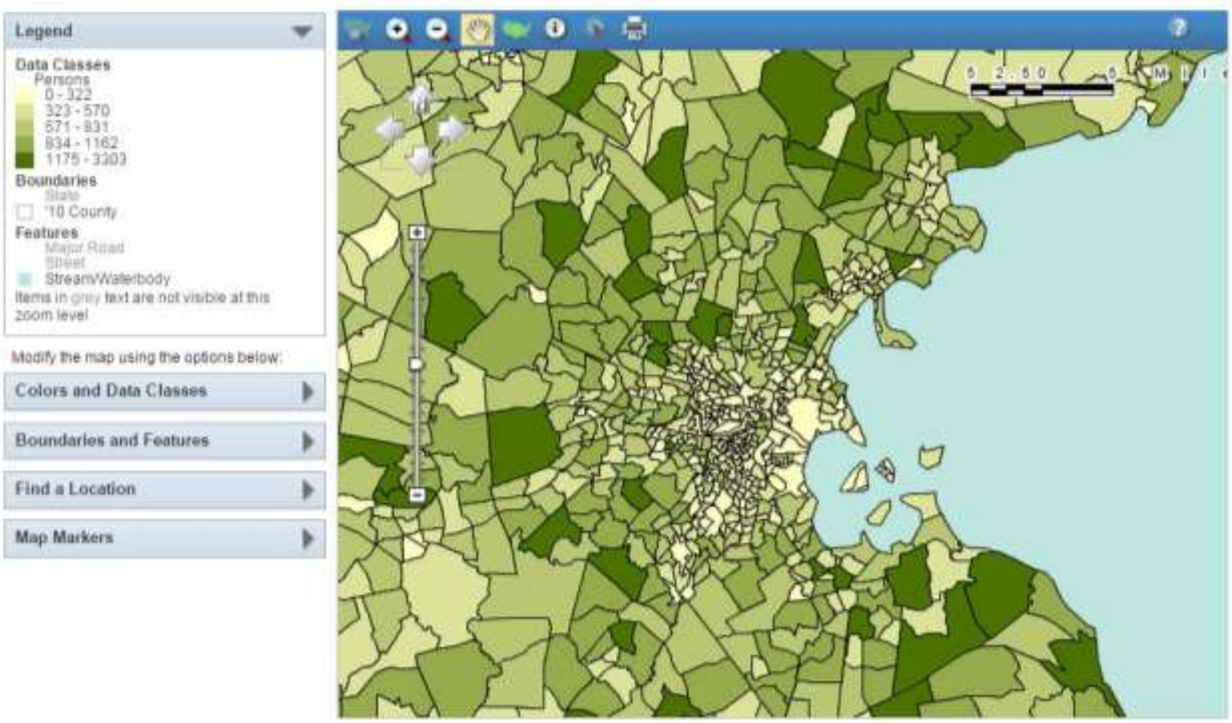
[2] U.S. Census Bureau, 2010 Census.
Profile of General Population and Housing Characteristics: 2010, 2010 Demographic Profile Data
American FactFinder:
http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table

Figure 3-9
Persons 65 yrs and Over in 2010 by Census Tract





Source: U.S. Census Bureau, 2010 Census.
Profile of General Population and Housing Characteristics: 2010, 2010 Demographic Profile Data
American FactFinder: http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table

Disease Incidence/Compromised Health

Disease data/maps presented below are excerpted from the Environmental Public Health Tracking system provided by the Massachusetts Departemnet of Public Health, Bureau of Environmental Health (see https://matracking.ehs.state.ma.us/#)

Asthma – Asthma prevalence in children varies widely over the state as shown in Figure 3-10. Areas with higher than average asthma are: (1) well covered by ozone monitors because the entire state is well covered; (2) partially covered by $PM_{2.5}$ monitors, with the northern border and south central areas the most prominent areas without PM monitors (although the overall population of children in those areas is relatively low, so the absolute number of asthma cases is also relatively low).

Emergency room visits for asthma in Figure 3-11 show a similar pattern, with the exception that there are higher rates of ER visits on Cape Cod and the Islands than would be explained by the pediatric prevalence.

Figure 3-10
Pediatric Asthma Prevalence per 100 Students School Years 2007-2012 Ages 5-14

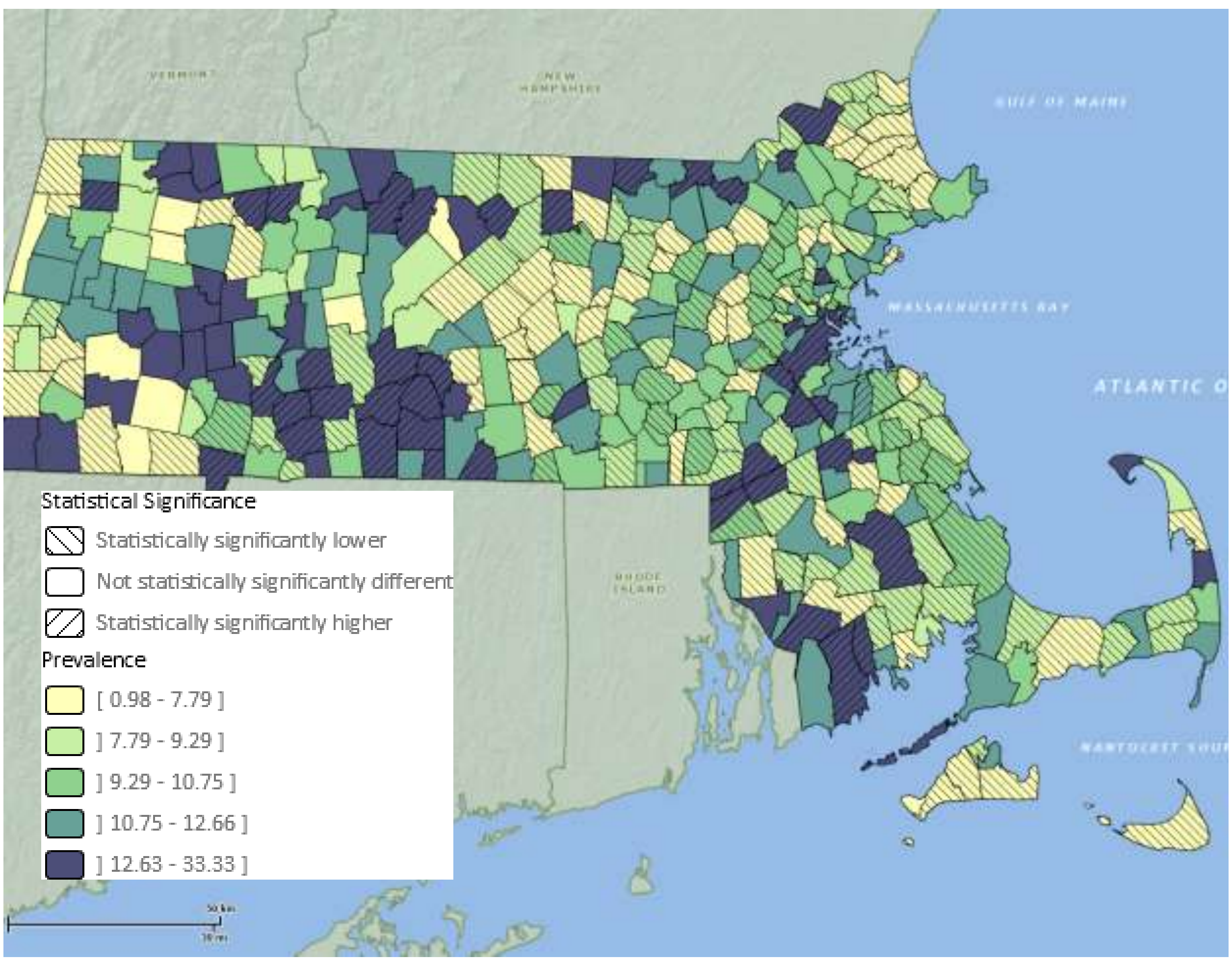
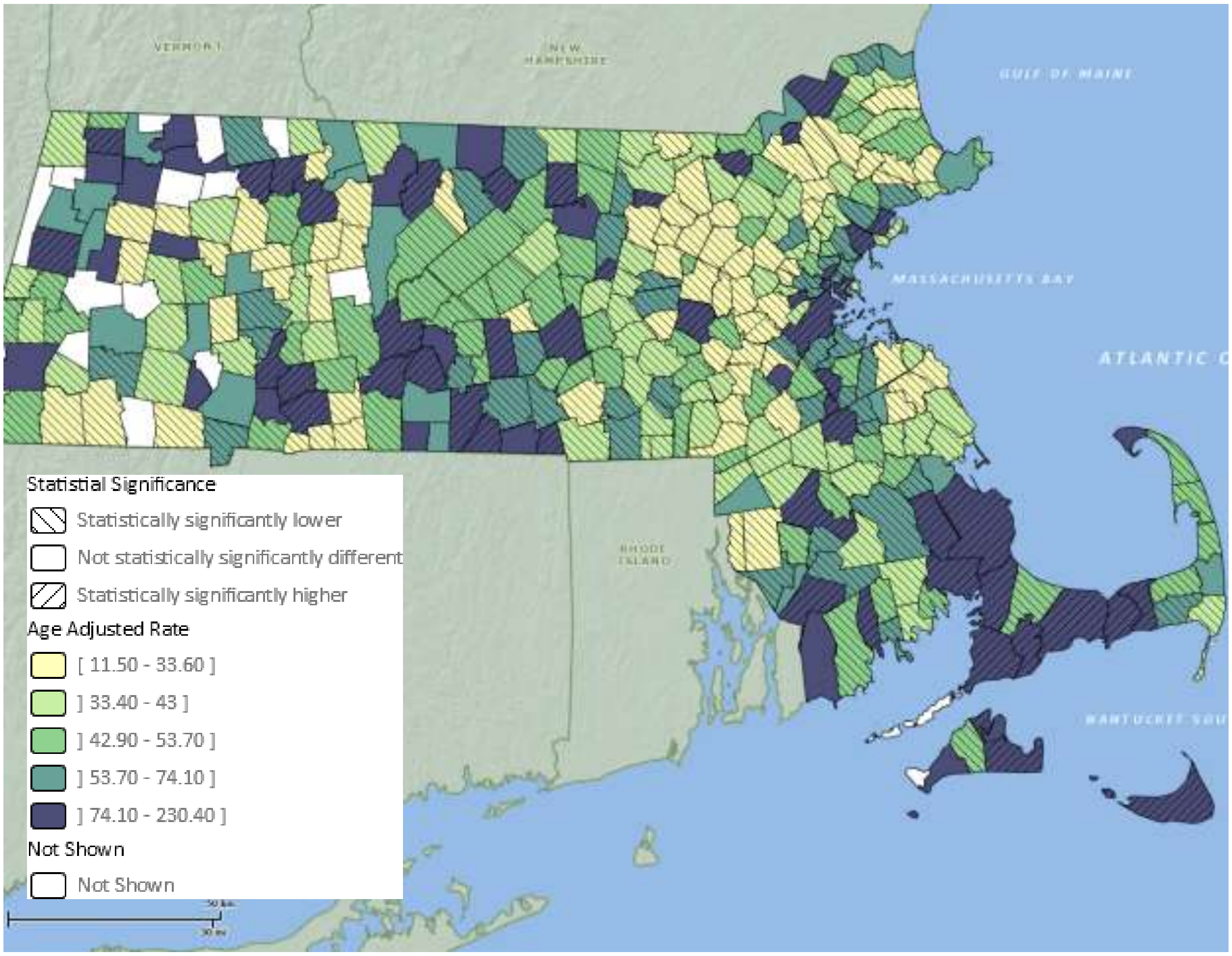
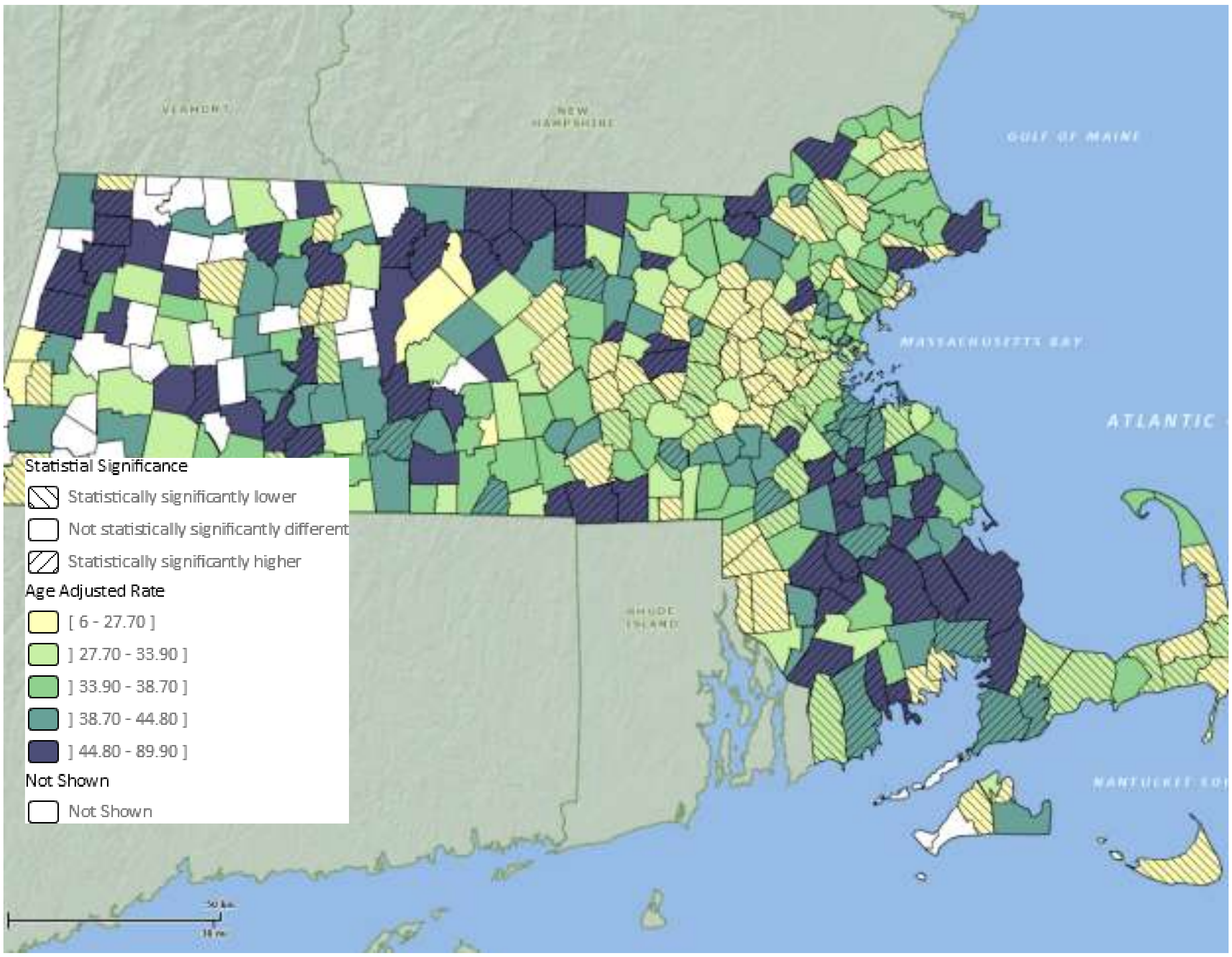


Figure 3-11
Age Adjusted Rates of Emergency Dept Visits for Asthma per 10,000 People 2005-2010



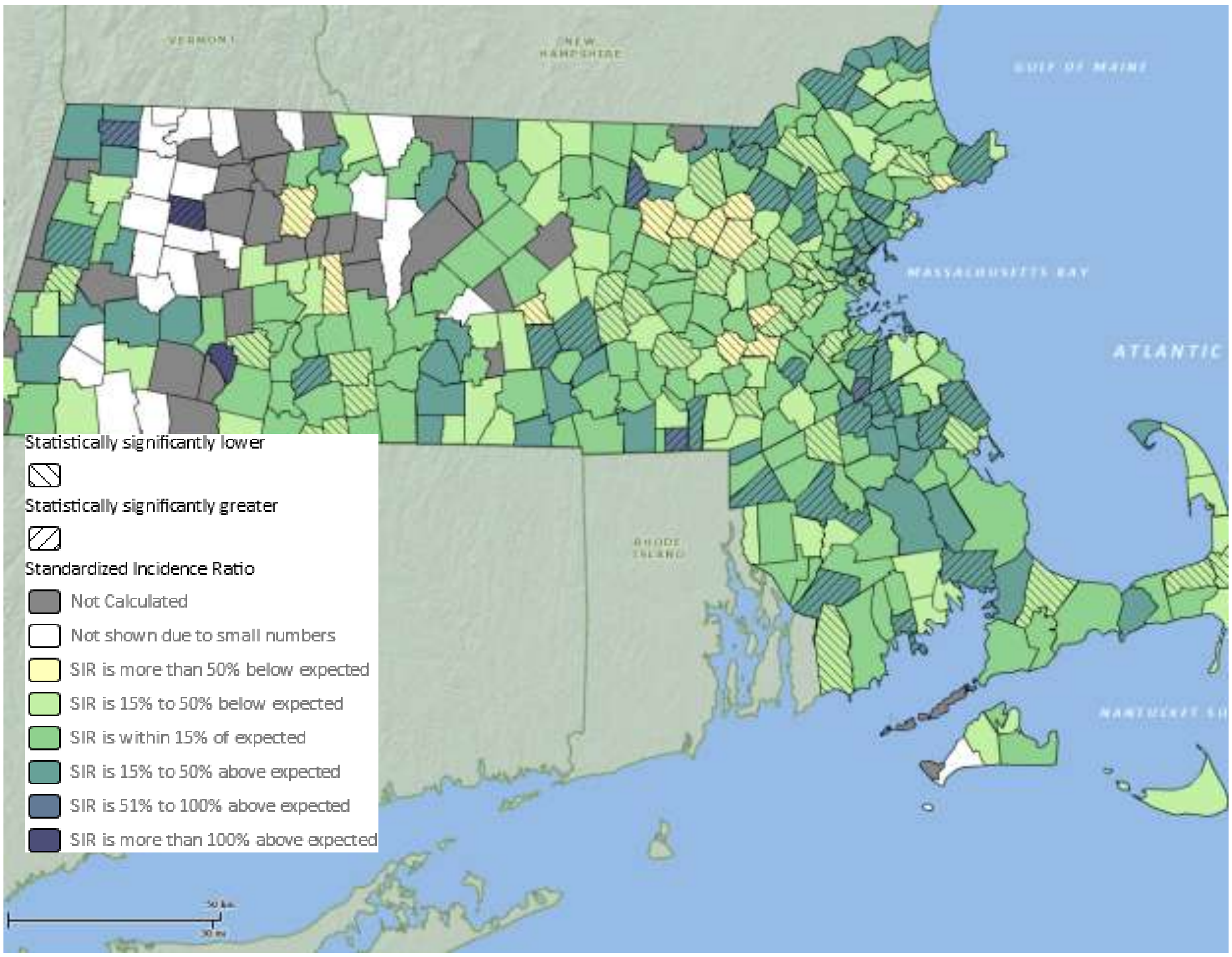
Cardiovascular Illness – Figure 3-12 shows hospital admissions for heart attack, which is a surrogate for cardiovascular illness. Areas with higher rates are scattered except for north central and southeast parts of the state. These areas do not have high population densities overall.

Figure 3-12
Age Adjusted Rates of Hospital Admission for Myocardial Infarction per 10,000 People Age 35+ for 2005-2010



Cancer – Lung and bronchus cancer rates available by community are Standardized Incidence Ratios (SIRs). An SIR is the ratio of the observed number of cancer diagnoses in an area (such as a community or census tract) to the number of expected diagnoses based on the statewide cancer experience. Figure 3-13 shows no discernible pattern of cancer above/below what is expected based on the rate for the whole state.

Figure 3-13
Lung and Bronchus Cancers (SIR) 2005-2009



Environmental Justice Populations

Figure 3-14 shows environmental justice (EJ) communities with monitoring stations overlayed. EJ communities are defined as block groups meeting one or more of the following criteria:[3]

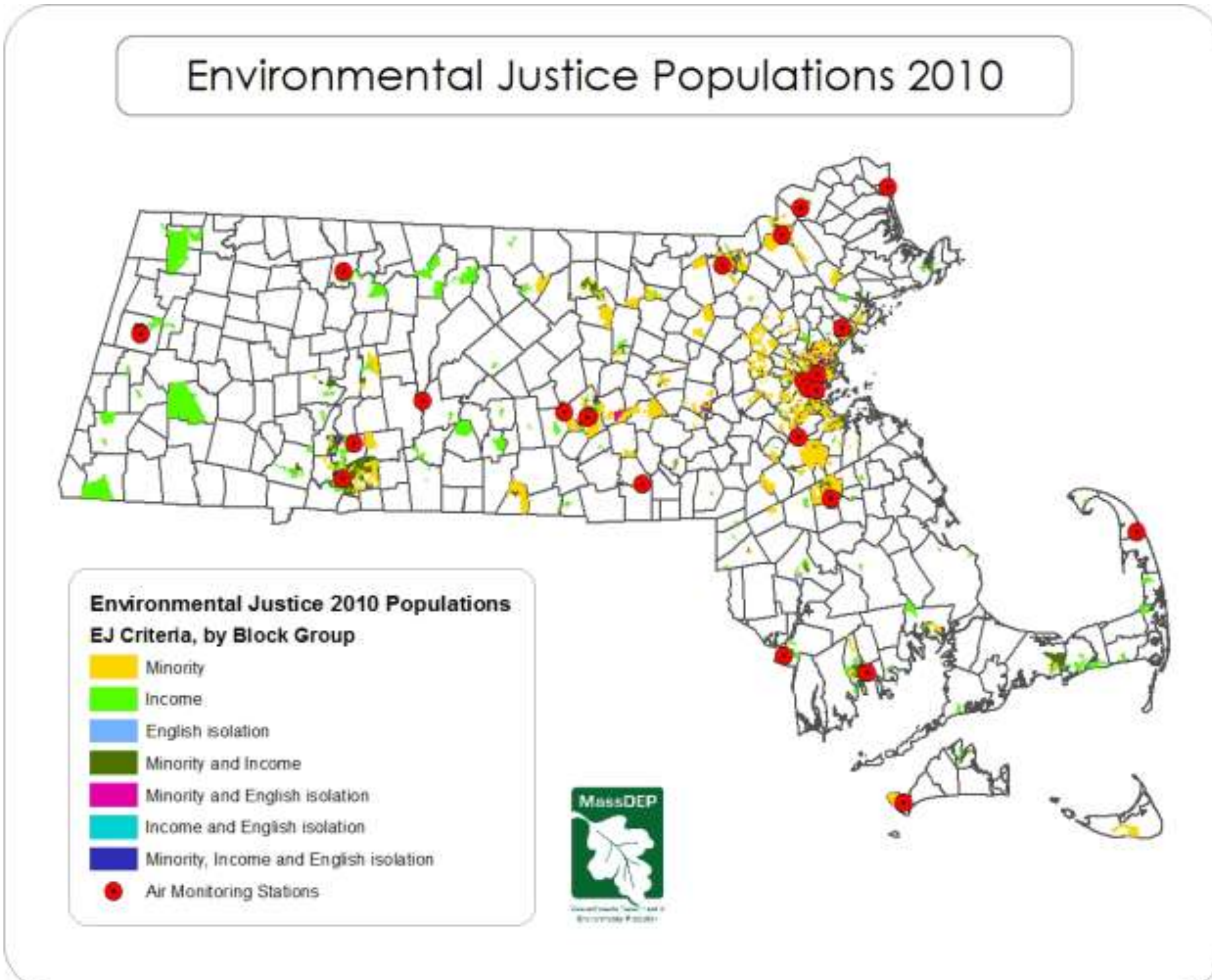
1. high minority (≥25%)
2. low-income (median income <65% of the statewide median income)
3. English isolation – a household in which all members 14 years old and over speak a non-English language and also speak English less than ‘‘Very well’’ (have difficulty with English). populations. Any Block Group with 25% or more of all households identified as English-isolated was selected as an EJ population.

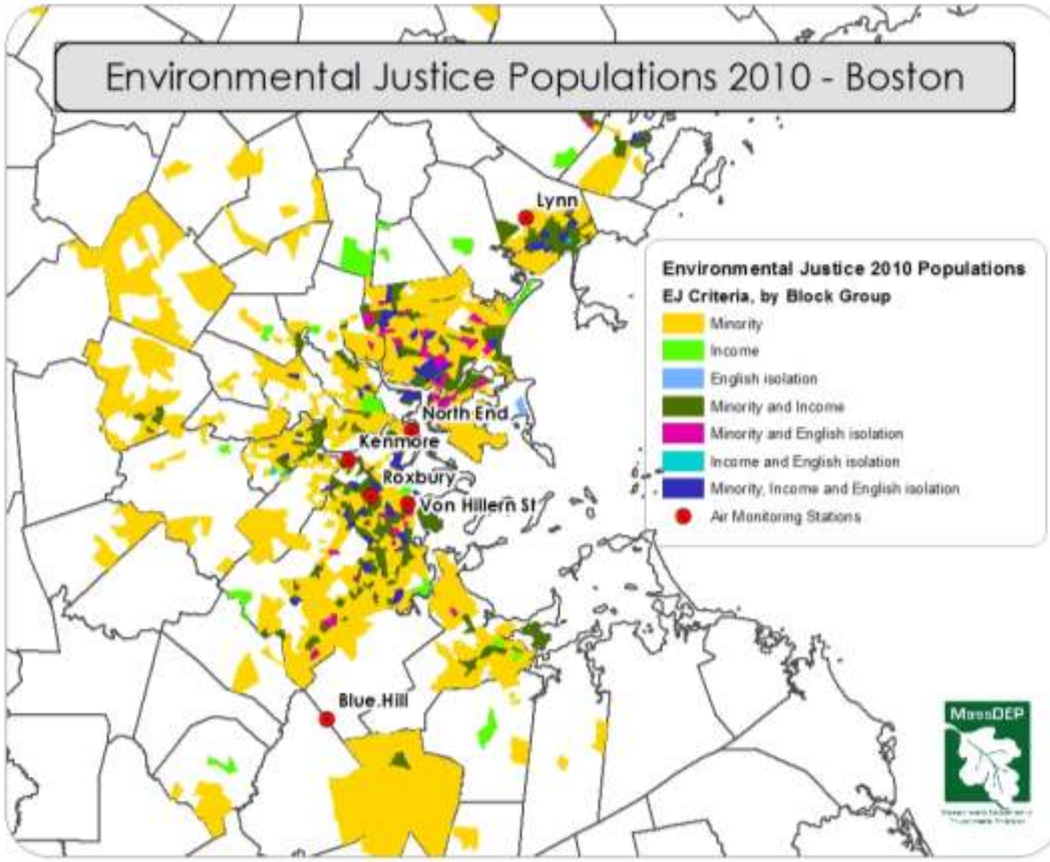
Figure 3-14 shows that:

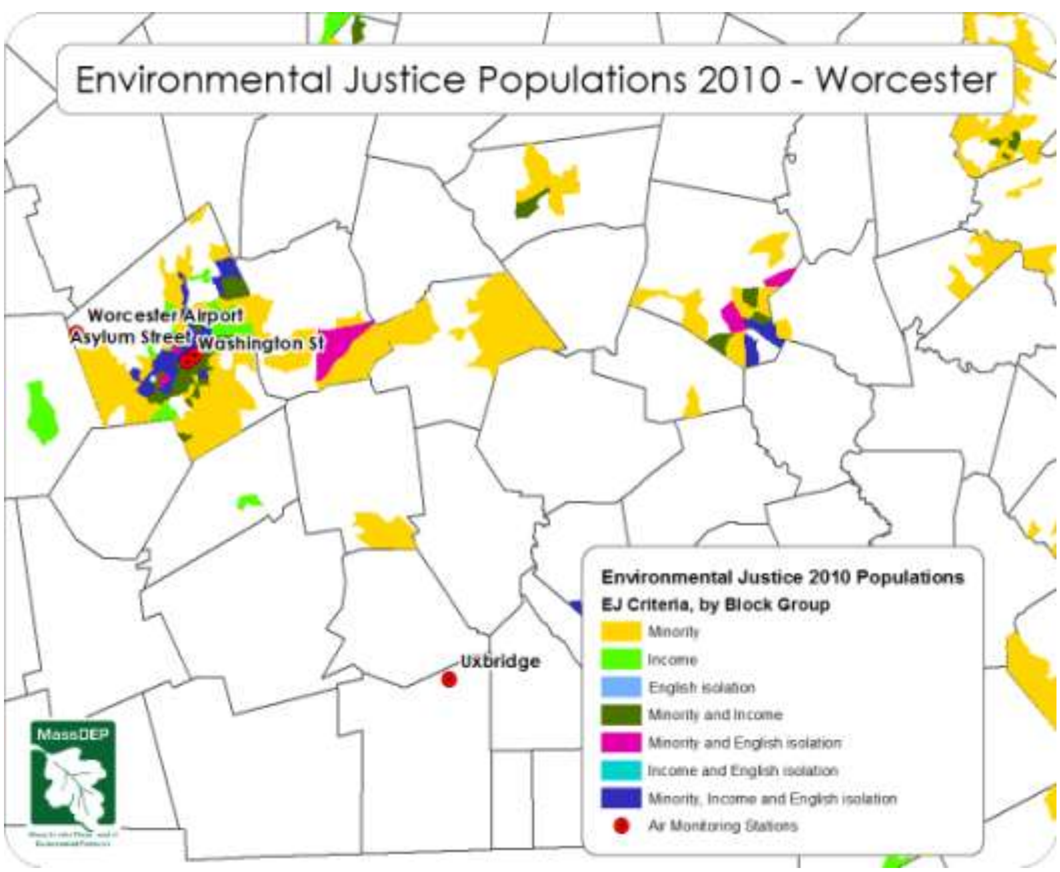
- PM2.5 – With the exception of Leominster/Fitchburg and Framingham, the larger clusters of urban environmental justice areas are covered by $PM_{2.5}$ monitors. Rural EJ areas in Western Massachusetts are represented adequately by monitors in Greenfield and Pittsfield, which should experience similar emissions and meteorological conditions to the EJ areas.
- Ozone – the entire state is adequately covered by ozone monitors, and levels do not vary dramatically over small distances.
- SO2 – The only remaining significant source of SO_2 is the Brayton Point power plant in Somerset, which is scheduled to close in 2017. The nearby monitor in Fall River covers the EJ communities in that area.
- NOx – the near-road monitor at Von Hillern in Boston is designed to measure a maximum exposure level, and therefore generally would cover other areas of the state.
- CO – CO levels are so low that EJ coverage is not a consideration.

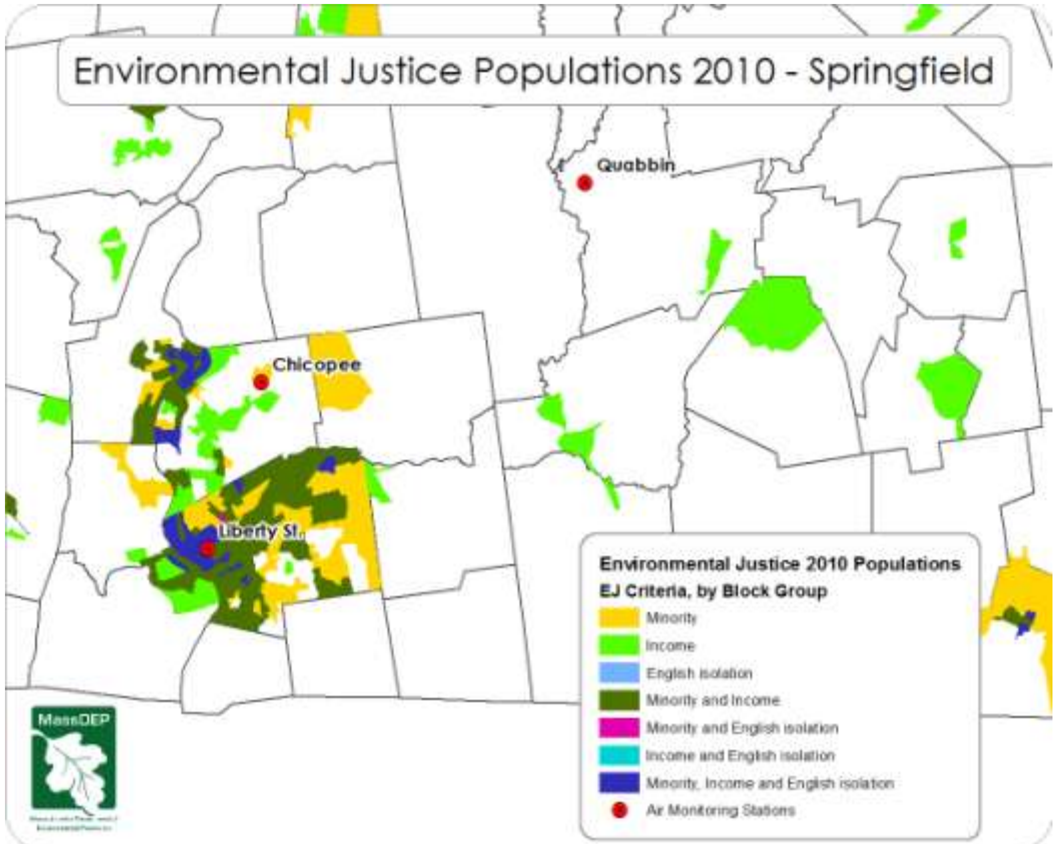
[3] Additional adjustments were made to this data set to exclude inappropriate areas such as colleges, prisons, parks, and airports.

Figure 3-14
Massachusetts EJ Populations 2010 – Income, Race, Language




Environmental Justice Populations 2010 - Boston
Lynn
North End
Kenmore
Roxbury
Von Hillern St
Blue Hill
Environmental Justice 2010 Populations
EJ Criteria, by Block Group
Minority
Income
English isolation
Minority and Income
Minority and English isolation
Income and English isolation
Minority, Income and English isolation
Air Monitoring Stations
MassDEP


Environmental Justice Populations 2010 - Worcester
Worcester Airport
Asylum Street
Washington St
Uxbridge
Environmental Justice 2010 Populations
EJ Criteria, by Block Group
Minority
Income
English isolation
Minority and Income
Minority and English isolation
Income and English isolation
Minority, Income and English isolation
Air Monitoring Stations
MassDEP


Environmental Justice Populations 2010 - Springfield
Quabbin
Chicopee
Liberty St.
Environmental Justice 2010 Populations
EJ Criteria, by Block Group
Minority
Income
English isolation
Minority and Income
Minority and English isolation
Income and English isolation
Minority, Income and English isolation
Air Monitoring Stations
MassDEP

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 change in population and road system distribution across the state and therefore limited change in the distribution of area and mobile source emissions across the state.

Ozone remains an important issue, especially with the new lower 2015 ozone standard. MassDEP maintains an extensive ozone monitoring network, especially in Southeastern Massachusetts, where the last violations of the ozone standard occurred. MassDEP has been proactive in monitoring $PM_{2.5}$ and black carbon, especially to characterize wood smoke emissions, by maintaining continuous and filter-based $PM_{2.5}$ and black carbon monitors at Springfield - Liberty Street and the new Greenfield site, and continuous $PM_{2.5}$ and PM Speciation at the Ware - Quabbin Summit site. MassDEP is in the process of locating a new site in Pittsfield that will have and continuous and filter-based $PM_{2.5}$ and black carbon monitors, as well as ozone.

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 "unclassified" or "attainment" for all of the NAAQS except the 2008 ozone standard, for which just Dukes County is classified as marginal nonattainment. However, beginning with monitoring data for 2012 – 2014, that Dukes County now attains the 2008 ozone standard.

Figure 4-1

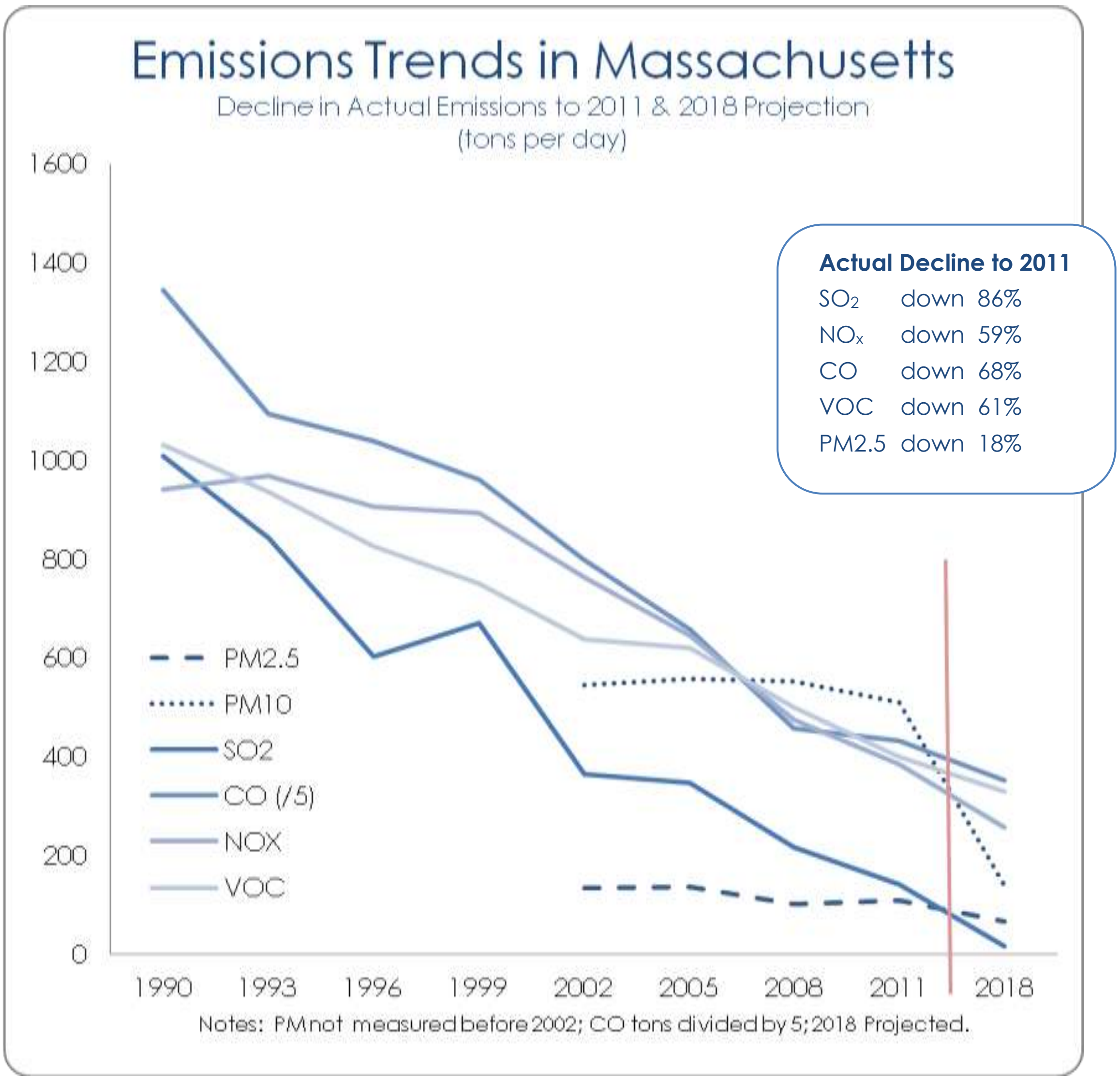
National Ambient Air Quality Standards

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	98th 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	98th 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	99th 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 for 1990 and 2011 (the most recent published inventory), as preliminary projected reductions in 2018,[4] which show that the downward trend for all pollutants is expected to continue.

Figure 4-2

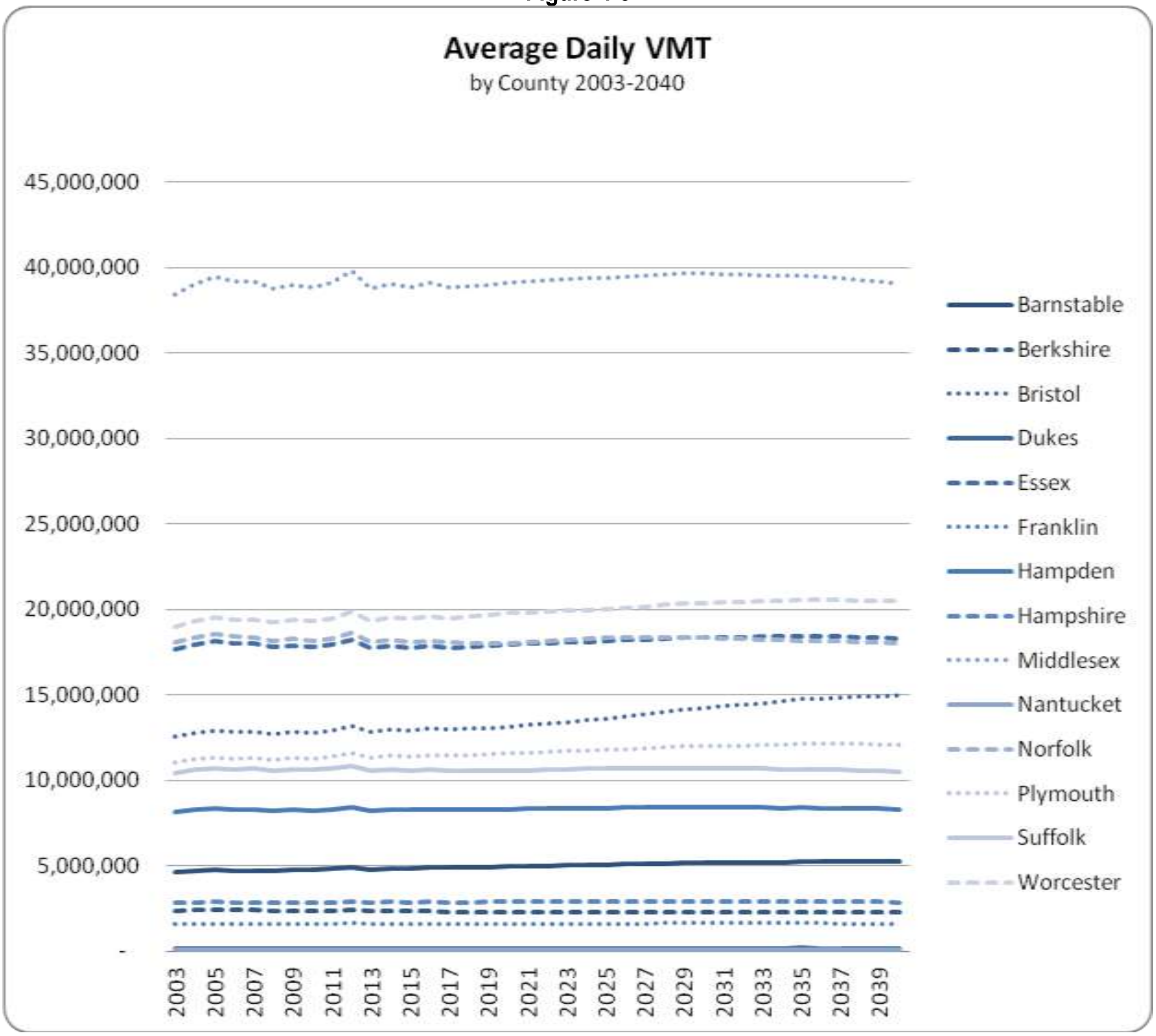


[4] EPA Ozone NAAQS Emissions Modeling Platform (2011v6.1)
Index of /EmisInventory/2011v6/ozone_naaqs/reports/ftp://ftp.epa.gov/EmisInventory/2011v6/ozone_naaqs/reports/
File: 2018ef_v6_11g_state_sector_totals.xlsx 12/1/14, 2:37:00 PM

Vehicles make up one of the largest sources of VOC and NOx 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 indicate this general distribution is expected to remain constant into the future. The one exception is Bristol County, where VMT is expected to rise gradually at a higher rate than other areas of the state. This change in VMT in Bristol County is not deemed significant for the purpose of designing the monitoring network.

Figure 4-3



Sources:
2003 - 2012 data based on FHWA published figures (annual state VMT), and MassDOT reports to FHWA for HPMS (daily state VMT).
2013 figures from preliminary HPMS traffic volume data.
2014 - 2020 projections all factored to HPMS and based on: Modeled traffic growth, recent state population projections, plus state and national VMT growth trends.

Distribution of Emission Reductions

Figure 4-4 shows that, except for Nantucket and Dukes Counties, emissions have declined fairly uniformly across the state.

Figure 4-4
Emissions Reduction by Pollutant and County 1990 - 2011

County	Pollutant	1990	2002	2005	2011	% change 1990 - 2011
Barnstable	CO	213,453	201,372	210,206	47,949	-78%
	NO_x	18,652	23,181	12,723	8,141	-56%
	$PM_{2.5}$	3,603	4,074	3,346	1,491	-59%
	SO_2	63,372	28,445	28,276	1,309	-98%
	VOC	19,681	21,209	15,975	8,245	-58%
Berkshire	CO	98,671	54,441	27,745	30,996	-69%
	NO_x	10,665	8,349	6,105	4,364	-59%
	$PM_{2.5}$	4,315	2,414	2,393	2,631	-39%
	SO_2	10,629	1,962	2,521	707	-93%
	VOC	14,161	11,139	7,869	5,676	-60%
Bristol	CO	447,624	188,978	160,148	58,119	-87%
	NO_x	62,226	28,237	23,756	12,619	-80%
	$PM_{2.5}$	5,223	5,874	5,843	2,786	-47%
	SO_2	103,652	48,701	41,578	20,516	-80%
	VOC	32,154	24,870	19,159	11,125	-65%
Dukes	CO	25,104	24,053	20,948	12,283	-51%
	NO_x	696	4,291	2,119	2,544	266%
	$PM_{2.5}$	532	895	738	744	40%
	SO_2	229	1,557	313	526	130%
	VOC	4,248	3,398	2,460	2,466	-42%
Essex	CO	606,854	264,599	233,286	90,005	-85%
	NO_x	48,276	25,299	21,906	16,523	-66%
	$PM_{2.5}$	6,114	3,457	4,525	4,050	-34%
	SO_2	56,349	20,259	17,201	6,233	-89%
	VOC	50,166	30,433	26,192	16,435	-67%
Franklin	CO	131,409	78,095	53,340	22,215	-83%
	NO_x	6,726	5,950	3,971	2,856	-58%
	$PM_{2.5}$	2,914	2,342	2,324	2,140	-27%
	SO_2	2,370	895	1,029	567	-76%
	VOC	12,687	8,581	30,042	4,691	-63%

County	Pollutant	1990	2002	2005	2011	% change 1990 - 2011
Hampden	CO	403,137	207,516	166,954	62,090	-85%
	NO_x	26,049	19,981	10,861	10,827	-58%
	$PM_{2.5}$	4,830	3,940	3,858	3,400	-30%
	SO_2	20,242	9,851	9,710	2,453	-88%
	VOC	25,328	20,105	16,192	11,505	-55%
Hampshire	CO	155,653	87,955	63,832	24,911	-84%
	NO_x	7,683	5,698	4,337	3,539	-54%
	$PM_{2.5}$	2,905	2,512	2,498	2,206	-24%
	SO_2	3,248	1,000	1,526	587	-82%
	VOC	12,788	9,191	6,382	4,170	-67%
Middlesex	CO	1,194,565	686,832	581,188	157,134	-87%
	NOx	62,563	49,016	43,608	26,233	-58%
	$PM_{2.5}$	12,491	7,391	7,418	5,459	-56%
	SO_2	36,758	14,068	15,249	5,336	-85%
	VOC	87,722	62,071	54,218	27,230	-69%
Nantucket	CO	16,927	21,379	15,134	7,082	-58%
	NOx	2,325	18,760	644	1,139	-51%
	$PM_{2.5}$	302	1,899	611	270	-11%
	SO_2	625	10,541	99	271	-57%
	VOC	2,612	2,890	1,632	1,161	-56%
Norfolk	CO	620,449	430,702	375,218	74,817	-88%
	NO_x	27,280	28,588	25,053	13,135	-52%
	$PM_{2.5}$	5,560	3,931	3,899	2,556	-54%
	SO_2	10,548	4,137	4,270	2,796	-73%
	VOC	42,215	33,557	27,741	12,847	-70%
Plymouth	CO	391,226	193,139	168,608	60,471	-85%
	NO_x	18,899	13,313	11,060	10,417	-45%
	$PM_{2.5}$	6,851	4,191	4,147	2,808	-59%
	SO_2	7,606	3,005	2,723	2,463	-68%
	VOC	36,613	22,757	16,980	11,279	-69%
Suffolk	CO	388,528	202,518	178,554	53,251	-86%
	NO_x	59,772	21,453	18,719	14,784	-75%
	$PM_{2.5}$	6,075	1,781	2,403	2,241	-63%
	SO_2	21,869	5,787	5,367	4,388	-80%
	VOC	25,017	20,254	18,613	11,059	-56%
Worcester	CO	701631	421,181	366,744	101,129	-86%
	NO_x	37,342	32,895	28,065	17,606	-53%
	$PM_{2.5}$	10,254	6,882	7,941	7,556	-26%
	SO_2	14,381	6,159	6,837	3,600	-75%
	VOC	52,203	42,911	34,030	18,682	-64%

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 activities.

Particulate Matter (PM)

Network Description

MassDEP operates PM monitors at 19 locations across the Commonwealth. At least one monitor is located in each county except for Middlesex, Franklin, Barnstable, Dukes, and Nantucket. The PM network consists of:

- PM_{10}: 5 sites:
  - 4 with low volume samplers,
  - 1 (Boston-Harrison Avenue) with 2 collocated low-volume samplers. Filters from this site are analyzed for toxic elements as part of the National Air Toxics Trends (NATTS) air monitoring program and for lead as required by the NCore program.

- $PM_{2.5}$: 18 sites including:
  - 15 Federal Reference Method (FRM) $PM_{2.5}$ sites. 3 sites (Brockton, Chicopee, Boston-North Street) have two collocated samplers. Boston-North Street runs on a daily sampling schedule. All of the others sample on a 1-in-3 day schedule. Data from all sites from MassDEP's FRM network are currently used to determine compliance with the $PM_{2.5}$ NAAQS.

  - 13 Federal Equivalent Method (FEM) sites, 10 of which are collocated with FRM samplers and one of which is collocated with an IMPROVE $PM_{2.5}$ site that does not have an FRM designation. MassDEP uses all of its FEM sites (except Springfield) for compliance with the NAAQS. FEMs provide the hourly $PM_{2.5}$ data that appears on MassDEP's website. Milton-Blue Hill and Pittsfield-South Street are stand alone FEM monitors, although an FRM sampler is located about a quarter of a mile away at the Pittsfield-Center Street site.

- PM_{coarse} (PM_{10} – $PM_{2.5}$): 1 site in compliance with NCore requirements at the designated NCore site at Boston-Harrison Avenue.

- Speciated $PM_{2.5}$: 2 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.

Massachusetts also has two IMPROVE sampling sites 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. IMPROVE monitors are at the following sites:

- Truro - National Sea Shore, operated by the National Park Service
- Ware - Quabbin Reservoir, operated by MassDEP

The Wampanoag Tribe of Gay Head (Aquinnah) on Martha's Vineyard also operates an IMPROVE sampler.

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

Figure 5-1
PM Monitoring Sites

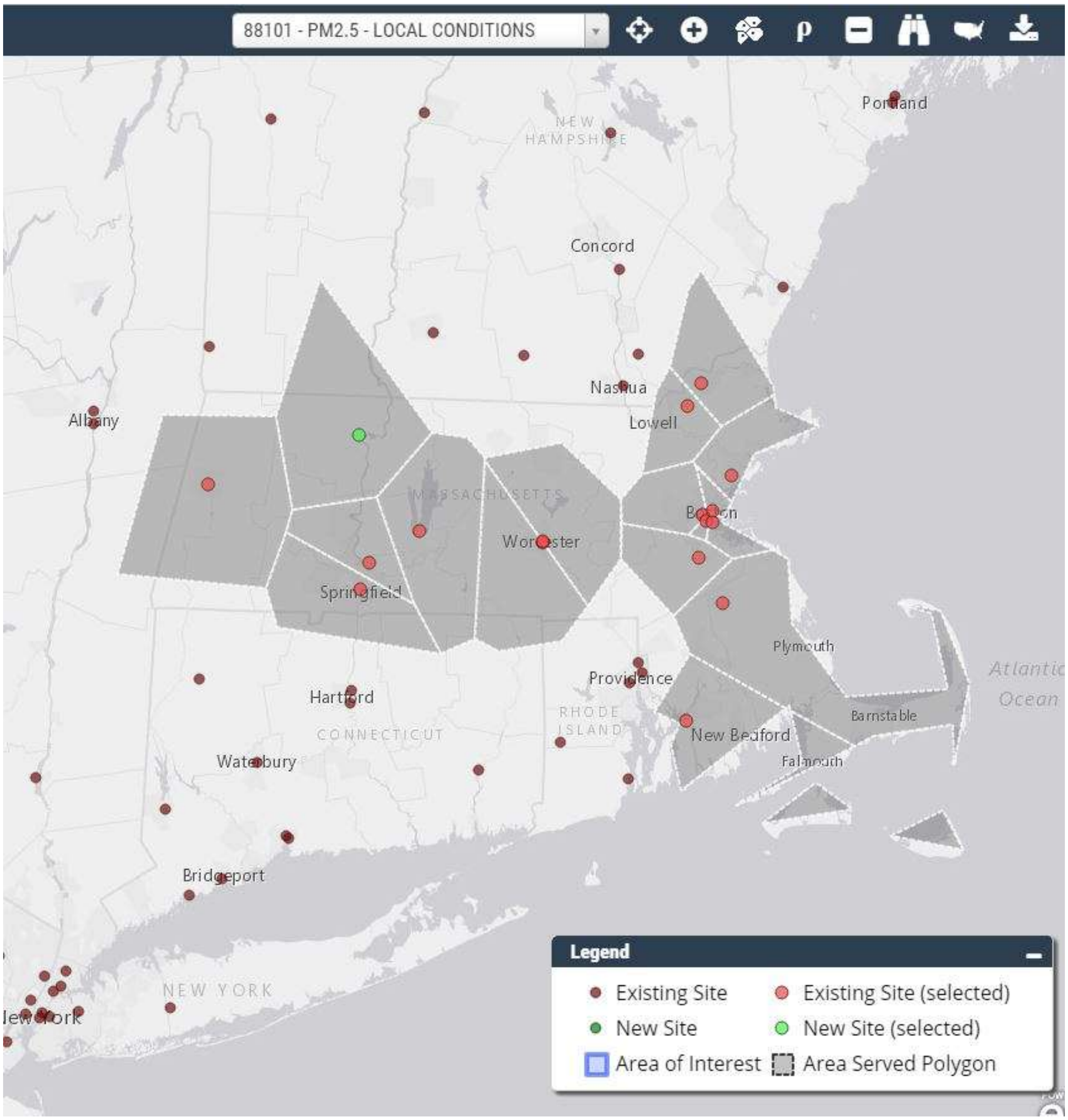
SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	DATE ESTA-BLISHED	MSA/CMSA	PM TYPE
25-025-0002	BOSTON	SUFFOLK	KENMORE SQUARE	Middle	-Highest Concentration -Population Exposure	1/1/1965	Boston CMSA; Boston Metropolitan MSA	PM10 (LV) $PM_{2.5}$ (3-DAY)
25-025-0044	BOSTON	SUFFOLK	VON HILLERN STREET	Middle	Highest Concentration Population Exposure (Near Road)	6/15/2013	Boston CMSA; Boston Metropolitan MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM) BLACK CARBON
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	Neigh-borhood	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA	Pb, PM_{10} (LV)(2), $PM_{2.5}$(3-DAY), $PM_{2.5}$ (FEM)(2) BLACK CARBON, SPECIATED SAMPLES
25-025-0043	BOSTON	SUFFOLK	150 NORTH STREET	Middle	-Population Exposure -Maximum Concentration	1/1/2000	Boston CMSA; Boston Metropolitan MSA	$PM_{2.5}$(2) (3-DAY / Daily) $PM_{2.5}$ (FEM) BLACK CARBON
25-023-0004	BROCKTON	PLYMOUTH	170 CLINTON STREET	Neighbo r-hood	Population Exposure	6/30/2013	Boston CMSA; Brockton MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM)
25-013-0008	CHICOPEE	HAMPDEN	ANDERSON ROAD	Urban	Population Exposure	1/1/1983	Springfield MSA	$PM_{2.5}$ (3-DAY) (2), SPECIATED SAMPLES
25-005-1004	FALL RIVER	BRISTOL	GLOBE STREET	Neigh-borhood	-Highest Concentration -Population Exposure	2/1/1975	Providence-Pawtucket-Fall River MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM)
25-011-2005	GREENFIELD	FRANKLIN	VETERANS FIELD	Urban/N eighbor hood	Highest Concentration Population Exposure	1/1/2014	Springfield MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM) BLACK CARBON
25-009-5005	HAVERHILL	ESSEX	WASHING-TON STREET	$PM_{2.5}$: Neigh-borhood	Population Exposure	7/19/1994	Boston CMSA; Lawrence MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM)
25-009-6001	LAWRENCE	ESSEX	WALL EXPERI-MENT STATION	Neigh-borhood	Population Exposure	4/3/1999	Boston CMSA; Lawrence MSA	$PM_{2.5}$ (3-DAY)
25-009-2006	LYNN	ESSEX	390 PARKLAND	Urban	Population Exposure	1/1/1992	Boston CMSA; Boston Metropolitan MSA	$PM_{2.5}$ (3-DAY), $PM_{2.5}$ (FEM)
25-021-3003	MILTON	NORFOLK	BLUE HILL	Urban	Maximum Concentration	4/2/2002	Boston CMSA; Boston Metropolitan MSA	$PM_{2.5}$ (FEM)
25-003-5001	PITTSFIELD	BERKSHIRE	78 CENTER STREET	Neigh-borhood	Population Exposure	12/1/1998	Pittsfield MSA	$PM_{2.5}$ (FEM)

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	DATE ESTA-BLISHED	MSA/CMSA	PM TYPE
25-003-0006	PITTSFIELD	BERKSHIRE	1 SOUTH STREET	Neigh-borhood	Population Exposure	12/1/2005	Pittsfield MSA	$PM_{2.5}$ (3-DAY)
25-013-0016	SPRINGFIELD	HAMPDEN	LIBERTY STREET	Neigh-borhood	-Population Exposure -Maximum Concentration	4/1/1988	Springfield MSA	$PM_{2.5}$, (3-DAY), $PM_{2.5}$ (FEM), Pb, PM_{10} (LV),,, BLACK CARBON
25-001-0002	TRURO	BARN-STABLE	FOX BOTTOM AREA	Re-gional	General / Background	4/1/1987	No MSA; Downwind Providence-Pawtucket , RI	IMPROVE $PM_{2.5}$ (3-DAY)
25-015-4002	WARE	HAMPSHIRE	QUABBIN SUMMIT	Neigh-borhood	Population Exposure	6/1/1985	Springfield MSA	PM_{10} (LV), $PM_{2.5}$ (FEM), IMPROVE $PM_{2.5}$ (3-DAY)
25-027-0016	WORCESTER	WORCESTER	2 WASHING-TON STREET	Neigh-borhood	Population Exposure	10/1/2003	Boston CMSA; Worcester MSA	$PM_{2.5}$ (3-DAY)
25-027-0023	WORCESTER	WORCESTER	SUMMER STREET	Neigh-borhood	Population Exposure	1/1/2004	Boston CMSA; Worcester MSA	PM_{10} (LV), $PM_{2.5}$ (2)(3-DAY), $PM_{2.5}$ (FEM)

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 NetAssess, a network assessment tool developed by LADCO. The $PM_{2.5}$ polygons show an unserved area on Cape Cod and in northern Middlesex County.

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



Note: A site was treated as a PM monitor if it had either a FEM or FRM. Co-located instruments were treated as 1. Pittsfield has an FEM and FRM located a small distance from each other – these were treated as 1 site.
Source: NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool

Air monitoring network assessment tool suite developed by Lake Michigan Air Directors Consortium (LADCO). It is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from .
https://ebailey78.shinyapps.io/NetAssessApp/

PM_{10} MONITORING DATA

2014 PM_{10} Data Summary

Figure 5-3 shows a summary of 2014PM_{10} data. There were 6 PM_{10} sites in operation during 2014 in the state-operated monitoring network. All of the sites achieved data capture requirements for the year.

Figure 5-3
2014 PM_{10} FRM Annual Data Summary

SITE ID		CITY	COUNTY	ADDRESS	%OBS	1ST MAX 24-HR	2ND MAX 24-HR	3RD MAX 24-HR	4TH MAX 24-HR	DAYS MAX >STD	ARITH MEAN
25-013-0016		Springfield	Hampden	LIBERTY	86	21	18	16	13	0	9.4
25-013-2009		Springfield	Hampden	1860 MAIN	83	27	21	20	19	0	12.9
25-015-4002		Ware	Hampshire	QUABBIN SUMMIT	95	13	13	10	10	0	6.0
25-025-0002		Boston	Suffolk	KENMORE SQ	95	78	53	45	37	0	14.9
25-025-0027		Boston	Suffolk	ONE CITY SQ	97	69	66	37	29	0	15.5
25-025-0042		Boston	Suffolk	HARRISON AVE	98	69	61	41	37	0	13.9
25-025-0042	colloc	Boston	Suffolk	HARRISON AVE	96	70	61	41	37	0	13.8
25-027-0023		Worcester	Worcester	SUMMER ST	93	74	67	60	53	0	15.3

PM_{10} Hi Vol Standards: 24-hour = 150 $\mu g/m^3$

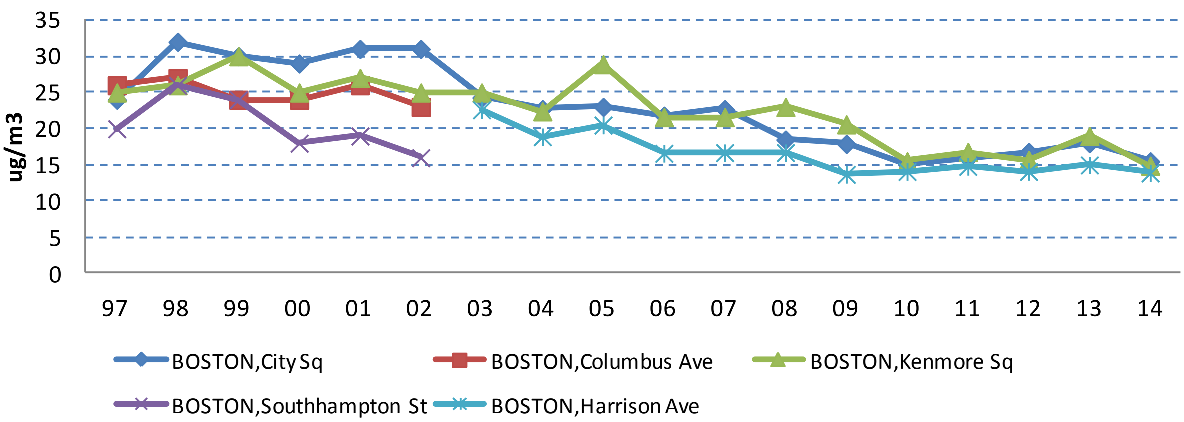
ABBREVIATIONS AND SYMBOLS USED IN TABLE

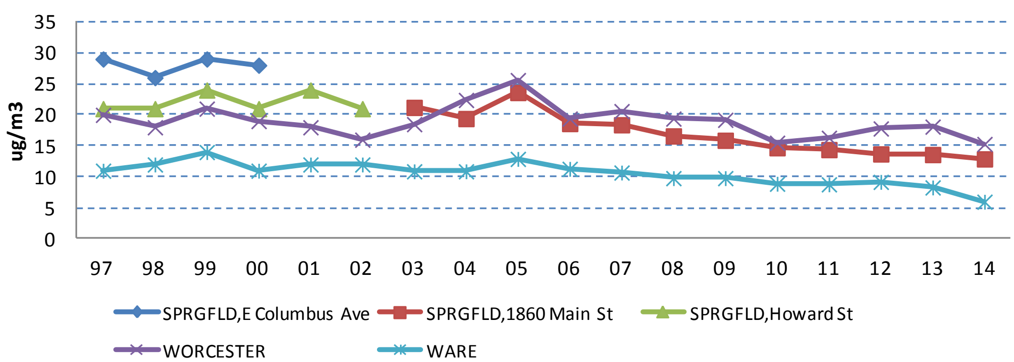
SITE ID = AIRS SITE IDENTIFICATION NUMBER % OBS = DATA CAPTURE PERCENTAGE 1ST, 2ND, 3RD, 4TH 24-HR MAX = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR DAY MAX > 150 = DAILY MAXIMUM VALUE GREATER THAN STANDARD OF 150 g/m³ WTD ARITH MEAN = WEIGHTED ANNUAL ARITHMETIC MEAN

PM_{10} Trends

Figure 5-4 shows long-term trends for each PM_{10} site using the annual arithmetic mean as an indicator. The data shows a yearly variability at most sites, with the overall trend being downward.

Figure 5-4
PM_{10} Trends 1997-2014 Annual Arithmetic Mean





$PM_{2.5}$ 2014 Data Summary

Figure 5-5 shows a summary of the 2014 FRM $PM_{2.5}$ data.

Figure 5-5
2014 $PM_{2.5}$ FRM Annual Data Summary

SITE ID		CITY	COUNTY	ADDRESS	NUMBER CREDITABLE DAYS	1ST MAX 24-HR	2ND MAX 24-HR	3RD MAX 24-HR	4TH MAX 24-HR	98TH PERCENTILE 24-HOUR	ARITH MEAN
25-025-0002		Boston	Suffolk	KENMORE	119	16.6	14.8	14.6	13.5	14.6	6.02
25-025-0027		Boston	Suffolk	ONE CITY SQ	108	17.3	14.8	14.4	13.2	14.4	6.05
25-025-0042		Boston	Suffolk	HARRISON AVE	119	15.9	13.3	12.7	12.6	12.7	5.94
25-025-0043		Boston	Suffolk	174 NORTH ST	339	18.7	18.2	17.5	17.1	14.5	6.99
25-025-0043	colloc	Boston	Suffolk	174 NORTH ST	296	19	17.7	17.5	14.8	14.2	6.88
25-025-0044		Boston	Suffolk	19 VON HILLERN	116	15.0	14.9	14.9	14.4	14.9	6.25
25-023-0004		Brockton	Plymouth	COMMERCIAL ST	29	12.2	11.9	11.4	11.2	12.2	5.67*
25-023-0004	colloc	Brockton	Plymouth	COMMERCIAL ST	24	12.2	11.5	10.6	10	12.2	5.71
25-023-0005		Brockton	Plymouth	170 CLINTON	112	18.3	13.4	12.4	11.6	12.4	5.43
25-023-0005	colloc	Brockton	Plymouth	170 CLINTON	71	13.2	13	12	10	13	5.15*
25-013-0008		Chicopee	Hampden	ANDERSON RD AFB	119	18.9	16.5	16.5	14.4	16.5	5.46
25-013-0008	colloc	Chicopee	Hampden	ANDERSON RD AFB	100	17.8	16.2	14.7	14.1	16.2	5.32
25-005-1004		Fall River	Bristol	659 GLOBE ST	115	13.9	13.5	12.9	11.5	12.9	4.94
25-011-2005		Greenfield	Franklin	VETERANS FIELD	111	23.0	17.5	13.2	13.2	13.2	5.78
25-009-5005		Haverhill	Essex	685 WASHINGTON	114	15.6	11.8	11.8	11.6	11.8	4.85
25-009-6001		Lawrence	Essex	37 SHATTUCK	117	13.0	12.8	11.5	11.5	11.5	5.21
25-009-2006		Lynn	Essex	390 PARKLAND	119	12.9	11.9	11.8	11.7	11.8	4.59
25-003-5001		Pittsfield	Berkshire	78 CENTER ST	115	18.4	17.5	17.3	14.7	17.3	6.00
25-013-0016		Springfield	Hampden	LIBERTY STREET	118	23.6	23.3	17.5	17.4	17.5	6.42
25-013-2009		Springfield	Hampden	1860 MAIN ST	59*	21.4	19.5	16.2	15.2	19.5	6.26
25-027-0016		Worcester	Worcester	WASHINGTON ST	118	16.7	13.5	13.1	12.4	13.1	5.61
25-027-0023		Worcester	Worcester	SUMMER ST	117	16.9	15.9	15.0	14.2	15.0	5.86

* indicates that the mean does not satisfy summary criteria for one quarter

ABBREVIATIONS AND SYMBOLS USED IN TABLE

SITE ID = AIRS SITE IDENTIFICATION TYPE = TYPE OF INSTRUMENT 1ST, 2ND, 3RD, 4TH MAX = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR WTD ARITH MEAN = WEIGHTED ANNUAL ARITHMETIC MEAN (STANDARD = 12.0 $\mu g/m^3$)

$PM_{2.5}$ 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 98th percentile of the daily samples taken in a given year for each of the 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.

Figure 5-6 shows the most recent design values for each $PM_{2.5}$ FRM monitor.

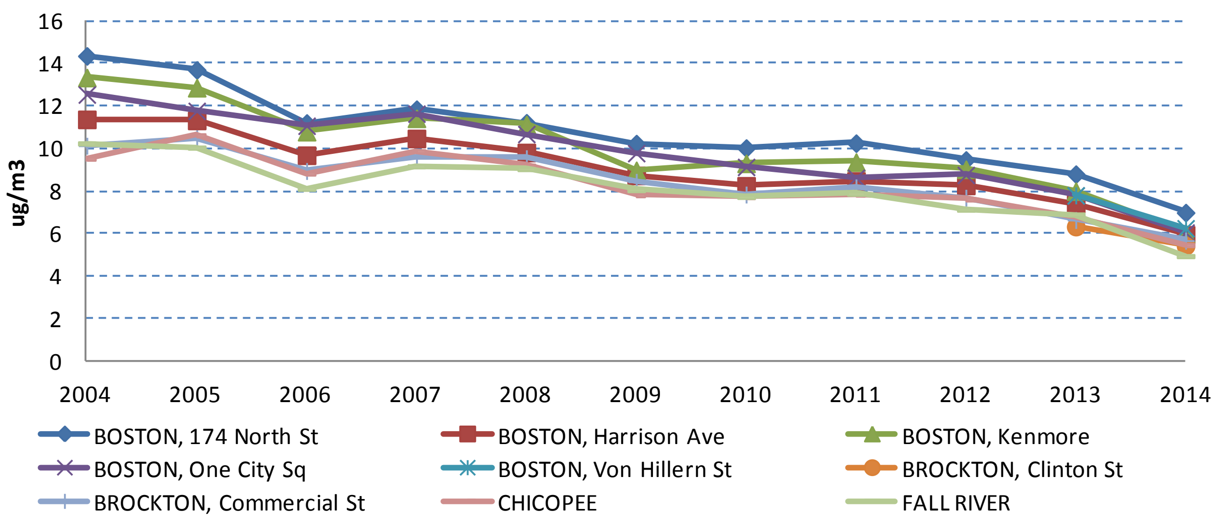
Figure 5-6
FRM $PM_{2.5}$ 2014 Design Value for Each Monitor

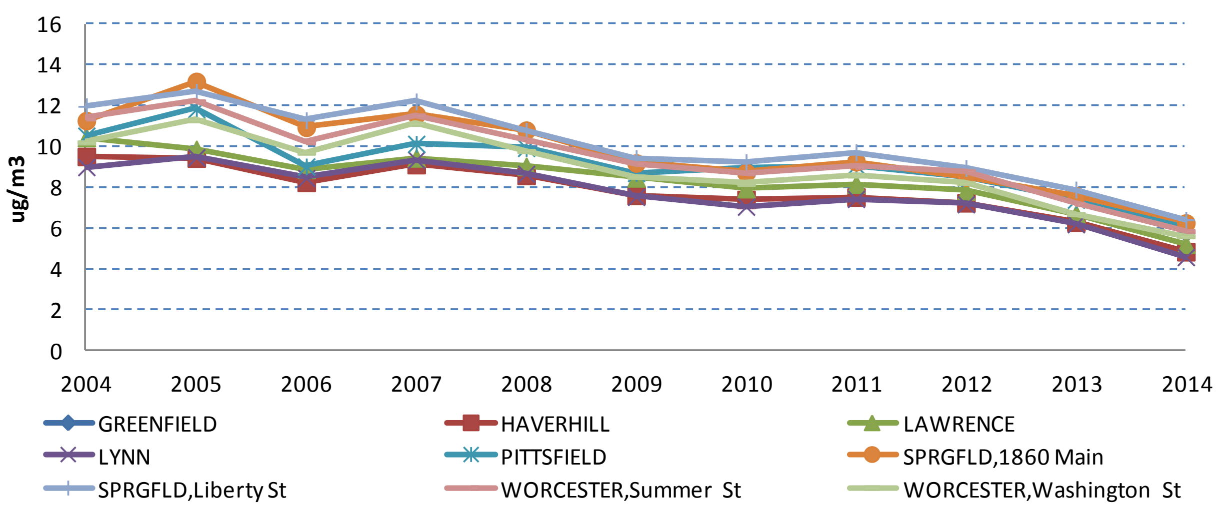
SITE ID	TOWN/ADDRESS	2012-2014 $PM_{2.5}$ DESIGN VALUE	
		ANNUAL STANDARD = 15 UG/M^3	24 HOUR STANDARD = 35 UG/M^3
25-003-5001	PITTSFIELD	7.3	17.8
25-013-0008	CHICOPEE	6.6	16.8
25-013-0016	SPRINGFIELD-LIBERTY STREET	7.8	19.1
25-013-2009	SPRINGFIELD-1860 MAIN STREET	7.4	19.1
25-005-1004	FALL RIVER	6.3	15.0
25-009-2006	LYNN	6.0	15.3
25-009-5005	HAVERHILL	6.2	15.0
25-009-6001	LAWRENCE	6.6	15.3
25-023-0004	BROCKTON	6.7	15.4
25-025-0002	BOSTON-KENMORE SQUARE	7.7	18.1
25-025-0027	BOSTON-ONE CITY SQUARE	7.5	18.3
25-025-0042	BOSTON-HARRISON AVENUE	7.2	16.4
25-025-0043	BOSTON-150 NORTH STREET	8.4	18.2
25-027-0016	WORCESTER-2 WASHINGTON STREET	6.8	16.0
25-027-0023	WORCESTER-SUMMER STREET	7.3	17.6

$PM_{2.5}$ Monitoring Data Trends

Figure 5-7 shows the trends in $PM_{2.5}$ ambient level data from FRM monitors in the state.

Figure 5-7
$PM_{2.5}$ Annual Standard Trends





2014 FEM $PM_{2.5}$ BAM Data Summary

Figure 5-8 shows a summary of the 2014FEM BAM $PM_{2.5}$ data.

Figure 5-8
2014 FEM 24-Hour Data Summary

SITE ID		CITY	COUNTY	ADDRESS	NUMBER CREDITABLE DAYS	1ST MAX	2ND MAX	3RD MAX	4TH MAX	98TH PERCENTILE 24-HOUR	ARITH MEAN
25-025-0042	*	Boston	Suffolk	HARRISON AVE	343	26.2	23.0	22.2	21.9	17.6	8.42
25-025-0043		Boston	Suffolk	174 NORTH ST	318	27.4	26	23.1	22.4	21.5	10.42
24-025-0044		Boston	Suffolk	VON HILLERN ST	345	27.5	24.7	24.3	22.8	20	9.06
25-023-0005		Brockton	Plymouth	1 CLINTON ST	338	31.8	23.3	19.9	17.7	17.1	8.29
25-005-1004	*	Fall River	Bristol	659 GLOBE ST	341	22.5	21.5	21.1	20.2	18.1	8.39
25-011-2005		Greenfield	Franklin	VETERANS FIELD	311	27.4	27.3	24.7	23.6	21.1	8.86
25-009-5005	*	Haverhill	Essex	685 WASHINGTON	346	22.4	18.6	17.2	16.4	15.1	6.62
25-009-2006	*	Lynn	Essex	390 PARKLAND	352	24.7	20.8	19.6	18.9	15.9	7.56
25-021-3003	*	Milton	Norfolk	BLUE HILL OBSERV	333	17.7	17.2	15.6	15.1	13.5	6.13
25-003-0006		Pittsfield	Berkshire	1 SOUTH ST	338	31.4	29	29	27.6	25.3	10.45
25-013-0016		Springfield	Hampden	LIBERTY ST	350	31.3	30.4	30	29.4	22.5	8.83
25-015-4002		Ware	Hampshire	QUABBIN SUMMIT	340	21.8	21.3	19.2	18.8	17.1	8.09
25-027-0023	*	Worcester	Worcester	SUMMER ST	353	27.1	25.6	24.5	23.5	18.8	7.55

Note: All monitors used for comparison to the NAAQS except Springfield
* Sites where FRM/FEM comparisons found to be acceptable in 2013.

ABBREVIATIONS AND SYMBOLS USED IN TABLE

SITE ID = AIRS SITE IDENTIFICATION TYPE = TYPE OF INSTRUMENT 1ST, 2ND, 3RD, 4TH MAX = 1ST, 2ND, 3RD, AND 4TH HIGHEST 24-HOUR VALUES FOR THE YEAR WTD ARITH MEAN = WEIGHTED ANNUAL ARITHMETIC MEAN (STANDARD = 12..0 ug/m³)

Figure 5-9
FEM $PM_{2.5}$ 2014 Design Value for Each Monitor

SITE ID	TOWN/ADDRESS	2012-2014 $PM_{2.5}$ DESIGN VALUE	
		ANNUAL STANDARD = 15 μg/m³	24 HOUR STANDARD = 35 μg/m³
25-003-0006	[1] PITTSFIELD- 1 SOUTH STREET	11.1	25.7
25-015-4002	[1] WARE-QUABBIN SUMMIT	7.4	18.4
25-013-0016	SPRINGFIELD-LIBERTY STREET	9.4	24.9
25-011-2005	[2]GREENFIELD-VICTORY FIELD	7.0	21.1
25-005-1004	FALL RIVER-GLOBE STREET	8.3	19.9
25-009-2006	LYNN-390 PARKLAND AVENUE	8.1	19.4
25-009-5005	HAVERHILL-WASHINGTON STREET	7.4	19.0
25-021-3003	[1] MILTON-BLUE HILL OBSERVATORY	6.2	15.1
25-023-0005	[2]BROCKTON-170 CLINTON STREET	5.3	12.1
25-025-0044	[2]BOSTON-VON HILLERN STREET	7.1	14.1
25-025-0042	BOSTON-HARRISON AVENUE	8.6	19.2
25-025-0043	BOSTON-150 NORTH STREET	10.8	22.2
25-027-0023	WORCESTER-SUMMER STREET	8.1	19.6

1. Monitors not collocated with FRM Monitors.
2. As of January 1, 2015 monitors have not operated long enough to generate design values.

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 6th day for 24 hours.

$PM_{2.5}$

MassDEP operates 15 FRM filter-based monitors and 13 FEM BAMs 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 interval between when the sample is collected and the data is available
- 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:
  - o visiting sites to collect the samples and bring them to the laboratory for analysis
  - o 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. In recent years, BAMs have been designated as a Federal Equivalent Method (FEM), which makes a BAM an acceptable alternate to the FRM monitor. MassDEP analyzers passed the method comparison test at six of the seven method (FRM and FEM) collocated sites in 2013, and designated these BAMs for use in determining compliance with the NAAQS. Three sites have only a BAM, and MassDEP also uses these for determining compliance with the NAAQS. MassDEP also uses three new sites with collocated FRM and FEM BAMs for determining compliance with the NAAQS.

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. MassDEP has no current plans to measure PM_{coarse} at any other sites at this time.

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 IMPROVE or the speciation methods.

ADEQUACY OF THE PM NETWORK

EPA Requirements

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

Figure 5-10
$PM_{2.5}$ 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

CSA / MSA	POPULATION	3 YEAR DESIGN VALUES (MAXIMUM FOR ANY MONITOR IN CSA / MSA)				> 85% OF ANY NAAQS?	# MONITORS NEEDED	# MONITORS IN NETWORK
		ANNUAL		24 HOUR				
		VALUE	% OF STD	VALUE	% OF STD			
Boston-Worcester-Manchester, MA-RI-NH CSA	4,986,409	8.4(10.8)	70%/90%	18.3(22.2)	52%/63%	YES	2	12
Pittsfield, MA Metro Area	130,545	7.3	61%	17.8	51%	NO	0	1
Springfield, MA Metro Area	695,819	7.8	65%	19.1	55%	NO	1	3
Barnstable Town, MA Metro Area	215,449	no dv		no dv		NO	0	0

ADDITIONAL $PM_{2.5}$ MONITOR REQUIREMENTS	BOSTON-WORCESTER-MANCHESTER, MA-RI-NH CSA	SPRINGFIELD, MA METRO AREA	PITTSFIELD, MA METRO AREA (NOT REQUIRED)
At least one monitoring station is to be sited in a population-oriented area of expected maximum concentration.	Boston-Kenmore -Boston-North End Fall River	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 Boston- Harrison Ave Boston-North End	Liberty Street & Chicopee 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.	8 Continuous 7 Collocated	3 Continuous 2 Collocated	1 Continuous
Each State shall install and operate at least one $PM_{2.5}$ site to monitor for 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	Ware IMPROVE station and Met One BAM		

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 (STN).	1	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.

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

> NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool
> Developed by Lake Michigan Air Directors Consortium (LADCO). NetAssess is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from 2013.
> https://ebailey78.shinyapps.io/NetAssessApp/

Exceedance Probability

NetAssess provides a probability map to help determine where new monitors may be needed. The method is explained in the excerpt below from the NetAssess documentation website (http://ladco.github.io/NetAssessApp/tools.html).

Exceedence 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. NetAssess 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

The surface probability maps can be seen below. For ozone, three different thresholds can be selected. The $PM_{2.5}$ map has a threshold of 35 µg/m^3:

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

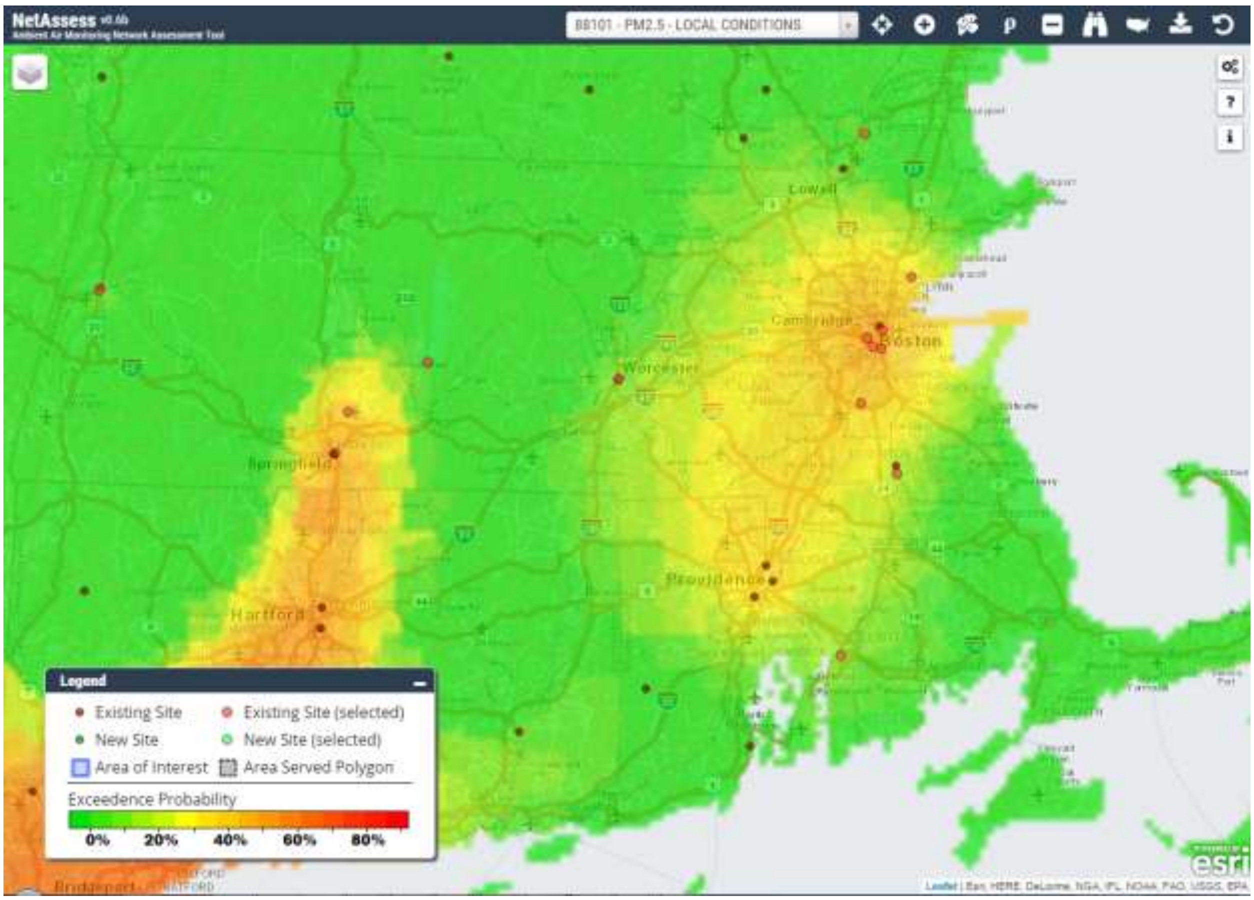
The surface probability maps were created by using EPA/CDC downscaler data. Downscaler data are daily estimates of ground level ozone and $PM_{2.5}$ for every census tract in the continental US. These are statistical estimates from "fusing" photochemical modeling data and ambient monitoring data using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

Daily downscaler estimates for 8-hour maximum ozone and 24-hour mean $PM_{2.5}$ for the years 2007 and 2008 were obtained from the EPA website. Years 2009-2011 were obtained from the CDC's Environmental Public Health Tracking Program.

[for further information see http://ladco.github.io/NetAssessApp/tools.html]

Figure 5-11 shows the probability of exceeding the 35 µg/m3 $PM_{2.5}$ NAAQS. There are no areas of high probability for an exceedance. All of the areas of moderate probability are covered by monitors, with the possible exception of the Framingham area between Boston and Worcester.

Figure 5-11
Probability of Exceeding the $PM_{2.5}$ 35 µg/m3 Daily NAAQS



Source: NetAssess

Site Correlation Analysis

The NetAssess tool was used to provide correlations between monitors. This is explained in the following excerpt from the NetAssess documentation:

Correlation Matrices

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. Within the NetAssess App the Correlation Matrix Tool generates a graphical display and a downloadable CSV file which summarize the results for each selected site pair. The purpose of this tool is to provide a means of determining possible redundant sites that could be removed. Possible redundant sites would figure fairly high correlations consistently across all of 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 figure 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.

Graphic

The Correlation Matrix tool generates a graphical display that summarizes the correlation, relative difference and distance between pairs of monitoring sites. Within the graphical display, the shape of the ellipses represents the Pearson correlation between sites. Circles represent zero correlation and straight diagonal lines represent a perfect correlation.

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. For this purpose, the color of the ellipses represents the average relative difference between sites where the daily relative difference is defined as:

$$\frac{abs(s1-s2)}{avg(s1,s2)}$$

where s1 and s2 represent the ozone concentrations at sites one and two in the pairing, abs is the absolute difference between the two sites and avg is the average of the two site concentrations. 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. The distance between site pairs in the correlation matrix graphic is displayed in kilometers in the middles of each ellipse. . . . .

Data

The Correlation Matrix tool uses daily summary pollutant concentration data for ozone and fine particles collected between January 1, 2011 and December 31, 2013. Data was retrieved using the AQS AMP 435 Daily Summary Report. . . . .

For PM2.5, the correlation matrix tool calculates Pearson Correlations (r) for all valid 24-hour fine particle concentration pairs stored under AQS parameter codes 88101 (PM2.5 Local Conditions - FRM/FEM/ARM) or 88502 (Acceptable PM2.5 AQI & Speciation Mass). . . . . If a site has more than one monitor collecting PM2.5 data, the daily average PM2.5 concentration is the average of all valid results for that site on that date.

Figure 5-12 shows the correlation between the measured air quality at each $PM_{2.5}$ monitoring site based on FRM and FEM data.

Most monitors had correlations > 0.8. Twelve pairs had correlations 0.9 or higher as shown in Figure 5-13. 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 5-13.

Figure 5-12
Correlation Matrix for FRM and BAM $PM_{2.5}$ Monitors

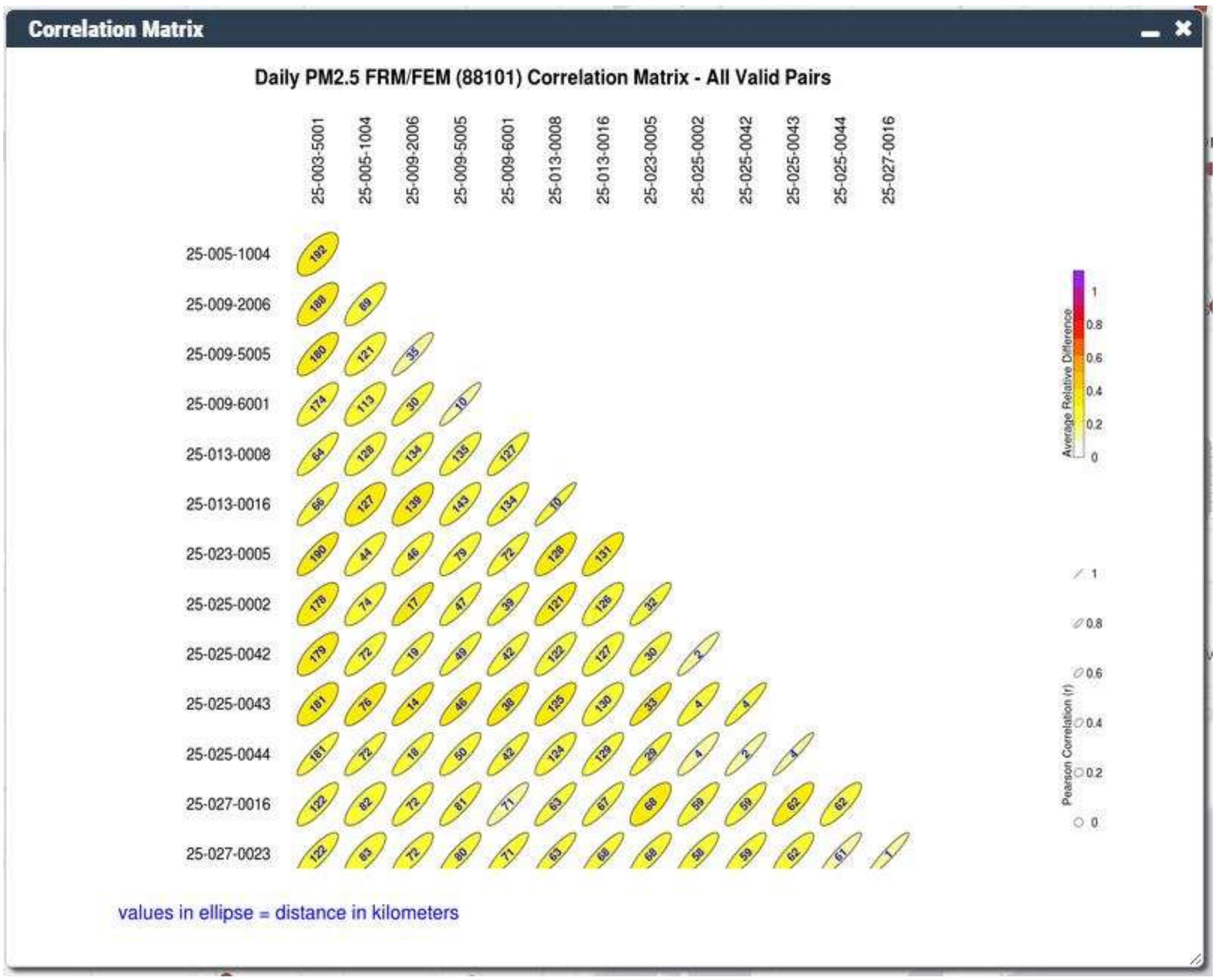


Figure 5-13
Correlation Over 0.9 for FRM and BAM $PM_{2.5}$ Monitors

Site 1	Site 2	Correlation	n	Rel. Diff	Distance (km)	Name
25-025-0043	25-025-0044	0.958	31	0.142	4	North End - Von Hillern
25-013-0008	25-013-0016	0.944	354	0.21	10	Chicopee - Springfield Liberty St
25-027-0016	25-027-0023	0.944	346	0.147	1	Worcester-Worcester
25-009-5005	25-009-6001	0.932	347	0.164	10	Haverhill - Lawrence
25-025-0042	25-025-0044	0.929	31	0.163	2	Roxbury - Von Hillern
25-025-0002	25-025-0042	0.928	345	0.174	2	Kenmore - Roxbury
25-025-0042	25-025-0043	0.921	347	0.223	4	Roxbury - North End
25-025-0044	25-027-0023	0.920	31	0.177	61	Von Hillern - Worcester Summer St
25-009-2006	25-009-5005	0.908	345	0.178	35	Lynn - Haverhill
25-023-0005	25-025-0044	0.907	30	0.241	29	Brockton - Von Hillern
25-013-0008	25-027-0023	0.901	355	0.231	63	Chicopee - Worcester Summer St

Grey are low n.
Tan are high relative difference.
Source: NetAssess

Removal Bias Analysis

Removal bias was calculated among all of the $PM_{2.5}$ monitors within the state, treating FRM and FEM as equivalent. In addition, because the Pittsfield sites are very close together and will be consolidated, they were treated as 1 BAM site.

Removal bias was calculated with NetAssess, which explains the process in its documentation as follows:

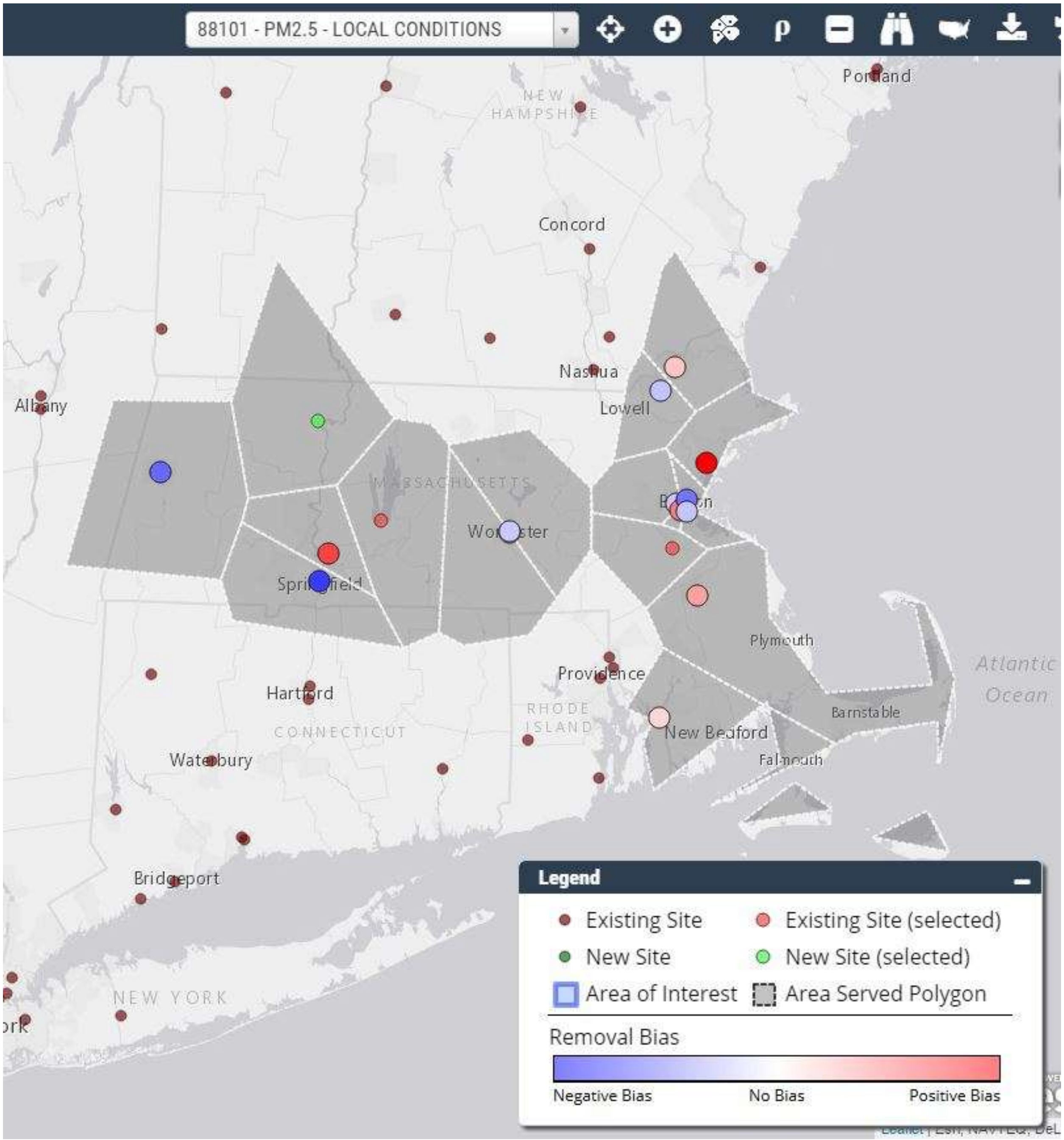
> The removal bias tool is meant to aid in determining redundant sites. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance 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. (http://ladco.github.io/NetAssessApp/tools.html)

Figure 5-14 and 5-15 display the results. Note that NetAssess does not include data from Blue Hill, Ware, or the new Greenfield site, which limits the usefulness of this analysis.

Mean removal bias ranged from (absolute value) 0.3-1.9 µg/m3. Closely located pairs of monitors generally had the lowest bias: Haverhill/Lawrence; Worcester Washington St./Worcester Summer St.). Two of the Boston sites had low removal bias (Kenmore/Von Hillern Street), but the other Boston sites had higher biases. Though located far from other sites, Fall River also has a low removal bias.

Although redundancies are indicated, some of these sites have other value indicating they should be retained. In particular Kenmore has a long monitoring history; Von Hillern is designed to capture maximum near road values; and Lawrence is a low-cost test facility.

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



Source: NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool
Air monitoring network assessment tool suite developed by Lake Michigan Air Directors Consortium (LADCO). It is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from December 31, 2013 .

https://ebailey78.shinyapps.io/NetAssessApp/

Figure 5-15
Removal Bias for FRM and BAM $PM_{2.5}$ Monitors

Site ID	Name	Mean Removal Bias	Min Removal Bias	Max Removal Bias	Removal Bias Standard Deviation	Neighbors Included
25-003-5001	Pittsfield Center St	-1.1	-13.7	7.32	2.3	5
25-005-1004	FALL RIVER	0.3	-5.61	6.77	2.0	7
25-009-2006	Lynne	1.9	-4.73	13.3	1.6	7
25-009-5005	Haverhill	0.4	-2.95	5.95	1.3	5
25-009-6001	Lawrence	-0.4	-7.08	2.1	1.3	5
25-013-0008	Chicopee	1.4	-4.31	10.3	1.8	5
25-013-0016	Springfield Liberty St	-1.4	-11.5	3.05	1.8	6
25-023-0005	Brockton	0.7	-1.24	2.91	1.2	9
25-025-0002	Kenmore	-0.4	-7.1	3.87	1.5	7
25-025-0042	Roxbury	0.9	-3.92	8.43	1.3	5
25-025-0043	North End	-1.0	-8.45	5.78	1.8	4
25-025-0044	Von Hillern	-0.4	-3.09	1.74	1.2	4
25-027-0016	Worcester Washington St	0.4	-6.5	10.3	1.5	9
25-027-0023	Worcester Summer St	-0.4	-10.3	6.5	1.5	5

Source: NetAssess

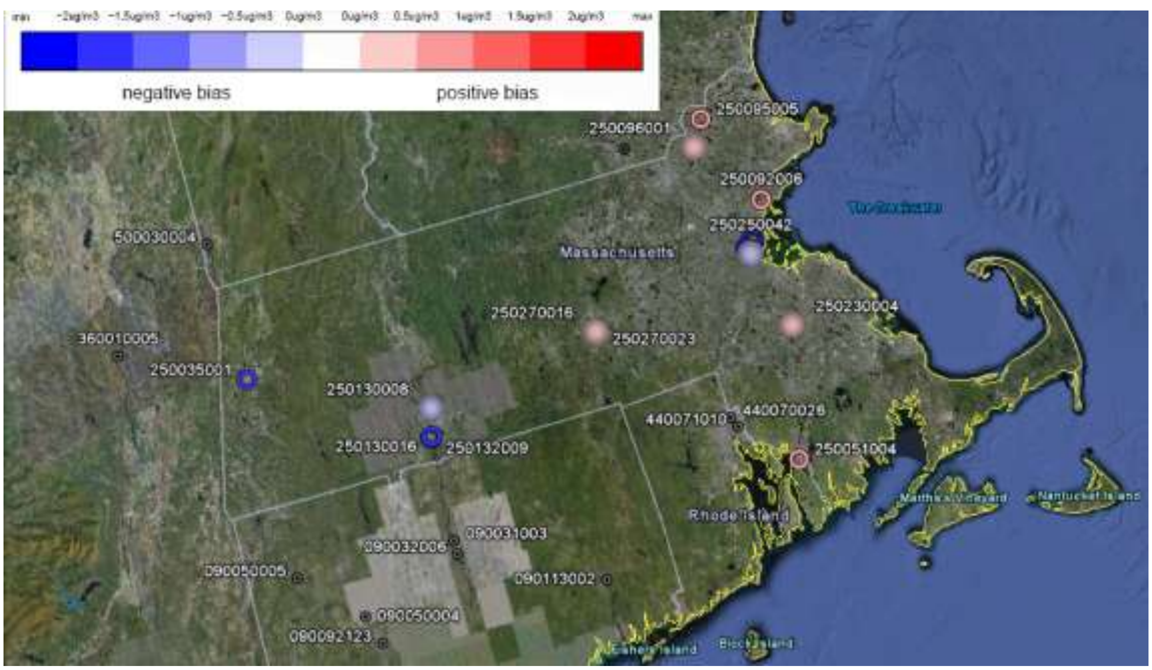


Figure 5-16
Factors Affecting the Need For New PM Monitors In Massachusetts

Middlesex/Worcester – North Portions

Issue	Mitigating Factors	Supporting Factors
Population	–	Substantial population along Route 2 corredor and Lowell areas. Relatively high population of children.
Health	Generally typical levels of the heath indicators examined for this report. –	Higher prevalence of pediatric asthma.
Emissions		Increased use of wood for residential heating could result in localized increases of $PM_{2.5}$ levels.
Env. Justice		Many EJ areas along Route 2 corridor and Lowell.
Other		No PM monitor in Middlesex county.

Middlesex South / Norfolk West (area between Boston, Providence, Worcester)

Issue	Mitigating Factors	Supporting Factors
Population		Substantial and growing population within Route 495 belt. Mostly affluent, but some EJ communities. Relatively high population of children.
Health	Generally typical levels of the heath indicators examined for this report.	Higher prevalence of pediatric asthma.
Emissions		Increased use of wood for residential heating could result in localized increases of $PM_{2.5}$ levels.
Env. Justice		Some EJ areas in inner suburbs and Framingham.
Other		No PM monitor in Middlesex county; higher probability of exceedance identified by NetAssess.

Barnstable

Issue	Mitigating Factors	Supporting Factors
Population	Relatively small population – 214,915 people – 2% of state population – Lower child population	High population of elderly. Generally losing population over time.
Health	Generally typical levels of the heath indicators examined for this report.	On a county wide basis well above state incidence rate for asthma related hospitalizations
Emissions		In the 2005 emissions inventory, Canal Electric was listed as a major source; however, in recent years this plant has not seen significant levels of operation and is not expected to in the future. The area is downwind of Brayton Point, the last major coal-fired power plant (although this plant is expected to close in 2017).
Env. Justice		There are a few EJ areas on the Cape and the Islands
Other		

		No PM monitor in Barnstable County

Ozone

NETWORK DESCRIPTION

MassDEP operates 14 ozone monitoring sites in 14 municipalities across the state. There is at least one state-operated ozone monitor located in each county except Berkshire, Dukes (Martha's Vineyard), and Nantucket. The Wampanoag Tribe of Gay Head (Aquinnah) operates an ozone monitor in Dukes County. This year, MassDEP plans to install a consolidated air monitoring site in Berkshire County (in the Pittsfield Area) to address the lack of ozone monitoring coverage in that county caused by the loss on the Adams site in 2014. MassDEP closed the Boston - Long Island, Stow, and Amherst ozone sites within the last several years, and added ozone monitoring in Brockton, Chelmsford, Fall River, and Greenfield.

Figure 5-17
Ozone Monitoring Sites, Location, Scale and Purpose

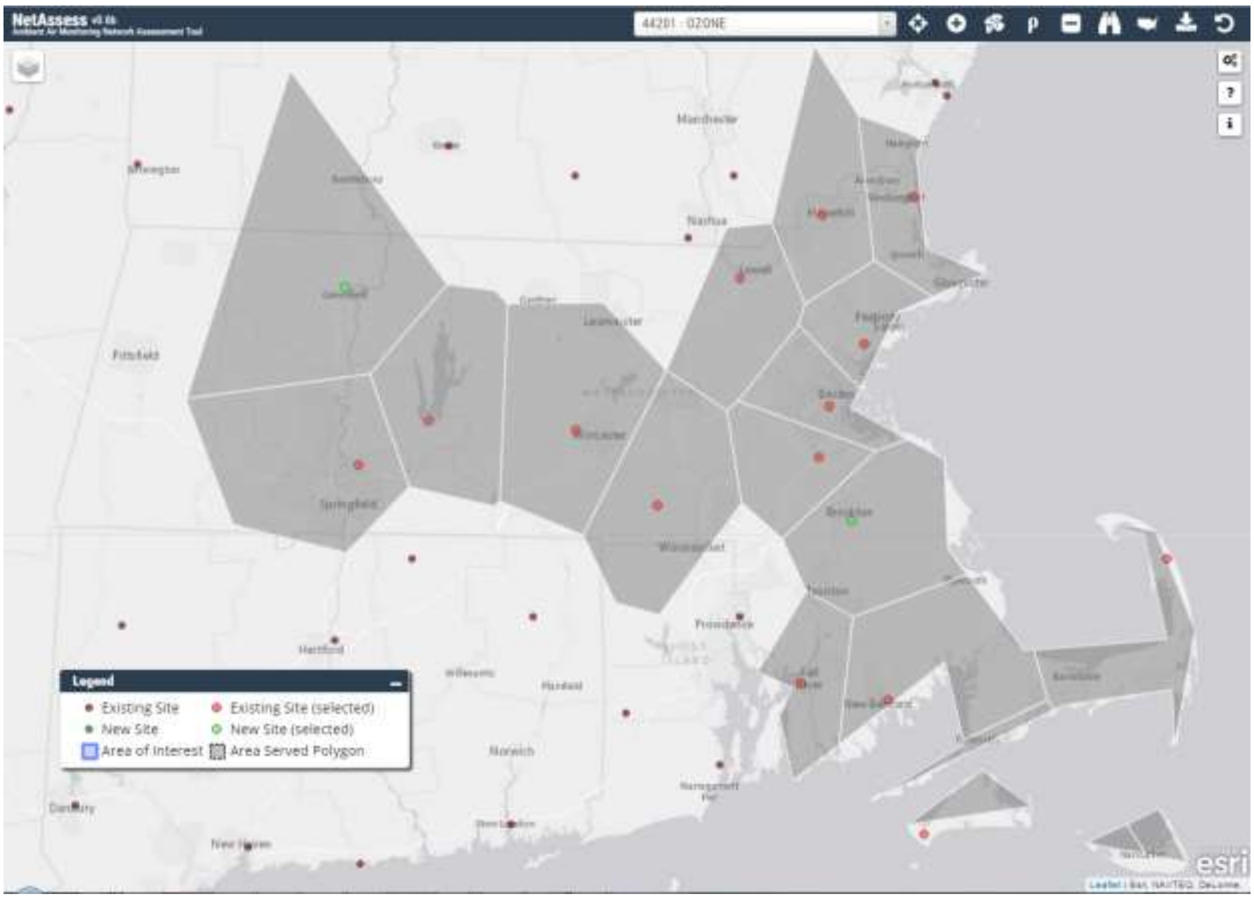
SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	Neighbor-hood	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA
25-023-0004	BROCKTON	PLYMOUTH	170 CLINTON STREET	Neighbor-hood	Population Exposure	6/30/2013	Boston CMSA; Brockton MSA
25-013-0008	CHICOPEE	HAMPDEN	ANDERSON ROAD	Urban	-PAMS: Springfield Type 2 (Maximum Precursor) -Others: Population Exposure	1/1/1983	Springfield MSA
25-017-0009	CHELMSFORD	MIDDLESEX	USEPA NERL 11 TECHNOLOGY DRIVE	Urban	Population Exposure	4/1/2005	Boston CMSA
25-005-1006	FAIRHAVEN	BRISTOL	HASTINGS SCHOOL	Regional/ Urban	Population Exposure	6/30/2013	Providence-Pawtucket-Fall River MSA
25-005-1004	FALL RIVER	BRISTOL	GLOBE STREET	Neighbor-hood	Highest Concentration Population Exposure	2/1/1975	Providence-Pawtucket-Fall River MSA
25-011-2005	GREENFIELD	FRANKLIN	VETERANS FIELD	Urban/Neigh borhood	Highest Concentration Population Exposure	1/1/2014	Springfield MSA
25-009-5005	HAVERHILL	ESSEX	WASHINGTON STREET	Urban	Population Exposure	7/19/1994	Boston CMSA; Lawrence MSA
25-009-2006	LYNN	ESSEX	390 PARKLAND	Urban	-PAMs: Boston Type 2 (Maximum Precursor) -Ozone: Population Exposure	1/1/1992	Boston CMSA; Boston Metropolitan MSA
25-021-3003	MILTON	NORFOLK	MILTON MA, BLUE HILL	Urban	-PAMS: Boston Type 1 (Upwind Background) -PAMS Providence Type 3 (Maximum Concentration)	4/2/2002	Boston CMSA; Boston Metropolitan MSA

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-009-4005	NEWBURYPORT	ESSEX	261 NORTHERN BLVD	Urban	PAMS Boston Type 3 (Maximum Ozone Concentration) -Others: Population Exposure	6/2010 (note this replaced the former NEWBURY site)	Boston CMSA; Boston Metropolitan MSA
25-001-0002	TRURO	BARNSTABLE	FOX BOTTOM AREA	Regional	General / Background	4/1/1987	No MSA; Downwind Providence-Pawtucket , RI
25-027-0024	UXBRIDGE	WORCESTER	366 E. HARTFORD AVE.	Urban	-Ozone Transport (state line upwind) -Population Exposure	11/1/2008	Boston CMSA; Worcester MSA
25-015-4002	WARE	HAMPSHIRE	QUABBIN SUMMIT	Urban	-PAMS: Springfield Type 3 (Maximum Ozone Concentration)	6/1/1985	Springfield MSA
25-027-0015	WORCESTER	WORCESTER	WORCESTER AIRPORT	Urban	Worcester/Springfield Interface	5/7/1979	Boston CMSA; Worcester MSA

OZONE MONITOR AREAS SERVED

Figure 5-18 shows the area served by each ozone monitor as defined by Voronoi polygons. These polygons were developed using NetAssess, a network assessment tool developed by LADCO. The ozone polygons show that all areas of the state are well covered by monitors in Massachusetts or in neighboring states.

Figure 5-18
Area Served – Ozone sites



Source: NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool
Air monitoring network assessment tool suite developed by Lake Michigan Air Directors Consortium (LADCO). It is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from December 31, 2013 .
https://ebailey78.shinyapps.io/NetAssessApp/

OZONE MONITORING DATA

Massachusetts currently attains the 8-hour 0.075 ppm ozone standard. On October 1, 2015, EPA lowered the standard to 0.070 ppm. Attainment status with the new standard will be based on 2014 – 2016 monitoring data.

2014 Ozone Data Summary

Figure 5-19 shows a summary of the data collected during the 2014 ozone season (April 1 – Sept. 30). All fifteen sites achieved the data capture standard of 75% or greater for the year.

Figure 5-19
2014 Ozone Data Summary

SITE ID	CITY	COUNTY	ADDRESS	% OBS	1ST MAX 1-HR	2ND MAX 1-HR	1-HR MAX>.125 STD	1ST MAX 8-HR	2ND MAX 8-HR	3RD MAX 8-HR	4TH MAX 8-HR	8-HR MAX>.075 STD
25-003-4002	Adams	Berkshire	ROUTE 8 ADAMS	98	.074	.072	0	.066	.066	.065	.063	0
25-007-0001	Aquinnah	Dukes	1 HERRING CREEK RD	95	.075	.067	0	.066	.062	.059	.059	0
25-025-0041	Boston	Suffolk	LONG ISLAND	97	.081	.071	0	.065	.062	.061	.060	0
25-025-0042	Boston	Suffolk	HARRISON AVE	98	.073	.065	0	.056	.054	.054	.054	0
25-023-0005	Brockton	Plymouth	1 CLINTON ST	99	.076	.073	0	.066	.065	.064	.060	0
25-017-0009	Chelmsford	Middlesex	11 TECHNOLOGY	97	.080	.075	0	.069	.064	.064	.064	0
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	92	.096	.087	0	.070	.066	.066	.065	0
25-005-1006	Fairhaven	Bristol	30 SCHOOL ST	96	.075	.072	0	.062	.061	.058	.058	0
25-005-1004	Fall River	Bristol	659 GLOBE ST	98	.076	.075	0	.065	.064	.061	.060	0
25-011-2005	Greenfield	Franklin	VETERANS FIELD	98	.076	.073	0	.067	.062	.061	.058	0
25-009-5005	Haverhill	Essex	685 WASHINGTON	98	.076	.073	0	.065	.065	.064	.064	0
25-009-2006	Lynn	Essex	390 PARKLAND	99	.083	.076	0	.073	.066	.064	.063	0
25-021-3003	Milton	Norfolk	BLUE HILL OBSERV	98	.086	.083	0	.072	.071	.068	.067	0
25-009-4005	Newburyport	Essex	HARBOR STREET	96	.079	.072	0	.067	.067	.066	.064	0
25-015-0103	North Amherst	Hampshire	N PLEASANT ST	52	.075	.073	0	.065	.064	.063	.061*	0
25-001-0002	Truro	Barnstable	FOX BOTTOM AREA	98	.077	.069	0	.065	.062	.060	.059	0
25-027-0024	Uxbridge	Worcester	366 E HARTFORD DR	98	.084	.080	0	.069	.066	.065	.064	0
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	99	.093	.085	0	.070	.069	.069	.068	0
25-027-0015	Worcester	Worcester	375 AIRPORT	98	.085	.082	0	.075	.070	.066	.065	0

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER **% OBS** = PERCENTAGE OF VALID DAYS MONITORED DURING O3 SEASON **1ST, 2ND MAX 1-HR** = MAXIMUM 1-HR VALUE FOR THE 1ST & 2ND HIGHEST DAY **DAY MAX ≥ 0.125** = NUMBER OF MEASURED DAILY 1-HOUR MAXIMUM VALUES GREATER THAN OR EQUAL TO 0.125 PPM (1-HR STANDARD) **1ST, 2ND, 3RD & 4TH MAX 8-HR** = MAXIMUM 8-HR VALUE FOR THE 1ST, 2ND, 3RD & 4TH HIGHEST DAY **DAY MAX ≥ 0.075** = NUMBER OF MEASURED DAILY 8-HOUR MAXIMUM VALUES GREATER THAN OR EQUAL TO 0.075 PPM (8-HR STANDARD)

Ozone Design Values

The 2008 8-hour NAAQS for ozone is 0.075 parts per million (ppm). The design value is the 3-year average of the annual fourth-highest daily maximum 8-hour ozone concentration. Figure 5-20 shows ozone design values based on 2012-2014 monitored data.

Figure 5-20
Ozone Monitor 2014 Design Values (ppmv)

SITE ID	TOWN	ADDRESS	DESIGN VALUE 2012-2014
250010002	Truro	FOX BOTTOM AREA	0.070
250034002	Adams	MT GREYLOCK SUMMIT[1]	0.067
250051006	Fairhaven	HASTINGS SCHOOL	0.060*
250070001	Aquinnah	HERRING CREEK RD, OFF STATE RD AT AQUINNAH (GAY HEAD)	0.069
250092006	Lynn	390 PARKLAND	0.069
250094005	Newburyport	NORTHERN BOULEVARD	0.070
250095005	Haverhill	WASHINGTON ST-'CONSENTINO SCHOOL	0.069
250130008	Chicopee	ANDERSON RD AFB	0.070
250150103	Amherst	N PLEASANT ST[1]	0.063*
250154002	Ware	QUABBIN SUMMIT	0.071
250170009	Chelmsford	11 TECHNOLOGY DRIVE, EPA NEW ENGLAND REGIONAL LAB	0.068
250051004	Fall River	Globe Street	0.072
250213003	Milton	BLUE HILL OBS	0..071
250250041	Boston	LONG ISLAND[1]	0.066
250250042	Boston	HARRISON AV	0.058
250270015	Worcester	WORC AIRPORT	0.067
250270024	Uxbridge	366 E HARTFORD DR	0.067
250230005	Brockton	170 CLINTON StTREET	0.060*
250112005	Greenfield	VICTORY FIELD	0.058*

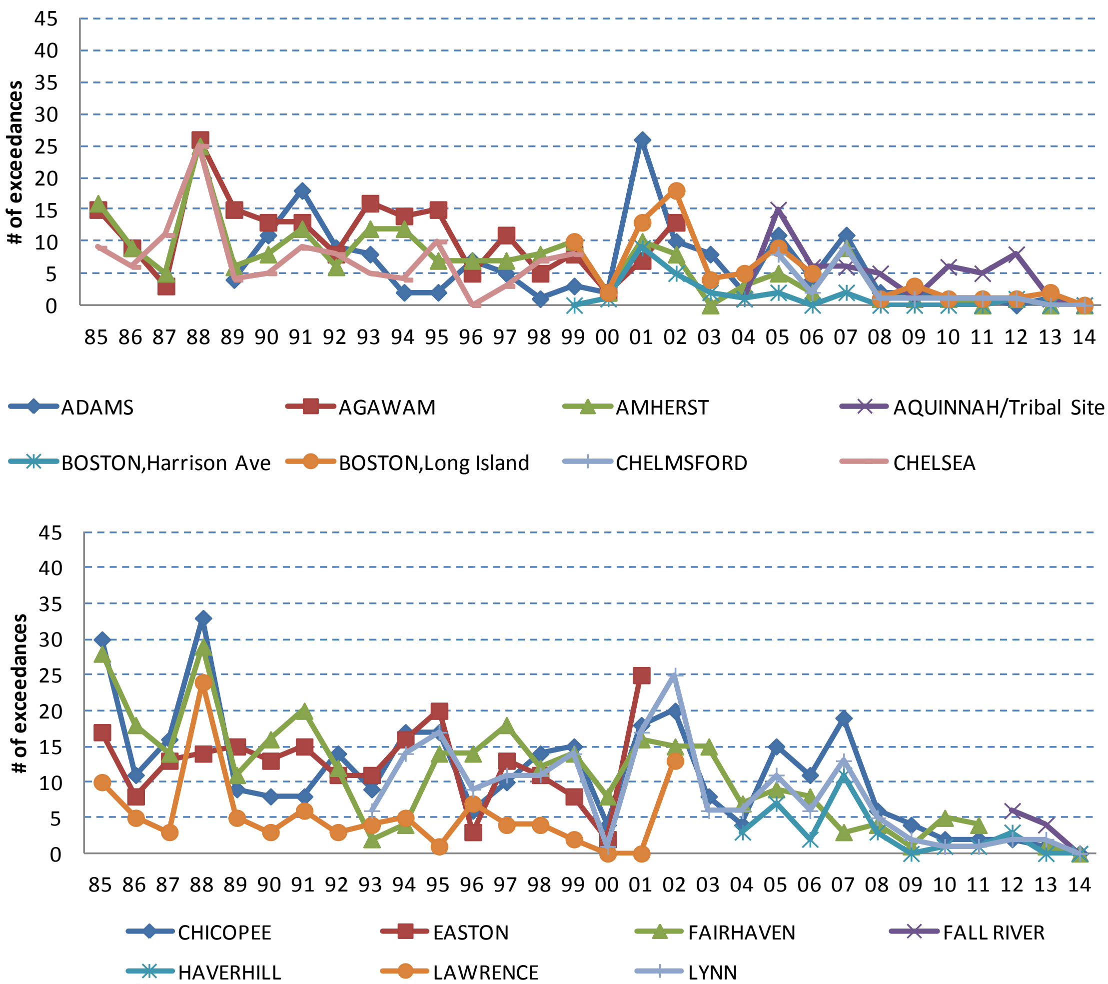
* Not operated for three full years.

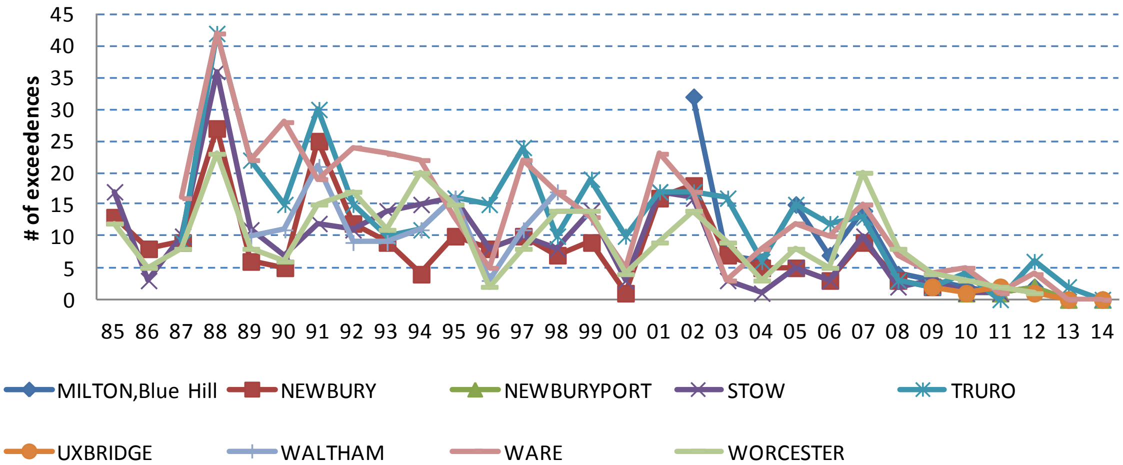
1. Sites closed in 2014.

8-hour Ozone Exceedance Trends

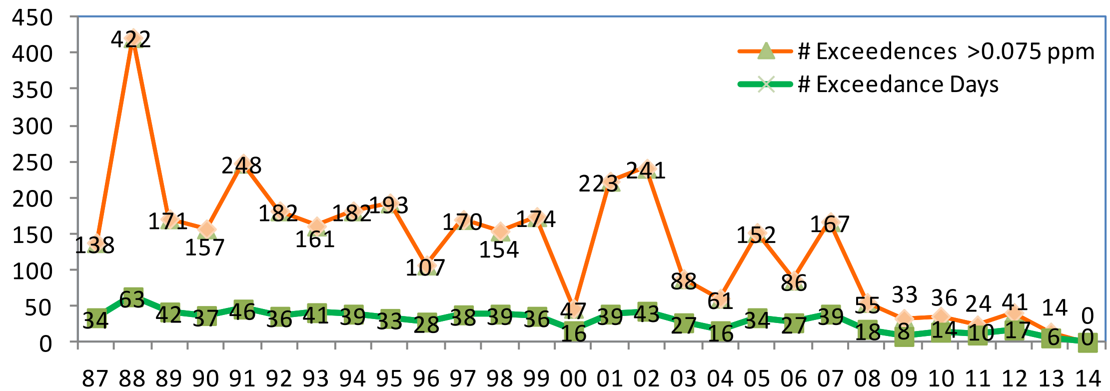
Figure 5-21 shows the long-term trends of 8-hour ozone exceedances for each site based on the 2008 8-hour standard.

Figure 5-21
8-hour Ozone Exceedance Trends 1985 – 2014
Standard = 0.075 ppm





8-hr Ozone Exceedance Days and Total Exceedances 1987-2014
8-hour standard = 0.075 ppm
Years 1987-2007 show what exceedances
would have been with a 0.075 ppm 8-hour standard



Exceedances by Site in Massachusetts and Downwind States

Figure 5-22 shows the number of exceedances of the 8-hour standard in the years 2012-2014 for each ozone monitor in Massachusetts and in downwind sites in Rhode Island, New York, Maine, New Hampshire, and Connecticut, into which ozone and ozone precursors are transported from Massachusetts.

Figure 5-22
Measured Ozone Exceedances in MA and Downwind States 2011-2013

STATE	SITE ID	CITY	ADDRESS	CMSA	MSA NAME	CITY POPULATIONL	# EXCEEDANCES		
							11	12	13
RI	440030002	Not in a city	W.Alton Jones Campus URI		Providence-Fall River-Warwick, RI-MA	5,085	4	2	2
RI	440071010	E. Providence	Francis School 64 Bourne Ave		Providence-Fall River-Warwick, RI-MA	48,688	3	8	5
RI	440090007	Not in a city	Tarzwell Rd Narragansett		Providence-Fall River-Warwick, RI-MA	12,088	3	7	4
NH	330012004	Laconia	Green St			16,411	0	0	0
NH	330050007	Keene	Water St			22,563	0	0	0
NH	330074001	Not in a city	Mt. Washington				0	0	2
NH	330074002	Not in a city	Green's Grant Camp Dodge RT 16				0	0	0
NH	330090010	Lebanon	Lebanon Airport			12,568	0	0	0
NH	330099991	Not in a city	Hubbard Brook N. Woodstock				0	0	0
NH	330111011	Nashua	Gilson Rd		Boston-Worcester-Lawrence MA-NH-ME-CT	86,605	1	2	0
NH	330115001	Peterborough	Pack Monadnock Summit				0	2	0
NH	330131007	Concord	Hazen Dr			40,687	0	0	0
NH	330150014	Portsmouth	Peirce Island			20,784	1	1	1
NH	330150016	Rye	Seacoast Science Center			4,508	2	1	0
NH	330150018	Not in a city	150 Pillsbury Rockingham Cty				1	2	0
MA	250010002	Truro	Fox Bottom Area		Not in a MSA	1486	0	6	2
MA	250034002	Adams	Mt Greylock Summit				1	0	1
MA	250051002	Fairhaven	60 Sconticut Neck Rd		New Bedford, MA	15,759	4	0	n/a
MA	250051006	Fairhaven2	30 School St				n/a	n/a	1
MA	250051004	Fall River	659 Globe St				n/a	6	4

STATE	SITE ID	CITY	ADDRESS	CMSA	MSA NAME	CITY POPULATIONL	# EXCEEDANCES		
							11	12	13
MA	250070001	Aquinnah Tribal Site	1 Herring Creek				5	8	1
MA	250092006	Lynn	390 Parkland		Boston, MA-NH	89,050	1	2	2
MA	250095005	Haverhill	685 Washington St		Lawrence, MA-NH	58,969	1	3	0
MA	250130008	Chicopee	Anderson Rd AFB		Springfield, MA	54,653	2	2	1
MA	250150103	N. Amherst	N. Pleasant St		Springfield, MA	6,019	0	1	0
MA	250154002	Ware	Quabbin Summit		Springfield, MA	6,174	1	4	0
MA	250170009	Chelmsford	11 Technology Dr USEPAI		Lowell, MA-NH	31,174	1	1	0
MA	250171102	Stow	US Military Res		Boston, MA-NH	5,144	1	n/a	n/a
MA	250213003	Milton	Blue Hill OBS		Boston, MA-NH	26,062	1	2	0
MA	250250041	Boston	Long island		Boston, MA-NH	617,594	1	1	2
MA	250250042	Boston	Harrison Ave		Boston, MA-NH	617,594	0	1	0
MA	250270015	Worcester	375 Airport Dr		Worcester, MA	172,648	2	1	0
MA	250270024	Uxbridge	366 E Hartford Dr		Worcester,MA		2	1	0
CT	090010017	Greenwich	Tods Driftway		Stamford-Norwalk, CT	59,578	8	15	8
CT	090011123	Danbury	White St at 8th Ave		Danbury, CT	74,848	6	8	4
CT	090013007	Stratford	USCG Lighthouse Prospect St		Bridgeport, CT	50,541	8	15	10
CT	090019003	Westport	Sherwood Island State Park		Stamford-Norwalk, CT	25,749	9	14	12
CT	090031003	E. Hartford	Remington Rd		Hartford, CT	49,575	3	6	4
CT	090050005	Cornwall	Mohawk Mountain Rd		Not in a MSA		1	3	2
CT	090070007	Middleton	Conn Valley Hospital, Shew Hall Eastern D		Hartford, CT		6	12	6
CT	090090027	New Haven	1 James St				6	13	3
CT	090093002	Madison	Hammonasset State Park				8	10	8
CT	090110124	Groton	141 Smith St		Norwich-New London, CT		9	8	6

STATE	SITE ID	CITY	ADDRESS	CMSA	MSA NAME	CITY POPULATIONL	# EXCEEDANCES		
							11	12	13
CT	090131001	Stafford	Route 190, Shenipsit State Forest				1	8	5
CT	090159991	Not in a city	80 Ayers Rd				1	2	1
ME	230010014	Not in a city	Route 9, Durham				0	0	0
ME	230031100	Presque Isle	8 Northern Rd				0	0	0
ME	230039991	Not in a city	45 Radar Rd, Ashland, ME				0	0	0
ME	230050029	Portland	356 State St				0	0	0
ME	230052003	Not in a city	Two lights State park				1	2	3
ME	230090102	Not in a city	Top of Cadillac Mountain				1	2	3
ME	230090103	Not in a city	McFarland Hill				0	0	1
ME	230112005	Gardiner	14 Pray St			6,198	0	0	0
ME	230130004	Not in a city	Port Clyde Marshall Point				0	0	4
ME	230173001	Not in a city	Route 5, North Lovell DOT				0	0	0
ME	230191100	Not in a city	27 Wabanaki Way Indian Island				n/a	0	n/a
ME	230194008	Not in a city	Summit of Rider Bluff(WLBZ)				0	0	1
ME	230199991	Not in a city	Lagrange Rd, Howland, ME				0	0	n/a
ME	230230006	Not in a city	Brown's Point Rd				0	0	0
ME	230290019	Not in a city	Public Landing , Jonesport				0	0	1
ME	230290032	Not in a city	184 County Road				0	0	0
ME	230310038	Not in a city	34 Town farm Rd, Hollis				0	1	0
ME	230310040	Not in a city	RT 11, Shapleigh Ball Park				0	0	0
ME	230312002	Kennebunkport	Ocean Ave/Parson Way				2	4	4

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) also are required at PAMS sites. Two Type 3 PAMS sites (Ware and Newburyport) measure NO_y (total reactive oxides of nitrogen), which better characterizes atmospheric nitrogen reactions 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.

CO trace is measured at Type 2 sites as a general indicator of the urban plume.

Although Massachusetts is currently in attainment with the ozone NAAQS, and is not required to participate in PAMS monitoring, MassDEP continues to be funded by EPA to operate the four sites. Good reasons to continue to operate PAMS sites in the future (at least the Type 2 locations), include the possible lowering of the NAAQS value this year (leading us again to nonattainment), the trend value of the collection of twenty years of PAMS data, and the geographic location of Massachusetts at the end of 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 the 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.

MassDEP continues to participate in regional and national discussions designed to make sure the PAMS and ozone network is both efficient and relevant moving forward and continues to meet the needs of MassDEP and the Ozone Transport Commission for air pollution forecasting and ozone SIP development and implementation, and of MANE-VU for regional haze planning. A closer review of the ozone and PAMS monitoring networks is required now that EPA has established a new lower ozone NAAQS.

Figure 5-23
Location and Description of PAMS Sites

SITE ID	CITY	ADDRESS	SCALE	REASON FOR MONITOR	MSA/CMSA	METEOROLOGICAL	POLLUTANTS
25-009-2006	LYNN	390 PARKLAND	Urban	PAMs: Boston Type 2 (Maximum Precursor)	Boston CMSA; Boston Metropolitan MSA	FULL MET (WS/WD TEMP, RH, BP, SOLAR, & PRECIP)	O_3, tCO, NO, NO_2, NOx, $PM_{2.5}$ (3-DAY), VOC Speciation (PAMS), CARBONYLS (PAMS)
25-013-0008	CHICOPEE	ANDERSON ROAD	Urban	PAMS: Springfield Type 2 (Maximum Precursor)	Springfield MSA	WS/WD, TEMP, RH, BP, SOLAR	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY), VOC Speciation (PAMS), CARBONYLS (PAMS) PM Speciation, tCO
25-009-4005	NEWBURYPORT	261 NORTHERN BLVD	Urban	PAMS Boston Type 3 (Maximum Ozone Concentration)	Boston CMSA; Boston Metropolitan MSA	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, NO_A, NOY, VOC Speciation (PAMS)
25-015-4002	WARE	QUABBIN SUMMIT	Urban	PAMS: Springfield Type 3 (Maximum Ozone Concentration)	Springfield MSA	FULL MET & PRECIP	O_3, tSO_2, NO, NO_2, NO_x, NOA, NOY, PM_{10} (LV), IMPROVE. $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC Speciation (PAMS)

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 currently employs Automated Gas Chromatographs (AutoGCs), with flame ionization detectors (FID) to measure ozone precursor target hydrocarbon VOCs (volatile organic compounds) at all PAMS sites. These instruments employ an hourly sample collection and analysis cycle to measure target VOCs

The current network assessment occurs at the cusp of changes to the nation-wide and local PAMS program. Massachusetts is currently attaining the 2008 8-hour ozone standard and is not required to perform PAMS measurements. However, the new lower 2015 standard could result in new nonattainment areas. In recent years, MassDEP has wrestled with level the resources necessary to process and perform proper quality control review and adjustments on the huge amount of data that is produced each Summer. MassDEP is applying higher technical standards and more rigorous quality control to PAMS VOC data. To this end and to reduce the turnaround time for processing and reporting data, MassDEP has temporarily limited reporting of PAMS data for 2015 to the two Type 2 locations (Lynn and Chicopee). The proposed EPA initiative to reduce the number of PAMS target VOCs should assist in making PAMS data more manageable and useful.

ADEQUACY OF THE EXISTING MONITORING NETWORK

EPA Requirements

As demonstrated in Figure 5-24, MassDEP's ozone monitoring network meets minimum EPA requirements.

Figure 5-24
Minimum Ozone Monitoring Requirements

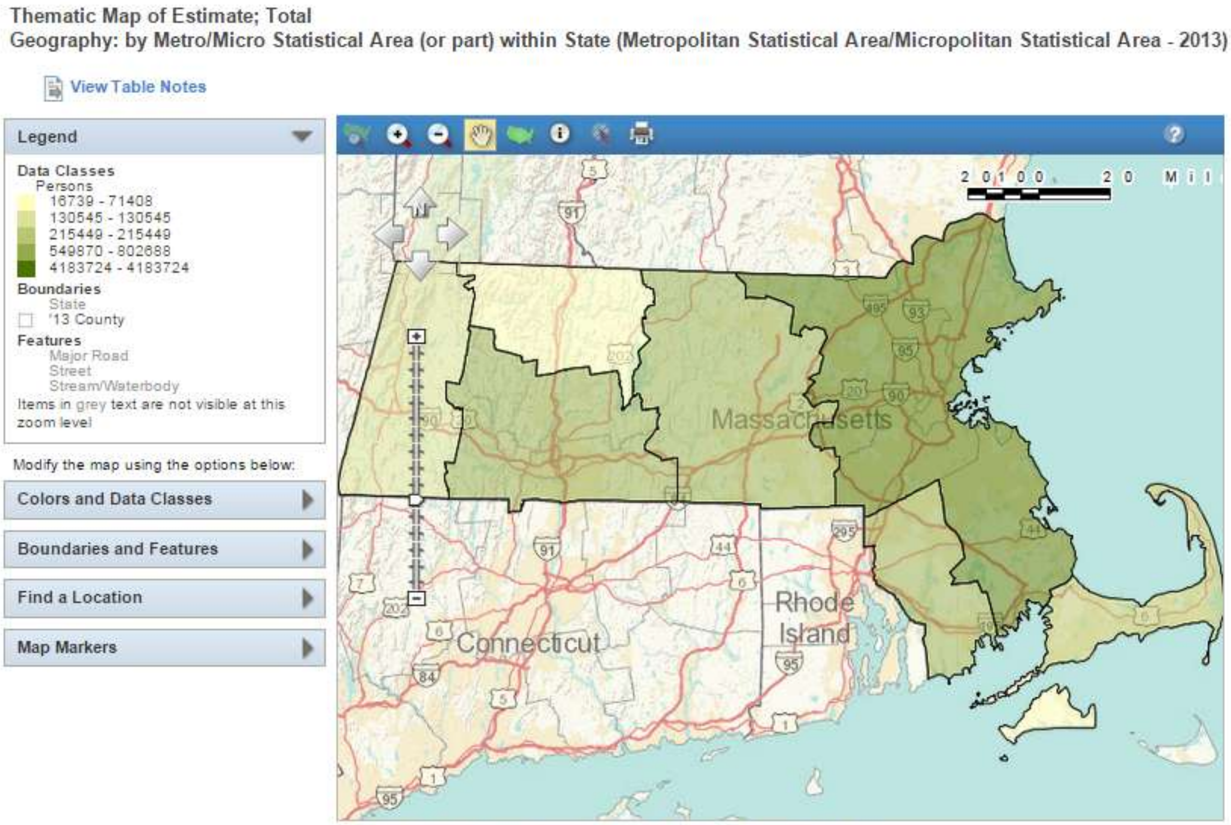
MSA	POPULATION 2013 EST	DESIGN VALUE (max for MSA)	≥85% OF STD?	# MONITORS REQUIRED*	# MONITORS IN NETWORK	MAXIMUM CONCENTRATION SITE FOR EACH MSA
Boston-Cambridge-Newton, MA-NH Metro Area (part); Massachusetts	4,183,724	0.071	Yes	3	7	Newburyport
Worcester, MA-CT Metro Area (part); Massachusetts	802,688	0.067	Yes	2	2	Worcester Airport
Pittsfield, MA Metro Area; Massachusetts	130,545	na	No	0	0 *	-
Springfield, MA Metro Area; Massachusetts	695,819	0.071	Yes	2	3	Ware
Barnstable Town, MA Metro Area; Massachusetts	215,449	0.070	Yes	1	1	Truro

Source: U.S. Census, 2009-2013 American Community Survey 5-Year Estimates, B01003: TOTAL POPULATION - Universe: Total population. American FactFinder: http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_13_5YR_B01003&prodType=table

If the Design value is ≥85% of the standard:

- CSA/MSAs with a population of 4- 10 million require 3 monitors
- CSA/MSA s with a population of 350,000 - < 4 million require 2 monitors
- CSAs/MSAs with a population of 50,000 – 349,999 require 1 monitor

Figure 5-25
Metro/Micro Statistical Areas in Massachusetts



Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey

MassDEP continues to participate in regional and national discussions designed to make sure the PAMS and ozone network is both efficient and relevant moving forward and continues to meet the needs of MassDEP and the Ozone Transport Commission for air pollution forecasting and ozone SIP development and implementation, and of MANE-VU for regional haze planning.

Exceedance Probability, Correlations, Removal Bias

EPA recommends 3 analytical approaches for identifying potentially underserved areas and redundant sites that are used here. MassDEP used NetAssess to conduct these analyses.

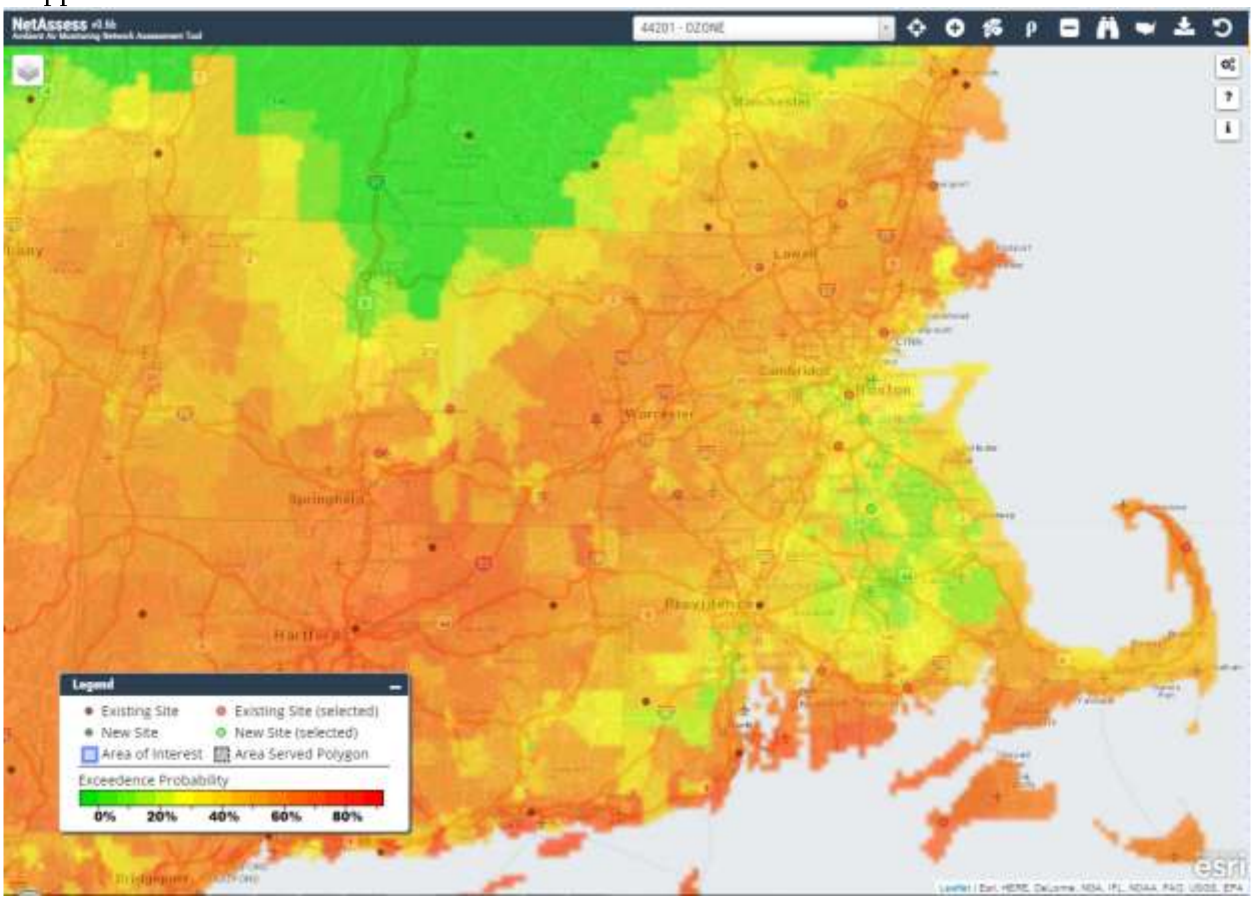
<u>Exceedance Probability</u>

NetAssess provides a probability map to help determine where new monitors may need to be located. Note that Daily downscaler estimates for 8-hour maximum ozone for the years 2007 and 2008 were obtained from EPA. Years 2009-2011 were obtained from the CDC's Environmental Public Health Tracking Program.

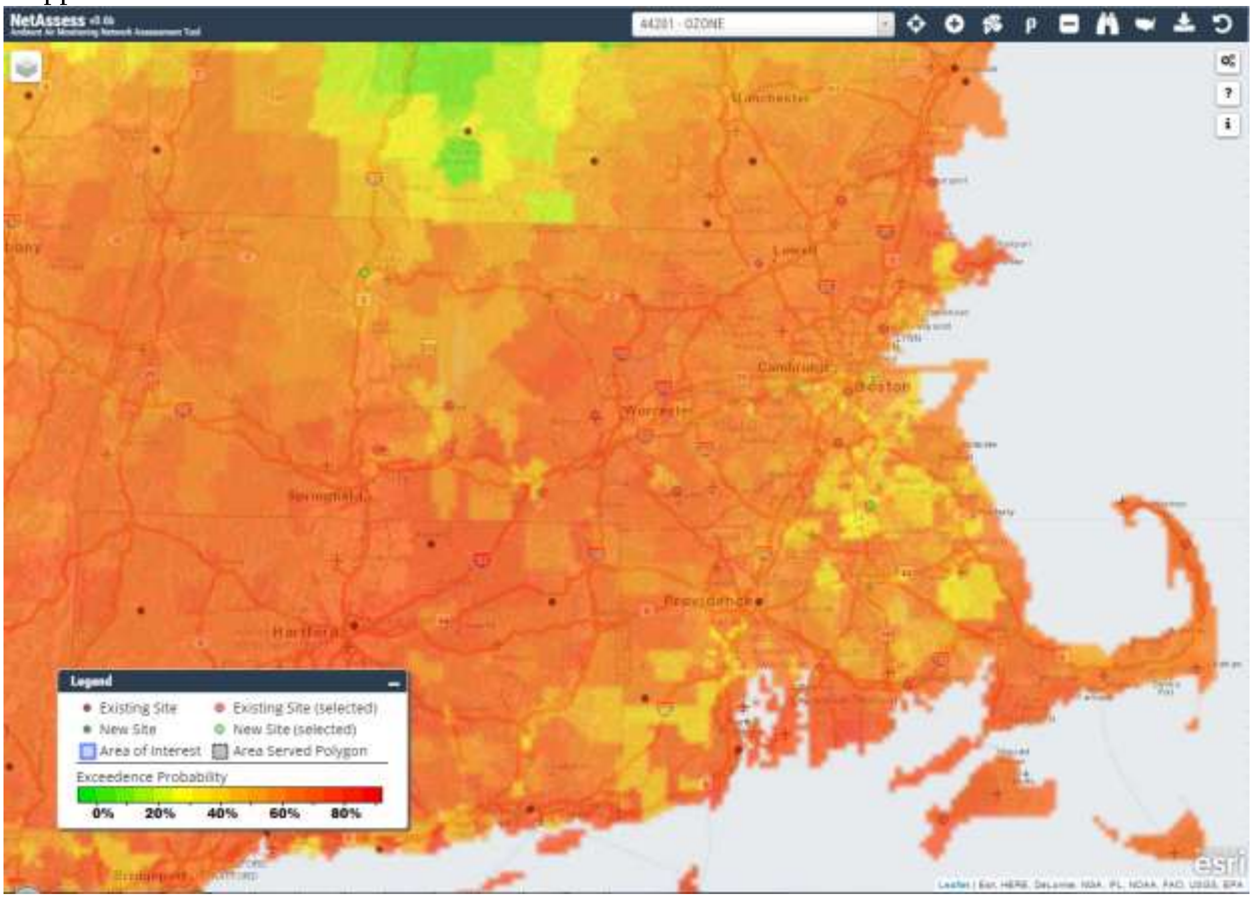
Figure 5-26 shows the probability of exceeding the existing 75 ppb NAAQS and a potential 70 ppb standard. All areas of 60% and greater probability are covered by existing monitors, with the possible exception of Berkshire County, particularly in the southwest portion. Those areas, however, are partically covered by monitors in Connecticut and New York to the south/ southwest.

Figure 5-26
New Sites Analysis

75 ppb



70 ppb



<u>Site Correlation Analysis</u>

The NetAssess tool was used to provide correlations between ozone monitors (NetAssess documentation is available at: <u>http://ladco.github.io/NetAssessApp/tools.html</u>)

Data

The Correlation Matrix tool uses daily summary pollutant concentration data for ozone and fine particles collected between January 1, 2011 and December 31, 2013. Data was retrieved using the AQS AMP 435 Daily Summary Report.

For ozone, the correlation matrix tool calculates a Pearson Correlation (r) for all valid 8-hour average ozone concentration pairs (DURATION CODE=W, DAILY CRITERIA IND=Y). In the AMP 435 Report, the daily maximum 8-hour ozone concentration is stored in the field labeled "MAX VALUE". Individual monitoring sites are identified using the AQS Site ID, which is a combination of the STATE CODE, COUNTY CODE, and SITE ID fields (XX-XXX-XXXX). 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 5-27 shows the correlation between ozone measurements at monitoring sites in Massachusetts. Overall, the ozone monitors are highly correlated with an average of 0.79. Figure 5-28 shows that there are several ozone monitoring sites (highlighted) that are fairly well correlated with each other (> 0.90) with low average relative difference (< 0.8; average is 0.159). They also are relatively close to each other (40 km or less; average is 92 km).

Figure 5-27
Correlation Between Ozone Monitors in Massachusetts

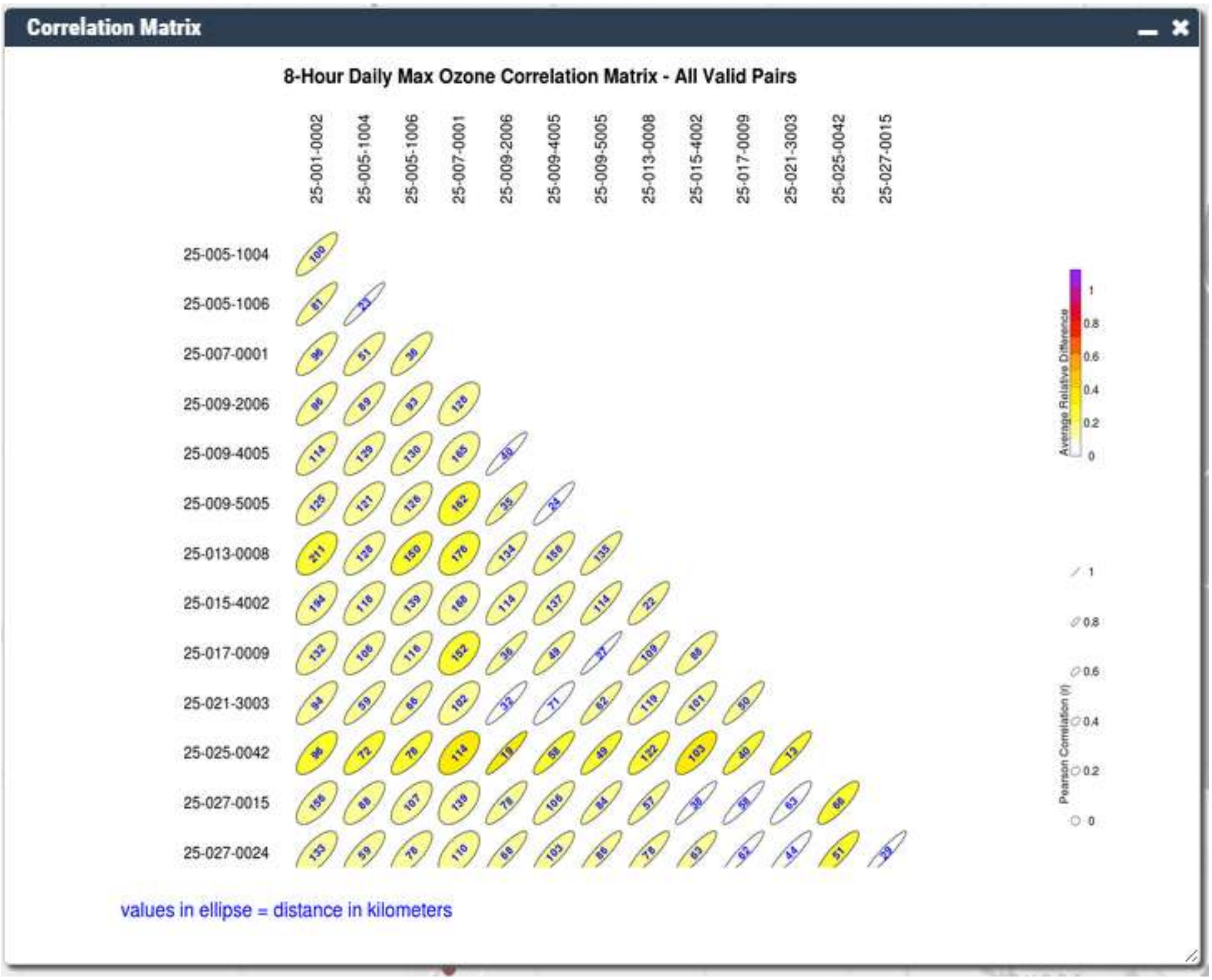


Figure 5-28
Highly Correlated Ozone Monitors in Massachusetts

Site 1	Site 2	Site 1	Site 2	Correlat		Rel.	Distance (k
25-009-5005	25-017-0009	HAVERHILL	CHELMSFORD	0.958	734	0.0674	27
25-005-1004	25-005-1006	FALL RIVER	FAIRHAVEN	0.953	180	0.0786	23
25-027-0015	25-027-0024	WORCESTER AIRPORT	UXBRIDGE	0.943	694	0.073	29
25-009-2006	25-009-4005	LYNN	NEWBURYPORT	0.939	724	0.075	40
25-015-4002	25-027-0015	WARE	WORCESTER AIRPORT	0.932	694	0.0712	38
25-017-0009	25-027-0024	CHELMSFORD	UXBRIDGE	0.929	727	0.0815	62
25-009-2006	25-025-0042	LYNN	ROXBURY	0.928	1056	0.302	19
25-009-4005	25-009-5005	NEWBURYPORT	HAVERHILL	0.923	717	0.0886	24
25-017-0009	25-027-0015	CHELMSFORD	WORCESTER AIRPORT	0.923	706	0.0854	58
25-009-2006	25-021-3003	LYNN	BLUE HILL	0.922	720	0.0794	32
25-009-2006	25-009-5005	LYNN	HAVERHILL	0.908	738	0.104	35
25-021-3003	25-027-0024	BLUE HILL	UXBRIDGE	0.908	710	0.0966	44
25-021-3003	25-025-0042	BLUE HILL	ROXBURY	0.907	717	0.277	13
25-009-2006	25-017-0009	LYNN	CHELMSFORD	0.904	1057	0.104	36
25-013-0008	25-017-0009	CHICOPEE	CHELMSFORD	0.904	1073	0.116	109
25-009-5005	25-021-3003	HAVERHILL	BLUE HILL	0.903	721	0.107	62

Removal Bias Analysis

Removal bias was calculated with NetAssess. Figures 5-29 and 5-30 show the removal bias that would result from eliminating each ozone monitor individually. Note that NetAssess does not contain data from the new Brockton or Greenfield ozone sites which limits the usefulness of this analysis.

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 much bias on average, but would introduce the potential for relatively large errors (imprecision). This analysis therefore does not point to any particular monitor/s as redundant and a good candidate for removal.

Figure 5-29
Removal Bias for Ozone Monitors

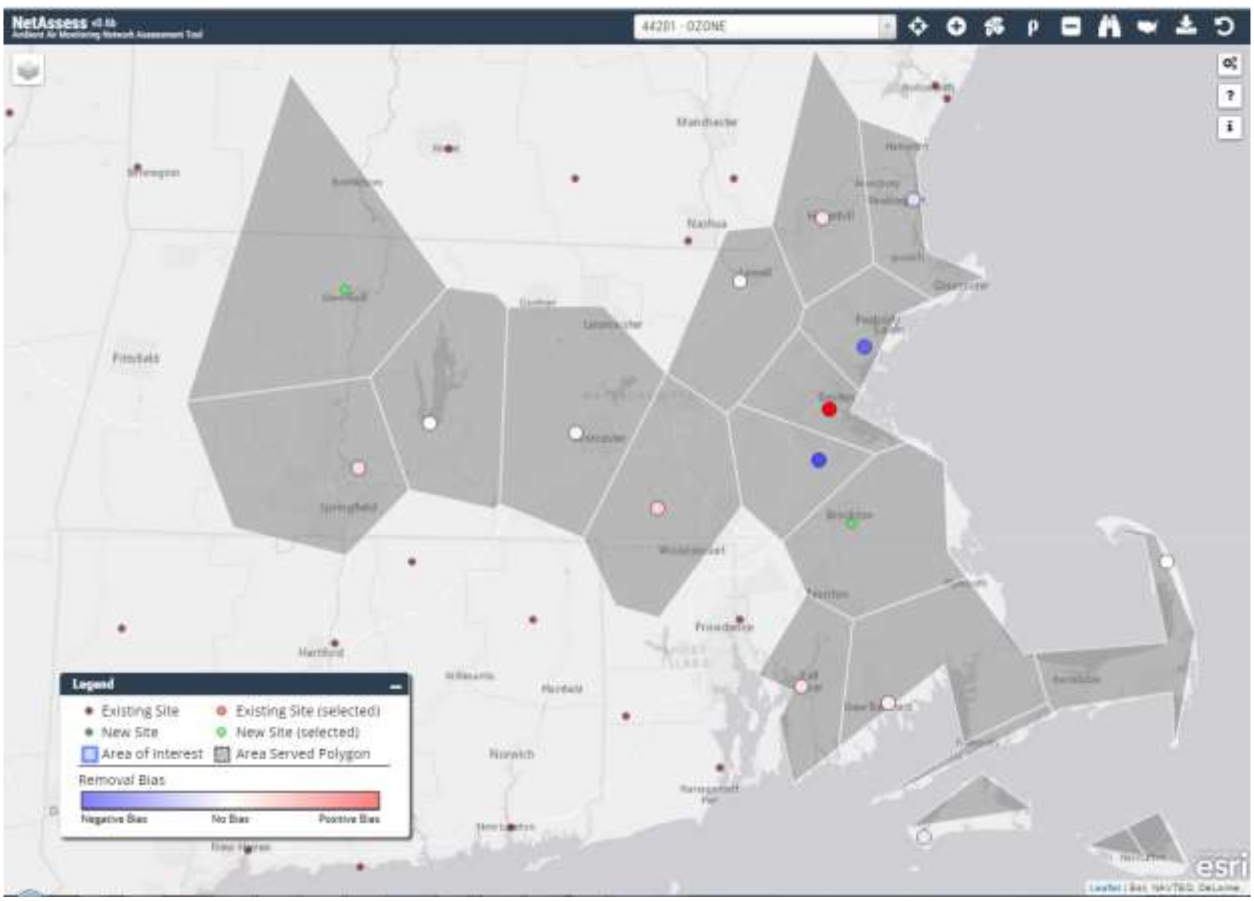


Figure 5-30
Removal Bias Statistics for Ozone Monitors

Site ID	Name	Mean Removal Bias	Min Removal Bias	Max Removal Bias	Removal Bias Standard Deviation	Neighbors Included
25-021-3003	BLUE HILL	-0.0067	-0.034	0.006	0.004	7
25-009-2006	LYNN	-0.0057	-0.020	0.012	0.004	7
25-009-4005	NEWBURYPORT	-0.0014	-0.018	0.008	0.003	5
25-007-0001	AQUINNAH WAMPANOAG	-0.0009	-0.030	0.027	0.007	9
25-027-0015	WORCESTER AIRPORT	-0.0005	-0.015	0.012	0.003	5
25-017-0009	CHELMSFORD	-0.0003	-0.012	0.018	0.003	7
25-001-0002	TRURO	-0.0001	-0.036	0.036	0.006	12
25-015-4002	WARE	-0.0001	-0.019	0.035	0.006	6
25-005-1006	FAIRHAVEN	0.0008	-0.011	0.012	0.003	5
25-009-5005	HAVERHILL	0.0012	-0.017	0.011	0.003	5
25-005-1004	FALL RIVER	0.0013	-0.010	0.047	0.004	5
25-013-0008	CHICOPEE	0.0013	-0.032	0.025	0.006	6
25-027-0024	UXBRIDGE	0.0018	-0.009	0.018	0.003	7
25-025-0042	ROXBURY	0.0094	-0.003	0.040	0.004	3

ANALYSIS RESULTS

MassDEP's analysis indicates that there is no need for additional ozone or PAMs monitors in Massachusetts. While it is possible that some ozone sites could be eliminated, MassDEP measures other pollutants at most ozone monitoring sites, providing additional benefit (only five ozone sites measure only ozone).

Carbon Monoxide (CO)

CO NETWORK DESCRIPTION

MassDEP currently operates 6 carbon monoxide (CO) monitors in 5 cities in Essex, Hampden, Suffolk, and Worcester Counties. The network employs full-scale, NAAQS compliance instruments that measure 0 to 50 ppm at 1 location (Springfield-Liberty Street) and trace-level instruments that measure from 0 to 5 parts per million at 5 sites. Trace-level monitors are used at locations where CO measurement is of interest, but where levels are expected to be less than 2 parts per million. The trace-level CO instruments at Lynn and Chicopee (Type 2 PAMS sites) are designed to track the commuting plume. Trace-level CO instruments are also located at the designated NCore site (Boston-Harrison Avenue), at the near-road site at Von Hillern Street (Boston), and in Worcester (Summer Street). Since values have been consistently low for quite some time, MassDEP is planning to replace the last remaining full scale CO monitor in Springfield when resources allow.

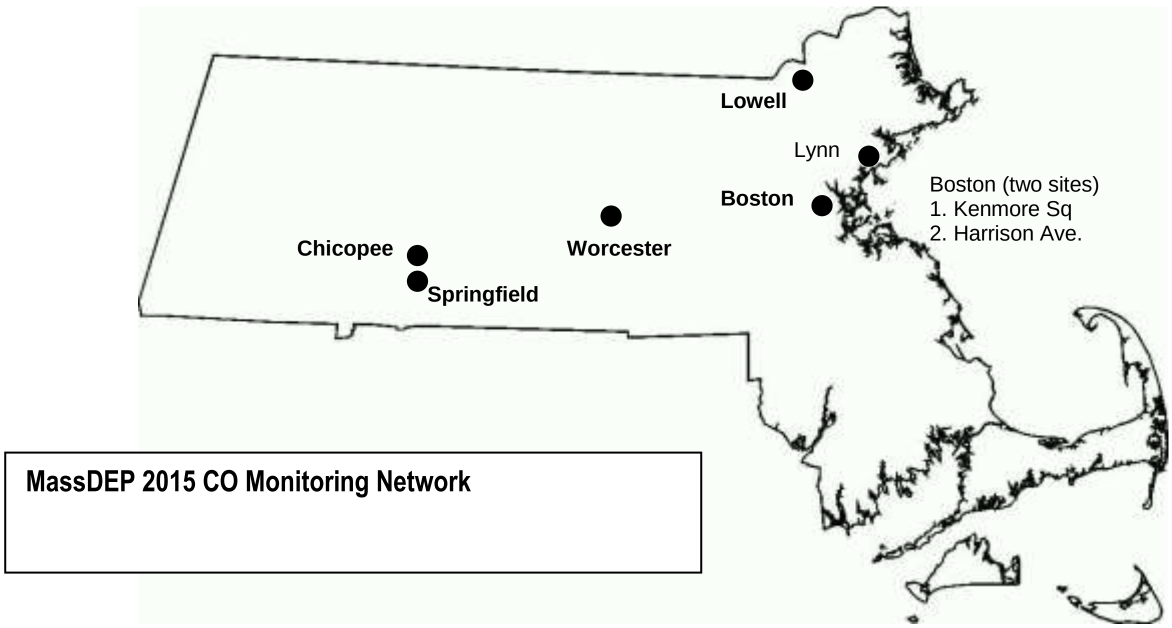
Figure 5-31 lists the location, purpose, description and EPA scale of each of the CO monitoring stations.

Figure 5-31
CO Monitoring Network Description

SITE ID	CITY	COUNTY	AD-DRESS	SCALE OF CO MONITOR	REASON FOR CO MONITOR	YEAR ESTAB-LISHED	MSA/CMSA	POLLUTANTS
25-009-2006	LYNN	ESSEX	390 PARK-LAND	Urban	Trace Urban Plume	1/1/1992	Boston CMSA; Boston Metropolitan MSA	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC (TOXICS), VOC (PAMS), CARBONYLS (PAMS)
25-013-0008	CHICOPEE	HAMPDEN	ANDER-SON ROAD	Urban	Trace urban Plume	1/1/1983	Springfield MSA	O_3, tCO, NO, NO_2, NOx, $PM_{2.5}$ (3-DAY)(2) , VOC (PAMS), CARBONYLS (PAMS) PM $_{2.5}$ SPECIATION
25-013-0016	SPRING-FIELD	HAMPDEN	LIBERTY STREET	Middle	-Population Exposure -Maximum Concentration	4/1/1988	Springfield MSA	CO, SO_2, NO, NO_2, NOx, $PM_{2.5}$ (2) (3-DAY), $BAM_{2.5}$, BLACK CARBON
25-025-0044	BOSTON	VON HILLERN STREET	WS/WD, TEMP, RH, BP, SOLAR	Middle	-Population Exposure -Maximum Concentration	6/15/2013	Boston CMSA; Boston Metropolitan MSA	tCO,,NO, NO_2, NO_x, $PM_{2.5}$ (3 DAY), $BAM_{2.5}$, BLACK CARBON
25-025-0042	BOSTON	SUFFOLK	HARRI-SON AVENUE	Middle	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA	O_3, tCO, tSO_2, Pb, NO, NO_2, NO_x, NO_Y, PM_{10} (LV) (2), $PM_{2.5}$ (3-DAY) (2), $BAM_{2.5}$, VOC (TOXICS), CARBONYLS (6th-DAY), BLACK CARBON NCore, Speciation, PM_{10} (2: HV & TOXICS), PM_{coarse}, Cr6+, PAHS
25-027-0023	WOR-CESTER	WORCESTER	SUMMER STREET	Middle	Population Exposure	1/1/2004	Boston CMSA; Worcester MSA	Cot,, SO_2, NO, NO_2, NO_x, PM_{10} (LV), $PM_{2.5}$ (2) (3-DAY), $BAM_{2.}$ Radiation

Figure 5-32 shows the location of each of the CO monitors.

Figure 5-32



CO DATA

Massachusetts has been in statewide compliance with the CO NAAQS since 2002. No significant increase in reported CO values was observed after the placement of the near-road Von Hillern Street sites in Boston.

2014 Summary Data

Figure 5-33 summarizes 2014 CO data. All of the sites achieved the requirement of 75% or greater data capture for the year.

Figure 5-33
2014 CO Monitoring Data Summary

SITE ID	CITY	COUNTY	ADDRESS	% OBS	1ST MAX 1-HR	2ND MAX 1-HR	OBS >1HR STD	1ST MAX 8-HR	2ND MAX 8-HR	OBS >8HR STD
25-025-0002	Boston	Suffolk	KENMORE SQ	90	1.5	1.3	0	1.1	.9	0
25-025-0042	Boston	Suffolk	HARRISON AVE	91	1.950	1.713	0	1.4	1.1	0
25-025-0044	Boston	Suffolk	19 VON HILLERN	78	1.890	1.620	0	.9	.9	0
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	92	1.030	.945	0	.8	.7	0
25-009-2006	Lynn	Essex	390 PARKLAND	87	1.096	.885	0	.8	.7	0
25-013-0016	Springfield	Hampden	LIBERTY STREET	93	1.5	1.4	0	.9	.9	0
25-027-0023	Worcester	Worcester	SUMMER ST	92	2.6	2.6	0	1.5	1.1	0

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

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER **% OBS** = DATA CAPTURE PERCENTAGE **1ST, 2ND MAX 1-HR** = FIRST AND SECOND HIGHEST VALUE FOR TIME PERIOD INDICATED **OBS > 35** = NUMBER OF 1-HR AVG. GREATER THAN 35 PPM (1-HR STANDARD) **1ST, 2ND MAX 8-HR** = FIRST AND SECOND HIGHEST VALUE FOR TIME PERIOD INDICATED **OBS > 9** = NUMBER OF 8-HR AVG. GREATER THAN 9 PPM (8-HR STD)

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 5-34 shows that Massachusetts is consistently well below both the 8-hour and 1-hour CO standards.

Figure 5-34
2014 Summary Values for CO (ppm)

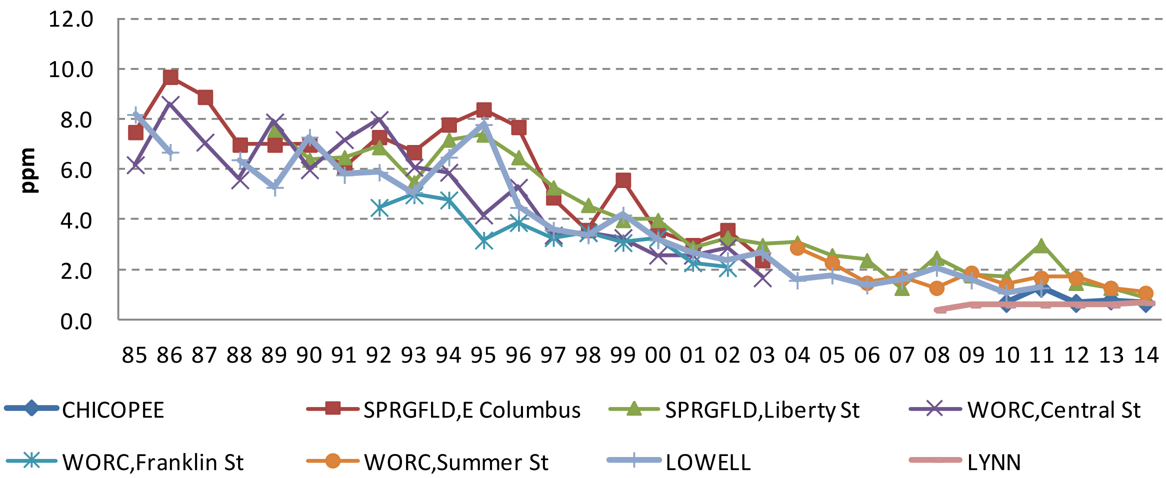
SITE ID	CITY	SITE ADDRESS	2012-2014 Maximum VALUE	
			8 HOUR	1 HOUR
250092006	LYNN	390 PARKLAND	0.8	1.0
250130008	CHICOPEE	ANDERSON RD AFB	0.9	1.1
250130016	SPRINGFIELD	LIBERTY STREET	1.7	2.0
250250002	[1]BOSTON	KENMORE SQUARE	1.1	1.5
250250042	BOSTON	HARRISON AVENUE	1.9	2.3
250250044	*BOSTON	VON HILLERN	1.5	1.8
250270023	WORCESTER	SUMMER STREET	2.0	2.6

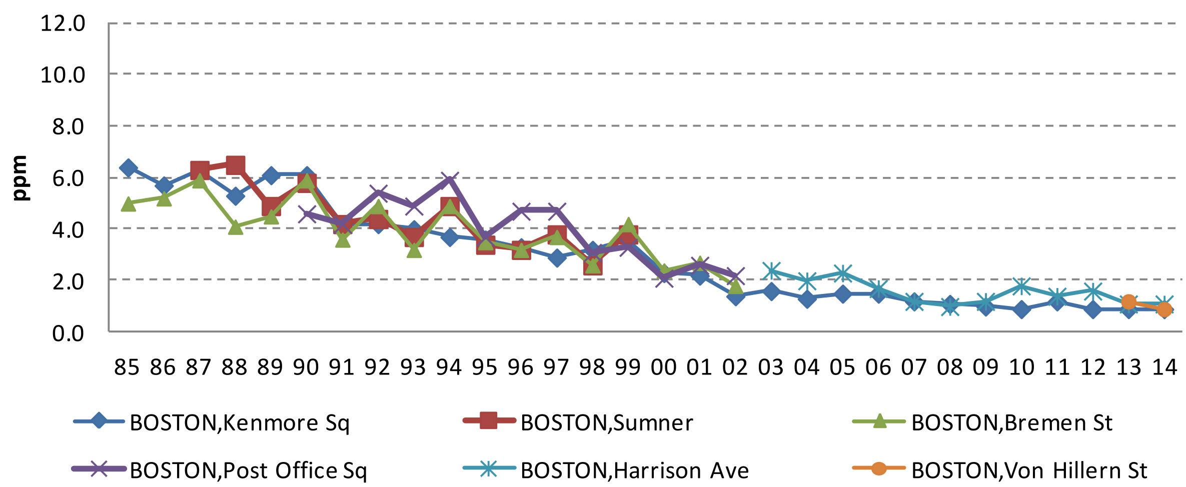
* Full three years of data not available.
1. Site closed at the end of 2014.

CO Trends

The long-term trends for each CO site are shown in Figure 5-35.

Figure 5-35
CO Trends 1985-2014
2nd Maximum 8-hour Values
Standard = 9 ppm





CO TECHNOLOGY

MassDEP uses gas filter correlation (GFC) for monitoring CO. In addition, MassDEP has deployed several trace-level (low concentration range) CO monitors over the last few years. 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. At this time, EPA regulations do not have a minimum network size for monitoring CO. However, continued operation of existing CO sites using FRM or FEM monitors is required until discontinuation is approved by EPA. The discontinuation of the Kenmore Square (Boston) CO was approved by EPA and the monitor was closed at the end of 2014. The Boston-Harrison Avenue, Worcester - Summer Street, and Springfield - Liberty Street monitors represent inner city, urban background.

The recently promulgated CO NAAQS (which did not change) did not change CO monitoring requirements for Massachusetts.

ANALYSIS RESULTS

The overwhelming downward trend in CO concentrations does not warrant the consideration of any new CO monitoring efforts at this time.

Sulfur Dioxide (SO_2)

SO_2 NETWORK DESCRIPTION

MassDEP currently operates 6 sulfur dioxide (SO_2) monitors in 5 municipalities in Suffolk, Worcester, Bristol, Hampden and Hampshire Counties.

Like CO, SO_2 concentrations have dropped over the years to a point where measuring it using trace instruments is warranted. Currently, three of the six sites employ trace instruments.

Figure 5-36 lists the location, purpose and description of the SO_2 monitoring stations and their EPA scales for SO_2 monitoring purposes.

Figure 5-36
SO_2 Monitoring Network Description

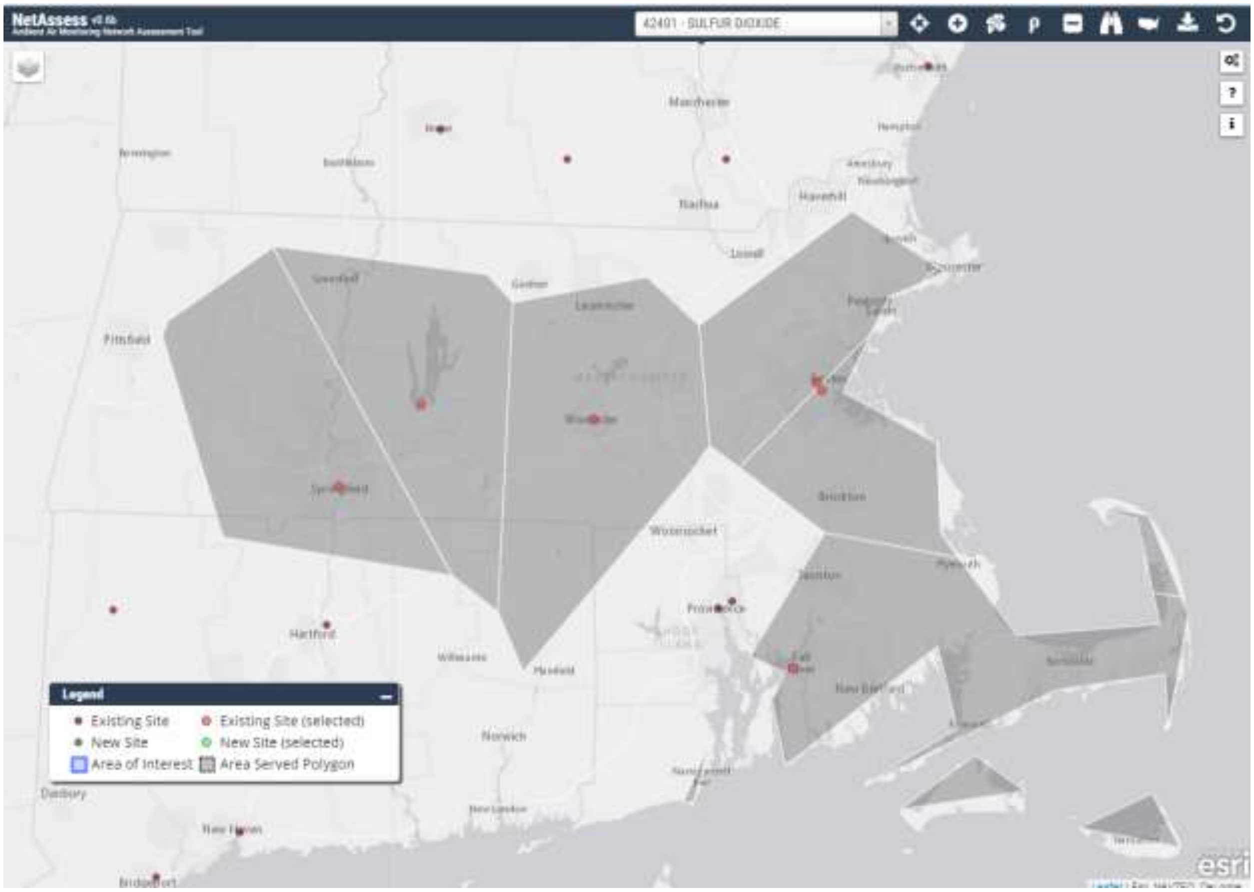
SITE ID	CITY	COUNTY	ADDRESS	SCALE FOR SO_2 MONITOR	REASON FOR MONITOR	YEAR ESTABLISHED	MSA/CMSA
25-025-0002	BOSTON	SUFFOLK	KENMORE SQUARE	Middle	Population Exposure (Trace Level)	1/1/1965	Boston CMSA; Boston Metropolitan MSA
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	Neighbor-hood	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA
25-005-1004	FALL RIVER	BRISTOL	GLOBE STREET	Neighbor-hood	-Highest Concentration -Population Exposure	2/1/1975	Providence-Pawtucket-Fall River MSA
25-013-0016	SPRINGFIELD	HAMPDEN	LIBERTY STREET	Neighbor-hood	-Population Exposure -Maximum Concentration	4/1/1988	Springfield MSA
25-015-4002	WARE	HAMPSHIRE	QUABBIN SUMMIT	Regional	Population Exposure (Trace Level)	6/1/1985	Springfield MSA
25-027-0023	WORCESTER	WORCESTER	SUMMER STREET	Neighbor-hood	Population Exposure	1/1/2004	Boston CMSA; Worcester MSA

COVERAGE AREA

Figure 5-37 shows the area served by each SO_2 monitor as defined by Voronoi polygons. These polygons were developed using NetAssess. While the SO2 polygons show unserved areas on the Cape, Berkshire County, and the northern border area of the state, SO2 is primarily a point source pollutant, and all but one major SO2 point source has ceased operation, and the remaining source

(Brayton Point in Somerset) has significantly reduced SO2 emissions and is scheduled to close in 2017. The values at the other monitors in the state have remained low and there are no significant sources in areas that are not covered by an SO2 monitor .

Figure 5-37
Coverage Areas for SO_2 Monitor



Source: NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool
Air monitoring network assessment tool suite developed by Lake Michigan Air Directors Consortium (LADCO). It is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from December 31, 2013 .
https://ebailey78.shinyapps.io/NetAssessApp/

SO_2 DATA

Massachusetts has been in attainment of the annual, 24-hour, and 3-hour SO_2 standards since before 1985. Current monitors also show attainment with the 201 1-hour SO2 standard. MassDEP therefore does not plan additional SO2 monitoring beyond its existing monitoring network.

2014 SO_2 Data Summary

Figure 5-38 summarizes 2014 monitoring data for SO_2. The 6 SO_2 sites in operation during 2014 achieved the required 75% data capture for the year.

Figure 5-38
2014 $S0_2$ Summary Data (ppb)

SITE ID	CITY	COUNTY	ADDRESS	COMPLETED QTRS	% OBS	1ST MAX 1-HR	2ND MAX 1-HR	99TH PCTL 1-HR	1-HR MAX >75 ppb STD	ARITH MEAN
25-025-0002	Boston	Suffolk	KENMORE SQ	4	94	15.5	12.0	9.7	0	.94
25-025-0042	Boston	Suffolk	HARRISON AVE	4	95	28.4	24.2	12.3	0	1.06
25-005-1004	Fall River	Bristol	659 GLOBE ST	4	97	16.2	14.9	13.4	0	1.50
25-013-0016	Springfield	Hampden	LIBERTY ST	4	95	10.4	9.4	6.7	0	1.37
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	4	96	7.1	5.4	5.2	0	.75
25-027-0023	Worcester	Worcester	SUMMER ST	4	95	9.1	9.0	8.5	0	1.45

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER **% OBS** = DATA CAPTURE PERCENTAGE **1ST, 2ND MAX 24-HR, MAX 3-HR, MAX 1-HR** = FIRST AND SECOND HIGHEST VALUE FOR TIME PERIOD INDICATED **# OBS > 0.14** = NUMBER OF OBSERVATIONS ABOVE THE 24-HOUR STANDARD OF 0.14 PPM **# OBS > 0.50** = NUMBER OF OBSERVATIONS ABOVE THE 3-HOUR STANDARD OF 0.50 PPM **ARITH MEAN** = ANNUAL ARITHMETIC MEAN (STANDARD = 0.03 PPM)

SO_2 Design Values

Figure 5-39 shows the 2014 design value for SO_2. The annual NAAQS for SO_2 is primary standard 99^{th} percentile of the 1-hour daily maximum concentrations averaged over 3 years at a level of 75 ppb.

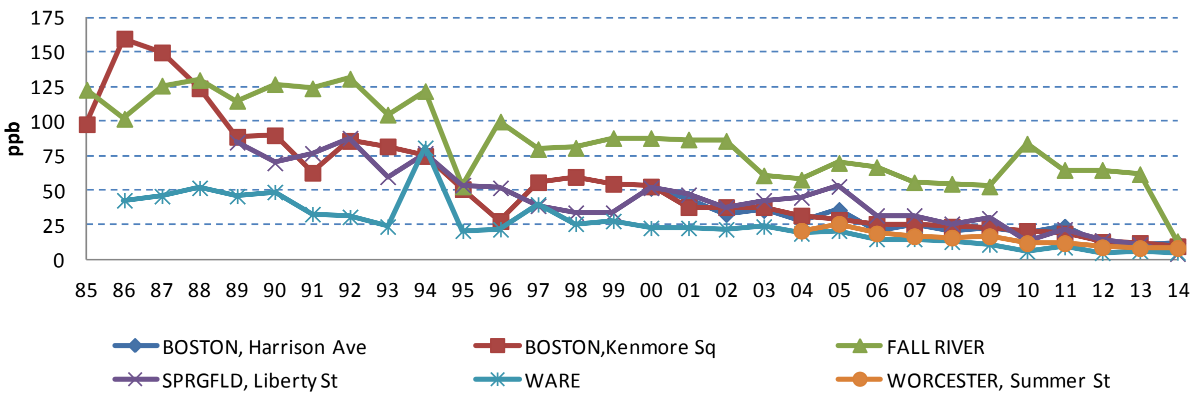
Figure 5-39
2008 2012-2014 SO_2 Design Value (ppbv)

SITE ID	SITE CITY	SITE ADDRESS	2008 2012-2014 DESIGN VALUE	
			ANNUAL MEAN	99^{th} PERCENTILE
250051004	FALL RIVER	GLOBE STREET	2.10	46.8
250130016	SPRINGFIELD	LIBERTY STREET	1.5	10.6
250154002	WARE	QUABBIN SUMMIT	0.74	5.6
250250002	BOSTON	KENMORE SQUARE	1.28	11.8
250250042	BOSTON	HARRISON AVENUE	1.09	11.7
250270023	WORCESTER	SUMMER STREET	2.46	8.7

SO_2 Trend Data

The long-term trends for each SO_2 site are shown in Figure 5-40.

Figure 5-40
SO_2 Trends 1985 – 2014
1-hour 99th Percentile Annual Average
Standard = 75 ppb (effective June 2010)



The Fall River monitor was sited near a coal-burning power plant, Brayton Point in Somerset. This plant has signficantly reduced SO_2 emissions in recent years and is scheduled to close in 2017.

SO_2 TECHNOLOGY

MassDEP uses an ultraviolet fluorescence continuous monitoring technology to measure ambient SO_2 concentrations. The same technology is used for both trace and standard monitors. 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 and no new monitors are planned. Figure 5-41 shows the PWEI and number of SO_2 monitors for the state's CBSAs.

Figure 5-41
EPA Monitoring Requirements for SO_2

COUNTY	JULY 1, 2014 POPULATION ESITMATES*			SO_2 TONS PER YEAR **	PWEI!	# REQUIRED SO_2 MONITORS***		
	COUNTY	CBSA	TOTAL MA COUNTIES IN CBSA			PER NEW RULE****	EXISTING	NEW NEEDED
Barnstable	214914	Barnstable Town MSA	214914	1309	6,253	1	0	1
Berkshire	128715	Pittsfield MSA	128715	707	326	0	0	0
Bristol	554194	Providence-New Bedford-Fall River, RI-MA MSA:	554194	20,516	22,761	1	1	0
Worcester	813475	Worcester MSA	813475	3,600	5,495	1	1	0
Essex	769091	Boston-Cambridge-Quincy, MA-NH MSA	4305936	21216	186,670	2	2 but both in Boston	0
Middlesex	1570315							
Norfolk	692254							
Plymouth	507022							
Suffolk	767254							
Hampden	468161	Springfield MSA	629100	3040	7046	1	1	0
Hampshire	160939							
	* Per US Census Bureau			** 2011 MassDEP Emissions Inventory	!*1,000,000	*** # SO_2 monitors required 1 if 5000<PWEI<100,000 2 if 100,000 <PWEI <1,000,000 3 if PWEI >1,000,000		

ANALYSIS RESULTS

Massachusetts no longer has any significant fossil fuel combustion facilities, which would warrant any new ambient SO_2 monitoring sites.

Nitrogen Dioxide (NO2)

NETWORK DESCRIPTION

MassDEP operates 10 NO_2 monitors in 8 municipalities (see Figure 5-42) 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 5 NO_2 sites for NAAQS compliance based on population exposure and operates NO_2 monitors at the 5 sites for Photochemical Assessment Monitoring Stations (PAMS) and ozone monitoring purposes

Boston - Von Hillern Street was established in 2013 as a near-road site to monitor compliance with the 1-hour NO_2 standard. Haverhill was closed in 2012 because it was redundant with the Newburyport site and Boston - Long Island was closed in 2014 when the site became inaccessible.

Figure 5-42: NO_2 Monitor Site Location, Description and Other Pollutants Monitored

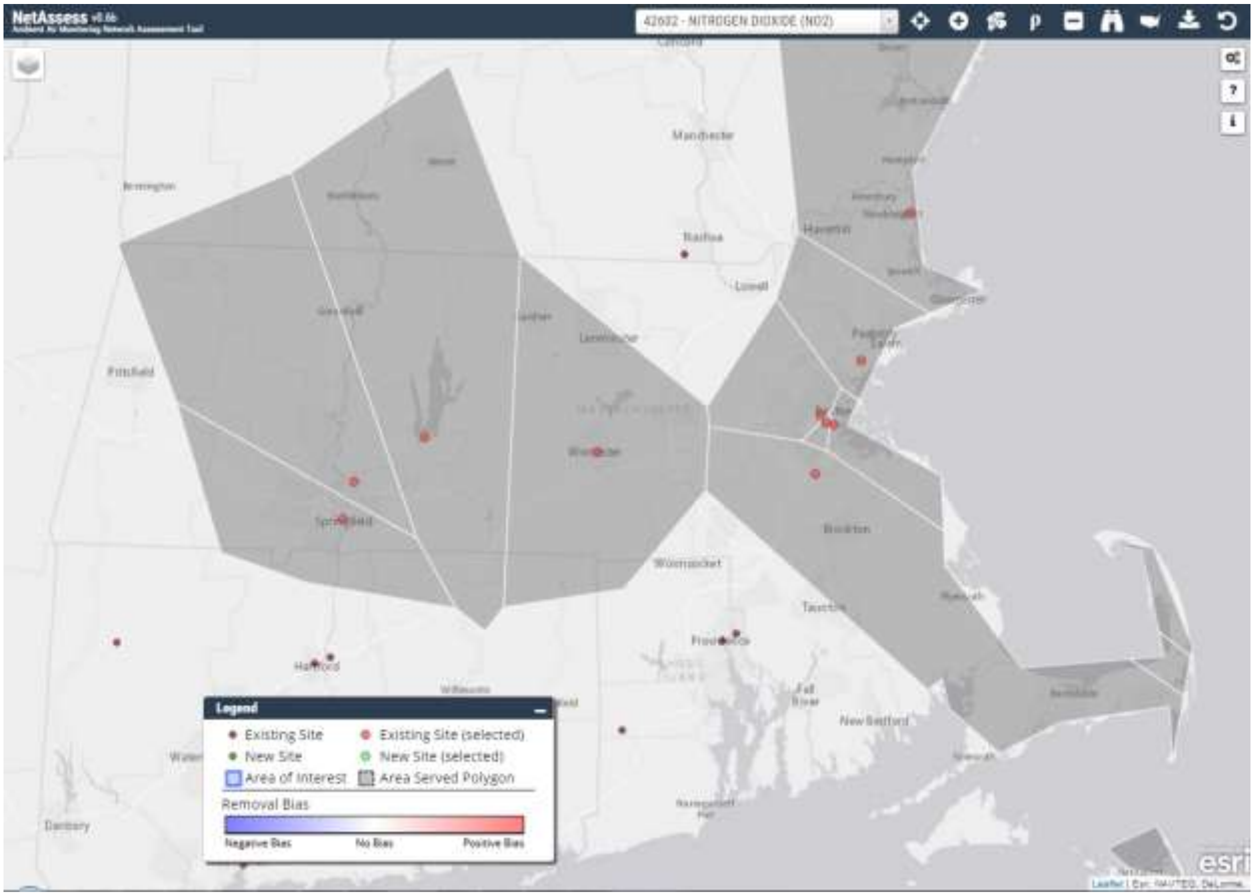
SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR NO_2 MONITOR	YEAR ESTAB-LISHED	MSA/CMSA	POLLUTANTS
25-025-0002	BOSTON	SUFFOLK	KENMORE SQUARE	Middle	-Highest Concentration Population Exposure	1/1/1965	Boston CMSA; Boston Metropolitan MSA	CO, SO_2, NO, NO_2, NO_x, PM_{10} (LV), $PM_{2.5}$ (3-day)
25-025-0042	BOSTON	SUFFOLK	HARRISON AVENUE	-CO: middle scale -Others: Neighbor-hood	Population Exposure	12/15/1998	Boston CMSA; Boston Metropolitan MSA	O_3, tCO, tSO_2, Pb, NO, NO_2, NO_x, NOY, PM_{10} (LV) (2), $PM_{2.5}$ (3-DAY) (2), $BAM_{2.5}$, VOC (TOXICS), CARBONYLS (6-DAY), BLACK CARBON, NCore, Speciation, PM_{10} (2: HV & TOXICS), PMcoarse, Cr6+, PAHS
25-025-0044	BOSTON	SUFFOLK	VON HILLERN STREET	Middle	Near Road Exposure	6/15/13	Boston CMSA; Boston Metropolitan MSA	tCO,,NO, NO_2, NO_x, $PM_{2.5}$ (3 DAY), $BAM_{2.5}$, BLACK CARBON
25-013-0008	CHICOPEE	HAMPDEN	ANDERSON ROAD	Urban	PAMS: Springfield Type 2 (Maximum Precursor)	1/1/1983	Springfield MSA	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY)(2), VOC (PAMS), CARBONYLS (PAMS), Speciation
25-009-2006	LYNN	ESSEX	390 PARKLAND	Urban	PAMs: Boston Type 2 (Maximum Precursor)	1/1/1992	Boston CMSA; Boston Metropolitan MSA	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC (TOXICS), VOC (PAMS), CARBONYLS (PAMS)
25-021-3003	MILTON	NORFOLK	MILTON MA, BLUE HILL	Urban	Transport (Upwind Background)	4/2/2002	Boston CMSA; Boston Metropolitan MSA	O_3, NO, NO_2, NO_x, $BAM_{2.5}$,

SITE ID	CITY	COUNTY	ADDRESS	SCALE	REASON FOR NO_2 MONITOR	YEAR ESTAB-LISHED	MSA/CMSA	POLLUTANTS
25-009-4005	NEWBURY-PORT	ESSEX	261 NORTHERN BLVD	Urban	PAMS Boston Type 3 (Maximum Ozone Concentration)	6/2010	Boston CMSA; Boston Metropolitan MSA	O_3, NO, NO_2, NO_X, NOA, NO_Y, VOC (PAMS)
25-013-0016	SPRINGFIE LD	HAMPDEN	LIBERTY STREET	Neigh-borhood	-Population Exposure -Maximum Concentration	4/1/1988	Springfield MSA	$PM_{2.5}$, (3-DAY), $BAM_{2.5,}$ Pb, PM_{10} (LV),,, BLACK CARBON
25-015-4002	WARE	HAMP-SHIRE	QUABBIN SUMMIT	Ozone: Urban PM: Neighbor-hood	-PAMS: Springfield Type 3 (Maximum Ozone Concentration)	6/1/1985	Springfield MSA	O_3, tSO_2, NO, NO_2, NO_x, NOA, NO_Y, PM_{10} (LV), IMPROVE. $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC (PAMS)
25-027-0023	WOR-CESTER	WOR-CESTER	SUMMER STREET	-CO: Middle Scale -Others: Neighbor-hood	Population Exposure	1/1/2004	Boston CMSA; Worcester MSA	CO, SO_2, NO, NO_2, NO_x, PM_{10} (LV), $PM_{2.5}$ (2) (3-DAY), $BAM_{2.5}$

COVERAGE AREA

Figure 5-43 shows the area served by each NO_2 monitor as defined by Voronoi polygons. These polygons were developed using NetAssess. The NO_2 polygons show an unserved area on Cape Cod as well as in northern Middlesex County. However, because the largest sources of NO_2 are roadways, the roadway network is a better indicator of area served than the polygons. Significant roadway interchanges in these areas are near Lowell and on roadways leading to Cape Cod (seasonally).

Figure 5-43
NO_2 Monitor Coverage Area



Source: NetAssess v0.6b Ambient Air Monitoring Network Assessment Tool
Air monitoring network assessment tool suite developed by Lake Michigan Air Directors Consortium (LADCO). It is an update of the original EPA Network Assessment tools developed by Mike Rizzo for the 2010 5-year Network Assessment. The latest data in this version is from December 31, 2013 .
https://ebailey78.shinyapps.io/NetAssessApp/

NO_2 DATA

2014 NO_2 Data Summary

A summary of the 2014 NO_2 data is shown in Figure 5-44. There were 11 NO_2 sites in operation during 2014 in the state-operated monitoring network. All sites met the requirement of 75% data capture for the year with the exception of Boston - Long Island, which was closed in October.

Figure 5-44
Summary of 2014 NO_2 Monitoring Data

SITE ID	CITY	COUNTY	ADDRESS	COMPLETED QTRS	% OBS	1ST MAX 1-HR	2ND MAX 1-HR	98TH PERCENTILE VALUE	ARITH MEAN
25-025-0002	Boston	Suffolk	KENMORE SQ	4	92	52.0	52.0	49.0	17.17
25-025-0041	Boston	Suffolk	LONG ISLAND	3	73	54.0	45.0	38.0	6.52*
25-025-0042	Boston	Suffolk	HARRISON AVE	4	94	62.0	60.0	51.0	15.76
25-025-0044	Boston	Suffolk	19 VON HILLERN	4	95	64.0	62.0	53.0	17.49
25-013-0008	Chicopee	Hampden	ANDERSON RD AFB	4	93	46.0	45.0	41.0	7.11
25-009-2006	Lynn	Essex	390 PARKLAND	4	95	48.0	46.0	42.0	7.11
25-021-3003	Milton	Norfolk	695 HILLSIDE ST	4	93	42.0	41.0	28.0	4.64
25-009-4005	Newburyport	Essex	HARBOR STREET	4	94	40.0	39.0	25.0	3.85
25-013-0016	Springfield	Hampden	LIBERTY STREET	4	95	50.0	44.0	42.0	13.35
25-015-4002	Ware	Hampshire	QUABBIN SUMMIT	4	91	26.0	20.0	17.0	2.78
25-027-0023	Worcester	Worcester	SUMMER ST	4	95	60.0	53.0	49.0	13.01

STANDARDS: Annual Arithmetic Mean = 53 ppb 1-hour = 100 ppb
Note: * indicates that the mean does not satisfy summary criteria.

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION NUMBER **% OBS** = DATA CAPTURE PERCENTAGE **1^{ST}, 2^{ND} MAX 1-HR** = FIRST AND SECOND HIGHEST VALUE FOR TIME PERIOD INDICATED **ARITH MEAN** = ANNUAL ARITHMETIC MEAN

NO_2 Design Values

Figure 5-45 shows the 2008 design values for NO_2. The NO_2 annual average NAAQS is 53 ppb, and the design value is the highest average annual 1-hour average the past three years. The NO_2 1-hour maximum NAAQS is 100 ppb. The design value is the 3-year average of the annual 98^{th} percentile of the daily 1-hour maximum.

Figure 5-45
2014 Design Values for NO_2

Site ID	Site City	Site Address	2012-2014 Average Annual Mean Std = 53 ppb	2012-2014 98th Percentile 1-hour maximum Design Value Std = 100 ppb
250092006	LYNN	390 PARKLAND	7.55	41.0
250094005	NEWBURYPORT	[2]HARBOR STREET	3.84	25.7
250130008	CHICOPEE	ANDERSON ROAD	6.89	38.3
250130016	SPRINGFIELD	LIBERTY STREET	13.57	42.3
250154002	WARE	QUABBIN SUMMIT	2.68	20.7
250213003	MILTON	BLUE HILL	4.22	26
250250002	BOSTON	KENMORE SQUARE	18.02	48.7
250250041	BOSTON	[1]LONG ISLAND	6.58	36.3
250250042	BOSTON	HARRISON AVENUE	16.33	48.3
250250044	BOSTON	VON HILLERN STREET	*17.43	*50.33
250270023	WORCESTER	SUMMER STREET	12.53	47.3

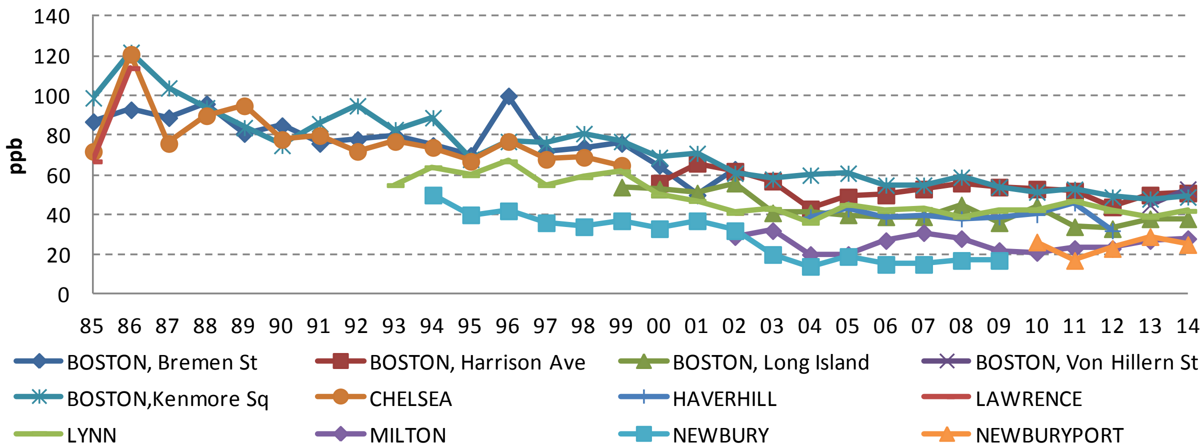
* Von Hillern Street started in July 2013.

1. Long Island closed in October 2014.
2. As PAMS sites, Milton and Long Island were seasonal (May to September) until 2014. Newburyport was a seasonal PAMS site until 2013, when it permanently replaced Haverhill NOx as the regional monitor.

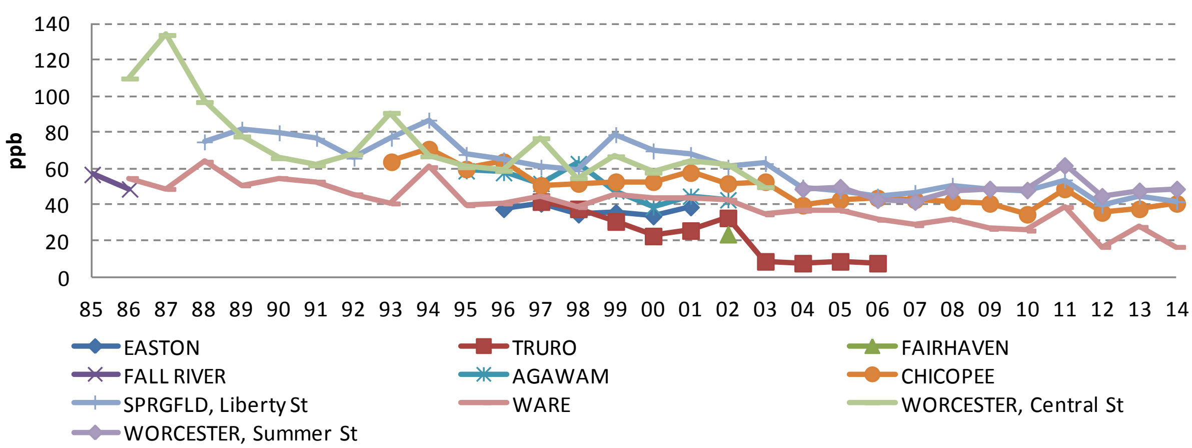
NO_2 Trends Data

The long-term trends for each NO_2 site are shown in Figure 5-46

Figure 5-46
NO_2 Trends 1985 – 2014
1-hour 98th Percentile Annual Average
Standard = 100 ppb



NO_2 Trends 1985 – 2009 Annual Arithmetic Means (Standard = 0.053 ppm)



TECHNOLOGY

MassDEP uses continuous chemiluminescence-based instruments to measure NO_2, NO_x, NO_y and NOA. There is no plan to change the equipment at this time. Chemilumenescent NOx monitors measure NO_2 indirectly, by subtracting NO (Nitric Oxide) from NOx (total oxides of nitrogen). Under some circumstances, this difference can include the inadvertent inclusion of other nitrogen compounds. Within the last year a new analyzer (Cavity Attenuated Phase Shift) has become available, which measures NO_2 directly. MassDEP is interested in this technology; however, the current application is unclear since NO_2 measured at urban locations contains very small quantities of the confounding nitrogen compounds because they represent fresh emissions, and values measured at downwind PAMS locations are low so that differences and resolution may be negligible.

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 near heavily traveled roadways, as well as community-wide monitoring. The number of "roadway" and "area wide" monitors required in each Core Based Statistical Area (CBSA) in the state depends upon the CBSA's population and the Annual Average Daily Traffic counts (AADTs) for major roadways in the CBSA as follows:

- 1 roadway monitor if the CBSA population is between 500,000 and 2,500,000,
- 2 roadway monitors if the CBSA population greater than 2,500,000,
- 1 additional roadway if the AADT is greater than 250,000 for any road segment in the CBSA,
- 1 area wide monitor if the CBSA population is greater than 1,000,000.

Figure 5-47 shows the number of NO_2 monitors required in each Massachusetts CBSA.

Figure 5-47
EPA NO_2 Monitoring Requirements

County	July 1 2014 Population (US Census Bureau Estimate)				# Required NO_2 Monitors				
	County	CBSA	Total: CBSA	Total: MA Counties in CBSA	Roadway based on population	Roadway based on AADT *	Com-munity wide	Existing	New needed in CBSA
Barnstable	214,914	Barnstable Town MSA	214,914	214,914	0	0	0	0	0
Berkshire	128,715	Pittsfield MSA	128,715	128,715	0	0	0	0	0
Bristol	554,194	Providence-Warwick, RI-MA Metro Area	1609367 1	554,194	1	0	0	1 RI	0
Worcester	813,475	Worcester MSA	813,475	813,475	1	0	0	1 area	1 roadway
Essex	769,091	Boston-Cambridge-Newton, MA-NH Metro Area	4732161 4	4,305,936	2	0	0	6 area	1 roadway (one operating)
Middlesex	1,570,315								
Norfolk	692,254								
Plymouth	507,022								
Suffolk	767,254								
Hampden	468,161	Springfield MSA	698,903	624,411	1	0	0	2 area	1 roadway
Hampshire	160,939								
Franklin	70862			70862					

* MassDOT data 2005-2007 shows no segment exceeding 250,000 AADTs
ttp://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2014_PEPANNRES&src=pt

ANALYSIS RESULTS

As shown in Figure 5-47, near-road requirements for Massachusetts include:

- 2 roadway sites in the Boston-Cambridge-Quincy, MA-NH MSA
- 1 roadway site in the Worcester MSA
- 1 roadway site in the Springfield MSA
- 1 roadway site and 1 community-wide site in the Providence-New Bedford-Fall River, RI-MA MSA (these 2 monitors could be sited in RI)

The siting of monitors in Rhode Island has satisfied the Southeastern Massachusetts requirement. MassDEP sited one near-road monitor in the Boston Area at Von Hillern Street in 2013, and is in the process of locating a second site in the Boston Area in Chelmsford at the I-495 and Route 3 intersection or in Woburn at the I-95 and I-93 intersection.

Because of the complexity of NO_2 measurements, which requires subtracting nitric oxide (NO) concentrations from total nitrogen oxides (NO_x) concentrations, NO_2 monitoring requires more attention than the other continuous gaseous pollutants. Start up costs for near-road sites are considerable and the ongoing operational costare high as well. Since near-road measurements at one or two locations may be representative of near-road environments elsewhere, EPA is considering forgoing the last two phases of near-road monitoring, which for Massachusetts would be sites in Worcester and Springfield.

MassDEP believes that its existing Boston – Von Hillern Street near-road monitor and a potential second monitor North of Boston, together with the NO_2 monitors in Rhode Island, provide sufficient NO_2 monitoring coverage.

Lead (Pb)

NETWORK DESCRIPTION

MassDEP monitored lead at the Boston-Kenmore Square site (on Total Suspended Particulate filters) for over 25 years. There was a three year hiatus in the mid-1990s when all lead monitoring in New England was discontinued because measured lead values had decreased dramatically after the phase-out of leaded gasoline. MassDEP resumed monitoring at the Boston-Kenmore Square site at the request of EPA for trends purposes. Lead sampling moved from Kenmore Square to Harrison Avenue (Boston) in 2009, after a prescribed downsizing of the Kenmore site foot print.

After the lead NAAQS was lowered in 2008, the monitoring methodology was changed to the collection of samples using low volume PM_{10} samplers. This methodology takes advantage of existing PM_{10} samplers at NCore sites, where lead sampling is required. MassDEP started monitoring for PM_{10} Lead in 2010 and discontinued TSP based Lead there in 2011. MassDEP also decided to monitor lead in Springfield (currently at Liberty Street). As required, MassDEP also conducted a source-oriented one-year air monitoring study for lead adjacent to the main runway at Nantucket Memorial Airport. This was part of a 15 airport nation-wide study of lead emissions from gasoline-fueled airplane take-offs and landings. Monitoring for this study was from January 2012 to February 2013.

LEAD MONITORING DATA

Massachusetts has been in compliance for more than 25 years with the 1.5 µg/m^3 annual standard. In 2008, EPA lowered the annual NAAQS for lead from 1.5 µg/m^3 to 0.15 µg/m^3 and established new requirements for measuring lead. Monitoring data collected in Boston and Springfield since 2011 indicates that Massachusetts continues be well below the 2008 lead standard. Concentrations measured by the year-long Nantucket Airport study also show levels well below the NAAQS.

2014 Pb Data Summary

A summary of the 2014 Pb data is shown in Figure 5-48.

Figure 5-48

SITE ID		CITY	COUNTY	ADDRESS	# OBS	1ST MAX VALUE	2ND MAX VALUE	3RD MAX VALUE	4TH MAX VALUE	ARITH MEAN
25-013-2009		Springfield	Hampden	1860 MAIN ST	58	.008	.008	.008	.008	.003
25-025-0042		Boston	Suffolk	HARRISON AVE	59	.007	.007	.007	.007	.003
25-025-0042	colloc	Boston	Suffolk	HARRISON AVE	30	.006	.005	.005	.005	.003

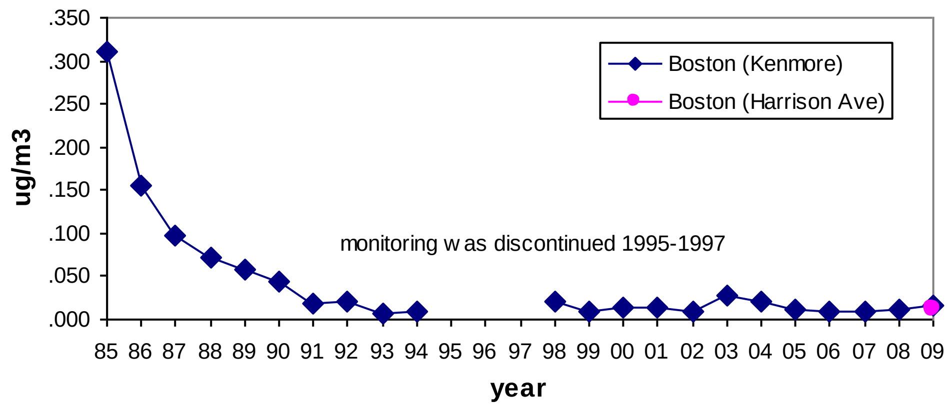
STANDARD: 0.15 µg/m^3 (rolling 3-month average)

ABBREVIATIONS AND SYMBOLS USED IN TABLE
SITE ID = AIRS SITE IDENTIFICATION; **#OBS** = NUMBER OF OBSERVATIONS; **1ST, 2ND, 3rd, 4th MAX VALUE** = 1ST, 2ND, 3rd, 4th MAXIMUM 24-HOUR VALUES; **ARITH MEAN** = ARITHMETIC MEAN

Pb Trend Data

Figure 5-49 shows the trends in lead concentrations from 1985 – 2009 (when the legacy method was in place), showing a dramatic decline in ambient lead concentrations, which were already in steep decline, after the removal of lead from gasoline in 1975. The flattening of the trend in the 1990's demonstrates the removal of most pre-1975 vehicles from the fleet. Recently measured ambient data shows that ambient lead levels are well below the 2008 NAAQS, which is ten times more stringent than the previous one.

Figure 5-49
Pb Concentrations 1985 – 2009
Annual Arithmetic Mean
Standard = 1.5 ug/m3



TECHNOLOGY

MassDEP currently collects Teflon low volume PM_{10} samples at the Boston - Harrison Avenue and Springfield - Liberty Street sites, which are analyzed via X-ray fluorescence by EPA contractors. This methodology replaced laboratory-based acid digestion and atomic absorption analysis of samples collected with a high-volume Total Suspended Particulate (TSP) sampler. The samples are taken every 6^{th} day for 24 hours.

ADEQUACY OF THE MONITORING NETWORK

EPA Requirements

In addition to the NCore monitoring, EPA requires monitoring near lead sources that emit 0.5 tons or greater annually. Massachusetts does not have any source of lead emissions that meet this level. MassDEP has completed the required 1-year monitoring at Nantucket Memorial Airport.

ANALYSIS RESULTS

Average measured concentrations at the Boston and Springfield sites are well below the lead NAAQS of 0.15 ug/m^3. MassDEP has no plans to expand lead monitoring. MassDEP will continue lead monitoring at the Boston - Harrison Avenue site as long as it is a NATTS (National Air Toxics Trends Site) site, since it is a byproduct of toxics metals analysis.

Meteorology

NETWORK DESCRIPTION

MassDEP operates the following types of meteorological intruments 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

MassDEP also is operating a continuous atmospheric radiation sampler for the EPA National Air and Radiation Environmental Laboratory (EPA NAREL) at the Worcester-Summer Street site.

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

- Ware –Quabbin Reservoir operated by the University of Massachusetts, Amherst
- Truro - operated by the National Park Service

Figure 5-50 describes all of the meteorological monitors MassDEP operates.

Figure 5-50
Description of Existing Meteorological Monitoring Network

SITE ID	CITY	ADDRESS	METEOROLOGICAL	POLLUTANTS
25-025-0044	BOSTON	VON HILLERN STREET	WS/WD, TEMP, RH, BP, SOLAR	tCO,,NO, NO_2, NO_x, $PM_{2.5}$,(3 DAY), $BAM_{2.5}$, BLACK CARBON
25-025-0042	BOSTON	HARRISON AVENUE	WS/WD, TEMP, RH, BP, SOLAR	O_3, tCO, tSO_2, Pb, NO, NO_2, NO_x, NO_Y, PM_{10} (LV) (2), $PM_{2.5}$,(3-DAY) (2), $BAM_{2.5}$, VOC (TOXICS), CARBONYLS (6th-DAY), BLACK CARBON -*SPECIAL MONITOR*ING: NCore, Speciation, PM10 (2: HV & TOXICS), PM_{coarse}, Cr6+, PAHS
25-013-0008	CHICOPEE	ANDERSON ROAD	WS/WD, TEMP, RH, BP, SOLAR	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY)(2), VOC (PAMS), CARBONYLS (PAMS) *SPECIAL MONITORING:* Speciation, tCO
25-005-1002	FAIRHAVEN	HASTINGS SCHOOL	WS/WD, TEMP, RH, BP, SOLAR	O_3
25-011-2005	GREENFIELD	VETERANS FIELD	WS/WD, TEMP, RH, BP, SOLAR	O_3, $PM_{2.5}$,(3 DAY), $BAM_{2.5}$

SITE ID	CITY	ADDRESS	METEOROLOGICAL	POLLUTANTS
25-009-5005	HAVERHILL	WASHINGTON STREET	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY), $BAM_{2.5}$
25-009-2006	LYNN	390 PARKLAND	FULL MET & PRECIP	O_3, tCO, NO, NO_2, NO_x, $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC (TOXICS), VOC (PAMS), CARBONYLS (PAMS)
25-021-3003	MILTON	MILTON MA, BLUE HILL	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, $BAM_{2.5}$, VOC (PAMS)
25-009-4005	NEWBURYPORT	261 NORTHERN BLVD	WS/WD, TEMP, RH, BP, SOLAR	O_3, NO, NO_2, NO_x, NOA, NO_Y, VOC (PAMS)
25-001-0002	TRURO	FOX BOTTOM AREA	WS/WD, TEMP, RH, BP, SOLAR	O_3, IMPROVE, $PM_{2.5}$ (3-DAY)
25-027-0024	UXBRIDGE	366 E. HARTFORD AVE.	WS/WD, TEMP, RH, BP, SOLAR	O_3
25-015-4002	WARE	QUABBIN SUMMIT	FULL MET & PRECIP	O_3, tSO_2, NO, NO_2, NO_x, NOA, NO_Y, PM_{10} (LV), IMPROVE, $PM_{2.5}$ (3-DAY), $BAM_{2.5}$, VOC (PAMS)
25-027-0015	WORCESTER	WORCESTER. AIRPORT	WS/WD, TEMP	O_3

TECHNOLOGY

The Figure 5-51 below summarizes the technology MassDEP uses to measure meteorology. There are no plans to change existing technology.

Figure 5-51
Meteorological Monitoring Technology

PARAMETER	WORKSHEET ABBREVIATION	SAMPLING METHODOLOGY	ANALYTICAL METHOD	SAMPLE FREQUENCY	COMMENTS
Wind Speed/Direction	WS/ WD	Continuous Instrument	Ultrasonic Sensors	Hourly	Thirteen Meteorological Sites in State
Solar	SOLAR	Continuous Instrument	Pyranometer	Hourly	Thirteen Meteorological Sites in State
Relative Humidity	RH	Continuous Instrument	Electronic Sensor	Hourly	Thirteen Meteorological Sites in State
Ambient Temperature	TEMP	Continuous Instrument	Electronic Thermister	Hourly	Thirteen Meteorological Sites in State
Barometric Pressure	BP	Continuous Instrument	Electronic Sensor	Hourly	Thirteen Meteorological Sites in State
Precipitation	Precip	Continuous Instrument	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. Plans to install meteorological equipment at a new Pittsfield Area (Berkshire County) site in the 2015/2016 timeframe will provide better coverage for the far western part of Massachusetts.

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) level 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.

Date Acquisition System

- MassDEP's data system is capable of a digital system, remote diagnostics, and remotely enabled checks. Over the past three years, 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 4 field sites 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;
- A Gas Chromatograph-Mass Spectrometer for measuring trace levels of Toxic VOCs; and
- A Field Gas Chromatograph (at Boston - Kenmore Square) for measuring trace levels of selected Toxic VOCs.