pscleanair.org
Puget Sound Clean Air Agency

1904 Third Avenue, Suite 105
Seattle, Washington 98101
www.pscleanair.org

2018

Air Quality Data Summary

September 2019

Working Together for Clean Air

Table of Contents

List of Figures

List of Maps

List of Tables

Appendix – Data Tables

The 2018 Air Quality Data Summary is available
for viewing or download on the internet at:

www.pscleanair.org

Links to additional documents for download are also available at the web site.

This material is available in alternate formats for people with disabilities. Please call Joanna Cruse at (206) 689-4067 (1-800-552-3565, ext. 4067).

Executive Summary

The Puget Sound Clean Air Agency (the Agency) summarizes air quality data from our core monitoring network every year. This report summarizes regional air quality by presenting air quality monitoring results for six criteria air pollutants and air toxics. The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards (NAAQS) for the criteria pollutants. The criteria pollutants are:

- Particulate Matter (particles 10 micrometers [PM_{10}] and 2.5 micrometers in diameter [$PM_{2.5}$])
- Ozone
- Nitrogen Dioxide
- Carbon Monoxide
- Sulfur Dioxide
- Lead (monitoring discontinued due to very low levels)

Air toxics are defined by Washington State and the Agency to include hundreds of chemicals and compounds that are associated with a broad range of adverse health effects, including cancer.[1] Many air toxics are a component of either particulate matter or volatile organic compounds (a precursor to ozone). The Air Quality Index (AQI) is a nationwide reporting standard for the criteria pollutants. The AQI is used to relate air quality levels to health effects in a simplified way, and is intended mainly for forecasting and real-time communication. "Good" AQI days continued to dominate our air quality in 2018. However, air quality degraded into "moderate", "unhealthy for sensitive groups", or "unhealthy" for brief periods.

The Agency and the Washington State Department of Ecology (Ecology) work together to monitor air quality within the Puget Sound region.[2] The Agency's jurisdiction includes King, Snohomish, Pierce, and Kitsap counties. Real-time air monitoring data are available for pollutants at https://www.pscleanair.org/157/Request-Air-Quality-Data. To receive the Agency's most updated news and stay current on air quality issues in King, Kitsap, Pierce and Snohomish counties, visit http://www.pscleanair.org/258/Connect-With-Us and select your favorite news feed method. Friends and subscribers receive the latest on air quality news and updates on projects in the Puget Sound region. You can also find us on Facebook and Twitter.

Data included in this report are for our core monitoring network. We also perform local, seasonal monitoring studies – you can see reports on these study results at the library on our website at http://www.pscleanair.org/.

The Agency and Ecology continued to monitor the region's air quality in 2018. Over the last two decades, many pollutant levels have declined and air quality has improved overall. In 2018, there were several periods when wildfire smoke caused degraded air quality, so 2018 did not show improving

[1] Washington Administrative Code 173-460. See Table of Toxic Air Pollutants, WAC 173-425-150. apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150

[2] The Agency's jurisdiction covers King, Kitsap, Pierce, and Snohomish Counties in Washington State.

trends. While air quality is improving overall, we face challenges. The Environmental Protection Agency (EPA) regularly revises national ambient air quality standards as directed by the Clean Air Act to protect public health.

Elevated fine particle levels pose the greatest air quality challenge in our jurisdiction. While fine particle levels met EPA's health-based standard of 35 micrograms per cubic meter in 2018, sites in four counties (King, Pierce, Kitsap, and Snohomish) exceeded the Agency's more stringent local $PM_{2.5}$ health goal of 25 micrograms per cubic meter.

Ozone levels remain a concern in our region. The Enumclaw Mud Mountain monitor has the highest regional ozone concentrations, at levels above the revised 2015 federal standard.

Air toxics were measured at levels that posed adverse health effects. These health effects include, but are not limited to, increased cancer risk, respiratory, and developmental effects.

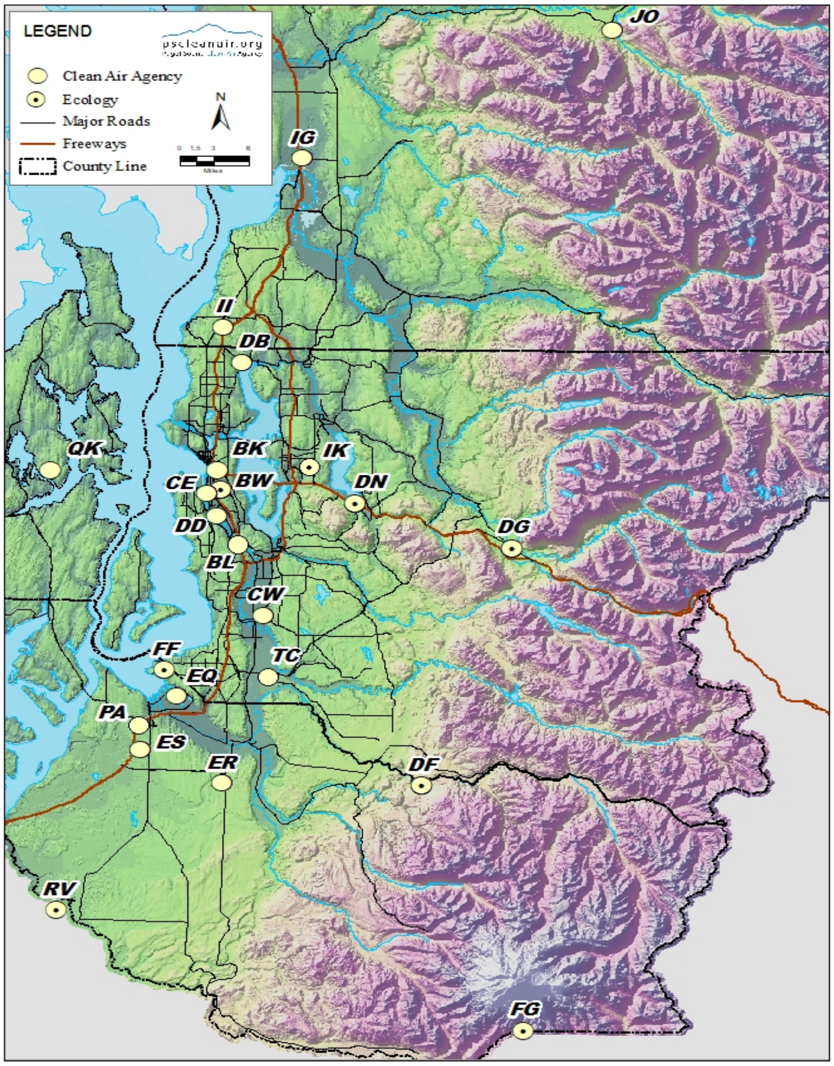
Increasingly, our air quality monitoring program is moving towards local, short-term studies that inform on a local scale what air quality is like in communities with specific impacts (for example, communities located near major roadways).

Monitoring Network

The Puget Sound Clean Air Agency (the Agency) and the Washington State Department of Ecology (Ecology) operated the Puget Sound region's monitoring network in 2018. The network is comprised of meteorological, pollutant-specific equipment, and equipment for special studies. Data from the network are normally collected automatically via the Ecology data network, or in some cases, collected manually by field staff. Monitoring stations are located in a variety of geographic locations in the Puget Sound region. Monitors are sited according to EPA criteria to ensure a consistent and representative picture of air quality.

Map 1 and Table 1 show King, Pierce, Snohomish, and Kitsap County monitoring sites used in 2018. An interactive map is available at https://secure.pscleanair.org/AirQuality/NetworkMap.

Map 1: Active Air Quality Monitoring Station Locations 2018



BK	Seattle 10th & Weller
BL	Tukwila
BW	Seattle Beacon Hill
CE	Seattle Duwamish
CW	Kent
DB	Lake Forest Park
DD	Seattle South Park
DF	Enumclaw Mud Mt Dam
DG	North Bend
DN	Lake Sammamish State Park
EQ	Tacoma Alexander
ER	Puyallup South Hill
ES	Tacoma South L Street
FF	Tacoma Indian Hill
FG	Mount Rainier
IG	Marysville
II	Lynnwood
IK	Bellevue
JO	Darrington
PA	Tacoma South 36th
QK	Bremerton Spruce
RV	Yelm
TC	Auburn

Table 1: Air Quality Monitoring Network Parameters 2018

Station ID	Location	$PM_{2.5}$ Ref	$PM_{2.5}$ Spec	$PM_{2.5}$ FEM	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
BK◉	10th & Weller, Seattle SPECIATION SITE		●	●		●			●	●		●	●	●		a
BL	11675 44th Ave S, Tukwila Allentown			●	●	●					●	●	●		●	b, e, f
BW◉	Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE	●	●	●			●	●	●	●		●	●	●		b, d, f
CE	Duwamish, 4700 E Marginal Way S, Seattle			●	●	●					●	●	●		●	a, e
CW	James St & Central Ave, Kent			●	●	●					●	●	●		●	b, d
DB	17171 Bothell Way NE, Lake Forest Park				●						●	●			●	b, d, f
DD	South Park, 8201 10th Ave S, Seattle				●						●				●	b, e, f
DF◉	30525 SE Mud Mountain Road, Enumclaw						●					●	●			c
DG◉	42404 SE North Bend Way, North Bend				●		●				●	●	●		●	c, d, f
DN◉	20050 SE 56th, Lake Sammamish State Park, Issaquah						●									b, d
EQ	Tacoma Tideflats, 2301 Alexander Ave,				●	●					●	●			●	a, e
ER	South Hill, 9616 128th St E, Puyallup				●						●	●	●		●	b, f
ES	7802 South L St, Tacoma SPECIATION SITE	●	●	●	●	●					●	●	●		●	b, f
FF◉	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma											●	●			b, f
FG◉	Mt Rainier National Park, Jackson Visitor Center						●									c
IG	Marysville JHS, 1605 7th St, Marysville SPECIATION SITE			●	●	●					●	●	●		●	b, d
II	6120 212th St SW, Lynnwood			●	●						●	●	●		●	b, d
IK	14310 SE 12th St, Bellevue				●						●				●	a, d
JO	Darrington High School, Darrington 1085 Fir St			●	●						●	●	●		●	d, f
PA	1802 S 36th St, Tacoma			●					●			●	●			a, f
QK	Spruce, 3250 Spruce Ave, Bremerton			●	●						●	●	●		●	b, f
TC	M St SE, Auburn			●	●						●	●	●		●	b, f

⦿	Station operated by Ecology	SO_2	Sulfur Dioxide
⬣	Indicates parameter currently monitored	NO_y	Nitrogen Oxides
$PM_{2.5}$ ref	Particulate matter <2.5 micrometers (reference)	CO	Carbon Monoxide
$PM_{2.5}$ Spec	Speciation	b_{sp}	Light scattering by atmospheric particles (nephelometer)
$PM_{2.5}$ FEM	Particulate matter <2.5 micrometers (TEOM-fdms continuous	Wind	Wind direction and speed
$PM_{2.5}$ ls	Particulate matter <2.5 micrometers (light scattering nephelometer continuous)	Temp	Air temperature (relative humidity also measured at BW, IG, ES)
$PM_{2.5}$ bc	Particulate matter <2.5 micrometers black carbon (light absorption aethalometer)	AT	Air Toxics
O_3	Ozone (May through September except Beacon Hill and Mt Rainier)	VSBY	Visual range (light scattering by atmospheric particles)
		PHOTO	Visibility (camera)
Location			
a	Urban Center	d	Commercial
b	Suburban	e	Industrial
c	Rural	f	Residential

The Agency conducted monitoring as early as 1965. A summary of the monitoring stations and parameters used over the history of the program is on page A-3 of the Appendix. The network changes periodically because the Agency and Ecology regularly re-evaluate monitoring objectives, resources and logistics.

Page A-2 of the Appendix shows a list of the methods used for monitoring the criteria pollutants. Additional information on these methods is available at EPA's website at epa.gov/ttn/amtic/. Information on air toxics monitoring methods is available at epa.gov/ttn/amtic/airtox.html.

Air Quality Index

EPA established the air quality index (AQI) as a simplified index for communicating daily air quality for forecasts and near real-time information. People can use this information to plan their daily activities. The AQI indicates how clean or polluted air is and what associated health effects might be a concern. It focuses on health effects that may be experienced within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter or PM), carbon monoxide, sulfur dioxide, and nitrogen dioxide.

EPA mainly developed the AQI as a daily indicator or forecast of air quality. To view the real-time AQI for your area, visit http://www.airnow.gov. For more information about local air quality, visit http://www.pscleanair.org/27/Air-Quality.

A higher AQI indicates higher levels of air pollution and corresponding health concern. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. It's important to note that health effects can be experienced even at "good" or "moderate" levels.

The purpose of the AQI is to help people understand what local air quality means to health. To make it easier to understand, the AQI is divided into six categories:

Air Quality Index (AQI) Values	**Levels of Health Concern**	**Colors**
When the AQI is:	*...air quality condition is:*	*...look for this color:*
0 – 50	**Good**	**Green**
51 – 100	**Moderate**	**Yellow**
101 – 150	**Unhealthy for Sensitive Groups**	**Orange**
151 – 200	**Unhealthy**	**Red**
201 – 300	**Very Unhealthy**	**Purple**
301 - 500	**Hazardous**	**Maroon**

Table 2 shows the AQI breakdown by percentage in each category for 2018. Most days in the Puget Sound region are in the “Good” category, but local meteorological conditions, along with polluting sources, cause levels to rise into “Moderate” or above. 2018 presented a challenge in air quality because of the numerous wildfires that caused high levels of smoke – which formed into both fine particulate matter ($PM_{2.5}$) and ozone pollution. See the appendix for more information on the AQI.

Table 2: Air Quality Index (AQI) Ratings for 2018

	AQI Rating (% of year)				
County	**Good**	**Moderate**	**Unhealthy for Sensitive Groups**	**Unhealthy**	**Highest AQI**
Snohomish	78.9 %	18.6 %	1.4 %	1.1%	177
King	73.2 %	23.0 %	2.2 %	1.6 %	192
Pierce	77.0 %	20.3 %	1.1 %	1.6 %	178
Kitsap	95.3 %	3.0 %	0.6 %	1.1 %	172

Particulate Matter

"Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

PM_{10}

PM_{10} is particulate matter with a diameter of 10 micrometers (or microns) or less. The Agency ceased direct PM_{10} monitoring in 2006. For a historic look at Puget Sound area PM_{10} levels, please see the 2007 data summary.

$PM_{2.5}$ Health and Environmental Effects

$PM_{2.5}$ (or fine particulate matter) has a diameter of 2.5 microns or less. An extensive body of scientific evidence shows that exposure to particle pollution is linked to a variety of significant health problems, such as increased hospital admissions and emergency department visits for cardiovascular and respiratory problems, including non-fatal heart attacks and premature death. Older adults, children, pregnant women, and those with pre-existing health conditions are more at risk from exposure to particle pollution. Particle pollution also reduces visibility in cities and some of our nation's most treasured national parks.

Fine particles are emitted directly from a variety of sources, including wood burning (both outside, and in wood stoves and fireplaces), vehicles and industry. They also form when gases from some of these same sources react in the atmosphere.

Ultrafine Particulate Matter (UFP)

Emerging health studies indicate that very tiny ultrafine particles with a diameter of 0.1 micron and less may be linked with health effects. We have started learning new methods for measuring and assessing ultrafine particles. The technology is not yet ready to add to our core monitoring network.

$PM_{2.5}$– Federal Reference Method and Continuous Methods

Fine particulate matter ($PM_{2.5}$) is measured using a variety of methods to ensure quality and consistency. EPA has defined a filter-based method as the federal reference method (FRM)—the primary method used to determine $PM_{2.5}$ concentrations. EPA further defined several federal equivalent methods (FEM), which are continuous instruments operated under specific standard operating procedures. The advantage of continuous FEMs is that they provide highly time-resolved data (hourly averages).

The Agency uses the FRM, FEMs, and a nephelometer estimation method to provide data. These methods determine fine particulate matter concentration differently:

- The FRM involves pulling in air (at a given flow rate) for a 24-hour period and collecting particles with a diameter of 2.5 microns or smaller on a filter. The filter is weighed and the mass is divided by air volume (determined from flow rate and amount of time) to provide concentration. Particles on the filter can later be analyzed for more information about the types of particulate matter.
- There are now three FEM instruments used in the network: (1) The tapered element oscillating microbalance-filter dynamic measurement system (TEOM-FDMS), (2) The TEOM 1405F, a newer model that replaced the TEOM-FDMS, and (3) The Met-One BAM, a beta attenuation monitor which uses the attenuation of beta radiation to assess the $PM_{2.5}$ mass on a filter tape.
- The nephelometer measures the scattering of light in a photomultiplier tube; its results are then compared to FRM and FEM method data to produce an estimate of $PM_{2.5}$. While light scattering has been proven to correlate well with direct $PM_{2.5}$ measurements, this is an “unofficial” method because it does not measure particle mass directly.

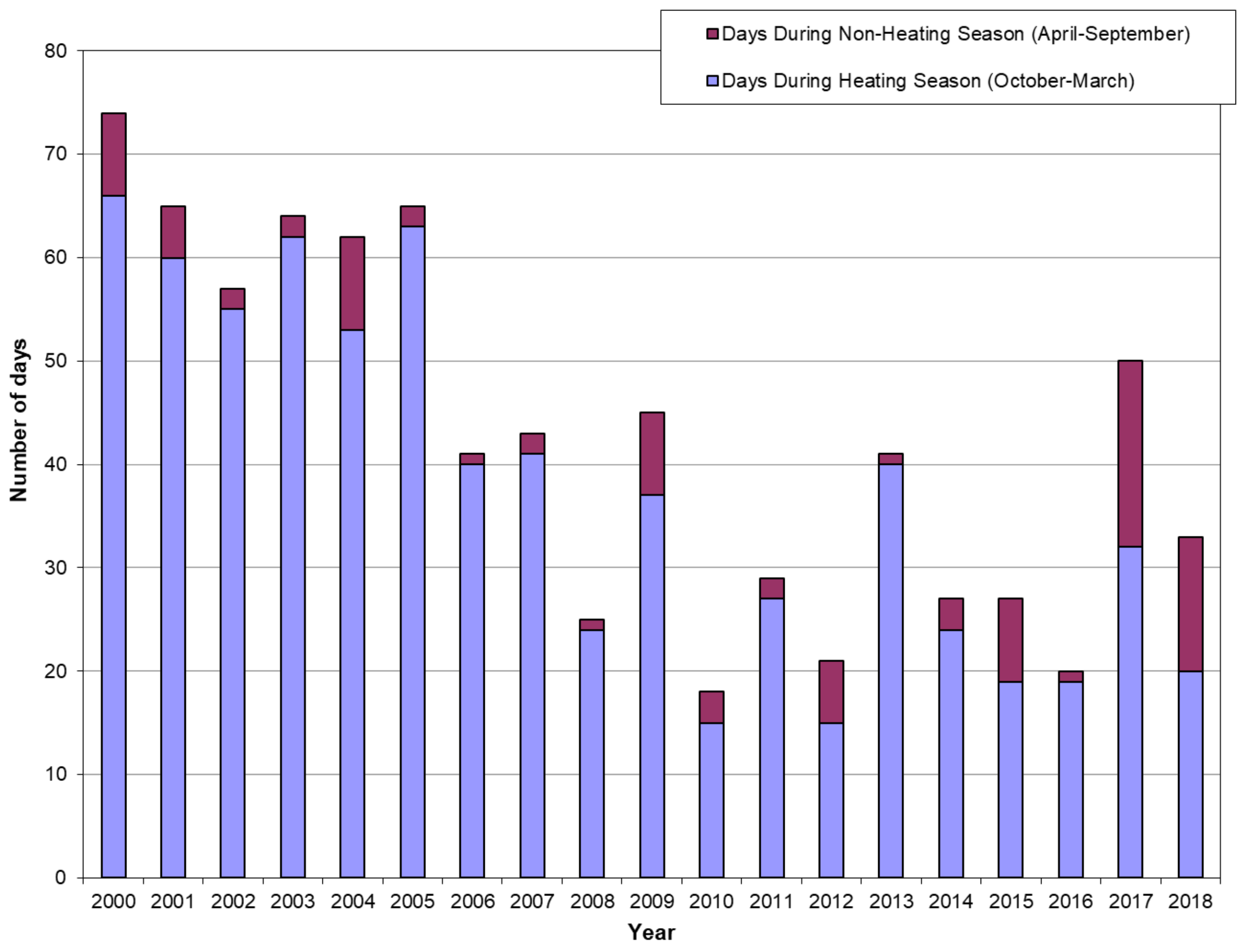
The Agency and Ecology work together on quality assurance to ensure the FEM-generateddata are directly comparable to those generated by the reference method.

$PM_{2.5}$ Daily Federal Standard and Health Goal

The EPA set a daily health-based fine particle standard of 35 micrograms per cubic meter ($\mu g/m^3$). Monitors in all four counties exceeded this standard in 2018. In addition to the federal standard, our Board of Directors adopted a more stringent health goal of 25 $\mu g/m^3$ in 1999, based on recommendations from our Particulate Matter Health Committee. Monitors in King, Kitsap, Pierce and Snohomish Counties also exceeded the local health goal of 25 $\mu g/m^3$ during 2018, in part because of the impact of regional wildfires in early August.

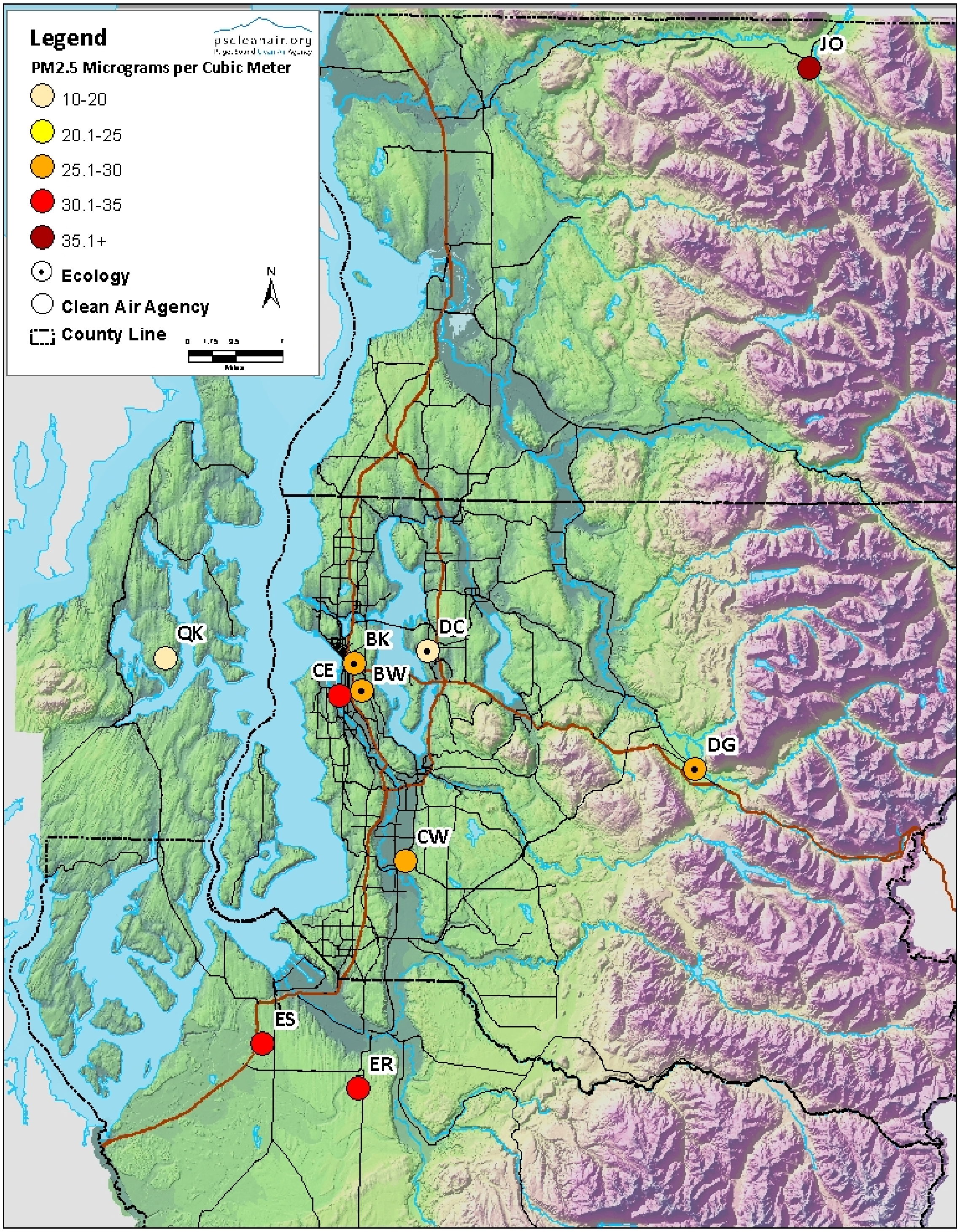
Figure 1 shows the number of days the health goal was exceeded annually in the region, from 2000 to 2018. Our highest fine particulate days overwhelmingly take place during the winter wood heating months, however, due to 2018 wildfire impacts, there were several days during non-winter months when our region exceeded the health goal. While we have made progress reducing the number of days exceeding the health goal overall, we are falling short of our goal of having zero days health goal exceedances, especially during winter months.

Figure 1: Days Exceeding the $PM_{2.5}$ Health Goal at One or More Monitoring Sites



Map 2 shows the 98th percentile of the 3-year average of daily $PM_{2.5}$ concentrations. The map includes only those monitoring sites with three years of complete data from 2016 to 2018. This map incorporates data collected from federal reference, federal equivalent, and nephelometer estimate methods.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2018

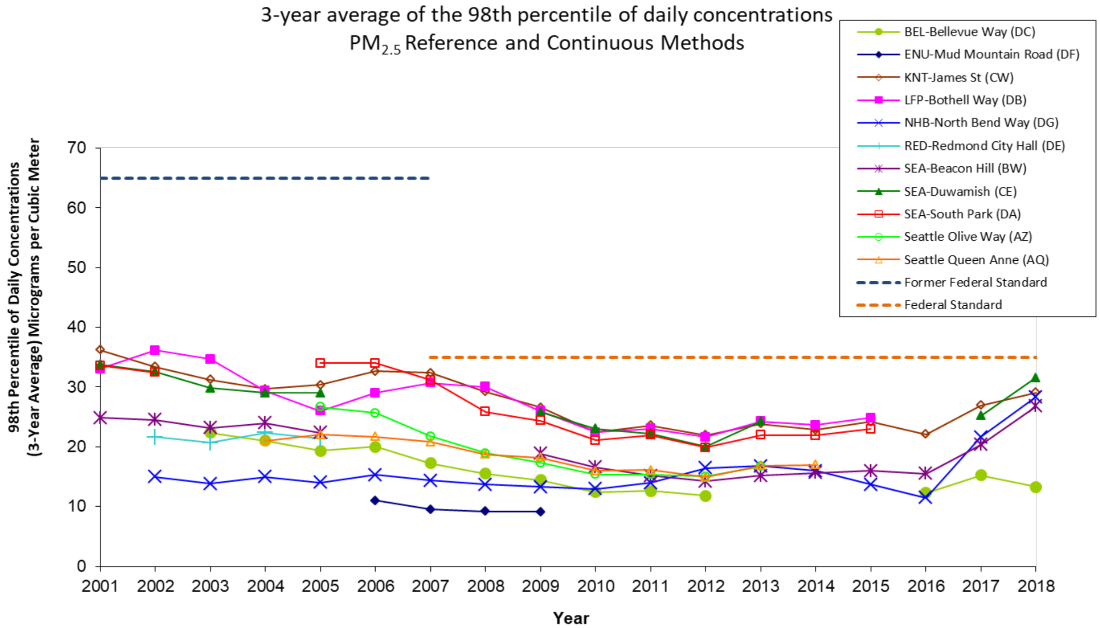


Figures 2 through 9 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard. Points on the graphs represent averages for three consecutive years. For example, the value for 2018 is the average of the 98th percentile daily concentration for 2016, 2017, and 2018. These figures incorporate data collected from federal reference, federal equivalent, and nephelometer estimate methods. For each county, we include two figures: the first shows the entire dataset, and the second shows levels with nine wildfire smoke-impacted days removed. The EPA allows data from days that were influenced by exceptional events that are beyond the ability of air agencies to control, such as wildfires or dust storms, to be excluded from regulatory calculations. These nine 2018 days are: Aug 14, 15, and 19-25. With wildfire smoke-impacted days excluded, all monitors in all four counties are below the federal standard of 35 $\mu g/m^3$. Without excluding wildfire smoke-impacted days, monitors in Pierce and Snohomish Counties equaled or exceeded the standard in 2018.

Figures 4 and 5 do not include a three-year average for Kitsap County in 2008-2010 or 2012-2014 because the monitor did not meet data completeness criteria, and the monitoring site was moved. Kitsap County data show that $PM_{2.5}$ levels are below the federal standard.

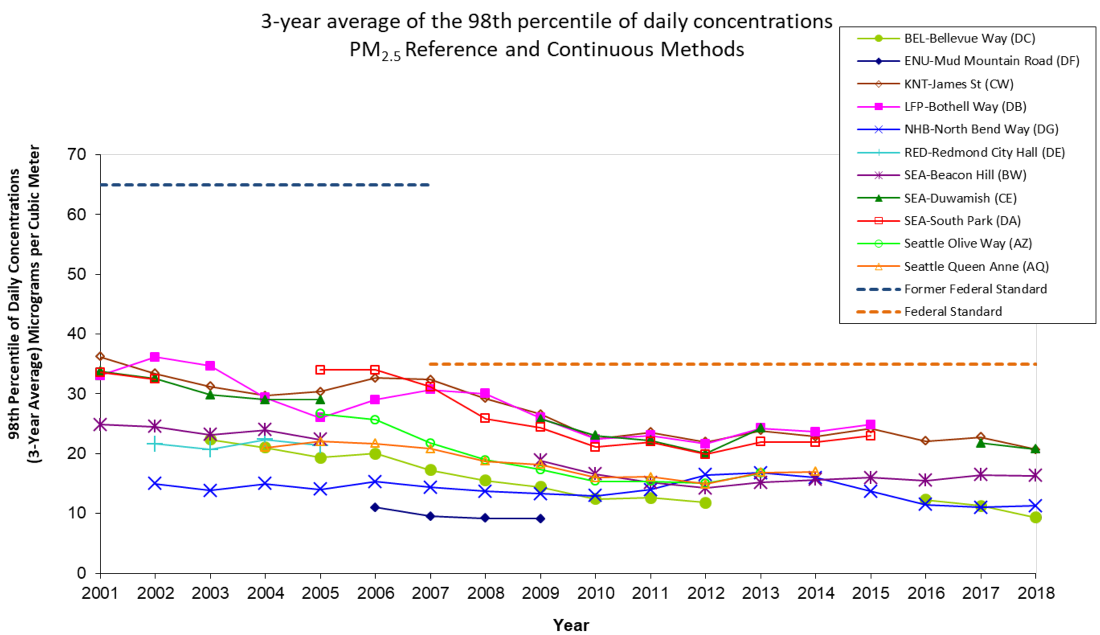
Statistical summaries for 98th percentile daily concentrations for 2018 data are provided on pages A-9 through A-11 of the Appendix.

Figure 2: Daily $PM_{2.5}$ for King County



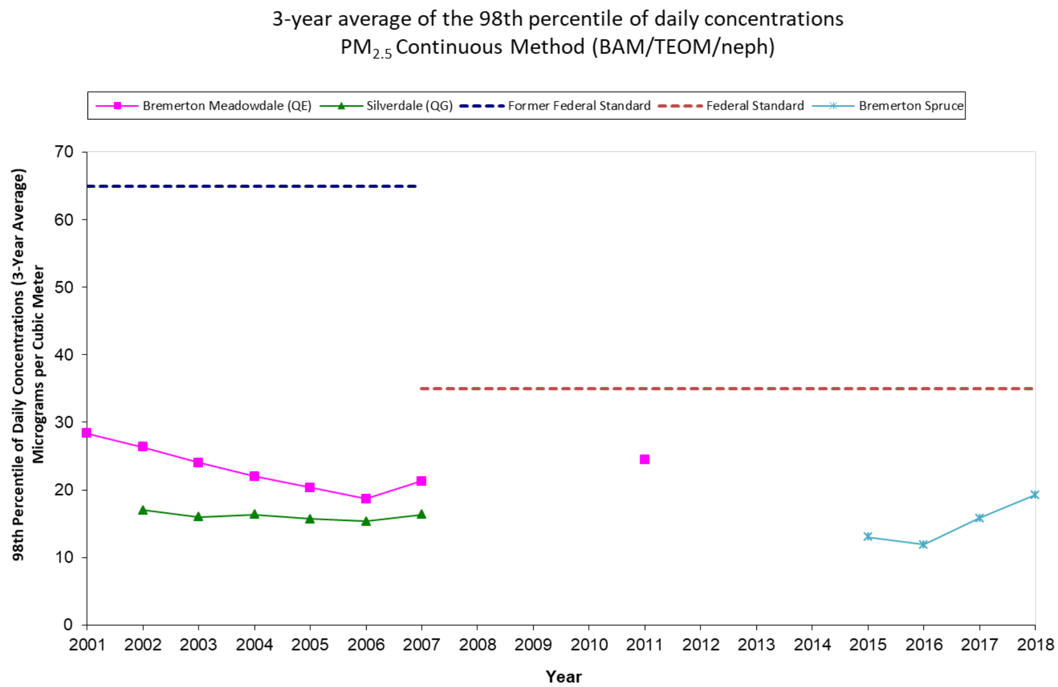
Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2018. Beacon Hill (BW) data are FRM from 1999-2018. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-2015. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2016. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-12. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2015. Olive Way (AZ) data are neph from 2003-2013, site disc 8/5/14. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2018. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011-2018. Enumclaw (DF) data are from neph in 2000-2009.

Figure 3: Daily $PM_{2.5}$ for King County with wildfire-impacted days removed



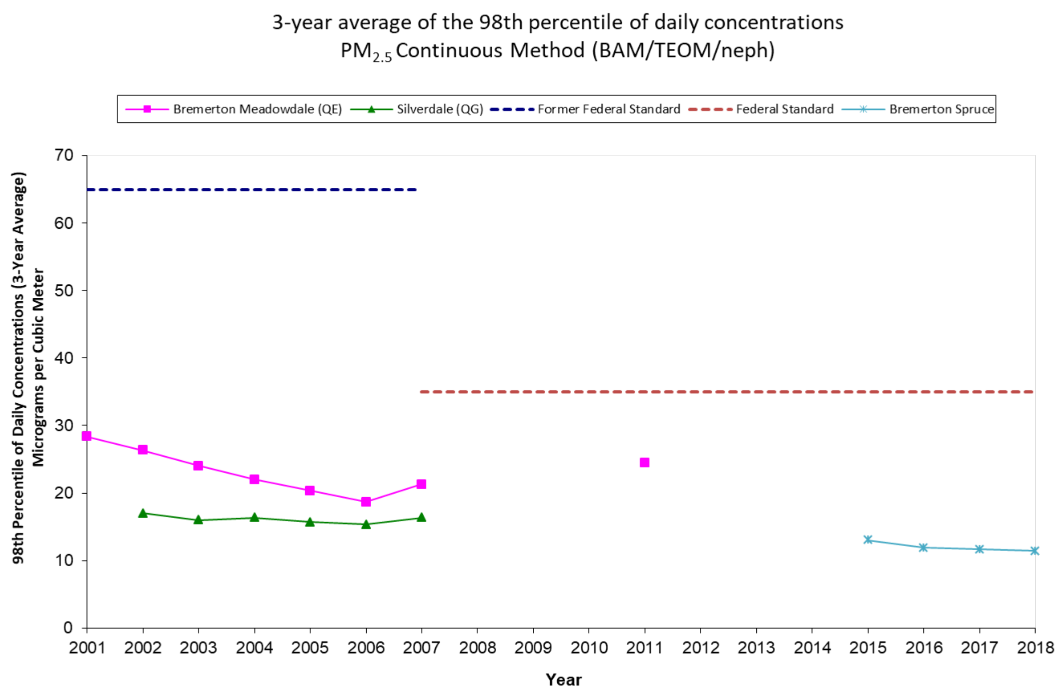
Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2018. Beacon Hill (BW) data are FRM from 1999-2018. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-2015. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2016. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-12. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2015. Olive Way (AZ) data are neph from 2003-2013, site disc 8/5/14. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2018. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011-2018. Enumclaw (DF) data are from neph in 2000-2009.

Figure 4: Daily $PM_{2.5}$ for Kitsap County



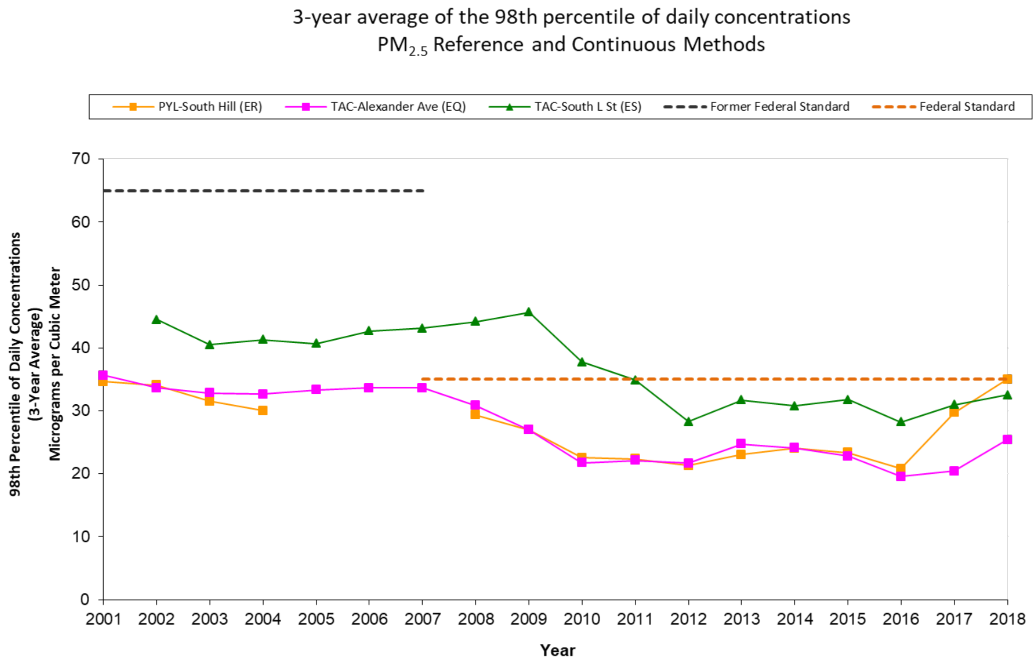
Note: 75% of data is required to calculate 98th percentile. Insufficient data available for 2008 so 3 year calculation not available for 2008-2010. 2011-2014 data are TEOM-FEM. Meadowdale site ended 4/30/12, Spruce site began 5/1/2012.

Figure 5: Daily PM2.5 for Kitsap County with wildfire-impacted days removed



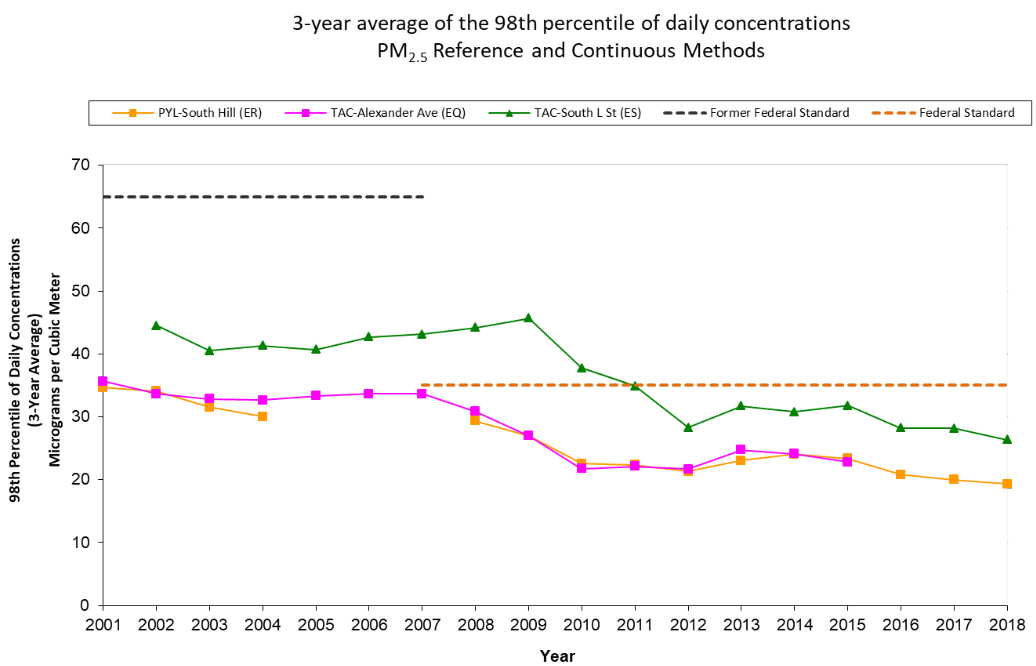
Note: 75% of data is required to calculate 98th percentile. Insufficient data available for 2008 so 3 year calculation not available for 2008-2010. 2011-2014 data are TEOM-FEM. Meadowdale site ended 4/30/12, Spruce site began 5/1/2012.

Figure 6: Daily $PM_{2.5}$ for Pierce County



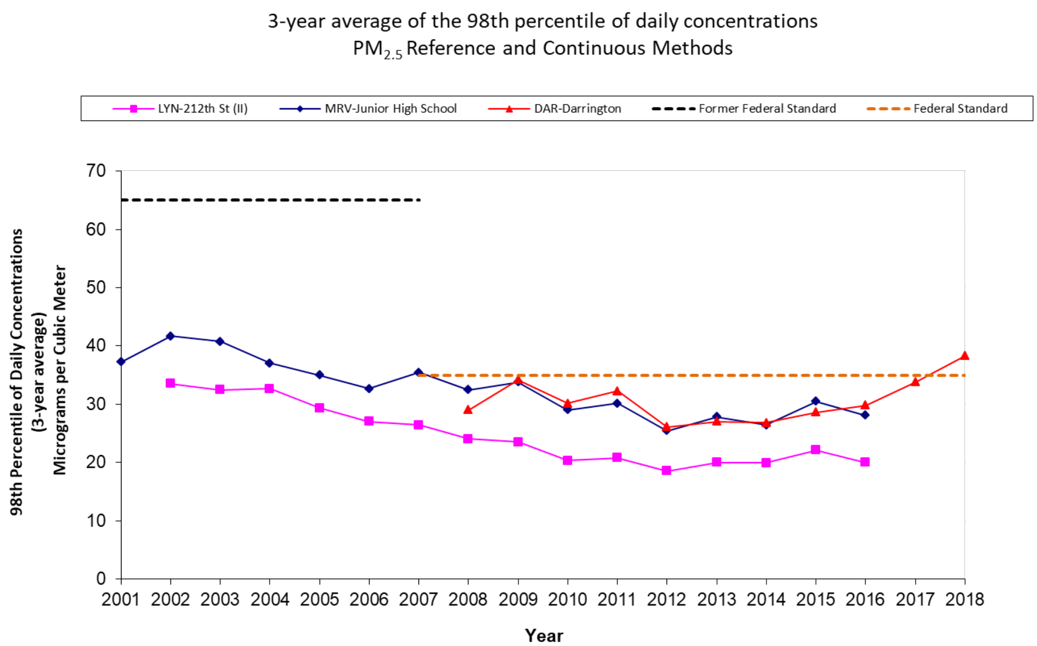
Note: All South L data are FRM from 2000- 2018. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2018.
South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2018 Incomplete nephelometer data was collected from South Hill in 2005.

Figure 7: Daily $PM_{2.5}$ for Pierce County with wildfire-impacted days removed



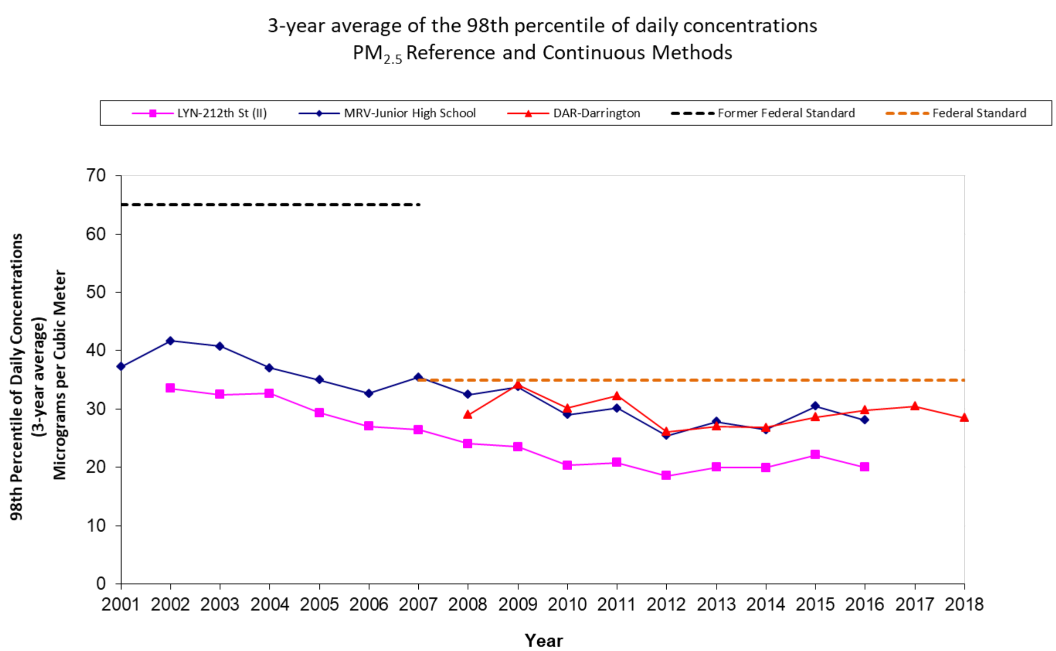
Note: All South L data are FRM from 2000- 2018. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2018.
South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2018 Incomplete nephelometer data was collected from South Hill in 2005.

Figure 8: Daily $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM 1999-2011, TEOM-FEM 2012-2016. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, TEOM-FEM 2011-2016. Darrington (JO) data are neph in 2006, FRM in 2007-2011, TEOM-FEM 2012-2016. Marysville and Lynnwood did not meet data completeness requirements in 2017.

Figure 9: Daily $PM_{2.5}$ for Snohomish County with wildfire-impacted days removed



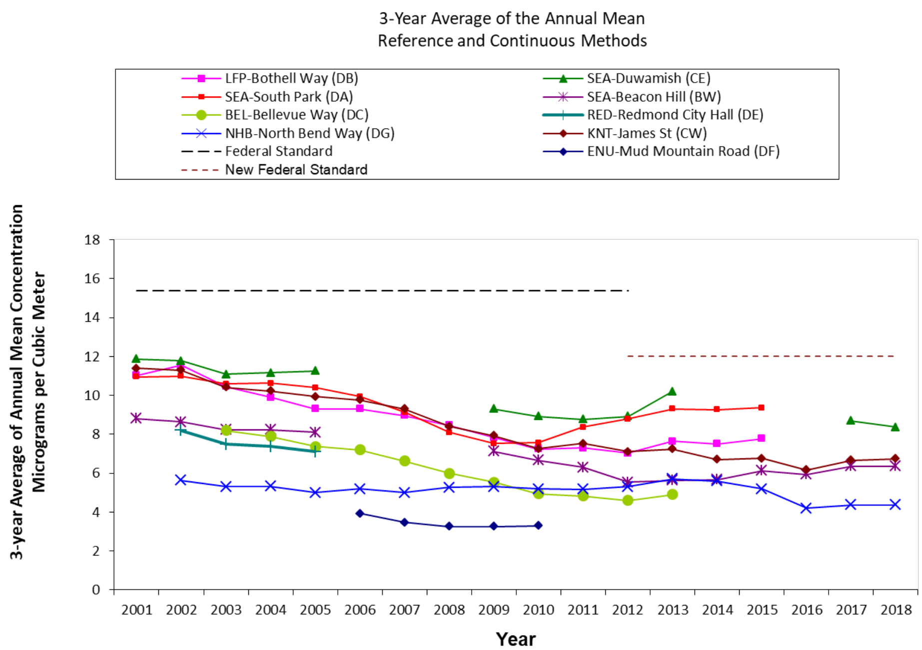
Note: Marysville (IG) data are FRM 999-2011, TEOM-FEM 2012-2016. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, TEOM-FEM 2011-2016. Darrington (JO) data are neph in 2006, FRM in 2007-2011, TEOM-FEM 2012-2016. Marysville and Lynnwood did not meet data completeness requirements in 2017.

$PM_{2.5}$ Annual Federal Standard

Figures 10 through 17 show 3-year annual averages at each monitoring station for King, Kitsap, Pierce and Snohomish Counties. In 2012, the EPA strengthened the annual standard from 15 $\mu g/m^3$ to 12 $\mu g/m^3$. All counties have levels below the 12 $\mu g/m^3$ annual standard. Figures 12 and 13 do not show any 2008-2010, or 2012-2014 data for Kitsap County because the monitor did not meet data completeness criteria, and the monitoring site was relocated.

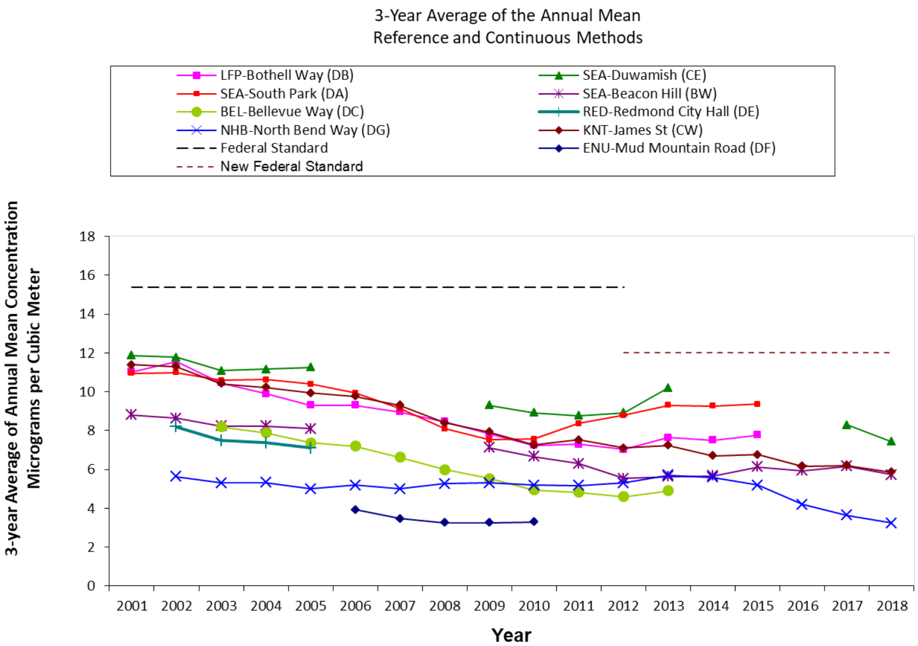
Figures 10 through 17 include data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is an average for three consecutive years. For example, the value shown for 2018 is the average of the annual averages for 2016, 2017, and 2018. As with the daily standard, for each county we include two figures: the first shows the entire dataset, and the second shows levels with nine wildfire smoke-impacted days removed. The list of wildfire smoke-impacted days is on page 12.

Figure 10: Annual $PM_{2.5}$ for King County



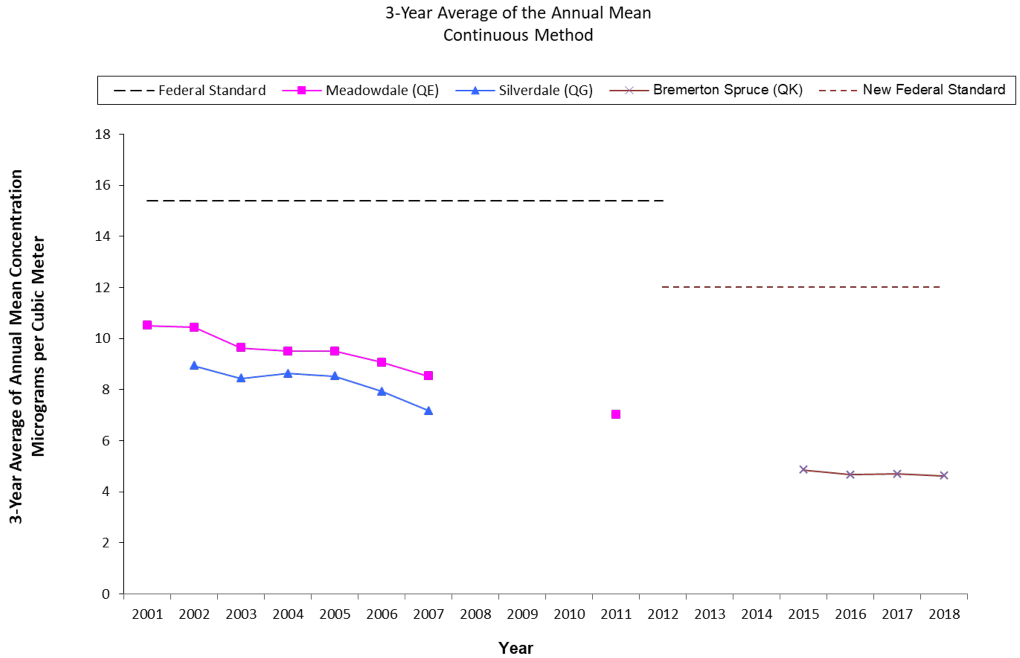
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2015. Beacon Hill (BW) data are FRM from 1999-2017. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2017. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2018. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2018. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010,TEOM-FEM 2011-2016. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2017.

Figure 11: Annual $PM_{2.5}$ for King County with wildfire-impacted days removed



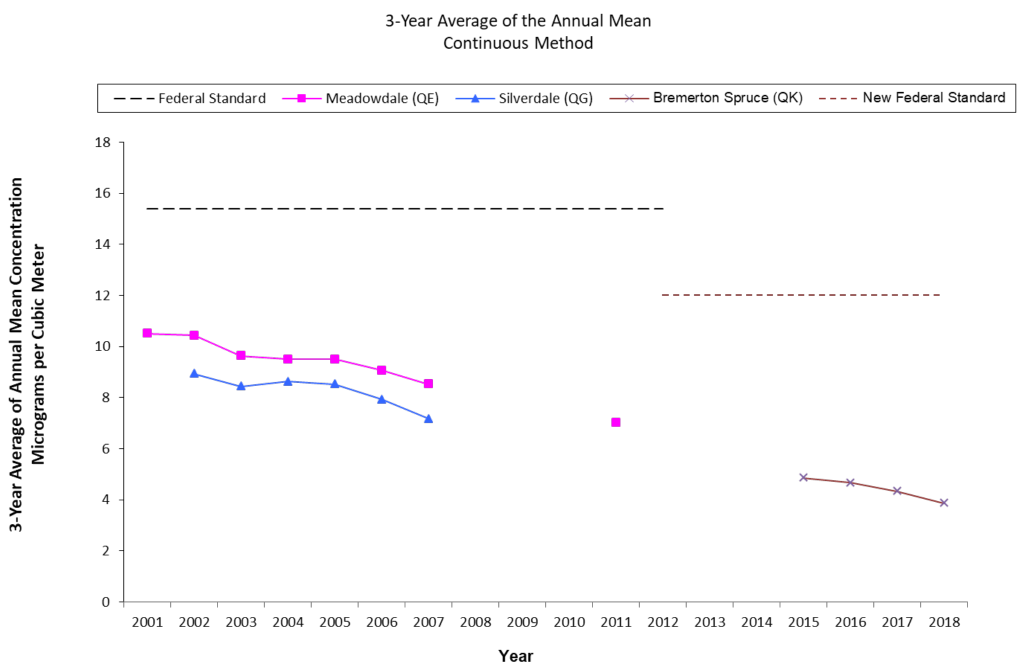
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2015. Beacon Hill (BW) data are FRM from 1999-2017. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2018. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2018. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2018. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010, TEOM-FEM 2011-2016. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2017.

Figure 12: Annual $PM_{2.5}$ for Kitsap County



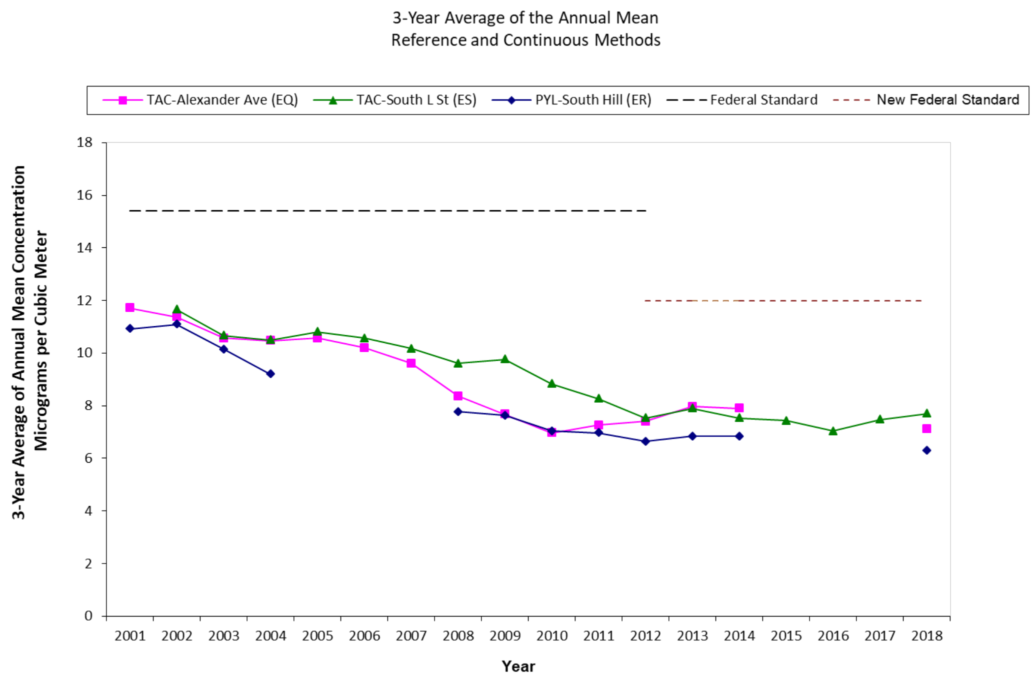
Note: Meadowdale (QE) and Silverdale (QG) data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011-2017. Bremerton Spruce (QK) data are TEOM-FEM.

Figure 13: Annual $PM_{2.5}$ for Kitsap County with wildfire impacted-days removed



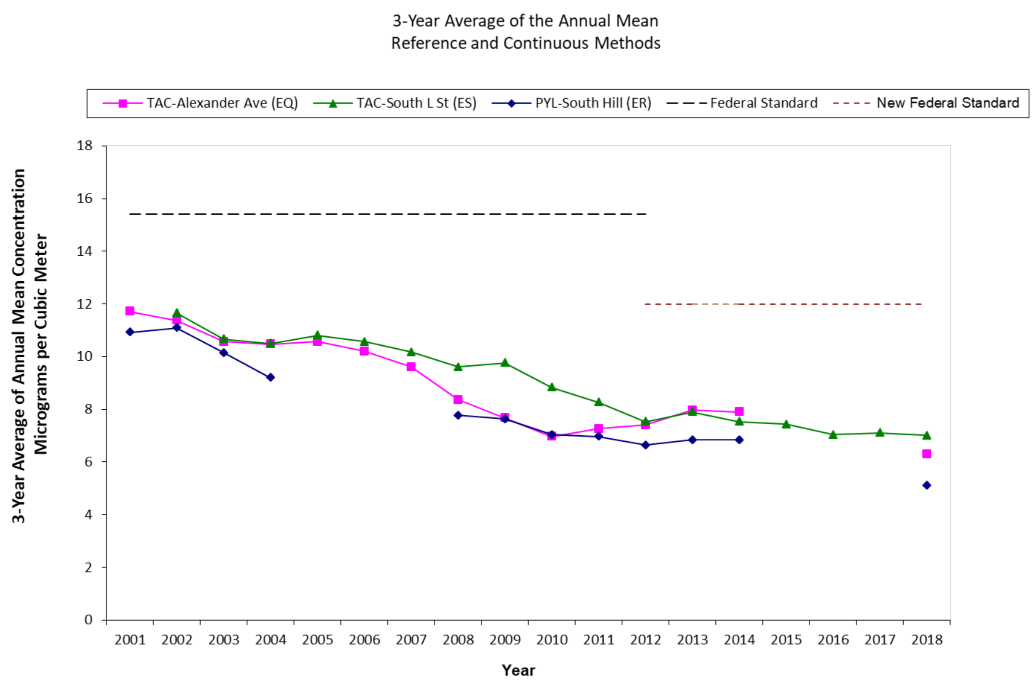
Note: Meadowdale (QE) and Silverdale (QG) data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011-2017. Bremerton Spruce (QK) data are TEOM-FEM.

Figure 14: Annual $PM_{2.5}$ for Pierce County



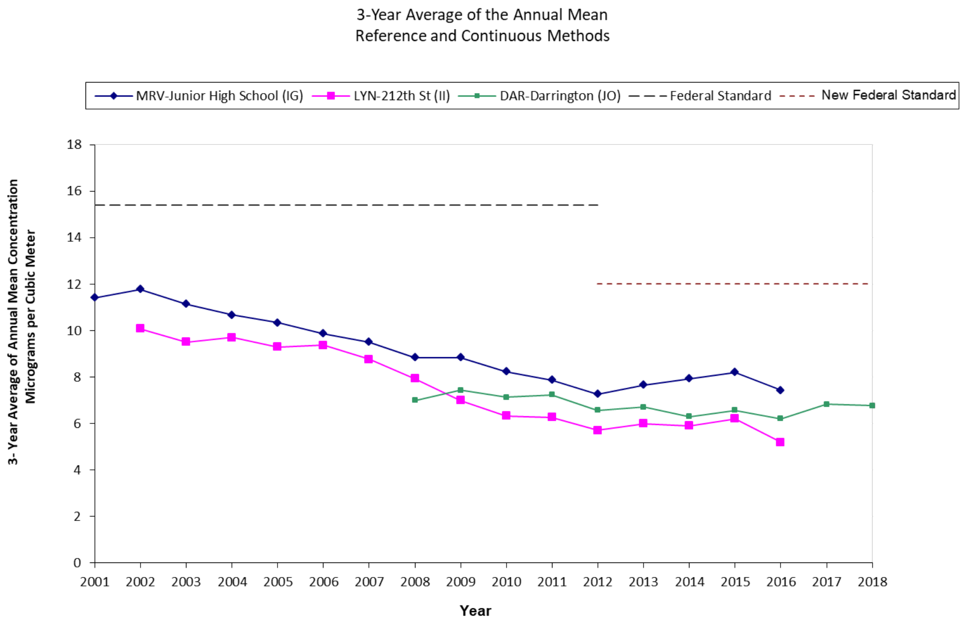
Note: South L St. (ES) data are FRM. South Hill (ER) data are FRM from 1999-2002. South Hill (ER) data 2003, 2004, 2008-2018 were measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002, nephelometer from 2003-2010 & 2018, and TEOM-FEM 2011-2016.

Figure 15: Annual $PM_{2.5}$ for Pierce County with wildfire-impacted days removed



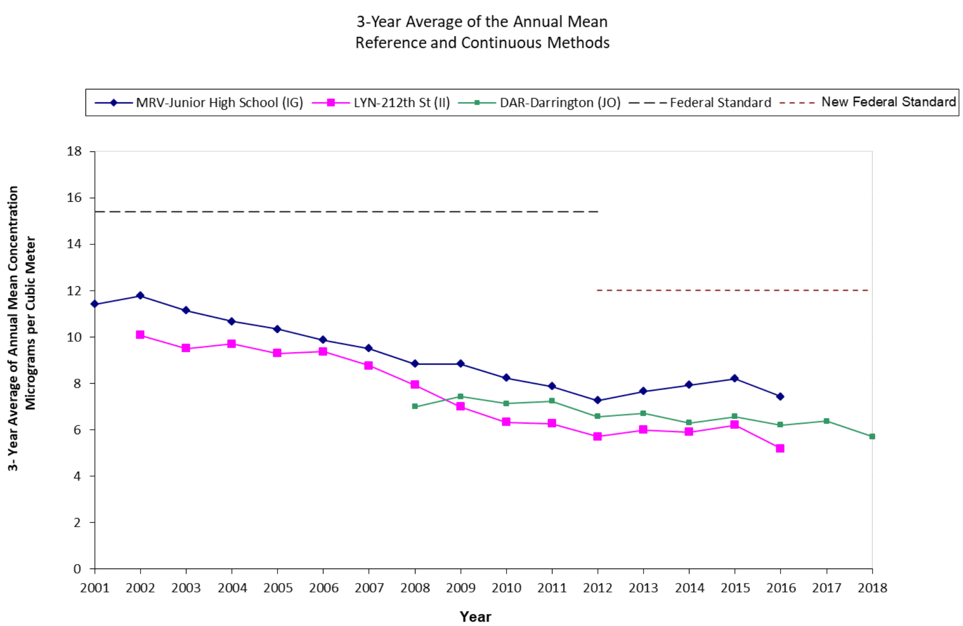
Note: South L St. (ES) data are FRM. South Hill (ER) data are FRM from 1999-2002. South Hill (ER) data 2003, 2004, 2008-2018 were measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002, nephelometer from 2003-2010 & 2018, and TEOM-FEM 2011-2016.

Figure 16: Annual $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2011, TEOM-FEM 2014. Lynnwood (II) data are FRM except 2004, 2007-2011, TEOM-FEM 2012-2016. The 2004, 2007-2011 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2011, TEOM-FEM 2012-2018. Marysville and Lynnwood did not meet data completeness criteria in 2017.

Figure 17: Annual $PM_{2.5}$ for Snohomish County with wildfire-impacted days removed



Note: Marysville (IG) data are FRM from 1999-2011, TEOM-FEM 2014. Lynnwood (II) data are FRM except 2004, 2007-2011, TEOM-FEM 2012-2016. The 2004, 2007-2011 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2011, TEOM-FEM 2012-2018. Marysville and Lynnwood did not meet data completeness criteria in 2017.

$PM_{2.5}$ Continuous Data and Seasonal Variability

Continuous monitoring data provide information on how concentration levels vary throughout the year. For example, many sites have elevated $PM_{2.5}$ levels during the winter when residential wood burning and air stagnations are at their peak, but have low levels of $PM_{2.5}$ during the summer. For more detailed information on continuous data, please see the Air Graphing tool at https://secure.pscleanair.org/airgraphing to plot the sites and timeframes of interest.

Particulate Matter – $PM_{2.5}$ Speciation and Aethalometers

Although there are no regulatory requirements to go beyond measuring the total mass of fine particulate matter, it is important to know the chemical makeup of particulate matter in addition to its mass. Knowledge about the composition of fine particulate can help to guide emissions reduction strategies. Information on fine particulate composition helped guide the Agency's commitment to reducing wood smoke and diesel particulate emissions.[3,4,5]

Speciation Monitoring and Source Apportionment

Speciation monitoring involves determining the chemical composition of fine particulate matter collected on different types of filters. Speciation filters are analyzed to determine what metals and organic molecules make up the fine particulate at a site. Over 40 chemical species are measured at speciation monitors in the area. These data are used in source apportionment models to estimate contributing sources to $PM_{2.5}$. Source apportionment models use statistical patterns in data to identify likely pollution sources and then estimate how much each source is contributing at each site.

Ecology conducted speciation monitoring at three sites in the Puget Sound region in 2018:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day, operated by Ecology)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day, operated by Ecology)
- Seattle 10th & Weller – Near Road micro-scale monitoring site (speciation samples collected every sixth day, operated by Ecology).

Scientific and health researchers have analyzed speciation data from these sites. In addition to using speciation data for concentrations of specific species or source apportionment modeling, the Agency uses them to qualitatively look at the makeup of fine particulate at our monitoring sites. For a list of $PM_{2.5}$ analytes measured at these sites, please see page A-12 of the Appendix.

Aethalometer Data

Aethalometers provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations using seven channels. Two of these channels are important in our evaluation, black carbon (BC) and ultraviolet (UV). Concentrations from the black carbon channel correlate well with elemental carbon (EC) speciation data. Qualitatively, the difference between the UV and BC channel (UV-BC) correlates with

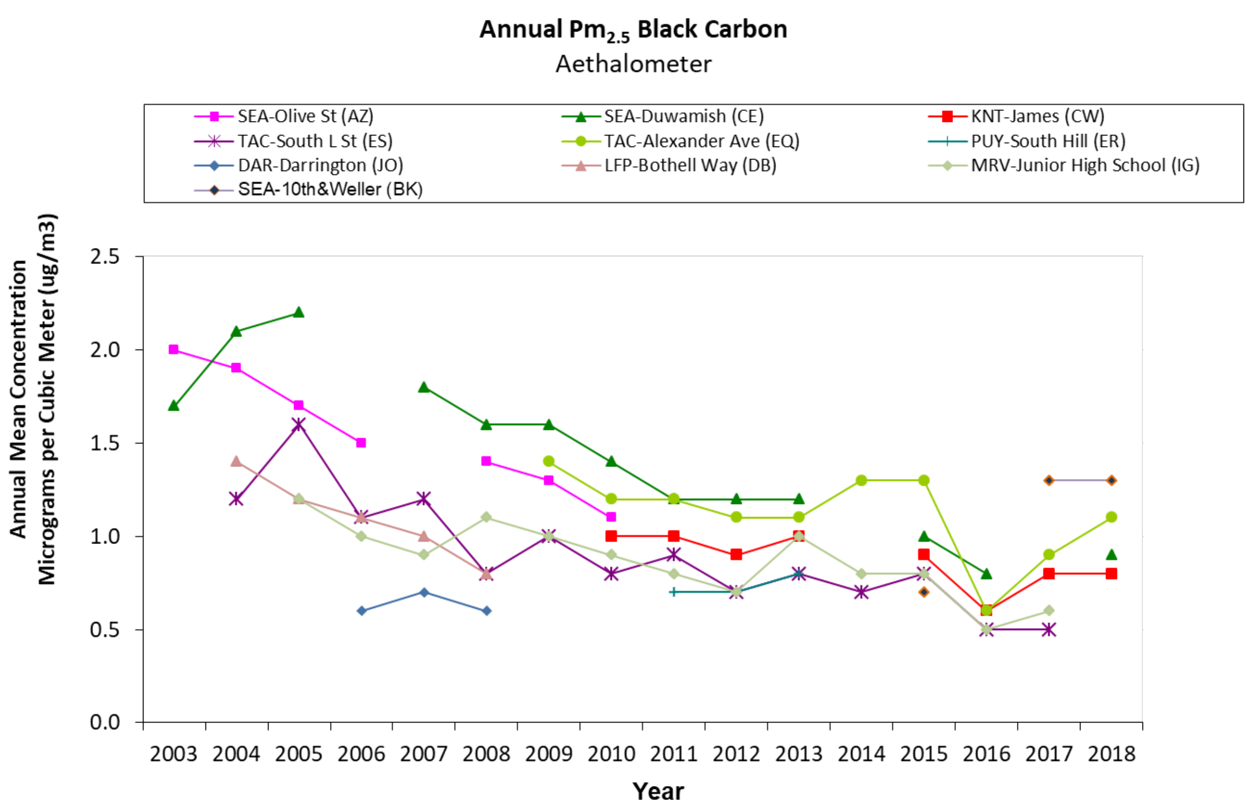
[3] Puget Sound Air Toxics Evaluation, October 2003. https://www.pscleanair.org/DocumentCenter/View/2355/Puget-Sound-Air-Toxics-Evaluation-Final-ReportPDF?bidId=
[4] Tacoma and Seattle Air Toxics Evaluation, October 2010. epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.
[5] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area". PublicationNumber 10-02-009. https://fortress.wa.gov/ecy/publications/documents/1002009.pdf

organic carbon (OC) speciation data. Elemental and organic carbons are related to diesel particulate, wood smoke particulate and particulate from other combustion sources.[6] Unfortunately, neither is uniquely attributed to a particular combustion type – so the information gained from aethalometer data is qualitative.

The Agency maintains aethalometers at monitoring sites with high particulate matter concentrations, as well as sites with speciation data, so that the methods to measure carbon may be compared.

Figure 18 shows annual average trending of black carbon concentrations. Since 2003, the general trend shows reducing BC levels. A statistical summary of aethalometer black carbon data is presented on page A-13 of the Appendix.

Figure 18: Annual $PM_{2.5}$ Black Carbon



[6]Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area

Ozone

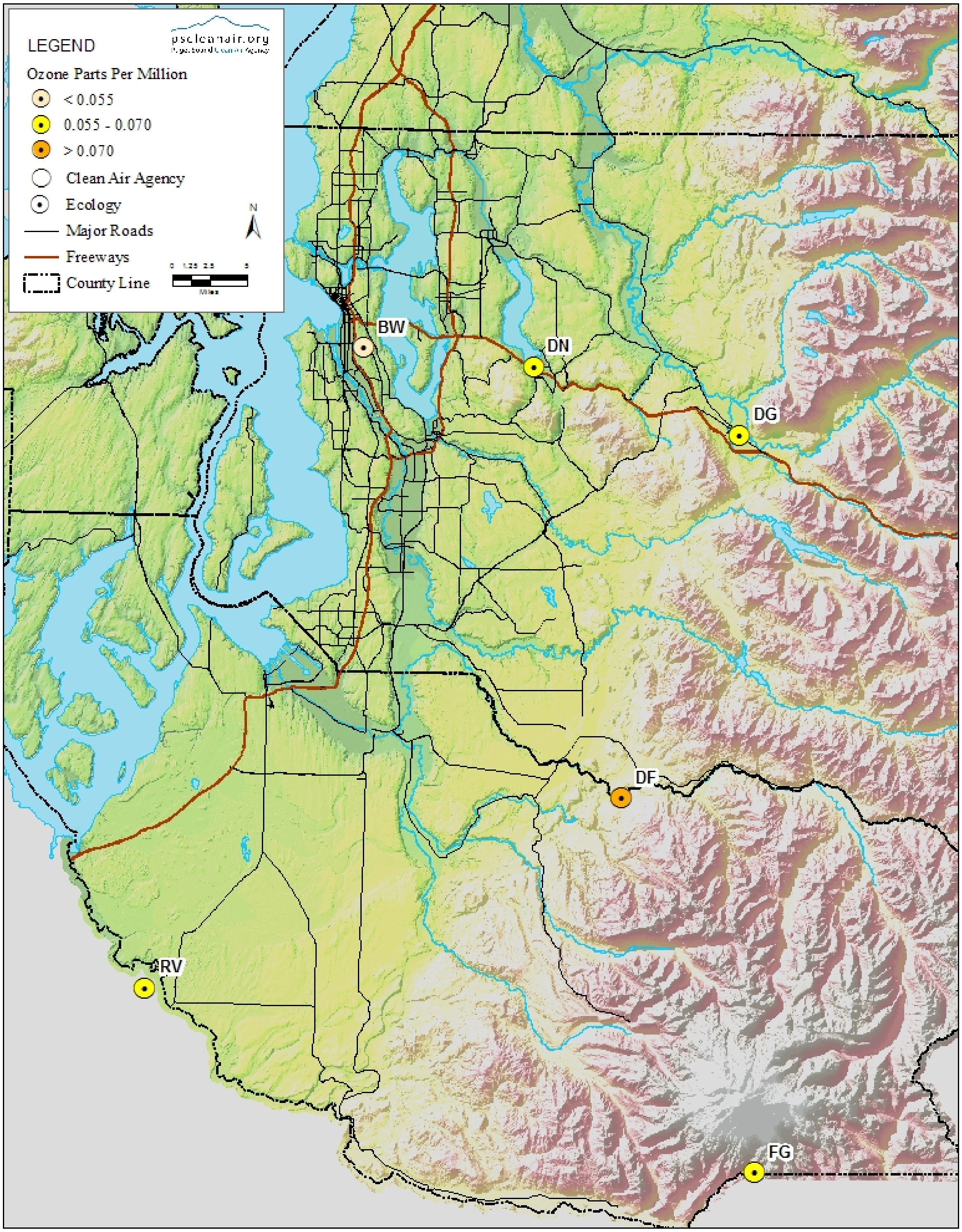
Ozone is a summertime air pollution problem in our region and is not directly emitted by pollutant sources. Ozone forms when photochemical pollutants react with sunlight. These pollutants are called ozone precursors and include volatile organic compounds (VOC) and nitrogen oxides (NO_x), with some influence by carbon monoxide (CO). These precursors come from human activities such as mobile sources and industrial and commercial solvent use (anthropogenic), as well as natural sources (biogenic). Ozone levels are usually highest in the afternoon because of the intense sunlight and the time required for ozone to form in the atmosphere. The Washington State Department of Ecology conducts the ozone monitoring in our counties.

People sometimes confuse upper atmosphere ozone with ground-level ozone. Stratospheric ozone helps to protect the earth from the sun's harmful ultraviolet rays. In contrast, ozone formed at ground level is unhealthy. Elevated concentrations of ground-level ozone can cause reduced lung function and respiratory irritation, and can aggravate asthma.[7] Ozone has also been linked to immune system impairment. People with respiratory conditions should limit outdoor exertion if ozone levels are elevated. Even healthy individuals may experience respiratory symptoms on a high-ozone day. Ground-level ozone can also damage forests and agricultural crops, interfering with their ability to grow and produce food.[8]

Most ozone monitoring stations are located in rural areas of the Puget Sound region, although the precursor chemicals that react with sunlight to produce ozone are generated primarily in large metropolitan areas (mostly by cars and trucks). The photochemical formation of ozone takes several hours. Thus, the highest concentrations of ozone are measured in the communities downwind of these large urban areas. In the Puget Sound region, the hot sunny days favorable for ozone formation also tend to have light north-to-northwest winds. Map 3 shows the ozone network and the monitoring sites that show the levels found this year.

[7] EPA, Air Quality Index: A Guide to Air Quality and Your Health; epa.gov/airnow/aqi_brochure_02-14.pdf.
[8] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ozone-pollution/ozone-basics.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2018



Figures 19 and 20 present data for each monitoring station and the 8-hour federal standard. Figure 19 shows levels with the entire dataset, and Figure 20 shows ozone levels with thirteen wildfire smoke impacted days removed (the same days listed on page 12). The federal standard is based on the 3-year average of the 4th highest 8-hour concentration, called the "design value". The year on the x-axis represents the last year averaged. For example, concentrations shown for 2018 are an average of 2016, 2017, and 2018 4th highest concentrations.

The EPA's 2015 8-hour standard is 0.070 ppm. The highest 2018 site design value (for the entire dataset, including wildfire smoke impacted days) is 0.077 ppm at the Enumclaw site. This level was elevated based on a high 4th highest concentration in 2017 of 0.094 ppm. While this level was clearly over the 8-hour federal standard, our area remained in attainment with the federal standard because EPA completed designations for the 2015 ozone standard in early November 2017, based on data from 2014-2016.

Statistical summaries for 8-hour average ozone data are provided on page A-14 of the Appendix.

For additional information on ozone, visit https://www.epa.gov/ozone-pollution.

Figure 19: Ozone for Puget Sound Region

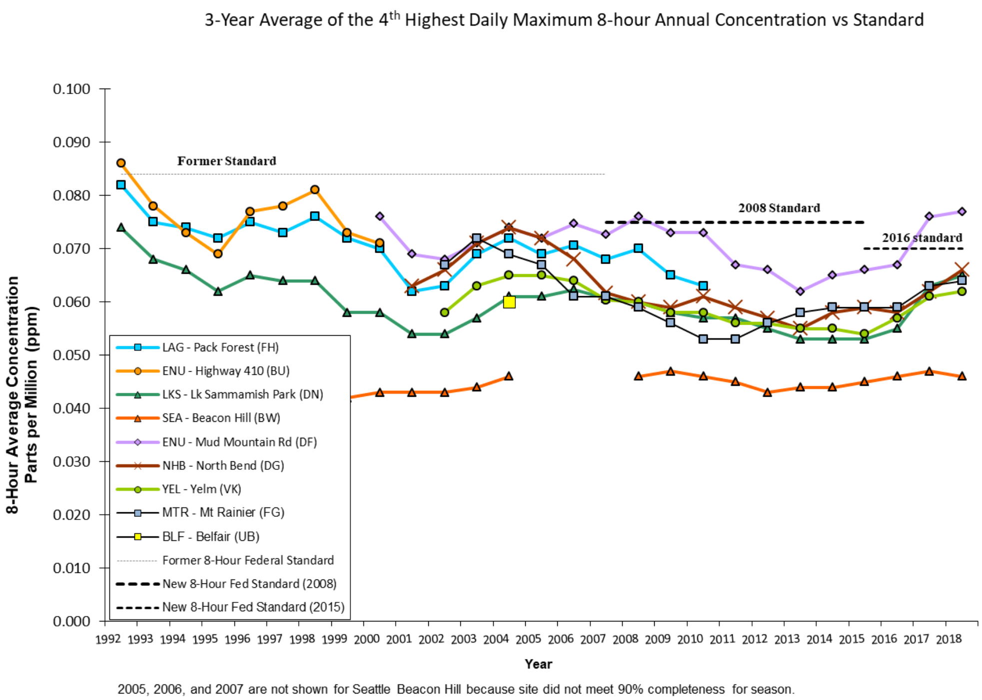
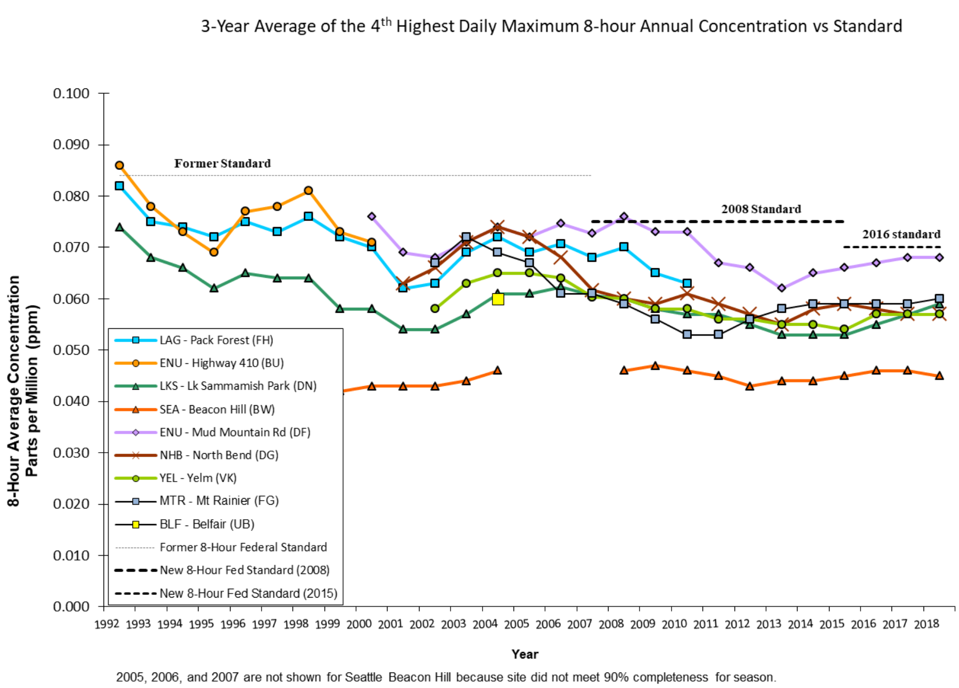


Figure 20: Ozone for Puget Sound Region with wildfire impacted days removed



Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and hydroperoxy (HO_2) and alkylperoxy (RO_2) free radicals in the atmosphere. NO_2 can cause coughing, wheezing and shortness of breath in people with respiratory diseases such as asthma.[9] Long-term exposure can lead to respiratory infections.

The term NO_x is defined as NO + NO_2. NO_x participates in a complex chemical cycle with volatile organic compounds (VOCs) which can result in the production of ozone. NO_x can also be oxidized to form nitrates, which are an important component of fine particulate matter. On-road vehicles such as trucks and automobiles and off-road vehicles such as construction equipment, marine vessels and port cargo-handling equipment are the major sources of NO_x. Industrial boilers and processes, home heaters and gas stoves also produce NO_x.

Motor vehicle and non-road engine manufacturers have been required by EPA to reduce NO_x emissions from cars, trucks and non-road equipment. As a result, emissions have reduced dramatically since the 1970s.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.[10] Since then, Department of Ecology added two "near road" monitoring sites very close to Interstate 5: one in Seattle, and one in Tacoma. To learn more about the monitoring method visit https://www3.epa.gov/ttn/amtic/nearroad.html These near road sites are not included in Figure 12 because they do not yet have the 3 years of data that are required. In addition, recent years aren't shown for Beacon Hill because of data loss.

In addition to the near road sites, the Department Ecology measures nitrogen dioxide at the Seattle Beacon Hill site. The monitoring method now records NO_y instead of NO_x, in order to observe all reactive nitrogen compounds. NO_y is NO_x plus all other reactive nitrogen oxides present in the atmosphere. NO_y components such as nitric acid (HNO_3) and peroxyacetyl nitrate (PAN) can be important contributors to the formation of ozone and fine particulate matter

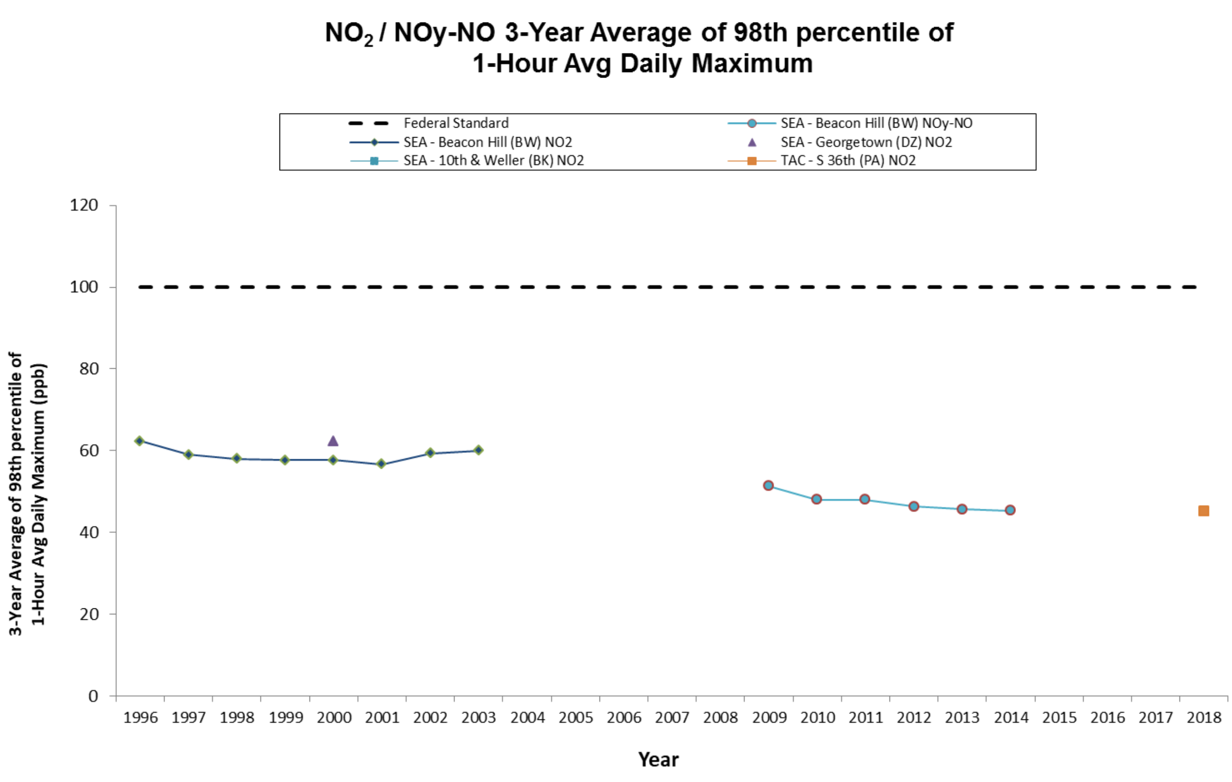
Figure 21 shows NO_2 concentrations for Beacon Hill through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location on the same property. From 2007 onward, the concentration of NO_2 is represented as NO_y – NO, since NO_2 is no longer directly recorded, and NO_y = NO + NO_2 + other nitroxyl compounds.

The 2010 1-hour standard is 100 ppb, and is based on the 98th percentile of 1-hour daily maximum concentrations, averaged over three years. Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Ecology, are typically below (cleaner than) the 1-hour standard. The 1-hour standard is depicted in Figure 21 with historical data since 1996. The years prior to 2010 have been included on the graphs for historical comparison.

[9] EPA, Airnow, NO_X Chief Causes for Concern; epa.gov/airquality/nitrogenoxides/
[10] EPA. New 1-hour National Ambient Air Quality Standards for Nitrogen Dioxide; epa.gov/airquality/nitrogenoxides/actions.html.

Visit epa.gov/airquality/nitrogenoxides/ for additional information on NO_2.

Figure 21: 2010 1-Hour Maximum Standard for Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)



Note: Beacon Hill site relocated in 2006. Monitoring method changed in 2007 to NOy-NO. Seattle Beacon Hill site had incomplete data in 2015, had incomplete data in 2017, insufficient data completeness for 3-year annual average. Seattle 10th & Weller site sampling started June 1, 2014, had incomplete data in 2017, insufficient data completeness for 3-year annual average. Tacoma S 36th site sampling started Jan 1, 2016.

Carbon Monoxide

Carbon monoxide (CO) is an odorless, colorless gas that can enter the bloodstream through the lungs and reduce the amount of oxygen that reaches organs and tissues. Carbon monoxide forms when the carbon in fuels does not burn completely. The vast majority of CO emissions come from motor vehicles.

Elevated levels of CO in ambient air occur more frequently in areas with heavy traffic and during the colder months of the year when temperature inversions are more common. People with cardiovascular disease or respiratory problems may experience chest pain and increased cardiovascular symptoms, particularly while exercising, if CO levels are high. High levels of CO can affect alertness and vision even in healthy individuals.

Although urban portions of the Puget Sound region historically violated the CO standard, CO levels have decreased significantly primarily due to emissions controls on car engines. EPA designated the Puget Sound region as a CO attainment area in 1996. Ecology has substantially reduced its CO monitoring network, and only the Beacon Hill site remains from the historical network. The near road site at 10th & Weller began operation in June 2014. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

The CO national ambient air quality standard is based on the 2nd highest 8-hour average using the procedures in the federal register. The EPA federal standards also include a 1-hour standard for CO of 35 ppm, not to be exceeded more than once a year. Measured 1-hour concentrations in the Puget Sound area are historically much lower than the 35 ppm standard.

For a historic look at the Puget Sound region's carbon monoxide levels, please see the 2015 Air Quality Data Summary which is available on our website at http://www.pscleanair.org/DocumentCenter/View/2294/Air-Quality-Data-Summary-2015PDF.

For additional information on CO, visit epa.gov/airquality/carbonmonoxide.

Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless, reactive gas produced by burning fuels containing sulfur, such as coal and oil, and by industrial processes. Historically, the greatest sources of SO_2 were industrial facilities that derived their products from raw materials such as metallic ore, coal and crude oil, or that burned coal or oil to produce process heat (petroleum refineries, cement manufacturing and metal processing facilities). Marine vessels, on-road vehicles and diesel construction equipment are the main contributors to SO_2 emissions today.

SO_2 may cause people with asthma who are active outdoors to experience bronchial constriction, where symptoms include wheezing, shortness of breath and tightening of the chest. People should limit outdoor exertion if SO_2 levels are high. SO_2 can also form sulfates in the atmosphere, a component of fine particulate matter.

The Puget Sound area has experienced a significant decrease in SO_2 from sources such as pulp mills, cement plants and smelters in the last two decades

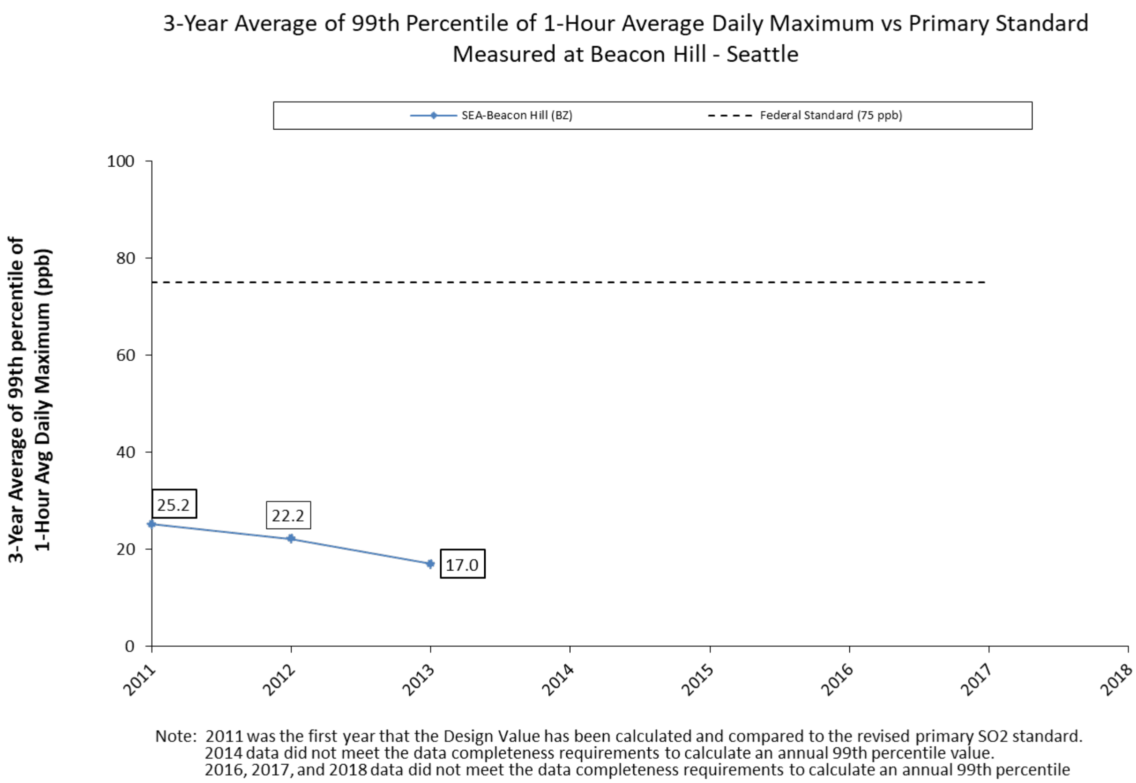
EPA changed the SO_2 standard in June of 2010 to a more short-term (1-hour) standard and revoked the former annual and daily average standards. Historic comparisons to federal and Washington State standards can be seen in our 2009 data summary which is available upon request.

The 2010 standard is a 3-year average of the 99th percentile of the daily 1-hour maximum concentrations. Levels must be below 75 ppb. Sulfur dioxide levels at the Seattle Beacon Hill site are below the 2010 standard.

Figure 22 shows the maximum 3-year average of the 99th percentile of 1-hour maximum concentrations at Beacon Hill. Seattle Beacon Hill did not meet data completeness requirements in recent years and it would not be appropriate to compare the available data to the current standard.

Additional information on SO_2 is available at https://www.epa.gov/so2-pollution.

Figure 22: Sulfur Dioxide (SO_2) 1-Hour Maximum Concentrations (3-Year Average of the 99th Percentile) for the Puget Sound Region



Lead

Lead is a highly toxic metal that was used for many years in household products (e.g. paints), automobile fuel and industrial chemicals. Nationally, industrial processes, particularly primary and secondary lead smelters and battery manufacturers, are now responsible for most of the remaining lead emissions. Lead from aviation gasoline used in small aircraft is also of concern nationally.

People, animals and fish are mainly exposed to lead by breathing and ingesting it in food, water, soil or dust. Lead accumulates in the blood, bones, muscles and fat. Infants and young children are especially sensitive to even low levels of lead. Lead can have health effects ranging from behavioral problems and learning disabilities to seizures and death.

Since the phase-out of lead in fuel and the closure of the Harbor Island secondary lead smelter, levels of lead in ambient air have decreased substantially. For a historic look at the Puget Sound region's lead levels, please see page 87 of the 2007 Air Quality Data Summary which is available upon request.

In October 2008, EPA strengthened the lead standard from 1.5 µg/m^3 to 0.15 µg/m^3 (rolling three-month average).[11] As part of this rulemaking, EPA initiated a pilot lead monitoring program that focuses on lead from aviation gasoline at small airports, including two in our region. Results are available here: https://fortress.wa.gov/ecy/publications/SummaryPages/1302040.html. EPA maintained this level in its 2016 review of the lead standard.

For additional information on lead, visit https://www.epa.gov/lead-air-pollution.

[11] US EPA, National Ambient Air Quality Standard for Lead, Final Rule. Federal Register, November 12, 2008; http://www.gpo.gov/fdsys/pkg/FR-2008-11-12/pdf/E8-25654.pdf

Visibility

Visibility data is presented as an indicator of air quality. Visibility is explained in terms of visual range and light extinction. *Visual range* is the maximum distance, usually miles or kilometers, that you can see a black object against the horizon. *Light extinction* is the sum of light scattering and light absorption by fine particles and gases in the atmosphere. The more light extinction, the shorter the visual range. Visual range as measured by nephelometer instruments using light-scattering methodology provides one approach to measuring visibility at a specific location.

Reduced visibility is caused by weather such as clouds, fog, rain and air pollution, including fine particles and gases. The major contributor to reduced visual range is fine particulate matter ($PM_{2.5}$), which is present near the ground, can be transported aloft and may remain suspended for a week or longer. Figures 23 through 27 show visibility for the overall Puget Sound area, as well as King, Kitsap, Pierce and Snohomish Counties. Visibility on these graphs, in units of miles, is determined by continuous nephelometer monitoring. The nephelometer measures light scattering due to particulate matter (b_{sp}), and this value is converted into estimates of visibility in miles. Nephelometer data are shown on page A-11 of the Appendix.

The red line represents the monthly average visibility. The large fluctuations are due to seasonal variability. The blue line shows the average of the previous 12-months. This moving average reduces seasonal variation and allows longer-term trends to be observed. The moving average shows that the visibility for the Puget Sound area has steadily increased (improved) over the last decade with some year-to-year variability. For the 24-year period from December 1990 through December 2018, the 12-month moving average increased from 47 miles to 83 miles.

For additional information on visibility, visit https://www.epa.gov/visibility.

Figure 23: Puget Sound Visibility

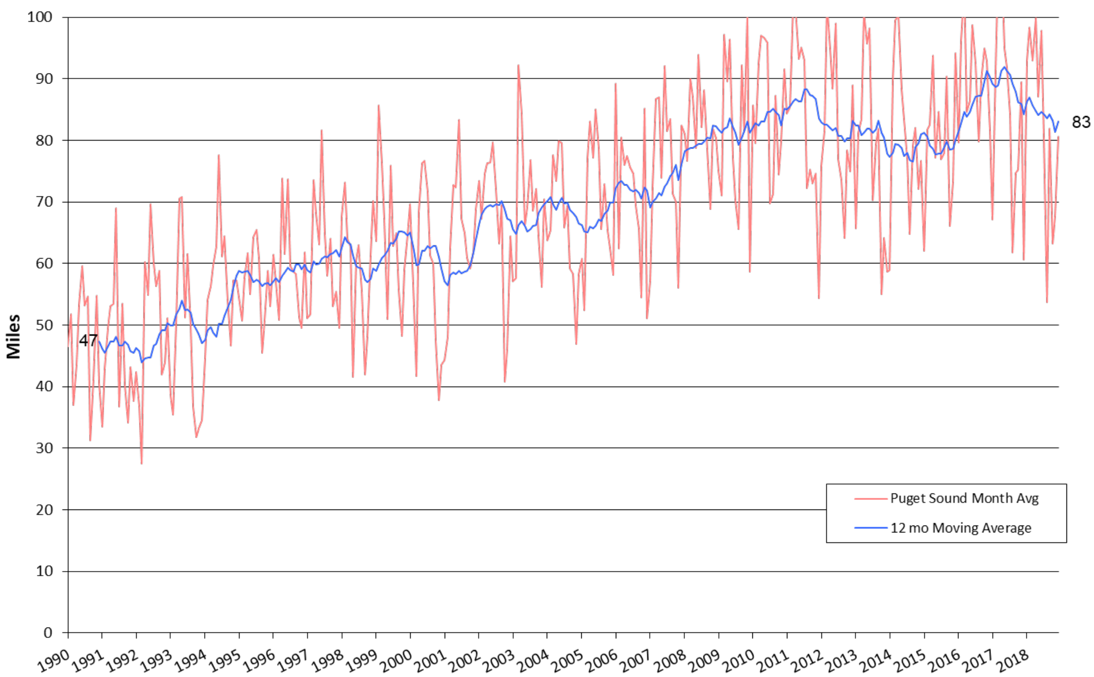


Figure 24: King County Visibility

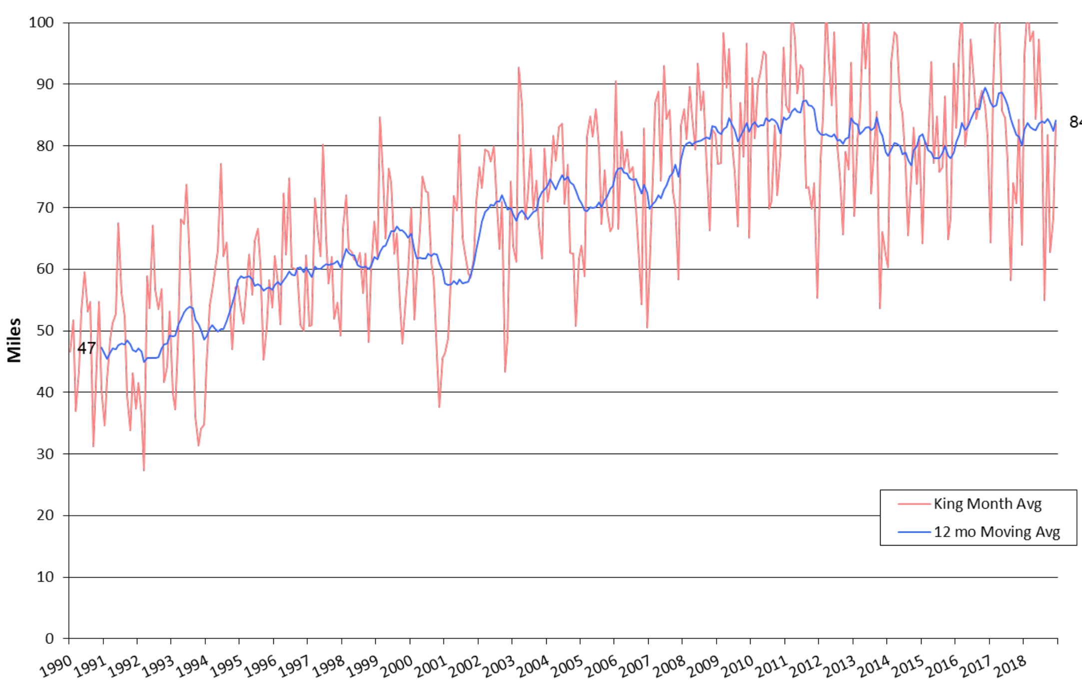


Figure 25: Kitsap County Visibility

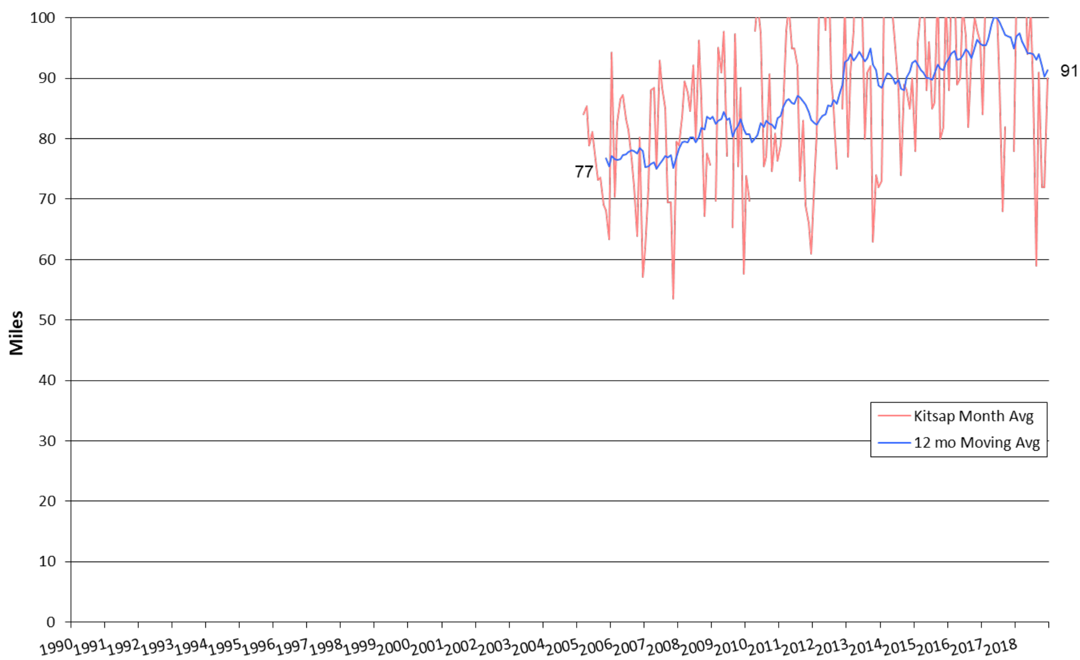


Figure 26: Pierce County Visibility

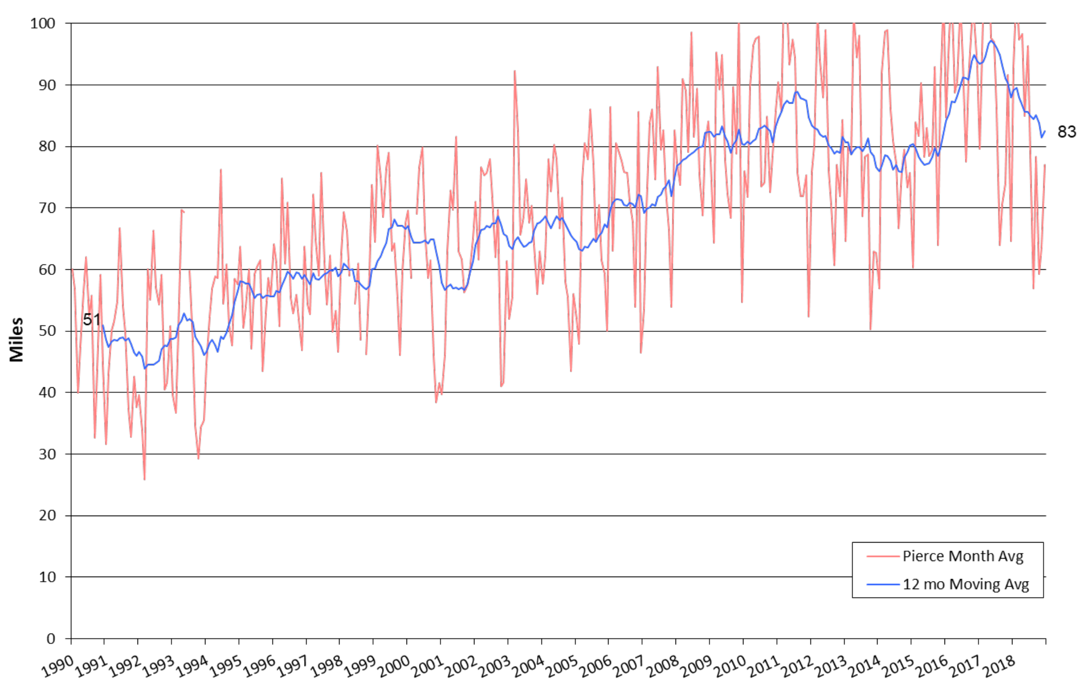
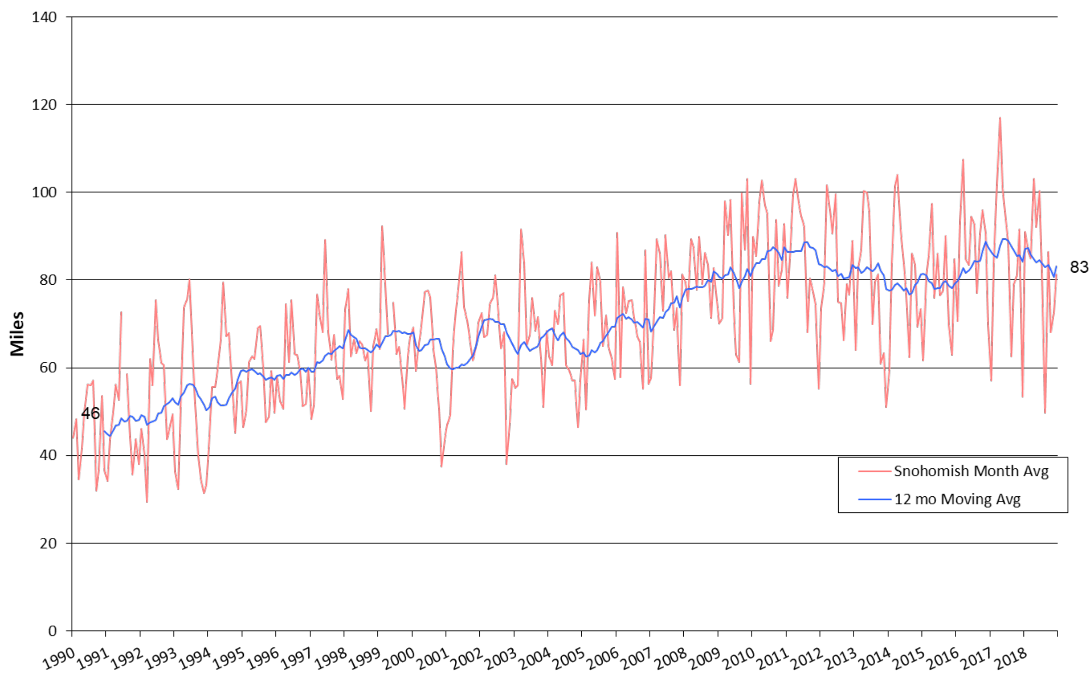


Figure 27: Snohomish County Visibility



Air Toxics

"Air toxics" are air pollutants known or suspected to cause health problems. Potential health effects include cancer, birth defects, lung damage, immune system damage, and nerve damage.[12,13] The Agency considers over 400 different air pollutants as air toxics.

This section presents a relative ranking of these toxics based on potential cancer health risks, as well as trends over time. We provide a short description of each air toxic of concern, including their health effects and sources.

The Washington State Department of Ecology (Ecology) monitors for air toxics at the Seattle Beacon Hill site. The Beacon Hill site is one of 27 EPA-sponsored National Air Toxic Trends Sites. As in previous years, Ecology monitored toxics every six days. The 2006 dataset is incomplete due to relocation of the Beacon Hill site that year. For general information on air toxics, see https://www.pscleanair.org/162/Air-Toxics. Air toxics statistical summaries are provided starting on page A-15 of the Appendix.

From September 2016 through August 2017, we conducted a special, EPA-Funded study on near-road air toxics in the Seattle Chinatown-International District. The results of this study became available in June 2018. Samples were collected at a number of sites throughout the community, both near the I-5 freeway and at locations of community interest, with the goal of characterizing the impact of freeways on the neighborhood's air quality. Of the more than 100 air toxics measured, the study found 14 that were over our health screening value (one-in-a-million potential cancer risk). These toxics and their concentrations were similar to other sites across the country, and are consistent with levels we observed in previous air toxics studies in Seattle and Tacoma. The greatest air toxics risk in this area remains that from diesel particles, consistent with previous studies. At the near-road site, more than 75% of the potential cancer risk is attributable to this diesel particulate matter. The full study report can be found at http://www.pscleanair.org/DocumentCenter/View/3398/Air-Toxics-Study-in-the-Chinatown-International-District-Full-Report.

Relative ranking based on cancer risk & unit risk factors

Table 3 below ranks 2018 air toxics from the Beacon Hill monitoring site according to mean potential cancer risk per million. It shows monitored pollutants ranked from highest concern (#1) to lowest, based on ambient concentrations multiplied by unit risk factors. A unit risk factor takes into account how toxic a pollutant is. Potential cancer risk estimates are shown here to provide a meaningful basis of comparison between pollutants and are not intended to represent any one community or individual exposure.

[12] US EPA, Hazardous Air Pollutants: https://www.epa.gov/haps.
[13] US EPA, Risk Assessment for Toxic Air Pollutants: A Citizen's Guide: https://www3.epa.gov/airtoxics/3_90_024.html.

Potential cancer risk is an estimate of the number of potential additional cancers (out of a population of one million) that may develop from exposure to air toxics over a lifetime (set at 70 years). A risk level of one in a million is commonly used as a screening value, and is used here.[14]

For details on how air toxics were ranked, please see page A-16 in the Appendix.

Risks presented in this table are based on annual average ambient (outside) concentrations. Risks based on 95th percentile concentrations (a more protective statistic than presented in Table 3) are presented on page A-17 of the Appendix. Page A-17 also lists the frequency (percentage) of samples that were over the cancer screening level of one in a million risk.

[14] US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; https://archive.org/details/APreliminaryRisk-basedScreeningApproachForAirToxicsMonitoringDataSets

Table 3: 2018 Beacon Hill Air Toxics Ranking

(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk[a]
Carbon Tetrachloride	1	26
Benzene	2	15
1,3-Butadiene	3	11
Formaldehyde	4	5
Acetaldehyde	5	2
Arsenic (PM_{10})	5	2
Chloroform	7	3
Hexavalent Chromium	7	*3*[b]
Ethylene Dichloride	9	2
Naphthalene	10	1
Dichloromethane	10	1
Ethylbenzene	12	<1
Cadmium (PM_{10})	12	<1

[a]Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)[15]

[b]Sampling for hexavalent chromium was discontinued in 2013 and the included estimate is based on 2013.

PM_{10} = fine particles less than 10 micrometers in diameter

The two air toxics that present the majority of potential health risk in the Puget Sound area, diesel particulate matter and wood smoke particulate, are not included in the table. No direct monitoring method currently exists for these toxics. Modeling for these air toxics was not conducted for this report.

[15]Washington State Administrative Code WAC 173-460-150, apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150

Health effects other than cancer

Air toxics can also have chronic non-cancer health effects. These include respiratory, cardiac, immunological, nervous system and reproductive system effects.

In order to determine non-cancer health risks, we compared each air toxic to its chronic reference concentration, as established by California EPA (the most comprehensive dataset available). A chronic reference concentration (RfC) is considered a safe level of continuous exposure to toxics for non-cancer health effects.

Only one air toxic, acrolein, failed the screen for non-cancer chronic health effects, with measured concentrations consistently exceeding the reference concentration. Acrolein irritates the lungs, eyes, and nose, and is a combustion by-product.[16] Unfortunately, acrolein is one of the most difficult pollutants to monitor, and its measurements have large uncertainty.[17] Therefore, for acrolein, we did not explore a trend analysis as the results are likely all within the historical uncertainty of the measurement.

Reference concentrations and hazard indices are shown for each air toxic on page A-18 of the Appendix. A hazard index is the concentration of a pollutant (either mean or other statistic) divided by the reference concentration. Typically, no adverse non-cancer health effects for that pollutant are associated with a hazard index less than 1, although it is important to consider that people are exposed to many pollutants at the same time.

We did not explore acute non-cancer health effects, because the Beacon Hill air toxics concentrations are based on 24-hour samples.

Air toxics trends

Annual average potential cancer risks are shown on the following pages for air toxics collected from 2000 to 2018 at Beacon Hill. For many air toxics, our analysis of the trends shows a statistically significant decrease in annual average concentrations.

EPA has not set ambient air standards for air toxics, so graphs do not include reference lines for federal standards. A statistical summary of the trends shown on the following pages can be found on page A-19 of the Appendix.

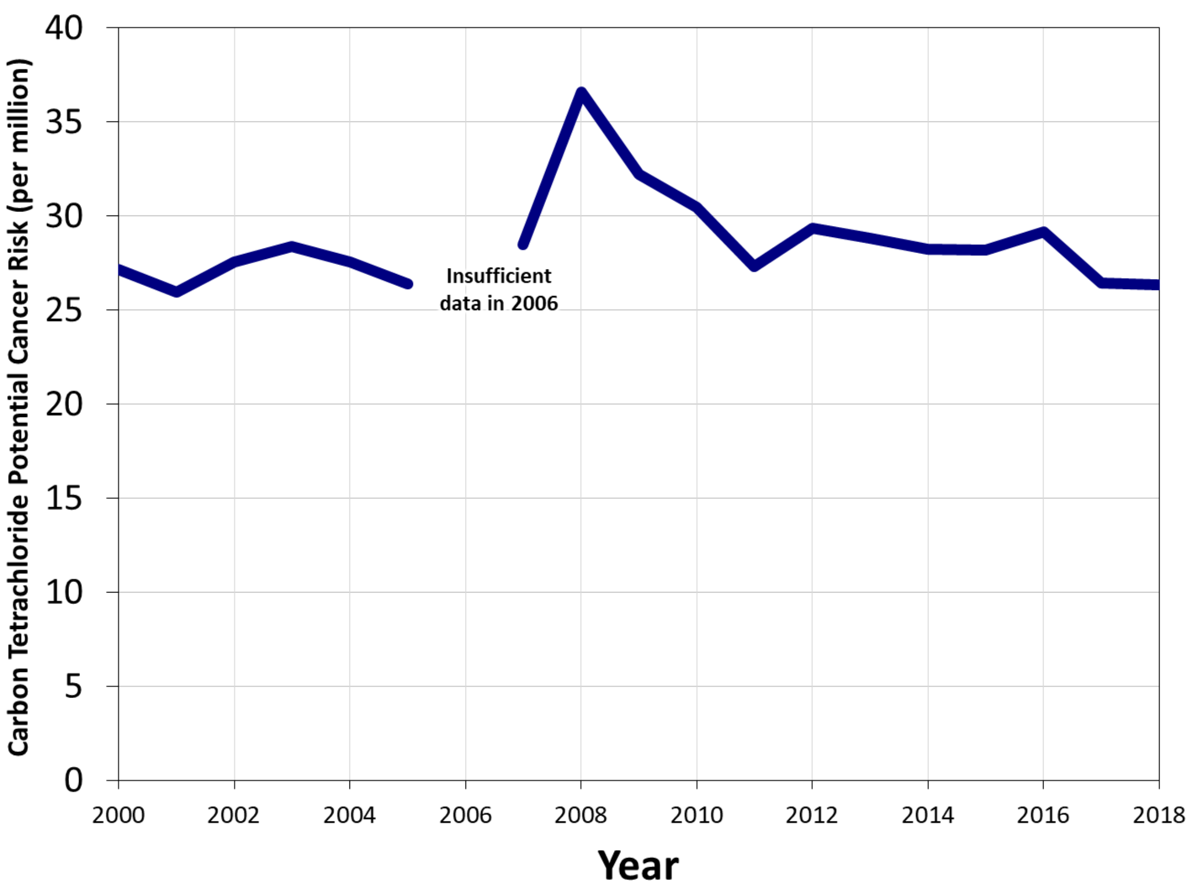
[16] EPA, Acrolein Hazard Summary; https://www.epa.gov/sites/production/files/2016-08/documents/acrolein.pdf.
[17] EPA, Schools Monitoring Acrolein Update, https://www3.epa.gov/air/sat/pdfs/acroleinupdate.pdf.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[18] It was widely used as a solvent in both industry and consumer applications and was banned from consumer use in 1995. Trace amounts are still emitted by wastewater treatment plants. Carbon tetrachloride is relatively ubiquitous, has a long half-life, and occurs in similar concentrations in urban and rural areas. Carbon tetrachloride's 2018 average potential cancer risk estimate at Beacon Hill was 26 in a million.

The Agency does not target efforts at reducing carbon tetrachloride emissions, as carbon tetrachloride has already been banned. We did not find a statistically significant trend in carbon tetrachloride levels over time.

Figure 28: Carbon Tetrachloride Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



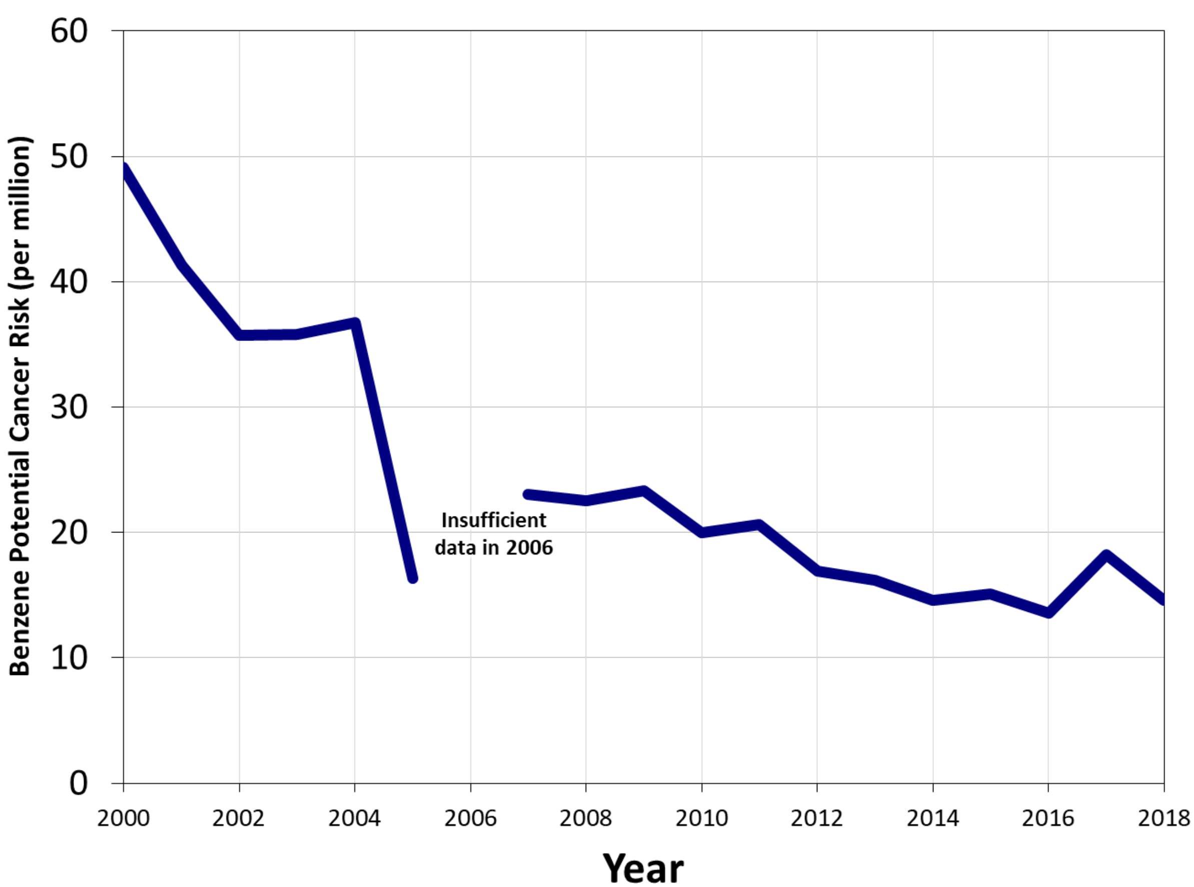
[18] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/carbon-tetrachloride.pdf.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune and nervous system disorders.[19] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvent and other combustion. Benzene's 2018 average potential cancer risk estimate at Beacon Hill was 15 in a million.

Benzene levels are likely decreasing in our area due to factors including: less automobile pollution with cleaner vehicles coming into the fleet, better fuels and fewer gas station emissions due to better compliance (vapor recovery at the pump and during filling of gas station tanks). We found a statistically significant drop in risk from benzene at a rate of about 1.6 per million per year since 2000.

Figure 29: Benzene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



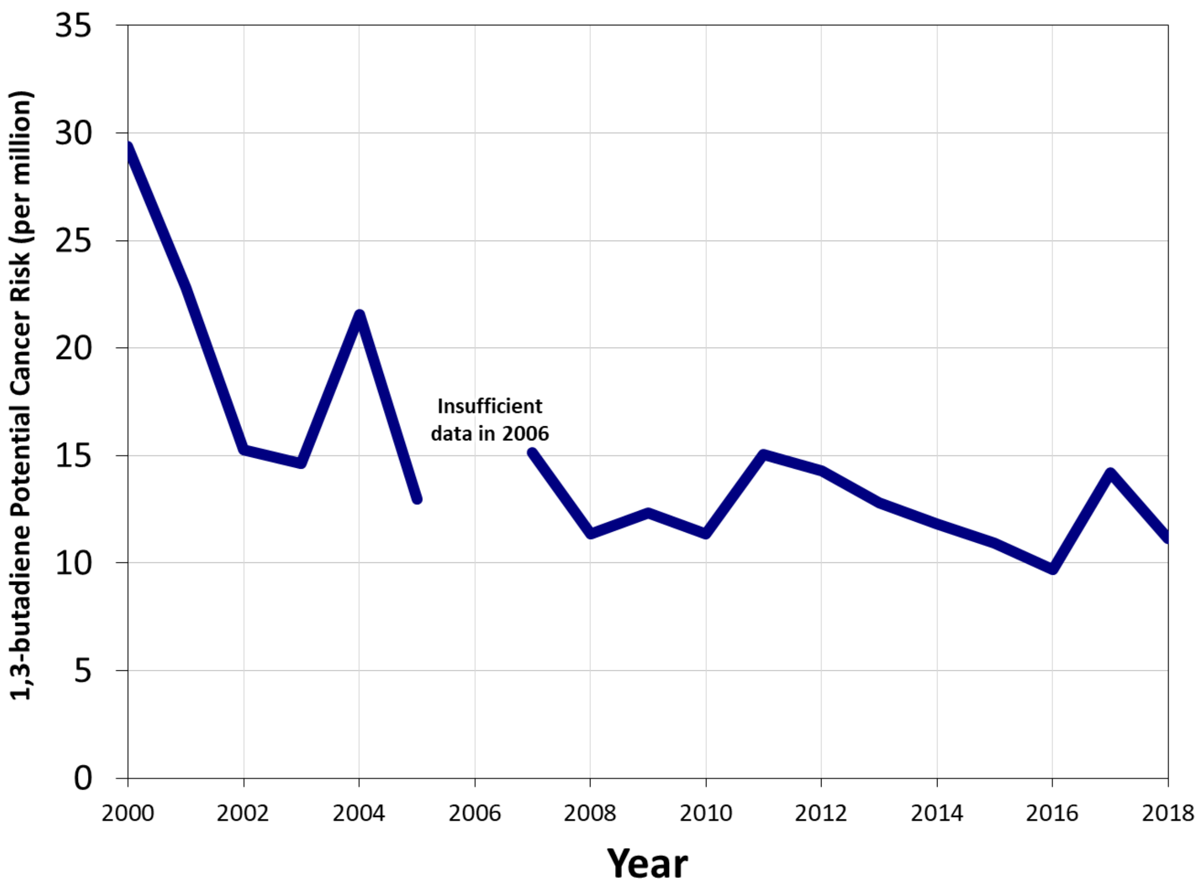
[19]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[20] Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-butadiene's 2018 average potential cancer risk estimate at Beacon Hill was 11 in a million. Because about 39% of the sample results were below method detection limits, we used Kaplan-Meier analysis to estimate the mean, as this method is designed to overcome bias from samples below the detection limit and other forms of censored data. Without using this technique, the potential cancer risk for 2018 would have been 10 per million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce 1,3-butadiene emissions. Since 2000, we found a statistically significant drop in risk from 1,3-butadiene at a rate of about 0.6 per million per year.

Figure 30: 1,3-butadiene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



[20] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-08/documents/13-butadiene.pdf.

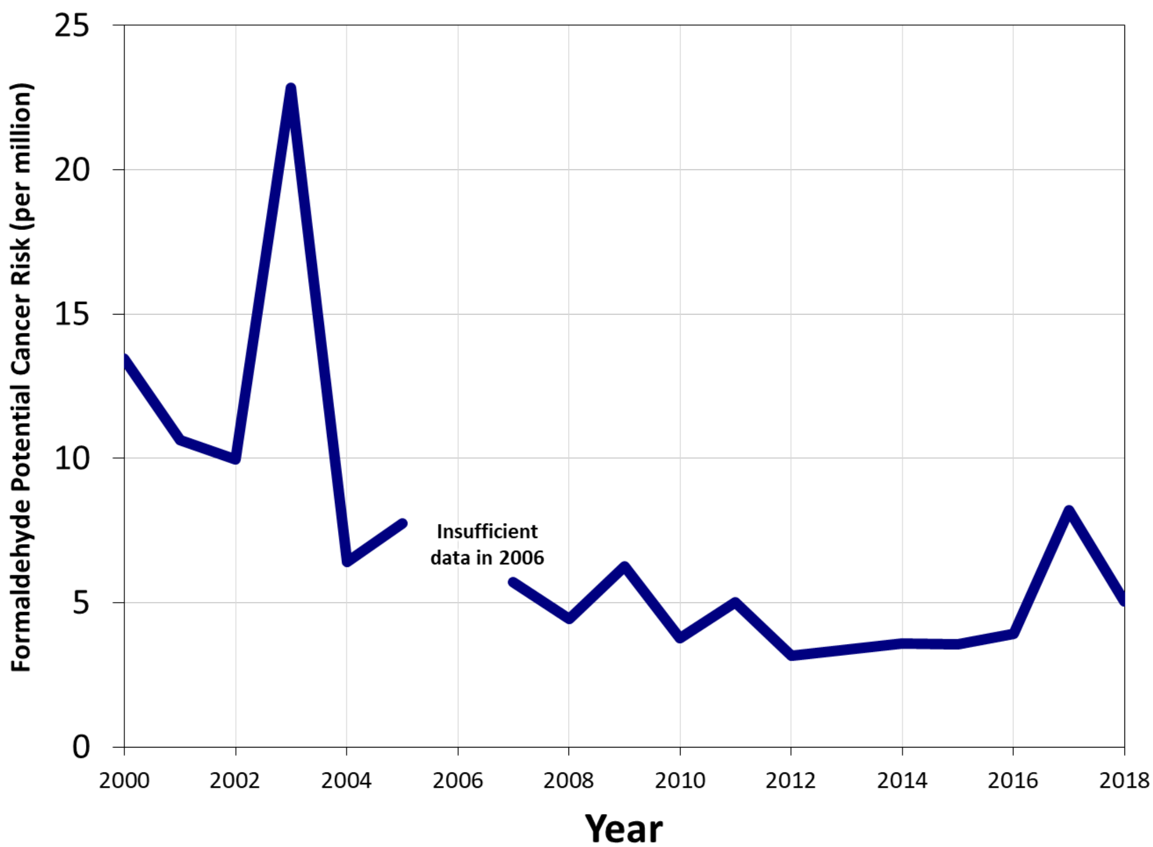
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat and lung irritation.[21] Sources of ambient formaldehyde include automobiles, trucks, wood burning and other combustion. Formaldehyde's 2018 average potential cancer risk estimate at Beacon Hill was 5 in a million.

The sharp increase in average formaldehyde concentration in 2003 was due to nine anomalous sampling days in July 2003 when levels were roughly ten times the normal levels. It is possible that a local formaldehyde source was present at the Beacon Hill reservoir during this month and inadvertently affected the monitors.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce formaldehyde emissions. Since 2000, we found a statistically significant drop in risk from formaldehyde at a rate of about 0.5 per million per year.

Figure 31: Formaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



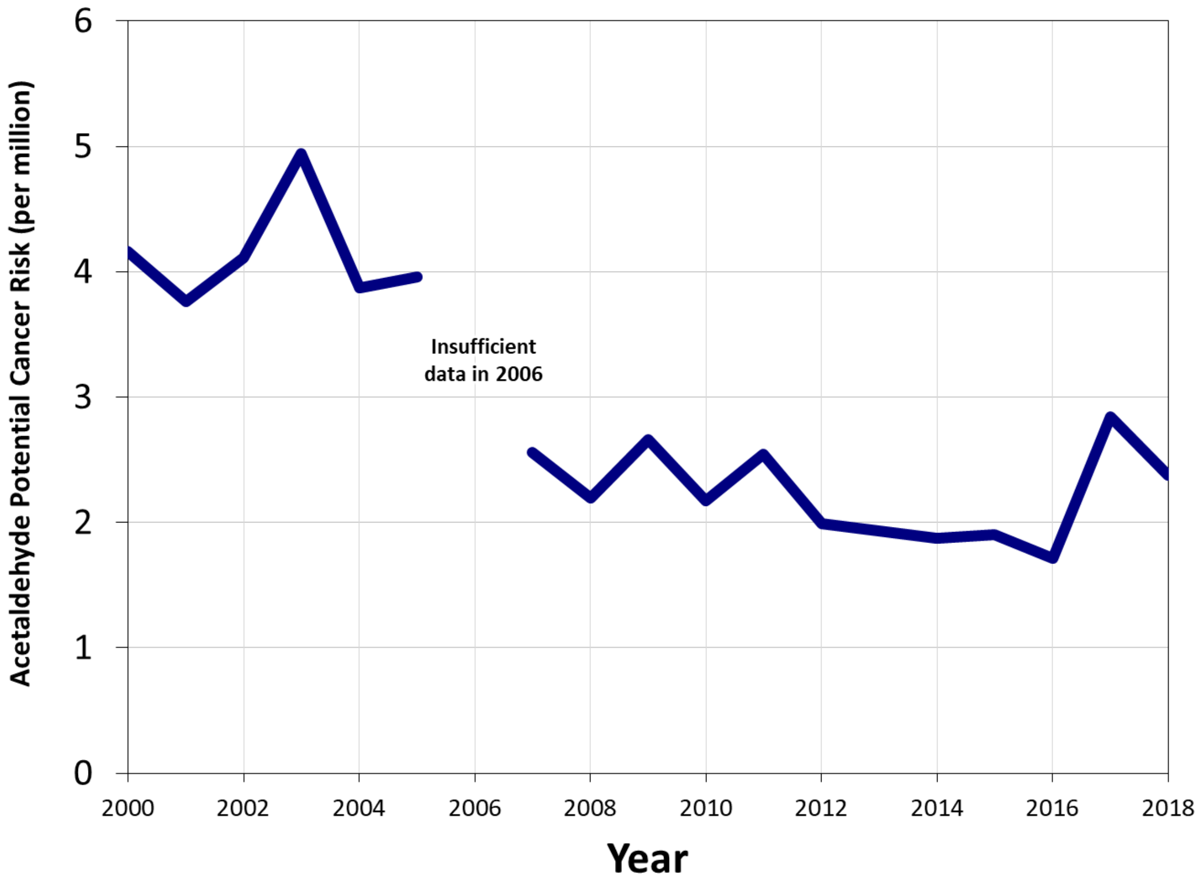
[21]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/formaldehyde.pdf.

Acetaldehyde

The EPA lists acetaldehyde as a probable human carcinogen. Acetaldehyde inhalation is also associated with irritation of eyes, throat and lungs, and long-term effects similar to those of alcoholism.[22] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2018 average potential cancer risk estimate at Beacon Hill was 2 in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce acetaldehyde emissions. Since 2000, we found a statistically significant drop in risk from acetaldehyde at a rate of about 0.1 per million per year.

Figure 32: Acetaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



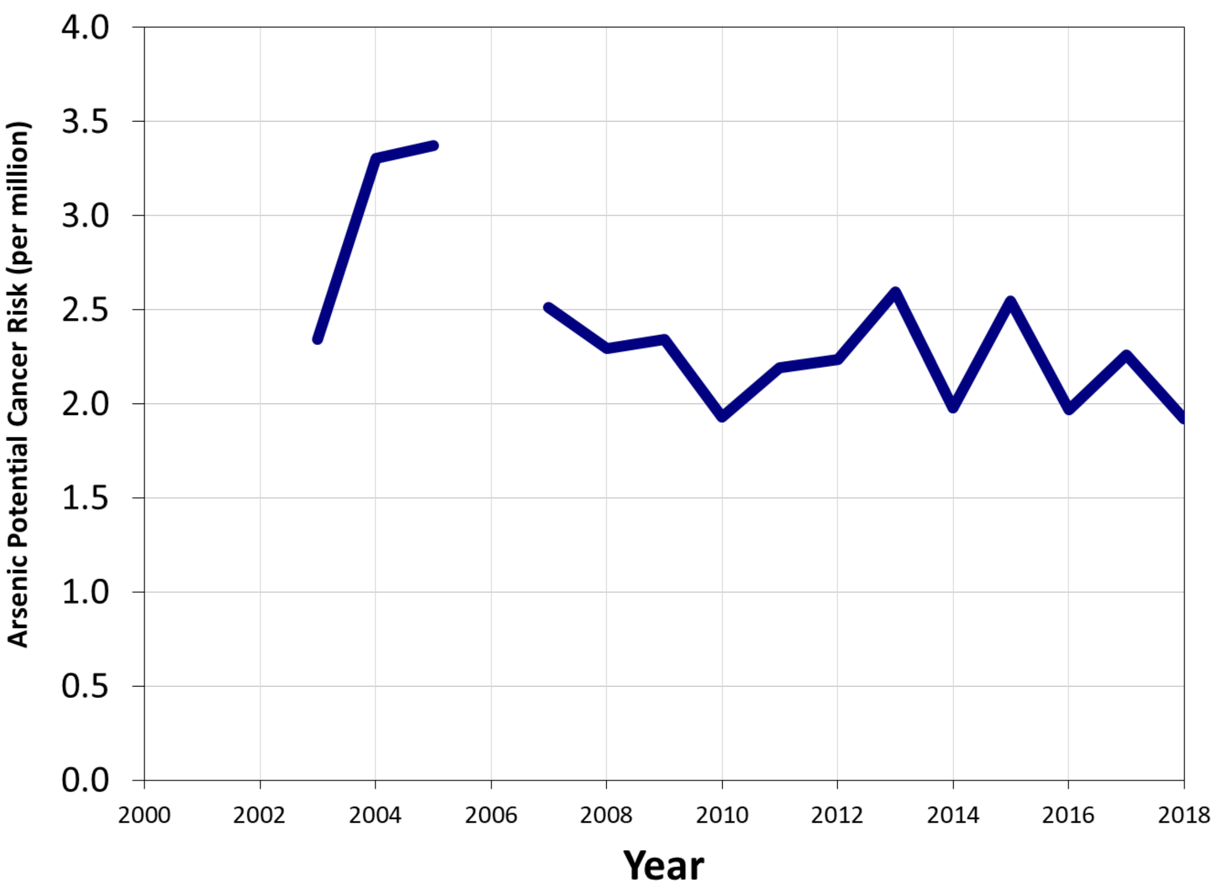
[22] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/acetaldehyde.pdf.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation and liver and kidney damage.[23] Arsenic is used to treat wood and in colored glass. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2018 average potential cancer risk estimate at Beacon Hill was 2 in a million. Since 2000, we found a statistically significant drop in risk from arsenic at a rate of about 0.1 per million per year.

The Agency's permitting program works with and regulates industrial users of arsenic to reduce emissions. Illegal burning, especially of treated wood, can also contribute to arsenic emissions in our area.

Figure 35: Arsenic Annual Average Potential Cancer Risk at Beacon Hill, 2003-2018



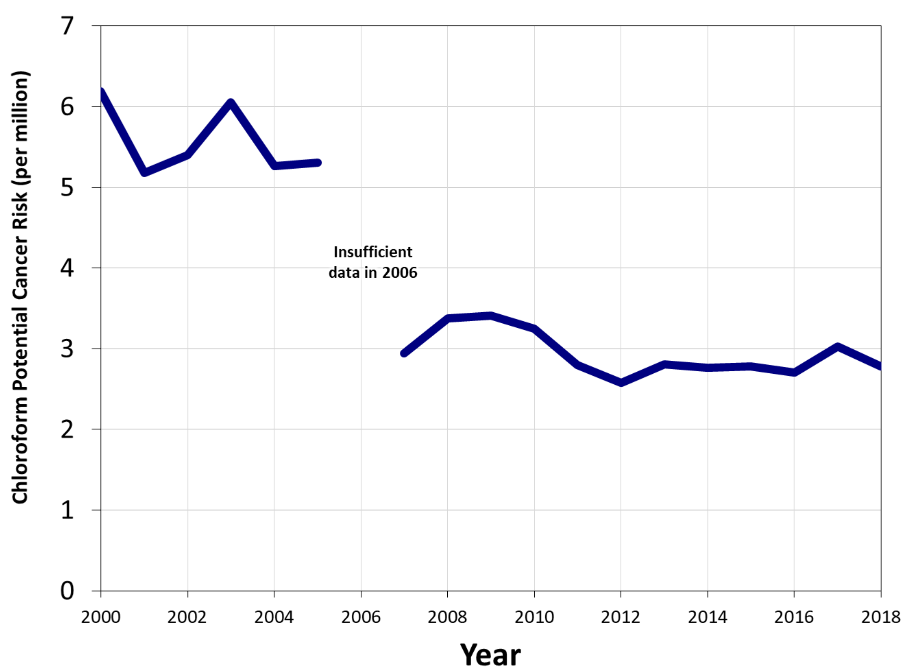
[23]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/arsenic-compounds.pdf.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[24] Main sources of chloroform are water treatment plants and reservoirs.[25] Because the Beacon Hill monitoring site is located at the Beacon Hill reservoir, which was uncovered prior to 2009, the chloroform measurements from 2000 through 2008 may be higher than expected for most of our region. However, the reservoir underwent a major renovation in 2008 and 2009 and is now completely enclosed, possibly at least partially explaining the drop in chloroform levels around that time. Chloroform's 2018 average potential cancer risk estimate at Beacon Hill was 3 in a million.

The Agency does not prioritize efforts to reduce chloroform emissions, as it does not likely present risk in areas other than those directly adjacent to reservoirs, the majority of which have been covered in accordance with a 2006 federal regulation on drinking water protection.[26] Since 2000, we found a statistically significant drop in risk from chloroform at a rate of about 0.2 per million per year.

Figure 33: Chloroform Annual Average Potential Cancer Risk at Beacon Hill, 2000-2018



[24]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chloroform.pdf.
[25]Seattle Public Utilities. 2018 Water Quality Analysis shows detectable levels of trihalomethanes in treated drinking water, which is stored in reservoirs (trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform); https://www.seattle.gov/Documents/Departments/SPU/Services/Water/Water_Quality_Report_2018.pdf.
[26]Long Term 2 Enhanced Surface Water Treatment Rule; https://www.epa.gov/dwreginfo/long-term-2-enhanced-surface-water-treatment-rule-documents

Hexavalent Chromium

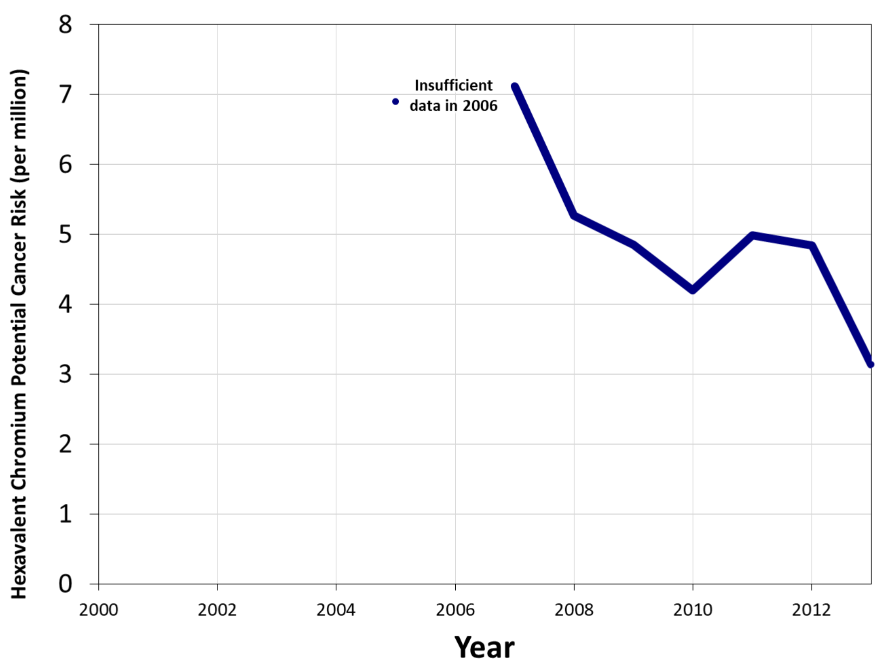
Chromium is present in two chemical states (trivalent and hexavalent) in our air. Trivalent chromium occurs naturally, while hexavalent comes from human activities and is much more toxic. EPA lists hexavalent chromium as a known carcinogen, associated primarily with lung cancer. Hexavalent chromium is often abbreviated as chromium +6 or chromium(VI).

Exposure to hexavalent chromium is also associated with adverse respiratory, liver, and kidney effects.[27] Sources of hexavalent chromium include industrial processes such as chrome electroplating, as well as combustion of distillate oil, green glass production, and combustion of gasoline and diesel fuels (car, truck and bus exhaust).

Due to the significant cost of monitoring for this pollutant, monitoring for total suspended particulate (TSP) hexavalent chromium was stopped in June 2013. The 2013 estimated average potential cancer risk for hexavalent chromium at Beacon Hill was 3 in a million based on the first half of the year.

In some years, up to 20% of the samples were below method detection limits. For the trend below, we used Kaplan-Meier analysis to estimate the annual means, as this method is designed to overcome bias from samples below the detection limit and other forms of censored data. Since 2000, we found a statistically significant drop in risk from hexavalent chromium at a rate of about 0.4 per million per year. The Agency's permitting program works with and regulates industrial chromium plating operations to reduce hexavalent chromium emissions.

Figure 34: Hexavalent Annual Average Potential Cancer Risk at Beacon Hill, 2005-2013



[27] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chromium-compounds.pdf.

Ethylene Dichloride

EPA lists ethylene dichloride as a probable human carcinogen. It is primarily used as a solvent in the production of other chemicals like vinyl chloride. It is also added to leaded gasoline, but this is expected to be a very minor source, as leaded gas for on-road vehicle use was phased out in 1996.[28,29]

We estimated ethylene dichoride's 2018 average potential cancer risk estimate at Beacon Hill at 2 in a million.

There is no useful trend information for this air toxic since this estimate includes samples near the practical quantitation limit of the measurement method. That is, most of the samples in 2018 were within twice the method detection limit. Additionally, in prior years, most of the samples were also below the quantitation limits. In the years for which we have ethylene dichloride data, the detection limit for this air toxic is typically near the one in a million potential cancer risk level.

The Agency's permitting program works with and regulates industrial producers of ethylene dichloride to reduce emissions.

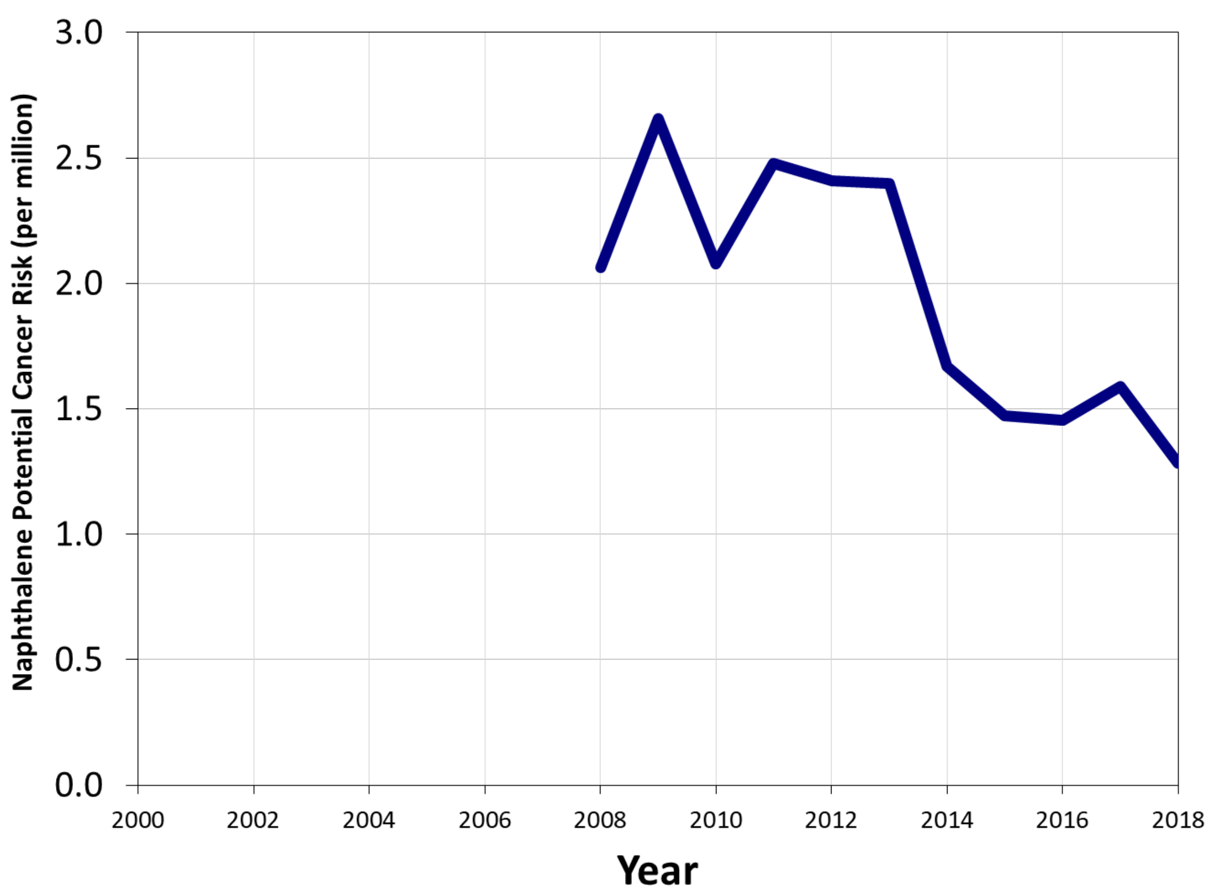
[28] EPA Hazard Summary, https://www.epa.gov/sites/production/files/2016-09/documents/ethylene-dichloride.pdf.
[29] US Energy Information Administration: Gasoline and the Environment; https://www.eia.gov/energyexplained/index.php?page=gasoline_environment

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is also associated with respiratory effects and retina damage.[30] Local sources of naphthalene include combustion of wood and heavy fuels. Naphthalene's 2018 average potential cancer risk estimate at Beacon Hill was at 1 in a million.

The Agency works with and regulates wood burning through burn bans and wood stove replacement programs to reduce naphthalene emissions. Since 2000, we found a statistically significant drop in risk from naphthalene at a rate of about 0.1 per million per year. Monitoring for naphthalene and other polycyclic aromatic hydrocarbons started in 2008.

Figure 36: Naphthalene Annual Average Potential Cancer Risk at Beacon Hill, 2008-2018



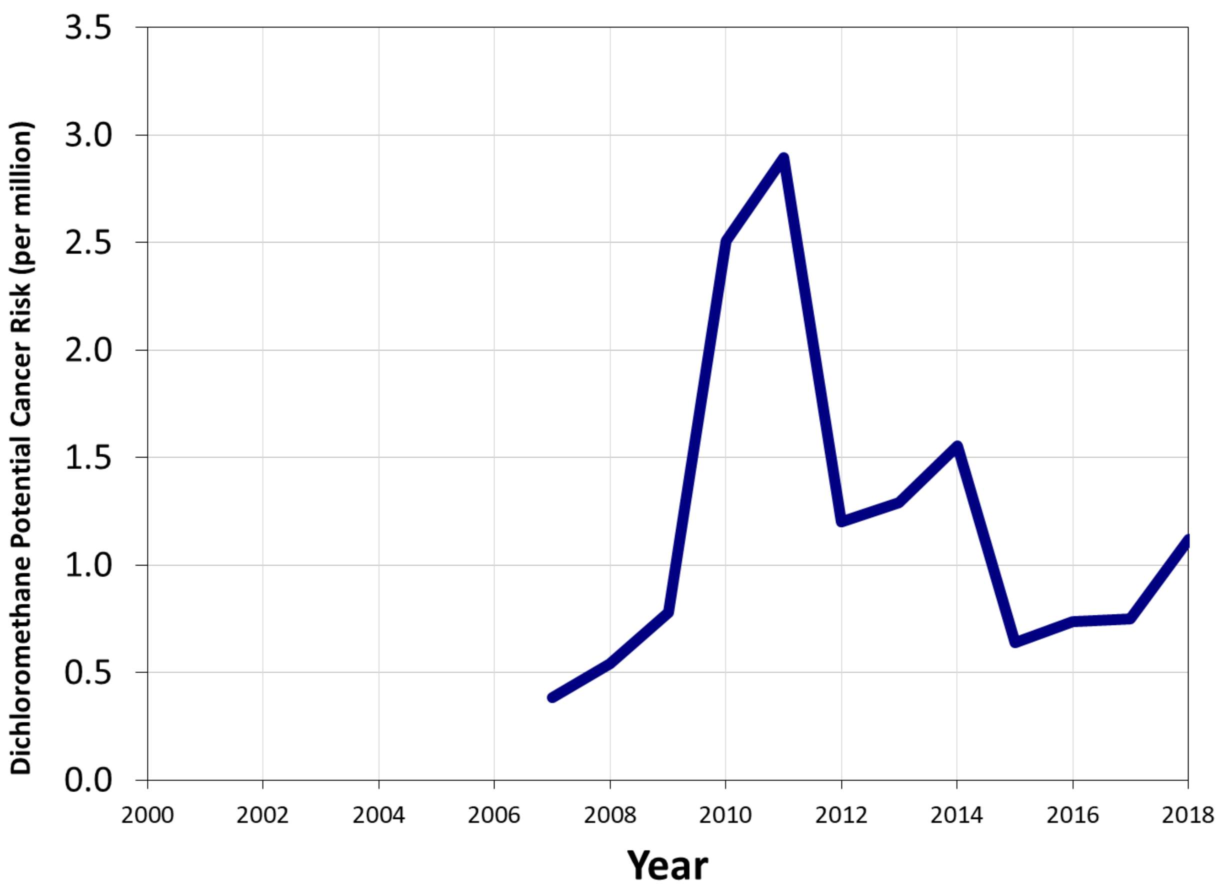
[30] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/naphthalene.pdf.

Dichloromethane

EPA lists dichloromethane as a probable human carcinogen. Dichloromethane is also known as methylene chloride. Dichloromethane is a common solvent used for paint and industrial and cleaning processes.[31] Dichloromethane's 2018 average potential cancer risk estimate at Beacon Hill was 1 in a million. We did not find a statistically significant trend in dichloromethane levels over the 2007-2018 time frame for which we have data.

The Agency's permitting program works with and regulates industrial producers of dichloromethane to reduce emissions. We do not have a program that addresses emissions from household products like paint strippers that may contain dichloromethane.

Figure 38: Dichloromethane Annual Average Potential Cancer Risk at Beacon Hill, 2007-2018

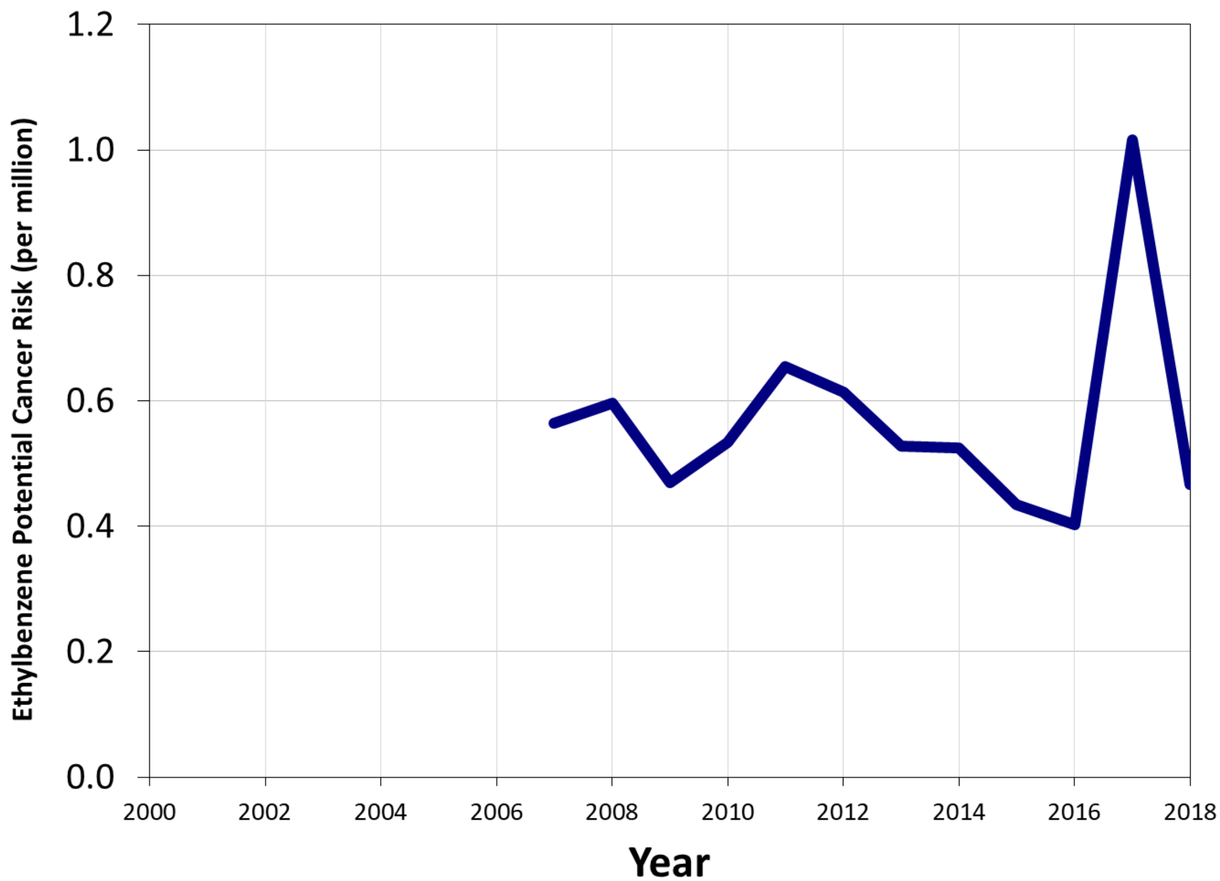


[31] EPA Hazard Summary, https://www.epa.gov/sites/production/files/2016-09/documents/methylene-chloride.pdf.

Ethylbenzene

EPA lists ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[32] Chronic exposure to ethylbenzene may affect the blood, liver, and kidneys. Local sources of ethylbenzene are from fuels, asphalt and naphtha. It is also used in styrene production. Ethylbenzene's 2018 average potential cancer risk estimate at Beacon Hill was less than one in a million. We did not find a statistically significant trend in ethylbenzene levels over the 2007-2018 time frame for which we have data. The Agency works with and regulates solvent-using businesses to reduce ethylbenzene emissions.

Figure 37: Ethylbenzene Annual Average Potential Cancer Risk at Beacon Hill, 2007-2018



[32]EPA Hazard Summary: https://www.epa.gov/sites/production/files/2016-09/documents/ethylbenzene.pdf.

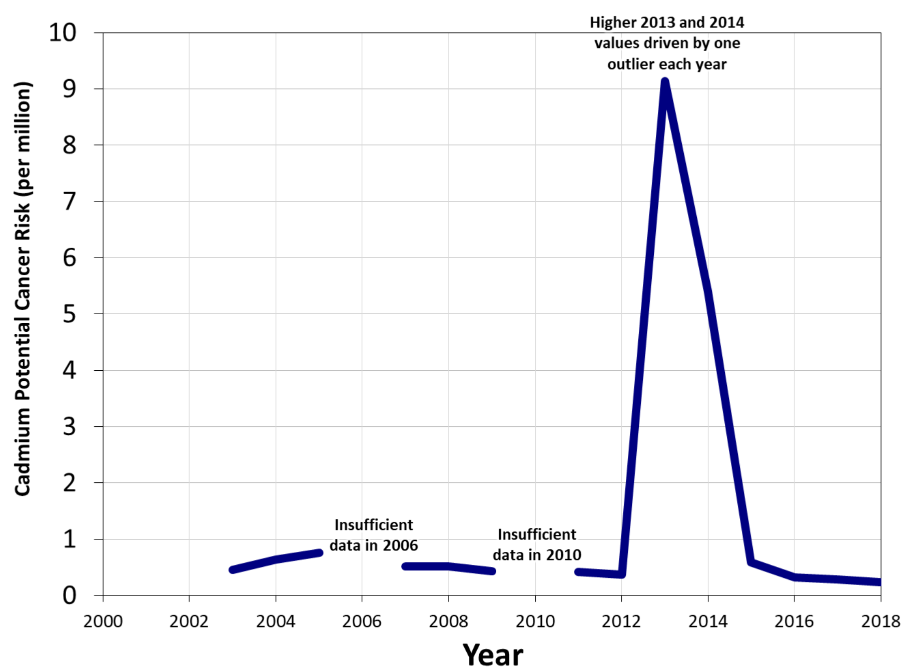
Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[33] Combustion of distillate oil is a main source of cadmium in the Puget Sound area.

Cadmium's 2018 average potential cancer risk estimate at Beacon Hill was less than 1 in a million. Our trend is affected by a number of factors, including the fact that over half the samples in 2010 were below the detection limits and thus we did not have sufficient data to make a comparable average. Extremely high outlier results on 11/18/13 and 9/8/14 resulted in high average concentrations in each of those respective years. On those days, no other metal concentrations were statistical outliers compared to their respective annual variability. With the outliers excluded for 2013 and 2014, the estimated annual potential cancer risks for those years would be < 1. With or without the outliers included, we found no statistically significant trend for cadmium.

The Agency's permitting program works with and regulates industrial producers of cadmium to reduce emissions.

Figure 39: Cadmium Annual Average Potential Cancer Risk at Beacon Hill, 2003-2018



[33]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/cadmium-compounds.pdf.

Definitions

General Definitions

Air Quality Index

Table 4: 2018 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[a]	$PM_{2.5}$(µg/m^3) 24 hour	PM_{10}(µg/m^3) 24 hour	CO (ppm) 8 hour	SO_2[c](ppb) 1 hour	NO_2 (ppb) 1 hour	AQI value	Category
0.000–0.054	—	0.0–12.0	0–54	0.0–4.4	0–35	0–53	0–50	Good
0.055–0.070	—	12.1–35.4	55–154	4.5–9.4	36–75	54–100	51–100	Moderate
0.071–0.085	0.125–0.164	35.5–55.4	155–254	9.5–12.4	76–185	101–360	101–150	Unhealthy for sensitive groups
0.086–0.105	0.165–0.204	55.5–150.4	255–354	12.5–15.4	(186–304)[d]	361–649	151–200	Unhealthy
0.106–0.200	0.205–0.404	150.5–250.4	355–424	15.5–30.4	(305–604)[d]	650–1249	201–300	Very unhealthy
(b)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	(604–804)[d]	1250–1649	301–400	Hazardous
(b)	0.505–0.604	350.5–500.4	505–604	40.5–50.4	(805–1004)[d]	1650–2049	401–500	

[a]Areas are generally required to report the AQI based on 8-hour ozone values. However, there are a small number of areas where an AQI based on 1-hour ozone values would be safer. In these cases, in addition to calculating the 8-hour ozone value, the 1-hour ozone value may be calculated, and the greater of the two values reported.

[b]8-hour O_3 values do not define higher AQI values (above 300). AQI values above 300 are calculated with 1-hour O_3 concentrations.

[c]EPA changed the SO_2 standard on June 22, 2010 to be based on an hourly maximum instead of a 24-hour and annual average.

[d] 1-hour SO_2 values do not define higher AQI values (≥ 200). AQI values of 200 or greater are calculated with 24-hour SO_2 concentrations.

For more information on the AQI, see airnow.gov/index.cfm?action=aqibasics.aqi.

Air shed

A geographic area that shares the same air, due to topography, meteorology and climate.

Air Toxics

Air toxics are broadly defined as over 400 pollutants that the Agency considers potentially harmful to human health and the environment. These pollutants are listed in the Washington Administrative Code at apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150. Hazardous air pollutants (see below) are checked on this list to identify them as a subset of air toxics. Air toxics are also called Toxic Air Contaminants (TAC) under Agency Regulation III.

Criteria Air Pollutant (CAP)

The Clean Air Act of 1970 defined *criteria pollutants* and provided EPA the authority to establish ambient concentration standards for these criteria pollutants to protect public health. EPA periodically revises the original concentration limits and methods of measurement, most recently in 2011. The six criteria air pollutants are: particulate matter (10 micrometers and 2.5 micrometers), ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide and lead. See appendix page A-20 for more information.

ppm, ppb (parts per million, or parts per billion)

A unit of concentration used for a many air pollutants. A ppm (ppb) means one molecule of the pollutant per million (or billion) molecules of air.

Hazardous Air Pollutant (HAP)

A *hazardous air pollutant* is an air contaminant listed in the Federal Clean Air Act, Section 112(b). EPA currently lists 187 pollutants as HAPs at https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications.

Temperature Inversions

Air temperature usually decreases with altitude. On a sunny day, air near the surface is warmed and is free to rise. The warm surface air can rise to altitudes of 4,000 feet or more and is dispersed (or mixed) into higher altitudes. In contrast, on clear nights with little wind, the surface can cool rapidly (by 10 degrees or more), which also cools the air just above the surface. The air aloft does not cool, which creates a very stable situation where the warm air aloft effectively caps the cooler air below. This limits mixing to just a few hundred feet or less. This situation is called a temperature inversion and allows for pollutants to accumulate to high concentrations.

Unit Risk Factor (URF)

A unit risk factor is a measure of a pollutant's cancer risk based on a 70-year inhalation exposure period. The units are risk/concentration. Unit risk factors are multiplied by concentrations to estimate potential cancer risk.

Visibility/Regional Haze

Visibility is often explained in terms of visual range and light extinction. *Visual range* is the maximum distance (usually miles or kilometers) a black object can be seen against the horizon. *Light extinction* is the sum of light scattering and light absorption by fine particles and gases in the atmosphere. The more light extinction, the shorter the visual range. Reduced visibility (or visual range) is caused by weather (clouds, fog, and rain) and air pollution (fine particles and gases).

Volatile Organic Compound (VOC)

An organic compound that participates in atmospheric photochemical reactions. This excludes compounds determined by EPA to have negligible photochemical reactivity.

pscleanair.org
Puget Sound Clean Air Agency

1904 Third Avenue, Suite 105
Seattle, Washington 98101
www.pscleanair.org

2018

Air Quality Data Summary Appendix

September 2019

Working Together for Clean Air

Monitoring Methods Used from 1999 to 2018 in the Puget Sound Air shed

Pollutant Code	Measurement	Method	Units
Bap	Light Absorption by Particles	Light Absorption by Aethalometer	bap (x 10 exp-4)/m
Bsp	Light Scattering by Particles	Nephelometer - Heated Inlet	bsp (x 10 exp-4)/m
CO	Carbon Monoxide	Gas Nondispersive Infrared Radiation	parts per million
NO_x	Nitrogen Oxides (NO_x)	Chemiluminescence	parts per million
	Nitric Oxide (NO)	Chemiluminescence	parts per million
	Nitrogen Dioxide (NO_2)	Chemiluminescence	parts per million
NO_Y	Reactive Nitrogen Compounds (NO_X + other reactive compounds)	Chemiluminescence	parts per billion
O_3	Ozone	UV Absorption	parts per million
Pb	Lead	Standard High Volume	micrograms per standard cubic meter
PM_{10} ref	PM_{10} Reference	Reference - Hi Vol Andersen/GMW 1200	micrograms per cubic meter
PM_{10} bam	PM_{10} Beta Attenuation	Andersen FH621-N	micrograms per cubic meter
PM_{10} teom	PM_{10} Teom	R&P Mass Transducer	micrograms per cubic meter
$PM_{2.5}$ ref	$PM_{2.5}$ Reference	Reference—R&P Partisol 2025	micrograms per cubic meter
$PM_{2.5}$ bam	$PM_{2.5}$ Beta Attenuation	Andersen FH621-N	micrograms per cubic meter
$PM_{2.5}$ teom	$PM_{2.5}$ Teom	R&P Mass Transducer	micrograms per cubic meter
$PM_{2.5}$ ls	$PM_{2.5}$ Nephelometer	Radiance Research M903 Nephelometer	micrograms per cubic meter
$PM_{2.5}$ bc	$PM_{2.5}$ Black Carbon	Light Absorption by Aethalometer	micrograms per cubic meter
RH	Relative Humidity	Continuous Instrument Output	percent
SO_2	Sulfur Dioxide	UV Fluorescence	parts per million
Temp	Temperature	Continuous Instrument Output	degrees F
TSP	PM Total Hi-Vol	Standard High Volume	micrograms per standard cubic meter
Vsby	Visual Range	Light Scattering by Nephelometer	miles
Wind	Wind Speed/ Wind Direction	RM Young 05305 Wind Monitor AQ (old method)	miles per hour/degrees
	Wind Speed/ Wind Direction	Ultrasonic (new method)	miles per hour/degrees

Historical Air Quality Monitoring Network

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
AO◉	Northgate, 310 NE Northgate Way, Seattle (ended Mar 31, 2003)												X						b, d, f
AQ	Queen Anne Hill, 400 W Garfield St, Seattle (photo/visibility included) (ended 3/18/2015)							X						X	X	X		X	a, d, f
AR◉	4th Ave & Pike St, 1424 4th Ave, Seattle (ended Jun 30, 2006)												X						a, d
AS◉	5th Ave & James St, Seattle (ended Feb 28, 2001)												X						a, d
AU◉	622 Bellevue Way NE, Bellevue (ended Jul 30, 1999)												X						a, d
AZ	Olive Way & Boren Ave, 1624 Boren Ave, Seattle SPECIATION SITE (ended 8/6/2014)							X	X					X	X	X		X	a, d
BF◉	University District, 1307 NE 45th St, Seattle (ended Jun 30, 2006)												X						b, d
BK◉	10th & Weller, Seattle SPECIATION SITE					●	●		●			●	●		●	●	●		a
BL	11675 44th Ave S, Tukwila Allentown						●	●	●					●	●	●		●	b, e, f
BU◉	Highway 410, 2 miles E of Enumclaw (ended Sep 30, 2000)									X									c, e
BV	Sand Point, 7600 Sand Pt Way NE, Seattle (ended Aug 31, 2006)							X						X	X	X			b, d
BW◉/ BZ◉	Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE				●		●	X	X	●	●	●	●	X	●	●	●	●	b, d, f
CE	Duwamish, 4700/4752 E Marginal Way S, Seattle SPECIATION SITE	X		X	X	●	●	●	●		X			X	●	●	X	●	a, e
CG◉	Woodinville, 17401 133rd Av NE, Woodinville (ended April 2010)							X						X					b ,d ,f
CW	James St & Central Ave, Kent	X		X	X		●	●	●					●	●	●		●	b, d
CX	17711 Ballinger Way NE, Lake Forest Park (ended Jun 4, 1999)	X	X											X	X			X	b, d, f
CZ	Aquatic Center, 601 143rd Ave NE, Bellevue (ended May 31, 2006)						X	X						X				X	b, f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
DA	South Park, 8025 10th Ave S, Seattle (ended Dec 31, 2002)	X			X			X						X	X			X	b, e, f
DB	17171 Bothell Way NE, Lake Forest Park	X	X		X		X	●	X					●	●	X		●	b, d, f
DC⦿	305 Bellevue Way NE, Bellevue				X			●						●				●	a, d
DD	South Park, 8201 10th Ave S, Seattle							●						●				●	b, e, f
DE⦿	City Hall, 15670 NE 85th St, Redmond (ended Dec 14, 2005)				X			X						X				X	a, d
DF⦿	30525 SE Mud Mountain Road, Enumclaw				X			X		●				X	●	●		X	c
DG⦿	42404 SE North Bend Way, North Bend				X		X	●		●				●	●	●		●	c, d, f
DH⦿	2421 148th Ave NE, Bellevue (ended 1/21/2010)												X						b, d
DK⦿	43407 212th Ave SE, 2 mi west of Enumclaw (ended Sep 6, 2006)														X	X			c
DL⦿	NE 8th St & 108th Ave NE, Bellevue (ended March 4, 2003)												X						a, d
DN⦿	20050 SE 56th, Lake Sammamish State Park, Issaquah									●					X	X			b, d
DP⦿	504 Bellevue Way NE, Bellevue (ended Sep 30, 1999)	X			X														a, d
DZ⦿	Georgetown, 6431 Corson Ave S, Seattle (ended August 31, 2002)											X	X		X				a, d, e, f
EA	Fire Station #12, 2316 E 11th St, Tacoma (ended Dec 31, 2000)	X	X												X				a, e
EP	27th St NE & 54th Ave NE, Tacoma (ended Feb 29, 2000)	X									X				X				b, e, f
EQ	Tacoma Tideflats, 2301 Alexander Ave, Tacoma SPECIATION SITE	X	X	X	X		X	●	●		X			●	●	●	X	●	a, e
ER	South Hill, 9616 128th St E, Puyallup	X	X		X	X		●	●					●	●	●		●	b, f
ES	7802 South L St, Tacoma SPECIATION SITE				●	●	●	●	●					●	●	●	X	●	b, f
FF⦿	Tacoma Indian Hill, 5225 Tower Drive NE, northeast Tacoma														●	●			b, f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
FG⦿	Mt Rainier National Park, Jackson Visitor Center									●									c
FH⦿	Charles L Pack Forest, La Grande (ended 9/30/2010)									X									c, f
FL⦿	1101 Pacific Ave, Tacoma (ended Jun 30, 2006)												X						a, d
ID	Hoyt Ave & 26th St, Everett (ended Feb 29, 2000)										x				X				a, e, d
IG	Marysville JHS, 1605 7th St, Marysville SPECIATION SITE	X	X		X		●	●	●					●	●	●		●	b, d
IH	20935 59th Place West, Lynnwood (ended Jun 8, 1999)	X		X										X	X			X	a, d
II	6120 212th St SW, Lynnwood				X	X	●	●						●	●	●		●	b, d
IK⦿	14310 SE 12th St, Bellevue						●							●				●	a, d
JN⦿	5810 196th Street, Lynwood (ended Jun 30, 2006)												X						a, d
JO	Darrington High School, Darrington 1085 Fir St				X		●	●	●					●	●	●		●	d, f
JP⦿	2939 Broadway Ave, Everett (ended March 31, 2003)												X						a, d
JQ⦿	44th Ave W & 196th St SW, Lynnwood (ended May 3, 2004)												X						a, d
JS⦿	Broadway & Hewitt Ave, Everett (ended May 21, 2000)												X						a, d
PA⦿	1802 S 36th St, Tacoma					●	●					●			●	●			a, f
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton (ended 5/1/2012)	X				X	X	X						X	X	X		X	b, f
QF	Lions Park, 6th Ave NE & Fjord Dr, Poulsbo (ended Feb 29, 2000)														X				b, f
QG	Fire Station #51, 10955 Silverdale Way, Silverdale (ended September 4, 2008)					X		X						X	X	X		X	a, d
QK	Spruce, 3250 Spruce Ave, Bremerton						●	●						●	●	●		●	b, f
RV⦿	Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm									●									c, f

Station ID	Location	PM_{10} Ref	PM_{10} bam	PM_{10} Teom	$PM_{2.5}$ ref	$PM_{2.5}$ bam	$PM_{2.5}$ teom	$PM_{2.5}$ ls	$PM_{2.5}$ bc	O_3	SO_2	NO_Y	CO	b_{sp}	Wind	Temp	AT	Vsby	Location
RZ	Gig Harbor, 9702 Crescent Valley Dr NW, Gig Harbor							●						●	●	●		●	f
TR	Eatonville, 560 Center St, Eatonville							●						●	●	●		●	F
TS	1301 Yesler Way, Seattle								●								●		a, f
TT	602 S. Jackson St, Seattle								●								●		a, f
UB⦿	71 E Campus Dr, Belfair (ended Sep 30, 2004)									X									c
VK⦿	Fire Station, 709 Mill Road SE, Yelm (ended Oct 2005)									X									c, f

⦿	Station operated by Ecology	SO_2	Sulfur Dioxide
RV⦿	Shading indicates station functioning	NO_y	Nitrogen Oxides
●	Indicates parameter currently monitored	CO	Carbon Monoxide
X	Indicates parameter previously monitored	b_{sp}	Light scattering by atmospheric particles (nephelometer)
PM_{10} ref	Particulate matter <10 micrometers (reference)	Wind	Wind direction and speed
PM_{10} bam	Particulate matter <10 micrometers (beta attenuation continuous)	Temp	Air temperature (relative humidity also measured at BW, IG, ES)
PM_{10} teom	Particulate matter <10 micrometers (teom continuous)	AT	Air Toxics
$PM_{2.5}$ ref	Particulate matter <2.5 micrometers (reference)	VSBY	Visual range (light scattering by atmospheric particles)
$PM_{2.5}$ bam	Particulate matter <2.5 micrometers (beta attenuation continuous)	PHOTO	Visibility (camera)
$PM_{2.5}$ teom	Particulate matter <2.5 micrometers (teom-fdms continuous)	O_3	Ozone (May through September)
$PM_{2.5}$ ls	Particulate matter <2.5 micrometers (light scattering nephelometer continuous)		
$PM_{2.5}$ bc	Particulate matter <2.5 micrometers black carbon (light absorption aethalometer)		

Location		e	Industrial
a	Urban Center	f	Residential
b	Suburban		
c	Rural		
d	Commercial		

Burn Bans 1988 - 2018

1988 Jan 25 (0830) - Jan 28 (0830)
Feb 5 (1630) - Feb 6 (0930)
Dec 1 (1430) - Dec 2 (0800)
Dec 4 (1430) - Dec 5 (1400)
Dec 16 (1430) - Dec 18 (1430)

1989 Jan 19 (1430) - Jan 20 (1430)
Jan 24 (1430) - Jan 26 (0930)
Feb 6 (1430) - Feb 8 (0930)
Feb 10 (1430) - Feb 16 (0930)
Nov 29 (1430) - Dec 2 (0930)
Dec 22 (1430) - Dec 23 (1430)

1990 Jan 19 (1430) - Jan 21 (1430)
Dec 7 (1430) - Dec 8 (0930)
Dec 25 (1430) - Dec 27 (0815)*
*(Dec 26 1430 – Dec 27 0815) 2nd Stage

1991 Jan 5 (1430) - Jan 6 (0930)
Jan 21 (1430) - Jan 24 (1500)*
*(Jan 22 0930 – Jan 24 1500) 2nd Stage
Jan 29 (1430) - Jan 31 (0830)
Dec 15 (1430) - Dec 17 (1430)*
*(Dec 16 1430 – Dec 17 0930) 2nd Stage

1992 Jan 8 (1430) - Jan 9 (0930)
Jan 19 (1430) - Jan 20 (1430)
Feb 5 (1000) - Feb 6 (1430)
Nov 25 (1430) - Nov 26 (1430)

1993 Jan 11 (1430) - Jan 13 (0830)
Jan 15 (1430) - Jan 16 (0700)
Jan 17 (1430) - Jan 19 (0600)
Jan 31 (1430) - Feb 3 (0830)
Dec 20 (1430) - Dec 21 (1430)
Dec 26 (1430) - Dec 29 (0830)

1994 None

1995 Jan 4 - Jan 7

1996 Feb 14 (1430) - Feb 16 (1630)

1997 Nov 13 (1500) - Nov 15 (1500)
Dec 4 (1500) - Dec 7 (1800)

1998 None

1999 Jan 5 (1400) - Jan 6 (1000)
Dec 29 (1400) - Dec 31 (0600)

2000 Feb 18 (1400) - Feb 20 (1000)
Nov 15 (1700) - Nov 23 (0600)

2001 Nov 8 (1400) - Nov 12 (1800)

2002 Nov 1 (1500) - Nov 6 (0900)
Nov 27 (1000) - Dec 4 (1000)

2003 Jan 7 (1500) - Jan 9 (1300)

2004 None

2005 Feb 21 (1600) - Feb 28 (0800)
Dec 9 (1700) - Dec 18 (1200)

2006 None

2007 Jan 13 (1400) - Jan 16 (1500)
Jan 28 (1400) - Jan 31 (1400)
Dec 9 (1400) - Dec 11 (0930)

2008 Jan 23 (1400) - Jan 26 (1200)

2009 Jan 16 (1200) - Jan 24 (1200)
Feb 3 (1400) - Feb 6 (0900)
Dec 8 (1000) - Dec 13 (1000)
Dec 23 (1600) - Dec 30 (1200)

2010 Jan 28 (1200) – Jan 31 (1000)
Dec 30 (1700) – 31 Dec (2400)*
* continued to Jan 4 (1700)

2011 Jan 1 (0000) – Jan 4 (1700)
Nov 30 (1700) – Dec 7 (1300)
Dec 11 (1700) – Dec 14 (1600)

2012 Jan 11 (1600) – Jan 14 (1000)
Jan 27 (1200) – Jan 28 (1700)
Feb 3 (1600) – Feb 6 (1600)
Nov 25 (1300) – Nov 28 (0900)
Dec 29 (1700) – Dec 31 (2400)*
* continued to Jan 3 (1200)

2013 Jan 1 (0000) – Jan 3 (1200)
Jan 12 (1300) – Jan 22 (1000)
Nov 22 (1600) – Nov 29 (1000)
Dec 7 (1400) – Dec 9 (1000)
Dec 25 (1700) – Dec 26 (1100)

2014 Jan 26 (1200) – Jan 27 (1000)
Nov 14 (1700) – Nov 20 (0600)
Nov 30 (1300) – Dec 2 (1200)
Dec 30 (1600) – Dec 31 (2400)*
* continued to Jan 3 (1200)

2015 Jan 1 (0000) – Jan 3 (1200)
Jan 10 (1200) – Jan 10 (1900)
Jan 11 (1200) – 12 Jan (1100)
Nov 25 (1600) – Dec 1 (0800)
24 Dec (1600) – 25 Dec (0830)

2016 1 Jan (1300) – 4 Jan (0930)
7 Jan (1300) – 9 Jan (1200)
10 Jan (1300) – 11 Jan (0900)
15 Dec (1300) – 18 Dec (0900)

2017 4 Jan (1800) – 7 Jan (1300)
11 Jan (1200) – 16 Jan (1700)
24 Jan (1400) – 25 Jan (1200)
2 Aug (1600) – 5 Aug (1100)
8 Aug (1400) – 11 Aug (1400)
8 Dec (1400) – 13 Dec (1400)
22 Dec (1400) – 24 Dec (1200)

2018 1 Jan (1400) – 2 Jan (1100)
20 Aug (1700) – 23 Aug (1300)

PARTICULATE MATTER ($PM_{2.5}$) - Federal Reference Method

Micrograms per Cubic Meter

Reference Sampling Method: R&P Partisol 2025 Sampler – Teflon Filter

2018

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
7802 South L St, Tacoma	319	6.4	4.8	--	11.5	--	--	81.8
15th S & Charlestown, Beacon Hill, Seattle	107	4.0	4.4	14.1	6.8	7.3	37.8	88.3

Notes:

(1) Sampling occurs for a 24 hour period from midnight to midnight.

(2) Quarterly averages are shown only if 75 percent or more of the data are available.

(3) Annual averages are shown only if there is at least 75 percent of each of the 4 quarterly averages.

(4) Data from primary sampler at site

PARTICULATE MATTER ($PM_{2.5}$) – Federal Equivalent Methods

Micrograms per Cubic Meter

Equivalent Sampling Methods: [a]Mass Transducer R&P TEOM 1400ab-8500 FDMS – Teflon-coated Glass Fiber
[b]Met One BAM

2018

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington[a]	355	6.6	2.4	11.3	6.2	6.6	41.9	105.1
Marysville JHS, 1605 7th St, Marysville[a]	355	5.7	4.7	12.1	9.8	8.1	31.2	98.8
6120 212th St SW, Lynnwood[a]	326	4.4	3.3	9.7	--	--	--	93.1
10th and Weller, Seattle[b]	355	6.1	6.7	14.0	10.4	9.3	35.5	102.2
Beacon Hill, 15th S and Charlestown, Seattle[a]	353	3.7	4.1	11.6	6.5	6.5	37.0	98.1
Duwamish, 4752 E Marginal Way S, Seattle[b]	338	4.3	3.6	13.7	11.2	8.2	40.3	99.6
Allentown, 11675 44th Ave S, Tukwila[a]	344	4.9	4.6	8.6	7.9	6.5	26.3	80.2
James St & Central Ave, Kent[a]	348	4.6	4.5	10.5	8.4	7.0	32.8	74.1
7802 South L St, Tacoma[a]	350	9.3	7.4	11.4	12.6	10.1	39.6	85.0
Spruce, 3250 Spruce Ave, Bremerton[a]	348	9.3	7.4	11.4	12.3	10.1	39.6	85.0

Notes
(1) Sampling occurs continuously for 24 hours each day.
(2) Quarterly averages are shown only if 75 percent or more of the data for the quarter is available.
(3) Annual averages are shown only if 75 percent or more of the data for each of the 4 quarters is available.
(4) Data from primary sampler at site.

PARTICULATE MATTER ($PM_{2.5}$) – Continuous - Nephelometer

Micrograms per Cubic Meter

Sampling Method: Ecotech Nephelometer

2018

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	346	8.5	2.9	12.1	7.1	7.7	52.5	106.3
Marysville JHS, 1605 7th St, Marysville	350	5.6	4.2	13.4	10.1	8.3	57.6	127.0
6120 212th St SW, Lynnwood	361	4.4	3.5	11.9	7.5	6.8	37.5	115.2
17171 Bothell Way NE, Lake Forest Park	343	5.5	4.8	14.6	10.2	8.8	50.7	134.7
Duwamish, 4752 E Marginal Way S, Seattle	343	7.2	6.7	17.0	12.0	10.7	52.3	143.5
South Park, 8025 10th Ave S, Seattle*	365	7.0	6.6	14.2	10.2	9.5	43.8	109.8
Allentown, 11675 44th Ave S, Tukwila	365	5.7	5.2	14.0	9.7	8.7	51.5	114.7
14310 SE 12th St, Bellevue, Bellevue	278	2.7	3.1	--	--	--	--	16.5
42404 SE North Bend Way, North Bend	365	2.0	2.6	10.1	3.9	4.7	34.6	71.4
James St & Central Ave, Kent	365	5.4	5.1	12.5	8.7	7.9	42.4	86.5
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	365	5.3	5.0	12.7	9.0	8.0	35.1	103.8
7802 South L St, Tacoma	365	6.0	4.5	13.5	11.4	8.9	36.3	125.6
South Hill, 9616 128th St E, Puyallup	356	3.8	3.6	12.5	8.2	7.0	37.5	108.5
Spruce, 3250 Spruce Ave, Bremerton*	365	3.7	3.8	11.7	6.3	6.4	40.9	119.1

Notes
(1) Sampling occurs continuously for 24 hours each day.
(2) Quarterly averages are shown only if 75 percent or more of the data for the quarter is available.
(3) Annual averages are shown only if 75 percent or more of the data for each of the 4 quarters is available.
(4) All data values are calculated using site-specific relationships with Federal Reference Method samplers when available. *Not available at these sites.
(5) Data from primary sampler at site.

$PM_{2.5}$ Speciation Analytes Monitored in 2018
in Micrograms per Cubic Meter

Acceptable Pm2.5 Aqi & Speciation Mass	Oc1 Pm2.5 Lc
Aluminum Pm2.5 Lc	Oc2 Csn_Rev Unadjusted Pm2.5 Lc
Ammonium Ion Pm2.5 Lc	Oc2 Pm2.5 Lc
Ammonium Nitrate Pm2.5 Lc	Oc3 Csn_Rev Unadjusted Pm2.5 Lc
Ammonium Sulfate Pm2.5 Lc	Oc3 Pm2.5 Lc
Antimony Pm2.5 Lc	Oc4 Csn_Rev Unadjusted Pm2.5 Lc
Arsenic Pm2.5 Lc	Oc4 Pm2.5 Lc
Barium Pm2.5 Lc	Op Csn_Rev Unadjusted Pm2.5 Lc Tor
Bromine Pm2.5 Lc	Op Csn_Rev Unadjusted Pm2.5 Lc Tot
Cadmium Pm2.5 Lc	Op Pm2.5 Lc Tor
Calcium Pm2.5 Lc	Op Pm2.5 Lc Tot
Cerium Pm2.5 Lc	Organic Carbon Mass Pm2.5 Lc
Cesium Pm2.5 Lc	Phosphorus Pm2.5 Lc
Chloride Pm2.5 Lc	Pm2.5 - Local Conditions
Chlorine Pm2.5 Lc	Potassium Ion Pm2.5 Lc
Chromium Pm2.5 Lc	Potassium Pm2.5 Lc
Cobalt Pm2.5 Lc	Rubidium Pm2.5 Lc
Copper Pm2.5 Lc	Selenium Pm2.5 Lc
Ec Csn_Rev Pm2.5 Lc Tor	Silicon Pm2.5 Lc
Ec Csn_Rev Pm2.5 Lc Tot	Silver Pm2.5 Lc
Ec Pm2.5 Lc Tor	Sodium Ion Pm2.5 Lc
Ec Pm2.5 Lc Tot	Sodium Pm2.5 Lc
EC1 CSN_Rev Unadjusted PM2.5 LC	Soil Pm2.5 Lc
Ec1 Pm2.5 Lc	Strontium Pm2.5 Lc
EC2 CSN_Rev Unadjusted PM2.5 LC	Sulfate Pm2.5 Lc
Ec2 Pm2.5 Lc	Sulfur Pm2.5 Lc
EC3 CSN_Rev Unadjusted PM2.5 LC	Tin Pm2.5 Lc
Ec3 Pm2.5 Lc	Titanium Pm2.5 Lc
Indium Pm2.5 Lc	Total Nitrate Pm2.5 Lc
Iron Pm2.5 Lc	Vanadium Pm2.5 Lc
Lead Pm2.5 Lc	Zinc Pm2.5 Lc
Magnesium Pm2.5 Lc	Zirconium Pm2.5 Lc
Manganese Pm2.5 Lc	
Nickel Pm2.5 Lc	
Nitrite Pm2.5 Lc	
Oc Csn_Rev Unadjusted Pm2.5 Lc Tor	
Oc Csn_Rev Unadjusted Pm2.5 Lc Tot	
Oc Pm2.5 Lc Tor	
Oc Pm2.5 Lc Tot	
Oc1 Csn_Rev Unadjusted Pm2.5 Lc	

Additional information can be obtained at: aqs.epa.gov/aqsweb/documents/data_mart_welcome.html

$PM_{2.5}$ BLACK CARBON

Micrograms per Cubic Meter

Sampling Method: Light Absorption by Aethalometer

2018

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Duwamish, 4401 E Marginal Way S, Seattle	352	1.0	0.5	1.0	1.6	1.0	7.5
Allentown, 11675 44th Ave S, Tukwila	337	1.0	0.5	0.9	1.8	1.1	7.3
James St & Central Ave, Kent	363	0.8	0.5	0.8	1.4	0.9	5.0
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	364	1.1	0.5	0.9	1.9	1.1	6.1
10th and Weller, Seattle	353	1.1	1.0	1.5	1.5	1.3	6.3

Notes
(1) Sampling occurs continuously for 24 hours each day.
(2) Quarterly averages are shown only if 75 % or more of the data is available.
(3) Annual averages are shown only if there is at least 75 percent of each 4 quarterly averages.

OZONE

(parts per million)

2018

Location / Continuous Sampling Period(s)	2017 4th Highest Daily 8-Hour Concentration		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2015	2016	2017	2015 – 2017
Beacon Hill, 15th S & Charlestown Seattle, WA 1 Jan – 31 Dec	.045	9 May	.046	.047	.045	.046
20050 SE 56th Lake Sammamish State Park, WA 1 May – 30 Sep	.067	8 Aug	.054	.076	.067	.065
42404 SE North Bend Way, North Bend, WA 1 May – 30 Sep	.071	15 Aug	.054	.073	.071	.066
30525 SE Mud Mountain Road, Enumclaw, WA 1 May – 30 Sep	.077	9 Aug	.061	.094	.077	.077
931 Northern Pacific Rd SE, Yelm, WA 1 May – 30 Sep	.063	20 Jun	.058	.067	.063	.062
Jackson Visitors Center Mt Rainier National Park 1 Jan – 31 Dec	.067	16 Jul	.058	.069	.067	.064

Notes
(1) All ozone stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations ozone was measured using the continuous ultraviolet photometric detection method.

2018 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in parts per billion*)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tetrachloride	Chloroform	Dichloro methane	Ethylbenzene	Ethylene Dichloride	Formaldehyde	Tetrachloroethylene
2018 Count	61	61	61	61	61	61	61	61	61	61	61
ND's (reported as 0)	7	0	0	0	0	0	0	0	0	0	5
Median (ppb)	0.0217	0.642	0.182	0.156	0.100	0.0237	0.248	0.0381	0.0213	0.693	0.0113
Mean (ppb)	0.0260*	0.880	0.184	0.157	0.100	0.0248	0.322	0.0466*	0.0213	0.843	0.0125
95th Percentile (ppb)	0.0572	2.10	0.311	0.297	0.114	0.0354	0.850	0.0883	0.0295	1.85	0.0239
Max (ppb)	0.0754	2.82	0.346	0.427	0.126	0.043	1.52	0.153	0.0362	3.14	0.0438
# Below MDL	24	0	48	0	0	0	0	15	2	0	39
% Below MDL	39%	0%	79%	0%	0%	0%	0%	25%	3%	0%	64%

Parameters in gray are over 50% below the method detection limit.

ND = Non-Detects (values reported as zero)

MDL = Method Detection Limit

* = Kaplan-Meier method used to estimate these means due to a large proportion of results being below the MDL.

2018 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in nanograms per cubic meter*)

	Arsenic (PM_{10})	Cadmium (PM_{10})	Naphthalene	Nickel (PM_{10})
2018 Count	76	76	60	76
ND's (reported as 0)	0	0	0	0
Median (ng/m^3)	0.393	0.0355	35.0	0.626
Mean (ng/m^3)	0.581	0.0555	37.8	0.922
95th Percentile (ng/m^3)	1.51	0.183	74.6	2.49
Max ng/m^3)	3.15	0.330	108	6.09
# Below MDL	0	2	0	59
% Below MDL	0%	3%	0%	78%

Estimates of Air Toxics Risk
2018 Air Toxics Unit Risk Factors

Potential cancer risk is estimated by multiplying the concentration of a pollutant by its unit risk factor (URF), a constant that takes into account its cancer potency. This is shown in the equation below:

*Potential cancer risk = ambient concentration (µg/m^3) * unit risk factor (risk/µg/m^3)*

Unit risk factors are often based on epidemiological studies (studies of diseases occurring in human populations) and are also extrapolated from laboratory animal studies. Unit risk factors are typically based on an assumed 70-year (lifetime) exposure interval and are available from multiple sources. In this data summary, cancer risk was estimated using unit risk factors from the Washington State Acceptable Source Impact Levels (ASIL) table.[1] The ASIL values relevant to this summary are in the table below. The two sources from which values in the ASIL table are derived are the U.S. EPA's Integrated Risk Information System[2] (IRIS) and California EPA's Office of Environmental Health and Hazard Assessment[3] (OEHHA). Unit risk factors from both of these sources are derived from extensive reviews of peer-reviewed literature and other datasets. The cancer rating, based on IARC definitions, refers to its "weight of evidence" ranking: 1 = carcinogenic to humans, 2A = probably carcinogenic to humans and 2B = possibly carcinogenic to humans.[4]

2018 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/µg/m^3	CANCER RATING[5]
1,3-Butadiene	1.7×10^{-4}	1
Acetaldehyde	2.7×10^{-6}	2B
Arsenic	3.3×10^{-3}	1
Benzene	2.9×10^{-5}	1
Cadmium	4.2×10^{-3}	1
Carbon Tetrachloride	4.2×10^{-5}	2B
Chloroform	2.3×10^{-5}	2B
Chromium (Hexavalent)	1.5×10^{-1}	1
Dichloromethane	1.0×10^{-6}	2A
Ethylbenzene	2.5×10^{-6}	2B
Ethylene Dichloride	2.1×10^{-5}	2B
Formaldehyde	6.0×10^{-6}	1
Naphthalene	3.4×10^{-5}	2B
Nickel (Subsulfide)	2.4×10^{-4}	1
Tetrachloroethylene	7.4×10^{-6}	2A

[1]Washington State Administrative Code. apps.leg.wa.gov/wac/default.aspx?cite=173-460-150.
[2]Integrated Risk Information System, EPA; epa.gov/iris/.
[3]California EPA, Consolidated Table of OEHHA/ARB-Approved Risk Assessment Health Values, May 8, 2018; arb.ca.gov/toxics/healthval/healthval.htm.
[4]International Agency for Research on Cancer; http://monographs.iarc.fr/.
[5]Ratings per International Agency for Research on Cancer, updated July 2019; http://monographs.iarc.fr/ENG/Classification/

2018 Beacon Hill Potential Cancer Risk Estimates per 1,000,000 – 95th Percentile Percentage of samples greater than cancer screen value

Air Toxic	Rank	Risk based on 95th percentile concentrations (Washington ASIL)	% of samples > ASIL screen
Carbon Tetrachloride	3	30	100%
Benzene	1	28	100%
1,3-Butadiene	2	22	89%
Acrolein	5	12	100%
Formaldehyde	4	11	100%
Acetaldehyde	6	6	90%
Arsenic (PM_{10})	7	5	64%
Chloroform	8	4	100%
Ethylene Dichloride	9	3	100%
Dichloromethane	11	3	39%
Naphthalene	9	3	62%
Nickel (PM_{10})	14	1	9%
Tetrachloroethylene	11	1	5%
Ethylbenzene	11	1	3%
Cadmium (PM_{10})	14	1	1%

2018 Non-cancer Reference Concentrations (RfC) and Hazard Indices >1

Air toxic	Non-cancer RfC (*ug*/m^3)	Mean Hazard Index
Acrolein	**0.35**	**1.20**
Benzene	3	0.168
Formaldehyde	9	0.094
Nickel (PM_{10})	0.014	0.066
Manganese (PM_{10})	0.09	0.060
Arsenic (PM_{10})	0.015	0.039
1,3-Butadiene	2	0.033
Carbon Tetrachloride	40	0.016
Acetaldehyde	140	0.006
Dichloromethane	400	0.003
Tetrachloroethylene	35	0.002
Chloroform	300	< 0.001
Beryllium (PM_{10})	0.007	< 0.001
Trichloroethylene	600	< 0.001

Reference concentrations are based on chronic values from California Air Resources Board (OEHHA).

Mean hazard index is based on HQ=1, HI = mean concentration/reference concentration.

Acrolein is the only air toxic that fails the screen with a hazard index greater than 1.

2000-2018 Air Toxics Trends Statistical Summary

The following table includes the statistical information for the potential cancer risk trends found in the data summary, including if the trend is statistically significant at the 95% confidence level.

Air Toxic	Significance (p-value)	Slope (change in risk per million per year)	y-intercept	Correlation (R^2)	Number of years (N)
1,3-Butadiene	True (0.001)	-0.615	21.074	0.502	18
Acetaldehyde	True (0)	-0.141	4.301	0.664	18
Arsenic PM_{10}	True (0.015)	-0.057	3.057	0.374	15
Benzene	True (0)	-1.633	40.698	0.759	18
Cadmium PM_{10}	False (0.565)	0.088	0.392	0.028	14
Carbon Tetrachloride	False (0.825)	0.025	28.335	0.003	18
Chloroform	True (0)	-0.202	5.863	0.774	18
Chromium VI TSP	True (0.005)	-0.428	9.598	0.754	8
Dichloromethane	False (0.858)	-0.013	1.370	0.003	12
Ethylbenzene	False (0.758)	0.004	0.508	0.010	12
Formaldehyde	True (0.005)	-0.533	12.484	0.393	18
Naphthalene	True (0.003)	-0.116	3.587	0.633	11
Nickel PM_{10}	True (0.001)	-0.058	1.620	0.601	14
Tetrachloroethylene	True (0)	-0.050	1.288	0.721	18

Air Quality Standards and Health Goals

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$ [(1)]	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb [(2)]	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm [(3)]	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 $\mu g/m^3$	annual mean, averaged over 3 years
		secondary	1 year	15.0 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb [(4)]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 $\mu g/m^3$ as a calendar quarter average) also remain in effect.
(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.
(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.
(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2)any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. ***Primary standards*** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. ***Secondary standards*** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

EPA has set National Ambient Air Quality Standards for six principal pollutants, called "criteria" pollutants (listed below). Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air ($\mu g/m^3$).
EPA is required to re-visit and update standards every five years, to incorporate the latest health and welfare information.

The state of Washington and the Puget Sound region have adopted these standards. For more information, EPA air quality standards and supporting rationale are available at https://www.epa.gov/criteria-air-pollutants. Washington State air quality regulations are available at https://ecology.wa.gov/Regulations-Permits?topics=27.[6] The air quality standards that apply to the Puget Sound air shed are summarized below.

Pollutants typically have multiple standards with different averaging times; for example, daily and annual standards. Multiple standards are created and enforced to address health impacts as a result of a shorter, high-level exposure versus longer, low-level exposures. These differences are addressed pollutant-by-pollutant. Additional information is on EPA's website at https://www.epa.gov/criteria-air-pollutants/naaqs-table

The Agency has developed an air quality health goal for daily $PM_{2.5}$ concentrations. The Agency convened a Particulate Matter Health Committee, comprised of local health professionals, who examined the fine particulate health research.[7] The Health Committee did not consider the federal standard at the time to be protective of human health. In 1999, the Agency adopted a health goal of 25 $\mu g/m^3$ for a daily average, more protective than the current federal standard of 35 $\mu g/m^3$. This level is consistent with the American Lung Association's goal and the EPA Clean Air Science Advisory Committee's recommended lower range for the EPA's 2006 ambient air quality standard revision.[8] The Agency did not adopt a separate health goal for the annual average.

---

[6]Washington Administrative Code chapters 173-470, 173-474, and 173-475.

[7]Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency $PM_{2.5}$ Stakeholder Group; October 1999. Report available on request

[8]EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; https://yosemite.epa.gov/sab/SABPEOPLE.NSF/PeopleSearch/60BA5C6D6F54A288852568A900645FE4?OpenDocument.