pscleanair.org
Puget Sound Clean Air Agency

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

2016

Air Quality Data Summary

July 2017

Working Together for Clean Air

Table of Contents

List of Figures

List of Maps

List of Tables

Appendix – Data Tables

The 2016 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 and 2.5 micrometers in diameter)
- 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 2016. However, air quality degraded into "moderate" or "unhealthy for sensitive groups" 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 pscleanair.org/airquality/ourairquality/Pages/currentaq.aspx. To receive the Agency's most updated news and stay current on air quality issues in King, Kitsap, Pierce and Snohomish counties, visit pscleanair.org/contact/Pages/connect.aspx 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 2016. Over the last two decades, many pollutant levels have declined and air quality has improved. While air quality is

[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.

improving, we face new 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 2016, sites in three counties (King, Pierce 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 close to the 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.

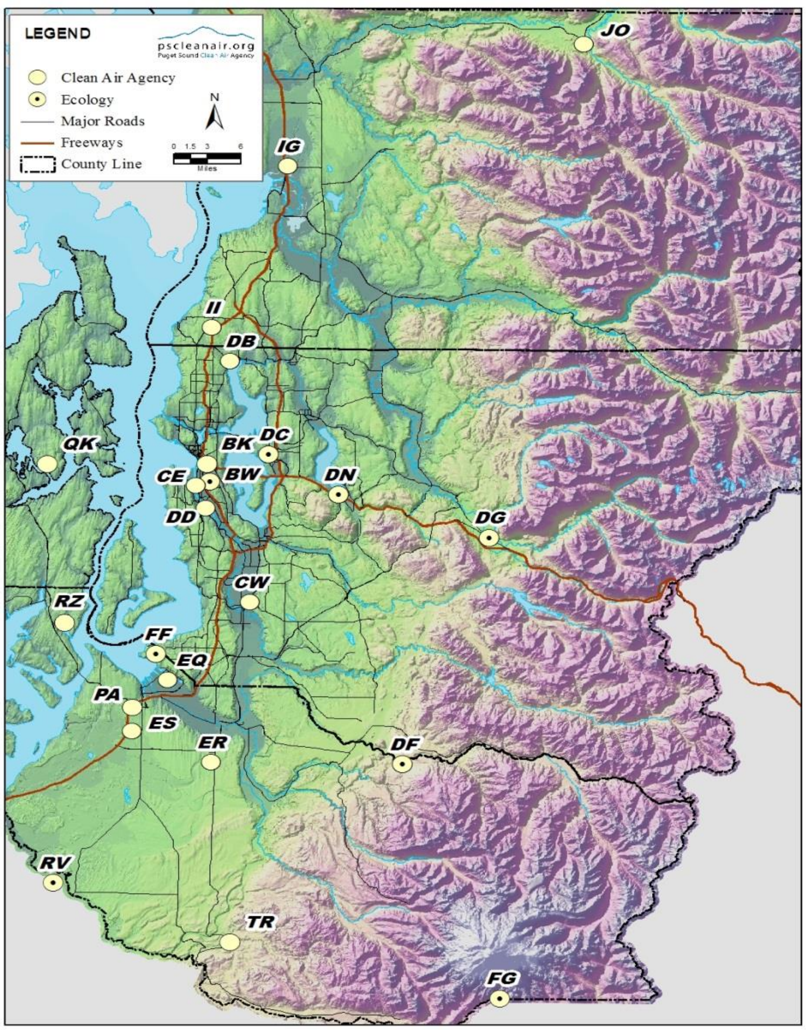
Increasingly, our air quality monitoring program is moving towards local, short-term studies that inform on a very local scale what air quality is like in communities with specific impacts (for example, communities located near major roadways). These studies, often using new sensor technology, are available on our website in the "Library" section.

Monitoring Network

The Agency and Ecology operated the Puget Sound region's monitoring network in 2016. 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 2016. A more interactive map is available at http://www.pscleanair.org/airquality/ourairquality/Pages/NetworkMap.aspx.

Map 1: Active Air Quality Monitoring Station Locations 2016



BK Seattle 10th & Weller
BW Seattle Beacon Hill
CE Seattle Duwamish
CW Kent
DB Lake Forest Park
DC Bellevue
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
FG Mount Rainier
FF Tacoma Indian Hill
II Lynnwood
IG Marysville
JO Darrington
PA Tacoma South 36th
QK Bremerton Spruce
RV Yelm
RZ Gig Harbor
TR Eatonville

Table 1: Air Quality Monitoring Network Parameters 2016

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		●	●		●			●	●		●	●			a
BW⦿	Beacon Hill, 4103 Beacon Ave S, Seattle	●	●	●			●	●	●	●		●	●	●		b, d, f
CE	Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE			●	●	●					●	●	●		●	a, e
CW	James St & Central Ave, Kent			●	●	●					●	●	●		●	b, d
DB	17171 Bothell Way NE, Lake Forest Park				●						●	●			●	b, d, f
DC⦿	305 Bellevue Way NE, Bellevue				●						●				●	a, d
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, Tacoma				●	●					●	●			●	a, e
ER	South Hill, 9616 128th St E, Puyallup				●						●	●	●		●	b, f
ES	7802 South L St, Tacoma	●	●	●	●	●					●	●	●		●	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			●	●	●					●	●	●		●	b, d
II	6120 212th St SW, Lynnwood			●	●						●	●	●		●	b, 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
RZ	Gig Harbor, 9702 Crescent Valley Dr NW, Gig Harbor				●						●	●			●	f
TR	Eatonville, 560 Center St, Eatonville				●						●	●			●	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), carbon monoxide, sulfur dioxide and nitrogen dioxide.

EPA's main intent with development of the AQI is that it is used as a daily indicator or forecast of air quality – it's most useful when used this way. This local, almost-real-time information can be found here: pscleanair.org/airquality/ourairquality.

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 2016. 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. $PM_{2.5}$ generally determines the AQI in the

Puget Sound area on days considered unhealthy for sensitive groups. See the appendix for more information on the AQI.

Table 2: AQI Ratings for 2016

	AQI Rating (% of year)				
County	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	**Highest AQI**
Snohomish	83.9 %	15.3 %	0.8 %	0 %	120
King	82.2 %	17.8 %	0 %	0 %	95
Pierce	88.0 %	11.7 %	0 %	0.3 %	155
Kitsap	99.7 %	0.3 %	0 %	0 %	55

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}

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

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.

PM2.5– 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 defined the federal reference method (FRM) to be the method used to determine $PM_{2.5}$ concentrations. The reference method is a filter-based method. EPA further defined several federal equivalent methods (FEM), which are continuous instruments operated under specific standard operating procedures. The continuous FEM's advantage is that it provides highly time resolved data (hourly averages).

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

- The FRM method involves pulling in air (at a given flow rate) for a 24-hour period and collecting particles of a certain size (in this case $PM_{2.5}$) 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 methods used in the network: (1) The tapered element oscillating microbalance (TEOM-FDMS) method measures mass and uses a filter dynamic measurement system, (2) The TEOM 1405 F model is a new model that replaces (TEOM-FDMS) instruments, and (3) The Met-One BAM is a beta attenuation monitor which uses the attenuation of beta radiation to assess the PM2.5 mass on a filter tape. All of these are considered Federal Equivalent Method (FEM) for $PM_{2.5}$.
- The nephelometer uses scattering of light in a photomultiplier tube, which is then compared to Reference and Equivalent method data to produce an estimate of $PM_{2.5}$. While light scattering has been proven to correlate well with $PM_{2.5}$, this is an "unofficial" method using a surrogate.

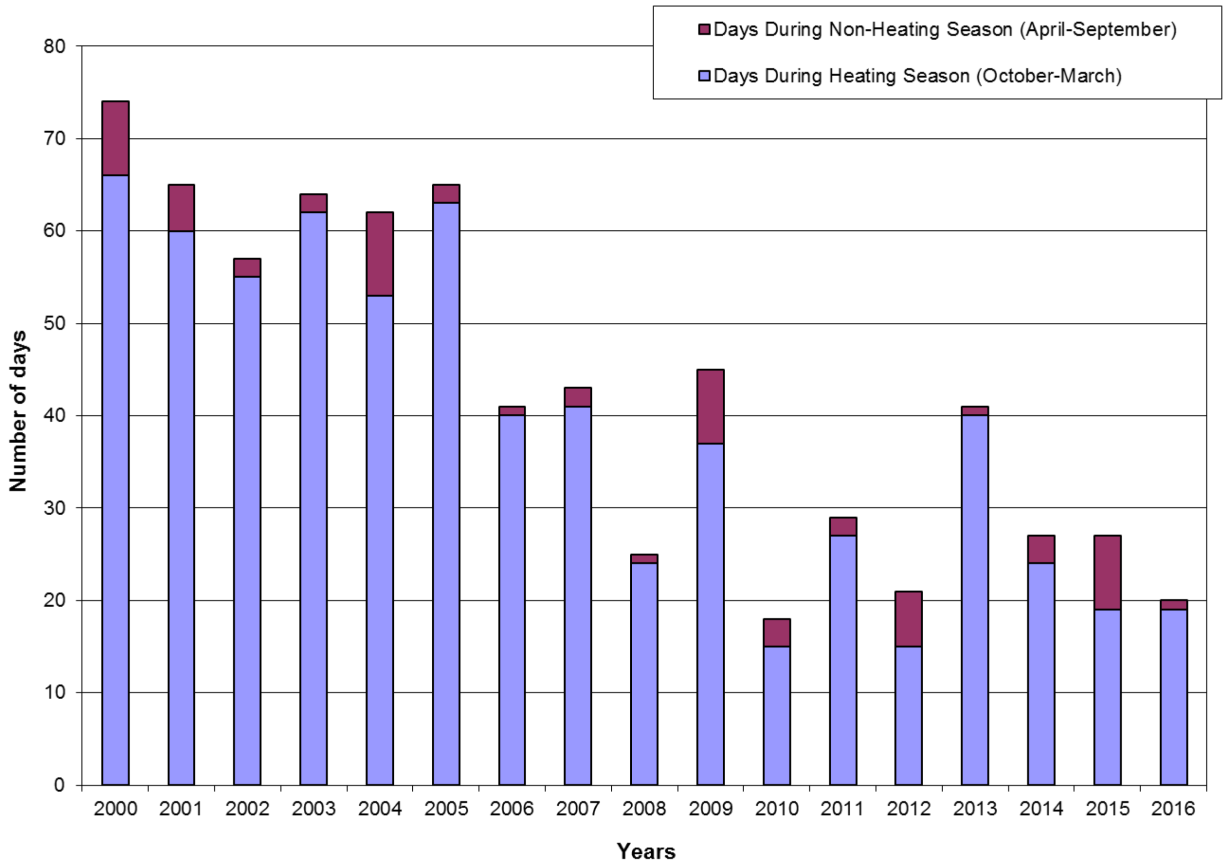
The Agency and Ecology work together to quality assure the FEM technology as compared to the reference method.

$PM_{2.5}$ 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 met this standard in 2016. In addition to the federal standard, our Board of Directors adopted a more stringent health goal in 1999, based on recommendations from our Particulate Matter Health Committee. Monitors in King, Pierce and Snohomish exceeded the local health goal of 25 $\mu g/m^3$ during the 2016 winter season. Our monitor in Kitsap County did not exceed the local health goal.

Figure 1 shows the number of days the health goal was exceeded annually in the region, from 2000 to 2016. The shading demonstrates that our highest fine particulate days overwhelmingly take place during the winter wood heating months. While the graph indicates that we have made progress reducing the number of days we exceed the health goal, it also shows that we are falling short of our goal of having zero days exceeding the health goal, especially during winter months.

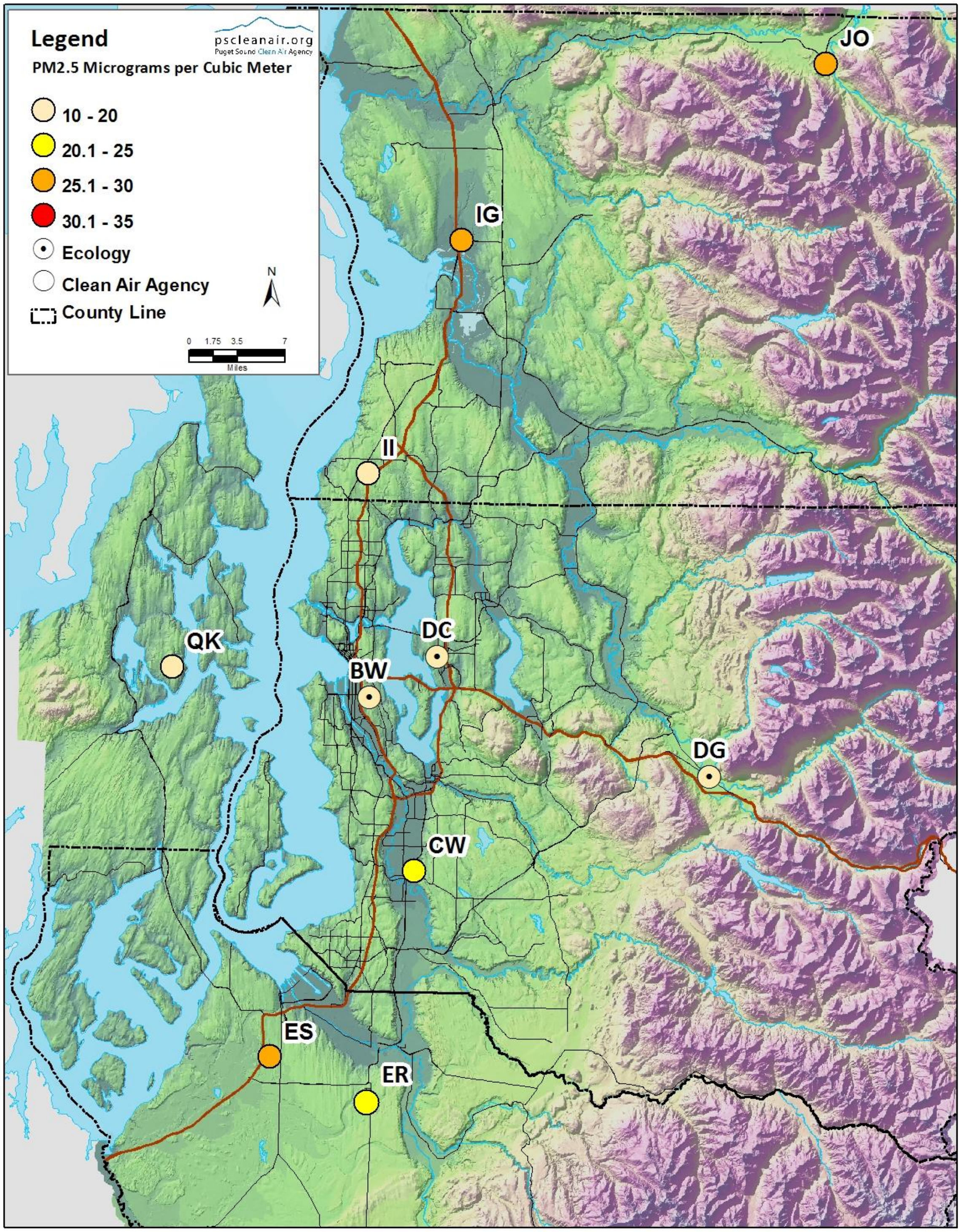
Figure 1: Days Exceeding the PM2.5 Health Goal at One or More Monitoring Sites



Includes data from all sites in King, Kitsap, Pierce, and Snohomish counties, both daily and continuous methods. The Darrington monitor was added in 2004.

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 2014 to 2016. 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 2016

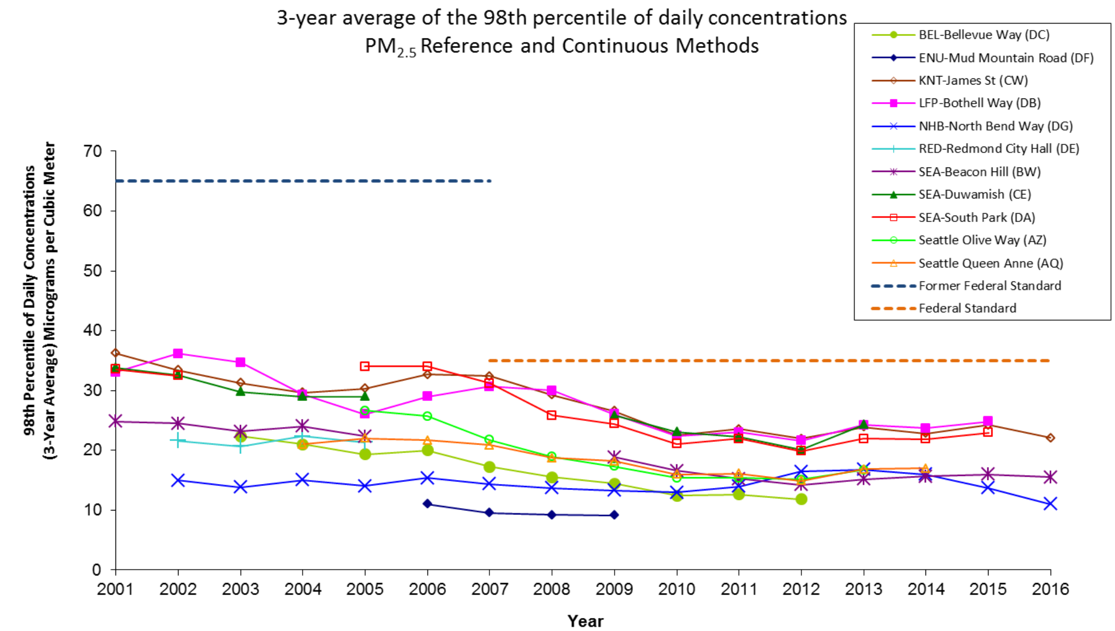


Figures 2 through 5 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard – all are below the standard in 2016. Points on the graphs represent averages for three consecutive years. For example, the value for 2016 is the average of the 98th percentile daily concentration for 2014, 2015, and 2016. These figures incorporate data collected from federal reference, federal equivalent, and nephelometer estimate methods.

Figure 3 does 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 shows that PM2.5 levels are below the federal standard.

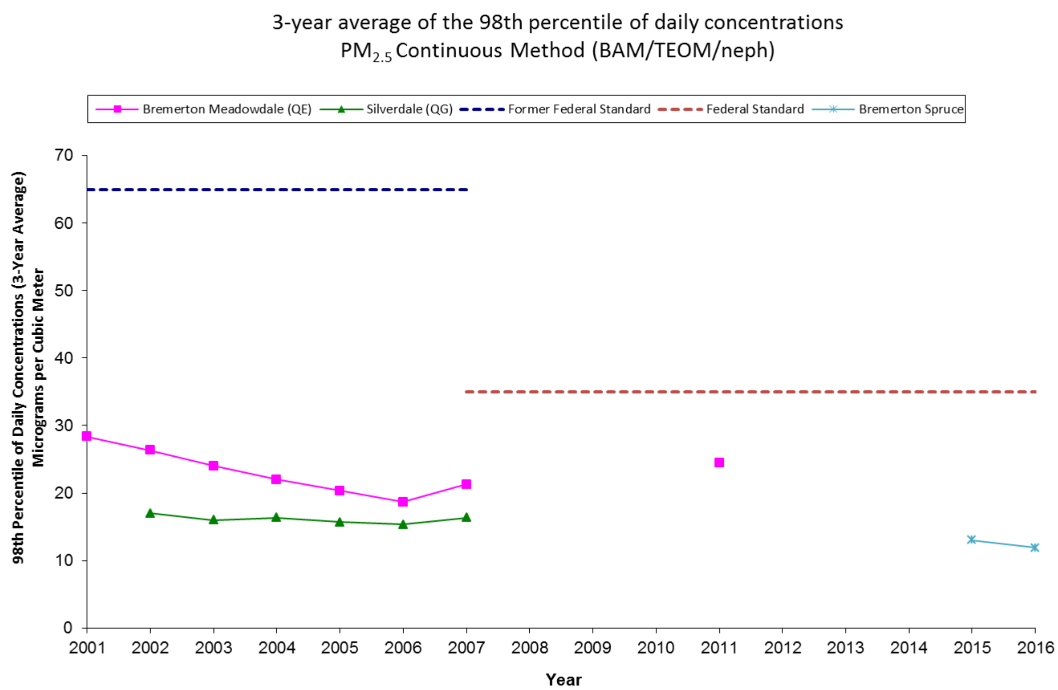
Statistical summaries for 98th percentile daily concentrations for 2016 data are provided on page A-8 through A-10 of the Appendix.

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



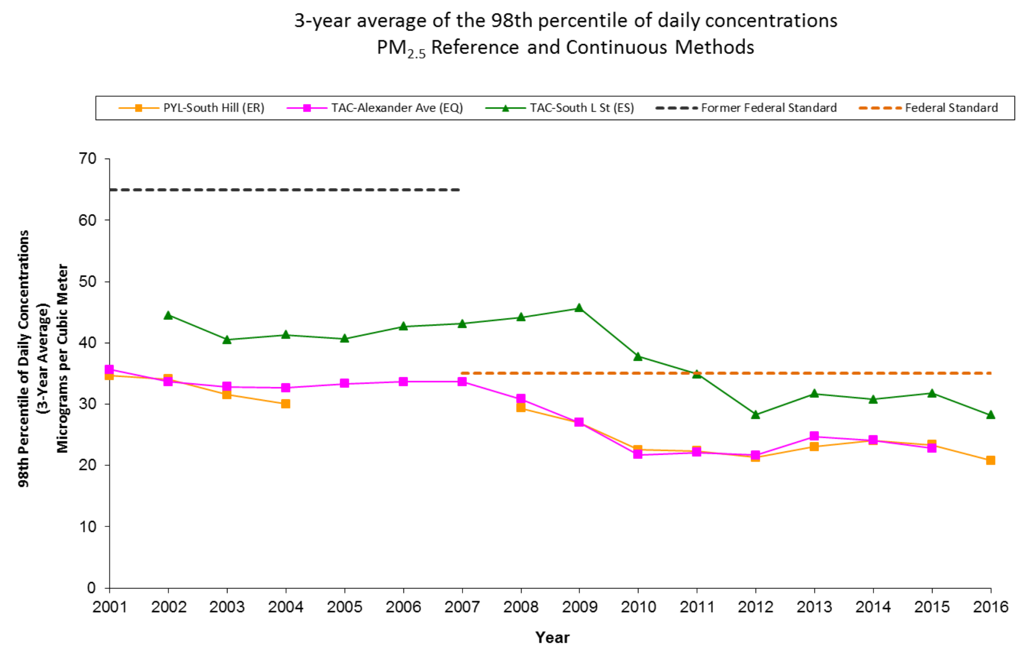
Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2016. Beacon Hill (BW) data are FRM from 1999-2016. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-2016. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2016. 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 2005-2016. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011-2016. Enumclaw (DF) data are from neph in 2000-2009.

Figure 3: Daily $PM_{2.5}$ for Kitsap County



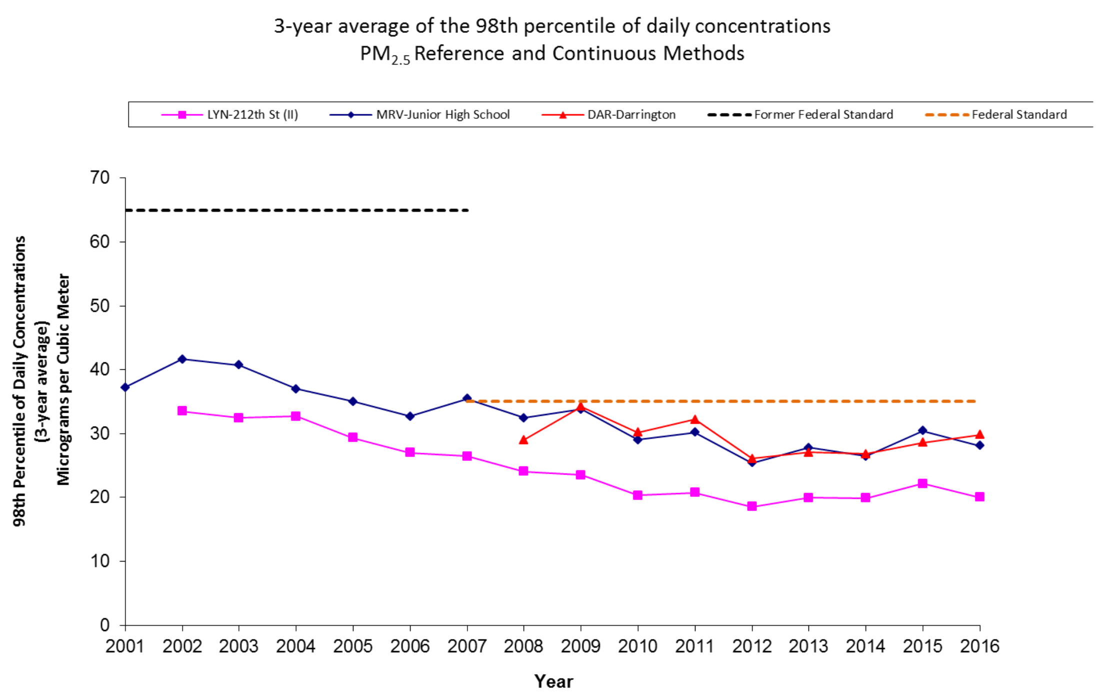
Note: 75% of data is required to calculate 98th percentile. Insufficient data available for 2008 so 3 year calculation not available for 2008-2010. 2011-2014 data are TEOM-FEM. Meadowdale site ended 4/30/12, Spruce site began 5/1/2012.

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



Note: All South L data are FRM from 2000- 2016. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2016. South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2016 incomplete nephelometer data was collected from South Hill in 2005.

Figure 5: Daily $PM_{2.5}$ for Snohomish County



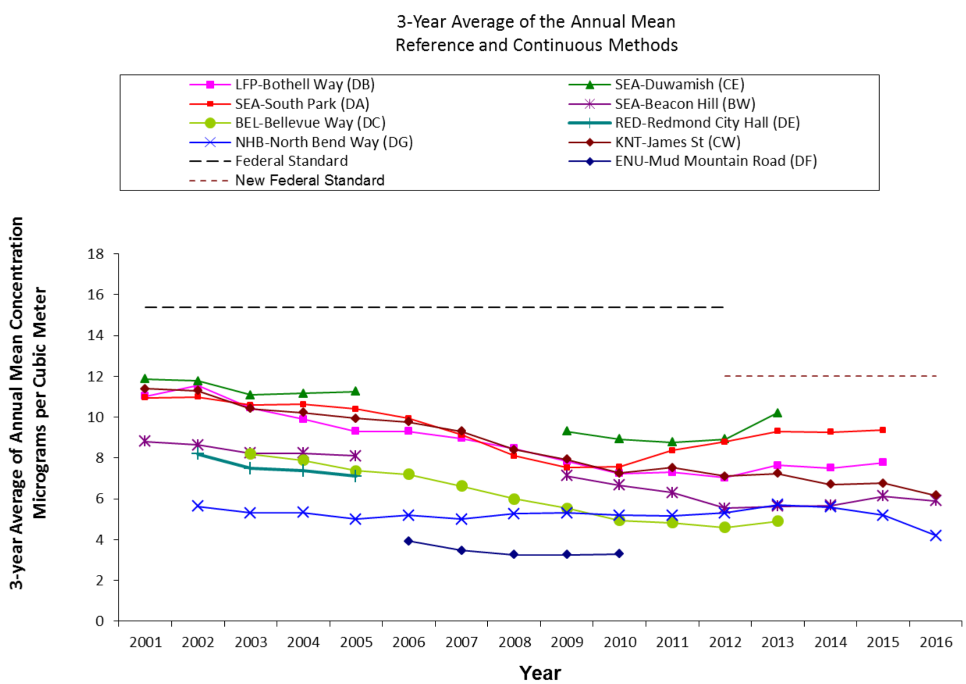
Note: Marysville (IG) data are FRM 999-2011, TEOM-FEM 2012-2016. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, TEOM-FEM 2011-2016. Darrington (JO) data are neph in 2006, FRM in 2007-2011, TEOM-FEM 2012-2016.

$PM_{2.5}$ Annual Federal Standard

Figures 6 through 9 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 micrograms per cubic meter to 12 micrograms per cubic meter. All counties have levels below the annual standard of 12 micrograms per cubic meter and all counties are in attainment for the annual standard. Figure 7 does not show any 2008, 2009, 2010, or 2012-2014 data for Kitsap County because the monitor did not achieve data completeness criteria or the monitoring site was relocated.

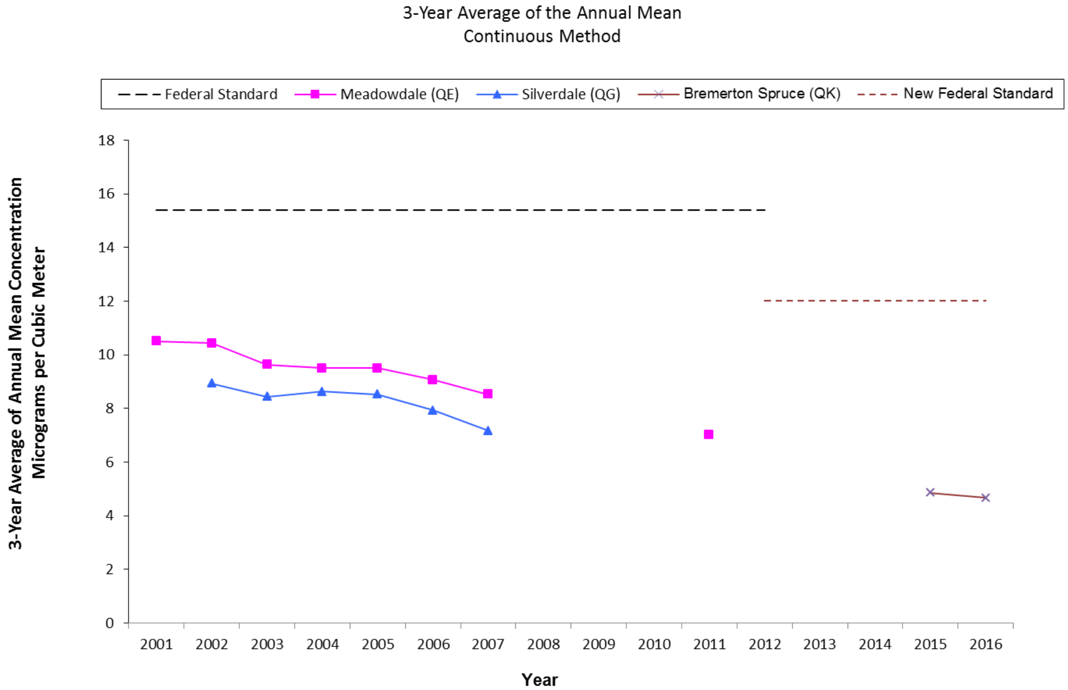
Figures 6 through 9 show data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is an average for three consecutive years. For example, the value shown for 2016 is the average of the annual averages for 2014, 2015, and 2016.

Figure 6: Annual $PM_{2.5}$ for King County



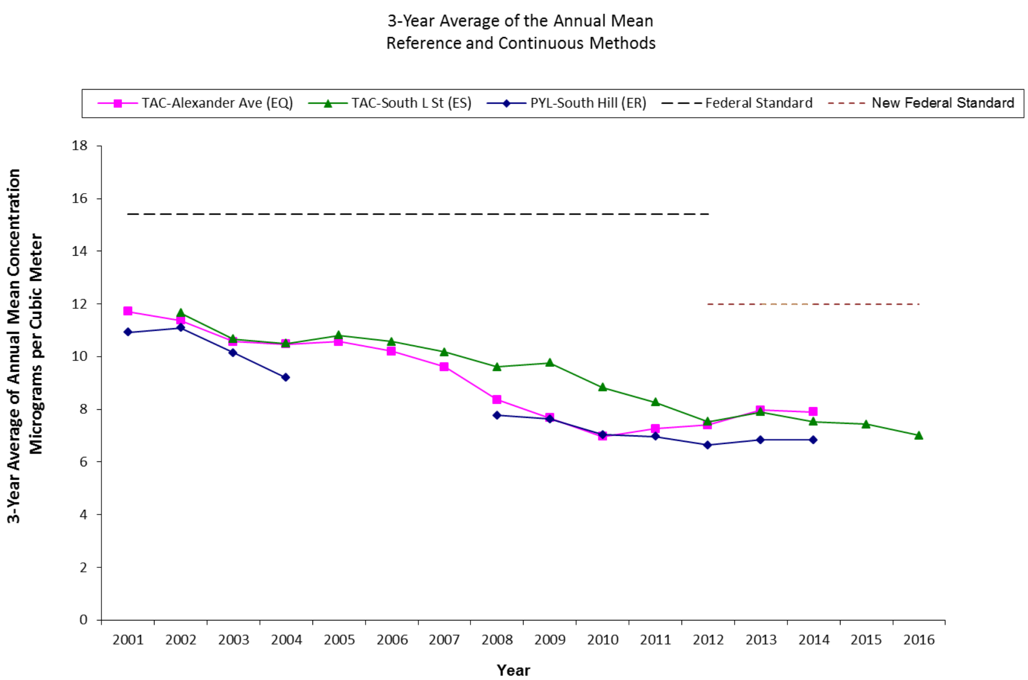
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2015. Beacon Hill (BW) data are FRM from 1999-2016. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2016. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2016. Redmond (DE) data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

Figure 7: Annual $PM_{2.5}$ for Kitsap County



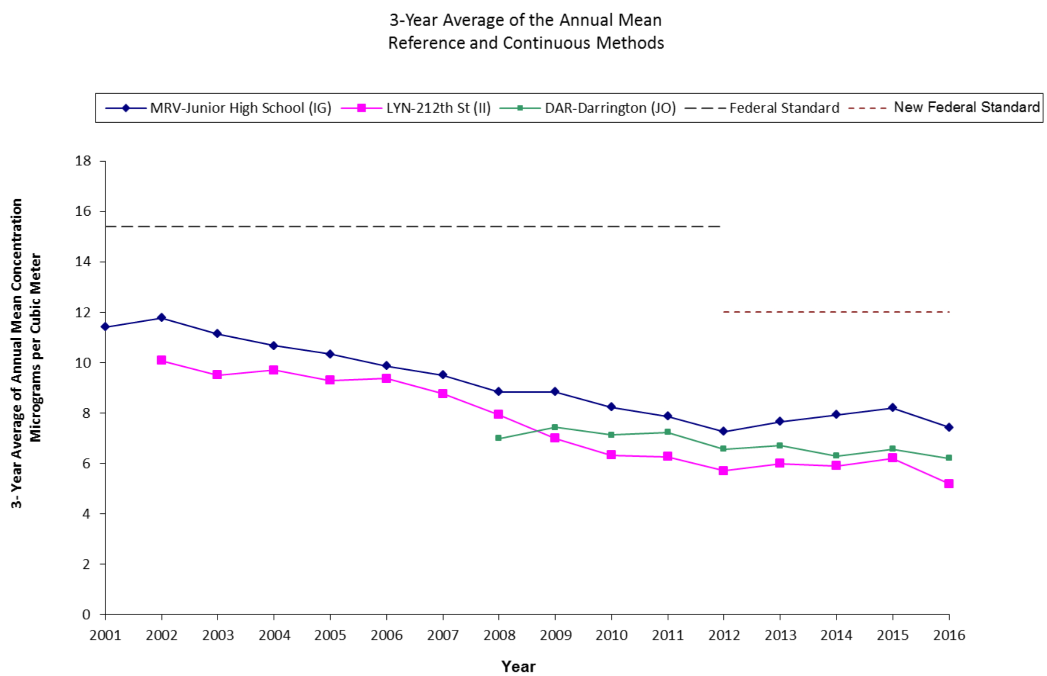
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011-2016. Insufficient data in 2008 resulted in the inability to calculate a 3 year average for 2008, 2009, 2010.

Figure 8: 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, 2008-2016 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002, nephelometer from 2003-2010, and TEOM-FEM 2011-2016.

Figure 9: 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 2012-2016.

$PM_{2.5}$ 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 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 Airgraphing tool at http://airgraphing.pscleanair.org/ 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 emission reduction strategies. Information on fine particulate composition helped guide the Agency's commitment to reduce wood smoke and diesel particulate emissions.[3,4,5]

Speciation Monitoring and Source Apportionment

Speciation monitoring involves determining the individual fractions of metals and organics in fine particulate matter on different types of filters. Speciation filters are analyzed to determine the makeup of fine particulate at that site. Over 40 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 monitoring sites in the Puget Sound region in 2016:

- 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 Appendix A-11.

Aethalometer Data

Aethalometers provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations using two channels, 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 well with organic carbon (OC) speciation data. Elemental and organic carbons are related to diesel particulate, wood smoke particulate and particulate from other

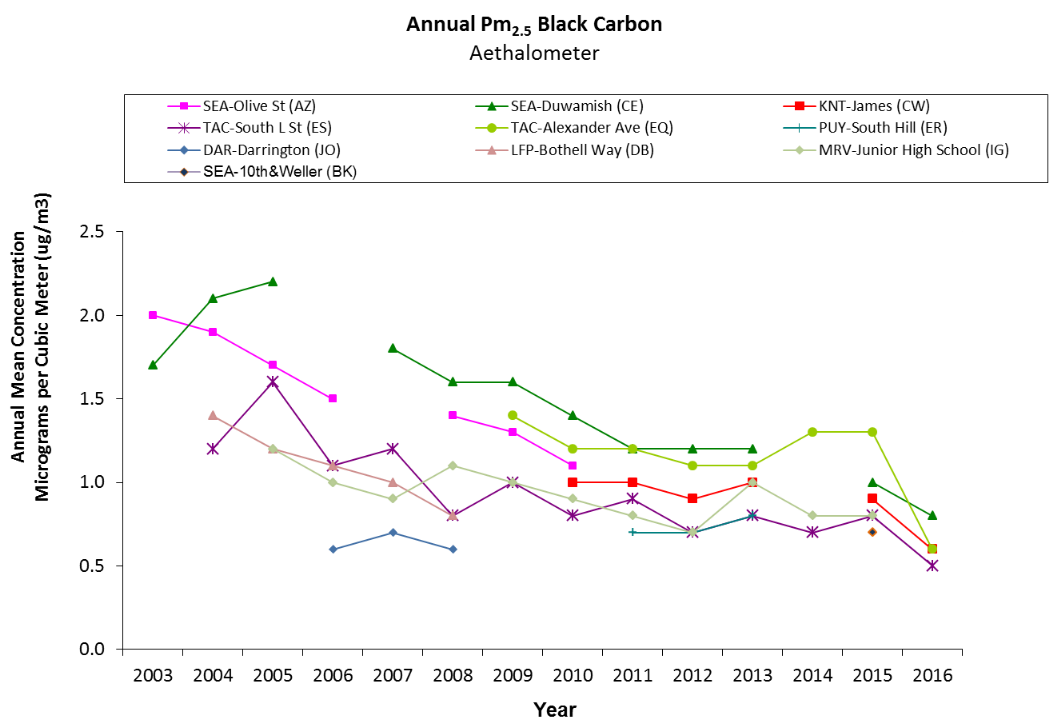
[3] Puget Sound Air Toxics Evaluation, October 2003.
[4] Tacoma and Seattle Air Toxics Evaluation, October 2010: epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.
[5] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area". PublicationNumber 10-02-009.

combustion sources.[6] Unfortunately, neither is uniquely attributed to a particular combustion type – so the information gained from aethalometer data is largely qualitative.

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

Figure 10 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-12 of the Appendix.

Figure 10: 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.[8] 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.[9]

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.
[9] 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 2016

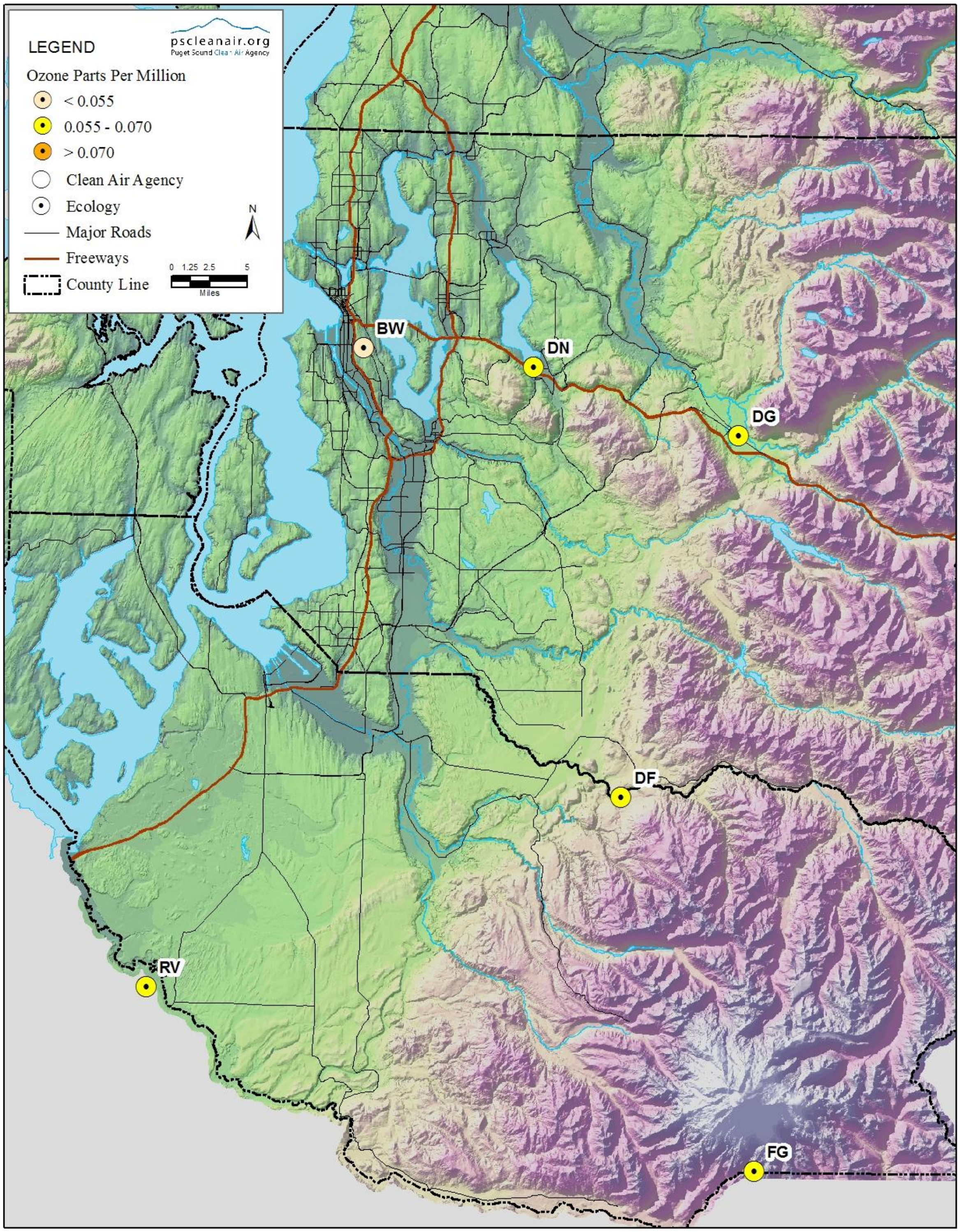


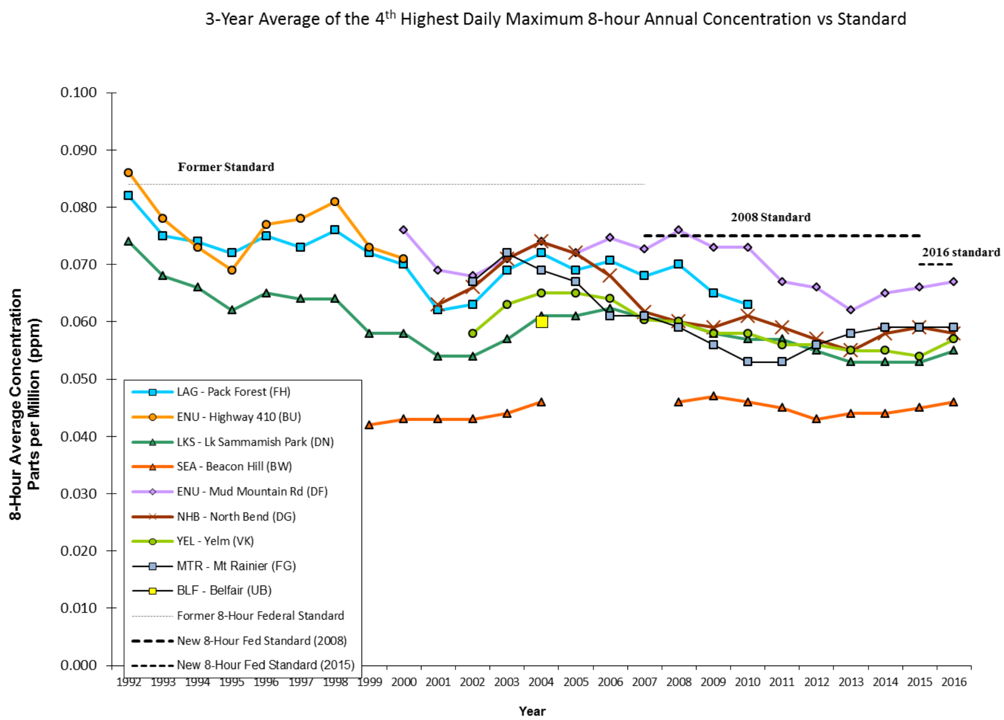
Figure 11 presents data for each monitoring station and the 8-hour federal standard. The EPA revised its 8-hour standard from 0.075 parts per million (ppm) to 0.070 ppm in December 2015. The federal standard is based on the 3-year average of the 4th highest 8-hour concentration, called the "design value". The year on the x-axis represents the last year averaged. For example, concentrations shown for 2008 are an average of 2006, 2007 and 2008 4th highest concentrations. The highest 2016 site design value is 0.067 ppm at the Enumclaw site, below the standard.

For 2016, the Puget Sound area is below EPA's 0.070 ppm 8-hour standard.

Statistical summaries for 8-hour average ozone data are provided on page A-13 of the Appendix.

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

Figure 11: Ozone for Puget Sound Region



2005, 2006, and 2007 are not shown for Seattle Beacon Hill because site did not meet 90% completeness for season.

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.[10] 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.[11] 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 3 years of data are required.

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

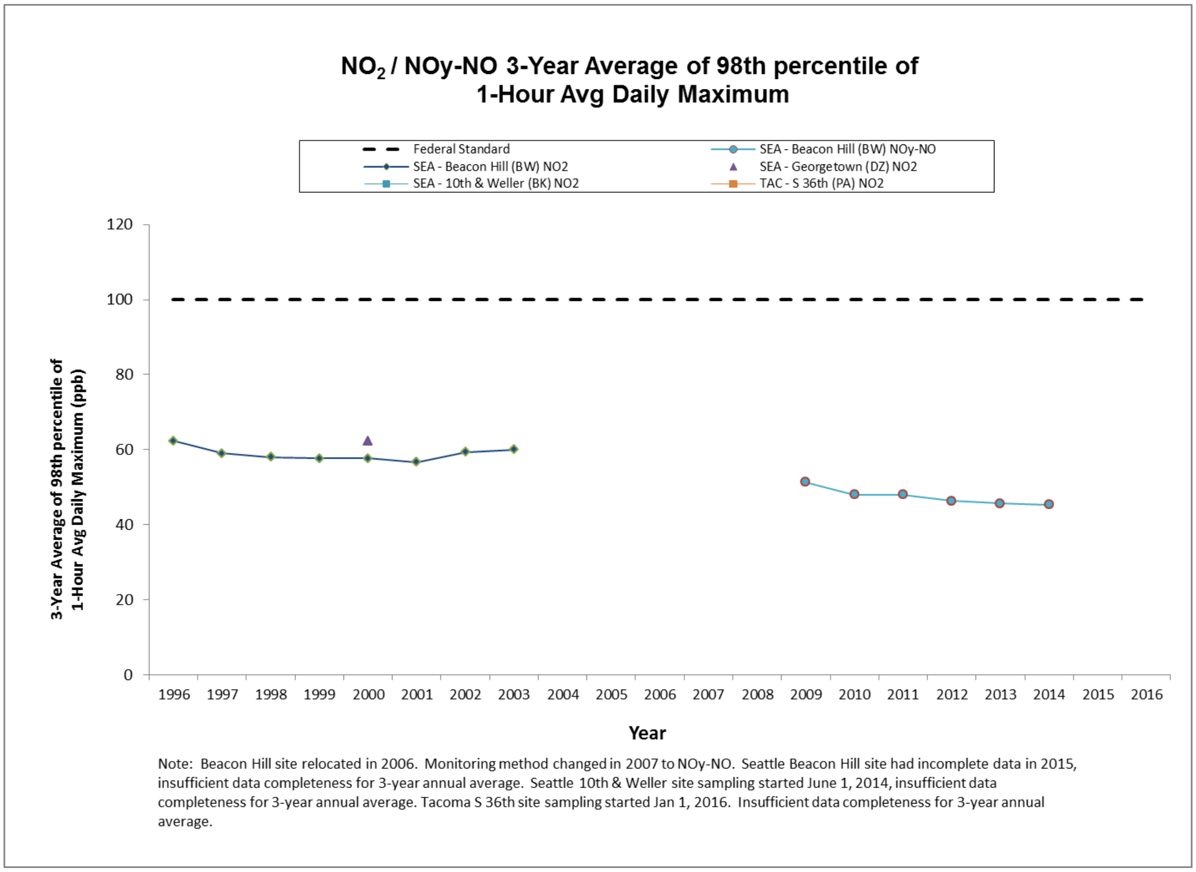
Figure 13 shows NO_2 concentrations for Beacon Hill through 2005. In 2006, no data were recorded due to the relocation of the Beacon Hill monitor to a different location on the same property. From 2007 onward, the concentration of NO_2 is represented as NO_y – NO, since NO_2 is no longer directly recorded, 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 12 with historical data since 1998. The years prior to 2010 have been included on the graphs for historical comparison.

[10] EPA, Airnow, NO_X Chief Causes for Concern; epa.gov/airquality/nitrogenoxides/
[11] 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 12: 2010 1-Hour Maximum Standard for Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)



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/library/Pages/Documents.

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

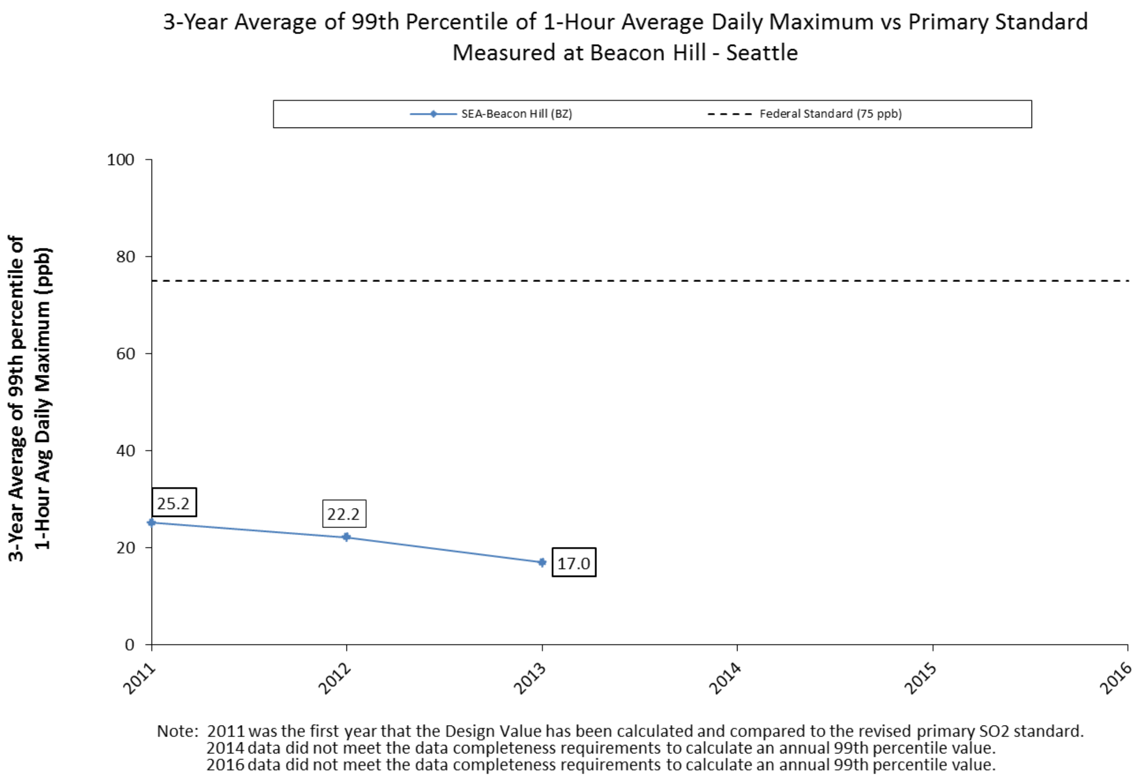
EPA changed the SO_2 standard in June of 2010 to a more short-term (1-hour) standard and revoked the former annual and daily average standards. Historic comparisons to federal and Washington State standards can be seen in our 2009 data summary which is available upon request.

The 2010 standard is a 3-year average of the 99^{th} 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 13 shows the maximum 3-year average of the 99^{th} percentile of 1-hour maximum concentrations at Beacon Hill. Seattle Beacon Hill did not meet data completeness requirements 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 13: 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 $\mu g/m^3$ to 0.15 $\mu g/m^3$ (rolling three-month average).[12] 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.

[12] 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 14 through 18 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-10 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 2016, the 12-month moving average increased from 47 miles to 90 miles.

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

Figure 14: Puget Sound Visibility

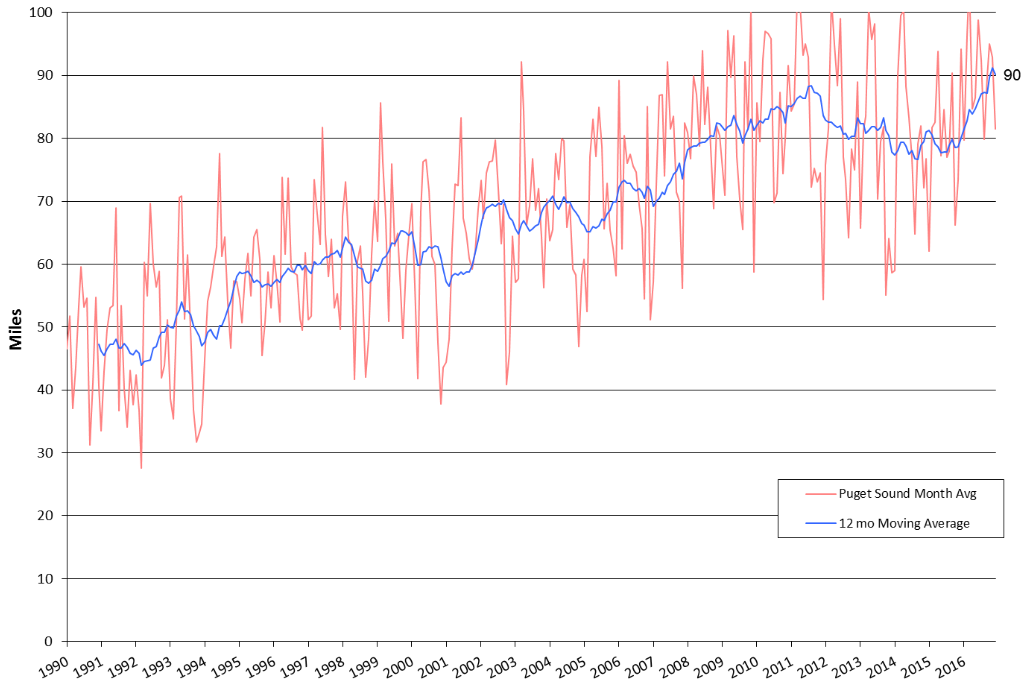


Figure 15: King County Visibility

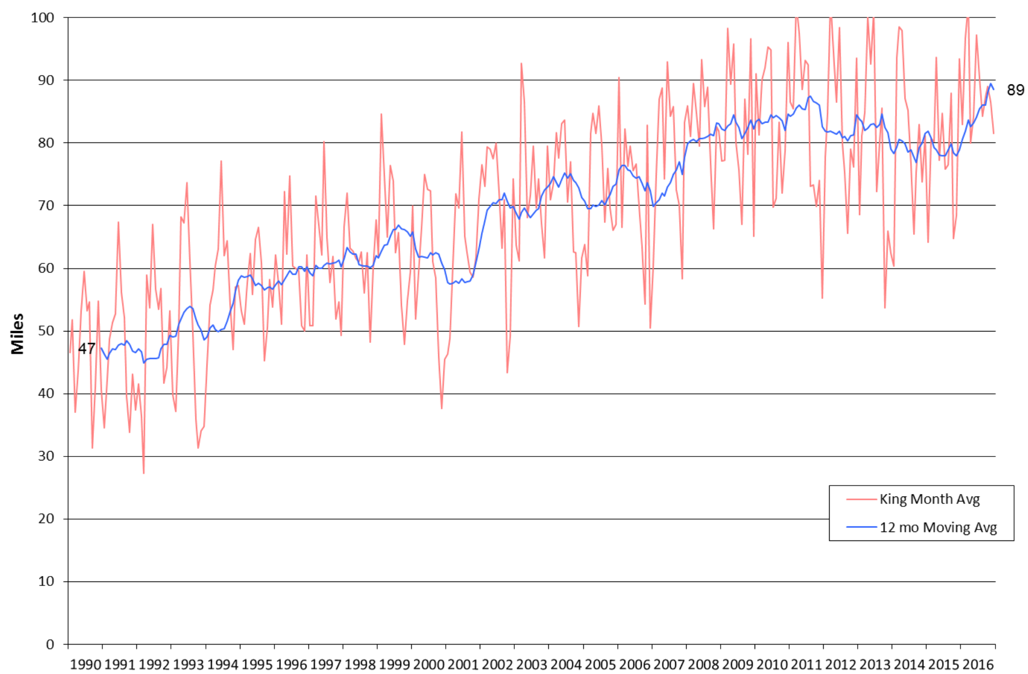


Figure 16: Kitsap County Visibility

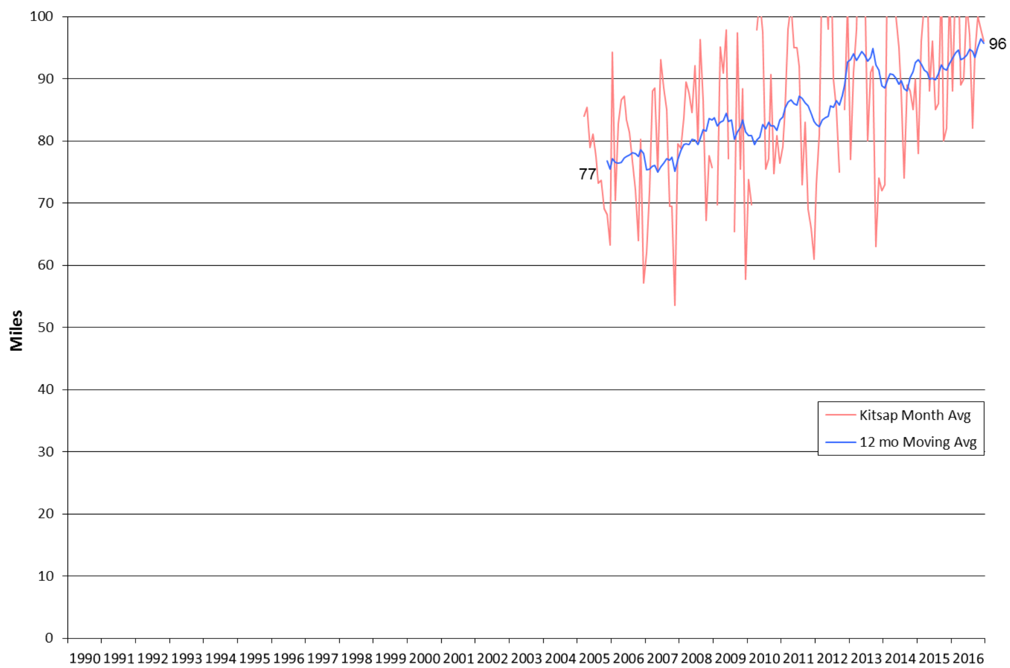


Figure 17: Pierce County Visibility

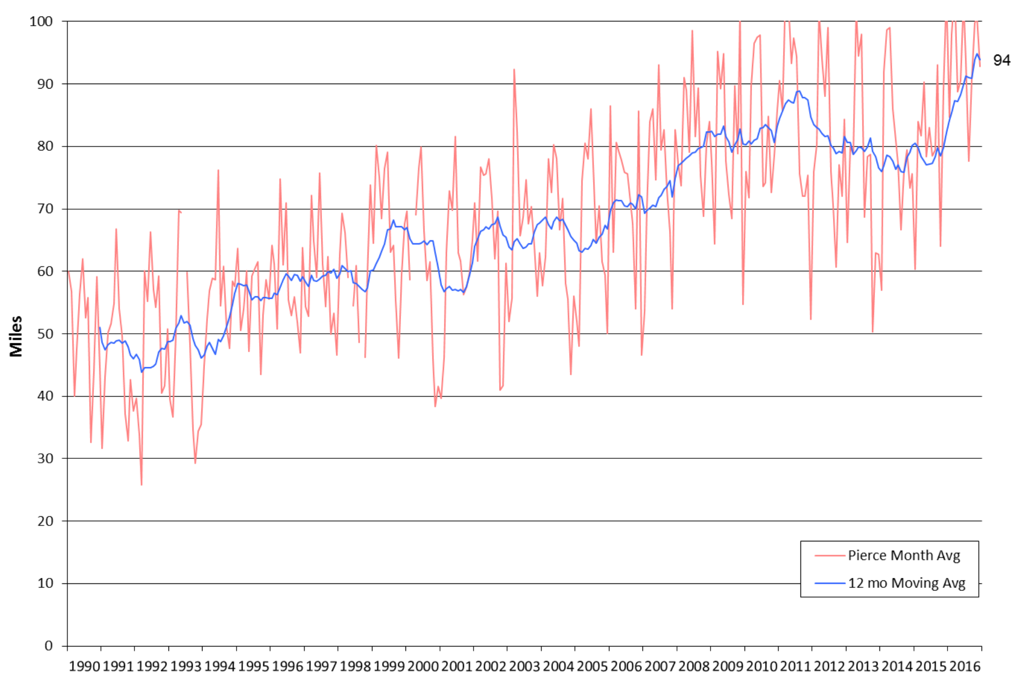
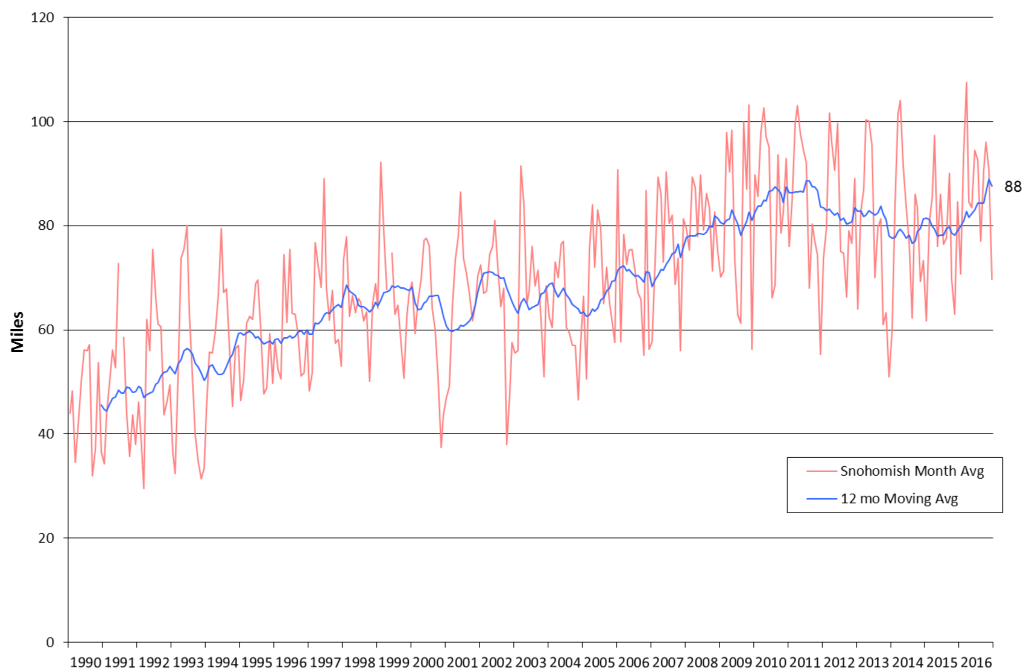


Figure 18: Snohomish County Visibility



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.[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 30 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 http://www.pscleanair.org/airquality/airqualitybasics/airtoxics/Pages/default.aspx. Air toxics statistical summaries are provided starting on page A-14 of the Appendix.

Relative ranking based on cancer risk & unit risk factors

Table 3 below ranks 2016 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.

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 pages A-15 and 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-16 of the Appendix. Page A-16 also lists the frequency (percentage) of samples that were over the cancer screening level of one in a million risk.

[13] US EPA, Risk Assessment for Toxic Air Pollutants: A Citizen's Guide: https://www3.epa.gov/airtoxics/3_90_024.html.
[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: 2016 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	29
Benzene	2	14
1,3-Butadiene	3	10
Formaldehyde	4	4
Chloroform	5	3
Hexavalent Chromium	5	*3*[b]
Acetaldehyde	7	2
Arsenic (PM_{10})	7	2
Ethylene Dichloride	7	2
Dichloromethane	10	1
Naphthalene	10	1
Cadmium (PM_{10})	12	<1
Ethylbenzene	12	<1
Nickel (PM_{10})	12	<1
Tetrachloroethylene	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

TSP = total suspended particulate

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 reference concentration, as established by California EPA (the most comprehensive dataset available). A reference concentration (RfC) is considered a safe level for toxics for non-cancer health effects.

Only one air toxic, acrolein, failed the screen for non-cancer 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 uncertainty of the measurement.

Reference concentrations and hazard indices are shown for each air toxic on page A-17 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 2016 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. The statistical results can be found on page A-18 of the Appendix.

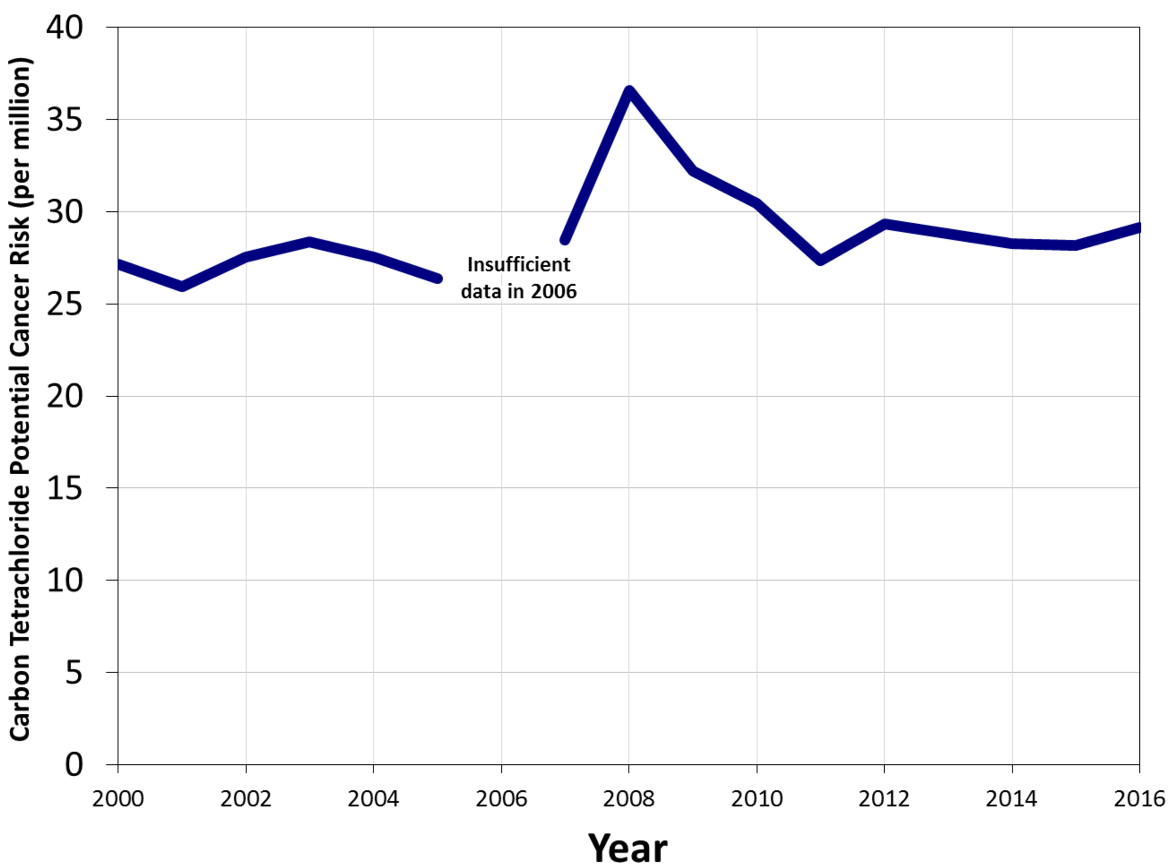
[16] EPA, Acrolein Hazard Summary; https://www.epa.gov/sites/production/files/2016-08/documents/acrolein.pdf.
[17] EPA, Schools Monitoring Acrolein Update, https://www3.epa.gov/air/sat/pdfs/acroleinupdate.pdf.

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 for both industry and consumer users and was banned from consumer use in 1995. Trace amounts are still emitted by local sewage treatment plants. Carbon tetrachloride is relatively ubiquitous and has a long half-life and concentrations are similar in urban and rural areas. Carbon tetrachloride's 2016 average potential cancer risk estimate at Beacon Hill was 29 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 19: Carbon Tetrachloride Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



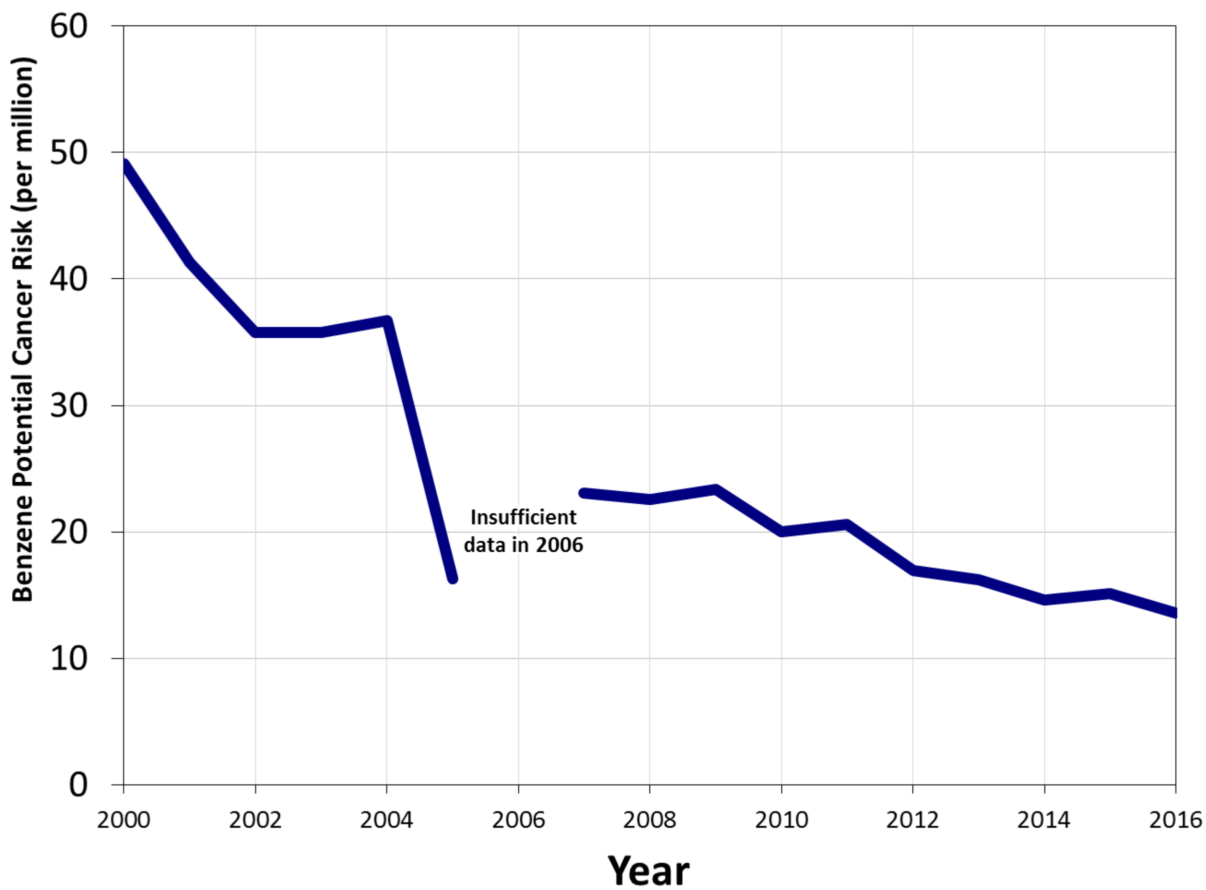
[18] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/carbon-tetrachloride.pdf.

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 2016 average potential cancer risk range estimate at Beacon Hill was 14 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 two per million per year since 2000.

Figure 20: Benzene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



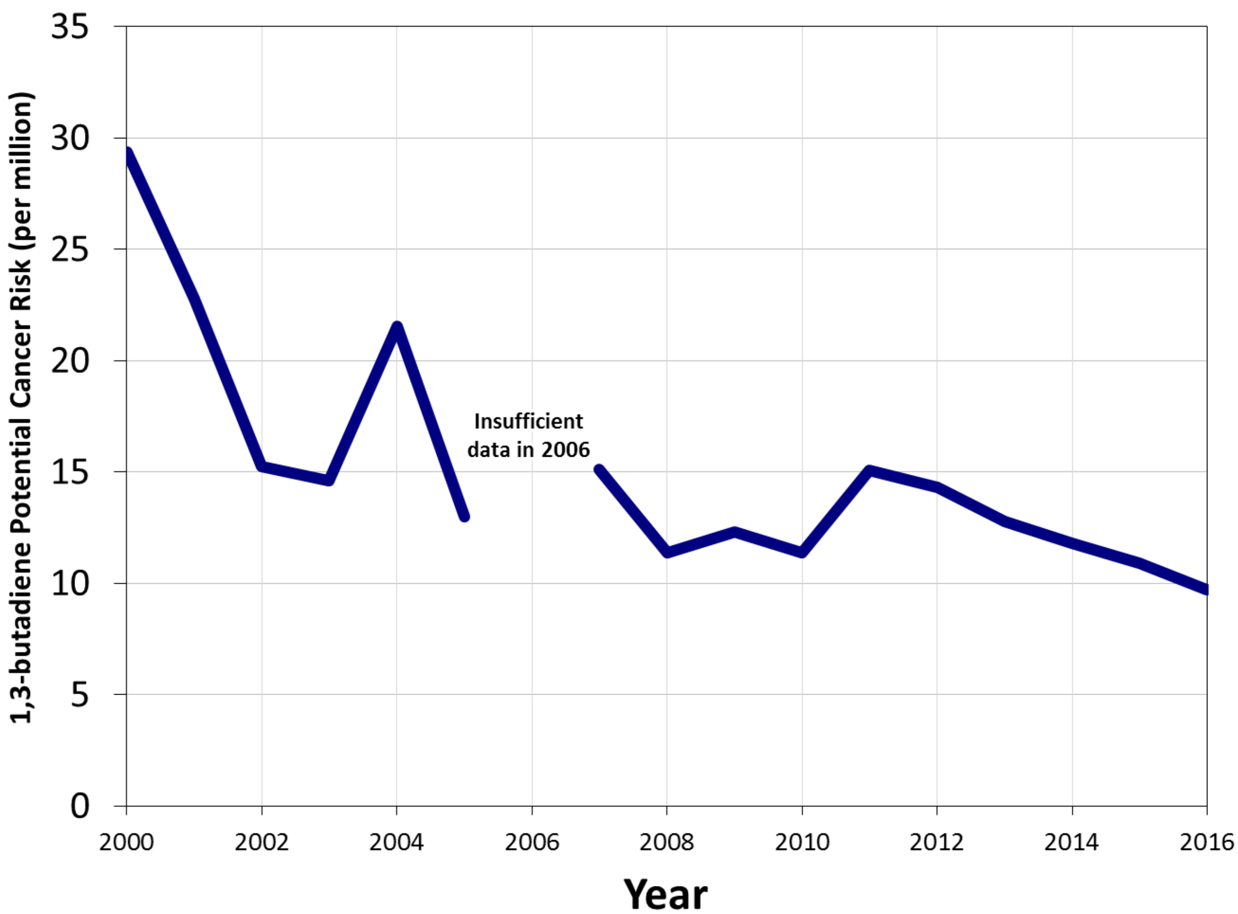
[19]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf.

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 2016 average potential cancer risk estimate at Beacon Hill was 10 in a 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 one per million per year.

Figure 21: 1,3-butadiene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



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

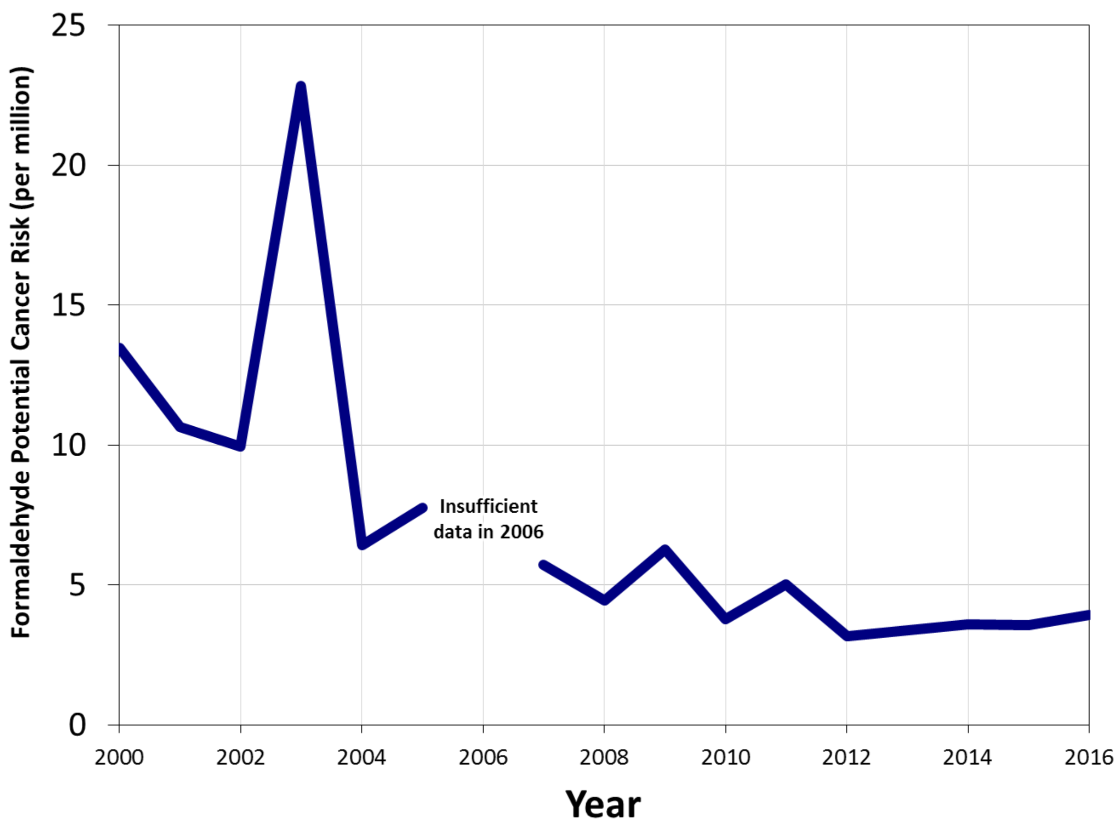
Formaldehyde

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 2016 average potential cancer risk range estimate at Beacon Hill was 4 in a million.

The increase in formaldehyde 2003 concentrations is due to 9 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 one per million per year.

Figure 22: Formaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



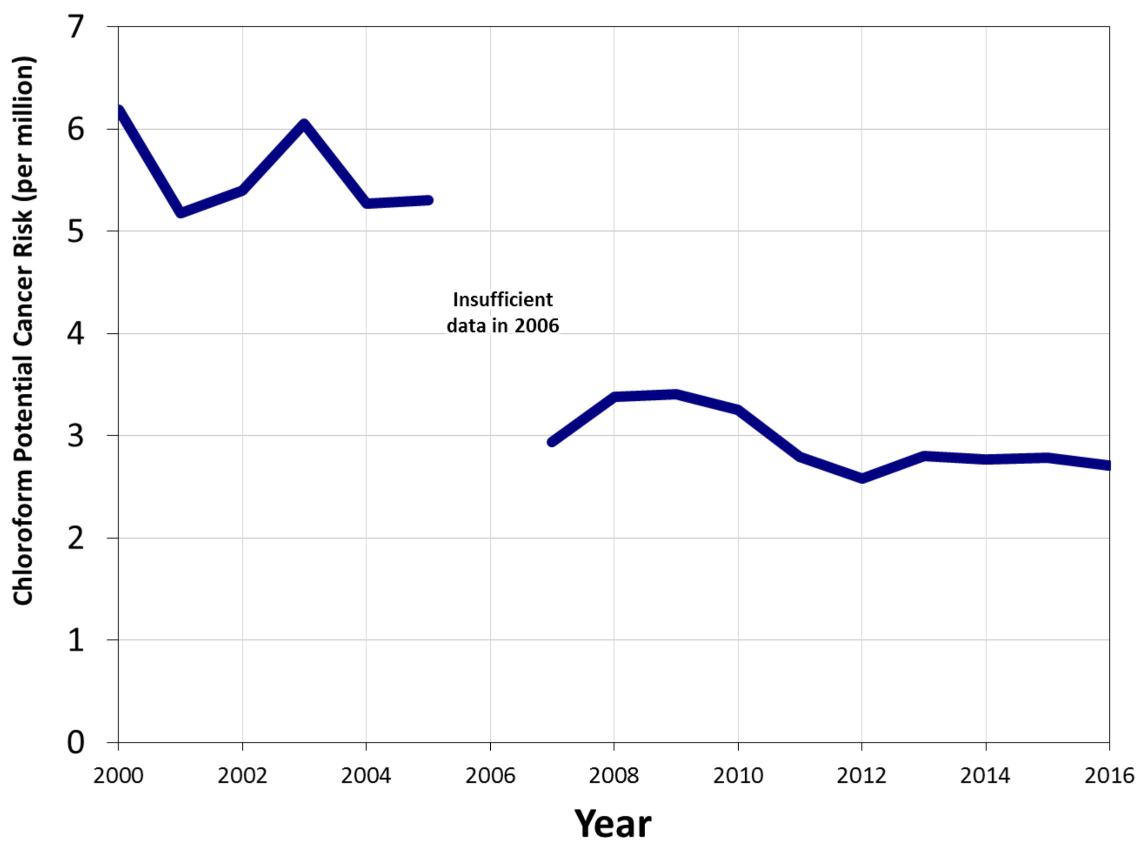
[21]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/formaldehyde.pdf.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[22] Main sources of chloroform are water treatment plants and reservoirs. Since the Beacon Hill monitoring site is located at the Beacon Hill reservoir, the chloroform data may be biased high. However, it is still useful to calculate and assess the long-term trend and potential risk. Chloroform's 2016 average potential cancer risk range 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.[23] Since 2000, we found a statistically significant drop in risk from chloroform at a rate of about 0.2 per million per year.

Figure 23: Chloroform Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



[22]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chloroform.pdf.
[23]Seattle Public Utilities. 2011Water Quality Analysis shows detectable levels of trihalomethanes; http://web.archive.org/web/20160716103024/http://www.seattle.gov/util/groups/public/@spu/@water/documents/webcontent/02_016357.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform.

Hexavalent Chromium

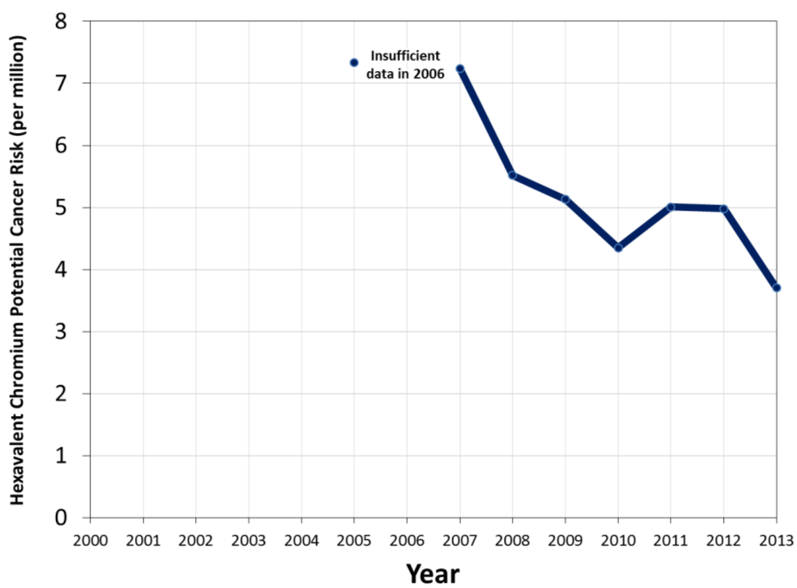
Chromium is present in two chemical states (trivalent and hexavalent) in our air. Trivalent chromium occurs naturally, while hexavalent comes from human activities and is much more toxic. EPA lists hexavalent chromium as a known carcinogen, associated primarily with lung cancer. Hexavalent chromium is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

Exposure to hexavalent chromium is also associated with adverse respiratory, liver, and kidney effects.[24] Sources of hexavalent chromium include chrome electroplaters, as well as combustion of distillate oil, 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 range 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 the Kaplan-Meier method to estimate the mean to better account for potential left-sensored data biases for each year and changes in detection limits. 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 24: Hexavalent Annual Average Potential Cancer Risk at Beacon Hill, 2005-2013



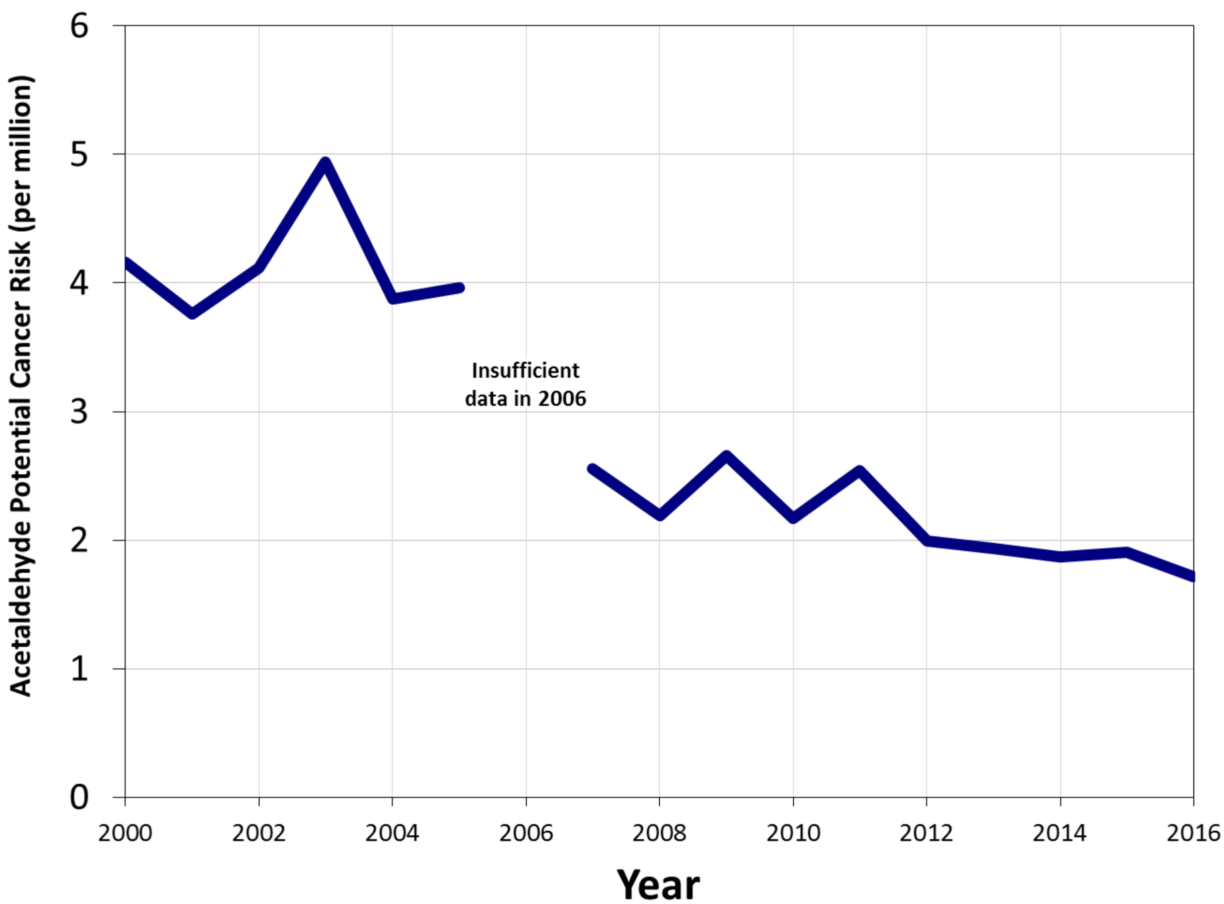
[24]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/chromium-compounds.pdf.

Acetaldehyde

The EPA lists acetaldehyde as a probable human carcinogen. Acetaldehyde inhalation is also associated with irritation of eyes, throat and lungs, and effects similar to alcoholism.[25] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2016 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 0.2 per million per year.

Figure 25: Acetaldehyde Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



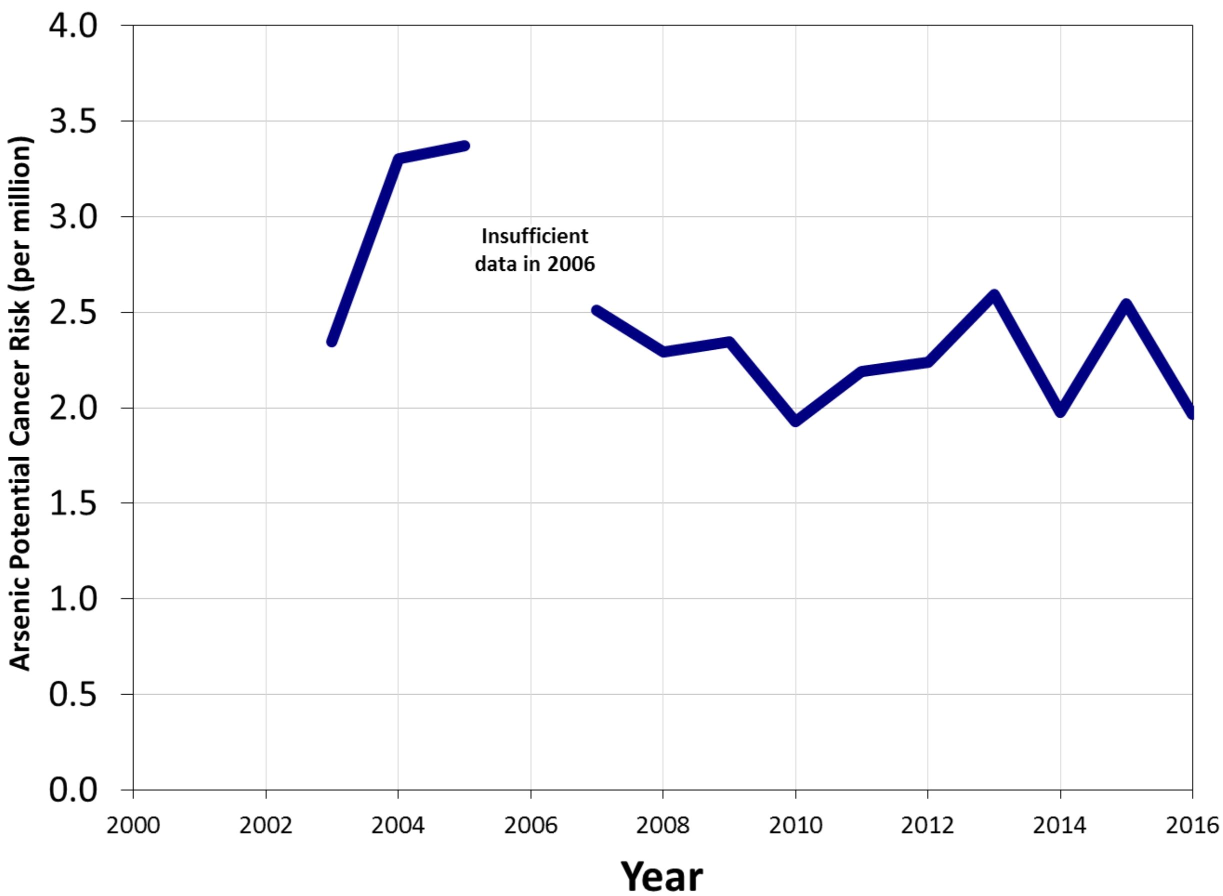
[25] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/acetaldehyde.pdf.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation and liver and kidney damage.[26] 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 2016 average potential cancer risk range 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 also works with and regulates industrial producers of arsenic to reduce emissions. Illegal burning can also contribute to arsenic emissions in our area.

Figure 26: Arsenic Annual Average Potential Cancer Risk at Beacon Hill, 2003-2016



[26]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/arsenic-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 gas.[27]

We estimated ethylene dichoride's 2016 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 2016 were within twice the method detection limit. Additionally, in prior years, most of the samples were also below the method detection limits. Through the years, the detection limits for this air toxic is 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.

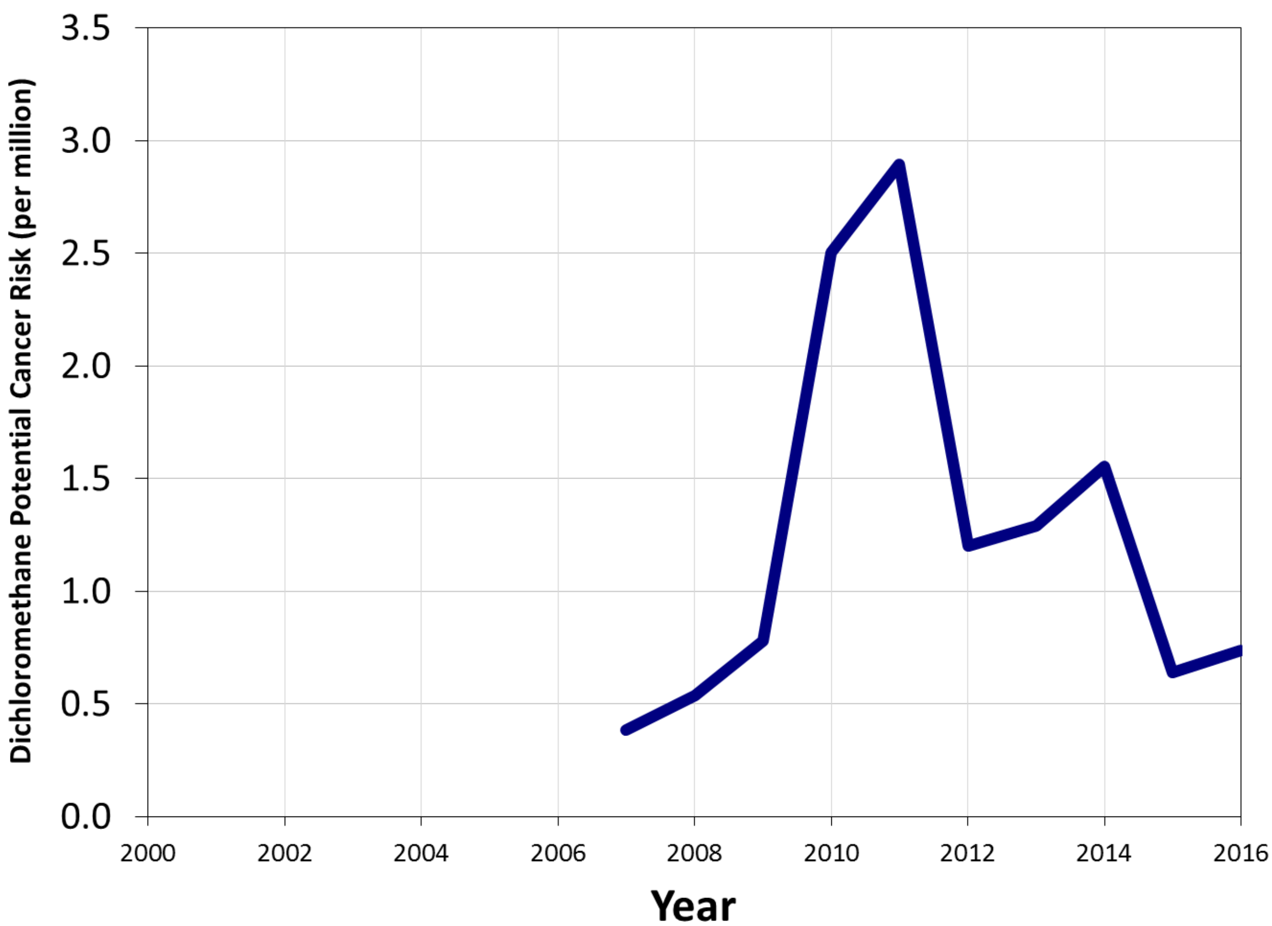
[27] EPA Hazard Summary, https://www.epa.gov/sites/production/files/2016-09/documents/ethylene-dichloride.pdf.

Dichloromethane

EPA lists dichloromethane as a probable human carcinogen. Dichloromethane is also known as methylene chloride. Dichloromethane is a common solvent used for paint, extraction, and cleaning processes.[28] Dichloromethane's 2016 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 this time frame.

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 27: Dichloromethane Annual Average Potential Cancer Risk at Beacon Hill, 2007-2016



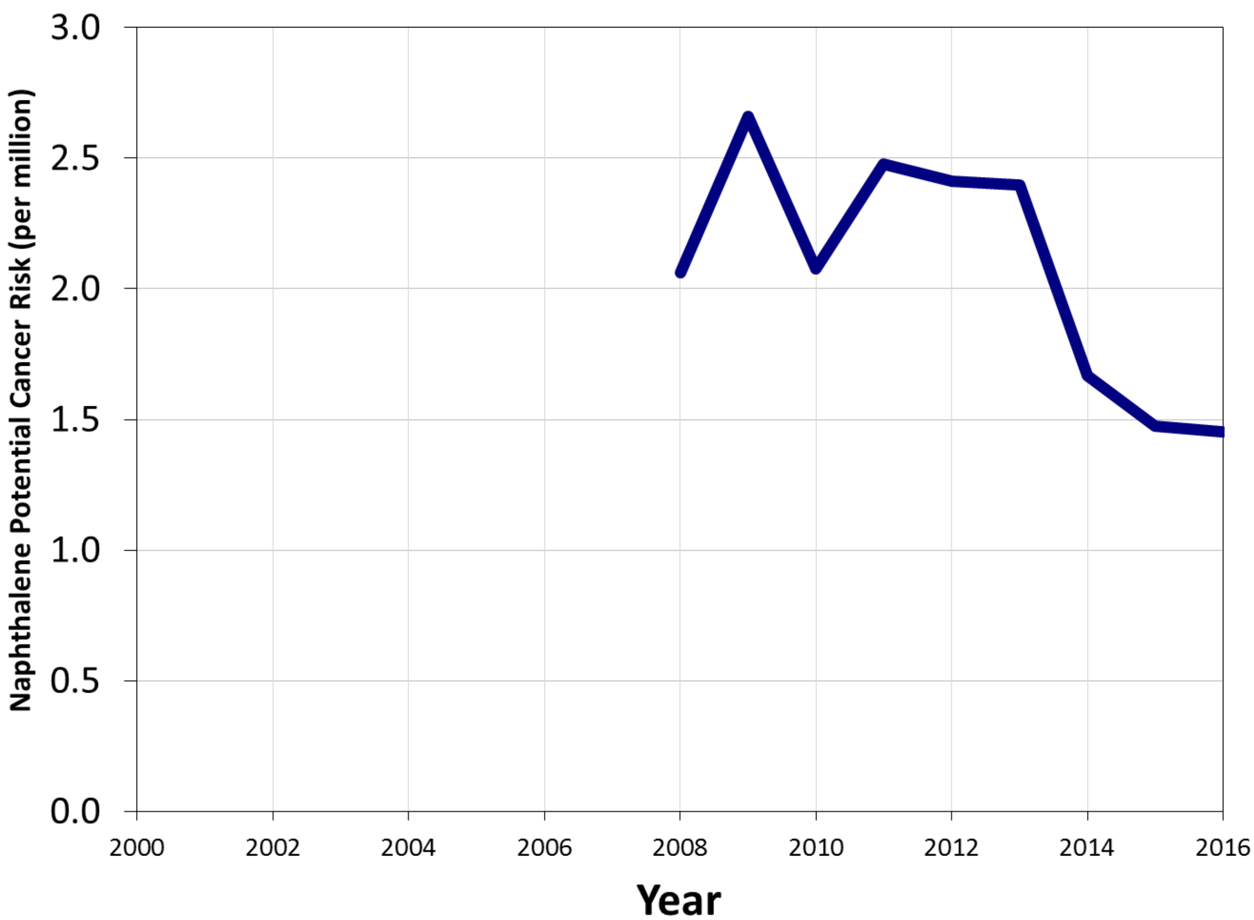
[28] EPA Hazard Summary, https://www.epa.gov/sites/production/files/2016-09/documents/methylene-chloride.pdf.

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is similarly associated with respiratory effects and retina damage.[29] Local sources of naphthalene include combustion of wood and heavy fuels. Naphthalene's 2016 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 28: Naphthalene Annual Average Potential Cancer Risk at Beacon Hill, 2008-2016



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

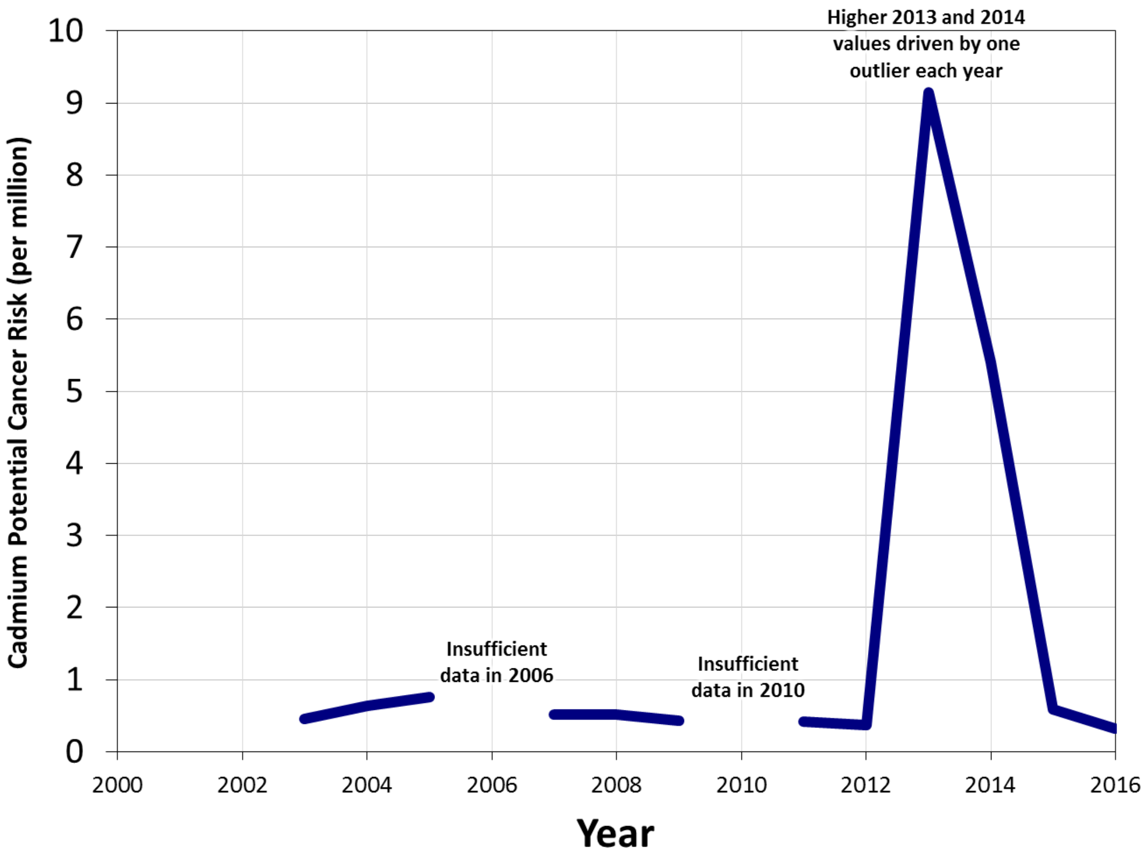
Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[30] Combustion of distillate oil is a main source of cadmium in the Puget Sound area.

Cadmium's 2016 average potential cancer risk estimate at Beacon Hill was less than 1 in a million. Over half the samples in 2010 were below the detection limits and did not have sufficient data to make a comparable average. We found sampled outliers on 9/8/14 and 11/18/13. On those days, no other metal concentrations were statistical outliers compared to their respective annual variability. With the outliers excluded for both years, the estimated annual potential cancer risk for cadmium 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 29: Cadmium Annual Average Potential Cancer Risk at Beacon Hill, 2003-2016

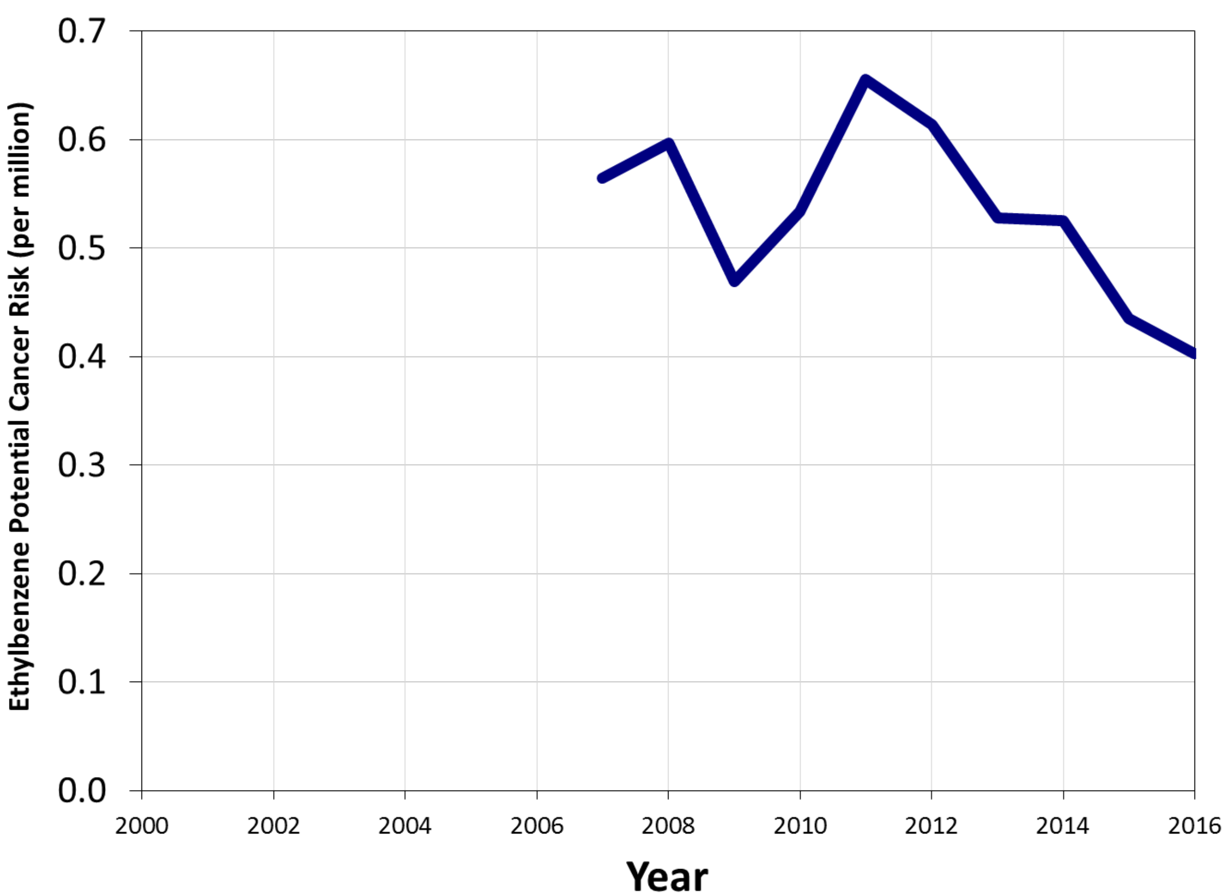


[30] EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/cadmium-compounds.pdf.

Ethylbenzene

EPA lists ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[31] 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 2016 average potential cancer risk estimate at Beacon Hill was below one in a million. We did not find a statistically significant trend in ethylbenzene levels over this time frame. The Agency works with and regulates solvent-using businesses to reduce ethylbenzene emissions.

Figure 30: Ethylbenzene Annual Average Potential Cancer Risk at Beacon Hill, 2007-2016

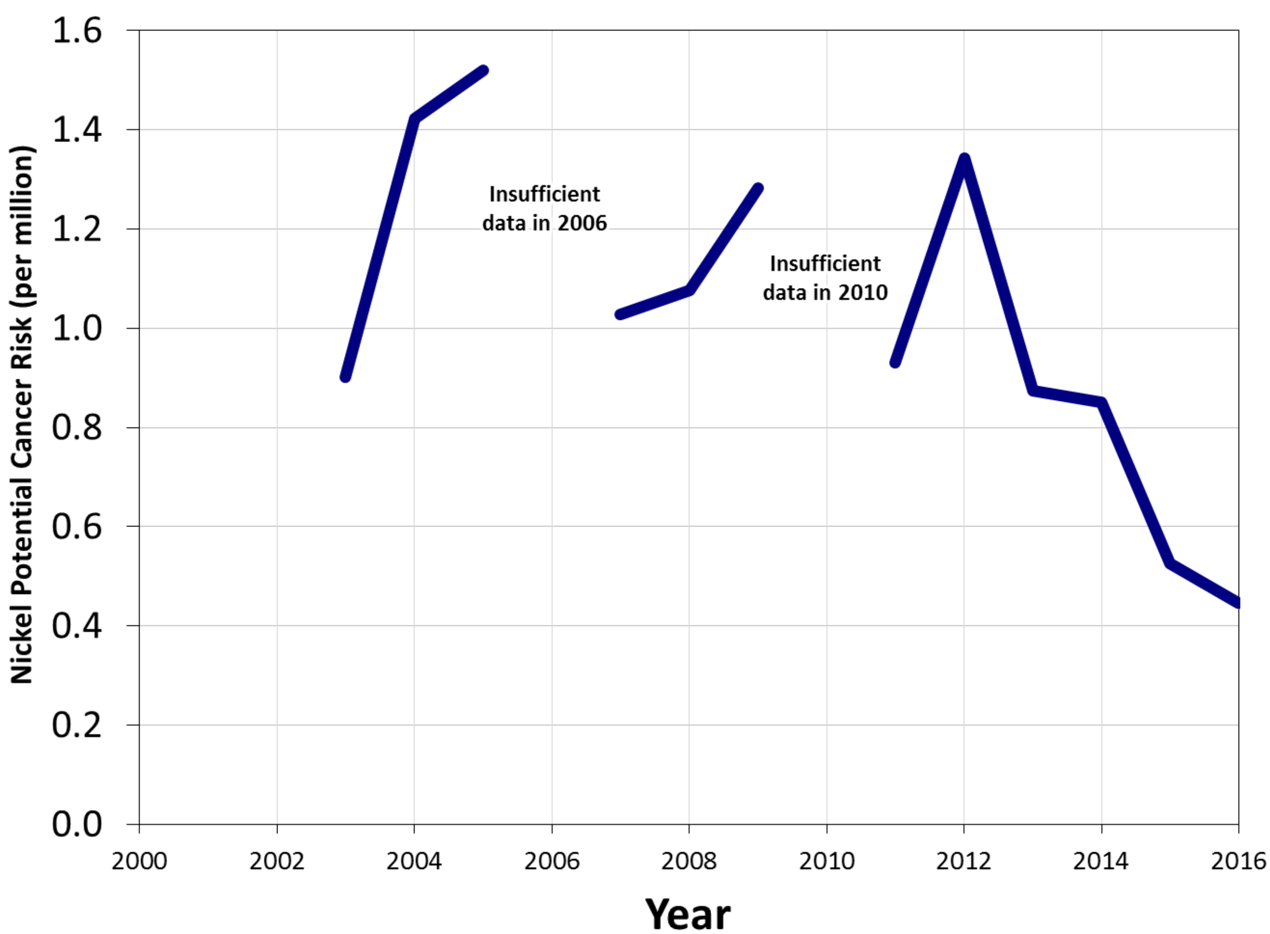


[31] EPA Hazard Summary: https://www.epa.gov/sites/production/files/2016-09/documents/ethylbenzene.pdf.

Nickel

EPA lists nickel as a known human carcinogen. Nickel is also associated with dermatitis and respiratory effects.[32] Combustion of gasoline and diesel fuels (car, truck and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2016 average potential cancer risk estimate at Beacon Hill was below one in a million. Since 2000, we found a statistically significant drop in risk from nickel at a rate of about 0.1 per million per year. Agency efforts that target reducing vehicle exhaust also reduce nickel emissions.

Figure 31: Nickel Annual Average Potential Cancer Risk at Beacon Hill, 2003-2016



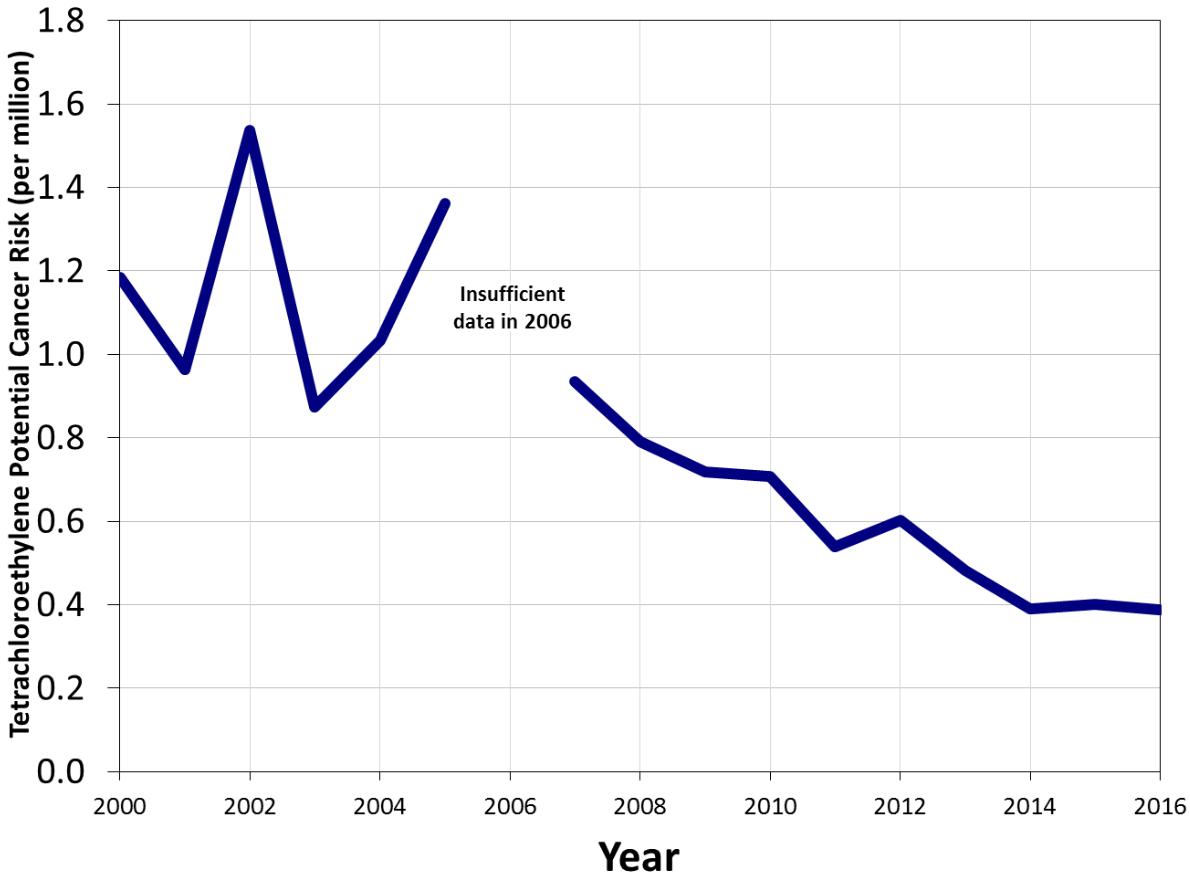
[32]EPA Hazard Summary; https://www.epa.gov/sites/production/files/2016-09/documents/nickle-compounds.pdf.

Tetrachloroethylene

EPA lists tetrachloroethylene, also known as perchloroethylene or "perc", as a probable human carcinogen. Tetrachloroethylene inhalation is also associated with central nervous system effects, liver and kidney damage, and cardiac arrhythmia.[33] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2016 average potential cancer risk estimate at Beacon Hill was below one in a million.

The Agency works with dry cleaners to monitor for and repair leaks in their equipment to reduce the release of tetrachloroethylene. Since 2000, we found a statistically significant drop in risk from tetrachloroethylene at a rate of about 0.1 per million per year.

Figure 32: Tetrachloroethylene Annual Average Potential Cancer Risk at Beacon Hill, 2000-2016



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

Definitions

General Definitions

Air Quality Index

Table 4: 2016 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O_3 (ppm) 8-hour[d]	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
0.000–0.059	—	0.0–12.0	0–54	0.0–4.4	0–35	0–53	0–50	Good
0.060–0.075	—	12.1–35.4	55–154	4.5–9.4	36–75	54–100	51–100	Moderate
0.076–0.095	0.125–0.164	35.5–55.4	155–254	9.5–12.4	76–185	101–360	101–150	Unhealthy for sensitive groups
0.096–0.115	0.165–0.204	55.5–150.4	255–354	12.5–15.4	186–304	361–649	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	305–604	650–1249	201–300	Very unhealthy
(b)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	604–804	1250–1649	301–400	Hazardous
(b)	0.505–0.604	350.5–500.4	505–604	40.5–50.4	805–1004	1650–2049	401–500	Hazardous

[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] EPA tightened the O_3 standard Oct 26, 2015 (effective 12/28/15) and new values are not reflected in this chart.

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 188 pollutants as HAPs at epa.gov/ttn/atw/188polls.html.

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 4000 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

2016

Air Quality Data Summary Appendix

July 2017

Working Together for Clean Air

Monitoring Methods Used from 1999 to 2016 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)							●						●	●	●		●	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							**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
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, 4752 E Marginal Way S, Seattle SPECIATION SITE	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
DA	South Park, 8025 10th Ave S, Seattle (ended Dec 31, 2002)	X			X			X						X	X			X	b, e, 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
DB	17171 Bothell Way NE, Lake Forest Park	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												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			●	●	●		●	a, e
ER	South Hill, 9616 128th St E, Puyallup	X	X		X	X		●	**X**					●	●	●		●	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

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
FH◉	Charles L Pack Forest, La Grande									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
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	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
RZ	Gig Harbor, 9702 Crescent Valley Dr NW, Gig Harbor							●						●	●			●	f
TR	Eatonville, 560 Center St, Eatonville							●							●	●			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
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 - 2016

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)

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

Micrograms per Cubic Meter

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

2016

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
7802 South L St, Tacoma	333	8.7	5.9	5.8	6.7	6.7	30.0	60.7
15th S & Charlestown, Beacon Hill, Seattle	118	5.2	5.6	5.9	4.7	5.4	11.8	14.6

Notes:

(1) Sampling occurs for a 24 hour period from midnight to midnight.
Quarterly averages are shown only if 75 percent or more of the data is available.

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

(3) Data from primary sampler at site

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
7802 South L St, Tacoma	303	29	0	1
15th S & Charlestown, Beacon Hill, Seattle	116	2	0	0

PARTICULATE MATTER (PM2.5) – Continuous -TEOM

Micrograms per Cubic Meter

Equivalent Sampling Methods: Mass Transducer R&P TEOM 1400ab-8500 FDMS – Teflon-coated Glass Fiber

2016

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	343	8.9	3.0	2.9	7.6	5.6	31.0	43.2
Marysville JHS, 1605 7th St, Marysville	343	7.8	6.4	5.0	5.5	6.1	22.4	37.7
6120 212th St SW, Lynnwood	365	5.1	3.3	3.1	4.6	4.0	17.7	22.7
10th and Weller, Seattle	318		7.7	8.3	6.3			20.7
Beacon Hill, 15th S and Charlestown, Seattle	363	4.6	5.4	5.7	6.1	5.4	13.6	16.3
Duwamish, 4752 E Marginal Way S, Seattle	366	9.6	5.1	4.9	6.5	6.5	18.1	30.3
James St & Central Ave, Kent	352	6.2	4.9	5.4	5.6	5.5	18.5	32.9
7802 South L St, Tacoma	357	8.3	5.2	5.6	6.8	6.4	21.0	62.3
Spruce, 3250 Spruce Ave, Bremerton	357	4.4	4.2	4.2	3.9	4.1	9.8	13.9

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 (PM2.5) – Continuous - Nephelometer

Sampling Method: Equivalent – Ecotech Nephelometer Micrograms per Cubic Meter

2016

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	334	8.4		4.1	9.5			36.2
Marysville JHS, 1605 7th St, Marysville	349	6.7	4.3	4.5	5.3	5.1	21.0	32.7
6120 212th St SW, Lynnwood	326		4.0	4.0	4.6			21.9
17171 Bothell Way NE, Lake Forest Park	60							28.3
Duwamish, 4752 E Marginal Way S, Seattle	355	8.5	7.6	8.1	9.0	8.3	19.8	30.5
South Park, 8025 10th Ave S, Seattle *	316	8.6	7.1		8.1			26.9
305 Bellevue Way NE, Bellevue	366	2.4	3.8	3.8	3.8	3.4	7.9	10.8
42404 SE North Bend Way, North Bend	363	5.0	6.7	4.0	2.9	4.6	12.6	16.1
James St & Central Ave, Kent	366	6.5	5.3	5.7	6.2	5.9	16.5	25.2
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	317	7.1		6.3	5.3			34.1
7802 South L St, Tacoma	359	7.5	4.1	4.6	6.1	5.5	20.3	49.3
South Hill, 9616 128th St E, Puyallup	365	5.4	3.9	4.4	5.1	4.7	16.5	24.9
Spruce, 3250 Spruce Ave, Bremerton *	363	4.3	4.2	4.4	4.2	4.2	9.0	12.8
9702 Crescent Valley Dr NW, Gig Harbor	348	5.1	4.7	4.5	4.9	4.8	9.5	11.8
560 Center St, Eatonville *	366	1.5	2.5	3.1	1.6	2.1	6.5	10.1

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 2016
Average Annual Concentrations in Micrograms per Cubic Meter

Parameter
Acceptable Pm2.5 Aqi & Speciation Mass
Aluminum Pm2.5 Lc
Ammonium Ion Pm2.5 Lc
Antimony Pm2.5 Lc
Arsenic Pm2.5 Lc
Barium Pm2.5 Lc
Bromine Pm2.5 Lc
Cadmium Pm2.5 Lc
Calcium Pm2.5 Lc
Cerium Pm2.5 Lc
Cesium Pm2.5 Lc
Chlorine Pm2.5 Lc
Chromium Pm2.5 Lc
Cobalt Pm2.5 Lc
Copper Pm2.5 Lc
Indium Pm2.5 Lc
Iron Pm2.5 Lc
Lead Pm2.5 Lc
Magnesium Pm2.5 Lc
Manganese Pm2.5 Lc
Nickel Pm2.5 Lc
Phosphorus Pm2.5 Lc
Potassium Ion Pm2.5 Lc
Potassium Pm2.5 Lc
Rubidium Pm2.5 Lc
Selenium Pm2.5 Lc
Silicon Pm2.5 Lc
Silver Pm2.5 Lc
Sodium Ion Pm2.5 Lc
Sodium Pm2.5 Lc
Strontium Pm2.5 Lc
Sulfate Pm2.5 Lc
Sulfur Pm2.5 Lc
Tin Pm2.5 Lc
Titanium Pm2.5 Lc
Total Nitrate Pm2.5 Lc
Vanadium Pm2.5 Lc
Zinc Pm2.5 Lc
Zirconium Pm2.5 Lc
Elemental Carbon TOR
Organic Carbon TOR
Total Carbonaceous Mass
Soil
Reconstructed Fine Mass - Urban PM2.5

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

2016

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Marysville JHS, 1605 7th St, Marysville	366	0.7	0.3	0.3	0.5	0.5	3.2
Duwamish, 4401 E Marginal Way S, Seattle	363	1.1	0.5	0.5	1.2	0.8	4.7
James St & Central Ave, Kent	350	0.7	0.4	0.5	0.8	0.6	3.2
7802 South L St, Tacoma	353	0.9	0.2	0.3	0.6	0.5	4.8
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	355	1.3	0.4	0.2	0.5	0.6	4.7
10th and Weller, Seattle	266	- -	1.2	1.3	1.5	- -	4.6

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 are at least 75 percent of each 4 quarterly averages.

OZONE

(parts per million)

2016

Location / Continuous Sampling Period(s)	2016 4 Highest Daily 8-Hour Concentrations		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2014	2015	2016	2014 – 2016
Beacon Hill, 15th S & Charlestown Seattle, WA 1 Jan – 31 Dec	.046	3 May	.044	.048	.046	.046
20050 SE 56th Lake Sammamish State Park, WA 1 May – 30 Sep	.054	13 Aug	.052	.059	.054	.055
42404 SE North Bend Way, North Bend, WA 1 May – 30 Sep	.054	7 May	.060	.061	.054	.058
30525 SE Mud Mountain Road, Enumclaw, WA 1 May – 30 Sep	.061	12 Aug	.067	.074	.061	.067
931 Northern Pacific Rd SE, Yelm, WA 1 May – 30 Sep	.058	26 Aug	.056	.058	.058	.057
Jackson Visitors Center Mt Rainier National Park 1 Jan – 31 Dec	.058	17 Apr	.058	.062	.058	.059

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.

2016 Beacon Hill Air Toxics Statistical Summary for Air Toxics (*units in parts per billion*)

	1,3-Butadiene	Acetaldehyde	Acrolein	Benzene	Carbon Tetrachloride	Chloroform	Dichloromethane	Ethylbenzene	Ethylene Dichloride	Formaldehyde	Tetrachloro ethylene
2016 Count	61	61	60	61	61	61	61	61	61	61	61
ND's (reported as 0)	3	0	0	0	0	0	0	0	7	0	20
Median (ppb)	0.019	0.284	0.209	0.132	0.111	0.023	0.143	0.033	0.016	0.533	0.009
Mean (ppb)	0.026	0.352	0.229	0.146	0.110	0.024	0.213	0.042	0.014	0.533	0.010
95th Percentile (ppb)	0.071	0.764	0.427	0.305	0.131	0.034	0.687	0.104	0.021	1.33	0.025
Max (ppb)	0.094	1.17	0.879	0.549	0.140	0.036	0.819	0.185	0.024	1.78	0.05
# Below MDL	40	0	10	0	0	0	0	7	17	0	49
% Below MDL	66%	0%	17%	0%	0%	0%	0%	11%	28%	0%	80%

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

2016 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})
2016 Count	58	58	61	58
ND's (reported as 0)	0	0	0	0
Median (ng/m^3)	0.466	0.054	39.2	0.680
Mean (ng/m^3)	0.596	0.076	42.7	0.911
95th Percentile (ng/m^3)	1.51	0.217	84.7	2.27
Max ng/m^3)	2.22	0.370	129	3.33
# Below MDL	0	0	0	2
% Below MDL	0%	0%	0%	3%

Estimates of Air Toxics Risk
2016 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. Cancer risk was estimated using unit risk factors from the Washington State Acceptable Source Impact Levels (ASIL).[1] The two sources for the ASIL include EPA's Integrated Risk Information System[2] (IRIS) as well as California EPA's Office of Environmental Health and Hazard Assessment[3] (OEHHA). Both of these sources are based on peer-reviewed literature and extensive review. We present potential cancer risk estimates based on the Washington ASIL values (listed below). 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]

2016 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}	2B
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, June 25, 2008; 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 June 2016; http://monographs.iarc.fr/ENG/Classification/

2016 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	1	35	100%
Benzene	2	28	100%
1,3-Butadiene	3	27	95%
Formaldehyde	4	10	93%
Arsenic (PM10)	5	5	100%
Acetaldehyde	6	4	82%
Chloroform	6	4	74%
Naphthalene	8	3	66%
Dichloromethane	9	2	30%
Ethylene Dichloride	9	2	18%
Cadmium (PM10)	11	1	5%
Ethylbenzene	11	1	8%
Nickel (PM10)	11	1	7%
Tetrachloroethylene	11	1	7%

2016 Non-cancer Reference Concentrations (RfC) and Hazard Indices >1

Air toxic	Non-cancer RfC (*ug*/m^3)	Mean Hazard Index
Acrolein	**0.35**	**1.50**
Formaldehyde	9	0.073
Manganese (PM_{10})	0.09	0.061
Arsenic (PM_{10})	0.015	0.040
Nickel (PM_{10})	0.05	0.018
Carbon Tetrachloride	40	0.017
Benzene	60	0.008
Acetaldehyde	140	0.005
1,3-Butadiene	20	0.003
Tetrachloroethylene	35	0.002
Dichloromethane	400	0.002
Chloroform	300	< 0.001
Beryllium (PM_{10})	0.007	< 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.

2000-2016 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.

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)	-0.751	21.9	0.558	16
Acetaldehyde	True (0)	-0.184	4.57	0.822	16
Arsenic PM10	True (0.039)	-0.062	3.10	0.334	13
Benzene	True (0)	-1.90	42.4	0.801	16
Cadmium PM10	False (0.272)	0.215	-0.685	0.119	12
Carbon Tetrachloride	False (0.301)	0.136	27.6	0.076	16
Chloroform	True (0)	-0.237	6.09	0.825	16
Chromium VI Tsp	True (0.005)	-0.428	9.60	0.754	8
Dichloromethane	False (0.886)	0.015	1.07	0.003	10
Ethylbenzene	False (0.103)	-0.014	0.712	0.297	10
Formaldehyde	True (0.002)	-0.715	13.6	0.517	16
Naphthalene	True (0.037)	-0.115	3.57	0.484	9
Nickel PM10	True (0.016)	-0.051	1.57	0.455	12
Tetrachloroethylene	True (0)	-0.059	1.34	0.764	16

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 µg/m3 as a calendar quarter average) also remain in effect.
(2) The level of the annual NO2 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) O3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.
(4) The previous SO2 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 SO2 standards or is not meeting the requirements of a SIP call under the previous SO2 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 ecy.wa.gov/laws-rules/ecywac.html#air.[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; epa.gov/sab/panels/casacpmpanel.html.