pscleanair.org
Puget Sound Clean Air Agency

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2012

Air Quality
Data Summary

SEPTEMBER 2013

Working Together for Clean Air

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The 2012 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) reports air quality data every year. The purpose is to summarize 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

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. Most days are "Good" AQI days. However, air quality degrades into "moderate" or "unhealthy for sensitive groups" for brief periods.

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 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/airq/aqi.aspx. To find more extensive air quality data, educational materials and discussions of current topics, visit the Agency's website at pscleanair.org/default.aspx. Wind roses, air quality graphing tools and historical data summaries are available at pscleanair.org/airq/reports.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/news/agencynews.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.

The Agency and Ecology continued to monitor the region's air quality in 2012. Over the last two decades, many pollutant levels have declined and air quality has improved.

Elevated fine particle levels pose the greatest air quality challenge in our jurisdiction. Of the six criteria air pollutants monitored in the Puget Sound area, $PM_{2.5}$ is associated with the most serious health effects. Achieving significant reductions in particulate matter is a top priority of the Agency. Exposure

[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.

to $PM_{2.5}$ is linked with respiratory disease, decreased lung function, asthma attacks, heart attacks and premature death. Children, older adults and people with respiratory illnesses are especially at risk. Further, some types of particulate matter are air toxics. For example, exposure to particulate matter from diesel exhaust is associated with increased risk of cancer. Fine particles are also responsible for reducing visibility in the beautiful Puget Sound region.

We have one area that is not in attainment with the EPA's health-based daily fine particle standard of 35 micrograms per cubic meter: the Tacoma-Pierce County nonattainment area, comprised of most of Tacoma and surrounding Pierce County communities. Data in this summary show continued improvement in fine particle levels there.

Monitoring sites in three of four counties (King, Pierce and Snohomish) continued to exceed the Agency's more stringent local $PM_{2.5}$ health goal of 25 micrograms per cubic meter. In 2012, our Kitsap County monitor met the Agency's local $PM_{2.5}$ health goal.

Ozone levels remain a concern in our region. Over the last decade, ozone concentrations have not decreased as significantly as other pollutants. The Enumclaw Mud Mountain monitor has the highest regional ozone concentrations.

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

The Agency's jurisdiction is currently in attainment for carbon monoxide, ozone, lead, sulfur dioxide, and PM_{10}.

The Agency issues burn bans to prevent burning when air inversions trap fine particle pollution emitted from our chimneys. We have two stages of burn bans. Stage 1 prohibits burning from fireplaces and uncertified wood stoves except when the wood-burning device is the only adequate source of heat. Stage 2 prohibits burning in fireplaces, uncertified wood stoves, EPA certified wood stoves, and pellet stoves unless the wood-burning device is the only adequate source of heat.

The Agency issued five burn bans in 2012: Jan 11-14, Jan 27-28, Feb 3-6, Nov 25-28, and Dec 29-Jan 3 2013.

Many of the same emission sources that produce criteria and toxic air pollutants also generate greenhouse gases. The Agency works with public and private partners to reduce greenhouse gases[3]. For more information, see pscleanair.org/programs/climate/default.aspx.

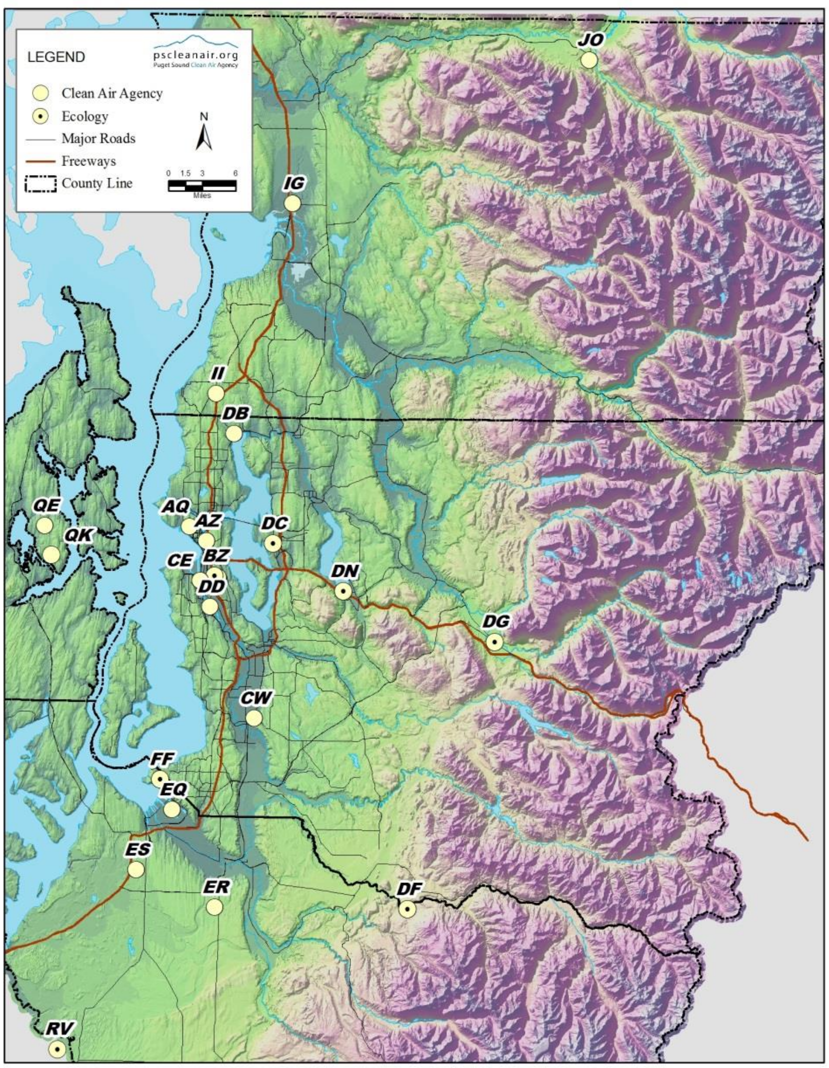
[3] Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; pscleanair.org/programs/climate/rptfin.pdf.

Monitoring Network

The Agency and Ecology operated the Puget Sound region's monitoring network in 2012. 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.

King, Pierce, Snohomish, and Kitsap County monitoring sites used in 2012 are shown in Map 1 and Table 1, Monitoring Network for 2012. A more interactive map is available at http://www.pscleanair.org/airq/network/default.aspx.

Map 1: Active Air Quality Monitoring Station Locations 2012



AQ Seattle Queen Anne
AZ Seattle Olive & Boren
BZ 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
QE Bremerton Meadowdale
QK Bremerton Spruce

Two Ozone sites (FG & FH) located in Mount Rainier National Park are not shown on this map.

Table 1: Air Quality Monitoring Network Parameters 2012

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
AQ	Queen Anne Hill, 400 W Garfield St, Seattle (photo/visibility included)				●						●	●	●		●	a, d, f
AZ	Olive Way & Boren Ave, 1624 Boren Ave, Seattle				●						●	●	●		●	a, d
BW ⦿	Beacon Hill, 4103 Beacon Ave S, Seattle	●	●	●			●	●	●	●		●	●	●		b, d, f
CE	Duwamish, 4401 E Marginal Way S, Seattle		●	●	●	●					●	●	●		●	a, e
CW	James St & Central Ave, Kent			●	●	●					●	●	●		●	b, d
DB	17171 Bothell Way NE, Lake Forest Park				●						●	●			●	b, d, f
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
QE	Meadowdale, 7252 Blackbird Dr NE, Bremerton			●	●						●	●	●		●	b, f
QK	Spruce, 3250 Spruce Ave, Bremerton			●	●						●	●	●		●	b, f

⦿	Station operated by Ecology	SO_2	Sulfur Dioxide
⬣	Indicates parameter currently monitored	NO_y	Nitrogen Oxides
$PM_{2.5}$ ref	Particulate matter <2.5 micrometers (reference)	CO	Carbon Monoxide
$PM_{2.5}$ Spec	Speciation	b_{sp}	Light scattering by atmospheric particles (nephelometer)
$PM_{2.5}$ FEM	Particulate matter <2.5 micrometers (teom-fdms continuous)	Wind	Wind direction and speed
$PM_{2.5}$ ls	Particulate matter <2.5 micrometers (light scattering nephelometer continuous)	Temp	Air temperature (relative humidity also measured at BW)
$PM_{2.5}$ 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)
Location		PHOTO	Visibility (camera)
a	Urban Center		
b	Suburban		
c	Rural		
d	Commercial		
e	Industrial		
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-6 of the Appendix. The network changes periodically because the Agency and Ecology regularly re-evaluate monitoring objectives, resources and logistics.

A list of the methods used for monitoring the criteria pollutants is shown on page A-5 of the Appendix. Additional information on these methods is available at EPA's website at http://www.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 an index for reporting daily air quality. It tells you how clean or polluted your air is and what associated health effects might be a concern for you. The AQI focuses on health effects that you may experience 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.

Think of the AQI as a yardstick that runs from 0 to 500. As the AQI increases, the level of air pollution and the health concern increases. 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. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered unhealthy first for certain sensitive groups of people, then for everyone as AQI values get higher.

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**

GOOD AQI is 0 – 50: Air pollution poses little or no risk.

MODERATE AQI is 51 – 100: Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

UNHEALTHY FOR SENSITIVE GROUPS AQI is 101 – 150: Although the general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. .

UNHEALTHY AQI is 151 – 200: Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.

VERY UNHEALTHY AQI is 201 – 300: This would trigger a health alert signifying that everyone may experience more serious health effects.

HAZARDOUS is AQI greater than 300: This would trigger a health warning of emergency conditions. The entire population is more likely to be affected.

Table 2 shows the AQI breakdown by percentage in each category for 2012. Snohomish County registered the highest daily AQI value of 156 on July 4, which was $PM_{2.5}$. $PM_{2.5}$ normally determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups.

Table 2: AQI Ratings for 2012

County	**AQI Rating (% of year)**				**Highest AQI**
	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	
Snohomish	88%	12%	0%	0%	156
King	86%	13%	1%	0%	116
Pierce	88%	11%	1%	0%	144
Kitsap	97%	3%	0%	0%	68

The Agency participates in a forecasting and a real time AQI reporting website. National information can be found at the Air Now page here: airnow.gov/index.cfm?action=airnow.main. Local information can be found at the Current Air Quality link at our home page here: pscleanair.org/airq/aqi.aspx.

Further, we have tracked how many days each year our data indicated in each AQI category, as summarized by the following charts by county. Most days in the Puget Sound region are in the “Good” category, but the local meteorological conditions, along with polluting sources cause levels to rise into “Moderate” or above.

Figure 1: Number of Days Air Quality Rated As "Good" Per AQI

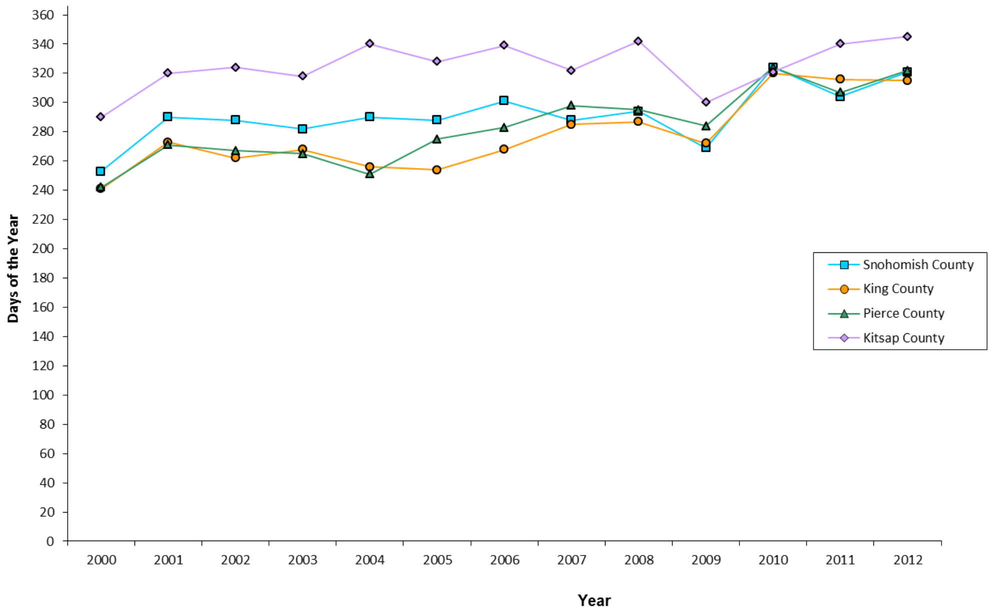


Figure 1 (above) shows the number of days that the AQI fell into the Good category for each of the four counties of our jurisdiction.

Figures 2 through 5 present number of AQI days that were not “good” for King, Kitsap, Pierce, and Snohomish Counties.

Graphs include numbers adjacent to the “unhealthy for sensitive groups” and “unhealthy” lines for clarification of the number of days with these designations.

Pages A-1 through A-4 of the Appendix present summaries for each county.

Summaries include “good”, “moderate”, “unhealthy for sensitive groups”, and “unhealthy” days from 1990 to 2012.

Figure 2: Air Quality for King County

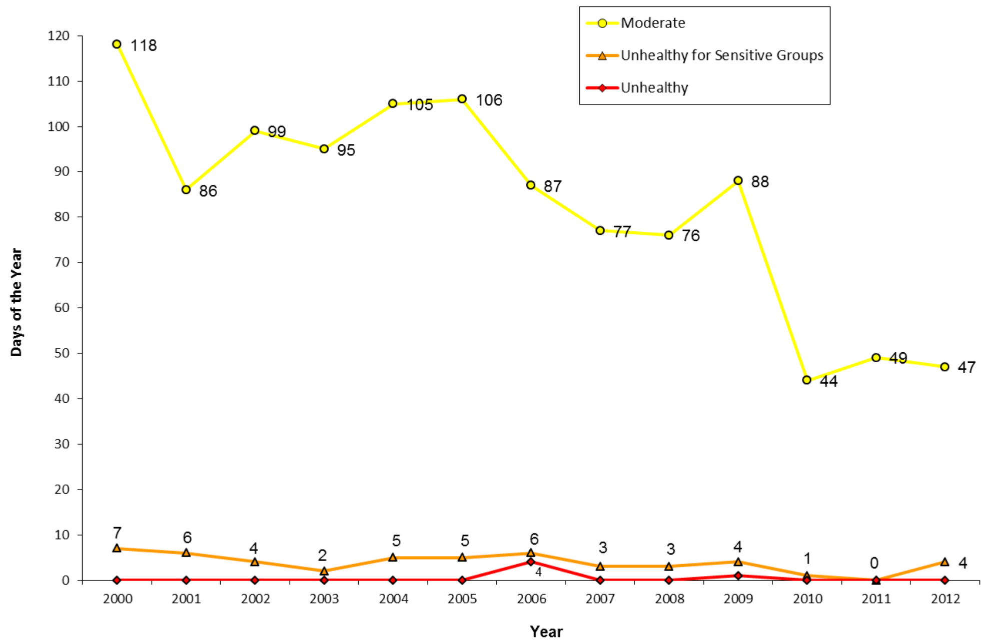


Figure 3: Air Quality for Kitsap County

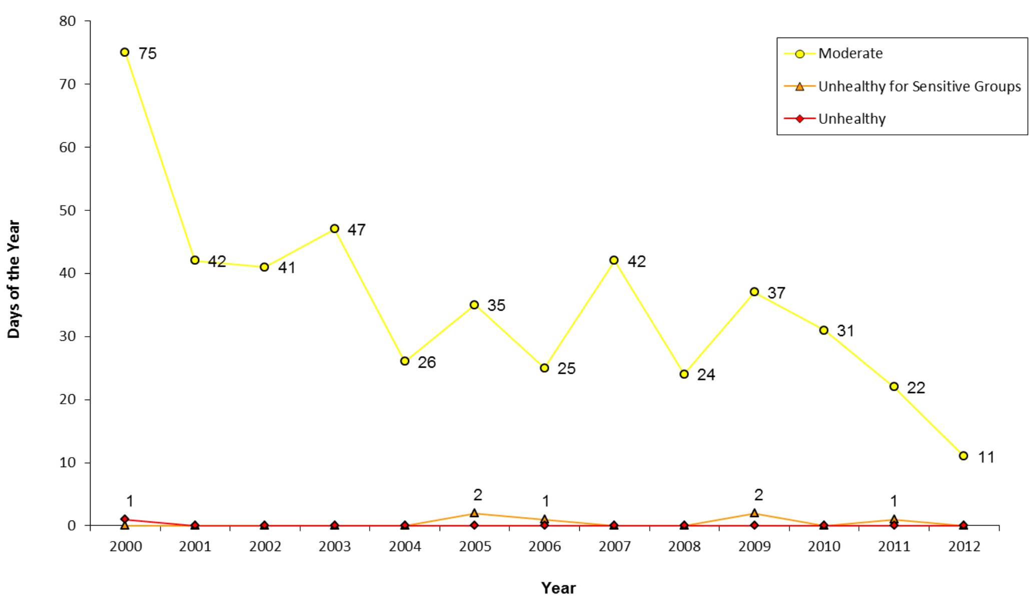
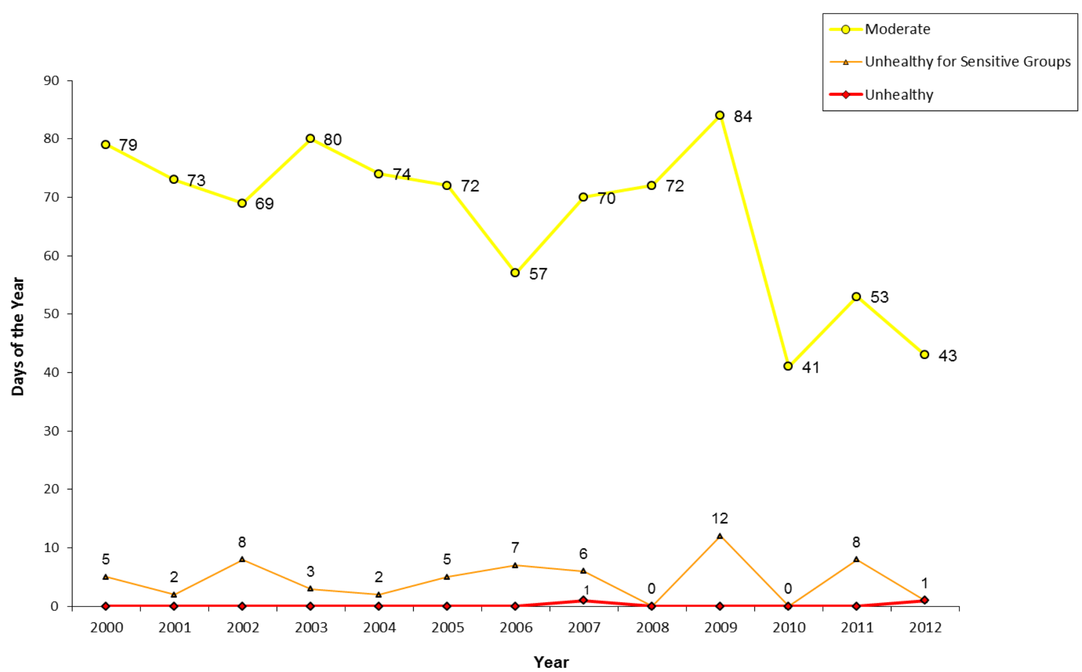


Figure 4: Air Quality for Pierce County

Figure 5: Air Quality for Snohomish County



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.

EPA groups particle pollution into two categories. "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter. "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller.

PM_{10}

The Agency ceased all PM_{10} monitoring in 2006 and focused its efforts on $PM_{2.5}$ monitoring. For a historic look at Puget Sound area PM_{10} levels, please see pages 32-35 of the 2007 data summary at pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

$PM_{2.5}$ Health and Environmental Effects

Scientific evidence shows that exposure to particle pollution is linked to a variety of significant health problems, such as respiratory disease, decreased lung function, asthma attacks, heart attacks, and premature death. People at risk from particle pollution exposure include people with heart or lung disease (including asthma), older adults and children. Particles act as a mode of transportation into the body for other toxic pollutants that adsorb to them. Particle pollution also contributes to haze 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.

PM2.5– Federal Reference Method and Continuous Methods

We measure Fine particulate matter ($PM_{2.5}$) 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 that are equivalent to the reference method. The Agency uses the FRM, the FEM and a Nephelometer estimation method to provide data. These methods determine fine particulate matter concentration differently:

- FRM: This 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.

- FEM: The tapered element oscillating microbalance (TEOM-FDMS) method measures mass and uses a filter dynamic measurement system to eliminate moisture measurements from the sample, allowing the mass to be converted.
- The nephelometer detects particle scattering by flowing a sample into a chamber with a light source. The light source scatters off the particles, and is then amplified by a photomultiplier tube. The system measures the light scattering coefficient compares it to FRM and FEM data to produce an estimate of $PM_{2.5}$. Light scattering correlates well with the FRM and FEM.

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

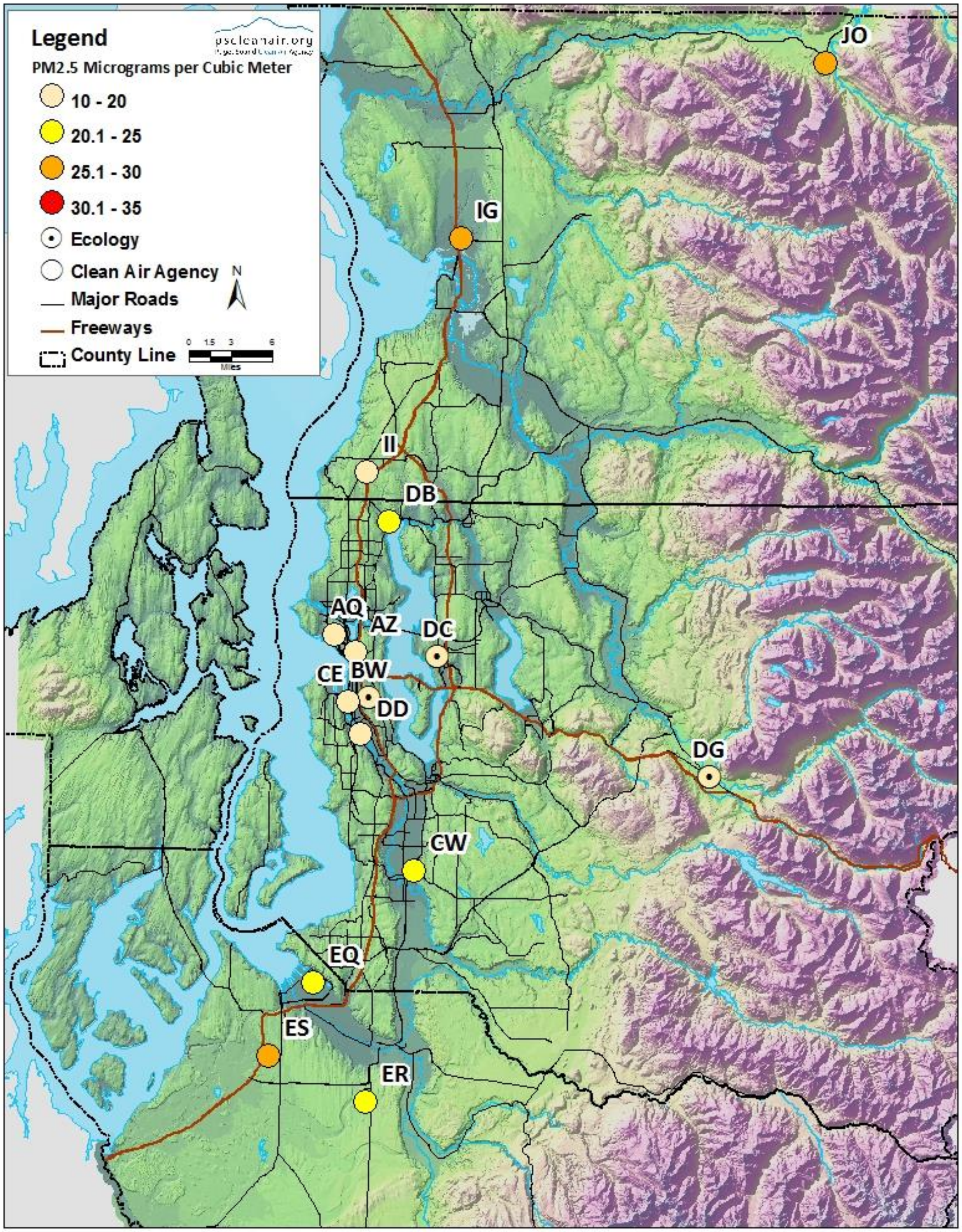
In 2012, EPA maintained its daily health-based standard of 35 micrograms per cubic meter.[4] We are working together with partners to reduce harmful emissions in our Tacoma-Pierce nonattainment area and bring the area into attainment using three main strategies: Enhanced enforcement of burn bans; required removal of older, more polluting uncertified wood stoves; and Implementation of strategies to reduce fine particle emissions from cars, trucks, ships, and industry.

In addition to the federal standard, our Board of Directors adopted a more stringent health goal based on recommendations from the regional Particulate Matter Health Committee. Monitors in King, Pierce and Snohomish counties exceeded the local health goal of 25 $\mu g/m^3$ during the winter season. Our Kitsap County monitor achieved the local health goal.

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 2010 to 2012.

[4] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2012; epa.gov/particles/actions.html.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2012



Figures 6 through 9 show daily 98th percentile 3-year averages at each monitoring station in King, Kitsap, Pierce, and Snohomish Counties compared to the current daily federal standard. Points on the graphs represent averages for three consecutive years. For example, the value for 2012 is the average of the 98th percentile daily concentration for 2010, 2011, and 2012. The FRM measured concentrations for King, Pierce, and Snohomish Counties except where noted.[5] The FEM measured concentrations for Kitsap County.

Figure 7 does not include a three-year average for Kitsap County in 2008-2010, or 2012 because the monitoring site was moved. Kitsap County data shows that PM2.5 levels are below the federal standard.

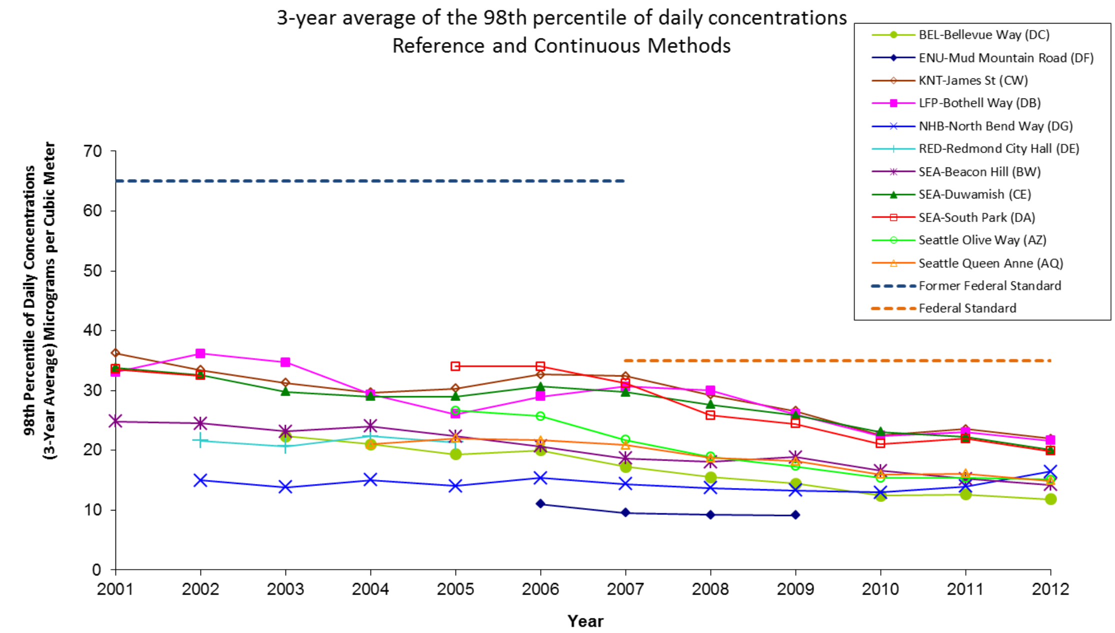
Figure 8 shows that PM2.5 concentrations the Tacoma South L Site (located in the Tacoma South End neighborhood) are below the federal standard of 35 µg/m^3, at 28 µg/m^3.

Figure 9 shows concentrations at the Marysville and Darrington monitors in Snohomish County are at 25 and 26 µg/m^3, respectively.

Statistical summaries for 98th percentile daily concentrations for 2012 data are provided on page A-11 through A-13 of the Appendix.

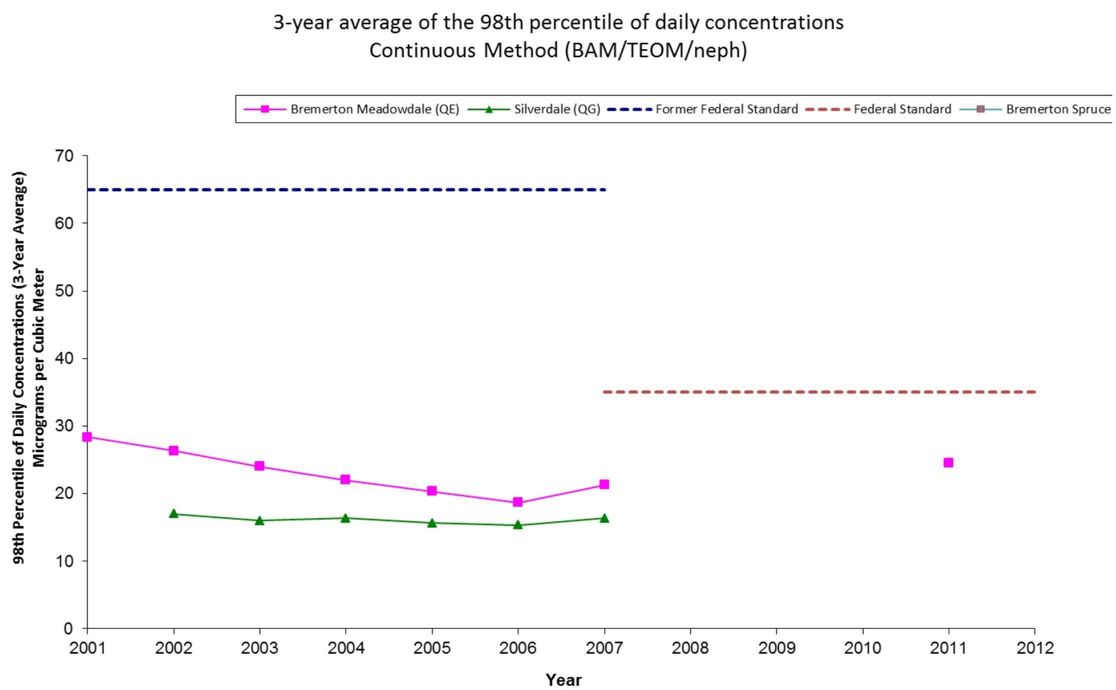
[5] Where possible, nephelometer method data are compared to the reference method values and calculations are made to estimate the PM 2.5. The estimate is used to make the data set “FRM-like”.

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



Note: Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2012. Beacon Hill (BW) data are FRM from 1999-2012. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-12. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2012. 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 2002-2012. Olive Way (AZ) data are neph from 2003-2012. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2012. Kent (CW) data are FRM from 1999-2004, neph in 2005-2010, TEOM-FEM 2011-2012. Enumclaw (DF) data are from neph in 2000-2009.

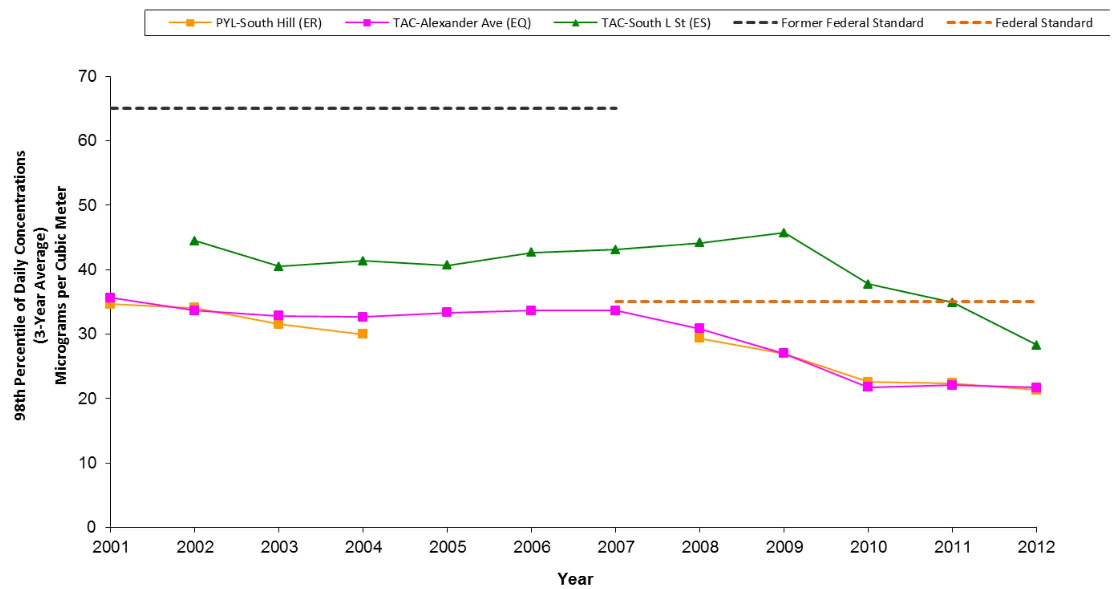
Figure 7: Daily $PM_{2.5}$ for Kitsap County



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

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

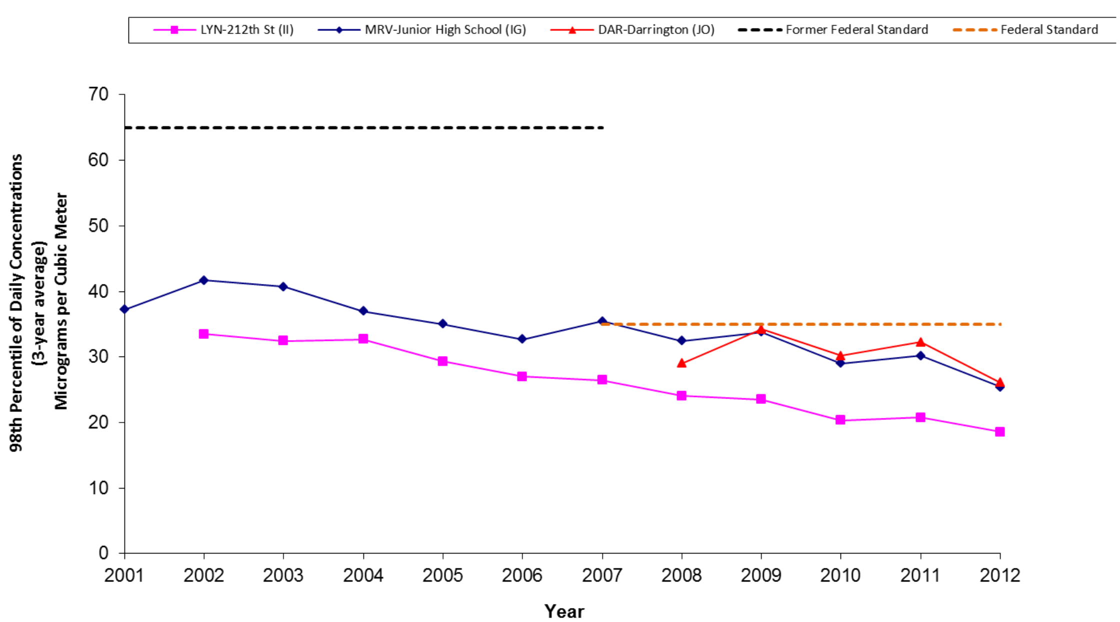
3-year average of the 98th percentile of daily concentrations
Reference and Continuous Methods



Note: All South L data are FRM from 2000- 2012. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2012.
South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004 and 2006-2012; incomplete nephelometer data was collected from South Hill in 2005.

Figure 9: Daily $PM_{2.5}$ for Snohomish County

3-year average of the 98th percentile of daily concentrations
Reference and Continuous Methods



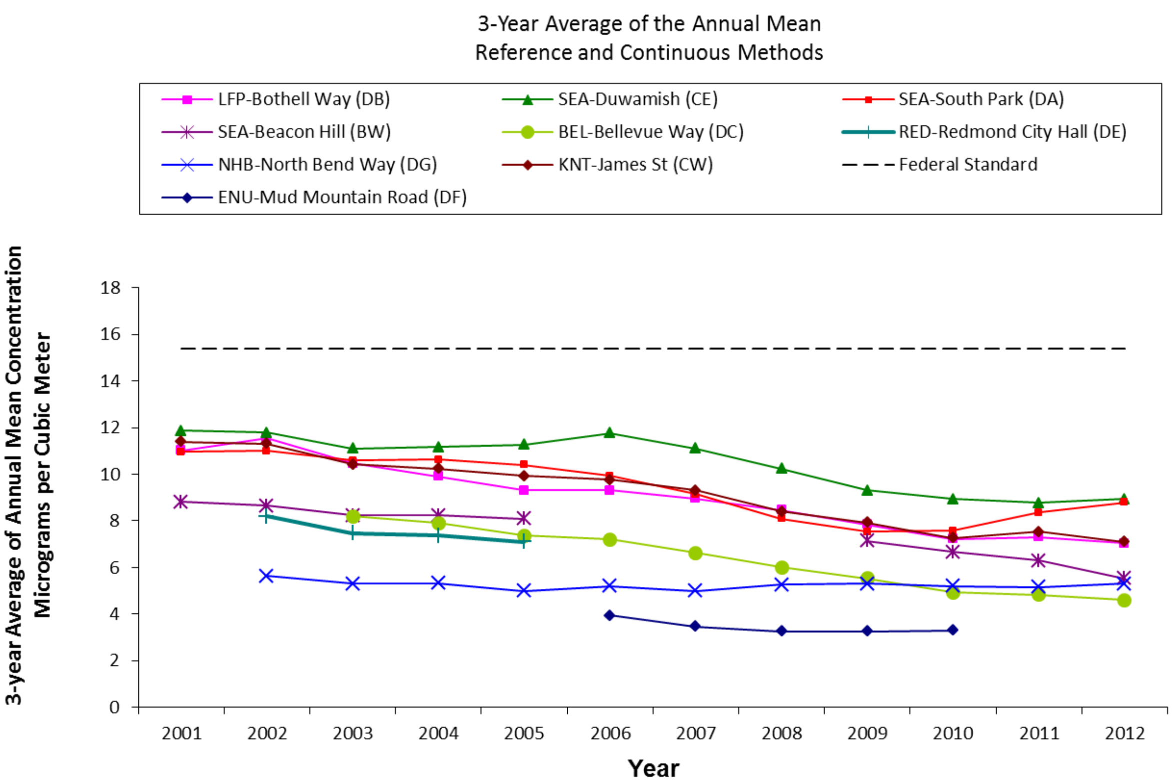
Note: Marysville (IG) data are FRM 999-2011, TEOM-FEM 2012. Lynnwood (II) data are FRM except 2004, 2007-2010 which were nephelometer, TEOM-FEM 2011-2012. Darrington (JO) data are neph in 2006, FRM in 2007-2011, TEOM-FEM 2012.

$PM_{2.5}$ Annual Federal Standard

Figures 10 through 13 show annual averages at each monitoring station for King, Kitsap, Pierce and Snohomish Counties. In late 2012, the EPA strengthened the annual standard from 15 micrograms per cubic meter to 12 micrograms per cubic meter. Monitors in all four counties have levels below the annual standard of 12 micrograms per cubic meter and all counties are in attainment for the annual standard. Figure 11 does not show any 2008, 2009, 2010, or 2012 data for Kitsap County because the monitor did not achieve data completeness criteria or the monitoring site was relocated.

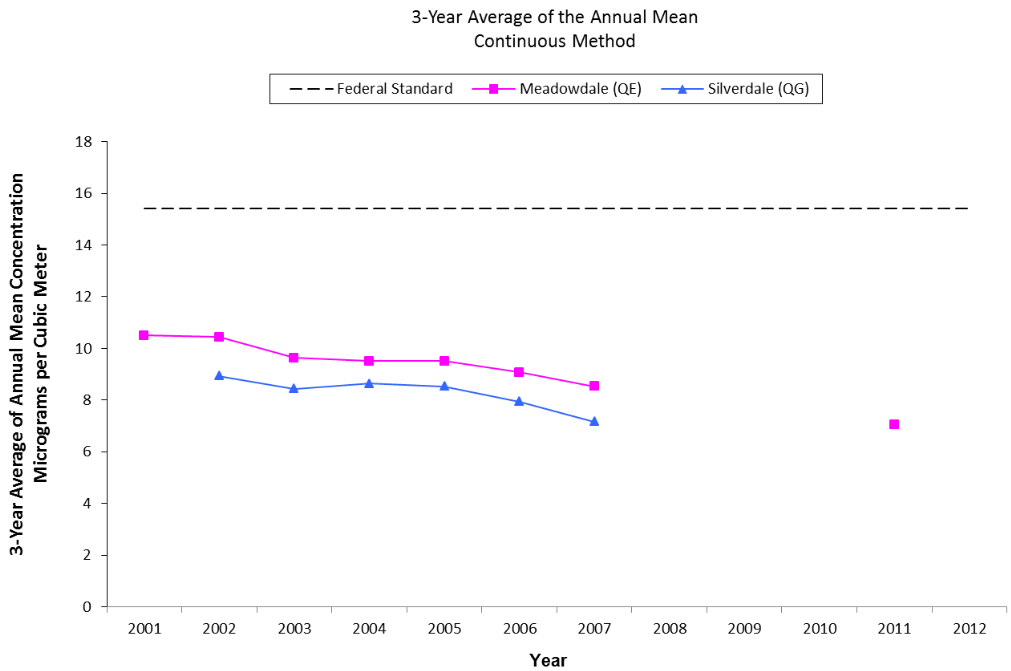
Figures 10 through 13 show data from the federal reference method (FRM) and continuous method monitors. The federal standard is based on a 3-year average, so each value on the graph is an average for three consecutive years. For example, the value shown for 2012 is the average of the annual averages for 2010, 2011, and 2012.

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



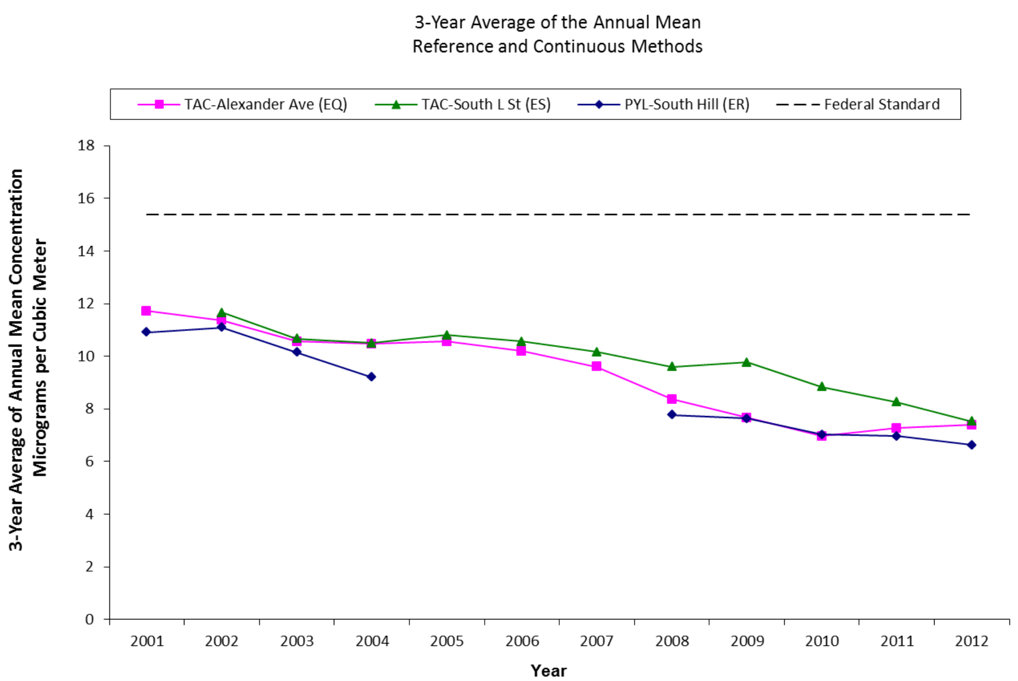
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2012. Beacon Hill (BW) data are FRM from 1999-2012. Duwamish (CE) data are FRM from 1999-2009, nephelometer 2010, TEOM-FEM 2011-2012. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2012. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2012. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2010, TEOM-FEM 2011-2012. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005-2012.

Figure 11: Annual $PM_{2.5}$ for Kitsap County



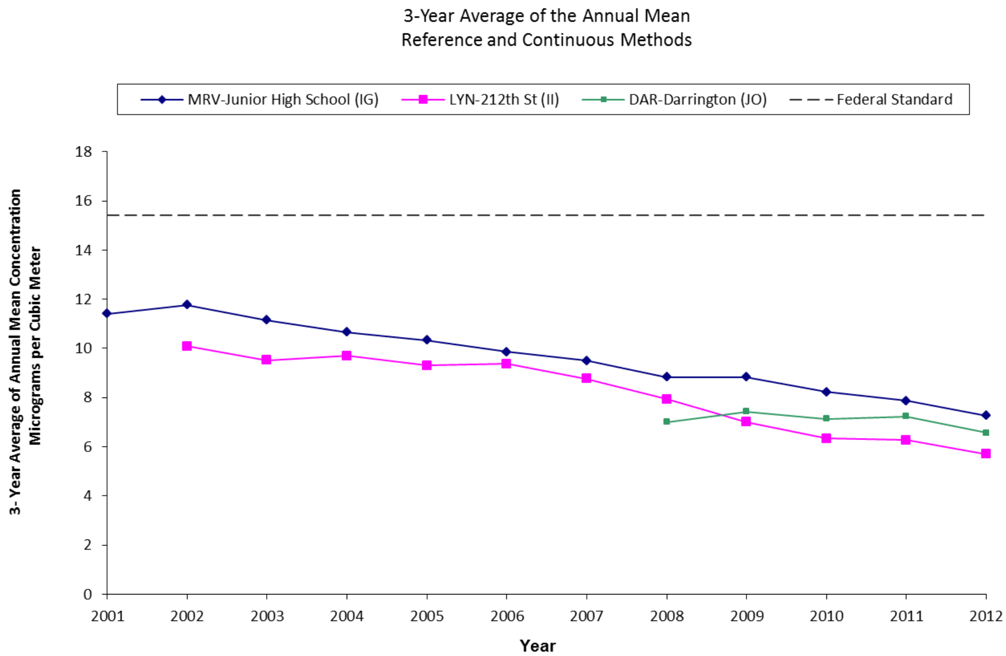
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2010, TEOM-FEM 2011-2012. Insufficient data in 2008 resulted in the inability to calculate a 3 year average for 2008, 2009, 2010.

Figure 12: 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, 2008-2012 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002. Alexander Ave (EQ) data 2003-2010 was measured with a nephelometer.

Figure 13: Annual $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2011, TEOM-FEM 2012. Lynnwood (II) data are FRM except 2004, 2007-2011, TEOM-FEM 2012. 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.

$PM_{2.5}$ 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 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.[6,7,8]

Speciation Monitoring and Source Apportionment

Speciation monitoring involves determining the individual fractions of metals, ions, and organics in fine particulate matter on different types of filters. We collect the filters and send them to the laboratory. The laboratory analyzes the filters to determine the makeup of fine particulate at that site. The laboratory reports over 40 species for each sample. We estimate contributing sources to $PM_{2.5}$ by performing source apportionment models. Source apportionment models use mathematical analysis techniques to estimate how much each source is contributing at each site.

Ecology conducted speciation monitoring at three monitoring sites in the Puget Sound region in 2012:

- 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)
- Marysville – residential area, impacts from wood combustion (speciation samples collected every sixth day, operated by Ecology)

We discontinued two sites in early 2012 (Seattle Duwamish, and Tacoma Tideflats). 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-14.

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

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[6] Puget Sound Air Toxics Evaluation, October 2003; pscleanair.org/airq/basics/psate_final.pdf.

[7] Tacoma and Seattle Air Toxics Evaluation, October 2010: epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf.

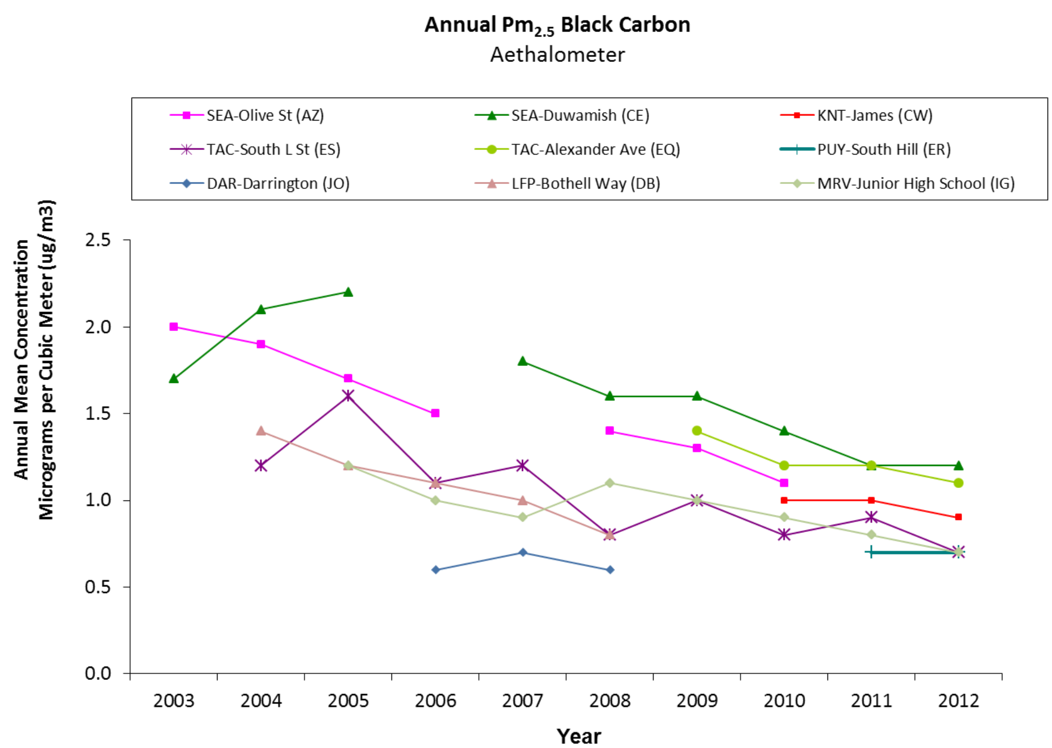
[8] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area". PublicationNumber 10-02-009.

organic carbons make up parts of diesel particulate, wood smoke particulate and particulate from other combustion sources.[9] 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. For more information on aethalometers, refer to our aethalometer monitoring paper at pscleanair.org/airq/Aeth-Final.pdf.

Figure 14 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-15 of the Appendix.

Figure 14: Annual $PM_{2.5}$ Black Carbon



[9] Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area; pscleanair.org/airq/Aeth-Final.pdf.

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 anthropogenic sources such as mobile sources and industrial and commercial solvent use, 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 currently monitors ozone from May through September, as this is the period of concern for elevated ozone levels in the Pacific Northwest.

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.[10] Ozone has also been linked to immune system impairment.[11] 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.[12]

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. 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. Precursors are transported downwind from their source by the time the highest ozone concentrations have formed in the afternoon and early evening. As shown on Map 3, the highest ozone concentrations occur at a monitor southeast of the urban area at the Enumclaw site.

[10] EPA, Air Quality Index: A Guide to Air Quality and Your Health; epa.gov/airnow/aqi_brochure_08-09.pdf.
[11] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ttn/oarpg/naaqsfin/o3health.html.
[12] EPA Health and Environmental Effects of Ground Level Ozone; epa.gov/ttn/oarpg/naaqsfin/o3health.html.

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2012

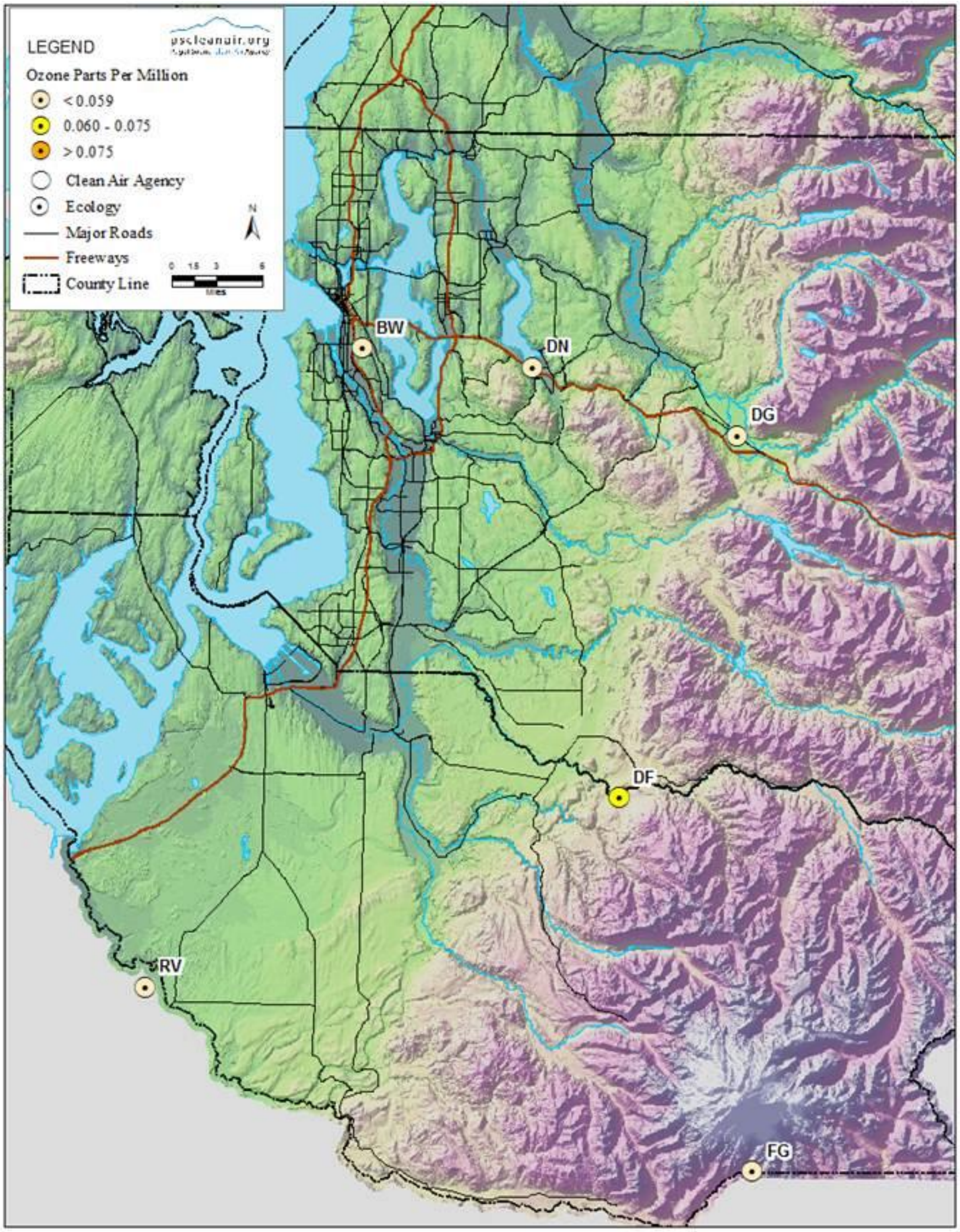


Figure 15 presents data for each monitoring station and the 8-hour federal standard. EPA revised its 8-hour standard from 0.08 parts per million (ppm) to 0.075 ppm in March 2008. The federal standard is based on the 3-year average of the 4th highest 8-hour concentration, called the "design value". The 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 2012 design value is 0.066 ppm, which does not violate the 2008 standard. The highest 2012 8-hour ozone concentration of 0.082 ppm was recorded at the Enumclaw Mud Mountain monitor.

For 2012, the Puget Sound area is in attainment with the 0.075 ppm standard.

Figure 16 presents 8-hour average data for the months of May through September, the months when ozone levels are greatest in the Puget Sound.

Statistical summaries for 8-hour average ozone data are provided on page A-16 of the Appendix.

For additional information on ozone, visit epa.gov/air/ozonepollution.

Figure 15: Ozone for Puget Sound Region

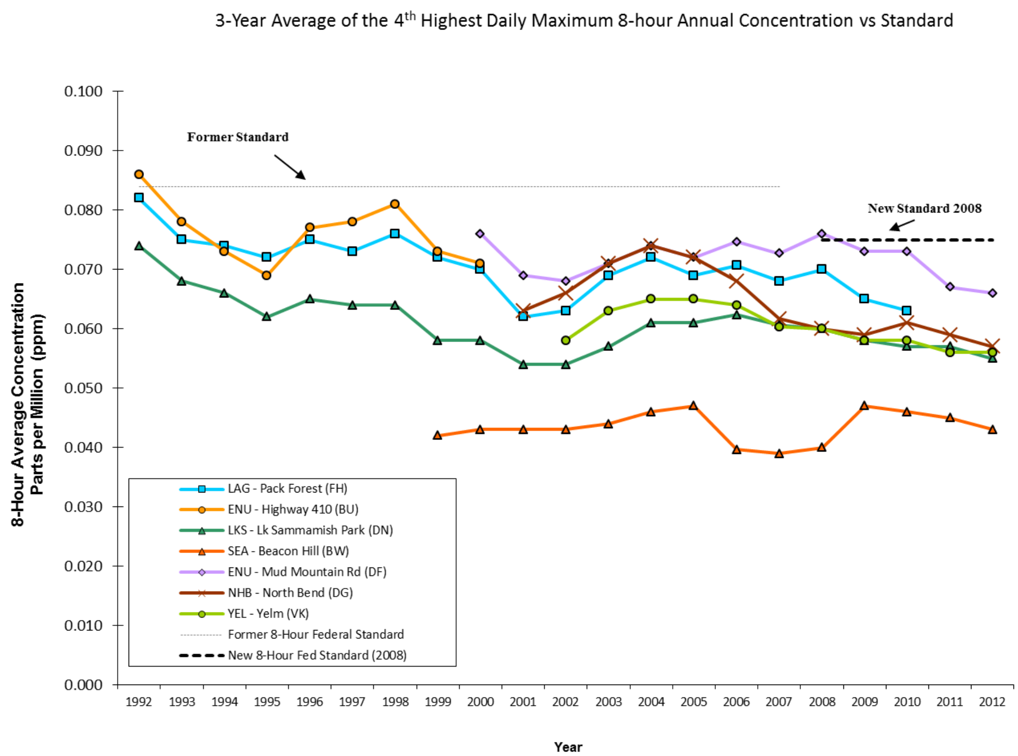
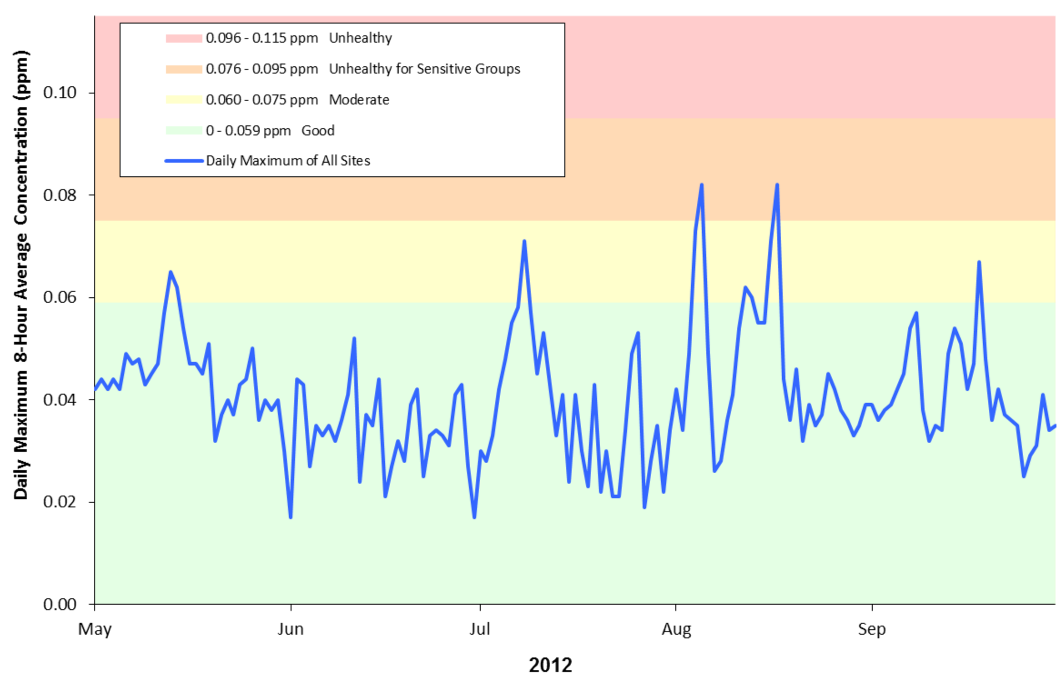


Figure 16: Ozone (O_3) for Puget Sound Region May-September 2012



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.[13] 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 been reduced dramatically since the 1970s.

Ecology maintains one monitoring site for nitrogen dioxide at the Beacon Hill station. In 2007, the monitoring technique and equipment changed to record 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. The additional nitroxyl compounds are generally present in much lower concentrations than NO_2 (or NO_x).

Figure 17 shows NO_2 concentrations 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 annual average for each year has consistently been less than half of the federal standard, as shown in Figure 17 and in the statistical summary on page A-17 of the Appendix.

The maximum 1-hour average of NO_y – NO, measured in 2012, was 0.057 ppm on August 16. Visit epa.gov/air/nitrogenoxides/ for additional information on NO_2.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010.[14] The new 1-hour standard is 100 ppb. The design value is calculated by following the procedures in the Federal Register. EPA retained the current annual health-based standard for nitrogen dioxide of 53 ppb (0.053 ppm). Nitrogen dioxide levels in the Puget Sound region, as currently monitored by Ecology, are typically below (cleaner than) the levels in the new standard. The new standard is depicted in Figure 18 with historical data since 1998. The years prior to 2010 have been included on the graphs for historical comparison; the new air quality standard applies to 2010 and subsequent years.

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[13] EPA, Airnow, NO_X Chief Causes for Concern; epa.gov/air/nitrogenoxides/

[14] EPA. New 1-hour National Ambient Air Quality Standards for Nitrogen Dioxide; epa.gov/air/nitrogenoxides/actions.html#jan10, accessed September, 2010.

Figure 17: Annual Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)

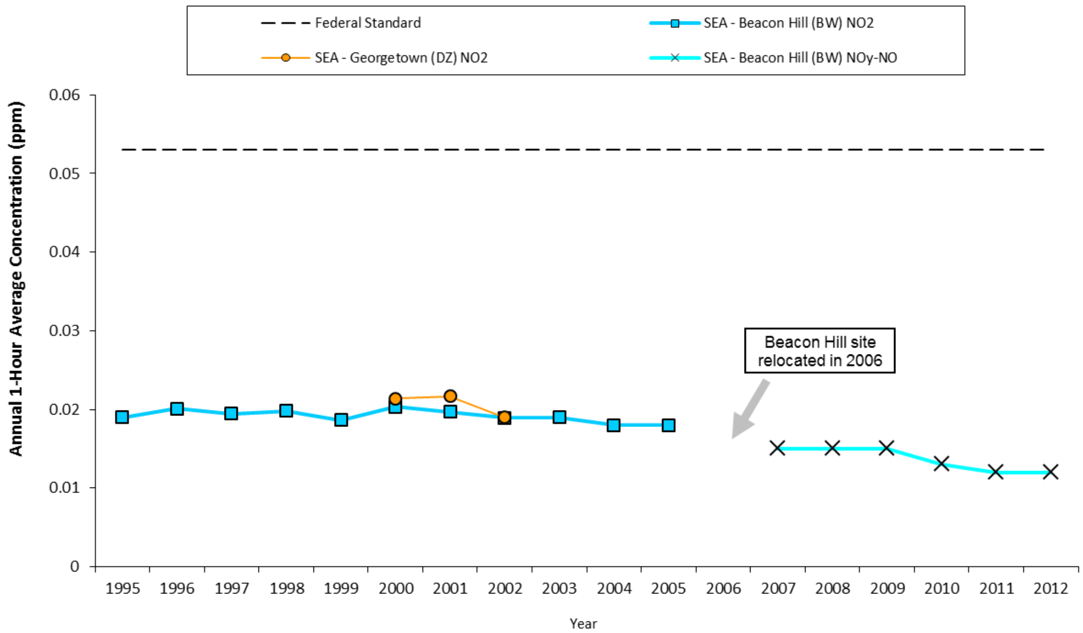
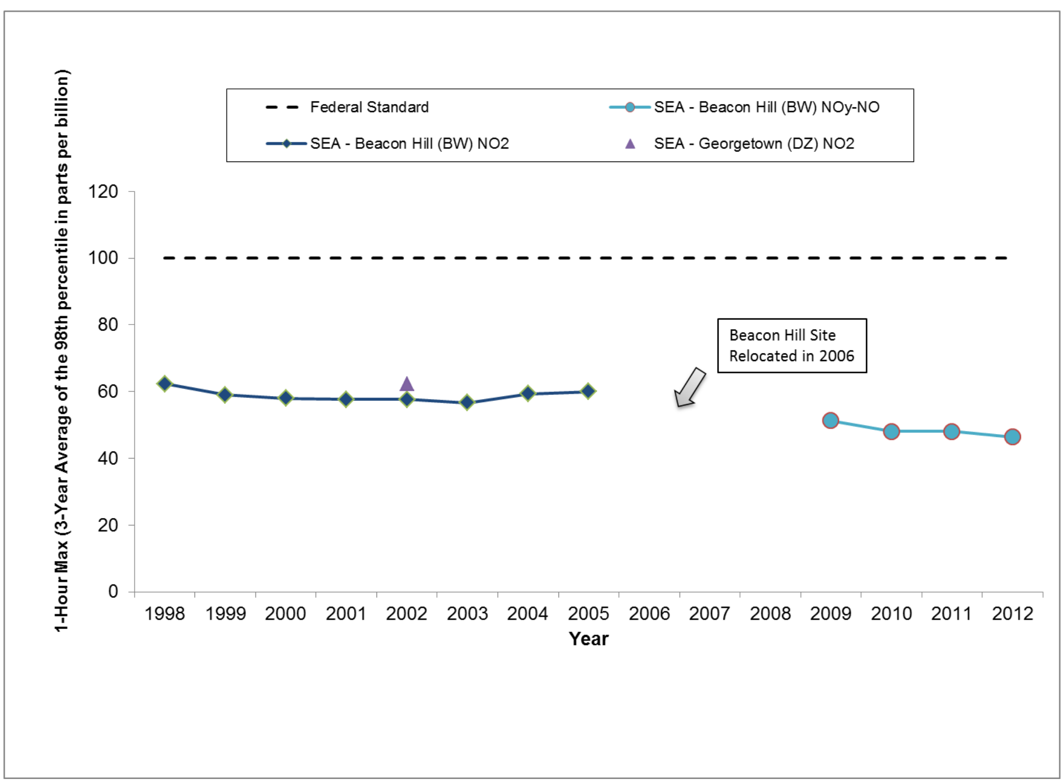


Figure 18: 2010 1-Hour Maximum Standard for Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_y – NO) (2007-Present)



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 operated during 2012.

The CO national ambient air quality standard is based on the 2nd highest 8-hour average. Figure 19 shows the 2nd highest 8-hour concentrations and the federal standard (9 ppm) for the Puget Sound region. There currently are no CO monitoring stations in Kitsap, Pierce, or Snohomish Counties.

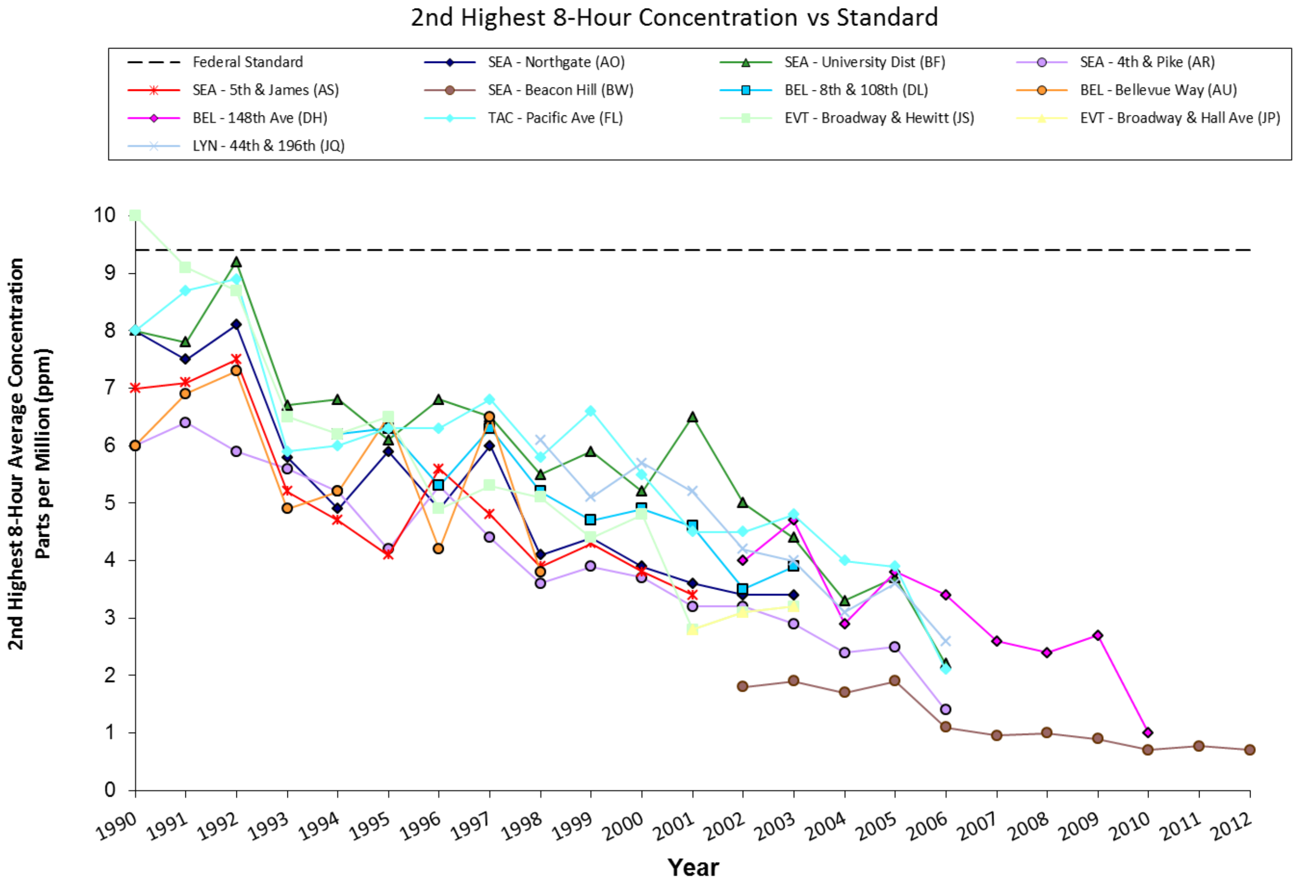
The maximum 8-hour concentration for CO in 2012 was 0.7 parts per million (ppm) and occurred on September 18 at the Seattle Beacon Hill site.

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.

In 2011, EPA completed an ambient standard review for carbon monoxide, and left the level of the health-based standards unchanged.

Statistical summaries for 8-hour average CO data are provided on page A-18 of the Appendix. For additional information on CO, visit epa.gov/air/urbanair/co/index.html.

Figure 19: Carbon Monoxide (CO): 2nd Highest Annual 8-hour Value for Puget Sound Region



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. Additionally, levels of sulfur in diesel and gasoline fuels have decreased due to EPA regulations. The Puget Sound Clean Air Agency stopped monitoring for SO_2 in 1999 because of these decreases. We monitored SO_2 at locations near industrial areas. Ecology monitored SO_2 at the Beacon Hill site from 2000-2005. In 2006, the SO_2 monitor was relocated to a different location on the same property. The monitor was not operating most of 2006 so no data are reported for that year.

EPA changed the SO_2 standard in June of 2010 to a more short-term (1-hour) standard and revoked the annual and daily average standards. Historic comparisons to federal and Washington State standards can be seen in our 2009 data summary at pscleanair.org/news/library/reports/2009_AQDS_Report.pdf.

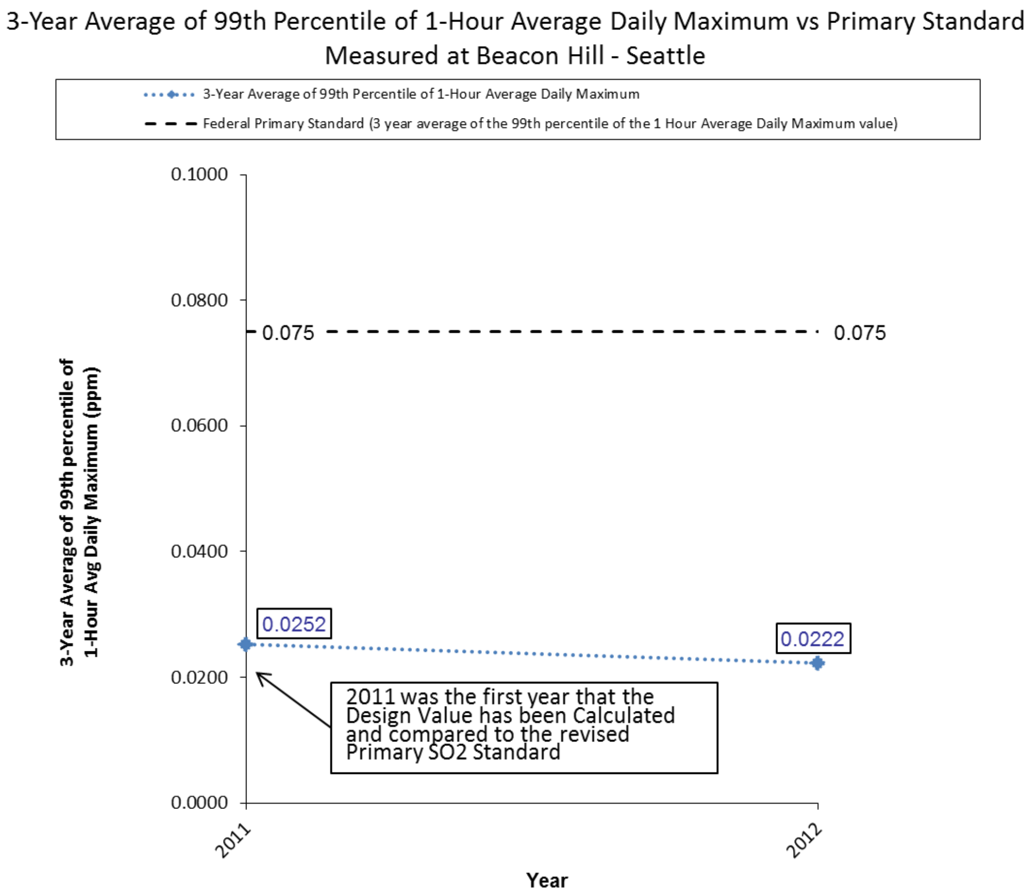
The new standard is a 3-year average of the 99th percentile of the daily 1-hour maximum concentrations. Levels must be below 0.075 ppm. Demonstration of attainment is determined from the 2008-2010 data. The Seattle Beacon Hill site is below the new standard.

Figure 20 shows the maximum 3-year average of the 99th percentile of 1-hour maximum concentrations at Beacon Hill. The maximum measured SO_2 concentrations in 2012 were below standards.

Statistical summaries for SO_2 data from the Beacon Hill site are available on page A-19 of the Appendix.

Additional information on SO_2 is available at epa.gov/air/sulfurdioxide/.

Figure 20: 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.

According to EPA, the primary sources of lead exposure are lead-based paint, lead-contaminated dust and lead-contaminated residual soils. See the EPA website at epa.gov/ttnatw01/hlthef/lead.html for ways to limit your exposure to these lead sources.

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 located at pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

In October 2008, EPA strengthened the lead standard from 1.5 µg/m^3 to 0.15 µg/m^3 (rolling three-month average).[15] 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. For additional information on lead, visit epa.gov/air/lead.

Washington Department of Ecology conducted monitoring of lead at two airports as part of a national EPA study. Results of the study are available from Ecology.

[15] US EPA, National Ambient Air Quality Standard for Lead, Final Rule. Federal Register, November 12, 2008; epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf.

Visibility

Visibility data is an indicator of air quality. We quantify visibility 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. We estimate visual range with nephelometer instruments using light-scattering measurements and then calculating estimated visual range 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 21 through 25 show the visibility for the overall Puget Sound area, as well as King, Kitsap, Pierce and Snohomish Counties. The nephelometer measures the light scattering coefficient (b_{sp}). We calculate the visual range estimate (in miles) by using the light scattering coefficient. Page A-13 of the Appendix shows nephelometer data.

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 22-year period from December 1990 through December 2012, the 12-month moving average increased from 47 miles to 83 miles.

For additional information on visibility, visit epa.gov/air/visibility/index.html.

Figure 21: Puget Sound Visibility

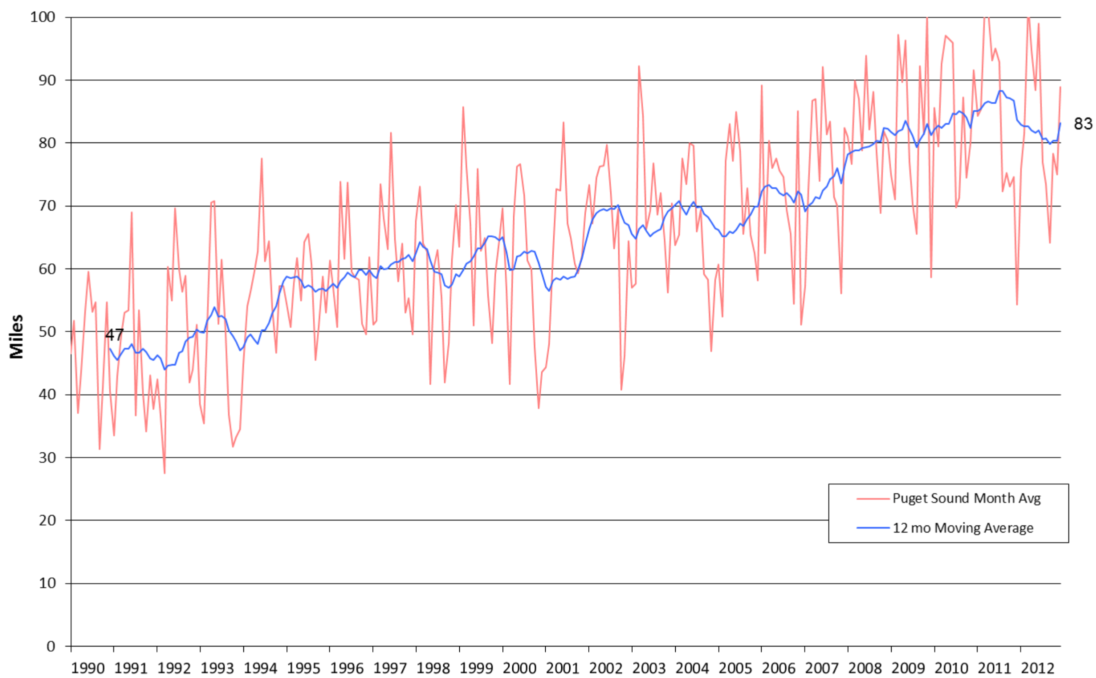


Figure 22: King County Visibility

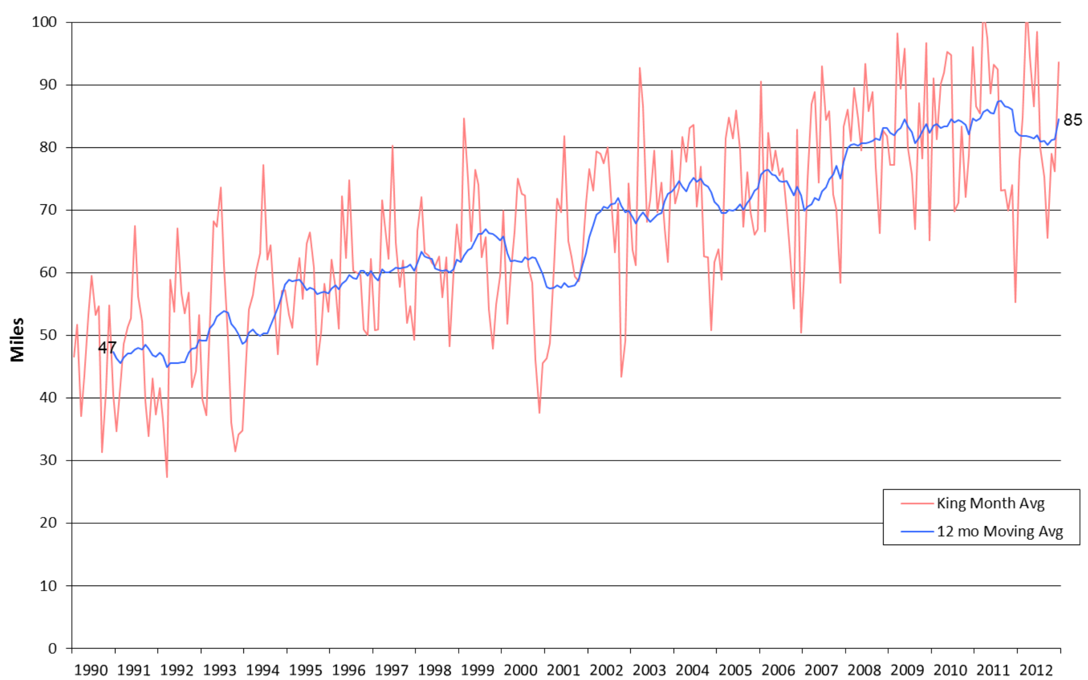


Figure 23: Kitsap County Visibility

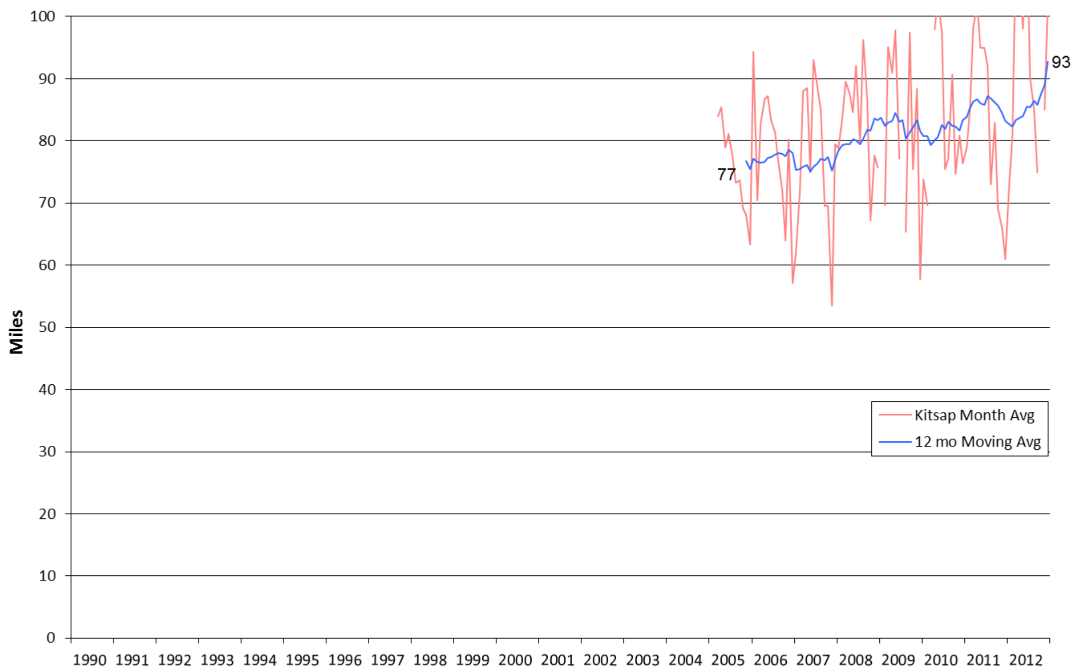


Figure 24: Pierce County Visibility

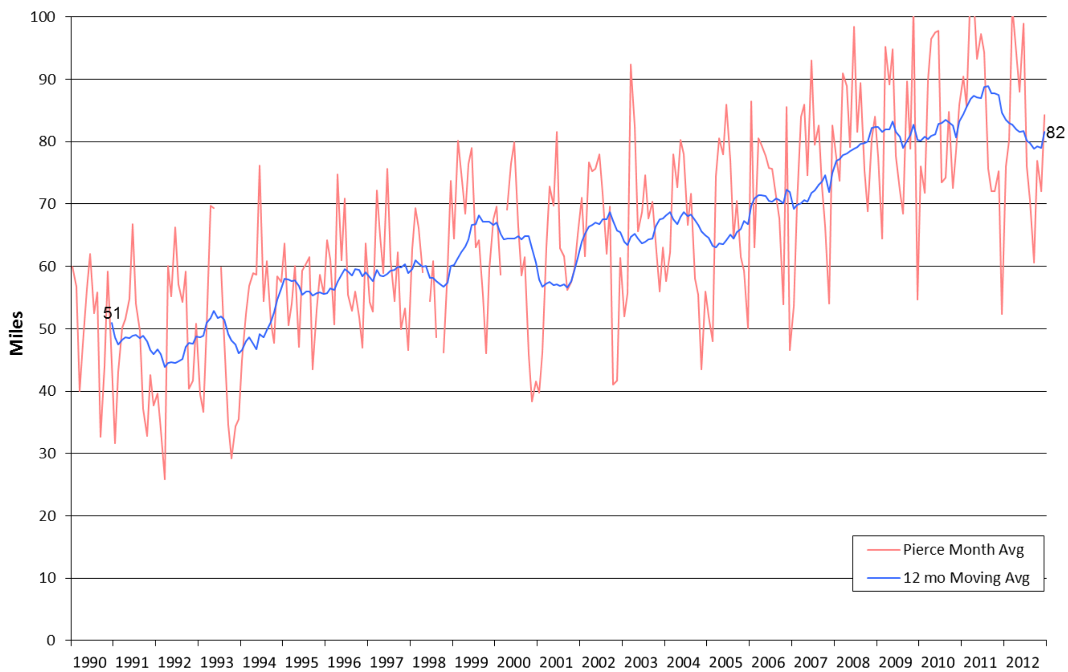
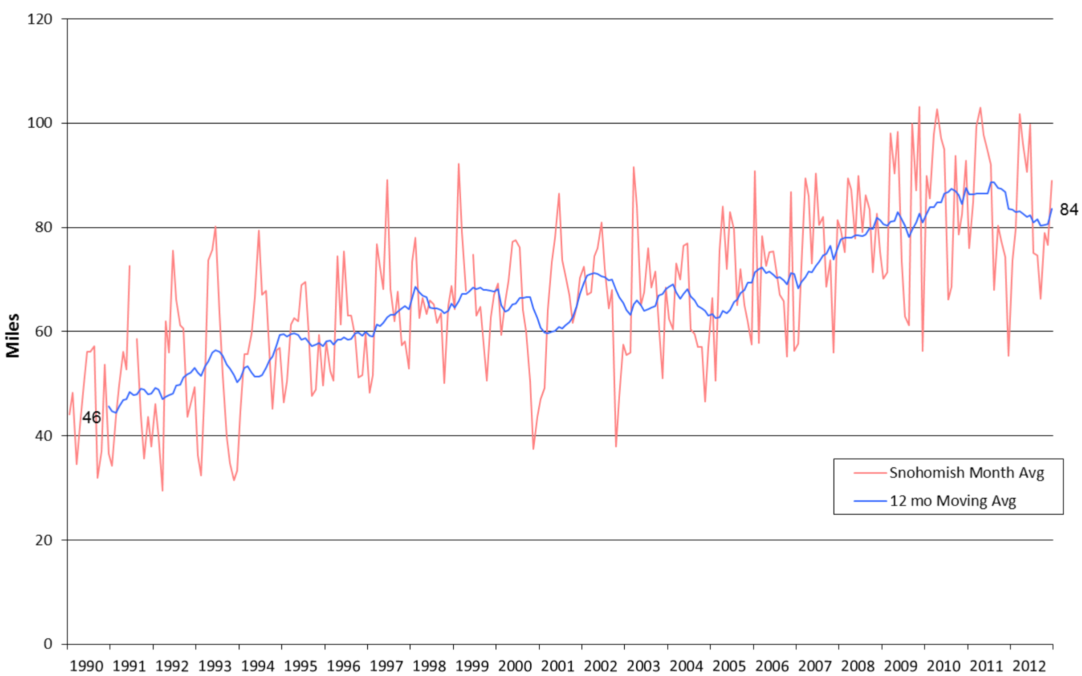


Figure 25: Snohomish County Visibility



Air Toxics

Air toxics are broadly defined as over 400 pollutants that the Agency considers potentially harmful to human health and the environment. Washington State Department of Ecology (Ecology) monitored for air toxics in 2012 at the Seattle Beacon Hill site. The Beacon Hill site is part of an EPA-sponsored network of National Air Toxic Trends Sites. As in previous years, Ecology monitored toxics every six days. This section presents a relative ranking of these toxics based on potential cancer health risks, as well as annual average graphs. Data for 2006 do not appear on these graphs because the 2006 dataset is incomplete due to relocation of the Beacon Hill site that year. We provide a short description of health effects associated with each air toxic and their sources.

From November 2008 to October 2009, we sampled for air toxics at four additional sites in Seattle and Tacoma as part of an EPA-funded air toxics study. For more details, see our report at pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

For general information on air toxics, see pscleanair.org/airq/basics/airtoxics.aspx. Air toxics statistical summaries are provided on page A-20 of the Appendix.

Relative Ranking Based on Cancer Risk & Unit Risk Factors

Table 3 ranks 2012 air toxics from the Beacon Hill monitoring site according to mean potential cancer risk per million. It shows monitored pollutants ranked from highest concern/risk (#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 estimates can be interpreted as 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.[16]

For details on how air toxics were ranked, please see pages A-21 and A-22 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-22 of the Appendix. Page A-22 also lists the frequency (percentage) of samples that were over the cancer screening level of one-in-a-million risk.

[16] US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; epa.gov/region4/air/airtoxic/Screening_111610_KMEL.pdf

Table 3: 2012 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk*
Carbon Tetrachloride	1	29
Benzene	2	17
1,3-Butadiene	3	14
Chromium VI (TSP) M	4	5
Formaldehyde	5	3
Chloroform	6	3
Arsenic (PM_{10}) M	7	2
Acetaldehyde	8	2
Ethylene Dichloride	9	2
Nickel (PM_{10}) M	10	1
Dichloromethane	11	1
Ethylbenzene	12	1
Tetrachloroethylene	13	1
Cadmium (PM_{10}) M	14	< 1

*Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)[17]

M = metal

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.

[17] 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.[18] Reference concentrations and hazard indices are shown for each air toxic on page A-23 of the Appendix. A hazard index is the concentration of a pollutant (either mean or other statistic) divided by the reference concentration. Acrolein's mean 2012 hazard index was 2.0. 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 Graphs

Annual average concentrations are shown on the following pages for air toxics collected from 2000 to 2012 at Beacon Hill. While this report does not statistically investigate trends, a precursory look at most data show that annual average concentrations have typically decreased from 2000 to 2012. We do not present graphs for air toxics metals because few exceed potential cancer risk screening levels. EPA has not set ambient air standards for air toxics, so graphs do not include reference lines for federal standards.

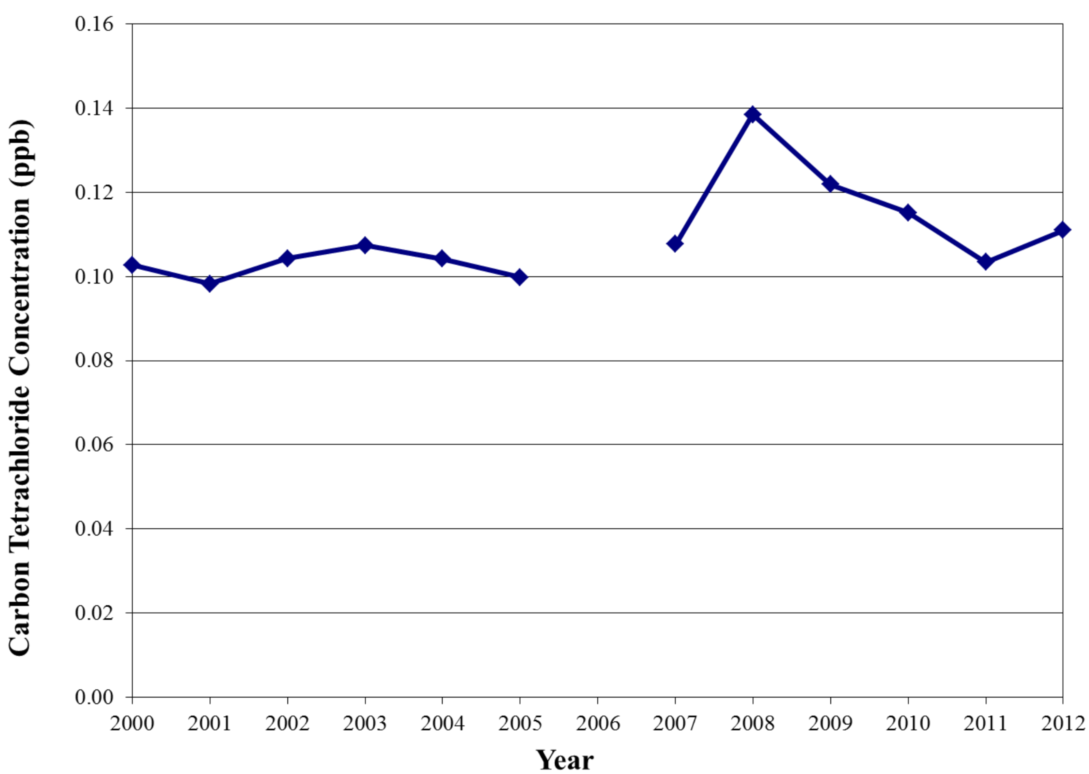
[18]EPA, Acrolein Hazard Summary; epa.gov/ttn/atw/hlthef/acrolein.html.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[19] 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 2012 average potential cancer risk range estimate at Beacon Hill was 29 in a million.

The Agency does not target efforts at reducing carbon tetrachloride emissions, as carbon tetrachloride has been banned already.

Figure 26: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2012



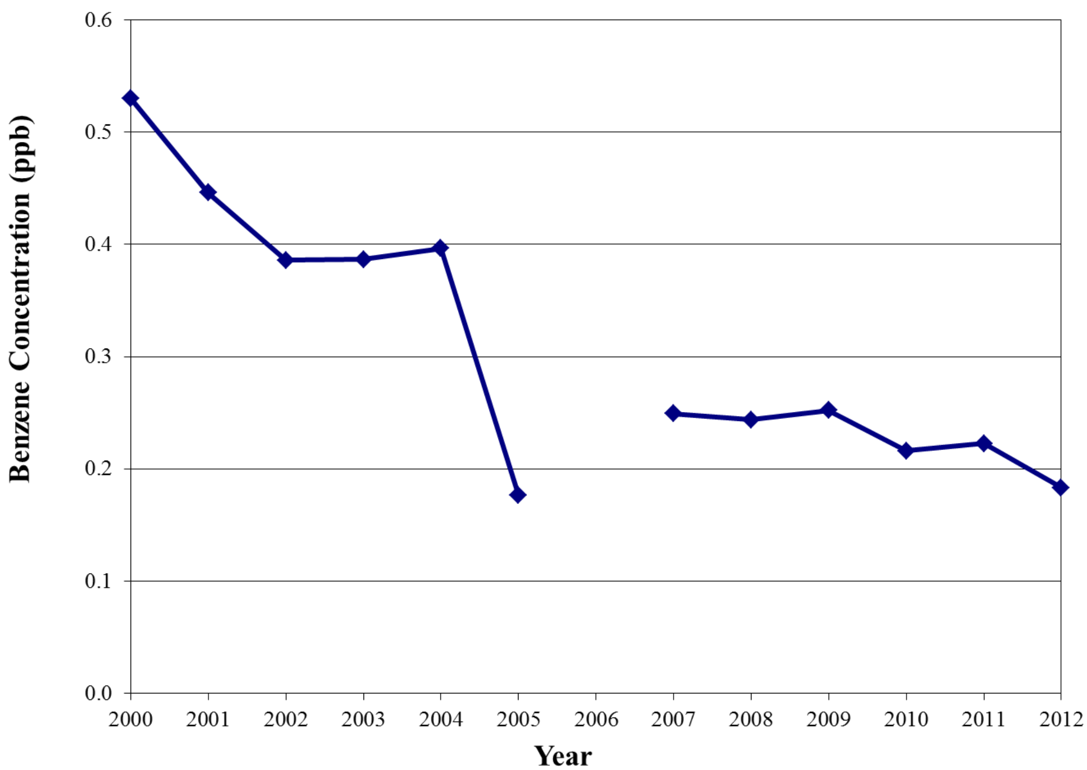
[19]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/carbonte.html.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune and nervous system disorders.[20] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvent and other combustion. Benzene's 2012 average potential cancer risk range estimate at Beacon Hill was 17 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).

Figure 27: Benzene Annual Average Concentrations at Beacon Hill, 2000-2012



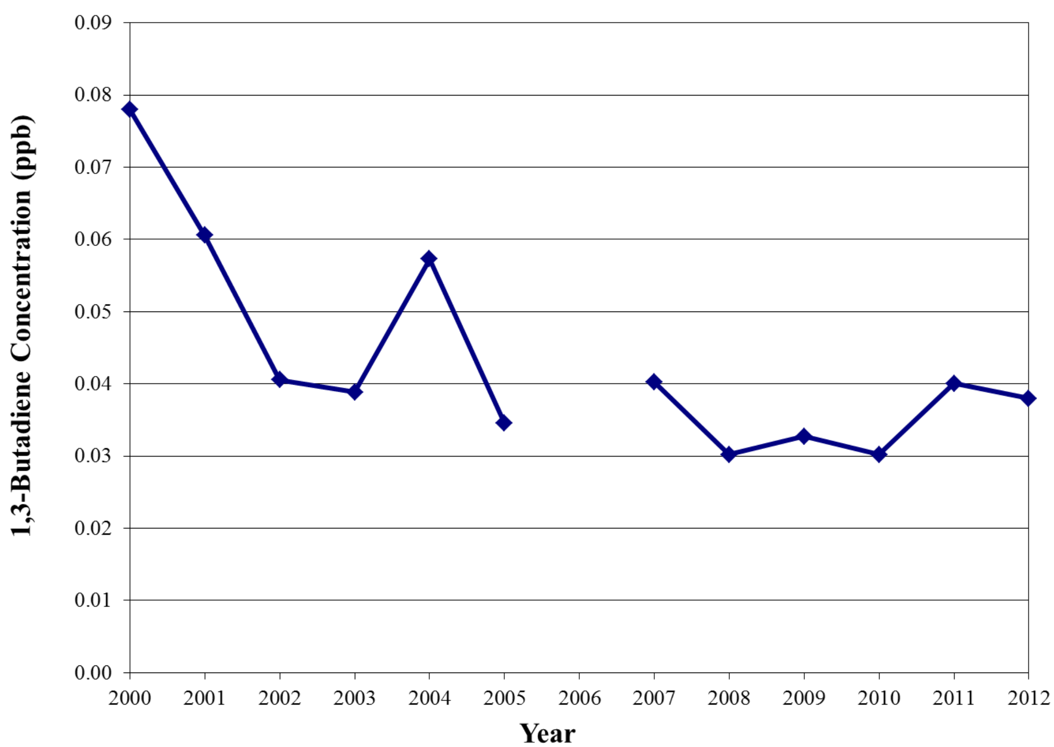
[20] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/benzene.html.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[21] Primary sources of 1,3-butadiene include cars, trucks, buses and wood burning. 1,3-butadiene's 2012 average potential cancer risk estimate at Beacon Hill was 14 in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce 1,3-butadiene emissions.

Figure 28: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2012



[21]EPA Hazard Summary; epa.gov/ttnatw01/hlthef/butadien.html.

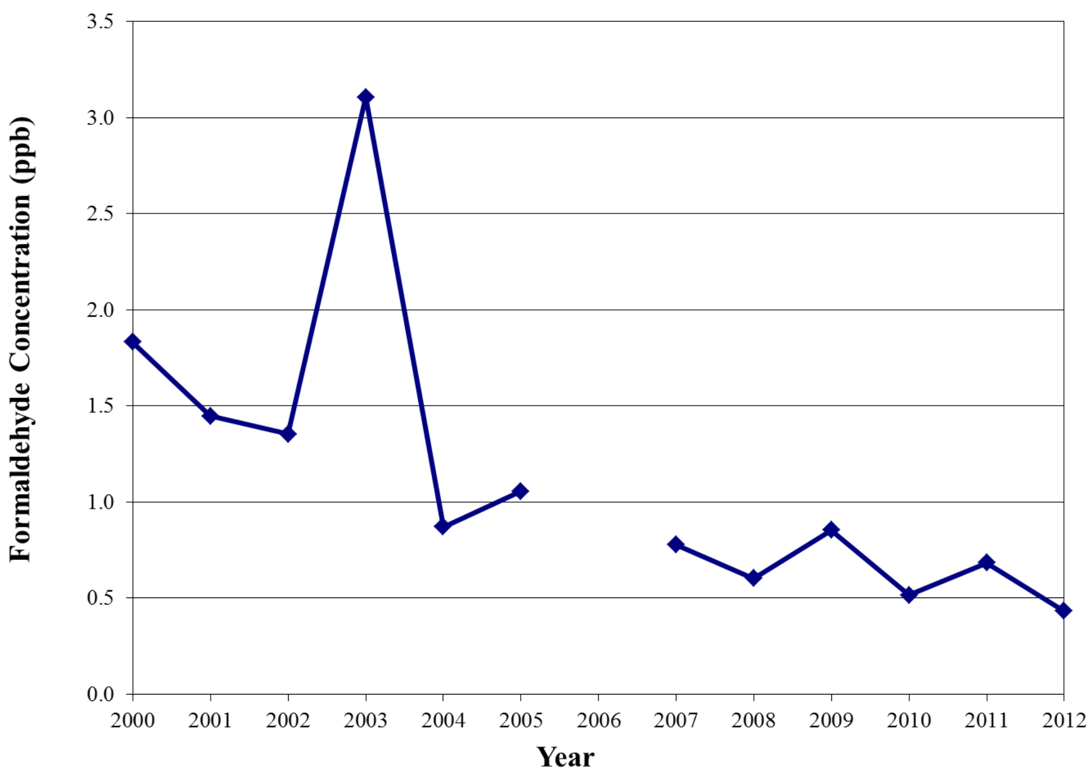
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat and lung irritation.[22] Sources of ambient formaldehyde include automobiles, trucks, wood burning and other combustion. Formaldehyde's 2012 average potential cancer risk range estimate at Beacon Hill was 3 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.

Figure 29: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2012



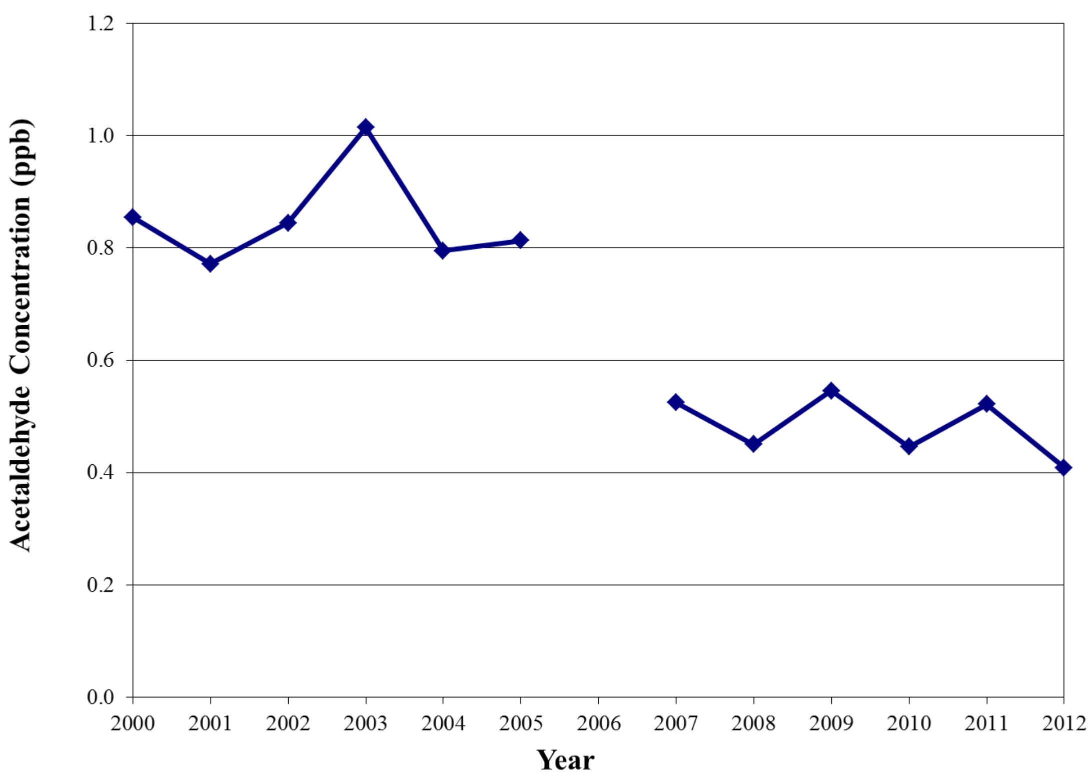
[22]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/formalde.html.

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.[23] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2012 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.

Figure 30: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2012



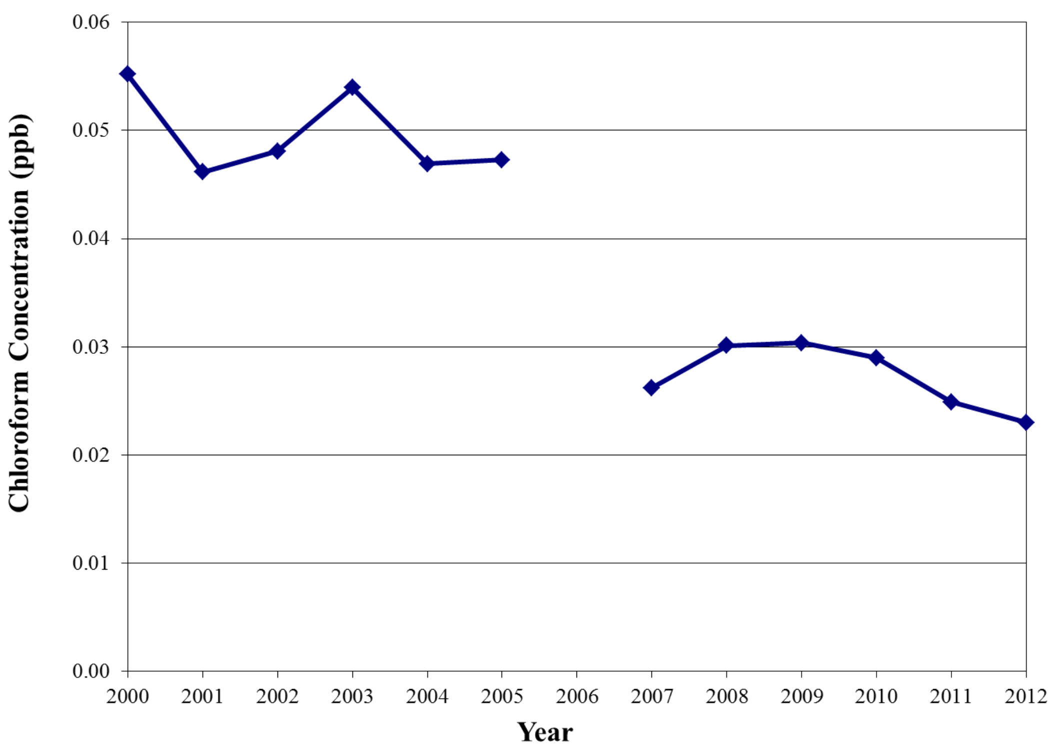
[23]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/acetalde.html.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is associated with central nervous system effects and liver damage.[24] Main sources of chloroform are water treatment plants and reservoirs. 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 2012 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.[25]

Figure 31: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2012

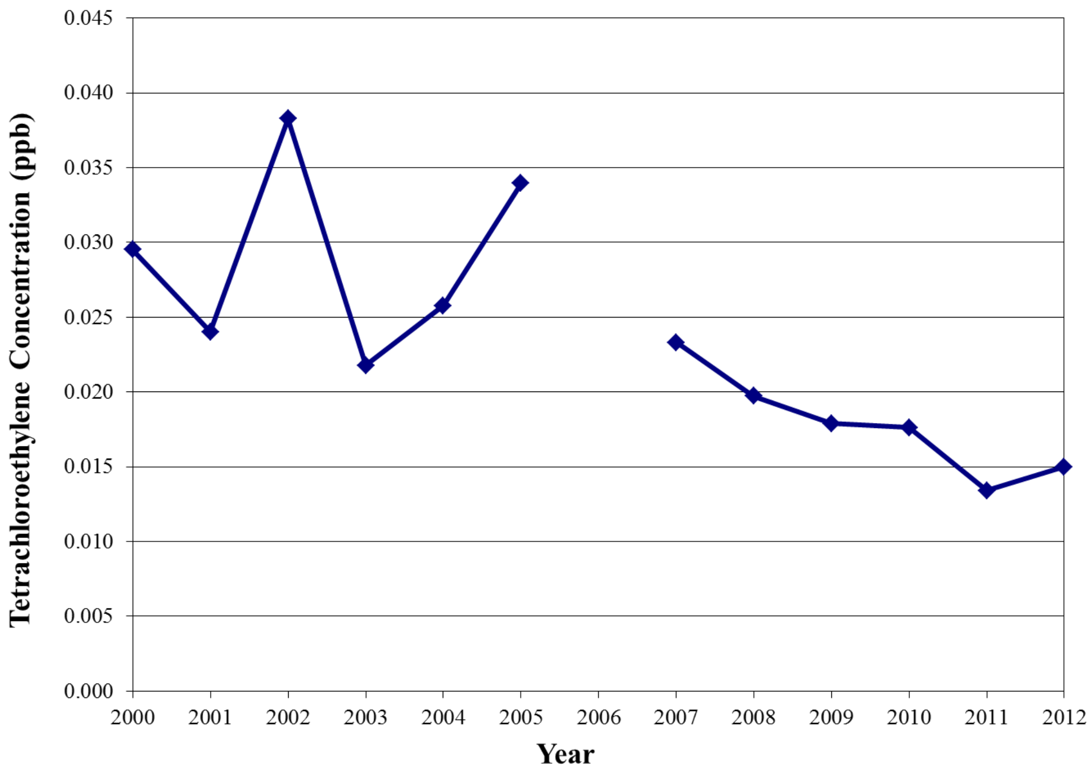


[24]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chlorofo.html.
[25]Seattle Public Utilities. 2011Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/groups/public/@spu/@water/documents/webcontent/02_016357.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform.

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.[26] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2012 average potential cancer risk estimate at Beacon Hill was one-in-a-million.

Figure 32: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2012



[26]EPA Hazard Summary; epa.gov/ttn/atw/hlthef/tet-ethy.html.

Ethylene Dichloride

EPA lists ethylene dichloride as a Group B2 probable human carcinogen. Chronic exposure to ethylene dichloride may affect the liver and kidneys. Ethylene dichloride is often used in the production of chemicals and as a solvent. Ethylene Dichloride's 2012 average potential cancer risk estimate at Beacon Hill was two-in-a-million. The Agency works with and regulates solvent-using businesses to reduce ethylene dichloride emissions.

Ethylbenzene

EPA lists Ethylbenzene as a Group D pollutant, which is not classifiable as to human carcinogenicity due to limited information available.[27] 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 2012 average potential cancer risk estimate at Beacon Hill was one-in-a-million. The Agency works with and regulates solvent-using businesses to reduce Ethylbenzene emissions.

Naphthalene

EPA lists naphthalene as a possible human carcinogen. Naphthalene is similarly associated with respiratory effects and retina damage.[28] Local sources of naphthalene include combustion of wood and heavy fuels. Naphthalene's 2012 average potential cancer risk estimate at Beacon Hill was below one in a million. Since naphthalene is below one-in-a-million cancer risk no graph of estimated potential risk is presented.

The Agency works with and regulates wood burning through burn bans and wood stove replacement programs to reduce naphthalene emissions.

Metals

Table 3 (2012 Beacon Hill Air Toxics Ranking), shown previously in this section, includes estimated potential cancer risks for several PM_{10} metals monitored at Beacon Hill, as well as total suspended particulate (TSP) hexavalent chromium. Hexavalent chromium and arsenic posed the greatest potential cancer risks. Other metals were below non-cancer screening levels (see Appendix page A-23).

Health effects from exposure to these and other monitored metals are listed below, along with local sources.

[27] EPA Hazard Summary: epa.gov/ttn/atw/hlthef/ethylben.html.
[28] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/naphthal.html.

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. Exposure to hexavalent chromium is also associated with adverse respiratory, liver and kidney effects.[29] 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).

In recent years, the monitoring method for total suspended particulate (TSP) hexavalent chromium has improved. The estimated average potential cancer risk range for hexavalent chromium at Beacon Hill was 5 in a million.

The Agency's permitting program works with and regulates industrial chromium plating operations to reduce hexavalent chromium emissions.

Arsenic

EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation and liver and kidney damage.[30] Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2012 average potential cancer risk range estimate at Beacon Hill was 2 in a million.

Nickel

EPA lists nickel as a known human carcinogen. Nickel is also associated with dermatitis and respiratory effects.[31] Combustion of gasoline and diesel fuels (car, truck and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2012 average potential cancer risk estimate at Beacon Hill was one-in-a-million.

Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[32] Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2012 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

Manganese

EPA lists manganese as "not classifiable" for cancer. Manganese exposures are primarily associated with central nervous system effects.[33] Manganese is naturally occurring and is usually present in the air in small amounts. Additional local sources include steel foundries and

[29] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/chromium.html.
[30] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/arsenic.html.
[31] EPA Hazard Summary; epa.gov/iris/subst/0273.htm.
[32] EPA Hazard Summary; epa.gov/ttn/atw/hlthef/cadmium.html.
[33] EPA National Air Toxics Assessment; epa.gov/ttnatw01/hlthef/manganes.html.

blasting of metal parts. 2012 manganese levels in the Puget Sound area are below levels indicating health risk, with a hazard index of less than one.

Definitions

General Definitions

Air Quality Index

Table 4: 2012 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
O_3 (ppm) 8-hour	**O_3 (ppm) 1-hour[(a)]**	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2[(e)] (ppm)	NO_2 (ppm)	AQI value	Category
0.000–0.059	—	0.0–15.4	0–54	0.0–4.4	0.000–0.034	(b)	0–50	Good
0.060–0.075	—	15.5–35.4[(d)]	55–154	4.5–9.4	0.035–0.074	(b)	51–100	Moderate
0.076–0.095	0.125–0.164	35.5–55.4[(d)]	155–254	9.5–12.4	0.075–0.184	(b)	101–150	Unhealthy for sensitive groups
0.096–0.115	0.165–0.204	55.5–150.4	255–354	12.5–15.4	0.185–0.304	(b)	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	0.305–0.804	0.65–1.24	201–300	Very unhealthy
(c)	0.405–0.504	250.5–350.4	425–504	30.5–40.4	0.605–0.804	1.25–1.64	301–400	
(c)	0.505–0.604	350.4–500.4	505–604	40.5–50.4	0.805–1.004	1.65–2.04	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)] NO_2 has no short-term National Ambient Air Quality Standard (NAAQS) and can generate an AQI only above a value of 200.

[(c)] 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.

[(d)] Although EPA changed the $PM_{2.5}$ standard in 2006, EPA has not yet revised the AQI breakpoints to reflect the revised $PM_{2.5}$ daily standard. On January 15, 2009, EPA proposed to change the AQI to be reflective of the levels of the federal standard (that is, the "unhealthy for sensitive groups" category will start at 35.4 $\mu g/m^3$, instead of the current 40.4 $\mu g/m^3$). As a result, we amended the AQI to reflect the proposed change. That is, the AQI for $PM_{2.5}$ in this document may have a slight increase in the number of days in the "unhealthy for sensitive groups" range than in it may have had based on the older definition.

[(e)] 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.

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.

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.