pscleanair.org
Puget Sound Clean Air Agency

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

2009

Air Quality
Data Summary

April 2011

Working Together for Clean Air

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

APPENDIX – DATA TABLES

The 2009 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 Carol Pogers at (206) 689-4080 (1-800-552-3565, ext. 4080).

INTRODUCTION

BACKGROUND

The Puget Sound Clean Air Agency (the agency) has issued an air quality data summary report almost every year for over 30 years. The purpose of this report has been to summarize regional air quality by presenting air monitoring results for six criteria air pollutants. The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards (NAAQS) for these pollutants. These criteria air pollutants are:

- Particulate Matter (particles 10 micrometers and 2.5 micrometers in diameter)
- Ozone
- Nitrogen Dioxide
- Carbon Monoxide
- Sulfur Dioxide
- Lead

Beginning in 2004, the agency added additional information on air toxics to the Air Quality Data Summary. Air toxics are pollutants broadly 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), so there are overlaps between the criteria pollutants and toxics.

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 some pollutants on the Internet at http://www.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 http://www.pscleanair.org/default.aspx. Wind roses, air quality graphing tools, and historical data summaries are available at http://www.pscleanair.org/airq/reports.aspx. To receive the agency's monthly electronic newsletter, Clean Air Newsline, and stay current on air quality issues in King, Kitsap, Pierce, and Snohomish Counties, visit http://www.pscleanair.org/news/agencynews.aspx and select Clean Air Newsline. Subscribers receive the latest on air quality news and updates on projects that affect local communities in the Puget Sound region. The Newsline also provides timely and important messages about burn bans, smog forecasts, and early calls to action when air quality deteriorates.

The agency is expanding and refining our internet site to better serve the residents of the Puget Sound region. We encourage feedback on our air quality data and program via e-mail to Mary Hoffman at maryh@pscleanair.org or at 206-689-4006.

[1] Washington Administrative Code 173-460. See Table of Toxic Air Pollutants, WAC 173-425-150. http://www.ecy.wa.gov/pubs/wac173460.pdf.
[2] The Agency's jurisdiction covers King, Kitsap, Pierce, and Snohomish Counties in Washington State.

REPORT ORGANIZATION

A brief overview of this report is provided in the Executive Summary. The Executive Summary is followed by background on the Air Quality Index (AQI) and the agency's monitoring program and network, and the 2009 agency-issued burn bans and smog forecasts.

The primary focus of this report is to present information on criteria air pollutants. Graphs, statistical summaries, and health effects information are provided for each pollutant monitored in 2009 in our four-county area, as well as comparisons to ambient air quality standards and health goals. Information about visibility based on fine particulates is included as part of our particulate matter presentation.

In addition to the information on criteria air pollutants, a summary of air toxics data based on monitoring by Ecology is also presented, along with links to more comprehensive reports describing air toxics concentrations and health effects information.

EXECUTIVE SUMMARY

The agency, along with the Department of Ecology, continued to monitor the region's air quality in 2009. Over the last two decades, many pollutant levels have declined, and air quality has generally improved.

While air quality is improving, we face new challenges. The Environmental Protection Agency (EPA) is required to review national ambient air quality standards periodically, and revises them to better protect public health. EPA substantially strengthened the standards for both fine particles and ozone in their recent reviews. As a result, after more than a decade of attaining all federal standards, the agency faces nonattainment for fine particle ($PM_{2.5}$) and potential future nonattainment for ozone.

Elevated fine particle levels present the greatest air quality challenge in our jurisdiction. Fine particle concentrations at the South L Street Tacoma monitoring site, located in the South End of Tacoma, violate EPA's daily $PM_{2.5}$ standard. In 2009, EPA designated much of Tacoma and surrounding Pierce County areas and cities as nonattainment for fine particles. Fine particle concentrations at monitoring sites in Snohomish County are close to EPA's daily $PM_{2.5}$ standard, and sites in all four counties (King, Kitsap, Pierce, and Snohomish) continue to exceed the agency's more stringent 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 its precursor pollutants (the pollutants that form ozone). EPA strengthened its 8-hour ozone standard in March 2008, and expressed intent in 2010 to strengthen it further. The 2009 ozone levels shown in this report just meet EPA's 2008 standard, and they likely will not meet a further-strengthened standard.

Air toxics are also present in our airshed at levels that pose adverse health effects.[3,4] These health effects include, but are not limited to, increased cancer risk and respiratory effects.

Many of the same sources that produce criteria and toxic air pollutants also generate greenhouse gases. The agency collaborates with public and private partners to reduce greenhouse gases.[5] Unlike the criteria pollutants and air toxics included in this summary, we do not monitor their levels in the ambient air. For more information, refer to http://www.pscleanair.org/programs/climate/default.aspx.

The agency is taking action with many partners to face these air quality challenges. Visit our website at www.pscleanair.org for more information about emission reduction programs.

[3]Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.
[4]Tacoma and Seattle Air Toxics Evaluation, 2010; http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf
[5]Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound; http://www.pscleanair.org/programs/climate/rptfin.pdf.

AIR QUALITY INDEX (AQI)

The AQI is a nationwide reporting standard developed by EPA for the criteria pollutants. The AQI is used to report daily air quality. "Good" AQI days continued to dominate our air quality in 2009. However, air quality degraded into "moderate" approximately one fifth of the time and to "unhealthy for sensitive groups" for brief periods.

Table 1 shows the AQI breakdown by percentage in each category for 2009. King County registered the highest AQI value of 160 on July 5. $PM_{2.5}$ determined the AQI on July 5. $PM_{2.5}$ typically determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups.

Table 1: AQI Ratings for 2009

	AQI Rating (% of year)				
County	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Highest AQI
Snohomish	74%	23%	3%	0%	117
King	75%	24%	1%	0%	160
Pierce	78%	18%	4%	0%	158
Kitsap	82%	11%	1%	0%	111

IMPAIRED AIR QUALITY – BURN BANS AND SMOG FORECASTS

The agency issues temporary bans on indoor and outdoor burning when air inversions trap fine particle pollution emitted from our chimneys, cars, trucks, and other activities close to ground level. These burn bans are mandatory. There are two stages of the 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 four burn bans in 2009. The dates (and counties-highest stage reached) were: Jan 16 – 24 (King-2, Pierce-2, Snohomish-2, Kitsap-2), Feb 3 – 6 (Pierce-1), Dec 8 – 13 (King-2, Pierce-2, Snohomish-2, Kitsap-2), and Dec 23 – 30 (Pierce-2, Kitsap-1, Snohomish-1).

The agency also may issue a smog forecast when predicted ozone levels are expected to persist for several days. During a smog forecast, the agency works with media and other partners to let the public know that ozone levels are unhealthy. We encourage people to work with our health partners to take steps to protect themselves and their families. The agency issued smog forecasts on July 24, 27, and August 19.

CRITERIA AIR POLLUTANTS AND VISIBILITY

The Puget Sound airshed is currently in attainment for carbon monoxide, ozone, and PM_{10}, and has maintenance plans in place for these pollutants.

EPA designated the Tacoma South L Street monitor and surrounding area as nonattainment for fine particles in December 2009. Levels at the Marysville and Darrington monitors, both in Snohomish County, remain relatively close to the standard. Concentrations at monitors in all four counties continue to exceed our more stringent, local health goal.

A more protective 8-hour ozone federal standard may result in nonattainment at the Enumclaw Mud Mountain monitor in the future. This monitor typically has the highest regional ozone concentrations during high-ozone episodes.

Monitoring shows that visibility associated with fine particulate matter in the Puget Sound area has continued to improve over the last decade.

AIR TOXICS

Ecology began monitoring air toxics at the Seattle Beacon Hill site in 2000, as part of EPA's National Air Toxics Trends Stations network.

Carbon tetrachloride, a chemically persistent air toxic banned in 1995, presented the highest potential cancer risk from air toxics monitored in 2009 at the Seattle Beacon Hill site. Benzene, an air toxic from gasoline and other combustion, ranked second. It is important to note that this ranking does not include diesel and wood smoke particulate matter. A comprehensive 2003 and 2010 evaluation showed that diesel particulate matter presents the majority of potential air toxics cancer health risk in our area.[6,7]

Unfortunately, there is no direct monitoring method to measure diesel particulate matter. A statistical model using three years of data with over 50 different pollutants is used to estimate diesel particulate.

[6]Puget Sound Final Air Toxics Evaluation, 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.

[7] Tacoma and Seattle Area Air Toxics Evaluation, 2010; http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

AIR QUALITY INDEX

The air quality index (AQI) is reported according to a 500-point scale for five of the six major criteria air pollutants: ozone, particulate matter (both $PM_{2.5}$ and PM_{10}), carbon monoxide, nitrogen dioxide, and sulfur dioxide. The highest pollutant determines the daily ranking. For example, if an area has a carbon monoxide index value of 132 on a given day and all other pollutants are below 50, the AQI for that day would be 132. The scale breaks down into 6 categories, listed below. Each category has a corresponding color, shown with pollution concentration breakpoints for each category (see Table 5 in the Definitions section of this document).

- **0-50: Good.** Satisfactory air quality; little or no risk from pollution.
- **51-100: Moderate.** Acceptable air quality; potential moderate health concerns for a very small number of people.
- **101-150: Unhealthy for Sensitive Groups.** Air quality is acceptable for the general public, but people with health conditions that make them sensitive to a particular pollutant are at greater risk of health problems.
- **151-200: Unhealthy.** Everyone may experience some health effects, more serious for members of sensitive groups.
- **201-300: Very Unhealthy.** Everyone may experience more serious health effects.
- **301-500: Hazardous.** Health risk is at emergency levels. Everyone is likely to be affected.

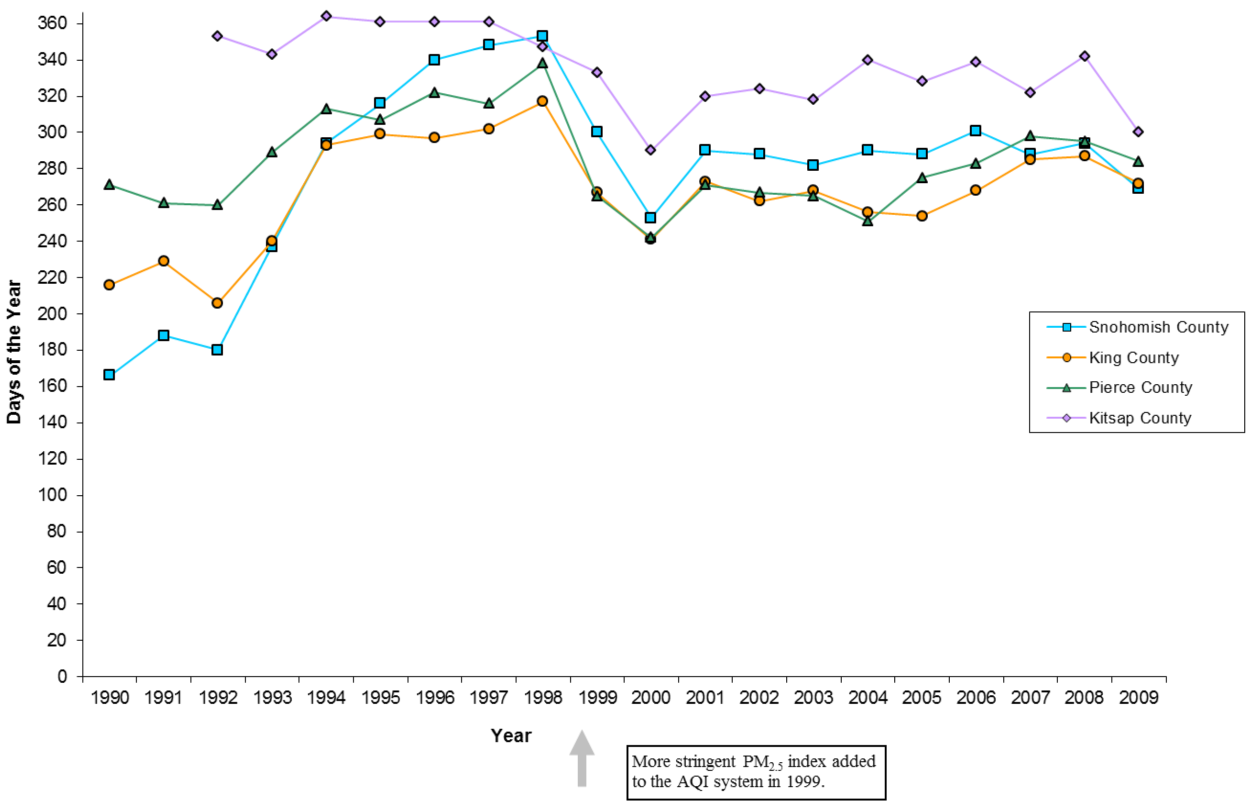
The AQI is a national index, so the reported values and colors used to show local air quality and the associated level of health concern will be the same throughout the United States. Current and archived AQI values for Puget Sound can be found on our website at www.pscleanair.org.

The number of "good" air quality days continues to dominate our air quality in the Puget Sound area. However, air quality degraded into "moderate", "unhealthy for sensitive groups", and "unhealthy" for brief periods. Table 1, presented in the Executive Summary, shows the AQI breakdown by percentage in each category for the year.

In 2008, EPA revised the AQI breakpoints for ozone in order to be consistent with the new ozone standard. 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.

Figure 1 presents the annual number of "good" AQI days for each of the four counties. The number of "good" days has been relatively constant over the last few years for each county. Lower numbers of "good" days now cannot be directly compared with the numbers before 1999, when $PM_{2.5}$ was added to the index and the "unhealthy" category was divided into "unhealthy" and "unhealthy for sensitive groups".

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



Figures 2 through 5 present AQI days 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 1980 to 2009 (from 1990 to 2009 for Kitsap County).

Figure 2: Air Quality for King County

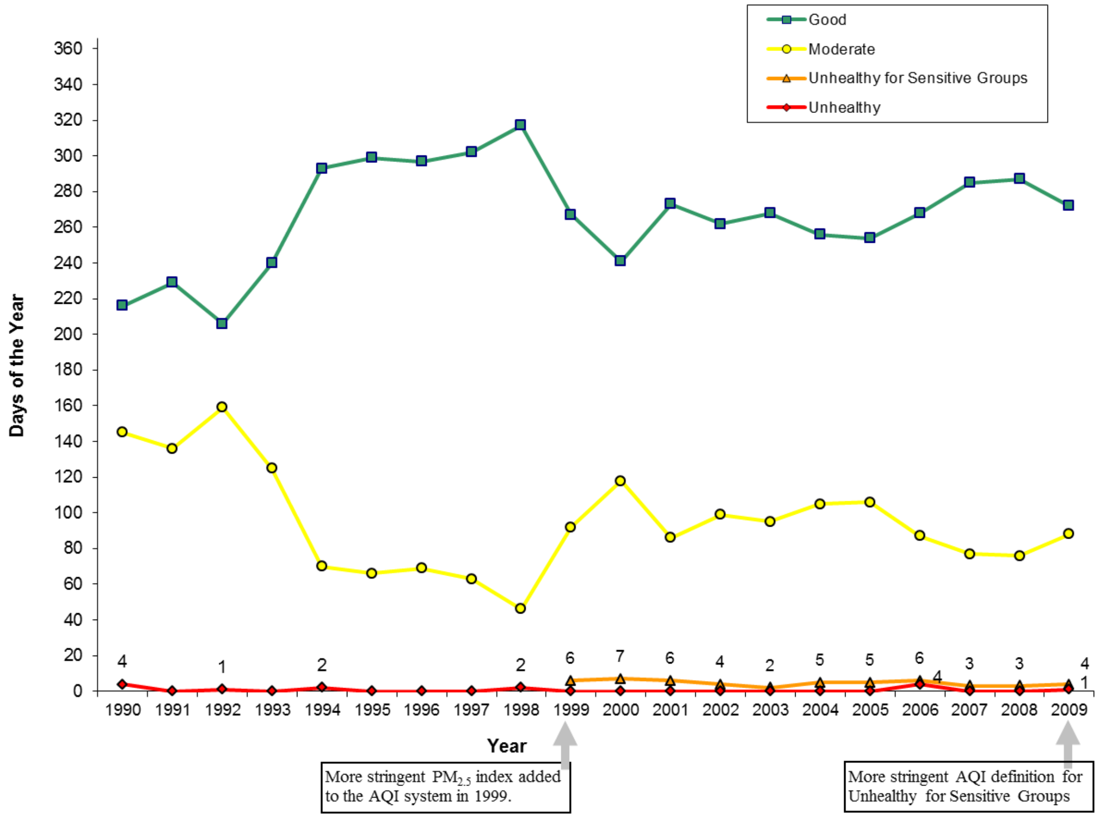


Figure 3: Air Quality for Kitsap County

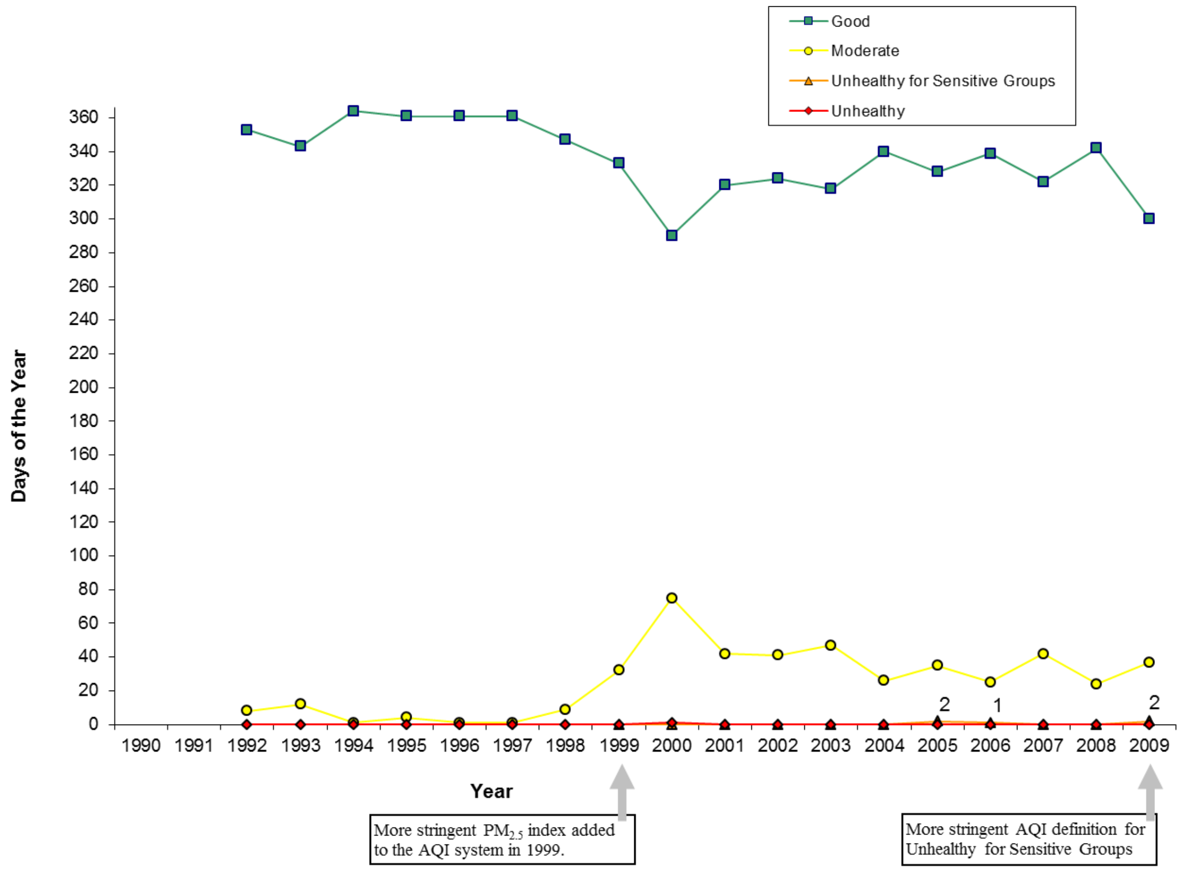


Figure 4: Air Quality for Pierce County

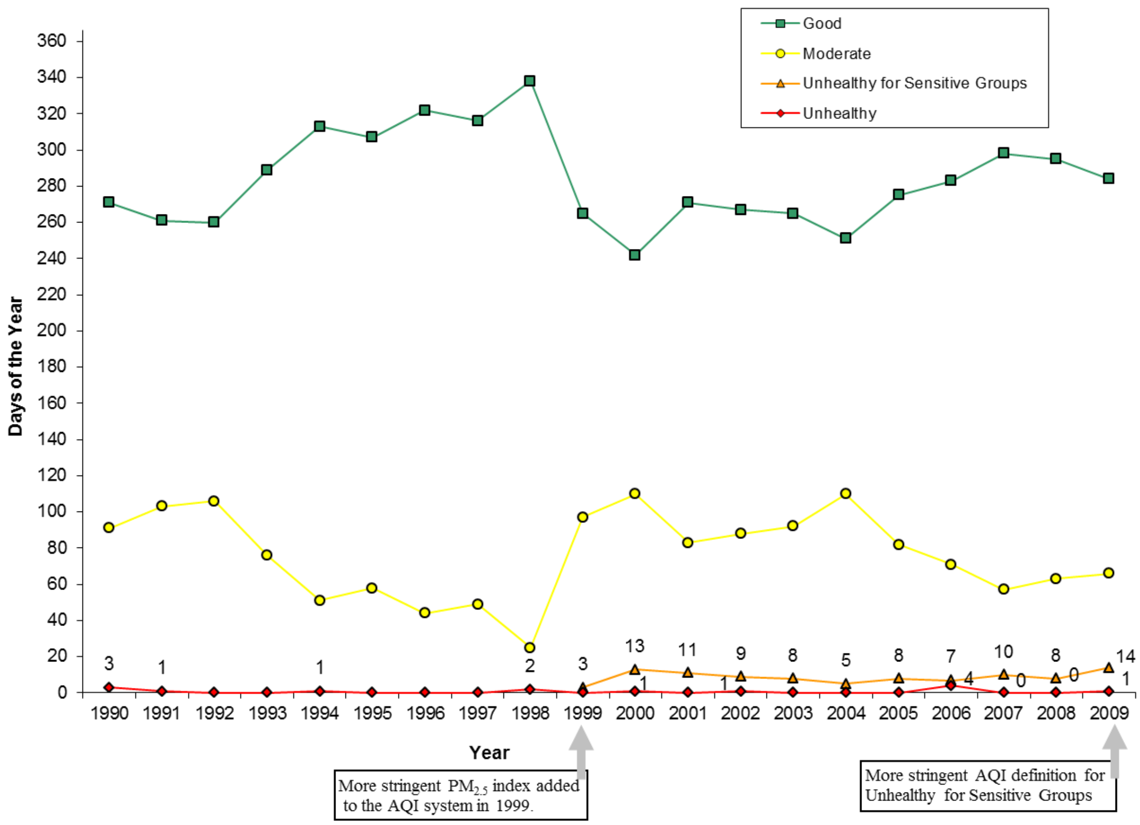
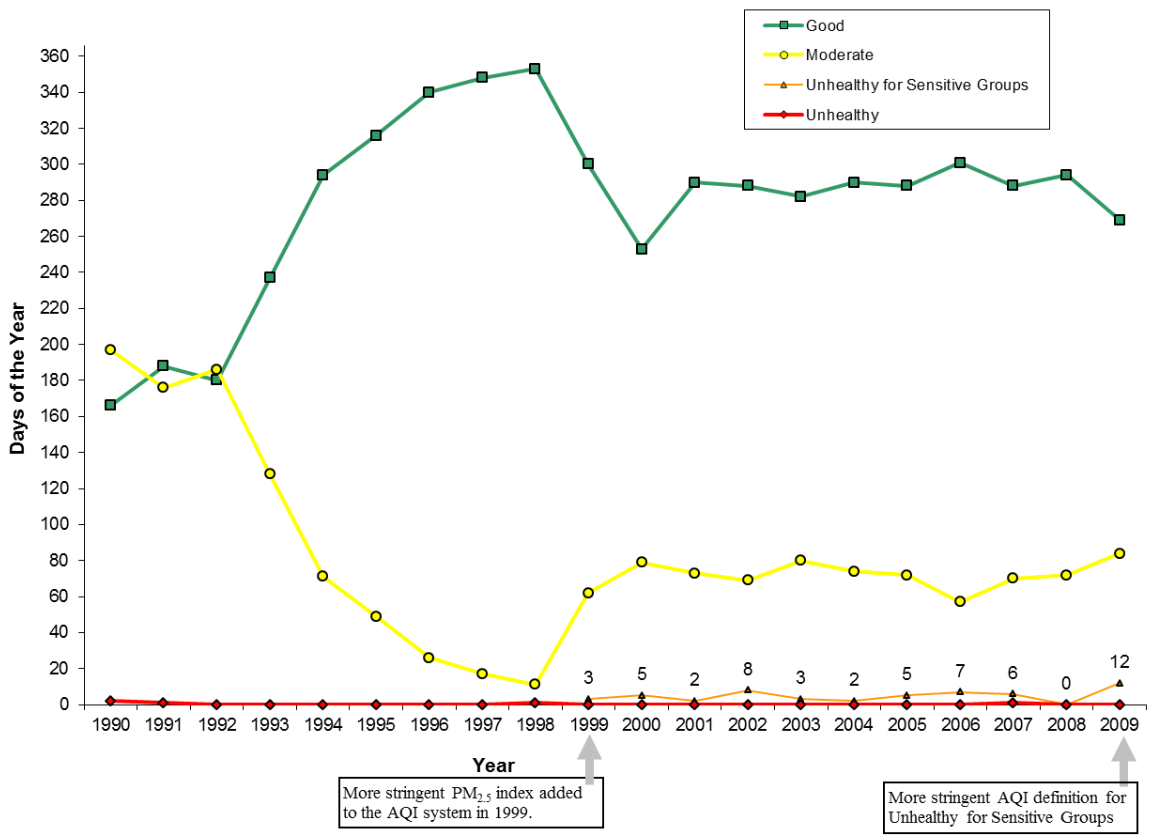


Figure 5: Air Quality for Snohomish County



Monitoring Network

The agency and Ecology operate the Puget Sound region's monitoring network, comprised of both meteorological and pollutant-specific equipment. Data from the network are either collected manually by field staff or sent directly to engineers and scientists through a telemetry network.

The agency conducted monitoring as early as 1965; however, this report will focus on post-1999 monitoring. Table 2 presents a summary of the monitoring stations and parameters monitored from 1999 through 2009. Some parameters were monitored for only part of this time frame. Shaded stations in the table operated in 2009. Similarly, a filled circle denotes a pollutant that was monitored in 2009. An "x" denotes a pollutant that was no longer monitored in 2009. The network changes because the agency and Ecology regularly re-evaluate monitoring resources to measure and report on the pollutants that are most relevant to public health. Additionally, sometimes logistical issues (such as loss or gain of real estate) cause changes in the network.

Monitoring stations are located in a variety of geographic locations in the Puget Sound region. Most are located in highly populated areas. Monitors are sited according to EPA criteria to ensure a consistent and representative picture of air quality. Map 1 on page 18 shows monitoring stations that were active in 2009.

The station IDs shown on the map correspond with table identification letters. These same identification letters are used throughout this data summary. General location descriptors are also provided for each station in the last column of the monitoring network table. These descriptors make broad distinctions between urban center, suburban, and rural, and also provide information as to whether areas are more commercial, industrial, or residential. Sites that have more than two descriptors have varied land use; for example, both residential and commercial. In addition, some sites are selected to focus on the emissions of a specific pollutant or source (for example, near a busy roadway or residential areas where wood is used for home heating). Pollutant-specific sections of this report highlight these monitoring locations and objectives.

The agency and Ecology measure criteria air pollutants using federal reference methods (FRM) that are approved by the Environmental Protection Agency (EPA). In addition to the federal reference method, the agency measures particulate matter using alternate methods. These methods help engineers and scientists better understand the presence and behavior of these pollutants. For example, as shown in the monitoring network table, fine particulate ($PM_{2.5}$) is monitored according to the EPA reference method ("ref" in the table), as well as several other methods that provide real-time values.

A list of the methods used for monitoring the criteria pollutants can be found 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 http://www.epa.gov/ttn/amtic/airtox.html.

FINE PARTICULATE MONITORING – FEDERAL REFERENCE METHOD AND CONTINUOUS METHODS

Fine particulate matter ($PM_{2.5}$) is measured using a variety of methods because it is the main pollutant of concern in our area. EPA considers the federal reference method (FRM) to be the most accurate way to determine $PM_{2.5}$ concentrations. This 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 be later analyzed and modeled for more information about the types of particulate matter. Unfortunately, the FRM does not provide continuous or rapid turnaround information.

The agency uses the FRM as well as two continuous methods to provide more time-relevant data. Our agency has been a national leader in this type of continuous monitoring.

These methods determine fine particulate matter concentration differently:

- the nephelometer uses scattering of light
- the tapered element oscillating microbalance (TEOM) measures mass

The agency also uses instruments to measure organic components of fine particulate matter, called aethalometers. These instruments measure light absorption.

In this report, continuous method data are compared, where possible, to the reference method values and calculations are made to determine the degree of difference from the reference method. The differences are then applied to the current continuous values in an attempt to make them “FRM-like”. Continuous concentrations from Kitsap County are not adjusted to make them “FRM-like”, as there is no site-specific FRM data at the Meadowdale monitoring site.

Table 2: 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							●	●					●	●	●		●	a, d
BF⦿	University District, 1307 NE 45th St, Seattle (ended Jun 30, 2006)												X						b, d
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				●		●	●	●	●	●	●	●	●	●	●	●	●	b, d, f
CE	Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE	X		X	●		●	●	●		X			●	●	●		●	a, e
CG⦿	Woodinville, 17401 133rd Av NE, Woodinville							●						●					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		●		●	●	●					●	●	●		●	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			●		●				●	●	●		●	c
DG⦿	42404 SE North Bend Way, North Bend				X		X	●		●				●	●	●		●	c, d, f
DH⦿	2421 148th Ave NE, Bellevue												●						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									●					●	●			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		●						●	●	●		●	b, f
ES	7802 South L St, Tacoma (began Oct 3, 1999) 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									●									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		●		●	●	●					●	●	●		●	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				●			●	●					●	●	●		●	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
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
RV⦿	Yelm N Pacific Road, 931 Northern Pacific Rd SE, Yelm (began May 2005)									●									c,f
UB⦿	71 E Campus Dr, Belfair (ended Sep 30, 2004)									X									c
VK⦿	Fire Station, 709 Mill Road SE, Yelm (began May 1, 2000, ended in Oct 2005)									X									c,f

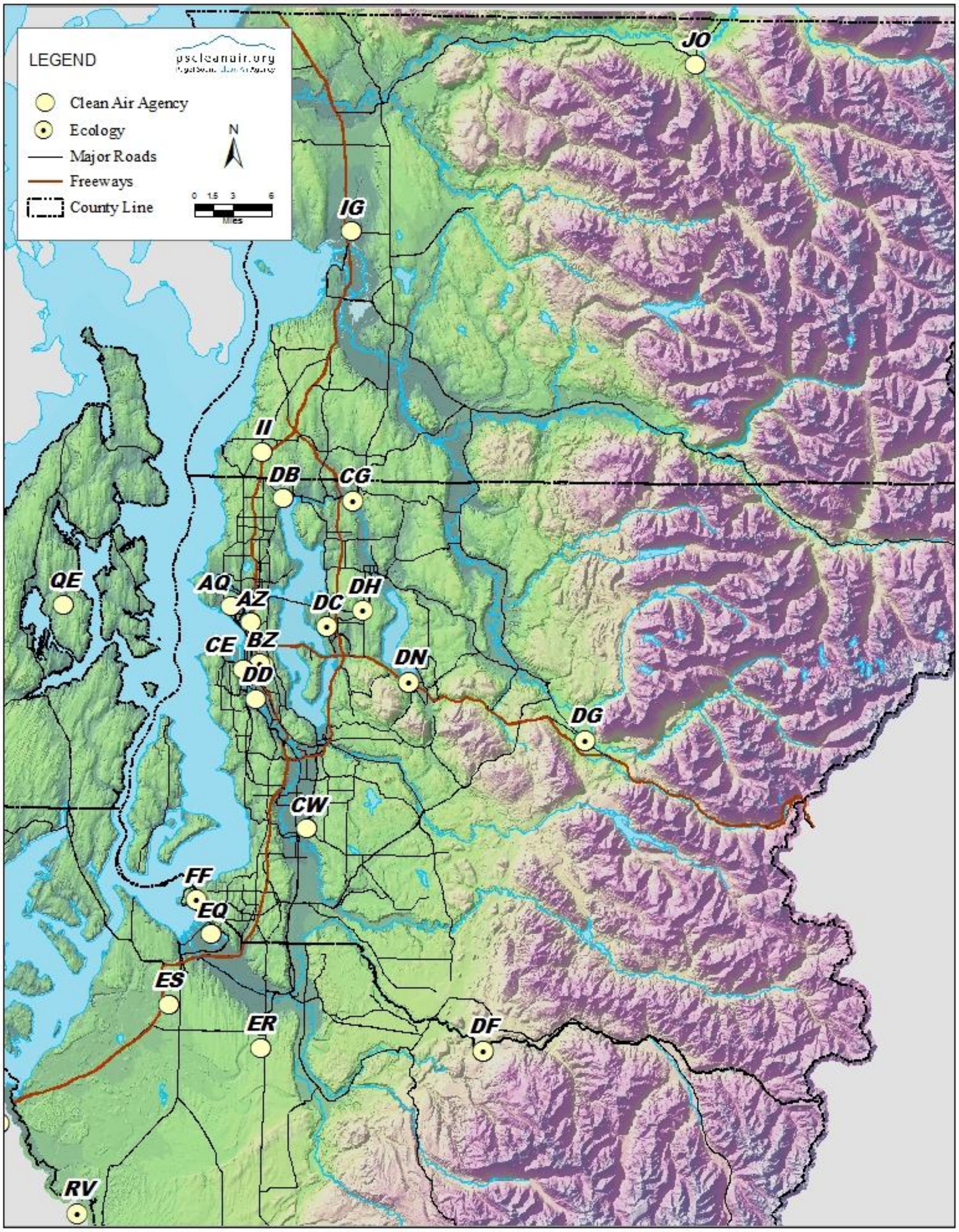
⦿	Station operated by Ecology
RV⦿	Shading indicates station currently functioning
⬣	Indicates parameter currently monitored
X	Indicates parameter previously monitored
PM_{10} ref	Particulate matter 10 micrometers (reference)
PM_{10} bam	Particulate matter 10 micrometers (beta attenuation continuous)
PM_{10} teom	Particulate matter 10 micrometers (teom continuous)
$PM_{2.5}$ ref	Particulate matter 2.5 micrometers (reference)
$PM_{2.5}$ bam	Particulate matter 2.5 micrometers (beta attenuation continuous)
$PM_{2.5}$ teom	Particulate matter 2.5 micrometers (teom continuous)
$PM_{2.5}$ 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

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

SO_2	Sulfur Dioxide
NO_x	Nitrogen Oxide
CO	Carbon Monoxide
b_{sp}	Light scattering by atmospheric particles
Wind	Wind direction and speed
Temp	Air temperature (relative humidity also measured at
AT	Air Toxics
VSBY	Visual range (light scattering by atmospheric
PHOTO	Visibility (camera)
O_3	Ozone (May through September)

Map 1: Active Air Monitoring Network for 2009



IMPAIRED AIR QUALITY – BURN BANS AND SMOG WATCH

BURN BANS

Washington State has a winter impaired air quality program focusing on particulate matter from wood stoves and fireplaces. The agency enforces this program by working with local media and partners to issue temporary bans on indoor burning (in wood stoves and fireplaces) when inversions trap fine particle pollution and air quality degrades. Outdoor burning of yard waste, in areas where such burning is normally allowed, is also prohibited during burn bans on indoor burning. These burn bans and are enforced by agency inspectors.

There are two stages of the indoor burn bans. For a Stage 1 burn ban, residential burning in fireplaces and uncertified wood stoves is prohibited (unless a wood-burning device is the only adequate source of heat).[8] For a Stage 2 burn ban, the use of any kind of wood-burning device (including certified wood stoves and pellet stoves) is prohibited unless a wood-burning device is the only adequate source of heat.

Before 2008, a Stage 1 burn ban could be declared by the agency when $PM_{2.5}$ levels reached 35 $\mu g/m^3$ (24-hour average). A Stage 2 burn ban could be declared when $PM_{2.5}$ levels reached 60 $\mu g/m^3$ (24-hour average). In 2008, the Washington State Legislature revised the burn ban triggers to be consistent with the new, stricter federal $PM_{2.5}$ standard. Under the revised statute, a Stage 1 burn ban is triggered when meteorological conditions are predicted to cause fine particulate levels to exceed 35 $\mu g/m^3$ (based on a 24-hour average) within 48 hours. A Stage 2 burn ban is generally triggered when the following three things have happened:

1) a Stage 1 burn ban has been enforced and has not been sufficient to reduce the increasing fine particulate pollution trend,
2) $PM_{2.5}$ levels are recorded at or above 25 $\mu g/m^3$ (based on a 24-hour average), and
3) forecasted meteorological conditions are not expected to allow $PM_{2.5}$ concentrations to decline.

In the past, Stage 2 burn bans were rare. The new burn ban thresholds, however, will likely result in more Stage 2 burn bans. The agency called four burn bans in 2009. The dates (and counties-highest stage reached) were: Jan 16 – 24 (King-2, Pierce-2, Snohomish-2, Kitsap-2), Feb 3 – 6 (Pierce-1), Dec 8 – 13 (King-2, Pierce-2, Snohomish-2, Kitsap-2), and Dec 23 – 30 (Pierce-2, Kitsap-1, Snohomish-1).

Monitoring data from the Dec. 23 burn ban is shown in Figure 6. The 24-hour average $PM_{2.5}$ concentrations from two Snohomish county sites and from one Kitsap and Pierce site are plotted along with the Air Quality Index (AQI) category and the federal daily standard (35 $\mu g/m^3$). The 24-hour average values are a running mean of the previous 12 and future 12 hourly values.

[8] Uncertified wood stoves emit more pollution than ones certified by the EPA. To determine if your wood stove is certified, visit our website for more information at http://www.pscleanair.org/actions/woodstoves/basics.aspx.

Figure 6: $PM_{2.5}$ at four monitoring sites during the Dec. 23-30, 2009 burn ban

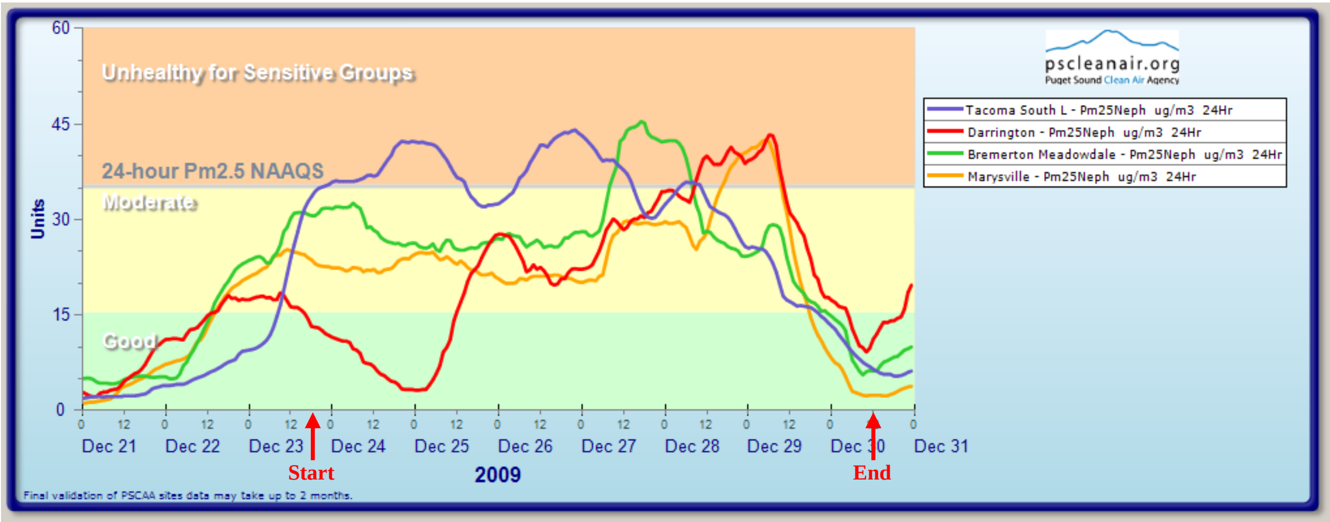
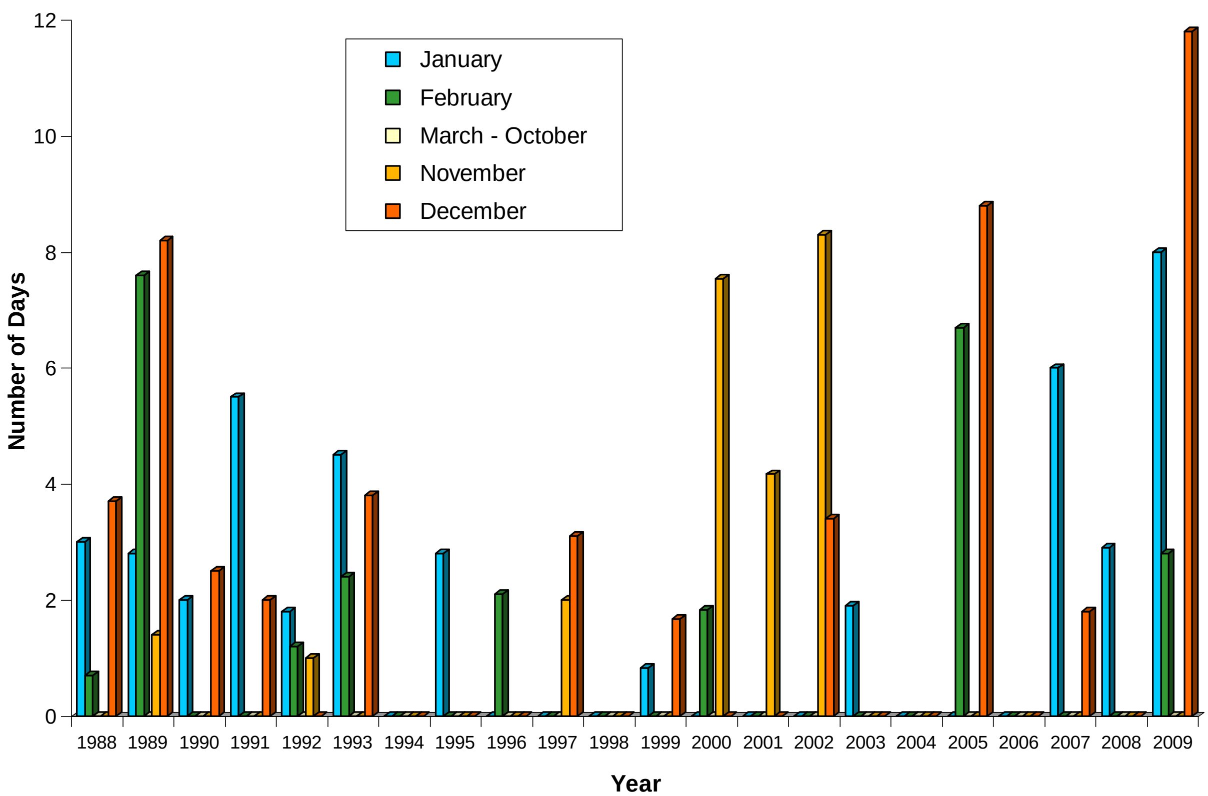


Figure 7: Number of Days with Indoor Burning Bans in the Puget Sound Region



Smog Forecasts

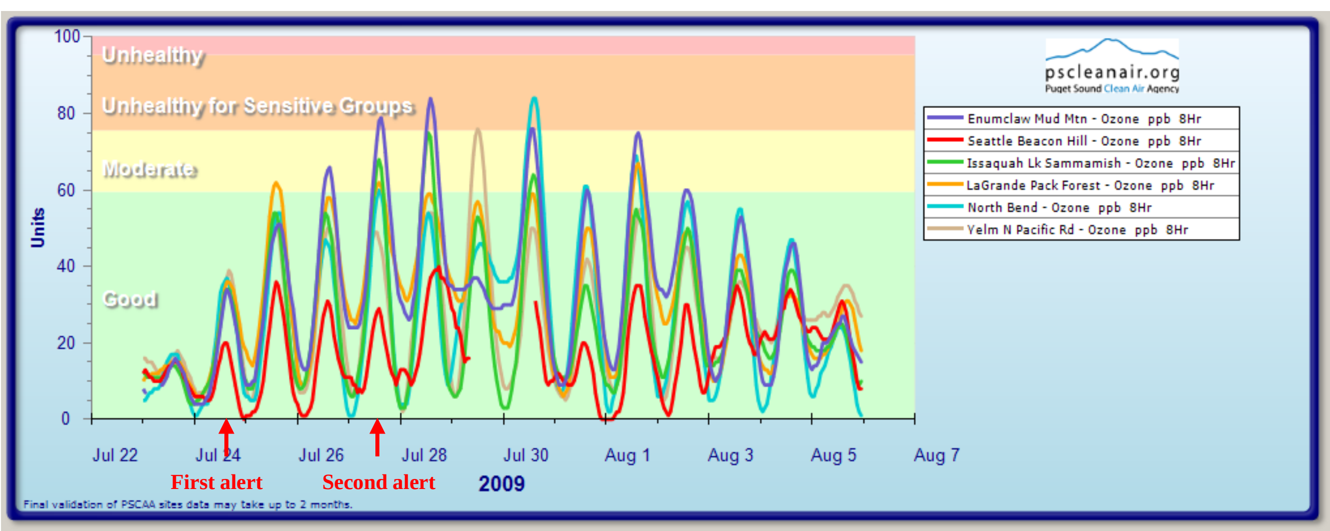
The agency maintains a voluntary air quality smog forecast program. During the summer, the agency notifies residents of potential unhealthy ozone levels. Summer ozone typically becomes a problem on hot stagnant summer days. Thus, advisories are driven more by meteorology than by monitored air quality data. The agency announces smog forecasts when weather forecasts predict temperatures in the upper 80s or higher, with little or no wind for at least a 48-hour period.

The agency communicates with meteorologists, traffic reporters, news media, and local businesses and agencies during smog forecast advisories. The agency and its health partners encourage people to take measures to reduce their exposure to unhealthy smog and protect their health.

The agency issued smog alerts on July 24, 27, and August 19, 2009. 8-hour average ozone concentrations from the smog event at the end of July through early August are shown in Figure 8. The stations plotted include Enumclaw, Beacon Hill, Lake Sammamish, Pack Forest, North Bend, and Yelm.

8-hour ozone concentrations are shown on page A-13 of the Appendix.

Figure 8: Smog Forecast Events



AIR QUALITY STANDARDS AND HEALTH GOALS

The national Clean Air Act (CAA), last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for criteria pollutants considered harmful to public health and the environment. These standards are designed to protect the public, including sensitive populations such as asthmatics, children, and the elderly. They are also intended to safeguard public welfare by reducing effects such as decreased visibility and damage to animals, crops, vegetation, and buildings. EPA has established standards for six criteria pollutants including carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead, and separate standards for the two size ranges of particulate matter. 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 http://epa.gov/air/criteria.html. Washington State air quality regulations are available at http://www.ecy.wa.gov/laws-rules/ecywac.html#air.[9] The air quality standards that apply to the Puget Sound airshed are summarized in Table 3.

In addition to air quality standards, 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.[10] 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.[11,12] The form of the agency's health goal is "never-to-be-exceeded." The agency did not adopt a separate health goal for the annual $PM_{2.5}$ average.

[9] Washington Administrative Code chapters 173-470, 173-474, and 173-475.
[10] Puget Sound Clean Air Agency. Final Report of the Puget Sound Clean Air Agency $PM_{2.5}$ Stakeholder Group; http://www.pscleanair.org/news/library/reports/pm2_5_report.pdf.
[11] American Lung Association; http://www.lungusa.org/assets/documents/publications/state-of-the-air/state-of-the-air-report-2006.pdf.
[12] EPA Clean Air Science Advisory Committee (CASAC) Particulate Matter (PM) Review Panel; http://www.epa.gov/sab/panels/casacpmpanel.html.

Table 3: Puget Sound Region Air Quality Standards for Criteria Pollutants for 2009

Pollutant	Standard	Level[a,b]
Ozone[c]	The 3-year average of the 4th highest daily maximum 8-hour average concentration must not exceed the level (round to the nearest 0.01)	0.075 ppm (0.075 ppm)
Particulate Matter (10 micrometers)	The 3-year average of the 99th percentile (based on the number of samples taken) of the daily concentrations must not exceed the level (round to the nearest 10)	154 $\mu g/m^3$ (150 $\mu g/m^3$)
Particulate Matter (2.5 micrometers)	The 3-year annual average of the daily concentrations must not exceed the level (round to the nearest 0.1)	15.04 $\mu g/m^3$ (15.0 $\mu g/m^3$)
	The 3-year average of the 98th percentile (based on the number of samples taken) of the daily concentrations must not exceed the level (round to the nearest 1)	35 $\mu g/m^3$ (35.4 $\mu g/m^3$)
Carbon Monoxide	The 1-hour average must not exceed the level more than once per year	35.4 ppm (35 ppm)
	The 8-hour average must not exceed the level more than once per year (round to the nearest 1)	9.4 ppm (9 ppm)
Sulfur Dioxide	Annual arithmetic mean of 1-hour averages must not exceed	0.02 ppm
	24-hour average must not exceed	0.10 ppm
	1-hour average must not exceed	0.40 ppm[d]
	AND no more than twice in 7 consecutive days can the 1-hour average exceed	0.25 ppm[d]
Lead[e]	The quarterly average (by calendar) must not exceed the level (round to the nearest 0.01)	0.15 $\mu g/m^3$ (0.15 $\mu g/m^3$)
Nitrogen Dioxide[f]	The annual mean of 1-hour averages must not exceed the level (round to the nearest 0.0001)	0.0534 ppm (0.053 ppm)

[a]Daily concentration is the 24-hour average, measured from midnight to midnight.

[b]EPA adopts rounding conventions. Numbers with no parentheses represent highest values that will meet standards using EPA's rounding convention. Numbers in parentheses represent the rounded standards.

[c]EPA changed the 8-hour ozone standard from 0.08 to 0.075 in March of 2008.

[d]Since this report was written, EPA changed the 1-hour average standard for sulfur dioxide to 0.075 ppm on June 2, 2010. The number above reflects the 2009 standard.

[e]EPA changed the quarterly standard for lead from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$ in October 2008.

[f]EPA added a nitrogen dioxide standard in January 2010. The new standard sets a 1-hour standard at 100 parts per billion, to be measured as the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. EPA also retained the annual standard of 53 parts per billion (ppb). The table above reflects the 2009 (annual) standard.

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 in the following sections. Additional information is on EPA's website at http://epa.gov/air/criteria.html.

Particulate Matter

Particulate matter (PM) includes both solid matter and liquid droplets suspended in the air. Particles smaller than 2.5 micrometers in diameter are called "fine" particles, or $PM_{2.5}$. Particles between 2.5 and 10 micrometers in diameter are called "coarse" particles. PM_{10} includes both fine and coarse particles.

PM_{10}

In 2006, EPA revoked the annual PM_{10} standard due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution.[13] The agency ceased all PM_{10} monitoring in 2006 and has focused its efforts on $PM_{2.5}$ monitoring. Fine particles have a greater impact than coarse particles at locations far from the emitting source because they remain suspended in the atmosphere longer, and travel farther. For a historic look at Puget Sound area PM_{10} levels, please see pages 32-35 of the 2007 data summary at http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

$PM_{2.5}$ Health and Environmental Effects

$PM_{2.5}$ is one of the major air pollution concerns affecting our region. $PM_{2.5}$ primarily comes from wood burning and vehicle exhaust including cars, diesel trucks, and buses. Fine particulate can also be formed in the atmosphere through chemical reactions of pollutant gases.

Exposure to $PM_{2.5}$ can have serious health effects. Fine particles are most closely associated with increased respiratory disease, decreased lung function, and even premature death.[14,15,16,17] Children, older adults, and people with some illnesses are more sensitive and more likely to develop heart or lung problems associated with $PM_{2.5}$.[18,19] People with respiratory or heart disease, older adults, and children should avoid outdoor exertion if $PM_{2.5}$ levels are elevated. $PM_{2.5}$ can also significantly affect visibility.

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

On September 21, 2006, EPA adopted a new daily standard of 35 $\mu g/m^3$.[20] The Puget Sound area had violated the National Ambient Air Quality Standards (NAAQS) in 2008, at the South L Tacoma monitor located at the south end of Tacoma, in Pierce County. In 2009, this monitor again violated the NAAQS for $PM_{2.5}$. EPA designated the Tacoma/Pierce County fine particle nonattainment on December 14, 2009. The Washington State Department of Ecology and our Agency will work together to develop a

[13] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; http://www.epa.gov/particles/actions.html.
[14] Pope et al. Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association.* 287: pp 1132-1141, March 6, 2002.
[15] Gauderman et al. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. *The New England Journal of Medicine.* Volume 351: pp 1057–1067, Number 11, September 9, 2004.
[16] Kunzli et al. Ambient Air Pollution and Atherosclerosis in Los Angeles. *Environmental Health Perspectives.* Volume 113, 2: pp 201-206, February 2005; http://ehp.niehs.nih.gov/members/2004/7523/7523.pdf.
[17] U.S. Environmental Protection Agency. Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information. EPA-452/R-05-005, June 2005; http://www.epa.gov/ttn/naaqs/standards/pm/data/pmstaffpaper_20050630.pdf.
[18] Park et al. Effects of Air Pollution on Heart Rate Variability: The VA Normative Aging Study. *Environmental Health Perspectives.* Volume 113, 3. pp 304-309, March 2005; http://ehp.niehs.nih.gov/members/2004/7447/7447.pdf.
[19] Goss et al. Effect of Ambient Air Pollution on Pulmonary Exacerbations and Lung Function in Cystic Fibrosis. *American Journal of Respiratory Critical Care Medicine.* Volume 169: pp 816-821. January 12, 2004.
[20] U.S. Environmental Protection Agency, Particulate Matter, PM Standard Revisions, 2006; http://www.epa.gov/particles/actions.html.

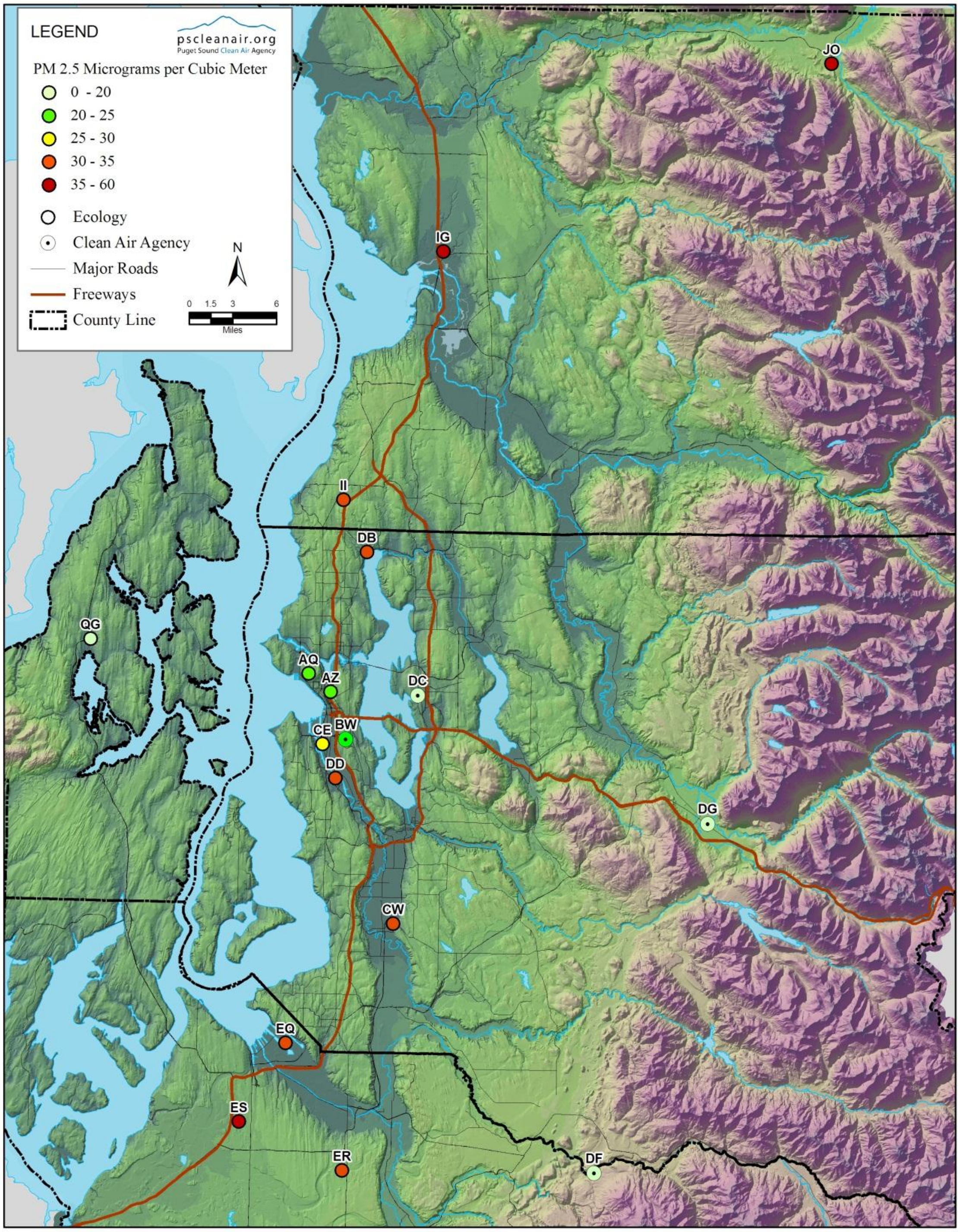
State Implementation Plan by December 2012 for EPA approval. State Implementation Plans are used to devise a plan for complying with the federal Clean Air Act. More information on State Implementation Plans can be found at http://www.epa.gov/airquality/urbanair/sipstatus/overview.html.

Concentrations at the Marysville and Darrington monitors, both located in Snohomish County, remain close to violating the daily standard.

In addition to the federal standard, our Board of Directors adopted a more stringent goal based on recommendations from our Particulate Matter Health Committee. Monitors in all four counties of our jurisdiction exceed this local health goal of 25 $\mu g/m^3$ during the winter season.

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 2007 to 2009.

Map 2: The 98th Percentile 3-Year Average Daily $PM_{2.5}$ Concentrations for 2009*



* The Woodinville monitor was started in February 2009 and therefore does not have three years of complete data.

Figures 9 through 12 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 2009 is the average of the 98th percentile daily concentration for 2007, 2008, and 2009. Concentrations for King, Pierce, and Snohomish Counties were measured using the FRM, except where noted.[21] Concentrations for Kitsap County were measured using continuous methods.[22]

Figure 10 does not include 2009 data for Kitsap County. This is because monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for part of the year, resulting in an incomplete dataset. Historical data for the county is well below the federal standard.

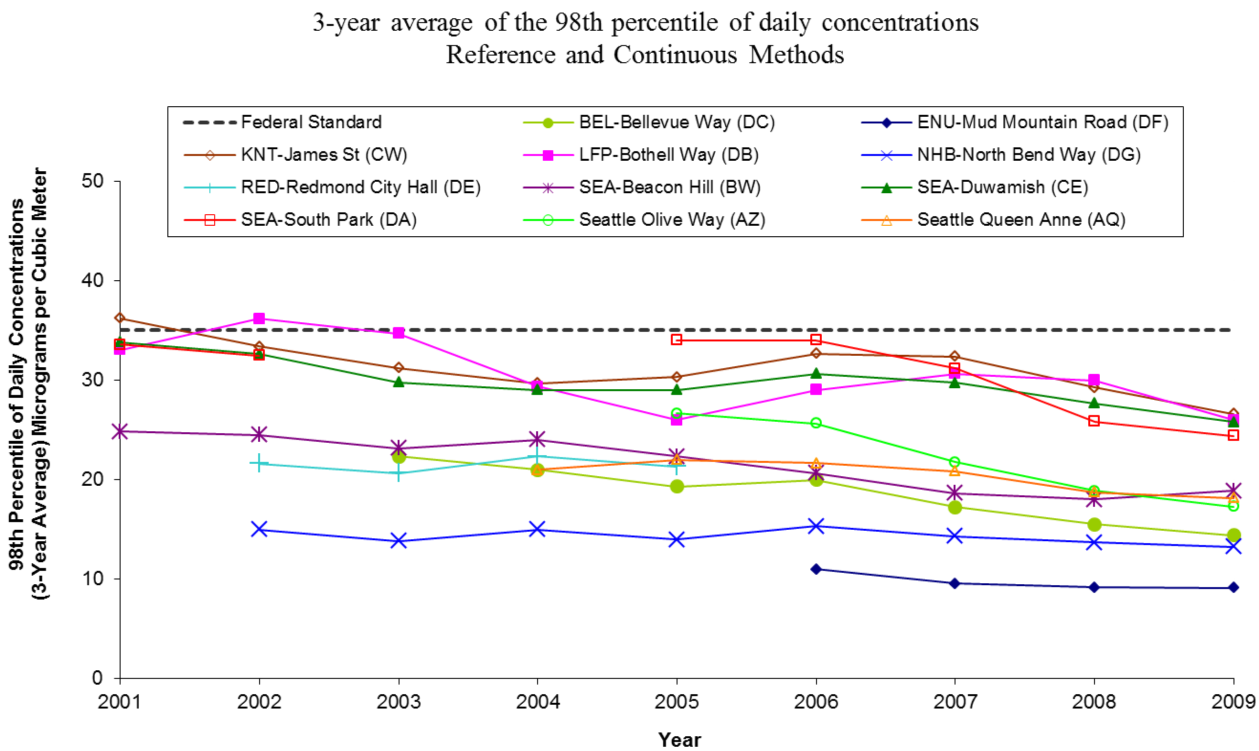
Figure 11 shows that the Tacoma South L Site, located in the Tacoma South End neighborhood, continues to violate the federal standard of 35 $\mu g/m^3$. Concentrations at the Darrington and Marysville monitors in Snohomish County, and the Tacoma Tideflats monitor in Pierce County and are the next highest range of concentrations between 30 to 35 $\mu g/m^3$.

Statistical summaries for 98th percentile daily concentrations for 2009 data are provided on page A-7 through A-10 of the Appendix.

[21] Where possible, continuous method data are compared to the reference method values and calculations are made to determine the degree of difference from the reference method. The differences are then applied to the current continuous values in an attempt to make them "FRM-like".

[22] Continuous concentrations in Kitsap are not adjusted to make them "FRM-like", as there is no site-specific FRM data at the Meadowdale and Silverdale monitoring sites.

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



Note: Duwamish (CE) and Beacon Hill (BW) data are FRM from 1999-2009. Lake Forest Park (DB) data are FRM from 1999-2007, neph in 2008-09. South Park (DA) data are FRM from 1999-2002, (3 yr avg 2004-06 was FRM in 2004, neph in 2005-2009. Bellevue Way (DC) data are FRM from 2001-2004, neph 2005-09. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2009. Olive Way (AZ) data are neph from 2003-2009. North Bend (DG) data are FRM from 2000-2004, neph in 2005-2009. Kent (CW) data are FRM from 1999-2004, neph in 2005-2009. Enumclaw (DF) data are from neph in 2000-2009.

Figure 10: Daily $PM_{2.5}$ for Kitsap County

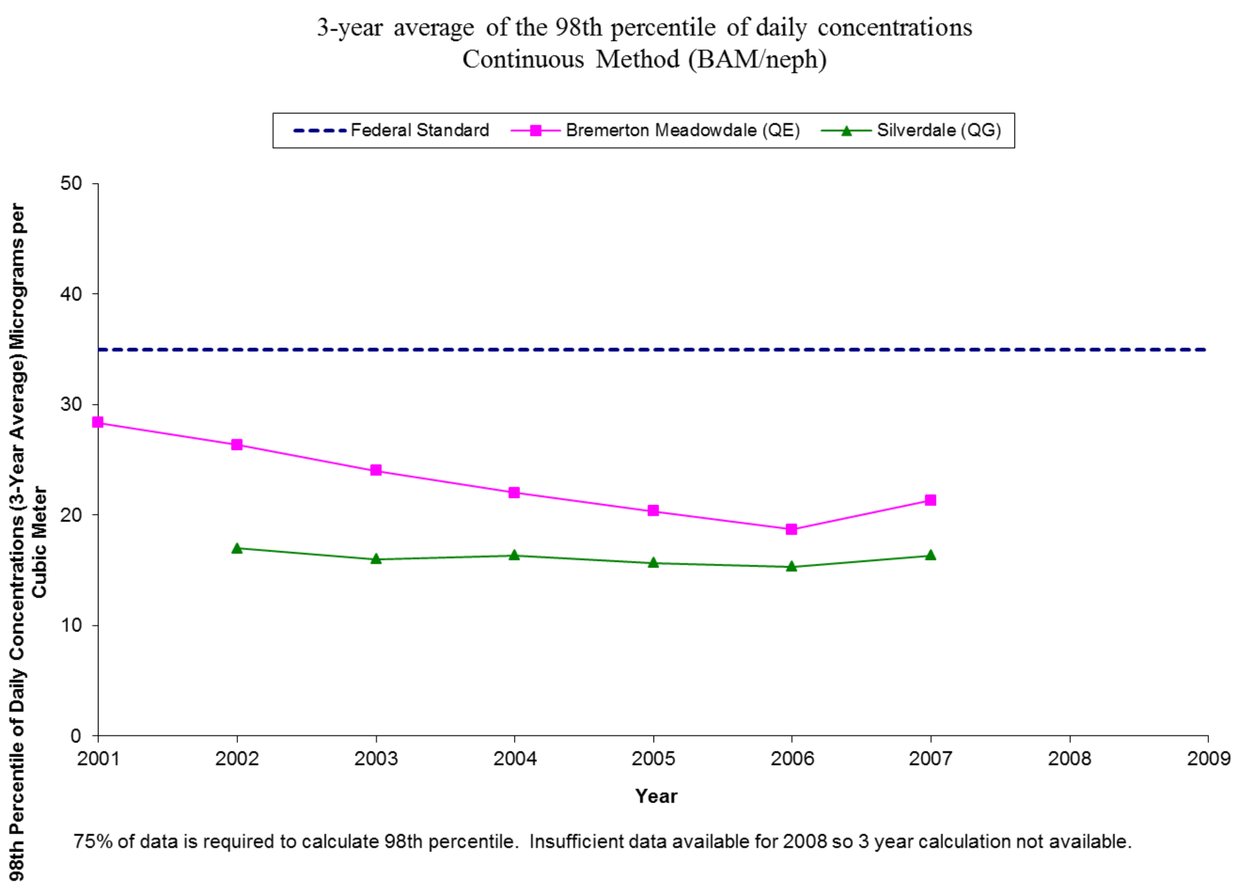
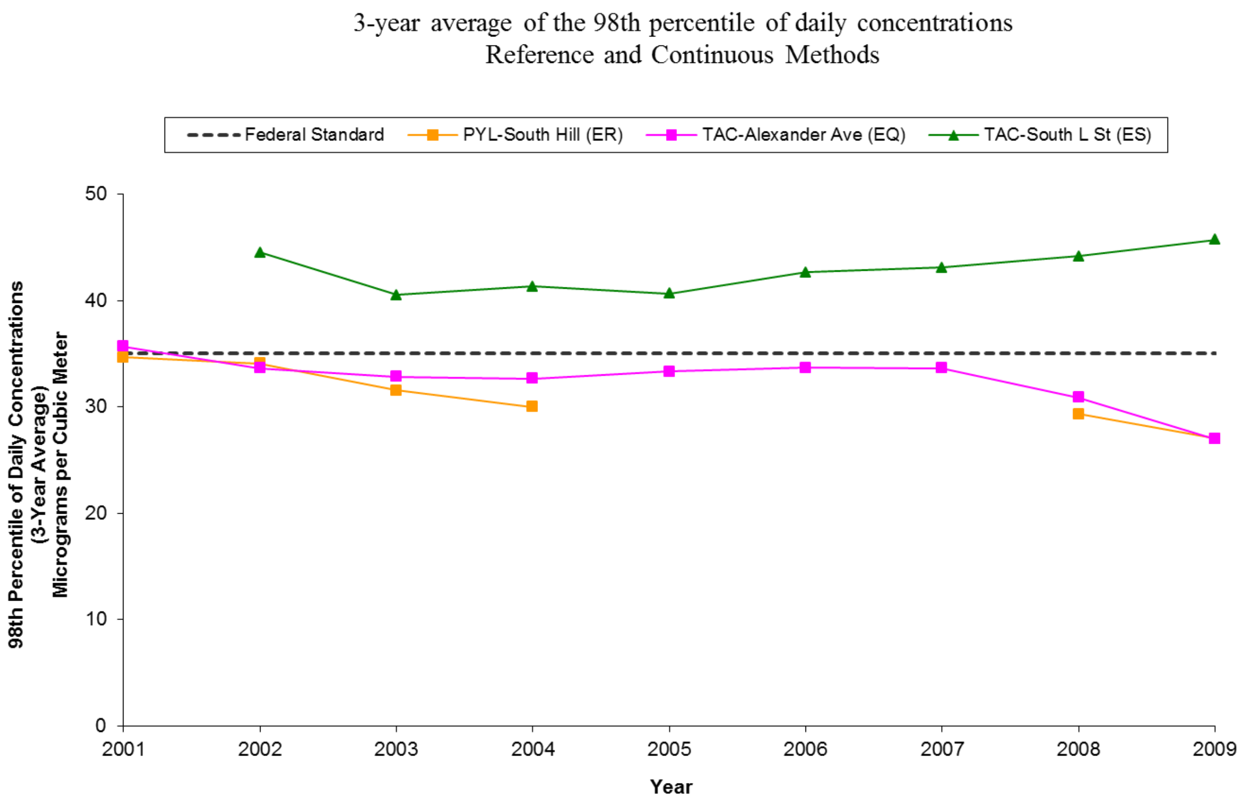
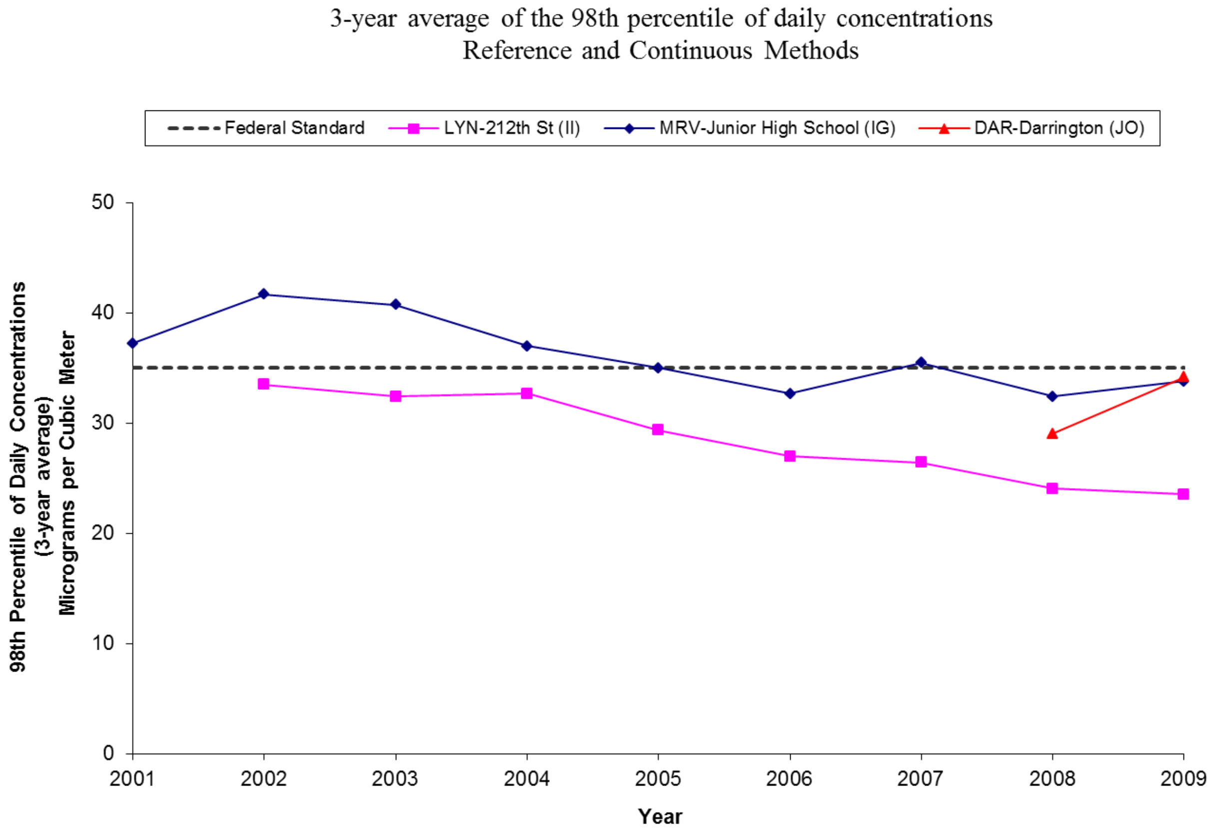


Figure 11: Daily $PM_{2.5}$ for Pierce County



Note: All South L data are FRM from 2000- 2009. Alexander Avenue data are FRM from 1999-2002 and nephelometer from 2003-2009. South Hill data are FRM from 1999-2002 and nephelemeter from 2003-2004; incomplete nephelometer data was collected from South Hill in 2005.

Figure 12: Daily $PM_{2.5}$ for Snohomish County

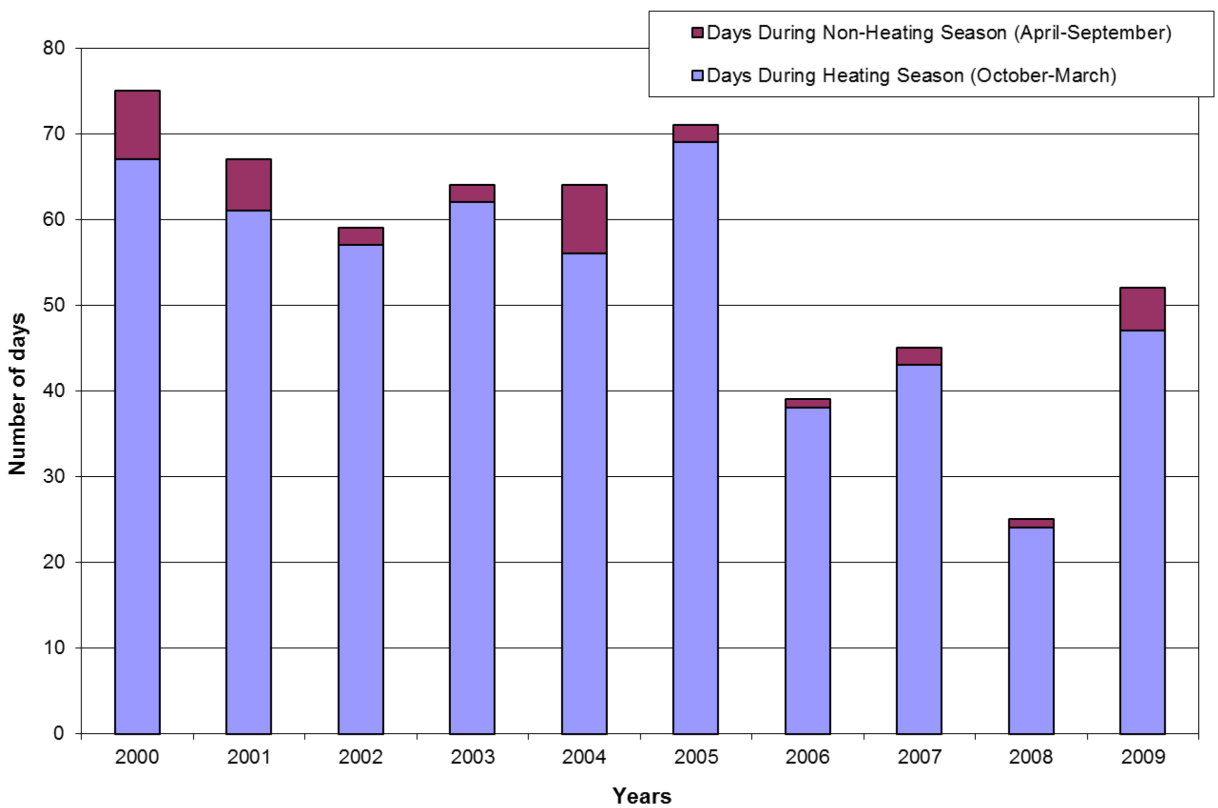


Note: Marysville data are FRM from 1999-2009. Lynnwood (II) data are FRM except 2004, 2007-2009 which were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007-2009.

As described in the Air Quality Standards and Health Goals section, the agency also has a daily fine particulate health goal. Many of the monitoring sites in King, Pierce, and Snohomish Counties exceed the agency's daily fine particulate health goal of 25 μg/m^3 for a 24-hour average. This health goal is intended to never be exceeded (unlike the federal standard that is based on the 98th percentile of a 3-year average).

Figure 13 shows the number of days the health goal is exceeded annually in the region, from 2000 to 2009. The shading demonstrates that our highest fine particulate days overwhelmingly take place during the winter wood heating months. While the graph indicates that we may be making slow 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 13: Days Exceeding the $PM_{2.5}$ Health Goal at One or More Monitoring Sites



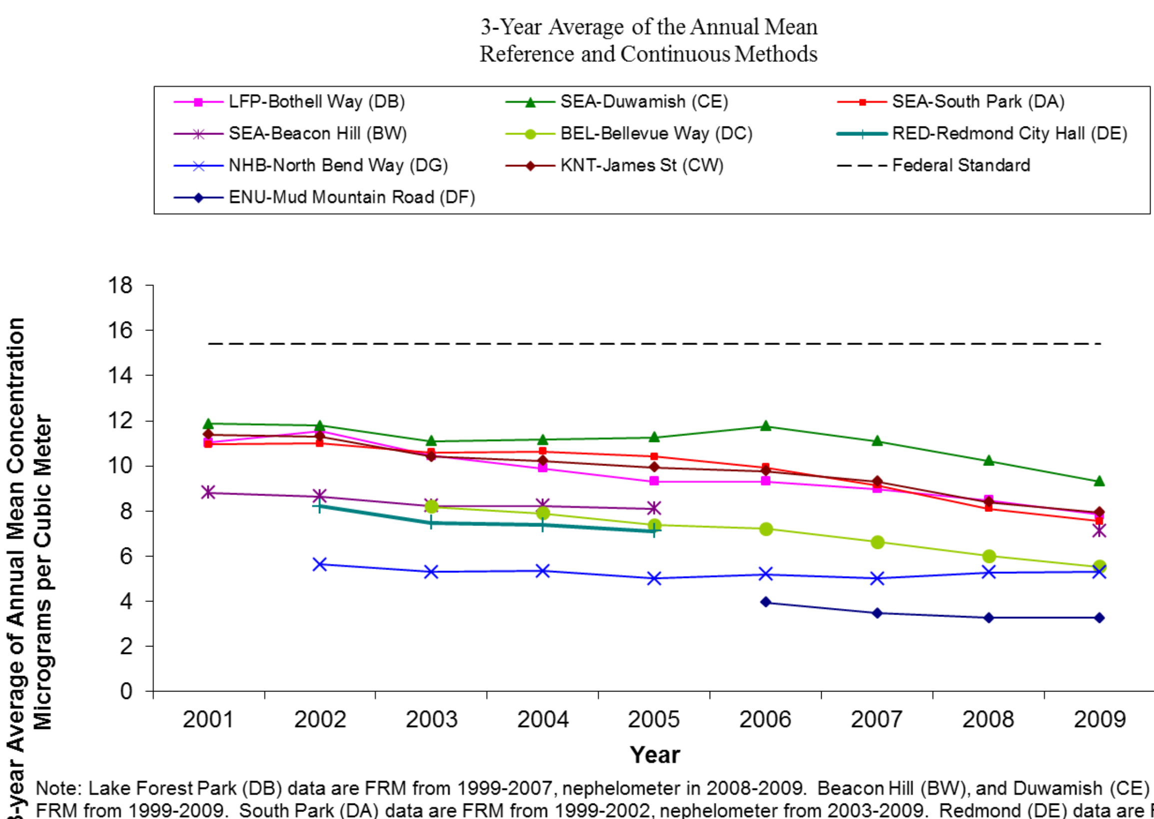
Includes data from all sites in King, Kitsap, Pierce, and Snohomish counties, both daily and continuous methods. The Darrington monitor was added in 2004.

PM$_{2.5}$ Annual Federal Standard

The Puget Sound airshed has been in compliance with the annual PM$_{2.5}$ standard since the EPA promulgated it in 1997. The annual standard was not updated when EPA revised the 24-hour standard in 2006. Figures 14 through 17 show annual averages at each monitoring station for King, Kitsap, Pierce, and Snohomish Counties and the federal annual standard. Figure 15 doesn't show any 2008 or 2009 data for Kitsap County. This is because monitoring at the Silverdale site was discontinued, and the Bremerton site had equipment problems for part of the 2008, resulting in an incomplete dataset. Figures 14 through 17 show data from both 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 actually an average for three consecutive years. For example, the value shown for 2009 is the average of the annual averages for 2007, 2008, and 2009.

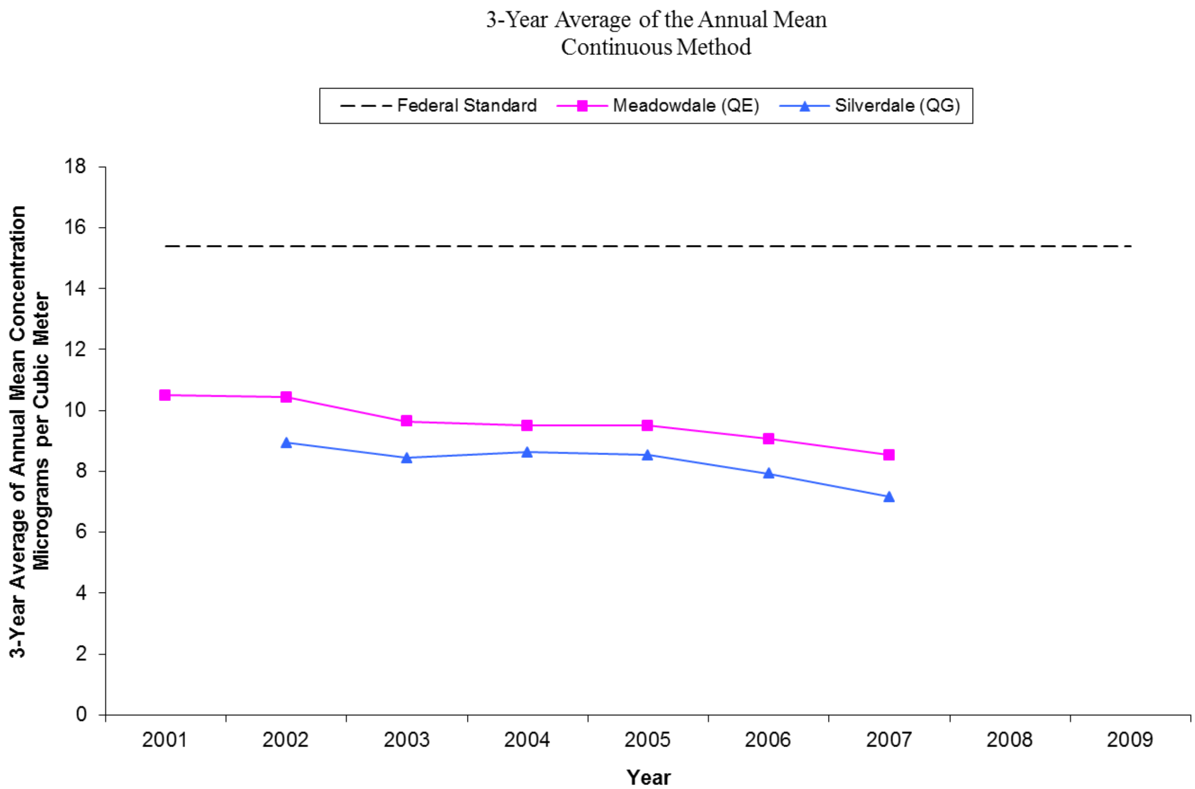
The agency's Particulate Matter Health Committee did not recommend an annual PM$_{2.5}$ health goal lower than the federal annual standard (15 μg/m^3).

Figure 14: Annual PM$_{2.5}$ for King County



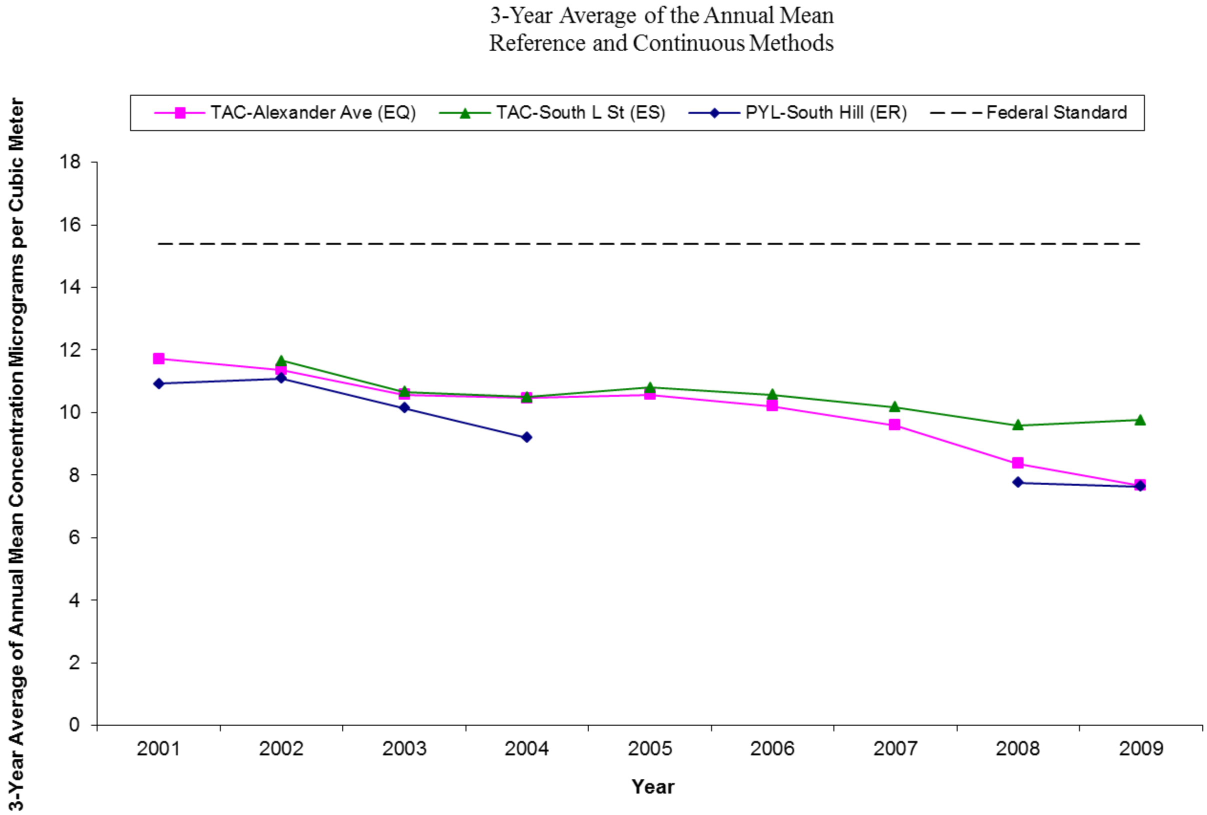
Note: Lake Forest Park (DB) data are FRM from 1999-2007, nephelometer in 2008-2009. Beacon Hill (BW), and Duwamish (CE) data are FRM from 1999-2009. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2009. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue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

Figure 15: Annual $PM_{2.5}$ for Kitsap County



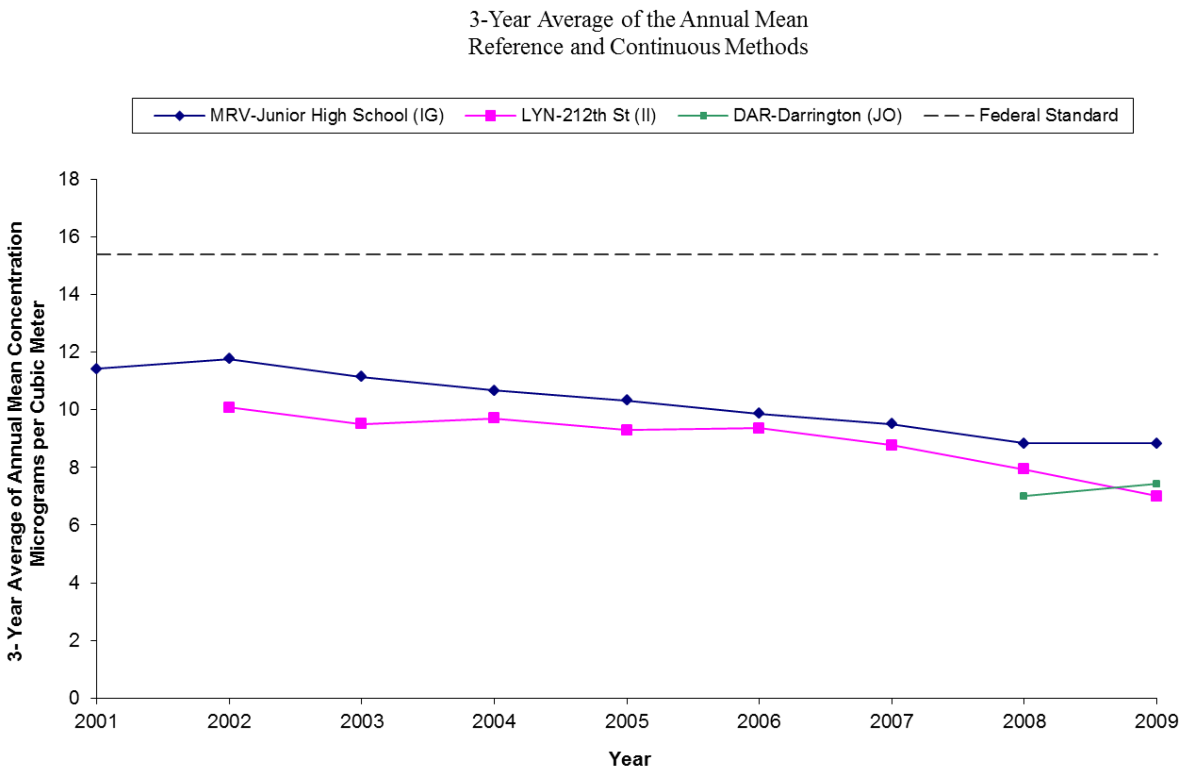
Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor) 1999-2005, nephelometer 2006-2009.

Figure 16: 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, 2008-2009 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002. Alexander Ave (EQ) data 2003-2009 was measured with a nephelometer.

Figure 17: Annual $PM_{2.5}$ for Snohomish County



Note: Marysville (IG) data are FRM from 1999-2009. Lynnwood (II) data are FRM except 2004, 2007-2009. The 2004, 2007-2009 values for Lynnwood were measured with a nephelometer. Darrington (JO) data are neph in 2006, FRM in 2007 - 2009.

$PM_{2.5}$ 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 that you are interested in.

PARTICULATE MATTER – $PM_{2.5}$ SPECIATION AND AETHALOMETERS

The methods described above show the total amount of fine particulate matter, but do not tell us anything about chemical composition. 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.[23,24,25]

Two methods help to inform us about the type of fine particulate matter present in our area: source apportionment modeling of speciation data, and aethalometers.

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. These filters are weighed and analyzed to determine the makeup of fine particulate at that site. Over 60 species are measured at speciation monitors in the area. Each species and its annual average concentration are shown on page A-11 of the Appendix. These data can then be 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.

Our Agency and Ecology conducted speciation monitoring at five monitoring sites in the Puget Sound region in 2009:

- Seattle Beacon Hill – typical urban impacts, mixture of sources (speciation samples collected every third day, operated by Ecology)
- Seattle Duwamish – urban industrial area, impacts from industrial sources and diesel emissions (speciation samples collected every sixth day, operated by PSCAA)
- Tacoma South L – urban residential area, impacts from residential wood combustion (speciation samples collected every sixth day, operated by Ecology)
- Tacoma Tideflats – urban industrial area, impacts from industrial sources and diesel emissions (speciation samples collected every sixth day, operated by PSCAA)
- Marysville – residential area, impacts from wood combustion (speciation samples collected every sixth day, operated by Ecology)

Several researchers have used speciation data from these sites to better understand air quality. 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. Using a mass reconstruction equation to simplify analytes into five broad categories, we can look

[23] Puget Sound Air Toxics Evaluation, October 2003; http://www.pscleanair.org/airq/basics/psate_final.pdf.
[24] Tacoma and Seattle Air Toxics Evaluation, October 2010: http://www.epa.gov/ttn/amtic/files/20072008csatam/PSCAA_CommunityAssessment_FR.pdf
[25] Ogulei, D. WA State Dept of Ecology (2010). "Sources of Fine Particles in the Wapato Hills-Puyallup River Valley PM2.5 Nonattainment Area". Publication number 10-02-009.

at main contributors to mass when fine particle levels are highest, and compare sites.[26,27] Major constituents of fine particulate matter in our region include:

- Organic and Elemental Carbon – Largely from combustion sources.
- Sulfate and Nitrates – Formed in the atmosphere from sulfur and nitrogen oxides, SO_x and NO_x. The largest sources of SO_x and NO_x in our area are on-road and non-road mobile sources (gasoline and diesel fuels). Large industrial sources also contribute substantially to SO_x (about 20%). Voluntary and regulatory programs that have started reducing the sulfur content in fuels will begin to reduce the SO_x and sulfates in our area.
- A "soil" component comprised of analytes typically associated with crustal materials – The soil fraction includes aluminum, silicon, calcium, iron, titanium, and potassium.

Figures 18 through 25 show simplified, major contributors at the speciation sites for the 2009 samples (annual average), as well as on the highest concentration days. Because speciation samples are collected on either every third or sixth day schedules, it's not possible to capture some of the most elevated concentration days (for samples > 20 $\mu g/m^3$). This schedule results in only a handful of samples represented in the 'highest concentration' pie charts below (five samples for Tacoma South L, five for Tacoma Tideflats, two for Seattle Duwamish, and none for Seattle Beacon Hill and Marysville).

All the sites show organic carbon as the main contributor to $PM_{2.5}$ mass, with an increase in carbon on the most elevated fine particulate days. Organic carbon comes from combustion sources, and most notably from wood smoke. Highest percentages of organic carbon come from sites where wood smoke is more prominent, especially the Tacoma South L site.

[26]Brook, Dann, and Burnett. The Relationship Among TSP, PM_{10}, $PM_{2.5}$, and Inorganic Constituents of Atmospheric Particulate Matter at Multiple Canadian Locations. Journal of Air & Waste Management. Volume 47: pp 2-19. January 1997. Page 6 includes a mass reconstruction equation for soil components.

[27]Jeffrey Brook and Tom Dann. Contribution of Nitrate and Carbonaceous Species to $PM_{2.5}$ Observed in Canadian Cities. Journal of Air & Waste Management. Volume 49: pp 193-199. February 1999. Results demonstrate that organic carbon concentrations should be multiplied by a factor of roughly 1.4 to account for the molecular form.

Figure 18: Tacoma South L Average Contributions 2009

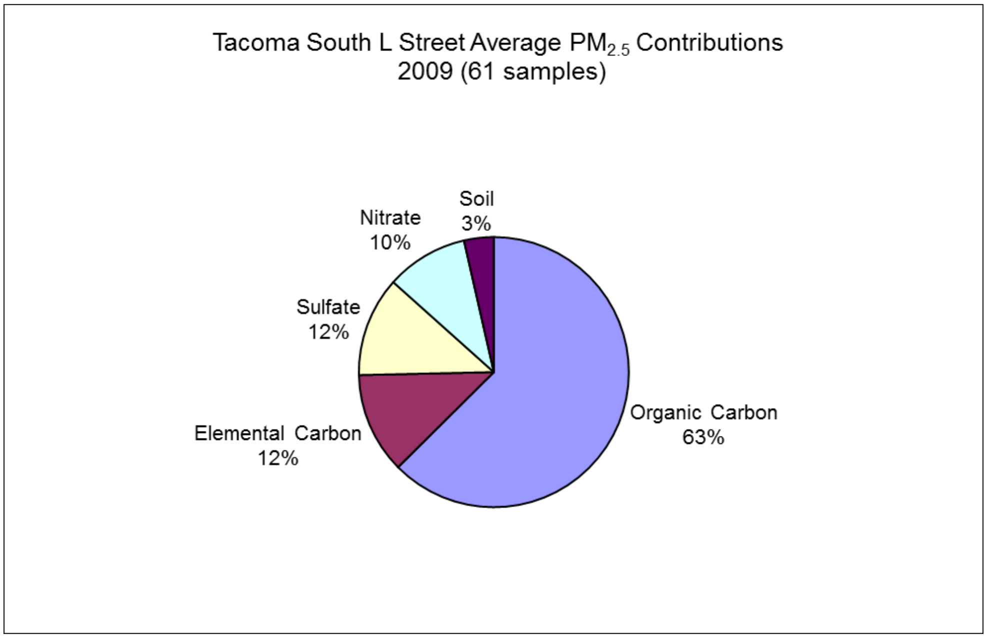


Figure 19: Tacoma South L Contributions on Highest Days 2009 (5 samples over 20 $\mu g/m^3$)

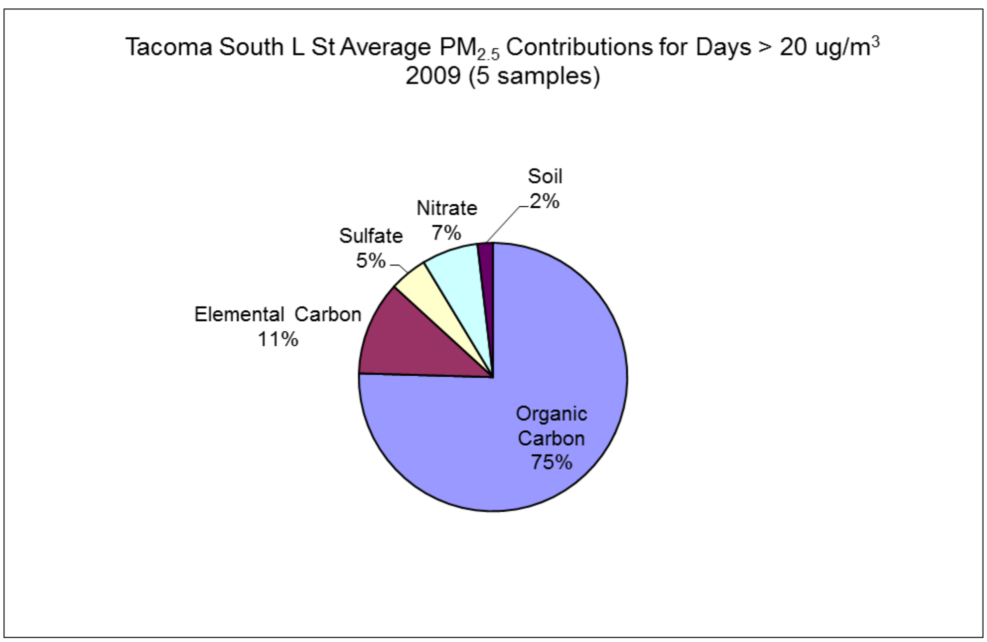


Figure 20: Tacoma Tideflats Average Contributions 2009

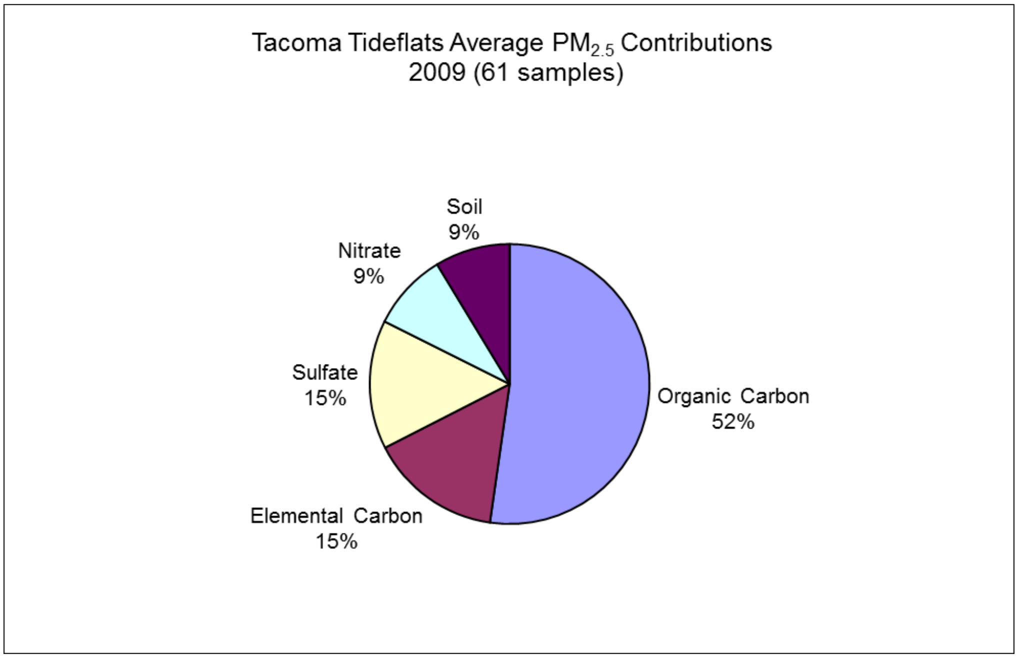


Figure 21: Tacoma Tideflats Contributions on Highest Days 2009 (5 samples over 20 $\mu g/m^3$)

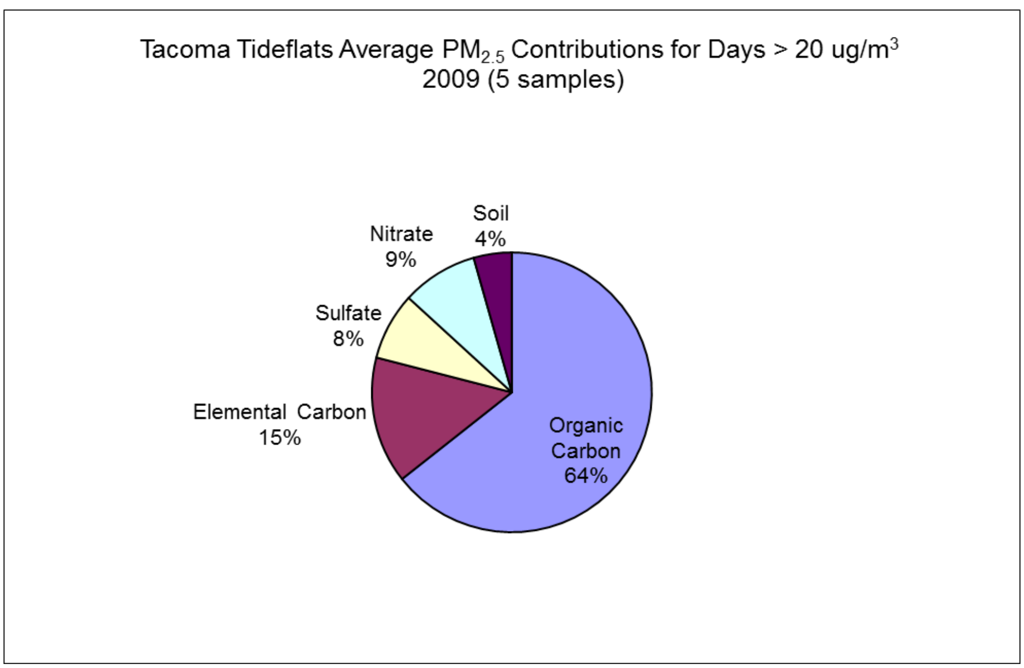


Figure 22: Seattle Duwamish Average Contributions 2009

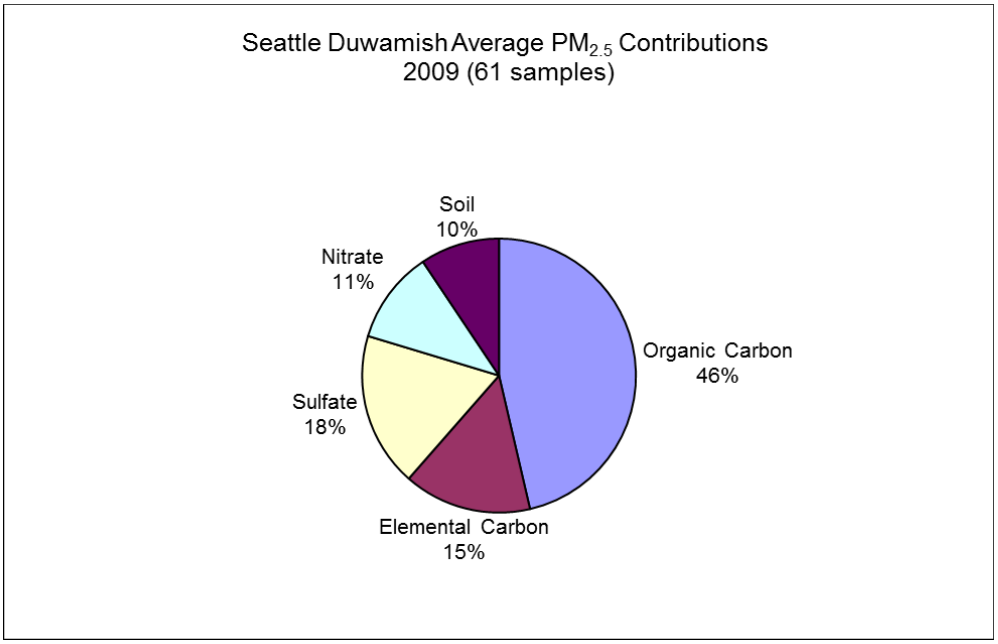


Figure 23: Seattle Duwamish Contributions on Highest Days 2009 (2 samples over 20 $\mu g/m^3$)

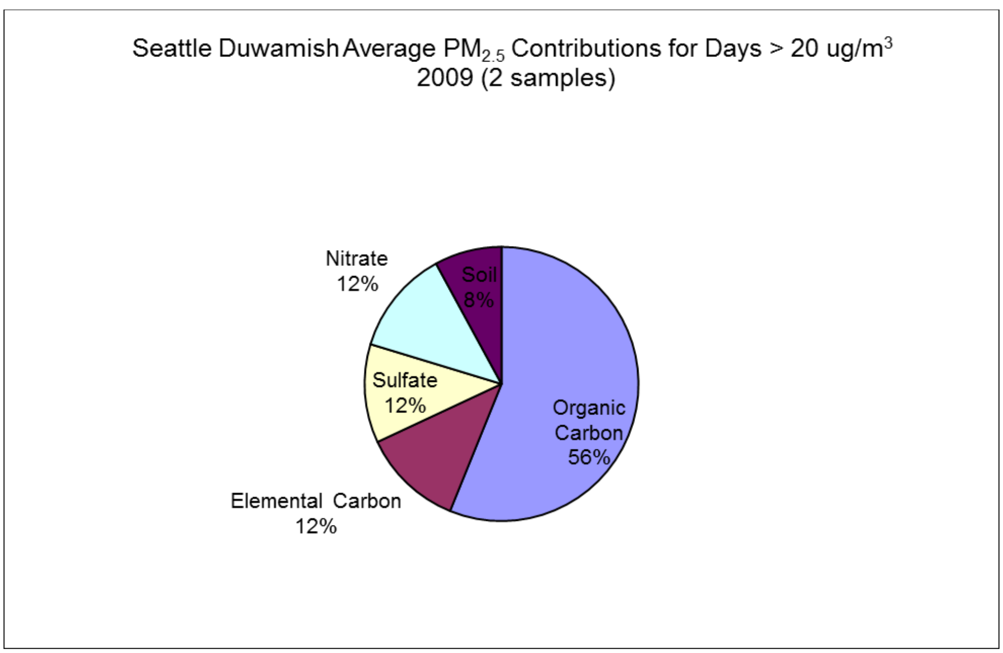
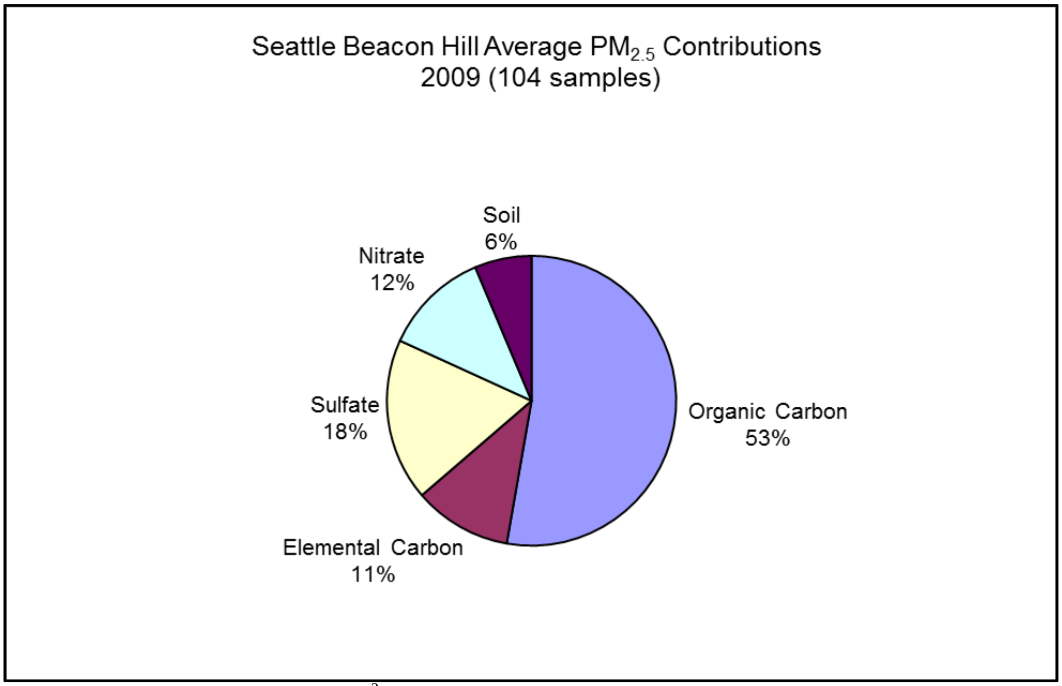
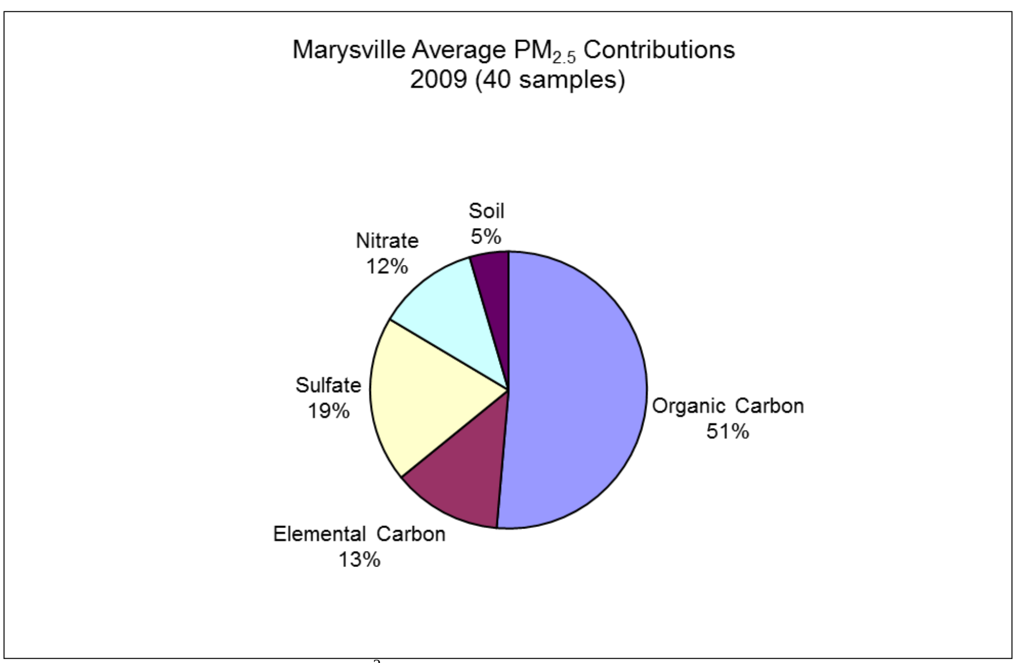


Figure 24: Seattle Beacon Hill Average Contributions 2009*



*There were no samples over 20 $\mu g/m^3$ over this period.

Figure 25: Marysville Average Contributions 2009*



*There were no samples over 20 $\mu g/m^3$ over this period. Sampling in Marysville started April 7, 2009.

AETHALOMETER DATA

Aethalometers are monitoring instruments that provide information about the carbon fraction of fine particulate matter. Aethalometers continuously measure light absorption to estimate carbon concentrations. The aethalometer measures two channels, black carbon (BC) and ultraviolet (UV). The instrument translates information into concentrations; concentrations from the black carbon channel correlates 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 carbon are related to diesel particulate, wood smoke particulate, and particulate from other combustion sources.[28] Unfortunately, neither are uniquely correlated 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 http://www.pscleanair.org/airq/Aeth-Final.pdf.

A statistical summary of aethalometer black carbon data is presented on page A-12 of the Appendix.

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

OZONE

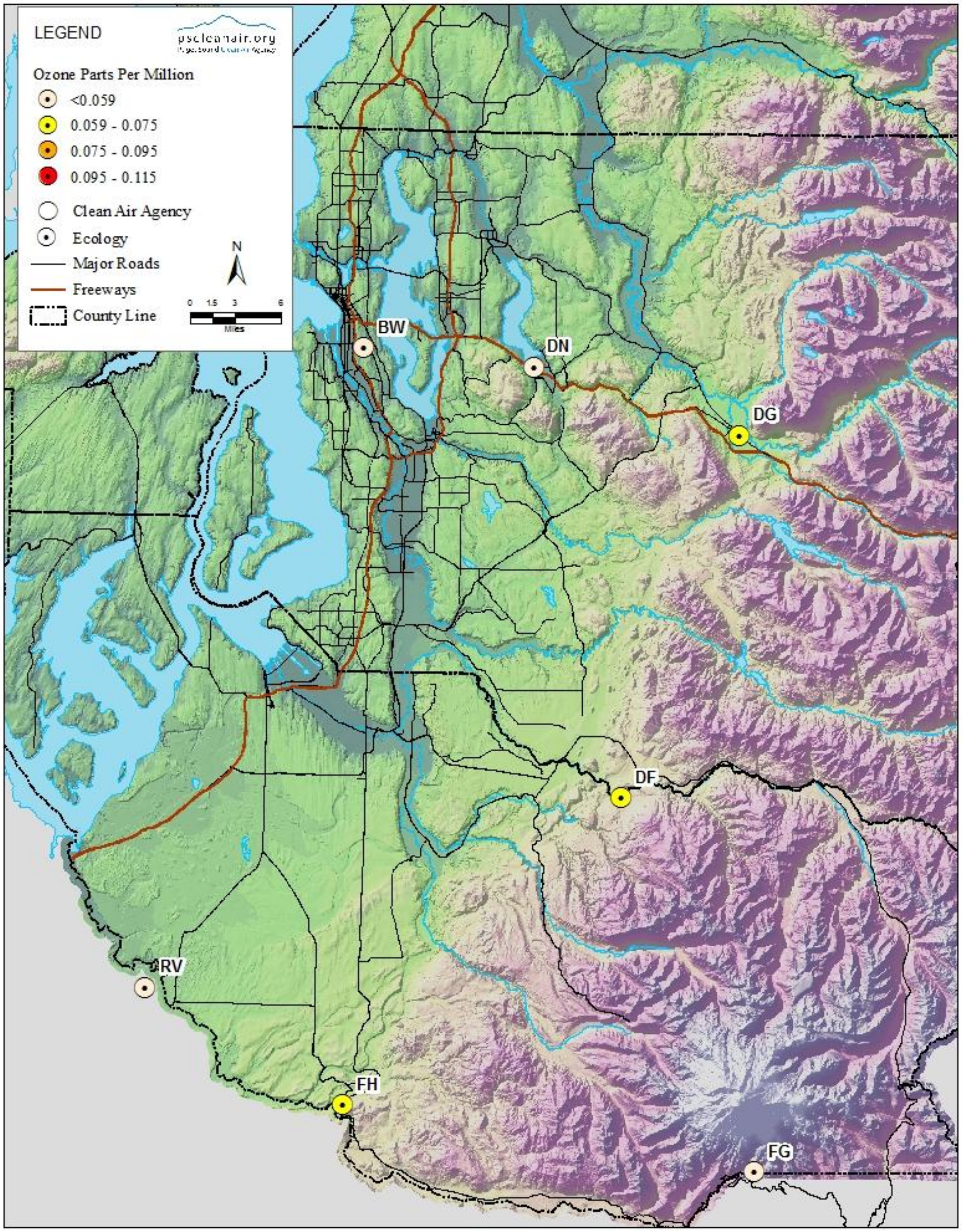
Ozone is a summertime air pollution problem and is not directly emitted by pollutant sources. Ozone forms when photochemical pollutants react with sunlight. These pollutants are called ozone precursors and include volatile organic compounds (VOC) and nitrogen oxides (NO_x), with some influence by carbon monoxide (CO). These precursors come from anthropogenic sources such as mobile sources and industrial and commercial solvent use, as well as natural sources (biogenics). Ozone levels are usually highest in the afternoon because of the intense sunlight and the time required for ozone to form in the atmosphere. Ozone levels are highly affected by weather. The Washington State Department of Ecology currently monitors ozone from May through September, as this is the time 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.[29] Ozone has also been linked to immune system impairment.[30] 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.[31]

The majority of 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 has typically been transported 10 to 30 miles downwind from their source by the time the highest ozone concentrations have formed in the afternoon and early evening. Regional meteorology inhibits regular production of elevated ozone levels. As shown on Map 3, the highest ozone concentrations occur at monitors southeast of the urban area (especially the Enumclaw and Pack Forest monitors, labeled DF and FH on the map).

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

Map 3: Ozone 3-year Average of 4th Highest 8-hr Value for 2009



* Seattle Beacon Hill was down most of 2006 and has fewer data points to calculate the 98th percentile 3-year average.

Figure 26 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. EPA expressed intent to strengthen the standard in 2010 further,[32] but delayed any decision until at least July 2011.[33]

Figure 26 shows that the Enumclaw Mud Mountain monitor violated the 2008 8-hour ozone standard for the period 2006 through 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 2009 design value is 0.073 ppm, which does not violate the 2008 standard. The highest 2009 8-hour ozone concentration of 0.084 ppm was recorded at both the North Bend and Enumclaw Mud Mountain monitors.

As of the publication of this report, the Puget Sound area will not be designated nonattainment under the (2008) 0.075 ppm standard. Considering the EPA has expressed its intent to strengthen the standard to 0.070 ppm or lower, it is highly likely that the region would be designated nonattainment in the future.

Figure 27 presents 8-hour average data for the months of May through September, the months when ozone levels are greatest. The early June and late July ozone episodes when levels reached the AQI "unhealthy for sensitive groups" category, are apparent.

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

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

[32] EPA. EPA to Reconsider Ozone Pollution Standards; http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. September 2009.
[33] EPA. 2008 Revised Ground-Level Ozone Standards; http://www.epa.gov/air/ozonepollution/actions.html.

Figure 26: Ozone for Puget Sound Region

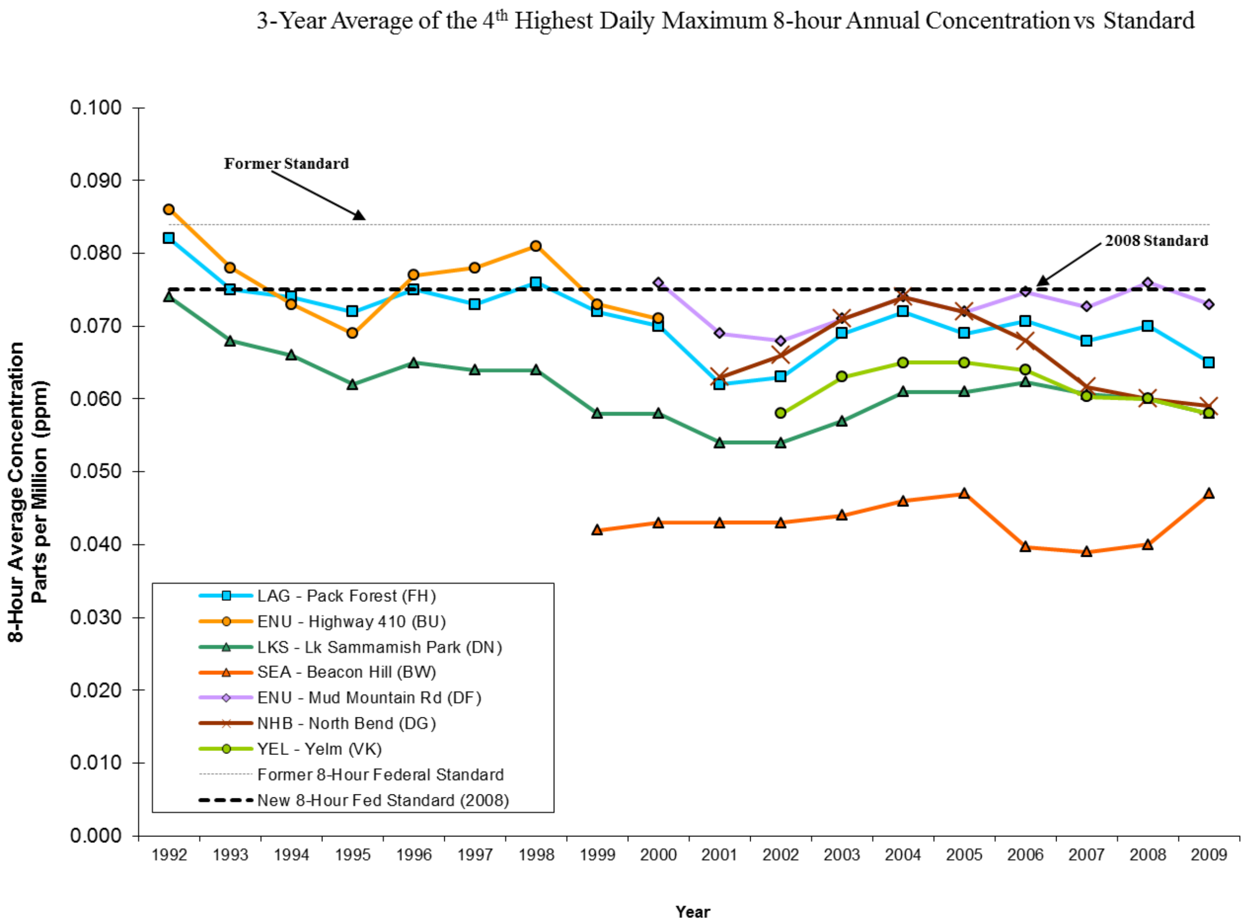
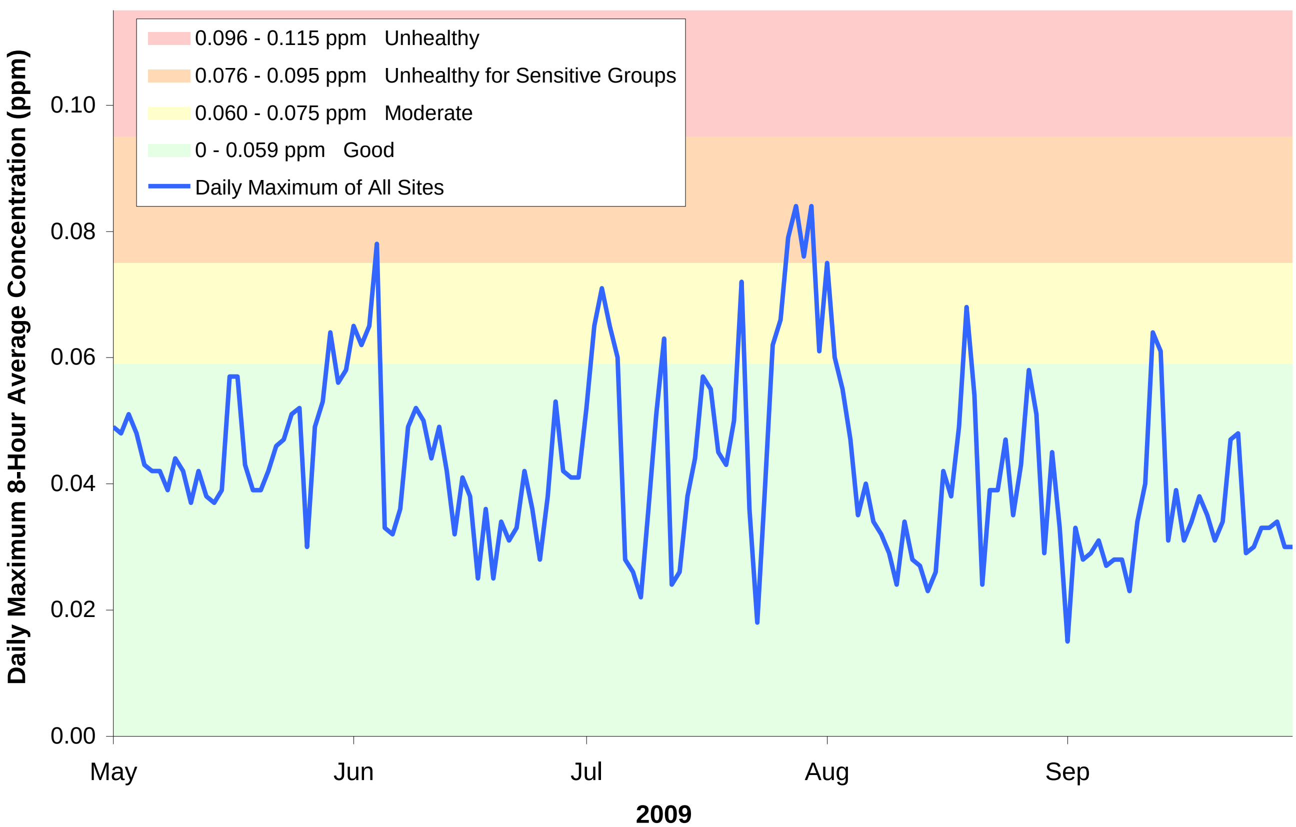


Figure 27: Ozone (O_3) for Puget Sound Region May-September 2009



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.[34] 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 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. NO_2 in itself is not considered a significant pollution problem in the Puget Sound area. However, NO_x emissions are important as they affect ozone and nitrate formation.

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 notroxyl 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 PAN can be important contributors to the formation of ozone and fine particulate matter. The additional notroxyl compounds are generally present in much lower concentrations than NO_2 (or NO_X). Figure 28 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 notroxyl compounds. The annual average for each year has consistently been less than half of the 2009 federal standard, as shown in Figure 28 and in the statistical summary on page A-14 of the Appendix.

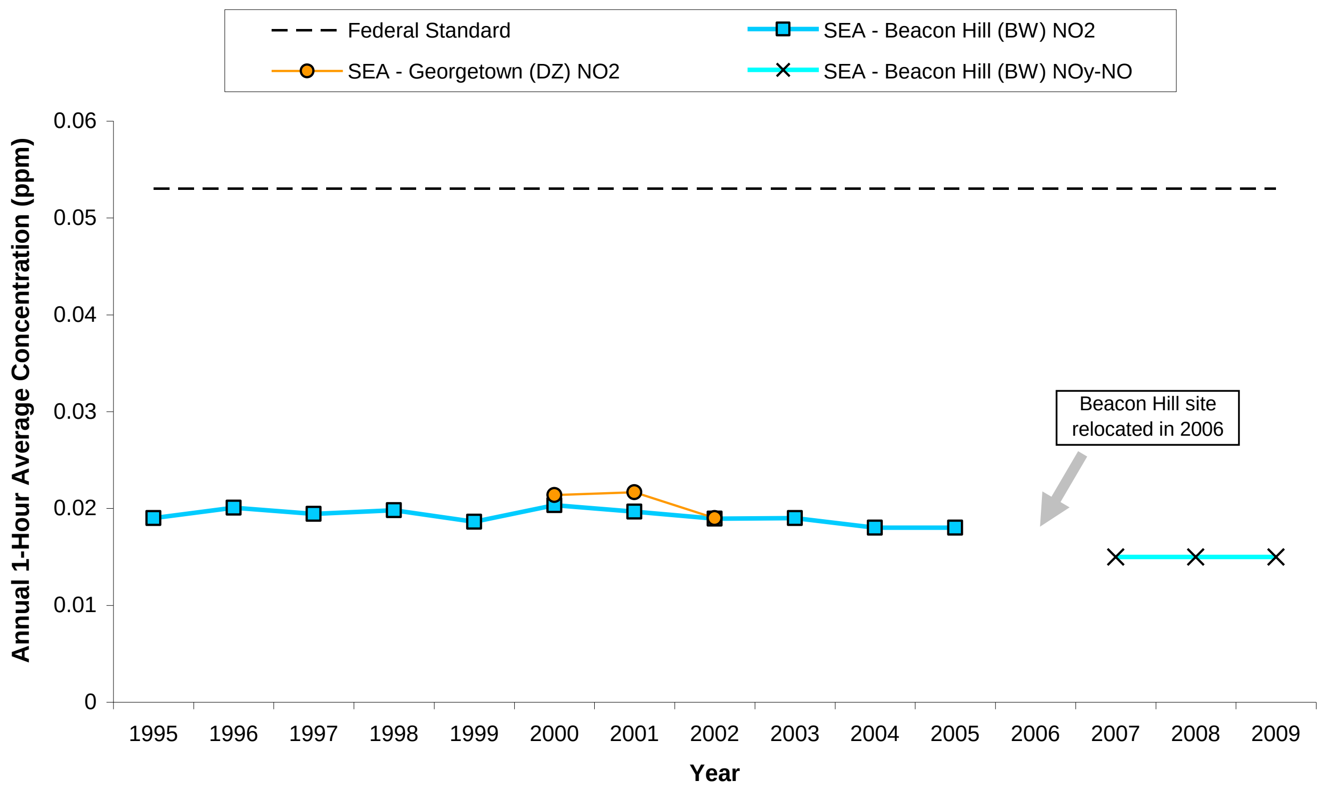
The maximum 1-hour average of NO_Y- NO, measured in 2009, was 0.070 ppm on June 3. Visit www.epa.gov/air/nitrogenoxides/ for additional information on NO_2.

EPA promulgated a 1-hour national ambient air quality standard for nitrogen dioxide on January 22, 2010. [35] The new 1-hour standard (100 ppb or 0.1 ppm) is calculated as the 3-year average of the 98th percentile of the highest daily 1-hour value. 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. However, potential changes to where NO_2 (or NO_Y) is monitored (for example, closer to roadways) may have result in higher values.

[34] EPA, Airnow, NO_X Chief Causes for Concern; http://epa.gov/air/urbanair/nox/chf.html.

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

Figure 28: Nitrogen Dioxide (NO_2) (1995-2005) and Reactive Nitrogen (NO_Y) - NO (2007-2009)



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 burned 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.

Ecology conducts all of the CO monitoring in the region. Historically, CO monitoring stations are located in areas with heavy traffic congestion. These include central business areas, roadsides, and shopping malls. Although urban portions of the Puget Sound region violated the CO standard for many years, CO levels have decreased significantly in the Puget Sound area, 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 Bellevue 148th Ave site and the Beacon Hill site ran during 2009.

The CO national ambient air quality standard is based on the 2nd highest 8-hour average. Figure 29 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 2009 was 2.7 parts per million (ppm) and occurred on February 4 at the Bellevue site.

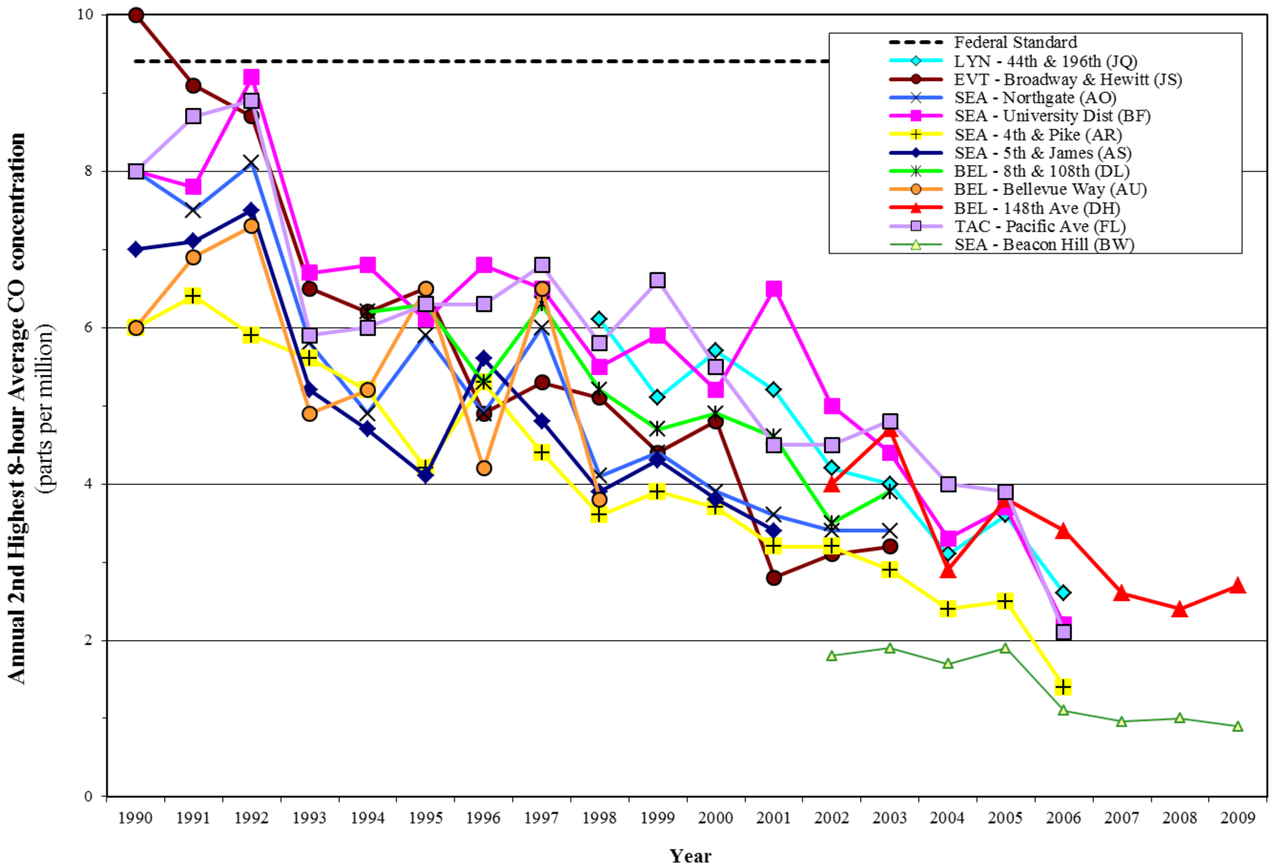
The EPA federal standards also include a 1-hour standard for CO of 35 ppm, not to be exceeded more than once a year. Measured 1-hour concentrations in the Puget Sound area are historically much lower than the 35 ppm standard, and therefore 1-hour CO trends are not graphed.

EPA completed a NAAQS review for carbon monoxide in January 2011, and proposed that the standards remain unchanged, although required monitoring locations will likely be modified. EPA plans to issue the final rule by August 2011. [36]

Statistical summaries for 8-hour average CO data are provided on page A-15 of the Appendix. For additional information on CO, visit www.epa.gov/air/urbanair/co/index.html.

[36] US EPA. Proposed Rule for the National Ambient Air Quality Standards for Carbon Monoxide. January 2011. http://www.epa.gov/airquality/carbonmonoxide/pdfs/COFactSheet.pdf.

Figure 29: 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.

People with asthma who are active outdoors may 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. Monitoring sites for SO_2 were historically sited in or near former 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.

Figures 30 and 31 show the maximum 24-hour and 1-hour concentrations, respectively, at individual monitoring sites. The July 1994 spike shown on these graphs was the result of a short-term release from an Everett paper mill. The maximum measured SO_2 concentrations in 2009 were below all federal and regional standards. The maximum 1-hour and 24-hour Beacon Hill averages in 2009 were 0.053 ppm on September 8 and 0.008 ppm on both February 4 and August 2, respectively.

EPA changed the SO_2 1-hour average standard to 0.075 ppm in June 2010. The 2009 1-hour SO_2 standard of 0.40 ppm is shown in this report.

Statistical summaries for SO_2 data from the Beacon Hill site are available on page A-16 of the Appendix.

Additional information on SO_2 is available at www.epa.gov/air/urbanair/so2/index.html.

Figure 30: Sulfur Dioxide (SO_2) 24-Hour Average for Puget Sound Region

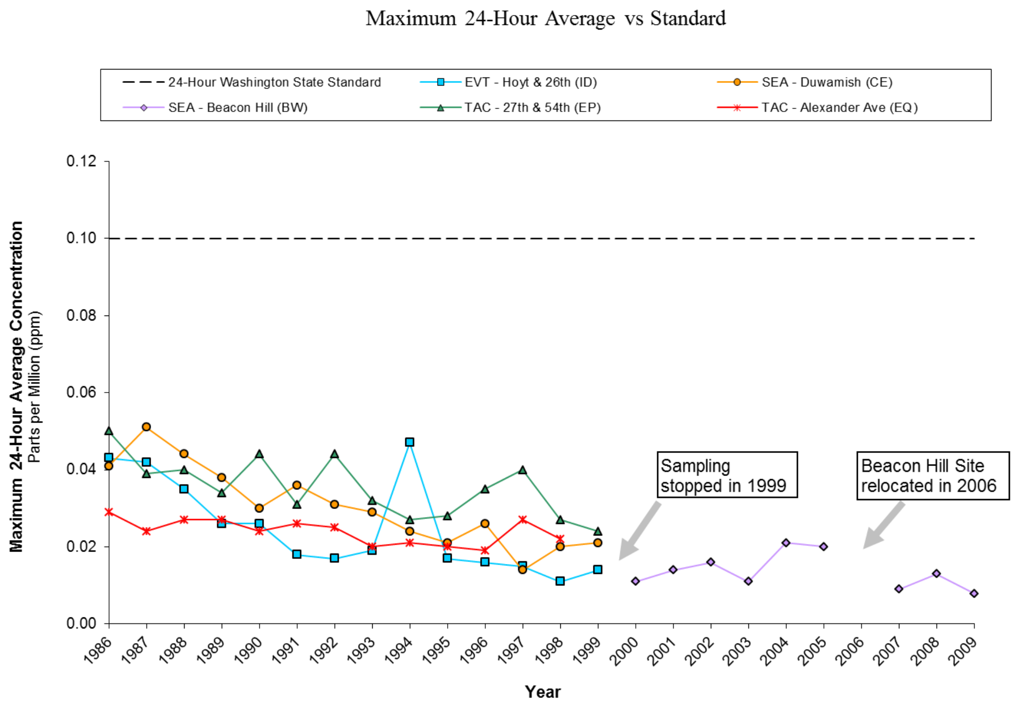
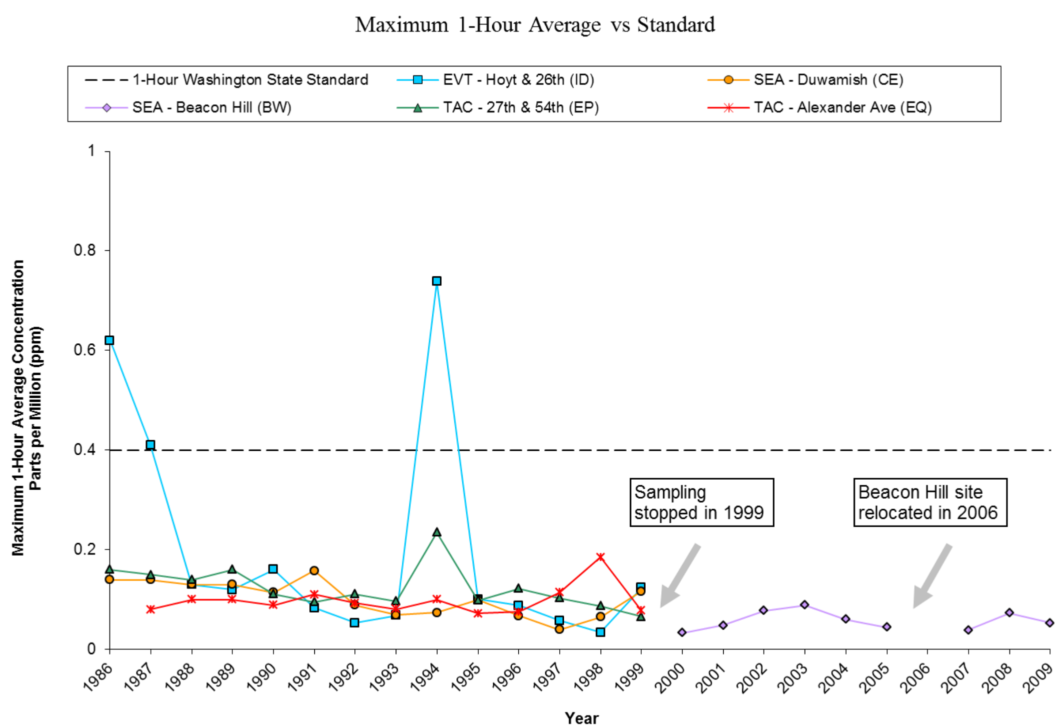


Figure 31: Sulfur Dioxide (SO_2) 1-Hour Average for Puget Sound Region



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 www.epa.gov/ttnatw01/hlthef/lead.html for ways to limit your exposure to these lead sources.

Lead has not been monitored for comparison to the federal standard in the Puget Sound area since 1999.[37] 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 http://www.pscleanair.org/news/library/reports/2007AQDSFinal.pdf.

In October 2008, EPA strengthened the lead standard from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$.[38] As part of this rulemaking, EPA initiated a pilot lead monitoring program that focuses on lead from aviation gasoline at small airports. This monitoring will take place in 2012, and we will include results of the pilot study in future reports.

For additional information on lead, visit www.epa.gov/air/lead.

[37] Lead is a pollutant that is both a criteria air pollutant and an air toxic. Lead is no longer monitored by FRM as a criteria air pollutant in Puget Sound; however, the lead fraction of $PM_{2.5}$ is measured at speciation monitors.

[38] US EPA, National Ambient Air Quality Standard for Lead, FinalRule. Federal Register, November 12, 2008; http://www.epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf.

VISIBILITY

There are no separate federal or state standards established for visibility. Visibility data is presented (without comparison to a standard) as an indicator of air quality. Visibility is often 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 an objective approach to measuring visibility at a specific location, but does not address individual perceptions regarding the "quality" of a view on a given day.

Reduced visibility is caused by weather such as clouds, fog, and 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. Fine particles have a greater impact than coarse particles at locations far from the emitting source because they remain suspended in the atmosphere longer.

Figures 32 through 36 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 miles, which is more intuitive. The nephelometer cannot account for meteorological effects on visibility such as cloudiness, so the visibility in these graphs is only related to particulate matter. Nephelometer data are shown on page A-9 of the Appendix.

The red line on the graphs represents the monthly average visibility. The large fluctuations are due to seasonal variability. The summer months typically have better visibility while the winters are usually worse. The blue line shows the average of the previous 12-months. This average (called a moving average) smooths out much of this 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 caused by meteorology. For the 20-year period from December 1990 through December 2009, the 12-month moving average increased from 49 miles to 81 miles.

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

Figure 32: Puget Sound Visibility

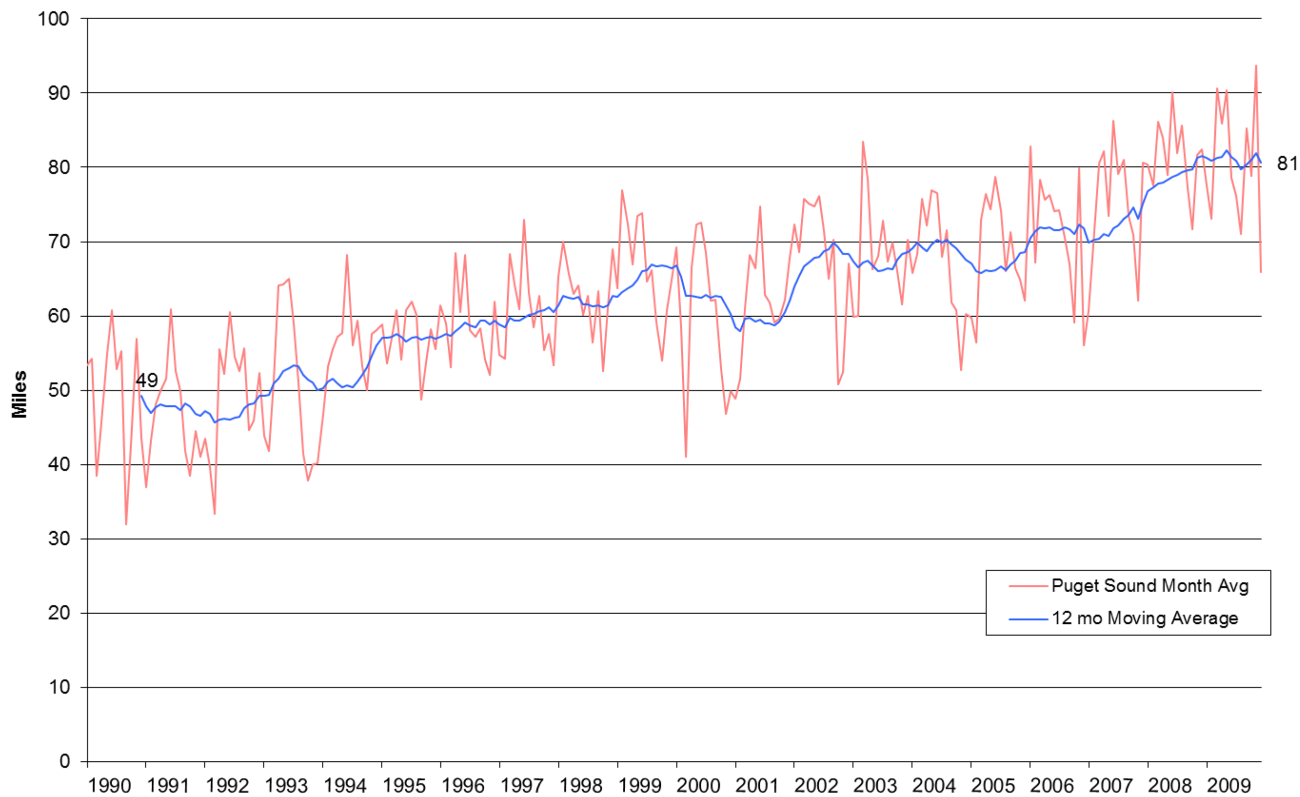


Figure 33: King County Visibility

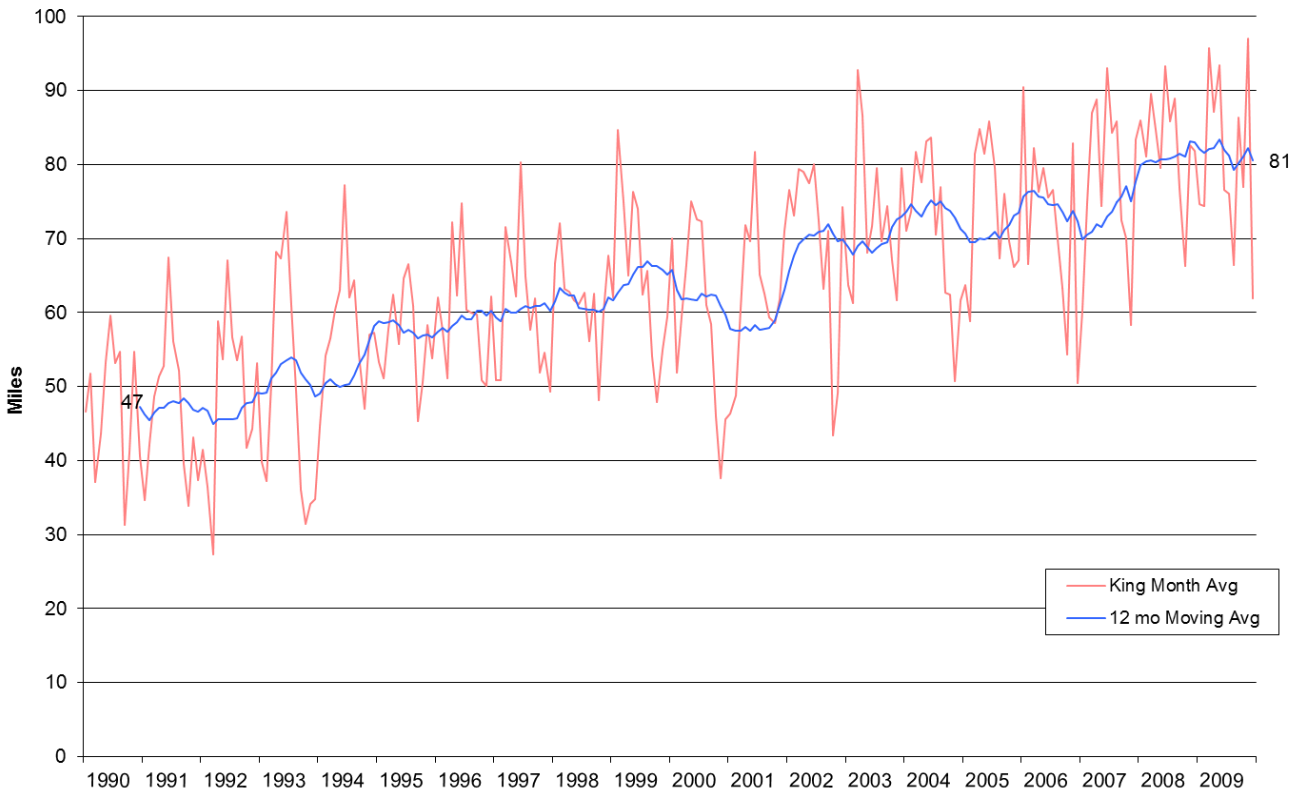


Figure 34: Kitsap County Visibility

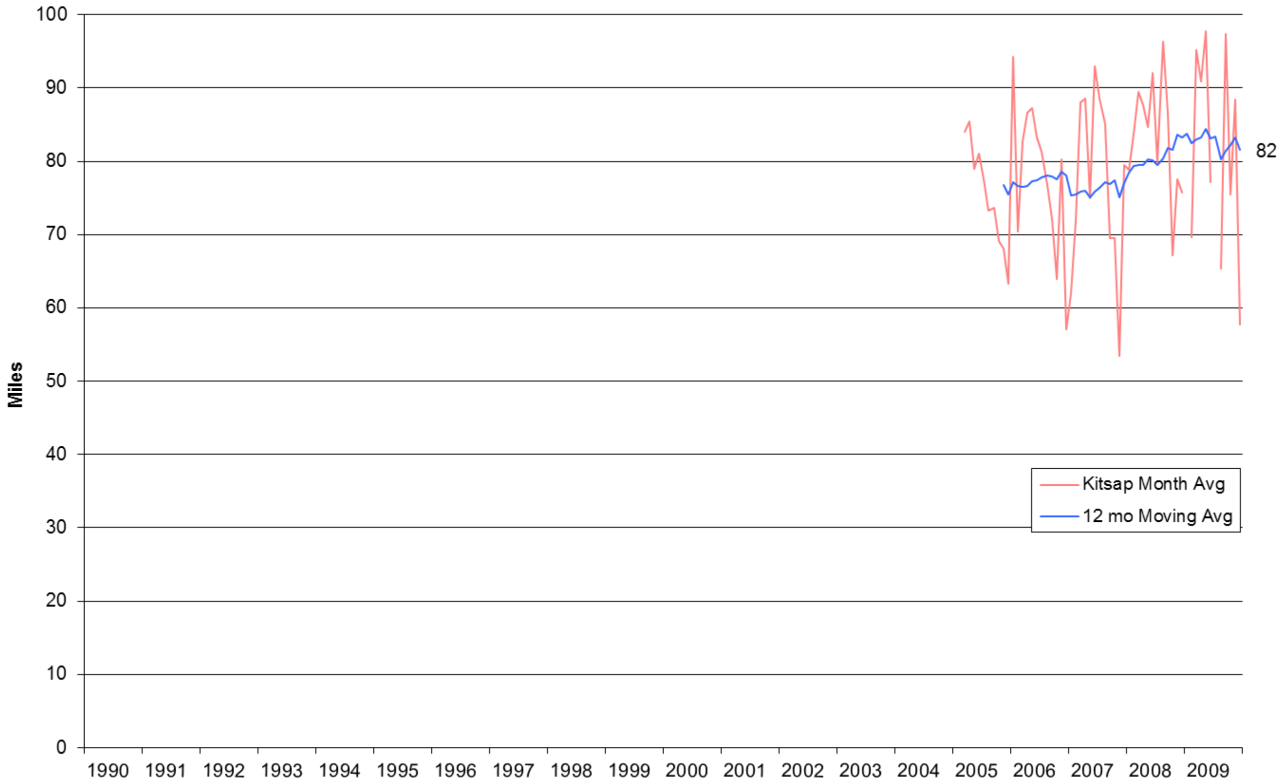


Figure 35: Pierce County Visibility

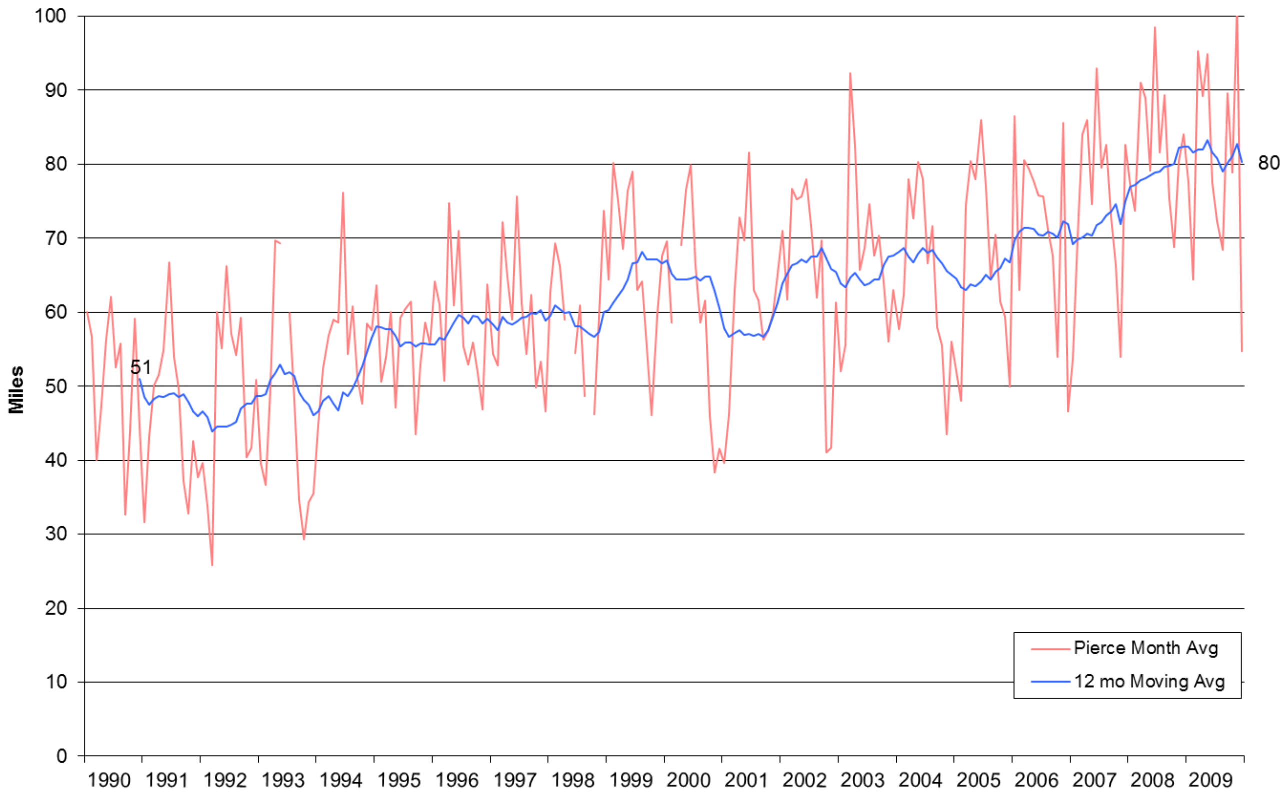
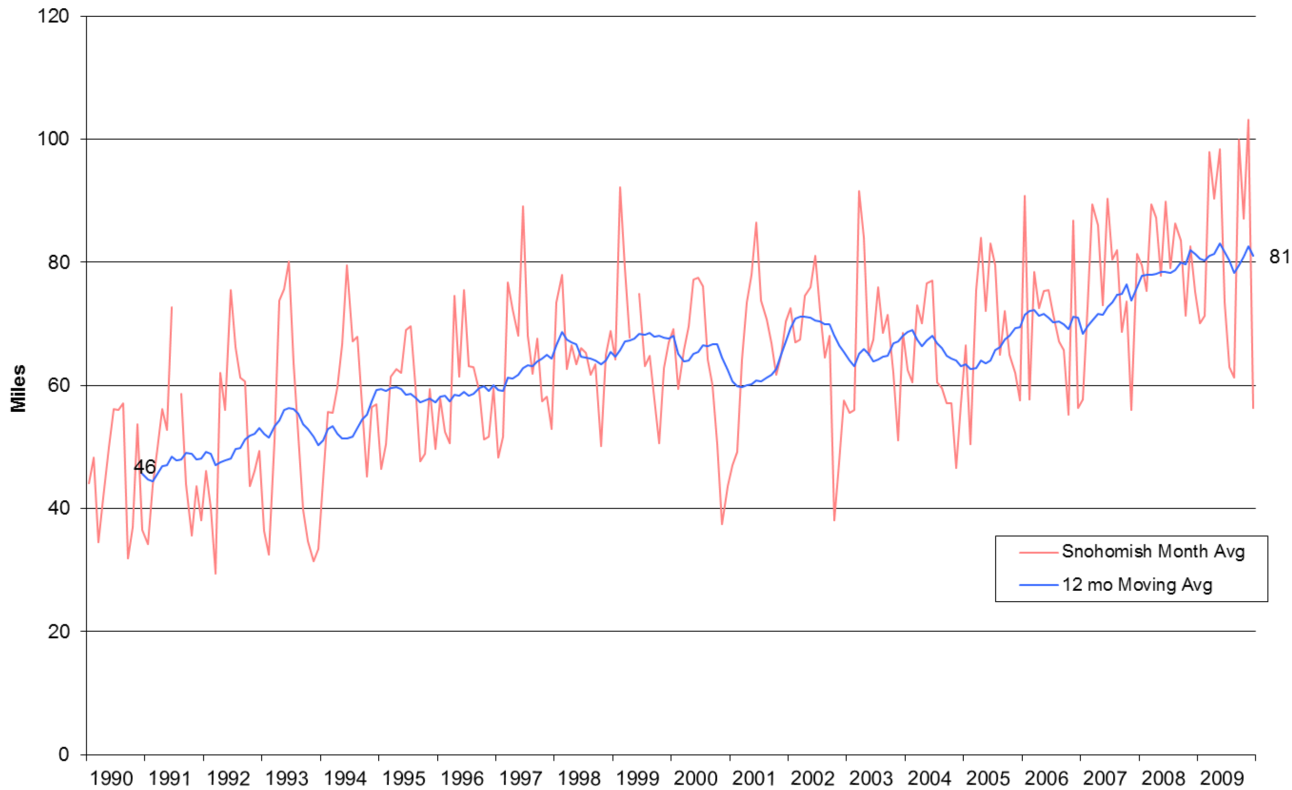


Figure 36: Snohomish County Visibility



AIR TOXICS

Washington State Department of Ecology (Ecology) monitored for air toxics in 2009 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 in 2006). 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 http://www.pscleanair.org/news/library/reports/2010_Tacoma-Seattle_Air_Toxics_Report.pdf.

For general information on air toxics, see http://www.pscleanair.org/airq/basics/airtoxics.aspx. Air toxics statistical summaries are provided on page A-17 of the Appendix.

RELATIVE RANKING BASED ON CANCER RISK & UNIT RISK FACTORS

Table 4 ranks 2009 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 community's or individual's potential 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.[39]

For details on how air toxics were ranked, please see pages A-18 and A-19 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 4) are presented on page A-20 of the Appendix. Page A-20 also lists the frequency (percentage) of samples that were over the cancer screening level of one-in-a-million risk.

[39] US EPA, A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets. EPA-904-B-06-001, February 2006; http://www.gpoaccess.gov/harvesting/airtoxics.pdf.

Table 4: 2009 Beacon Hill Air Toxics Ranking
(Average Potential Cancer Risk Estimate per 1,000,000)

Air Toxic	Rank	Average Potential Cancer Risk*
Carbon Tetrachloride	1	32
Benzene	2	23
1,3-Butadiene	3	12
Formaldehyde	4	6
Chromium 6 TSP	5	5
Chloroform	6	3
Naphthalene	7	3
Acetaldehyde	8	3
Arsenic PM_{10} (M)	9	2
Tetrachloroethylene	10	<1
Dichloromethane	11	<1
Nickel PM_{10} (M)	12	<1
Cadmium PM_{10} (M)	13	<1
Trichloroethylene	14	<1
Lead PM_{10} (M)	15	<1
Vinyl Chloride	16	<1
Beryllium PM_{10} (M)	17	<1
Manganese PM_{10} (M)	18	na

*Risk based on unit risk factors as adopted in Washington State Acceptable Source Impact Level (WAC 173-460-150)[40]

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.

[40] Washington Sate Administrative Code. WAC 173-460-150. http://www.ecy.wa.gov/pubs/wac173460.pdf.

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, each air toxic was compared 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.[41] Monitoring for acrolein started in 2007. Due to the limited number of data points, a graph was not included in this report. Reference concentrations and hazard indices are shown for each air toxic on page A-20 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.

Acute non-cancer health effects were not explored, 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 2009 at Beacon Hill. A ten-year period is a relatively short time to characterize trends, and the annual average concentrations increase and decrease from year-to-year. 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 2009. Graphs are not presented for metals because fewer years of data are available, and few exceed potential cancer risk screening levels. Federal ambient air concentration standards have not been set for air toxics, so graphs do not include reference lines for federal standards.

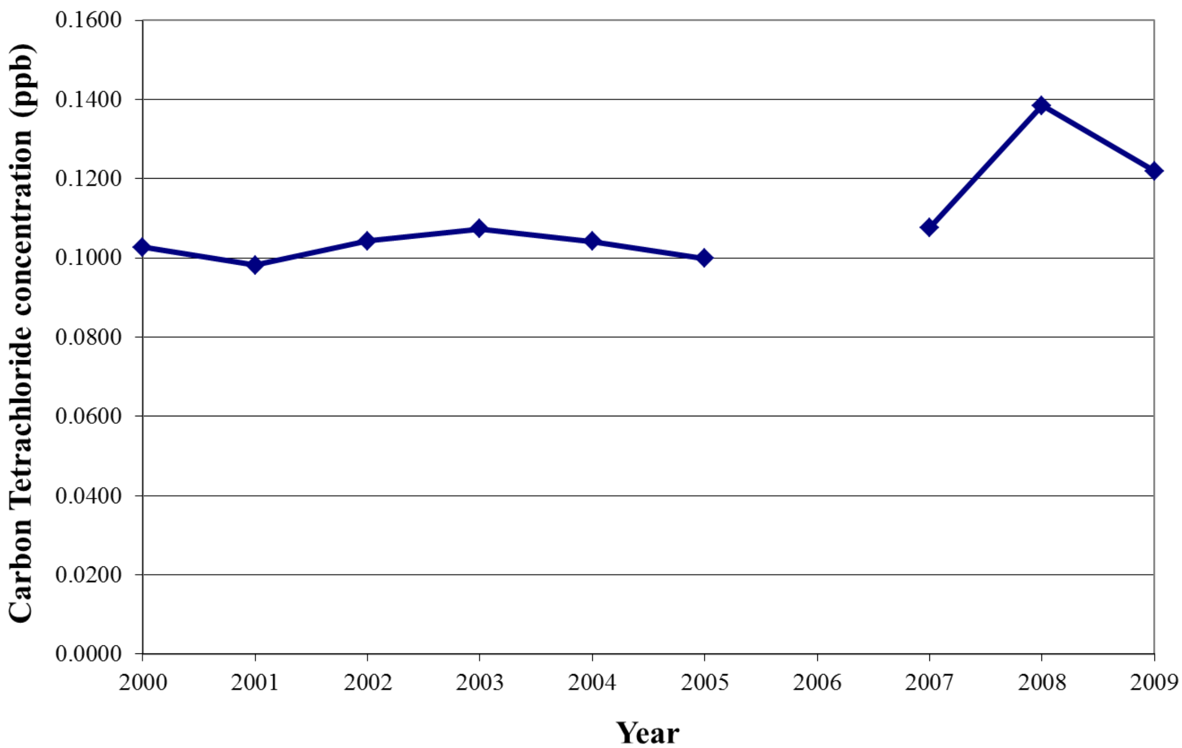
[41] EPA, Acrolein Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/acrolein.html.

Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[42] 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 2009 average potential cancer risk range estimate at Beacon Hill was 32 in a million.

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

Figure 37: Carbon Tetrachloride Annual Average Concentrations at Beacon Hill, 2000-2009



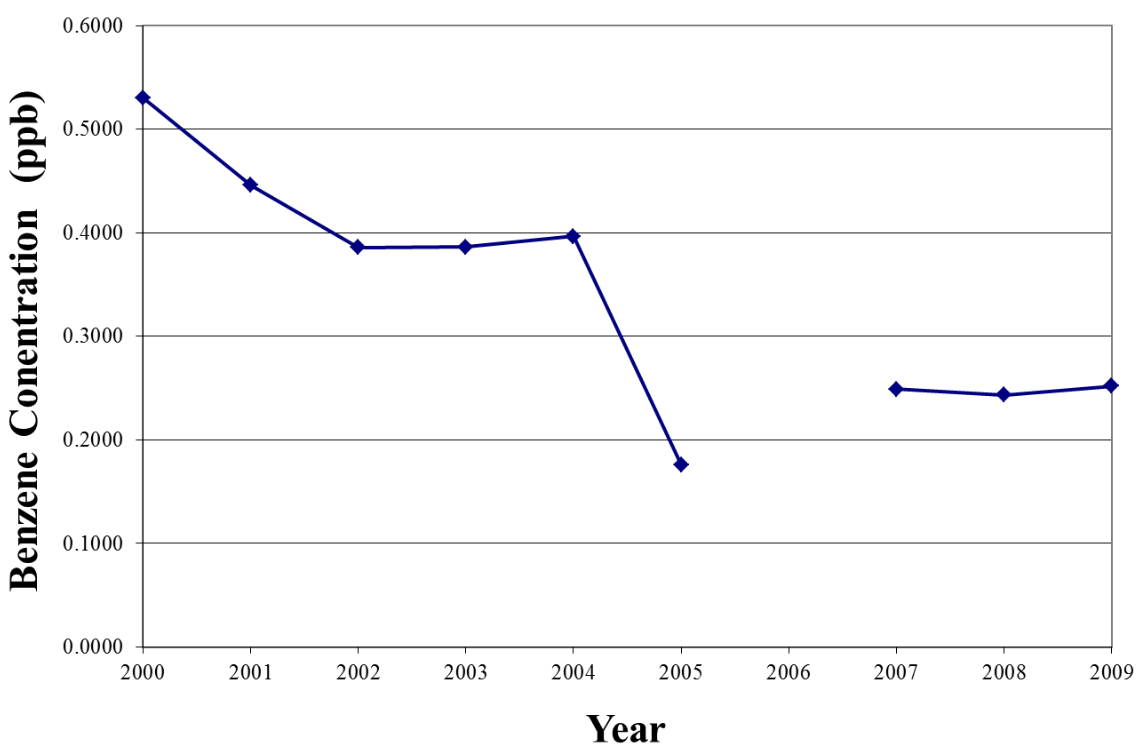
[42]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/carbonte.html.

Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune, and nervous system disorders.[43] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvents, and other combustion. Benzene's 2009 average potential cancer risk range estimate at Beacon Hill was 23 in a million.

Benzene levels are likely decreasing in our area due to factors including: less automobile pollution with newer, cleaner vehicles coming into the fleet; major refiners in the area reducing benzene gasoline content, and fewer gas station emissions due to better compliance (vapor recovery at the pump and during filling of gas station tanks).

Figure 38: Benzene Annual Average Concentrations at Beacon Hill, 2000-2009



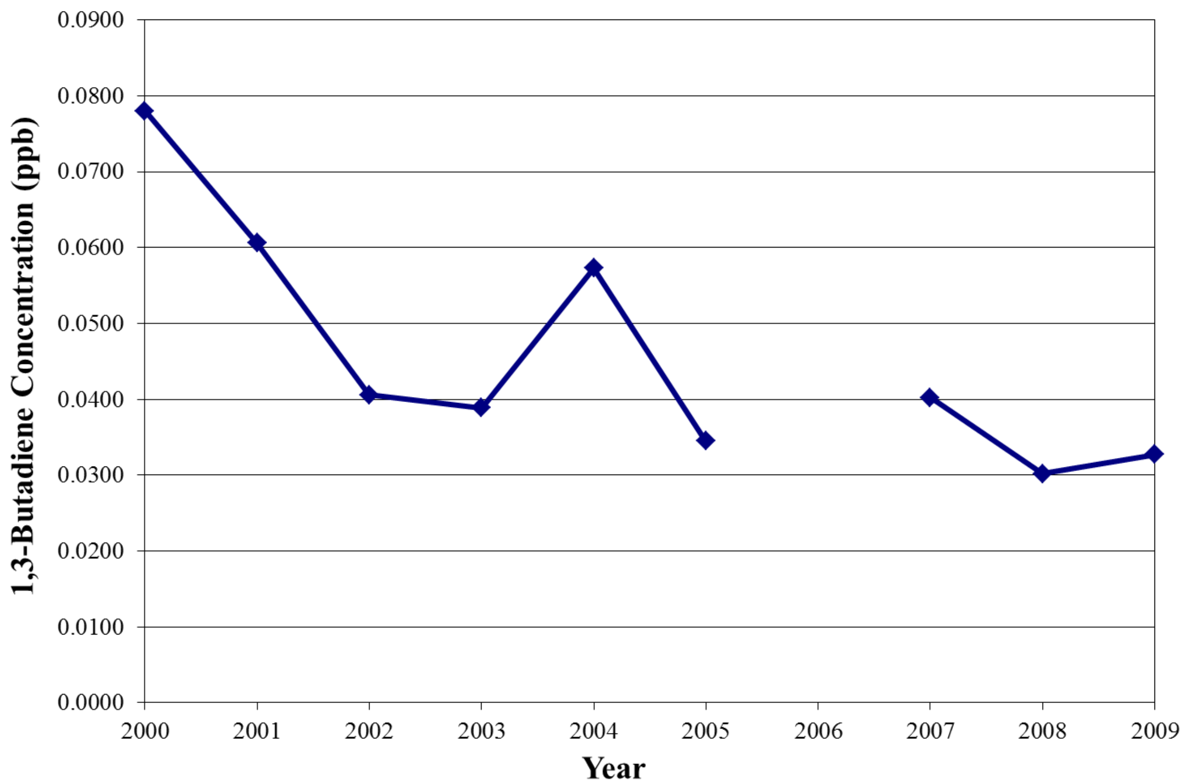
[43]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/benzene.html.

1,3-Butadiene

The EPA lists 1,3-butadiene as a known human carcinogen. 1,3-butadiene inhalation is also associated with neurological effects.[44] Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-butadiene's 2009 average potential cancer risk range estimate at Beacon Hill was 12 in a million.

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

Figure 39: 1,3-Butadiene Annual Average Concentrations at Beacon Hill, 2000-2009



[44]EPA Hazard Summary; http://www.epa.gov/ttnatw01/hlthef/butadien.html.

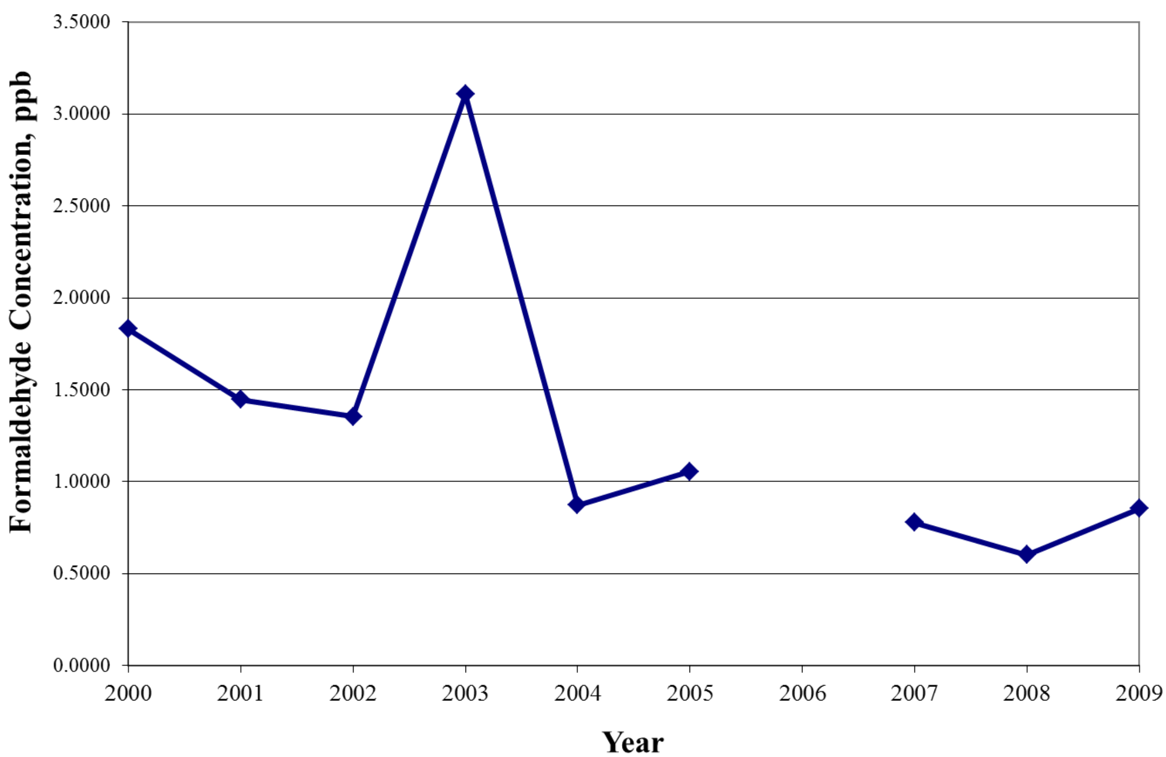
Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat, and lung irritation.[45] Sources of ambient formaldehyde include automobiles, trucks, wood burning, and other combustion. Formaldehyde's 2009 average potential cancer risk range estimate at Beacon Hill was 6 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 40: Formaldehyde Annual Average Concentrations at Beacon Hill, 2000-2009



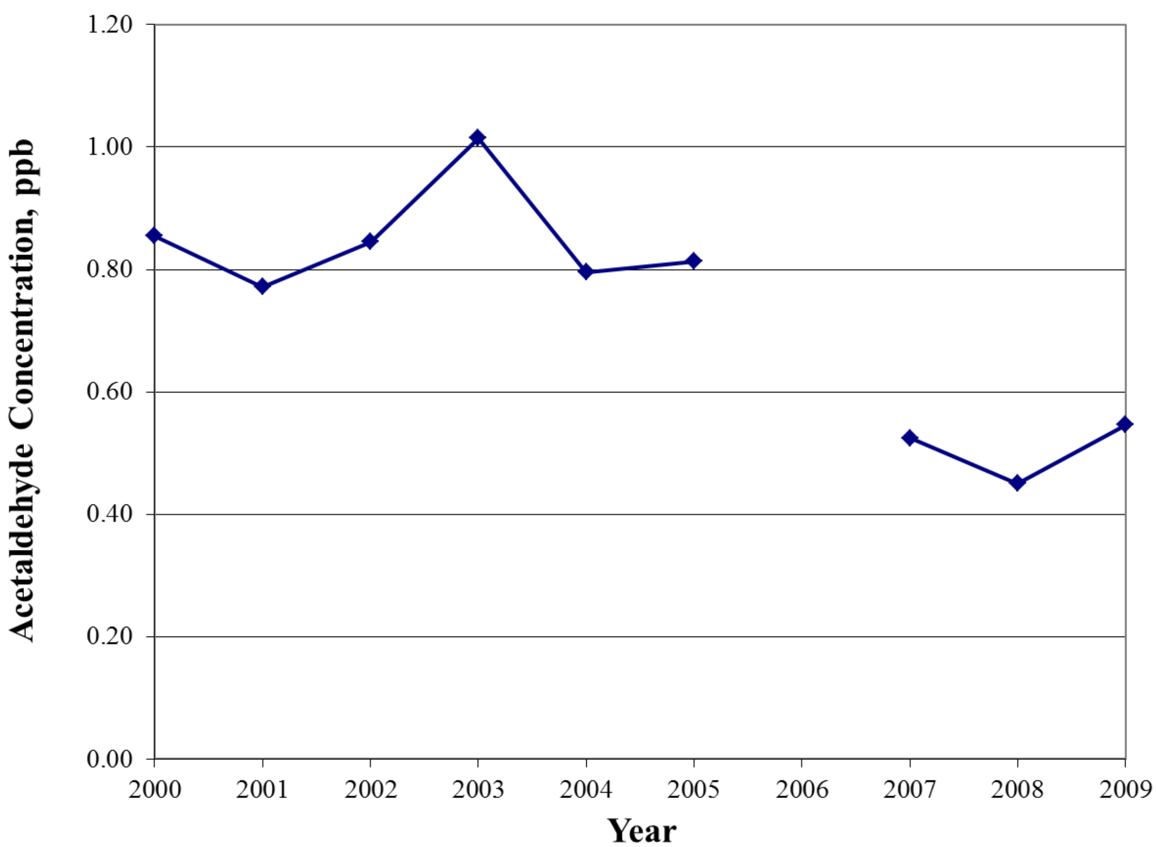
[45]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/formalde.html.

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.[46] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's 2009 average potential cancer risk estimate at Beacon Hill was 3 in a million.

Agency efforts that target vehicle exhaust and wood stove emission reductions also reduce acetaldehyde emissions.

Figure 41: Acetaldehyde Annual Average Concentrations at Beacon Hill, 2000-2009



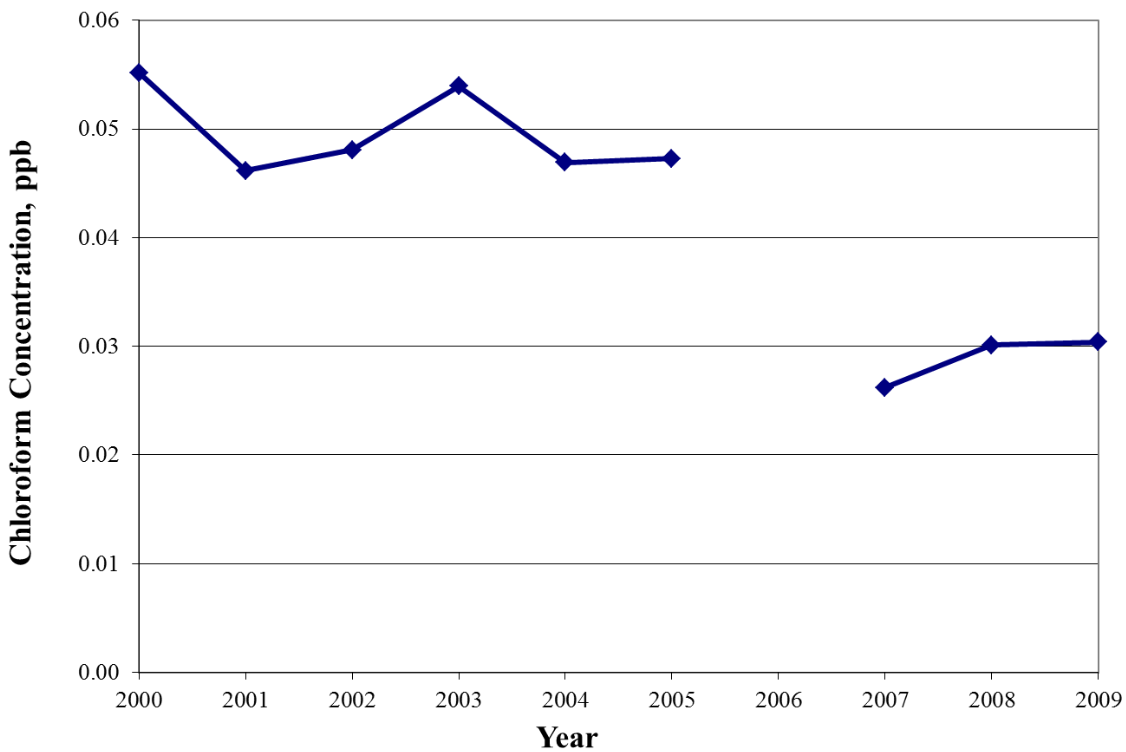
[46]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/acetalde.html.

Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is also associated with central nervous system effects and liver damage.[47] Main sources of chloroform are water treatment plants and reservoirs. The Beacon Hill monitoring site is located at the Beacon Hill reservoir; concentrations measured and risks estimated are likely not representative of actual regional concentrations and potential risk (they are likely higher than typical levels). Chloroform's 2009 average potential cancer risk range estimate at Beacon Hill was 3 in a million. The Beacon Hill 2006 monitor location change and 2006 covering of the Beacon Hill reservoir potentially contribute to reduced post-2005 chloroform emissions and concentrations.

The agency does not prioritize efforts to reduce chloroform emissions, as it doesn't likely present risk in areas other than those directly adjacent to reservoirs.[48]

Figure 42: Chloroform Annual Average Concentrations at Beacon Hill, 2000-2009



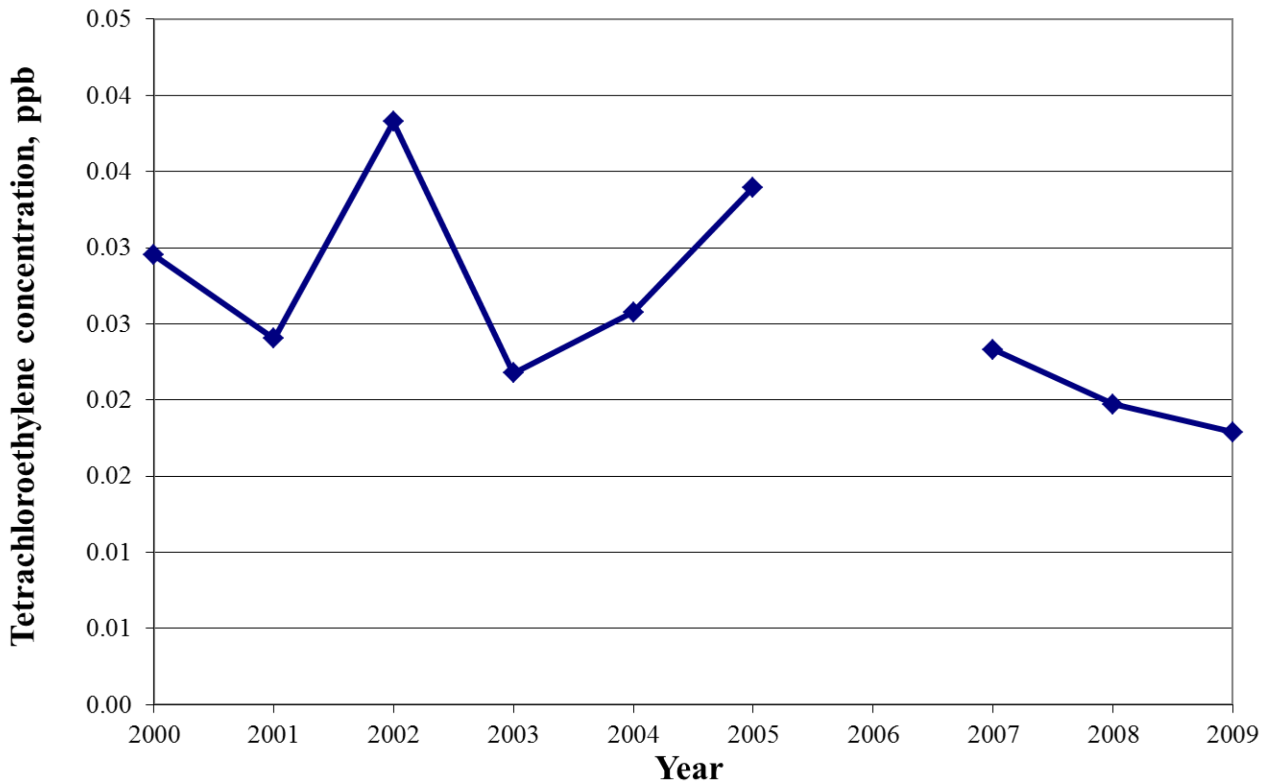
[47]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/chlorofo.html.
[48]Seattle Public Utilities. 2008 Water Quality Analysis shows detectable levels of trihalomethanes; http://www.seattle.gov/util/stellent/groups/public/@spu/@fom/documents/webcontent/spu01_003889.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform; http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Quality/GLOSSARYO_200312020916386.asp.

Tetrachloroethylene

EPA lists tetrachloroethylene, also known as "perc" or perchloroethylene, as a probable human carcinogen. Tetrachloroethylene inhalation is also associated with central nervous system effects, liver and kidney damage, and cardiac arrhythmia.[49] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

In an effort to reduce perc emissions and exposures, the agency has required local dry cleaners to adopt closed systems and perform regular inspection and maintenance.[50]

Figure 43: Tetrachloroethylene Annual Average Concentrations at Beacon Hill, 2000-2009



[49]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html.
[50]Agency Regulation III, Section 3.03; http://www.pscleanair.org/regulated/businesses/regulations.aspx.

Trichloroethylene

EPA lists trichloroethylene as a probable human carcinogen. Trichloroethylene is also associated with central nervous system effects.[51] Local sources of trichloroethylene include solvents used for degreasing and surface-coating operations. Trichloroethylene's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million, based on estimated concentrations. More than 75% of the trichloroethylene dataset was below the laboratory report detection limit, so no graph of estimated concentrations is presented. The agency works with and regulates solvent-using businesses to reduce trichloroethylene emissions.

Dichloromethane

EPA lists dichloromethane as a probable human carcinogen. Dichloromethane is also associated with central nervous system effects.[52] Local sources of dichloromethane include solvents used in paint stripping and cleaning. Dichloromethane's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million. We do not graph dichloromethane as potential cancer risks continue to be significantly below one-in-a-million. The agency works with and regulates solvent-using businesses to reduce dichloromethane emissions.

Vinyl Chloride

EPA lists vinyl chloride as a known human carcinogen. Vinyl chloride is similarly associated with central nervous system effects.[53] Local sources of vinyl chloride include the manufacturing of plastics (polyvinyl chloride or PVC). Vinyl chloride's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million, based on estimated concentrations. More than 95% of the vinyl chloride dataset was below the laboratory report detection limit, so no graph of estimated concentrations is presented.

The agency works with and regulates businesses forming plastics to reduce vinyl chloride emissions.

METALS

Table 4 (2009 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-20).

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

[51] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html.
[52] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/methylen.html.
[53] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/vinylchl.html.

Hexavalent Chromium

Chromium is present in two chemical states in our airshed, trivalent and hexavalent. 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.[54] 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.[55] Arsenic is used to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Arsenic's 2009 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.[56] Combustion of gasoline and diesel fuels (car, truck, and bus exhaust) is a main source of nickel in the Puget Sound area. Nickel's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

Cadmium

EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[57] Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

[54] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/chromium.html.
[55] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/arsenic.html.
[56] EPA Hazard Summary; http://www.epa.gov/iris/subst/0273.htm.
[57] EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/cadmium.html.

Lead

EPA lists lead as a probable human carcinogen. Lead is associated primarily with central nervous system effects, and is also associated with reproductive and digestive effects.[58] Lead is especially harmful to children.

Lead is not present at significant levels in ambient air in the Puget Sound area, although a local source includes steel foundries. National ambient levels declined dramatically after leaded gasoline was phased out.

Lead can be present in indoor environments, particularly in homes with lead paint that is disturbed (peeling or crumbling). For more information, visit EPA's website at http://www.epa.gov/lead/. Lead's 2009 average potential cancer risk estimate at Beacon Hill was less than one-in-a-million.

EPA lists lead as both an air toxic and a criteria pollutant. For more information on the review of the national ambient air quality standards for lead, please see page 55.

Beryllium

EPA has classified beryllium as a probable human carcinogen. Beryllium exposures are also associated with lung inflammation and immunological effects.[59] Beryllium sources include combustion of coal and fuel oil that contain beryllium, and tobacco smoke. Beryllium's 2009 average potential cancer risk estimate was less than one-in-a-million, based on estimated concentrations. More than 75% of the beryllium dataset was below the laboratory report detection limit.

Manganese

EPA lists manganese as "not classifiable" for cancer. Manganese exposures are primarily associated with central nervous system effects.[60] Manganese is naturally-occurring and is usually present in the air in small amounts. Additional local sources include steel foundries and blasting of metal parts. 2009 manganese levels in the Puget Sound area are below levels indicating health risk, with a hazard index of less than one.

---

[58]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/lead.html.
[59]EPA Hazard Summary; http://www.epa.gov/ttn/atw/hlthef/berylliu.html.
[60]EPA National Air Toxics Assessment; http://www.epa.gov/ttnatw01/hlthef/manganes.html.

DEFINITIONS

GENERAL DEFINITIONS

Air Quality Index

Table 5: 2009 Calculation and Breakpoints for the Air Quality Index (AQI)

Breakpoints for Criteria Pollutants							AQI Categories	
0_3 (ppm) 8-hour	**0_3 (ppm) 1-hour**[(a)]	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO (ppm)	SO_2 (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	0.035–0.144	(b)	51–100	Moderate
0.076–0.095	0.125–0.164	35.5–55.4[(d)]	155–254	9.5–12.4	0.145–0.224	(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	0.225–0.304	(b)	151–200	Unhealthy
0.116–0.374	0.205–0.404	150.5–250.4	355–424	15.5–30.4	0.305–0.604	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	Hazardous
(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	

(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 µg/m^3, instead of the current 40.4 µg/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.

For more information on the AQI and the pollutants it measures, see www.epa.gov/airnow/aqibroch.

Airshed

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 http://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 Regulation III.

Criteria Air Pollutant (CAP)

The Clean Air Act of 1970 defined *criteria pollutants* and provided EPA the authority to establish ambient concentrations for these criteria pollutants to protect public health. EPA periodically has revised the original concentration limits and methods of measurement, most recently in 2010. 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 http://www.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 all compounds determined to have negligible photochemical reactivity by EPA and listed in 40 CFR 51.100(s) in effect July 1, 2005.

pscleanair.org
Puget Sound Clean Air Agency

PUGET SOUND CLEAN AIR AGENCY **www.pscleanair.org**

2009

Air Quality Data Summary Appendix

April 2011

Working Together for Clean Air

Air Quality Index
1980 – 2009

King County															
	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
						All Days				Unhealthy Days					
Year	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1980	73	275		18	0	95	270	1		1	17		194	Jan 23	PM
1981	69	267		28	1	109	254	2		5	24		213	Jan 15	CO
1982	86	268		10	1	96	264	5		1	10		214	Feb 6	PM
1983	98	258		9	0	101	261	3		0	9		183	Jan 28	CO
1984	146	218		2	0	111	242	13		2	0		103	Dec 6	PM
1985	150	202		10	3	156	206	3		6	7		204	Dec 12	PM
1986	130	226		8	1	113	246	6		1	8		206	Jan 7	PM
1987	120	238		7	0	119	246	0		3	4		184	Feb 6	PM
1988	215	146		5	0	67	298	1		2	3		150	Dec 3	CO
1989	231	134		0	0	129	233	3		0	0		100	Jan 19 #	CO
1990	216	145		4	0	139	201	6	19	0	0	4	131	Aug 11	O_3
1991	229	136		0	0	140	190	8	27	0	0	0	100	Dec 15 #	CO
1992	206	159		1	0	103	230	1	32	0	1	0	167	Feb 3	CO
1993	240	125		0	0	118	235	1	11	0	0	0	88	Jan 11	PM
1994	293	70		2	0	72	270	1	22	0	0	2	134	Jul 21	O_3
1995	299	66		0	0	95	249	5	16	0	0	0	89	Jan 3	CO
1996	297	69		0	0	85	252	2	27	0	0	0	100	Oct 9	CO
1997	302	63		0	0	117	230	0	18	0	0	0	94	Jan 16	PM
1998	317	46		2	0	111	228	0	26	0	0	2	114	Jul 27 #	O_3
1999	267	92	6	0	0	251	60	0	54	5	0	1	134	Jan 4	PM
2000	241	118	7	0	0	288	25		53	5	0	2	114	Nov 21	PM
2001	273	86	6	0	0	295	10		60	6	0	0	118	Nov 10	PM
2002	262	99	4	0	0	275	11		79	4	0	0	113	Nov 27	PM
2003	268	95	2	0	0	250	5		110	0	0	2	132	Jun 6	O_3
2004	256	105	5	0	0	280	2		84	4	0	1	132	Dec 18	PM
2005	254	106	5	0	0	302	3		60	5	0	0	117	Dec 11	PM
2006	268	87	6	4	0	273	2		90	6	0	4	169	Jul 22	O_3
2007	285	77	3	0	0	278	0		87	2	0	1	115	Jan 29	PM
2008	287	76	3	0	0	306	0		60	0	0	3	140	Jun 29	O_3
2009	272	88	4	1	0	254	0		111	1	0	4	160	Jul 5	PM
Totals	6650	4140	51	111	6	5128	4723	61	1046	59	83	26			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1990 – 2009

Kitsap County															
	Days in Each Air Quality Category					**Pollutant Determining the AQI**							**Highest Value**		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1990															
1991															
1992	353	8		0	0	361				0			68	Nov 25	PM
1993	343	12		0	0	355				0			62	Jan 11	PM
1994	364	1		0	0	248	117			0	0		54	Dec 23	CO
1995	361	4		0	0	86	279			0	0		57	Jan 5	CO
1996	361	1		0	0	206	156			0	0		51	Mar 2	PM
1997	361	1		0	0	362				0			55	Jan 15	PM
1998	347	9		0	0	356				0			87	Nov 8	PM
1999	333	32	0	0	0	365				0			81	Jan 5 #	PM
2000	290	75	0	1	0	366				1			159	Jul 4	PM
2001	320	42	0	0	0	362				0			91	Dec 25	PM
2002	324	41	0	0	0	365				0			78	Nov 2	PM
2003	318	47	0	0	0	365				0			78	Nov 3	PM
2004	340	26	0	0	0	366				0			80	Jul 4	PM
2005	328	35	2	0	0	365				2			136	Jul 4	PM
2006	339	25	1	0	0	365				1			105	Dec 17	PM
2007	322	42	0	0	0	364				0			92	Nov 24	PM
2008	342	24	0	0	0	366				0			78	Dec 23	PM
2009	300	37	2	0	0	339				2			111	Dec 3	PM
Totals	6046	462	5	1	0	5962	552	0	0	6	0	0			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1980 – 2009

Pierce County

	Days in Each Air Quality Category					**Pollutant Determining the AQI**							**Highest Value**		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	O_3	AQI	Date	Pollutant
1980	83	271		12	0	256	107	3		4	8		160	Apr 12	PM
1981	74	278		10	3	222	137	6		1	12		227	Jan 12	CO
1982	119	242		4	0	255	101	9		0	4		167	Dec 30	CO
1983	140	222		3	0	228	128	9		1	2		137	Dec 23	PM
1984	162	198		6	0	207	149	10		0	6		117	Jan 19 #	CO
1985	140	213		12	0	252	109	4		1	11		165	Dec 13	PM
1986	161	197		7	0	247	114	4		2	5		167	Oct 23	CO
1987	173	177		13	2	227	136	2		5	10		220	Feb 5	CO
1988	226	132		8	0	184	175	7		3	5		183	Jan 27	CO
1989	260	103		2	0	217	121	27		0	2		117	Nov 30 #	CO
1990	271	91		3	0	219	87	41	18	1	0	2	118	May 5	PM
1991	261	103		1	0	247	85	12	21	0	1	0	117	Jan 31	CO
1992	260	106		0	0	231	83	27	25	0	0	0	100	Feb 3 #	CO
1993	289	76		0	0	247	82	23	13	0	0	0	89	Feb 1	CO
1994	313	51		1	0	235	75	31	24	0	0	1	105	Jul 21	O_3
1995	307	58		0	0	239	97	13	16	0	0	0	83	Jan 3	PM
1996	322	44		0	0	206	119	23	18	0	0	0	78	Oct 9	CO
1997	316	49		0	0	262	75	16	12	0	0	0	84	Jan 16	PM
1998	338	25		2	0	213	112	25	15	0	0	2	120	Jul 27	O_3
1999	265	97	3	0	0	318	1	1	45	3	0	0	139	Jan 4	PM
2000	242	110	13	1	0	318	2		46	14	0	0	153	Dec 6	PM
2001	271	83	11	0	0	306	2		57	11	0	0	139	Nov 10	PM
2002	267	88	9	1	0	291	1		73	10	0	0	158	Nov 27	PM
2003	265	92	8	0	0	264	1		100	8	0	0	122	Jan 7	PM
2004	251	110	5	0	0	272			94	5	0	0	133	Nov 5	PM
2005	275	82	8	0	0	276	2		87	8	0	0	120	Dec 10	PM
2006	283	71	7	4	0	270			95	8	0	3	170	Dec 17	PM
2007	298	57	10	0	0	261			104	9		1	137	Jan 29	PM
2008	295	63	8	0	0	259			107	5		3	129	Aug 16	O_3
2009	284	66	14	1	0	250			115	15		0	158	Jul 5	PM
Totals	7211	3555	96	91	5	7479	2101	293	1085	114	66	12			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Air Quality Index
1980 – 2009

Snohomish County

	Days in Each Air Quality Category					Pollutant Determining the AQI							Highest Value		
			Unhealthy for Sensitive		Very	All Days				Unhealthy Days					
Year	Good	Moderate	Groups	Unhealthy	Unhealthy	PM	CO	SO_2	O_3	PM	CO	SO_2	AQI	Date	Pollutant
1980	340	19		0	0	356		3		0		0	60	Jan 23	PM
1981	350	11		0	0	340		21		0		0	62	Jan 16	PM
1982	334	30		1	0	277	70	18		0	1	0	117	Dec 30	CO
1983	308	56		1	0	191	150	24		0	1	0	117	Nov 30	CO
1984	309	57		0	0	105	217	44		0	0	0	92	Sep 28	PM
1985	300	64		1	0	152	166	47		0	1	0	117	Dec 11	CO
1986	324	41		0	0	169	148	48		0	0	0	89	Jan 25	CO
1987	203	158		3	0	96	250	18		0	3	0	117	Jun 26 #	CO
1988	174	184		8	0	15	345	6		0	8	0	133	Sep 13 #	CO
1989	150	213		2	0	26	338	1		0	2	0	133	Feb 10	CO
1990	166	197		2	0	29	335	1		0	2	0	117	Mar 2 #	CO
1991	188	176		1	0	32	333	0		0	1	0	117	Dec 16	CO
1992	180	186		0	0	34	332	0		0	0	0	100	Feb 4 #	CO
1993	237	128		0	0	56	306	0	3	0	0	0	79	Jan 11	PM
1994	294	71		0	0	28	334	1	2	0	0	0	78	Dec 30	CO
1995	316	49		0	0	59	294	1	11	0	0	0	78	Jul 7	CO
1996	340	26		0	0	54	299	0	13	0	0	0	67	Jul 26	O_3
1997	348	17		0	0	210	151	0	4	0	0	0	67	Jan 14	PM
1998	353	11		1	0	143	219	3		1	0	0	153	Dec 22	PM
1999	300	62	3	0	0	260	105	0		3	0	0	129	Jan 3	PM
2000	253	79	5	0	0	301	36			5	0		113	Jul 4	PM
2001	290	73	2	0	0	356	9			2	0		111	Nov 10	PM
2002	288	69	8	0	0	343	22			8	0		116	Nov 4	PM
2003	282	80	3	0	0	364	1			3	0		108	Nov 4	PM
2004	290	74	2	0	0	364	2			2	0		107	Nov 5	PM
2005	288	72	5	0	0	360	5			5	0		139	Dec 11	PM
2006	301	57	7	0	0	364	1			7	0		143	Dec 17	PM
2007	288	70	6	1	0	365	0			7			155	Jan 15	PM
2008	294	72	0	0	0	366	0			0			96	Dec 19	PM
2009	269	84	12	0	0	365	0			12			117	Jul 5	PM
Totals	8357	2486	53	21	0	6180	4468	236	33	55	19	0			

PM = Particulate Matter CO = Carbon Monoxide SO_2 = Sulfur Dioxide O_3 = Ozone # = 1st Occurrence

Note: In 1987 the particulate matter (PM) standard, total suspended particulates (TSP), was replaced by only that fraction of particulate matter with particle diameters equal to or less than 10 micrometers (PM_{10}).

In 1999 the Pollutant Standard Index (PSI) was replaced by the Air Quality Index (AQI) and included new and more stringent fine particle ($PM_{2.5}$) and 8-hour ozone (O_3) standards. The O_3 standard was again revised in March 2008.

Monitoring Methods Used from 1999 to 2009 in the Puget Sound Airshed

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

Burn Bans
1988 – 2009

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)

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

Micrograms per Cubic Meter

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

2009

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	134	10.7	4.7	6.3	10.4	8.0	42	45
Marysville JHS, 1605 7th St, Marysville	362	10.9	6.6	8.0	11.8	9.3	37	46
Duwamish, 4752 E Marginal Way S, Seattle	122	9.9	7.7	9.5	9.9	9.3	27	33
7802 South L St, Tacoma	115	11.3	6.3	6.8	14.6	9.8	48	51

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 are at least three quarterly averages.

Summary of Maximum Observed Concentrations and Values >40

Location	Jan 19 Mon	Jan 22 Thu	Jul 5 Sun	Dec 3 Thu	Dec 7 Mon	Dec 8 Tue	Dec 9 Wed	Dec 12 Sat	Dec 24 Thu	Dec 27 Sun
Darrington HS, 1085 Fir St, Darrington	42	45	--		--	--		42		
Marysville JHS, 1605 7th St Marysville			43		45	42	46	42		
Duwamish, 4752 E Marginal Way, Seattle	33		--		--	--				
7802 South L St, Tacoma			--	50	--	--	48	51	43	44

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	118	13	3	
Marysville JHS, 1605 7th St, Marysville	313	41	8	
Duwamish, 4752 E Marginal Way S, Seattle	110	12		
7802 South L St, Tacoma	99	9	7	

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

Micrograms per Cubic Meter

Equivalent Sampling Methods: F - Mass Transducer R&P TEOM 1400ab-8500 FDMS Tef-coat Glass Fiber

2009

Location	Method	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean	98th Percentile	Max Value
Marysville JHS, 1605 7th St, Marysville		352	12	7.2	8.6	13.5	10.3	33.5	49
6120 T6120 212th St SW, Lynnwood	F	314	9.7	7.1	8.3		8.7	27.7	34
17171 Bothell Way NE, Lake Forest Park		351	7.2	6.9	8.1	12.0	8.6	25.2	35
Duwamish, 4752 E Marginal Way S, Seattle	F	340	13.8	12.9	15.4	14.3	14.1	31.8	39
James St & Central Ave, Kent		357	11.1	7.8	9.8	11.8	10.1	26.5	71
7802 South L St, Tacoma		356	13.0	6.9	8.9	14.5	10.9	38.4	78

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

Summary of Maximum Observed Concentrations and Values >40

Location	Method	Jan 19 Mon	Jul 4 Sat	Jul 5 Sun	Dec 3 Thu	Dec 4 Fri	Dec 10 Thu	Dec 11 Fri	Dec 12 Sat	Dec 26 Sat	Dec 27 Sun
Marysville JHS, 1605 7th St, Marysville			41	49			--	40	43		
6120 212th St SW, Lynnwood	F					34					
17171 Bothell Way NE, Lake Forest Park				35							
Duwamish, 4401 E Marginal Way S, Seattle	F	39									
James St & Central Ave, Kent				71							
7802 South L St, Tacoma				78	44		48	42	40	42	41

-- Indicates no sample on specified day

Air Quality Index Summary

Location	Method	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Marysville JHS, 1605 7th St, Marysville		297	49	6	
6120 212th St SW, Lynnwood	F	299	37		
17171 Bothell Way NE, Lake Forest Park		325	26		
Duwamish, 4752 E Marginal Way S, Seattle	F	254	106	3	
James St & Central Ave, Kent		312	44		1
7802 South L St, Tacoma		297	45	13	1

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

Micrograms per Cubic Meter

Sampling Method: Equivalent - Radiance Research M903 Nephelometer

2009

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	98th Percentile	Daily Max Value
		1st	2nd	3rd	4th			
Darrington HS, 1085 Fir St, Darrington	361	10.7	3.5	6.0	10.4	7.7	32.9	40
Marysville JHS, 1605 7th St, Marysville	348	8.3	5.7	7.2	11.1	8.1	37.8	45
6120 212th St SW, Lynnwood	343	7.1	4.9	6.4	8.0	6.6	21.5	28
17171 Bothell Way NE, Lake Forest Park	357	7.9	5.6	7.0	9.7	7.6	25.0	32
Queen Anne Hill, 400 W Garfield St, Seattle	334	5.7	5.0	7.1	5.9	5.9	18.3	23
Olive & Boren, Seattle	363	5.9	4.7	6.0	6.2	5.7	15.2	20
15th S & Charlestown, Beacon Hill, Seattle	340	6.4	5.6	6.9	5.9	6.2	17.6	28
Duwamish, 4752 E Marginal Way S, Seattle	364	8.0	5.8	8.2	9.8	8.0	24.5	38
South Park, 8025 10th Ave S, Seattle	349	8.8	5.4	7.2	9.1	7.6	25.7	34
305 Bellevue Way NE, Bellevue	359	6.4	5.0	5.5	5.1	5.5	15.7	22
42404 SE North Bend Way, North Bend	364	4.5	5.5	6.9	4.6	5.4	13.7	23
James St & Central Ave, Kent	339	8.2	5.8	8.7	8.8	7.9	27.1	62
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	348	8.0	5.3	6.4	9.1	7.2	25.3	35
7802 South L St, Tacoma	361	8.8	4.6	6.5	11.5	7.9	40.0	52
South Hill, 9616 128th St E, Puyallup	365	8.8	5.5	8.2	9.2	7.9	27.0	68
30525 SE Mud Mountain Road, Enumclaw	365	2.2	4.1	5.8	2.3	3.6	10.9	14
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	339	8.7	5.3	7.2	11.8	8.3	29.1	46

Notes
(1) Sampling occurs continuously for 24 hours each day.
Quarterly averages are shown only if 75 percent or more of the data is available.
(2) Annual averages are shown only if there are at least three quarterly averages.
(3) All data values are correlated using site-specific relationships with Federal Reference Method samplers.

Summary of Maximum Observed Concentrations and Values >40

Location	Jan 20 Tue	Jul 5 Sun	Aug 6 Thu	Dec 3 Thu	Dec 4 Fri	Dec 7 Mon	Dec 8 Tue	Dec 9 Wed	Dec 10 Thu	Dec 11 Fri	Dec 12 Sat	Dec 26 Sat	Dec 27 Sun
Darrington HS, 1085 Fir St, Darrington											40		
Marysville JHS, 1605 7th St, Marysville						44	41	45			43		
6120 212th St SW, Lynnwood					28								
17171 Bothell Way NE, Lake Forest Park		32											
Queen Anne Hill, 400 W Garfield St, Seattle		23											
Olive & Boren, Seattle	20	--											
15th S & Charlestown, Beacon Hill, Seattle	28									--	--		
Duwamish, 4752 E Marginal Way S, Seattle					38								
South Park, 8025 10th Ave S, Seattle					34								
305 Bellevue Way NE, Bellevue	22												
42404 SE North Bend Way, North Bend											23		
James St & Central Ave, Kent		62											
Tacoma Tideflats, 2301 Alexander Ave, Tacoma		35											
7802 South L St, Tacoma		47		46	42				52	46	44	41	
South Hill, 9616 128th St E, Puyallup		68											
30525 SE Mud Mountain Road, Enumclaw			14										
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	--			46									42

-- Indicates no sample on specified day

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

Air Quality Index Summary

Location	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Darrington HS, 1085 Fir St, Darrington	309	48	4	
Marysville JHS, 1605 7th St, Marysville	310	31	7	
6120 212th St SW, Lynnwood	316	27		
17171 Bothell Way NE, Lake Forest Park	320	37		
Queen Anne Hill, 400 W Garfield St, Seattle	322	12		
Olive & Boren, Seattle	356	7		
15th S & Charlestown, Beacon Hill, Seattle	329	11		
Duwamish, 4752 E Marginal Way S, Seattle	326	37	1	
South Park, 8025 10th Ave S, Seattle	310	39		
305 Bellevue Way NE, Bellevue	351	8		
42404 SE North Bend Way, North Bend	359	5		
James St & Central Ave, Kent	306	32	1	
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	311	37		
7802 South L St, Tacoma	320	30	11	
South Hill, 9616 128th St E, Puyallup	323	41	1	
30525 SE Mud Mountain Road, Enumclaw	365			
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co	300	35	4	

$PM_{2.5}$ Speciation Analytes Monitored in 2009
Average Annual Concentrations in Micrograms per Cubic Meter

Analyte	Seattle Beacon Hill	Seattle Duwamish	Marysville*	Tacoma South L St	Tacoma Tideflats
Acceptable Pm2.5 Aqi & Speciation Mass	6.93	9.81	9.64	10.41	9.62
Aluminum Pm2.5 Lc	1.99E-02	N/A	N/A	N/A	1.85E-02
Ammonium Ion Pm2.5 Lc	4.32E-01	4.73E-01	3.73E-01	3.77E-01	4.41E-01
Antimony Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Arsenic Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Barium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Bromine Pm2.5 Lc	1.93E-03	3.49E-03	2.22E-03	2.80E-03	2.56E-03
Cadmium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Calcium Pm2.5 Lc	2.51E-02	1.25E-01	1.30E-02	1.84E-02	4.76E-02
Cerium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Cesium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Chlorine Pm2.5 Lc	4.16E-02	8.92E-02	5.22E-02	8.11E-02	6.48E-02
Chromium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Cobalt Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Copper Pm2.5 Lc	1.37E-02	8.65E-03	N/A	7.09E-03	5.44E-03
Indium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Iron Pm2.5 Lc	5.51E-02	1.14E-01	4.61E-02	4.73E-02	1.64E-01
Lead Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Magnesium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Manganese Pm2.5 Lc	2.67E-03	7.01E-03	N/A	N/A	N/A
Nickel Pm2.5 Lc	2.57E-03	3.52E-03	N/A	N/A	4.32E-03
Phosphorus Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Potassium Ion Pm2.5 Lc	4.26E-02	5.52E-02	8.28E-02	9.31E-02	5.83E-02
Potassium Pm2.5 Lc	3.84E-02	5.06E-02	7.79E-02	8.73E-02	5.70E-02
Rubidium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Selenium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Silicon Pm2.5 Lc	4.65E-02	6.49E-02	3.00E-02	3.33E-02	5.82E-02
Silver Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Sodium Ion Pm2.5 Lc	1.75E-01	2.29E-01	1.83E-01	1.81E-01	1.78E-01
Sodium Pm2.5 Lc	1.24E-01	1.83E-01	1.18E-01	1.22E-01	1.27E-01
Strontium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Sulfate Pm2.5 Lc	1.09E+00	1.34E+00	9.78E-01	8.68E-01	1.14E+00
Sulfur Pm2.5 Lc	3.54E-01	4.46E-01	3.32E-01	3.08E-01	4.01E-01
Tin Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Titanium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Total Nitrate Pm2.5 Lc	7.11E-01	8.05E-01	6.00E-01	7.13E-01	6.82E-01
Vanadium Pm2.5 Lc	N/A	7.68E-03	N/A	N/A	7.61E-03
Zinc Pm2.5 Lc	6.30E-03	1.84E-02	7.52E-03	9.01E-03	2.61E-02
Zirconium Pm2.5 Lc	N/A	N/A	N/A	N/A	N/A
Elemental Carbon TOR	6.59E-01	1.11E+00	6.43E-01	8.77E-01	1.16E+00
Organic Carbon TOR	3.17E+00	3.41E+00	2.59E+00	4.54E+00	3.99E+00
Total Carbonaceous Mass	3.77E+00	4.52E+00	3.23E+00	5.42E+00	5.15E+00
Soil	3.83E-01	6.90E-01	2.29E-01	2.58E-01	6.63E-01
Reconstructed Fine Mass - Urban PM2.5	6.62E+00	7.76E+00	5.51E+00	8.05E+00	8.06E+00

N/A = Over 50% Below the MDL
25-50% Below the MDL
* Sampling started 4/7/09

$PM_{2.5}$ BLACK CARBON

micrograms per cubic meter

Sampling Method: Light Absorption by Aethalometer

2009

Location	Number of Values	Quarterly Arithmetic Averages				Annual Mean	Max Value
		1st	2nd	3rd	4th		
Darrington HS, 1085 Fir St, Darrington	152	0.8					2.4
Marysville JHS, 1605 7th St, Marysville	304	1.1	0.7	0.8	1.5	1.1	5.2
Olive & Boren, Seattle	326	1.5	1.0	1.3		1.4	5.2
Duwamish, 4401 E Marginal Way S, Seattle	353	1.7	1.0	1.5	2.0	1.5	7.9
7802 South L St, Tacoma	352	1.2	0.5	0.6	1.6	1.0	6.1
Tacoma Tideflats, 2301 Alexander Ave, Tacoma	364	1.5	0.8	1.2	2.1	1.4	6.6

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

Summary of Maximum Observed Concentrations

Location	Jan 21 Wed	Feb 2 Mon	Feb 5 Thu	Dec 7 Mon	Dec 10 Thu	Dec 18 Fri
Darrington HS, 1085 Fir St, Darrington	2.4			--	--	
Marysville JHS, 1605 7th St, Marysville	--			5.2		
Olive & Boren, Seattle			5.2			
Duwamish, 4752 E Marginal Way S, Seattle		7.9				
7802 South L St, Tacoma					6.1	
Tacoma Tideflats, 2301 Alexander Ave, Tacoma						6.6

-- Indicates no sample on specified day

OZONE
(parts per million)
2009

Location / Continuous Sampling Period(s)	2009 Six Highest Daily 8-Hour Concentrations		4th Highest Daily 8-Hour Concentration			3-Year Average of 4th Highest 8-Hour Concentration
	Value	Date	2007	2008	2009	2007 - 2009
Beacon Hill, 15th S & Charlestown	.052	4 Jun				
Seattle, Wa	.050	2 Jun				
1 Jan-31 Dec	.049	1 May				
	.049	1 Jun	.046	.047	.049	.047
	.046	3 May				
	.046	3 Jun				
20050 SE 56th	.075	28 Jul				
Lake Sammamish State Park, Wa	.072	4 Jun				
1 May-30 Sep	.068	27 Jul				
	.064	30 Jul	.058	.054	.064	.058
	.060	3 Jun				
	.058	1 Jun				
42404 SE North Bend Way,	.084	30 Jul				
North Bend, Wa	.071	3 Jul				
1 May-30 Sep	.069	1 Aug				
	.063	29 May	.057	.058	.063	.059
	.063	21 Jul				
	.061	4 Jul				
30525 SE Mud Mountain Road,	.084	28 Jul				
Enumclaw, Wa	.079	27 Jul				
1 May-30 Sep	.078	4 Jun				
	.076	30 Jul	.068	.075	.076	.073
	.075	1 Aug				
	.072	21 Jul				
Charles L Pack Forest	.068	4 Jun				
La Grande, Wa	.068	19 Aug				
17 May-30 Sep	.067	1 Aug				
	.064	12 Sep	.063	.068	.064	.065
	.063	1 Jun				
	.062	27 Jul				
931 Northern Pacific Rd SE,	.076	29 Jul				
Yelm, Wa	.062	4 Jun				
1 May-30 Sep	.061	3 Jun				
	.060	4 Jul	.054	.060	.060	.058
	.057	27 Aug				
	.057	16 May				

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.

REACTIVE NITROGEN
(parts per million)
2009

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages												No of 1-Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Beacon Hill, 15th S & Charlestown, Seattle	.018	.020	.014	.014	.012	.011	.015	.015	.017	.015	.013	.020	8524	.015

Maximum and Second Highest Concentrations

Location / Continuous Sampling Periods(s)	1-Hour Average		
	Value	Date	End Time
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan - 31 Dec	.070 .063	3 Jun 29 Jul	2200 1900

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations nitrogen dioxide was measured using the continuous chemiluminescence method

CARBON MONOXIDE

(parts per million)
2009

Location / Continuous Sampling Period(s)	Six Highest Concentrations					Number of 8-Hour Averages Exceeding 9 ppm	Number of Days 8-Hour Averages Exceeded 9 ppm
	1 Hour Average			8 Hour Average			
	Value	Date	End Time	Value	Date		
2421 148th Ave NE	4.1	4 Feb	1900	2.9	4 Feb	0	0
Bellevue	4.0	3 Feb	1800	2.7	3 Feb		
1 Jan-31 Dec	3.7	4 Feb	2000	2.5	19 Jan		
	3.6	19 Jan	1900	2.0	18 Jan		
	3.3	3 Feb	1900	1.9	3 Dec		
	3.3	4 Feb	2100	1.8	20 Jan		
Beacon Hill, 15th S and	1.4	3 Feb	1000	1.0	5 Feb	0	0
Charlestown	1.3	19 Jan	2100	0.9	3 Feb		
Seattle	1.3	3 Feb	1100	0.9	4 Dec		
1 Jan-31 Dec	1.2	5 Feb	1000	0.9	20 Jan		
	1.1	5 Feb	1100	0.9	19 Jan		
	1.1	5 Feb	1300	0.8	23 Sep		

Notes
(1) All carbon monoxide 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 carbon monoxide was measured using the continuous nondispersive infrared method.

SULFUR DIOXIDE
(parts per million)
2009

Monthly and Annual Arithmetic Averages

Location	Monthly Arithmetic Averages Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	No of 1-Hour Samples	Year Arith Mean
Beacon Hill, 15th S & Charlestown, Seattle	.001	.002	.001	.001	.001	.001	.002	.002	.002	.001	.001	.001	8152	.002

Maximum and Second Highest Concentrations for Various Averaging Periods

Location / Continuous Sampling Periods(s)	1-Hour Average			24-Hour Average	
	Value	Date	End Time	Value	Date
Beacon Hill, 15th S & Charlestown, Seattle 1 Jan-31 Dec	.053 .032	8 Sep 4 Feb	2300 1700	.008 .008	4 Feb 2 Aug

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values, the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) Sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

2009 Beacon Hill Air Toxics Statistical Summary for Air Toxic Gases (units in parts per billion)

	benzene	1,3-butadiene	carbon tet	chloroform	dichloromethane	tetrachloroethylene	trichloroethylene	acrolein	acetaldehyde	formaldehyde
2009 count	62	62	62	62	62	62	62	62	63	63
NDs (reported as 0)	0	2	0	0	0	8	49	0	0	0
Median (ppb)	0.197	0.021	0.118	0.028	0.126	0.014	0.000	0.201	0.406	0.483
Mean (ppb)	0.252	0.033	0.122	0.030	0.225	0.018	0.003	0.267	0.546	0.853
95%tile (ppb)	0.542	0.085	0.170	0.051	0.410	0.047	0.017	0.467	1.125	1.557
Max (ppb)	1.680	0.402	0.185	0.081	2.640	0.084	0.033	1.660	1.870	13.500
MDL (ppb)	0.006	0.003	0.002	0.002	0.008	0.003	0.002	0.015	0.0071	0.011
# below MDL	0	2	0	0	0	8	49	0	0	0
% below MDL	0.0%	3.2%	0.0%	0.0%	0.0%	12.9%	79.0%	0.0%	0.0%	0.0%

NDs (nondetects) – reported as “0” in dataset.

MDL – minimum detection limit provided by laboratory. Concentrations provided below this value are estimates.

Trichloroethylene is shaded because greater than 75% of its samples were below limits of detection. Statistics are shown, but a graph in the main text is not presented because of the level of uncertainty in quantification.

2009 Beacon Hill Air Toxics Statistical Summary for PM_{10} Metals (units in nanograms per cubic meter)

	Arsenic	Beryllium	Cadmium	Chromium	Cr+6 TSP	Lead	Manganese	Nickel
2009 count	59	59	59	59	61	59	59	59
NDs (reported as 0)	0	10	0	0	13	0	0	0
Median (ng/m3)	0.537	0.001	0.078	2.040	0.020	2.870	4.490	1.710
Mean (ng/m3)	0.710	0.002	0.103	2.298	0.032	3.637	7.149	2.615
95%tile (ng/m3)	1.818	0.009	0.205	3.886	0.115	7.609	22.090	7.473
Max (ng/m3)	2.690	0.017	0.744	6.730	0.232	16.200	31.400	11.200
MDL (ng/m3)	0.0097	0.003	0.027	0.3234	0.0048	0.062	0.073	0.138
# below MDL	0	45	2	0	13	0	0	0
% below MDL	0.0%	76.3%	3.4%	0.0%	21.3%	0.0%	0.0%	0.0%

Beryllium is shaded because greater than 75% of its samples were below limits of detection.

Estimates of Air Toxics Risk
2009 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 $(\mu g/m^3)$ * *unit risk factor* $(risk/\mu g/m^3)$

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).[4] 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 refers to its "weight of evidence" ranking: A = known carcinogen, B1 = probable carcinogen, based on incomplete human data, B2 = probable carcinogen, based on adequate animal data.[5]

2009 Air Toxics Unit Risk Factors

AIR TOXIC	WA ASIL 460 UNIT RISK FACTOR RISK/$\mu g/m^3$	CANCER RATING[6]
Formaldehyde	6.0E-06	B1
Benzene	2.9E-05	A
Carbon Tetrachloride	4.2E-05	B2
Chromium (Hexavalent) (M)	1.5E-01	A
Chloroform	2.3E-05	B2
Arsenic (M)	3.3E-03	A
1,3-Butadiene	1.7E-04	A
Acetaldehyde	2.7E-06	B2
Nickel (Subsulfide) (M)	2.4E-04	A
Tetrachloroethylene	7.4E-06	B2
Trichloroethylene	1.6E-05	B2
Cadmium (M)	4.2E-03	B1
Lead (M)	1.2E-05	B2
Beryllium (M)	2.4E-03	B1
Dichloromethane	1.0E-06	B2
Vinyl Chloride	7.8E-5	A

[1]Washington State Administrative Code. http://apps.leg.wa.gov/wac/default.aspx?cite=173-460-150.
[2]Integrated Risk Information System, EPA; http://www.epa.gov/iris/.
[3]California EPA, Consolidated Table of OEHHA/ARB-Approved Risk Assessment Health Values, June 25, 2008; http://www.arb.ca.gov/toxics/healthval/healthval.htm.
[4]For details on the ASIL, see: http://www.ecy.wa.gov/laws-rules/wac173460_400/February/ASIL_20list_20pollutants2-8-08-5pm1.pdf.
[5]International Agency for Research on Cancer; http://monographs.iarc.fr/.
[6]Ratings per 1986 EPA guidelines.

2009 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
Benzene	1	50	100%
Carbon Tetrachloride	2	45	100%
1,3-Butadiene	3	32	95%
Formaldehyde	4	11	97%
Naphthalene	5	7	100%
Chromium Vi(TSP)	6	7	79%
Arsenic PM_{10} STP	7	6	100%
Chloroform	8	6	11%
Acetaldehyde	9	5	59%
Nickel PM_{10} STP	10	2	100%
Trichloroethylene	11	1	0%
Dichloromethane	12	1	3%
Tetrachloroethylene	13	1	0%
Cadmium PM_{10} STP	14	<1	100%
Lead PM_{10} STP	15	<1	100%
Beryllium PM_{10} STP	16	<1	68%
Vinyl Chloride	17	<1	0%
Manganese PM_{10} STP	18	na	na

Shaded air toxics have >75% of samples with estimated concentrations (values below the reported laboratory detection limit).
Screening value used is concentration equivalent to an estimated one-in-a-million potential cancer risk.

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

Air toxic	Non Cancer RfC (ug/m3)	Mean Hazard Index
Benzene	60	0.004
1,3-butadiene	20	0.002
Carbon Tetrachloride	40	0.003
Chloroform	300	0.000
Dichloromethane	400	0.001
Tetrachloroethylene	35	0.001
Trichloroethylene	600	0.000
Acrolein	0.35	4.4
Acetaldehyde	140	0.061
Formaldehyde	9	0.284
Arsenic	0.015	0.024
Beryllium	0.007	0.000
Cadmium	0.02	0.005
Manganese	0.09	0.036
Nickel	0.05	0.052
Chromium 6 TSP	0.2	0.000

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.