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

# 2005
# Air Quality Data Summary

July 2006

**Working Together for Clean Air**

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The 2005 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

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 (CAPs). The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards (NAAQS) for these pollutants. These criteria air pollutants are:

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

Last year, with the 2004 data summary, the Agency added additional information on air toxics. Air toxics are pollutants beyond the six CAPs and are broadly defined by the Agency as a category that covers over 400 air pollutants. These pollutants are associated with a broad range of adverse health effects, including cancer. We continue to summarize local air toxics data in this year's report to more comprehensively report on the area's air quality. We've also added additional fine particulate matter monitoring information this year, in an effort to continually improve this report.

The Puget Sound Clean Air Agency and Washington State Department of Ecology work together to monitor air quality within the Puget Sound region.[1] Real-time air monitoring data are available for some pollutants on the Internet at http://www.pscleanair.org/airq/aqi.aspx and https://fortress.wa.gov/ecy/aqp/Public/aqn.shtml. We encourage you to visit our website to find more extensive air quality data, educational materials, monthly air quality summaries, and discussions of current topics.

We are expanding and refining our internet site to better serve the residents of the Puget Sound region. We want your feedback on our air quality data and program. Please submit your comments via email to Mary Hoffman at maryh@pscleanair.org or call at 206-689-4006.

## Report Organization

A brief overview of the report is provided in the executive summary. A description and summary of the Air Quality Index (AQI) and the Agency's monitoring program and network are provided directly following the executive summary. Agency-issued burn bans and smog watches and a local emissions inventory are then presented.

[1] The Agency's jurisdiction covers Snohomish, King, Pierce, and Kitsap counties.

The primary focus of this report is to present information on criteria air pollutants, which are monitored most thoroughly in the Puget Sound region. Graphs, statistical summaries, and health effect information are provided for each pollutant. Comparisons to ambient air quality standards and relevant health goals are also provided. A presentation of visibility based on fine particulate measurement is also included.

Air toxics monitored by the Washington State Department of Ecology are also presented. Statistical summaries and health effects information are provided for each monitored air toxic, and graphs are presented for those with several years of monitoring data. Unlike criteria air pollutants, air toxics do not have federal standards. Instead of a comparison of concentrations to air quality standards, carcinogenic air toxics are ranked here based on potential cancer risk.

## Executive Summary for 2005

The Agency, along with partners, continued to monitor the region's air quality in 2005. While the area enjoys improving air quality in many ways, we are facing new challenges. Some of these challenges are related to growth in our region, while others are related to new health information and potentially changing air pollution standards.

With the exception of fine particulate matter ($PM_{2.5}$) and ozone, criteria air pollutant concentrations have fallen well below levels of concern in our jurisdiction. The region has been in attainment for all criteria air pollutants for almost a decade.

While the region has never violated the $PM_{2.5}$ federal standard, fine particulate matter is a main pollutant of concern in the Puget Sound area. Because of its adverse health effects, the Agency has established a health goal for fine particulate matter. Monitoring sites in three of four counties (Snohomish, King, and Pierce) continue to exceed this goal.

The Agency also faces potential violation if a proposed fine particulate matter federal standard is promulgated. In December 2005, EPA proposed a stricter daily fine particulate matter standard that's substantially lower than the current standard (about 50% lower).[2] Current monitored concentrations in two counties (Snohomish and Pierce) could potentially violate this new standard if adopted. The Agency will need to increase its efforts with partners to reduce fine particulate matter emissions in order to maintain $PM_{2.5}$ attainment status in our region. These efforts will need to achieve wood smoke emissions reductions, as the highest $PM_{2.5}$ levels occur in heating months when wood stoves and fireplaces contribute the majority of $PM_{2.5}$. Additionally, the Agency recently added $PM_{2.5}$ monitoring in the town of Darrington, which has levels that may violate the *current* standard.

In addition to fine particulate matter, ozone levels remain a concern in our region because concentrations have not reduced as significantly as precursor pollutants have. Air toxics are also present in our airshed at levels that pose adverse health effects.[3] These health effects include but are not limited to increased cancer risk and respiratory, cardiovascular, and neurological effects.

Many of the same sources that produce criteria and toxic air pollutants also generate greenhouse gases. The Agency continues to work with partners to reduce greenhouse gases to make the Northwest region a leader in the field.[4] A greenhouse gas emissions inventory is included in this report in the "Regional Emissions Inventory" section. Greenhouse gases are unique. Unlike the criteria pollutants and air

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[2] EPA. National Ambient Air Quality Standard, Proposed Rule. http://www.epa.gov/fedrgstr/EPA-AIR/2006/January/Day-17/a177.pdf. January 17, 2006. The proposed rule was announced on December 21st, 2005, but did not post to the Federal Register until January 2006. The current federal daily standard is currently 65 $\mu g/m^3$; the proposed daily standard is 35 $\mu g/m^3$ .
[3] Puget Sound Final Air Toxics Evaluation. 2003. http://www.pscleanair.org/airq/basics/psate_final.pdf. 2005 air toxics were detected at levels associated with potential cancer risk.
[4] Roadmap for Climate Change: Reducing Greenhouse Gas Emissions in Puget Sound. http://www.pscleanair.org/programs/climate/rptfin.pdf.

toxics included in this summary, we do not monitor their levels in the atmosphere or present historic trends. The Agency currently focuses on local inventories and reduction strategies, and is exploring ways to present trends in future reports. For more information please refer to http://www.pscleanair.org/programs/climate/default.aspx.

The Agency is taking action with many partners to face these challenges. These actions include exploring new methods to better characterize fine particulate and air toxics, quantifying greenhouse gas emissions, developing reduction strategies, working with planning agencies, and implementing programs that achieve reductions. Diesel Solutions® is an example. This award-winning program has resulted in clean air retrofits on thousands of diesel vehicles in the Puget Sound region over the past five years. Please visit our website at www.pscleanair.org for more information about these projects.

There are multiple ways to measure the quality of our ambient air. Some are summarized in the following pages for 2005.

## Air Quality Index (AQI)

The AQI is a nationwide standard developed by the EPA for the criteria pollutants. The AQI is used to report daily air quality. The number of "good" AQI days continued to dominate regionally in the Puget Sound area in 2005. However, air quality degraded into "moderate" for approximately a quarter of the time and "unhealthy for sensitive groups" for brief periods.

The table below shows the AQI breakdown by percentage in each category for 2005. Snohomish County registered the highest AQI value of 139 on December 11. The greatest pollutant level determines the AQI. Fine particulate matter ($PM_{2.5}$) determined the AQI on December 11. $PM_{2.5}$ typically determines the AQI in the Puget Sound area on days considered unhealthy for sensitive groups.

**2005 AQI Ratings**

| | AQI Rating (% of year) | | | | |
|---|---|---|---|---|---|
| County | Good | Moderate | Unhealthy for Sensitive Groups | Unhealthy | Highest AQI |
| Snohomish | 79% | 20% | 1% | - | 139 |
| King | 70% | 29% | 1% | - | 117 |
| Pierce | 75% | 22% | 2% | - | 120 |
| Kitsap | 90% | 10% | 1% | - | 136 |

## Emissions Inventory

The 2004 emission inventory is included in this data summary, because the 2005 emission inventory was not yet completed at the time of publishing. The 2005 emission inventory will likely be very similar to the 2004. The 2004 inventory shows that on-road vehicles continue to be the greatest contributors to both criteria pollutant and air toxics emissions in the Puget Sound airshed. Area sources such as outdoor and indoor burning are major contributors to $PM_{2.5}$ emissions.

## Impaired Air Quality -- Burn Bans and Smog Watches

The agency issues burn bans to protect human health during high particulate matter events. 2005 was an interesting year for burn bans. The 2005 Legislature changed the $PM_{10}$ burn ban "trigger" to a fine particulate ($PM_{2.5}$) trigger. This new criteria enables the Agency to better protect public health by issuing burn bans more effectively.

The Agency issued two burn bans in 2005: a February ban based on the old $PM_{10}$ trigger, and a longer December ban based on the new $PM_{2.5}$ trigger. The February burn ban was seven days, from February 21 to February 28. The December burn ban was nine days, from December 9 to December 18.

The Agency did not issue any smog watches in 2005. The Puget Sound area had a mild summer; the hot weather conditions and meteorology conducive to ozone formation did not occur.

## Criteria Air Pollutants and Visibility

The Puget Sound area did not violate any National Ambient Air Quality Standards (NAAQS) in 2005. The area kept its status as maintenance for particulate matter, ozone, and carbon monoxide.[5]

While the federal NAAQS were achieved in 2005, air quality in the region still falls short of the local health goal for fine particulate matter. Daily concentrations of fine particulate matter ($PM_{2.5}$) at monitoring stations in King, Snohomish, and Pierce counties continue to exceed the health goal set by the Agency's Particulate Matter Health Committee.[6,7]

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

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[5] The region was previously non-attainment for these three criteria air pollutants.

[6] The federal standard for daily $PM_{2.5}$ concentrations is currently 65 $\mu g/m^3$. The proposed new daily standard is 35$\mu g/m^3$. Our Board of Directors adopted a more stringent goal based on recommendations from our Particulate Matter Health Committee. The Committee conducted a systematic review of health data and recommended that a daily average of 25 $\mu g/m^3$ is protective of human health.

[7] Kitsap County also exceeded the local health goal on the July 4 and July 5. This is likely due to fireworks and other combustion associated with the holiday. Kitsap County didn't exceed the health goal on any other days in 2005.

## Air Toxics

The Department of Ecology monitored air toxics in 2005 at the Seattle Beacon Hill site, where air toxics have been monitored since 2000. Air toxics were detected at levels that present potential health risk.[8] Six years (2000 – 2005) is a short time period to attempt to characterize trends. Nonetheless, 2005 annual averages are lower than 2000 annual averages for all air toxics except one.[9]

Air toxics that were *monitored directly in 2005* were ranked according to potential cancer risk. Formaldehyde, primarily from vehicles and other combustion, presented the highest potential cancer risk in 2005. It is important to note that this ranking does not include diesel particulate matter. A comprehensive 2003 evaluation showed that diesel particulate matter presents the majority of potential air toxics cancer health risk in our area.[10] Unfortunately, there is no direct monitoring method to measure diesel particulate matter. The Agency, the Washington Department of Ecology, the University of Washington, and other partners are using various monitoring methods to characterize indicators of diesel particulate matter.[11]

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[8] Air toxics concentrations were detected at levels associated with potential cancer risk, at both mean and upper bound (95th percentile) concentrations.
[9] The one exception is tetrachloroethylene, whose levels remain relatively constant and close to the analytical minimum detection limit (MDL).
[10] Puget Sound Final Air Toxics Evaluation. 2003. http://www.pscleanair.org/airq/basics/psate_final.pdf.
[11] These methods are described further in the fine particulate section of this report.

## Air Quality Index

The 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.[12] The highest pollutant determines the ranking. For example, if an area has a carbon monoxide 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 six categories, listed below. Each category has a corresponding color, shown with pollution concentration breakpoints for each category, shown on page 117 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.

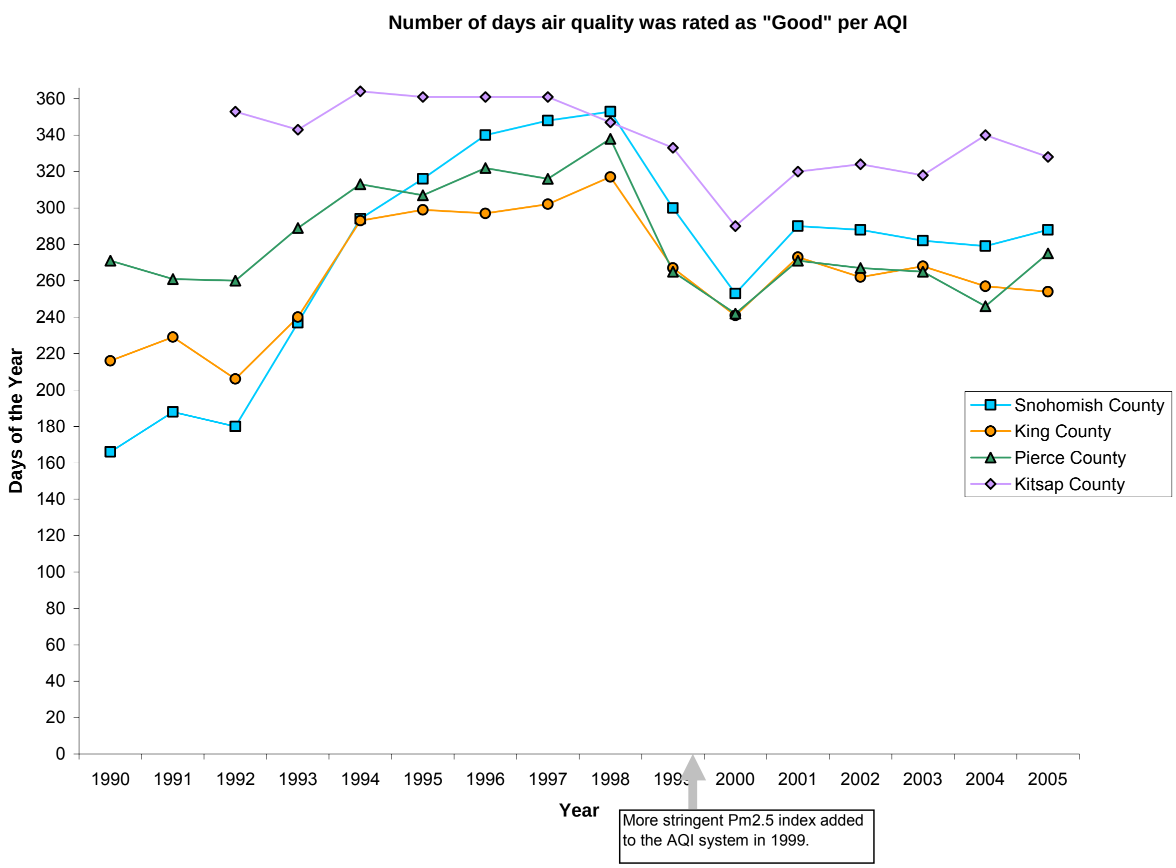
The AQI is a national index, so the values and colors used to show local air quality and the associated level of health concern will be the same throughout the United States. Current and archived AQI values for Puget Sound can be found on our website at www.pscleanair.org.

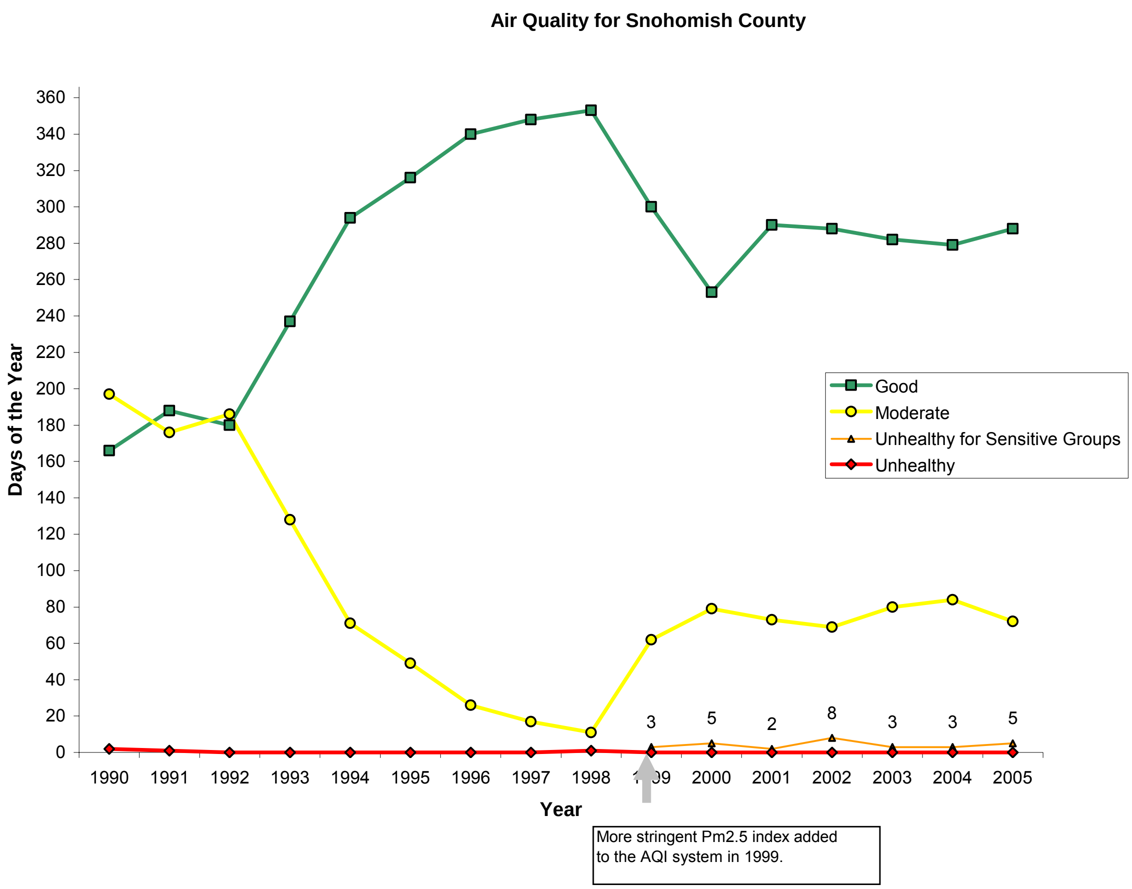
The number of "good" air quality days continues to dominate regionally in the Puget Sound area. However, air quality degraded into "moderate" or "unhealthy for sensitive groups" for brief periods. The table presented in the executive summary shows the AQI breakdown by percentage in each category for the year.

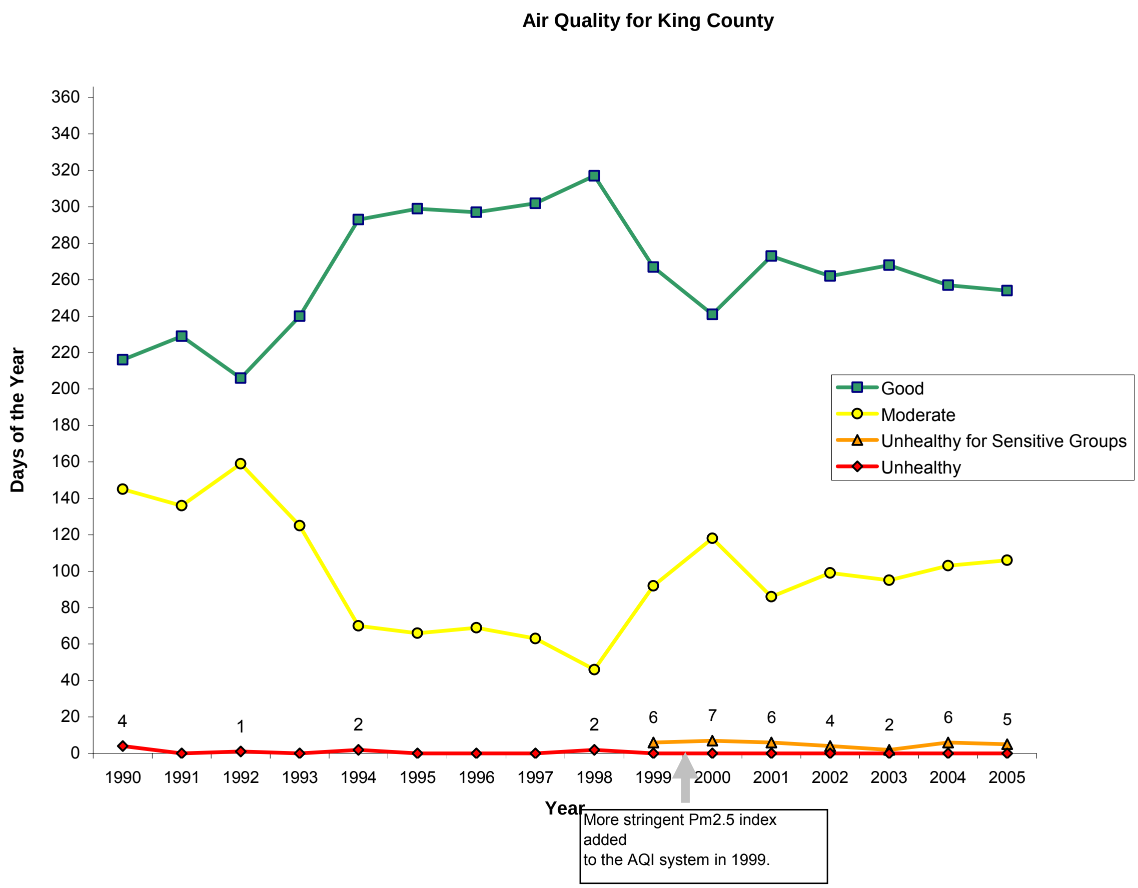
The graph on page 8 presents the annual number of "good" AQI days for each of the four counties. The number of "good" days has been relatively constant over the last few years for each county. Lower numbers of "good" days now can not be directly compared with the numbers before 1999, when $PM_{2.5}$ was added to the index and the "unhealthy" category was divided into "unhealthy" and "unhealthy for sensitive groups."

[12] Lead is not included in the AQI.

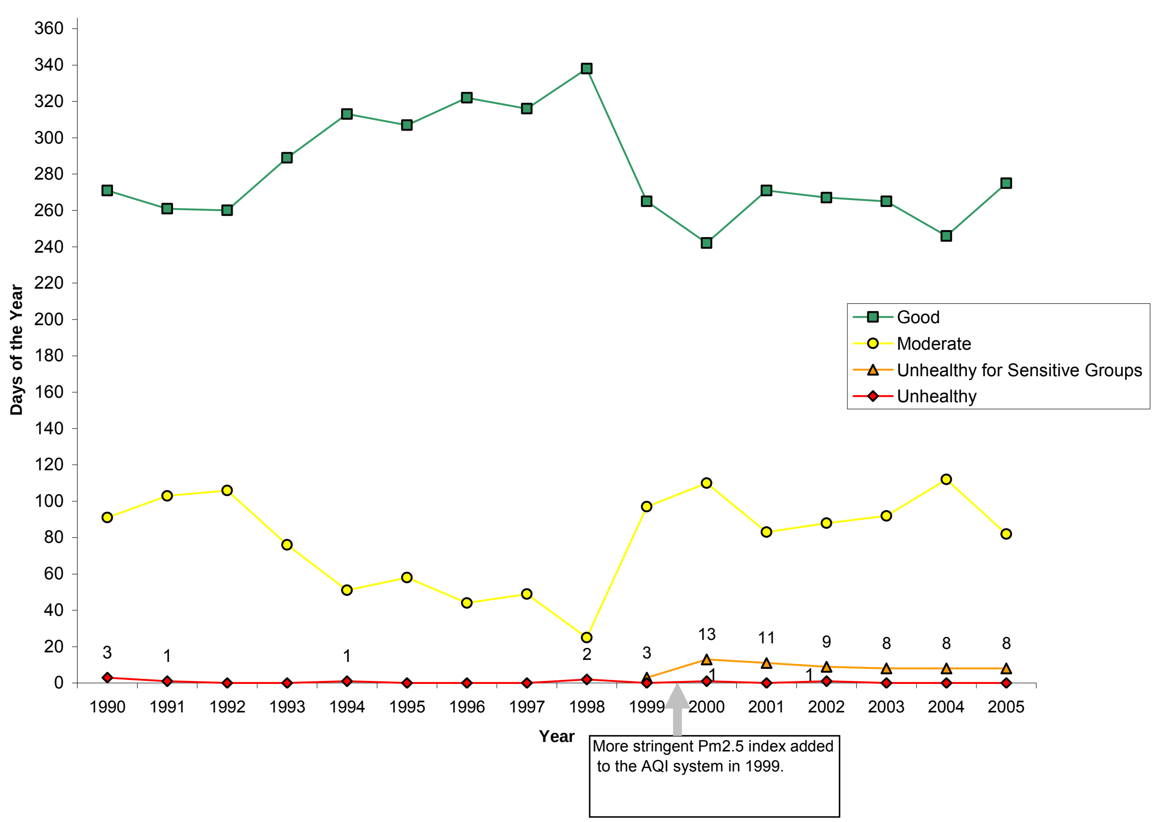
Graphs on pages 9 through 12 present AQI days for Snohomish, King, Pierce, and Kitsap. Graphs include numbers adjacent to the "unhealthy for sensitive groups" and "unhealthy" lines for clarification of the number of days with these designations. Pages A-1 through A-4 of the Appendix present summaries for each county.

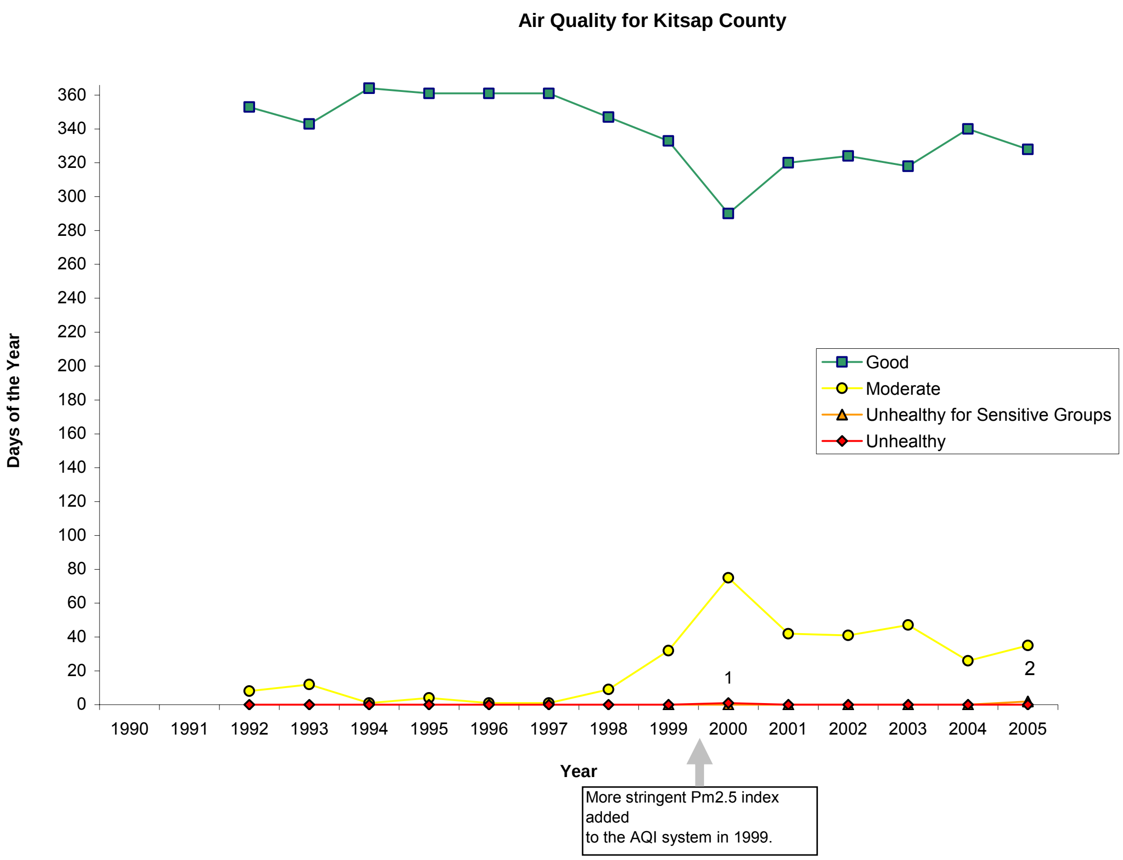



Air Quality for Snohomish County
Days of the Year
Year
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
3
5
2
8
3
3
5
More stringent Pm2.5 index added to the AQI system in 1999.


Air Quality for King County
Days of the Year
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
4
1
2
2
6
7
6
4
2
6
5
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
More stringent Pm2.5 index added
to the AQI system in 1999.

**Air Quality for Pierce County**




Air Quality for Kitsap County
Days of the Year
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
1
2
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
More stringent Pm2.5 index added
to the AQI system in 1999.

## Monitoring Network

The Agency and the Washington State Department of Ecology operate the Puget Sound 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 is currently working with the Washington State Department of Ecology and other local air agencies to improve the efficiency of the telemetry network.

The table on pages 16 through 19 presents a summary of the monitoring stations used and parameters monitored from 1999 through 2005.[13] Some parameters were monitored for only part of this time frame. Shaded stations in the table are currently functioning. Those that are not shaded are no longer in operation. Similarly, a filled circle denotes a pollutant that's currently monitored (in 2005). An "x" denotes a pollutant that was no longer monitored in 2005. The network changes because the Agency regularly re-evaluates its 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; some are located in representative rural areas. Monitors are sited according to specific EPA criteria. EPA developed siting criteria to ensure a consistent and representative picture of air quality in an overall area. The monitoring network map on page 20 shows monitoring stations that were active in 2005, and reflects this attempt at a representative picture.

The station IDs shown on the map correspond with table identification letters. These same identification numbers 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 the Washington State Department of Ecology measure criteria air pollutants using federal reference methods (FRM) that are approved by the Environmental Protection Agency (EPA). In addition, we measure particulate matter using more than one method. These additional methods help engineers and scientists to better understand the presence and behavior of these pollutants. For example,

[13] The Agency conducted monitoring well before 1999. For simplicity, only monitors from 1999 on are presented.

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.

The table on page 21 lists the methods used for the criteria pollutants. Additional information on these methods is available at EPA's website: http://www.epa.gov/ttn/amtic/. Information on air toxics monitoring methods is available at http://www.epa.gov/ttn/amtic/airtox.html.

## Special Monitoring Projects

In addition to the network described in this section and presented on the map on page 20, the Agency conducted two short-term special monitoring projects in 2005 to address specific data needs.

Both of the 2005 special monitoring projects were begun in 2004. The Agency has committed to incorporate one of these, a fine particulate matter project in the town of Darrington, into its "regular" monitoring network. Additional information on the Darrington special project is presented in the fine particulate matter ($PM_{2.5}$) data section of this report.

Another project conducted in south Seattle and west Seattle during summer 2005 was targeted at sulfur dioxide and nitrogen oxide to address odor issues. To refer to information on this site, please see our website for details at http://www.pscleanair.org/programs/community/southpark/air_monitoring.aspx.

## 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. The EPA considers the federal reference method (FRM) to be the most accurate way to determine $PM_{2.5}$ concentrations.[14] This method involves pulling in air (at a given flow rate) and trapping particles of a certain size (in this case $PM_{2.5}$) on a filter. The filter is then weighed and divided by 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 timely information.

The Agency uses the FRM as well as three 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

[14] The EPA also accepts continuous methods that have been adjusted to make them "FRM-like."

- the beta-ray attenuation monitor (BAM) measures beta-ray transmission across a filter tape

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

## Monitoring Network 1999-2005

| 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 | $O_3$ | $SO_2$ | $NO_x$ | CO | $b_{sp}$ | Wind | Temp | AT | Vsby | Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AO◉ | Northgate, 310 NE Northgate Way, Seattle (ended 3/31/03) | | | | | | | | | | | | 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 | | | | | | | | | | | | ● | | | | | | a, d |
| *AS*◉ | 5th Ave & James St, Seattle (ended Feb 28, 2001) | | | | | | | | | | | | X | | | | | | a, d |
| *AU*◉ | 622 Bellevue Way NE, Bellevue (ended Jul 30, 1999) | | | | | | | | | | | | X | | | | | | a, d |
| AZ | Olive Way & Boren Ave, 1624 Boren Ave, Seattle SPECIATION SITE | | | | | | | ● | ● | | | | | ● | ● | | | ● | a, d |
| BF◉ | University District, 1307 NE 45th St, Seattle | | | | | | | | | | | | ● | | | | | | 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 | | | | | | | | | | | | | | ● | ● | | | b, d |
| BW◉ | Beacon Hill, 15th S & Charlestown, Seattle SPECIATION SITE | | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | b, d, f |
| CE | Duwamish, 4752 E Marginal Way S, Seattle SPECIATION SITE | ● | | ● | ● | | ● | ● | ● | | ● | | | ● | ● | | | ● | a, e |
| CW | James St & Central Ave, Kent | 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 | | | | | | ● | ● | | | | | | ● | | | | ● | b, f |
| *DA* | South Park, 8025 10th Ave S, Seattle (ended Dec 31, 2002) | X | | | X | | | X | | | | | | X | X | | | X | b, e, f |
| DB | 17171 Bothell Way NE, Lake Forest Park SPECIATION SITE | X | X | | ● | | ● | ● | ● | | | | | ● | ● | ● | | ● | b, d, f |
| DC◉ | 305 Bellevue Way NE, Bellevue | | | | X | | | ● | | | | | | ● | | | | ● | a, d |

## Monitoring Network 1999-2005

| 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 | $O_3$ | $SO_2$ | $NO_x$ | CO | $b_{sp}$ | Wind | Temp | AT | Vsby | Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DD | South Park, 8201 10th Ave S, Seattle | | | | | | | ● | | | | | | ● | | | | ● | b, e, f |
| DE⦿ | City Hall, 15670 NE 85th St, Redmond | | | | X | | | ● | | | | | | ● | | | | ● | a, d |
| DF⦿ | 30525 SE Mud Mountain Road, Enumclaw | | | | X | | | ● | | ● | | | | | ● | ● | | ● | c |
| DG⦿ | 42404 SE North Bend Way, North Bend | | | | X | | ● | ● | | ● | | | | ● | ● | ● | | ● | c, d, f |
| DH⦿ | 2421 148th Ave NE, Bellevue | | | | | | | | | | | | ● | | | | | | b, d |
| DK⦿ | 43407 212th Ave SE, 2 mi west of Enumclaw | | | | | | | | | | | | | | ● | ● | | | 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 | Port of Tacoma, 2301 Alexander Ave, Tacoma[11] | X | ● | | X | | ● | ● | | | X | | | ● | ● | | | ● | a, e |
| ER | South Hill, 9616 128th St E, Puyallup | X | X | | X | ● | | ● | | | | | | ● | ● | | | ● | b, f |
| ES | 7802 South L St, Tacoma (began Oct 3, 1999) | | | | ● | | ● | ● | ● | | | | | ● | ● | | | ● | b, f |
| FF⦿ | 5225 Tower Drive NE, northeast Tacoma | | | | | | | | | | | | | | ● | ● | | | b, f |
| FG⦿ | Mt Rainier National Park, Jackson Visitor Center | | | | | | | | | ● | | | | ● | | | | | c |

## Monitoring Network 1999-2005

| 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 | $O_3$ | $SO_2$ | $NO_x$ | CO | $b_{sp}$ | Wind | Temp | AT | Vsby | Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FH⦿ | Charles L Pack Forest, La Grande | | | | | | | | | ● | | | | | | | | | c, f |
| FL⦿ | 1101 Pacific Ave, Tacoma | | | | | | | | | | | | ● | | | | | | a, d |
| *ID* | Hoyt Ave & 26th St, Everett (ended Feb 29, 2000) | | | | | | | | | | x | | | | x | | | | a, e, d |
| IG | Marysville JHS, 1605 7th St, Marysville | 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 | | | | ● | ● | ● | ● | | | | | | ● | ● | | | ● | b, d |
| JN⦿ | 5810 196th Street, Lynwood | | | | | | | | | | | | ● | | | | | | 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 | | | | ● | | | | | | | | | ● | | | | b, f |
| *QF* | Lions Park, 6th Ave NE & Fjord Dr, Poulsbo (ended Feb 29, 2000) | | | | | | | | | | | | | | X | | | | b, f |
| QG | Fire Sta #51, 10955 Silverdale Way, Silverdale (began Jun 2, 2000) | | | | | ● | | ● | | | | | | | ● | | | | a, d |
| UB⦿ | 71 E Campus Dr, Belfair (ended September 30, 2004) | | | | | | | | | X | | | | | | | | | c |
| VK⦿ | Fire Station, 709 Mill Road SE, Yelm (began May 1, 2000) | | | | | | | | | ● | | | | | | | | | c. f |

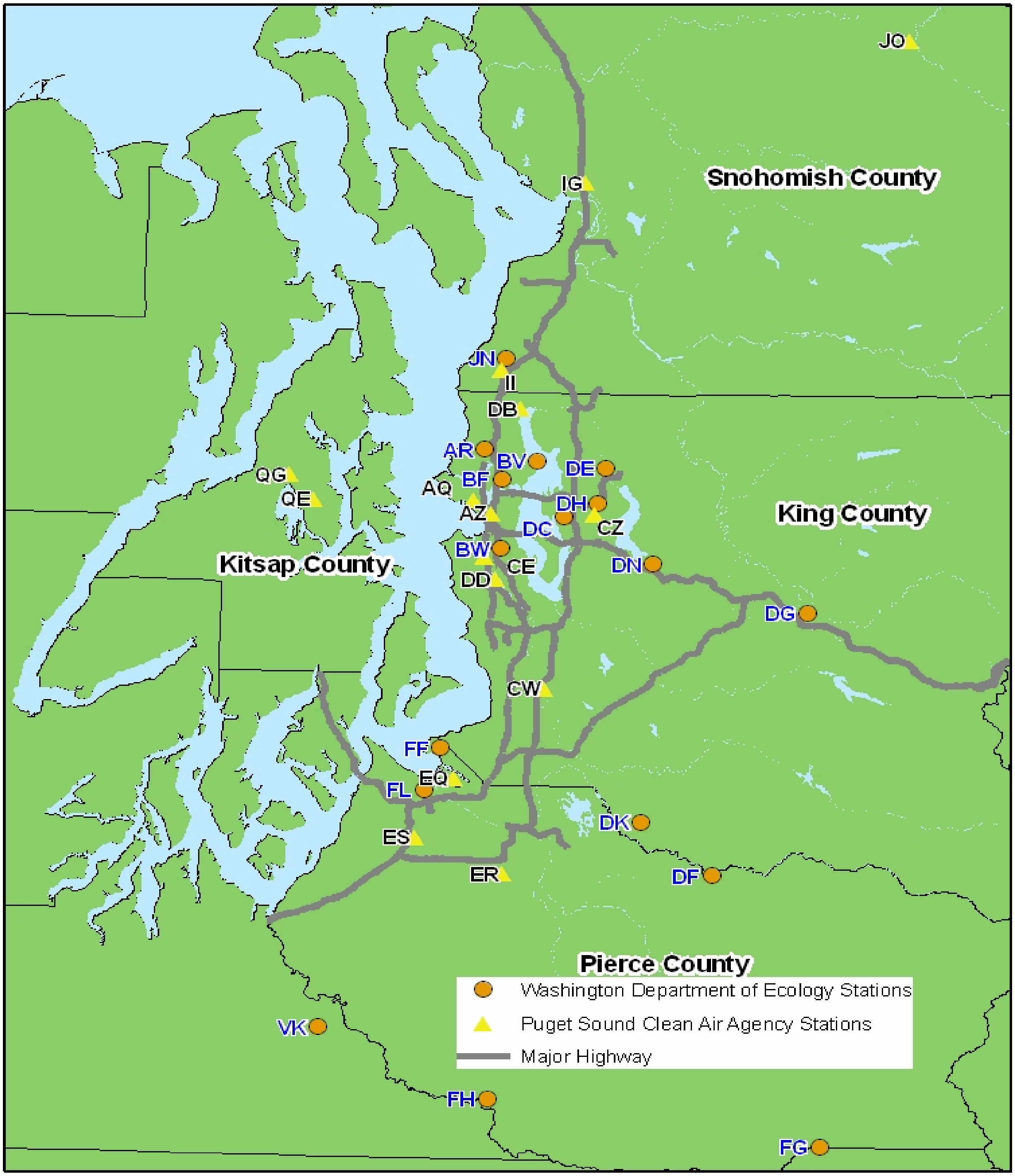
# Monitoring Network 1999-2005

**Monitoring Network Table Notes:**

| | | | |
|---|---|---|---|
| ⦿ | Station operated by Washington State Department of Ecology | $SO_2$ | Sulfur Dioxide |
| VK⦿ | Shading indicates station currently functioning | $NO_x$ | Nitrogen Oxide |
| ⬣ | Indicates parameter currently monitored | CO | Carbon Monoxide |
| X | Indicates parameter previously monitored | $b_{sp}$ | Light scattering by atmospheric particles (nephelometer) |
| $PM_{10}$ ref | Particulate Matter 10 micrometers (reference) | Wind | Wind direction & speed |
| $PM_{10}$ bam | Particulate Matter 10 micrometers (beta attenuation continuous) | Temp | Air temperature (relative humidity also measured at Beacon Hill) |
| $PM_{10}$ teom | Particulate Matter 10 micrometers (teom continuous) | AT | Air Toxics |
| $PM_{2.5}$ ref | Particulate Matter 2.5 micrometers (reference) | VSBY | Visual range (light scattering by atmospheric particles) |
| $PM_{2.5}$ bam | Particulate Matter 2.5 micrometers (beta attenuation continuous) | PHOTO | Visibility (camera) |
| $PM_{2.5}$ teom | Particulate Matter 2.5 micrometers (teom continuous) | $O_3$ | Ozone (May through September) |
| $PM_{2.5}$ ls | Particulate Matter 2.5 micrometers (light scattering nephelometer continuous) | | |
| $PM_{2.5}$ bc | Particulate Matter 2.5 micrometers black carbon (light absorption aethalometer) | | |

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

## 2005 Active Monitoring Sites



## Monitoring Methods Used from 1999 to 2005 in 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 |
| $O_3$ | 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 Relative Humidity |
| $SO_2$ | 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 | RM Young 05305 Wind Monitor AQ | Miles per Hour |
| | Wind Direction | RM Young 05305 Wind Monitor AQ | Degrees |

# Impaired Air Quality—Burn Bans and Smog Watch

## Burn Bans

Washington State has a winter impaired air quality program targeting sources of particulate matter from wood stoves and fireplaces.

2005 was an unusual burn ban year: the Agency issued two burn bans using two different air quality action levels ("triggers"). In 2005, the Washington State Legislature changed the trigger from $PM_{10}$ to $PM_{2.5}$.[15] The $PM_{2.5}$ trigger allows the Agency to better protect public health.

The first 2005 burn ban was declared at 4:00 p.m. on February 21 and called off at 8:00 a.m. on February 28. This burn ban was based on the $PM_{10}$ trigger (24-hour average of 60µg/m$^3$). The second 2005 burn ban was declared at 5:00 p.m. on December 9 and called off at noon on December 18. This ban was based on the new $PM_{2.5}$ trigger (24-hour average of 35µg/m$^3$).

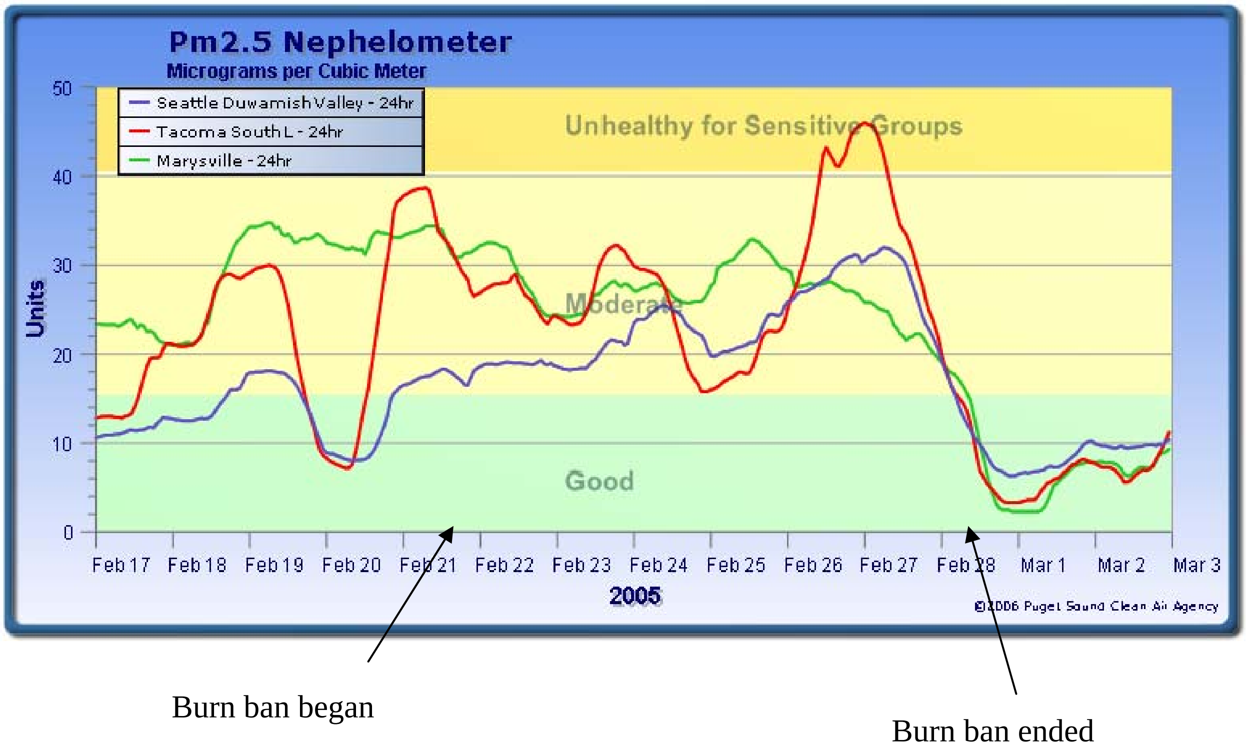
Fine particulate levels at three monitoring sites during the February and December burn bans are shown on pages 23 and 24. These three sites (Marysville in Snohomish County, Duwamish in King County, and Tacoma South L in Pierce County) are shown because they typically register some of the highest fine particulate levels in the region. Graphs show the 24-hour average $PM_{2.5}$ concentrations, with Air Quality Index (AQI) shading.[16] Even with the burn ban, air quality reached the "unhealthy for sensitive groups" designation for some monitoring sites during these long winter inversions. It's also noteworthy that these sites exceeded the Agency's health goal of 25 µg/m$^3$ during the burn bans.

Both burn bans were first-stage bans. For a first-stage burn ban, residential burning in fireplaces or uncertified wood stoves is prohibited (unless it is the only adequate source of heat).[17] A second-stage burn ban may be declared when $PM_{2.5}$ levels reach 60 µg/m$^3$ (24-hour average). For a second stage burn ban, the use of any kind of wood-burning device is prohibited. The Agency has not issued a second-stage burn ban since 1991.

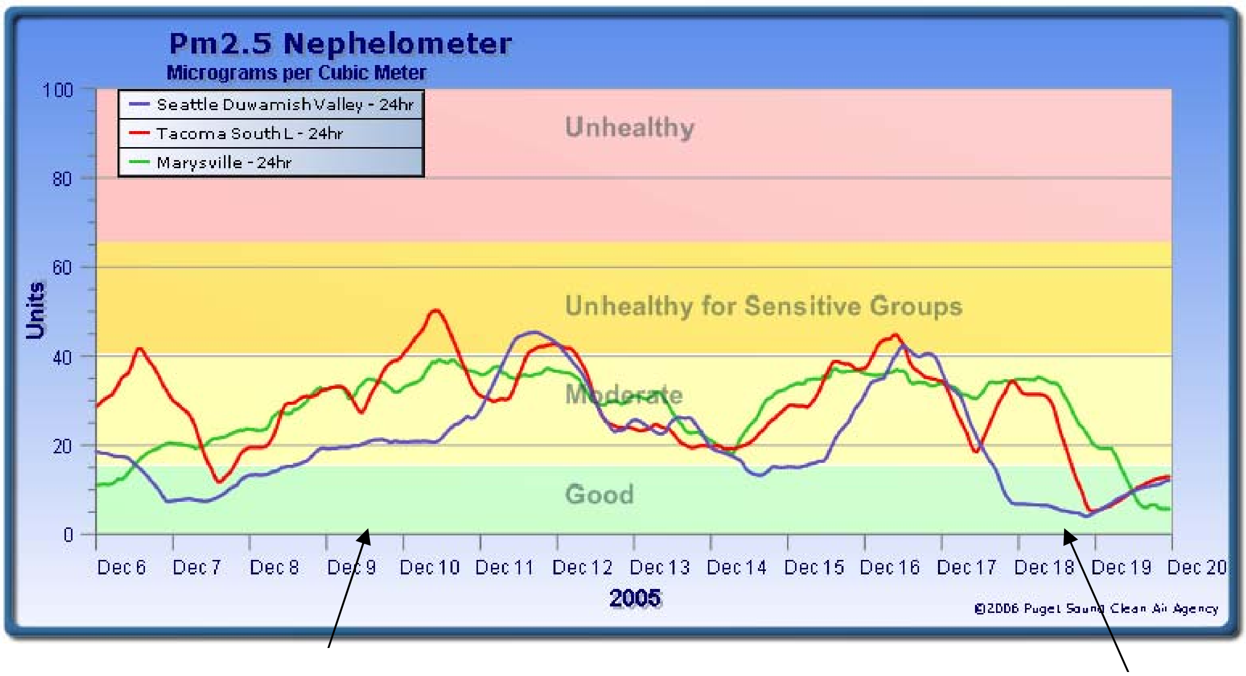
Burn bans typically occur in November through February. The graph on page 25 shows the number of days when burn bans have been declared since 1988. A detailed list of these burn bans is included on page A-5 of the Appendix.

[15] Burn bans are included in the Agency's Regulation I, Article 13 Solid Fuel Burning Device Standards. http://www.pscleanair.org/regulated/reg1/reg1.pdf.
[16] Graph concentrations are based on $PM_{2.5}$ nephelometer measurements. Each point represents a 24-hour average, based on the 12 hours before and after.
[17] Uncertified wood stoves emit much 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.

February Burn Ban

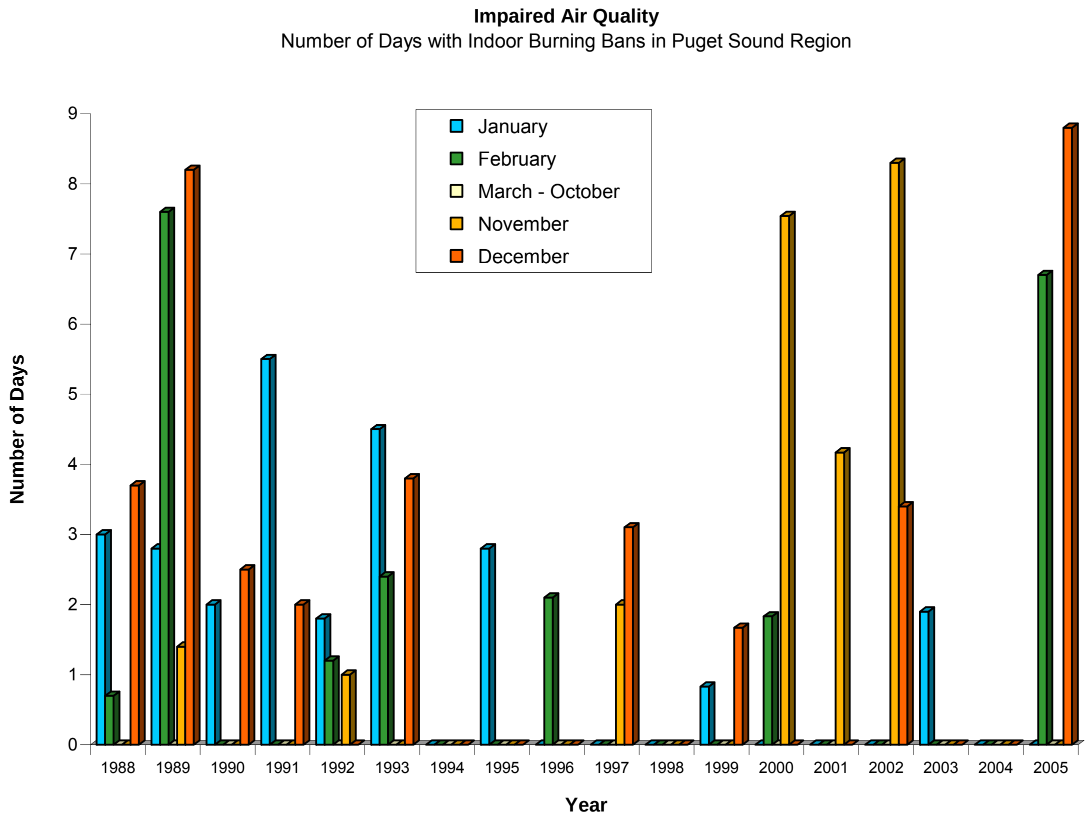


December Burn Ban




Burn ban began

Burn ban ended




## Smog Watch

The Agency maintains a voluntary air quality program called Smog Watch. This program addresses causes of summer smog between June and September through outreach awareness. Smog Watch advises residents of potential smog problems and recommends short-term actions to help reduce ozone levels. Summer smog typically becomes a problem on hot stagnant summer days when ozone accumulates. Thus, advisories are driven more by meteorology than by monitored air quality data. The Agency calls a Smog Watch when 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 Watch advisories. The Agency and its partners encourage people to take measures to reduce smog levels. These voluntary actions include driving less (by carpooling, riding transit, teleworking), waiting until it cools off to use gasoline-powered mowers and power equipment, and refueling vehicles during the cooler evening hours.

Meteorology in summer 2005 did not require the Agency to issue any Smog Watches.

# Regional Emissions Inventory

## Introduction

This section presents a 2004 air emissions inventory summary for four criteria air pollutants: carbon monoxide (CO), nitrogen oxides ($NO_X$), fine particulate matter ($PM_{2.5}$), and sulfur dioxide ($SO_2$). An emission inventory is also presented for volatile organic compounds (VOCs). VOCs, like $NO_X$, are precursors of ozone, another criteria air pollutant. This section also summarizes greenhouse gases and air toxics emission inventories.

The Agency conducts emission inventories to identify sources of pollutants. Once identified, emissions can be reduced through strategies such as improved control technologies, education and outreach targeting specific behavior changes, regulatory changes, and economic incentives.

The National Emission Inventory (NEI) is prepared by the EPA every three years with input from local and state agencies. The Agency conducts comprehensive emission inventories for criteria air pollutants and air toxics in NEI years. The Agency is in the processing of completing the 2005 NEI, and it is not yet available for this report.

The 2004 criteria air pollutant inventory presented below is based on adjustments to the 2002 NEI inventory. These adjustments may include the most recently available activity levels such as: vehicle miles traveled, acres burned, and updated population information and surveys.

## Source Categories

Four general categories characterize anthropogenic (caused by humans) emission sources. The four general categories are listed below, with some major subcategories bulleted. In addition to these four, biogenic (naturally-occurring) sources also emit pollutants. Examples include volatile organic compound emissions from trees and plants and nitrous oxide emissions from soil.

1. Point Sources

   Point sources are those that many people consider when thinking of air pollution. These include large industries that emit several tons of pollution or more per year from a single location, often through a smokestack. Historically, point sources contributed a large portion of air pollutants in this area. Today, this category typically represents a very small fraction of pollutant emissions in the Puget Sound area. This large reduction is due to improved control technology and regulation, and closure of some large industrial facilities, particularly smelters.

2. Mobile On-Road Sources

- Gasoline vehicles
- Diesel vehicles

Mobile on-road sources include cars, trucks, and buses, both commercial and private. This category includes vehicles that run on gasoline or diesel fuel. On-road mobile sources are the single greatest contributors to air pollution in this region. Reduction strategies include: lower-emitting vehicles such as hybrids, better fuels such as ultra-low sulfur diesel, emission control technology such as diesel particulate filters and oxidation catalysts, and behavior changes such as carpooling and teleworking.

3. Mobile Non-Road Sources

- Off-road vehicles and equipment
- Marine vessels and watercraft
- Aircraft and airport equipment
- Railroad engines

Mobile non-road sources include marine vessels, construction vehicles and equipment, aircraft, trains, and garden equipment. The 2004 emission inventory separates mobile non-road sources into three subcategories: off-road vehicles and equipment, marine vessel emissions, and aircraft and airport emissions. Marine vessel emissions are a concern due to increased foreign shipping activity in local ports. The Agency, along with other members of the Puget Sound Maritime Air Forum, recently committed to an exhaustive inventory of greater Puget Sound to quantify emissions. This inventory will provide a level of detail beyond the NEI inventory.

Reduction strategies for mobile non-road sources include: better fuels such as ultra-low sulfur and biodiesel, use of electrical lawn equipment, ship use of land-based electricity while in port (instead of running engines to generate electricity), and alternatives to diesel-fueled vehicles at the regional airport.

4. Stationary Area Sources

- Outdoor burning
- Indoor wood burning
- Other

Although area sources emit far less than point sources on an individual basis, the large numbers of these activities make them significant contributors to pollution in this region. The 2004 emission inventory lists indoor and outdoor burning area source subcategories separately. These two subcategories contribute significant emissions to fine particulate matter, a pollutant of concern in the Puget Sound area. Burning in a wood stove, pellet stove, or fireplace are examples of indoor burning. Burning stumps and brush to clear land and burning yard waste are examples of outdoor burning.

Area sources also include small commercial businesses. Small business activities that emit pollutants include solvent loss during surface coating, and degreasing. Road dust is also included as an area source, significant for $PM_{2.5}$.

Reduction strategies for stationary area sources include: less indoor burning and cleaner indoor burning (use of EPA-certified wood stoves and inserts), less outdoor burning (including larger areas where burning is prohibited), use of low-emission paints and solvents, and improved practices such as closed-loop dry cleaning machines.

## 2004 Emission Inventory

The Agency modified the 2002 draft NEI to estimate 2004 emissions for criteria air pollutants, VOCs, and carbon dioxide. Carbon dioxide is presented as a major greenhouse gas. The 2004 inventory includes anthropogenic sources listed above. Biogenic emission sources such as vegetation and soil are also included where appropriate.

As with any emission inventory, the 2004 inventory has a level of uncertainty. This uncertainty comes from estimation of activity levels, such as how often people burn wood in a fireplace, or how far and often people drive in their cars. Surveys designed to provide this data inevitably have limitations in sample size, population reached, and results interpretation. In addition to activity level uncertainty, there is also the question of the emission factors themselves. These values designate how much of a pollutant is released from a certain activity, and are typically developed by EPA, in consultation with state and local air agencies and industry. Some of these emission factors are based on several studies, and some are based on only a few. Emission factors may also vary under different circumstances. Additional information on emission factors and how they are derived is available on EPA's website at http://www.epa.gov/oar/oaqps/efactors.html.

The following table presents the contributions from each major source category for criteria pollutants, VOCs, and carbon dioxide. $PM_{2.5}$ is listed for particulate matter.

Puget Sound Region 2004 Estimated Criteria Air Pollutant Emission Inventory Summary (thousands of tons)[18]

| Source Category | $PM_{2.5}$ | $NO_x$ | $SO_x$ | CO | VOC |
|---|---|---|---|---|---|
| **Point Sources (Large Facilities)** | **1** | **8** | **3** | **6** | **4** |
| **On-road Mobile Sources** | **2** | **106** | **4** | **931** | **80** |
| *On-road Gasoline Vehicles* | *1* | *63* | *3* | *920* | *78* |
| *On-road Diesel Vehicles* | *1* | *42* | *1* | *11* | *2* |
| **Non-Road Mobile Sources** | **4** | **41** | **5** | **315** | **25** |
| *Marine Vessels and Watercraft* | *2* | *14* | *2* | *28* | *6* |
| *Off-road Vehicles and Equipment* | *2* | *23* | *2* | *261* | *17* |
| *Aircraft and Airport Equipment* | *0.2* | *3* | *0.2* | *26* | *2* |
| **Stationary Area Sources** | **23** | **9** | **1** | **59** | **74** |
| *Outdoor Burning* | *10* | *2* | *0.5* | *30* | *4* |
| *Indoor Wood Burning* | *4* | *1* | *0.1* | *25* | *13* |
| *Other Sources* | *9* | *6* | *0.1* | *3* | *57* |
| **Biogenic Sources** | **0** | **2** | **0** | **0** | **71** |
| **Totals** | **29** | **165** | **12** | **1,311** | **255** |

This 2004 inventory demonstrates that on-road vehicles continue to be the greatest contributor to criteria pollutant emissions in the Puget Sound airshed. Area sources are the major contributor of $PM_{2.5}$ emissions. Each pollutant is discussed briefly below, and information in the table above is presented in graphs.

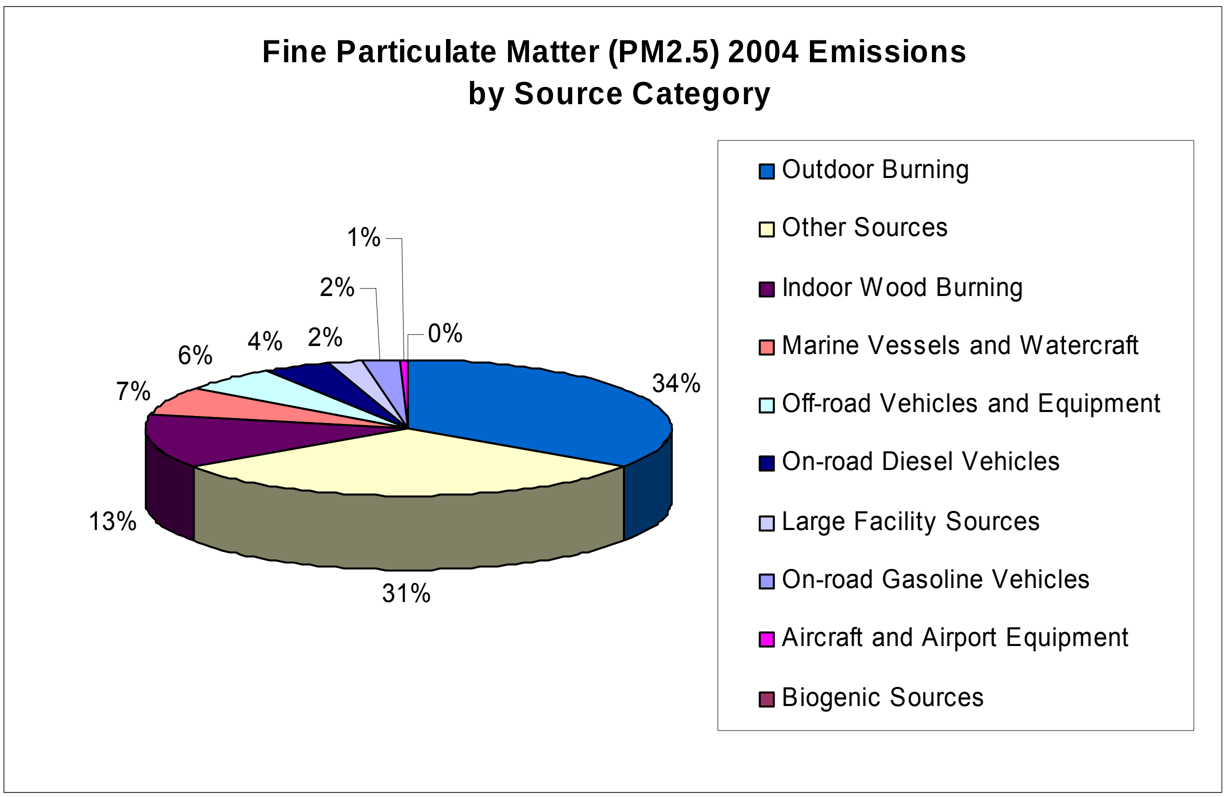
[18] Totals represent rounding to the nearest thousand tons and are not simply the sum of the rounded subcategory values.

## Particulate Matter ($PM_{2.5}$)

Burning wood (included in stationary area soures) is clearly the largest contributor to fine particulate matter in the Puget Sound area. Outdoor and indoor wood burning estimates combined contribute almost half of the fine particulate contribution of all area sources. Less burning and cleaner burning practices are the reduction strategies to reduce emissions from these categories.

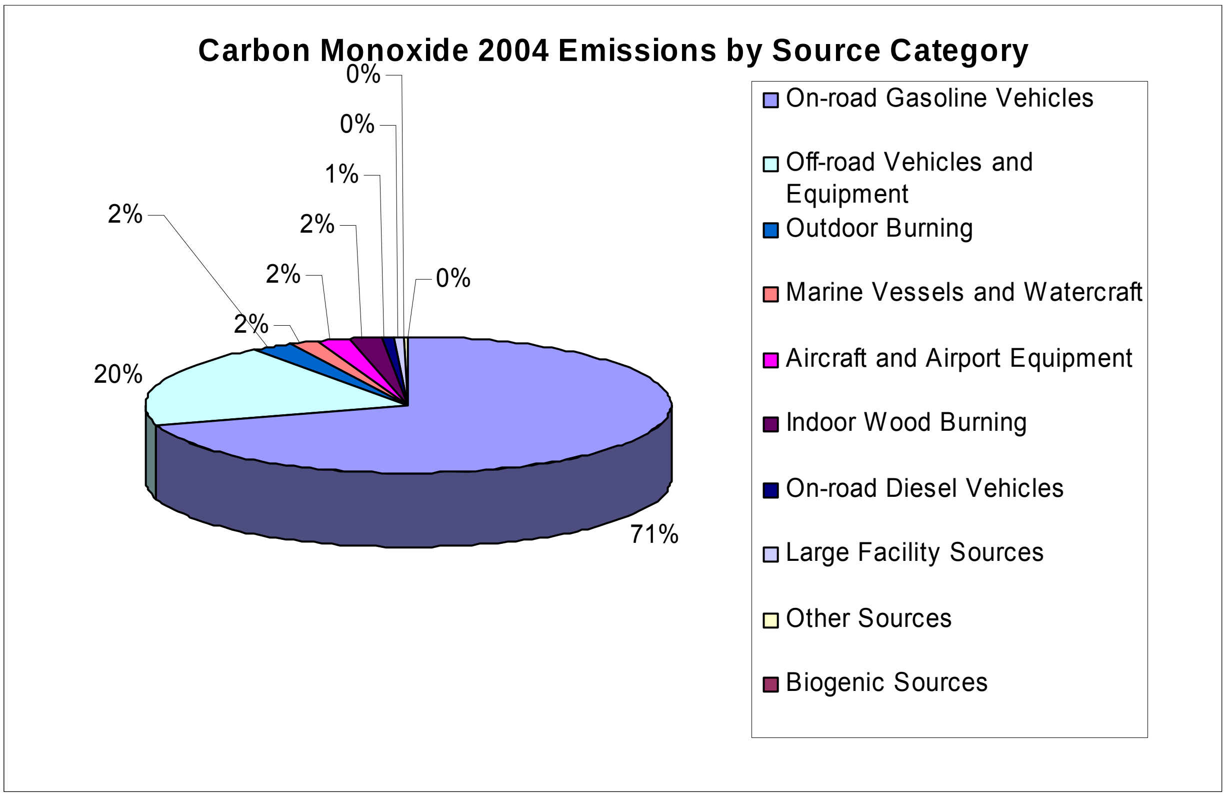
The "Other" category for $PM_{2.5}$, with 31% of emissions, is largely made up of dust from paved and unpaved roads and dust from construction. Fine particulate from cooking, particularly charbroiling and deep frying, is also included in this category.

All mobile sources, including on-road and non-road, contribute 20% of overall $PM_{2.5}$ emissions in the Puget Sound area.



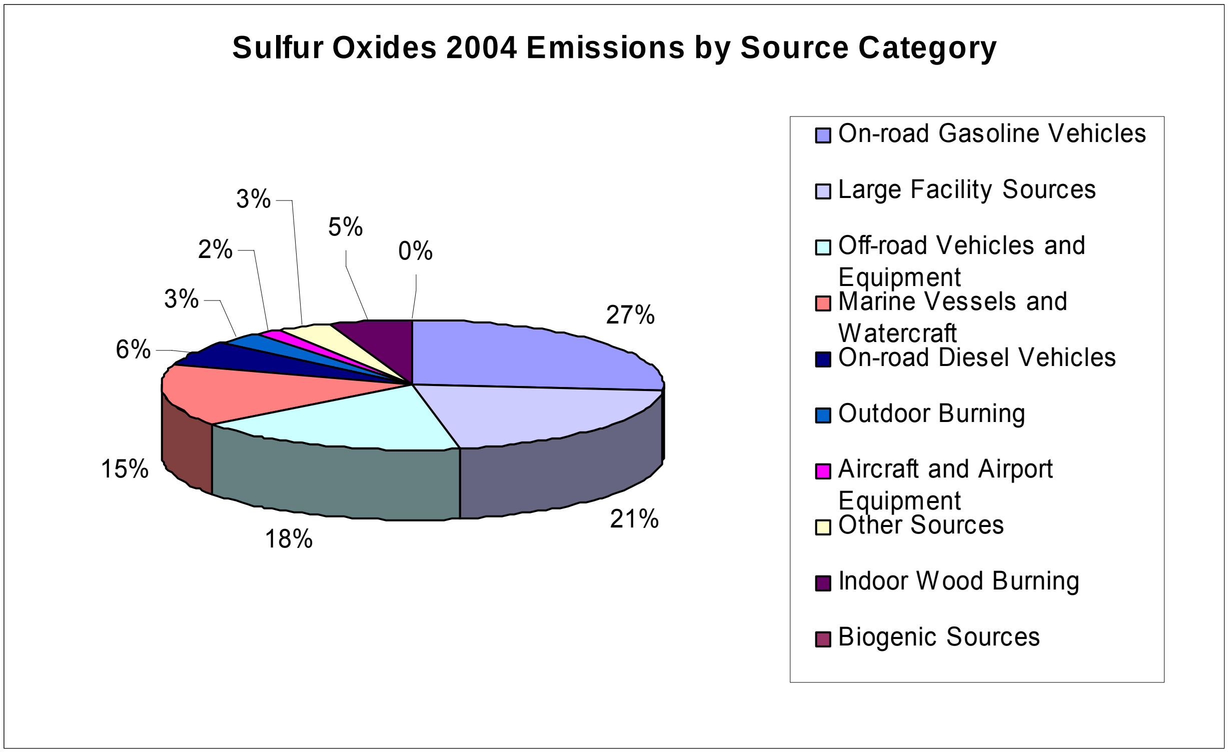
## Carbon Monoxide

On-road gasoline vehicles, such as cars, trucks, and SUVs, are clearly the greatest contributor of carbon monoxide (CO) emissions in the Puget Sound area. CO is not a pollutant prioritized for reduction strategies in the Puget Sound area, as ambient levels are typically very low.



## Sulfur Dioxide

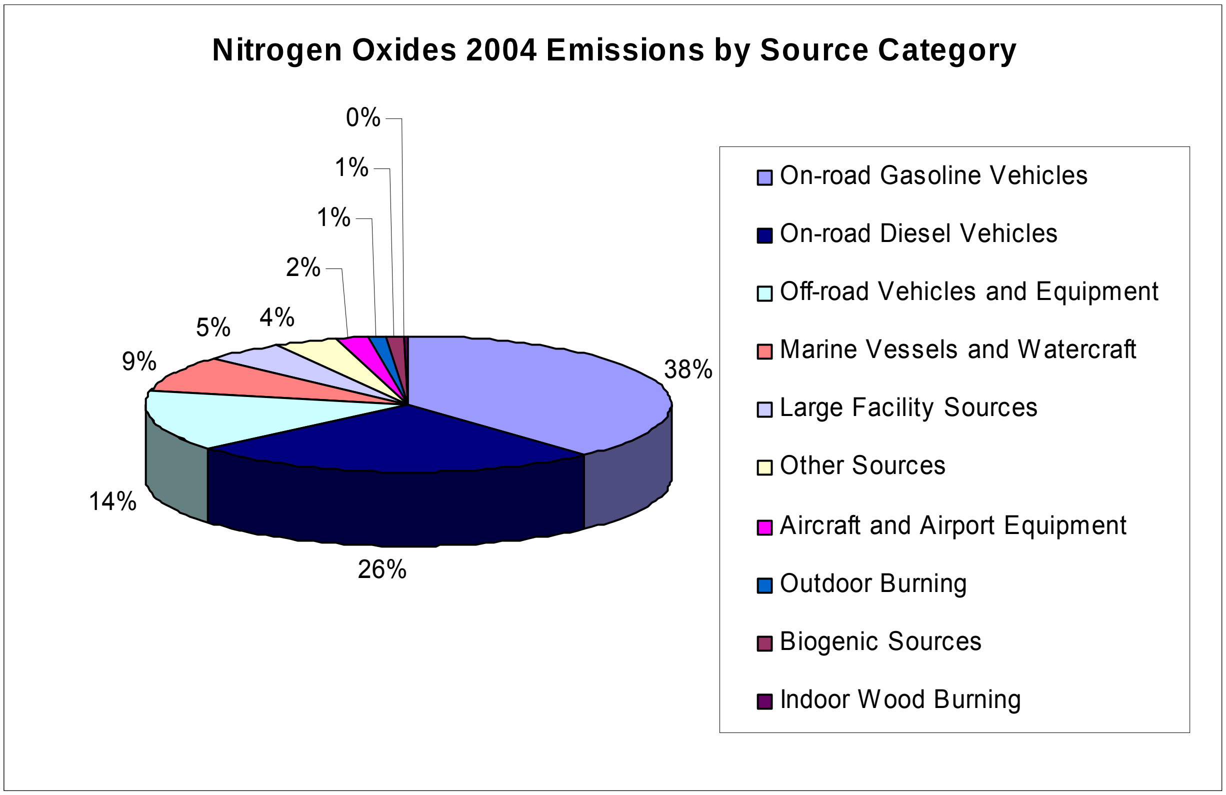
On-road gasoline vehicles comprise the greatest portion of contributors of $SO_x$ emissions, with almost one third of the total contribution.[19] Large facilities and off-road vehicles and equipment also contributed a significant portion, with over 20% and almost 20%, respectively. Greater distribution and use of ultra-low sulfur fuel is the main strategy to reduce $SO_x$ emissions from these sources.




[19] Sulfur oxides include predominantly sulfur dioxide, as well as other oxides of sulfur.

## Nitrogen Oxides

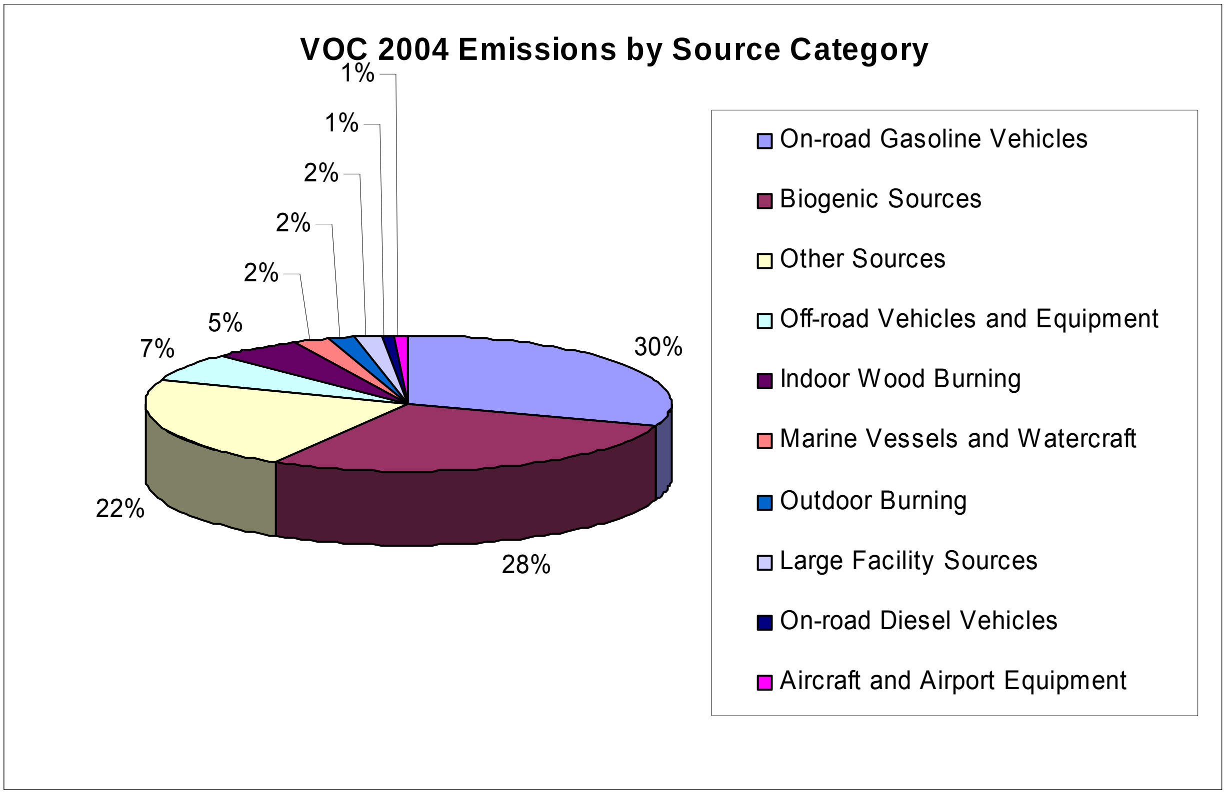
On-road vehicles are the greatest source of emissions of nitrogen oxides ($NO_X$), with 64% of the total source contribution between gasoline and diesel vehicles. In addition to being a criteria air pollutant, $NO_X$ also contributes to the formation of ozone, another criteria air pollutant.[20]




[20] Nitrogen dioxide is a criteria pollutant. Nitrogen oxides ($NO_X$) include nitrogen dioxide as well as other oxides of nitrogen.

## Volatile Organic Compounds

VOCs are a primary precursor for ozone, a criteria pollutant. The graph below shows that on-road vehicles contribute a large portion of VOC emissions, with 30% of the total. Biogenic sources are also a significant contributor of VOC emissions (28%), since trees and plants release significant quantities of VOCs. The "Other" category includes evaporation of VOCs from paints, solvents, and fuels. Indoor burning and outdoor burning are shown as 5% and 2% contributors, respectively, in this annual emission inventory. The EPA emission factor for calculating VOCs from fireplace burning may be high when compared to open burning VOC factors, hence, indoor burning VOC emissions may not be as significant as presented here.



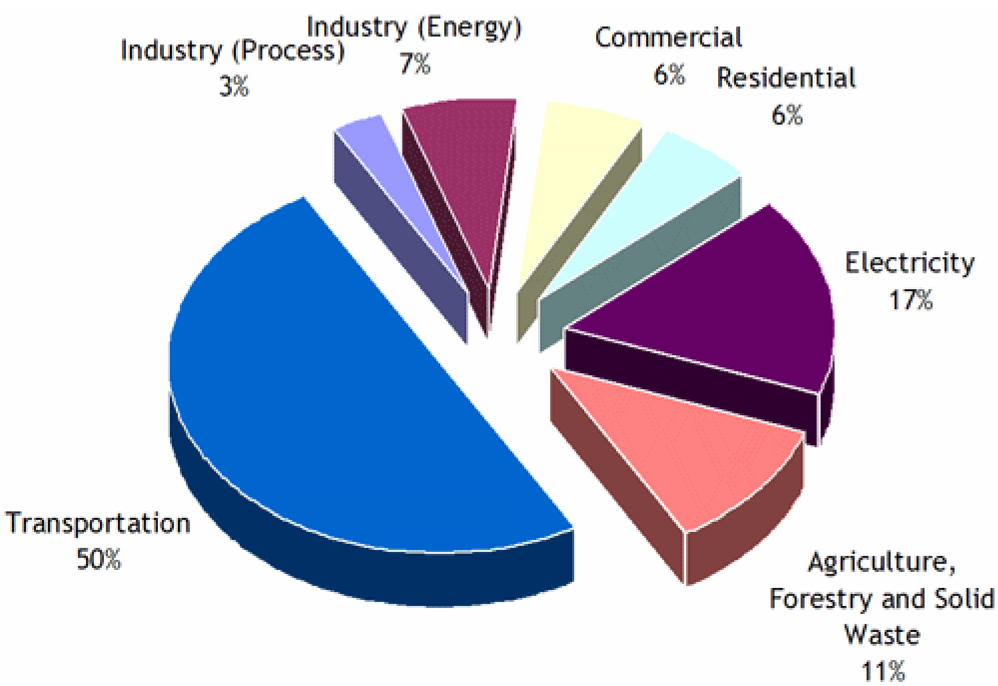
## Greenhouse Gases

The Agency conducted a complete greenhouse gas emissions inventory for year 2000 emissions as part of its Climate Protection Advisory Committee (CPAC) process. This inventory covered the six types of gases included in the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The inventory shows that the transportation sector contributed half of all greenhouse gases in the Puget Sound area.

A complete description of the inventory and the CPAC recommendations to reduce global warming emissions in our area is provided in our CPAC report.[21] The graph below shows the 2002 inventory, based on the 2000 inventory and scaled for growth.

### Sources of greenhouse gases

**Sources in region: CO2 Equivalents**
*Inventory for year 2002*




[21] Roadmap for Climate Protection: Reducing Greenhouse Gas Emissions in Puget Sound. The Puget Sound Clean Air Agency Climate Protection Advisory Committee. http://www.pscleanair.org/programs/climate/rptfin.pdf.

## Air Toxics

Air toxics are a large group of pollutants associated with adverse health effects. Some air toxics are also VOCs. Some air toxics are associated with particulate matter. The Agency conducted an air toxics emissions inventory for the 2002 NEI, and is currently working on the 2005 NEI air toxics inventory. Due to the large number of pollutants involved, the Agency did not complete an interim-year (2004) air toxics inventory.

The chart below is based on the 2002 emissions inventory and represents emissions from hazardous air pollutants, a subset of 188 air toxics designated by EPA. The categories are not broken down as completely as other pollutants: non-road mobile is not broken down into subcategories, for example.

On-road gasoline vehicles contributed the greatest amount of air toxics. Emissions of toluene, xylenes, and benzene made up the majority of this contribution. Formaldehyde, an air toxic of concern, also has significant emissions from on-road vehicles.

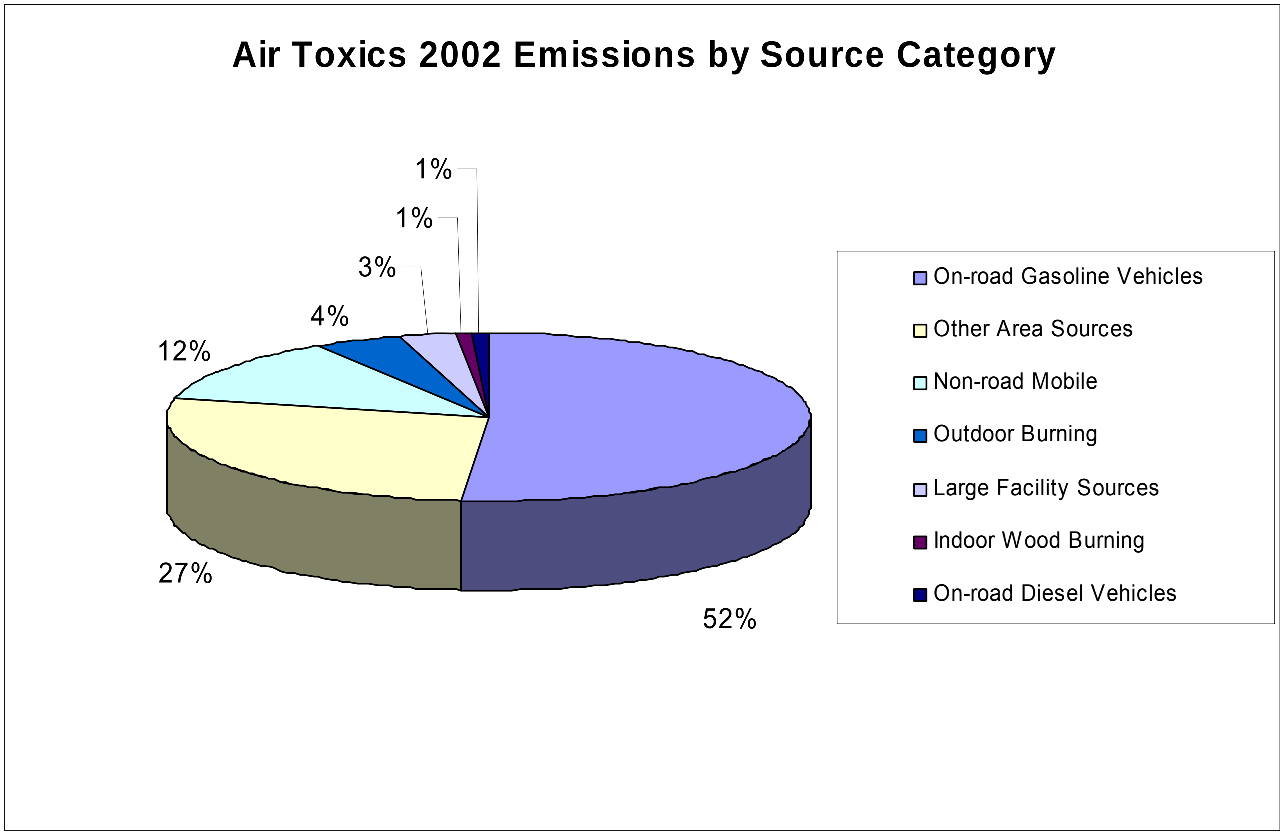
Two significant area source categories are shown individually on the chart below, outdoor (4%) and indoor burning (1%). Toluene and formaldehyde are two significant air toxics in these burning groups. The “Other” section of area sources (27% of total) includes emissions from a variety of sources, primarily industrial, commercial, and residential solvent use.

It is ***very important*** to note that the chart below shows only the estimated amount of pollutant emitted. It is essential to look at both the amount and toxicity of air toxics when assessing risk and prioritizing reductions. A perfect example is diesel exhaust. Although diesel vehicles contribute a small amount to the total amount of air toxics (less than 1%), this small amount translates to high risk because of the high toxicity of diesel particulate matter, a component of diesel exhaust. Thus, diesel vehicles are a high priority for emission reductions.

The air toxics of greatest concern in the Puget Sound area include diesel particulate matter, wood smoke, benzene, formaldehyde, acetaldehyde, chromium, 1,3-butadiene, and acrolein. These toxics are of concern because of their quantities in our local airshed, as well as their toxicity.

Actions for reducing these main toxics of concern include installing retrofit technology on diesel vehicles and equipment, substituting cleaner cars such as hybrids for older dirtier ones, and replacing wood burning with cleaner alternatives (propane, natural gas, or electricity).

More specific information about the 2002 air toxics inventory is available upon request.


Air Toxics 2002 Emissions by Source Category
1%
1%
3%
4%
12%
27%
52%
On-road Gasoline Vehicles
Other Area Sources
Non-road Mobile
Outdoor Burning
Large Facility Sources
Indoor Wood Burning
On-road Diesel Vehicles

# 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 primarily protect the general 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. The EPA has established standards for six criteria pollutants. The list below contains seven pollutants, which includes two size ranges of particulate matter.

The State of Washington and the Puget Sound region have adopted these standards, and in the case of sulfur dioxide have also applied a stricter state standard. For more information, the EPA air quality standards and supporting rationale are available on the web 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.[22] The air quality standards that apply to the Puget Sound airshed are summarized in the table on page 39.

The EPA proposed a new, lower fine particulate standard in December 2005. The proposed daily standard of 35 $\mu g/m^3$ is more consistent with the Agency's health goal, discussed below. In addition to reducing the fine particulate daily standard, EPA proposed to repeal the $PM_{10}$ standard and replace it with a PM Coarse ($PM_{10\text{-}2.5}$) standard. PM Coarse includes particulate matter between $PM_{2.5}$ and $PM_{10}$. These proposed standards are scheduled to be promulgated in fall 2006. The proposed standards may be changed before they are actually adopted and enforced.

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, and conducted an extensive process to examine the fine particulate standard.[23] The Health Committee did not consider the current federal standard to be protective of human health. In 1999, the Agency adopted a health goal of 25 $\mu g/m^3$ for a daily average, well below the current standard of 65 $\mu g/m^3$. The form of this goal is "never-to-be-exceeded." The Agency did not adopt a separate health goal for the annual $PM_{2.5}$ average.

[22] Washington Administrative Code chapters 173-470, 173-474, and 173-475
[23] 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.

## Puget Sound Region Air Quality Standards for Criteria Pollutants

| Pollutant | Standard | Level |
|---|---|---|
| Ozone | The daily maximum 1-hour average must not exceed the level more than an average of once per year over a 3-consecutive-year period (no longer applicable after June 15, 2005) | 0.12 ppm |
| | The 3-year average of the 4th highest daily maximum 8-hour average concentration must not exceed the level | 0.08 ppm |
| Particulate Matter (10 micrometers) | The 3-year annual average of the daily concentrations must not exceed the level | 54 μg/m³ |
| | The 3-year average of the 99th percentile (based on the number of samples taken) of the daily concentrations must not exceed the level | 154 μg/m³ |
| Particulate Matter (2.5 micrometers) | The 3-year annual average of the daily concentrations must not exceed the level | 15 μg/m³ |
| | The 3-year average of the 98th percentile (based on the number of samples taken) of the daily concentrations must not exceed the level | 65 μg/m³ |
| Carbon Monoxide | The 1-hour average must not exceed the level more than once per year | 35 ppm |
| | The 8-hour average must not exceed the level more than once per year | 9.4 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 |
| | AND no more than twice in 7 consecutive days can the 1-hour average exceed | 0.25 ppm |
| Lead | The quarterly average (by calendar) must not exceed the level | 1.5 μg/m³ |
| Nitrogen Dioxide | The annual mean of 1-hour averages must not exceed the level | 0.053 ppm |

Note: Daily concentration is the 24-hour average, measured from midnight to midnight.

Note: EPA adopts rounding conventions. Values in this table may look slightly different than values on EPA's website.

Pollutants typically have multiple standards with different averaging times; for example, daily and annual standards. Multiple standards are created and enforced to address different health impacts that happen 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, and additional information is on EPA's website at http://epa.gov/air/criteria.html.

A distinction exists between "exceeding" and "violating" a standard. The two are not equivalent. This distinction is due to the nature of the standards. In most instances it is allowable for a monitoring site to exceed the standard a few times. This allowance is made to account for possible meteorological aberrances. For example, a carbon monoxide 8-hour average of 10 ppm clearly exceeds the standard. It does not, however, violate the standard if it is the only exceedance that year (the standard allows for one exceedance).

The EPA standards typically apply to an "area", which may be defined in different ways. Data are presented for multiple monitoring stations in the following sections because this provides insight into the distribution of pollutants in the Puget Sound area. The summaries that follow show how the Puget Sound airshed compared to federal standards for the year 2005. Some graphs also incorporate the AQI where applicable. AQI shading is shown to aid interpretation of air quality, but does not imply whether or not standards were actually met for each pollutant; only meeting the conditions listed in the table on page 39 warrant compliance. Additionally, one graph presents the number of days that our region did not meet the Agency's $PM_{2.5}$ health goal.

## Particulate Matter (10 micrometers)

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. Coarse particles typically come from crushing or grinding operations and dust from roads. $PM_{10}$ can aggravate respiratory conditions such as asthma. People with respiratory conditions should avoid outdoor exertion if $PM_{10}$ levels are high.

$PM_{10}$ is currently monitored in the Puget Sound area using continuous methods at four monitoring sites. Continuous data is more helpful than reference method data in many ways, as it informs of air quality in near real time. Historically, monitoring $PM_{10}$ was required to call burn bans.[24] The Agency ceased monitoring $PM_{10}$ with the federal reference method in 2003.

All four counties have been below the daily and annual $PM_{10}$ federal standards since the early 1990s, and EPA designated the Puget Sound region in attainment for $PM_{10}$ in 2001. $PM_{10}$ is no longer a major concern in the Puget Sound area.

EPA recently proposed a new standard for PM Coarse, to include only particles with diameters ranging from 2.5 – 10 micrometers. EPA's proposal includes eliminating the $PM_{10}$ standard. Anticipated PM Coarse concentrations in our area, based on current and historic monitoring, are likely to be well below the proposed PM Coarse standard.

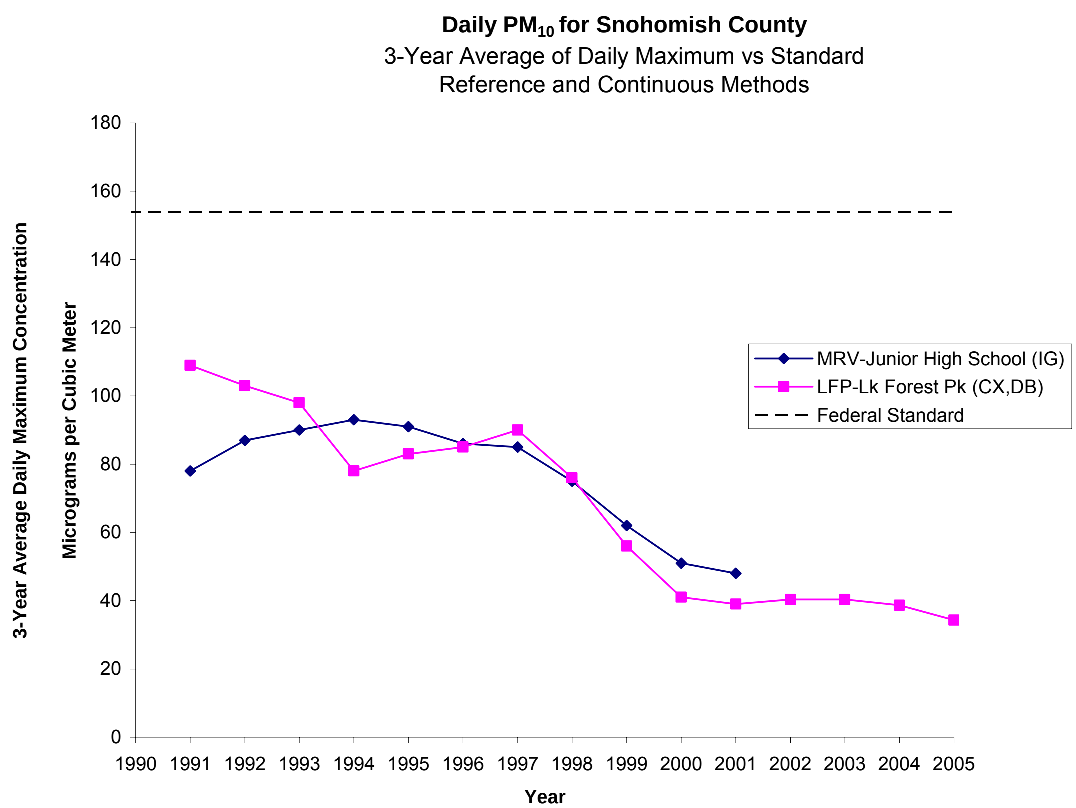
The graphs on the following pages show daily $PM_{10}$ concentrations compared to the federal standard. These graphs include historical reference method monitoring prior to 2004. The 2004 and 2005 values represent three-year averages calculated using continuous methods.[25] Graphs for the annual $PM_{10}$ standard are not presented. The area's monitors show annual average values less than half the standard of 54 $\mu g/m^3$.

A statistical summary of 2005 continuous method $PM_{10}$ concentrations is provided on page A-6 of the Appendix. The highest daily $PM_{10}$ concentration was 91 $\mu g/m^3$ on February 24th at the Seattle Duwamish monitoring site, well below the federal standard.

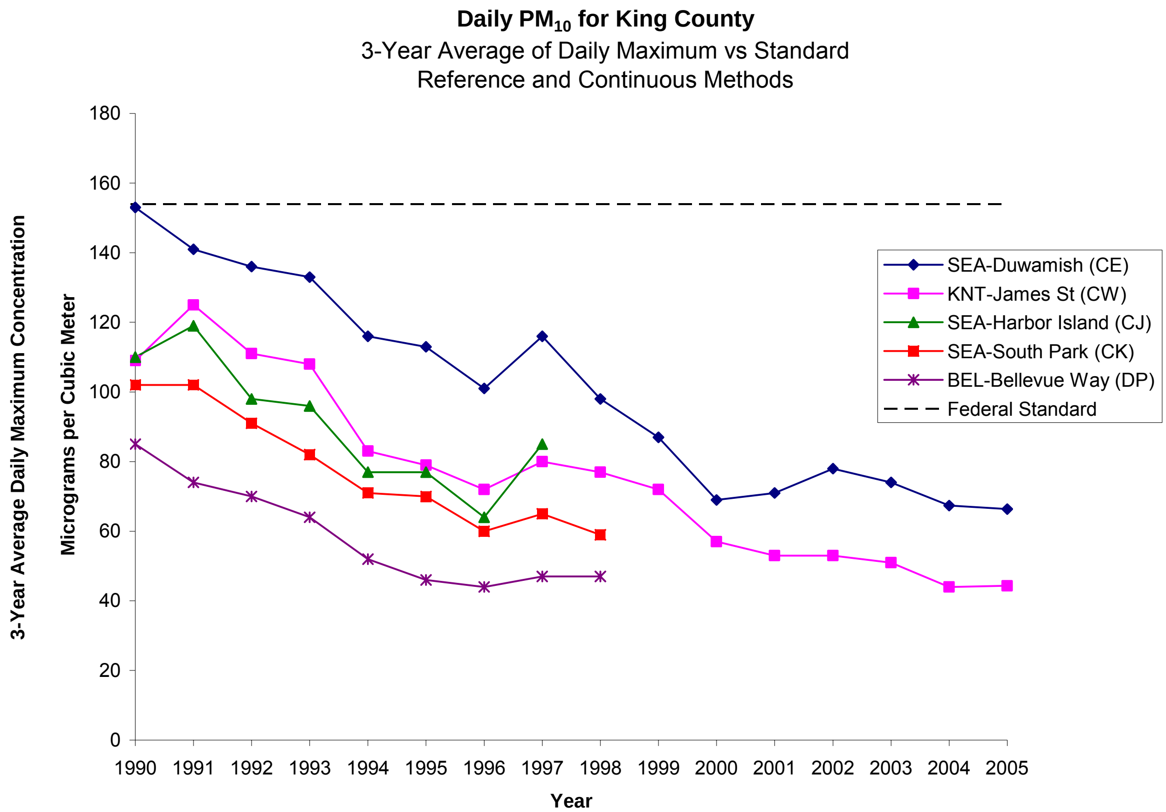
Visit www.epa.gov/air/urbanair/pm/index.html for additional information on $PM_{10}$. More information on $PM_{10}$ is also presented in question/answer format in the definitions section of this document.

[24] The Washington state burn ban trigger was changed to $PM_{2.5}$ in early 2005.

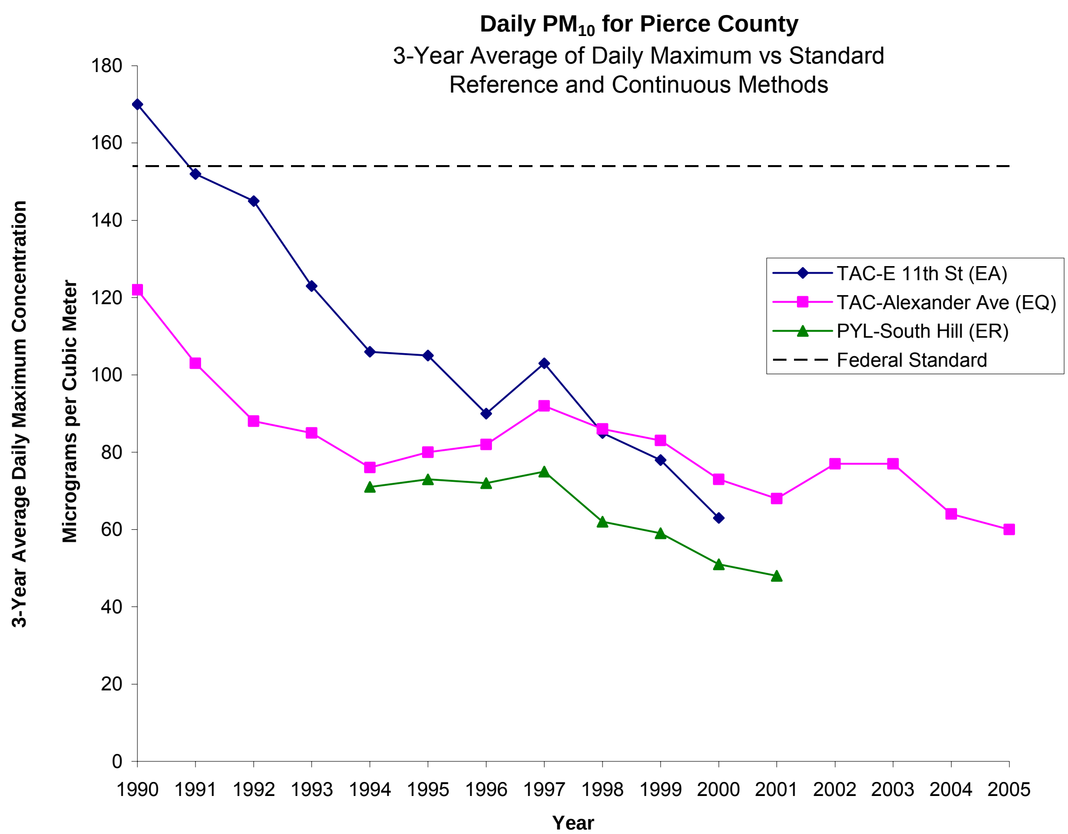
[25] Concentrations measured with reference method are maximum daily concentrations. Concentrations measured with continuous methods are the 99th percentile of daily concentrations. Reference method data demonstrate very similar values for maximum and 99th percentile, in many cases identical. Thus, this difference in statistical measure does not strongly affect the graphs.



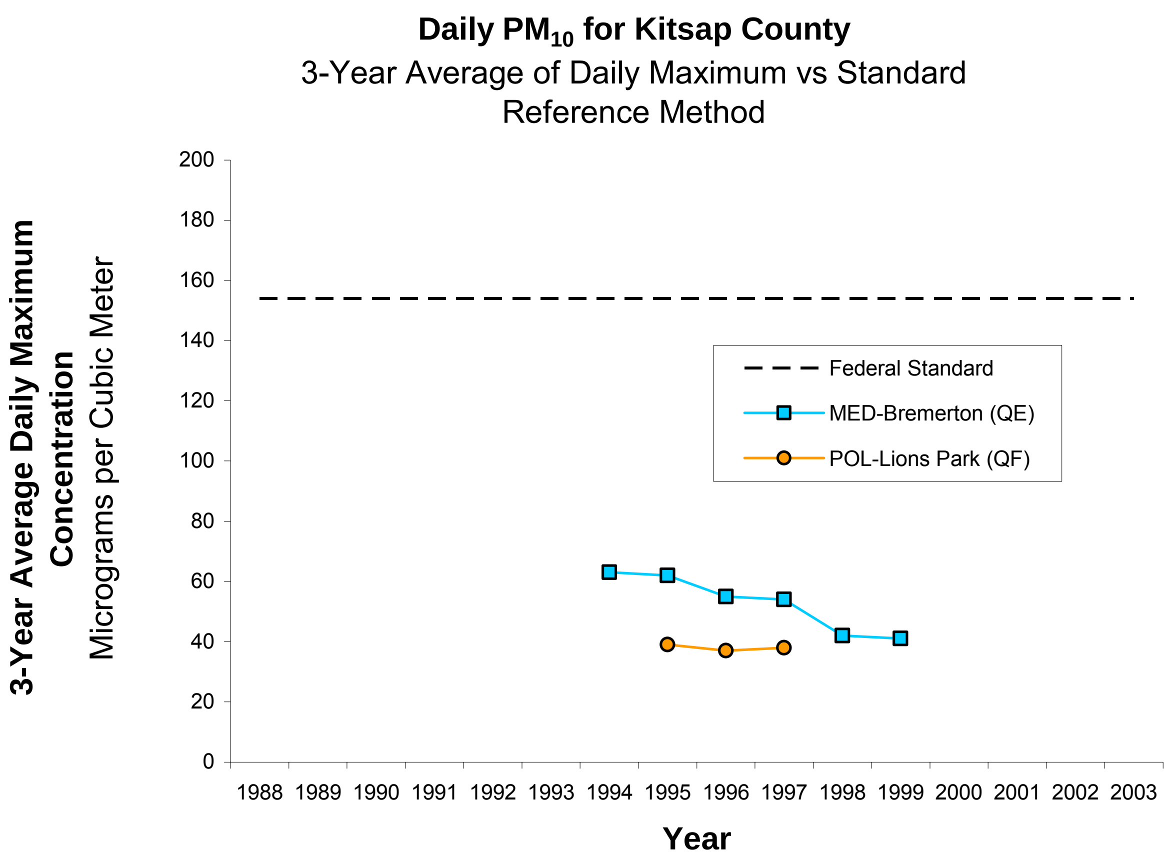

Note: 2002, 2003, 2004, and 2005 values are three year averages of the 99th percentile, based on continuous monitoring at this site




Note: 2004 and 2005 values are three year averages of the 99th percentile, based on continuous monitoring at these sites




Note: 2004 and 2005 values are 3-year averages of the 99th percentile, based on continuous monitoring at this site


Daily $PM_{10}$ for Kitsap County
3-Year Average of Daily Maximum vs Standard Reference Method
3-Year Average Daily Maximum Concentration
Micrograms per Cubic Meter
200
180
160
140
120
100
80
60
40
20
0
Federal Standard
MED-Bremerton (QE)
POL-Lions Park (QF)
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Year

# Particulate Matter (2.5 micrometers)

## Health Effects and Significance

Particles smaller than 2.5 micrometers in diameter are called "fine" particulate, or $PM_{2.5}$. The Agency considers $PM_{2.5}$ one of the major air pollution concerns affecting our region. $PM_{2.5}$ generally comes from wood burning and other area sources, as well as vehicle exhaust including cars, diesel trucks, and buses. Fine particulate can also be formed secondarily 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.[26, 27,28, 29] Children, older adults, and people with some illnesses are more sensitive and more likely to develop heart or lung problems associated with $PM_{2.5}$.[30,31] People with respiratory or heart disease, older adults, and children should avoid outdoor exertion if $PM_{2.5}$ levels are high. $PM_{2.5}$ also significantly affects visibility.

## Daily Federal Standard and Health Goal

The Puget Sound airshed has been in compliance with the daily $PM_{2.5}$ standard since 1997, when the EPA promulgated it. EPA has proposed a new, stricter daily standard for $PM_{2.5}$. The proposal, if promulgated, will change the current daily standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$, a level much closer to our health goal of 25 $\mu g/m^3$.

[26] Pope et al. Lung Cancer, Cardiopulmonary Mortality, and Long–Term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association*. 287: 1132-1141. March 6, 2002.
[27] 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: 1057–1067. Number 11. September 9, 2004.
[28] Kunzli et al. Ambient Air Pollution and Atherosclerosis in Los Angeles. *Environmental Health Perspectives.* Volume 113, 2: 201-206. February 2005. http://ehp.niehs.nih.gov/members/2004/7523/7523.pdf
[29] US Environmental Protection Agency (US EPA). 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
[30] 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.
[31] 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.

Comparison of Relevant Daily $PM_{2.5}$ Standards and Goals

| Standard or Goal | Level ($\mu g/m^3$) | Form |
|---|---|---|
| Current Federal Standard | 65 | 3-year average of 98th percentile |
| *Proposed* Federal Standard[32] | 35 | 3-year average of 98th percentile |
| Local Health Goal | 25 | Never to be exceeded |

The graphs on pages 48 through 51 show daily 98th percentile averages at each monitoring station in Snohomish, King, Pierce, and Kitsap counties against the current and proposed daily federal standards. The NAAQS 98th percentile is based on a 3-year average. Points on graphs represent averages of three consecutive years. For example, the value for 2005 is the average of the 98th percentile daily concentration for 2003, 2004, and 2005. Concentrations for Snohomish, King, and Pierce counties were measured with the FRM, except where noted.[33] Concentrations for Kitsap County were measured with continuous methods.[34] Both the current and proposed federal standards are shown with dashed lines; the proposed standard shows that sites in both Pierce and Snohomish counties may potentially violate EPA's proposed standard if it is adopted at the current level.

As described in the *Air Quality Standards and Health Goals* section, the Agency also has a daily fine particulate health goal. Although the daily federal standard is met in the region, many of the monitoring sites in Snohomish, King, and Pierce counties exceed the Agency's daily fine particulate health goal of 25 $\mu g/m^3$ for a 24-hour average. This health goal is intended to never be exceeded (unlike the federal standard, based on the 98th percentile of a 3-year average).

The graph on page 52 shows the number of days the health goal is exceeded annually in the region, from 2000 to 2005.[35] 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're falling short of our goal of having zero days exceeding the health goal, especially during winter months.

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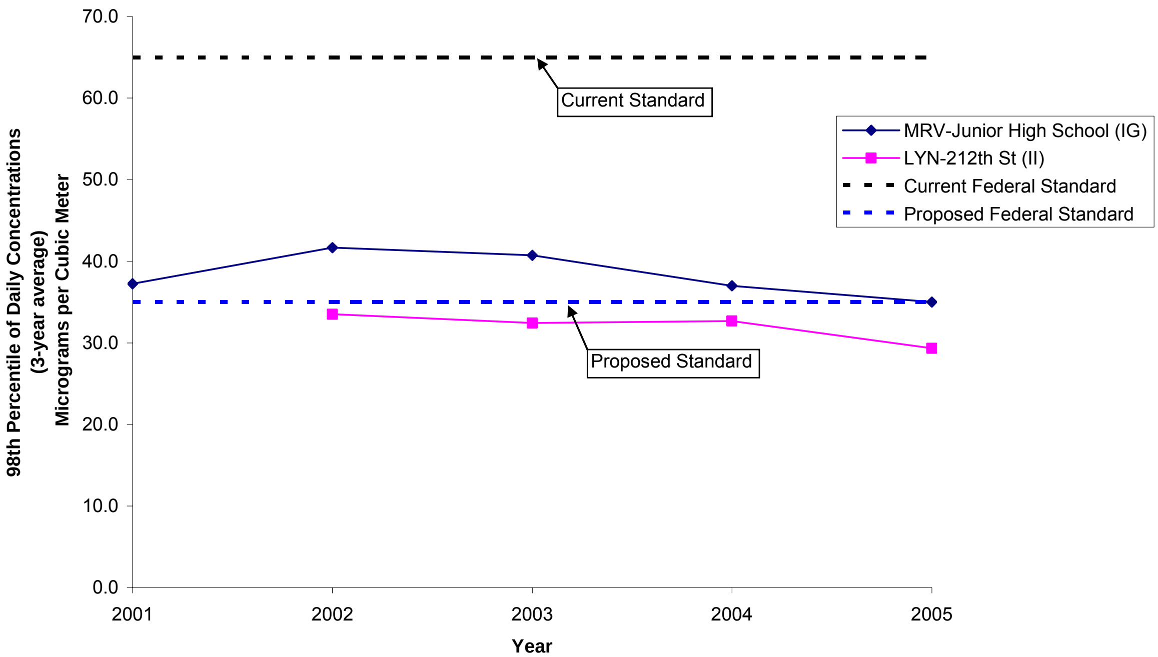
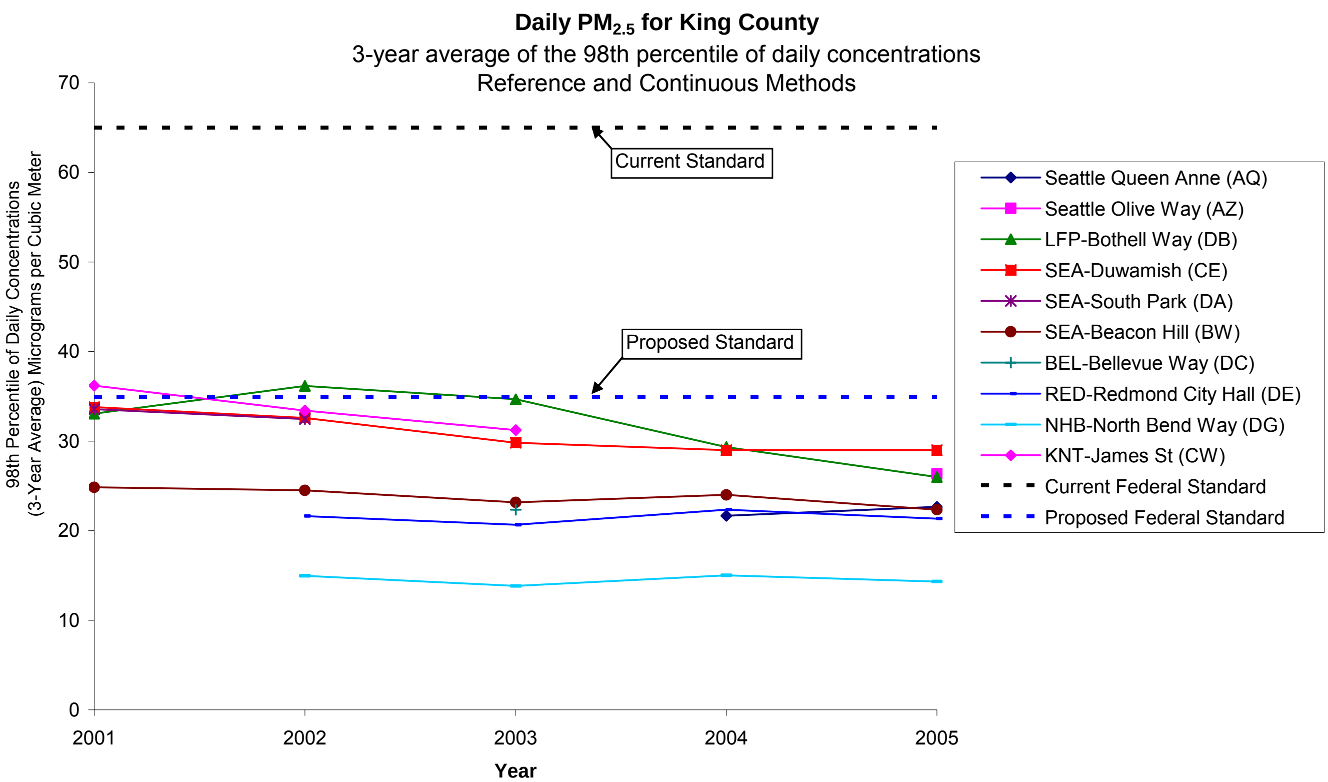
32 The proposed daily federal standard may change before it is promulgated in fall 2006.
33 Where possible, continuous method data are compared to the reference method values and calculations are made to determine the degree of difference from the reference method. The differences are then applied to the current continuous values in an attempt to make them "FRM-like."
34 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.
35 The graph includes all $PM_{2.5}$ continuous and federal reference monitoring sites, but does not include the Darrington (JO) site, as it was started as a special monitoring project.

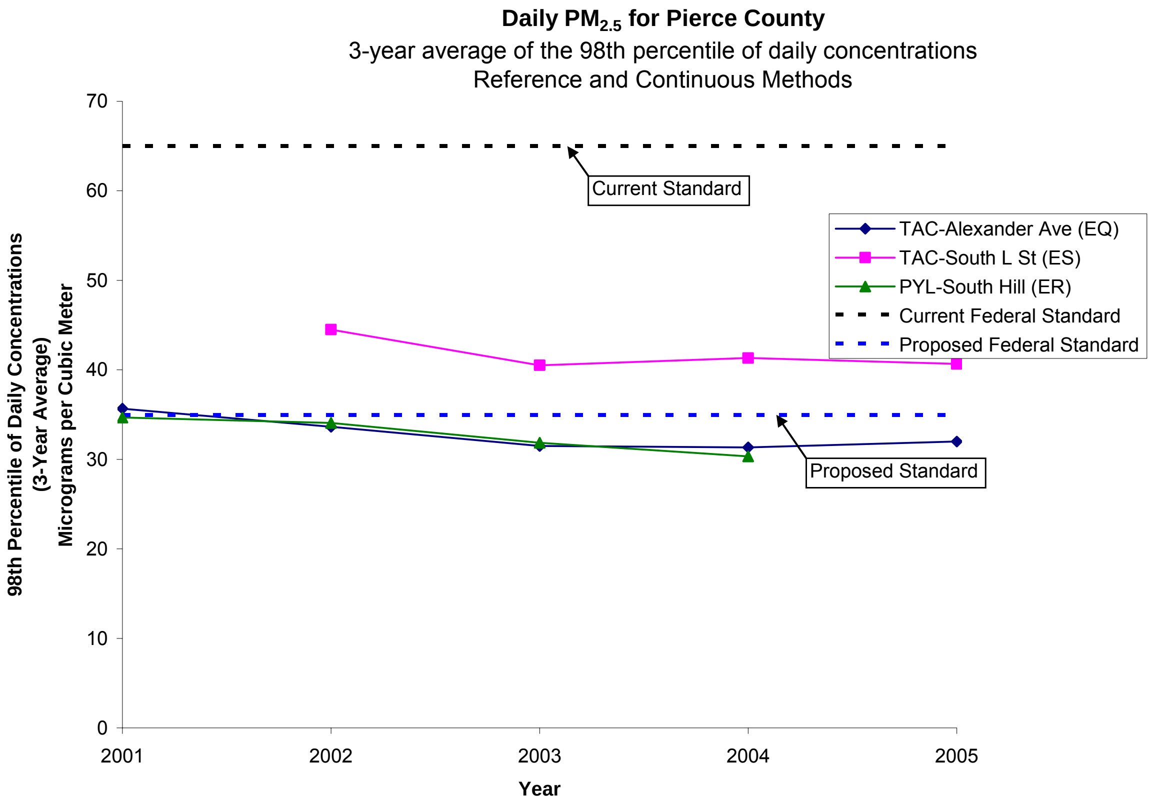
**Daily $PM_{2.5}$ for Snohomish County**
3-year average of the 98th percentile of daily concentrations
Reference and Continuous Methods



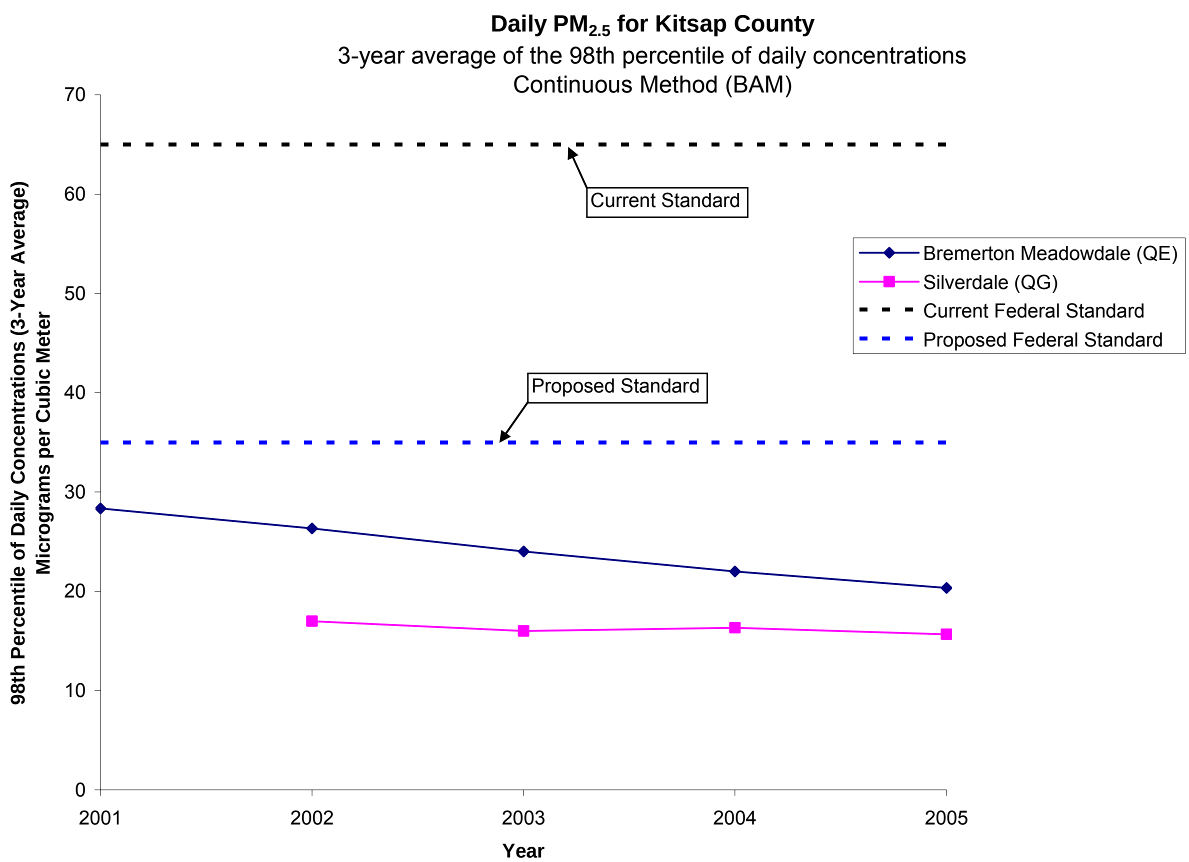

Note: Marysville data are FRM from 1999-2005. Lynnwood (II) data are FRM (except 2004) from 2000-2005. 2004 value for Lynnwood (II) was measured with a nephelometer.

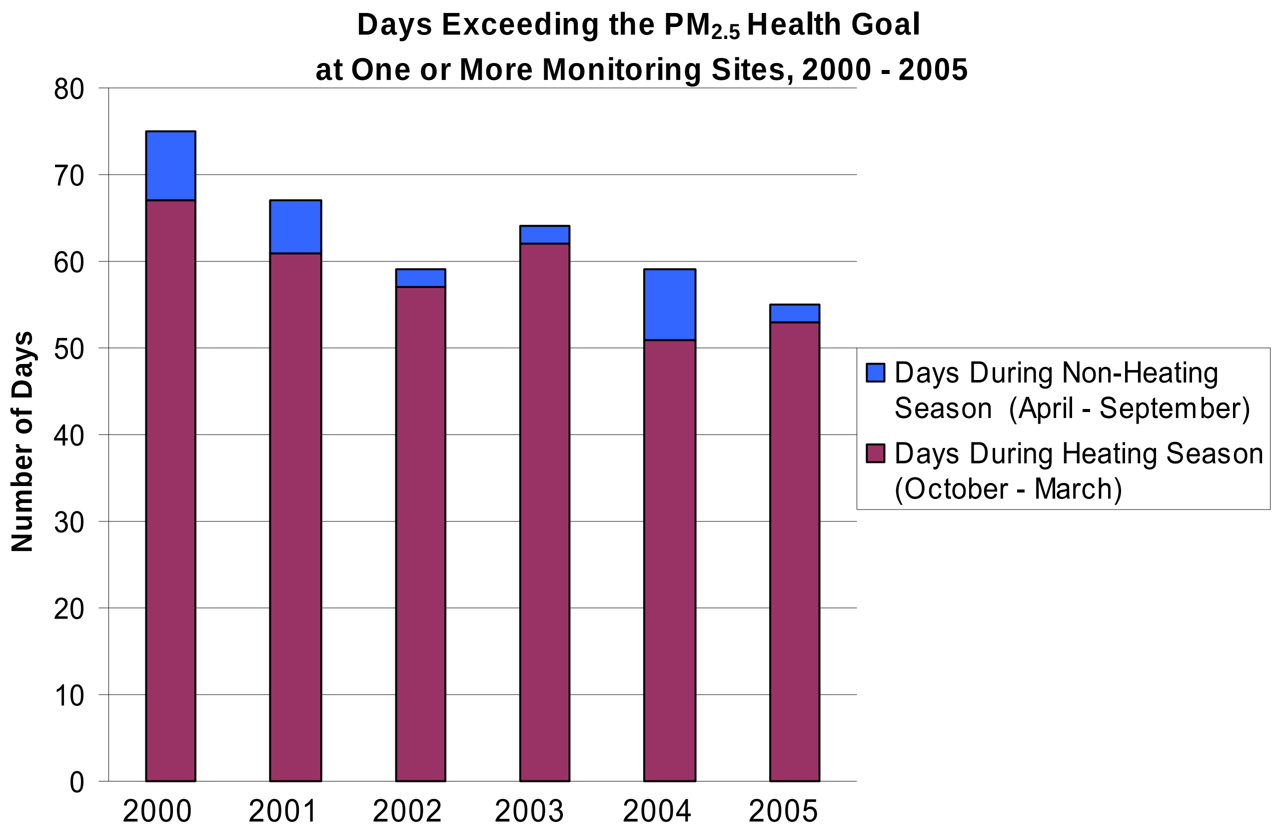



Note: Duwamish (CE), Beacon Hill (BW), and LFP (DB) data are FRM from 1999-2005. South Park (DA) data are FRM from 1999-2002. Bellevue Way (DC) data are FRM from 2001-2003. Redmond (DE) data are FRM from 2000-2002, neph from 2003-2005. Queen Anne (AQ) data are neph from 2002-2005. Olive Way (AZ) data are neph from 2003-2005. North Bend (DG) data are FRM from 2000-2004, neph in 2005. Kent (CW) data are FRM from 1999-2003.




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


Daily PM2.5 for Kitsap County
3-year average of the 98th percentile of daily concentrations
Continuous Method (BAM)
98th Percentile of Daily Concentrations (3-Year Average)
Micrograms per Cubic Meter
70
60
50
40
30
20
10
0
2001
2002
2003
2004
2005
Year
Current Standard
Proposed Standard
Bremerton Meadowdale (QE)
Silverdale (QG)
Current Federal Standard
Proposed Federal Standard

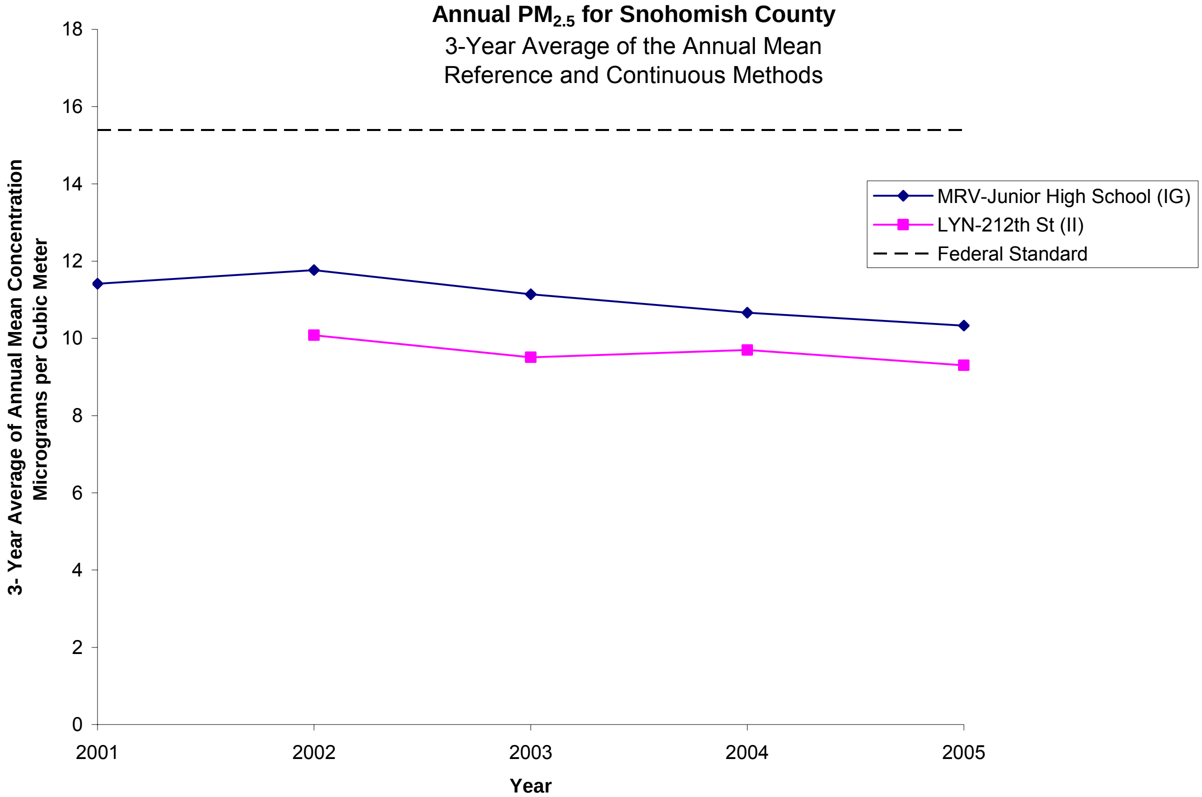



Includes data from all sites (in Snohomish, King, Pierce, and Kitsap counties), both daily and continuous methods.
The non-heating season includes the 4th of July holiday, which typically exceeds the health goal.

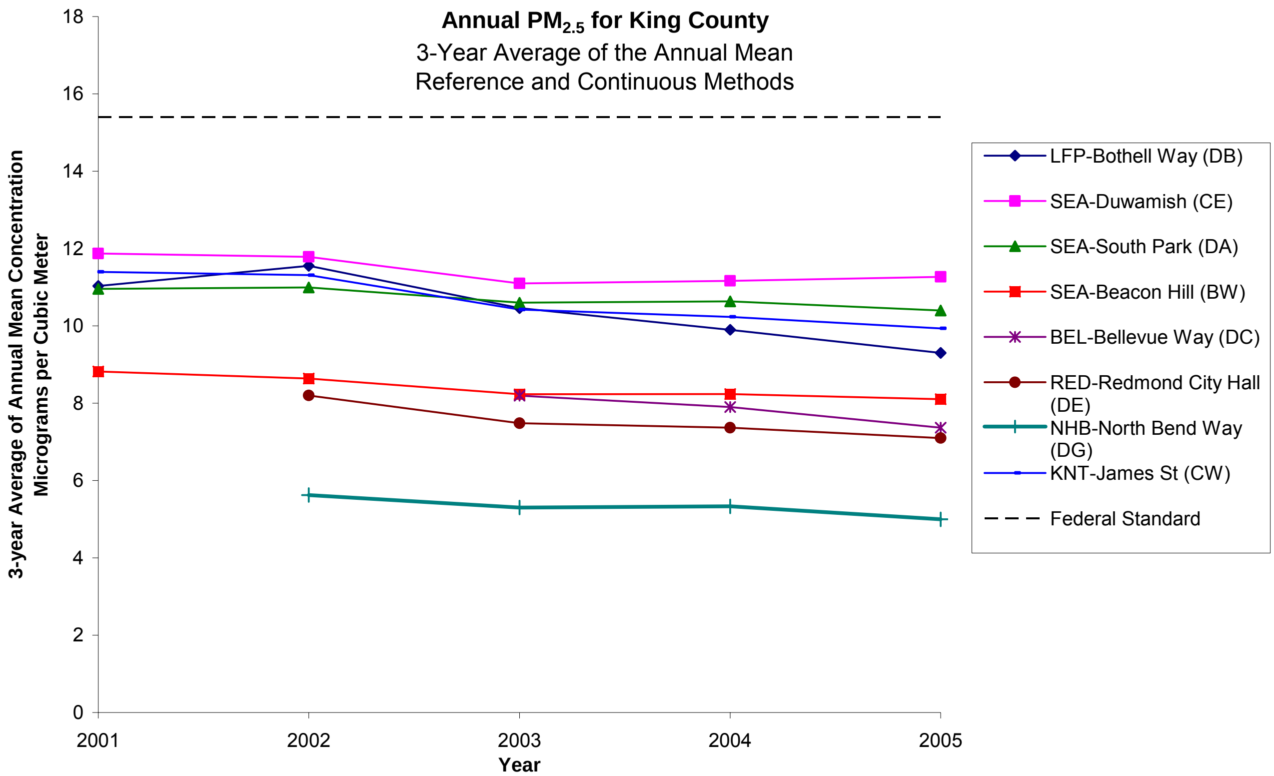
## Annual Federal Standard

The Puget Sound airshed has been in compliance with the annual $PM_{2.5}$ standard since the EPA promulgated it in 1997. The graphs on pages 53 through 56 show annual averages at each monitoring station for Snohomish, King, Pierce, and Kitsap counties and the federal annual standard. These graphs show data from both 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 for 2005 is the average of the annual averages for 2003, 2004, and 2005.

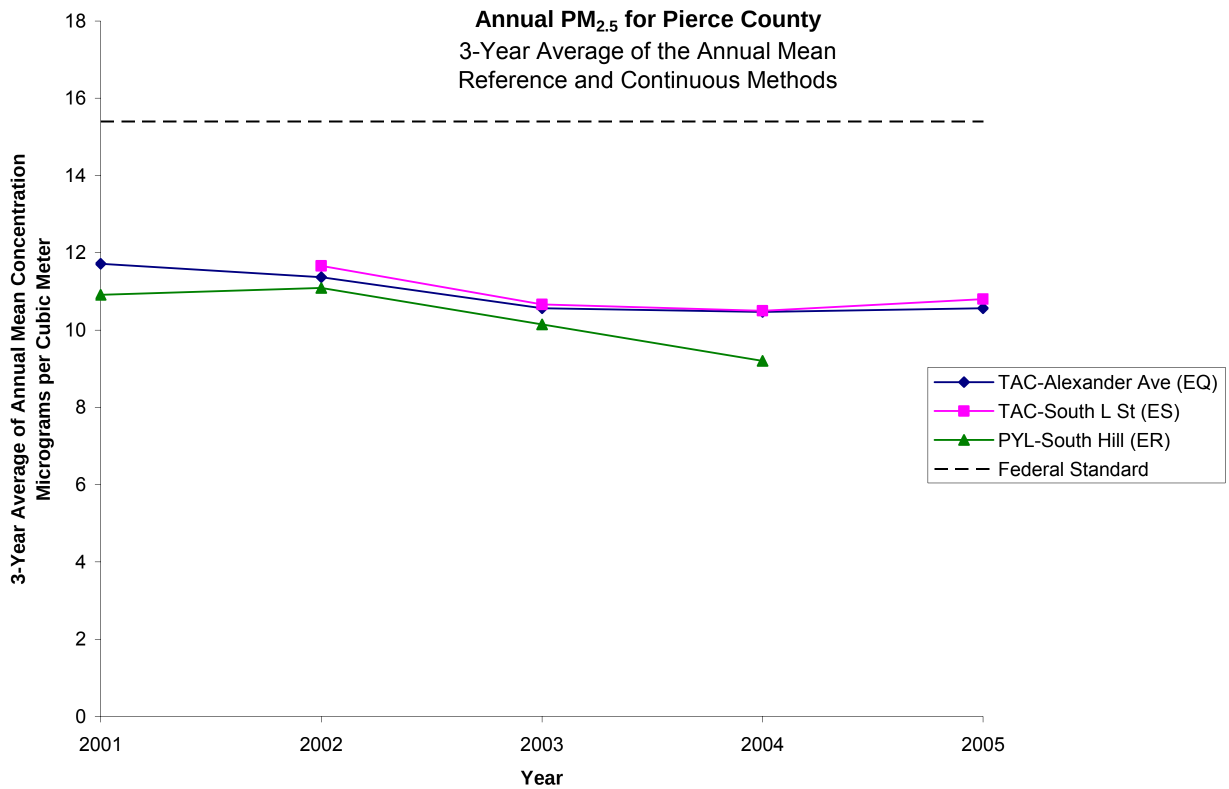
The EPA did not propose a lower $PM_{2.5}$ annual standard in its December 2005 proposal, so only the current standard is shown. The Agency's Health Committee did not recommend an annual $PM_{2.5}$ health goal lower than the federal annual standard (15 $\mu g/m^3$).



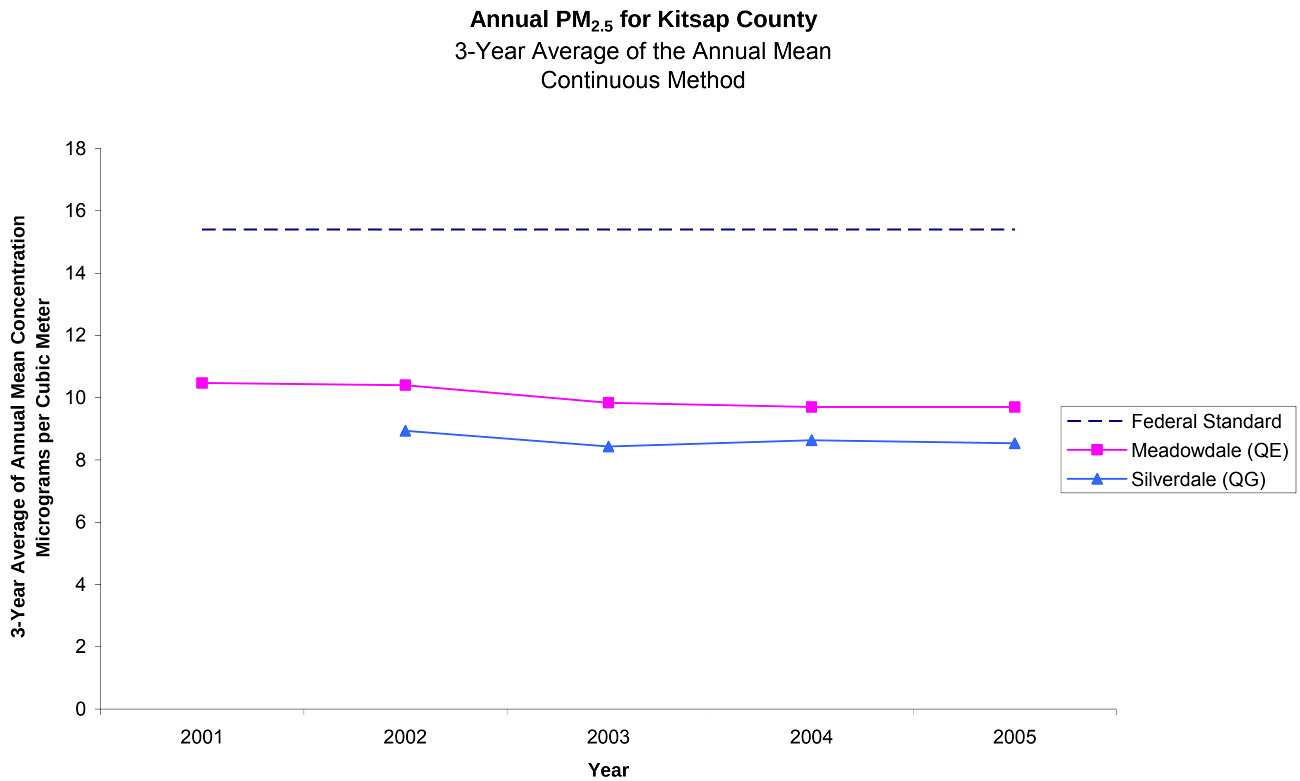

Note: Marysville (IG) data are FRM from 1999-2005. Lynnwood (II) data are FRM except 2004. The 2004 value for Lynnwood was measured with a nephelometer.




Note: Lake Forest Park (DB), Beacon Hill (BW), and Duwamish (CE) data are FRM from 1999-2005. South Park (DA) data are FRM from 1999-2002, nephelometer from 2003-2005. Redmond (DE) data are FRM from 2000-2002, nephelometer from 2003-2005. Bellevue Way (DC) data are FRM from 2001-2003, nephelometer from 2004-2005. Kent (CW) data are FRM from 1999-2003, nephelometer 2004-2005. North Bend (DG) data are FRM 2000-2004, nephelometer in 2005. Enumclaw data are FRM in 2004, nephelometer in 2005 (not shown because only two years of data).




Note: South L St. (ES) data are FRM. South Hill (ER) data are FRM from 1999-2002. South Hill (ER) data 2003 and 2004 was measured with a nephelometer. Alexander Ave (EQ) data are FRM from 1999-2002. Alexander Ave (EQ) data 2003-2005 was measured with a nephelometer.




Note: Meadowdale and Silverdale data are BAM (Beta Attenuation Monitor).

## $PM_{2.5}$ Special Monitoring Project

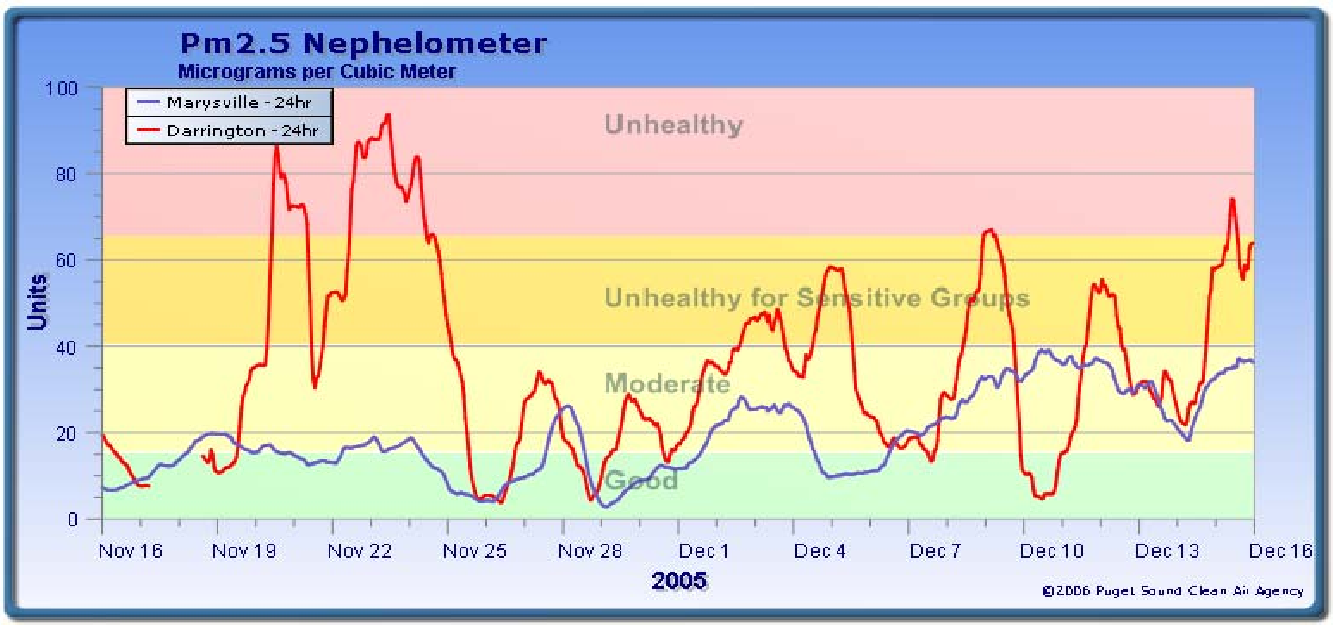
In 2004, the town of Darrington approached the Agency with air quality concerns and an interest in monitoring. The Agency shortly began monitoring for fine particulate in Darrington as a special project and part of a community education and wood stove change-out program. The Agency continued to monitor fine particulate in Darrington in 2005, and we now have an entire calendar year of data. The community expressed an interest in a continued monitoring presence. The Agency will incorporate fine particulate monitoring in Darrington into its regular monitoring network because of the need to manage air quality in this area.

The monitor in Darrington is different than the rest of our monitoring network. Because of its unique location in an east/west valley, the city is highly susceptible to winter inversions. The graph on page 57 shows both the Darrington monitor and the Marysville monitor during a winter inversion. Although the Marysville monitor is also located near residential wood burning, one can see that the Darrington fine particulate concentrations are much higher during a winter inversion.

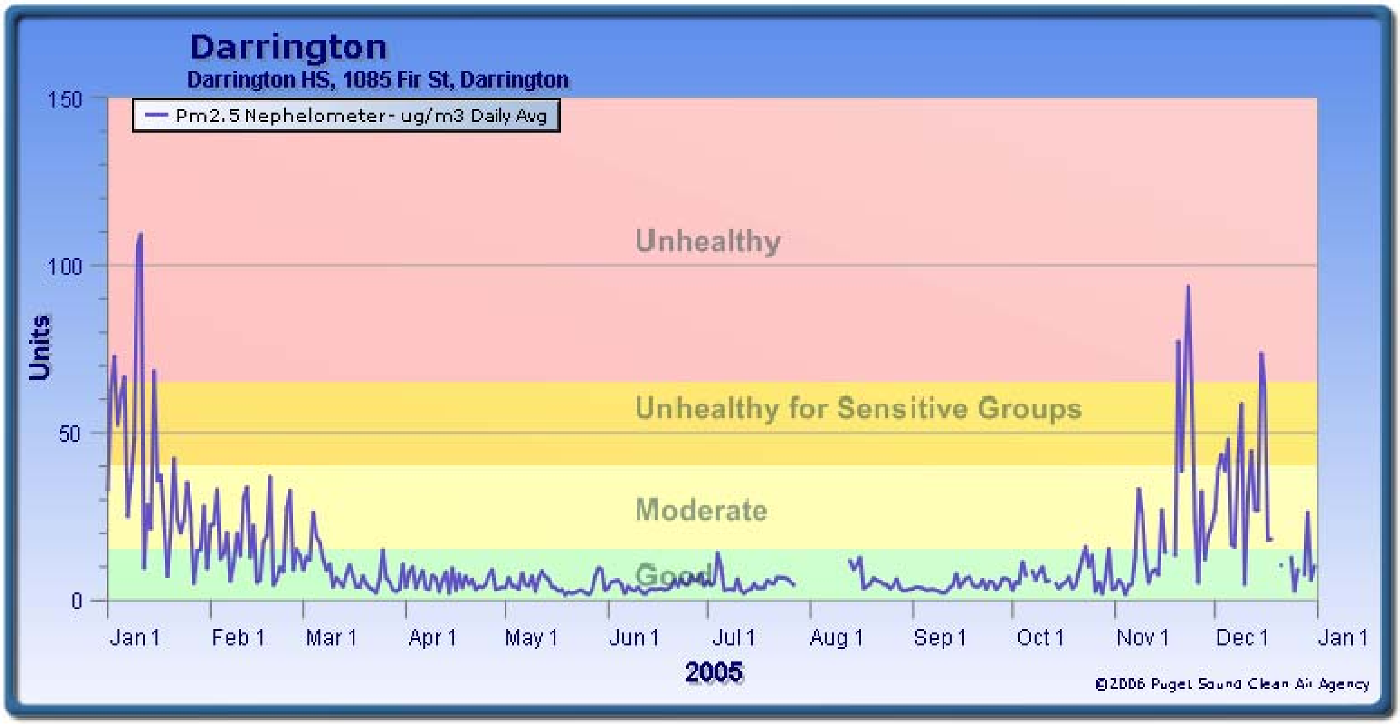
The graph on page 58 shows that, during the non-heating season, Darrington's particulate levels are quite low. In fact, for the majority of the year, Darrington enjoys "good" air quality on the AQI scale. Fine particulate reaches "unhealthy" AQI levels only in the winter months with the combination of residential wood burning and winter inversions. The graph on page 59 compares 2005 AQI rankings for Darrington and Marysville. This graph reinforces that, for the majority of the year, Darrington enjoys good air quality.

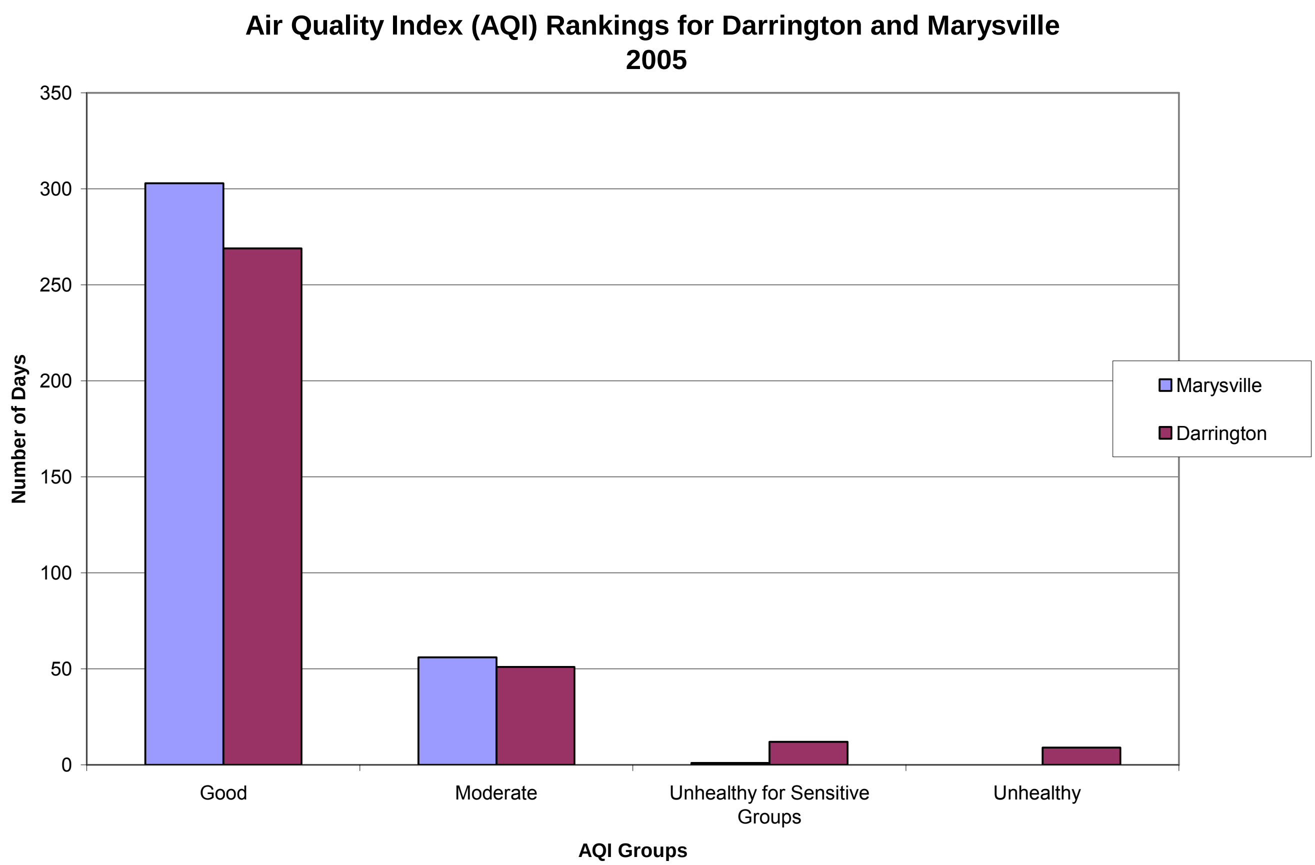
The graph on page 60 shows the 98th percentile of daily values for Darrington and the Marysville site, along with references to the current and proposed federal standards. The 98th percentile is the form of the standard and is the level that will be compared to determine compliance. Although we don't have three years of monitoring data (required to compare a monitoring site to the NAAQS), it's clear that Darrington could feasibly violate the current standard, and violate the proposed standard by a margin of more than 30 $\mu g/m^3$. As noted above, the Agency is currently conducting a wood smoke change-out program with the community to reduce residential wood smoke emissions.

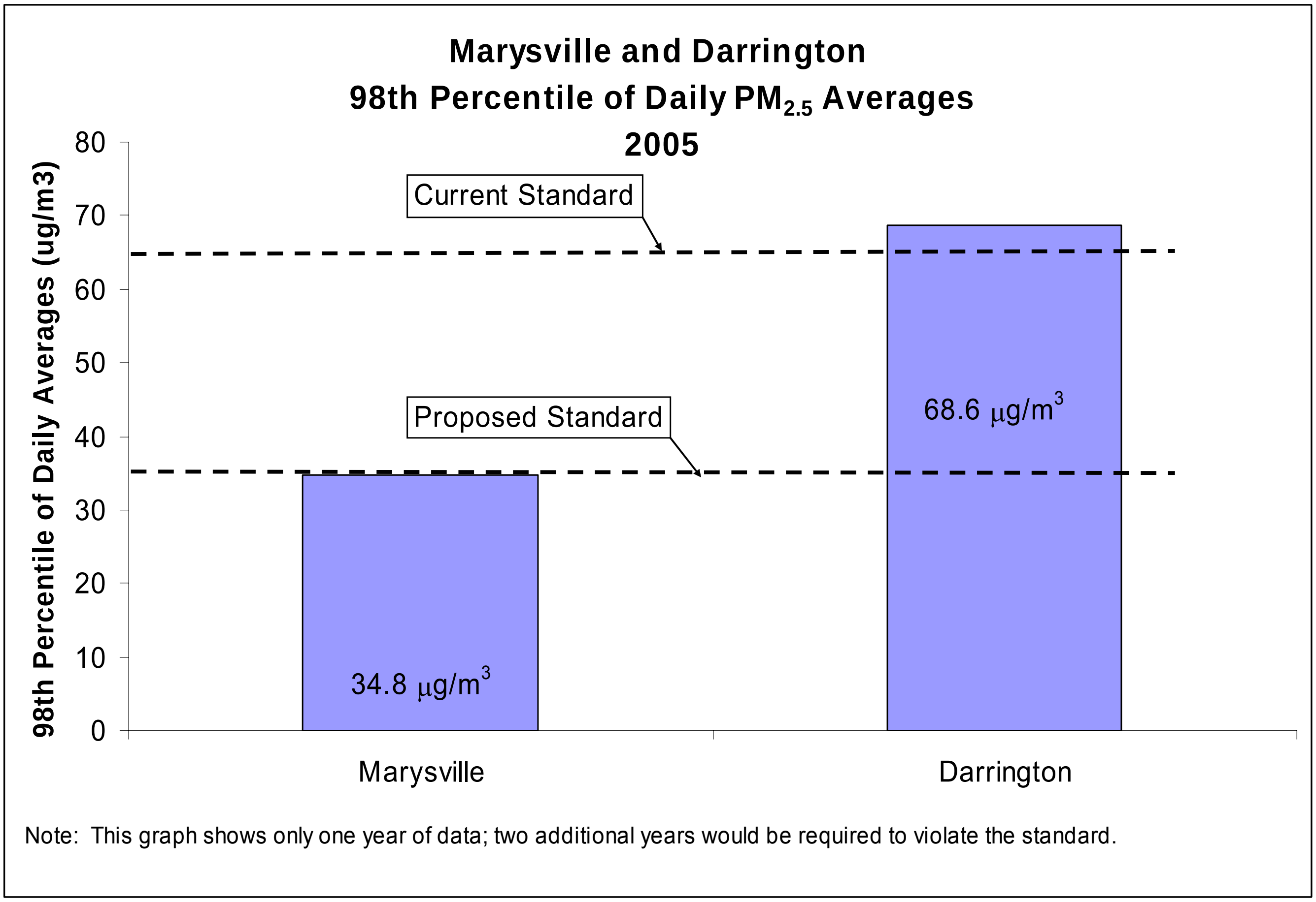
Daily $PM_{2.5}$ Concentrations at Darrington and Marysville During Winter Air Stagnation



Darrington's Fine Particulate Levels Year-Round




Air Quality Index (AQI) Rankings for Darrington and Marysville
2005
350
300
250
200
150
100
50
0
Number of Days
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
AQI Groups
Marysville
Darrington




## Continuous Data and Seasonal Variability

Graphs on pages 62 through 72 show daily $PM_{2.5}$ concentrations measured at 11 sites during 2005 by continuous analyzers (nephelometer, TEOM, or BAM) set against a backdrop of AQI breakpoints. Several sites are monitored by both nephelometer and TEOM. The two methods, one using light scattering and the other mass, correspond well with each other.

The 11 monitoring sites characterize different areas and these differences are reflected in the continuous data. The four sites most associated with high residential wood burning exhibit the greatest seasonal variability, with a pattern of higher $PM_{2.5}$ concentrations in winter months (October – March). These four sites include Marysville, Tacoma South L, Lake Forest Park, and Lynnwood. These sites register AQI levels in the "unhealthy for sensitive groups" range occasionally in the winter months. The summer peaks at these monitoring sites (as well as others) dramatically reflect the short-term effect of 4th of July fireworks on local air quality.

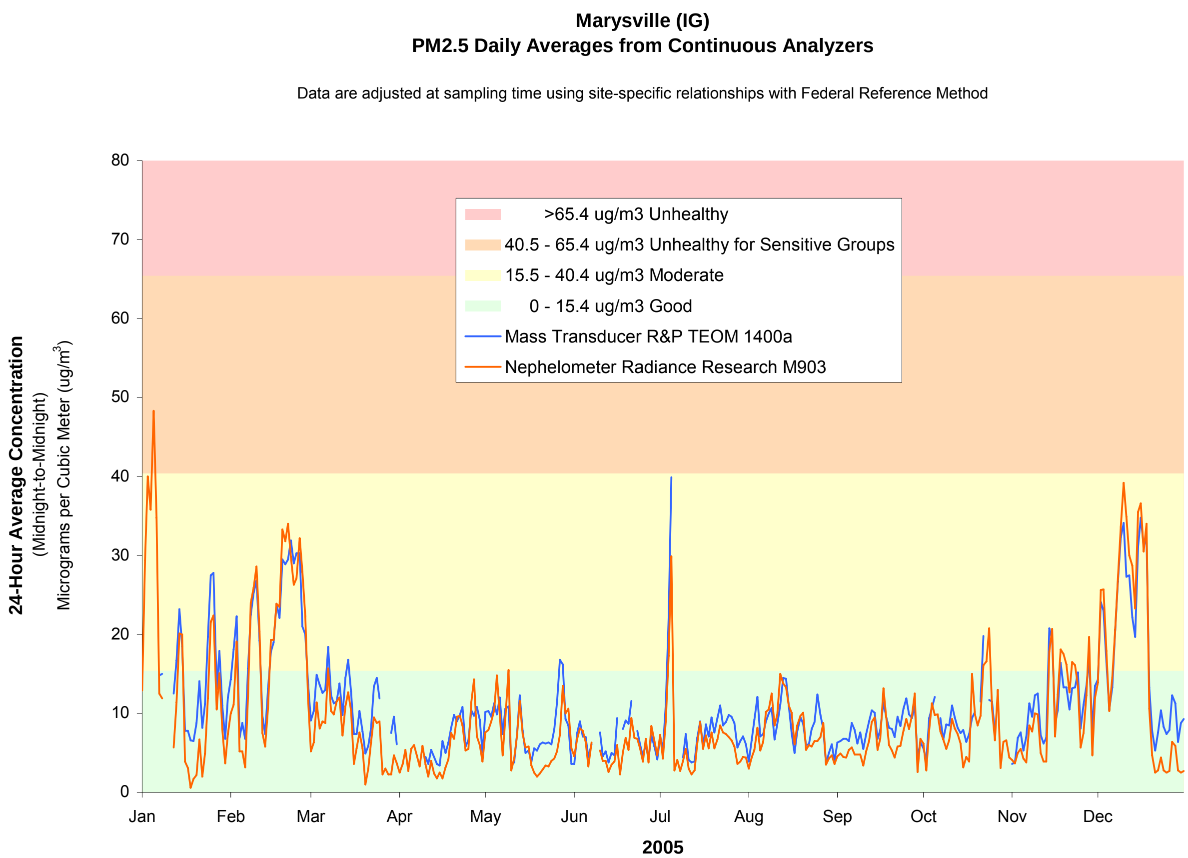
The Seattle Duwamish and Tacoma Port sites are industrial, with a small amount of wood smoke influence as well in winter months. The Kent site is both residential and commercial. These three sites also register AQI levels in the "unhealthy for sensitive groups" range in winter months.

The Bellevue monitoring site is similar to the Kent site with both residential and commercial, but is in an area with more natural gas heating and less wood burning. The topography at the Bellevue site is also different than the Kent site. Its graph reflects these differences, with very little seasonal variation and lower concentrations.

Three monitoring sites are presented that exhibit low concentrations and low seasonal variability. These areas have lower housing density, and likely less wood smoke impact. The three sites include: Bremerton Meadowdale, North Bend, and Silverdale.[36]

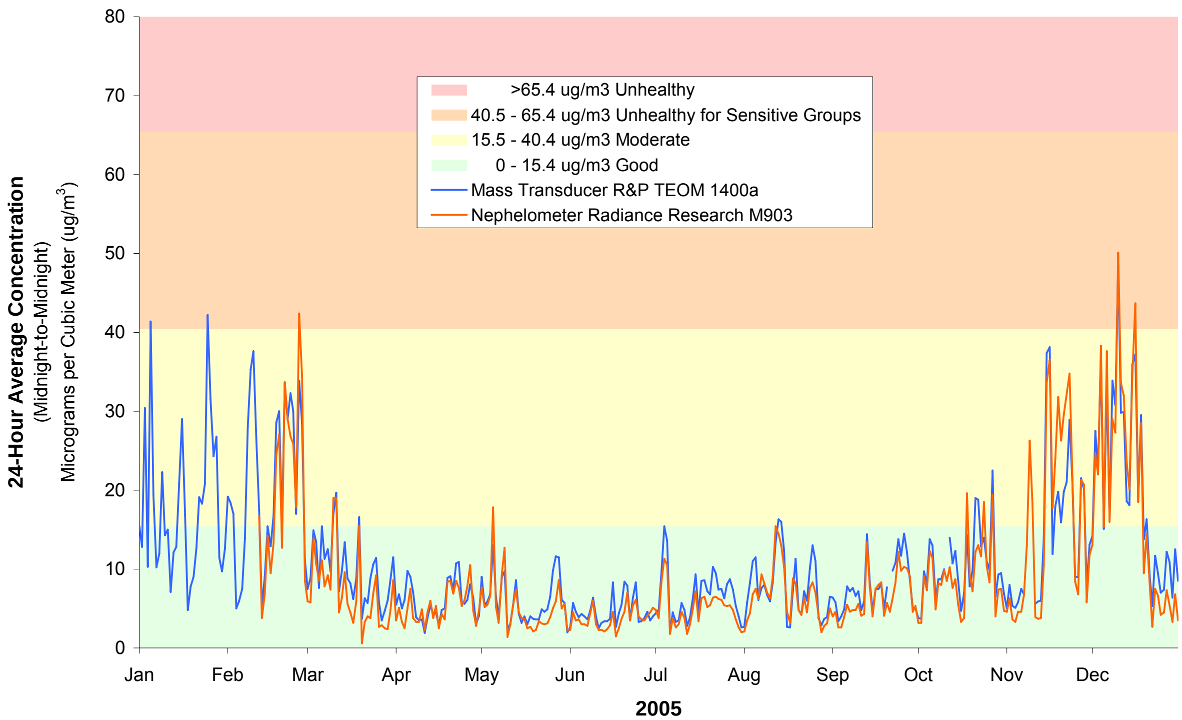
Statistical summaries for $PM_{2.5}$ data (both FRM and continuous monitors) are shown in tables on pages A-7 through A-10 of the Appendix. Summaries of AQI levels based on FRM and continuous monitors are included. The AQI that is reported to the public and used for air quality decisions is the one reflecting the highest concentration, regardless of the method of measurement. The highest daily concentration of $PM_{2.5}$ measured in 2005 was 60 $\mu g/m^3$, measured by nephelometer at the Lynnwood site on December 11. For additional information on particulate matter, visit www.epa.gov/air/urbanair/pm/index.html. Information on $PM_{2.5}$ is also presented in a question/answer format in the definitions section of this document.

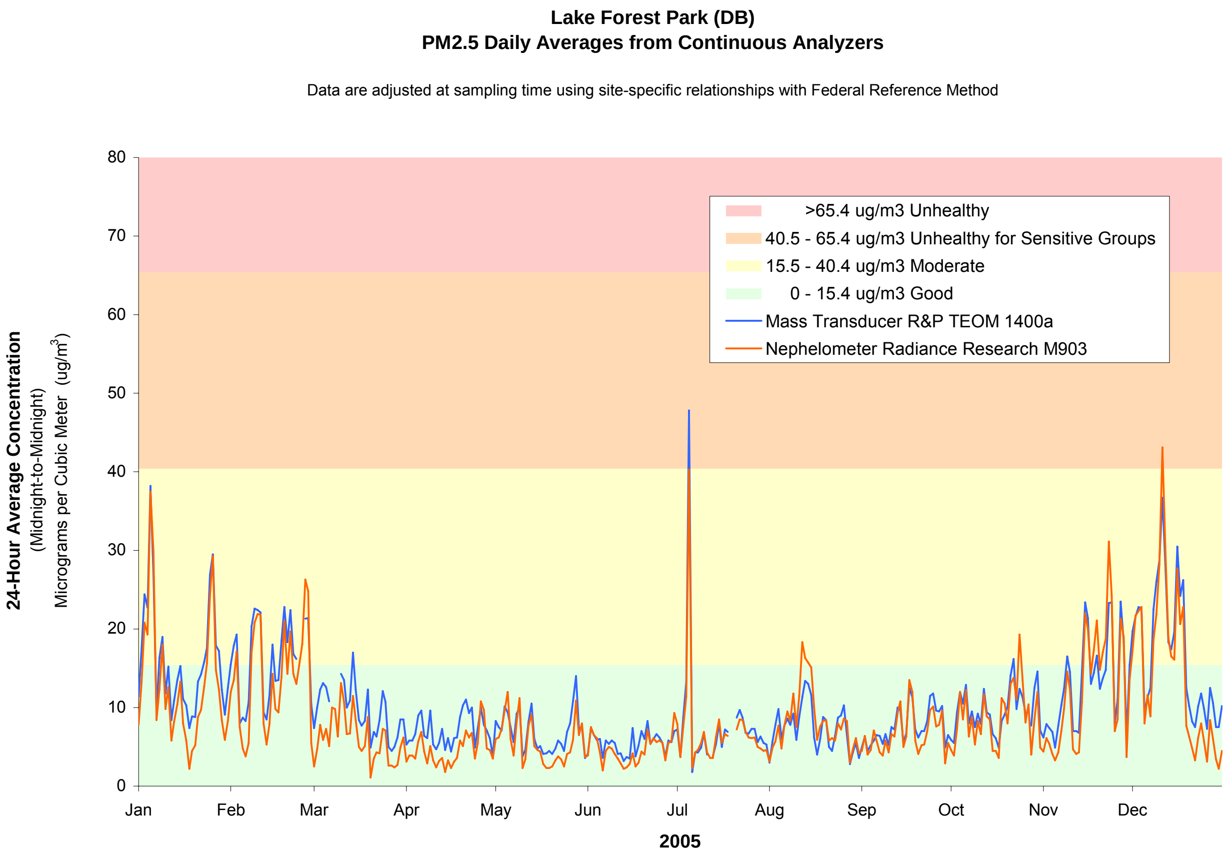
[36] The Puyallup monitoring site is often included with this group, but had only a partial year of continuous data in fall 2005.

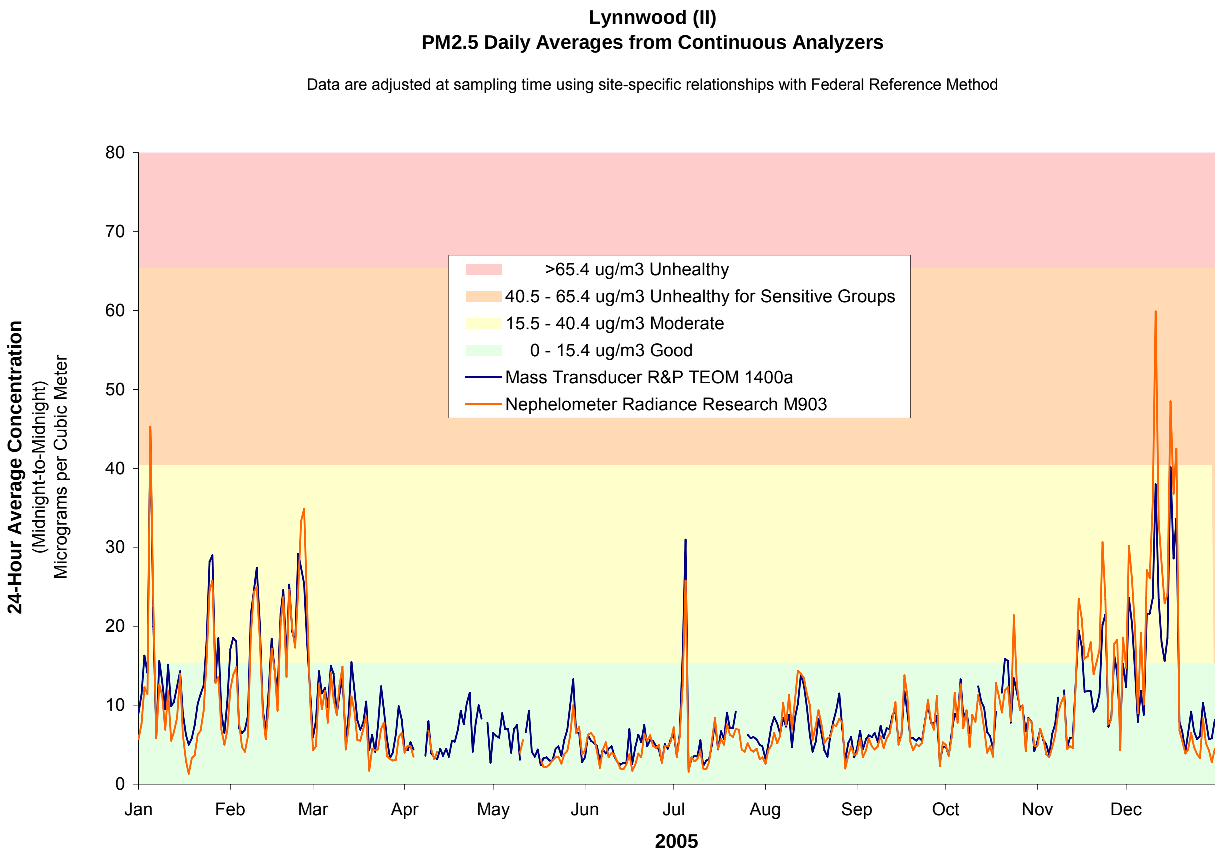

Marysville (IG)
PM2.5 Daily Averages from Continuous Analyzers
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method
>65.4 ug/m3 Unhealthy
40.5 - 65.4 ug/m3 Unhealthy for Sensitive Groups
15.5 - 40.4 ug/m3 Moderate
0 - 15.4 ug/m3 Good
Mass Transducer R&P TEOM 1400a
Nephelometer Radiance Research M903
24-Hour Average Concentration
(Midnight-to-Midnight)
Micrograms per Cubic Meter (ug/m3)
0
10
20
30
40
50
60
70
80
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2005

Tacoma, South L Street (ES)
PM2.5 Daily Averages from Continuous Analyzers

Data are adjusted at sampling time using site-specific relationships with Federal Reference Method

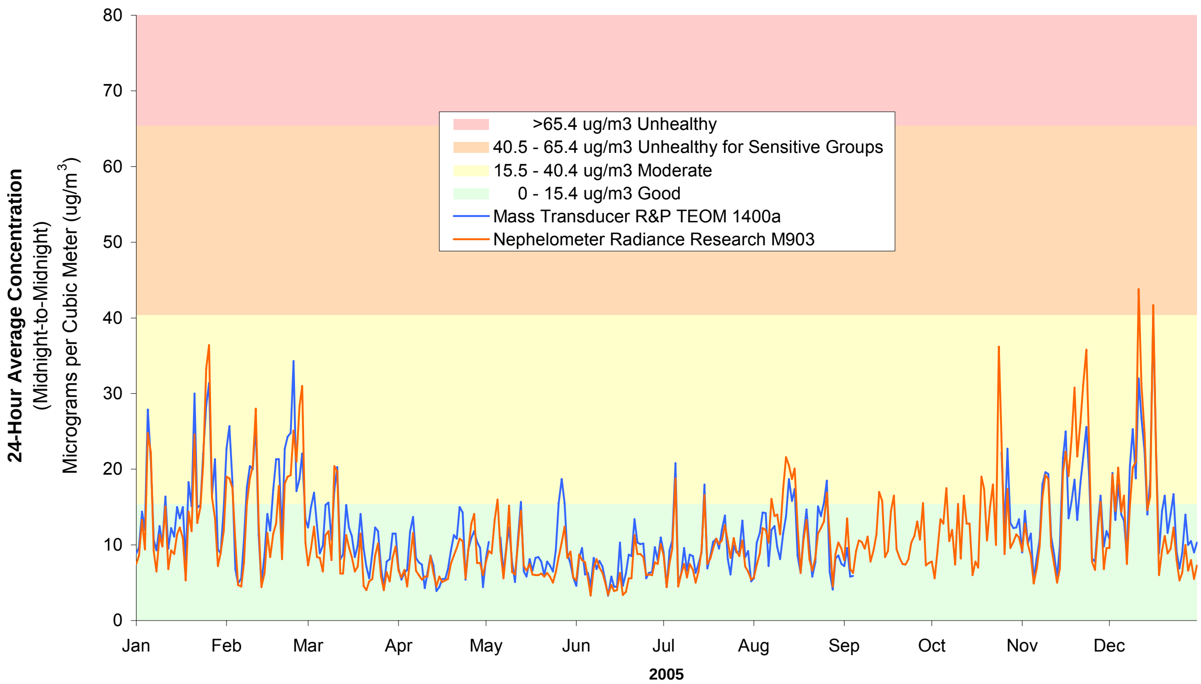



Lake Forest Park (DB)
PM2.5 Daily Averages from Continuous Analyzers
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method
24-Hour Average Concentration
(Midnight-to-Midnight)
Micrograms per Cubic Meter (ug/m3)
>65.4 ug/m3 Unhealthy
40.5 - 65.4 ug/m3 Unhealthy for Sensitive Groups
15.5 - 40.4 ug/m3 Moderate
0 - 15.4 ug/m3 Good
Mass Transducer R&P TEOM 1400a
Nephelometer Radiance Research M903
0
10
20
30
40
50
60
70
80
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2005


Lynnwood (II)
PM2.5 Daily Averages from Continuous Analyzers
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method
24-Hour Average Concentration
(Midnight-to-Midnight)
Micrograms per Cubic Meter
>65.4 ug/m3 Unhealthy
40.5 - 65.4 ug/m3 Unhealthy for Sensitive Groups
15.5 - 40.4 ug/m3 Moderate
0 - 15.4 ug/m3 Good
Mass Transducer R&P TEOM 1400a
Nephelometer Radiance Research M903
0
10
20
30
40
50
60
70
80
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2005

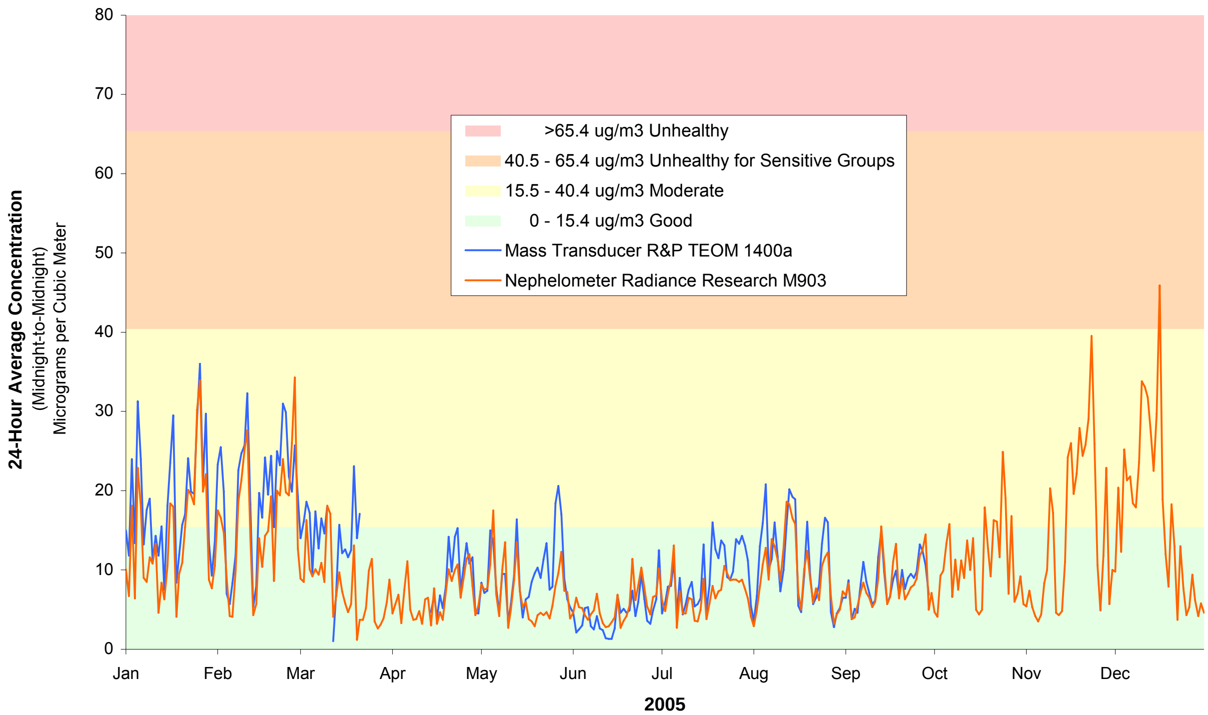
**Seattle, Duwamish (CE)**
**PM2.5 Daily Averages from Continuous Analyzers**

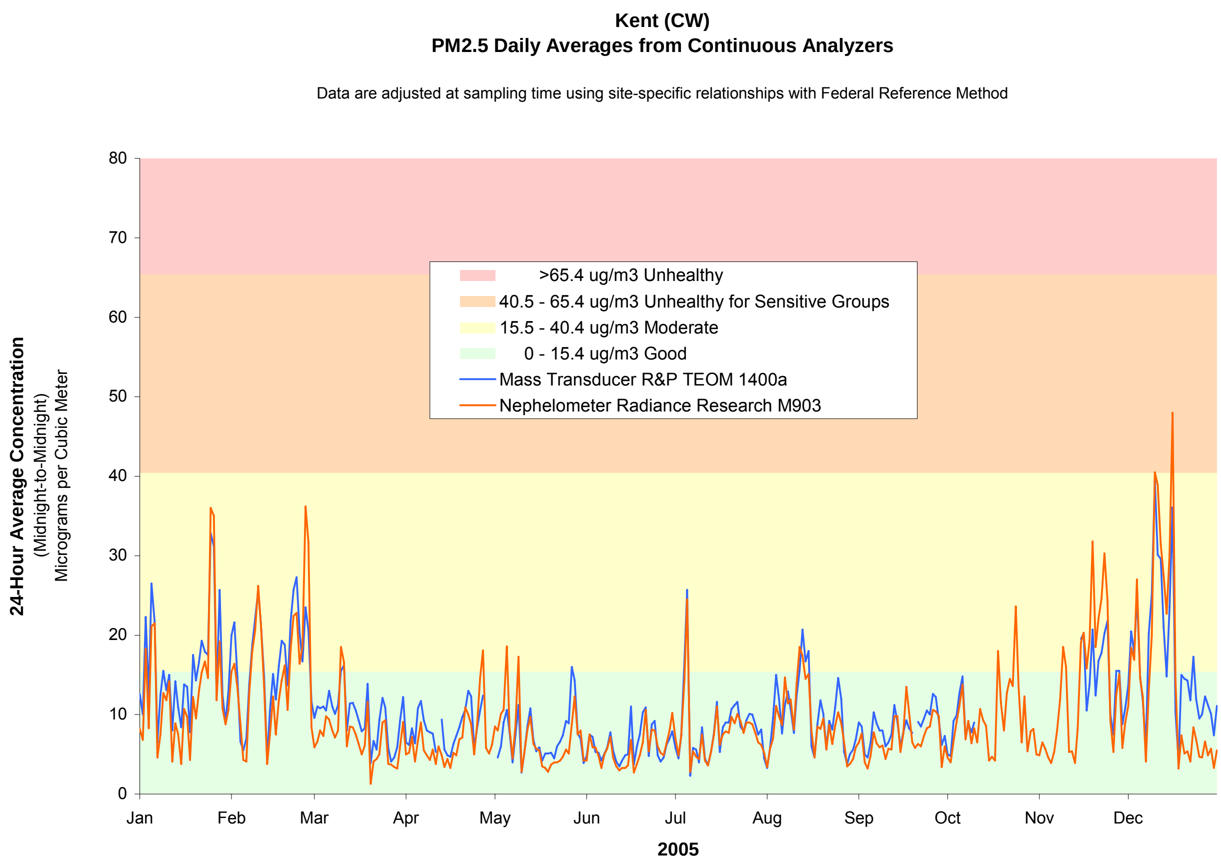
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method



**Tacoma, Port Area (EQ)**
**PM2.5 Daily Averages from Continuous Analyzers**

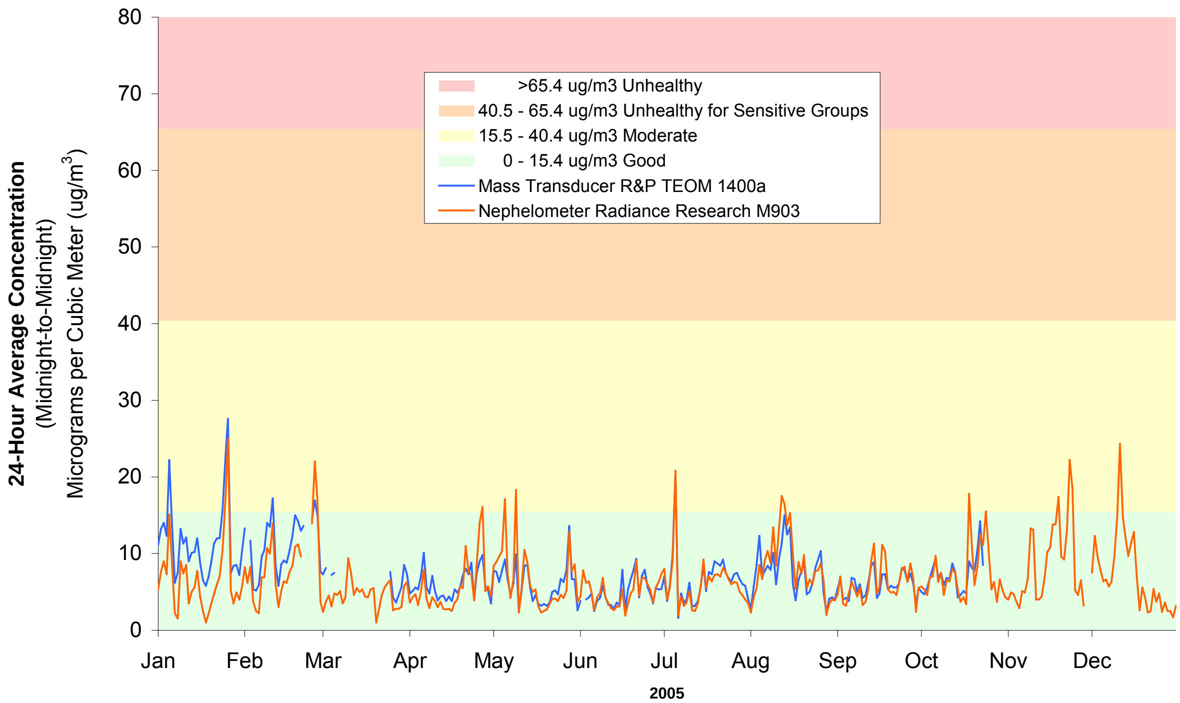
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method



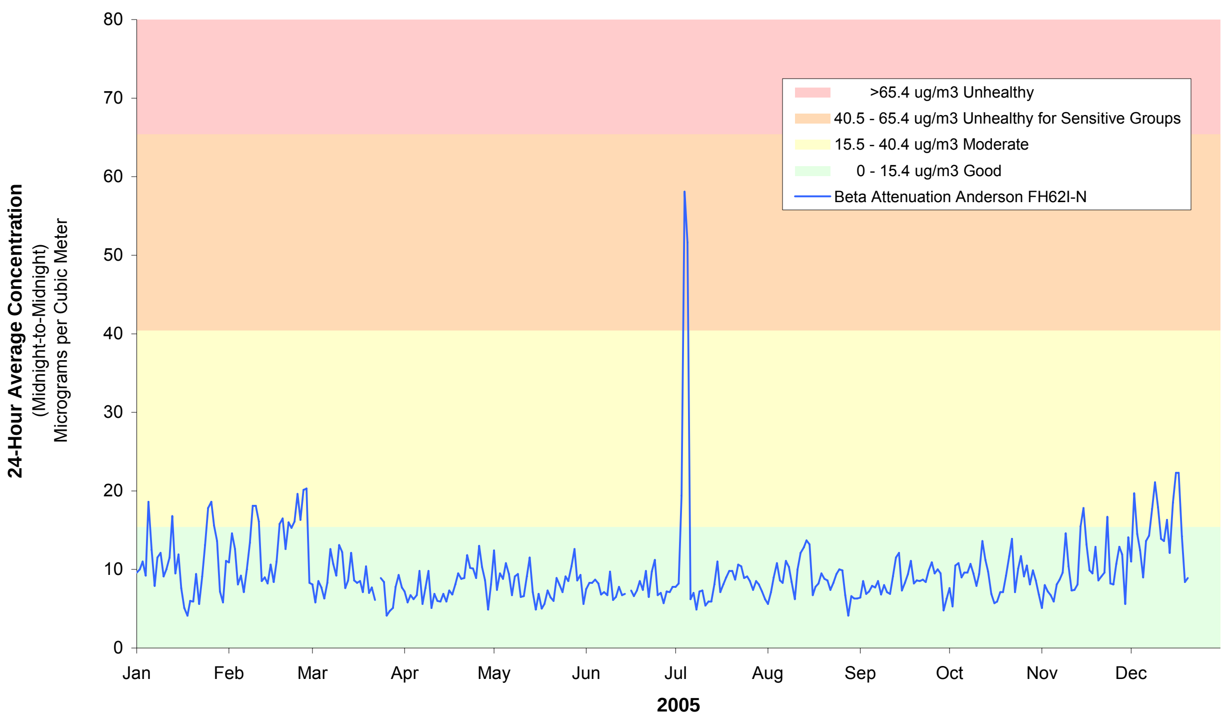

Kent (CW)
PM2.5 Daily Averages from Continuous Analyzers
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method
>65.4 ug/m3 Unhealthy
40.5 - 65.4 ug/m3 Unhealthy for Sensitive Groups
15.5 - 40.4 ug/m3 Moderate
0 - 15.4 ug/m3 Good
Mass Transducer R&P TEOM 1400a
Nephelometer Radiance Research M903
24-Hour Average Concentration
(Midnight-to-Midnight)
Micrograms per Cubic Meter
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2005

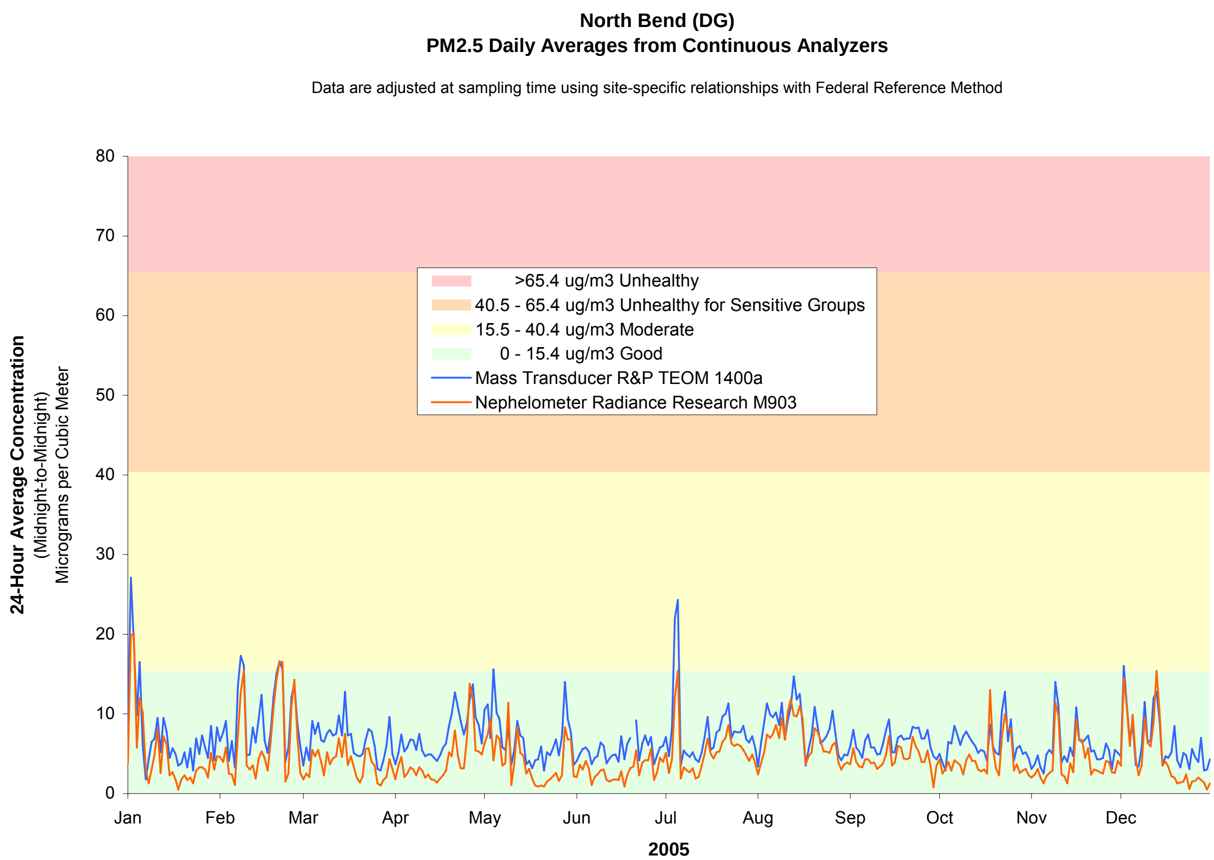
**Bellevue, 143rd Ave NE (CZ)**
**PM2.5 Daily Averages from Continuous Analyzers**

Data are adjusted at sampling time using site-specific relationships with Federal Reference Method

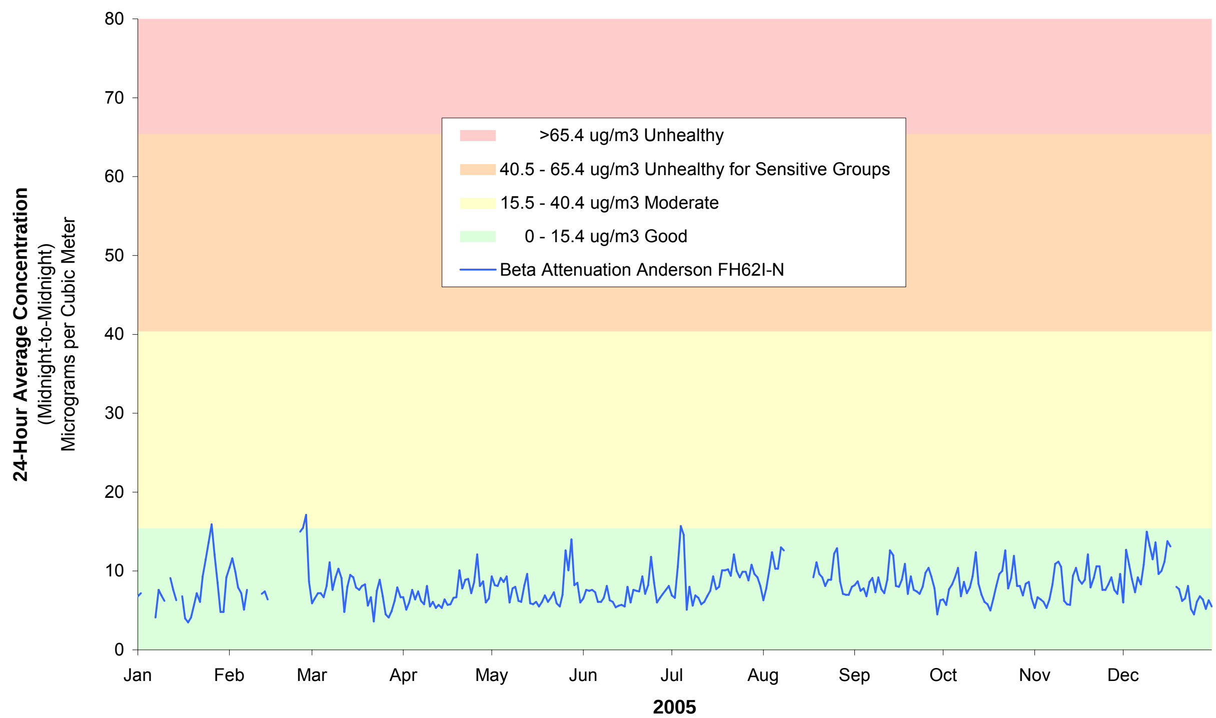


**Bremerton, Meadowdale (QE)**
**PM2.5 Daily Averages from Continuous Analyzers**




North Bend (DG)
PM2.5 Daily Averages from Continuous Analyzers
Data are adjusted at sampling time using site-specific relationships with Federal Reference Method
>65.4 ug/m3 Unhealthy
40.5 - 65.4 ug/m3 Unhealthy for Sensitive Groups
15.5 - 40.4 ug/m3 Moderate
0 - 15.4 ug/m3 Good
Mass Transducer R&P TEOM 1400a
Nephelometer Radiance Research M903
24-Hour Average Concentration
(Midnight-to-Midnight)
Micrograms per Cubic Meter
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2005

**Silverdale (QG)**
**PM2.5 Daily Averages from Continuous Analyzers**



## $PM_{2.5}$ Speciation and Aethalometers – Relevance and Practice

The methods described above show the total amount of fine particulate matter, but do not tell us anything about its chemical composition. Although there are no regulatory requirements to go beyond measuring the total amount of fine particulate matter, it's important to know what type of particulate matter is present in addition to its mass. The makeup of fine particulate matter can help the Agency determine potential health risks, as particulate matter from different sources have varying toxicities. Those from combustion sources, and specifically diesel combustion engines, are especially toxic. Information on fine particulate composition helped guide the Agency's commitment to reduce wood smoke and diesel particulate emissions.[37]

Knowledge about the type of fine particulate can help to guide emissions reduction strategies. For example, if a study of fine particulate shows that a large portion is comprised of wood smoke particulate, then strategies to reduce wood smoke are appropriate to reduce total particulate matter concentrations.

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 various 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 analytes are measured at speciation monitors in the area. Analytes and annual average concentrations are shown on pages A-11 and A-12 of the Appendix. These data are then used in source apportionment models to estimate contributing sources to $PM_{2.5}$. Source apportionment models use "fingerprints" from sources, which characterize the chemical fractions emitted by each identified source. The model matches these fingerprints with the speciation data to estimate how much each source is contributing.

The Washington Department of Ecology currently conducts speciation monitoring at four monitoring sites with different land use characteristics:

- Seattle Beacon Hill site – typical suburban/urban impacts, mixture of sources, "neighborhood scale". (speciation samples collected every third day)
- Seattle Duwamish site – industrial area, combination of mobile source, industrial, and limited wood smoke impacts (speciation samples collected every sixth day)

[37] Puget Sound Air Toxics Evaluation. October 2003. http://www.pscleanair.org/airq/basics/psate_final.pdf.

- Lake Forest Park – residential area, impacts from residential wood combustion (speciation samples collected every sixth day)

- Seattle Olive Street – downtown Seattle, located adjacent to I-5, heavy mobile source impacts (speciation samples collected every sixth day)

The Agency and the University of Washington have historically used this data to conduct source apportionment modeling. This modeling was especially useful to estimate diesel particulate matter and wood smoke particulate concentrations at Beacon Hill.[38]

Several researchers have recently used data from these sites to better understand air quality. These include:

- The Washington State Department of Ecology and the University of Washington recently conducted a source apportionment modeling study, using different types of models and comparing data from Seattle Beacon Hill and a Portland, Oregon site.[39]

- The University of Washington recently used iridium data, one of the analytes measured at speciation sites, to help them explore its potential use as a diesel exhaust indicator.[40]

- Clarkson University recently used speciation data to perform source apportionment modeling, and specifically look at impacts from ship emissions.[41] Clarkson University and the University of Washington also used this data to make comparisons about the spatial distribution of $PM_{2.5}$ in the northwest.[42]

- The University of Washington recently used speciation data and source apportionment to estimate fine particulate sources in Seattle using two different types of data sets.[43]

In addition to using speciation data for specific analytes or source apportionment modeling, the Agency uses it to qualitatively look at the makeup of fine particulate at our monitoring sites. Using a mass

[38] Puget Sound Air Toxics Evaluation. October 2003. http://www.pscleanair.org/airq/basics/psate_final.pdf
[39] Chang-Fu Wu, Timothy Larson, and L-J Sally Liu. Source Apportionment of Seattle and Portland Air Toxics and PM2.5 Data. Final Report for the US EPA Region 10's 2004 Regional Geographic Initiative Grant. February 9, 2006.
[40] The University of Washington is using Iridium as a type of "tracer" for diesel exhaust, in addition to other parameters in a research study examining diesel exhaust in school buses before and after retrofitting. In progress.
[41] Philip K. Hopke. Estimation of the Effects of Ship Emissions Using Existing $PM_{2.5}$ Particle Compositions. Presentation for the California Air Resources Board. Manuscript in progress.
[42] Eugene Kim, Philip Hopke, and Timothy Larson. Source Identification and Spatial Distributions of $PM_{2.5}$ Collected at Multiple Sites in Northwestern U.S. In preparation for 2006 AAAR conference.
[43] Timothy Larson. Estimates of $PM_{2.5}$ Source Contributions in Seattle, WA: A Comparison of Receptor Model Predictions Using Both IMPROVE and Enhanced STN Data Sets. #U2C619 QT-RT-04001775. October 2005.

reconstruction equation to simplify analytes into five broad categories, we can look at seasonal differences and compare sites.[44, 45]

The graphs on pages 76 through 79 show simplified, major constituents of speciation data from the four speciation sites. Major constituents of fine particulate matter in our region include:

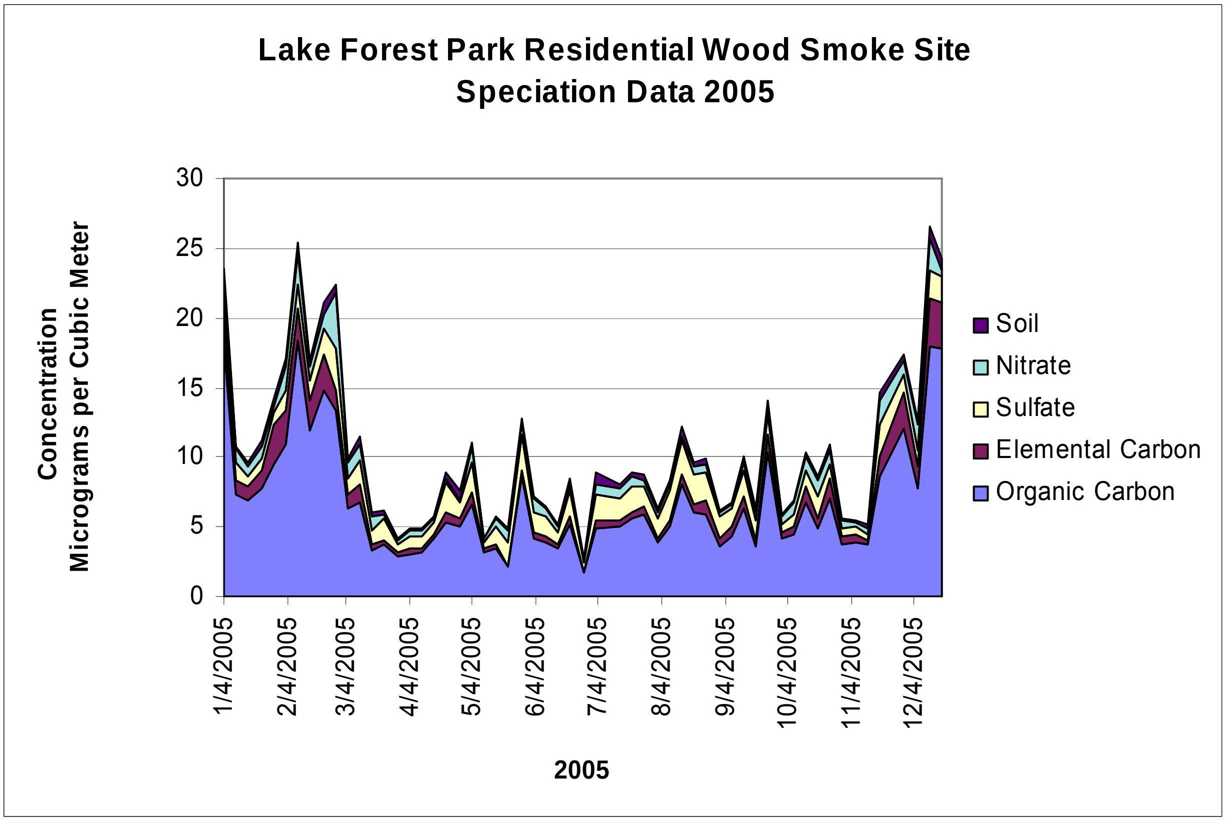
- Organic and Elemental Carbon – These are largely from combustion sources.
- Sulfate and Nitrates – These are formed in the atmosphere from sulfur and nitrogen oxides, $SO_X$, and $NO_X$. The largest sources of $SO_X$ and $NO_X$ in our area are on-road and non-road mobile sources (gasoline and diesel 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 may 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.

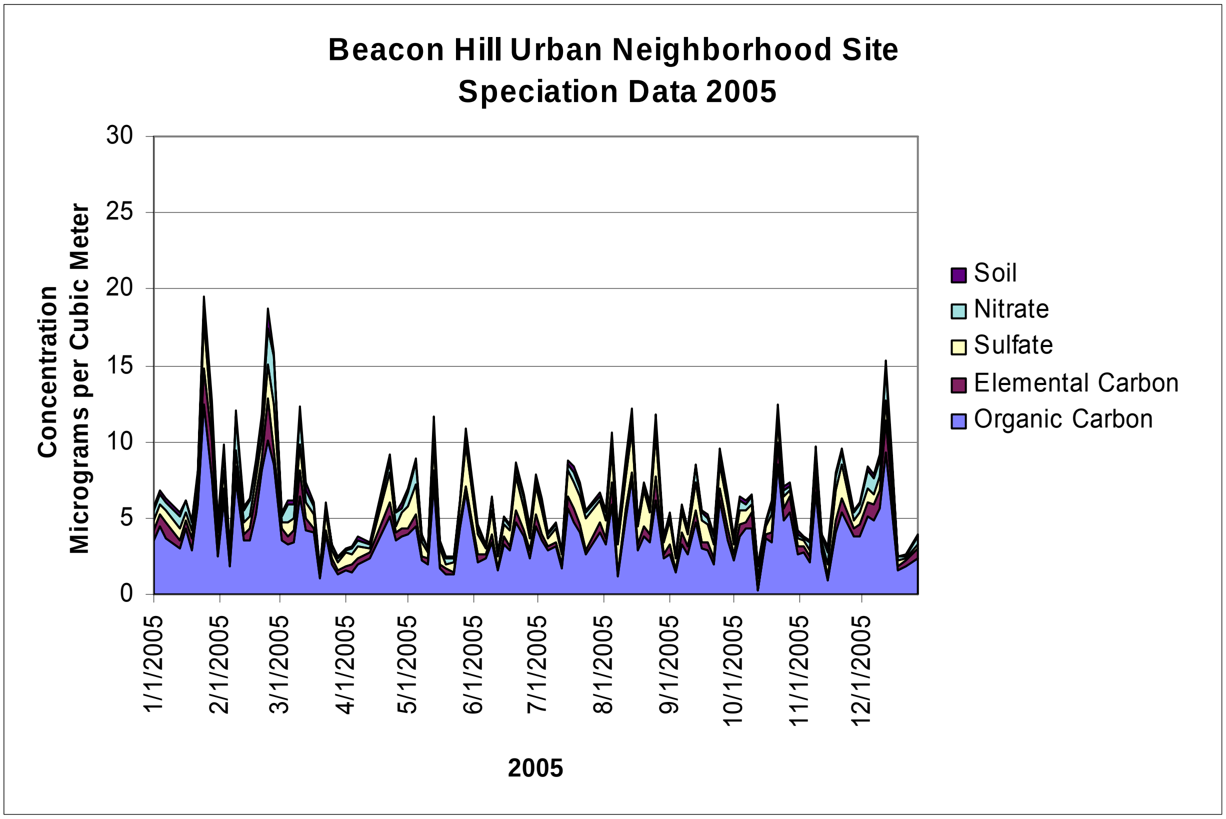
It is important to note that these are not all fine particulate components, but a simplification.

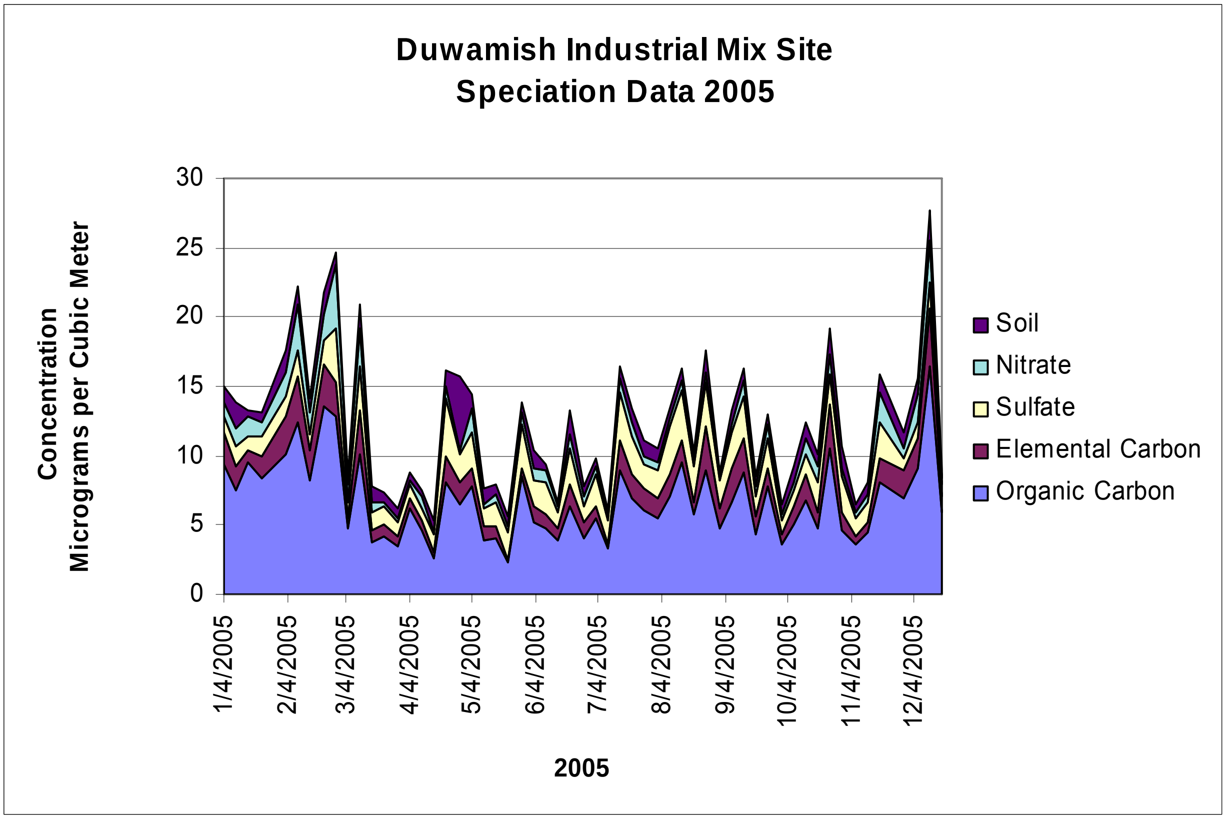
As expected, the wood smoke site (Lake Forest Park) shows more seasonal variability, with carbon concentrations substantially greater in the heating months. The other sites do not show such a clear pattern. These graphs qualitatively show that a large amount of our fine particulate comes from the combustion sources (the carbon fractions).

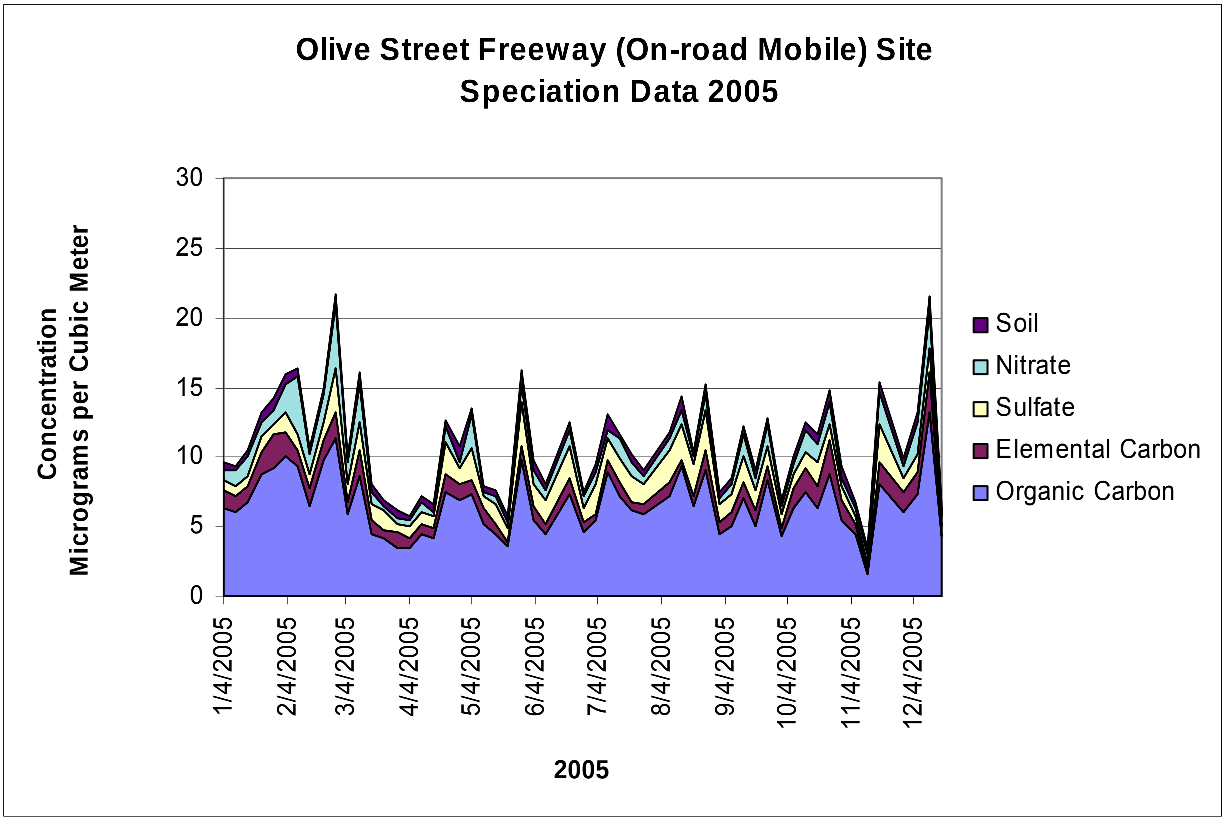
[44] Brook, Dann, and Burnett. The Relationship Among TSP, $PM_{10}$, $PM_{2.5}$, and Inorganic Constituents of Atmospheric Particulate Matter at Multiple Canadian Locations. Journal of Air & Waste Management. Volume 47: 2–19. January 1997. Page 6 includes a mass reconstruction equation for soil components.

[45] 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: 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.


Lake Forest Park Residential Wood Smoke Site
Speciation Data 2005
Concentration
Micrograms per Cubic Meter
30
25
20
15
10
5
0
1/4/2005
2/4/2005
3/4/2005
4/4/2005
5/4/2005
6/4/2005
7/4/2005
8/4/2005
9/4/2005
10/4/2005
11/4/2005
12/4/2005
2005
Soil
Nitrate
Sulfate
Elemental Carbon
Organic Carbon


Beacon Hill Urban Neighborhood Site
Speciation Data 2005
Concentration
Micrograms per Cubic Meter
30
25
20
15
10
5
0
1/1/2005
2/1/2005
3/1/2005
4/1/2005
5/1/2005
6/1/2005
7/1/2005
8/1/2005
9/1/2005
10/1/2005
11/1/2005
12/1/2005
2005
Soil
Nitrate
Sulfate
Elemental Carbon
Organic Carbon


Duwamish Industrial Mix Site
Speciation Data 2005
Concentration
Micrograms per Cubic Meter
30
25
20
15
10
5
0
1/4/2005
2/4/2005
3/4/2005
4/4/2005
5/4/2005
6/4/2005
7/4/2005
8/4/2005
9/4/2005
10/4/2005
11/4/2005
12/4/2005
2005
Soil
Nitrate
Sulfate
Elemental Carbon
Organic Carbon


Olive Street Freeway (On-road Mobile) Site
Speciation Data 2005
Concentration
Micrograms per Cubic Meter
30
25
20
15
10
5
0
1/4/2005
2/4/2005
3/4/2005
4/4/2005
5/4/2005
6/4/2005
7/4/2005
8/4/2005
9/4/2005
10/4/2005
11/4/2005
12/4/2005
2005
Soil
Nitrate
Sulfate
Elemental Carbon
Organic Carbon

## 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.[46] The aethalometer can provide time-resolved information. This is an especially important feature when investigating woodsmoke, which has a strong variance between the evening heating hours and the rest of the day.

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.[47]

The graphs on pages 81 and 82 demonstrate that the aethalometer black carbon channel is related to diesel particulate matter. The first graph is from a 2003 analysis of traffic counts and black carbon monitoring. This graph shows a log-scale traffic count for light-duty gasoline and diesel vehicles (in light blue and blue). Traffic counts are based on hourly Washington State Department of Transportation traffic count data for I-5.[48] Black carbon concentrations from the Seattle Olive Street site (adjacent to I-5) are shown below (in brown). The decrease in diesel vehicles on Saturday and Sunday corresponds with decreases in black carbon concentrations. The second graph demonstrates the same weekend decrease in black carbon concentrations at the Seattle Duwamish site during a summer 2005 week, although total fine particulate concentrations remained higher.

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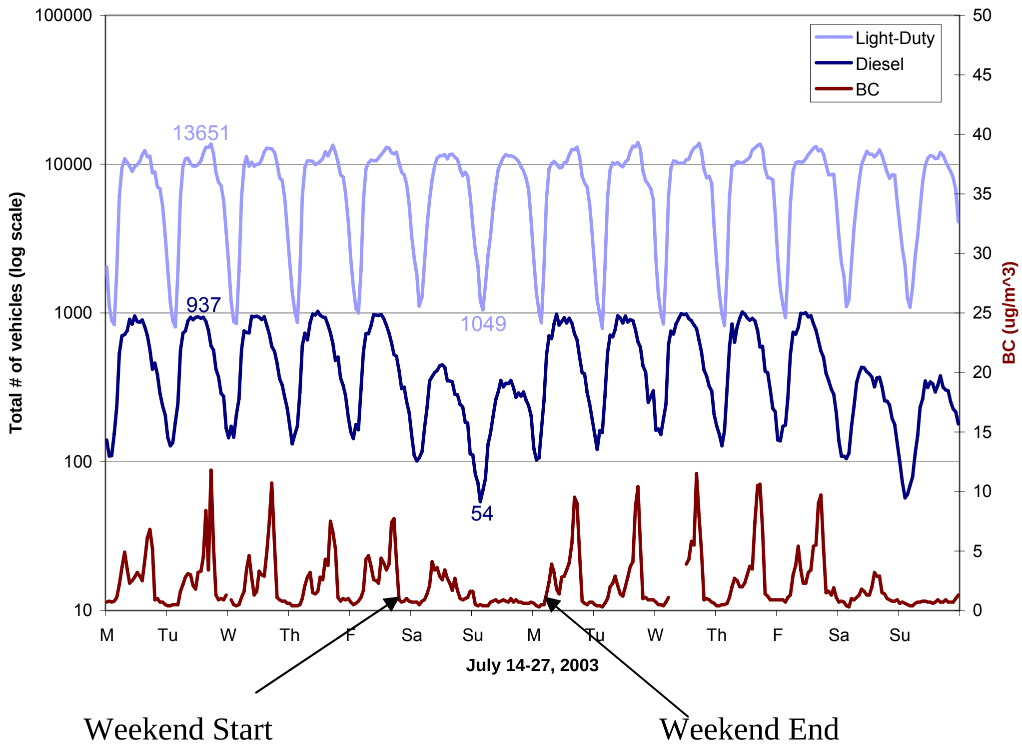
[46] Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area. http://www.pscleanair.org/airq/Aeth-Final.pdf.

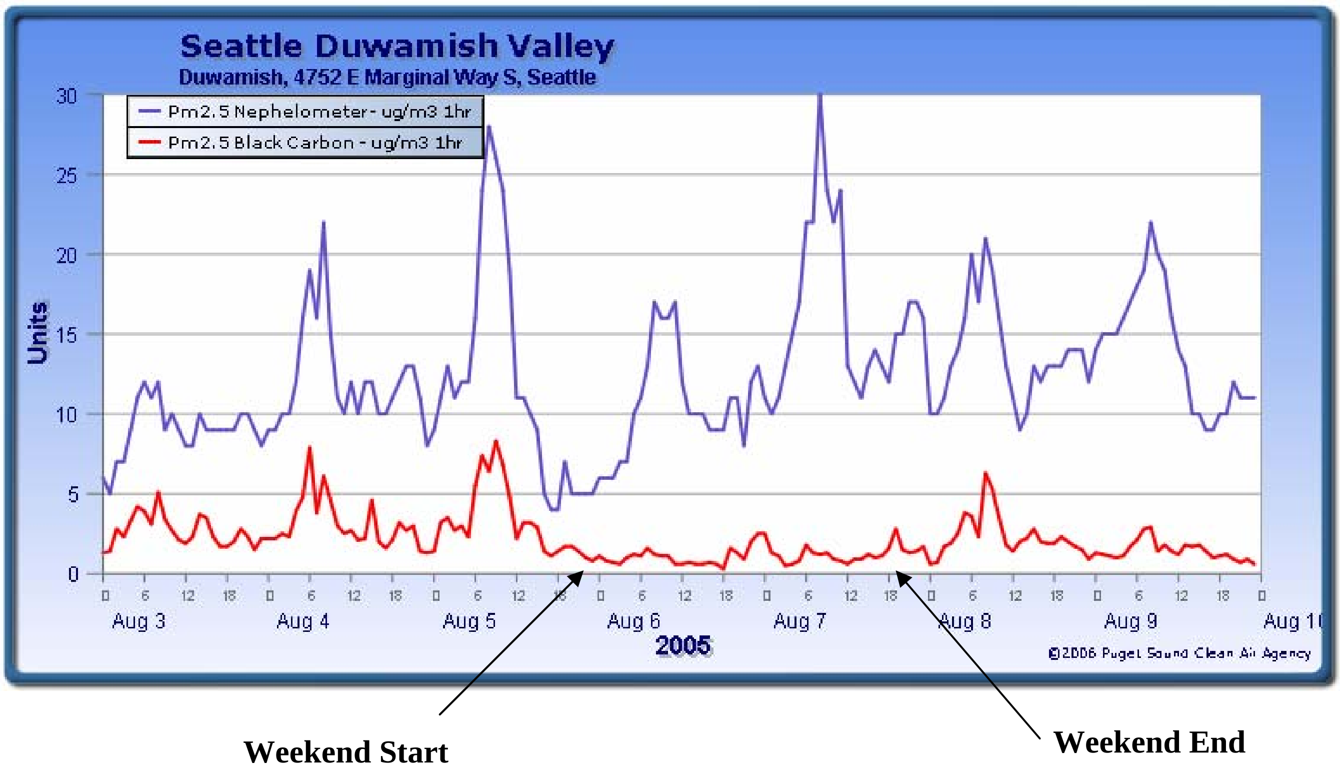
[47] Both aethalometer and fine particulate ($PM_{2.5}$) speciation monitoring were conducted at four sites in 2005: Seattle Olive (AZ), Seattle Beacon Hill (BW), Seattle Duwamish (CE), and Lake Forest Park (DB).

[48] Traffic count data comes from Washington State Department of Transportation MP176, from July 10-31$^{st}$, 2003. The black carbon data is from the Olive Street monitor located at MP166, approximately 20 meters from I-5.

Vehicle Counts and Aethalometer Black Carbon Concentrations



Aethalometer Black Carbon and Fine Particulate Concentrations at Seattle Duwamish Site




Pages A-13 through A-14 in the appendix show the correlation and equation relating BC (from aethalometers) and EC (from speciation data) at the four sites with speciation data: Lake Forest Park, Duwamish, Olive Street, and Beacon Hill. All four show good correlation, with R squared greater than 0.8, with the Duwamish site showing the highest correlation of 0.96.

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-15 of the Appendix.

# 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 nitrous 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). Levels are usually highest in the afternoon because of the intense sunlight and the time required for ozone to form. Ozone levels are highly affected by weather. The Washington State Department of Ecology monitors ozone from May through September, as this is the time period of concern for high ozone levels in the Pacific Northwest.

People frequently hear of ozone in the upper atmosphere. In this context ozone is considered beneficial because it helps to protect the earth from the sun's 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.[49] People with respiratory conditions should limit outdoor exertion if ozone levels are high. Ozone has also been linked to immune system effects.[50] Even healthy individuals may experience respiratory symptoms on a high-ozone day. Ground-level ozone can also damage agricultural crops and forests, interfering with their ability to produce food and grow.[51]

The majority of monitoring stations measuring ozone are located in rural regions of the Puget Sound, 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. Ozone has typically been transported 10 to 30 miles downwind from the original source by the time the highest concentrations have formed in the afternoon and early evening. Highest ozone concentrations are measured in areas such as North Bend and Enumclaw.

The graph on page 84 presents data for each monitoring station and the federal standard, and shows that the Puget Sound area has fallen below the standard since 1993. Nonetheless, ozone concentrations have not decreased as significantly as precursor pollutants.

The federal standard is based on the 3-year average of the 4$^{th}$-highest 8-hour concentration. This means the three highest concentrations can exceed the level of the standard while still maintaining attainment. There is also a 3-year averaging component to the standard. Values presented on the graph are 3-year averages of 4$^{th}$-highest concentrations. The year on the x-axis represents the last year averaged. For

[49] EPA AirNow. How Can Ground-Level Ozone Affect Your Health? http://www.airnow.gov/index.cfm?action=static.ozone2#3.
[50] EPA Health and Environmental Effects of Ground Level Ozone. http://www.epa.gov/ttn/oarpg/naaqsfin/o3health.html.
[51] EPA Health and Environmental Effects of Ground Level Ozone. http://www.epa.gov/ttn/oarpg/naaqsfin/o3health.html.

example, concentrations shown for 2005 are an average of 2003, 2004, and 2005 concentrations. The table on page A-16 of the Appendix shows that the 8-hour standard of 0.08 ppm was not exceeded in 2005.

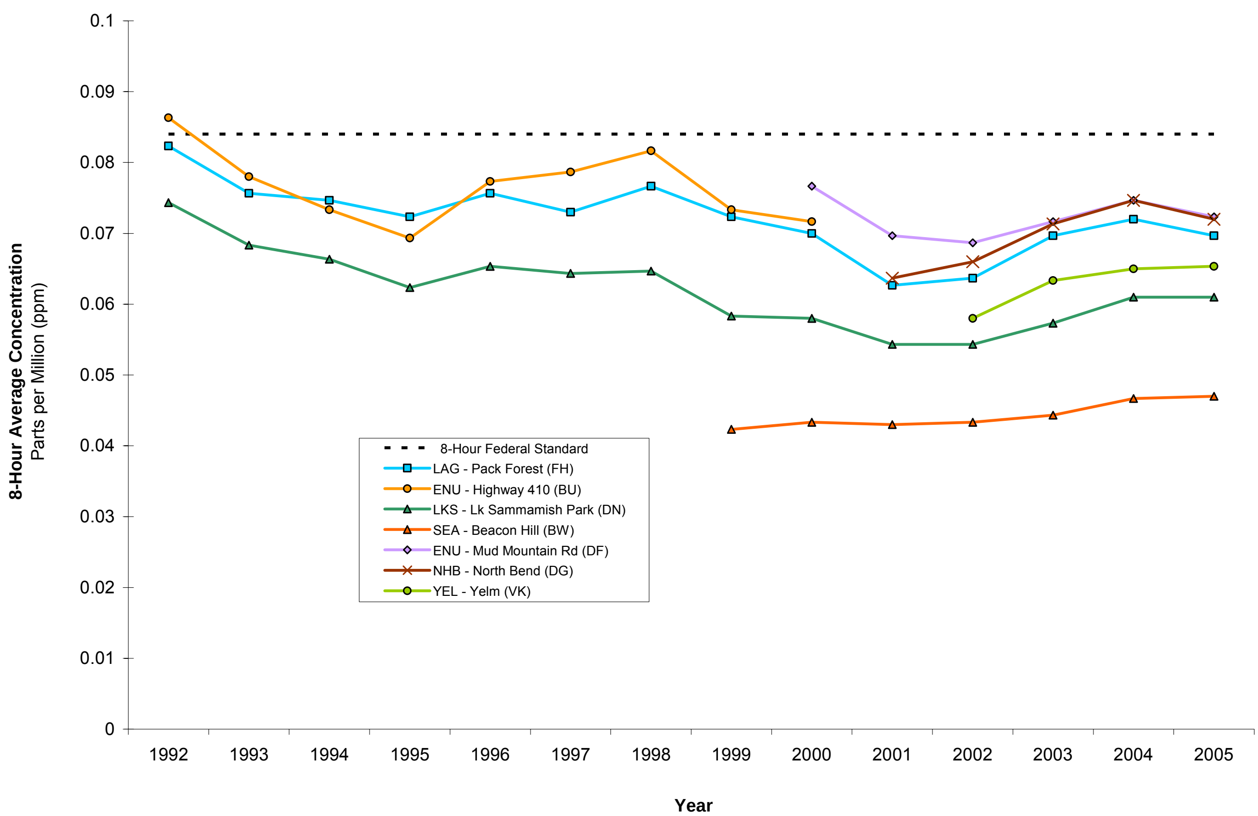
The graph on page 85 presents 8-hour average data for the months of May through September, as these are the months where ozone levels are greatest. The shading on the graph corresponds to the AQI breakpoints for ozone, based on the 8-hour average. The graph on page 86 shows the trend of ozone over the summer for the last eight years. Levels have occasionally reached the "unhealthy for sensitive groups" zone in recent years.

The 1-hour standard of 0.12 ppm was not exceeded in 2005 at any site during measurements, as seen in the table on page A-17 of the Appendix. Additionally, the EPA phased out the one hour form of the standard in June 2005.

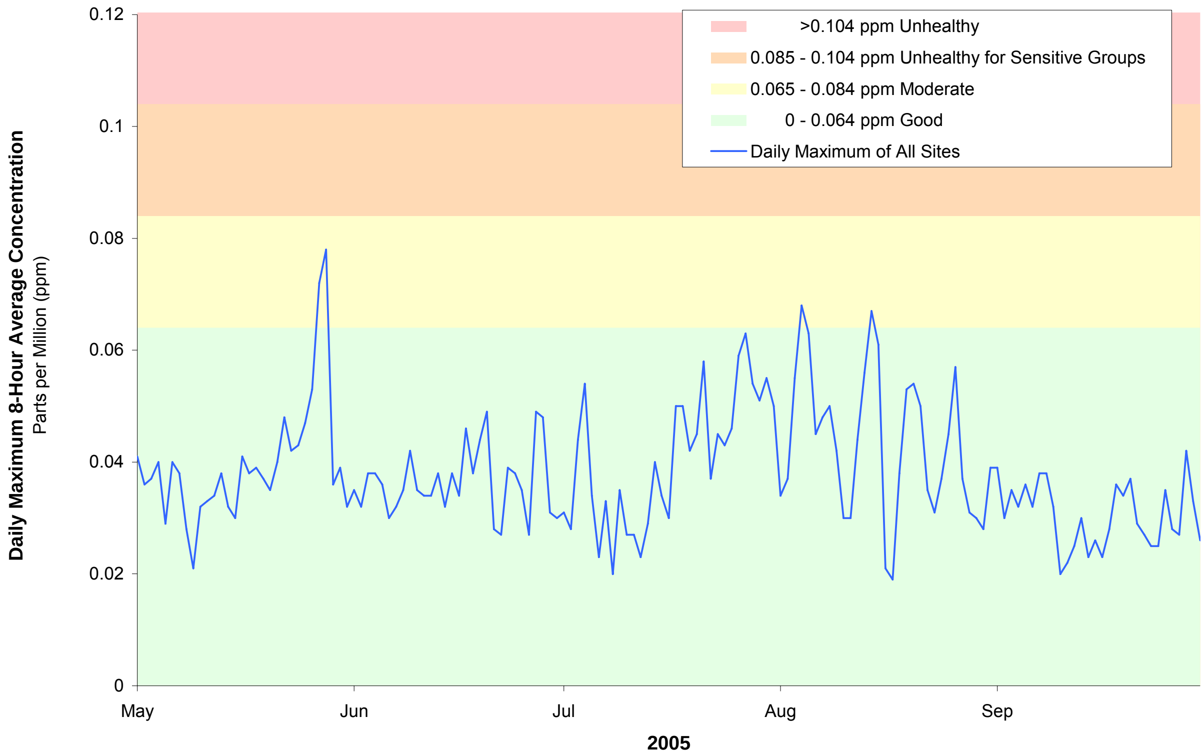
For additional information on ozone, visit www.epa.gov/air/urbanair/ozone/index.html. There is also additional information on ozone in question/answer format in the definitions section of this document.

**8-Hour Ozone**

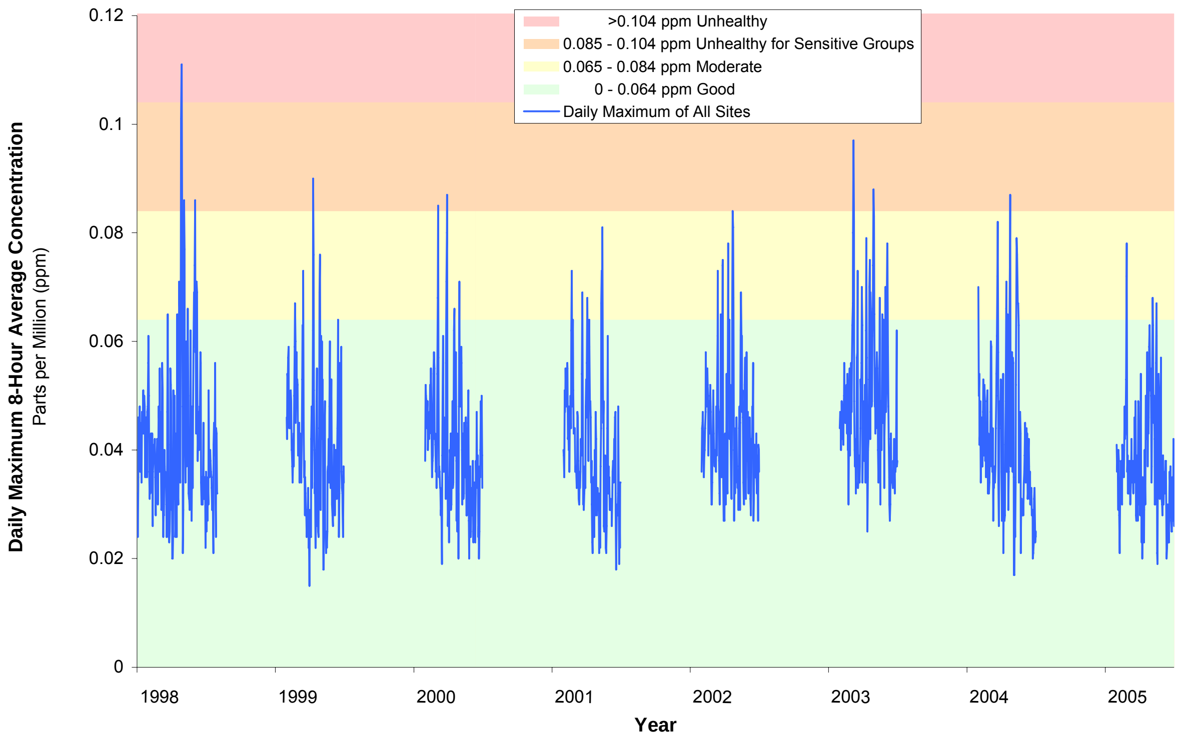
3-Year Average of 4th Highest Annual Concentration vs Standard



**Ozone ($O_3$) in Puget Sound Region**
Daily Maximum 8-Hour Concentration



**Ozone ($O_3$) in Puget Sound Region**
for the months May through September
Daily Maximum 8-Hour Concentration



## Nitrogen Dioxide

Nitrogen dioxide ($NO_2$) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and oxygen in the atmosphere. The term "$NO_X$", which is frequently used, refers to both NO and $NO_2$. $NO_2$ will react with volatile organic compounds (VOCs) and can result in the formation of ozone. $NO_X$ can also form nitrates in the atmosphere, a component of fine particulate matter. On-road vehicles such as trucks and automobiles are the major sources of $NO_X$. Industrial boilers and processes, home heaters, and gas stoves also produce $NO_X$. $NO_X$ pollution is greatest in cold weather.

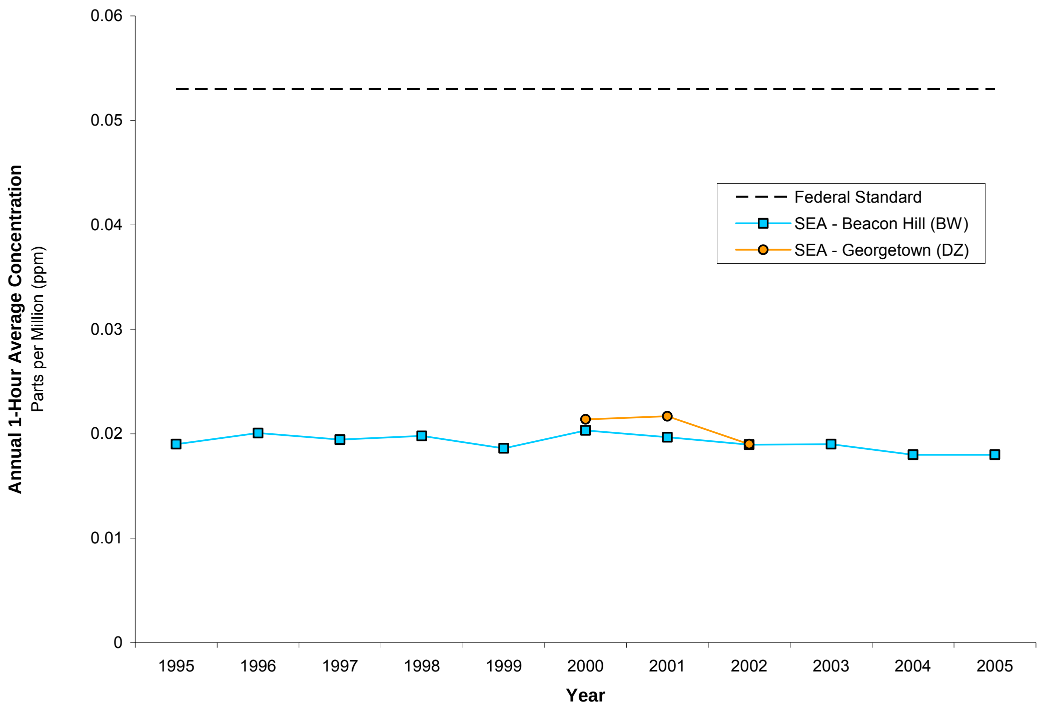
$NO_2$ can cause respiratory symptoms such as coughing, wheezing, and shortness of breath in people with respiratory diseases such as asthma.[52] Long-term exposure can lead to respiratory infections.

Motor vehicle manufacturers have been required to reduce $NO_X$ emissions from cars and trucks since the 1970s, and emissions have reduced dramatically. Nitrogen dioxide 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.

The Washington State Department of Ecology maintains one monitoring site for nitrogen dioxide at the Beacon Hill monitoring site. The annual average for each year has consistently been less than half of the NAAQS , as shown in the graph on page 88 and in the statistical summary on page A-18 of the Appendix. The maximum 1-hour average of $NO_2$ measured in 2005 was 0.078 ppm on June 6. Visit www.epa.gov/air/urbanair/nox/index.html for additional information on $NO_2$.

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

**Nitrogen Dioxide ($NO_2$)**
Annual 1-Hour Average vs Standard



# 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 doesn't burn completely. The majority of CO comes from vehicle exhaust. In cities, 85-95% of all CO emissions may come from motor vehicle exhaust.

Elevated levels of CO in ambient air can occur in areas with heavy traffic congestion, and happen during the colder months of the year when temperature inversions are more frequent. 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.

The Washington State Department of Ecology conducts all CO monitoring. CO monitoring stations are located in areas with heavy traffic congestion. These include central business areas, roadsides, and shopping malls. CO levels have reduced significantly in the last fifteen years in the Puget Sound area, primarily due to cleaner car technology.

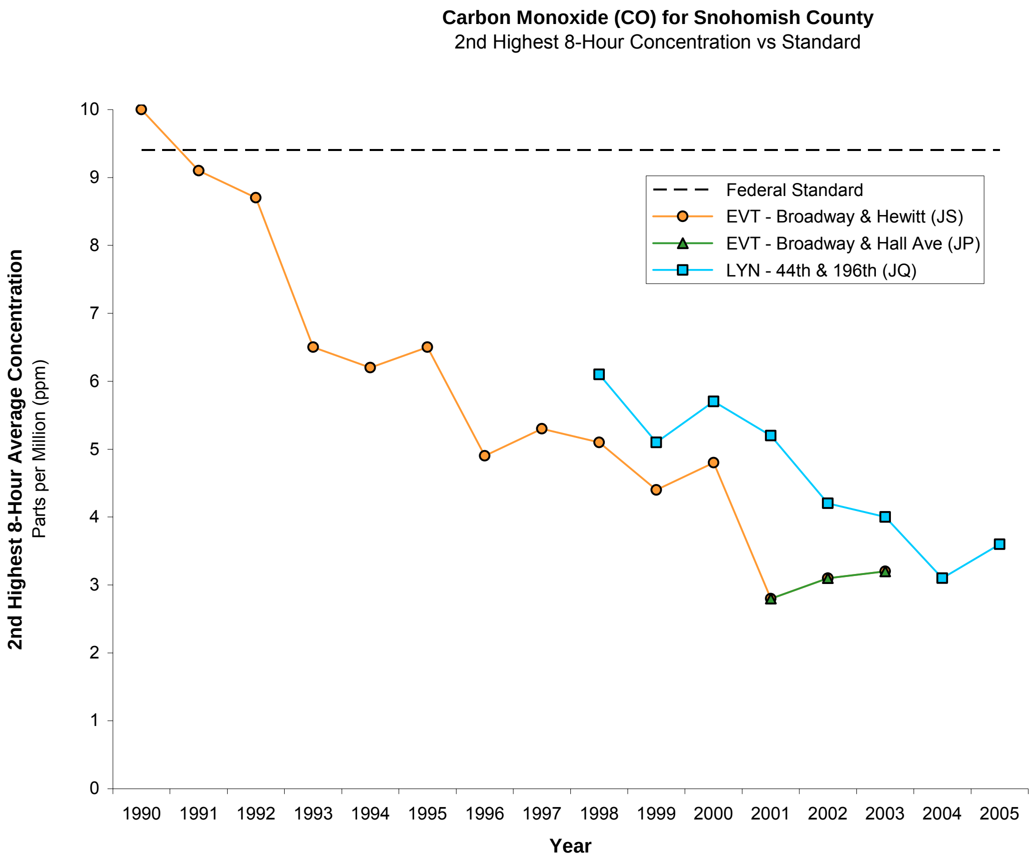
The CO federal standard (NAAQS) is based on the second highest 8-hour average. Graphs on pages 90 through 92 show the second highest 8-hour concentrations and the federal standard for Snohomish, King, and Pierce counties. There are no CO monitoring stations in Kitsap County. These graphs confirm the general downward trend that CO has taken from the early 1990s to present. EPA designated the Puget Sound region as a CO attainment area in 1996.

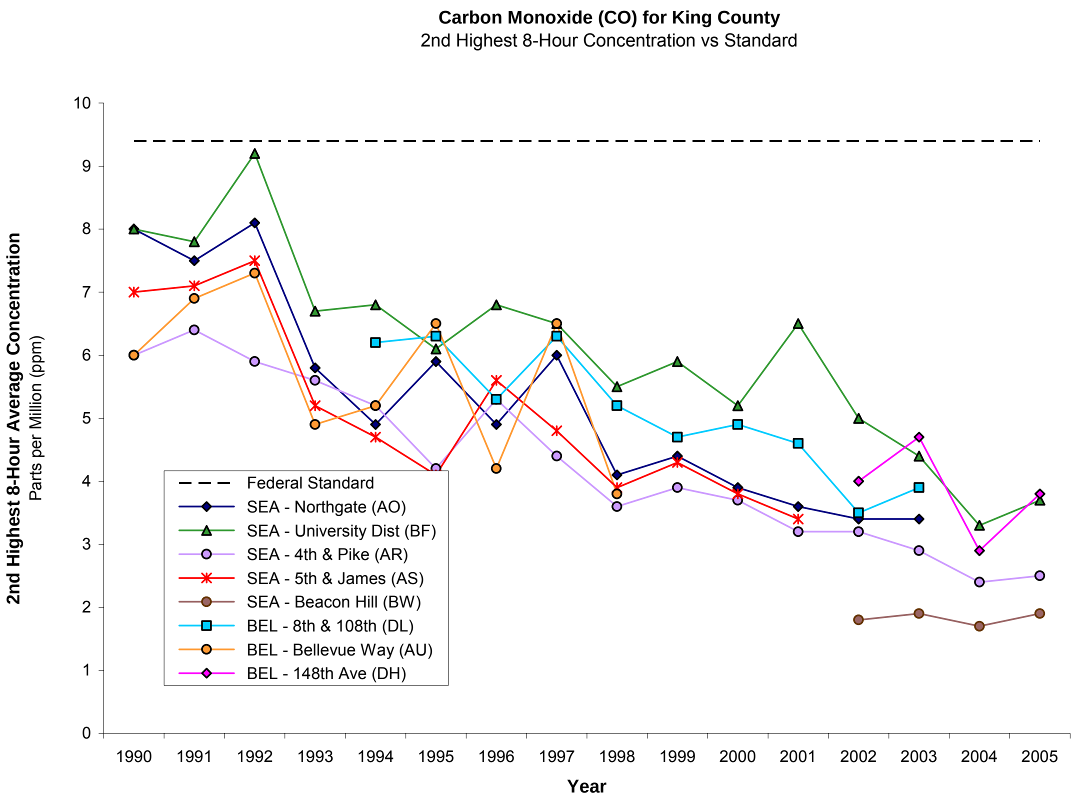
The maximum 8-hour concentration for CO in 2005 was 4.6 parts per million (ppm) on February 23 at the Tacoma Pacific Avenue site.

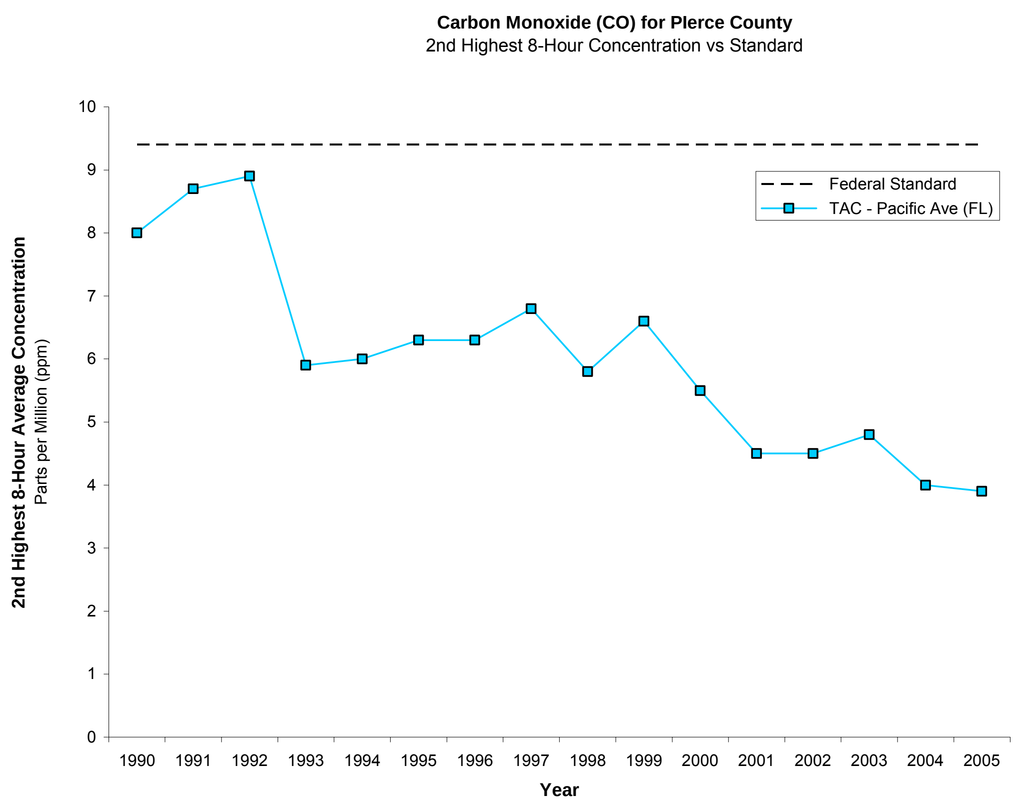
The NAAQS also includes a 1-hour standard for CO of 35 ppm, not to be exceeded more than once a year. Measured 1-hour concentrations in the Puget Sound area are historically much lower than the 35 ppm standard, and therefore 1-hour CO trends are not graphed. The maximum 1-hour CO concentration in 2005 was 6.6 ppm on February 23 at the Tacoma Pacific Avenue site.

Statistical summaries for 8-hour and 1-hour average CO data are provided on page A-19 of the Appendix.

For additional information on CO, visit www.epa.gov/air/urbanair/co/index.html. CO information is also provided in question/answer format in the definitions section of this document.


Carbon Monoxide (CO) for Snohomish County
2nd Highest 8-Hour Concentration vs Standard
2nd Highest 8-Hour Average Concentration
Parts per Million (ppm)
Federal Standard
EVT - Broadway & Hewitt (JS)
EVT - Broadway & Hall Ave (JP)
LYN - 44th & 196th (JQ)
Year
0
1
2
3
4
5
6
7
8
9
10
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005


Carbon Monoxide (CO) for King County
2nd Highest 8-Hour Concentration vs Standard
2nd Highest 8-Hour Average Concentration
Parts per Million (ppm)
10
9
8
7
6
5
4
3
2
1
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
Federal Standard
SEA - Northgate (AO)
SEA - University Dist (BF)
SEA - 4th & Pike (AR)
SEA - 5th & James (AS)
SEA - Beacon Hill (BW)
BEL - 8th & 108th (DL)
BEL - Bellevue Way (AU)
BEL - 148th Ave (DH)


Carbon Monoxide (CO) for PIerce County
2nd Highest 8-Hour Concentration vs Standard
2nd Highest 8-Hour Average Concentration
Parts per Million (ppm)
Federal Standard
TAC - Pacific Ave (FL)
Year
0
1
2
3
4
5
6
7
8
9
10
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005

.

# 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). Today, on-road vehicles, diesel construction equipment, and marine craft also release significant $SO_2$ emissions to the air.

People with asthma who are active outdoors may experience bronchoconstriction, 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.

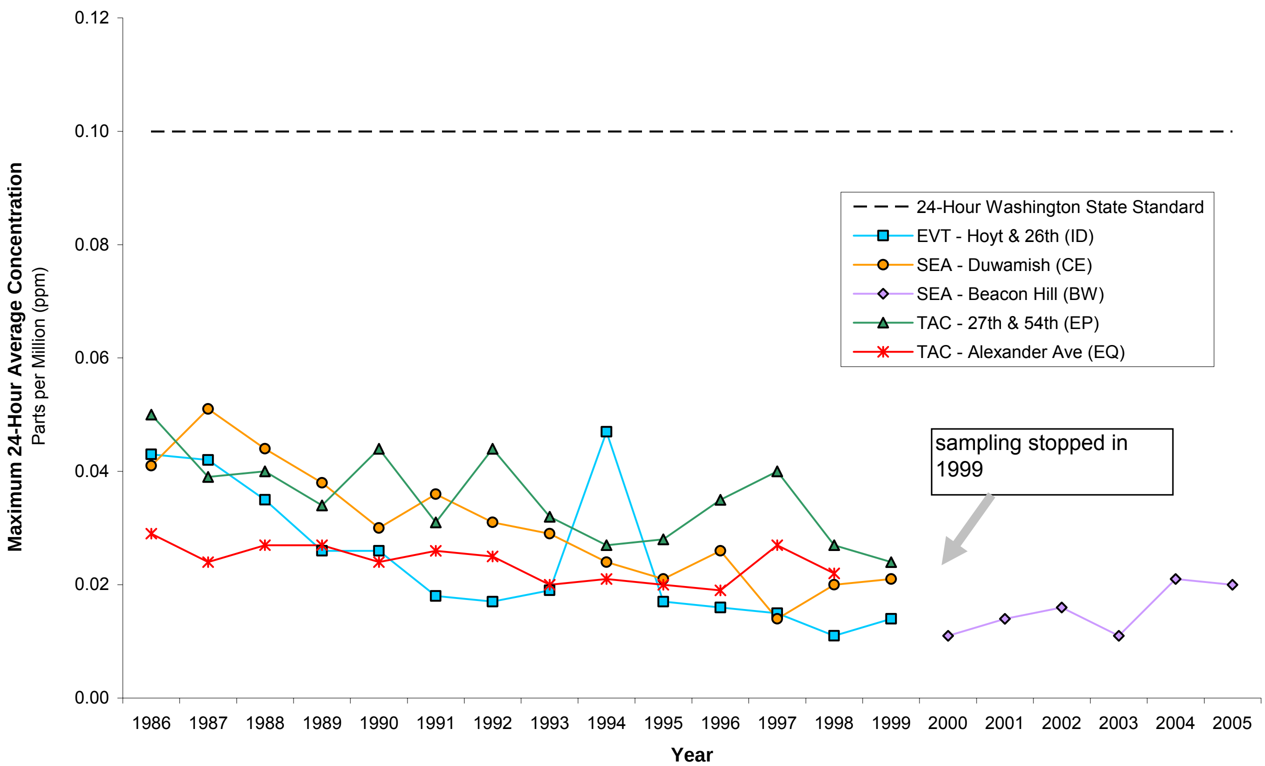
The Puget Sound area has experienced a significant decrease in $SO_2$ from sources such as pulp mills, cement plants, and smelters in the last several years. Additionally, levels of sulfur in diesel and gasoline fuels are decreasing due to EPA regulations. The Puget Sound Clean Air Agency stopped monitoring for $SO_2$ in 1999 because of these decreases. Monitoring sites for $SO_2$ were historically sited in or near former industrial areas. The Washington State Department of Ecology currently monitors for $SO_2$ at the Beacon Hill site. This monitoring started in May 2000.

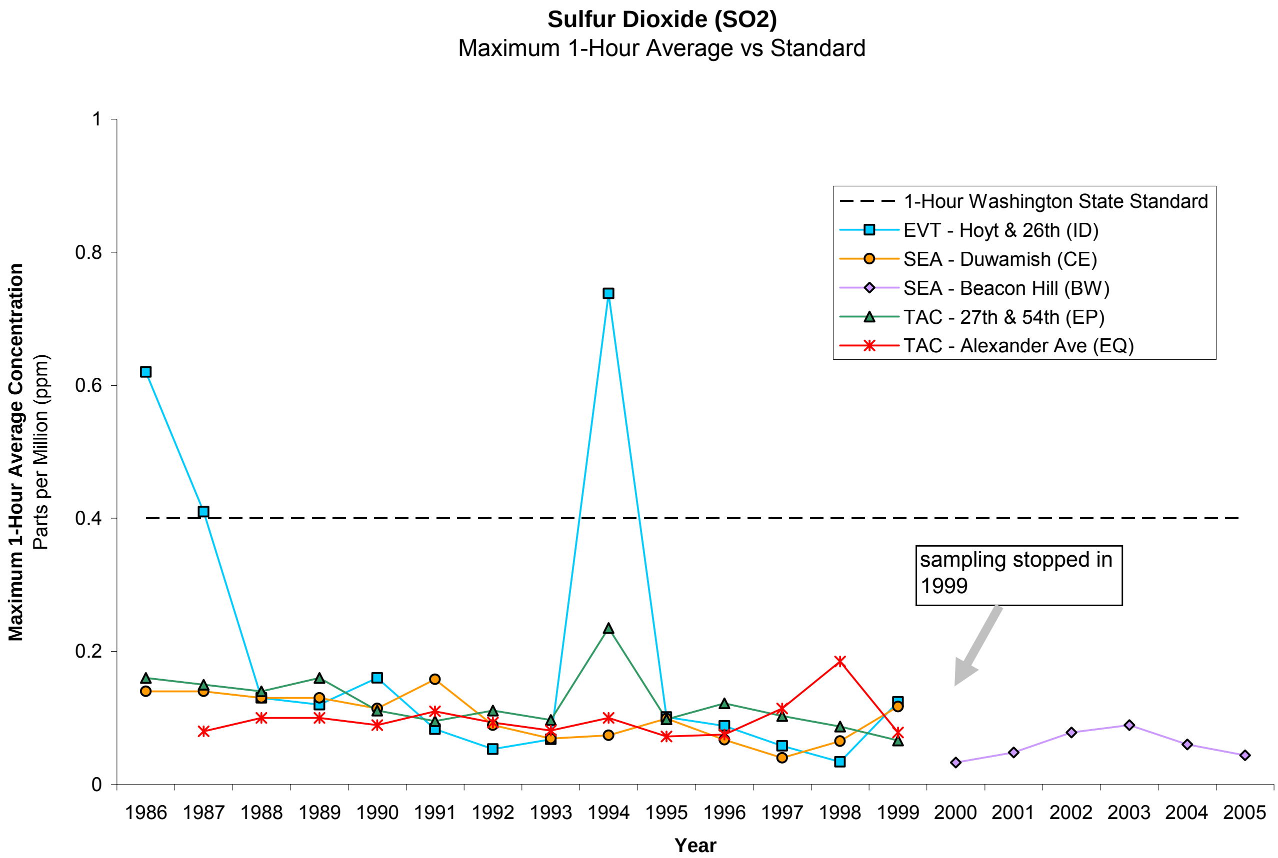
The graphs on pages 94 and 95 show the maximum 24-hour and 1-hour concentrations, respectively, at individual monitoring sites. The July 1994 spike shown on these graphs was the result of a release from an Everett paper mill. The maximum measured $SO_2$ concentrations in 2005 were below all federal and regional standards. The maximum 24-hour and 1-hour Beacon Hill averages in 2005 were 0.020 ppm on April 7 and 0.044 ppm on October 21, respectively.

Statistical summaries for $SO_2$ data from the Beacon Hill site are available on page A-20 of the Appendix.

Additional information on $SO_2$ is available at www.epa.gov/air/urbanair/so2/index.html. $SO_2$ information is also provided in question/answer format in the definitions section of this document.

**Sulfur Dioxide ($SO_2$)**
Maximum 24-Hour Average vs Standard




Sulfur Dioxide (SO2)
Maximum 1-Hour Average vs Standard
Maximum 1-Hour Average Concentration
Parts per Million (ppm)
1
0.8
0.6
0.4
0.2
0
1-Hour Washington State Standard
EVT - Hoyt & 26th (ID)
SEA - Duwamish (CE)
SEA - Beacon Hill (BW)
TAC - 27th & 54th (EP)
TAC - Alexander Ave (EQ)
sampling stopped in 1999
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Year

# Lead

Lead is a highly toxic metal that was used for many years in household products, automobile fuel, and industrial chemicals. Locally, airborne lead was associated primarily with automobile exhaust and lead smelters. The large reductions in lead emissions from motor vehicles have changed the nature of the air quality lead problem in the United States. Industrial processes, particularly primary and secondary lead smelters and battery manufacturers, are now responsible for most of the remaining lead emissions.

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.

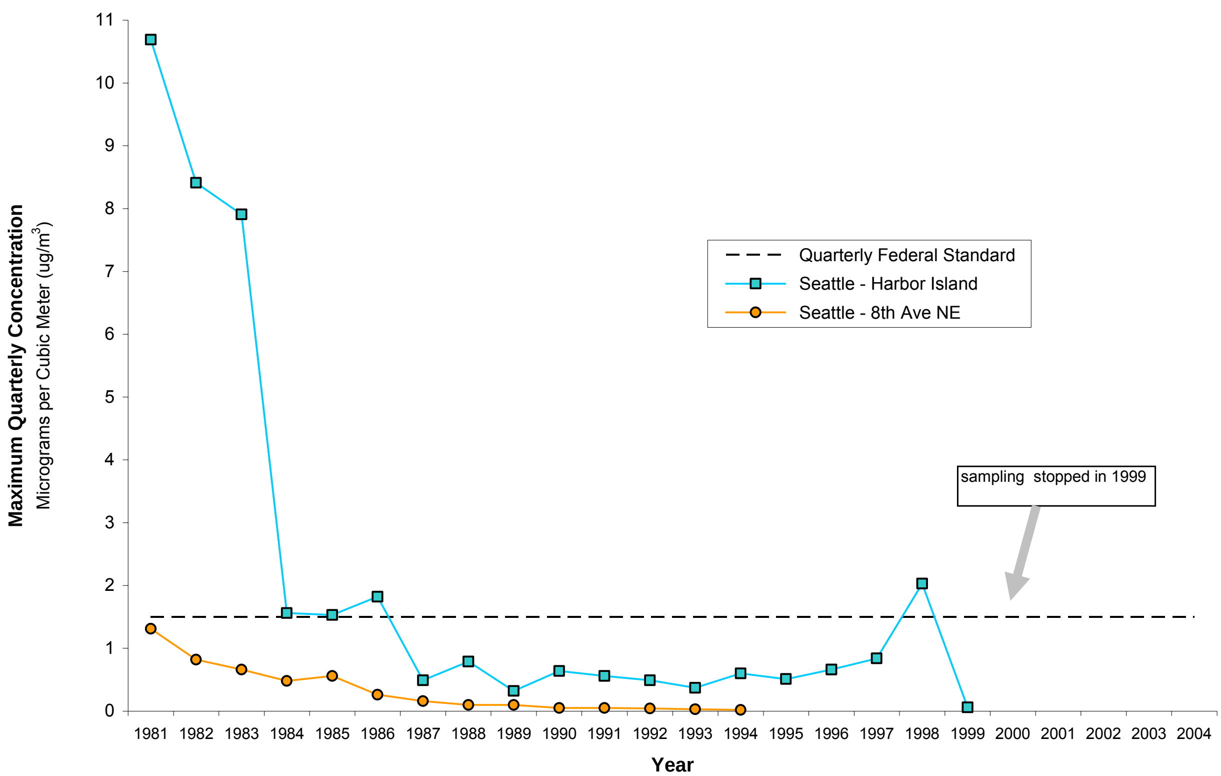
According to the EPA, the primary sources of lead exposure are lead-based paint, lead-contaminated dust, and lead-contaminated residual soils. Refer to the EPA website www.epa.gov/ttnatw01/hlthef/lead.html for ways to limit your exposure to these lead sources.

Lead has not been monitored in the Puget Sound area since 1999.[53] Since the phase-out of lead in fuel and the closure of the Harbor Island lead smelter, lead in ambient air is no longer a public health concern in the region. The graph on page 97 is included to show the historical reduction of airborne lead in the Puget Sound region. The elevated concentration that violated federal quarterly standards in early 1998 was due to the Harbor Island lead smelter. The smelter ceased all operations in May 1998.

For additional information on lead, visit www.epa.gov/air/urbanair/lead/index.html. Lead information is also available in a question/answer format in the definitions section of this report.

[53] 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.

**Lead (Pb)**
Maximum Quarterly Average vs Standard



# Visibility

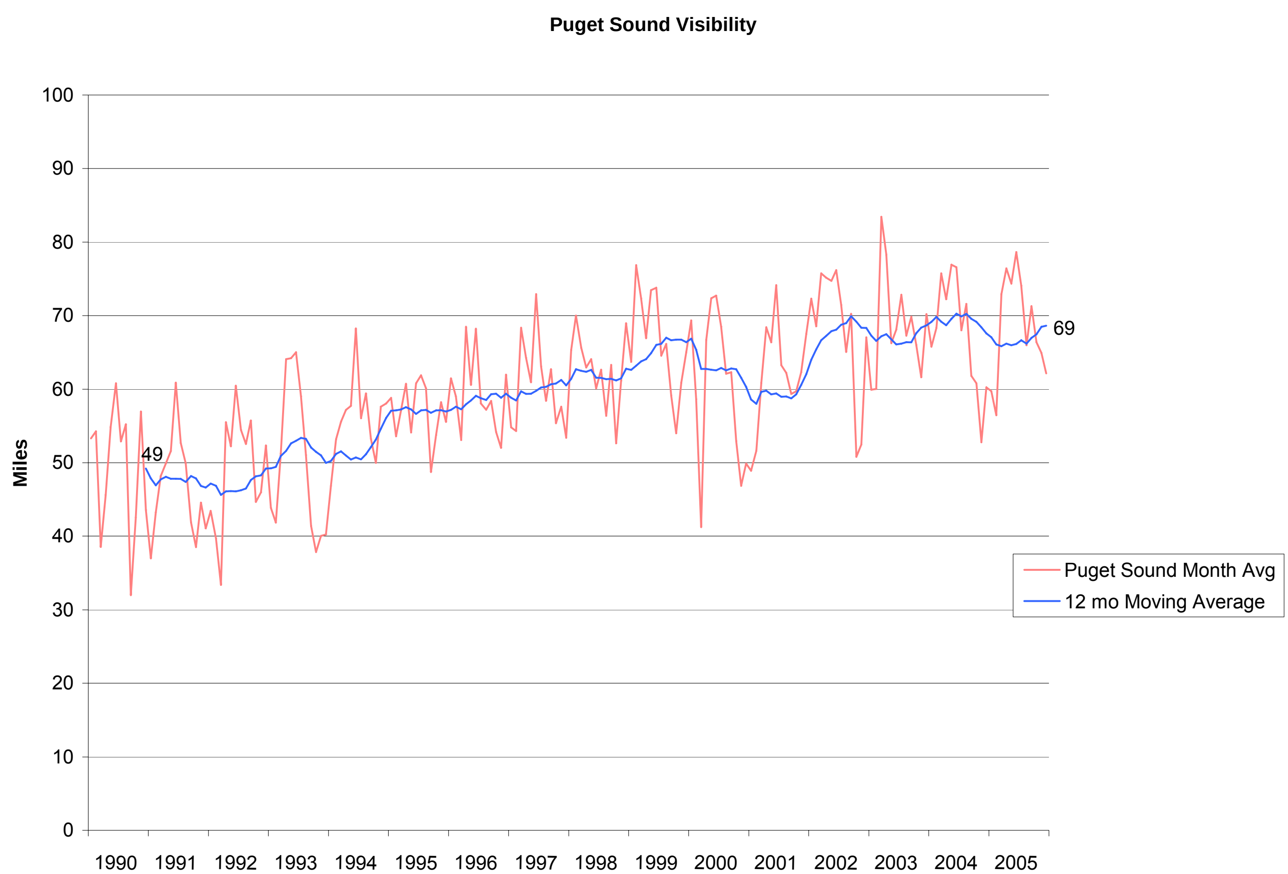
There are no federal or state standards established for visibility. This parameter is presented (without comparison to a standard) as an easily-understood indicator of air quality. Visibility is often explained in terms of visual range and light extinction. *Visual range* is the maximum distance—usually 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 you have, the shorter your visual range will be. 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.

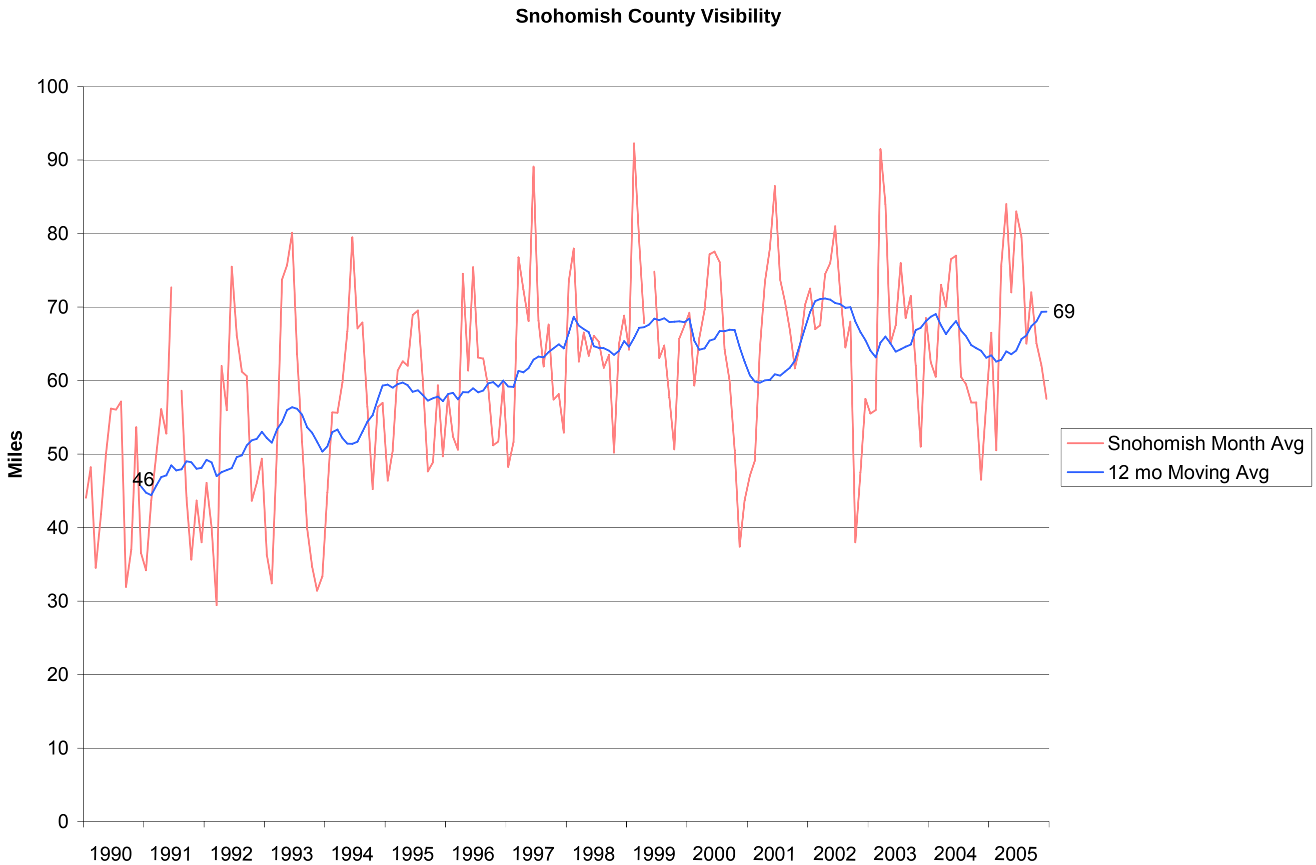
Reduced visibility is caused by weather such as clouds, fog, and rain, and air pollution, including fine particles and gases. The major pollution contributor to reduced visual range is fine particulate matter ($PM_{2.5}$), which is transported aloft and may remain suspended for a week or longer. Fine particles have a greater impact than coarse particles at locations far from the emitting source because they remain suspended in the atmosphere longer and travel farther. $PM_{2.5}$ also presents some of the most serious health hazards to the public, so you can roughly assume that the worse the visibility due to particulate matter, the unhealthier the air is to breathe.

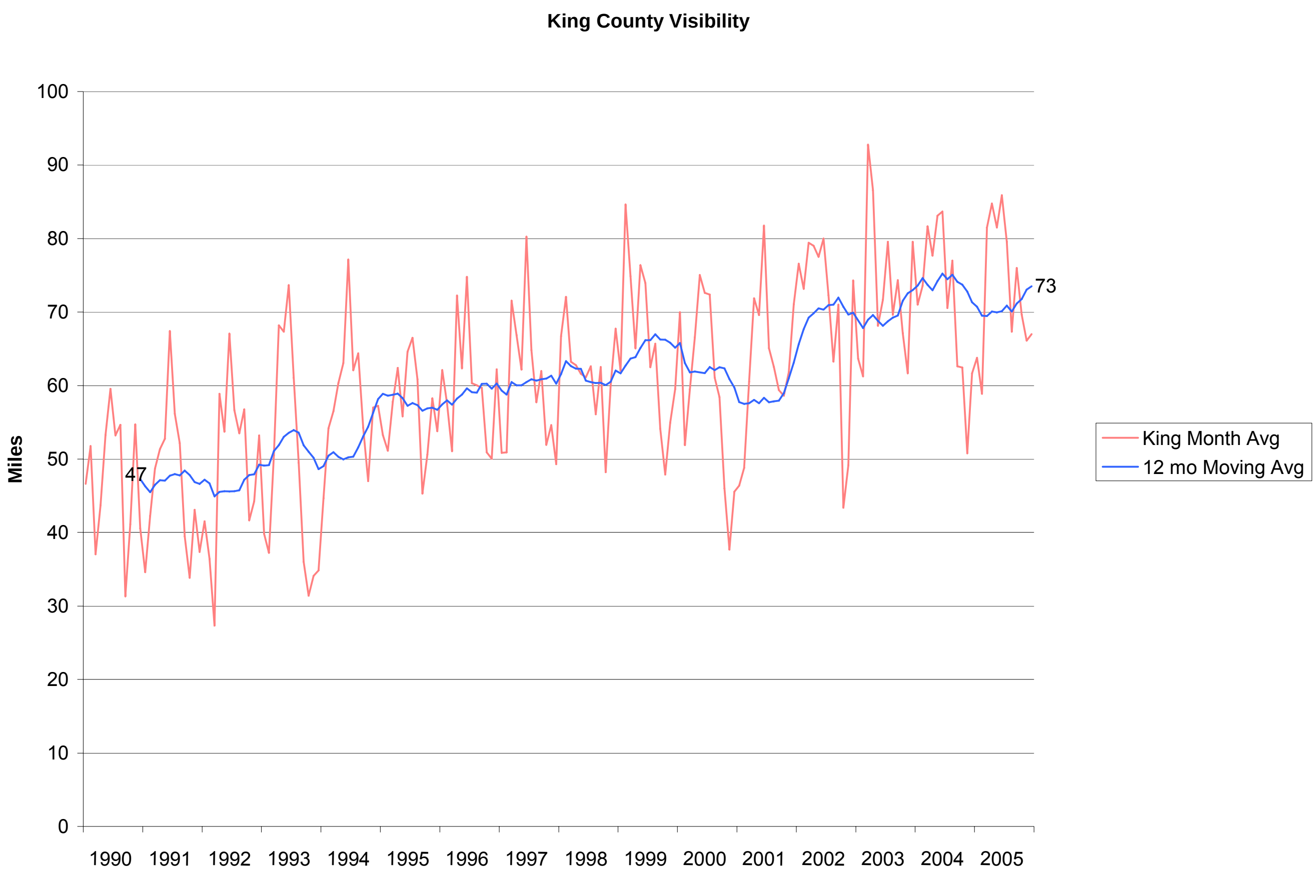
Graphs on the following pages show visibility for the overall Puget Sound area, as well as Snohomish, King, and Pierce counties. Visibility on these graphs, in units of miles, is determined by continuous nephelometer monitoring. The nephelometer measures light scattering due to particulate matter, and then converts this unit ($b_{sp}$) into miles, more readily understood. The nephelometer does not take into account meteorology visibility effects such as cloudiness, so the visibility in these graphs is visibility as related to particulate matter. Nephelometer data are shown on page A-9 of the Appendix.

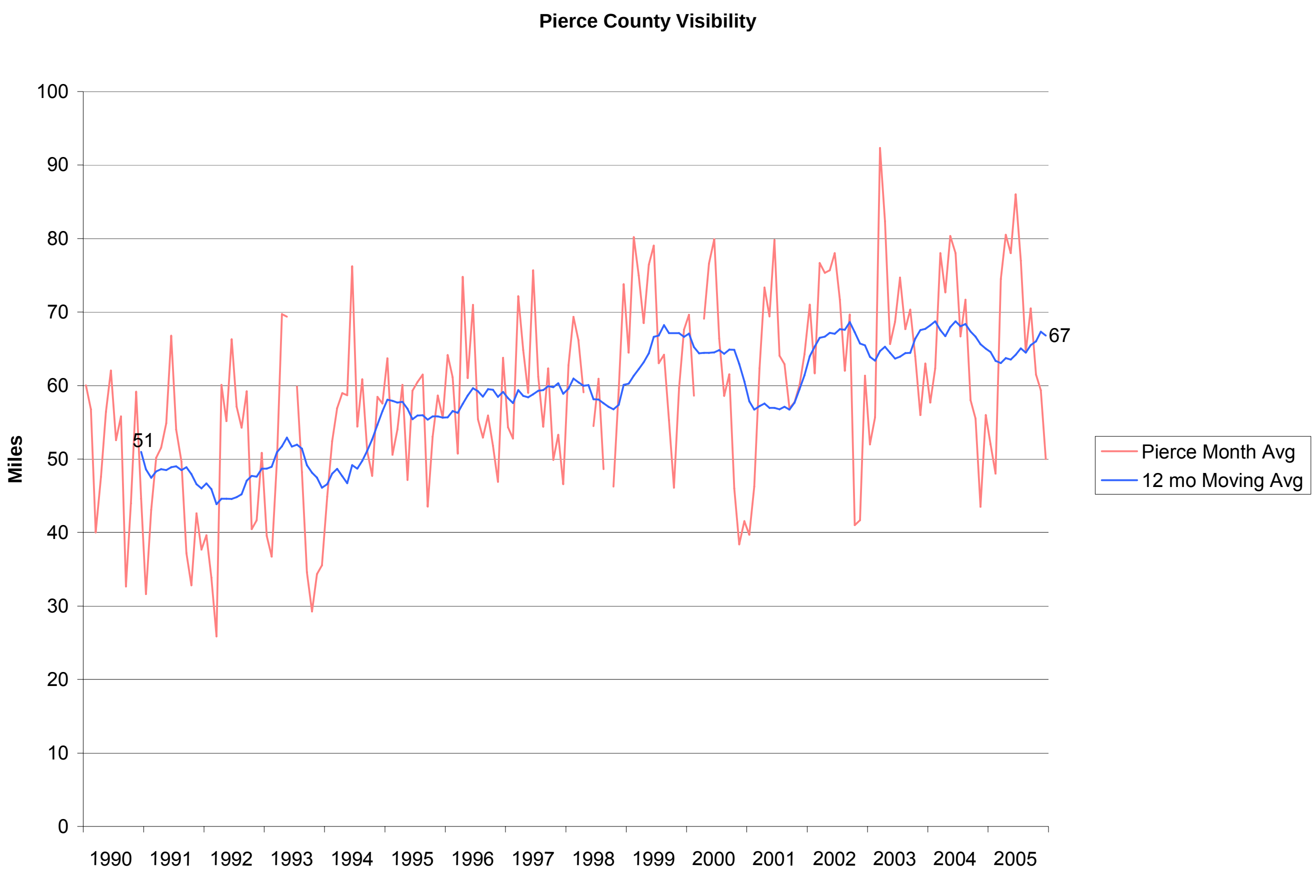
The red line on the graphs represents the monthly average visibility; it is apparent that there are large fluctuations, which correspond to the highest levels of visibility in the summer months and the lowest levels in the winter. The blue line shows a 12-month moving average, which incorporates the average of the previous 12 months to aid in smoothing out this seasonal variation. The blue line shows that the average visibility for the Puget Sound area has steadily increased over the last decade with year-to-year variability caused by meteorology. For the 16-year period from December 1990 through December 2005, the 12-month moving average of visual range increased from 46 miles to 69 miles.

For additional information on visibility, visit http://www.epa.gov/air/visibility/index.html. Visibility information is also available in a question/answer format in the definitions section of this document.




Snohomish County Visibility
Miles
100
90
80
70
60
50
40
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
46
69
Snohomish Month Avg
12 mo Moving Avg


King County Visibility
Miles
100
90
80
70
60
50
40
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
47
73
King Month Avg
12 mo Moving Avg


Pierce County Visibility
Miles
100
90
80
70
60
50
40
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
51
67
Pierce Month Avg
12 mo Moving Avg

# Air Toxics

The Washington State Department of Ecology (Ecology) monitored 17 air toxics in 2005 at the Beacon Hill site, including seven $PM_{10}$ metals. 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 graphs for Beacon Hill air toxics showing annual averages for six years of monitoring data. Graphs are not presented for $PM_{10}$ metals because they have only three years of data, 2003 through 2005. A short description of health effects associated with each air toxic and local sources are also provided.

A comprehensive, cumulative risk evaluation is beyond the scope of this summary report. For more information, consult the 2003 Puget Sound Air Toxics Evaluation at. http://www.pscleanair.org/airq/basics/psate_final.pdf. For general information on air toxics, visit our website at http://www.pscleanair.org/airq/basics/airtoxics.aspx.

Air toxics statistical summaries are provided on page A-21 of the Appendix. Summaries include the minimum detection limit (MDL) for each air toxic. This is the minimum analytical level at which each air toxic can be detected.

## Relative Ranking

The table on page 104 ranks 2005 air toxics according to mean potential cancer risk per million. Potential cancer risk estimates are shown here to provide a meaningful basis of comparison between pollutants. 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 toxicity.[54] Unit risk factors used and their sources are listed on page A-22 of the Appendix. 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.

Mean risks are also presented in this table and are based on annual average concentrations. Upper bound risks based on 95$^{th}$ percentile concentrations are included on page A-23 of the Appendix.[55] It is important to note that many air toxics also have non-cancer health effects.

[54] Potential cancer risks use Unit Risk Factors (URFs), which are based on an assumed 70-year (lifetime) inhalation exposure.
[55] Upper bound estimates are often protectively used in health evaluations. Use of upper bounds is intended to conservatively account for populations that may be exposed to air toxics at concentrations greater than a mean statistic.

These non-cancer effects are not quantitatively reported here. Again, potential cancer risk estimates are shown here as a basis of comparison.

Chromium is listed with a range of mean risks, based on two different monitoring methods and risk estimates that are further described in the *Chromium* section (page 114).

2005 Beacon Hill Potential Cancer Risk Estimates per 1,000,000

| AIR TOXIC | MEAN RISK |
|---|---|
| Formaldehyde | 16.8 |
| Chromium (M) | 0.5 – 10.1[56] |
| Carbon Tetrachloride | 9.4 |
| Chloroform | 5.3 |
| Benzene[57] | 4.4 |
| Arsenic (M) | 4.4 |
| Acetaldehyde | 3.2 |
| 1,3-Butadiene | 2.3 |
| Nickel (M) | 1.5 |
| Tetrachloroethylene | 1.4 |
| Trichloroethylene | 0.3 |
| Cadmium (M) | 0.3 |
| Lead (M) | 0.05 |
| Beryllium (M) | 0.01 |
| Manganese (M) | na[58] |

M = metal
Two air toxics monitored in 2005, vinyl chloride and 1,2-dichloropropane, are not listed in the table because they were never detected at measurable levels.

[56] Chromium estimated risks of 10.1 in a million are based on $PM_{10}$ total chromium and EPA's 1999 estimate that 66% of total chromium (hexavalent and trivalent) is hexavalent in the Beacon Hill Census Tract. EPA 1999 National Air Toxic Assessment. http://www.epa.gov/ttn/atw/nata1999/. Hexavalent chromium pilot monitoring conducted in 2005 shows that hexavalent is only 3% of total chromium, and that risks are less than one in a million.

[57] 2005 Benzene risk is much lower than previous years based on Beacon Hill monitoring. The Agency is still exploring possible reasons why Benzene levels appear so low in 2005. See page 109.

[58] Manganese is not associated with cancer, so it has no potential risk estimate. Manganese is associated with nervous system effects. http://www.epa.gov/ttn/atw/hlthef/manganes.html

***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***.[59]

Acrolein is an air toxic that also presents potential health risk in the Puget Sound area, in the form of respiratory irritation.[60] An accurate monitoring method for acrolein is currently being developed.

Air toxics annual concentrations, risk estimates, and ranking order in 2005 are generally similar to those in our 2003 Air Toxics Evaluation.[61]

## Air Toxics Graphs

Annual mean concentrations are shown on the following pages for air toxics collected from 2000 to 2005 at Beacon Hill. A six-year period is a relatively short time to characterize trends, and the annual mean concentrations increase and decrease from year to year. Nonetheless, data show that annual mean concentrations have decreased from 2000 to 2005 for all but one air toxic (tetrachloroethylene is the one exception).[62] The Agency will continue to track and examine possible trends in future data summaries. Graphs are not presented for $PM_{10}$ metals because the metals data represent only three years, 2003 through 2005. Federal ambient air concentration standards have not been set for air toxics, so graphs do not include reference lines for federal standards.

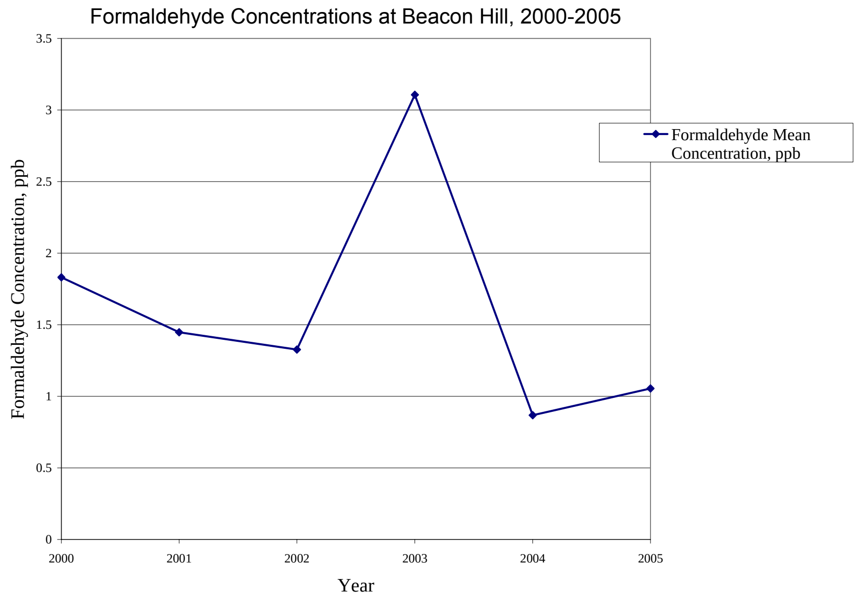
[59] A brief description of source apportionment modeling used to estimate concentrations of these air toxics is included in the $PM_{2.5}$ section of this report.
[60] Acrolein health effects estimate is based on modeling. EPA 1999 National Air Toxics Assessment. http://www.epa.gov/ttn/atw/nata1999/.
[61] The 2003 Puget Sound Air Toxics Evaluation is based on 2001 monitoring. http://www.pscleanair.org/airq/basics/psate_final.pdf.
[62] Tetrachloroethylene concentrations have remained relatively constant, and are close to the minimum detection limit (MDL).

## Formaldehyde

The EPA lists formaldehyde as a probable human carcinogen. Formaldehyde inhalation is also associated with eye, nose, throat, and lung irritation.[63] Sources of formaldehyde include automobiles, trucks, wood burning and other combustion, and plywood off-gassing. Formaldehyde's 2005 mean potential cancer risk estimate at Beacon Hill was 16.8 in a million.

The increase in formaldehyde 2003 concentrations is due to nine anomalous sampling days in July 2003 when levels were roughly 10 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.[64]

Agency efforts that target vehicle exhaust and wood stoves emissions reductions also reduce formaldehyde emissions.



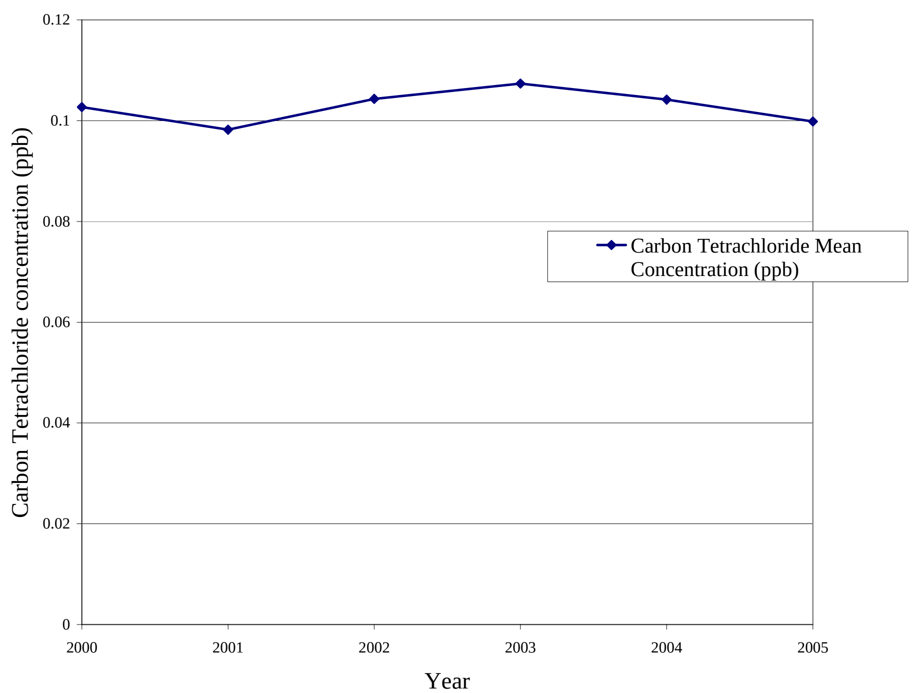

[63] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/formalde.html.
[64] A possible source of formaldehyde could include solvents that are sometimes used in research projects. The academic community occasionally uses the Beacon Hill reservoir for its research. It's not known at this time if this is what caused a significant increase in concentrations.

## Carbon Tetrachloride

The EPA lists carbon tetrachloride as a probable human carcinogen. Carbon tetrachloride inhalation is also associated with liver and kidney damage.[65] Carbon tetrachloride was widely used as a solvent for both industry and consumer users, and was banned for consumer use in 1996. Trace amounts are still emitted by local sewage treatment plants. Carbon tetrachloride is relatively ubiquitous and has a long half-life; concentrations are similar in urban and rural areas. Carbon tetrachloride's 2005 mean potential cancer risk estimate at Beacon Hill was 9.4 in a million.

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

Carbon Tetrachloride Concentrations at Beacon Hill, 2000 - 2005



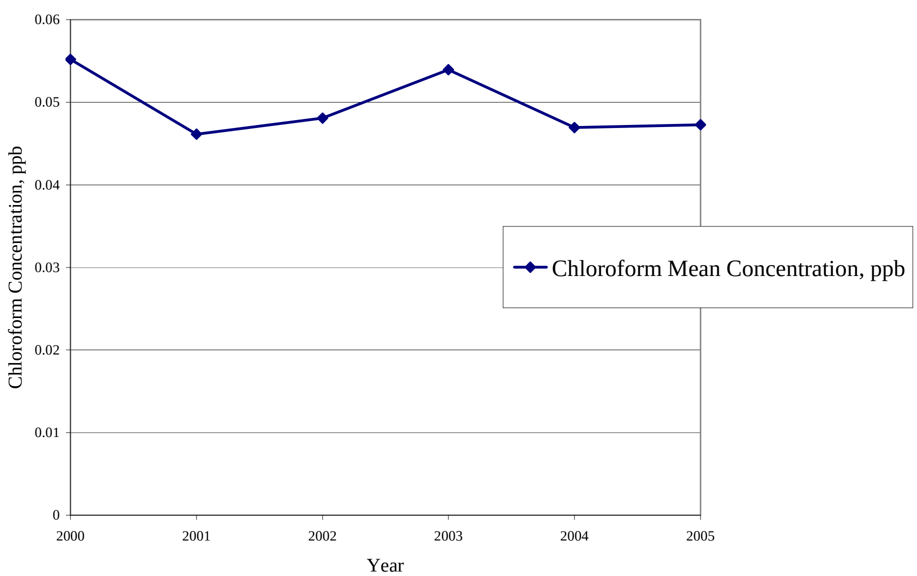

[65] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/carbonte.html.

## Chloroform

The EPA lists chloroform as a probable human carcinogen. Chloroform inhalation is also associated with central nervous system effects and liver damage.[66] 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 levels most people are actually exposed to). Chloroform's 2005 mean potential cancer risk estimate at Beacon Hill was 5.3 in a million.

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.[67,68]

Chloroform Concentrations at Beacon Hill, 2000 - 2005

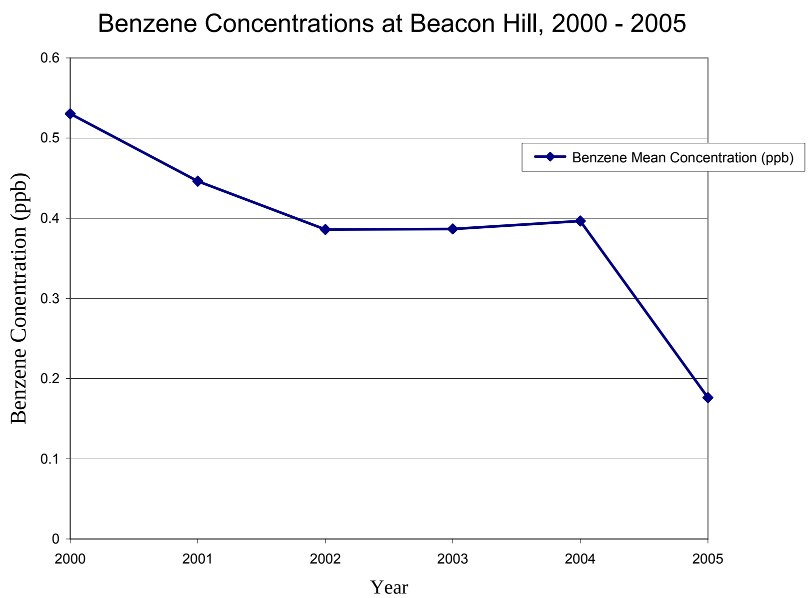



[66] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/chlorofo.html.
[67] Seattle Public Utilities. 2005 Water Quality Analysis shows detectable levels of trihalomethanes. http://www.ci.seattle.wa.us/util/stellent/groups/public/@spu/@fob/@wqs/documents/webcontent/cos_005087.pdf. Trihalomethanes include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform. http://www.ci.seattle.wa.us/util/About_SPU/Water_System/Water_Quality/GLOSSARYO_200312020916386.asp
[68] Modeling supports that chloroform is not a priority air toxic in the Puget Sound area. Chloroform is modeled as presenting potential cancer risk less than one in a million for the Puget Sound area. Environmental Protection Agency NATA 1999. http://www.pscleanair.org/airq/basics/NATA%20Overview%202006%20Feb%20Release.pdf.

## Benzene

The EPA lists benzene as a known human carcinogen. Benzene inhalation is also linked with blood, immune, and nervous system disorders.[69] This air toxic comes from a variety of sources, including car/truck exhaust, wood burning, evaporation of industrial solvents, and other combustion. Benzene's 2005 mean potential cancer risk estimate at Beacon Hill was 4.4 in a million.

Benzene's 2005 annual average concentration was less than half of previous years. The Agency is working with partners to better understand this reduction. 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 (one major refinery in our area added a process in July 2004 which significantly reduced benzene gasoline content); and fewer gas station emissions due to better compliance (vapor recovery at the pump and during filling of gas station tanks). Even with these factors combined, a reduction in benzene's annual average concentration may be more gradual than the dramatic decrease seen from 2004 to 2005. The Agency continues to explore the benzene data at the time of publishing this data summary.



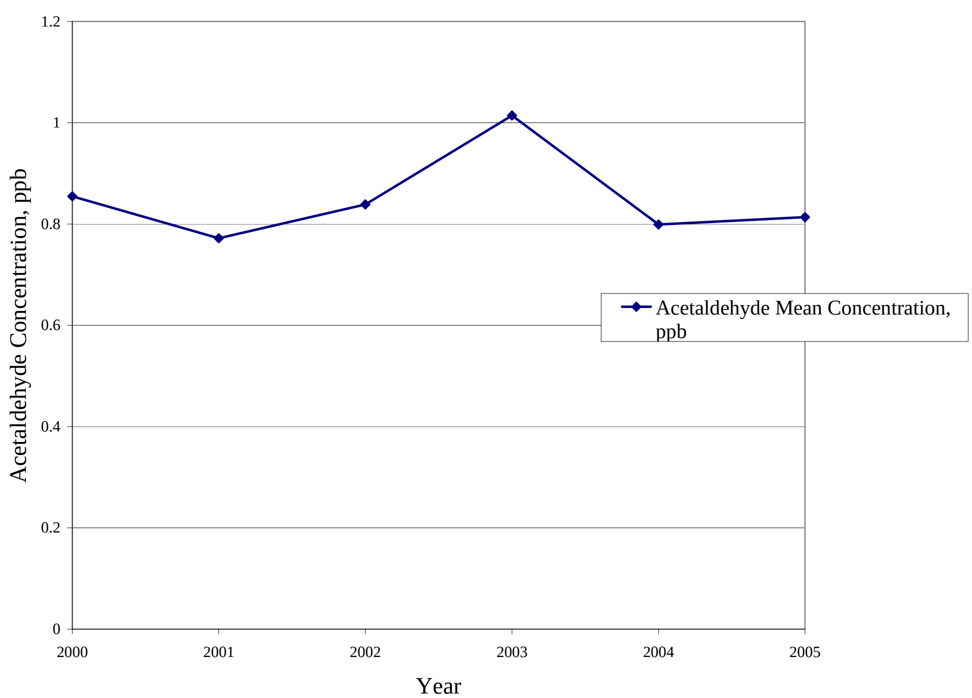

[69] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/benzene.html

## 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.[70] Main sources of acetaldehyde include wood burning and car/truck exhaust. Acetaldehyde's mean 2005 potential cancer risk estimate at Beacon Hill was 3.2 in a million.

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

Acetaldehyde Concentrations at Beacon Hill, 2000-2005

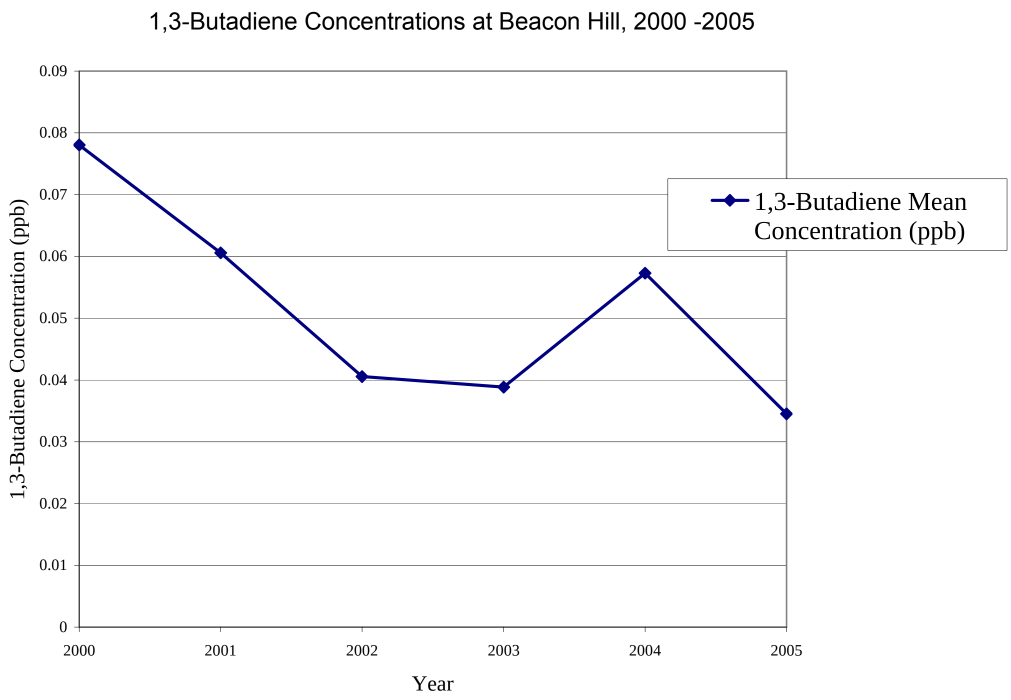



70 EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/acetalde.html.

## 1,3-Butadiene

The EPA lists 1,3-butadiene as a probable human carcinogen. 1,3-Butadiene inhalation is also associated with neurological effects.[71] Primary sources of 1,3-butadiene include cars, trucks, buses, and wood burning. 1,3-Butadiene's mean 2005 potential cancer risk estimate at Beacon Hill was 2.3 in a million.

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

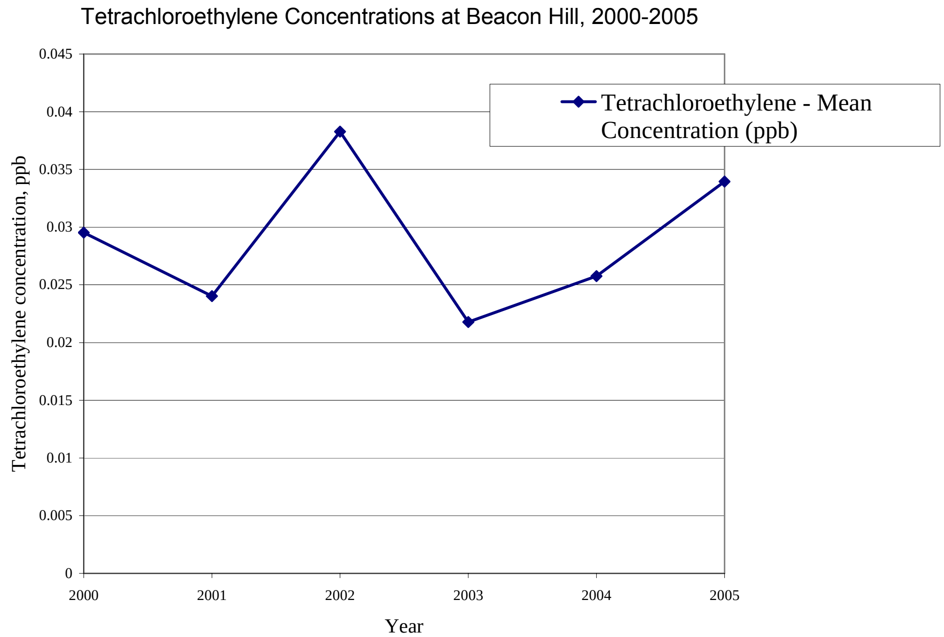



[71] EPA Hazard Summary. http://www.epa.gov/ttnatw01/hlthef/butadien.html.

## 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.[72] Dry cleaners are the main source of tetrachloroethylene. Tetrachloroethylene's 2005 mean potential cancer risk estimate at Beacon Hillwas 1.4 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.[73]



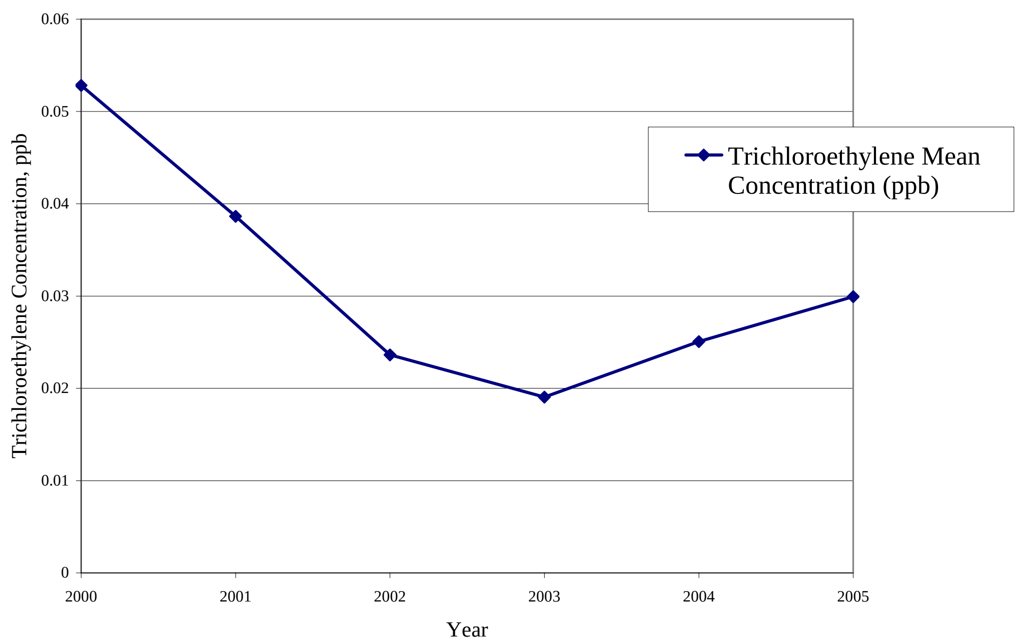

[72] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html, Tetrachloroethylene fact sheet http://www.weblakes.com/toxic/TETRACHLOROETHYLENE.HTML.
[73] Agency Regulations, Section 3. Article 3.03. http://www.pscleanair.org/regulated/reg3/reg3.pdf.

## Trichloroethylene

EPA lists trichloroethylene as a probable/possible human carcinogen. Trichloroethylene is also associated with central nervous system effects.[74] Local sources of trichloroethylene include solvents used for degreasing and surface coating operations. Trichloroethylene's 2005 mean potential cancer risk estimate at Beacon Hill was 0.3 in a million.

The Agency's works with and regulates solvent-using businesses to reduce trichloroethylene emissions.

Trichloroethylene Concentrations at Beacon Hill, 2000 - 2005




[74] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html.

## Metals

The table on page 104 includes potential cancer risks for seven $PM_{10}$ metals monitored at Beacon Hill. Chromium, arsenic, and nickel posed the greatest potential cancer risks. Health effects from exposure to these and other monitored metals are listed below, along with local sources.

### 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.[75] 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).

Chromium is listed with a range of potential cancer risk estimates in 2005, as low as 0.5 in a million to 10.1 in a million. This range is a result of two different monitoring methods that yielded different results for chromium at Beacon Hill.

The potential cancer risk estimate of 10.1 in a million is based on total chromium $PM_{10}$ monitoring and EPA's estimate that roughly two thirds of chromium present near the Beacon Hill monitor is hexavalent, the most toxic form.[76] This is likely an overestimate of the fraction that is in fact hexavalent.[77]

The potential cancer risk estimate of 0.5 in a million is based on a monitoring pilot program that measures just the hexavalent portion of chromium in total suspended particulate (TSP). Using this method, the hexavalent chromium concentrations and corresponding potential cancer risk are much lower. As this monitoring method is further established, the Agency will likely begin to only report this number, rather than rely on a hexavalent fraction estimate.

The Agency's permitting program works with and regulates chrome electroplaters to reduce hexavalent chromium emissions.

[75] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/chromium.html.
[76] EPA 1999 National Air Toxics Assessment. http://www.epa.gov/ttn/atw/nata/gloss1.html.
[77] A comparison of hexavalent/total chromium ratios for Puget Sound and Oregon monitoring sites shows that roughly 2-3% of total chromium is hexavalent. In the 2004 data summary, a hexavalent chromium potential cancer risk of 6 in a million was based on EPA's older (1996 NATA) estimate that one third of total chromium is hexavalent.

## Arsenic

The EPA lists arsenic as a known carcinogen. Exposure to arsenic is also associated with skin irritation, and liver and kidney damage.[78] Arsenic is used mainly to treat wood. Combustion of distillate oil is also a source of arsenic in the Puget Sound area. Puget Sound monitoring sites with significant wood burning show higher arsenic levels.[79] Arsenic's 2005 mean potential cancer risk estimate at Beacon Hill was 4.4 in a million.

## Nickel

The EPA lists nickel as a known human carcinogen. Nickel is also associated with dermatitis and respiratory effects.[80] Combustion of gasoline and diesel fuels (car, truck, and bus exhaust) is the main source of nickel in the Puget Sound area. Nickel's 2005 mean potential cancer risk estimate at Beacon Hill was 1.5 in a million.

## Cadmium

The EPA lists cadmium as a probable human carcinogen. Cadmium exposures are also associated with kidney damage.[81] Combustion of distillate oil is a main source of cadmium in the Puget Sound area. Cadmium's 2005 mean potential cancer risk estimate at Beacon Hill was 0.3 in a million.

## Lead

The 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.[82] 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/leadinfo.htm. Lead's 2005 mean potential cancer risk estimate at Beacon Hill was 0.05 in a million.

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[78] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/arsenic.html.
[79] Puget Sound Clean Air Agency. Final Puget Sound Air Toxics Evaluation. 2003. http://www.pscleanair.org/airq/basics/psate_final.pdf. The Lake Forest Park monitoring site, near residential wood burning, showed higher arsenic concentrations.
[80] EPA Hazard Summary. http://www.epa.gov/iris/subst/0273.htm.
[81] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/cadmium.html.
[82] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/lead.html.

## Beryllium

EPA has classified beryllium as a probable human carcinogen. Beryllium exposures are also associated with lung inflammation and immunological effects.[83] Beryllium sources include combustion of coal and fuel oil that contain beryllium, and tobacco smoke. Beryllium levels are extremely low in the Puget Sound area, where there are no known sources. Beryllium's 2005 mean potential cancer risk estimate was 0.01 in a million.

## Manganese

EPA lists manganese as "not classifiable" for cancer. Manganese exposures are primarily associated with central nervous system effects.[84] Manganese is naturally-occurring and is usually present in air in small amounts. Additional local sources include steel foundries and blasting of metal parts. Manganese levels are extremely low in ambient air the Puget Sound area, well below levels indicating significant risk.[85]

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[83] EPA Hazard Summary. http://www.epa.gov/ttn/atw/hlthef/berylliu.html.
[84] EPA National Air Toxics Assessment. http://www.epa.gov/ttnatw01/hlthef/manganes.html.
[85] Manganese risk is based on the reference concentration of 0.05 µg/m$^3$ for non-cancer health effects. The manganese 2004 upper bound concentration was 0.03 µg/m$^3$.

# Definitions

## *General Definitions*

**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 |
| 0.000–0.064 | — | 0.0–15.4 | 0–54 | 0.0–4.4 | 0.000–0.034 | (b) | 0–50 | Good |
| 0.065–0.084 | — | 15.5–40.4 | 55–154 | 4.5–9.4 | 0.035–0.144 | (b) | 51–100 | Moderate |
| 0.085–0.104 | 0.125–0.164 | 40.5–65.4 | 155–254 | 9.5–12.4 | 0.145–0.224 | (b) | 101–150 | Unhealthy for sensitive groups |
| 0.105–0.124 | 0.165–0.204 | 65.5–150.4 | 255–354 | 12.5–15.4 | 0.225–0.304 | (b) | 151–200 | Unhealthy |
| 0.125–0.374 | 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 $0_3$ concentrations.

For more detailed information about the AQI and the pollutants it measures, go to 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 Puget Sound Clean Air Agency Regulation III at http://www.pscleanair.org/regulated/reg3/asil.pdf. 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.

## Certified Wood Stove

A wood stove that has been certified by EPA. Certified wood stoves emit significantly less pollution than non-certified stoves and are identified by an EPA certification plate. A wood stove cannot be retrofitted to become certified but rather is manufactured to meet EPA particulate emission standards. Visit http://www.pscleanair.org/actions/woodstoves/default.aspx to learn more about certified wood stoves.

## Criteria Air Pollutant (CAP)

The Clean Air Act of 1970 defined six *criteria pollutants* and established ambient concentrations to protect public health. EPA periodically has revised the original concentration limits and methods of measurement, most recently in 1997. The six criteria air pollutants are: particulate matter (10 micrometers and 2.5 micrometers), ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead.

## Hazardous Air Pollutant (HAP)

A *hazardous air pollutant* is an air contaminant listed in the Federal Clean Air Act, Section 112(b). 188 pollutants are currently listed as HAPs. They are listed by EPA at http://www.epa.gov/ttn/atw/188polls.html. They are also included under Puget Sound Clean Air Agency Regulation III.

## R Squared ($R^2$)

The *R squared* ($R^2$) is a statistical measure from 0 to 1 that indicates how well a regression line approximates data points. An $R^2$ of 1 indicates a perfect fit. R squared values for linear regressions of aethalometer black carbon and elemental carbon (pages A-13 and A-14 in the Appendix) indicate a strong relationship between these two measures.

## Temperature Inversions

The earth gains and loses most of its energy at its surface. It is warmed by solar heating during the day and cooled by radiation emissions at night. During the late morning and afternoon hours, the air near the surface is warmer than the air aloft and allows for good pollutant dispersion (vertical mixing may be 1,500 meters or more). At night with clear skies, the surface radiates heat into outer space, creating cooler air at the surface and warmer air aloft. Warmer air above cooler air (temperature inversion) is a stable condition and limits the upward movement of pollution because the warmer air acts as a barrier. With little or no wind, pollutants are trapped near the surface (vertical mixing may be 200 meters or less) and can reach high levels of concentration.

## Uncertified Wood Stove

A wood stove that is not certified by the EPA. These wood stoves emit twice as much pollution as certified wood stoves.

## 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.

## 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.

## 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—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 you have, the shorter your visual range will be. Reduced visibility (or visual range) is caused by weather (clouds, fog, and rain) and air pollution (fine particles and gases). The major pollution contributor is fine particulate matter ($PM_{2.5}$) emissions, which are 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 and travel farther. $PM_{2.5}$ also presents some of the most serious health hazards to the public, so you can roughly assume that the worse the visibility, the unhealthier the air is to breathe.

## *Criteria Air Pollutants*

### Ozone ($O_3$)

- **What is it?**
  Ozone, a bluish-colored gas molecule with a strong odor, is composed of three atoms of oxygen. In the upper atmosphere, ozone occurs naturally and partially absorbs the sun's harmful ultraviolet rays. Ozone at ground level is a summertime air pollution problem.
- **How is it caused?**
  Ozone forms when photochemical pollutants from cars, trucks, and industrial sources react with sunlight. Ozone-forming pollutants include $NO_X$ and VOCs. Even gasoline-powered yard equipment, paints, solvents, and boat motors contribute.
- **When does it happen?**
  Ozone pollution is most common in the summer months, when sunlight and stable atmospheric conditions occur. Ozone levels are usually highest in the afternoon, as sunlight photochemically transforms $NO_x$ and VOCs into ozone.
- **Who is affected?**
  Adults and children who are active outdoors, people with respiratory disease such as asthma, and people with unusual sensitivity to ozone. During physical activity, ozone penetrates deeper into the lungs and can do more damage.

  Ozone is a very reactive gas. For this reason, high concentrations of ozone can cause respiratory distress and disease in humans, decreased yields of agricultural crops and forests, and damage to some rubber products, plastics, and paints used outdoors. National crop losses from ozone exposure are estimated at $3 billion to $5 billion annually. Forest losses are harder to estimate.
- **What are the health effects?**
  Ozone can cause coughing and throat irritation, make deep vigorous breathing more difficult, and increase the chance of respiratory infections. It increases sensitivity to allergens and can trigger asthma attacks. The damage it causes to the lungs heals within a few days, but repeated or prolonged exposure may cause permanent damage.
- **What can I do about it?**
  If ozone levels are high and you have a respiratory condition or are normally active outdoors, try to limit your outdoor exertion.

In the United States, management of ozone and other photochemical oxidants has been a major goal of federal and state clean air legislation (Clean Air Act). Although many of the pollution control efforts required by the CAA have been implemented, efforts to decrease ozone pollution have been only partially successful.

In the Puget Sound region the ozone trend is flat and is marginally within the Federal standards.

- **Where is it measured?**
  Unlike other pollutants monitored here in the Puget Sound region, ozone is formed by precursors that react in the atmosphere. Winds transport ozone and chemical emissions from one area to another. For the Puget Sound region, ozone precursors are emitted into the air in industrial areas of the Everett-Seattle-Tacoma urban corridor and subsequently travel southeasterly to more rural areas as they react to form ozone. The highest concentrations are measured downwind in areas such as North Bend, Enumclaw, and Eatonville. As a result, for the Puget Sound airshed the majority of sites that measure ozone are located in rural areas south to southeast of Seattle and Tacoma. See the map on page 20 of the Puget Sound measuring locations. The Washington State Department of Ecology maintains all ozone-monitoring stations.

## Particulate Matter ($PM_{2.5}$ and $PM_{10}$)

- **What is it?**
  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. The Agency considers $PM_{2.5}$ one of the major air pollution concerns affecting our community.

- **How is it caused?**
  - $PM_{2.5}$ comes from all types of combustion, including cars, diesel trucks, power plants, and wood burning, and from some industrial processes. It can also be formed in the atmosphere by chemical reactions of pollutant gases.
  - The "coarse" particles in $PM_{10}$ typically come from crushing or grinding operations and dust from roads.

- **When does it happen?**
  Any time.

- **Who is affected?**
  People with asthma or heart or lung diseases, the elderly, and children are particularly susceptible. $PM_{2.5}$ also significantly affects visibility.
- **What are the health effects?**
  Fine particulates ($PM_{2.5}$) pose a greater risk to human health than coarse particulates, because they penetrate deeper into the respiratory system.
  - $PM_{2.5}$ exposure can have serious health effects. People with heart or lung diseases are at increased risk of attacks or premature death. Children and the elderly are more likely to develop heart or lung problems.
  - $PM_{10}$ can aggravate respiratory conditions such as asthma.
- **What can I do about it?**
  - If $PM_{2.5}$ levels are high, people with respiratory or heart disease, the elderly, and children should avoid outdoor exertion.
  - If $PM_{10}$ levels are high, people with respiratory conditions should avoid outdoor exertion.
- **Where is it measured?**
  Due to the health risks associated with PM, both $PM_{2.5}$ and $PM_{10}$ are monitored throughout the Puget Sound. The majority of PM monitoring stations are maintained by the Agency.

## Carbon Monoxide (CO)

- **What is it?**
  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.
- **How is it caused?**
  Carbon monoxide forms when the carbon in fuels doesn't burn completely. 60% of all CO comes from vehicle exhaust, and up to 95% occurs in cities.
- **When does it happen?**
  CO pollution is worst in cold weather because fuels burn less efficiently in low temperatures. It is usually at its peak during morning and evening rush hours.
- **Who is affected?**
  People with cardiovascular disease, such as angina, or cardiovascular or respiratory problems; also possibly fetuses and young infants.
- **What are the health effects?**
  Chest pain and increased cardiovascular symptoms, particularly while exercising. High levels of CO can affect alertness and vision even in healthy individuals.

- **What can I do about it?**
  If CO levels are high, limit exertion and avoid sources of CO such as heavy traffic.
- **Where is it measured?**
  CO monitoring stations are located in areas with heavy traffic congestion. These include central business areas, roadsides, and shopping malls. The Washington State Department of Ecology conducts all CO monitoring.

## Sulfur Dioxide ($SO_2$)

- **What is it?**
  Sulfur dioxide is a colorless, reactive gas.
- **How is it caused?**
  $SO_2$ is produced by burning sulfur-containing fuels such as coal and oil, and by industrial processes.
- **Where does it happen?**
  The highest concentrations of $SO_2$ are usually near large industrial sources.
- **Who is affected?**
  People with asthma who are active outdoors.
- **What are the health effects?**
  Bronchoconstriction, which can cause wheezing, shortness of breath, and tightening of the chest. When exposure to $SO_2$ ends, the symptoms should clear up within an hour.
- **What can I do about it?**
  If $SO_2$ levels are high, limit your outdoor exertion.
- **Where is it measured?**
  Because the large primary sources of $SO_2$ in the Puget Sound area no longer exist, the Agency has not monitored for $SO_2$ since the end of 1999.

## Lead (Pb)

- **What is it?**
  Lead is a highly toxic metal that was used for many years in household products, automobile fuel, and industrial chemicals.
- **How is it caused?**
  Locally, airborne lead is associated primarily with automobile exhaust and lead smelters. Since the phase-out of lead in fuels, however, cars and trucks are no longer a significant

source of lead. Also, the lead smelter on Seattle's Harbor Island ceased operation at the end of 1998.

- **When does it happen?**
Lead concentrations are likely to be highest near sources where current or former lead smelting/processing operations caused particle fallout, especially in nearby soils such as unpaved parking lots.
- **Who is affected?**
Everyone. Children six years and younger are most at risk.
- **What are the health effects?**
Lead can have health effects ranging from behavioral problems and learning disabilities to seizures and death.
- **What can I do about it?**
According to EPA, the primary sources of lead exposure are lead-based paint, lead-contaminated dust, and lead-contaminated residual soils. Refer to EPA's website for ways to limit your exposure to these lead sources.
- **Where is it measured?**
Due to the phase-out of leaded fuels and the closure of Seattle's lead smelter in 1998, the Agency no longer monitors for airborne lead.

## Nitrogen Dioxide ($NO_2$)

- **What is it?**
Nitrogen dioxide ($NO_2$) is a reddish brown, highly reactive gas that forms from the reaction of nitrogen oxide (NO) and oxygen in the atmosphere. $NO_2$ will react with VOCs and can result in the formation of ozone.
- **How is it caused?**
High temperature combustion sources such as power plants and automobiles are major producers of NO. Home heaters and gas stoves can also produce NO.
- **When does it happen?**
$NO_2$ pollution is greatest in cold weather. It follows a similar trend to CO.
- **Who is affected?**
People with respiratory diseases such as asthma; also children.
- **What are the health effects?**
$NO_2$ can cause respiratory symptoms such as coughing, wheezing, and shortness of breath. Long-term exposure can lead to respiratory infections.

- **What can I do about it?**
  Since the 1970s, motor vehicle manufacturers have been required to reduce NO emissions from cars and trucks. It is not a significant pollution problem in the Puget Sound area.
- **Where is it measured?**
  Because $NO_2$ is not a major concern of the Puget Sound region, it is measured at only one location, Beacon Hill. The Washington State Department of Ecology conducts all $NO_2$ monitoring.

## *Pollution Sources*

### Anthropogenic Emissions

Any emissions released as a result of human activity.

#### Area Sources

Countywide categories of pollution sources, in which each individual source emits pollutants below the thresholds for a point source facility.

#### Biogenics

Natural sources such as trees, plants, grass, crops, and soils. The worldwide emission rate of these natural hydrocarbons has been estimated to exceed that of non-methane hydrocarbons originating from human sources. Isoprene, one of the major constituents of biogenic emissions, is very photoreactive, and would seem to make biogenic VOC a contributor in the formation of ozone. The study of hydrocarbon emissions from plants is therefore of key importance to our understanding of the global effects of naturally produced hydrocarbons.

#### Emission Factor

A value derived from source tests, material balance calculations, or engineering comparisons with similar processes. Used to estimate emissions from process quantities or activity levels.

#### Non-road Mobile Sources

Farm vehicles, on-site construction/industrial vehicles, logging equipment, small marine craft, aircraft, trains, ocean-going ships, tugs and ferries, lawn and garden equipment.

## On-road Mobile Sources

Cars, trucks, sport utility vehicles, and buses.

## Point Sources

Facilities that have annual air contaminant emissions equal to or exceeding 100 tons per year of CO; 25 tons per year of nitrogen oxides ($NO_x$), $PM_{10}$, $PM_{2.5}$, sulfur oxides ($SO_x$) such as $SO_2$ and sulfur trioxide ($SO_3$), or volatile organic compounds (VOC); or 2 tons per year of a any single HAP or 6 tons per year of facility total HAP.

## Registered Facility

The total of all pollutant-emitting activities located on adjacent or contiguous properties owned or operated by one person or corporate entity. It includes all of the pollutant-emitting buildings, processes, structures, equipment, control apparatuses, and storage areas at a facility. The annual fees for large and small registered emission sources are based on Regulation I, 5.07(c)(1) and 5.07(c)(2), respectively.

## Stationary Area Sources

Also called area sources. Pollution sources where each individual source emits pollutants below the thresholds for a point source facility. Sources include wood stoves/fireplaces, outdoor burning, architectural surface coating, automobile painting, commercial/consumer solvents, dry cleaning, printing, stationary diesel engines, small utility engines, and construction activities.

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

# 2005
# Air Quality Data Summary Appendix

July 2006

**Working Together for Clean Air**

# Air Quality Index
# 1980 - 2005

## Snohomish County

| Year | Good | Moderate | Unhealthy for Sensitive Groups | Unhealthy | Very Unhealthy | PM (All Days) | CO (All Days) | $SO_2$ (All Days) | $O_3$ (All Days) | PM (Unhealthy Days) | CO (Unhealthy Days) | $SO_2$ (Unhealthy Days) | AQI | Date | Pollutant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Days in Each Air Quality Category** | | | | | **Pollutant Determining the AQI** | | | | | | | **Highest Value** | | |
| 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 | 279 | 84 | 3 | 0 | 0 | 365 | 1 | | | 3 | 0 | | 116 | Nov 5 | PM |
| 2005 | 288 | 72 | 5 | 0 | 0 | 360 | 5 | | | 5 | 0 | | 139 | Dec 11 | PM |
| Totals | 7194 | 2213 | 29 | 20 | 0 | 4721 | 4466 | 236 | 33 | 30 | 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.

# Air Quality Index
# 1980 - 2005

## 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 | 257 | 103 | 6 | 0 | 0 | 279 | 2 | | 85 | 5 | 0 | 1 | 132 | Dec 18 | PM |
| 2005 | 254 | 106 | 5 | 0 | 0 | 302 | 3 | | 60 | 5 | 0 | 0 | 117 | Dec 11 | PM |
| Totals | 5539 | 3810 | 36 | 106 | 6 | 4016 | 4721 | 61 | 699 | 51 | 83 | 14 | | | |

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.

# Air Quality Index
# 1980 - 2005

## 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 8 | PM |
| 2004 | 246 | 112 | 8 | 0 | 0 | 257 | 17 | | 92 | 8 | 0 | 0 | 137 | Nov 5 | PM |
| 2005 | 275 | 82 | 8 | 0 | 0 | 276 | 2 | | 87 | 8 | 0 | 0 | 120 | Dec 10 | PM |
| Totals | 6046 | 3300 | 60 | 86 | 5 | 6424 | 2118 | 293 | 662 | 80 | 66 | 5 | | | |

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.

# Air Quality Index
# 1990 - 2005

## 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 |
| Totals | 4743 | 334 | 2 | 1 | 0 | 4528 | 552 | 0 | 0 | 3 | 0 | 0 | | | |

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

Note: 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.

# Burn Bans
# 1988 - 2005

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)

## PARTICULATE MATTER ($PM_{10}$) - Continuous

Micrograms per Cubic Meter

Equivalent Sampling Methods: B - BetaAtten ANDERSEN FH62I-N Glass Fiber strip
T - Mass Transducer R&P TEOM 1400a Teflon Coated Glass Fiber

2005

| Location | Method | Number of Values | Quarterly Arithmetic Averages | | | | Year Arith Mean | 99th Percentile | Max Value |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | 4th | | | |
| 17171 Bothell Way NE, Lake Forest Park | B | 171 | 17.1 | 13.7 | | | | 30 | 35 |
| Duwamish, 4752 E Marginal Way S, Seattle | T | 361 | 33.7 | 21.5 | 24.5 | 27.8 | 26.9 | 63 | 91 |
| James St & Central Ave, Kent | T | 363 | 23.5 | 15.3 | 20.3 | 20.1 | 19.8 | 49 | 58 |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | B | 307 | 25.6 | 19.2 | | 23.5 | 22.7 | 54 | 75 |

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 adjusted using seasonal site-specific relationships with Federal Reference Method samplers.

**Summary of Maximum Observed Concentrations and Values >60**

| Location | Method | Jan 5 Wed | Jan 21 Fri | Feb 2 Wed | Feb 18 Fri | Feb 23 Wed | Feb 24 Thu | Mar 11 Fri | Aug 23 Tue | Dec 16 Fri |
|---|---|---|---|---|---|---|---|---|---|---|
| 17171 Bothell Way NE, Lake Forest Park | B | 35 | | | | | -- | | -- | -- |
| Duwamish, 4752 E Marginal Way S, Seattle | T | 62 | 63 | 81 | 61 | 68 | 91 | 61 | 61 | 63 |
| James St & Central Ave, Kent | T | | | | | 58 | | | | |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | B | | | | | 75 | 63 | | -- | |

-- Indicates no sample on specified day

**Air Quality Index Summary**

| Location | Method | Good | Moderate | Unhealthy for Sensitive Groups |
|---|---|---|---|---|
| 17171 Bothell Way NE, Lake Forest Park | B | 171 | 0 | 0 |
| Duwamish, 4752 E Marginal Way S, Seattle | T | 346 | 15 | 0 |
| James St & Central Ave, Kent | T | 362 | 1 | 0 |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | B | 304 | 3 | 0 |

## PARTICULATE MATTER ($PM_{2.5}$)

Micrograms per Cubic Meter

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

2005

| Location | Number of Values | Quarterly Arithmetic Averages 1st | 2nd | 3rd | 4th | Year Arith Mean | 98th Percentile | Max Value |
|---|---|---|---|---|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | 119 | 14.8 | 6.1 | 7.2 | 13.1 | 10.3 | 37 | 42 |
| 6120 212th St SW, Lynnwood | 114 | 12.1 | 5.6 | 6.5 | 11.3 | 8.8 | 27 | 35 |
| 17171 Bothell Way NE, Lake Forest Park | 113 | 12.0 | 5.6 | 7.6 | 11.1 | 9.0 | 25 | 36 |
| Beacon Hill, 15th S & Charlestown, Seattle | 359 | 9.1 | 6.1 | 7.6 | 8.9 | 7.9 | 20 | 28 |
| Duwamish, 4752 E Marginal Way S, Seattle | 110 | 14.0 | 8.3 | 9.4 | 14.2 | 11.6 | 30 | 31 |
| 7802 South L St, Tacoma | 120 | 16.5 | 5.3 | 7.1 | 17.1 | 11.5 | 41 | 46 |

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 4 Tue | Jan 25 Tue | Jan 26 Wed | Jul 5 Tue | Nov 15 Tue | Dec 6 Tue | Dec 15 Thu | Dec 18 Sun |
|---|---|---|---|---|---|---|---|---|
| Marysville JHS, 1605 7th St Marysville | 42 | | -- | -- | -- | | | |
| 6120 212th St SW, Lynnwood | | | -- | -- | -- | -- | | 35 |
| 17171 Bothell Way NE, Lake Forest Park | | | -- | 36 | -- | -- | -- | -- |
| Beacon Hill, 15th S & Charlestown | | | 28 | -- | -- | | | |
| Duwamish, 4752 E Marginal Way, Seattle | | 31 | -- | -- | -- | | | |
| 7802 South L St, Tacoma | | | -- | -- | 41 | 44 | 46 | |

-- Indicates no sample on specified day

**Air Quality Index Summary**

| Location | Good | Moderate | Unhealthy for Sensitive Groups |
|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | 99 | 19 | 1 |
| 6120 212th St SW, Lynnwood | 100 | 14 | |
| 17171 Bothell Way NE, Lake Forest Park | 98 | 15 | |
| Beacon Hill, 15th S & Charlestown, Seattle | 335 | 24 | |
| Duwamish, 4752 E Marginal Way S, Seattle | 89 | 21 | |
| 7802 South L St, Tacoma | 96 | 21 | 3 |

## PARTICULATE MATTER ($PM_{2.5}$) - Continuous

Micrograms per Cubic Meter

Equivalent Sampling Methods: T - Mass Transducer R&P TEOM 1400a Tef-coat Glass Fiber
B - BetaAtten ANDERSEN FH62I-N Glass Fiber strip

2005

| 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 | T | 331 | 15.1 | 7.3 | 8.5 | 13.1 | 10.9 | 31 | 40 |
| 6120 212th St SW, Lynnwood | T | 353 | 13.2 | 5.4 | 6.8 | 11.7 | 9.3 | 29 | 45 |
| 17171 Bothell Way NE, Lake Forest Park | T | 356 | 13.9 | 6.5 | 7.6 | 13.2 | 10.2 | 27 | 48 |
| Duwamish, 4752 E Marginal Way S, Seattle | T | 312 | 14.6 | 8.3 | | | 12.0 | 27 | 40 |
| 601 143rd Ave NE, Bellevue | T | 276 | 10.4 | 5.6 | 6.7 | | 7.3 | 17 | 28 |
| James St & Central Ave, Kent | T | 324 | 13.9 | 7.2 | 8.9 | | 10.9 | 27 | 40 |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | T | 248 | 17.8 | 7.5 | 9.6 | | 11.5 | 30 | 36 |
| 7802 South L St, Tacoma | T | 360 | 16.0 | 5.5 | 7.4 | 15.1 | 11.0 | 37 | 49 |
| South Hill, 9616 128th St E, Puyallup | B | 66 | | | | 16.7 | | | 37 |
| *Meadowdale, 7252 Blackbird Dr NE, Kitsap Co | B | 338 | 10.7 | 7.9 | 9.5 | 10.9 | 9.7 | 20 | 58 |
| *10955 Silverdale Way NW, Silverdale | B | 352 | 8.0 | 7.3 | 8.9 | 8.5 | 8.1 | 14 | 17 |

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 adjusted using seasonal site-specific relationships with Federal Reference Method samplers except those marked with an asterisk.

**Summary of Maximum Observed Concentrations and Values >40**

| Location | Method | Jan 5 Wed | Jan 25 Tue | Jan 26 Wed | Feb 27 Sun | Jul 4 Mon | Jul 5 Tue | Dec 10 Sat | Dec 16 Fri |
|---|---|---|---|---|---|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | T | -- | | | | | 40 | | |
| 6120 212th St SW, Lynnwood | T | 45 | | | | | | | |
| 17171 Bothell Way NE, Lake Forest Park | T | | | | | | 48 | | |
| Duwamish, 4752 E Marginal Way S, Seattle | T | | | | | | | | 40 |
| 601 143rd Ave NE, Bellevue | T | | | 28 | | | | | |
| James St & Central Ave, Kent | T | | | | | | | 40 | |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | T | | | 36 | | | | -- | -- |
| 7802 South L St, Tacoma | T | 41 | 42 | | | | | 49 | |
| South Hill, 9616 128th St E, Puyallup | B | -- | -- | -- | -- | -- | -- | | 33 |
| *Meadowdale, 7252 Blackbird Dr NE, Kitsap Co | B | | | | | 58 | 52 | | |
| *10955 Silverdale Way NW, Silverdale | B | -- | | | 17 | | | | |

-- 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 | T | 279 | 52 | 0 | |
| 6120 212th St SW, Lynnwood | T | 305 | 47 | 1 | |
| 17171 Bothell Way NE, Lake Forest Park | T | 302 | 53 | 1 | |
| Duwamish, 4752 E Marginal Way S, Seattle | T | 245 | 67 | 0 | |
| 601 143rd Ave NE, Bellevue | T | 269 | 7 | 0 | |
| James St & Central Ave, Kent | T | 270 | 54 | 0 | |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | T | 186 | 62 | 0 | |
| 7802 South L St, Tacoma | T | 292 | 65 | 3 | |
| South Hill, 9616 128th St E, Puyallup | B | 40 | 26 | 0 | |
| *Meadowdale, 7252 Blackbird Dr NE, Kitsap Co | B | 311 | 25 | 2 | |
| *10955 Silverdale Way NW, Silverdale | B | 349 | 3 | 0 | |

## PARTICULATE MATTER ($PM_{2.5}$) - Continuous

Micrograms per Cubic Meter

Sampling Method: Equivalent - Radiance Research M903 Nephelometer

2005

| Location | Number of Values | Quarterly Arithmetic Averages 1st | 2nd | 3rd | 4th | Year Arith Mean | 98th Percentile | Max Value |
|---|---|---|---|---|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | 360 | 13.6 | 6.0 | 7.0 | 12.0 | 9.6 | 35 | 48 |
| 6120 212th St SW, Lynnwood | 329 | 11.4 | | 6.5 | 13.1 | 9.3 | 33 | 60 |
| 17171 Bothell Way NE, Lake Forest Park | 363 | 10.9 | 5.0 | 7.4 | 11.8 | 8.8 | 28 | 43 |
| Queen Anne Hill, 400 W Garfield St, Seattle | 362 | 7.1 | 4.8 | 6.5 | 9.4 | 7.0 | 21 | 32 |
| Olive & Boren, Seattle | 365 | 9.3 | 5.7 | 6.9 | 9.1 | 7.8 | 23 | 32 |
| Beacon Hill, 15th S & Charlestown, Seattle | 361 | 8.6 | 6.3 | 7.3 | 8.8 | 7.7 | 21 | 25 |
| Duwamish, 4752 E Marginal Way S, Seattle | 361 | 12.5 | 7.5 | 10.4 | 14.4 | 11.2 | 31 | 44 |
| South Park, 8025 10th Ave S, Seattle | 349 | 11.7 | 6.1 | 7.8 | 13.8 | 9.7 | 35 | 48 |
| City Hall, 15670 NE 85th, Redmond | 301 | 9.8 | | 5.7 | 7.3 | 7.1 | 20 | 42 |
| 601 143rd Ave NE,, Bellevue | 360 | 6.5 | 5.7 | 6.8 | 7.7 | 6.7 | 18 | 25 |
| 305 Bellevue Way NE, Bellevue | 342 | 8.1 | 5.3 | 6.3 | 8.3 | 7.0 | 18 | 26 |
| 42404 SE North Bend Way, North Bend | 365 | 5.1 | 3.7 | 5.4 | 4.3 | 4.6 | 15 | 20 |
| James St & Central Ave, Kent | 365 | 11.8 | 6.5 | 8.0 | 12.5 | 9.7 | 32 | 48 |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | 365 | 12.6 | 6.4 | 8.3 | 14.2 | 10.4 | 30 | 46 |
| 7802 South L St, Tacoma | 323 | | 4.7 | 6.0 | 14.6 | 9.0 | 35 | 50 |

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 3 Mon | Jan 5 Wed | Jan 26 Wed | Feb 26 Sat | Nov 23 Wed | Dec 10 Sat | Dec 11 Sun | Dec 16 Fri | Dec 18 Sun |
|---|---|---|---|---|---|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | | 48 | | | | | | | |
| 6120 212th St SW, Lynnwood | | 45 | | | | | 60 | 49 | 43 |
| 17171 Bothell Way NE, Lake Forest Park | | | | | | | 43 | | |
| Queen Anne Hill, 400 W Garfield St, Seattle | | | | | | | 32 | | |
| Olive & Boren, Seattle | | | 32 | | | | | | |
| Beacon Hill, 15th S & Charlestown, Seattle | | | | | 25 | | | | |
| Duwamish, 4752 E Marginal Way S, Seattle | | | | | | | 44 | 42 | |
| South Park, 8025 10th Ave S, Seattle | | | | | | | 48 | 41 | |
| City Hall, 15670 NE 85th, Redmond | | | 42 | | | | | -- | -- |
| 601 143rd Ave NE,, Bellevue | | | 25 | | | | | | |
| 305 Bellevue Way NE, Bellevue | | | 26 | -- | | | | | |
| 42404 SE North Bend Way, North Bend | 20 | | | | | | | | |
| James St & Central Ave, Kent | | | | | | 41 | | 48 | |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | | | | | | | | 46 | |
| 7802 South L St, Tacoma | -- | -- | -- | 42 | | 50 | | 44 | |

-- Indicates no sample on specified day

**Air Quality Index Summary**

| Location | Good | Moderate | Unhealthy for Sensitive Groups | Unhealthy |
|---|---|---|---|---|
| Marysville JHS, 1605 7th St, Marysville | 303 | 56 | 1 | |
| 6120 212th St SW, Lynnwood | 282 | 43 | 4 | |
| 17171 Bothell Way NE, Lake Forest Park | 356 | 46 | 1 | |
| Queen Anne Hill, 400 W Garfield St, Seattle | 344 | 18 | 0 | |
| Olive & Boren, Seattle | 344 | 21 | 0 | |
| Beacon Hill, 15th S & Charlestown, Seattle | 343 | 18 | 0 | |
| Duwamish, 4752 E Marginal Way S, Seattle | 292 | 67 | 2 | |
| South Park, 8025 10th Ave S, Seattle | 291 | 56 | 2 | |
| City Hall, 15670 NE 85th, Redmond | 282 | 18 | 1 | |
| 601 143rd Ave NE,, Bellevue | 345 | 15 | 0 | |
| 305 Bellevue Way NE, Bellevue | 331 | 11 | 0 | |
| 42404 SE North Bend Way, North Bend | 361 | 4 | 0 | |
| James St & Central Ave, Kent | 312 | 51 | 2 | |
| Port of Tacoma, 2301 Alexander Ave, Tacoma | 295 | 69 | 1 | |
| 7802 South L St, Tacoma | 277 | 43 | 3 | |

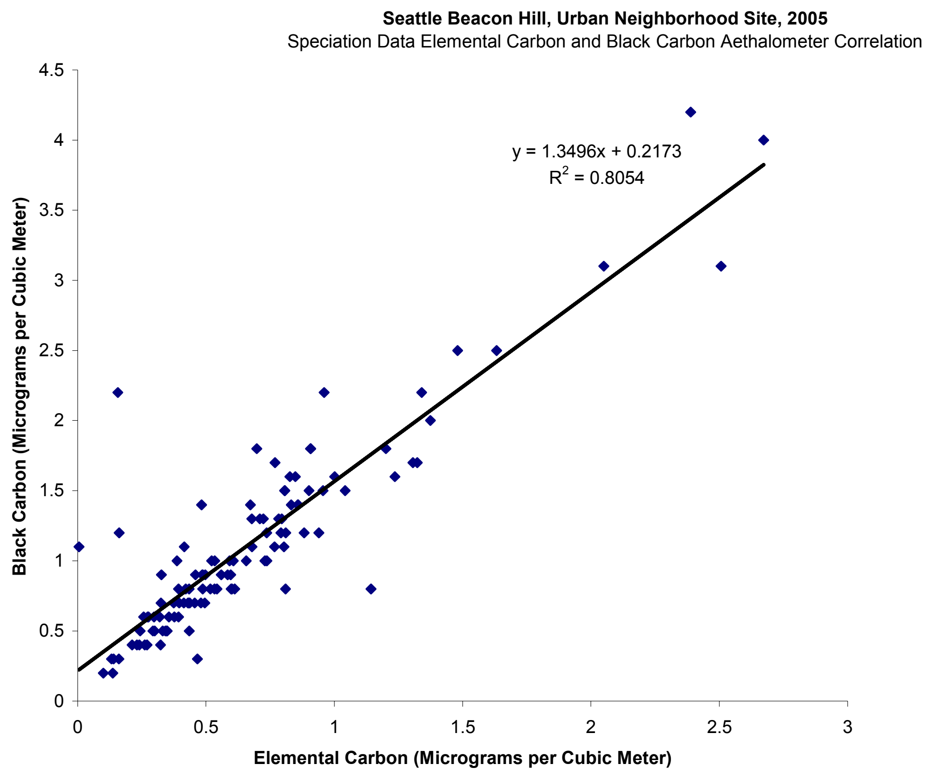
## $PM_{2.5}$ Speciation Analytes Monitored at Beacon Hill in 2005
## Average Annual Concentrations in Micrograms per Cubic Meter

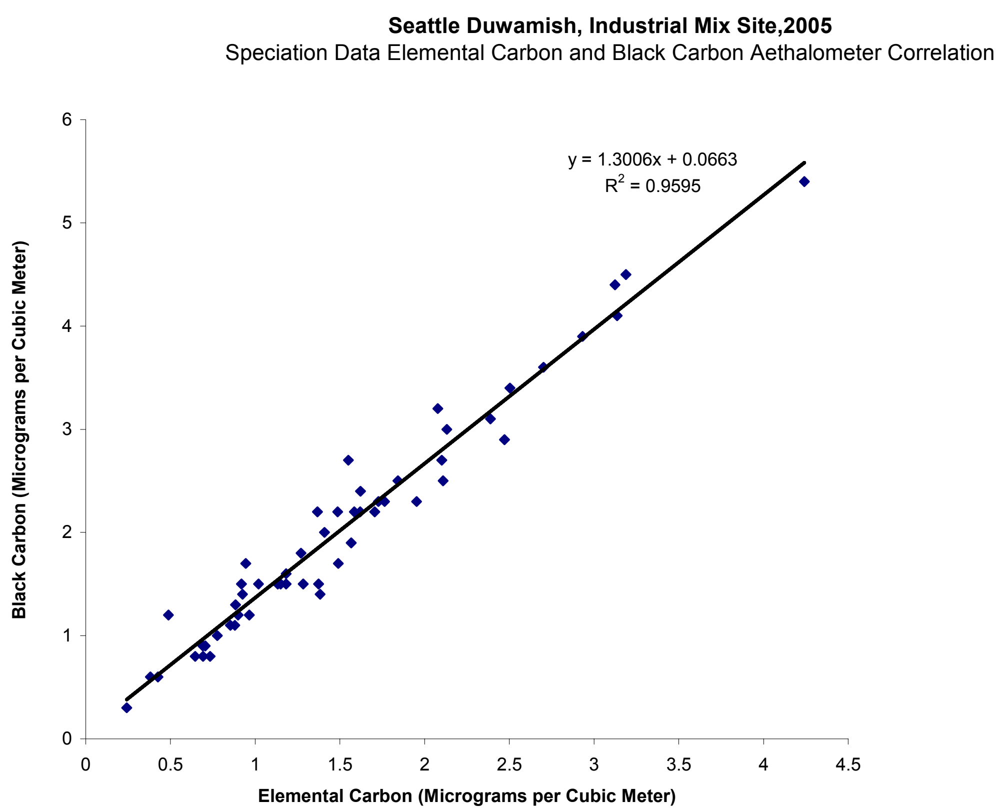
| Anaylyte | Beacon Hill | Duwamish | Olive Street | Lake Forest Park |
|---|---|---|---|---|
| **Total Mass** | 9.65 | 12.48 | 10.49 | 9.98 |
| **Ammonium** | 4.26E-01 | 6.40E-01 | 6.28E-01 | 4.49E-01 |
| **Nitrate** | 6.09E-01 | 1.01E+00 | 1.20E+00 | 8.04E-01 |
| **Nitrate_Non-volatile** | 3.45E-01 | na | na | na |
| **Nitrate_volatile** | 2.64E-01 | na | na | na |
| **Potassium** | 4.09E-02 | 5.80E-02 | 4.96E-02 | 6.65E-02 |
| **Sodium** | 1.30E-01 | 2.53E-01 | 2.06E-01 | 1.90E-01 |
| **Sulfate** | 1.13E+00 | 1.94E+00 | 1.45E+00 | 1.40E+00 |
| **OC and EC Ext3 PM2_5Elemental carbon** | 6.44E-01 | 1.52E+00 | 1.12E+00 | 9.71E-01 |
| **OC and EC Ext3 PM2_5Organic carbon** | 2.77E+00 | 4.78E+00 | 4.70E+00 | 4.80E+00 |
| **OC and EC Ext3 PM2_5Pk1_OC** | 6.91E-01 | 1.45E+00 | 1.36E+00 | 9.78E-01 |
| **OC and EC Ext3 PM2_5Pk2_OC** | 7.28E-01 | 1.23E+00 | 1.29E+00 | 1.38E+00 |
| **OC and EC Ext3 PM2_5Pk3_OC** | 5.98E-01 | 1.01E+00 | 9.84E-01 | 1.11E+00 |
| **OC and EC Ext3 PM2_5Pk4_OC** | 6.84E-01 | 1.02E+00 | 1.00E+00 | 1.14E+00 |
| **OC and EC Ext3 PM2_5PyrolC** | 6.68E-02 | 6.23E-02 | 5.98E-02 | 1.95E-01 |
| **OC and EC Ext3 PM2_5Total carbon** | 3.41E+00 | 6.30E+00 | 5.83E+00 | 5.77E+00 |
| **XRF - Aluminum** | 4.29E-03 | 2.00E-02 | 1.30E-02 | 7.29E-03 |
| **XRF - Antimony** | 3.42E-03 | 4.02E-03 | 2.46E-03 | 1.95E-03 |
| **XRF - Arsenic** | 1.10E-03 | 1.76E-03 | 8.97E-04 | 1.22E-03 |
| **XRF - Barium** | 5.28E-03 | 7.22E-03 | 8.80E-03 | 5.76E-03 |
| **XRF - Bromine** | 1.91E-03 | 2.95E-03 | 2.52E-03 | 3.16E-03 |
| **XRF - Cadmium** | 6.13E-04 | 1.03E-03 | 1.43E-03 | 6.66E-04 |
| **XRF - Calcium** | 2.05E-02 | 1.94E-01 | 4.80E-02 | 2.10E-02 |
| **XRF - Cerium** | 1.21E-03 | 2.04E-02 | 5.69E-03 | 3.82E-03 |
| **XRF - Cesium** | 1.55E-04 | 3.22E-04 | 1.09E-03 | 1.49E-03 |
| **XRF - Chlorine** | 4.02E-02 | 9.77E-02 | 7.49E-02 | 4.92E-02 |
| **XRF - Chromium** | 1.37E-03 | 4.71E-03 | 1.73E-03 | 5.51E-04 |
| **XRF - Cobalt** | 1.10E-04 | 7.76E-05 | 5.19E-05 | 8.50E-05 |
| **XRF - Copper** | 2.47E-03 | 6.11E-03 | 7.17E-03 | 3.05E-03 |
| **XRF - Europium** | 9.15E-04 | 2.00E-03 | 1.36E-03 | 7.34E-04 |
| **XRF - Gallium** | 1.19E-04 | 2.26E-04 | 1.74E-04 | 1.55E-04 |
| **XRF - Gold** | 4.02E-04 | 4.68E-04 | 2.65E-04 | 3.18E-04 |
| **XRF - Hafnium** | 7.63E-04 | 1.69E-03 | 9.07E-04 | 1.09E-03 |
| **XRF - Indium** | 1.01E-03 | 1.09E-03 | 9.89E-04 | 1.62E-03 |
| **XRF - Iridium** | 8.38E-05 | 3.19E-04 | 6.05E-05 | 1.21E-04 |
| **XRF - Iron** | 5.19E-02 | 1.90E-01 | 1.44E-01 | 5.56E-02 |
| **XRF - Lanthanum** | 1.62E-03 | 1.89E-02 | 3.34E-03 | 2.85E-03 |
| **XRF - Lead** | 3.08E-03 | 7.76E-03 | 3.40E-03 | 3.42E-03 |
| **XRF - Magnesium** | 5.73E-03 | 9.31E-03 | 1.24E-02 | 8.92E-03 |
| **XRF - Manganese** | 4.80E-03 | 1.70E-02 | 4.58E-03 | 1.43E-03 |
| **XRF - Mercury** | 1.24E-03 | 1.08E-03 | 8.91E-04 | 1.15E-03 |
| **XRF - Molybdenum** | 4.56E-05 | 1.05E-03 | 2.95E-04 | 2.31E-04 |
| **XRF - Nickel** | 2.10E-03 | 5.23E-03 | 2.36E-03 | 9.43E-04 |
| **XRF - Niobium** | 1.18E-05 | 1.96E-04 | 1.65E-04 | 1.89E-04 |

## $PM_{2.5}$ Speciation Analytes Monitored at Beacon Hill in 2005
## Average Annual Concentrations in Micrograms per Cubic Meter
## (Contd.)

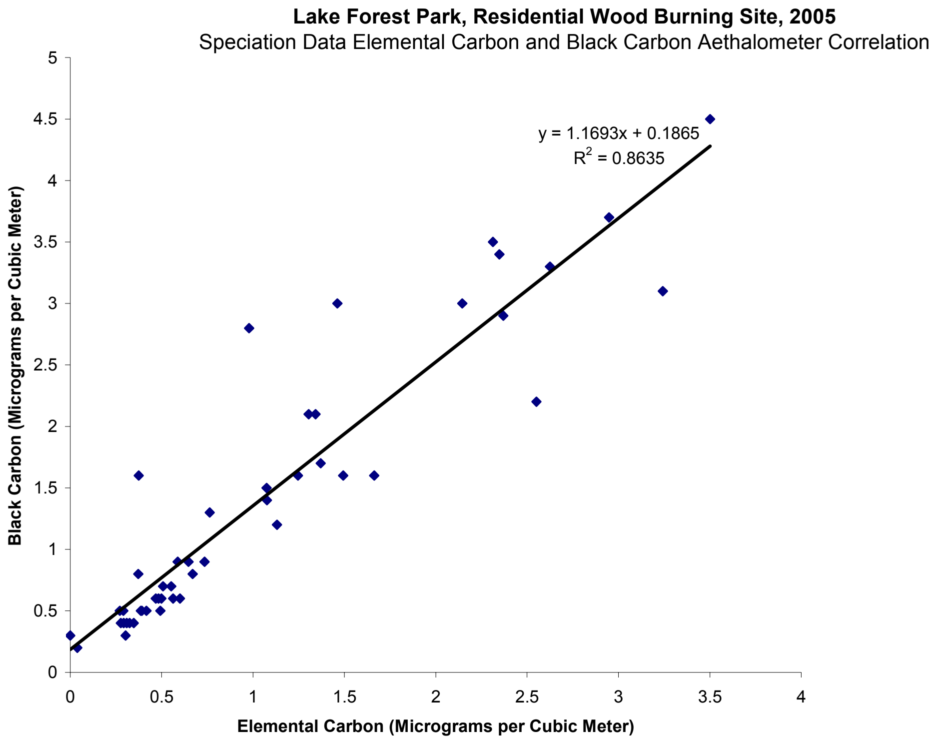
| Anaylyte | Beacon Hill | Duwamish | Olive Street | Lake Forest Park |
|---|---|---|---|---|
| **XRF - Phosphorus** | 1.23E-04 | 4.07E-04 | 6.19E-04 | 1.16E-04 |
| **XRF - Potassium** | 4.63E-02 | 7.78E-02 | 6.52E-02 | 8.22E-02 |
| **XRF - Rubidium** | 1.06E-04 | 2.12E-04 | 1.55E-04 | 1.46E-04 |
| **XRF - Samarium** | 4.45E-04 | 2.14E-03 | 1.38E-03 | 4.49E-04 |
| **XRF - Scandium** | 1.52E-06 | 1.08E-04 | 4.29E-05 | 6.89E-05 |
| **XRF - Selenium** | 1.61E-03 | 4.19E-03 | 1.39E-03 | 6.61E-04 |
| **XRF - Silicon** | 2.33E-02 | 1.01E-01 | 5.24E-02 | 3.91E-02 |
| **XRF - Silver** | 1.23E-03 | 9.20E-04 | 8.36E-04 | 1.05E-03 |
| **XRF - Sodium** | 9.45E-02 | 2.07E-01 | 1.60E-01 | 1.13E-01 |
| **XRF - Strontium** | 4.50E-04 | 1.90E-03 | 9.20E-04 | 6.99E-04 |
| **XRF - Sulfur** | 3.94E-01 | 6.75E-01 | 4.79E-01 | 4.59E-01 |
| **XRF - Tantalum** | 2.09E-04 | 3.51E-04 | 2.66E-04 | 2.27E-04 |
| **XRF - Terbium** | 2.07E-03 | 7.18E-03 | 4.59E-03 | 1.82E-03 |
| **XRF - Tin** | 2.47E-03 | 6.85E-03 | 2.85E-03 | 2.57E-03 |
| **XRF - Titanium** | 9.00E-04 | 9.72E-03 | 6.48E-03 | 2.63E-03 |
| **XRF - Vanadium** | 5.03E-03 | 1.18E-02 | 5.79E-03 | 2.91E-03 |
| **XRF - Wolfram** | 2.76E-04 | 3.77E-04 | 6.35E-04 | 2.73E-04 |
| **XRF - Yttrium** | 1.80E-04 | 2.77E-04 | 1.40E-04 | 3.02E-04 |
| **XRF - Zinc** | 9.62E-03 | 3.08E-02 | 2.17E-02 | 1.02E-02 |
| **XRF - Zirconium** | 3.22E-04 | 7.06E-04 | 1.18E-03 | 5.52E-04 |

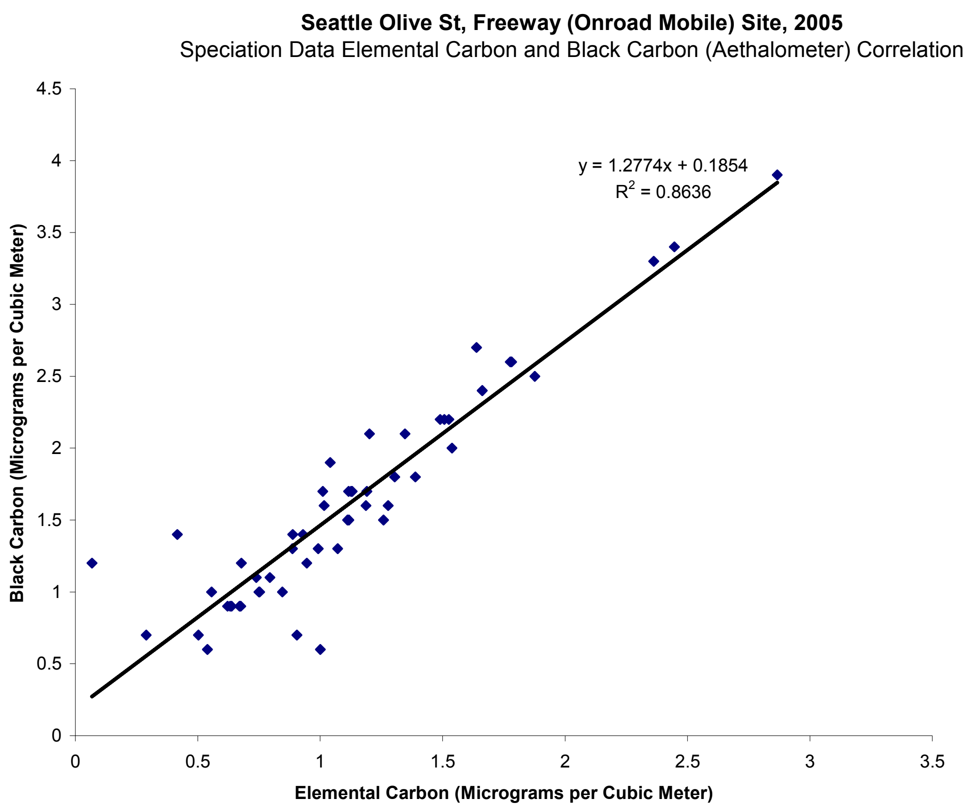
## Aethalometer and Speciation Data Correlations



# Aethalometer and Speciation Data Correlations



## PM2.5 BLACK CARBON

Micrograms per Cubic Meter

Sampling Method: Light Absorption by Aethalometer

2005

| Location | Number of Values | Quarterly Arithmetic Averages | | | | Annual Mean | Max Value |
|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | | |
| 17171 Bothell Way NE, Lake Forest Park | 344 | 2.0 | 0.6 | | 1.6 | 1.3 | 5.4 |
| Olive & Boren, Seattle | 364 | 1.9 | 1.3 | 1.3 | 2.1 | 1.6 | 5.0 |
| Beacon Hill, 15th S & Charlestown, Seattle | 315 | 1.3 | 0.8 | 1.0 | 1.3 | 1.1 | 5.1 |
| Duwamish, 4752 E Marginal Way S, Seattle | 351 | 2.8 | 1.5 | 1.9 | 2.5 | 2.1 | 8.1 |
| 7802 South L St, Tacoma | 304 | 2.0 | 0.7 | | 2.1 | 1.4 | 6.7 |

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**

| Location | Jan 21 Fri | Jan 26 Tue | Apr 5 Thu | Dec 10 Fri |
|---|---|---|---|---|
| 17171 Bothell Way NE, Lake Forest Park | -- | 5.4 | | |
| Olive & Boren, Seattle | | 5.0 | | |
| Beacon Hill, 15th S & Charlestown, Seattle | | | 5.1 | |
| Duwamish, 4752 E Marginal Way S, Seattle | 8.1 | | | |
| 7802 South L St, Tacoma | | | | 6.7 |

-- Indicates no sample on specified day

# OZONE

(Parts per Million)
2005

| Location / Continuous Sampling Period(s) | 2005 Six Highest Daily 8-Hour Concentrations: Value | Date | End Time | 4th Highest Daily 8-Hour Concentration: 2003 | 2004 | 2005 | 3-Year Average of 4th Highest 8-Hour Concentration: 2003 - 2005 |
|---|---|---|---|---|---|---|---|
| Beacon Hill, 15th S & Charlestown | .050 | 28 May | 1500 | | | | |
| Seattle, Wa | .049 | 27 Jun | 1700 | | | | |
| 1 May-14 Jul, 1 Sep-30 Sep | .047 | 28 Jun | 0200 | | | | |
| | .043 | 26 May | 1500 | .050 | .048 | .043 | .047 |
| | .040 | 22 May | 1100 | | | | |
| | .039 | 30 May | 1300 | | | | |
| 20050 SE 56th | .067 | 14 Aug | 1400 | | | | |
| Lake Sammamish State Park, Wa | .058 | 4 Aug | 1500 | | | | |
| 1 May-17 May, 3 Jun-30 Sep | .056 | 13 Aug | 1400 | | | | |
| | .054 | 21 Jul | 1600 | .066 | .063 | .054 | .061 |
| | .051 | 15 Aug | 1400 | | | | |
| | .050 | 26 Jul | 1400 | | | | |
| 42404 SE North Bend Way, | .078 | 28 May | 1600 | | | | |
| North Bend, Wa | .068 | 4 Aug | 1600 | | | | |
| 1 May-30 Sep | .062 | 14 Aug | 1500 | | | | |
| | .061 | 15 Aug | 1400 | .079 | .076 | .061 | .072 |
| | .058 | 21 Jul | 1600 | | | | |
| | .056 | 27 May | 1500 | | | | |
| 30525 SE Mud Mountain Road, | .072 | 27 May | 1600 | | | | |
| Enumclaw, Wa | .069 | 28 May | 1600 | | | | |
| 1 May-30 Sep | .066 | 4 Aug | 1500 | | | | |
| | .063 | 27 Jul | 1500 | .080 | .074 | .063 | .072 |
| | .061 | 14 Aug | 1500 | | | | |
| | .060 | 5 Aug | 1400 | | | | |
| Charles L Pack Forest | .069 | 27 May | 1500 | | | | |
| La Grande, Wa | .067 | 4 Aug | 1400 | | | | |
| 1 May-30 Sep | .064 | 14 Aug | 1500 | | | | |
| | .061 | 5 Aug | 1400 | .077 | .071 | .061 | .070 |
| | .060 | 15 Aug | 1400 | | | | |
| | .056 | 21 Jul | 1500 | | | | |
| 709 Mill Road SE, | .064 | 4 Aug | 1500 | | | | |
| Yelm, Wa | .063 | 5 Aug | 1600 | | | | |
| 1 May-30 Sep | .062 | 27 May | 1500 | | | | |
| | .059 | 14 Aug | 1500 | .072 | .065 | .059 | .065 |
| | .055 | 13 Aug | 1500 | | | | |
| | .053 | 26 May | 1500 | | | | |

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 p

# OZONE

(Parts per Million)
2005

| Location / Continuous Sampling Period(s) | Six Highest Daily Maximum 1 Hour Averages | | | Estimated No. of Days Daily Maximum 1 Hour Average Exceeded .12 ppm | | | No. of Days Daily Maximum 1 Hour Average Expected to Exceed .12 ppm |
|---|---|---|---|---|---|---|---|
| | Value | Date | End Time | 2003 | 2004 | 2005 | |
| Beacon Hill, 15th S & Charlestown | .056 | 27 Jun | 1700 | 0.0 | 0.0 | 0.0 | 0.0 |
| Seattle, Wa | .055 | 28 May | 1500 | | | | |
| 1 May-14 Jul, 1 Sep-30 Sep | .055 | 28 Jun | 0400 | | | | |
| | .049 | 26 May | 1800 | | | | |
| | .045 | 17 Jun | 1600 | | | | |
| | .043 | 16 May | 1200 | | | | |
| 20050 SE 56th | .077 | 14 Aug | 1500 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lake Sammamish State Park, Wa | .070 | 13 Aug | 1600 | | | | |
| 1 May-17 May, 3 Jun-30 Sep | .068 | 4 Aug | 1600 | | | | |
| | .066 | 21 Jul | 1700 | | | | |
| | .061 | 3 Aug | 1700 | | | | |
| | .059 | 18 Jul | 1700 | | | | |
| 42404 SE North Bend Way, | .088 | 28 May | 1700 | 0.0 | 0.0 | 0.0 | 0.0 |
| North Bend | .085 | 4 Aug | 1700 | | | | |
| 1 May-30 Sep | .079 | 14 Aug | 1700 | | | | |
| | .075 | 15 Aug | 1700 | | | | |
| | .071 | 13 Aug | 1700 | | | | |
| | .067 | 27 May | 1600 | | | | |
| 30525 SE Mud Mountain Road, | .087 | 27 May | 1600 | 0.0 | 0.0 | 0.0 | 0.0 |
| Enumclaw | .076 | 4 Aug | 1600 | | | | |
| 1 May-30 Sep | .075 | 28 May | 1600 | | | | |
| | .071 | 5 Aug | 1700 | | | | |
| | .070 | 21 Jul | 1700 | | | | |
| | .070 | 27 Jul | 1700 | | | | |
| Charles L Pack Forest | .079 | 4 Aug | 1400 | 0.0 | 0.0 | 0.0 | 0.0 |
| La Grande, Wa | .078 | 14 Aug | 1500 | | | | |
| 1 May-30 Sep | .077 | 27 May | 1700 | | | | |
| | .068 | 15 Aug | 1600 | | | | |
| | .067 | 27 Jul | 1700 | | | | |
| | .067 | 5 Aug | 1600 | | | | |
| 709 Mill Road SE, | .074 | 4 Aug | 1700 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yelm, Wa | .070 | 5 Aug | 1600 | | | | |
| 1 May-30 Sep | .069 | 27 May | 1500 | | | | |
| | .066 | 14 Aug | 1800 | | | | |
| | .061 | 13 Aug | 1500 | | | | |
| | .060 | 19 Aug | 1700 | | | | |

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.

**NITROGEN DIOXIDE**
(Parts per Million)
2005

Monthly and Annual Arithmetic Averages

| Location | Monthly Arithmetic Averages | | | | | | | No of 1 Hour Samples | Year Arith Mean |
|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb<br>Aug | Mar<br>Sep | Apr<br>Oct | May<br>Nov | Jun<br>Dec | Jul | | |
| Beacon Hill, 15th S & Charlestown, Seattle | .020 | .024 | .018 | .015<br>.018 | .015 | .015 | .017 | 6449 | .018 |

Maximum and Second Highest Concentrations

| Location / Continuous Sampling Periods(s) | 1 Hour Average | | |
|---|---|---|---|
| | Value | Date | End Time |
| Beacon Hill, 15th S & Charlestown, Seattle<br>1 Jan-16 Aug, 8 Sep-28 Sep, 1 Nov-12 Dec, 27 Dec-31 Dec | .078<br>.078 | 6 Jun<br>6 Jun | 0000<br>0100 |

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)
2005

| Location / Continuous Sampling Period(s) | Six Highest Concentrations | | | | | Number of 8 Hour Averages Exceeding 9 ppm | Number of Days 8 Hour Average Exceeded 9 ppm |
|---|---|---|---|---|---|---|---|
| | 1 Hour Average | | | 8 Hour Average | | | |
| | Value | Date | End Time | Value | Date | | |
| 44th Ave W & 196th St SW | 5.1 | 16 Dec | 2200 | 4.3 | 16 Dec | 0 | 0 |
| Lynnwood | 5.0 | 24 Feb | 0800 | 3.6 | 18 Dec | | |
| 11 Feb-31 Dec | 4.7 | 16 Dec | 2000 | 3.5 | 11 Dec | | |
| | 4.5 | 16 Dec | 1800 | 3.5 | 17 Dec | | |
| | 4.5 | 16 Dec | 2300 | 3.2 | 12 Dec | | |
| | 4.4 | 18 Dec | 1800 | 3.1 | 14 Nov | | |
| 2421 148th Ave NE | 5.9 | 5 Jan | 1700 | 4.0 | 23 Feb | 0 | 0 |
| Bellevue | 5.9 | 5 Jan | 1800 | 3.8 | 5 Jan | | |
| 1 Jan-31 Dec | 5.7 | 11 Feb | 1900 | 3.4 | 24 Feb | | |
| | 5.3 | 23 Feb | 1800 | 3.2 | 2 Feb | | |
| | 5.0 | 24 Jan | 1900 | 3.2 | 23 Nov | | |
| | 4.6 | 13 Dec | 1800 | 3.0 | 11 Dec | | |
| University District, 1307 NE 45th St | 4.6 | 23 Feb | 2200 | 3.8 | 23 Feb | 0 | 0 |
| Seattle | 4.4 | 23 Feb | 2100 | 3.7 | 24 Feb | | |
| 1 Jan-31 Dec | 4.1 | 23 Feb | 1900 | 2.9 | 5 Jan | | |
| | 4.1 | 23 Feb | 2400 | 2.8 | 26 Jan | | |
| | 3.9 | 19 Feb | 0200 | 2.8 | 18 Feb | | |
| | 3.8 | 5 Jan | 1700 | 2.8 | 19 Feb | | |
| 1424 4th Ave | 3.6 | 24 Feb | 0800 | 2.7 | 24 Feb | 0 | 0 |
| Seattle | 3.2 | 16 Dec | 0900 | 2.5 | 16 Dec | | |
| 1 Jan-31 Dec | 3.1 | 23 Feb | 1700 | 2.4 | 11 Dec | | |
| | 3.1 | 16 Dec | 0800 | 2.0 | 27 Feb | | |
| | 2.9 | 24 Feb | 0700 | 2.0 | 10 Dec | | |
| | 2.9 | 11 Dec | 1700 | 1.9 | 26 Jan | | |
| Beacon Hill, 15th S and Charlestown | 2.7 | 25 Jan | 1000 | 1.9 | 25 Jan | 0 | 0 |
| Seattle | 2.7 | 16 Nov | 0800 | 1.9 | 24 Feb | | |
| 1 Jan-31 Dec | 2.6 | 21 Jan | 1900 | 1.8 | 11 Dec | | |
| | 2.4 | 21 Jan | 2000 | 1.7 | 26 Jan | | |
| | 2.4 | 16 Nov | 0700 | 1.7 | 12 Dec | | |
| | 2.1 | 25 Jan | 0800 | 1.6 | 21 Jan | | |
| 1101 Pacific Ave | 6.6 | 23 Feb | 1800 | 4.6 | 23 Feb | 0 | 0 |
| Tacoma | 6.1 | 2 Feb | 1800 | 3.9 | 2 Feb | | |
| 1 Jan-15 Aug, 12 Sep-31 Dec | 5.4 | 2 Feb | 1700 | 3.7 | 24 Feb | | |
| | 5.4 | 9 Mar | 0900 | 3.3 | 26 Jan | | |
| | 5.3 | 23 Feb | 1700 | 3.3 | 8 Deb | | |
| | 4.9 | 8 Dec | 1800 | 3.1 | 5 Jan | | |

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)
2005

Monthly and Annual Arithmetic Averages

| Location | Monthly Arithmetic Averages | | | | | | | No of 1 Hour Samples | Year Arith Mean |
|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb<br>Aug | Mar<br>Sep | Apr<br>Oct | May<br>Nov | Jun<br>Dec | Jul | | |
| Beacon Hill, 15th S & Charlestown, Seattle | | .006<br>.005 | .004<br>.004 | .005<br>.003 | .003<br>.002 | <br>.002 | .003 | 8095 | .004 |

Maximum and Second Highest Concentrations for Various Averaging Periods

| Location / Continuous Sampling Periods(s) | 1 Hour Average | | | 3 Hour Average | | | 24 Hour Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Value | Date | End Time | Value | Date | End Time | Value | Date | End Time |
| Beacon Hill, 15th S & Charlestown, Seattle<br>1 Jan-31 Dec | .044<br>.042 | 21 Oct<br>14 Aug | 1800<br>0900 | .030<br>.027 | 23 Feb<br>6 Apr | 2300<br>1400 | .020<br>.016 | 7 Apr<br>24 Feb | 0100<br>1200 |

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.

**Air Toxics**

2005 Beacon Hill Statistical Summaries

Concentrations in parts per billion by volume (ppbv)

| Statistic | Benzene | 1,3-butadiene | Carbon Tetrachloride | Chloroform | Perc | Trichloroethylene | Acetaldehyde | Formaldehyde |
|---|---|---|---|---|---|---|---|---|
| 2005 Count | 60 | 60 | 60 | 60 | 60 | 60 | 56 | 56 |
| Non detects | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 0.116 | 0.022 | 0.100 | 0.032 | 0.030 | 0.025 | 0.800 | 1.050 |
| Mean | 0.176 | 0.035 | 0.100 | 0.047 | 0.034 | 0.030 | 0.813 | 1.055 |
| 95th Percentile | 0.530 | 0.111 | 0.110 | 0.101 | 0.079 | 0.078 | 1.550 | 1.900 |
| Maximum | 0.700 | 0.130 | 0.120 | 0.140 | 0.110 | 0.097 | 1.900 | 2.700 |
| MDL | 0.009 | 0.018 | 0.010 | 0.020 | 0.010 | 0.009 | 0.009 | 0.016 |

Perc = tetrachloroethylene

All 60 vinyl chloride and 1,2-dichloropropane samples were non-detect (MDL for both is 0.05 ppb)

All air toxics data (VOC and metals) received from John Williamson, WA Department of Ecology.

MDL = minimum detection limit, provided by WA Department of Ecology.

TSP – total suspended particulate

**Statistical Summaries for 2005 Beacon Hill Air Toxics $PM_{10}$ Metals**

Concentrations in nanograms per cubic meter ($ng/m^3$)

| Statistic | Arsenic | Beryllium | Cadmium | Hexavalent Chromium TSP | Total Chromium | Lead | Manganese | Nickel |
|---|---|---|---|---|---|---|---|---|
| 2005 Count | 61 | 45 | 61 | 49 | 58 | 61 | 61 | 61 |
| Non detects | 0 | 16 | 0 | 10 | 2 | 0 | 0 | 0 |
| Median | 0.883 | 0.003 | 0.135 | 0.031 | 0.916 | 3.540 | 7.300 | 1.610 |
| Mean | 1.022 | 0.005 | 0.181 | 0.041 | 1.342 | 4.362 | 10.386 | 3.100 |
| 95th Percentile | 2.510 | 0.009 | 0.400 | 0.101 | 3.229 | 9.840 | 34.800 | 12.600 |
| Maximum | 3.350 | 0.024 | 1.560 | 0.166 | 10.571 | 13.400 | 53.600 | 16.206 |
| MDL | 0.008 | 0.002 | 0.001 | 0.012 | 0.139 | 0.069 | 0.091 | 0.084 |

## 2005 Air Toxics Unit Risk Factors

| AIR TOXIC | UNIT RISK FACTOR RISK/µg/m$^3$ | CANCER RATING[1] | SOURCE |
|---|---|---|---|
| Formaldehyde | 1.3E-05 | B1 | IRIS[2] |
| Benzene | 7.8E-06 | A | IRIS |
| Carbon Tetrachloride | 1.5E-05 | B2 | IRIS |
| Chromium (Hexavalent) (M) | 1.2E-02 | A | IRIS |
| Chloroform | 2.3E-05 | B2 | IRIS |
| Arsenic (M) | 4.3E-03 | A | IRIS |
| 1,3-Butadiene | 3E-05 | A | IRIS |
| Acetaldehyde | 2.2E-06 | B2 | IRIS |
| Nickel (Subsulfide) (M) | 4.8E-04 | A | IRIS |
| Tetrachloroethylene | 5.9E-06 | B2 | CAL EPA[3] |
| Trichloroethylene | 2E-06 | B2 | CAL EPA, EPA NATA[4] |
| Cadmium (M) | 1.8E-03 | B1 | IRIS |
| Lead (M) | 1.2E-05 | B2 | CAL EPA |
| Beryllium (M) | 2.4E-03 | B1 | IRIS |

[1] Ratings per 1986 EPA guidelines.
[2] Integrated Risk Information System. EPA. http://www.epa.gov/iris/.
[3] California Environmental Protection Agency. Office of Environmental Health Hazard Assessment. http://www.arb.ca.gov/toxics/healthval/healthval.htm.
[4] EPA. National Air Toxics Assessment. Health Effects Information. 1999. http://www.epa.gov/ttn/atw/nata1999/99pdfs/healtheffectsinfo.pdf.

## 2005 Beacon Hill Potential Cancer Risk Estimate per 1,000,000
## Upper Bound – 95th Percentile

| AIR TOXIC | UPPER-BOUND POTENTIAL RISK (95TH PERCENTILE) |
|---|---|
| Formaldehyde | 30.3 |
| Chromium (M)[5] | 25.6 |
| Benzene | 13.2 |
| Chloroform | 11.3 |
| Arsenic (M) | 10.8 |
| Carbon Tetrachloride | 10.4 |
| 1,3-Butadiene | 7.3 |
| Acetaldehyde | 6.1 |
| Nickel (M) | 6.0 |
| Tetrachloroethylene | 3.1 |
| Trichloroethylene | 0.8 |
| Cadmium (M) | 0.7 |
| Lead (M) | 0.1 |
| Beryllium (M) | 0.02 |
| Manganese (M) | na |

M = Metal, na = not applicable (manganese is not classified as a carcinogen)

[5] Chromium estimated risks are based on EPA's 1999 National Air Toxics Assessment (NATA) estimate that 66% of total chromium at Beacon Hill is hexavalent, the most toxic form. EPA 1999 National Air Toxic Assessment. http://www.epa.gov/ttn/atw/nata1999/.