4.0 Analyses of Individual Nonattainment Area

4.10 Region 10 Nonattainment Areas

4.10.4 Washington

State of Washington Area Designations For the
24-Hour Fine Particle National Ambient Air Quality Standard

The table below identifies the counties in Washington State that EPA has designated as not attaining the 2006 24-hour fine particle (PM2.5) standard.[1] A county (or part thereof) is designated as nonattainment if it has an air quality monitor that is violating the standard or if the county is determined to be contributing to the violation of the standard.

Area	WA Recommended Nonattainment Counties	EPA's Designated Nonattainment Counties
Wapato Hills-Puyallup River Valley (Tacoma)	Pierce (partial)	Pierce (partial)

EPA has designated the remaining counties in the state as "attainment/unclassifiable."

EPA Technical Analysis for the Wapato Hills-Puyallup River Valley nonattainment area in Washington State

Introduction

Pursuant to section 107(d) of the Clean Air Act, EPA must designate as nonattainment those areas that violate the NAAQS and those nearby areas that contribute to violations. This technical analysis for the Wapato Hills-Puyallup River Valley nonattainment area identifies the single county in Washington State with a monitor that violates the 24-hour PM2.5 standard (Pierce County) and evaluates nearby counties in the Seattle-Tacoma-Olympia area for contributions to fine particle concentrations in the area. EPA has evaluated these counties based on the weight of evidence of the following nine factors recommended in EPA guidance and any other relevant information:

- pollutant emissions
- air quality data
- population density and degree of urbanization

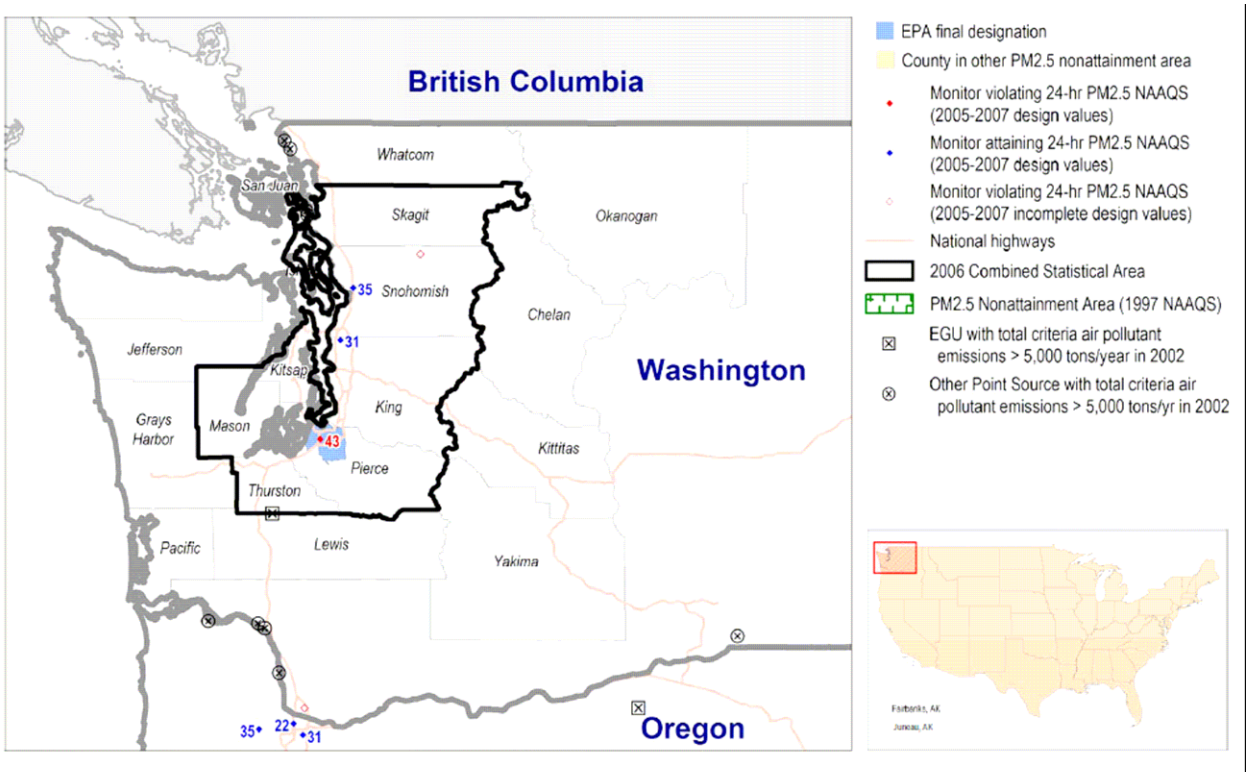
[1] EPA designated nonattainment areas for the 1997 fine particle standards in 2005. In 2006, the 24-hour $PM_{2.5}$ standard was revised from 65 micrograms per cubic meter (average of 98^{th} percentile values for 3 consecutive years) to 35 micrograms per cubic meter; the level of the annual standard for $PM_{2.5}$ remained unchanged at 15 micrograms per cubic meter (average of annual averages for 3 consecutive years).

- traffic and commuting patterns
- growth
- meteorology
- geography and topography
- jurisdictional boundaries
- level of control of emissions sources

We also used analytical tools and data such as pollution roses, fine particle composition monitoring data, back trajectory analyses, and the contributing emission score (CES) to evaluate these areas. (See additional discussion of the CES under factor 1 below.)

Figure 1 is a map of the counties in the Seattle-Tacoma-Olympia area and other relevant information such as the locations and design values of air quality monitors, and the metropolitan area boundary.

Figure 1. Wapato Hills-Puyallup River Valley (partial Pierce County) nonattainment area and surrounding counties in Seattle Tacoma area



The violating monitor in the Pierce County area is located at 7802 South L Street (South L Street monitor) in a suburban area of the City of Tacoma. The nonattainment area is referred to as the Wapato Hills-Puyallup River Valley (WHPRV) area. The City of Tacoma is a major urban center in the Southern Puget Sound Region. Situated on Commencement Bay, an inlet of Puget Sound, Tacoma lies at the foot of Mt. Rainier in the Puyallup River valley, bordered by mountains. Commencement Bay serves the Port of Tacoma, a major center of international trade. The Port handled more than $36.33 billion in annual trade and nearly 2 million TEUs (Twenty-foot Equivalent container Units) in 2007. Tacoma is situated in the Seattle-Tacoma-Olympia Consolidated Statistical Area, a highly urbanized area along the Interstate 5 corridor. To the east of Interstate 5, along the eastern portion of Pierce, King, Snohomish, and Thurston Counties the Cascade mountains rise to over 14,000 feet in elevation at Mt Rainier in Pierce County. Tacoma is about 36 miles south from the city of Seattle, the largest city in Washington State and 30 miles north of the City of Olympia, the Capitol of Washington State. See Figure 2. The Puyallup Indian Reservation is located in the Tacoma Area, about five miles northeast of the violating monitor and is located within in the Wapato Hills-Puyallup River Valley partial county nonattainment area boundary. See Figure 3. The nonattainment area boundary is the pink line and the Puyallup Indian Reservation is shown in cross hatch.

Figure 2. Southern Puget Sound area topography

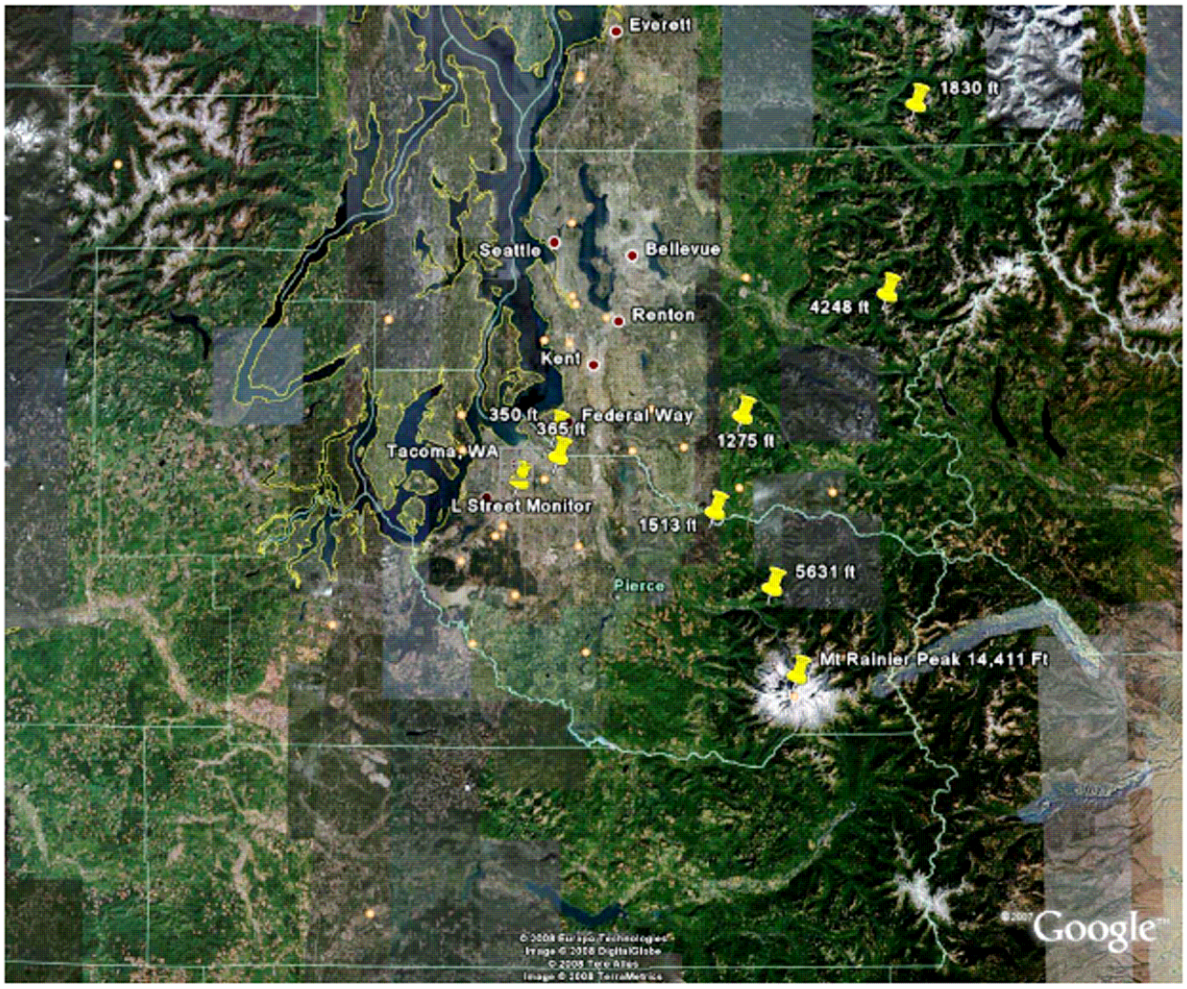
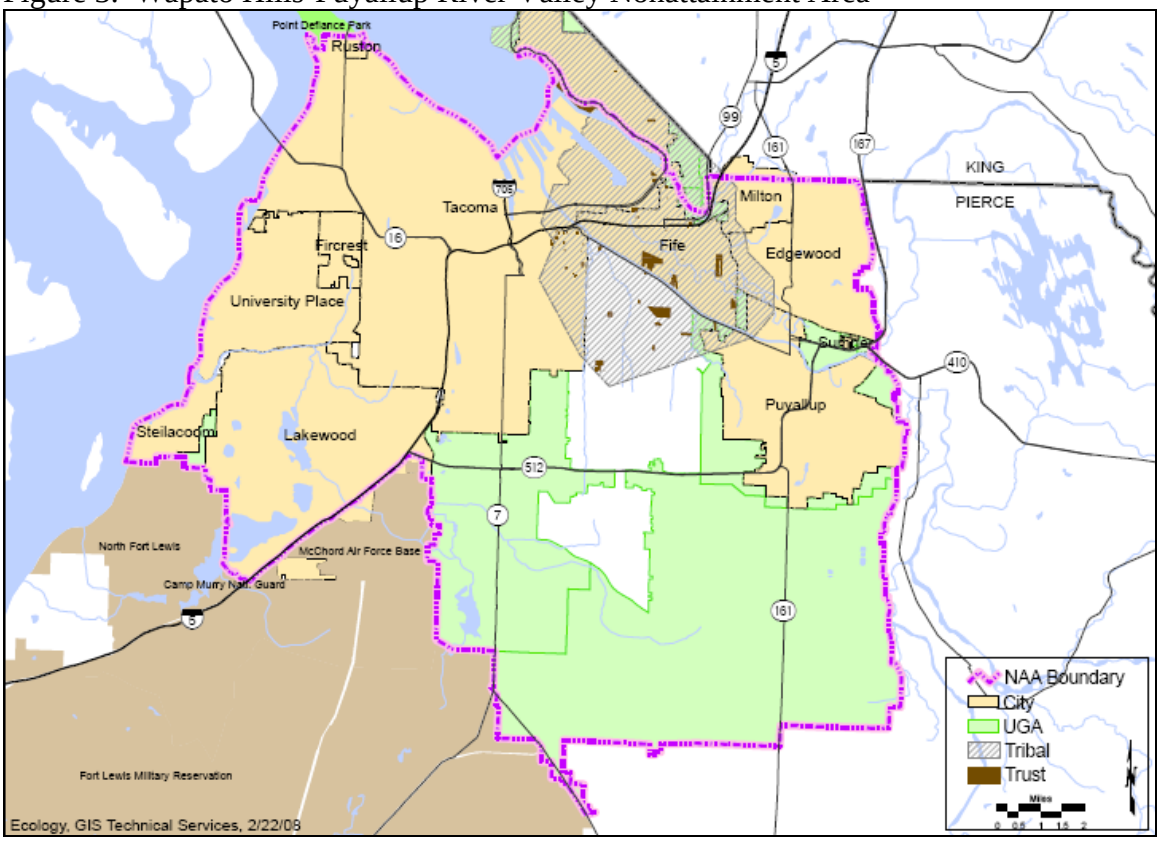


Figure 3. Wapato Hills-Puyallup River Valley Nonattainment Area



The boundary of the Wapato Hills-Puyallup River Valley nonattainment area is described as follows:

- Starting from where an extension of Kennedy Road Northeast would intersect Commencement Bay, proceed north to the intersection of Marine View Drive (State Route 509) and Kennedy Road Northeast.
- Proceed south on Marine View Drive to Hylebos Creek.
- Proceed south along Hylebos Creek to 12th Street East.
- Proceed east on 12th Street East to 70th Avenue East.
- Proceed south on 70th Avenue East to State Route 99 (S.R. 99).
- Proceed north on S.R. 99 0.1 mile north of Birch Street to a driveway to the east.
- Proceed east along the driveway and continue east along the same alignment to the Pierce County Line/Comprehensive Urban Growth Area (CUGA) boundary.
- Proceed east along the Pierce County Line/CUGA boundary to the eastern boundary of Edgewood.
- Proceed south along the eastern boundary of Edgewood to eastern boundary of the Sumner Urban Service Area.
- Proceed south along eastern boundary of the Sumner Urban Service Area to the eastern boundary of the Puyallup Urban Service Area.

- Proceed south along the eastern boundary of the Puyallup Urban Service Area to the eastern boundary of Puyallup/CUGA boundary.
- Proceed south and then west along the CUGA boundary to the eastern boundary of McChord Air Force Base.
- Proceed north along the eastern boundary of McChord Air Force Base to the northernmost point on the eastern boundary.
- Proceed from the northernmost point on the eastern boundary of McChord Air Force Base to the south right-of-way of S.R. 512.
- Proceed west along the south right-of-way of S.R. 512 to the south right-of-way of I-5.
- Proceed south along the south right-of-way to I-5 to the point opposite the boundary between Lakewood and Camp Murray.
- Proceed north across I-5 to the boundary between Lakewood and Camp Murray.
- Proceed north along the western boundary of Lakewood to the point where the western boundary coincides with the CUGA boundary.
- Proceed north along the CUGA boundary to the southern boundary of Point Defiance Park.
- Proceed east along the southern boundary of Point Defiance Park to Commencement Bay/CUGA boundary.
- Proceed southeast, then northeast, and finally northwest along the CUGA boundary to the starting point.

In December 2007, the State of Washington recommended that a portion of Pierce County (the Wapato Hills-Puyallup River Valley area) be designated as "nonattainment" for the 2006 24-hour $PM_{2.5}$ standard based on air quality data from 2004-2006. These data are from Federal Reference Method (FRM) monitors located in the State. See December 18, 2007 letter from Jay Manning, Director of the Washington Department of Ecology to Elin Miller, Regional Administrator EPA Region 10. On March 13, 2008, the State submitted to EPA the partial county boundary shown in Figure 27. The State also submitted the following information to supplement their recommendation in a letter to EPA on July 25, 2008[2]:

- An analysis of speciation data for the South L Street monitor and monitors in the Duwamish area and Lake Forest Park area
- An analysis of meteorological data from meteorological instrumentation co-located with the South L Street monitor
- An analysis of continuous monitoring data including diurnal air quality trends for monitors in King and Pierce Counties

Based on EPA's technical analysis and review of information provided by the State as described below, EPA has designated the Wapato Hills-Puyallup River Valley area (a portion of Pierce County) in State of Washington as nonattainment for the 24-hour $PM_{2.5}$ air-quality standard, based upon currently available information (see table below).

Wapato Hills-Puyallup River Valley nonattainment area	WA Recommended Nonattainment Counties	EPA's-Final Designated Nonattainment Counties
Washington State	Pierce (partial)	Pierce (partial)

The following is a technical analysis for the Wapato Hills-Puyallup River Valley nonattainment area (a portion of Pierce County) in State of Washington.

Factor 1: Emissions data

For this factor, EPA evaluated county level emission data for the following $PM_{2.5}$ components and precursor pollutants: "$PM_{2.5}$ emissions total," "$PM_{2.5}$ emissions carbon," "$PM_{2.5}$ emissions other," "SO_2," "NO_x," "VOCs," and "NH_3." "$PM_{2.5}$ emissions total" represents direct emissions of $PM_{2.5}$ and includes: "$PM_{2.5}$ emissions carbon," "$PM_{2.5}$ emissions other", primary sulfate (SO_4), and primary nitrate. (Although primary sulfate and primary nitrate, which are emitted directly from stacks rather than forming in atmospheric reactions with SO_2 and NO_x, are part of "$PM_{2.5}$ emissions total," they are not shown in Table 1 as separate items). "$PM_{2.5}$ emissions

[2] See the following docket materials:
- July 25 WA State letter attachment PS Diurnals_2005-2007 data.png
- July 25 WA State letter attachment Presentation to OAQPS_as of25-Jul-08.pdf
- July 25 WA State letter attachment Tacoma L Street characteristics.pdf
- July 25 WA State letter attachment Tacoma L Street Speciation.pdf
- July 25 WA State letter attachment Tacoma_PM2.5 episode_12-16-Jan-07.png
- July 25 WA State letter attachment Duwamish_SO4_NO3_OC_ECvs_PM2.5_with_FRM.png
- July 25 WA State letter attachment Lake Forest_Park_SO4_NO3_OC_ECvs_PM2.5_with_FRM.png

carbon" represents the sum of organic carbon (OC) and elemental carbon (EC) emissions, and "$PM_{2.5}$ emissions other" represents other inorganic particles (crustal). Emissions of SO_2 and NO_x, which are precursors of the secondary $PM_{2.5}$ components sulfate and nitrate, are also considered. VOCs (volatile organic compounds) and NH_3 (ammonia) are also potential $PM_{2.5}$ precursors and are included for consideration.

Emissions data were derived from the 2005 National Emissions Inventory (NEI), version 1. See http://www.epa.gov/ttn/naaqs/pm/pm25_2006_techinfo.html.

EPA also considered the Contributing Emissions Score (CES) for each county. The CES is a metric that takes into consideration emissions data, meteorological data, and air quality monitoring information to provide a relative ranking of counties in and near an area. Note that this metric is not the exclusive manner for considering data for these factors. A summary of the CES is included in attachment 2, and a more detailed description can be found at http://www.epa.gov/ttn/naaqs/pm/pm25_2006_techinfo.html#C.

Table 1 shows emissions of $PM_{2.5}$ and precursor pollutants components (given in tons per year) and the CES for violating and potentially contributing counties in the Seattle-Tacoma-Olympia area. Counties are listed in descending order by CES.

Table 1. $PM_{2.5}$ Related Emissions and Contributing Emissions Score

County	State Recommended Nonattainment?	CES Score (Rank)	PM2.5 emissions - total (tpy)	PM2.5 emissions - carbon (tpy)	PM2.5 emissions - other (tpy)	SO2 emissions (tpy)	NOx emissions (tpy)	VOC emissions (tpy)	NH3 emissions (tpy)
King	No	100 (1)	6,362	4,168	2,194	7,361	75,825	89,446	2,564
Pierce	Yes (partial)	60 (2)	3,766	2,255	1,511	3,200	31,905	32,097	1,410
Thurston	No	17 (3)	2,221	1,348	873	478	8,389	14,985	1,620
Kitsap	No	14 (4)	2,204	1,201	1,004	442	6,199	9,588	274
Snohomish	No	13 (5)	3,714	2,223	1,492	2,256	22,687	28,861	1,932
Skagit	No	11	1,605	819	786	10,345	12,417	11,173	1,809
Island	No	4	841	453	388	485	4,463	4,128	358
Mason	No	3	767	439	328	100	1,623	3,846	90

Total $PM_{2.5}$ emissions in King County as well as individual chemical precursor components of $PM_{2.5}$ are generally two times the emissions in Pierce County, the county which contains the violating monitor. In addition, the CES score of 100 indicates potential contributing emissions from King County. The next highest CES score of 17 was for Thurston County, which contains the City of Olympia located 36 miles to the south of the violating monitor. Given the low CES scores and relatively low emissions in Thurston, Kitsap, Snohomish, Skagit, Island and Mason Counties these Counties are less likely to contribute to the exceedences at the South L Street monitor than King County and Pierce County which have higher emissions and CES scores. We note that in counties with large land areas and complex terrain such as King and Pierce Counties, the CES does not account for diurnal variation in hourly $PM_{2.5}$ and sharp spatial gradients in

emissions.[3] Those factors were separately considered and used in developing our designation rationale.

The State of Washington submitted seasonal emissions inventory data as part of its nine factors analysis attachment to its letter to EPA dated December 18, 2007. Figure 4 and Table 2 display seasonal emissions in Pierce County, Washington for 2005 from the State's submittal. As discussed below in factor 2 (air quality data), $PM_{2.5}$ exceedences at the violating monitor in Pierce County have occurred in the months of November, December, January and February during the years 2004-2007.

Winter season (December through February) air emissions of $PM_{2.5}$ in Pierce County are balanced among:

(1) outdoor open burning (202 tons per season, 24%),

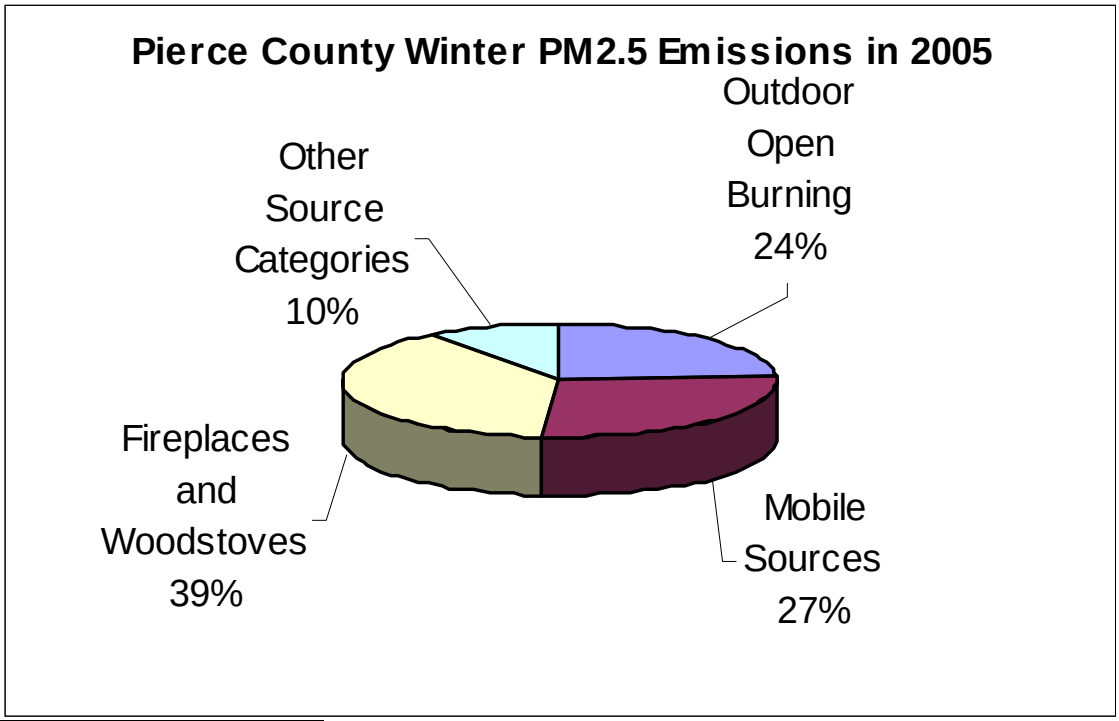
(2) mobile sources (230 tons per season, 27%),

(3) fireplaces and woodstoves (326 tons per season, 39%), and

(4) other sources (84 tons per season, 10%)

Washington noted that these are estimates for a countywide emission inventory, and that outdoor open burning (with an estimated 24% contribution) is likely not occurring in the urban portion of the county near the violating monitor. Open burning is prohibited in these areas.

Figure 4.



[3] See supporting documentation section on limitations of the CES. Because of differences in county size, and topography across the country, the score may require careful interpretation for some areas, particularly in the western United States.

Table 2. Pierce County Seasonal $PM_{2.5}$ Emission Sources in 2005

2005 Category PM2.5 Emissions					PM2.5 Emission Source Categories and Subcategories	2005 Subcategory PM2.5 Emissions				
tpy	tons/season					tpy	tons/season			
Annual	Summer	Fall	Winter	Spring		Annual	Summer	Fall	Winter	Spring
1,258	**377**	**377**	**202**	**302**	**Outdoor Open Burning**					
					Land clearing burning	941	282	282	151	226
					Yard waste burning	185	56	56	30	44
					Forest wildfires and managed burns	117	35	35	19	28
					Structural fires	11	3	3	3	3
					Agricultural waste burning	4	1	1	1	1
1,036	**284**	**259**	**230**	**263**	**Mobile Sources**					
					On-road gasoline vehicles	296	77	74	71	74
					Non-road diesel engines	280	78	67	62	73
					On-road diesel vehicles	201	52	50	48	50
					Non-road gasoline engines	80	22	19	18	21
					Ocean-going vessels	54	14	14	14	14
					Harbor vessels	35	9	9	9	9
					Railroad diesel engines	27	7	7	7	7
					On-road CNG and LPG engines	4	1	1	1	1
					Aircraft ground support engines	3	1	1	1	1
					Aircraft	2	1	1	1	1
					Non-road LPG engines	2	1	1	1	1
					Recreational boats	52	22	17	0	13
679	**34**	**95**	**326**	**224**	**Fireplaces and Woodstoves**					
					Wood stove wood burning	430	22	60	206	142
					Fireplace wood burning	165	8	23	79	54
					Fireplace and wood stove firelog burning	78	4	11	37	26
					Pellet stove wood burning	6	0	1	3	2
261	**49**	**56**	**84**	**72**	**Other Source Categories**					
					Industrial point sources	181	45	45	45	45
					Natural gas burning	67	3	9	32	22
					Boiler and furnace distillate oil burning	11	1	2	5	4
					Propane furnaces and boilers	2	0	0	1	1
3,234	**744**	**787**	**842**	**860**	**Totals**	**3,234**	**744**	**787**	**842**	**860**

Fireplaces and woodstoves are the largest source of emissions in Pierce County (39%). The State conducted additional analyses to determine the spatial variation in wood burning activities. Figure 5 displays the number of people using wood as a primary source of heat in the immediate area of the South L monitor, per square mile. The information source is the 2000 census, and is presented at a block group level[4]. This information does not capture those who use wood as a secondary heat source, or those who use fireplaces for ambiance. The highest density of woodstove/fireplace use occurs within the Tacoma urban growth boundary and in census blocks north of SR 512 in the vicinity of the monitor. See Figures 5 and 6.

Based on annual emissions inventory data for Pierce, King and surrounding counties, VOC and NOx emissions comprise the largest portion of total $PM_{2.5}$ emissions. However, this data is annual data and exceedences of the 24-hour $PM_{2.5}$ standard at the South L Street monitor occur exclusively in the late fall-winter seasons. Seasonal emissions inventory data submitted by the State indicates that emissions from woodstoves and fireplaces account for over 40% of the

[4] US Census Bureau. http://factfinder.census.gov/home/saff/main.html

total emissions in Pierce County, while mobile sources account for 27% of total emissions in Pierce County during the winter season when exceedences of the 24-hour $PM_{2.5}$ standard occur.

Based on emission levels and CES values, EPA considered King and Pierce Counties candidates for a 24-hour $PM_{2.5}$ nonattainment designation for violations at the South L Street monitor in Pierce County. However, we have further evaluated potential contributions from surrounding counties in the Seattle-Tacoma-Olympia area in our analysis of the remaining nine-factors.

Figure 5.

Tacoma Area Households
Using Wood for Primary Heat, per Square Mile

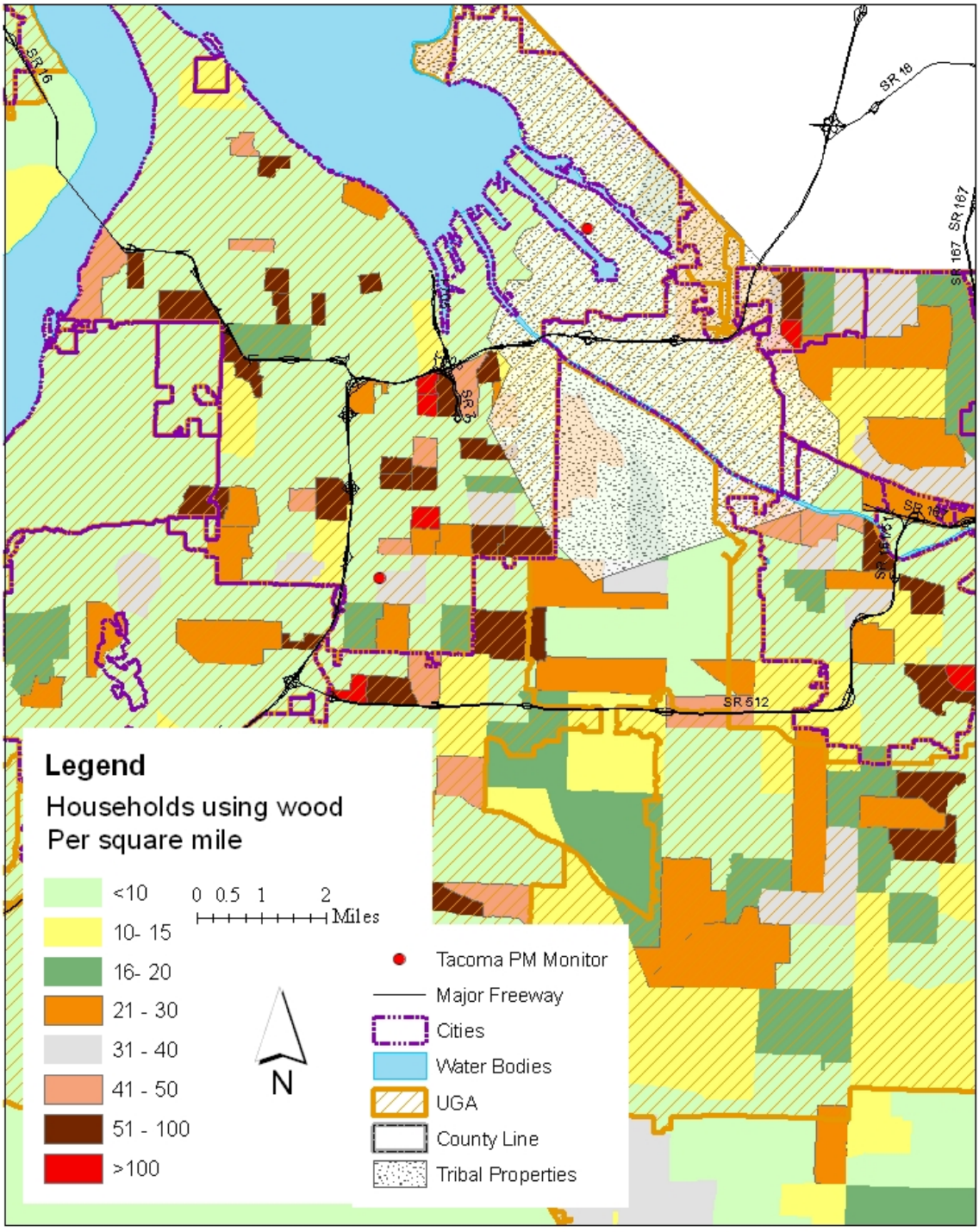
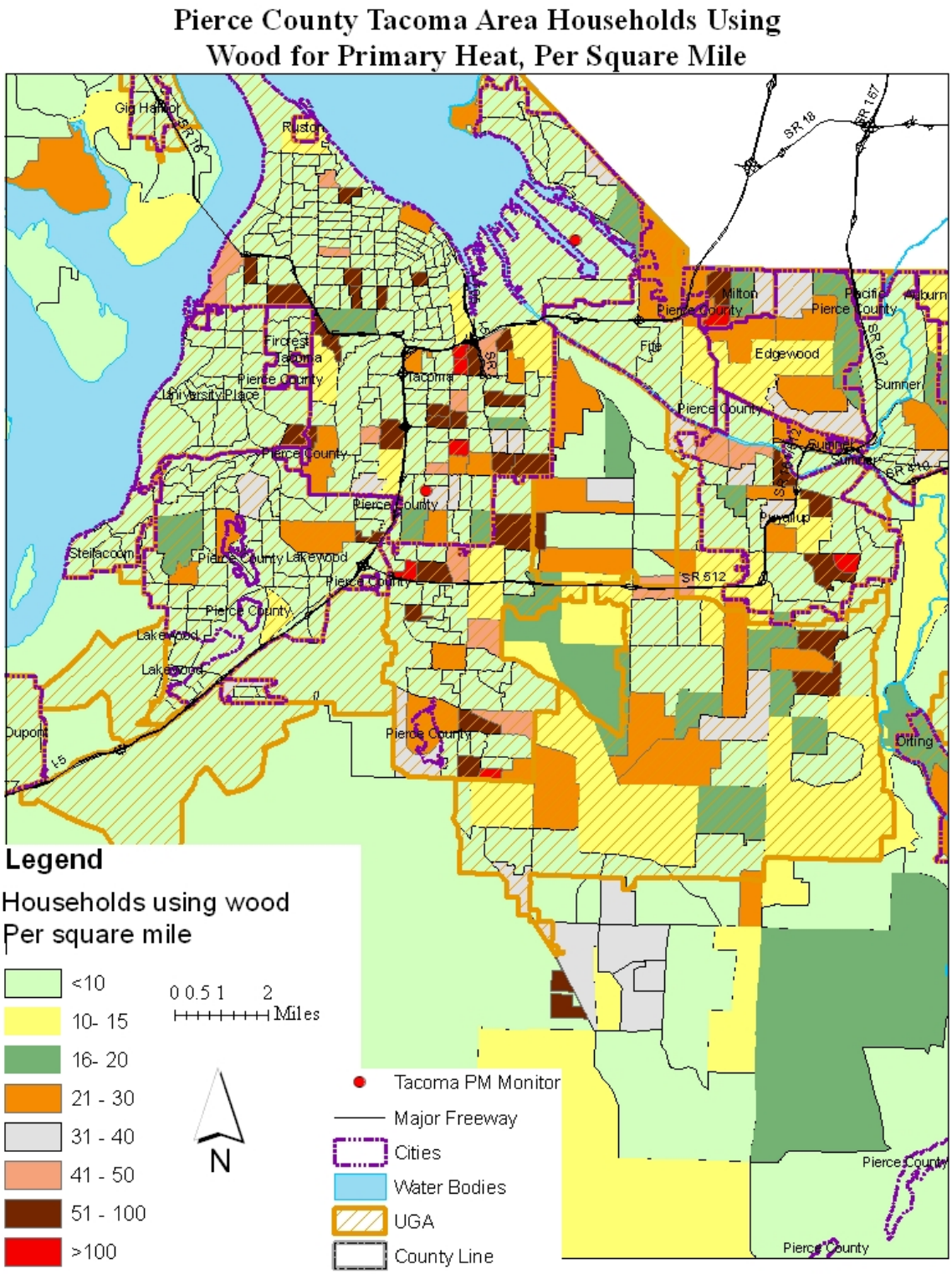


Figure 6.


Pierce County Tacoma Area Households Using Wood for Primary Heat, Per Square Mile
Legend
Households using wood
Per square mile
<10
10- 15
16- 20
21 - 30
31 - 40
41 - 50
51 - 100
>100
0 0.5 1 2
Miles
N
Tacoma PM Monitor
Major Freeway
Cities
Water Bodies
UGA
County Line
Gig Harbor
Ruston
Tacoma
Fircrest
University Place
Steilacoom
Lakewood
DuPont
Milton
Pacific
Auburn
Fife
Edgewood
Sumner
Puyallup
Orting
SR 512
SR 18
SR 167
SR 410
I-5

Factor 2: Air quality data

This factor considers the 24-hour $PM_{2.5}$ design values (in $\mu g/m^3$) for air quality monitors in counties in the Seattle-Tacoma-Olympia based on data for the 2005-2007 period. A monitor's design value indicates whether that monitor attains a specified air quality standard. The 24-hour $PM_{2.5}$ standards are met when the 3-year average of a monitor's 98^{th} percentile values is 35 $\mu g/m^3$ or less. A design value is only valid if minimum data completeness criteria are met.
.
The 24-hour $PM_{2.5}$ design values for counties in the Seattle-Tacoma-Olympia area are shown in Table 3.

Table 3. Air Quality Data for Seattle-Tacoma-Olympia Area

County	State Recommended Nonattainment?	Design Values 2004-06 ($\mu g/m^3$)	Design Values 2005-07 ($\mu g/m^3$)
Pierce, WA	Yes	42	43
King, WA	No	29	31
Snohomish, WA	No	33	35
Thurston, WA	No	N/A	N/A
Island, WA	No	N/A	N/A
Kitsap, WA	No	N/A	N/A
Mason, WA	No	N/A	N/A

In Washington State, the monitor at 7802 South L Street in Tacoma (Pierce County) is the only monitor that violates the 24-hour $PM_{2.5}$ standard based on 2005-2007 data. King and Snohomish County do not violate based on 2004-2006 or 2005-2007 data. The remaining counties do not have Federal Reference Method monitor, therefore Federal Reference Method[5] data is not available for these counties.

Although the surrounding counties of King and Snohomish do not violate the standard, this alone was not sufficient information for EPA to eliminate King County or Snohomish County as candidates for inclusion in the nonattainment area. Nearby counties could be contributing to the violations at the South L Street monitor even though there are no violating monitors in those counties.

EPA analyzed data submitted by the State of Washington collected from monitoring several sites in addition to the Pierce County Tacoma South L Street Site to better characterize $PM_{2.5}$ in Tacoma and in the surrounding counties. Since the high CES score for King County indicates a potential contribution to the exceedences at the South L Street monitor from King County, and since western King County is a highly urbanized area, this analysis focused in particular on examining additional air quality data for King County.

[5] Design values are based on data collected at FRM or FEM monitors. The State operates other monitors in these counties but they are not FRM or FEM monitors.

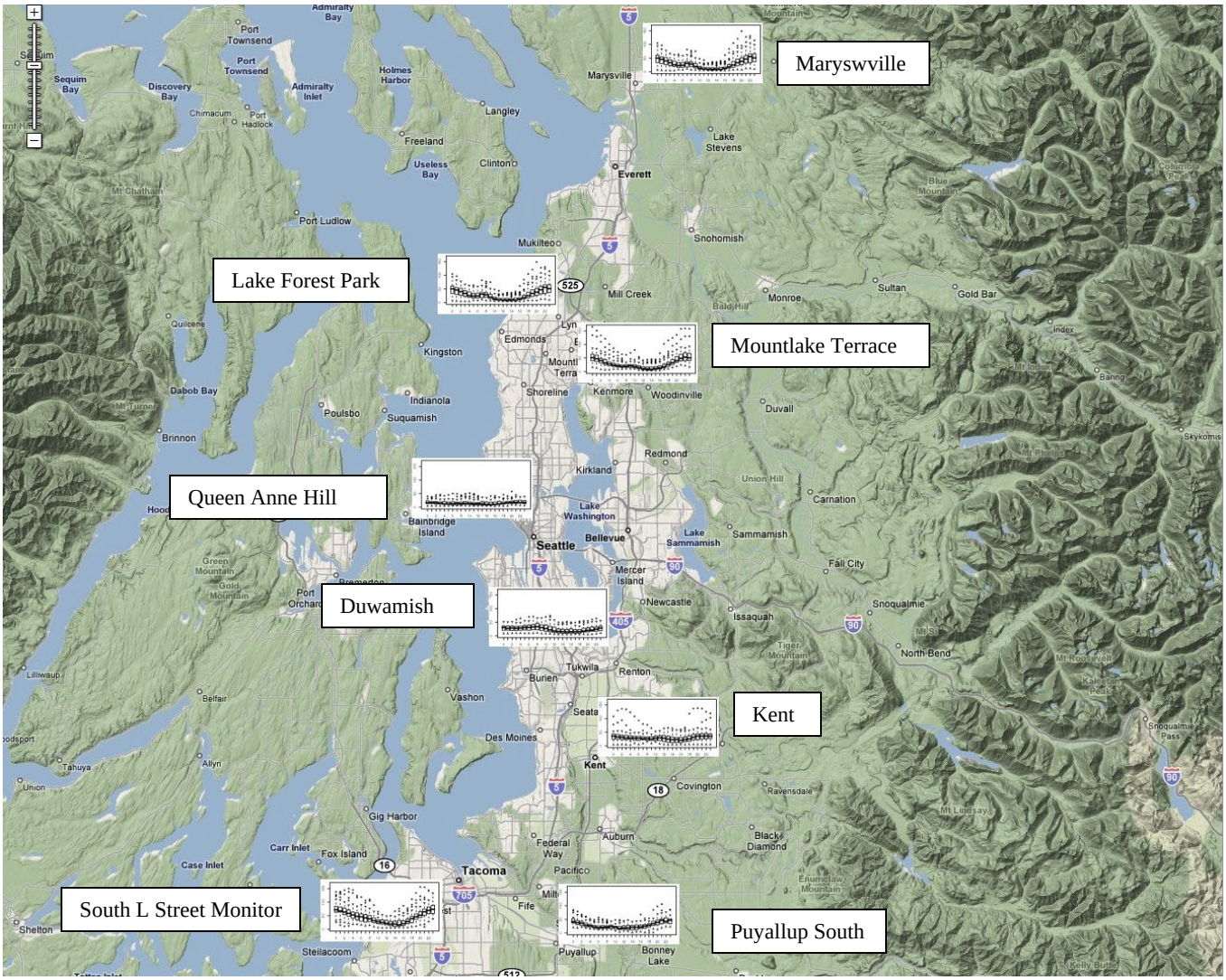
Figure 7 shows the location of several monitors in the Puget Sound area. The following pages discuss air quality data from these sites located along the Interstate 5 corridor in Pierce and King Counties. These areas include Marysville, Lynnwood, Lake Forest Park and Tacoma, which are largely urban-suburban residential areas, and the Duwamish, Puyallup South and Kent Valley areas, which are more industrialized areas.

Table 4 displays the top 5% of concentrations at the South L Street Monitor from 2004-2007 from EPA's Air Quality System (AQS) repository of ambient air quality data. All of these concentrations occurred during the months of November, December, January or February with the exception of one which occurred in late October, 2007. The exceedences at the South L Street monitor occur during the winter as the State suggests in its nine factor analysis.

Table 4. Top 5% values at Tacoma L Street Monitor from 2004-2007

Top 5% PM2.5 Values at L Street FRM for 2004-2007								
Rank	Date	ug/m3	Date	ug/m3	Date	ug/m3	Date	ug/m3
1	11/4/2004	57.00	12/15/2005	45.50	12/16/2006	68.00	1/15/2007	58.60
2	11.20/2004	51.30	12/6/2005	43.50	12/31/2006	50.20	2/2/2007	46.70
3	1/7/2004	43.70	11/15/2005	40.50	12/28/2006	42.70	11/23/2007	45.20
4	11/13/2004	39.50	2/9/2005	40.30	2/19/2006	33.70	1/12/2007	44.70
5	1/13/2004	33.50	1/25/2005	39.00	12/19/2006	32.60	1/30/2007	38.20
6	12/23/2006	31.90	12/9/2005	38.70	11/1/2006	32.30	10/27/2007	31.70
7			2/21/2005	38.70				

Figure 7. Puget Sound Area monitor locations



Speciation Profiles

The State submitted chemical speciation monitoring data collected at the Tacoma South L Street monitoring site in the year 2006. Fifty nine (59) samples were collected (one sample every six days). Out of these 59 samples, four samples were for days above 30 µg/m^3, and 55 samples were for days that were below 20 µg/m^3. Figure 8 displays percentage of the speciated components of total $PM_{2.5}$ for the two highest days in 2006 for which the speciation data was collected. On December 19th, 21.57 µg/m^3 (74%) of the total $PM_{2.5}$ was organic and elemental carbon. Sulfate and nitrate were .87 µg/m^3 (3%) and 1.86 (6%) respectively of the total PM $_{2.5}$. On December 31, 37.67 µg/m^3 of $PM_{2.5}$ (69%) was organic carbon, 2.86 µg/m^3 was elemental carbon (5%), 1.94 (4%) was sulfate and 1.54 µg/m^3 (3%) was nitrate.

Figure 8. Speciated components of Total $PM_{2.5}$ from the Tacoma South L Street Monitor on high days in 2006

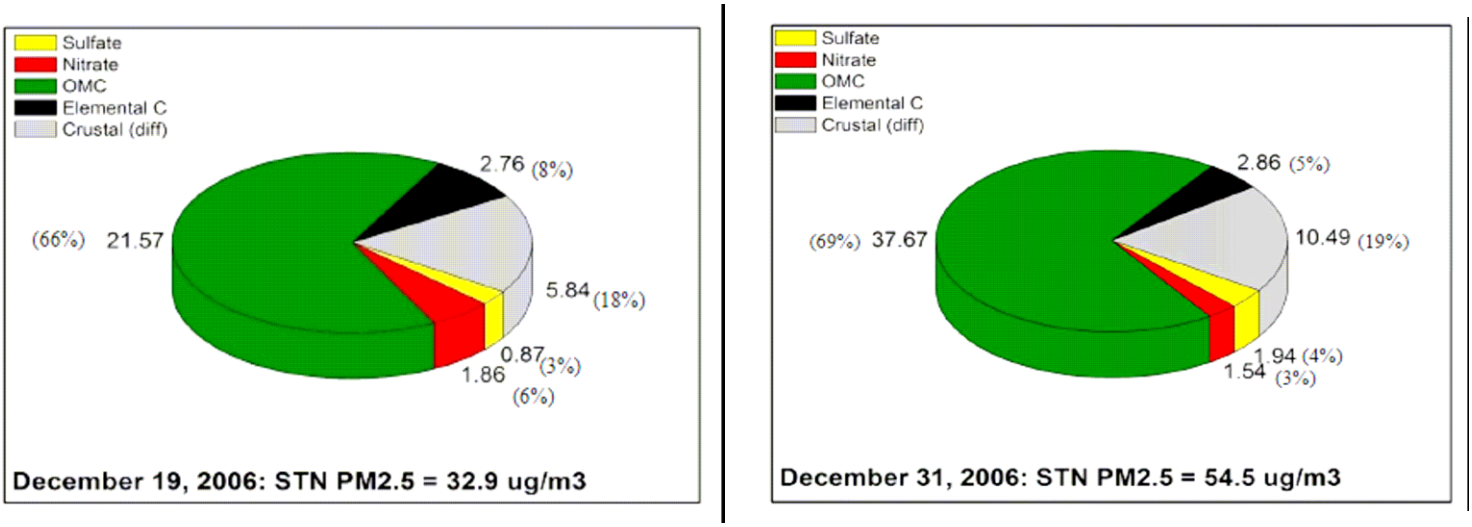
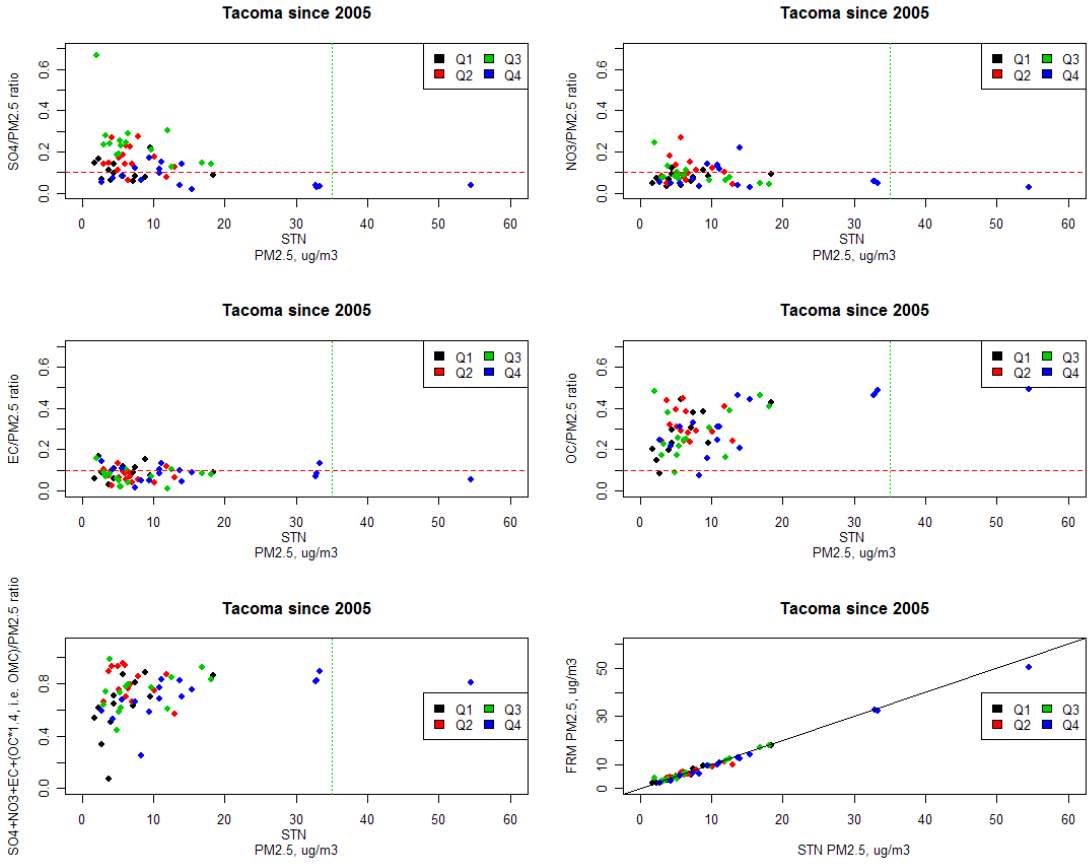


Figure 9 is a plot of $PM_{2.5}$ fraction components by season against $PM_{2.5}$ concentration. The highest concentrations of $PM_{2.5}$ occur at the L Street monitor in November and December. During the first (Jan- March) and fourth (Oct-Dec) quarters when the exceedences occur, the ratios of sulfate and nitrate with total $PM_{2.5}$ are generally less than 0.2. The highest ratios of sulfate and nitrate to total $PM_{2.5}$ (above 0.2) occur in the second (April-June) and third (June-August) quarters when $PM_{2.5}$ concentrations are less than 15 µg/m^3. The organic carbon fraction to total $PM_{2.5}$ ratio is highest of any component at all times during the year ranging from 0.2-0.5). In the fourth quarter, the OC/total PM reaches its highest levels when $PM_{2.5}$ concentrations are greater than 30 µg/m^3.

Figure 9. Seasonal PM2.5 components collected at the South L Street monitor in 2006.



Positive Matrix Factorization analysis of chemical components on Pierce County filter

Since an analysis of chemical speciation data for high PM2.5 days at the South L Street monitor in 2006 was an important part of the State's submittal, EPA evaluated the State's submittal of speciation data for the South L Street site using the Positive Matrix Factorization (PMF) tool. PMF is one of the receptor models that EPA's Office of Research and Development has developed to provide scientific support for current ambient air quality standards and for implementation of those standards by identifying and quantifying contributions for source apportionment. This model draws from ambient air quality data sets and receptor model algorithms to compute profiles and relative contributions from different source categories. See http://www.epa.gov/heasd/products/pmf/pmf.htm.[6] This evaluation using the PMF tool also supplements the speciation data and other information provided by the State on source contributions to the violations at the South L Street monitor by providing information on categories of sources and relative contributions from these sources to the violations at the South L Street Federal Reference Monitor. This analysis was particularly informative in our evaluation of the unique Tacoma area PM 2.5 pollution problem where the State's submittal suggests localized sources cause and contribute to the violations at the South L Street monitor and where, as explained above, and distinct from most other areas in the country we have evaluated, the CES tool had limitations for the area. Additionally, and as explained above, our final boundary determination for this area is based on a myriad of factors and various analyses, only one of which is a PMF analysis. Taken together with other data and facts analyzed and explained in detail elsewhere in this document, it helps us to better understand the types of source categories which cause or contribute to the PM2.5 pollution in the Tacoma area.

The 2006-07 PMF data set included 111 data points (a sample every 6th day), most of which was the same period that the State used in their speciation monitoring study of the area. EPA's evaluation of this dataset using PMF indicates relative source contributions that support the State's analysis of the chemical speciation and other air quality data which indicates that smoke from woodstoves and fireplaces is the major contributor to PM2.5 on high days at the South L Street monitor. PMF results indicate that wood smoke contributed 60-90% of the mass on 6 out of 7 days when total PM2.5 mass exceeded 30 μg/m3. See Table 5. More detailed information on the PMF analysis for the South L Street monitor is included in the docket for this action.

[6] Positive matrix factorization (PMF) (Footnoted: A. Reff et al, "Receptor Modeling of Ambient Particulate Matter Data Using Positive Matrix Factorization: Review of Existing Methods," Journal of the Air and Waste Management Association, 57:146-154, February 2007.) is a recent development in the class of data analysis techniques called factor analysis, in which the fundamental problem is to resolve the identities and contributions of components in an unknown mixture. PMF has been used extensively for source apportionment of ambient particulate matter (PM), to resolve the mixture of sources that contributes to PM samples. PMF is especially applicable to working with environmental data because it incorporates the variable uncertainties often associated with measurements of environmental samples, and forces all of the values in the solution profiles and contributions to be nonnegative, which is more realistic than solutions from previously used methods like principal components analysis.

Table 5. Positive Matrix Factorization Results for L Street monitor for days over 30 in 2006 and 2007

Date	Nitrate	Soil	Sulfate	Marine	Mobile	Smoke	% Smoke
11/1/06	1.46	4.76	0.70	0.04	5.39	23.14	65
12/19/06	2.87	1.50	0.00	0.08	2.64	22.77	76
12/31/06	0.71	1.04	2.11	0.03	0.71	43.73	90
1/12/07	5.97	0.00	0.00	0.11	2.23	28.80	78
1/30/07	5.47	4.94	1.20	0.05	3.47	26.75	64
10/27/07	3.79	1.82	1.69	0.09	4.27	18.05	61
11/8/07	5.10	4.24	4.84	0.04	5.77	9.93	33

Comparison with monitoring data from other sites in King County

Figure 10 contains seasonal $PM_{2.5}$ components from two monitors, one in an industrialized area the southern portion of King County (Duwamish) and the other in northern King County in a residential area, Lake Forest Park. The Lake Forest Park monitor is a neighborhood scale site and is representative of the Lake Forest Park general area.[7] Figure 11 shows the location of these monitors in relation to the South L Street Monitor in Tacoma. The Duwamish monitor is about 30 miles north of the South L Street Monitor and the Lake Forest Park Monitor is about 50 miles north of the South L Street Monitor.

The Lake Forest Park monitor generally shows the same pattern observed at the South L Street monitor. Organic carbon dominates all fractions but the highest (>20 ug/m3 occur) fraction occurs in the first and fourth quarters. The highest fractions of sulfate and nitrate occur in the second and third quarters of the year when $PM_{2.5}$ concentrations are lowest (generally below 10). The Duwamish monitor shows a shift upward of sulfate/ $PM_{2.5}$ ratio for all quarters. Ratios of sulfate to total $PM_{2.5}$ are more consistent throughout the year at the Duwamish monitor and generally range between .1-.3. The data points at this monitor are more tightly clustered showing less seasonal variation then at the Lake Forest Park and Tacoma monitor.

[7] Washington State Department of Ecology 2008 Ambient Air Monitoring Network Report

Figure 10. Seasonal $PM_{2.5}$ components at Lake Forest Park and Duwamish since 2005

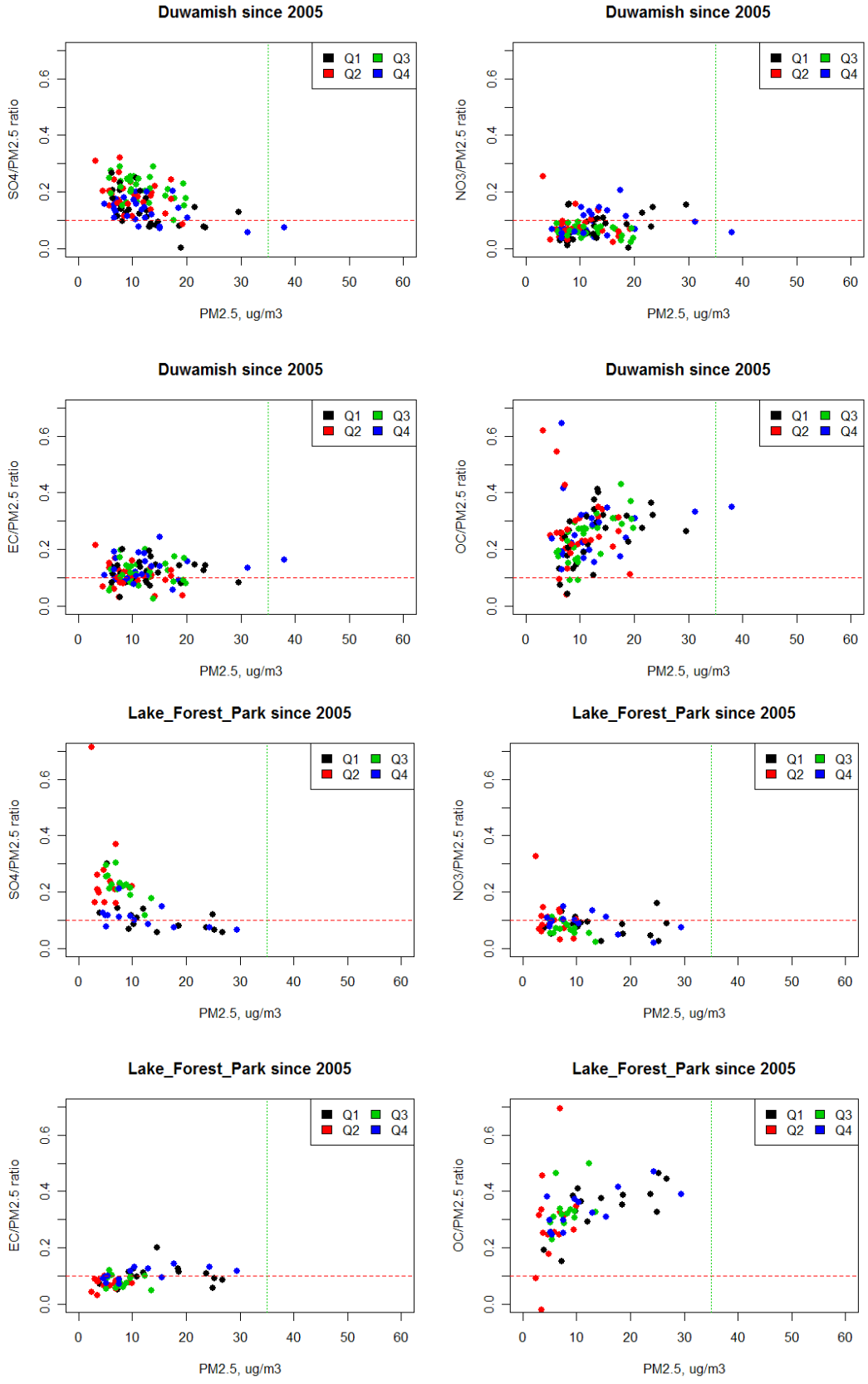
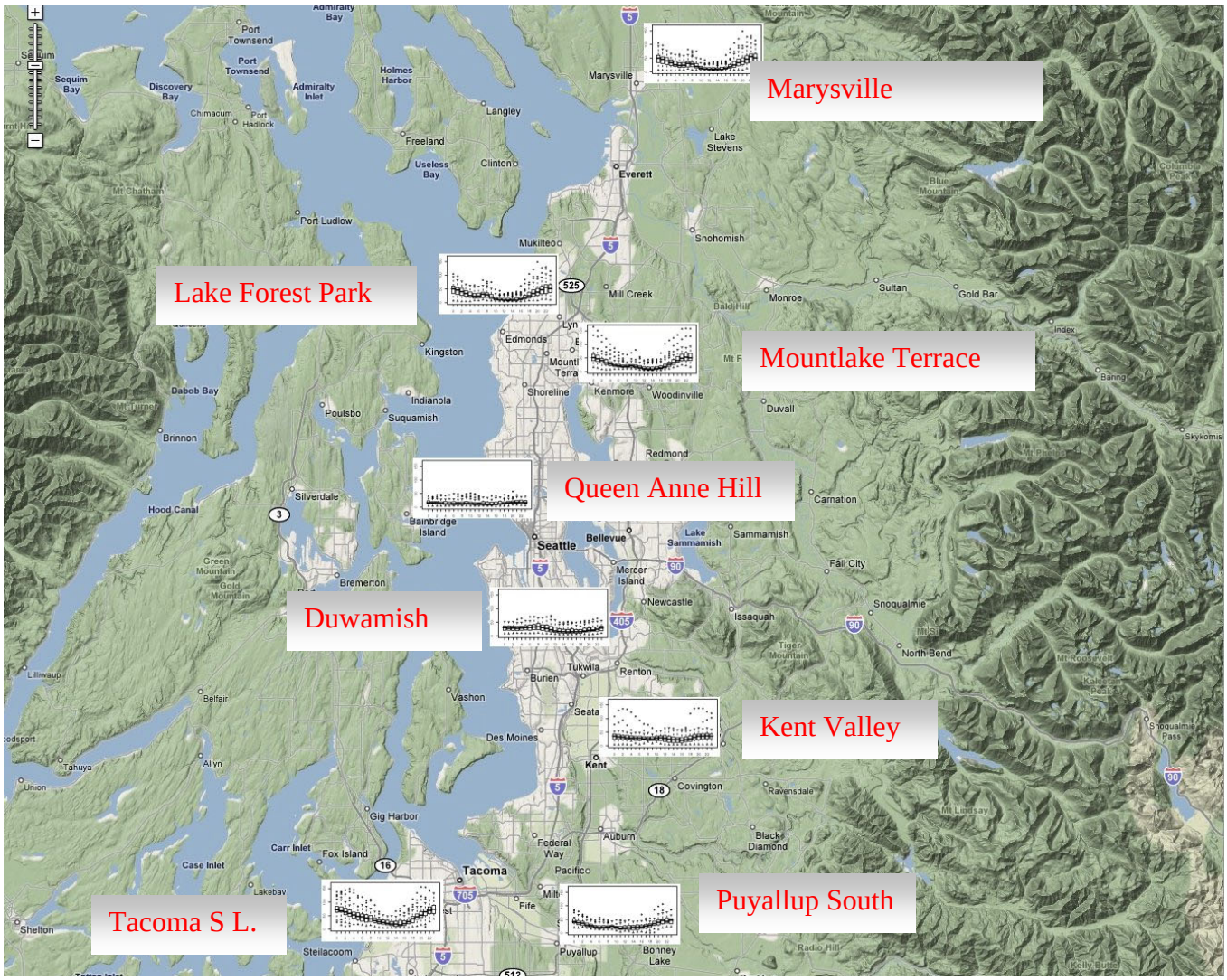


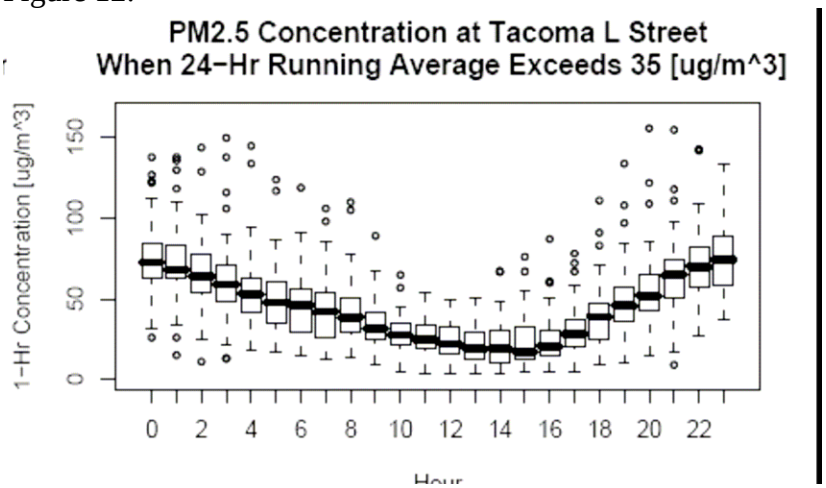
Figure 11. Location of monitors in the Southern Puget Sound Area

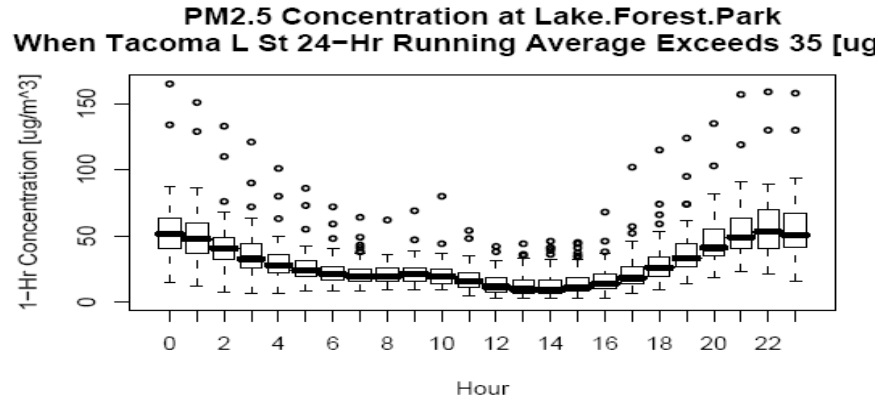


Diurnal Profiles

Figures 12-14 display diurnal $PM_{2.5}$ concentrations at continuous monitors throughout the Puget Sound Area. Figure 12 shows diurnal $PM_{2.5}$ concentrations at the South L Street monitor for the period 2001-2007. PM concentrations at the South L Street monitor rise sharply beginning in the late afternoon and then peak around midnight then tail off around mid day. Survey data from Washington State indicate that this profile is related to woodstove use[8]. Surveys indicate that individuals ignite or add fresh fuel in the late afternoon or early evening and often add fuel before bedtime resulting in peak concentrations at night and lowest concentrations during the day while individuals are away from home. The diurnal profile for the Lake Forest Park monitor (Figure 13) shows a similar "V" shaped profile to the profile observed at the L Street monitor while the profile while the profile for the Duwamish monitor (Figure 14) is relatively flat. Figure 15 is a map of the monitors throughout the Puget Sound area with diurnal profiles. The "V" shaped profile is observed at monitors in the communities in Snohomish County to the North (Lynnwood, Lake Forest Park and Marysville). A flatter profile is observed at the monitors in central and southern King County; the Queen Anne monitor, the Seattle Duwamish Valley monitor and the Kent Valley monitor.

Figure 12.





[8] Puget Sound Clean Air Agency 2007 woodstove use survey

Figure 14.

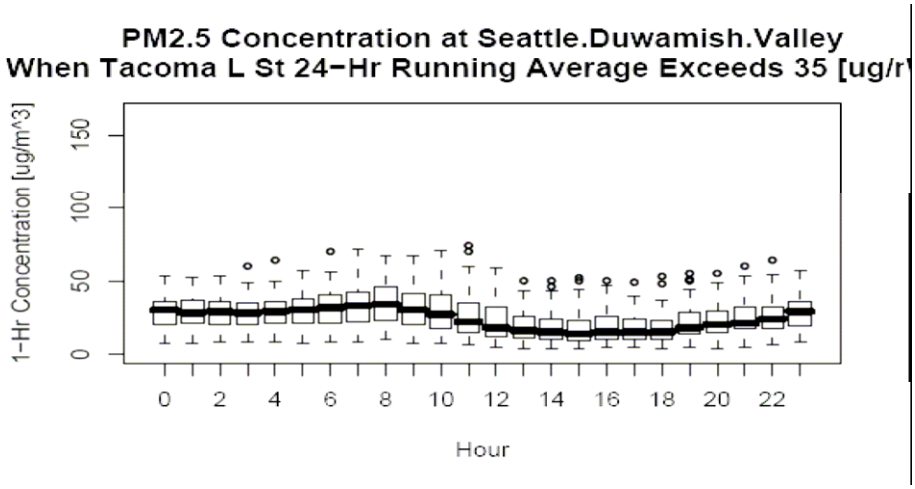


Figure 15. Diurnal profiles at monitoring sites in Pierce, King and Snohomish Counties

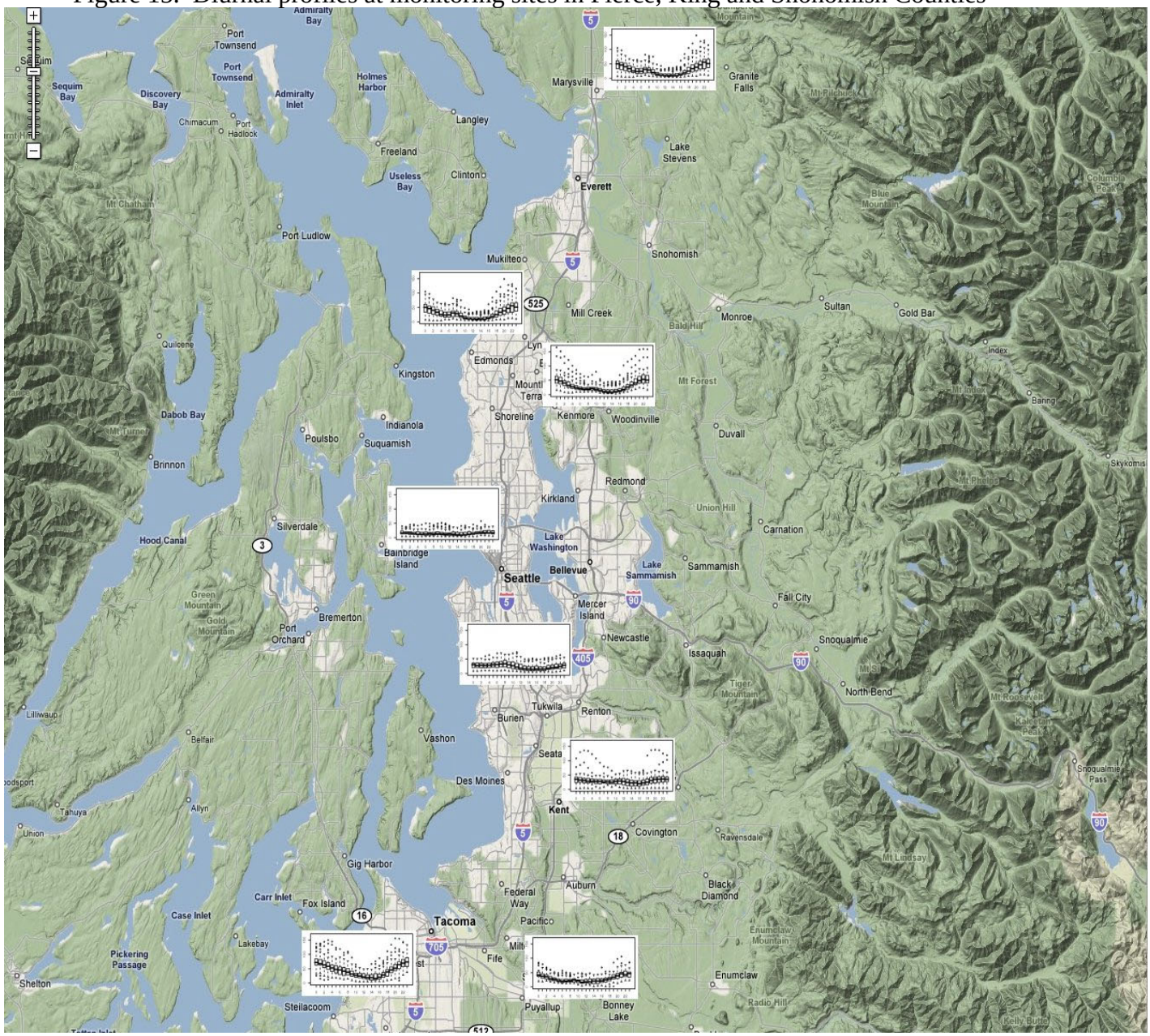


Figure 16 plots one hour averages from a co-located nephelometer at the Tacoma L Street monitor during an episode. On January 12, 2007 the 24-hour design value at the L Street monitor was 44.7 µg/m^3 and on January 15, 2007, the 24-hour design value at the L Street monitor was 58.6 µg/m^3. The red line indicates the 24-hour standard, 35 µg/m^3. Peak $PM_{2.5}$ during this episode occurred around midnight on January 13 and January 15. During the day of the 12th and the 13th $PM_{2.5}$ levels dropped to less than 10 µg/m^3. The pattern repeats with nighttime highs climbing well above the standard and daytime lows.

When this pattern is observed at Tacoma, an identical pattern is noted at the other monitors throughout the Region with the V shaped profile. In between events, $PM_{2.5}$ levels generally drop to very low levels (<10 µg/m^3) indicating that there is not significant transport of PM precursors from other areas (Figure 18). Days that do not drop to very low levels are days where inversions have not broken down completely.

Figure 16. $PM_{2.5}$Tacoma L Street January 11-16 2007

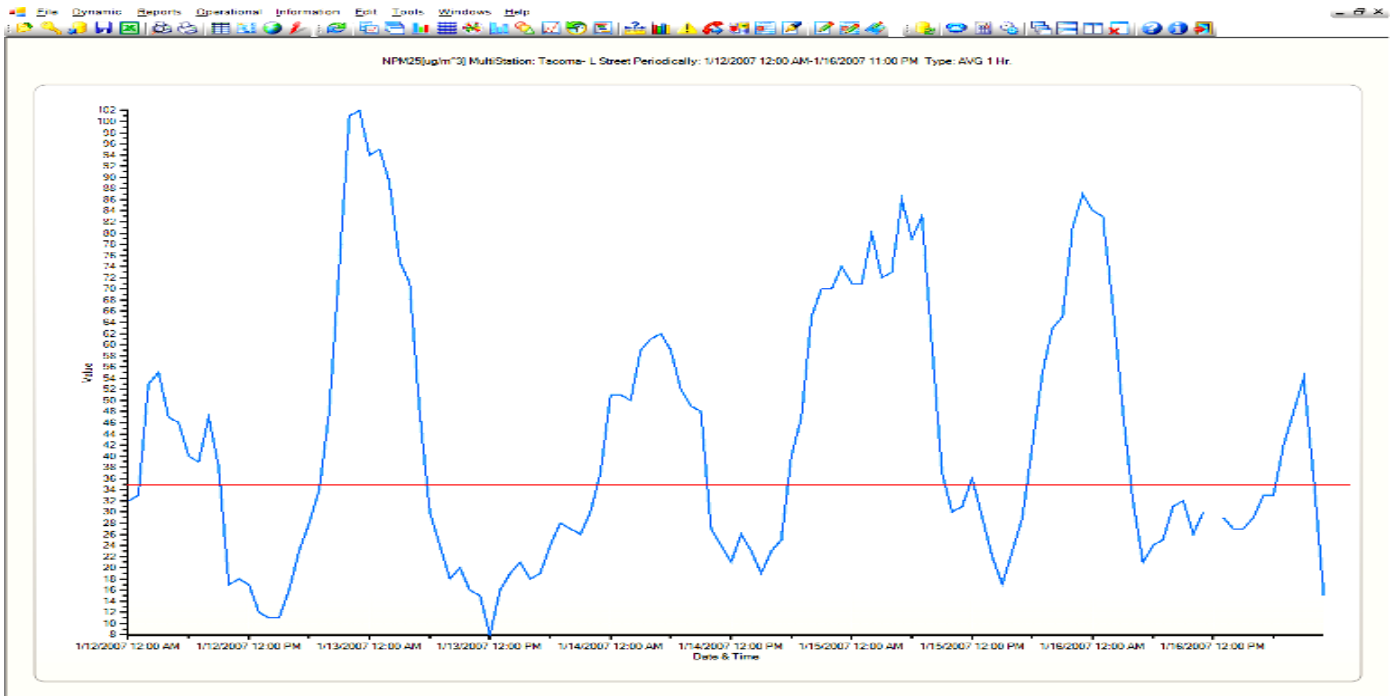
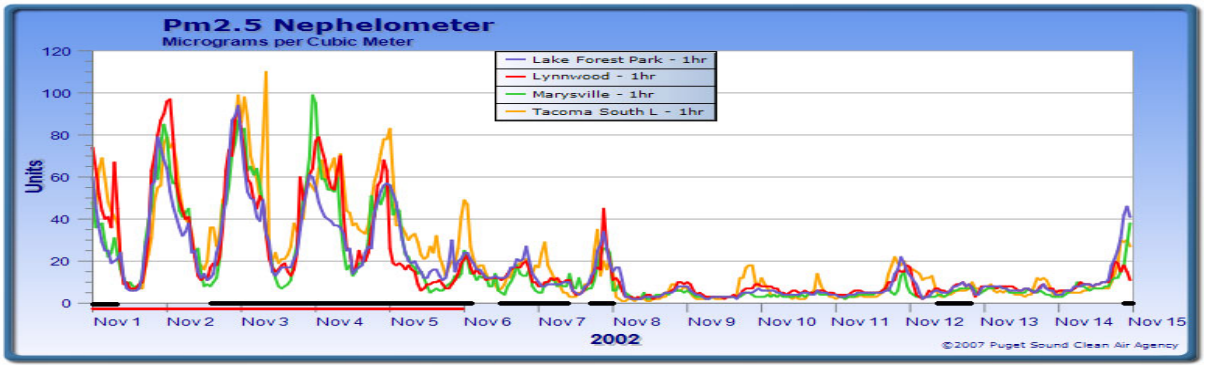


Figure 17. Simultaneous $PM_{2.5}$ peaks at Southern Puget Sound monitors



Air Quality Data Discussion/Conclusions

Concentrations of $PM_{2.5}$ throughout the Southern Puget Sound area peak at night and in the winter. The diurnal patterns are observed at neighborhood scale monitors in Pierce and King County and show peaks consistent with use of woodstoves collected through woodstove surveys. Monitors in the more industrial areas in southern King County (Kent and Duwamish) between the neighborhood scale monitors to the north and the South L Street monitor to the south do not exhibit strong diurnal patterns consistent with woodstove use surveys. Seasonality of sulfate and nitrate concentrations at these monitors is also less variable than the seasonality of sulfate, nitrate and organic carbon observed at the South L Street monitor and other neighborhood monitors (Lake Forest Park). The diurnal profiles and seasonality of organic carbon (components that are associated with burning of wood) indicate that emissions from woodstoves and fireplaces contribute to elevated wintertime concentrations in residential areas such as the South L Street and Lake Forest Park areas.

Based on EPA's PMF analysis, organic carbon/woodstoves contribute 60-90% of $PM_{2.5}$ to the exceedences at the South L Street Monitor. Contributions of regional $PM_{2.5}$ precursors (SOx and NOx) that dominate the King County emissions inventory contribute less than 20-30% of total $PM_{2.5}$ to the Tacoma monitor. Based on speciation monitoring at the South L Street monitoring site, organic carbon and elemental carbon contribute over 70% of the $PM_{2.5}$ concentration on the highest days in 2006 and sulfate and nitrate contribute less than 10% combined of the total $PM_{2.5}$ concentration on these days. Based on speciation monitoring, emissions from King County (over 75,000 tpy NOx and 7500 tpy SOx) as well as emissions from the other counties in the CMSA potentially contribute less than 10 % of total $PM_{2.5}$ concentrations on high days at the South L Street Monitor.

Based on the foregoing analyses, EPA concludes that sources contributing the violations of the $PM_{2.5}$ exceedences at the South L Street monitor are predominantly local sources dominated by woodstove and fireplace emissions in the Tacoma area and not transport from King County or other counties in the Seattle-Tacoma-Olympia area.

This information along with the information discussed in the other factors, particularly factors 6 and 7 (meteorology and topography) was used to determine that the partial Pierce County boundary submitted by the State on March 13, 2008 is sufficiently large enough to contains sources contributing to the 24-hour $PM_{2.5}$ violations at the South L Street monitor.

Factor 3: Population density and degree of urbanization (including commercial development)

Table 6 shows the 2005 population for each county in the Seattle-Tacoma-Olympia area being evaluated, as well as the population density for each County in that area. Population data give an indication of whether it is likely that population-based emissions might contribute to violations of the 24-hour $PM_{2.5}$ standards. King County, Pierce County and Snohomish County contain large cities with large populations. Most of the areas in between are urban or suburban. The City of Everett is the largest city in Snohomish County. King County has the highest population (1.79 million) and the highest population density with 824 people/square mile. Pierce County has the next highest population at 753,209 with the third highest population density in the Seattle-Tacoma-Olympia area. Snohomish County has the third highest population in the area. King County and Pierce Counties have the highest CES scores at 100 and 60 respectively. The CES Score for Snohomish County is much lower at 13.

Table 6. Population in the Puget Sound area

County	State Recommended Nonattainment?	2005 Population	2005 Population Density (people/sq mi)	Percent Population Change (2000-05)
King	No	1,799,119	824	3
Pierce	Yes	753,209	445	7
Thurston	No	228,881	305	10
Kitsap	No	241,525	583	4
Snohomish	No	655,564	312	8
Skagit	No	113,181	65	9
Island	No	79,983	377	11
Mason	No	54,169	54	9

The State addressed population density in its nine factor analysis. Figure 18 shows population density for the city of Tacoma and surrounding Pierce County areas, at the 2000 census block group level. In Pierce County, the highest population density occurs inside of the Comprehensive Urban Growth Area (CUGA) in the vicinity of the L Street monitor, and along the eastern shore of the Puget Sound to the north of the Port of Tacoma. [9] Population density generally decreases to the south and the east of the Port of Tacoma and the CUGA. Figure 19 shows the population of the recommended nonattainment area and the surrounding portions of Pierce County.

Based on the air quality data we reviewed above and the additional factors that we review below which indicate that local sources cause the violations at the South L Street monitor, and based on population data which indicate that the highest population density in the Pierce County area is within the Tacoma CUGA, EPA concludes that a boundary that includes populations/potential sources in the Tacoma CUGA is appropriately large enough to include populations and sources contributing to the violations at the South L Street monitor.

[9] See Chapter 36.70A RCW for more on the Washington State Growth Management Act which defines an urban growth area or areas within which urban growth shall be encouraged and outside of which growth can occur only if it is not urban in nature.

Figure 18.

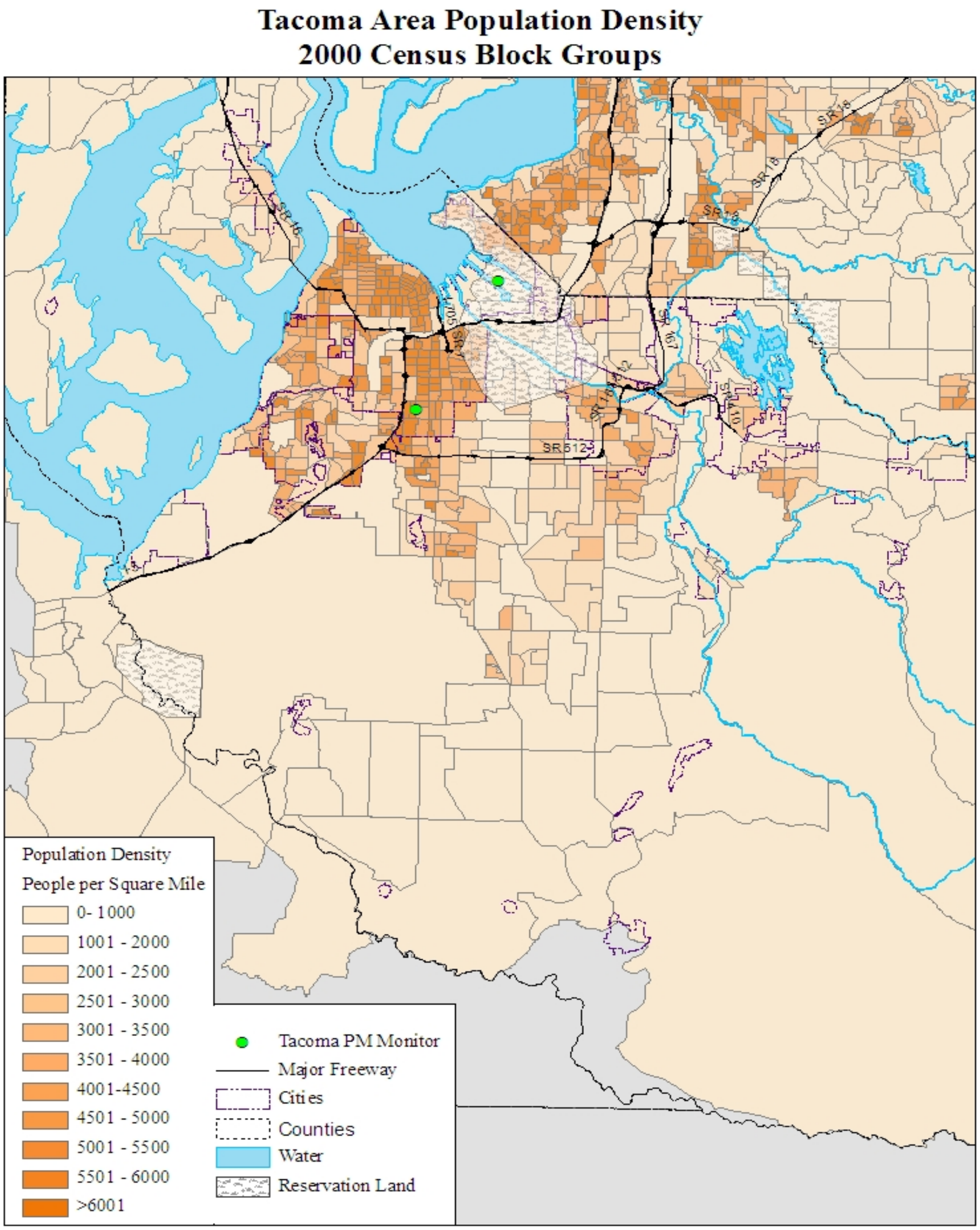
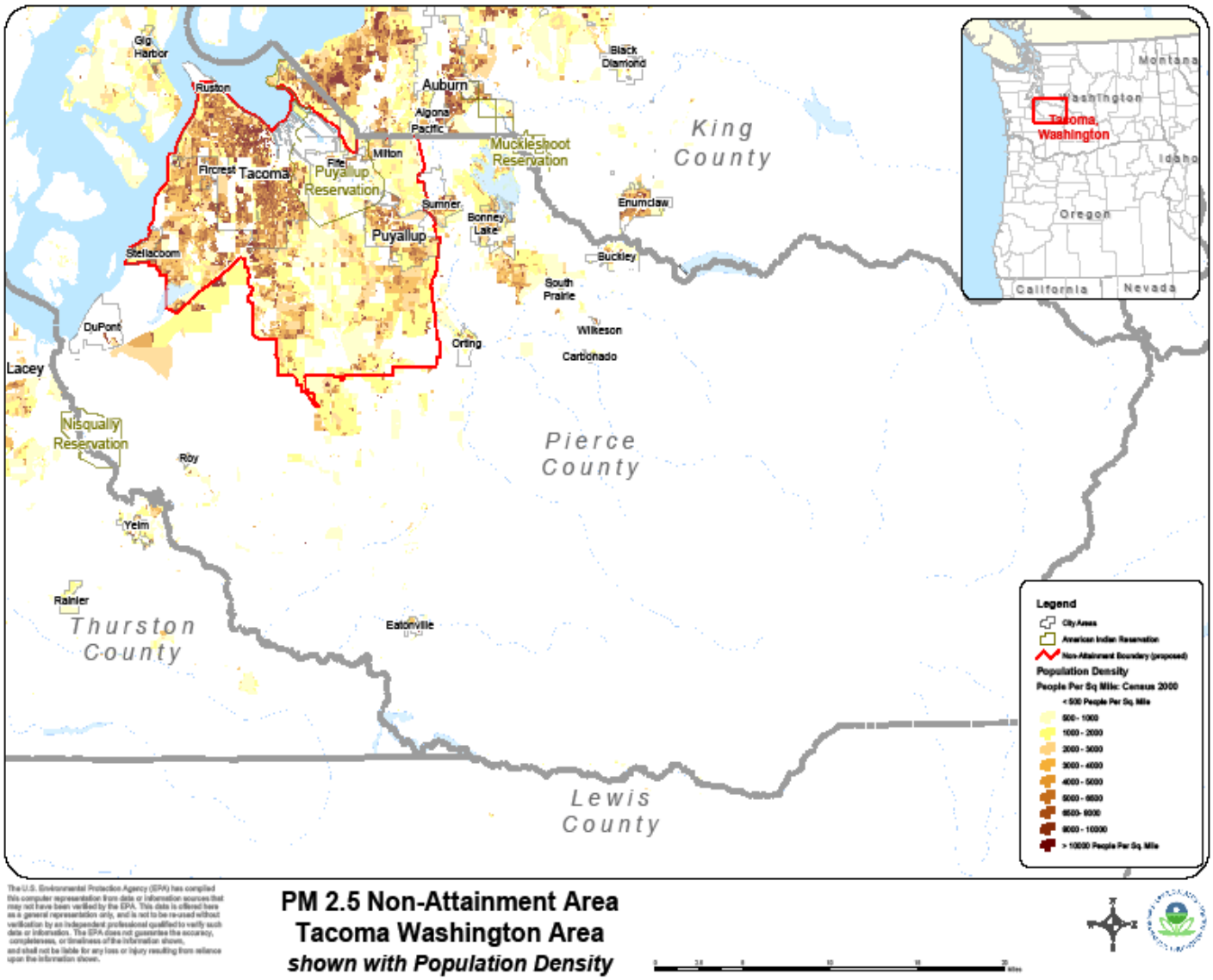

Tacoma Area Population Density
2000 Census Block Groups
SR 16
SR 18
I-705
SR 167
SR 512
Population Density
People per Square Mile
0- 1000
1001 - 2000
2001 - 2500
2501 - 3000
3001 - 3500
3501 - 4000
4001-4500
4501 - 5000
5001 - 5500
5501 - 6000
>6001
Tacoma PM Monitor
Major Freeway
Cities
Counties
Water
Reservation Land

Figure 19. Pierce County Population Density with recommended nonattainment area boundary



Factor 4: Traffic and commuting patterns

This factor considers the number of commuters in each county who drive to another county within the Seattle-Tacoma-Olympia area, the percent of total commuters in each county who commute to other counties within the Seattle-Tacoma-Olympia area, as well as the total Vehicle Miles Traveled (VMT) for each county in millions of miles (see Table 7). A county with numerous commuters is generally an integral part of an urban area and could be an appropriate

county for implementing mobile-source emission control strategies, thus warranting inclusion in the nonattainment area. [10]

Table 7. Traffic and commuting patterns in the Puget Sound area

County	State recommended Nonattainment?	Vehicle Miles Traveled in 2005 (millions annually)	Percent VMT Growth (1996-2005)	Number commuting into any violating counties	Percent commuting into any violating counties	Number commuting into and w/in the statistical area	Percent commuting into and w/in the statistical area
King	No	16,806	10	18,560	2	903,520	99
Pierce	Yes (P)	6,247	13	228,280	70	319,830	99
Thurston	No	2,146	7	14,350	14	96,030	95
Kitsap	No	1,633	(10)	5,120	5	104,640	98
Snohomish	No	5,225	9	1,240	0	296,750	99
Skagit	No	1,185	35	140	0	42,950	95
Island	No	397	(5)	50	0	31,510	97
Mason	No	438	13	860	5	18,310	97

The listing of Counties on Table 7 reflects a ranking based on the number of people commuting to other counties. King County VMT in 2005 was the highest in the area with historic VMT growth of 10%. Two percent of commuters from King County commute into Pierce County, the County with the violating monitor. Seventy percent of commuters in Pierce County remain within Pierce County. VMT growth in Pierce County between 1996-2005 was 13%. Both King County and Pierce County contain major ports (the Port of Tacoma and the Port of Seattle), so there are increased levels of diesel traffic to move goods at the Ports. Interstate 5 is a major N-S corridor along the West Coast of the United States with significant diesel truck traffic.

Washington looked at Pierce County VMT growth in its nine factors analysis. Washington obtained information from the Puget Sound Regional Council's recently released draft Vision 2040 transportation plan for the region, incorporating known travel improvements and the preferred growth options emphasizing core centers for development. The output from PSRC's transportation demand model provides some travel growth estimates for the Pierce County area and is shown in Table 8.[11]

[10] Note: The 2005 VMT data used for table 5 and 6 of the 9-factor analysis has been derived using methodology similar to that described in "Documentation for the final 2002 Mobile National Emissions Inventory, Version 3, September 2007, prepared for the Emission Inventory Group, U.S. EPA. This document may be found at: at ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/mobile/2002_mobile_nei_version_3_report_092807.pdf The 2005 VMT data were taken from documentation which is still draft, but which should be released in 2008.

[11] Puget Sound Regional Council. Draft Vision 2040 Supplemental Draft Environmental Impact Statement (SDEIS). July 2007. http://www.psrc.org/projects/vision/pubs/sdeis/index.htm and http://www.psrc.org/tpbgrowthandtrans2.pdf. Puget Sound Regional Council. Vision 2020 Update DEIS. Transportation Demand Model Output Data. Appendix D-5, pages D-18 to D-29. http://www.psrc.org/projects/vision/deis/appd.pdf.

Table 8. Pierce County Daily Travel Measures by Category in 2000 and 2040

Daily Category of Travel	2000 Reference Data	2040	Units
Work Person Trips	293,886	535,330	Trips
Non-work Person Trips	1,757,784	3,183,447	Trips
Freeways Vehicle Miles Traveled	6,288,090	8,870,622	VMT
Arterials/Local Streets VMT	10,650,108	16,299,840	VMT
Freeways Vehicle Hours Traveled	129,929	191,106	VHT
Arterials/Local Streets VHT	363,175	617,769	VHT

Even with planned road and transit improvements, work and non-work person trips are estimated to increase by over 80%, while vehicle miles traveled and vehicle hours traveled are estimated to increase by 40% and 60%, respectively, from 2000 to 2040. Based on EPA's PMF analysis of air quality data, mobile emissions likely do not contribute more than 5-10% of total $PM_{2.5}$ at the L Street monitor on high days. The State's boundary includes potential mobile source related contributions in the Tacoma area including the Port of Tacoma as well as sections of Interstate 5 and State Highway 99 and EPA has concluded that the inclusion of these areas is sufficient to capture potential contributions from these sources.

Note: The 2005 VMT data used for table 5 and 6 of the 9-factor analysis have been derived using methodology such as that described in "Documentation for the 2005 Mobile National Emissions Inventory, Version 2," December 2008, prepared for the Emission Inventory Group, U.S. EPA. This document may be found at: ftp://ftp.epa.gov/EmisInventory/2005_nei/mobile_sector/documentation/2005_mobile_nei_version_2_report.pdf

Factor 5: Growth rates and patterns

This factor looks at expected population and VMT for Counties in the Seattle-Tacoma-Olympia area from 2000 to 2005, as well as patterns of population and VMT growth. A county with rapid population or VMT growth is generally an integral part of an urban area and could be contributing to fine particle concentrations in the area.

Table 9 below shows population, population growth, VMT and VMT growth for counties that are included in the Seattle-Tacoma-Olympia area. Counties are listed in descending order based on VMT growth between 1996 and 2005.

Table 9. Population and VMT Growth and Percent Change

County	2005 Population	Percent Population Change (2000-05)	Vehicle Miles Traveled in 2005 (millions annually)	Percent VMT Growth (1996-2005)
King, WA	1,799,119	3	16,806	10
Pierce, WA	753,209	7	6,247	13
Thurston, WA	228,881	10	2,146	7
Kitsap, WA	241,525	4	1,633	(10)
Snohomish, WA	655,564	8	5,225	9
Skagit, WA	113,181	9	1,185	35
Island, WA	79,983	11	397	(5)
Mason,WA	54,169	9	438	13

King County has the highest population but had the lowest population growth rate from 2000-2005 (3%). Pierce County population growth was double that of King County for the same time period. Thurston County and Island Counties experienced the highest growth in population from 2000-2005 at 10% and 11% respectively. However, the population of both of these areas is 1-2 orders of magnitude lower than that of King County and 3-8 times lower than that of Pierce County. As stated above, based on air quality data, mobile emissions likely do not contribute more than 5-10% of total $PM_{2.5}$ to L Street monitor $PM_{2.5}$ concentrations on high days. EPA's final boundary includes most of the Pierce County Growth area including the Port of Tacoma.

Factor 6: Meteorology (weather/transport patterns)

For this factor, EPA considered data from National Weather Service instruments in the area. Wind direction and wind speed data for 2005-2007 were analyzed, with an emphasis on "high $PM_{2.5}$ days" for each of two seasons (an October-April "cold" season and a May-September "warm" season). These high days are defined as days where any FRM or FEM air quality monitors had 24-hour $PM_{2.5}$ concentrations above 95% on a frequency distribution curve of $PM_{2.5}$ 24-hour values.

For each air quality monitoring site, EPA developed a "pollution rose" to understand the prevailing wind direction and wind speed on the days with highest fine particle concentrations. The figure identifies 24-hour PM2.5 values by color; days exceeding 35 ug/m3 are denoted with a red or black icon. A dot indicates the day occurred in the warm season; a triangle indicates the day occurred in the cool season. The center of the figure indicates the location of the air quality monitoring site, and the location of the icon in relation to the center indicates the direction from which the wind was blowing on that day. An icon that is close to the center indicates a low average wind speed on that day. Higher wind speeds are indicated when the icon is further away from the center.

Figure 20 is a pollution rose from instrumentation at Boeing Field, a King County airport which is located about 24 miles north of the violating monitor. Based on this pollution rose, the prevailing surface wind directions for the highest $PM_{2.5}$ days in King County are from the southeast of the Lake Forest Park monitoring site in King County.

Given terrain influence and complex meteorology in King County and Pierce County, it was important to look at data from a meteorological station located closer to the violating monitor. As mentioned above, the Boeing Field monitor is located 24 miles away from the South L Street monitor. EPA, therefore, also created a pollution rose using data from the McChord Air Force Base which is located about 3 miles southwest of the violating monitor. Figure 21 is the pollution rose created with the McChord data. Based on this pollution rose, during high days at the Tacoma L Street monitor, wind speeds are less than 2 miles per hour. Because of these low wind speeds we could not draw a conclusion on an average prevailing surface wind direction for high $PM_{2.5}$ days (exceeding 30 ug/m3). For days below 30 ug/m3 average prevailing winds are from the southwest. The low wind speeds as well as the direction of the average prevailing winds at the McChord indicate that emissions from King County are not likely contributing to the violations at the South L Street monitor.

Figure 20. Pollution Rose for King County WA (Source: Boeing Field)

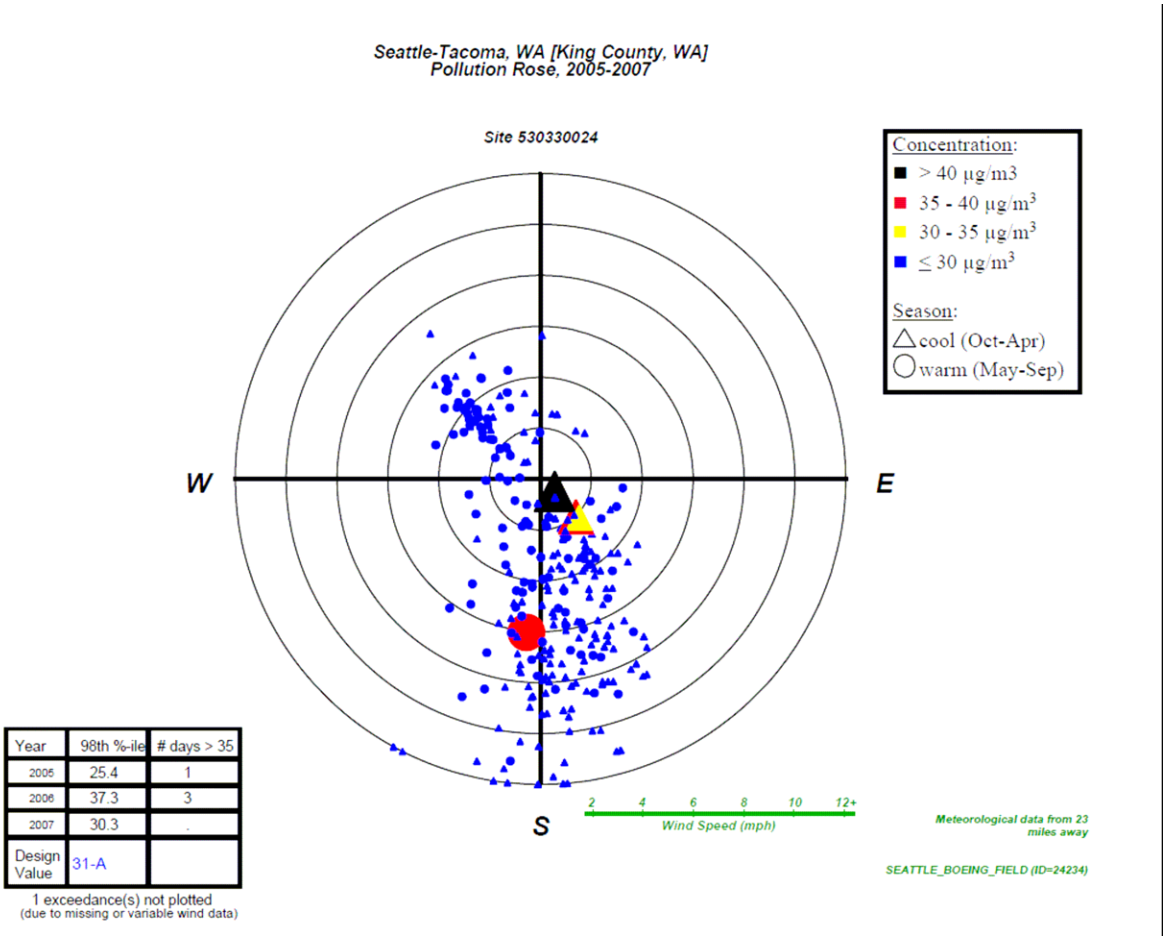
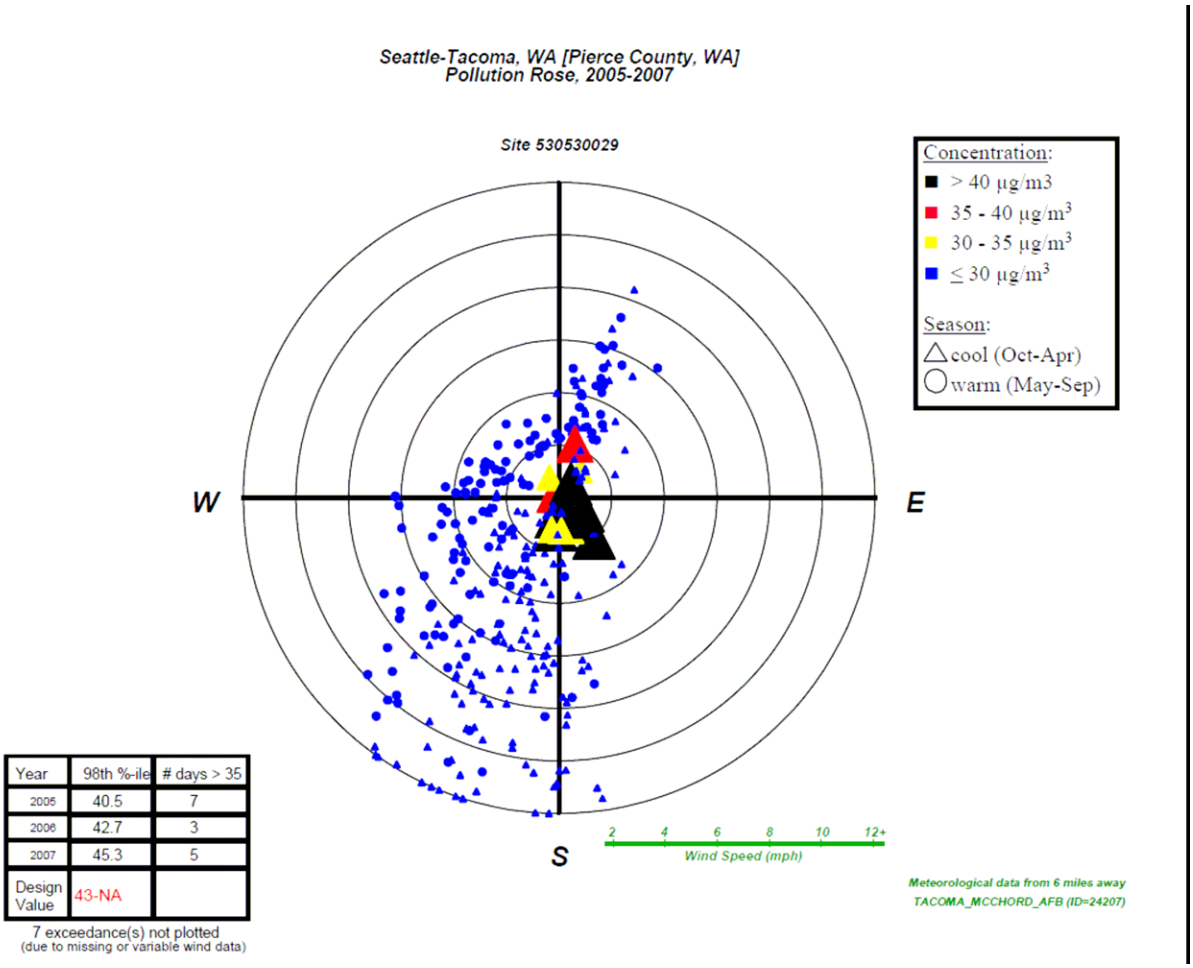


Figure 21. Pollution rose for Pierce County WA (Source: McChord AFB)



We note that the meteorology factor is also considered in each county's Contributing Emissions Score because the method for deriving this metric included an analysis of trajectories of air masses for high $PM_{2.5}$ days. The data used to create the CES for the Tacoma monitor was from the Seattle –Tacoma International Airport which is located 6 miles south of Boeing Field. Given the complex meteorology and topography of the area, and given that EPA's pollution roses for the McChord Air Force Base meteorological site and the King County Boeing Field Airport show very different wind patterns, EPA considered the data from the McChord Air Force Base meteorological site in lieu of the CES for the meteorological factor analysis for the Wapato Hills-Puyallup River Valley area**.**

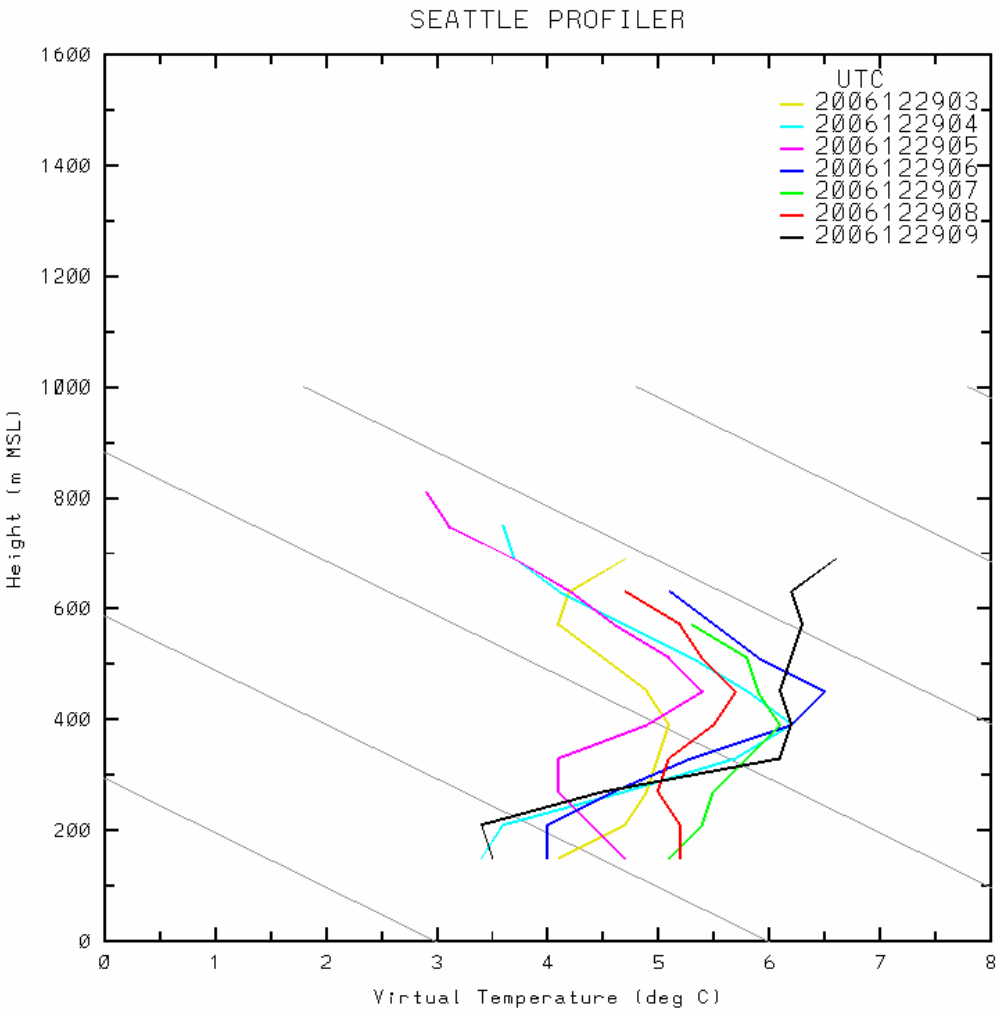
The wind rose from the McChord Air Force base demonstrates meteorological conditions in the Wapato Hills-Puyallup River Valley area during the fall and winter seasons when the exceedences occur at the South L Street monitor. During this time, regional air stagnations interrupt westerly wind flows and strong subsidence temperature inversions trap pollution levels and colder mean temperatures stimulate the use of residential heating devices.

Temperature inversions vary in intensity and can persist over a period of days. These inversions change the mixing layer depth dramatically but generally lower the layer to less than 800m. During persistent winter stagnations, mixing heights less than 300m are frequently observed typically these conditions occur when the duration of stable conditions extends beyond three days. [12] This occurs approximately 3-4 times during the fall and winter seasons.

Puget Sound Clean Air Agency, in coordination with the National Weather Service office in Seattle operates a radar wind profiler at the Sand Point Laboratory of the NOAA. Figure 22 displays the mixing height during the typical stagnation event in the Puget Sound area. Mixing heights at 600 meters or less are observed during the typical $PM_{2.5}$ event.

[12] A Presentation to Northwest AirQuest on Analysis of Sand Point Wind Profiler and RASS system, included in the docket for this action.

Figure 22. Typical inversion profile for the Southern Puget Sound Region stagnation



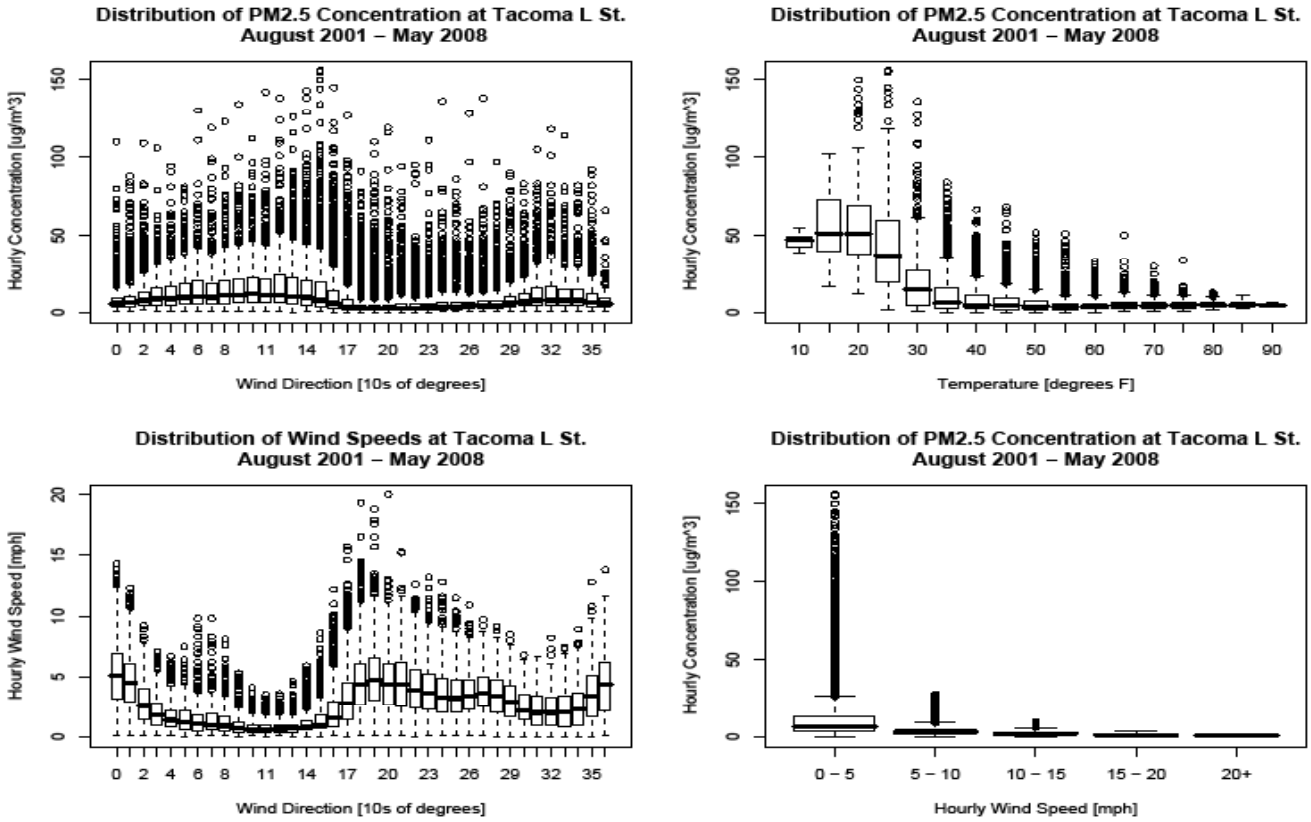
Air movement in the area surrounding the South L Street monitoring station is influenced by these meteorological conditions. Figure 26 plots wind direction against hourly concentrations, wind direction against wind speed, wind speed against hourly concentrations and temperature against hourly concentration data gathered from a 2001-2008 Washington State temporary monitoring study[13]. This data indicates that meteorological conditions that are present at the L Street Monitoring site are typical of those observed in the area's fall and winter seasons including periods influenced by moderate temperatures, strong Pacific storms, and air stagnations. Highest hourly concentrations occur at temperatures below freezing, highest concentrations are associated with winds below 5 mph and often times less than 1 mph, and the highest winds from

[13] Study results are included in the State of Washington's Nine Factors Analysis

the south and the southwest quadrant correspond to lowest $PM_{2.5}$ concentrations and the lowest winds from the east to southeast correspond to highest $PM_{2.5}$ concentrations.

EPA determined from this meterological data that transport from King County and other areas is not occurring during the periods of the highest concentrations and that a partial county boundary surrounding the South L Street monitor and capturing the sources in the Tacoma area within the CUGA is sufficiently large enough to sources of emissions that contribute to the violations at the South L Street monitor.

Figure 23. Hourly concentrations and wind speed at Tacoma L Street Monitor from 2001-2008



Factor 7: Geography/topography (mountain ranges or other air basin boundaries)

The geography/topography analysis evaluates the physical features of the land that might have an effect on the air shed and therefore on the distribution of $PM_{2.5}$ over the Wapato Hills-Puyallup River Valley/Tacoma area. Tacoma lies east of the Cascade Mountains, which act as a topographical barrier to pollution flow from east to west. The Olympic Mountains to the west result also influence pollution flow. Air flow from the west typically flows around the Olympics and converges in the Seattle Tacoma area. See Figure 24. This flow is interrupted during periods of stagnation during which low lying topographic features can influence the flow of pollution.

Local topography in the Tacoma area has an influence on pollutant transport. Figure 25 displays topography in the Tacoma area. The Port area of Tacoma is surrounded by bowl like topography. Beyond the Port to the north, hills rise to 400 ft creating a topographical barrier between the north and the south. The northernmost boundary occurs at the foot of this bluff along SR 509. Based on our review of topographical information, as well as air quality data which shows that local sources contribute to the violations at the South L Street monitor and meteorology data which indicates that wind speeds are less than 5 mph during exceedences, EPA's boundary follows the topographical bluff along SR 509 is sufficiently large enough to capture the sources in the area contributing to the violations at the South L Street monitor.

Figure 24. Seattle-Tacoma-Olympia area topography

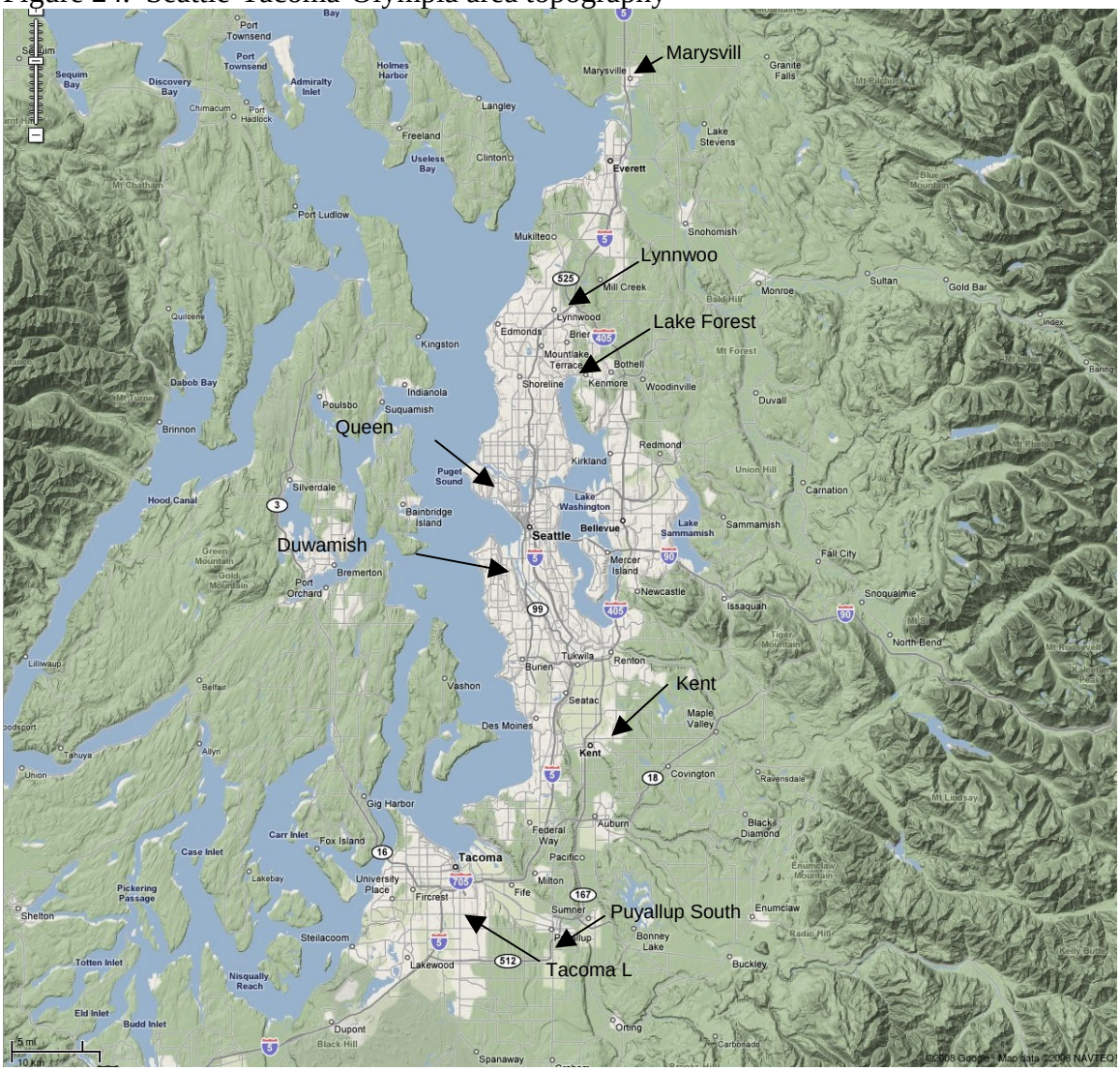
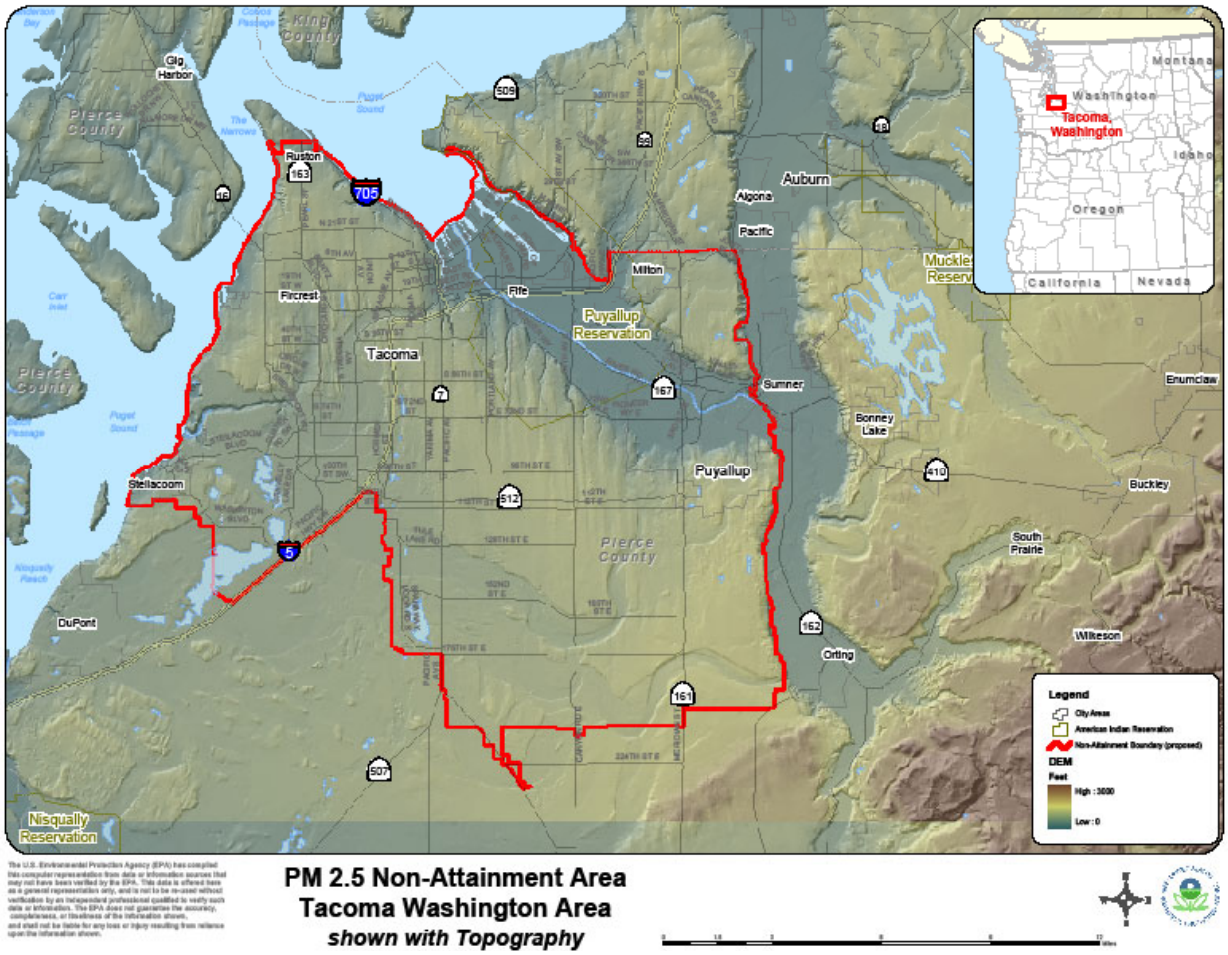


Figure 25. Tacoma area topography



Factor 8: Jurisdictional boundaries (e.g., existing PM2.5 areas)

In evaluating the jurisdictional boundary factor, EPA gave special consideration to areas that were already designated nonattainment in 2005 for violating the 1997 fine particle standards. Analysis of chemical composition data in these areas indicates that the same components that make up most of the PM2.5 mass in the area on an annual average basis (such as sulfate and direct PM2.5 carbon in many eastern areas) also are key contributors to the PM2.5 mass on days exceeding the 24-hour PM2.5 standard. These data indicate that in many cities, the same source categories that contribute to violations of the annual standard also contribute to exceedances of the 24-hour standard.

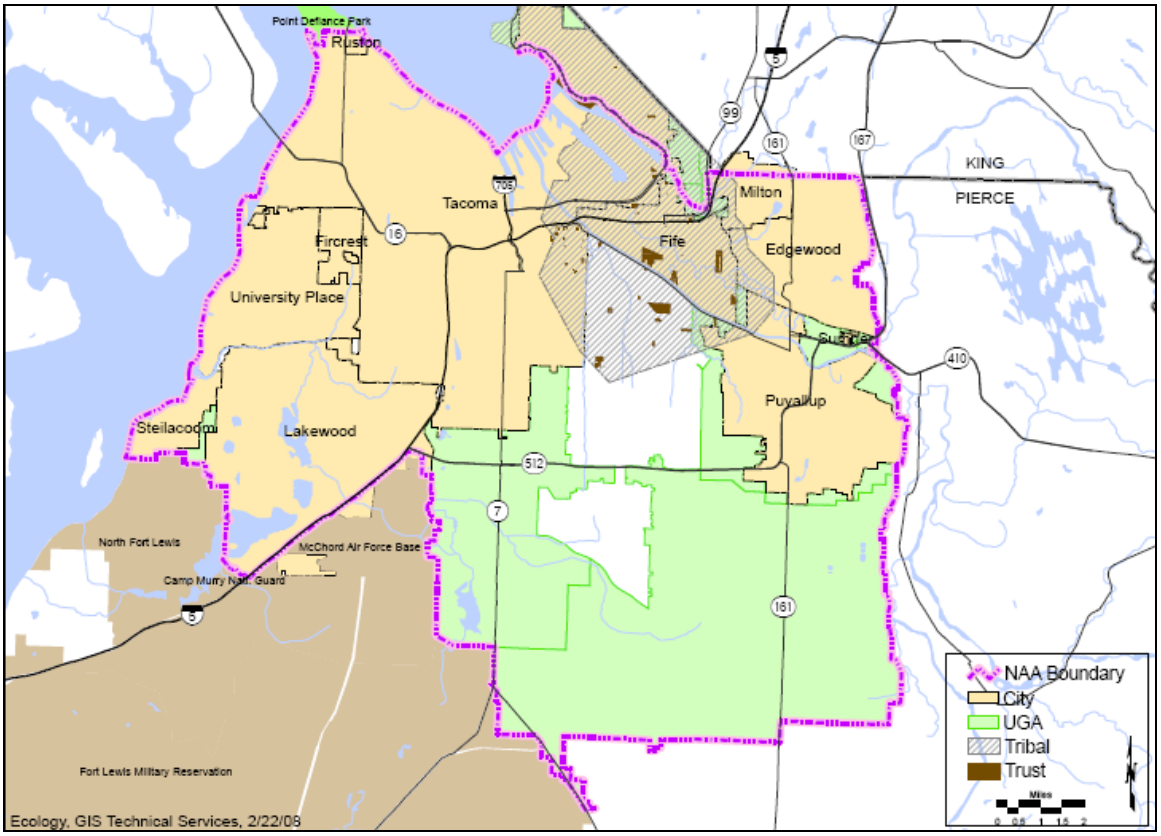
Most areas that were originally designated nonattainment for the PM2.5 standards still have not attained the standards. Thus, EPA has generally concluded that counties that were designated as having emissions sources contributing to fine particle concentrations which continue to exceed the 1997 standards (all areas violated the annual standard, two also violated the previous 24-hour standard) also contribute to fine particle concentrations on the highest days. For this reason,

EPA believes that for most existing nonattainment areas, the nonattainment area for the 2006 24-hour standard should be the same. Consideration also should be given to existing boundaries and organizations as they may facilitate air quality planning and the implementation of control measures to attain the standard. Areas already designated as nonattainment represent important boundaries for state air quality planning.

Given that no areas in Washington State violated the 1997 $PM_{2.5}$ standards, our analysis of jurisdictional boundaries considered the planning and organizational structure of the Seattle-Tacoma-Olympia area to determine if the implementation of controls in a potential nonattainment area can be carried out in a cohesive manner. The boundary of King and Pierce County is less than 5 miles north of the Port of Tacoma and runs east-west along the top of the bluff north of the Port of Tacoma.

Puyallup Tribal trust land parcels are located within 5-10 miles to the north and northwest of the L Street monitor and are contained within the boundary of the nonattainment area recommended by the State. To the south of the L Street monitor, Fort Lewis and the McChord Airforce base form a jurisdictional boundary (federal/state) land. (Figure 26).

Figure 26. Wapato Hills-Puyallup River Valley nonattainment area and jurisdictional boundaries of surrounding areas



EPA examined emissions from the two military jurisdictions to determine if sources in these areas are contributing to the violations at the South L Street Monitor. Emissions from the

McChord Airforce base are less than 1.5 tons per year in 2006. On-base housing units include only 11 wood burning fireplaces and no woodstoves. Additionally, emissions at Fort Lewis are 5 tons per year or less than 0.2% of the total $PM_{2.5}$ for the PM2.5 inventory for Pierce County. Accordingly, EPA is excluding these military areas from the nonattainment area boundary.

The Wapato Hills-Puyallup River Valley nonattainment area contains the Puyallup Indian Reservation. Congress explicitly authorized the State of Washington and local agencies to administer environmental laws regulating activities on non-trust lands within the Puyallup Indian Reservation under the Puyallup Tribe of Indians Land Claims Settlement Act of 1989, 25 U.S.C. 1773. Activities on trust and restricted lands within the boundary of the Puyallup Reservation are the responsibility of EPA and the Tribe. Given these separate jurisdictions, the Wapato Hills- Puyallup River Valley nonattainment area will be managed as a multi-jurisdictional nonattainment area with the EPA and the Puyallup Tribe responsible for nonattainment area air quality planning activities on trust and restricted lands within the Puyallup Reservation and the State responsible for nonattainment area air quality planning activities on all other portions of the nonattainment area including non-trust lands within the boundary of the Puyallup Reservation.

Given low potential contributions of the McChord Air Force Base, the Fort Lewis Military Base, and King County to the north (based on the air quality, topography and meteorology data discussed above), as well as low potential contributions from areas outside of the Tacoma CUGA, EPA's boundary follows the Pierce-King County line, excluding King County to the north and along the boundaries of the military bases, to the south, excluding those boundaries as well as excluding areas to the east of the easternmost boundary of the Tacoma CUGA.

Factor 9: Level of control of emission sources

Under this factor, the existing level of control of emission sources is taken into consideration. The emissions data used by EPA in this technical analysis and provided in Table 1 (under Factor 1) represent emissions levels taking into account any control strategies implemented in the Seattle-Tacoma-Olympia area before 2005 on stationary, mobile, and area sources. Data are presented for $PM_{2.5}$ components that are directly emitted (carbonaceous $PM_{2.5}$ and crustal $PM_{2.5}$) and for pollutants which react in the atmosphere to form fine particles (e.g. SO_2, NOx, VOC, and ammonia).

The State addressed the level of control of emission sources in the Seattle-Tacoma-Olympia area in their nine factors analysis noting a number of regulatory and non-regulatory programs in the area.

However, given that EPA's analysis of the other eight factors has shown that the State's boundary is sufficient to capture sources contributing to the violations at the South L Street monitor, this information was not an important consideration in our decision on our intended boundary.

The following is a summary of the State's submittal followed by a summary of EPA's nine factor analysis.

Summary of the State's submittals

The State submitted to EPA the partial county boundary shown in Figure 27 to EPA on March 13, 2008. In its nine factors analysis included with this and its December 18, 2007 submittal, the State focused on local sources potentially contributing to the violating monitor at South L Street. The State explained that air quality data indicates that exceedences occur during the winter months (November-February), when meteorology is conducive to inversions that trap pollutants and people use wood to heat their homes. Continuous air quality monitors and woodstove survey data indicate that concentrations are highest during evening hours, and this corresponds to times when people burn in woodstoves and fireplaces. The State also reviewed $PM_{2.5}$ speciation data from the South L Street monitor for the highest day in 2006 that indicates that carbonaceous $PM_{2.5,}$ which is an indicator of emissions from burning of wood, accounts for 74% or more of the total $PM_{2.5}$ observed at the South L Street monitor.

The State's conclusion from this air quality data as well as the other data it analyzed in its nine factors analysis is that elevated concentrations at the South L Street monitor are due to local emissions (dominated by woodstove and fireplace emissions) occurring under meteorological conditions conducive to trapping those emissions locally. Accordingly, the State used the comprehensive urban growth area (CUGA) as a starting point for defining the nonattainment area because it encompasses woodstoves and other sources in Tacoma, its suburbs and the Urban Growth Area. They further excluded areas in the CUGA from inclusion in the boundary based on lack of population or sources of emissions. These areas include Port Defiance Park, Fort Lewis Base and McChord Air Force Base to the south and a topographic bluff to the northernmost edge of the (CUGA). See Figure 27. The State's basis for excluding these areas is:

1) The Fort Lewis and McChord Air Force Bases have minimal $PM_{2.5}$ emissions, population density and forecasted growth. The State also argued that these areas are not upwind of the violating monitor when it experiences elevated $PM_{2.5}$ concentrations.
2) Throughout the area near the Pierce-King County line, sites are either on highlands or in valleys with little in between. The State's analysis found that the highlands along the northern county line are in a different air shed from the land to the south and that the bluffs bordering Commencement Bay and the river valley to the south help trap fine particulates and increase pollutant concentrations during inversions that occur in the winter months. The State drew the northwestern boundary of the proposed nonattainment area to exclude these bluffs. They used surrogates of a road (S.R 509) and a stream to draw the boundary. This use of surrogates does not exclude any major sources from the nonattainment area.
3) The State excluded Point Defiance Park from the proposed nonattainment area because the area does not contribute to nonattainment. Only 105 of the Park's 702 acres are maintained.

In focusing its initial analysis on the CUGA and local sources, the State did not directly address whether or not contributions from areas outside of the CUGA contribute to the violations at the L

Street monitor. After EPA shared information with the states from contributing emissions score (CES) modeling which indicated a potential contribution from regional sources to the north, the State submitted additional analyses and data that focused on assessing regional contributions to the Tacoma L Street Monitor. This information included the following:

1) Hourly monitoring data over 24-hour periods for the South L Street site and other sites in Puget Sound that show 24-hour patterns in $PM_{2.5}$ levels at sites in the southern King County industrial areas (Duwamish and Kent), differ from those observed at monitors in N. King County (Lake Forest Park) and in Tacoma. In N. King County and in Tacoma, "v" shaped diurnal patterns are observed. These patterns indicate that peak $PM_{2.5}$ concentrations occur at night and concentrations decrease during the day. These patterns generally correspond with periods of increased woodstove use in the evening hours noted on surveys conducted by the Puget Sound Clean Air Agency.

2) Speciated $PM_{2.5}$ data for the South L Street monitor compared with data for other sites indicating that carbonaceous PM impacts the Tacoma monitor predominantly in the winter when fractions of sulfate and nitrate compared with total $PM_{2.5}$ are low. The Duwamish monitor shows ratios of sulfate/total PM that are more consistent throughout the year.

3) Additional meteorological data for the L Street Monitor showing that exceedences occur in the winter during very low wind speeds (less than 5 mph) indicating stagnant conditions.

The State concluded from this additional analysis that high Tacoma concentrations are due to local emissions dominated by emissions of carbonaceous $PM_{2.5}$ occurring under conditions conducive to high concentrations (meteorology) and not transport.

Conclusion: EPA's review of the State's submittal and summary of final decision

Based on monitoring data for the years 2005-2007, EPA's nine factors analysis for the Seattle-Tacoma-Olympia area and other relevant factual and technical information as discussed above, EPA is designating the Wapato Hills-Puyallup River Valley (a portion of Pierce County) area in the State of Washington as "nonattainment" for the 24-Hour $PM_{2.5}$ standard. See Figure 27.

EPA's final designations for the State of Washington also included a review of information submitted by the State of Washington in determining the attainment status for the 24-Hour $PM_{2.5}$ standard areas in the State of Washington as well as the boundary for the Wapato Hills-Puyallup River Valley Nonattainment area[14].

[14] On March 13, 2008, the State submitted a supplement to their initial designation recommendation letter and nine factors analysis dated December 18th letter and included a boundary recommendation for the area surrounding the monitor at 7802 South L Street (South L Street monitor). In addition to the March 13th letter, the State submitted a letter dated July 28, 2008 containing addition technical information for EPA's consideration.

We note that The Wapato Hills-Puyallup River Valley nonattainment area is a multi-jurisdictional nonattainment area, with the EPA and the Puyallup Tribe responsible for nonattainment area air quality planning activities on Puyallup tribal trust and restricted lands and the State responsible for nonattainment area air quality planning activities on all other portions of the nonattainment area including non-trust lands within the boundary of the Puyallup Reservation.[15].

EPA conducted a nine factors analysis of data for the Wapato Hills-Puyallup River Valley area and surrounding areas (counties in the Seattle-Tacoma-Olympia CMSA) and reviewed information that Washington State submitted on March 13, 2008 focused on the Tacoma CUGA as well as the information it later submitted on July 25, 2008. EPA's nine factors analysis and review of the State's submittals supports using the partial county boundary that the State of Washington submitted to EPA because:

- Chemical speciation data indicates that there is a 74% or more contribution from carbonaceous $PM_{2.5}$ PM which is associated with burning in woodstoves and fireplaces, and 10% or less contribution from $PM_{2.5}$ components that are typically regional such as sulfate and nitrate.

- EPA's analysis of positive matrix factorization data indicates that 60-90% of total $PM_{2.5}$ on exceeding days at the South L Street monitor is from wood smoke. There are no other sources of smoke during the winter season in the CUGA. By law outdoor burning is prohibited in this area.

- Hourly $PM_{2.5}$ levels at the South L Street monitor peak in the evenings and decrease dramatically during the day. These patterns are consistent with woodstove surveys conducted in Tacoma which show that on high $PM_{2.5}$ days, woodstove use $PM_{2.5}$ peaks in the late evening and is lowest around noon.

- Meteorological data shows very low mixing heights during stagnation events when the exceedences are occurring, and low wind speeds (typically less than 5 mph). Local topographical features in the area restrict pollution flow in the Tacoma area during stagnation events.

- Population density in Pierce County is concentrated within the CUGA. The Fort Lewis and McChord Air Force Base military installations to the south are not included in the nonattainment area because emissions from the bases contribute less than 0.2% to the total inventory of $PM_{2.5}$ emissions in the area.

- The nonattainment area includes the Port of Tacoma because it has substantial PM2.5 emissions (estimated at 90 tons per year). This does not include off-terminal emissions, which contribute additional $PM_{2.5}$. The Port projects a

[15] Congress explicitly authorized state and local agencies to adminster activities only on non-trust lands within the Puyallup Indian Reservation under the Puyallup Tribe of Indians Land Claims Settlement Act of 1989, 25 U.S.C. 1773. Activities on trust land restricted ands within the boundary of the Puyallup Reservation are the responsibility of EPA and the PuyallupTribe.

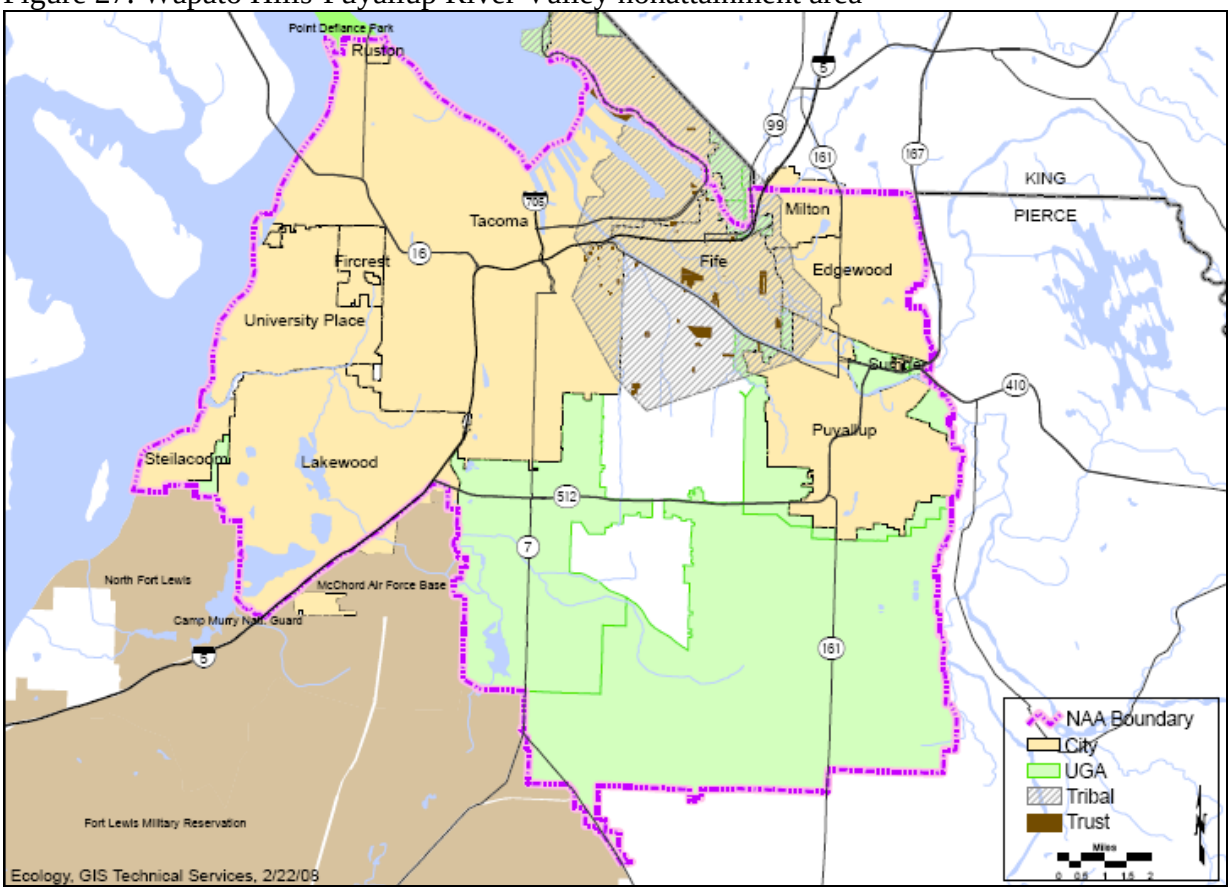
dramatic increase of its cargo handling capacity in the next two decades, with an estimated cargo growth factor of 4.8 from 1999 to 2015.

- Analyses of speciated $PM_{2.5}$ data, diurnal patterns of $PM_{2.5}$ concentrations, and meteorological information from the Puget Sound region indicate that sources contributing the violations of the 24-hour $PM_{2.5}$ standard at the South L Street monitor are predominantly local sources dominated by woodstove and fireplace emissions in the Tacoma area and not transport from King County or other counties in the Seattle-Tacoma-Olympia area.

EPA has determined the boundary submitted by the State of Washington in March 2008 is appropriately sized to contain the sources that contribute to the violations at the South L Street monitor including populated areas in the Tacoma area where households operate woodstoves and fireplaces in the winter, and mobile sources and diesel traffic associated with good movements at the Port of Tacoma and sections of Interstate 5 and State Highway 99. The final boundary includes all land within the boundary of the Puyallup Indian Reservation.

Additional information regarding responses to specific State comments can be found in EPA's Response to Comments document at http://www.epa.gov/pmdesignations/2006standards/tech.htm.

Figure 27. Wapato Hills-Puyallup River Valley nonattainment area



Attachment 2
Description of the Contributing Emissions Score

The CES is a metric that takes into consideration emissions data, meteorological data, and air quality monitoring information to provide a relative ranking of counties in and near an area. Using this methodology, scores were developed for each county in and around the relevant metro area. The county with the highest contribution potential was assigned a score of 100, and other county scores were adjusted in relation to the highest county. The CES represents the relative maximum influence that emissions in that county have on a violating county. The CES, which reflects consideration of multiple factors, should be considered in evaluating the weight of evidence supporting designation decisions for each area.

The CES for each county was derived by incorporating the following significant information and variables that impact $PM_{2.5}$ transport:

- Major $PM_{2.5}$ components: total carbon (organic carbon (OC) and elemental carbon (EC)), SO_2, NO_x, and inorganic particles (crustal).
- $PM_{2.5}$ emissions for the highest (generally top 5%) $PM_{2.5}$ emission days (herein called "high days") for each of two seasons, cold (Oct-Apr) and warm (May-Sept)
- Meteorology on high days using the NOAA HYSPLIT model for determining trajectories of air masses for specified days
- The "urban increment" of a violating monitor, which is the urban $PM_{2.5}$ concentration that is in addition to a regional background $PM_{2.5}$ concentration, determined for each $PM_{2.5}$ component
- Distance from each potentially contributing county to a violating county or counties

[A more detailed description of the CES can be found at
http://www.epa.gov/ttn/naaqs/pm/pm25_2006_techinfo.html#C.]