TECHNICAL SUPPORT DOCUMENT FOR DESIGNATION OF AREAS IN MISSOURI FOR THE $PM_{2.5}$ 24- HOUR NATIONAL AMBIENT AIR QUALITY STANDARD

Missouri Department of Natural Resources

AIR POLLUTION CONTROL PROGRAM

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1.0 INTRODUCTION

The United States Environmental Protection Agency (US EPA) promulgated air quality standards for airborne particulate matter smaller than 2.5 micrometers aerodynamic diameter ($PM_{2.5}$) in 1997 (62 **Federal Register** 38652, July 17, 1997). The standards were:

- 15 micrograms per cubic meter ($\mu g/m^3$), based on the 3-year average of annual arithmetic mean concentrations from single or multiple community-oriented monitors,

- 65 $\mu g/m^3$, based on the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area.

As required by the Clean Air Act, areas must be designated as attainment, nonattainment, or unclassifiable with respect to these standards. In December 2004, US EPA announced designation of the following areas in Missouri as nonattainment, effective in April 2005, consistent with the State of Missouri's analysis and recommendations: Franklin County, Jefferson County, St. Charles County, St. Louis County, and St. Louis City. This determination was made on the basis of the annual standard; these areas were in attainment of the 65 $\mu g/m^3$ 24-hour standard.

US EPA promulgated a revised 24-hour $PM_{2.5}$ standard in 2006 (71 **Federal Register** 61144, October 17, 2006). This revision reduced the 24-hour standard from 65 to 35 $\mu g/m^3$. Designation of areas as attainment, nonattainment, or unclassifiable with respect to this revised 24-hour standard is planned to proceed on the following schedule:

1. December 18, 2006, effective date of revised 24-hour $PM_{2.5}$ standard.

2. December 18, 2007, State and Tribal recommendations due for designation of attainment and nonattainment areas,

3. No later than August 20, 2008, US EPA notifies States and Tribes concerning any modifications to their recommendations,

4. No later than December 18, 2008, US EPA issues final 24-hour $PM_{2.5}$ area designations, effective April 2009 (this process may be extended up to one year if US EPA has insufficient information to make designations),

5. April 2012 (or 2013 if the date under no. 4 is extended), State implementation plans are due for $PM_{2.5}$ nonattainment areas,

6. April 2014-2019, Date for attainment of $PM_{2.5}$ standards (5 years after designation date, with a possible extension of up to 5 years).

This document provides technical support for the State of Missouri recommendations for designation of attainment and nonattainment areas (number 2 above).

On June 8, 2007 US EPA issued guidance for determining boundaries of $PM_{2.5}$ attainment and nonattainment areas. This guidance is strongly based on previous guidance issued in 2003 for the previous designation process. Unlike the previous guidance, the current guidance states that US EPA is not establishing a presumption that the boundaries for urban nonattainment areas should be based on Metropolitan Area boundaries. However, the guidance states that US EPA "anticipates that the same boundaries established for implementing the annual $PM_{2.5}$ standard may also be appropriate for implementing the 24-hour $PM_{2.5}$ NAAQS in areas where both standards are violated [emphasis added]."

The guidance lists nine factors that US EPA will consider in assessing designation recommendations; these same factors were included in the previous guidance and were used in US EPA's analysis on which the previous designations were based:

1. "Emission data,"

2. "Air quality data,"

3. "Population density and degree of urbanization (including commercial development),"

4. "Traffic and commuting patterns,"

5. "Growth rates and patterns,"

6. "Meteorology (weather/transport patterns),"

7. "Geography/topography (mountain ranges or other air basin boundaries),"

8. "Jurisdictional boundaries (e.g., counties, air districts, Reservations, metropolitan planning organizations (MPOs)),"

9. "Level of control of emission sources."

This document considers each of these factors in evaluating areas to be designated as attainment or nonattainment in Missouri.

2.0 ST. LOUIS AREA INFORMATION

2.1 $PM_{2.5}$ AIR MONITORING RESULTS

There are thirteen Federal Reference Method monitoring sites in the St. Louis area. Eleven are neighborhood scale and two are middle scale. The middle scale sites, Mound Street (St.) and VFW, are source oriented and not appropriate for comparison to the annual average National Ambient Air Quality Standard (NAAQS). However, a request to redesignate the Mound Street site as neighborhood scale has been sent to EPA Region VII, due to changes to nearby sources. In addition, there are four speciation sites and the St. Louis Supersite in East St. Louis, operated by Washington University, that provide detailed information on the different species of $PM_{2.5}$ in addition to total mass. Also, four continuous $PM_{2.5}$ monitors have been operated in the area, one each at Blair St., Ladue, and Arnold; and one at the St. Louis Supersite.

2.1.1 Annual Average

The $PM_{2.5}$ NAAQS annual standard is 15.0 µg/m^3. The annual standard is met when the 3-year average of annual arithmetic means is less than 15.05 µg/m^3, due to rounding. Annual averages for St. Louis area sites are shown in Table 2.1-1. Only two sites, Granite City and E. St. Louis in Illinois, are in violation of the NAAQS annual standard. Measured $PM_{2.5}$ concentrations at the remaining sites are near, but below, the standard. Unless there is a substantial increase in their annual concentration for several years, these sites will continue to attain the standard.

The spatial distribution map (Figure 2.1-1) shows a high concentration area, 5 to 6 µg/m^3 above background, centered around Granite City and East St. Louis, with decreasing concentrations as distance from this area increases. Concentrations at the fringes of the urban area (Arnold, West Alton, and Swansea) are 2 to 3 µg/m^3 above background levels measured at rural sites.

2.1.2 24-hour Average

The 24-hour standard is met when the 3-year average of the 98th percentile of daily $PM_{2.5}$ concentrations is less than or equal to 35 µg/m^3. This standard was reduced from 65 µg/m^3 by EPA in 2006. Under the previous standard, no site was near the 24-hour standard. However, under the new standard two sites, VFW and Granite City, are over the standard and will be in violation when the designation is made unless a substantial reduction occurs this year (Figure 2.1-2). All other sites in the area are near, but below, the standard.

Table 2.1-2 shows the correlation (R^2 values) for 24-hour average concentrations for each pair of sites in the St. Louis area. The correlation between most pairs of sites, especially the Missouri sites, is fairly high, which indicates that the sites are affected by similar meteorological factors and sources, including regional, mobile, area, and point sources. Correlations of all sites with the VFW and Granite City sites are lower than for other pairs of sites, indicating that these two sites may be influenced by local sources. This is especially true for correlations with the VFW site, which are, on average, the lowest in the table. As shown in the table, the average correlation for each site is increased when its correlation with VFW and Granite City are not included in the average.

Because the focus of this document is on the 24-hour $PM_{2.5}$ standard, it is instructive to examine measurement results at various sites on individual days. Table 2.1-3 lists measured $PM_{2.5}$ concentrations at the VFW, Granite City, and E. St. Louis sites in Illinois, the Blair St. site in urban St. Louis, Missouri, and the rural Bonne Terre site in Missouri on days when the concentration at one or more of the sites exceeded 35 $\mu g/m^3$. Review of the data in this table reveals the following features:

- Because the sampling frequency is greater (daily) at Blair St. than at the VFW, Granite City, and E. St. Louis sites, even more high-concentration days might be reasonably expected at the latter three sites than at Blair St.

- For most summer days and a few winter days, high concentrations were measured at multiple sites, suggesting the influence of regional or remote sources and/or meteorological conditions common to all of the urban sites. However, concentrations on summer days were generally higher at the VFW and Granite City sites than at Blair St., suggesting a local source contribution in addition to regional influences.

- On spring days and most of the winter days, high concentrations were measured at the VFW and/or Granite City sites but not at the Blair St. site, suggesting significant local source contributions at the two Illinois sites. The greatest differences between an urban site and the rural Bonne Terre site were on days with high concentrations at the VFW and/or Granite City sites, again suggesting significant local source contributions at those sites.

Table 2.1-4 lists $PM_{2.5}$ concentrations for the same days as listed in the previous table, but with differences between the VFW and Blair St. sites and differences between the Granite City and Blair St. sites calculated. Figure 2.1-3 shows these differences graphically. The average difference between either of the two Illinois sites and the Blair St. site on these high days is about 5 $\mu g/m^3$. Additional discussion of some of these high days may be found in Section 2.3 below. (Note: The relatively low $PM_{2.5}$ concentration at VFW on February 3, 2005 and the resultant large negative difference may be erroneous and is considered to be an outlier.)

Table 2.1-1. St. Louis Annual $PM_{2.5}$ Total Mass for 2004-2006

	24-hr Std = 35 μg/m³, 98th percentile				Annual Mean Std = 15.0 μg/m³			
	98th percentile				Annual Mean			
Missouri	**2004**	**2005**	**2006**	**04-06**	**2004**	**2005**	**2006**	**04-06**
West Alton	30.2	38.5	27.1	**31.9**	11.9	15.2	11.6	**12.9**
Margaretta	26.5	40.0	30.5	**32.3**	12.1	15.1	12.5	**13.2**
Blair Street	27.9	40.3	29.2	**32.5**	13.2	16.1	13.4	**14.2**
Mound St.	30.3	40.8	29.6	**33.6**				
S.Broadway	28.5	38.6	30.4	**32.5**	13.1	15.9	13.1	**14.0**
Clayton	25.6	43.5	27.7	**32.3**	12.2	15.5	11.8	**13.2**
Arnold	27.0	39.9	30.2	**32.4**	12.5	15.4	12.6	**13.5**
Illinois								
Alton	28.9	45.1	27.6	**33.9**	11.5	16.0	13.1	**13.5**
Wood River	30.0	41.2	28.3	**33.2**	13.2	16.0	13.1	**14.1**
VFW	35.3	41.2	32.9	**36.5**				
Granite City	35.4	44.1	36.3	**38.6**	15.4	18.2	16.3	**16.6**
E. St. Louis	30.2	39.6	29.2	**33.0**	14.7	17.1	14.5	**15.4**
Swansea	26.6	37.9	28.1	**30.9**	13.2	16.0	13.4	**14.2**

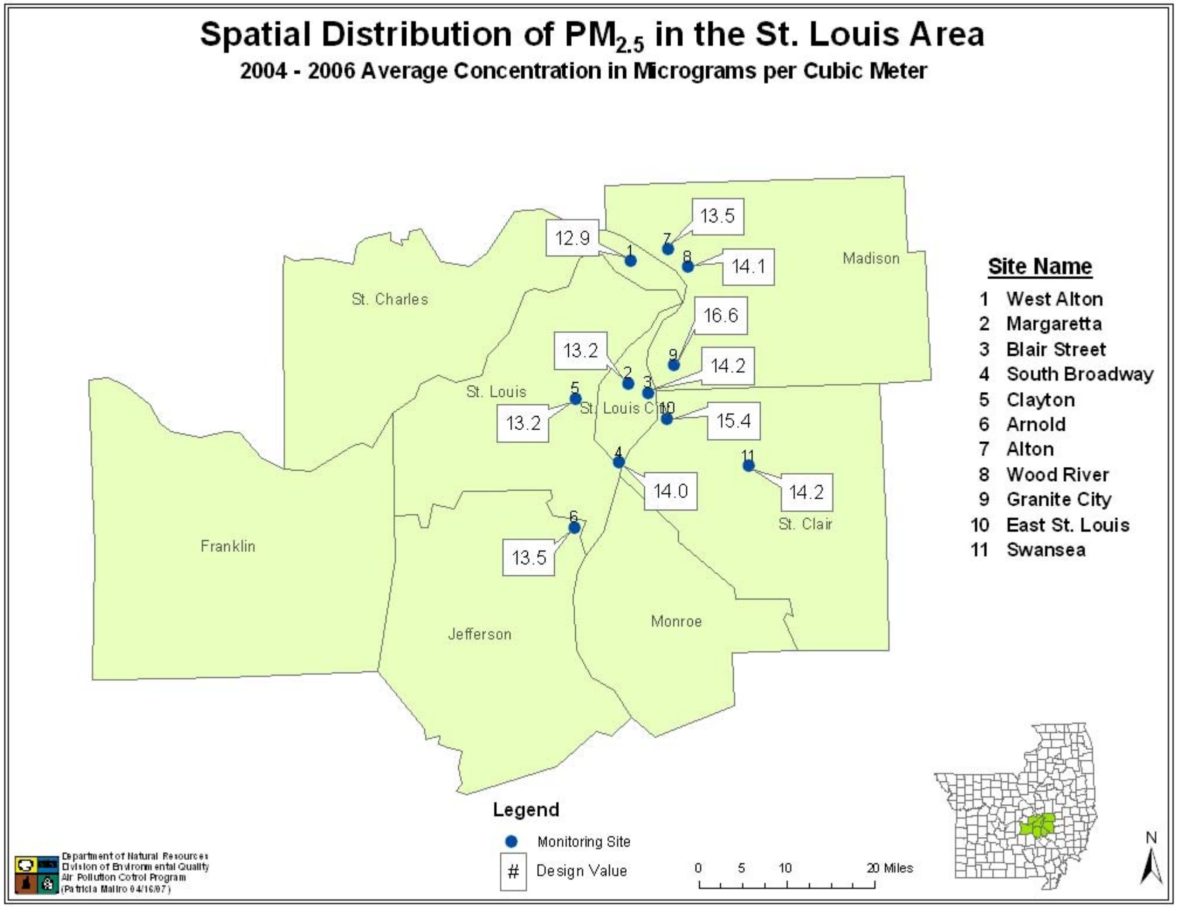


Figure 2.1-1. Spatial distribution of 2004-2006 average annual $PM_{2.5}$ in the St. Louis area.

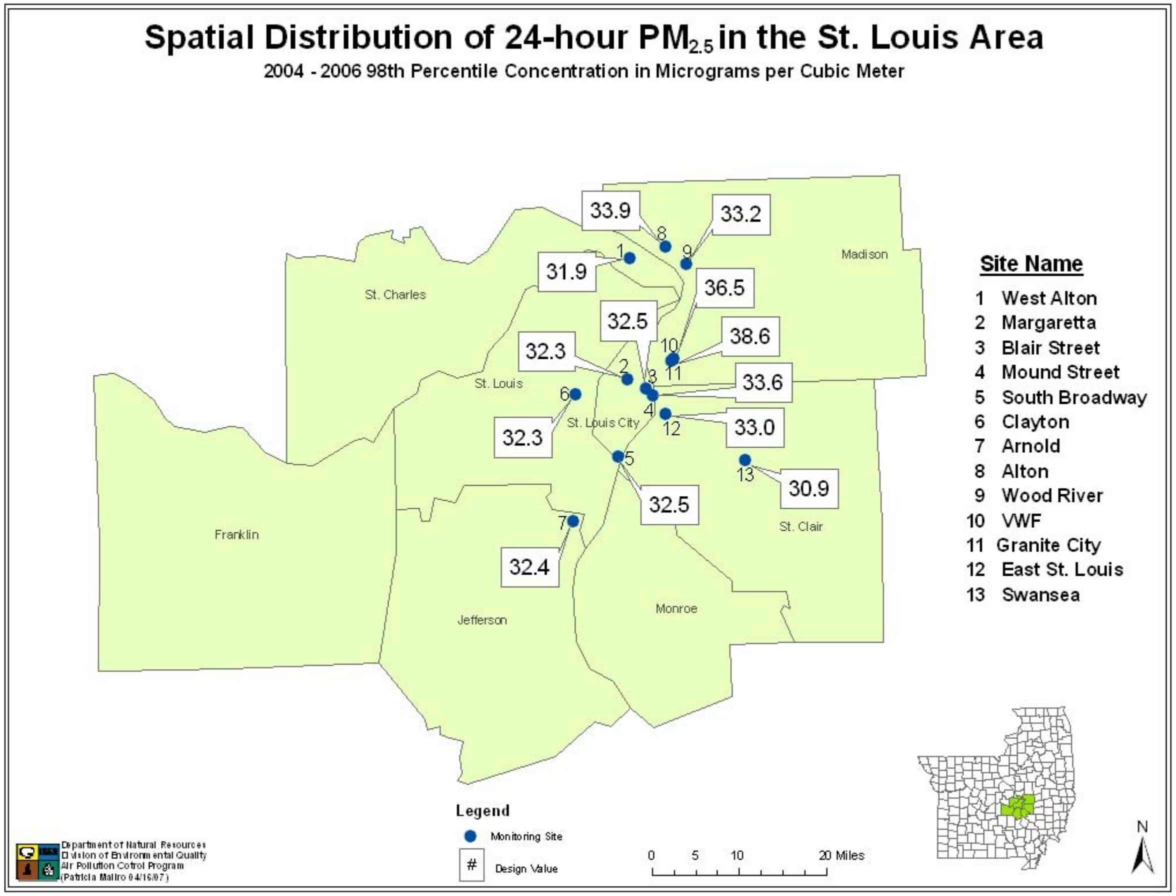


Figure 2.1-2. Spatial distribution of 2004-2006 average 24-hour $PM_{2.5}$ in the St. Louis area.

Table 2.1-2. Correlation Coefficients for $PM_{2.5}$ Measurements at St. Louis Area Sites

Highlighted values are less than the average (0.7006).

	West Alton	Marga-retta	Blair St.	South Broadway	Clayton	Arnold	Alton	Wood River	Granite City	VFW	East St. Louis	Swansea
West Alton		0.9214	0.7099	0.6883	0.9104	0.7166	0.8404	0.8560	0.7821	0.6172	0.7732	0.7246
Margaretta	0.9214		0.7692	0.7336	0.9335	0.7507	0.7838	0.8370	0.7685	0.5806	0.8147	0.7869
Blair St.	0.7099	0.7692		0.9344	0.7502	0.9071	0.6267	0.6230	0.5890	0.4271	0.5824	0.6517
South Broadway	0.6883	0.7336	0.9344		0.7496	0.9273	0.6330	0.6021	0.5786	0.4403	0.6105	0.6547
Clayton	0.9104	0.9335	0.7502	0.7496		0.7588	0.7797	0.8074	0.7506	0.5433	0.7887	0.7818
Arnold	0.7166	0.7507	0.9071	0.9273	0.7588		0.6328	0.6207	0.6016	0.4497	0.6105	0.6800
Alton	0.8404	0.7838	0.6267	0.6330	0.7797	0.6328		0.7614	0.7121	0.5391	0.6959	0.6425
Wood River	0.8560	0.8370	0.6230	0.6021	0.8074	0.6207	0.7614		0.7185	0.6227	0.7286	0.6967
Granite City	0.7821	0.7685	0.5890	0.5786	0.7506	0.6016	0.7121	0.7185		0.6407	0.6943	0.5031
VFW	0.6172	0.5806	0.4271	0.4403	0.5433	0.4497	0.5391	0.6227	0.6407		0.5122	0.6490
East St. Louis	0.7732	0.8147	0.5824	0.6105	0.7887	0.6105	0.6959	0.7286	0.6943	0.5122		0.7355
Swansea	0.7246	0.7869	0.6517	0.6547	0.7818	0.6800	0.6425	0.6967	0.6490	0.4995	0.7355	
Average	0.7764	0.7891	0.6883	0.6866	0.7776	0.6960	0.6952	0.7158	0.6805	0.5339	0.6861	0.6824
Average, not including Granite City and VFW	0.7934	0.8145	0.7283	0.7259	0.8067	0.7338	0.7107	0.7259			0.7045	0.7060

Table 2.1-3. Days with PM2.5 greater than 35 ug/m3 at one or more of four sites.

Numbers in parentheses are sampling frequency, i.e. (3) indicates every third day sampling, etc.
Highlights indicate concentrations greater than 35 ug/m3.

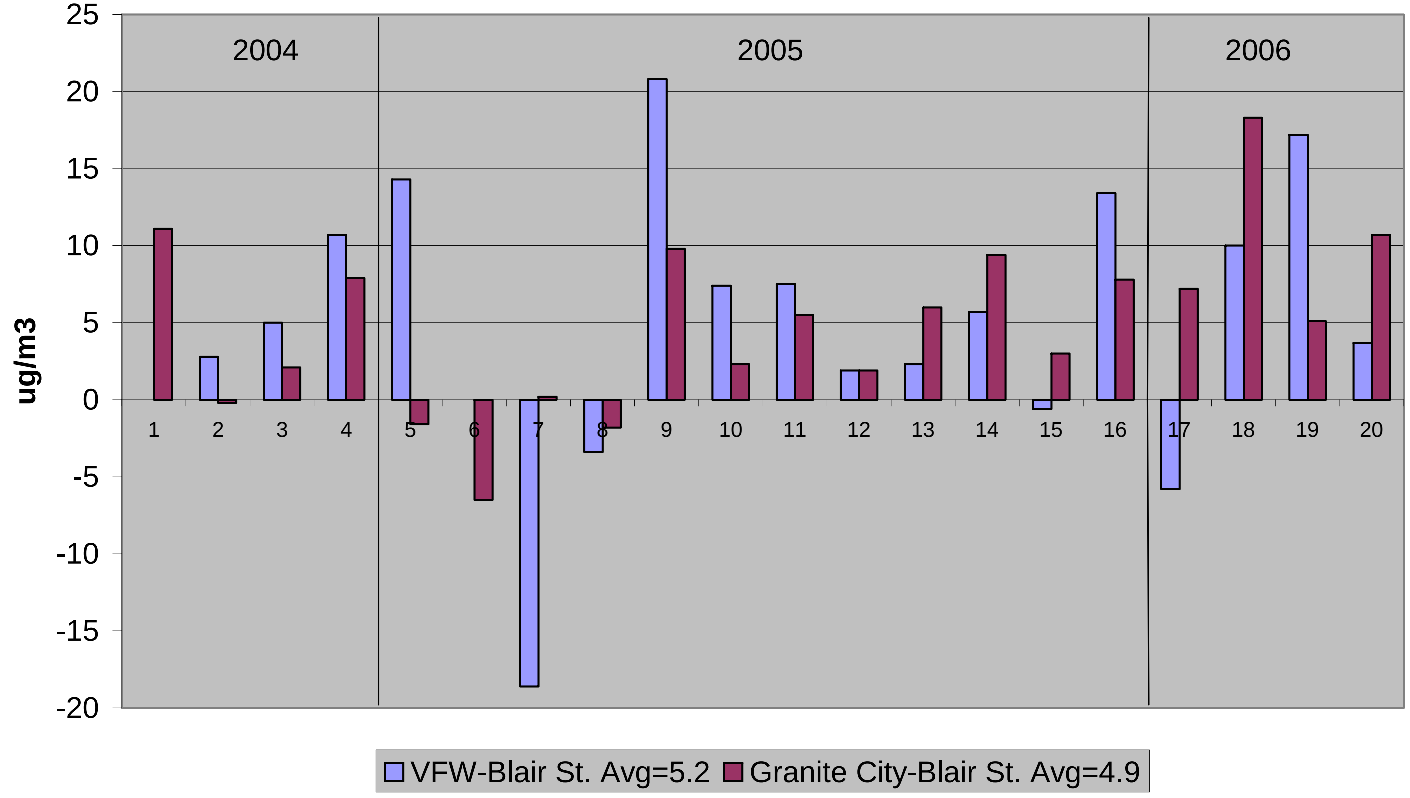
	VFW(3)	Granite City(3)	E. St. Louis(6)	Blair St.(1)	Bonne Terre	VFW(3)-BonneTerre	Granite City(3)-BonneTerre	E. St. Louis(6)-BonneTerre	Blair St.(1)-BonneTerre
QTR1(Jan Feb Mar)									
18-Feb-04		35.4		24.3					
28-Jan-05	35.1	19.2	17.8	20.8	13.7	21.4	5.5	4.1	7.1
31-Jan-05		39.6		46.1	26.3		13.3		19.8
3-Feb-05	23.0	41.8		41.6	23.6	-0.6	18.2		18.0
27-Feb-05	36.3	37.9	39.5	39.7	29.3	7.0	8.6	10.2	10.4
17-Mar-05	37.0	26.0	18.3	16.2	17.1	19.9	8.9	1.2	-0.9
28-Feb-06	27.0	40.0	29.2	32.8	12.0	15.0	28.0	17.2	20.8
avg	31.7	34.3	26.2	31.6	20.3	11.3	13.9	5.9	11.3
QTR2(Apr May Jun)									
4-Apr-05	38.2	21.5	15.2		16.6	21.6	4.9	-1.4	
24-Jun-05	41.1	36.0		33.7	23.5	17.6	12.5		10.2
27-Jun-05	46.1	44.1	39.6	38.6	27.8	18.3	16.3	11.8	10.8
29-Apr-06	28.0	36.3	18.4	18.0	14.6	13.4	21.7	3.8	3.4
8-May-06	37.2	25.1		20.0	8.4	28.8	16.7		11.6
avg	38.1	32.6	24.4	27.6	18.2	19.9	14.4	6.2	9.4
QTR3(Jul Aug Sept)									
29-Jul-04	35.3	32.3		32.5					
3-Sep-04	47.9	45.0		42.9					
12-Sep-04	38.6	35.8	34.8	27.9	24.7	13.9	11.1	10.1	3.2
2-Aug-05	41.2	41.2	38.6	39.3	24.8	16.4	16.4	13.8	14.5
8-Aug-05	41.0	44.7	40.4	38.7	22.6	18.4	22.1	17.8	16.1
7-Sep-05	42.1	45.8		36.4	25.7	16.4	20.1		10.7
10-Sep-05	39.1	42.7		39.7	28.1	11.0	14.6		11.6
13-Sep-05	36.0	30.4	22.0	22.6	20.5	15.5	9.9	1.5	2.1
12-Aug-06	32.9	39.9		29.2	35.9	-3.0	4.0		-6.7
avg	39.3	39.8	34.0	34.4	26.0	13.3	13.7	7.9	8.3
QTR4(Oct Nov Dec)									
(none)									

Table 2.1-4. Days with PM2.5 greater than 35 ug/m3 at one or more of three sites.

Numbers in parentheses are sampling frequency, i.e. (3) indicates every third day sampling, etc.
Highlights indicate concentrations greater than 35 ug/m3.

	VFW(3)		Granite City(3)	Blair St.(1)	VFW-Blair St. Avg=5.2	Granite City-Blair St. Avg=4.9
18-Feb-04			35.4	24.3		11.1
29-Jul-04	35.3		32.3	32.5	2.8	-0.2
3-Sep-04	47.9		45.0	42.9	5.0	2.1
12-Sep-04	38.6		35.8	27.9	10.7	7.9
28-Jan-05	35.1		19.2	20.8	14.3	-1.6
31-Jan-05			39.6	46.1		-6.5
3-Feb-05	23.0	*	41.8	41.6	-18.6	0.2
27-Feb-05	36.3		37.9	39.7	-3.4	-1.8
17-Mar-05	37.0		26.0	16.2	20.8	9.8
24-Jun-05	41.1		36.0	33.7	7.4	2.3
27-Jun-05	46.1		44.1	38.6	7.5	5.5
2-Aug-05	41.2		41.2	39.3	1.9	1.9
8-Aug-05	41.0		44.7	38.7	2.3	6.0
7-Sep-05	42.1		45.8	36.4	5.7	9.4
10-Sep-05	39.1		42.7	39.7	-0.6	3.0
13-Sep-05	36.0		30.4	22.6	13.4	7.8
28-Feb-06	27.0		40.0	32.8	-5.8	7.2
29-Apr-06	28.0		36.3	18.0	10.0	18.3
8-May-06	37.2		25.1	20.0	17.2	5.1
12-Aug-06	32.9		39.9	29.2	3.7	10.7
Average					5.2	4.9

Figure 2.1-3. PM2.5 Concentration Differences on Days with High Concentrations, VFW and Granite City minus Blair St.



2.2 $PM_{2.5}$ CONTINUOUS MONITOR RESULTS

Continuous $PM_{2.5}$ measurements are available from four sites in the St. Louis area: Blair St., Ladue, Arnold, and the Supersite in East St. Louis. Figure 2.2-10 shows the average hourly concentration. The figure shows a morning increase at all sites, but greater at sites closer to downtown, which may result from morning traffic, and an evening increase, which may result from evening traffic and/or from increased nighttime meteorological stability. These continuous monitor results do not reveal other consistent features that might help in local source identification.

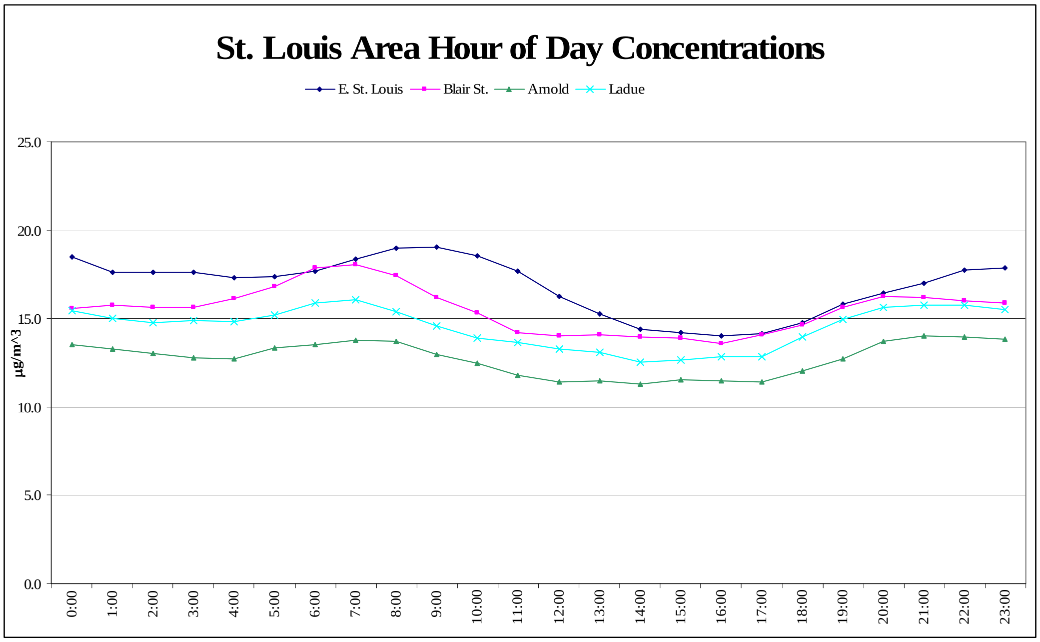


Figure 2.2-10. Average $PM_{2.5}$ concentrations by hour of day. Data are from 2004-6 except for Arnold, which began sampling in July 2005.

2.3 $PM_{2.5}$ SPECIATION RESULTS

In addition to measurement of $PM_{2.5}$ mass concentration, as discussed in Sections 2.1 and 2.2, collection and analysis of chemical species in $PM_{2.5}$ particulate matter has been done at several sites in Missouri. Speciation analysis results, along with meteorological analysis, help in evaluating the contribution of emission sources to $PM_{2.5}$ mass concentrations.

$PM_{2.5}$ Speciation Trends Network (STN) samplers were operated at the following sites in Missouri during 2004, 2005, and 2006:

- Blair St., an urban site in St. Louis
- Arnold, a suburban site south of St. Louis
- Bonne Terre, a rural site south of St. Louis
- Pleasant Green, a rural site in central Missouri (discontinued at the end of June 2006)
- Liberty, a suburban site northeast (generally downwind) of Kansas City

All sites except Pleasant Green were operated on an every-third-day schedule; Pleasant Green was operated on an every-sixth-day schedule.

Figures 2.3-1 to 6 show time series plots of major species concentrations (mass, sulfate, nitrate, ammonium, organic carbon, and elemental carbon measured at the three sites in the St. Louis area during 2004, 2005, and 2006. These figures support the following conclusions:

- Results at the three St. Louis area sites are well-correlated, both for total mass and for individual major species,
- Sulfate tends to be high in summer and contribute to summer mass peaks,
- Nitrate tends to be high in winter and contribute to winter mass peaks,
- Organic and elemental carbon peaks don’t show as much seasonality, but tend to occur in the fall.

Examining time series plots of ratios of concentrations between sites can highlight differences between sites. Figures 2.3-7 to 12 show time series plots of ratios of Arnold to Blair St. results and Bonne Terre to Blair St. results for $PM_{2.5}$ mass, sulfate, nitrate, ammonium, organic carbon, and elemental carbon. These figures support the following conclusions:

- The mass ratio for Arnold to Blair St. is close to one, while the ratio for Bonne Terre to Blair St. is less than one, highlighting the higher $PM_{2.5}$ mass concentration at the urban and suburban sites as compared to the rural site,

- Sulfate ratios are close to one, suggesting that sulfate is widespread and/or results from distant sources,

- The nitrate ratio for Arnold to Blair St. is close to one, while the ratio for Bonne Terre to Blair St. is less than one, suggesting that some part of the nitrate particulate matter results from localized urban and/or suburban sources in contrast to sulfate, which appears to result from regional sources,

- Results for ammonium are similar to those for nitrate but show little difference between the Arnold and Bonne Terre sites, suggesting that there is a strong regional component to ammonium aerosol,

- The organic carbon ratio is close to one for Arnold to Blair St. and less then one for Bonne Terre to Blair St., suggesting urban and suburban sources of organic aerosol,

- The elemental carbon ratios are both less than one, and the ratio is significantly lower for Bonne Terre than Arnold, suggesting that elemental carbon emissions are quite localized in the urban area.

Quarterly average measurement results from these sites have been analyzed using the following assumptions, similar to those used in analyzing data from the Interagency Monitoring of Protected Visual Environment (IMPROVE) network: all sulfate is ammonium sulfate (although a small amount may actually be uncombined sulfuric acid); all nitrate is ammonium nitrate; organic mass is 1.8 times organic carbon as reported with $PM_{2.5}$ data minus annual site average organic carbon blank; elemental carbon is elemental carbon as reported with $PM_{2.5}$ data; and crustal includes Al, Si, Ca, Fe, Ti, each adjusted by a factor to account for oxides. The "other" category includes primarily other metallic elements not included in the crustal category. The procedure for reducing organic and elemental carbon data has changed from that used in previous reports, but is believed to be more accurate. The net result of these changes is higher organic mass concentrations and lower elemental carbon mass concentrations than presented in previous reports. This calculation procedure generally over-predicts (but sometimes under-predicts) total mass slightly, so values were then normalized to total $PM_{2.5}$ mass.

Figure 2.3-13 to 15 shows the results of this analysis for Blair St. for 2004 through 2006. Figures 2.3-16-18 and 2.3-19-21 show the results for Arnold and Bonne Terre. As seen in the time series plots, the ammonium sulfate contribution to $PM_{2.5}$ mass concentration was highest in the third quarter (summer), and the ammonium nitrate contribution was highest in the first quarter (winter). Organic species show some seasonal dependence, with the highest concentration in the third quarter or summer. Elemental carbon, crustal species, and other species show little seasonal dependence

Comparison in the past of speciation results for the Alton site in Illinois, generally downwind of St. Louis, to the Liberty site, generally downwind of Kansas City has shown similar speciation results, but every major species shows a slightly higher concentration downwind of St. Louis than downwind of Kansas City.

Although speciation results near Kansas City and near St. Louis are similar, St. Louis results do show differences in speciation from the results of measurements in rural areas. During the previous designation process, US EPA estimated urban excess for St. Louis using Speciation Trends Network (STN) data for St. Louis and IMPROVE data for the Mingo site in rural southeast Missouri (US EPA, **Technical Support for State and Tribal Air Quality Fine Particle (PM2.5) Designations,** December 2004, http://www.epa.gov/pmdesignations/documents/final/TSD/Ch6.pdf). Because of systematic differences in organic and elemental carbon results from the two networks, only total carbonaceous mass was used in comparing the urban and rural sites. Estimated urban excesses for St. Louis are as follows:

- $PM_{2.5}$ mass concentration, 6.2 $\mu g/m^3$
- Sulfate, 0.5 $\mu g/m^3$,
- Nitrate, 1.8 $\mu g/m^3$,
- Total carbonaceous mass, 3.6 $\mu g/m^3$ (using a factor of 1.4 to convert organic carbon to organic compound mass),
- Crustal, 0.3 $\mu g/m^3$.

There are differences in measurement of carbonaceous material between the STN and IMPROVE networks, and there were problems in the past with data for carbonaceous material at the Mingo site, so the difference in total carbonaceous mass is somewhat uncertain. Nevertheless, it appears that the greatest species contribution to urban excess is total carbonaceous mass.

Another study shows a rural background concentration of approximately 11 $\mu g/m^3$ and an urban excess $PM_{2.5}$ mass concentration of approximately 6 $\mu g/m^3$ (Lake Michigan Air Directors Consortium [LADCO], **$PM_{2.5}$ in the Upper Midwest**, June 2, 2003).

Estimates of the contributions of various major species to the urban excess can also be made by comparing the $PM_{2.5}$ STN data from Blair St. and Bonne Terre (figures 2.3-22 to 24) or by comparing Blair St. results to those from the Pleasant Green site in rural central Missouri (figures 2.3-25 and 26; 2006 data are not compared for Pleasant Green because that site was discontinued mid-2006). The comparison of Blair St. to Bonne Terre shows, on average, no excess ammonium sulfate, an excess of about 1 $\mu g/m^3$ of ammonium nitrate, 3 $\mu g/m^3$ of carbonaceous mass, and a total mass concentration excess of about 4 $\mu g/m^3$. The comparison of Blair St. to Pleasant Green shows, on average, an excess of about 1 $\mu g/m^3$ of ammonium sulfate, 0.5 $\mu g/m^3$ of ammonium nitrate, 3 $\mu g/m^3$ of carbonaceous mass, and a total mass concentration excess of about 6 $\mu g/m^3$. The apparent excess of sulfate for Blair St. as compared to Pleasant Green probably results from an east-west gradient in the regional sulfate concentration, as supported by measurements at other sites, rather than an urban-rural difference. The common feature of all of these results is that predominantly carbonaceous material and, to a lesser extent, nitrate are the primary contributors to the average urban excess $PM_{2.5}$ concentration.

Neil Frank of US EPA has developed a data analysis approach, called SANDWICH (Frank, N., "Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities," **J. Air & Waste Management Association 56**: 500–511 (2006) and Neil Frank, "SANDWICH Material Balance Approach for PM2.5 Data Analysis," presented at 2006 National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006, http://www.epa.gov/ttn/amtic/files/ambient/2006conference/frank.pdf) that attempts to reconcile differences between $PM_{2.5}$ federal reference method (FRM) measurement results and $PM_{2.5}$ STN results by adjusting the STN results for known differences in the two methodologies and making the total mass consistent between the two. Adjustments to the STN data include increasing the sulfate mass to account for water associated with sulfate aerosol, decreasing the nitrate mass to account for nitrate aerosol volatility, and using subtraction of all other species from total mass to estimate total carbonaceous mass to account for uncertainties in carbonaceous species measurements. These adjustments are useful in making the adjusted mass from an STN sampler agree with a collocated FRM sampler, but it is questionable whether calculation of a difference is superior to an actual measurement (albeit one with uncertainties) of carbonacous species concentrations. When this approach is applied to Blair St. $PM_{2.5}$ STN data, the ammonium sulfate mass is increased by about 2 $\mu g/m^3$, the ammonium nitrate mass is decreased by about 1 $\mu g/m^3$, and the total carbonaceous mass is decreased by about 1.5 $\mu g/m^3$ (on average, for 2004 and 2005 data). Thus data that have been reduced in this way would tend to make the nitrate and total carbonaceous mass contributions slightly less significant, but still the dominant components of the urban excess.

As discussed in Section 2.1, because this document focuses on the 24-hour $PM_{2.5}$ standard, it is instructive to examine measurement results on individual days with relatively high measured $PM_{2.5}$ concentrations. The highest $PM_{2.5}$ concentration measured by the FRM sampler at the Blair St. site during 2004-2006 was 46.1 $\mu g/m^3$ on January 31, 2005 (47.2 $\mu g/m^3$ as measured by the STN sampler). Figure 2.3-27 shows the concentrations of each of the major species on that day at Blair St. compared to the quarterly average (not including January 31, 2005). Figure 2.3-28 shows similar analysis results for the Arnold site for the same day. The similarity of the three pie charts in each figure indicates that the distribution of species at both sites on that day is essentially the same as the quarterly average and suggests that meteorological conditions on that day contributed to a higher concentration of $PM_{2.5}$ at both sites, with essentially the same distribution of species as during the rest of the quarter.

The second highest $PM_{2.5}$ concentration measured by the FRM sampler at the Blair St. site during 2004-2006 was 42.9 $\mu g/m^3$ on September 3, 2004 (42.2 $\mu g/m^3$ as measured by the STN sampler). Figure 2.3-29 shows the concentrations of each of the major species on that day compared to the quarterly average (not including September 3, 2004). Figure 2.3-30 shows similar analysis results for the Arnold site for the same day. The graphs in both figures, especially the third pie charts in both figures, show that the excess $PM_{2.5}$ on that day was dominated by ammonium sulfate (79 percent of the excess mass at Blair St., 84 percent at Arnold), with organic species the second-most significant contributor. This result, together with the widespread high $PM_{2.5}$ concentration on that day (see Table 2.1-3) suggests that meteorological conditions on that day resulted in a widespread higher concentration of sulfate of regional origin in the St. Louis area. In other words, the high $PM_{2.5}$ concentration on that day did not result primarily from localized sources, but from regional sulfate. However, slightly higher concentrations at the VFW and Granite City sites than at Blair St. on many summer days suggest a local source contribution at those sites in addition to regional influences.

Figures 2.3-31 and 2.3-32 show the results of the same kind of analysis for February 18, 2004, a winter day showing a fairly large difference between the Granite City and Blair St. $PM_{2.5}$ concentrations (see Table 2.1-4). The results are similar to those for January 31, 2005 described above. As with the January 31, 2005 data, the similar concentrations and compositions at Blair St. and Arnold suggest that the higher concentration at the Granite City site resulted in part from local sources.

Figures 2.3-33 and 2.3-34 show the results of the same kind of analysis for September 7, 2005, a summer day showing a fairly large difference between $PM_{2.5}$ concentrations measured at either the VFW or Granite City site and that measured at the Blair St. site (see Table 2.1-4). The results are similar to those for September 3, 2004 described above. As with the September 3, 2004 data, the excess at both sites above the seasonal average consists primarily of ammonium sulfate with organic species making the second-highest contribution. The similar results at both sites suggest that meteorological conditions on that day resulted in a widespread higher concentration of sulfate of regional origin in the St. Louis area. And again, the higher concentrations at the VFW and Granite City sites than at Blair St. suggest a local source contribution at those sites in addition to regional influences.

Figure 2.3-1. PM2.5 Total Mass Concentration

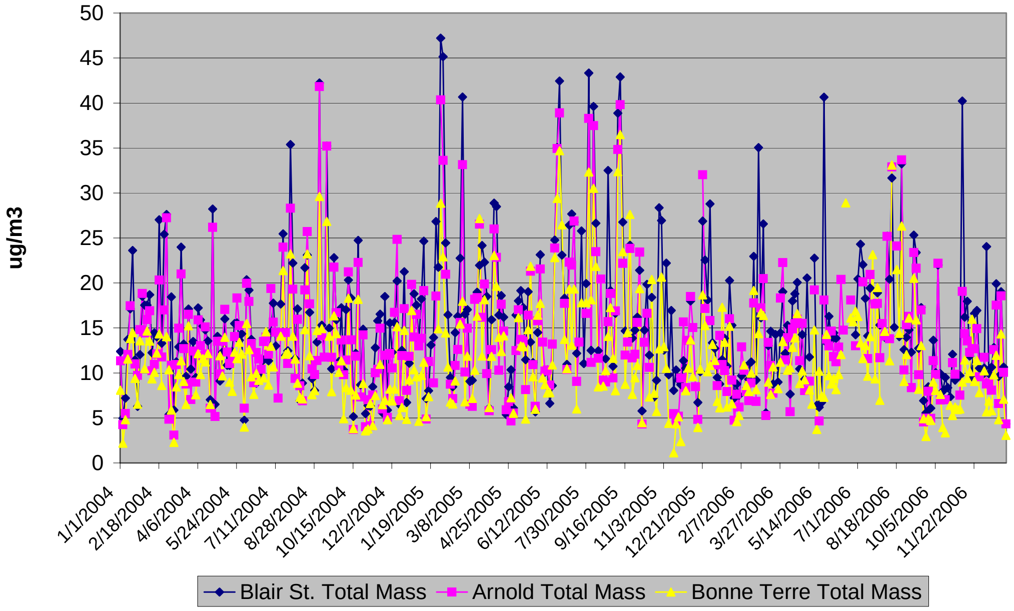


Figure 2.3-2. PM2.5 Sulfate Concentration

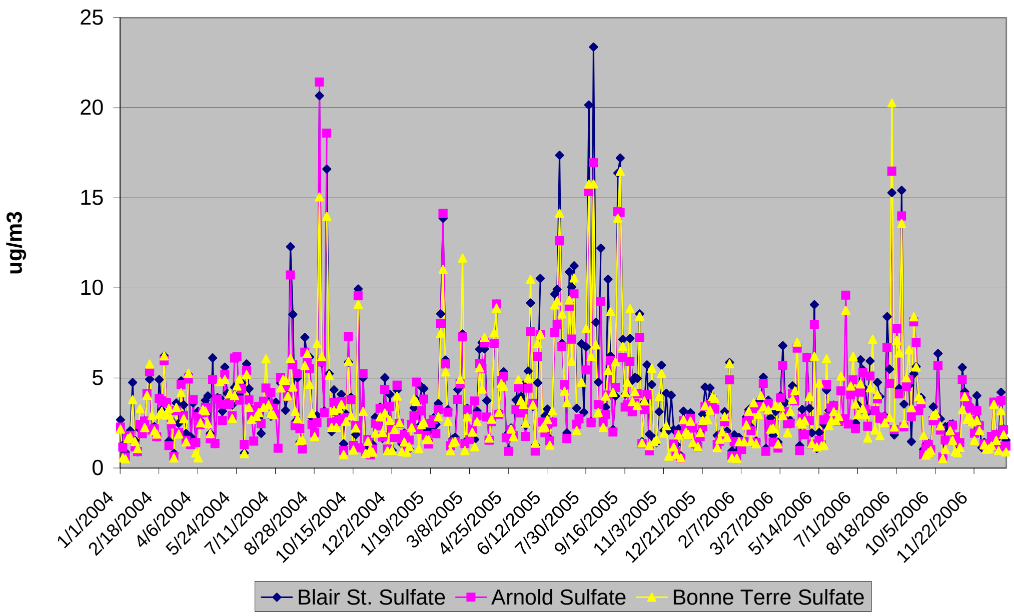


Figure 2.3-3. PM2.5 Nitrate Concentration

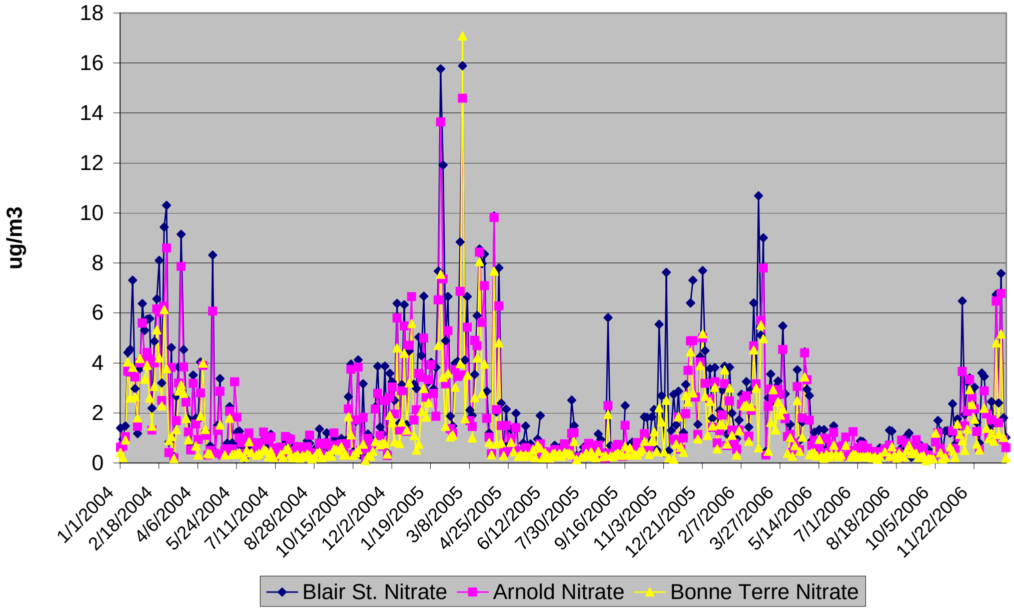


Figure 2.3-4. PM2.5 Ammonium Concentration

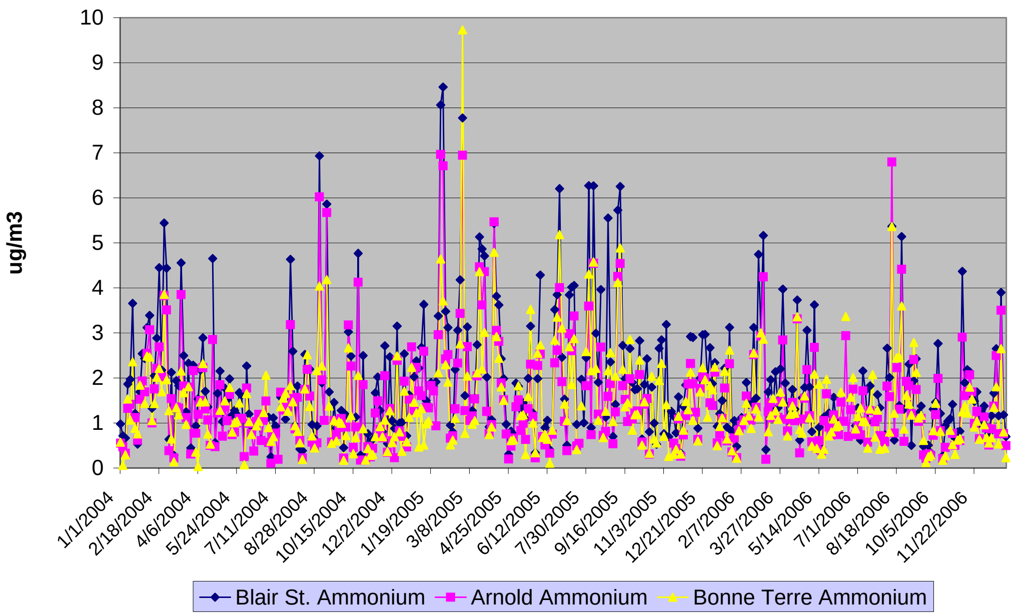


Figure 2.3-5. PM2.5 Organic Carbon Concentration

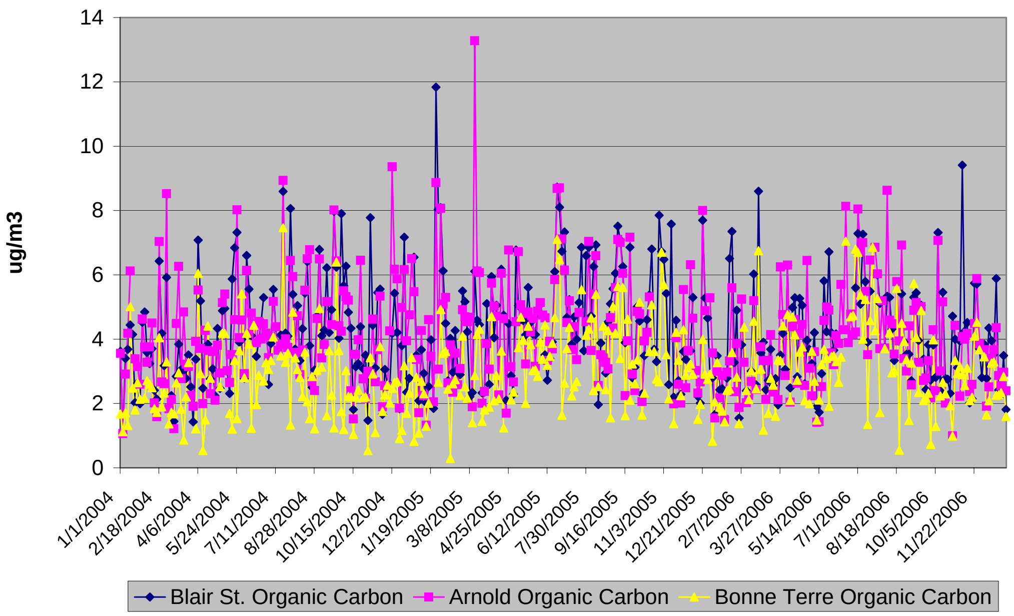


Figure 2.3-6. PM2.5 Elemental Carbon Concentration

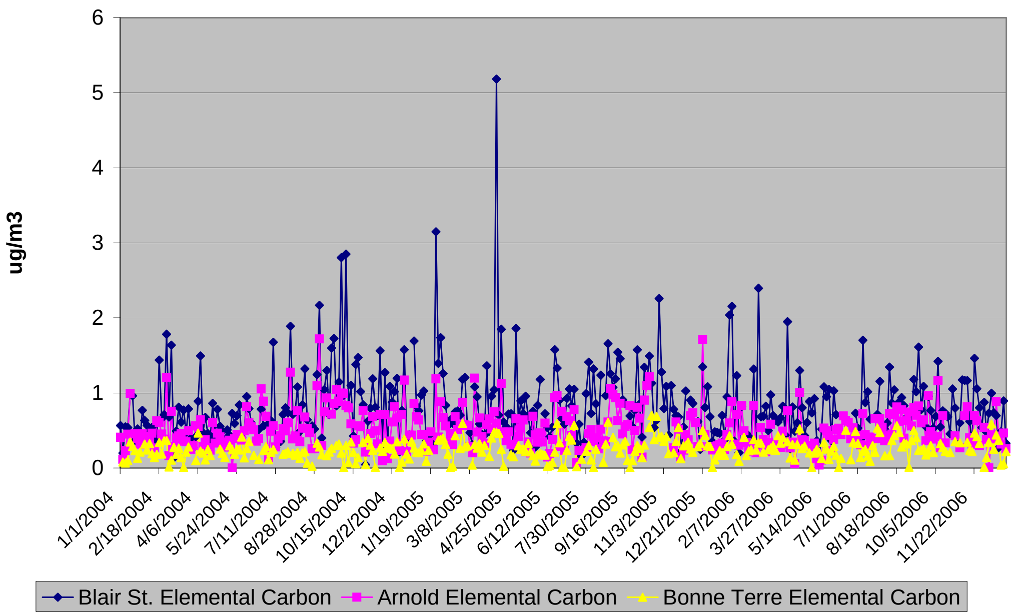


Figure 2.3-7. PM2.5 Total Mass Ratios

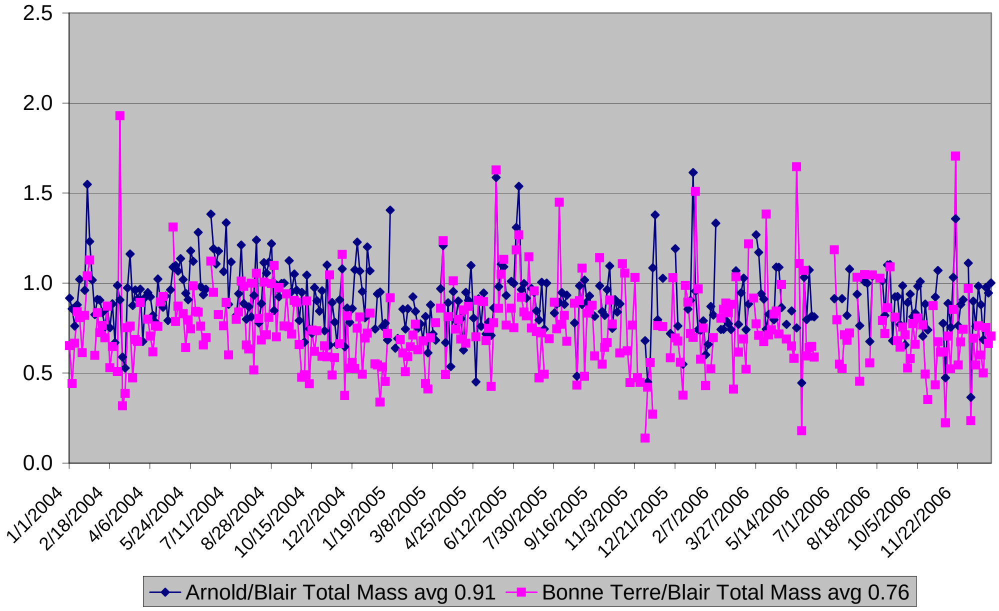


Figure 2.3-8. PM2.5 Sulfate Ratios

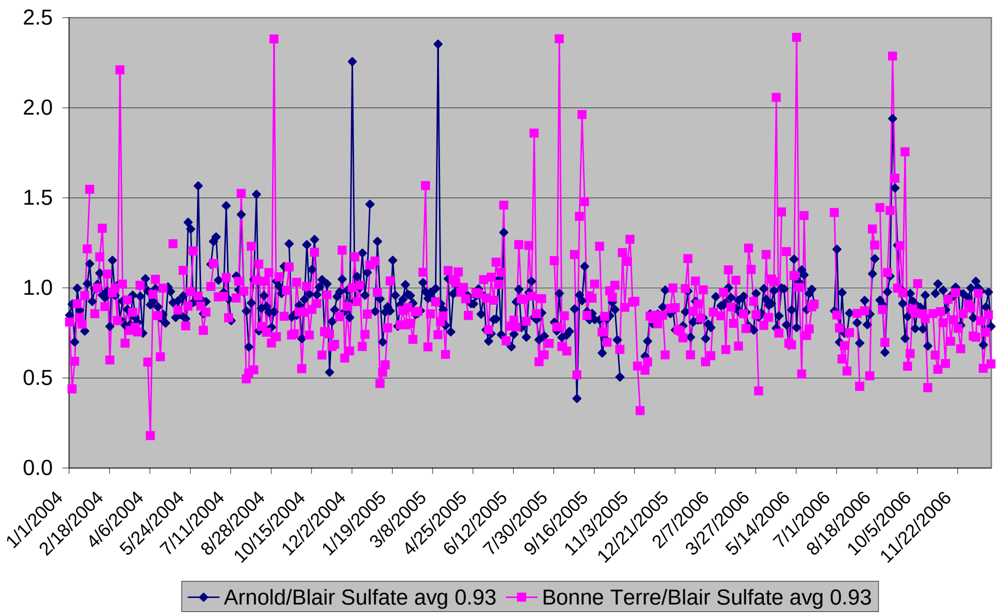


Figure 2.3-9. PM2.5 Nitrate Ratios

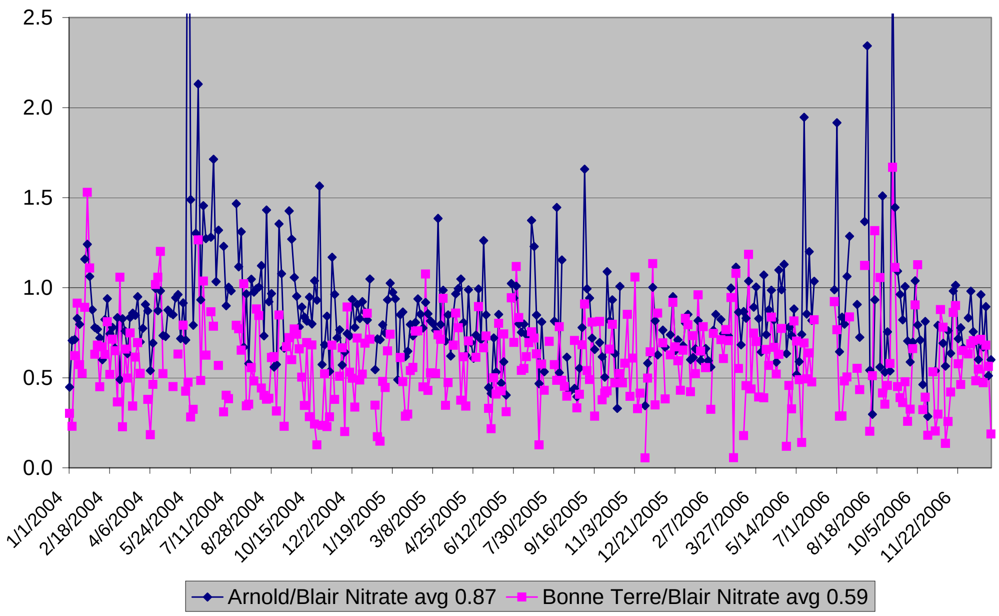


Figure 2.3-10. PM2.5 Ammonium Ratios

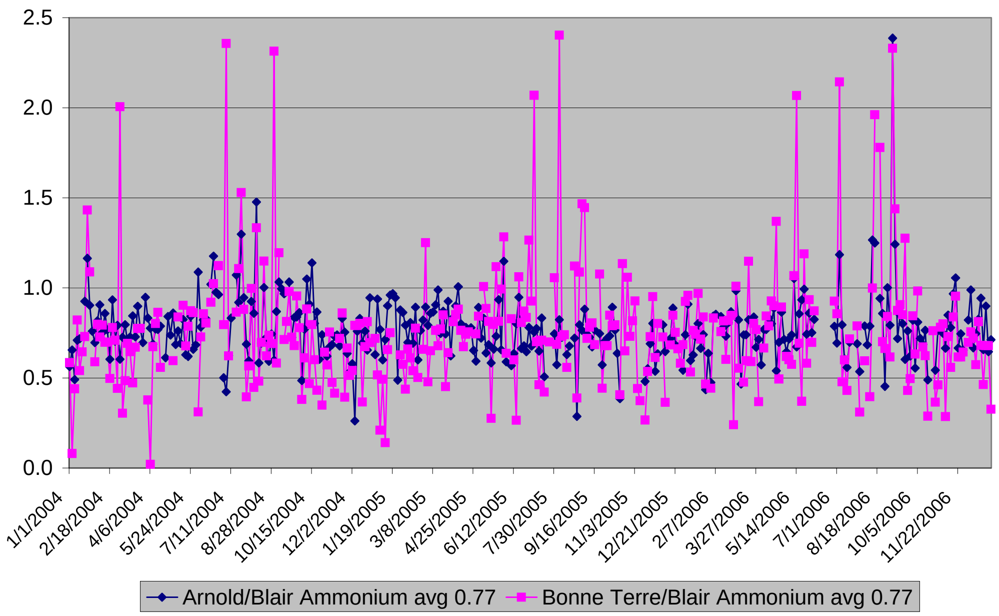


Figure 2.3-11. PM2.5 Organic Carbon Ratios

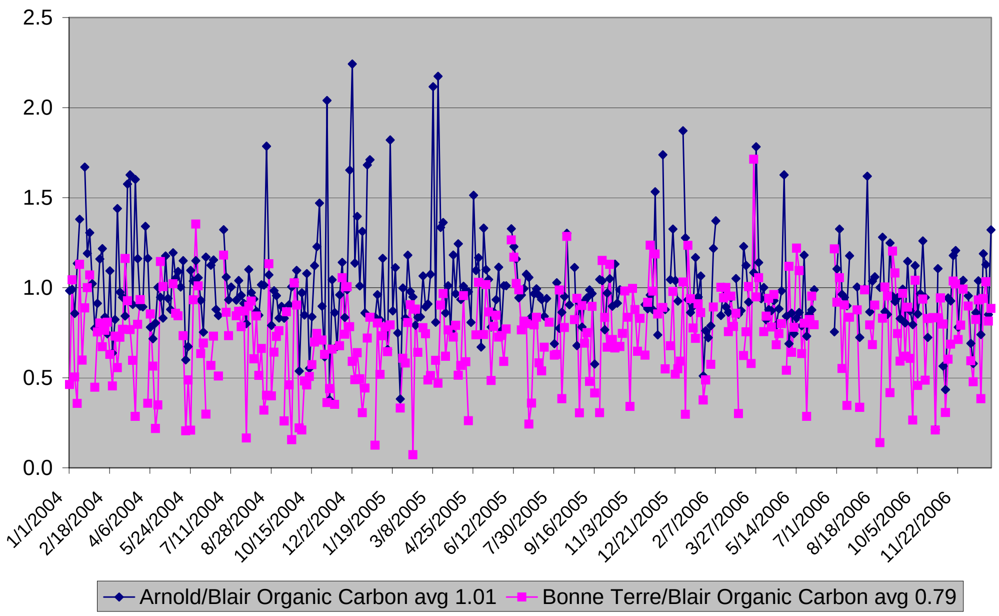
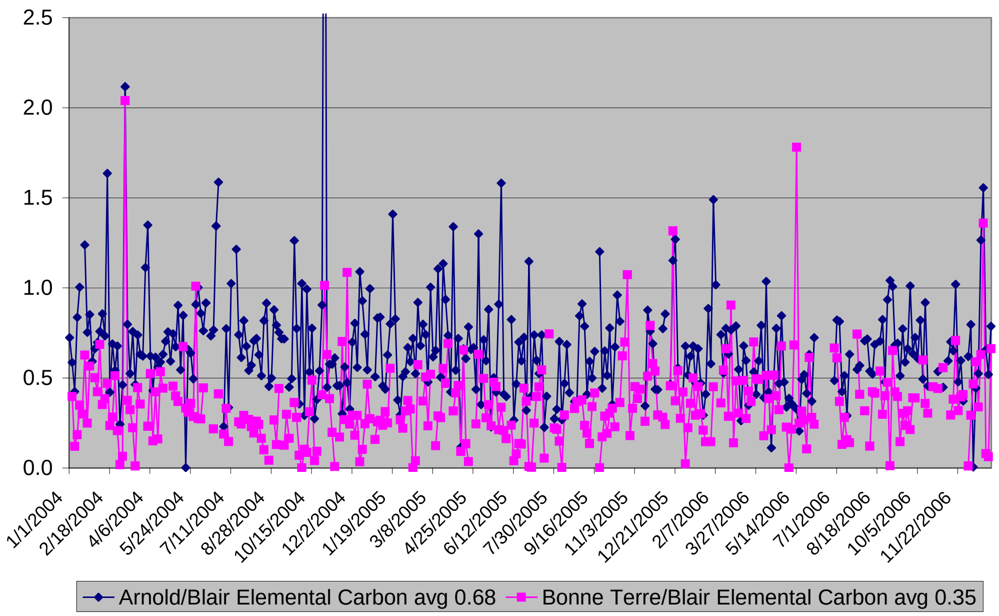


Figure 2.3-12. PM2.5 Elemental Carbon Ratios



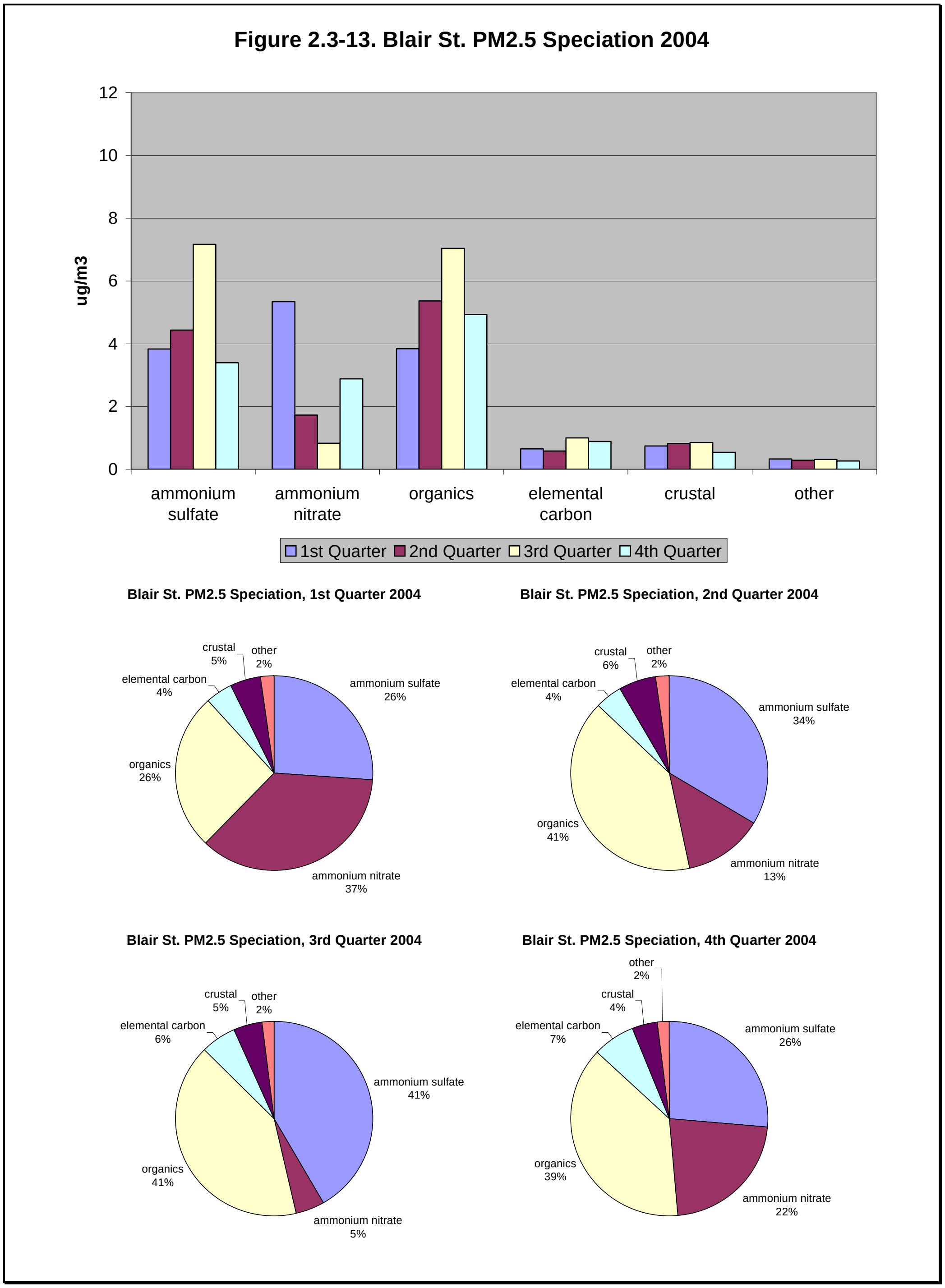


Figure 2.3-13. Blair St. PM2.5 Speciation 2004
ug/m3
12
10
8
6
4
2
0
ammonium sulfate
ammonium nitrate
organics
elemental carbon
crustal
other
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
Blair St. PM2.5 Speciation, 1st Quarter 2004
crustal 5%
other 2%
elemental carbon 4%
ammonium sulfate 26%
organics 26%
ammonium nitrate 37%
Blair St. PM2.5 Speciation, 2nd Quarter 2004
crustal 6%
other 2%
elemental carbon 4%
ammonium sulfate 34%
organics 41%
ammonium nitrate 13%
Blair St. PM2.5 Speciation, 3rd Quarter 2004
crustal 5%
other 2%
elemental carbon 6%
ammonium sulfate 41%
organics 41%
ammonium nitrate 5%
Blair St. PM2.5 Speciation, 4th Quarter 2004
other 2%
crustal 4%
elemental carbon 7%
ammonium sulfate 26%
organics 39%
ammonium nitrate 22%

Figure 2.3-14. Blair St. PM2.5 Speciation 2005

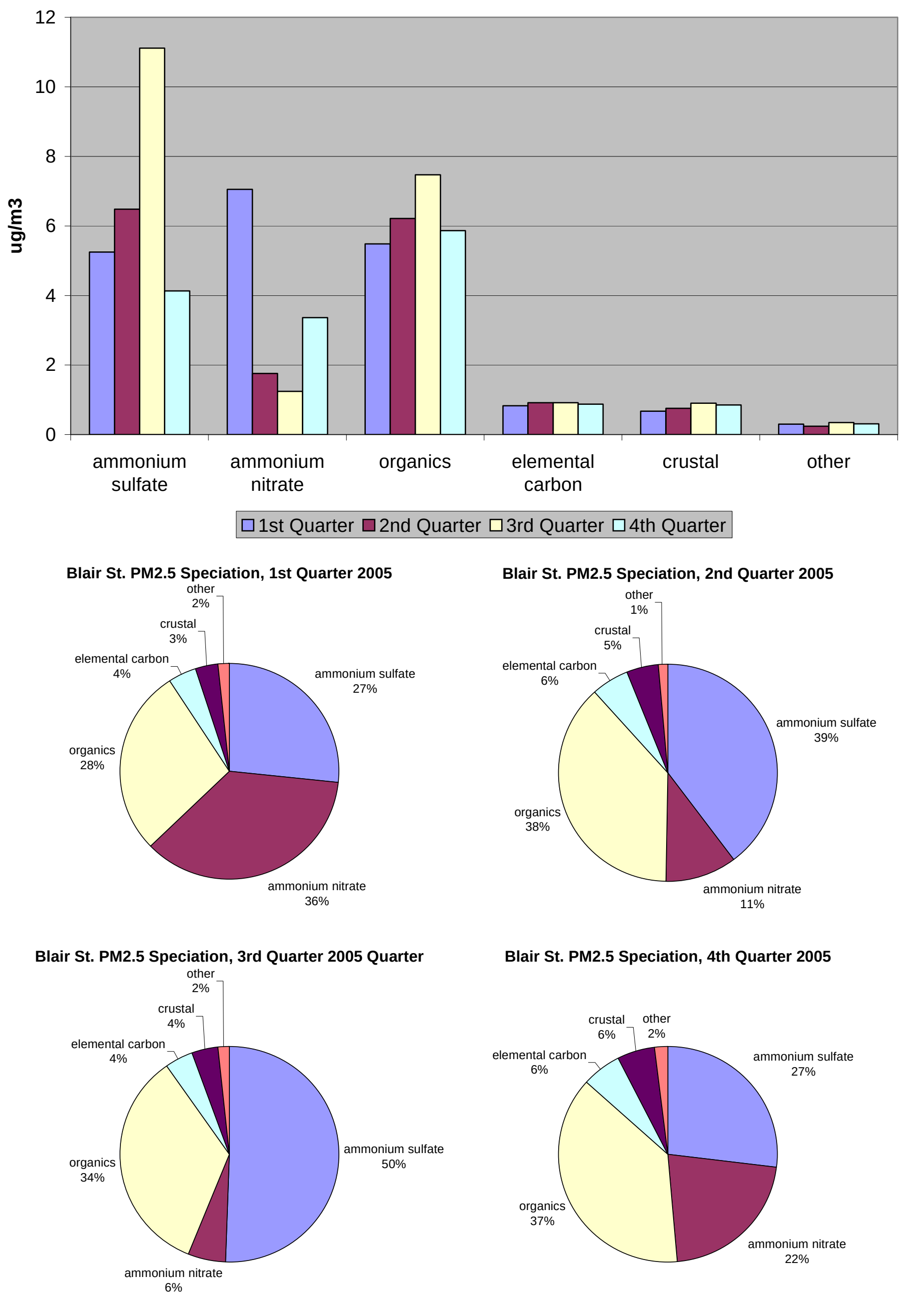


Figure 2.3-15. Blair St. PM2.5 Speciation 2006

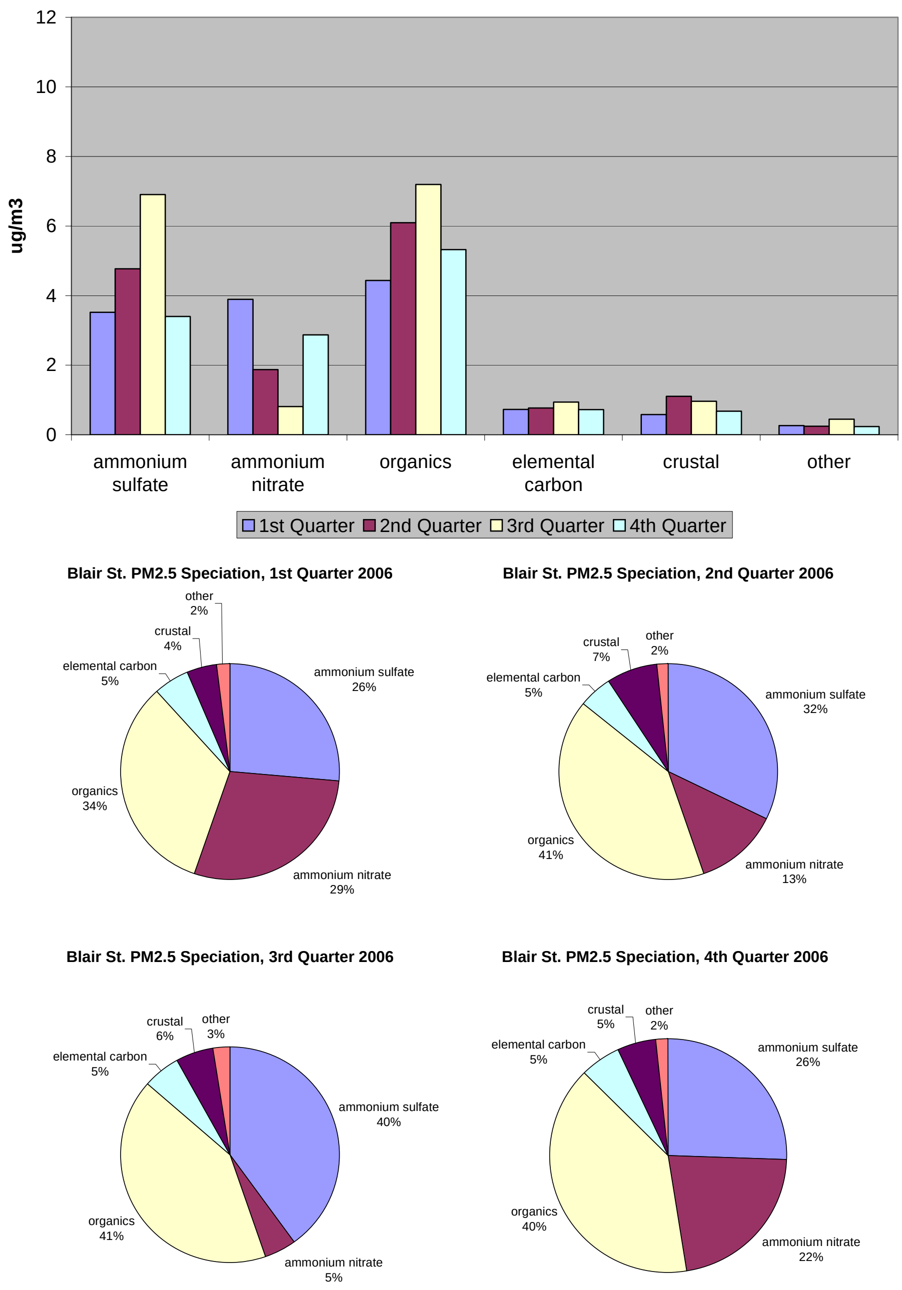


Figure 2.3-16. Arnold PM2.5 Speciation 2004

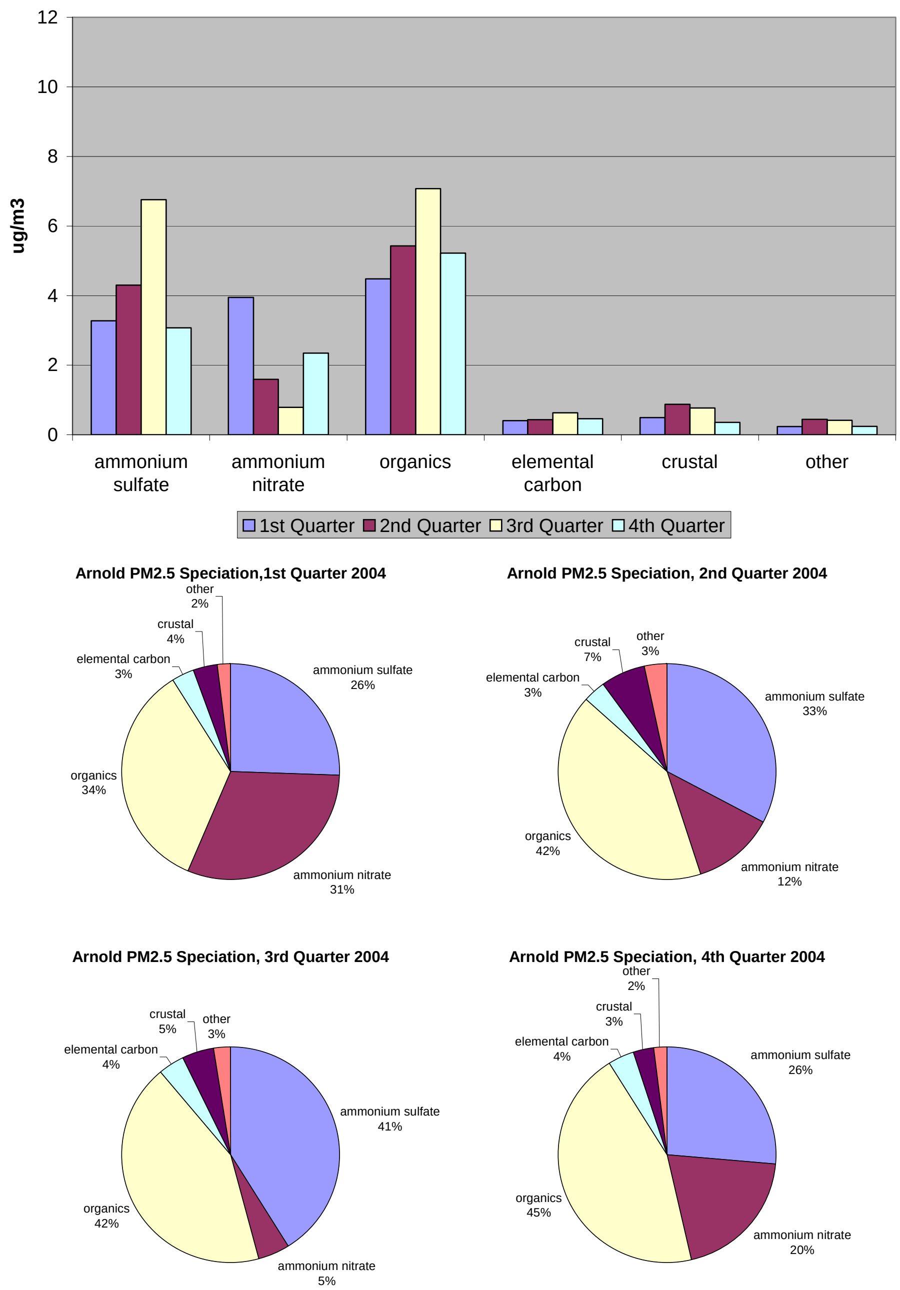


Figure 2.3-17. Arnold PM2.5 Speciation 2005

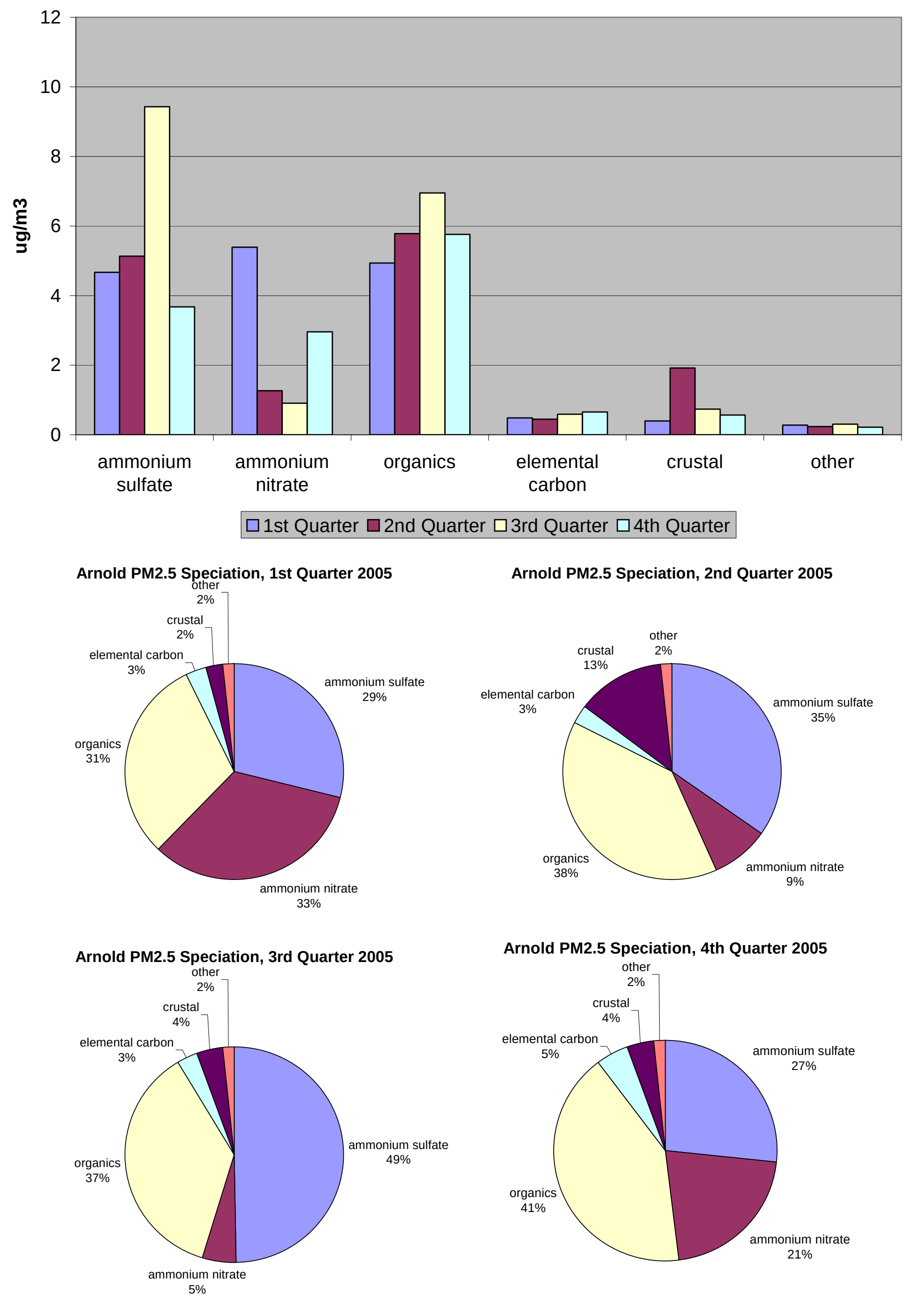


Figure 2.3-18. Arnold PM2.5 Speciation 2006

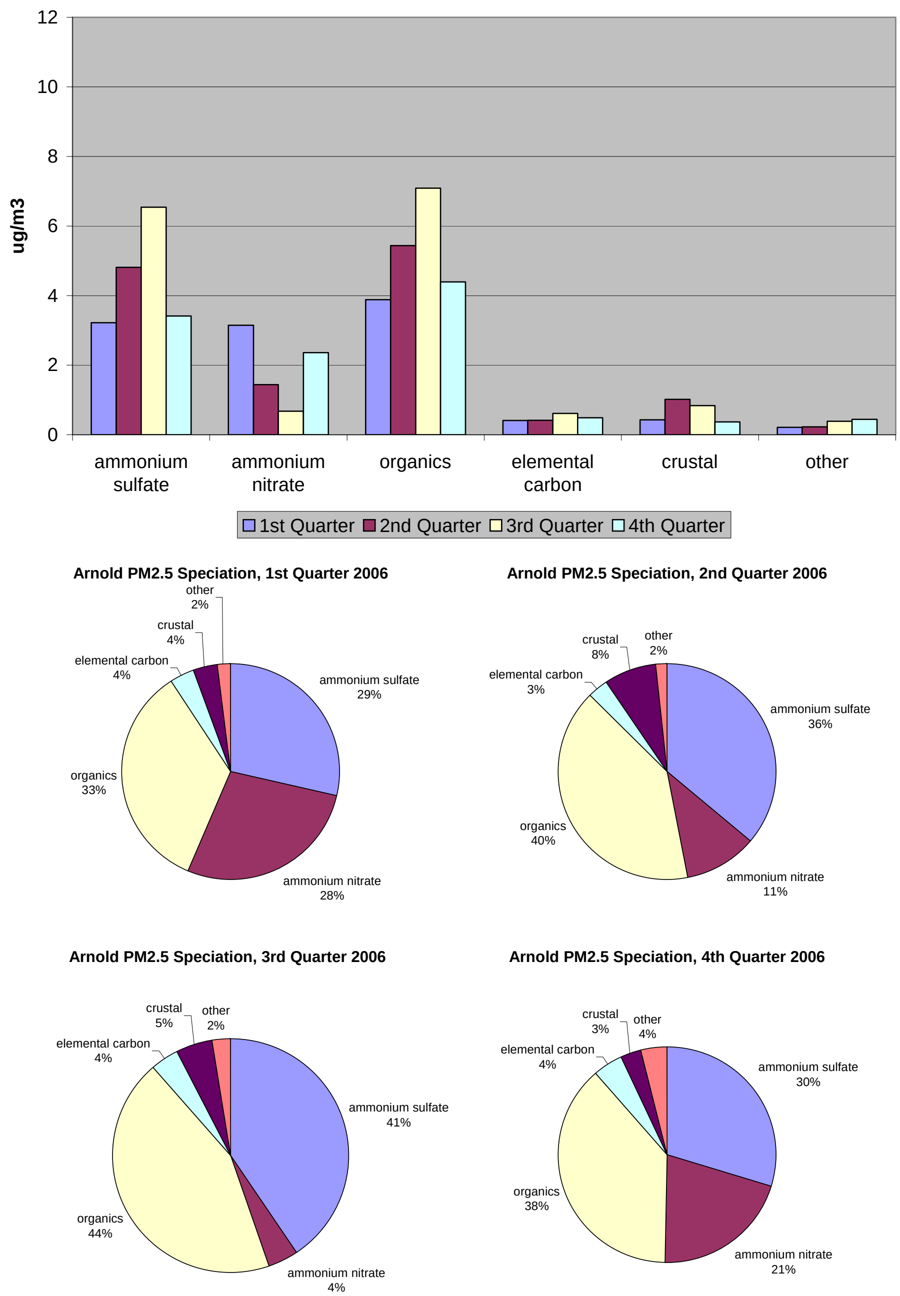


Figure 2.3-19. Bonne Terre PM2.5 Speciation 2004

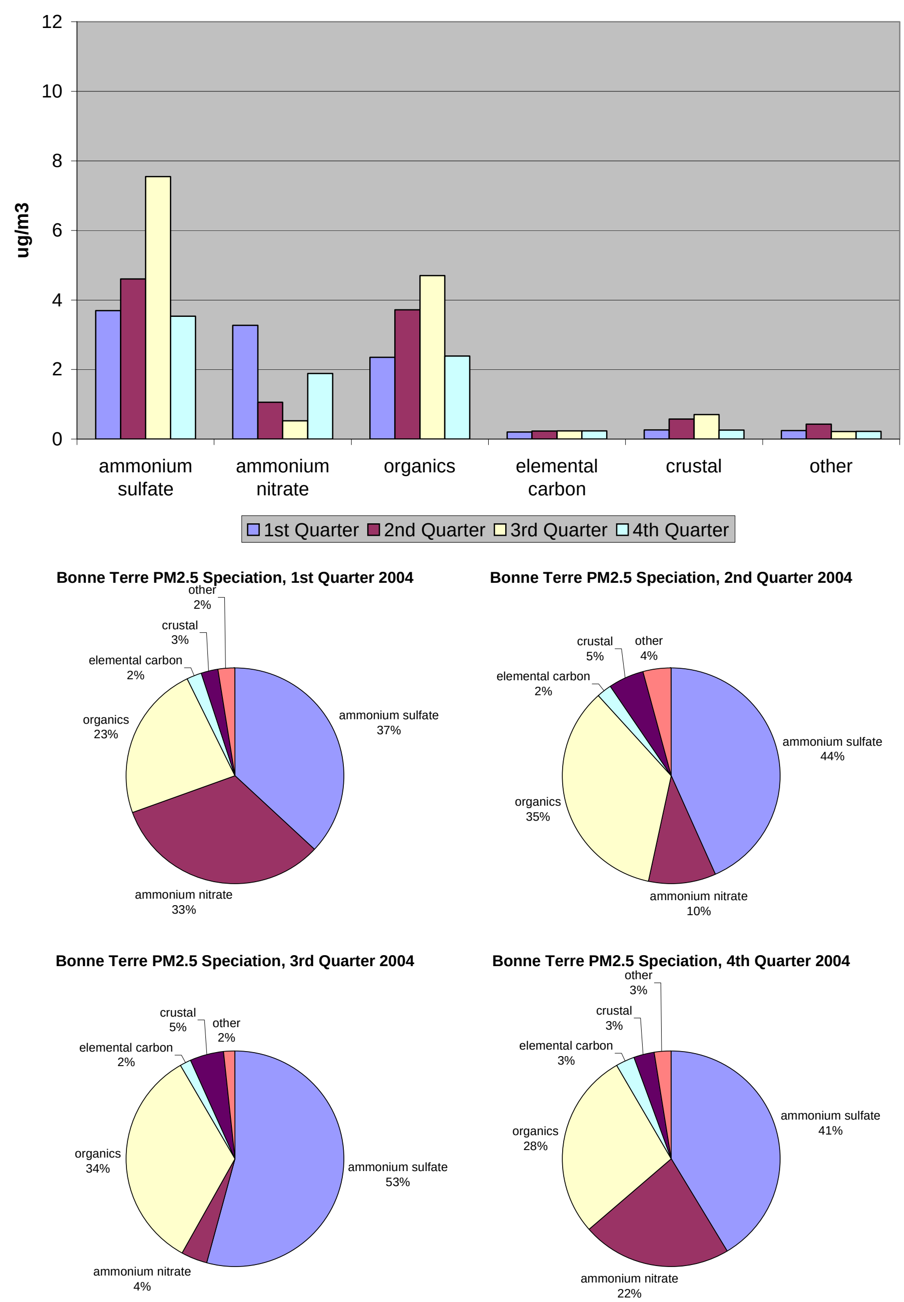
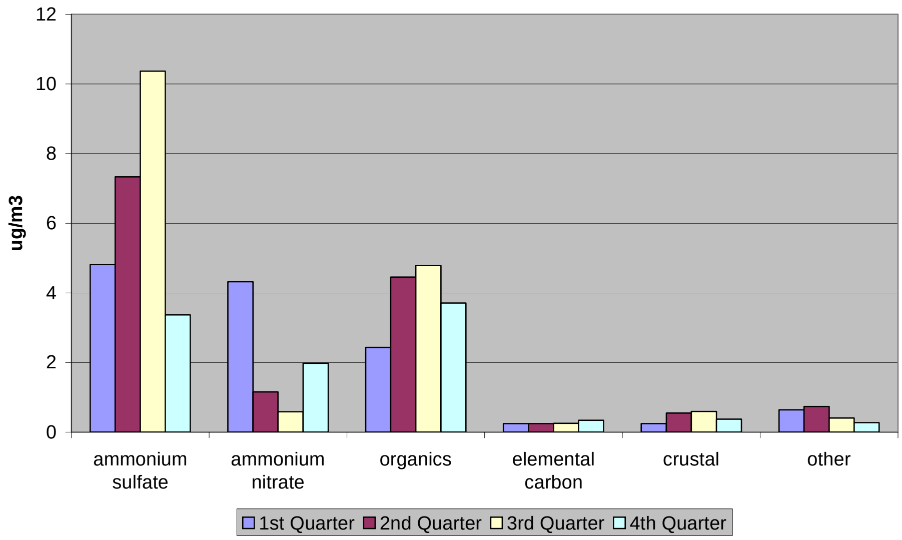
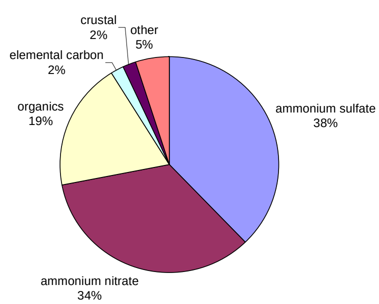


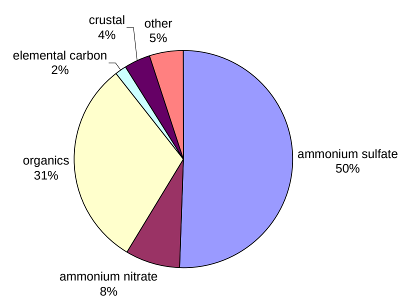
Figure 2.3-20. Bonne Terre PM2.5 Speciation 2005



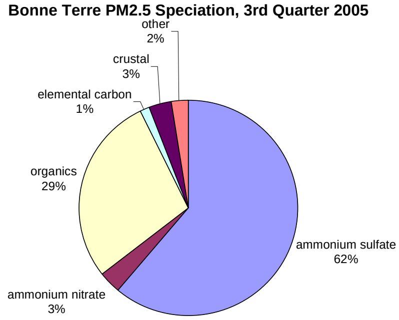
Bonne Terre PM2.5 Speciation, 1st Quarter 2005



Bonne Terre PM2.5 Speciation, 2nd Quarter 2005



Bonne Terre PM2.5 Speciation, 3rd Quarter 2005



Bonne Terre PM2.5 Speciation, 4th Quarter 2005

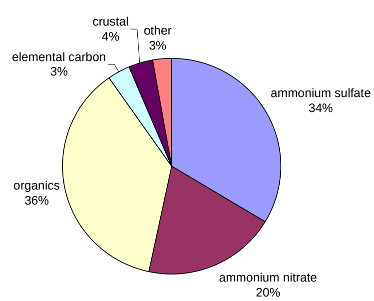


Figure 2.3-21. Bonne Terre PM2.5 Speciation 2006

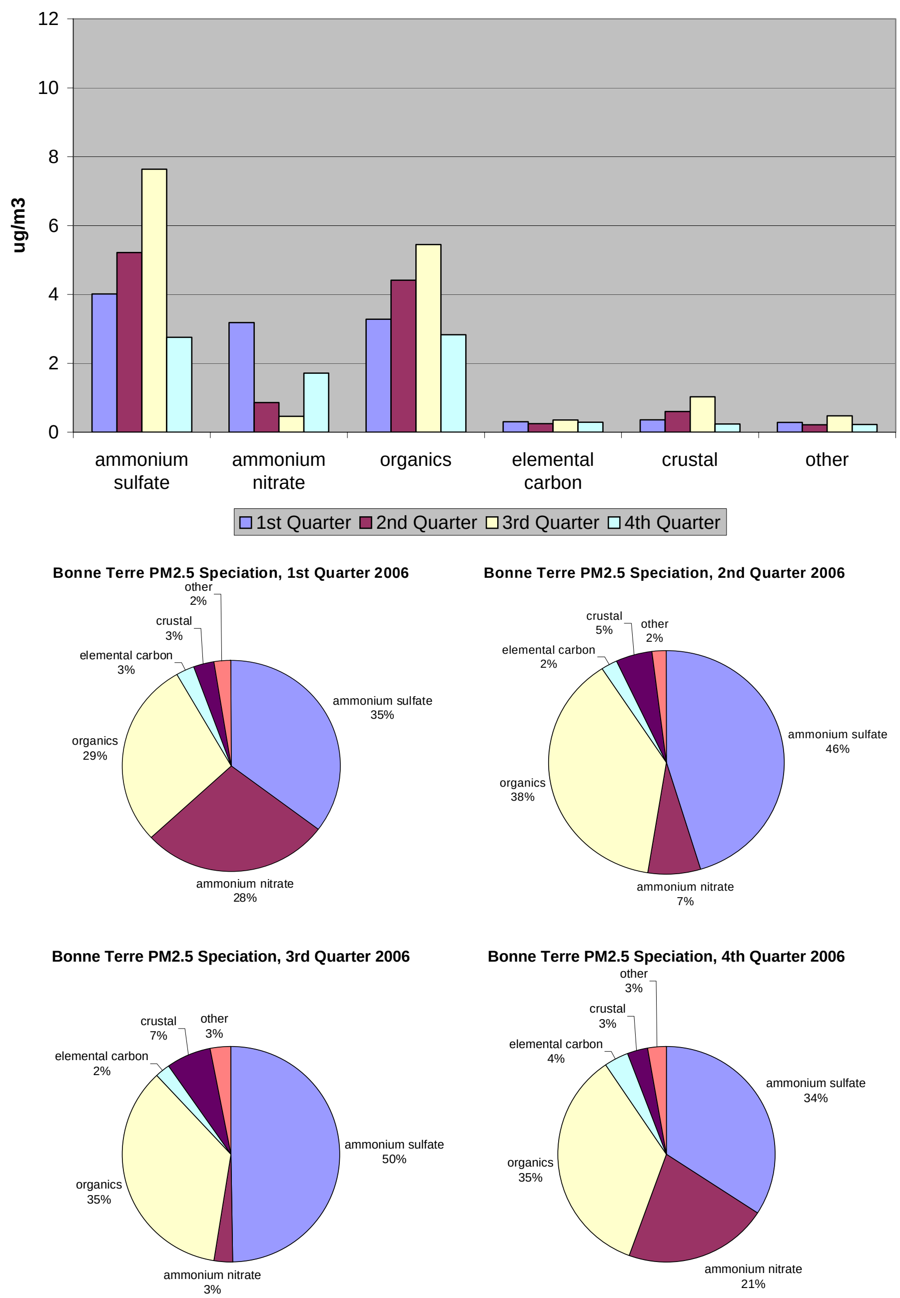


Figure 2.3-22. Blair St. minus Bonne Terre PM2.5 Speciation 2004

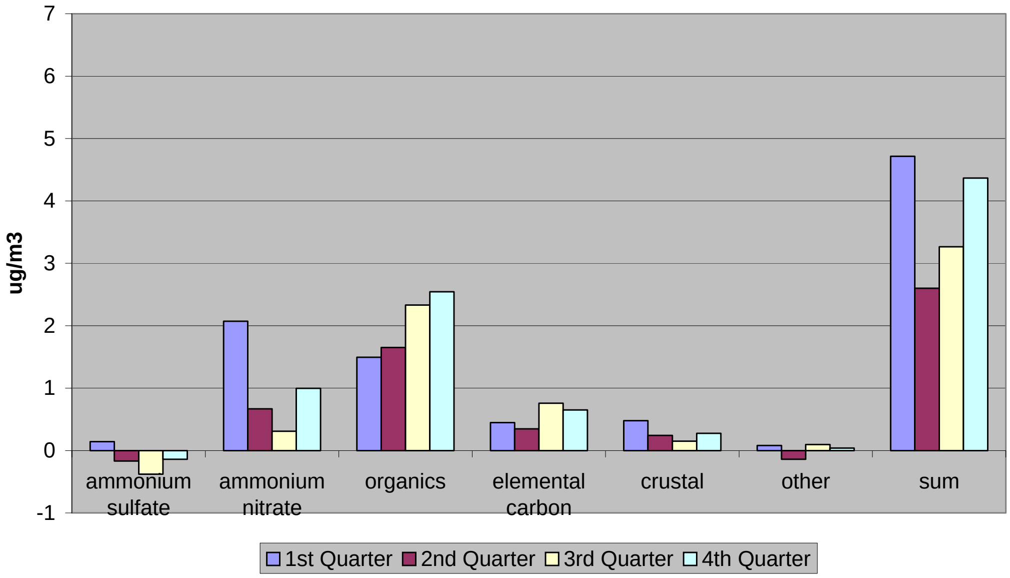


Figure 2.3-23. Blair St. minus Bonne Terre PM2.5 Speciation 2005

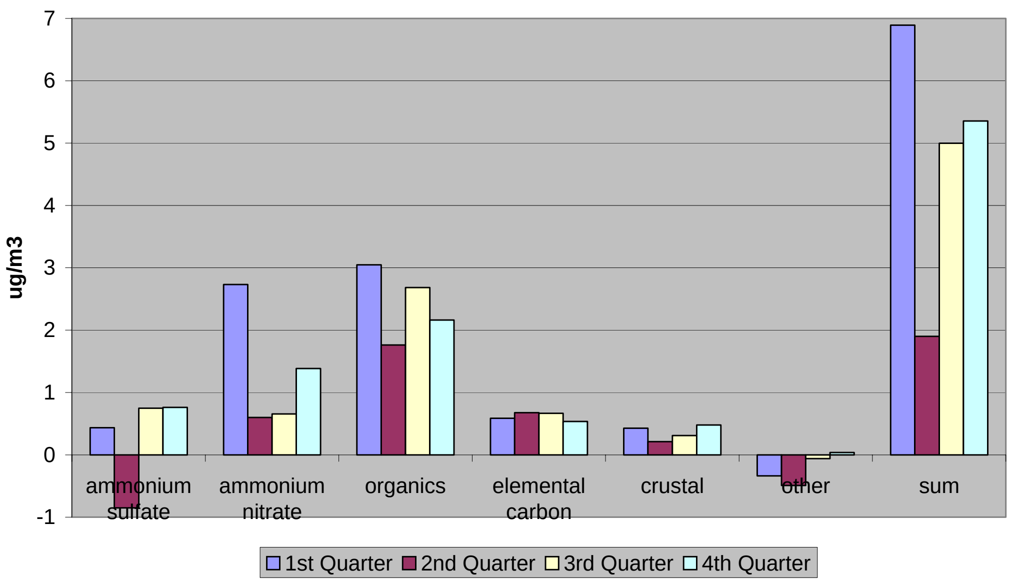


Figure 2.3-24. Blair St. minus Bonne Terre PM2.5 Speciation 2006

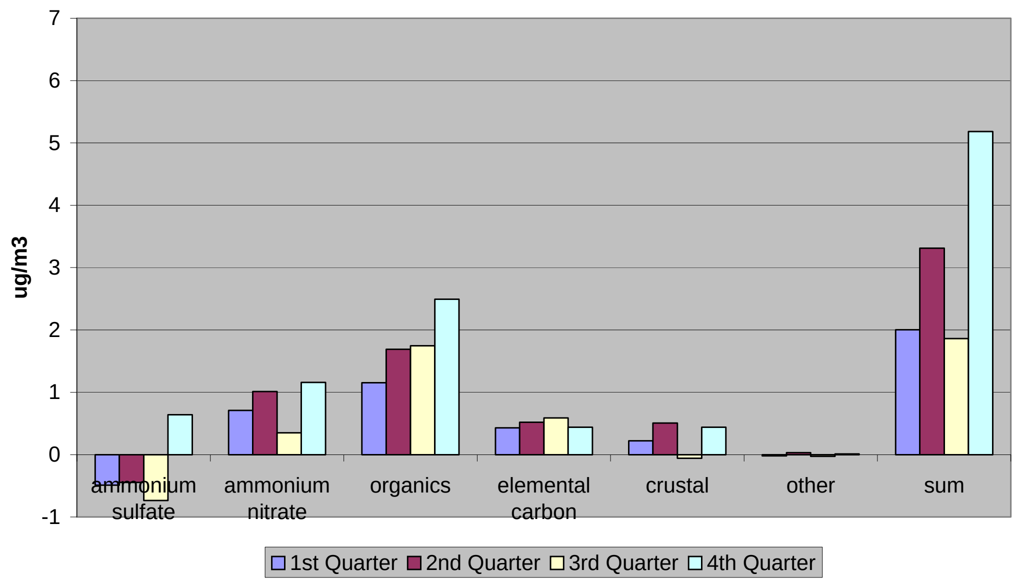


Figure 2.3-25. Blair St. minus Pleasant Green PM2.5 Speciation 2004

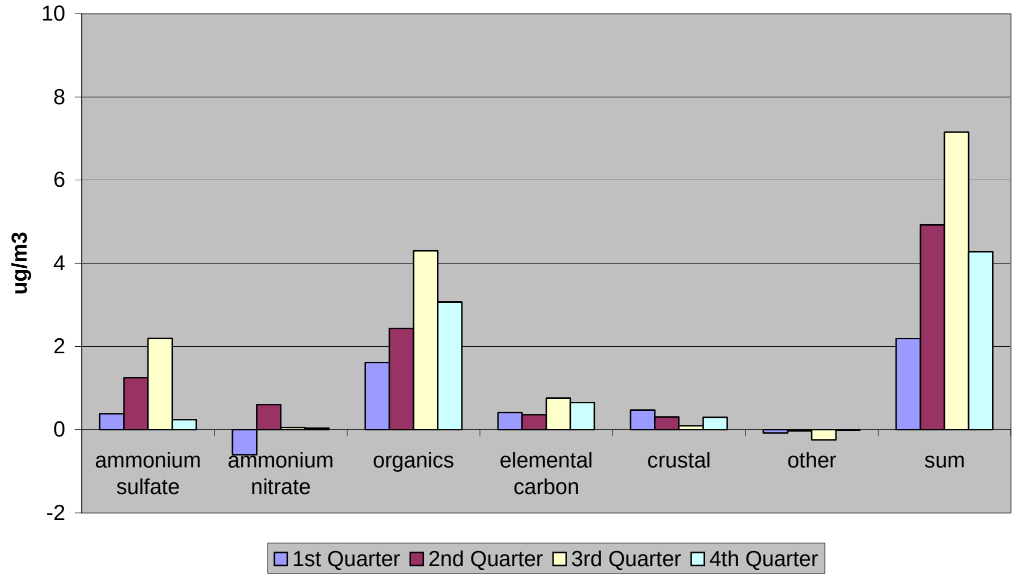
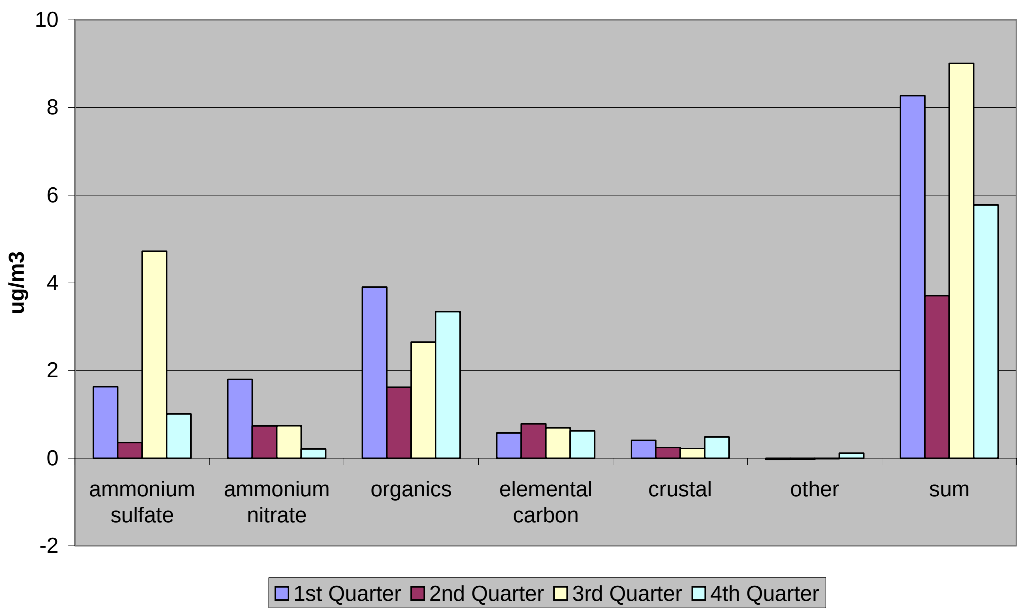


Figure 2.3-26. Blair St. minus Pleasant Green PM2.5 Speciation 2005



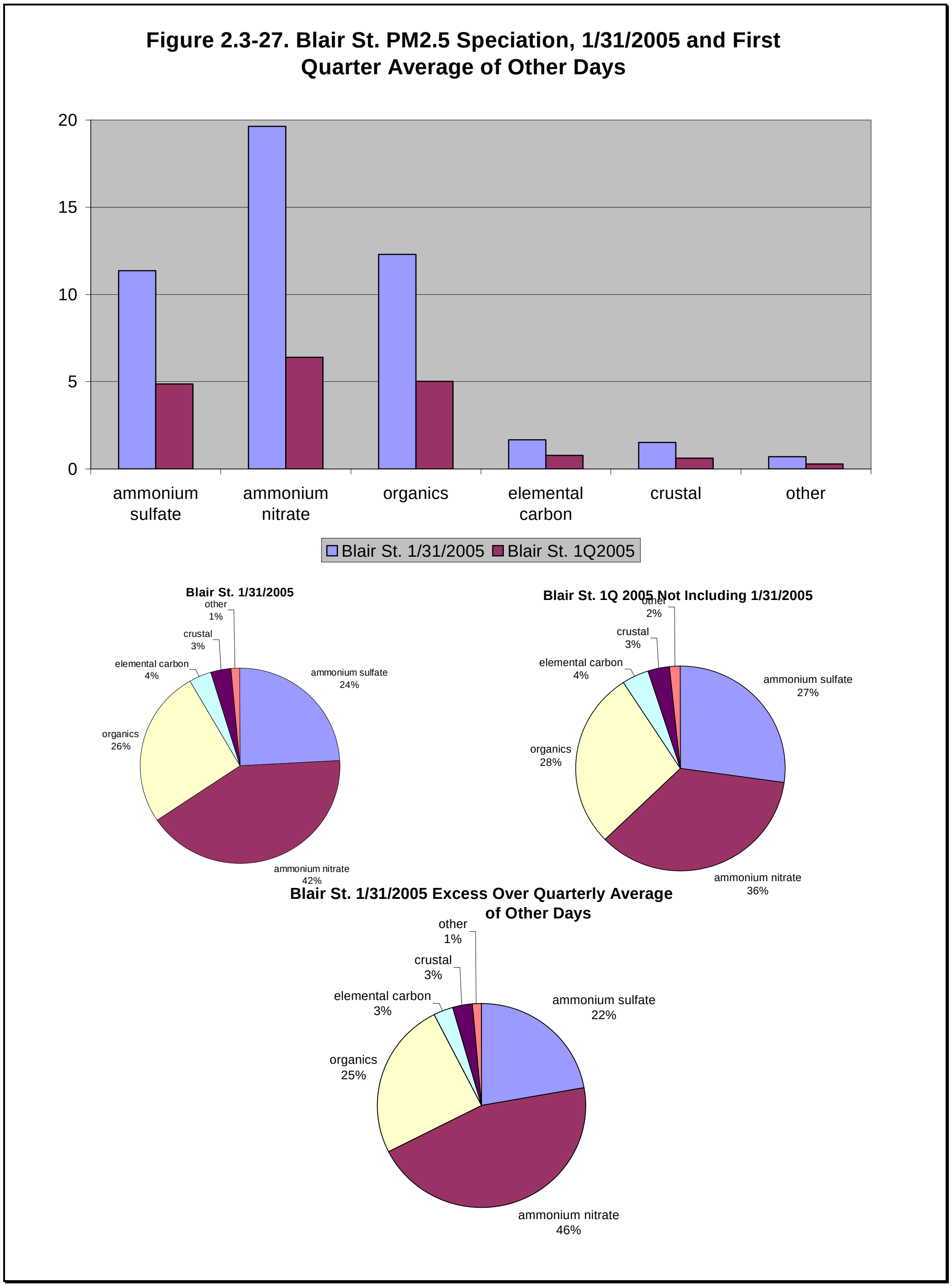


Figure 2.3-27. Blair St. PM2.5 Speciation, 1/31/2005 and First Quarter Average of Other Days
20
15
10
5
0
ammonium sulfate
ammonium nitrate
organics
elemental carbon
crustal
other
Blair St. 1/31/2005
Blair St. 1Q2005
Blair St. 1/31/2005
other 1%
crustal 3%
elemental carbon 4%
ammonium sulfate 24%
organics 26%
ammonium nitrate 42%
Blair St. 1Q 2005 Not Including 1/31/2005
other 2%
crustal 3%
elemental carbon 4%
ammonium sulfate 27%
organics 28%
ammonium nitrate 36%
Blair St. 1/31/2005 Excess Over Quarterly Average of Other Days
other 1%
crustal 3%
elemental carbon 3%
ammonium sulfate 22%
organics 25%
ammonium nitrate 46%

Figure 2.3-28. Arnold PM2.5 Speciation, 1/31/2005 and First Quarter Average of Other Days

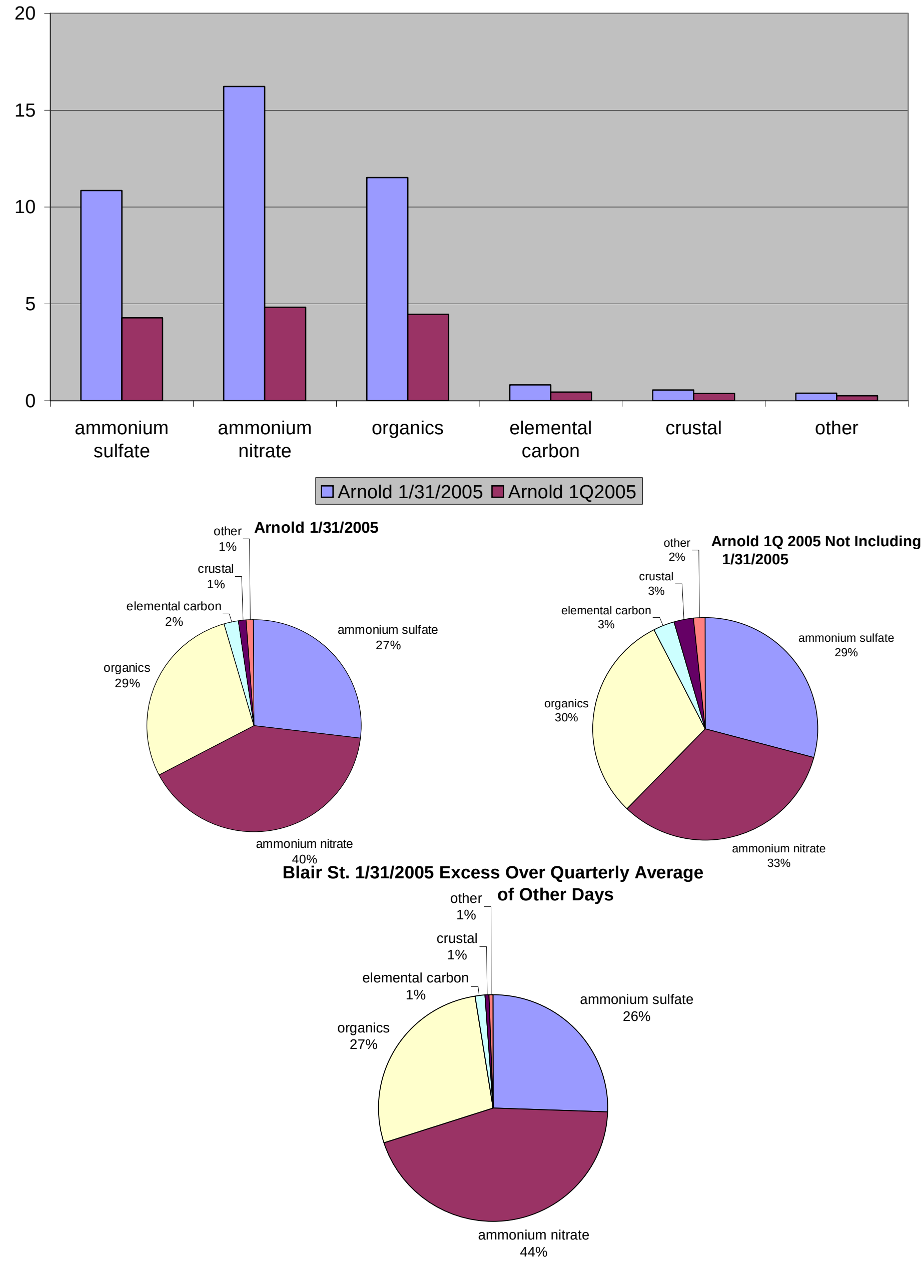


Figure 2.3-29. Blair St. PM2.5 Speciation, 9/3/2004 and Third Quarter Average of Other Days

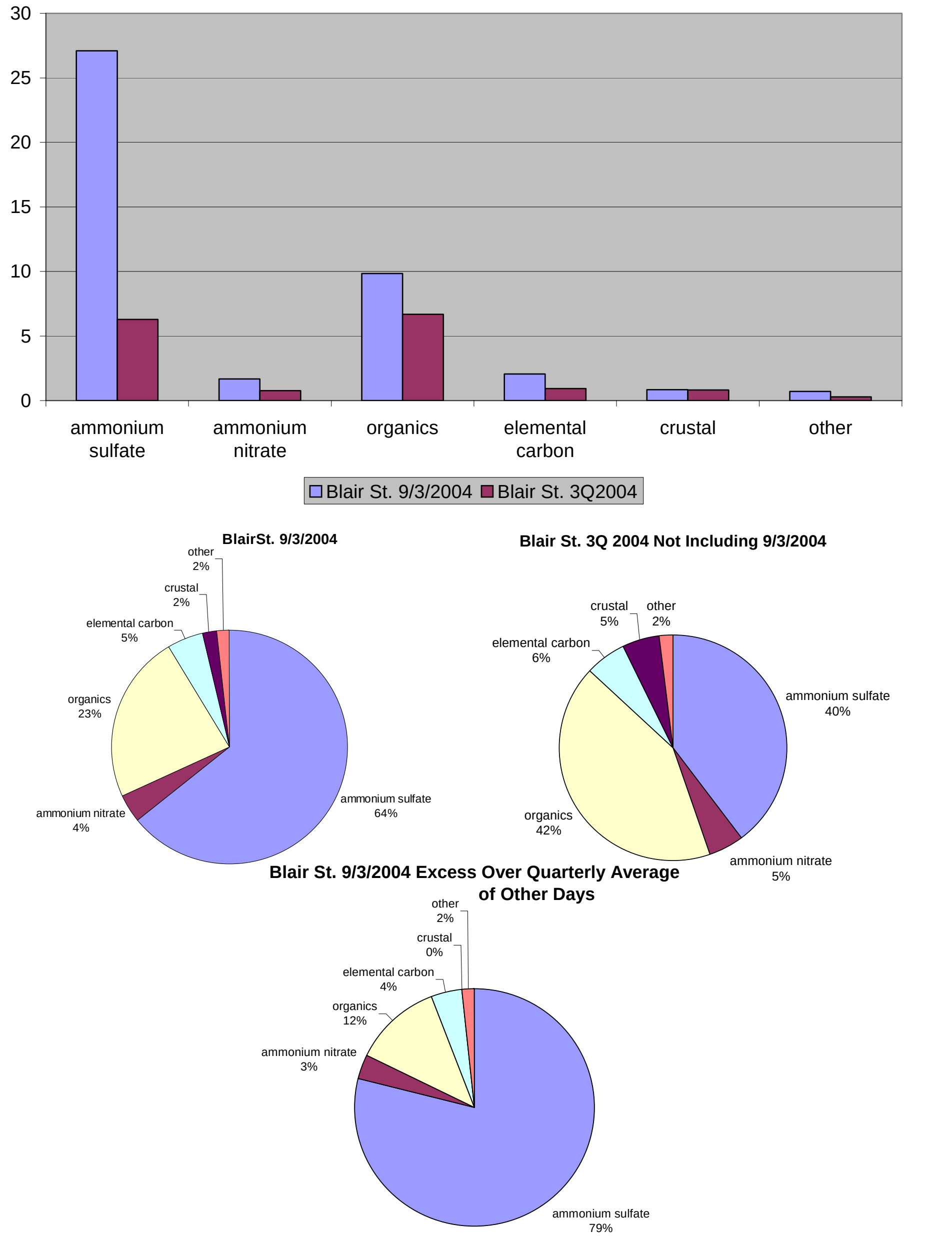


Figure 2.3-30. Arnold PM2.5 Speciation, 9/3/2004 and Third Quarter Average of Other Days

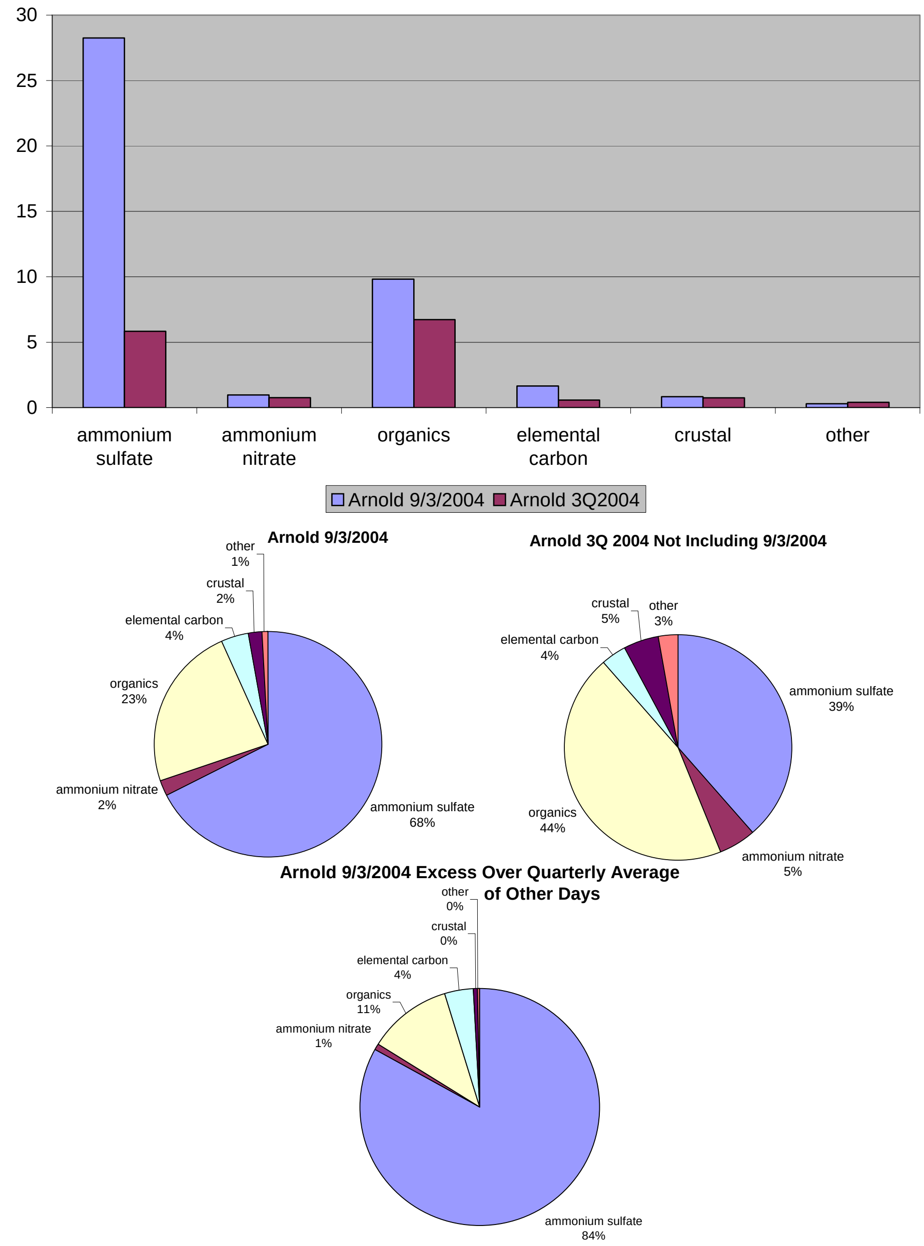


Figure 2.3-31. Blair St. PM2.5 Speciation, 2/18/2004 and First Quarter Average of Other Days

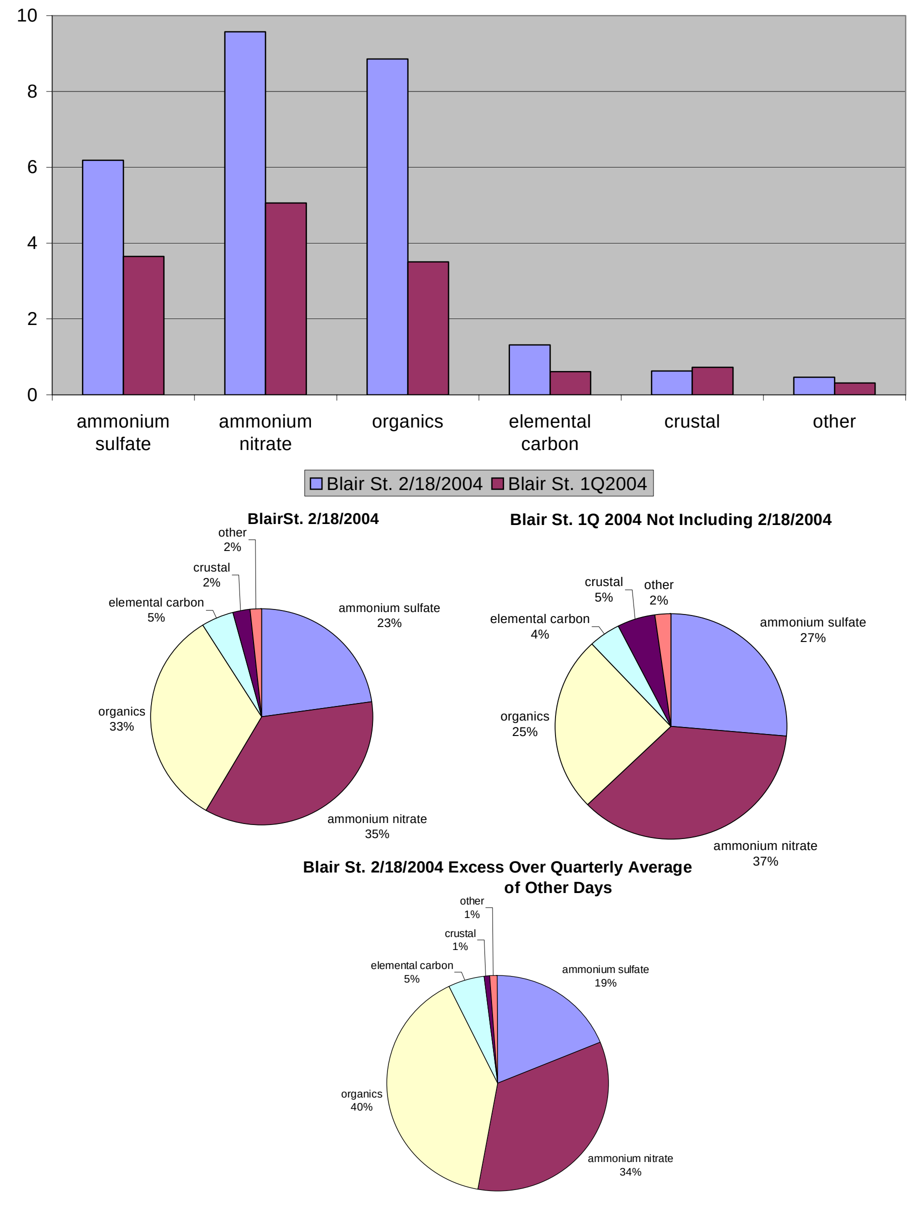


Figure 2.3-32. Arnold PM2.5 Speciation, 2/18/2004 and First Quarter Average of Other Days

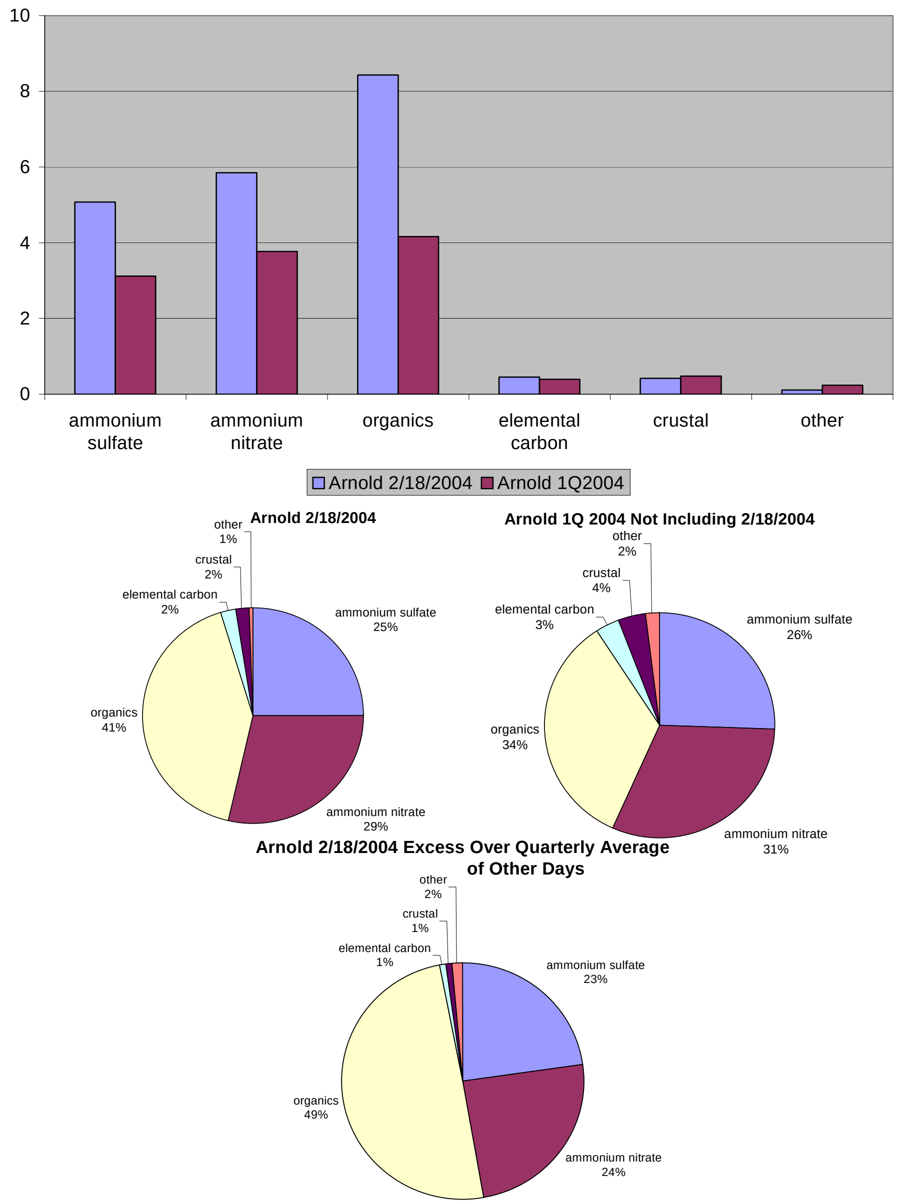


Figure 2.3-33. Blair St. PM2.5 Speciation, 9/7/2005 and Third Quarter Average of Other Days

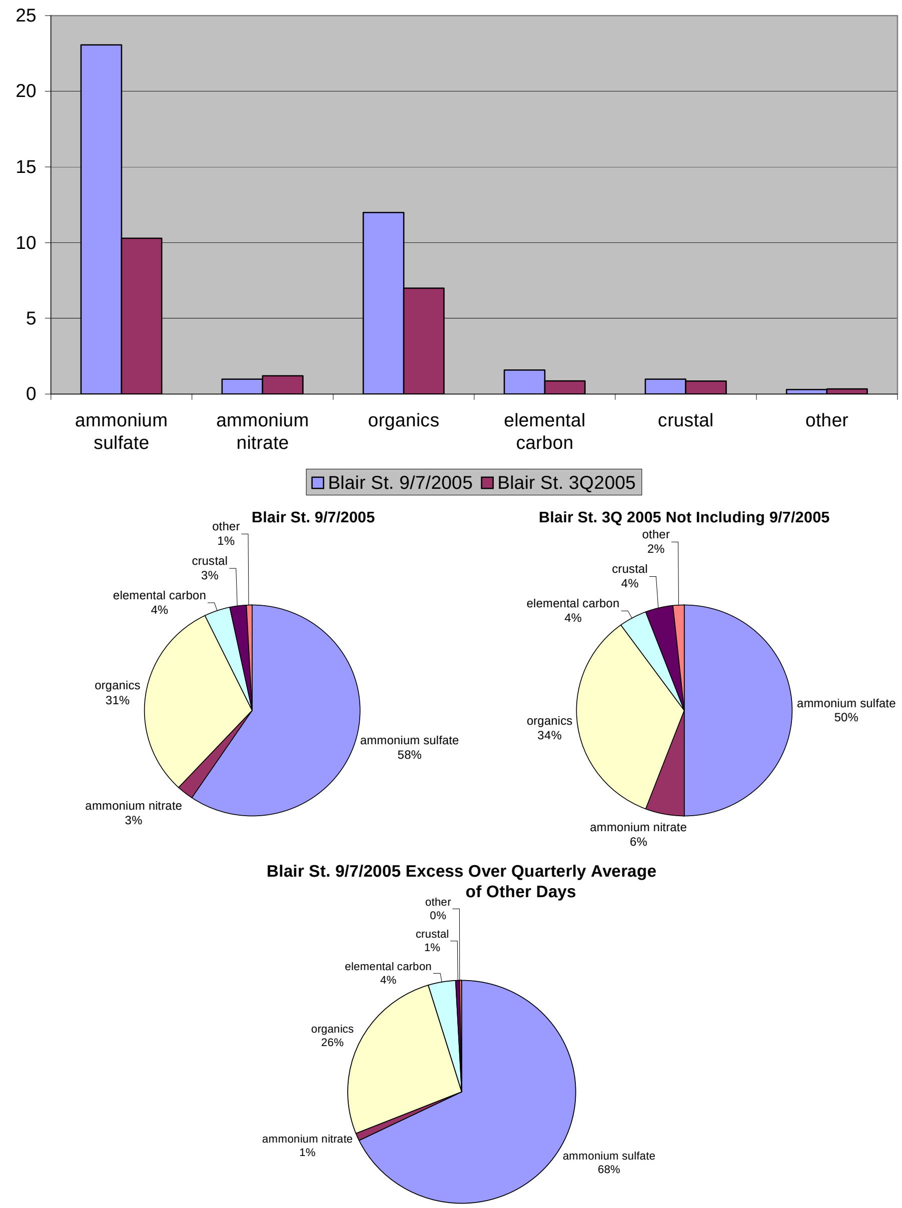
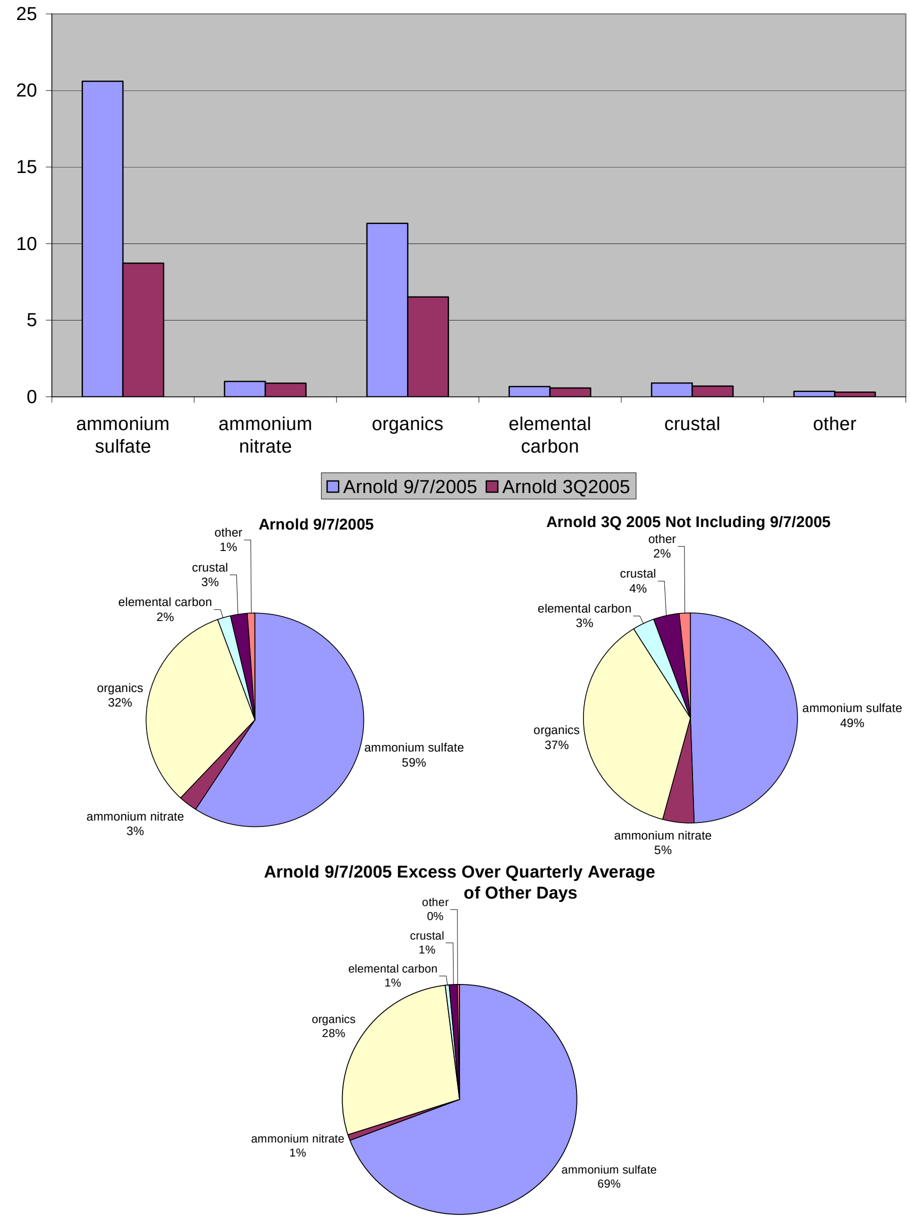


Figure 2.3-34. Arnold PM2.5 Speciation, 9/7/2005 and Third Quarter Average of Other Days



2.4 EMISSION INVENTORY DATA

Fine particulate matter is chiefly composed of the effluent from combustion processes taking place in fossil fuel-fired power plants, transportation, industry, agriculture, construction, waste disposal, and other sectors. In addition to the primary $PM_{2.5}$ directly emitted from these combustion processes, the majority of airborne $PM_{2.5}$ is secondary, formed downstream from the emission point by the condensation of sulfur and nitrogen oxides (SO_X and NO_X), volatile organic compounds (VOC), and ammonia (NH_3) emitted by these same processes. The same sources that emit $PM_{2.5}$ and its precursors are largely responsible for emissions of the VOC and NO_X that cause the formation of ozone as well. For the St. Louis area $PM_{2.5}$ emission inventory, direct emissions of PM_{10}, $PM_{2.5}$, SO_X, NO_X, VOC, and NH_3 must therefore be considered. Emissions information was obtained from the *Final* 2002 National Emission Inventory (2002 NEI). This inventory was developed by the EPA, state, local, and tribal air agencies, regional air planning organizations, universities, and environmental consultants to establish base year emissions for ozone, $PM_{2.5}$ and regional haze designations, modeling, and state implementation plans (SIPs).

2.4.1 2002 National Emission Inventory (NEI)

The 2002 NEI is EPA's latest comprehensive national emission inventory for the entire United States. It contains emission measurements and estimates for criteria air pollutants and hazardous air pollutants. The 2002 NEI includes emissions for all major contributors to air pollution including point sources (large industrial sources such as electric utilities and petroleum refineries), mobile sources (both onroad sources such as cars and trucks, as well as nonroad engines such as construction equipment, agricultural equipment, etc.), and nonpoint sources (small stationary sources such as residential fuel use and various types of fires). The NEI is developed using the latest data and best estimation methods including data collected from all 50 States, as well as many local and tribal air agencies. The NEI files are posted on the Clearinghouse for Inventories and Emission Factors (CHIEF) Web site at http://www.epa.gov/ttn/chief/net/2002inventory.html.

The Missouri Department of Natural Resources (MDNR) Air Pollution Control Program (APCP) prepared Missouri’s inventory for the 2002 NEI as required by the Consolidated Emissions Reporting Rule (CERR) that includes point, area, and onroad mobile source emissions. All source inventories prepared for the NEI contain county-level emission estimates. Emissions growth rates throughout the St. Louis area can be evaluated by comparison to the 1999 NEI, and 2001, 2004, and 2005 facility point source emissions compiled in the Missouri Emissions Inventory System (MoEIS). Projections of total point, area, onroad and nonroad mobile source emissions have been made to 2005 and 2008.

2.4.2 Point Source Emissions

Point sources are large stationary power plants and industrial facilities. The APCP defines point sources as sources with a Basic, Intermediate, or Part 70 operating permit that must report their actual emissions to the APCP on an annual basis. Point source emissions in the 2002 NEI are based on statewide facility Emissions Inventory Questionnaire (EIQ) submittals compiled in the Missouri Emission Inventory System (MoEIS). Major source emissions for the NEI were developed using the latest data and estimation methods, including data from stack testing, AP-42 and Factor Information Retrieval (FIRE) emission factors, mass balance calculations, and continuous emissions monitors (CEMs). MoEIS facility and emissions data was transcribed into National Emissions Inventory Input Format (NIF) and extensively reviewed for quality.

2.4.3 Area Source Emissions

Area sources include a wide range of smaller stationary sources of emissions that are too numerous and diffuse to inventory individually. These include smaller industries and shops as well as commercial, institutional, and residential fuel combustion, surface coating, and solvent utilization activities. In addition, consumer product use, paved and unpaved road dust, agricultural tilling, waste incineration, and open burning are all inventoried employing area source estimation methods. New estimates are included for emissions from wildfires and managed burns. The 2002 area source inventory is a consolidation of emissions estimates prepared by the Air Pollution Control Program and Pechan Associates, with remaining gaps filled in with data prepared for the EPA's NEI.

2.4.4 Onroad Mobile Source Emissions

Onroad motor vehicle emissions include emissions from cars, vans, trucks, buses, and motorcycles that are used for transportation on public streets and highways. The emission rates were generated using the EPA's MOBILE6.2 model. The model calculates emissions by multiplying an emission factor in grams per mile by the corresponding vehicle miles traveled (VMT) and converts the product to units of tons of emissions. The 2002 VMT data for the St. Louis area were obtained from the East-West Gateway Coordinating Council (EWGCC), based on actual demographic data.

2.4.5 Nonroad Mobile Source Emissions

Offroad mobile sources constitute an array of motor vehicles ranging from small lawn and garden equipment to heavy-duty agricultural and construction vehicles, aircraft, locomotives, and marine vessels. For the purposes of determining their emissions, offroad engines are classified according to over two hundred distinct nonroad equipment categories. The EPA determined offroad motor vehicle emissions using updated emissions for nonroad engines based on the NONROAD2005 model to generate emission inventories for all gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG) offroad equipment types. Supplemental methods were employed by the EPA to calculate emissions for aircraft, commercial marine vessels, and locomotives.

2.4.6 Pollutant Emission Profiles of St. Louis Area Counties

Reviewing a side-by-side comparison of emission summaries for point, area, onroad and nonroad mobile source categories in the 14 counties in and adjacent to the St. Louis area will serve to distinguish which counties potentially contribute to elevated $PM_{2.5}$ levels. Table 2.4-1 summarizes the emission inventory for 14 Missouri counties in the St. Louis area. The discussion below addresses the principal sources and quantities found for each pollutant in each county. Graphs of the data in the table provide an overview in Figures 2.4-1 to 2.4-14.

PM_{10} and $PM_{2.5}$

Point, area, and on- and off-road PM_{10} and $PM_{2.5}$ emissions are shown by county in the graphs in Figures 2.4-1 and 2.4-2. The prominent feature is that 94 percent of all PM_{10} and 73 percent of all $PM_{2.5}$ emissions are from area sources, dwarfing other sources of PM_{10} such as electricity generation and mobile sources. Area sources of PM include paved and unpaved roads, agricultural tilling, construction, miscellaneous fugitive dust, forest wildfires, prescribed burning, and various other types of fugitive dust and open burning. About 70 percent of all PM_{10} emissions are shown to be from paved and unpaved road fugitive emissions. This is not in reality the case, however.

The 2002 NEI tracks primary $PM_{2.5}$ emissions, which average 40 percent of ambient $PM_{2.5}$ overall, the rest being secondary $PM_{2.5}$, formed by the condensation of gaseous ammonia, sulfates, nitrates, and organics after their release from a source. Of the 40 percent which is primary emissions, about 80 percent are from area sources, mainly paved and unpaved roads, which are crustal in composition. However, most crustal $PM_{2.5}$ doesn't travel far, is released at ground level and generally removed by vegetation or deposited within a few kilometers of being emitted. $PM_{2.5}$ speciation measurements show that only about 2 to 3 percent of $PM_{2.5}$ in the Midwest is crustal materials, while 50 to 60 percent of the $PM_{2.5}$ captured on the filter is ammonium nitrate and sulfate, and the remainder is organic compounds and metals. This feature of the inventory is not unique to the St. Louis area, but is characteristic of the 2002 NEI across the country.

The EPA has recognized that there is a discrepancy between modeled $PM_{2.5}$ concentrations based on emission inventories on the one hand and measured concentrations and speciation on the other. This discrepancy results because current air quality models do not adequately account for removal mechanisms for airborne particulate matter. To reduce the over-prediction in the models, EPA has published a table of transportable fractions by county for all US counties. These factors are based on ground cover data for each county. Conceptually, the transportable fraction for a dense forest would approach 0, and the fraction for a barren surface would approach 1. These factors are recommended for use in grid model analysis for emissions from paved roads, unpaved roads, construction, tilling and quarrying until better factors become available or until particle removal mechanisms are better incorporated into models (Thompson G. Pace**, Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban Scale Air Quality Analyses**, US EPA, 2005, http://www.epa.gov/ttn/chief/emch/invent/transportable_fraction_080305_rev.pdf). Table 2.4-2 lists transportable fractions for Missouri and Illinois counties in the St. Louis area (http://www.epa.gov/ttn/chief/emch/invent/transportfractions052506rev.xls).

As inventoried, point, on-, and offroad sources generate only 27 percent of the estimated $PM_{2.5}$. Of these the largest sources of primary $PM_{2.5}$ are power plants, lead smelters, cement kilns and lime processing, other industrial combustion, and motor vehicles in St. Louis County and City. Heavy-duty diesel truck emissions range from 35 to 70 percent of all onroad and nonroad diesel $PM_{2.5}$ and NO_X emissions in St. Louis area counties.

Sulfur Dioxide (SO_2)

SO_2 emissions are shown by county in Figure 2.4-3. The principal point sources are coal and oil combustion, most notably coal-fired electrical generation. Industrial processes comprise the next main group of point sources, the highest of these being lead smelters, breweries, cement kilns, and lime processing.

Nitrogen Oxides (NO_X)

NO_X emissions as shown in Figure 2.4-4 are dominated by onroad and offroad motor vehicles. Electric utilities, heating fuel, and industrial fuel combustion sources such as lead smelters, breweries, cement kilns, and lime processing also have a significant impact.

Volatile Organic Compounds (VOCs)

Onroad mobile and area source categories contribute the most to the VOCs shown in Figure 2.4-5. The single highest emissions are from light-duty gas cars and trucks. Consumer product use, lawn and garden equipment, architectural surface coatings, pesticide application, residential fireplaces, and gasoline station Stage II transfers are among the main area source categories with high VOC emissions. Numerous other smaller VOC sources fall under the heading of area sources.

Ammonia (NH_3)

Ammonia sources are primarily due to agricultural livestock and agricultural crops, which are area sources, as shown in Figure 2.4-6. Other significant sources are agricultural chemical manufacturing, light-duty gasoline vehicles, and sewage treatment (publicly owned treatment works, or POTWs).

2.4.7 Total St. Louis Area Emissions

Total emissions for the 14 St. Louis area counties in Missouri are graphed in Figure 2.4-7 by source category and in Figure 2.4-8 by pollutant (Note that these totals include $PM_{2.5}$, SO_X, NO_X, VOC, and NH_3, but exclude PM_{10}). The five counties corresponding to the St. Louis area ozone nonattainment area account for 77.6 percent of emissions overall. Pike and Ste. Genevieve Counties each have two major facilities causing them to have emissions intermediate between the metropolitan counties and the other rural counties. The remaining rural counties display relatively low emissions, 14.4 percent of the total area emissions, for the seven counties combined.

2.4.8 St. Louis Area Trends and Projected Emissions

A comparison of total emissions throughout the St. Louis region based on the 1999 NEI Draft V.3 to the *Final* 2002 NEI is shown in Figure 2.4-9 (These totals include $PM_{2.5}$, SO_X, NO_X, VOC, and NH_3, and exclude PM_{10}). These totals are not strictly comparable due to additions and changes in source category estimation methodologies. Overall they show a 6.1 percent decrease in total emissions. This result is not consistent with Energy Information Administration reports that electrical energy usage and transportation fuel consumption is steadily increasing in Missouri, as it is throughout United States. It is nevertheless interesting to graph how these emissions would change in 2005 and 2008, assuming a constant rate of change based on the 1999 NEI and 2002 NEI. This projection is shown in Figure 2.4-10.

Ste. Genevieve County's two major facilities are expanding their operations and a new cement kiln, reportedly the largest in the US, is also under construction in Ste. Genevieve County. This will result in a net increase in NO_X emissions of approximately 9,000 tons per year, as well as higher SO_X, VOC, PM_{10}, and $PM_{2.5}$ emissions. The effect on future emissions overall is included in the graph in Figure 2.4-10, over and above the projected emissions based on the NEI. Ste. Genevieve County's emissions will increase to 5.3 percent of the total for the St. Louis area, slightly above the 4.7 percent level in Pike County.

2.4.9 Trends in Point Source Emissions

In an effort to elucidate further whether any identifiable trends in EGU and industrial emissions could be identified, point source emissions directly from MoEIS were compiled. Figure 2.4-11 displays total point source emissions for each of the fourteen counties for 1999, 2002, 2004, and 2005. For purposes of direct comparison, these totals do not include $PM_{2.5}$ and NH_3, since these emissions were not reported in the 1999 and 2002 inventories. Graphs of pollutant totals for each year are shown in Figures 2.4-12 to 2.4-15.

2.4.10 Major Point Source Maps

Figures 2.4-16 through 20 are maps showing the locations of large emission point sources in the greater St. Louis area of Missouri of primary $PM_{2.5}$, PM_{10}, SO_x, NO_x (greater than 100 tons per year), and VOC (greater than 25 tons per year). These maps reinforce the characterization of the five ozone nonattainment counties as the area including the majority of emission sources. Ste. Genevieve and Pike Counties also have some major sources, which necessitates evaluation of these two counties in the process of developing recommendations for $PM_{2.5}$ attainment and nonattainment areas. The remaining rural Missouri counties contain a relatively small number of large point sources and uniformly low emissions overall.

2.4.11 Area-Specific Emission Controls

St. Louis City; St. Louis, St. Charles, Jefferson, Franklin, Madison (IL), Monroe (IL), and St. Clair (IL) Counties have specific fuel requirements for control of VOC emissions. Since Missouri and Illinois opted into the federal reformulated gasoline program for the St. Louis area, reformulated gasoline (RFG) is required to be sold in these counties throughout the entire year. In addition, the St. Louis maintenance area has a vehicle inspection and maintenance program, Missouri rule, on-board diagnostics motor vehicle emissions inspection - 10 CSR 10-5.381.

Deleted: s

There are several other VOC point and area source regulations in place in the Missouri portion of the area:

1. open burning - 10 CSR 10-5.070,
2. petroleum storage/loading/transfer (Stage I/II) - 10 CSR 10-5.220,
3. aerospace manufacturing/rework - 10 CSR 10-5.295,
4. solvent metal cleaning - 10 CSR 10-5.300,
5. liquified cutback asphalt - 10 CSR 10-5.310,
6. industrial surface coating - 10 CSR 10-5.330,
7. rotogravure/flexographic printing - 10 CSR 10-5.340,
8. synthesized pharmaceutical products - 10 CSR 10-5.350,
9. polyethylene bag sealing operations - 10 CSR 10-5.360,
10. application of deadeners and adhesives - 10 CSR 10-5.370,
11. manufacturing of paint, laquer, varnish, enamels - 10 CSR 10-5.390,
12. manufacturing of polystyrene resins - 10 CSR 10-5.410,
13. equipment leaks from synthetic organic/polymer manufacturing - 10 CSR 10-5.420,
14. bakery ovens - 10 CSR 10-5.440,
15. offset lithographic printing - 10 CSR 10-5.442,
16. traffic coatings - 10 CSR 10-5.450,
17. aluminum foil rolling - 10 CSR 10-5.451,
18. solvent cleanup operations - 10 CSR 10-5.455,
19. municipal solid waste landfills - 10 CSR 10-5.490,
20. volatile organic liquid storage - 10 CSR 10-5.500,
21. existing major sources (RACT fixups) - 10 CSR 10-5.520,
22. wood furniture manufacturing - 10 CSR 10-5.530,

23. batch process operations - 10 CSR 10-5.540, and
24. reactor and distillation processes for synthetic organic chemical manufacture - 10 CSR 10-5.550.

These rules help to control VOC $PM_{2.5}$ precursors.

Missouri also has a NO_X RACT rule, control of emissions of nitrogen oxides - 10 CSR 10-5.510 for major NO_X sources, in the St. Louis area and has implemented NO_X reduction requirements under the state rule, emission limitations and emissions trading of oxides of nitrogen - 10 CSR 10-6.350. It establishes emission limitation on electric generating units (EGUs). EGUs in the eastern one-third of the state are subject to 0.25 lbs NO_X /MMBTU heat input emission limitation. The State of Illinois has been included in the NO_X SIP call and EGU control will be set at 0.15 lb/MMBTU in the trading program.

Other recently enacted statewide rules that will help control regional transport of NO_X and SO_X, which are precursors to $PM_{2.5}$ are:

1. NO_X emissions from upwind sources - 10 CSR 10-6.345,
2. NO_X emissions from electric generation units and non-electric generating boilers - 10 CSR 10-6.360,
3. clean air interstate rule annual NO_X trading program - 10 CSR 10-6.362,
4. clean air interstate rule seasonal NO_X trading program - 10 CSR 10-6.364,
5. clean air interstate rule SO_X trading program - 10 CSR 10-6.366,
6. mercury emissions from electric generating units - 10 CSR 10-6.368,
7. NO_X emissions from portland cement kilns - 10 CSR 10-6.380,
8. NO_X emissions from large stationary internal combustion engines - 10 CSR 10-6.390, and
9. emissions banking and trading - 10 CSR 10-6.410.

Table 2.4-1: 2002 Emission Inventory for Missouri and Illinois (MSA) Counties in the St. Louis Area

	VOC (TPY)				NO_X (TPY)				SO_X (TPY)			
MISSOURI:	**POINT**	**AREA**	**MOBILE**	**TOTAL**	**POINT**	**AREA**	**MOBILE**	**TOTAL**	**POINT**	**AREA**	**MOBILE**	**TOTAL**
ST. LOUIS	4,725.1	22,206.0	31,642.8	58,573.9	10,439.0	5,340.1	48,060.4	63,839.4	16,689.4	9,957.9	2,015.9	28,663.1
ST. LOUIS CITY	3,851.7	10,312.2	7,609.6	21,773.6	2,014.3	2,001.2	21,782.4	25,797.9	6,771.2	3,437.5	1,843.7	12,052.5
ST. CHARLES	1,455.4	4,241.4	7,794.4	13,491.2	14,691.3	1,219.4	12,029.3	27,940.0	46,644.9	2,043.4	602.5	49,290.8
JEFFERSON	789.5	4,508.3	4,776.0	10,073.8	9,202.1	662.2	8,050.6	17,914.9	39,281.2	789.4	332.2	40,402.8
FRANKLIN	816.1	2,086.7	3,446.1	6,348.9	7,851.8	706.7	6,192.2	14,750.7	47,612.6	1,003.9	260.9	48,877.4
LINCOLN	105.7	1,202.6	1,681.1	2,989.4	113.6	316.5	2,633.7	3,063.8	13.2	202.0	176.9	392.2
WARREN	145.2	1,130.5	1,390.1	2,665.8	37.2	218.0	1,971.1	2,226.4	5.0	181.0	112.6	298.5
Missouri MSA	**11,888.7**	**45,687.7**	**58,340.2**	**115,916.6**	**44,349.3**	**10,464.2**	**100,719.6**	**155,533.1**	**157,017.5**	**17,615.2**	**5,344.6**	**179,977.3**
St. Francois	220.9	1,340.1	1,418.7	2,979.7	257.7	218.4	1,911.0	2,387.1	37.2	341.6	90.6	469.4
Washington	28.9	1,001.3	619.9	1,650.1	11.4	82.8	827.3	921.5	0.3	80.8	40.5	121.6
Crawford	73.1	1,095.3	1,597.7	2,766.1	14.0	138.1	2,023.0	2,175.0	1.0	187.8	93.0	281.8
Pike	1,869.5	881.8	1,238.6	3,989.8	7,833.0	377.0	2,185.8	10,395.9	13,496.0	98.6	190.5	13,785.1
Ste. Genevieve	166.9	712.8	1,090.9	1,970.7	4,478.8	362.8	2,126.6	6,968.1	6,079.7	283.8	196.8	6,560.2
Ste. Genevieve (Growth)	914.9	712.8	1,090.9	2,718.7	14,278.8	362.8	2,126.6	16,768.1	9,120.7	283.8	196.8	9,601.2
Gasconade	110.8	653.9	597.6	1,362.3	3.3	124.0	1,399.7	1,526.9	0.1	146.0	92.0	238.1
Montgomery	0.3	729.8	1,128.9	1,859.0	98.1	87.9	1,837.5	2,023.5	225.6	86.2	99.4	411.2
ILLINOIS:												
CLINTON	104.3	1,780.7	1,011.9	2,897.0	752.0	128.2	2,223.9	3,104.1	356.4	13.9	137.4	507.6
JERSEY	18.6	1,139.8	514.6	1,673.0	0.0	68.2	1,576.9	1,645.1	0.0	8.5	193.2	201.7
MADISON	2,727.7	7,952.2	4,679.0	15,358.9	10,608.5	1,020.5	9,237.4	20,866.4	26,745.6	113.6	533.2	27,392.3
MONROE	22.7	1,827.3	710.2	2,560.1	3.5	96.7	2,974.9	3,075.1	0.1	11.7	270.3	282.1
ST. CLAIR	1,038.0	5,027.1	4,162.2	10,227.3	368.8	710.7	8,769.7	9,849.2	1,540.7	78.4	547.5	2,166.5
Illinois MSA	**3,911.2**	**17,727.1**	**11,078.0**	**32,716.2**	**11,732.7**	**2,024.3**	**24,782.9**	**38,539.9**	**28,642.7**	**226.2**	**1,681.4**	**30,550.3**
MSA Total	**15,799.9**	**63,414.7**	**69,418.2**	**148,632.8**	**56,082.0**	**12,488.5**	**125,502.5**	**194,073.0**	**185,660.2**	**17,841.3**	**7,026.0**	**210,527.6**

Key:
COUNTY - Counties in the Ozone 1-Hour Nonattainment Area
COUNTY - Counties in MSA
County - Additional Counties

Table 2.4-1 *(Continued)* : 1999 - 2001 Emission Inventory for Missouri and Illinois (MSA) Counties in the St. Louis Area

	PM_{10} (TPY)				$PM_{2.5}$ (TPY)				NH3 (TPY)			
MISSOURI:	**POINT**	**AREA**	**MOBILE**	**TOTAL**	**POINT**	**AREA**	**MOBILE**	**TOTAL**	**POINT**	**AREA**	**MOBILE**	**TOTAL**
ST. LOUIS	1,147.3	26,339.6	1,523.7	29,010.6	634.9	3,120.9	1,535.3	5,291.2	48.1	1,449.5	813.9	2,311.6
ST. LOUIS CITY	936.9	4,821.8	683.3	6,441.9	610.0	611.7	660.2	1,881.9	9.5	58.4	0.8	68.7
ST. CHARLES	1,622.3	26,043.7	424.4	28,090.4	1,377.5	2,863.2	423.2	4,664.0	106.7	746.3	179.9	1,032.9
JEFFERSON	1,985.0	41,443.7	173.1	43,601.8	979.1	5,024.3	178.9	6,182.3	69.3	183.6	141.8	394.7
FRANKLIN	1,789.6	25,605.2	219.4	27,614.3	1,005.6	3,213.7	184.0	4,403.3	129.1	1,519.7	95.9	1,744.7
LINCOLN	150.0	13,596.9	114.3	13,861.2	66.0	1,679.1	100.4	1,845.5	0.0	1,066.9	33.0	1,099.9
WARREN	59.5	8,973.9	79.7	9,113.1	23.9	1,157.9	67.7	1,249.5	0.0	492.9	36.3	529.2
Missouri MSA	**7,690.6**	**146,824.8**	**3,217.9**	**157,733.3**	**3,242.3**	**33,857.8**	**3,102.1**	**40,202.3**	**362.8**	**7,813.5**	**2,584.4**	**14,157.5**
St. Francois	152.4	12,453.9	66.9	12,673.2	69.7	1,535.1	55.2	1,660.0	5.2	401.3	39.5	446.0
Washington	27.1	8,592.5	29.8	8,649.4	9.9	1,153.9	24.8	1,188.6	0.0	382.6	16.5	399.2
Crawford	42.1	7,787.7	73.4	7,903.2	20.9	1,070.8	60.5	1,152.2	0.0	329.3	34.0	363.3
Pike	491.8	5,855.6	107.2	6,454.7	301.9	812.6	96.6	1,211.1	161.6	1,135.8	20.2	1,317.6
Ste. Genevieve	1,645.5	6,154.7	84.0	7,884.2	548.3	801.4	73.1	1,422.9	0.0	681.8	24.1	705.9
Ste. Genevieve (Growth)	2,718.5	6,154.7	84.0	8,957.2	1,621.3	801.4	73.1	2,495.9	0.0	681.8	24.1	705.9
Gasconade	6.8	5,806.2	52.9	5,865.8	2.7	771.2	47.0	820.9	0.0	896.4	10.7	907.1
Montgomery	110.5	6,724.5	75.3	6,910.3	45.3	864.2	64.7	974.2	0.0	986.9	31.4	1,018.3
ILLINOIS:												
CLINTON	71.8	6,943.8	108.5	7,124.1	31.5	1,044.3	98.3	1,174.1	0.5	2,849.9	32.3	2,882.8
JERSEY	27.2	4,157.0	82.5	4,266.7	10.0	653.3	75.2	738.5	0.0	378.1	17.1	395.2
MADISON	3,756.7	10,310.9	387.8	14,455.5	2,601.4	1,652.9	334.2	4,588.5	26.2	1,077.3	228.8	1,332.3
MONROE	83.3	4,769.3	125.3	4,977.9	27.6	831.7	113.4	972.7	0.0	616.6	28.5	645.1
ST. CLAIR	548.1	9,223.9	356.2	10,128.2	271.6	1,337.4	304.7	1,913.7	21.8	947.0	217.9	1,186.7
Illinois MSA	**4,487.1**	**35,405.0**	**1,060.4**	**40,952.4**	**2,942.1**	**5,519.6**	**925.8**	**9,387.5**	**48.5**	**5,868.9**	**524.6**	**6,442.1**
MSA Total	**12,177.7**	**182,229.7**	**4,278.2**	**198,685.7**	**6,184.4**	**39,377.4**	**4,028.0**	**49,589.8**	**411.3**	**13,682.4**	**3,109.0**	**20,599.5**

Key:
COUNTY - Counties in the 0zone 1-Hour Nonattainment Area
COUNTY - Counties in MSA
County - Additional Counties

Table 2.4-2 Transportable Fractions to be Applied to PM2.5 Emissions in Certain Categories

State	County	Transportable Fraction
Missouri		
	CRAWFORD	0.03
	FRANKLIN	0.29
	GASCONADE	0.08
	JEFFERSON	0.16
	LINCOLN	0.59
	MONTGOMERY	0.48
	PIKE	0.61
	ST CHARLES	0.61
	STE GENEVIEVE	0.19
	ST FRANCOIS	0.23
	ST LOUIS	0.51
	ST LOUIS (CITY)	0.60
	WARREN	0.26
	WASHINGTON	0.02
Illinois		
	CLINTON	0.71
	JERSEY	0.62
	MADISON	0.60
	MONROE	0.61
	ST CLAIR	0.61

Figure 2.4-1. PM_{10} EMISSIONS IN THE ST. LOUIS AREA

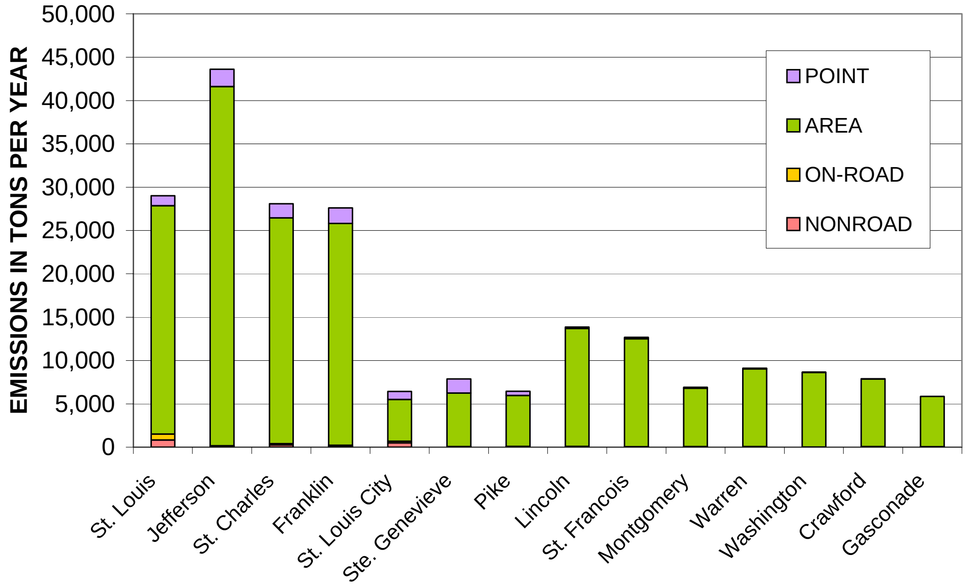


Figure 2.4-2. $PM_{2.5}$ EMISSIONS IN THE ST. LOUIS AREA

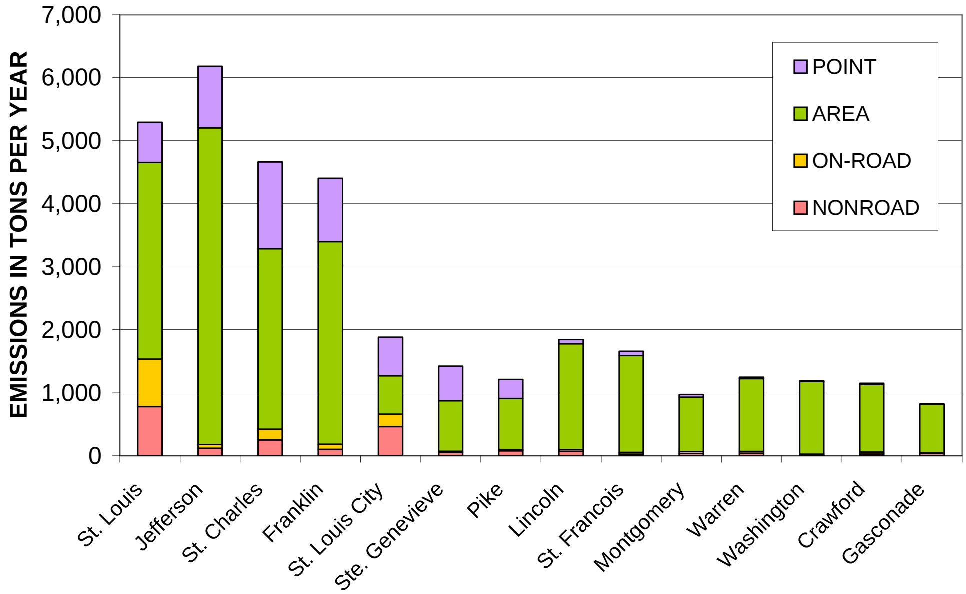


Figure 2.4-3. SO_2 EMISSIONS IN THE ST. LOUIS AREA

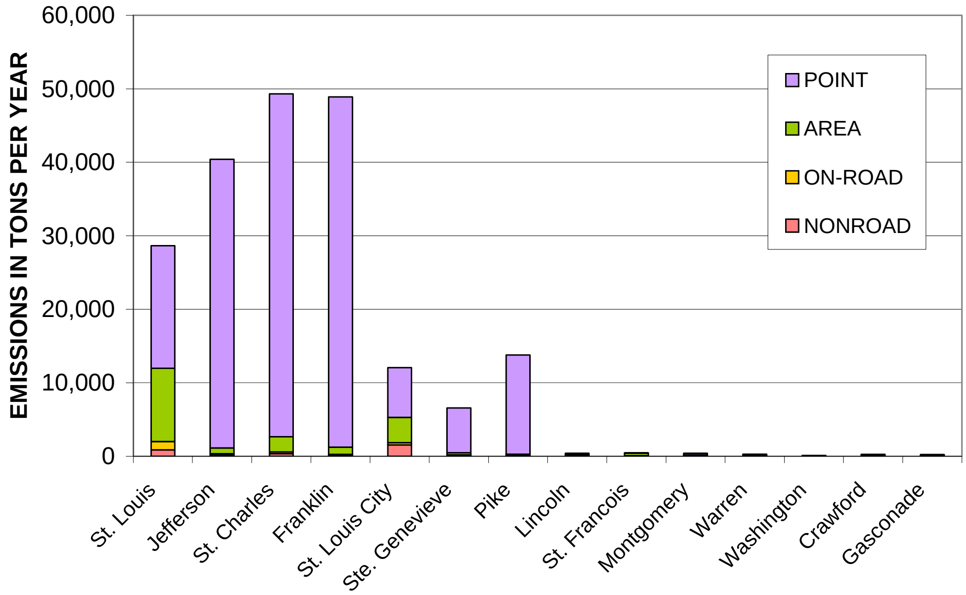


Figure 2.4-4. NO_X EMISSIONS IN THE ST. LOUIS AREA

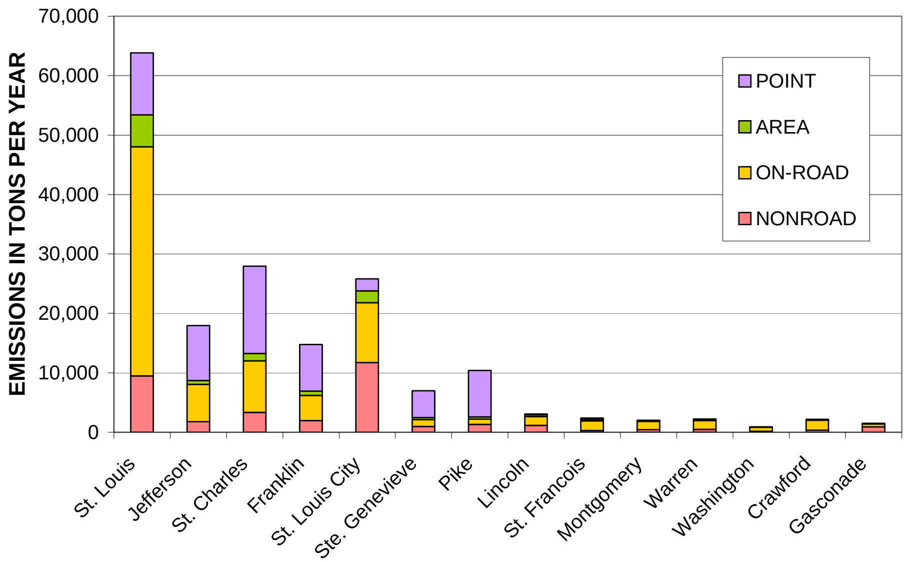


Figure 2.4-5. VOC EMISSIONS IN THE ST. LOUIS AREA

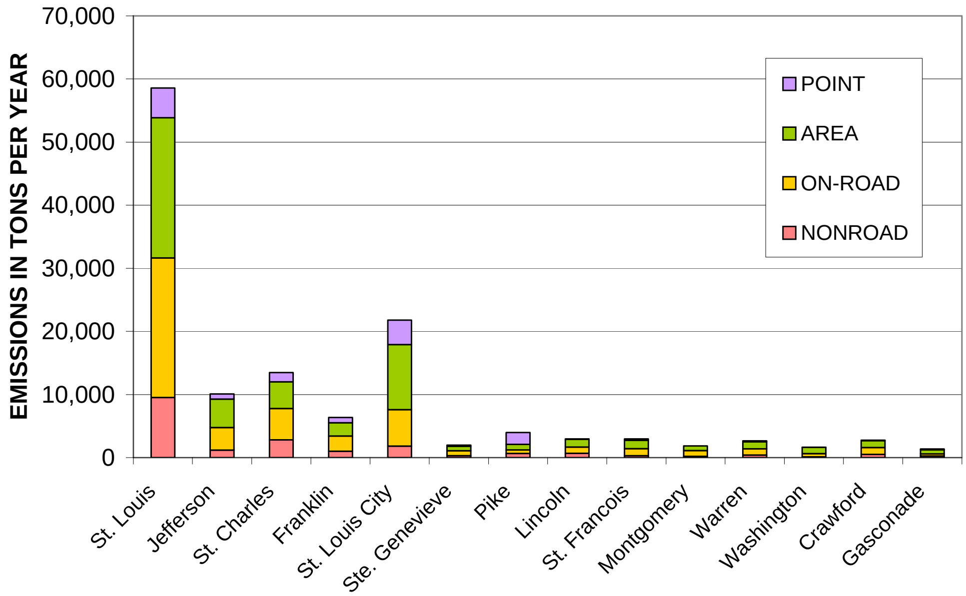


Figure 2.4-6. NH_3 EMISSIONS IN THE ST. LOUIS AREA

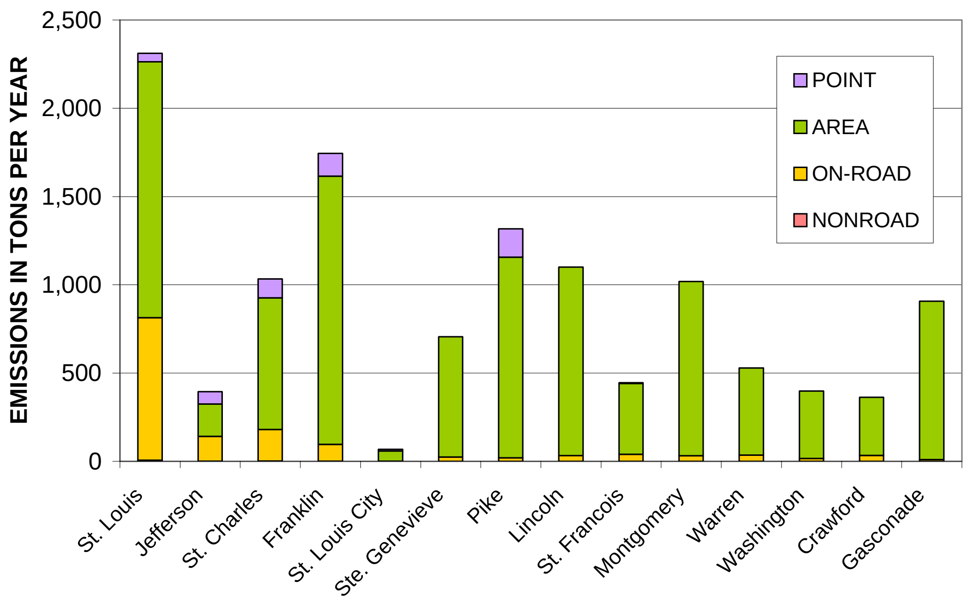


Figure 2.4-7. Total 2002 NEI St. Louis Area Emissions by Source Category

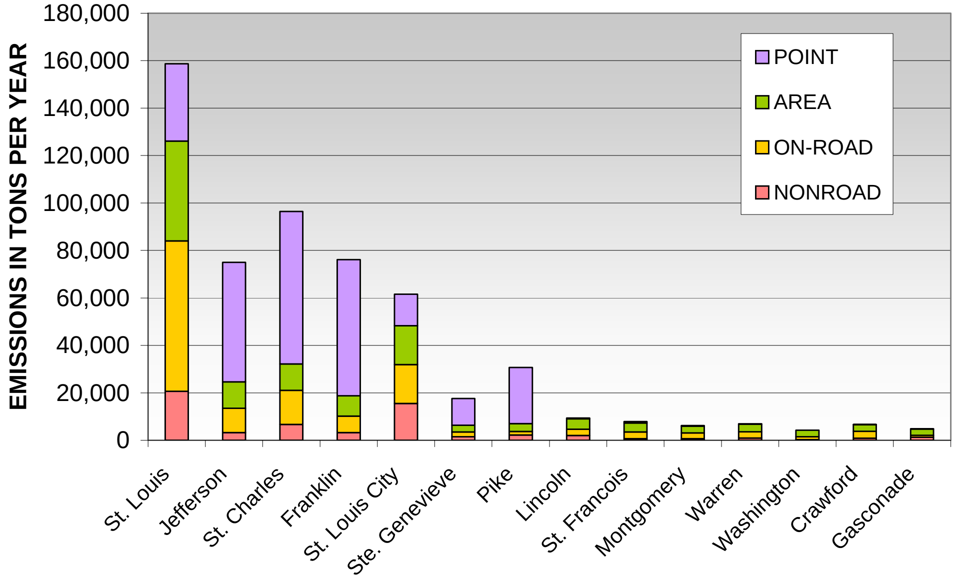


Figure 2.4-8. Total 2002 NEI St. Louis Area Emissions

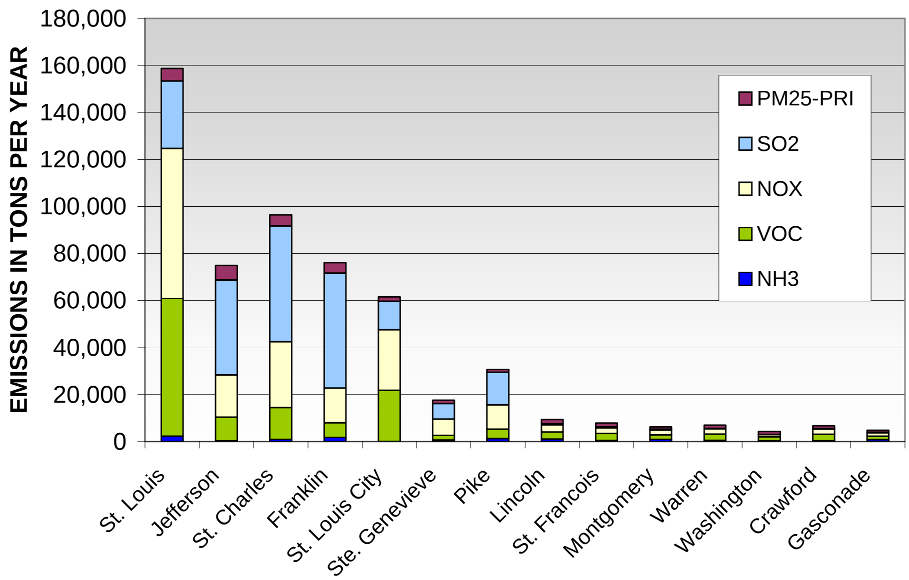


Figure 2.4-9. Comparison of Total Emissions between 1999 NEI and 2002 NEI

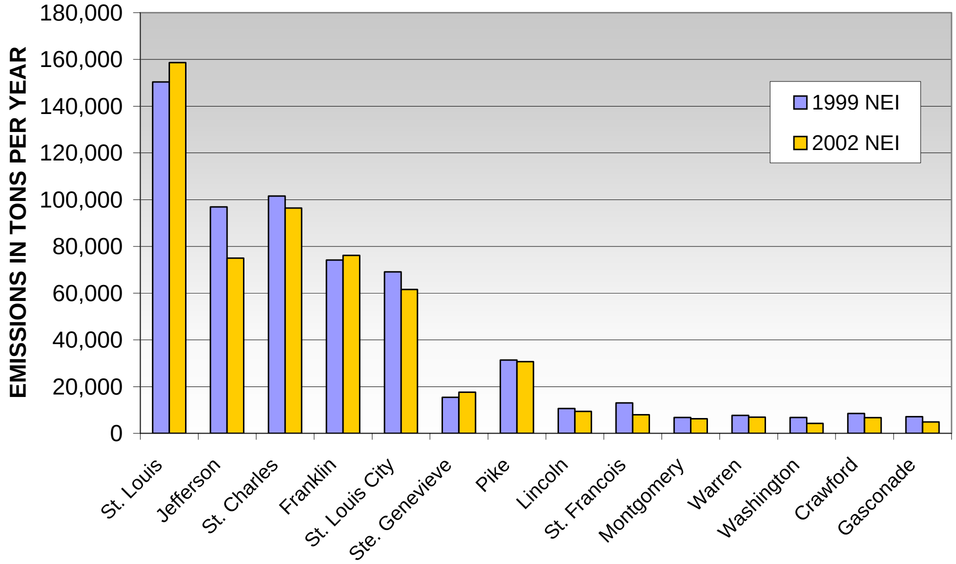


Figure 2.4-10. Trends in Total Emissions from 1999 NEI to 2002 NEI; Projections to 2005 & 2008 showing new construction in Ste. Genevieve County in 2008

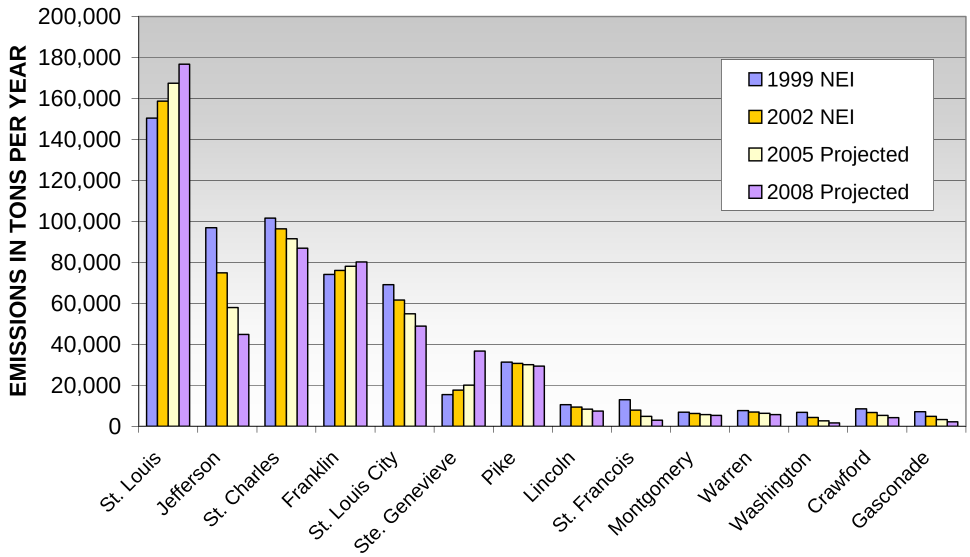


Figure 2.4-11. MoEIS Total Point Source Emissions in the St. Louis Area

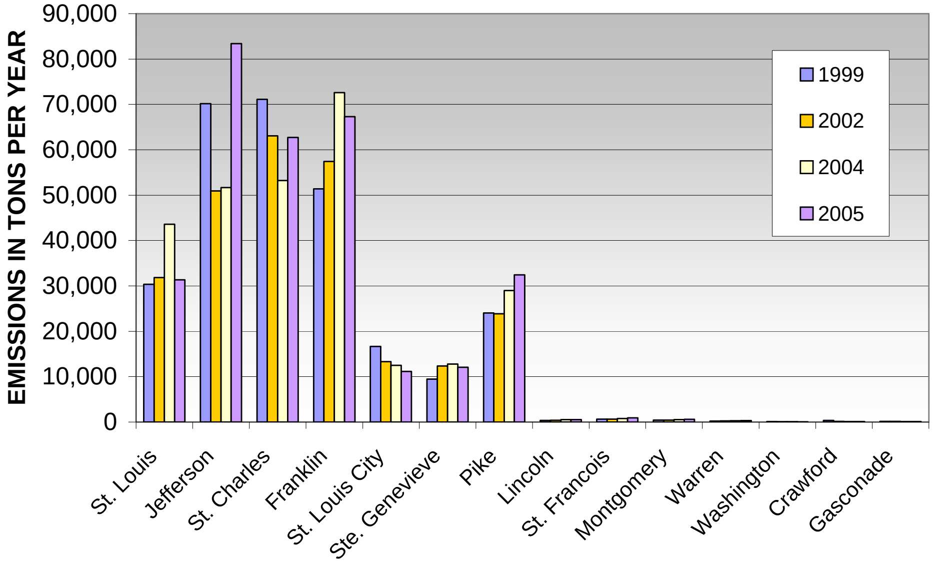


Figure 2.4-12. 1999 MoEIS Point Source Emissions in the St. Louis Area

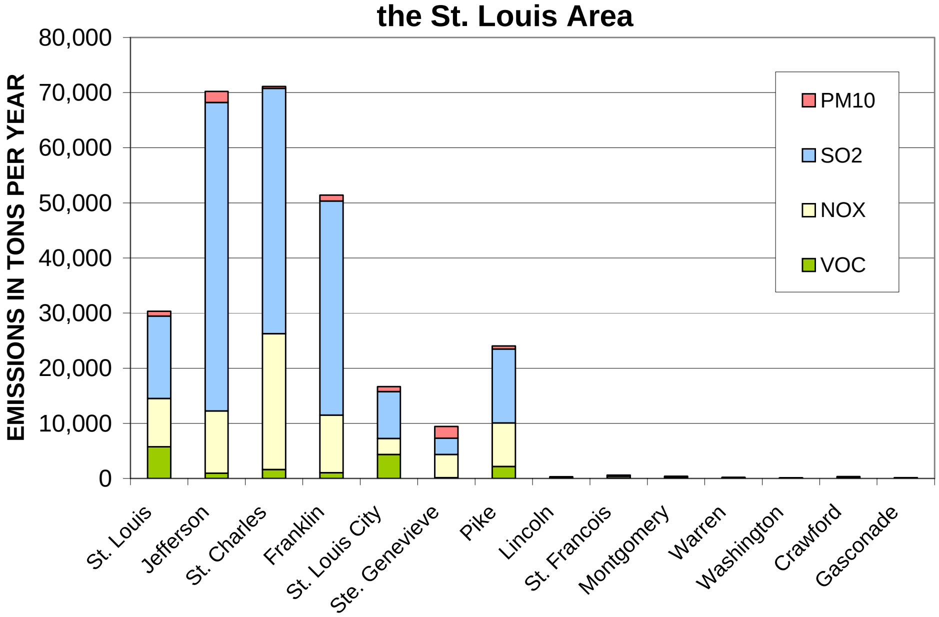


Figure 2.4-13. 2002 MoEIS Point Source Emissions in the St. Louis Area

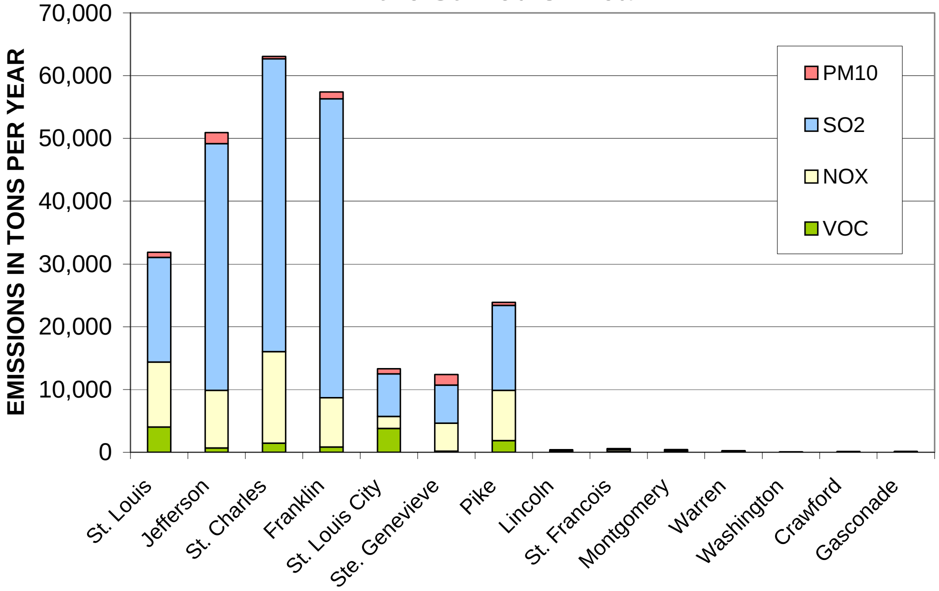


Figure 2.4-14. 2004 MoEIS Point Source Emissions in the St. Louis Area

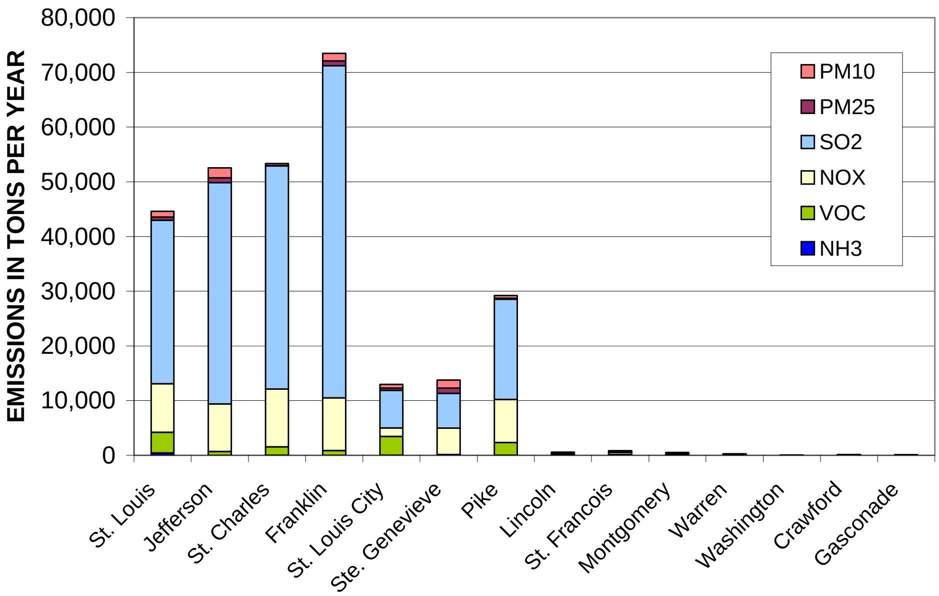
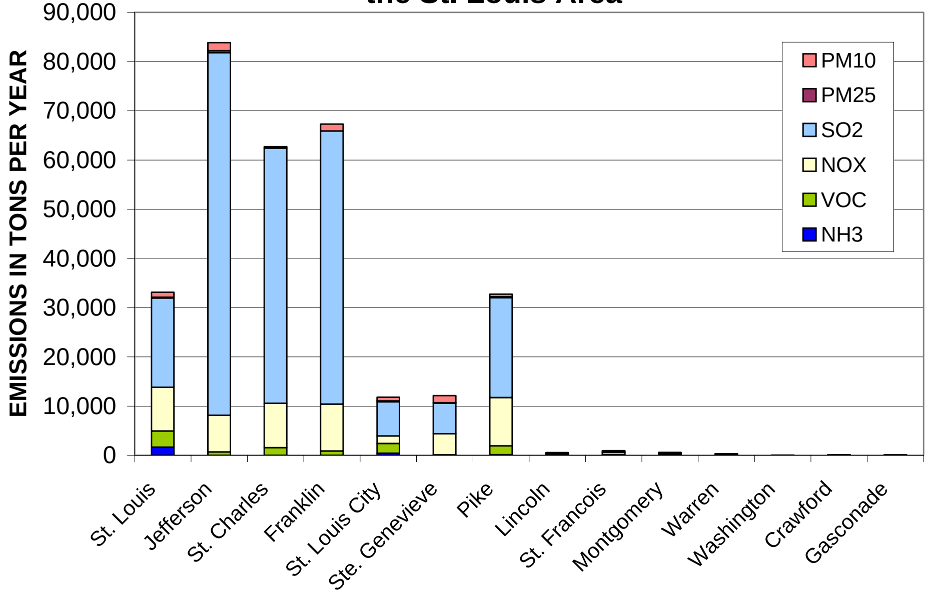


Figure 2.4-15. 2005 MoEIS Point Source Emissions in the St. Louis Area



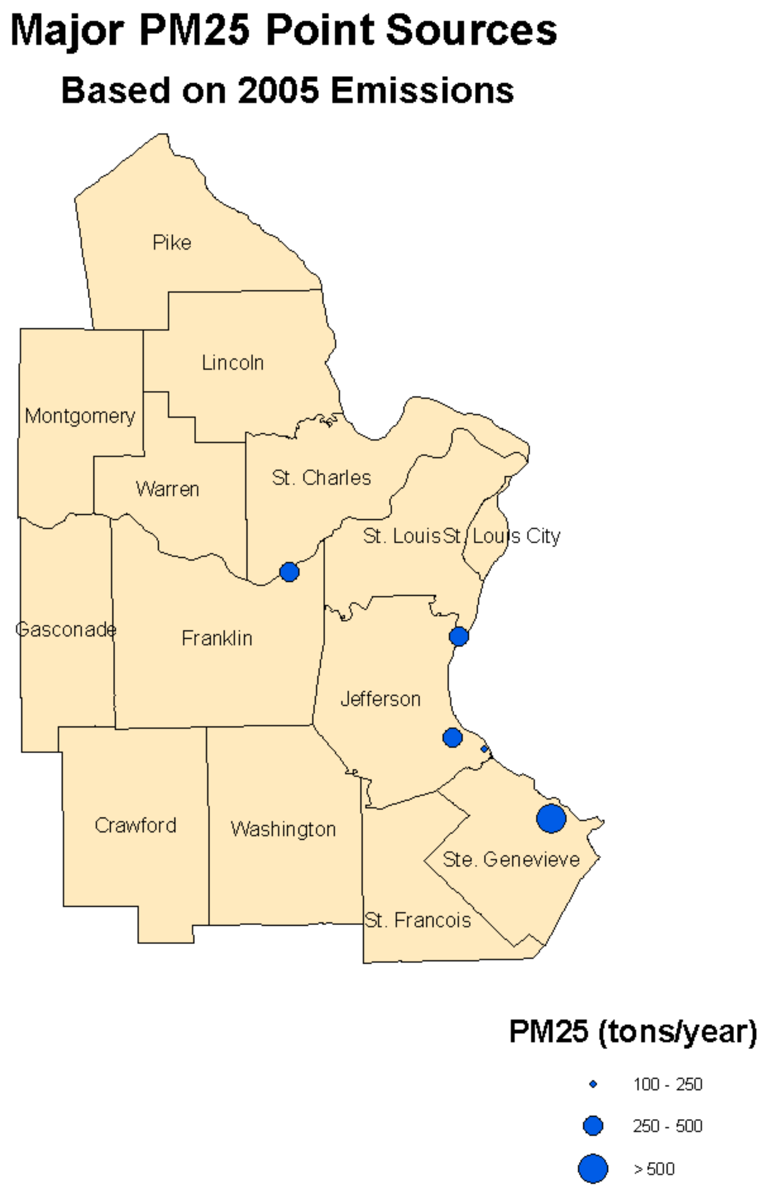


Figure 2.4-16. Locations of major $PM_{2.5}$ point sources in St. Louis area counties.

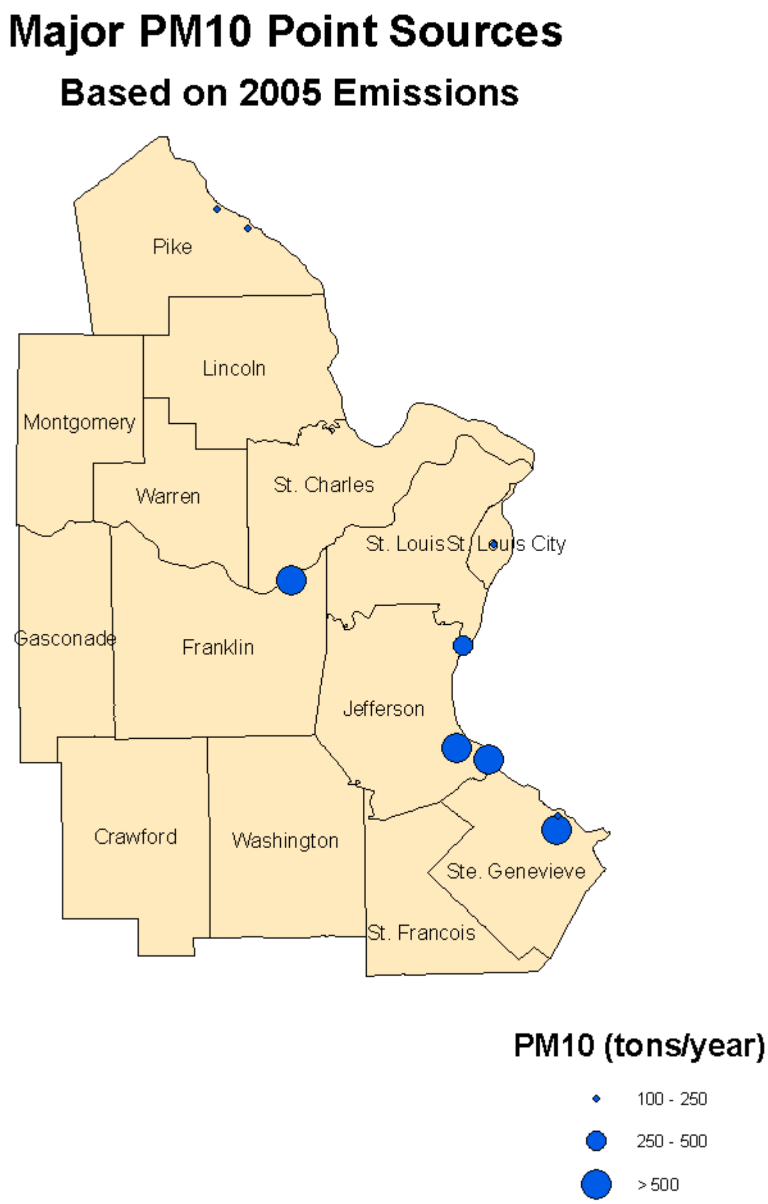


Figure 2.4-17. Locations of major PM_{10} point sources in St. Louis area counties.

Figure 2.4-18. Locations of major SO_2 point sources in St. Louis area counties.

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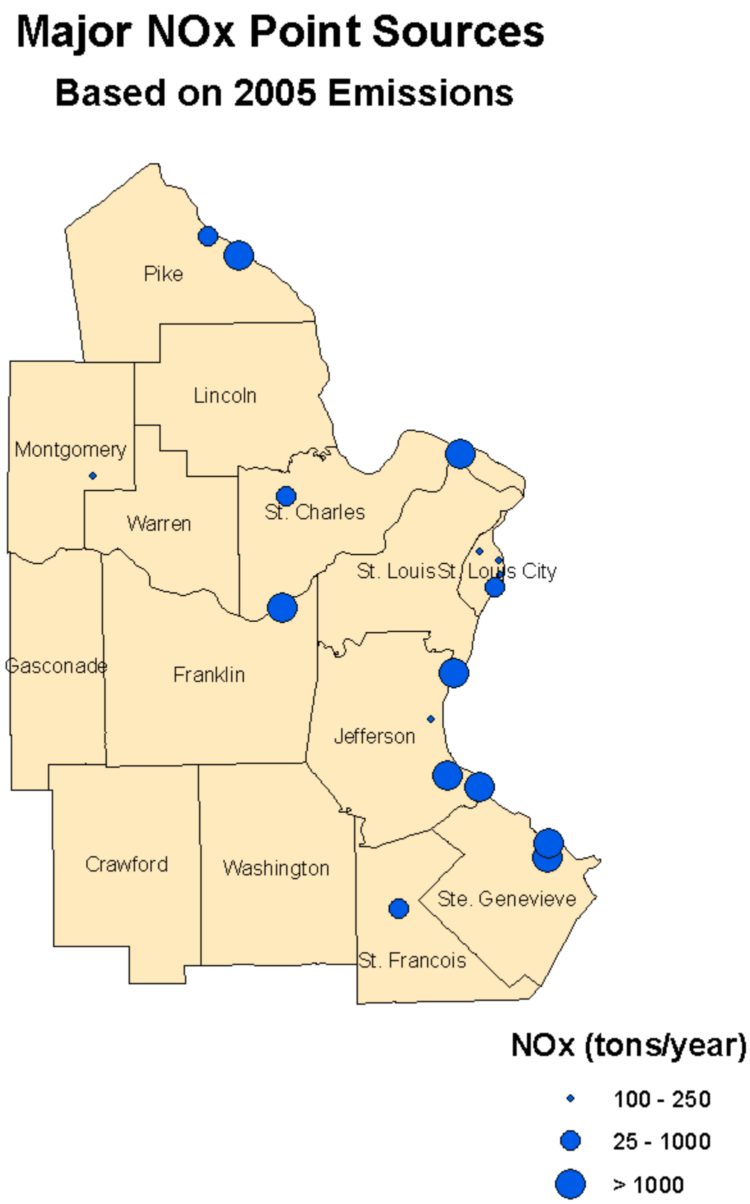

Figure 2.4-19. Locations of major NO_X point sources in St. Louis area counties.

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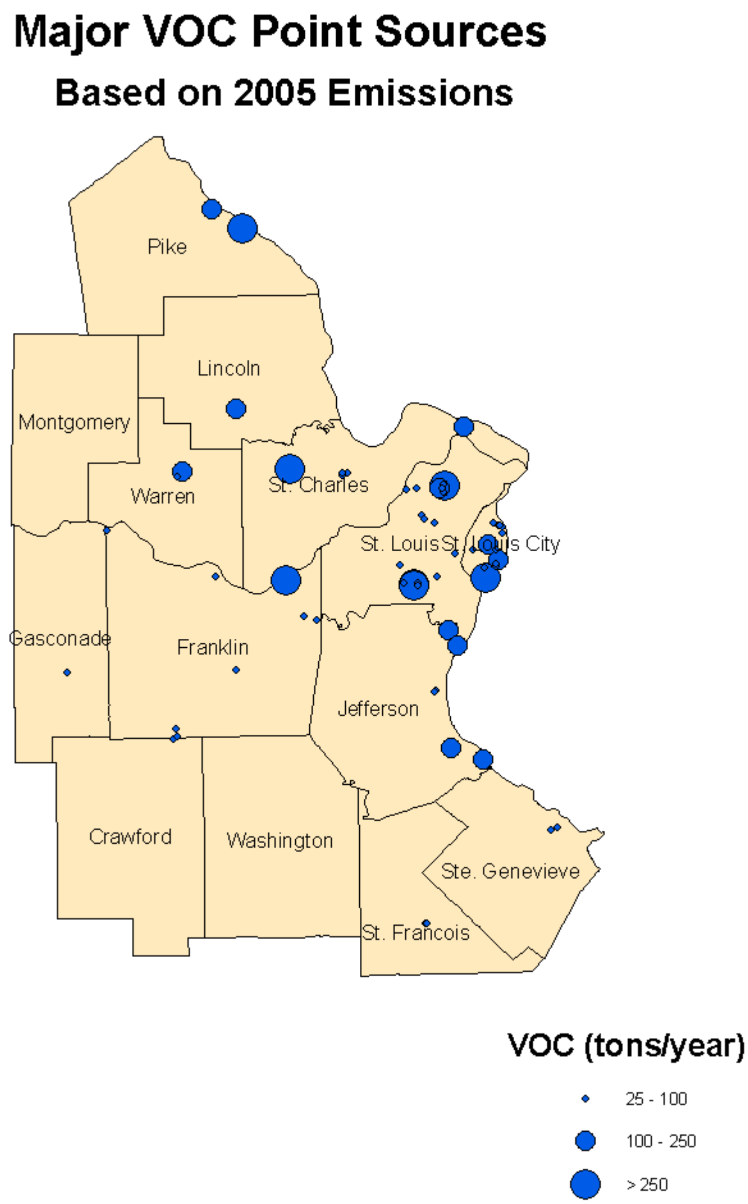

Figure 2.4-20. Locations of major VOC point sources in St. Louis area counties.

2.5 POPULATION AND TRAFFIC INFORMATION

2.5.1 Population Density and Urbanization

Table 2.5-1 lists employment (year 2000) and population (years 1990 and 2000) data for seven Missouri counties in the St. Louis MSA, St. Louis City, six Illinois counties in the St. Louis MSA, and six additional Missouri counties bordering on the MSA. Six of the counties and the City of St. Louis (all in the MSA) each had a population (year 2000) greater than 70,000 people. None of the other counties listed has a high population. Figure 2.5-1 shows population density (year 2000) in persons per square mile. This figure shows an urban population base that includes most of St. Louis City and County, northern Jefferson County, and a portion of St. Charles County. Pockets of higher population density are located in Franklin and St. Francois Counties. Figure 2.5-2 shows urban areas in the St. Louis region. This figure supports the same conclusions as the population density figure. Much of the urbanization has occurred in the area contiguous to St. Louis City with St. Charles County as a notable exception.

The employment data in Table 2.5-1 generally show high employment in the same counties that have high population.

2.5.2 Expected Growth

As listed in Table 2.5-1, population growth above 15% occurred in the following counties between 1990 and 2000: Franklin, Jefferson, St. Charles, Lincoln, Warren, Crawford, and Monroe in Illinois. Additional population growth information, including growth projections, is presented in Table 2.5-2. The 2000-2020 population growth projection data show the same counties for growth above 15% as the 1990-2000 information. However, Lincoln and Warren counties still are expected to have less than 60,000 people in 2020. Of the larger counties, the highest growth rate for both periods is in St. Charles County, and St. Louis City has the largest population reduction for both periods.

2.5.3 Traffic and Commuting Patterns

Figure 2.5-3 illustrates the traffic patterns in the St. Louis area based on data provided by the Missouri Department of Transportation for 2001. These patterns suggest a typical pattern of high urban core traffic with the major interstate highways (70, 270, 44, and 55) contributing the majority of the remaining vehicle miles traveled (VMT). The interstate highways outside the core urban area contribute the majority of the VMT in those particular counties. St. Francois County is a notable exception to this statement, with no interstate highways and higher VMT than many of the other surrounding counties.

Additional connectivity information is included in Table 2.5-3, which is a matrix of residence and workplace by county for Missouri counties in the St. Louis area, based on 2000 census data. For example, the number of people that live in St. Louis County and work in Jefferson County can be determined (34,331). Several important pieces of information can be gained from review of this data:

- Over 90% of the employed people who live in the current ozone and $PM_{2.5}$ areas work in these areas,

- The vast majority of employed people who live in the MSA work in the MSA,

- Lincoln, Warren, Jersey (IL), and Clinton (IL) counties have the highest percentage of people who work in the ozone and $PM_{2.5}$ areas, but the total number of employed residents is less than 20,000 per county,

- There is no strong linkage to the current ozone and $PM_{2.5}$ areas from any of the non-MSA counties in Missouri.

Table 2.5-1. Population and Employment Data for the St. Louis Area

	2000 Employment	1990 Population	2000 Population	Pop Growth 1990-00
MISSOURI				
St. Louis	586,848	993,529	1,016,315	2.3%
St. Louis City	263,578	396,685	348,189	-12.2%
St. Charles	95,534	212,907	283,883	33.3%
Jefferson	35,679	171,380	198,099	15.6%
Franklin	31,821	80,603	93,807	16.4%
St. Francois	16,577	48,904	55,641	13.8%
Lincoln	6,922	28,892	38,944	34.8%
Warren	5,967	19,534	24,525	25.6%
Washington	2,926	20,380	23,344	14.5%
Crawford	5,152	19,173	22,804	18.9%
Pike	3,810	15,969	18,351	14.9%
Ste. Genevieve	5,284	16,037	17,842	11.3%
Gasconade	4,698	14,006	15,342	9.5%
Montgomery	2,850	11,355	12,136	6.9%
ILLINOIS				
Madison	85,279	249,238	258,941	3.9%
St. Clair	75,291	262,852	256,082	-2.6%
Clinton	8,111	33,944	35,535	4.7%
Monroe	6,240	22,422	27,619	23.2%
Jersey	4,638	20,539	21,668	5.5%

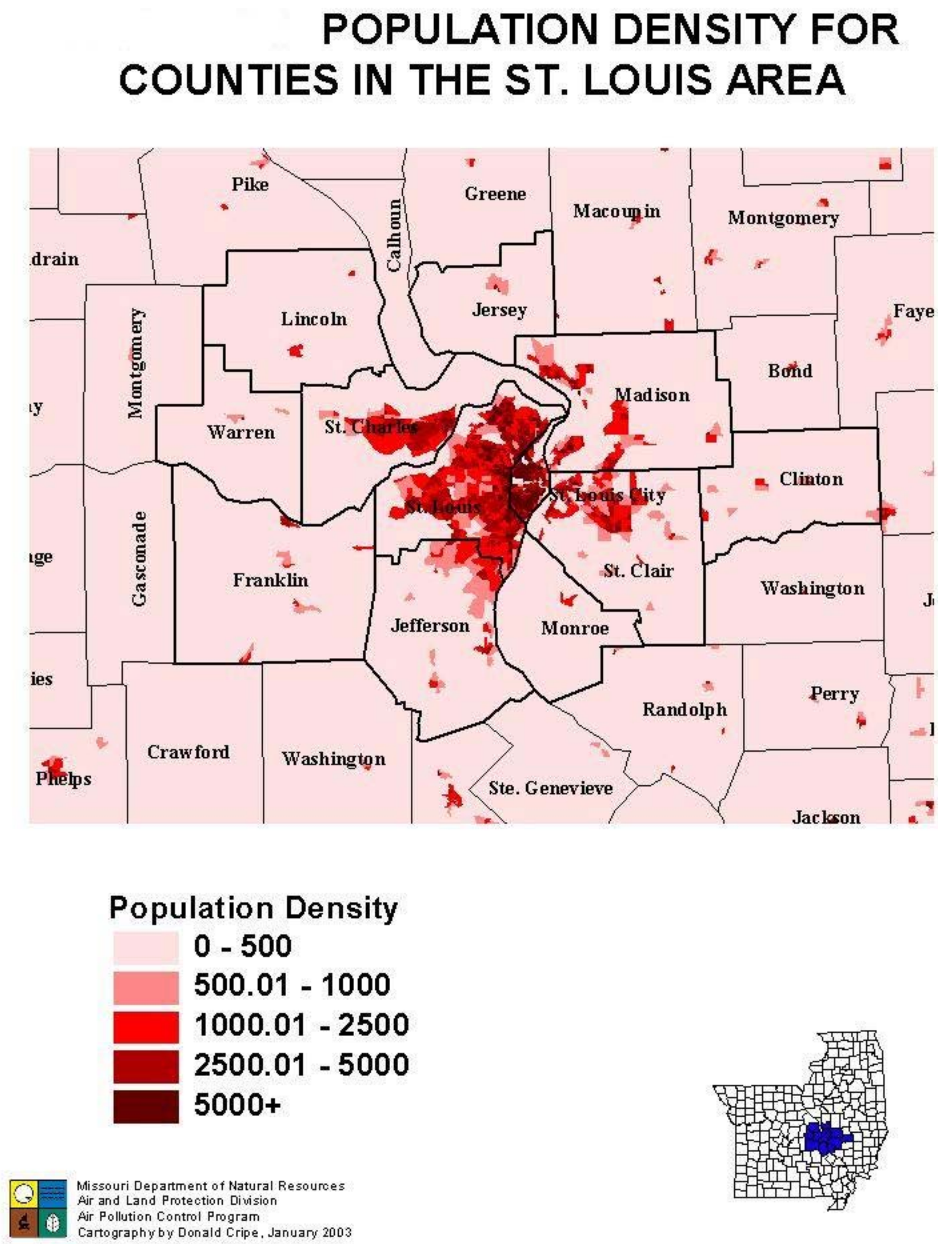

Figure 2.5-1. Population density (year 2000), persons per square mile, in the St. Louis area.