Composition, Sources, and Emissions – PM2.5

Washington DC-MD-VA NAA

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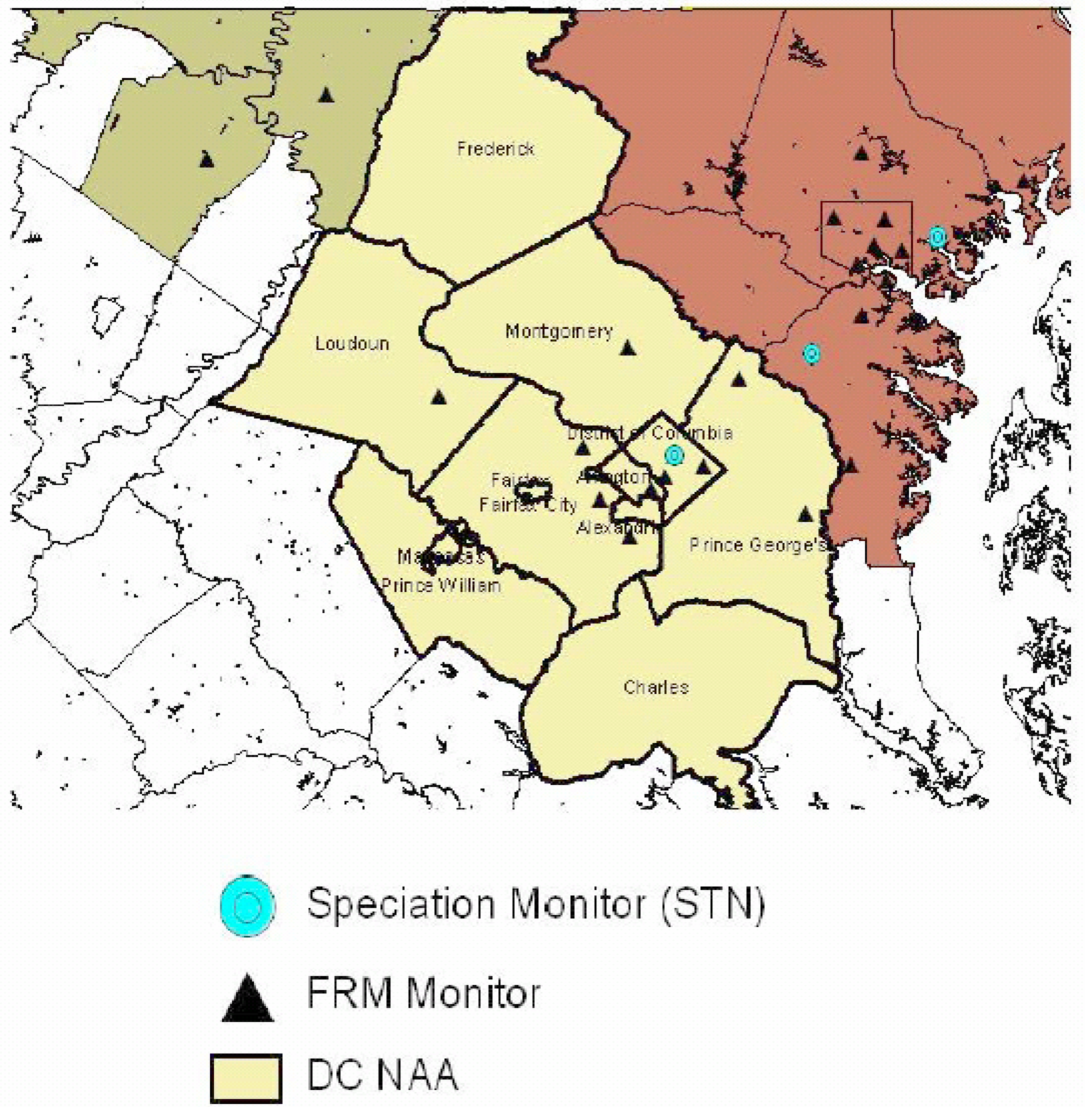
TAC, COG

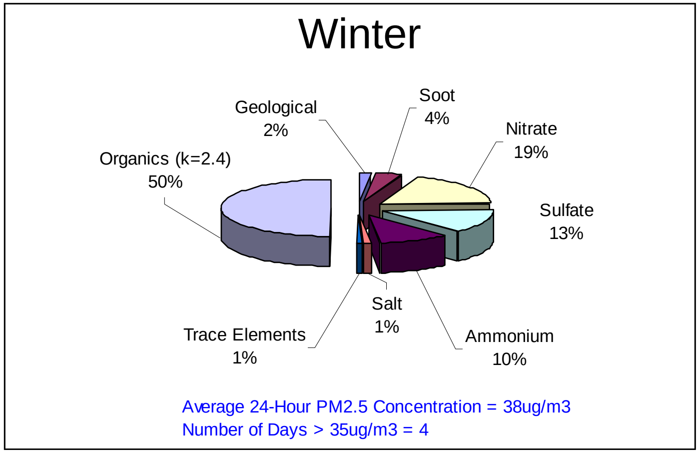
June 8, 2007

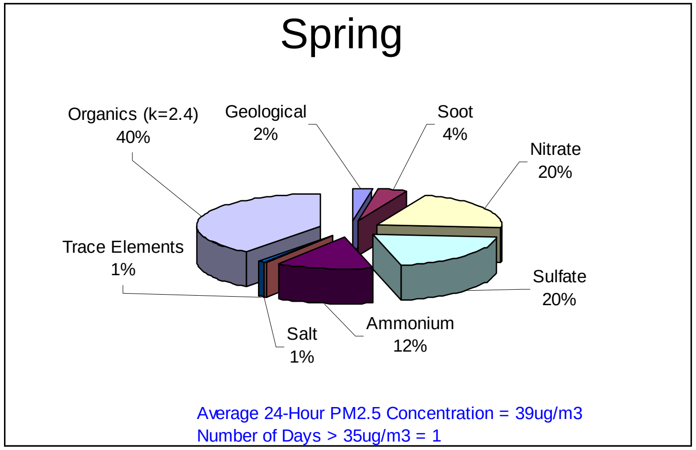
Washington DC-MD-VA PM2.5 NAA

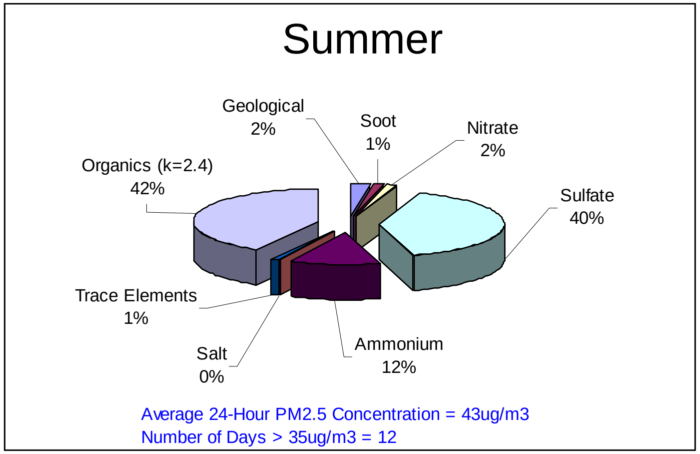


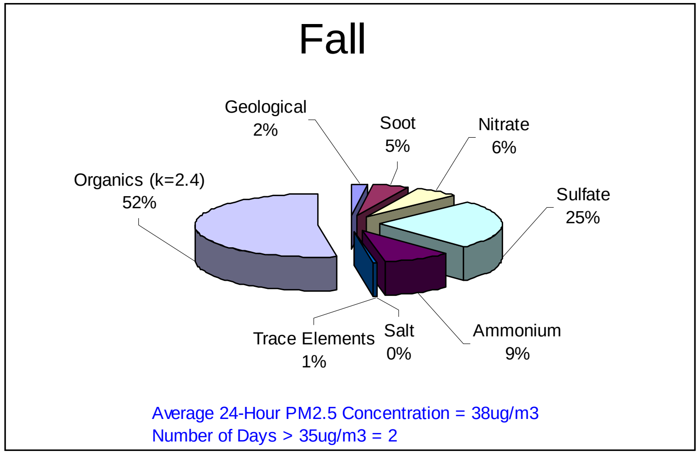
PM2.5 Composition – High Level Days

McMillian (Washington, DC) - 2001-2003



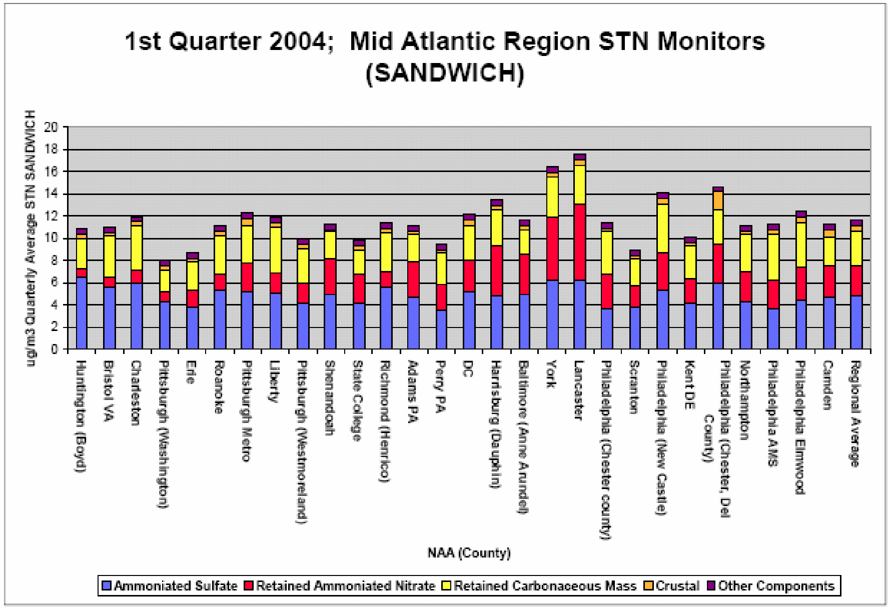




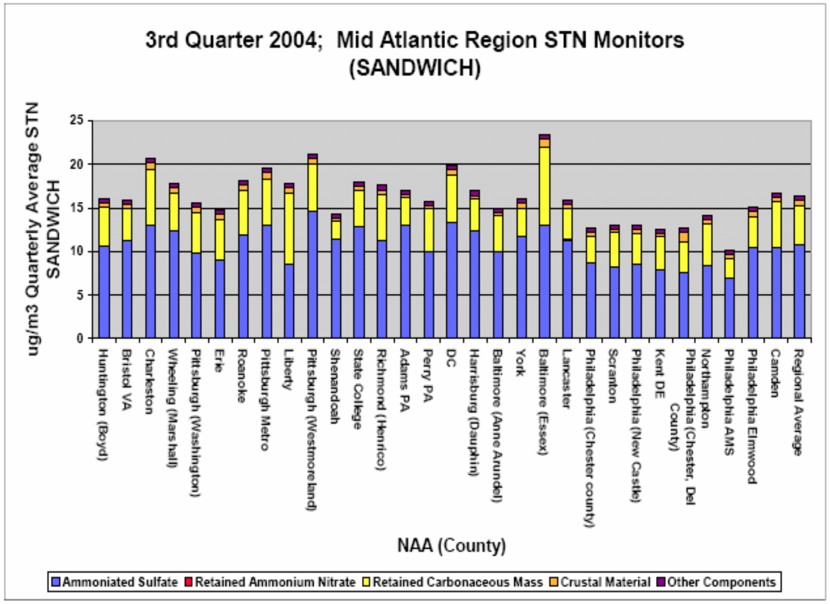


PM2.5 Composition – STN Data
McMillian (Washington, DC) - 2004

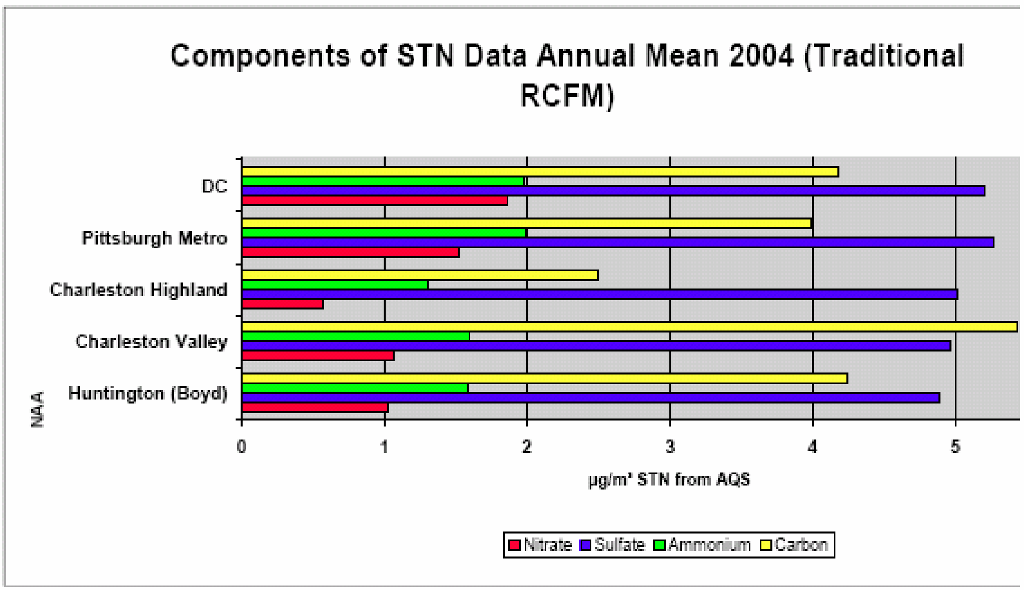
Winter

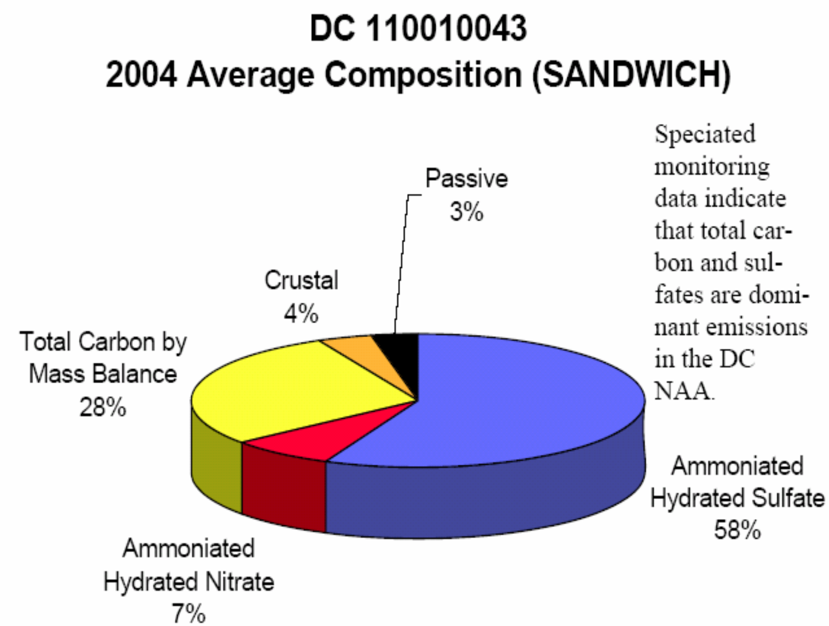


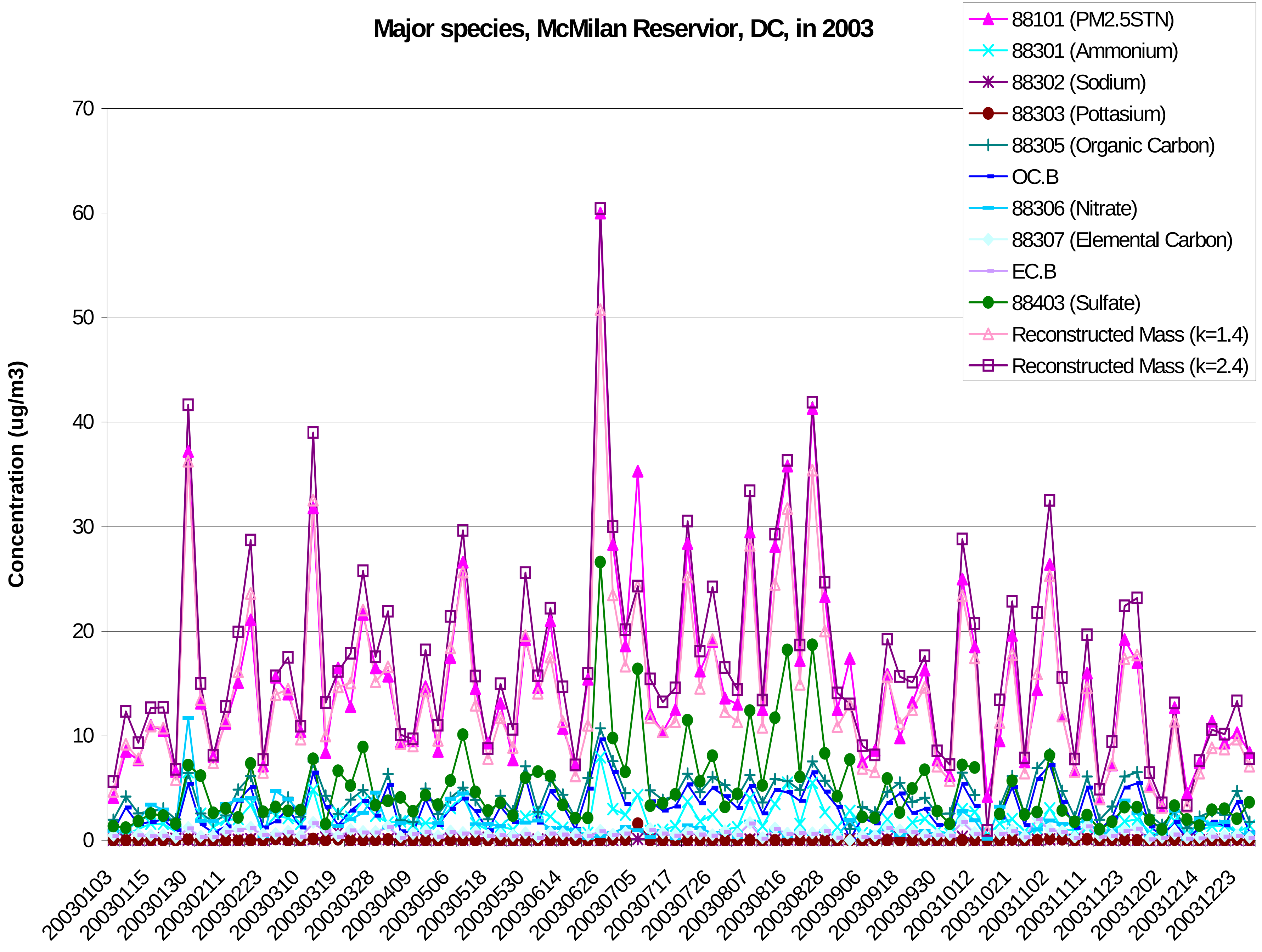
Summer



PM2.5 Composition – STN Data
McMillian (Washington, DC) - 2004







Major species, McMilan Reservior, DC, in 2003
Concentration (ug/m3)
70
60
50
40
30
20
10
0
20030103
20030115
20030130
20030211
20030223
20030310
20030319
20030328
20030409
20030506
20030518
20030530
20030614
20030626
20030705
20030717
20030726
20030807
20030816
20030828
20030906
20030918
20030930
20031012
20031021
20031102
20031111
20031123
20031202
20031214
20031223
88101 (PM2.5STN)
88301 (Ammonium)
88302 (Sodium)
88303 (Pottasium)
88305 (Organic Carbon)
OC.B
88306 (Nitrate)
88307 (Elemental Carbon)
EC.B
88403 (Sulfate)
Reconstructed Mass (k=1.4)
Reconstructed Mass (k=2.4)

PM2.5 - Source Contribution

- Kim & Hopke – Source Apportionment of Fine Particles in Washington, DC, Utilizing Temperature-Resolved Carbon Fractions (AWMA Journal, July 2004)
  - Study based on PM2.5 data (1988-97) for Washington, DC

Table. The comparison of average source contribution (%) to $PM_{2.5}$ mass concentrations between previous study with two carbon fractions and this study with eight carbon fractions.

	Average Source Contribution (Standard Error)		
	PMF with Two Carbon Fractions[a]	PMF with Eight Carbon Fractions[b]	
SO_4^{2-}-rich secondary aerosol I	46.9 (5.1)	42.8 (1.4)	**Total Sulfate = 60%**
Motor vehicle	9 (1.7)	—	
Gasoline vehicle	—	21 (0.6)	→ **Mostly OC**
SO_4^{2-}-rich secondary aerosol II	—	10.6 (0.4)	
NO_3^--rich secondary aerosol	19.6 (3.5)	8.7 (0.3)	
SO_4^{2-}-rich secondary aerosol III	—	6 (0.2)	
Coal combustion	10 (1.7)	—	
Incinerator	5.3 (1.7)	3.7 (0.1)	
Aged sea salt	3.2 (1.4)	2.2 (0.1)	
Airborne soil	2.7 (1)	1.9 (0.1)	
Diesel emissions	—	1.8 (0.1)	
Oil combustion	3.3 (1.3)	1.5 (0.1)	

PM2.5 - Source Contribution

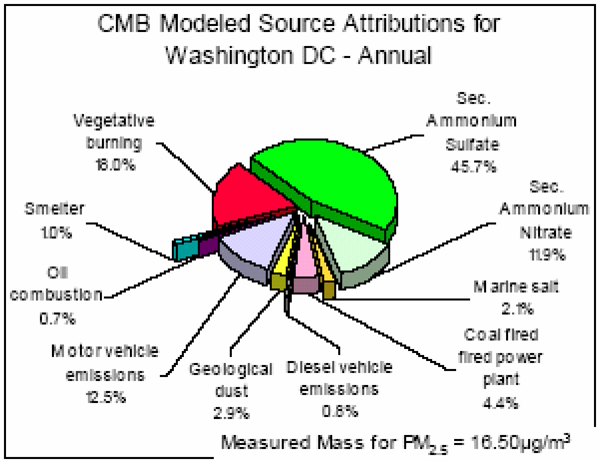
- Battelle & Sonoma Tech –
  - **EIGHT-SITE SOURCE APPORTIONMENT OF PM2.5 SPECIATION TRENDS DATA (September 2003)**

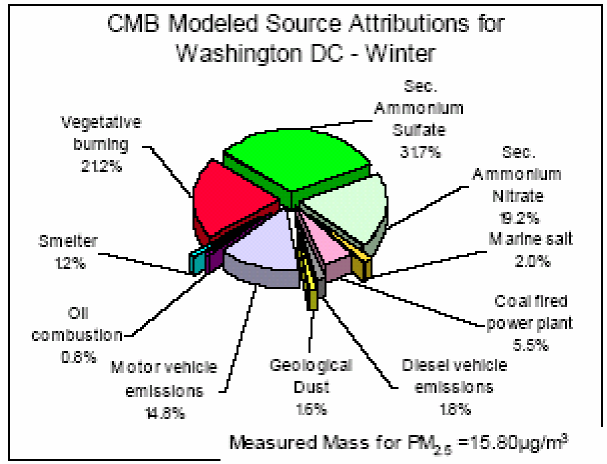
Table - Summary of the Washington, D.C., Results

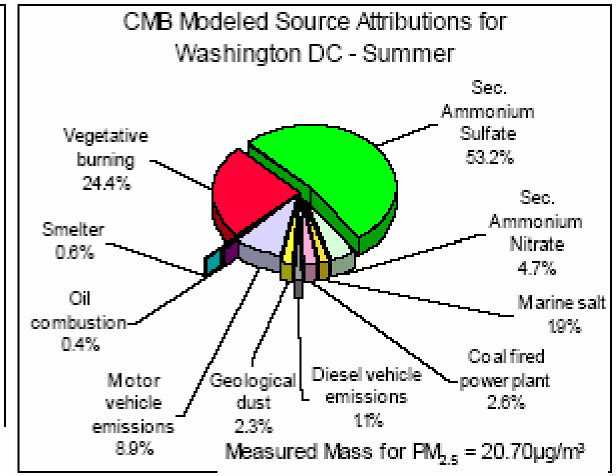
Source	Mass, $\mu g/m^3$	Comments	Day of week	High Season	Pollution Rose	Back Trajectory Location
Vegetative Burning and Fireworks	0.5 3.2%	It is assumed that if the main event is removed, that the remainder is vegetative burning.	Weekday	Summer	NW, N	Central MI, DE, MD, Southern NJ, NC, Atlantic Ocean, SC, Southern AR, Central MO
Coal Combustion	7.7 46.2%		Weekday	Spring and Summer	N, NE, E, SE, S, SW	NC, SC, VA, WV, Eastern KY and TN, OH, IN, Eastern IL, Southwestern and Northern PA, Southern NY, Southern AR, Western GA, Atlantic Ocean
Ammonium Nitrate and Salt	1.2 7.4%	Has NaCl and may have some substitution of chloride with nitrate. Possibly a mix with road salt.	Slightly more on weekdays	Winter	Easterly	Eastern PA, Central NY, MD, DE, Southern NJ, Central TN, KY, Southwestern WV, Northwestern OH, Central and Southern IL, Canada
Mobile Sources	4.7 28.3%	Local and transported pollutants: gasoline dominant (OC>EC), however the day of week pattern is not as expected. May also include power plant combustion, note Se, Ni, V, and sulfate.	Slightly more on weekends	Fall and Summer	NE, E, SE, S, SW	VA, NC, SC, Atlantic Ocean, Southern MD, DE, WV, Central KY, Central and Western TN, Eastern GA, Central AL, Western IL
Canadian Fires	1.1 6.7%	Coincides with transport from large known fire event.	Weekend	Summer	N, SW	Central VA, Southern MD and DE, SC, Central KY, Western IL, Northeastern MO, Southern AR, Central AL, Eastern IA
Road Construction	1.5 8.8%	Crustal component with diesel influence. Note EC, metals, and Mn plus day of week pattern (WD>WE).	Weekday	Fall	NE, E, SE, S	IN, Southwestern OH, Eastern IL, Northern KY, Central TN, Central NC, Eastern VA and MD, DE, Northern NY

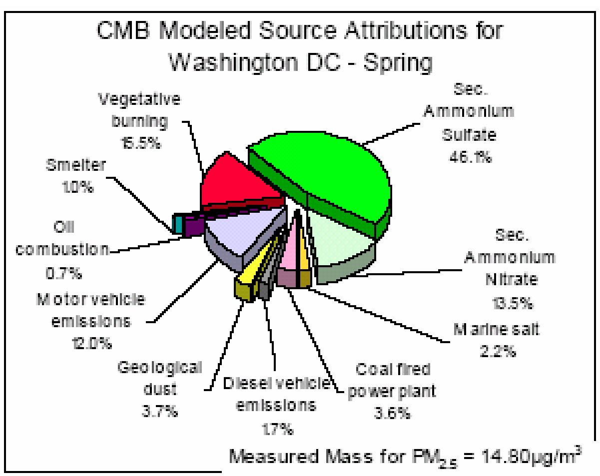
PM2.5 - Source Contribution

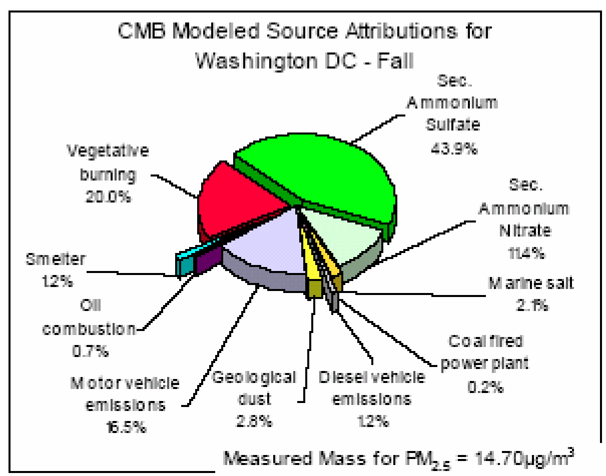
- DRI Report 2005 –
  Source Apportionment Analysis of Air Quality Monitoring Data: Phase II (DRI Report, March 2005)











Seasonal Variation – PM2.5 Components

- DRI Report 2005 –
  Source Apportionment Analysis of Air Quality Monitoring Data: Phase II (DRI Report, March 2005)

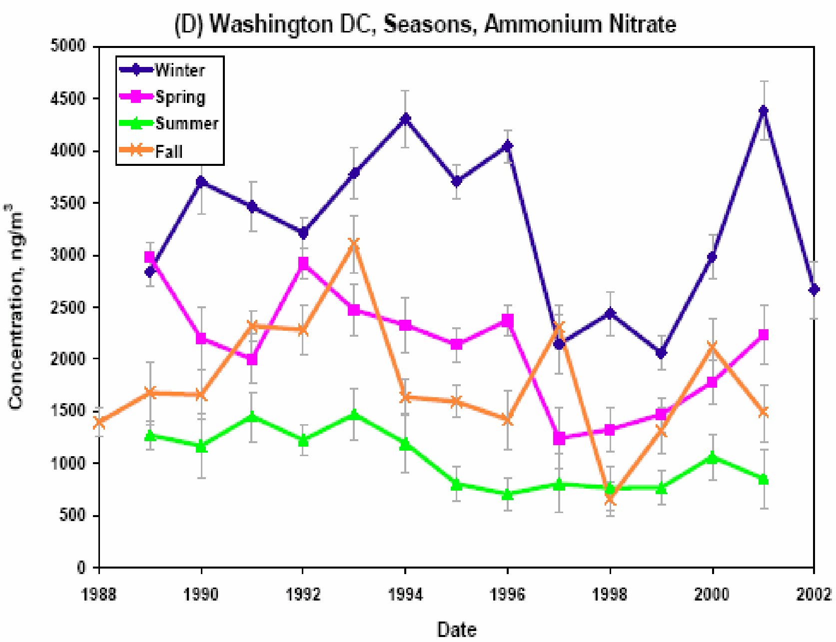


Figure — Temporal and seasonal variations of ammonium nitrate at Washington DC, ascribed partly to NOx from the motor vehicles and the available sunlight during the different seasons. The slight downward trend over the ten-year interval, as seen from the summer plot is evidence of diminishing NOx from motor vehicles.

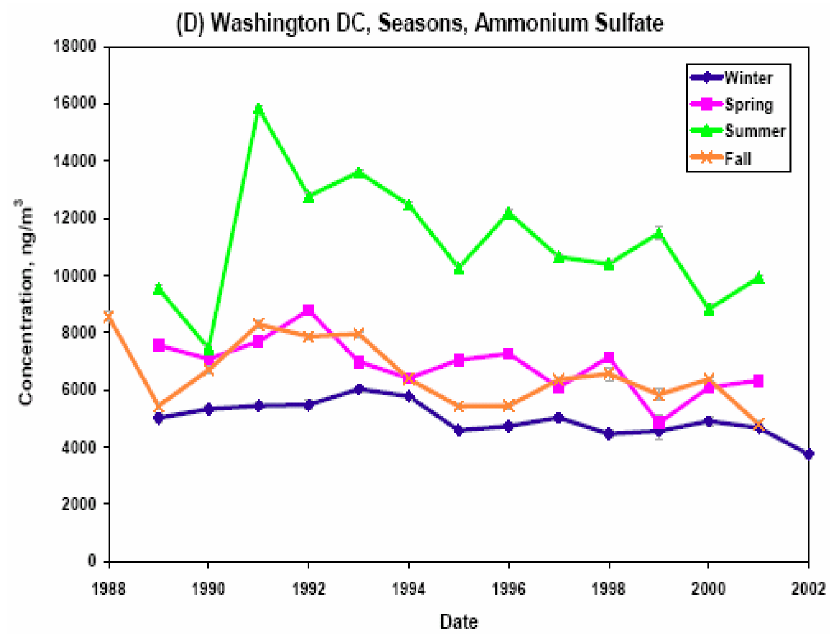


Figure — Temporal and seasonal variations of ammonium sulfate at Washington DC, with consistently low values during the winter months. There is a slight decrease in ammonium sulfate over the ten-year period.

Seasonal & Daily Variation – PM2.5 Mass

- DRI Report 2005 –

Source Apportionment Analysis of Air Quality Monitoring Data: Phase II (DRI Report, March 2005)

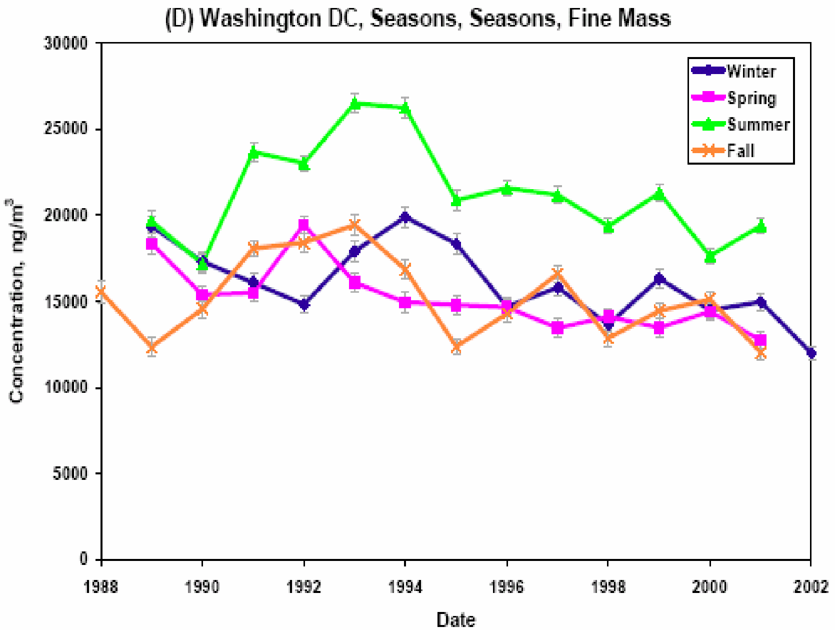


Figure — Site and seasonal fine mass comparisons over the 1992 – 2001 ten-year periods, for Washington DC. All four seasons show negative trends over the ten-year period with overlapping plots for winter, spring, and fall, and higher $PM_{2.5}$ values for the summer months.

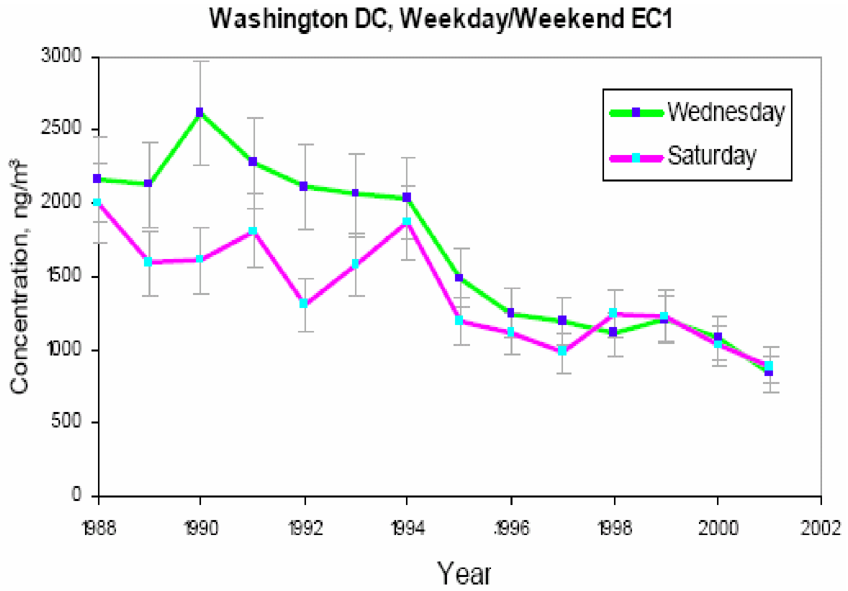


Figure — Weekday/weekend comparison for Washington DC of EC1. The weekday levels are consistently higher between 1988 and 1997, after which the two plots merge and remain similar. This may be pointing to more motor vehicle traffic on weekdays prior to 1997 but similar weekday/weekend traffic since then.

Conclusion – PM2.5 Composition

- Highest daily PM2.5 levels – Summer & Winter

- PM2.5 composition –

Component	Summer	Winter	Annual (2004)
– Organics (Organic & Elemental Carbon)	42%	50%	28%
– Sulfate	40%	13%	58%
– Ammonium	12%	10%	
– Nitrate	2%	19%	7%

❑ Organic & Elemental Carbon and Sulfate are the main constituents of PM2.5 in Washington, DC PM2.5 non-attainment area.

Conclusion – Source Contribution

- Source Contribution (Battelle Study)
  - Coal combustion – 46%
  - Motor vehicles – 28%

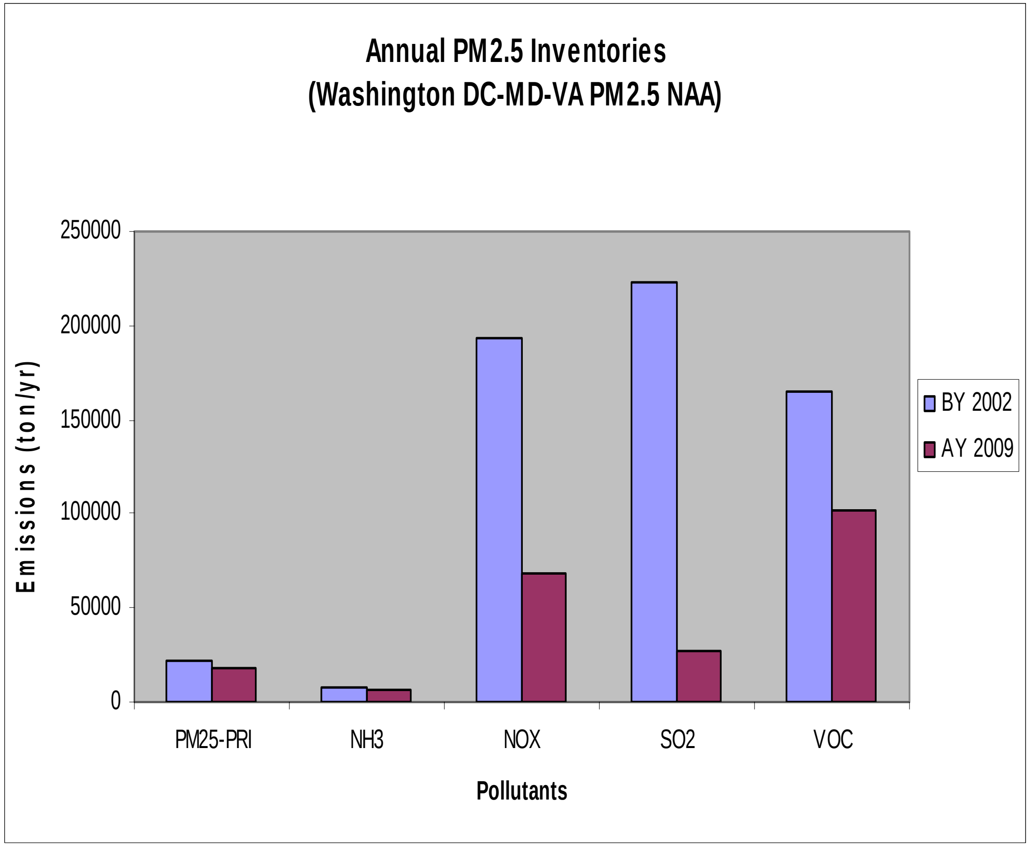
    Gasoline vehicles – Major source of organic carbon (OC = ~21% of total PM2.5 mass, Kim, Hopke)
  - Road construction – 9%
  - Ammonium Nitrate – 7%
  - Canadian fire – 7%
  - Vegetative burning – 3%

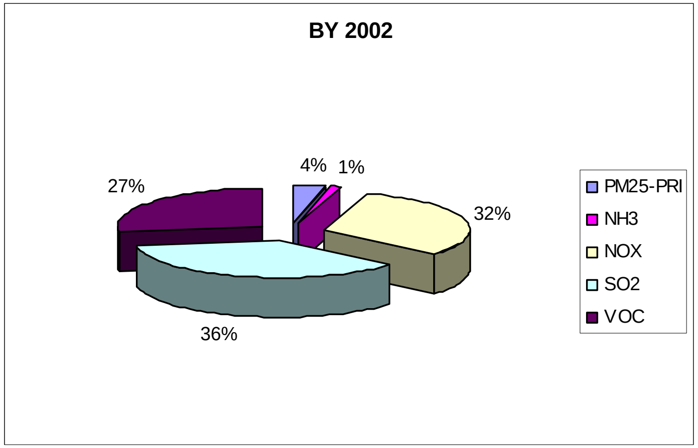
Conclusion – Source Contribution

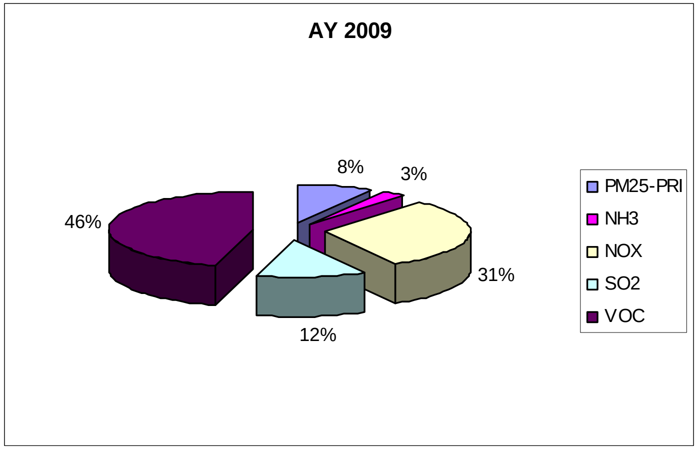
- Source Contribution (DRI Study)

Source	Summer	Winter
– Ammonium sulfate	52%	32%
– Vegetative burning	24%	21%
– Ammonium nitrate	5%	19%
– Motor vehicle	9%	15%
– Diesel vehicle	1%	2%
– Coal fired power plant	3%	6%

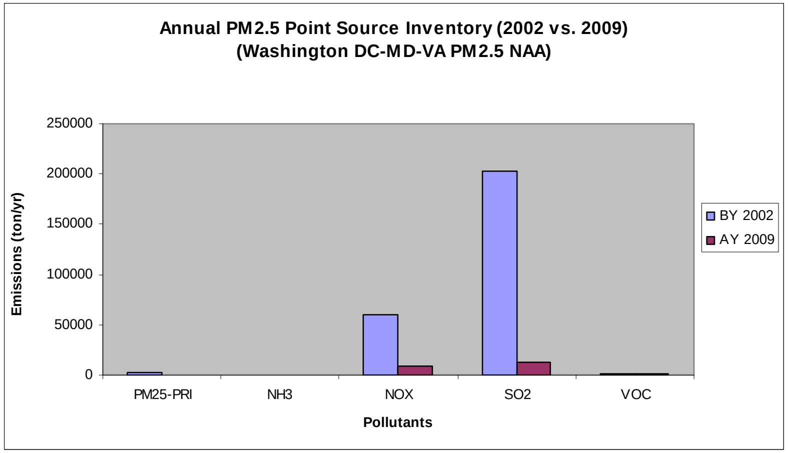
Comparison of Emissions (2002 vs. 2009)

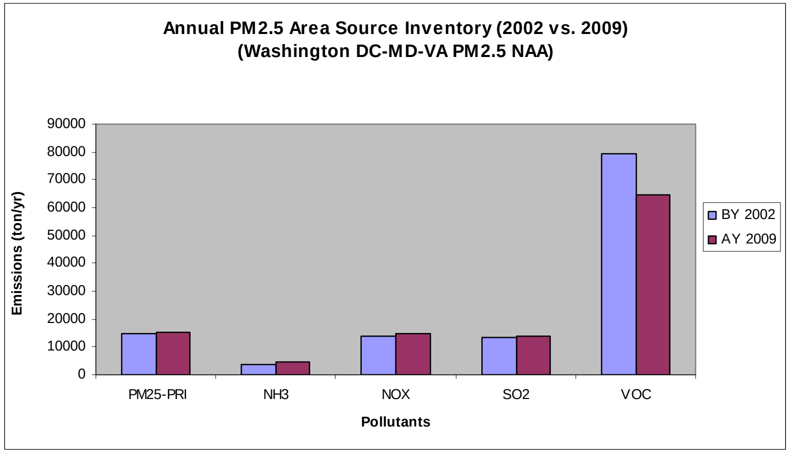


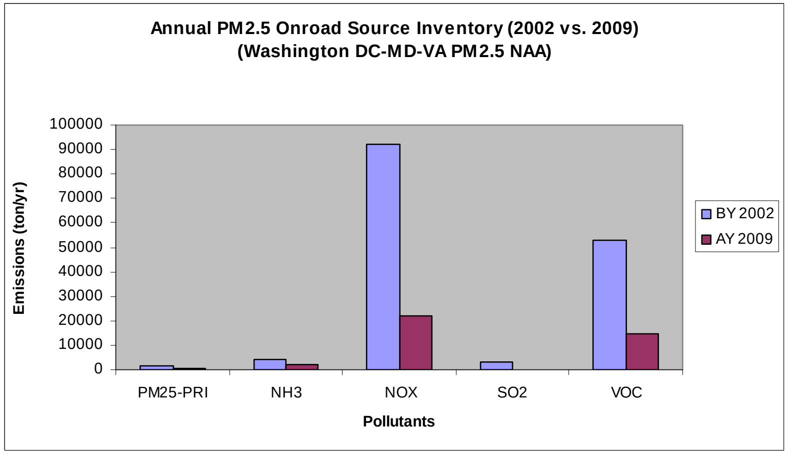


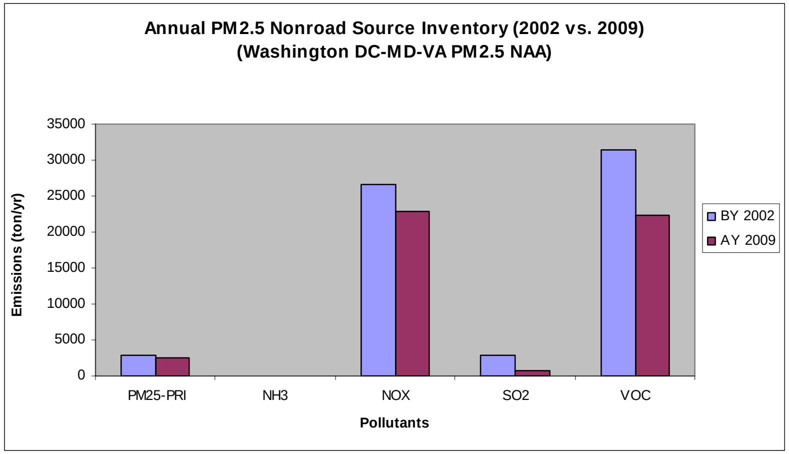


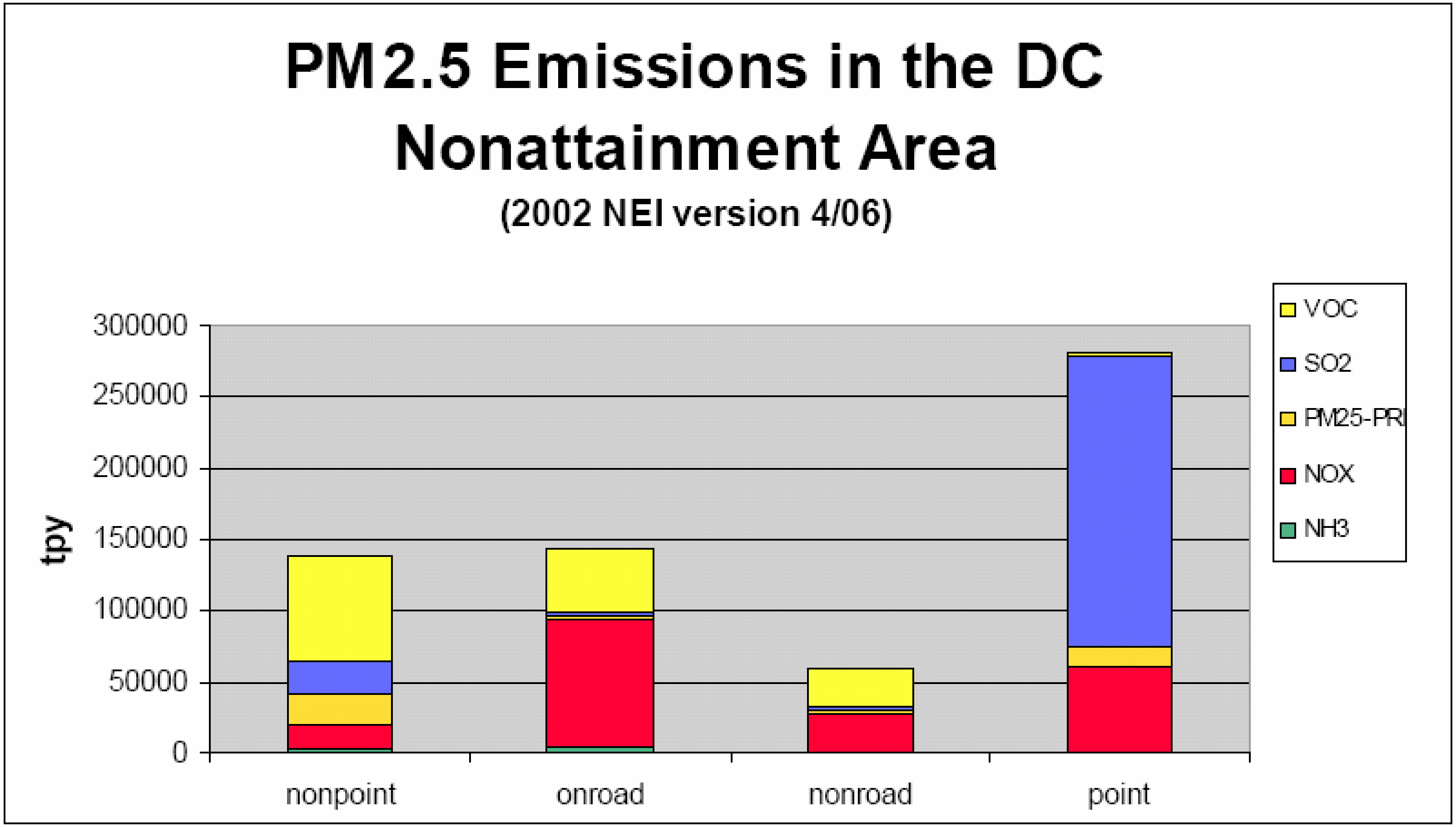
Comparison of Emissions (2002 vs. 2009)











SO2 from Point Sources is the biggest contributor to the PM2.5 problem in the DC Nonattainment Area. Point Sources and Onroad Sources are also significant emitters of NOx. Nonpoint Sources and Onroad sources are important sources of VOCs.

Area or Nonpoint Sources are the largest contributors of PM2.5-Pri emissions with road construction and residential wood burning emissions contributing the most.

Conclusion

- Organic & Elemental Carbon and Sulfate are the main constituents of PM2.5 in Washington, DC PM2.5 non-attainment area.

- OC & EC are part of PM2.5-Pri emissions (emitted directly from sources). Sulfate forms due to oxidation of SO_2 in the air and also due to reaction of SO_2 with NH_3 (Ammonium Sulfate).

- Point sources are the largest contributors of PM2.5-Pri and SO_2 emissions.

- Area or Nonpoint Sources are the largest contributors of PM2.5-Pri emissions with road construction and residential wood burning emissions contributing the most.

- NO_x emissions from motor vehicles contribute significantly towards nitrate formation, an important constituent during winter.