Recommendation for $PM_{2.5}$ Designation

Technical Support Document

Connecticut Department of Environmental Protection
Bureau of Air Management

December 14, 2007

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1. Introduction

The United States Environmental Protection Agency (EPA) revised the 24-hour National Ambient Air Quality Standard (NAAQS) for fine particulate matter (less than 2.5 microns in diameter, or $PM_{2.5}$) with an effective date of December 18, 2006. This document provides justification for Connecticut's recommendations regarding attainment and nonattainment designations as required by Section 107 of the Clean Air Act.

The EPA first promulgated $PM_{2.5}$ NAAQS on July 18, 1997. The annual average NAAQS for $PM_{2.5}$ was set at 15 micrograms per cubic meter ($\mu g/m^3$) and the 24-hour average NAAQS was set at 65 $\mu g/m^3$**.** After years of litigation, the United States Supreme Court upheld the standards in 2001. Subsequently, in 2005, EPA identified and established nonattainment areas for the 1997 standards based on monitored data. EPA determined that air quality in Connecticut was in compliance with the 24-hour $PM_{2.5}$ NAAQS, but that emissions from Fairfield and New Haven Counties contributed to measured violations of the annual $PM_{2.5}$ NAAQS in New York City. As a result, EPA included those two Connecticut counties in a multi-state nonattainment area also comprised of the New York and New Jersey counties that make up the New York City Metropolitan Area. The three affected states are currently developing revisions to their air quality State Implementation Plans (SIPs) to provide for attainment of the 1997 annual $PM_{2.5}$ NAAQS by the 2010 attainment deadline.

Meanwhile, as required by Clean Air Act (CAA) section 109(d)(1) and governed by a March 2003 consent decree reached with national environmental organizations, EPA conducted a review of more recent health effects studies to assess the adequacy of the 1997 $PM_{2.5}$ NAAQS. As result of that review, EPA promulgated revised NAAQS for $PM_{2.5}$ on October 17,2006 (71 Federal Register 61144). The EPA retained the annual $PM_{2.5}$ standard of 15 $\mu g/m^3$ and revised the 24-hour $PM_{2.5}$ standard, changing it from 65 $\mu g/m^3$ to 35 $\mu g/m^3$. The effective date for the new 24-hour $PM_{2.5}$ standard was December 18, 2006.

Section 107(d) of the CAA specifies the process for area designations following the establishment of new or revised NAAQS. Under section 107(d), states are required to submit designation recommendations to EPA not later than one year after the promulgation of a new or revised standard. Therefore, states are required to provide designation recommendations to EPA by December 18, 2007 for the revised 24-hour $PM_{2.5}$ NAAQS. Areas should be identified as attaining, or not attaining, the revised 24-hour $PM_{2.5}$ standard, or as not classifiable on the basis of available information. If EPA intends to promulgate a designation that deviates from the state recommendation, EPA must notify the state at least 120 days prior to promulgating the modified designation, and EPA must provide the state an opportunity to comment on the potential modification. The Clean Air Act requires EPA to complete the designation process within two years of the effective date of the standard (i.e., by December 18, 2008) unless the Administrator finds that additional information is needed to make these decisions. In such a case, EPA may take up to an additional year to make the designations (by December 18, 2009).

EPA recommends that states identify violating areas using the most recent three years of air quality data. In most cases, initial state recommendations will be based on data from calendar years 2004-2006 that are stored in the EPA Air Quality System (AQS). In general, violations are identified using data from Federal reference method (FRM) and Federal equivalent method (FEM) monitors that are sited and operated in accordance with 40 CFR Part 58, as revised on October 17, 2006 (see 71 FR 61236). Air quality monitoring data affected by exceptional events may be excluded from use in identifying a violation if they meet the criteria for such an exclusion, as specified in the Final Rule on the Treatment of Data Influenced by Exceptional Events (72 FR 13560). For determining violations of the 24-hour $PM_{2.5}$ NAAQS, EPA has requested that states ensure that any 2004-2006 monitoring data affected by an exceptional event be flagged in AQS by October 1, 2007.

The EPA issued guidance[1] for determining the boundaries of 24-hour $PM_{2.5}$ nonattainment areas on June 8, 2007. The nine factors to be used by EPA for determining 24-hour $PM_{2.5}$ nonattainment areas are essentially the same as those previously used for designating annual $PM_{2.5}$ nonattainment areas, with the exception that EPA will not presume that urban nonattainment area boundaries should be based on metropolitan area boundaries defined by the U.S. Office of Management and Budget.

As described below, after analyzing the nine factors specified by EPA's guidance, CTDEP's recommendation is to include Fairfield and New Haven Counties in a 24-hour $PM_{2.5}$ multi-state nonattainment area encompassing the New York City Metropolitan Area. It is CTDEP's understanding that New York and New Jersey are recommending that the same counties currently included in the existing annual $PM_{2.5}$ nonattainment area also be included in a new 24-hour $PM_{2.5}$ nonattainment area. If EPA concurs with the three states' recommendations, the resulting multi-state New York City 24-hour $PM_{2.5}$ nonattainment area will have the same geographical boundaries as the existing annual $PM_{2.5}$ nonattainment area.

2. Nine Factor Analysis

EPA guidance suggests that, when making boundary recommendations for nonattainment areas, states should evaluate each area on a case-by-case basis. The CAA requires that a nonattainment area must include not only the area that is violating the standard, but also nearby areas that contribute to the violation. Thus, for each monitor or group of monitors that indicate violations of a standard, EPA intends to establish nonattainment boundaries that cover a sufficiently large area to include both the area that violates the standard and the areas that contribute to the violations. EPA recommends that states base their boundary recommendations for violating areas on an evaluation of the nine factors[2] used in the prior $PM_{2.5}$ designations process, as well as on any other relevant factors or circumstances specific to a particular area. The nine factors are: air quality data, emissions, population and population density, traffic and commuting patterns, expected growth, meteorology, geography/topography, jurisdictional boundaries, and level of control of emission sources. Each of these factors is addressed below for Connecticut in relation to the 2006 24-hour $PM_{2.5}$ NAAQS.

[1] "Area Designations for the Revised 24-Hour Fine Particle National Ambient Air Quality Standard"; Memorandum from Robert Meyers, EPA Acting Assistant Administrator, to EPA Regional Administrators; June 8, 2007.
[2] Ibid.

1) **Air Quality.** The CTDEP's monitoring network includes 11 federal reference method (FRM) $PM_{2.5}$ monitors that provide adequate data to determine design values for the 2004-2006 period (Table 1). As shown in the table below, violations of the 24-hour $PM_{2.5}$ NAAQS were recorded at three sites, all located in coastal Fairfield and New Haven Counties along the I-95 corridor. Violating monitors are located in New Haven (State Street: 38 $\mu g/m^3$ and James Street: 37 $\mu g/m^3$) and Bridgeport (Roosevelt School: 36 µg/m3), with two additional monitors recording compliant 2006 design values equal to the 24-hour NAAQS of 35 $\mu g/m^3$ (Norwalk and New Haven Woodward Street).

Table 1. CONNECTICUT 2006 24-hour $PM_{2.5}$ DESIGN VALUES $\mu g/m^3$

		Annual 98th Percentile Values			**2006 3-Yr Avg of 98th Percentiles**	
		2004	**2005**	**2006**	**All Years**	**Valid Years (24-hr DV)**
Bridgeport	Roosevelt	34.2	**38.3**	**36.7**	**36**	**36**
Danbury	WCSU	27.5	33.4	33.8	32	32
Norwalk	Health Dept	35.2	34.9	**35.9**	35	35
Westport	Sherwood Is	30.9	35.2	31.3	32	32
East Hartford	McAuliffe	30.8	34	31.2	32	32
New Haven	Woodward Av	31.5	**36.4**	**36.5**	35	35
New Haven	James St	**36.7**	**38.2**	**36.7**	**37**	**37**
New Haven	State St	**36.2**	**40.8**	**38.1**	**38**	**38**
New Haven	Huntington St	32.1	32.8	33.9	33	33
Waterbury	Bank St	30.4	35.9	**35.6**	34	34
Norwich	Court House	31.1	34.8	28.3	31	31

[yellow box]: Designates value does not meet EPA completeness criteria, but each quarter has a minimum of 11 samples

Notes:

1. 3-year average of "Valid Years" includes only "complete" years except when "incomplete" years exceed the standard or the resulting DV would exceed the standard.

Design values for 2006 are spatially depicted in the following figure (Figure 1), which shows that the three violating monitors are all located in coastal Fairfield and New Haven Counties, along the I-95 corridor. No violations of the 24-hour $PM_{2.5}$ NAAQS were recorded in any of the six other Connecticut counties.

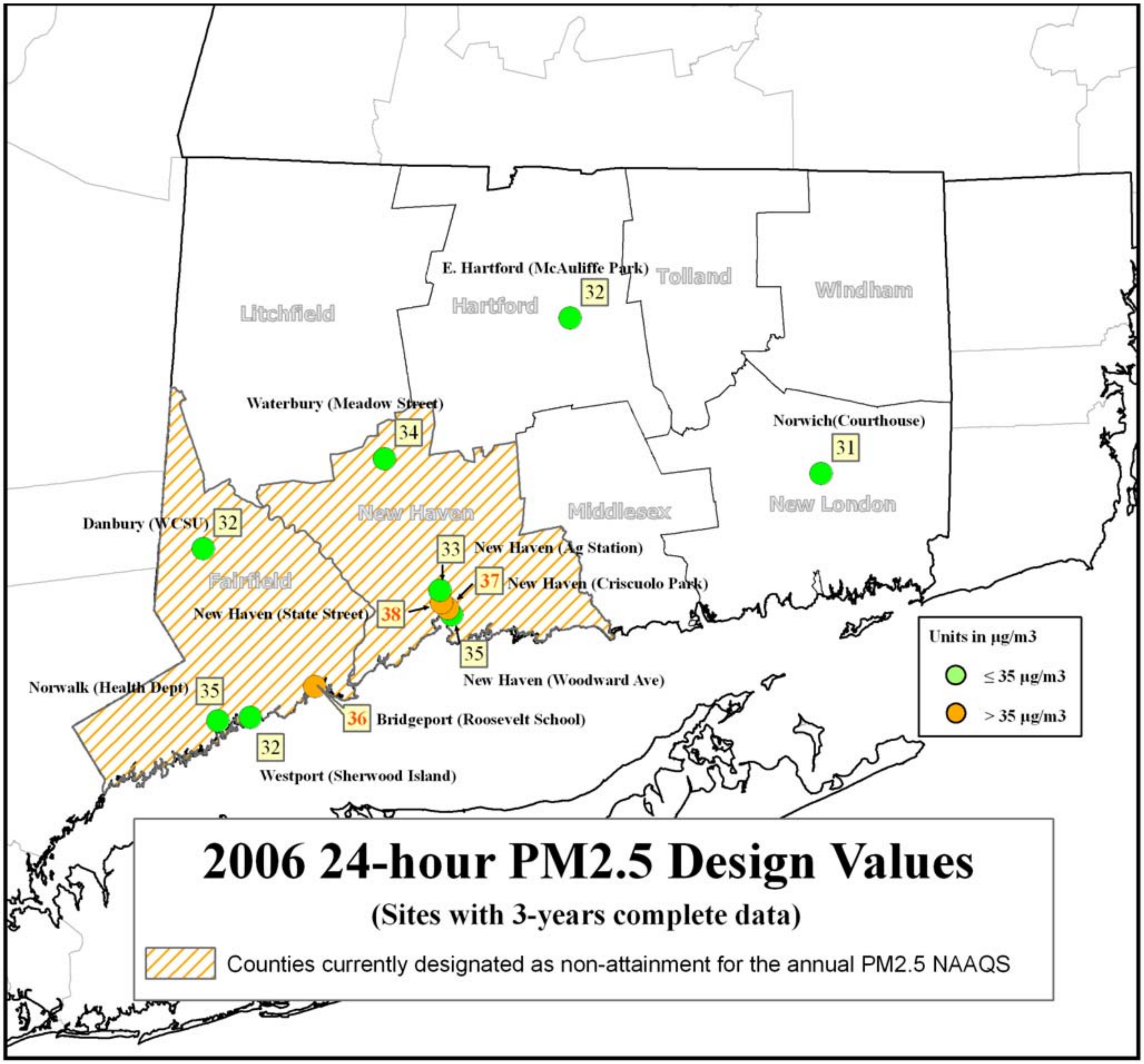


Figure 1. Map of $PM_{2.5}$ Monitors in Connecticut with valid 2006 Design Values

The following graphs (Figures 2 and 3) show the 24-hour design value trends for the period from 2001 through 2006. Separate graphs are provided for the Fairfield/New Haven County monitors and all other monitors in the state (Greater Connecticut). In general, there is no discernable trend in design values over the period.

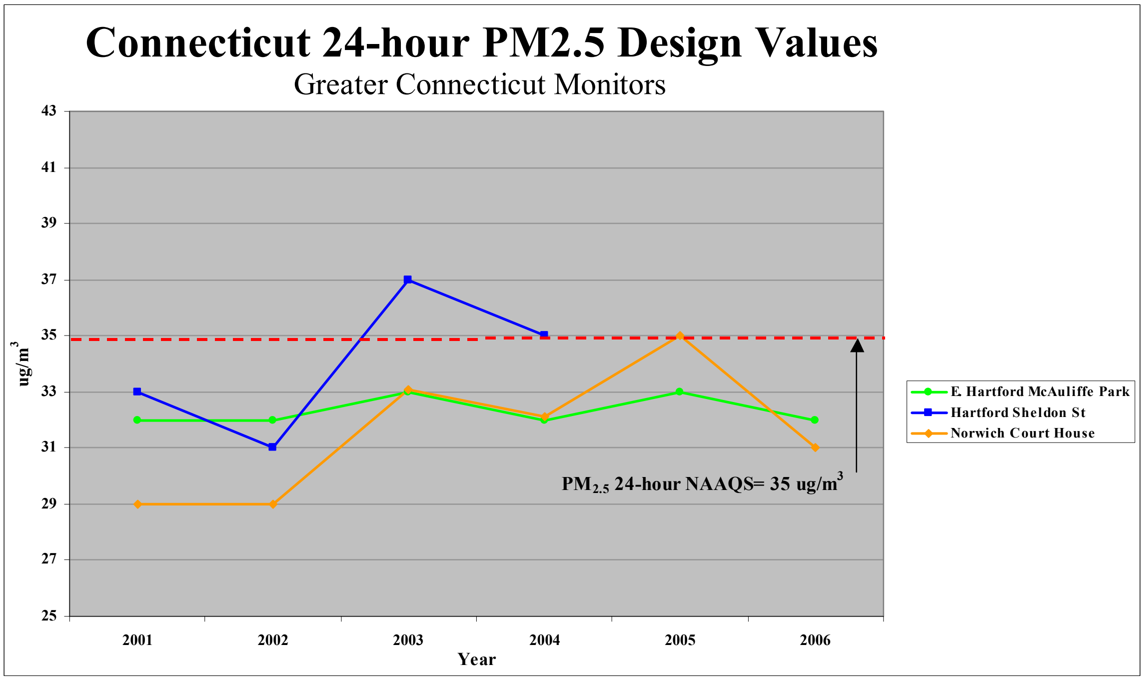


Figure 2. Graph of 24-hour Design Values for Greater Connecticut, 2001-2006

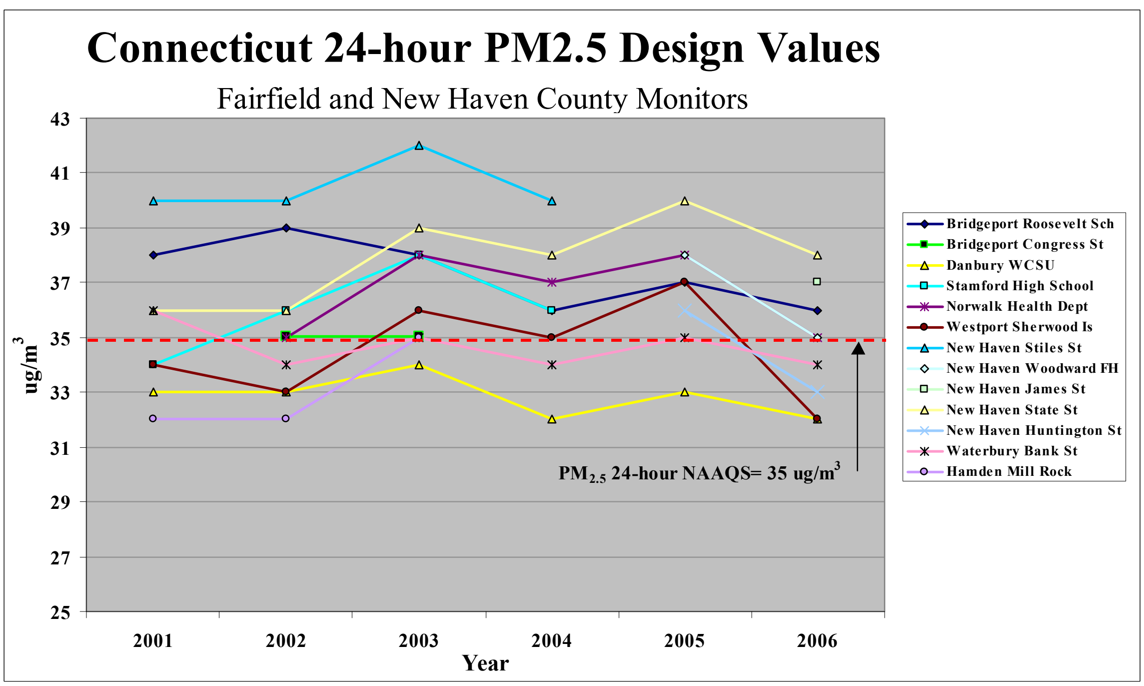


Figure 3. Graph of 24-hour Design Values for Fairfield and New Haven Counties, 2001-2006

Considering air quality data alone, only Fairfield and New Haven Counties should be included as part of a 24-hour $PM_{2.5}$ nonattainment area.

2) **Emissions.** The MANE-VU 2002 (Version 3) Emission Inventory (ftp://ftp.marama.org/) was developed for PM and regional haze planning purposes. It provides a comparison of emission levels in each of Connecticut's eight counties. In addition to primary $PM_{2.5}$ emissions, MANE-VU estimates of nitrogen oxides (NOx) and sulfur dioxide (SO_2) are provided in the following table (Table 2), along with corresponding emission densities for each county. Figure 4 is a bar graph showing the breakdown for the three pollutants for each of the counties.

Table 2. MANE-VU 2002 version 3 emissions for counties in Connecticut (ftp://ftp.marama.org/)

County Name	2002 MANE-VU NOx		2002 MANE-VU PM25-Pri		2002 MANE-VU SO_2	
	(tons/yr)	(tons/year/sq mile)	(tons/yr)	(tons/year/sq mile)	(tons/yr)	(tons/year/sq mile)
Fairfield County	30,620.8	48.9	3,304.8	5.3	9,007.0	14.4
Hartford County	27,743.7	37.7	3,480.8	4.7	3,555.2	4.8
Litchfield County	4,708.4	5.1	2,010.6	2.2	1,031.1	1.1
Middlesex County	7,390.4	20.0	1,341.1	3.6	1,872.0	5.1
New Haven County	28,486.9	47.0	3,300.8	5.5	9,492.4	15.7
New London County	12,121.7	18.2	2,361.5	3.5	5,450.9	8.2
Tolland County	4,774.3	11.6	1,225.4	3.0	800.0	2.0
Windham County	40,42.1	7.9	1,340.8	2.6	952.1	1.9
State Total	**119,888.3**	**24.7**	**18,365.9**	**3.8**	**32,160.7**	**6.6**

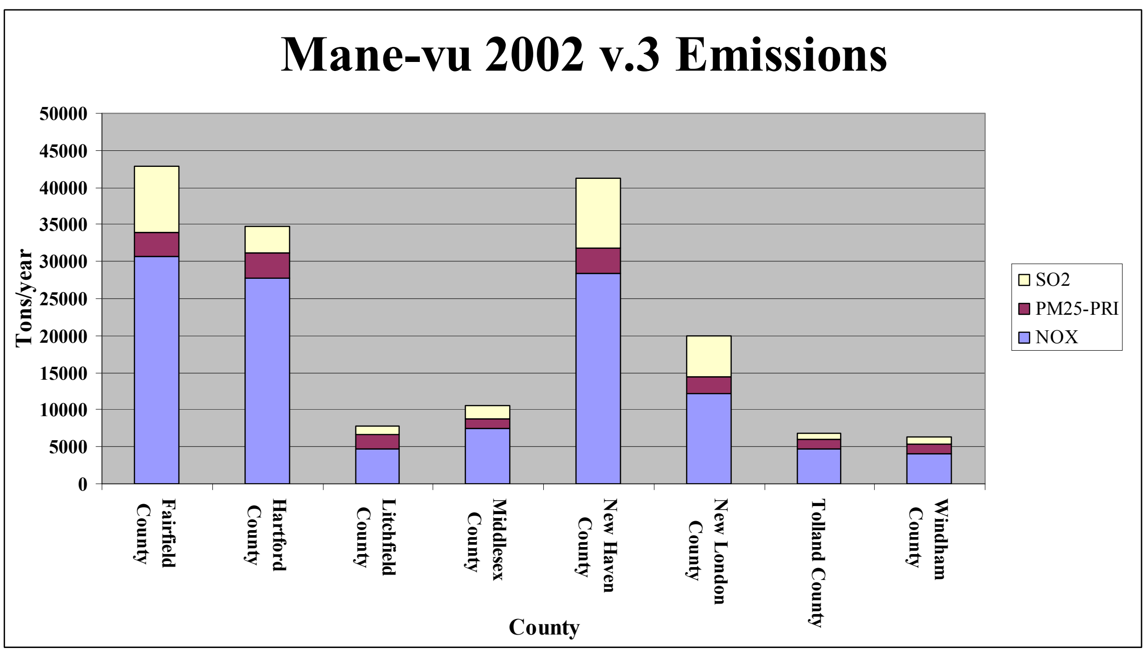


Figure 4. Bar Graph of MANE-VU 2002 version 3 emissions for counties in Connecticut

Connecticut's most populated counties (Fairfield, Hartford and New Haven) produce the highest levels of primary $PM_{2.5}$ and NOx emissions. New Haven and Fairfield Counties contribute the highest level of SO_2 emissions, while Hartford County ranks fourth out of the eight counties. When examined based on emissions density, Fairfield and New Haven Counties rank the highest for all three pollutants, with Hartford County ranking third for NOx and primary $PM_{2.5}$ emissions and fifth for SO_2 emissions out of the eight counties.

Based on these emissions data, only Hartford County would warrant further consideration for inclusion in a nonattainment area with Fairfield and New Haven Counties, and then only if such emissions were contributing to the high $PM_{2.5}$ levels in Fairfield and New Haven Counties.

3) **Population and Population Density**. Both the highest population and the highest population densities in Connecticut occur in Fairfield, Hartford and New Haven Counties. As can be determined from the data in the following table, the population densities of Fairfield and New Haven Counties are 20% and 15% greater, respectively than those in Hartford County.

Table 3. 2006 Population and Population Densities for Connecticut Counties[3]

County	2006 Population	2006 Population Density (population/square mile)
Fairfield County	900,440	1439
Hartford County	876,927	1192
Litchfield County	190,119	207
Middlesex County	163,774	444
New Haven County	845,244	1396
New London County	263,293	395
Tolland County	148,140	361
Windham County	116,872	228
State Total	**3,504,809**	**723**

Considering these population data, once again only Hartford County would warrant further consideration for inclusion in a 24-hour $PM_{2.5}$ nonattainment area with Fairfield and New Haven Counties, but only if emissions from Hartford County are contributing to high monitored $PM_{2.5}$ concentrations in Fairfield and New Haven Counties.

[3] http://quickfacts.census.gov/qfd/states/09000.html

4) Traffic and Commuting Patterns. The following map (Figure 5) provides a spatial depiction of the daily commuting patterns[4] between the two Connecticut counties violating the 24-hour $PM_{2.5}$ NAAQS (i.e., Fairfield and New Haven Counties) and surrounding Connecticut counties. Commuting patterns are supplemented with a color overlay displaying primary $PM_{2.5}$ on-road emissions in each of Connecticut's eight counties. In this diagram, the violating counties for the 24-hour $PM_{2.5}$ NAAQS, Fairfield and New Haven Counties, were grouped together as a single entity for the purpose of illustrating the effect that primary on-road $PM_{2.5}$ emissions due to commuting from surrounding counties might have on the area. Arrows on the map represent the number of workers commuting between surrounding counties and the Fairfield/ New Haven County area, with the percent representing the portion of the total workforce in destination county (ies) that reside in the origin county (ies).

Hartford County is the only county that would have sufficient on-road $PM_{2.5}$ emissions to possibly have an effect on the violating counties. However, the total workforce commuting from Hartford County into the Fairfield/New Haven County area is slightly less than those commuting in the opposite direction into Hartford County (19613, or 2.4% of the total Fairfield/ New Haven County workforce vs. 23,561 or 4.9% of the Hartford County workforce). Based on these data, the commuting patterns from Hartford County are not contributing significantly to the non-attainment monitors in New Haven and Fairfield Counties.

[4] http://www.census.gov/population/www/cen2000/commuting.html

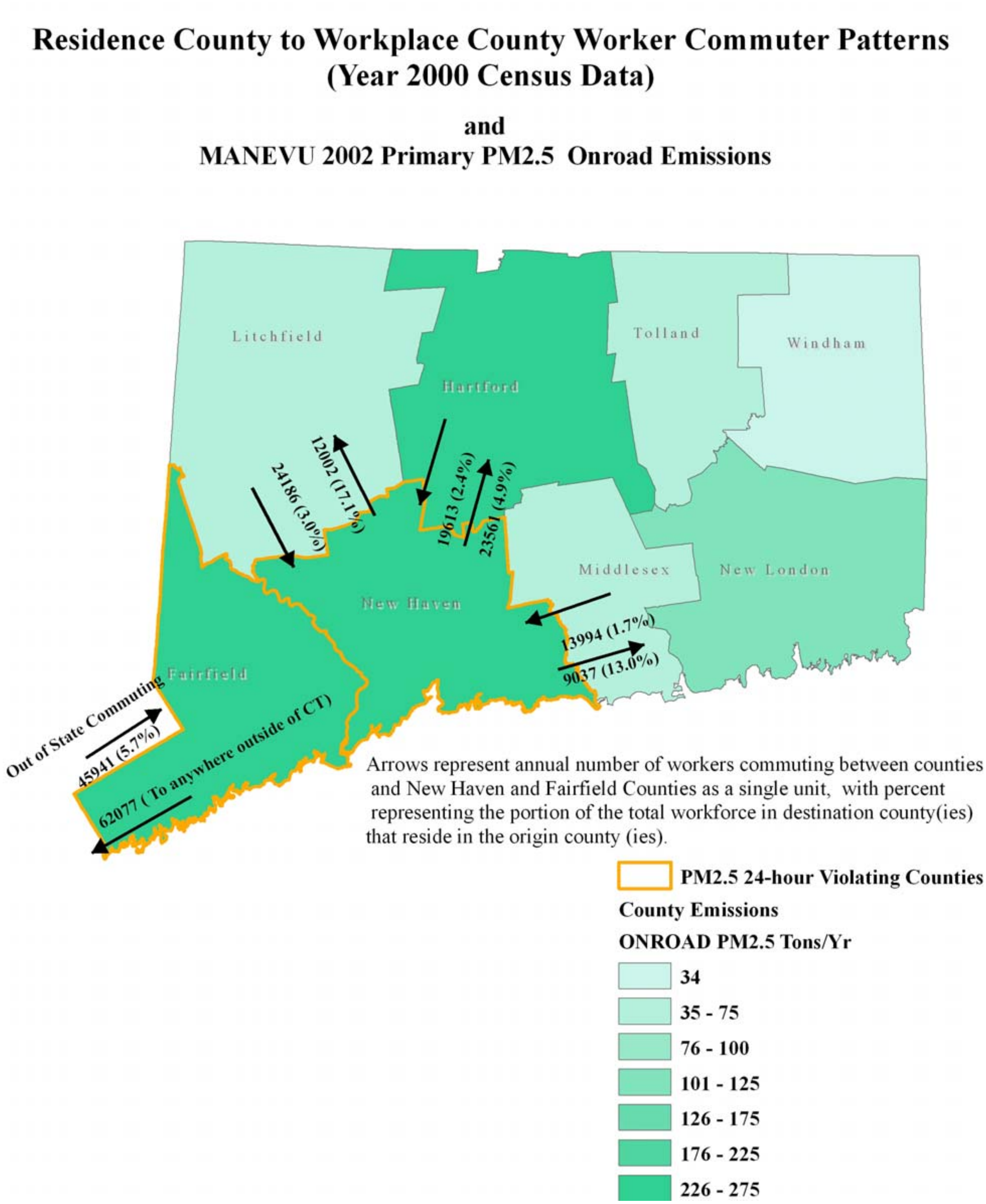


Figure 5. Map showing Commuting Patterns in Connecticut for the Year 2000

5) **Expected Growth.** Table 4 summarizes U.S. Census Bureau population estimates for 2000-2006. Overall, population growth in Connecticut during the period was 2.7%, with the most populous counties (Fairfield, Hartford and New Haven Counties) growing at rates less than the state average. Figure 6 presents the results graphically for those three counties, indicating that growth was minimal over the last half of the period. Growth rates for Connecticut are expected to remain relatively flat for the foreseeable future, as depicted by projected population data released by the U.S. Census Bureau and displayed in Figure 7 below. Connecticut's population is projected to increase by about 5% over the period from 2005 to 2030, comparable to most nearby states except New Jersey, which is expected to grow by about 12% over the period.

Table 4. U.S. Census Bureau Population Growth Estimates[5]

County	2000	2001	2002	2003	2004	2005	2006	Growth % 2000-2006
Fairfield County	884,916	890,375	895,083	899,018	900,683	901,086	900,440	1.8%
Hartford County	858,539	862,030	866,517	871,471	872,435	875,422	876,927	2.1%
Litchfield County	182,679	184,386	186,332	187,688	188,967	189,358	190,119	4.1%
Middlesex County	155,662	157,260	159,537	161,359	162,044	162,824	163,774	5.2%
New Haven County	825,108	829,445	834,395	840,287	842,707	844,510	845,244	2.4%
New London County	259,520	260,772	262,534	264,594	265,918	264,265	263,293	1.5%
Tolland County	136,904	138,984	142,382	145,204	146,632	147,454	148,140	8.2%
Windham County	109,211	109,949	111,147	112,705	114,507	115,782	116,872	7.0%
Connecticut Total	3,412,539	3,433,201	3,457,927	3,482,326	3,493,893	3,500,701	3,504,809	2.7%

5 http://www.census.gov/popest/counties/CO-EST2006-popchg2000_2006.html

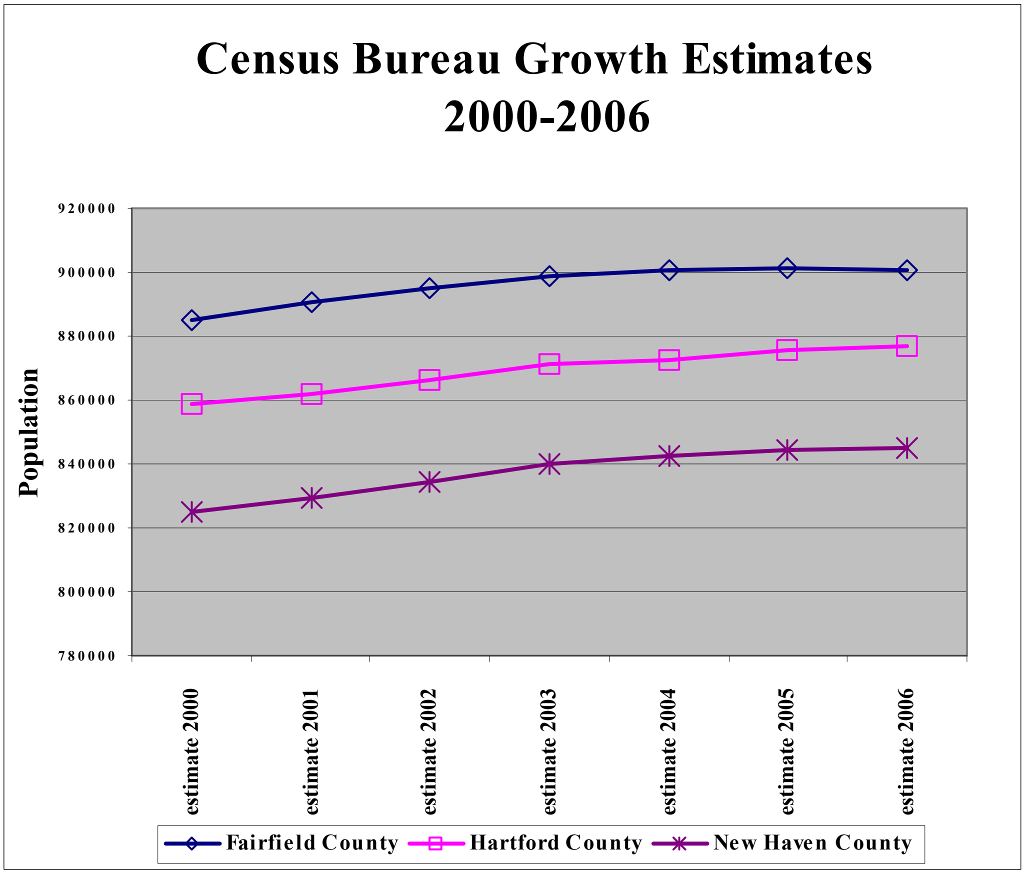


Figure 6. U.S. Census Bureau Population Projections 2000-2006

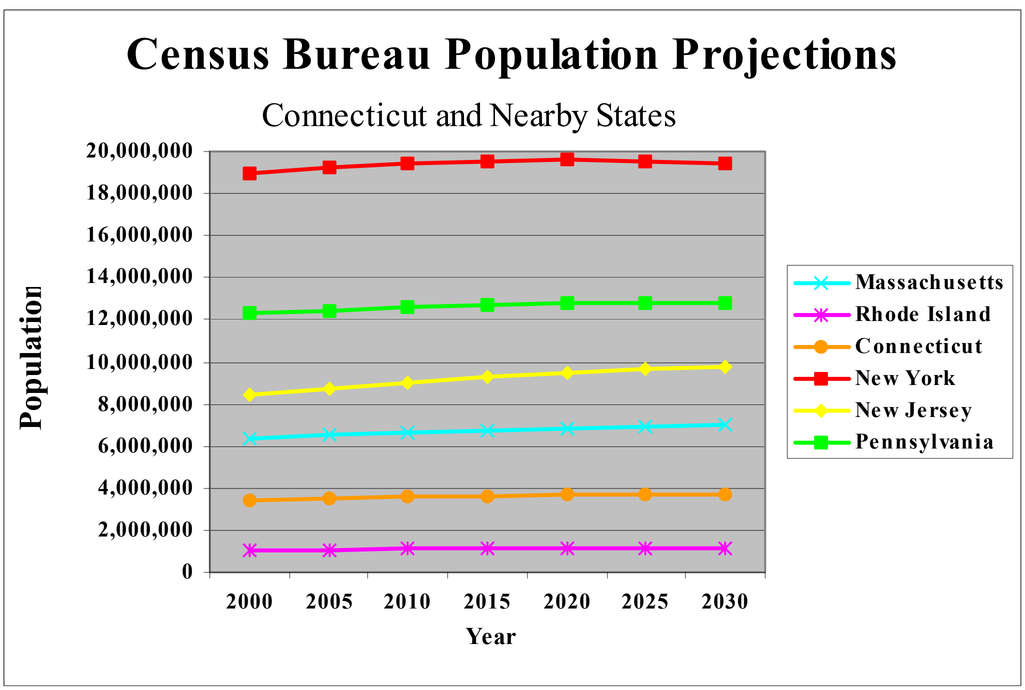


Figure 7. U.S. Census Bureau Population Projections through 2030[6]

[6] http://www.census.gov/population/projections/PressTab6.xls

Connecticut Department of Transportation (CTDOT) projections[7] of daily vehicle miles traveled on Connecticut roads are summarized in Table 5 for the period from 2002 through 2012. Future VMT growth is not expected to exceed 1% annually for Fairfield, New Haven or Hartford Counties.

Table 5. CTDOT VMT Projections Through 2012 (miles traveled per summer day)

County	2002	2008	2009	2012	Avg Annual Growth % 2008-2012
Fairfield	22,473,990	23,758,281	23,964,492	24,537,525	**0.8%**
Hartford	23,438,693	25,453,988	25,728,832	26,449,411	**1.0%**
Litchfield	4,231,315	4,537,429	4,591,780	4,714,207	**1.0%**
Middlesex	5,205,681	5,537,734	5,602,984	5,763,574	**1.0%**
New Haven	20,739,814	22,120,300	22,337,635	22,920,844	**0.9%**
New London	9,066,405	10,052,269	10,225,010	10,705,140	**1.6%**
Tolland	4,497,778	4,848,680	4,907,363	5,094,796	**1.3%**
Windham	3,191,455	3,466,501	3,507,841	3,607,614	**1.0%**
State Total	**92,845,131**	**99,775,182**	**100,865,937**	**103,793,111**	**1.0%**

6) **Meteorology.** The weather conditions that are responsible for the highest $PM_{2.5}$ concentrations in Connecticut vary from summer to winter. This is described in a recent NESCAUM report titled "The Nature of the Fine Particle and Regional Haze Air Quality Problems in the MANE-VU Region: A Conceptual Description" (NESCAUM, 2006)[8] and summarized as follows:

> *The conceptual description that explains elevated regional PM2.5 peak concentrations in the summer differs significantly from that which explains the largely urban peaks observed during winter. On average, summertime concentrations of sulfate in the northeastern United States are more than twice that of the next most important fine particle constituent, organic carbon (OC), and more than four times the combined concentration of nitrate and black carbon (BC) constituents. Episodes of high summertime sulfate concentrations are consistent with stagnant meteorological flow conditions upwind of the MANE-VU region and the accumulation of airborne sulfate (via atmospheric oxidation of SO2) followed by long-range transport of sulfur emissions from industrialized areas within and outside the region.*
>
> *National assessments have indicated that in the winter, sulfate levels in urban areas are higher than background sulfate levels across the eastern U.S.,*

[7] Series 28D projections provided by CTDOT Bureau of Policy and Planning (March, 2007)

[8] http://bronze.nescaum.org/committees/attainment/conceptual/2006-1102--PM%20conceptual%20model.pdf

indicating that the local urban contribution to wintertime sulfate levels is significant relative to the regional sulfate contribution from long-range transport. A network analysis for the winter of 2002 suggests that the local enhancement of sulfate in urban areas of the MANE-VU region ranges from 25 to 40% and that the long-range transport component of PM2.5 sulfate is still the dominant contributor in most eastern cities.

In the winter, urban OC and sulfate each account for about a third of the overall PM2.5 mass concentration observed in Philadelphia and New York City. Nitrate also makes a significant contribution to urban PM2.5 levels observed in the northeastern United States during the winter months. Wintertime concentrations of OC and nitrate in urban areas can be twice the average regional concentrations of these pollutants, indicating the importance of local source contributions. This is likely because winter conditions are more conducive to the formation of local inversion layers which prevent vertical mixing. Under these conditions, emissions from tailpipe, industrial and other local sources become concentrated near the Earth's surface, adding to background pollution levels associated with regionally transported emissions.

So, sulfates transported from the west and southwest from coal burning power plants make up the bulk of the $PM_{2.5}$ composition during the summer, while carbonaceous matter and nitrates become more prevalent during the winter. The wintertime episodes frequently occur when wind conditions are light and during the coldest nights when a near-surface temperature inversion occurs. This is mostly observed at the East Hartford monitoring site, which is located in the Connecticut River Valley and is most prone to the trapping of particulates from combustion sources during temperature inversions. At this site, winds are often channeled in the north-south direction, as readily observed on the wind roses from the site meteorological data.

<u>Pollution Roses</u>

Figure 8 depicts wind direction pollution roses showing the direction of the wind on the days when $PM_{2.5}$ levels exceed 35 $\mu g/m^3$ at four of the monitoring sites. The daily wind directions were derived by summing the hourly wind direction unit vectors. The two coastal sites show the exceedance wind directions from the south and southwest quadrants. Danbury has exceedances mostly with west to south wind directions. East Hartford shows the north-south wind-channeling phenomenon, with the highest frequency of PM exceedance days occurring on southerly winds. During the winter, high pressure over the Northeast with very light winds can enable north to south channeling within the Connecticut River Valley. This north to south channeling has also been observed during the summer under weak high-pressure conditions. In conclusion, 2006 design values at the East Hartford monitor comply with the 24-hour $PM_{2.5}$ NAAQS and the pollution roses from the other sites in Connecticut indicate that emissions from Hartford County would not contribute significantly to non-attainment in either New Haven or Fairfield counties.

Back Trajectories

Figures 9 and 10 show the actual 72-hour back trajectories on $PM_{2.5}$ exceedance days from two of the coastal monitoring sites, Westport and New Haven State Street. The back trajectories are shown for three ending elevations: 10 meters, 500 meters and 1000 meters above the surface. For all $PM_{2.5}$ exceedance days, the 72-hour back trajectories originate from west or south of Connecticut. None of these trajectories originate or cross over Hartford County. Therefore, as indicated previously, emissions from Hartford County are not transported to the non-attainment monitors in New Haven or Fairfield Counties on days when $PM_{2.5}$ levels are high. Therefore only New Haven and Fairfield Counties should be designated non-attainment for $PM_{2.5}$.

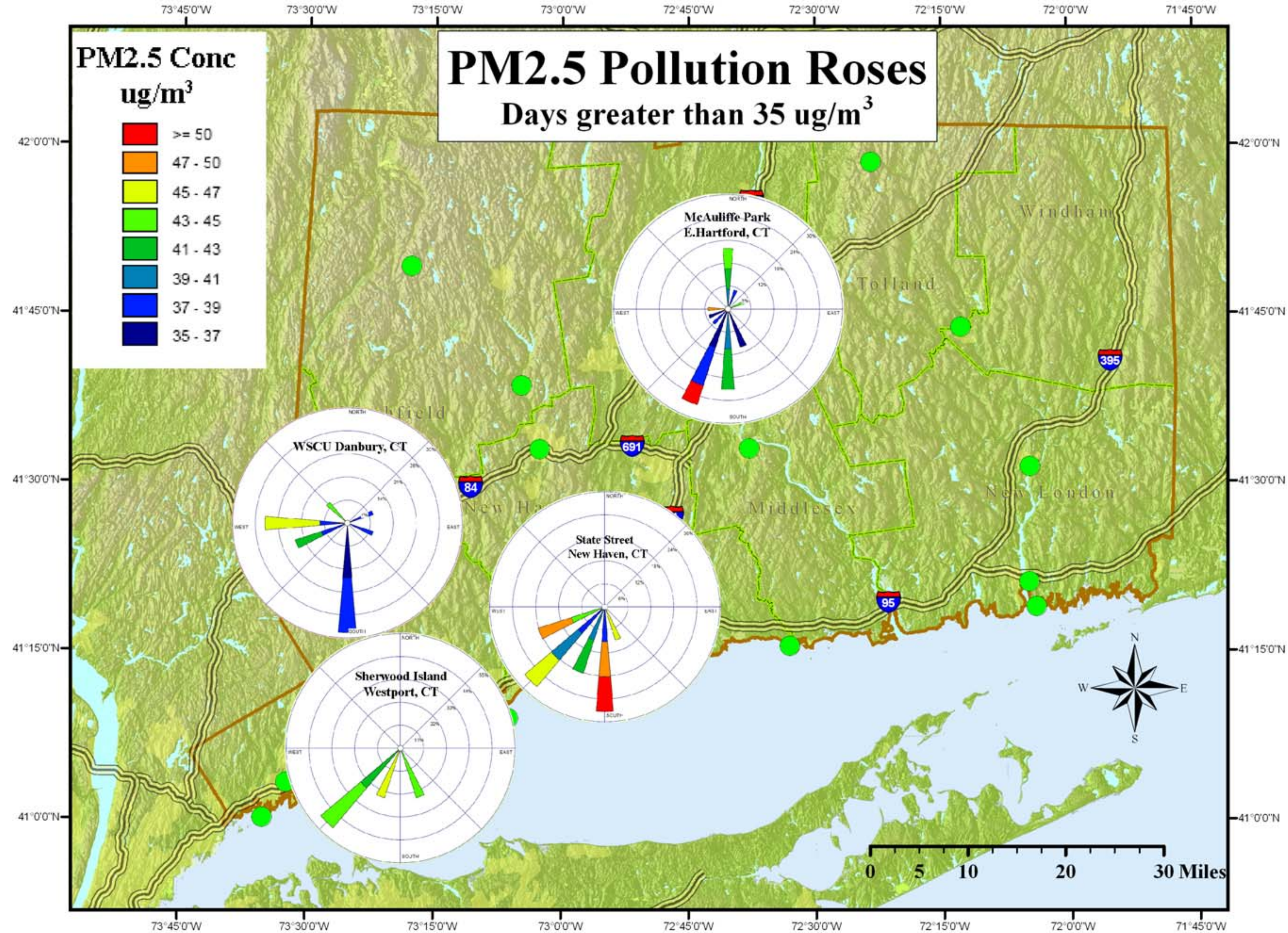


Figure 8. $PM_{2.5}$ Pollution Wind Direction Roses

Figure 9. 72-hour back Trajectories from State Street, New Haven, CT 2000-2004
Days when $PM_{2.5} > 35 \mu g/m^3$ (1 in 3 day sampling)

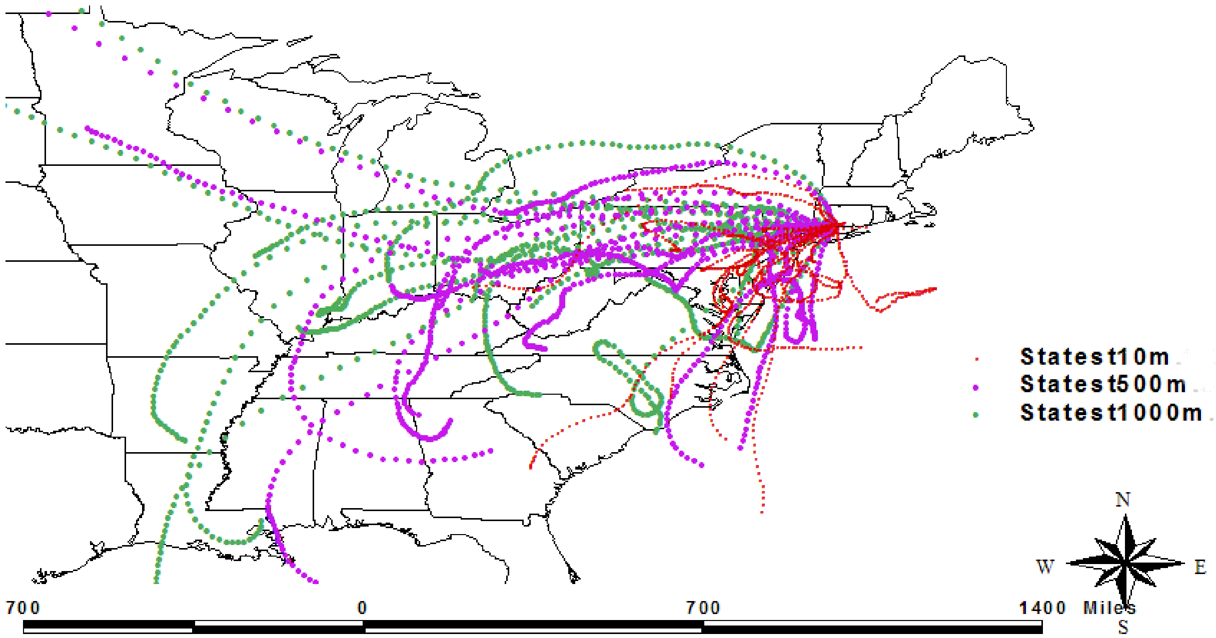
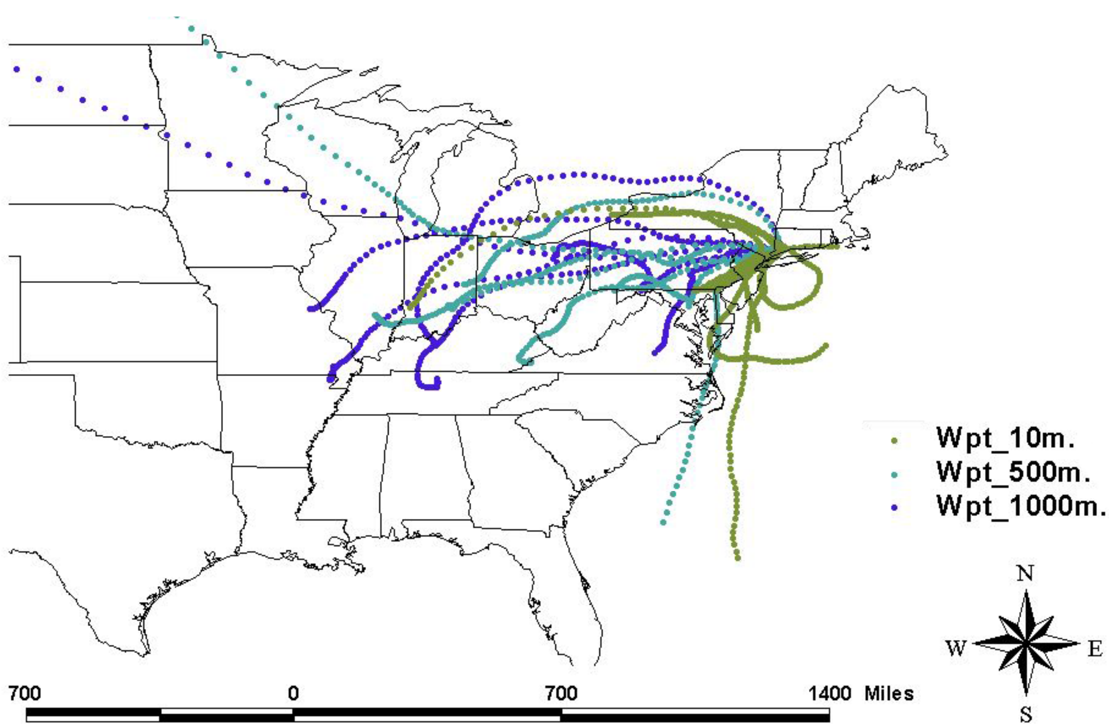


Figure 10. 72-hour back Trajectories from Westport, CT 2000-2004
Days when $PM_{2.5} > 35 \mu g/m^3$ (1 in 3 day sampling)



Monitor Speciation: Urban/rural speciation characterization

Over the past several years the CTDEP has collected speciated $PM_{2.5}$ data from four monitor locations. Monitoring equipment was moved sequentially from site to site for the three coastal sites, as listed in Table 6. The sites were operated using the Speciation Trends Network (STN) protocol. They were designed to characterize air quality influenced by local urban sources, primarily motor vehicles, as they are close to urban centers and interstate highways (I-95 and I-91). Additionally, their close proximity to Long Island Sound (LIS) allowed them to measure PM transport on days with southwest winds. This transport is coming from out-of-state upwind areas in the NYC Metro Area as well as from other states south and west of Connecticut. Despite the temporal and spatial difference between the three sites, the speciation profiles are similar.

Table 6. STN Monitors in Connecticut

Monitor Location	**Period of Operation/record**
Westport (Fairfield County)	May 2002-December 2003
New Haven State Street (New Haven County)	December 2003-May 2004
New Haven Criscuolo Park (New Haven County)	May 2004-April 2007

CTDEP also operates a rural monitor located on Mohawk Mountain in Cornwall (Table7) using the IMPROVE (Interagency Monitoring of Protected Visual Environments)[9] protocol for speciated PM. It is located at an elevation of 1683 feet above sea level and is designed to capture upwind transported air pollution.

Table 7. IMPROVE Monitor in Connecticut

Monitor Location	**Period of Operation/record**
Cornwall (Litchfield County)	September 2001- December 2004

Figure 11 uses pie charts to depict the speciation profiles for the monitors superimposed on a map of CT. The pie chart for New Haven is a combination of the State Street and Criscuolo Park STN monitors. They show the five major species: sulfate, nitrate, elemental carbon, organic carbon and crustal material.

Sulfate, or SO_4, is a secondary pollutant, being transformed from SO_2 in the presence of water vapor in the atmosphere. Ammonium sulfate is the most prevalent form of sulfate that is formed. Sulfate also competes with nitrate for ammonium, with the most efficient conversion to ammonium sulfate occurring in summer. The primary source of SO_2 is coal combustion. Most of the coal burned in the Northeast is by electricity generating units in the states of Pennsylvania, West Virginia and Ohio, states that are located to the south and west of Connecticut. Therefore much of the sulfate measured in Connecticut most likely originates in these states.

The sources of nitrate are high temperature fuel combustion and agricultural operations. Nitrogen oxides are emitted and eventually converted to ammonium nitrate in the

[9] http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm

presence of water vapor. The largest source sectors emitting nitrogen oxides are mobile sources, coal fired power plants, industrial boilers and residential furnaces. The atmospheric and chemical conversion to ammonium nitrate can occur relatively quickly, but preferentially in the winter. Hence ammonium nitrate concentrations are highest in the winter but are present all year.

Elemental carbon, (EC is also known as black carbon or soot) is the product of incomplete fuel combustion. Sources can include diesel trucks or wood fires, residential fires or wild fires. Summertime presence of high EC can sometimes be attributed to wildfires, especially when accompanied with high concentrations of potassium. Wintertime EC can sometimes be attributed to residential wood combustion.

Organic carbon can come from fuel or solvent evaporation and fuel combustion. The highest density of these sources typically occurs in urban areas, i.e., motor vehicles, home heating, fuel handling, and business and industrial operations (factories, dry cleaners, bakeries, etc.). Natural sources (vegetation) that emit gaseous volatile organic compounds also contribute to secondary organic carbon particles in the atmosphere.

Crustal material is defined here as the sum of elemental Al, Ca, Fe, Si, and Ti. Crustal material can be measured in clean air masses (though concentrations are low) and also in dust kicked up by road traffic.

Although the speciation analysis does not explicitly pinpoint the source of the pollutants, it does show a pattern consistent with other monitors in the eastern United States. Overall $PM_{2.5}$ concentrations are lower at the rural Cornwall site, compared to the urban Westport and New Haven sites and sulfate concentrations are a greater percentage of the total at the Cornwall site. Also the elemental and volatile carbon fractions are greater in the urban areas, likely due to the diesel traffic and other combustion sources. Unlike for annual $PM_{2.5}$ concentrations, where urban excess is more easily quantifiable, the daily $PM_{2.5}$ concentrations above 35 µg/m3 are mostly due to regional transport of $PM_{2.5}$ and its precursors, as illustrated in conceptual diagram provided in Figure 12.

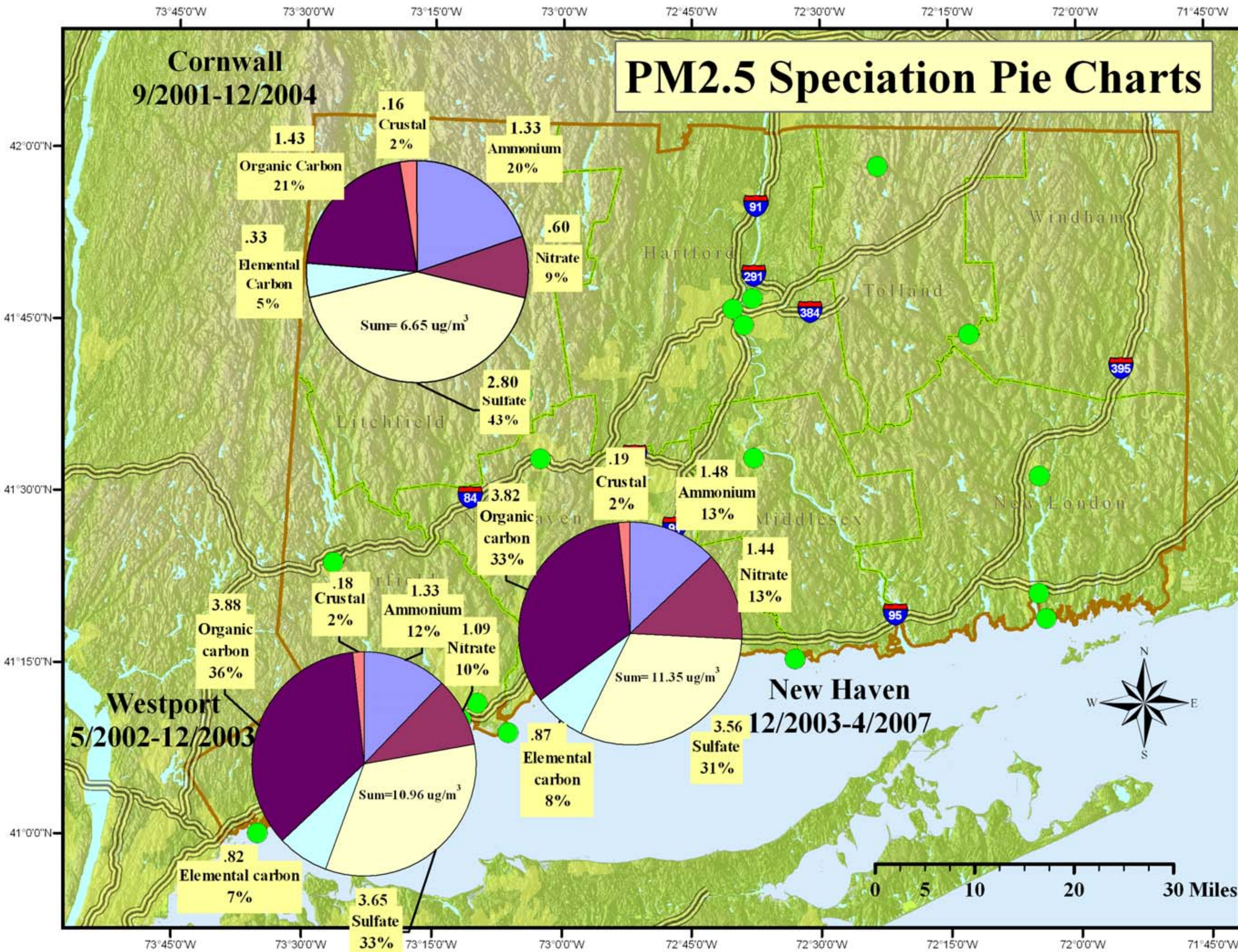


Figure 11. $PM_{2.5}$ Speciation Pie Charts

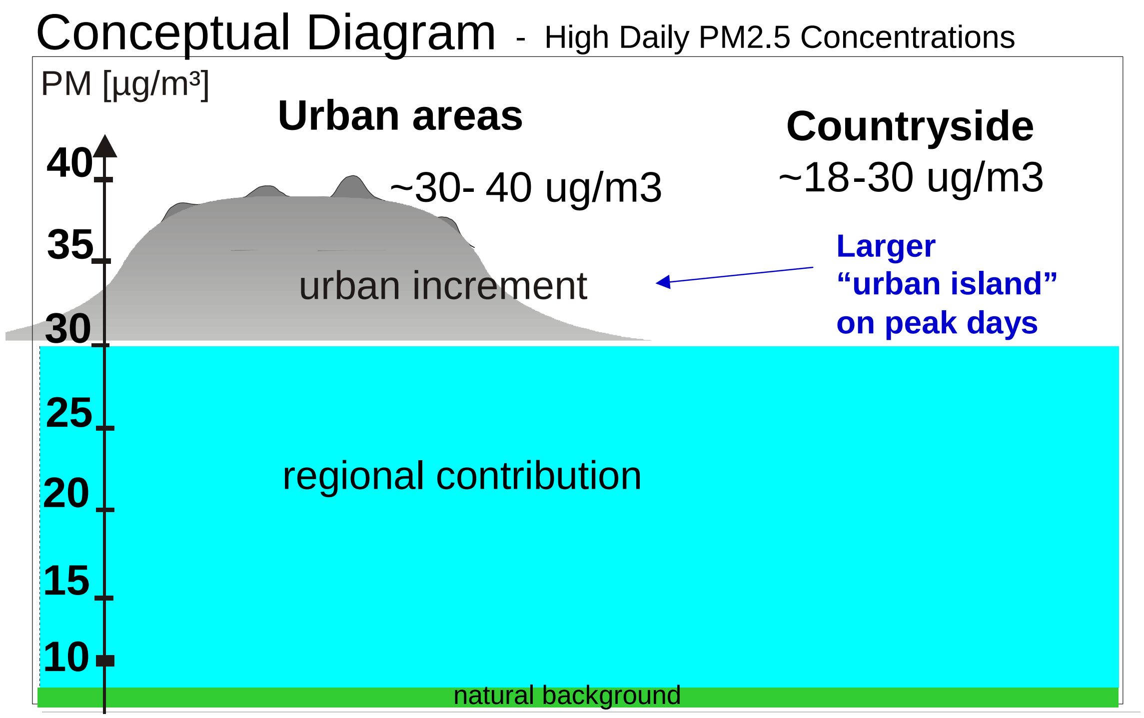


Figure 12. Conceptual Diagram of High PM2.5 Days.(From Neil Frank USEPA,2007)

In summary, the effects of meteorology suggest the highest $PM_{2.5}$ levels in Connecticut are enhanced significantly from sources outside of Connecticut, especially during the summer, when most exceedances occur. Also, there is no evidence that emissions of $PM_{2.5}$ or precursors emitted from Hartford County have a significant impact on the non-attaining $PM_{2.5}$ monitors in either Fairfield or New Haven Counties. Thus, along with the fact that Hartford County contains no violating monitors, CTDEP concludes that Hartford County should not be included as a recommended nonattainment area for the 24-hour $PM_{2.5}$ NAAQS.

7) **Geography/topography.** Connecticut is a small state, geographically, with topographical features that do not have a significant effect on airshed boundaries. This factor does not play a role in $PM_{2.5}$ attainment area boundaries.

8) **Jurisdictional boundaries.** Fairfield and New Haven Counties are currently included as part of the New York City nonattainment area for the annual $PM_{2.5}$ NAAQS. Monitors in the New York and New Jersey portions of this area have recorded violations of the 24-hour $PM_{2.5}$ NAAQS. With Connecticut violations of the 24-hour $PM_{2.5}$ NAAQS limited to Fairfield and New Haven Counties, it makes administrative sense to retain the current jurisdictional boundaries for the new 24-hour $PM_{2.5}$ nonattainment area.

9) **Level of Control of Emission Sources.** Recommendations for 24-hour $PM_{2.5}$ designations are based on monitored design values from the 2004-2006 period. Final designations to be made by EPA will rely on monitored data from the 2005-2007 (and possibly 2008) period. This analysis was prepared using 2002 emission estimates developed by MANE-VU. However emission control programs implemented since 2003 and have, and will continue to produce $PM_{2.5}$ reductions.

   For the 2003-2008 period, Connecticut has will continue to implement several control program that result in lower emissions of primary PM and gaseous pollutants contributing to the formation of $PM_{2.5}$. For example, Section 22a-174-19a of CTDEP's regulations requires electric generating units and large boilers to comply with progressively more stringent sulfur dioxide emission limits: 0.55 lbs SO2/MMBtu after January 1, 2002 and 0.33 lbs SO2/MMBtu after January 1, 2003. Emission reductions resulting from the second phase of this rule are not reflected in the 2002 MANE-VU inventory. Similarly, CTDEP's Section 22a-174-38 regulation required further NOx reductions from municipal waste combustion units, effective May 2003. In addition, phased-in federal regulations for on-road and non-road engines will result in accumulating reductions of NOx, PM and sulfur emissions due to more stringent tailpipe and fuel standards throughout the period.

   These post-2002 emission control requirements apply throughout Connecticut. As a result, it is not expected that relative emission levels or emission densities between counties will differ significantly from those in the 2002 MANE-VU estimates. Therefore, this factor does not alter CTDEP's recommended designations for the 24-hour $PM_{2.5}$ NAAQS.

3. <u>Conclusions</u>

Considering the above nine factors together, CTDEP recommends that Fairfield and New Haven Counties be designated as nonattainment and the remaining counties in Connecticut be designated as attainment for the 24-hour $PM_{2.5}$ NAAQS.