Recommendation for $PM_{2.5}$ Designation

Technical Support Document

Connecticut Department of Environmental Protection
Bureau of Air Management

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(Corrected)

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Corrected
Pg.30, 1st paragraph: “24-hour” replaced with “annual”

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Figure No. **Description**

Executive Summary

$PM_{2.5}$ National Ambient Air Quality Standard Recommended Designations for Connecticut

The United States Environmental Protection Agency (EPA) promulgated the National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$) on July 18, 1997. The annual average NAAQS for $PM_{2.5}$ is 15 $\mu g/m^3$ (micrograms per cubic meter) and the 24-hour average NAAQS is 65 $\mu g/m^3$. The State of Connecticut Department of Environmental Protection (CTDEP or Department) designed a network and began $PM_{2.5}$ monitoring in 1999.

States are required to provide EPA with recommendations by February 15, 2004 for $PM_{2.5}$ area attainment and nonattainment designations based on three years of monitored data. EPA has indicated the presumptive boundaries for nonattainment areas will be based on combined metropolitan statistical areas (or CSA's). EPA's presumptive use of CSA boundaries would create a multi-state nonattainment area consisting of southwest Connecticut plus southern New York and northern New Jersey, however, the technical analysis herein concludes that there is no merit to such outcome.

For the three-year period ending in 2002, all of the $PM_{2.5}$ monitoring sites in Connecticut measured levels below the annual and 24-hour NAAQS, except for the Stiles Street monitoring site in New Haven, which is measuring a three year annual average (or "design value") of 16.6 $\mu g/m^3$.

The Department's technical review concludes that the high annual average $PM_{2.5}$ concentrations at the Stiles Street site are the result of "microscale" effects even though this site is currently classified by EPA as a middle scale site. As outlined in EPA guidance, data from sites considered microscale should not be used to determine annual $PM_{2.5}$ nonattainment status. This site is simply not representative of community exposure to $PM_{2.5}$ levels in New Haven. The Department has also demonstrated that emissions from Connecticut sources are not contributing significantly to measured nonattainment in New York City and northern New Jersey, so including Connecticut with this nonattainment area is neither technically justified nor necessary to effectuate attainment in those areas. Therefore, the purpose of this document is to demonstrate the following:

1) The Stiles Street New Haven $PM_{2.5}$ monitor should be classified as a microscale site and data should not be used for annual nonattainment designation; and
2) The Connecticut portion of the New York City CSA should not be included with the New York City nonattainment area.

Measured $PM_{2.5}$ levels in Connecticut are below the $PM_{2.5}$ NAAQS.

Ambient $PM_{2.5}$ levels in CT are produced by a complicated combination of transported and local pollutants. The transported components can travel hundreds to thousands of miles before being measured by an air quality monitor. The local components include emissions from vehicles, industry and residences across urban corridors. We have compared the measured levels against EPA's National Ambient Air Quality Standards of 15 $\mu g/m^3$ for an annual average and 65 $\mu g/m^3$ for 24-hour averages. The levels are shown in the table below and in Figure 1. The measured values are all well below the NAAQS with the exception of the 16.6 $\mu g/m^3$ annual value at the Stiles Street monitor in New Haven. Data from Stiles Street, because of its microscale properties, can appropriately be used only for 24-hr designations (this is discussed in further detail below). The annual $PM_{2.5}$ values at monitors representative of community exposure range from 11.6 $\mu g/m^3$ in East Hartford to 13.9 $\mu g/m^3$ at the New Haven State Street site. Levels along the I-95 corridor of Fairfield County are generally well below the NAAQS of 15 $\mu g/m^3$. $PM_{2.5}$ design values for the 24-hour averages range from 31 $\mu g/m^3$ in Hartford and Norwich to 41 $\mu g/m^3$ at the New Haven Stiles Street site, well below the 24-hour NAAQS.

2000-2002 $PM_{2.5}$ Design Values in CT ($\mu g/m^3$)

Monitor Location	Annual	24hr*	Monitor Location	Annual	24hr*
Bridgeport Roosevelt School	13.7	39	New Haven Stiles St.**	16.6	41
Bridgeport Congress St.	12.8	35	Norwalk	13.0	35
Danbury	12.9	34	Norwich	11.8	31
East Hartford	11.6	35	Stamford	13.1	36
Hamden	11.7	33	Waterbury	13.7	34
Hartford	12.6	31	Westport	12.4	34
New Haven State St.	13.9	37	**NAAQS**	**15.0**	**65.0**

* Design values for 24-hr levels are the three-year average of the 98th percentile daily values.

** Microscale effects at the Stiles Street monitor preclude its use in annual attainment designations.

The $PM_{2.5}$ monitor at Stiles Street is strongly influenced by microscale phenomena and should be classified as a microscale monitor.

The Stiles Street monitor is located immediately adjacent to the southbound I-95 on-ramp approaching the Quinnipiac River Bridge. Consequently, the monitor is significantly influenced by microscale phenomena, particularly diesel truck emissions from heavily loaded trucks accelerating up the steeply graded on-ramp and approach to the Q-bridge (see Figures 2 and 3). The footprint of this hotspot is on the order of tens of meters, much smaller than a football field, and does not include residential areas. As such, it is not representative of community exposure and, consistent with EPA's guidance, should be treated as a microscale site for $PM_{2.5}$ classification purposes. Data from the Stiles Street site should not be used for annual average attainment designations. Upon EPA Region I's recommendation, DEP conducted an outreach campaign, providing several presentations to various groups in New Haven and around the State. The intent was to reach the regulated community, environmental groups, and the general public to inform them that a microscale monitor classification could lead to an attainment designation.

One presentation has been televised statewide on a public information cable network. The technical support materials included in this document provide details of the Stiles Street site along with data supporting the microscale argument.

$PM_{2.5}$ emissions from CT sources are contributing insignificantly to measured $PM_{2.5}$ nonattainment in New York and New Jersey.

The New York City CSA includes much of northern New Jersey and southern New York, plus Litchfield, Fairfield and New Haven Counties in Connecticut. Monitors in New York City, NY and Union City, NJ are measuring annual $PM_{2.5}$ levels above the NAAQS of 15 µg/m^3. Air quality in primarily rural Litchfield County and along the urbanized corridor of New Haven and Fairfield Counties is well below the level of the NAAQS. Furthermore, computer modeling of the transport and dispersion of pollutants conducted by both the Department and EPA conclude that emissions from Connecticut sources contribute insignificantly to elevated pollution levels in New York City and northern New Jersey. Therefore it is appropriate, according to EPA's guidance, that EPA will consider reducing the size of nonattainment areas from the presumptive metropolitan area boundaries provided that certain factors are adequately addressed. The factors to be assessed include air quality levels, emissions, population distribution, traffic, growth patterns, meteorology, topography, jurisdiction, and control programs. This technical support document addresses these factors in more detail.

Recently adopted programs are expected to provide significant air quality benefits to Connecticut citizens regardless of the attainment designation.

If any part of Connecticut is designated as nonattainment for $PM_{2.5}$ it then becomes subject to a number of planning requirements. These plans, in large part, will only document the effectiveness of existing and expected programs. For examples, see the table below.

Existing and expected federal programs designed to reduce $PM_{2.5}$ levels
Tier 1 and tier 2 vehicle emission standards
Low sulfur gasoline fuel standards
Heavy duty diesel truck and bus engine standards
Ultra low sulfur diesel fuel standards
Non-road compression ignition and diesel engine standards
Non-road fuel standards
NOx SIP call
IAQR or equivalent transport rule

Planning efforts, if required, have high administrative costs and would divert resources away from the Department's environmental goal of achieving additional $PM_{2.5}$ pollution reductions in urban areas through local measures. The federal programs identified above are already in place, or expected to be adopted in the near future, and emission reductions from these programs will occur regardless of Connecticut's planning efforts. EPA's modeling indicates significant air quality improvements will be realized from the federal programs that are already promulgated as well as those recently proposed.

The best use of Agency resources is to support additional PM reductions.

There is no “bright line” below which $PM_{2.5}$ levels are healthy. In fact, DEP provides daily forecasts of the Air Quality Index (AQI), which occasionally fall in the “unhealthy for sensitive groups” (USG) category for $PM_{2.5,}$ even though the levels are less than the NAAQS. These levels need to be reduced further to adequately protect sensitive individuals.   Given limited departmental resources, an attainment designation would more appropriately provide the opportunity to focus its efforts on further reducing urban area $PM_{2.5}$ levels statewide through programs such as school bus retrofit initiatives, widespread use of clean fuels, anti-idling (outreach and enforcement), targeted retrofits on diesel fleets, opacity testing, etc. DEP has already been developing a number of these programs and would like to expand upon the following:

- Coordinating with municipalities on school bus retrofits, clean fuels and anti-idling efforts;
- Coordinating with Connecticut Department of Transportation (CTDOT) on opacity testing, diesel truck retrofits and expanded retrofits of off-road vehicles, clean fuels and anti-idling requirements in construction contracts; and
- Coordinating with Connecticut Department of Motor Vehicles (CTDMV) on random roadside truck opacity testing and anti-idling (outreach and enforcement).

Additionally the Department is already pursuing a number of potential programs to further reduce $PM_{2.5}$ levels including, limiting off-road diesel fuel and home heating oil sulfur levels to less than 500 parts per million (ppm), anti-idling enforcement and CTDMV targeted opacity testing for urban fleets.

Conclusion

In light of the demonstrated microscale characteristics of the New Haven Stiles Street site and measured compliance with the $PM_{2.5}$ standards throughout the state, EPA should designate the entire State of Connecticut as attainment for the $PM_{2.5}$ NAAQS. A statewide attainment classification will free DEP from the resource burden of fulfilling numerous planning requirements providing limited air quality benefits, thus allowing scarce resources to be committed to implementing several programs that will provide earlier and more effective air quality improvements, especially in urban areas.

1. Introduction

The United States Environmental Protection Agency (EPA) promulgated the National Ambient Air Quality Standards (NAAQS) for fine particulate matter (less than 2.5 microns in diameter, or $PM_{2.5}$) on July 18, 1997. After years of litigation, the standards were recently upheld by the United States Supreme Court. The annual average NAAQS for $PM_{2.5}$ is 15 $\mu g/m^3$ (micrograms per cubic meter) and the 24-hour average NAAQS is 65 $\mu g/m^3$**.** The State of Connecticut Department of Environmental Protection (DEP or the Department) designed a network and began $PM_{2.5}$ monitoring in 1999.

Pursuant to section 107(d)(1) of the Clean Air Act (CAA) and section 6102(c) of the Transportation Equity Act for the 21st Century (as modified by Sec 425(6) of the Consolidated Appropriations Bill, H.R. 2673, signed by the President on January 23, 2004), Governors are required by February 15, 2004 to submit recommendations regarding attainment designations and geographic boundaries for the $PM_{2.5}$ NAAQS. Following states recommendations, EPA is required to promulgate designations by December 31, 2004.

Section 107(d)(1) of the CAA requires areas to be designated nonattainment if they do not meet the NAAQS or if they contribute to ambient air quality in a nearby area that does not meet the standard. EPA guidance further recommends that metropolitan areas (identified by the federal Office of Management and Budget based on U.S. Census Bureau data) serve as the presumptive boundaries for $PM_{2.5}$ nonattainment areas. EPA recommends that the presumptive boundaries for nonattainment areas be metropolitan statistical areas (MSA's) or combined statistical areas (CSA's). For example, parts of Connecticut have been included with southern New York and northern New Jersey with respect to the 1-hour ozone nonattainment designation.

EPA will allow deviations from these boundaries provided that a number of factors are adequately addressed. As described briefly below and in more detail later, available air quality data indicate that the citizens of Connecticut are not being exposed to $PM_{2.5}$ levels above the NAAQS and emissions from Connecticut sources are not contributing significantly to measured $PM_{2.5}$ nonattainment in the New York and New Jersey portions of the New York City CMSA. Therefore, all of Connecticut should be designated attainment with respect to the 24-hour average and annual average $PM_{2.5}$ NAAQS. This variance from the metropolitan area boundary is consistent with the recommended boundaries being submitted by the States of New York and New Jersey.

For the three-year period ending in 2002, all of the $PM_{2.5}$ monitoring sites in Connecticut are measuring levels below the annual and 24-hour NAAQS, except for the Stiles Street microscale site in New Haven, which is measuring a three-year annual average of 16.6 $\mu g/m^3$. Similarly, $PM_{2.5}$ values below the level of the NAAQS have been monitored at most locations in New York and New Jersey with the exception that a number of monitors in New York City and in urban areas of northern New Jersey have recorded $PM_{2.5}$ levels above the annual NAAQS of 15 $\mu g/m^3$.

The Department believes that $PM_{2.5}$ concentrations at the Stiles Street site in excess of the annual $PM_{2.5}$ NAAQS are the result of microscale effects even though this site is currently classified by EPA as a middle scale site. As a microscale site, data from this monitor should not be used to determine annual nonattainment status. This site is simply not representative of community exposure to $PM_{2.5}$ levels in New Haven. The Department also believes that emissions from Connecticut sources are not contributing significantly to measured nonattainment in New York City and northern New Jersey, so including Connecticut with this nonattainment area is neither technically justified nor necessary to effectuate attainment in those areas. Therefore, the purpose of this document is to demonstrate the following:

1) The Stiles Street New Haven $PM_{2.5}$ monitor should be classified as a microscale site; and
2) The Connecticut portion of the New York City CSA should not be included with the New York City nonattainment area.

The evidence presented in Section 2 of this document suggests that unique characteristics of the Stiles Street monitor location classify the site as "microscale", meaning it is significantly affected by sources at distances between 10 and 100 meters and should not be used for determining compliance with the annual $PM_{2.5}$ NAAQS. Information presented in Section 2 includes an examination of Stiles Street site characteristics as well as analyses of the spatial and temporal distributions of $PM_{2.5}$ and contributing chemical species.

Section 3 of this document discusses three ambient impact analyses that support the conclusion that Connecticut does not significantly contribute to $PM_{2.5}$ concentrations in the New York City area. Section 3 also discusses commuting and transportation pattern from Connecticut to New York and New Jersey.

According to the April 1, 2003 EPA guidance memorandum from Jeffrey R. Holmstead, EPA will consider a number of factors in assessing whether to exclude portions of a metropolitan area from a nonattainment designation. One of the factors listed is meteorology (weather/ transport patterns). Section 3 includes results obtained with the ISCST3 model, demonstrating that because of transport patterns, primary particulate matter emissions have a low impact on receptors in New York City and Hudson County, New Jersey.

Maximum daily $PM_{2.5}$ concentrations for over a nearly five year period (January 1999 through September 2003) at P.S. 59 in New York City were also analyzed and rank-ordered from highest to lowest. The dates of the top and bottom 10 percentile were obtained. Back trajectory winds were run once a day for each of those days at three height levels (10m, 500m, and 1000m above ground level). All 72 hourly positions of the model run were saved for the high and low categories. Results of this study, also summarized in Section 3, show the air mass during the dirtiest days originated from and passed through locations in a sector from SSW and SW through W and WNW from New York City (i.e., did not pass over Connecticut).

In the proposed "Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Interstate Air Quality Rule)", Federal Register / Vol. 69, No. 20 / published on Friday, January 30, 2004, EPA conducted an evaluation of the upwind contributions to downwind $PM_{2.5}$ non-attainment. In this study, Connecticut was found to make an insignificant contribution of $PM_{2.5}$ concentration to a downwind site in New York City. Relevant results from EPA's analysis are also included in Section 3.

EPA Region I had recommended that Connecticut DEP conduct public outreach prior to the reclassification of the Stiles Street $PM_{2.5}$ monitor to "microscale." Section 4 of this document provides an overview of several presentations that were conducted in this regard.

Section 5 presents a summary of guidance from the EPA relating to $PM_{2.5}$ monitor siting criteria and the NAAQS designations for $PM_{2.5}$.

2. Analysis of Monitoring Data for Connecticut $PM_{2.5}$ NAAQS Attainment Boundary Designations: Classifying the Stiles Street Monitor as Microscale

A. Background

The EPA promulgated $PM_{2.5}$ NAAQS on July 18, 1997. The State of Connecticut designed a monitoring network and began implementing $PM_{2.5}$ monitoring in 1999. Per statute, evaluation of the $PM_{2.5}$ standards requires three years of concurrent data. As such, a partial evaluation of three concurrent years of monitoring data was first made for the 1999-2001 period. A more complete three-year data set was available for 2000-2002. Among the Connecticut $PM_{2.5}$ State/Local Air Monitoring Sites (SLAMS sites) and Special Purpose sites, only the Stiles Street, New Haven site exceeded the annual average NAAQS. The 2000-2002 $PM_{2.5}$ annual average design value (DV) for Stiles Street was 16.6 $\mu g/m^3$, while the other Connecticut monitors were well below the annual average NAAQS with design values ranging from 11.6 $\mu g/m^3$ to 13.7 $\mu g/m^3$ (Figure 1). All Connecticut monitors including Stiles Street, New Haven, are well below with the 24-hour average $PM_{2.5}$ NAAQS. (24-hour design values are determined as the 98^{th} percentile of daily values over a three-year period).

The timetable for implementation of the standards requires State recommendations for designation of $PM_{2.5}$ NAAQS non-compliance areas be submitted by February 15, 2004. This section provides technical information and data in support of the Department's boundary designation recommendations.

The Department believes that the high annual average $PM_{2.5}$ concentrations at the Stiles Street site result from both large-scale regional sources and local sources. The regional, transported components can travel hundreds to thousands of miles before being measured by an air quality monitor. The local components can include emissions from vehicles, industry, and residences across urban corridors. Local sources influencing the Stiles Street monitor include: heavy duty diesel vehicles accessing Interstate-95 (I-95) from Stiles Street, the high volume of traffic on the interstate highway, and regular and frequent traffic congestion due to insufficient carrying capacity of the Veterans Memorial Bridge over the Quinnipiac River (Q Bridge). The evidence presented in this document suggests that unique characteristics of the Stiles Street monitor location classify the site as "microscale," significantly affected by sources at distances between 10 and 100 meters. Further, the state, including the City of New Haven, is embedded in a very large region of downward-trending fine particle concentrations, which suggests that Stiles Street $PM_{2.5}$ concentrations will be lower than the NAAQS within a few years.

B. Site Description

The Stiles Street $PM_{2.5}$ monitoring site is located in a commercial/industrial area near I-95 and US Route 1, at the juncture of the Quinnipiac River and New Haven harbor. Photographs of the monitoring shed and the I-95 access ramp are given in Figures 2 and 3. The geographic coordinates of the site are at latitude 41.2937° and longitude –72.9007°. The $PM_{2.5}$ sample intake is located on the roof of the monitoring shed. The shed is located on a grass parcel bounded by I-95 to the west, the I-95 southbound on-ramp to the north and east, and Stiles Street to the south and southeast. The respective distances to the bounding roadways are Stiles Street:

less than 10 meters, I-95 access ramp: less than 10 meters and I-95: less than 30 meters. Figure 4 is a site map showing the relationship of the site to the major roadways and the New Haven harbor terminal area. The site relationship is also documented in the attached Appendix, which is "Appendix K Connecticut DEP PM Monitoring Network Plan, 7/1/98, New Haven Stiles Street."

Some of the unique characteristics that distinguish the Stiles Street site from other Connecticut urban areas with potentially high $PM_{2.5}$ levels include: (1) extremely close distances to traveled roadways, (2) high volumes of heavy duty diesel trucks serving the New Haven Terminal and other local industries accessing the interstate highway via Stiles Street, and (3) significant uphill grades on both the I-95 southbound entrance ramp and the subsequent I-95 approach to the Q-Bridge that requires vehicles to accelerate under higher loads, producing greater particulate matter emissions.

In addition to the Stiles Street site, there are several $PM_{2.5}$ monitors within the greater New Haven area. Figure 5 shows the seven current New Haven area monitors, including the new station at Criscuolo Park. Three monitors, at the West Haven toll booth, at the Connecticut Agricultural Experiment Station, and at the Woodward Fire House, were implemented beginning the second quarter of 2003 as special purpose monitors for this study. The State Street, Stiles Street, and Hamden Mill Rock Basins sites have been used for monitoring $PM_{2.5}$ since 1999. Black carbon, which is considered an indicator of primary $PM_{2.5}$ emissions, has been monitored at both the Stiles Street and State Street sites during 2003. A detailed view of the State Street site is provided in Figure 6.

C. Spatial Distribution of Average Fine Particulate Concentrations

The 2000-2002 $PM_{2.5}$ design values for 24-hour and annual time periods are presented in Table 2.1. As demonstrated by the annual design values, the Stiles Street annual average $PM_{2.5}$ concentrations are an anomaly among the Connecticut monitoring sites. Figure 7 shows the 2000-2002 $PM_{2.5}$ design values for the three regular New Haven area sites: Stiles Street and State Street, New Haven, and Mill Rock Basins, Hamden. The design values indicate a steep $PM_{2.5}$ concentration gradient between Stiles Street and the other two nearby sites. The Stiles Street and Mill Rock Basins sites are 5.3 km (3.3 mi) apart, with a difference in design values of 4.9 $\mu g/m^3$. State Street, which is 1.5 miles from Stiles Street and approximately midway between the Stiles and Mill Rock sites, has a design value of 2.7 $\mu g/m^3$ less than Stiles Street.

As part of this study, three additional special purpose monitors were installed and operated within the New Haven area starting in April 2003. The average $PM_{2.5}$ concentrations for the period April through September 2003 are shown in Figure 8. These values are once every third-day samples (intermediate Stiles Street one-day samples are omitted) that include only monitoring days for which there are valid Stiles Street values. The average $PM_{2.5}$ values for the six-month period substantiate the evidence of a strong spatial gradient between Stiles Street and the other local monitors. The period of record is not representative of annual averages, as summertime PM2.5 levels tend to be higher than annual averages. Note that the three sites with values above 13 $\mu g/m^3$ (Stiles Street, State Street and the former West Haven toll booth) are those that are located less than 50 meters to an interstate highway or on-ramp. The former toll booth is within 50 meters of I-95, but is not within close proximity to any access or exit ramps as at Stiles Street, and State Street is within 75 meters of two high-volume access ramps, but is about 200 meters distance from I-91. Regardless of the proximity to the interstate highway, the Stiles Street monitored levels are 10 to 15% higher than the other near-highway sites. The Woodward Fire House average concentration of 11.9 μg/m^3 is 3.8 μg/m^3 less than the concentration measured approximately one half mile away at Stiles Street even though this site is only about one quarter mile from I-95.

Daily Stiles Street $PM_{2.5}$ data for the six-month 2003 period of record was compared with the five other New Haven area monitors. Statistical plots are provided for each site paired with Stiles Street in Figures 9-13. The linear regression lines for each pair of sites have correlation coefficients greater than 0.95, and have slopes close to a value of 1. This suggests that all of these sites monitor approximately the same New Haven area background $PM_{2.5}$, and that differences among sites result from an additive local $PM_{2.5}$ contributions that are roughly 2-4 μg/m^3 higher at Stiles Street than the other sites. This is an indication of the magnitude of the microscale component being measured at Stiles Street. There is minimal variability between Stiles Street and the other sites and this is an indication that the magnitude of the urban to regional scale component of PM2.5 in the New Haven area can range from 5 to 50 μg/m^3

Table 2.1: 2000-2002 Annual and 24-Hour$PM_{2.5}$ Design Values in Connecticut

Monitor Location	Annual Mean $PM_{2.5}$ Design Values (μg/m^3)	24-Hour Average $PM_{2.5}$ Design Values** (μg/m^3)
Bridgeport Roosevelt School	13.7	39
Bridgeport Congress Street	12.8	35 (35)
Danbury	12.9	34
East Hartford	11.6	36 (35)
Hamden	11.7	33
Hartford	12.6	31 (31)
New Haven Stiles Street	16.6*	41
New Haven State Street	13.9	38 (37)
Norwalk	13.0	35 (35)
Norwich	11.8	28 (31)
Stamford	13.1	37 (36)
Waterbury	13.7	34
Westport	12.4	34
NAAQS	**15.0**	**65**

Notes:
* Microscale siting at Stiles Street precludes its use in annual attainment designations.
** 24 hour design values computed using 98th percentile values only for calendar years having 75% quarterly data completeness, per CFR40 Part 50 App N. Parenthetical values are computed using 98th percentile values from all calendar years (2000-2002).

Table 2.1 also includes computed 24-hour average $PM_{2.5}$ design values. The design values are the arithmetic average of the yearly 98th percentiles of 24-hour $PM_{2.5}$ values for three consecutive calendar years (i.e.: 2000-2002). Statute requires that each annual data set has a minimum of 75 percent data completeness. For the period 2000-2002, approximately one-half of the sites have at least one year with less than 75 percent complete quarters. As such, for purposes of analysis, 24-hour design values are presented in Table 2.1 computed two ways, (a) using only annual 98th percentile values from years with four "complete" quarters, and (b) using all three annual 98th percentile values regardless of data completeness.

The Connecticut 24-hour design values are uniformly lower than the NAAQS. This is most likely due to the nature of high 24-hour $PM_{2.5}$ events, which tend to occur on a regional scale. In contrast, monitors that are in close proximity to heavily-traveled interstate highways or other known sources show daily average $PM_{2.5}$ concentrations that are a few micrograms per cubic meter higher than regional or background levels, independent of what those background levels are.

D. Fine Particulate Matter Ambient Air Trends

Available ambient air monitoring data supports the view that fine particle concentrations in Connecticut and the surrounding region are in steady decline since the late 1980's. This is observed from declining concentrations of both surrogate parameters (i.e. PM_{10}) and component parameters, such as particulate sulfate.

Monitoring of $PM_{2.5}$ in Connecticut by federal reference or equivalence methods commenced during the first quarter of 1999. This time scale of approximately four years is not of sufficient length to identify overall trends in $PM_{2.5}$ concentrations in the state, due to the high degree of year-to-year variability caused by the effects of meteorology on measured pollutant concentrations. Alternative methods used to assess longer-term fine particle trends in this study include site-specific estimation using PM_{10} as a surrogate and speciated-particle analysis from IMPROVE type samplers.

Time series trend plots of 24-hour FRM PM concentrations were developed to show statewide patterns for the period 1988 to 2003 for seven selected sites. The selected sites are:

- Stiles Street, New Haven (adjacent to I-95 southbound on-ramp);
- State Street, New Haven (adjacent to I-91 northbound on-ramp);
- Roosevelt School, Bridgeport (adjacent to I-95/Rt 8 interchange);
- West Avenue/Interstate-95 (PM_{10}) and Health Department ($PM_{2.5}$), Norwalk;
- Bank and Meadow Streets, Waterbury (adjacent to I-84 eastbound exit ramp);
- Sheldon Street ($PM_{2.5}$) and Capital Community Technical College (PM_{10}), Hartford;
- McAuliffe Park ($PM_{2.5}$) and High Street (PM_{10}), East Hartford.

These sites were selected for comparison primarily to provide a relatively well-distributed network of monitoring points over the western Connecticut region, with an emphasis on locations in close proximity to busy interstate highways. The sites were also chosen because they had both $PM_{2.5}$ and PM_{10} monitoring either collocated at the site or at nearby sites since 1999. The two New Haven sites, Bridgeport and Waterbury had collocated PM_{10} and $PM_{2.5}$ for the period 1999 through 2001.

The Norwalk, Hartford and East Hartford sites had PM_{10} and $PM_{2.5}$ sampling at nearby, non-collocated sites. In Norwalk, PM_{10} was monitored at the West Avenue/I-95 ramp site, and $PM_{2.5}$ was monitored approximately 0.7 miles to the Northeast at the Norwalk Health Department. In East Hartford, $PM_{2.5}$ is monitored at McAuliffe Park, and PM_{10} is monitored approximately 3 miles south at High Street. Prior to 1999, PM_{10} was monitored at East Hartford City Hall, about 1.5 miles southwest of McAuliffe Park. In Hartford, $PM_{2.5}$ monitoring takes place approximately 25 miles east of PM_{10} monitoring at the former Capital Community Technical College (CCTC) on Flatbush Avenue.

Using the 1999-2001 PM10 and $PM_{2.5}$ 24-hour sample data from the above sites, linear relationships for each site (or pair of sites if not collocated) were derived from least squares linear regression curves for each meteorological season (i.e.: Dec-Feb, Mar-Jun, etc.). Slopes of the linear functions generally ranged from 0.6 to 0.9, and correlation coefficients were in the range of 0.6 to 0.95. Linear regression data are summarized in Table 2.2.

Table 2.2: Site-Specific $PM_{2.5}$:PM_{10} Regression Relationship Data for Meteorological Quarters.

	Spring				Summer				Fall				Winter			
Site:	**m**	**b**	**r^2**	**N**	**m**	**b**	**r^2**	**N**	**m**	**b**	**r^2**	**N**	**m**	**b**	**r^2**	**N**
Norwalk	0.6371	-4.4141	0.6904	35	0.7316	-7.2775	0.6941	43	0.7256	-5.5492	0.893	29	0.5794	-2.2313	0.6144	22
East Hartford	0.4897	1.22	0.5833	41	0.8826	-2.8929	0.8117	41	0.9453	-3.2815	0.8361	40	0.3976	3.9913	0.5665	39
Hartford	0.6731	0.3777	0.5965	46	0.9279	-2.8012	0.8442	40	0.8678	-1.3419	0.8536	37	0.7529	2.3813	0.7003	42
Waterbury	0.6132	0.0237	0.6022	52	0.8827	-3.0559	0.8231	57	0.8344	-2.0919	0.7509	44	0.6664	1.4064	0.6861	51
Bridgeport	0.6571	0.037	0.7538	58	0.9168	3.368	0.9095	53	0.7948	-1.7872	0.9333	49	0.819	-0.6144	0.9139	50
New Haven-Stiles St.	0.403	4.008	0.4294	56	0.7875	-4.2573	0.7155	56	0.6452	-0.9148	0.683	49	0.5465	2.4873	0.5719	49
New Haven-State St.	0.6919	-0.7381	0.7733	59	0.9827	-4.4719	0.9445	54	0.8038	-1.262	0.9509	48	0.7894	-0.652	0.8769	51

In Figures 14 and 15, the estimated and measured data are combined to show "$PM_{2.5}$ trends" from 1988 to the present for Stiles Street and State Street. The estimated and measured annual average concentrations are given in Figure 16, which also includes estimated $PM_{2.5}$ concentrations for the Burlington and Torrington sites. These concentrations are based on seasonal $PM_{2.5}$ /PM_{10} relationships from the nearest site having both parameters (Waterbury). Note that while average concentrations vary from year to year, the differences between the sites remains relatively constant. All sites have decreasing concentrations indicated by least squares linear regression lines with slopes ranging from –0.33 μg/m^3-yr in East Hartford to –0.77 μg/m^3-yr at Stiles Street, New Haven. Figure 17 presents the estimated and measured combined annual average trends for the two New Haven vs. five non-New Haven urban sites, comparing the downtrending of these two sectors.

In addition to these FRM-based measurements and estimations, NESCAUM (NorthEast States for Coordinated Air Use Management) sampling from 1988 through 1993 and IMPROVE (Interagency Monitoring of PROtected Visual Environments) sampling starting in late 2001 show $PM_{2.5}$ average concentrations at Mohawk Mountain, Cornwall, gradually declining over this period (Figure 18). This rural site is representative of regional background $PM_{2.5}$ in northwest Connecticut.

Analysis of trends of the 5^{th} and 95^{th} percentiles of quarterly periods indicates declining concentrations of the entire range of data, supporting the validity of the downward concentration trends. In addition, the average concentration regression line equations were used to estimate the 2000-2002 DVs, which are presented on the figures together with the calculated DVs. The estimated and calculated DVs are in close agreement. It should be noted that the Stiles Street estimated $PM_{2.5}$ data may be biased high for the earlier period because of local management practices implemented during the 1990s to reduce levels of coarse particulate matter (i.e.: concrete barricades were installed to prevent passage of heavy duty trucks across an unpaved lot that entrained dust and contributed to monitored PM_{10} concentrations).

Figure 19 compares trend line characteristics of the seven sites. Initial (1988) concentration is plotted against slope, showing that the dirtiest sites are improving at the fastest rate. The relationship between these parameters appears to be close to linear for these sites.

E. Particulate Sulfate Concentrations

Particulate matter elemental and ionic speciation data from the EPA STN (Speciation Trends Network), IMPROVE and NESCAUM network samplers were examined to provide information about potential $PM_{2.5}$ sources and concentration trends. Results of an EPA analysis of fine particle speciation data, shown in Figure 20, indicate that sulfate is a smaller fraction, and total carbon is a larger fraction, of fine particulate matter for urban sites compared to rural sites.

Figures 21-25 present time series sulfate concentrations for three regional rural sites (Brigantine National Wildlife Refuge in Oceanville, NJ; Mohawk Mountain, Cornwall, CT; and Quabbin Summit, Ware, MA) and two urban sites (Stiles Street, New Haven, and State Street, New Haven). The 24-hour samples were collected on three to six day schedules. The Brigantine site had a nearly continuous record of 3-4 day interval monitoring from 1992 through first quarter 2003. Fine particulate sulfate was only monitored at Mohawk Mountain and Quabbin Summit from 2001-2003. However, $PM_{2.5}$ samples collected from 1988-1993 were analyzed for total sulfur, as were the most recent samples. As such, site-specific ratios of fine particulate sulfur to sulfate were established from this data, and fine particle sulfate was estimated from these ratios using the total sulfur data for the earlier periods. At the two New Haven sites, the sulfate analyses were from PM_{10} filters, which may result in higher concentrations if there is significant coarse fraction sulfate.

Comparison of the sulfate data linear regression plots among the five sites reveals similarity in both the rate of concentration decline over time and average concentration values. At the rural sites, average sulfate is declining at rates of from 0.063 to 0.094 $\mu g/m^3/yr$, while at the New Haven sites, it is declining at a rates of 0.12 and 0.15 $\mu g/m^3/yr$ for Stiles Street and State Street, respectively. Estimated average sulfate, from the linear regression line on January 1, 2002, ranged from about 2.6 $\mu g/m^3$ at Quabbin and Mohawk to 3.8 $\mu g/m^3$ at New Haven and Brigantine. These results indicate that the New Haven area is imbedded in a large region of relatively uniform sulfate concentrations, and that these concentrations are declining across the region uniformly. The slightly lower sulfate concentrations at Mohawk and Quabbin may be due in part to those site's higher elevations, which promotes a greater degree of atmospheric mixing at times when morning inversions cap pollutants near the surface at lower elevations.

F. Particulate Black Carbon

Ongoing monitoring of particulate black carbon (BC) has been conducted in New Haven at the Stiles Street site since December 2002, and at the State Street site since April 2003. At each site, continuous samples are analyzed using Magee Scientific model AE2100 aethalometers that provide five-minute average concentrations. Hourly and 24-hour arithmetic average concentrations are computed using five-minute and validated one-hour values, respectively.

Black Carbon, which is emitted from many types of combustion sources, is most notably associated with diesel fuel combustion in the absence of significant biomass combustion. As such, an urban site having a high BC to $PM_{2.5}$ ratio would most likely be impacted by high diesel emissions. A comparison of the average of the daily $BC/PM_{2.5}$ ratios for the Stiles Street and State Street sites presented in Table 2.3 shows a 33 percent higher average $BC/PM_{2.5}$ ratio (0.16 at Stiles Street compared to 0.12 at State Street). Note also that black carbon at Stiles Street is 71% (2.28 $\mu g/m^3$) higher than at State Street (1.33 $\mu g/m^3$).

Table 2.3: Black Carbon: PM $_{2.5}$ Ratios
for Stiles Street and State Street, New Haven
4/2003 through 9/2003

	Stiles Street			State Street		
	BC	**$PM_{2.5}$**	**$BC/PM_{2.5}$***	**BC**	**$PM_{2.5}$**	**$BC/PM_{2.5}$***
Average	2.28	16.24	0.16	1.33	14.36	0.12
Count	44	44	29	29	44	29
Max	6.16	53.9	0.26	3.15	48.8	0.2
Min	0.56	4.7	0.06	0.4	4.7	0.05
St Deviation	1.19	10.53	0.06	0.83	10.34	0.04

*Averages of the ratios computed using only days with valid BC and PM data for both sites.

An indication of regional background black carbon is provided by time series plots of total elemental carbon data from Mohawk Mountain and Quabbin Summit (Figures 26 and 27). Average black carbon at these sites is in the range of 0.3 – 0.4 $\mu g/m^3$, a fraction of the average black carbon in New Haven.

The above data suggests that New Haven black carbon is strongly dependent on local sources. To assess this further, hourly black carbon concentrations were compared to hourly average wind directions to investigate the direct impact of potential local sources. Average black carbon concentrations were computed for each 45° wind direction octant for daytime (6AM-6PM) and nighttime (6PM-6AM) hours. The results for Stiles Street (Figure 28) and State Street (Figure 29) show distinct patterns between the two sites, and between day and night for Stiles Street.

The Stiles Street and State Street nighttime black carbon vs. wind direction patterns are similar to each other with regard to relative average black carbon maxima and minima occurring for certain wind directions. When winds are from the south to south-southwest, nighttime average black carbon concentrations are about the same at the two sites. At State Street, the day and night black carbon levels are similar for most wind directions, whereas at Stiles Street, black carbon concentrations are significantly greater during daytime hours than nighttime hours when winds are blowing from the south-west-northeast sector. As can be seen from the Stiles Street site map (Figure 4), this western segment includes the closest approach to I-95, which encircles the site to its west from the south to the north. The highest nighttime black carbon concentrations are found in the north-northeast to east-northeast directions, which are the closest approach of the I-95 southbound entrance ramp. As discussed below, traffic count studies conducted for the entrance ramp indicate heavy traffic for the 4 AM to 10 AM period, which includes some nighttime hours. At State Street (Figure 6), the closest approach to the I-91 on ramp is less than 30 meters to the south, which corresponds to the higher black carbon levels for wind directions from that sector.

Figures 30 and 31 show diurnal hourly average black carbon and average hourly traffic for the Stiles Street and State Street access ramps, respectively. These data (obtained from the Connecticut Department of Transportation) show weekday traffic volume in the 8:00 hour of about 400 vehicles for Stiles Street, and about 330 vehicles for State Street. However, average black carbon at Stiles Street is greater than 4 ug/m^3 from 7:00 –9:00 A.M., while at State Street black carbon is about 2.2 ug/m^3 during this time. Factors that could contribute to the higher observed black carbon at Stiles Street for similar ramp traffic densities include: higher fraction of heavy-duty diesel truck traffic, shorter distance between ramps and monitors, and shorter distance of interstate highways to monitors.

On Wednesday, January 21, 2004, CTDEP personnel conducted traffic counts at the Stiles Street site for vehicles traveling the I-95 southbound access ramp from 5:00 A.M. to 9:30 A.M. (Table 2.4). The counts were of 10 to 15 minute durations, distinguishing among light-duty, medium-duty and heavy-duty vehicles. Heavy trucks (GVW > 26,000 lbs) are prohibited from using the ramp from 7:00 to 8:30 A.M., apparently to ease traffic congestion and slowdowns on the Q Bridge during morning rush hours. The percentage of trucks using the ramp ranged from 79 percent in the 5:00 A.M. hour to 23 percent in the 9:00 A.M. hour, with the exception of the prohibition. During the prohibition period, the fraction of observed heavy vehicles was from 3 percent to 5 percent.

Table 2.4: I-95 Southbound Access Ramp Traffic Count Data, Stiles Street New Haven, January 21, 2004

Start Time	End Time	Scaling Factor	Hourly LDV	Hourly MDV	Hourly HDV	Hourly Total Vehicles	% HDV
5:21	5:36	4	12	0	44	56	79
6:04	6:19	4	44	4	56	104	54
6:50	7:00	6	114	0	60	174	34
7:15	7:30	4	276	16	16	308	5
8:10	8:25	4	516	8	16	540	3
9:01	9:16	4	304	4	92	400	23

G. Highway Traffic Density

The proximity of several selected monitoring sites to high-volume highways was reviewed. Average $PM_{2.5}$ concentrations were computed for the period April 2003 through September 2003 to include the three new monitors in the New Haven area (Woodward Street Fire House, West Haven Toll Plaza, and CT Agricultural Experiment Station). For each site, lateral distance from the monitor to the nearest major interstate or state highway was determined from available GIS mapping, and average daily traffic for the nearest segment of highway was obtained from Connecticut DOT 2001 Traffic Data. The values of these parameters are provided in Figure 32. The Stiles Street site, with the highest $PM_{2.5}$ value, has daily traffic in the higher range (approximately 130,000 vehicles per day) along with the other New Haven area sites, Fairfield County and Waterbury. Stiles Street is also the closest site to a highway at less than 100 meters, followed by West Haven and Norwalk at under 200 meters. Other factors that may elevate $PM_{2.5}$ at sites such as Hartford, Bridgeport, and State Street, are the proximity of busy highway ramps and connectors (Hartford, State Street), and additional nearby highways (Norwalk, Bridgeport).

H. Conclusions

A review of the data and analyses presented in this document may be summarized in the following points:

- Although most of the regular Connecticut $PM_{2.5}$ monitors are sited in industrial/urban areas in proximity to major interstate highways, only one site (Stiles Street, New Haven) exceeds $PM_{2.5}$ NAAQS (annual arithmetic mean).
- The Stiles Street monitor location has the local maximum average $PM_{2.5}$ concentrations, with a strong decreasing gradient extending out to the surrounding New Haven area monitors, indicating the existence of a strong local source at Stiles Street.
- A combination of actual and estimated $PM_{2.5}$ data in Connecticut show reductions in average $PM_{2.5}$ for all sites over the most recent 18-year period, with higher concentration

sites improving faster that lower concentration sites. Rural background $PM_{2.5}$ from measured data also shows declines, suggesting that $PM_{2.5}$ in Connecticut is derived from ubiquitous sources, likely large power plants and mobile sources.

- Observed sulfate trends have been declining, albeit at a slower rate than $PM_{2.5}$ concentrations, reflecting reductions in sulfur emissions from acid rain programs.
- Regional rural background elemental carbon is about 0.3-0.4 ug/m3, while urban New Haven black carbon was 4 to 7 times higher, suggesting that local sources are the primary contributor of black carbon. Higher ratios of black carbon to $PM_{2.5}$ at Stiles Street compared to State Street suggest that the Stiles Street monitor is more highly impacted by local diesel tailpipe emissions than State Street.
- Hourly black carbon and wind direction data indicates that wind direction has a more significant impact on black carbon at Stiles Street than at State Street. Also, daytime black carbon was highest with winds from the direction of I-95, while black carbon was highest with winds from the direction of the access ramp during nighttime hours at Stiles Street. The State Street black carbon did not exhibit as strong a directional or time of day dependence as Stiles Street.
- Traffic counts and diurnal black carbon data suggest a relationship between high-density heavy duty diesel truck traffic and morning black carbon maxima at Stiles Street. Since black carbon is acknowledged as an indicator of primary $PM_{2.5}$ emissions, it is plausible that the unusual nature of the Stiles Street monitor (i.e., high volume of heavy-duty transport vehicles serving harbor terminal bulk fuel farms and other commodities, proximity and uphill grade of the area's major I-95 southbound access ramp) are contributory to the $PM_{2.5}$ levels observed at the site.

3. Studies to Determine the Impact of Connecticut's $PM_{2.5}$ Emissions on New York and New Jersey

This section presents the results from four studies that will further the case that Connecticut does not significantly contribute $PM_{2.5}$ concentrations to receptors in New York and New Jersey. Three of the studies were undertaken by staff at CTDEP, while another study conducted by EPA for the proposed Interstate Air Quality Rule, is referenced in this section. Taken together, these studies present a weight of evidence leading to the conclusion that Connecticut counties should not be included in the greater New York City CSA non-attainment area. Section A describes ISCST3 (Industrial Source Complex Simple Terrain) area source modeling that was used to show State's contribution of $PM_{2.5}$ to receptors in CT, NY and NJ. Section B shows the results of back trajectory analysis using the HYSPLIT4 (HYbrid Single-Particle Lagrangian Integrated Trajectory) model. Section C excerpts a portion of the proposed EPA Interstate Air Quality Rule technical support document that shows Connecticut's contribution of $PM_{2.5}$ to NYC. Section D examines United States Census Bureau data describing southwest Connecticut commuting patterns to New York City and New Jersey.

A. ISCST3 Area Source Modeling of Primary $PM_{2.5}$

I. Introduction

States must provide recommendations for area designations by February 15, 2004. In the past, some parts of Connecticut were included in the 1-hour ozone nonattainment area with southern New York and northern New Jersey. According to the April 1, 2003 memo from Jeffrey R. Holmstead, EPA will consider a number of factors in assessing whether to exclude portions of a metropolitan area from the boundaries of a $PM_{2.5}$ nonattainment area. One of the factors listed was meteorology (weather/ transport patterns). Connecticut has recently used the ISCST3 model to demonstrate that because of transport patterns, primary fine-particulate matter emissions from Connecticut sources have a low impact on receptors in New York City and Hudson County New Jersey.

II. Methodology

It has been recognized for a number of years that air quality models using fugitive dust emission inventories substantially overestimate the ambient $PM_{2.5}$ crustal material actually found in ambient samples (EPA memo, Thomas G. Pace, August 22, 2003). It was suggested that most of a dust plume remains close to the ground and that air quality models "do not adequately account for injection height, deposition losses and impaction losses near fugitive dust emission sources." Because of this, fugitive emissions from the following SCCs (source classification codes) were reduced by 90 percent to provide a better estimate of $PM_{2.5}$:

- SCC 2311020000 (Industrial Processes, Construction, Heavy Construction, Total)
- SCC 2311030000 (Industrial Processes, Construction, Road Construction, Total)
- SCC 2325000000 (Industrial Processes, Mining and Quarrying, All Processes, Total)

- SCC 2801000003 (Misc. Area Sources, Agricultural Production, Agricultural Crops, Tilling)
- SCC 2294000000 (Mobile Sources, Paved Roads, All Paved Roads, Total: Fugitives)
- 2296000000 (Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives)

For all the residential wood burning (stationary source fuel combust, residential, wood) and all SCC8 categories: SCCs (210008030, 2104008004, 210400850, 2104008003, 2104008001, 2104008010, and 2104008002), the estimated emissions were reduced to zero pending a new report from MARAMA (Mid-Atlantic Regional Air Management Association) that is expected to revise the estimates.

Finally, the following SCCs were revised using estimates from the MANE-VU (Mid-Atlantic/Northeast Visibility Union) report on open burning "Open Burning in Residential Areas, Emissions Inventory Development Report" prepared by EH Pechan and Assoc. Inc. January 31, 2003 for MANE-VU:

- SCC 2610000400 (Waste disposal/treatment, open burning, all categories, yard waste-brush spec. unspecified)
- SCC 2610000100 (Waste disposal/treatment, open burning, all categories, yard waste-leaf spec. unspecified)
- SCC 2610030000 (Waste disposal/treatment, open burning, residential, household waste)

- SCC 2610000500 (Waste disposal/treatment, open burning, all categories, land clearing debris) was reduced to zero, since it was not accounted for in the report.

For simplicity, it was decided to add the point, non-road, and mobile source emissions to the area source emissions from each county, to obtain a total area source emissions to input into the model. Each county was converted into an approximately shaped rectangular area and placed on a map grid of the region (Figure 33). All counties were oriented horizontally, except the Manhattan County source, which was rotated at a 25-degree clockwise angle. The southwest corner coordinates for each rectangular county area were then obtained and input to the model. A Summary of Emission sources is provided in Table 3.1.

The approximate locations for the five discrete Cartesian receptor points were also obtained from the modeling grid and the input from all source counties was run for each of the receptor points. The county containing the receptor was included since the model allows it (except for very small areas of a few meters across). The modeled source receptor locations are also shown in Figure 33.

In order to test the variability from meteorological conditions, each receptor was run using two different meteorological data sets. One run used 1994 surface data from LaGuardia, NY and upper air data from Atlantic City, NJ, and the other run used 1974 surface data from Sikorsky Airport in Bridgeport, CT and upper air data from Kennedy Airport, NY.

The ISCST3 dispersion model was run using the area source subroutine with the following parameters:

- Regulatory DEFAULT option
- URBAN dispersion parameter
- CONCENTRATION output units
- NO COMPLEX terrain
- 24 Hour averaging PERIOD
- No particle deposition
- Output= annual average concentration from each source

III. Results

The emissions and modeled estimates are for primary $PM_{2.5}$ and are not intended to represent any secondarily formed PM, such as sulfates, nitrates or organic aerosols. Also the modeling is not designed to replicate any localized neighborhood or microscale effects.

Table 3.2 shows results for the New York City receptor. The model results indicate that Connecticut source contributions ranged from 1.7% of the total using LaGuardia surface met data to 2.1% of the total when Bridgeport surface met data was input to the ISCST3 model. Connecticut source contributions for the Union City, New Jersey receptor ranged from 2.9% of the total (LaGuardia met data) to 2.3% of the total for Bridgeport met data (Table 3.2). For comparison purposes, results to three Connecticut receptors are also included. Contributions from the individual States to each receptor are also plotted in pie charts (Figure 34). For the receptors in Bridgeport and New Haven, Connecticut sources contributed more than half the primary $PM_{2.5}$ totals, with New Jersey and New York contributing significant percentages.

As stated earlier, the area source emissions were adjusted for specific categories, and this resulted in the substantial reduction of area source emissions from all the counties. Most of the differences can be attributed to the 90% reduction of the primary fugitive dust categories. In order to compare the effect that this adjustment had on the modeling output, Table 3.1 include a column with results from running the model with the unadjusted annual emissions for the NYC receptor. The concentration at this receptor increased by 47% overall, however, as displayed on the pie chart (Figure 34), the contribution from CT sources only increased from 1.7% to 2.8% of the total. Clearly, adjusting the emissions inventory did not affect the significance of the CT contribution.

The model was also run using 20km grid points as receptors and the results are displayed in Figures 35 and 36. Grid point concentration values are generally higher around the immediate NYC area when using the Bridgeport (Sikorsky Airport) meteorological surface data. To better visualize the relative impacts, these grid point data are plotted as concentration circles in Figures 37 and 38. Wind rose diagrams have been plotted for the LaGuardia and Bridgeport surface meteorological inputs in Figures 39 and 40. These show the wind patterns for their respective years to be noticeably difference in appearance. Regardless of this fact, the Connecticut contribution to the NYC receptor has been shown to increase only slightly when using the Bridgeport meteorological data.

PM 2.5 Modeling Area Source 1999 NEI Emissions

(Using LaGuardia Met Data)

County	State	County Code	Km²	x Km	y Km	Rectangle Km²	SW Corner (x,y)	Point Source Emissions TPY	Area Source Emissions TPY	Adjusted Area Source TPY	Highway Emissions TPY	Non-road Emissions TPY	Total Emissions TPY	Adjusted Total Emissions TPY	Adjusted Emissions g/s/m²	Unadjusted Emissions g/s/m²	NYC Adjusted Annual Average µg/m³	NYC Unadjusted Annual Average µg/m³
New Haven	CT	9	1603	40	40	1600	186,130	718	2334	484	410	620	4082	2232	4.01E-08	7.33E-08	0.051	0.094
Litchfield	CT	5	2448	43	57	2451	140,150	22	1978	347	91	98	2189	558	6.56E-09	2.57E-08	0.008	0.032
Fairfield	CT	1	1671	38	44	1672	147,112	267	3626	682	454	746	5093	2149	3.70E-08	8.77E-08	0.085	0.200
Hartford	CT	3	1945	40	48	1920	183,157	276	4752	767	460	337	5825	1840	2.72E-08	8.62E-08	0.033	0.106
Middlesex	CT	7	997	28	35	980	206,120	190	1478	199	112	111	1891	612	1.77E-08	5.46E-08	0.008	0.024
New London	CT	11	1793	51	35	1785	232,126	1223	2202	370	192	189	3806	1974	3.17E-08	6.11E-08	0.015	0.028
Tolland	CT	13	1080	24	45	1080	223,160	9	1327	207	113	51	1500	380	1.01E-08	4.00E-08	0.006	0.024
Windham	CT	15	1349	32	42	1344	248,160	31	1180	191	106	44	1361	372	7.93E-09	2.90E-08	0.004	0.016
Dutchess	NY	27	2137	39	55	2145	100,150	7	3983	527	204	151	4345	889	1.20E-08	5.85E-08	0.010	0.047
Putnam	NY	79	637	36	18	648	100,130	0.04	1460	135	63	47	1570.04	245.04	1.11E-08	7.09E-08	0.004	0.028
Westchester	NY	119	1230	28	44	1232	100,84	68	4657	734	239	505	5469	1546	3.62E-08	1.28E-07	0.069	0.245
Bronx	NY	5	111	11	10	110	100,70	37	2261	577	338	218	2854	1170	3.03E-07	7.40E-07	0.254	0.620
New York	NY	61	72	3.5	21	73.5	92.6,58.4	439	3080	2125	418	1171	5108	4153	1.66E-06	2.04E-06	9.753	11.986
Queens	NY	81	280	17	16	272	101,51	463	4787	1751	548	786	6584	3548	3.65E-07	6.77E-07	0.258	0.479
Kings	NY	47	179	13	13	169	94,46	226	4363	1357	647	411	5647	2641	4.24E-07	9.08E-07	0.516	1.104
Nassau	NY	59	717	21	34	714	118,46	135	7314	949	361	481	8291	1926	7.73E-08	3.33E-07	0.043	0.184
Suffolk	NY	103	2388	100	24	2400	140,60	324	9040	1228	413	1017	10794	2982	3.59E-08	1.30E-07	0.017	0.062
Richmond	NY	85	150	12	12	144	77,40	242	1929	485	106	144	2421	977	1.87E-07	4.64E-07	0.081	0.200
Orange	NY	71	2173	55	40	2200	44,113	136	4529	492	264	158	5087	1050	1.39E-08	6.74E-08	0.020	0.099
Rockland	NY	87	515	20	26	520	85,96	195	1768	379	74	118	2155	766	4.28E-08	1.20E-07	0.026	0.073
Sussex	NJ	37	1388	32	43	1376	26,87	7	1519	210	110	101	1737	428	8.87E-09	3.60E-08	0.017	0.071
Passaic	NJ	31	510	18	29	522	66,77	26	1713	399	210	245	2194	880	4.96E-08	1.24E-07	0.066	0.164
Bergen	NJ	3	640	20	32	640	80,72	207	3558	912	383	817	4965	2319	1.04E-07	2.23E-07	0.203	0.436
Hudson	NJ	13	132	10	13	130	85,55	470	1842	552	257	876	3445	2155	4.70E-07	7.51E-07	0.605	0.966
Essex	NJ	13	332	17	20	340	66,60	270	3145	699	363	654	4432	1986	1.72E-07	3.84E-07	0.194	0.432
Union	NJ	39	269	19	14	266	60,46	97	2559	565	230	451	3337	1343	1.44E-07	3.57E-07	0.048	0.119
Morris	NJ	27	1246	42	30	1260	27,63	56	3215	541	253	408	3932	1258	2.90E-08	9.08E-08	0.054	0.170
Warren	NJ	41	940	22	43	946	0,56	227	1275	201	123	91	1716	642	1.96E-08	5.25E-08	0.012	0.031
Hunterdon	NJ	19	1134	33	34	1122	0,30	52	1772	224	156	130	2110	562	1.43E-08	5.35E-08	0.007	0.025
Somerset	NJ	35	790	20	40	800	32,24	171	2369	444	148	286	2974	1049	3.82E-08	1.08E-07	0.019	0.053
Middlesex	NJ	23	818	25	32	800	48,12	400	4584	832	347	661	5992	2240	7.88E-08	2.11E-07	0.068	0.182
Mercer	NJ	21	593	24	25	600	22,0	174	3043	1046	214	335	3766	1769	8.58E-08	1.83E-07	0.032	0.068
Monmouth	NJ	25	1235	49	25	1225	48,0	31	3950	724	325	565	4871	1645	3.83E-08	1.13E-07	0.050	0.148

	NYC Adjusted Annual Average µg/m³	NYC Unadjusted Annual Average µg/m³
Sum Total	12.64	18.52
CT	0.21	0.52
NY	11.05	15.13
NJ	1.37	2.87

Table 3.1: Area Source Parameters as Inputs to the ISCST3 Model.

		NYC (Manhattan)		Bridgeport CT		New Haven CT		Greenwich CT		Union City NJ	
Source County		**Adjusted Annual Average $\mu g/m^3$ Contribution** LaGuardia/ Atlc City 1994 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** Sikorsky/ Kennedy 1974 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** LaGuardia/ Atlc City 1994 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** Sikorsky/ Kennedy 1974 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** LaGuardia/ Atlc City 1994 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** Sikorsky/ Kennedy 1974 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** LaGuardia/ Atlc City 1994 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** Sikorsky/ Kennedy 1974 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** LaGuardia/ Atlc City 1994 Met Data	**Adjusted Annual Average $\mu g/m^3$ Contribution** Sikorsky/ Kennedy 1974 Met Data
New Haven	CT	0.051	0.043	0.192	0.214	0.578	0.686	0.068	0.068	0.046	0.042
Litchfield	CT	0.008	0.007	0.012	0.016	0.015	0.019	0.010	0.010	0.009	0.007
Fairfield	CT	0.085	0.067	0.488	0.585	0.079	0.159	0.265	0.301	0.078	0.067
Hartford	CT	0.033	0.025	0.046	0.040	0.051	0.056	0.045	0.033	0.033	0.024
Middlesex	CT	0.008	0.009	0.016	0.018	0.026	0.030	0.008	0.011	0.007	0.009
New London	CT	0.015	0.022	0.023	0.031	0.028	0.041	0.017	0.022	0.014	0.022
Tolland	CT	0.006	0.004	0.011	0.008	0.014	0.010	0.007	0.006	0.006	0.004
Windham	NY	0.004	0.003	0.007	0.006	0.009	0.008	0.005	0.005	0.004	0.003
Dutchess	NY	0.010	0.013	0.021	0.019	0.029	0.017	0.015	0.020	0.009	0.012
Putnam	NY	0.004	0.006	0.015	0.009	0.006	0.007	0.008	0.012	0.004	0.005
Westchester	NY	0.069	0.088	0.040	0.085	0.022	0.062	0.343	0.426	0.073	0.069
Bronx	NY	0.254	0.308	0.018	0.045	0.012	0.032	0.071	0.104	0.210	0.204
New York	NY	9.753	5.445	0.062	0.144	0.042	0.107	0.197	0.261	1.453	1.467
Queens	NY	0.258	0.192	0.077	0.099	0.053	0.083	0.154	0.156	0.102	0.237
Kings	NY	0.516	0.163	0.047	0.063	0.035	0.055	0.084	0.101	0.259	0.168
Nassau	NY	0.043	0.065	0.055	0.067	0.038	0.050	0.147	0.081	0.032	0.068
Suffolk	NY	0.017	0.041	0.080	0.062	0.081	0.062	0.025	0.050	0.015	0.039
Richmond	NY	0.081	0.068	0.014	0.022	0.010	0.018	0.025	0.028	0.100	0.091
Orange	NY	0.020	0.029	0.020	0.021	0.015	0.019	0.045	0.028	0.021	0.028
Rockland	NJ	0.026	0.044	0.015	0.031	0.009	0.026	0.057	0.047	0.026	0.036
Sussex	NJ	0.017	0.011	0.004	0.009	0.003	0.008	0.008	0.010	0.018	0.011
Passaic	NJ	0.066	0.064	0.009	0.031	0.006	0.024	0.022	0.048	0.061	0.061
Bergen	NJ	0.203	0.465	0.025	0.095	0.018	0.066	0.077	0.179	0.200	0.280
Hudson	NJ	0.605	0.678	0.027	0.063	0.019	0.048	0.072	0.103	3.497	3.968
Essex	NJ	0.194	0.288	0.017	0.060	0.014	0.048	0.033	0.104	0.270	0.306
Union	NJ	0.048	0.129	0.012	0.030	0.009	0.024	0.025	0.049	0.068	0.175
Morris	NJ	0.054	0.064	0.008	0.032	0.007	0.025	0.015	0.050	0.065	0.060
Warren	NJ	0.012	0.018	0.003	0.013	0.002	0.011	0.006	0.016	0.013	0.016
Hunterdon	NJ	0.007	0.022	0.003	0.010	0.002	0.009	0.004	0.013	0.007	0.022
Somerset	NJ	0.019	0.053	0.007	0.020	0.006	0.017	0.011	0.029	0.021	0.059
Middlesex	NJ	0.068	0.089	0.023	0.039	0.018	0.034	0.038	0.049	0.077	0.105
Mercer	NJ	0.032	0.047	0.014	0.026	0.012	0.023	0.022	0.032	0.036	0.053
Monmouth	NJ	0.050	0.042	0.019	0.024	0.016	0.020	0.025	0.030	0.054	0.047
TOTAL	**(µg/m3)**	**12.64**	**8.61**	**1.43**	**2.04**	**1.29**	**1.90**	**1.95**	**2.48**	**6.89**	**7.76**
CT Total	**(µg/m3)**	**0.21**	**0.18**	**0.79**	**0.92**	**0.80**	**1.01**	**0.43**	**0.46**	**0.20**	**0.18**
NY Total	**(µg/m3)**	**11.05**	**6.46**	**0.46**	**0.67**	**0.35**	**0.54**	**1.17**	**1.31**	**2.30**	**2.42**
NJ Total	**(µg/m3)**	**1.37**	**1.97**	**0.17**	**0.45**	**0.13**	**0.36**	**0.36**	**0.71**	**4.39**	**5.16**
%	**CT**	**1.7**	**2.1**	**55.6**	**45.1**	**62.2**	**53.0**	**21.8**	**18.4**	**2.9**	**2.3**
%	**NY**	**87.5**	**75.0**	**32.4**	**32.8**	**27.5**	**28.3**	**59.9**	**52.9**	**33.4**	**31.2**
%	**NJ**	**10.9**	**22.9**	**12.0**	**22.2**	**10.3**	**18.7**	**18.3**	**28.7**	**63.7**	**66.5**

Table 3.2: Summary of Annual Average Modeled $PM_{2.5}$ Concentrations

B. Back Trajectory Analysis of Days with High and Low $PM_{2.5}$ Concentrations in New York City

The highest $PM_{2.5}$ concentrations measured in New York City are at the P.S.59 monitor in Manhattan. The daily $PM_{2.5}$ concentrations over a nearly 5-year period (1/99-9/03) at P.S. 59 were analyzed and rank-ordered from highest to lowest. The dates for the top and bottom 10 percentile were obtained. The National Oceanic and Atmospheric Administration's HYSPLIT4 model (http://www.arl.noaa.gov/ready/hysplit4.html) was then used to produce back trajectories once a day for each of those days at three height levels (10, 500, and 1000 meters above ground level). All 72 hourly positions (or back trajectories) of the model run at each vertical level were saved each day for the "dirty" and "clean" categories.

The back trajectories for the "dirtiest" or highest 10 percentile $PM_{2.5}$ concentration days are plotted in Figure 41 and the "cleanest" or lowest 10 percentile $PM_{2.5}$ concentration days are plotted in Figure 42. One can see immediately that the source regions from which air is being transported into New York City are distinctly different for the two scenarios. These figures demonstrate that during the dirtiest days, the air arriving in New York City comes from and passes through locations in a sector from the south and west (Figure 41). Conversely, during the cleanest days the air arriving in New York City comes from and passes through locations in a sector from the north and east.

Since Connecticut is northeast of New York City, this back trajectory analysis supports the conclusion that Connecticut's emissions are not contributing significantly to the highest PM2.5 levels measured in New York City.

C. Interstate Air Quality Rule Modeling

In the proposed "Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Interstate Air Quality Rule)", Federal Register / Vol. 69, No. 20 / published on Friday, January 30, 2004, EPA conducted an evaluation of the upwind contributions to downwind $PM_{2.5}$ non-attainment.

EPA used the REgional Modeling System for Aerosols and Deposition (REMSAD) as the tool for simulating base year and future concentrations of PM, visibility, and deposition in support of the IAQR air quality assessments. According to the Technical Support Document for the Interstate Air Quality Rule Air Quality Modeling Analyses (January 2004):

> "The basis for REMSAD is the atmospheric diffusion equation (also called the species continuity or advection/diffusion equation). This equation represents a mass balance in which all of the relevant emissions, transport, diffusion, chemical reactions, and removal processes are expressed in mathematical terms. REMSAD employs finite-difference numerical techniques for the solution of the advection/diffusion equation."

The REMSAD model is much more sophisticated than the modeling that CTDEP staff conducted with the ISCST3 model, in that it involves secondary $PM_{2.5}$ formation. The aforementioned Technical Support Document describes it as follows:

> " Primary PM emissions in REMSAD are treated as inert species. They are advected and deposited without any chemical interaction with other species. Secondary PM species, such as sulfate and nitrate are formed through chemical reactions within the model. SO_2 is the gas phase precursor for particulate sulfate, while nitric acid is the gas phase precursor for particulate nitrate. Several other gas phase species are also involved in the secondary reactions. There are two pathways for sulfate formation; gas phase and aqueous phase. Aqueous phase reactions take place within clouds, rain, and/or fog. In-cloud processes can account for the majority of atmospheric sulfate formation in many areas."

EPA used REMSAD to perform State-by-State zero-out modeling to quantify the contribution from emissions in each State to future $PM_{2.5}$ nonattainment in other States. They analyzed a total of 41 States on a State-by-State basis in different model runs. EPA is proposing to use a criterion of 0.15 µg/m3 for determining whether emissions in a State make a significant contribution (before considering cost) to $PM_{2.5}$ nonattainment in another State. Of the States analyzed for this proposal, 28 States and the District of Columbia contribute 0.15 $\mu g/m_3$ or more to nonattainment in other States and therefore would be found to make a significant contribution to $PM_{2.5}$.

The maximum downwind contribution from each upwind State to a downwind nonattainment county is provided in Table 3.3 (from page 4608 Federal Register / Vol. 69, No. 20) and Connecticut was found to contribute .07 $\mu g/m^3$ of $PM_{2.5}$ concentration to a New York City receptor. According to the EPA criteria described above, Connecticut does not significantly contribute to non-attainment in New York, NY.

TABLE 3.3. MAXIMUM DOWNWIND $PM_{2.5}$ CONTRIBUTION ($\mu g/m^3$) FOR EACH OF 41 UPWIND STATES

Upwind state	Maximum Downwind contribution $\mu g/m^3$	Downwind nonattainment county of maximum contribution
Alabama	1.17	Floyd, GA.
Arkansas	0.29	St. Clair, IL.
Connecticut	**0.07**	**New York, NY.**
Colorado	0.04	Madison, IL.
Delaware	0.17	Berks, PA.
Florida	0.52	Russell, AL.
Georgia	1.52	Russell, AL.
Illinois	1.50	St. Louis, MO.
Indiana	1.06	Hamilton, OH.
Iowa	0.43	Madison, IL.
Kansas	0.15	Madison, IL.
Kentucky	1.10	Clark, IN.
Louisiana	0.25	Jefferson, AL.
Maryland/District of Columbia	0.85	York, PA.
Maine	0.03	New Haven, CT.
Massachusetts	0.21	New Haven, CT.
Michigan	0.88	Cuyahoga, OH.
Minnesota	0.39	Cook, IL.
Mississippi	0.30	Jefferson, AL.
Missouri	0.89	Madison, IL.
Montana	0.03	Cook, IL.
Nebraska	0.08	Madison, IL.
New Hampshire	0.06	New Haven, CT.
New Jersey	0.45	New York, NY.
New Mexico	0.03	Knox, TN.
New York	0.85	New Haven, CT.
North Carolina	0.41	Sullivan, TN.
North Dakota	0.12	Cook, IL.
Ohio	1.90	Hancock, WV.
Oklahoma	0.14	Madison, IL.
Pennsylvania	1.17	New Castle, DE.
Rhode Island	0.01	New Haven, CT.
South Carolina	0.72	Richmond, GA.
South Dakota	0.04	Madison, IL.
Tennessee	0.57	Floyd, GA.
Texas	0.37	St. Clair, IL.
Vermont	0.06	New Haven, CT.
Virginia	0.67	Washington, DC.
West Virginia	0.89	Allegheny, PA.
Wisconsin	1.00	Cook, IL.
Wyoming	0.05	Madison, IL.

D. Southwest Connecticut Commuting Patterns to New York and New Jersey

EPA guidance on nonattainment area designations for $PM_{2.5}$ states "a nonattainment area must be defined not only to include the area that is violating the standard, but also to include the nearby source areas that contribute to the violation" (see page 4 of Attachment 2 to J. Holmstead's memorandum of April 1, 2003). Discussion in the sections above provides evidence from air quality modeling and air parcel trajectory analyses indicating that emissions emanating from within the borders of Connecticut do not significantly contribute to $PM_{2.5}$ levels in either the New York or New Jersey portions of the New York City Consolidated Statistical Area (CSA). In order to develop a more complete picture of the Connecticut's potential impact on $PM_{2.5}$ levels in the New York and New Jersey portions of the CSA, it is also important to examine Connecticut's contribution to motor vehicle traffic traveling within the remainder of the CSA.

Available 2000 Census Bureau data on work-trip origins and destinations were judged to provide a reasonable surrogate for assessing Connecticut's contribution to traffic levels in the New York City CSA. Ideally, detailed and current traffic survey data would have been used to determine the fraction of vehicular traffic traveling in the non-Connecticut portion of the New York City CSA originating from within Connecticut's portion of the CSA (i.e., Fairfield, New Haven, and Litchfield Counties). However, efforts to identify and obtain such data were unsuccessful. Excel spreadsheets were developed to process county-level work-trip data for each of the three states to determine the fraction of all work trips to various portions of the New York City CSA that originated in Connecticut. Results of that analysis are summarized below in Table 3.4.

Table 3.4 Work Trips from the Connecticut Portion of the CSA as a Percentage of Total Work-Trips Into:

Combined NY and NJ Portion of CSA	New Jersey Portion of CSA	New York State Portion of CSA	New York City portion of CSA
0.7%	0.1%	1.0%	0.9%

Overall, Connecticut's portion of the CSA contributes only 0.7% of total work-trips destined for the combined New York and New Jersey portions of the CSA. When the work-trip data are examined on a smaller geographic scale, Connecticut's contribution ranges from 0.1% in the New Jersey portion to 1.0% in the New York State portion of the CSA. For all work-trips headed into the five boroughs of New York City, only 0.9% of work trips originate from Connecticut's portion of the CSA.

The above data do not differentiate between the various modes of travel available to commuters, such as motor vehicles and mass transit. The 2000 Census Bureau travel data were not differentiated between travel modes, however, CTDEP previously analyzed 1990 travel data as part of the redesignation SIP package prepared for the Southwest Connecticut carbon monoxide nonattainment area. That analysis found 0.6% of all motor vehicle work-trips to the five boroughs of New York City originated in Connecticut's Fairfield County, consistent with the figures in the above table.

Based on these travel data, it is logical to conclude that Connecticut's motor vehicle emissions within the New York and New Jersey portions of the CSA are an insignificant fraction of the total. When viewed together with the dispersion modeling and trajectory analyses presented earlier, it is clear that Connecticut emission sources do not significantly affect ambient $PM_{2.5}$ levels throughout the remainder of the New York City CSA.

4. Outreach Activities Undertaken Regarding the Reclassifying of the Stiles Street Monitor to Microscale.

Upon the recommendation of EPA Region I, CTDEP conducted an outreach campaign, providing several presentations to various groups in New Haven and around the State. The intent of the outreach was to inform the regulated community, environmental groups, and the general public that reclassification of the Stiles Street monitor could lead to an attainment designation for $PM_{2.5}$.

In addition to addressing the consequences of monitor reclassification, the outreach presentations included a discussion of the rational for reclassification. The Stiles Street monitor is significantly influenced by microscale phenomena, particularly diesel truck emissions from heavily loaded trucks accelerating up the steeply graded I-96 southbound access ramp. The access ramp and nearest section of I-95, the approach to the Q-Bridge, are within distances on the order of tens of meters from the monitor. The immediate area of the monitor is highly industrial, and does not include residential areas. As such, it is not representative of community exposure and, consistent with EPA's guidance, should be treated as a microscale site for $PM_{2.5}$ classification purposes.

The following presentations were given to inform the public of the reclassification of the Stiles Street $PM_{2.5}$ monitor:

a) June 6, 2003- Presentation to the CTDEP Air Bureau
b) June 16, 2003- Presentation to EPA Region 1, quarterly meeting
c) November 12, 2003- Presentation to the New Haven EQ Group
d) January 8, 2004- Presentation to SIPRAC meeting
e) January 22, 2004- Presentation to a New Haven public meeting

Note, item (d) above contains the CTDEP Website link to the January 8, 2004 SIPRAC meeting presentation.

5. Appropriate Use of Stiles Street Monitoring Data Based on EPA Regulations and Guidance Documents

The purpose of this section is to: 1) examine available EPA regulations and guidance to provide some general perspective on the siting of $PM_{2.5}$ monitoring sites and the appropriate use of collected data for determining compliance with the PM2.5 NAAQS; and 2) consider how EPA's guidance should be applied to the New Haven Stiles Street monitor. Excerpts from the following EPA documents are reproduced and discussed below.

Doc. A **Guidance for Network Design and Optimum Site Exposure for $PM_{2.5}$ and PM10 (EPA-454/R-99-022, December 1997)**

Doc. B **Designations for the Fine Particle National Ambient Air Quality Standards (EPA memo, J. Holmstead, April 1, 2003)**

Doc. C **40CFR58, Appendix D. Network Design for State and Local Air Monitoring Stations (SLAMS), National Air Monitoring Stations (NAMS), and Photochemical Assessment Monitoring Stations (PAMS)**

Doc. D **40CFR58, Appendix E. Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring**

The Jeff Holmstead memorandum regarding $PM_{2.5}$ designations includes a brief section desribing how NAAQS violations are to identified when examining monitoring data (see Section 3 of Doc. B). It notes exceptional circumstances when concentrations above the level of the standard are not to be interpreted as violations, stating:

> *"Sites that monitor source-oriented hot spots in some cases should be assessed only with respect to the 24-hour standard, not the annual average standard. In 40CFR Part 58 (Appendix D, section 2.8.1.2.3), EPA states that monitoring sites representing unique localized conditions not found elsewhere in the area should not be compared with the annual average standard."*

The following discussion takes a closer look at EPA background information directly affecting the applicability of this potential exception to the Stiles Street monitoring site.

A. EPA Changes in Monitoring Objectives Under the New $PM_{2.5}$ Standards

EPA's guidance for network design (see Doc. A, section 1.0) describes how monitoring objectives have changed with the implementation of the new $PM_{2.5}$ standards, pointing out distinct differences between the objectives for $PM_{2.5}$ versus PM_{10} networks:

> *"Previously, the PM NAAQS applied to the highest 24-hour or annual averages found within a monitoring planning area, and monitoring networks were often designed to measure these highest values. These networks did not necessarily*

represent the overall exposure of populations to excessive PM concentrations. Some data from these networks were disregarded by epidemiologists as being unrelated to health indicators such as hospital admissions and death. Air quality districts may have been reluctant to locate source-oriented monitors that might assist in understanding source impacts because such monitors might cause a large area to be designated in nonattainment of NAAQS.

The new forms for these standards are intended to provide more robust measures for the PM indicator. While PM_{10} network design and siting criteria are unchanged, new $PM_{2.5}$ monitoring networks to determine compliance or non-compliance are intended to best represent the exposure of populations that might be affected by elevated $PM_{2.5}$ concentrations. As used in this document, the word compliance means attainment of a NAAQS. This involves new concepts of spatial averaging and the operation of some monitoring sites for $PM_{2.5}$ measurements that are not eligible for comparison to one or both of the $PM_{2.5}$ NAAQS."

It is clear from the excerpt above that EPA recognized the need for a fundamental change in PM network design and the use of collected monitoring data for the new $PM_{2.5}$ standard. Previous use of source-oriented monitors not representative of overall population exposure for determining NAAQS compliance was judged by EPA to be inappropriate for $PM_{2.5}$, given that potential exposures at these locations are unrelated to health indicators such as hospital admissions and premature death which provided the basis for the new $PM_{2.5}$ standards. EPA reiterates this point in 40CFR58, Appendix D (see section 2.8.1.2.3 of Doc. D):

"The health-effects data base that served as the basis for selecting the new PM2.5 standards relied on a spatial average approach that reflects average community oriented area-wide PM exposure levels."

In the previous excerpt from the network design guidance (Doc. A, section 1.0), EPA provides a more detailed discussion of the distinction between PM_{10} and $PM_{2.5}$ monitoring networks under the new standards. PM_{10} design and siting criteria remain unchanged, retaining their focus on identifying the highest concentrations in an area, regardless of the potential for overall population exposure. However, EPA states that new $PM_{2.5}$ networks intended for determining NAAQS compliance should represent the exposure of populations that might be affected by elevated $PM_{2.5}$ levels.

EPA notes that these fundamentally new concepts would result in operation of some $PM_{2.5}$ monitoring sites that are not eligible for comparison to one or both of the $PM_{2.5}$ NAAQS. EPA acknowledges that, in the past, use of such source-oriented sites for NAAQS compliance served as a disincentive for air quality agencies to site such monitors for purposes of characterizing source contributions in an area, due to concerns that collected data might lead to a nonattainment designation.

Based on the discussion in previous sections of this technical support document (TSD), there is little doubt that the Stiles Street monitor is a source-oriented site. The site is located in a heavily industrialized/commercialized area, far removed from areas of general population exposure. The monitor is sited within the CTDOT right-of-way, immediately adjacent to (and sandwiched between) the I-95 freeway, the southbound Stiles Street entrance ramp to the interstate, and Stiles Street. Traffic volumes on that portion of I-95 exceed 100,000 vehicles per day, while the freeway ramp and Stiles Street serve as the primary I-95 access point for heavy trucks leaving the New Haven Terminal and many other nearby businesses. Both the entrance ramp and the adjacent portion of I-95 are built on steep, uphill grades due to their immediate proximity to a major river crossing, the Q-Bridge. As a result, trucks passing by the monitor experience high-load acceleration to achieve/maintain highway speeds as they merge onto the interstate from the ramp and/or approach the Q-Bridge on I-95.

Consistent with EPA's guidance, CTDEP views the Stiles Street $PM_{2.5}$ monitor as a source-oriented site, appropriately used for characterization of source contributions, but not for determining compliance with the $PM_{2.5}$ NAAQS. As evidenced elsewhere in this TSD, CTDEP is in the process of analyzing data from this (and other) monitor(s) to gain a better understanding of source contributions in the area. Based on initial results, the Department is already developing control strategies to reduce emissions in New Haven and elsewhere in the state.

B. Appropriate Classification Scale for the Stiles Street Monitor

EPA's fundamental change in network design for the new $PM_{2.5}$ standard is reflected in several new concepts introduced in the network design guidance document, including what EPA calls the "Receptor Site Zone of Representation" and "Community-Oriented Monitoring" (see Sections 2.2.2 and 2.2.3 of Doc. A).

> ***"2.2.2 Receptor Site Zone of Representation***
> *PM_{10} and $PM_{2.5}$ concentrations measured at any receptor result from contributions of emissions from nearby and distant sources and the zone of representation of a monitoring site depends on the relative amounts contributed by sources on different spatial scales. The dimensions given below are nominal rather than exact and are presented as defined in 40 CFR part 58. They indicate the diameter of a circle, or the length and width of a grid square, with a monitor at its center.*
>
> •
> •
> •
>
> • ***Microscale (10 to 100 m):*** *Microscale monitors show significant differences between $PM_{2.5}$ monitors separated by 10 to 50 m. This often occurs when monitors are located right next to a low-level emissions source, such as a busy roadway, construction site, wood stove chimney, or short stack. Compliance monitoring site exposure criteria intend to avoid microscale influences even for source-oriented monitoring sites. A microscale zone of representation is primarily useful for studying emissions rates and zones of influence, as illustrated in Figure 2.1.7.*
>
> • ***Middle Scale (100 to 500 m):*** *Middle-scale monitors show significant differences between locations that are ~0.1 to 0.5 km apart. These differences*

may occur near large industrial areas with many different operations or near large construction sites. Monitors with middle-scale zones of representation are often source-oriented, used to determine the contributions from emitting activities with multiple, individual sources to nearby community exposure monitors.

- ***Neighborhood Scale (500 m to 4 km):*** *Neighborhood-scale monitors do not show significant differences in particulate concentrations with spacing of a few kilometers. This dimension is often the size of emissions and modeling grids used in large urban areas for PM source assessment, so this zone of representation of a monitor is the only one that should be used to evaluate such models. Sources affecting neighborhood-scale sites typically consist of small individual emitters, such as clean, paved, curbed roads, uncongested traffic flow without a significant fraction of heavy-duty vehicles, or neighborhood use of residential heating devices such as fireplaces and wood stoves.*

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2.2.3 Community-Oriented Monitoring
Community-oriented (core) monitoring sites are beyond the zone of influence of a single source, and should have neighborhood- to urban- scale zones of representation. The principal purpose of community-oriented monitoring sites is to approximate the short-term and long-term exposures of large numbers of people where they live, work, and play. A monitor placed at the fence line of an emissions source would not be considered to represent community exposures, even though there might be residences abutting that fence line. A monitor placed in the middle of an area adjacent to a source would, however, be deemed a community exposure monitor for that neighborhood provided that the location represented a zone of at least 0.5 km in diameter. The fence line monitor might still be operated because it provides information on how much the nearby source contributes to the community-oriented site. The data from the fence line monitor would not be used to determine annual NAAQS compliance, though it might be used to make comparisons to the 24-hour standard or to design control strategies to bring the area into compliance with the annual NAAQS."

The Stiles Street monitor's location immediately adjacent to both extremely high volumes of traffic on I-95 and significant amounts of accelerating heavy truck traffic on Stiles Street and the highway entrance ramp is consistent with EPA's above description of a microscale zone of representation.

The localized effect of trucks traveling on Stiles Street and the on-ramp, when combined with the extreme accelerations required to achieve highway speeds due to the steep, uphill grades of the ramp and I-95 approach to the Q-Bridge, appear to create a situation that is unique from other areas in New Haven. This is evidenced by available ambient measurements from three other monitoring sites in the area (i.e., 195 Oleander Avenue at the previous West Haven toll plaza, Woodward Fire House, and State Street; see Figure 8) that are also located in the immediate vicinity of high traffic interstate highways. For the 6-month period from April through September 2003, measured values at those sites ranged from 1.5 to 3.8 ug/m^3 less than the 15.7 ug/m^3 average recorded at Stiles Street (see Figure 8 of this TSD). The unique, localized influences in the Stiles Street area are the likely cause of this 2 to 4 ug/m^3 increment that results in $PM_{2.5}$ values at Stiles Street exceeding the annual standard. When these microscale influences are considered together with the fact that the Stiles Street monitor does not meet EPA's description of a community-oriented monitoring site (i.e., beyond the influence of a single source, with a neighborhood to urban scale of representation), CTDEP concludes that data from this site should not be used to determine compliance with the annual $PM_{2.5}$ NAAQS.

EPA provides additional elaboration on classification scales later in the same network design guidance document (see section 2.3.3 and 2.3.4 of Doc. A).

> ***"2.3.3 Monitoring Networks***
> *$PM_{2.5}$ monitoring networks may be new networks or part of existing networks. Additional sites may be added to existing networks according to this guidance.*
>
> - ***State and Local Air Monitoring Stations (SLAMS):*** *SLAMS are designed and operated by local air pollution control districts to determine: 1) the highest concentrations expected to occur in each MPA; 2) representative concentrations in areas of high population density; 3) the impact on ambient pollution levels of significant sources or source categories; 4) general background concentration levels; 5) the extent of regional pollutant transport among populated areas, and 6) welfare-related impacts in rural and remote areas (i.e., visibility impairment and effects on vegetation). Only population-oriented SLAMS acquire data for determining compliance with $PM_{2.5}$ standards, and community-oriented (core) SLAMS acquire data for compliance with the annual $PM_{2.5}$ standard."*

CTDEP records indicate that the Stiles Street $PM_{2.5}$ monitor has been classified as a "peak concentration" SLAMS site, not as a "population-oriented" site. Therefore, consistent with the above language from EPA's guidance, the site is not appropriate for determining compliance with the $PM_{2.5}$ NAAQS.

Similarly, Appendix D to 40CFR58 (see section 2.8.1.2.3 of Doc. C) states:

> *"…$PM_{2.5}$ data collected from SLAMS and special purpose monitors that are representative, not of area-wide but rather, of relatively unique population-oriented microscale, or localized hot spot, or unique population-oriented middle-scale impact sites are only eligible for comparison only to the 24-hour $PM_{2.5}$ NAAQS. However, in instances where certain population-oriented micro- or middle-scale PM2.5 monitoring sites are determined by the EPA Regional Administrator to collectively identify a larger region of localized high ambient $PM_{2.5}$ concentrations, data from these population-oriented sites would be eligible for comparison to the annual NAAQS."*

As a “peak concentration” SLAMS monitor (i.e., not population-oriented”) sited at a localized hot-spot, this CFR excerpt corroborates that the Stiles Street monitor should not be used for annual NAAQS compliance determination.

Section 2.3.4 later adds to the above, providing a definition of community-oriented (core) sites that does not encompass the Stiles Street monitor due to the fact that it is clearly “located within the microscale or middle-scale zone of influence of a specific, nearby particle emitter”; therefore, the monitor should not be used to determine annual $PM_{2.5}$ NAAQS compliance:

> *“**2.3.4 Site Types***
> *Several types of sampling sites, not all of which are designated for determining compliance with NAAQS, will be part of the $PM_{2.5}$ measurement networks.*
>
> *• **Community-Oriented (Core) Sites:** Community-oriented sites are located where people live, work, and play rather than at the expected maximum impact point for specific source emissions. These sites are not located within the microscale or middle-scale zone of influence of a specific, nearby particle emitter. Community-oriented sites may be located in industrial areas as well as and in residential, commercial, recreational, and other areas where a substantial number of people may spend a significant fraction of their day.”*

Later in Section 2.3.4, EPA defines “daily compliance sites”:

> *“• **Daily Compliance Sites:** Daily compliance sites are used to determine NAAQS compliance for the 24-hour (daily) $PM_{2.5}$ standard, but not for the annual standard. Because a daily compliance site does not necessarily represent community-oriented monitoring, it may be located near an emitter with a microscale or middle-scale zone of influence.*
>
> *The PM monitoring regulations state that any population-oriented site is eligible for comparison to the 24-hour $PM_{2.5}$ standard. If the monitoring site is also representative of community-wide air quality, it is eligible for comparison to the annual $PM_{2.5}$ NAAQS. With a few anticipated exceptions, almost all sites in the new network will be population-oriented. A site may be population-oriented and at the same time be source oriented or reflective of maximum concentration. The same is true for the existing PM_{10} network.*
>
> *Population-oriented sites may be located in hot spot locations and other portions of the above areas which are likely to invoke exposure to fine particles for at least part of a 24-hour sampling period. Hot spot locations have a micro or middle measurement scale of representativeness. Microscale means that the 24-hour measurements should vary by no more than ±10% within a circle of diameter 100 meters. Middle scale means that the 24-hour measurements should vary no more than ±10% within a circle of diameter 100-500 meters. These distances are the area around the monitor which may be different than the distance to the nearest major influencing source.”*

Although CTDEP wouldn't agree, it is possible that the above description of daily compliance sites could be interpreted to include the Stiles Street monitor. If this argument is conceded, data from this site could be used for 24-hour $PM_{2.5}$ NAAQS compliance determinations. In any case, though, EPA guidance is clear that data Stiles Street data should not be used to determine annual $PM_{2.5}$ NAAQS compliance due to its peak concentration objective and siting in an area not representative of community exposure.

Appropriate scales of representativeness for $PM_{2.5}$ compliance monitoring are also addressed in Appendices D and E of 40CFR58 (Doc. C and Doc. D, respectively, as defined at the beginning of Section 5 of this TSD). The EPA guidance discussed earlier is clear in stating that monitors intended for determining annual NAAQS compliance should represent the neighborhood scale exposure of populations and not the highest concentrations in a non-populated area measured by a source-oriented monitor such as Stiles Street. This point is echoed in Appendix D of 40CFR58 (see Section 2.8.1.2.2 of Doc. C), which states:

> *"2.8.1.2.2 Comparisons to the PM2.5 NAAQS may be based on data from SPMs in addition to SLAMS (including NAMS, core SLAMS and collocated PM2.5 sites at PAMS), that meet the requirements of § 58.13 and Appendices A, C and E of this part, that are included in the PM monitoring network description. For comparison to the annual NAAQS, the monitors should be neighborhood scale community-oriented locations."*

Later in the same reference (see 2.8.1.3.7 of Doc. C) EPA elaborates, stating:

> *"2.8.1.3.7 Core monitoring sites shall represent neighborhood or larger spatial scales. A monitor that is established in the ambient air that is in or near a populated area, and meets appropriate 40 CFR part 58 criteria (i.e., meets the requirements of § 58.13 and § 58.14, Appendices A, C, and E of this part) can be presumed to be representative of at least a neighborhood scale, is eligible to be called a core site and shall produce data that are eligible for comparison to both the 24-hour and annual PM2.5 NAAQS. If the site is adjacent to a dominating local source or can be shown to have average 24-hour concentrations representative of a smaller spatial scale, then the site would only be compared to the 24-hour PM2.5 NAAQS."*

This excerpt again supports the conclusion that the Stiles Street monitor, based on its location immediately adjacent to I-95 and the Stiles Street ramp, should not be used to determine annual PM2.5 NAAQS compliance.

Appendix E to 40CFR58 (see Section 8.3 of Doc. D) provides information on scales of representativeness related to spacing of PM samplers from nearby roadways. Figure 2 in Appendix E (reproduced here on the last page) depicts acceptable distances for micro, middle, neighborhood, and urban scale PM_{10} monitoring, based on the measured distance from the edge of the nearest traffic lane presumed to have the most influence on the site.

EPA notes that this presumption is an oversimplification of usual urban settings, which normally have several streets impacting a given site.

It should also be noted that this section of the CFR appears to only apply to NAMS monitors (the Stiles Street $PM_{2.5}$ monitor is a SLAMS, but not a NAMS). Additionally, the associated figure was developed for PM_{10}, and may not be applicable for $PM_{2.5.}$ (PM_{10} has greater potential for particle settling, so the 15 meter microscale cutoff in Figure 2 may be underestimated for $PM_{2.5}$.)

Notwithstanding these caveats, applying Figure 2 to the Stiles Street site, and assuming I-95 (average daily traffic in excess of 100,000 vehicles per day) is the most influencing roadway, CTDEP's monitor would be representative of a "middle scale" because it is located somewhat further away from the road than 15 meters. Applying the same figure to the Stiles Street on-ramp, assuming that accelerating trucks and cars make it the most influencing roadway despite lower traffic volumes, would classify the CTDEP monitor as representative of a "microscale" due to the less than 15-meter separation between the probe inlet and the edge of the roadway. However, regardless of whether the Stiles Street monitor is microscale or middle-scale, it is clear from the figure that it does not qualify for a neighborhood scale classification. This is crucial because of the many excerpts cited above from EPA guidance and regulations that indicate annual PM2.5 NAAQS compliance should be determined based on data from monitors sited at neighborhood scale, community-oriented, locations.

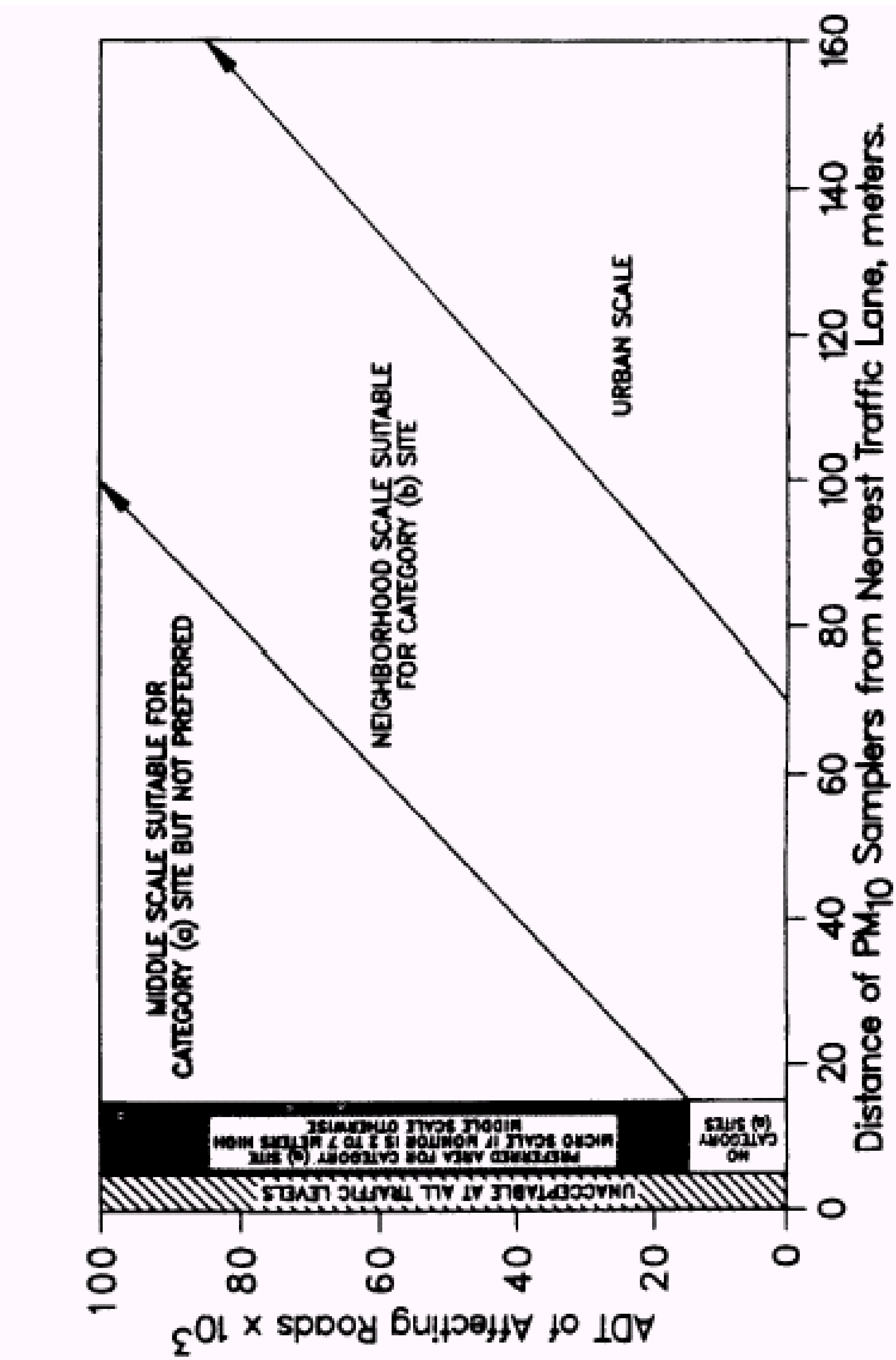

Figure 2. Acceptable Areas for PM_{10} Micro, Middle, Neighborhood, and Urban Samplers Except for Microscale Street Canyon Sites.