

# 1998

## CONNECTICUT ANNUAL AIR QUALITY SUMMARY



STATE OF CONNECTICUT  
DEPARTMENT OF ENVIRONMENTAL PROTECTION  
79 Elm Street  
Hartford, CT 06106-5127

Arthur J. Rocque, Jr.  
Commissioner

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## **EXECUTIVE SUMMARY**

This report is a compilation of the air pollution measurements made in 1998 at the official air monitoring network sites operated by the Department of Environmental Protection (DEP). These monitoring sites are components of the State/Local Air Monitoring Stations (SLAMS) network and its subsets, the National Air Monitoring Stations (NAMS) network and the Photochemical Assessment Monitoring Stations (PAMS) network. The air pollution measurements were made for both criteria pollutants and non-criteria pollutants. Criteria pollutants are those for which ambient standards have been set, based on established criteria for risk to human health and/or environmental degradation. The criteria pollutants monitored in Connecticut are carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>), particulate matter less than 10 microns in aerodynamic diameter (PM<sub>10</sub>), and lead (Pb). The non-criteria pollutants are nitrogen oxide (NO) and volatile organic compounds (VOCs). Various meteorological parameters are also recorded at many of the network monitoring sites; they include wind speed and wind direction, temperature, dew point, precipitation, barometric pressure and solar radiation. In addition, the DEP is currently building a network to monitor particulate matter less than 2.5 microns in aerodynamic diameter (PM<sub>2.5</sub>).

The major health effects and the long-term trend of each criteria pollutant are described in this report. The attainment status of each pollutant is also addressed both geographically within the state and with respect to the level of any applicable standards. Monthly climatological data from two National Weather Service stations in the state are also presented, both as monthly averages for 1997 and 1998 and as historic means. In addition, wind measurements from two air pollutant monitoring sites are presented in the form of wind roses for 1997 and 1998.

This report also contains a discussion of the various monitoring networks referred to earlier with respect to quality assurance, monitoring methodologies, network design and probe siting. Included also is a description of the Pollutant Standards Index, an air quality index available to the public on a daily basis. Validated data for 1998, as well as historical data, are available from EPA's AIRS database ([www.epa.gov/airsweb](http://www.epa.gov/airsweb)).

### **AIR QUALITY MONITORING**

The monitoring network was developed and is operated to protect public health from the impacts of air pollution by: determining when health-based standards are or may be violated, providing scientific data for decision-making, and providing a measure of program effectiveness.

The monitoring effort began in the 1950s and has grown considerably in complexity to better serve the need for information. In 1957, sporadic assessment of total suspended particulates began. In 1973, the DEP installed its first computerized network and began daily pollution forecasting with the Pollution Standards Index. The years 1978 and 1979 saw the commitment to the SLAMS and NAMS programs, respectively. Moreover, the decade of the 1970s witnessed the development and use of vastly improved continuous monitoring for gaseous pollutants, which displaced more manual methodologies. Ambient dioxin monitoring was instituted in 1987 around each municipal waste combustor operated by the Connecticut Resources Recovery Authority. In 1992, the DEP developed a special purpose monitoring capability and established its first PAMS site. And, by 1995, the Department developed the capability to monitor 100 toxic air pollutants and committed to the PAMS program. In 1998, the network included 37 permanent criteria pollutant sites, seven dioxin monitoring sites and eight mercury monitoring sites.

### **AIR EMISSIONS AND TRENDS**

Over the last twenty years, monitored levels of the criteria pollutants have decreased significantly due to various control measures implemented by DEP and EPA. Since 1975, ambient levels of sulfur dioxide

and carbon monoxide have each decreased by 66%; ozone by 60%; and nitrogen dioxide by 45%. Particulate matter levels have dropped 45% since 1985. Lead levels show the most remarkable decline with monitored concentrations shrinking by 93% since 1975.

The 1980s was a decade of transition for air quality. With new automobiles equipped with catalytic converters, emissions of NO<sub>2</sub>, CO and VOC were greatly reduced. The phasing out of leaded gasoline led to much lower lead levels. New air pollution control technologies for stationary sources, including low sulfur fuels, greatly reduced emissions of SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and VOC. However, even with the decline in monitored levels of all these pollutants, several problems need to be addressed.

Ozone continues to be Connecticut's worst single air pollutant, with the entire state designated nonattainment with the National Ambient Air Quality Standard (NAAQS). Two areas remain nonattainment for CO -- the New Haven CMSA and the Connecticut portion of the CT/NY/NJ CMSA. However, the New Haven CMSA is expected to be redesignated attainment very soon. Also, New Haven is designated nonattainment for particulate matter, but is expected to be redesignated attainment within the next year.

### **MONITORING CHALLENGES**

In addition to these nonattainment issues, the air monitoring program faces a host of challenges in the upcoming years. For example, implementation of a new ozone standard, in which the former one hour averaging time has been increased to eight hours, has required changes in the software developed both for assessing violations and for pollution forecasting. Also, implementation of a new standard for fine particulate matter will necessitate: development of an approved methodology; network planning and expansion; purchase of necessary equipment; the institution of fine particulate monitoring on an accelerated basis; and a revised and expanded quality assurance plan.

In the coming years, monitoring emphasis will shift from criteria pollutants to regional issues, especially transport; local issues, such as hazardous air pollutants; and multi-media studies. Each of these new areas present significant challenges.

Analysis of regional issues requires obtaining and analyzing regional data. The Air Bureau will need more measurement information than can be delivered by its own network. Data from other agencies and states will need to be imported, assessed and utilized. An example of this is the challenge posed by secondary pollutants. Although primary pollutants (e.g., SO<sub>2</sub>) can be transported great distances, it is mostly the secondary pollutants (e.g., O<sub>3</sub> and PM<sub>2.5</sub>) that cause problems at great distances from their precursor emission points. This is due both to the tonnage emitted and the ability of these pollutants to shape-shift in transit. For example, ammonium sulfate particles -- formed from SO<sub>2</sub> and ammonia gas -- can radically change size as they absorb or lose water. And the natural "decay" of ozone late in the day can create nitrogen-based compounds that store up energy which, when released the following day, helps reproduce ozone. These challenges will need to be addressed through cooperative, regional efforts, like the ozone mapping system which the Bureau is helping to develop with EPA and other East Coast States. This type of graphic display will be more effective in reaching the public and conveying a general understanding of air pollution problems. However, significant technology problems must be overcome before real time data can be reliably shared over large areas.

The Bureau is also being called upon more frequently to conduct localized studies on suspected hazardous air pollutants (HAPs), particularly in urban areas. As a result, the development of toxics monitoring capability has become a crucial and emerging field. The Bureau of Air Management must grapple with a variety of problems associated with the measurement of HAPs. In addition to assigning priorities to the nearly 200 such pollutants identified pursuant to section 112(b) of the Clean Air Act, measurement techniques must be developed and field tested for many HAPs because no EPA-approved measurement techniques currently exist.

Cross-program issues of concern, such as mercury and nitrogen deposition, are coming to the forefront. They require monitoring to assess the local and transported contributions to the problems clearly

identified in the water management program. This too requires new monitoring capacity development for the Bureau of Air Management. This multi-media monitoring approach is certain to expand, as awareness grows about the interconnections between the transport of airborne pollutants that result in the deposition of these materials to our food and water supplies.

# I. INTRODUCTION

The 1998 Air Quality Summary of ambient air quality in Connecticut is a compilation of air pollutant measurements made at the official air monitoring network sites operated by the Department of Environmental Protection (DEP).

## A. OVERVIEW OF AIR POLLUTANT CONCENTRATIONS IN CONNECTICUT

The assessment of ambient air quality in Connecticut is made by comparing the measured concentrations of a pollutant to each of two types of Federal air quality standards. The first is the primary standard which is established to protect public health with an adequate margin of safety. The second is the secondary standard which is established to protect plants and animals and to prevent economic damage. The specific air quality standards are listed in Table 1-1 along with the time and data constraints imposed on each.

The following section briefly describes the status of Connecticut's air quality for 1998. More detailed discussions of each of the six pollutants are provided in subsequent sections of this Air Quality Summary.

### 1. PARTICULATE MATTER (PM<sub>10</sub>)

**Revision of the Particulate Matter Standard** - In 1971, the federal Environmental Protection Agency (EPA) promulgated primary and secondary national ambient air quality standards for particulate matter, measured as total suspended particulates or "TSP." The primary standards were set at 260  $\mu\text{g}/\text{m}^3$ , 24-hour average not to be exceeded more than once per year, and 75  $\mu\text{g}/\text{m}^3$ , annual geometric mean. The secondary standard was set at 150  $\mu\text{g}/\text{m}^3$ , 24-hour average not to be exceeded more than once per year. These standards were adopted by Connecticut in 1972.

In accordance with sections 108 and 109 of the Clean Air Act, EPA reviewed and revised the health and welfare criteria upon which these primary and secondary particulate matter standards were based. EPA found that a size-specific indicator for primary standards representing small particles was warranted and that it should include particles of diameter less than or equal to a nominal 10 micrometers "cut point." Such a standard would place substantially greater emphasis on controlling small particles than does a TSP indicator, but would not completely exclude larger particles from all control.

On March 20, 1984, EPA proposed changes in the standards for particulate matter based on its review and revision of the health and welfare criteria. On July 1, 1987, EPA announced its final decisions regarding these changes. They include: (1) replacing TSP as the indicator for particulate matter for the ambient standards with a new indicator that includes only those particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM<sub>10</sub>); (2) replacing the 24-hour primary TSP standard with a 24-hour PM<sub>10</sub> standard of 150  $\mu\text{g}/\text{m}^3$  with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM<sub>10</sub> standard of 50  $\mu\text{g}/\text{m}^3$ , expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM<sub>10</sub> standards that are identical in all respects to the primary standards. On July 7, 1993 the state of Connecticut adopted these new standards for particulate matter.

**Compliance Assessment** - Measured PM<sub>10</sub> concentrations during 1998 did not exceed the 50  $\mu\text{g}/\text{m}^3$  level of the primary and secondary annual standards or the 150  $\mu\text{g}/\text{m}^3$  level of the primary and secondary 24-hour standards at any site. Furthermore, the 24-hour standards were not violated because the "expected number of exceedances" for the most recent 3 years at each site did not exceed one per year. The annual standards were also not violated because the "expected annual mean" for the most recent 3 years at each site did not exceed 50  $\mu\text{g}/\text{m}^3$ .

## 2. SULFUR DIOXIDE (SO<sub>2</sub>)

**Compliance Assessment** - None of the air quality standards for sulfur dioxide were exceeded in Connecticut in 1998. Measured concentrations were below the 80 µg/m<sup>3</sup> primary annual standard, the 365 µg/m<sup>3</sup> primary 24-hour standard, and the 1300 µg/m<sup>3</sup> secondary 3-hour standard at all monitoring sites.

## 3. OZONE (O<sub>3</sub>)

**National Ambient Air Quality Standard (NAAQS)** - On February 8, 1979, the U.S. Environmental Protection Agency (EPA) established an ambient air quality standard for ozone of 0.12 ppm, one-hour average not to be exceeded more than once per year. Furthermore, in order to determine compliance with the 0.12 ppm ozone standard, EPA directs the states to record the number of daily exceedances of 0.12 ppm at a given monitoring site over a consecutive 3-year period and then calculate the average number of daily exceedances for this interval. If the resulting average number of daily exceedances is less than or equal to 1.0, (that is, if the fourth highest daily value in a consecutive 3-year period is less than or equal to 0.12 ppm), the ozone standard is considered to be attained at that site. This standard replaces the old photochemical oxidant standard of 0.08 ppm. The definition of the pollutant was also changed, along with the numerical value of the standard, partly because the instruments used to measure photochemical oxidants in the air really measure only ozone. Ozone is one of a group of chemicals which are formed photochemically in the air and are called photochemical oxidants. In the past, the two terms have often been used interchangeably. This Air Quality Summary uses the term "ozone" in conjunction with the new NAAQS to reflect the changes in both the numerical value of the NAAQS and the definition of the pollutant.

**Compliance Assessment** - The primary 1-hour ozone standard was exceeded at seven of the eleven DEP ozone monitoring sites in 1998 (see Table 1-2). Moreover, nonattainment of the standard remains a fact at eight of the eleven monitoring sites in 1998 because the average number of annual exceedances at each site was greater than one per year over the period 1996-1998. The East Hartford, New Haven and Torrington sites were technically in compliance with the ozone standard over the same period.

## 4. NITROGEN DIOXIDE (NO<sub>2</sub>)

**Compliance Assessment** - The annual average NO<sub>2</sub> standard of 100 µg/m<sup>3</sup> was not exceeded at any site in Connecticut in 1998.

## 5. CARBON MONOXIDE (CO)

**Compliance Assessment** - The primary 8-hour standard of 9 ppm was not exceeded at any of the five carbon monoxide monitoring sites in Connecticut during 1998. In addition, there were no exceedances of the primary 1-hour standard of 35 ppm at any site.

## 6. LEAD (Pb)

**Compliance Assessment** - The primary and secondary ambient air quality standard for lead is 1.5 µg/m<sup>3</sup>, maximum arithmetic mean averaged over three consecutive calendar months. As has been the case since 1980, the lead standard was not exceeded at the lead monitoring site operated in Connecticut during 1998.

## **B. AIR MONITORING NETWORK**

A computerized Air Monitoring Network consisting of an IBM System 7 computer and numerous telemetered monitoring sites was operated in Connecticut for several years. In 1985, this data acquisition system was modernized by installing new data loggers at the monitoring sites and replacing the dedicated IBM System 7 computer with a non-dedicated Data General Eclipse MV10000 computer, which was replaced in 1988 with a MV15000 model. This essentially improved both data accuracy and data capture. In April of 1996, the system was further upgraded with the purchase of state-of-the-art data loggers and PC-based charting software. In addition, the data polling functions performed by the Data General MV15000 were replaced with a primary polling and back-up system on Pentium-class PCs.

As many as 14 measurement parameters are transmitted from a monitoring site via telephone lines to PCs located in the DEP Hartford office and the DEP Windsor lab. The data are then compiled three times daily into 24-hour summaries. The telemetered sites are located in the towns of Bridgeport (2), Danbury, East Hartford (2), Enfield, Greenwich, Groton (2), Hartford (2), Madison, Mansfield, Middletown, New Haven (2), Stafford, Stamford (2), Stratford, Torrington, Waterbury and Westport.

Continuously measured parameters include the pollutants sulfur dioxide, particulates (measured as PM<sub>10</sub>), carbon monoxide, nitric oxide, total nitrogen oxides, ozone and volatile organic compounds or VOC (June through August only). Meteorological data consists of wind speed and direction, temperature, precipitation, barometric pressure, solar radiation and dew point. Other parameters used for quality assurance and troubleshooting are room temperature, calibrator oven temperature, line voltage and air flow.

The real-time capabilities of the telemetry network have enabled the DEP to report the Pollutant Standards Index for a number of towns on a daily basis, while continuously keeping a close watch for high pollution levels which may occur during adverse weather conditions.

The complete monitoring network used in 1998 consisted of the following:

16	Particulate matter (PM <sub>10</sub> ) hi-vol samplers
1	Lead hi-vol sampler
9	Sulfur dioxide analyzers
11	Ozone analyzers
3	Nitrogen dioxide analyzers
5	Carbon monoxide analyzers
3	Automated gas chromatographs for VOC

A complete description of all permanent air monitoring sites in Connecticut operated by DEP in 1998 is available from the Department of Environmental Protection, Bureau of Air Management, Planning & Standards Division, 79 Elm Street, Hartford, Connecticut, 06106-5127.

## **C. POLLUTANT STANDARDS INDEX**

The Pollutant Standards Index (PSI) is a daily air quality index recommended for common use in state and local agencies by the U.S. Environmental Protection Agency. Starting on November 15, 1976, Connecticut began reporting the PSI on a 7-day basis, but is currently reporting the PSI on a 5-day basis for most of the year (6-day during the ozone season) with predictions for the weekends. The PSI incorporates three pollutants : sulfur dioxide, PM<sub>10</sub> and ozone. The index converts each air pollutant concentration into a normalized number where the National Ambient Air Quality Standard for each pollutant corresponds to PSI = 100 and the Significant Harm Level corresponds to PSI = 500.

Figure 1-1 shows the breakdown of index values for the commonly reported pollutants (PM<sub>10</sub>, SO<sub>2</sub>, and O<sub>3</sub>) in Connecticut. For the winter of 1998, Connecticut reported the PM<sub>10</sub> PSI for the towns of

Bridgeport, Burlington, Hartford, New Haven, New London, Norwalk, Norwich, Torrington and Waterbury; and reported the sulfur dioxide PSI for the towns of Bridgeport, Danbury, East Hartford, New Haven, Stamford and Waterbury. For the summer, the ozone PSI was reported for the towns of Danbury, East Hartford, Greenwich, Groton, Madison, Middletown, New Haven, Stafford, Stratford, Torrington and Westport. Each day, the pollutant with the highest PSI value of all the monitored pollutants is reported for each town, along with the dimensionless PSI number and a descriptor label to characterize the daily air quality. A descriptor label of each subsequent day's forecast is also included.

A telephone recording of the PSI is available each afternoon after approximately 3 PM, five days a week, and can be heard by dialing (860) 424-4167. Predictions for weekends are included on the Friday recordings. For answers to specific questions, you can call a DEP representative at (860) 424-3027. The PSI information, as well as health effects information, is also available to the public during weekdays from the American Lung Association of Connecticut in East Hartford by calling (860) 289-5401 or 1-800-992-2263.

#### **D. QUALITY ASSURANCE**

Quality assurance requirements for State and Local Air Monitoring Stations (SLAMS), for National Air Monitoring Stations (NAMS), as part of the SLAMS network, and for Photochemical Assessment Monitoring (PAMS) are specified by the code of Federal Regulations, Title 40, Part 58, Appendix A. The regulations were enacted to provide a consistent approach to quality assurance activities across the country, so that ambient data with a defined precision and accuracy is produced.

Quality assurance of air monitoring systems includes two distinct and important interrelated functions. One function is the control of the measurement process through the implementation of policies, procedures and corrective actions. A quality assurance program was initiated in Connecticut with written procedures covering, but not limited to, the following:

- Equipment procurement
- Equipment acceptance testing
- Equipment installation
- Equipment calibration
- Equipment operation
- Sample analysis
- Maintenance checks
- Performance audits
- Data handling
- Data quality assessment

Quality assurance procedures for the above activities were fully operational on January 1, 1981 for all NAMS monitoring sites. On January 1, 1983 the above procedures were fully operational for all SLAMS monitoring sites. Interim procedures have been in use for all PAMS monitoring sites since June of 1994. In addition, a Quality Assurance Project Plan covering all PAMS sites has been submitted to EPA and is pending approval.

The other function of quality assurance is the assessment of the quality of the air monitoring data -- the product of the measurement process. This assessment is accomplished by determining precision and accuracy values for the analyzer network. Precision and accuracy values are reported in the form of 95% probability limits as defined by equations found in Appendix A of the Federal regulations cited above.

##### **1. PRECISION**

Precision is a measure of repeatability of the measurement process when measuring the same thing, without regard to the accuracy of the measurement. The precision of an air monitoring network is determined as follows:

a. **Manual Samplers** (PM<sub>10</sub>)

A second PM<sub>10</sub> hi-vol sampler is placed alongside the regular network sampler and operated concurrently. In a precision check, the concentration value from the collocated hi-vol sampler is compared to the network sampler concentration value, and the percentage difference is calculated for the measurement pair. The average and the standard deviation of the percentage differences are determined for each sampling site.

The statistics from each sampling site are used to calculate an average percentage difference and a pooled standard deviation for the entire sampling network. These network statistics are then used to report the precision of the sampling network as a range of percentage differences with a lower and upper probability limit. As reported, the precision expresses a 95% confidence that the specified range contains the true average percentage difference for the network.

b. **Automated Analyzers** (SO<sub>2</sub>, O<sub>3</sub>, CO and NO<sub>2</sub>)

All NAMS and SLAMS analyzers are challenged with a low level pollutant concentration a minimum of once every two weeks: 8 to 10 ppm for CO and 0.08 to 0.10 ppm for SO<sub>2</sub>, O<sub>3</sub> and NO<sub>2</sub>. In a precision check, the percentage difference between the analyzer response and the input concentration is calculated. For each analyzer, the average and the standard deviation of the percentage differences are calculated from the precision checks.

The statistics from each sampling site are used to calculate an average percentage difference and a pooled standard deviation for the entire sampling network. These network statistics are then used to report the precision of the sampling network as a range of percentage differences with a lower and upper probability limit. As reported, the precision expresses a 95% confidence that the specified range contains the true average percentage difference for the network.

c. **Automated Analyzers** (VOC)

Analyzers are challenged with a low level calibration standard every fifty hours. The standard contains all fifty-five VOC target compounds in concentrations ranging from 2.5 to 6 parts per billion carbon (ppbc). The mean measured value for each compound is used as the target value from which precision estimates are generated.

2. **ACCURACY**

Accuracy is an estimate of the closeness of a measured value to a known value. The accuracy of an air monitoring network is determined in the following manner:

a. **Manual Methods** (PM<sub>10</sub>)

Accuracy for PM<sub>10</sub> is assessed by auditing the flow measurement phase of the sampling method. In Connecticut, this is accomplished by attaching a secondary standard calibrated orifice to the hi-vol inlet and comparing the measured flow rate

to the design flow rate. A minimum of 25% of the PM<sub>10</sub> network samplers is audited each quarter.

In an accuracy audit, the percentage difference between the measured flow rate and the design flow rate is calculated for each sampler. The average and the standard deviation of the percentage differences are determined for the entire sampling network from the audits on the individual samplers. These network statistics are then used to report the accuracy of the sampling network as a range of percentage differences with a lower and upper probability limit. As reported, the accuracy expresses a 95% confidence that the specified range contains the true average percentage difference for the network.

**b. Manual Methods (Lead)**

Accuracy for lead is assessed by auditing the flow, as in 2.a. above.

**c. Automated Analyzers (SO<sub>2</sub>, O<sub>3</sub>, CO and NO<sub>2</sub>)**

Automated analyzer data accuracy is determined by challenging each analyzer with three predetermined concentration levels (four for NO<sub>2</sub>). Each quarter, accuracy values are calculated for approximately 25% of the analyzers in a pollutant sampling network, at each concentration level. The results for each concentration level of a particular pollutant are used to assess automated analyzer accuracy. The audit concentration levels are as follows:

SO <sub>2</sub> , O <sub>3</sub> , and NO <sub>2</sub> (PPM)	CO (PPM)
0.03 to 0.08	3 to 8
0.15 to 0.20	15 to 20
0.35 to 0.45	35 to 45

For each audit concentration, the percentage difference between the input concentration and the analyzer response is calculated. For each audit concentration level, the average and the standard deviation of the percentage differences for the entire analyzer network are determined from the audit results on each analyzer. These network statistics are then used to report the accuracy of the sampling network, for each concentration level, as a range of percentage differences with a lower and upper probability limit. As reported for a concentration level, the accuracy expresses a 95% confidence that the specified range contains the true average percentage difference for the network.

**d. Automated Analyzers (VOC)**

The accuracy of automated gas chromatographs used for VOC analysis is determined by analyzing "blind" audit samples supplied by EPA. Audit samples contain an unknown number of VOC at unspecified concentrations. Both the analysis results and the audit gas are sent back to EPA. EPA reanalyzes the audit gas (i.e., if sufficient quantity remains) to establish stability of the mixture, and returns audit results which highlight compounds outside expected accuracy levels (typically +/-35%).

**TABLE 1-1**

**ASSESSMENT OF AMBIENT AIR QUALITY**

POLLUTANT	SAMPLING PERIOD	DATA REDUCTION	STATISTICAL BASE	AMBIENT AIR QUALITY STANDARDS			
				PRIMARY		SECONDARY	
				: g/m <sup>3</sup>	ppm	: g/m <sup>3</sup>	ppm
Particulates (PM <sub>10</sub> ) <sup>a</sup>	24 Hours (every 6th day)	24-Hour Average	Annual Arithmetic Mean <sup>b</sup>	50 <sup>c</sup>		50 <sup>c</sup>	
			24-Hour Average	150 <sup>d</sup>		150 <sup>d</sup>	
Sulfur Oxides (measured as SO <sub>2</sub> )	Continuous	1-Hour Average	Annual Arithmetic Mean <sup>e</sup>	80	0.03		
			24-Hour Average <sup>e</sup>	365 <sup>f</sup>	0.14 <sup>f</sup>		
			3-Hour Average <sup>e</sup>			1300 <sup>f</sup>	0.5 <sup>f</sup>
Nitrogen Dioxide	Continuous	1-Hour Average	Annual Arithmetic Mean <sup>e</sup>	100	0.053	100	0.053
Ozone	Continuous	1-Hour Average	1-Hour Average	235 <sup>g</sup>	0.12 <sup>g</sup>	235 <sup>g</sup>	0.12 <sup>g</sup>
			8-Hour Average		0.08 <sup>h</sup>		0.08 <sup>h</sup>
Carbon Monoxide	Continuous	1-Hour Average	8-Hour Average <sup>e</sup>	10 <sup>f,i</sup>	9 <sup>f</sup>	10 <sup>f,i</sup>	9 <sup>f</sup>
			1-Hour Average	40 <sup>f,i</sup>	35 <sup>f</sup>	40 <sup>f,i</sup>	35 <sup>f</sup>
Lead	24 Hours (every 6th day)	Monthly Composite	3-Month Average <sup>j</sup>	1.5		1.5	

<sup>a</sup> Particulate matter with an aerodynamic diameter not greater than a nominal 10 micrometers.

<sup>b</sup> EPA assessment criteria require 4 calendar quarters of data per year and at least 75% of the scheduled samples per quarter in each of the most recent 3 years.

<sup>c</sup> The "expected annual mean" for the most recent 3 years must not exceed the level of the standard.

<sup>d</sup> The "expected number of exceedances" per calendar year should be less than or equal to one, for the most recent 3 years.

<sup>e</sup> EPA assessment criteria require at least 75% of the possible data to compute a valid average. For the annual mean, 9 months of data are required, and each calendar quarter must have at least 2 months of data. Furthermore, a valid month must have at least 21 days of data, and a valid day must have at least 18 hours of data.

<sup>f</sup> Not to be exceeded more than once per year.

<sup>g</sup> Daily maximum. The expected number of days that exceed the level of standard is not to average more than one per year in three years at a site.

<sup>h</sup> Daily maximum. The 3-year average of the annual fourth highest daily maximum at a site must not exceed the level of the standard.

<sup>i</sup> Units are mg/m<sup>3</sup>, not : g/m<sup>3</sup>.

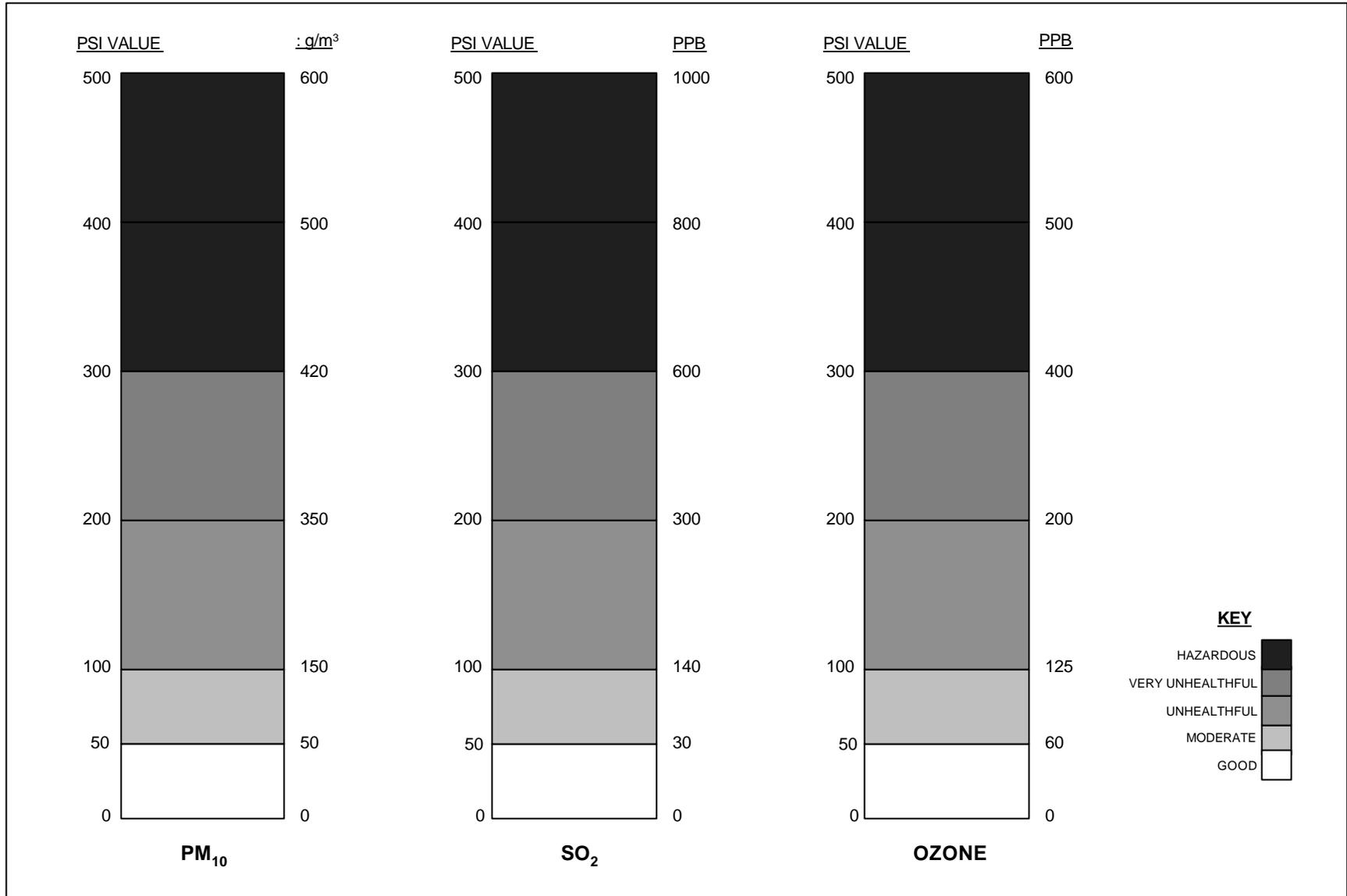
<sup>j</sup> State of Connecticut assessment criteria require at least 75% of the scheduled samples to compute a valid average.

**TABLE 1-2****AIR QUALITY STANDARDS EXCEEDED IN CONNECTICUT IN 1998**  
**BASED ON MEASURED CONCENTRATIONS**

<u>SITE</u>	<u>OZONE</u>			
	<u>Level Exceeding 1-Hour standard (0.12 PPM)</u>		<u>Level Exceeding 8-Hour standard (0.08 PPM)</u>	
	<u>Highest Observed Level (ppm)</u>	<u>Number of Days Standard Exceeded</u>	<u>Highest Observed Level (ppm)</u>	<u>Number of Days Standard Exceeded</u>
Danbury 123			0.102	9
East Hartford 003	0.139	1	0.103	2
Greenwich 017			0.097	8
Groton 008	0.135	1	0.109	3
Madison 002	0.139	2	0.107	9
Middletown 007	0.145	1	0.114	5
New Haven 123			0.088	3
Stafford 001	0.142	2	0.118	8
Stratford 007	0.148	3	0.109	11
Torrington 006			0.098	10
Westport 003	0.133	2	0.106	13

# FIGURE 1-1

## POLLUTANT STANDARDS INDEX



## II. PARTICULATE MATTER

### HEALTH EFFECTS

Particulate matter is the generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles originate from a variety of stationary and mobile sources. They may be emitted directly or formed in the atmosphere by transformations of gaseous emissions such as sulfur oxides, nitrogen oxides, and volatile organic substances. The chemical and physical properties of particulate matter vary greatly with time, region, meteorology and source category.

The major effects associated with high exposures to particulate matter include reduced lung function; interference with respiratory mechanics; aggravation or potentiation of existing respiratory and cardiovascular disease, such as chronic bronchitis and emphysema; increased susceptibility to infection; interference with clearance and other host defense mechanisms; damage to lung tissues; carcinogenesis and mortality.

Harm may also occur in the form of changes in the human body caused by chemical reactions with pollution particles that pass through the lung membranes to poison the blood or be carried by the blood to other organs. This can happen with inhaled lead, cadmium, beryllium, and other metals, and with certain complex organic compounds that can cause cancer.

Population subgroups that appear likely to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly, children, smokers, and mouth or oronasal breathers.

### REVISION OF THE PARTICULATE MATTER STANDARD

In 1971, the federal Environmental Protection Agency (EPA) promulgated primary and secondary national ambient air quality standards for particulate matter, measured as total suspended particulates or "TSP." The primary standards were set at  $260 \mu\text{g}/\text{m}^3$ , 24-hour average not to be exceeded more than once per year, and  $75 \mu\text{g}/\text{m}^3$ , annual geometric mean. The secondary standard, also measured as TSP, was set at  $150 \mu\text{g}/\text{m}^3$ , 24-hour average not to be exceeded more than once per year. These standards were adopted by the state of Connecticut in 1972. In accordance with sections 108 and 109 of the Clean Air Act, EPA has reviewed and revised the health and welfare criteria upon which these primary and secondary particulate matter standards were based.

The TSP standard directs control efforts towards particles of lower risk to health because of its inclusion of large particles which can dominate the measured mass concentration, but which are deposited only in the extrathoracic region. Smaller particles penetrate furthest in the respiratory tract, settling in the tracheobronchial region and in the deepest portion of the lung, the alveolar region. Available evidence demonstrates that the risk of adverse health effects associated with deposition of typical ambient fine and coarse particles in the thorax are markedly greater than those associated with deposition in the extrathoracic region. EPA found that a size-specific indicator for primary standards representing small particles was warranted and that it should include particles of diameter less than or equal to a nominal 10 micrometers "cut point." Such a standard places substantially greater emphasis on controlling smaller particles than does a TSP indicator, but doesn't completely exclude larger particles from all control.

On March 20, 1984, EPA proposed changes in the standards for particulate matter based on its review and revision of the health and welfare criteria. On July 1, 1987, EPA announced its final decisions regarding these changes. They include: (1) replacing TSP as the indicator for particulate matter for the ambient standards with a new indicator that includes only those particles with an aerodynamic diameter less

than or equal to a nominal 10 micrometers (PM<sub>10</sub>); (2) replacing the 24-hour primary TSP standard with a 24-hour PM<sub>10</sub> standard of 150 :g/m<sup>3</sup> with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM<sub>10</sub> standard of 50 :g/m<sup>3</sup>, expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM<sub>10</sub> standards that are identical in all respects to the primary standards. The federal standards became effective on July 31, 1987. On July 7, 1993, the state of Connecticut adopted these new standards for particulate matter.

## **CONCLUSIONS**

Measured PM<sub>10</sub> concentrations during 1998 did not exceed the 50 µg/m<sup>3</sup> level of the primary and secondary annual standards or the 150 µg/m<sup>3</sup> level of the primary and secondary 24-hour standards at any site. Moreover, the 24-hour standards were not violated because the "expected number of exceedances" for the most recent 3 years at each site did not exceed one per year. The annual standards were also not violated anywhere because the "expected annual mean" for the most recent 3 years at each site did not exceed 50 µg/m<sup>3</sup>. (The "expected" statistic is an extrapolation that compensates for the fact that PM<sub>10</sub> sampling is not done on a daily basis, but every sixth day.)

## **SAMPLE COLLECTION AND ANALYSIS**

**High Volume TSP Sampler (Hi-vol)** - The high volume sampler resembles a vacuum cleaner in its operation, with an 8" X 10" piece of fiberglass filter paper replacing the vacuum bag. Hi-vols are equipped with retractable lids in order to eliminate passive sampling error. The sampler normally operates every sixth day (midnight to midnight, standard time).

The matter collected on the filters is analyzed for weight in the case of the PM<sub>10</sub> samplers and for both weight and chemical composition in the case of the hi-vol samplers. The chemical composition of the suspended particulate matter is determined at each hi-vol site as follows. Two standardized strips of every filter are cut out and prepared for two different analyses. In the first analysis, a sample is digested in acid and the resulting solution is analyzed for metals by means of an atomic absorption spectrophotometer. The results are reported for each individual metal in µg/m<sup>3</sup>. In the second analysis, a sample is dissolved in water, filtered and the resulting solution is analyzed by means of wet chemistry techniques to determine the concentration of certain water soluble components. The results are reported for each individual constituent of the water soluble fraction in µg/m<sup>3</sup>.

**PM<sub>10</sub> Sampler** - Before 1988, Connecticut's particulate sampling network was comprised of standard high-volume (hi-vol) samplers, whose function was to measure TSP. With the promulgation of a PM<sub>10</sub> standard, hi-vol samplers were needed that could screen out most particles larger than 10 microns. The samplers also had to be omnidirectional and have a constant inlet velocity so that wind direction and speed would not affect the amount of material collected.

In anticipation of a PM<sub>10</sub> standard, Connecticut installed a small number of PM<sub>10</sub> samplers in 1985. The samplers, manufactured by Sierra-Andersen, were the first PM<sub>10</sub> samplers on the market. These early samplers were found to have relatively high maintenance requirements and to be biased towards particles larger than 10 microns. To remedy these problems, the samplers were physically modified after 1986. In 1987, PM<sub>10</sub> samplers by Wedding & Associates came on the market. These samplers replaced the Andersen samplers in the sampling network in 1988. The Wedding samplers have demonstrated lower maintenance requirements and greater precision (repeatability) and accuracy than the Andersen samplers they replaced.

The PM<sub>10</sub> samplers, like the standard hi-vol samplers, operate from midnight to midnight (standard time) at least every sixth day at all sites. However, PM<sub>10</sub> samplers use quartz fiber filters instead of fiberglass filters, in order to eliminate sulfate artifact formation. The matter collected on the filter is analyzed only for weight and sulfates at the present time. The air flow is recorded during sampling. The weight in

micrograms ( $\mu\text{g}$ ) divided by the volume of air in standard cubic meters ( $\text{m}^3$ ) yields the concentration of  $\text{PM}_{10}$  for the day in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ).

**TEOM Sampler** - Connecticut also operates real-time  $\text{PM}_{10}$  monitors that employ tapered element oscillating microbalance (TEOM) technology. The TEOM technique utilizes an exchangeable filter cartridge on the end of a hollow tapered tube. The other (wider) end of the tube is fixed. Air is passed through the filter, on which particulate matter deposits, and the filtered air passes through the tapered tube to a flow controller.

The tapered tube is maintained in oscillation. The frequency of oscillation is dependent upon the physical characteristics of the tapered tube and the mass on its free end. As particulate matter lands on the filter, the filter mass change is detected as a frequency change in the oscillation of the tube. The mass of the particulate matter is then determined directly and inertially. When this mass change is combined with the flow rate through the system, the device yields an accurate measurement of the particulate concentration in real time.

Such a continuous particulate monitoring system has advantages over manual systems like the hi-vol. Not only does TEOM technology provide more detailed information than a 24-hour average, but it also reduces the amount of labor required for these measurements, since the filter handling procedures are significantly reduced.

## **DISCUSSION OF DATA**

**Monitoring Network** - In 1998, the Connecticut DEP operated sixteen sampling sites for  $\text{PM}_{10}$  in the state (see Figure 2-1).

**Precision and Accuracy** - Precision checks were conducted at three  $\text{PM}_{10}$  sampling sites which had collocated samplers. On the basis of 109 precision checks, the 95% probability limits for precision ranged from -7% to +11%. Accuracy is based on air flow through the monitor. The 95% probability limits for accuracy, based on 19 audits conducted on the  $\text{PM}_{10}$  monitoring system network, ranged from -3% to +8%. (For an explanation of the use of 95% probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**Annual Averages** - The Federal EPA has established minimum sampling criteria (see Table 1-1) for use in determining compliance with the primary and secondary annual NAAQS for  $\text{PM}_{10}$ . A site must have 75% of the scheduled samples in each calendar quarter for the the most recent 3 years. Using the EPA criteria, one finds that a determination of attainment or nonattainment of the  $50 \mu\text{g}/\text{m}^3$  primary and secondary annual standards could be obtained at twelve of the sixteen  $\text{PM}_{10}$  monitoring sites in Connecticut in 1998. These twelve sites proved to be in attainment of the annual standards. A determination of attainment or nonattainment could not be obtained at Bridgeport, Danbury, Darien and New Haven 018, where there were insufficient data at each site in at least one calendar quarter during the most recent three years. Nevertheless, given the 95 percent confidence limits about the annual mean at these sites (see Table 2-1), it is likely that attainment was achieved.

A summary of annual average  $\text{PM}_{10}$  data for 1996 -1998 is presented in Table 2-1. This table also includes an indication of whether the aforementioned EPA minimum sampling criteria were met at each site for each year. If the sampling in any year was insufficient to meet the EPA criteria, an asterisk appears next to the year. Figure 2-2 illustrates the annual average  $\text{PM}_{10}$  concentrations at each site in 1998.

**Statistical Projections** - The statistical projections presented in Table 2-1 are prepared by a DEP computer program which analyzes data from all sites operated by DEP. Inputs to the program include the site location, the year, the number of samples (usually a maximum of 61), the annual arithmetic and geometric mean concentrations, and the arithmetic and geometric standard deviations. For each site, the program makes two calculations. It determines the 95% confidence limits about the annual arithmetic mean of the sample concentrations. And it predicts the number of days in each year that would have exceeded the

level of the primary and secondary 24-hour standards (i.e.,  $150 \mu\text{g}/\text{m}^3$ ) if sampling had been conducted every day. (For comparison, Table 2-1 also shows the number of days, if any, at each site when the level of the primary and secondary 24-hour standards was actually exceeded, as demonstrated by actual measurements at the site.)

The statistical predictions of the number of days that would have seen an exceedance of the level of the 24-hour standards are based on the assumption of a lognormal distribution of the data. They indicate that more frequent  $\text{PM}_{10}$  sampling from 1996 to 1998 would not have resulted in an exceedance of the 24-hour standards.

Due to manpower and economic limitations,  $\text{PM}_{10}$  sampling for particulate matter cannot be conducted every day. As a result, a degree of uncertainty is introduced as to whether the air quality at a site has either met or exceeded the level of the annual standards. This uncertainty can be expressed by means of a statistic called a confidence limit. Assuming a normal distribution of the pollutant data, 95% confidence limits can be calculated about the annual arithmetic mean of the sample concentrations at each site. For example (see Table 2-1), at East Hartford in 1997, 59 samples were analyzed and an arithmetic mean of  $20.8 \mu\text{g}/\text{m}^3$  was then calculated. The columns labeled "95-PCT-LIMITS" show the lower and upper limits of the 95% confidence interval to be 18.4 and  $23.3 \mu\text{g}/\text{m}^3$ , respectively. This means that, if sampling were done every day, there is a 95% chance that the true arithmetic mean would fall between these limits. Since the upper 95% limit is less than  $50 \mu\text{g}/\text{m}^3$ , one can be confident that the level of the annual standards was not exceeded at the site. However, if the upper 95% limit were greater than and the lower 95% limit were less than  $50 \mu\text{g}/\text{m}^3$ , then one could not be confident that the standard was not exceeded at the site. If both the upper and lower 95% limits were greater than  $50 \mu\text{g}/\text{m}^3$ , then one could assume that the level of the standards was exceeded sometime during the year. These three possibilities are illustrated in Figure 2-3.

It should be noted that the above discussion of statistical projections does not affect the actual determination of attainment or nonattainment of the  $\text{PM}_{10}$  standards. The promulgated regulations specify the requirements for making an attainment determination. Those requirements, mentioned in a limited way in Table 1-1, address the projection of exceedances and the calculation and use of arithmetic means in ways that are different from the foregoing discussion.

**24-Hour Averages** - Figure 2-4 presents the maximum 24-hour concentrations recorded at each site. There were no  $\text{PM}_{10}$  concentrations at any site that exceeded the  $150 \mu\text{g}/\text{m}^3$  level of the primary and secondary 24-hour standards in 1998. Of the fourteen sites that had sufficient data in both 1997 and 1998, eleven sites had lower maximum concentrations and three sites had higher maximum concentrations in 1998 than in 1997. The largest decrease was  $28 \mu\text{g}/\text{m}^3$  at Voluntown, and the largest increase was  $6 \mu\text{g}/\text{m}^3$  at Burlington.

A determination of actual compliance with the primary and secondary 24-hour standards can be made for a site only when the minimum sampling criteria are met in each calendar quarter for the most recent 3 years. Based on these criteria, compliance was achieved at 12 of the 16 sites in 1998. A determination of compliance could not be made for the 4 sites mentioned earlier because there were insufficient data at each site in at least one calendar quarter during the most recent three years. But based upon the data that is available, it is highly improbable that an exceedance would have occurred at any of these sites.

**Highest Daily Concentrations and Wind Data** - On a statewide and historical basis, the highest  $\text{PM}_{10}$  concentrations occur most often on days when persistent winds out of the southwest quadrant predominate. During the fifteen year period between 1981 and 1995, 45% of the annual ten highest daily concentrations of particulate matter at each monitoring site in the state occurred when such wind conditions prevailed. This relationship between southwest quadrant winds and high particulate levels has historically been more prevalent in southwestern Connecticut.

Notwithstanding the above, many of the maximum levels at some urban sites do not occur with southwest quadrant winds, indicating that these sites are possibly influenced by local sources or transport from different out-of-state sources. Also, a large scale southwesterly air flow is often diverted into a

southerly flow up the Connecticut River Valley and, for sites located there, many of the highest PM<sub>10</sub> days occur when the winds are from the south.

**Trends** - Pollutant trends can be illustrated in a number of ways. It is desirable to portray a PM<sub>10</sub> trend that is both statewide in nature and relevant to one of the ambient air quality standards. This can be accomplished by averaging the annual mean PM<sub>10</sub> concentrations at a number of monitoring sites for each year of a period of years. This is done in Figure 2-5 for seven monitoring sites from 1989, the first full year of PM<sub>10</sub> monitoring. The seven sites are Burlington, East Hartford, Enfield, New Haven 123, Norwalk, Norwich and Waterbury. These sites were used because they were the only sites that met the minimum sampling criteria in each year of the period. Figure 2-5 shows that, in spite of the year-to-year variation, statewide PM<sub>10</sub> levels appear to be trending downward.

Significant changes in annual PM<sub>10</sub> levels can be caused by a number of things. Among these are simple changes of weather; changes in annual fuel use associated with conservation efforts or heating demand; the frequency of precipitation events, which wash out particulates from the atmosphere; changes in average wind speed, since higher winds result in greater dilution of emissions; and a change in the frequency of southwest quadrant winds, which affect the amount of particulate matter transported into Connecticut from the New York City metropolitan area and from other sources of emissions located west to south of the state. In illustrating a trend, these year-to-year effects can be diminished, if not eliminated, by using a multiple-year average of three years or more. Figure 2-6 illustrates the trend of PM<sub>10</sub> using a three-year average. The trend is clearly down and shows a 20.4% decrease over the eight years.

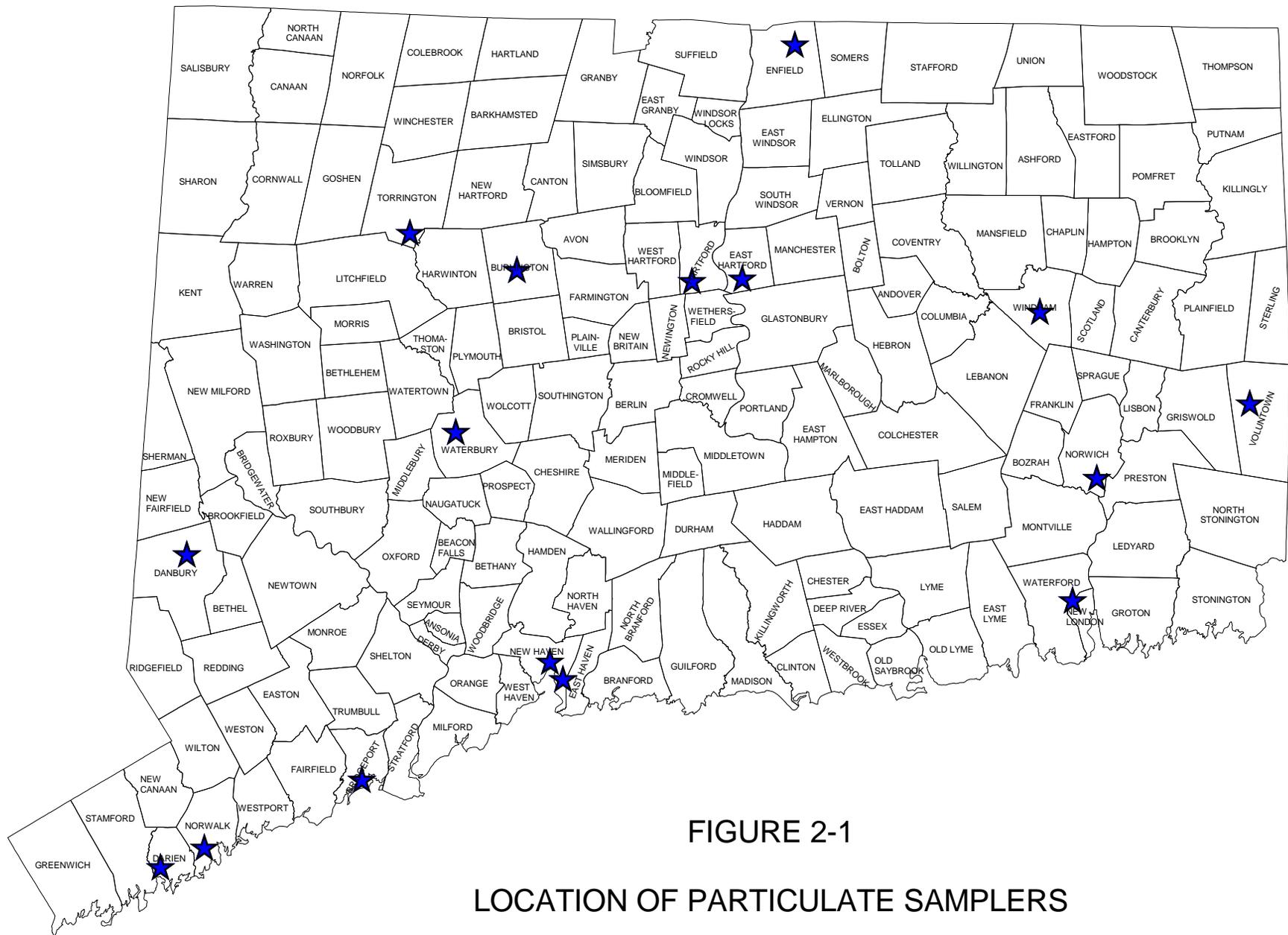


FIGURE 2-1

LOCATION OF PARTICULATE SAMPLERS

**TABLE 2-1**

**1996-1998 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS**

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC	95--PCT--LIMITS		STANDARD	PREDICTED	MEASURED
				MEAN	LOWER	UPPER	DEVIATION	DAYS OVER 150 : g/m <sup>3</sup>	DAYS OVER 150 : g/m <sup>3</sup>
BRIDGEPORT	010	1996	59	20.6	18.4	22.8	9.272		
BRIDGEPORT	010	1997*	54	21.5	18.8	24.2	10.820		
BRIDGEPORT	010	1998	57	20.6	18.4	22.8	9.026		
BRIDGEPORT	014	1996	60	26.8	24.2	29.3	11.002		
BURLINGTON	001	1996	58	12.4	10.4	14.4	8.160		
BURLINGTON	001	1997	58	13.7	11.7	15.7	8.188		
BURLINGTON	001	1998	56	13.5	11.6	15.4	7.690		
DANBURY	123	1996*	51	21.7	19.3	24.2	9.381		
DANBURY	123	1997	60	21.2	18.8	23.6	10.189		
DANBURY	123	1998	57	20.2	18.2	22.2	8.062		
DARIEN	001	1996*	56	23.2	20.6	25.7	10.365		
DARIEN	001	1997	59	25.9	23.4	28.4	10.397		
DARIEN	001	1998	61	23.5	21.5	25.5	8.504		
EAST HARTFORD	004	1996	60	20.0	17.7	22.4	9.988		
EAST HARTFORD	004	1997	59	20.8	18.4	23.3	10.150		
EAST HARTFORD	004	1998	58	19.3	17.2	21.4	8.723		
ENFIELD	005	1996	58	15.9	13.6	18.3	9.897		
ENFIELD	005	1997	59	16.2	14.1	18.3	8.857		
ENFIELD	005	1998	58	15.7	13.7	17.8	8.347		
GREENWICH	017	1996	57	18.0	15.8	20.2	9.071		
GREENWICH	017	1997	61	19.9	16.7	23.1	13.660		

\* THE NUMBER OF SAMPLES IS NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

## TABLE 2-1, CONTINUED

### 1996-1998 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC	95--PCT--LIMITS		STANDARD	PREDICTED	MEASURED
				MEAN	LOWER	UPPER	DEVIATION	DAYS OVER 150 : g/m <sup>3</sup>	DAYS OVER 150 : g/m <sup>3</sup>
HARTFORD	013	1996	59	17.2	15.1	19.4	9.004		
HARTFORD	013	1997	61	18.9	16.6	21.2	9.977		
HARTFORD	013	1998	61	18.0	16.2	19.9	8.003		
HARTFORD	015	1996	60	21.3	18.8	23.7	10.526		
HARTFORD	015	1997	59	22.4	19.8	25.0	10.775		
MIDDLETOWN	003	1996	59	17.7	15.4	20.0	9.619		
MIDDLETOWN	003	1997	58	18.5	16.3	20.8	9.257		
NEW HAVEN	018	1996	58	28.2	25.3	31.1	11.963		
NEW HAVEN	018	1997*	54	29.1	26.3	31.8	11.046		
NEW HAVEN	018	1998	60	27.1	24.6	29.6	10.485		
NEW HAVEN	020	1996*	50	21.0	18.1	23.8	10.647		
NEW HAVEN	020	1997	61	21.7	19.5	23.8	9.093		
NEW HAVEN	123	1996	61	20.6	18.3	22.8	9.792		
NEW HAVEN	123	1997	61	21.2	19.0	23.5	9.588		
NEW HAVEN	123	1998	59	20.7	18.5	22.8	8.904		
NEW LONDON	004	1996	58	18.3	15.8	20.8	10.274		
NEW LONDON	004	1997	54	17.9	15.4	20.4	10.047		
NEW LONDON	004	1998	60	16.6	14.9	18.3	7.356		
NORWALK	014	1996	58	32.5	29.4	35.6	12.789		
NORWALK	014	1997	59	31.4	28.6	34.2	11.838		
NORWALK	014	1998	59	28.1	25.8	30.4	9.705		

\* THE NUMBER OF SAMPLES IS NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

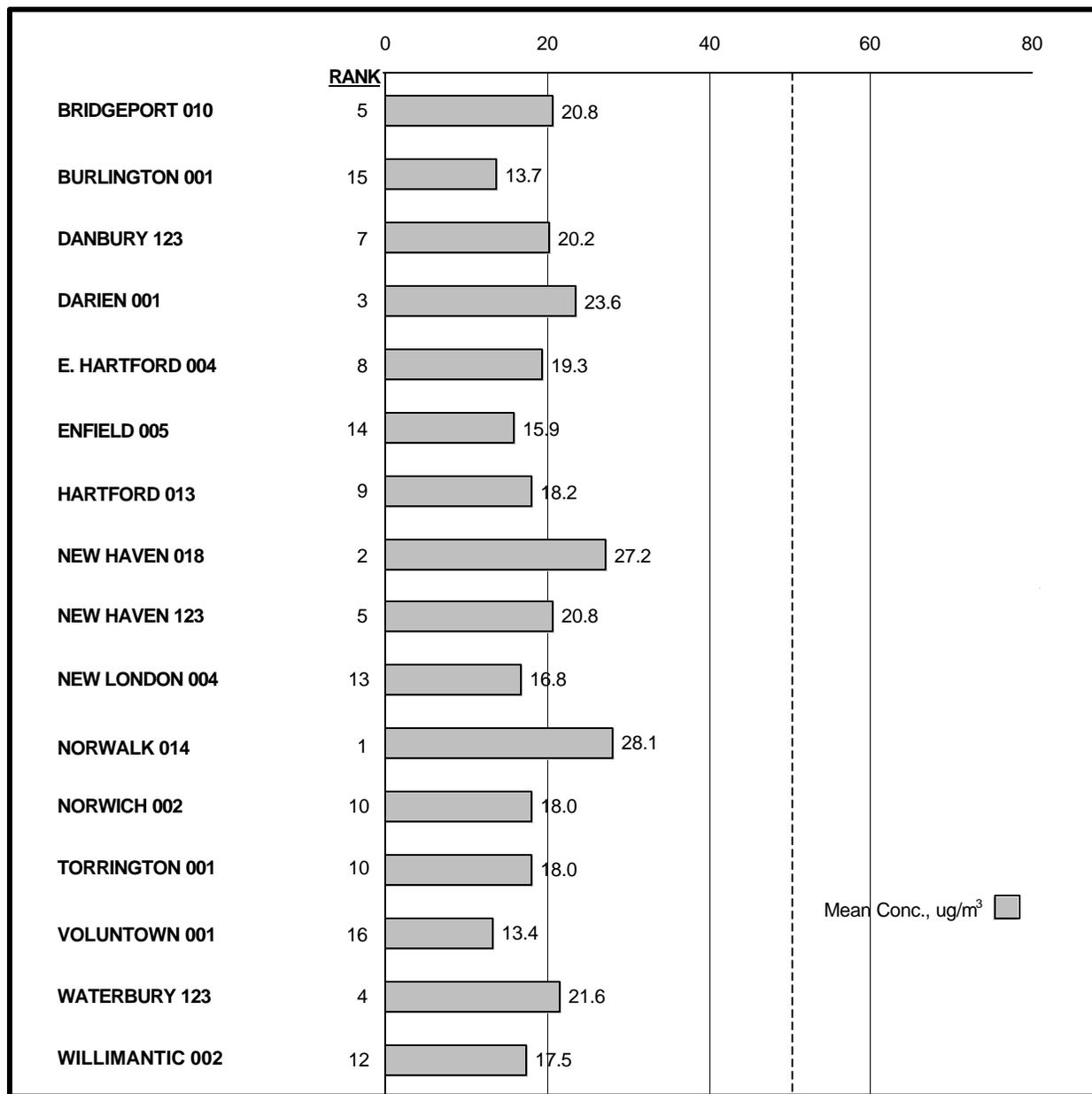
## TABLE 2-1, CONTINUED

### 1996-1998 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC	95--PCT--LIMITS		STANDARD DEVIATION	PREDICTED	MEASURED
				MEAN	LOWER	UPPER		DAYS OVER 150 : g/m <sup>3</sup>	DAYS OVER 150 : g/m <sup>3</sup>
NORWICH	002	1996	59	19.1	16.3	21.8	11.457		
NORWICH	002	1997	56	18.9	16.6	21.2	9.251		
NORWICH	002	1998	59	17.8	15.9	19.7	8.036		
TORRINGTON	001	1996	59	18.1	15.7	20.5	9.955		
TORRINGTON	001	1997	57	18.4	16.4	20.4	8.186		
TORRINGTON	001	1998	59	17.9	15.9	19.9	8.349		
VOLUNTOWN	001	1996	54	14.4	11.8	17.1	10.561		
VOLUNTOWN	001	1997	59	15.4	12.8	18.0	10.886		
VOLUNTOWN	001	1998	60	13.4	11.6	15.1	7.374		
WALLINGFORD	006	1996	61	17.2	14.9	19.4	9.645		
WALLINGFORD	006	1997	60	18.2	15.8	20.5	9.774		
WATERBURY	123	1996	61	25.4	22.3	28.5	13.250		
WATERBURY	123	1997	58	23.3	21.0	25.5	9.419		
WATERBURY	123	1998	58	21.7	19.5	23.8	8.943		
WILLIMANTIC	002	1996	60	17.8	15.5	20.0	9.493		
WILLIMANTIC	002	1997	59	17.4	15.4	19.4	8.429		
WILLIMANTIC	002	1998	59	17.4	15.4	19.3	8.040		

# FIGURE 2-2

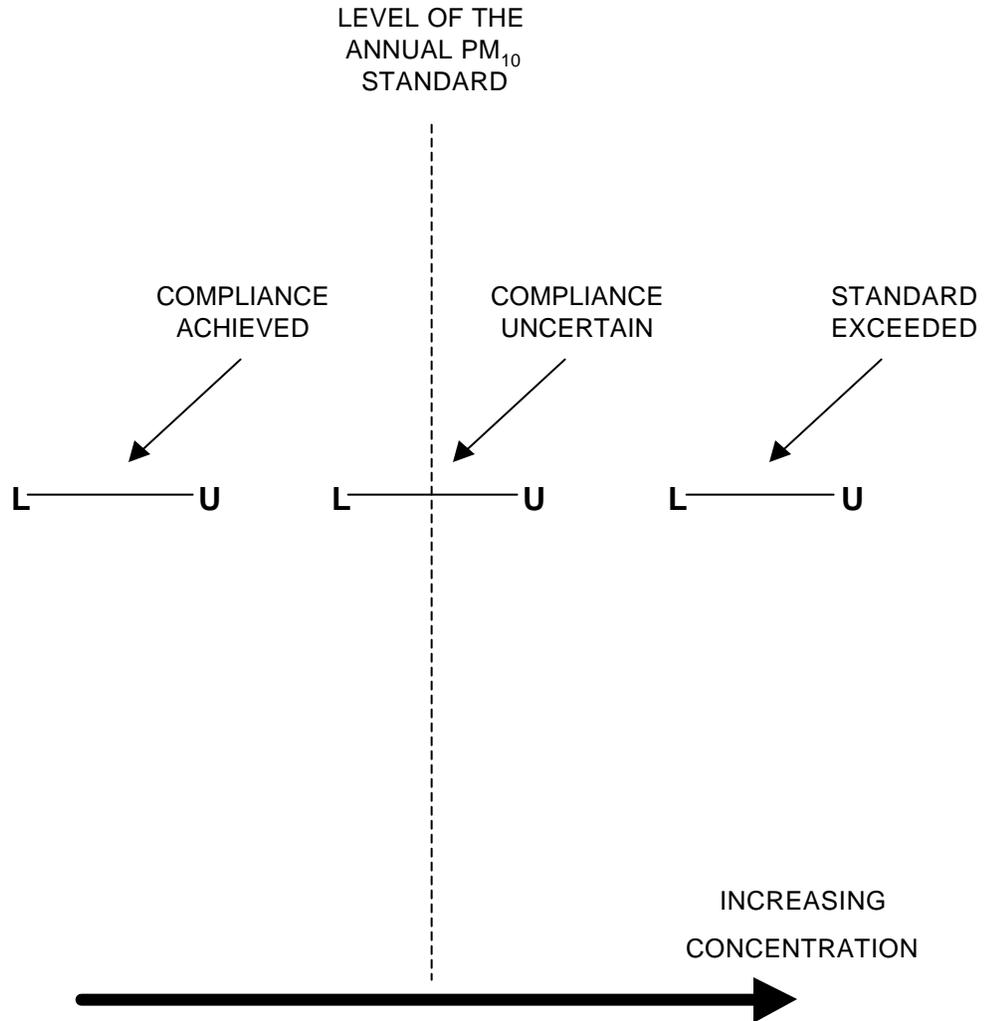
## ANNUAL AVERAGE PM10 CONCENTRATIONS IN 1998



50 ug/m<sup>3</sup>  
EXCEEDANCE LEVEL OF THE  
PRIMARY AND  
SECONDARY STANDARD

**FIGURE 2-3**

**COMPLIANCE WITH THE LEVEL OF THE ANNUAL PM<sub>10</sub> STANDARDS**  
**USING 95% CONFIDENCE LIMITS ABOUT**  
**THE ANNUAL ARITHMETIC MEAN CONCENTRATION**

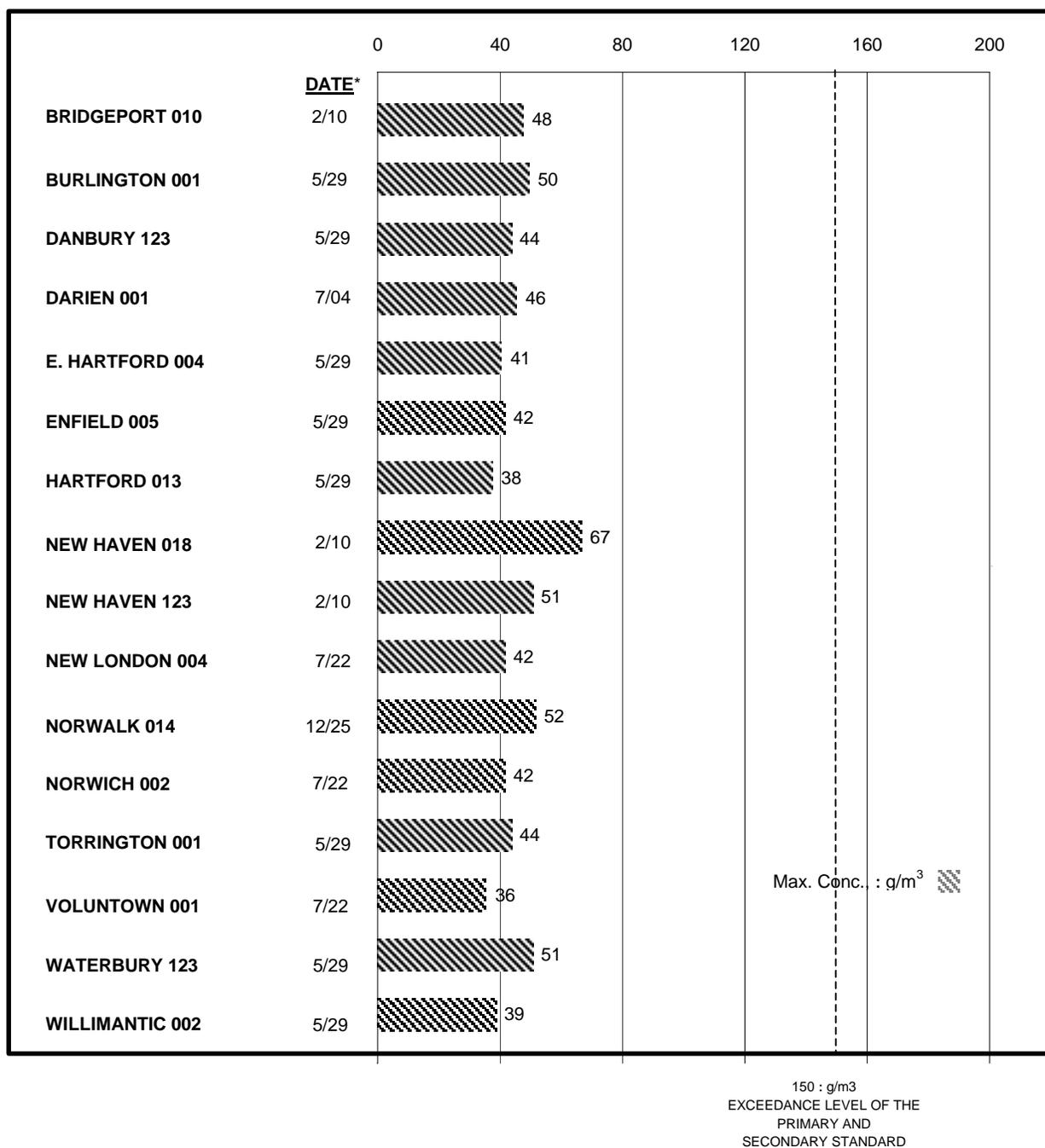


L = lower limit of the 95% confidence interval about the annual arithmetic mean concentration

U = upper limit of the 95% confidence interval about the annual arithmetic mean concentration

# FIGURE 2-4

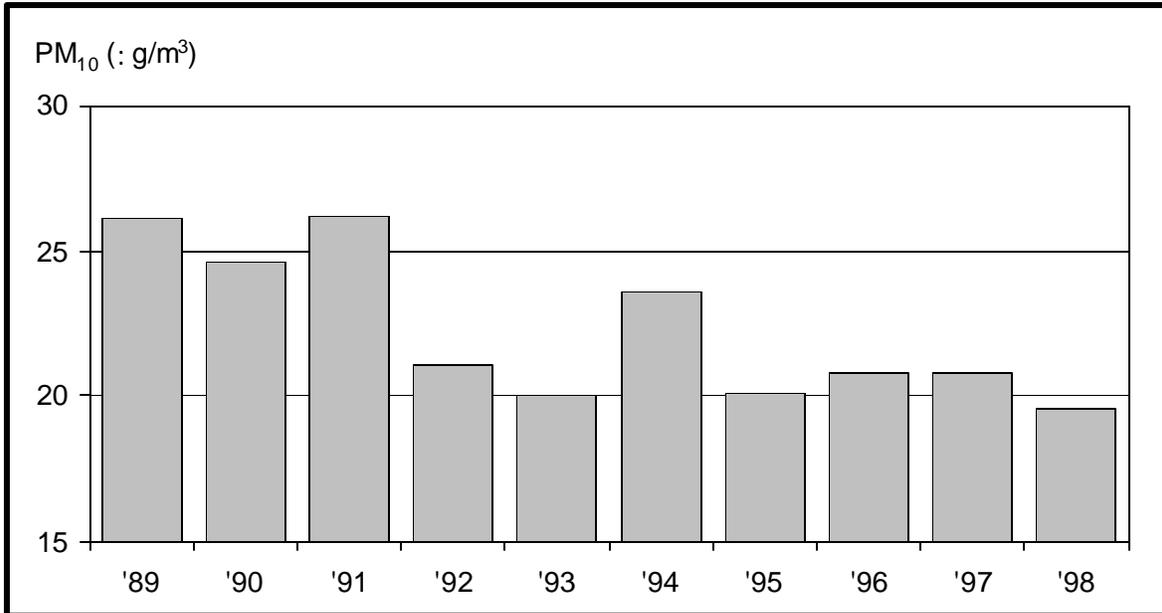
## MAXIMUM 24-HOUR PM10 CONCENTRATIONS IN 1998



\* The date is the month/day of occurrence.

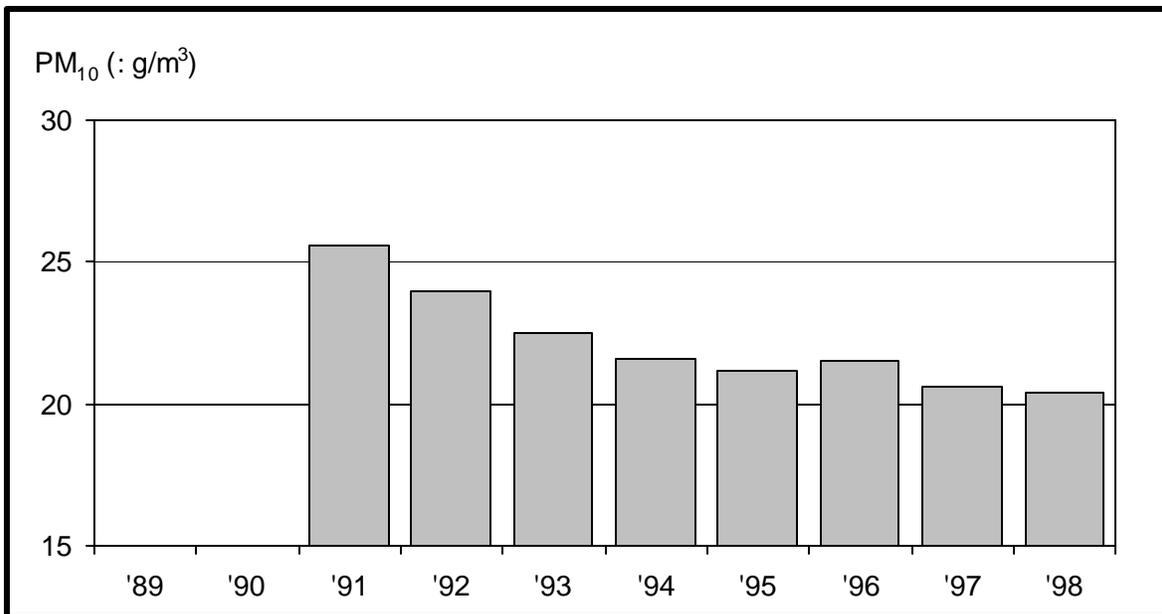
**FIGURE 2-5**

**AVERAGES OF THE ANNUAL PM10 CONCENTRATIONS**  
**AT SEVEN SITES**



**FIGURE 2-6**

**3-YEAR AVERAGES OF THE ANNUAL PM10 CONCENTRATIONS**  
**AT SEVEN SITES**



### III. SULFUR DIOXIDE

#### HEALTH EFFECTS

Sulfur oxides are heavy, pungent, yellowish gases that come from the burning of sulfur-containing fuel, mainly coal and oil-derived fuels, and also from the smelting of metals and from certain industrial processes. They have a distinctive odor. Sulfur dioxide (SO<sub>2</sub>) comprises about 95 percent of these gases, so scientists use a test for SO<sub>2</sub> alone as a measure of all sulfur oxides.

Exposure to high levels of sulfur oxides can cause an obstruction of breathing that doctors call "pulmonary flow resistance." The amount of breathing obstruction has a direct relation to the amount of sulfur compounds in the air. Moreover, the effect of sulfur pollution is enhanced by the presence of other pollutants, especially particulates and oxidants. The action of two or more pollutants is synergistic: each pollutant augments the other and the combined effect is greater than the sum of the effects that each alone would have.

Many types of respiratory disease are associated with sulfur oxides: coughs and colds, asthma, bronchitis, and emphysema. Some researchers believe that the harm is due not only to the sulfur oxide gases but also to other sulfur compounds that accompany the oxides.

#### CONCLUSIONS

Sulfur dioxide concentrations in 1998 did not exceed any federal primary or secondary standards. Measured concentrations were substantially below the 365 µg/m<sup>3</sup> primary 24-hour standard, and well below both the 80 µg/m<sup>3</sup> primary annual standard and the 1300 µg/m<sup>3</sup> secondary 3-hour standard.

#### METHOD OF MEASUREMENT

The DEP Air Monitoring Unit used the pulsed fluorescence method to continuously measure sulfur dioxide levels at all nine sites in 1998.

#### DISCUSSION OF DATA

**Monitoring Network** - Nine continuous SO<sub>2</sub> monitors were used to record data in nine towns during 1998 (see Figure 3-1):

Bridgeport 012  
Danbury 123  
East Hartford 006  
Enfield 005  
Groton 007

Mansfield 003  
New Haven 123  
Stamford 124  
Waterbury 123

**Precision and Accuracy** - 535 precision checks were made on SO<sub>2</sub> monitors in 1998, yielding 95% probability limits ranging from -4% to +6%. Accuracy is determined by introducing a known amount of SO<sub>2</sub> into each of the monitors. Three different concentration levels are tested: low, medium, and high. The 95% probability limits for accuracy based on 13 audits were: low, -5% to +4%; medium, -5% to +3%; and high, -5% to +1%. (For an explanation of the use of 95%

probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**Annual Averages** - SO<sub>2</sub> levels were below the primary annual standard of 80 µg/m<sup>3</sup> at all monitoring sites in 1998 (see Table 3-1). The annual average SO<sub>2</sub> levels decreased from 1997 to 1998 at Danbury, Enfield, Groton and Stamford and increased at Mansfield, New Haven and Waterbury. There was no change at Bridgeport and East Hartford. The largest decrease was 2 µg/m<sup>3</sup> at Danbury and Groton; the largest increase was 2 µg/m<sup>3</sup> at Waterbury.

**Statistical Projections** - A statistical analysis of the sulfur dioxide data is presented in Table 3-2. This analysis is produced by a DEP computer program and provides information to compensate for any loss of data caused by instrumentation problems. The format of Table 3-2 is the same as that used to present the statistical projections for particulate matter (see Table 2-1). Since the statistical projections are made for the 24-hour standard, the hourly SO<sub>2</sub> data are first converted to calendar day averages. These 24-hour "samples" form the basis for the annual arithmetic and geometric means and the arithmetic and geometric standard deviations employed by the DEP computer program to make the statistical projections and calculate the 95% confidence limits.

The monitored data indicate that there were no violations of the primary 24-hour SO<sub>2</sub> standard at any site in Connecticut in the last three years. The statistical projections confirm that no days exceeding the primary 24-hour standard of 365 µg/m<sup>3</sup> would have occurred during this period at any site, if sampling were complete.

The annual averages in Table 3-2 differ slightly from those in Table 3-1 due to the manner in which they were derived. The averages in Table 3-1 are based on the available hourly readings, while those in Table 3-2 are based on valid calendar day 24-hour averages. (At least 18 hourly readings are required to produce a valid 24-hour average.)

**24-Hour Averages** - Figure 3-2 presents the first and second high calendar day average concentrations recorded at each monitoring site in 1998. The second highest concentration is important because a violation of the primary SO<sub>2</sub> standard occurs when there are two exceedances of the level of the standard. No site recorded SO<sub>2</sub> concentrations in excess of the 24-hour primary standard of 365 µg/m<sup>3</sup>. Second high calendar day SO<sub>2</sub> average concentrations decreased at seven monitoring sites and increased at two monitoring sites, Mansfield and Waterbury, from 1997 to 1998. The largest decrease was 18 µg/m<sup>3</sup> at Bridgeport and the largest increase was 4 µg/m<sup>3</sup> at Mansfield.

Current EPA policy bases compliance with the primary 24-hour SO<sub>2</sub> standard on calendar day averages. Assessment of compliance is based on the second highest calendar day average in the year. A 24-hour average is an average computed for the 24-hour period ending at any hour. If 24-hour averages were used, assessment of compliance would be based on the value of the second highest of the two highest non-overlapping 24-hour periods in the year. There has been some contention over which average is the more appropriate one on which to base compliance. Table 3-3 contains the two highest SO<sub>2</sub> concentrations at each site in terms of both the 24-hour averages and calendar day averages. The first and second high 24-hour averages are all greater than the corresponding calendar day averages.

**3-Hour Averages** - Figure 3-3 presents the first and second high 3-hour average concentrations recorded at each monitoring site. A 3-hour average is an average computed for the 3-hour period ending at any hour. The second highest concentration is important because a violation of the secondary SO<sub>2</sub> standard occurs when there are two exceedances of the level of the standard. Measured SO<sub>2</sub> concentrations were far below the secondary 3-hour standard of 1300 µg/m<sup>3</sup> at all DEP monitoring sites in 1998. Compared to 1997, eight sites had lower second

high concentrations and Waterbury had a higher second high concentration. The largest decrease was  $49 \mu\text{g}/\text{m}^3$  at Bridgeport and the increase at Waterbury was  $3 \mu\text{g}/\text{m}^3$ .

**Highest Daily Concentrations and Wind Data** - As is the case with particulate matter, the highest  $\text{SO}_2$  concentrations occur on days when persistent winds out of the southwest quadrant predominate. During the fifteen year period between 1981 and 1995, 46% of the annual ten highest daily concentrations of  $\text{SO}_2$  at each monitoring site in the state occurred when such wind conditions prevailed. This relationship is caused, at least in part, by  $\text{SO}_2$  transport, but any transport is limited by the chemical instability of  $\text{SO}_2$ . In the atmosphere,  $\text{SO}_2$  reacts with other gases to produce, among other things, sulfate particulates. Therefore,  $\text{SO}_2$  is not likely to be transported very long distances. Previous studies conducted by the DEP have shown that, during periods of southwest winds, levels of  $\text{SO}_2$  in Connecticut decrease with distance from the New York / New Jersey metropolitan area. This relationship tends to support the transport hypothesis. These studies also revealed that certain adverse meteorological conditions, most notably low mixing heights and low wind speeds, are more conducive to high  $\text{SO}_2$  levels on days when there are southwest quadrant winds than on other days.

An examination of the available data for the period 1981-1995 also suggests another reason for maximum  $\text{SO}_2$  days. Approximately 77% of such days occurred during the winter, and 21% occurred in late autumn. This phenomenon is due to the fact that more fuel oil is burned during cold weather, resulting in greater  $\text{SO}_2$  emissions. In addition, temperature inversions, which are characterized by reduced mixing heights, are more prevalent in autumn and winter.

In summary, high levels of  $\text{SO}_2$  in Connecticut seem to be caused by a number of related factors. First, Connecticut experiences its highest  $\text{SO}_2$  levels during the late fall and winter months when there is an increased amount of fuel combustion. Second, large emission sources are located to the south and west of Connecticut, and their emissions can be transported to Connecticut by southwest quadrant winds. Also, adverse meteorological conditions are often associated with such winds. The net effect is that during the colder months, when a persistent southwest quadrant wind occurs, an air mass picks up increased amounts of  $\text{SO}_2$  over the New York City metropolitan area and transports this  $\text{SO}_2$  into Connecticut, adding to Connecticut's own contribution to ambient levels. In addition, relatively low mixing heights inhibit vertical mixing and contribute to the enhanced  $\text{SO}_2$  concentrations. The levels of transported  $\text{SO}_2$  eventually decline with increasing distance from New York City, as the  $\text{SO}_2$  is dispersed and as it slowly reacts to produce sulfate particulates. These sulfate particulates may fall to the ground in either a dry state (dry deposition) or in a wet state after combination with water droplets (wet deposition or "acid rain").

**Trends** - The  $\text{SO}_2$  trend over the ten year period from 1989 to 1998 is presented in Figure 3-4. The trend is clearly down over the ten year period.

As was the case with the particulate matter trend, we wanted to portray an  $\text{SO}_2$  trend that is both statewide in nature and relevant to one of the ambient air quality standards for  $\text{SO}_2$ . We chose to average the annual  $\text{SO}_2$  concentrations at a number of sites: Bridgeport, Enfield, Groton, New Haven and Waterbury. These sites were the only sites that had sufficient data and valid annual averages over a twelve year period.

Annual  $\text{SO}_2$  levels can be dramatically affected by a number of factors, including annual fuel use, frequency of precipitation events, and changes in wind speed and direction. The importance of these relatively short-term factors can be diminished in the portrayal of a pollution trend by means of multiple-year averaging. Figure 3-5 employs a three-year average of the data in Figure 3-4 and shows a smoother year-to-year transition as a result. The  $\text{SO}_2$  trend is clearly down and reflects a decrease of 50.2% over the last ten years.

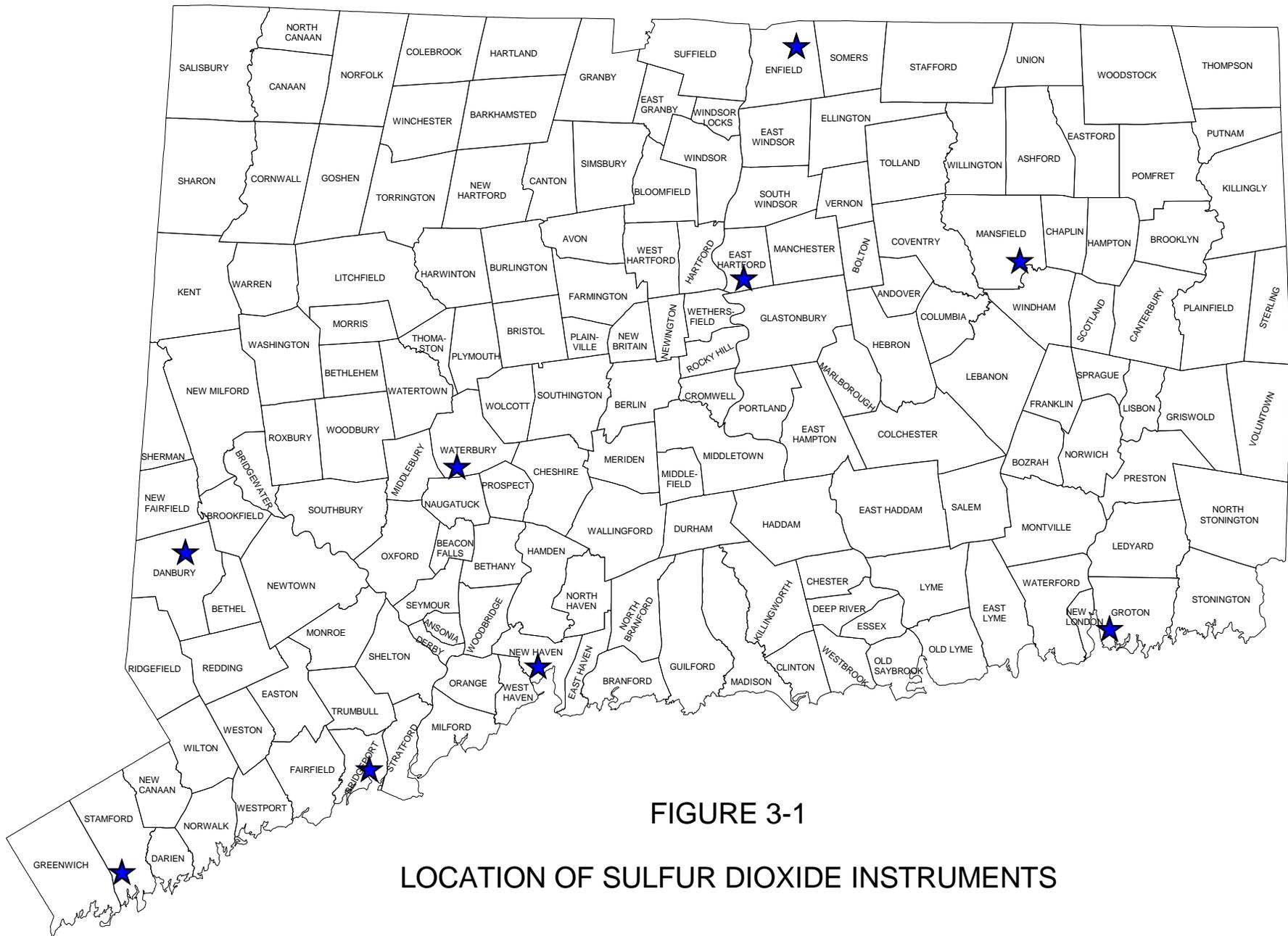


FIGURE 3-1

LOCATION OF SULFUR DIOXIDE INSTRUMENTS

## TABLE 3-1

### ANNUAL ARITHMETIC AVERAGES OF SULFUR DIOXIDE IN 1998

(PRIMARY STANDARD: 80  $\mu\text{g}/\text{m}^3$ )

<u>SITE</u>	<u>SITE NAME</u>	<u>ANNUAL AVG.</u> ( $\mu\text{g}/\text{m}^3$ )
Bridgeport 012	Edison School	18
Danbury 123	Western CT State University	11
East Hartford 006	High Street	14
Enfield 005	Department of Corrections	8
Groton 007	Fire Headquarters	10
Mansfield 003	Dept. of Transportation	8
New Haven 123	State Street	16
Stamford 124	Stamford High School	16
Waterbury 123	Bank Street	16

**TABLE 3-2**

**1996-1998 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS**

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC	95--PCT--LIMITS		STANDARD	PREDICTED	MEASURED
				MEAN	LOWER	UPPER	DEVIATION	DAYS OVER 365 : g/m <sup>3</sup>	DAYS OVER 365 : g/m <sup>3</sup>
BRIDGEPORT	012	1996	353	14.8	14.5	15.1	13.675		
BRIDGEPORT	012	1997	359	17.7	17.5	17.9	14.515		
BRIDGEPORT	012	1998	354	17.8	17.6	18.0	12.742		
DANBURY	123	1996	334	11.2	10.9	11.5	10.405		
DANBURY	123	1997	363	12.8	12.7	12.9	10.019		
DANBURY	123	1998	365	11.4	11.4	11.4	9.161		
EAST HARTFORD	006	1996	354	15.1	14.9	15.3	11.018		
EAST HARTFORD	006	1997	363	14.1	14.0	14.2	9.318		
EAST HARTFORD	006	1998	357	13.6	13.4	13.7	9.637		
EAST HAVEN	003	1996	350	10.7	10.5	10.9	10.777		
EAST HAVEN	003	1997	358	12.7	12.5	12.8	10.026		
ENFIELD	005	1996	354	12.6	12.4	12.7	8.787		
ENFIELD	005	1997	354	9.0	8.8	9.1	8.090		
ENFIELD	005	1998	354	8.5	8.4	8.7	7.056		
GREENWICH	017	1996	355	12.3	12.1	12.4	8.684		
GREENWICH	017	1997	365	11.0	11.0	11.0	9.229		
GROTON	007	1996	363	11.8	11.7	11.9	7.583		
GROTON	007	1997	365	11.6	11.6	11.6	7.538		
GROTON	007	1998	365	10.1	10.1	10.1	6.952		
HARTFORD	018	1996	363	11.7	11.6	11.8	10.004		
HARTFORD	018	1997	364	10.8	10.7	10.8	9.338		

N.B. THE ARITHMETIC MEAN AND STANDARD DEVIATION HAVE UNITS OF MICROGRAMS PER CUBIC METER.

### TABLE 3-2, CONTINUED

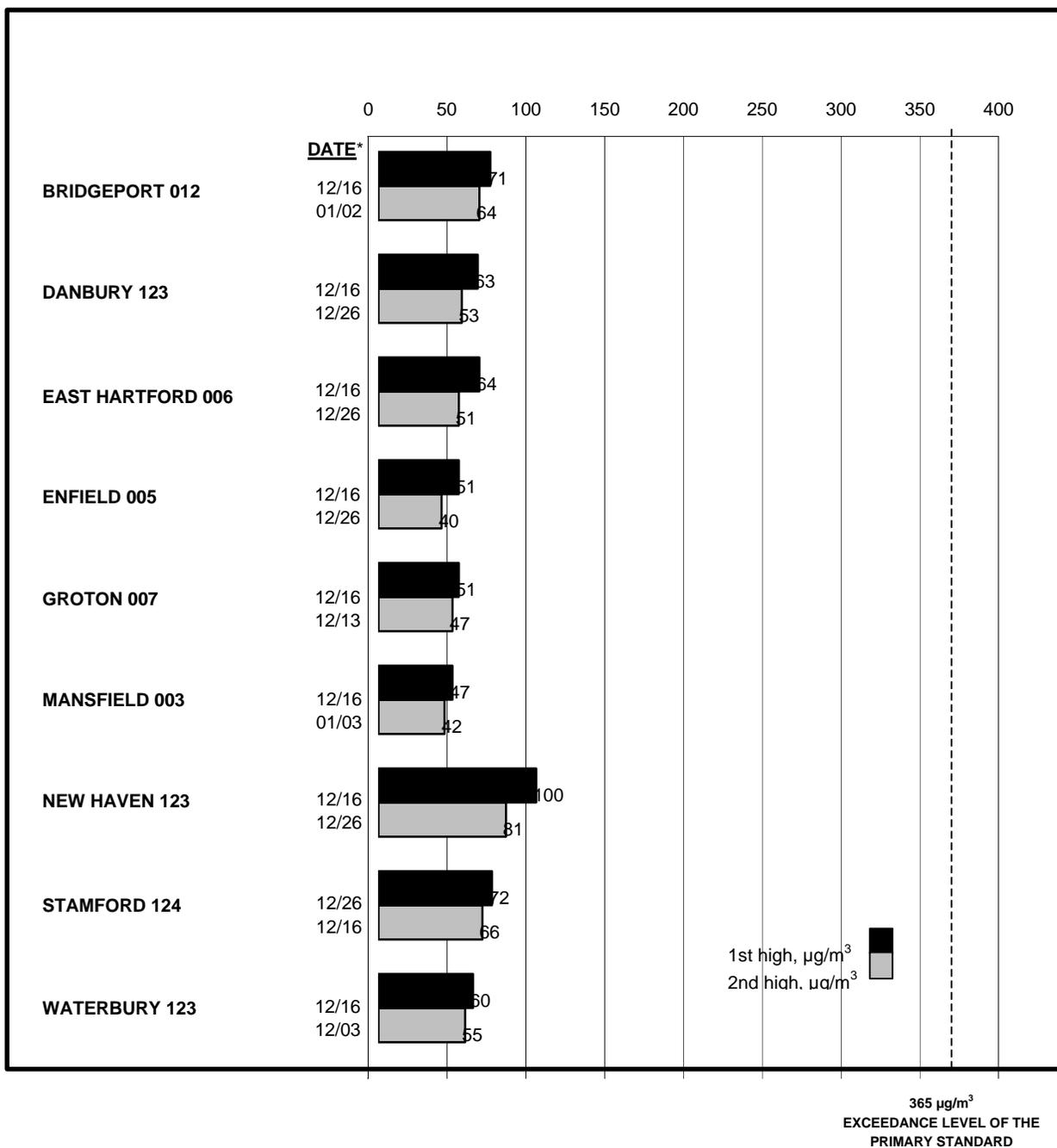
#### 1996-1998 SO<sub>2</sub> ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC	95--PCT--LIMITS		STANDARD DEVIATION	PREDICTED	MEASURED
				MEAN	LOWER	UPPER		DAYS OVER 365 : g/m <sup>3</sup>	DAYS OVER 365 : g/m <sup>3</sup>
MANSFIELD	003	1996	361	7.0	6.9	7.0	5.608		
MANSFIELD	003	1997	362	6.9	6.9	7.0	5.905		
MANSFIELD	003	1998	353	8.5	8.4	8.7	6.349		
NEW HAVEN	123	1996	357	19.5	19.3	19.8	14.763		
NEW HAVEN	123	1997	359	15.1	14.9	15.2	14.037		
NEW HAVEN	123	1998	355	15.9	15.6	16.1	13.762		
STAMFORD	124	1996	362	14.0	13.8	14.1	12.898		
STAMFORD	124	1997	365	16.6	16.6	16.6	12.480		
STAMFORD	124	1998	364	15.8	15.8	15.9	11.990		
WATERBURY	123	1996	364	13.2	13.1	13.3	10.516		
WATERBURY	123	1997	359	13.7	13.6	13.8	9.244		
WATERBURY	123	1998	364	15.6	15.6	15.7	9.038		

N.B. THE ARITHMETIC MEAN AND STANDARD DEVIATION HAVE UNITS OF MICROGRAMS PER CUBIC METER.

**FIGURE 3-2**

**MAXIMUM CALENDAR DAY AVERAGE SO<sub>2</sub> CONCENTRATIONS IN 1998**



\* The date is the month/day of occurrence.

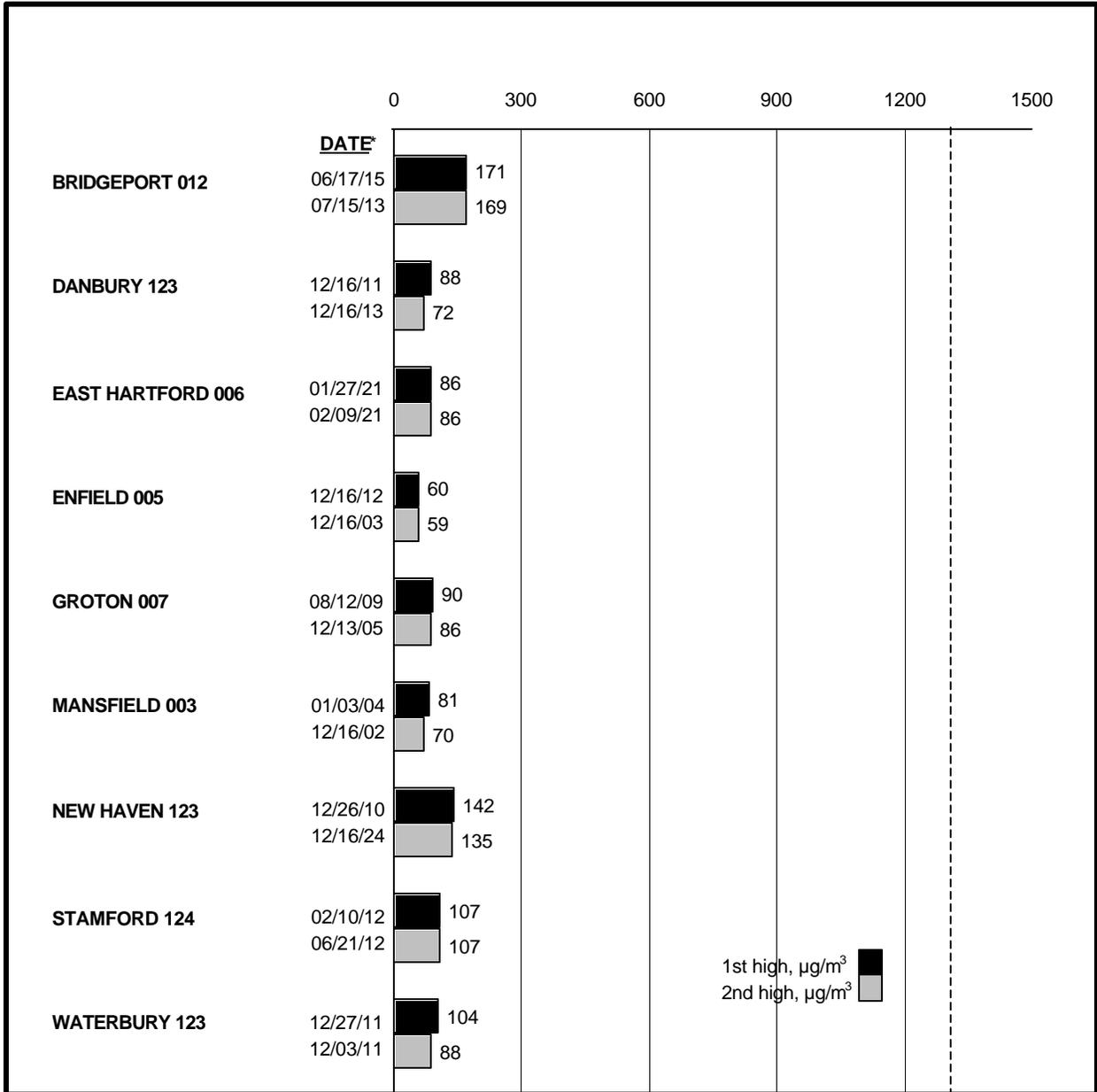
**TABLE 3-3****COMPARISONS OF FIRST AND SECOND HIGH 24-HOUR AND  
CALENDAR DAY SO<sub>2</sub> AVERAGES IN 1998**

SITE	<u>FIRST HIGH AVERAGE</u>		<u>SECOND HIGH AVERAGE</u>	
	<u>24-HOUR</u>	<u>CALENDAR DAY</u>	<u>24-HOUR</u>	<u>CALENDAR DAY</u>
Bridgeport 012	76	71	75	64
Danbury 123	65	63	56	53
East Hartford 006	67	64	55	51
Enfield 005	56	51	43	40
Groton 007	57	51	50	47
Mansfield 003	58	47	44	42
New Haven 123	104	100	89	81
Stamford 124	74	72	74	66
Waterbury 123	65	60	57	55

N.B. The averages have units of micrograms per cubic meter.

**FIGURE 3-3**

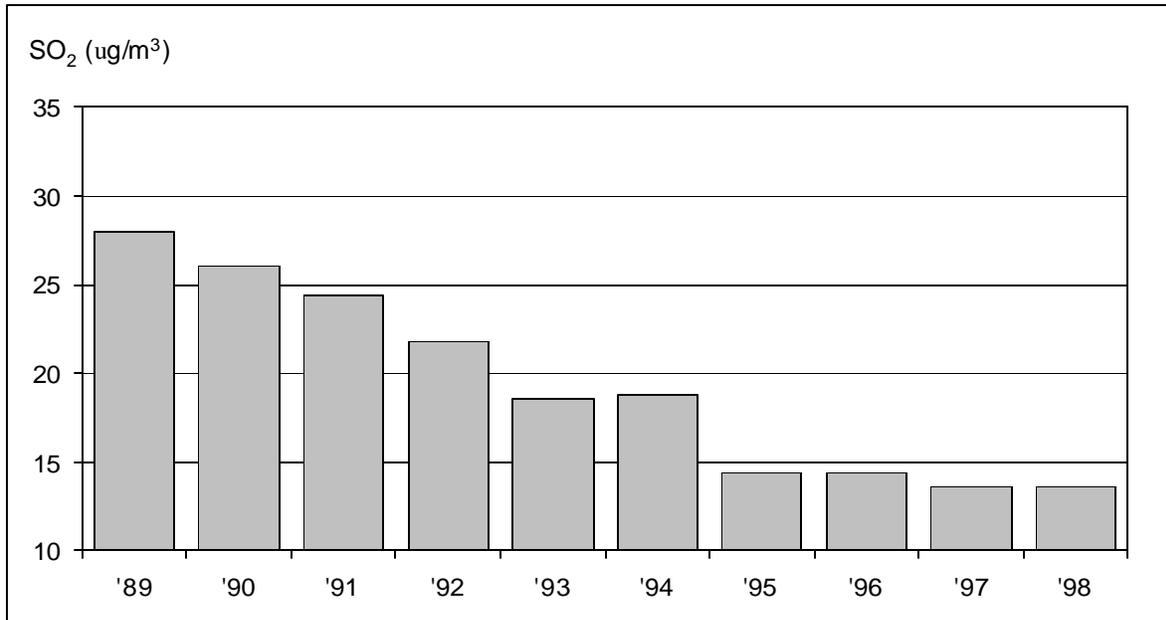
**MAXIMUM 3-HOUR AVERAGE SO2 CONCENTRATIONS IN 1998**



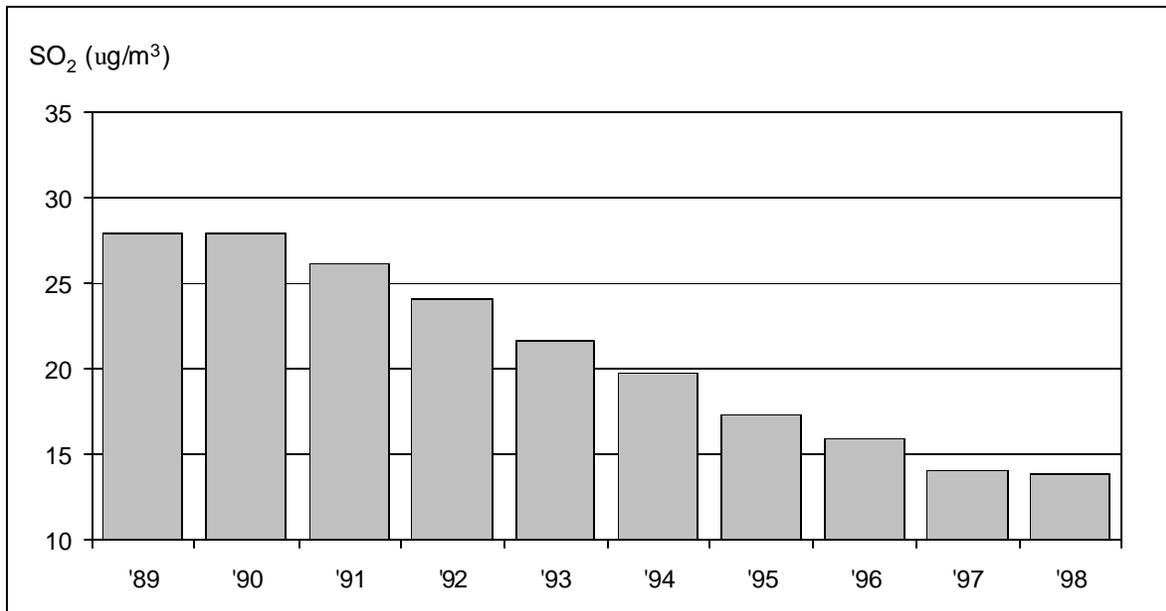
1300 µg/m<sup>3</sup>  
EXCEEDANCE LEVEL OF THE  
SECONDARY STANDARD

\* The date is the month/day/ending hour (standard time) of occurrence.

**FIGURE 3-4**  
**AVERAGES OF THE ANNUAL SO<sub>2</sub> CONCENTRATIONS**  
**AT FIVE SITES**



**FIGURE 3-5**  
**3-YEAR AVERAGES OF THE ANNUAL SO<sub>2</sub> CONCENTRATIONS**  
**AT FIVE SITES**



## **IV. OZONE**

### **HEALTH EFFECTS**

Ozone is a highly reactive form of oxygen and the principal component of modern smog. Originally, EPA called this type of pollution "photochemical oxidants." After 1979, ozone became the term of reference because ozone is the most plentiful component of smog, and more selective measurement techniques for ozone became available.

Ozone and other oxidants -- including peroxyacetal nitrates (PAN), formaldehyde and peroxides -- are not usually emitted into the air directly. These secondary pollutants are formed by chemical reactions in the air from two other pollutants: hydrocarbons and nitrogen oxides. Energy from sunlight is needed for these chemical reactions. This accounts for the term photochemical smog, as well as for the daily variation in ozone levels, which increase during the day and decrease at night.

Ozone is a pungent gas with a faintly bluish color. It irritates the mucous membranes of the respiratory system, causing coughing, choking and impaired lung function. It aggravates chronic respiratory diseases like asthma and bronchitis and is believed capable of hastening the death, by pneumonia, of persons in already weakened health. PAN and the other oxidants that accompany ozone are powerful eye irritants.

### **NATIONAL AMBIENT AIR QUALITY STANDARD**

On February 8, 1979 the EPA established revised primary and secondary national ambient air quality standards (NAAQS) for ozone of 0.12 ppm for a one-hour average. Compliance with this standard was determined by summing the number of days at each monitoring site over a consecutive three-year period when the 1-hour standard was exceeded and then computing the average number of exceedances over this interval. If the resulting average value was less than or equal to 1.0 (that is, if the fourth highest daily value in a consecutive three-year period was less than or equal to 0.12 ppm) the ozone standard was considered attained at the site. This standard replaced the old photochemical oxidant standard of 0.08 ppm, 1-hour average not to be exceeded more than once per year at a monitoring site.

In accordance with Sections 108 and 109 of the Clean Air Act, the EPA began a study of ozone air quality criteria and standards in August 1992. The study is a periodic one whose purpose is to see to it that the air quality criteria for ozone accurately reflect the latest scientific knowledge linking exposures to ambient ozone to adverse health and welfare effects. The examination led to a proposed revision of the existing primary and secondary standards for ozone. After external review and public comment, the EPA revised the primary and secondary NAAQS for ozone, effective September 16, 1997.

The revision replaces the 0.12 ppm 1-hour standard with an 8-hour standard at a level of 0.08 ppm. Compliance with this standard is based on a 3-year average of the annual fourth highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area. Compliance with the standard is achieved when the resulting 3-year average concentration is less than or equal to 0.08 ppm. Notwithstanding the revision, the 0.12 ppm 1-hour standard will be retained in Connecticut until compliance with that standard has been demonstrated.

The EPA defines the revised ozone standard to two decimal places. Therefore, the standard is considered to be exceeded when a level of 0.09 ppm is reached for the 3-year average. However, since the EPA requires ozone levels to be reported to three decimal places, any three-year average which equals or is greater than 0.085 ppm is considered to be an exceedance of the 0.08 ppm standard.

## CONCLUSIONS

As in past years, Connecticut experienced high concentrations of ozone in the summer months of 1998. Levels in excess of the one-hour NAAQS of 0.12 ppm were recorded at seven of the eleven ozone monitoring sites (see Figure 4-1 and Table 4-1). Moreover, the 1-hour ozone standard was violated at eight of the sites because the calculated number of days per year with maximum hourly average concentrations above 0.12 ppm exceeded one day at each of the eight sites for the most recent three years (see Table 4-2). Based on this criterion, the 1-hour standard was not violated at East Hartford, New Haven or Torrington because there were fewer than four daily exceedances at each site for the most recent three years. The highest hourly concentration in 1998 was 0.148 ppm, which was measured at Stratford (see Fig. 4-2).

The incidence of hourly ozone concentrations in excess of the 1-hour 0.12 ppm standard was significantly lower in 1998 than in 1997 (see Table 4-1). There was a total of 117 hourly exceedances in 1997 and 25 hourly exceedances in 1998 at the eleven monitoring sites. This represents a decrease in the frequency of such exceedances from 2.50 per 1000 sampling hours in 1997 to 0.53 per 1000 sampling hours in 1998: a 79% decrease. The actual number of hours when the state experienced at least one exceedance of the 1-hour ozone standard decreased from 48 in 1997 to 14 in 1998.

The number of site-days on which the ozone monitors experienced ozone levels in excess of the 1-hour standard decreased from 37 in 1997 to 12 in 1998 at the eleven monitoring sites (see Table 4-2). This represents a decrease in the frequency of such occurrences from 1.90 per 100 sampling days in 1997 to 0.61 per 100 sampling days in 1998: a 68% decrease. The actual number of days when the state experienced at least one exceedance of the 1-hour ozone standard decreased from 12 in 1997 to 5 in 1998.

Concentrations of ozone in excess of the 8-hour NAAQS of 0.08 ppm were recorded at all eleven of the ozone monitoring sites that were operated in Connecticut in 1998 (see Table 4-3). The highest 8-hour concentration in 1998 was 0.118 ppm, which was measured at Stafford (see Fig. 4-3).

The number of hours and days when the 8-hour ozone standard of 0.08 ppm was exceeded at each ozone monitoring site in 1998 is shown in Table 4-3 and Table 4-4, respectively.

Much of the year-to-year variation in ozone concentrations can be attributed to variations in regional weather conditions, especially wind direction, temperature and the amount of sunlight. A large percentage of the peak ozone concentrations in Connecticut is caused by the transport of ozone and/or precursors (i.e., hydrocarbons and nitrogen oxides) from the New York City area and from other points west and south of Connecticut. Therefore, a decrease in the **frequency of winds** out of the southwest quadrant would help to explain the decrease in the number of ozone exceedances from 1997 to 1998. However, the percentage of such winds during the "ozone season" increased from 39% in 1997 to 47% in 1998, as is shown by the wind roses from the Stafford 001 site (Figures 4-4 and 4-5). The magnitude of high ozone levels can be partly associated with yearly **variations in temperature**, since ozone production is greatest at high temperatures and in strong sunlight. The summer season's daily high temperatures were lower in 1998 than in 1997. This is demonstrated by the number of days exceeding 90° F which decreased from five in 1997 to two in 1998 at Sikorsky Airport in Bridgeport, and from sixteen in 1997 to eight in 1998 at Bradley International Airport in Windsor Locks. The incidence of high ozone levels is also dependent on the **amount of sunlight**, since sunlight is essential to the creation of ozone. According to measurements recorded at Stafford 001 site, the amount of solar radiation decreased 6.1% from 1997 to 1998, as determined by the daily mean for the months June through August. Of the meteorological parameters discussed above, both temperature and solar radiation can be seen as contributing to the decrease in ozone levels from 1997 to 1998.

The meteorological influences notwithstanding, additional and important factors contributing to the decrease in ozone concentrations over time are the continuing efforts of the EPA and the state Department of Environmental Protection to control the emissions of nitrogen oxides and hydrocarbons. Newer automobiles continue to be less polluting, and the use of reformulated gasoline, which was initiated in January of 1995, reduces vehicle hydrocarbon emissions by 15-17% and lowers the vapor pressure of gasoline in the summer months, reducing evaporative emissions. In addition, the state's inspection and

maintenance program for motor vehicles, as well as the Stage I and Stage II vapor recovery requirements, also lessen the emissions of hydrocarbons into the air.

### **METHOD OF MEASUREMENT**

The DEP employs monitors that use light intensity variation (photometry) to determine concentrations of ozone. This continuous monitoring technique relies on the absorption of ultraviolet radiation by ozone molecules. Properly calibrated, instruments of this type are shown to be remarkably reliable and stable. However, emerging data indicate that this technique – although widely used – is biased in a manner that causes some peak concentrations to be over-reported.

### **DISCUSSION OF DATA**

**Monitoring Network** - In order to gather information which will further the understanding of ozone production and transport, DEP operated a state-wide ozone monitoring network consisting of four types of sites in 1998 (see Figure 4-1):

Urban	- East Hartford, Middletown
Advection from Southwest	- Greenwich, Groton, Madison, Stratford, Westport
Urban and advection from Southwest	- Danbury, New Haven
Rural	- Stafford, Torrington

**Precision and Accuracy** - A total of 326 precision checks were performed on the ozone monitoring network during 1998. The resulting 95% probability limits for those checks were -3% to +4%. Network accuracy was determined by introducing a known amount of ozone into each of the monitors. Fifteen audits for accuracy were conducted on the ozone monitoring network in 1998. Three different concentration levels were tested: low, medium, and high. The 95% probability limits ranged from -2% to +5% for the low level test; -3% to +5% for the medium level test; and -3% to +4% for the high level test. (For an explanation of the use of 95% probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**1-Hour Average** - The 1-hour ozone standard of 0.12 ppm was exceeded at seven of the eleven DEP monitoring sites in 1998, where an exceedance is defined as an hourly concentration of 0.125 ppm or greater. The highest 1-hour concentration was 0.148 ppm at Stratford.

Between 1997 and 1998, the maximum 1-hour concentration decreased at all eleven monitoring sites. The largest decrease was 0.049 ppm at Greenwich; the smallest decrease was 0.003 ppm at Torrington. The second highest 1-hour concentration also decreased at all eleven sites between 1997 and 1998. The largest decrease in the second highest concentration was 0.034 ppm at Groton; the smallest decrease was 0.000 ppm at Stratford.

The number of hours when the 1-hour standard was exceeded at each site during the summertime "ozone season" is presented in Table 4-1. The number of days on which the 1-hour standard was exceeded at each site is presented in Table 4-2. Figure 4-2 shows the year's high and second high concentrations at each site.

**8-Hour Average** - The 8-hour ozone standard of 0.08 ppm was exceeded at all eleven DEP monitoring sites in 1998, where an exceedance is defined as an 8-hour average concentration of 0.085 ppm or greater. The highest 8-hour concentration was 0.118 ppm at Stafford.

The number of hours when the 8-hour ozone standard was exceeded at each site during the summertime "ozone season" is presented in Table 4-3. The number of days on which the 8-hour standard was exceeded at each site is presented in Table 4-4. Figure 4-3 shows the year's high and second high concentrations at each site.

**Highest Hourly Ozone Concentrations and Wind Data** - As with particulate matter and sulfur dioxide, the highest ozone levels in Connecticut occur on days with persistent winds out of the southwest quadrant. During the fifteen year period between 1981 and 1995, 74% of the annual ten highest daily 1-hour average concentrations of ozone at each monitoring site in the state occurred when such wind conditions prevailed. This is due to the special features of a southwest quadrant wind blowing over Connecticut. One feature is that, during the summer, these winds are usually accompanied by high temperatures and bright sunshine, which are important to the production of ozone. Another feature of such winds is that they will transport precursor emissions from New York City and from other urban areas west and south of Connecticut. It is the combination of these factors that often produces unhealthy ozone levels in Connecticut.

There are also instances of high ozone levels on non-southwest wind days. This suggests that pollution control programs currently being implemented in this state are also needed to protect the public health of Connecticut's citizenry on days when Connecticut is responsible for its own pollution.

**Trends** - Ozone trends can be illustrated in a number of ways by using various statistics: daily mean concentration, daily maximum concentration, number of hourly exceedances, number of daily exceedances, etc. Each has its merits. The mean daily maximum ozone concentration is used here as the basis for a trend analysis because: (1) it represents a more robust data set than hourly or daily exceedances, and (2) a maximum concentration is more relevant to the NAAQS for ozone.

Figure 4-6 shows the unweighted average of the annual means of the maximum daily concentrations at nine ozone sites from 1989 to 1998. There is a lot of variation in the statistic from one year to the next. The importance of meteorology in the formation of ozone explains much of this variation. However, unless the effect of meteorology can be factored out, one cannot judge the effect of emission control measures on ozone production. A regression line through the data in Figure 4-6 would trend down, but the reason for this would not be evident.

The effect of meteorology on an ozone trend can be diminished by multiple year averaging. Periods of multiple years exhibit much less meteorological variability than do single years, and a trend analysis based on multiple years should more clearly reveal the effect of emission controls on ambient ozone concentrations. Figure 4-7 illustrates five-year averages of the data that is presented in Figure 4-6. With the variability of the weather minimized, it appears that ozone is leveling off, after trending downward earlier in the ten-year period. The decrease in ozone over the period is approximately 6.7%.

## **PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS (PAMS)**

**Introduction** - Current analyses indicate that pollutant concentrations in the United States have steadily declined over the past decade. However, many areas of the country continue to be troubled by pervasive and chronic ozone nonattainment problems. This is especially true of the northeastern United States in general and of Connecticut in particular. State and local air pollution control agencies have normally employed ozone control strategies that focus solely on reductions of volatile organic compound (VOC) emissions, which are common photochemical precursors of ozone. More recent data, however, suggest that the ozone abatement problem is more complex and requires the implementation of more varied and effective strategies.

**Background** - In order to meet the challenges faced by the state and local air pollution control agencies in attaining the National Ambient Air Quality Standards (NAAQS) for ozone, a more comprehensive ambient air quality database for ozone and its precursors was needed to explain the effects of ozone management strategies. To this end, the 1990 Clean Air Act Amendments (CAAA) required enhanced monitoring for ozone (O<sub>3</sub>) and oxides of nitrogen (NO<sub>x</sub>) and monitoring for VOC in ozone nonattainment areas classified as serious, severe or extreme. In particular, the United States Environmental Protection Agency (EPA) focused attention on several pertinent issues:

- (i) In addition to VOC limitations, examination of emission controls for NO<sub>x</sub>,
- (ii) Expanded monitoring of ozone precursors in order to confirm emissions trends, and
- (iii) Creation of ambient monitoring strategies to directly measure the success of implemented ozone precursor controls.

In order to comply with the requirements of the CAAA, the EPA promulgated final amendments to the ambient air quality surveillance rules on February 12, 1993. They provide for the enhanced monitoring of ozone, oxides of nitrogen, volatile organic compounds (including carbonyls), and meteorological parameters. These rules required the affected areas to establish Photochemical Assessment Monitoring Stations (PAMS) networks in ozone nonattainment areas classified as serious, severe or extreme.

**PAMS Monitoring Objectives** - PAMS design criteria are site specific. Concurrent measurements of O<sub>3</sub>, NO<sub>x</sub>, speciated VOC, and meteorology are obtained at PAMS. Design criteria for the PAMS network are based on a selection of an array of site locations relative to O<sub>3</sub> precursor source areas and predominant wind directions associated with high O<sub>3</sub> events. Specific monitoring objectives are associated with each location. The overall design should enable characterization of precursor emission sources within the area, transport of O<sub>3</sub> and its precursors into and out of the area, and the photochemical processes related to O<sub>3</sub> nonattainment. Specific objectives that must be addressed include assessing ambient trends in O<sub>3</sub>, NO, NO<sub>2</sub>, NO<sub>x</sub>, VOC (including carbonyls) and VOC species; determining spatial and diurnal variability of O<sub>3</sub>, NO, NO<sub>2</sub>, NO<sub>x</sub>, and VOC species; and assessing changes in the VOC species profiles that occur over time, particularly those occurring due to the reformulation of fuels.

A maximum of five PAMS sites are required in an affected nonattainment area depending on the population of either the Metropolitan Statistical Area / Consolidated Metropolitan Statistical Area (MSA/CMSA) or nonattainment area, whichever is larger. Specific monitoring objectives associated with each of these sites result in four distinct types of site.

Type (1) sites are established to characterize upwind background and transported O<sub>3</sub> and its precursor concentrations entering the area and will identify those areas which are subject to overwhelming transport. Type (1) sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions.

Type (2) sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact. In addition, these sites may be suited for the monitoring of urban air toxic pollutants. Type (2) sites are located immediately downwind of the area of maximum precursor emissions and are typically placed near the downwind boundary of the central business district to obtain neighborhood-scale measurements. Two type (2) stations are typically required in each PAMS area.

Type (3) sites are intended to monitor maximum O<sub>3</sub> concentrations occurring downwind from the area of maximum precursor emissions. Type (3) sites should be located so that urban-scale measurements are obtained, typically 10 to 30 miles from the fringe of the urban area.

Type (4) sites are established to characterize the extreme downwind transported O<sub>3</sub> and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas. Type (4) sites are located in the predominant afternoon downwind direction from the local area of maximum precursor emissions and at a distance sufficient to obtain urban-scale measurements.

**PAMS Monitoring Network** - In order to comply with the federal rules requiring states to establish PAMS networks in ozone nonattainment areas classified as serious or severe (see Figure 9-1), DEP operated a PAMS monitoring network consisting of three types of sites in 1998 (see Figure 4-8):

- Type (1) - Westport 003
- Type (2) - East Hartford 003
- Type (3) - Stafford 001

**PAMS Method of Measurement** – The DEP employs gas chromatography techniques using flame ionization detectors to measure ambient levels of VOCs. The term VOCs refers to gaseous aliphatic and aromatic nonmethane organic compounds that have a vapor pressure greater than 0.14 Hg at 25°C, and generally have a carbon number in the range of two to twelve.

**PAMS Data** - As mentioned earlier, the EPA promulgated final amendments to the ambient air quality surveillance rules to provide for the enhanced monitoring of ozone, oxides of nitrogen, volatile organic compounds (including carbonyls) and meteorological parameters. As a result, detailed ambient pollutant and meteorological measurements are currently conducted or planned for the PAMS sites.

More than fifty hydrocarbons (C<sub>2</sub>-C<sub>12</sub>) compounds, along with ozone (O<sub>3</sub>), oxides of nitrogen (NO, NO<sub>2</sub>, NO<sub>x</sub>) are measured continuously during the summer (1-hour measurements from June through August). In addition, carbonyl measurements are taken at 3-hour sampling intervals at the East Hartford site. Surface (10 meter) meteorological measurements are taken at all PAMS sites and include: wind speed, wind direction, air temperature, solar radiation and precipitation (Stafford 001 only). It is anticipated that one or more upper air meteorological stations may be deployed in the near future to record wind speed and direction and temperatures aloft, but this is only in the planning stage.

Table 4-5 lists all the volatile organic compounds presently being measured at the PAMS sites. The seasonal means of the 1-hour concentrations of these compounds are presented in Table 4-6 for each of the three PAMS sites.

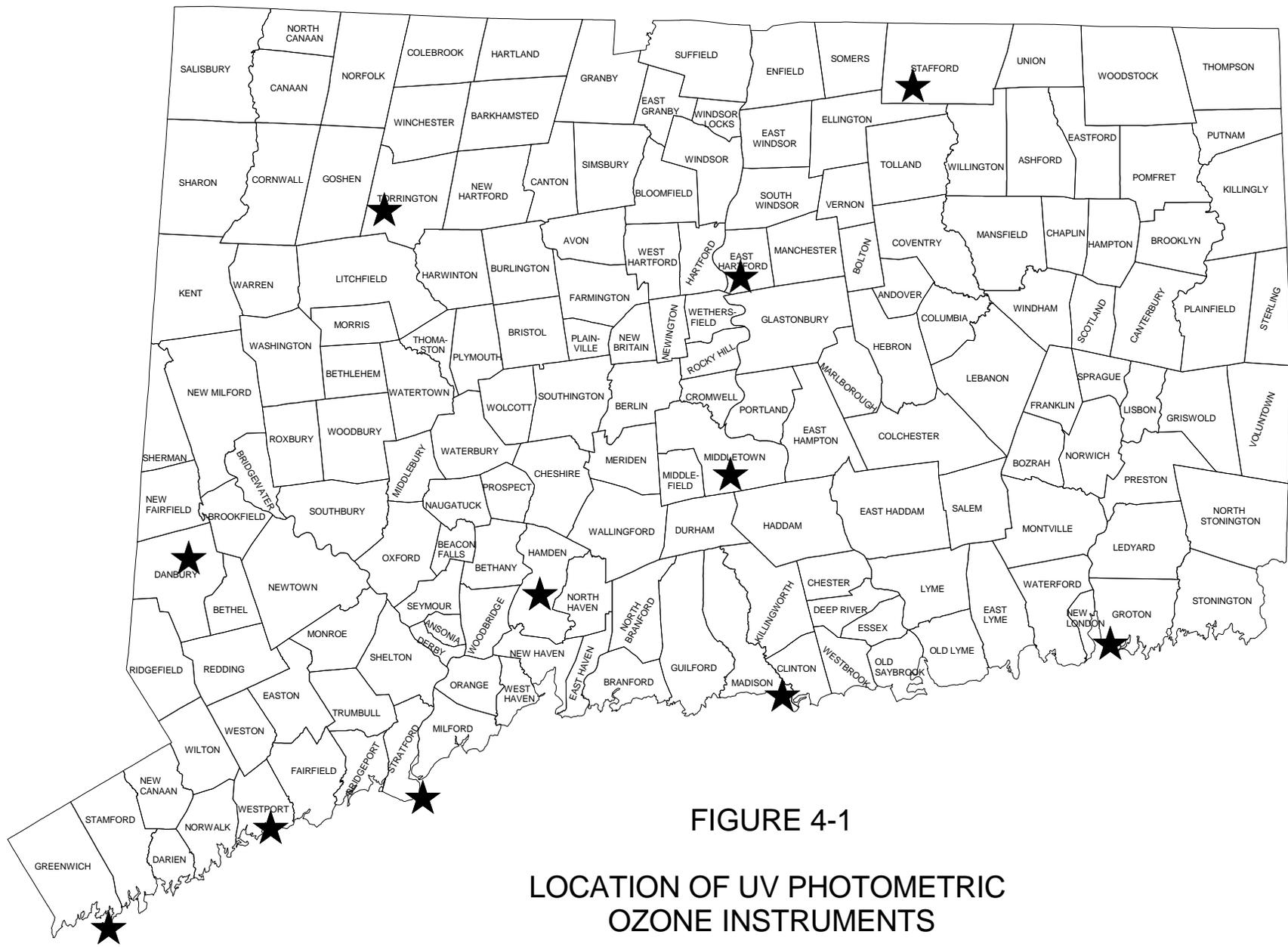


FIGURE 4-1

LOCATION OF UV PHOTOMETRIC  
OZONE INSTRUMENTS

**TABLE 4-1****NUMBER OF HOURS WHEN THE 1-HOUR OZONE STANDARD  
WAS EXCEEDED IN 1998**

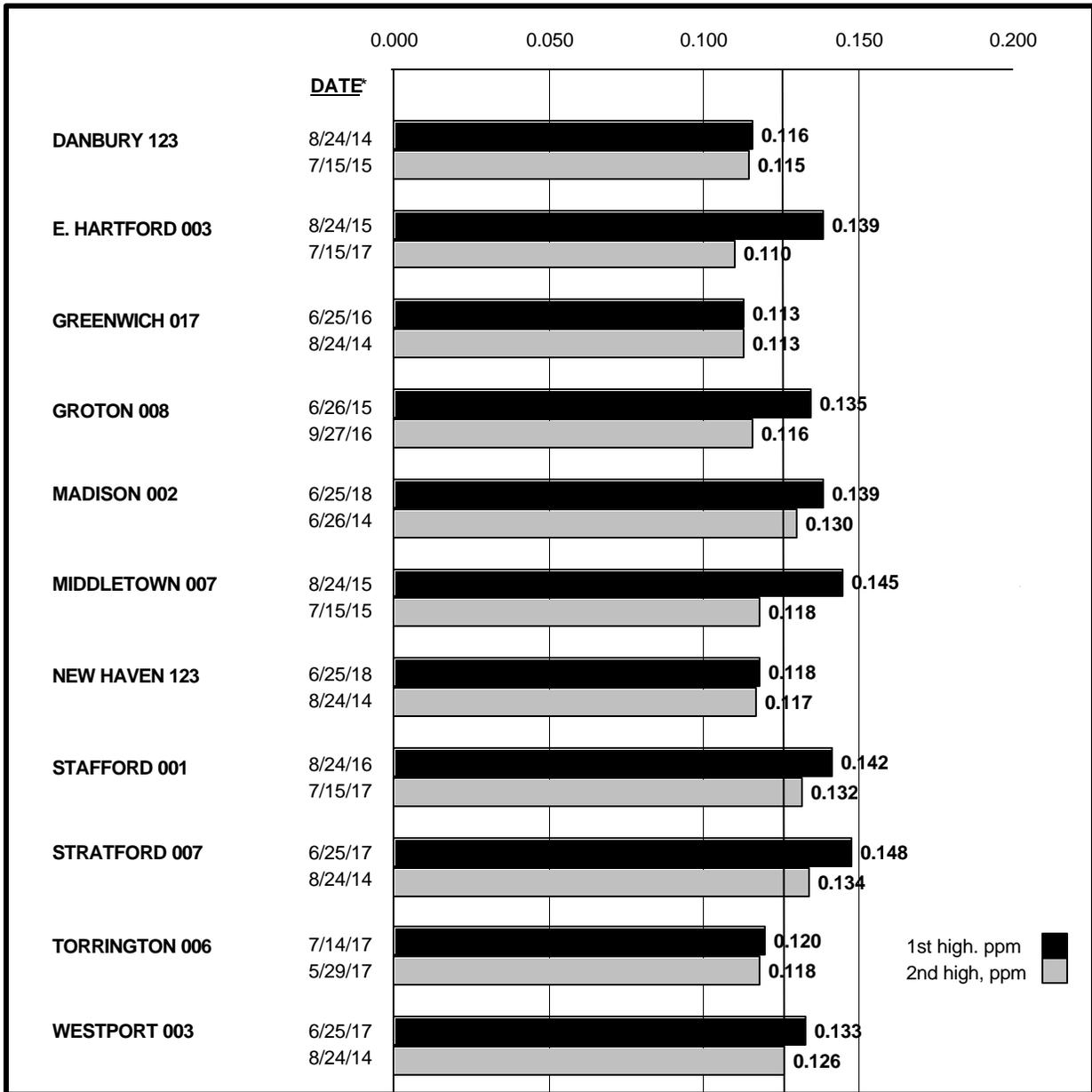
<u>SITE</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>1998</u>	<u>1997</u>	<u>1996</u>
Danbury 123	0	0	0	0	0	0	0	8	0
E. Hartford 003	0	0	0	0	1	0	1	10	0
Greenwich 017	0	0	0	0	0	0	0	10	1
Groton 008	0	0	3	0	0	0	3	16	3
Madison 002	0	0	5	0	0	0	5	19	0
Middletown 007	0	0	0	0	3	0	3	8	2
New Haven 123	0	0	0	0	0	0	0	3	0
Stafford 001	0	0	0	2	3	0	5	13	0
Stratford 007	0	0	2	0	3	0	5	15	1
Torrington 006	0	0	0	0	0	0	0	0	0
Westport 003	0	0	2	0	1	0	3	15	3
<b>Total Site Hours</b>	0	0	12	2	11	0	25	117	10

**TABLE 4-2****NUMBER OF DAYS WHEN THE 1-HOUR OZONE STANDARD  
WAS EXCEEDED IN 1998**

<u>SITE</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>1998</u>	<u>1997</u>	<u>1996</u>
Danbury 123	0	0	0	0	0	0	0	4	0
E. Hartford 003	0	0	0	0	1	0	1	2	0
Greenwich 017	0	0	0	0	0	0	0	3	1
Groton 008	0	0	1	0	0	0	1	4	1
Madison 002	0	0	2	0	0	0	2	6	0
Middletown 007	0	0	0	0	1	0	1	2	1
New Haven 123	0	0	0	0	0	0	0	2	0
Stafford 001	0	0	0	1	1	0	2	2	0
Stratford 007	0	0	1	0	2	0	3	6	1
Torrington 006	0	0	0	0	0	0	0	0	0
Westport 003	0	0	1	0	1	0	2	6	2
<b>Total Site Days</b>	0	0	5	1	6	0	12	37	6

**FIGURE 4-2**

**MAXIMUM DAILY 1-HOUR OZONE CONCENTRATIONS IN 1998**



0.125  
 EXCEEDANCE LEVEL OF THE  
 PRIMARY AND  
 SECONDARY STANDARD

\* The date is the month/day/hour (standard time) of occurrence.

**TABLE 4-3****NUMBER OF HOURS WHEN THE 8-HOUR OZONE STANDARD  
WAS EXCEEDED IN 1998**

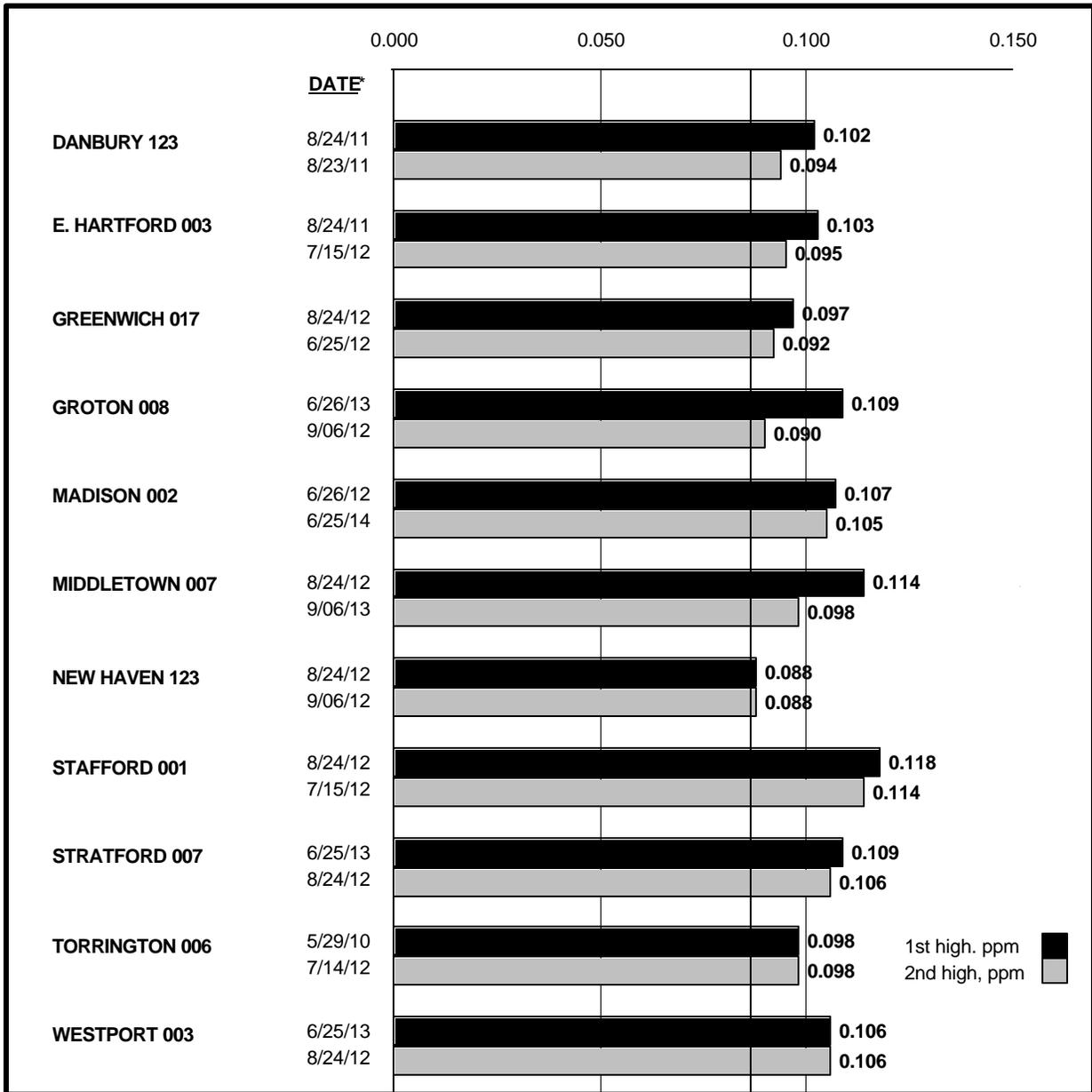
<u>SITE</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>1998</u>
Danbury 123	0	8	0	13	21	0	42
E. Hartford 003	0	0	0	4	7	0	11
Greenwich 017	0	3	4	5	16	0	28
Groton 008	0	0	7	0	0	10	17
Madison 002	0	2	14	0	11	16	43
Middletown 007	0	0	2	3	9	10	24
New Haven 123	0	0	0	2	2	4	8
Stafford 001	0	6	0	27	12	3	48
Stratford 007	0	0	12	5	24	13	54
Torrington 006	0	11	0	19	14	3	47
Westport 003	0	3	6	8	19	5	41
<b>Total Site Hours</b>	0	33	45	86	135	64	363

**TABLE 4-4****NUMBER OF DAYS WHEN THE 8-HOUR OZONE STANDARD  
WAS EXCEEDED IN 1998**

<u>SITE</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>1998</u>
Danbury 123	0	2	0	3	4	0	9
E. Hartford 003	0	0	0	1	1	0	2
Greenwich 017	0	1	1	1	5	0	8
Groton 008	0	0	1	0	0	2	3
Madison 002	0	1	2	0	3	3	9
Middletown 007	0	0	1	1	1	2	5
New Haven 123	0	0	0	1	1	1	3
Stafford 001	0	1	0	4	2	1	8
Stratford 007	0	0	2	2	4	3	11
Torrington 006	0	3	0	4	2	1	10
Westport 003	0	1	2	2	5	3	13
<b>Total Site Days</b>	0	9	9	19	28	16	81

**FIGURE 4-3**

**MAXIMUM DAILY 8-HOUR OZONE CONCENTRATIONS IN 1998**

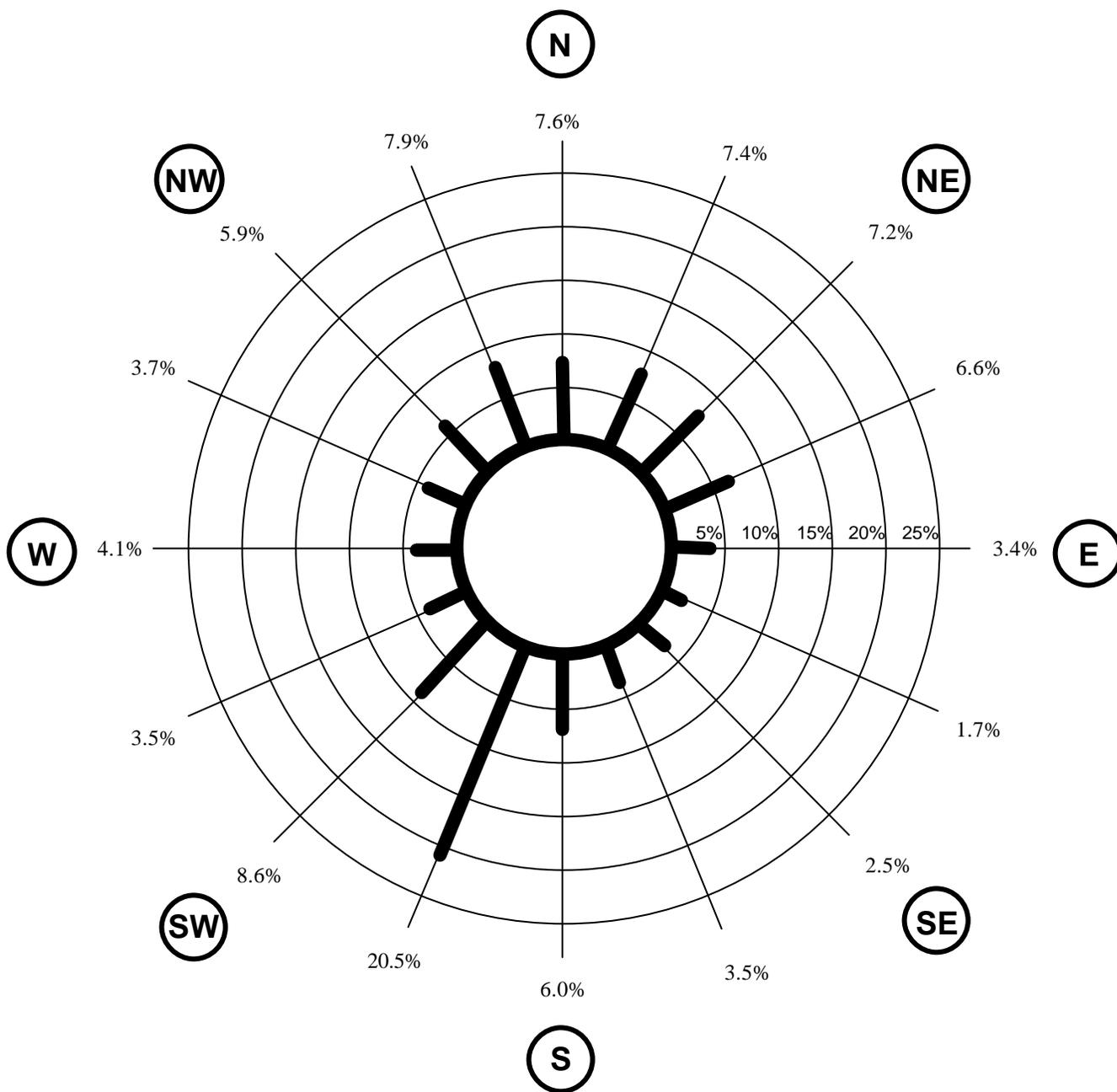


0.085  
 EXCEEDANCE LEVEL OF THE  
 REVISED PRIMARY AND  
 SECONDARY STANDARD

\* The date is the month/day/beginning hour (standard time) of occurrence.

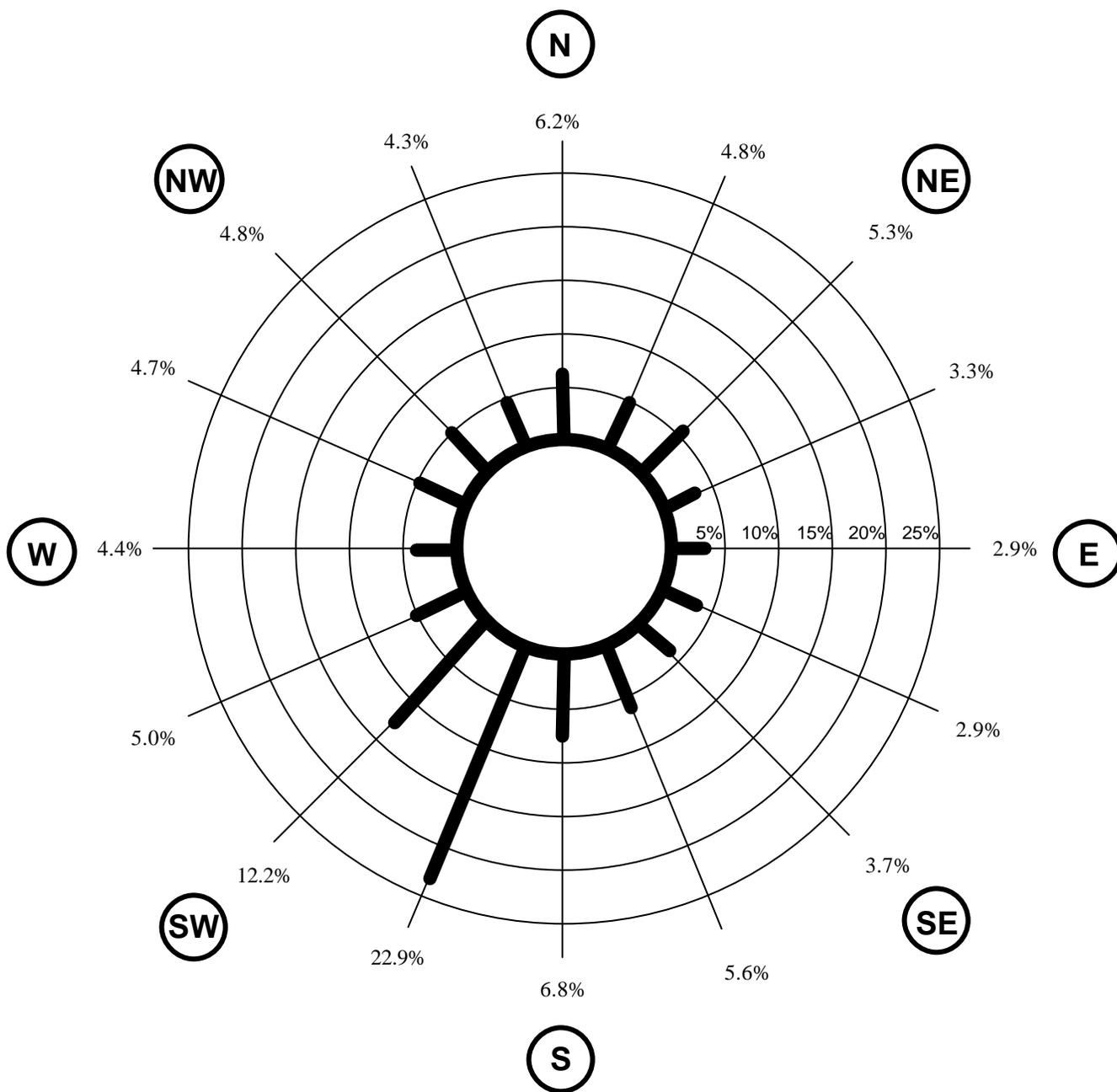
**FIGURE 4-4**

**WIND ROSE FOR JUNE-AUGUST 1997**  
**STAFFORD 001 MONITORING SITE**  
**SHENIPSIT STATE FOREST**



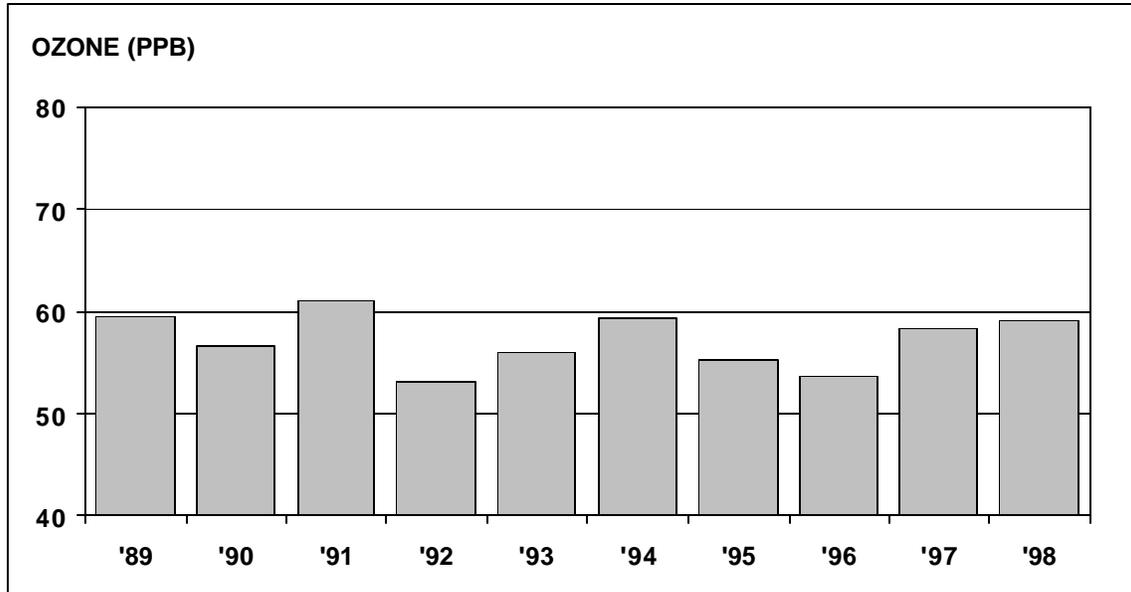
**FIGURE 4-5**

**WIND ROSE FOR JUNE-AUGUST 1998**  
**STAFFORD 001 MONITORING SITE**  
**SHENIPSIT STATE FOREST**



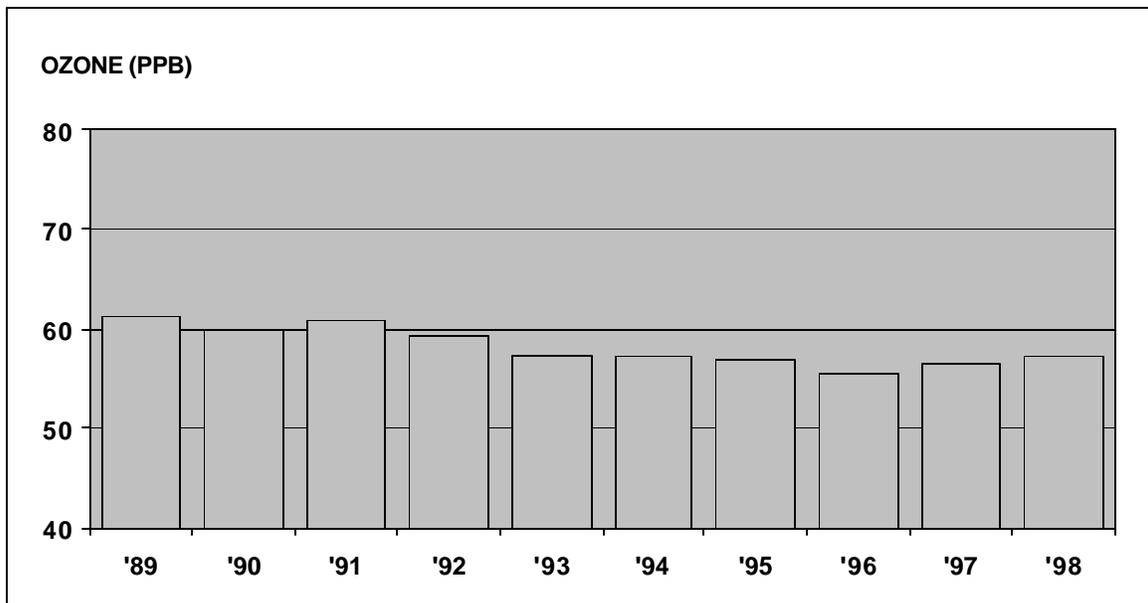
**FIGURE 4-6**

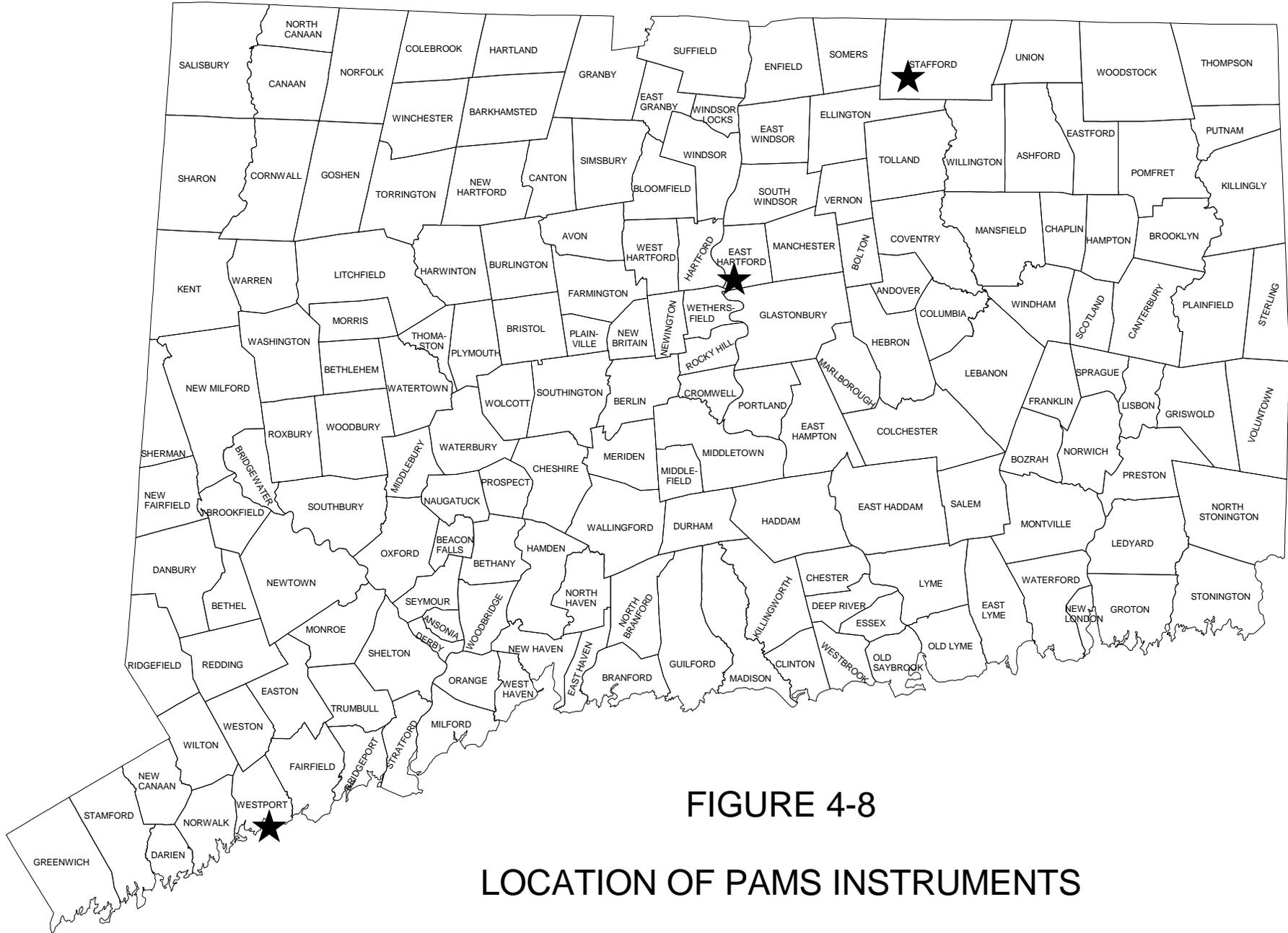
**AVERAGES OF THE ANNUAL MEAN DAILY MAXIMUM OZONE CONCENTRATIONS AT NINE SITES**



**FIGURE 4-7**

**5-YEAR AVERAGES OF THE ANNUAL MEAN DAILY MAXIMUM OZONE CONCENTRATIONS AT NINE SITES**





**FIGURE 4-8**

**LOCATION OF PAMS INSTRUMENTS**

TABLE 4-5

**VOC MEASURED AT PAMS SITES**

<b>Volatile Organic Compounds</b>		
<b>acetylene</b>	<b>ethane</b>	<b>2-methylpentane</b>
<b>benzene</b>	<b>ethylene</b>	<b>3-methylpentane</b>
<b>m-diethylbenzene</b>	<b>n-heptane</b>	<b>methylcyclopentane</b>
<b>p-diethylbenzene</b>	<b>2-methylheptane</b>	<b>2,2,4-trimethylpentane</b>
<b>ethylbenzene</b>	<b>3-methylheptane</b>	<b>2,3,4-trimethylpentane</b>
<b>isopropylbenzene</b>	<b>n-hexane</b>	<b>1-pentene</b>
<b>n-propylbenzene</b>	<b>cyclohexane</b>	<b>cis-2-pentene</b>
<b>1,2,3-trimethylbenzene</b>	<b>2-methylhexane</b>	<b>trans-2-pentene</b>
<b>1,2,4-trimethylbenzene</b>	<b>3-methylhexane</b>	<b>propane</b>
<b>1,3,5-trimethylbenzene</b>	<b>methylcyclohexane</b>	<b>propylene</b>
<b>n-butane</b>	<b>isoprene</b>	<b>styrene</b>
<b>2,2-dimethylbutane</b>	<b>n-nonane</b>	<b>toluene</b>
<b>2,3-dimethylbutane</b>	<b>n-octane</b>	<b>m-ethyltoluene</b>
<b>isobutane</b>	<b>n-pentane</b>	<b>o-ethyltoluene</b>
<b>1-butene</b>	<b>cyclopentane</b>	<b>p-ethyltoluene</b>
<b>cis-2-butene</b>	<b>2,3-dimethylpentane</b>	<b>n-undecane</b>
<b>trans-2-butene</b>	<b>2,4-dimethylpentane</b>	<b>m,p-xylene</b>
<b>n-decane</b>	<b>isopentane</b>	<b>o-xylene</b>
		<b>TNMHC<sup>1</sup></b>

<sup>1</sup> total non-methane hydrocarbons (C<sub>2</sub>-C<sub>12</sub>)

**TABLE 4-6****JUNE-AUGUST MEAN HOURLY VOC CONCENTRATIONS (ppbc)**

VOC	East Hartford			<b>Stafford</b>				Westport		
	'95	'97	'98	'95	'96	'97	'98	'96	'97	'98
<b>acetylene</b>	2.18	0.31	1.01	0.75	0.94	0.26	0.62	1.42	0.47	1.26
<b>benzene</b>	2.13	1.38	1.29	1.00	0.98	0.66	0.73	1.49	1.58	1.07
<b>m-diethylbenzene</b>	0.39	0.32	0.32	0.26	0.29	0.26	0.24	0.26	0.26	0.27
<b>p-diethylbenzene</b>	0.36	0.43	0.30	0.27	0.34	0.28	0.24	0.24	0.30	0.24
<b>ethylbenzene</b>	1.23	0.93	0.82	0.46	0.46	0.36	0.34	0.56	0.75	0.54
<b>isopropylbenzene</b>	0.27	0.25	0.22	0.27	0.25	0.26	0.25	0.23	0.22	0.24
<b>n-propylbenzene</b>	0.52	0.28	0.25	0.26	0.27	0.25	0.24	0.26	0.27	0.25
<b>1,2,3-trimethylbenzene</b>	1.48	1.44	0.89	0.82	1.00	0.67	0.76	0.79	0.85	0.55
<b>1,2,4-trimethylbenzene</b>	1.84	1.51	1.15	0.45	1.13	0.39	0.40	0.61	0.83	0.52
<b>1,3,5-trimethylbenzene</b>	0.74	0.50	0.49	0.29	0.32	0.24	0.25	0.30	0.37	0.31
<b>n-butane</b>	3.54	2.71	2.42	1.45	1.43	1.17	1.08	2.70	2.09	2.21
<b>isobutane</b>	0.44	0.24	0.28	0.28	0.30	0.17	0.22	0.24	0.17	0.29
<b>isobutane</b>	0.66	0.49	0.47	0.32	0.36	0.18	0.27	0.32	0.25	0.42
<b>isobutane</b>	1.72	1.44	1.38	0.72	0.85	0.57	0.63	1.45	1.04	1.34
<b>1-butene</b>	0.31	0.22	0.26	0.26	0.26	0.18	0.22	0.53	0.23	0.27
<b>cis-2-butene</b>	0.31	0.20	0.21	0.26	0.25	0.20	0.19	0.23	0.17	0.24
<b>trans-2-butene</b>	0.49	0.23	0.36	0.37	0.26	0.16	0.40	0.27	0.26	0.52
<b>n-decane</b>	1.32	1.40	0.64	0.35	0.31	0.26	0.25	0.37	0.50	0.37
<b>ethane</b>	3.60	3.66	3.96	3.14	3.21	2.52	2.93	4.10	2.73	3.84
<b>ethylene</b>	1.89	1.29	1.96	0.95	1.00	0.51	0.75	2.04	1.09	1.88
<b>n-heptane</b>	0.66	0.61	0.58	0.37	0.32	0.30	0.30	0.54	0.64	0.50
<b>2-methylheptane</b>	0.32	0.30	0.26	0.29	0.26	0.24	0.24	0.25	0.24	0.28
<b>3-methylheptane</b>	0.34	0.32	0.30	0.28	0.25	0.25	0.24	0.28	0.32	0.29
<b>n-hexane</b>	1.51	1.24	1.06	0.58	0.53	0.43	0.39	0.86	1.21	0.81
<b>cyclohexane</b>	0.33	0.33	0.37	0.26	0.26	0.25	0.25	0.29	0.30	0.29
<b>2-methylhexane</b>	0.92	0.65	0.58	0.37	0.34	0.30	0.29	0.56	0.64	0.49
<b>3-methylhexane</b>	1.12	0.78	0.66	0.62	0.41	0.37	0.35	0.72	0.82	0.60
<b>methylcyclohexane</b>	0.52	0.47	0.41	0.28	0.26	0.25	0.25	0.39	0.53	0.36

**TABLE 4-6 ... cont'd**

**JUNE-AUGUST MEAN HOURLY VOC CONCENTRATIONS (ppbc)**

VOC	East Hartford			Stafford				Westport		
	'95	'97	'98	'95	'96	'97	'98	'96	'97	'98
<b>isoprene</b>	2.60	1.88	1.47	5.19	4.17	4.68	3.63	2.29	2.43	2.44
<b>n-nonane</b>	0.60	0.69	0.42	0.28	0.27	0.25	0.24	0.30	0.33	0.29
<b>n-octane</b>	0.43	0.45	0.41	0.31	0.28	0.26	0.25	0.36	0.37	0.32
<b>n-pentane</b>	2.94	1.65	1.98	1.12	1.25	0.92	0.84	1.95	1.72	1.72
<b>cyclopentane</b>	0.35	0.31	0.25	0.26	0.26	0.20	0.22	0.26	0.24	0.25
<b>2,3-dimethylpentane</b>	0.72	0.73	0.60	0.40	0.32	0.32	0.29	0.58	0.62	0.45
<b>2,4-dimethylpentane</b>	0.47	0.60	0.41	0.28	0.26	0.31	0.25	0.39	0.75	0.32
<b>isopentane</b>	8.47	3.84	4.73	2.63	2.57	2.06	1.82	5.27	4.31	4.27
<b>2-methylpentane</b>	2.26	1.26	1.45	0.72	0.80	0.45	0.58	0.92	0.74	1.26
<b>3-methylpentane</b>	1.66	0.95	0.93	0.60	0.60	0.34	0.40	0.68	0.67	0.80
<b>methylcyclopentane</b>	0.75	0.64	0.67	0.37	0.32	0.27	0.29	0.59	0.44	0.55
<b>2,2,5-trimethylpentane</b>	1.68	1.69	1.52	0.79	0.71	0.57	0.53	1.68	1.58	1.27
<b>2,3,5-trimethylpentane</b>	0.55	0.48	0.47	0.34	0.32	0.28	0.28	0.58	0.53	0.48
<b>1-pentene</b>	0.35	0.24	0.25	0.25	0.26	0.15	0.22	0.23	0.14	0.23
<b>cis-2-pentene</b>	0.24	0.24	0.20	0.25	0.25	0.21	0.24	0.23	0.15	0.21
<b>trans-2-pentene</b>	0.50	0.26	0.38	0.25	0.25	0.20	0.24	0.25	0.17	0.26
<b>propane</b>	6.50	7.92	5.64	2.70	2.84	2.79	2.20	4.88	4.15	4.09
<b>propylene</b>	4.18	0.86	0.90	0.59	0.48	0.41	0.52	1.18	0.94	0.98
<b>styrene</b>	0.98	0.53	0.40	0.60	0.43	0.33	0.38	0.26	0.29	0.25
<b>toluene</b>	6.26	6.38	5.40	2.29	2.14	1.94	1.85	4.16	4.91	3.59
<b>m-ethyltoluene</b>	0.90	0.94	0.61	0.36	0.38	0.32	0.32	0.61	0.56	0.36
<b>o-ethyltoluene</b>	0.51	0.42	0.28	0.36	0.29	0.26	0.24	0.25	0.28	0.25
<b>p-ethyltoluene</b>	1.28	0.71	0.50	0.62	0.38	0.42	0.39	0.59	0.55	0.52
<b>n-undecane</b>	0.99	1.46	0.62	0.29	0.29	0.33	0.25	0.23	0.43	0.36
<b>m/p-xylene</b>	3.84	2.96	2.60	1.06	1.13	0.77	0.75	2.00	2.28	1.56
<b>o-xylene</b>	1.34	1.14	0.89	0.46	0.52	0.35	0.34	0.77	0.94	0.62
<b>TOTAL</b>	75.42	59.26	52.67	36.07	35.11	29.01	28.21	49.31	45.80	44.10

## V. NITROGEN DIOXIDE

### HEALTH EFFECTS

Nitrogen dioxide (NO<sub>2</sub>) is a toxic gas with a characteristic pungent odor and a reddish-orange-brown color. It is highly oxidizing and extremely corrosive.

The presence of NO<sub>2</sub> in the atmosphere is accounted for by the oxidation of nitric oxide (NO) to NO<sub>2</sub> by means of reactions with various chemical species, principally ozone, hydroperoxyl radicals and organic peroxy radicals. Large amounts of NO are emitted into the air by high temperature combustion processes. Industrial furnaces, power plants and motor vehicles are the primary sources of NO emissions.

Exposure to NO<sub>2</sub> is believed to increase the risks of acute respiratory disease and susceptibility to chronic respiratory infection. NO<sub>2</sub> also contributes to heart, lung, liver and kidney damage. At high concentrations, this pollutant can be fatal. At lower levels of 25 to 100 parts per million, it can cause acute bronchitis and pneumonia. Occasional exposure to low levels of NO<sub>2</sub> can irritate the eyes and skin.

Other effects of nitrogen dioxide are its toxicity to vegetation and its ability to combine with water vapor to form nitric acid. Furthermore, NO<sub>2</sub> is an essential ingredient, along with hydrocarbons, in the formation of ozone.

### CONCLUSIONS

Nitrogen dioxide (NO<sub>2</sub>) concentrations at all monitoring sites did not violate the NAAQS for NO<sub>2</sub> in 1998. The annual arithmetic mean NO<sub>2</sub> concentration at each site was well below the federal standard of 100 µg/m<sup>3</sup>. The highest annual mean was 51 µg/m<sup>3</sup>, which occurred at the New Haven site.

### SAMPLE COLLECTION AND ANALYSIS

The DEP Air Monitoring Unit used continuous electronic analyzers employing the chemiluminescent reference method to continuously monitor NO<sub>2</sub> levels.

### DISCUSSION OF DATA

**Monitoring Network** – Four nitrogen oxide monitoring sites were operated in Connecticut in 1998 (see Figure 5-1). Two of the sites -- at East Hartford and New Haven – were operated for the purpose of determining annual statistics for nitrogen dioxide. They were located in urban areas near major expressways in order to obtain maximum NO<sub>2</sub> readings. The Westport site was operated primarily as a type (1) PAMS site to monitor nitrogen oxides (NO<sub>x</sub>) upwind of the Hartford area. A fourth site in Stafford was operated from April through September as a type (3) PAMS site for the purpose of gathering NO<sub>x</sub> data downwind of the Hartford area.

**Precision and Accuracy** – Ninety-seven precision checks were made on the NO<sub>2</sub> monitors in 1998, yielding 95% probability limits ranging from -13% to +8%. Accuracy is determined by introducing a known amount of NO<sub>2</sub> into each of the monitors. Eight audits for accuracy were conducted on the monitoring network in 1998. Three different concentration levels were tested on each monitor: low, medium, and high. The 95% probability limits for the low level

test ranged from -11% to +5%; those for the medium level test ranged from -14% to +5%; and those for the high level test ranged from -12% to +4%. (For an explanation of the use of 95% probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**Annual Averages** - The annual average NO<sub>2</sub> standard of 100 µg/m<sup>3</sup> was not exceeded in 1998 at any site in Connecticut (see Table 5-1). In addition, three sites had sufficient data to compute valid arithmetic means. This permits some comparisons with the 1996 and 1997 annual averages. The Stafford site is omitted from the table because it is operated only during the ozone season.

**Statistical Projections** - The format of Table 5-1 is the same as that used to present the particulate matter and sulfur dioxide data, except that for NO<sub>2</sub> there are no 24-hour standards and, therefore, no projections of violations are possible. However, Table 5-1 gives the annual arithmetic mean of the hourly NO<sub>2</sub> concentrations in order to allow direct comparison to the annual NO<sub>2</sub> standard. The 95% confidence limits about the arithmetic mean for each site demonstrate that it is unlikely that any site exceeded the primary annual standard of 100 µg/m<sup>3</sup> in 1998.

**Highest Hourly Concentrations and Wind Data** - As was the case with particulate matter, sulfur dioxide and ozone, the highest NO<sub>2</sub> concentrations occur most often on days when persistent winds out of the southwest quadrant predominate. During the ten year period between 1986 and 1995, 68% of the annual ten highest hourly NO<sub>2</sub> concentrations at each monitoring site in the state occurred on days when such wind conditions prevailed. This is not unexpected, since the NO<sub>2</sub> monitoring sites were deliberately located to the north and east of major expressways and interchanges, which are major sources of nitrogen oxide emissions.

In addition, according to National Weather Service local climatological data recorded at Bradley Airport, 75% of the high NO<sub>2</sub> days had at least 50% of the possible sunshine. A high percentage of the possible sunshine is interpreted to confirm the importance of photochemical oxidation in the formation of NO<sub>2</sub>.

**Trends** - The weighted averages of the annual NO<sub>2</sub> concentrations at two monitoring sites -- East Hartford and New Haven -- are illustrated in Figure 5-2. These sites were the only ones that had data over a twelve-year period. The year-to-year variation appears to be quite choppy. In spite of this, a slight downward trend in the annual NO<sub>2</sub> concentrations is evident.

Given the importance of meteorology -- sunlight, in general, and southwest winds in Connecticut, in particular -- on the formation of NO<sub>2</sub>, a trend might best be illustrated by the averaging of the data over multiple years. As was the case with ozone, a trend based on multiple years of data should diminish the effect of meteorology and, thereby, reveal the effect of nitrogen oxide and hydrocarbon emission controls on ambient concentrations of NO<sub>2</sub>. Figure 5-3 shows that the five-year average NO<sub>2</sub> concentration, with the influence of meteorology minimized, has been trending downward slightly over the past ten years. The decrease in NO<sub>2</sub> is approximately 9.6%.

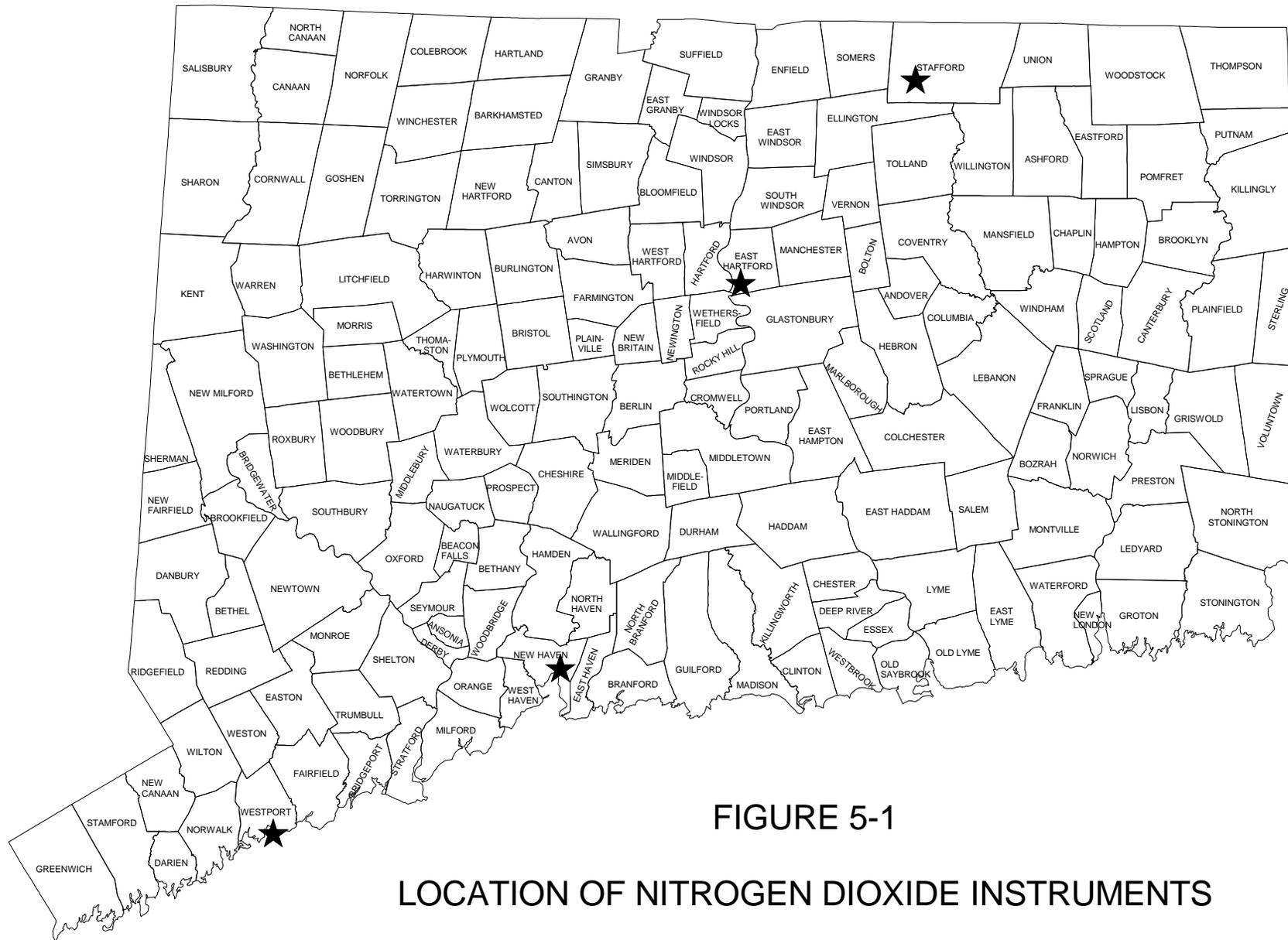


FIGURE 5-1

LOCATION OF NITROGEN DIOXIDE INSTRUMENTS

**TABLE 5-1****1996-1998 NITROGEN DIOXIDE ANNUAL AVERAGES**

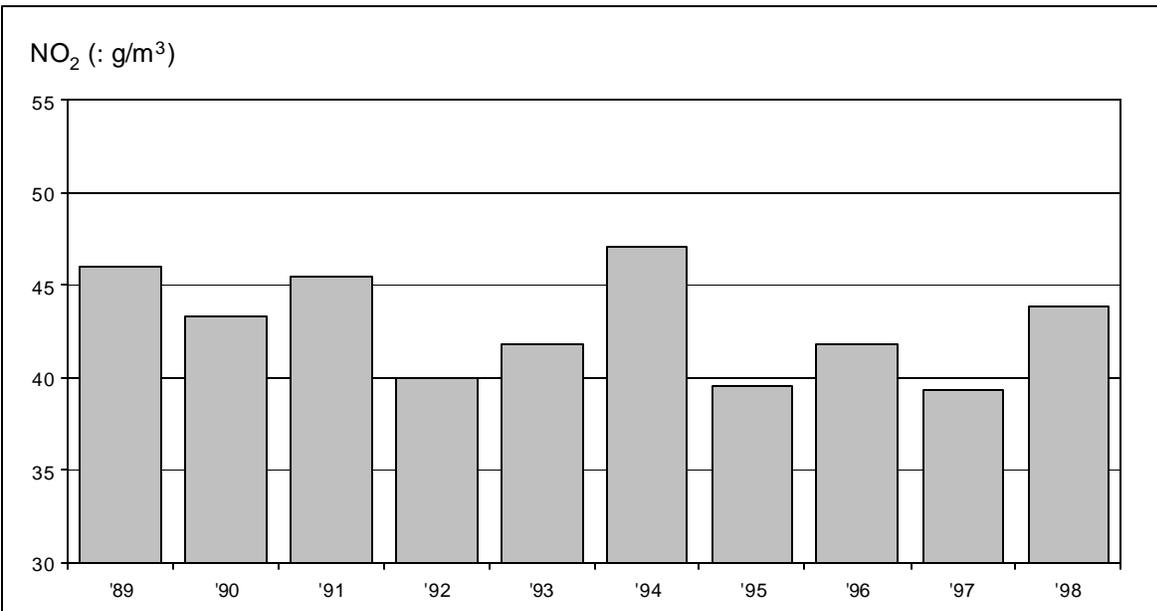
TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95--PCT--LIMITS LOWER	UPPER	STANDARD DEVIATION
BRIDGEPORT	013	1996	8119	44.2	44.1	44.4	24.660
BRIDGEPORT	013	1997	8414	42.5	42.4	42.6	22.826
EAST HARTFORD*	003	1996	4575	29.7	29.2	30.2	25.586
EAST HARTFORD*	003	1997	7671	33.7	33.5	33.9	21.749
EAST HARTFORD	003	1998	8377	37.3	37.2	37.4	22.632
NEW HAVEN	123	1996	8366	48.4	48.3	48.5	22.718
NEW HAVEN	123	1997	8525	44.4	44.3	44.4	21.440
NEW HAVEN	123	1998	8360	50.6	50.5	50.7	25.731
WESTPORT	003	1998	8533	34.6	34.5	34.6	24.175

\* The site was shut down from July, 1996 through January, 1997 due to construction in the area.

N.B. The arithmetic mean and associated statistics have units of  $\mu\text{g}/\text{m}^3$ .

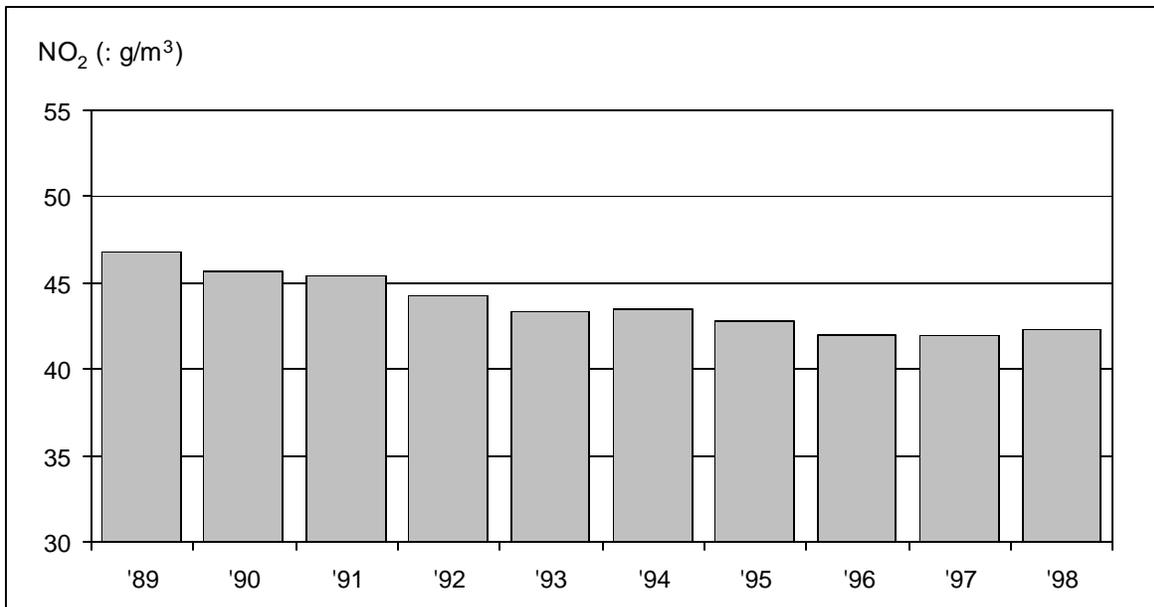
**FIGURE 5-2**

**AVERAGES OF THE ANNUAL NO<sub>2</sub> CONCENTRATIONS  
AT TWO SITES**



**FIGURE 5-3**

**5-YEAR AVERAGES OF THE ANNUAL NO<sub>2</sub> CONCENTRATIONS  
AT TWO SITES**



## **VI. CARBON MONOXIDE**

### **HEALTH EFFECTS**

Carbon monoxide (CO) is a colorless, odorless, poison gas formed from incomplete combustion of carbon-containing fuels and from oxidation of hydrocarbons in the atmosphere. Carbon monoxide is by far the most plentiful air pollutant monitored by the State of Connecticut. Fortunately, this deadly gas does not persist in the atmosphere. CO is converted by natural processes to carbon dioxide, and this is done quickly enough to prevent any general buildup. However, CO can reach dangerous levels in local areas, such as city-street canyons with heavy auto traffic and little wind.

Clinical experience with accidental CO poisoning has shown clearly how it affects the body. When the gas is breathed, CO replaces oxygen in the red blood cells, reducing the amount of oxygen that can reach the body cells and maintain life. Lack of oxygen affects the brain, and the first symptoms are impaired perception and thinking. Reflexes are slowed, judgment weakened, and drowsiness ensues. An auto driver breathing high levels of CO is more likely to have an accident; an athlete's performance and skill drop suddenly. Lack of oxygen then affects the heart. If a person is exposed to very high levels of CO, death can come from heart failure or general asphyxiation. Fortunately, such levels are many times higher than the National Ambient Air Quality Standards for CO, which by definition are established with a cushion of safety for population exposure.

### **CONCLUSIONS**

Neither the one-hour National Ambient Air Quality Standard of 35 parts per million (ppm) nor the 8-hour standard of 9 ppm was exceeded at any of the five carbon monoxide monitoring sites in Connecticut during 1998.

In order to put the monitored data into proper perspective, one must realize that carbon monoxide concentrations vary greatly from place to place. The magnitude and frequency of high concentrations observed at any monitoring site are not necessarily indicative of widespread CO levels. Mobile sources contribute 83% of the CO emissions in Connecticut, and three quarters of this is attributed to motor vehicles. Therefore, the highest concentrations occur in areas of traffic congestion. In fact, 4 of the 5 CO monitors in Connecticut are sited specifically to measure CO levels from high traffic areas. The fifth monitor (Hartford 013) is located in a populated area and represents background levels of a neighborhood scale.

As Connecticut implements its SIP control strategies, there should continue to be a decrease in the number of areas with traffic congestion. Also, as federal and state mandated controls continue to reduce emissions from new motor vehicles, ambient levels of CO should continue to decline.

Unlike SO<sub>2</sub>, particulate matter, and O<sub>3</sub>, elevated CO levels are not often associated with winds out of the southwest quadrant, indicating that this pollutant is more of a local-scale, rather than a regional-scale, problem. Moreover, high CO levels tend to occur during the colder months, when there are low atmospheric mixing heights, stable conditions and high CO auto emissions due to cold engine operation. Inversions, which are characterized by cold temperatures at the surface and warm temperatures aloft, and other stable conditions discourage surface mixing and result in calm surface conditions. With little or no surface winds, CO emissions can accumulate to unhealthy levels.

### **METHOD OF MEASUREMENT**

The DEP uses instruments employing a non-dispersive infrared technique to continuously measure carbon monoxide levels. The instantaneous concentrations are electronically recorded at the site, averaged for each hour, and stored for transmission to the central computer in Hartford. Due to the relative inertness of CO, a long sampling line can be used without the danger of CO being depleted by chemical reactions within the line. The most important consideration in the measurement of CO is the placement of the sampling probe inlet -- that is, its proximity to traffic lanes.

## **DISCUSSION OF DATA**

**Monitoring Network** - The monitoring network in 1998 consisted of five carbon monoxide monitoring sites: Bridgeport, Hartford 013, Hartford 017, New Haven, and Stamford. They are all located in urban areas west of the Connecticut River, with three of them in coastal towns (see Figure 6-1).

**Precision and Accuracy** – A total of 227 precision checks were performed on the carbon monoxide monitoring network during 1998. The resulting 95% probability limits for those checks were -2% to +4%. Network accuracy was determined by introducing a known amount of CO into each of the monitors. Eight audits for accuracy were conducted on the CO monitoring network in 1998. Three different concentration levels were tested on each monitor: low, medium and high. The 95% probability limits ranged from -3% to +5% for the low level test; -3% to +4% for the medium level test; and -2% to +5% for the high level test. (For an explanation of the use of 95% probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**8-Hour and 1-Hour Averages** – An 8-hour average for CO is an average computed for the 8-hour period ending at any hour. An 8-hour average concentration exceeds the standard of 9 ppm if it is equal to or greater than 9.5 ppm. No site had an exceedance of the 8-hour CO standard, which means that the 8-hour standard was not violated in Connecticut in 1998. The maximum 8-hour averages decreased from 1997 to 1998 at Bridgeport, New Haven and Stamford, and increased at Hartford 017. The second highest 8-hour averages followed the same pattern. The second highest concentration is important because a violation of the secondary CO standard occurs when there are two exceedances of the level of the standard.

As for 1-hour averages, no site in the state recorded a value exceeding the primary 1-hour standard of 35 ppm. The maximum 1-hour averages decreased from 1997 to 1998 at Bridgeport, New Haven and Stamford, and increased at the two Hartford sites. The second high 1-hour values followed the same pattern. The second highest concentration is important because two exceedances of the level of the primary standard are required before the standard can be said to be violated.

The maximum and second high CO concentrations at each site are presented in Table 6-1. Table 6-2 presents monthly high concentrations and the monthly average concentration at each site. Seasonal variations in CO levels can be observed using this table.

**Trends** - Due to the local nature of CO emissions, it is not appropriate to give an estimate of widespread CO trends. However, local CO trends can be addressed in a number of ways. Exceedances of the 8-hour standard can be tracked in order to determine if a CO problem is worsening or abating at a site. This is illustrated in Table 6-3. One can see that over the past five years the Hartford 017 site is the only monitoring site with an exceedance of the 8-hour CO standard.

A better way of illustrating local CO trends is to use longer averaging periods. This has the advantage of smoothing out the abrupt, transitory changes in CO levels that are often evident in consecutive sampling periods and from one season to the next. Figure 6-2 shows the 36-month averages of the hourly CO concentrations at each monitoring site. CO levels are trending downward slightly at all the sites. Because the New Haven site has been in operation only since February of 1995, it lacks sufficient data for 36-month averages beginning before 1998.

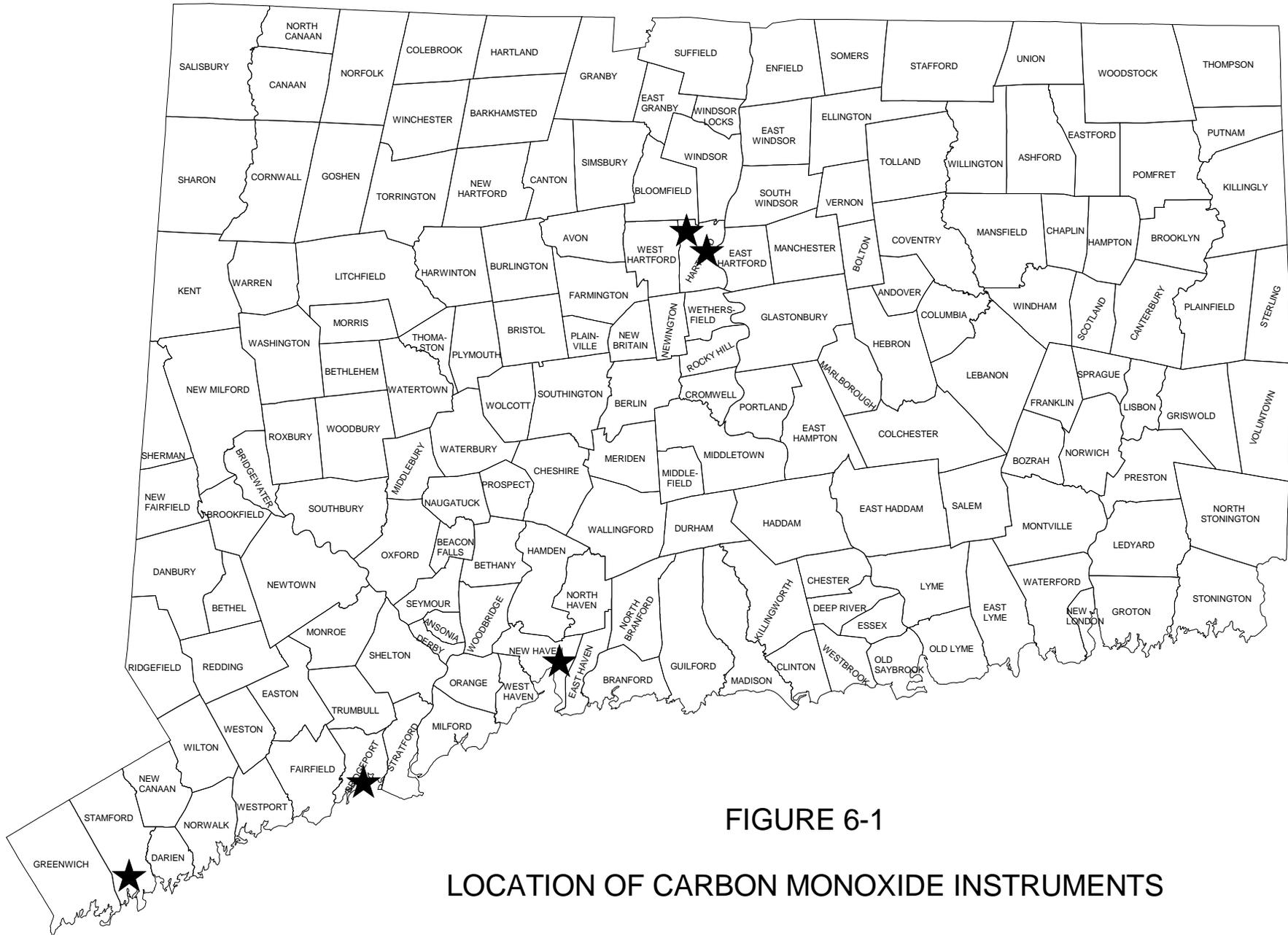


FIGURE 6-1

LOCATION OF CARBON MONOXIDE INSTRUMENTS

## TABLE 6-1

### 1998 CARBON MONOXIDE STANDARDS ASSESSMENT SUMMARY

<u>TOWN-SITE</u>	<u>MAXIMUM 8-HOUR AVERAGE</u>	<u>TIME OF MAXIMUM 8-HOUR AVERAGE<sup>1</sup></u>	<u>2<sup>ND</sup> HIGH 8-HOUR AVERAGE</u>	<u>TIME OF 2<sup>ND</sup> HIGH 8-HOUR AVERAGE<sup>1</sup></u>	<u>MAXIMUM 1-HOUR AVERAGE</u>	<u>TIME OF MAXIMUM 1-HOUR AVERAGE<sup>2</sup></u>	<u>2<sup>ND</sup> HIGH 1-HOUR AVERAGE</u>	<u>TIME OF 2<sup>ND</sup> HIGH 1-HOUR AVERAGE<sup>2</sup></u>
Bridgeport 004	3.1	02/10/01	2.8	12/07/06	4.8	02/09/22	4.4	11/28/23
Hartford 013	4.0	12/17/01	3.7	02/07/05	4.7	12/16/20	4.7	12/16/21
Hartford 017	7.9	01/29/23	7.1	02/06/23	17.0	01/29/18	12.8	01/29/17
New Haven 025	3.6	12/17/01	2.7	11/19/20	5.2	12/03/18	4.4	12/16/24
Stamford 020	5.0	01/03/01	3.8	02/09/24	6.2	01/02/19	6.0	01/02/24

<sup>1</sup> The time of the 8-hour average is reported as follows: month/day/hour (EST), specifying the end of the 8-hour period.

<sup>2</sup> The time of the 1-hour average is reported as follows: month/day/hour (EST), specifying the end of the 1-hour period.

N.B. The CO averages are expressed in terms of parts per million (ppm).

**TABLE 6-2**

**1998 CARBON MONOXIDE SEASONAL FEATURES**

<u>TOWN-SITE</u>	<u>AVERAGING PERIOD</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>
Bridgeport 004	Max. 1-Hour	3.2	4.8	3.3	2.3	3.0	2.1	2.3	2.7	2.9	2.8	4.4	4.0
	Max. 8-Hour	2.6	3.1	1.9	1.5	2.1	1.9	1.6	1.9	1.8	1.7	2.6	2.8
	Month	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.2
Hartford 013	Max. 1-Hour	2.8	3.9	2.4	2.0	1.3	1.3	1.6	1.2	1.8	1.8	3.1	4.7
	Max. 8-Hour	2.6	3.7	2.0	1.4	1.1	1.1	1.2	1.0	1.4	1.5	3.0	4.0
	Month	0.7	0.8	0.7	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.9	0.8
Hartford 017	Max. 1-Hour	17.0	12.3	8.0	5.5	4.9	4.2	4.0	3.9	4.5	6.1	7.2	8.9
	Max. 8-Hour	7.9	7.1	4.3	3.4	3.6	2.8	2.7	2.8	3.0	3.6	4.2	5.8
	Month	1.9	1.7	1.5	1.4	1.3	1.1	1.3	1.2	1.3	1.5	1.8	1.6
New Haven 025	Max. 1-Hour	3.3	3.6	2.3	2.1	2.2	2.6	2.3	2.4	2.4	3.2	4.2	5.2
	Max. 8-Hour	2.6	2.6	1.8	1.4	1.8	1.9	1.5	1.8	1.6	1.5	2.7	3.6
	Month	1.0	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.1
Stamford 020	Max. 1-Hour	6.2	4.9	3.5	3.4	4.3	3.0	2.8	3.1	4.0	3.7	4.2	5.5
	Max. 8-Hour	5.0	3.8	2.7	2.2	2.0	1.9	2.1	1.8	2.1	2.6	3.5	3.5
	Month	1.5	1.3	1.2	1.2	0.9	1.1	1.1	1.0	1.2	1.3	1.4	1.5
NETWORK	Month	1.2	1.1	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.1	1.2	1.2

N.B. The CO concentrations are expressed in terms of parts per million (ppm).

**TABLE 6-3**

**EXCEEDANCES OF THE 8-HOUR CO STANDARD FOR 1994-1998**

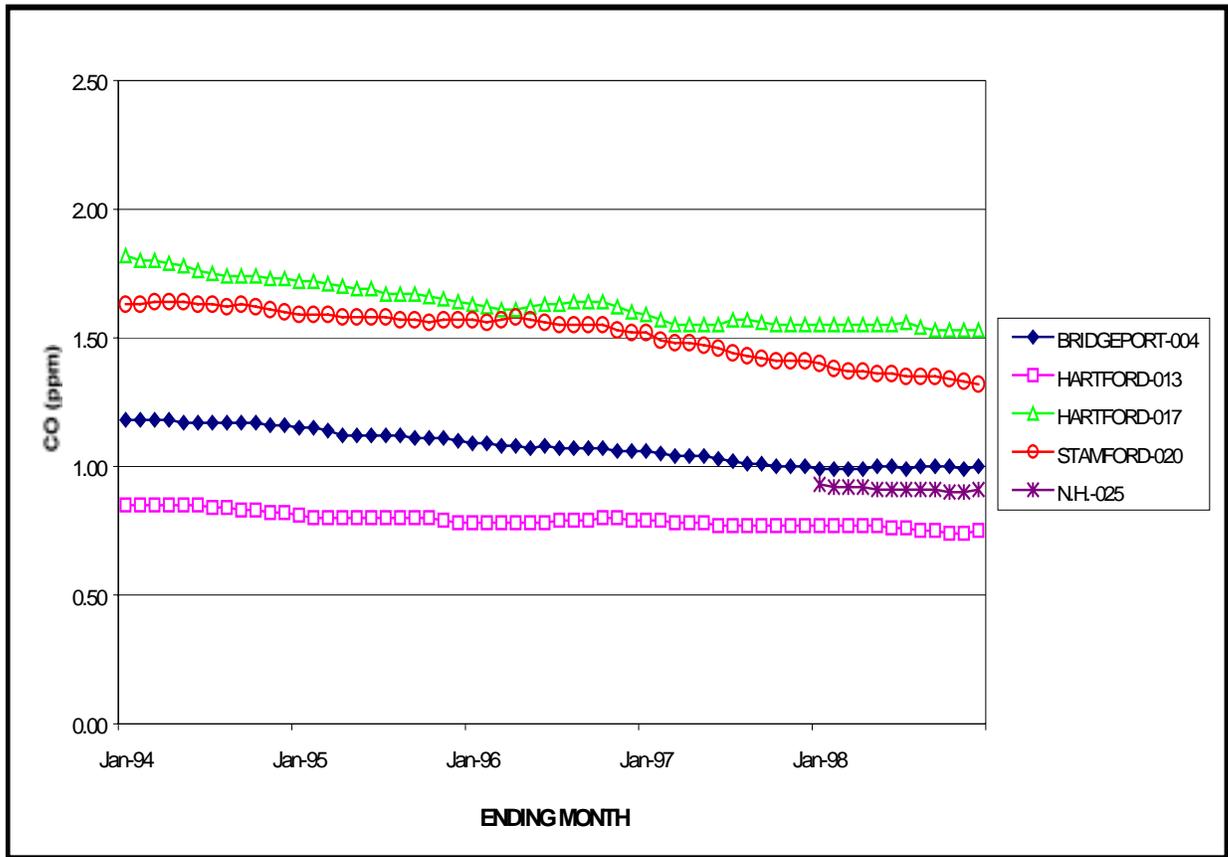
TOWN-SITE	<u>1994</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>
Bridgeport 004	0	0	0	0	0
Hartford 013	0	0	0	0	0
Hartford 017	0	1	0 <sup>a</sup>	0 <sup>a</sup>	0
New Haven 019/025 <sup>b</sup>	0	0	0	0	0
Stamford 020	0	0	0	0	0

<sup>a</sup>The site was closed down in February of 1996, due to nearby construction work, and was reactivated on April 30, 1997, when the work was completed.

<sup>b</sup>Site 025 replaced site 019 in February of 1995.

FIGURE 6-2

**36-MONTH AVERAGES OF THE HOURLY CO CONCENTRATIONS**



## VII. LEAD

### HEALTH EFFECTS

Lead (Pb) is a soft, dull gray, odorless and tasteless heavy metal. It is a ubiquitous element that is widely distributed in small amounts, particularly in soil and in all living things. Although the metallic form of lead is reactive and rarely occurs in nature, lead is prevalent in the environment in the form of various inorganic compounds, and occasional concentrated deposits of lead compounds occur in the earth's crust.

The presence of lead in the atmosphere is primarily accounted for by the emissions of lead compounds from man-made processes, such as the extraction and processing of metallic ores, the incineration of solid wastes, and fuel combustion. Nationally, in recent years, these source categories contributed 57%, 17% and 13%, respectively, of the atmospheric lead. The motor vehicle contribution at 0.5% is a very minor source of airborne lead emissions, and has decreased significantly since 1988, when it was the largest source of nationwide airborne lead emissions. Lead compound emissions are in the form of fine-to-coarse particulate matter and are comprised of lead sulfate, ammonium lead halides, and lead halides, of which the chief component is lead bromochloride. The halide compounds appear to undergo chemical changes over a period of hours and are converted to lead carbonate, oxide and oxycarbonate.

The most important sources of lead in humans and other animals are ingestion of foods and beverages, inhalation of airborne lead, and the eating of non-food substances. From the standpoint of the general population, the intake of lead into the body is primarily through ingestion. The airborne lead settles out on crops and water supplies and is then ingested by the general population. The direct intake of lead from the ambient air is relatively small.

Overexposure to lead in the United States is primarily a problem in children. Age, pica, diet, nutritional status, and multiple sources of exposure serve to increase the risk of lead poisoning in children. This is especially true in the inner cities where the prevalence of lead poisoning is greatest. Overexposure to lead compounds may result in undesirable biologic effects. These effects range from reversible clinical or metabolic symptoms, which disappear after cessation of exposure, to permanent damage or death from a single extreme dose or prolonged overexposure. Clinical lead poisoning is accompanied by symptoms of intestinal cramps, peripheral nerve paralysis, anemia, and severe fatigue. Very severe exposure results in permanent neurological, renal, or cardiovascular damage or death.

### CONCLUSIONS

The Connecticut primary and secondary ambient air quality standard for lead and its compounds is  $1.5 \mu\text{g}/\text{m}^3$ , maximum arithmetic mean averaged over three consecutive calendar months. This standard was not exceeded at the lead monitoring site in Connecticut during 1998.

### SAMPLE COLLECTION AND ANALYSIS

The Air Monitoring Unit used a hi-vol sampler in 1998 to obtain ambient concentrations of lead. This type of sampler is used to collect particulate matter onto fiberglass filters. The particulate matter collected on the filter is subsequently analyzed for its chemical composition. Wet chemistry techniques are used to separate the particulate matter into various components.

The lead content of the particulate matter is determined using an atomic absorption spectrophotometer.

Unlike hi-vol particulate samples which are analyzed separately, the hi-vol lead sample is a composite of all the individual samples obtained at a site in a single month. That is, a cutting is taken from each filter during the month, and these cuttings are collectively chemically analyzed for lead.

## **DISCUSSION OF DATA**

**Monitoring Network** - In 1998, a hi-vol sampler was operated in Waterbury to determine lead levels. The sampler is situated in the downtown area near an I-84 on-ramp in order to monitor "worst-case" motor vehicle lead concentrations.

Chemical analysis of hi-vol and lo-vol particulate samples for lead has been an important element of Connecticut's air monitoring program since 1970. For this reason, the lead sampling network was identical to the particulate sampling network for much of the decade of the seventies. It decreased in size throughout the eighties, compared to the number of particulate samplers.

Much of the lead monitoring network was dismantled in 1988 due to the changeover from hi-vol to PM<sub>10</sub> monitoring in the particulate matter network. By the end of that year, all but two of the hi-vol lead sampling sites were terminated: Hartford 013 and New Haven 013. By the end of 1989, the remaining hi-vol samplers were terminated and only five lo-vol samplers were in use.

In 1991, the lo-vols were replaced by hi-vols. The primary reason for this has to do with data losses resulting from instrument problems or failures. With a lo-vol, an entire month of data is invalidated if an instrument fails because lo-vols operate continuously for a month. In the case of a hi-vol, instrument problems or failures result in the loss of only a single 24-hour sample.

By 1996, atmospheric lead levels had fallen to such low levels compared to the applicable standard, a decision was made to cease sampling for lead altogether. No sampling was performed in 1997. By 1998, lead sampling was reinstated in Waterbury, in order that lead levels in at least one location in the state be monitored and made available to the public.

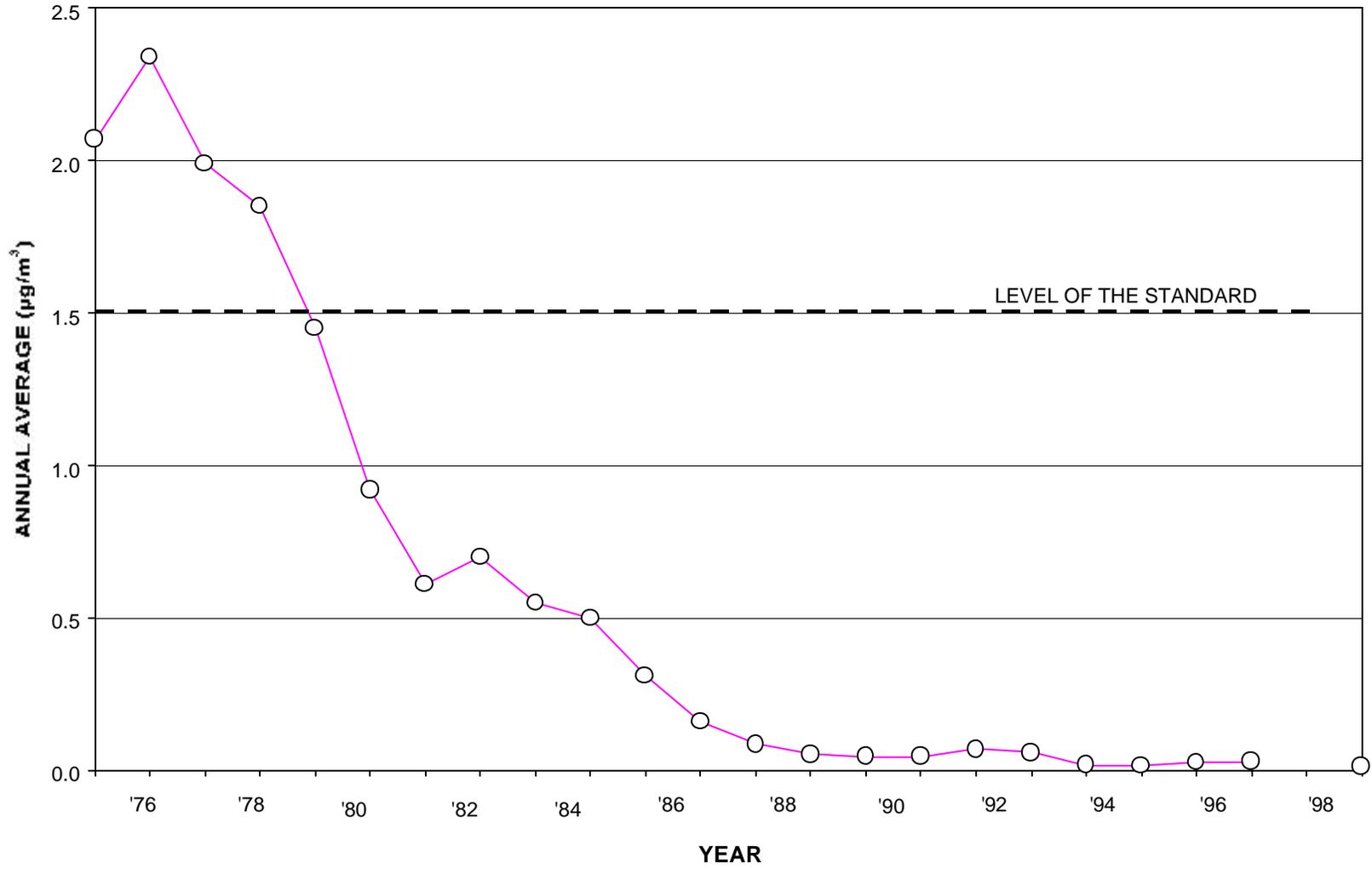
**Precision and Accuracy** - Due to the very low airborne lead concentrations, precision checks yield 95% probability limits that are statistically unrealistic. Accuracy for lead is assessed by auditing the air flow through the monitor. Two audits for flow accuracy were conducted on the monitoring network in 1998. The probability limits ranged from -1% to +6%. (For an explanation of the use of 95% probability limits, the reader should refer to section I.D. Quality Assurance in the Introduction of this Air Quality Summary.)

**NAAQS** - Connecticut's ambient air quality standard for lead and its compounds, measured as elemental lead, is: 1.5 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), maximum arithmetic mean averaged over three consecutive calendar months. This standard was enacted on November 2, 1981. Previously, Connecticut's lead standard was identical to the national standard: 1.5  $\mu\text{g}/\text{m}^3$  for a calendar quarter-year average. The change to an average based on three consecutive months means that a more stringent standard applies in Connecticut, since there are three times as many data blocks within a calendar year which must not exceed the limiting concentration of 1.5  $\mu\text{g}/\text{m}^3$ .

**3-Month Averages** - Three-month average lead concentrations at the Waterbury site for 1998 did not exceed 0.02  $\mu\text{g}/\text{m}^3$ . This is significantly below the standard of 1.5  $\mu\text{g}/\text{m}^3$ .

**FIGURE 7-1**

**ANNUAL AVERAGE LEAD CONCENTRATIONS AT WATERBURY**



## VIII. CLIMATOLOGICAL DATA

Weather is often the most significant factor influencing short-term changes in air quality. It also has an effect on long-term trends. Climatological information from the National Weather Service station at Bradley International Airport in Windsor Locks is presented in Table 8-1 for the years 1997 and 1998. Table 8-2 contains comparable information from the National Weather Service station located at Sikorsky Memorial Airport near Bridgeport. All data are compared to "mean" or "normal" values. Wind speeds<sup>1</sup> and temperatures are shown as monthly and yearly averages. Precipitation data include both the number of days with more than 0.01 inches of precipitation and the total water equivalent. Also shown are the number of degree days<sup>2</sup> (heating requirement) and the number of days with temperatures exceeding 90°F.

Wind roses for State of Connecticut monitoring sites in Greenwich and Stafford have been developed from 1998 wind measurements taken at these sites and are shown in Figures 8-2 and 8-4, respectively. Wind roses from these stations for 1997 are shown in Figures 8-1 and 8-3, respectively.

<sup>1</sup> The mean wind speed for a month or year is calculated from all the hourly wind speeds, regardless of the wind directions.

<sup>2</sup> The degree day value for each day is arrived at by subtracting the average temperature of the day from 65°F. This number is used as a base value because it is assumed that there is no heating requirement when the outside temperature is 65°F or above.

**TABLE 8-1**

**1997 AND 1998 CLIMATOLOGICAL DATA**  
**BRADLEY INTERNATIONAL AIRPORT, WINDSOR LOCKS**

	AVERAGE TEMPERATURE °F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 °F			HEATING DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1997	1998	Mean <sup>a</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Mean <sup>a</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Mean <sup>c</sup>
Jan	27.1	32.6	26.7	0	0	0.0	1167	998	1252	3.15	3.37	3.57	12	11	10.7	9.2	8.4	9.0
Feb	34.7	36.2	28.0	0	0	0.0	841	801	1050	1.38	3.12	3.15	12	10	10.1	8.9	9.1	9.5
Mar	36.2	40.3	37.1	0	0	0.0	883	769	853	3.60	4.87	3.73	15	10	11.2	10.1	9.1	10.1
Apr	47.2	49.9	48.2	0	0	0.3	526	447	489	2.43	3.35	3.75	8	12	10.7	9.4	8.5	9.9
May	56.1	62.9	59.2	0	0	1.1	274	101	194	3.37	7.84	3.73	11	16	11.8	10.1	8.6	8.8
Jun	68.7	67.0	67.9	8	1	3.6	49	59	20	1.90	7.18	3.57	7	20	11.5	7.0	7.6	8.1
Jul	72.3	72.9	72.4	5	4	8.0	3	1	0	3.92	2.23	3.45	10	7	9.4	7.0	6.8	7.3
Aug	70.1	73.6	71.0	3	2	4.8	6	3	6	7.33	1.98	3.92	17	7	9.6	6.1	6.3	7.0
Sep	63.2	65.7	63.5	0	1	1.3	104	61	96	0.97	2.33	3.60	8	10	9.3	6.8	6.9	7.4
Oct	50.6	52.6	52.9	0	0	*	445	378	397	1.65	5.67	3.23	6	10	8.2	6.5	8.4	7.8
Nov	38.8	41.6	42.0	0	0	0.0	777	694	693	5.87	2.34	3.82	13	7	11.2	8.0	7.3	8.5
Dec	31.4	36.8	30.6	0	0	0.0	1036	873	1101	2.18	0.83	3.67	9	6	12.3	7.2	7.1	8.6
YEAR	49.7	52.7	50.0	16	8	19.1	6111	5185	6151	37.75	45.11	43.15	128	126	126.0	8.0	7.8	8.5

\* Less than 0.05

<sup>a</sup> 1905-1998

<sup>b</sup> 1961-1990

<sup>c</sup> 1961-1998

Extracted from: Local Climatological Data Charts  
 U.S. Department of Commerce  
 National Oceanic and Atmospheric Administration  
 Environmental Data Service

**TABLE 8-2**

**1997 AND 1998 CLIMATOLOGICAL DATA**  
**SIKORSKY INTERNATIONAL AIRPORT, STRATFORD**

	AVERAGE TEMPERATURE °F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 °F			HEATING DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1997	1998	Mean <sup>a</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Mean <sup>c</sup>	1997	1998	Normal <sup>b</sup>	1997	1998	Mean <sup>d</sup>
Jan	30.3	36.7	28.7	0	0	0.0	1073	869	1119	2.95	4.61	3.55	12	12	10.2	11.2	10.2	12.7
Feb	37.3	37.9	30.7	0	0	0.0	768	752	969	2.15	4.00	3.20	10	11	9.6	9.9	10.3	13.0
Mar	38.7	41.0	38.0	0	0	0.0	810	739	818	4.89	4.71	3.94	14	8	11.0	11.2	10.1	13.0
Apr	48.1	49.3	48.1	0	0	*	502	464	504	3.39	5.49	3.86	8	11	9.8	10.2	9.6	12.4
May	56.1	60.9	58.5	0	0	0.1	268	165	219	3.04	7.35	3.70	12	14	11.0	9.9	9.6	11.2
Jun	67.7	66.8	67.9	1	1	0.9	65	52	18	1.44	5.08	3.22	8	11	10.2	8.0	8.6	9.8
Jul	73.1	73.7	73.4	3	1	2.8	2	0	0	4.20	0.97	3.04	11	5	8.3	8.0	7.4	9.7
Aug	71.5	74.2	72.0	1	0	1.4	0	0	0	4.97	1.49	3.98	12	5	9.1	7.6	7.5	9.3
Sep	65.2	67.4	65.2	0	0	0.3	70	39	54	6.60	2.16	3.48	5	6	8.0	8.7	8.1	10.5
Oct	53.9	55.1	54.7	0	0	0.0	351	298	302	2.07	3.65	3.34	8	10	7.2	8.1	9.2	11.3
Nov	42.2	45.7	44.2	0	0	0.0	678	574	582	3.87	1.22	3.71	14	5	10.7	9.7	9.1	11.8
Dec	35.5	39.3	33.5	0	0	0.0	908	790	952	3.23	1.05	3.63	11	10	11.4	9.0	8.3	12.0
YEAR	51.6	54.0	51.2	5	2	5.5	5495	4742	5537	36.80	41.78	42.63	125	108	116.5	9.3	9.0	11.4

\* Less than 0.05

<sup>a</sup> 1903-1998

<sup>b</sup> 1961-1990

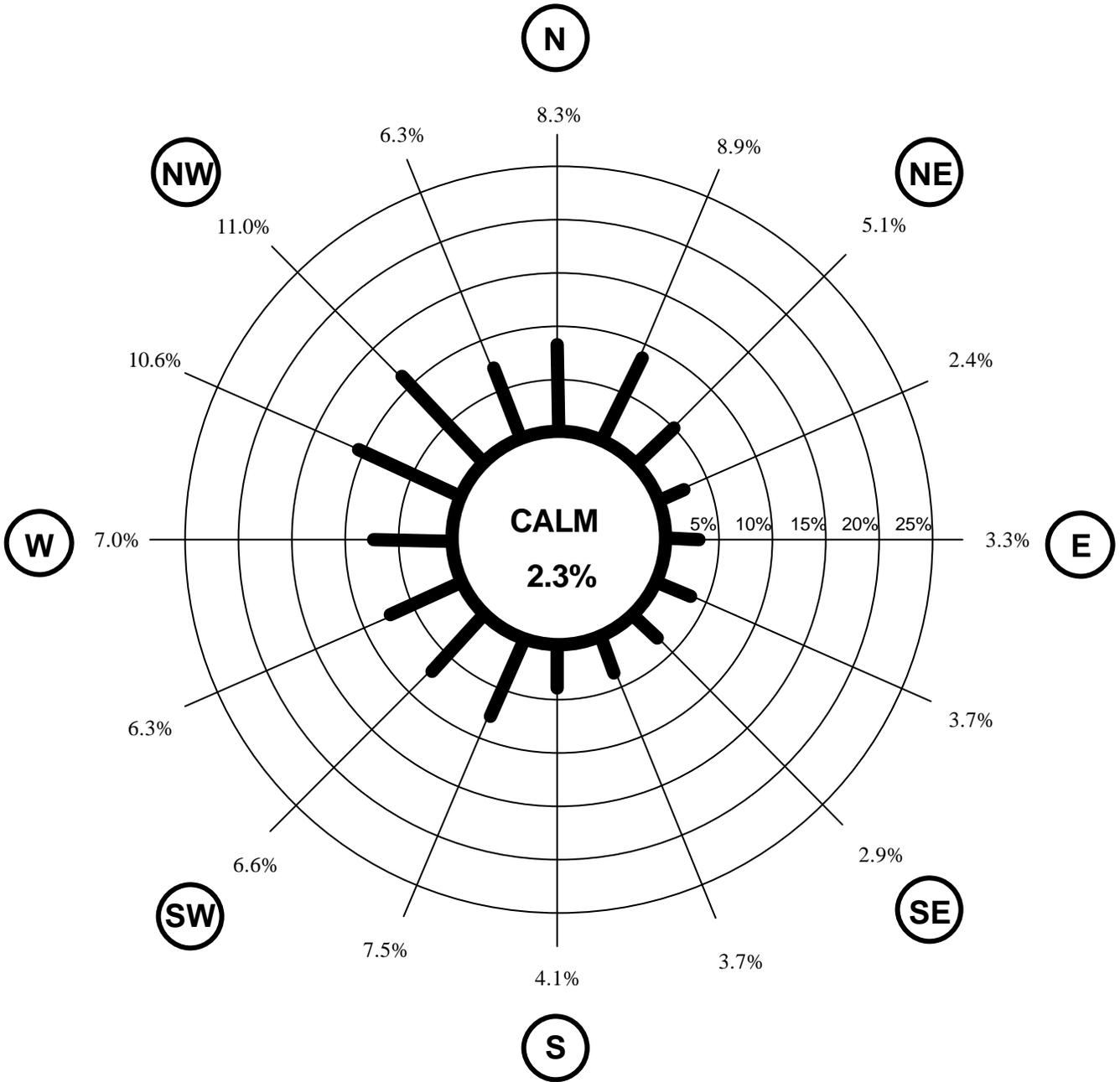
<sup>c</sup> 1904-1998

<sup>d</sup> 1981-1998

Extracted from: Local Climatological Data Charts  
 U.S. Department of Commerce  
 National Oceanic and Atmospheric Administration  
 Environmental Data Service

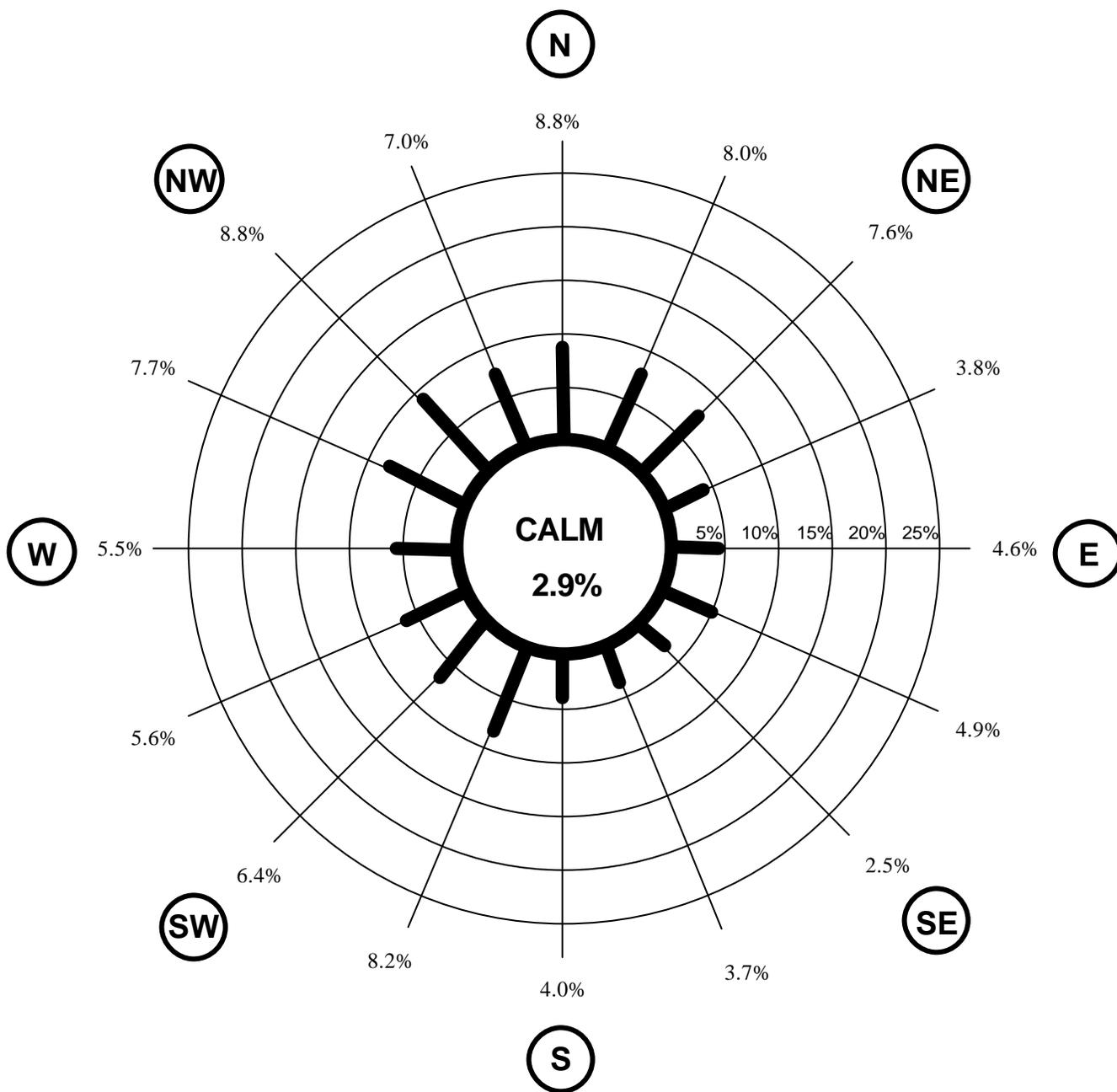
**FIGURE 8-1**

**ANNUAL WIND ROSE FOR 1997**  
**GREENWICH 017 MONITORING SITE**  
**GREENWICH POINT PARK**



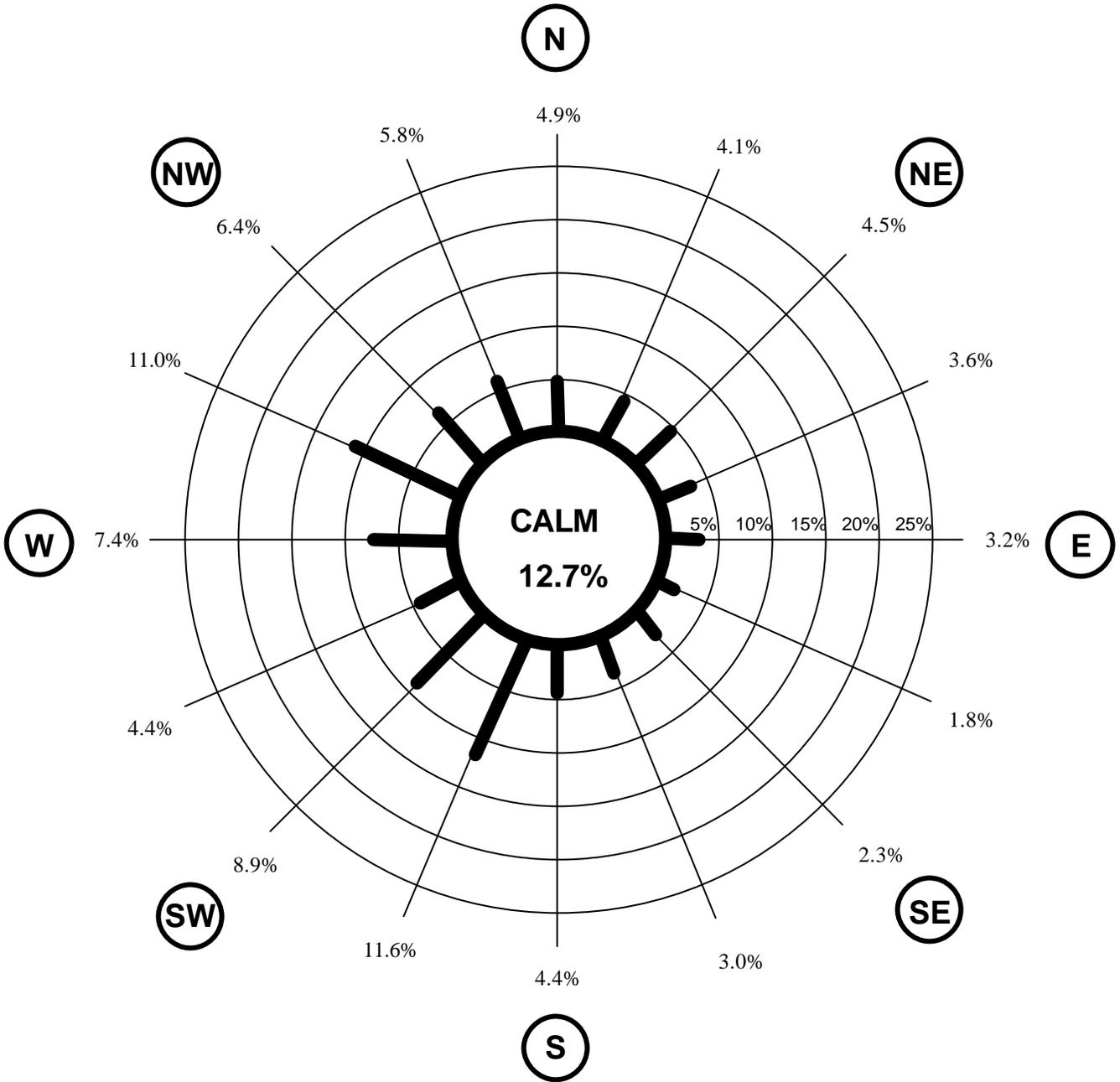
**FIGURE 8-2**

**ANNUAL WIND ROSE FOR 1998**  
**GREENWICH 017 MONITORING SITE**  
**GREENWICH POINT PARK**



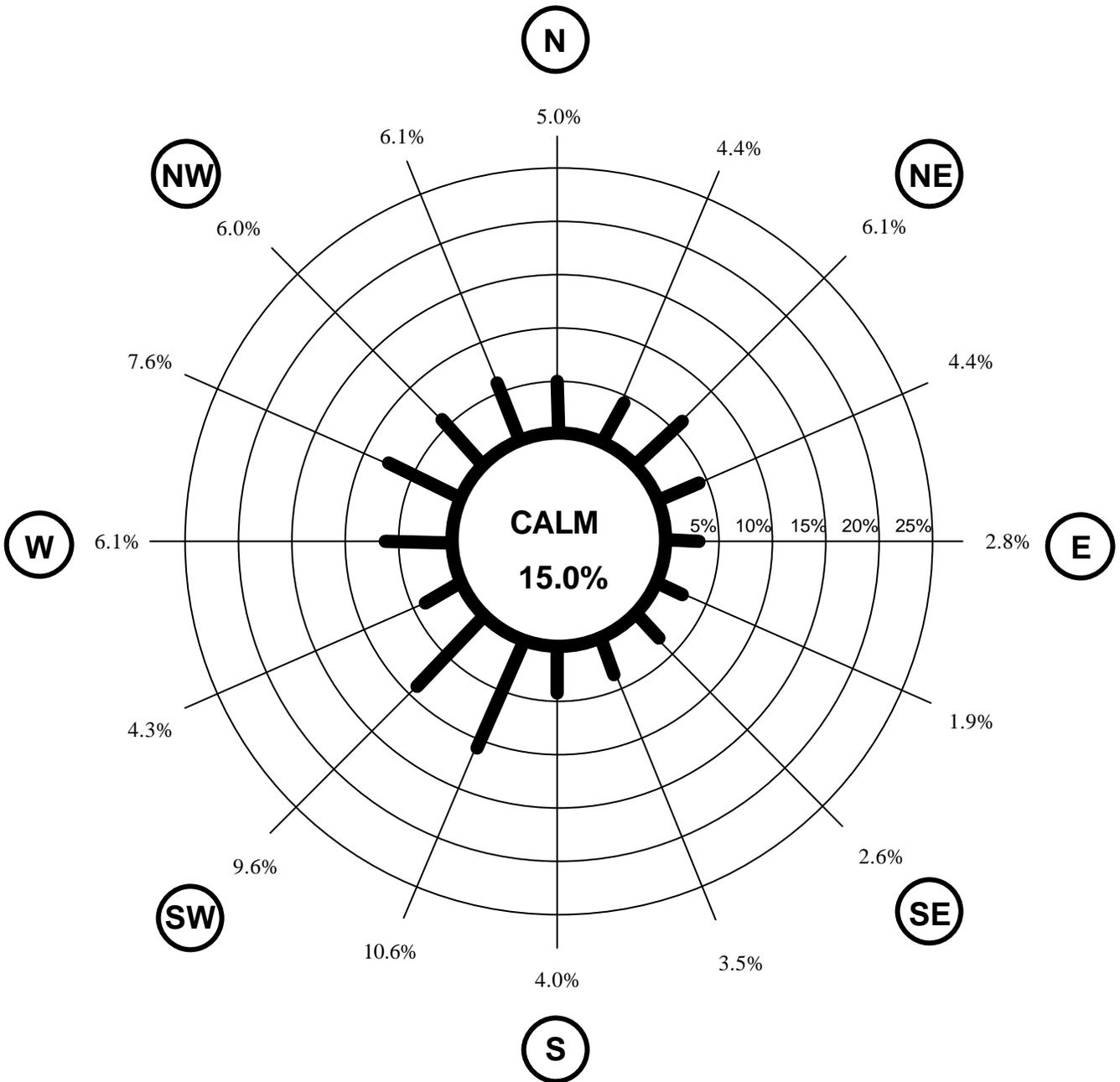
**FIGURE 8-3**

**ANNUAL WIND ROSE FOR 1997**  
**STAFFORD 001 MONITORING SITE**  
**SHENIPSIT STATE FOREST**



**FIGURE 8-4**

**ANNUAL WIND ROSE FOR 1998**  
**STAFFORD 001 MONITORING SITE**  
**SHENIPSIT STATE FOREST**



## IX. ATTAINMENT AND NONATTAINMENT OF THE NAAQS IN CONNECTICUT

The State of Connecticut can be broadly designated as either attainment or nonattainment with respect to the National Ambient Air Quality Standards (NAAQS) for the following criteria pollutants: particulate matter no greater than 10 micrometers in diameter (PM<sub>10</sub>); sulfur dioxide (SO<sub>2</sub>); ozone (O<sub>3</sub>); nitrogen dioxide (NO<sub>2</sub>); carbon monoxide (CO); and lead (Pb). The 1998 designations are:

Attainment	Nonattainment
NO <sub>2</sub>	O <sub>3</sub>
Pb	CO
SO <sub>2</sub>	PM <sub>10</sub>

When the State has been designated as attainment for a pollutant, all regions of the State are in compliance with all the standards (i.e., short term and long term; primary and secondary) for the particular pollutant. This is the case for NO<sub>2</sub>, Pb, and SO<sub>2</sub>.

When the State has been designated as nonattainment for a pollutant, one or more of the standards for the pollutant have been violated in one or more regions of the State. The nonattainment designation that is subsequently applied to a region can reflect the "degree" of nonattainment depending upon a number of factors: the air pollution history in the region; previous designation of the region as either attainment or nonattainment; lack of air pollutant monitoring in the region; and inferences based on pollutant monitoring done in adjacent or similar regions. For example, the whole state is designated as nonattainment for the 1-hour standard for ozone, but the degree of nonattainment varies between regions (see Figure 9-1). The region comprising Fairfield County (less Shelton), New Milford and Bridgewater is designated as "severe nonattainment" for ozone, while the rest of the State is designated as "serious nonattainment." The difference in the two designations is explained by higher ozone concentrations in excess of the 1-hour ozone standard in the Fairfield County portion of the NY-NJ-CT nonattainment area. Attainment of the 8-hour standard for ozone cannot be addressed until the 8-hour ozone concentrations have been monitored for at least three years.

For CO, there is a mix of attainment and nonattainment regions (see Figure 9-2). The region comprising Fairfield County (less Shelton), New Milford and Bridgewater is designated as "moderate nonattainment" primarily due to exceedances of the 8-hour CO standard in the New York / New Jersey portion of the region (not shown). The region comprising Hartford County (less Hartland), Tolland County, Middlesex County and Plymouth was redesignated as "attainment" by EPA on January 2, 1996. And the region comprising New Haven County, Bethlehem, Watertown, Woodbury, Thomaston and Shelton was redesignated as "attainment" by EPA on December 4, 1998. These redesignations were based on technical analyses prepared by the Bureau of Air Management which demonstrate that the two areas have maintained and will continue to maintain ambient CO concentrations levels within the air quality health standards. The two remaining regions of the State -- the eastern section and the northwest corner -- are designated as "unclassified attainment." This designation reflects the fact that, although no CO monitoring has been done in these regions, their status as attainment areas can be inferred from population and traffic density data.

For PM<sub>10</sub>, the whole State is designated as attainment, except for the city of New Haven (see Figure 9-3).





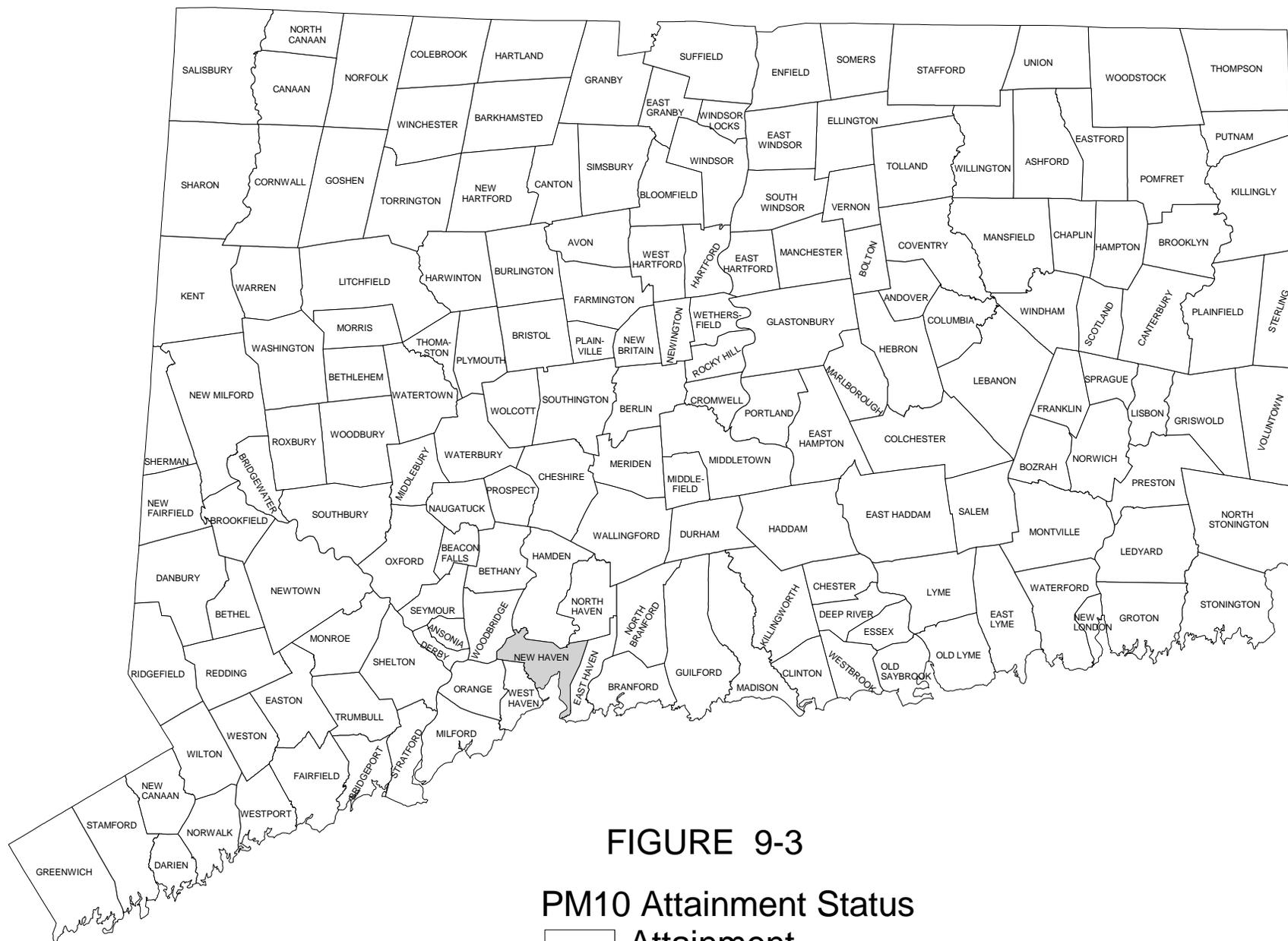


FIGURE 9-3

PM10 Attainment Status

- Attainment
- Non-Attainment

## **X. CONNECTICUT SLAMS, NAMS AND PAMS NETWORKS**

On May 10, 1979, the U.S. Environmental Protection Agency made public its final rulemaking for ambient air monitoring and data reporting requirements in the "Federal Register" (Vol. 44, No. 92). These regulations, which can also be found in Title 40 of the Code of Federal Regulations (CFR), Part 58, Appendix A through G, are meant to ensure the acceptability of air measurement data, the comparability of data from all monitoring stations nationwide, the cost-effectiveness of monitoring networks, and timely data submission for assessment purposes. The regulations address a number of key areas including quality assurance, monitoring methodologies, network design, probe siting and data reporting. Detailed requirements and specific criteria are provided which form the framework for ambient air quality monitoring. These regulations apply to all parties conducting ambient air quality monitoring for the purpose of supporting or complying with environmental regulations. In particular, state/local control agencies and industrial/private concerns involved in air monitoring are directly influenced by specific requirements, compliance dates and recommended guidelines

### **QUALITY ASSURANCE**

The regulations specify the minimum quality assurance requirements for State and Local Air Monitoring Stations (SLAMS) networks and for National Air Monitoring Stations (NAMS) networks and Photochemical Assessment Monitoring Stations (PAMS) networks, which are both subsets of SLAMS. Two distinct and equally important functions make up the quality assurance program: assessment of the quality of monitoring data by statistically calculating their precision and accuracy, and control of the quality of the data by implementation of quality control policies, procedures and corrective actions, and by overseeing their proper implementation. (See Part D of Section I, Quality Assurance).

The data assessment requirements entail the determination of precision and accuracy for both continuous and manual methods. A one-point precision check must be carried out at least once every other week on each automated analyzer used to measure SO<sub>2</sub>, NO<sub>2</sub>, CO, O<sub>3</sub> and VOC. Standards from which the precision check test data are derived must meet specifications detailed in the regulations. For manual methods, precision checks are to be accomplished by operating collocated duplicate samplers. In 1998, Connecticut maintained two collocated PM<sub>10</sub> samplers (New Haven 123 and Waterbury 123).

Accuracy determinations for automated analyzers are accomplished for SO<sub>2</sub>, NO<sub>2</sub>, CO, and O<sub>3</sub> by audits performed by an independent auditor utilizing equipment and gases which are dissociated from the normal network operations; and for VOC by audits performed by site operators utilizing blind standards. Accuracy determinations are accomplished via traceable standard flow devices for hi-vols. During each calendar quarter, at least 25% of SLAMS network for each pollutant must be audited.

All precision and accuracy results are statistics derived through calculation methods specified by the regulations, with the data and results reported quarterly. The NAMS and PAMS networks are actually part of the SLAMS network; so the SLAMS accuracy determinations also apply to both the NAMS and PAMS networks.

The distinguishing characteristics of NAMS are: 1) the sites are located in high population, high pollution areas (i.e., urban areas); 2) only continuous instruments are used to monitor gaseous pollutants; 3) the regulations specify a minimum number of sites and locations for them; and 4) the data are required to be reported quarterly to EPA. PAMS share most of these characteristics, except that the monitoring sites are located relative to O<sub>3</sub> precursor source areas and predominant wind directions associated with high O<sub>3</sub> events.

In order to control the quality of data, the monitoring program has operational procedures for each of the following activities:

1. Selection of methods, analyzers, and samplers,
2. Site selection and probe siting,
3. Equipment purchase, check-out and installation,
4. Instrument calibration,
5. Control checks and their frequency,
6. Control limits for control checks, and corrective actions when such limits are exceeded,
7. Preventive and remedial maintenance,
8. Documentation of quality control information, and
9. Data recording, reduction, validation and reporting

### **MONITORING METHODOLOGIES**

Except as otherwise stated within the regulations, the monitoring methods used must be "reference" or "equivalent," as designated by the EPA. Table 10-1 lists methods used in Connecticut's network in 1998 which were on the EPA-approved list as of April 30, 1996. Although there are no such methods for VOCs, the monitoring methods used for VOCs are those recommended as appropriate in technical assistance documents issued by EPA. Additional updates to these approved methods are provided through the "Federal Register."

### **NETWORK DESIGN**

The regulations also describe monitoring objectives and general criteria to be applied in establishing the SLAMS, NAMS and PAMS networks and for choosing general locations for new monitors. Criteria are also presented for determining the location and number of monitors. These criteria have served as the framework for all State Implementation Plan (SIP) monitoring networks since January 1, 1984 for SLAMS and NAMS, and since February 12, 1993 for PAMS.

The SLAMS and NAMS networks are designed to meet four basic monitoring objectives which are pollutant specific: (1) to determine the highest pollutant concentration in the area; (2) to determine representative concentrations in areas of high population density; (3) to determine the ambient impact of significant sources or source categories; and (4) to determine general background concentration levels.

PAMS design criteria are site specific and are based on the selection of an array of site locations. Specific monitoring objectives are associated with each location: (1) to characterize upwind background and transported O<sub>3</sub> and its precursor concentrations; (2) to monitor the magnitude and type of precursor emissions at the expected impact area; (3) to monitor maximum O<sub>3</sub> concentrations occurring downwind from the area of maximum precursor emissions; (4) to characterize the extreme downwind transported O<sub>3</sub> and its precursor concentrations.

Proper siting of a monitor requires precise specification of the monitoring objectives, which includes a spatial scale of representativeness. The spatial scales of representativeness are specified in the regulations for all pollutants and monitoring objectives. The 1998 SLAMS, NAMS and PAMS networks in Connecticut are presented and described in Table 10-2.

### **PROBE SITING**

Location and exposure of monitoring probes are described in Title 40 of the Code of Federal Regulations, Part 58, Appendix E. The probe siting criteria promulgated in the regulations are specific. They are also sufficiently comprehensive to define the requirements for ensuring the uniform collection of compatible and comparable air quality data.

These criteria are detailed by pollutant and include vertical and horizontal probe placement, spacing from obstructions and trees, spacing from roadways, probe material and sample residence time, and various other considerations. A summary of the probe siting criteria is presented in Table 10-3. The siting criteria generally apply to all spatial scales, except where noted. The most notable exception is spacing from roadways, which is dependent on traffic volume.

For the chemically reactive gases SO<sub>2</sub>, NO<sub>2</sub>, and O<sub>3</sub>, the regulations specify borosilicate glass, FEP teflon or their equivalent as the only acceptable sample train materials. For VOC sampling at those SLAMS designated as PAMS, the regulations specify borosilicate glass, stainless steel, or its equivalent. Additionally, in order to minimize the effects of particulate deposition on probe walls, sample trains for reactive gases must have residence times of less than 20 seconds.

**TABLE 10-1**

**U. S. EPA-APPROVED MONITORING METHODS USED IN CONNECTICUT IN 1998**

Pollutant	Monitoring Methods		
	Reference Manual	Reference Automated	Equivalent Automated
PM <sub>10</sub>	High Volume Method <i>[Wedding &amp; Associates Critical Flow Hi-vol]</i>		Tapered Element Oscillating Microbalance <i>[Rupprecht &amp; Patashnick TEOM Series 1400]</i>
SO <sub>2</sub>			Pulsed Fluorescence <i>[Thermo Electron 43 (0.5) &amp; Thermo Electron 43A (0.5)]</i>
O <sub>3</sub>			UV Photometry <i>[Thermal Environmental Instruments 49C (1.0)]</i>
CO		Non-dispersive Infrared <i>[Thermo Electron 48 (50)]</i>	
NO <sub>2</sub>		Chemiluminescence <i>[Thermo Electron 42 (1.0)]</i>	
Lead	High Volume Method <i>[General Metal Works GL 2000H]</i>		

( ) = Approved range in ppm

**TABLE 10-2**

**1998 SLAMS, NAMS AND PAMS SITES IN CONNECTICUT**

<u>Town</u>	<u>Urban Area</u>	<u>Site</u>	<u>SLAMS NAMS or PAMS</u>	<u>Sampling Method</u>	<u>Analytic Method</u>	<u>Operating Schedule</u>	<u>Monitoring Objective</u>	<u>Spatial Scale of Representativeness</u>
<b><u>PARTICULATE MATTER (PM10)</u></b>								
Bridgeport	Bridgeport	010	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Burlington	NONE	001	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Danbury	Danbury	123	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Darien	Stamford	001	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
E. Hartford	Hartford	004	S	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Enfield	MA-CT*	005	S	Hi-Vol	Gravimetric	6th day	Population	Regional
Hartford	Hartford	013	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
New Haven	New Haven	018	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
New Haven	New Haven	123	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
New London	New London/ Norwich	004	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Norwalk	Norwalk	014	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Norwich	New London/ Norwich	002	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Torrington	NONE	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Voluntown	NONE	001	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Waterbury	Waterbury	123	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Willimantic	NONE	002	S	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
<b><u>LEAD (PB)</u></b>								
Waterbury	Waterbury	123	S	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood

\* Includes Springfield, Chicopee, Holyoke in MA; East Windsor, Enfield, Suffield, Windsor Locks in CT.

## TABLE 10-2, CONTINUED

### 1998 SLAMS, NAMS AND PAMS SITES IN CONNECTICUT

<u>Town</u>	<u>Urban Area</u>	<u>Site</u>	<u>SLAMS NAMS or PAMS</u>	<u>Sampling &amp; Analytic Method</u>	<u>Operating Schedule</u>	<u>Monitoring Objective</u>	<u>Spatial Scale of Representativeness</u>
<b><u>CARBON MONOXIDE</u></b>							
Bridgeport	Bridgeport	004	S	NDIR	Continuous	High Concentration	Micro
Hartford	Hartford	013	N	NDIR	Continuous	Population	Neighborhood
Hartford	Hartford	017	N	NDIR	Continuous	High Concentration	Micro
New Haven	New Haven	025	S	NDIR	Continuous	High Concentration	Micro
Stamford	Stamford	020	S	NDIR	Continuous	High Concentration	Micro
<b><u>SULFUR DIOXIDE</u></b>							
Bridgeport	Bridgeport	012	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Danbury	Danbury	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
E. Hartford	Hartford	006	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Enfield	MA - CT*	005	S	Pulsed Fluorescence	Continuous	Population	Regional
Groton	New London/ Norwich	007	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Mansfield	NONE	003	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
New Haven	New Haven	123	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Stamford	Stamford	124	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Waterbury	Waterbury	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood

\* Includes Springfield, Chicopee, Holyoke in MA; East Windsor, Enfield, Suffield, Windsor Locks in CT.

**TABLE 10-2, CONTINUED**

**1998 SLAMS, NAMS AND PAMS SITES IN CONNECTICUT**

<u>Town</u>	<u>Urban Area</u>	<u>Site</u>	<u>SLAMS NAMS or PAMS</u>	<u>Sampling &amp; Analytic Method</u>	<u>Operating Schedule</u>	<u>Monitoring Objective</u>	<u>Spatial Scale of Representativeness</u>
<b><u>NITROGEN OXIDES</u></b>							
E. Hartford	Hartford	003	S/P	Chemiluminescence	Continuous	High Concentration	Neighborhood
New Haven	New Haven	123	S	Chemiluminescence	Continuous	High Concentration	Neighborhood
Stafford	NONE	001	P	Chemiluminescence	Continuous	Maximum Ozone	Regional
Westport	Norwalk	003	S/P	Chemiluminescence	Continuous	Upwind Concentration	Regional
<b><u>OZONE</u></b>							
Danbury	Danbury	123	S	UV Photometry	Continuous	High Concentration	Urban
E. Hartford	Hartford	003	N/P	UV Photometry	Continuous	Population	Neighborhood
Greenwich	Stamford	017	S	UV Photometry	Continuous	High Concentration	Urban
Groton	New London/ Norwich	008	S	UV Photometry	Continuous	High Concentration	Urban
Madison	NONE	002	S	UV Photometry	Continuous	High Concentration	Urban
Middletown	Hartford	007	N	UV Photometry	Continuous	High Concentration	Urban
New Haven	New Haven	123	N	UV Photometry	Continuous	Population	Neighborhood
Stafford	NONE	001	N/P	UV Photometry	Continuous	High Conc. /Max. Ozone	Urban / Regional
Stratford	Bridgeport	007	N	UV Photometry	Continuous	High Concentration	Urban
Torrington	NONE	006	S	UV Photometry	Continuous	High Concentration	Urban
Westport	Norwalk	003	S/P	UV Photometry	Continuous	High Concentration	Urban
<b><u>VOC</u></b>							
E. Hartford	Hartford	003	P	GC-FID	Continuous	Max. Concentration	Neighborhood
Stafford	NONE	001	P	GC-FID	Continuous	Maximum Ozone	Regional
Westport	Norwalk	003	P	GC-FID	Continuous	Upwind Concentration	Regional

## TABLE 10-3

### SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal <sup>a</sup>		
PM <sub>10</sub>	Micro		>2	2-7	<ol style="list-style-type: none"> <li>1. The sampler should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from a sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes from the sampler, except for street canyon sites.<sup>b</sup></li> <li>3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites.</li> <li>4. No furnace or incineration flues should be nearby.<sup>c</sup></li> <li>5. The spacing from roads varies with traffic<sup>d</sup>, except for street canyon sites which must be from 2 to 10 meters from the edge of the nearest traffic lane.</li> </ol>
	Middle, neighborhood, urban and regional		>2	2-15	<ol style="list-style-type: none"> <li>1. The sampler should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from a sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes from the sampler.<sup>b</sup></li> <li>3. There must be unrestricted air flow 270 degrees around the sampler.</li> <li>4. No furnace or incineration flue should be nearby.<sup>c</sup></li> <li>5. The spacing from roads varies with traffic.<sup>d</sup></li> </ol>

## TABLE 10-3, CONTINUED

### SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal <sup>a</sup>		
Lead	Micro		>2	2-7	<ol style="list-style-type: none"> <li>1. The sampler should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from a sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes from the sampler, except for street canyon sites.<sup>b</sup></li> <li>3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites.</li> <li>4. No furnace or incineration flues should be nearby.<sup>c</sup></li> <li>5. The sampler must be 5 to 15 meters from a major roadway.</li> </ol>
	Middle, neighborhood, urban and regional		>2	2-15	<ol style="list-style-type: none"> <li>1. The sampler should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from a sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes from the sampler.<sup>b</sup></li> <li>3. There must be unrestricted air flow 270 degrees around the sampler.</li> <li>4. No furnace or incineration flue should be nearby.<sup>c</sup></li> <li>5. The spacing from roads varies with traffic.<sup>d</sup></li> </ol>

## TABLE 10-3, CONTINUED

### SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal <sup>a</sup>		
SO <sub>2</sub>	All	3-15	>1	>1	<ol style="list-style-type: none"> <li>1. The probe should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe.<sup>b</sup></li> <li>3. There must be unrestricted air flow 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building.</li> <li>4. No furnace or incineration flue should be nearby.<sup>c</sup></li> </ol>
O <sub>3</sub> or VOC	All	>1	>1	3-15	<ol style="list-style-type: none"> <li>1. The probe should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe.</li> <li>3. There must be unrestricted air flow in an arc of at least 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building.<sup>e</sup></li> <li>4. The spacing from roads varies with traffic.<sup>d</sup></li> </ol>

## TABLE 10-3, CONTINUED

### SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal <sup>a</sup>		
CO	Micro	2.5 - 3.5	>1	>1	<ol style="list-style-type: none"> <li>1. The probe should be &gt;10 meters from the street intersection and should be at a midblock location.</li> <li>2. The probe must be 2 to 10 meters from the edge of the nearest traffic lane.</li> <li>3. There must be unrestricted air flow 180 degrees around the inlet probe.</li> </ol>
	Middle neighborhood	3 - 15	>1	>1	<ol style="list-style-type: none"> <li>1. There must be unrestricted air flow 270 degrees around the inlet probe, or 180 degrees if the probe is on the outside of a building.</li> <li>2. The spacing from roads varies with traffic.<sup>d</sup></li> </ol>
NO <sub>2</sub>	All	3 - 15	>1	>1 <sup>f</sup>	<ol style="list-style-type: none"> <li>1. The probe should be &gt;20 meters from the dripline, and must be 10 meters from the dripline when any tree acts as an obstruction.</li> <li>2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe.<sup>b</sup></li> <li>3. There must be unrestricted air flow in an arc of at least 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building.<sup>e</sup></li> <li>4. The spacing from roads varies with traffic.<sup>d</sup></li> </ol>

<sup>a</sup> When a probe is located on a rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.

<sup>b</sup> Sites not meeting this criterion would be classified as middle scale.

<sup>c</sup> Distance is dependent on height of furnace or incineration flue, type of fuel or waste burned, and quality of fuel (sulfur and ash content). This is to avoid undue influences from minor pollutant sources.

<sup>d</sup> Distance is dependent upon traffic ADT, pollutant and spatial scale.

<sup>e</sup> In addition, for PAMS, the predominant wind direction for the period of greatest pollutant concentration must be included in the arc.

<sup>f</sup> 3-15 for PAMS

## XI. ERRATA

During the preparation of this Air Quality Summary, a number of errors were discovered in previous editions of this document. For the benefit of the reader, the corrections are presented below:

- Regarding the 1997 edition of the Air Quality Summary,
  1. On page 54, under **DISCUSSION OF DATA**, the last sentence under **Precision and Accuracy** should read in part: "... those for the medium level test ranged from -9% to +4%."
  2. On page 55, under **DISCUSSION OF DATA**, the last sentence under **Annual Averages** should read in part: "... show a decrease in annual average NO<sub>2</sub> concentrations *between* 1995 and 1997."
  3. On page 83, in Table 9-2, the **Sampling & Analytic Method** for ozone is *UV Photometry*, not Chemiluminescent.
  4. On page 83, in Table 9-2, the **Sampling & Analytic Method** for VOC is *GC-FID*, not Chemiluminescent.
  
- Regarding the 1991-1996 editions of the Air Quality Summary,
  1. In Table 10-2, the **Sampling & Analytic Method** for ozone is *UV Photometry*, not Chemiluminescent.
  
- Regarding the 1988-1990 editions of the Air Quality Summary,
  1. In Table 11-2, the **Sampling & Analytic Method** for ozone is *UV Photometry*, not Chemiluminescent.
  
- Regarding the 1987 edition of the Air Quality Summary,
  1. In Table 35, the **Sampling & Analytic Method** for ozone is *UV Photometry*, not Chemiluminescent.

# APPENDICES

## APPENDIX 1: ABBREVIATIONS & DEFINITIONS

CAAA	Clean Air Act Amendments of 1990
CMSA Department of	Consolidated Metropolitan Statistical Area (as defined by the U.S. Commerce)
CO	carbon monoxide
collocated device and	refers to a sampling device placed alongside the regular network sampling operated concurrently
DEP	Department of Environmental Protection
EPA	Environmental Protection Agency
EST	Eastern Standard Time
GC-FID	gas chromatography using a flame-ionization detector
hi-vol	a high-volume sampler (approx. 60 cubic feet per minute)
mg/m <sup>3</sup>	milligrams per cubic meter
micron	one millionth of a meter
MSA Commerce)	Metropolitan Statistical Area (as defined by the U.S. Department of
NAAQS	National Ambient Air Quality Standard
NAMS	National Air Monitoring Stations
NO	nitrogen oxide
NO <sub>x</sub>	the sum of NO and NO <sub>2</sub>
NO <sub>2</sub>	nitrogen dioxide
O <sub>3</sub>	ozone
PAMS	Photochemical Assessment Monitoring Stations
Pb	lead
PM <sub>10</sub>	particulate matter less than 10 microns in diameter
ppbc	parts per billion (by weight) as carbon

ppm	parts per million (by volume)
PSI	Pollutant Standards Index
SLAMS	State and Local Air Monitoring Stations
SO <sub>2</sub>	sulfur dioxide
TEOM matter	tapered element oscillating microbalance (a type of continuous particulate monitor)
TSP	total suspended particulates
UV	ultraviolet
VOC	volatile organic compound
µg/m <sup>3</sup>	micrograms per cubic meter

## APPENDIX 2: STATISTICAL TERMS

1-hour average	an average computed from 1-minute average data for a 60-minute period ending at any hour (EST)
3-hour average period	an average computed from 1-hour average data for a 3-hour ending at any hour (EST)
8-hour average period	an average computed from 1-hour average data for an 8-hour ending at any hour (EST) for CO, or beginning at any hour (EST) for O <sub>3</sub>
24-hour average	an average computed from 1-hour average data for a 24-hour period ending at any hour (EST)
calendar day average	an average computed from 1-hour average data for a 24-hour period ending at 12 a.m. (EST)
monthly composite	a composite of the individual hi-vol samples obtained at a monitoring site within a calendar month
3-month average	an average computed from monthly composite data for 3 consecutive months
annual arithmetic mean	the average of the 1-hour average values in a calendar year for SO <sub>2</sub> or NO <sub>2</sub> ; or the average of the hi-vol sample concentrations in a calendar year for PM <sub>10</sub>
annual arithmetic average	see annual arithmetic mean
annual geometric mean	the nth root of the product of the calendar day averages in a calendar year for SO <sub>2</sub> , where n is the number of calendar day averages; or the nth root of the product of the hi-vol sample concentrations in a calendar year for PM <sub>10</sub> , where n is the number of the hi-vol samples

### **APPENDIX 3: MONITORING SITE DESCRIPTION**

<b>TOWN</b>	<b>SITE</b>	<b>LOCATION</b>	<b>POLLUTANTS</b>
BRIDGEPORT	004	MCLEVY HALL, STATE STREET	CO
	010	ROOSEVELT SCHOOL, 60 PARK AVENUE	PM <sub>10</sub>
	012	EDISON SCHOOL, 115 BOSTON TERRACE	SO <sub>2</sub>
BURLINGTON	001	FISH HATCHERY, PUNCH BROOK	PM <sub>10</sub>
DANBURY	123	WCSU, OSBORNE STREET	O <sub>3</sub> , PM <sub>10</sub> , SO <sub>2</sub>
DARIEN	001	I-95 & BROOKSIDE DRIVE	PM <sub>10</sub>
EAST HARTFORD	003	McAULIFFE PARK	O <sub>3</sub> , NO <sub>2</sub> , HC
	004	CITY HALL, 70 MAIN STREET	PM <sub>10</sub>
	006	85 HIGH STREET	SO <sub>2</sub>
ENFIELD	005	DEPT. OF CORRECTIONS, SHAKER ROAD	PM <sub>10</sub> , SO <sub>2</sub>
GREENWICH	017	GREENWICH POINT PARK	O <sub>3</sub>
GROTON	007	FIRE HEADQUARTERS, 140 BROAD STREET	SO <sub>2</sub>
	008	UCONN, AVERY POINT	O <sub>3</sub>
HARTFORD	013	HARTFORD TECH, FLATBUSH AVENUE	CO, PM <sub>10</sub>
	017	COURT HOUSE, 155 MORGAN STREET	CO
MADISON	002	HAMMONASSET STATE PARK	O <sub>3</sub>
MANSFIELD	003	D.O.T., 100 N. FRONTAGE ROAD	SO <sub>2</sub>

### **APPENDIX 3: MONITORING SITE DESCRIPTION**

<b>TOWN</b>	<b>SITE</b>	<b>LOCATION</b>	<b>POLLUTANTS</b>
MIDDLETOWN	007	CONNECTICUT VALLEY HOSPITAL, SHEW HALL	O <sub>3</sub>
NEW HAVEN	018	STILES STREET	PM <sub>10</sub>
	025	SUPERIOR COURT, 121 ELM STREET	CO
	123	715 STATE STREET	O <sub>3</sub> , PM <sub>10</sub> , SO <sub>2</sub> , NO <sub>2</sub>
NEW LONDON	004	PERKINS STREET	PM <sub>10</sub>
NORWALK	014	I-95 RIGHT OF WAY, WEST AVENUE	PM <sub>10</sub>
NORWICH	002	COURT HOUSE, MAIN STREET & COURT HOUSE SQ.	PM <sub>10</sub>
STAFFORD	001	SHENIPSIT STATE FOREST	O <sub>3</sub> , NO <sub>2</sub> , HC
STAMFORD	020	FERGUSON LIBRARY, 96 BROAD STREET	CO
	124	STAMFORD H.S., HILLENDALE AVENUE	SO <sub>2</sub>
STRATFORD	007	STRATFORD POINT LIGHTHOUSE	O <sub>3</sub>
TORRINGTON	001	CITY HALL, 140 MAIN STREET	PM <sub>10</sub>
	006	UCONN, UNIVERSITY ROAD	O <sub>3</sub>
VOLUNTOWN	001	PACHAUG STATE FOREST	PM <sub>10</sub>
WATERBURY	123	MEADOW & BANK STREETS	PM <sub>10</sub> , SO <sub>2</sub> , Pb
WESTPORT	003	SHERWOOD ISLAND STATE PARK	O <sub>3</sub> , NO <sub>2</sub> , HC
WILLIMANTIC	002	COURT HOUSE, 108 VALLEY STREET	PM <sub>10</sub>

## **APPENDIX 4: EVOLUTION OF MONITORING NETWORK**

Year	Milestone
1957	Sporadic measurement of total suspended particulates
1973	First computerized network and began daily Pollution Standards Index (pollution forecasting)
1978	Committed to State and Local Air Monitoring Sites (SLAMS) program
1979	Redesigned network to meet National Air Monitoring Site (NAMS) standards
1985	Monitoring began for PM <sub>10</sub> (the first new criteria pollutant indicator)
1987	Initiated ambient pre-operational dioxin monitoring around proposed RRFs <sup>1</sup>
1992	Developed special purpose monitoring capability to supplement SLAMS and NAMS
1992	Established first photochemical assessment monitoring station
1995	Developed capability to monitor for 100 toxic air pollutants
1995	Committed to photochemical assessment monitoring stations program (PAMS)

<sup>1</sup> Resource recovery facilities

## **APPENDIX 5: PUBLICATIONS**

The following is a partial listing of technical papers and study reports dealing with various aspects of Connecticut air pollutant levels and air quality data.

1. Bruckman, L., **Asbestos: An Evaluation of Its Environmental Impact in Connecticut**, internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, March 12, 1976.
2. Lepow, M. L., L. Bruckman, R.A. Rubino, S. Markowitz, M. Gillette and J. Kapish, **"Role of Airborne Lead in Increased Body Burden of Lead in Hartford Children,"** Environ. Health Perspect., May, 1974, pp. 99-102.
3. Bruckman, L. and R.A. Rubino, **"Rationale Behind a Proposed Asbestos Air Quality Standard,"** paper presented at the 67th Annual Meeting of the Air Pollution Control Association, Denver, Colorado, June 9-11, 1974, J. Air Pollut. Cntr. Assoc., 25: 1207-15 (1975).
4. Rubino, R.A., L. Bruckman and J. Magyar, **"Ozone Transport,"** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975, J. Air Pollut. Cntr. Assoc.: 26, 972-5 (1976).
5. Bruckman, L., R.A. Rubino and T. Helfgott, **"Rationale Behind a Proposed Cadmium Air Quality Standard,"** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975.
6. Rubino, R.A., L. Bruckman, A. Kramar, W. Keever and P. Sullivan, **"Population Density and Its Relationship to Airborne Pollutant Concentrations and Lung Cancer Incidence in Connecticut,"** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975.
7. Lepow, M.L., L. Bruckman, M. Gillette, R.A. Rubino and J. Kapish, **"Investigations into Sources of Lead in the Environment of Urban Children,"** Environ. Res., 10: 415-26 (1975).
8. Bruckman, L., E. Hyne and P. Norton, **"A Low Volume Particulate Ambient Air Sampler,"** paper presented at the APCA Specialty Conference entitled "Measurement Accuracy as it Relates to Regulation Compliance," New Orleans, Louisiana, October 26-28, 1975, APCA publication SP-16, Air Pollution Control Association, Pittsburgh, Pennsylvania, 1976.
9. Bruckman, L. and R.A. Rubino, **"High Volume Sampling Errors Incurred During Passive Sample Exposure Periods,"** J. Air Pollut. Cntr. Assoc., 26: 881-3 (1976).
10. Bruckman, L., R.A. Rubino and B. Christine, **"Asbestos and Mesothelioma Incidence in Connecticut,"** J. Air Pollut. Cntr. Assoc., 27: 121-6 (1977).
11. Bruckman, L., **Suspended Particulate Transport in Connecticut: An Investigation Into the Relationship Between TSP Concentrations and Wind Direction in Connecticut**, internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, December 24, 1976.
12. Bruckman, L. and R.A. Rubino, **"Monitored Asbestos Concentrations in Connecticut,"** paper presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, June 20-24, 1977.

13. Bruckman, L., "**Suspended Particulate Transport**," paper presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, June 20-24, 1977.
14. Bruckman, L., "**A Study of Airborne Asbestos Fibers in Connecticut**," paper presented at the "Workshop in Asbestos: Definitions and Measurement Methods" sponsored by the National Bureau of Standards/U.S. Department of Commerce, July 18-20, 1977.
15. Bruckman, L., "**Monitored Asbestos Concentrations Indoors**," paper presented at The Fourth Joint Conference of Sensing Environmental Pollutants, New Orleans, Louisiana, November 6-11, 1977.
16. Bruckman, L., paper presented at the Joint Conference on Applications of Air Pollution Meteorology, Salt Lake City, Utah, November 28 - December 2, 1977.
17. Bruckman, L., E. Hyne, W. Keever, "**A Comparison of Low Volume and High Volume Particulate Sampling**," internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, 1976.
18. "**Data Validation and Monitoring Site Review**," (part of the Air Quality Maintenance Planning Process), internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, June 15, 1976.
19. "**Air Quality Data Analysis**," (part of the Air Quality Maintenance Planning Process), internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, August 16, 1976.
20. Bruckman, L., "**Investigation into the Causes of Elevated SO<sub>2</sub> Concentrations Prevalent Across Connecticut During Periods of SW Wind Flow**," paper presented at the 71st Annual Meeting of the Air Pollution Control Association, Paper #78-16.4, Houston, Texas, June 25-29, 1978.
21. Anderson, M.K., "**Power Plant Impact on Ambient Air: Coal vs. Oil Combustion**," paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Paper #75-33.5, Boston, MA, June 15-20, 1975.
22. Anderson, M.K., G. D. Wight, "**New Source Review: An Ambient Assessment Technique**," paper presented at the 71st Annual Meeting of the Air Pollution Control Association, Paper #78-2.4, Houston, TX, June 25-29, 1978.
23. Wolff, G.T., P.J. Liroy, G.D. Wight, R.E. Pasceri, "**Aerial Investigation of the Ozone Plume Phenomenon**," J. Air Pollut. Control Association, 27: 460-3 (1977).
24. Wolff, G.T., P.J. Liroy, R.E. Meyers, R.T. Cederwall, G.D. Wight, R.E. Pasceri, R.S. Taylor, "**Anatomy of Two Ozone Transport Episodes in the Washington, D.C., to Boston, Mass., Corridor**," Environ. Sci. Technol., 11-506-10 (1977).
25. Wolff, G.T., P.J. Liroy, G.D. Wight, R.E. Meyers, and R.T. Cederwall, "**Transport of Ozone Associated With an Air Mass**," In: Proceed. 70 Annual Meeting APCA, Paper 377-20.3, Toronto, Canada, June, 1977.
26. Wight, G.D., G.T. Wolff, P.J. Liroy, R.E. Meyers, and R.T. Cederwall, "**Formation and Transport of Ozone in the Northeast Quadrant of the U.S.**," In: Proceed. ASTM Sym. Air Quality and Atmos. Ozone, Boulder, Colo., Aug. 1977.

27. Wolff, G.T., P.J. Lioy, and G.D. Wight, "**An Overview of the Current Ozone Problem in the Northeastern and Midwestern U.S.,**" In: Proceed. Mid-Atlantic States APCA Conf. on Hydrocarbon Control Feasibility, p. 98, New York, N.Y., April, 1977.
28. Wolff, G.T., P.J. Lioy, G.D. Wight, R.E. Meyers, and R.T. Cederwall, "**An Investigation of Long-Range Transport of Ozone Across the Midwestern and Eastern U.S.,**" Atmos. Environ. 11:797 (1977).
29. Bruckman, L., R.A. Rubino, and J. Gove, "**Connecticut's Approach to Controlling Toxic Air Pollutants,**" paper presented at the STAPPA / ALAPCO Air Toxics Conference, Air Toxics Control: An Environmental Challenge, Washington, D. C., October 15-17, 1986.
30. Wackter, D.J., and P.V. Bayly, "**The Effectiveness of Emission Controls on Reducing Ozone Levels in Connecticut from 1976 through 1987,**" paper presented at the APCA Specialty Conference on: The Scientific and Technical Issues Facing Post-1987 Ozone Control Strategies, Hartford, Connecticut, November 17-19, 1987.
31. Wackter, D.J., "**Sensitivity Analysis of Ozone Predictions by the Urban Airshed Model in the Northeast,**" paper presented at the Air Pollution Control Association Conference on VOC and Ozone, Northampton, MA, November 1-2, 1988.
32. Leston, A.R., J. Catalano, K. Crossman, R. Pirolli, N. Rowe, G. Hunt and B. Maisel, "**The Connecticut Department of Environmental Protection's Evaluation of Pre/Post Operational Dioxin Monitoring Conducted at Four Resources Recovery Facilities,**" paper presented at the Dioxin '91 Conference, RTP, North Carolina, Sept., 1991.
33. Leston, A.R., and W. Ollison, "**Estimated Accuracy of Ozone Design Values: Are They Compromised by Method Interference?,**" In: Proceed. A&WMA's Conference "Tropospheric Ozone: Nonattainment and Design Value Issues," Boston, Massachusetts, October 27-30, 1992.
34. Leston, A.R., and S.A. Bailey, "**Preliminary Report on Establishing a Prototype PAMS Site in the Urban Northeast,**" In: Proceed. A&WMA's 86th Annual Meeting & Exhibition, Denver, Colorado, June 14-18, 1993.
35. Hartman, R.M., and A. Leston, "**Use of an OPSIS Open Path Monitor for Ambient Aldehyde Monitoring,**" In: Proceed. A&WMA's Conference "Optical Sensing for Environmental and Process Monitoring," McLean, Virginia, November 7-10, 1994.
36. Main, H.H., P.T. Roberts, A.R. Leston, and P. Brunelli, "**Data Validation of PAMS Auto-GC Data: Lessons Learned,**" In: Proceed. A&WMA's Conference "Measurement of Toxic And Related Air Pollutants," RTP, North Carolina, May 7-9, 1996.
36. Leston, A.R., A. VanArsdale, and Allen OI, "**Comparative Results of Ambient Air Analysis by Two Methods: Automated Field GC Versus Integrated Canister,**" In: Proceed. A&WMA's Conference "Measurement of Toxic And Related Air Pollutants," RTP, North Carolina, April 29-May 1, 1997.