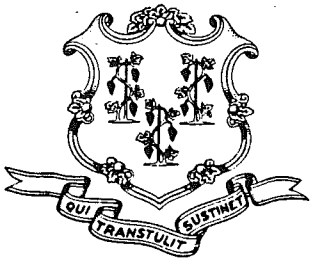
1988

STATE OF CONNECTICUT

ANNUAL AIR QUALITY SUMMARY



Lowell P. Weicker, Jr.

Governor

Timothy R. E. Keeney

Commissioner

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

I. INTRODUCTION

The 1988 Air Quality Summary of ambient air quality in Connecticut is a compilation of all air pollutant measurements made at the Department of Environmental Protection (DEP) air monitoring network sites.

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 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 the year 1988. More detailed discussions of each of the six pollutants are provided in subsequent sections of this Air Quality Summary.

1. PARTICULATE MATTER (PM_{10})

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 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year, and 75 $\mu g/m^3$, annual geometric mean. The secondary standard was set at 150 $\mu g/m^3$, 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. 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_{10}); (2) replacing the 24-hour primary TSP standard with a 24-hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM_{10} standard of 50 $\mu g/m^3$, expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM_{10} standards that are identical in all respects to the primary standards. The state of Connecticut is in the process of adopting these standards.

Compliance Assessment - Measured PM_{10} concentrations during 1988 did not exceed the 50 µg/m³ level of the primary and secondary annual standards or the 150 µg/m³ level of the primary and secondary 24-hour standards at any site. However, the 24-hour standards were violated because the "expected number of exceedances" for the most recent 3 years exceeded one per year at the New Haven 018 site (see Table 1-2). The annual standards were also violated at New Haven 018 because the "expected annual mean" for the most recent 3 years at the site exceeded 50 µg/m³.

2. SULFUR DIOXIDE (SO_2)

None of the air quality standards for sulfur dioxide were exceeded in Connecticut in 1988. Measured concentrations were below the 80 µg/m³ primary annual standard, the 365 µg/m³ primary 24-hour standard, and the 1300 µg/m³ secondary 3-hour standard at all monitoring sites.

3. OZONE (O_3)

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 for a one-hour average. That level is 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 value 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. 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 many times at each of the DEP ozone monitoring sites in 1988 (see Table 1-2). Consequently, the standard was violated at each site.

4. NITROGEN DIOXIDE (NO_2)

The annual average NO_2 standard of 100 µg/m³ was not exceeded at any site in Connecticut in 1988.

5. CARBON MONOXIDE (CO)

The primary eight-hour standard of 9 ppm was exceeded at one of the five carbon monoxide monitoring sites in Connecticut during 1988. The standard was exceeded three times at Hartford 017 (see Table 1-2). Two exceedances at a particular site are required for a standard to be violated. This means that the eight-hour standard was violated at Hartford 017 in 1988. Violations of the standard have occurred at Hartford 017 since 1984.

There were no violations of the primary one-hour standard of 35 ppm at any monitoring site in 1988.

6. LEAD (Pb)

The primary and secondary ambient air quality standard for lead is 1.5 $\mu g/m^3$, maximum arithmetic mean averaged over three consecutive calendar months. As has been the case since 1980, the lead standard was not exceeded at any site in Connecticut during 1988.

B. AIR MONITORING NETWORK

A computerized Air Monitoring Network consisting of an IBM System 7 computer and numerous telemetered monitoring sites has 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 MV/10000 computer. This essentially improved both data accuracy and data capture. As many as 12 measurement parameters are transmitted from a site via telephone lines to the Data General unit located in the DEP Hartford office. The data are then compiled three times daily into 24-hour summaries. The telemetered sites are located in the towns of Bridgeport, Danbury, East Hartford, East Haven, Enfield, Greenwich, Groton, Hartford, Madison, Middletown, Milford, New Britain, New Haven, Norwalk, Stafford, Stamford, Stratford and Waterbury.

Continuously measured parameters include the pollutants sulfur dioxide, particulates (measured as the PM_{10}), carbon monoxide, nitrogen dioxide and ozone. Meteorological data consists of wind speed and direction, wind horizontal sigma, temperature, precipitation, barometric pressure and solar radiation (insolation).

The real-time capabilities of the Data General telemetry network have enabled the Air Monitoring Unit 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 1988 consisted of:

- 42 Particulate matter (PM_{10}) hi-vol sites
- 13 Lead hi-vol sites
- 7 Lead lo-vol sites
- 18 Sulfur dioxide sites
- 10 Ozone sites
- 3 Nitrogen dioxide sites
- 5 Carbon monoxide sites

A complete description of all permanent air monitoring sites in Connecticut operated by DEP in 1988 is available from the Department of Environmental Protection, Air Compliance Unit, Monitoring Section, State Office Building, Hartford, Connecticut, 06106.

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 (i.e., with predictions for the weekends). The PSI incorporates three pollutants : sulfur dioxide, PM_{10} 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_{10}, SO_2, and O_3) in Connecticut. For the winter of 1988, Connecticut reported the PM_{10} PSI for the towns of Bridgeport, Danbury, Greenwich, Groton, Hartford, Meriden, Milford, New Britain, New Haven, Norwalk, Norwich, Stamford, Wallingford, and Waterbury; and reported the sulfur dioxide PSI for the towns of Bridgeport, Danbury, East Hartford, East Haven, Enfield, Greenwich, Groton, Hartford, Milford, New Britain, New Haven, Norwalk, Stamford, and Waterbury. For the summer, the ozone PSI was reported for the towns of Bridgeport, Danbury, East Hartford, Greenwich, Groton, Madison, Middletown, New Haven, Stafford, and Stratford. Each day, the pollutant with the highest PSI value of all the pollutants being monitored is reported for each town, along with the dimensionless PSI number and a descriptor word to characterize the daily air quality.

A telephone recording of the PSI is taped each afternoon at approximately 3 PM, five days a week, and can be heard by dialing 566-3449. Predictions for weekends are included on the Friday recordings. For residents outside of the Hartford telephone exchange, the PSI is now available toll-free from the DEP representative at the Governor's State Information Bureau. The number is 1-800-842-2220. This information is also available to the public during weekday afternoons from the American Lung Association of Connecticut in East Hartford. The number there is 289-5401 or 1-800-992-2263.

D. QUALITY ASSURANCE

Quality Assurance requirements for State and Local Air Monitoring Stations (SLAMS) and the National Air Monitoring Stations (NAMS), as part of the (SLAMS) network, 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.

A Quality Assurance program was initiated in Connecticut with written procedures covering, but not limited to, the following:

Equipment procurement
Equipment installation
Equipment calibration
Equipment operation
Sample analysis
Maintenance audits
Performance audits
Data handling and 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.

Data 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 data repeatability (grouping) and is determined as follows:

a. **Manual Samplers** (PM_{10})

A second (co-located) PM_{10} hi-vol sampler is placed alongside a regular PM_{10} network sampler and operated concurrently. The concentration values from the co-located hi-vol sampler are compared to the network sampler and precision values are generated from the comparison.

b. **Manual Samplers** (Lead)

Duplicate strips are cut from the hi-vol sampler filters and individually analyzed for lead. The resulting concentration values are compared and precision values are generated from the comparison.

c. **Automated Analyzers** (SO_2, O_3, CO and NO_2)

All NAMS and SLAMS analyzers are challenged with a low level pollutant concentration a minimum of once every two weeks: 0.08 to 0.10 ppm for SO_2, O_3 and NO_2, and 8 to 10 ppm for CO. The comparison of analyzer response to input concentration is used to generate automated analyzer precision values.

2. ACCURACY

Accuracy is an estimate of the closeness of a measured value to a known value and is determined in the following manner:

a. **Manual Methods** (PM_{10} and Lead)

Accuracy for PM_{10} and lead 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 flow rates. A minimum of 25% of the PM_{10} and lead network samplers are audited each quarter.

b. **Automated Analyzers** (SO_2, O_3, CO and NO_2)

Automated analyzer data accuracy is determined by challenging each analyzer with three predetermined concentration levels. 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 of a particular pollutant are used to assess automated analyzer accuracy. The audit concentration levels are as follows:

SO_2, O_3, and NO_2 (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
0.80 to 0.90 (NO_2 only)	

TABLE 1-1

ASSESSMENT OF AMBIENT AIR QUALITY

POLLUTANT	SAMPLING PERIOD	DATA REDUCTION	STATISTICAL BASE	AMBIENT AIR QUALITY STANDARDS			
				PRIMARY		SECONDARY	
				µg/m^3	ppm	µg/m^3	ppm
Particulates (PM_{10})[a]	24 Hours (every sixth day)	24-Hour Average	Annual Arithmetic Mean[b]	50[c]		50[c]	
			24-Hour Average	150[d]		150[d]	
Sulfur Oxides (measured as sulfur dioxide)	Continuous	1-Hour Average	Annual Arithmetic Mean[e]	80	0.03		
			24-Hour Average[e]	365[f]	0.14[f]		
			3-Hour Average[e]			1300[f]	
Nitrogen Dioxide	Continuous	1-Hour Average	Annual Arithmetic Mean[e]	100	0.05	100	0.05
Ozone	Continuous	1-Hour Average	1-Hour Average	235[g]	0.12[g]	235[g]	0.12[g]
Lead	24 Hours (every sixth day)	Monthly Composite	Weighted 3-Month Average[h]	1.5		1.5	
Carbon Monoxide	Continuous	1-Hour Average	8-Hour Average[e]	10[f,i]	9[f]	10[f,i]	9[f]
			1-Hour Average	40[f]	35[f]	40[f]	35[f]

[a] Particulate matter with an aerodynamic diameter not greater than a nominal 10 micrometers.

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

[c] The "expected annual mean" for the most recent 3 years.

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

[e] EPA assessment criteria require at least 75% of the possible data to compute a valid average.

[f] Not to be exceeded more than once per year.

[g] Not to be exceeded more than an average of once per year in three years.

[h] State of Connecticut assessment criteria require at least 75% of the scheduled samples to compute a valid average.

[i] Units are mg/m^3.

TABLE 1-2

AIR QUALITY STANDARDS EXCEEDED IN CONNECTICUT IN 1988 BASED ON MEASURED CONCENTRATIONS

		OZONE		CARBON MONOXIDE		PM10	
		Level Exceeding 1-Hour Standard		Level Exceeding 8-Hour Standard		Level Exceeding 24-Hour Standard	
TOWN	SITE	Highest Observed Level (ppm)	Number of Days Standard Exceeded	Highest Observed Level 8-Hour (ppm)	Number of Times Standard Exceeded	Highest Observed Level ($\mu g/m^3$)	Number of Times Standard Exceeded
Bridgeport	123	0.232	18	-	-	-	-
Danbury	123	0.222	20	-	-	-	-
East Hartford	003	0.210	10	-	-	-	-
Greenwich	017	0.237	17	-	-	-	-
Groton	008	0.181	9	-	-	-	-
Hartford	017	-	-	13.1	3	-	-
Madison	002	0.204	12	-	-	-	-
Middletown	007	0.239	13	-	-	-	-
New Haven	018	-	-	-	-	274[a]	3[a,b]
New Haven	123	0.216	10	-	-	-	-
Stafford	001	0.238	13	-	-	-	-
Stratford	007	0.221	21	-	-	-	-

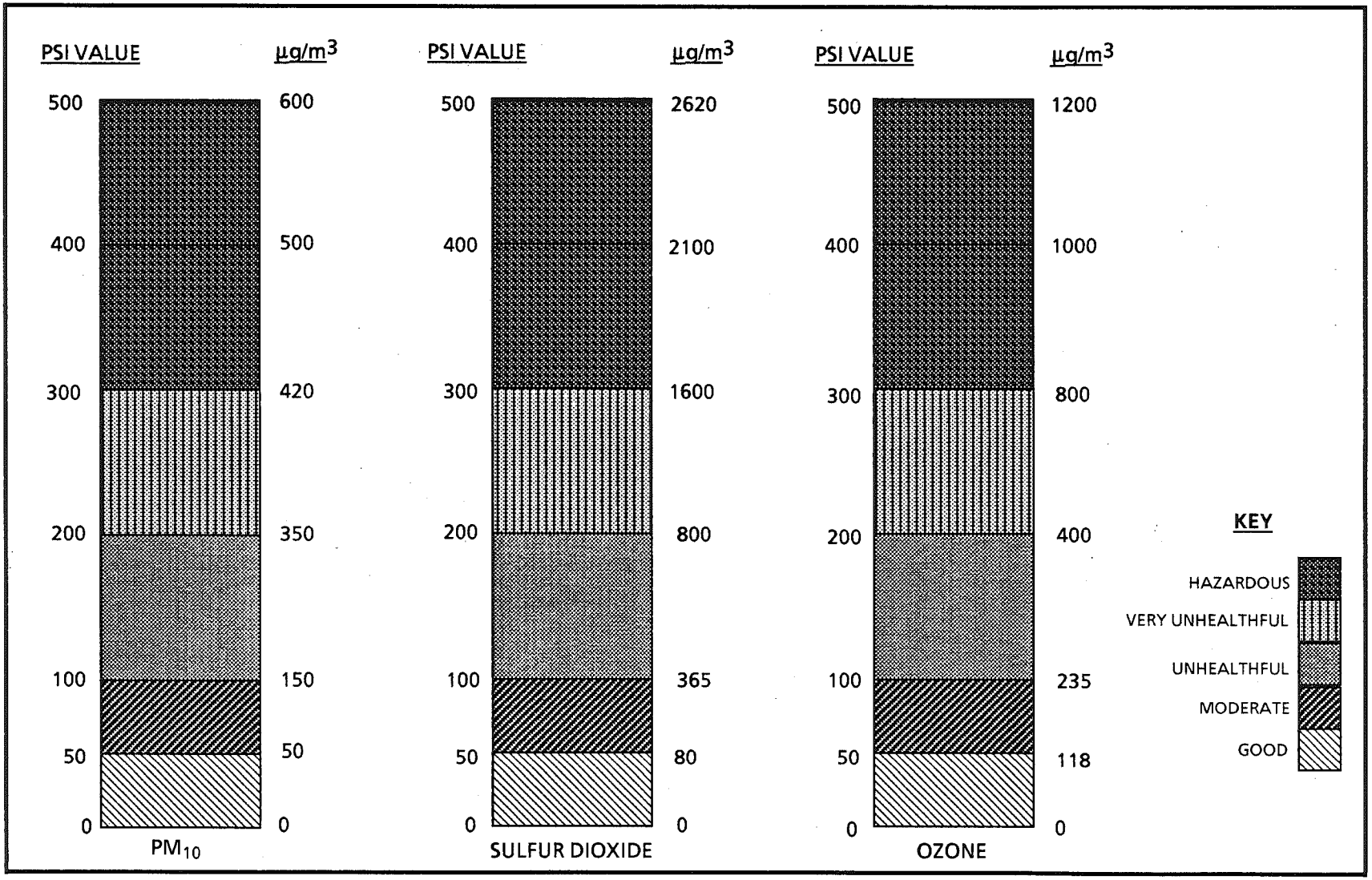
- : The pollutant is not monitored at the site.

[a] During the period 1986-1988 inclusive.

[b] The number of times the standard is exceeded is used to calculate the "expected number of exceedances" which is 7.9.

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 risks of adverse effects associated with deposition of ambient fine and coarse particles in the thorax (tracheobronchial and alveolar regions of the respiratory tract) are markedly greater than for deposition in the extrathoracic (head) region. Maximum particle penetration to the thoracic regions occurs during oronasal or mouth breathing.

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 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year, and 75 $\mu g/m^3$, annual geometric mean. The secondary standard, also measured as TSP, was set at 150 $\mu g/m^3$, 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 depositon of typical ambient fine and coarse particles in the thorax are markedly greater than those associated with depositon 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 would place substantially greater emphasis on controlling smaller 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_{10}); (2) replacing the 24-hour primary TSP standard with a 24-hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM_{10} standard of 50 $\mu g/m^3$, expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM_{10} standards that are identical in all respects to the primary standards. The state of Connecticut is in the process of adopting these standards.

CONCLUSIONS

Measured PM_{10} concentrations during 1988 did not exceed the 50 $\mu g/m^3$ level of the primary and secondary annual standards or the 150 $\mu g/m^3$ level of the primary and secondary 24-hour standards at any site. However, the 24-hour standards were violated because the "expected number of exceedances" for the most recent 3 years exceeded one per year at the New Haven 018 site. The annual standards were also violated at New Haven 018 because the "expected annual mean" for the most recent 3 years at the site exceeded 50 $\mu g/m^3$.

SAMPLE COLLECTION AND ANALYSIS

PM_{10} Sampler - Before 1988, Connecticut's particulate sampling network was comprised of standard high-volume (hi-vol) samplers, whose function was to measure TSP. These hi-vols resemble vacuum cleaners in their operation, with an 8" X 10" piece of fiberglass filter paper replacing the vacuum bag. With the promulgation of a PM_{10} 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_{10} standard being promulgated, Connecticut installed a small number of PM_{10} samplers in 1985. The samplers, manufactured by Sierra-Andersen, were the first PM_{10} 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_{10} 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_{10} samplers, like the standard hi-vol samplers, operate from midnight to midnight (standard time) at least every sixth day at all sites. However, PM_{10} samplers use quartz fiber filters instead of fiberglass filters, in order to eliminate sulfate artifact formation. The matter collected on the filter is analyzed for weight. The air flow is recorded during sampling. The weight in micrograms (μg) divided by the volume of air in standard cubic meters (m^3) yields the PM_{10} concentration for the day in micrograms per cubic meter.

Low Volume Sampler (Lo-vol) - The low volume sampler is a 30-day continuous sampler. It is enclosed in a shelter similar to a hi-vol, uses the same fiberglass filter paper, but operates at an air sampling flow rate approximately one-tenth that used by a standard hi-vol (i.e., 4 cfm as opposed to 40-

60 cfm). The air flow through the lo-vol is measured by a temperature compensating dry gas meter. The lo-vol measurement is essentially an average for the 30-day sampling interval.

The matter collected on the filters is analyzed for both weight and chemical composition. The chemical composition of the suspended particulate matter is determined at each lo-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 $\mu g/m^3$. 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 particular water soluble components. The results are reported for each individual constituent of the water soluble fraction in $\mu g/m^3$.

DISCUSSION OF DATA

Monitoring Network - In 1988, 42 PM_{10} samplers were operated in Connecticut (see Figure 2-1). The PM_{10} network consisted of 5 samplers in 1986 and 1987: Bridgeport 010, Hartford 015, New Haven 018, Waterbury 123, and West Haven 003. In 1985, there were also 5 samplers in the network. However, the Bridgeport site was moved in April of 1985 from site 123 to its present site 010, and the New Haven site was moved in October of 1985 from site 123 to its present site 018.

As part of the 1988 network for monitoring the airborne concentrations of lead, five lo-vol samplers were used to gather information on the chemical composition of TSP in the state. These samplers were Bridgeport 010, Hartford 015, Hartford 016, New Haven 018 and Waterbury 123 (see Figure 7-3 in section VII. Lead).

Precision and Accuracy - Precision checks were conducted at two PM_{10} sampling sites which had co-located samplers. On the basis of 61 precision checks, the 95% probability limits for precision ranged from -14% to + 12%. Accuracy is based on air flow through the monitor. The 95% probability limits for accuracy, based on 66 audits conducted on the PM_{10} monitoring system network, ranged from -7% to + 4%. (See section I.D. of this Air Quality Summary for a discussion of precision and accuracy.)

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 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 $\mu g/m^3$ primary and secondary annual standards could be reached at only 3 of the PM_{10} monitoring sites in Connecticut in 1988. Attainment of the annual standards was demonstrated at the Hartford 015 and Waterbury 123 sites. Nonattainment of the annual standards was demonstrated at New Haven 018. The "expected annual mean" PM_{10} concentration at New Haven 018 was determined to be 55 $\mu g/m^3$, which exceeded the level of the standard by 5 $\mu g/m^3$.

Of the 42 sampling sites in the network, the above 3 sites were the only ones that could satisfy the minimum sampling criteria. The primary reason for this is that a major part of the network (37 sites) was installed after the first calendar quarter of 1988.

Historical Data - A summary of annual average PM_{10} data for 1985 -1988 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. The amount of sampling data is considered to be adequate at a site if it includes 75% of the scheduled samples in each calendar quarter. If the sampling was insufficient to meet the EPA criteria, an asterisk appears next to the number of samples.

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. Input to the program includes 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 lists the input, calculates the 95% confidence limits about the annual arithmetic mean, and predicts the number of days in each year that the level of the primary and secondary 24-hour standards (150 $\mu g/m^3$) would have been exceeded if sampling had been conducted every day. For comparison, Table 2-1 also shows the number of days 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 PM_{10} sampling in 1986, 1987 and 1988 at New Haven 018 might have resulted in measured violations (i.e., four or more exceedances in three years) of the 24-hour standards.

Because manpower and economic limitations dictate that PM_{10} sampling for particulate matter cannot be conducted every day, 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 were calculated about the annual arithmetic mean at each site. For example (see Table 2-1), at West Haven 003 in 1986, 57 samples were analyzed and an arithmetic mean of 37.9 $\mu g/m^3$ was then calculated. The columns labeled "95-PCT-LIMITS" show the lower and upper limits of the 95% confidence interval to be 34 and 42 $\mu g/m^3$, respectively. This means that there is a 95% chance that the true arithmetic mean would fall between these limits. Since the upper 95% limit is less than 50 $\mu g/m^3$, one can be confident that the level of the annual standards was not exceeded at the site. However, if the upper 95% limit happened to be greater, and the lower limit less, than 50 $\mu g/m^3$, then one could not be confident that the standard was not exceeded at the site. And if both the upper and lower 95% limits were greater than 50 $\mu g/m^3$, then one could assume that the level of the standards was indeed exceeded. These three possibilities are illustrated in Figure 2-2.

Table 2-2 summarizes the statistical predictions from Table 2-1 regarding compliance with the level of the annual air quality standards, using the State's confidence limit criteria. The table shows that the level of the primary and secondary annual standards was probably achieved at the 3 sites that met the minimum sampling criteria in 1988. The results for the years 1985 through 1987 are also tabulated.

It should be noted that the above discussion of statistics does not affect the actual determination of attainment or nonattainment of the 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 2-3 presents the maximum 24-hour concentrations recorded at each site. There were no PM_{10} concentrations at any site that exceeded the level of the primary and secondary 24-hour standards in 1988. As mentioned earlier, all but 3 of the sites had insufficient data for the year.

Table 2-3 summarizes the statistical predictions from Table 2-1 regarding the number of sites that would have seen PM_{10} concentrations exceeding the level of the 24-hour standards, if sampling had been conducted every day. In 1988, there would have been one such site. The results for 1985 through 1987 are also given. In all cases, results are presented only for those sites that met the minimum sampling criteria for the year.

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 Hartford 015 and Waterbury 123. Compliance was not achieved at New Haven 018, where the "expected number of exceedances" of the 150 $\mu g/m3$ level of the 24-hour standards was determined to be greater than one per year.

Lo-vol Averages - Monthly and annual averages of the chemical components from the lo-vol TSP monitors have been computed for 1988 and are presented in Table 2-4.

10 High Days with Wind Data - Table 2-5 lists the 10 highest 24-hour average PM_{10} readings with the dates of occurrence for each PM_{10} hi-vol site in Connecticut which complied with EPA's minimum sampling criteria during 1988. This table also shows the average wind conditions which occurred on each of these dates. The resultant wind direction (DIR, in compass degrees clockwise from true north) and velocity (VEL, in mph), the average wind speed (SPD, in mph), and the ratio between the velocity and the speed are presented for each of four National Weather Service stations located in or near Connecticut. The resultant wind direction and velocity are vector quantities and are computed from the individual wind direction and speed readings in each day. The closer the wind speed ratio is to 1.000, the more persistent the wind. It should be noted that the Connecticut stations have local influences which change the speed and shift the direction of the near-surface air flow (e.g., the Bradley Field air flow is channeled north-south by the Connecticut River Valley and the Bridgeport air flow is frequently subject to sea breezes).

On a statewide basis, this table shows that approximately 30% of the high PM_{10} days occur with winds out of the southwest quadrant and most of those days have relatively persistent winds. This relationship between southwest winds and high particulate levels has historically been more prevalent in southwestern Connecticut. However, many of the maximum levels at some urban sites do not occur with southwest winds, indicating that these sites are possibly influenced by local sources or transport from different out-of-state sources. As noted above, a large scale southwesterly air flow is often diverted into a southerly flow up the Connecticut River Valley. At sites in the Connecticut River Valley, many of the highest PM_{10} days occur when the winds at Bradley Airport are from the south.

Trends - Any attempt to assess statewide trends in air pollution levels must account for the tendency of local changes to obscure the statewide pattern. In order to reach some statistically valid conclusions concerning trends in pollutant levels in Connecticut, the DEP has applied a statistical test called a paired *t* test (referred to hereafter as the *t* test) to the annual average data for PM_{10}.

The *t* test is a parametric test which can ascertain a statistically significant change in the statewide annual average pollutant concentration in Connecticut. The *t* test makes it possible to overcome the trend analysis problems which arise due to the changes in the number and location of monitoring sites from year-to-year, as well as problems associated with making equitable comparisons among sites. The annual mean pollutant concentrations for consecutive years are compared at each site, and the difference is noted. There is no inter-site comparison. Then, the mean and the standard deviation of the differences are used to calculate a *t* statistic, which is employed to determine the statistical significance of the apparent statewide change in pollutant level. For example, if a high proportion of sites experience an increase and/or if the magnitude of the increases at several sites is of much greater importance than the magnitude of the decreases at other sites, the *t* test will show that the increase was statistically significant for those two years.

The results of the *t* test for PM_{10} are presented in Table 2-6 . The analyses were performed only on data computed for sites at which the EPA's minimum sampling criteria were met. The first three columns of Table 2-6 show the years of data that were paired, the number of sites, and the average of the geometric mean pollutant concentrations at the sites in each year. The remaining columns show the average and standard deviation of the paired year means ; as well as the statistical significance of any change in the statewide pollutant average. The significance of a change is indicated by an arrow for each confidence limit, and is also given numerically as the number of chances in 10,000 that the change in the statewide PM_{10} level was not significant. For example, the statewide annual average for PM_{10} decreased between 1986 and 1987 from 39.6 to 35.4. This change represented a significant decrease at the 95% confidence level, but it did not represent a significant change at the 99% confidence level. The "probability that change is not significant" is given as 0.0339, meaning that there are only 339 chances in

10,000 that the apparent decrease in PM_{10} levels did not occur. The results of the *t* test show that the year-to-year PM_{10} levels in Connecticut apparently remained unchanged from 1985 to 1988, except for a decrease at the 95% confidence level from 1986 to 1987. The reader should be advised that the results should be interpreted with caution when the number of paired sites is small, as is the case with the 1985-1988 data.

These trend analyses do not account for the uncertainty associated with the individual annual mean computed for each PM_{10} site. Most particulate sampling is conducted only every sixth day, producing a maximum possible total of 61 samples per year. Therefore, the *t* test really compares year-to-year averages of the sampled concentrations, not actual annual averages. However, the every-sixth-day sampling schedule is believed to be sufficient to produce representative annual averages. The every-sixth-day schedule for particulate sampling began in 1971.

Significant changes in annual PM_{10} levels can be caused by a number of things. Among these are simple changes of weather, particularly the wind; 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 southwesterly 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 to the southwest.

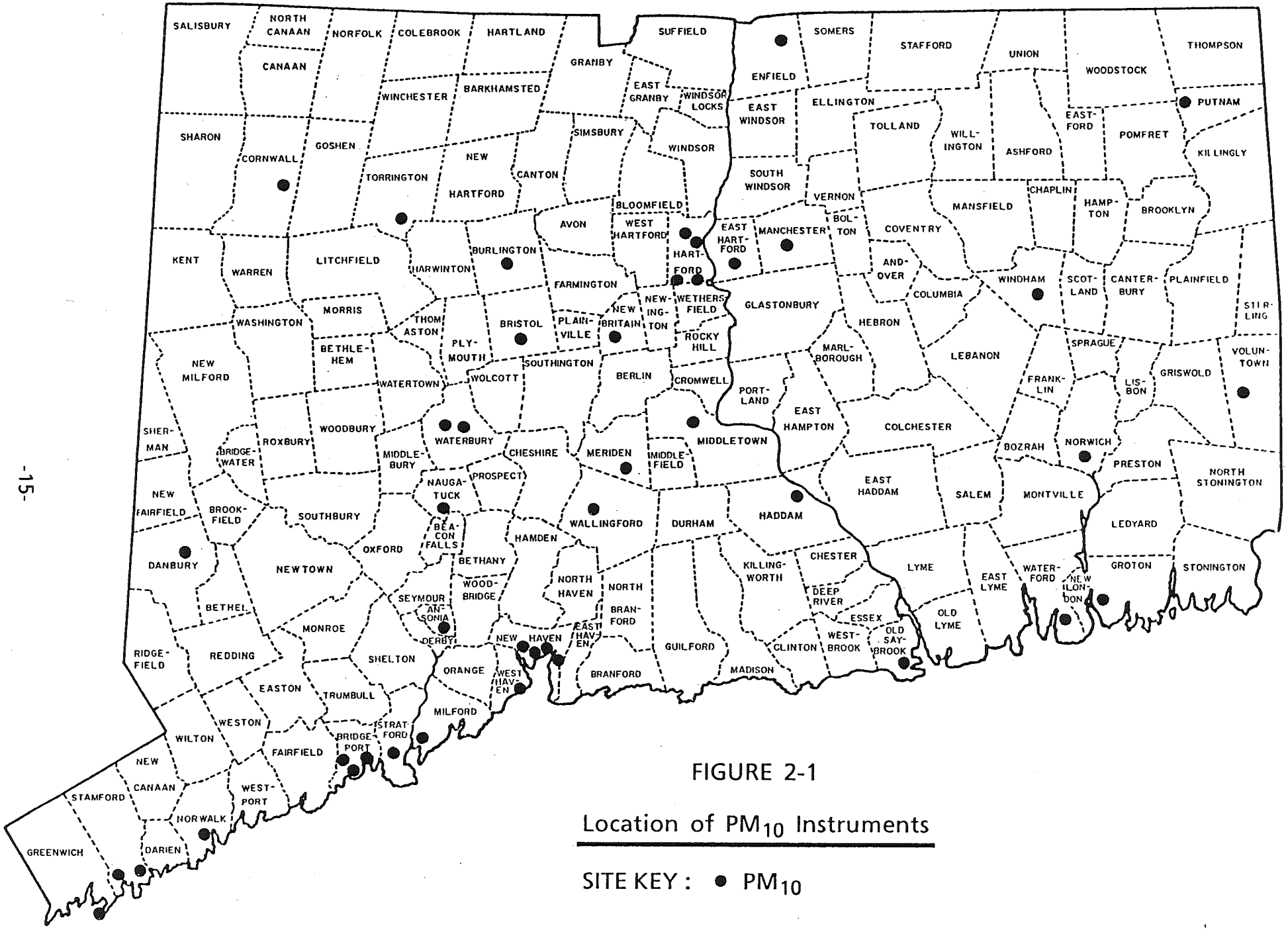


FIGURE 2-1

Location of PM_{10} Instruments

SITE KEY : • PM_{10}

TABLE 2-1

1985-1988 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	95-PCT-LIMITS UPPER	STD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
ANSONIA	004	1988	37*	26.0	21	31	15.720		
BRIDGEPORT	010	1985	42*	38.7	34	43	15.663		
BRIDGEPORT	010	1986	58	33.6	29	38	16.865		
BRIDGEPORT	010	1987	59	30.6	27	34	13.190		
BRIDGEPORT	010	1988	53*	28.6	25	32	14.904		
BRIDGEPORT	013	1988	33*	27.5	22	32	15.032		
BRIDGEPORT	014	1988	10*	33.1	27	39	8.031		
BRIDGEPORT	123	1985	16*	40.5	33	48	14.722		
BRISTOL	001	1988	29*	22.9	19	27	11.730		
BURLINGTON	001	1988	44*	17.7	14	22	14.312		
CORNWALL	005	1988	17*	10.8	7	14	6.723		
DANBURY	123	1988	36*	25.8	21	30	14.363		
EAST HARTFORD	004	1988	27*	24.6	20	29	12.093		
ENFIELD	005	1988	27*	20.3	17	24	9.832		
GREENWICH	017	1988	34*	24.9	19	30	16.432		
GROTON	006	1988	28*	21.6	17	26	11.860		
HADDAM	002	1988	26*	17.6	14	21	9.688		
HARTFORD	013	1988	38*	23.3	19	27	12.724		
HARTFORD	014	1988	25*	21.6	18	25	8.984		

* THE NUMBER OF SAMPLES FOR THE YEAR IS INSUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

TABLE 2-1, CONTINUED

1985-1988 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
HARTFORD	015	1985	58	37.8	35	41	13.045		
HARTFORD	015	1986	59	37.3	34	41	14.717		
HARTFORD	015	1987	59	35.2	31	39	15.746		
HARTFORD	015	1988	54	29.9	26	34	15.261		
HARTFORD	018	1988	7*	25.7	16	35	10.124		
MANCHESTER	001	1988	26*	19.6	16	24	10.150		
MERIDEN	002	1988	25*	22.7	19	27	10.027		
MIDDLETOWN	003	1983	26*	23.0	19	27	11.019		
MILFORD	010	1988	9*	19.1	15	24	5.934		
NAUGATUCK	001	1988	29*	25.8	21	31	12.957		
NEW BRITAIN	012	1988	22*	19.9	17	23	7.397		
NEW HAVEN	013	1988	39*	26.2	22	30	13.873		
NEW HAVEN	018	1985	40*	50.3	45	55	17.123		
NEW HAVEN	018	1986	163	57.4	56	59	22.856	2	
NEW HAVEN	018	1987	157	57.9	56	60	33.257	5	3
NEW HAVEN	018	1988	300	45.6	45	47	21.269	1	
NEW HAVEN	020	1988	31*	30.0	25	35	12.933		
NEW HAVEN	123	1985	123*	38.2	37	39	15.381		
NEW HAVEN	123	1988	37*	28.5	24	33	14.069		
NORWALK	014	1988	13*	33.9	29	39	7.956		

* THE NUMBER OF SAMPLES FOR THE YEAR IS INSUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

TABLE 2-1, CONTINUED

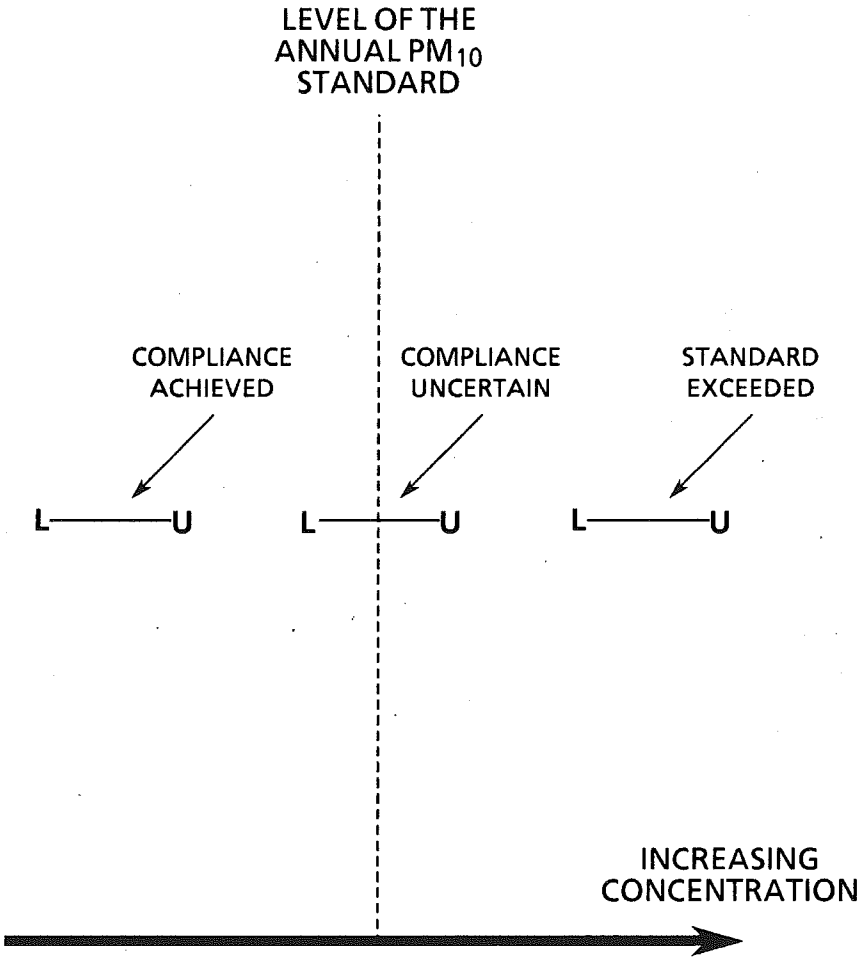
1985-1988 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
NORWICH	002	1988	29*	24.4	20	29	12.138		
OLD SAYBROOK	002	1988	24*	21.3	18	25	8.278		
PUTNAM	002	1988	27*	18.8	15	22	9.298		
STAMFORD	001	1988	25*	24.2	18	30	14.319		
STAMFORD	026	1988	11*	26.3	17	36	14.461		
STRATFORD	005	1988	26*	24.1	19	29	12.071		
TORRINGTON	001	1988	28*	21.5	18	25	10.675		
VOLUNTOWN	001	1988	40*	16.7	13	20	11.457		
WALLINGFORD	006	1988	9*	24.3	18	31	8.446		
WATERBURY	007	1988	29*	27.2	23	32	12.792		
WATERBURY	123	1985	56	40.2	36	44	15.205		
WATERBURY	123	1986	56	40.1	35	45	20.002	1	
WATERBURY	123	1987	59	33.4	30	37	14.235		
WATERBURY	123	1988	57	32.9	28	37	18.257		
WATERFORD	001	1988	28*	20.9	16	26	13.255		
WEST HAVEN	003	1985	28*	48.5	43	54	15.461		
WEST HAVEN	003	1986	57	37.9	34	42	15.939		
WEST HAVEN	003	1987	55	30.9	28	34	12.862		
WEST HAVEN	003	1988	41*	27.6	24	31	12.572		
WILLIMANTIC	002	1988	28*	20.5	17	24	8.736		

* THE NUMBER OF SAMPLES FOR THE YEAR IS INSUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

FIGURE 2-2

COMPLIANCE WITH THE LEVEL OF THE ANNUAL PM10 STANDARDS USING 95% CONFIDENCE LIMITS ABOUT THE ANNUAL ARITHMETIC MEAN CONCENTRATION



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

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

TABLE 2-2

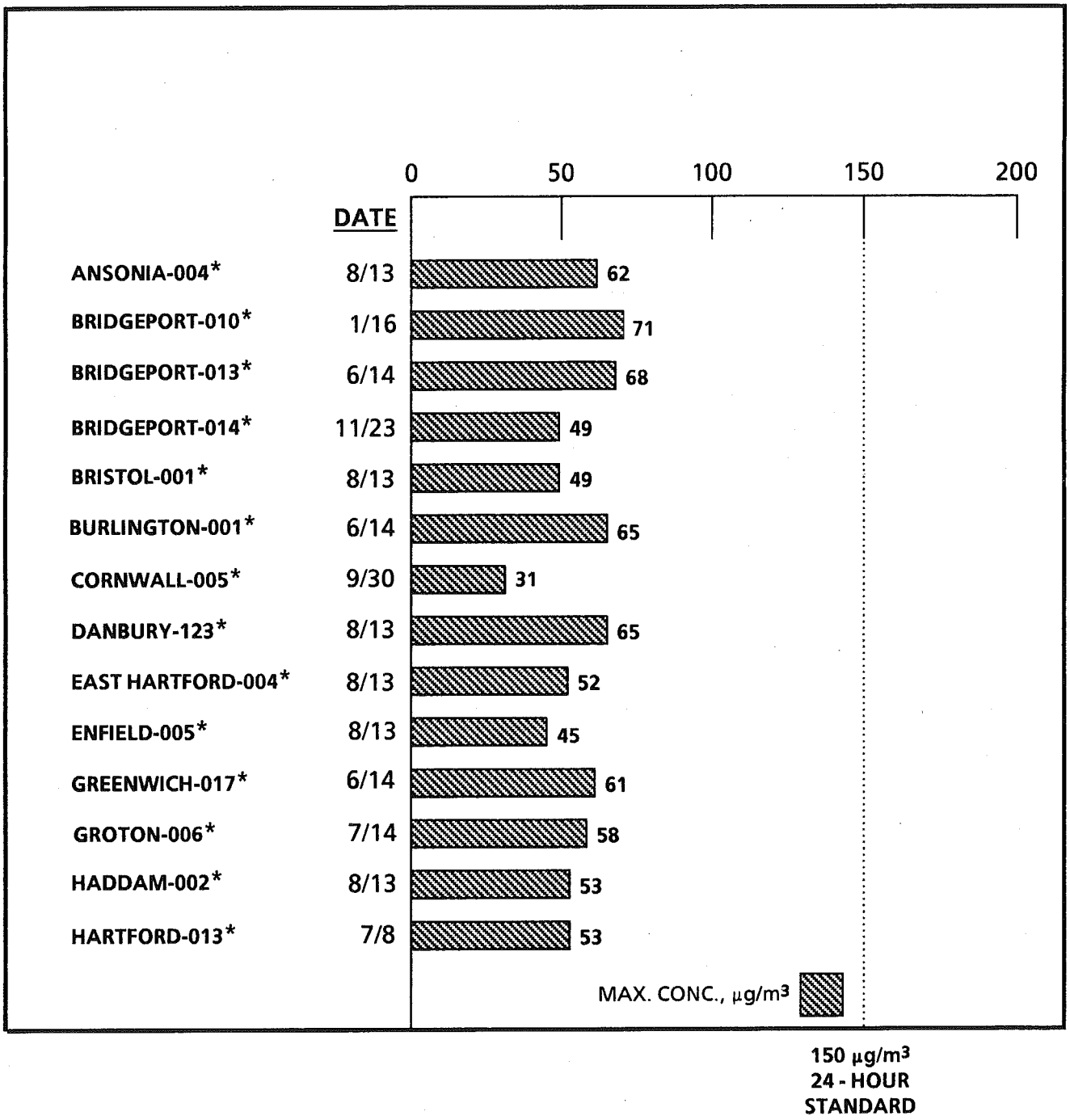
STATISTICALLY PREDICTED NUMBER OF SITES IN COMPLIANCE WITH THE LEVEL OF THE ANNUAL PM10 STANDARDS*

	COMPLIANCE ACHIEVED	COMPLIANCE UNCERTAIN	STANDARD EXCEEDED
1985	2	0	0
1986	4	0	1
1987	4	0	1
1988	3	0	0

* Using 95% confidence limits about the arithmetic mean concentration at only those sites which had sufficient data to satisfy the minimum sampling criteria.

FIGURE 2-3

1988 MAXIMUM 24-HOUR PM10 CONCENTRATIONS

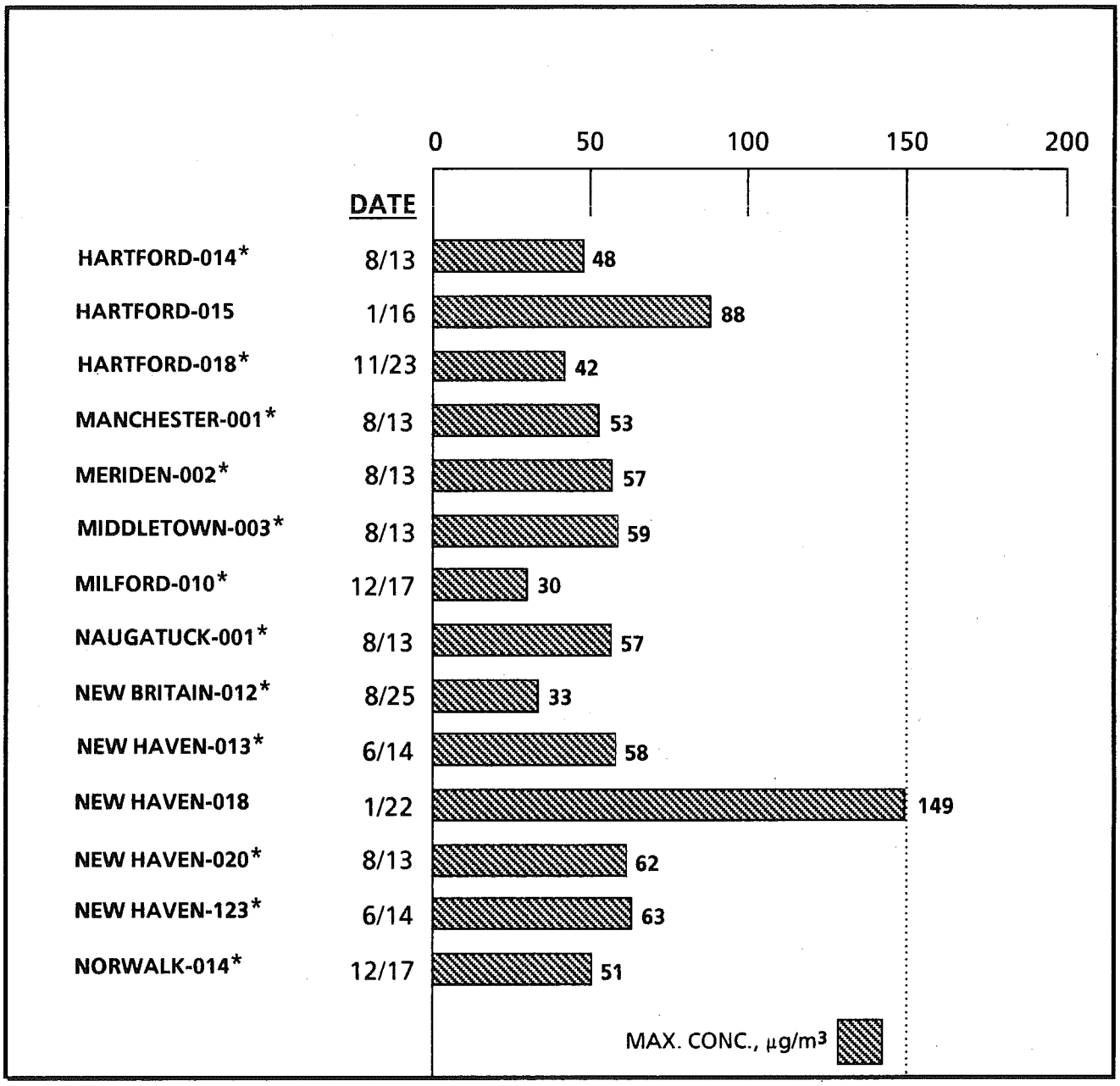


* The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date is given.

FIGURE 2-3, continued

1988 MAXIMUM 24-HOUR PM10 CONCENTRATIONS

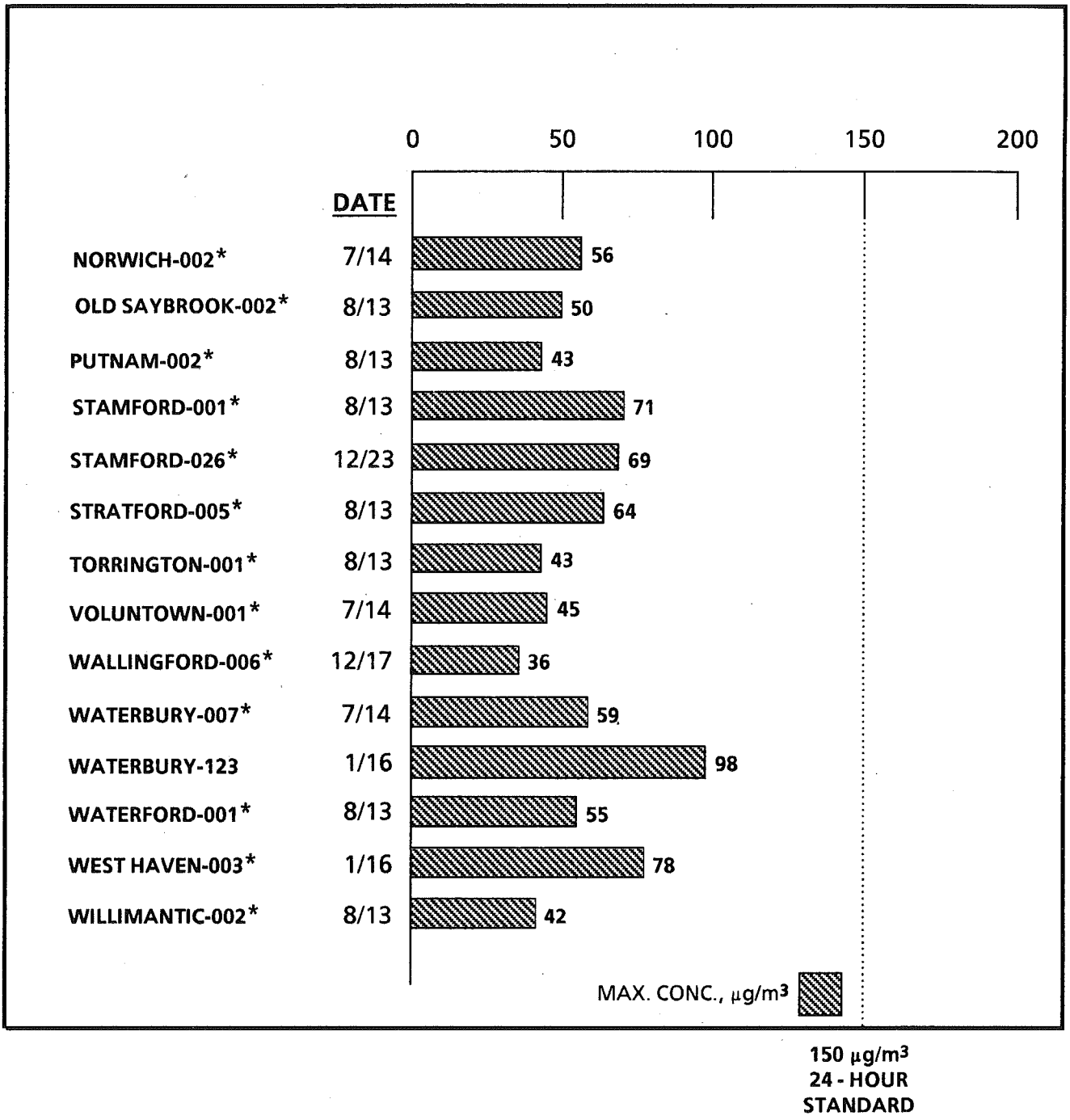


* The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date is given.

FIGURE 2-3, continued

1988 MAXIMUM 24-HOUR PM10 CONCENTRATIONS



* The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date is given.

TABLE 2-3

SUMMARY OF THE STATISTICALLY PREDICTED NUMBER OF PM10 SITES EXCEEDING THE LEVEL OF THE 24-HOUR STANDARDS

YEAR	NO. OF SITES[1]	SITES WITH ≧ 1 DAY EXCEEDING 150 μg/m³	
		No. of Sites	Percentage of All Sites
1985	2	0	0%
1986	5	2	40%
1987	5	1	20%
1988	3	1	33%

[1] Only those sites are used which had sufficient data to satisfy the minimum sampling criteria.

TABLE 2-4

MONTHLY CHEMICAL CHARACTERIZATION OF 1988 LO-VOL TSP

TOWN	AREA	SITE
Bridgeport	**0060**	**010**

	MONTHLY AVERAGE												ANNUAL AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
METALS (ng/m³)													
BERYLLIUM		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CADMIUM		1.7	0.8	1.0	1.0			1.0	0.6	0.9	0.8	1.4	1.0
CHROMIUM		20	10	11	20			7	5	4	5	5	10
COPPER		20	20	20	20			20	20	20	20	20	20
IRON		2010	1650	1440	1350			1800	1010	1220	920	120	1280
LEAD		70	60	90	50			110	40	60	50	60	70
MANGANESE		28	22	25	26			27	15	17	14	19	21
NICKEL		44	24	19	21			18	13	20	25	30	24
VANADIUM		80	40	30	20			30	20	30	40	50	40
ZINC		140	140	100	130			130	80	110	120	160	120
WATER SOLUBLES (ng/m³)													
NITRATE		4450	4340	3400	3640			3050	3890	3450	2300	3320	3540
SULFATE		9680	7770	6080	6340			12,040	8180	8680	8390	7900	8340
AMMONIUM		660	290	<10	130			350	50	80	200	480	250[a]
TSP (µg/m³)		82	71	54	56			70	42	48	40	54	57

[a] The average was calculated using one quarter of the reportable limit in April.

TABLE 2-4, continued

MONTHLY CHEMICAL CHARACTERIZATION OF 1988 LO-VOL TSP

TOWN	AREA	SITE
Hartford	**0420**	**015**

	MONTHLY AVERAGE												ANNUAL AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
METALS (ng/m³)													
BERYLLIUM		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CADMIUM		1.7	2.0	2.1	2.1	1.7	0.9	1.2	1.2	1.1	1.3	1.2	1.5
CHROMIUM		10	6	5	4	5	5	4	3	5	5	6	5
COPPER		30	20	20	20	20	20	20	10	20	20	20	20
IRON		2490	2380	1790	1510	2240	1580	1530	1070	1530	1480	1950	1780
LEAD		70	60	40	50	60	50	50	30	60	70	80	60
MANGANESE		28	28	29	30	37	27	28	18	25	27	27	28
NICKEL		32	19	8	9	10	10	11	6	10	10	21	13
VANADIUM		50	40	10	10	10	20	20	10	10	10	30	20
ZINC		120	100	100	110	130	130	210	80	100	90	140	120
WATER SOLUBLES (ng/m³)													
NITRATE		3090	3350	2400	2100	3290	1320	1480	3110	2760	1820	2930	2510
SULFATE		7120	6750	5010	6600	8180	10,500	11,110	5800	7720	6230	6900	7450
AMMONIUM		430	100	<10	120	340	250	300	<10	60	60	530	200[a]
TSP (µg/m³)		104	95	67	64	82	72	69	41	57	51	84	

[a] The average was calculated using one quarter of the reportable limit in April and September.

TABLE 2-4, continued

MONTHLY CHEMICAL CHARACTERIZATION OF 1988 LO-VOL TSP

TOWN	AREA	SITE
Hartford	**0420**	**016**

	MONTHLY AVERAGE												ANNUAL AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
METALS (ng/m³)													
BERYLLIUM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CADMIUM	0.9	1.3	1.1	0.5	0.8	1.0		1.2	1.3	0.8	0.7	0.4	0.9
CHROMIUM	9	7	6	3	5	8		6	5	6	5	4	6
COPPER	20	20	20	10	20	20		30	20	20	20	10	20
IRON	1770	2240	1930	980	1550	2450		2340	1520	1970	1470	1160	1760
LEAD	110	80	60	30	50	60		60	50	60	80	50	60
MANGANESE	22	28	22	13	25	39		38	25	33	24	18	26
NICKEL	47	38	16	5	8	10		13	9	13	16	18	18
VANADIUM	90	80	30	10	10	10		20	10	10	20	30	30
ZINC	130	100	100	60	100	130		150	90	100	100	70	100
WATER SOLUBLES (ng/m³)													
NITRATE	3170	3570	3360	1290	2320	2700		1090	3110	2980	2000	1540	2470
SULFATE	8600	7370	6230	3680	6910	8000		12,820	6630	8210	8310	5640	7490
AMMONIUM	1310	930	220	<10	240	230		570	40	90	130	90	350[a]
TSP (µg/m³)	90	101	82	37	64	85		85	53	65	52	50	69

[a] The average was calculated using one quarter of the reportable limit in April.

TABLE 2-4, continued

MONTHLY CHEMICAL CHARACTERIZATION OF 1988 LO-VOL TSP

TOWN	AREA	SITE
New Haven	**0700**	**018**

	MONTHLY AVERAGE												ANNUAL AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
METALS (ng/m³)													
BERYLLIUM		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CADMIUM		3.4	1.4	1.4	1.1	1.7	1.1	1.7	1.0	1.3	1.3	1.0	1.5
CHROMIUM		11	10	2	9	14	7	7	11	12	9	8	9
COPPER		60	70	80	60	90	60	80	90	80	70	50	70
IRON		1820	1820	11,610	6970	10,800	5940	6640	1080	6710	6740	5410	5960
LEAD		120	120	170	90	140	90	100	230	190	110	100	130
MANGANESE		114	108	14	8	13	60	88	135	79	75	78	70
NICKEL		34	24	23	15	23	17	18	23	27	32	37	25
VANADIUM		70	60	50	30	40	30	30	40	40	50	60	50
ZINC		200	230	320	180	330	190	210	280	170	210	210	230
WATER SOLUBLES (ng/m³)													
NITRATE		3390	3040	2440	3210	3770	3610	3650	3700	3110	2260	1990	3110
SULFATE		8600	6890	6030	5470	8830	11,360	12,420	16,510	10,190	11,330	5590	9380
AMMONIUM		490	260	10	150	320	450	60	40	40	50	220	190
TSP (µg/m³)		253	238	208	161	228	147	153	319	138	139	159	195

TABLE 2-4, continued

MONTHLY CHEMICAL CHARACTERIZATION OF 1988 LO-VOL TSP

TOWN	AREA	SITE
Waterbury	**1240**	**123**

	MONTHLY AVERAGE												ANNUAL AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
METALS (ng/m³)													
BERYLLIUM						<0.1		<0.1			<0.1	<0.1	
CADMIUM						1.4		1.7			3.7	2.5	
CHROMIUM						29		19			25	34	
COPPER						40		50			50	60	
IRON						1500		1710			1230	2150	
LEAD						30		50			80	90	
MANGANESE						23		29			18	34	
NICKEL						6		11			15	24	
VANADIUM						10		20			20	30	
ZINC						140		310			220	240	
WATER SOLUBLES (ng/m³)													
NITRATE						2790		1610			2230	2810	
SULFATE						6400		11,850			7640	8770	
AMMONIUM						20		380			160	1090	
TSP (µg/m³)						58		70			48	89	

TABLE 2-5

1988 TEN HIGHEST 24-HOUR AVERAGE PM10 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
HARTFORD-015 (0054)		88	59	59	59	54	49	49	48	48	47
	DATE	1/16/88	7/ 8/88	2/ 9/88	6/14/88	6/20/88	1/22/88	7/14/88	2/27/88	8/ 1/88	7/26/88
METEOROLOGICAL SITE	DIR (DEG)	200	120	120	260	230	320	190	70	160	30
NEWARK	VEL (MPH)	4.6	3.3	2.0	6.6	8.9	5.3	6.8	6.8	4.7	2.1
	SPD (MPH)	5.8	6.3	6.6	7.8	11.1	6.3	9.5	9.1	5.6	6.8
	RATIO	0.797	0.522	0.296	0.853	0.805	0.846	0.715	0.750	0.845	0.318
METEOROLOGICAL SITE	DIR (DEG)	170	160	170	260	190	360	180	10	220	220
BRADLEY	VEL (MPH)	3.0	4.2	2.6	4.7	7.0	5.4	6.0	3.6	2.7	5.8
	SPD (MPH)	4.9	6.9	6.3	6.2	8.5	7.0	10.5	3.9	5.3	8.2
	RATIO	0.617	0.612	0.409	0.767	0.825	0.763	0.570	0.931	0.512	0.706
METEOROLOGICAL SITE	DIR (DEG)	250	230	130	230	220	330	220	90	220	170
BRIDGEPORT	VEL (MPH)	5.0	6.3	3.7	6.5	8.7	5.9	6.9	10.1	3.2	2.2
	SPD (MPH)	6.9	8.5	6.2	8.1	9.3	6.6	7.2	12.1	5.0	5.5
	RATIO	0.727	0.744	0.592	0.813	0.935	0.887	0.965	0.838	0.628	0.398
METEOROLOGICAL SITE	DIR (DEG)	270	250	240	300	250	30	240	90	300	240
WORCESTER	VEL (MPH)	7.5	4.7	1.6	7.0	9.4	2.7	8.5	3.1	3.4	4.4
	SPD (MPH)	9.8	7.5	4.6	8.1	11.8	4.9	10.4	4.2	5.6	5.9
	RATIO	0.764	0.634	0.355	0.866	0.796	0.556	0.821	0.736	0.605	0.746
NEW HAVEN-018 (0300)		149	121	119	115	115	113	112	107	106	105
	DATE	1/22/88	2/25/88	9/24/88	11/23/88	3/ 8/88	2/19/88	6/15/88	2/29/88	1/12/88	7/11/88
METEOROLOGICAL SITE	DIR (DEG)	320	290	340	330	130	80	260	240	170	230
NEWARK	VEL (MPH)	5.3	8.0	5.2	3.2	2.3	6.5	6.3	4.2	3.3	7.8
	SPD (MPH)	6.3	10.4	8.2	6.8	6.3	7.9	8.8	6.5	5.0	10.2
	RATIO	0.846	0.772	0.631	0.470	0.357	0.828	0.716	0.653	0.655	0.763
METEOROLOGICAL SITE	DIR (DEG)	360	320	340	330	130	110	250	210	180	300
BRADLEY	VEL (MPH)	5.4	4.1	7.1	3.5	1.6	3.5	5.7	5.0	2.2	2.5
	SPD (MPH)	7.0	6.0	8.5	5.2	6.6	6.5	8.3	6.6	4.9	6.5
	RATIO	0.763	0.686	0.838	0.670	0.248	0.540	0.682	0.751	0.452	0.385
METEOROLOGICAL SITE	DIR (DEG)	330	290	330	340	250	80	230	230	60	220
BRIDGEPORT	VEL (MPH)	5.9	4.2	3.9	8.7	6.0	9.7	6.1	6.4	1.8	6.7
	SPD (MPH)	6.6	6.9	5.5	9.3	8.5	9.8	6.3	6.5	2.0	8.2
	RATIO	0.887	0.609	0.720	0.926	0.706	0.992	0.971	0.996	0.892	0.824
METEOROLOGICAL SITE	DIR (DEG)	30	290	310	310	330	170	280	260	250	270
WORCESTER	VEL (MPH)	2.7	5.9	8.1	7.2	3.0	3.5	6.2	5.1	4.7	4.2
	SPD (MPH)	4.9	7.0	8.9	8.8	5.2	6.8	7.5	6.6	8.3	6.3
	RATIO	0.556	0.840	0.905	0.822	0.579	0.512	0.827	0.771	0.560	0.662
WATERBURY-123 (0057)		98	85	73	66	59	58	56	55	53	51
	DATE	1/16/88	7/ 8/88	1/28/88	2/ 9/88	6/20/88	7/14/88	1/22/88	1/10/88	8/13/88	6/14/88
METEOROLOGICAL SITE	DIR (DEG)	200	120	260	120	230	190	320	340	240	260
NEWARK	VEL (MPH)	4.6	3.3	5.8	2.0	8.9	6.8	5.3	6.3	9.5	6.6
	SPD (MPH)	5.8	6.3	7.2	6.6	11.1	9.5	6.3	6.8	11.6	7.8
	RATIO	0.797	0.522	0.808	0.296	0.805	0.715	0.846	0.937	0.816	0.853
METEOROLOGICAL SITE	DIR (DEG)	170	160	280	170	190	180	360	320	230	260
BRADLEY	VEL (MPH)	3.0	4.2	2.6	2.6	7.0	6.0	5.4	5.1	5.1	4.7
	SPD (MPH)	4.9	6.9	4.9	6.3	8.5	10.5	7.0	5.6	6.9	6.2
	RATIO	0.617	0.612	0.525	0.409	0.825	0.570	0.763	0.916	0.740	0.767

TABLE 2-5, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE PM10 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	250	230	280	130	220	220	330	360	240	230
BRIDGEPORT	VEL (MPH)	5.0	6.3	6.5	3.7	8.7	6.9	5.9	6.7	7.7	6.5
	SPD (MPH)	6.9	8.5	8.2	6.2	9.3	7.2	6.6	7.0	8.1	8.1
	RATIO	0.727	0.744	0.788	0.592	0.935	0.965	0.887	0.950	0.957	0.813
METEOROLOGICAL SITE	DIR (DEG)	270	250	280	240	250	240	30	330	280	300
WORCESTER	VEL (MPH)	7.5	4.7	6.7	1.6	9.4	8.5	2.7	6.3	6.1	7.0
	SPD (MPH)	9.8	7.5	7.8	4.6	11.8	10.4	4.9	6.8	7.8	8.1
	RATIO	0.764	0.634	0.863	0.355	0.796	0.821	0.556	0.929	0.783	0.866

TABLE 2-6

PM10 TRENDS: 1985-1988

(PAIRED *t* TEST)

PAIRED YEARS	AVERAGE OF ANNUAL GEOMETRIC MEANS ($\mu g/m^3$)	NO. OF SITES[1]	DIFFERENCES OF THE PAIRED YEAR MEANS		SIGNIFICANCE LEVEL[1]		
					TREND AT		PROBABILITY THAT CHANGE IS NOT SIGNIFICANT
			AVG.	STD. DEV.	95% LEVEL	99% LEVEL	
85 86	36.3 35.2	2 2	-1.10	0.57	N.C.	N.C.	0.2220
86 87	39.6 35.5	4 4	-3.72	2.03	↓	N.C.	0.0339
87 88	37.8 32.3	3 3	-5.50	4.20	N.C.	N.C.	0.1514

Key to Symbols : ↓ = Significant downward trend

↑ = Significant upward trend

N.C. = No significant change

[1] When the number of paired sites is small, the results should be interpreted with caution.

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_2) comprises about 95 percent of these gases, so scientists use a test for SO_2 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 1988 did not exceed any federal primary or secondary standards. Measured concentrations were substantially below the 365 $\mu g/m^3$ primary 24-hour standard and well below both the 80 $\mu g/m^3$ primary annual standard and the 1300 $\mu g/m^3$ secondary 3-hour standard.

METHOD OF MEASUREMENT

The DEP Air Monitoring Unit used the pulsed fluorescence method (Teco instruments) to continuously measure sulfur dioxide levels at all 18 sites in 1988.

DISCUSSION OF DATA

Monitoring Network - Eighteen continuous SO_2 monitors were used to record data in 14 towns during 1988 (see Figure 3-1):

Bridgeport 012
Bridgeport 013
Danbury 123
East Hartford 005
East Haven 003
Enfield 005
Greenwich 017
Groton 007
Hartford 123
Milford 010
New Britain 011
New Haven 017
New Haven 123
Norwalk 013
Stamford 025
Stamford 123
Waterbury 008
Waterbury 123

All of these sites telemetered their data to the central computer in Hartford three times each day (i.e., at 0700, 1400, and 2400 hours).

Precision and Accuracy - 634 precision checks were made on SO_2 monitors in 1988, yielding 95% probability limits ranging from -8% to +8%. Accuracy is determined by introducing a known amount of SO_2 into each of the monitors. Three different concentration levels are tested: low, medium, and high. The 95% probability limits for accuracy based on 34 audits were: low, -13% to +11%; medium, -10% to +11%; and high, -8% to +11%.

Annual Averages - SO_2 levels were below the primary annual standard of 80 $\mu g/m^3$ at all sites in 1988 (see Table 3-1). The annual average SO_2 levels increased at 9, and decreased at 3, of the 15 monitoring sites that had adequate data in both 1987 and 1988 to produce valid annual averages. The highest increase was 4 $\mu g/m^3$, which occurred at Greenwich, Groton, Waterbury 123, and both New Haven sites. The largest annual average decrease was 4 $\mu g/m^3$, which occurred at Stamford 123 and Waterbury 008.

Statistical Projections - A statistical analysis of the sulfur dioxide data is presented in Table 3-2. This analysis 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 annual averages for particulate matter (see Table 2-1). However, Table 3-2 gives the annual arithmetic mean of the valid 24-hour SO_2 averages to allow direct comparison to the annual SO_2 standards. The 95% limits and standard deviations are also arithmetic calculations. Since the distribution of the SO_2 data tends to be lognormal, the geometric means and standard deviations were used to predict the number of days the 24-hour standard of 365 $\mu g/m^3$ would be exceeded at each site, if sampling had been conducted every day.

The data indicate that there were no violations of the primary SO_2 standard at any site in Connecticut in the last three years. However, statistical predictions of one day exceeding the primary 24-hour standard of 365 $\mu g/m^3$ did occur during this period at New Haven 017 in 1988. This indicates that a slight increase in SO_2 emissions might have jeopardized the attainment of the standard at this site. Two days over the standard are required for the standard to be violated at a site.

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 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 1988 no sites recorded SO_2 levels in excess of the 24-hour primary standard of 365 $\mu g/m^3$. Second high calendar day SO_2 average concentrations increased at all of the 15 monitoring sites that had a sufficient distribution and quantity of data in both 1987 and 1988. The increases ranged from 16 $\mu g/m^3$ at Milford 010 to 81 $\mu g/m^3$ at Waterbury 123.

Current EPA policy bases compliance with the primary 24-hour SO_2 standard on calendar day averages. Assessment of compliance is based on the second highest calendar day average in the year. Running averages are averages computed for the 24-hour periods ending at every hour. If running 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 maximum 24-hour SO_2 readings from both the running averages and the calendar day averages for comparison. The maximum 24-hour running averages are all higher than the maximum calendar day averages, and the differences range up to 23 $\mu g/m^3$, which occurred at Waterbury 008.

3-Hour Averages - Figure 3-3 presents the first and second high 3-hour concentrations recorded at each monitoring site. Measured SO_2 concentrations were far below the federal secondary 3-hour

standard of 1300 $\mu g/m^3$ at all DEP monitoring sites in 1988. Of the 15 sites that had a sufficient distribution and quantity of data in both 1987 and 1988, 11 had higher second high concentrations in 1988. The increases ranged from 3 $\mu g/m^3$ at Danbury 123 to 74 $\mu g/m^3$ at New Britain 011. Four sites had lower second high concentrations in 1988. The decreases ranged from 12 $\mu g/m^3$ at Milford 010 to 25 $\mu g/m^3$ at Waterbury 123.

10-High Days with Wind Data - Table 3-4 lists the ten highest 24-hour calendar day SO_2 averages and the dates of occurrence for each SO_2 site in Connecticut in 1988. Only those 16 sites were used which had a sufficient distribution and quantity of data to produce a valid annual average. The table also shows the average wind conditions that occurred on each of these dates. (The origin and use of these wind data are described in the discussion of Table 2-5 in the particulate matter section of this Air Quality Summary.)

Once again, as with particulate matter, many (i.e., 34%) of the highest SO_2 days occurred with winds out of the southwest quadrant, and most of these days had relatively persistent winds. This relationship is caused, at least in part, by SO_2 transport, but any transport is limited by the chemical instability of SO_2. In the atmosphere, SO_2 reacts with other gases to produce, among other things, sulfate particulates. Therefore, 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 SO_2 in Connecticut decrease with distance from the New York City metropolitan area. This relationship tends to support the transport hypothesis. On the other hand, these studies also revealed that certain meteorological parameters, most notably mixing height and wind speed, are more conducive to high SO_2 levels on days when there are southwesterly winds than on other days.

The data in Table 3-4 were used to make a tally, by date, of the frequency of occurrence of high SO_2 levels. If a given date recurred at five or more sites in this tally, the SO_2 levels and meteorological conditions were investigated further. There were 13 such days. A close look at these days revealed two important points. First, 9 of the 13 days occurred during winter, and the rest occurred in late autumn. This can be attributed to more fuel being burned during the cold weather. Second, 5 of the 13 days had relatively persistent southwest winds for the calendar day, and 2 other days had such winds for the previous 24 hours.

In summary, high levels of SO_2 in Connecticut seem to be caused by a number of related factors. First, Connecticut experiences its highest SO_2 levels during the winter months, when there is an increased amount of fuel combustion. Second, the New York City metropolitan area, a large emission source, is located to the southwest of Connecticut, and southwest winds occur relatively often in this region in comparison to other wind directions. Also, adverse meteorological conditions are often associated with southwest winds. The net effect is that during the winter months when a persistent southwesterly wind occurs, an air mass picks up increased amounts of SO_2 over the New York City metropolitan area and transports this SO_2 into Connecticut. Here, the SO_2 levels remain high because the relatively low mixing heights associated with the southwest flow and the low winter temperatures will not allow much vertical mixing. The levels of transported SO_2 eventually decline with increasing distance from New York City, as the 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 - In order to perform a valid trend analysis, the data for the period of interest must be adequate, reliable and from similar sampling methods. Up until 1978, the only monitoring method for SO_2 that was thought to consistently fit these criteria was the sulfation plate. Between 1978 and 1982 there were approximately three times as much sulfation rate data as continuous SO_2 data and the former method was used for the purpose of analyzing SO_2 trends. However, recent information now indicates that sulfation rate-derived SO_2 values may not be as accurate as once thought. Sulfation rate data are dependent on relative humidity and wind speed -- being extremely sensitive to the latter -- and the precision of the data suffers even under uniform conditions. Furthermore, EPA has requested that DEP use continuous SO_2 data in order to analyze SO_2 trends. Consequently, the SO_2 trend analysis now uses

only continuous SO_2 data. The data are restricted to the period 1977-1988 because earlier data are judged not to be adequate or reliable. The results are summarized in Figure 3-4 and Table 3-5. (For a discussion of the paired *t* test used in Table 3-5, see the discussion of Table 2-6 in the particulate matter section of this Air Quality Summary.)

In response to the skyrocketing prices of low sulfur fuels in the late 1970's, most states relaxed their sulfur-in-fuel requirements to the full extent the law allowed, creating considerable pressure on Connecticut to follow suit. This caused Connecticut to reevaluate its philosophy for controlling sulfur oxide emissions in 1981. To meet the challenge of increased costs of fuel in the economy, DEP restructured its air pollution control requirements for fuel burning sources. Under this new "three-pronged" program, Connecticut's businesses and industries are (1) now allowed (effective November 1981) to burn a less expensive grade of oil with a higher sulfur content -- one percent (1.0%) sulfur oil, and (2) allowed to burn higher sulfur content oil in exchange for reductions in energy use. The third aspect of the program is the repeal of the 24-hour secondary air quality standard for sulfur oxides.

This action increased statewide allowable sulfur oxide emissions by almost 60%. (Sulfur oxide emissions were not doubled by going from 0.5% to 1.0% sulfur-in-fuel since residential fuel users, which account for almost one-third of annual statewide sulfur oxide emissions, use distillate fuel oil with a sulfur content of less than 0.5%.) One would have expected measured SO_2 levels to increase in 1982 and subsequent years, as compared to 1981, due to the use of 1.0% sulfur oil. However, no significant trend was apparent in 1982; SO_2 levels actually declined in 1983; and since 1983, there has been no significant change in SO_2 levels (see Table 3-5). This may be attributable to year-to-year fluctuations in meteorology or decreased fuel use caused by increased fuel prices and/or increased fuel efficiency (i.e., 'tighter' buildings).

The long-term trend of SO_2 concentrations is shown in graphical form in Figure 3-4. An improvement in SO_2 levels is demonstrated by the decrease over time of concentrations in excess of 30 $\mu g/m^3$. Table 3-5 shows the year-to-year trend in ambient SO_2 levels. Decreases in SO_2 concentrations from 1979 to 1980 and from 1982 to 1983 are evident. However, no significant change in SO_2 levels is evident since 1983.

The results of continuous SO_2 monitoring indicate that sulfur dioxide levels in 1988 were not significantly different from those in 1987 (see Table 3-5). Temperature is an important factor in determining SO_2 emissions. This is normally reflected in the number of "degree days" - a measure of heating requirement (see Tables 9-1 and 9-2). There was a 7% increase in degrees days for heating from 1987 to 1988. There was also a 20% increase in degree days for cooling (not shown in Tables 9-1 and 9-2). These facts would normally lead to increased fuel use and a resulting increase in SO_2 emissions. This was not the case in 1988. Factors alluded to above, like meteorology and increased fuel efficiency, may explain the lower than expected SO_2 levels. However, further investigation is needed before any definite conclusions can be drawn.

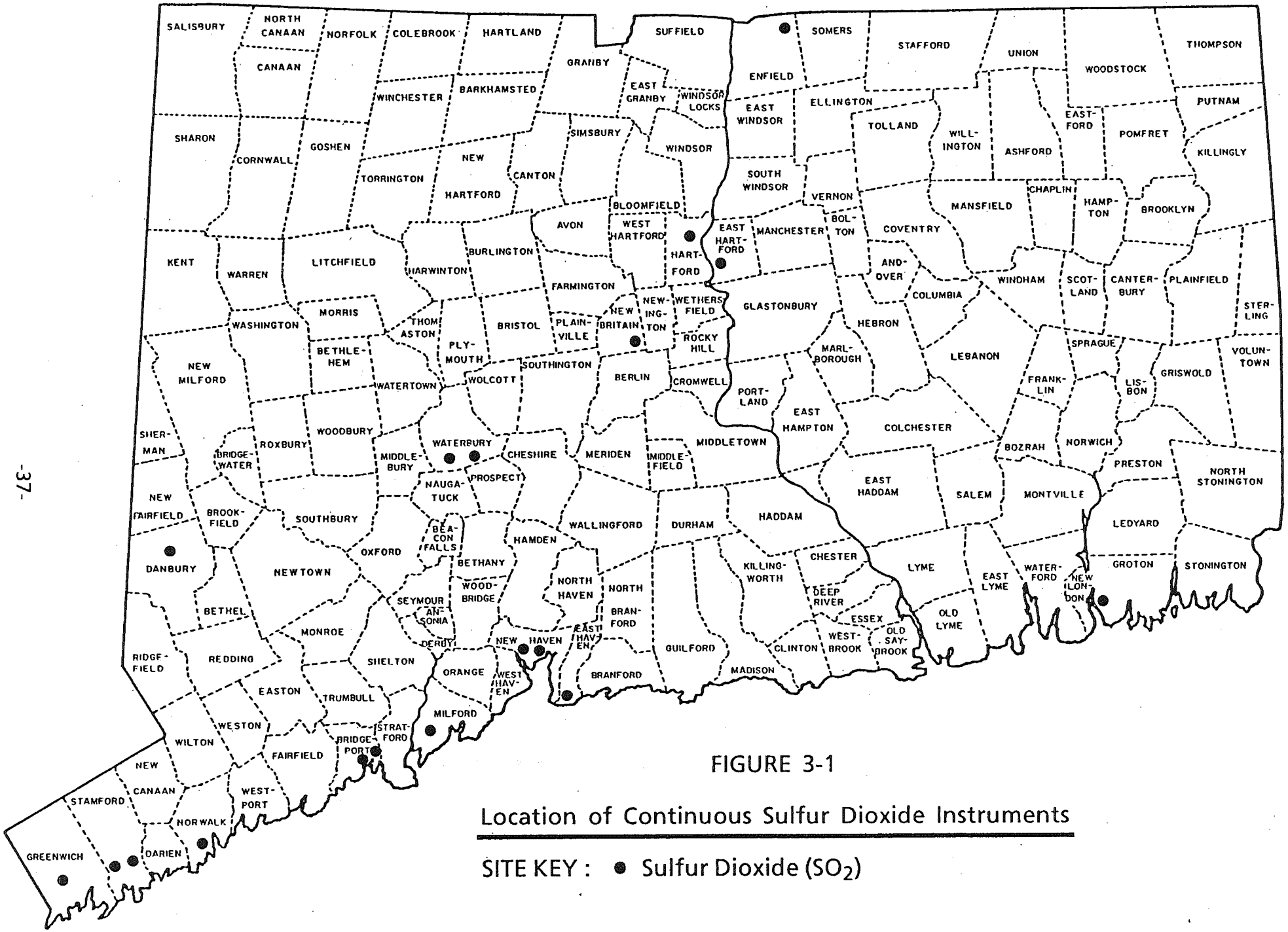


FIGURE 3-1

Location of Continuous Sulfur Dioxide Instruments

SITE KEY : ● Sulfur Dioxide (SO_2)

TABLE 3-1

1988 ANNUAL ARITHMETIC AVERAGES OF SULFUR DIOXIDE AT SITES WITH CONTINUOUS MONITORS

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

TOWN-SITE	SITE NAME	ANNUAL AVG ($\mu g/m^3$)
Bridgeport-012	Edison School	36
Bridgeport-013	Hallett Street	28
Danbury-123	Western CT State College	23
East Hartford-005	Fire House - Engine Co. #5	29*
East Haven-003	Animal Shelter	25
Enfield-005	Department of Corrections	19
Greenwich-017	Greenwich Point Park	16
Groton-007	Fire Headquarters	23
Hartford-123	State Office Building	27
Milford-010	Devon Community Center	27
New Britain-011	Armory	25
New Haven-017	Lombard St. Fire House	40
New Haven-123	State Street	44
Norwalk-013	Ludlow School	28*
Stamford-025	Recreation Center	27
Stamford-123	Health Department	25
Waterbury-008	Armory	27
Waterbury-123	Bank Street	26

* A valid annual average cannot be calculated because the number of observations does not satisfy the minimum sampling criteria.

TABLE 3-2

1986-1988 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

				LOGNORMAL DISTRIBUTION				
TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 365 UG/M3
BRIDGEPORT	012	1986	353	32.6	32.1	33.1	25.153	
BRIDGEPORT	012	1987	351	33.4	32.9	33.9	25.564	
BRIDGEPORT	012	1988	363	35.5	35.3	35.8	28.269	
BRIDGEPORT	013	1988	363	28.1	27.9	28.3	23.821	
BRIDGEPORT	123	1986	360	29.8	29.5	30.1	23.094	
BRIDGEPORT	123	1987	306	28.3	27.3	29.3	22.802	
DANBURY	123	1986	360	20.1	19.9	20.3	14.590	
DANBURY	123	1987	345	20.9	20.5	21.3	16.253	
DANBURY	123	1988	341	23.1	22.6	23.7	20.905	
EAST HARTFORD	005	1986	314	21.8	21.1	22.5	17.838	
EAST HARTFORD	005	1987	327	26.3	25.5	27.0	21.715	
EAST HARTFORD	005	1988	228*	26.7	25.4	28.0	16.599	
EAST HAVEN	003	1986	354	21.6	21.2	21.9	20.122	
EAST HAVEN	003	1987	346	25.1	24.6	25.6	20.861	
EAST HAVEN	003	1988	347	25.0	24.5	25.6	24.503	
ENFIELD	005	1986	335	15.9	15.5	16.3	13.614	
ENFIELD	005	1987	343	16.8	16.3	17.2	16.057	
ENFIELD	005	1988	344	18.9	18.5	19.4	16.213	
GREENWICH	017	1986	346	13.9	13.6	14.2	12.487	
GREENWICH	017	1987	346	12.2	11.9	12.4	10.825	
GREENWICH	017	1988	356	16.1	15.9	16.3	12.034	
GROTON	007	1986	343	21.5	21.2	21.9	13.408	
GROTON	007	1987	353	18.9	18.6	19.1	13.858	
GROTON	007	1988	357	22.7	22.4	22.9	16.958	

* SAMPLING NOT RANDOM OR OF INSUFFICIENT SIZE FOR REPRESENTATIVE ANNUAL STATISTICS.

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

TABLE 3-2, CONTINUED

1986-1988 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

				LOGNORMAL DISTRIBUTION				
TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 365 UG/M3
HARTFORD	123	1986	348	34.8	34.2	35.3	23.498	
HARTFORD	123	1987	341	26.0	25.4	26.6	21.972	
HARTFORD	123	1988	304	26.8	25.7	28.0	24.517	
MILFORD	010	1987	332	25.1	24.4	25.8	21.359	
MILFORD	010	1988	280	27.2	25.8	28.7	25.024	
NEW BRITAIN	011	1986	358	25.8	25.5	26.2	21.270	
NEW BRITAIN	011	1987	364	25.9	25.8	26.1	21.866	
NEW BRITAIN	011	1988	359	25.1	24.7	25.5	27.279	
NEW HAVEN	017	1986	352	35.5	34.9	36.1	30.593	
NEW HAVEN	017	1987	327	36.3	35.2	37.4	31.847	
NEW HAVEN	017	1988	303	40.3	38.7	42.0	35.247	1
NEW HAVEN	123	1986	351	39.2	38.5	40.0	35.466	
NEW HAVEN	123	1987	348	39.7	39.0	40.5	31.906	
NEW HAVEN	123	1988	362	43.9	43.5	44.3	37.280	
NORWALK	013	1986	348	23.3	22.8	23.8	21.868	
NORWALK	013	1987	344	23.1	22.5	23.7	23.071	
NORWALK	013	1988	81*	28.5	22.6	34.4	30.490	
STAMFORD	025	1986	347	29.3	28.8	29.9	23.547	
STAMFORD	025	1987	319	29.2	28.3	30.1	23.574	
STAMFORD	025	1988	338	27.6	26.8	28.3	25.278	
STAMFORD	123	1986	355	27.5	27.1	27.9	20.827	
STAMFORD	123	1987	357	29.4	29.0	29.7	23.767	
STAMFORD	123	1988	360	24.5	24.2	24.9	23.560	

* SAMPLING NOT RANDOM OR OF INSUFFICIENT SIZE FOR REPRESENTATIVE ANNUAL STATISTICS.

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

TABLE 3-2, CONTINUED

1986-1988 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

LOGNORMAL DISTRIBUTION

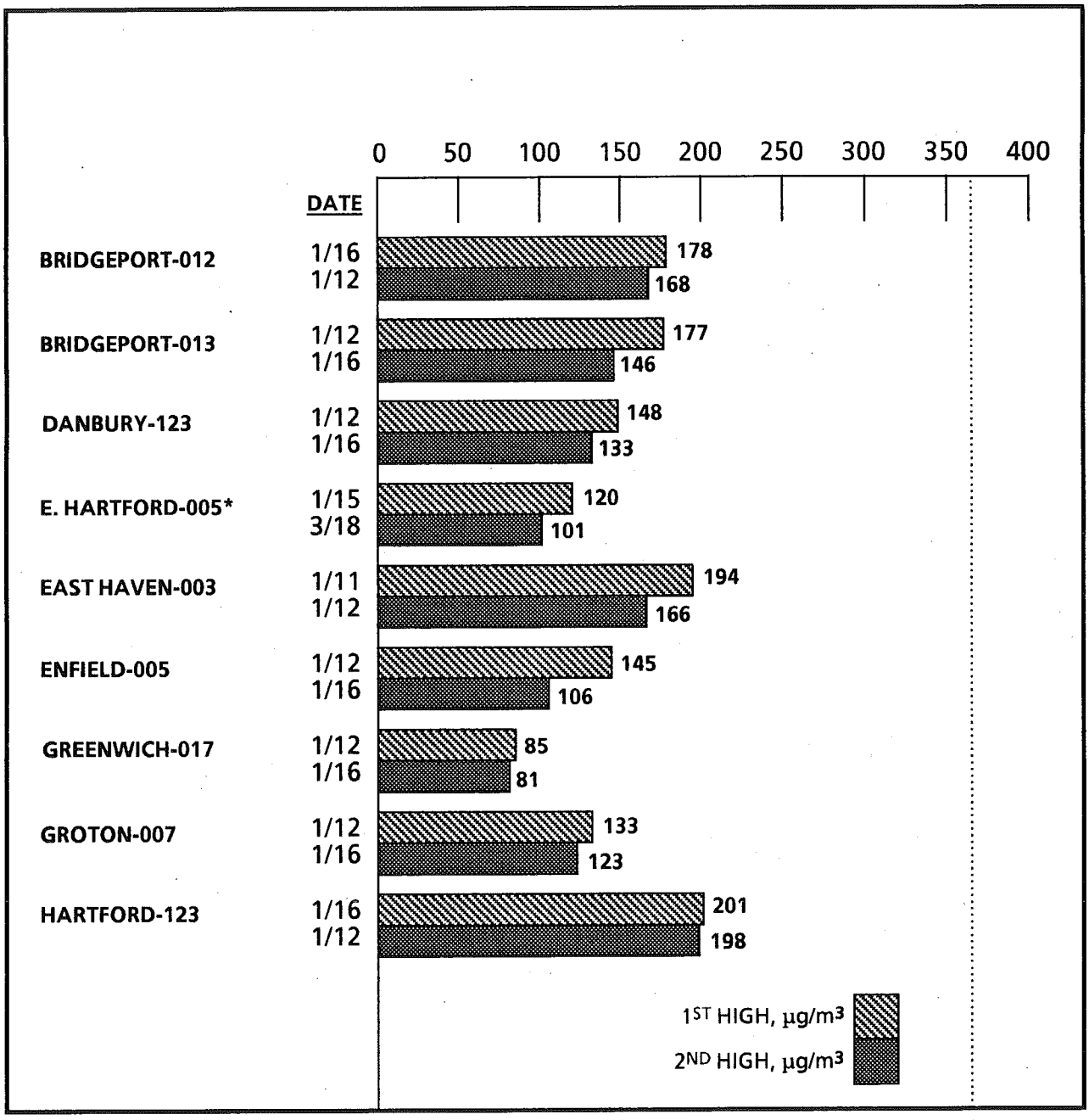
TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 365 UG/M3
WATERBURY	008	1986	125*	33.8	30.6	37.0	22.397	
WATERBURY	008	1987	343	30.6	30.0	31.3	23.874	
WATERBURY	008	1988	343	26.7	26.0	27.5	27.919	
WATERBURY	123	1986	359	22.0	21.8	22.3	18.366	
WATERBURY	123	1987	349	21.5	21.1	21.8	17.693	
WATERBURY	123	1988	351	26.2	25.7	26.6	22.552	

* SAMPLING NOT RANDOM OR OF INSUFFICIENT SIZE FOR REPRESENTATIVE ANNUAL STATISTICS.

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

FIGURE 3-2

1988 MAXIMUM CALENDAR DAY AVERAGE SO2 CONCENTRATIONS

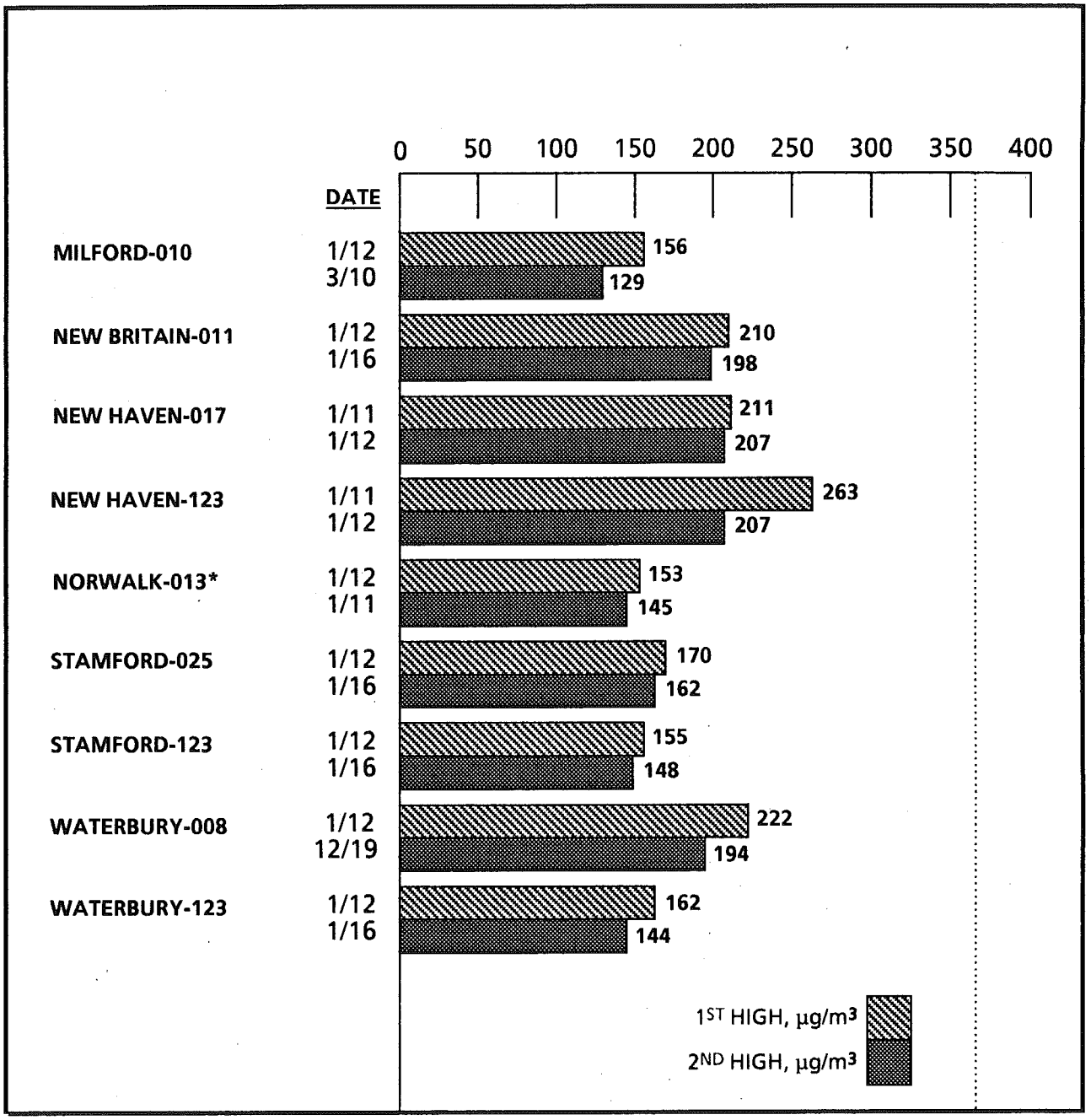


* The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date of occurrence is given first.

FIGURE 3-2, CONTINUED

1988 MAXIMUM CALENDAR DAY AVERAGE SO2 CONCENTRATIONS



* The site has insufficient data to satisfy the minimum sampling sriteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date of occurrence is given first.

TABLE 3-3

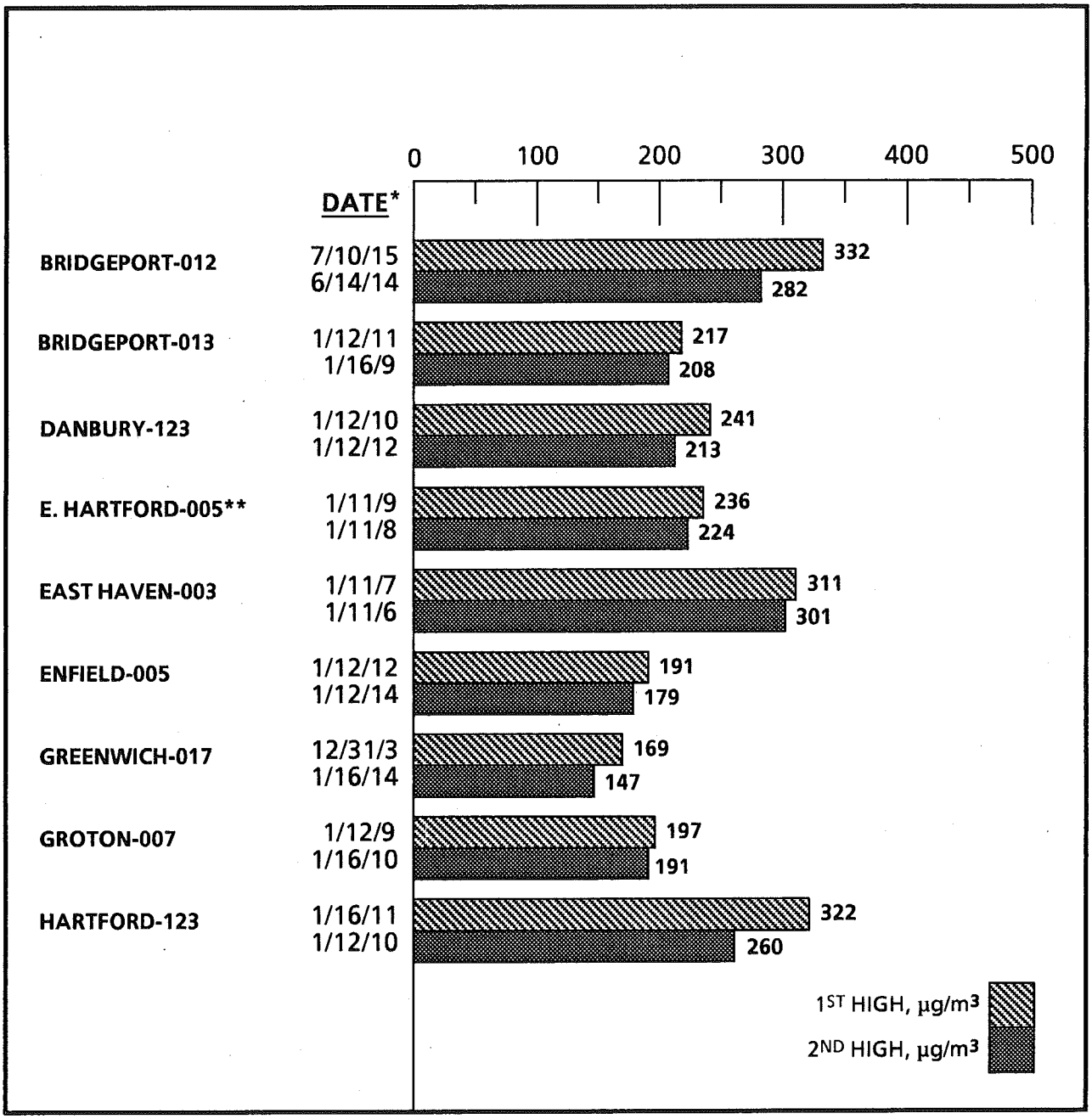
COMPARISONS OF FIRST AND SECOND HIGH CALENDAR DAY AND 24-HOUR RUNNING SO2 AVERAGES FOR 1988

SITE	FIRST HIGH AVERAGE		SECOND HIGH AVERAGE	
	RUNNING 24-HOUR	CALENDAR DAY	RUNNING 24-HOUR	CALENDAR DAY
Bridgeport-012	193	178	173	168
Bridgeport-013	181	177	163	146
Danbury-123	152	148	134	133
E. Hartford-005*	125	120	105	101
East Haven-003	200	194	184	166
Enfield-005	148	145	112	106
Greenwich-017	97	85	87	81
Groton-007	148	133	131	123
Hartford-123	213	201	203	198
Milford-010	159	156	143	129
New Britain-011	216	210	205	198
New Haven-017	217	211	208	207
New Haven-123	269	263	251	207
Norwalk-013*	172	153	146	145
Stamford-025	191	170	177	162
Stamford-123	170	155	157	148
Waterbury-008	246	222	201	194
Waterbury-123	162	162	151	144

* The site has insufficient data to satisfy the minimum sampling criteria.
N.B. The averages have units of $\mu g/m^3$.

FIGURE 3-3

1988 MAXIMUM 3-HOUR RUNNING AVERAGE SO2 CONCENTRATIONS



* The date is the month/day/ending hour of occurrence.

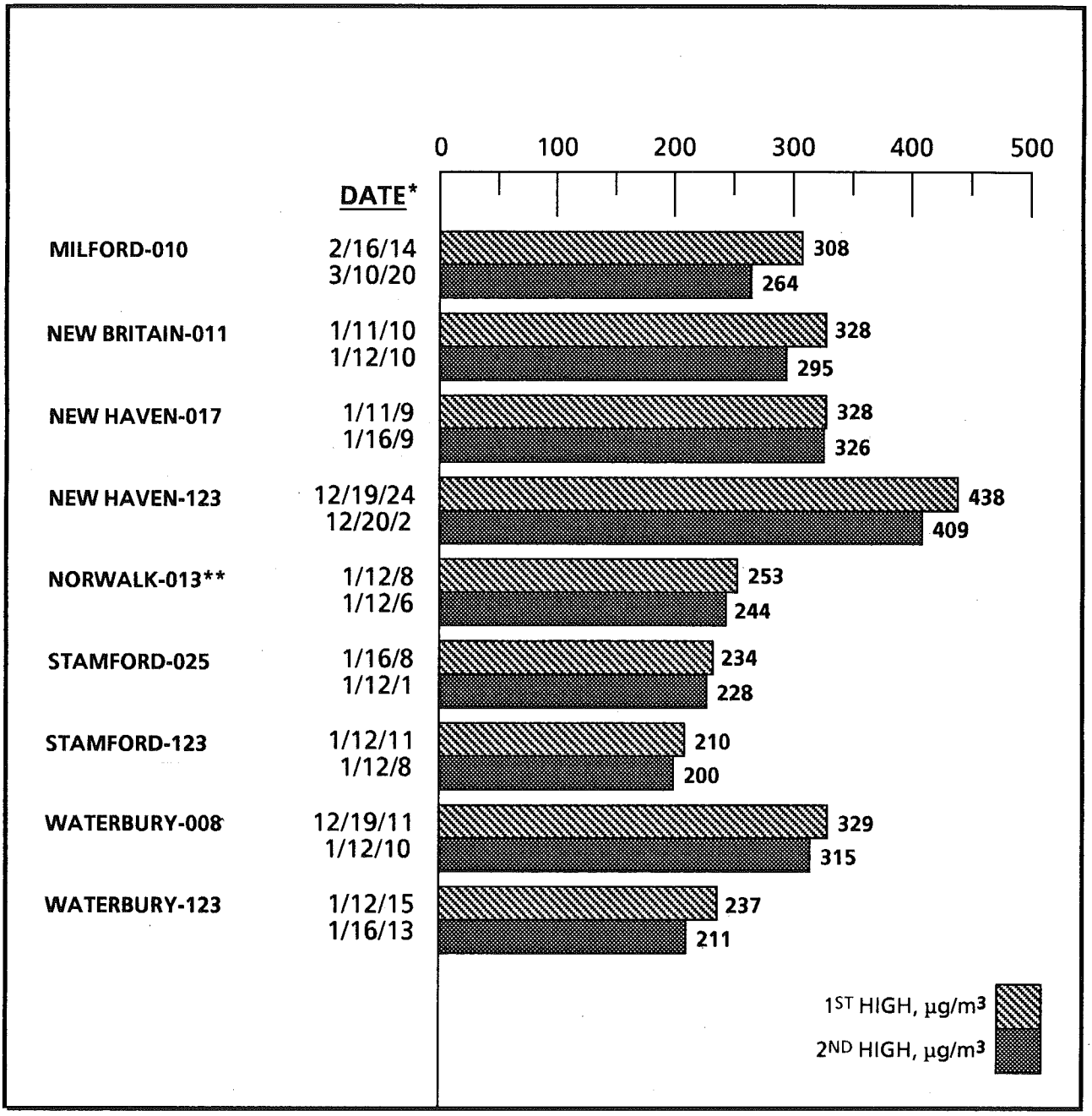
** The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date of occurrence is given first.

Secondary standard = 1300 µg/m^3.

FIGURE 3-3, CONTINUED

1988 MAXIMUM 3-HOUR RUNNING AVERAGE SO2 CONCENTRATIONS



* The date is the month/day/ending hour of occurrence.

** The site has insufficient data to satisfy the minimum sampling criteria.

N.B. When a listed concentration occurs more than once at a site, the earliest date of occurrence is given first.

Secondary standard = 1300 µg/m3.

TABLE 3-4

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
BRIDGEPORT-012 (0363)	SO2	178	168	143	137	136	134	134	117	116	107
	DATE	1/16/88	1/12/88	1/15/88	1/11/88	1/31/88	2/29/88	2/23/88	12/19/88	2/15/88	2/ 1/88
METEOROLOGICAL SITE	DIR (DEG)	200	170	240	220	220	240	230	200	210	230
NEWARK	VEL (MPH)	4.6	3.3	1.7	3.5	3.4	4.2	10.4	3.0	3.2	4.2
	SPD (MPH)	5.8	5.0	3.6	4.6	5.2	6.5	13.1	6.8	6.2	6.8
	RATIO	0.797	0.655	0.469	0.771	0.651	0.653	0.797	0.449	0.519	0.623
METEOROLOGICAL SITE	DIR (DEG)	170	180	160	170	180	210	220	220	180	190
BRADLEY	VEL (MPH)	3.0	2.2	3.1	2.2	8.1	5.0	3.5	2.8	4.8	8.2
	SPD (MPH)	4.9	4.9	5.0	4.7	11.1	6.6	8.8	5.2	7.6	11.6
	RATIO	0.617	0.452	0.617	0.467	0.729	0.751	0.397	0.535	0.631	0.707
METEOROLOGICAL SITE	DIR (DEG)	250	60	320	270	250	230	260	220	230	220
BRIDGEPORT	VEL (MPH)	5.0	1.8	2.2	4.0	6.3	6.4	9.1	2.3	7.8	6.4
	SPD (MPH)	6.9	2.0	3.6	7.3	6.3	6.5	10.8	3.2	8.5	6.8
	RATIO	0.727	0.892	0.615	0.541	0.990	0.996	0.844	0.726	0.915	0.943
METEOROLOGICAL SITE	DIR (DEG)	270	250	270	270	260	260	270	250	240	250
WORCESTER	VEL (MPH)	7.5	4.7	7.3	7.2	8.4	5.1	11.6	6.0	11.8	5.9
	SPD (MPH)	9.8	8.3	9.1	8.6	10.9	6.6	16.5	7.8	15.0	8.8
	RATIO	0.764	0.560	0.812	0.838	0.773	0.771	0.705	0.770	0.788	0.671
BRIDGEPORT-013 (0363)	SO2	177	146	143	117	113	107	102	99	94	89
	DATE	1/12/88	1/16/88	1/11/88	1/15/88	12/19/88	1/31/88	2/29/88	12/ 6/88	12/31/88	12/30/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	240	200	220	240	220	290	250
NEWARK	VEL (MPH)	3.3	4.6	3.5	1.7	3.0	3.4	4.2	7.6	6.7	5.3
	SPD (MPH)	5.0	5.8	4.6	3.6	6.8	5.2	6.5	8.8	9.5	8.6
	RATIO	0.655	0.797	0.771	0.469	0.449	0.651	0.653	0.863	0.708	0.613
METEOROLOGICAL SITE	DIR (DEG)	180	170	170	160	220	180	210	170	280	180
BRADLEY	VEL (MPH)	2.2	3.0	2.2	3.1	2.8	8.1	5.0	5.4	8.6	3.2
	SPD (MPH)	4.9	4.9	4.7	5.0	5.2	11.1	6.6	7.2	12.4	6.0
	RATIO	0.452	0.617	0.467	0.617	0.535	0.729	0.751	0.755	0.697	0.524
METEOROLOGICAL SITE	DIR (DEG)	60	250	270	320	220	250	230	250	280	150
BRIDGEPORT	VEL (MPH)	1.8	5.0	4.0	2.2	2.3	6.3	6.4	8.6	5.0	.9
	SPD (MPH)	2.0	6.9	7.3	3.6	3.2	6.3	6.5	9.5	5.2	2.6
	RATIO	0.892	0.727	0.541	0.615	0.726	0.990	0.996	0.911	0.958	0.361
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	270	250	260	260	240	300	270
WORCESTER	VEL (MPH)	4.7	7.5	7.2	7.3	6.0	8.4	5.1	8.4	10.0	4.8
	SPD (MPH)	8.3	9.8	8.6	9.1	7.8	10.9	6.6	9.5	12.1	5.8
	RATIO	0.560	0.764	0.838	0.812	0.770	0.773	0.771	0.885	0.828	0.835
DANBURY-123 (0341)	SO2	148	133	115	112	111	90	87	85	84	81
	DATE	1/12/88	1/16/88	1/15/88	1/11/88	12/20/88	12/19/88	12/ 6/88	1/17/88	1/29/88	1/28/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	240	220	200	200	220	170	180	260
NEWARK	VEL (MPH)	3.3	4.6	1.7	3.5	7.1	3.0	7.6	3.3	2.3	5.8
	SPD (MPH)	5.0	5.8	3.6	4.6	8.9	6.8	8.8	5.2	4.9	7.2
	RATIO	0.655	0.797	0.469	0.771	0.794	0.449	0.863	0.646	0.468	0.808
METEOROLOGICAL SITE	DIR (DEG)	180	170	160	170	190	220	170	180	180	280
BRADLEY	VEL (MPH)	2.2	3.0	3.1	2.2	6.9	2.8	5.4	7.2	3.0	2.6
	SPD (MPH)	4.9	4.9	5.0	4.7	8.8	5.2	7.2	9.5	5.2	4.9
	RATIO	0.452	0.617	0.617	0.467	0.789	0.535	0.755	0.759	0.572	0.525

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	60	250	320	270	240	220	250	230	240	280
BRIDGEPORT	VEL (MPH)	1.8	5.0	2.2	4.0	4.9	2.3	8.6	7.3	4.1	6.5
	SPD (MPH)	2.0	6.9	3.6	7.3	4.9	3.2	9.5	7.6	6.8	8.2
	RATIO	0.892	0.727	0.615	0.541	0.994	0.726	0.911	0.954	0.609	0.788
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	270	250	250	240	260	300	280
WORCESTER	VEL (MPH)	4.7	7.5	7.3	7.2	12.2	6.0	8.4	13.0	3.0	6.7
	SPD (MPH)	8.3	9.8	9.1	8.6	15.5	7.8	9.5	16.8	5.5	7.8
	RATIO	0.560	0.764	0.812	0.838	0.788	0.770	0.885	0.775	0.552	0.863
EAST HAVEN-003 (0347)	SO2	194	166	143	123	114	102	99	95	94	92
	DATE	1/11/88	1/12/88	1/15/88	1/16/88	1/10/88	1/ 3/88	1/23/88	11/26/88	12/13/88	12/30/88
METEOROLOGICAL SITE	DIR (DEG)	220	170	240	200	340	30	290	180	360	250
NEWARK	VEL (MPH)	3.5	3.3	1.7	4.6	6.3	4.0	3.1	3.4	7.2	5.3
	SPD (MPH)	4.6	5.0	3.6	5.8	6.8	4.2	4.2	4.9	7.6	8.6
	RATIO	0.771	0.655	0.469	0.797	0.937	0.955	0.738	0.689	0.948	0.613
METEOROLOGICAL SITE	DIR (DEG)	170	180	160	170	320	360	250	70	360	180
BRADLEY	VEL (MPH)	2.2	2.2	3.1	3.0	5.1	2.7	2.6	1.1	7.0	3.2
	SPD (MPH)	4.7	4.9	5.0	4.9	5.6	2.9	3.9	2.6	7.0	6.0
	RATIO	0.467	0.452	0.617	0.617	0.916	0.941	0.674	0.433	0.995	0.524
METEOROLOGICAL SITE	DIR (DEG)	270	60	320	250	360	60	260	240	20	150
BRIDGEPORT	VEL (MPH)	4.0	1.8	2.2	5.0	6.7	5.6	6.2	2.1	8.1	.9
	SPD (MPH)	7.3	2.0	3.6	6.9	7.0	6.0	7.9	3.0	8.5	2.6
	RATIO	0.541	0.892	0.615	0.727	0.950	0.936	0.788	0.695	0.958	0.361
METEOROLOGICAL SITE	DIR (DEG)	270	250	270	270	330	160	280	280	70	270
WORCESTER	VEL (MPH)	7.2	4.7	7.3	7.5	6.3	.6	4.6	6.0	4.6	4.8
	SPD (MPH)	8.6	8.3	9.1	9.8	6.8	3.6	5.0	6.8	5.6	5.8
	RATIO	0.838	0.560	0.812	0.764	0.929	0.172	0.906	0.886	0.826	0.835
ENFIELD-005 (0344)	SO2	145	106	82	78	77	73	59	58	58	57
	DATE	1/12/88	1/16/88	1/17/88	1/11/88	1/15/88	12/19/88	12/ 6/88	1/31/88	12/13/88	12/ 7/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	170	220	240	200	220	220	360	260
NEWARK	VEL (MPH)	3.3	4.6	3.3	3.5	1.7	3.0	7.6	3.4	7.2	8.8
	SPD (MPH)	5.0	5.8	5.2	4.6	3.6	6.8	8.8	5.2	7.6	11.1
	RATIO	0.655	0.797	0.646	0.771	0.469	0.449	0.863	0.651	0.948	0.797
METEOROLOGICAL SITE	DIR (DEG)	180	170	180	170	160	220	170	180	360	280
BRADLEY	VEL (MPH)	2.2	3.0	7.2	2.2	3.1	2.8	5.4	8.1	7.0	3.4
	SPD (MPH)	4.9	4.9	9.5	4.7	5.0	5.2	7.2	11.1	7.0	6.9
	RATIO	0.452	0.617	0.759	0.467	0.617	0.535	0.755	0.729	0.995	0.490
METEOROLOGICAL SITE	DIR (DEG)	60	250	230	270	320	220	250	250	20	280
BRIDGEPORT	VEL (MPH)	1.8	5.0	7.3	4.0	2.2	2.3	8.6	6.3	8.1	6.4
	SPD (MPH)	2.0	6.9	7.6	7.3	3.6	3.2	9.5	6.3	8.5	7.0
	RATIO	0.892	0.727	0.954	0.541	0.615	0.726	0.911	0.990	0.958	0.908
METEOROLOGICAL SITE	DIR (DEG)	250	270	260	270	270	250	240	260	70	290
WORCESTER	VEL (MPH)	4.7	7.5	13.0	7.2	7.3	6.0	8.4	8.4	4.6	7.7
	SPD (MPH)	8.3	9.8	16.8	8.6	9.1	7.8	9.5	10.9	5.6	10.4
	RATIO	0.560	0.764	0.775	0.838	0.812	0.770	0.885	0.773	0.826	0.746

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
GREENWICH-017 (0356)	SO2	85	81	67	64	56	55	52	50	48	47
	DATE	1/12/88	1/16/88	12/31/88	1/11/88	12/ 7/88	12/19/88	12/ 6/88	1/31/88	12/30/88	10/15/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	290	220	260	200	220	220	250	220
NEWARK	VEL (MPH)	3.3	4.6	6.7	3.5	8.8	3.0	7.6	3.4	5.3	6.3
	SPD (MPH)	5.0	5.8	9.5	4.6	11.1	6.8	8.8	5.2	8.6	8.2
	RATIO	0.655	0.797	0.708	0.771	0.797	0.449	0.863	0.651	0.613	0.769
METEOROLOGICAL SITE	DIR (DEG)	180	170	280	170	280	220	170	180	180	110
BRADLEY	VEL (MPH)	2.2	3.0	8.6	2.2	3.4	2.8	5.4	8.1	3.2	1.8
	SPD (MPH)	4.9	4.9	12.4	4.7	6.9	5.2	7.2	11.1	6.0	3.2
	RATIO	0.452	0.617	0.697	0.467	0.490	0.535	0.755	0.729	0.524	0.585
METEOROLOGICAL SITE	DIR (DEG)	60	250	280	270	280	220	250	250	150	240
BRIDGEPORT	VEL (MPH)	1.8	5.0	5.0	4.0	6.4	2.3	8.6	6.3	.9	4.9
	SPD (MPH)	2.0	6.9	5.2	7.3	7.0	3.2	9.5	6.3	2.6	5.5
	RATIO	0.892	0.727	0.958	0.541	0.908	0.726	0.911	0.990	0.361	0.892
METEOROLOGICAL SITE	DIR (DEG)	250	270	300	270	290	250	240	260	270	290
WORCESTER	VEL (MPH)	4.7	7.5	10.0	7.2	7.7	6.0	8.4	8.4	4.8	3.4
	SPD (MPH)	8.3	9.8	12.1	8.6	10.4	7.8	9.5	10.9	5.8	5.2
	RATIO	0.560	0.764	0.828	0.838	0.746	0.770	0.885	0.773	0.835	0.662
GROTON-007 (0357)	SO2	133	123	108	96	71	66	63	62	61	60
	DATE*	1/12/88	1/16/88	1/11/88	1/15/88	12/31/88	10/15/88	12/19/88	11/23/88	12/ 7/88	11/26/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	240	290	220	200	330	260	180
NEWARK	VEL (MPH)	3.3	4.6	3.5	1.7	6.7	6.3	3.0	3.2	8.8	3.4
	SPD (MPH)	5.0	5.8	4.6	3.6	9.5	8.2	6.8	6.8	11.1	4.9
	RATIO	0.655	0.797	0.771	0.469	0.708	0.769	0.449	0.470	0.797	0.689
METEOROLOGICAL SITE	DIR (DEG)	180	170	170	160	280	110	220	330	280	70
BRADLEY	VEL (MPH)	2.2	3.0	2.2	3.1	8.6	1.8	2.8	3.5	3.4	1.1
	SPD (MPH)	4.9	4.9	4.7	5.0	12.4	3.2	5.2	5.2	6.9	2.6
	RATIO	0.452	0.617	0.467	0.617	0.697	0.585	0.535	0.670	0.490	0.433
METEOROLOGICAL SITE	DIR (DEG)	60	250	270	320	280	240	220	340	280	240
BRIDGEPORT	VEL (MPH)	1.8	5.0	4.0	2.2	5.0	4.9	2.3	8.7	6.4	2.1
	SPD (MPH)	2.0	6.9	7.3	3.6	5.2	5.5	3.2	9.3	7.0	3.0
	RATIO	0.892	0.727	0.541	0.615	0.958	0.892	0.726	0.926	0.908	0.695
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	270	300	290	250	310	290	280
WORCESTER	VEL (MPH)	4.7	7.5	7.2	7.3	10.0	3.4	6.0	7.2	7.7	6.0
	SPD (MPH)	8.3	9.8	8.6	9.1	12.1	5.2	7.8	8.8	10.4	6.8
	RATIO	0.560	0.764	0.838	0.812	0.828	0.662	0.770	0.822	0.746	0.886
HARTFORD-123 (0304)	SO2	201	198	123	112	92	92	89	88	85	82
	DATE	1/16/88	1/12/88	1/17/88	1/ 3/88	2/29/88	1/31/88	1/29/88	1/10/88	1/24/88	1/28/88
METEOROLOGICAL SITE	DIR (DEG)	200	170	170	30	240	220	180	340	160	260
NEWARK	VEL (MPH)	4.6	3.3	3.3	4.0	4.2	3.4	2.3	6.3	4.6	5.8
	SPD (MPH)	5.8	5.0	5.2	4.2	6.5	5.2	4.9	6.8	5.9	7.2
	RATIO	0.797	0.655	0.646	0.955	0.653	0.651	0.468	0.937	0.774	0.808
METEOROLOGICAL SITE	DIR (DEG)	170	180	180	360	210	180	180	320	180	280
BRADLEY	VEL (MPH)	3.0	2.2	7.2	2.7	5.0	8.1	3.0	5.1	5.4	2.6
	SPD (MPH)	4.9	4.9	9.5	2.9	6.6	11.1	5.2	5.6	7.5	4.9
	RATIO	0.617	0.452	0.759	0.941	0.751	0.729	0.572	0.916	0.716	0.525

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	250	60	230	60	230	250	240	360	190	280
BRIDGEPORT	VEL (MPH)	5.0	1.8	7.3	5.6	6.4	6.3	4.1	6.7	6.5	6.5
	SPD (MPH)	6.9	2.0	7.6	6.0	6.5	6.3	6.8	7.0	9.3	8.2
	RATIO	0.727	0.892	0.954	0.936	0.996	0.990	0.609	0.950	0.700	0.788
METEOROLOGICAL SITE	DIR (DEG)	270	250	260	160	260	260	300	330	230	280
WORCESTER	VEL (MPH)	7.5	4.7	13.0	.6	5.1	8.4	3.0	6.3	6.3	6.7
	SPD (MPH)	9.8	8.3	16.8	3.6	6.6	10.9	5.5	6.8	8.5	7.8
	RATIO	0.764	0.560	0.775	0.172	0.771	0.773	0.552	0.929	0.747	0.863
MILFORD-010 (0280)	SO2	156	129	126	120	116	107	101	90	86	83
	DATE	1/12/88	3/10/88	1/14/88	1/16/88	1/11/88	2/16/88	1/15/88	12/ 7/88	12/ 6/88	3/22/88
METEOROLOGICAL SITE	DIR (DEG)	170	340	330	200	220	330	240	260	220	340
NEWARK	VEL (MPH)	3.3	15.5	14.5	4.6	3.5	11.3	1.7	8.8	7.6	9.0
	SPD (MPH)	5.0	16.1	15.7	5.8	4.6	11.9	3.6	11.1	8.8	10.4
	RATIO	0.655	0.965	0.926	0.797	0.771	0.946	0.469	0.797	0.863	0.870
METEOROLOGICAL SITE	DIR (DEG)	180	330	330	170	170	320	160	280	170	340
BRADLEY	VEL (MPH)	2.2	13.5	11.6	3.0	2.2	10.4	3.1	3.4	5.4	9.0
	SPD (MPH)	4.9	14.2	13.1	4.9	4.7	10.8	5.0	6.9	7.2	9.9
	RATIO	0.452	0.951	0.890	0.617	0.467	0.964	0.617	0.490	0.755	0.909
METEOROLOGICAL SITE	DIR (DEG)	60	350	350	250	270	350	320	280	250	340
BRIDGEPORT	VEL (MPH)	1.8	15.3	11.3	5.0	4.0	11.9	2.2	6.4	8.6	10.2
	SPD (MPH)	2.0	15.5	11.4	6.9	7.3	12.1	3.6	7.0	9.5	10.5
	RATIO	0.892	0.985	0.997	0.727	0.541	0.984	0.615	0.908	0.911	0.972
METEOROLOGICAL SITE	DIR (DEG)	250	340	330	270	270	330	270	290	240	320
WORCESTER	VEL (MPH)	4.7	14.4	10.7	7.5	7.2	9.6	7.3	7.7	8.4	11.5
	SPD (MPH)	8.3	15.2	11.4	9.8	8.6	10.1	9.1	10.4	9.5	12.5
	RATIO	0.560	0.946	0.941	0.764	0.838	0.954	0.812	0.746	0.885	0.921
NEW BRITAIN-011 (0359)	SO2	210	198	190	159	119	117	116	113	103	92
	DATE	1/12/88	1/16/88	1/11/88	1/15/88	12/ 6/88	1/31/88	1/17/88	1/ 3/88	11/26/88	2/29/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	240	220	220	170	30	180	240
NEWARK	VEL (MPH)	3.3	4.6	3.5	1.7	7.6	3.4	3.3	4.0	3.4	4.2
	SPD (MPH)	5.0	5.8	4.6	3.6	8.8	5.2	5.2	4.2	4.9	6.5
	RATIO	0.655	0.797	0.771	0.469	0.863	0.651	0.646	0.955	0.689	0.653
METEOROLOGICAL SITE	DIR (DEG)	180	170	170	160	170	180	180	360	70	210
BRADLEY	VEL (MPH)	2.2	3.0	2.2	3.1	5.4	8.1	7.2	2.7	1.1	5.0
	SPD (MPH)	4.9	4.9	4.7	5.0	7.2	11.1	9.5	2.9	2.6	6.6
	RATIO	0.452	0.617	0.467	0.617	0.755	0.729	0.759	0.941	0.433	0.751
METEOROLOGICAL SITE	DIR (DEG)	60	250	270	320	250	250	230	60	240	230
BRIDGEPORT	VEL (MPH)	1.8	5.0	4.0	2.2	8.6	6.3	7.3	5.6	2.1	6.4
	SPD (MPH)	2.0	6.9	7.3	3.6	9.5	6.3	7.6	6.0	3.0	6.5
	RATIO	0.892	0.727	0.541	0.615	0.911	0.990	0.954	0.936	0.695	0.996
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	270	240	260	260	160	280	260
WORCESTER	VEL (MPH)	4.7	7.5	7.2	7.3	8.4	8.4	13.0	.6	6.0	5.1
	SPD (MPH)	8.3	9.8	8.6	9.1	9.5	10.9	16.8	3.6	6.8	6.6
	RATIO	0.560	0.764	0.838	0.812	0.885	0.773	0.775	0.172	0.886	0.771

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
NEW HAVEN-017 (0303)	SO2	211	207	178	178	166	165	144	127	115	114
	DATE	1/11/88	1/12/88	1/15/88	1/16/88	12/ 6/88	12/19/88	11/26/88	3/ 2/88	1/23/88	12/ 7/88
METEOROLOGICAL SITE	DIR (DEG)	220	170	240	200	220	200	180	220	290	260
NEWARK	VEL (MPH)	3.5	3.3	1.7	4.6	7.6	3.0	3.4	6.5	3.1	8.8
	SPD (MPH)	4.6	5.0	3.6	5.8	8.8	6.8	4.9	8.6	4.2	11.1
	RATIO	0.771	0.655	0.469	0.797	0.863	0.449	0.689	0.758	0.738	0.797
METEOROLOGICAL SITE	DIR (DEG)	170	180	160	170	170	220	70	180	250	280
BRADLEY	VEL (MPH)	2.2	2.2	3.1	3.0	5.4	2.8	1.1	6.0	2.6	3.4
	SPD (MPH)	4.7	4.9	5.0	4.9	7.2	5.2	2.6	8.2	3.9	6.9
	RATIO	0.467	0.452	0.617	0.617	0.755	0.535	0.433	0.734	0.674	0.490
METEOROLOGICAL SITE	DIR (DEG)	270	60	320	250	250	220	240	240	260	280
BRIDGEPORT	VEL (MPH)	4.0	1.8	2.2	5.0	8.6	2.3	2.1	4.9	6.2	6.4
	SPD (MPH)	7.3	2.0	3.6	6.9	9.5	3.2	3.0	8.1	7.9	7.0
	RATIO	0.541	0.892	0.615	0.727	0.911	0.726	0.695	0.604	0.788	0.908
METEOROLOGICAL SITE	DIR (DEG)	270	250	270	270	240	250	280	260	280	290
WORCESTER	VEL (MPH)	7.2	4.7	7.3	7.5	8.4	6.0	6.0	8.9	4.6	7.7
	SPD (MPH)	8.6	8.3	9.1	9.8	9.5	7.8	6.8	10.6	5.0	10.4
	RATIO	0.838	0.560	0.812	0.764	0.885	0.770	0.886	0.832	0.906	0.746
NEW HAVEN-123 (0362)	SO2	263	207	206	194	185	183	167	156	147	137
	DATE	1/11/88	1/12/88	11/26/88	1/15/88	12/19/88	12/ 6/88	1/16/88	12/20/88	1/10/88	1/ 3/88
METEOROLOGICAL SITE	DIR (DEG)	220	170	180	240	200	220	200	200	340	30
NEWARK	VEL (MPH)	3.5	3.3	3.4	1.7	3.0	7.6	4.6	7.1	6.3	4.0
	SPD (MPH)	4.6	5.0	4.9	3.6	6.8	8.8	5.8	8.9	6.8	4.2
	RATIO	0.771	0.655	0.689	0.469	0.449	0.863	0.797	0.794	0.937	0.955
METEOROLOGICAL SITE	DIR (DEG)	170	180	70	160	220	170	170	190	320	360
BRADLEY	VEL (MPH)	2.2	2.2	1.1	3.1	2.8	5.4	3.0	6.9	5.1	2.7
	SPD (MPH)	4.7	4.9	2.6	5.0	5.2	7.2	4.9	8.8	5.6	2.9
	RATIO	0.467	0.452	0.433	0.617	0.535	0.755	0.617	0.789	0.916	0.941
METEOROLOGICAL SITE	DIR (DEG)	270	60	240	320	220	250	250	240	360	60
BRIDGEPORT	VEL (MPH)	4.0	1.8	2.1	2.2	2.3	8.6	5.0	4.9	6.7	5.6
	SPD (MPH)	7.3	2.0	3.0	3.6	3.2	9.5	6.9	4.9	7.0	6.0
	RATIO	0.541	0.892	0.695	0.615	0.726	0.911	0.727	0.994	0.950	0.936
METEOROLOGICAL SITE	DIR (DEG)	270	250	280	270	250	240	270	250	330	160
WORCESTER	VEL (MPH)	7.2	4.7	6.0	7.3	6.0	8.4	7.5	12.2	6.3	.6
	SPD (MPH)	8.6	8.3	6.8	9.1	7.8	9.5	9.8	15.5	6.8	3.6
	RATIO	0.838	0.560	0.886	0.812	0.770	0.885	0.764	0.788	0.929	0.172
STAMFORD-025 (0338)	SO2	170	162	149	122	110	108	103	102	101	99
	DATE	1/12/88	1/16/88	1/11/88	1/31/88	1/15/88	1/17/88	12/19/88	12/ 7/88	12/31/88	2/29/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	220	240	170	200	260	290	240
NEWARK	VEL (MPH)	3.3	4.6	3.5	3.4	1.7	3.3	3.0	8.8	6.7	4.2
	SPD (MPH)	5.0	5.8	4.6	5.2	3.6	5.2	6.8	11.1	9.5	6.5
	RATIO	0.655	0.797	0.771	0.651	0.469	0.646	0.449	0.797	0.708	0.653
METEOROLOGICAL SITE	DIR (DEG)	180	170	170	180	160	180	220	280	280	210
BRADLEY	VEL (MPH)	2.2	3.0	2.2	8.1	3.1	7.2	2.8	3.4	8.6	5.0
	SPD (MPH)	4.9	4.9	4.7	11.1	5.0	9.5	5.2	6.9	12.4	6.6
	RATIO	0.452	0.617	0.467	0.729	0.617	0.759	0.535	0.490	0.697	0.751

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	60	250	270	250	320	230	220	280	280	230
BRIDGEPORT	VEL (MPH)	1.8	5.0	4.0	6.3	2.2	7.3	2.3	6.4	5.0	6.4
	SPD (MPH)	2.0	6.9	7.3	6.3	3.6	7.6	3.2	7.0	5.2	6.5
	RATIO	0.892	0.727	0.541	0.990	0.615	0.954	0.726	0.908	0.958	0.996
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	260	270	260	250	290	300	260
WORCESTER	VEL (MPH)	4.7	7.5	7.2	8.4	7.3	13.0	6.0	7.7	10.0	5.1
	SPD (MPH)	8.3	9.8	8.6	10.9	9.1	16.8	7.8	10.4	12.1	6.6
	RATIO	0.560	0.764	0.838	0.773	0.812	0.775	0.770	0.746	0.828	0.771
STAMFORD-123 (0360)	SO2	155	148	132	109	108	101	98	94	94	91
	DATE	1/12/88	1/16/88	1/11/88	1/31/88	1/17/88	1/15/88	2/29/88	12/19/88	1/ 3/88	12/31/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	220	170	240	240	200	30	290
NEWARK	VEL (MPH)	3.3	4.6	3.5	3.4	3.3	1.7	4.2	3.0	4.0	6.7
	SPD (MPH)	5.0	5.8	4.6	5.2	5.2	3.6	6.5	6.8	4.2	9.5
	RATIO	0.655	0.797	0.771	0.651	0.646	0.469	0.653	0.449	0.955	0.708
METEOROLOGICAL SITE	DIR (DEG)	180	170	170	180	180	160	210	220	360	280
BRADLEY	VEL (MPH)	2.2	3.0	2.2	8.1	7.2	3.1	5.0	2.8	2.7	8.6
	SPD (MPH)	4.9	4.9	4.7	11.1	9.5	5.0	6.6	5.2	2.9	12.4
	RATIO	0.452	0.617	0.467	0.729	0.759	0.617	0.751	0.535	0.941	0.697
METEOROLOGICAL SITE	DIR (DEG)	60	250	270	250	230	320	230	220	60	280
BRIDGEPORT	VEL (MPH)	1.8	5.0	4.0	6.3	7.3	2.2	6.4	2.3	5.6	5.0
	SPD (MPH)	2.0	6.9	7.3	6.3	7.6	3.6	6.5	3.2	6.0	5.2
	RATIO	0.892	0.727	0.541	0.990	0.954	0.615	0.996	0.726	0.936	0.958
METEOROLOGICAL SITE	DIR (DEG)	250	270	270	260	260	270	260	250	160	300
WORCESTER	VEL (MPH)	4.7	7.5	7.2	8.4	13.0	7.3	5.1	6.0	.6	10.0
	SPD (MPH)	8.3	9.8	8.6	10.9	16.8	9.1	6.6	7.8	3.6	12.1
	RATIO	0.560	0.764	0.838	0.773	0.775	0.812	0.771	0.770	0.172	0.828
WATERBURY-008 (0343)	SO2	222	194	142	131	124	114	113	109	102	99
	DATE	1/12/88	12/19/88	12/ 6/88	12/20/88	12/18/88	12/ 7/88	11/26/88	12/10/88	12/30/88	1/28/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	220	200	270	260	180	260	250	260
NEWARK	VEL (MPH)	3.3	3.0	7.6	7.1	8.2	8.8	3.4	8.2	5.3	5.8
	SPD (MPH)	5.0	6.8	8.8	8.9	10.2	11.1	4.9	9.6	8.6	7.2
	RATIO	0.655	0.449	0.863	0.794	0.804	0.797	0.689	0.847	0.613	0.808
METEOROLOGICAL SITE	DIR (DEG)	180	220	170	190	240	280	70	250	180	280
BRADLEY	VEL (MPH)	2.2	2.8	5.4	6.9	3.6	3.4	1.1	3.5	3.2	2.6
	SPD (MPH)	4.9	5.2	7.2	8.8	5.5	6.9	2.6	8.5	6.0	4.9
	RATIO	0.452	0.535	0.755	0.789	0.652	0.490	0.433	0.415	0.524	0.525
METEOROLOGICAL SITE	DIR (DEG)	60	220	250	240	300	280	240	290	150	280
BRIDGEPORT	VEL (MPH)	1.8	2.3	8.6	4.9	5.1	6.4	2.1	6.7	.9	6.5
	SPD (MPH)	2.0	3.2	9.5	4.9	5.3	7.0	3.0	6.9	2.6	8.2
	RATIO	0.892	0.726	0.911	0.994	0.964	0.908	0.695	0.978	0.361	0.788
METEOROLOGICAL SITE	DIR (DEG)	250	250	240	250	290	290	280	300	270	280
WORCESTER	VEL (MPH)	4.7	6.0	8.4	12.2	7.7	7.7	6.0	4.5	4.8	6.7
	SPD (MPH)	8.3	7.8	9.5	15.5	8.3	10.4	6.8	6.2	5.8	7.8
	RATIO	0.560	0.770	0.885	0.788	0.921	0.746	0.886	0.732	0.835	0.863

TABLE 3-4, CONTINUED

1988 TEN HIGHEST 24-HOUR AVERAGE SO2 DAYS WITH WIND DATA

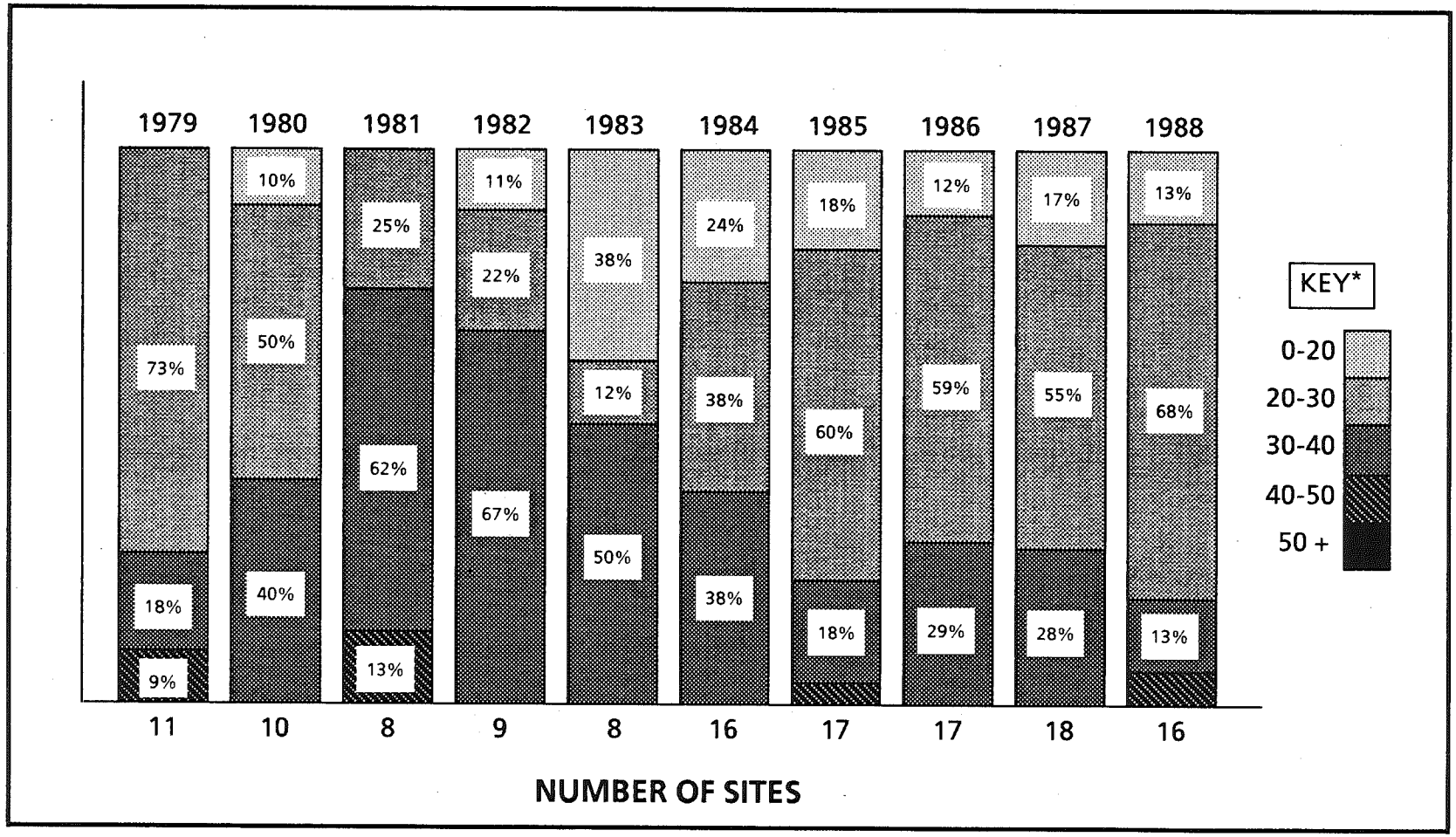
UNITS : MICROGRAMS PER CUBIC METER

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
WATERBURY-123 (0351)	SO2	162	144	123	122	113	106	98	98	97	88
	DATE	1/12/88	1/16/88	12/19/88	12/20/88	1/15/88	12/ 7/88	1/17/88	1/31/88	12/21/88	1/11/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	200	200	240	260	170	220	260	220
NEWARK	VEL (MPH)	3.3	4.6	3.0	7.1	1.7	8.8	3.3	3.4	4.2	3.5
	SPD (MPH)	5.0	5.8	6.8	8.9	3.6	11.1	5.2	5.2	10.6	4.6
	RATIO	0.655	0.797	0.449	0.794	0.469	0.797	0.646	0.651	0.397	0.771
METEOROLOGICAL SITE	DIR (DEG)	180	170	220	190	160	280	180	180	270	170
BRADLEY	VEL (MPH)	2.2	3.0	2.8	6.9	3.1	3.4	7.2	8.1	2.4	2.2
	SPD (MPH)	4.9	4.9	5.2	8.8	5.0	6.9	9.5	11.1	8.2	4.7
	RATIO	0.452	0.617	0.535	0.789	0.617	0.490	0.759	0.729	0.298	0.467
METEOROLOGICAL SITE	DIR (DEG)	60	250	220	240	320	280	230	250	270	270
BRIDGEPORT	VEL (MPH)	1.8	5.0	2.3	4.9	2.2	6.4	7.3	6.3	3.7	4.0
	SPD (MPH)	2.0	6.9	3.2	4.9	3.6	7.0	7.6	6.3	4.5	7.3
	RATIO	0.892	0.727	0.726	0.994	0.615	0.908	0.954	0.990	0.840	0.541
METEOROLOGICAL SITE	DIR (DEG)	250	270	250	250	270	290	260	260	290	270
WORCESTER	VEL (MPH)	4.7	7.5	6.0	12.2	7.3	7.7	13.0	8.4	16.0	7.2
	SPD (MPH)	8.3	9.8	7.8	15.5	9.1	10.4	16.8	10.9	19.7	8.6
	RATIO	0.560	0.764	0.770	0.788	0.812	0.746	0.775	0.773	0.812	0.838

FIGURE 3-4

SULFUR DIOXIDE TREND FROM CONTINUOUS DATA

"PERCENT OF SITES WITHIN EACH RANGE"



PRIMARY ANNUAL STANDARD = 80 µg/m³

* ANNUAL ARITHMETIC MEAN (µg/m³)

TABLE 3-5

SO2 TRENDS FROM CONTINUOUS DATA: 1979-1988

(PAIRED *t* TEST)

PAIRED YEARS	AVERAGE OF ANNUAL GEOMETRIC MEANS ($\mu g/m^3$)	NO. OF SITES	DIFFERENCES OF THE PAIRED YEAR MEANS		SIGNIFICANCE LEVEL		
					TREND AT		PROBABILITY THAT CHANGE IS NOT SIGNIFICANT
			AVG.	STD. DEV.	95% LEVEL	99% LEVEL	
79 80	21.8 19.8	10 10	-1.95	2.22	↓	N.C.	0.0215
80 81	21.1 20.9	8 8	-0.20	4.83	N.C.	N.C.	0.9100
81 82	20.9 21.0	8 8	0.09	3.98	N.C.	N.C.	0.9522
82 83	20.0 18.1	8 8	-1.96	0.79	↓	↓	0.0002
83 84	18.1 18.2	8 8	0.11	3.20	N.C.	N.C.	0.9237
84 85	16.4 16.5	15 15	0.04	3.51	N.C.	N.C.	0.9654
85 86	14.6 15.5	16 16	0.86	3.76	N.C.	N.C.	0.3772
86 87	15.6 16.1	16 16	0.47	2.65	N.C.	N.C.	0.4899
87 88	16.5 16.4	15 15	-0.13	3.06	N.C.	N.C.	0.8784

Key to Symbols : ↓ = Significant downward trend

↑ = Significant upward trend

N.C. = No significant change

IV. OZONE

HEALTH EFFECTS

Ozone is a highly reactive form of oxygen and the principal component of modern smog. Until recently, EPA called this type of pollution "photochemical oxidants." The name has been changed to ozone because ozone is the only oxidant actually measured and is the most plentiful.

Ozone and other oxidants -- including peroxyacetal nitrates (PAN), formaldehyde and peroxides -- are not usually emitted into the air directly. They 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 and 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 a national ambient air quality standard (NAAQS) for ozone of 0.12 ppm for a one-hour average. Compliance with this standard is determined by summing the number of days at each monitoring site over a consecutive three-year period when the 1-hour standard is exceeded and then computing the average number of exceedances over this interval. If the resulting average value is less than or equal to 1.0 (that is, if the fourth highest daily value in a consecutive three-year period is less than or equal to 0.12 ppm) the ozone standard is considered attained at the site. This standard replaces the old photochemical oxidant Standard of 0.08 ppm. The definition of the pollutant was 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 NAAQS to reflect the change in both the numerical value of the NAAQS and the definition of the pollutant.

The EPA defines the ozone standard to two decimal places. Therefore, the standard is considered exceeded when a level of 0.13 ppm is reached. However, since the DEP still measures ozone levels to three decimal places, any one-hour average ozone reading which equals or is greater than 0.125 ppm is considered an exceedance of the 0.12 ppm standard in Connecticut. This interpretation of the ozone standard differs from the one used by the DEP before 1982, when a one-hour ozone concentration of 0.121 ppm was considered an exceedance of the standard.

CONCLUSIONS

As in past years, Connecticut experienced very high concentrations of ozone in the summer months of 1988. Levels in excess of the one-hour NAAQS of 0.12 ppm were frequently recorded at all ten monitored sites. Nine sites experienced levels greater than 0.20 ppm in 1988, compared to one site in

1987 and no sites in 1986. Regarding the nine sites that operated in both 1987 and 1988, both the highest and second highest one-hour concentrations increased at all but the Groton 007 site.

The incidence of ozone concentrations in excess of the 1-hour 0.12 ppm standard was higher in 1988 than in 1987 (see Table 4-1). There was a total of 180 exceedances in 1987 and 429 exceedances in 1988 at those monitored sites that operated in both years. This represents a rise in the frequency of such exceedances from 4.3 per 1000 sampling hours in 1987 to 10.0 per 1000 sampling hours in 1988: a 133% increase. If one eliminates the duplication that results when two or more sites experience an exceedance in the same hour, then the number of exceedances increased from 122 to 183. On this basis, the state experienced a 48% increase in the frequency of hourly exceedances of the standard. The difference between the 133% increase and the 48% increase can be explained by the widespread nature of the ozone problem during the exceedance hours.

The number of site-days on which the ozone monitors experienced ozone levels in excess of the 1-hour standard increased from 66 in 1987 to 125 in 1988 at those monitoring sites that operated in both years (see Table 4-2). This represents a rise in the frequency of such occurrences from 3.8 per 100 sampling days in 1987 to 7.0 per 100 sampling days in 1988: an 84% increase. If the duplication that results when two or more sites experience an exceedance on the same day is eliminated, then the number of exceedances increased from 27 to 34. On this basis, the state experienced a 19% increase in the frequency of daily exceedances of the standard. The difference between the 84% increase and the 19% increase can be explained by the widespread nature of the ozone problem during the exceedance days.

The yearly changes in ozone concentrations can usually be attributed to year-to-year variations in regional weather conditions, especially wind direction, temperature and the amount of sunlight. Moreover, a large portion 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 other points to the west and southwest. An increase in the frequency of winds out of the southwest helps to explain the increase in the number of ozone exceedances from 1987 to 1988. The percentage of southwest winds during the "ozone season" increased significantly from 29% in 1987 to 35% in 1988, as is shown by the wind roses from Newark (Figures 4-1 and 4-2) -- the wind roses from Bradley (Figures 4-3 and 4-4) are believed to be not as representative, since the airport is located in the Connecticut River Valley and the wind gets channeled up or down the valley. 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 higher in 1988 than in 1987. This is demonstrated by the number of days exceeding 90° F which increased from nine in 1987 to fifteen in 1988 at Sikorsky Airport in Bridgeport, and from twenty in 1987 to thirty in 1988 at Bradley International Airport (see Tables 9-1 and 9-2). The incidence of high ozone levels is dependent on the percentage of possible sunshine, since sunlight is essential to the creation of ozone. According to National Weather Service local climatological data recorded at Bradley Airport, the percentage of possible sunshine increased from 52% in 1987 to 65% in 1988 for the months June through September. The average for the summer months at Bradley is usually 61%. Clearly, each of the above three meteorological factors can be invoked to explain the increase in ozone levels from 1987 to 1988.

In additon, calculations based on a recent study (see publication no. 30 in section XIII. Publications) suggest that most of the increase in the ozone levels between 1987 and 1988 can be attributed to the increased incidence of ozone "exceedance conducive days." Such days reflect both high maximum daily temperatures and the frequency of winds out of the southwest.

METHOD OF MEASUREMENT

The DEP Air Monitoring Unit uses UV photometry to measure and record instantaneous concentrations of ozone continuously by means of a UV absorption technique. Properly calibrated, instruments of this type are shown to be remarkably reliable and stable.

DISCUSSION OF DATA

Monitoring Network - In order to gather information which will further the understanding of ozone production and transport, and to provide real-time data for the daily Pollutant Standards Index, DEP operated a state-wide ozone monitoring network consisting of four types of sites in 1988 (see Figure 4-5):

Urban	- East Hartford, Middletown
Advection from Southwest	- Greenwich, Groton, Madison, Stratford
Urban and advection from Southwest	- Bridgeport, Danbury, North Haven
Rural	- Stafford

Precision and Accuracy - The ozone monitors had a total of 253 precision checks during 1988. The resulting 95% probability limits were -5% to +6%. Accuracy is determined by introducing a known amount of ozone into each of the monitors. Three different concentration levels are tested: low, medium, and high. The 95% probability limits, based on 20 audits conducted on the monitoring system, were: low, -7% to +10%; medium, -5% to +4%; and high, -7% to +4%.

1-Hour Average - The 1-hour ozone standard was exceeded at all ten DEP monitoring sites in 1988. Moreover, the highest 1-hour average ozone concentrations were higher in 1988 than in 1987 at all the sites except Groton 007. Stafford 001 had the largest increase of 0.088 ppm.

The number of hours when the ozone 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 4-6 shows the year's high and second high concentrations at each site.

10 High Days with Wind Data - Table 4-3 lists the ten highest 1-hour ozone averages and their dates of occurrence for each ozone site in 1988. The wind data associated with these high readings are also presented. (See the discussion of Table 2-5 in the particulate matter section of this Air Quality Summary for a description of the origin and use of these wind data.)

Many (i.e., 56%) of the high ozone levels occurred on days with winds out of the southwest. This is due to the special features of a southwest wind blowing over Connecticut. The first feature is that, during the summer, southwest winds are usually accompanied by high temperatures and bright sunshine, which are important to the production of ozone. The second feature of a southwest wind is that it will transport precursor emissions from New York City and other urban areas to the southwest of Connecticut. It is the combination of these factors that often produces unhealthful ozone levels in Connecticut.

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

TABLE 4-1

NUMBER OF EXCEEDANCES OF THE 1-HOUR OZONE STANDARD IN 1988

SITE	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	THIS YEAR	LAST YEAR
Bridgeport-013	0	3	14	26	13	0	0	56	-
Danbury-123	0	5	18	33	23	0	0	79	19
E. Hartford-003	0	1	5	29	0	0	0	35	0
Greenwich-017	0	1	16	18	17	4	0	56	24
Groton-008	0	0	10	14	4	0	0	28	43
Madison-002	0	0	12	9	11	0	0	32	16
Middletown-007	0	0	10	18	15	0	0	43	12
New Haven-123	0	0	7	15	7	0	0	29	18
Stafford-001	0	4	19	16	9	0	0	48	2
Stratford-007	0	2	21	35	20	1	0	79	46
							TOTAL SITE HOURS[a]	429	180
							TOTAL INDIVIDUAL HOURS[a]	183	122

[a] Excluding Bridgeport-013.

TABLE 4-2

NUMBER OF DAYS WHEN THE 1-HOUR OZONE STANDARD WAS EXCEEDED IN 1988

SITE	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	THIS YEAR	LAST YEAR
Bridgeport-013	0	2	3	8	5	0	0	18	-
Danbury-123	0	2	4	7	7	0	0	20	6
E. Hartford-003	0	1	1	8	0	0	0	10	0
Greenwich-017	0	1	3	6	6	1	0	17	10
Groton-008	0	0	4	4	1	0	0	9	10
Madison-002	0	0	3	3	6	0	0	12	6
Middletown-007	0	0	3	6	4	0	0	13	5
New Haven-123	0	0	2	5	3	0	0	10	9
Stafford-001	0	1	4	6	2	0	0	13	2
Stratford-007	0	1	3	9	7	1	0	21	18
							TOTAL SITE DAYS[a]	125	66
							TOTAL INDIVIDUAL DAYS[a]	34	27

[a] Excluding Bridgeport-013.

FIGURE 4-1

WIND ROSE FOR APRIL - OCTOBER 1987
NEWARK INTERNATIONAL AIRPORT
NEWARK, NEW JERSEY

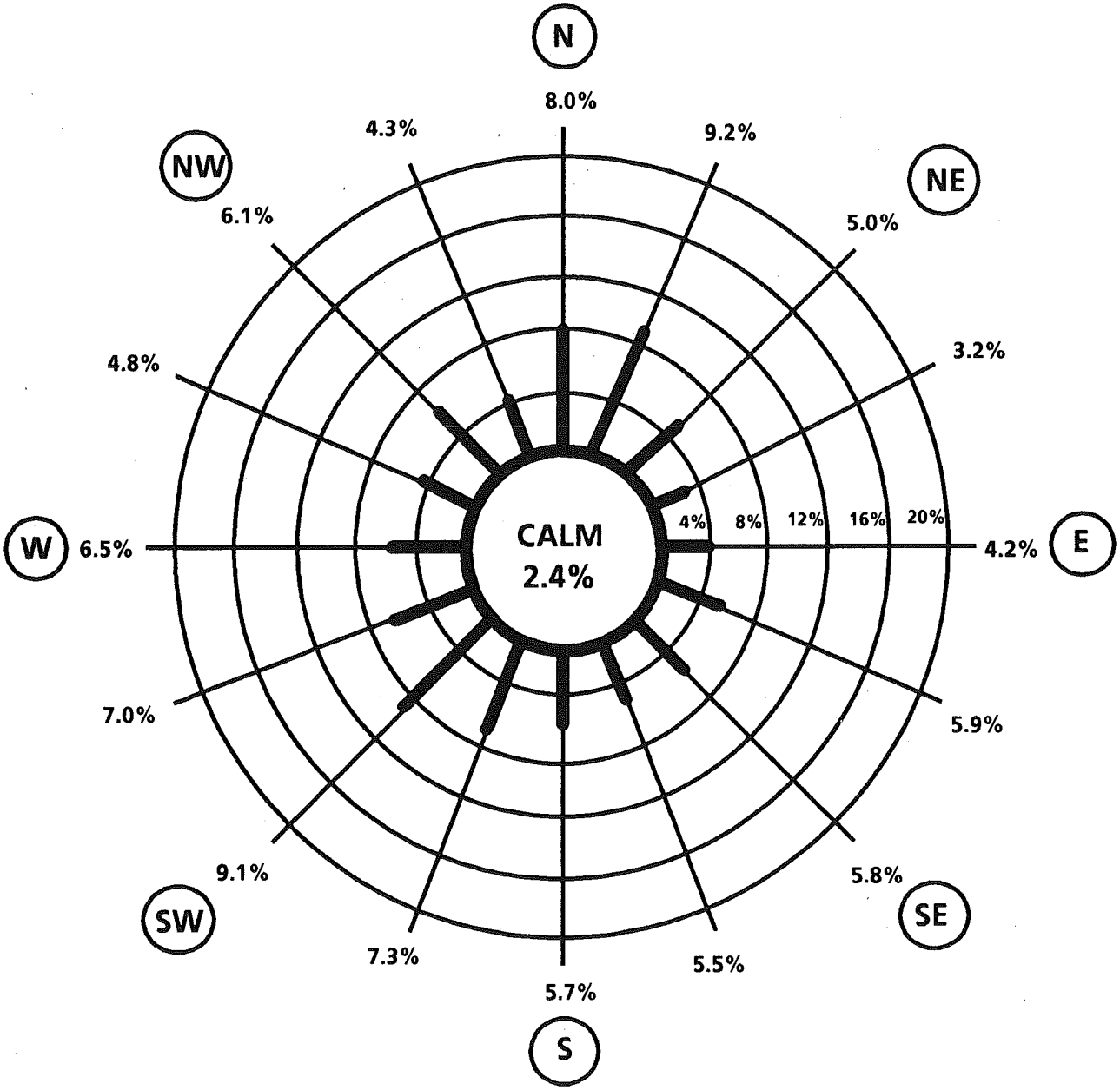


FIGURE 4-2

WIND ROSE FOR APRIL - OCTOBER 1988
NEWARK INTERNATIONAL AIRPORT
NEWARK, NEW JERSEY

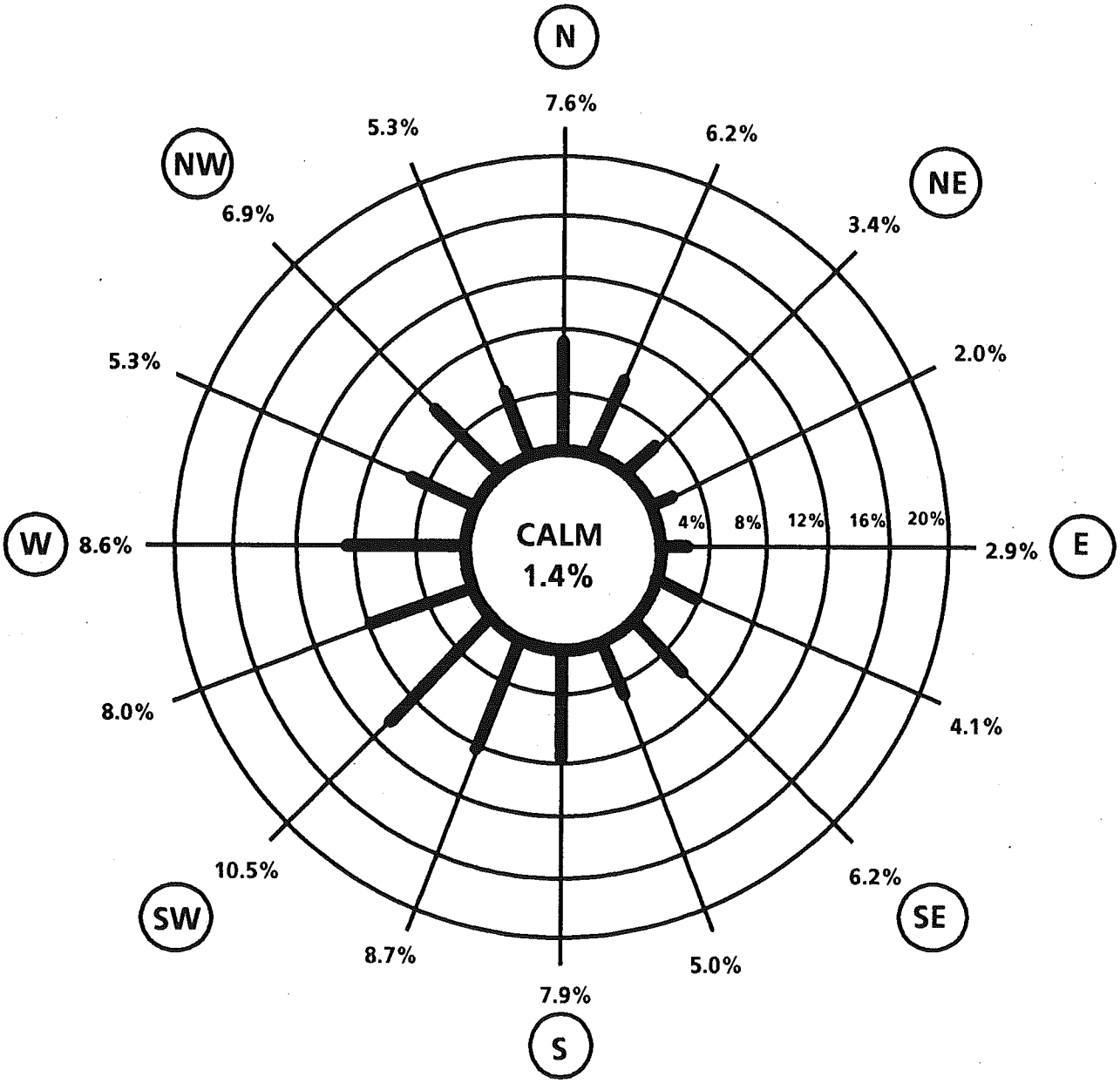


FIGURE 4-3

WIND ROSE FOR APRIL - OCTOBER 1987
BRADLEY INTERNATIONAL AIRPORT
WINDSOR LOCKS, CONNECTICUT

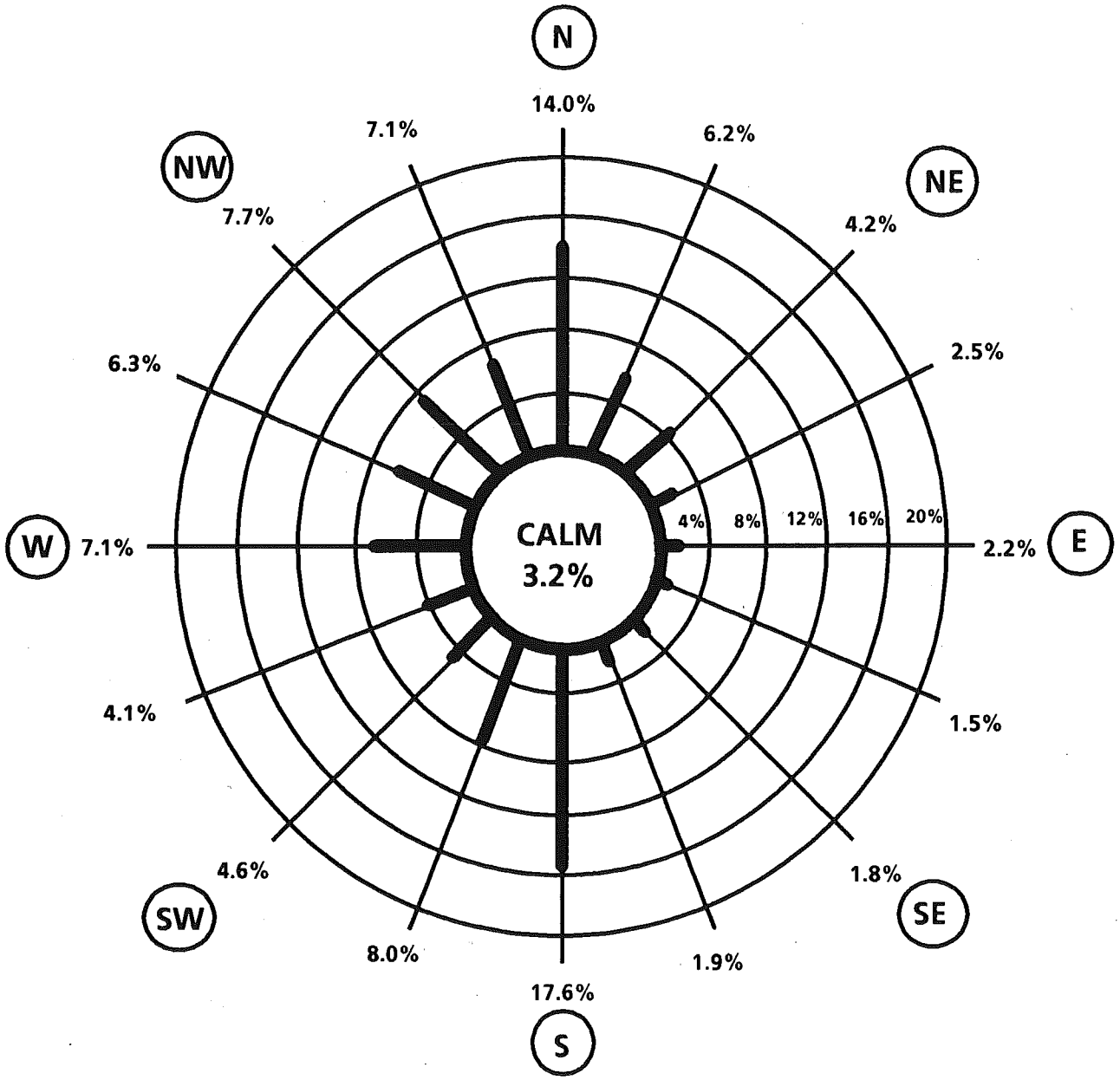
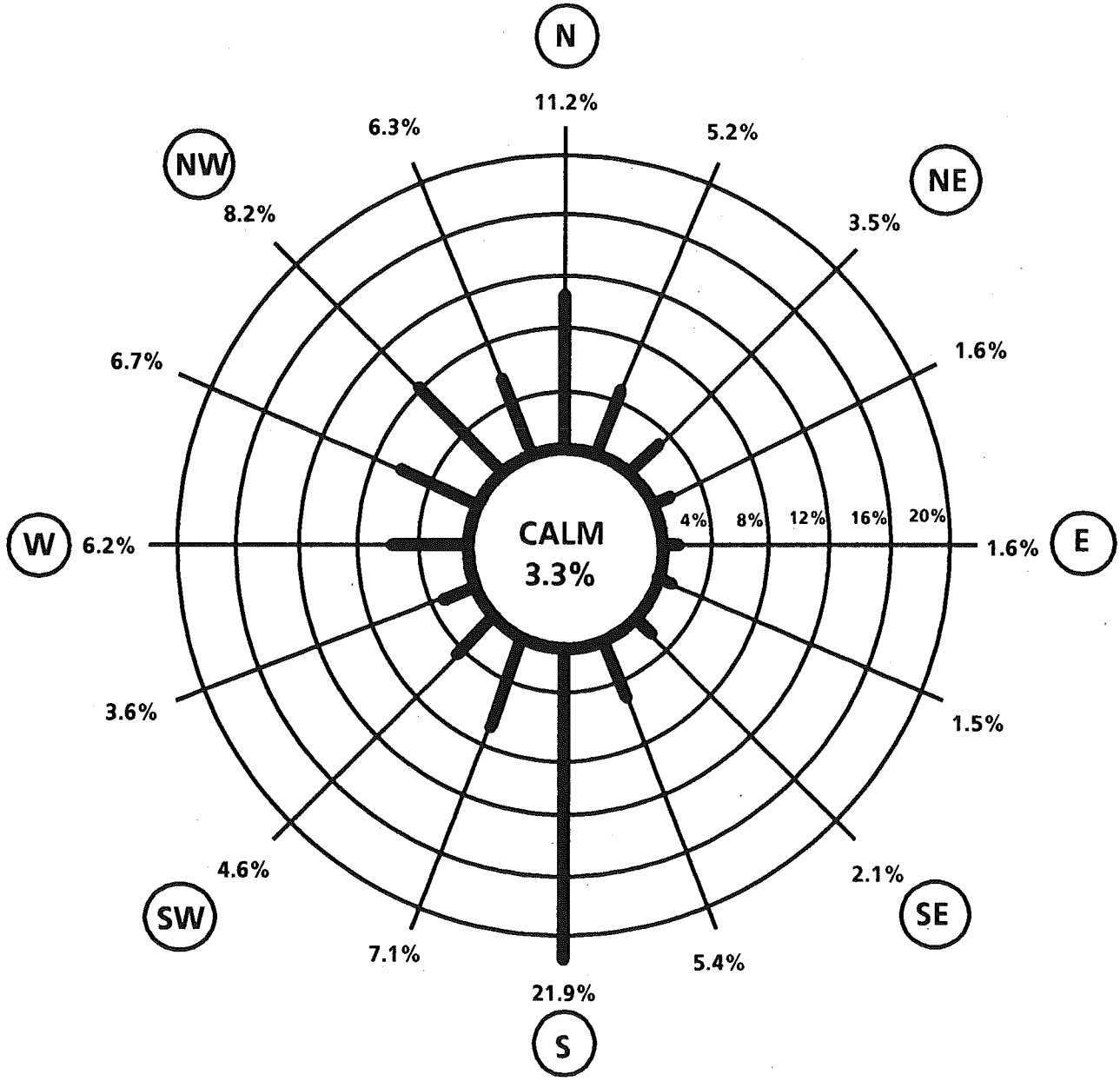


FIGURE 4-4

WIND ROSE FOR APRIL - OCTOBER 1988
BRADLEY INTERNATIONAL AIRPORT
WINDSOR LOCKS, CONNECTICUT



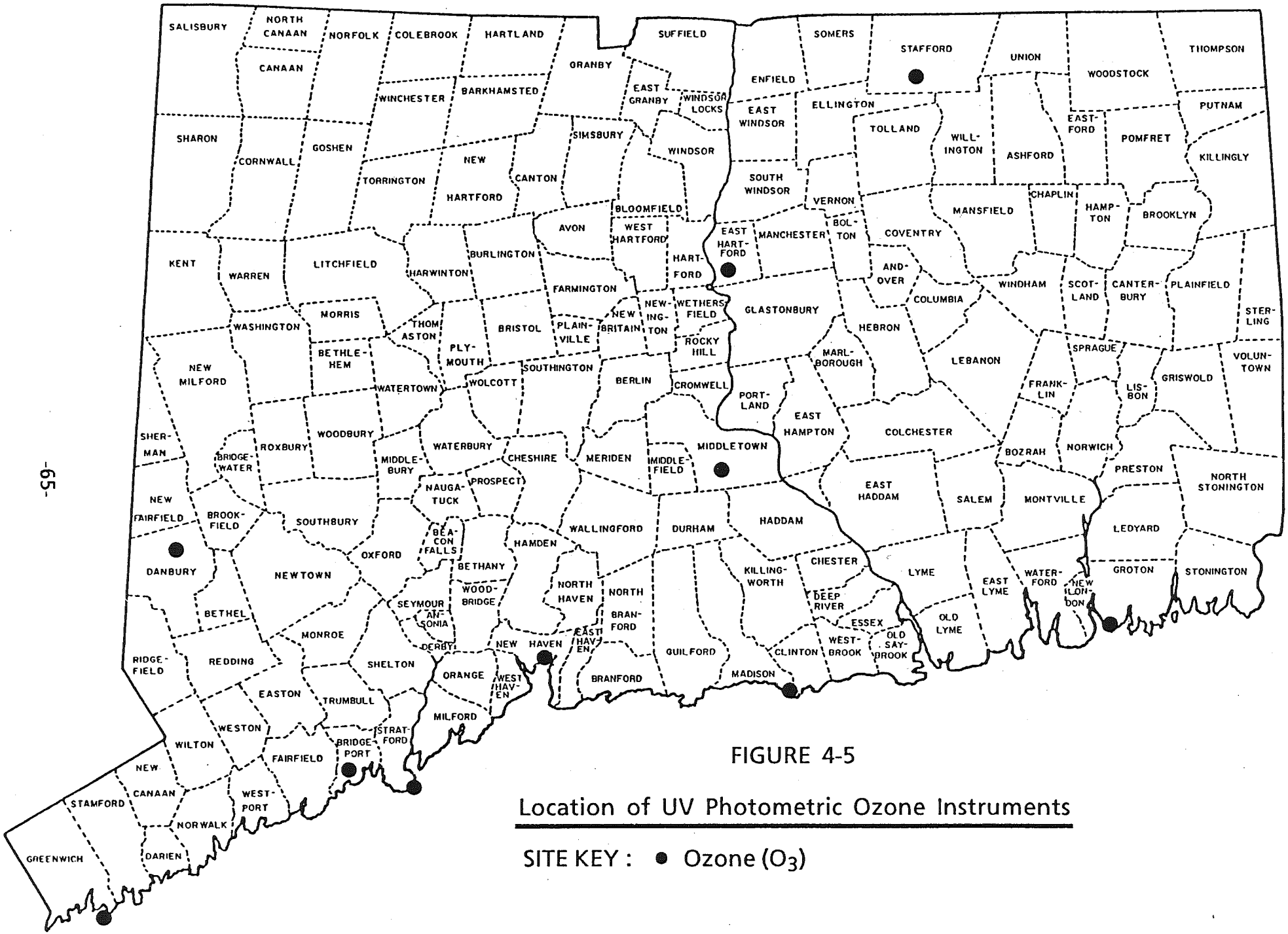


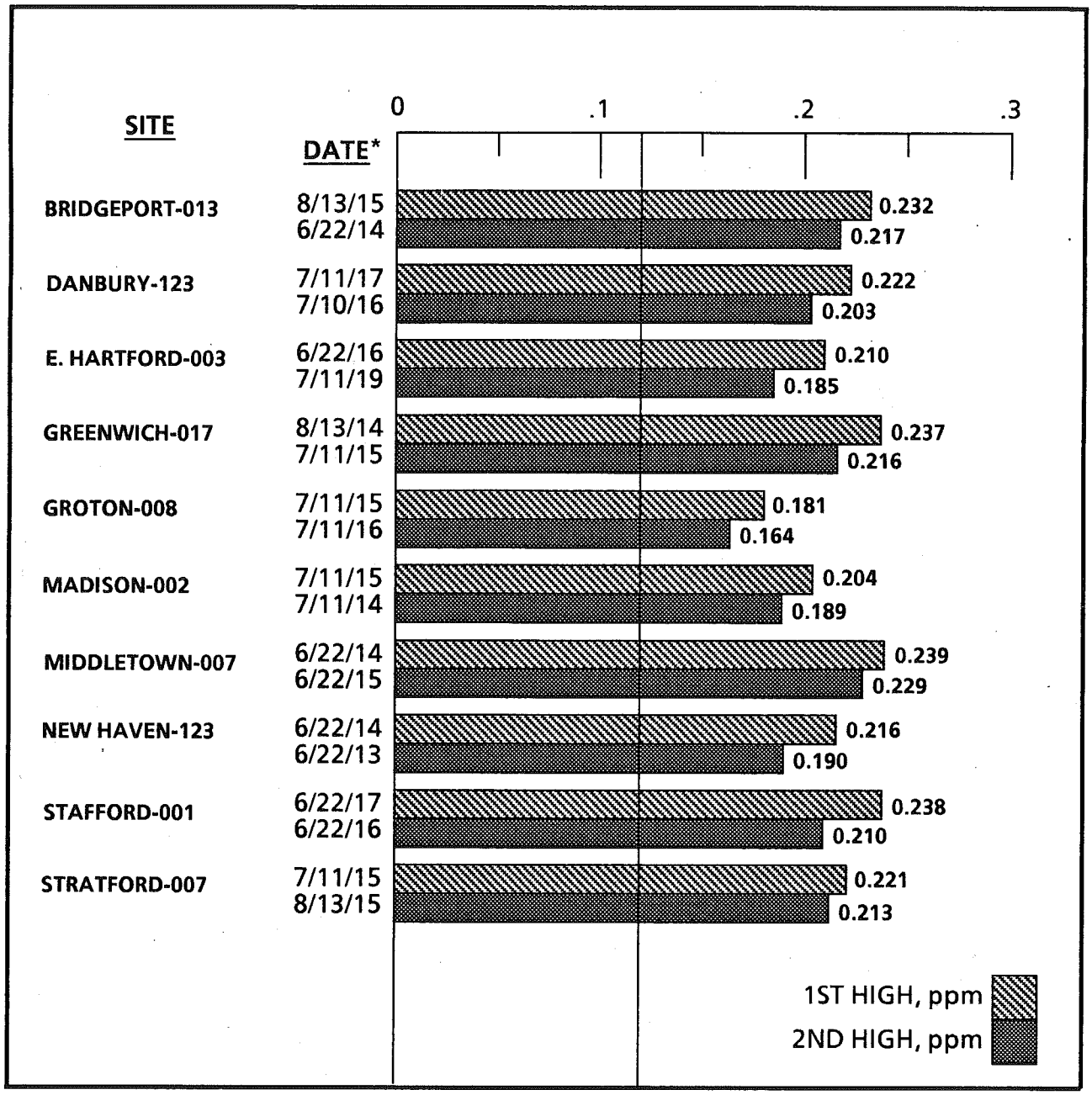
FIGURE 4-5

Location of UV Photometric Ozone Instruments

SITE KEY : • Ozone (O_3)

FIGURE 4-6

1988 MAXIMUM 1-HOUR OZONE CONCENTRATIONS



* The date is the month/day/ending hour of occurrence.

N.B. When a listed concentration occurs more than once at a site, the earliest date is given first.

TABLE 4–3

1988 TEN HIGHEST 1–HOUR AVERAGE OZONE DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN–SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
BRIDGEPORT–013 (4890)	OZONE	.232	.217	.199	.186	.174	.155	.153	.148	.148	.147
	DATE	8/13/88	6/22/88	7/10/88	7/11/88	7/30/88	8/14/88	6/14/88	8/12/88	6/15/88	7/27/88
METEOROLOGICAL SITE	DIR (DEG)	240	230	170	230	260	230	260	230	260	220
NEWARK	VEL (MPH)	9.5	10.0	5.9	7.8	5.3	10.0	6.6	6.3	6.3	4.0
	SPD (MPH)	11.6	11.1	9.6	10.2	6.8	12.9	7.8	8.2	8.8	6.3
	RATIO	0.816	0.903	0.611	0.763	0.780	0.771	0.853	0.769	0.716	0.630
METEOROLOGICAL SITE	DIR (DEG)	230	200	230	300	240	210	260	300	250	210
BRADLEY	VEL (MPH)	5.1	6.3	4.1	2.5	3.1	6.8	4.7	2.3	5.7	2.7
	SPD (MPH)	6.9	7.6	6.8	6.5	5.9	8.8	6.2	5.8	8.3	4.6
	RATIO	0.740	0.823	0.607	0.385	0.532	0.780	0.767	0.406	0.682	0.585
METEOROLOGICAL SITE	DIR (DEG)	240	210	230	220	220	230	230	240	230	230
BRIDGEPORT	VEL (MPH)	7.7	6.0	6.0	6.7	5.9	9.4	6.5	7.9	6.1	7.9
	SPD (MPH)	8.1	7.5	6.3	8.2	6.2	9.6	8.1	8.5	6.3	8.3
	RATIO	0.957	0.809	0.943	0.824	0.962	0.980	0.813	0.926	0.971	0.952
METEOROLOGICAL SITE	DIR (DEG)	280	240	280	270	280	250	300	290	280	260
WORCESTER	VEL (MPH)	6.1	5.7	5.7	4.2	6.5	7.7	7.0	5.3	6.2	4.4
	SPD (MPH)	7.8	6.0	6.5	6.3	8.2	9.1	8.1	6.9	7.5	5.6
	RATIO	0.783	0.938	0.886	0.662	0.799	0.852	0.866	0.774	0.827	0.791
DANBURY–123 (4574)	OZONE	.222	.203	.200	.179	.178	.167	.163	.161	.159	.158
	DATE	7/11/88	7/10/88	6/22/88	7/ 8/88	7/ 6/88	7/29/88	8/11/88	8/ 1/88	8/ 3/88	8/ 2/88
METEOROLOGICAL SITE	DIR (DEG)	230	170	230	120	110	240	230	160	180	140
NEWARK	VEL (MPH)	7.8	5.9	10.0	3.3	3.2	4.4	6.6	4.7	5.7	5.3
	SPD (MPH)	10.2	9.6	11.1	6.3	6.3	6.6	8.5	5.6	9.8	6.2
	RATIO	0.763	0.611	0.903	0.522	0.504	0.659	0.781	0.845	0.587	0.852
METEOROLOGICAL SITE	DIR (DEG)	300	230	200	160	170	120	200	220	190	190
BRADLEY	VEL (MPH)	2.5	4.1	6.3	4.2	4.1	2.1	4.9	2.7	6.4	4.2
	SPD (MPH)	6.5	6.8	7.6	6.9	6.6	5.3	7.2	5.3	8.5	6.5
	RATIO	0.385	0.607	0.823	0.612	0.622	0.402	0.685	0.512	0.750	0.656
METEOROLOGICAL SITE	DIR (DEG)	220	230	210	230	180	200	220	220	220	170
BRIDGEPORT	VEL (MPH)	6.7	6.0	6.0	6.3	3.7	4.4	6.0	3.2	7.0	4.0
	SPD (MPH)	8.2	6.3	7.5	8.5	5.3	4.7	6.5	5.0	7.5	4.5
	RATIO	0.824	0.943	0.809	0.744	0.688	0.937	0.922	0.628	0.931	0.894
METEOROLOGICAL SITE	DIR (DEG)	270	280	240	250	280	300	290	300	260	270
WORCESTER	VEL (MPH)	4.2	5.7	5.7	4.7	4.1	5.0	5.2	3.4	6.2	3.9
	SPD (MPH)	6.3	6.5	6.0	7.5	5.6	6.2	7.2	5.6	7.6	5.8
	RATIO	0.662	0.886	0.938	0.634	0.736	0.812	0.718	0.605	0.811	0.674
EAST HARTFORD–003 (4893)	OZONE	.210	.185	.177	.168	.154	.144	.141	.141	.126	.125
	DATE	6/22/88	7/11/88	7/16/88	7/ 8/88	7/ 7/88	7/ 6/88	7/14/88	7/10/88	7/ 9/88	5/28/88
METEOROLOGICAL SITE	DIR (DEG)	230	230	220	120	150	110	190	170	190	200
NEWARK	VEL (MPH)	10.0	7.8	6.8	3.3	3.4	3.2	6.8	5.9	4.4	6.4
	SPD (MPH)	11.1	10.2	10.6	6.3	5.9	6.3	9.5	9.6	7.5	8.9
	RATIO	0.903	0.763	0.639	0.522	0.576	0.504	0.715	0.611	0.586	0.715
METEOROLOGICAL SITE	DIR (DEG)	200	300	200	160	170	170	180	230	180	190
BRADLEY	VEL (MPH)	6.3	2.5	7.9	4.2	6.1	4.1	6.0	4.1	2.4	6.8
	SPD (MPH)	7.6	6.5	8.9	6.9	8.1	6.6	10.5	6.8	8.5	8.3
	RATIO	0.823	0.385	0.884	0.612	0.754	0.622	0.570	0.607	0.284	0.813

TABLE 4-3, CONTINUED

1988 TEN HIGHEST 1-HOUR AVERAGE OZONE DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	210	220	230	230	230	180	220	230	250	220
BRIDGEPORT	VEL (MPH)	6.0	6.7	8.2	6.3	7.1	3.7	6.9	6.0	3.3	7.8
	SPD (MPH)	7.5	8.2	8.8	8.5	7.5	5.3	7.2	6.3	4.2	8.1
	RATIO	0.809	0.824	0.933	0.744	0.948	0.688	0.965	0.943	0.789	0.964
METEOROLOGICAL SITE	DIR (DEG)	240	270	250	250	260	280	240	280	290	280
WORCESTER	VEL (MPH)	5.7	4.2	8.0	4.7	4.4	4.1	8.5	5.7	4.9	6.3
	SPD (MPH)	6.0	6.3	9.5	7.5	6.9	5.6	10.4	6.5	7.3	8.2
	RATIO	0.938	0.662	0.839	0.634	0.631	0.736	0.821	0.886	0.671	0.768
GREENWICH-017 (4705)	OZONE	.237	.216	.203	.188	.187	.177	.163	.162	.156	.146
	DATE	8/13/88	7/11/88	7/10/88	6/22/88	6/15/88	7/ 8/88	8/11/88	6/14/88	8/12/88	7/16/88
METEOROLOGICAL SITE	DIR (DEG)	240	230	170	230	260	120	230	260	230	220
NEWARK	VEL (MPH)	9.5	7.8	5.9	10.0	6.3	3.3	6.6	6.6	6.3	6.8
	SPD (MPH)	11.6	10.2	9.6	11.1	8.8	6.3	8.5	7.8	8.2	10.6
	RATIO	0.816	0.763	0.611	0.903	0.716	0.522	0.781	0.853	0.769	0.639
METEOROLOGICAL SITE	DIR (DEG)	230	300	230	200	250	160	200	260	300	200
BRADLEY	VEL (MPH)	5.1	2.5	4.1	6.3	5.7	4.2	4.9	4.7	2.3	7.9
	SPD (MPH)	6.9	6.5	6.8	7.6	8.3	6.9	7.2	6.2	5.8	8.9
	RATIO	0.740	0.385	0.607	0.823	0.682	0.612	0.685	0.767	0.406	0.884
METEOROLOGICAL SITE	DIR (DEG)	240	220	230	210	230	230	220	230	240	230
BRIDGEPORT	VEL (MPH)	7.7	6.7	6.0	6.0	6.1	6.3	6.0	6.5	7.9	8.2
	SPD (MPH)	8.1	8.2	6.3	7.5	6.3	8.5	6.5	8.1	8.5	8.8
	RATIO	0.957	0.824	0.943	0.809	0.971	0.744	0.922	0.813	0.926	0.933
METEOROLOGICAL SITE	DIR (DEG)	280	270	280	240	280	250	290	300	290	250
WORCESTER	VEL (MPH)	6.1	4.2	5.7	5.7	6.2	4.7	5.2	7.0	5.3	8.0
	SPD (MPH)	7.8	6.3	6.5	6.0	7.5	7.5	7.2	8.1	6.9	9.5
	RATIO	0.783	0.662	0.886	0.938	0.827	0.634	0.718	0.866	0.774	0.839
GROTON-008 (4908)	OZONE	.181	.151	.147	.144	.143	.136	.133	.132	.129	.124
	DATE	7/11/88	8/13/88	6/15/88	7/10/88	7/30/88	7/29/88	6/21/88	6/22/88	6/14/88	8/12/88
METEOROLOGICAL SITE	DIR (DEG)	230	240	260	170	260	240	290	230	260	230
NEWARK	VEL (MPH)	7.8	9.5	6.3	5.9	5.3	4.4	7.0	10.0	6.6	6.3
	SPD (MPH)	10.2	11.6	8.8	9.6	6.8	6.6	11.2	11.1	7.8	8.2
	RATIO	0.763	0.816	0.716	0.611	0.780	0.659	0.623	0.903	0.853	0.769
METEOROLOGICAL SITE	DIR (DEG)	300	230	250	230	240	120	310	200	260	300
BRADLEY	VEL (MPH)	2.5	5.1	5.7	4.1	3.1	2.1	7.1	6.3	4.7	2.3
	SPD (MPH)	6.5	6.9	8.3	6.8	5.9	5.3	8.1	7.6	6.2	5.8
	RATIO	0.385	0.740	0.682	0.607	0.532	0.402	0.888	0.823	0.767	0.406
METEOROLOGICAL SITE	DIR (DEG)	220	240	230	230	220	200	280	210	230	240
BRIDGEPORT	VEL (MPH)	6.7	7.7	6.1	6.0	5.9	4.4	4.3	6.0	6.5	7.9
	SPD (MPH)	8.2	8.1	6.3	6.3	6.2	4.7	7.5	7.5	8.1	8.5
	RATIO	0.824	0.957	0.971	0.943	0.962	0.937	0.578	0.809	0.813	0.926
METEOROLOGICAL SITE	DIR (DEG)	270	280	280	280	280	300	310	240	300	290
WORCESTER	VEL (MPH)	4.2	6.1	6.2	5.7	6.5	5.0	6.4	5.7	7.0	5.3
	SPD (MPH)	6.3	7.8	7.5	6.5	8.2	6.2	7.8	6.0	8.1	6.9
	RATIO	0.662	0.783	0.827	0.886	0.799	0.812	0.829	0.938	0.866	0.774

TABLE 4-3, CONTINUED

1988 TEN HIGHEST 1-HOUR AVERAGE OZONE DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
MADISON-002 (4807)	OZONE	.204	.161	.155	.155	.149	.149	.147	.141	.135	.133
	DATE	7/11/88	6/15/88	8/14/88	8/ 1/88	8/13/88	7/10/88	8/12/88	6/22/88	8/ 5/88	6/14/88
METEOROLOGICAL SITE	DIR (DEG)	230	260	230	160	240	170	230	230	200	260
NEWARK	VEL (MPH)	7.8	6.3	10.0	4.7	9.5	5.9	6.3	10.0	4.9	6.6
	SPD (MPH)	10.2	8.8	12.9	5.6	11.6	9.6	8.2	11.1	9.1	7.8
	RATIO	0.763	0.716	0.771	0.845	0.816	0.611	0.769	0.903	0.546	0.853
METEOROLOGICAL SITE	DIR (DEG)	300	250	210	220	230	230	300	200	210	260
BRADLEY	VEL (MPH)	2.5	5.7	6.8	2.7	5.1	4.1	2.3	6.3	6.4	4.7
	SPD (MPH)	6.5	8.3	8.8	5.3	6.9	6.8	5.8	7.6	9.2	6.2
	RATIO	0.385	0.682	0.780	0.512	0.740	0.607	0.406	0.823	0.694	0.767
METEOROLOGICAL SITE	DIR (DEG)	220	230	230	220	240	230	240	210	240	230
BRIDGEPORT	VEL (MPH)	6.7	6.1	9.4	3.2	7.7	6.0	7.9	6.0	8.3	6.5
	SPD (MPH)	8.2	6.3	9.6	5.0	8.1	6.3	8.5	7.5	8.5	8.1
	RATIO	0.824	0.971	0.980	0.628	0.957	0.943	0.926	0.809	0.981	0.813
METEOROLOGICAL SITE	DIR (DEG)	270	280	250	300	280	280	290	240	250	300
WORCESTER	VEL (MPH)	4.2	6.2	7.7	3.4	6.1	5.7	5.3	5.7	7.5	7.0
	SPD (MPH)	6.3	7.5	9.1	5.6	7.8	6.5	6.9	6.0	9.8	8.1
	RATIO	0.662	0.827	0.852	0.605	0.783	0.886	0.774	0.938	0.765	0.866
MIDDLETOWN-007 (4646)	OZONE	.239	.181	.172	.172	.154	.150	.146	.140	.140	.140
	DATE	6/22/88	7/11/88	8/13/88	8/14/88	7/16/88	8/11/88	8/12/88	7/30/88	7/ 8/88	7/10/88
METEOROLOGICAL SITE	DIR (DEG)	230	230	240	230	220	230	230	260	120	170
NEWARK	VEL (MPH)	10.0	7.8	9.5	10.0	6.8	6.6	6.3	5.3	3.3	5.9
	SPD (MPH)	11.1	10.2	11.6	12.9	10.6	8.5	8.2	6.8	6.3	9.6
	RATIO	0.903	0.763	0.816	0.771	0.639	0.781	0.769	0.780	0.522	0.611
METEOROLOGICAL SITE	DIR (DEG)	200	300	230	210	200	200	300	240	160	230
BRADLEY	VEL (MPH)	6.3	2.5	5.1	6.8	7.9	4.9	2.3	3.1	4.2	4.1
	SPD (MPH)	7.6	6.5	6.9	8.8	8.9	7.2	5.8	5.9	6.9	6.8
	RATIO	0.823	0.385	0.740	0.780	0.884	0.685	0.406	0.532	0.612	0.607
METEOROLOGICAL SITE	DIR (DEG)	210	220	240	230	230	220	240	220	230	230
BRIDGEPORT	VEL (MPH)	6.0	6.7	7.7	9.4	8.2	6.0	7.9	5.9	6.3	6.0
	SPD (MPH)	7.5	8.2	8.1	9.6	8.8	6.5	8.5	6.2	8.5	6.3
	RATIO	0.809	0.824	0.957	0.980	0.933	0.922	0.926	0.962	0.744	0.943
METEOROLOGICAL SITE	DIR (DEG)	240	270	280	250	250	290	290	280	250	280
WORCESTER	VEL (MPH)	5.7	4.2	6.1	7.7	8.0	5.2	5.3	6.5	4.7	5.7
	SPD (MPH)	6.0	6.3	7.8	9.1	9.5	7.2	6.9	8.2	7.5	6.5
	RATIO	0.938	0.662	0.783	0.852	0.839	0.718	0.774	0.799	0.634	0.886
NEW HAVEN-123 (4882)	OZONE	.216	.174	.170	.153	.151	.148	.138	.133	.129	.128
	DATE	6/22/88	8/13/88	7/10/88	7/11/88	8/14/88	7/30/88	6/14/88	7/ 8/88	8/ 1/88	7/27/88
METEOROLOGICAL SITE	DIR (DEG)	230	240	170	230	230	260	260	120	160	220
NEWARK	VEL (MPH)	10.0	9.5	5.9	7.8	10.0	5.3	6.6	3.3	4.7	4.0
	SPD (MPH)	11.1	11.6	9.6	10.2	12.9	6.8	7.8	6.3	5.6	6.3
	RATIO	0.903	0.816	0.611	0.763	0.771	0.780	0.853	0.522	0.845	0.630
METEOROLOGICAL SITE	DIR (DEG)	200	230	230	300	210	240	260	160	220	210
BRADLEY	VEL (MPH)	6.3	5.1	4.1	2.5	6.8	3.1	4.7	4.2	2.7	2.7
	SPD (MPH)	7.6	6.9	6.8	6.5	8.8	5.9	6.2	6.9	5.3	4.6
	RATIO	0.823	0.740	0.607	0.385	0.780	0.532	0.767	0.612	0.512	0.585

TABLE 4-3, CONTINUED

1988 TEN HIGHEST 1-HOUR AVERAGE OZONE DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	210	240	230	220	230	220	230	230	220	230
BRIDGEPORT	VEL (MPH)	6.0	7.7	6.0	6.7	9.4	5.9	6.5	6.3	3.2	7.9
	SPD (MPH)	7.5	8.1	6.3	8.2	9.6	6.2	8.1	8.5	5.0	8.3
	RATIO	0.809	0.957	0.943	0.824	0.980	0.962	0.813	0.744	0.628	0.952
METEOROLOGICAL SITE	DIR (DEG)	240	280	280	270	250	280	300	250	300	260
WORCESTER	VEL (MPH)	5.7	6.1	5.7	4.2	7.7	6.5	7.0	4.7	3.4	4.4
	SPD (MPH)	6.0	7.8	6.5	6.3	9.1	8.2	8.1	7.5	5.6	5.6
	RATIO	0.938	0.783	0.886	0.662	0.852	0.799	0.866	0.634	0.605	0.791
STAFFORD-001 (4700)	OZONE	.238	.153	.152	.149	.143	.140	.136	.134	.134	.131
	DATE	6/22/88	7/16/88	6/16/88	7/11/88	7/10/88	5/28/88	8/ 3/88	6/20/88	8/ 2/88	7/ 8/88
METEOROLOGICAL SITE	DIR (DEG)	230	220	210	230	170	200	180	230	140	120
NEWARK	VEL (MPH)	10.0	6.8	6.0	7.8	5.9	6.4	5.7	8.9	5.3	3.3
	SPD (MPH)	11.1	10.6	9.3	10.2	9.6	8.9	9.8	11.1	6.2	6.3
	RATIO	0.903	0.639	0.640	0.763	0.611	0.715	0.587	0.805	0.852	0.522
METEOROLOGICAL SITE	DIR (DEG)	200	200	210	300	230	190	190	190	190	160
BRADLEY	VEL (MPH)	6.3	7.9	3.5	2.5	4.1	6.8	6.4	7.0	4.2	4.2
	SPD (MPH)	7.6	8.9	9.6	6.5	6.8	8.3	8.5	8.5	6.5	6.9
	RATIO	0.823	0.884	0.358	0.385	0.607	0.813	0.750	0.825	0.656	0.612
METEOROLOGICAL SITE	DIR (DEG)	210	230	220	220	230	220	220	220	170	230
BRIDGEPORT	VEL (MPH)	6.0	8.2	6.9	6.7	6.0	7.8	7.0	8.7	4.0	6.3
	SPD (MPH)	7.5	8.8	7.0	8.2	6.3	8.1	7.5	9.3	4.5	8.5
	RATIO	0.809	0.933	0.973	0.824	0.943	0.964	0.931	0.935	0.894	0.744
METEOROLOGICAL SITE	DIR (DEG)	240	250	250	270	280	280	260	250	270	250
WORCESTER	VEL (MPH)	5.7	8.0	5.5	4.2	5.7	6.3	6.2	9.4	3.9	4.7
	SPD (MPH)	6.0	9.5	7.3	6.3	6.5	8.2	7.6	11.8	5.8	7.5
	RATIO	0.938	0.839	0.748	0.662	0.886	0.768	0.811	0.796	0.674	0.634
STRATFORD-007 (4576)	OZONE	.221	.213	.197	.181	.180	.178	.168	.161	.159	.153
	DATE	7/11/88	8/13/88	6/22/88	6/15/88	6/14/88	8/ 1/88	7/10/88	7/30/88	7/27/88	8/12/88
METEOROLOGICAL SITE	DIR (DEG)	230	240	230	260	260	160	170	260	220	230
NEWARK	VEL (MPH)	7.8	9.5	10.0	6.3	6.6	4.7	5.9	5.3	4.0	6.3
	SPD (MPH)	10.2	11.6	11.1	8.8	7.8	5.6	9.6	6.8	6.3	8.2
	RATIO	0.763	0.816	0.903	0.716	0.853	0.845	0.611	0.780	0.630	0.769
METEOROLOGICAL SITE	DIR (DEG)	300	230	200	250	260	220	230	240	210	300
BRADLEY	VEL (MPH)	2.5	5.1	6.3	5.7	4.7	2.7	4.1	3.1	2.7	2.3
	SPD (MPH)	6.5	6.9	7.6	8.3	6.2	5.3	6.8	5.9	4.6	5.8
	RATIO	0.385	0.740	0.823	0.682	0.767	0.512	0.607	0.532	0.585	0.406
METEOROLOGICAL SITE	DIR (DEG)	220	240	210	230	230	220	230	220	230	240
BRIDGEPORT	VEL (MPH)	6.7	7.7	6.0	6.1	6.5	3.2	6.0	5.9	7.9	7.9
	SPD (MPH)	8.2	8.1	7.5	6.3	8.1	5.0	6.3	6.2	8.3	8.5
	RATIO	0.824	0.957	0.809	0.971	0.813	0.628	0.943	0.962	0.952	0.926
METEOROLOGICAL SITE	DIR (DEG)	270	280	240	280	300	300	280	280	260	290
WORCESTER	VEL (MPH)	4.2	6.1	5.7	6.2	7.0	3.4	5.7	6.5	4.4	5.3
	SPD (MPH)	6.3	7.8	6.0	7.5	8.1	5.6	6.5	8.2	5.6	6.9
	RATIO	0.662	0.783	0.938	0.827	0.866	0.605	0.886	0.799	0.791	0.774

V. NITROGEN DIOXIDE

HEALTH EFFECTS

Nitrogen dioxide (NO_2) 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_2 in the atmosphere is accounted for by the conversion of nitric oxide (NO) to NO_2 by means of the photochemical interaction between nitrogen oxide compounds and hydrocarbons. 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_2 is believed to increase the risks of acute respiratory disease and susceptibility to chronic respiratory infection. NO_2 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_2 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_2 is an essential ingredient, along with hydrocarbons, in the formation of ozone.

CONCLUSIONS

Nitrogen dioxide (NO_2) concentrations at all monitoring sites did not violate the NAAQS for NO_2 in 1988. The annual arithmetic mean NO_2 concentration at each site was well below the federal standard of 100 $\mu g/m^3$.

SAMPLE COLLECTION AND ANALYSIS

The DEP Air Monitoring Unit used continuous electronic analyzers employing the chemiluminescent reference method to continuously measure NO_2 levels.

DISCUSSION OF DATA

Monitoring Network - There were three nitrogen dioxide monitoring sites in 1988 (see Figure 5-1). The sites -- Bridgeport 013, East Hartford 003 and New Haven 123 -- were located in three urban areas near major expressways in order to obtain maximum NO_2 readings.

Precision and Accuracy - Forty-eight precision checks were made on the NO_2 monitors in 1988, yielding 95% probability limits ranging from -7% to + 10%. Accuracy is determined by introducing a known amount of NO_2 into each of the monitors. Eight audits for accuracy were conducted on the monitoring network in 1988. Four different concentration levels were tested on each monitor: low, low/medium, medium/high and high. The 95% probability limits for the low level test ranged from -7% to + 9%; those for the low/medium level test ranged from -7% to + 5%; those for the medium/high level test ranged from -5% to 0%; and those for the high level test ranged from -5% to + 1%.

Historical Data - The DEP's historical file of annual average nitrogen dioxide data from gas bubblers for 1973-1980 is available in the 1980 Air Quality Summary. Data from continuous electronic analyzers for the years 1981 through 1987 can be found in each respective year's Air Quality Summary.

Annual Averages - The annual average NO_2 standard of 100 $\mu g/m^3$ was not exceeded in 1988 at any site in Connecticut (see Table 5-1). In 1988, all three sites had sufficient data to compute valid arithmetic means. This permits comparisons with the 1986 and 1987 annual averages - except for Bridgeport 013 which replaced Bridgeport 123 in 1988. The annual average NO_2 concentration increased at New Haven 123 and decreased slightly at East Hartford 003 between 1987 and 1988.

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_2 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_2 concentrations in order to allow direct comparison to the annual NO_2 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 $\mu g/m^3$ in 1988.

10-High Days with Wind Data - Table 5-2 presents for each site the ten days in 1988 when the highest hourly NO_2 readings occurred, along with the associated wind conditions for each day. (See the discussion of Table 2-5 in the particulate matter section for a description of the origin and use of the wind data.)

According to National Weather Service local climatological data recorded at Bradley Airport, 14 of the 18 days listed in the table had at least 50% of the possible sunshine. This is interpreted to confirm the importance of photochemical oxidation in the formation of NO_2.

Using the National Weather Service data from the Bridgeport meteorological site for Bridgeport 013 and New Haven 123, and using the data from Bradley for East Hartford 003, one finds that over 80% of the days have persistent winds out of the southwest. This is not unexpected given the fact that the NO_2 sites were deliberately located to the north and east of major expressways and interchanges, which are major sources of nitrogen oxide emissions.

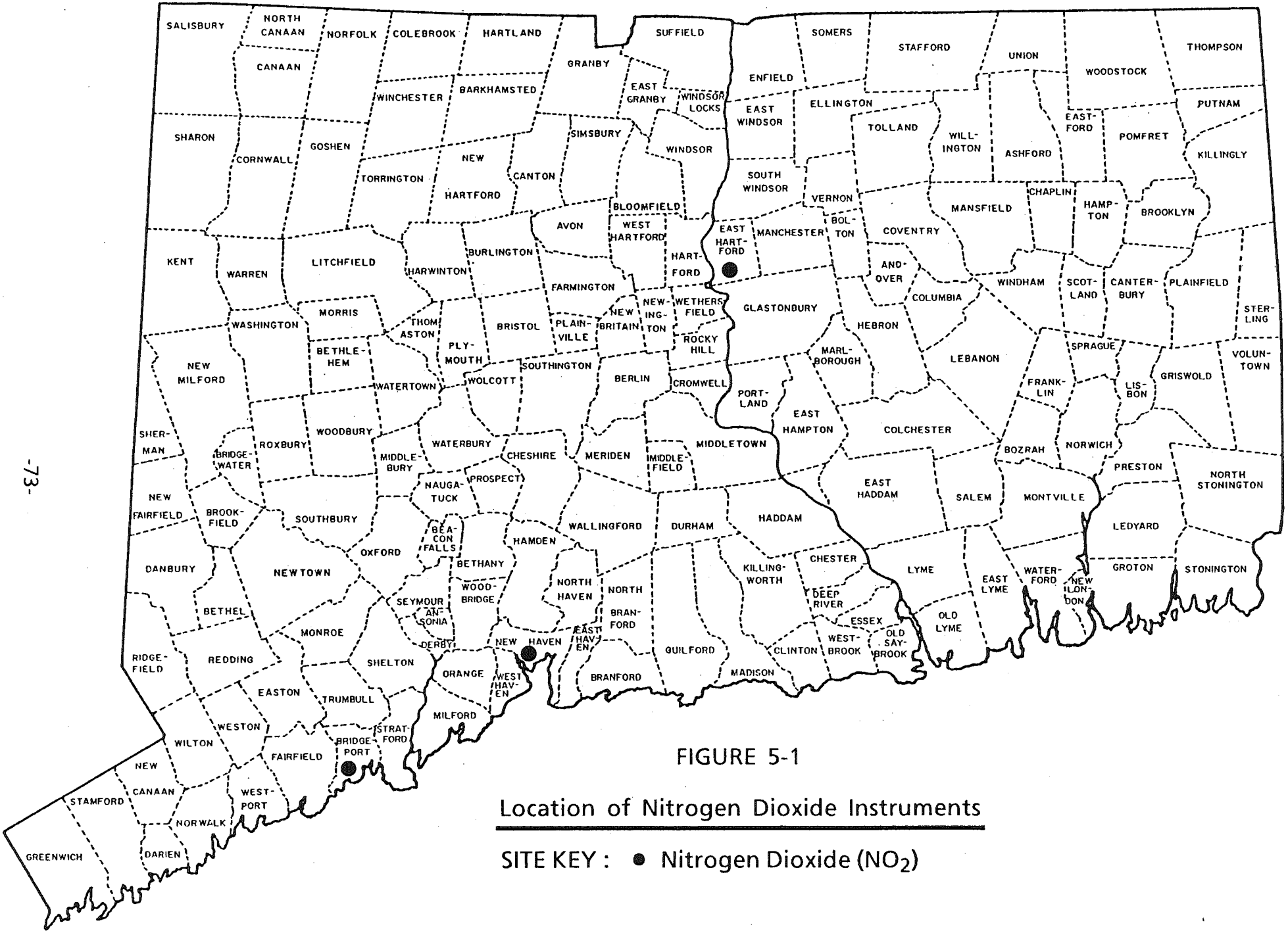


FIGURE 5-1

Location of Nitrogen Dioxide Instruments

SITE KEY : ● Nitrogen Dioxide (NO_2)

TABLE 5-1

1986 -1988 NITROGEN DIOXIDE ANNUAL AVERAGES

Town Name	Site	Year	Samples	Arithmetic Mean	95-Percent-Limits Lower	Upper	Standard Deviation
Bridgeport	123	1986	8093	50.02	49.87	50.18	25.90
Bridgeport	123	1987	7701	48.43	48.21	48.64	28.02
Bridgeport	013	1988	8674	51.03	50.97	51.10	27.18
East Hartford	003	1986	8272	40.77	40.65	40.88	22.60
East Hartford	003	1987	8522	38.70	38.62	38.78	23.85
East Hartford	003	1988	8702	38.42	38.37	38.47	23.39
New Haven	123	1986	8057	54.34	54.18	54.51	26.46
New Haven	123	1987	7887	53.70	53.51	53.89	27.42
New Haven	123	1988	8695	55.26	55.21	55.32	26.38

N.B. The arithmetic mean and standard deviation have units of $\mu g/m^3$.

TABLE 5-2

1988 TEN HIGHEST 1-HOUR AVERAGE NO2 DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN-SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
BRIDGEPORT-013 (8674)	NO2	.107	.103	.098	.095	.090	.088	.086	.086	.083	.083
	DATE	1/16/88	6/14/88	6/22/88	10/15/88	2/17/88	1/12/88	1/11/88	12/20/88	5/23/88	7/11/88
METEOROLOGICAL SITE	DIR (DEG)	200	260	230	220	250	170	220	200	200	230
NEWARK	VEL (MPH)	4.6	6.6	10.0	6.3	3.9	3.3	3.5	7.1	2.2	7.8
	SPD (MPH)	5.8	7.8	11.1	8.2	5.5	5.0	4.6	8.9	6.2	10.2
	RATIO	0.797	0.853	0.903	0.769	0.719	0.655	0.771	0.794	0.353	0.763
METEOROLOGICAL SITE	DIR (DEG)	170	260	200	110	170	180	170	190	180	300
BRADLEY	VEL (MPH)	3.0	4.7	6.3	1.8	5.2	2.2	2.2	6.9	5.8	2.5
	SPD (MPH)	4.9	6.2	7.6	3.2	6.5	4.9	4.7	8.8	7.8	6.5
	RATIO	0.617	0.767	0.823	0.585	0.811	0.452	0.467	0.789	0.753	0.385
METEOROLOGICAL SITE	DIR (DEG)	250	230	210	240	230	60	270	240	230	220
BRIDGEPORT	VEL (MPH)	5.0	6.5	6.0	4.9	4.1	1.8	4.0	4.9	6.2	6.7
	SPD (MPH)	6.9	8.1	7.5	5.5	4.7	2.0	7.3	4.9	6.6	8.2
	RATIO	0.727	0.813	0.809	0.892	0.860	0.892	0.541	0.994	0.941	0.824
METEOROLOGICAL SITE	DIR (DEG)	270	300	240	290	270	250	270	250	280	270
WORCESTER	VEL (MPH)	7.5	7.0	5.7	3.4	4.9	4.7	7.2	12.2	6.0	4.2
	SPD (MPH)	9.8	8.1	6.0	5.2	7.2	8.3	8.6	15.5	7.9	6.3
	RATIO	0.764	0.866	0.938	0.662	0.679	0.560	0.838	0.788	0.761	0.662
EAST HARTFORD-003 (8702)	NO2	.094	.077	.076	.075	.074	.069	.067	.067	.066	.065
	DATE	1/12/88	1/16/88	11/23/88	1/11/88	6/15/88	1/29/88	6/14/88	1/31/88	3/24/88	6/21/88
METEOROLOGICAL SITE	DIR (DEG)	170	200	330	220	260	180	260	220	220	290
NEWARK	VEL (MPH)	3.3	4.6	3.2	3.5	6.3	2.3	6.6	3.4	6.9	7.0
	SPD (MPH)	5.0	5.8	6.8	4.6	8.8	4.9	7.8	5.2	11.5	11.2
	RATIO	0.655	0.797	0.470	0.771	0.716	0.468	0.853	0.651	0.600	0.623
METEOROLOGICAL SITE	DIR (DEG)	180	170	330	170	250	180	260	180	210	310
BRADLEY	VEL (MPH)	2.2	3.0	3.5	2.2	5.7	3.0	4.7	8.1	3.8	7.1
	SPD (MPH)	4.9	4.9	5.2	4.7	8.3	5.2	6.2	11.1	9.9	8.1
	RATIO	0.452	0.617	0.670	0.467	0.682	0.572	0.767	0.729	0.384	0.888
METEOROLOGICAL SITE	DIR (DEG)	60	250	340	270	230	240	230	250	230	280
BRIDGEPORT	VEL (MPH)	1.8	5.0	8.7	4.0	6.1	4.1	6.5	6.3	6.4	4.3
	SPD (MPH)	2.0	6.9	9.3	7.3	6.3	6.8	8.1	6.3	8.5	7.5
	RATIO	0.892	0.727	0.926	0.541	0.971	0.609	0.813	0.990	0.752	0.578
METEOROLOGICAL SITE	DIR (DEG)	250	270	310	270	280	300	300	260	260	310
WORCESTER	VEL (MPH)	4.7	7.5	7.2	7.2	6.2	3.0	7.0	8.4	7.0	6.4
	SPD (MPH)	8.3	9.8	8.8	8.6	7.5	5.5	8.1	10.9	12.1	7.8
	RATIO	0.560	0.764	0.822	0.838	0.827	0.552	0.866	0.773	0.581	0.829
NEW HAVEN-123 (8695)	NO2	.121	.120	.106	.098	.097	.097	.097	.095	.091	.089
	DATE	6/15/88	7/11/88	1/16/88	6/21/88	6/13/88	1/11/88	7/29/88	1/12/88	6/14/88	2/17/88
METEOROLOGICAL SITE	DIR (DEG)	260	230	200	290	280	220	240	170	260	250
NEWARK	VEL (MPH)	6.3	7.8	4.6	7.0	5.8	3.5	4.4	3.3	6.6	3.9
	SPD (MPH)	8.8	10.2	5.8	11.2	7.0	4.6	6.6	5.0	7.8	5.5
	RATIO	0.716	0.763	0.797	0.623	0.830	0.771	0.659	0.655	0.853	0.719
METEOROLOGICAL SITE	DIR (DEG)	250	300	170	310	300	170	120	180	260	170
BRADLEY	VEL (MPH)	5.7	2.5	3.0	7.1	4.8	2.2	2.1	2.2	4.7	5.2
	SPD (MPH)	8.3	6.5	4.9	8.1	6.0	4.7	5.3	4.9	6.2	6.5
	RATIO	0.682	0.385	0.617	0.888	0.798	0.467	0.402	0.452	0.767	0.811

TABLE 5–2, CONTINUED

1988 TEN HIGHEST 1–HOUR AVERAGE NO2 DAYS WITH WIND DATA

UNITS : PARTS PER MILLION

TOWN–SITE (SAMPLES)	RANK	1	2	3	4	5	6	7	8	9	10
METEOROLOGICAL SITE	DIR (DEG)	230	220	250	280	260	270	200	60	230	230
BRIDGEPORT	VEL (MPH)	6.1	6.7	5.0	4.3	6.7	4.0	4.4	1.8	6.5	4.1
	SPD (MPH)	6.3	8.2	6.9	7.5	7.2	7.3	4.7	2.0	8.1	4.7
	RATIO	0.971	0.824	0.727	0.578	0.931	0.541	0.937	0.892	0.813	0.860
METEOROLOGICAL SITE	DIR (DEG)	280	270	270	310	300	270	300	250	300	270
WORCESTER	VEL (MPH)	6.2	4.2	7.5	6.4	8.6	7.2	5.0	4.7	7.0	4.9
	SPD (MPH)	7.5	6.3	9.8	7.8	9.5	8.6	6.2	8.3	8.1	7.2
	RATIO	0.827	0.662	0.764	0.829	0.903	0.838	0.812	0.560	0.866	0.679

VI. CARBON MONOXIDE

HEALTH EFFECTS

Carbon monoxide (CO) is a colorless, odorless, poison gas formed when carbon-containing fuel is not burned completely. It is by far the most plentiful air pollutant. Fortunately, this deadly gas does not persist in the atmosphere. It is apparently converted by natural processes to harmless carbon dioxide in ways not yet understood, 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, judgement 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. Death can come from heart failure or general asphyxiation if a person is exposed to very high levels of CO.

CONCLUSIONS

The eight-hour National Ambient Air Quality Standard of 9 parts per million (ppm) was exceeded at one of the five carbon monoxide monitoring sites in Connecticut during 1988. There were three exceedances at Hartford 017, which means that the 8-hour standard was violated at this site. No exceedance of the 35 ppm one-hour standard was measured at any site in 1988.

In order to put the monitoring data into proper perspective, it must be realized that carbon monoxide concentrations vary greatly from place-to-place. More than 95% of the CO emissions in Connecticut come from motor vehicles. Therefore, concentrations are greatest in areas of traffic congestion. The magnitude and frequency of high concentrations observed at any monitoring site are not necessarily indicative of widespread CO levels. In fact, CO monitors in Connecticut are sited specifically to measure CO levels in neighborhoods and at traffic intersections.

The CO standards are likely to be exceeded in any city in the state where there are areas of traffic congestion. However, as Connecticut's SIP control strategies are implemented, there should continue to be a decrease in the number of congested areas. Also, as federally - mandated controls which reduce emissions from new motor vehicles are implemented, a reduction in ambient CO levels should be achieved.

Unlike SO_2, particulate matter, and O_3, elevated CO levels are not often associated with southwesterly winds, 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 low atmospheric mixing heights and stable conditions are more prevalent. Stable conditions, which are characterized by cold temperatures at the surface and warm temperatures aloft, 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 Air Monitoring Unit 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 lines. 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 network in 1988 consisted of five carbon monoxide monitors: Bridgeport 004, Hartford 013, Hartford 017, New Haven 019, and Stamford 020. They are all located in urban areas. All the sites are located west of the Connecticut River, with three of them in coastal towns (see Figure 6-1). Hartford 013 is a relatively new site and has been in existence for two years.

Precision and Accuracy - The carbon monoxide monitors had a total of 91 precision checks during 1988. The resulting 95% probability limits were -15% to + 15%. Accuracy is determined by introducing a known amount of CO into each of the monitors. Eight audits for accuracy were conducted on the monitoring network in 1988. Three different concentration levels were tested on each monitor: low, medium and high. The 95% probability limits ranged from -25% to + 10% for the low level test; -7% to + 1% for the medium level test; and -4% to + 1% for the high level test.

8-Hour and 1-Hour Averages - Hartford 017 had a second high CO concentration exceeding the 8-hour standard of 9 ppm, which means that the standard was violated at this site in 1988 (see Table 6-1). This has been the case since the monitor began operating in 1984. Regarding the maximum 8-hour running average at each site, there were increases from 1987 to 1988 at Bridgeport 004, Hartford 013 and Stamford 020. Decreases occurred at Hartford 017 and New Haven 019. The second highest 8-hour running average increased from 1987 to 1988 at Hartford 013 and Stamford 020 and decreased at Bridgeport 004, Hartford 017 and Stamford 020.

As for 1-hour averages, no site in the state recorded a value exceeding the primary 1-hour standard of 35 ppm. Both Hartford 013 and Stamford 020 recorded maximum 1-hour values greater than the year before. Second high 1-hour values were also higher in 1988 at these sites, as well as at Bridgeport 004.

The maximum and second high CO concentrations at each site are presented in Table 6-1. Table 6-2 presents monthly highs and a monthly tally of the number of times the standards were exceeded 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 and in Figure 6-2. One can see that over the past five years the Hartford-017 site has shown a higher frequency of exceedances relative to the other sites, albeit with no established trend. The number of exceedances shows a downward trend at Stamford 020. No exceedances are evident at Bridgeport 004, Hartford 013 or New Haven 019, and for this reason these sites are excluded from Figure 6-2.

Another way of illustrating local CO trends is to use running averages. Running averages have the advantage of smoothing out the abrupt, transitory changes in pollutant levels that are often evident in consecutive sampling periods and from one season to the next. Figure 6-3 shows the 36-month running averages of the hourly CO concentrations at Bridgeport 004, Hartford 017 and Stamford 020. CO levels seem to be trending downward at these three sites. The Hartford 013 and the New Haven 019 sites are not included because they lack sufficient data.

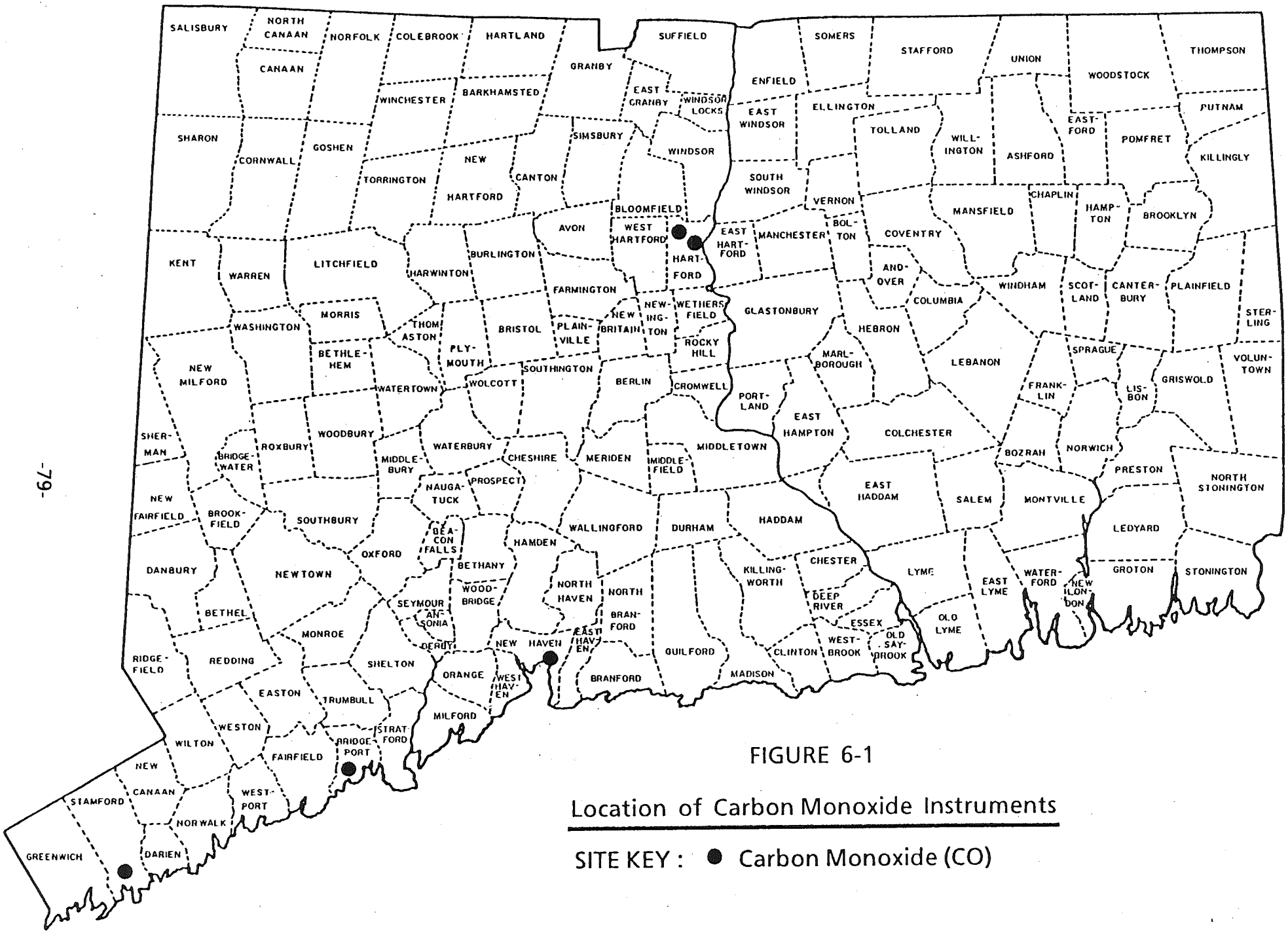


FIGURE 6-1

Location of Carbon Monoxide Instruments

SITE KEY : ● Carbon Monoxide (CO)

TABLE 6-1

1988 CARBON MONOXIDE STANDARDS ASSESSMENT SUMMARY

TOWN-SITE	MAXIMUM 8-HOUR RUNNING AVERAGE	TIME OF MAXIMUM 8-HOUR RUNNING AVERAGE[1]	2ND HIGH 8-HOUR RUNNING AVERAGE	TIME OF 2ND HIGH 8-HOUR RUNNING AVERAGE[1]	MAXIMUM 1-HOUR AVERAGE	TIME OF MAXIMUM 1-HOUR AVERAGE[2]	2ND HIGH 1-HOUR AVERAGE	TIME OF MAXIMUM 1-HOUR AVERAGE[2]
Bridgeport-004	6.7	11/26/24	5.1	11/26/21	9.4	01/25/09	8.8	01/11/10
Hartford-013	4.4	01/11/12	4.4	01/12/13	7.3	01/25/08	6.6	01/11/09
Hartford-017	13.1	01/18/19	10.1	01/11/23	21.0	01/18/19	19.9	01/18/18
New Haven-019	7.4	11/27/04	7.0	12/19/24	10.6	01/11/18	10.6	12/14/18
Stamford-020	8.6	02/02/15	6.9	11/26/24	12.8	02/02/10	11.2	01/19/09

[1] The time of the 8-hour average is reported as follows: month/day/hour (EST), specifying the end of the 8-hour period.
[2] 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

1988 CARBON MONOXIDE SEASONAL FEATURES

TOWN-SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bridgeport-004	Max. 1-Hour	9.4	6.8	4.3	4.7	3.8	5.2	4.0	3.9	3.9	5.0	8.5	8.1
	Max. Running 8-Hour	5.0	4.5	3.5	3.6	2.7	3.2	3.2	3.2	3.1	3.5	6.7	4.7
	No. of 8-Hour Exceedances	0	0	0	0	0	0	0	0	0	0	0	0
Hartford-013	Max. 1-Hour	7.3	4.4	2.6	2.8	2.3	2.7	1.7	1.8	2.7	3.9	5.2	5.5
	Max. Running 8-Hour	4.4	2.9	2.5	2.2	1.5	1.6	1.0	1.2	1.5	2.8	4.1	3.8
	No. of 8-Hour Exceedances	0	0	0	0	0	0	0	0	0	0	0	0
Hartford-017	Max. 1-Hour	21.0	10.0	13.1	8.6	6.8	8.2	7.4	7.5	8.6	8.3	10.1	11.5
	Max. Running 8-Hour	13.1	6.2	6.2	5.5	5.1	5.8	5.8	5.9	5.4	6.1	7.9	8.5
	No. of 8-Hour Exceedances	3	0	0	0	0	0	0	0	0	0	0	0
New Haven-019	Max. 1-Hour	10.6	7.4	7.6	6.3	4.6	5.8	6.2	6.8	4.7	8.0	9.3	10.6
	Max. Running 8-Hour	6.9	3.8	3.4	3.7	3.4	4.2	4.0	4.4	3.6	4.3	7.4	7.0
	No. of 8-Hour Exceedances	0	0	0	0	0	0	0	0	0	0	0	0
Stamford-020	Max. 1-Hour	11.2	12.8	5.9	8.3	4.2	5.7	5.4	4.9	5.0	10.3	8.6	10.3
	Max. Running 8-Hour	6.6	8.6	5.8	3.6	3.3	4.2	4.2	3.3	3.2	3.9	6.9	5.6
	No. of 8-Hour Exceedances	0	0	0	0	0	0	0	0	0	0	0	0

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

TABLE 6-3

EXCEEDANCES OF THE 8-HOUR CO STANDARD FOR 1984 -1988

SITE	1984	1985	1986	1987	1988
Bridgeport-004	0	0	0	0	0
Hartford-013	-	-	-	0[a]	0
Hartford-017	7	5	3	8	3
New Haven-019	-	-	0[b]	0	0
Stamford-020	2	1	1	0	0

[a] Data is missing for January and February.
[b] Data is missing for January through March.

FIGURE 6-2

EXCEEDANCES OF THE 8-HOUR CO STANDARD FOR 1984-1988

SITE: HARTFORD-017

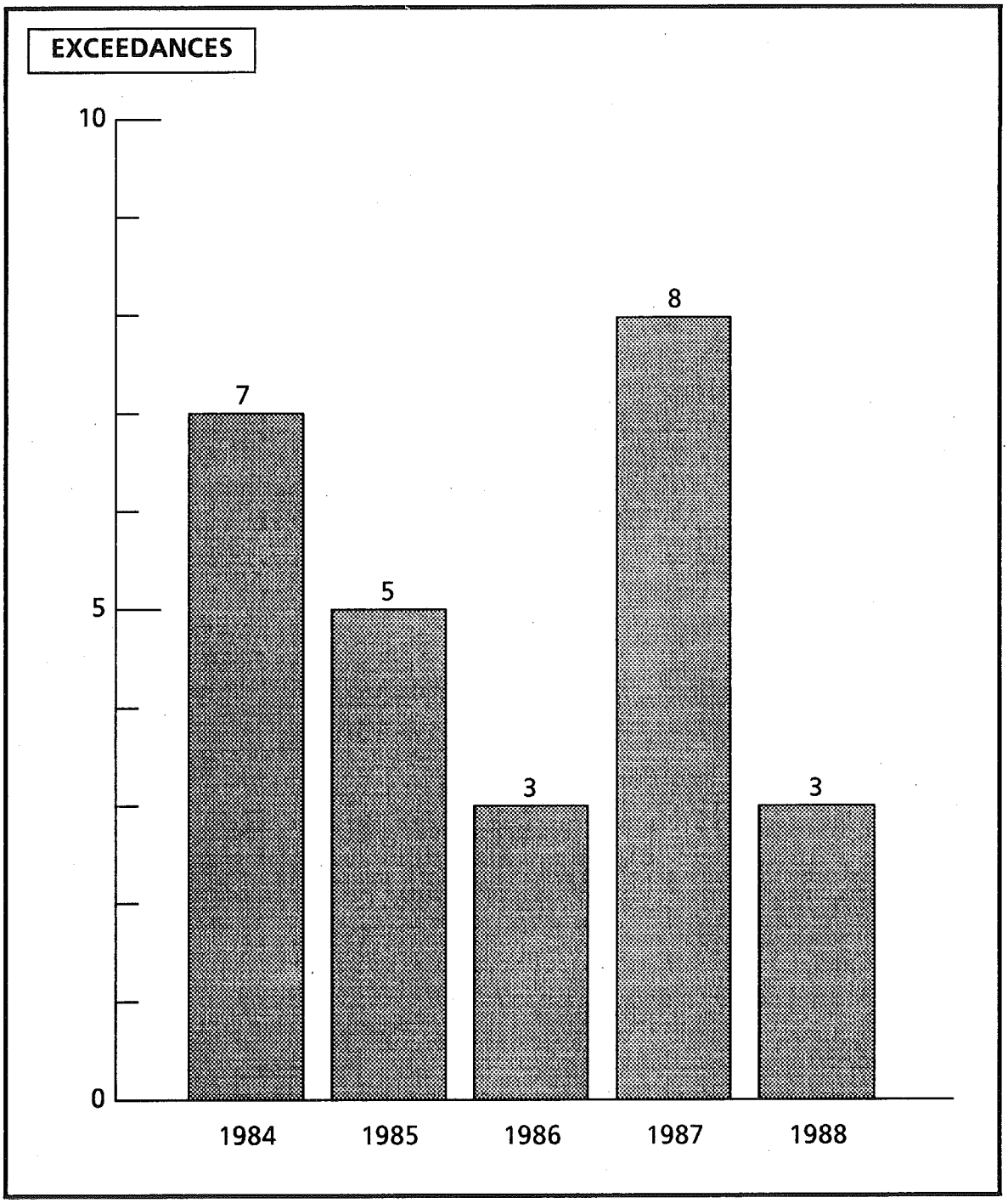


FIGURE 6-2, CONTINUED

EXCEEDANCES OF THE 8-HOUR CO STANDARD FOR 1984-1988

SITE: STAMFORD-020

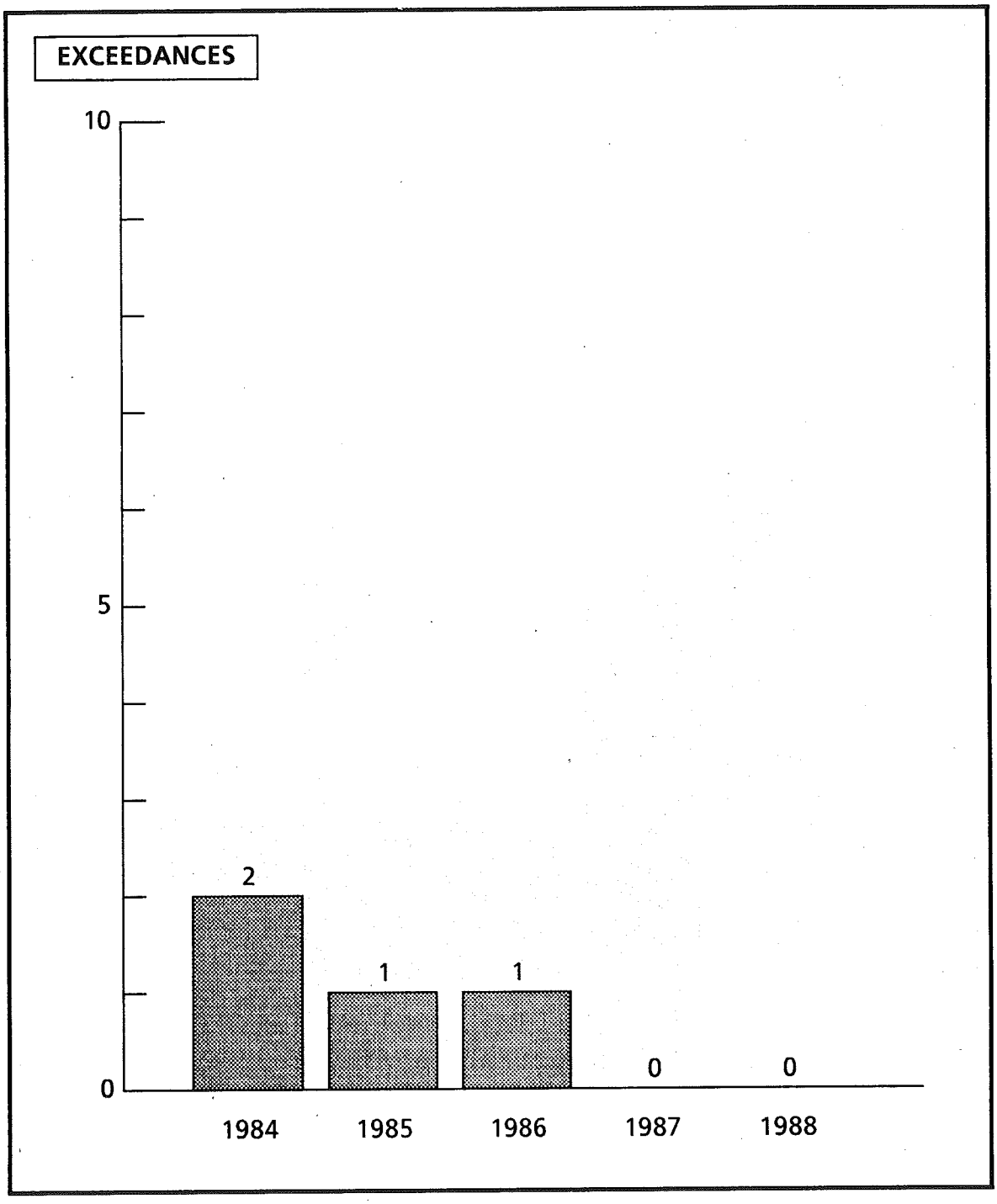
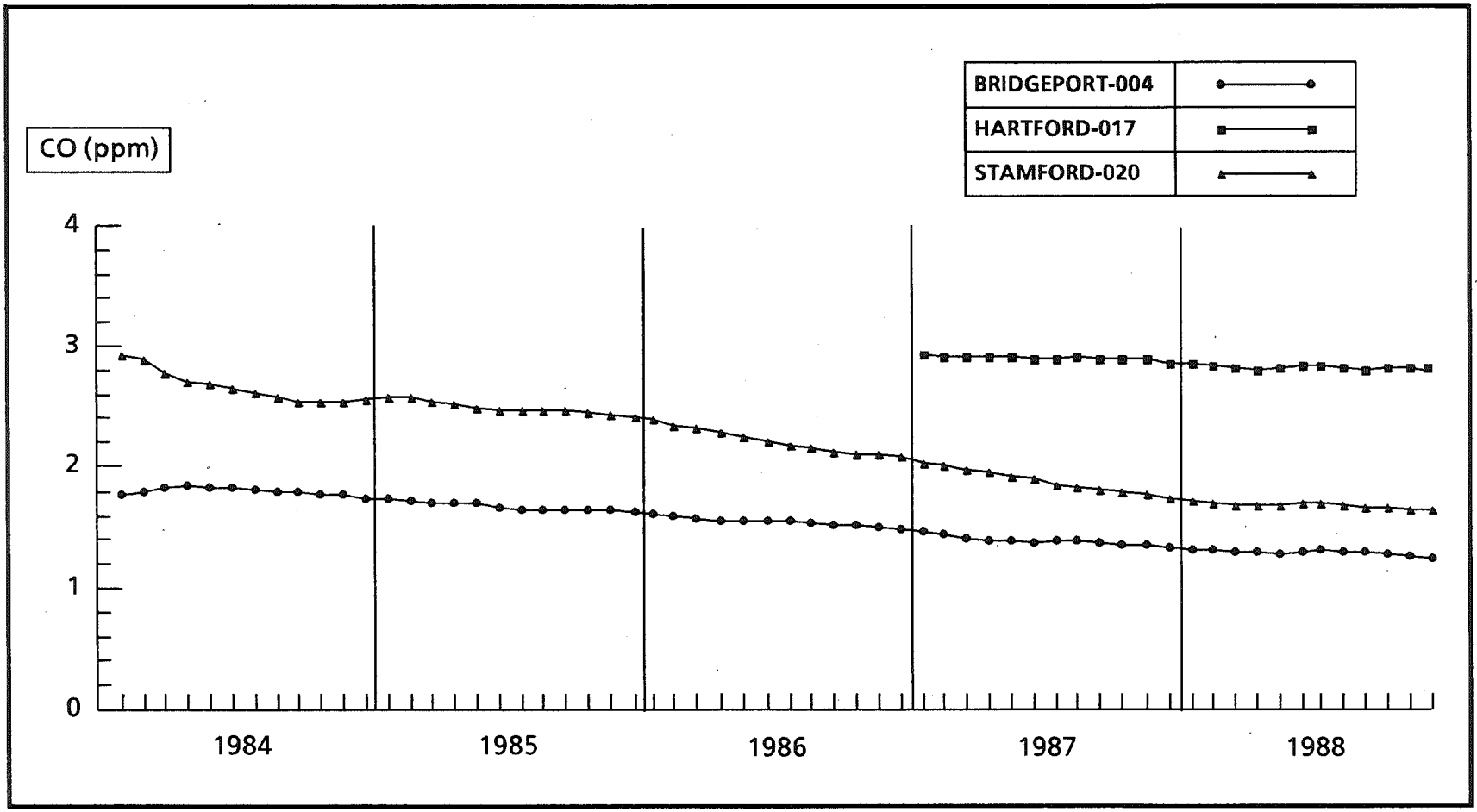


FIGURE 6-3

36-MONTH RUNNING 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 the operation of motor vehicles. Nationally, in 1988, these source categories contributed 26%, 33% and 34%, respectively, of the atmospheric lead. The motor vehicle contribution, while still the largest source of airborne lead emissions, has decreased significantly from a 71% share in 1985. These emissions are in the form of fine-to-course 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 was not exceeded at any site in Connecticut during 1988.

The monitoring sites where the lead levels were highest were generally in urban locations with moderate to heavy traffic. In Connecticut, this is due to the fact that the primary source of lead to the atmosphere is the combustion of gasoline, which still contains small amounts of lead.

A downward trend in measured concentrations of lead has been observed since 1977. This is probably due to the increasing use of unleaded gasoline. Figure 7-1 shows that the decrease in statewide ambient average lead concentrations has been commensurate with a decrease in lead emissions from gasoline combustion from 1979 to 1988. In fact, this relationship is so close it has a correlation coefficient of 0.957 (see Figure 7-2). Regarding Figures 7-1 and 7-2, the reader should note that after 1981 a change occurred in the way in which lead concentrations were determined. From 1979 through 1981, lead

concentrations were determined by analysis of individual daily samples from existing TSP monitors. Beginning in 1982, lead concentrations were determined by analysis of monthly composite samples from only approved lead monitors. Both the single sample and monthly composite data points are depicted in Figure 7-1 for 1982. The discontinued method gives a lower average lead concentration in 1982 than the new method. The higher average lead concentration is used in Figure 7-2.

SAMPLE COLLECTION AND ANALYSIS

The Air Monitoring Unit used hi-vol and lo-vol samplers in 1988 to obtain ambient concentrations of lead. These samplers are used to collect particulate matter onto fiberglass filters. The particulate matter collected on the filters 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. The lo-vol sampler is similar to the hi-vol sampler, except that it operates continuously, at a reduced flow rate, for an entire month. Because this results in a one month integrated sample, compositing is not required.

DISCUSSION OF DATA

Monitoring Network - In 1988, both hi-vol and lo-vol samplers were operated in Connecticut to monitor lead levels (see Figure 7-3). There were 13 hi-vol monitors and 7 lo-vol monitors operated at 19 sites throughout the State as part of the State and Local Air Monitoring Stations (SLAMS) network and the National Air Monitoring Stations (NAMS) network (see Table 11-2). The DEP operated the lo-vol monitors in areas with populations of 200,000 or more. They are Bridgeport 010, Hartford 015 and 016, New Haven 018, Stamford 022, Waterbury 123 and West Haven 003. These "micro-scale" lead sites are situated near some of the busiest city streets and highways in order to monitor "worst-case" lead concentrations. EPA approval for these lo-vol monitors was granted in February 1984.

Much of the lead monitoring network was dismantled in 1988 due to the changeover from hi-vol to PM_{10} monitoring in the particulate matter network. By the end of the year, all of the hi-vol lead samplers were terminated, as were two of the lo-vols. The lo-vol samplers that remained in operation were Bridgeport 010, Hartford 015 and 016, New Haven 018 and Waterbury 123 .

Precision and Accuracy - The hi-vol lead monitors had a total of 19 precision checks at four sites in 1988. The resulting 95% probability limits were too low to calculate. Accuracy for lead can be assessed in two ways. One is by auditing the air flow through the monitors. On this basis, 20 audits for accuracy were conducted on the monitoring network in 1988, and they produced 95% probability limits that ranged from -7% to +6%. Accuracy can also be defined as the accuracy of the analysis method. This is determined by the chemical analysis of known lead samples. On this basis, 9 audits were performed on the network. Two different concentration levels were tested: high and low. The 95% probability limits for the low level ranged from -9% to + 10%; those for the high level ranged from -10% to + 15%.

NAAQS - Connecticut's ambient air quality standard for lead and its compounds, measured as elemental lead, is: 1.5 micrograms per cubic meter ($\mu g/m^3$), maximum arithmetic mean averaged over three consecutive calendar months. This standard was enacted on November 2, 1981. Previously, Connecticut's lead standard was substantially identical to the national standard: 1.5 $\mu g/m^3$ for a calendar quarter-year average. The change to a 3-month running average means that a more stringent standard applies in Connecticut, since there are three times as many data blocks within a calendar year which must be below the limiting concentration of 1.5 $\mu g/m^3$.

3-Month Running Averages - Three-month running average lead concentrations for 1988 are given in Table 7-1. All are significantly below the primary and secondary standard of 1.5 $\mu g/m^3$. The lead concentrations at the listed sites are also noticeably lower than those in 1987 and continue to trend downward.

Trends - As was mentioned above, airborne concentrations of lead have been trending steadily downward in Connecticut since 1977. This was demonstrated on a statewide level for the period 1979-1988 in Figure 7-1. The decrease in lead levels has been commensurate with the decrease in lead emissions from gasoline combustion.

However, the downward trend in airborne lead concentrations can be expected to level off at some point in the near future and and then begin to increase. This is due to the likelihood that, as the use of leaded gasoline is phased out, gasoline combustion will no longer be the major source of lead emissions. The small amounts of lead remaining in Connecticut's atmosphere will be primarily associated with incineration, demolition, reentrainment, coal burning, and removal of old paint from bridges, buildings and other structures. The increased processing of solid wastes and the construction of new solid waste incineration plants will begin to add moderate amounts of lead to the admittedly low prevalent airborne concentrations.

This can be illustrated by the changes in lead emissions that occurred from 1986 to 1988. Lead emissions from gasoline decreased from 96 metric tons to 31 metric tons, while emissions from stationary point sources increased from 10 metric tons to 18 metric tons in the same period. The increased point source emissions were the result of solid waste incineration plants that went into operation in Bridgeport, Bristol and Hartford.

FIGURE 7-1

STATEWIDE ANNUAL LEAD EMISSIONS FROM GASOLINE AND STATEWIDE ANNUAL AVERAGE LEAD CONCENTRATIONS

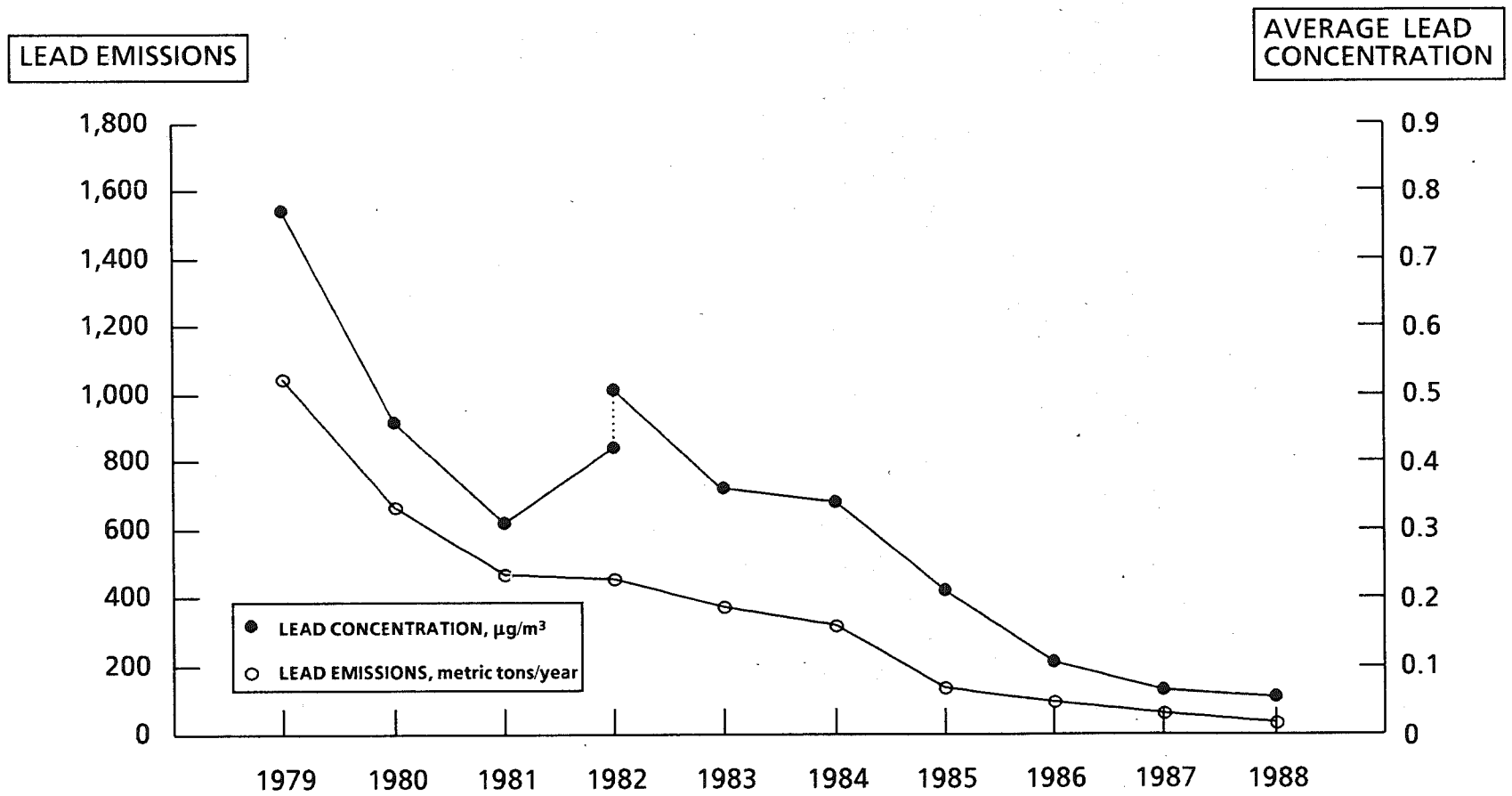
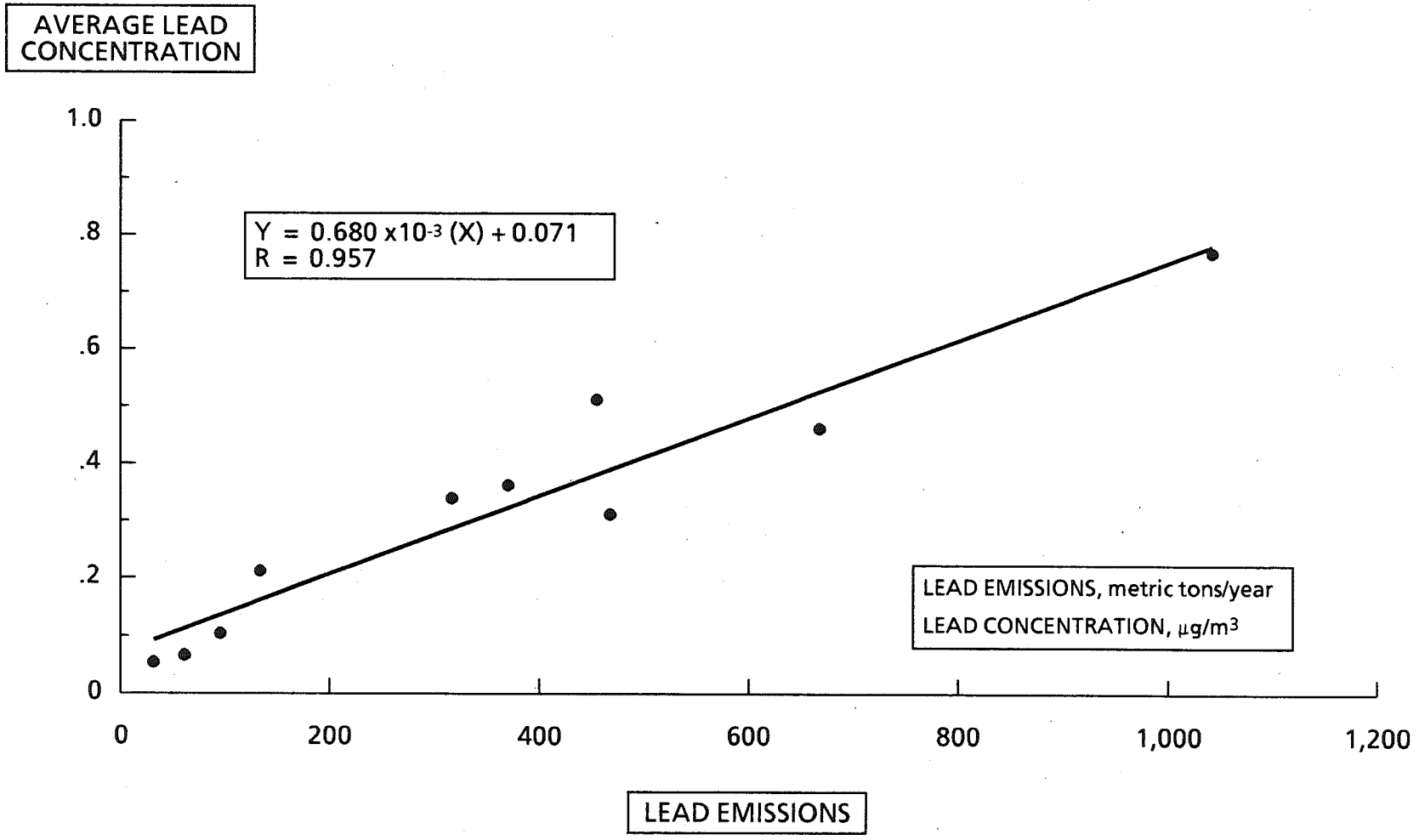


FIGURE 7-2

STATEWIDE ANNUAL AVERAGE LEAD CONCENTRATIONS

VS.

STATEWIDE ANNUAL LEAD EMISSIONS FROM GASOLINE



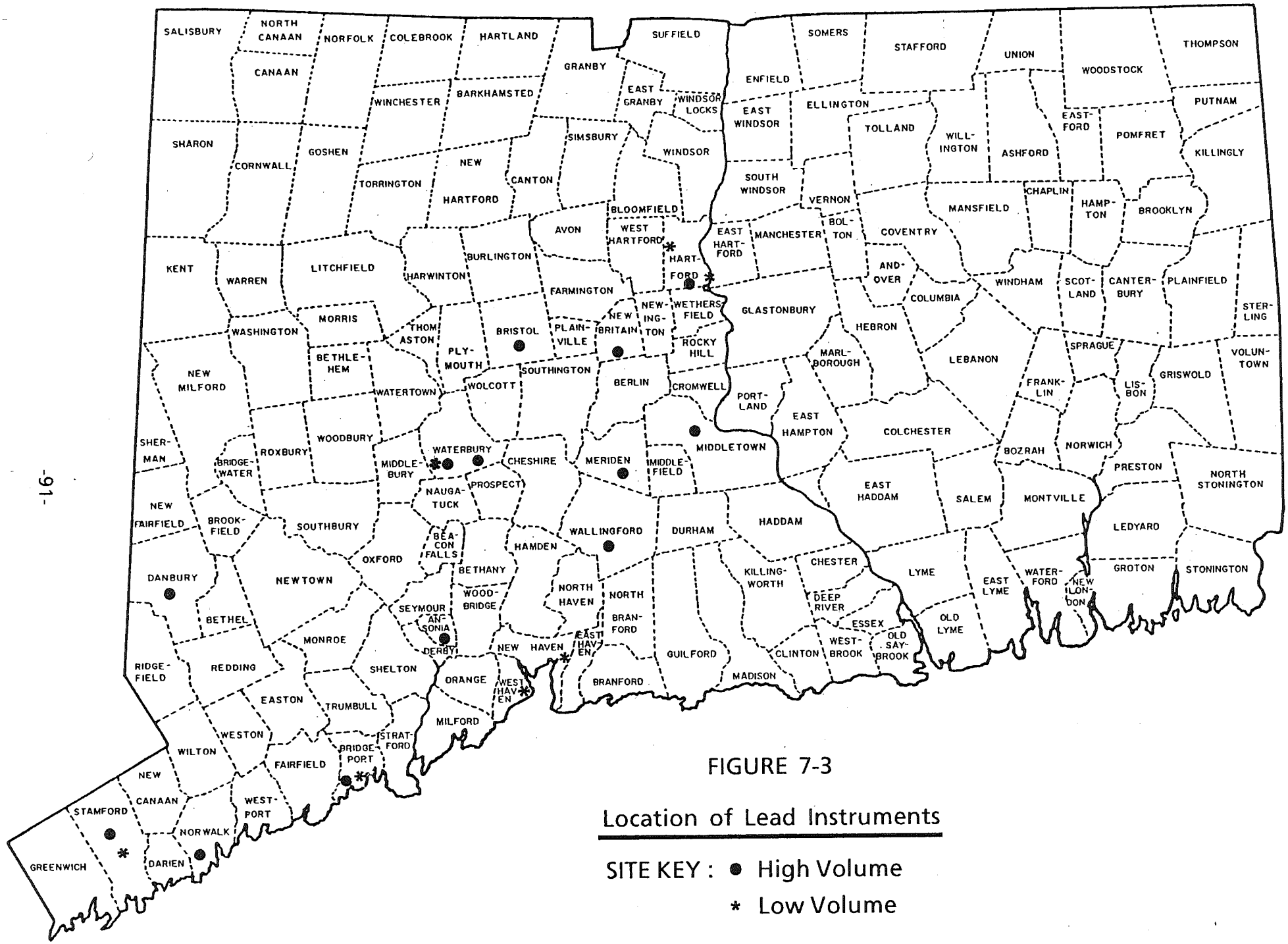


FIGURE 7-3

Location of Lead Instruments

SITE KEY : ● High Volume

* Low Volume

TABLE 7-1

1988 3-MONTH RUNNING AVERAGE LEAD CONCENTRATIONS[a]

TOWN-SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ansonia-004	0.060	0.053	0.043	0.030	------	------	------	------	------	------	------	------
Bridgeport-009	0.032	0.033	0.033	0.029	0.029	0.033	0.030	0.030	0.027	------	------	------
Bridgeport-010	------	------	------	0.063	0.060	------	------	------	------	0.050	0.043	0.043
Bristol-001	0.037	0.047	0.047	0.030	0.016	0.016	------	------	------	------	------	------
Danbury-002	0.043	0.043	0.037	0.024	------	------	------	------	------	------	------	------
Hartford-014	0.050	0.047	0.037	0.023	0.020	0.020	------	------	------	------	------	------
Hartford-015	------	------	------	0.050	0.043	0.047	0.047	0.040	0.030	0.033	0.043	0.057
Hartford-016	0.090	0.083	0.070	0.050	0.043	0.037	------	------	------	------	------	0.053
Meriden-002	0.040	0.033	0.030	0.023	0.023	0.020	0.016	------	------	------	------	------
Middletown-003	0.037	0.037	0.030	0.019	0.017	0.017	------	------	------	------	------	------
New Britain-007	0.034	0.037	0.034	0.027	0.020	0.020	------	------	------	------	------	------
New Haven-018	------	------	------	0.110	0.100	------	------	------	0.117	0.143	0.157	0.110
Norwalk-012	0.040	0.043	0.043	0.030	0.033	0.033	0.033	0.030	0.030	------	------	------
Stamford-001	0.043	0.040	0.037	0.027	0.030	0.033	0.033	------	------	------	------	------
Stamford-022	0.067	0.063	0.060	0.053	------	------	-----	-----	-----	------	------	------
Wallingford-001	0.043	0.037	0.030	0.017	0.013	0.013	0.017	0.023	0.026	0.023	------	------
Waterbury-007	0.097	------	------	------	------	0.049	------	------	------	------	------	------
Waterbury-123[b]	0.074	0.073	0.067	0.053	------	------	------	------	------	------	------	------
West Haven-003	0.063	0.057	0.043	0.033	------	------	------	------	------	------	------	------

[a] The lead concentrations are in terms of micrograms per cubic meter ($\mu g/m^3$).

[b] A hi-vol sampler operated through April and was replaced by a lo-vol sampler in June. There were insufficient monthly data to calculate 3-month averages for the lo-vol sampler.

VIII. ACID PRECIPITATION

MONITORING PROGRAM

Recently, there has been a growing public concern about the occurrence and effects of atmospheric deposition, most notably acid precipitation or "acid rain." It has become apparent that, in order to address this concern, basic data need to be collected on the chemical properties of precipitation. Recognizing this, the State of Connecticut, through the Department of Environmental Protection, has agreed to cooperate with the Water Resources Division of the United States Geological Survey (USGS) to establish the Connecticut Atmospheric Deposition Monitoring Program.

PROGRAM OBJECTIVES

The program is designed to collect and analyze precipitation on an event basis and has the following objectives:

(1) to determine selected chemical and physical properties of precipitation in Connecticut;

(2) to determine the spatial and temporal distribution of precipitation chemistry in the State;

(3) to determine the relationships between precipitation chemistry and meteorological conditions, such as storm track and air mass movement;

(4) to provide baseline information that can be used to determine trends and estimate loads; and

(5) to use techniques and methodologies consistent with those of the national monitoring networks in order to provide comparative information.

DATA COLLECTION SITES

Data collection sites have been established according to siting criteria used in the National Atmospheric Deposition Program (NADP). Use of these criteria ensures the validity of comparisons made between data which are collected through Connecticut's program and data from other atmospheric deposition programs. Other objectives considered during the siting process were the collection of samples representative of different geographic areas of the State, and the sampling of precipitation representative of long-range transport and not merely local sources. Using these criteria, precipitation sampling sites were established in the towns of Plainfield, Marlborough and Litchfield (Morris Dam). The locations of these sites are shown in Figure 8-1.

EQUIPMENT

Each site is equipped with an automatic wet-dry sensing type of precipitation collector -- the same type used by the NADP and the National Trends Network (NTN). The collector operates when precipitation wets an electronic sensor, completing an electrical circuit. This activates a motor that opens a lid over the sample container when the precipitation event begins and closes the lid when the precipitation ceases. The purpose of the lid is to retard the loss of samples through evaporation and to prevent contamination by dry fallout.

Each site is also equipped with an automatic rain gage which provides a record of the quantity of rain at 15-minute intervals.

DATA COLLECTION

Samples of precipitation are gathered from the automatic collectors as soon as possible following the end of a precipitation event, in most cases within 24 hours. The samples are immediately tested for acidity through pH measurements. The samples are also tested for specific conductance. This is a measure of the ions (i.e., the dissolved solids) in solution and, therefore, of the pollutant load.

Samples from selected precipitation events are also sent to a USGS laboratory for further analyses to determine the concentrations of additional chemical constituents, including major anions, cations, nutrients and trace metals.

Through the Connecticut Atmospheric Deposition Monitoring Program, a network capable of providing uninterrupted baseline data on precipitation quality within the State has been developed. Data collected through the program is currently being published monthly by the USGS in its report, Water Resources Conditions in Connecticut. Historical data are available from the Water Resources Division of the USGS or from the Natural Resources Center of the DEP at the addresses provided below. When using the data, one should note that they are specific only to the time and place of their collection.

DISCUSSION OF DATA

Presently, the data that have been collected in the initial stages of the study are being analyzed to determine, on a preliminary basis, the distribution and magnitude of atmospheric deposition in Connecticut. Because precipitation chemistry is a function of air quality and climate, both of which fluctuate over time and space, several more years of continuous data collection will be necessary to develop an adequate baseline to determine trends accurately and to more fully define the controlling processes. However, a preliminary evaluation of the data indicates that the precipitation occurring within Connecticut has been chemically affected by man-made contaminants. Normal rain has a pH of 5.6, which already places it in the acidic range. The current data show that the annual mean pH of the precipitation at the 3 data collection sites has varied between 4.1 and 4.4 from 1984 through 1988. The annualized data are presented in Table 8-1 and illustrated in Figure 8-2. Further evaluation of the data may provide more information on the source of the contaminants and the effects upon the environment.

It is important to stress that it is presently difficult to forecast statewide trends in the chemical properties of precipitation, or to perform comparative analyses, because of a lack of a large long-term data base. Generally, a 20-year or greater period of record is an acceptable statistical data base. When performing comparative analyses, some hydrologic data bases use 60 years or more of record keeping. Therefore, it should be apparent that data collection under the Connecticut Atmospheric Deposition Monitoring Program must continue until a sufficient period of record has been obtained.

Further information is available from the Water Resources Division, United States Geological Survey, 450 Main Street, Hartford, Connecticut 06103 at (203) 240-3060, or from the Natural Resources Center, Department of Environmental Protection, 165 Capitol Avenue, Hartford, Connecticut 06106 at (203) 566-3540.

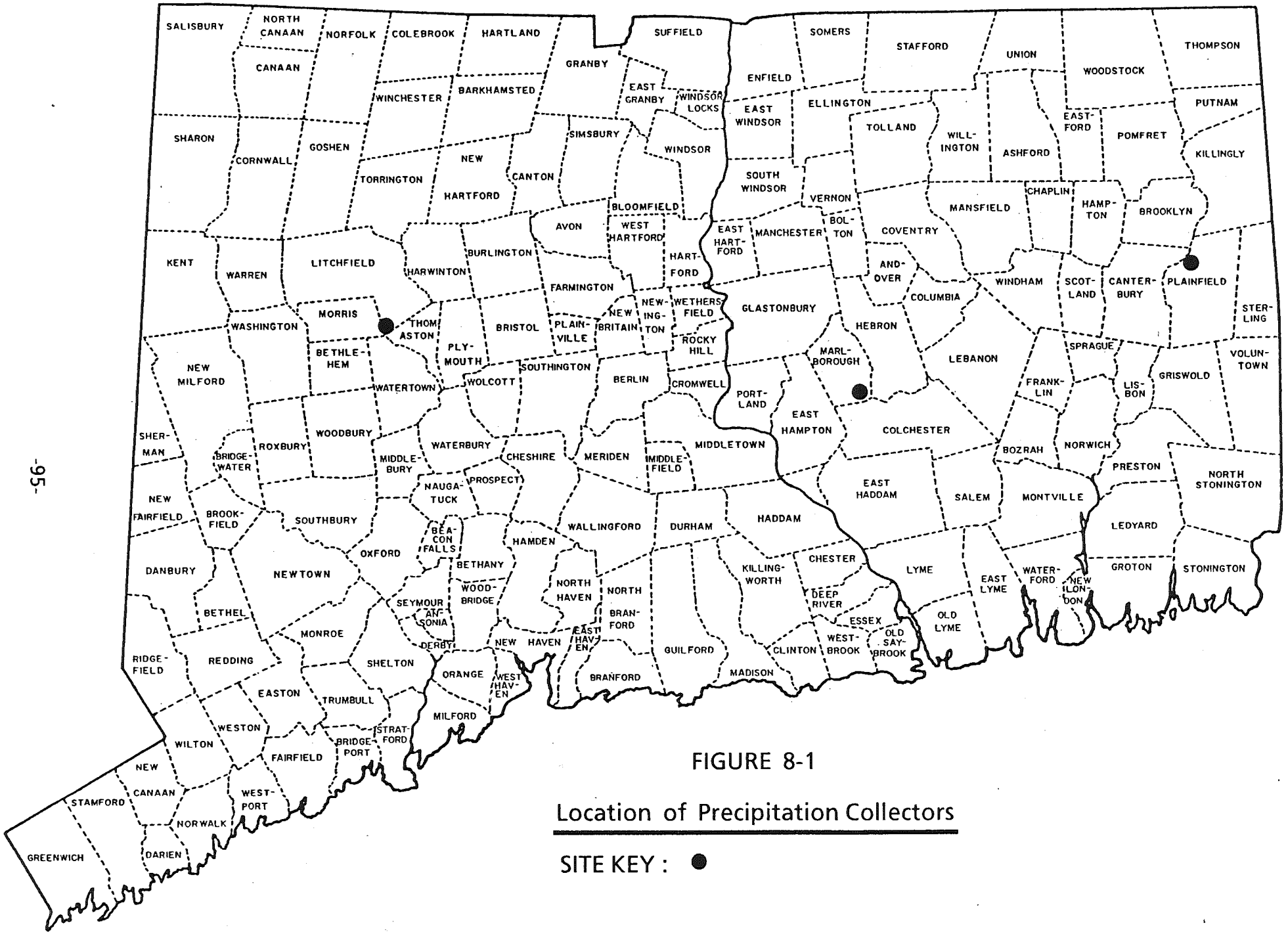


FIGURE 8-1

Location of Precipitation Collectors

SITE KEY : ●

TABLE 8-1

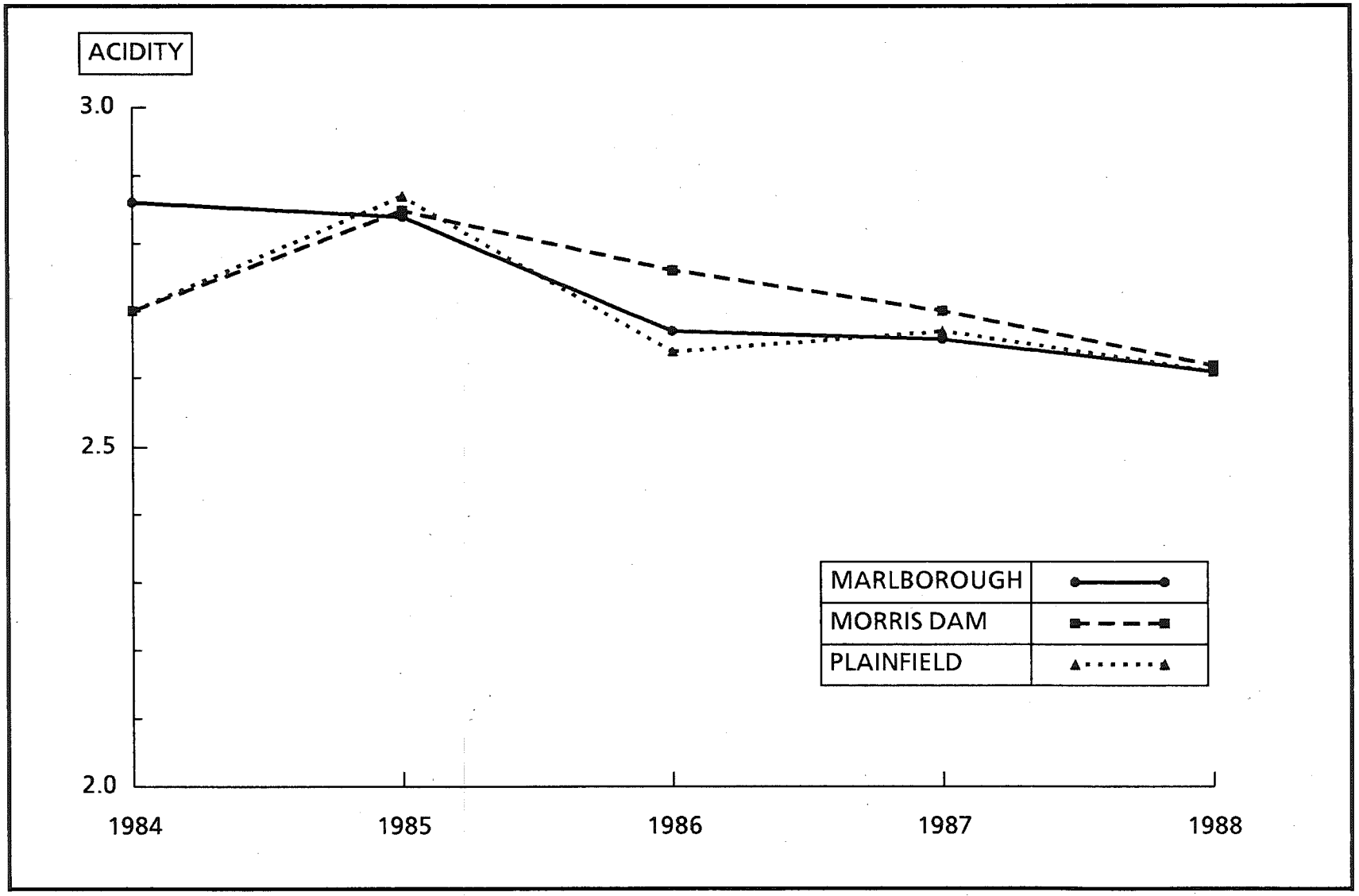
ANNUAL MEAN ACIDITY OF PRECIPITATION AT 3 SITES[1]

	Marlborough	Morris Dam	Plainfield
1984	2.86	2.70	2.70
1985	2.84	2.85	2.87
1986	2.67	2.76	2.64
1987	2.66	2.70	2.67
1988	2.61	2.62	2.61

[1] Acidity = 7 - pH

FIGURE 8-2

ANNUAL MEAN ACIDITY OF PRECIPITATION AT 3 SITES[1]



[1] ACIDITY = 7 - pH

IX. CLIMATOLOGICAL DATA

Weather is often the most significant factor influencing short-term changes in air quality. It also has an affect on long-term trends. Climatological information from the National Weather Service station at Bradley International Airport in Windsor Locks is shown in Table 9-1 for the years 1987 and 1988. Table 9-2 contains 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* and temperatures are shown as monthly and yearly averages. Precipitation data includes both the number of days with more than 0.01 inches of precipitation and the total water equivalent. Also shown are degree days** (heating requirement) and the number of days with temperatures exceeding 90°F.

Wind roses for Bradley Airport and Newark Airport have been developed from 1988 National Weather Service surface observations and are shown in Figures 9-2 and 9-4, respectively. Wind roses from these stations for 1987 are shown in Figures 9-1 and 9-3, respectively.

* The mean wind speed for a month or year is calculated from all the hourly wind speeds, regardless of the wind directions.

** The degree day value for each day is arrived at by subtracting the average temperature of the day from 65°F. This number (65) is used as a base value because it is assumed that there is no heating requirement when the outside temperature is 65°F.

TABLE 9-1

1987 AND 1988 CLIMATOLOGICAL DATA
BRADLEY INTERNATIONAL AIRPORT, WINDSOR LOCKS

	AVERAGE TEMPERATURE °F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 °F			DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1987	1988	Mean[a]	1987	1988	Mean[b]	1987	1988	Normal[c]	1987	1988	Mean[a]	1987	1988	Mean[d]	1987	1988	Mean[d]
Jan	25.0	23.1	26.4	0	0	0.0	1230	1292	1234	6.20	3.36	3.56	12	9	10.6	8.7	8.6	9.0
Feb	26.7	28.3	27.7	0	0	0.0	1065	1057	1047	0.45	3.99	3.22	4	9	10.2	9.6	9.4	9.4
Mar	39.8	38.5	37.1	0	0	0.0	773	817	874	4.44	2.06	3.71	9	8	11.3	9.8	10.4	10.0
Apr	49.7	47.4	48.2	0	0	0.2	452	523	486	5.23	2.35	3.75	15	9	11.1	10.1	10.4	10.1
May	60.8	59.7	59.1	3	0	1.2	191	186	197	2.18	3.46	3.59	10	16	11.6	8.7	8.5	8.9
Jun	68.8	66.7	67.8	3	6	3.6	29	75	20	3.66	0.67	3.55	13	7	11.3	7.8	8.8	8.1
Jul	74.2	75.2	73.2	10	10	7.9	1	9	0	2.27	8.43	3.57	7	16	9.7	7.5	7.5	7.5
Aug	69.0	74.5	71.0	4	14	4.8	31	23	8	4.25	2.12	3.79	11	5	9.8	7.6	8.1	7.2
Sep	62.9	62.2	63.5	0	0	1.4	100	112	102	7.19	1.88	3.60	12	6	9.4	7.8	7.8	7.3
Oct	49.2	47.6	53.0	0	0	*	481	539	391	3.67	2.29	3.15	8	7	8.2	8.2	8.6	7.7
Nov	41.4	42.3	42.0	0	0	0.0	700	672	702	3.66	7.84	3.84	10	11	11.2	9.6	9.3	8.4
Dec	33.2	29.3	30.4	0	0	0.0	981	1101	1113	1.57	1.35	3.72	11	6	12.0	8.9	9.4	8.6
YEAR	50.1	49.6	50.0	20	30	19.2	6034	6406	6174	44.77	39.80	43.05	122	109	126.5	8.7	8.9	8.5

* Less than 0.05

[a] 1905-1988

[b] 1960-1988

[c] 1951-1980

[d] 1955-1988

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

TABLE 9-2

1987 AND 1988 CLIMATOLOGICAL DATA
SIKORSKY INTERNATIONAL AIRPORT, STRATFORD

	AVERAGE TEMPERATURE °F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 °F			DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1987	1988	Mean[a]	1987	1988	Mean[b]	1987	1988	Normal[c]	1987	1988	Mean[d]	1987	1988	Mean[e]	1987	1988	Mean[f]
Jan	30.1	26.4	28.4	0	0	0.0	1077	1186	1101	4.78	2.65	3.58	13	10	10.6	---	---	13.2
Feb	30.0	31.2	30.5	0	0	0.0	975	974	963	0.43	3.64	3.27	4	12	9.6	---	---	13.6
Mar	41.3	39.4	38.0	0	0	0.0	727	787	831	4.77	2.36	3.93	10	11	11.2	---	---	13.5
Apr	50.2	48.1	48.0	0	0	0.0	434	499	492	4.73	1.59	3.85	11	7	10.4	---	---	13.0
May	58.8	59.4	58.5	2	1	0.2	232	195	220	1.20	2.65	3.66	7	13	11.0	---	---	11.6
Jun	68.6	68.2	67.8	1	5	1.0	23	45	20	1.55	0.79	3.33	9	5	9.4	---	---	10.5
Jul	74.9	75.5	73.3	4	4	3.1	0	6	0	1.78	8.53	3.74	9	16	8.5	---	---	10.0
Aug	71.0	75.6	71.9	2	5	1.6	10	3	0	3.89	1.86	3.93	11	5	9.2	---	---	10.1
Sep	65.2	64.6	65.2	0	0	0.4	53	62	49	4.09	2.26	3.46	12	6	8.5	---	---	11.2
Oct	51.3	50.5	54.6	0	0	0.0	417	449	285	2.20	3.26	3.31	7	7	7.1	---	---	11.9
Nov	44.3	45.9	44.2	0	0	0.0	596	569	585	2.87	7.58	3.83	9	9	10.1	---	---	12.7
Dec	36.8	32.7	33.3	0	0	0.0	867	995	955	2.08	1.63	3.64	10	6	11.2	---	---	13.0
YEAR	51.9	51.5	51.1	9	15	6.3	5411	5770	5501	34.37	38.80	43.55	112	107	116.8	---	---	12.0

[a] 1903-1988
[b] 1966-1988
[c] 1951-1980
[d] 1894-1988
[e] 1949-1988
[f] 1958-1980

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

FIGURE 9-1

ANNUAL WIND ROSE FOR 1987
BRADLEY INTERNATIONAL AIRPORT
WINDSOR LOCKS, CONNECTICUT

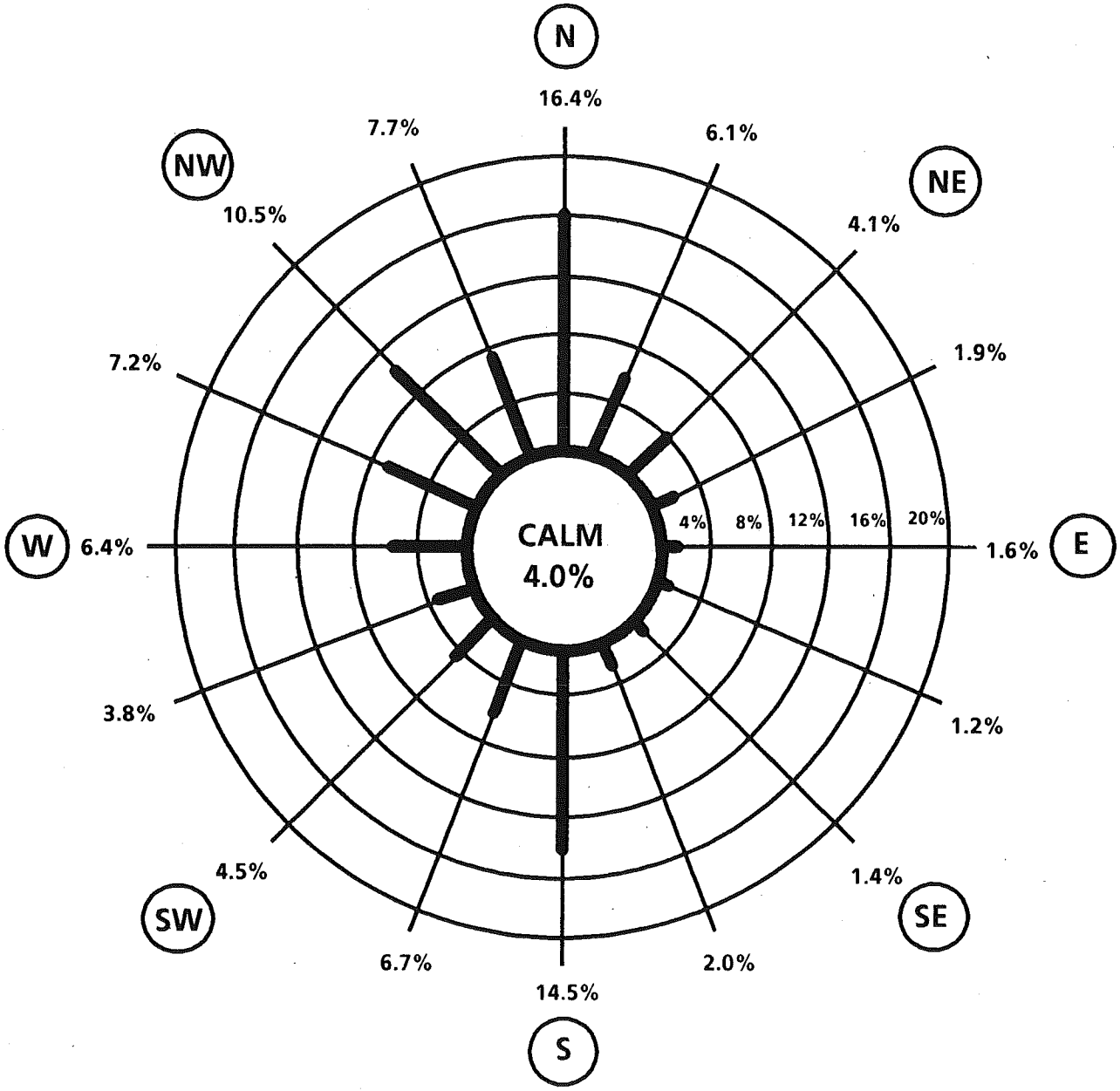


FIGURE 9-2

ANNUAL WIND ROSE FOR 1988
BRADLEY INTERNATIONAL AIRPORT
WINDSOR LOCKS, CONNECTICUT

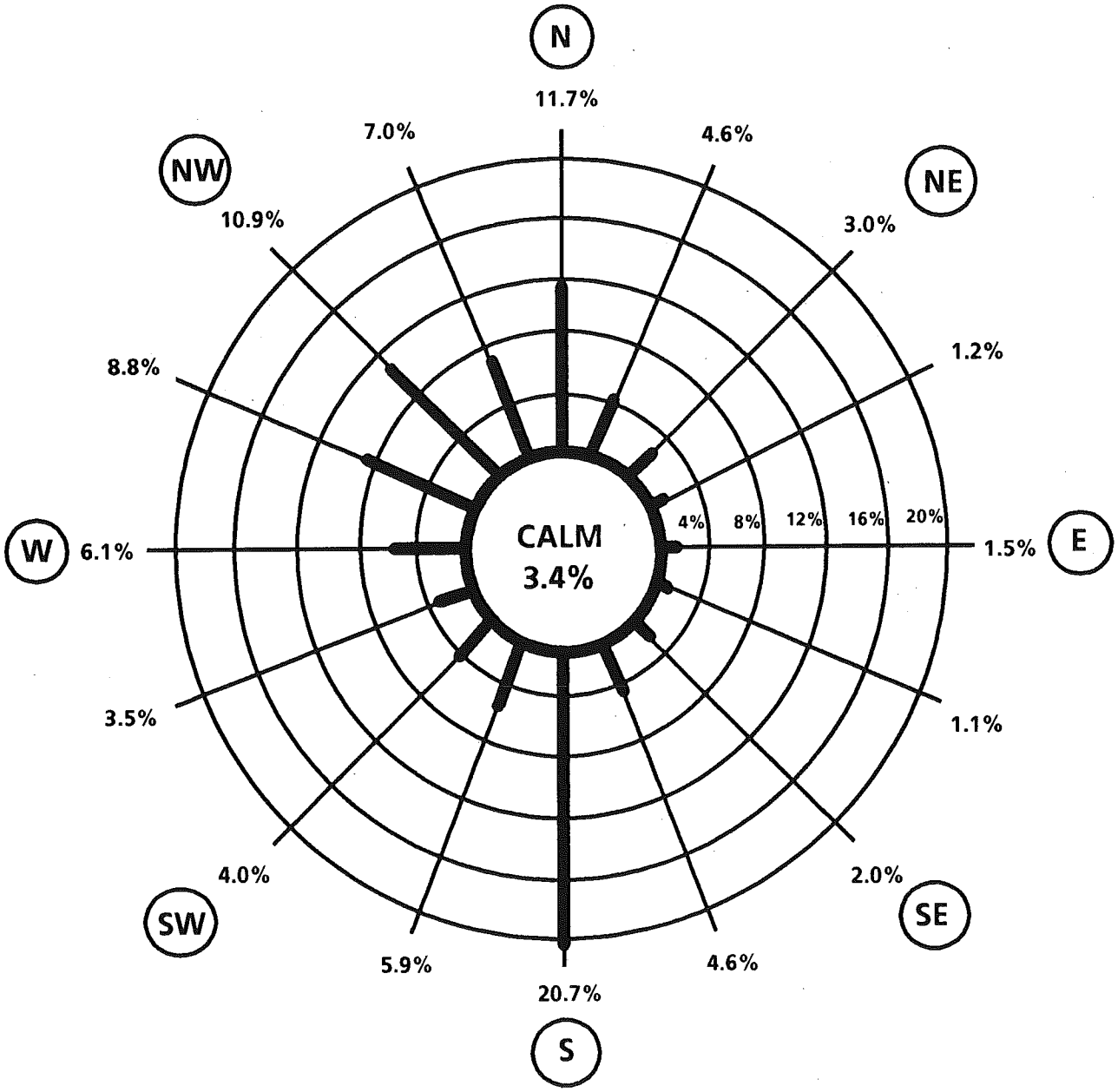


FIGURE 9-3

ANNUAL WIND ROSE FOR 1987
NEWARK INTERNATIONAL AIRPORT
NEWARK, NEW JERSEY

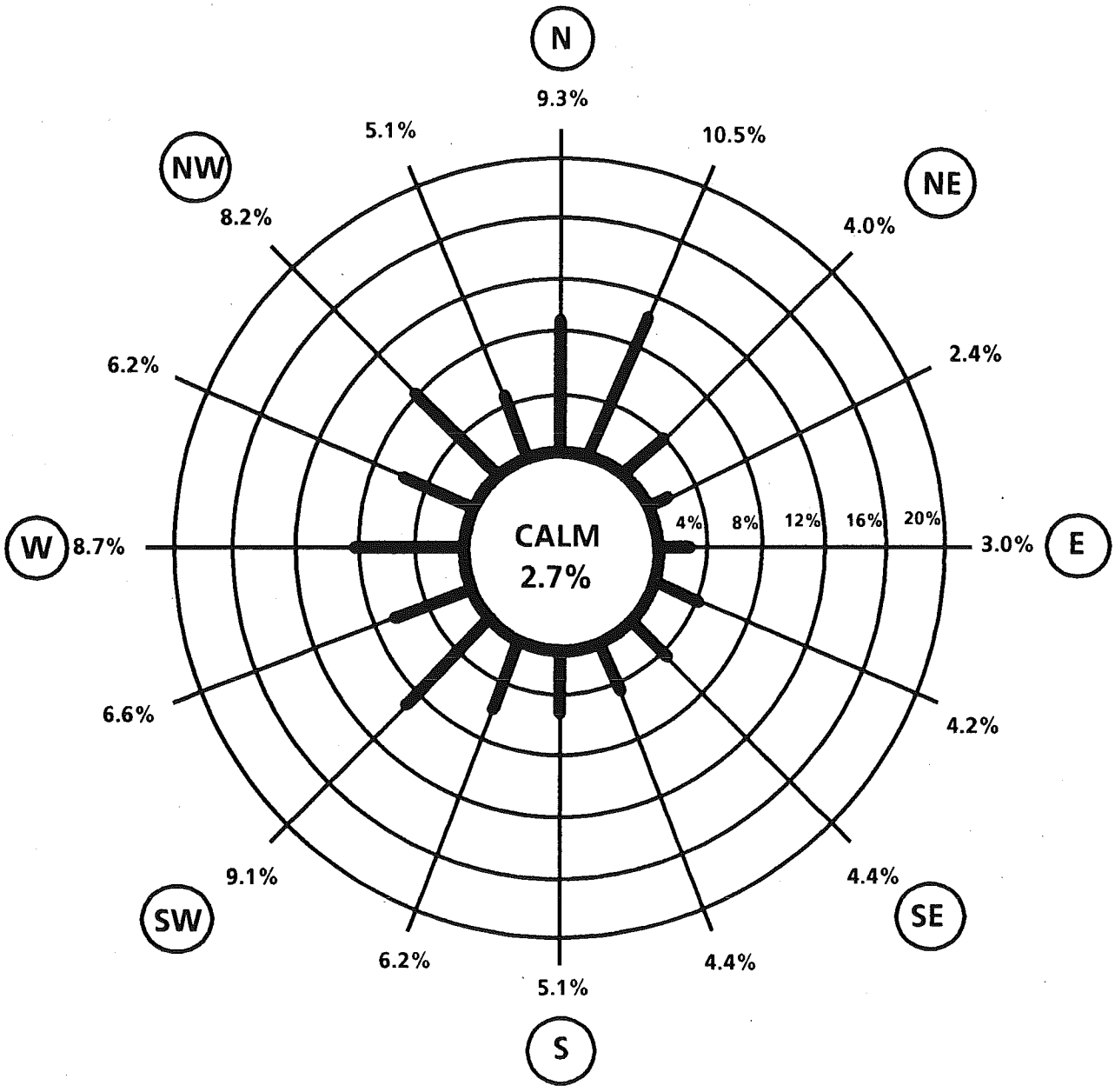
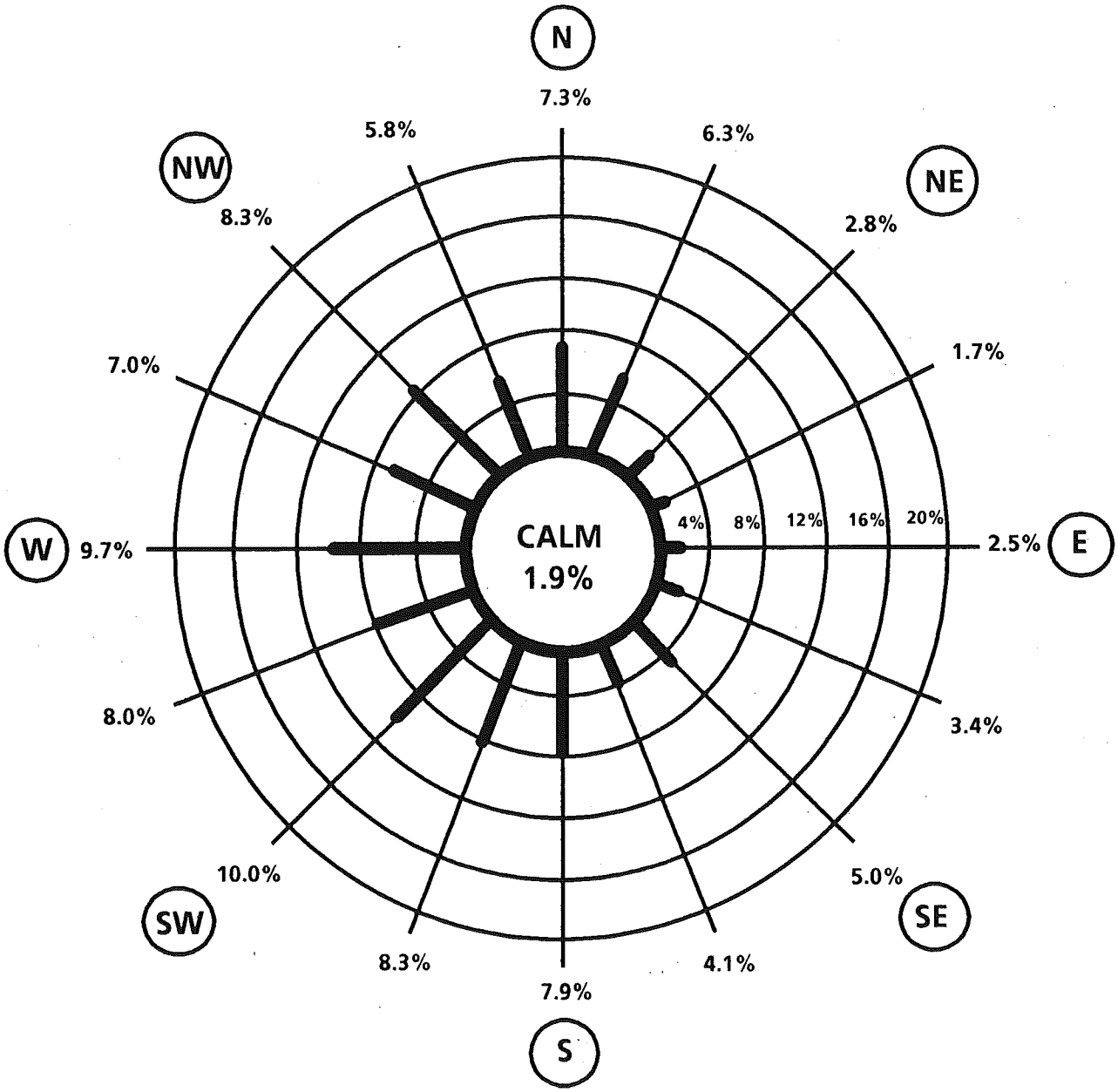


FIGURE 9-4

ANNUAL WIND ROSE FOR 1988
NEWARK INTERNATIONAL AIRPORT
NEWARK, NEW JERSEY



X. ATTAINMENT AND NON-ATTAINMENT OF NAAQS IN CONNECTICUT'S AQCR'S

The attainment status designations for Connecticut's four Air Quality Control Regions (AQCR's, see Figure 10-1) with regard to the National Ambient Air Quality Standards (NAAQS) have been determined for 1988 for the following pollutants: particulate matter no greater than 10 micrometers in diameter (PM_{10}); sulfur dioxide (SO_2); ozone (O_3); nitrogen dioxide (NO_2); carbon monoxide (CO) ; and lead (Pb). Table 10-1 shows the attainment status of each AQCR by pollutant. The AQCR's are classified as attainment, nonattainment or unclassifiable. These classifications conform to federal EPA guidelines and were applied in each case only after federal approval was granted. The federal EPA classifies an AQCR as attainment for a particular pollutant when all standards for the pollutant are attained (i.e., short term, long term, primary and secondary, wherever applicable). This notwithstanding, Table 10-1 contains the AQCR classifications with respect to each relevant short-term and long-term standard.

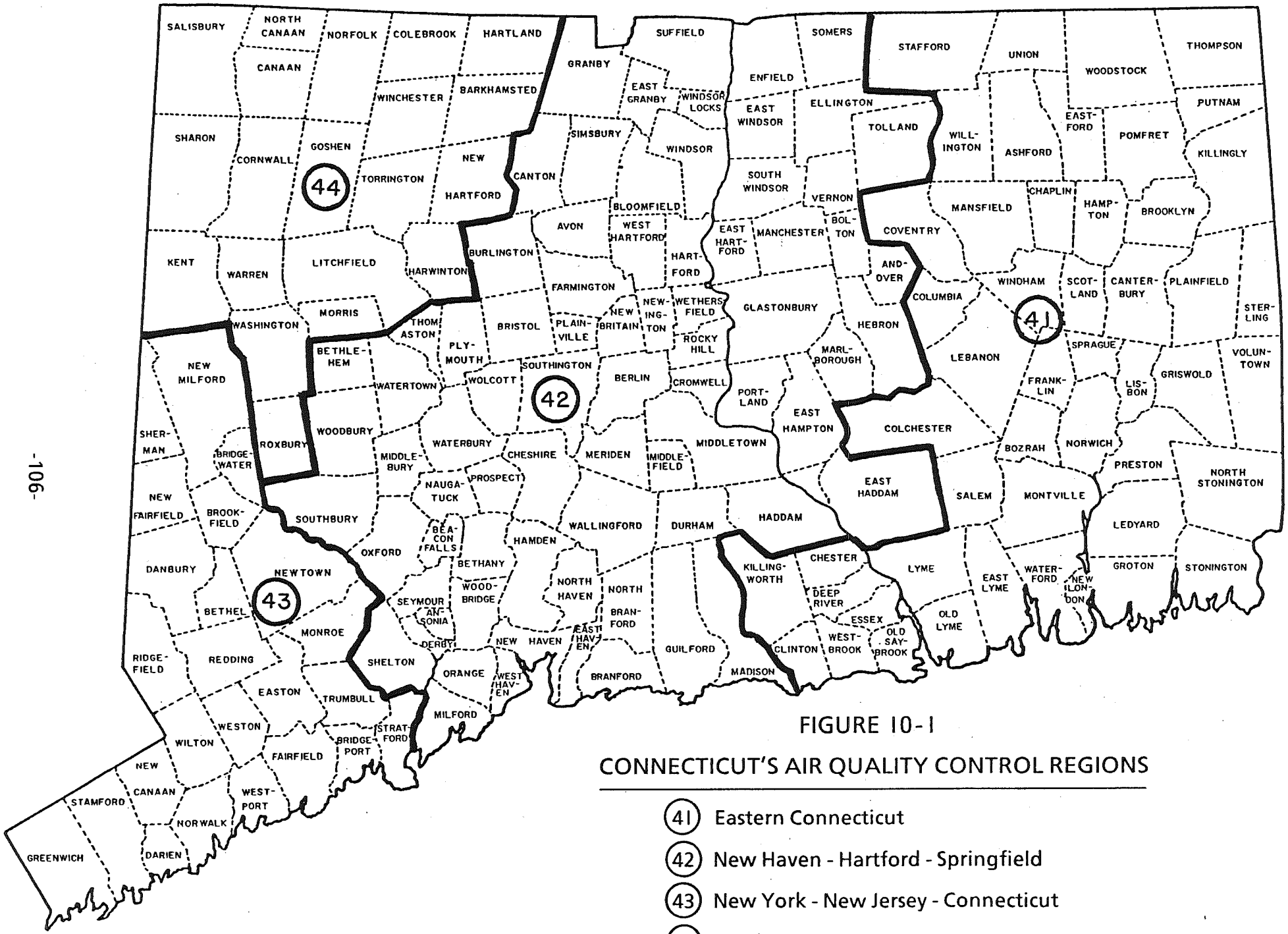


FIGURE 10-1

CONNECTICUT'S AIR QUALITY CONTROL REGIONS

(41) Eastern Connecticut

(42) New Haven - Hartford - Springfield

(43) New York - New Jersey - Connecticut

(44) Northwestern Connecticut

TABLE 10-1

CONNECTICUT'S COMPLIANCE BY AQCR WITH THE NAAQS IN 1988

Pollutant	Primary or Secondary	NAAQS	AQCR 41	AQCR 42	AQCR 43	AQCR 44
PM_{10}	Both	Annual	A	X	A	A
	Both	24-Hour	A	X	A	A
SO_2	Primary	Annual	A	A	A	A
		24-Hour	A	A	A	A
	Secondary	3-Hour	A	A	A	A
Ozone	Both	1-Hour	X	X	X	X
NO_2	Both	Annual	A	A	A	A
CO	Both	1-Hour	A	A	A	A
		8-Hour	U	X	X	U
Lead	Both	3-Month	A	A	A	A

X = Nonattainment
U = Unclassifiable
A = Attainment

XI. CONNECTICUT SLAMS AND NAMS NETWORK

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 are meant to ensure the acceptability of air measurement data, the comparability of data from all monitoring stations, 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 and probe siting. 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, National Air Monitoring Stations (NAMS) networks, and Prevention of Significant Deterioration (PSD) air monitoring. Two distinct and equally important functions make up the quality assurance program: assessment of the quality of monitoring data by estimating their precision and accuracy, and control of the quality of the data by implementation of quality control policies, procedures, and corrective actions. (See Part E 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_2, NO_2, CO and O_3. 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 co-located duplicate samplers. In addition, precision checks for lead are also accomplished by analysis of duplicate strips. In 1988, Connecticut maintained two co-located PM_{10} monitors (New Haven 123 and Waterbury 123) and three co-located lead monitors (Bridgeport 009, Waterbury 007, and Waterbury 123). In addition, duplicate strip analyses were performed at two sites (Hartford 016 and New Haven 018).

Accuracy determinations for automated analyzers (SO_2, NO_2, CO, O_3) are accomplished by audits performed by an independent auditor utilizing equipment and gases which are disassociated from the normal network operations. Accuracy determinations are accomplished via traceable standard flow devices for hi-vols and via spiked strip analyses for lead. For SLAMS analyzers, accuracy audits must be performed on each analyzer at least once per calendar year. Each PSD analyzer must be audited at least once each calendar quarter.

All precision and accuracy data are derived through calculation methods specified by the regulations, with the results reported quarterly on Data Assessment Report Forms. The NAMS network is actually part of the SLAMS network; so the SLAMS accuracy determinations also apply to the NAMS network. 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 and locations for them; and 4) the data, in addition to being included in the annual report, are required to be reported quarterly to EPA.

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

1. Installation of equipment,
2. Selection of methods, analyzers, or samplers,
3. Zero/span checks and analyzer adjustments,
4. Calibration,
5. Control limits for zero/span and other control checks, and respective corrective actions when such limits are exceeded,
6. Control checks and their frequency,
7. Preventive and remedial maintenance,
8. Calibration and zero/span checks for multi-range analyzers,
9. Recording and validating data, and
10. Documentation of quality control information.

MONITORING METHODOLOGIES

Except as otherwise stated within the regulations, the monitoring methods used must be "reference" or "equivalent," as designated by the EPA. Table 11-1 lists methods used in Connecticut's network in 1988 which were on the EPA-approved list as of April 10, 1986. 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 networks and for choosing general locations for new monitors. Criteria are also presented for determining the location and number of monitors. These criteria serve as the framework for all State Implementation Plan (SIP) monitoring networks that were to be complete and in operation by January 1, 1984.

The SLAMS network is designed to meet four basic monitoring objectives: (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. Proper siting of a monitor requires precise specification of the monitoring objectives, which usually includes a desired spatial scale of representativeness. The spatial scales of representativeness are specified in the regulations for all pollutants and monitoring objectives. The 1988 SLAMS and NAMS networks in Connecticut are presented and described in Table 11-2.

PROBE SITING

Location and exposure of monitoring probes have been an area of confusion for a number of years because of conflicting guidelines and a lack of guidance or recommended criteria. 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 11-3. 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_2, NO_2, and O_3,the regulations specify borosilicate glass, FEP teflon or their equivalent as the only acceptable sample train materials. 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 11-1

U. S. EPA-APPROVED MONITORING METHODS USED IN CONNECTICUT IN 1988

Pollutant	Monitoring Methods		
	Reference Manual	Reference Automated	Equivalent Automated
PM_{10}	Wedding & Associates Critical Flow Hi-vol		
SO_2			Thermo Electron 43 (0.5)
O_3			DASIBI 1008-RS (0.5)
CO		Bendix 8501-5CA (50)	
NO_2		Thermo Electron 14 B/E (0.5)	
Lead	High Volume Method Low Volume Method*		

* This is a modified reference method approved by EPA on 2/29/84.

( ) = Approved range in ppm

TABLE 11-2

1988 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling Method	Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				PARTICULATE MATTER (PM_{10})				
Ansonia	Bridgeport	004	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Bridgeport	Bridgeport	010	N	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Bridgeport	Bridgeport	013	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Bridgeport	Bridgeport	014	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Bristol	Bristol	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Burlington	NONE	001	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Cornwall	NONE	005	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Danbury	Danbury	123	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
E. Hartford	Hartford	004	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Enfield	MA-CT*	005	S	Hi-Vol	Gravimetric	6th day	Population	Regional
Greenwich	Stamford	017	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Groton	New London/ Norwich	006	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Haddam	NONE	002	S	Hi-Vol	Gravimetric	6th day	Population	Regional
Hartford	Hartford	013	N	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Hartford	Hartford	014	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Hartford	Hartford	015	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Hartford	Hartford	018	S	Hi-Vol	Gravimetric	6th day	Population	Micro
Manchester	Hartford	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Meriden	Meriden	002	N	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Middletown	Hartford	003	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Milford	Bridgeport	010	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Naugatuck	Waterbury	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood

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

TABLE 11-2, CONTINUED

1988 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling Method	Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				PARTICULATE MATTER (PM_{10})				
New Britain	New Britain	012	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
New Haven	New Haven	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	020	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
New Haven	New Haven	123	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
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
Old Saybrook	NONE	002	S	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Putnam	NONE	002	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Stamford	Stamford	001	N	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Stamford	Stamford	026	S	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Stratford	Bridgeport	005	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
Wallingford	New Haven	006	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Waterbury	Waterbury	007	N	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Waterbury	Waterbury	123	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Waterford	New London/ Norwich	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
West Haven	New Haven	003	S	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Willimantic	NONE	002	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood

TABLE 11-2, CONTINUED

1988 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling & Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				SULFUR DIOXIDE			
Bridgeport	Bridgeport	012	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Bridgeport	Bridgeport	013	N	Pulsed Fluorescence	Continuous	Population	Neighborhood
Danbury	Danbury	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
E. Hartford	Hartford	005	N	Pulsed Fluorescence	Continuous	Population	Neighborhood
East Haven	New Haven	003	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Enfield	MA - CT*	005	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Greenwich	Stamford	017	S	Pulsed Fluorescence	Continuous	Background	Regional
Groton	New London/ Norwich	007	S	Pulsed Fluorescence	Continuous	Background	Urban
Hartford	Hartford	123	N	Pulsed Fluorescence	Continuous	Population	Neighborhood
Milford	Bridgeport	010	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
New Britain	New Britain	011	S	Pulsed Fluorescence	Continuous	Source	Neighborhood
New Haven	New Haven	017	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
New Haven	New Haven	123	N	Pulsed Fluorescence	Continuous	Population	Neighborhood
Norwalk	Norwalk	013	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Stamford	Stamford	025	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Stamford	Stamford	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Waterbury	Waterbury	008	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Waterbury	Waterbury	123	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
						Population	Neighborhood

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

TABLE 11-2, CONTINUED

1988 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling & Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				NITROGEN OXIDES			
Bridgeport	Bridgeport	013	S	Chemiluminescent	Continuous	High Concentration	Neighborhhod
E. Hartford	Hartford	003	S	Chemiluminescent	Continuous	High Concentration	Neighborhhod
New Haven	New Haven	123	S	Chemiluminescent	Continuous	High Concentration	Neighborhood
				OZONE			
Bridgeport	Bridgeport	013	N	Chemiluminescent	Continuous	Population	Neighborhood
Danbury	Danbury	123	S	Chemiluminescent	Continuous	Population	Urban
E. Hartford	Hartford	003	N	Chemiluminescent	Continuous	Population	Neighborhood
Greenwich	Stamford	017	S	Chemiluminescent	Continuous	Background	Regional
Groton	New London/ Norwich	008	S	Chemiluminescent	Continuous	High Concentration	Urban
Middletown	Hartford	007	N	Chemiluminescent	Continuous	High Concentration	Urban
New Haven	New Haven	123	N	Chemiluminescent	Continuous	Population	Neighborhood
Stafford	Hartford	001	N	Chemiluminescent	Continuous	High Concentration	Urban
Stratford	Bridgeport	007	N	Chemiluminescent	Continuous	High Concentration	Urban
				CARBON MONOXIDE			
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	019	S	NDIR	Continuous	High Concentration	Micro
Stamford	Stamford	020	S	NDIR	Continuous	High Concentration	Micro

TABLE 11-2, CONTINUED

1988 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling Method	Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
					LEAD			
Ansonia	Bridgeport	004	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Bridgeport	Bridgeport	009	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Bridgeport	Bridgeport	010	S	Lo-Vol	Atomic Abs.	1 month	High Concentration	Middle
Bristol	Bristol	001	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Danbury	Danbury	002	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Hartford	Hartford	014	N	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Hartford	Hartford	015	N	Lo-Vol	Atomic Abs.	1 month	High Concentration	Micro
Hartford	Hartford	016	N	Lo-Vol	Atomic Abs.	1 month	High Concentration	Micro
Meriden	Meriden	002	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Middletown	Hartford	003	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
New Britain	New Britain	007	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
New Haven	New Haven	018	S	Lo-Vol	Atomic Abs.	1 month	High Concentration	Middle
Norwalk	Norwalk	012	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Stamford	Stamford	001	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Stamford	Stamford	022	S	Lo-Vol	Atomic Abs.	1 month	High Concentration	Neighborhood
Wallingford	New Haven	001	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Waterbury	Waterbury	007	S	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Waterbury	Waterbury	123	S	Hi-Vol	Atomic Abs.	6th day	High Concentration	Middle
Waterbury	Waterbury	123	S	Lo-Vol	Atomic Abs.	1 month	High Concentration	Middle
West Haven	New Haven	003	S	Lo-Vol	Atomic Abs.	1 month	Population	Middle

TABLE 11-3

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
PM_{10}	Micro		>2	2 - 7	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler, except for street canyon sites.[b] 3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic[d], except for street canyon sites which must be from 2 to 10 meters from the edge of the nearest traffic lane.
	Middle, neighborhood, urban and regional		>2	2 - 15	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic.[d]

TABLE 11-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
Pb	Micro		>2	2 - 7	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites. 4. No furnace or incineration flues should be nearby.[c] 5. The sampler must be 5 to 15 meters from a major roadway.
	Middle, neighborhood, urban and regional		>2	2 - 15	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic.[d]

TABLE 11-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
SO_2	All	3 - 15	>1	>1	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 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.[b] 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. 4. No furnace or incineration flues should be nearby.[c]
O_3	All	>1	>1	3 - 15	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 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. 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. 4. The spacing from roads varies with traffic.[d]

TABLE 11-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
CO	Micro	3 + or -1/2	>1	>1	1. The probe must be >10 meters from the street intersection and should be at a midblock location. 2. The probe must be 2 to 10 meters from the edge of the nearest traffic lane. 3. There must be unrestricted airflow 180 degrees around the inlet probe.
	Middle neighborhood	3 - 15	>1	>1	1. There must be unrestricted airflow 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building. 2. The spacing from roads varies with traffic.[d]
NO_2	All	3 - 15	>1	>1	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 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.[b] 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. 4. The spacing from roads varies with traffic.[d]

[a] When the probe is located on a rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.

[b] Sites not meeting this criterion would be classified as middle scale.

[c] Distance is dependent upon 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.

[d] Distance is dependent upon traffic ADT, pollutant, and spatial scale.

XII. EMISSIONS INVENTORY

The State of Connecticut maintains a computerized emissions inventory which contains a point source file of approximately 7,000 stationary industrial, commercial and institutional sources of air pollution. Emissions from these sources are determined on the basis of actual operating data, such as actual fuel use and actual material throughputs, and with the help of pollutant emission factors contained in the Compilation of Air Pollutant Emission Factors, designated as EPA publication AP-42.

This inventory does not account for all the pollution sources in the state, however. There are a host of other industrial, commercial, agricultural, and human activities that account for most of the pollution emitted into Connecticut's air. These sources cannot be individually inventoried due to their nature, or large numbers, or widespread occurrence, etc. In spite of this, the emissions from these so-called area souces can be quantified by various means. For example, motor vehicle emissions can be determined from Connecticut Department of Transportation figures on vehicle-miles travelled (VMT's) on interstate and local roads, and from EPA MOBILE 4 emission factors; commercial and residential fuel-burning emissions can be determined from U. S. Department of Energy data, census figures, and AP-42 emission factors; national per capita emissions, which are available from EPA for a number of pollution-causing activities, can be used in conjunction with census figures to calculate emissions by town, county, etc.

The computerized point source inventory and the more indirectly arrived at, but much larger, area source inventory together provide a good picture of the pollutants that are emitted into Connecticut's air each year. Table 12-1 summarizes the actual in-state emissions of each of the five major air pollutants in Connecticut -- TSP, SO_2, CO, NO_2, and volatile organic compounds or VOC, -- by county, for 1988. The table reveals two things. First, the most populous counties have the largest pollutant totals; second, excluding SO_2, which is largely generated by utilities, area sources (mobile sources in particular) account for the bulk of the total emissions.

County names and geographic locations are displayed in Figure 12-1, which also serves as a reference for the charts that follow.

Figures 12-2 through 12-16 give various visual displays of the level of emissions for each of the major air pollutants. The pie charts show the percent of each air pollutant contibuted by each of Connecticut's eight counties. The shaded maps are pictorial displays of emissions by county, where the darker areas indicate higher emission levels. The 3-dimensional maps also display each county's contribution to statewide emissions.

It should be noted that annual area source emissions will automatically increase from year to year due to a built-in 2% projected increase in annual VMT's. However, other effects may tend to mask this increase. For instance, in 1988, emissions were added for new area source categories, such as publicly operated sewage treatment plants, small industrial surface coating operations, chemical spills, leaking underground storage tanks, and gasoline off-highway vehicles. For these and other reasons, area source emissions in Connecticut increased from 1987 to 1988 by nearly 10% for TSP and SO_2, and by nearly 20% for CO, VOC and NO_2. These changes may be more apparent than real, since some of the increased emissions should also be applied to 1987. Therefore, it is not advisable to compare area source emissions reported in different editions of the Annual Air Quality Summary.

Regarding point source emissions, significant increases occurred in Hartford and Fairfield counties due to the start-up of several new resource recovery facilities. Middlesex county also experienced increased point source emissions due to a significant increase in fuel use by the resident electric utility plant. These and other factors caused statewide point source emissions to increase from 1987 to 1988 by approximately 4% for VOC, 8% for TSP, 14% for SO_2, 26% for NO_2 and 41% for CO.

TABLE 12-1

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY

		TONS PER YEAR OF EMISSIONS				
County	Sources	TSP	SO_2	CO	VOC	NO_x[1]
Fairfield	Area	10,581.6	5,057.0	180,729.0	33,564.1	28,079.2
	Point	2,416.7	32,896.6	5,317.0	3,915.6	18,585.9
	All	12,998.3	37,953.6	186,046.0	37,479.7	46,665.1
Hartford	Area	11,563.8	5,350.7	194,074.7	34,181.3	30,583.6
	Point	777.1	4,445.9	1,928.3	3,761.6	4,863.8
	All	12,340.9	9,796.6	196,003.0	37,942.9	35,447.4
Litchfield	Area	2,292.8	1,039.0	34,916.7	6,783.1	5,757.2
	Point	190.5	650.6	60.3	650.5	253.0
	All	2,483.3	1,689.6	34,977.0	7,433.6	6,010.2
Middlesex	Area	2,149.4	1,016.7	31,306.3	6,008.0	5,687.9
	Point	748.4	8,056.7	719.9	772.0	8,412.2
	All	2,897.8	9,073.4	32,026.2	6,780.0	14,100.1
New Haven	Area	10,011.3	4,635.2	150,677.1	30,299.4	24,362.2
	Point	1,195.8	26,793.7	1,191.3	4,221.8	8,475.3
	All	11,207.1	31,428.9	151,868.4	34,521.2	32,837.5
New London	Area	3,591.7	1,695.1	57,675.8	11,083.6	9,456.9
	Point	921.4	12,029.4	461.7	3,007.5	3,992.8
	All	4,513.1	13,724.5	58,137.5	14,091.1	13,449.7
Tolland	Area	1,892.0	800.1	29,495.5	5,585.8	5,193.1
	Point	124.2	829.3	35.6	69.0	280.6
	All	2,016.2	1,629.4	29,531.1	5,654.8	5,473.7
Windham	Area	1,448.9	612.6	22,693.4	4,113.4	3,617.3
	Point	254.2	488.3	839.5	433.8	316.2
	All	1,703.1	1,101.9	23,532.9	4,547.2	3,933.5
TOTAL	Area	43,531.5	20,206.5	701,568.5	131,618.7	112,737.2
	Point	6,628.3	86,190.6	10,553.6	16,831.8	45,179.7
	All	50,159.8	106,397.1	712,122.1	148,450.5	157,916.9

[1] NO_x emissions are expressed as NO_2.

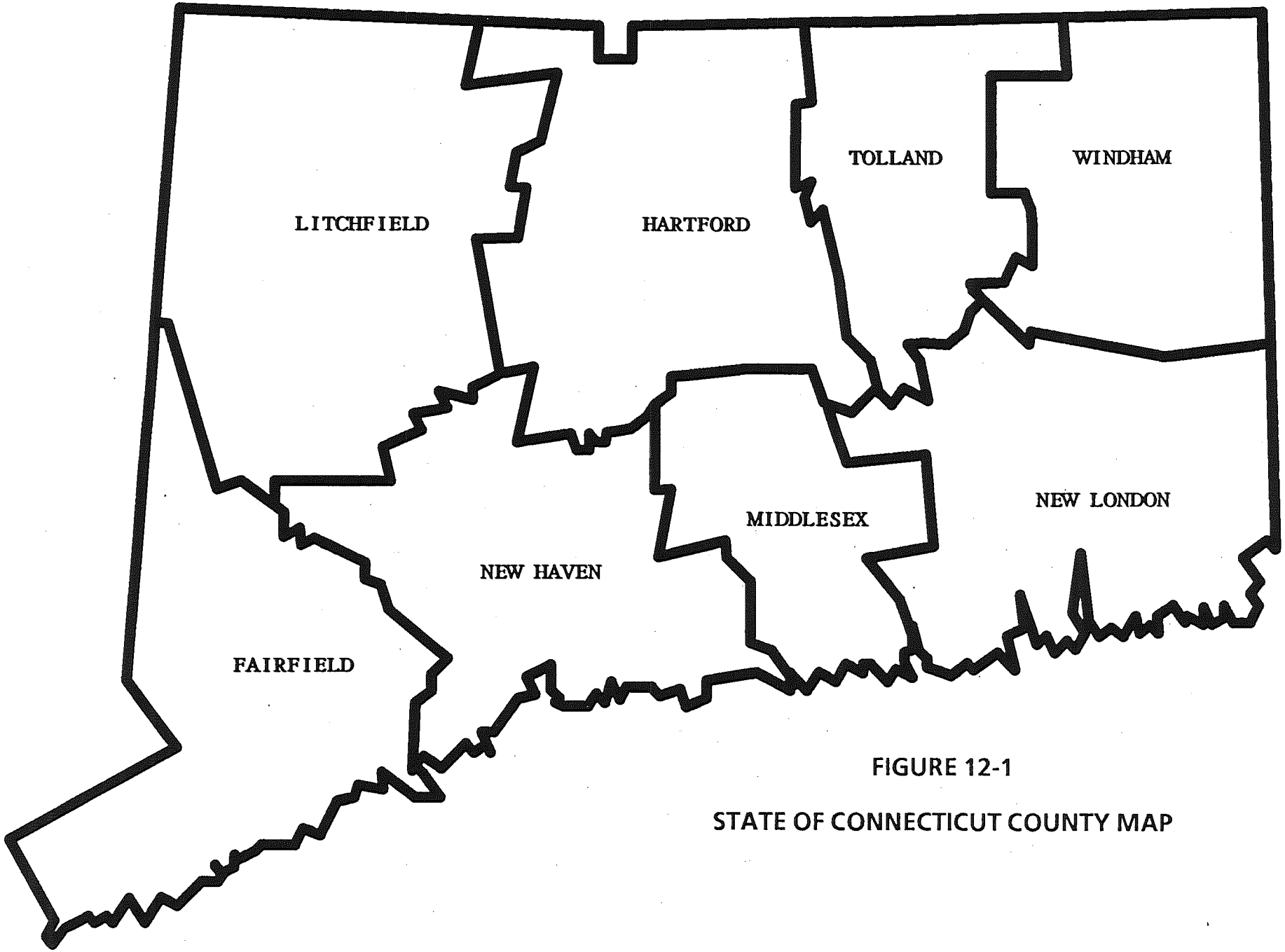


FIGURE 12-1

STATE OF CONNECTICUT COUNTY MAP

FIGURE 12-2

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY
TOTAL SUSPENDED PARTICULATES

(TOTAL TONS PER YEAR: 50,160)

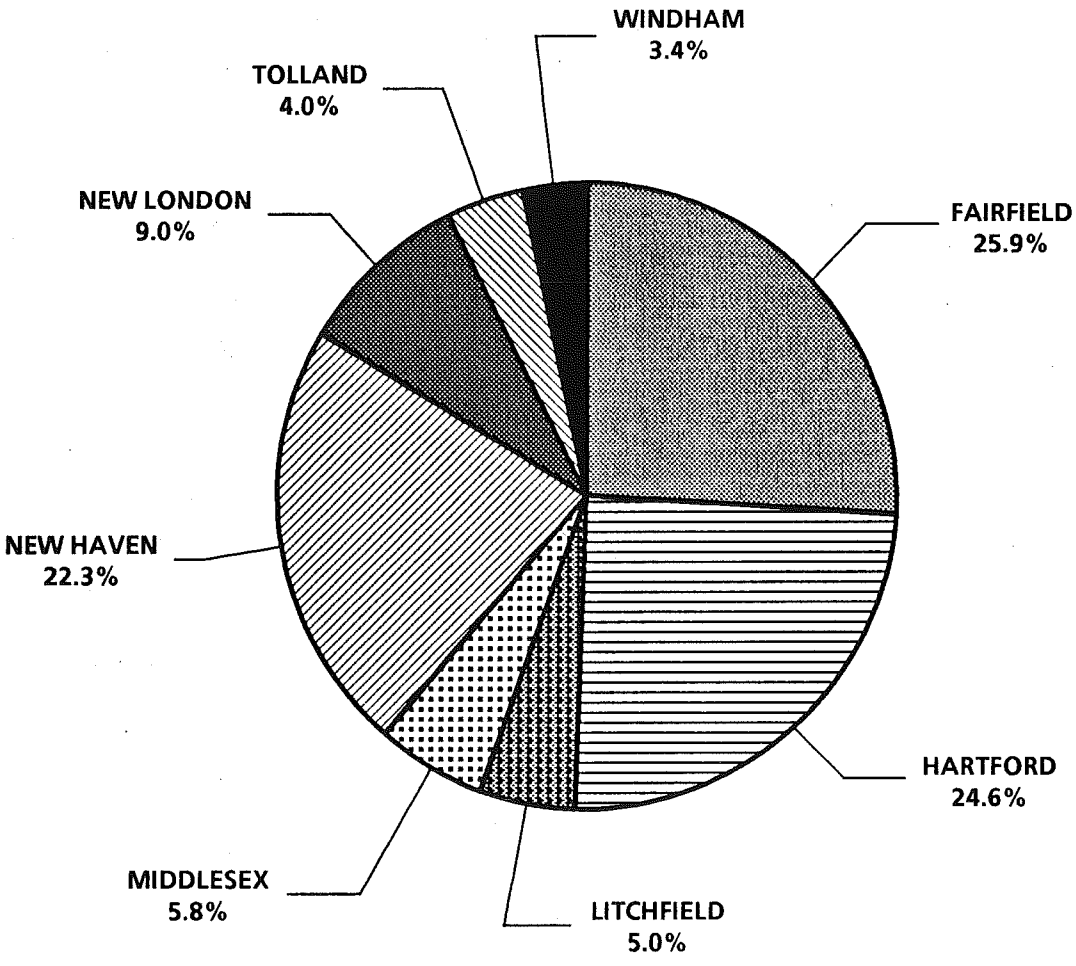
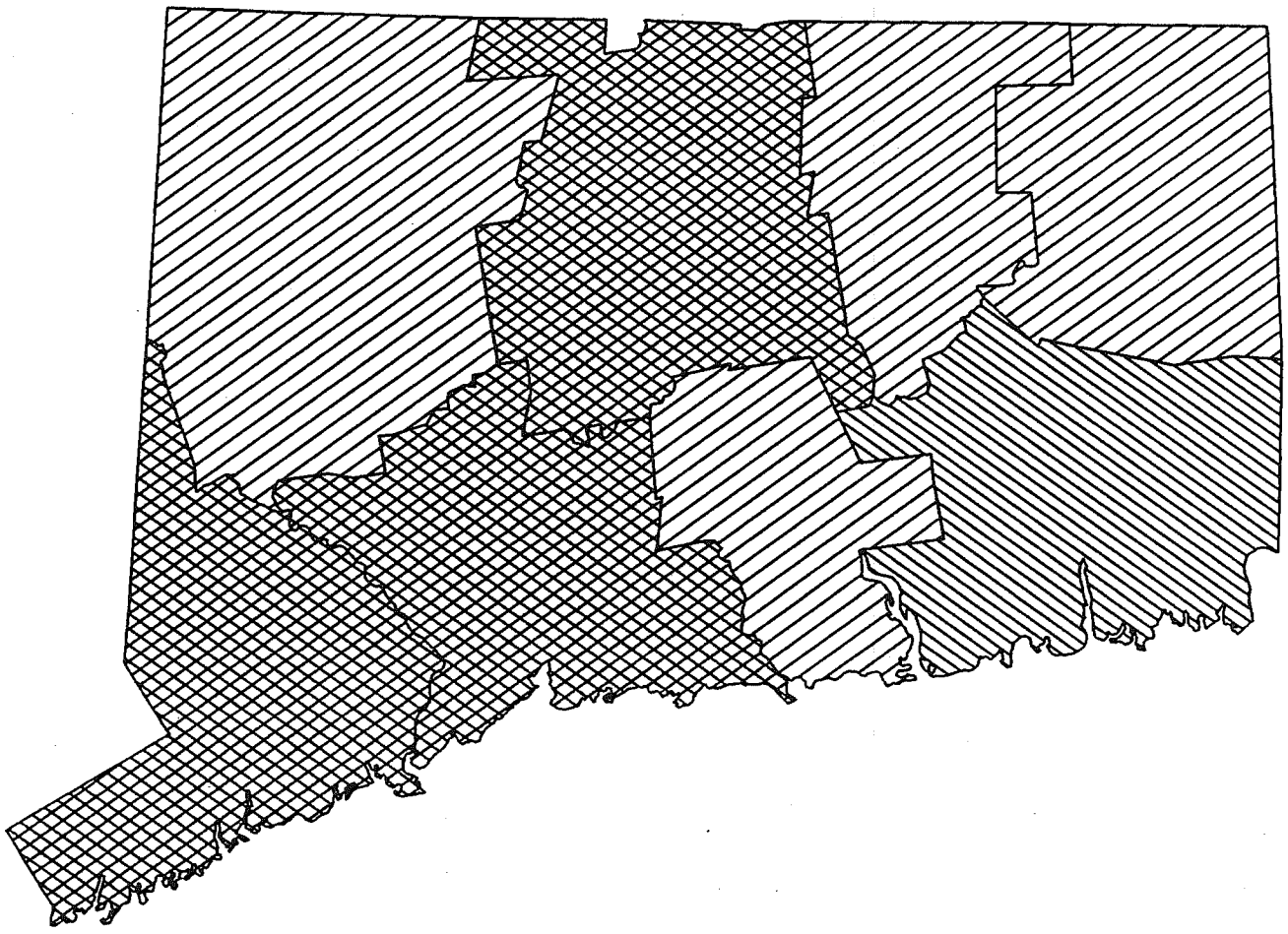


FIGURE 12-3

1988 TOTAL SUSPENDED PARTICULATES

Total Emissions by County

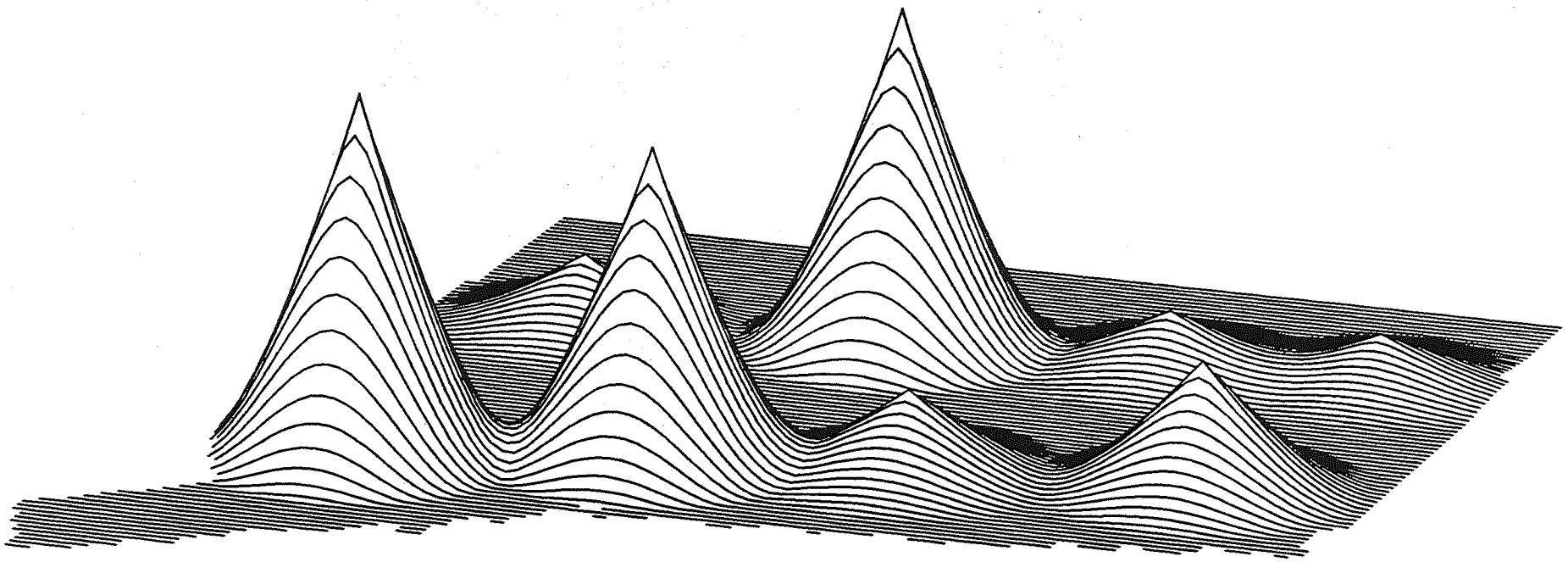


ACTUAL TSP (TPY) LESS THAN 3000 3000 TO 6000 OVER 9000

FIGURE 12-4

1988 TOTAL SUSPENDED PARTICULATES

Total Emissions by County



Three Dimensional View of TSP Emissions

FIGURE 12-5

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY
SULFUR DIOXIDE

(TOTAL TONS PER YEAR : 106,397)

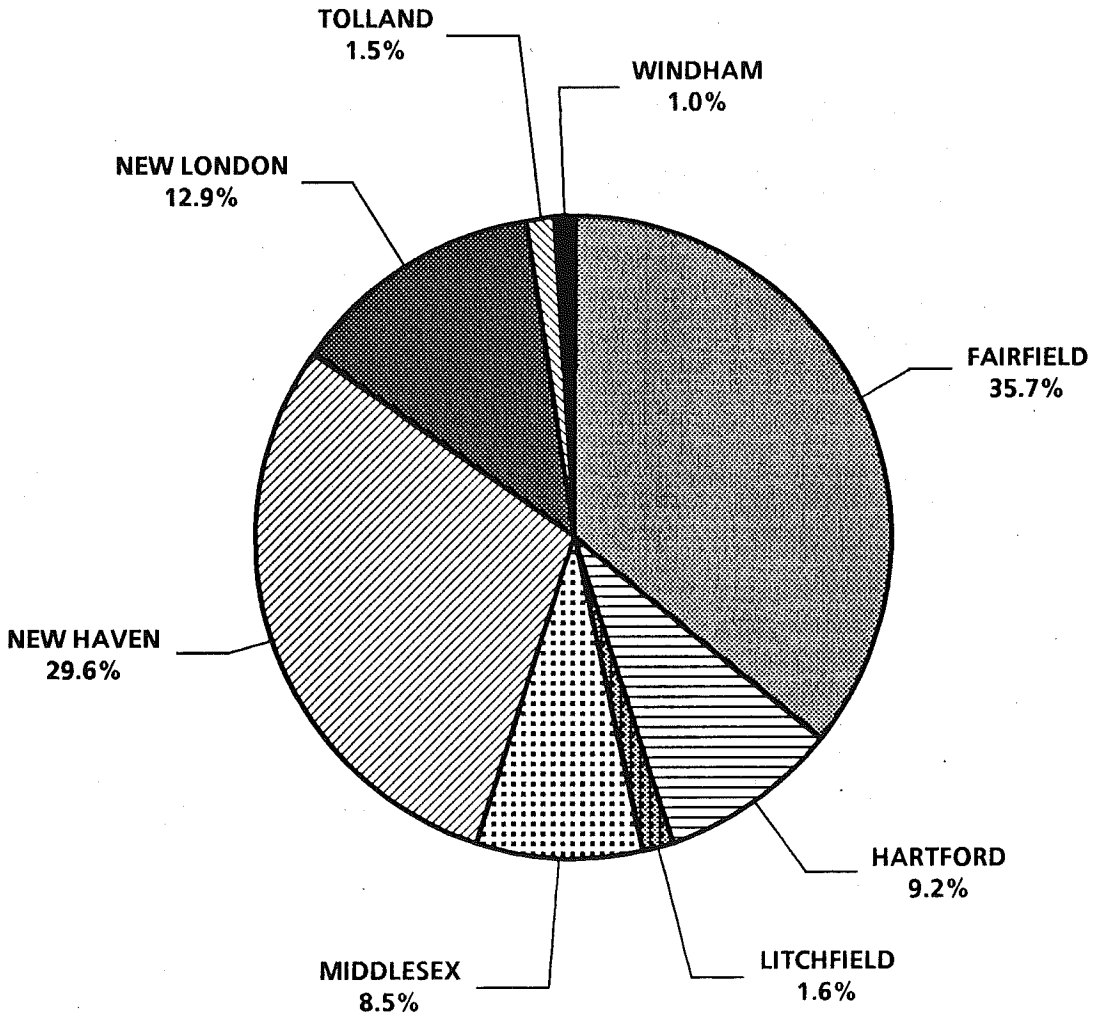


FIGURE 12-6

1988 SULFUR DIOXIDE

Total Emissions by County

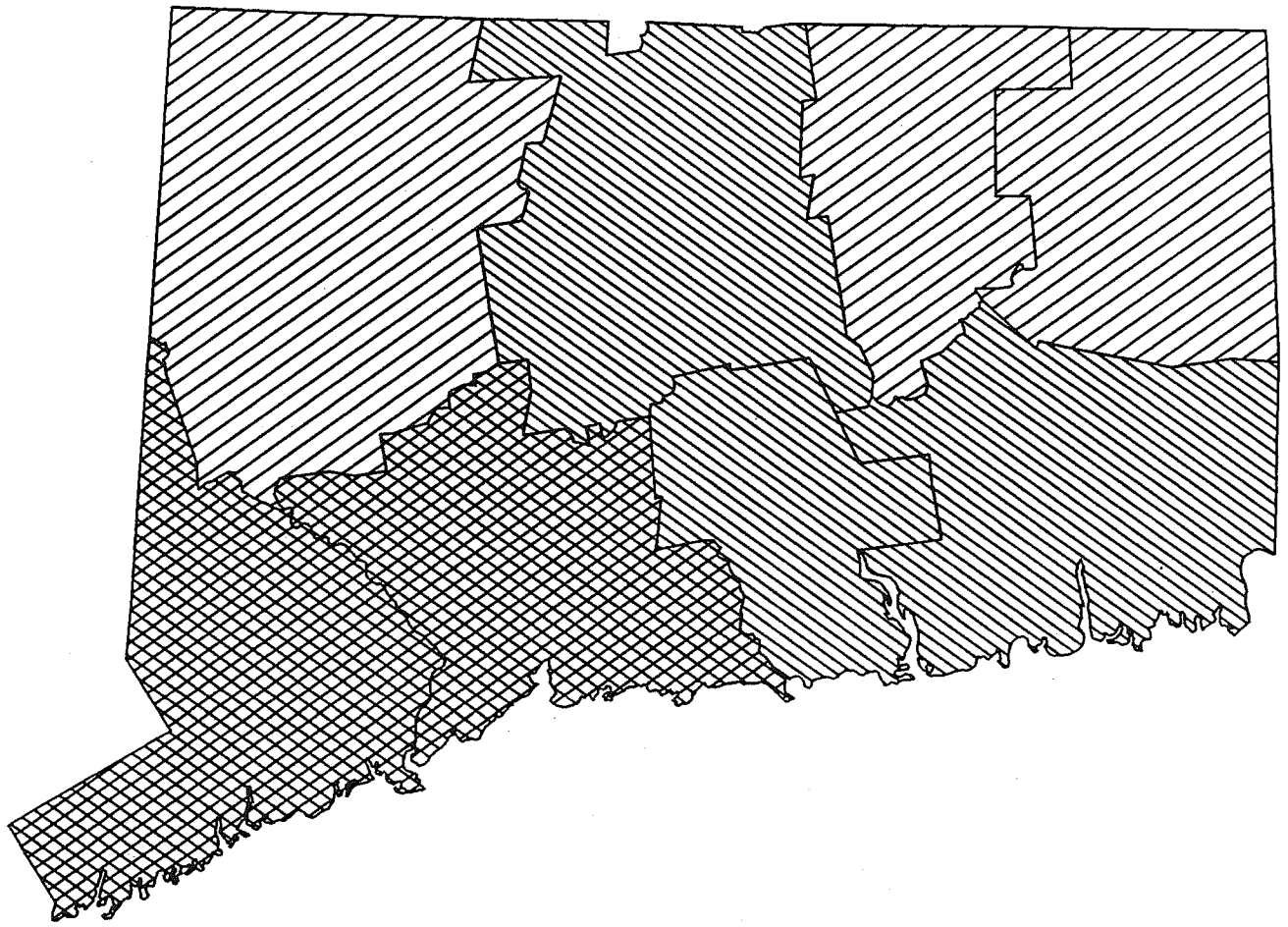
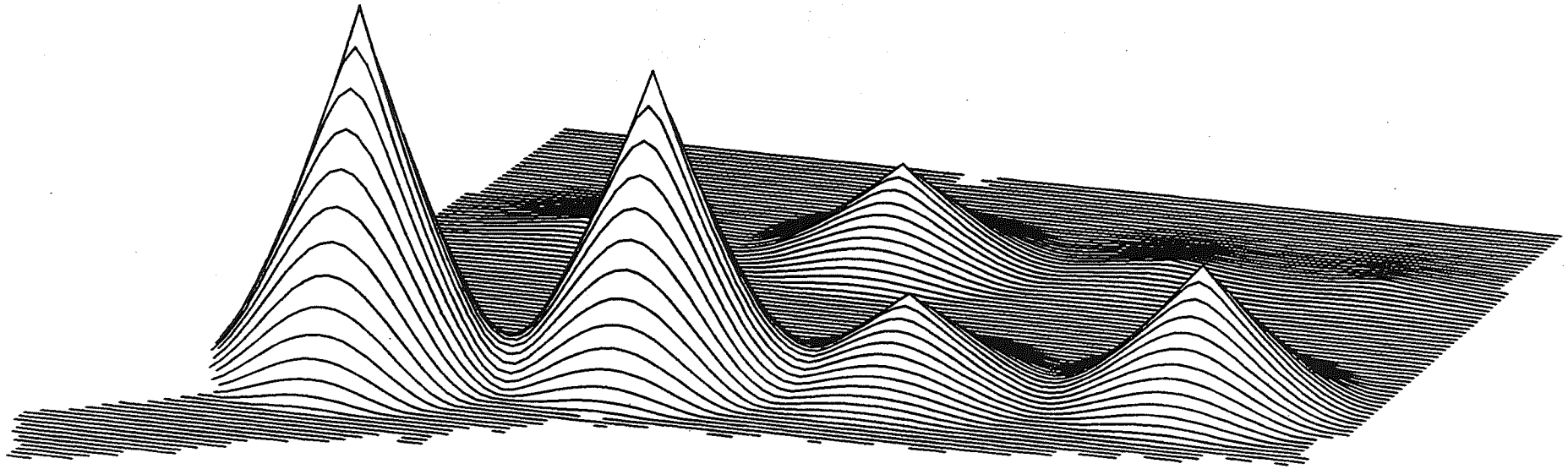


FIGURE 12-7

1988 SULFUR DIOXIDE

Total Emissions by County



Three Dimensional View of SO2 Emissions

FIGURE 12-8

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY
CARBON MONOXIDE

(TOTAL TONS PER YEAR : 712,122)

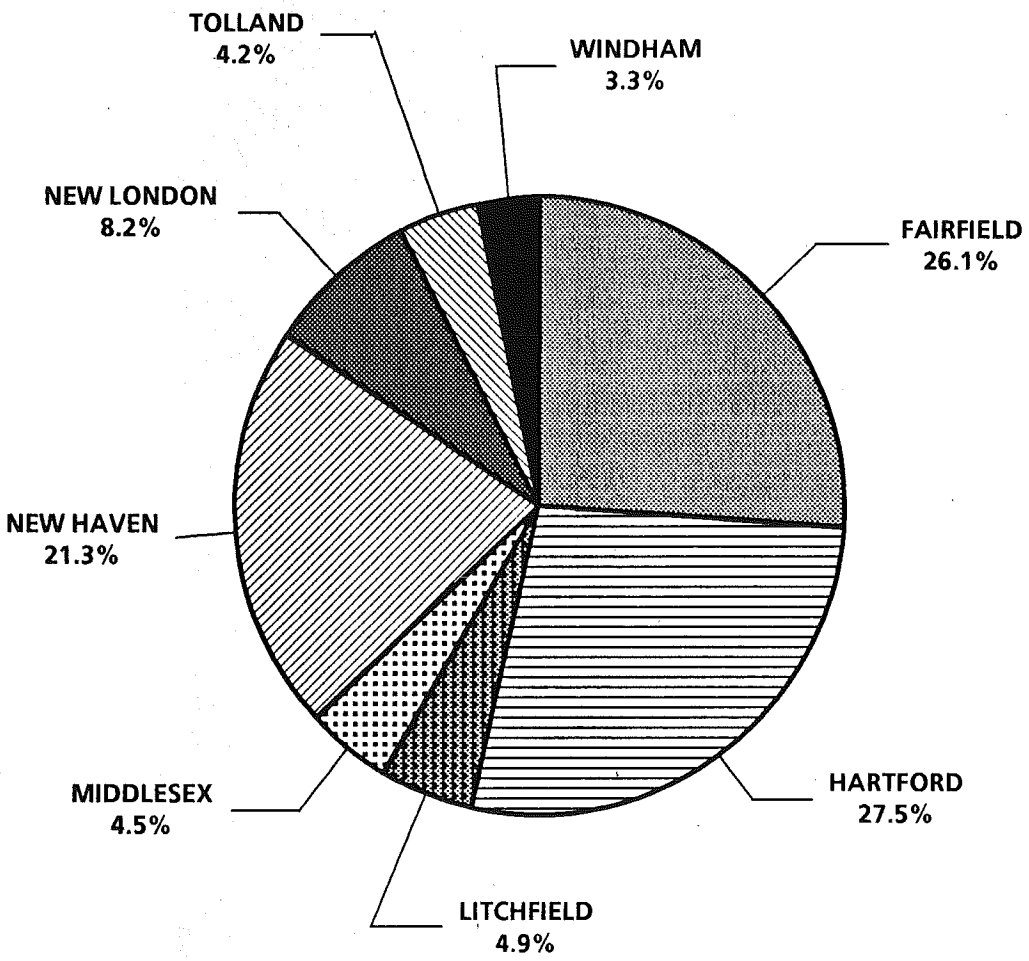
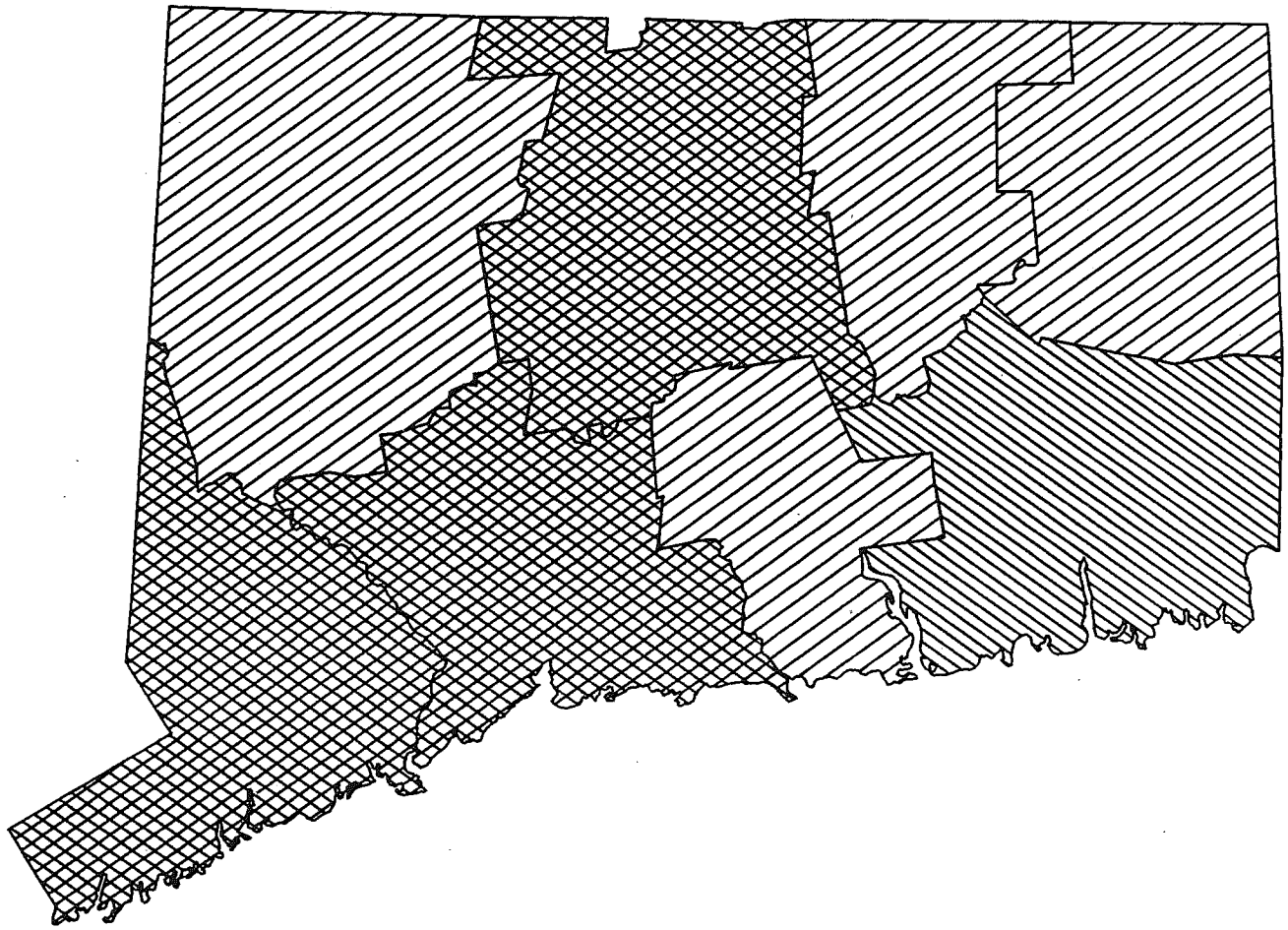


FIGURE 12-9

1988 CARBON MONOXIDE

Total Emissions by County

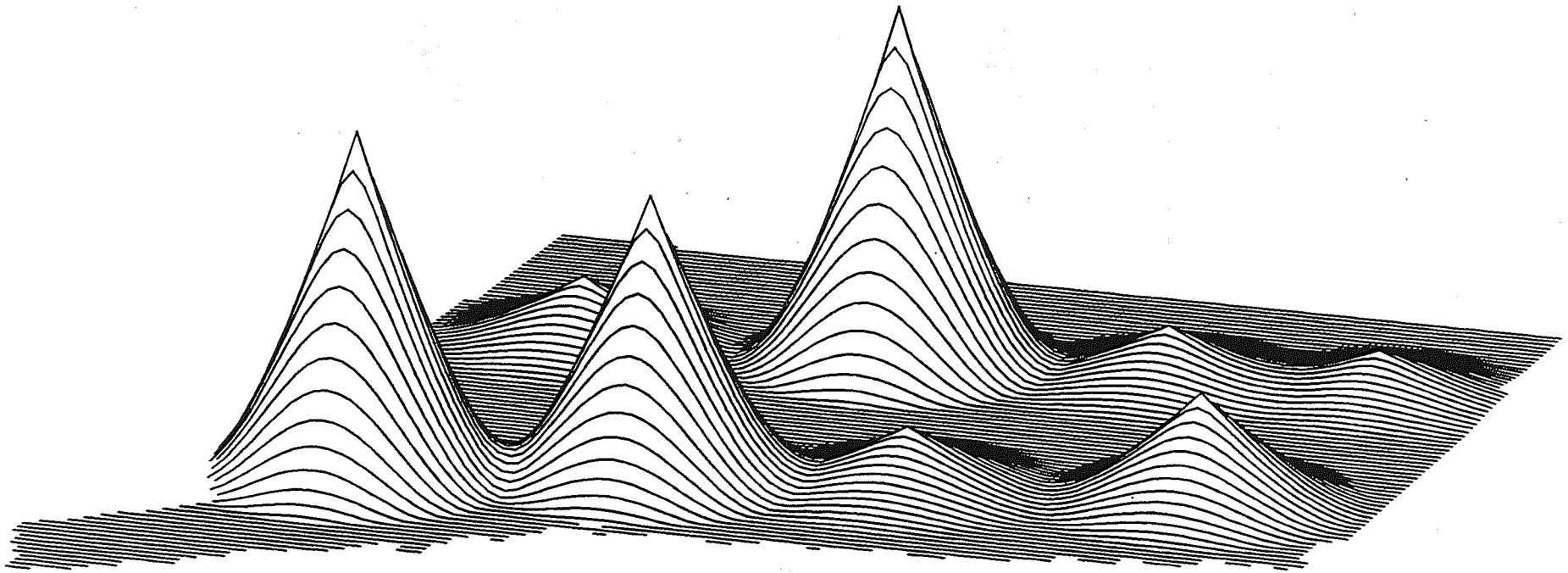


ACTUAL CO (TPY) LESS THAN 40K 40K TO 80K OVER 120K

FIGURE 12-10

1988 CARBON MONOXIDE

Total Emissions by County



Three Dimensional View of CO Emissions

FIGURE 12-11

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY VOLATILE ORGANIC COMPOUNDS

(TOTAL TONS PER YEAR : 148,451)

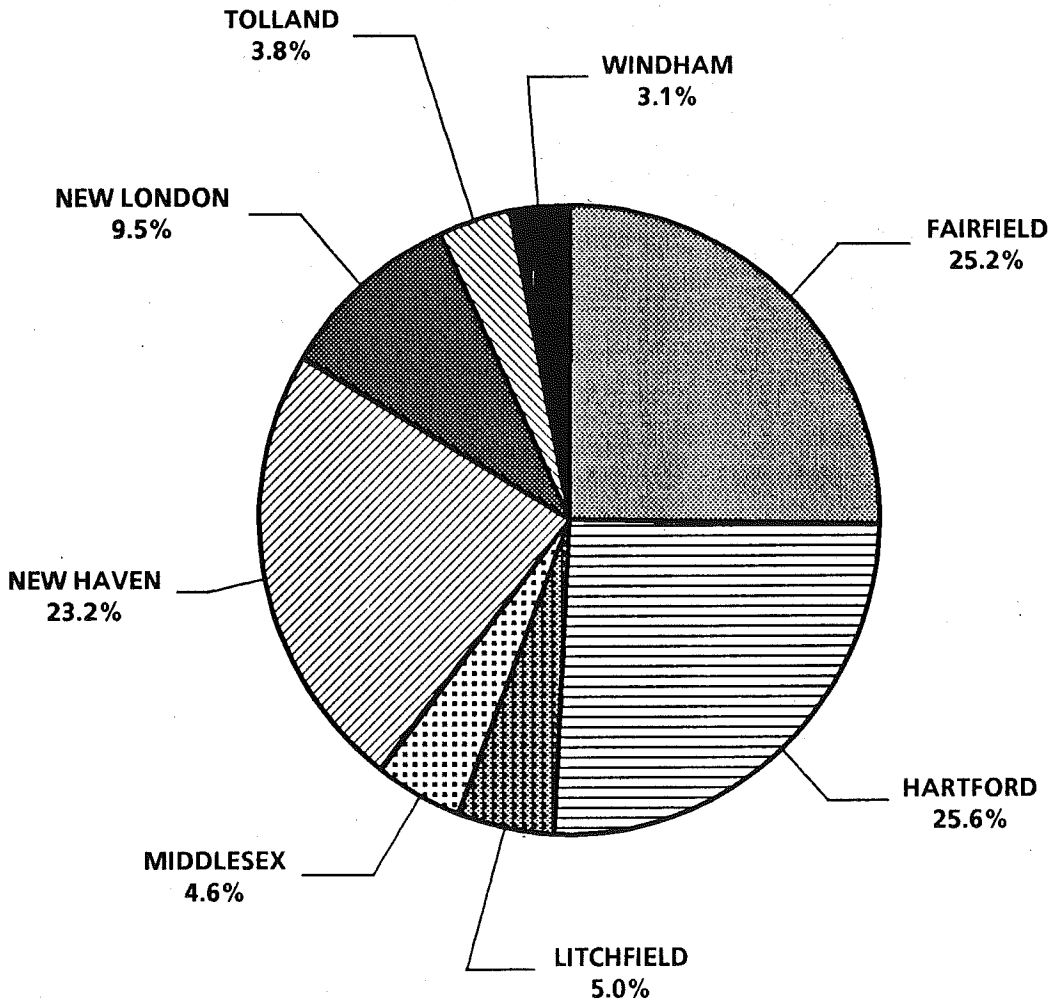
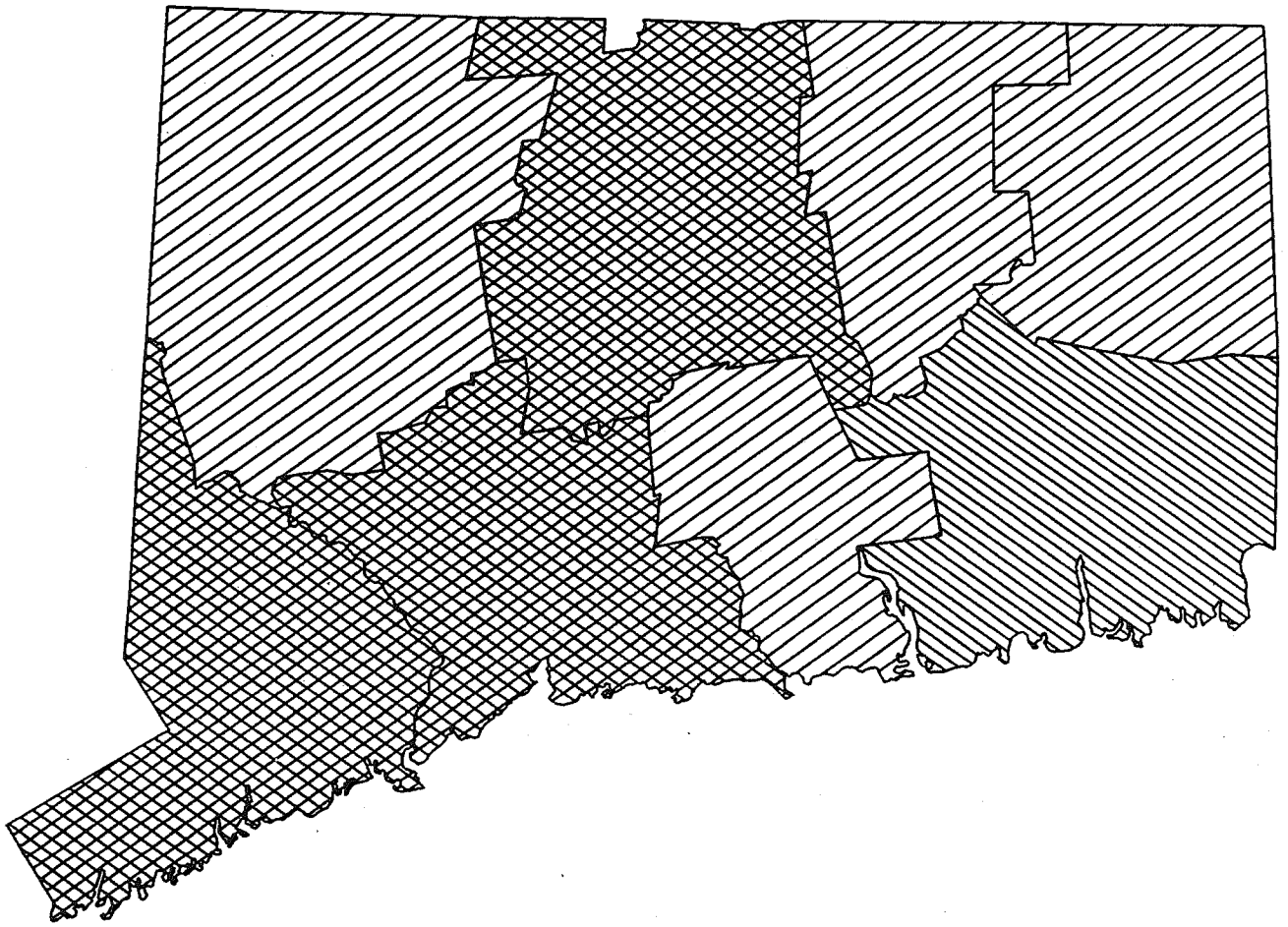


FIGURE 12-12

1988 VOLATILE ORGANIC COMPOUNDS

Total Emissions by County

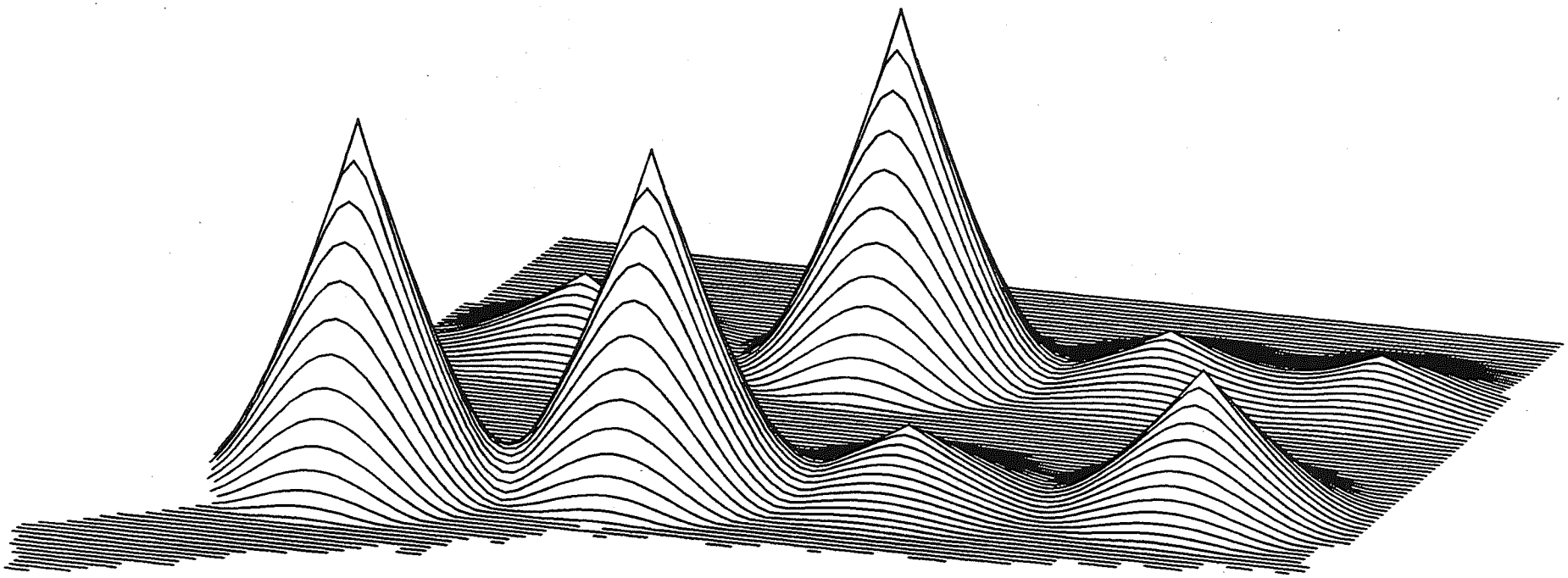


ACTUAL VOC (TPY) LESS THAN 10,000 10,000 TO 20,000 30,000 TO 40,000

FIGURE 12-13

1988 VOLATILE ORGANIC COMPOUNDS

Total Emissions by County



Three Dimensional View of VOC Emissions

FIGURE 12-14

1988 CONNECTICUT EMISSIONS INVENTORY BY COUNTY
NITROGEN OXIDES

(Expressed as Nitrogen Dioxide)

(TOTAL TONS PER YEAR : 157,917)

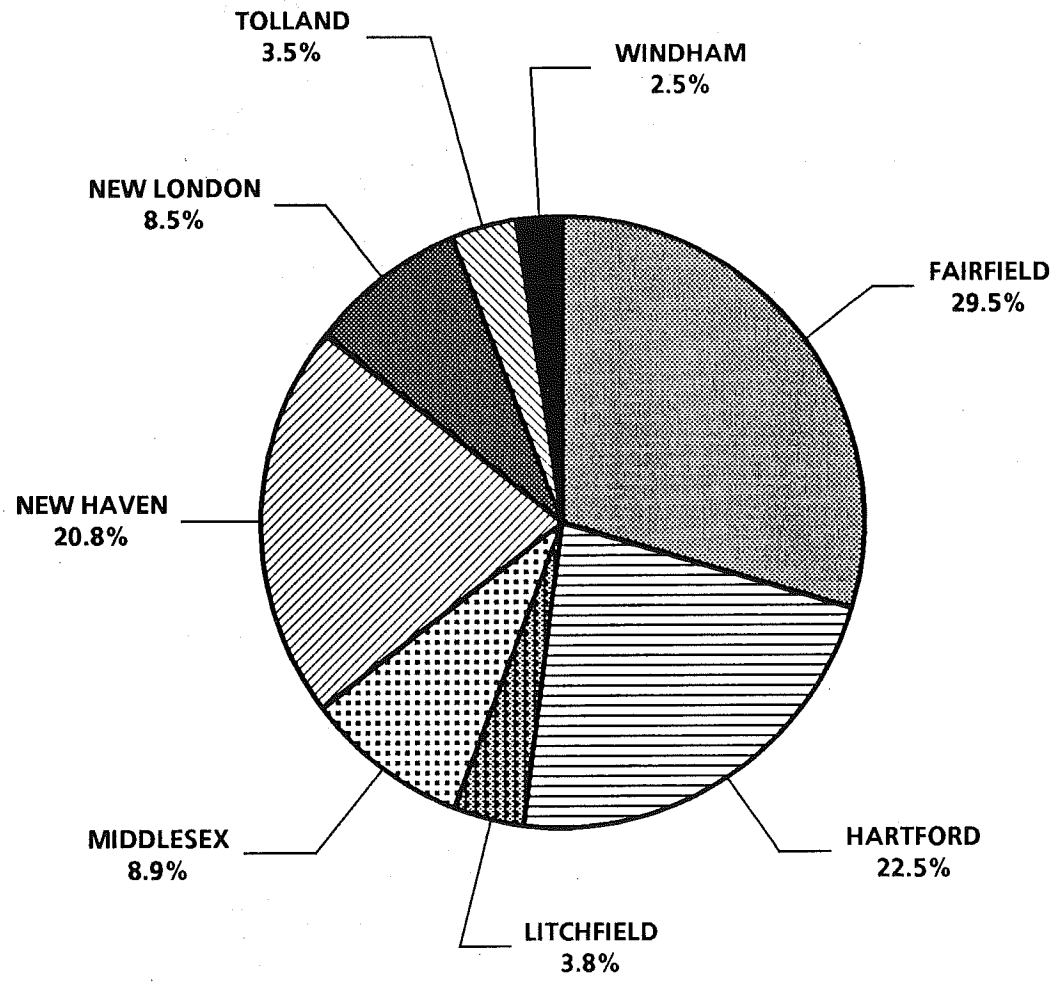
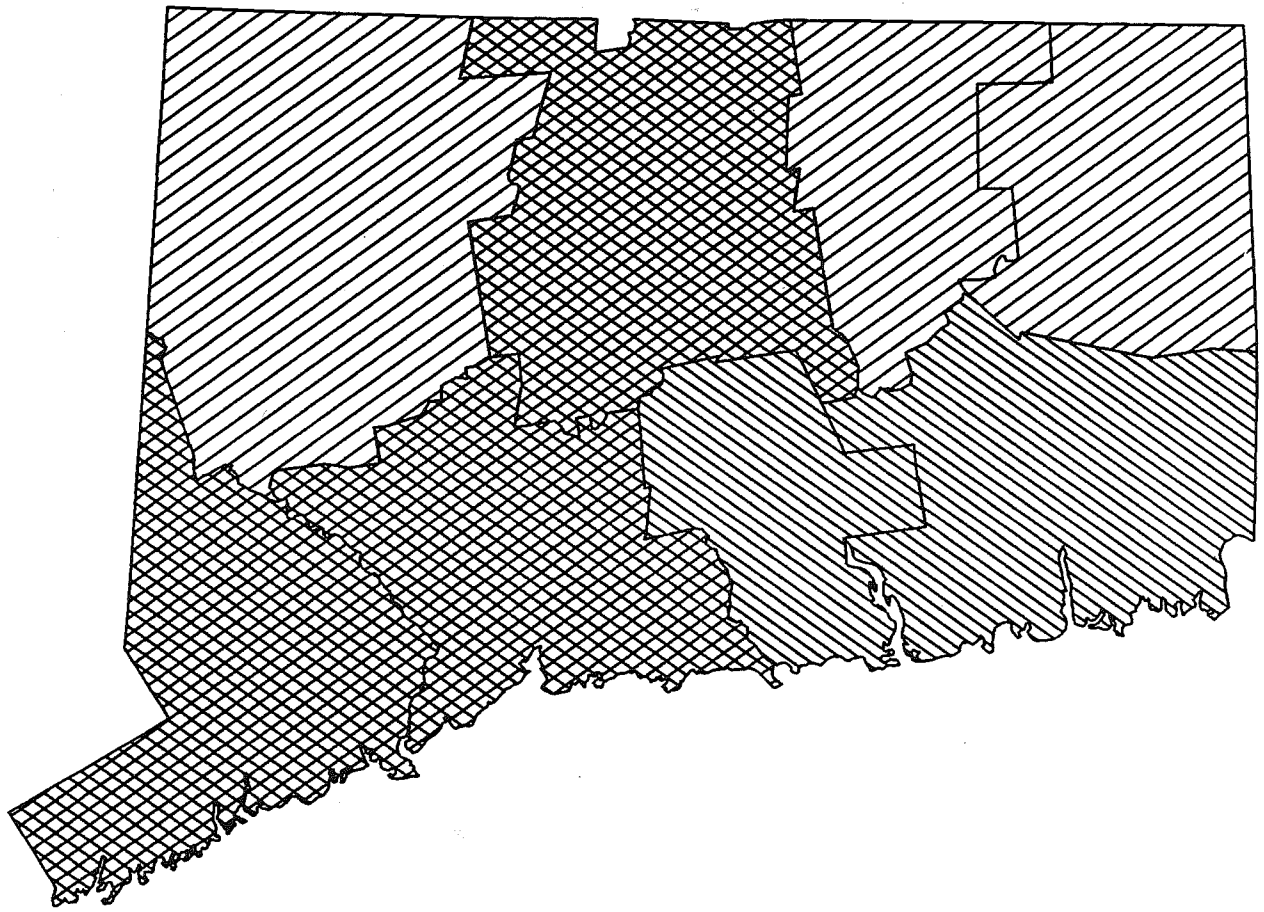


FIGURE 12-15

1988 NITROGEN OXIDES

(Expressed as Nitrogen Dioxide)

Total Emissions by County



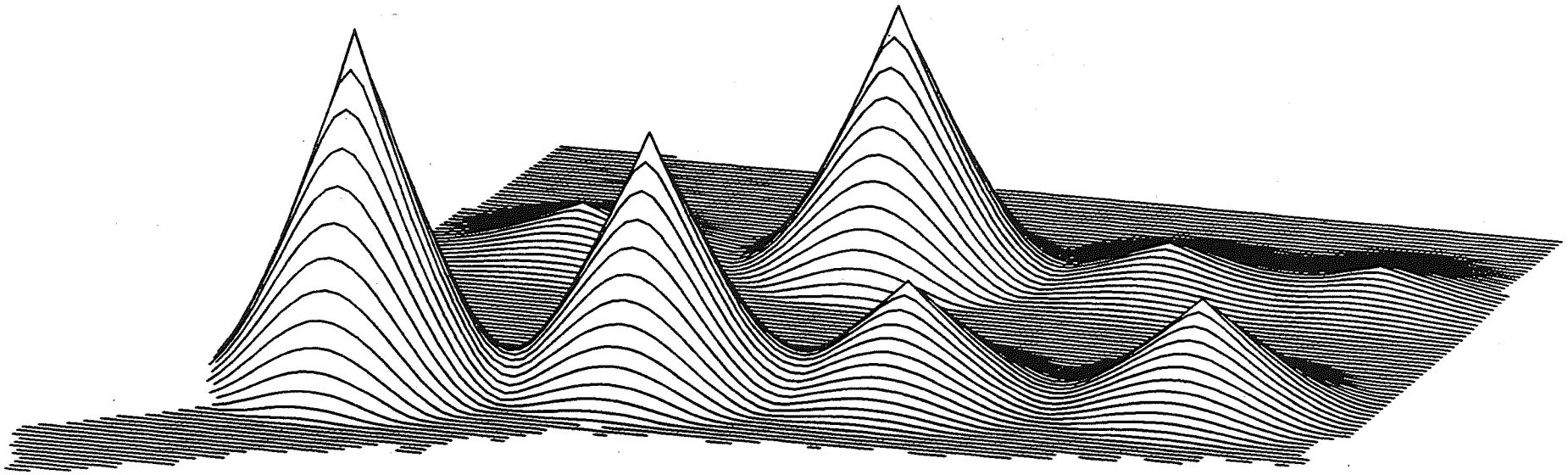
ACTUAL NO2 (TPY) LESS THAN 10,000 10,000 TO 20,000 OVER 30,000

FIGURE 12-16

1988 NITROGEN OXIDES

(Expressed as Nitrogen Dioxide)

Total Emissions by County



Three Dimensional View of NOx Emissions

XIII. 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 SO2 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. Lioy, G.D. Wight, R.E. Pasceri, ***"Aerial Investigation of the Ozone Plume Phenomenon,"*** J. Air Pollut.8 Control Association, 27: 460-3 (1977).

24. Wolff, G.T., P.J. Lioy, R.E. Meyers, R.T. Cederalll, 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. Lioy, 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. Lioy, 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.

XIV. ERRATA

During the preparation of this Air Quality Summary, a number of errors were discovered in previous editions of this document. In order to inform the reader of these changes, the errors and corrections are presented below:

- Regarding the 1987 Air Quality Summary,

  1. In Section III, on page 96, the second sentence in the paragraph under "Annual Averages" should say that 8 (not 9) of the 16 sites showed increased levels of SO_2. The third sentence should say that five (not seven) sites showed decreases (not increases) from 1986 to 1987.

  2. In Section III, on page 99, the annual average for the site Bridgeport-123 is 28 (not 31) in Table 12.

  3. In Section IV, on pages 127-130, October should replace September in the titles of Figures 7, 8, 9 and 10.

  4. In Section VI, on page 140, Figure 12 should show two carbon monoxide instruments in Hartford and none in New Britain.

- Regarding the 1985-1987 Air Quality Summaries,

  1. In Section II, in Table 9, on page 37, the heading should show the area code for Ansonia to be 0008 (not 0060).

- Regarding the 1984 Air Quality Summary,

  1. In Section III, on page 109, certain of the highest and second-highest 3-hour running SO_2 concentrations in Table 16 need to be corrected. The new values are 321 and 274 at Bridgeport-123; 210 and 181 at Danbury; 334 and 305 at East Hartford; 253 and 224 at East Haven; 226 and 167 at Enfield; 173 and 164 at Greenwich; 171 and 167 at Groton; and 348 and 300 at Hartford.