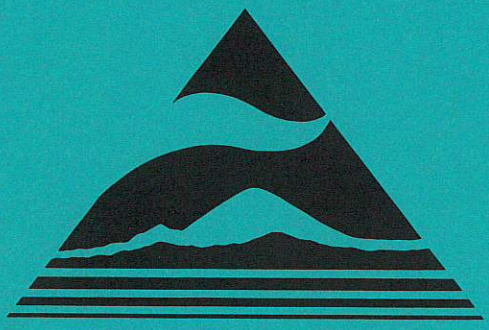
KNECHTEL

1989 Air Quality Data Summary

for the counties

King
Kitsap
Pierce
Snohomish



PUGET SOUND AIR POLLUTION CONTROL AGENCY
200 West Mercer Street, Room 205
Seattle, WA 98119-3958

PUGET SOUND AIR POLLUTION CONTROL AGENCY

Serving King, Kitsap, Pierce and Snohomish Counties

1989 AIR QUALITY DATA SUMMARY

Contents

Reference copies of this summary have been placed in public and college libraries within the Puget Sound region. Copies are available at the Puget Sound Air Pollution Control Agency Seattle headquarters office. A single copy picked up at the Seattle office is free, otherwise the price for each copy is:
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EXECUTIVE SUMMARY

Introduction

This eighteenth annual data summary reviews 1989 air quality and meteorological data for the Puget Sound Region. The report begins with sampling network tables providing the address and type of sampling at each location. Summaries of pollutant measurements and information to assist in interpretation appear within the report. Sections near the back provide a summary of air pollution episodes and impaired air quality periods and meteorological analyses consisting of lower atmosphere temperature soundings, wind speed averages and wind roses.

Air pollution consists of a complex mixture of compounds that are often difficult to quantify. National ambient air quality standards have been established for the six common pollutants known as carbon monoxide, particulate matter, ozone, sulfur dioxide, lead and nitrogen dioxide. For these pollutants Federal law requires meeting the National primary standards which protect health by certain dates. Except for particulate matter, the date to attain the primary standards has passed and many areas in the country have not attained these standards, though most show improvement over levels existing in the 1970's.

The Washington Department of Ecology and the Puget Sound Air Pollution Control Agency have established state and local ambient air quality standards for the same six pollutants which are at least as stringent as the national standards. The state and the local ambient sulfur dioxide standard pre-dates the national standard and is also more stringent than the national standard. A table of all these ambient air quality standards and a discussion of the characteristics and effects of each of those air pollutants appear on the last two facing pages of this report.

For the Puget Sound Region, the standards are not yet attained in specific areas for the pollutants carbon monoxide and particulate matter. The Puget Sound Region was redesignated as attainment for the pollutant ozone early in 1987. The Region is in attainment of the standards for sulfur dioxide, lead and nitrogen dioxide.

Carbon Monoxide

The carbon monoxide nonattainment areas are located in Seattle (downtown and the University district), in Bellevue (downtown), and in Tacoma (downtown). Recent data shows that none of the Seattle downtown locations exceeded the level of the standard more than once during the last four years. Conversely, a small area in downtown Everett has recorded values which exceed the standard. The following table summarizes 1989 carbon monoxide data for locations with measured values exceeding the level of the primary (health related) standard of 9 ppm averaged over eight hours.

Location	Number of Days 8 hr Avg Exceeded 9 ppm	Highest 8 hr Avg (ppm)
Everett,		
Broadway	2	11
Bellevue,		
Bellevue Wy	2	11
Tacoma,		
1101 Pacific	2	10

Particulate Matter

The particulate matter standards adopted by the U. S. EPA in July, 1987, measure only the component of Total Suspended Particulates (TSP) known as PM_{10} (particles 10 micrometers or less in diameter). The levels for the national primary and secondary PM_{10} standards are identical, 150 ug/m^3 for a 24 hour average and 50 ug/m^3 annual arithmetic mean. Washington State and Puget Sound Region PM_{10} standards have been established at the same level as the

national PM_{10} standards. For 1989, none of the daily or annual average PM_{10} values exceeded the level of the standard except for one daily value in Bellevue. The following table summarizes the maximum daily PM_{10} value and the annual PM_{10} arithmetic average by monitoring location for the year 1989.

1989 PM_{10} Summary

Location	Maximum Daily PM_{10} Value (ug/m^3)	Annual PM_{10} Arith Avg (ug/m^3)
Marysville, City Hall (began Nov 10)	60	--
Everett, Hoyt & 26th (began Oct 30)	41	--
Everett, 2730 Colby (ended Oct 19)	86	27.8
Bellevue, Bellevue Wy NE	208	28.2
Lake Forest Pk, City Hall (began Jun 02)	88	--
Seattle, N 98 & Stone (ended May 22)	87	--
Seattle, 301 2nd Ave S (ended Sep 25)	88	29.3
Seattle, Harbor Is	141	40.1
Seattle, Duwamish	147	39.5
Seattle, South Park	108	29.9
Kent, James & Central	127	33.8
NE Tacoma, 27th & 54th	98	32.9
Tacoma, Taylor Way	124	37.1
Tacoma, Alexander	124	35.5
Tacoma, E 11th St	141	38.5

None of the annual PM_{10} values for the past three calendar years exceeded the annual PM_{10} standard of 50 ug/m^3, so the Puget Sound Region is in compliance with the annual PM_{10} standard.

The last three years of data must also be used to determine compliance with the 24 hour average PM_{10} standard. The U. S. EPA requires attainment to be determined by statistically adjusting for days without data and then calculating the average number of days per year exceeding the standard at a particular location for the last three years. If this "expected" number of days above the standard exceeds one, then the PM_{10} standard has not been attained.

This calculation shows two areas within the Puget Sound Region where the "expected" number of days above the standard exceeds one per year. These are the industrialized Seattle Harbor Island-Duwamish area and the industrialized Tacoma Port area. The following table shows the monitoring locations where the "expected" number of days per year on which daily values exceed 150 ug/m^3 is more than one day.

Location	Number of Days Expected to Exceed 150 ug/m^3
Seattle, Duwamish	1.4
Tacoma, Taylor Way	2.0
Tacoma, Alexander	1.3
Tacoma, E 11th St	2.4

The areas which exceed the Washington State and Puget Sound Region annual TSP standard of 60 ug/m^3 are the same industrialized Seattle Harbor Island-Duwamish area and the industrialized Tacoma Port area. The long record of TSP measurements provides the best information to give perspective to the 1989 values as to any trend. The following table shows the TSP annual geometric means beginning with 1972 for these two industrialized areas along with a background location at Tolt in

the foothills of the Cascades. PM_{10} annual arithmetic mean values are shown in parenthesis after these measurements began.

Annual Particulate Matter Averages (ug/m^3)

	Seattle-- Duwamish		Tacoma--- Port area		Tolt
Year	TSP	(PM_{10})	TSP	(PM_{10})	TSP
1972	81		71		14
1973	68		82		12
1974	68		69		13
1975	53		53		9
1976	75		87		12
1977	94		91		11
1978	100		98		10
1979	101		107		10
1980	83		101		10
1981	85		88		15
1982	74		66		10
1983	71	(49)	67	(48)	9
1984	64	(45)	66	(47)	9
1985	77	(54)	80	(55)	10
1986	71	(43)	68	(42)	9
1987	80	(45)	79	(48)	9
1988	73	(39)	69	(43)	9
1989	73	(40)	64	(39)	8

These data show the two separate nonattainment areas are similar and both are quite different from the background site outside the urban area. The Tolt site shows a low, reasonably steady value during this eighteen year period. The two industrial areas appeared to achieve the 60 ug/m^3 annual standard in 1975, but values considerably exceeded the standard in the late 70's and then decreased to levels just above the standard by the end of 1989. The PM_{10} levels in these same two areas exceeded the 50 ug/m^3 annual standard only in 1985 and are now clearly better than the standard requires.

In an effort to determine if wood smoke was threatening the PM_{10} standard in some residential areas, survey sampling was conducted during the winters from late 1986 through early 1989 under a special project grant from the U. S. EPA to the University of Washington Department of Civil Engineering. The study identified marked variations in the smoke levels in residential areas determined to a large extent by topography.

As a result, in early June, 1989, the Puget Sound Air Pollution Control Agency installed a fully instrumented PM_{10} monitoring station in an identified wood smoke impacted area near the City Hall in Lake Forest Park. The study suggested this location would be similar to and could be representative of many other wood smoke impacted valleys in the Puget Sound Region.

Following installation on June 2, 1989, the maximum daily PM_{10} value measured at Lake Forest Park was 88 ug/m^3 on November 2. A period of "impaired air quality" resulted in a burn ban from the afternoon of November 29 until the morning of December 2. During this period the highest PM_{10} daily values at the four stations which operated almost daily were as follows:

Seattle, Duwamish 147 ug/m^3 on Nov 30;
Tacoma Port area 135 ug/m^3 on Nov 30;
Kent 108 ug/m^3 on Nov 30;
Lake Forest Park 85 ug/m^3 on Nov 29.

Continued PM_{10} monitoring at Lake Forest Park will provide daily PM_{10} values for a variety of stagnant weather conditions. During the significant stagnant period and burn ban just cited, the Lake Forest Park PM_{10} values were lower than those in the Duwamish, Kent and Tacoma Port industrial, commercial areas.

Ozone

Ozone is a photochemical pollutant with highest levels measured on hot days from mid May to mid September. Though the Puget Sound Region has attained the ozone standard, there have been a few cases where a measured ozone value exceeded the level of the 1 hour standard of 0.12 ppm. The following table summarizes the maximum 1 hour average ozone value during 1989 for each ozone monitoring site.

1989 Ozone Summary

Location	Maximum 1 hr Avg (ppm)
Lake Sammamish State Park	0.09
Cedar River, near Kangley	0.10
Enumclaw, Highway 410	0.10
Graham, Pierce County	0.094
Carbon River, Mt Rainier Natl Prk	0.093
La Grande, Pack Forest	0.103

Unless a particular location measures more than one daily maximum hour per year, averaged over the last three years, which is in excess of 0.12 ppm, the standard continues to be attained. None of the 1989 maximum 1 hour averages exceeded the level of the standard. Further, for the three year period ending in 1989, the "expected" number of days per year with an hourly average above 0.12 ppm was less than one at all ozone monitoring locations.

Daily Air Quality

The Agency uses the national Pollutant Standards Index to report daily air quality. The Index value is calculated directly from measurements for each of the pollutants, and the report includes a descriptive term for the daily Index value.

These terms describe the air quality (in progressively more polluted stages) as "Good", "Moderate", "Unhealthful", or "Very Unhealthful". Any pollutant measurement exceeding the short term national primary standard causes the Index value to be in the Unhealthful or a worse category.

The daily Pollutant Standards Index values provide a way to summarize the air quality for the entire year. In 1989:

Everett had 150 Good, 213 Moderate, and 2 Unhealthful days;
Seattle had 231 Good, 134 Moderate, and zero Unhealthful days;
Tacoma had 260 Good, 103 Moderate, and 2 Unhealthful days.

Weather and Air Quality

Finally, another variable that influences the air quality on a given day is the weather. Weather never causes high pollutant levels, but sometimes under stable conditions the pollutants emitted from human activities are not quickly dispersed.

Poor dispersion exists on about one-third of the days during nighttime and early morning hours, but the weather effectively disperses pollutants by afternoon on most of these days. A few times during the months of October, November, December, January or February each year poor dispersion persists for 24 or more hours and may result in the declaration of an "Air Pollution Episode" or local "Impaired Air Quality". These cases are often associated with the higher pollutant levels.

During 1989, the Department of Ecology declared the "Forecast" stage of an air pollution episode which included the Puget Sound region during the following periods:

5:30 pm, Thursday, November 30 - 3:00 pm, Friday, December 1;

2:00 pm, Monday, December 11 - 10:00 am, Sunday, December 17.

During 1989, the Agency declared a local condition of "Impaired Air Quality" resulting in a burn ban on six occasions. These six periods with a burn ban in effect for the four counties of King, Kitsap, Pierce and Snohomish were:

2:30 pm, Thursday, January 19 -
2:30 pm, Friday, January 20;

2:30 pm, Tuesday, January 24 -
9:30 am, Thursday, January 26;

2:30 pm, Monday, February 6 -
9:30 am, Wednesday, February 8;

2:30 pm, Friday, February 10 -
9:30 am, Thursday, February 16;

2:30 pm, Wednesday, November 29 -
9:30 am, Saturday, December 2;

2:30 pm, Friday, December 22 -
2:30 pm, Saturday, December 23.

Other Information Sources

All data collected are reported to the Washington State Department of Ecology; some of it is forwarded from there to the National Aerometric Data Bank maintained by the U. S. EPA. The Department of Ecology conducts air monitoring within the Puget Sound area in addition to that done by our Agency. The Department publishes an annual summary of data for the entire state. Requests for the state summary should be directed to the Washington Department of Ecology - PV11, Air Program, Olympia, WA 98504-8711.

The current daily Index is available from the Puget Sound Air Pollution Control Agency by dialing 296-5100 or by dialing 1-800-433-2215 from outside Seattle.

1989 SAMPLING NETWORK

Location	Type of Sampling			
Tolt River Watershed, King County, Wa		TSP		
City Hall, 514 Delta Ave, Marysville, Wa	PM_{10}			
(began Nov 10) *3402 28th Place NE, Everett, Wa				SO_2
(discontinued Sep 26) *Legion Park, W Marine View Dr, Everett, Wa				SO_2
(discontinued Apr 30) Hoyt Ave & 26th St, Everett, Wa	PM_{10}			b_{sp}, SO_2, Wind
(began Oct 19) Medical-Dental Bldg, 2730 Colby, Everett, Wa	PM_{10}			b_{sp}, SO_2, Wind
(discontinued Oct 19) *Broadway & Hewitt Ave, Everett, Wa			CO	
*622 Bellevue Way NE, Bellevue, Wa			CO	
*504 Bellevue Way NE, Bellevue, Wa	PM_{10}			
*20050 SE 56th, Lake Sammamish State Park, Wa				O_3
17711 Ballinger Way NE, Lake Forest Park, Wa	PM_{10}			b_{sp}, Wind
(began Jun 02) *Northgate, 310 NE Northgate Way, Seattle, Wa			CO	
North 98th St & Stone Ave N, Seattle, Wa	PM_{10}	TSP		b_{sp}, Pb, Wind
(discontinued May 31) *5701 8th Ave NE, Seattle, Wa		TSP		Pb
*4511 University Way NE, Seattle, Wa			CO	
(discontinued Sep 19) *1960 NE Pacific St, Seattle, Wa			CO	
*1424 4th Ave, Seattle, Wa			CO	
*5th Ave & James St, Seattle, Wa			CO	
*Courthouse, 4th Ave & James St, Seattle, Wa			CO	
(discontinued Jul 24) *Fire Station #10, 301 2nd Ave S, Seattle, Wa	PM_{10}		CO	
(discontinued Sep 25) *Beacon Hill, 15th S & Charlestown, Seattle, Wa				Wind
Harbor Island, 2555 13th Ave SW, Seattle, Wa		TSP		Pb
Harbor Island, 3400 13th Ave SW, Seattle, Wa	PM_{10}			
Duwamish, 4752 E Marginal Way S, Seattle, Wa	PM_{10}	TSP		$PM_{2.5}$, b_{sp}, SO_2, Wind
*Georgetown, 6431 Corson Ave S, Seattle, Wa		TSP		

Notes- (1) Type of Sampling:

- PM_{10} = Particulate Matter 10 micrometers or smaller
- TSP = Total Suspended Particulates
- CO = Carbon Monoxide
- $PM_{2.5}$ = Particulate Matter smaller than 2.5 micrometers
- Wind = Wind Direction & Speed
- b_{sp} = Atmospheric Particles (by nephelometer)
- O_3 = Ozone
- SO_2 = Sulfur Dioxide
- Pb = Lead

(2) * Station operated by Washington State Department of Ecology.

1989 SAMPLING NETWORK

Location	Type of Sampling			
South Park, 723 S Concord St, Seattle, Wa	PM_{10}			
Duwamish Valley, 12026 42nd Ave S, King Co, Wa		TSP		
James St & Central Ave, Kent, Wa	PM_{10}			$PM_{2.5}$, b_{sp}, Wind
*Cedar River Watershed, near Kangley, Wa (seasonal)				O_3
115 E Main St, Auburn, Wa		TSP		
Pac Coast Coal, 270th Ave SE, Black Diamond, Wa (discontinued Aug 26)		TSP		
*Highway 410, 2 miles east of Enumclaw, Wa (seasonal)				O_3
Sumner Jr HS, 1508 Willow St, Sumner, Wa		TSP		
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	PM_{10}			b_{sp}, SO_2, Wind
2340 Taylor Way, Tacoma, Wa	PM_{10}			
2301 Alexander Ave, Tacoma, Wa	PM_{10}			SO_2, Wind
Fire Station #12, 2316 E 11th St, Tacoma, Wa	PM_{10}	TSP		$PM_{2.5}$, b_{sp}, Wind
*951 Portland Ave, Tacoma, Wa				SO_2, Wind
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa (discontinued Jun 03)		TSP		
Cascadia, 2002 E 28th St, Tacoma, Wa		TSP		
Willard School, S 32nd & S 'D' St, Tacoma, Wa		TSP		
*1101 Pacific Ave, Tacoma, Wa			CO	
SW 283rd & 101st Ave SW, Maury Island, Wa (discontinued Dec 30)		TSP		
Ruston School, 5219 N Shirley St, Tacoma, Wa		TSP		Pb, As
*Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa (discontinued Aug 02)		TSP		
City Hall, 239 4th St, Bremerton, Wa (discontinued Dec 30)		TSP		
*Burwell St & Pacific Ave, Bremerton, Wa			CO	
*Pierce Co Fire D #21, 8102 304th, Graham, Wa (seasonal; discontinued Oct 30)				O_3
*Mt Rainier National Park, Carbon River RS, Wa (seasonal)				O_3
*Charles L Pack Forest, La Grande, Wa (seasonal)				O_3

Notes- (1) Type of Sampling:

PM_{10}	= Particulate Matter 10 micrometers or smaller	b_{sp}	= Atmospheric Particles (by nephelometer)
TSP	= Total Suspended Particulates	O_3	= Ozone
CO	= Carbon Monoxide	SO_2	= Sulfur Dioxide
$PM_{2.5}$	= Particulate Matter smaller than 2.5 micrometers	Pb	= Lead
Wind	= Wind Direction & Speed	As	= Arsenic

(2) * Station operated by Washington State Department of Ecology.

POLLUTANT STANDARDS INDEX

The Pollutant Standards Index (PSI) provides a nationally uniform way to report daily air quality levels. In cooperation with the Washington State Department of Ecology, the Agency began reporting the PSI in 1980 for the Everett, Seattle, and Tacoma areas.

Measured pollutant levels during each day are transferred to a scale indicating if there are potential health effects. This PSI scale of zero to 500 categorizes air quality by the following descriptions:

from 0 to 50, Good;
from 51 to 100, Moderate;
from 101 to 199, Unhealthful;
from 200 to 299, Very Unhealthful;
from 300 to 500, Hazardous.

The table below shows the averaging period and each pollutant concentration for all the category break-points of the Index. Values between break-points are determined by linear interpolation.

Whenever the PSI is above 100, a measured pollutant level has exceeded the national primary air quality standard established to protect health. An index value of 200 means the pollutant concentration has reached the "Alert" level in the Washington Episode Avoidance Plan.

Each day the pollutant levels within the cities of Everett, Seattle and Tacoma are used to calculate the Index. The daily Index value for each city is determined by the pollutant with the highest value on the PSI scale. The highest PSI values normally occur near congested traffic or an industrial area, and the values in suburban residential areas are usually lower.

Tables which follow summarize the daily PSI values for Everett, Seattle, and Tacoma. The higher PSI values tend to occur during the fall and winter months often coinciding with air stagnation periods. The 1989 summary table shows for each month the number of days in each PSI interval, the maximum Index, the date of the maximum and the pollutant determining the maximum value.

A summary table for 1980 through 1989 presents by year the number of days in each air quality category and the number of days each pollutant determined the PSI. For all the unhealthful days each year (Index values greater than 100), this summary also tabulates the pollutant responsible.

Pollutant		Averaging Period & Units
Carbon Monoxide	(CO)	8 hour average in parts per million
Particulate Matter	(PM_{10})	24 hour average in micrograms per cubic meter
Sulfur Dioxide	(SO_2)	24 hour average in parts per million
Ozone	(O_3)	1 hour average in parts per million

PSI Break-points and Pollutant Concentrations

PSI value	CO (8 hrs)	PM_{10} (24 hrs)	SO_2 (24 hrs)	O_3 (1 hr)
50	4.5	50	0.03	0.06
100	9.0	150	0.14	0.12
200	15.0	350	0.30	0.20
300	30.0	420	0.60	0.40
400	40.0	500	0.80	0.50
500	50.0	600	1.00	0.60

POLLUTANT STANDARDS INDEX

1989

EVERETT

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	15	11	21	12	15	11	17	11	4	9	15	9	150
MODERATE	(51 to 100)	16	16	10	18	16	19	14	20	26	22	14	22	213
UNHEALTHFUL	(101 to 199)	0	1	0	0	0	0	0	0	0	0	1	0	2
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		100	133	100	100	89	100	78	78	100	89	117	89	133
Date		19th	10th	24th	11th#	5th	23rd	21st#	4th#	1st	5th#	30th	22nd	Feb 10
Pollutant		CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO

SEATTLE

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	13	9	21	22	29	26	29	29	15	10	13	15	231
MODERATE	(51 to 100)	18	19	10	8	2	4	2	2	15	21	17	16	134
UNHEALTHFUL	(101 to 199)	0	0	0	0	0	0	0	0	0	0	0	0	0
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		100	100	78	67	59	56	56	56	67	78	99	92	100
Date		19th	9th	20th	11th	5th	26th#	12th#	14th#	13th#	17th	30th	1st	Jan 19
Pollutant		CO	CO	CO	CO	PM	CO	CO	CO	PM	CO	PM	PM	CO

TACOMA

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	23	16	22	20	26	26	30	27	14	17	22	17	260
MODERATE	(51 to 100)	8	12	9	10	5	4	1	4	16	14	7	13	103
UNHEALTHFUL	(101 to 199)	0	0	0	0	0	0	0	0	0	0	1	1	2
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		78	96	78	67	64	67	51	60	74	78	117	117	117
Date		19th#	8th	10th	14th	16th	29th	25th	18th	13th	17th	30th	1st	Nov 30
Pollutant		CO	PM	CO	CO	PM	CO	PM	PM	PM	CO	CO	CO	CO

PM = Particulate Matter; CO = Carbon Monoxide; SO2 = Sulfur Dioxide.

Earliest date of occurrence

POLLUTANT STANDARDS INDEX

1980 - 1989

EVERETT

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	340	19	0	0	356	-	3	0	-	0	60	Jan 23	PM
1981	350	11	0	0	340	-	21	0	-	0	62	Jan 16	PM
1982	334	30	1	0	277	70	18	0	1	0	117	Dec 30	CO
1983	308	56	1	0	191	150	24	0	1	0	117	Nov 30	CO
1984	309	57	0	0	105	217	44	0	0	0	92	Sep 28	PM
1985	300	64	1	0	152	166	47	0	1	0	117	Dec 11	CO
1986	324	41	0	0	169	148	48	0	0	0	89	Jan 25	CO
1987	203	158	3	0	96	250	18	0	3	0	117	Jun 26#	CO
1988	174	184	8	0	15	345	6	0	8	0	133	Sep 13#	CO
1989	150	213	2	0	26	338	1	0	2	0	133	Feb 10	CO
Totals	2792	833	16	0	1727	1684	230	0	16	0			

SEATTLE

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	73	275	18	0	95	270	1	1	17	0	194	Jan 23	PM
1981	69	267	28	1	109	254	2	5	24	0	213	Jan 15	CO
1982	86	268	10	1	96	264	5	1	10	0	214	Feb 6	PM
1983	98	258	9	0	101	261	3	0	9	0	183	Jan 28	CO
1984	146	218	2	0	111	242	13	2	0	0	103	Dec 6	PM
1985	150	202	10	3	156	206	3	6	7	0	204	Dec 12	PM
1986	130	226	8	1	113	246	6	1	8	0	206	Jan 7	PM
1987	120	238	7	0	119	246	0	3	4	0	184	Feb 6	PM
1988	215	146	5	0	67	298	1	2	3	0	150	Dec 3	CO
1989	231	134	0	0	129	233	3	0	0	0	100	Jan 19#	CO
Totals	1318	2232	97	6	1096	2520	37	21	82	0			

TACOMA

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	83	271	12	0	256	107	3	4	8	0	160	Apr 12	PM
1981	74	278	10	3	222	137	6	1	12	0	227	Jan 12	CO
1982	119	242	4	0	255	101	9	0	4	0	167	Dec 30	CO
1983	140	222	3	0	228	128	9	1	2	0	137	Dec 23	PM
1984	162	198	6	0	207	149	10	0	6	0	117	Jan 19#	CO
1985	140	213	12	0	252	109	4	1	11	0	165	Dec 13	PM
1986	161	197	7	0	247	114	4	2	5	0	167	Oct 23	CO
1987	173	177	13	2	227	136	2	5	10	0	220	Feb 5	CO
1988	226	132	8	0	184	175	7	3	5	0	183	Jan 27	CO
1989	260	103	2	0	217	121	27	0	2	0	117	Nov 30#	CO
Totals	1538	2033	77	5	2295	1277	81	17	65	0			

Earliest date of occurrence

PARTICULATE MATTER

Introduction

Particulate Matter as a general term includes small particles of dust, soot, organic matter and compounds containing sulfur, nitrogen, and metals. In July, 1987, the U. S. EPA changed the national particulate matter standards from the measurement of Total Suspended Particulates (TSP) to the measurement of only that fraction of particulate matter with particle diameters smaller than or equal to 10 micrometers (PM_{10}). The levels for the national primary and secondary standards are identical, 150 ug/m^3 for a 24 hour average and 50 ug/m^3 annual arithmetic mean. The PM_{10} standards also include calculation formulas for statistically determining whether the standards are attained.

Particulate Sources and Air Quality

Particulates directly enter the air from industrial operations, from fuel combustion including wood stoves and fireplaces, from auto and truck traffic, from construction, and from other sources. These emissions change from day to day due to intermittent industrial operations, equipment upset or breakdown, traffic cycles and building heating requirements. Gaseous transformation products like sulfates, nitrates, and some organics are also a component of particulate matter. In the air, particulate matter disperses and is transported by the wind. Ambient levels change from day to day in response to what enters the air and to different weather conditions.

Manual Sampling Methods

The approved U. S. EPA reference methods to measure PM_{10} all draw outside air first through an inlet which traps particulates larger than 10 micrometers and then through a filter which collects the remaining particulate matter (PM_{10}). A PM_{10} inlet installed on a high volume sampler is sometimes called a size selective inlet. Sampling for a single measurement continues for 24 hours usually from midnight to midnight. After sampling, the pre-weighed filter is manually removed and, following conditioning in a controlled atmosphere to remove moisture effects, the filter is weighed on a precise balance to determine the net weight of particulate matter collected. The volume of air sampled, corrected to standard temperature and pressure conditions, is calculated from the flow rate and sampling time. The ambient PM_{10} concentration is the weight (mass) of the particulate collected divided by the volume of air sampled, and is reported in micrograms per standard cubic meter.

The TSP method measures the total particulate concentration following a procedure essentially like the PM_{10} reference method except that the inlet is not size selective. For TSP, outside air reaches the collection filter after being drawn under the edge of the roof covering a small rectangular shelter containing the high volume sampler.

Continuous Sampling

An instrument called an integrating nephelometer continuously measures the light scattering extinction coefficient. A component of the scattering coefficient, (b_{sp}), is a measure of atmospheric particles. This dry particle scattering coefficient correlates well to PM_{10} values. The particulate level measured by this method is reported as a scattering coefficient per meter times 10^{-4}.

When operated at a site concurrent with the reference method, a relationship between the two methods may be developed for that site. Relationships for 1989 are documented in a succeeding section of this report. Each relationship (multiple regression equation) enables use of the continuous nephelometer measurement to provide a satisfactory real-time estimate of the manual reference PM_{10} value.

Data Summaries

The following tables summarize PM_{10}, TSP, and nephelometer measurements during 1989. The areas not yet achieving the particulate matter standards are the industrialized Seattle Harbor Island-Duwamish area and the industrialized Tacoma Port area.

PARTICULATE MATTER (PM10)
Micrograms per Standard Cubic Meter

Sampled by Size Selective Inlet - Hi Vol SA1200 Quartz Fiber filters

1989

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean
Medical-Dental Bldg, 2730 Colby, Everett, Wa	48	28.4	26.4	28.7	-	27.8
504 Bellevue Way NE, Bellevue, Wa	109	44.9	20.7	21.6	25.5	28.2
17711 Ballinger Way NE, Lake Forest Park, Wa	206		-	22.7	38.9	-
North 98th St & Stone Ave N, Seattle, Wa	22	29.8	-			-
Fire Station #10, 301 2nd Ave S, Seattle, Wa	35	36.1	23.6	28.1		29.3
Harbor Island, 3400 13th Ave SW, Seattle, Wa	59	46.9	32.8	35.5	45.1	40.1
Duwamish, 4752 E Marginal Way S, Seattle, Wa	351	43.7	33.5	34.0	46.9	39.5
South Park, 723 S Concord St, Seattle, Wa	60	35.2	22.6	25.9	35.8	29.9
James St & Central Ave, Kent, Wa	345	38.2	27.0	30.3	39.5	33.8
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	58	27.3	33.4	36.3	34.7	32.9
2340 Taylor Way, Tacoma, Wa	56	39.2	31.7	37.1	40.2	37.1
2301 Alexander Ave, Tacoma, Wa	147	34.6	27.8	34.7	45.0	35.5
Fire Station #12, 2316 E 11th St, Tacoma, Wa	338	41.0	34.3	35.8	43.0	38.5

Notes
(1) Nationally scheduled particulate matter sampling occurs each sixth day. Quarterly averages are shown only when at least one data value exists for 75 percent or more of the six day intervals.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum and 2nd High Observed Concentrations

Location	Feb 8 Wed	Feb 9 Thu	Feb 14 Tue	Feb 15 Wed	Sep 13 Wed	Oct 30 Mon	Nov 2 Thu	Nov 29 Wed	Nov 30 Thu	Dec 22 Fri	Dec 27 Wed
City Hall, 514 Delta Ave, Marysville, Wa	--	--	--	--	--	--	--	--	--	55	60
Hoyt Ave & 26th St, Everett, Wa	--	--	--	--	--	37	--	--	--	41	
Medical-Dental Bldg, 2730 Colby, Everett, Wa	--		--	86	64	--	--	--	--	--	--
504 Bellevue Way NE, Bellevue, Wa	--	208	--	75		--	--	--		--	--
17711 Ballinger Way NE, Lake Forest Park, Wa	--	--	--	--			88	85			
North 98th St & Stone Ave N, Seattle, Wa	--	66	--	87	--	--	--	--	--	--	--
Fire Station #10, 301 2nd Ave S, Seattle, Wa	--	75	--	88		--	--	--	--	--	--
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--		--	126		--	--	--	141	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa								138	147		
South Park, 723 S Concord St, Seattle, Wa	--		--	91		--	--	--	108	--	--
James St & Central Ave, Kent, Wa			127						108		
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--		--		81	--	--	--	98	--	--
2340 Taylor Way, Tacoma, Wa	--		--	101		--	--	--	124	--	--
2301 Alexander Ave, Tacoma, Wa	--			--	--	--	105	--	124	--	--
Fire Station #12, 2316 E 11th St, Tacoma, Wa	141								135		

-- Indicates no sample on specified day

PARTICULATE MATTER (PM10)
Micrograms per Standard Cubic Meter

Sampled by Size Selective Inlet - Hi Vol SA1200 Quartz Fiber filters

Jan - Jun, 1989

Summary of Observations Equal To or Greater Than 90

Location	Jan 19 Thu	Jan 25 Wed	Feb 6 Mon	Feb 7 Tue	Feb 8 Wed	Feb 9 Thu	Feb 10 Fri	Feb 11 Sat	Feb 13 Mon	Feb 14 Tue	Feb 15 Wed
504 Bellevue Way NE, Bellevue, Wa	--		--	--	--	208	--	--	--	--	
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--	--	--	--	--		--	--	--	--	126
Duwamish, 4752 E Marginal Way S, Seattle, Wa	104					91	112			97	120
South Park, 723 S Concord St, Seattle, Wa	--	--	--	--	--		--	--	--	--	91
James St & Central Ave, Kent, Wa			94	98		105	100		100	127	94
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--	--	--	--	--		--	--	--	--	
2340 Taylor Way, Tacoma, Wa	--	--	--	--	--		--	--	--	--	101
2301 Alexander Ave, Tacoma, Wa		--	--		--		--		--		--
Fire Station #12, 2316 E 11th St, Tacoma, Wa		90	97	98	141	113	108	101	105	104	129

-- Indicates no sample on specified day

Jul - Dec, 1989

Summary of Observations Equal To or Greater Than 90

Location	Sep 13 Wed	Sep 22 Fri	Oct 17 Tue	Nov 2 Thu	Nov 28 Tue	Nov 29 Wed	Nov 30 Thu	Dec 1 Fri	Dec 11 Mon
504 Bellevue Way NE, Bellevue, Wa			--	--	--	--		--	--
Harbor Island, 3400 13th Ave SW, Seattle, Wa		--	--	--	--	--	141	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa			94	96		138	147	133	
South Park, 723 S Concord St, Seattle, Wa		--	--	--	--	--	108	--	--
James St & Central Ave, Kent, Wa						105	108		99
27th St NE & 54th Ave NE, Northeast Tacoma, Wa		--	--	--	--	--	98	--	--
2340 Taylor Way, Tacoma, Wa	98	--	--	--	--	--	124	--	--
2301 Alexander Ave, Tacoma, Wa	--	--	95	105		--	124	--	--
Fire Station #12, 2316 E 11th St, Tacoma, Wa		94	94	110	90	125	135	114	93

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (TSP)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Quartz Fiber filters

1989

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean	Year Geom Mean
Tolt River Watershed, King County, Wa	60	3.1	14.1	19.3	8.5	11.3	8.1
North 98th St & Stone Ave N, Seattle, Wa	23	44.8	-			-	-
5701 8th Ave NE, Seattle, Wa	52	-	49.9	46.3	47.5	47.9	45.3
Harbor Island, 2555 13th Ave SW, Seattle, Wa	61	65.7	49.7	61.4	59.5	59.1	52.6
Duwamish, 4752 E Marginal Way S, Seattle, Wa	349	90.7	83.5	70.8	86.7	82.9	72.7
Georgetown, 6431 Corson Ave S, Seattle, Wa	61	77.5	83.3	88.3	73.0	80.5	68.9
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	61	59.1	41.1	44.7	51.6	49.1	41.7
115 E Main St, Auburn, Wa	61	67.5	45.5	45.9	52.4	52.8	44.8
Pac Coast Coal, 270th Av SE, Black Diamond, Wa	38	17.5	37.1	-		-	-
Sumner Jr HS, 1508 Willow St, Sumner, Wa	59	40.3	38.0	44.5	44.3	41.8	36.3
Fire Station #12, 2316 E 11th St, Tacoma, Wa	284	71.2	79.0	79.9	72.8	75.7	63.6
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	26	70.1	81.7			-	-
Cascadia, 2002 E 28th St, Tacoma, Wa	61	46.7	61.1	55.5	46.8	52.5	42.3
Willard School, S 32nd & S 'D' St, Tacoma, Wa	60	50.9	46.9	44.7	50.6	48.3	39.2
SW 283rd & 101st Ave SW, Maury Island, Wa	61	23.6	20.1	22.0	27.4	23.3	20.3
Ruston School, 5219 N Shirley St, Tacoma, Wa	61	32.0	28.5	26.9	33.6	30.3	26.8
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	21	-	-	-		-	-
City Hall, 239 4th St, Bremerton, Wa	41	28.3	-	-	-	-	-

Notes
(1) Nationally scheduled particulate matter sampling occurs each sixth day. Quarterly averages are shown only when at least one data value exists for 75 percent or more of the six day intervals.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum and 2nd High Observed Concentrations

Location	Feb 8 Wed	Feb 9 Thu	Feb 15 Wed	Apr 10 Mon	Apr 16 Sun	May 4 Thu	May 16 Tue	Jul 27 Thu	Sep 13 Wed	Oct 19 Thu	Nov 29 Wed	Nov 30 Thu	Dec 12 Tue
Tolt River Watershed, King County, Wa	--			33				32	32		--		
North 98th St & Stone Ave N, Seattle, Wa	--	112	125					--	--	--	--	--	--
5701 8th Ave NE, Seattle, Wa	--	188	168								--		
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--		194								--	191	
Duwamish, 4752 E Marginal Way S, Seattle, Wa			274								279		
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	205									--	213	
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	166									--	163	
115 E Main St, Auburn, Wa	--	241	194								--		
Pac Coast Coal, 270th Av SE, Black Diamond, Wa	--	93			83				--	--	--	--	--
Sumner Jr HS, 1508 Willow St, Sumner, Wa	--								103		--		107
Fire Station #12, 2316 E 11th St, Tacoma, Wa	257	213											
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--		158				157	--	--	--	--	--	--
Cascadia, 2002 E 28th St, Tacoma, Wa	--			136		135					--		
Willard School, S 32nd & S 'D' St, Tacoma, Wa	--	142									--	147	
SW 283rd & 101st Ave SW, Maury Island, Wa	--		66								--	70	
Ruston School, 5219 N Shirley St, Tacoma, Wa	--		81								--	85	
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	--	148	135						--	--	--	--	--
City Hall, 239 4th St, Bremerton, Wa	--						--	--		67	--	65	

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (TSP)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Quartz Fiber filters

Jan - Feb, 1989

Summary of Observations Greater Than 150

Location	Jan 12 Thu	Jan 19 Thu	Jan 20 Fri	Jan 25 Wed	Jan 26 Thu	Feb 6 Mon	Feb 7 Tue	Feb 8 Wed	Feb 9 Thu	Feb 10 Fri	Feb 11 Sat	Feb 13 Mon	Feb 14 Tue	Feb 15 Wed
5701 8th Ave NE, Seattle, Wa	--	--	--	--	--	--	--	--	188	--	--	--	--	168
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--	--	--	--	--	--	--	--		--	--	--	--	194
Duwamish, 4752 E Marginal Way S, Seattle, Wa	166	208	160	198	190			161	216	234	158	170	163	274
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	--	--	--	--	--	--	--	205	--	--	--	--	190
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	--	--	--	--	--	--	--	166	--	--	--	--	159
115 E Main St, Auburn, Wa	--	--	--	--	--	--	--	--	241	--	--	--	--	194
Fire Station #12, 2316 E 11th St, Tacoma, Wa						172	164	257	213	208	172	186	208	206
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--	--	--	--	--	--	--	--		--	--	--	--	158

-- Indicates no sample on specified day

Mar - Jun, 1989

Summary of Observations Greater Than 150

Location	Mar 8 Wed	Mar 20 Mon	Mar 22 Wed	Apr 10 Mon	Apr 11 Tue	Apr 13 Thu	Apr 14 Fri	Apr 24 Mon	Apr 28 Fri	May 5 Fri	May 10 Wed	May 16 Tue
5701 8th Ave NE, Seattle, Wa	--		--		--	--	--	--		--		
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--	--	--		--	--	--	--		--		
Duwamish, 4752 E Marginal Way S, Seattle, Wa	165	192	173		166	153	189					
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	--	--	154	--	--	--	--		--	165	
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	--	--		--	--	--	--		--		
115 E Main St, Auburn, Wa	--	--	--		--	--	--	--		--		
Fire Station #12, 2316 E 11th St, Tacoma, Wa						--		156	165	152		168
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--	--	--		--	--	--	--		--		157

-- Indicates no sample on specified day

Jul - Dec, 1989

Summary of Observations Greater Than 150

Location	Aug 18 Fri	Sep 8 Fri	Sep 13 Wed	Sep 22 Fri	Oct 9 Mon	Oct 17 Tue	Nov 2 Thu	Nov 28 Tue	Nov 29 Wed	Nov 30 Thu	Dec 1 Fri
5701 8th Ave NE, Seattle, Wa	--	--		--	--	--	--	--	--		--
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--	--		--	--	--	--	--	--	191	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa					154	175	166		279	252	261
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	--	169	--	--	--	--	--	--	213	--
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	--		--	--	--	--	--	--	163	--
115 E Main St, Auburn, Wa	--	--		--	--	--	--	--	--		--
Fire Station #12, 2316 E 11th St, Tacoma, Wa	194	169		212		154	170	159	165	185	192
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--	--	--	--	--	--	--	--	--	--	--

-- Indicates no sample on specified day

PM_{10} SITE SPECIFIC RELATIONSHIPS and ANALYSIS FOR DAYS WITH THE HIGHEST PM_{10} VALUES

Introduction

The U. S. EPA approved reference methods to measure PM_{10} all collect particulate matter on a filter during a 24 hour period of sampling. The actual PM_{10} value is not available until the sampling period ends and each sampled filter is manually removed, transported from each sampling site to the Seattle laboratory, conditioned for at least 24 hours and then processed. This may not be completed for several days.

Since these PM_{10} reference methods provide only historic data, an alternate, acceptable real-time technique is needed to provide the PM_{10} value for the daily Pollutant Standards Index in view of the U. S. EPA requirement that the Index should be based on data obtained during the 24 hour period for which the Index is reported. Additionally, under the Washington Clean Air Act and Department of Ecology implementing regulations, real-time PM_{10} values are needed to declare an "impaired air quality" condition. The declaration of "impaired air quality" prohibits any outdoor fires and bans most indoor burning.

Site Specific Relationships

The Federal Regulations (40 CFR Part 58, Appendix G) provide that particulate measurements from samplers other than reference or equivalent method samplers may be included in Pollutant Standards Index calculations, if such measurements can be quantitatively related to reference or equivalent method measurements. The Puget Sound Air Pollution Control Agency used multiple linear regression to quantitatively relate continuous nephelometer particulate measurements of dry particle light scattering (b_{sp}), an area average precipitation variable and a day of week variable to the PM_{10} measurements during 1989 for specific sites in Everett, Lake Forest Park, Seattle-Duwamish, Kent, Northeast Tacoma and the Tacoma tideflats. All these sites are NAMS or SLAMS (National or State & Local Air Monitoring Stations). Similar site specific relationships for predicting the particulate matter values from continuous, real-time monitoring have been developed annually for each calendar year beginning with 1978.

A summary of the 1989 statistics and results of the multiple regression analysis appears in the table subtitled "Site Specific PM_{10}, b_{sp} Statistics and Equations". Review of the partial correlation coefficients reveals good correlation between the collocated continuous particulate measurement (b_{sp}) and the PM_{10} value, from .85 to .94, for the four sites which operated almost daily, Lake Forest Park, Seattle-Duwamish, Kent and the Tacoma tideflats. This same partial correlation coefficient was .83 for Everett and .69 for Northeast Tacoma based on the smaller data set from operation each sixth day.

As documented in the table, the other two independent variables, precipitation and day of week, are not correlated between each other or to the PM_{10} value, but when included in the multiple regression analysis the resulting equation predicts a PM_{10} value which correlates to the actual PM_{10} value even better than if based on the continuous particulate measurement alone. The multiple correlation coefficient improves to within a range of .89 to .94 for the four daily sites, to .88 for Everett, and to .79 for Northeast Tacoma.

Three of the daily sites obtained over 320 paired observations and the new site at Lake Forest Park obtained 190 paired observations providing a significant statistical basis for the multiple regression relationships developed for these locations. These site specific relationships which estimate the actual PM_{10} value as a function of the 24 hour average dry particle light scattering

measured by nephelometer (b_{sp}), the logarithm of the 24 hour precipitation (LPR) and the day of week variable (DAY) are presented in the table as an equation for each site. For real-time use, the 24 hour average PM_{10} estimate at each site may be calculated for any 24 hour period from the appropriate equation, given the real-time nephelometer measurement and values for the precipitation and day of week variables. Since the most weight in each equation comes from the b_{sp} value, b_{sp} is measured at each site. The precipitation value is obtained from an official National Weather Service station representing the entire area.

Analysis of Highest PM_{10} Values

For the four stations which operated almost daily during 1989 all of the dates when the PM_{10} value was 90 ug/m^3 or greater are included in a table covering January to June on one page and July to December on the following page. Also included are all of the dates during which an "impaired air quality" condition was in effect or the Department of Ecology declared the "Forecast" stage of an air pollution episode. This presents a chronological view of the significant data from which several questions can be answered.

First, the data shows that none of the measured values exceeded the level of the 24 hour average PM_{10} standard of 150 ug/m^3. Second, all of the measured values of 90 ug/m^3 and higher occurred during the fall and winter, primarily during the months of January, February, November and December. Of the values 90 ug/$m^3$and higher, ten occurred at the Seattle-Duwamish industrial station, eighteen at the Tacoma tideflats industrial station, ten at the Kent downtown station and none at the Lake Forest Park residential wood smoke station which began operating in June. There were nineteen different days on which at least one station measured a PM_{10} value of 90 ug/m^3 or greater, but only six days on which three stations concurrently measured values of 90 ug/m^3 or greater. As noted, Lake Forest Park began sampling in June, so only on the last two days of November is it certain that Lake Forest Park values were less than 90 ug/m^3 while all the other three stations recorded PM_{10} values greater than 90 ug/m^3.

Third, the PM_{10} estimate calculated from the site specific equation may be compared to the reference method PM_{10} value for all of these significant dates. On some days the predictions came very close, on February 13 all within 8 percent, on November 2 all within 6 percent. In two-thirds of the cases, the PM_{10} estimate is within 20 percent of the measured PM_{10} value. The other one-third of the cases are mostly associated with overpredictions as the "Forecast" stage ended on December 16 and 17 and as the "impaired air quality" period ended on December 23, or with underpredictions on February 8 and 9 and September 22.

In the overprediction cases on December 16, 17 and 23, both the PM_{10} estimates and measured values are all less than 45 ug/m^3, so the practical effect of overpredicting is not significant. During the "impaired air quality" period in February the nephelometer readings improved and all PM_{10} estimates are well below 90 ug/m^3 on the 8th and 9th, particularly at the Kent station. The reference method PM_{10} values exceed the estimates by more than 25 percent on these two days. Measurements of the coarse fraction (2.5 - 10 micrometers) showed increases of from 59 to 114 percent for values on the 9th compared to the 7th while the fine fraction (less than 2.5 micrometers) remained the same or decreased. The nephelometer is particularly responsive to particles smaller than 2.5 micrometers, so the increase in the proportion of the coarse fraction may partly explain the underpredictions in the PM_{10} estimates on

February 8 and 9. It is also likely the proportion of the coarse fraction was greater than usual for the case on September 22.

Finally, the table shows how the PM_{10} estimates performed in managing the "impaired air quality" program during the January - February and October - December wood smoke season. The PM_{10} estimates should correctly identify periods when PM_{10} levels reach 90 ug/m^3 which may trigger an "impaired air quality" condition. Actual PM_{10} values are never available except for an historic review such as done here.

The decision to declare "impaired air quality" is made by 2:30 pm daily, but the values presented in the table conform to the calendar day sampling period defined by the PM_{10} reference method. The "impaired air quality" condition is ended at 9:30 am or 2:30 pm on any day, so the last day in the table for any "impaired air quality" period shows the improvement in PM_{10} levels, documented both by the estimates and the measured values. Further, "impaired air quality" is generally not declared if improved meteorological dispersion will result in lower PM_{10} levels by the next day.

Reviewing the table shows that "impaired air quality" or a "Forecast" stage was in effect on 7 of the 10 days at the Seattle-Duwamish station when the measured PM_{10} values were 90 ug/m^3 or greater; on 9 of the 10 days at the Kent station and on 13 of the 18 days at the Tacoma tideflats station. Of the 90 ug/m^3 or greater days without "impaired air quality" in effect, one at each station was February 9 discussed above; September 22 at the Tacoma tideflats station was outside the season and was discussed above; October 17 and November 2 at each of the Duwamish and Tacoma stations were single days followed by improvement on the following day; November 28 at the Tacoma station just reached the value of 90 ug/m^3 at the day end and an "impaired air quality" condition was declared on November 29.

An "impaired air quality" condition was declared on December 22 when PM_{10} estimates exceeded 90 ug/m^3, but meteorological dispersion improved more rapidly than expected, and the condition was ended the next day.

In conclusion, these site specific relationships provide real-time PM_{10} estimates which enable satisfactory management of the "impaired air quality" program. The PM_{10} estimates also provide a real-time value needed to report the Pollutant Standards Index.

PARTICULATE MATTER (PM_{10})

Site Specific PM_{10}, b_{sp} Statistics and Equations
(Developed from Data Collected During Calendar Year 1989)

	Partial Correlation Coefficients				Mult Corr Coef			
Sta	PM_{10} b_{sp}	PM_{10} LPR	PM_{10} DAY	b_{sp} LPR	PM_{10} all	No. Obs	Equation	Std Err Est
EVT	.83	-.46	.19	-.24	.88	46	$PM_{10} = 4.3 + 23.1b_{sp} - 3.9LPR + 2.2DAY$	7.2
LFP	.94	-.15	.10	-.07	.94	190	$PM_{10} = 8.8 + 20.9b_{sp} - 1.3LPR + 1.6DAY$	5.2
DWM	.85	-.30	.36	-.22	.89	346	$PM_{10} = 4.6 + 32.2b_{sp} - 2.4LPR + 11.0DAY$	9.7
KNT	.90	-.39	.20	-.24	.92	322	$PM_{10} = 1.5 + 26.8b_{sp} - 3.6LPR + 5.8DAY$	7.9
TNE	.69	-.51	.22	-.24	.79	56	$PM_{10} = -0.8 + 24.2b_{sp} - 7.2LPR + 7.5DAY$	12.5
TDF	.86	-.41	.26	-.25	.90	332	$PM_{10} = 1.0 + 28.6b_{sp} - 4.8LPR + 8.7DAY$	10.5

Abbreviations

PM_{10}: 24 hour average particulate matter 10 micrometers or less in diameter (ug/m^3).
b_{sp}: 24 hour average light scattering due to dry particles ($\times 10^{-4}$ per meter).
LPR: the common logarithm of the 24 hour precipitation with .001 substituted for Zero and .005 substituted for Trace.
DAY: set to 1 for Mon, Tue, Wed, Thu or Fri; set to 0 for Sat or Sun.
No. Obs: number of collocated data observations in the regression analysis.

Station Addresses		(Record Period during 1989)
EVT:	2730 Colby Ave, Everett	(Jan - Oct)
LFP:	17711 Ballinger Way NE, Lake Forest Park	(Jun - Dec)
DWM:	Duwamish, 4752 E Marginal Way S, Seattle	(Jan - Dec)
KNT:	James St & Central Ave, Kent	(Jan - Dec)
TNE:	27th St NE & 54th Ave NE, Northeast Tacoma	(Jan - Dec)
TDF:	Fire Station #12, 2316 E 11th St, Tacoma	(Jan - Dec)

PARTICULATE MATTER (PM_{10})

Site Specific Analysis for Days when any PM_{10} Value was 90 ug/m^3 or Greater and for Episode or Impaired Air Quality Days

(Jan - Jun, 1989)

		LkFrstPk (LFP)			Seattle (DWM)			Kent (KNT)			Tacoma (TDF)		
Day	Date	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %
	Jan,89												
Thu	19 I	**			99	**104**	-5		**86**		86	**73**	18
Fri	20 I				80	**72**	11		**45**		70	**62**	13
Tue	24 I				54	**64**	-16	63	**62**	2	99	**88**	13
Wed	25 I				69	**88**	-22	54	**64**	-16	85	**90**	-6
Thu	26 I				69	**85**	-19	47	**54**	-13	63	**70**	-10
	Feb,89												
Mon	06 I				73	**74**	-1	97	**94**	3	97	**97**	0
Tue	07 I				57	**63**	-10	76	**98**	-22	99	**98**	1
Wed	08 I				49	**68**	-28	34	**47**	-28	79	**141**	-44
Thu	09				56	**91**	-38	58	**105**	-45	83	**113**	-27
Fri	10 I				95	**112**	-15	78	**100**	-22	98	**108**	-9
Sat	11 I				69	**82**	-16	63	**81**	-22	78	**101**	-23
Sun	12 I				78	**79**	-1	83	**87**	-5	82	**79**	4
Mon	13 I				83	**79**	5	92	**100**	-8	104	**105**	-1
Tue	14 I				109	**97**	12	97	**127**	-24	91	**104**	-13
Wed	15 I				103	**120**	-14	75	**94**	-20	108	**129**	-16
Thu	16 I				47	**35**	34	42	**39**	8	44	**41**	7

Notes

I: A condition of "impaired air quality" was in effect during the following times in King, Kitsap, Pierce and Snohomish counties...
2:30 pm, Thu, **Jan 19** - 2:30 pm, Fri, **Jan 20**;
2:30 pm, Tue, **Jan 24** - 9:30 am, Thu, **Jan 26**;
2:30 pm, Mon, **Feb 6** - 9:30 am, Wed, **Feb 8**;
2:30 pm, Fri, **Feb 10** - 9:30 am, Thu, **Feb 16**.

Est: Estimated 24 hour average PM_{10} using site specific equation.

Val: 24 hour average PM_{10} value measured by reference method.

Err: Error in PM_{10} estimate compared to measured value.

** : Sampling began in Lake Forest Park on June 2, 1989.

PARTICULATE MATTER (PM_{10})

Site Specific Analysis for Days when any PM_{10} Value was 90 ug/m^3 or Greater and for Episode or Impaired Air Quality Days
(Jul - Dec, 1989)

			LkFrstPk (LFP)			Seattle (DWM)			Kent (KNT)			Tacoma (TDF)		
Day	Date		Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %
	Sep,89													
Fri	22		29	38	-24	48	50	-4	49	69	-29	47	94	-50
	Oct,89													
Tue	17		48	50	-4	74	94	-21	46	49	-6	86	94	-9
	Nov,89													
Thu	02		88	88	0	97	96	1	94	89	6	103	110	-6
Tue	28		62	70	-11	68	80	-15	72	66	9	89	90	-1
Wed	29	I	72	85	-15	95	138	-31	93	105	-11	120	125	-4
Thu	30	I,E	64	70	-9	109	147	-26	110	108	2	131	135	-3
	Dec,89													
Fri	01	I,E	49	58	-16	108	133	-19	64	60	7	101	114	-11
Sat	02	I		37		28	38	-26	35	42	-17	39	46	-15
Mon	11	E	63	60	5	62	56	11	103	99	4	104	93	12
Tue	12	E	51	51	0	75	66	14	84	77	9	86	74	16
Wed	13	E	35	39	-10	45	42	7	46	50	-8	54	60	-10
Thu	14	E	46	55	-16	74	75	-1	68	68	0	71	71	0
Fri	15	E	40	40	0	59	49	20	51	41	24	65	52	25
Sat	16	E	35	28	25	40	27	48	38	28	36	44	30	47
Sun	17	E	33	24	38	31	21	48	30	21	43	37	23	61
Fri	22	I	56	51	10	88	76	16	85	68	25	101	81	25
Sat	23	I	31	23	35	32	26	23	44	35	26	40	29	38

Notes

I: A condition of "impaired air quality" was in effect during the following times in King, Kitsap, Pierce and Snohomish counties...
2:30 pm, Wed, Nov 29 - 9:30 am, Sat, Dec 2;
2:30 pm, Fri, Dec 22 - 2:30 pm, Sat, Dec 23.

E: The Department of Ecology declared the "Forecast" stage of an air pollution episode to be in effect during the following times...
5:30 pm, Thu, Nov 30 - 3:00 pm, Fri, Dec 1;
2:00 pm, Mon, Dec 11 - 10:00 am, Sun, Dec 17.

Est: Estimated 24 hour average PM_{10} using site specific equation.

Val: 24 hour average PM_{10} value measured by reference method.

Err: Error in PM_{10} estimate compared to measured value.

ATMOSPHERIC PARTICLES
(bsp (X 10 Exp-4)/M)
1989

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa											.62	.77	1706	.70
Medical-Dental Bldg, 2730 Colby, Everett, Wa	.66	1.16	.41	.44	.49	.46	.30	.47	.70				6901	.58
17711 Ballinger Way NE, Lake Forest Park, Wa							.27	.40	.72	1.30	1.22	1.37	4757	.82
North 98th St & Stone Ave N, Seattle, Wa	.84	1.05	.46	.43	.37								3609	.63
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.81	1.09	.58	.51	.46	.46	.34	.43	.76	.98	.86	.99	8572	.68
James St & Central Ave, Kent, Wa		1.38	.63	.48	.43	.44	.41	.49	.77	1.05	1.10	1.25	8027	.78
27th St NE & 54th Ave NE, Northeast Tacoma, Wa			.46	.43	.36	.35	.30	.33	.59	.77	.85	1.06	8024	.58
Fire Station #12, 2316 E 11th St, Tacoma, Wa	.84	1.46	.63	.47	.41	.43	.37	.40	.73	.98	.99	1.26	8654	.74

Statistical Summary

Location	No. of 1 Hour Samples	Frequency Distribution - Percent												Arith Mean	Geom Mean	Geom Std Dev	Arith Std Dev
		5	10	20	30	40	50	60	70	80	90	95	99				
Hoyt Ave & 26th St, Everett, Wa	1706	.1	.2	.2	.3	.5	.6	.7	.9	1.1	1.4	1.7	2.4	.70	.51	2.34	.53
Medical-Dental Bldg, 2730 Colby, Everett, Wa	6901	.1	.2	.2	.3	.3	.4	.5	.6	.8	1.2	1.7	2.9	.58	.42	2.22	.57
17711 Ballinger Way NE, Lake Forest Park, Wa	4757	.1	.2	.2	.3	.4	.5	.6	.9	1.2	1.9	2.7	4.6	.82	.52	2.60	.92
North 98th St & Stone Ave N, Seattle, Wa	3609	.1	.1	.2	.3	.3	.4	.5	.6	.9	1.4	2.1	3.3	.63	.41	2.47	.67
Duwamish, 4752 E Marginal Way S, Seattle, Wa	8572	.2	.2	.3	.3	.4	.5	.6	.7	1.0	1.5	2.0	3.1	.68	.50	2.19	.62
James St & Central Ave, Kent, Wa	8027	.1	.2	.2	.3	.4	.5	.6	.8	1.2	1.9	2.5	3.6	.78	.52	2.44	.77
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	8024	.1	.1	.2	.2	.3	.4	.5	.6	.9	1.3	1.7	2.8	.58	.40	2.33	.56
Fire Station #12, 2316 E 11th St, Tacoma, Wa	8654	.1	.2	.2	.3	.4	.4	.6	.7	1.1	1.8	2.5	3.9	.74	.47	2.57	.80

LEAD

The ambient air quality standard for lead is 1.5 ug/m^3 averaged over one calendar quarter. Lead emissions to the air across urban areas come principally from automobile exhaust. In some places localized industrial emissions of lead come from stationary sources such as primary and secondary nonferrous smelters. As shown below, lead concentrations measured at all stations during 1989 were lower than the ambient standard. These current ambient lead levels compared to levels prior to 1980 show significant improvement due primarily to the phase down of lead in gasoline. The lead levels at the Harbor Island station still document some effect from the nearby site of a secondary lead smelter which ceased operation several years ago.

LEAD
Micrograms per Standard Cubic Meter
1989

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
North 98th St & Stone Ave N, Seattle, Wa	.03	.07	.03	.03	.03								23	.04
5701 8th Ave NE, Seattle, Wa	.07	.10	.07	.06	.05	.06	.06	.16	.07	.06	.07	.05	57	.07
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.45	.33	.12	.15	.25	.33	.25	.21	.37	.20	.34	.42	61	.28
Ruston School, 5219 N Shirley St, Tacoma, Wa	.04	.05	.03	.02	.02	.02	.03	.04	.01	.02	.03	.02	61	.03

Location	Quarterly Arithmetic Averages			
	1st	2nd	3rd	4th
North 98th St & Stone Ave N, Seattle, Wa	.04	.03		
5701 8th Ave NE, Seattle, Wa	.08	.06	.10	.06
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.30	.24	.28	.32
Ruston School, 5219 N Shirley St, Tacoma, Wa	.04	.02	.03	.02

ARSENIC

Under the federal Clean Air Act the U. S. EPA has designated inorganic arsenic as a hazardous air pollutant. The principal source of arsenic in the Puget Sound area is the closed Tacoma Smelter site at Ruston. Smelting ceased in March, 1985 and arsenic processing ended in January, 1986. Site dismantling and reclamation followed under U. S. EPA supervision. Measurements during 1989 at the Ruston School, across the street just west of the smelter site, continue to document low ambient arsenic levels.

ARSENIC
Micrograms per Standard Cubic Meter
1989

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Ruston School, 5219 N Shirley St, Tacoma, Wa	.01	.04	<.01	.02	.02	.01	.01	.03	.02	.01	.01	.02	61	.02

Yearly arithmetic mean calculated using .0025 as a substitute for each <.01 value.

Introduction

The principal oxidant found in photochemical smog is ozone, a very reactive form of oxygen. Most photochemical oxidants result from sunlight driven chemical reactions in the ambient air between nitrogen oxides and volatile organic compounds (VOC). The highest ozone levels occur on hot summer afternoons since this is the period of most intense radiant energy from sunlight. However, even with strong sunlight, ozone levels would be low without the precursor nitrogen oxide and VOC pollutants emitted from human activities.

On any given day the photochemical reactions proceed for several hours and generally produce maximum ozone levels between noon and early evening at locations several miles away from the sources of nitrogen oxides and VOC. Each day after nightfall the high ozone levels diminish because the photochemical effect ends. However, the photochemical smog is such a complex mixture that significant ozone levels sometimes continue for hours into the night.

In the Puget Sound area the highest ozone levels occur from mid May to mid September on the few days favorable for significant photochemical activity. These high values develop when urban area emissions are trapped beneath a nighttime and morning temperature inversion followed during the day by very high temperatures. Light northerly winds often develop on these hot days. As a result, the highest ozone values normally occur south to southeast of the major cities or source areas.

Ozone Standard and Summary of Data

The U. S. EPA has set the level of the ozone standard at a value of 0.12 ppm. According to the federal regulation, the standard is attained when the expected number of days per calendar year with a maximum hourly average concentration above 0.12 ppm is one day or less.

If an "exceedance" means a day on which the maximum 1 hour average is higher than 0.12 ppm, the standard is attained when the expected number of exceedances is equal to or less than one. If no data are missing, the expected number of exceedances is the average number of measured exceedances per year at a particular location for the last three years.

When some data for a given year are missing, the number of exceedances in that year must be adjusted to estimate the true number. The estimate is calculated using the number of measured exceedances, the number of required monitoring days, the number of days with a measured maximum value and the number of days determined to be less than the level of the standard.

For each year the estimated number of exceedances is always equal to or greater than the measured number of exceedances. For stations where no exceedances are measured, the estimate is zero. The expected number of exceedances is then the average of the annual estimates for the last three years.

The 1989 ozone summary table on the following page lists the four highest daily maximum 1 hour averages for each monitoring location. For the three year period ending with 1989, the average number of ozone exceedances is less than 1.0 for all locations. On January 2, 1987, the U. S. EPA formally designated the Puget Sound Region as in attainment of the ozone standard.

Pollutant Standards Index

A one hour average ozone value of 0.12 ppm is equivalent to 100 on the Pollutant Standards Index scale. Since the high ozone levels occur some distance downwind of major cities, ozone never determines the Index for Everett, Seattle or Tacoma, but may occasionally cause unhealthful air quality for outlying locations such as Lake Sammamish, Enumclaw or La Grande.

OZONE
(Parts per Million)
1989

Location / Continuous Sampling Period(s)	Four Highest Daily Maximum 1 Hour Averages			Estimated No. of Days Daily Maximum 1 Hour Average Exceeded .12 ppm			No. of Days Daily Maximum 1 Hour Average Expected To Exceed .12 ppm
	Value	Date	End Time	1987	1988	1989	
20050 SE 56th, Lake Sammamish State Park, Wa 3 Apr-25 Oct; 6 Nov-31 Dec	.09 .08 .07 .07	24 Jun 11 Jun 30 Apr 4 May	1400 1600 1600 1600	0.0	1.0	0.0	0.3
Cedar River Watershed, near Kangley, Wa 19 Apr-31 Oct	.10 .09 .09 .09	24 Jun 5 Jun 11 Jun 12 Jul	900 1800 2000 1500			0.0	0.0
Highway 410, 2 miles east of Enumclaw, Wa 24 Apr-30 Jun; 12 Jul-17 Aug; 1 Oct-31 Oct	.10 .09 .09 .09	5 Jun 6 May 24 Jun 12 Jul	1600 1400 1500 1600	1.5	0.0	0.0	0.5
Pierce Co Fire D #21, 8102 304th, Graham, Wa 1 Apr-10 Aug; 23 Aug-3 Sep; 14 Sep-30 Oct	.09 .09 .09 .08	23 Sep 24 Sep 12 Jul 14 Apr	1500 1500 1600 1700	0.0	0.0	0.0	0.0
Mt Rainier National Park, Carbon River RS, Wa 18 May-31 Aug; 12 Sep-31 Oct	.09 .08 .08 .07	12 Jul 4 Jun 14 Sep 5 Jun	1700 1500 1700 1400			0.0	0.0
Charles L Pack Forest, La Grande, Wa 6 Apr-31 Oct	.10 .09 .08 .08	13 Sep 14 Sep 14 Apr 11 Jun	1500 1500 1700 1500	0.0	0.0	0.0	0.0

Notes
(1) All ozone stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations ozone was measured using the continuous ultraviolet photometric detection method.

SULFUR DIOXIDE

Sulfur dioxide is a common air pollutant for which standards have been established nation-wide. A summary of the national, state and local sulfur dioxide standards appears on page 48. Sulfur dioxide enters the air mainly from industrial processes and from the combustion of sulfur-containing fuels such as coal and oil. In the Puget Sound area, the four main industrial areas with sulfur dioxide point sources are the Everett Port area, Seattle Harbor Island-Duwamish Valley area, Tacoma Port area and the Bremerton Naval Shipyard. In the air, reactions occur to partially convert sulfur dioxide to other sulfur compounds such as sulfuric acid and various sulfate salts. Local sulfur dioxide standards have been in effect since 1968. The tables below summarize sulfur dioxide data collected during 1989.

SULFUR DIOXIDE
(Parts per Million)
1989

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa											.004	.005	1623	.005
Medical-Dental Bldg, 2730 Colby, Everett, Wa	.005	.007	.005		.008	.008	.011	.010	.010				6569	.008
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.005	.009	.007	.006	.005	.006	.005	.006	.010	.008	.011	.009	8511	.007
27th St NE & 54th Ave NE, Northeast Tacoma, Wa			.007	.005	.006	.005		.006	.009	.012	.012	.011	6754	.008
2301 Alexander Ave, Tacoma, Wa	.008	.009	.006	.006	.006	.007	.008		.008	.009	.010	.012	8109	.008

Summary of Maximum and Second Highest Concentrations
for Various Averaging Periods

Location / Continuous Sampling Period(s)	1 Hour Average			3 Hour Average			24 Hour Average		
	Value	Date	End Time	Value	Date	End Time	Value	Date	End Time
Hoyt Ave & 26th St, Everett, Wa	.04	10 Nov	1100	.020	24 Dec	1700	.008	22 Dec	0700
24 Oct-31 Dec	.03	10 Dec	1900	.017	10 Nov	1100	.008	28 Dec	0900
Medical-Dental Bldg, 2730 Colby, Everett, Wa	.12	11 Jul	1800	.097	11 Jul	1900	.026	22 Jun	1200
1 Jan-9 Apr; 21 Apr-18 Oct	.11	6 Aug	1100	.087	25 Jun	2000	.026	6 Aug	1100
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.13	5 Nov	2100	.107	5 Nov	2200	.038	6 Nov	1900
1 Jan-31 Dec	.13	23 Nov	1700	.100	6 Nov	1900	.023	24 Nov	1300
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.16	29 Nov	0900	.120	29 Nov	1000	.034	18 Oct	0100
1 Jan-8 Jan; 24 Feb-13 Jul; 26 Jul-31 Dec	.13	29 Nov	1000	.093	9 Oct	2300	.034	3 Nov	0100
2301 Alexander Ave, Tacoma, Wa	.10	17 Oct	1000	.063	19 Jan	1400	.027	8 Dec	1000
1 Jan-3 Aug; 25 Aug-31 Dec	.09	19 Jan	1300	.063	30 Nov	1400	.023	2 Dec	0900

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

CARBON MONOXIDE

Introduction

As a group, motor vehicles emit more carbon monoxide than any other source. For Puget Sound area cities, motor vehicles are the principal source of carbon monoxide causing the ambient levels to exceed air quality standards.

The occasions with high ambient levels of carbon monoxide occur mainly during autumn and winter months. The highest levels are measured in the vicinity of congested motor vehicle traffic present during late afternoon commuting and around shopping centers particularly during holiday shopping.

A contributing factor during some periods when levels are high is the existence of stable weather and light wind, thus temporarily reducing the means to disperse carbon monoxide which is emitted into the air.

Pollutant Standards Index and Washington State Episode Levels

The level of the 8 hour average standard is 9 parts per million (ppm), and this is equivalent to 100 on the Pollutant Standards Index scale. PSI values exceeding 100 are termed "Unhealthful". An 8 hour average of 15 ppm equals 200 on the PSI scale. Pollutant Standards Index values of 200 to 299 are described as "Very Unhealthful".

Episode criteria are specified in the Washington Episode Plan (Washington Administrative Code 173-435). The Alert stage is reached when the ambient carbon monoxide concentration reaches 15 ppm for an 8 hour average, and meteorological conditions are such that the carbon monoxide concentration can be expected to remain at or above that level for 12 or more hours, or to recur unless control actions are taken. Correspondingly, the carbon monoxide concentration for the Warning stage is 30 ppm for an 8 hour average, and for the Emergency stage is 40 ppm for an 8 hour average.

Summary of 1989 Data

The tables on the next two pages summarize the six highest 1 hour and 8 hour average carbon monoxide levels at each station during 1989. These data were obtained from Department of Ecology data summaries.

Measurements at three stations twice exceeded an 8 hour average of 9 ppm. Therefore, these three stations, located in Everett, Bellevue and Tacoma, violated the 8 hour average standard. None of the Seattle air monitoring sites exceeded the 8 hour average carbon monoxide standard.

Multi-Year Summary

A multi-year summary following the 1989 tables presents data and column graphs to show the long term historical trend. For the longest term sampling sites in the cities of Seattle, Everett, Bellevue, and Tacoma, the summary charts show by year the number of days on which the 8 hour average exceeded 9 ppm. The bottom row lists the value that was the 2nd high 8 hour average for each year.

The first complete year of carbon monoxide data for one Seattle station was 1972. The results at this station have improved from exceeding the primary standard over 100 days in 1972 and 1973, to zero exceedances during 1987 through 1989. Two other Seattle stations which began in 1978 confirm the same trend.

The significant improvement from levels in the mid 1970's is due mainly to the federal emission standards for new motor vehicles and to the program requiring an annual test of vehicle emissions to assure compliance with these standards.

For all cities, the data acquired since 1979 shows the decrease (improvement) in carbon monoxide values has leveled off. To show the standard has been attained for any station, the U. S. EPA requires that the number of cases exceeding the standard averaged over a two year period not exceed one per year.

CARBON MONOXIDE
(Parts per Million)
1989

Location / Continuous Sampling Period(s)	Six Highest Concentrations						Number of 8 Hour Averages Exceeding 9 ppm	Number of Days 8 Hour Average Exceeded 9 ppm
	1 Hour Average			8 Hour Average				
	Value	Date	End Time	Value	Date	End Time		
Broadway & Hewitt Ave, Everett, Wa	26	10 Feb	1800	11	10 Feb	2000	2	2
1 Jan-31 Dec	26	10 Feb	1900	10	30 Nov	2000		
	19	15 Feb	1900	9	19 Jan	2000		
	18	10 Feb	2000	9	11 Feb	2400		
	16	15 Feb	2000	9	15 Feb	2000		
	15	30 Nov	1900	9	24 Mar	1900		
622 Bellevue Way NE, Bellevue, Wa	14	1 Dec	1900	11	1 Dec	2400	2	2
1 Jan-31 Dec	14	1 Dec	1800	10	30 Nov	2400		
	13	30 Nov	1800	9	19 Jan	2400		
	13	28 Nov	1800	8	29 Nov	2400		
	12	10 Feb	1900	8	28 Nov	2400		
	12	30 Nov	1900	7	10 Feb	2400		
Northgate, 310 NE Northgate Way, Seattle, Wa	14	8 Feb	0800	9	20 Jan	0100	0	0
1 Jan-13 Mar; 1 May-7 Sep; 20 Sep-31 Dec	14	8 Feb	0900	8	9 Feb	2200		
	13	10 Feb	2000	8	10 Feb	2200		
	12	10 Feb	1900	8	30 Nov	2300		
	12	21 Feb	0800	7	19 Jan	0100		
	12	29 Nov	0900	7	8 Feb	0900		
4511 University Way NE, Seattle, Wa	13	11 Feb	2400	9	10 Feb	0200	0	0
1 Jan-7 Jul; 24 Jul-19 Sep	12	19 Jan	2300	8	12 Feb	0100		
	12	9 Feb	2300	7	19 Jan	0200		
	10	18 Jan	2400	7	19 Jan	2300		
	10	9 Feb	2400	7	21 Feb	1700		
	10	10 Feb	0100	6	10 Feb	2100		
1960 NE Pacific St, Seattle, Wa	12	19 Jan	2200	9	20 Jan	0100	0	0
1 Jan-26Jan; 9 Feb-23 Jul; 14 Aug-28 Nov;	10	19 Jan	2100	7	11 Feb	0100		
27 Dec-31 Dec	10	15 Feb	2100	7	15 Feb	2300		
	9	19 Jan	2000	6	18 Jan	2400		
	9	19 Jan	2300	6	9 Feb	2400		
	9	19 Jan	2400	6	12 Feb	0100		
1424 4th Ave, Seattle, Wa	10	30 Nov	2200	8	1 Dec	0200	0	0
1 Jan-31 Dec	10	1 Dec	1700	7	29 Nov	1900		
	9	19 Jan	1800	7	21 Dec	2000		
	9	16 Feb	1800	6	9 Feb	1900		
	9	29 Nov	1800	6	10 Feb	0800		
	9	30 Nov	2100	6	12 Feb	0300		

Notes
(1) All carbon monoxide stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations carbon monoxide was measured using the continuous nondispersive infrared method.

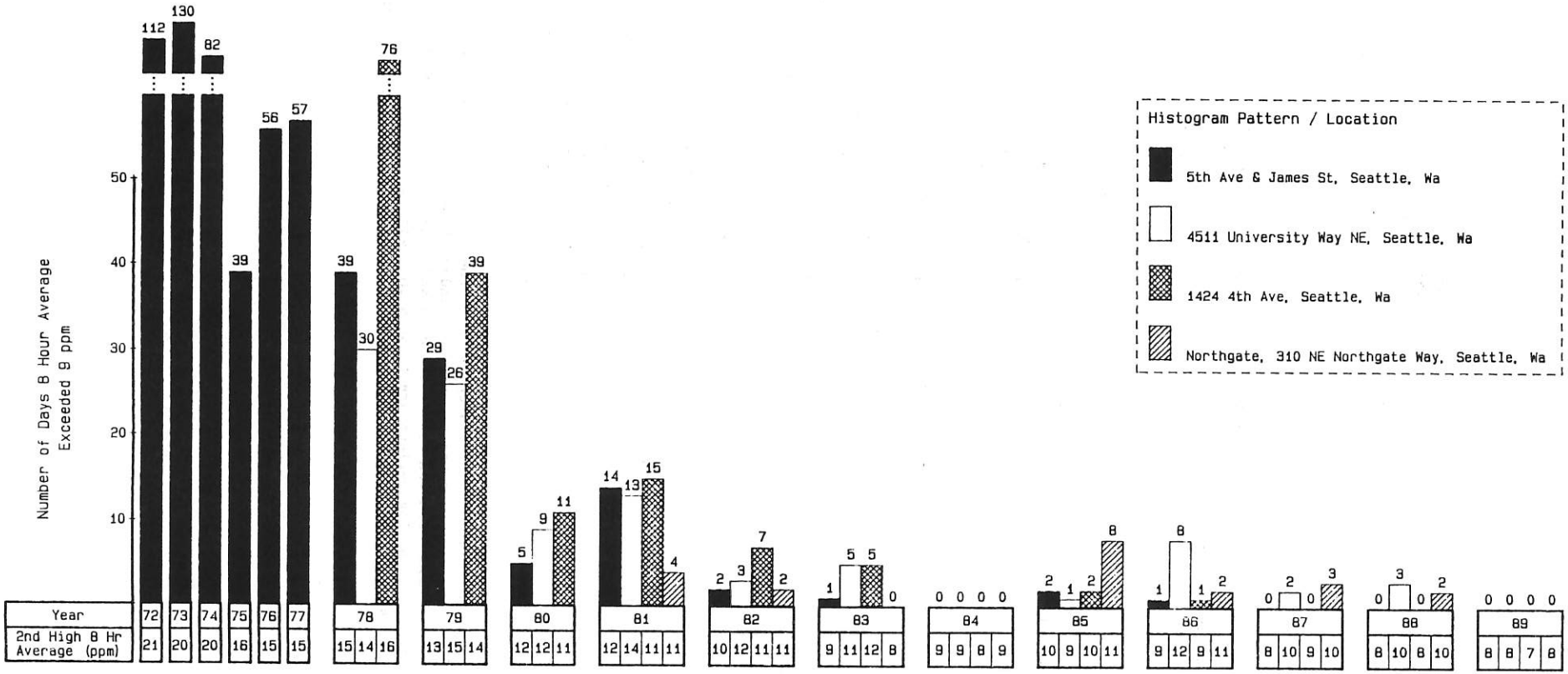
CARBON MONOXIDE
(Parts per Million)
1989

Location / Continuous Sampling Period(s)	Six Highest Concentrations						Number of 8 Hour Averages Exceeding 9 ppm	Number of Days 8 Hour Average Exceeded 9 ppm
	1 Hour Average			8 Hour Average				
	Value	Date	End Time	Value	Date	End Time		
5th Ave & James St, Seattle, Wa	10	19 Jan	1600	8	16 Feb	1600	0	0
1 Jan-31 Dec	10	16 Feb	1400	8	30 Nov	2400		
	10	16 Feb	1700	7	19 Jan	2300		
	10	30 Nov	2000	7	12 Feb	0200		
	10	14 Dec	1800	7	21 Feb	1600		
	9	18 Jan	1700	7	30 Nov	1400		
Courthouse, 4th Ave & James St, Seattle, Wa	12	9 Mar	1400	7	24 Feb	1700	0	0
1 Jan-24 Jul	10	19 Jan	2300	7	20 Mar	1600		
	10	21 Feb	0900	6	19 Jan	1500		
	10	24 Feb	1700	6	19 Jan	2300		
	10	20 Mar	1000	6	12 Feb	0100		
	9	24 Feb	1400	6	21 Feb	1500		
Fire Station #10, 301 2nd Ave S, Seattle, Wa	11	19 Jan	2300	7	20 Jan	0200	0	0
1 Jan-29 Jul	10	19 Mar	0200	6	12 Feb	0100		
	9	10 Mar	2400	5	18 Jan	2400		
	9	11 Mar	0100	5	9 Feb	2300		
	9	18 Mar	2300	5	10 Feb	0800		
	8	18 Jan	2200	5	11 Mar	0200		
1101 Pacific Ave, Tacoma, Wa	17	28 Nov	1800	10	30 Nov	2400	2	2
1 Jan-31 Dec	12	30 Nov	2100	10	1 Dec	2400		
	12	30 Nov	2000	9	28 Nov	2300		
	12	1 Dec	2000	7	19 Jan	1800		
	11	1 Dec	2300	7	25 Jan	1900		
	11	1 Dec	1700	7	21 Feb	2100		
Burwell St & Pacific Ave, Bremerton, Wa	15	14 Apr	2200	6	28 Jan	0100	0	0
1 Jan-31 Dec	14	10 Feb	2300	6	11 Feb	0200		
	13	27 Jan	2300	6	8 Apr	2400		
	13	2 Jun	2200	6	2 Jun	2400		
	13	23 Jun	2200	5	11 Feb	2400		
	12	6 May	2200	5	14 Apr	2200		

Notes
(1) All carbon monoxide stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations carbon monoxide was measured using the continuous nondispersive infrared method.

CARBON MONOXIDE

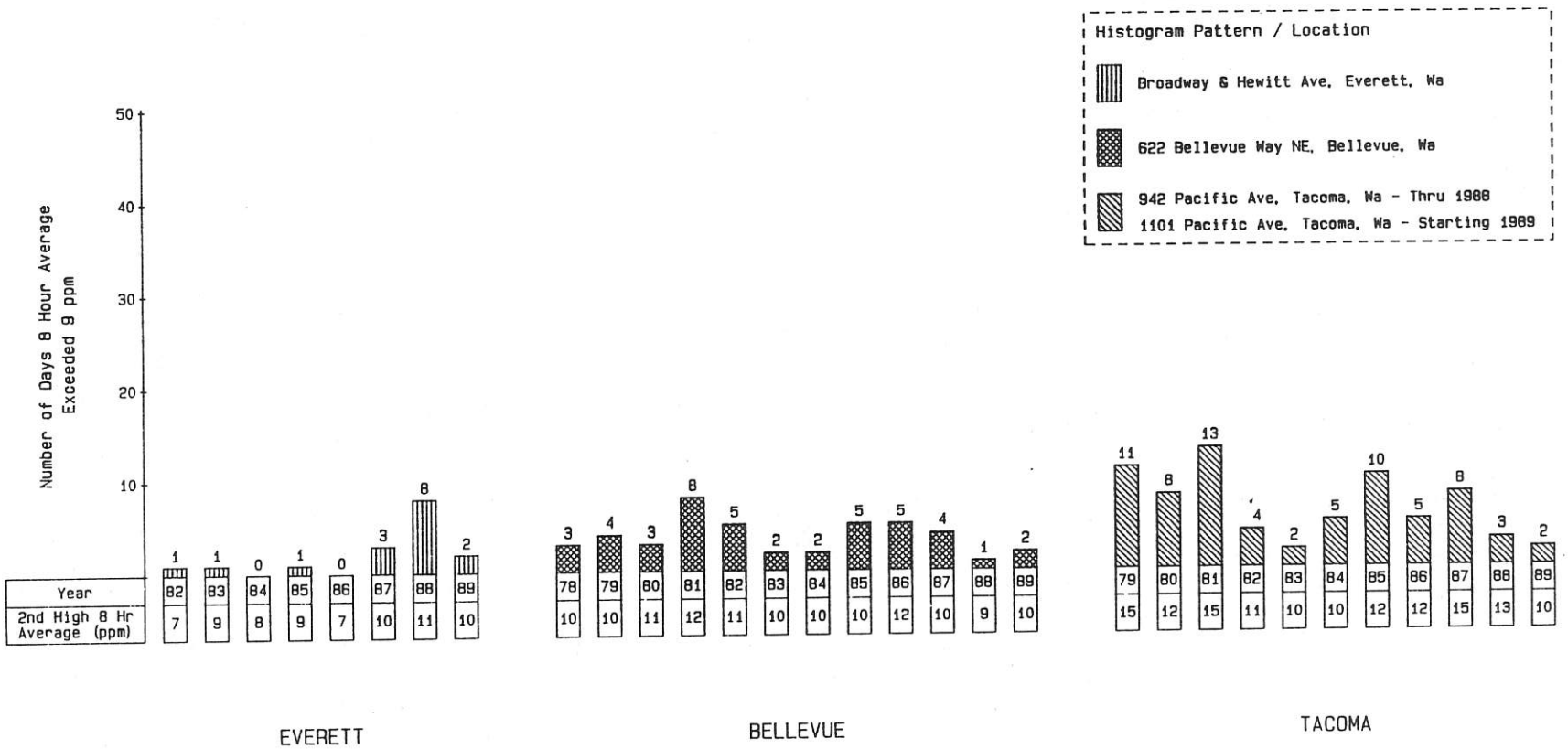
Multi-Year Summary



SEATTLE

CARBON MONOXIDE

Multi-Year Summary



QUALITY ASSURANCE

Introduction

Quality Assurance (QA) includes all activities involved with obtaining valid data and documenting the quality of the data. Quality Assurance is an integral part of all monitoring activities. Some specific QA activities are: selection of methods and analyzers; installation of equipment; calibration; zero and span checks and adjustments; control checks, limits, and corrective actions; maintenance; recording and validating data; and documentation of quality control information.

The Agency participates in audit programs conducted independently by the U.S. Environmental Protection Agency and the Washington State Department of Ecology. For the EPA, this consists of (1) on-site audits of some Agency monitoring equipment by EPA or their designated representative, and (2) Agency participation in EPA's national performance audits as they are announced. Each quarter the Department of Ecology also independently audits some Agency monitoring equipment in operation at various stations.

Precision and Accuracy Audits

The documentation for the QA program is established in Title 40, Code of Federal Regulations, Part 58, published May 10, 1979, and amended November 9, 1979, September 3, 1981, March 19, 1986, and July 1, 1987. The important QA characteristics which the regulations require to be developed and reported are *precision* and *accuracy*. In simple terms, *precision* means the ability to repeat a measurement of the same, known sample at a different time; *accuracy* means the agreement between a measurement and the true value.

Each instrument measuring a pollutant at a location must be audited for precision at least every two weeks and for accuracy at least once per year. For each audit, the percentage difference between the instrument indicated concentration and the true concentration is calculated. For each calendar quarter the average and the standard deviation of these percentage differences are calculated. These two statistics are then pooled for all audits involving the same pollutant.

Probability Limits

The federal regulation requires summary of the precision and accuracy audit results by computing the 95 Percent Probability Limits for each pollutant from the weighted average percent difference, D, and the pooled standard deviation, S_a, as follows:

$$\text{Upper 95 Percent Probability Limit} = D + 1.96(S_a)$$

$$\text{Lower 95 Percent Probability Limit} = D - 1.96(S_a)$$

These upper and lower limits reflect data quality by establishing that, with 95 percent probability, the pollutant measurements during the audit period are within the limits. As an example, if the average of the percent differences is zero and the standard deviation of the percent differences is 4.1 percent, the upper and lower 95 percent probability limits are respectively +8 and -8 percent.

Agency Precision and Accuracy

For many Agency monitoring locations precision audits are performed each week and accuracy audits are completed each month or each quarter. The table following this page summarizes the precision and accuracy probability limits by quarter for all air quality data which the Agency originated in 1989. For each pollutant the type of audit (accuracy or precision) is followed by a brief phrase description of the audit method. The number of audits and the lower and upper probability limits are presented for each quarter.

DATA QUALITY ASSESSMENT
1989

Lower and Upper 95 Percent Probability Limits
of Percent Differences

Pollutant & Type of Audit	Number of Stations	Audit Results by Quarter											
		1st			2nd			3rd			4th		
		No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr
Particulate Matter (TSP, Hi-Vol)	15												
Accuracy													
Flow Rate		3	-1	+5	30	-4	+3	6	-3	+3	9	-7	+8
Precision													
Collocated Samples		37	-5	+14	34	-7	+14	27	-9	+7	28	-3	+7
Particulate Matter (PM10, SSI Hi Vol)	11												
Accuracy													
Flow Rate		56	-5	+3	72	-4	+3	71	-3	+2	79	-4	+3
Precision													
Collocated Samples		30	-9	+6	31	-9	+5	41	-11	-1	45	-6	+6
Sulfur Dioxide	5												
Accuracy													
Level 1		5	-7	+13	6	-10	+13	9	-1	+15	10	-6	+13
Level 2		5	-8	+12	6	-12	+13	9	-5	+13	10	-7	+10
Level 3		5	-7	+11	6	-13	+11	9	-4	+12	10	-7	+10
Level 4					2	-2	+6	2	-10	+10	4	-8	+4
Precision													
One point check		37	-9	+12	45	-8	+10	40	-3	+11	46	-6	+10
Atmospheric Particles (Nephelometer)	7												
Precision													
One point check		36	-5	+6	40	-7	+6	38	-5	+5	42	-5	+6

AIR POLLUTION EPISODES and IMPAIRED AIR QUALITY PERIODS

Introduction

The policy and rules for air pollution episode avoidance and for restrictions on the use of solid fuel heating devices during periods of "Impaired Air Quality" are established by the Washington Clean Air Act and implemented by state and local regulations. The 1990 Washington Legislature amended the Clean Air Act sections dealing with solid fuel burning devices, "Impaired Air Quality" and air pollution episode avoidance. These revisions apply beginning in the fall of 1990. The following paragraphs summarize the rules in effect during 1989.

Air Pollution Episodes

The Washington Clean Air Act defines air pollution episodes and the policy for establishing an avoidance plan in RCW 70.94.710 through 70.94.730. The Washington State Department of Ecology has adopted WAC 173-435 which implements an episode avoidance plan.

The *"First"* or *"Forecast"* stage of the Episode Plan may be declared by the Department of Ecology when an "Air Stagnation Advisory" is issued by the National Weather Service or there is equivalent indication of stagnant atmospheric conditions and conditions are forecast to persist for 24 hours.

Outdoor fires are prohibited in the area covered by any declared stage of the Washington Episode Avoidance Plan. Further, under RCW 70.94.473, any person who has an adequate source of heat without burning wood shall not burn wood in any solid fuel heating device whenever the Department of Ecology has determined that any air pollution episode exists in that area.

During 1989, the Department of Ecology declared the "Forecast" stage of an air pollution episode which included the Puget Sound region during the following periods:

5:30 pm, Thursday, November 30 - 3:00 pm, Friday, December 1;

2:00 pm, Monday, December 11 - 10:00 am, Sunday, December 17.

Impaired Air Quality Periods

Under RCW 70.94.473 and WAC 173-433, *"Impaired Air Quality"* means a condition declared by the Department of Ecology or an air pollution control agency whenever meteorological conditions are conducive to an accumulation of air contamination concurrent with PM_{10} at an ambient level of 90 ug/m^3 measured on a 24 hour average. (Note: WAC 173-433 also establishes TSP at a level of 125 ug/m^3 for a 24 hour average or carbon monoxide at a level of 8 ppm for an 8 hour average as values for "Impaired Air Quality", but these limits are rarely the measurement which determines "Impaired Air Quality".)

During a declared "Impaired Air Quality" period for the geographical area, any person who has an adequate source of heat without burning wood shall not burn wood in any solid fuel heating device except wood stoves certified under WAC 173-433-100. The Puget Sound Air Pollution Control Agency Board of Directors adopted regulations implementing the curtailment restrictions of WAC 173-433 and also prohibiting any outdoor fires during any period of "Impaired Air Quality".

During 1989, a condition of "Impaired Air Quality" was in effect during the following times in the four counties of King, Kitsap, Pierce and Snohomish:

2:30 pm, Thursday, January 19 - 2:30 pm, Friday, January 20;

2:30 pm, Tuesday, January 24 - 9:30 am, Thursday, January 26;

2:30 pm, Monday, February 6 - 9:30 am, Wednesday, February 8;

2:30 pm, Friday, February 10 - 9:30 am, Thursday, February 16;

2:30 pm, Wednesday, November 29 - 9:30 am, Saturday, December 2;

2:30 pm, Friday, December 22 - 2:30 pm, Saturday, December 23.

LOWER ATMOSPHERE TEMPERATURE SOUNDINGS

The Washington State Department of Ecology operates a lower atmosphere sounding unit on the east shore of Portage Bay in Seattle. Normal operation provides one sounding to 700 millibars about 7 am local time each Monday through Friday except holidays.

This sounding provides the primary lower atmosphere data in the Puget Sound region and is an essential basis for many forecasts including the determination of air pollution episode and impaired air quality conditions. The Agency regularly uses the sounding to evaluate and interpret air quality data and also enters the sounding in a computerized data base.

Some important features may be determined from each sounding and these are important to the determination of air stagnation. Temperature increasing with height is termed a *"Temperature Inversion"*. A temperature inversion limits the height to which pollutants are mixed or dispersed vertically. The *"Mixing Depth"* is the height from the surface to the temperature inversion base. The mixing depth continuously changes in response to diurnal surface temperature changes and to other processes.

On days with no temperature inversion the mixing depth is unlimited, and this contributes to rapid pollutant dispersion and good air quality. In contrast, a temperature inversion near the surface too great in depth or too warm to be reversed during the daytime significantly restricts vertical dispersion. This stable condition is associated with higher pollutant levels.

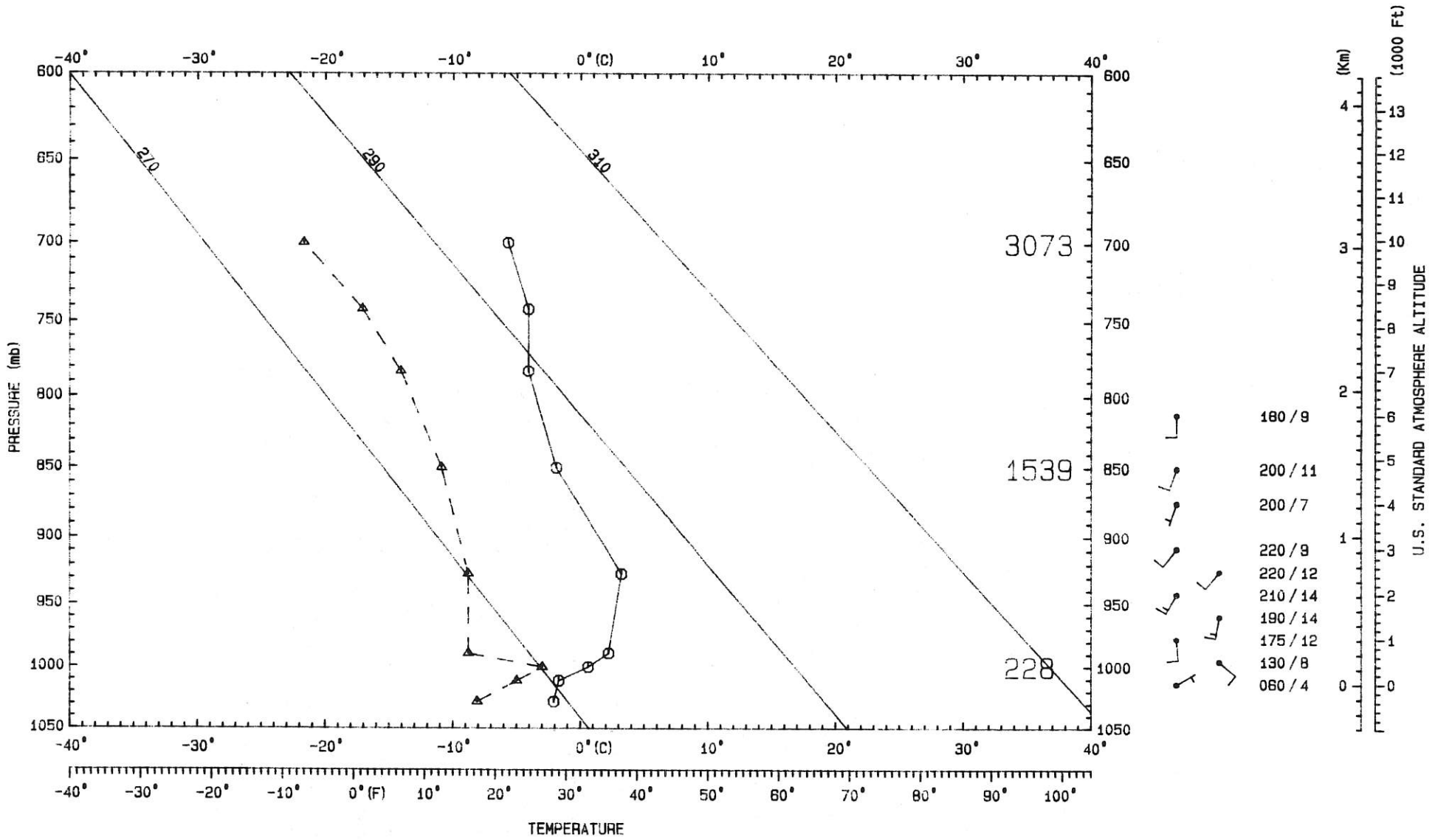
Several soundings from 1989 are included on the following pages. These soundings all reveal stagnant conditions on days when some PM_{10} values exceeded the level which determines "Impaired Air Quality".

On November 30, carbon monoxide values in Everett, Bellevue and Tacoma also exceeded the level of the primary 8 hour average standard. On each sounding, temperature is represented by a solid line connecting data points enclosed in small circles. The dewpoint temperature is represented by a dashed line connecting data points enclosed in small triangles. The wind at regular altitude intervals is plotted and also printed in degrees/knots to the right of the temperature sounding.

PSEUDO-ADIABATIC CHART

0700 PST Feb 10, 1989

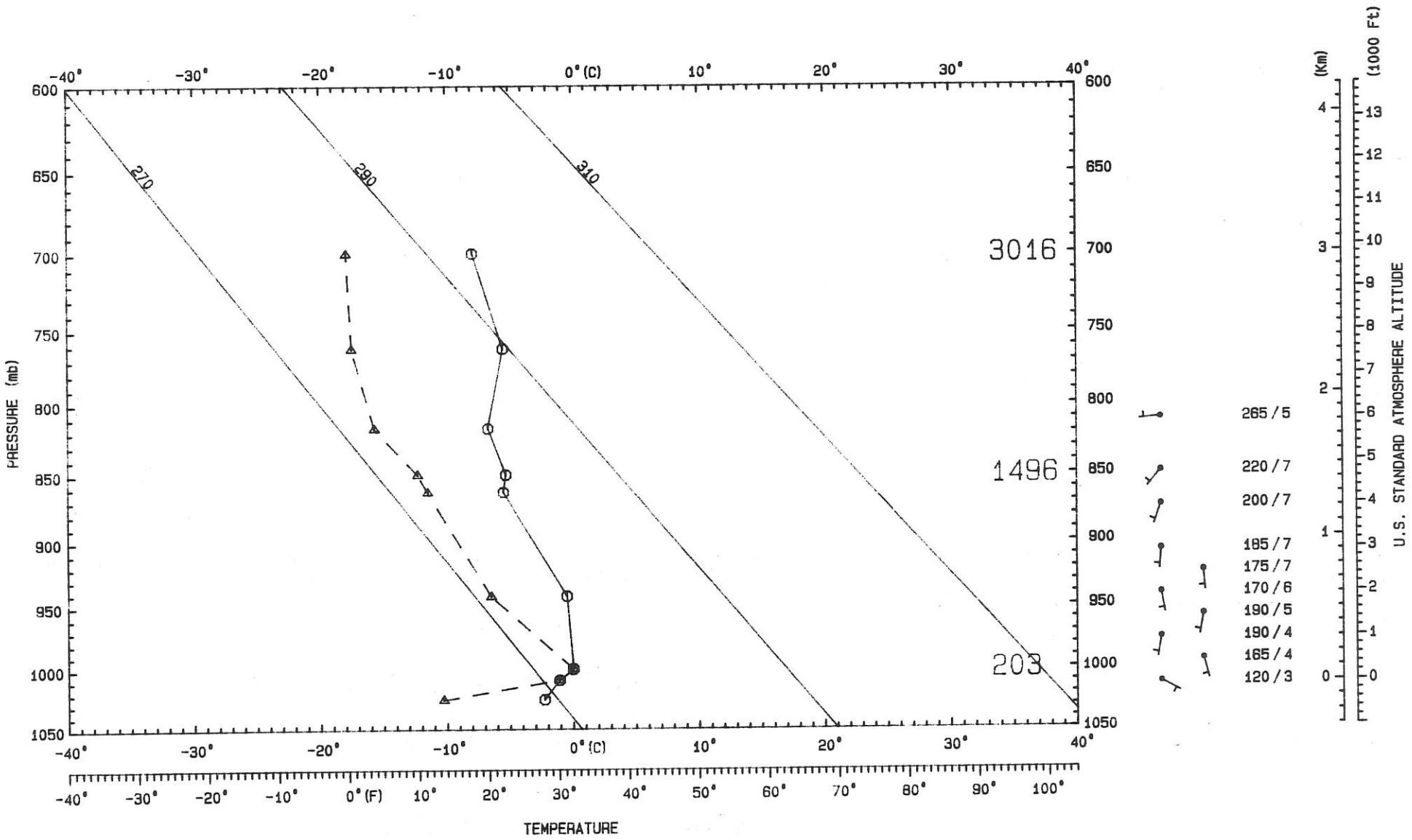
Portage Bay, 2725 Montlake Blvd E, Seattle, WA



PSEUDO-ADIABATIC CHART

0700 PST Feb 15, 1989

Portage Bay, 2725 Montlake Blvd E, Seattle, WA



PSEUDO-ADIABATIC CHART

0700 PST Nov 29, 1989

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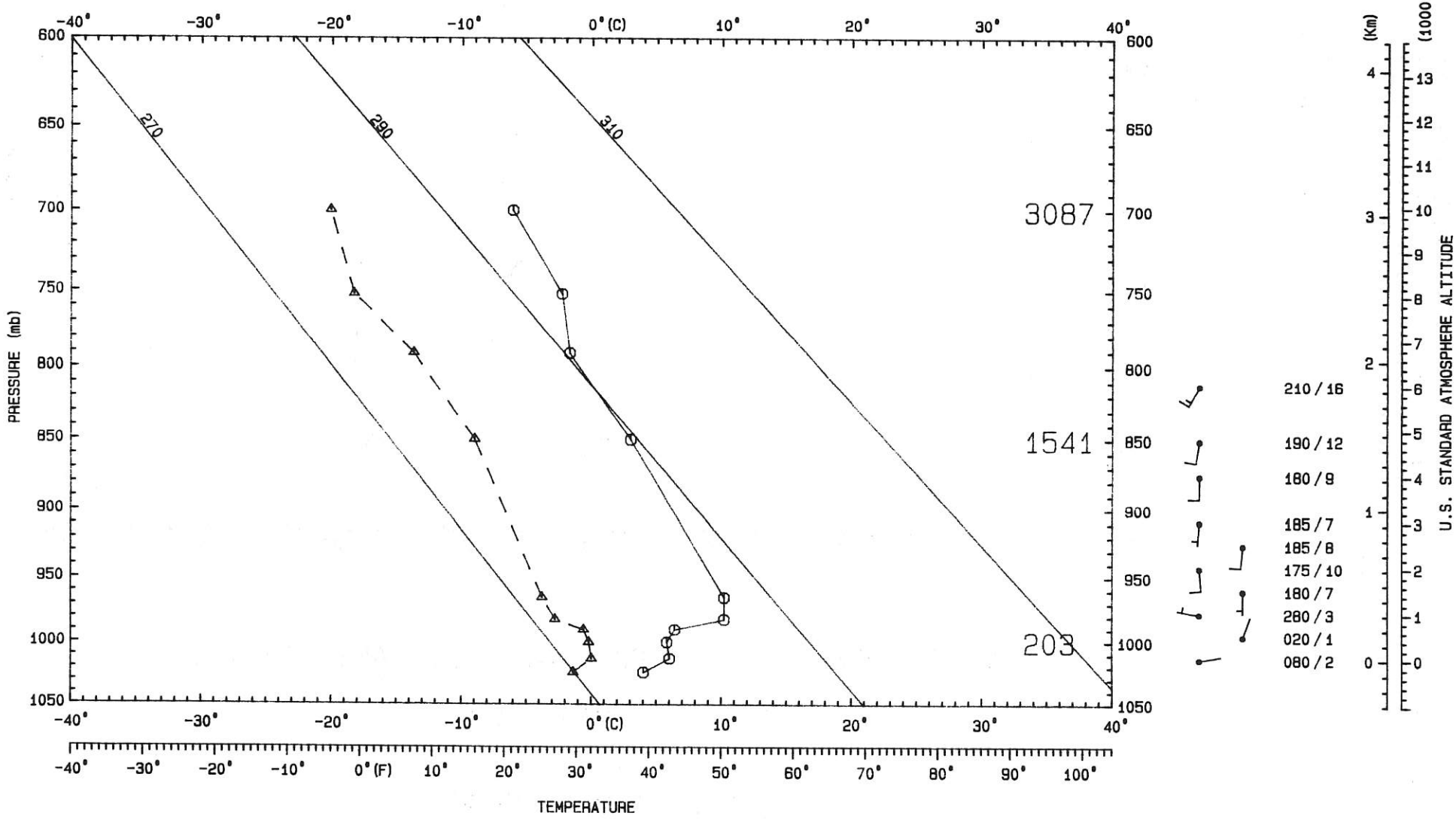
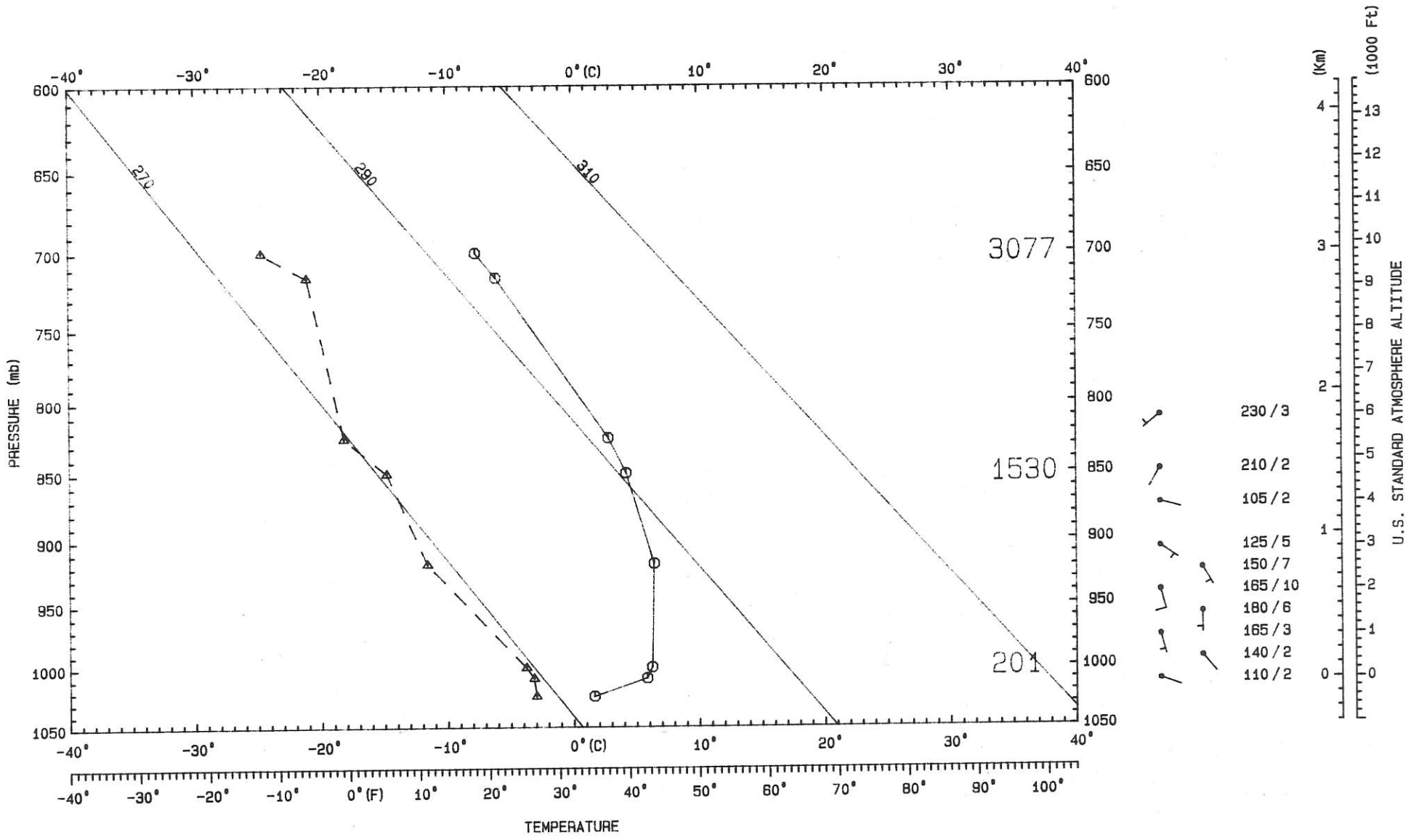


PSEUDO-ADIABATIC CHART

0700 PST Nov 30, 1989

Portage Bay, 2725 Montlake Blvd E, Seattle, WA



WIND ANALYSIS

Wind Data

Everyone has a qualitative sense of surface wind and some effects produced by the wind. The wind direction helps identify the sources or source areas affecting a specific location.

From an air pollution standpoint, low wind speed poorly dilutes pollutants and is therefore associated with higher air pollutant concentrations. During a stable, temperature inversion condition, the wind is often light or calm. When this condition persists, the natural process which effectively disperses pollutants is greatly diminished, and pollutant levels are higher near the source areas.

Wind Speed Averages

The table below presents monthly and annual average wind speed computed from hour average surface wind speed at wind monitoring locations. These average values are sometimes used to compare locations and different months or to provide data for calculations needing average speed values. Individual air stagnation episodes are not exposed by this analysis unless episode conditions predominate during most of a month.

Wind Roses

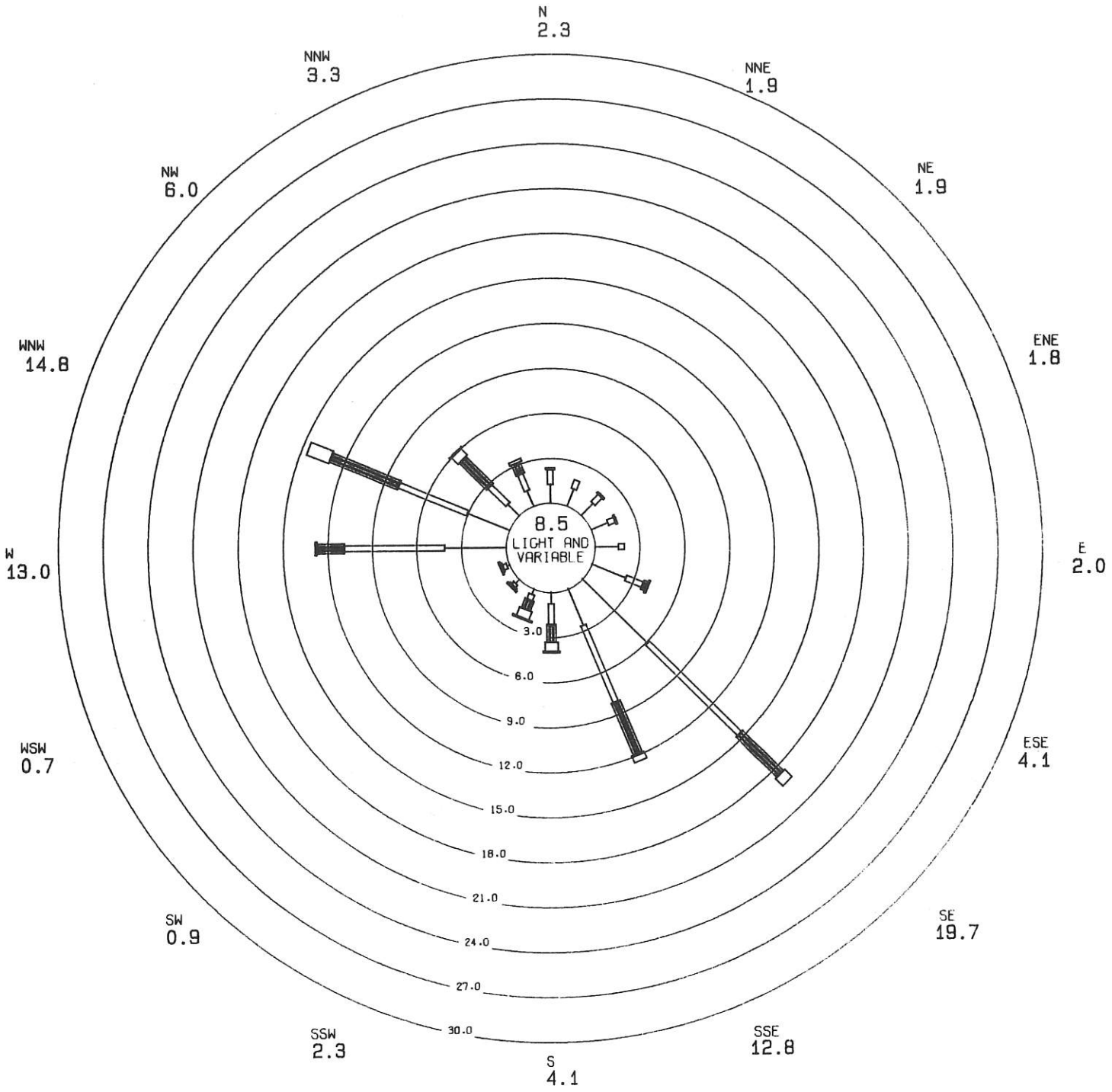
A wind rose is a quantitative graphical summary of the wind direction and speed for a given time period. It is a count, expressed on the following graphs as a percentage frequency, of the number of observations or hours which had a particular direction and speed during the summary period.

The wind rose spokes or arms represent 16 points of the compass and are labeled by wind direction. The percentage frequency of winds <u>from</u> a given direction (without regard to speed) is expressed numerically beneath that direction on the perimeter of each rose.

The length of each segment of a spoke represents the frequency of wind within a speed category. From this frequency and the total observations, the number of hours within each speed category may be determined. The percentage frequency of light and variable winds is printed in the center of the rose.

WIND SPEED
(Knots)
1989

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa											4.2	3.5	1470	4.0
Medical-Dental Bldg, 2730 Colby, Everett, Wa	6.2	5.4	6.4	5.4	4.8	5.4	5.5	4.6	4.7				6702	5.3
17711 Ballinger Way NE, Lake Forest Park, Wa										2.3	2.9	1.9	2478	2.3
North 98th St & Stone Ave N, Seattle, Wa	4.0	2.3	3.8	3.5	3.0								3426	3.3
Duwamish, 4752 E Marginal Way S, Seattle, Wa	4.8	3.0	4.3	4.3	3.8	3.6	3.4		4.1	4.2	4.9	3.5	7804	4.0
James St & Central Ave, Kent, Wa		2.7	3.4	3.3	3.0	3.0	2.8	2.7	2.3	2.9	3.8	2.6	7951	3.0
27th St NE & 54th Ave NE, Northeast Tacoma, Wa			3.2	3.3	2.4	2.5	2.2	2.3	2.7	3.4	3.7	2.6	7501	2.8
2301 Alexander Ave, Tacoma, Wa	4.2	3.2	3.8	3.9	4.2	4.2	3.6	3.7	3.3	3.8	4.3	3.1	8481	3.8
Fire Station #12, 2316 E 11th St, Tacoma, Wa	4.8	3.4	4.0	3.9	4.1	4.2			3.8	3.8	4.5	3.2	6824	4.0



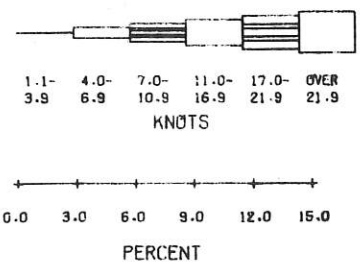
HOUR AVERAGE SURFACE WINDS

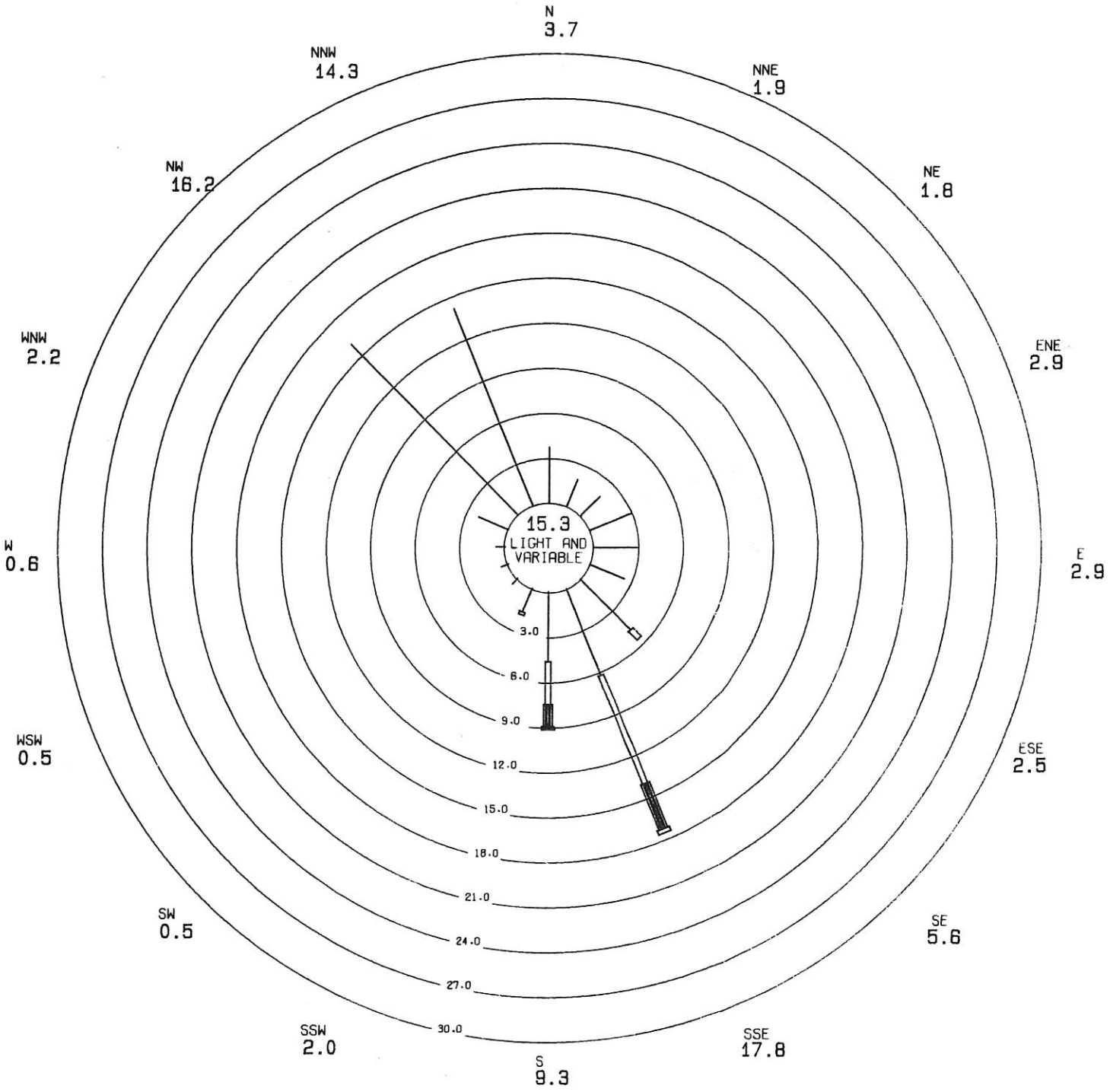
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Medical-Dental Bldg, 2730 Colby, Everett, Wa

INCLUSIVE DATES- JAN - OCT, 1989

TOTAL OBSERVATIONS- 6,702





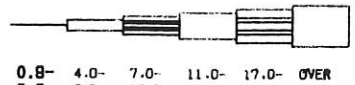
HOUR AVERAGE SURFACE WINDS

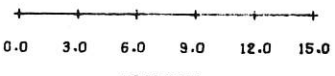
PERCENTAGE FREQUENCY OF OCCURRENCE

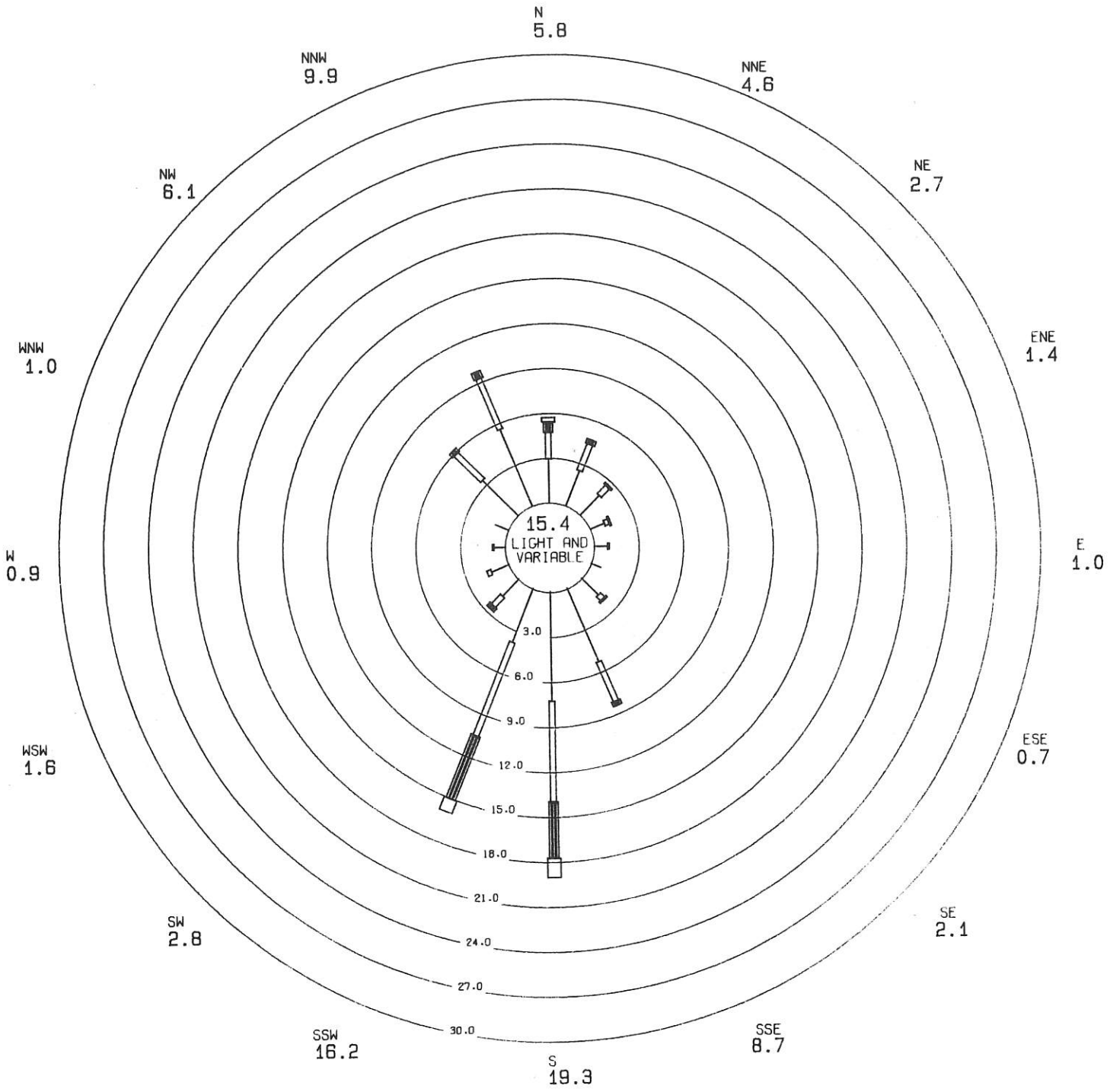
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
17711 Ballinger Way NE, Lake Forest Park, Wa

INCLUSIVE DATES- SEP - DEC, 1989

TOTAL OBSERVATIONS- 2, 478







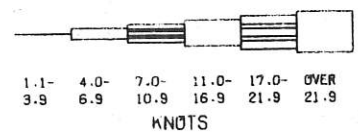
HOUR AVERAGE SURFACE WINDS

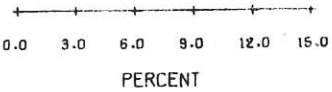
PERCENTAGE FREQUENCY OF OCCURRENCE

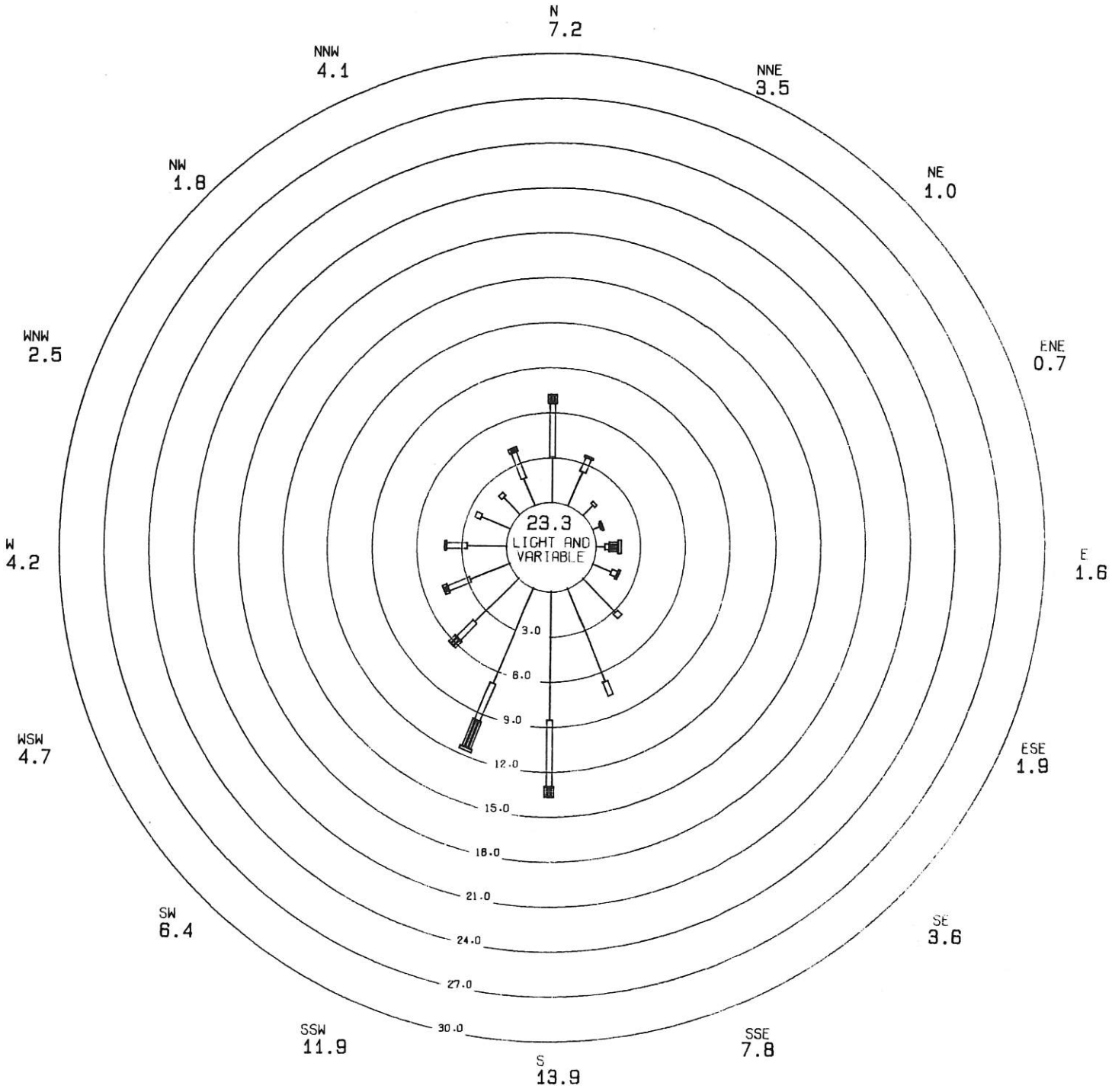
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Duwamish, 4752 E Marginal Way S, Seattle, Wa

INCLUSIVE DATES- ALL MONTHS 1989

TOTAL OBSERVATIONS- 7,804







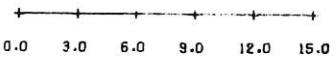
HOUR AVERAGE SURFACE WINDS

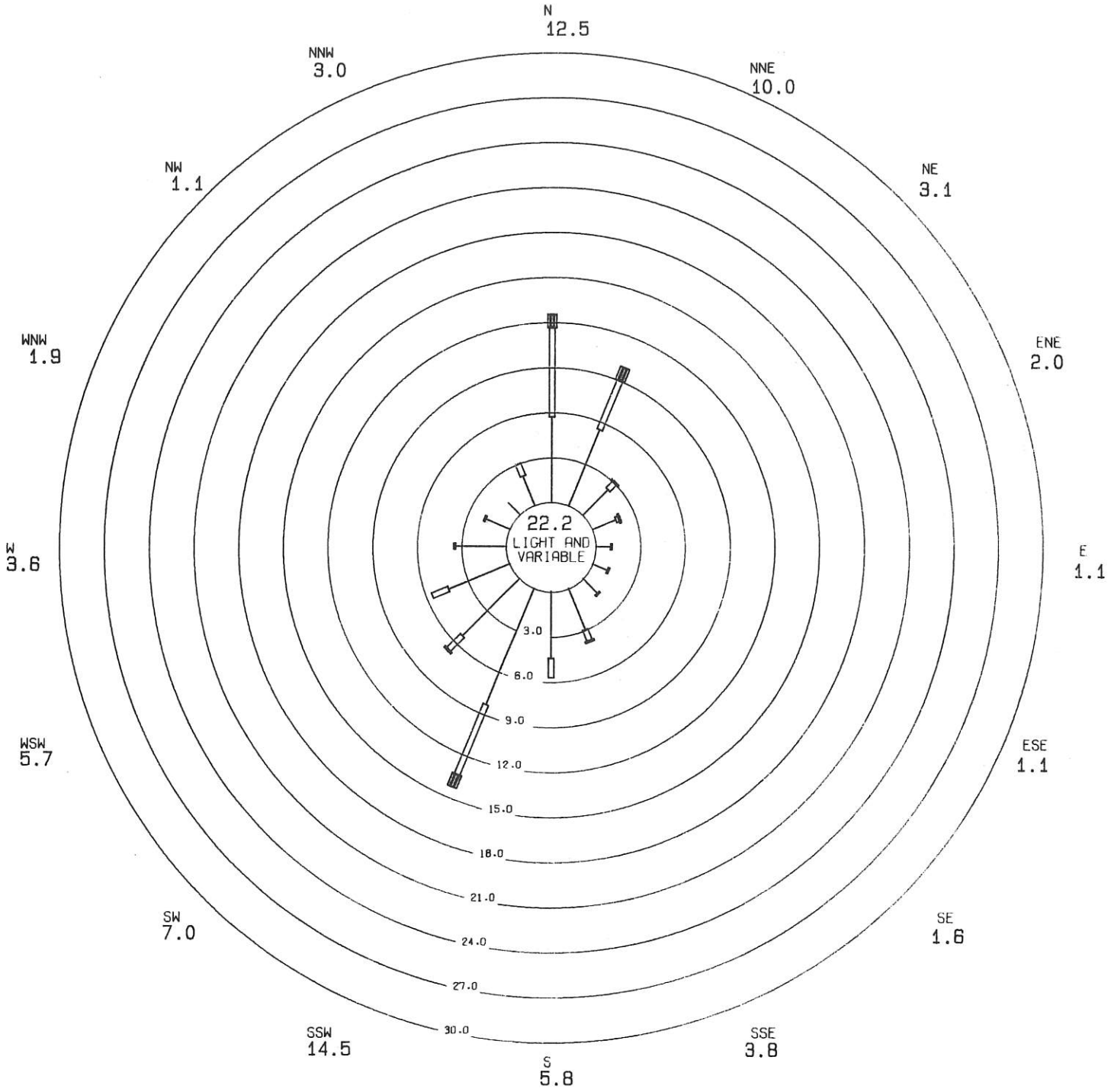
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
James St & Central Ave, Kent, Wa

INCLUSIVE DATES- ALL MONTHS 1989

TOTAL OBSERVATIONS- 7,951





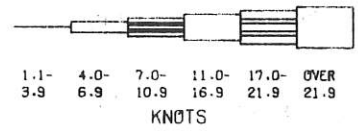
HOUR AVERAGE SURFACE WINDS

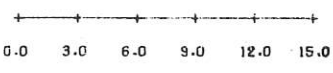
PERCENTAGE FREQUENCY OF OCCURRENCE

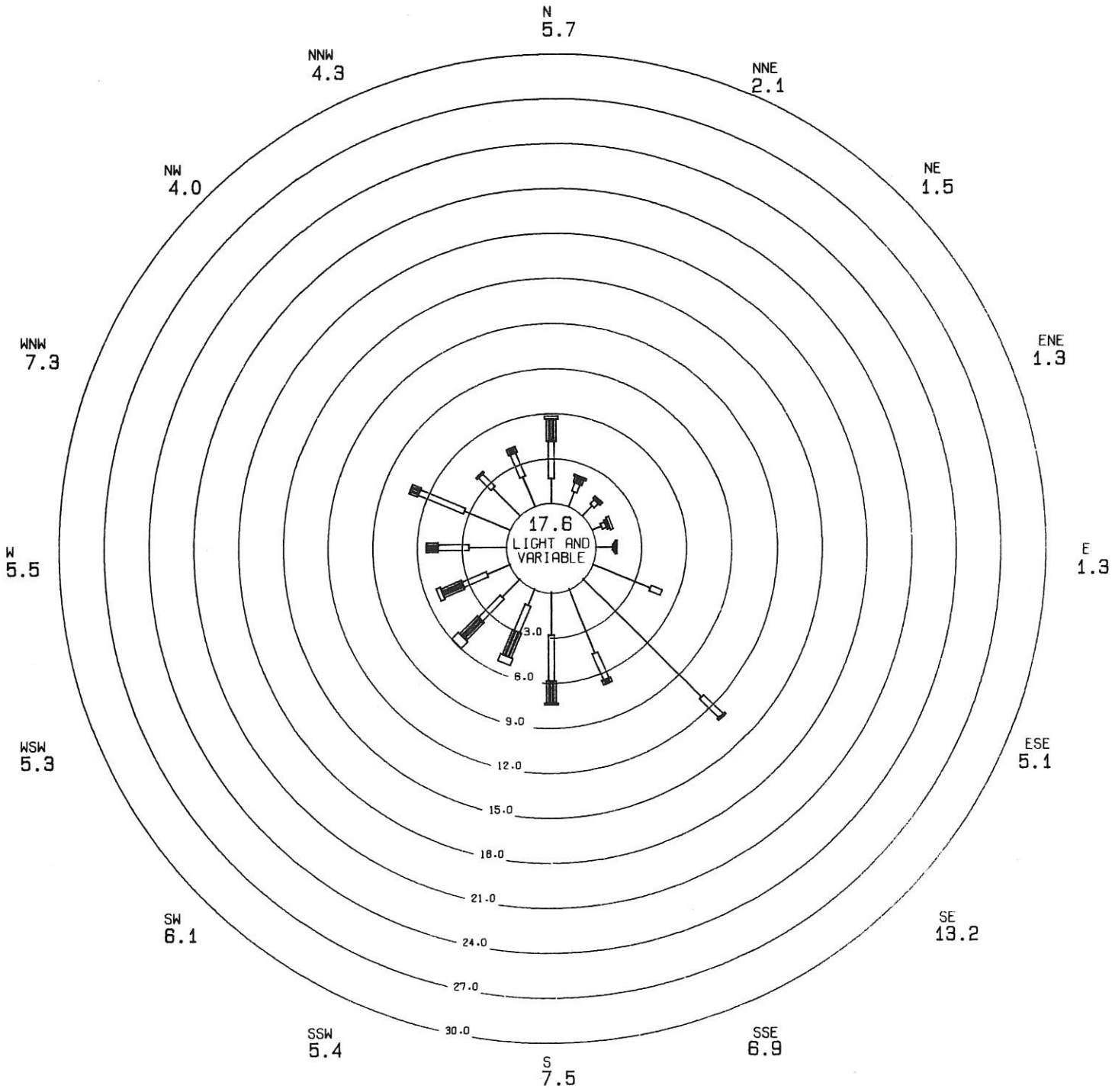
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
27th St NE & 54th Ave NE, Northeast Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1989

TOTAL OBSERVATIONS- 7,501







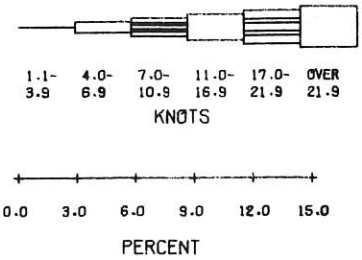
HOUR AVERAGE SURFACE WINDS

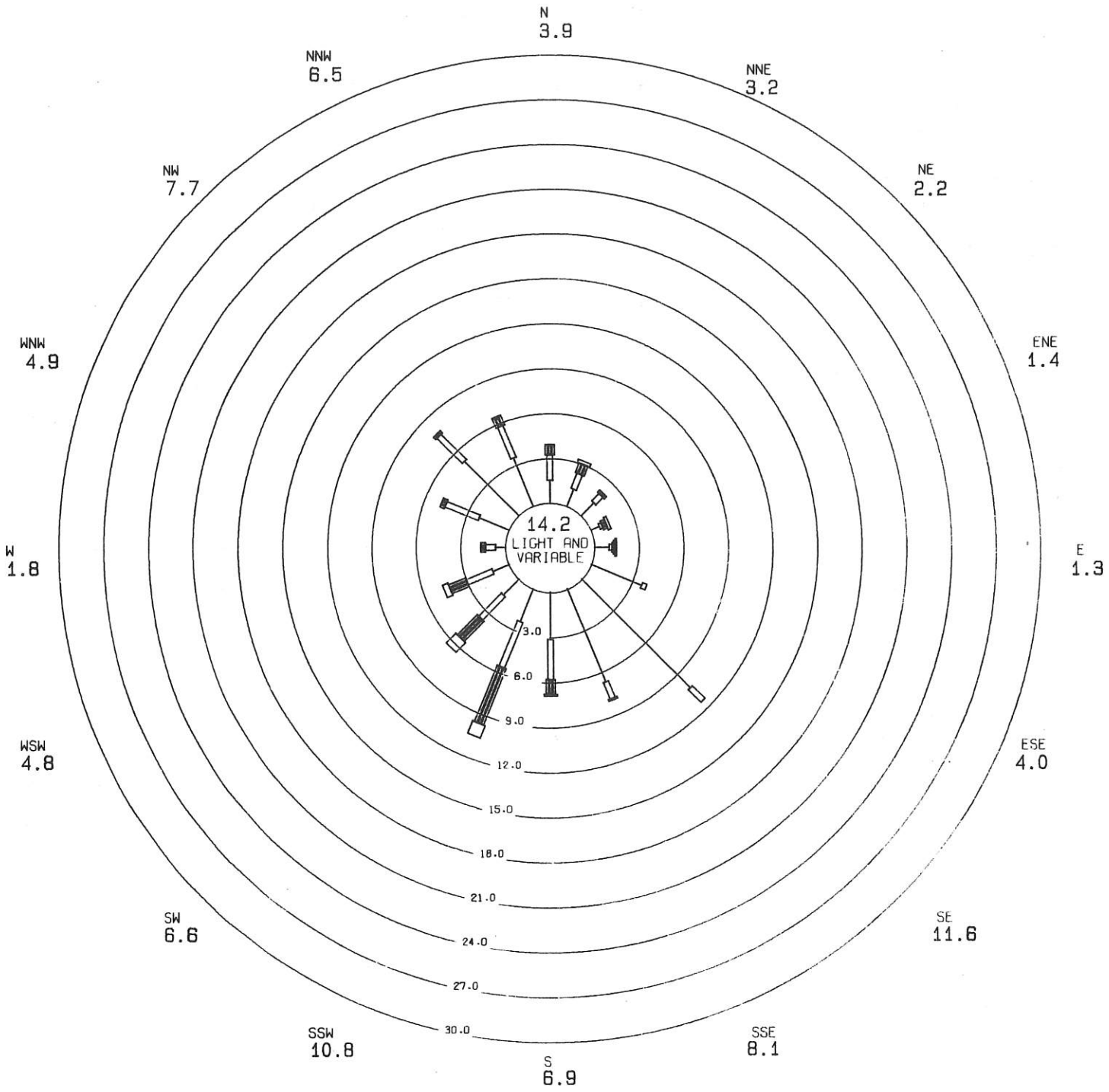
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
2301 Alexander Ave, Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1989

TOTAL OBSERVATIONS- 8,481





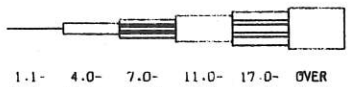
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Fire Station #12, 2316 E 11th St, Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1989

TOTAL OBSERVATIONS- 6,824



1.1-3.9	4.0-6.9	7.0-10.9	11.0-16.9	17.0-21.9	OVER 21.9

KNOTS

0.0 3.0 6.0 9.0 12.0 15.0

PERCENT

AMBIENT AIR QUALITY STANDARDS

POLLUTANT	NATIONAL Primary	NATIONAL Secondary	WASHINGTON STATE	PUGET SOUND REGION
CARBON MONOXIDE				
8 Hour Average	9 ppm		9 ppm	9 ppm
1 Hour Average	35 ppm		35 ppm	35 ppm
PARTICULATE MATTER (PM_{10})				
Annual Arithmetic Average	50 ug/m^3	50 ug/m^3	50 ug/m^3	50 ug/m^3
24 Hour Average[a]	150 ug/m^3	150 ug/m^3	150 ug/m^3	150 ug/m^3
TOTAL SUSPENDED PARTICULATES				
Annual Geometric Average			60 ug/m^3	60 ug/m^3
24 Hour Average			150 ug/m^3	150 ug/m^3
OZONE				
1 Hour Average[b]	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm
SULFUR DIOXIDE				
Annual Average	0.03 ppm		0.02 ppm	0.02 ppm
30 Day Average				0.04 ppm
24 Hour Average	0.14 ppm		0.10 ppm	0.10 ppm[c]
3 Hour Average		0.50 ppm		
1 Hour Average[d]			0.25 ppm	0.25 ppm
1 Hour Average			0.40 ppm	0.40 ppm[c]
5 Minute Average[e]				1.00 ppm
LEAD				
Calendar Quarter Average	1.5 ug/m^3	1.5 ug/m^3		1.5 ug/m^3
NITROGEN DIOXIDE				
Annual Average	0.05 ppm	0.05 ppm	0.05 ppm	0.05 ppm

Notes

(1) ppm = parts per million

(2) ug/m^3 = micrograms per cubic meter

(3) Annual, Quarter and 30 Day standards never to be exceeded, shorter term standards not to be exceeded more than once per year unless noted.

a - Standard attained when expected number of days per year with a 24 hour concentration above 150 ug/m^3 is equal to one or less.

b - Standard attained when expected number of days per year with an hourly average above 0.12 ppm is equal to one or less.

c - Sulfur Dioxide short-term standard never to be exceeded.

d - Not to be exceeded more than twice in seven days.

e - Not to be exceeded more than once in eight hours.

CHARACTERISTICS AND EFFECTS OF AMBIENT AIR POLLUTANTS

Carbon Monoxide

Carbon monoxide is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely. It chemically combines with the hemoglobin in the red blood cells to decrease the oxygen-carrying capacity of the blood. Carbon monoxide also weakens the contractions of the heart, thus reducing the amount of blood pumped throughout the body. People with heart disease and pregnant women are particularly at risk because of the effects of carbon monoxide.

Particulate Matter (PM_{10} and TSP)

Particulate matter with an aerodynamic diameter of less than or equal to 10 micrometers (PM_{10}) and Total Suspended Particulates (TSP) are small discrete masses of solid or liquid matter dispersed in the atmosphere. Slash and wood burning, and transportation and industrial activity are the major sources of particulate matter. Those particulates one micrometer or less in diameter are especially associated with a variety of adverse effects on public health and welfare. Particulate in the respiratory tract may produce injury by itself, or it may act in conjunction with gases to increase the effect on the body. The elderly, those suffering from respiratory illness, and young children are especially prone to the deleterious effects of particulates. Soiling of buildings and other property, and reduced visibility are further results of high particulate matter levels.

Ozone

Ozone is a pungent-smelling, colorless gas produced in the atmosphere when nitrogen oxides and some hydrocarbons chemically react under the effect of strong sunlight. It is a pulmonary irritant that affects lung tissues and respiratory functions. Ozone impairs the normal function of the lung and, at concentrations between 0.15 and 0.25 ppm, causes lung tightness, coughing and wheezing. Other oxidants that often accompany ozone cause eye irritation. Persons with chronic respiratory problems, such as asthma, seem most sensitive to increases in ozone concentration.

Sulfur Dioxide

Sulfur dioxide is a colorless, corrosive gas, that has a bitter taste, but no appreciable smell between 0.3 - 1.0 ppm. Industrial sites which use coal and oil for fuel - such as smelters, paper mills, power plants and steel manufacturing plants - are the main sources of sulfur dioxide pollution. The presence of sulfur dioxide in the ambient air has been associated with a variety of respiratory diseases and increased mortality rates. When sulfur dioxide is inhaled with small particles, the effect on health is increased. Inhalation of sulfur dioxide can cause increased airway resistance by constricting lung passages.

Lead

Lead particles or its compounds enter the air from vehicle exhaust and from industries that smelt, process and/or handle the metal. Lead affects humans in numerous ways, but the greatest impacts appear to be on the blood-forming system, the nervous system, and the kidneys. It affects some people more than others. Young children (ages 1 - 5) are particularly sensitive to lead exposure. The standard for lead in air is intended to prevent most children from exceeding blood lead levels of 30 micrograms per deciliter of blood.

Nitrogen Dioxide

Nitrogen dioxide is a poisonous, brownish gas which, in addition to being a strong oxidizing agent, quickly reacts with water vapor to form corrosive nitric acid. Nitrogen dioxide is formed as the result of high temperature fuel combustion and subsequent atmospheric reactions. The presence of nitrogen dioxide in ambient air has been connected with a range of respiratory diseases. Further, nitrogen dioxide plays an essential role in the production of ozone.

AIR QUALITY UNITS CONVERSION TABLE

Air quality standards for gases are defined in terms of micrograms (ug) or milligrams (mg) per cubic meter as well as in parts per million (ppm). As this data summary expresses measurements for gaseous pollutants in terms of ppm, the following conversion table is for the convenience of those who wish to interpret our results in terms of ug/cubic meter or mg/cubic meter. These conversion factors from the Federal Register assume a pressure of 760 mm Hg and a temperature of 25 degrees C.

Pollutant	Multiply ppm by	To Obtain
Carbon Monoxide	1.145	mg/cubic meter
Nitrogen Dioxide	1880	ug/cubic meter
Ozone	1961	ug/cubic meter
Sulfur Dioxide	2619	ug/cubic meter