1993 Air Quality Data Summary

for the counties

King
Kitsap
Pierce
Snohomish

PUGET SOUND AIR POLLUTION CONTROL AGENCY
110 Union Street, Suite 500
Seattle, WA 98101-2038

PUGET SOUND AIR POLLUTION CONTROL AGENCY

Serving King, Kitsap, Pierce and Snohomish Counties

1993 AIR QUALITY DATA SUMMARY

Contents

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EXECUTIVE SUMMARY

Introduction

This twenty-second annual data summary reviews 1993 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.

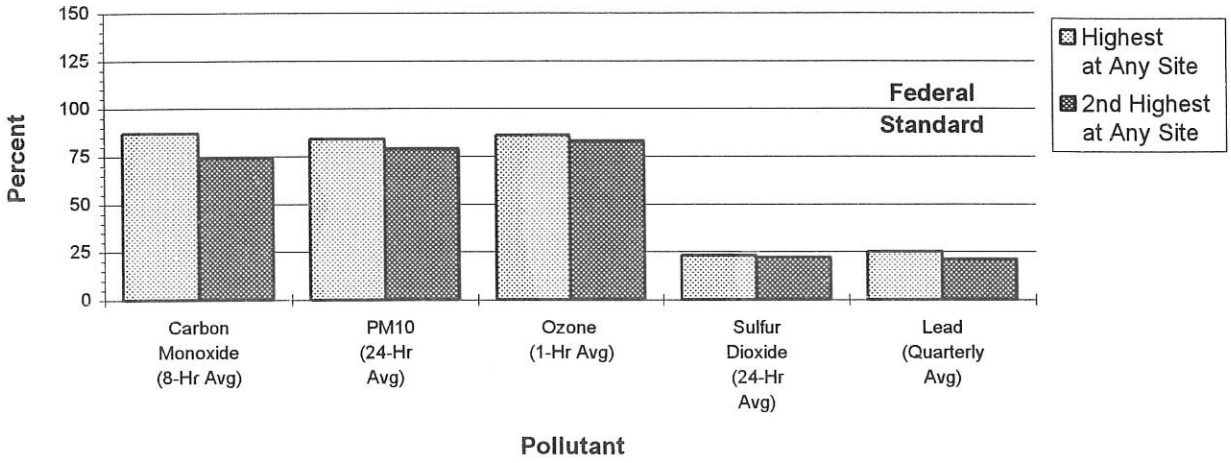
Sections near the back summarize air pollution episodes and "impaired air quality" periods and provide meteorological analyses consisting of wind speed averages and graphs of wind patterns. The last data section presents the Puget Sound Region emission inventory summarized in a variety of ways.

Air pollution is a complex mixture of compounds that each requires specialized equipment for identification and measurement. 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 that protect health and establishes deadlines for states to develop and implement plans to achieve and maintain the air quality standards. The Washington State 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 that are at least as stringent as the national standards. A discussion of the characteristics and effects of each of these air pollutants and a table of all the ambient air quality standards appear on pages 62 and 63 of this report.

The Puget Sound Region continues in compliance with the standards for sulfur dioxide, lead and nitrogen dioxide. In specific areas during the last six years, the Region has been out of compliance with the standards for the pollutants carbon monoxide, particulate matter and ozone.

The chart below displays 1993 maximum pollutant concentrations compared to the Federal primary standard. As shown, both the highest and the second highest concentration at any site did not exceed the standard. This means the Region complied with these air quality standards during 1993. Further, the Puget Sound Region has complied with all these ambient standards for three years through the end of 1993.

1993 Maximum Pollutant Concentrations Compared to the Federal Standard



Carbon Monoxide

The area that in the past has not complied with the carbon monoxide standard includes Everett, Seattle, Bellevue and Tacoma. During 1993, none of the monitoring sites measured a carbon monoxide value that exceeded the primary (health related) standard of 9 ppm averaged over eight hours. This completes three full years that the Puget Sound Region has complied with the standard. The following table summarizes the highest and second highest 8 hour average carbon monoxide values during 1993 for each carbon monoxide monitoring station.

1993 Carbon Monoxide Summary

Location	Highest 8 hr Avg (ppm)	2nd Highest 8 hr Avg (ppm)
Everett, Broadway	6.7	6.5
Bellevue, Bellevue Way NE	5.1	4.9
Seattle, NE Northgate Way	6.4	5.8
Seattle, University District	7.0	6.7
Seattle, 1424 4th Ave	5.9	5.6
Seattle, 5th Ave & James	5.9	5.2
Tacoma, 1101 Pacific Ave	7.8	5.9

Particulate Matter

The particulate matter standards adopted by the U. S. EPA in July 1987 measure only PM_{10} (particles 10 micrometers or less in diameter). The levels for the national primary and secondary PM_{10} standards are 150 micrograms per cubic meter ($\mu g/m^3$) for a 24 hour average and 50 $\mu g/m^3$ for an annual arithmetic mean. Washington State and Puget Sound Region PM_{10} standards were established at the same level as the national PM_{10} standards.

For 1993, none of the daily or annual average PM_{10} values exceeded the level of the standards. The following table summarizes the maximum daily PM_{10} value and the annual PM_{10} arithmetic average by monitoring location for the year 1993.

1993 PM_{10} Summary

Location	Maximum Daily PM_{10} Value ($\mu g/m^3$)	Annual PM_{10} Arith Avg ($\mu g/m^3$)
Marysville, Jr Hi School	108	26.9
Everett, Hoyt & 26th	72	23.3
Bellevue, Bellevue Wy NE	47	19.8
Lake Forest Pk, City Hall	89	28.1
Seattle, Harbor Is	93	30.9
Seattle, Duwamish	126	34.8
Seattle, South Park	81	26.6
Kent, James & Central	92	28.2
Puyallup, South Hill	68	23.9
NE Tacoma, 27th & 54th	72	26.4
Tacoma, Taylor Way	81	30.1
Tacoma, Alexander	76	29.1
Tacoma, E 11th St	120	33.4
Kitsap County, Meadowdale	78	23.4
Poulsbo, 6th Ave & Fjord Dr	44	---

Under the Federal regulation, the last three years of data must be used to determine compliance with the PM_{10} standards. For these past three calendar years, none of the annual PM_{10} values exceeded the annual PM_{10} standard of 50 $\mu g/m^3$ and none of the daily PM_{10} values exceeded the 24 hour average PM_{10} standard of 150 $\mu g/m^3$. Therefore the Puget Sound Region complies with the PM_{10} standards.

Ozone

Ozone is a photochemical pollutant with highest levels measured during record hot weather from mid May to mid September. In 1987 the Puget Sound Region attained the ozone standard, but monitoring data during the summer of 1990 resulted again in a

designation as out of compliance with this standard. If a particular location shows more than one (1.0) daily maximum hour per year, averaged over the last three years, with a concentration greater than 0.12 ppm, then the ozone standard has been violated.

There were no exceedances of the ozone standard at any site for the three years from 1991 through 1993. Therefore, all sites in the Puget Sound Region complied with the ozone standard at the end of 1993. The following table summarizes the maximum 1 hour average ozone value during 1993 for each ozone monitoring site.

1993 Ozone Summary

Location	Maximum 1 hr Avg (ppm)
Getchell 8426 99th Ave	0.093
Lake Sammamish State Park	0.098
Enumclaw, Highway 410	0.103
La Grande, Pack Forest	0.103

Weather and Air Quality

One of the variables 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. In the Puget Sound Region, poor dispersion exists on about one-third of the days during night to early morning hours, but weather effectively disperses pollutants by afternoon on most of these days.

A few times during the months of January, February, October, November or December, poor dispersion persists for 24 or more hours and may result in the declaration of an "air pollution episode" or local "impaired air quality". During 1993, the Department of Ecology did not declare any stage of an air pollution episode in the Puget Sound Region.

The Washington Clean Air Act established the criteria for determining "impaired air quality". During 1993, "impaired air quality" was in effect in the Puget Sound Region as follows:

"Impaired Air Quality" During 1993

Dates/Counties

2:30 pm, Monday, January 11 - 8:30 am, Wednesday, January 13; (King, Pierce, Snohomish & Kitsap)

2:30 pm, Friday, January 15 - 7:00 am, Saturday, January 16; (King, Pierce, Snohomish & Kitsap)

2:30 pm, Sunday, January 17 - 6:00 am, Tuesday, January 19; (King, Pierce, Snohomish & Kitsap)

2:30 pm, Sunday, January 31 - 8:30 am, Wednesday, February 3; (King, Pierce, Snohomish & Kitsap)

- - -

2:30 pm, Monday, December 20 - 2:30 pm, Tuesday, December 21; (King, Pierce & Snohomish)

2:30 pm, Sunday, December 26 - 8:30 am, Wednesday, December 29. (King, Pierce & Snohomish)

Daily Air Quality

The Agency uses the national Pollutant Standards Index to report daily air quality. The report includes the Index value as determined by pollutant levels and a descriptive term for the Index value. This term describes 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. Summarizing from the daily Pollutant Standards Index values, in 1993:

Everett had 238 Good, 127 Moderate, and 0 Unhealthful days;
Seattle had 251 Good, 114 Moderate, and 0 Unhealthful days;
Tacoma had 302 Good, 63 Moderate, and 0 Unhealthful days.

The current daily Pollutant Standards Index is available toll free from the Puget Sound Air Pollution Control Agency by dialing 1-800-433-2215.

1993 SAMPLING NETWORK

Location	*Type of Sampling*
* 8426 99th Avenue NE, Getchell, Wa (began May 1; seasonal)	O_3
Marysville JHS, 1605 7th St, Marysville, Wa	PM10 $(PM10)_{eq}$ Wind
Hoyt Ave & 26th St, Everett, Wa	PM10 SO_2, Wind
* Broadway & Hewitt Ave, Everett, Wa	CO
* 622 Bellevue Way NE, Bellevue, Wa	CO
* 504 Bellevue Way NE, Bellevue, Wa	PM10
* 20050 SE 56th, Lake Sammamish State Park, Wa (seasonal)	O_3
17711 Ballinger Way NE, Lake Forest Park, Wa	PM10 $(PM10)_{eq}$ bsp, Wind
* Northgate, 310 NE Northgate Way, Seattle, Wa	CO
* Sand Point, 7600 Sand Pt Way NE, Seattle, Wa	Wind, Temp, dT
* 5701 8th Ave NE, Seattle, Wa	TSP/Pb
* University Dist, 1307 NE 45th St, Seattle, Wa	CO
* 1424 4th Ave, Seattle, Wa	CO
* 5th Ave & James St, Seattle, Wa	CO
* Beacon Hill, 15th S & Charlestown, Seattle, Wa	Wind, Temp
Harbor Island, 2555 13th Ave SW, Seattle, Wa	TSP/Pb
Harbor Island, 3400 13th Ave SW, Seattle, Wa	PM10
Duwamish, 4752 E Marginal Way S, Seattle, Wa	PM10 $(PM10)_{eq}$ PM2.5, bsp, SO_2, Wind

Notes- (1) *Type of Sampling*:

PM10	=	Particulate Matter ≤ 10 micrometers (reference method)	bsp	=	Atmospheric Particles (by nephelometer)
$(PM10)_{eq}$	=	Particulate Matter ≤ 10 micrometers (equivalent method)	O_3	=	Ozone
CO	=	Carbon Monoxide	SO_2	=	Sulfur Dioxide
PM2.5	=	Particulate Matter ≤ 2.5 micrometers	TSP/Pb	=	Total Suspended Particulates and Lead
Wind	=	Wind Direction & Speed	Temp	=	Air Temperature
			dT	=	delta Temperature

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

1993 SAMPLING NETWORK

Location	*Type of Sampling*		
South Park, 723 S Concord St, Seattle, Wa	PM10		
James St & Central Ave, Kent, Wa	PM10	$(PM10)_{eq}$	PM2.5, bsp, Wind
* Highway 410, 2 miles east of Enumclaw, Wa (seasonal)			O_3
* Charles L Pack Forest, La Grande, Wa (seasonal)			O_3
South Hill, 9616 128th St E, Puyallup, Wa	PM10	$(PM10)_{eq}$	Wind
* 5225 Tower Drive NE, Northeast Tacoma, Wa			Wind, Temp
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	PM10		SO_2, Wind
2340 Taylor Way, Tacoma, Wa	PM10		
2301 Alexander Ave, Tacoma, Wa	PM10		SO_2, Wind
Fire Station #12, 2316 E 11th St, Tacoma, Wa	PM10	$(PM10)_{eq}$	PM2.5, bsp, Wind
* 1101 Pacific Ave, Tacoma, Wa		CO	
Meadowdale, 7252 Blackbird Dr NE, Kitsap Co, Wa	PM10	$(PM10)_{eq}$	Wind
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa (began Aug 29)	PM10	$(PM10)_{eq}$	Wind

Notes- (1) *Type of Sampling*:

PM10	=	Particulate Matter ≤ 10 micrometers (reference method)	bsp	=	Atmospheric Particles (by nephelometer)
$(PM10)_{eq}$	=	Particulate Matter ≤ 10 micrometers (equivalent method)	O_3	=	Ozone
CO	=	Carbon Monoxide	SO_2	=	Sulfur Dioxide
PM2.5	=	Particulate Matter ≤ 2.5 micrometers	Temp	=	Air Temperature
Wind	=	Wind Direction & Speed			

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

POLLUTANT STANDARDS INDEX

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

Measured pollutant levels during each day convert to a scale that shows if there are potential health effects. This Index scale, ranging from 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 pollutant concentration and the averaging period associated with each PSI value that is a break-point between Index categories. PSI values for pollutant concentrations between break-points are determined by linear interpolation.

Whenever the PSI is greater than 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.

Every day the concentration of each pollutant within the areas of Everett, Seattle and Tacoma determines an Index value. For each area, the pollutant with the highest Index value determines the PSI on that day. Highest values for these areas usually occur in the vicinity of heavy traffic or an industrial area.

Since high ozone levels occur some distance downwind of Everett, Seattle or Tacoma on hot summer afternoons, the Agency reports the ozone PSI value in a downwind area during the months from May through September. For 1993, the maximum ozone PSI value of 86 occurred near both Enumclaw and La Grande on August 4.

Tables that follow summarize the daily PSI values for Everett, Seattle, and Tacoma. The 1993 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 1980 through 1993 summary table shows for each 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. The right-hand columns list the highest PSI value for each year.

Pollutant Concentration for Each PSI Break-point Value

PSI Value	CO *8 hr Avg* (*ppm*)	PM10 *24 hr Avg* ($\mu g/m^3$)	SO_2 *24 hr Avg* (*ppm*)	O_3 *1 hr Avg* (*ppm*)
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

1993

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)	13	12	19	24	23	25	27	20	13	20	25	17	238
MODERATE	(51 to 100)	18	16	12	6	8	5	4	11	17	11	5	14	127
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		79	70	78	56	78	67	67	67	67	67	59	67	79
Date		11th	1st	31st	12th#	10th	25th	26th	2nd#	2nd#	1st#	9th	20th#	Jan 11
Pollutant		PM	PM	CO	CO	CO	CO	CO	CO	CO	CO	PM	CO	PM

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)	11	9	24	27	27	27	29	28	19	21	17	12	251
MODERATE	(51 to 100)	20	19	7	3	4	3	2	3	11	10	13	19	114
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		88	83	57	56	56	56	56	56	70	78	63	76	88
Date		11th	4th	12th	2nd#	1st#	6th#	1st#	16th#	7th	27th	9th	28th	Jan 11
Pollutant		PM	PM	PM	CO	CO	CO	CO	CO	PM	CO	PM	PM	PM

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)	21	12	29	30	31	30	31	30	22	27	21	18	302
MODERATE	(51 to 100)	10	16	2	0	0	0	0	1	8	4	9	13	63
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		68	89	55	44	44	33	33	54	58	59	67	67	89
Date		12th	1st	12th	16th	10th	4th#	2nd#	4th	10th	27th	9th#	21st#	Feb 1
Pollutant		PM	CO	PM	CO	CO	CO	CO	PM	PM	PM	PM	CO	CO

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

Earliest date of occurrence

POLLUTANT STANDARDS INDEX

1980 - 1993

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
1990	166	197	2	0	29	335	1	0	2	0	117	Mar 02#	CO
1991	188	176	1	0	32	333	0	0	1	0	117	Dec 16	CO
1992	180	186	0	0	34	332	0	0	0	0	100	Feb 04#	CO
1993	238	127	0	0	56	309	0	0	0	0	79	Jan 11	PM
Totals	3564	1519	19	0	1878	2993	231	0	19	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 06	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 06	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 07	PM
1987	120	238	7	0	119	246	0	3	4	0	184	Feb 06	PM
1988	215	146	5	0	67	298	1	2	3	0	150	Dec 03	CO
1989	231	134	0	0	129	233	3	0	0	0	100	Jan 19#	CO
1990	239	126	0	0	141	218	6	0	0	0	100	Jan 18	CO
1991	256	109	0	0	141	216	8	0	0	0	100	Dec 15#	CO
1992	238	127	1	0	105	260	1	0	1	0	167	Feb 03	CO
1993	251	114	0	0	119	245	1	0	0	0	88	Jan 11	PM
Totals	2302	2708	98	6	1602	3459	53	21	83	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 05	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
1990	289	75	1	0	237	87	41	1	0	0	118	May 05	PM
1991	282	82	1	0	268	85	12	0	1	0	117	Jan 31	CO
1992	285	81	0	0	256	83	27	0	0	0	100	Feb 03#	CO
1993	302	63	0	0	260	82	23	0	0	0	89	Feb 01	CO
Totals	2696	2334	79	5	3316	1614	184	18	66	0			

Earliest date of occurrence

LEAD

The ambient air quality standard for lead is 1.5 $\mu g/m^3$ averaged over one calendar quarter. The Puget Sound Region fully complies with this standard as shown by 1993 data in the table below. In the past, urban area lead levels violated the standard near high traffic roadways due principally to automobile exhaust. However, the current ambient lead levels near these roadways are now significantly lower as a result of the reduced amount of lead in gasoline. This is shown below for the Puget Sound Region where the freeway site at 5701 8th Ave NE documents that the lead concentration is about 2 percent of the standard in 1993. This compares to a level that was 116 percent of the standard at this site in 1979. Lead emissions come also from stationary industrial sources such as primary and secondary nonferrous smelters. The Harbor Island station in the table below is located just across the street from the site of a secondary lead smelter that ceased operation several years ago. The lead levels at this station reached 25 percent of the standard in 1993 still documenting some effect of past emissions from this closed lead smelter.

LEAD
Micrograms per Standard Cubic Meter
Sampling Method: Standard High Volume Quartz Fiber filters

1993

Location	Monthly Arithmetic Averages												No. of Obs	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
5701 8th Ave NE, Seattle, Wa	.03	.04	.03	.02	.02	.03	.02	.02	.02	.04	.02	.03	61	.03
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.08	.20	.11	.29	.55	.10	.21	.22	.10	.14	.46	.51	61	.25

Location	Quarterly Arithmetic Averages			
	1st	2nd	3rd	4th
5701 8th Ave NE, Seattle, Wa	.03	.02	.02	.03
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.13	.31	.18	.37

Summary of Individual 24 Hour Average Lead Values				
Location	Highest Value		Values Higher than .50	
	Value	Date	Value	Date
5701 8th Ave NE, Seattle, Wa	.07	27 Dec		
Harbor Island, 2555 13th Ave SW, Seattle, Wa	1.43	3 Dec	1.43	3 Dec
			1.41	15 Nov
			1.14	7 May
			.79	13 Apr
			.75	9 Dec
			.73	25 May
			.64	19 May
			.57	13 May
			.53	3 Nov

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 Total Suspended Particulates (TSP) to only that portion of particulate matter with particle diameters smaller than or equal to 10 micrometers (PM_{10}). The levels for both the national primary and secondary standards are: 150 $\mu g/m^3$ for a 24 hour average and 50 $\mu g/m^3$ annual arithmetic mean. The PM_{10} standards also include calculation formulas to statistically determine if the standards are attained (40 CFR Part 50, Appendix K).

Particulate Sources and Air Quality

Particulates directly enter the air from industrial operations, from auto, bus and truck traffic, from fuel combustion including wood stoves and fireplaces, from construction, and from other sources. These emissions into the air change daily due to intermittent industrial operations, equipment upset or breakdown, traffic cycles and building heating requirements. Gaseous transformation products in the air like sulfates, nitrates, and some organics are also components of particulate matter. The wind acts to disperse and transport airborne particulate matter. Ambient particulate levels change from day to day in response both to what enters the air and to the variations in weather.

Sampling Methods

Reference methods designated by the U. S. EPA to measure PM_{10} all draw outside air first through an inlet that removes particulates larger than 10 micrometers and then through a filter that collects the remaining particulate matter (PM_{10}). Sampling for a single measurement continues for 24 hours under time clock control and the required sampling period occurs from midnight to midnight.

After the sampling has completed as scheduled, the pre-weighed, sampled filter must be manually removed. Following conditioning in a controlled environment for 24 hours to remove moisture effects, the sampled filter is weighed again on a precision balance and the weight of particulate matter collected during the sample period is calculated. 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 for the specific location and sampling time is calculated by dividing the weight (mass) of collected particulate by the volume of air sampled. The PM_{10} concentration is reported in micrograms per standard cubic meter.

The U. S. EPA has designated three methods as *equivalent methods* for the measurement of PM_{10}; two use a measurement principle based on beta-ray attenuation; one uses a Tapered Element Oscillating Microbalance (TEOM). All three equivalent methods are automated and continuous so that PM_{10} values may be immediately determined and transmitted to a central computer. These methods also measure consecutive daily values without the need for manual servicing after each sampling day.

By the end of 1993, the Puget Sound Air Pollution Control Agency had five equivalent method PM_{10} beta attenuation instruments and four TEOM instruments in operation. During the year, beta attenuation instruments were moved from two of the wood smoke sites to two industrial sites and TEOM instruments were placed at those two wood smoke sites. A TEOM was also installed at Marysville and in the Poulsbo station that began operation in late August. Each beta attenuation and each TEOM instrument is collocated with one or more manual, reference method instrument(s) to enable data comparison. The Marysville station features collocation of both a beta attenuation instrument and TEOM along with the reference method.

The dichotomous sampler is one of the manual samplers designated as a *reference method* for the measurement of PM_{10}. This sampler is different from the more commonly used high volume sampler in that it further separates the PM_{10} at a particle diameter of 2.5 micrometers. The dichotomous sampler collects the small size particulates known as $PM_{2.5}$ on one filter and the coarse fraction containing particulates of size 2.5 to 10 micrometers on another filter. The Agency has collocated

dichotomous samplers with other particulate matter sampling at the Duwamish and Tacoma port industrial sites and also at the Kent station.

The integrating nephelometer continuously measures the light scattering extinction coefficient. A component of the scattering coefficient due to dry particles, (b_{sp}), generally shows good correlation to PM_{10} values and to visibility. The b_{sp} values are reported as a scattering coefficient per meter times 10^{-4}. Operating a nephelometer at a site concurrent with a reference method enables development of a relationship between the two methods for that site.

Summary of Data

During 1993, PM_{10} data in the Puget Sound Region was measured at fifteen locations, but seven of these sites were equipped only with a single manual reference method sampler. PM_{10} sampling usually occurred each sixth day at these seven locations for a total of about sixty PM_{10} values during the year at each of those sites.

Continuous PM_{10} data was obtained at eight locations that were equipped with additional reference method samplers and/or equivalent method monitors. Two of these continuous sites are industrial locations and six of the sites are primarily wood smoke monitoring locations. The industrial locations have operated since the PM_{10} standard was adopted and the wood smoke area monitoring began more recently.

Since adoption of the PM_{10} standard in 1987, none of the annual PM_{10} values have exceeded the annual PM_{10} standard. This means the Puget Sound Region is in compliance with the annual PM_{10} standard.

Under the Federal regulation, (40 CFR Part 50, Appendix K), the last three years of data must be used to determine compliance with the 24 hour average PM_{10} standard. This regulation 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; the location is out of compliance with the 24 hour average PM_{10} standard.

The 24 hour average PM_{10} standard has been met everywhere in the Puget Sound Region for the last five calendar years. A single daily value at a Tacoma port area station during 1990 exceeded the level of the 150 $\mu g/m^3$ daily standard, but this was not a violation of the standard because measurements occur each day at this site and none of the other values exceeded the level of the standard. With respect to the daily (24 hour average) PM_{10} standard, the last three years of data establish the Region is in compliance with this standard.

Charts on the following pages summarize PM_{10} data beginning in the first year following the PM_{10} standard adoption. Column graphs for the seven stations with continuous data present a PM_{10} history starting either in 1988 or with the beginning of data at each site. The new site in Poulsbo is not included in these charts since it operated only for the last four months of 1993.

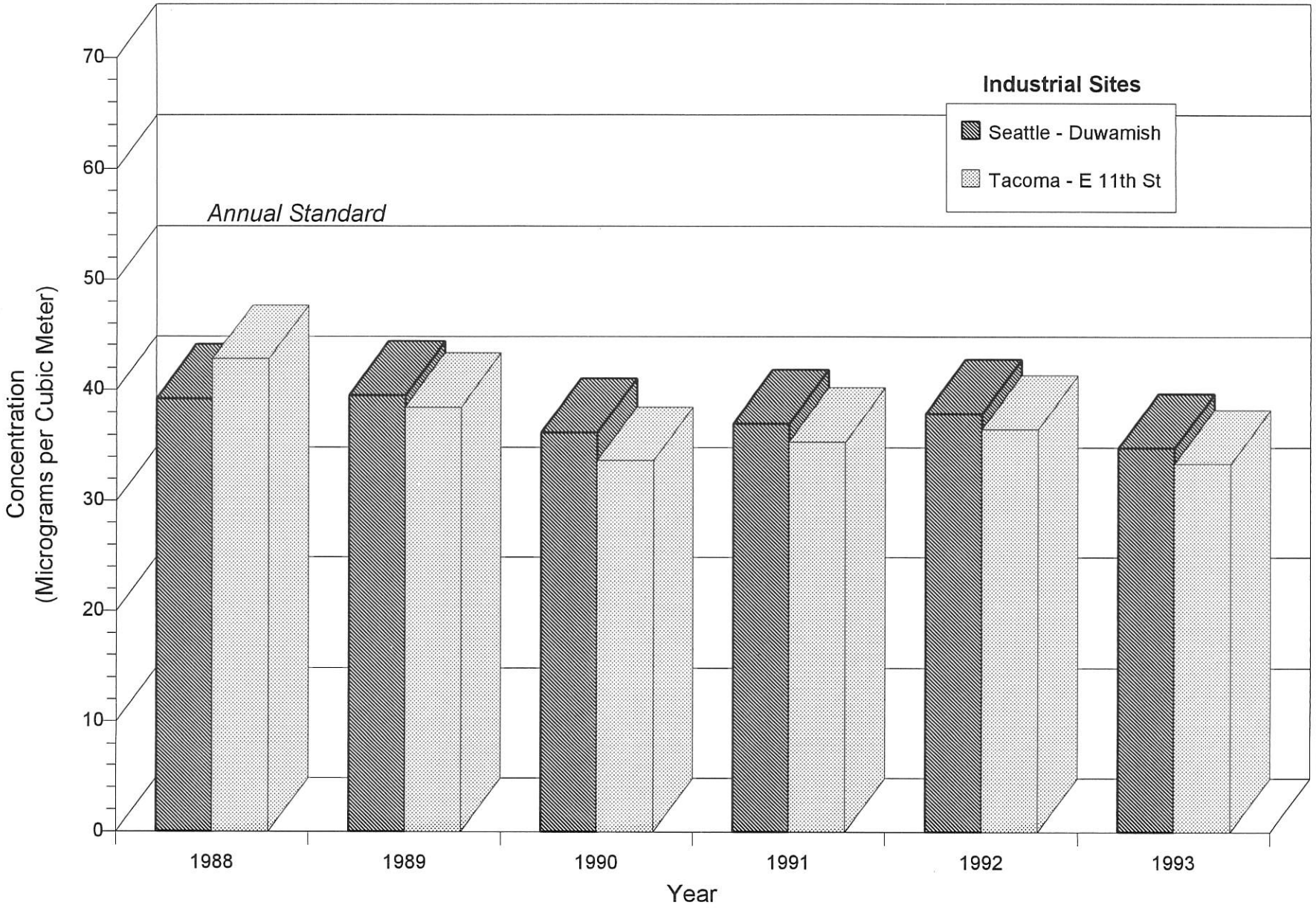
Separate charts for industrial sites and wood smoke sites show the annual arithmetic averages and maximum daily values. These charts show compliance with both the annual and 24 hour average PM_{10} standards for both types of monitoring locations. One can see the PM_{10} levels in the industrial areas have been and continue to be higher than those in the wood smoke areas.

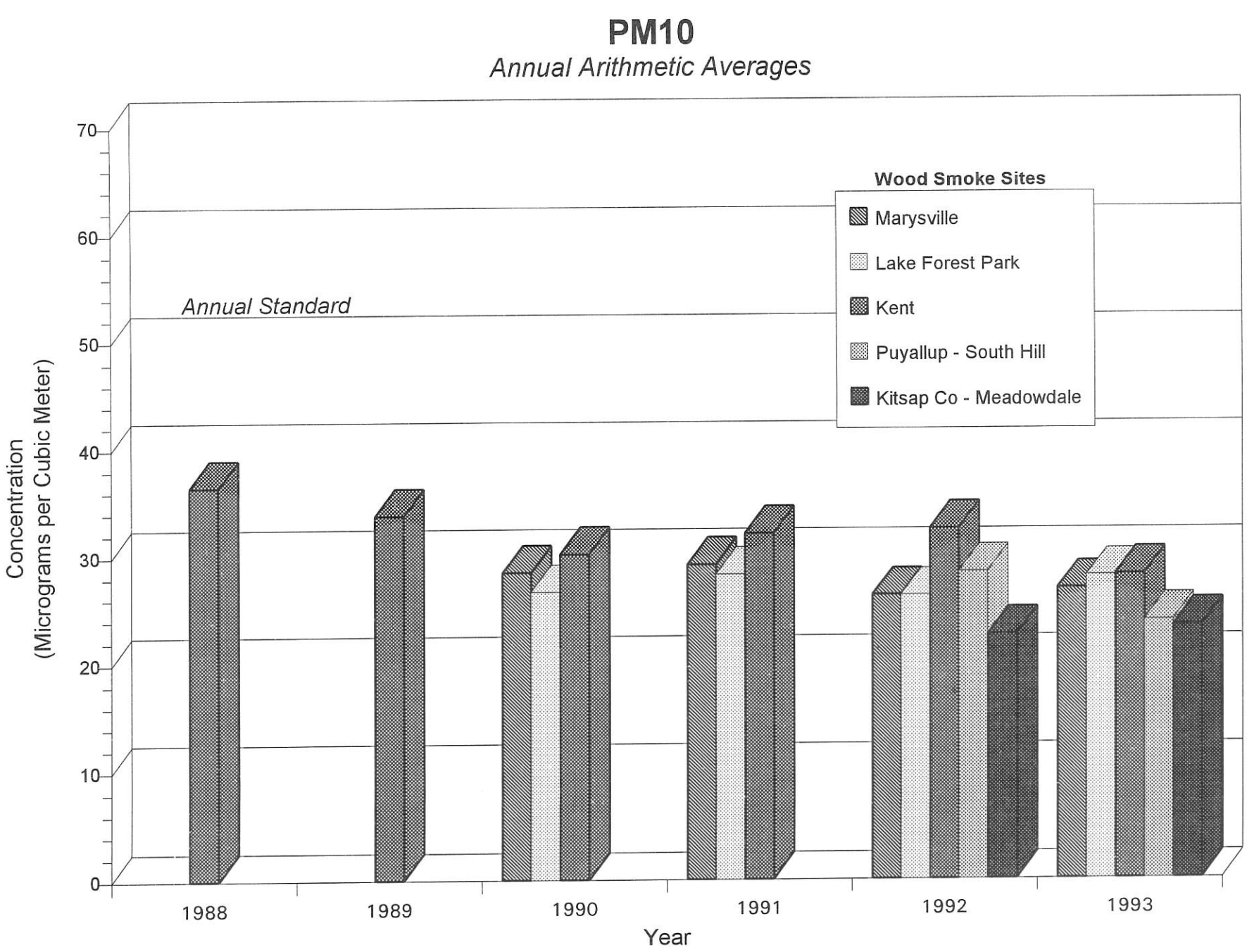
An additional set of charts shows the number of days when each of these stations exceeded the 75 $\mu g/m^3$ "impaired air quality" trigger level established in Washington State law. During the heating season beginning the last part of October and continuing into March, certain indoor burning in fireplaces and wood stoves is prohibited upon formal declaration that a period of "impaired air quality" is in effect.

Tables following the charts summarize for each station the 1993 PM_{10} data from both reference and equivalent methods, $PM_{2.5}$ data from dichotomous samplers and b_{sp} values from nephelometer measurements.

PM10

Annual Arithmetic Averages

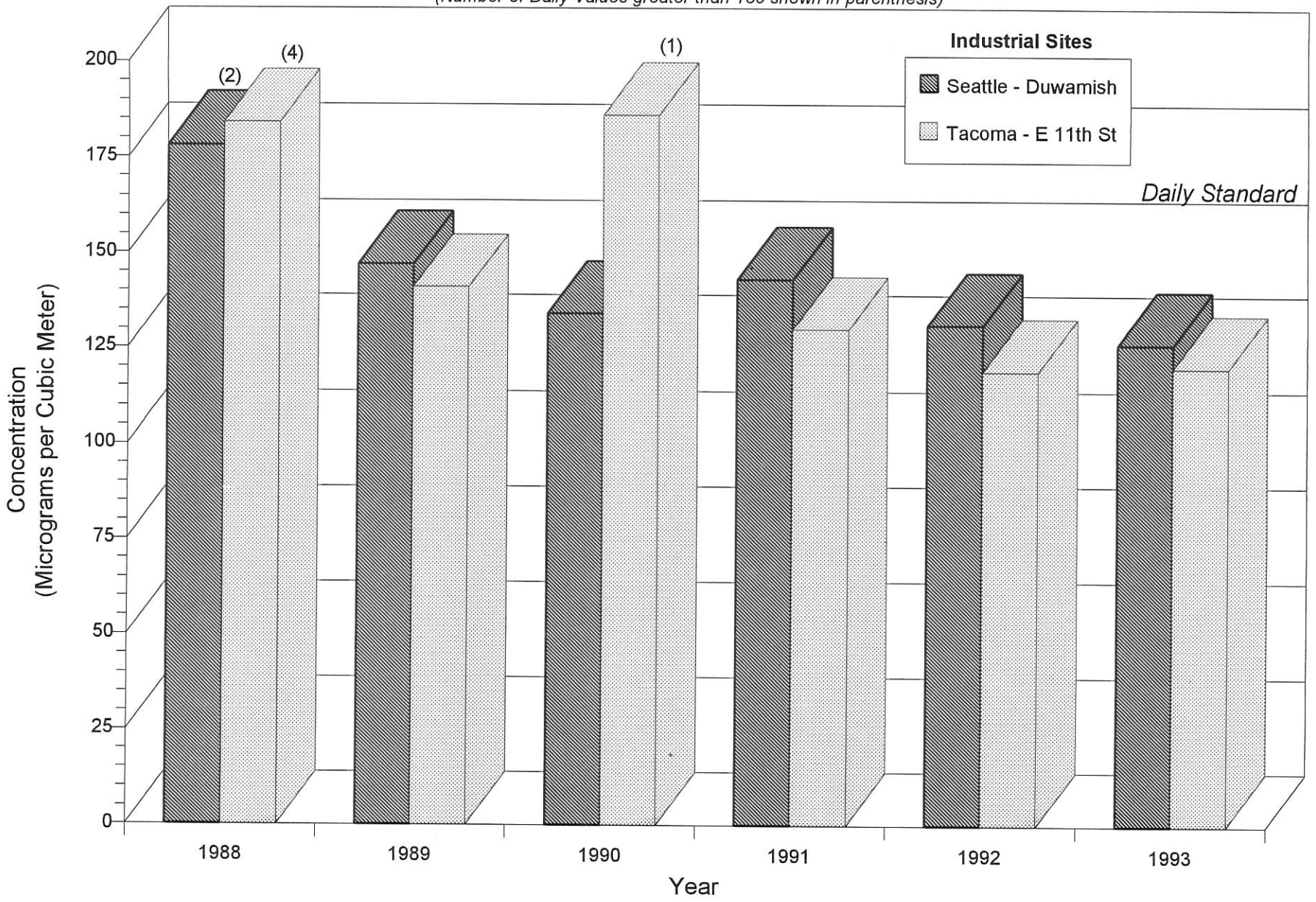


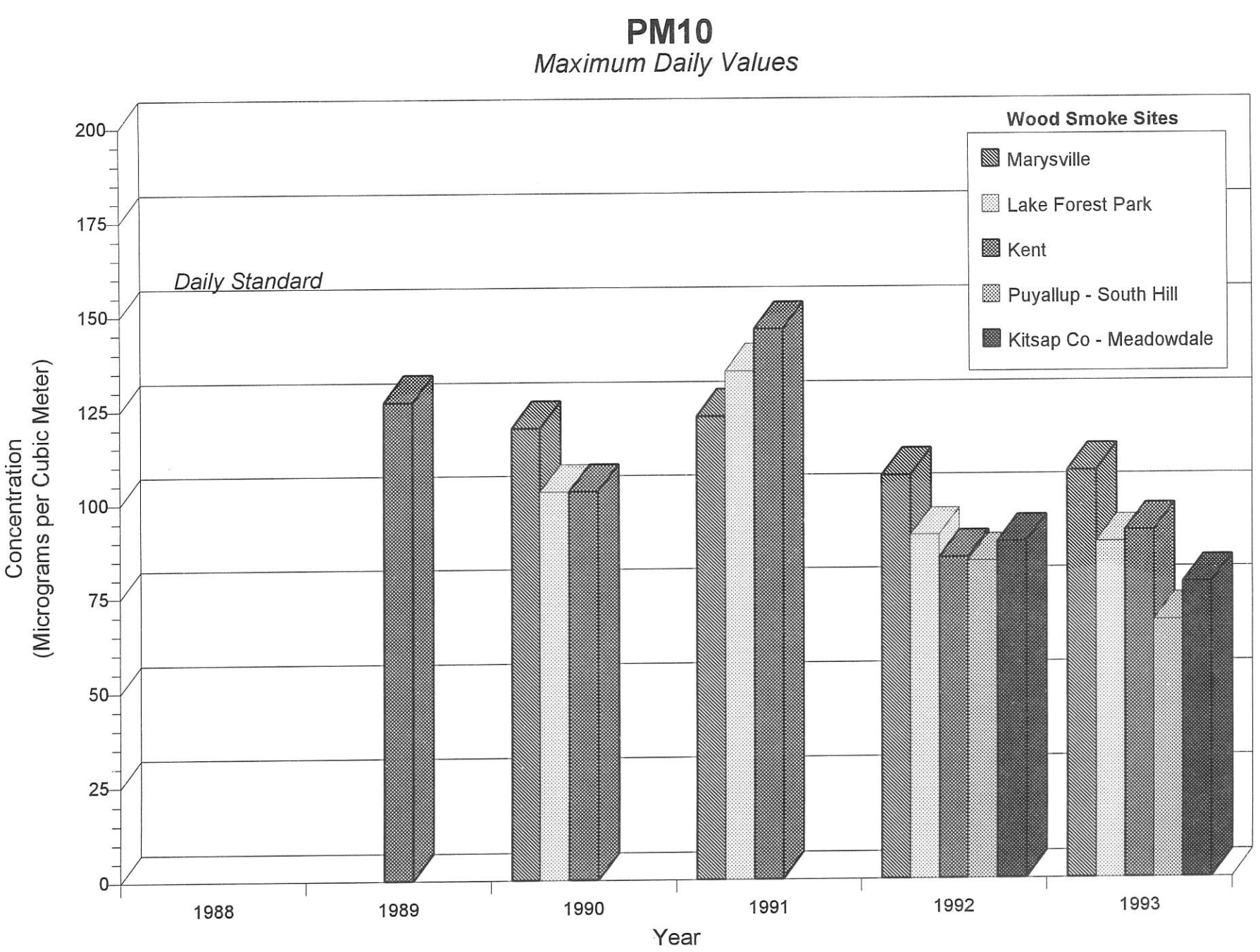

PM10
Annual Arithmetic Averages
Annual Standard
Wood Smoke Sites
Marysville
Lake Forest Park
Kent
Puyallup - South Hill
Kitsap Co - Meadowdale
Concentration
(Micrograms per Cubic Meter)
70
60
50
40
30
20
10
0
1988
1989
1990
1991
1992
1993
Year

PM10

Maximum Daily Values

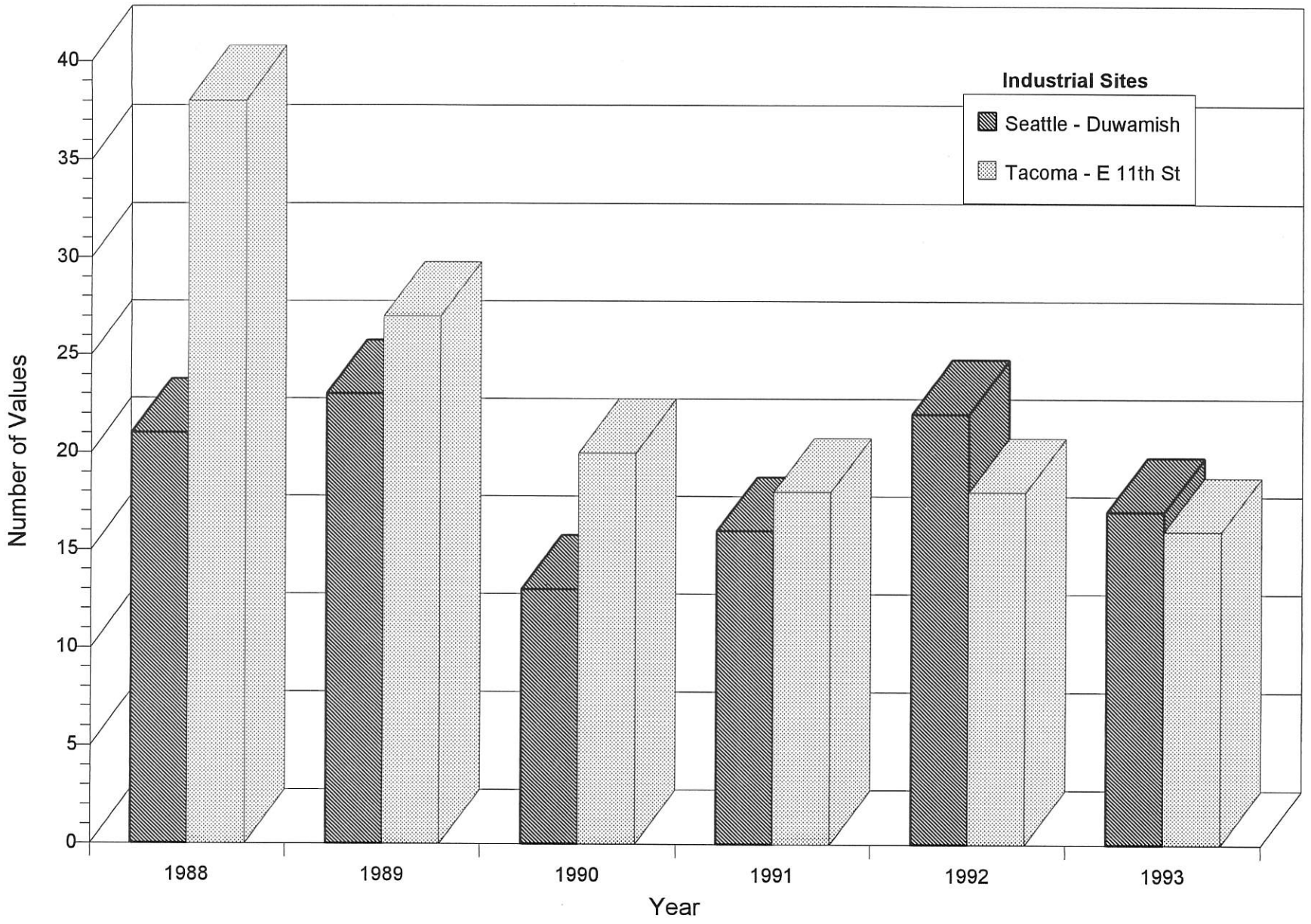
(Number of Daily Values greater than 150 shown in parenthesis)




PM10
Maximum Daily Values
Wood Smoke Sites
Marysville
Lake Forest Park
Kent
Puyallup - South Hill
Kitsap Co - Meadowdale
Daily Standard
Concentration
(Micrograms per Cubic Meter)
200
175
150
125
100
75
50
25
0
1988
1989
1990
1991
1992
1993
Year

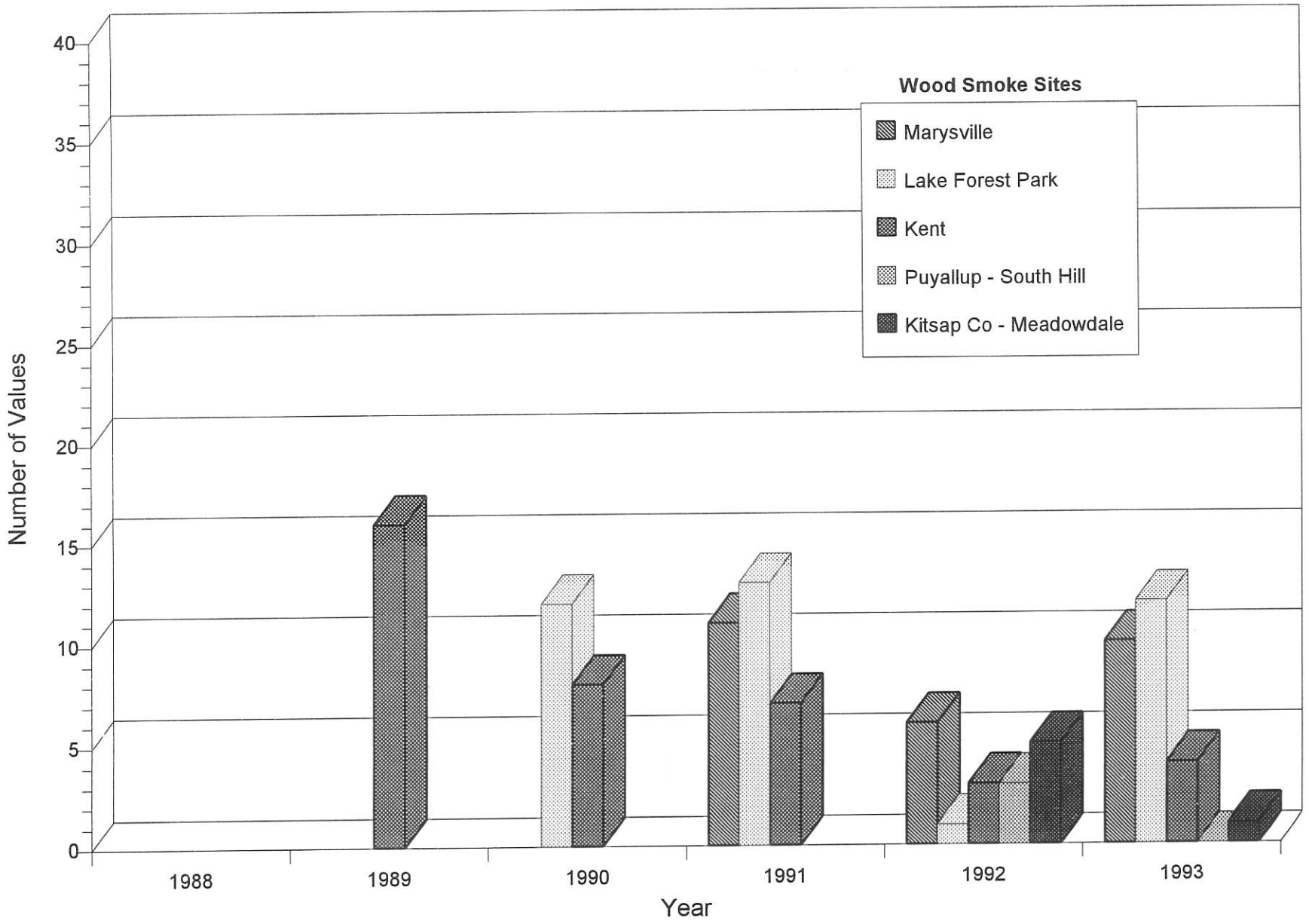
PM10

Number of Daily Values Greater than or Equal to 75 micrograms per cubic meter



PM10

Number of Daily Values Greater than or Equal to 75 micrograms per cubic meter



PARTICULATE MATTER (PM10)

Micrograms per Standard Cubic Meter

Sampling Method: Reference - Hi Vol ANDERSEN/GMW 1200 Quartz Fiber filters

1993

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean
		1st	2nd	3rd	4th	
Marysville JHS, 1605 7th St, Marysville, Wa	123	43.2	13.4	21.2	29.9	26.9
Hoyt Ave & 26th St, Everett, Wa	59	32.8	16.3	22.2	21.9	23.3
504 Bellevue Way NE, Bellevue, Wa	61	23.8	13.8	19.3	22.4	19.8
17711 Ballinger Way NE, Lake Forest Park, Wa	297	42.8	14.1	18.6	36.8	28.1
Harbor Island, 3400 13th Ave SW, Seattle, Wa	53	38.9	22.9	31.0		30.9
Duwamish, 4752 E Marginal Way S, Seattle, Wa	351	47.4	22.1	29.9	39.7	34.8
South Park, 723 S Concord St, Seattle, Wa	61	33.9	15.5	24.4	32.5	26.6
James St & Central Ave, Kent, Wa	302	32.0	17.5	26.5	36.7	28.2
South Hill, 9616 128th St E, Puyallup, Wa	60	35.9	11.8	17.9	30.1	23.9
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	61	31.1	15.4	27.8	31.3	26.4
2340 Taylor Way, Tacoma, Wa	61	37.9	17.9	27.3	37.1	30.1
2301 Alexander Ave, Tacoma, Wa	147	37.9	16.6	25.4	36.6	29.1
Fire Station #12, 2316 E 11th St, Tacoma, Wa	350	45.9	20.1	27.1	40.5	33.4
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	61	29.5	12.7	18.9	32.3	23.4
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa	21				23.5	

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	Jan 1 Fri	Jan 11 Mon	Jan 12 Tue	Jan 16 Sat	Jan 31 Sun	Feb 1 Mon	Feb 5 Fri	Feb 12 Fri	Feb 24 Wed	Sep 10 Fri	Nov 9 Tue	Dec 24 Fri	Dec 25 Sat	Dec 27 Mon	Dec 28 Tue
Marysville JHS, 1605 7th St, Marysville, Wa	96	-	-	97		-	-					-	-		-
Hoyt Ave & 26th St, Everett, Wa		-	-	-		-	-	72	49			-	-		-
504 Bellevue Way NE, Bellevue, Wa		-	-	-		-	-				46	-	-	47	-
17711 Ballinger Way NE, Lake Forest Park, Wa												89	87		
Harbor Island, 3400 13th Ave SW, Seattle, Wa		-	-	-		-	-	66			-	-	-	93	-
Duwamish, 4752 E Marginal Way S, Seattle, Wa		126	119												
South Park, 723 S Concord St, Seattle, Wa		-	-	-		-	-				71	-	-	81	-
James St & Central Ave, Kent, Wa														92	84
South Hill, 9616 128th St E, Puyallup, Wa		-	-	-	68	-	-					-	-	61	-
27th St NE & 54th Ave NE, Northeast Tacoma, Wa		-	-	-		-	-			65	72	-	-		-
2340 Taylor Way, Tacoma, Wa		-	-	-		-	-				81	-	-	75	-
2301 Alexander Ave, Tacoma, Wa	-	-			-	-	-	-	-	-	76	-		-	76
Fire Station #12, 2316 E 11th St, Tacoma, Wa						96	120								
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa		-	-	-	59	-	-					-	-	61	-
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa	-	-	-	-	-	-	-	-	-		35	-	-	40	-

- Indicates no sample on specified day

PARTICULATE MATTER (PM10)

Micrograms per Standard Cubic Meter

Sampling Method: Reference - Hi Vol ANDERSEN/GMW 1200 Quartz Fiber filters

Jan 1- Feb 9, 1993

Summary of Observations Equal To or Greater Than 75

Location	Jan 1 Fri	Jan 2 Sat	Jan 9 Sat	Jan 10 Sun	Jan 11 Mon	Jan 12 Tue	Jan 15 Fri	Jan 16 Sat	Feb 1 Mon	Feb 2 Tue	Feb 3 Wed	Feb 4 Thu	Feb 5 Fri	Feb 6 Sat	Feb 8 Mon
Marysville JHS, 1605 7th St, Marysville, Wa	96	-	-	88	-	-	-	97	-	-		-	-		-
17711 Ballinger Way NE, Lake Forest Park, Wa	81	81	85	-	78										
Harbor Island, 3400 13th Ave SW, Seattle, Wa		-	-	-	-	-	-	-	-	-	-	-	-		-
Duwamish, 4752 E Marginal Way S, Seattle, Wa					126	119	88		98	89	95	115	102		
South Park, 723 S Concord St, Seattle, Wa		-	-	-	-	-	-	-	-	-	-	-	-		-
James St & Central Ave, Kent, Wa				-											
2340 Taylor Way, Tacoma, Wa		-	-	-	-	-	-	-	-	-	-	-	-		-
2301 Alexander Ave, Tacoma, Wa	-			-	-		-		-		-		-		-
Fire Station #12, 2316 E 11th St, Tacoma, Wa					83	85	79		96	79	95	85	120	80	93

- Indicates no sample on specified day

Feb 9- Dec 31, 1993

Summary of Observations Equal To or Greater Than 75

Location	Feb 10 Wed	Feb 12 Fri	Feb 25 Thu	Feb 26 Fri	Feb 27 Sat	Oct 27 Wed	Nov 9 Tue	Nov 26 Fri	Dec 20 Mon	Dec 22 Wed	Dec 24 Fri	Dec 25 Sat	Dec 27 Mon	Dec 28 Tue
Marysville JHS, 1605 7th St, Marysville, Wa	-		-	-	76	-		-	-		-	-		-
17711 Ballinger Way NE, Lake Forest Park, Wa										79	89	87	76	
Harbor Island, 3400 13th Ave SW, Seattle, Wa	-		-	-	-	-	-	-	-	-	-	-	93	-
Duwamish, 4752 E Marginal Way S, Seattle, Wa	75		84	87		83	76		76				91	102
South Park, 723 S Concord St, Seattle, Wa	-		-	-	-	-		-	-	-	-	-	81	-
James St & Central Ave, Kent, Wa							76						92	84
2340 Taylor Way, Tacoma, Wa	-		-	-	-	-	81	-	-	-	-	-	75	-
2301 Alexander Ave, Tacoma, Wa	-	-		-		-	76	-	-	-	-		-	76
Fire Station #12, 2316 E 11th St, Tacoma, Wa		79					84	84					84	83

- Indicates no sample on specified day

PARTICULATE MATTER (PM_{10})

Micrograms per Standard Cubic Meter

Sampling Method: Equivalent - BetaAtten ANDERSEN FH62I-N Glass Fiber strip

1993

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean
		1st	2nd	3rd	4th	
Marysville JHS, 1605 7th St, Marysville, Wa	338	48.3	18.2	22.7	31.3	30.1
17711 Ballinger Way NE, Lake Forest Park, Wa	365	42.2	16.6	21.5	39.7	30.0
Duwamish, 4752 E Marginal Way S, Seattle, Wa	188			37.6	43.1	
James St & Central Ave, Kent, Wa	363	33.5	20.4	30.2	37.9	30.5
South Hill, 9616 128th St E, Puyallup, Wa	163	35.9	16.4			
Fire Station #12, 2316 E 11th St, Tacoma, Wa	204			35.2	45.3	
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	200	33.6	14.9			

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.

1993

Summary of Maximum and 2nd High Observed Concentrations

Location	Jan 1 Fri	Jan 11 Mon	Jan 17 Sun	Jan 30 Sat	Jan 31 Sun	Feb 4 Thu	Oct 27 Wed	Nov 9 Tue	Nov 26 Fri	Dec 24 Fri	Dec 25 Sat	Dec 27 Mon	Dec 28 Tue
Marysville JHS, 1605 7th St, Marysville, Wa	98	108	-	-	-					-	-	-	
17711 Ballinger Way NE, Lake Forest Park, Wa										100	94		
Duwamish, 4752 E Marginal Way S, Seattle, Wa	-	-	-	-	-	-	95						92
James St & Central Ave, Kent, Wa												97	91
South Hill, 9616 128th St E, Puyallup, Wa			68		69		-	-	-	-	-	-	-
Fire Station #12, 2316 E 11th St, Tacoma, Wa	-	-	-	-	-	-		102	86				
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa		78		69		69	-	-	-	-	-	-	-

- Indicates no sample on specified day

PARTICULATE MATTER (PM_{10})

Micrograms per Standard Cubic Meter

Sampling Method: Equivalent - BetaAtten ANDERSEN FH62I-N Glass Fiber strip

1993

Summary of Observations Equal To or Greater Than 75
Jan - Oct, 1993

Location	Jan 1 Fri	Jan 9 Sat	Jan 10 Sun	Jan 11 Mon	Jan 12 Tue	Jan 15 Fri	Feb 1 Mon	Feb 12 Fri	Feb 25 Thu	Feb 26 Fri	Feb 27 Sat	Sep 7 Tue	Sep 9 Thu	Sep 10 Fri	Oct 27 Wed
Marysville JHS, 1605 7th St, Marysville, Wa	98	83	89	108	81	-	89	80	81	77	76				
17711 Ballinger Way NE, Lake Forest Park, Wa	75	77	83	77		75									
Duwamish, 4752 E Marginal Way S, Seattle, Wa	-	-	-	-	-	-	-	-	-	-	-	89	77	77	95
James St & Central Ave, Kent, Wa															
Fire Station #12, 2316 E 11th St, Tacoma, Wa	-	-	-	-	-	-	-	-	-	-	-			75	83
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa				78								-	-	-	-

- Indicates no sample on specified day

Summary of Observations Equal To or Greater Than 75
Nov - Dec 1993

Location	Nov 9 Tue	Nov 12 Fri	Nov 24 Wed	Nov 25 Thu	Nov 26 Fri	Dec 6 Mon	Dec 17 Fri	Dec 19 Sun	Dec 22 Wed	Dec 23 Thu	Dec 24 Fri	Dec 25 Sat	Dec 26 Sun	Dec 27 Mon	Dec 28 Tue
Marysville JHS, 1605 7th St, Marysville, Wa								75			-	-	-	-	
17711 Ballinger Way NE, Lake Forest Park, Wa			80	80					82	85	100	94	76	83	
Duwamish, 4752 E Marginal Way S, Seattle, Wa	84								75					90	92
James St & Central Ave, Kent, Wa	78												85	97	91
Fire Station #12, 2316 E 11th St, Tacoma, Wa	102	79	78		86	80	75							83	84
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

- Indicates no sample on specified day

PARTICULATE MATTER (PM10)

Micrograms per Standard Cubic Meter

Sampling Method: Equiv - Mass Transducer R&P TEOM 1400a Tef-coat Glass Fiber

1993

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean
		1st	2nd	3rd	4th	
Marysville JHS, 1605 7th St, Marysville, Wa	141				27.0	
South Hill, 9616 128th St E, Puyallup, Wa	197			17.8	24.6	
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	162			17.7	27.7	
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa	122				20.8	

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	Nov 25 Thu	Dec 6 Mon	Dec 17 Fri	Dec 19 Sun	Dec 22 Wed	Dec 27 Mon	Dec 28 Tue
Marysville JHS, 1605 7th St, Marysville, Wa				66		-	65
South Hill, 9616 128th St E, Puyallup, Wa	65	65					
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	59		70				
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa					44	36	

- Indicates no sample on specified day

PARTICULATE MATTER (PM2.5)

Micrograms per Standard Cubic Meter

Sampling Method: Dichotomous Sampler - SA244E Teflon filters

1993

Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean
		1st	2nd	3rd	4th	
Duwamish, 4752 E Marginal Way S, Seattle, Wa	87	20.7		16.9	25.2	20.9
James St & Central Ave, Kent, Wa	92	19.2		10.3	20.3	16.6
Fire Station #12, 2316 E 11th St, Tacoma, Wa	94	20.5		11.4	21.7	17.9

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	Nov 9 Tue	Dec 27 Mon
Duwamish, 4752 E Marginal Way S, Seattle, Wa	48	74
James St & Central Ave, Kent, Wa	49	54
Fire Station #12, 2316 E 11th St, Tacoma, Wa	57	43

Summary of Observations Equal To or Greater Than 35

Location	Jan 12 Tue	Jan 23 Sat	Feb 13 Sat	Feb 25 Thu	Feb 27 Sat	Oct 28 Thu	Oct 30 Sat	Nov 9 Tue	Nov 27 Sat	Dec 18 Sat	Dec 21 Tue	Dec 27 Mon
Duwamish, 4752 E Marginal Way S, Seattle, Wa	39			36	35		35	48		42		74
James St & Central Ave, Kent, Wa		37	35		39			49				54
Fire Station #12, 2316 E 11th St, Tacoma, Wa						36		57	37		42	43

ATMOSPHERIC PARTICLES

(bsp (X 10 Exp-4)/M)

1993

Location	Monthly Arithmetic Averages												No of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
17711 Ballinger Way NE, Lake Forest Park, Wa	1.15	1.01	.51	.25	.24	.19	.29	.39	.58	.79	1.27	1.30	8408	.65
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.64	.73	.46	.30	.31	.26	.32	.43	.76	.88	.84	1.03	8617	.58
James St & Central Ave, Kent, Wa	.78	.80	.49	.28	.31		.32	.44	.73	.92	1.02	1.26	8512	.64
Fire Station #12, 2316 E 11th St, Tacoma, Wa	.91	1.04	.55	.28	.24	(discontinued)							3785	

1993

Statistical Summary

Location	No. of 1 hour Samples	Frequency Distribution - Percent											1 Hour Max	Arith Mean	Arith Std Dev
		5	10	20	30	40	50	60	70	80	90	95	99			
17711 Ballinger Way NE, Lake Forest Park, Wa	8408	.1	.1	.2	.2	.3	.4	.5	.7	.9	1.5	2.2	3.9	6.64	.65	.76
Duwamish, 4752 E Marginal Way S, Seattle, Wa	8617	.1	.2	.2	.3	.3	.4	.5	.7	.8	1.2	1.7	2.6	3.73	.58	.50
James St & Central Ave, Kent, Wa	8512	.1	.2	.2	.3	.3	.4	.5	.7	1.0	1.5	2.0	3.0	4.47	.64	.61
Fire Station #12, 2316 E 11th St, Tacoma, Wa	3785	.1	.1	.2	.2	.3	.3	.4	.6	.9	1.5	2.0	2.6	3.61	.58	.60

SULFUR DIOXIDE

Sulfur dioxide is a common air pollutant regulated under a national standard. Local sulfur dioxide standards have been in effect since 1968. The national, state and local sulfur dioxide standards are summarized on page 63. 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 Region, 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. Reactions in the air partially convert sulfur dioxide to other sulfur compounds such as sulfuric acid and various sulfate salts. The tables below summarize sulfur dioxide data collected during 1993 and show that the Puget Sound Region continues to comply with all sulfur dioxide standards.

SULFUR DIOXIDE
(Parts per Million)
1993

Monthly and Annual Arithmetic Averages

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	.006	.008	.006	.004	.006	.006	.006	.007	.007	.006	.004	.005	8648	.006
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.012	.012	.010	.010	.008	.006	.005	.010	.013	.009	.009	.009	8319	.009
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.010	.010	.006	.008	.006	.007	.008	.007	.010	.013	.012	.012	8210	.009
2301 Alexander Ave, Tacoma, Wa	.010	.011	.008	.007	.007	.006	.007	.008	.009	.009	.009	.010	8628	.009

Maximum and Second Highest Concentrations for Various Averaging Periods

Location / Continuous Sampling Periods(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	.068	13 Jan	0900	.044	12 Feb	1800	.019	1 Aug	2000
1 Jan-31 Dec	.065	12 Feb	1700	.040	13 Jan	1100	.018	5 Aug	1700
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.069	8 Apr	1400	.053	8 Apr	1400	.029	15 Jan	1700
1 Jan-31 Dec	.060	27 Jan	1200	.048	15 Jan	1000	.022	8 Sep	0800
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.097	28 Oct	0100	.070	10 Oct	2100	.032	11 Oct	1500
1 Jan-31 Dec	.095	10 Sep	0900	.067	7 Sep	0900	.031	2 Feb	1100
2301 Alexander Ave, Tacoma, Wa	.081	27 Dec	1500	.066	27 Dec	1600	.025	6 Feb	0600
1 Jan-31 Dec	.080	13 Sep	1000	.058	13 Sep	1000	.023	2 Feb	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 Region cities, motor vehicles contribute significantly in all cases of high carbon monoxide ambient levels.

The occasions with high ambient levels of carbon monoxide occur mainly during autumn and winter months near congested motor vehicle traffic. Traffic congestion occurs with afternoon commuting and increased shopping during holidays. Stable weather and light wind often exist during periods when levels are high. This weather condition temporarily reduces the means to disperse carbon monoxide that 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. 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 an 8 hour average of 15 ppm and meteorological conditions are such that this concentration can be expected to remain at or above that level for 12 or more hours, or to recur within 24 hours unless control actions are taken. If needed, the Plan includes more severe stages of Warning (30 ppm for an 8 hour average) and Emergency (40 ppm).

Summary of 1993 Data

The table in this section summarizes the six highest 1 hour and 8 hour average carbon monoxide levels at each station during 1993 as obtained from Department of Ecology data summaries. The Federal regulation, (40 CFR Part 50), directs that comparison of the data with the standards (in ppm) be made in terms of integers with fractional parts of 0.5 or greater rounding up. Further, the ambient concentration at a site shall not exceed the level of the standard more than once per year.

For the first time ever in the Puget Sound Region, no station measured carbon monoxide values that exceeded the level of the 8 hour average standard. In fact the highest 8 hour average at any location during 1993 was 7.8 ppm, a level only 87 percent of the standard. The 1 hour standard continues to be easily achieved everywhere.

Multi-Year Summary

Multi-year graphs for carbon monoxide present column charts to show the historical trend. For the longest term sampling sites in the cities of Seattle, Everett, Bellevue and Tacoma, one chart shows the number of days on which the 8 hour average exceeded 9 ppm for each year from 1979 to 1993. A companion chart graphs the value that was the second high 8 hour average for each of those years. If the second high 8 hour average equals or exceeds 9.5 ppm, this violates the standard.

For all cities, the data acquired since 1979 show that carbon monoxide values have improved, though there is some variability from year to year. As documented in previous annual data summaries, the first complete year of carbon monoxide data for the Seattle 5th Avenue and James Street station was 1972. The results at this station have improved from exceeding the primary standard 112 days in 1972 and 130 days in 1973, to zero exceedances during 1987 through 1993. The charts show that for the last three years, 1991 through 1993, the carbon monoxide levels throughout the Puget Sound Region have achieved the standards.

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 regular testing of vehicle emissions to assure compliance with these standards. Since November 1992, the requirement that only oxygenated gasoline be dispensed during the four months from November through February has also reduced carbon monoxide emissions.

CARBON MONOXIDE

(Parts per Million)

1993

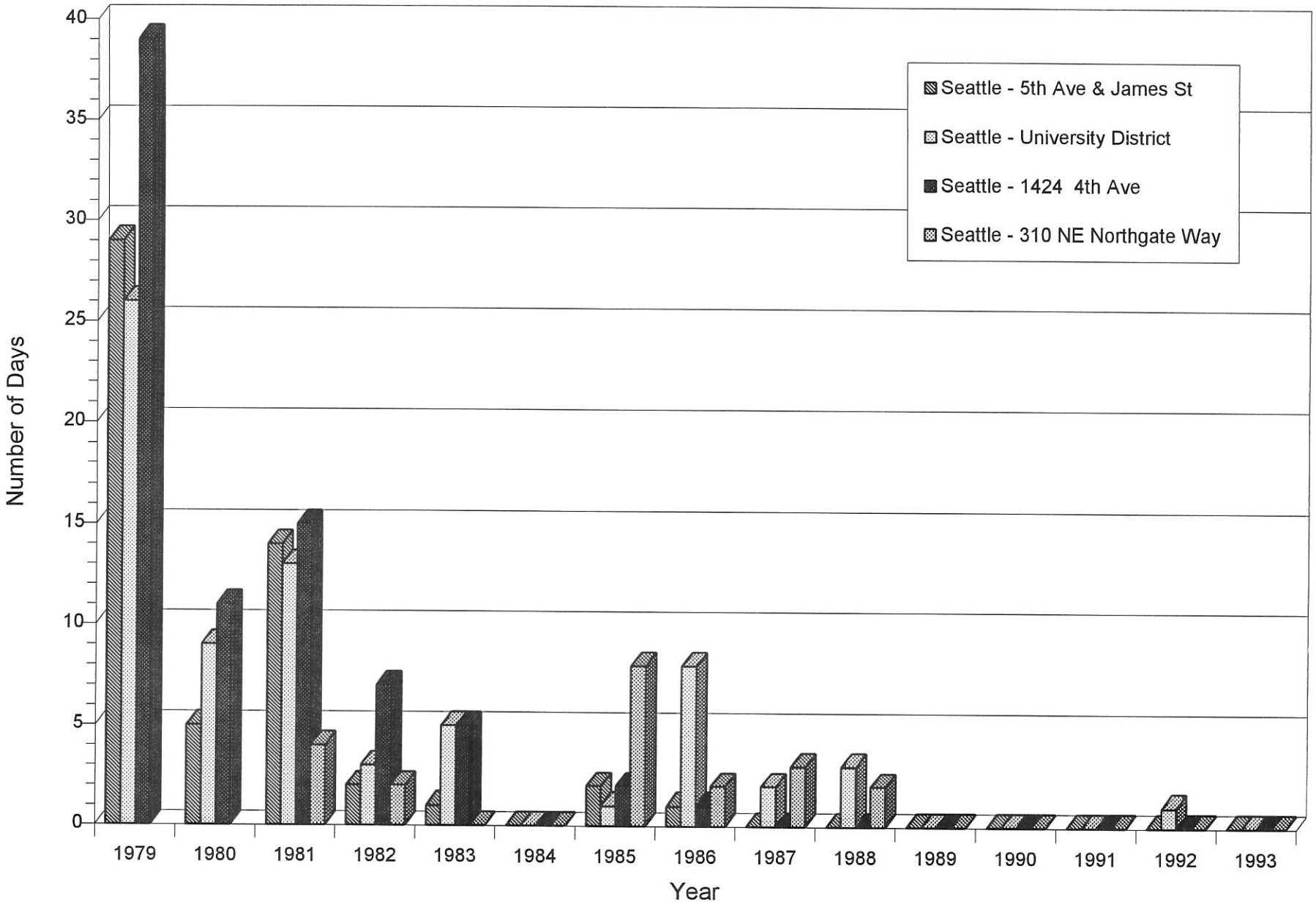
Location / Continuous Sampling Period(s)	Six Highest Concentrations						Number of 8 Hour Averages Exceeding 9 ppm	Number of Days 8 Hour Average Exceeded 9 ppm
	1 Hour Average			8 Hour Average				
	Value	Date	End Time	Value	Date	End Time		
Broadway & Hewitt Ave, Everett, Wa	10.2	12 Jan	0900	6.7	31 Mar	1800	0	0
1 Jan-31 Dec	9.4	14 Apr	1700	6.5	10 May	1700		
	9.1	22 Dec	1900	6.4	10 Sep	1800		
	9.0	12 Jan	0800	6.2	12 Feb	2200		
	9.0	8 Oct	1500	6.1	12 Jan	1300		
	8.9	11 Jan	1800	6.1	3 Sep	1700		
622 Bellevue Way NE, Bellevue, Wa	8.3	12 Jan	0900	5.1	4 Feb	0100	0	0
1 Jan-31 Dec	7.1	12 Jan	1000	4.9	27 Oct	2200		
	7.0	27 Oct	2100	4.9	9 Nov	2300		
	6.8	8 Jan	1900	4.7	22 Dec	2300		
	6.7	3 Feb	2000	4.5	29 Dec	2400		
	6.6	16 Jan	1900	4.4	23 Dec	2200		
Northgate, 310 NE Northgate Way	10.3	4 Feb	0900	6.4	27 Oct	2300	0	0
Seattle, Wa	10.0	18 Jan	0900	5.8	22 Dec	2400		
1 Jan-31 Dec	8.5	3 Feb	0800	5.2	4 Feb	1300		
	8.2	2 Feb	0900	5.1	26 Nov	2100		
	8.0	2 Feb	0800	5.0	18 Jan	1300		
	7.9	18 Jan	1000	4.9	31 Jan	0100		
University Dist, 1307 NE 45th St	15.7	26 May	0800	7.0	27 Oct	2200	0	0
Seattle, Wa	9.6	10 Nov	2300	6.7	31 Jan	0200		
1 Jan-31 Dec	9.3	4 Feb	2200	6.4	10 Oct	2400		
	9.0	30 Jan	2400	6.2	1 Feb	2400		
	8.8	3 Feb	1900	6.2	28 Dec	1800		
	8.5	27 Oct	2100	6.0	29 Dec	2000		
1424 4th Ave, Seattle, Wa	8.2	4 Feb	2100	5.9	5 Feb	0100	0	0
1 Jan-31 Dec	7.6	17 Dec	1800	5.6	22 Dec	2300		
	7.1	22 Dec	1800	5.4	23 Dec	1900		
	6.7	18 Jan	1000	5.1	17 Dec	1900		
	6.7	17 Dec	1900	4.7	4 Feb	1500		
	6.6	8 Jan	1900	4.6	21 Dec	2000		
5th Ave & James St, Seattle, Wa	9.1	4 Feb	2100	5.9	4 Feb	2300	0	0
1 Jan-31 Dec	9.1	3 Mar	1200	5.2	8 Feb	1800		
	8.5	4 Feb	2200	4.9	7 Sep	1700		
	8.0	24 Mar	1000	4.8	9 Nov	2000		
	7.7	30 Jan	2400	4.8	22 Dec	2200		
	7.6	9 Dec	1800	4.8	27 Dec	2300		
1101 Pacific Ave, Tacoma, Wa	10.7	1 Feb	1900	7.8	1 Feb	2400	0	0
1 Jan-31 Dec	10.1	1 Feb	1800	5.9	27 Dec	2300		
	9.5	27 Dec	1800	5.7	21 Dec	2400		
	8.7	24 Feb	2400	5.2	5 Feb	1500		
	8.6	27 Dec	1900	5.2	9 Nov	2100		
	8.3	28 Feb	1800	5.0	5 Feb	2300		

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.

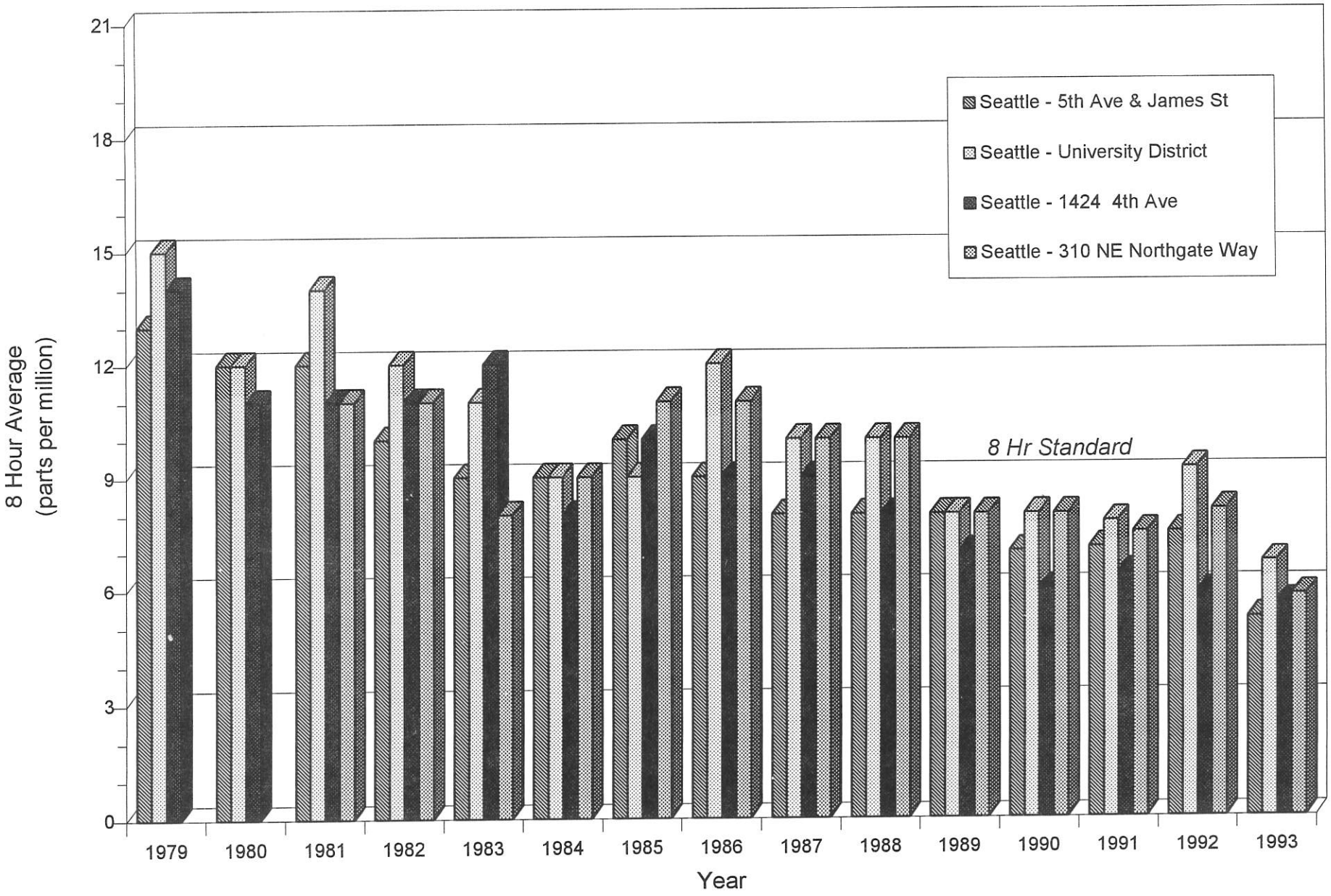
CARBON MONOXIDE

Number of Days 8 Hour Average Exceeded 9 ppm



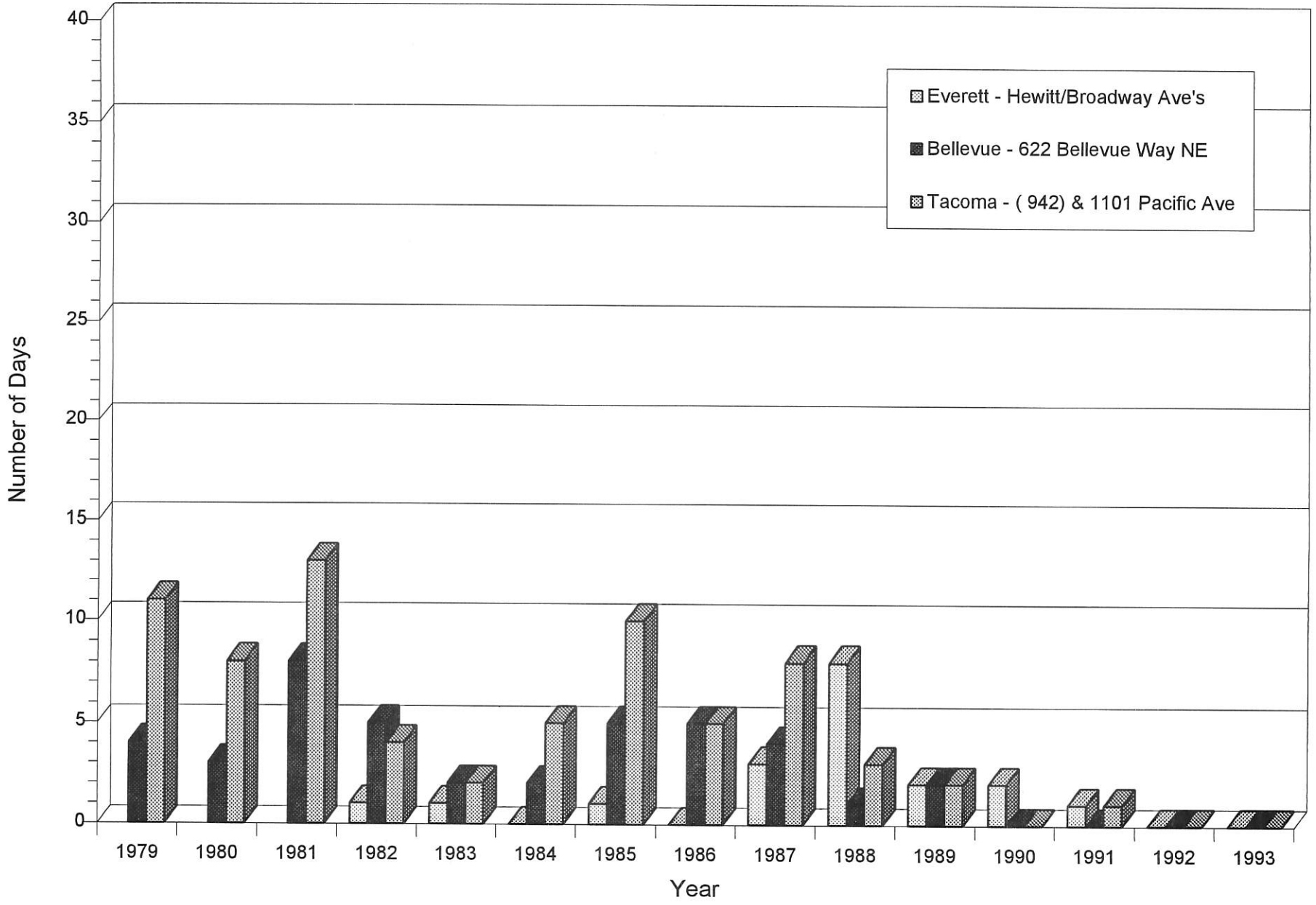
CARBON MONOXIDE

Second High 8 Hour Average



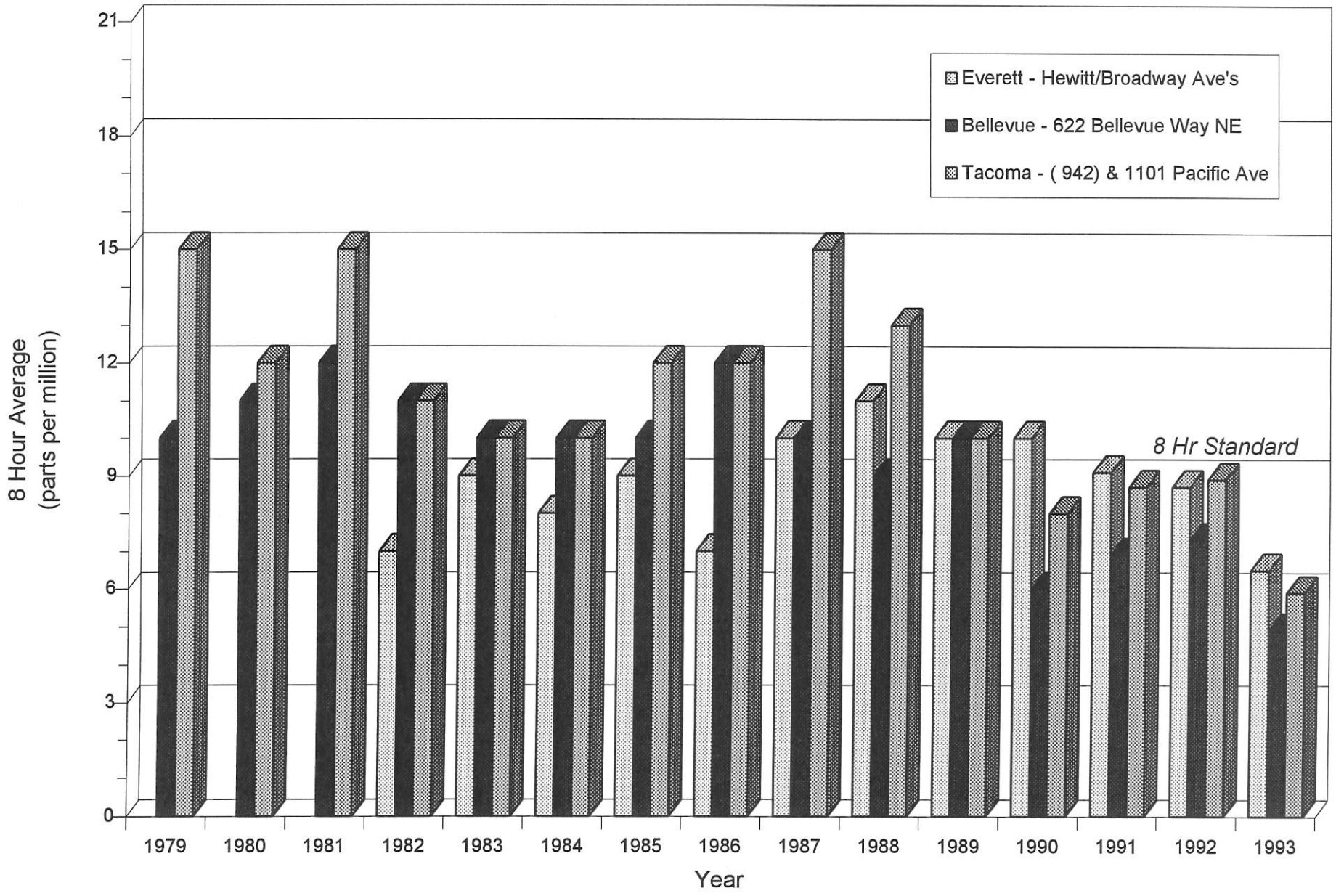
CARBON MONOXIDE

Number of Days 8 Hour Average Exceeded 9 ppm



CARBON MONOXIDE

Second High 8 Hour Average



OZONE

Introduction

The principal oxidant found in photochemical smog is ozone, a very reactive form of oxygen. Most photochemical oxidants result from chemical reactions in the ambient air between nitrogen oxides and volatile organic compounds (VOC) that take place under intense sunlight. 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 continue for several hours and generally produce maximum ozone levels between noon and early evening at locations miles away from the sources of nitrogen oxides and VOC. Each day after nightfall the high ozone levels diminish because the photochemical effect ends.

In the Puget Sound Region the highest ozone levels occur from mid May to mid September on the few hot 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.

The Ozone Standard and Pollutant Standards Index

The U. S. EPA has set the level of the ozone standard at a value of 0.12 ppm. A 1 hour average ozone value of 0.12 ppm is equivalent to 100 on the Pollutant Standards Index scale. According to the Federal regulation (40 CFR Part 50, Appendix H), 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. Compliance is established for a monitoring site by averaging the number of days with an hour average above 0.12 ppm over the past three years to determine if this is less than or equal to one day.

The required ozone monitoring season in Washington state is the period from April 1 through October 31. If any data at a site during this season are missing and there are any days where the maximum hour average exceeds 0.12 ppm, the number of exceedance days must be increased by a fraction using the procedure in Appendix H.

As indicated, the higher ozone levels occur some distance downwind rather than in Everett, Seattle or Tacoma. For 1993, the maximum ozone Index value of 86, described as "moderate" on the Index, occurred August 4 at Enumclaw and at La Grande.

Summary of Data

The 1993 ozone summary table on the following page lists the six highest daily maximum 1 hour averages for each monitoring location. There were no exceedances of the ozone standard at any site for the three years from 1991 through 1993. Therefore, all sites in the Puget Sound Region complied with the ozone standard at the end of 1993.

Graphs of ozone data for the years from 1979 through 1993 show the history. One column chart presents the number of days on which the 1 hour average exceeded 0.12 ppm for each year at the longer term monitoring sites in Snohomish, King and Pierce Counties. This chart shows two or more exceedances for the years 1979, 1981 and 1990. Eight of the other years in this period show zero exceedances. Four years (1985 - 1988) recorded just one exceedance at a site plus, in some cases, an added fraction due to missing data.

A companion chart shows the maximum 1 hour average at these locations. The highest 1 hour average of 0.16 ppm occurred at two sites in 1979 and values reached 0.15 ppm at one site in both 1981 and 1990. These charts suggest that short periods favorable for producing ozone existed during the summers of 1979, 1981 and 1990; during the remaining twelve years the standard was less in jeopardy. There is no clear trend in the numbers; however, there is a risk of exceeding the level of the standard during any summer that experiences record hot temperatures that accelerate and drive the ozone producing photochemical reactions.

OZONE

(Parts per Million)

1993

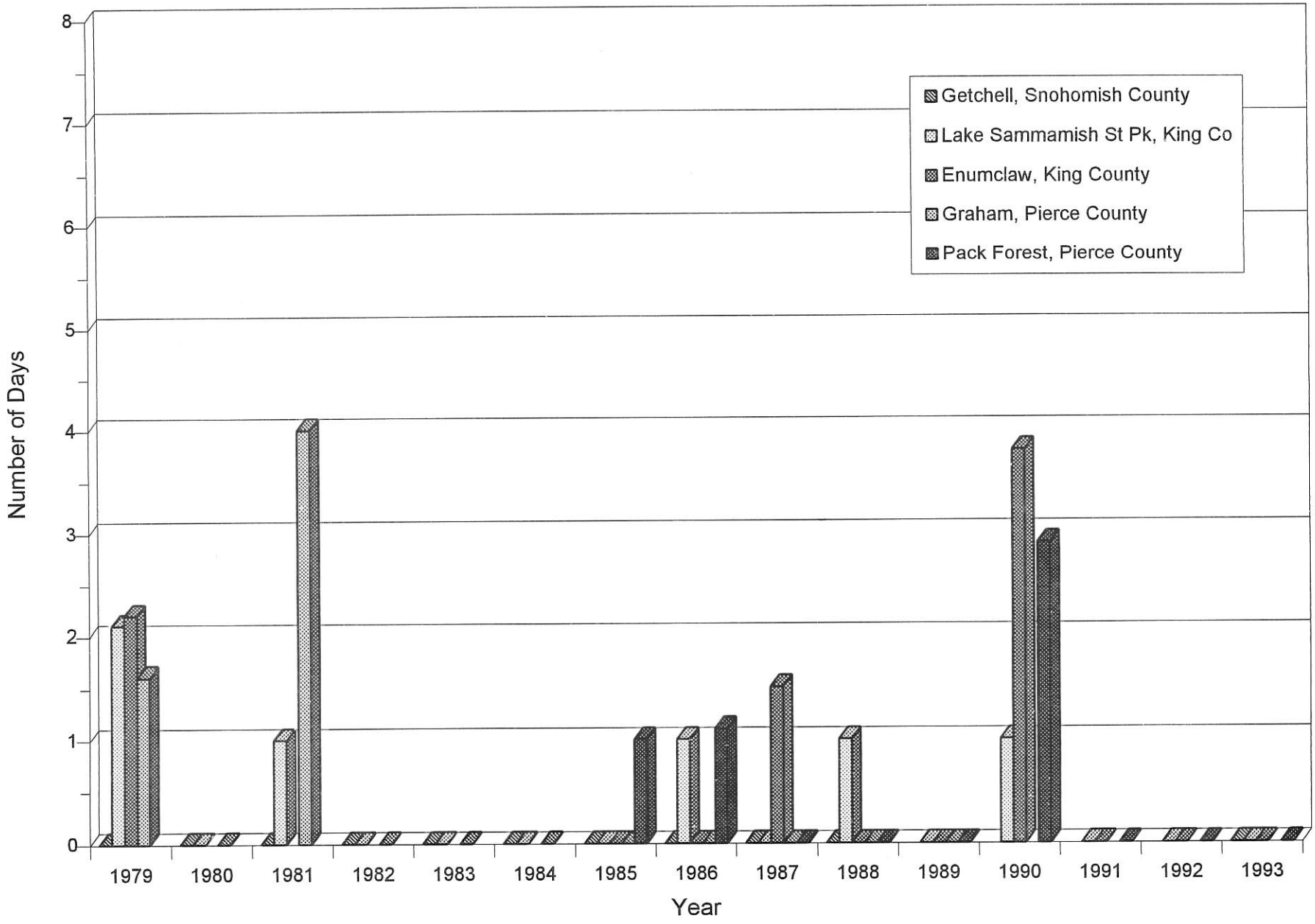
Location / Continuous Sampling Period(s)	Six Highest Daily Maximum 1 Hour Averages			Estimated No. of Days Daily Maximum 1 Hour Average Exceeded .12 ppm			No. of Days Daily Maximum 1 Hour Average Expected to Exceed .12 ppm
	Value	Date	End Time	1991	1992	1993 t	
Fire Station #22, 8426 99th Ave NE Getchell, Wa 29 Apr-31 Oct	.093 .088 .077 .075 .073 .071	10 Sep 5 Aug 3 Sep 4 Aug 17 May 2 Sep	1700 1500 1600 1900 1700 1700			0.0	0.0
20050 SE 56th Lake Sammamish State Park, Wa 1 Apr-31 Oct	.098 .097 .079 .079 .077 .074	4 Aug 5 Aug 8 Sep 9 Sep 3 Sep 3 Aug	1400 1700 1400 1600 1600 1500	0.0	0.0	0.0	0.0
Highway 410 2 miles east of Enumclaw, Wa 1 Apr-31 Oct	.103 .098 .088 .088 .086 .086	4 Aug 5 Aug 3 Aug 7 Sep 2 Aug 3 Sep	1600 1700 1600 1700 1700 1600	0.0	0.0	0.0	0.0
Charles L Pack Forest La Grande, Wa 1 Apr-31 Oct	.103 .100 .098 .087 .083 .082	4 Aug 3 Aug 7 Sep 5 Aug 9 Sep 2 Aug	1700 1600 1700 1800 1700 1700	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.

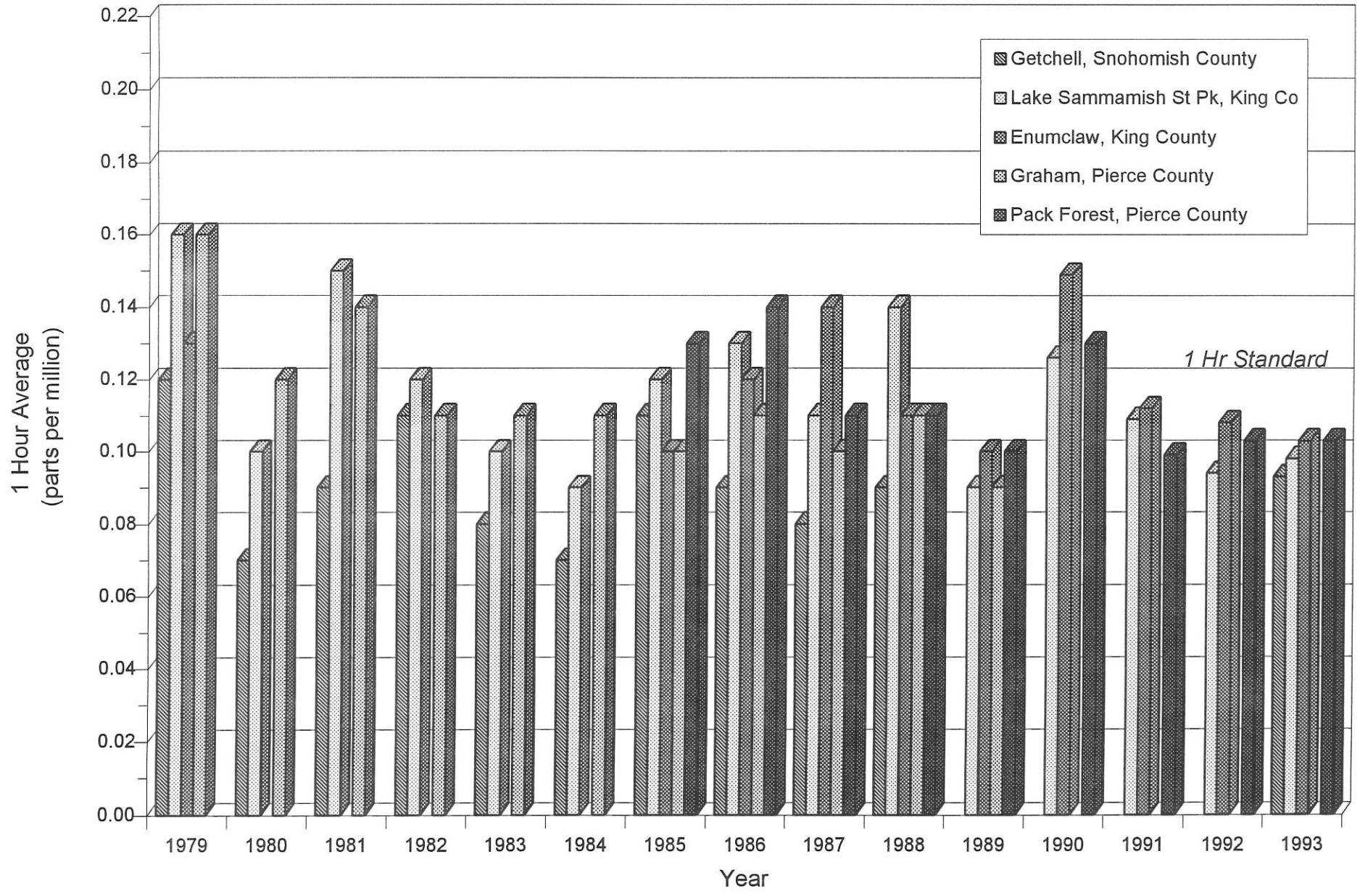
OZONE

Number of Days 1 Hour Average Exceeded 0.12 ppm



OZONE

Maximum 1 Hour Average



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) Agency participation in EPA's national performance audits, and (2) occasional on-site audits of some Agency monitoring equipment by EPA or a designated representative. Each quarter the Department of Ecology also independently performs audits on Agency monitoring equipment at various locations.

Precision and Accuracy Audits

The QA program requirements are established in Title 40, Code of Federal Regulations, Part 58. The important QA characteristics that 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.

At a minimum, 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.

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 parameter.

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 percentage 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 data values during the audit period fall within these limits. As an example, if the average of the percentage differences is zero and the standard deviation of the percentage differences is 4.1 percent, the upper and lower 95 percent probability limits are respectively +8 and -8 percent.

Agency Precision and Accuracy

For most Puget Sound Air Pollution Control 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 monitoring data that the Agency originated in 1993.

For each parameter, the type of audit, (accuracy or precision), is followed by a brief phrase description of the audit process or the actual measurement point that is audited. The number of audits and the lower and upper probability limits (of percentage differences) are presented for each quarter.

Wind sensor audits report the quarterly audit of the direction system for the cardinal points and the speed system at two controlled rates of shaft rotation. The propeller turned by the wind at the specific rate (revolutions per minute) should report the wind speed (miles per hour) as shown.

DATA QUALITY ASSESSMENT
1993

Lower and Upper 95 Percent Probability Limits of Percent Differences

Parameter & Type of Audit	Number of Stations	*Audit Results by Quarter*											
		1st			*2nd*			*3rd*			*4th*		
		Number of Audits	Prob. Limits Lwr (%)	Upr (%)	Number of Audits	Prob. Limits Lwr (%)	Upr (%)	Number of Audits	Prob. Limits Lwr (%)	Upr (%)	Number of Audits	Prob. Limits Lwr (%)	Upr (%)
Particulate Matter (PM10) (Reference Method)	14												
Accuracy													
Flow Rate		93	-5	4	88	-3	3	92	-3	3	97	-1	4
Precision													
Collocated Samples		23	-14	-1	14	-12	3	22	-6	2	24	-11	5
Particulate Matter (PM10) (Equivalent Method)	8												
Accuracy													
Flow Rate		15	-12	2	15	-5	5	22	-2	8	24	-4	3
Sulfur Dioxide	4												
Accuracy													
Level 1		9	-7	10	9	-4	9	14	-1	12	9	-2	11
Level 2		9	-9	9	9	-7	9	14	-4	11	9	-6	8
Level 3		9	-8	10	9	-7	9	14	-3	11	9	-5	8
Level 4		1			3	-1	5	3	-2	8	2	1	5
Precision													
One point check		54	-6	10	55	-4	7	54	-2	9	53	-4	5
Atmospheric Particles (Nephelometer)	6												
Precision													
One point check		69	-4	5	49	-1	3	38	-2	6	42	-3	5
Wind	11												
Direction													
Accuracy													
90 degrees (E)		10	0	0	10	-1	0	10	-1	0	11	-1	0
180 degrees (S)		10	-1	0	10	-1	0	10	-1	0	11	0	0
270 degrees (W)		10	0	0	10	-1	1	10	0	0	11	0	0
360 degrees (N)		10	0	0	10	-1	0	10	0	0	11	0	0
Speed													
Accuracy													
11 mph (1000 rpm)		10	-1	1	10	-1	1	10	-1	1	11	-1	1
32.9 mph (3000 rpm)		10	0	0	10	-1	1	10	-1	1	11	0	0

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 burning devices during periods of "impaired air quality" are established by the Washington Clean Air Act and implemented by state and local regulations. Legislative amendments significantly revised these rules effective in mid 1990.

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. During 1993, the Department of Ecology did not declare any stage of an air pollution episode in the Puget Sound Region.

Impaired Air Quality Periods

The Washington Clean Air Act defines two stages of "impaired air quality" in RCW 70.94.473. A *first stage* of "impaired air quality" is reached when PM_{10} is at an ambient level of 75 $\mu g/m^3$ measured on a 24 hour average or when carbon monoxide is at an ambient level of 8 ppm measured on an 8 hour average.

During a first stage of "impaired air quality", any person in a residence or commercial establishment which has an adequate source of heat without burning wood shall not burn wood in any solid fuel burning device except those certified as described in RCW 70.94.473 or a pellet stove either certified or issued an exemption by the U. S. Environmental Protection Agency.

A *second stage* of "impaired air quality" is reached when PM_{10} is at an ambient level of 105 $\mu g/m^3$ measured on a 24 hour average. When a second stage of "impaired air quality" is in effect, any person in a residence or commercial establishment which has an adequate source of heat without burning wood shall not burn wood in any solid fuel burning device.

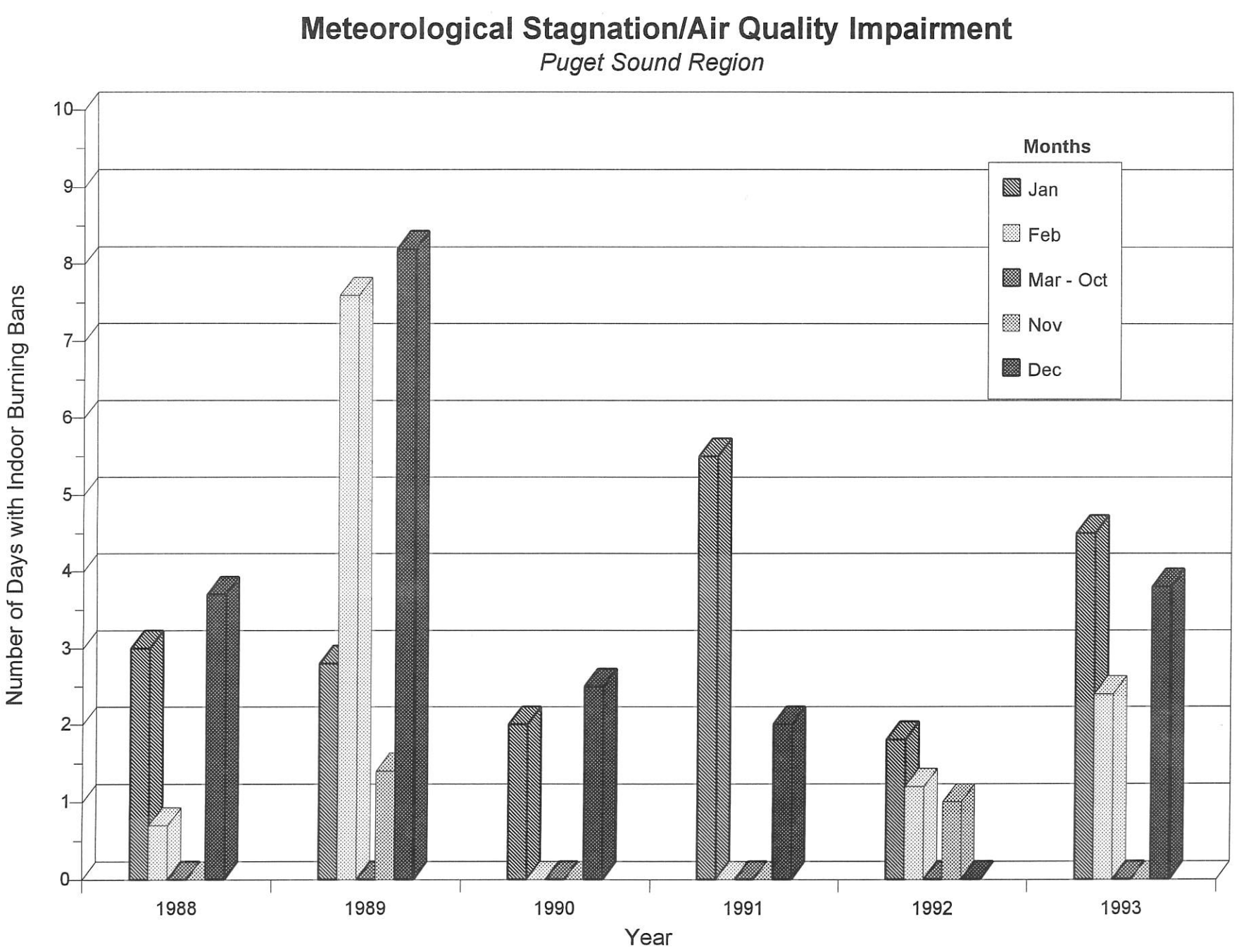
During 1993, "impaired air quality" was in effect in the Puget Sound Region as follows:

Stage	Dates/Counties
1	2:30 pm, Monday, January 11 - 8:30 am, Wednesday, January 13; (King, Pierce, Snohomish & Kitsap)
1	2:30 pm, Friday, January 15 - 7:00 am, Saturday, January 16; (King, Pierce, Snohomish & Kitsap)
1	2:30 pm, Sunday, January 17 - 6:00 am, Tuesday, January 19; (King, Pierce, Snohomish & Kitsap)
1	2:30 pm, Sunday, January 31 - 8:30 am, Wednesday, February 3; (King, Pierce, Snohomish & Kitsap)
	- - -
1	2:30 pm, Monday, December 20 - 2:30 pm, Tuesday, December 21; (King, Pierce & Snohomish)
1	2:30 pm, Sunday, December 26 - 8:30 am, Wednesday, December 29. (King, Pierce & Snohomish)

Along with the restrictions on the use of solid fuel burning devices as outlined above, all outdoor fires are prohibited during any period of "impaired air quality".

Air Quality Impairment Chart

The following graph displays occurrences of air quality impairment beginning in January 1988 when indoor burning restrictions were first applied. The number of days is determined from the total number of hours of prohibited indoor burning divided by 24. Results for January, February, November and December are displayed individually. The March - October category shows that no burn bans have ever occurred during those spring through fall months.


Meteorological Stagnation/Air Quality Impairment
Puget Sound Region
Number of Days with Indoor Burning Bans
0
1
2
3
4
5
6
7
8
9
10
1988
1989
1990
1991
1992
1993
Year
Months
Jan
Feb
Mar - Oct
Nov
Dec

WIND ANALYSIS

Wind Data

Everyone has a qualitative sense of surface wind and some effects produced by the wind. The wind direction helps to locate 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 ambient pollutant concentrations. During a stable, temperature inversion condition, the wind is often light or calm. When this condition persists, the natural process that 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 wind speed at various locations. These average values are sometimes used to compare locations or different months. Air stagnation episodes are not exposed by this analysis unless episode conditions predominate during most of a month.

Wind Roses

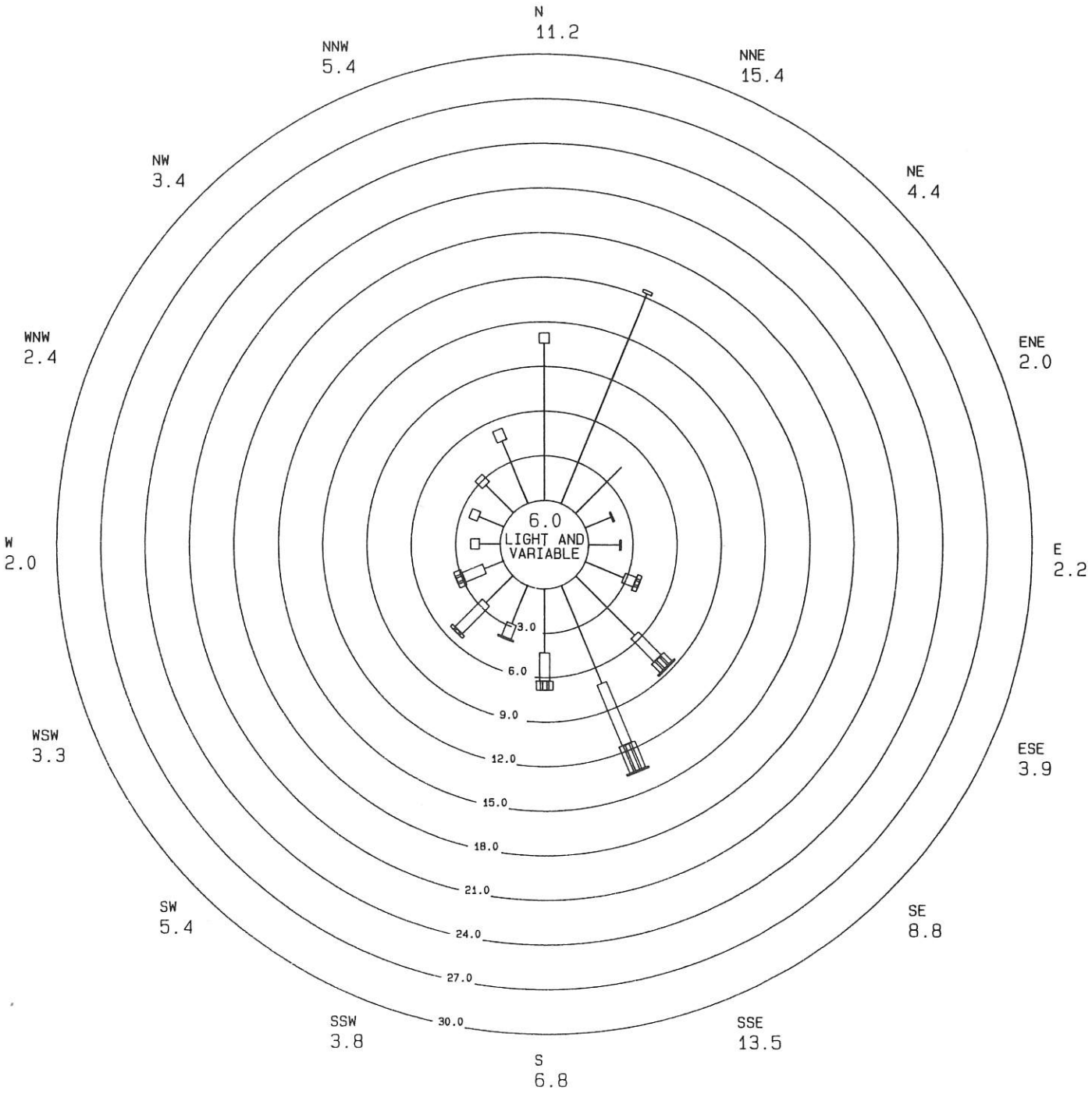
A wind rose is a quantitative graphical summary of the wind direction and speed for a given time. The following wind rose graphs show the number of observations or hours, expressed as a percentage, that had a particular direction and speed during the summary period.

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

For a particular wind direction the length of each segment of a spoke represents the percentage of time the wind speed was within a specific speed interval. If summed for all wind directions, the result would provide the percentage of all hours the wind speed was measured within a particular interval. The percentage of time during which the wind was light and variable shows in the center of the rose.

WIND SPEED
(Miles per Hour)
1993

Location	Monthly Arithmetic Averages												No. of 1 Hour	Year Arith
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Samples	Mean
Marysville JHS, 1605 7th St, Marysville, Wa	3.3	2.6	3.9	4.7	4.0	3.4	3.2	3.0	2.5	2.4	3.0	3.3	8642	3.3
Hoyt Ave & 26th St, Everett, Wa	4.7	4.1	5.0	5.3	4.7	4.6	4.0	3.9	3.8	3.6	5.0	4.8	8749	4.5
17711 Ballinger Way NE, Lake Forest Park, Wa	2.3	2.0	2.9	3.6	3.3	2.5	2.5	2.3	2.1	2.0	2.3	2.0	8746	2.5
Duwamish, 4752 E Marginal Way S, Seattle, Wa	4.8	3.7	4.6	5.3	5.3	4.7	4.4	4.3	3.4	3.3	4.8	3.9	8726	4.4
James St & Central Ave, Kent, Wa	4.1	4.0	4.2	4.1	4.4	4.3	3.7	3.7	2.9	2.6	3.8	3.3	8707	3.8
South Hill, 9616 128th St E, Puyallup, Wa	1.8	1.5	2.3	2.8	2.5	2.7	2.4	2.1	1.6	1.5	2.2	2.7	8697	2.2
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	4.7	4.1	4.1	3.4	3.8	3.3	2.8	3.4	3.2	2.8	3.5	3.2	8715	3.5
2301 Alexander Ave, Tacoma, Wa	5.1	4.3	4.8	5.4	6.1	5.8	5.1	5.3	4.4	3.6	4.7	4.6	8742	4.9
Fire Station #12, 2316 E 11th St, Tacoma, Wa	5.4	4.4	4.9	5.4	5.8	5.8	5.0	5.1	4.2	3.6	4.8	4.5	8742	4.9
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa	2.1	1.6	2.1	2.2	2.3	1.7	1.6	1.8	1.3	1.3	1.7	1.4	8741	1.8
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa										3.5	4.5	4.3	2390	4.0



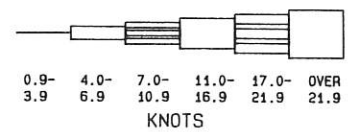
HOUR AVERAGE SURFACE WINDS

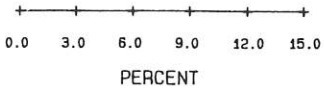
PERCENTAGE FREQUENCY OF OCCURRENCE

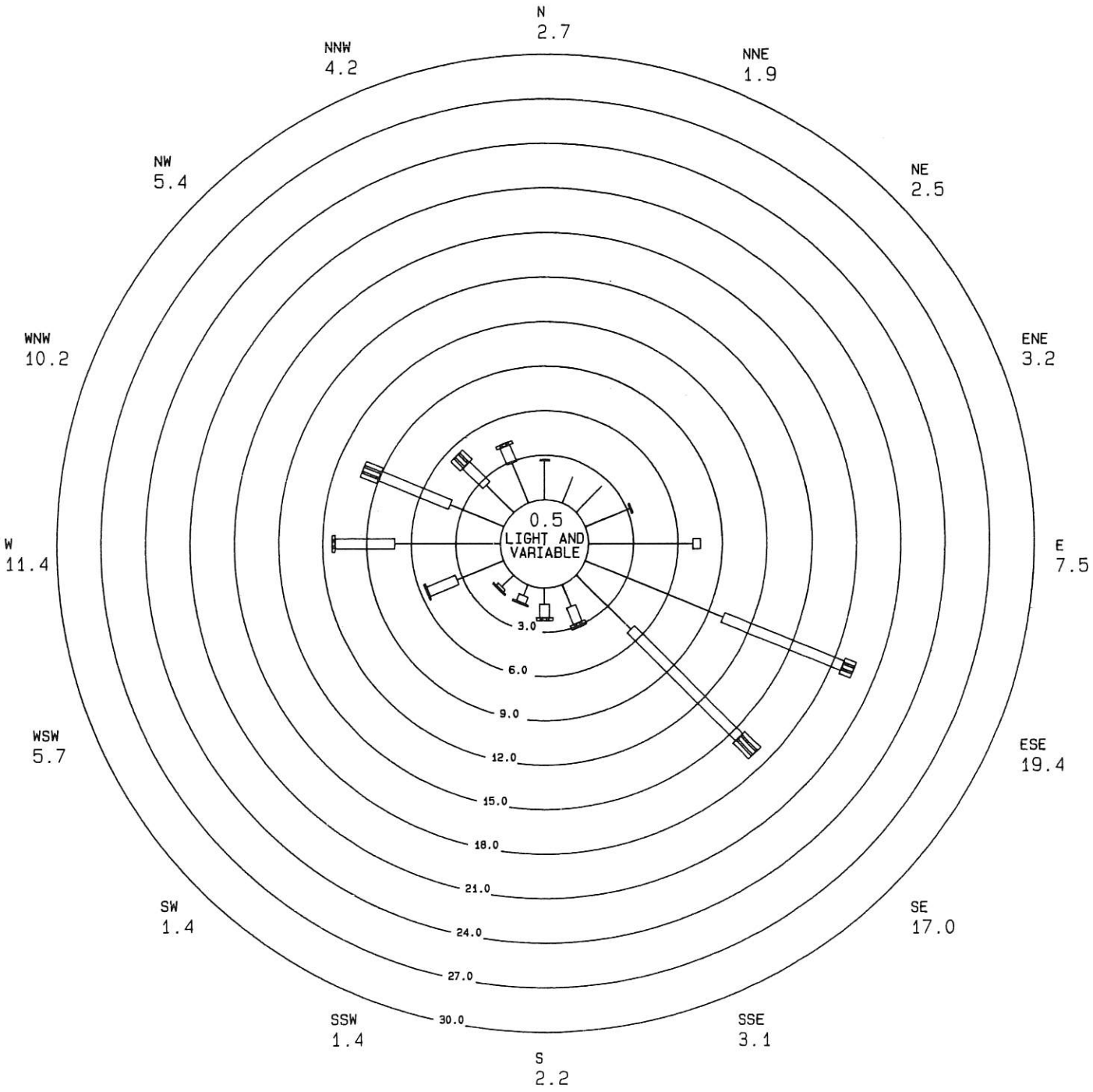
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Marysville JHS, 1605 7th St, Marysville, Wa

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,642







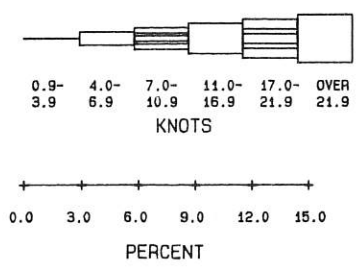
HOUR AVERAGE SURFACE WINDS

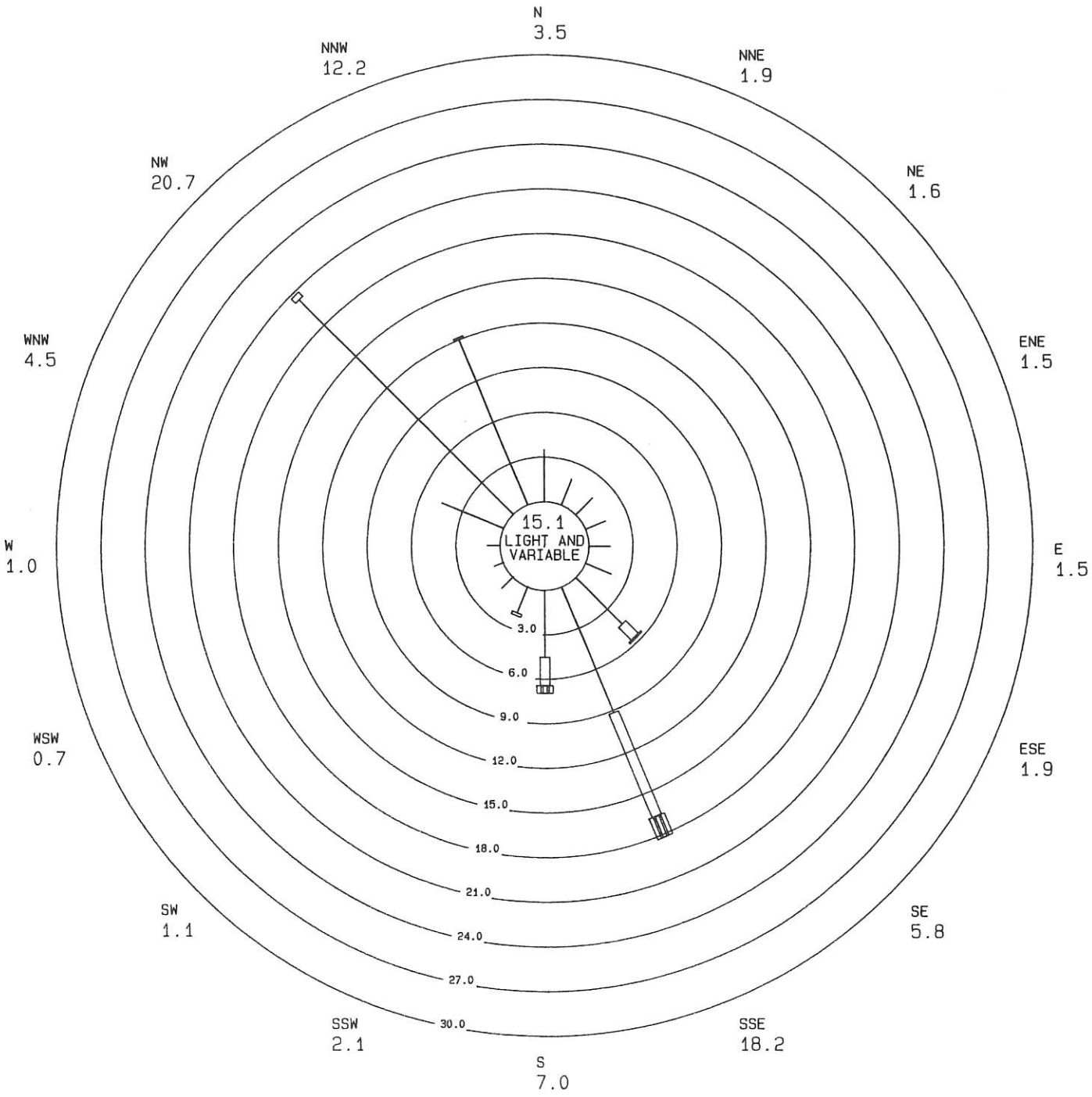
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Hoyt Ave & 26th St, Everett, Wa

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,749





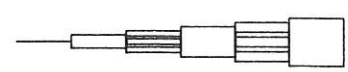
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,746

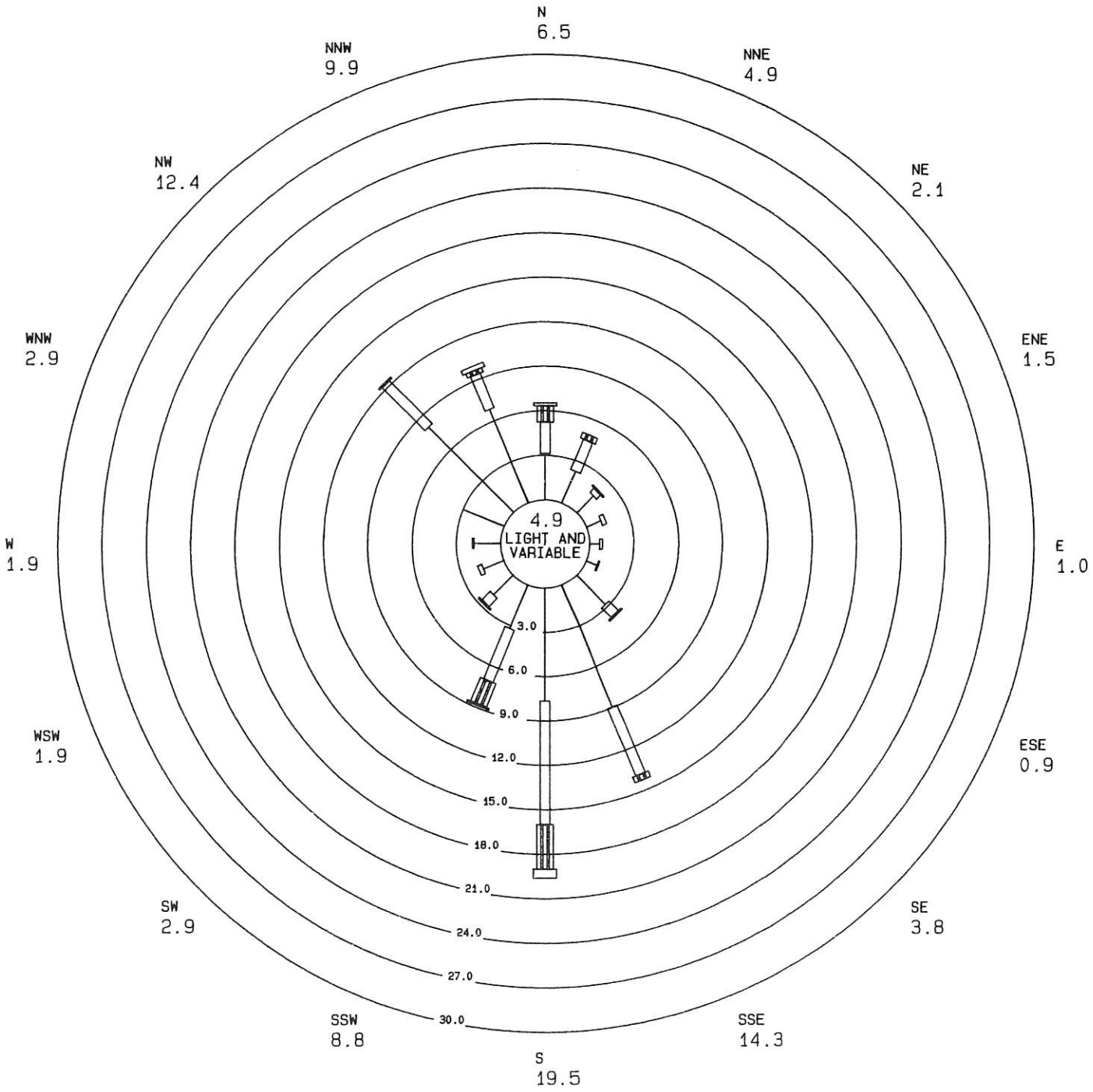


0.9- 3.9	4.0- 6.9	7.0- 10.9	11.0- 16.9	17.0- 21.9	OVER 21.9

KNOTS

0.0 3.0 6.0 9.0 12.0 15.0

PERCENT



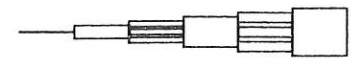
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

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

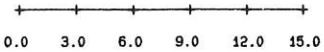
INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8, 389

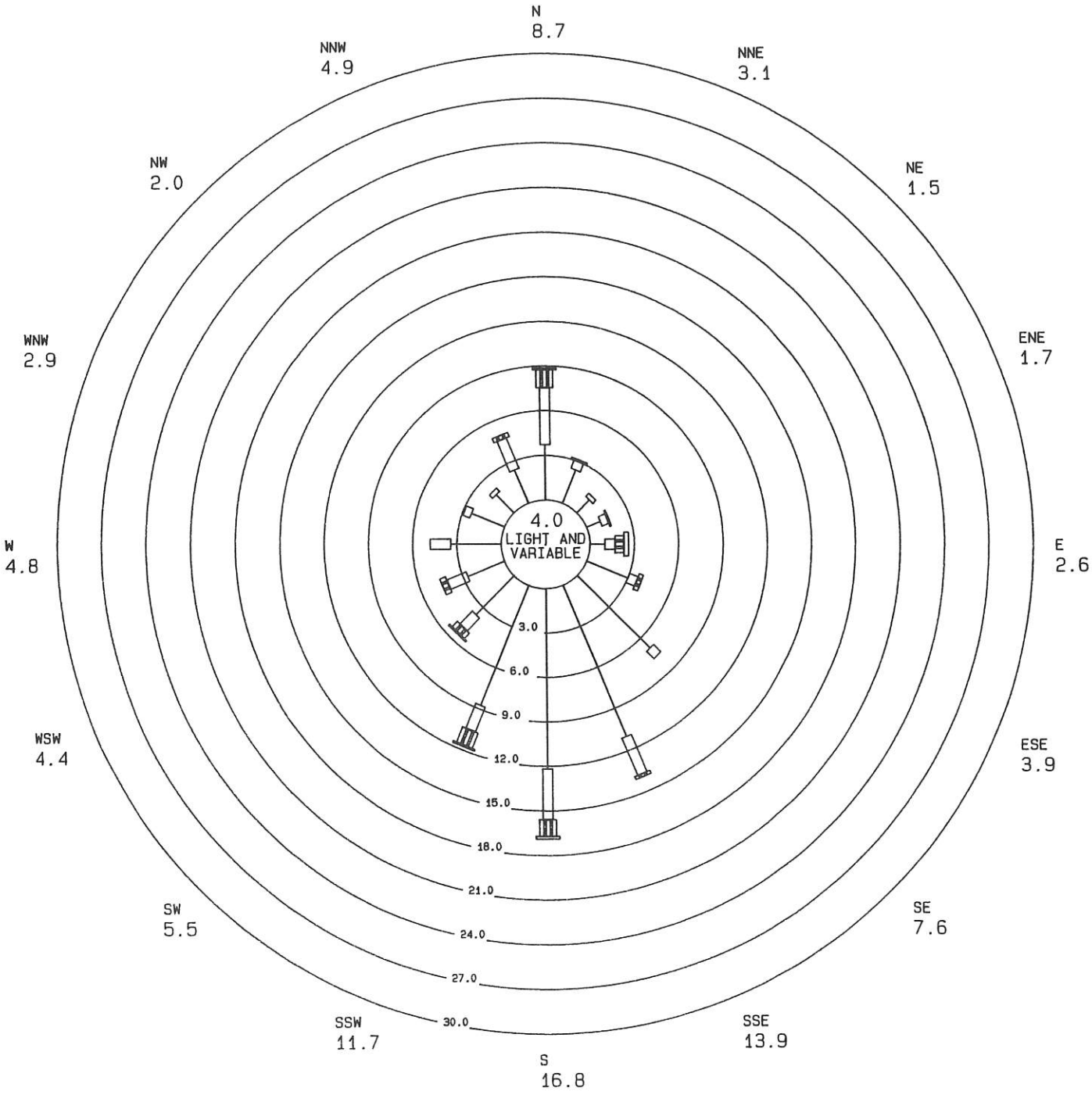


0.9- 3.9	4.0- 6.9	7.0- 10.9	11.0- 16.9	17.0- 21.9	OVER 21.9

KNOTS



PERCENT



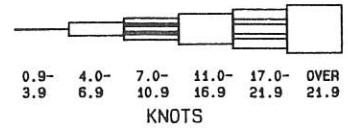
HOUR AVERAGE SURFACE WINDS

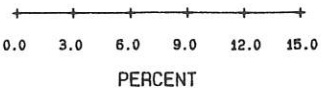
PERCENTAGE FREQUENCY OF OCCURRENCE

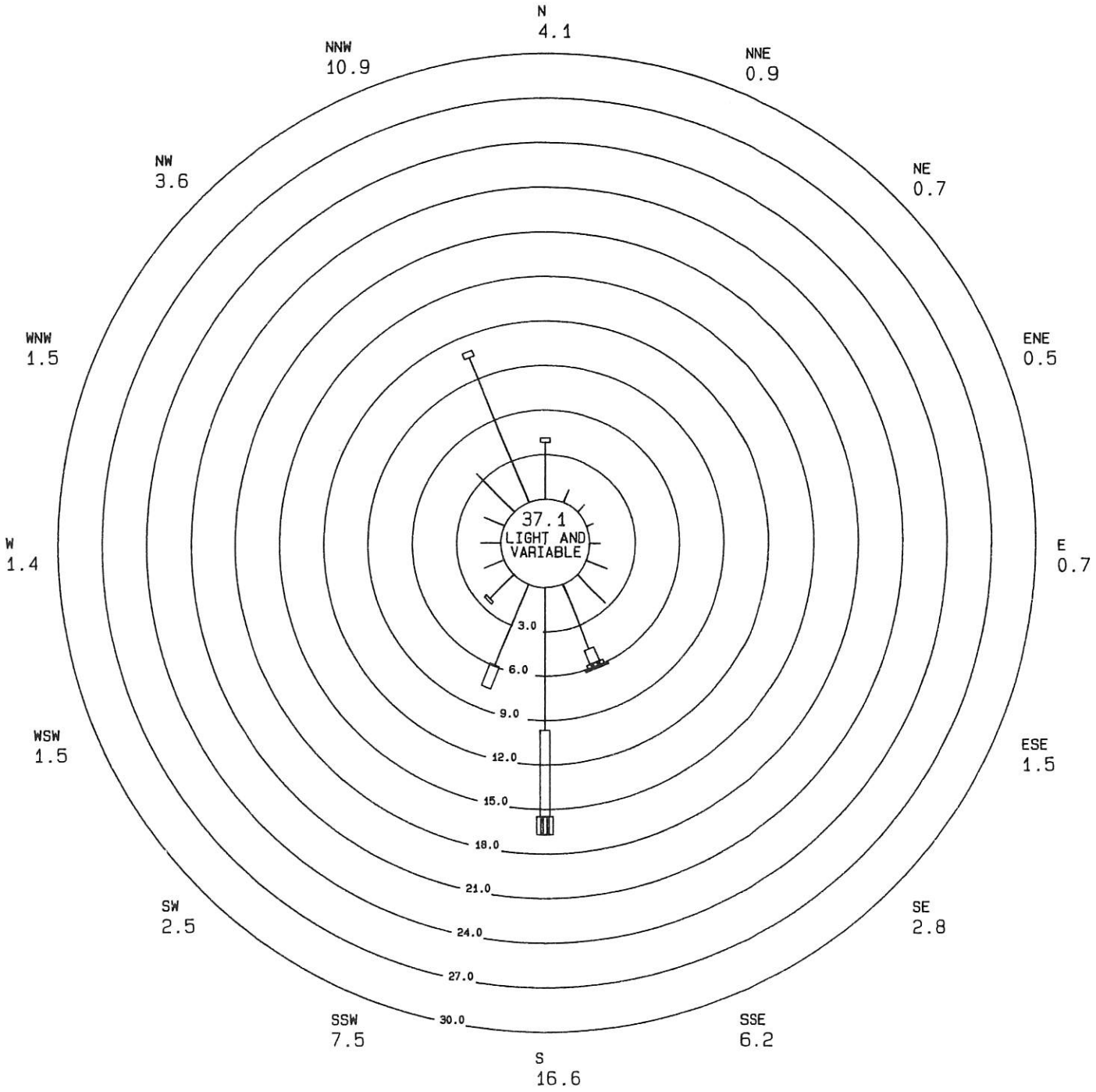
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
James St & Central Ave, Kent, Wa

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,707







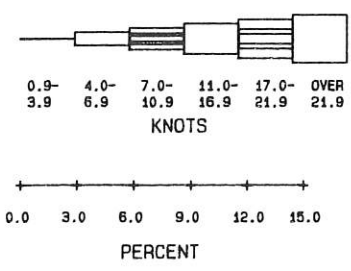
HOUR AVERAGE SURFACE WINDS

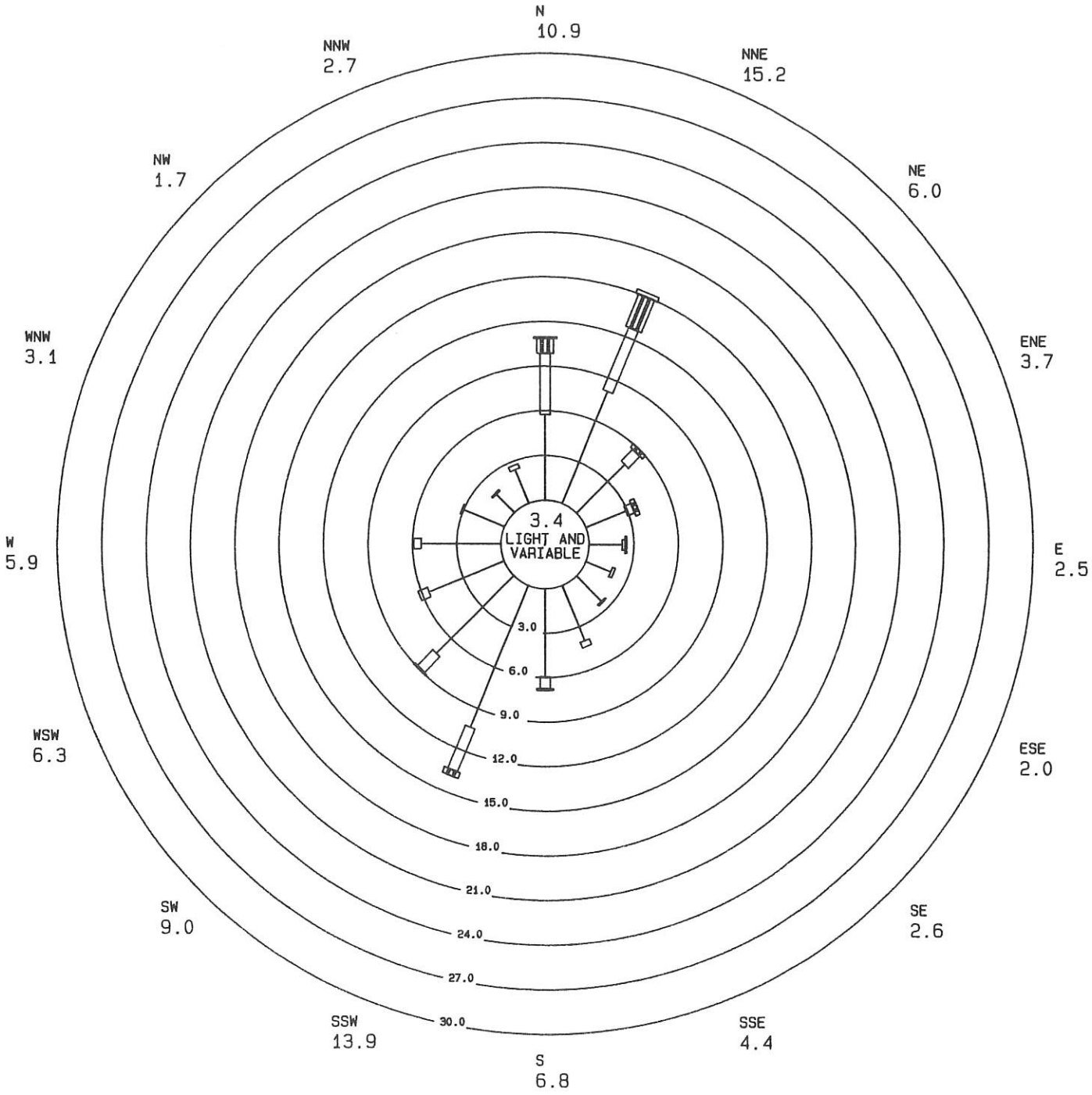
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
South Hill, 9616 128th St E, Puyallup, Wa

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,697





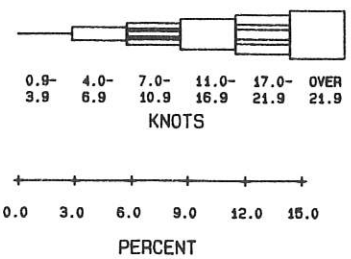
HOUR AVERAGE SURFACE WINDS

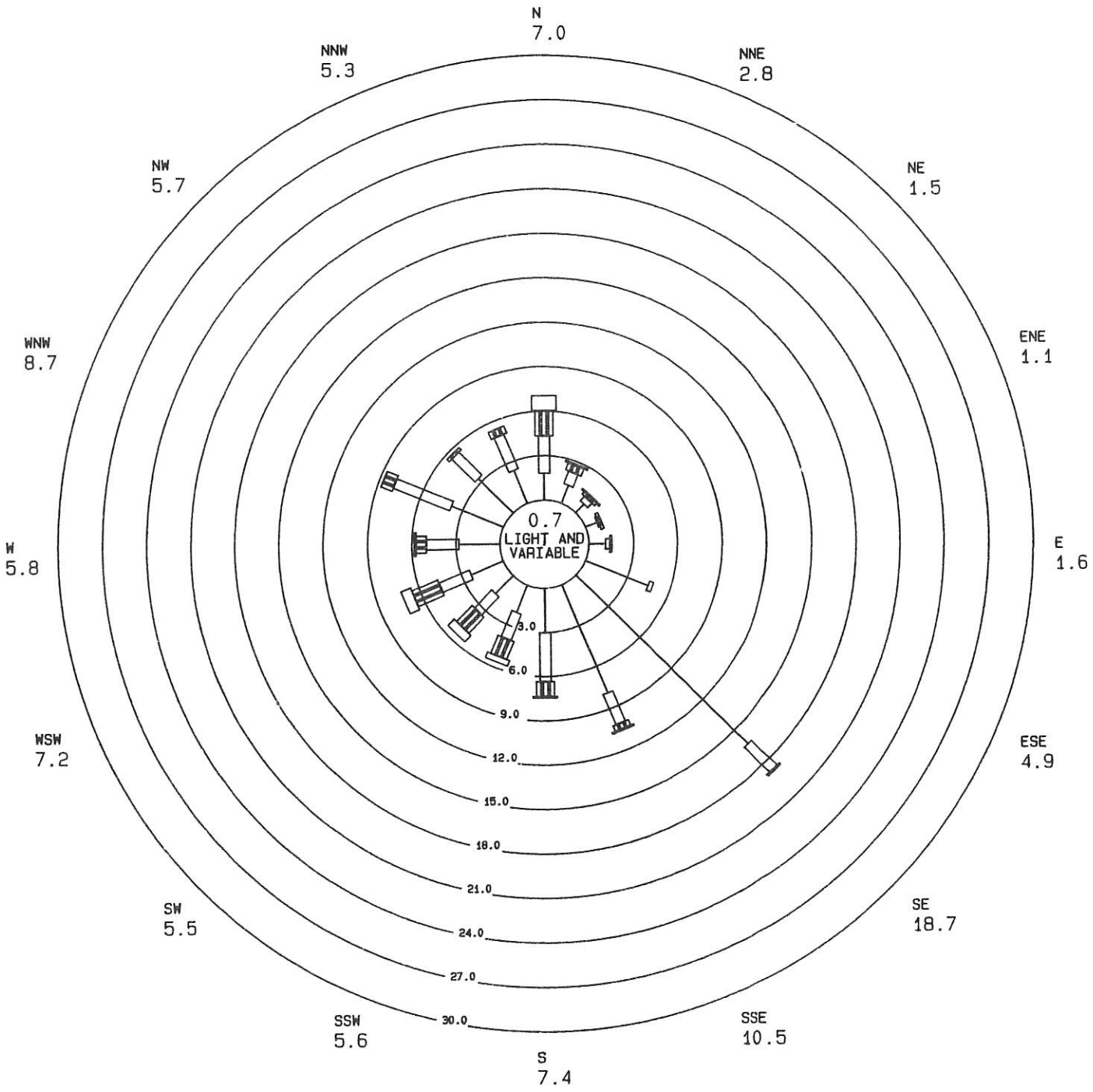
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,715





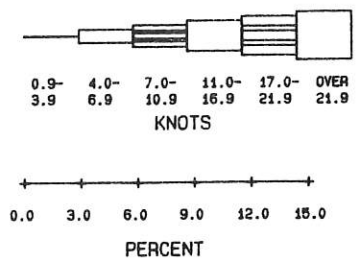
HOUR AVERAGE SURFACE WINDS

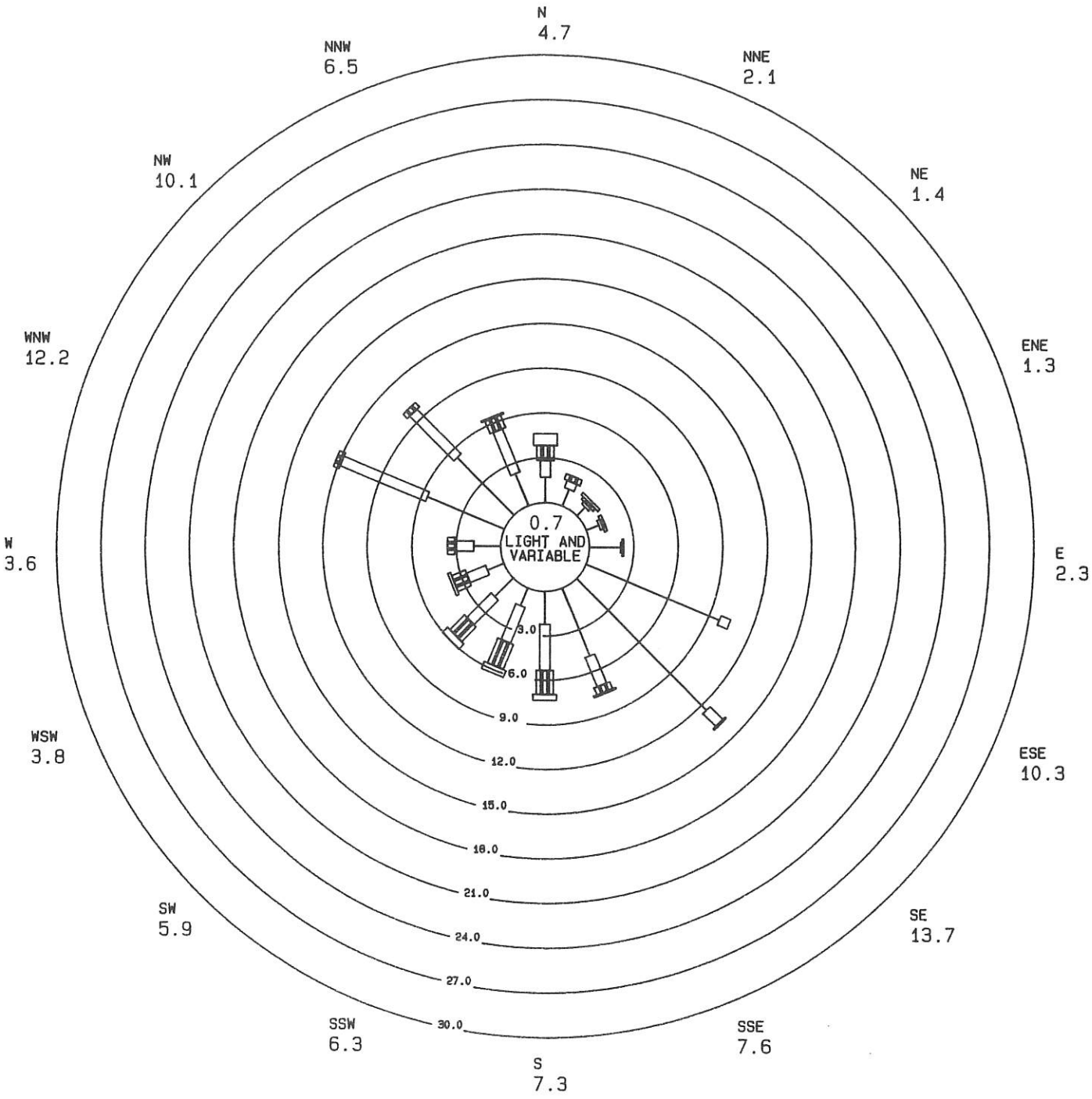
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,742





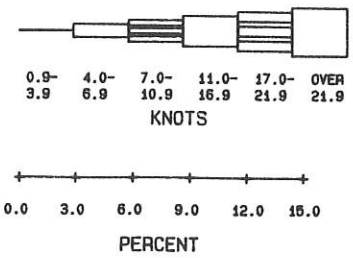
HOUR AVERAGE SURFACE WINDS

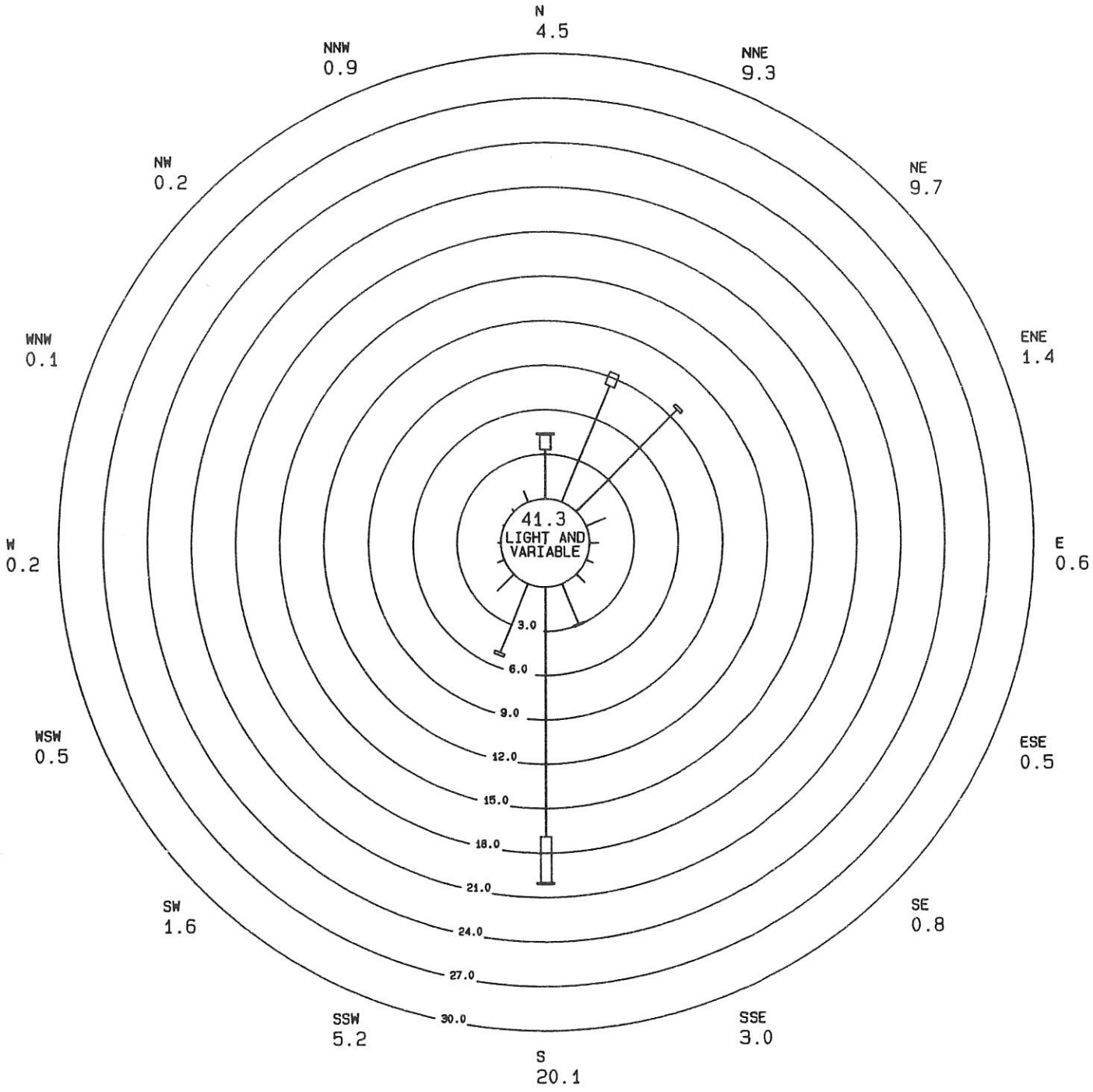
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,742





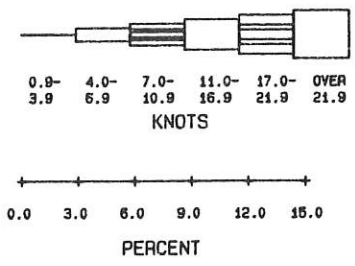
HOUR AVERAGE SURFACE WINDS

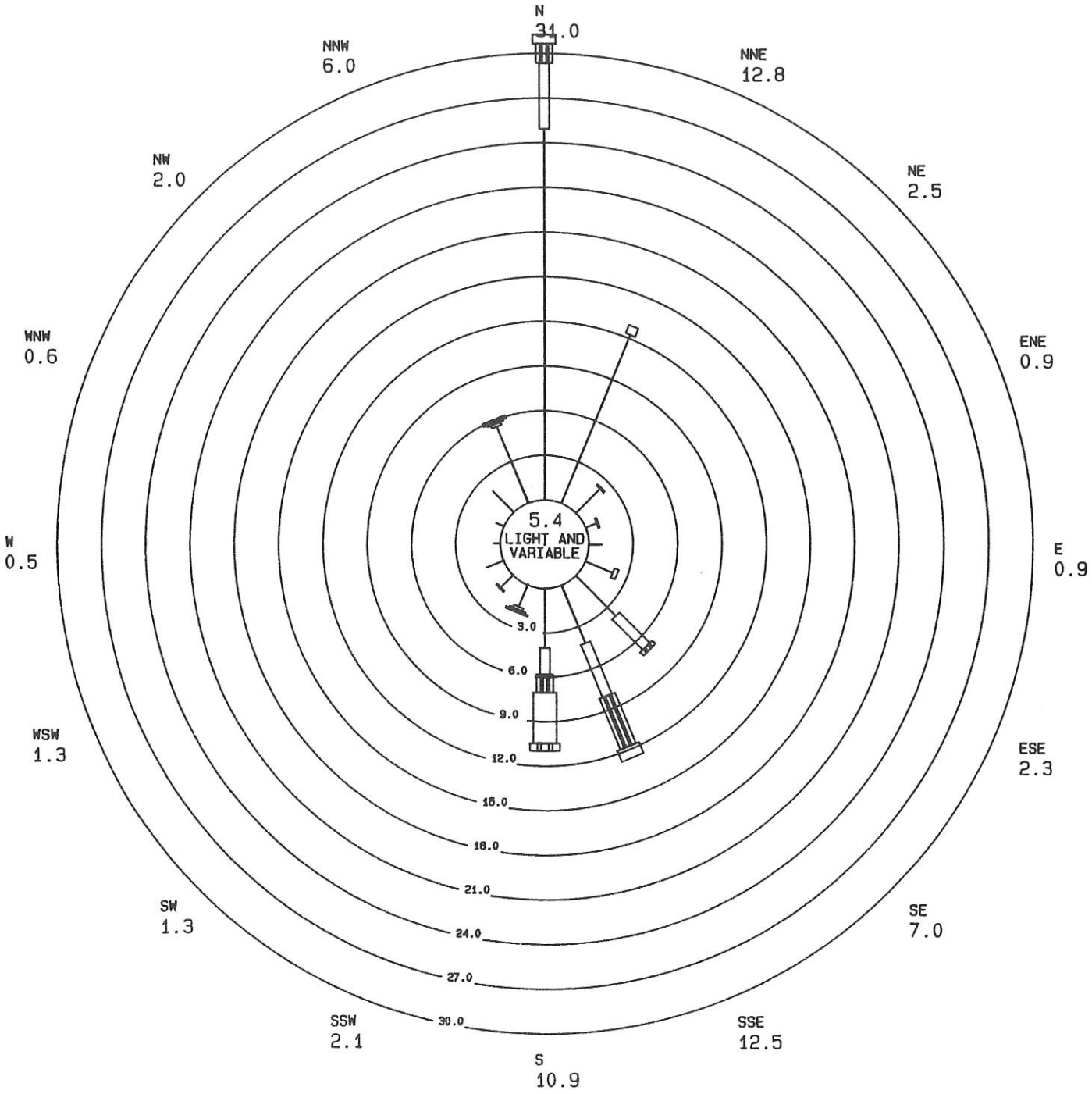
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Meadowdale, 7252 Blackbird Dr NE, KitsapCo, Wa

INCLUSIVE DATES- ALL MONTHS 1993

TOTAL OBSERVATIONS- 8,741





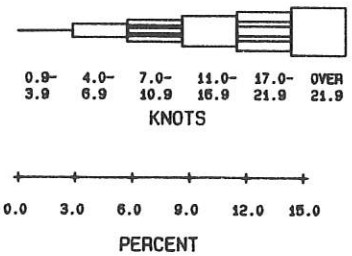
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Lions Park, 6th Ave NE & Fjord Dr, Poulsbo, Wa

INCLUSIVE DATES- SEP, OCT, NOV, DEC, 1993

TOTAL OBSERVATIONS- 2,390



EMISSION INVENTORY

The emissions of air pollution sources in the Puget Sound Region are inventoried to assess their relative contribution. Emission inventories can also be used to evaluate the potential for applying different control strategy options. The most recent data currently available for the Puget Sound Air Pollution Control Agency's four county area are presented in the following pages. Inventories may be displayed in a variety of ways including season, pollutant, source category and facility. The tables presented in this section include:

Table 1: 1990 Summer Day Ozone Precursor Emissions (tons/day)
Table 2: 1990 Winter Day Carbon Monoxide Emissions (tons/day)
Table 3: 1990 Puget Sound Stationary Area Source Emissions (tons/year)
Table 4: 1990 Puget Sound Non-road Mobile Source Emissions (tons/year)
Table 5: 1990 Puget Sound On-road Mobile Source Emissions (tons/day)
Table 6: 1993 Large Stationary Source Emissions (tons/year)

For reference some terms used in these inventories are defined below:

Term	Definition
CO	Carbon monoxide
HDDT	Heavy duty diesel trucks
HDGT	Heavy duty gasoline trucks
lb	Pounds
LDGV	Light duty gasoline vehicles
LDGT	Light duty gasoline trucks
MC	Motorcycles
NO2	Nitrogen dioxide
NR	Organic compounds which have negligible reactivity in low level ozone formation
Non-attainment area	Geographical area administratively designated as not meeting national ambient air quality standards
PM10	Particulate matter less than or equal to 10 micrometers
Precursor	Pollutants responsible for the formation of low level ozone such as nitrogen oxides and volatile organic compounds
PSAPCA	Puget Sound Air Pollution Control Agency
sd	Summer day
SO2	Sulfur dioxide
Stationary sources	Non-mobile emission sources; large stationary sources emit 25 tons or more of CO, NO2, PM10 or SO2 or 10 tons or more of VOC (including any NR compound) or TAC
TAC	Toxic air contaminants
tpd	Tons per day
tpy	Tons per year
VOC	Volatile organic compounds excluding any NR compounds
wd	Winter day

Table 1
1990 Summer Day Ozone Precursor Emissions (tons/day)

Source	CO tpd	CO %	NO2 tpd	NO2 %	VOC tpd	VOC %
Passenger vehicles, vans, motorcycles	1,887	58	173	43	252	24
Trucks, buses	340	11	106	27	42	4
Large stationary sources	88	3	22	6	34	3
Small stationary sources	228	7	20	5	162	16
Trees, crops	0	0	0	0	407	40
Aircraft, ships, recreational boats	688	21	76	19	134	13
Totals	3,231	100	397	100	1031	100

Reference: Supplement to the State Implementation Plan for Washington State, A Plan for Attaining and Maintaining National Air Quality Standards for Ozone in the Puget Sound Nonattainment Area, PSAPCA, August 1994

Note: Table 1 values represent totals for the entire counties of King, Pierce and Snohomish.

Table 2
1990 Winter Day Carbon Monoxide Emissions (tons/day)

Source	CO tpd	CO %
Passenger vehicles, vans, motorcycles	1,913	70
Trucks, buses	261	10
Large stationary sources	68	2
Small stationary sources	310	11
Aircraft, ships, recreational boats	198	7
Totals	2,750	100

Reference: Supplement to the State Implementation Plan for Washington State, A Plan for Attaining and Maintaining National Air Quality Standards for Carbon Monoxide in the Puget Sound Nonattainment Area, PSAPCA, August 1994

Note: Table 2 values represent the CO nonattainment area only of King, Pierce and Snohomish counties.

Table 3
1990 Puget Sound Stationary Area Source Emissions (tons/year)

Source Category	CO tpy	CO lb/wd	NO2 tpy	NO2 lb/sd	VOC tpy	VOC lb/sd
Agricultural Burning	0	0	1	13	7	67
Aircraft Refueling	0	0	0	0	649	3,950
Archit./Traffic Coating	0	0	0	0	6,526	42,549
Biogenics (Trees, Crops)	0	0	0	0	81,394	813,939
Bioprocesses	0	0	0	0	572	3,136
Commercial/Instit. Fossil Fuel	202	2507	1,006	1,107	27	30
Cutback Asphalt	0	0	0	0	473	0
Dry Cleaning	0	0	0	0	2,992	23,271
Engine Testing	2,992	16,399	77	425	100	549
Forest Wildfires	0	0	30	620	81	1,673
Gasoline Distribution	0	0	0	0	10,612	62,292
Graphic Arts	0	0	0	0	1,084	8,431
Industrial Fossil Fuel	637	4,082	3,941	25,262	49	312
Land Clearing Burning	6,313	35,982	1,155	7,912	4,389	30,065
Leaking Underground Tanks	0	0	0	0	52	285
Miscellaneous Solvents	0	0	0	0	8,189	52,489
Pesticide Application	0	0	0	0	367	3,353
Residential Fossil Fuel	854	9,291	2,161	2,051	106	100
Residential Garbage	319	1,748	50	272	249	1,362
Residential Wood	50,224	542,540	788	759	6,853	6,606
Slash Burning	0	0	175	1,519	603	5,243
Structure Burning	1,108	6,072	30	162	233	1,275
Surface Cleaning	0	0	0	0	2,371	15,198
Surface Coating	0	0	0	0	8,911	57,121
Waste Management	46	250	11	60	52	287
Yard Waste Burning	1,703	1,891	149	809	833	4,529
Totals	64,398	620,762	9,574	40,971	137,774	1,138,112

Reference: Supplement to the State Implementation Plan for Washington State, A Plan for Attaining and Maintaining National Air Quality Standards for Carbon Monoxide and Ozone in the Puget Sound Nonattainment Area, PSAPCA, August 1994

Note: Table 3 does not include Kitsap county; CO values include only the CO nonattainment area.

Table 4
1990 Puget Sound Non-road Mobile Source Emissions (tons/year)

Source Category	CO tpy	CO lb/wd	NO2 tpy	NO2 lb/sd	VOC tpy	VOC lb/sd
Agricultural Equip.	0	0	1,251	9,795	273	2,134
Aircraft & Airport Equipment	12,388	63,301	3,292	20,048	3,123	19,019
Commercial Vessels	1,990	10,903	6,799	37,261	705	3,861
Construction Equip.	8,939	43,714	9,507	55,808	1,553	9,116
Industrial/Commercial	34,799	223,064	1,984	12,720	2,296	14,718
Lawn & Garden Equip.	64,375	43,131	142	1,236	9,054	78,774
Logging Equipment	0	0	829	4,865	216	1,266
Railroads	115	630	1,025	5,618	73	398
Recreational Boats	10,179	2,239	336	4,822	4,066	58,343
Recreational Equipment	3,236	9,353	70	374	12,461	79,110
Totals	136,021	396,335	25,235	152,547	33,820	266,739

Reference: Supplement to the State Implementation Plan for Washington State, A Plan for Attaining and Maintaining National Air Quality Standards for Carbon Monoxide and Ozone in the Puget Sound Nonattainment Area, PSAPCA, August 1994

Note: Table 4 does not include Kitsap county; CO values include only the CO nonattainment area

Table 5
1990 Puget Sound On-road Mobile Source CO Emissions (tons/winter day)

Vehicle Type	King	Pierce	Snohomish
Passenger vehicles,vans			
LDGV	756	272	235
LDGT	384	141	121
Trucks, buses			
HDGT	145	47	42
HDDT	17	5	5
Total	1,302	465	403

1990 Puget Sound On-road Mobile Source NO2 Emissions (tons/summer day)

Vehicle Type	King	Pierce	Snohomish
Passenger vehicles,vans			
LDGV	66	25	23
LDGT	33	13	11
Trucks, buses			
HDGT	9	3	3
HDDT	53	20	18
Total	161	61	55

1990 Puget Sound On-road Mobile Source VOC Emissions (tons/summer day)

Vehicle Type	King	Pierce	Snohomish
Passenger vehicles,vans			
LDGV	93	36	31
LDGT	51	19	17
Trucks, buses			
HDGT	19	7	6
HDDT	6	2	2
Total	169	64	56

Reference: Seattle-Tacoma Urban Carbon Monoxide and Ozone Nonattainment Area 1990 Base Year On Road Mobile Source Emission Inventory, Washington State Department of Ecology, August 1994.

Note: The CO values represent emissions within the CO nonattainment area only of King, Pierce and Snohomish counties, whereas the NO2 and VOC emissions represent the Ozone nonattainment area within King, Pierce and Snohomish counties.

Table 6
1993 Large Stationary Source Emissions (tons/year)

Name	City	CO	NO2	PM10	SO2	TAC	VOC	NR
King County								
Ace Tank & Equipment Co.	Seattle	0	0	0	0	37	42	2
Alliedsignal Avionics Inc.	Redmond	0	0	0	0	10	8	2
American Millwork Inc.	Kirkland	0	0	0	0	65	67	0
American National Can Co.	Kent	0	8	0	0	203	241	0
ARCO Petroleum Products Co.	Seattle	0	0	0	0	0	61	0
Art Brass Plating Inc.	Seattle	0	0	0	0	22	22	0
Ash Grove Cement Co.	Seattle	957	720	26	72	0	0	0
Bakker's Fine Dry Cleaning	Bellevue	0	0	0	0	28	28	0
Ball Glass Container Corp.	Seattle	0	1,024	40	59	0	0	0
Bert-Well Industries Inc.	Kent	0	0	0	0	17	1	17
Birmingham Steel Corp.	Seattle	5,058	75	60	196	32	102	0
Boeing Commercial Airplane	Auburn	24	302	2	9	230	221	58
Boeing Commercial Airplane	Renton	13	140	3	23	285	221	79
Boeing Commercial Airplane (NBF)	Seattle	3	14	1	8	60	55	11
Boeing Commercial Airplane (Plant II)	Seattle	7	22	2	17	36	32	3
Boeing Defense & Space	Kent	5	23	1	11	23	19	5
Boeing Defense & Space (Electronics)	Renton	0	1	0	0	12	8	5
Boeing Military Aircraft (DC)	Seattle	5	18	0	0	20	22	11
Capital Industries Inc.	Seattle	0	0	0	0	49	51	0
Cello Bag Co. Inc.	Tukwila	0	0	0	0	65	65	0
Chemgrate Corp.	Wdnville.	0	0	0	0	11	11	0
Crain Industries	Kent	0	0	0	0	139	0	139
Fisher Mills Inc.	Seattle	0	0	58	0	2	2	0
Gai's Seattle French Baking Co.	Seattle	0	0	0	0	121	121	0

Table 6 (*continued*)
1993 Large Stationary Source Emissions (tons/year)

Name	City	CO	NO2	PM10	SO2	TAC	VOC	NR
King County								
Genie Industries Inc.	Redmond	0	0	0	0	21	14	9
Guardsman Products Inc.	Seattle	0	0	0	0	20	29	0
Haworth Inc. (Lundstead)	Kent	0	0	0	0	26	29	0
Heath Tecna	Auburn	0	0	0	0	31	32	2
Heath Tecna Aerospace	Kent	1	3	0	0	27	29	1
Holnam Inc. (Ideal)	Seattle	222	1,496	133	884	1	0	0
Huntsman Packaging Products Corp.	Kent	0	0	0	0	83	84	0
Hytek Finishes Co.	Kent	0	2	0	0	18	17	3
James Hardie Gypsum (WA) Inc.	Seattle	7	28	2	1	0	1	0
James River Corp. (Ridgway Packaging)	Redmond	0	0	0	0	32	37	0
Jorgensen Forge Corp.	Seattle	44	27	0	2	0	1	0
K-2 Corp.	Vashon	0	0	0	0	102	78	25
Kenworth Truck Co. (PACCAR)	Seattle	2	9	0	1	123	169	0
Kenworth Truck Co. (PACCAR)	Renton	1	4	0	0	37	46	1
King Co. Metropolitan Services Dept. (West Point)	Seattle	33	168	2	4	0	10	0
King Co. Public Works (Cedar Hills)	Maple Valley	77	62	0	20	13	2	0
Langendorf Baking Co. of Seattle Inc.	Seattle	0	3	0	0	124	124	0
Leathercare Inc.	Seattle	0	0	0	0	17	17	0
Livingston Molded Products Inc.	Auburn	0	0	0	0	44	44	0
Pacific Sound Resources	Seattle	1	6	0	1	7	20	0
Professional Coating Inc.	Seattle	0	0	0	0	34	34	0
Protective Coatings Inc.	Kent	0	0	0	0	25	22	3
Red Dot Corp.	Tukwila	0	0	0	0	21	21	0
Reynolds Metals Co. (Seattle Can Plant)	Kent	0	0	0	0	173	173	0
Rudd Co. Inc.	Seattle	0	0	0	0	23	26	0

Table 6 (*continued*)
1993 Large Stationary Source Emissions (tons/year)

Name	City	CO	NO2	PM10	SO2	TAC	VOC	NR
King County								
Seattle Disposal Co. (NW Waste Indust.)	Seattle	0	0	0	0	1	17	0
Seattle Steam Co.	Seattle	28	249	4	25	0	1	0
Shell Oil Co. (Harbor Island)	Seattle	0	1	0	0	1	37	0
Spic N'Span Cleaners #1	Seattle	0	0	0	0	1	20	0
Surftech Finishes Inc.	Kent	0	0	0	0	20	21	1
Tempress Inc.	Seattle	0	0	0	0	45	26	18
Texaco Refining & Marketing Inc.	Seattle	0	0	0	1	0	23	0
Todd Pacific Shipyards Corp.	Seattle	1	3	2	0	17	40	1
Tosco Corp.	Renton	0	0	0	0	1	31	0
University of Washington	Seattle	27	333	14	171	0	5	0
Western Cabinet & Millwork (Timberland)	Wdnville.	0	0	0	0	104	104	0
Western Pneumatic Tube Co.	Kirkland	0	0	0	0	19	19	0
King Co Totals		6,516	4,741	350	1,505	2,678	2,803	396
Kitsap County								
U S Navy Shipyard	Bremerton	96	270	14	71	74	81	14
U S Navy Submarine Base	Bangor	12	83	4	144	9	20	1
U S Navy Supply Center	Manchester	0	0	0	2	0	16	0
U S Navy Undersea Warfare	Keyport	4	20	2	7	50	43	22
Wilkins Distributing Co (Gull Ind.)	Port Orchard	0	0	0	0	0	44	0
Kitsap Co. Totals		112	373	20	224	133	204	37
Pierce County								
American Reinforced Plastics	Tacoma	0	0	0	0	13	13	0
Boeing Commercial Airplane	Fredericksn	4	15	0	0	16	18	1
Boise Cascade	Steilacoom	156	235	67	10	0	19	0
Buffelen Woodworking Co.	Tacoma	10	20	28	0	7	12	0
Darling Corp.	Tacoma	0	0	0	0	6	51	0
Domtar Gypsum Inc.	Tacoma	14	1	6	54	0	0	0
Dyno Overlays Inc.	Tacoma	0	0	0	0	104	104	0

Table 6 (*continued*)
1993 Large Stationary Source Emissions (tons/year)

Name	City	CO	NO2	PM10	SO2	TAC	VOC	NR
Pierce County								
General Plastics Manufacturing Co.	Tacoma	0	0	0	0	19	3	19
Girard Custom Coaters Inc.	Tacoma	0	0	0	0	147	195	0
Kaiser Aluminum & Chemical Corp. (Port)	Tacoma	0	0	32	0	0	0	0
Kaiser Aluminum & Chemical Corp. (Smelter)	Tacoma	9,184	1	131	1,340	0	58	0
Lianga Pacific Inc.	Tacoma	0	0	0	0	39	39	0
Matsushita Semiconductor	Puyallup	1	6	4	1	51	29	2
Mutual Materials (Closed)	Eatonville	1	9	3	34	0	1	0
Norcore Plastics Inc.	Tacoma	0	0	0	0	14	14	0
Occidental Chemical Corp.	Tacoma	6	140	1	0	19	1	18
Pacific Northwest Baking Co.	Sumner	0	0	0	0	45	45	0
Pasquier Panel Products Inc.	Puyallup	0	0	0	0	60	71	0
Rainier Plywood Co. (Plastics)	Tacoma	0	0	0	0	63	63	0
Simpson Tacoma Kraft	Tacoma	3,715	693	254	2,219	0	85	0
Sound Refining Inc. (Crysen)	Tacoma	4	26	8	80	0	51	0
Superior Oil Co. (Time Oil)	Tacoma	0	0	0	0	2	16	0
Tacoma City Light	Tacoma	52	346	26	172	0	0	0
Tosco Corp.	Tacoma	0	0	0	0	1	27	0
U. S. Air Force McChord	McChord	6	24	2	11	5	13	0
U. S. Army Fort Lewis	Fort Lewis	28	126	13	183	19	81	4
U. S. G. Interiors	Tacoma	1	3	28	0	0	20	0
U. S. Oil & Refining Co.	Tacoma	31	109	25	303	0	76	0
Pierce Co. Totals		13,213	1,754	628	4,407	630	1,105	44
Snohomish County								
Alliant Techsystems Inc. (Harbour Heights)	Mukilteo	0	0	0	0	13	1	13
Barmon Door	Lake Stevens	0	0	0	0	15	19	0

Table 6 (*continued*)
1993 Large Stationary Source Emissions (tons/year)

Name	City	CO	NO2	PM10	SO2	TAC	VOC	NR
Snohomish County								
Bayliner Marine Corp. (Brunswick)	Arlington	0	0	0	0	40	40	1
Boeing Commercial Airplane	Everett	29	103	2	28	739	631	125
Calvert Industries Inc.	Snohomish	0	0	0	0	38	38	0
Cascade Cabinet Corp.	Wdnville.	0	0	0	0	55	58	0
Chemical Proof Corp.	Arlington	0	0	0	0	14	14	0
Chevron USA Inc. (Asphalt Refinery)	Seattle	5	22	7	100	0	62	0
Chevron USA (Point Wells Distribution Center)	Edmonds	0	0	0	0	1	68	0
Coastal Manufacturing	Mukilteo	0	0	0	0	10	10	0
Crest Cabinet Corp.	Everett	0	0	0	0	16	33	0
Nord/Jeld-Wen of Everett Inc.	Everett	68	9	48	0	0	1	0
Northwest Composites Inc (Aerocell)	Marysville	0	0	0	0	63	62	1
Scott Paper Co.	Everett	5,238	1,299	0	462	0	187	0
T C Systems Inc.	Everett	0	0	0	0	18	16	3
Tiz's Door Sales Inc.	Everett	0	0	0	0	32	37	0
Tramco Inc. (South)	Everett	0	0	0	0	31	32	0
Wholesale Door Co.	Snohomish	0	0	0	0	16	16	0
Snohomish Co. Totals		5,340	1,433	57	590	1,101	1,325	152
Puget Sound Four County Totals		25,181	8,301	1,055	6,726	4,542	5,437	629

Note: The values listed in Table 6 represent emission quantities reported to PSAPCA by the facility as of September 27, 1994. A zero indicates that no emissions have been reported. Kaiser (Smelter), Simpson and Scott values represent emissions reported to the Washington State Department of Ecology as recorded in the U. S. Environmental Protection Agency's AIRS AFS data base as of September 27, 1994.

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. The automobile internal combustion engine is a principal source of carbon monoxide. Carbon monoxide chemically combines with the hemoglobin in the red blood cells to decrease the oxygen-carrying capacity of the blood. It also weakens the contractions of the heart, thus reducing the amount of blood pumped throughout the body. Additionally it can affect the functioning of the lungs and brain. People with heart disease and pregnant women are particularly at risk because of the effects of carbon monoxide.

Particulate Matter (PM_{10})

Particulate matter consists of small discrete solid or aerosol particles dispersed in the air. Particulate matter with an aerodynamic diameter of less than or equal to 10 micrometers is referred to as PM_{10}. Transportation, industrial activity and wood burning are major sources of particulate matter. Particulates one micrometer or less in diameter are especially associated with a variety of adverse effects on public health and welfare. The small particles can be breathed deeply into the lungs. 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. Particulate matter causes welfare effects through soiling of buildings and other property and by scattering and absorbing visible light thereby reducing visibility.

Ozone

Ozone is a pungent-smelling, colorless gas produced in the atmosphere when nitrogen oxides and volatile organic compounds 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. In contrast, ozone is beneficial when it occurs naturally, very high in the atmosphere, miles above the earth, where it protects us from harmful ultraviolet radiation.

Sulfur Dioxide

Sulfur dioxide is a colorless, corrosive gas, that has a bitter taste, but no appreciable smell between 0.3 and 1.0 ppm. Industrial sites 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 more significant. Inhalation of sulfur dioxide can cause increased airway resistance by constricting lung passages.

Lead

Particles of lead or its compounds enter the air from vehicle exhaust and from industries that smelt or process 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 from one to five years old 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 that, along with 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 photochemical reactions that produce ozone.

AMBIENT AIR QUALITY STANDARDS

POLLUTANT	NATIONAL Primary	NATIONAL Secondary	WASHINGTON STATE	PUGET SOUND REGION
CARBON MONOXIDE				
8 Hour Average [a]	9 ppm		9 ppm	9 ppm
1 Hour Average [a]	35 ppm		35 ppm	35 ppm
PARTICULATE MATTER (PM10)				
Annual Arithmetic Average [b]	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
24 Hour Average [c]	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
OZONE				
1 Hour Average [d]	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm
SULFUR DIOXIDE				
Annual Average [e]	0.03 ppm		0.02 ppm	0.02 ppm
24 Hour Average	0.14 ppm [a]		0.10 ppm [a]	0.10 ppm [e]
3 Hour Average [a]		0.50 ppm		
1 Hour Average [f]			0.25 ppm	0.25 ppm
1 Hour Average			0.40 ppm [a]	0.40 ppm [e]
LEAD				
Calendar Quarter Average [e]	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$		1.5 $\mu g/m^3$
NITROGEN DIOXIDE				
Annual Average [e]	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm

Notes

(1) ppm = parts per million.

(2) $\mu g/m^3$ = micrograms per cubic meter.

a -Not to be exceeded more than once per year.

b - Standard attained when the expected annual arithmetic mean concentration, as determined in accordance with 40 CFR Part 50, Appendix K, is less than or equal to 50 $\mu g/m^3$.

c -Standard attained when the expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$, as determined in accordance with 40 CFR Part 50, Appendix K, is equal to or less than one.

d -Standard attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than one, as determined by 40 CFR Part 50, Appendix H.

e - Never to be exceeded.

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

AIR QUALITY UNITS CONVERSION TABLE

Air quality standards for gases are defined in terms of micrograms (μg) 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 μg/cubic meter or mg/cubic meter. These conversion factors from the Federal Register assume a pressure of 760 millimeters Hg and a temperature of 25 degrees C.

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