Report No. NPS D-203

Annual Data Summary

ROCKY MOUNTAIN NATIONAL PARK

1994

National Park Service
Gaseous Air Pollutant Monitoring Network

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At Rocky Mountain National Park, ARD specifically recognizes Sue Williams for performing the technical and administrative skills required to help produce the data presented within this report.

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1.0 INTRODUCTION

1.1 THE NATIONAL PARK SERVICE GASEOUS POLLUTANT MONITORING NETWORK

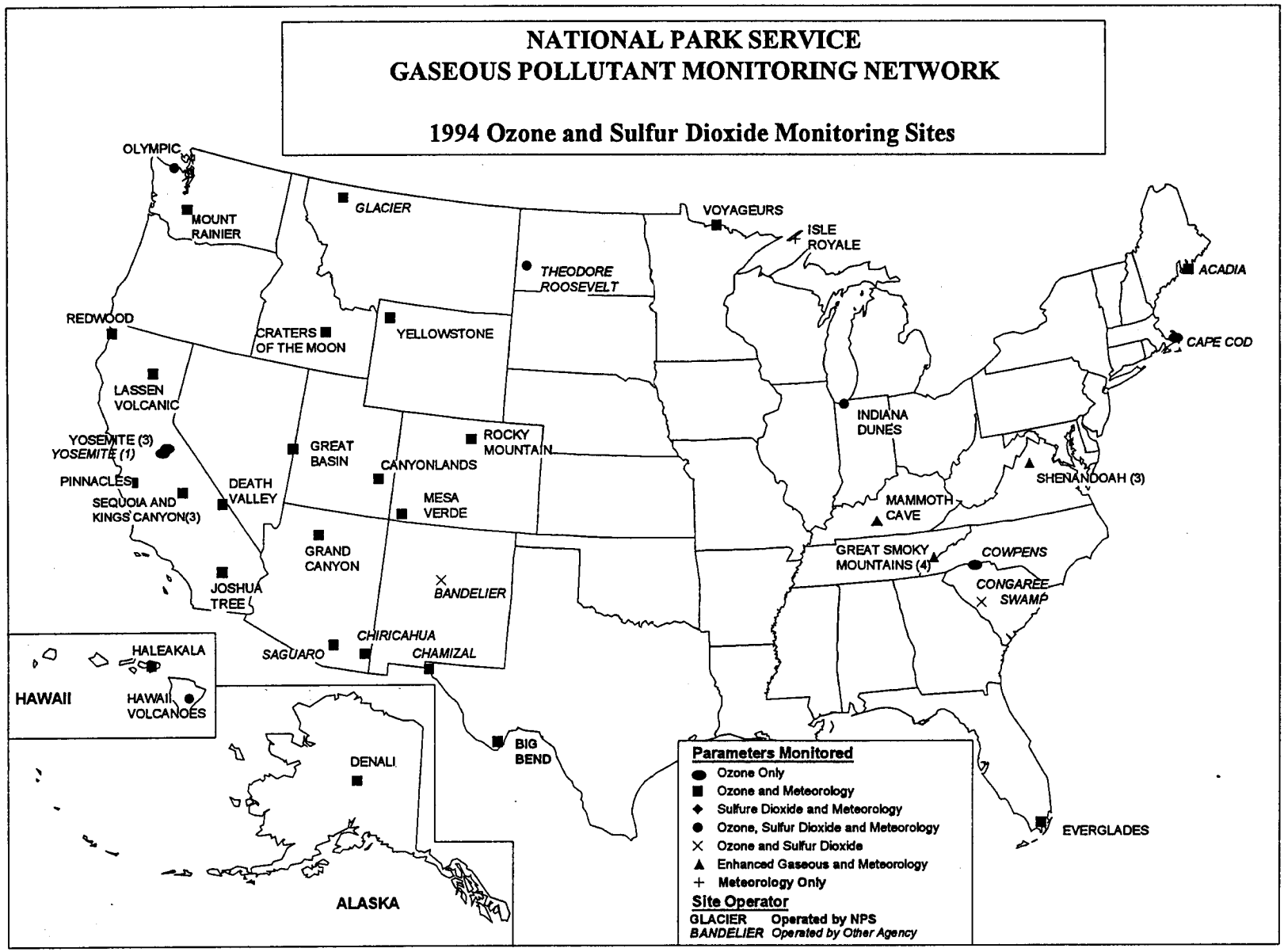
Gaseous air pollutants, including ozone and sulfur dioxide, are of concern to the National Park Service (NPS). Pollutants like these can affect park biological resources as well as the health of park residents and visitors. The NPS established a gaseous pollutant monitoring program for several pollutants linked to affects on NPS resources. This program was designed to meet certain resource management objectives.

The primary objective of this monitoring program is to establish the status and trends of park air quality conditions and to determine if a park is exceeding the National Ambient Air Quality Standards established by the U.S. Environmental Protection Agency (EPA) to protect public health and welfare. In addition, such monitoring is designed to detect changes or trends in pollution levels over time. A monitoring station may also be established if there is documented biological injury due to air pollution in a park unit. Information on ambient air pollution levels is an important part of research on affects of air pollutants on NPS resources, and can help confirm suspected causes of observed affects.

Other monitoring objectives call for the collection of data to support the National Park Service's required involvement in both the development of state air quality control plans, and the evaluation of permit applications for new or expanding air pollution sources wishing to locate near park units. The Clean Air Act gives federal land managers and superintendents an affirmative responsibility to protect air quality related values in Class I areas and to assess whether new sources will have an adverse impact on park resources and values. Information on air quality levels in NPS units can also be used to evaluate the performance of atmospheric models that simulate how pollutants are transported into parks and predict impacts on the park caused by air pollution sources.

The National Park Service Gaseous Pollutant Monitoring Network site locations and measured parameters collected in this reporting year are shown on the map on the following page. During this reporting period, 47 monitoring sites in 37 units of the National Park System had some combination of ozone, sulfur dioxide, and meteorological monitoring. Monitoring methods and quality assurance procedures used in the national park network meet the applicable 40 CFR Part 58 EPA requirements. This allows for the direct comparison of NPS collected data with that collected by the EPA, and state and local air pollution control agencies. Data collected by this network are incorporated in the EPA Aerometric Information Retrieval System (AIRS) database which is a national database of all air quality data collected throughout the country. These data are also stored in the NPS Air Resources Division's Information Management Center (IMC) that allows for easy access and analysis of data.

This report includes a variety of data summaries for data collected at an individual monitoring site at a national park during this reporting period. These summaries highlight the average range and frequency of the data collected during the year. A PC-compatible diskette containing a digital copy of all data collected during the year and data summary products included in this report is also included. Individual reports are generated for each site where monitoring was conducted in the national park network.


NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1994 Ozone and Sulfur Dioxide Monitoring Sites
OLYMPIC
MOUNT RAINIER
GLACIER
VOYAGEURS
ISLE ROYALE
THEODORE ROOSEVELT
ACADIA
CAPE COD
REDWOOD
CRATERS OF THE MOON
YELLOWSTONE
LASSEN VOLCANIC
INDIANA DUNES
YOSEMITE (3)
YOSEMITE (1)
GREAT BASIN
ROCKY MOUNTAIN
CANYONLANDS
SHENANDOAH (3)
PINNACLES
DEATH VALLEY
SEQUOIA AND KINGS CANYON(3)
MESA VERDE
MAMMOTH CAVE
GRAND CANYON
GREAT SMOKY MOUNTAINS (4)
COWPENS
JOSHUA TREE
BANDELIER
CONGAREE SWAMP
CHIRICAHUA
SAGUARO
CHAMIZAL
HALEAKALA
HAWAII
HAWAII VOLCANOES
BIG BEND
DENALI
EVERGLADES
ALASKA
Parameters Monitored
Ozone Only
Ozone and Meteorology
Sulfure Dioxide and Meteorology
Ozone, Sulfur Dioxide and Meteorology
Ozone and Sulfur Dioxide
Enhanced Gaseous and Meteorology
Meteorology Only
Site Operator
GLACIER Operated by NPS
BANDELIER Operated by Other Agency

1.2 ROCKY MOUNTAIN NATIONAL PARK

Rocky Mountain National Park, a Class I area, is located in north central Colorado about 50 miles northwest of Denver. Its location and site specifications are presented on the following page.

The act of Congress establishing Rocky Mountain National Park in 1915 stated the area was "...dedicated and set apart as a public park for the benefit and enjoyment of the people of the United States...with regulations being primarily aimed at the freest use of the said park for recreational purposes by the public and for the preservation of the natural conditions and scenic beauties thereof." The 1916 act that created the National Park Service also required that all lands within the National Park System be managed "to conserve the scenery and the natural and historic objects and the wildlife therein, and to provide for the enjoyment of same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." In 1976, the park was designated a Biosphere Reserve, and in 1980, about 3,000 acres of the park were designated as wilderness.

The park lies along the Continental Divide or "Front Range" and has an area of 410 square miles. Elevations range from 7,640 feet on the east side to 14,256 feet on Longs Peak. About one-third of the area and 107 named mountain peaks are over 11,000 feet in elevation.

Three vegetation zones are present. The upper montane is the lowest, occupying from 7,600 to 9,000 feet elevation. Ponderosa pine and Douglas fir communities are common. Characteristic mammals of this zone include elk, deer, marmot, squirrel, beaver, coyote and badger. Common birds include the robin, magpie, Stellar's jay, and red-tailed hawk.

From 9,000 to 11,500 feet elevation is the subalpine forest zone. The primary forest formation is the Engelmann spruce/subalpine fir community. Common mammals of the subalpine zone are squirrels, pine marten, snowshoe hare, and deer and elk (during spring and fall). Birds include the grey jay, Clark's nutcracker, and blue grouse.

The alpine tundra zone exists at elevations over 11,500 feet. This area with its more severe climate is characterized by grasses and dwarf flowering plants. The pica, marmot, gopher, bighorn sheep, and deer and elk (during summer) are common mammals. Common birds include the ptarmigan, water pipet, and rosy finch.

Historic resources of the park relate primarily to Indian sites dating back as long as 10,000 to 15,000 years ago and the settlement of the area by those of the westward advancing American culture.

2.0 DATA SUMMARY

2.1 OVERVIEW

Based on the site specifications during this annual reporting period, data summaries and statistics are provided in this section.

Data Collection Statistics
Rocky Mountain National Park

Final Data

01/01/94 - 12/31/94

Parameter	Par Code	Data Recovery			Valid Data	
		No. Possible	No. Collected	% Collected	No. Valid	% Valid
Ozone Analyzer	O3	8698	8190	94.2	8183	94.1
Scalar Wind Speed	SWS	8719	8547	98.0	8293	95.1
Vector Wind Speed	VWS	8719	8547	98.0	8293	95.1
Vector Wind Direction	VWD	8719	8547	98.0	8293	95.1
Standard Deviation for Wind Direction	SDWD	744	727	97.7	727	97.7
Ambient Temperature (aspirated)	TMP	8506	7973	93.7	7360	86.5
Delta Temperature	DTP	744	727	97.7	727	97.7
Relative Humidity	RH	744	727	97.7	727	97.7
* Dew Point	DPT	7762	7248	93.4		
* Relative Humidity - calculated	RHC	6633	6633	100.0		
Precipitation	RNF	744	738	99.2	738	99.2
Wetness Sensor	WET	744	743	99.9	743	99.9
Solar Radiation	SOL	744	727	97.7	727	97.7

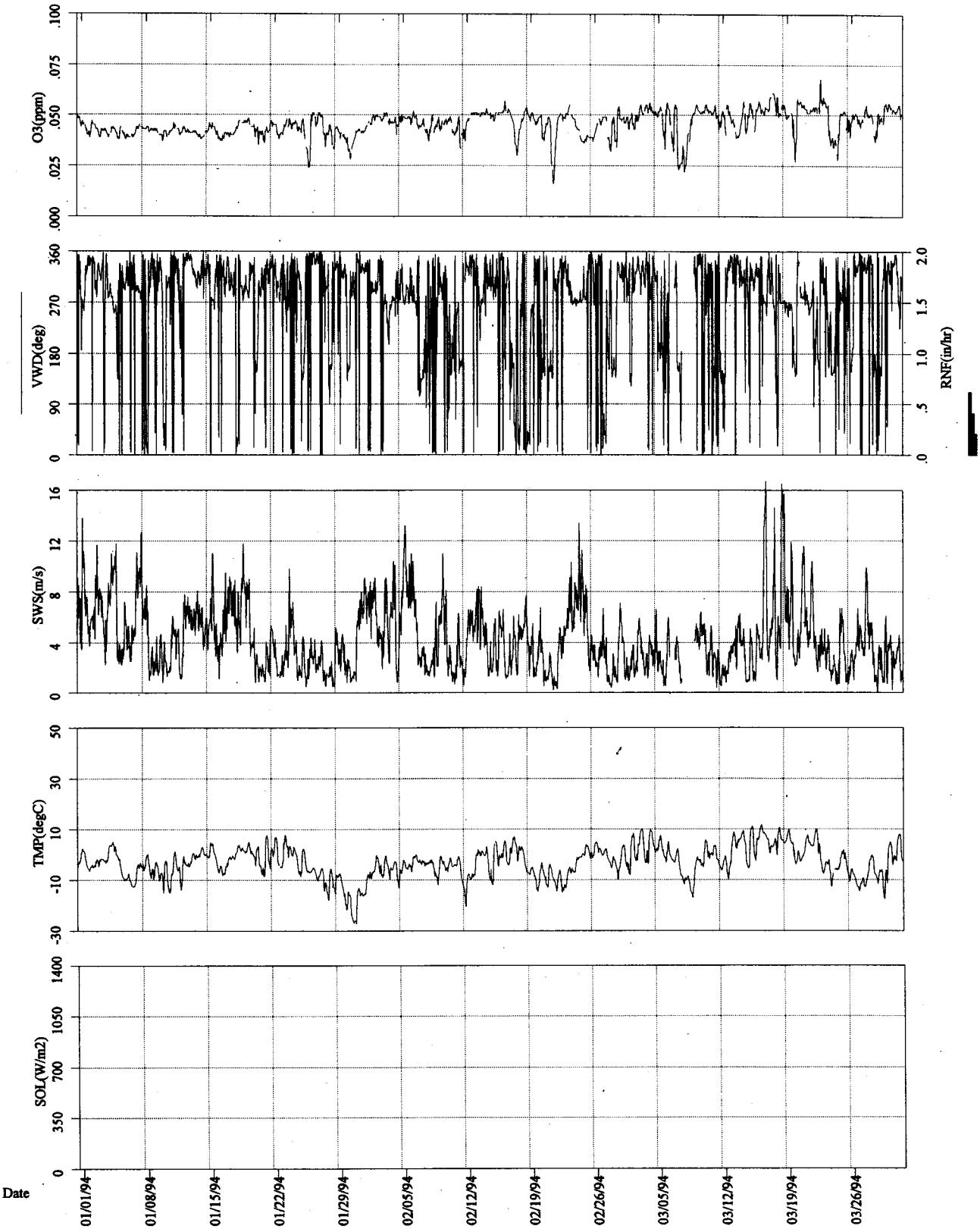
Notes: All statistics are for hourly averages.
The number collected does not include normal maintenance or events beyond the control of the network.
The percent valid is calculated against the number possible.
Automatic zeros and spans are performed daily on most ambient gas analyzers, therefore, no ambient data can be collected during this time. As a result, the maximum percent valid for ambient gas data typically can not be greater than 95.8.

NPS Performance Goals:

Quarterly Criteria:	Monthly Criteria:
100% of sites, >= 85% valid data capture	100% of sites, >= 60% valid data capture
90% of sites, >= 90% valid data capture	90% of sites, >= 75% valid data capture
80% of sites, >= 95% valid data capture	80% of sites, >= 85% valid data capture

* The validity of dew point and calculated relative humidity data is currently under investigation.

Rocky Mountain National Park

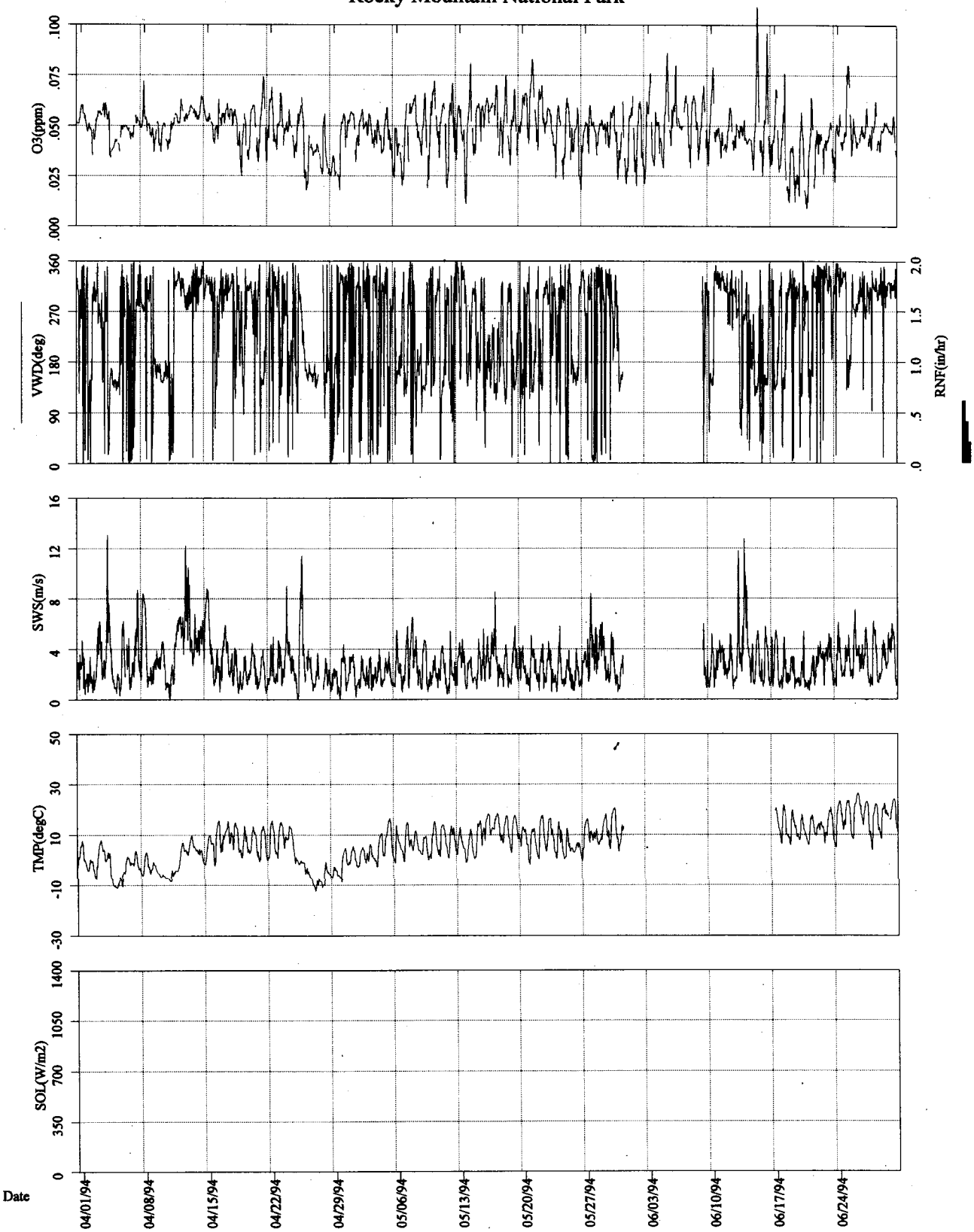


Final Validation

First Quarter 1994

romo94.stk - romo94.dat 08-06-1997

Rocky Mountain National Park



Final Validation

Second Quarter 1994

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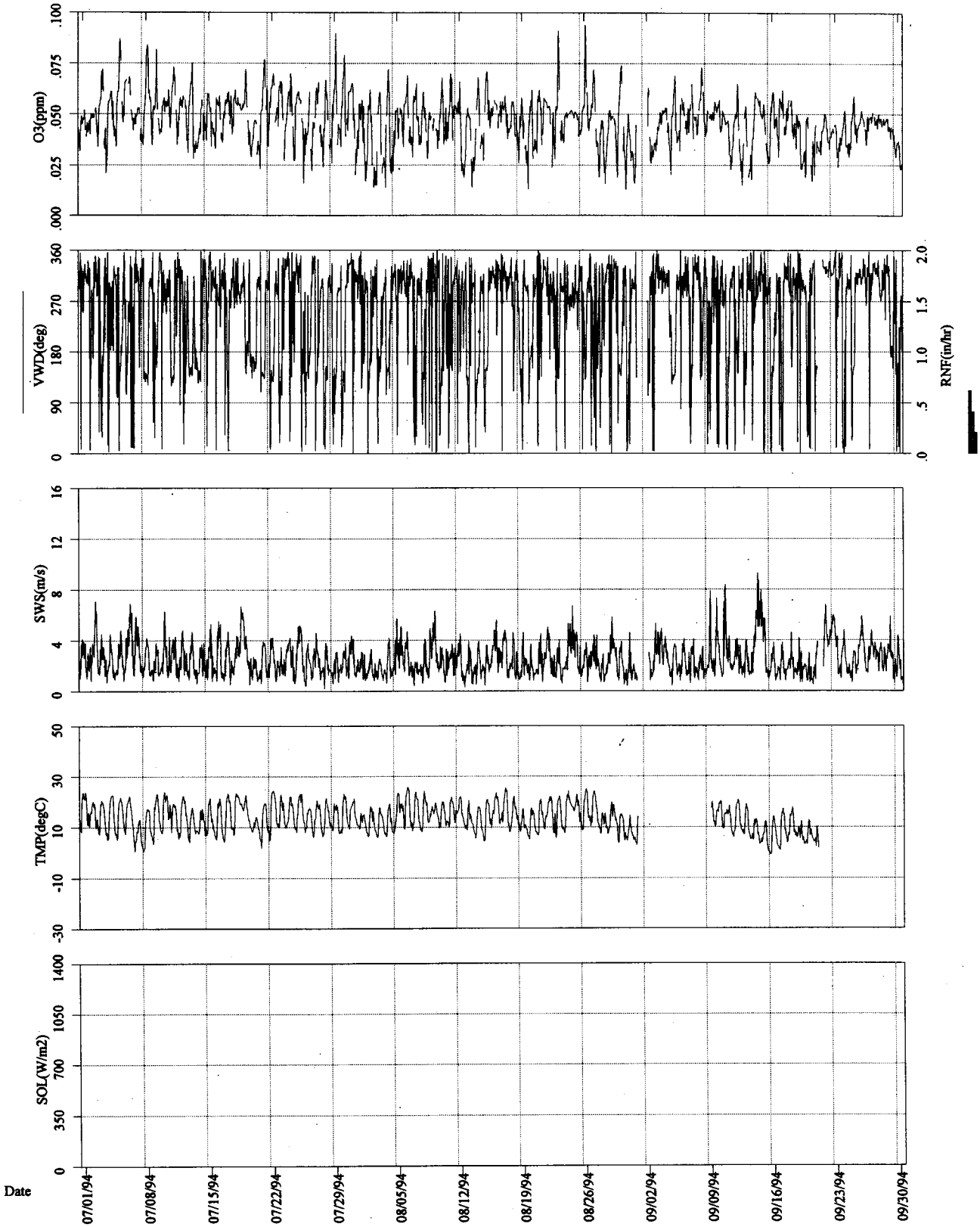
Rocky Mountain National Park

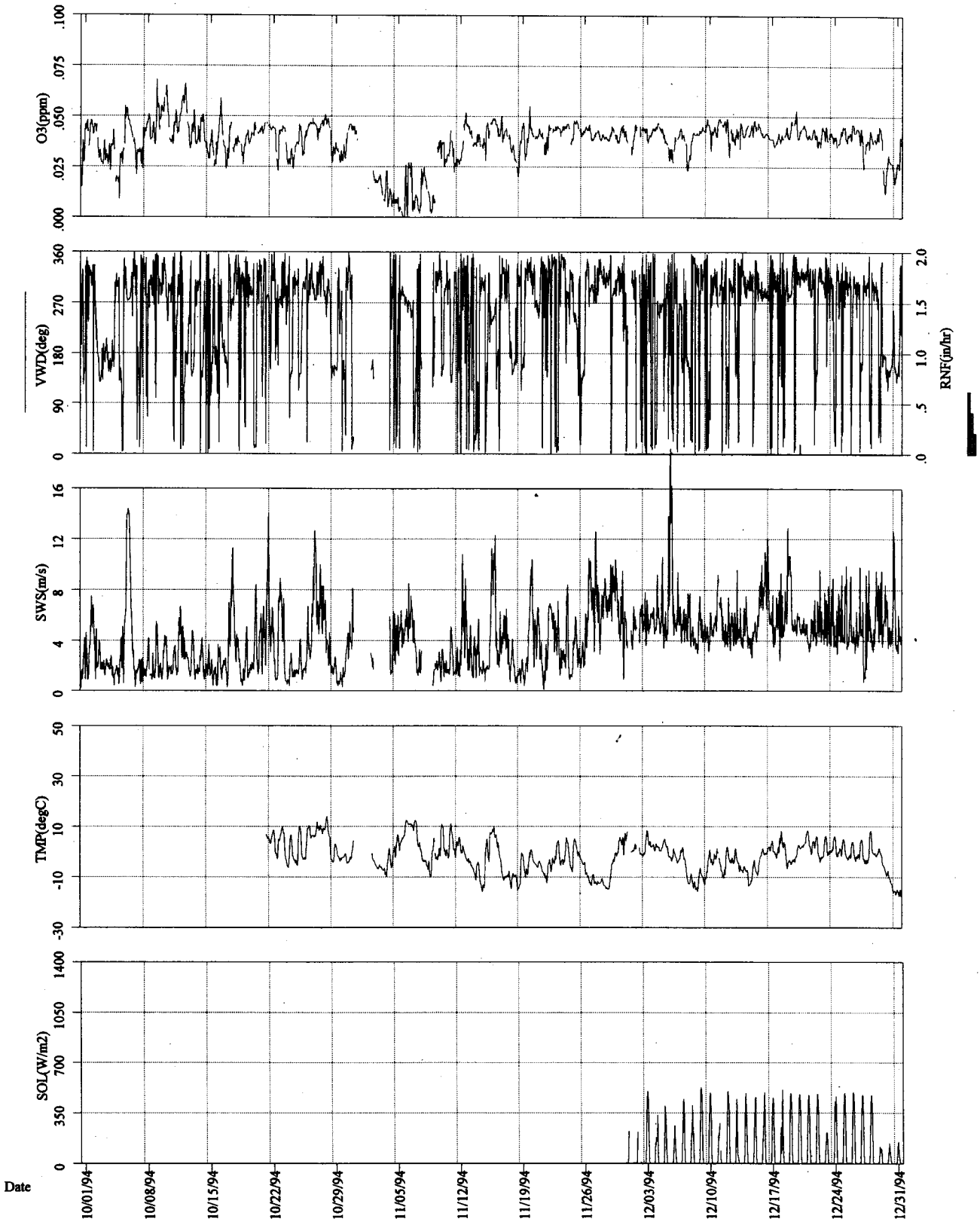


Final Validation

Third Quarter 1994

romo94.stk - romo94.dat 08-06-1997

Rocky Mountain National Park



Final Validation

Fourth Quarter 1994

romo94.stk - romo94.dat 08-06-1997

2.2 OZONE DATA SUMMARY

Ozone Precision Check Summary
Rocky Mountain National Park

Precision checks are required by the Environmental Protection Agency (EPA) of all monitoring instruments collecting data which are to be submitted to the EPA Aerometric Information Retrieval System (AIRS). A precision check is performed by challenging the pollutant analyzer with a known concentration of gas (between 0.08 and 0.10 ppm for ozone and sulfur dioxide) from the pollutant transfer standard. This precision check must be performed at least every 14 days of monitoring operation. The percent difference between the analyzer and the transfer standard is then calculated.[1] According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard. The table below gives the number of precision checks performed during each quarter, the average[2] of all the individual precision check percent differences for the quarter, and the upper and lower 95% probability limits[3] for precision checks. The probability limits represent the interval having a 95% chance of containing the true average percent difference. The quarterly average percent difference and probability limits should ideally be within +/- 10%.

Final Data 01/01/94 - 12/31/94				
Calendar Quarter	Number of Precision Checks	Average Percent Difference[1,2]	Lower 95% Probability Limit[3]	Upper 95% Probability Limit[3]
1	13	1.56	-1.53	4.64
2	0			
3	0			
4	0			

[1] Percent Difference= $\frac{\text{analyzer - transfer std}}{\text{transfer std}}$ X 100.

[2] Average Percent Difference is the mean of all individual precision check percent differences during the quarter.

[3] Upper/Lower 95% Probability Limits=(Average Percent Difference) +/- (1.96)(Standard Deviation of precision check percent differences in the quarter.)

Ozone Quick Look Annual Summary Statistics
Rocky Mountain National Park
01/01/94 - 12/31/94

STATISTIC*	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAY-SEP	ANNUAL
DAILY 1-HR MAXIMUM	51	57	68	74	83	109	90	94	73	68	55	53	109	109
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(364)
AVERAGE DAILY MAXIMUM	45	50	55	58	63	65	67	63	55	49	40	45	62	55
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(364)
MAXIMUM DAILY MEAN	47	52	57	57	63	56	61	56	54	55	46	45	63	63
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(31)	(28)	(29)	(150)	(358)
AVERAGE DAILY MEAN	42	46	49	48	49	46	51	45	44	40	33	40	47	44
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(31)	(28)	(29)	(150)	(358)
MAX PEAK:MIN RATIO	2.125	3.063	2.391	3.111	7.364	7.111	3.813	5.143	3.600	6.111	17.500	2.647	7.364	17.500
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(31)	(27)	(29)	(150)	(357)
AVERAGE PEAK:MIN RATIO	1.210	1.376	1.372	1.631	2.272	2.501	2.231	2.640	1.967	1.795	3.063	1.452	2.330	1.954
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(31)	(27)	(29)	(150)	(357)
MAX 9AM-4PM AVERAGE	49	53	57	64	75	79	70	63	57	60	47	47	79	79
NO. OF DAYS	(30)	(27)	(31)	(29)	(30)	(27)	(30)	(28)	(24)	(28)	(27)	(28)	(139)	(339)
MONTHLY 9AM-4PM AVERAGE	43	47	50	51	57	53	57	55	49	42	34	40	54	48
NO. OF DAYS	(30)	(27)	(31)	(29)	(30)	(27)	(30)	(28)	(24)	(28)	(27)	(28)	(139)	(339)
MAX 7AM-7PM AVERAGE	49	53	56	63	73	72	70	65	60	60	47	46	73	73
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(30)	(28)	(29)	(150)	(357)
MONTHLY 7AM-7PM AVERAGE	42	47	49	50	55	53	57	53	48	42	33	40	53	48
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(27)	(30)	(28)	(29)	(150)	(357)
MONTHLY MEAN	42	46	49	48	50	46	51	45	43	40	33	40	47	44
NO. OF DAYS	(706)	(638)	(708)	(680)	(703)	(681)	(705)	(697)	(639)	(699)	(641)	(686)	(3425)	(8183)
SUM0 EXPOSURE INDEX	29625	29183	34579	32769	34809	31231	35638	31617	27645	27841	20939	27203	160940	363079
NO. OF DAYS	(706)	(638)	(708)	(680)	(703)	(681)	(705)	(697)	(639)	(699)	(641)	(686)	(3425)	(8183)
SUM60 EXPOSURE INDEX	.	.	561	3401	*8177	5926	10152	4327	1406	636	.	.	29988	34586
NO. OF DAYS	(0)	(0)	(9)	(54)	(126)	(85)	(153)	(64)	(22)	(10)	(0)	(0)	(450)	(523)
SUM80 EXPOSURE INDEX	.	.	.	.	326	1220	838	530	.	.	.	.	2914	2914
NO. OF DAYS	(0)	(0)	(0)	(0)	(4)	(14)	(10)	(6)	(0)	(0)	(0)	(0)	(34)	(34)
W126 EXPOSURE INDEX	1439	2387	4372	4948	6936	5651	8025	5007	2819	1789	809	1137	28437	45316
NO. OF DAYS	(706)	(638)	(708)	(680)	(703)	(681)	(705)	(697)	(639)	(699)	(641)	(686)	(3425)	(8183)

Concentrations in parts per billion (ppb)
Exposures in parts per billion-hours (ppb-hr)

* Statistics defined in Section 4.1 Glossary

Ozone Annual Frequency Distribution
Rocky Mountain National Park

01/01/94 - 12/31/94

% Obs	# Obs	Min. Obs.	Percentile 10	30	50	70	90	95	99	Max. Obs.	2nd Max.	Arith. Mean	Geometric Mean	Geometric Std. Dev.
94	4813	.035	.050	.055	.059	.064	.074	.080	.094	.109	.096	.0608	.0599	1.18

Concentrations in parts per million (ppm).

Notes:
1 % Obs. is the percent of # valid observations / # possible observations during the AIRS Monitoring Season.
2 # Obs. is the total possible observations during the AIRS Monitoring Season.
3 Min. Obs. is the minimum daily maximum recorded during the AIRS Monitoring Season.
4 The data selected for the remainder of the table is determined by the AIRS Monitoring Season as defined in the AIRS Geo-Common file for the state in which the site resides.

Ozone Standards Report and
Daily Maximum 1-Hour Concentrations (ppm)
Rocky Mountain National Park
01/01/94 - 12/31/94

Day	Jan-94		Feb-94		Mar-94		Apr-94		May-94		Jun-94		Jul-94		Aug-94		Sep-94		Oct-94		Nov-94		Dec-94	
1	.050	S		T	.054	T	.060	F	.057	S	.065	W	.052	F	.057	M		T	.048	S	.050	T		T
2	.047	S	.050	W	.051	W	.054	S	.058	M	.062	T	.053	S	.062	T		F	.048	S	.039	W		F
3	.044	M	.051	T	.055	T	.059	S	.056	T	.076	F	.072	S	.061	W	.047	S	.038	M	.020	T	.045	S
4		T	.049	F	.056	F	.061	M	.053	W	.057	S	.061	M	.072	T	.053	S	.043	T	.044	F	.047	S
5	.044	W	.050	S	.054	S	.050	T	.059	T	.086	S	.087	T	.053	F	.069	M	.055	W	.039	S	.044	M
6	.041	T	.052	S	.056	S	.050	W	.049	F	.080	M		W	.069	S		T	.054	T	.036	S	.040	T
7	.045	F	.048	M	.055	M		T	.061	S		T	.053	T	.065	S	.065	W	.044	F	.045	M	.044	W
8	.044	S	.050	T	.045	T	.072	F	.065	S	.065	W	.084	F	.061	M	.073	T	.051	S	.035	T	.042	T
9	.043	S	.049	W	.055	W	.052	S	.066	M	.070	T	.082	S		T	.052	F	.068	S		W	.045	F
10	.042	M	.049	T	.055	T	.051	S	.072	T	.079	F	.058	S	.068	W	.057	S	.065	M	.035	T	.049	S
11	.046	T	.049	F	.055	F	.056	M	.061	W	.049	S	.073	M	.070	T	.052	S	.053	T	.039	F	.049	S
12	.044	W	.051	S	.055	S	.063	T	.071	T	.059	S	.059	T	.066	F	.065	M	.066	W	.044	S	.049	M
13	.043	T	.051	S	.055	S	.060	W	.060	F	.051	M	.075	W	.053	S		T	.053	T	.048	S	.047	T
14	.042	F	.053	M	.057	M	.065	T	.081	S	.053	T	.057	T	.068	S	.061	W	.051	F	.038	M	.047	W
15	.046	S	.051	T	.056	T	.060	F	.061	S	.109	W	.060	F	.071	M	.057	T	.043	S	.047	T	.048	T
16	.042	S	.057	W	.057	W	.063	S	.064	M	.096	T	.059	S		T	.061	F	.059	S	.046	W	.045	F
17	.041	M	.053	T	.061	T	.061	S	.070	T	.068	F	.061	S	.059	W	.062	S	.047	M	.046	T	.041	S
18	.047	T	.053	F	.061	F	.058	M	.075	W	.076	S	.062	M	.056	T	.057	S	.040	T	.036	F	.042	S
19	.048	W	.054	S	.055	S	.056	T	.068	T	.040	S	.072	T	.058	F	.050	M	.043	W	.040	S	.048	M
20	.045	T	.050	S	.058	S	.060	W	.066	F	.057	M	.047	W	.062	S		T		T	.049	S	.053	T
21	.045	F	.049	M	.056	M	.074	T	.083	S	.064	T	.077	T	.062	S	.045	W		F	.039	M	.046	W
22	.047	S	.051	T	.054	T	.069	F	.070	S	.048	W	.070	F	.058	M	.050	T	.046	S	.040	T	.044	T
23	.048	S	.055	W	.068	W	.066	S	.059	M	.052	T	.066	S		T	.045	F	.045	S	.039	W	.045	F
24	.048	M	.049	T	.043	T	.058	S	.060	T	.056	F	.070	S	.051	W	.052	S	.035	M	.041	T	.042	S
25	.048	T	.040	F	.052	F	.064	M	.064	W	.080	S	.061	M	.052	T	.059	S	.046	T	.043	F	.045	S
26	.051	W	.048	S	.051	S	.056	T	.059	T	.054	S	.061	T	.094	F	.052	M	.049	W	.041	S	.046	M
27	.051	T	.049	S	.053	S	.041	W	.058	F	.059	M	.066	W	.072	S	.051	T	.048	T	.043	S	.044	T
28	.045	F	.049	M	.055	M	.056	T	.060	S		T	.067	T	.047	S	.050	W	.051	F	.039	M	.043	W
29	.044	S			.051	T	.035	F	.053	S	.052	W	.090	F	.052	M	.048	T	.037	S	.041	T	.045	T
30	.040	S			.056	W	.056	S	.060	M	.055	T	.079	S	.074	T	.040	F	.044	S	.043	W	.031	F
31	.043	M			.055	T				T			.065	S	.050	W			.046	M			.040	S
Valid Days	30		27		31		29		30		28		30		28		25		29		29		29	
Maximum	.051		.057		.068		.074		.083		.109		.090		.094		.073		.068		.050		.053	
Violations																								

8219 Total Samples
93.8 % Possible
345 Valid daily maxima

0 Daily-maxima exceeding the standard of .125 ppm (starred[*])
14 Missing days assumed to be less than the standard
0 Daily maximums exceed the alert level of .200 ppm

Concentrations in parts per million (ppm)

EPA Proposed Primary Ozone Standards Attainment Status

Rocky Mountain NP

1994 Attainment Status With U.S. Environmental Protection Agency (EPA)
Proposed PRIMARY Ozone National Ambient Air Quality Standards
(61FR65716 December 13, 1996)

Ozone Season: March Through September

The primary National Ambient Air Quality Standard for ozone is designed to protect human health. The level of the proposed primary ozone standard is 0.08 parts per million (ppm) [80 parts per billion, (ppb)], daily maximum 8-hour average. The primary ozone standard is met at an ambient monitoring site when the 3-year average of the annual third-highest daily maximum 8-hour average ozone concentration is less than or equal to 0.08 ppm. This standard is not met when the 3-year average is greater than 0.08 ppm. Using the EPA's rounding convention, a computed 3-year average ozone concentration of 0.085 ppm (85 ppb) is the smallest value that is greater than the level of the 0.08 ppm standard.

The proposed primary standard requires 90 percent data completeness, on average, during the 3-year period, with no single year within the period having less than 75 percent data completeness. This data completeness requirement would have to be satisfied in order to determine that the standard has been met at a monitoring site. However, calendar years with less than 75 percent data completeness are included in the computation if the annual third highest daily maximum 8-hour concentration is greater than the level of the standard. A site could be found not to have met the standard with less than complete data. The percent data completeness is the percent of valid ozone monitoring days. A day is valid if valid 8-hour averages are available for at least 75 percent of possible hours in the day (i.e., at least 18 of the 24 averages). An 8-hour average is considered valid if at least 75 percent (or 6) of the hourly averages for the 8-hour period are available.

The table below lists the 3-year average third highest daily maximum 8-hour ozone concentration based on data collected in 1994 and the two previous years. This is the number to compare to the level of the proposed primary standard. The 3-year average data completeness percent and the 1994 highest five daily maximum 8-hour averages are also tabulated. A * in the Data Comp % Met? column indicates EPA data completeness requirement was not met for the three year period.

Year	3-Year Avg 3rd High Daily Max 8-hr Ozone (ppb)	3-Year Avg Data Comp %	Data Comp % Met?	Annual 1st High Daily Max 8-hr Ozone (ppb)	Annual 2nd High Daily Max 8-hr Ozone (ppb)	Annual 3rd High Daily Max 8-hr Ozone (ppb)	Annual 4th High Daily Max 8-hr Ozone (ppb)	Annual 5th High Daily Max 8-hr Ozone (ppb)
1994	74	95		83	81	77	77	76

EPA Proposed Secondary Ozone Standards Attainment Status

Rocky Mountain NP

1994 Attainment Status With U.S. Environmental Protection Agency (EPA) Proposed SECONDARY Ozone National Ambient Air Quality Standards (61FR65716 December 13, 1996)

Ozone Season: March Through September

The secondary National Ambient Air Quality Standard for ozone is designed to protect human welfare. Welfare effects include, but are not limited to, effects on vegetation, wildlife, property and materials, visibility and climate. The proposed secondary ozone standard is based on a 3-month cumulative index that sums all ambient hourly concentrations greater than or equal to 0.06 ppm (or 60 ppb, parts per billion) during the hours 8:00 am to 8:00 pm local standard time. This standard is met at an ambient air quality monitoring site when the annual maximum cumulative index value (SUM06) based on a consecutive 3-month period is less than or equal to 25 parts per million-hours (ppm-hr). If the concentrations are expressed in ppb, then the index value is SUM60 and the standard level is 25,000 parts per billion-hours (ppb-hr). The standard is not met if the annual maximum 3-month SUM06 is greater than 25 ppm-hr. Using the EPA's rounding convention, a 3-month SUM06 of 26 ppm-hr is the smallest value that is greater than the level of the 25 ppm-hr standard.

The daily SUM06 index is computed at the monitoring site for each calendar day in each month during the ozone monitoring season. A month is considered a valid ozone monitoring month if ozone concentrations are available for at least 75 percent of all possible 8 am to 8 pm hours in the month. For months with greater than 75 percent data completeness, the monthly total SUM06 is adjusted for missing data by multiplying the unadjusted SUM06 monthly index value by the ratio of the number of possible daylight hours to the number of daylight hours with valid ambient hourly concentrations.

The table below lists the 1994 annual maximum 3-month cumulative SUM06 and the ending month of the 3-month period in which this maximum was calculated.

Year	Ending Month of 3-month period with maximum SUM06	Maximum 3-Month Cumulative SUM06 (ppm-hr)
1994	JUL	23

Ozone
Ten Highest Daily 1-Hour Average Maximum Concentrations
Rocky Mountain National Park

Final Data
01/01/94 - 12/31/94

Rank	Date	Hour	Concentration (ppm)
1	06/15/94	14	0.109*
2	06/16/94	16	0.096*
3	08/26/94	15	0.094*
4	08/23/94	15	0.091*
5	07/29/94	16	0.090
6	07/05/94	15	0.087*
7	06/05/94	15	0.086
8	07/08/94	16	0.084*
9	05/21/94	14	0.083*
10	07/09/94	16	0.082**

* Other high value(s) were also recorded during one or more hours in the day.
** This value was also recorded on one or more days later in the reporting period.

Note: The primary and secondary ambient air standard for ozone is 0.12 ppm averaged over a one hour period not to be exceeded more than once per year. (A value greater than .12 ppm, 124 ppb, or 235 ug/m^3 exceeds the standard.) (40 CFR 50.9 with reference to Appendix D and H.)

Episodes with 1-Hour Ozone Concentrations
≥ 100 ppb and > 124 ppb
Rocky Mountain National Park

Final Data
01/01/94 - 12/31/94

Date	Beginning Hour	No. Hours > 100 ppb	No. Hours >124 ppb	Max (ppb)
06/15/94	14	2	0	109
Total		2	0	109

Note: The primary and secondary ambient air standard for ozone is 0.12 ppm over a one hour period not to be exceeded more than once per year. (A value greater than .12 ppm, 124 ppb, or 235 ug/m3 exceeds the standard.) (40 CFR 50.9 with reference to Appendix D and H.)

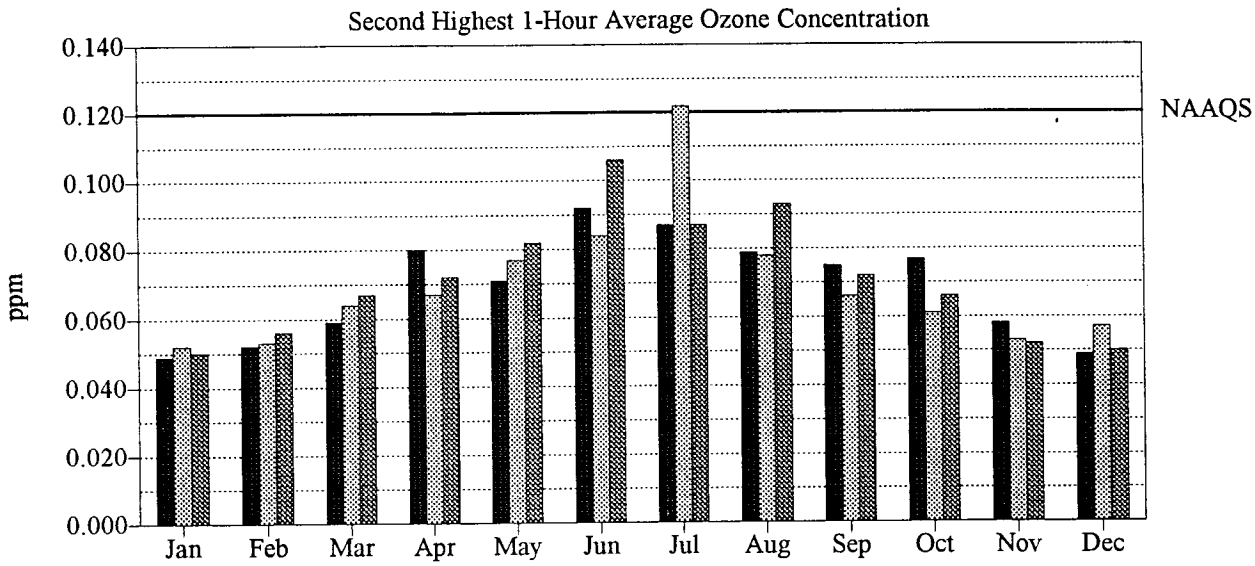
Ozone Rank Listings of Second Highest 1-Hour Average Concentrations, Maximum 8-Hour Average Concentrations, and Annual SUM60 Exposure Index for All NPS Monitoring Sites
01/01/94 - 12/31/94

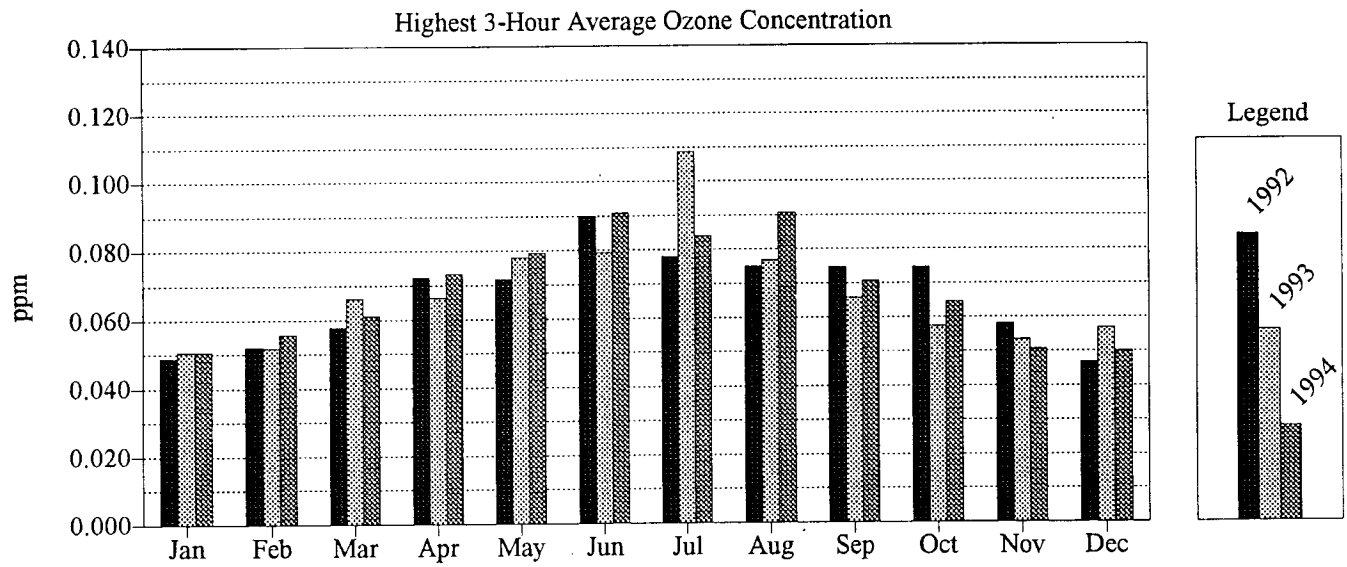
Second Highest 1-Hour Average Concentration		
Site	Rank	Concentration (ppb)
JOTR-YV	1	147
SEKI-AM	2	126
SEKI-LK	3	124
SEKI-GG	4	123
INDU-HQ	5	121
CHAM-XX	6	115
GRSM-CM	7	115
GRSM-LR	8	114
YOSE-TD	9	112
CACO-XX	10	109
GRSM-CC	11	109
ROMO-LP	12	106
MACA-OC	13	102
SAGU-PC	14	102
GRSM-CD	15	101
COWP-XX	16	99
DEVA-PV	17	98
YOSE-YV	18	97
PINN-ES	19	96
SHEN-DR	20	96
YOSE-CM	21	96
MORA-TW	22	95
ACAD-ST	23	95
SHEN-BM	24	93
YOSE-WV	25	92
LAVO-ML	26	91
COSW-XX	27	90
SHEN-SR	28	89
EVER-BC	29	85
BAND-XX	30	85
BIBE-KB	31	80
THRO-NO	32	78
CHIR-ES	33	77
GRCA-AB	34	76
GRBA-MY	35	74
CANY-IS	36	72
VOYA-BB	37	71
MEVE-MY	38	70
YELL-LY	39	70
CRMO-VC	40	69
OLYM-VC	41	60
GLAC-WG	42	60
HAVO-VC	43	53
DENA-HQ	44	52
REDW-RQ	45	50
HALE-OL	46	49

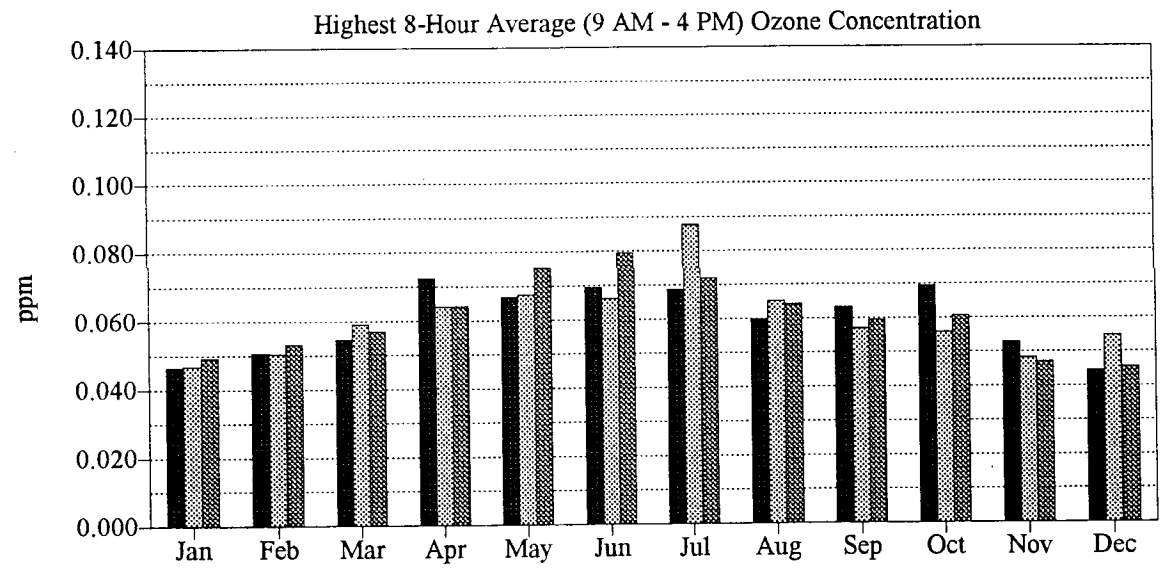
Maximum 8-hour Average Concentration (9 a.m. to 4 p.m.)		
Site	Rank	Concentration (ppb)
SEKI-LK	1	120
SEKI-GG	2	115
SEKI-AM	3	110
JOTR-YV	4	105
GRSM-CM	5	102
GRSM-LR	6	101
CHAM-XX	7	100
INDU-HQ	8	100
GRSM-CC	9	93
YOSE-TD	10	92
COWP-XX	11	91
YOSE-CM	12	90
GRSM-CD	13	89
YOSE-WV	14	88
DEVA-PV	15	88
MACA-OC	16	87
CACO-XX	17	87
SHEN-BM	18	85
MORA-TW	19	84
LAVO-ML	20	82
SHEN-SR	21	81
SHEN-DR	22	81
COSW-XX	23	80
BAND-XX	24	79
SAGU-PC	25	79
ROMO-LP	26	79
PINN-ES	27	78
YOSE-YV	28	78
BIBE-KB	29	73
EVER-BC	30	73
GRCA-AB	31	73
CHIR-ES	32	73
GRBA-MY	33	71
ACAD-ST	34	70
CANY-IS	35	68
VOYA-BB	36	65
CRMO-VC	37	64
YELL-LY	38	63
MEVE-MY	39	63
THRO-NO	40	60
GLAC-WG	41	55
DENA-HQ	42	52
HAVO-VC	43	50
HALE-OL	44	47
OLYM-VC	45	47
REDW-RQ	46	46

Annual Sum60 Exposure Index			
Site	Rank	Sum60	Count
JOTR-YV	1	204998	2696
SEKI-AM	2	176692	2281
SEKI-GG	3	167318	2180
SEKI-LK	4	143409	1805
YOSE-TD	5	139732	1966
GRSM-CM	6	101988	1470
DEVA-PV	7	95477	1406
GRSM-LR	8	94635	1366
SHEN-BM	9	73793	1101
YOSE-CM	10	69702	1015
SAGU-PC	11	60158	885
GRSM-CD	12	52963	796
SHEN-DR	13	50335	753
LAVO-ML	14	48090	711
PINN-ES	15	44901	655
COWP-XX	16	42881	619
YOSE-YV	17	40334	600
CHIR-ES	18	39280	617
YOSE-WV	19	34803	517
SHEN-SR	20	34758	518
ROMO-LP	21	34586	523
CACO-XX	22	31976	455
BAND-XX	23	31654	494
CANY-IS	24	30314	483
MACA-OC	25	29076	422
GRCA-AB	26	24570	386
BIBE-KB	27	22661	355
INDU-HQ	28	21966	311
GRBA-MY	29	20197	318
CHAM-XX	30	17526	238
CRMO-VC	31	16806	271
GRSM-CC	32	16512	239
ACAD-ST	33	14612	214
COSW-XX	34	10015	143
MEVE-MY	35	9019	145
MORA-TW	36	6347	89
YELL-LY	37	6015	96
VOYA-BB	38	3930	61
EVER-BC	39	2469	36
THRO-NO	40	1123	17
OLYM-VC	41	184	3
GLAC-WG	42	121	2
REDW-RQ	43	0	0
HALE-OL	44	0	0
HAVO-VC	45	0	0
DENA-HQ	46	0	0

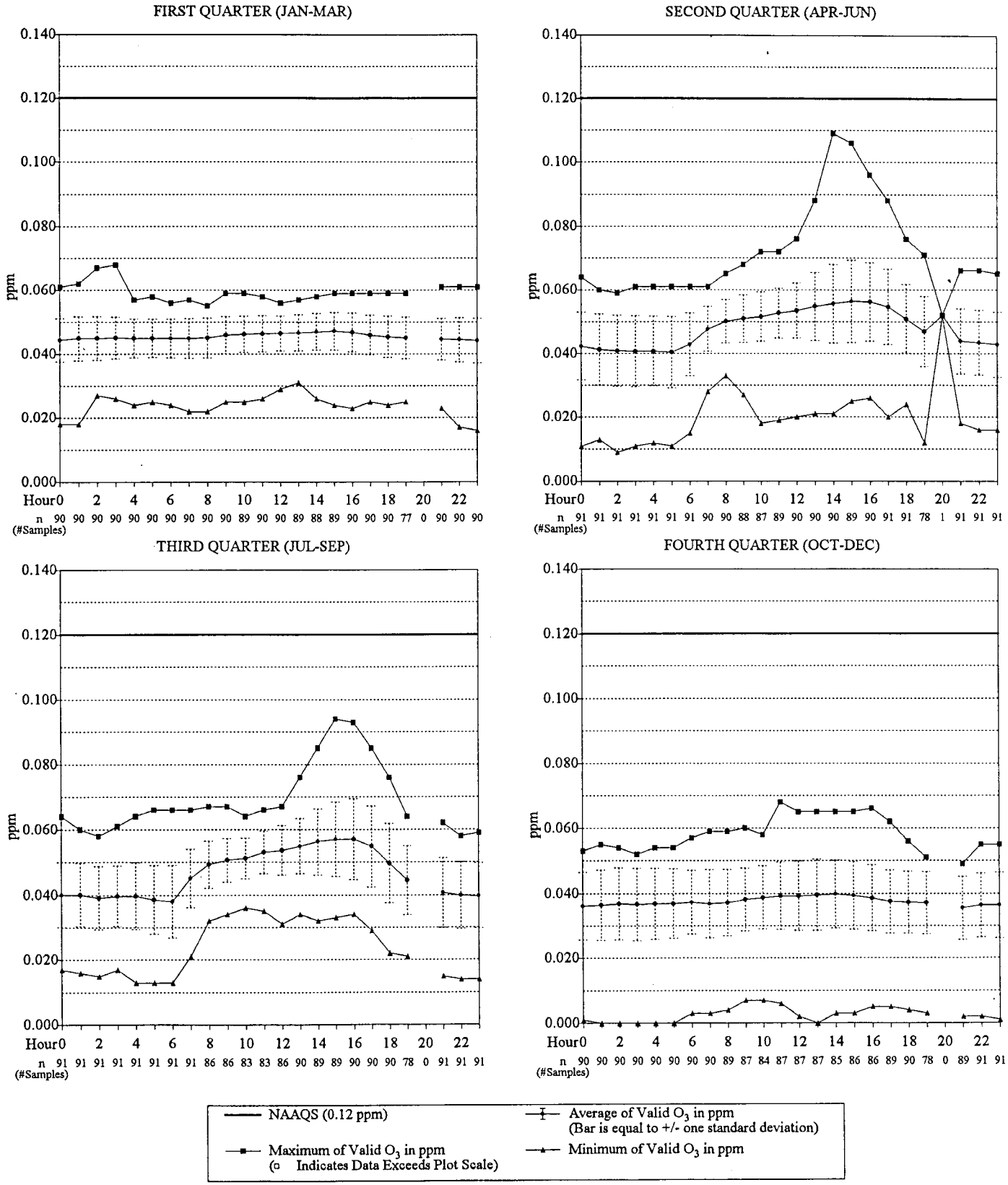
Ozone
Three Year Comparison of Second Highest Concentrations







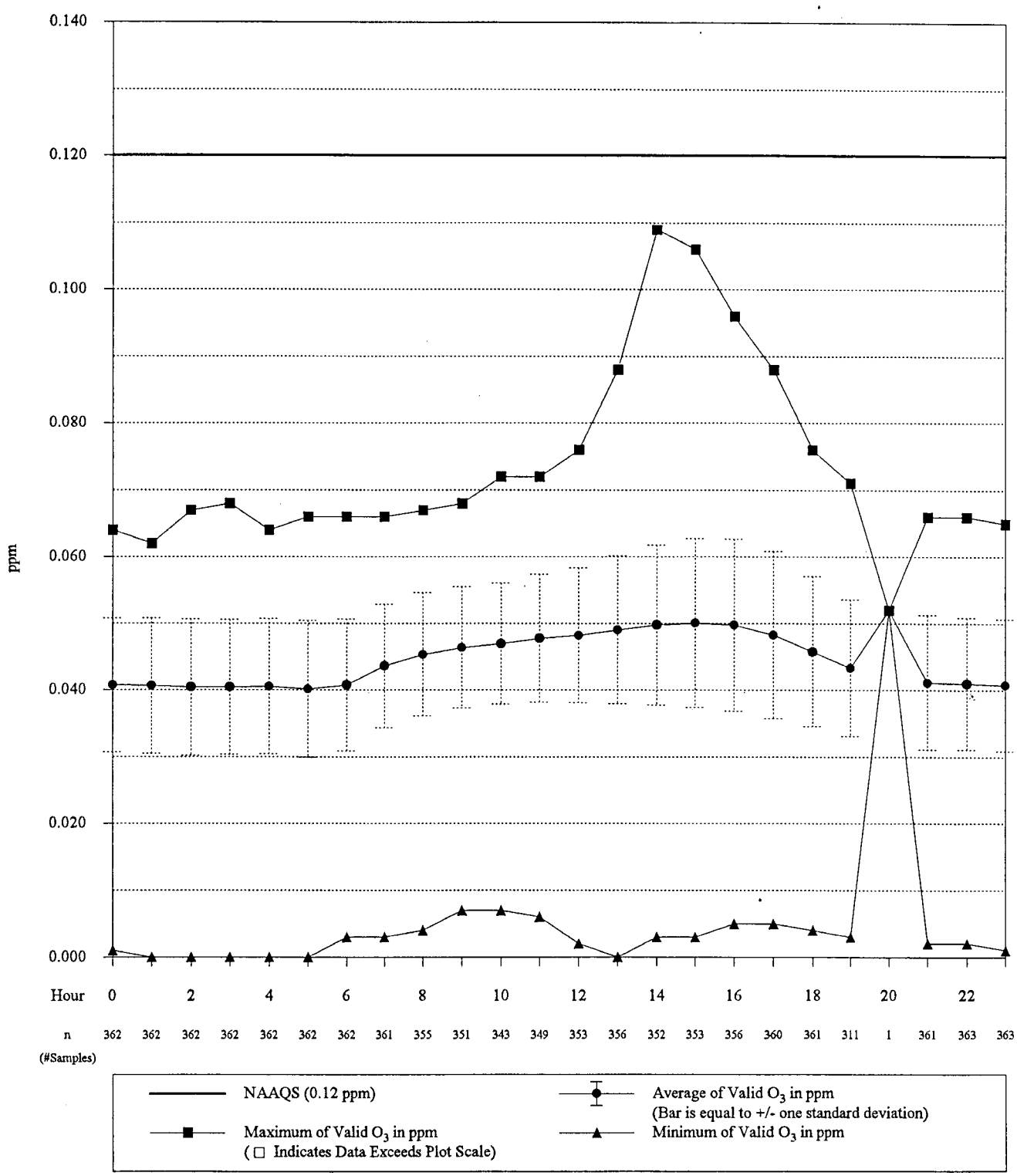
NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1994 Second Highest 1-Hour Ozone Concentrations (ppb)
OLYMPIC 60
95 MOUNT RAINIER
60 GLACIER
VOYAGEURS 71
78 THEODORE ROOSEVELT
95 ACADIA
CAPE COD 109
REDWOOD 50
CRATERS OF THE MOON 69
70 YELLOWSTONE
LASSEN VOLCANIC 91
121 INDIANA DUNES
YOSEMITE 112
GREAT BASIN 74
106 ROCKY MOUNTAIN
PINNACLES 96
CANYONLANDS 72
96 SHENENDOAH
126 SEQUOIA
DEATH VALLEY 98
MESA VERDE 70
MAMMOTH CAVE 102
76 GRAND CANYON
JOSHUA TREE 147
115 GREAT SMOKY MOUNTAINS
COWPENS 99
85 BANDELIER
90 CONGAREE SWAMP
SAGUARO 102
CHIRICAHUA 77
CHAMIZAL 115
HALEAKALA 49
Hawaii
HAWAII VOLCANOES 53
BIG BEND 80
52 DENALI
85 EVERGLADES
ALASKA


FIRST QUARTER (JAN-MAR)
SECOND QUARTER (APR-JUN)
THIRD QUARTER (JUL-SEP)
FOURTH QUARTER (OCT-DEC)
ppm
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Hour 0 2 4 6 8 10 12 14 16 18 20 22
n (#Samples)
NAAQS (0.12 ppm)
Average of Valid O3 in ppm
(Bar is equal to +/- one standard deviation)
Maximum of Valid O3 in ppm
(□ Indicates Data Exceeds Plot Scale)
Minimum of Valid O3 in ppm

Rocky Mountain National Park

Annual Diurnal Ozone Plot

1994



Final Validation

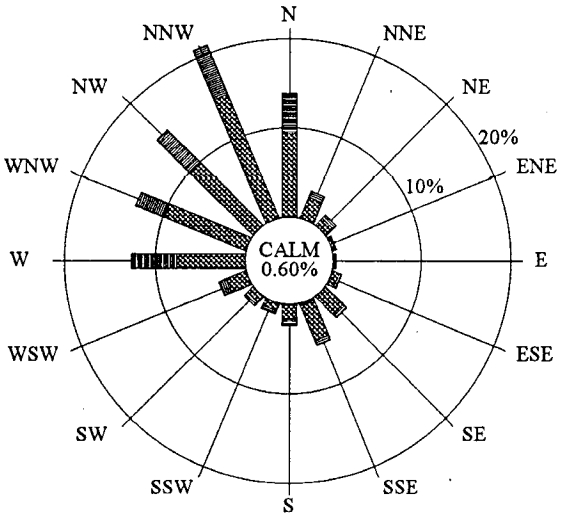
08-08-1997

Rocky Mountain National Park

Quarterly Ozone Pollutant Roses

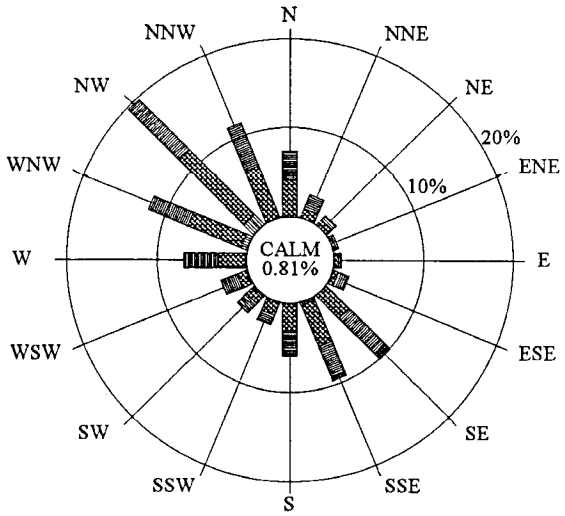
1994

FIRST QUARTER (JAN-MAR)



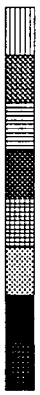
92.7% Collected 92.7% Valid
2160 Possible /2002 Collected /2002 Valid

SECOND QUARTER (APR-JUN)



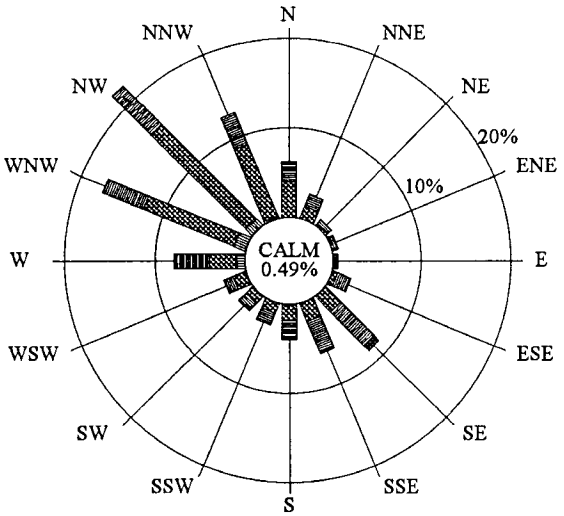
93.7% Collected 84.6% Valid
2184 Possible /2046 Collected /1848 Valid

Ozone (ppm)



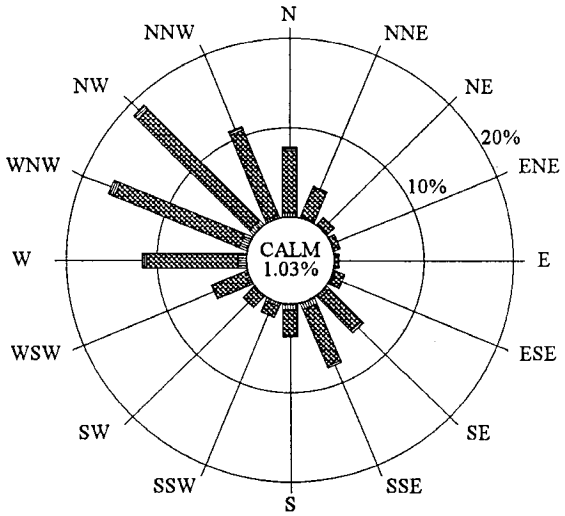
0.000-0.024
0.025-0.049
0.050-0.074
0.075-0.099
0.100-0.124
0.125-0.149
0.150-0.174
0.175+

THIRD QUARTER (JUL-SEP)



93.8% Collected 93.5% Valid
2167 Possible /2032 Collected /2026 Valid

FOURTH QUARTER (OCT-DEC)

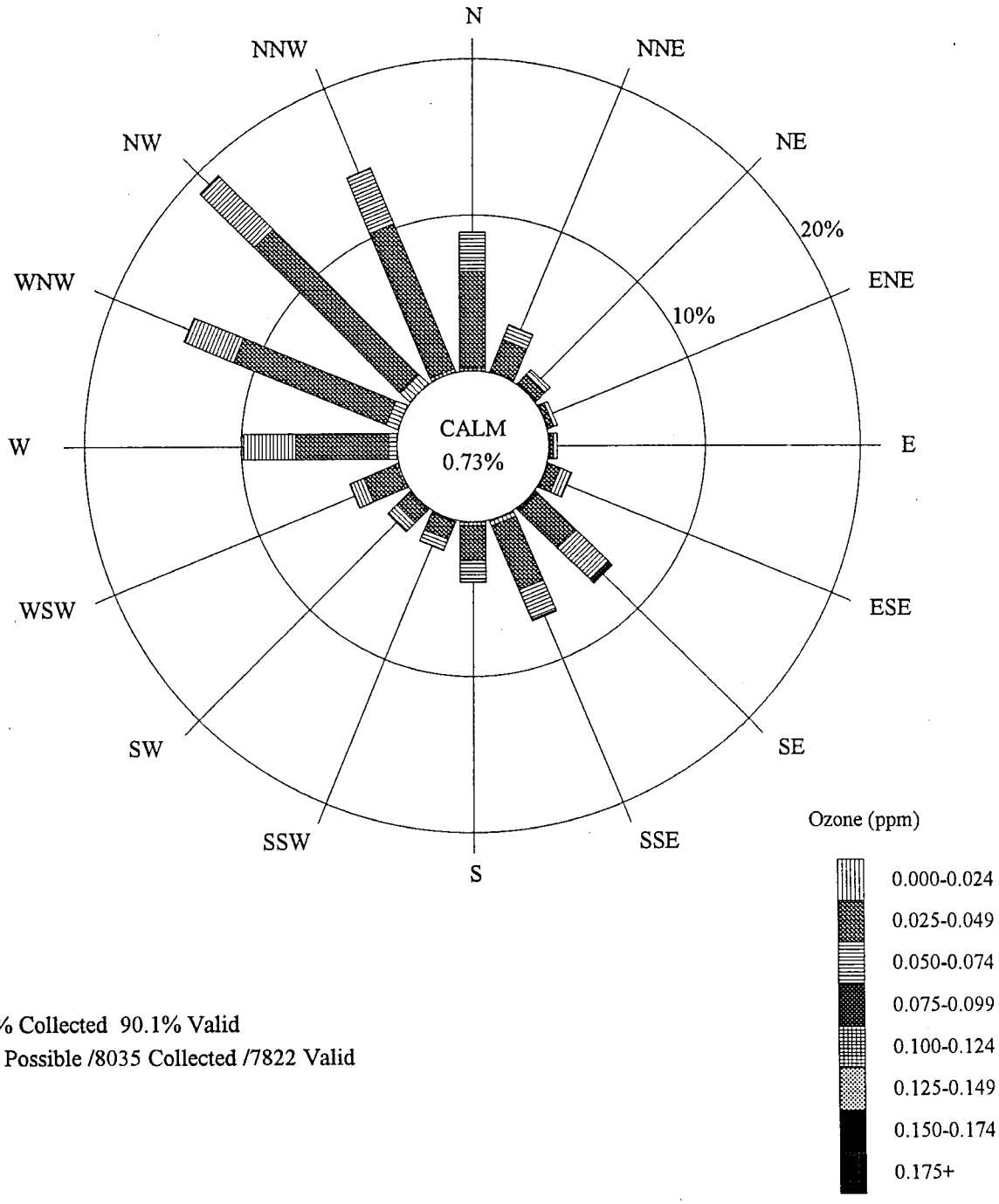


89.9% Collected 89.5% Valid
2174 Possible /1955 Collected /1946 Valid

Rocky Mountain
National Park

Annual Ozone
Pollutant Rose

1994



92.5% Collected 90.1% Valid
8685 Possible /8035 Collected /7822 Valid

Final Validation

08-08-1997

2.3 METEOROLOGICAL DATA SUMMARY

Summary of Selected Meteorological Data

Rocky Mountain National Park

Final Data

01/01/94 - 12/31/94

Parameter	Value	Units	Number	Std Dev
SCALAR WIND SPEED				
Average	7.2	mph	8293	4.8
Maximum	37.3	mph		
Percent calm = 0.43				
AMBIENT TEMPERATURE				
Average	3.5	degC	7360	9.4
Maximum	26.4	degC		
Minimum	-27.1	degC		
*RELATIVE HUMIDITY - calculated				
Average	NA			
Maximum				
Minimum				
PRECIPITATION (Rainfall or Snow melt)				
Average non-zero rate	.0	percent	7	.0
Maximum non-zero rate	.1	percent		
Minimum non-zero rate	.0	percent		
Accumulated during period	.2			
SOLAR RADIATION				
	NA			

Note: Calms are included in the average scalar wind speed and are defined as winds less than 0.5 m/s (1.0 mph). Solar radiation terms are based on the calculation of the total amount of solar energy incident on a unit area during each day. The maximum and minimum daily totals are selected from the list of daily totals. The totals for all days are then added and divided by the number of days to yield the average daily total.

NA indicates instrument not available.

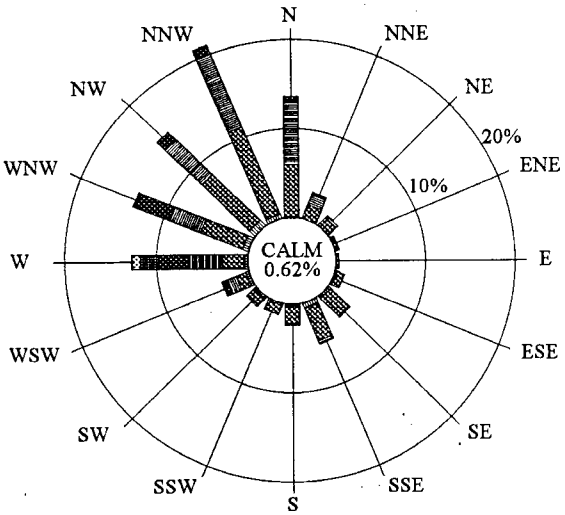
* The validity of calculated relative humidity is currently under investigation.

Rocky Mountain National Park

Quarterly Wind Roses

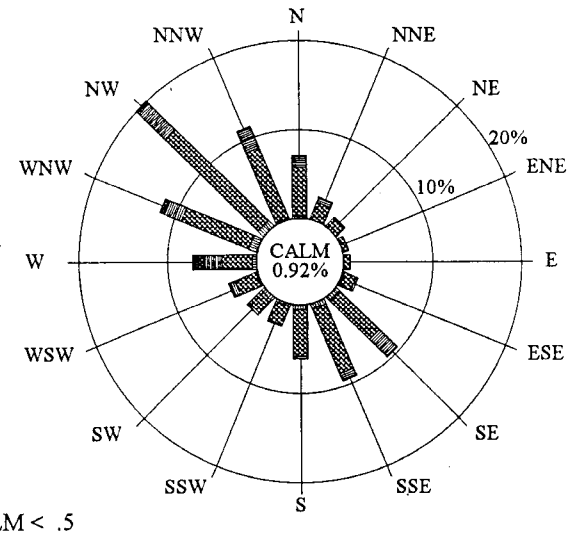
1994

FIRST QUARTER (JAN-MAR)



97.5% Collected 97.5% Valid
2160 Possible /2107 Collected /2107 Valid

SECOND QUARTER (APR-JUN)



99.1% Collected 89.5% Valid
2184 Possible /2164 Collected /1954 Valid

Wind Speed (m/s)

CALM < .5

0.5-0.9

1.0-3.9

4.0-6.9

7.0-9.9

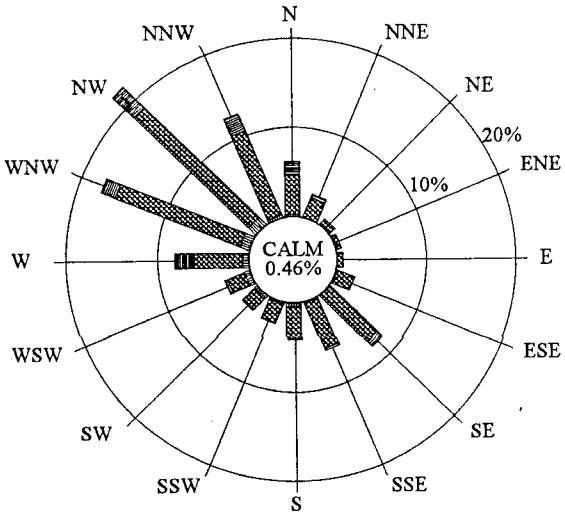
10.0-12.9

13.0-15.9

16.0-18.9

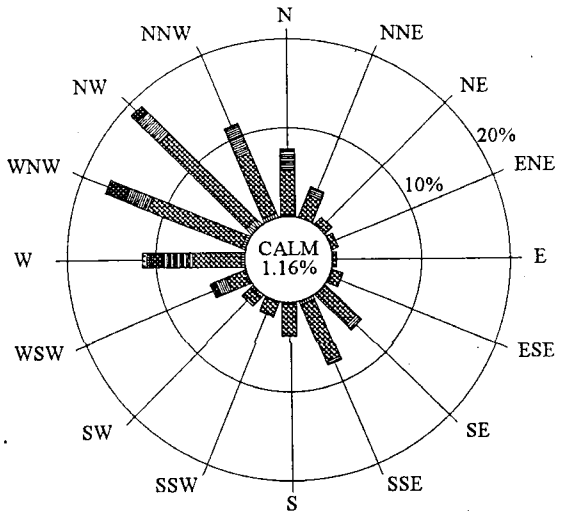
19.0+

THIRD QUARTER (JUL-SEP)



99.8% Collected 99.8% Valid
2167 Possible /2162 Collected /2162 Valid

FOURTH QUARTER (OCT-DEC)

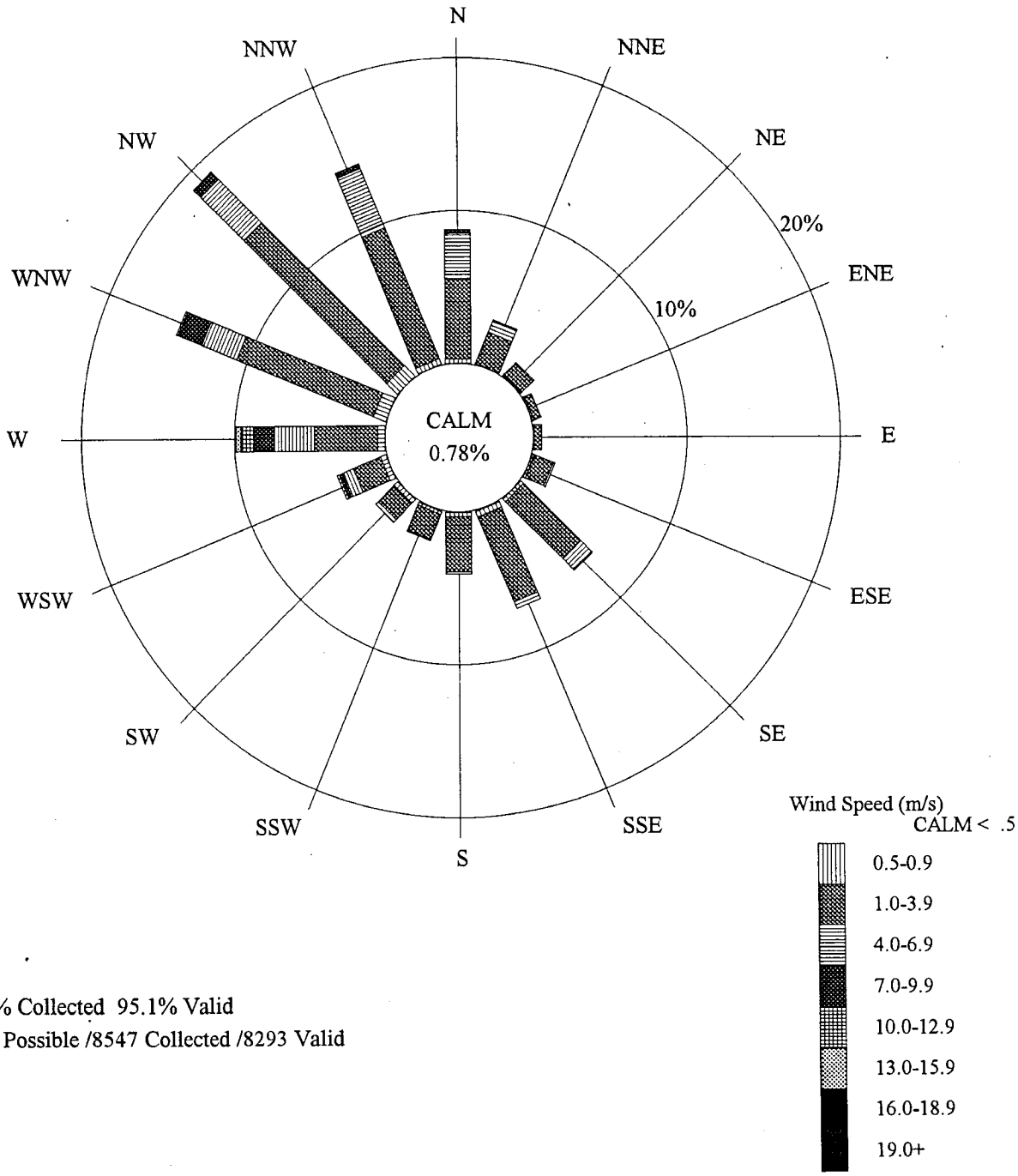


95.7% Collected 93.8% Valid
2208 Possible /2114 Collected /2070 Valid

Rocky Mountain
National Park

Annual Wind Rose

1994



98.0% Collected 95.1% Valid
8719 Possible /8547 Collected /8293 Valid

Final Validation

08-08-1997

3.0 NATIONAL PARK SERVICE AIR RESOURCES DIVISION DATA SOURCES

3.1 GUIDE TO ATTACHED DATA DISKS

The attached data disks contain ASCII files of the validated hourly data, as shown in the following table. These data may be imported into other programs to perform additional data processing and analysis. The data format of each file is included within each file. The second table describes the validation codes used in the data tables to indicate why data are missing or invalid. Wind and pollutant frequency distribution tables in ASCII format are also included on the diskette if available for this site.

Data users should acknowledge the National Park Service Air Resources Division whenever using these data or any portion of this report.

3.2 OTHER SOURCES FOR RETRIEVING NATIONAL PARK SERVICE GASEOUS POLLUTANT DATA

The data contained in this report may also be obtained from the following sources:

- National Park Service AIRWeb (http://www.aqd.nps.gov/natnet/ard) - available after last quarter 1997
- EPA AIRS database
- Data requests directed to:

NPS Air Resources Division
Information Management Center
c/o Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423
E-Mail: AIR-IMC@AIR-RESOURCE.COM

Data Disk Contents Summary	
File Name (s)	Description
ssssyy.DAT	All Validated Air Quality Data
ssssyymm.ppp	Monthly Data Summary Tables
ssssAN94.Rpp	Annual Wind and Pollutant Frequency Distribution
ssssQ194.Rpp	Quarter 1 Wind and Pollutant Frequency Distribution
ssssQ294.Rpp	Quarter 2 Wind and Pollutant Frequency Distribution
ssssQ394.Rpp	Quarter 3 Wind and Pollutant Frequency Distribution
ssssQ494.Rpp	Quarter 4 Wind and Pollutant Frequency Distribution

Where:

ssss = site code
yy = year
mm = month
ppp = air quality data parameter code
AN = Annual
Qn = Quarter 1-4
R = Wind Frequency distribution table

NPS IMC and AIRS Invalid Data Codes			
NPS IMC VAL CODE	REASON	AIRS CODE	AIRS REASON
TO	Sample time out of limits	9973	Sample time out of limits
IW	Instrument warmup	9978	Voided by operator
OE	Operator error	9978	
BM	Begin monitoring	9979	Miscellaneous void
TL	Station temp low	9979	
OS	Off scale	9979	
EM	End monitoring	9979	
LI	Local interference	9979	
TH	Station temp high	9979	
IM	Instrument malfunction	9980	Machine malfunction
IN	Interference	9981	Bad weather
RF	Recording system failure	9983	Collection error
NA	No data	9987	Monitoring waived
PF	Power failure	9988	Power Failure
PC	Precision check	9990	Precision Check
ZS	Instrument zero/span check	9991	QC Control Points (Zero/Span)
SA	System audit	9992	QC Audit
PA	Performance audit	9992	
MT	Maintenance	9993	Maintenance/Routine Repairs
OR	Out for repair	9993	
CA	Calibration	9995	Multipoint calibration
SC	Station check	9998	Precision/zero/span

4.0 GLOSSARY

4.1 DEFINITIONS AND COMPUTATIONAL PROCEDURES FOR NATIONAL PARK SERVICE QUICK LOOK ANNUAL SUMMARY STATISTICS REPORT

The National Park Service Quick Look Annual Summary Statistics Table (Page 2-9) provides ozone summary statistics for various indices computed on a monthly basis for an entire year. Growing season (generically defined to be May 1 - September 30) and annual statistics are also presented under the "MAY-SEP" and "ANNUAL" columns, respectively. All concentrations are expressed in the units of parts per billion (PPB) and exposures in parts per billion-hours (PPB-HR). The definitions for each of the statistics appearing on the Quick Look Annual Summary Table are given below.

(1) **Daily 1-Hr Maximum**. The maximum 1-hour average concentration recorded during each month, the growing season or the year regardless of the number of valid hourly observations recorded during a given day. The number in parentheses below this statistic, (N), indicates the number of days in the month, growing season, or year with valid data.

(2) **Average Daily Maximum**. The average of all Daily 1-Hr Maxima during the month regardless of the number of Daily 1-Hr Maxima recorded during the month. For the "MAY-SEP" column the average of all the Daily Maxima recorded during the growing season is given. For the "ANNUAL" column the average of all the Daily Maxima is given. N is as in (1) above.

(3) **Maximum Daily Mean**. The maximum of the valid daily means computed for each month, the growing season ("MAY-SEP" column), and the year ("ANNUAL" column). A valid daily mean is one for which 75% of the observations are available for each day, i.e., 18 hours. N is the number of days during each month, growing season, and year with at least 18 observations.

(4) **Average Daily Mean**. The average of all valid daily means for the month, the growing season ("MAY-SEP" column), and the year ("ANNUAL" column). N is as in (3) above.

(5) **Max Peak:Min Ratio**. The ratio of the Daily 1-Hr Maximum to the Daily 1-Hr Minimum. A ratio is computed only if a valid Daily Mean is computed and if the Daily 1-Hr Minimum is not equal to zero. N is the number of days with a valid Peak:Min ratio.

(6) **Average Peak:Min Ratio**. The average of all Peak:Min ratios for the month, growing season, or year. N is as in (5) above.

(7) **Max 9AM-4PM Average**. The maximum of all valid 9AM-4PM Averages computed for the month, growing season, or year. A valid 9AM-4PM Average is one which has 75% of the observations available during that time period (i.e., 6 hours. N is the number of days with valid averages.)

(8) **Monthly 9AM-4PM Average**. The average of all valid 9AM-4PM Averages for the month, growing season, or year. N is as in (7) above.

(9) **Max 7AM-7PM Average**. The maximum of all valid 7AM-7PM Averages computed for the month, growing season, or year. A valid 7AM-7PM Average is one which has 75% of the observations available during that time period, i.e., 9 hours. N is the number of days with valid averages.

(10) **Monthly 7AM-7PM Average**. The average of all valid 7AM-7PM averages for the month, growing season, or year. N is as in (9) above.

(11) **Monthly Mean**. The average of all 1-Hr ozone concentrations recorded during the month, growing season, or year. A mean is computed regardless of the number of hours with valid data. N is the number of hours with valid observations.

(12) **SUM0 Exposure Index**. The monthly sum of all hourly ozone concentrations. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours with valid observations and is the same N as in (11) above.

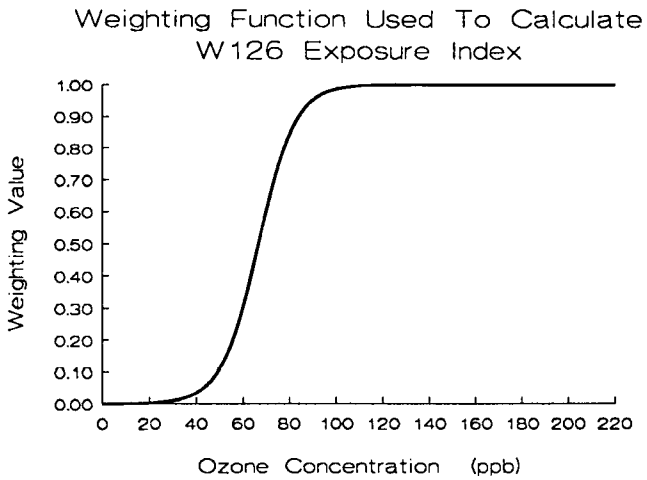
(13) **SUM60 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours equaling or exceeding 60 PPB during the month, growing season, or year.

(14) **SUM80 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 80 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours equaling or exceeding 80 PPB during the month, growing season, or year.

(15) **W126 Exposure Index**. The monthly sum of all hourly ozone concentrations where each concentration is weighted by a function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. This weighting function provides a weighting value that is unique for each hourly ozone concentration. The weighting function, as described by Lefohn, Laurence, and Kohut[1] is:

$$w_i = \frac{1}{1 + 4403 \exp(-.126c_i)}$$

where



w_i = weighting value for hourly concentration *i*, and
c_i = hourly concentration *i* in PPB.

The graph of weighting value versus ozone concentration, in the figure to the left, illustrates the greater weights given to higher hourly ozone concentrations.

Each hour's weighting value is multiplied by its corresponding hourly concentration. This product is summed over all the valid hours in each month to calculate the monthly W126 exposure.

Thus, the monthly W126 exposure is:

$$W126 = \sum_{i=1}^{n} w_i c_i$$

where

W126	= monthly W126 exposure index,
w_i	= weighting value for hourly concentration *i*,
c_i	= hourly concentration *i* in PPB, and
n	= number of hours in the month with valid ozone concentrations.

The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. The exposure units are PPB-HR.

Because each hour contributes to this exposure index, N is the number of hours with valid observations and is the same N as in (11) and (12) above.

The U.S. Environmental Protection Agency usually considers air quality statistics, such as a mean, to be "valid" (i.e., representative of the parameter being estimated for the time interval in question) only if 75% or more of the total possible observations have been measured during that time interval. Therefore, one should exercise caution when comparing these statistics between months and sites, particularly those that are <u>not</u> averages (e.g., maxima and exposures) whenever the number of valid observations is less than 75% of the total possible.

References

1. Lefohn, A.S., J. A. Laurence, and R. J. Kohut. 1988. A Comparison of Indices That Describe the Relationship Between Exposure to Ozone and Reduction in the Yield of Agricultural Crops. *Atmospheric Environment* 22, 1229-1240.

4.2 AIR QUALITY GLOSSARY

Acid Deposition: Air pollution produced when acid chemicals are incorporated into rain, snow, fog, or mist.

Aerometric Information Retrieval System (AIRS): A computer-based database of U.S. air pollution information administered by the EPA Office of Air Quality Planning and Standards (U.S. Environmental Protection Agency).

AIRWeb: Air Resources Web, an air quality information retrieval system for U.S. parks and wildlife refuges developed by the Air Resources Division of the National Park Service and the Air Quality Branch of the Fish and Wildlife Service.

Air Pollutant: An unwanted chemical or other material found in the air.

Air Pollution: Degradation of air quality resulting from unwanted chemicals or other materials occurring in the air.

Air Quality: The properties and degree of purity of air to which people and natural and heritage resources are exposed (in the context of national parks).

Air Pollution Control Permitting Process: Process by which facilities are permitted to emit specified types and quantities of air pollutants.

Air Quality Related Values (AQRVs): Values including visibility, flora, fauna, cultural and historical resources, odor, soil, water, and virtually all resources that are dependent upon and affected by air quality. "These values include visibility and those scenic, cultural, biological, and recreation resources of an area that are affected by air quality." *(43 Fed. Reg. 15016)*

Ambient Air: Air that is accessible to the public.

Class I: Areas of the country set aside under the Clean Air Act to receive the most stringent degree of air quality protection.

Class II: Areas of the country protected under the Clean Air Act but identified for somewhat less stringent protection from air pollution damage than Class I, except in specified cases.

Clean Air Act: Originally passed in 1963, our current national air pollution control program is based on the 1970 version of the law. Substantial revisions were made by the 1990 Clean Air Act Amendments.

Continuous Sampling Device: An air analyzer that measures air quality components continuously.

Criteria: Information on health and/or environmental effects of pollution (in the context of criteria air pollutants).

Criteria Air Pollutant: A group of very common air pollutants regulated by EPA on the basis of criteria and for which a National Ambient Air Quality Standard is established (SO_2, NO_2, PM_{10}, Pb, CO, O_3).

Emissions: Release of pollutants into the air from a source.

Environmental Protection Agency (EPA): The federal agency responsible for regulating air quality.

Monitoring: Measurement of air pollution.

National Ambient Air Quality Standards (NAAQS): Permissible levels of criteria air pollutant established to protect public health and welfare.

Ozone (O_3): A criteria air pollutant that is a strong oxidizing agent, reactive with many other compounds and surfaces, and a health hazard in high concentrations. Ozone is formed by nitrogen oxides and organic compounds reacting in sunlight.

Source: Any place or object from which air pollutants are released. Sources that are fixed in space are stationary sources; sources that move are mobile sources.

Sulfur Dioxide (SO_2): A criteria air pollutant that is a gas produced by burning coal and some industrial processes.

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* Recent updates to this glossary may be found on the NPSARD AIRWeb - http://www.aqd.nps.gov/natnet/ard/glossary.htm.