Annual Data Summary

GREAT SMOKY MOUNTAINS NATIONAL PARK
Clingmans Dome

1998

National Park Service
Gaseous Air Pollutant Monitoring Network

AIR RESOURCES DIVISION
RESEARCH AND MONITORING BRANCH
12795 West Alameda Parkway
P.O. Box 25287
Lakewood, Colorado 80225
Telephone: (303) 969-2820
Fax: (303) 969-2822

This Annual Data Summary was prepared under NPS Contract CX-1270-96-007 by:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423

For additional copies of this report or reports for other NPS units, contact:

National Park Service Air Resources Division
Information Management Center
c/o Air Resource Specialists, Inc.
1909 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423
E-Mail: AIR-IMC@AIR-RESOURCE.COM

or

National Park Service
Air Resources Division
P.O. Box 25287
Lakewood, Colorado 80225-02587
Telephone: (303) 969-2130
E-Mail: AQ_INFO@AQD.NPS.GOV

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At Great Smoky Mountains National Park, the ARD specifically recognizes Jim Renfro and Scott Berenyi 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

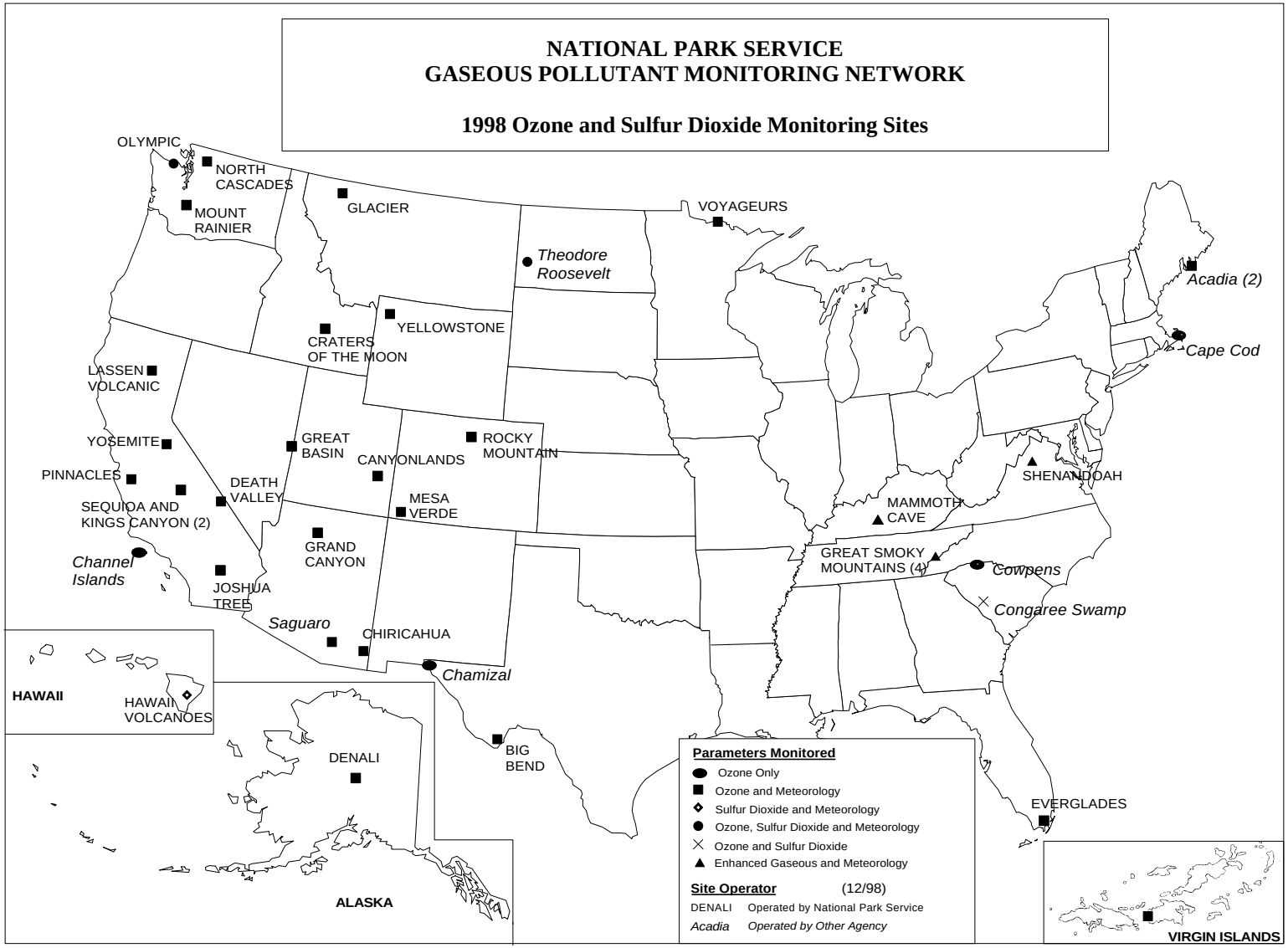
Gaseous air pollutants, including ozone and sulfur dioxide, are of concern to the National Park Service (NPS). Pollutants like these can affect park unit biological resources as well as the health of park unit residents and visitors. The NPS established a gaseous pollutant monitoring program for several pollutants linked to effects 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 unit air quality conditions and to determine if a park unit 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 effects of air pollutants on NPS resources, and can help confirm suspected causes of observed effects.

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 unit 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 park units and predict impacts on the park unit 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, 40 monitoring sites in 35 units of the National Park System had some combination of ozone, sulfur dioxide, meteorological, and CASTNet dry deposition 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 unit 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 available. Individual reports are generated for each site where monitoring was conducted in the national park network.


NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1998 Ozone and Sulfur Dioxide Monitoring Sites
OLYMPIC
NORTH CASCADES
MOUNT RAINIER
GLACIER
VOYAGEURS
Theodore Roosevelt
Acadia (2)
Cape Cod
YELLOWSTONE
CRATERS OF THE MOON
LASSEN VOLCANIC
YOSEMITE
GREAT BASIN
ROCKY MOUNTAIN
CANYONLANDS
PINNACLES
DEATH VALLEY
SEQUOIA AND KINGS CANYON (2)
MESA VERDE
SHENANDOAH
MAMMOTH CAVE
GRAND CANYON
Channel Islands
GREAT SMOKY MOUNTAINS (4)
Cowpens
JOSHUA TREE
Congaree Swamp
Saguaro
CHIRICAHUA
Chamizal
HAWAII
HAWAII VOLCANOES
BIG BEND
DENALI
EVERGLADES
ALASKA
VIRGIN ISLANDS
Parameters Monitored
Ozone Only
Ozone and Meteorology
Sulfur Dioxide and Meteorology
Ozone, Sulfur Dioxide and Meteorology
Ozone and Sulfur Dioxide
Enhanced Gaseous and Meteorology
Site Operator (12/98)
DENALI Operated by National Park Service
Acadia Operated by Other Agency

1.2 GREAT SMOKY MOUNTAINS NATIONAL PARK

Great Smoky Mountains National Park, a Class I area, is located in North Carolina and Tennessee. It is characterized by unusually rugged topography, with elevations ranging from 840 feet to 6,642 feet above sea level in a horizontal distance of a few miles, and includes 16 peaks above 6000 feet. Its location and site specifications are presented on the following page.

The park is world-renowned for the diversity of its plant and animal resources, the beauty of its ancient mountains, the quality of its remnants of American pioneer culture, and the depth and integrity of the wilderness sanctuary within its boundaries. Great Smoky Mountains is designated an International Biosphere Reserve.

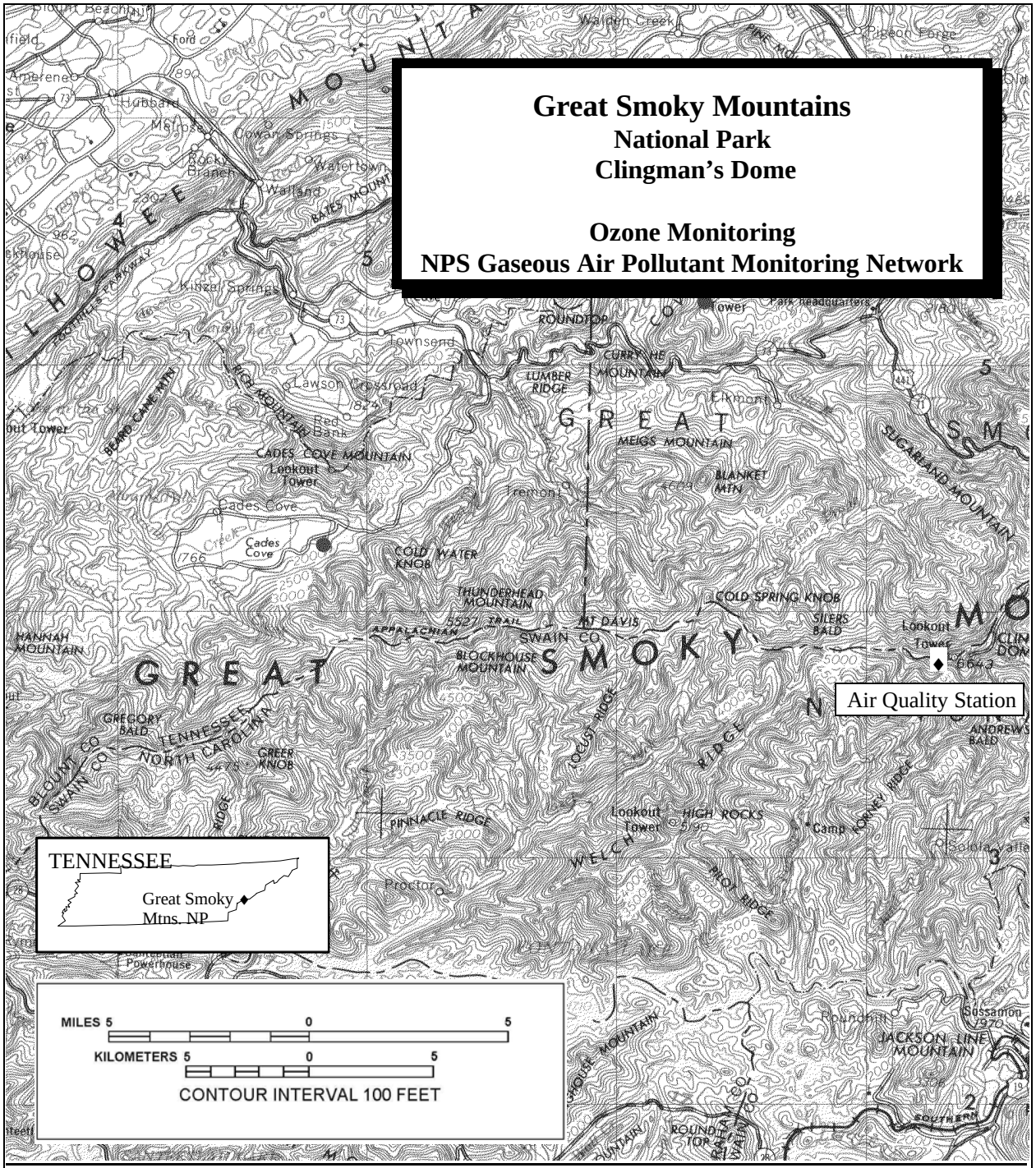
This area was established as a national park in 1926 "for the benefit and enjoyment of the people." The law creating the park also referenced the 1916 National Park Service Organic Act which stated that the fundamental purpose of national parks is "...to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Great Smoky Mountains National Park contains a wide diversity of temperate flora with about 1400 species of flowering plants and 2200 other plant species. It has one of the nation's richest inventories of plant groups such as fungi, mosses, and lichens. Included in the park are large expanses of virgin forest, similar to those found by early pioneers. Dominant tree species include maple, buckeye, birch, beech, spruce, poplar, pine, oak and hemlock. The park's Cove Forest alone has 25 to 30 tree species.

The park is inhabited by a highly diverse array of animal species. About 50 native mammals are known to dwell in the park including black bear, white-tailed deer, wild turkey, and many types of rodents. Over 200 species of birds have been observed in the park. Reptiles such as turtles, lizards, snakes, and amphibians such as salamanders are part of the park's fauna. Also, over 70 species of fish live in the park streams.

In addition to its natural values, the park is uniquely endowed with cultural resources. The physical remnants of a pioneer mountain culture exist in a large array of log structures scattered about the park. The structures date from about 1845 to 1910 and served the mountain pioneers in specific ways. Each structure has its own "face" and exhibits variations in design, materials, and workmanship.

Air quality and visibility are being degraded by pollutants originating outside the park. Anthropogenic sources of air pollution appear to be local and regional.



SITE IDENTIFICATION	
Site Abbreviation:	GRSM-CD
AIRS ID NO.:	47-155-0102

INSTRUMENTATION	
O_3 Analyzer	Temperature
Calibrator	Solar Radiation
Wind Speed	Precipitation
Wind Direction	Relative Humidity

MAP INFORMATION	
Mean Elevation:	2021 m
Longitude:	83° 29' 53"W
Latitude:	35° 33' 46"N
UTM Zone:	17
Easting:	273591 m
Northing:	3938128 m
Map Reference:	Knoxville 1972 1: 250,000

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
Great Smoky Mountains National Park
Clingmans Dome

Final Data

05/01/98 - 11/30/98

Parameter	Par Code	Data Recovery			Valid Data	
		No. Possible	No. Collected	% Collected	No. Valid	% Valid
Ozone Analyzer	O3	4987	4878	97.8	4291	86.0
Scalar Wind Speed	SWS	4440	4371	98.4	4337	97.7
Vector Wind Speed	VWS	4440	4368	98.4	4334	97.6
Vector Wind Direction	VWD	4438	4368	98.4	4336	97.7
Standard Deviation for Wind Direction	SDWD	4439	4367	98.4	4334	97.6
Ambient Temperature (aspirated)	TMP	4439	4368	98.4	4345	97.9
Relative Humidity	RH	4449	4392	98.7	3357	75.5
Precipitation	RNF	4421	4347	98.3	4105	92.9
Solar Radiation	SOL	4436	4369	98.5	4364	98.4

Notes: All statistics are for hourly averages.

The number collected does not include normal maintenance or events beyond the control of the network.

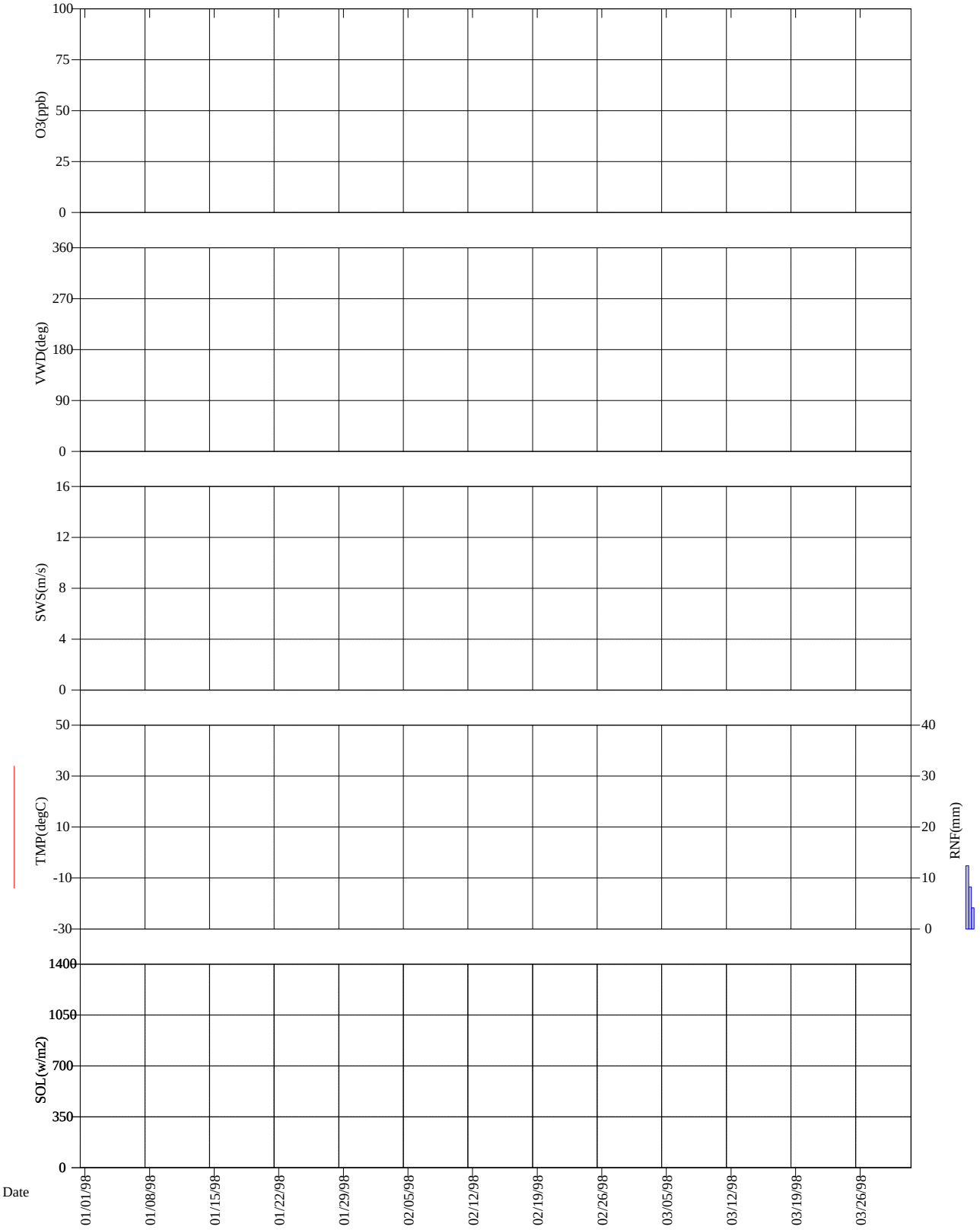
The percent valid is calculated against the number possible.

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

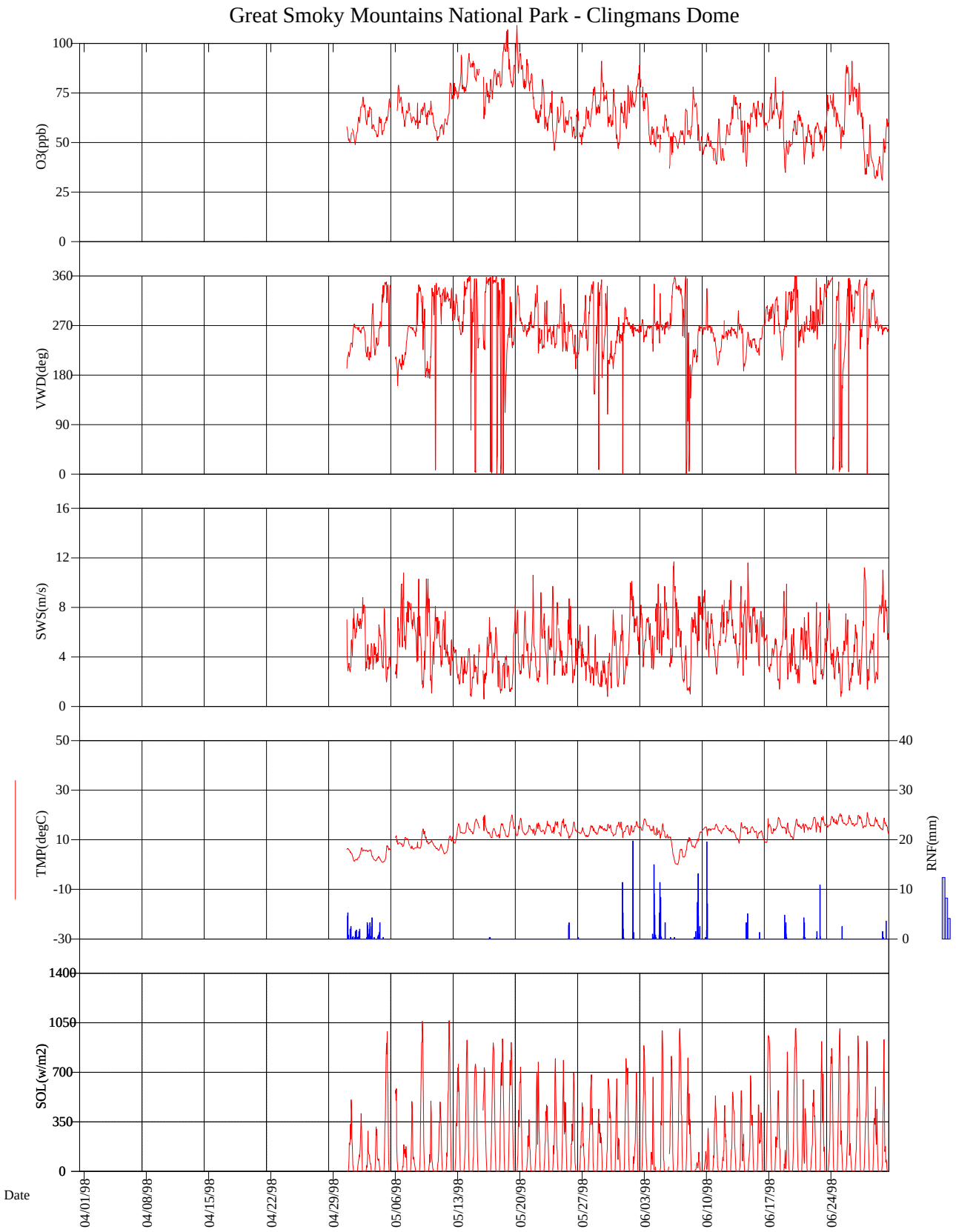
Great Smoky Mountains National Park - Clingmans Dome



Final Validation

First Quarter 1998

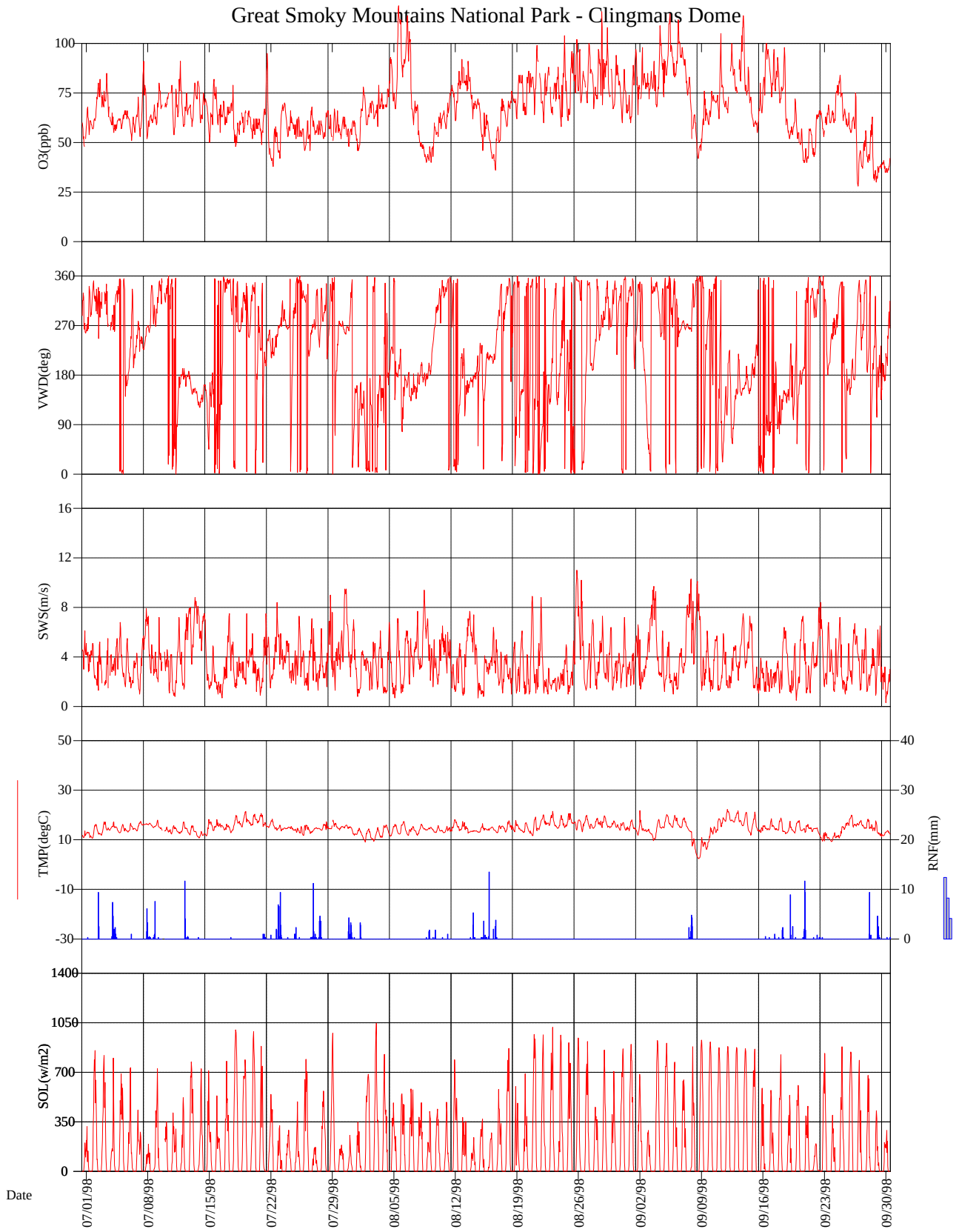
grsm-cd.stk - gscd98.dat 06-14-1999



Final Validation

Second Quarter 1998

grsm-cd.stk - gscd98.dat 06-14-1999

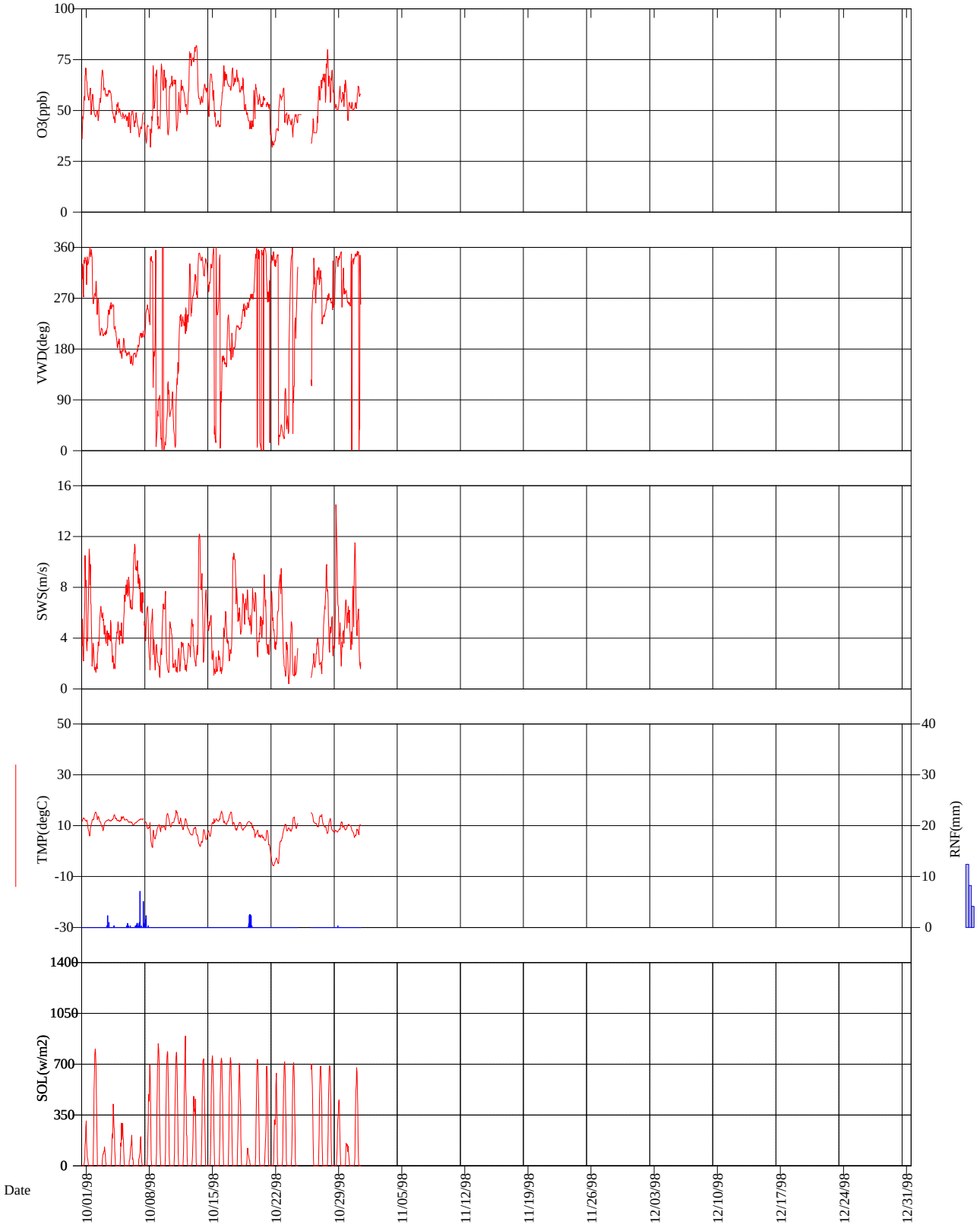


Final Validation

Third Quarter 1998

grsm-cd.stk - gscd98.dat 06-14-1999

Great Smoky Mountains National Park - Clingmans Dome



Final Validation

Fourth Quarter 1998

grsm-cd.stk - gscd98.dat 06-14-1999

2.2 OZONE DATA SUMMARY

Ozone Quick Look Annual Summary Statistics
Great Smoky Mountains National Park
Clingmans Dome
05/01/98 - 11/30/98

STATISTIC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAY-SEP	ANNUAL
DAILY 1-HR MAXIMUM					109	91	95	119	115	82			119	119
NO. OF DAYS					(31)	(30)	(31)	(31)	(30)	(31)			(153)	(184)
AVERAGE DAILY MAXIMUM					79	69	74	87	85	64			79	76
NO. OF DAYS					(31)	(30)	(31)	(31)	(30)	(31)			(153)	(184)
MAXIMUM DAILY MEAN					91	79	74	99	93	75			99	99
NO. OF DAYS					(29)	(30)	(30)	(31)	(30)	(29)			(150)	(179)
AVERAGE DAILY MEAN					69	58	62	72	68	54			66	64
NO. OF DAYS					(29)	(30)	(30)	(31)	(30)	(29)			(150)	(179)
MAX PEAK:MIN RATIO					1.652	2.171	2.500	2.000	2.679	2.250			2.679	2.679
NO. OF DAYS					(29)	(30)	(30)	(31)	(30)	(29)			(150)	(179)
AVERAGE PEAK:MIN RATIO					1.311	1.483	1.420	1.464	1.496	1.492			1.436	1.445
NO. OF DAYS					(29)	(30)	(30)	(31)	(30)	(29)			(150)	(179)
MAX 9AM-4PM AVERAGE					92	79	71	88	91	78			92	92
NO. OF DAYS					(30)	(29)	(31)	(30)	(30)	(31)			(150)	(181)
MONTHLY 9AM-4PM AVERAGE					67	56	58	67	64	52			63	61
NO. OF DAYS					(30)	(29)	(31)	(30)	(30)	(31)			(150)	(181)
MAX 7AM-7PM AVERAGE					90	79	72	91	91	78			91	91
NO. OF DAYS					(30)	(30)	(31)	(31)	(30)	(30)			(152)	(182)
MONTHLY 7AM-7PM AVERAGE					68	57	60	69	66	54			64	62
NO. OF DAYS					(30)	(30)	(31)	(31)	(30)	(30)			(152)	(182)
MONTHLY MEAN					69	58	62	72	68	54			66	64
NO. OF HOURS					(709)	(706)	(727)	(731)	(707)	(711)			(3580)	(4291)
SUM0 EXPOSURE INDEX					48779	41082	45220	52619	48206	38364			235906	274270
NO. OF HOURS					(709)	(706)	(727)	(731)	(707)	(711)			(3580)	(4291)
SUM60 EXPOSURE INDEX					39657	20866	28957	45985	38016	13956			173481	187437
NO. OF HOURS					(543)	(303)	(430)	(599)	(490)	(212)			(2365)	(2577)
SUM80 EXPOSURE INDEX					12962	1859	2010	19719	17639	487			54189	54676
NO. OF HOURS					(148)	(22)	(24)	(222)	(195)	(6)			(611)	(617)
W126 EXPOSURE INDEX					28129	14916	18589	34904	29704	9928			126242	136171
NO. OF HOURS					(709)	(706)	(727)	(731)	(707)	(711)			(3580)	(4291)

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

* Statistics defined in the Quick Look subsection of the Glossary

Frequency Distribution
Ozone Analyzer

Great Smoky Mountains National Park
Clingmans Dome
Monitoring Season: 05/01/98 - 10/31/98[1]

Averaging Period	% Obs.[3]	# Obs.[2]	Min. Obs.[4]	Percentile[5] 10	30	50	70	90	95	99	Max. Obs.	2nd Max.	Arith. Mean	Geo. Mean	Geo. Stdv.
1-Hour	98	4291	0.042	0.058	0.067	0.073	0.082	0.098	0.105	0.116	0.119	0.116	0.0760	0.0745	1.23

Concentrations in parts per million (ppm)

[1] Records for this report are selected in accordance with the AIRS Geo-Common file criteria. These criteria are based on the state-specific Monitoring Season defined in AIRS.

[2] The number of observations (# Obs.) includes all valid observations recorded within the Monitoring Season.

[3] The percent of valid observations (% Obs.) is the percentage of valid days to the number of possible monitoring days during the Monitoring Season. A valid day is defined as a day with 9 or more valid observations between 9:00 a.m. and 9:00 p.m..

[4] The minimum observation value (Min. Obs.) is the minimum daily maximum recorded during the Monitoring Season.

[5] The percentiles and other statistics are derived from the daily maximums.

Ozone Standards Report and
Daily Maximum 1-Hour Concentrations (ppm)

Great Smoky Mountains National Park

Clingmans Dome

05/01/98 - 11/30/98

Day	Jan-98	Feb-98	Mar-98	Apr-98	May-98		Jun-98		Jul-98		Aug-98		Sep-98		Oct-98		Nov-98	Dec-98
1					.058	F	.079	M	.068	W	.069	S	.092	T	.071	T	S	
2					.073	S	.089	T	.080	T	.078	S	.098	W	.058	F	M	
3					.069	S	.082	W	.085	F	.079	M	.086	T	.070	S	T	
4					.063	M	.058	T	.069	S	.078	T	.109	F	.060	S	W	
5					.072	T	.064	F	.066	S	.104	W	.115	S	.054	M	T	
6						W	.062	S	.066	M	.119	T	.112	S	.050	T	F	
7					.073	T	.056	S	.084	T	.114	F	.101	M	.049	W	S	
8					.070	F	.072	M	.091	W	.069	S	.083	T	.072	T	S	
9					.070	S	.078	T	.080	T	.048	S	.076	W	.073	F	M	
10					.071	S	.055	W	.075	F	.065	M	.076	T	.070	S	T	
11					.059	M	.062	T	.079	S	.075	T	.105	F	.067	S	W	
12					.080	T	.059	F	.091	S	.086	W		S	.079	M	T	
13					.094	W	.074	S	.080	M	.092	T		S	.082	T	F	
14					.095	T	.070	S	.081	T	.086	F	.114	M	.063	W	S	
15					.091	F	.070	M	.077	W	.072	S	.073	T	.068	T	S	
16					.083	S	.071	T	.082	T	.064	S	.100	W	.072	F	M	
17					.087	S	.075	W	.071	F	.072	M	.097	T	.071	S	T	
18					.100	M	.083	T	.079	S	.076	T	.098	F	.070	S	W	
19					.107	T	.076	F	.066	S	.084	W	.093	S	.057	M	T	
20					.109	W	.066	S	.066	M	.086	T	.072	S	.063	T	F	
21					.092	T	.064	S	.074	T	.099	F	.057	M	.057	W	S	
22					.073	F	.060	M	.095	W	.085	S	.066	T	.056	T	S	
23					.082	S	.060	T	.069	T	.088	S	.069	W	.061	F	M	
24					.076	S	.075	W	.070	F	.104	M	.076	T	.048	S	T	
25					.073	M	.067	T	.063	S	.096	T	.084	F		S	W	
26					.067	T	.091	F	.061	S	.102	W	.065	S	.046	M	T	
27					.066	W	.080	S	.068	M	.100	T	.075	S	.068	T	F	
28					.078	T	.063	S	.066	T	.097	F	.063	M	.080	W	S	
29					.091	F	.043	M	.067	W	.116	S	.043	T	.062	T	S	
30					.076	S	.062	T	.066	T	.094	S	.042	W	.065	F	M	
31					.077	S			.061	F	.087	M			.062	S		
Valid Days	0	0	0	0	30		30		31		31		28		30		0	0
Maximum	.000	.000	.000	.000	.109		.091		.095		.119		.115		.082		.000	.000
Violations	0	0	0	0	0		0		0		0		0		0		0	0

4291 Total Samples	0 Daily-maxima exceeding the standard of .12 ppm (starred[*])	
83.5 % Possible	2 Missing days assumed to be less than the standard	
180 Valid daily maxima	0 Daily maximas exceed the alert level of .200 ppm	Concentrations in parts per million (ppm)

Great Smoky Mountains - Clingmans Dome

1998 Attainment Status With U.S. Environmental Protection Agency (EPA)
PRIMARY Ozone National Ambient Air Quality Standard

Ozone Season: April through October

The primary National Ambient Air Quality Standard for ozone is designed to protect human health. The level of the primary ozone standard promulgated by the EPA on July 18, 1997 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 fourth-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 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 fourth-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 fourth-highest daily maximum 8-hour ozone concentration based on data collected during the reported year and the two previous years. This is the number to compare to the level of the new primary standard. The 3-year average data completeness percent and the reported year highest five daily maximum 8-hour averages are also tabulated. A 'No' in the Data Comp % Met? column indicates EPA data completeness requirement was not met for the three-year period.

Year	3-Year Avg 4th High Daily Max 8-hr Ozone (ppb)	3-Year Avg Data Complete %	Data Complete % 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)
1998	94	82%	No	113	112	107	106	104

Ozone
Ten Highest Daily 1-Hour Average Maximum Concentrations

Great Smoky Mountains National Park
Clingmans Dome

Final Data
05/01/98 - 11/30/98

Rank	Date	Hour	Concentration (ppb)
1	08/06/98	1	119*
2	08/29/98	4	116*
3	09/05/98	22	115*
4	08/07/98	1	114*
5	09/14/98	6	114*
6	09/06/98	21	112*
7	05/20/98	4	109
8	09/04/98	19	109
9	05/19/98	3	107*
10	09/11/98	17	105

* Other high value(s) were also recorded during one or more hours in the day.

Episodes with 1-Hour Ozone Concentrations
≥ 100 ppb and > 124 ppb
Great Smoky Mountains National Park
Clingmans Dome

Final Data
05/01/98 - 11/30/98

Date	Beginning Hour	No. Hours > 100 ppb	No. Hours >124 ppb	Max (ppb)
05/18/98	18	1	0	100
05/19/98	0	2	0	106
05/19/98	3	1	0	107
05/20/98	3	3	0	109
08/05/98	23	1	0	104
08/06/98	0	8	0	119
08/06/98	22	1	0	101
08/06/98	23	1	0	104
08/07/98	0	3	0	114
08/07/98	6	4	0	106
08/24/98	22	1	0	104
08/26/98	8	1	0	102
08/27/98	17	1	0	100
08/29/98	4	2	0	116
08/29/98	19	1	0	108
09/04/98	18	3	0	109
09/04/98	22	1	0	100
09/05/98	18	5	0	115
09/05/98	23	1	0	112
09/06/98	20	3	0	112
09/06/98	23	1	0	100
09/07/98	0	2	0	101
09/11/98	17	1	0	105
09/12/98	23	1	0	100
09/14/98	2	1	0	104
09/14/98	4	5	0	114
09/16/98	21	2	0	100
Total		57	0	119

Note: The primary and secondary national ambient air standard for ozone that applied in 1996 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/m^3 exceeds the standard.) (40 CFR 50.9 with reference to Appendix D and H.)

Episodes with 8-Hour Average Ozone Concentrations > 84 ppb
Great Smoky Mountains National Park
Clingmans Dome

Final Data
05/01/98 - 11/30/98

Date	Start and End Time of Daily Maximum 8-Hour Average > 84 ppb (hr)	Daily Maximum 8-Hour Average (ppb)	Number of 8-Hour Averages > 84 ppb During the Day
05/14/98	16 - 23	91	12
05/15/98	02 - 09	90	12
05/18/98	22 - 05	100	16
05/19/98	00 - 07	98	14
05/20/98	00 - 07	98	16
05/21/98	05 - 12	86	4
06/26/98	04 - 11	87	3
08/05/98	23 - 06	112	12
08/06/98	00 - 07	113	24
08/07/98	00 - 07	104	8
08/13/98	04 - 11	85	2
08/21/98	18 - 01	94	9
08/24/98	18 - 01	90	5
08/25/98	16 - 23	91	10
08/26/98	02 - 09	89	10
08/27/98	15 - 22	93	10
08/28/98	22 - 05	93	9
08/29/98	14 - 21	93	17
08/30/98	18 - 01	88	5
09/01/98	22 - 05	90	8
09/02/98	18 - 01	85	2
09/04/98	17 - 00	99	12
09/05/98	18 - 01	107	19
09/06/98	19 - 02	102	24
09/07/98	00 - 07	96	14
09/11/98	15 - 22	87	3
09/12/98	17 - 00	92	7
09/13/98	23 - 06	99	9
09/14/98	02 - 09	106	8
09/16/98	19 - 02	97	11
09/17/98	00 - 07	93	13
09/18/98	00 - 07	87	3
32	Days with 8-hour average concentrations > 84 ppb		

Note: This table presents episodes of high ozone based on running 8-hour averages. In 1997, the EPA published new primary and secondary national ambient air quality standards for ozone based on 8-hour average ozone concentrations. Attainment of the new primary standard is reached if the annual fourth highest daily maximum 8-hour ozone concentration, averaged over three years, does not exceed 0.08 ppm (84 ppb or 157 ug/m^3). (40 CFR 50.10.)

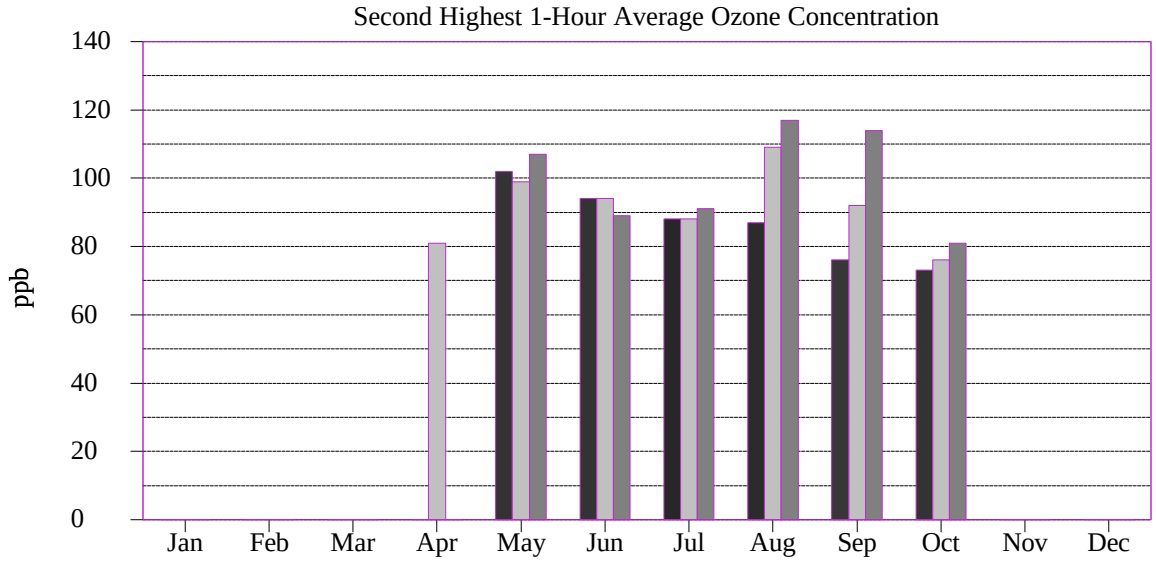
Ozone Rank Listings of Second Highest 1-Hour Average Concentrations, 4th Highest 8-Hour Average Concentrations, and Annual SUM60 Exposure Index for All NPS Monitoring Sites

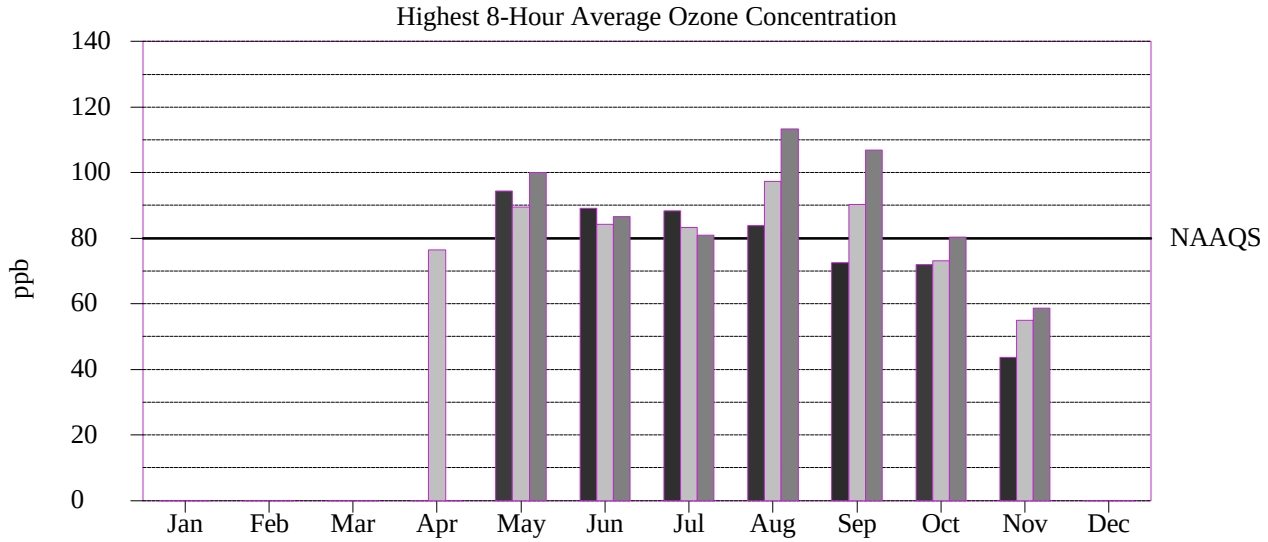
01/01/98 - 12/31/98

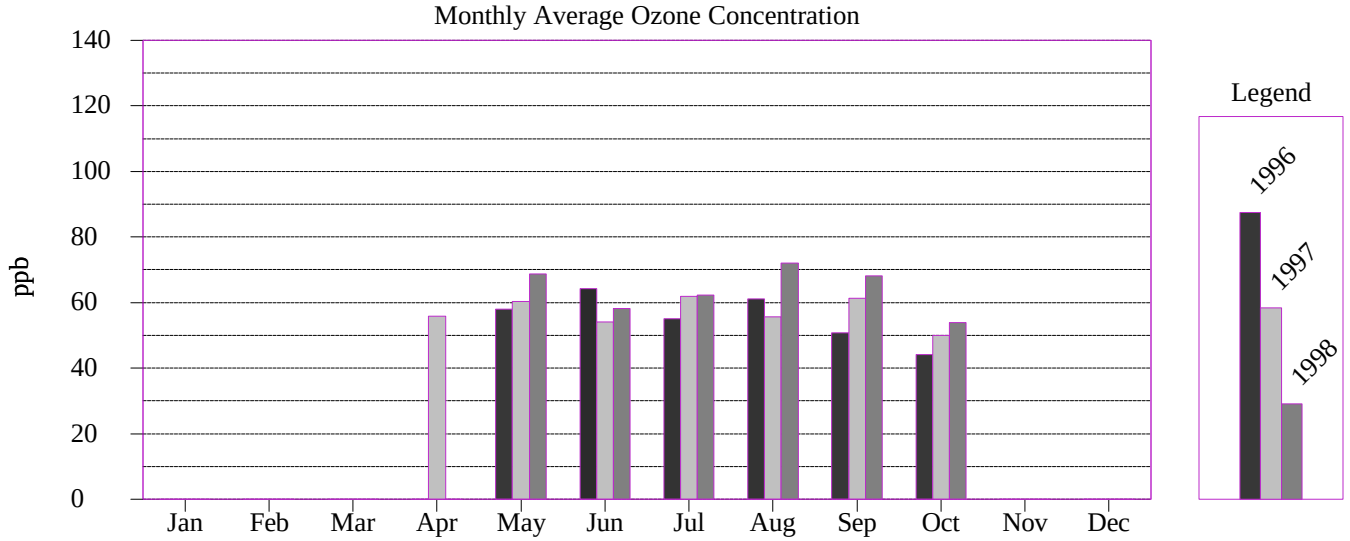
Second Highest 1-Hour Average Concentration		
Site	Rank	Concentration (ppb)
JOTR-YV	1	138
GRSM-LR	2	134
SEKI-LK	3	125
SHEN-BM	4	124
ACAD-CM	5	123
GRSM-CM	6	123
CHAM-XX	7	122
COWP-XX	8	122
GRSM-CD	9	117
SEKI-LP	10	117
CACO-XX	11	115
MACA-HM	12	114
PINN-ES	13	113
COSW-XX	14	106
GRSM-CC	15	105
YOSE-TD	16	105
ROMO-LP	17	100
SAGU-PC	18	94
LAVO-ML	19	91
EVER-BC	20	90
DEVA-PV	21	88
GRBA-MY	22	83
CHIS-XX	23	81
CHIR-ES	24	80
BIBE-KB	25	78
CANY-IS	26	78
VOYA-SB	27	78
GRCA-AS	28	76
MEVE-MY	29	73
YELL-WT	30	72
CRMO-VC	31	69
MORA-TW	32	69
GLAC-WG	33	63
OLYM-VC	34	62
THRO-VC	35	60
DENA-HQ	36	57
NOCA-MM	37	53
VIIS-LP	38	49

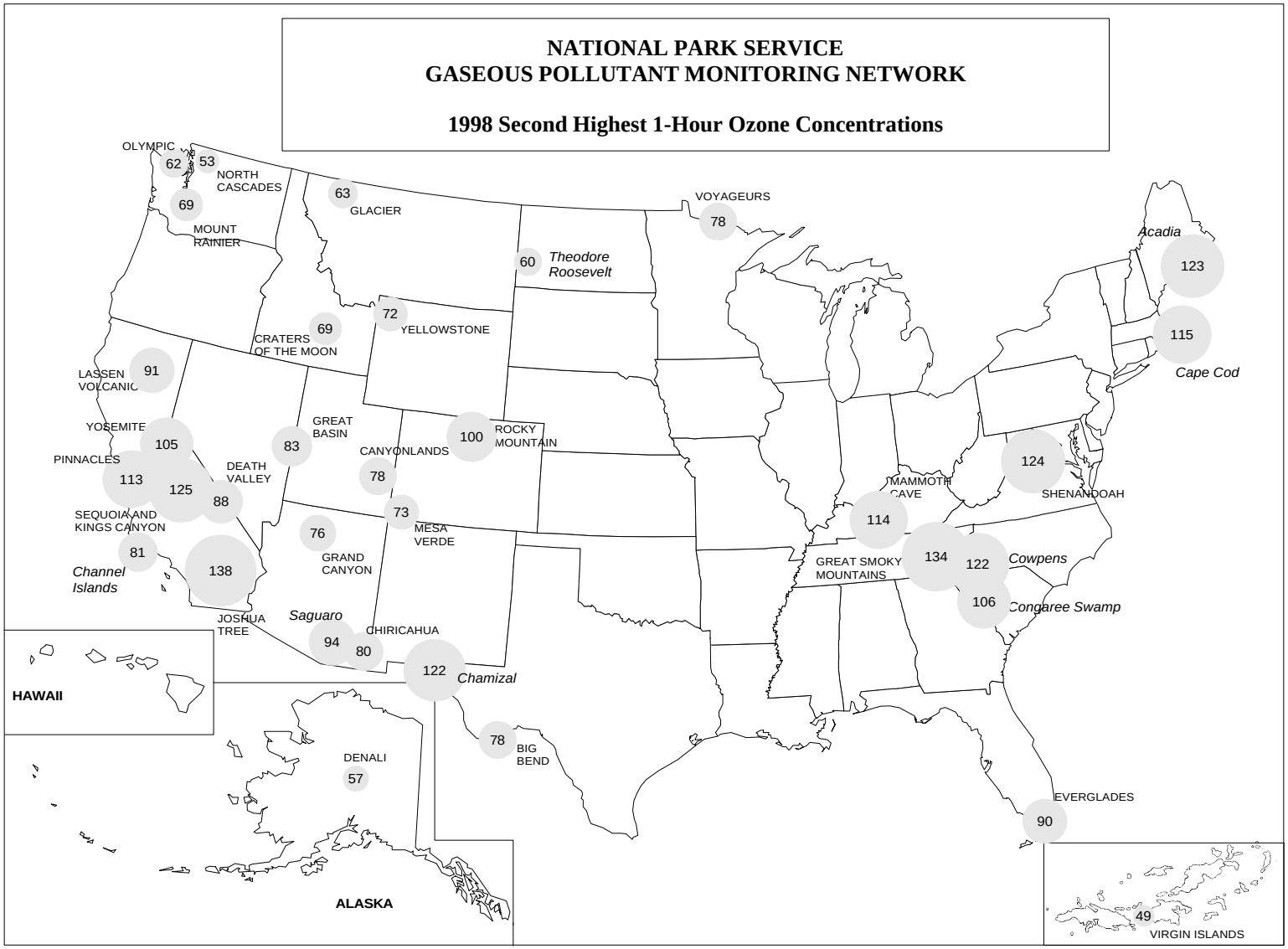
4th Highest 8-hour Average Concentration		
Site	Rank	Concentration (ppb)
GRSM-LR	1	110
JOTR-YV	2	110
GRSM-CM	3	107
SHEN-BM	4	107
GRSM-CD	5	106
SEKI-LP	6	99
MACA-HM	7	98
COWP-XX	8	97
ACAD-CM	9	95
SEKI-LK	10	94
YOSE-TD	11	94
CHAM-XX	12	89
PINN-ES	13	88
GRSM-CC	14	86
CACO-XX	15	84
COSW-XX	16	82
DEVA-PV	17	82
ROMO-LP	18	80
LAVO-ML	19	78
SAGU-PC	20	77
GRCA-AS	21	73
CANY-IS	22	72
EVER-BC	23	72
GRBA-MY	24	71
BIBE-KB	25	70
CHIR-ES	26	68
MEVE-MY	27	68
VOYA-SB	28	68
YELL-WT	29	67
CHIS-XX	30	66
CRMO-VC	31	66
GLAC-WG	32	58
DENA-HQ	33	55
THRO-VC	34	55
MORA-TW	35	51
OLYM-VC	36	46
NOCA-MM	37	43
VIIS-LP	38	39

Annual Sum60 Exposure Index			
Site	Rank	Sum60	Count
GRSM-CM	1	198342	2702
GRSM-CD	2	187437	2577
SHEN-BM	3	170745	2387
GRSM-LR	4	164447	2231
JOTR-YV	5	127317	1769
DEVA-PV	6	93818	1403
YOSE-TD	7	92922	1338
SEKI-LP	8	92214	1230
SEKI-LK	9	84666	1144
MACA-HM	10	82293	1162
COWP-XX	11	70877	970
CANY-IS	12	68500	1075
GRCA-AS	13	63994	996
ROMO-LP	14	59083	897
SAGU-PC	15	57929	869
GRSM-CC	16	52679	742
ACAD-CM	17	45061	638
CACO-XX	18	44769	651
PINN-ES	19	43209	609
CHIR-ES	20	35885	565
GRBA-MY	21	35229	551
LAVO-ML	22	33289	501
MEVE-MY	23	32220	511
CHAM-XX	24	31595	434
BIBE-KB	25	26226	409
COSW-XX	26	26019	364
CRMO-VC	27	17194	274
EVER-BC	28	16065	239
YELL-WT	29	9932	157
CHIS-XX	30	9696	150
VOYA-SB	31	8985	137
GLAC-WG	32	1407	23
MORA-TW	33	638	10
OLYM-VC	34	307	5
THRO-VC	35	181	3
DENA-HQ	36	0	0
NOCA-MM	37	0	0
VIIS-LP	38	0	0

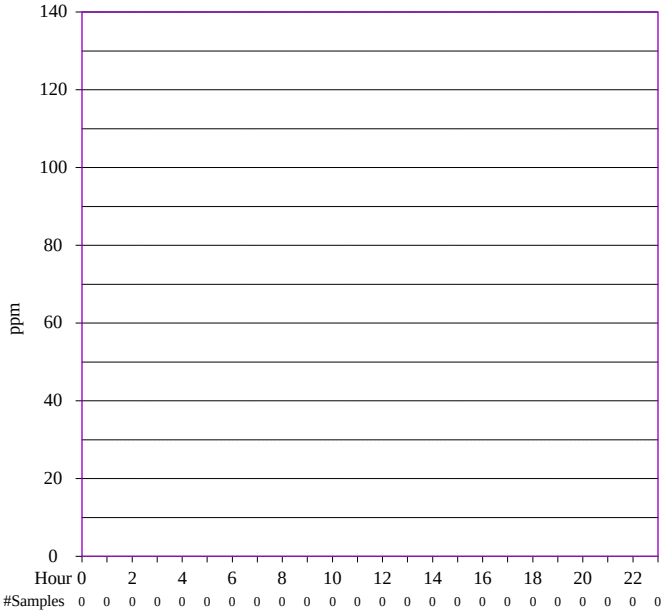

Second Highest 1-Hour Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Highest 8-Hour Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
NAAQS
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

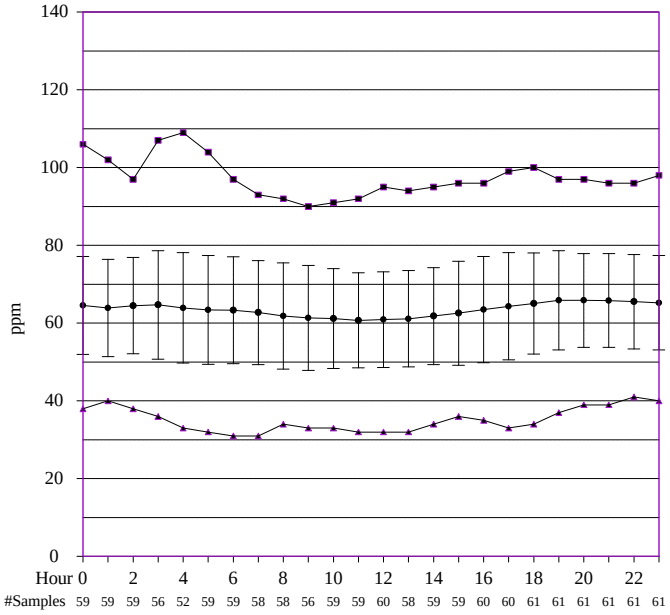

Monthly Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Legend
1996
1997
1998


NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1998 Second Highest 1-Hour Ozone Concentrations
OLYMPIC
62
53
NORTH CASCADES
69
MOUNT RAINIER
63
GLACIER
VOYAGEURS
78
60
Theodore Roosevelt
Acadia
123
115
Cape Cod
72
YELLOWSTONE
69
CRATERS OF THE MOON
LASSEN VOLCANIC
91
YOSEMITE
105
PINNACLES
113
125
88
DEATH VALLEY
83
GREAT BASIN
CANYONLANDS
78
100
ROCKY MOUNTAIN
SEQUOIA AND KINGS CANYON
81
Channel Islands
138
76
GRAND CANYON
73
MESA VERDE
JOSHUA TREE
Saguaro
94
CHIRICAHUA
80
122
Chamizal
78
BIG BEND
HAWAII
DENALI
57
ALASKA
MAMMOTH CAVE
114
GREAT SMOKY MOUNTAINS
134
122
Cowpens
106
Congaree Swamp
124
SHENANDOAH
EVERGLADES
90
49
VIRGIN ISLANDS

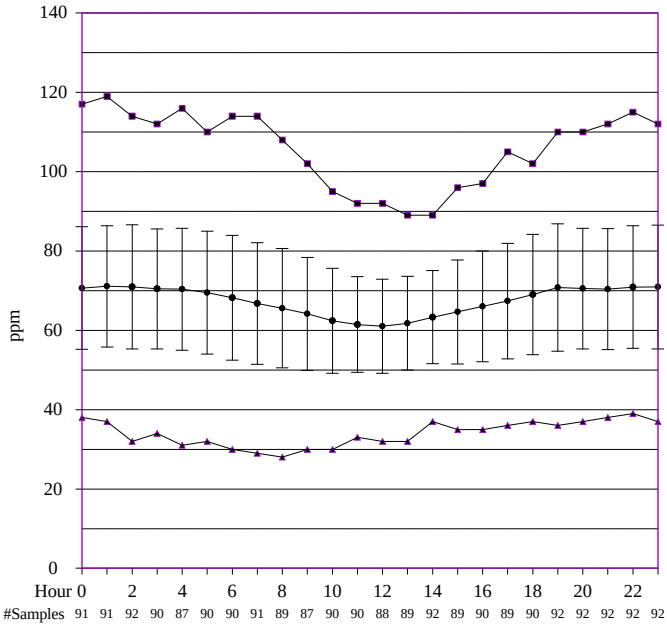
FIRST QUARTER (JAN-MAR)



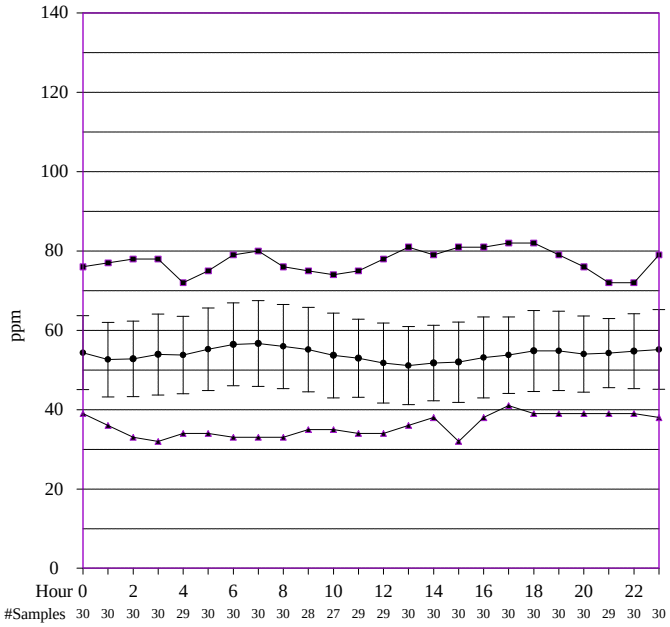
SECOND QUARTER (APR-JUN)



THIRD QUARTER (JUL-SEP)



FOURTH QUARTER (OCT-DEC)



Maximum of Valid O3 in ppm
(▫ Indicates Data Exceeds Plot Scale)

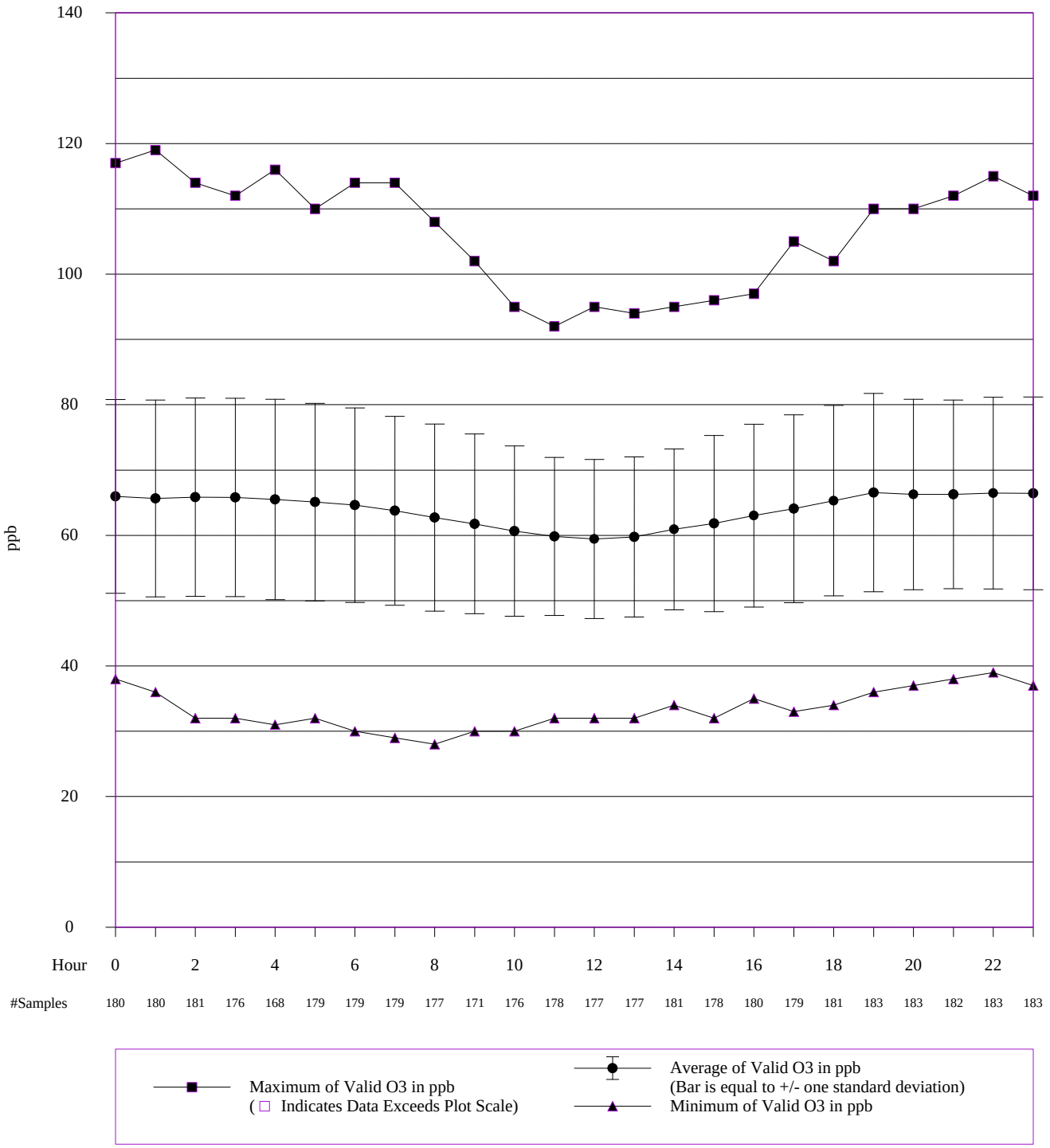
Average of Valid O3 in ppm
(Bar is equal to +/- one standard deviation)

Minimum of Valid O3 in ppm

Great Smoky Mountains National Park
Clingmans Dome

Annual Diurnal Ozone Plot

1998



Final Validation

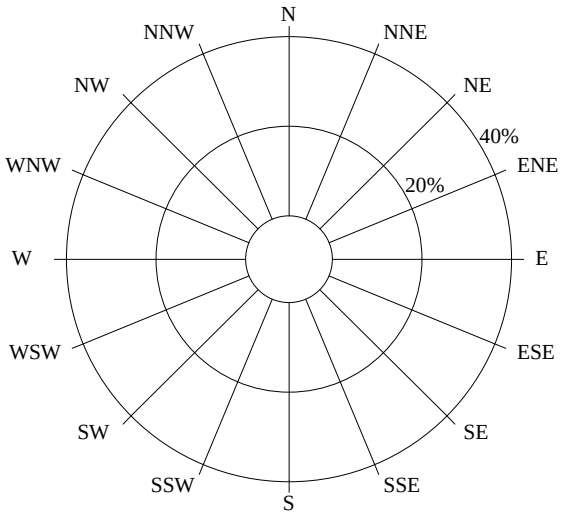
08-24-1999

Great Smoky Mountains National Park
Clingmans Dome

Quarterly Ozone Pollutant Rose

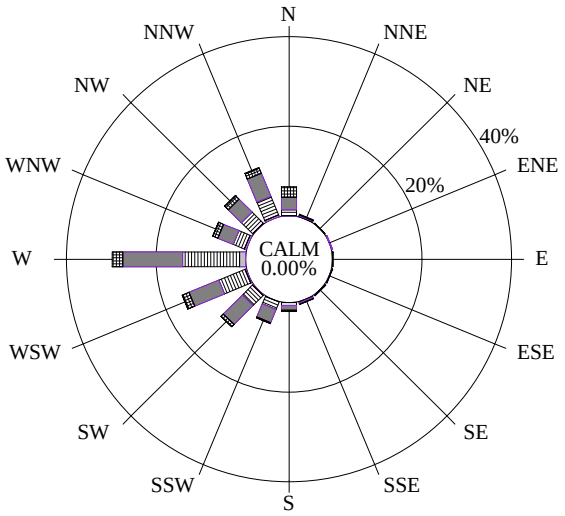
1998

FIRST QUARTER (JAN-MAR)



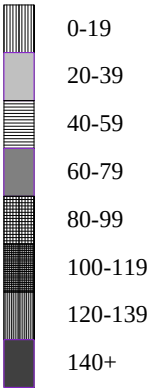
0.0% Collected 0.0% Valid
0 Possible /0 Collected /0 Valid

SECOND QUARTER (APR-JUN)

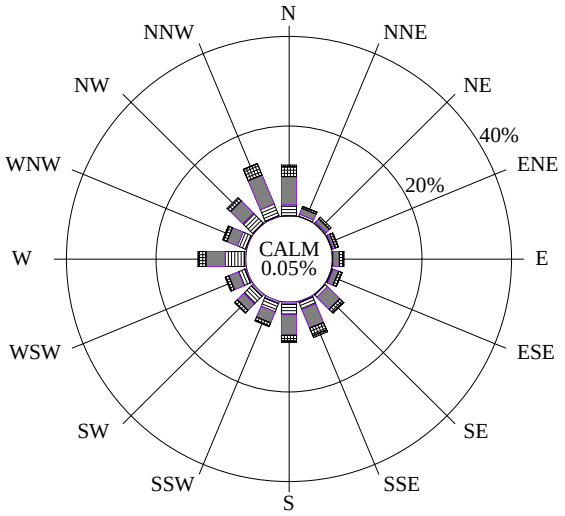


96.6% Collected 96.6% Valid
1464 Possible /1414 Collected /1414 Valid

Ozone (ppb)

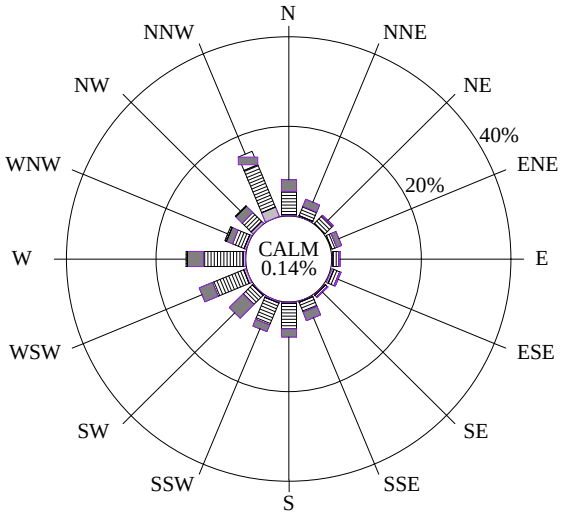


THIRD QUARTER (JUL-SEP)

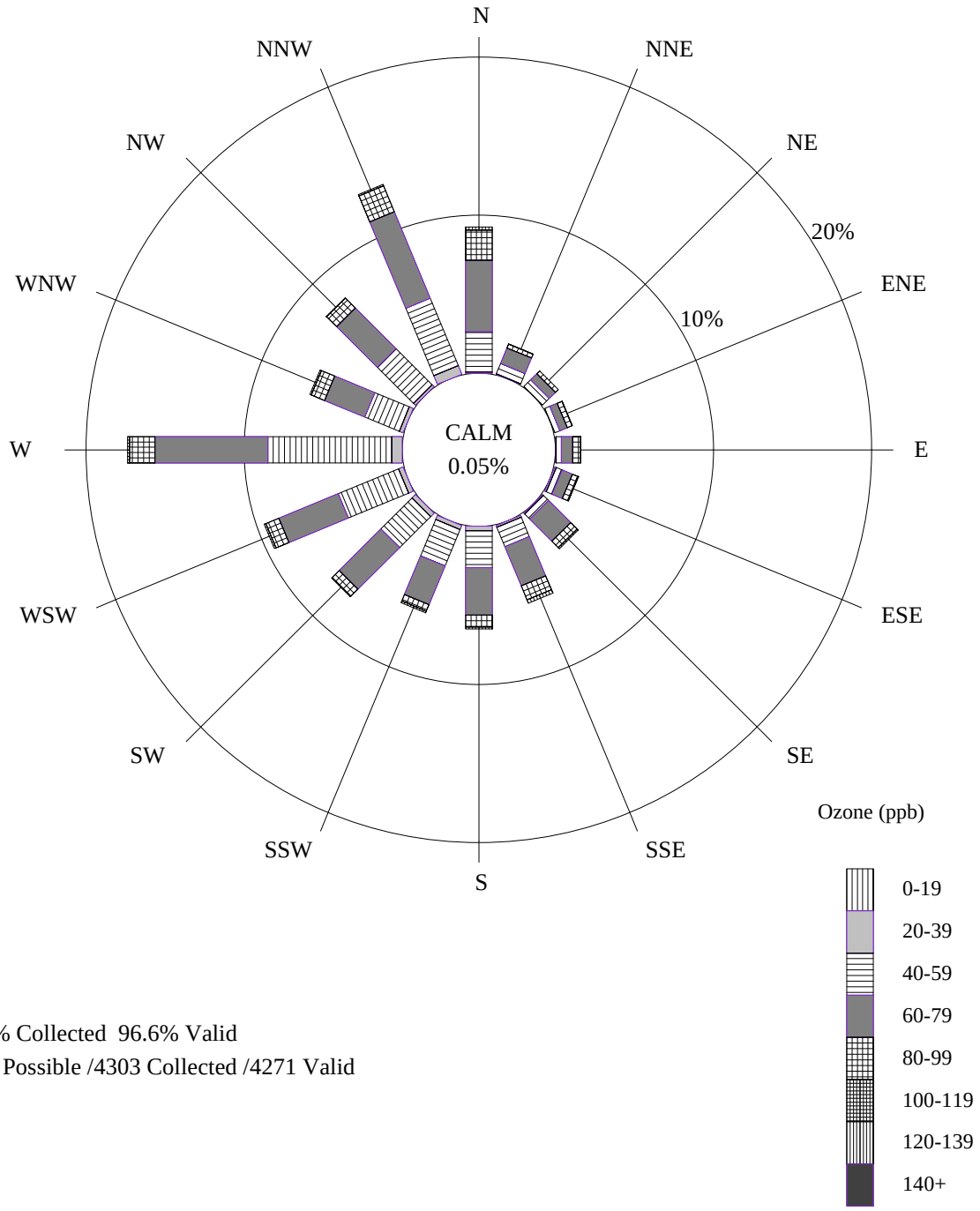


98.6% Collected 97.6% Valid
2208 Possible /2178 Collected /2155 Valid

FOURTH QUARTER (OCT-DEC)



94.7% Collected 93.5% Valid
751 Possible /711 Collected /702 Valid



97.3% Collected 96.6% Valid
4423 Possible /4303 Collected /4271 Valid

Ozone Precision Check Summary

Great Smoky Mountains National Park
Clingmans Dome

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[1] operation. The percent difference between the analyzer and the transfer standard is then calculated. According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard[2]. The table below gives the number of precision checks performed during each quarter, the average of all the individual[3] precision check percent differences for the quarter, and the upper and lower 95% probability limits 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 05/01/98 - 11/30/98				
Calendar Quarter	Number of Precision Checks	Average Percent Difference[1,2]	Lower 95% Probability Limit[3]	Upper 95% Probability Limit[3]
1	0			
2	13	0.92	-3.11	4.94
3	10	2.61	-0.48	5.70
4	3	0.40	-1.69	2.48

[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.)

2.3 METEOROLOGICAL DATA SUMMARY

Summary of Selected Meteorological Data

Great Smoky Mountains National Park

Clingmans Dome

Final Data

05/01/98 - 11/30/98

Parameter	Value	Units	Number	Std Dev
SCALAR WIND SPEED				
Average	4.2	m/s	4337	2.1
Maximum	14.5	m/s		
Percent calm = 0.05				
AMBIENT TEMPERATURE				
Average	13.2	degC	4345	3.9
Maximum	22.3	degC		
Minimum	-5.8	degC		
RELATIVE HUMIDITY				
Average	82	percent	3357	23
Maximum	100	percent		
Minimum	4	percent		
PRECIPITATION (Rainfall or Snow melt)				
Average non-zero rate	2.2	mm/hr	295	3.1
Maximum non-zero rate	19.8	mm/hr		
Minimum non-zero rate	.3	mm/hr		
Accumulated during period	642.3	mm		
SOLAR RADIATION				
Average Daily Total	13,361,784	joules/m2day	191	5,670,520
Maximum Daily Total	26,400,000	joules/m2day		
Minimum Daily Total	2,102,400	joules/m2day		

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. Only days with 24 valid values are included in these statistics.

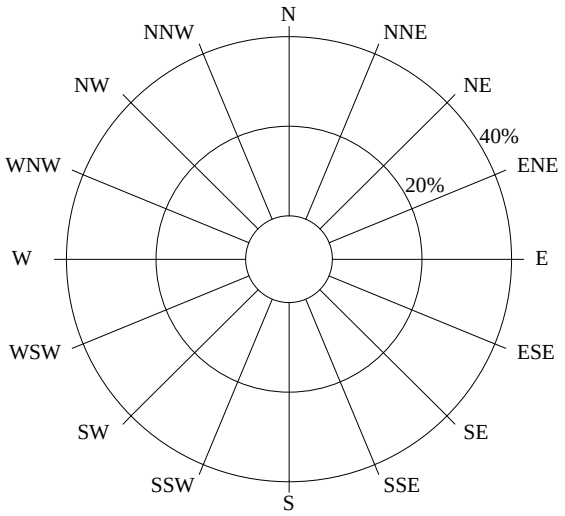
NA indicates instrument not available.

Great Smoky Mountains National Park
Clingmans Dome

Quarterly Wind Rose

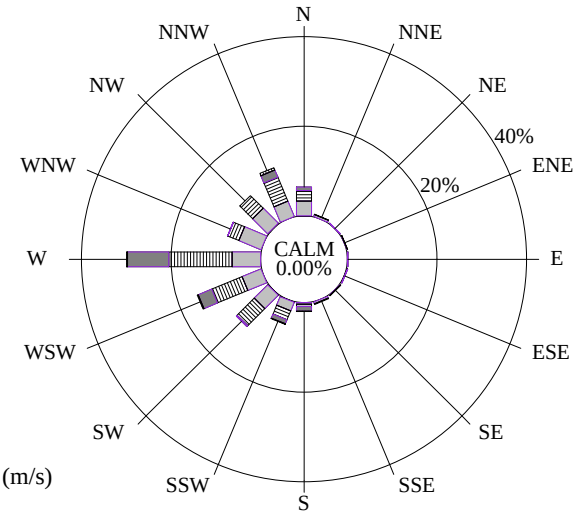
1998

FIRST QUARTER (JAN-MAR)



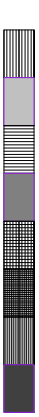
0.0% Collected 0.0% Valid
0 Possible /0 Collected /0 Valid

SECOND QUARTER (APR-JUN)



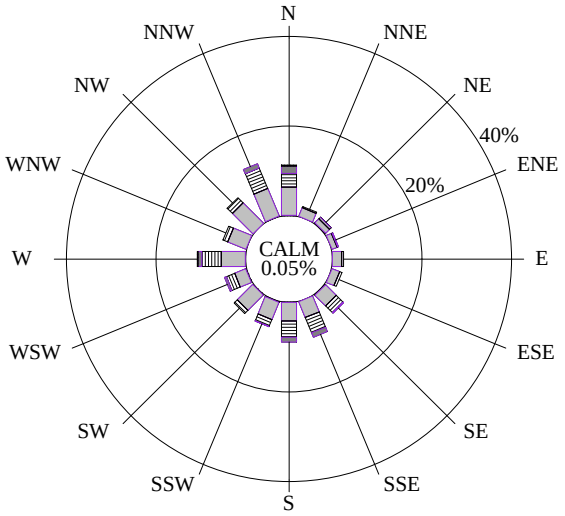
98.2% Collected 98.2% Valid
1464 Possible /1437 Collected /1437 Valid

Scalar Wind Speed (m/s)



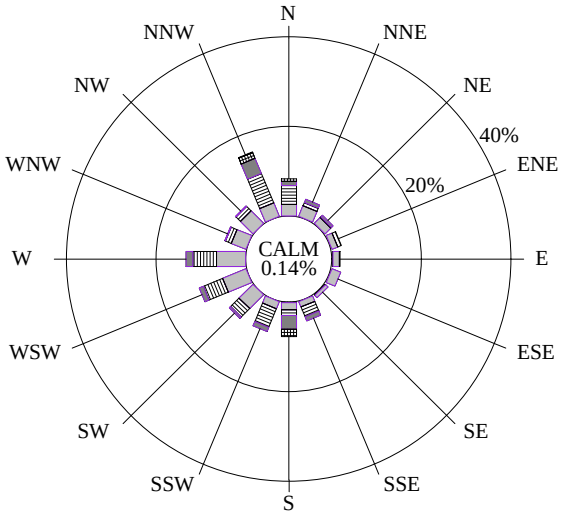
CALM < .5
0.5-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

THIRD QUARTER (JUL-SEP)

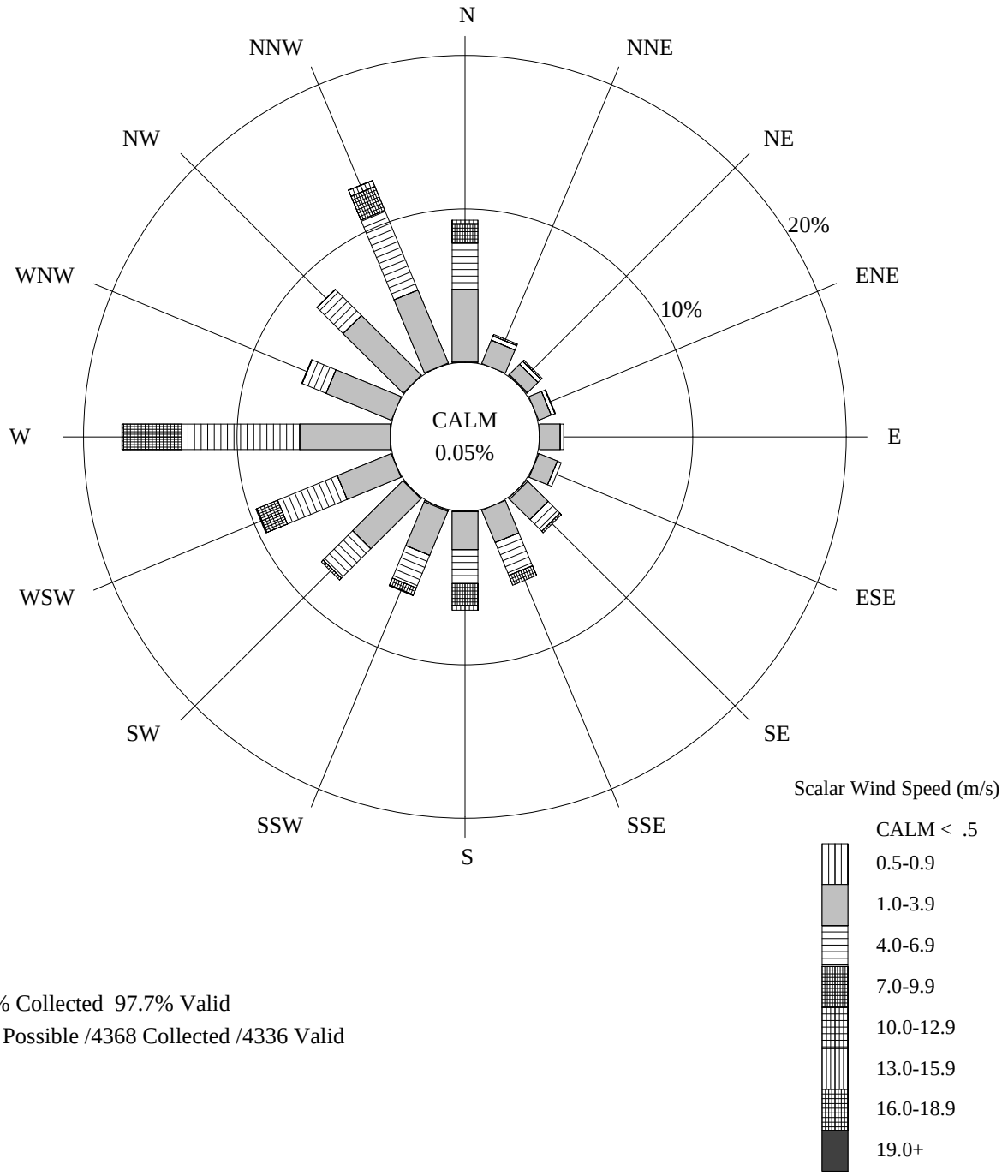


99.7% Collected 99.2% Valid
2208 Possible /2201 Collected /2191 Valid

FOURTH QUARTER (OCT-DEC)



95.3% Collected 92.4% Valid
766 Possible /730 Collected /708 Valid



98.4% Collected 97.7% Valid
4438 Possible /4368 Collected /4336 Valid

3.0 NATIONAL PARK SERVICE AIR RESOURCES DIVISION DATA SOURCES

3.1 GUIDE TO ATTACHED DATA DISKS

Data disks containing ASCII files of the validated hourly data, as shown in the following table are available. Please return the enclosed postcard or contact the address below. 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
Hourly	
ssssyy.DAT	All Validated Air Quality Data
ssssyymm.ppp	Monthly Data Summary Tables
ssssAN95.Rpp	Annual Wind and Pollutant Frequency Distribution
ssssQ195.Rpp	Quarter 1 Wind and Pollutant Frequency Distribution
ssssQ295.Rpp	Quarter 2 Wind and Pollutant Frequency Distribution
ssssQ395.Rpp	Quarter 3 Wind and Pollutant Frequency Distribution
ssssQ495.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	

CASTNet Weekly Species Summary Data	
File Name (s)	Description
CASTNet	
ssssCNyr.ASC	Weekly averages
Where: ssss = site code CN = CASTNet yr = year asc = ascii file	

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 2-8) 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.

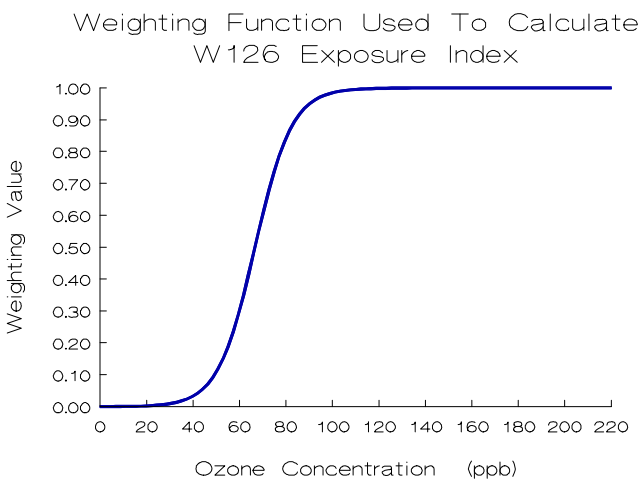
(13) **SUM60 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to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

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

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.

4.3 GLOSSARY OF AIR QUALITY UNITS

Units Conversion Table			
Parameter Type	Multiply	By	To Obtain
Pollutant	ppm	1000	ppb
	ppm	1960	$\mu g/m^3$ Ozone (at 25°C)
	ppm	2615	$\mu g/m^3$ Sulfur Dioxide (at 25°C)
	ppb	0.001	ppm
	ppb	1.960	$\mu g/m^3$ Ozone (at 25°C)
	ppb	2.615	$\mu g/m^3$ Sulfur Dioxide (at 25°C)
	$\mu g/m^3$ Ozone (25°C)	0.0005102	ppm
	$\mu g/m^3$ Ozone (25°C)	0.5102	ppb
	$\mu g/m^3$ Sulfur Dioxide (25°C)	0.0003824	ppm
	$\mu g/m^3$ Sulfur Dioxide (25°C)	0.3824	ppb
Wind Speed	m/s	2.05	mph
	mph	0.489	m/s
Solar Radiation	ly/min	697	w/m^2
	w/m^2	0.00143	ly/min
Precipitation	mm/hr	0.0394	in/hr
	in/hr	25.4	mm/hr
Temperature	°C + 17.78	1.8	°F
	°F - 32	5/9	°C

Where:
ppm = parts per million
ppb = parts per billion
$\mu g/m^3$ = micrograms per cubic meter (at 25°C)
m/s = meters per second
mps = miles per hour
ly/min = langleys per minute
w/m^2 = watts per square meter
mm/hr = millimeters per hour
in/hr = inches per hour
°C = degrees centigrade
°F = degrees fahrenheit