Annual Data Summary

GREAT SMOKY MOUNTAINS NATIONAL PARK
Cove Mountain

2002

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 C2350010840 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.
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

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 PROGRAM (GPMP)

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.

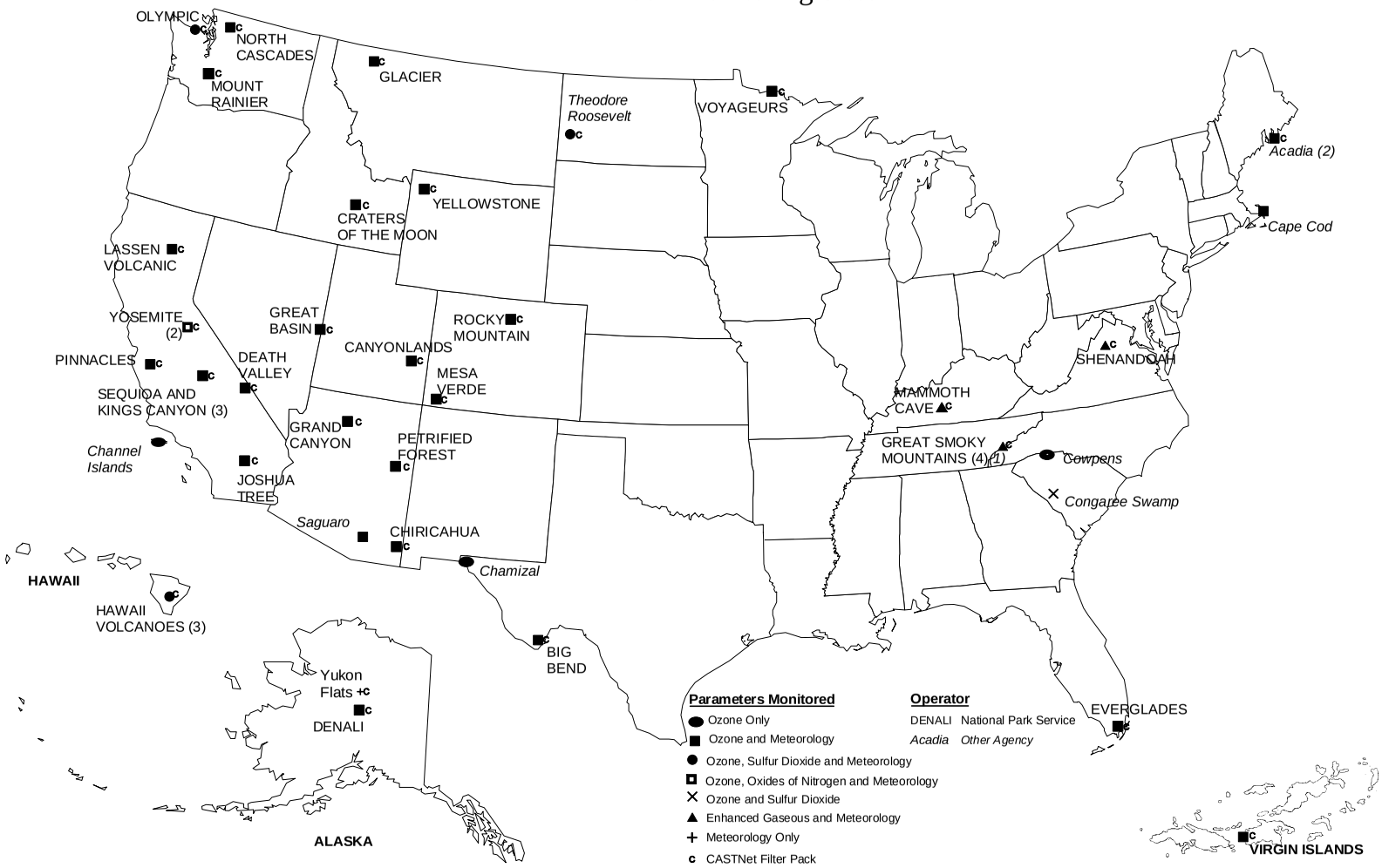
Other monitoring objectives call for the collection of data to support the National Park Service's required involvement in both the development of state air quality control plans, and the evaluation of permit applications for new or expanding air pollution sources wishing to locate near park units. The 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 Program 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, nitrogen, meteorological, and Clean Air Status and Trends Network (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 digital copy of all data collected during the year and data summary products are available; see Section 3.0 for information on obtaining these data. Individual reports are generated for each site where monitoring was conducted in the national park network.

NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK

2002 Monitoring Sites



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.

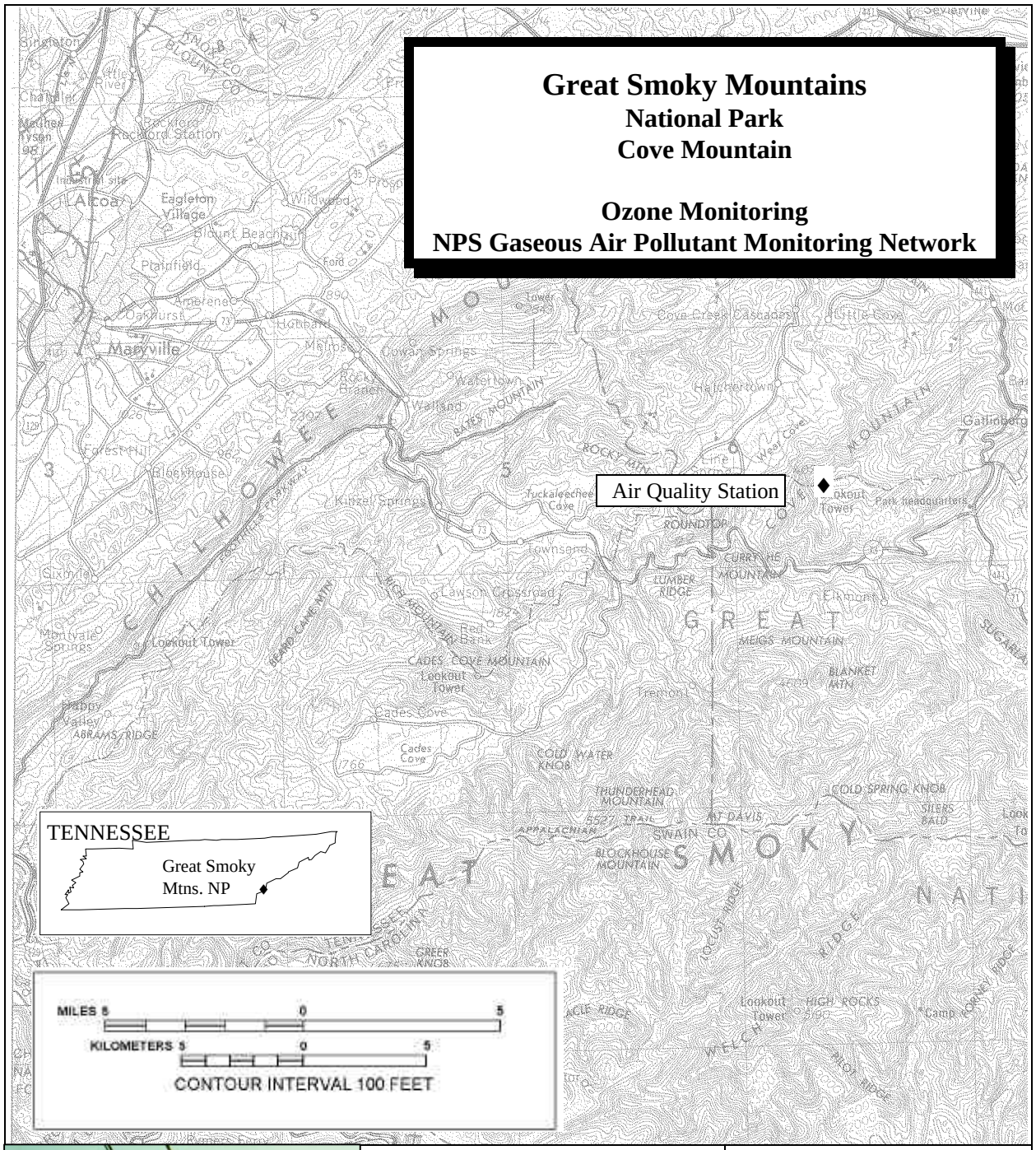
This area was established as a National Park in 1926 "for the benefit and enjoyment of the people." The law creating the park also referenced the 1916 National Park Service Organic Act which stated that the fundamental purpose of national parks is "...to conserve the scenery and the natural and historic 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-CM
AIRS ID NO.:	47-155-0101

INSTRUMENTATION	
O_3 Analyzer	Calibrator
Wind Speed	Barometer
Wind Direction	Temperature
Relative Humidity	Precipitation
Solar Radiation	SO_2 Analyzer

MAP INFORMATION	
Mean Elevation:	1243 m
Longitude:	83° 36' 35"W
Latitude:	35° 41' 48"N
UTM Zone:	17
Easting:	263850 m
Northing:	3953230 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
Cove Mountain

Final Validation

01/01/2002 - 12/31/2002

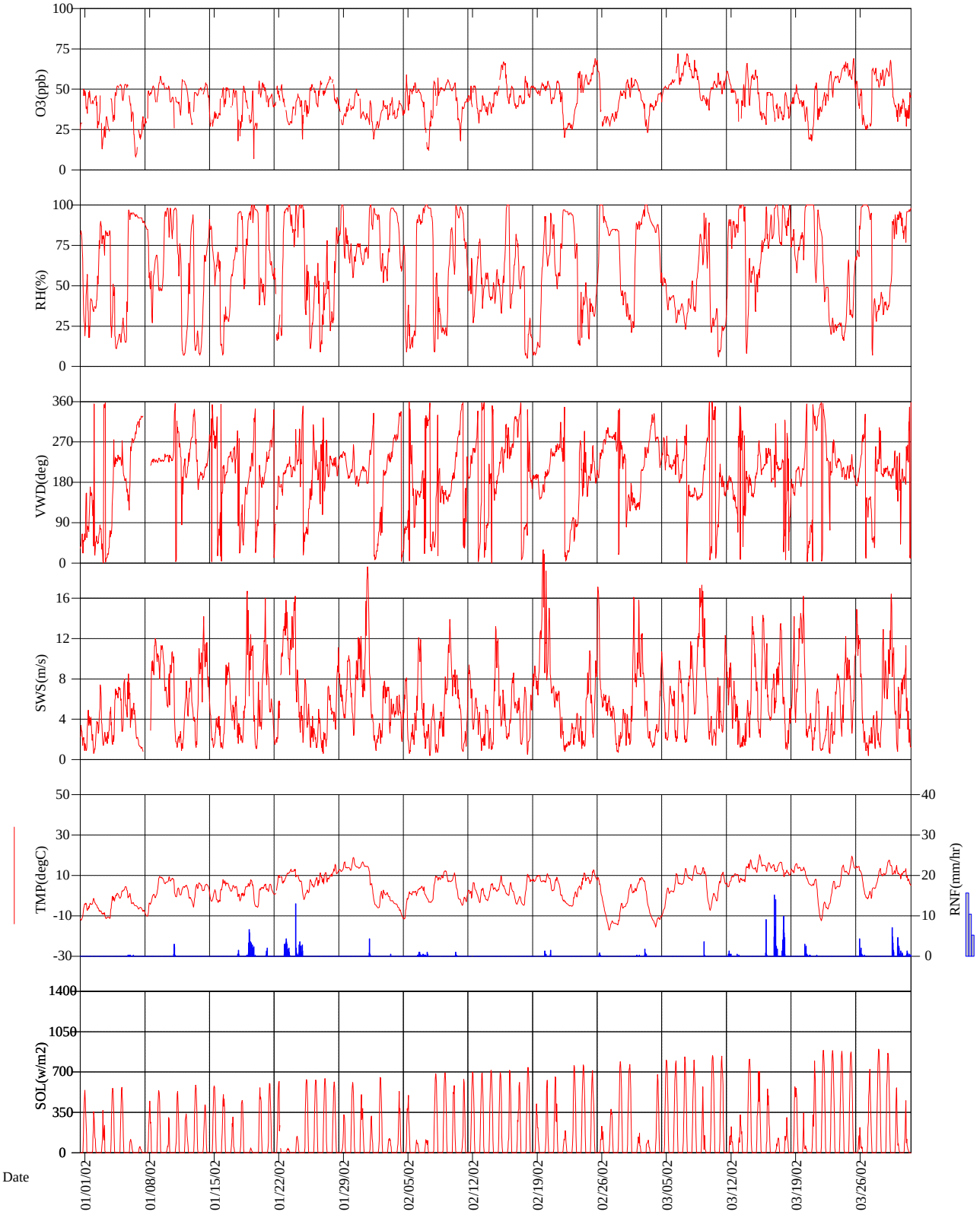
Parameter	Interval	Par Code	Data Recovery			Valid Data	
			No. Possible	No. Collected	% Collected	No. Valid	% Valid
Ozone Analyzer	hourly	O3	8760	8599	98.2	8585	98.0
Scalar Wind Speed	hourly	SWS	8760	8703	99.3	8701	99.3
Vector Wind Speed	hourly	VWS	8760	8703	99.3	8701	99.3
Vector Wind Direction	hourly	VWD	8760	8703	99.3	8701	99.3
Standard Deviation for Wind Direction	hourly	SDWD	8760	8703	99.3	8701	99.3
Ambient Temperature (aspirated)	hourly	TMP	8760	8750	99.9	8597	98.1
Relative Humidity	hourly	RH	8760	8750	99.9	8640	98.6
Precipitation	hourly	RNF	8760	8679	99.1	8677	99.1
Solar Radiation	hourly	SOL	8760	8756	100.0	8754	99.9
Barometric Pressure	hourly	BAR	8760	8756	100.0	8671	99.0

Notes: 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.

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

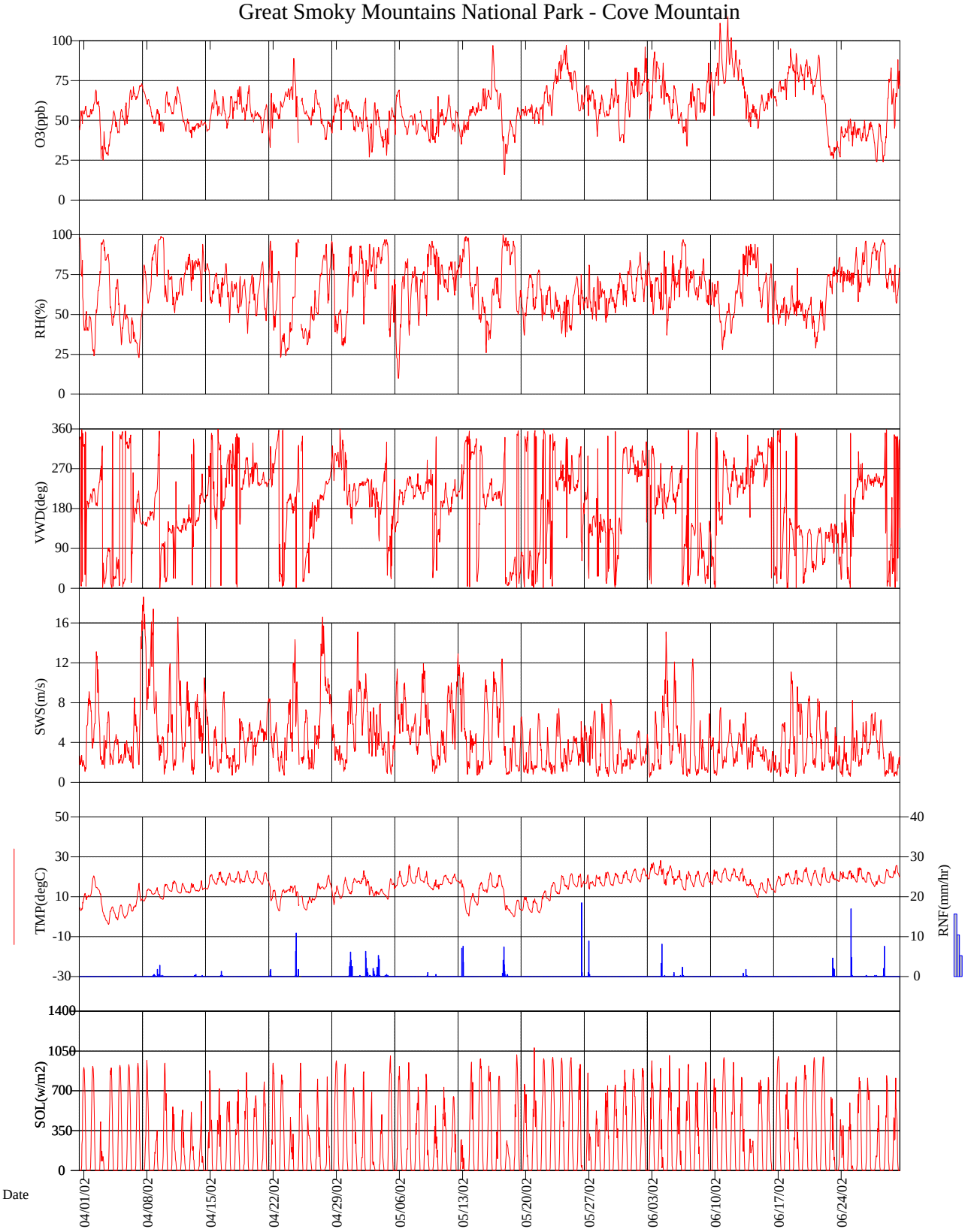
Great Smoky Mountains National Park - Cove Mountain



Final Validation

First Quarter 2002

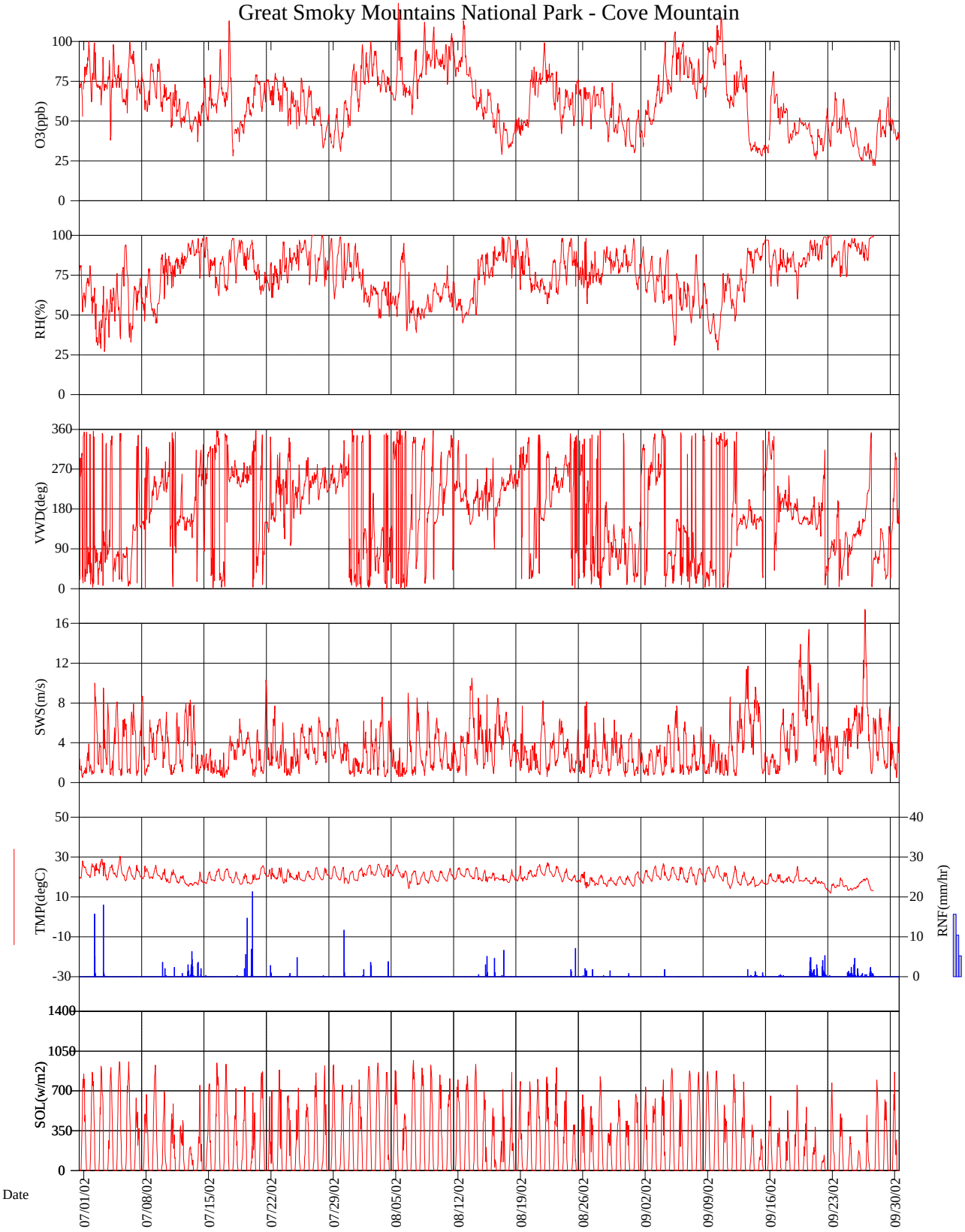
Great Smoky Mountains National Park - Cove Mountain



Final Validation

Second Quarter 2002

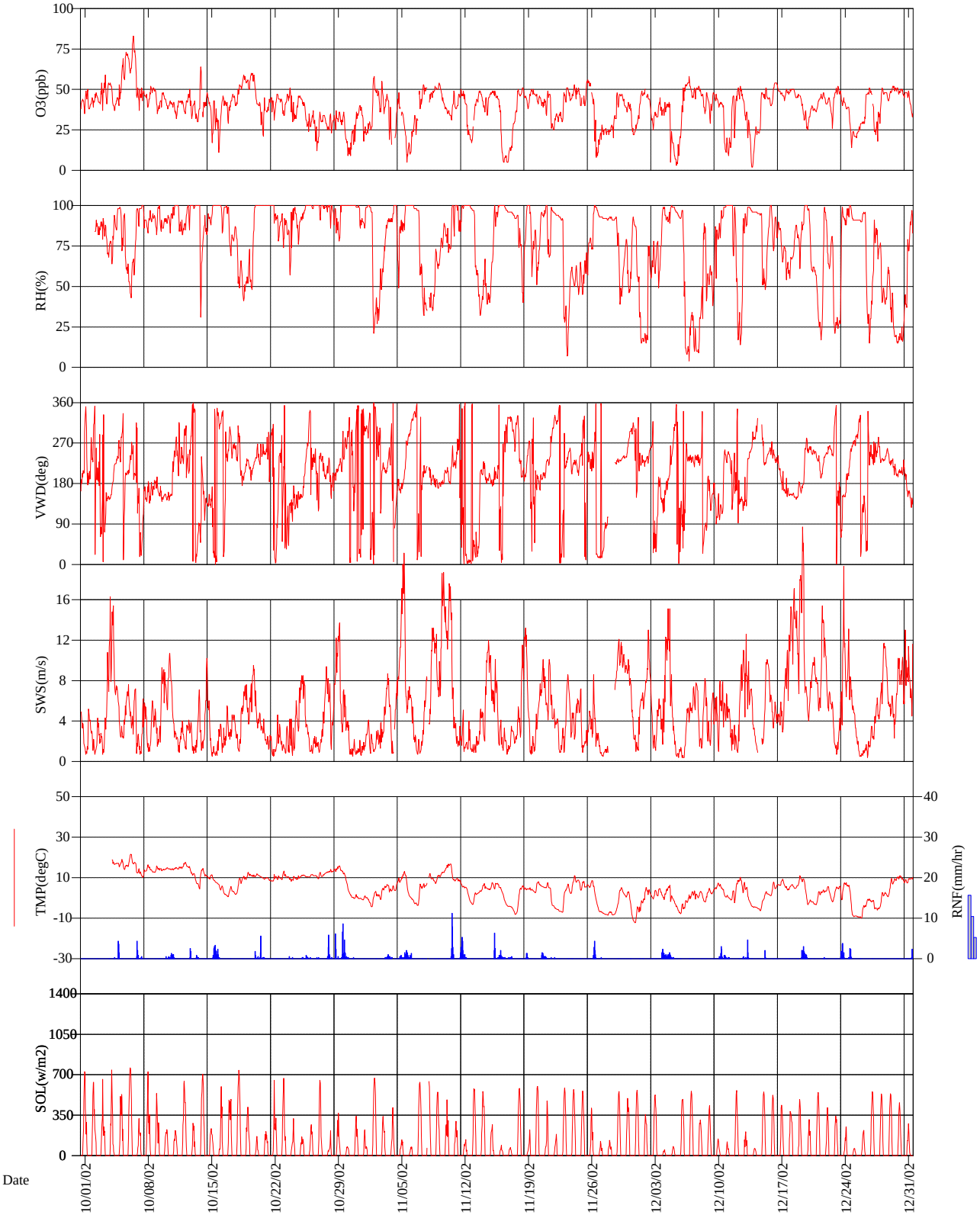
Great Smoky Mountains National Park - Cove Mountain



Final Validation

Third Quarter 2002

Great Smoky Mountains National Park - Cove Mountain



Final Validation

Fourth Quarter 2002

2.2 OZONE DATA SUMMARY

Ozone Quick Look Annual Summary Statistics
Great Smoky Mountains National Park
Cove Mountain
01/01/2002 - 12/31/2002

STATISTIC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAY-SEP	ANNUAL
DAILY 1-HR MAXIMUM	58	69	72	89	97	115	113	124	115	83	58	58	124	124
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(30)	(31)	(153)	(365)
AVERAGE DAILY MAXIMUM	50	53	57	65	68	77	80	84	71	51	47	48	76	62
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(30)	(31)	(153)	(365)
MAXIMUM DAILY MEAN	51	60	64	71	85	90	82	92	96	70	50	50	96	96
NO. OF DAYS	(31)	(28)	(31)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(363)
AVERAGE DAILY MEAN	41	43	48	55	56	63	64	69	56	41	38	39	61	51
NO. OF DAYS	(31)	(28)	(31)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(363)
MAX PEAK:MIN RATIO	7.000	3.583	3.000	2.480	3.125	3.208	2.750	2.034	2.700	4.182	9.200	14.000	3.208	14.000
NO. OF DAYS	(31)	(28)	(31)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(363)
AVERAGE PEAK:MIN RATIO	2.082	1.676	1.585	1.447	1.619	1.614	1.656	1.517	1.627	1.845	2.477	2.732	1.606	1.824
NO. OF DAYS	(31)	(28)	(31)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(29)	(31)	(153)	(363)
MAX 9AM-4PM AVERAGE	52	61	66	68	85	83	80	89	97	63	53	50	97	97
NO. OF DAYS	(31)	(28)	(28)	(29)	(31)	(30)	(31)	(31)	(30)	(30)	(27)	(31)	(153)	(357)
MONTHLY 9AM-4PM AVERAGE	41	43	48	55	54	61	60	66	56	40	38	39	59	50
NO. OF DAYS	(31)	(28)	(28)	(29)	(31)	(30)	(31)	(31)	(30)	(30)	(27)	(31)	(153)	(357)
MAX 7AM-7PM AVERAGE	52	62	66	71	86	87	82	93	97	67	51	49	97	97
NO. OF DAYS	(31)	(28)	(30)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(28)	(31)	(153)	(361)
MONTHLY 7AM-7PM AVERAGE	41	43	48	55	55	62	61	68	56	40	38	39	61	51
NO. OF DAYS	(31)	(28)	(30)	(29)	(31)	(30)	(31)	(31)	(30)	(31)	(28)	(31)	(153)	(361)
MONTHLY MEAN	41	43	48	55	56	63	64	69	56	41	37	39	61	51
NO. OF HOURS	(676)	(664)	(729)	(706)	(733)	(713)	(736)	(738)	(713)	(739)	(698)	(740)	(3633)	(8585)
SUM0 EXPOSURE INDEX	27841	28693	34775	38875	40705	44980	46840	50614	40130	30376	26102	28697	223269	438628
NO. OF HOURS	(676)	(664)	(729)	(706)	(733)	(713)	(736)	(738)	(713)	(739)	(698)	(740)	(3633)	(8585)
SUM60 EXPOSURE INDEX	-	2175	6723	14762	15966	33025	33102	39493	21881	2722	-	-	143467	169849
NO. OF HOURS	(0)	(34)	(106)	(227)	(227)	(443)	(459)	(507)	(277)	(40)	(0)	(0)	(1913)	(2320)
SUM80 EXPOSURE INDEX	-	-	-	346	3379	11778	6791	18016	10830	246	-	-	50794	51386
NO. OF HOURS	(0)	(0)	(0)	(4)	(39)	(136)	(77)	(200)	(118)	(3)	(0)	(0)	(570)	(577)
W126 EXPOSURE INDEX	2046	3105	5834	10308	12973	24419	23437	31293	18315	3221	1548	1808	110436	138305
NO. OF HOURS	(676)	(664)	(729)	(706)	(733)	(713)	(736)	(738)	(713)	(739)	(698)	(740)	(3633)	(8585)

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

Great Smoky Mountains National Park
Cove Mountain
Monitoring Season: 03/01/02 - 10/31/02[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	99	5807	0.035	0.048	0.057	0.067	0.077	0.095	0.100	0.115	0.124	0.115	0.0689	0.0665	1.31

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

Cove Mountain

01/01/2002 - 12/31/2002

Day	Jan-02		Feb-02		Mar-02		Apr-02		May-02		Jun-02		Jul-02		Aug-02		Sep-02		Oct-02		Nov-02		Dec-02	
1	.050	T	.043	F	.057	F	.059	M	.057	W	.083	S	.090	M	.098	T	.057	S	.050	T	.039	F	.047	S
2	.049	W	.043	S	.056	S	.069	T	.064	T	.096	S	.100	T	.100	F	.063	M	.048	W	.058	S	.050	M
3	.046	T	.045	S	.041	S	.062	W	.061	F	.093	M	.090	W	.094	S	.077	T	.059	T	.055	S	.042	T
4	.051	F	.043	M	.048	M	.056	T	.057	S	.087	T	.098	T	.082	S	.100	W	.054	F		M	.045	W
5	.053	S	.059	T	.053	T	.057	F	.058	S	.072	W	.085	F	.124*	M	.106	T	.070	S	.048	T	.042	T
6	.053	S	.054	W	.072	W	.069	S	.069	M	.070	T	.100	S	.106	T	.100	F	.083	S	.034	W	.053	F
7	.033	M	.043	T	.072	T	.073	S	.053	T	.069	F	.094	S	.095	W	.091	S	.074	M	.053	T	.058	S
8	.052	T	.057	F	.068	F	.072	M	.056	W	.073	S	.081	M	.112	T	.089	S	.052	T		F	.052	S
9	.058	W	.056	S	.055	S	.057	T	.050	T	.086	S	.089	T	.109	F	.097	M	.051	W	.054	S	.048	M
10	.054	T	.054	S	.055	S	.068	W	.065	F	.087	M	.083	W	.095	S	.110	T	.048	T	.045	S	.047	T
11	.046	F	.044	M	.060	M	.071	T	.065	S	.115	T	.073	T	.105	S	.115	W	.043	F	.049	M	.040	W
12	.056	S	.052	T	.061	T	.068	F	.066	S	.102	W	.064	F	.093	M	.081	T	.047	S	.050	T	.052	T
13	.050	S	.046	W		W	.051	S	.051	M	.088	T	.062	S	.113	T	.088	F	.050	S	.045	W	.050	F
14	.054	M	.048	T	.066	T	.050	S	.059	T	.066	F	.063	S	.077	W	.053	S	.064	M	.049	T	.027	S
15	.036	T	.067	F	.062	F	.064	M	.070	W	.066	S	.079	M	.070	T	.035	S	.048	T	.049	F	.051	S
16	.051	W	.066	S	.048	S	.069	T	.097	T	.070	S	.095	T	.068	F	.081	M	.046	W	.046	S	.054	M
17	.050	T	.046	S	.047	S	.065	W	.083	F	.075	M	.113	W	.059	S	.067	T	.047	T	.030	S	.053	T
18	.052	F	.058	M	.048	M	.071	T	.050	S	.095	T	.077	T	.051	S	.061	W	.056	F	.051	M	.050	W
19	.049	S	.052	T	.053	T	.072	F	.058	S	.092	W	.065	F	.052	M	.052	T	.060	S	.050	T	.047	T
20	.055	S	.055	W	.043	W	.056	S	.059	M	.088	T	.079	S	.082	T	.049	F	.060	S	.050	W	.040	F
21	.051	M	.055	T	.054	T	.060	S	.060	T	.089	F	.075	S	.084	W	.045	S	.045	M	.049	T	.047	S
22	.053	T	.049	F	.048	F	.067	M	.072	W	.091	S	.077	M	.099	T	.058	S	.047	T	.035	F	.048	S
23	.044	W	.060	S	.061	S	.068	T	.082	T	.042	S	.080	T	.081	F	.068	M	.047	W	.051	S	.052	M
24	.047	T	.061	S	.067	S	.089	W	.094	F	.046	M	.074	W	.070	S	.064	T	.051	T	.053	S	.049	T
25	.051	F	.069	M	.069	M		T	.097	S	.051	T	.077	T	.075	S	.052	W	.046	F	.055	M	.030	W
26	.053	S	.068	T	.055	T	.058	F	.080	S	.049	W	.075	F	.076	M	.046	T	.037	S	.056	T	.047	T
27	.056	S	.035	W		W	.069	S	.072	M	.050	T	.069	S	.072	T	.036	F	.036	S	.028	W	.051	F
28	.058	M	.049	T	.063	T	.050	S	.068	T	.048	F	.059	S	.071	W	.057	S	.035	M	.032	T	.051	S
29	.040	T			.068	F	.066	M	.064	W	.077	S	.058	M	.074	T	.065	S	.037	T	.048	F	.052	S
30	.050	W			.053	S	.063	T	.076	T	.088	S	.063	T	.061	F	.052	M	.036	W	.044	S	.051	M
31	.048	T			.048	S			.080	F			.086	W	.052	S			.040	T				
Valid Days	31		28		29		29		31		30		31		31		30		31		28		30	
Maximum	.058		.069		.072		.089		.097		.115		.113		.124		.115		.083		.058		.058	
Violations	0		0		0		0		0		0		0		1		0		0		0		0	

8561 Total Samples	1 Daily-maxima exceeding the standard of .12 ppm (starred[*])	
98.0 % Possible	5 Missing days assumed to be less than the standard	
359 Valid daily maxima	0 Daily maximas exceed the alert level of .200 ppm	Concentrations in parts per million (ppm)

Final Validation

4/22/03

Great Smoky Mountains National Park
Cove Mountain
2002 Attainment Status With U.S. Environmental Protection Agency (EPA)
PRIMARY Ozone National Ambient Air Quality Standard

Ozone Season: March 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)
2002	96	98%	Yes	107	104	104	103	102

Ozone Analyzer 10 Highest Daily 1-Hour Average Maximum Concentrations Great Smoky Mountains National Park Cove Mountain Final Validation 01/01/2002 - 12/31/2002			
Value	Date	Hour	Concentration (ppb)
Ozone Analyzer			
1	08/05/2002	19	124
2	06/11/2002	22	115
3	09/11/2002	1	115
4	07/17/2002	20	113
5	08/13/2002	3	113
6	08/08/2002	18	112
7	09/10/2002	14	110
8	08/09/2002	19	109
9	08/06/2002	0	106
10	09/05/2002	21	106

Episodes with 1-Hour Ozone Concentrations
≥ 100 ppb and > 124 ppb

Great Smoky Mountains National Park
Cove Mountain

01/01/2002 - 12/31/2002
FINAL VALIDATION

Site	Date	Beginning Hour	No. Hours ≥ 100 ppb	No. Hours >124 ppb	Max (ppb)
GRSM-CM	06/11/02	1	3	0	111
GRSM-CM	06/11/02	20	3	0	115
GRSM-CM	06/11/02	23	1	0	103
GRSM-CM	06/12/02	7	1	0	102
GRSM-CM	07/02/02	2	1	0	100
GRSM-CM	07/06/02	16	1	0	100
GRSM-CM	07/17/02	19	3	0	113
GRSM-CM	08/02/02	17	1	0	100
GRSM-CM	08/05/02	18	3	0	124
GRSM-CM	08/05/02	23	1	0	117
GRSM-CM	08/06/02	0	1	0	106
GRSM-CM	08/08/02	17	4	0	112
GRSM-CM	08/09/02	17	4	0	109
GRSM-CM	08/11/02	18	4	0	105
GRSM-CM	08/13/02	1	6	0	113
GRSM-CM	09/04/02	18	1	0	100
GRSM-CM	09/05/02	18	4	0	106
GRSM-CM	09/06/02	18	1	0	100
GRSM-CM	09/10/02	12	3	0	110
GRSM-CM	09/10/02	17	6	0	107
GRSM-CM	09/10/02	23	1	0	104
GRSM-CM	09/11/02	0	5	0	115
		Total	58	0	124

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/m³ 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
Cove Mountain
01/01/2002 - 12/31/2002
FINAL VALIDATION

Site	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
GRSM-CM	05/16/02	18 - 01	86	3
GRSM-CM	05/24/02	18 - 01	92	14
GRSM-CM	05/25/02	00 - 07	86	1
GRSM-CM	06/03/02	15 - 22	86	4
GRSM-CM	06/10/02	23 - 06	99	6
GRSM-CM	06/11/02	18 - 01	99	15
GRSM-CM	06/12/02	00 - 07	93	15
GRSM-CM	06/18/02	17 - 00	87	7
GRSM-CM	06/21/02	20 - 03	86	3
GRSM-CM	07/01/02	21 - 04	90	6
GRSM-CM	07/02/02	00 - 07	87	5
GRSM-CM	07/06/02	15 - 22	93	14
GRSM-CM	07/07/02	00 - 07	86	1
GRSM-CM	07/17/02	18 - 01	91	5
GRSM-CM	08/01/02	14 - 21	87	5
GRSM-CM	08/02/02	12 - 19	91	11
GRSM-CM	08/03/02	01 - 08	91	5
GRSM-CM	08/05/02	17 - 00	104	12
GRSM-CM	08/06/02	00 - 07	86	1
GRSM-CM	08/07/02	13 - 20	87	4
GRSM-CM	08/08/02	14 - 21	100	15
GRSM-CM	08/09/02	13 - 20	98	24
GRSM-CM	08/10/02	23 - 06	91	24
GRSM-CM	08/11/02	16 - 23	98	22
GRSM-CM	08/12/02	23 - 06	103	14
GRSM-CM	08/13/02	00 - 07	104	8
GRSM-CM	08/21/02	23 - 06	88	2
GRSM-CM	08/22/02	01 - 08	90	5
GRSM-CM	09/04/02	13 - 20	87	5
GRSM-CM	09/05/02	16 - 23	100	13
GRSM-CM	09/06/02	12 - 19	96	24
GRSM-CM	09/07/02	11 - 18	86	5
GRSM-CM	09/09/02	14 - 21	95	15
GRSM-CM	09/10/02	20 - 03	107	24

Episodes with 8-Hour Average Ozone Concentrations > 84 ppb Great Smoky Mountains National Park Cove Mountain 01/01/2002 - 12/31/2002 FINAL VALIDATION *Continued*				
Site	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
GRSM-CM	09/11/02	00 - 07	102	8
	35	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).

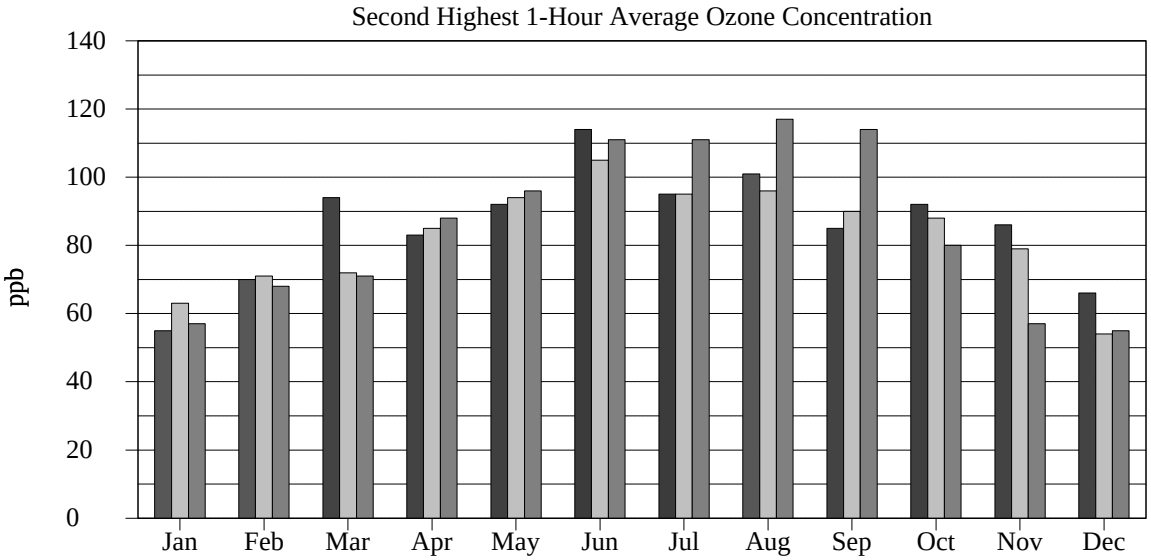
Ozone Rank Listings of Second Highest 1-Hour Average Concentrations, 4th Highest 8-Hour Average Concentrations, and Annual SUM60 Exposure Index for All NPS Monitoring Sites

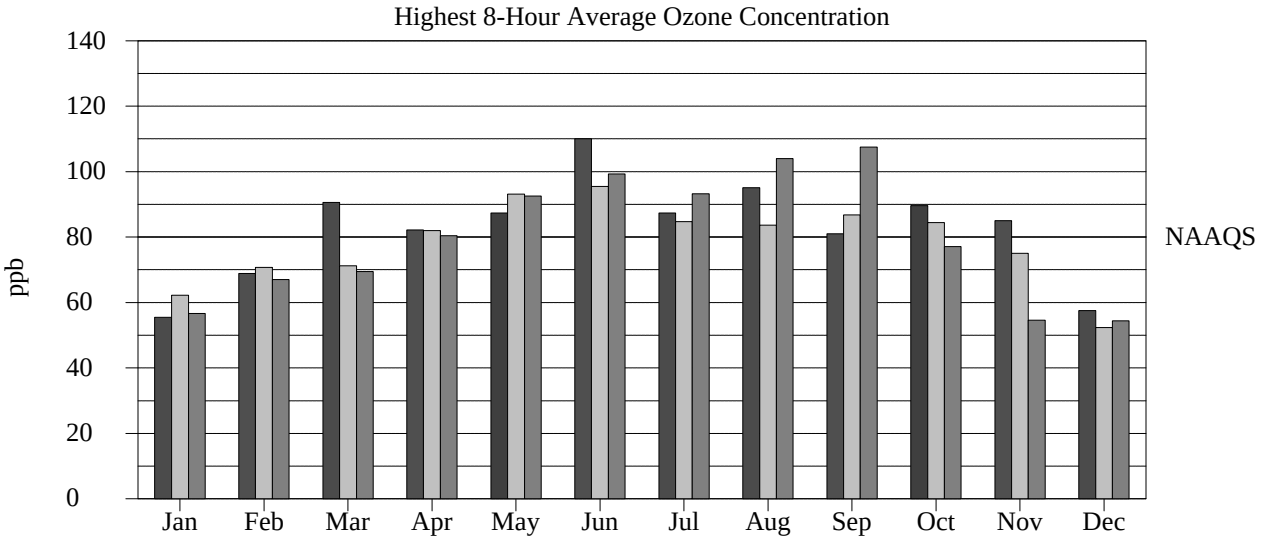
01/01/2002 - 12/31/2002

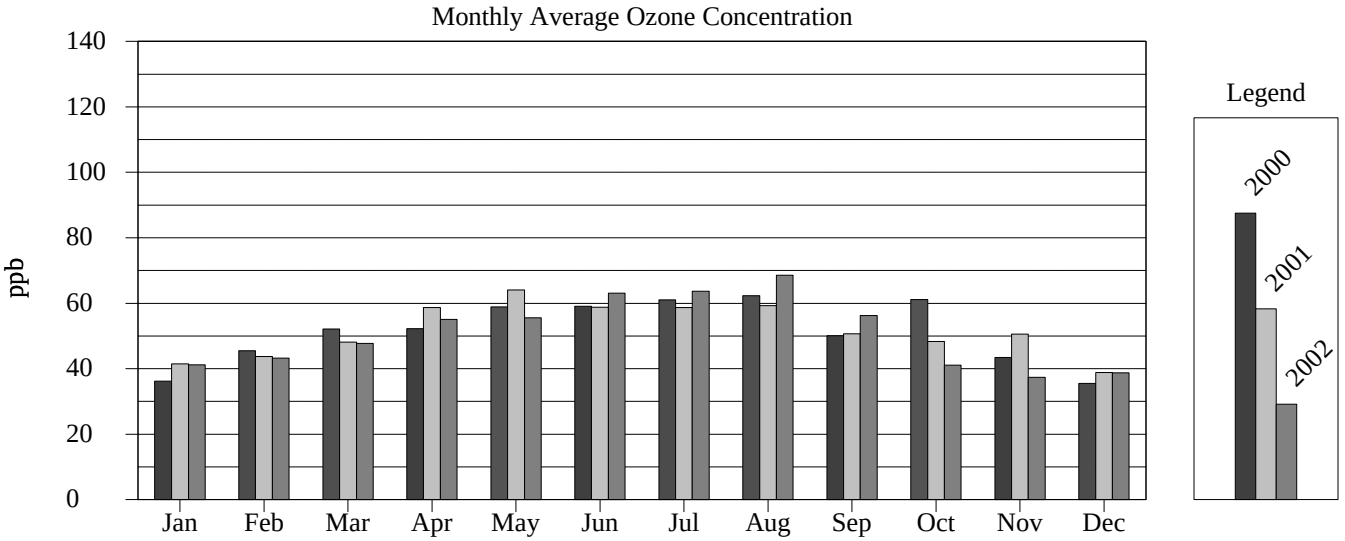
Second Highest 1-Hour Average Concentration		
Site	Rank	Concentration (ppb)
ACAD-CM	1	127
CHAM-XX	2	127
JOTR-YV	3	127
SEKI-LK	4	126
SEKI-AS	5	124
SEKI-LP	6	124
GRSM-LR	7	122
CACO-XX	8	118
COWP-XX	9	118
ACAD-MH	10	117
GRSM-CM	11	117
GRSM-CD	12	115
COSW-BL	13	111
MACA-HM	14	110
PINN-ES	15	110
GRSM-CC	16	108
ROMO-LP	17	106
GRSM-PK	18	105
YOSE-TD	19	105
SHEN-BM	20	103
DEVA-PV	21	97
SAGU-PC	22	90
GRBA-MY	23	89
GRCA-AS	24	85
LAVO-ML	25	84
CHIR-ES	26	80
YOSE-MR	27	80
MEVE-MY	28	79
CHIS-XX	29	78
CANY-IS	30	77
CRMO-VC	31	75
YELL-WT	32	73
THRO-VC	33	71
MORA-TW	34	70
NOCA-MM	35	70
VOYA-SB	36	70
PEFO-HB	37	69
BIBE-KB	38	68
EVER-BC	39	68
DENA-HQ	40	65
GLAC-WG	41	59
VIIS-LP	42	57
HAVO-TH	43	50
OLYM-VC	44	44

4th Highest 8-hour Average Concentration		
Site	Rank	Concentration (ppb)
SEKI-LP	1	109
SEKI-LK	2	108
JOTR-YV	3	107
SEKI-AS	4	107
GRSM-CM	5	103
GRSM-LR	6	102
GRSM-CD	7	101
ACAD-CM	8	100
GRSM-PK	9	94
CACO-XX	10	93
COWP-XX	11	93
YOSE-TD	12	93
ACAD-MH	13	89
CHAM-XX	14	89
ROMO-LP	15	87
PINN-ES	16	86
SHEN-BM	17	86
MACA-HM	18	85
DEVA-PV	19	83
COSW-BL	20	82
GRSM-CC	21	82
GRCA-AS	22	79
SAGU-PC	23	77
LAVO-ML	24	75
GRBA-MY	25	74
CANY-IS	26	72
YOSE-MR	27	72
MEVE-MY	28	70
CHIR-ES	29	69
CRMO-VC	30	69
CHIS-XX	31	66
YELL-WT	32	66
VOYA-SB	33	65
BIBE-KB	34	62
THRO-VC	35	62
EVER-BC	36	57
DENA-HQ	37	55
PEFO-HB	38	55
GLAC-WG	39	52
MORA-TW	40	52
VIIS-LP	41	48
NOCA-MM	42	46
HAVO-TH	43	42
OLYM-VC	44	39

Annual Sum60 Exposure Index			
Site	Rank	Sum60	Count
SEKI-LK	1	204306	2639
SEKI-AS	2	196849	2529
SEKI-LP	3	193795	2491
JOTR-YV	4	175177	2398
GRSM-CM	5	169849	2320
YOSE-TD	6	164764	2298
GRSM-LR	7	131936	1794
GRSM-CD	8	130649	1793
GRSM-PK	9	118538	1656
DEVA-PV	10	106174	1586
GRCA-AS	11	104360	1584
ROMO-LP	12	95145	1403
SHEN-BM	13	88006	1273
CANY-IS	14	68738	1068
COWP-XX	15	66858	924
PINN-ES	16	54322	767
MEVE-MY	17	49400	771
GRSM-CC	18	42779	611
CACO-XX	19	39974	546
MACA-HM	20	39775	571
ACAD-CM	21	39360	529
SAGU-PC	22	35867	540
COSW-BL	23	34655	491
CHAM-XX	24	34216	482
CRMO-VC	25	34186	537
CHIR-ES	26	32418	503
GRBA-MY	27	30461	466
YELL-WT	28	29522	470
ACAD-MH	29	26476	362
LAVO-ML	30	26432	394
YOSE-MR	31	22272	334
VOYA-SB	32	7405	116
BIBE-KB	33	7215	116
CHIS-XX	34	6974	106
THRO-VC	35	4004	63
DENA-HQ	36	996	16
PEFO-HB	37	951	15
EVER-BC	38	833	13
MORA-TW	39	453	7
NOCA-MM	40	267	4
GLAC-WG	41	124	2
HAVO-TH	42	0	0
OLYM-VC	43	0	0
VIIS-LP	44	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
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
NAAQS


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
2000
2001
2002

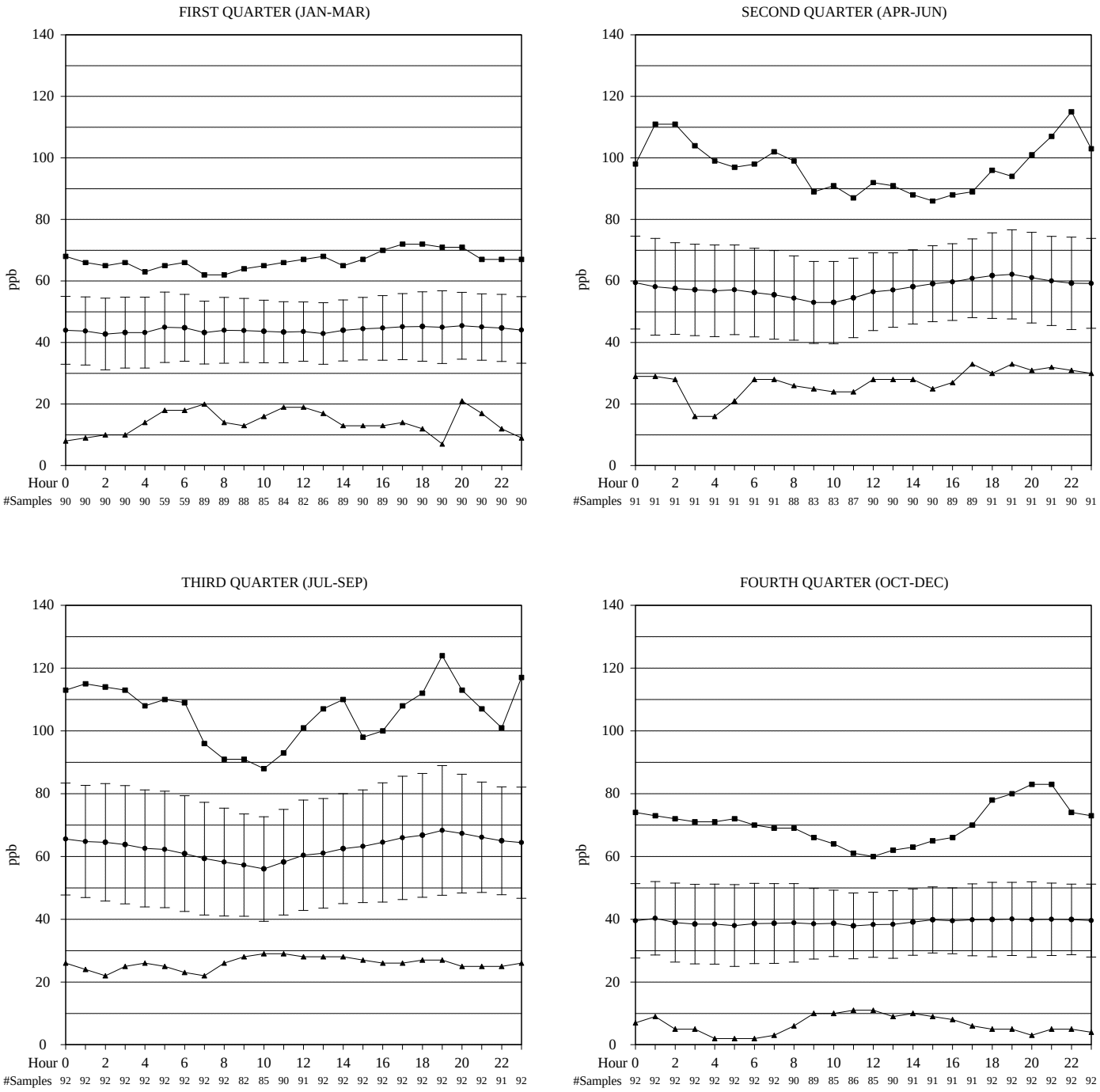
NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK

2002 Second Highest 1-Hour Ozone Concentrations

Great Smoky Mountains National Park
Cove Mountain

Quarterly Diurnal Ozone Plots

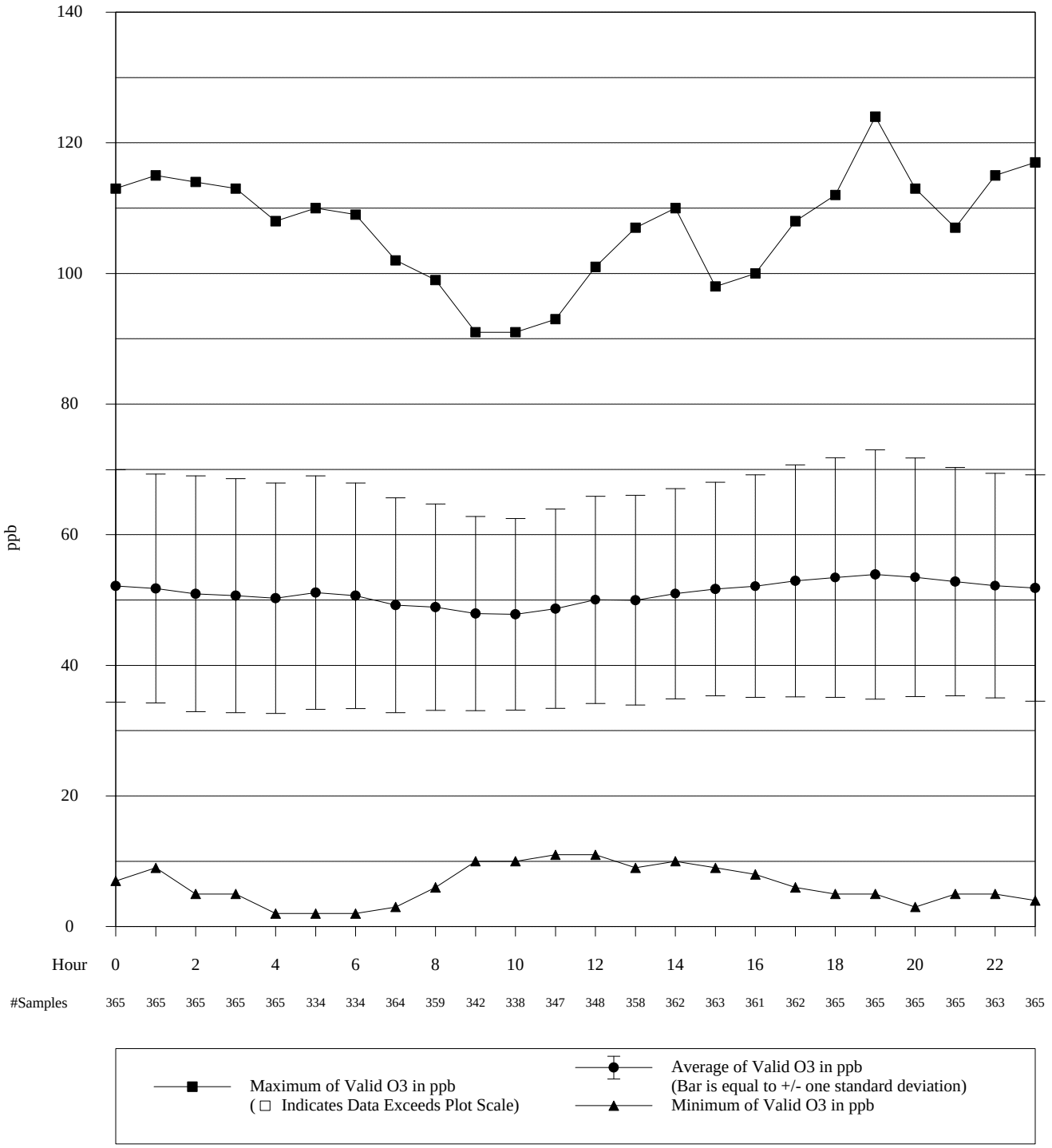
2002



Great Smoky Mountains National Park
Cove Mountain

Annual Diurnal Ozone Plot

2002



Final Validation

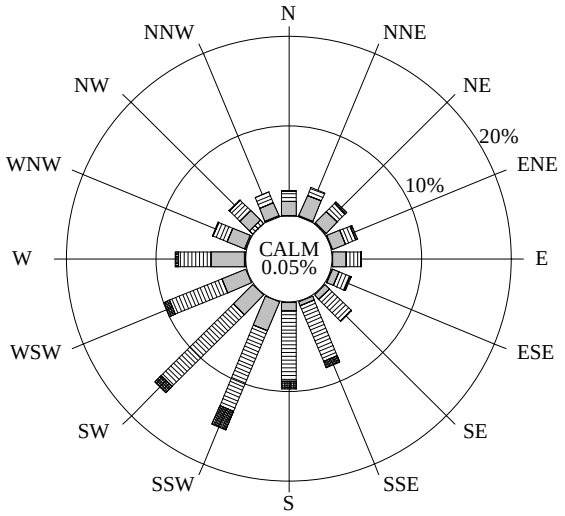
04-18-2003

Great Smoky Mountains National Park
Cove Mountain

Quarterly Ozone Pollutant Rose

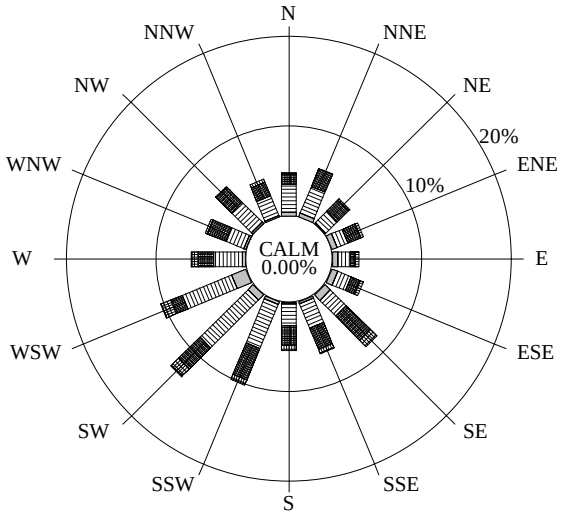
2002

FIRST QUARTER (JAN-MAR)



95.2% Collected 95.0% Valid
2160 Possible /2057 Collected /2052 Valid
(includes WS and WD)

SECOND QUARTER (APR-JUN)

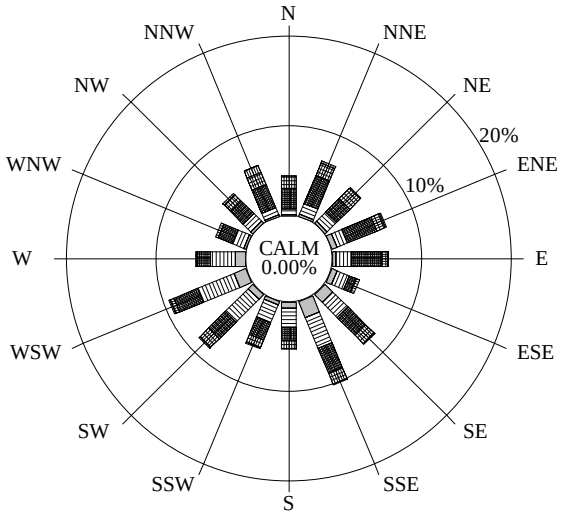


98.8% Collected 98.5% Valid
2184 Possible /2157 Collected /2152 Valid
(includes WS and WD)

Ozone (ppb)

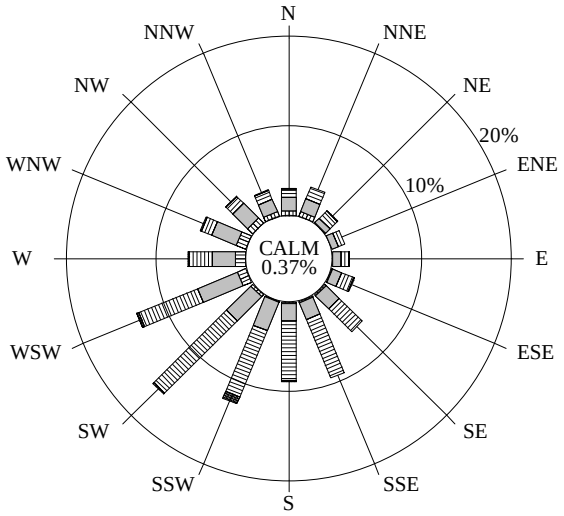
0-19
20-39
40-59
60-79
80-99
100-119
120-139
140+

THIRD QUARTER (JUL-SEP)



99.2% Collected 99.0% Valid
2208 Possible /2190 Collected /2187 Valid
(includes WS and WD)

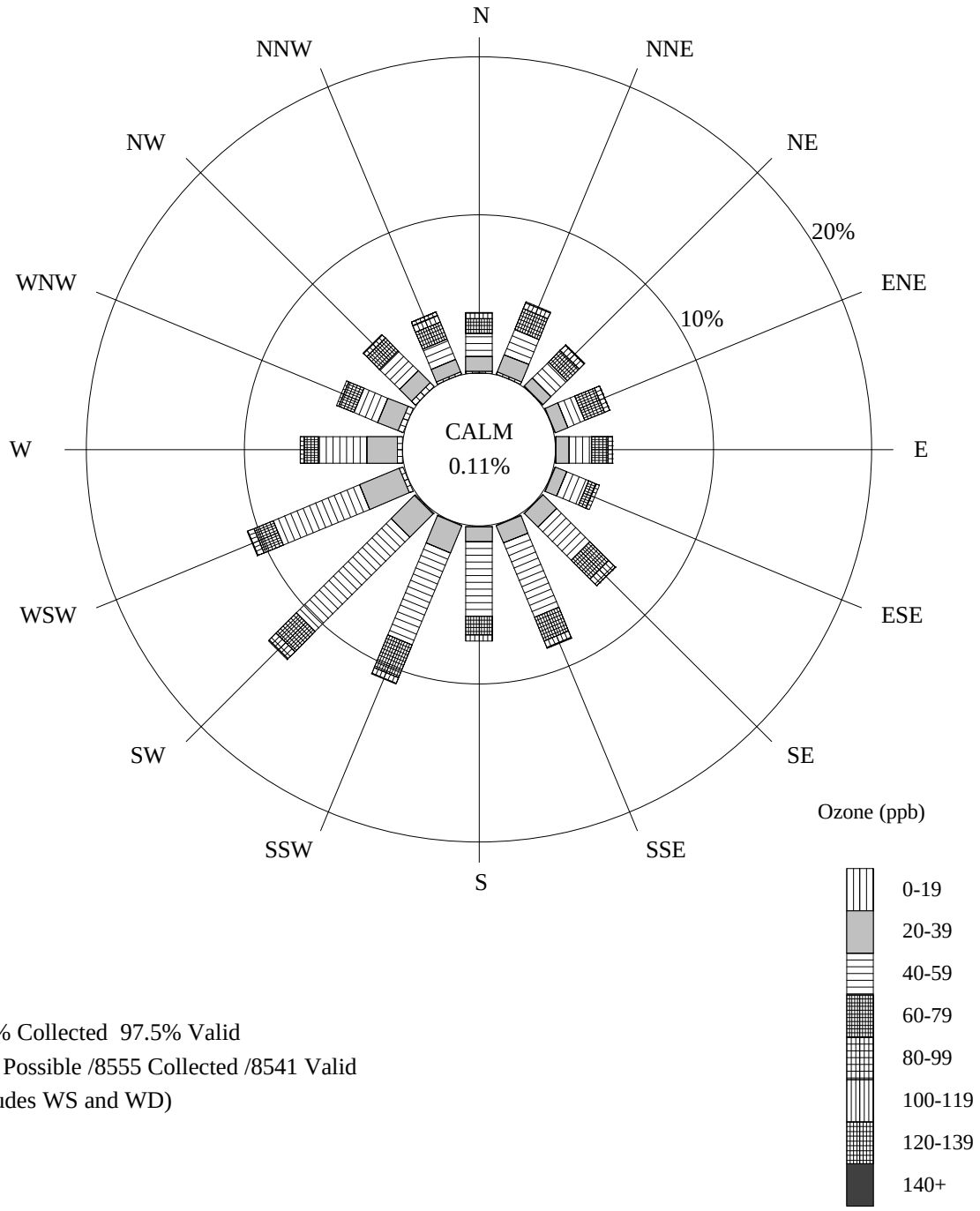
FOURTH QUARTER (OCT-DEC)



97.4% Collected 97.4% Valid
2208 Possible /2151 Collected /2150 Valid
(includes WS and WD)

Final Validation

04-18-2003



97.7% Collected 97.5% Valid
8760 Possible /8555 Collected /8541 Valid
(includes WS and WD)

Ozone Analyzer Precision Check Summary

Great Smoky Mountains National Park
Cove Mountain

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 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 Validation 01/01/2002 - 12/31/2002				
Calendar Quarter	Number of Precision Checks	Average Percent Difference [1] [2]	Lower 95% Probability Limit [3]	Upper 95% Probability Limit [3]
1	85	0.09	-4.42	4.60
2	68	0.17	-7.60	7.94
3	91	4.41	0.59	8.23
4	81	2.24	-3.10	7.58

[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

Cove Mountain

Final Validation

01/01/2002 - 12/31/2002

Parameter	Value	Units	Number	Std Dev
SCALAR WIND SPEED				
Average	4.6	m/s	8701	3.3
Maximum	23.2	m/s		
Percent calm = 0.11				
AMBIENT TEMPERATURE				
Average	11.1	degC	8597	9.0
Maximum	30.5	degC		
Minimum	-17.0	degC		
RELATIVE HUMIDITY				
Average	70	percent	8640	22
Maximum	100	percent		
Minimum	4	percent		
PRECIPITATION (Rainfall or Snow melt)				
Average non-zero rate	1.6	mm/hr	746	2.4
Maximum non-zero rate	21.3	mm/hr		
Minimum non-zero rate	.3	mm/hr		
Accumulated during period	1199.7	mm		
SOLAR RADIATION				
Average Daily Total	12,657,181	joules/m2day	363	6,783,094
Maximum Daily Total	27,872,000	joules/m2day		
Minimum Daily Total	544,000	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.

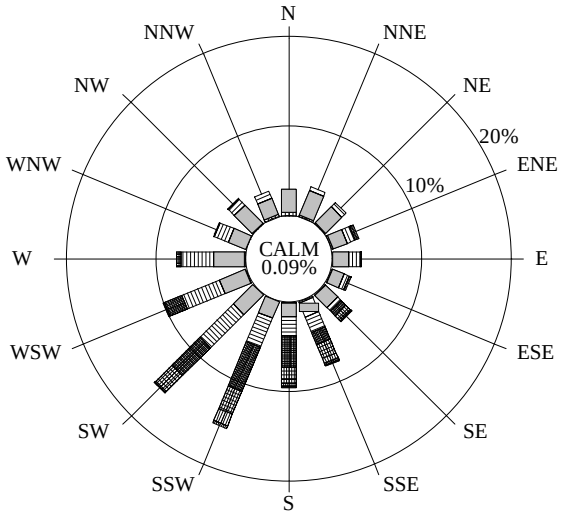
NA indicates instrument not available.

Great Smoky Mountains National Park
Cove Mountain

Quarterly Wind Rose

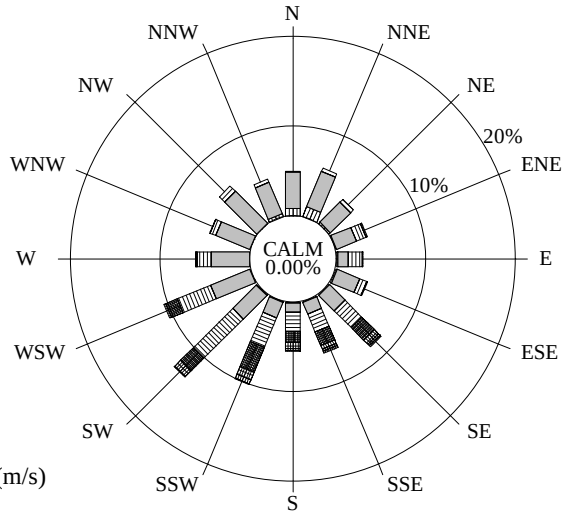
2002

FIRST QUARTER (JAN-MAR)



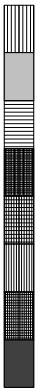
99.1% Collected 99.0% Valid
2160 Possible /2141 Collected /2139 Valid
(includes WS and WD)

SECOND QUARTER (APR-JUN)



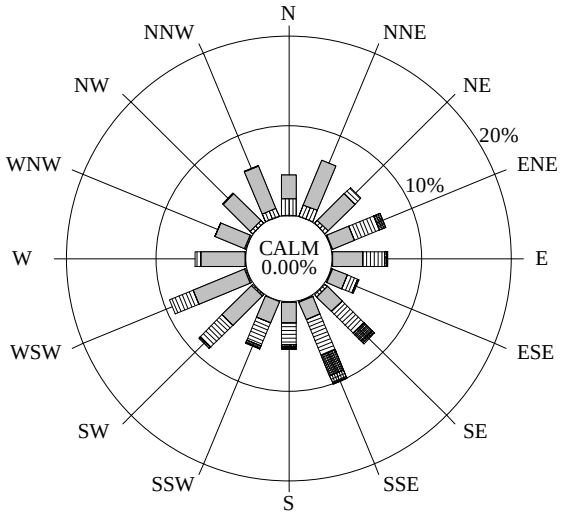
99.8% Collected 99.8% Valid
2184 Possible /2179 Collected /2179 Valid
(includes WS and WD)

Scalar Wind Speed (m/s)



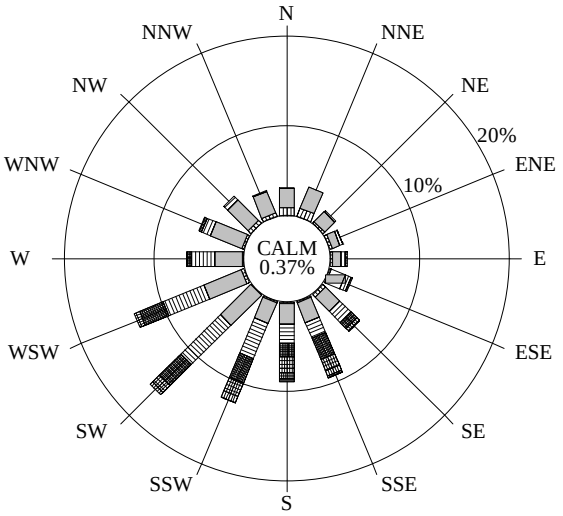
CALM < .5
0.5-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

THIRD QUARTER (JUL-SEP)



100.0% Collected 100.0% Valid
2208 Possible /2208 Collected /2208 Valid
(includes WS and WD)

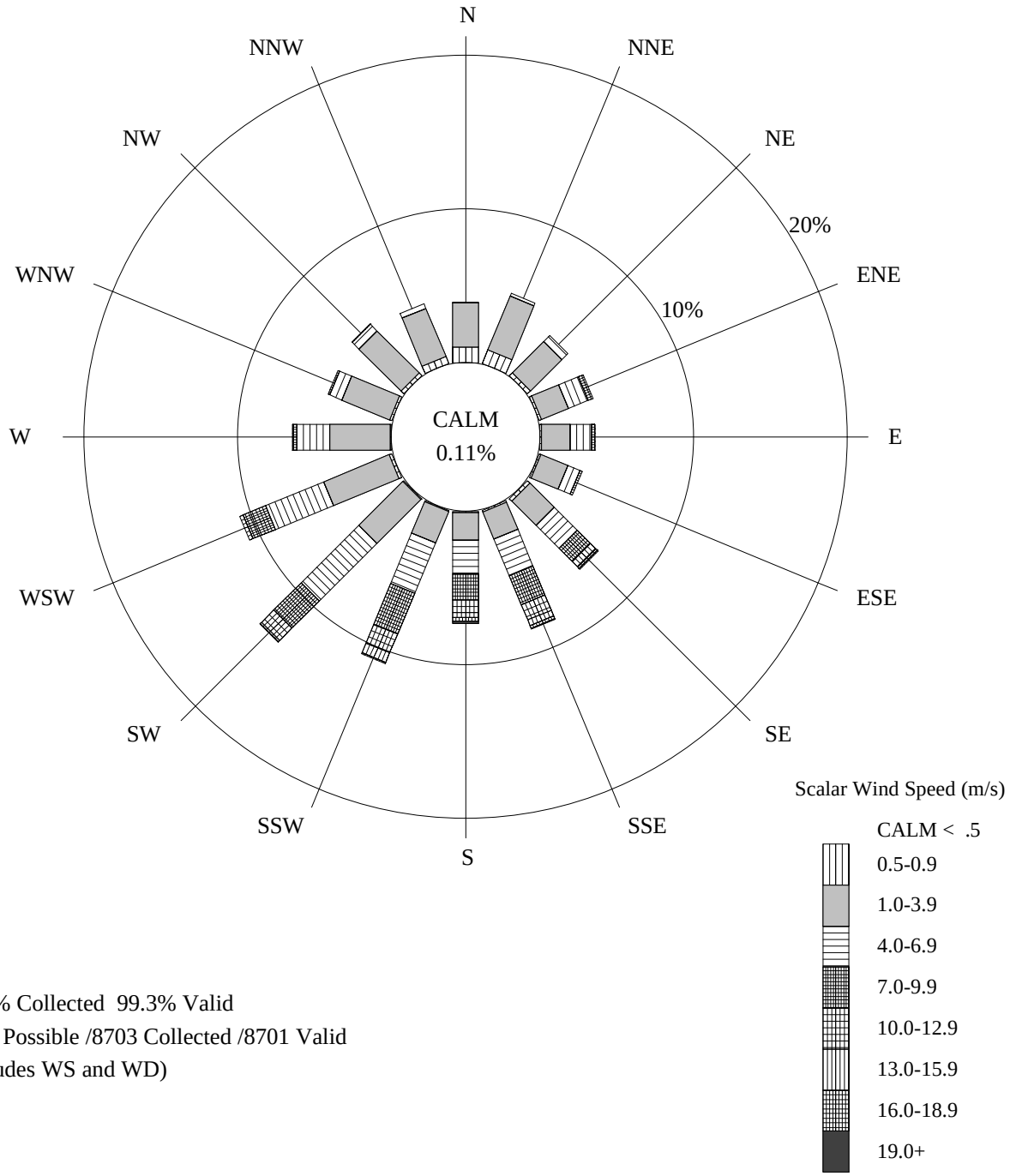
FOURTH QUARTER (OCT-DEC)



98.5% Collected 98.5% Valid
2208 Possible /2175 Collected /2175 Valid
(includes WS and WD)

Final Validation

04-18-2003



99.3% Collected 99.3% Valid
8760 Possible /8703 Collected /8701 Valid
(includes WS and WD)

3.0 NATIONAL PARK SERVICE AIR RESOURCES DIVISION DATA SOURCES

Meteorological and hourly gaseous data contained in this report may be obtained from the following sources:

- National Park Service AIRWeb (http://www.aqd.nps.gov/natnet/ard)
- 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

CASTNet concentration data may be obtained from the following Web site:

http://www.epa.gov/castnet/data.html

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.

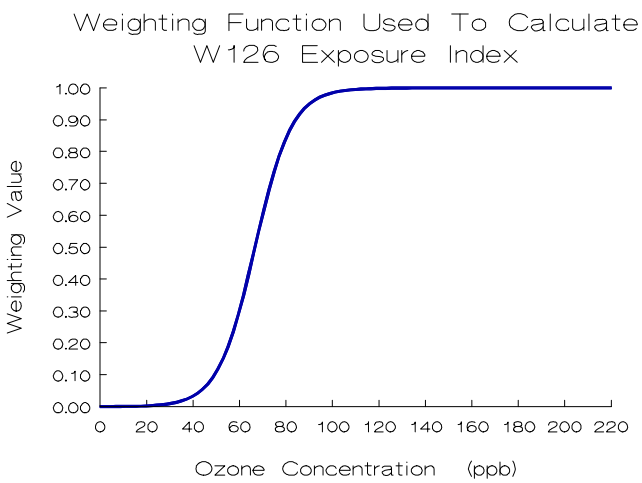
(13) **SUM60 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to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