Report No. NPS D-98

# Annual Data Summary

# THEODORE ROOSEVELT NATIONAL PARK

## 1998

## National Park Service
## Gaseous Air Pollutant Monitoring Network

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## ACKNOWLEDGEMENTS

The National Park Service Air Resources Division (ARD) recognizes the level of effort required by individual park units, site operators, auditors, cooperating state and local agencies, and ARD contractors. ARD sincerely appreciates the contributions of all participants in assisting with the collection, validation, and reporting of these air quality and meteorological data.

At Theodore Roosevelt National Park, ARD specifically recognizes North Dakota Department of Health Division of Environmental Engineering 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

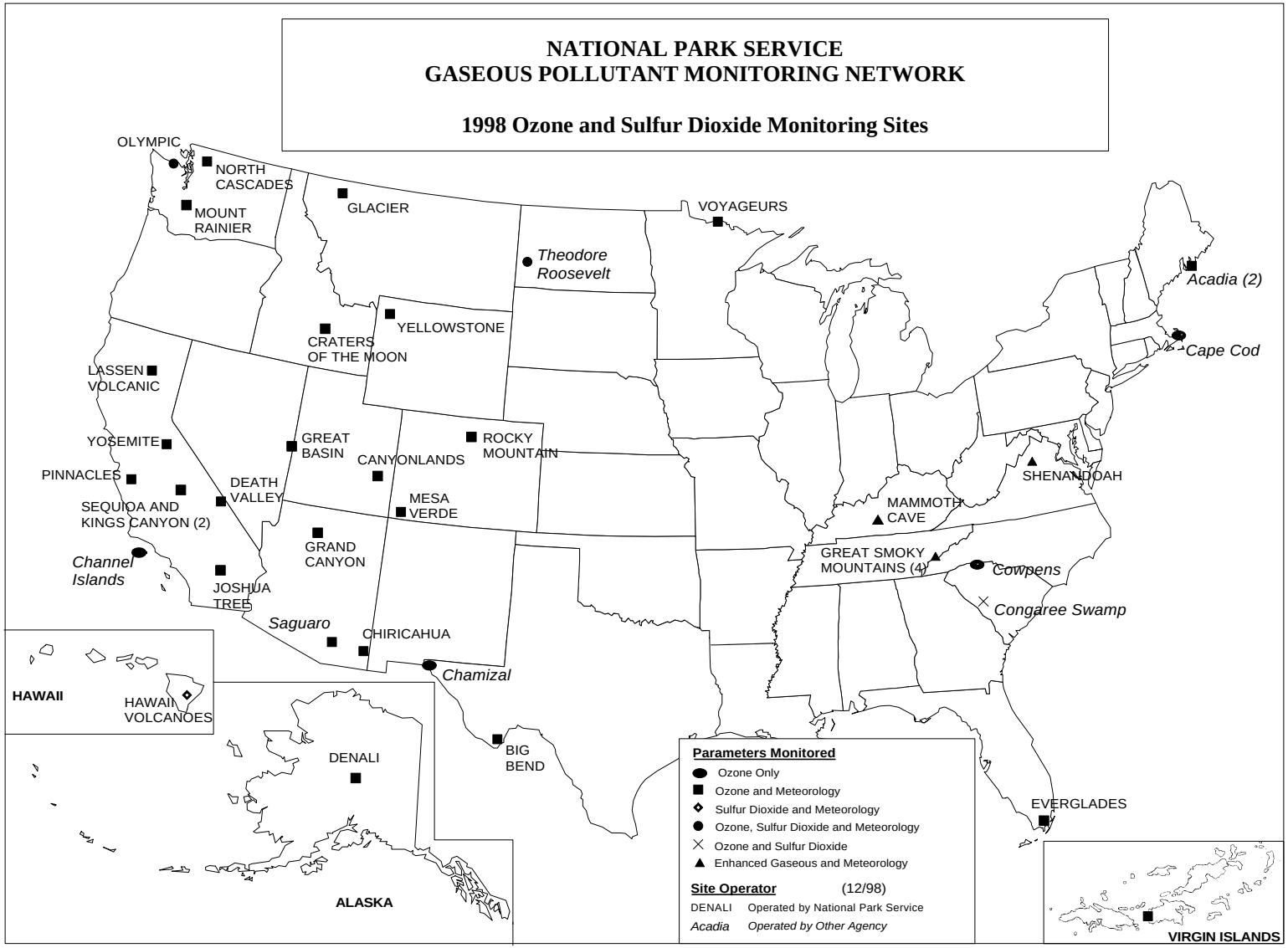
Gaseous air pollutants, including ozone and sulfur dioxide, are of concern to the National Park Service (NPS). Pollutants like these can affect park unit biological resources as well as the health of park unit residents and visitors. The NPS established a gaseous pollutant monitoring program for several 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
JOSHUA TREE
GREAT SMOKY MOUNTAINS (4)
Cowpens
Congaree Swamp
Saguaro
CHIRICAHUA
Chamizal
HAWAII
HAWAII VOLCANOES
DENALI
BIG BEND
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 THEODORE ROOSEVELT NATIONAL PARK

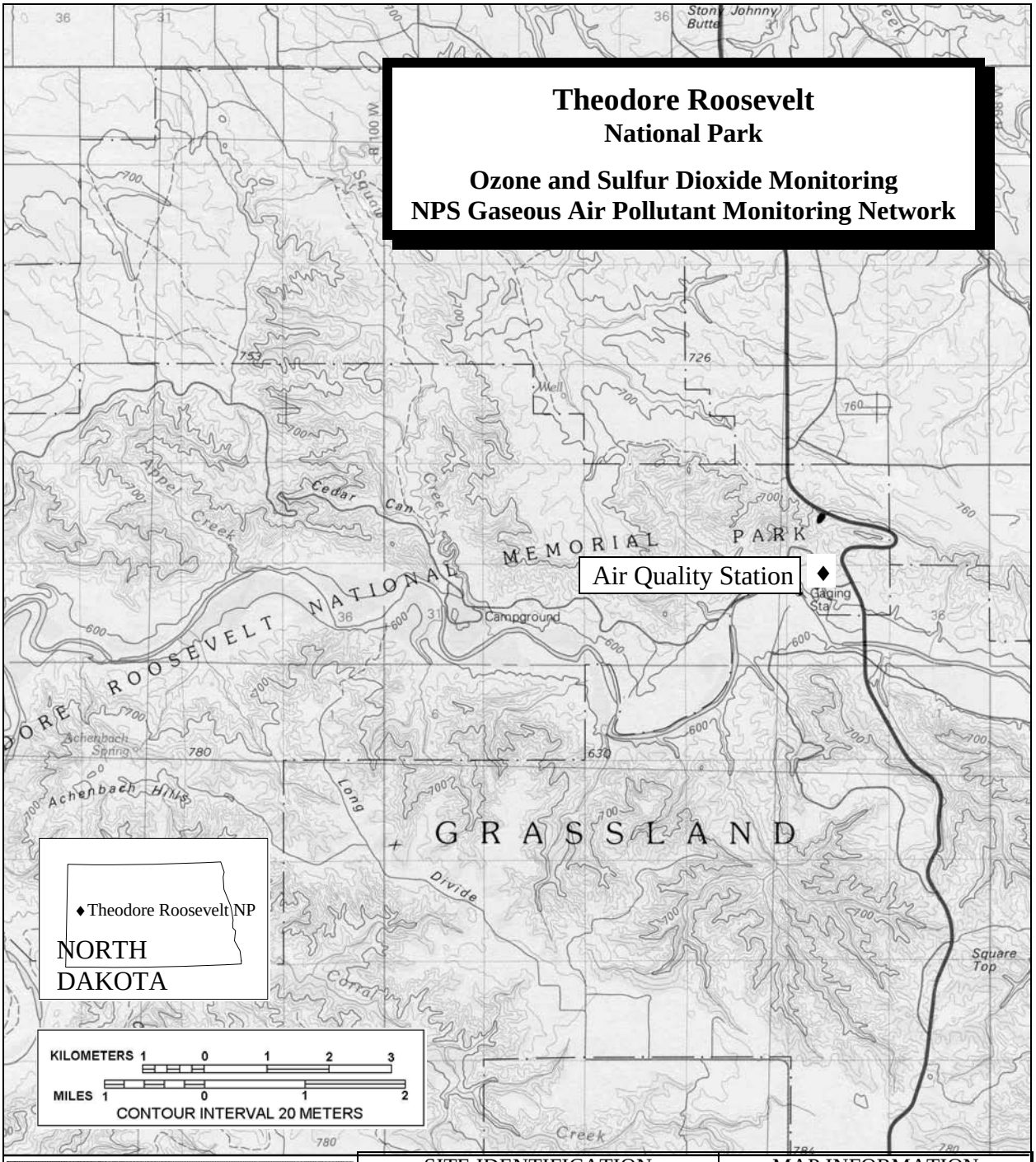
Theodore Roosevelt National Park, a Class I area, is located in the upper Missouri Basin of western North Dakota. Its location and site specifications are presented on the following page.

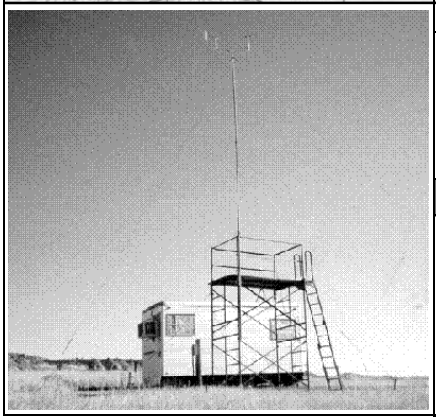
Theodore Roosevelt National Park was established by Congress on April 25, 1947. Nearly 30,000 acres of the park were designated a wilderness in 1978.

The park, over 70,000 acres in size, includes scenic badlands along the Little Missouri River and part of Theodore Roosevelt's Elkhorn Ranch.

# Theodore Roosevelt
## National Park

### Ozone and Sulfur Dioxide Monitoring
### NPS Gaseous Air Pollutant Monitoring Network



| SITE IDENTIFICATION | | MAP INFORMATION | |
|---|---|---|---|
| Site Abbreviation: | THRO | Mean Elevation: | 700 m |
| AIRS ID NO.: | 38-007-0002 | Longitude: | 108° 15' 51"W |
| | | Latitude: | 47° 36' 04"N |
| | | UTM Zone: | 13 |
| | | Easting: | 630483 m |
| | | Northing: | 5273208 m |
| | | Map Reference: | Watford City |
| | | | 1982 |
| | | | 47103-E1 |
| | | | 1:100,000 |

| INSTRUMENTATION | |
|---|---|
| Solar Radiation | Delta Temperature |
| Relative Humidity | Wind Speed |
| Precipitation | Wind Direction |
| Temperature | |

# 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
Theodore Roosevelt National Park
Visitor Center

Preliminary Data

07/27/98 - 12/31/98

| Parameter | Par Code | Data Recovery | | | Valid Data | |
|---|---|---|---|---|---|---|
| | | No. Possible | No. Collected | % Collected | No. Valid | % Valid |
| Ozone Analyzer | O3 | 3779 | 3653 | 96.7 | 3227 | 85.4 |
| Sulfur Dioxide Analyzer | SO2 | 3781 | 3658 | 96.7 | 3658 | 96.7 |
| Scalar Wind Speed | SWS | 3671 | 3554 | 96.8 | 3554 | 96.8 |
| Vector Wind Speed | VWS | 3671 | 3547 | 96.6 | 3547 | 96.6 |
| Vector Wind Direction | VWD | 3671 | 3549 | 96.7 | 3549 | 96.7 |
| Standard Deviation for Wind Direction | SDWD | 3671 | 3547 | 96.6 | 3547 | 96.6 |
| Ambient Temperature (aspirated) | TMP | 3671 | 3555 | 96.8 | 3555 | 96.8 |
| Delta Temperature | DTP | 3671 | 3555 | 96.8 | 3555 | 96.8 |
| Relative Humidity | RH | 3671 | 3555 | 96.8 | 3555 | 96.8 |
| Precipitation | RNF | 3671 | 3540 | 96.4 | 3540 | 96.4 |
| Wetness Sensor | WET | 3671 | 3558 | 96.9 | 3558 | 96.9 |
| Solar Radiation | SOL | 3671 | 3555 | 96.8 | 3555 | 96.8 |
| Filter Pack Flow Rate | FLOW | 2078 | 2069 | 99.6 | 2069 | 99.6 |

Notes: All statistics are for hourly averages.

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

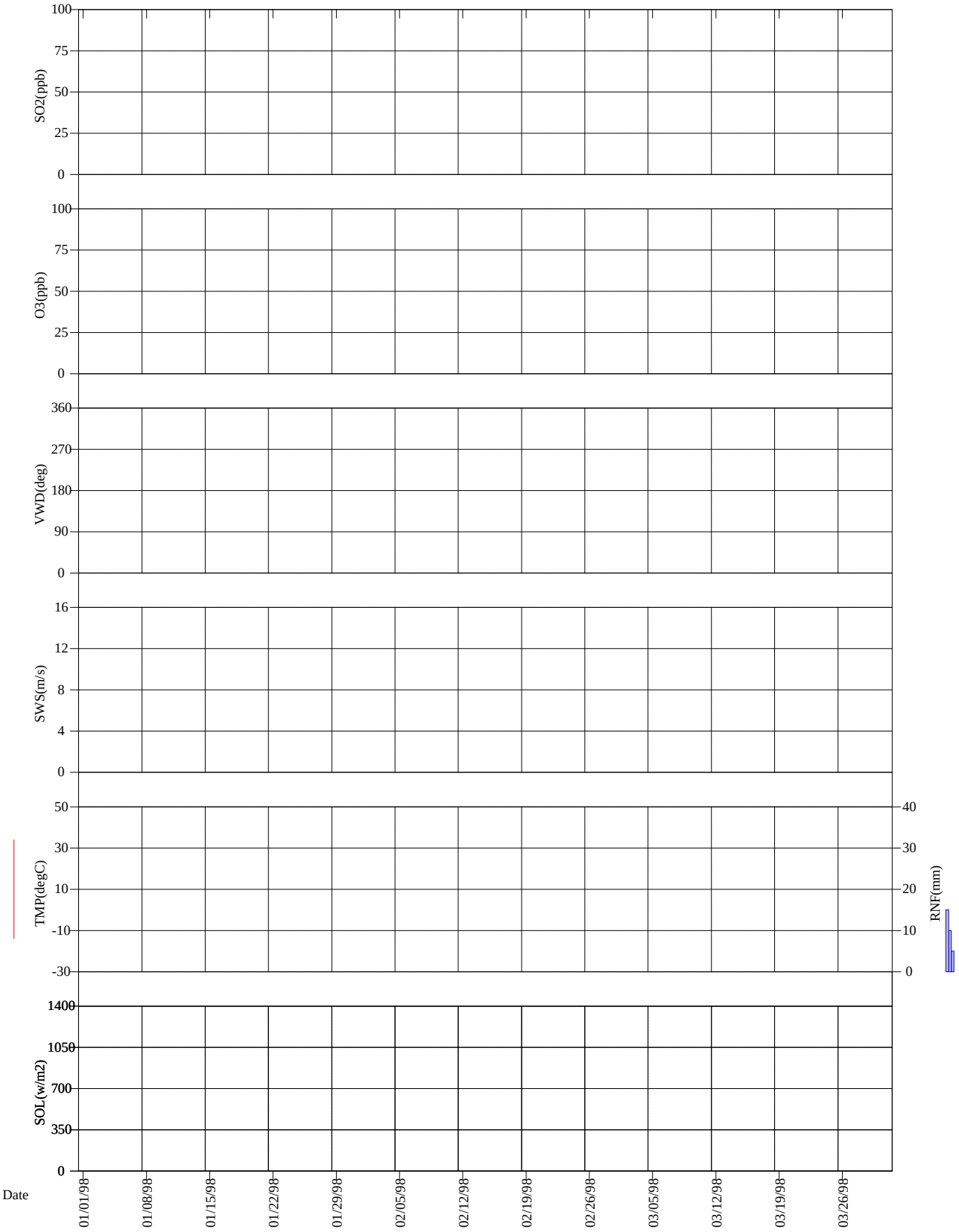
The percent valid is calculated against the number possible.

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 |

Theodore Roosevelt National Park

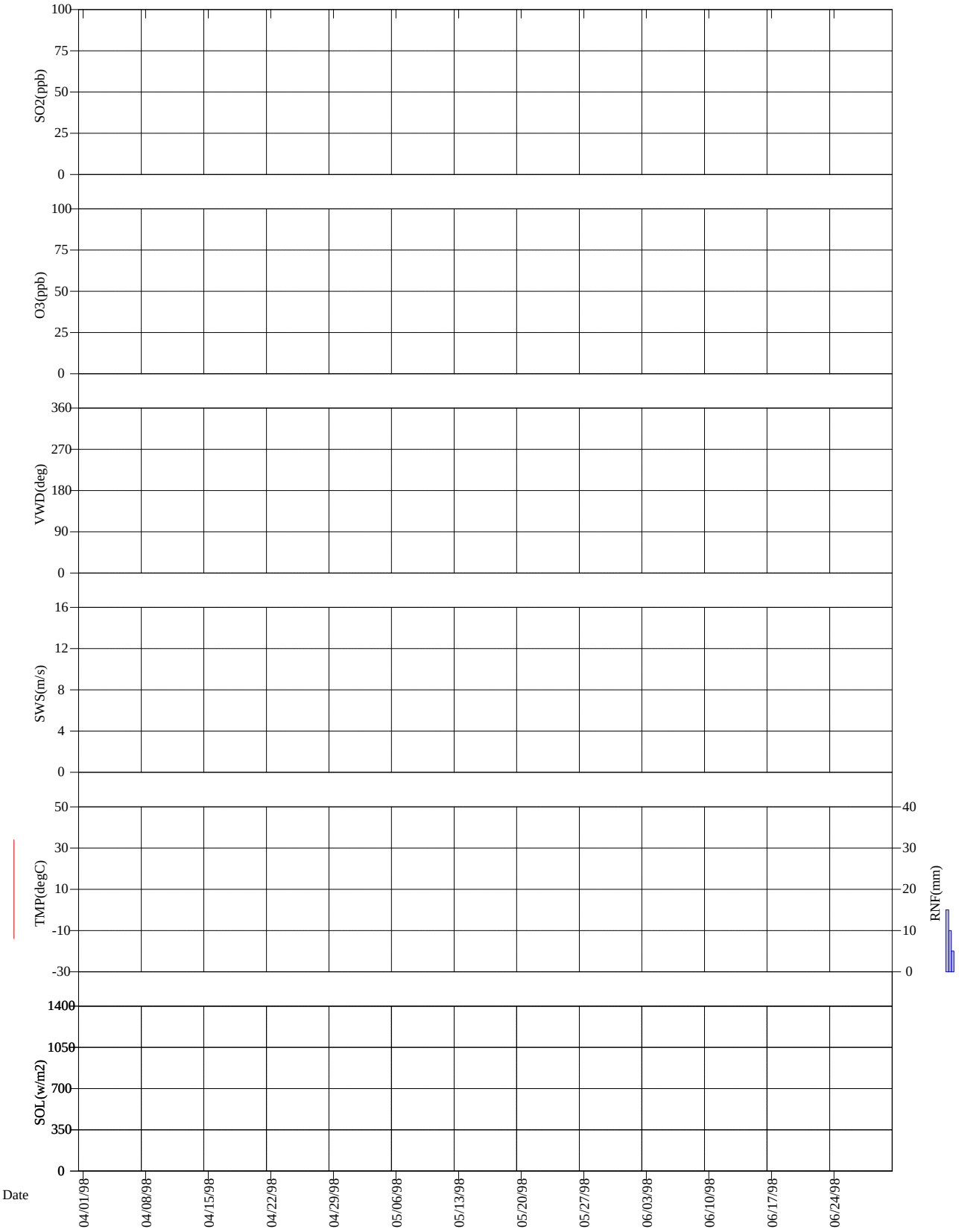



Final Validation

First Quarter 1998

trvc98.stk - trvc98.dat 08-24-1999

Theodore Roosevelt National Park

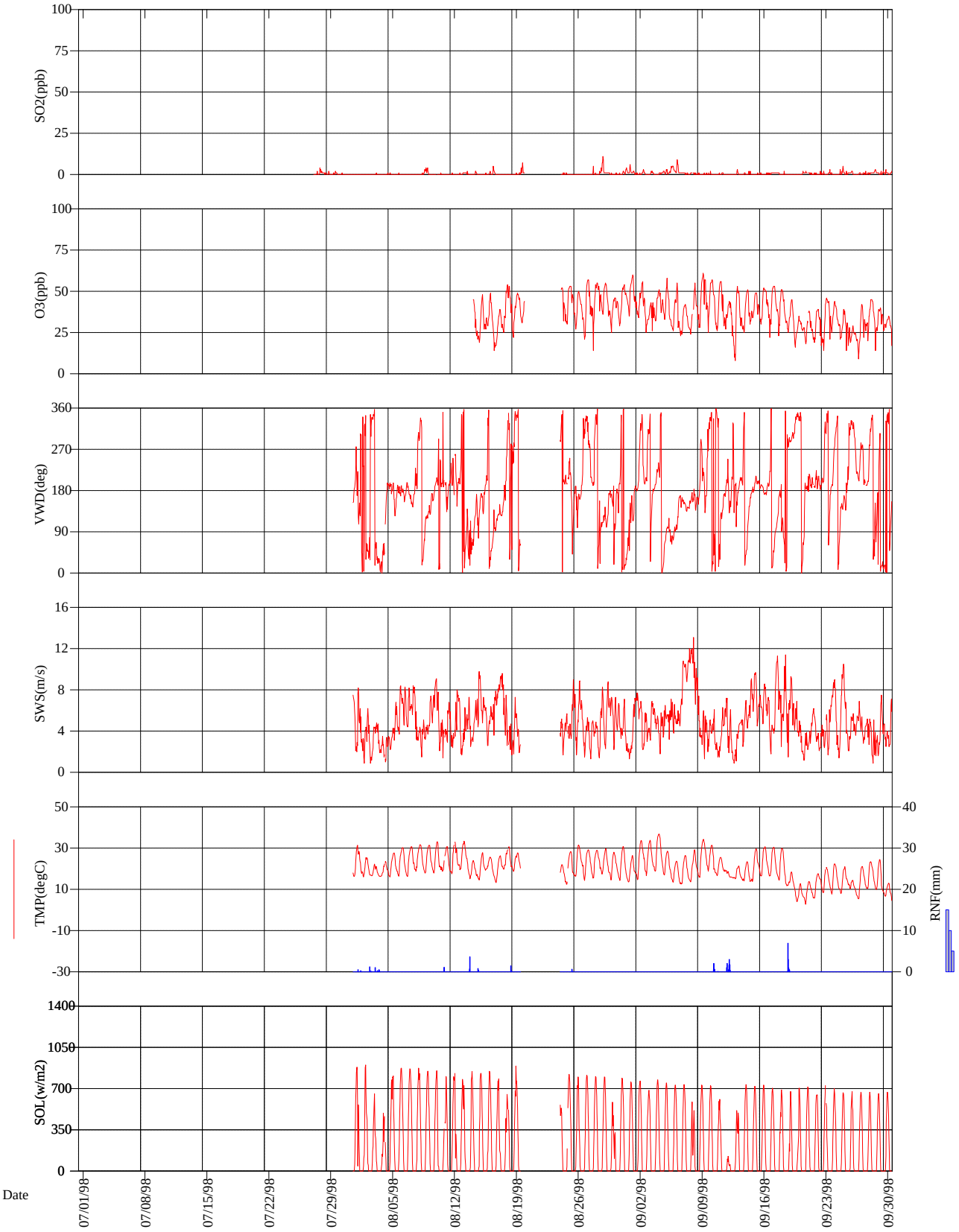



Final Validation

Second Quarter 1998

trvc98.stk - trvc98.dat 08-24-1999

Theodore Roosevelt National Park

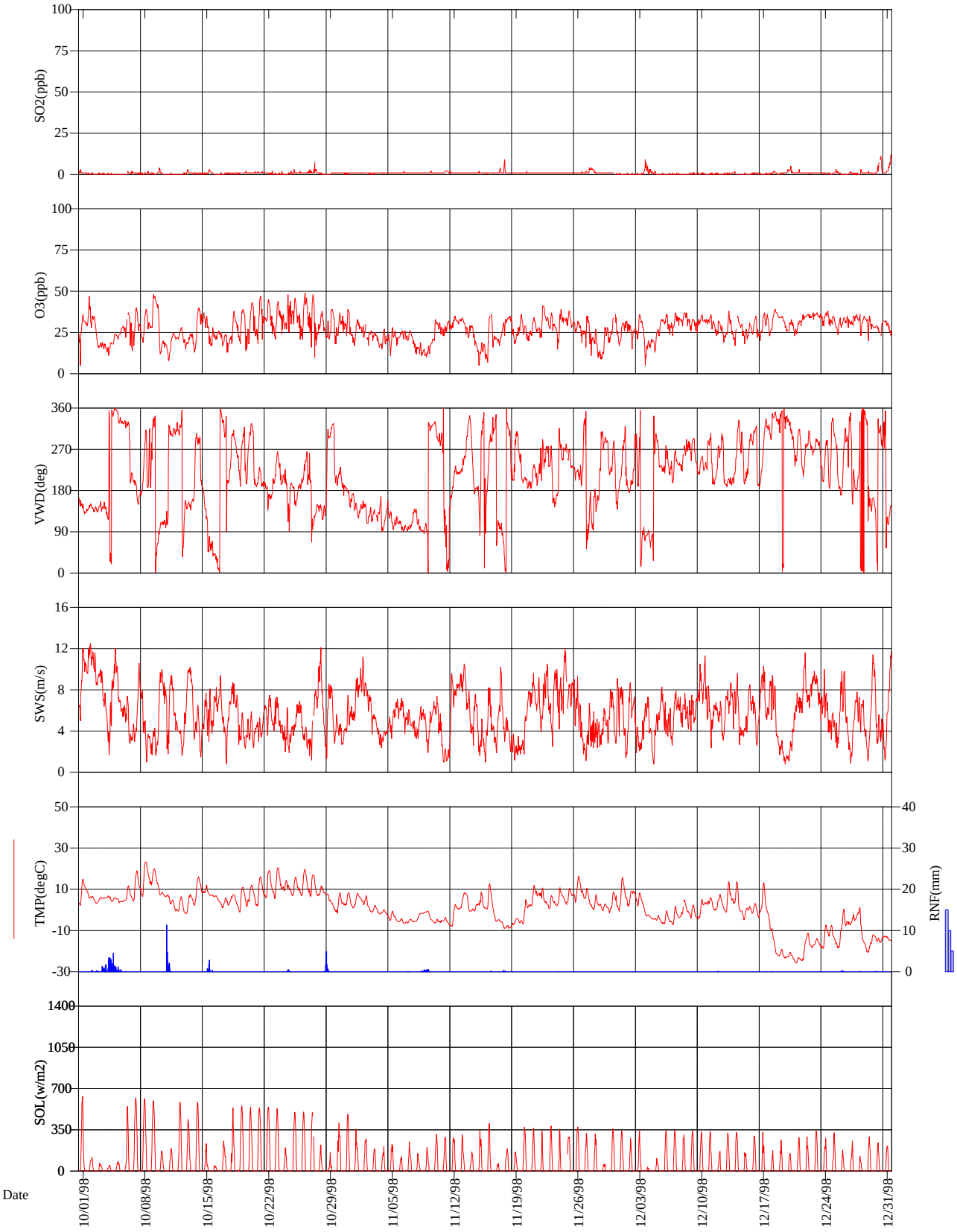



Final Validation

Third Quarter 1998

trvc98.stk - trvc98.dat 08-24-1999

Theodore Roosevelt National Park




Final Validation

Fourth Quarter 1998

trvc98.stk - trvc98.dat 08-24-1999

## 2.2 OZONE DATA SUMMARY

Ozone Quick Look Annual Summary Statistics
Theodore Roosevelt National Park
**Visitor Center**
07/27/98 - 12/31/98

| STATISTIC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MAY-SEP | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAILY 1-HR MAXIMUM | | | | | | | | 57 | 61 | 49 | 41 | 39 | 61 | 61 |
| NO. OF DAYS | | | | | | | | (15) | (30) | (31) | (30) | (31) | (45) | (137) |
| AVERAGE DAILY MAXIMUM | | | | | | | | 50 | 48 | 38 | 31 | 35 | 48 | 39 |
| NO. OF DAYS | | | | | | | | (15) | (30) | (31) | (30) | (31) | (45) | (137) |
| MAXIMUM DAILY MEAN | | | | | | | | 46 | 48 | 38 | 32 | 36 | 48 | 48 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (30) | (31) | (42) | (134) |
| AVERAGE DAILY MEAN | | | | | | | | 39 | 36 | 28 | 25 | 30 | 37 | 31 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (30) | (31) | (42) | (134) |
| MAX PEAK:MIN RATIO | | | | | | | | 3.929 | 6.625 | 7.200 | 5.143 | 4.400 | 6.625 | 7.200 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (30) | (31) | (42) | (134) |
| AVERAGE PEAK:MIN RATIO | | | | | | | | 2.297 | 2.323 | 2.364 | 1.985 | 1.648 | 2.316 | 2.098 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (30) | (31) | (42) | (134) |
| MAX 9AM-4PM AVERAGE | | | | | | | | 53 | 56 | 45 | 36 | 36 | 56 | 56 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (29) | (31) | (42) | (133) |
| MONTHLY 9AM-4PM AVERAGE | | | | | | | | 47 | 43 | 32 | 27 | 31 | 44 | 34 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (29) | (31) | (42) | (133) |
| MAX 7AM-7PM AVERAGE | | | | | | | | 50 | 53 | 42 | 35 | 36 | 53 | 53 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (29) | (31) | (42) | (133) |
| MONTHLY 7AM-7PM AVERAGE | | | | | | | | 44 | 41 | 30 | 26 | 30 | 42 | 33 |
| NO. OF DAYS | | | | | | | | (12) | (30) | (31) | (29) | (31) | (42) | (133) |
| MONTHLY MEAN | | | | | | | | 39 | 36 | 28 | 25 | 30 | 37 | 31 |
| NO. OF HOURS | | | | | | | | (318) | (717) | (741) | (711) | (740) | (1035) | (3227) |
| SUM0 EXPOSURE INDEX | | | | | | | | 12515 | 26046 | 20717 | 17577 | 21908 | 38561 | 98763 |
| NO. OF HOURS | | | | | | | | (318) | (717) | (741) | (711) | (740) | (1035) | (3227) |
| SUM60 EXPOSURE INDEX | | | | | | | | - | 181 | - | - | - | 181 | 181 |
| NO. OF HOURS | | | | | | | | (0) | (3) | (0) | (0) | (0) | (3) | (3) |
| SUM80 EXPOSURE INDEX | | | | | | | | - | - | - | - | - | - | - |
| NO. OF HOURS | | | | | | | | (0) | (0) | (0) | (0) | (0) | (0) | (0) |
| W126 EXPOSURE INDEX | | | | | | | | 820 | 1426 | 357 | 148 | 262 | 2246 | 3013 |
| NO. OF HOURS | | | | | | | | (318) | (717) | (741) | (711) | (740) | (1035) | (3227) |

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

Theodore Roosevelt National Park
Visitor Center
Monitoring Season: 07/27/98 - 09/30/98[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 | 64 | 1035 | 0.029 | 0.039 | 0.045 | 0.049 | 0.054 | 0.057 | 0.058 | 0.061 | 0.061 | 0.060 | 0.0485 | 0.0478 | 1.18 |

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.

Theodore Roosevelt National Park - North Unit

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

Ozone Season: May through September

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 | * | * | * | * | * | * | * | * |

* Data completeness has not been met

Ozone
Ten Highest Daily 1-Hour Average Maximum Concentrations

Theodore Roosevelt National Park
Visitor Center

Final Data
07/27/98 - 12/31/98

| Rank | Date | Hour | Concentration (ppb) |
|---|---|---|---|
| 1 | 09/09/98 | 15 | 61* |
| 2 | 09/01/98 | 16 | 60* |
| 3 | 09/05/98 | 13 | 58 |
| 4 | 08/27/98 | 14 | 57* |
| 5 | 09/10/98 | 15 | 57* |
| 6 | 09/02/98 | 19 | 56* |
| 7 | 09/11/98 | 14 | 56* |
| 8 | 08/28/98 | 15 | 55* |
| 9 | 08/29/98 | 14 | 55 |
| 10 | 09/06/98 | 16 | 55** |

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

Episodes with 1-Hour Ozone Concentrations
≥ 100 ppb and > 124 ppb
Theodore Roosevelt National Park
Visitor Center

Final Data
07/27/98 - 12/31/98

| Date | Beginning Hour | No. Hours | | Max (ppb) |
|---|---|---|---|---|
| | | > 100 ppb | >124 ppb | |
| No values exceeded 100 ppb during this period | | | | |
| Total | | 0 | 0 | |

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
Theodore Roosevelt National Park
Visitor Center

Final Data
07/27/98 - 12/31/98

| 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 |
|---|---|---|---|
| No values exceeded 84 ppb during this period | | | |
| 0 | 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 ). (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

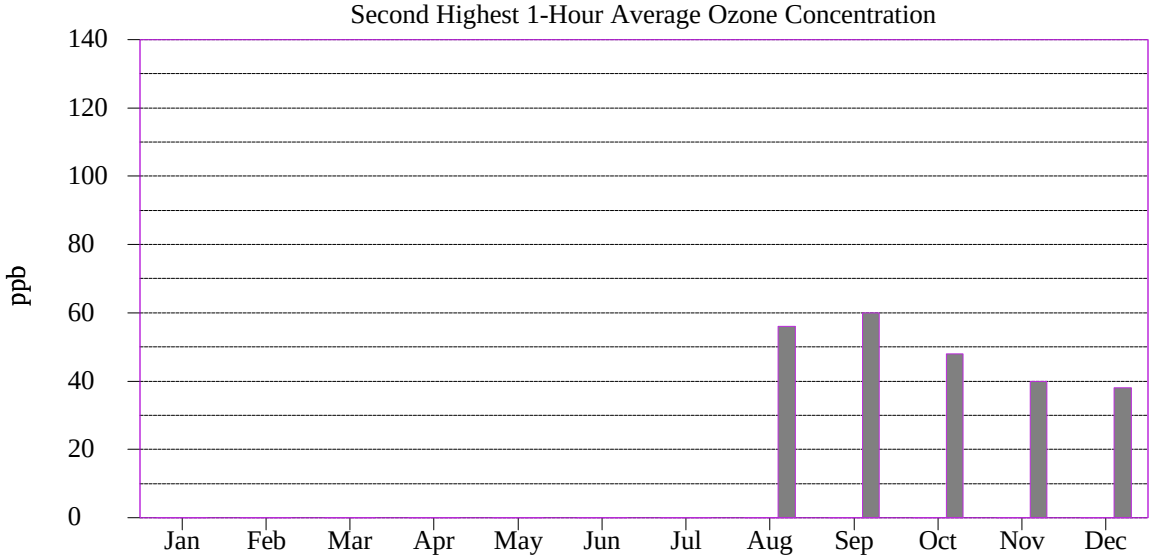
01/01/98 - 12/31/98

| 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 |

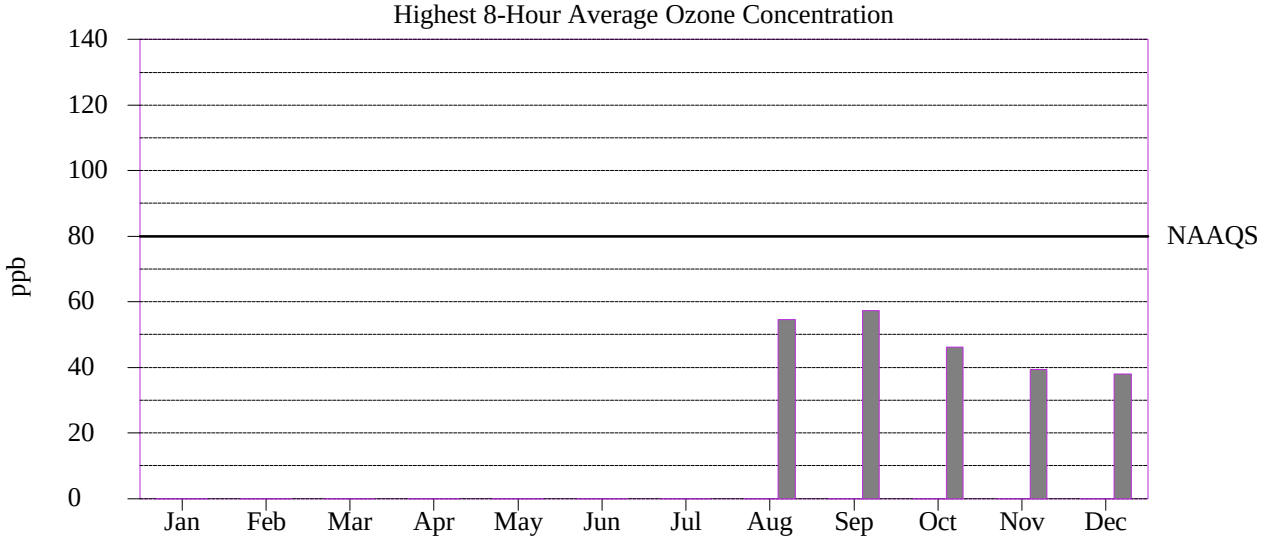
| 4th Highest 8-hour Average Concentration | | |
|---|---|---|
| Site | Rank | Concentration (ppb) |
| GRSM-LR | 1 | 110 |
| JOTR-YV | 2 | 110 |
| GRSM-CM | 3 | 107 |
| SHEN-BM | 4 | 107 |
| GRSM-CD | 5 | 106 |
| SEKI-LP | 6 | 99 |
| MACA-HM | 7 | 98 |
| COWP-XX | 8 | 97 |
| ACAD-CM | 9 | 95 |
| SEKI-LK | 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 |

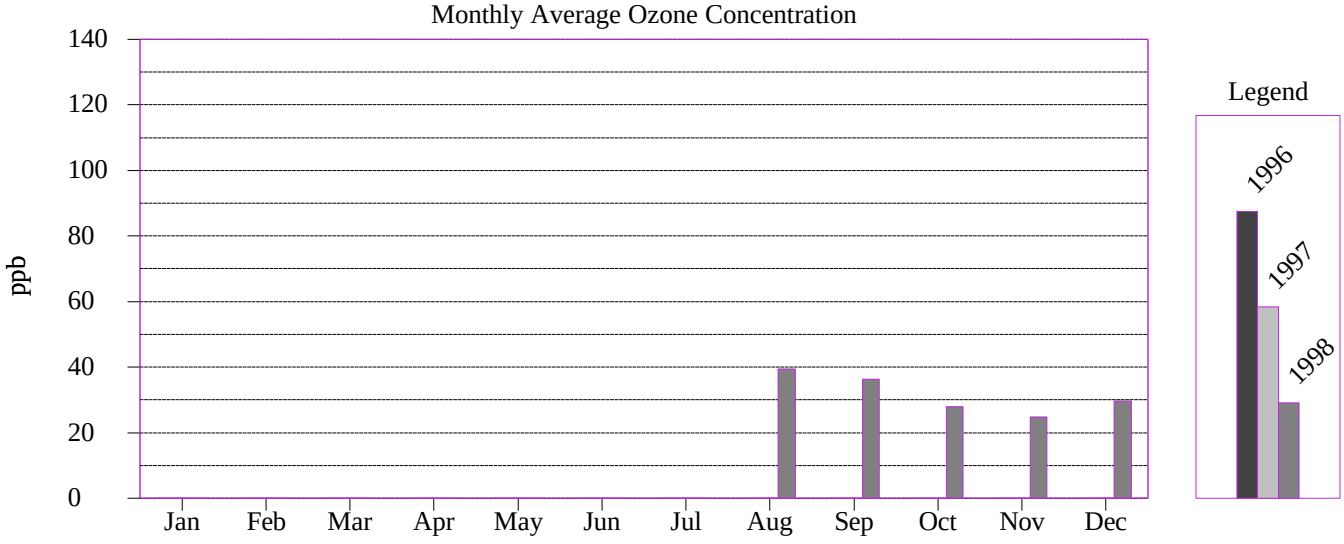
Second Highest 1-Hour Average Ozone Concentration

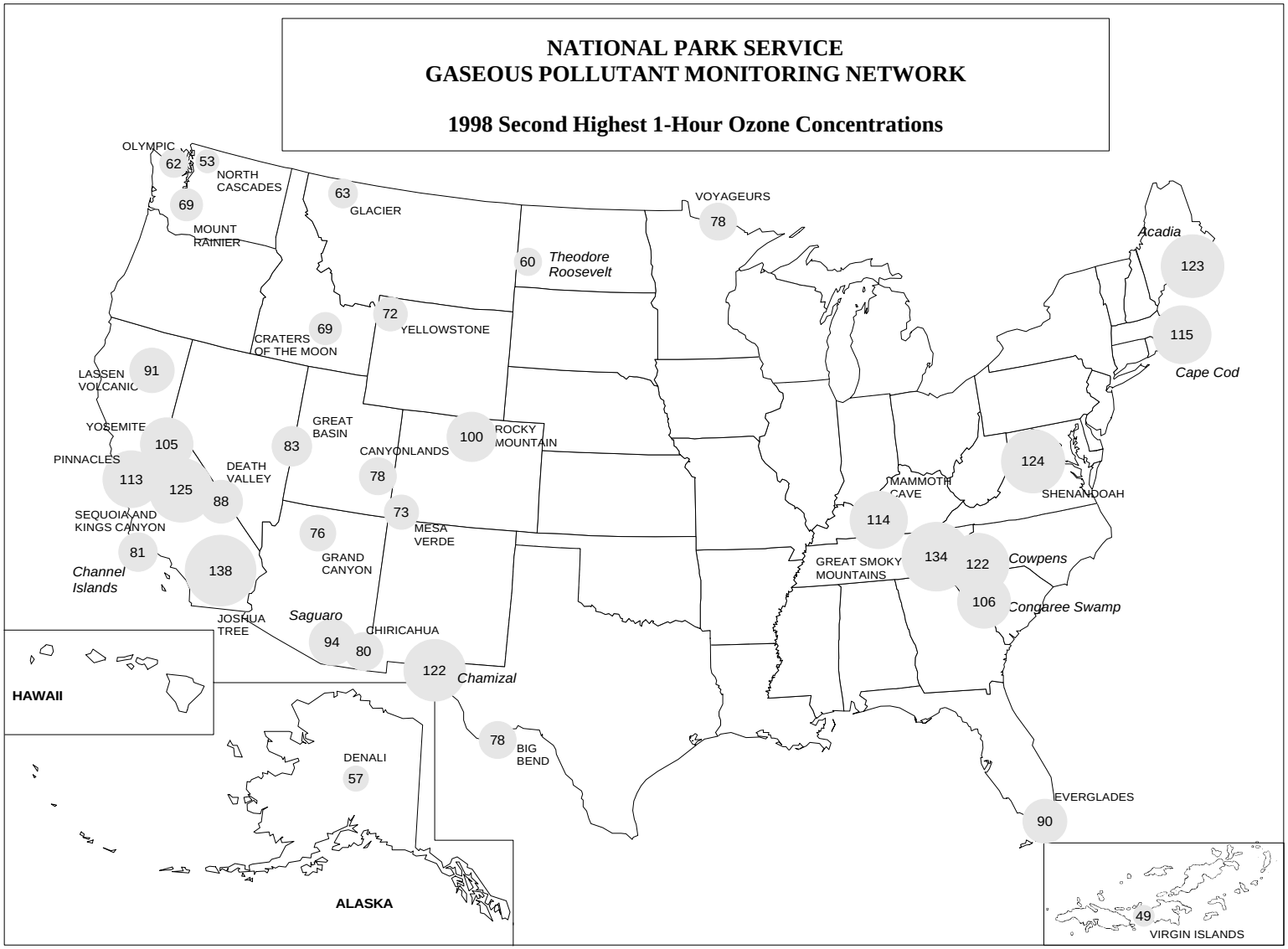



Highest 8-Hour Average Ozone Concentration




Monthly Average Ozone Concentration



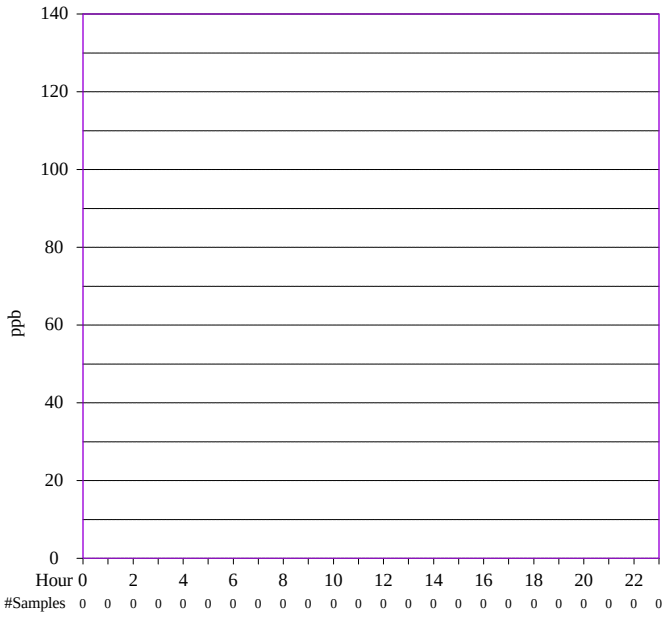

NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1998 Second Highest 1-Hour Ozone Concentrations
OLYMPIC
62
53
NORTH CASCADES
69
MOUNT RAINIER
63
GLACIER
VOYAGEURS
78
60
Theodore Roosevelt
Acadia
123
72
YELLOWSTONE
69
CRATERS OF THE MOON
115
Cape Cod
LASSEN VOLCANIC
91
YOSEMITE
105
PINNACLES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

Theodore Roosevelt
National Park
Visitor Center

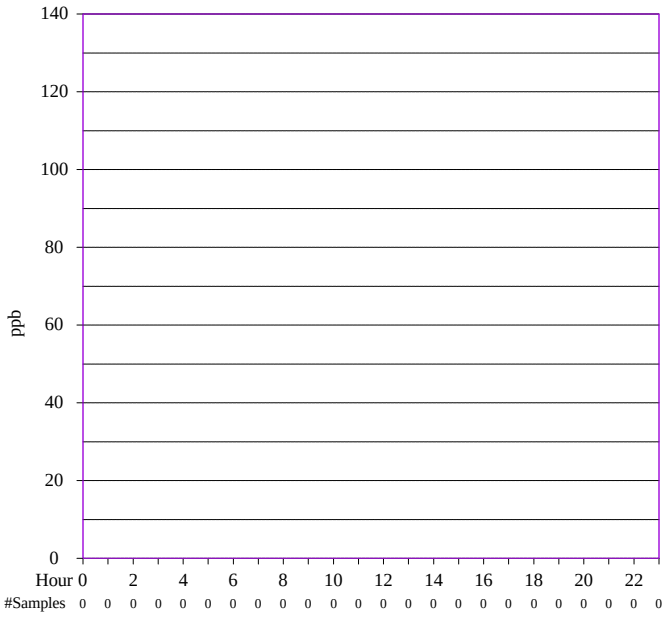
# Quarterly Diurnal Ozone Plots

1998

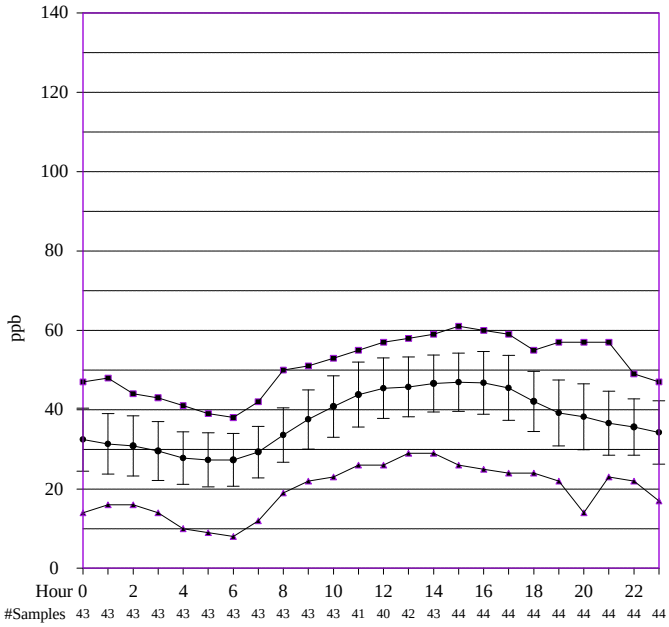
FIRST QUARTER (JAN-MAR)



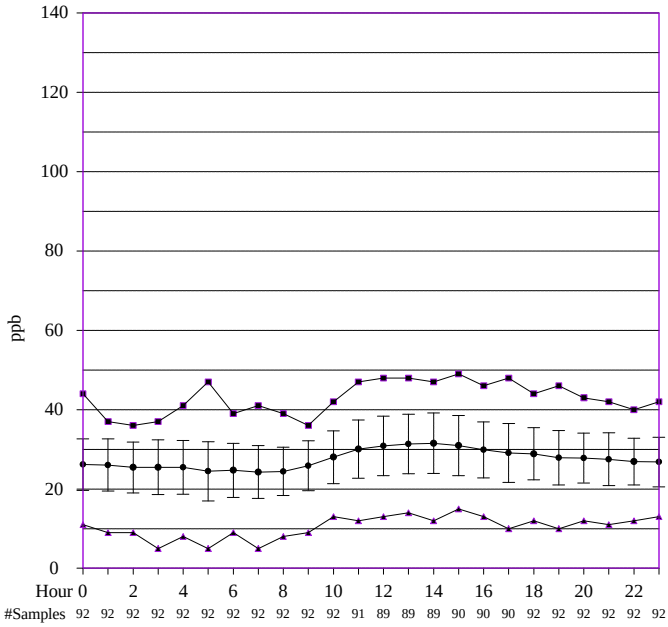

SECOND QUARTER (APR-JUN)




THIRD QUARTER (JUL-SEP)




FOURTH QUARTER (OCT-DEC)




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

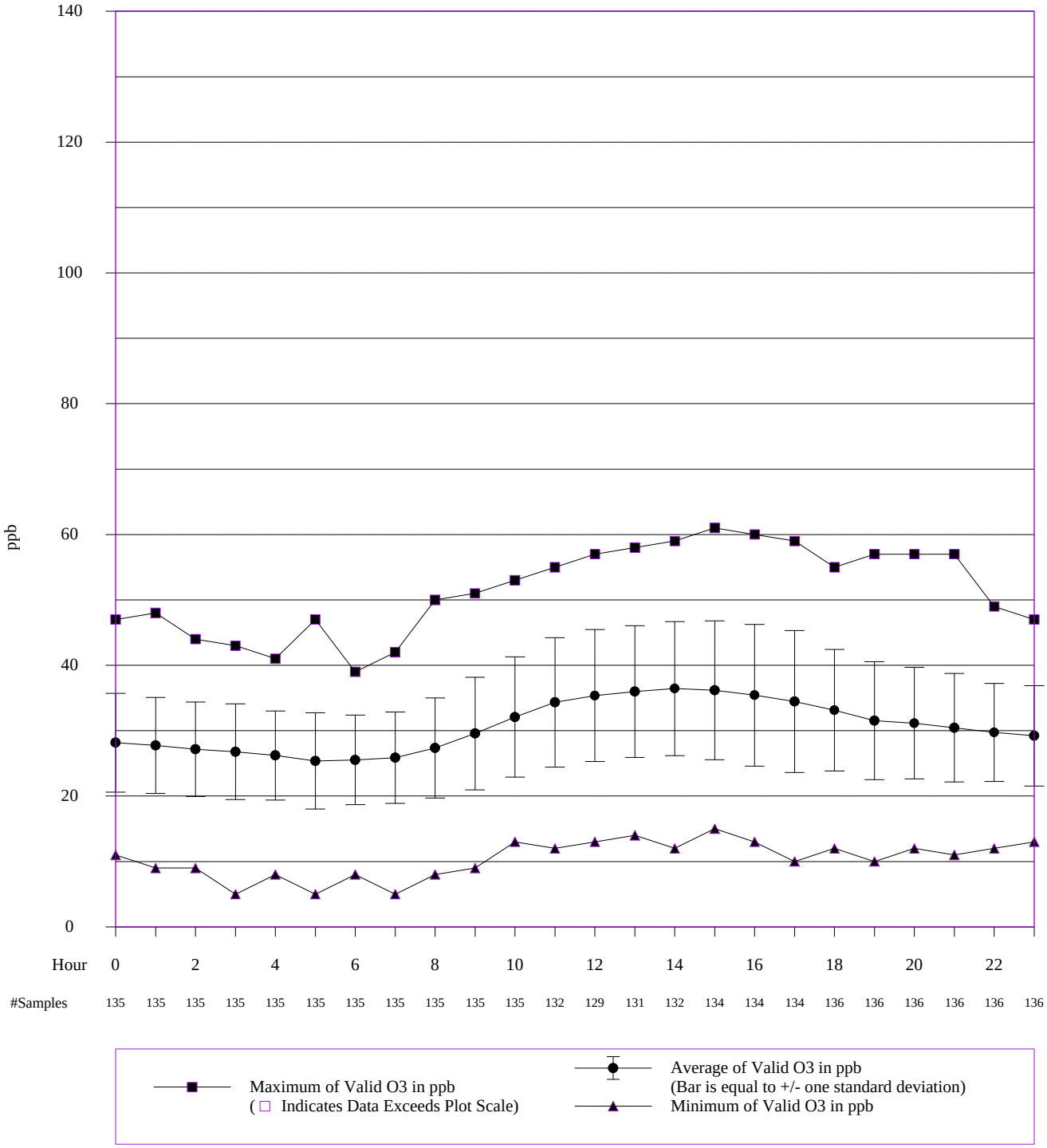
Average of Valid O3 in ppb
(Bar is equal to +/- one standard deviation)

Minimum of Valid O3 in ppb

Theodore Roosevelt
National Park
Visitor Center

Annual Diurnal
Ozone Plot

1998




Validation Level 0

08-05-1999

# Ozone Precision Check Summary

## Theodore Roosevelt National Park
## Visitor Center

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%.

Preliminary Data
07/27/98 - 12/31/98

| Calendar Quarter | Number of Precision Checks | Average Percent Difference[1,2] | Lower 95% Probability Limit[3] | Upper 95% Probability Limit[3] |
|---|---|---|---|---|
| 1 | 0 | | | |
| 2 | 0 | | | |
| 3 | 0 | | | |
| 4 | 0 | | | |

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

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

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

## 2.3 SULFUR DIOXIDE DATA SUMMARY

# Sulfur Dioxide Standards Report and
# Daily Maximum 1-Hour Concentrations (ppm)
# Theodore Roosevelt National Park
# 01/01/98 - 12/31/98

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | T | S | S | W | F | M | W | .000 S | .006 T | .003 T | .001 S | .001 T |
| 2 | F | M | M | T | S | T | T | .000 S | .003 W | .001 F | .001 M | .001 W |
| 3 | S | T | T | F | S | W | F | .001 M | .002 T | .001 S | .001 T | .002 T |
| 4 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .001 W | .009 F |
| 5 | M | T | T | S | T | F | S | .001 W | .003 S | .000 M | .001 T | .002 S |
| 6 | T | F | F | M | W | S | M | .001 T | .009 S | .002 T | .002 F | .001 S |
| 7 | W | S | S | T | T | S | T | .000 F | .001 M | .002 W | .001 S | .001 M |
| 8 | T | S | S | W | F | M | W | .001 S | .001 T | .002 T | .001 S | .000 T |
| 9 | F | M | M | T | S | T | T | .004 S | .001 W | .001 F | .002 M | .001 W |
| 10 | S | T | T | F | S | W | F | .001 M | .002 T | .004 S | .001 T | .001 T |
| 11 | S | W | W | S | M | T | S | .000 T | .001 F | .001 S | .002 W | .001 F |
| 12 | M | T | T | S | T | F | S | .001 W | .000 S | .001 M | .002 T | .001 S |
| 13 | T | F | F | M | W | S | M | .002 T | .003 S | .003 T | .001 F | .001 S |
| 14 | W | S | S | T | T | S | T | .002 F | .002 M | .001 W | .001 S | .002 M |
| 15 | T | S | S | W | F | M | W | .001 S | .001 T | .003 T | .002 S | .001 T |
| 16 | F | M | M | T | S | T | T | .005 S | .001 W | .001 F | .001 M | .001 W |
| 17 | S | T | T | F | S | W | F | .002 M | .001 T | .001 S | .004 T | .001 T |
| 18 | S | W | W | S | M | T | S | .000 T | .002 F | .001 S | .009 W | .002 F |
| 19 | M | T | T | S | T | F | S | .001 W | .000 S | .002 M | .001 T | .001 S |
| 20 | T | F | F | M | W | S | M | .007 T | .002 S | .002 T | .002 F | .005 S |
| 21 | W | S | S | T | T | S | T | F | .002 M | .002 W | .001 S | .003 M |
| 22 | T | S | S | W | F | M | W | S | .002 T | .002 T | .001 S | .001 T |
| 23 | F | M | M | T | S | T | T | S | .003 W | .001 F | .001 M | .001 W |
| 24 | S | T | T | F | S | W | F | .001 M | .001 T | .002 S | .001 T | .001 T |
| 25 | S | W | W | S | M | T | S | .001 T | .005 F | .003 S | .001 W | .003 F |
| 26 | M | T | T | S | T | F | S | .000 W | .002 S | .002 M | .002 T | .001 S |
| 27 | T | F | F | M | W | S | .001 M | .000 T | .001 S | .007 T | .004 F | .002 S |
| 28 | W | S | S | T | T | S | .004 T | .005 F | .002 M | .001 W | .004 S | .003 M |
| 29 | T | | S | W | F | M | .002 W | .011 S | .003 T | .001 T | .001 S | .002 T |
| 30 | F | | M | T | S | T | .002 T | .001 S | .003 W | .001 F | .001 M | .011 W |
| 31 | S | | T | | S | | .000 F | .004 M | | .001 S | | .012 T |
| Number | | | | | | | 106 | 644 | 716 | 740 | 713 | 739 |
| Maximum | | | | | | | .004 | .011 | .009 | .007 | .009 | .012 |
| Arith-Mean | | | | | | | .001 | .001 | .001 | .001 | .001 | .001 |

3658 Total Samples .001 Arith-Mean Does not meet summary criteria

41.8 % Possible .001 Arith-StdDev Primary standard of .030 ppm was met

Concentrations in parts per million (ppm)

# Sulfur Dioxide Standards Report and
# Daily Maximum 3-Hour Concentrations (ppm)
# Theodore Roosevelt National Park
# 01/01/98 - 12/31/98

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | T | S | S | W | F | M | W | .001 S | .004 T | .002 T | .001 S | .001 T |
| 2 | F | M | M | T | S | T | T | .001 S | .002 W | .001 F | .001 M | .001 W |
| 3 | S | T | T | F | S | W | F | .001 M | .002 T | .001 S | .001 T | .001 T |
| 4 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .001 W | .007 F |
| 5 | M | T | T | S | T | F | S | .001 W | .002 S | .001 M | .001 T | .001 S |
| 6 | T | F | F | M | W | S | M | .001 T | .007 S | .001 T | .002 F | .001 S |
| 7 | W | S | S | T | T | S | T | .001 F | .001 M | .002 W | .001 S | .001 M |
| 8 | T | S | S | W | F | M | W | .001 S | .001 T | .001 T | .001 S | .001 T |
| 9 | F | M | M | T | S | T | T | .003 S | .001 W | .001 F | .002 M | .001 W |
| 10 | S | T | T | F | S | W | F | .001 M | .001 T | .003 S | .001 T | .001 T |
| 11 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .002 W | .001 F |
| 12 | M | T | T | S | T | F | S | .001 W | .001 S | .001 M | .002 T | .001 S |
| 13 | T | F | F | M | W | S | M | .001 T | .002 S | .002 T | .001 F | .001 S |
| 14 | W | S | S | T | T | S | T | .002 F | .001 M | .001 W | .001 S | .001 M |
| 15 | T | S | S | W | F | M | W | .001 S | .001 T | .002 T | .001 S | .001 T |
| 16 | F | M | M | T | S | T | T | .004 S | .001 W | .001 F | .001 M | .001 W |
| 17 | S | T | T | F | S | W | F | .001 M | .001 T | .001 S | .003 T | .001 T |
| 18 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .006 W | .002 F |
| 19 | M | T | T | S | T | F | S | .001 W | .001 S | .002 M | .001 T | .001 S |
| 20 | T | F | F | M | W | S | M | .005 T | .001 S | .001 T | .001 F | .004 S |
| 21 | W | S | S | T | T | S | T | F | .001 M | .001 W | .001 S | .002 M |
| 22 | T | S | S | W | F | M | W | S | .001 T | .001 T | .001 S | .001 T |
| 23 | F | M | M | T | S | T | T | S | .002 W | .001 F | .001 M | .001 W |
| 24 | S | T | T | F | S | W | F | .001 M | .001 T | .001 S | .001 T | .001 T |
| 25 | S | W | W | S | M | T | S | .001 T | .003 F | .002 S | .001 W | .002 F |
| 26 | M | T | T | S | T | F | S | .001 W | .002 S | .001 M | .001 T | .001 S |
| 27 | T | F | F | M | W | S | .001 M | .001 T | .001 S | .004 T | .003 F | .001 S |
| 28 | W | S | S | T | T | S | .002 T | .002 F | .001 M | .001 W | .003 S | .003 M |
| 29 | T | | S | W | F | M | .001 W | .009 S | .002 T | .001 T | .001 S | .001 T |
| 30 | F | | M | T | S | T | .001 T | .001 S | .002 W | .001 F | .001 M | .010 W |
| 31 | S | | T | | S | | .001 F | .003 M | | .001 S | | .010 T |
| Number | | | | | | | 35 | 212 | 238 | 244 | 236 | 246 |
| Maximum | | | | | | | .002 | .009 | .007 | .004 | .006 | .010 |

1211 Total Samples
41.5 % Possible

0 Plussed (+) items exceeded the secondary standard of .550 ppm

Concentrations in parts per million (ppm)

# Sulfur Dioxide Standards Report and
# Daily Maximum 24-Hour Concentrations (ppm)
# Theodore Roosevelt National Park
# 01/01/98 - 12/31/98

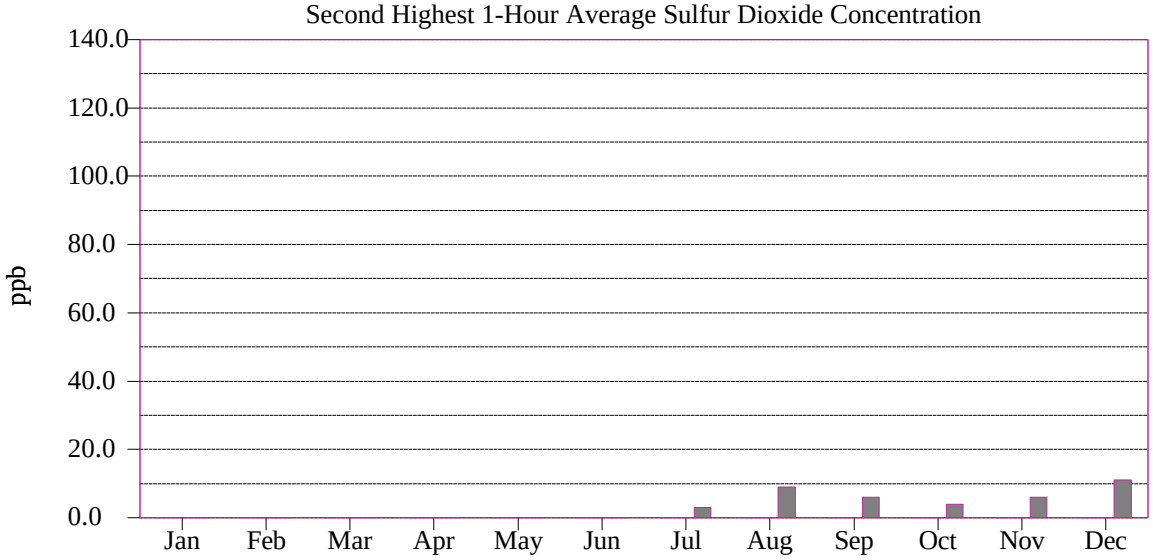
| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | T | S | S | W | F | M | W | .001 S | .002 T | .001 T | .001 S | .001 T |
| 2 | F | M | M | T | S | T | T | .001 S | .001 W | .001 F | .001 M | .001 W |
| 3 | S | T | T | F | S | W | F | .001 M | .001 T | .001 S | .001 T | .001 T |
| 4 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .001 W | .003 F |
| 5 | M | T | T | S | T | F | S | .001 W | .001 S | .001 M | .001 T | .001 S |
| 6 | T | F | F | M | W | S | M | .001 T | .004 S | .001 T | .001 F | .001 S |
| 7 | W | S | S | T | T | S | T | .001 F | .001 M | .001 W | .001 S | .001 M |
| 8 | T | S | S | W | F | M | W | .001 S | .001 T | .001 T | .001 S | .001 T |
| 9 | F | M | M | T | S | T | T | .002 S | .001 W | .001 F | .001 M | .001 W |
| 10 | S | T | T | F | S | W | F | .001 M | .001 T | .001 S | .001 T | .001 T |
| 11 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .001 W | .001 F |
| 12 | M | T | T | S | T | F | S | .001 W | .001 S | .001 M | .001 T | .001 S |
| 13 | T | F | F | M | W | S | M | .001 T | .001 S | .001 T | .001 F | .001 S |
| 14 | W | S | S | T | T | S | T | .001 F | .001 M | .001 W | .001 S | .001 M |
| 15 | T | S | S | W | F | M | W | .001 S | .001 T | .001 T | .001 S | .001 T |
| 16 | F | M | M | T | S | T | T | .001 S | .001 W | .001 F | .001 M | .001 W |
| 17 | S | T | T | F | S | W | F | .001 M | .001 T | .001 S | .001 T | .001 T |
| 18 | S | W | W | S | M | T | S | .001 T | .001 F | .001 S | .002 W | .001 F |
| 19 | M | T | T | S | T | F | S | .001 W | .001 S | .001 M | .001 T | .001 S |
| 20 | T | F | F | M | W | S | M | T | .001 S | .001 T | .001 F | .002 S |
| 21 | W | S | S | T | T | S | T | F | .001 M | .001 W | .001 S | .001 M |
| 22 | T | S | S | W | F | M | W | S | .001 T | .001 T | .001 S | .001 T |
| 23 | F | M | M | T | S | T | T | S | .001 W | .001 F | .001 M | .001 W |
| 24 | S | T | T | F | S | W | F | M | .001 T | .001 S | .001 T | .001 T |
| 25 | S | W | W | S | M | T | S | .001 T | .002 F | .001 S | .001 W | .001 F |
| 26 | M | T | T | S | T | F | S | .001 W | .001 S | .001 M | .001 T | .001 S |
| 27 | T | F | F | M | W | S | M | .001 T | .001 S | .002 T | .002 F | .001 S |
| 28 | W | S | S | T | T | S | .001 T | .001 F | .001 M | .001 W | .002 S | .001 M |
| 29 | T | | S | W | F | M | .001 W | .003 S | .001 T | .001 T | .001 S | .001 T |
| 30 | F | | M | T | S | T | .001 T | .001 S | .001 W | .001 F | .001 M | .004 W |
| 31 | S | | T | | S | | .001 F | .001 M | | .001 S | | .003 T |
| Number | | | | | | | 4 | 26 | 30 | 31 | 30 | 31 |
| Maximum | | | | | | | .001 | .003 | .004 | .002 | .002 | .004 |

152 Total Samples
41.6 % Possible

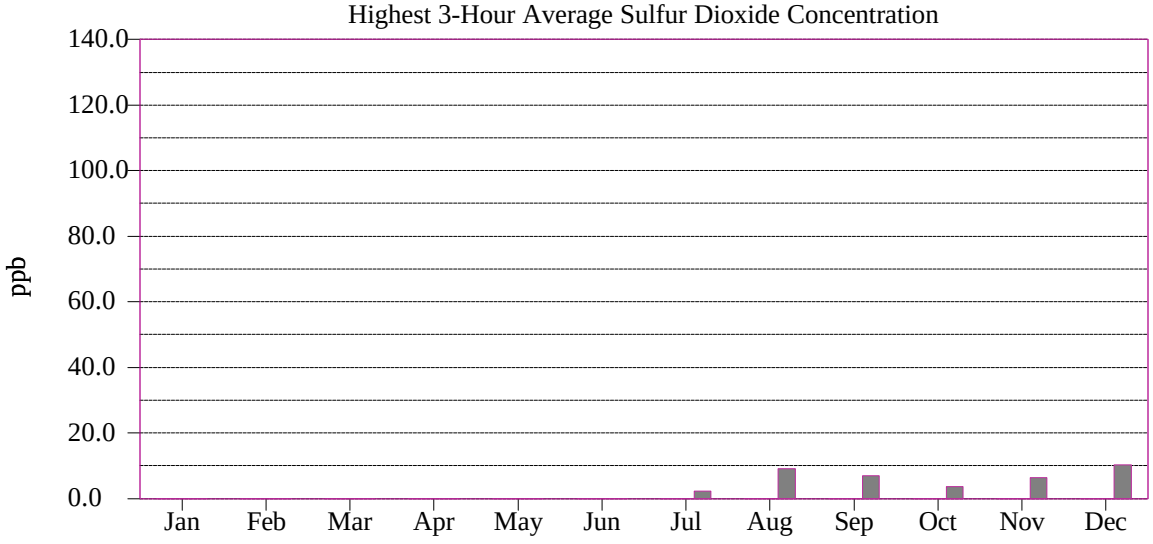
0 Starred (*) items exceeded the primary standard of .145 ppm

Concentrations in parts per million (ppm)

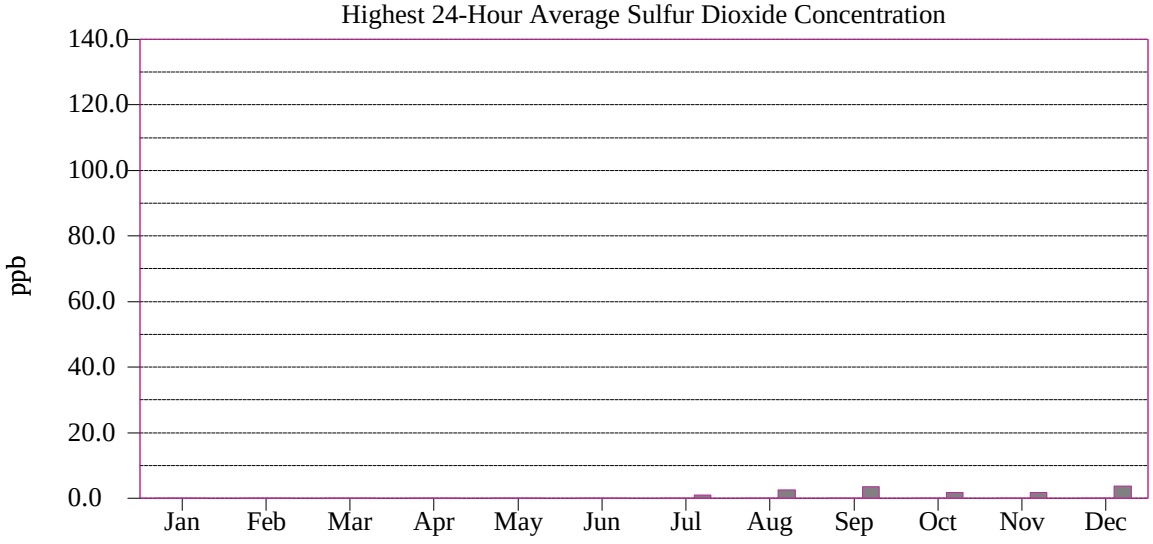
Second Highest 1-Hour Average Sulfur Dioxide Concentration

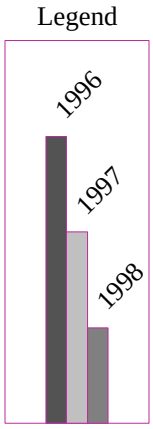



Highest 3-Hour Average Sulfur Dioxide Concentration




Highest 24-Hour Average Sulfur Dioxide Concentration



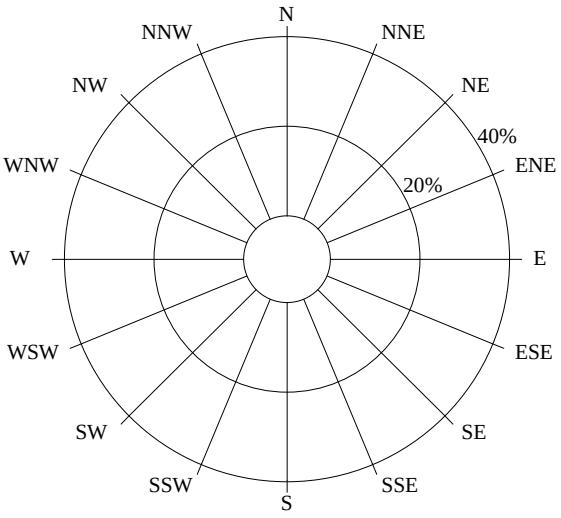



Theodore Roosevelt
National Park
Visitor Center

Quarterly SO2
Pollutant Rose

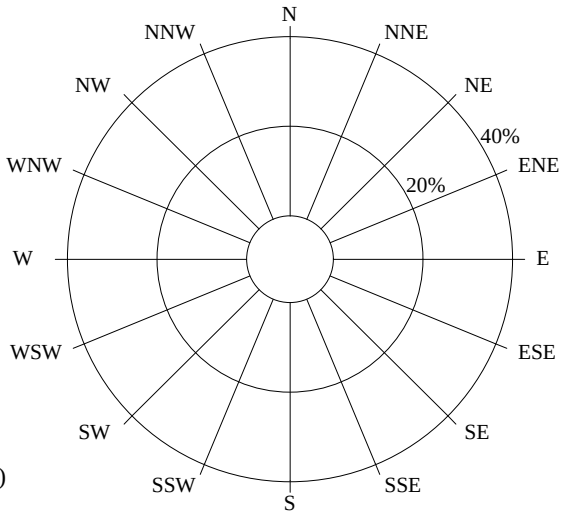
1998

FIRST QUARTER (JAN-MAR)



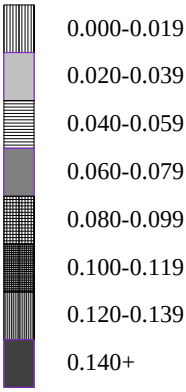

0.0% Collected 0.0% Valid
0 Possible /0 Collected /0 Valid

SECOND QUARTER (APR-JUN)

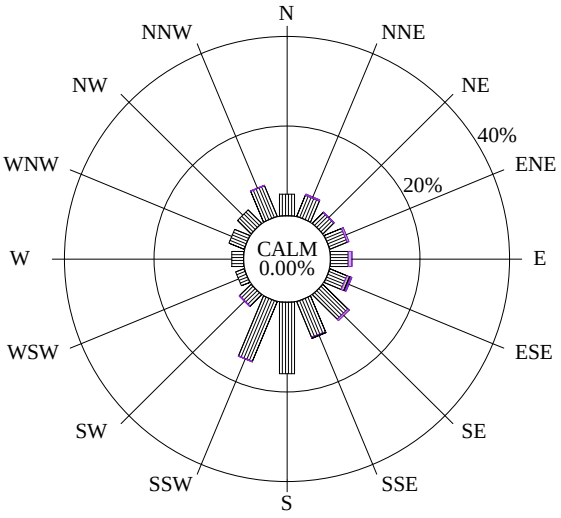



0.0% Collected 0.0% Valid
0 Possible /0 Collected /0 Valid

Sulfur Dioxide (ppm)

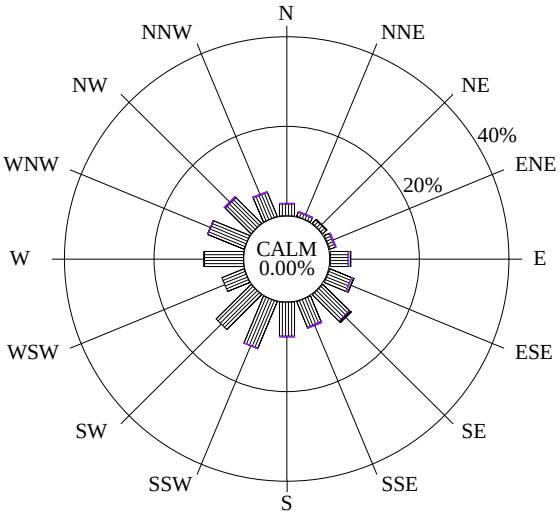



THIRD QUARTER (JUL-SEP)




91.5% Collected 91.5% Valid
1463 Possible /1339 Collected /1339 Valid

FOURTH QUARTER (OCT-DEC)




99.0% Collected 99.0% Valid
2208 Possible /2186 Collected /2186 Valid

## 2.4 Meteorological Data Summary

Summary of Selected Meteorological Data

Theodore Roosevelt National Park

Visitor Center

Final Data

07/27/98 - 12/31/98

| Parameter | Value | Units | Number | Std Dev |
|---|---|---|---|---|
| SCALAR WIND SPEED | | | | |
| Average | 5.4 | m/s | 3554 | 2.3 |
| Maximum | 13.1 | m/s | | |
| Percent calm = 0.00 | | | | |
| | | | | |
| AMBIENT TEMPERATURE | | | | |
| Average | 8.2 | degC | 3555 | 12.4 |
| Maximum | 36.8 | degC | | |
| Minimum | -25.8 | degC | | |
| | | | | |
| RELATIVE HUMIDITY | | | | |
| Average | 68 | percent | 3555 | 23 |
| Maximum | 100 | percent | | |
| Minimum | 19 | percent | | |
| | | | | |
| PRECIPITATION (Rainfall or Snow melt) | | | | |
| Average non-zero rate | .9 | mm/hr | 184 | 1.3 |
| Maximum non-zero rate | 11.3 | mm/hr | | |
| Minimum non-zero rate | .1 | mm/hr | | |
| Accumulated during period | 164.8 | mm | | |
| | | | | |
| SOLAR RADIATION | | | | |
| Average Daily Total | 9,305,530 | joules/m2day | 153 | 6,674,468 |
| Maximum Daily Total | 24,204,800 | joules/m2day | | |
| Minimum Daily Total | 470,400 | 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.

## 2.5 DRY DEPOSITION DATA SUMMARY

### Clean Air Status and Trends Network (CASTNet)
### Dry Deposition Monitoring

In 1995, the National Park Service (NPS) and the Environmental Protection Agency (EPA) entered a partnership to jointly measure dry deposition in park units, mostly in the West. A portion of the 1996 data collected from this partnership is presented in this section.

Atmospheric deposition of acidic species takes two pathways: wet deposition and dry deposition. Wet deposition is the result of precipitation events (rain, snow, or fog) that remove particles and gases from the atmosphere. Dry deposition is less event driven, but still involves the transfer of particles and gases from the atmosphere to surfaces and plants. Wet deposition has been well documented for many years. In the national parks, the National Acidic Deposition Program (NADP) measures and reports wet deposition (see the web site at http://nadp.sws.uiuc.edu for further information). Dry deposition is much harder to measure and a smaller network of monitoring stations are involved. The method used to measure dry deposition is sometimes called the "inferential method" because air quality concentration data is combined with meteorological measurements and land use functions to compute deposition velocities. The CASTNet program provides long-term estimates of total acidic deposition by adding dry deposition values to wet deposition values.

This annual summary report presents the air quality concentration portion of the dry deposition inferential method, which is the only currently available data set. These data were compiled from the analyses of filters collected by CASTNet deposition filter pack systems in the parks. The filter pack analyses yielded weekly average concentrations of particulate sulfate ($SO_4^{2-}$), particulate nitrate ($NO_3^-$), particulate ammonium ($NH_4^+$), sulfur dioxide ($SO_2$), and nitric acid ($HNO_3$). In some cases, the positive ions $Na^+$, $K^+$, $Ca^{2+}$, and $Mg^{2+}$ were also measured from the filter samples. These concentration data for the individual ionic species are presented as weekly bar charts and summarized by quarter and by year in this report. Concentration data can be used to compare sites and to indicate the amount of acidic species available for deposition. As with the continuous analyzer data, the filter pack concentration data are included on a computer diskette that accompanies this report.

Estimated dry deposition values derived from EPA modeling will be reported at a later time to complete the inferential analyses. When available, these modeling results will be posted on the NPS Air Resources Division Internet web site at http://www.aqd.nps.gov/ard1 or on the EPA CASTNet site (http://www.epa.gov/ardpublc/acidrain/castnet/about.html). Initial CASTNet results have shown that dry deposition can be a significant portion of total acidic deposition.

CASTNet Dry Deposition Monitoring
Quarterly and Annual Average Concentrations
Theodore Roosevelt National Park
1/1/98 - 12/31/98

| Quarter | No.Valid Samples | p-$NO_3$ ($ug/m^3$) | $HNO_3$ ($ug/m^3$) | Total $NO_3$ ($ug/m^3$) | $NH_4$ ($ug/m^3$) | p-$SO_4$ ($ug/m^3$) | $SO_2$ ($ug/m^3$) | $SO_4/SO_2$ Ratio |
|---|---|---|---|---|---|---|---|---|
| 4 | 12 | 0.635 | 0.481 | 1.108 | 0.421 | 0.833 | 1.097 | 0.760 |
| Annual Average | | 0.635 | 0.481 | 1.108 | 0.421 | 0.833 | 1.097 | 0.760 |
| Standard Deviation | | 0.749 | 0.235 | 0.656 | 0.281 | 0.293 | 0.398 | |

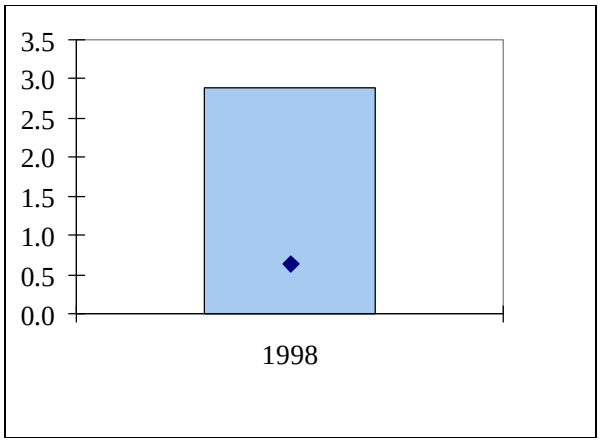
| Data Recovery Table | | | |
|---|---|---|---|
| Total No. Filters | No. Invalidated | Data Capture | No. Valid Hours |
| 12 | 0 | 100.0% | 2009.0 |

# CASTNet Dry Deposition Monitoring Weekly Concentrations Report
## Theodore Roosevelt National Park
## 1/1/98 - 12/31/98

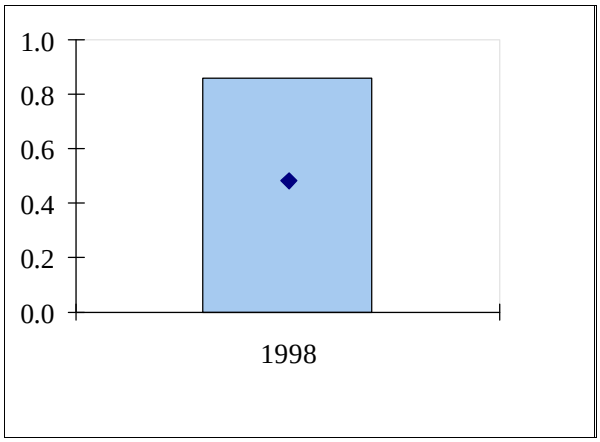
| On Date | Off Date | p-$NO_3$ ($ug/m^3$) | $HNO_3$ ($ug/m^3$) | Total $NO_3$ ($ug/m^3$) | $NH_4$ ($ug/m^3$) | p-$SO_4$ ($ug/m^3$) | $SO_2$ ($ug/m^3$) | $SO_4/SO_2$ Ratio |
|---|---|---|---|---|---|---|---|---|
| 10/06/98 | 10/12/98 | 0.374 | 0.661 | 1.025 | 0.336 | 0.863 | 0.899 | 0.960 |
| 10/12/98 | 10/20/98 | 0.197 | 0.857 | 1.040 | 0.298 | 1.000 | 1.045 | 0.957 |
| 10/20/98 | 10/27/98 | 0.329 | 0.823 | 1.138 | 0.426 | 1.089 | 1.208 | 0.901 |
| 10/27/98 | 11/03/98 | 0.956 | 0.486 | 1.435 | 0.610 | 0.959 | 0.738 | 1.299 |
| 11/03/98 | 11/10/98 | 2.887 | 0.119 | 3.005 | 1.184 | 1.220 | 0.583 | 2.092 |
| 11/10/98 | 11/17/98 | 0.481 | 0.631 | 1.101 | 0.569 | 1.180 | 0.839 | 1.406 |
| 11/17/98 | 11/24/98 | 0.076 | 0.528 | 0.596 | 0.353 | 0.928 | 1.242 | 0.747 |
| 11/24/98 | 12/01/98 | 0.528 | 0.503 | 1.023 | 0.248 | 0.433 | 1.057 | 0.410 |
| 12/01/98 | 12/08/98 | 0.705 | 0.366 | 1.065 | 0.435 | 0.772 | 1.849 | 0.417 |
| 12/08/98 | 12/15/98 | 0.158 | 0.338 | 0.491 | 0.115 | 0.304 | 0.609 | 0.499 |
| 12/15/98 | 12/22/98 | 0.404 | 0.212 | 0.612 | 0.158 | 0.514 | 1.573 | 0.327 |
| 12/22/98 | 12/29/98 | 0.525 | 0.246 | 0.767 | 0.326 | 0.737 | 1.516 | 0.487 |

CASTNet Dry Deposition Monitoring
Three Year Comparison of Maximum and Average Concentrations

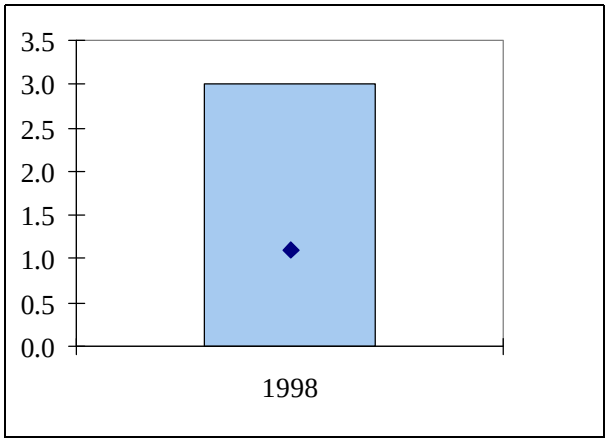
p-$NO_3$



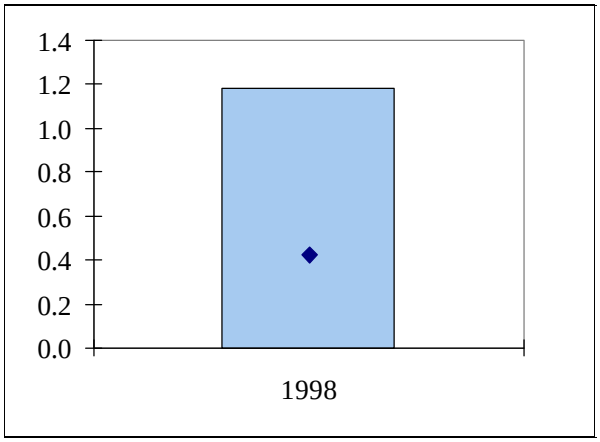

$HNO_3$



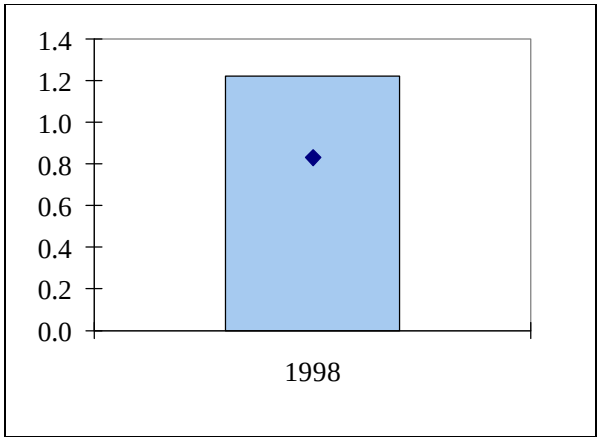

Total $NO_3$



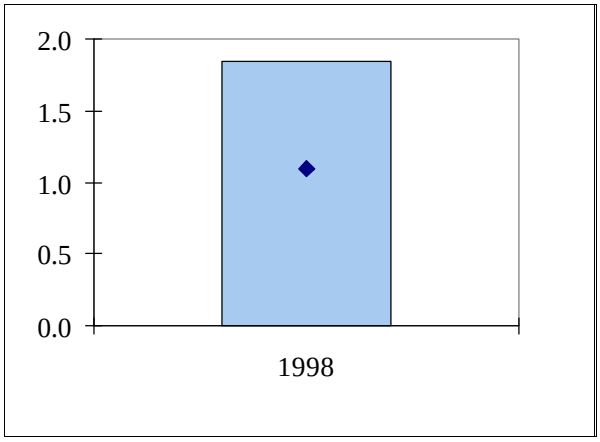

$NH_4$

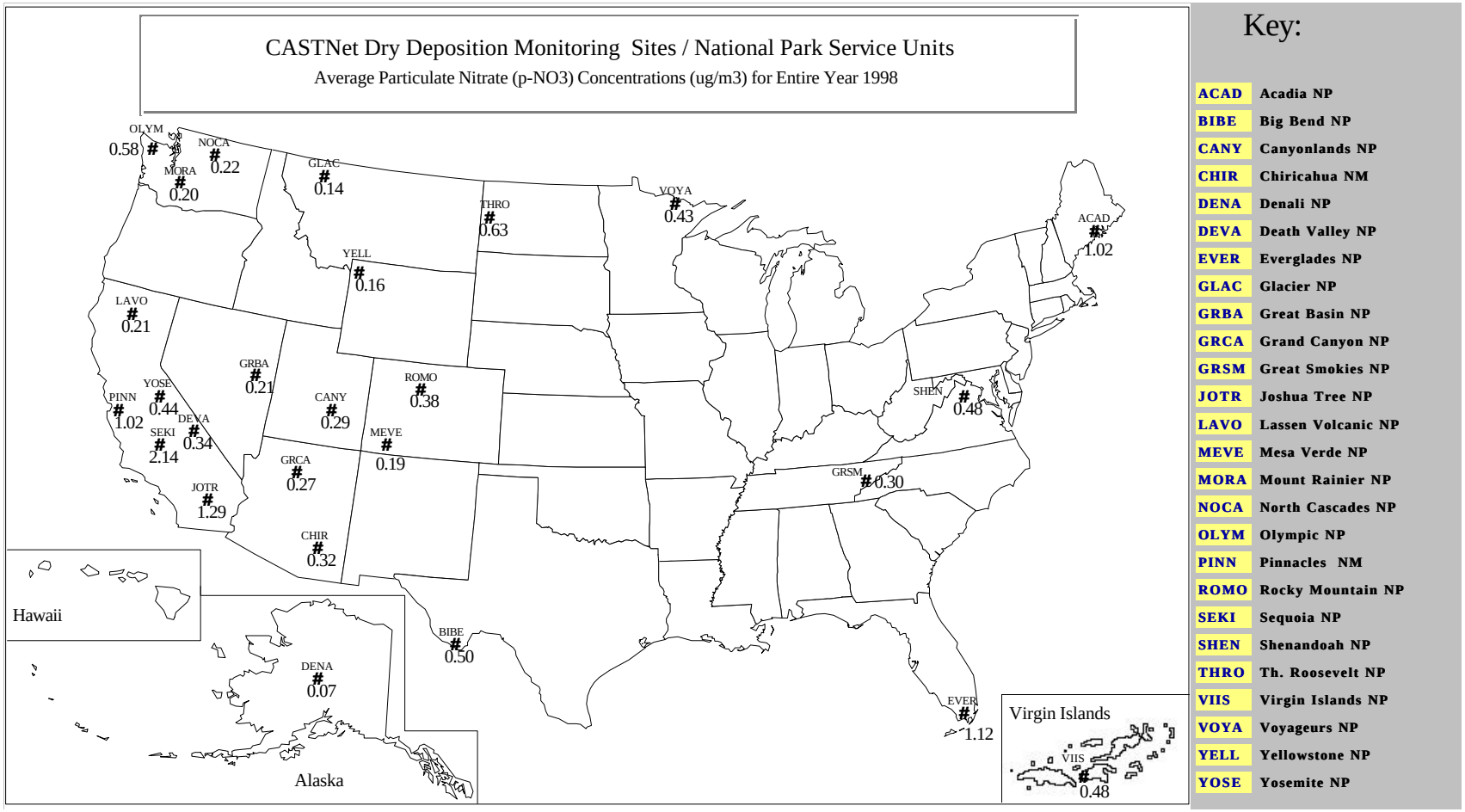


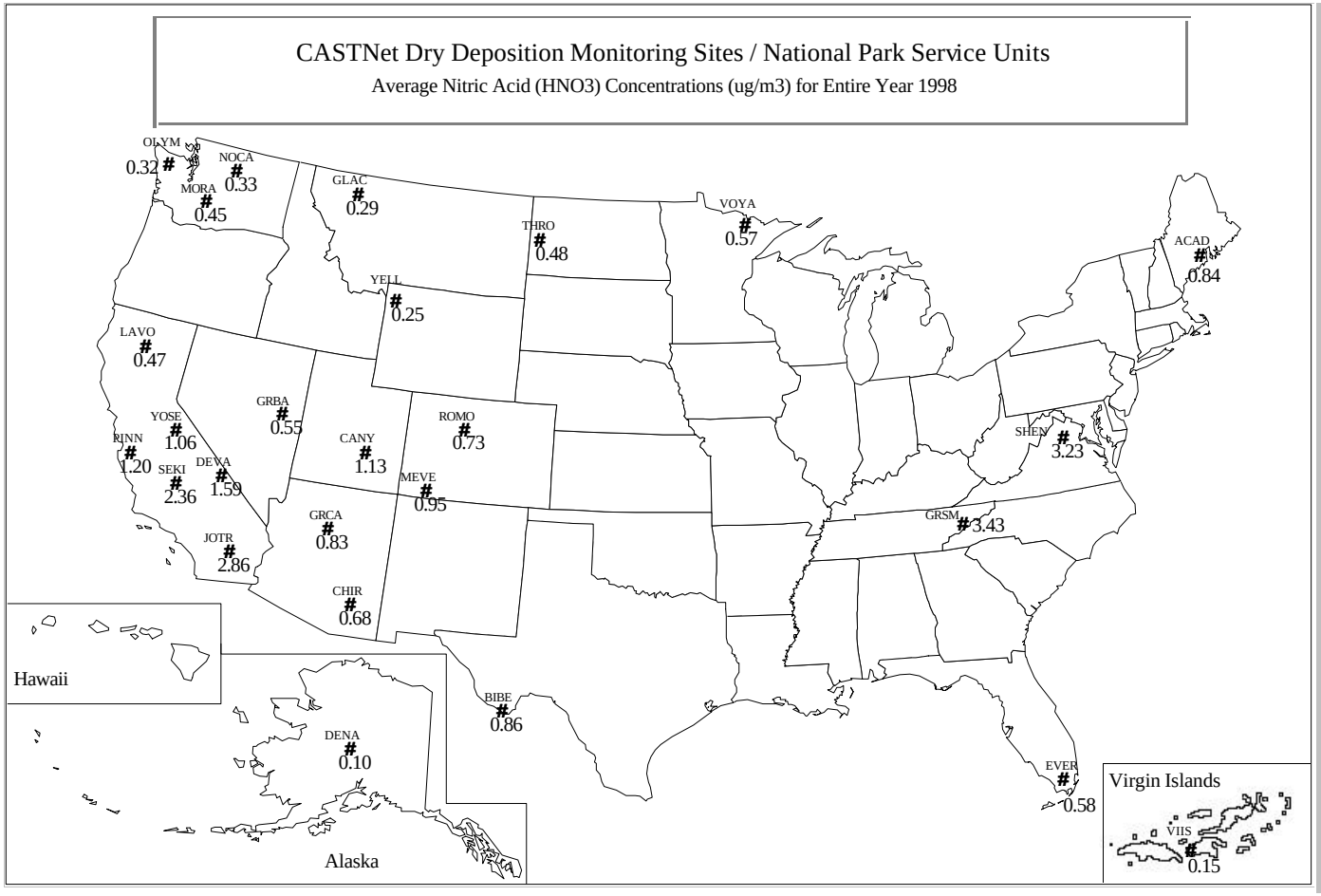

p-$SO_4$




$SO_2$

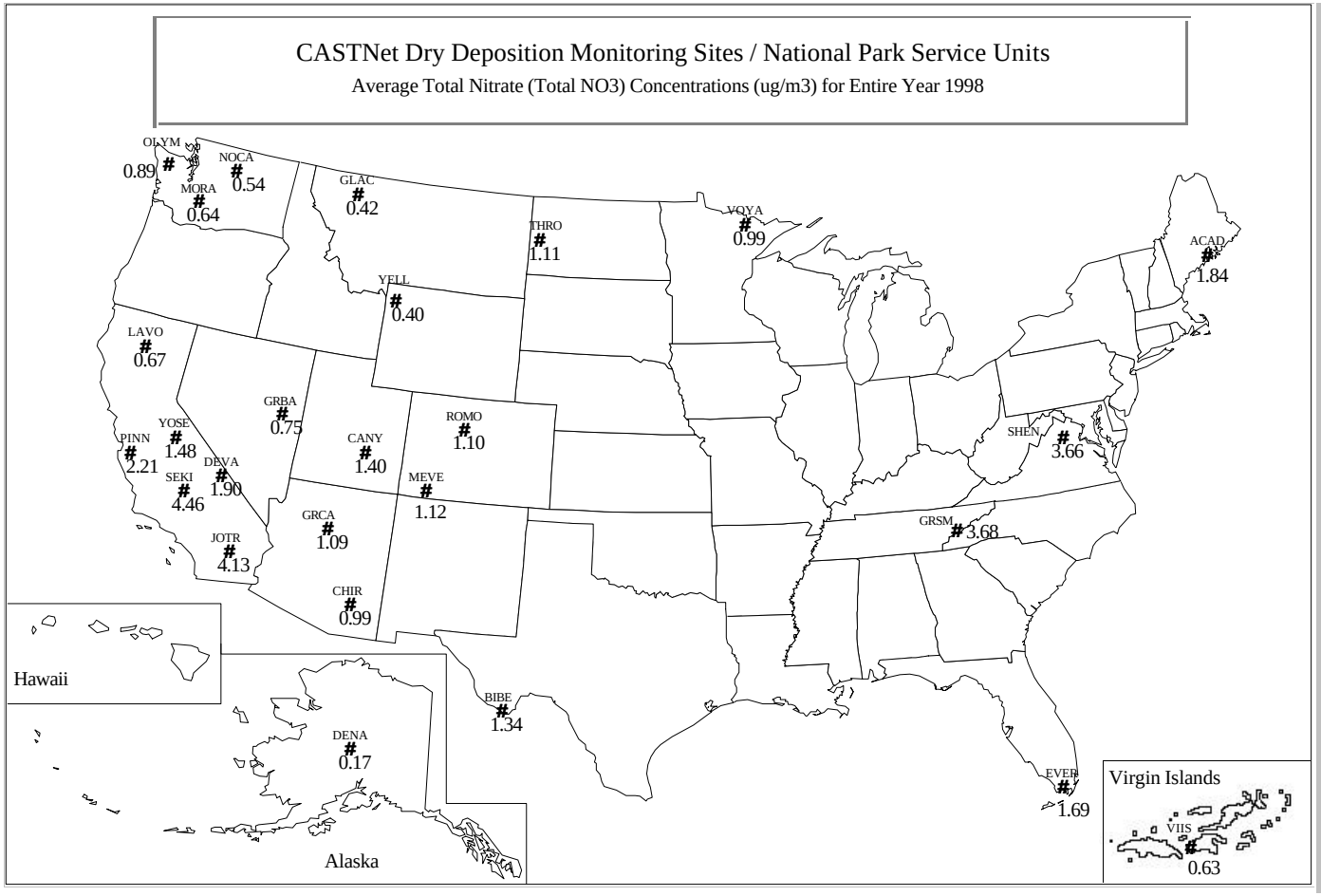




CASTNet Dry Deposition Monitoring Sites / National Park Service Units
Average Particulate Nitrate (p-NO3) Concentrations (ug/m3) for Entire Year 1998
OLYM 0.58
NOCA 0.22
MORA 0.20
GLAC 0.14
THRO 0.63
VOYA 0.43
ACAD 1.02
YELL 0.16
LAVO 0.21
GRBA 0.21
YOSE 0.44
PINN 1.02
DEVA 0.34
SEKI 2.14
CANY 0.29
ROMO 0.38
MEVE 0.19
SHEN 0.48
GRCA 0.27
GRSM 0.30
JOTR 1.29
CHIR 0.32
Hawaii
BIBE 0.50
DENA 0.07
EVER 1.12
Alaska
Virgin Islands
VIIS 0.48
Key:
ACAD Acadia NP
BIBE Big Bend NP
CANY Canyonlands NP
CHIR Chiricahua NM
DENA Denali NP
DEVA Death Valley NP
EVER Everglades NP
GLAC Glacier NP
GRBA Great Basin NP
GRCA Grand Canyon NP
GRSM Great Smokies NP
JOTR Joshua Tree NP
LAVO Lassen Volcanic NP
MEVE Mesa Verde NP
MORA Mount Rainier NP
NOCA North Cascades NP
OLYM Olympic NP
PINN Pinnacles NM
ROMO Rocky Mountain NP
SEKI Sequoia NP
SHEN Shenandoah NP
THRO Th. Roosevelt NP
VIIS Virgin Islands NP
VOYA Voyageurs NP
YELL Yellowstone NP
YOSE Yosemite NP




Key:

| | |
|---|---|
| ACAD | Acadia NP |
| BIBE | Big Bend NP |
| CANY | Canyonlands NP |
| CHIR | Chiricahua NM |
| DENA | Denali NP |
| DEVA | Death Valley NP |
| EVER | Everglades NP |
| GLAC | Glacier NP |
| GRBA | Great Basin NP |
| GRCA | Grand Canyon NP |
| GRSM | Great Smokies NP |
| JOTR | Joshua Tree NP |
| LAVO | Lassen Volcanic NP |
| MEVE | Mesa Verde NP |
| MORA | Mount Rainier NP |
| NOCA | North Cascades NP |
| OLYM | Olympic NP |
| PINN | Pinnacles NM |
| ROMO | Rocky Mountain NP |
| SEKI | Sequoia NP |
| SHEN | Shenandoah NP |
| THRO | Th. Roosevelt NP |
| VIIS | Virgin Islands NP |
| VOYA | Voyageurs NP |
| YELL | Yellowstone NP |
| YOSE | Yosemite NP |

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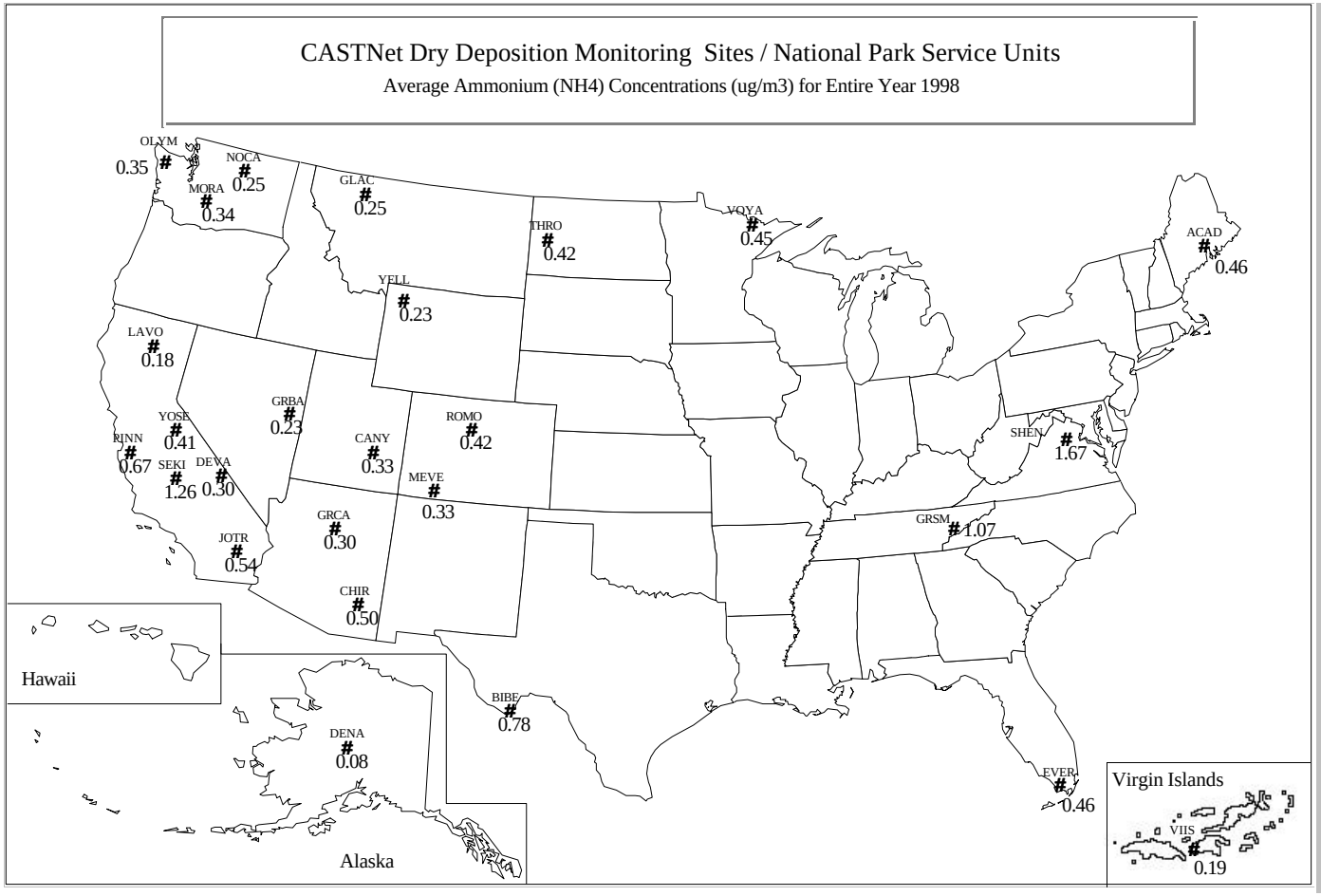


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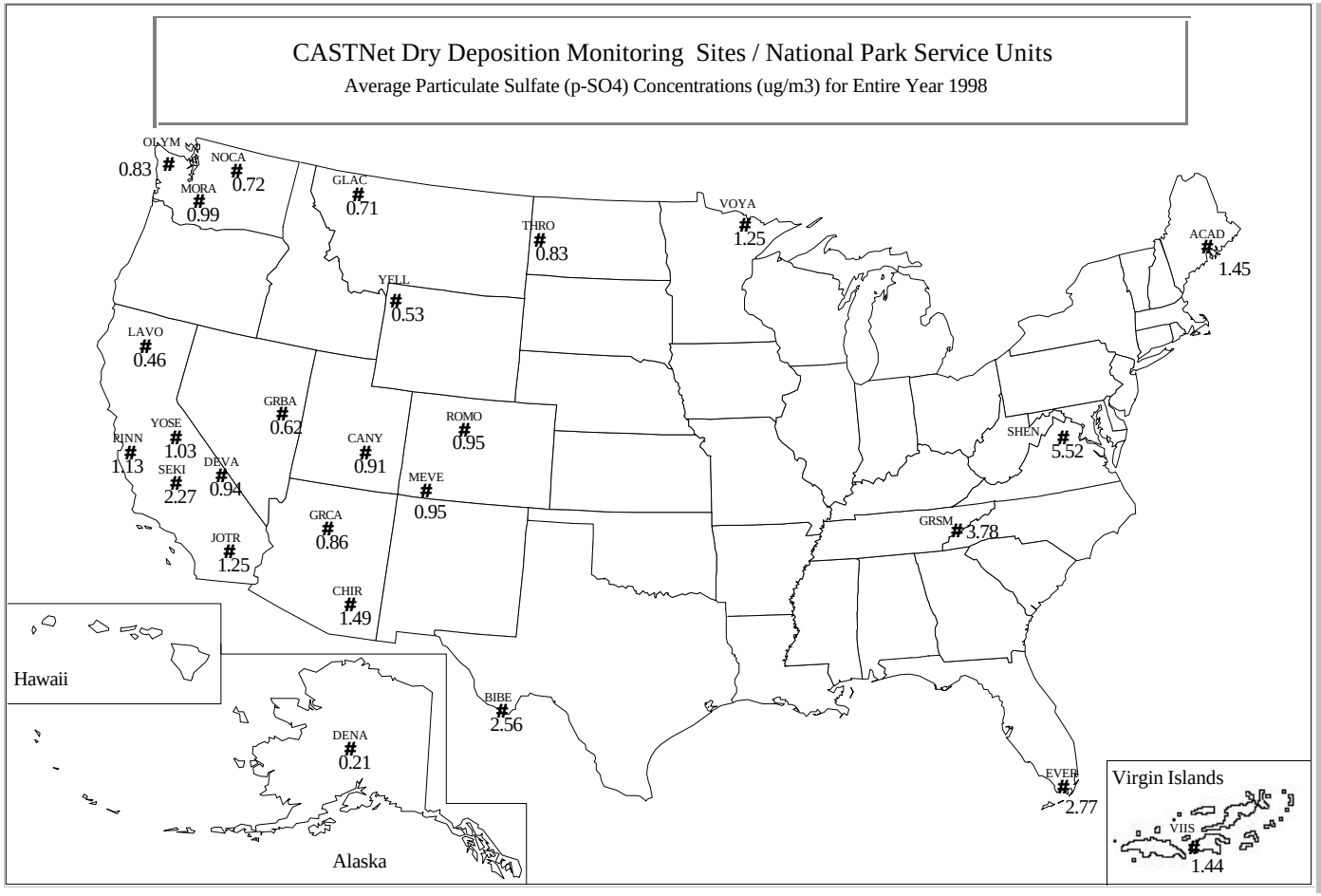


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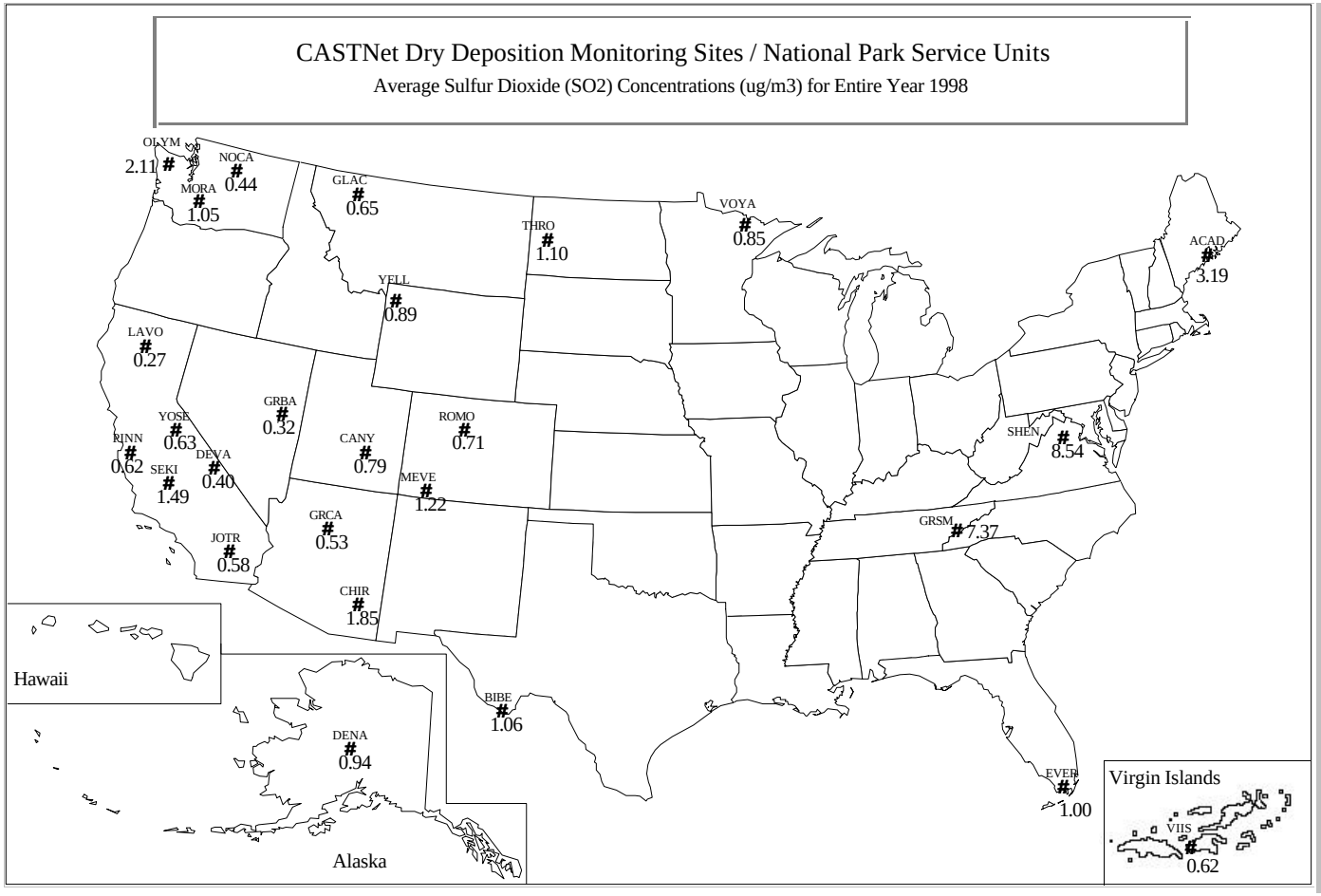


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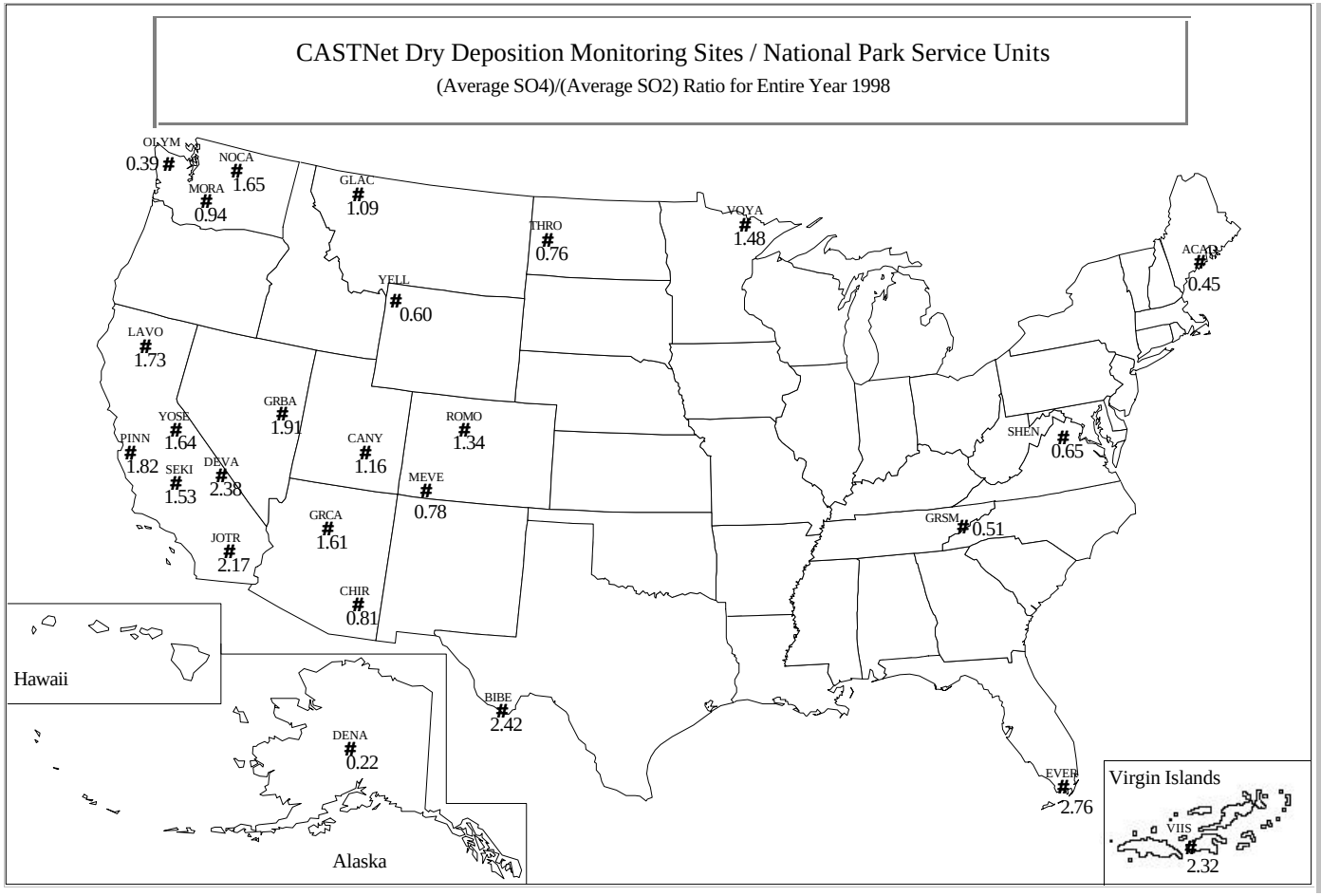
| VOYA | Voyageurs NP |
| YELL | Yellowstone NP |
| YOSE | Yosemite NP |

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| YOSE | Yosemite NP |

# 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:<br>ssss = site code<br>yy = year<br>mm = month<br>ppp = air quality data parameter code<br>AN = Annual<br>Qn = Quarter 1-4<br>R = Wind Frequency distribution table | |
| CASTNet Weekly Species Summary Data | |
| File Name (s) | Description |
| CASTNet | |
| ssssCNyr.ASC | Weekly averages |
| Where:<br>ssss = site code<br>CN = CASTNet<br>yr = year<br>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.

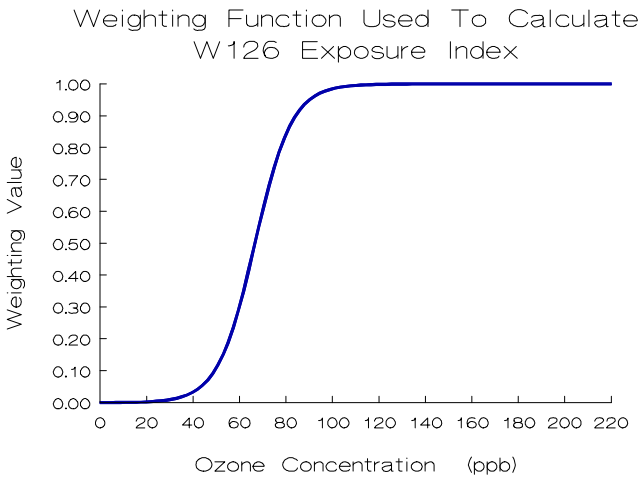
(13) **SUM60 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to 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 not 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.

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## 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