Environment

Submitted to:
ConocoPhillips Alaska Inc.
Anchorage, Alaska

Submitted by:
AECOM
Fort Collins, CO

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Nuiqsut Ambient Air Quality Monitoring Program
2007 Monitoring Year Data Summary
April 1, 2007 through March 31, 2008
Final

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Executive Summary

This report summarizes data collected at the Nuiqsut Ambient Air Quality Monitoring Station (Nuiqsut Station) during the 2007 monitoring year (April 2007 through March 2008). The Nuiqsut Station was established in April 1999 to address air quality concerns raised by citizens of Nuiqsut and the North Slope Borough, and has fulfilled the Alaska Department of Environmental Conservation (ADEC) 1-year monitoring requirement in the ConocoPhillips Alaska, Inc. Alpine construction permit. This station is part of the Nuiqsut Ambient Air Quality Monitoring Program (Monitoring Program), which is primarily designed to characterize ambient air in Nuiqsut as regional oilfield development continues. Currently, the Monitoring Program is being conducted on a voluntary basis to document air quality in Nuiqsut. Monitoring Program data also is used to support various ambient air quality impact analyses conducted for oilfield development in the Colville Delta region.

The Nuiqsut Station is equipped to continuously measure ambient air quality (oxides of nitrogen [NO_X], sulfur dioxide [SO_2], particulate matter with an aerodynamic diameter of 10 micrometers or less [PM_{10}], and ozone [O_3]) and dispersion meteorology parameters. Air quality and meteorology data collected at the Nuiqsut Station meet strict Quality Assurance (QA) and data capture requirements of the United States Environmental Protection Agency (USEPA) Prevention of Significant Deterioration program as administered by ADEC and other specific ADEC ambient monitoring QA requirements. Protocols used to collect data at the Nuiqsut Station are fully described in the project Monitoring and Quality Assurance Project Plan (QAPP).

The only variation from the QAPP procedures occurred during the 2nd Quarter Calibration at which point a field calibration check was not performed on the O_3 instrument when it was returned to the field after being repaired. The instrument passed the audit check and no data was invalidated as a result. This deviation from the QAPP is fully documented in Sections 2.5. Otherwise, there were no procedures used during the monitoring year that differed from those specified in the QAPP.

As shown in **Table ES-1**, air quality and meteorological quarterly data capture exceeded QAPP goals for a majority of the parameters with the exceptions shown in bold. The significant data losses were due to instrument failures, which in several cases required the affected instrument to be replaced or returned to the lab in Fort Collins, Colorado for repairs. Periods with invalidated data, their causes, and the resolution actions are detailed in Chapter 2.0.

The data record along with the prior years of data collection gives a history that characterizes typical air quality conditions experienced in Nuiqsut and the likelihood of any air quality exceedances. **Tables ES-2** through **ES-5** summarize average nitrogen dioxide [NO_2], SO_2, PM_{10}, and O_3 concentrations measured during the monitoring year. Measured concentrations of NO_2 and SO_2 were well below Alaska Ambient Air Quality Standards (AAAQS), which are the same as the national standards for the pollutants measured. There were exceedances of the 24-hr PM_{10} and the 8-hr O_3 AAAQS limits that are discussed in more detail.

The typical hourly NO_2 concentrations were just above instrument detection, and the annual average was well below applicable AAAQS. Concentrations measured this monitoring year generally were lower than historical measurements.

Measured SO_2 concentrations were at or below instrument detection the entire year. The low concentrations measured are consistent with an airshed containing relatively few and widely dispersed SO_2 sources. This trend has been typical of SO_2 measurements since monitoring began.

The annual average of hourly PM_{10} concentrations was well below the applicable annual AAAQS and reflective of global background levels. There were 3 days during the monitoring year that exceeded the 24-hr PM_{10} limit. These exceedances are considered exceptional events and are attributed to local windblown dust based on the high wind speeds and the dust sources located in the easterly direction from which the winds were blowing.

There were 8 exceedances of the 8-hr O_3 AAAQS. These exceedances were measured on September 13, 2007, hour ending 21:00 through September 14, 2007, hour ending 13:00, when a southerly wind was blowing significant smoke from the Anaktuvuk River tundra fire located approximately 60 to 80 miles south of the Nuiqsut Monitoring station. Average O_3 concentrations measured this year are typical of seasonal averages measured on the Alaskan North Slope (Prudhoe Bay, Kuparuk River Unit, and Barrow). In the absence of large combustion sources, strong frontal passages and high solar radiation, ambient O_3 levels will be spatially homogenous and representative of a regional background.

Table ES-1 Recovery Statistics 2007, Annual Data Summary

Parameter	2nd Quarter 2007 (%)	3rd Quarter 2007 (%)	4th Quarter 2007 (%)	1st Quarter 2008 (%)	Required Capture Rates (%)
Meteorological					
10-meters (m) Horizontal Wind Speed	99.5	95.9	**82.8**	99.2	90
10-m Horizontal Sigma-u (σ_u)	99.5	95.9	**82.8**	99.2	
10-m Horizontal Wind Direction	99.5	**53.8**	99.6	99.2	
10-m Sigma-Theta (σ_θ)	99.5	**53.8**	99.6	99.2	
10-m Vertical Wind Speed	96.9	95.2	**88.8**	**81.4**	
10-m Vertical Sigma-u (σ_w)	96.9	95.2	**88.8**	**81.4**	
10-m Temperature	99.6	**84.8**	99.7	99.5	
2-m Temperature	99.5	96.2	99.7	99.5	
10-2-m Temperature Lapse	99.5	**84.8**	99.7	99.5	
Total Solar Radiation	99.6	96.0	99.9	99.5	
Air Quality					
NO_2	98.1	95.2	97.6	**59.7**	80
SO_2	98.1	95.2	97.6	86.2	
O_3	**9.8**	95.2	97.6	96.5	
PM_{10} (TEOM)	**0.0**	**76.8**	97.2	**24.1**	

Table ES-2 Measured NO_2, 2007 Annual Data Summary

Monitoring Period	Year	Period Mean (parts per million [ppm])	Number of Exceedances
2nd Quarter	2007	0.001	None
3rd Quarter	2007	0.002	None
4th Quarter	2007	0.001	None
1st Quarter	2008	0.003	None
Annual	2007	0.002	None

National Ambient Air Quality Standards (NAAQS)/AAAQS:
Annual – 0.053 ppm (100 micrograms per cubic meter [µg/m^3]) – Compared to the annual arithmetic mean.

Table ES-3 Measured SO_2, 2007 Annual Data Summary

Monitoring Period	Year	3-hour (ppm)		24-hour (ppm)		Period Mean (ppm)	Number of Exceedances
		1st High	2nd High	1st High	2nd High		
2nd Quarter	2007	0.000	0.000	0.000	0.000	0.000	None
3rd Quarter	2007	0.001	0.001	0.001	0.001	0.000	None
4th Quarter	2007	0.001	0.001	0.001	0.001	0.000	None
1st Quarter	2008	0.002	0.002	0.002	0.002	0.000	None
Annual	2007	0.002	0.002	0.002	0.002	0.000	None

NAAQS/AAAQS:
3-hour – 0.5 ppm (1,300 µg/m^3) – Rolling average not to be exceeded more than once per year.
24-hour – 0.14 ppm – Midnight to midnight average not to be exceeded more than once per year.
Annual – 0.03 ppm – Compared to the annual arithmetic mean.

Table ES-4 Measured PM_{10} Data, 2007 Annual Data Summary

Monitoring Period	Year	24-hour (µg/m^3)		Period Mean (µg/m^3)	Number of Exceedances
		1st High	2nd High		
2nd Quarter	2007	NA	NA	NA	NA
3rd Quarter	2007	145.5	122.9	18.4	None
4th Quarter	2007	**354.8**	**239.4**	20.0	Three
1st Quarter	2008	14.0	10.9	6.0	None
Annual	2007	**354.8**	**239.4**	17.7	Three

NAAQS/AAAQS:
24 hour – 150 µg/m^3 – Not to be exceeded more than once per year measured from midnight to midnight at USEPA Standard Conditions.
Annual – 50 µg/m^3 – Compared to the 3 year average of the weighted annual arithmetic mean concentration measured at USEPA Standard Conditions.

Table ES-5 Measured O_3 Data, 2007 Annual Data Summary

Monitoring Period	Year	8-hour (ppm)			Period Mean (ppm)	Number of Exceedances
		1st High	2nd High	4th High		
2nd Quarter	2007	0.022	0.022	0.022	0.016	None
3rd Quarter	2007	**0.139**	**0.139**	**0.127**	0.018	Eight
4th Quarter	2007	0.036	0.036	0.036	0.027	None
1st Quarter	2007	0.036	0.036	0.036	0.019	None
Annual	2007	**0.139**	**0.139**	**0.127**	0.021	Eight

NAAQS/AAAQS:
8 hour – 0.08 ppm – Compared to the 3-year average of the fourth-highest daily maximum rolling 8-hour average concentrations.

1.0 Introduction

1.1 Project Summary

Since April 9, 1999 (prior to Alpine Central Processing Facility startup), ConocoPhillips Alaska, Inc. (CPAI) has operated an air quality and dispersion meteorology monitoring station in Nuiqsut, Alaska (Nuiqsut Station), which is located on the Alaskan North Slope. This station is part of the Nuiqsut Ambient Air Quality Monitoring Program (Monitoring Program), which is primarily designed to characterize ambient air in Nuiqsut as regional oilfield development continues. This Monitoring Program has been administered according to United States Environmental Protection Agency (USEPA) Prevention of Significant Deterioration (PSD) protocols; therefore, data collected is considered PSD quality.

Currently, the Monitoring Program is being conducted on a voluntary basis to document air quality in Nuiqsut. Monitoring Program data also is used to support various ambient air quality impact analyses conducted for oilfield development in the Colville Delta region.

Since the beginning, the Monitoring Program has been modified to enhance Quality Assurance (QA) and Quality Control (QC) and increase program utility through the addition of monitored parameters. Major Monitoring Program modifications include:

- Collocated Federal Reference Method (FRM) particulate matter with an aerodynamic diameter of 10 micrometers or less (PM_{10}) sampling initiated to evaluate the Monitoring Program Federal Equivalent Method sampling methodology (July 14, 2000). Collocated FRM PM_{10} sampling was discontinued in the fall 2002.
- Enhanced dispersion meteorology characterization through the addition of 10-meter (m) temperature, vertical wind speed, and solar radiation monitoring (July 24, 2001).
- Expanded background air quality evaluation through the addition of ozone (O_3) monitoring (November 19, 2004).

Since inception, the specific technical objectives of the Monitoring Program are to:

- Collect data meeting QA and data capture requirements of the USEPA PSD Program and other specific Alaska Department of Environmental Conservation (ADEC) ambient monitoring QA requirements (ADEC 1996);
- Document preconstruction air quality impacts at Nuiqsut prior to operation of Alpine (fulfilled);
- Document air quality conditions after Alpine is operational;
- Meet air quality and meteorological monitoring requirements listed in Alpine Permit No. 0073-AC060 (fulfilled); and
- Document dispersion meteorology conditions in Nuiqsut to support refined modeling of potential impacts in the region.

1.2 Measurement Methods

To meet project technical objectives, the Nuiqsut Station is instrumented and equipped to continuously measure the parameters listed in **Table 1-1**. **Table 1-1** also details the methods and instruments used for measurement. A complete description of the Monitoring Program, including the QA plan, is contained in the ADEC approved Monitoring and Quality Assurance Project Plan (QAPP), which consists of:

- The original project monitoring plan (SECOR 2000), approved by ADEC in April 2000;

- The Partisol Addendum to the original monitoring plan (SECOR 2001), approved by ADEC in October 2001;
- The draft Expanded Meteorology Addendum to the original monitoring plan (SECOR 2002), final ADEC approval pending; and
- The draft Ozone Monitoring Addendum to the original monitoring plan (SECOR 2004), final ADEC approval pending.

1.3 Variations from Quality Assurance Project Plan

The only variation from the QAPP procedures occurred during the 2nd Quarter Calibration at which point a field calibration check was not performed on the O_3 instrument when it was returned to the field after being repaired. The instrument passed the audit check and no data was invalidated as a result. This deviation from the QAPP is fully documented in Sections 2.5.

Table 1-1 Measurement Methods, 2007 Annual Data Summary

Parameter	Manufacturer/Model	Sample Frequency	Averaging Period	Measurement Range	Lower Detection Limit	Method
Nitrogen Oxides (NO_X, nitrogen dioxide (NO_2), nitric oxide [NO])	Thermo Environmental Instruments (TECO) Model 42C	Continuous	1-hour	1-500 parts per billion (ppb)	0.5 ppb	Chemiluminescence (USEPA reference method RFNA-1289-074)
Sulfur Dioxide (SO_2)	Thermo Environmental Instruments (TECO) Model 43C	Continuous	1-hour	2-500 ppb	2 ppb	Pulsed Fluorescence (USEPA equivalent method EQSA-0486-060)
PM_{10}	Rupprecht & Patashnick (R&P) Model 1400ab TEOM PM_{10}	Continuous	1-hour	<5 micrograms per cubic meter ($\mu g/m^3$) to several grams per cubic meter (g/m^3)	<5 $\mu g/m^3$	Tapered Element Oscillating Microbalance (USEPA equivalent method EQPM-1090-079)
O_3	Thermo Environmental Model 49	Continuous	1-hour	0-1,000 ppb	2 ppb	Pulsed UV Photometric (USEPA equivalent method EQOA-0880-047)
Horizontal Wind Speed (u) (10-m)	R.M. Young Wind Monitor AQ – 05305	Continuous	1-hour	0 to 50 meters per second (m/s)	0.4 m/s	Propeller/Magnetically Induced AC
Wind Speed Standard Deviation (σ_u) (10-m)	Campbell Scientific 23X	Continuous	1-hour	N.A.	N.A.	Computed by data logger
Wind direction (θ) (scalar) (10-m)	R.M. Young Wind Monitor AQ – 05305	Continuous	1-hour	0 to 360º	0.5 m/s at 10º displacement	Lightweight vane and precision potentiometer
Sigma-Theta (σ_θ) (10-m)	Campbell Scientific Model 23X	Continuous	1-hour	0 to 103.9 degrees	N.A.	Single Pass Estimator of Wind Direction Standard Deviation (Yamartino 1984)
Temperature (2-m)	YSI 44020	Continuous	1-hour	-50 degrees Celsius (°C) to 50°C	N.A.	Motor aspirated/shielded thermistor (triple-element)
Temperature (10-m)	YSI 44020	Continuous	1-hour	-50°C to 50°C	N.A.	Motor aspirated/shielded thermistor (triple-element)
10-m – 2-m Temperature Lapse (ΔT)	Campbell Scientific Model 23X	Continuous	1-hour	-100°C to 100°C	N.A.	Numerical Subtraction
Vertical Wind Speed (w) (10-m)	RM Young Propeller Anemometer Model 27106T	Continuous	1-hour	-35 m/s to 35 m/s	±0.25 m/s	Four blade helicoid propeller/AC
Sigma-w (σ_w) (10-m)	Campbell Scientific Model 23X	Continuous	1-hour	0 to 35 m/s	N.A.	Standard Deviation

N.A. = Not Applicable.

2.0 Station Performance Summary

2.1 Significant Project Events

Table 2-1 summarizes significant project events occurring during the year. Detailed discussions of project events affecting data capture are presented in Section 2.2.

Table 2-1 Significant Project Events, 2007 Annual Data Summary

Year	Date	Event/Comment
2007	April 1 through July 21	The PM_{10} instrument was offline following a sample pump failure in March 2007 resulting in PM_{10} data invalidation. A replacement pump was installed and the instrument brought back online sampling ambient air on July 21.
2007	April 1 through June 21	The O_3 instrument failed in March 2007 and O_3 data were invalidated. On May 24, the O_3 instrument was removed from service and shipped to AECOM for repairs. It was reinstalled and became operation on June 21, 2007.
2007	April 11	2-m temperature and 10-2 m temperature difference measurements were invalidated while the onsite technician tested the 2-m temperature measurement system.
2007	June 19 and June 22	The second quarter air quality measurement system calibration was conducted by AECOM. The calibration confirmed all systems that could be calibrated were reporting measurements to within acceptable limits. The ozone instrument was not tested by AECOM but passed the subsequent audit.
2007	June 20 through June 22	The second quarter air quality and first semiannual meteorological measurement systems independent performance audits were conducted by AMSTech. With the exception of solar radiation measurement accuracy at each point, the audit confirmed all audited systems were reporting measurements to within acceptable limits. The solar radiation sensor passed the audit criteria for slope, intercept, and correlation coefficient. The mean percent difference between the sensor and the audit sensor was 6.3 percent, which was slightly more than the audit pass criteria of 5% and therefore no data was invalidated.
2007	July 4	The 10-m wind speed, wind direction, and vertical wind speed and associated standard deviation data were invalidated due to sensors that were inoperational for several hours.
2007	July 12 through August 23	10-m wind direction and associated standard deviation were invalidated because the sensor potentiometer shaft had become disconnected from the sensor vane.
2007	August 20 through August 23	The quarterly air quality and second semi-annual meteorological measurement systems calibration were conducted by AECOM. Included in the calibration were scheduled replacement of data logger, wind speed/direction, and solar radiation sensors and the vertical wind speed and solar radiation sensor mounts. The calibration confirmed all systems were reporting measurements to within acceptable limits.
2007	August 25 through September 30	10-m temperature and associated 10-2 m temperature difference data were invalidated at various times due to an intermittent problem with the 10-m temperature sensor caused by a loose wire connecting the probe to the interface board. An AECOM technician repaired the loose wire and performed a calibration check on September 30.
2007	September 4	The third quarter air quality measurement systems independent performance audit was conducted by AMSTech. The auditor performed audits of the solar radiation sensors. The audit confirmed all audited systems were reporting measurements to within acceptable limits.
2007	September 17	The site technician performed repairs on the PM_{10} monitor; PM_{10} data were invalidated during this time.
2007	September 30	The 10-m vertical wind speed sensor and associated standard deviation data are invalid due to a frozen sensor and the sensor being removed while an AECOM technician performed repairs on the 10-m temperature sensor.

Table 2-1 Significant Project Events, 2007 Annual Data Summary

Year	Date	Event/Comment
2007	October 4 through October 6	Dust storms created by high winds blowing dust from the river bank and sand bars, the Nuiqsut gravel pit and roads caused high PM_{10} concentrations to be measured.
2007	October 21 through October 24	The 10-m vertical wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	October 22	The 10-m horizontal wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	October 24	The 10-m horizontal wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	October 25	The 10-m horizontal wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	October 31 through November 4	The 10-m vertical wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	November 4	All air quality data were invalidated due to a power failure.
2007	November 11 through November 13	The 10-m vertical wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	November 12 through November 13	The 10-m horizontal wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	November 26 through November 27	The 10-m vertical wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	November 27 through November 29	The fourth quarter air quality measurement systems calibration was conducted by AECOM. The calibration confirmed all systems were reporting measurements to within acceptable limits.
2007	November 28 through November 29	The fourth quarter air quality and semi-annual meteorological measurement systems independent performance audit was conducted by AMSTech. The solar radiation sensor was not audited due to insufficient light conditions. The audit confirmed all audited systems were reporting measurements to within acceptable limits.
2007	December 17	All air quality data were invalidated due to a power failure.
2007	December 14 through December 28	The 10-m horizontal wind speed and associated standard deviation data were invalidated due to a frozen sensor.
2007	December 27	All air quality data were invalidated due to a power failure.
2008	January 20	One hour of PM_{10} data was invalidated because it was outside of acceptable limits.
2008	January 22 through March 31	PM_{10} data were invalidated due to the instrument being inoperable from January 22 through March 31, 2008. On January 22, 2008, the instrument auxiliary flow dropped off rapidly; shortly thereafter, the instrument main flow began to decrease as well. The low flow problems were initially thought to be the result of a failing sample pump. The sample pump was replaced by the site tech. When the new pump failed to bring the instrument online, it became clear that the sample flow issues were likely the result of a failing sample flow controller, which could not be repaired in the field. Therefore, the instrument was shipped back to Fort Collins for repair.
2008	January 29 through March 4	All NO_X, NO_2, and NO data were invalidated due to the instrument being offline. The analyzer sampler pump failed and led to a blown fuse, forcing the instrument offline. The analyzer was replaced on February 27, 2008 and was brought online during the first quarter 2008 calibration.
2008	February 1 through February 24	SO_2 data were invalidated at 0600 each day due to residual gas in the line after calibration.
2008	February 24 through March 4	SO_2 data were invalidated because the instrument went offline due to a failed sample pump. The pump was refurbished during first quarter calibration.

Table 2-1 Significant Project Events, 2007 Annual Data Summary

Year	Date	Event/Comment
2008	March 3 through March 6	The first quarter calibration of the air quality and meteorological measurement systems was conducted by AECOM. The calibration tests revealed the flow rates for the PM_{10} instrument were outside of acceptable limits. The instrument was returned for repairs and data invalidated as previously discussed. The calibration and routine site maintenance visit confirmed all other air quality and meteorological measurement systems were operating within acceptable limits. The first quarter independent performance audit of the air quality measurement systems was conducted by AMSTech. The audit confirmed all air quality measurement systems were operating within acceptable limits. The PM_{10} instrument was not tested since it had been returned for repair.

2.2 Missing, Invalid and Adjusted Data

All hourly NO_X, SO_2, and O_3 data is routinely adjusted for instrument drift according to the procedure outlined in the USEPA Quality Assurance Handbook for Air Pollution Measurement Systems Vol. II: Part 1 (USEPA 1998) as presented in Appendix A, Section A.3. After instrument drift corrections were applied, all hourly NO_X, SO_2, and O_3 data less than 0.000 parts per million (ppm) were investigated and then set to 0.000 ppm to conservatively remove any remaining negative bias.

2.3 Network Data Completeness

Table 2-2 provides a summary of quarterly data capture for each parameter during the monitoring year. Data capture rates for each continuous air quality and meteorological parameter have been calculated according to the procedure discussed in Appendix A, Section A.1.

Network data capture that failed to achieve QAPP goals are indicated in **Table 2-2** with bold characters. Even with the poor data recovery in particular quarters, every parameter except PM_{10} had at least 75 percent recovery on an annual basis. PM_{10}, which had the lowest recovery, still had higher recovery on an annual basis than would have been achieved with 1 in 3 day filter based sampling.

All data losses were thoroughly detailed in **Table 2-1**. In summary the following events resulted in data capture rates below QAPP goals:

- Horizontal wind speed and associated standard deviation data losses were primarily the result of a frozen sensor;
- Vertical wind speed and σ_W data losses were the result of a frozen sensor;
- Horizontal wind direction and associated standard deviation losses were the result of a loose wire connecting the probe to the interface board;
- 10-m and 10-2-m temperature difference losses were the result of a loose wire connecting the probe to the interface board;
- NO_2 data losses were the result of the instrument being offline due to a blown fuse caused by a faulty pump;
- O_3 data losses were the result of the instrument being off-line and unable to be repaired on site; and
- PM_{10} data losses were the result of a failed sample pump and later a failed sample flow controller.

Table 2-2 Data Recovery Statistics, 2007 Annual Data Summary

Parameter	2nd Quarter 2007 (%)	3rd Quarter 2007 (%)	4th Quarter 2007 (%)	1st Quarter 2008 (%)	Required Capture Rates (%)
Meteorological					
10-m Horizontal Wind Speed	99.5	95.9	**82.8**	99.2	90
10-m Horizontal Sigma-u (σ_u)	99.5	95.9	**82.8**	99.2	
10-m Horizontal Wind Direction	99.5	**53.8**	99.6	99.2	
10-m Sigma-Theta (σ_θ)	99.5	**53.8**	99.6	99.2	
10-m Vertical Wind Speed	96.9	95.2	**88.8**	**81.4**	
10-m Vertical Sigma-u (σ_w)	96.9	95.2	**88.8**	**81.4**	
10-m Temperature	99.6	**84.8**	99.7	99.5	
2-m Temperature	99.5	96.2	99.7	99.5	
10-2-m Temperature Lapse	99.5	**84.8**	99.7	99.5	
Total Solar Radiation	99.6	96.0	99.9	99.5	
Air Quality					
NO_2	98.1	95.2	97.6	**59.7**	80
SO_2	98.1	95.2	97.6	86.2	
O_3	**9.8**	95.2	97.6	96.5	
PM_{10} (TEOM)	**0.0**	**76.8**	97.2	**24.1**	

2.4 Precision Statistics

2.4.1 Monitoring Network Precision Statistics

Quarterly NO_2, NO, SO_2, and O_3 precision check statistics shown in **Tables 2-3** through **2-6** indicate all air quality systems were reporting measurements to within QAPP established tolerances. Precision statistics have been calculated for NO_2, NO, SO_2, and O_3 instruments based on USEPA methods, which are summarized in Appendix A, Section A.2. Individual results from each precision check conducted are listed in Appendix B, **Tables B-1** through **B-4**.

Table 2-3 Second Quarter 2007 Precision Statistics Summary

Parameter	Number of Precision Checks (N)	Average Percent Difference ($\bar{d}_j$)	Standard Deviation (S_j)	Upper 95% Probability Limit (U_{95})	Lower 95% Probability Limit (L_{95})
NO	12	-1.2	0.6	-0.1	-2.4
NO_2	12	0.0	0.5	0.9	-1.0
SO_2	12	-0.5	1.6	2.6	-3.7
O_3	1	9.6	N/A	N/A	N/A
Precision Goal	N/A	±15	N/A	15	-15

Remarks:
Six valid precision checks are required per quarter by the QAPP, 12 were performed and the valid number is indicated in the table.
O_3 Precision Statistics: Only one valid O_3 precision check was conducted because the measurement system was offline most of the quarter.

Table 2-4 Third Quarter 2007 Precision Statistics Summary

Parameter	Number of Precision Checks (N)	Average Percent Difference ($đ_j$)	Standard Deviation (S_j)	Upper 95% Probability Limit (U_{95})	Lower 95% Probability Limit (L_{95})
NO	16	-1.6	1.0	0.3	-3.5
NO_2	16	0.1	0.5	1.2	-0.9
SO_2	16	-1.0	1.4	1.7	-3.7
O_3	16	0.4	1.5	3.0	-2.5
Precision Goal	N/A	±15	N/A	15	-15

Remarks:
Six valid precision checks are required per quarter by the QAPP, 16 were performed and the valid number is indicated in the table.

Table 2-5 Fourth Quarter 2007 Precision Statistics Summary

Parameter	Number of Precision Checks (N)	Average Percent Difference ($đ_j$)	Standard Deviation (S_j)	Upper 95% Probability Limit (U_{95})	Lower 95% Probability Limit (L_{95})
NO	28	-1.2	0.8	0.4	-2.8
NO_2	26	-0.1	0.5	0.8	-1.0
SO_2	28	-1.4	2.1	2.7	-5.5
O_3	28	-0.1	1.2	2.3	-2.6
Precision Goal	N/A	±15	N/A	15	-15

Remarks:
Six valid precision checks are required per quarter by the QAPP, 29 were performed and the valid number is indicated in the table.

Table 2-6 First Quarter 2008 Precision Statistics Summary

Parameter	Number of Precision Checks (N)	Average Percent Difference ($đ_j$)	Standard Deviation (S_j)	Upper 95% Probability Limit (U_{95})	Lower 95% Probability Limit (L_{95})
NO	17	-1.0	1.1	1.3	-3.2
NO_2	12	-0.4	1.9	3.3	-4.1
SO_2	26	0.2	2.0	4.0	-3.7
O_3	17	0.2	1.3	2.8	-2.4
Precision Goal	N/A	±15	N/A	15	-15

Remarks:
Six valid precision checks are required per quarter by the QAPP, 30 were performed and the valid number is indicated in the table.
O_3 Precision Statistics: The O_3 Primary Standard was off-line for approximately one-third of the quarter leading to the low number of precision checks.
NO_X Precision Statistics: The NO_X analyzer was off-line for approximately one-third of the quarter leading to the low number of precision checks.
SO_2 Precision Statistics: The SO_2 analyzer was off-line for a portion of the quarter leading to a lower number of precision checks than was possible. Four checks were not executed properly and not included in the statistics.

2.5 Accuracy Statistics

Meteorological and ambient air quality measurement systems are subjected to periodic calibrations/QC checks and independent QA performance audits to document measurement system accuracy. All calibration/QC check and audit equipment relies on NIST or other traceable standards. The purpose of calibration/QC and audit checks is to challenge measurement systems with known inputs, verifying the response of each system is accurate to within USEPA established tolerances listed in the QAPP. A complete copy of all calibration/QC check data, independent QA performance audits, and technical systems audits is included in Appendix C and are summarized below.

2.5.1 Instrument Calibration Statistics

A description of quarterly calibration/QC checks is presented below by quarter. These quarterly calibration/QC check descriptions are summarized in **Tables 2-7** through **2-10** for each measurement parameter during the monitoring year. Summarized results characterize an as-left instrument state. If as-found results were significantly different or failed QA criteria, they are discussed below and as part of the summary table.

2.5.1.1 Second Quarter 2007

The second quarter calibration of the air quality measurement systems was conducted by AECOM June 19 through 22, 2007. Results of this QA activity are summarized in **Table 2-7**, which shows all air quality systems were reporting measurements to within acceptable limits, except for the O_3 system, which was not calibrated after installation though passed subsequent auditor tests.

2.5.1.2 Third Quarter 2007

The third quarter calibration of the air quality measurement systems was conducted by AECOM on August 20 through 23, 2007. The solar radiation sensor calibration confirmed the previous quarter audit findings that the sensor was measuring between 5 to 6 percent lower than the reference sensor; therefore, the sensor was replaced. Results of this QA activity are summarized in **Table 2-8**, which shows all air quality and meteorological systems were reporting measurements to within acceptable limits.

2.5.1.3 Fourth Quarter 2007

The fourth quarter air quality measurement system calibration was conducted by AECOM from November 27 through 29, 2007. Results of this QA activity are summarized in **Table 2-9**, which shows all air quality systems were reporting measurements to within acceptable limits.

2.5.1.4 First Quarter 2008

The first quarter air quality and meteorological measurement system calibration was conducted by AECOM from March 3 through 4, 2008. Results of this QA activity are summarized in **Table 2-10**, which shows all air quality and meteorological systems were reporting measurements to within acceptable limits, except for the PM_{10} analyzer that was inoperable and returned to AECOM Fort Collins for repair.

2.5.2 Deviations from the QAPP

The only variation from the QAPP occurred during the 2nd Quarter Calibration at which point a field calibration check was not performed on the O_3 instrument when it was returned to the field after being repaired. The instrument passed the audit check so all data is considered valid.

2.5.3 Independent Quality Assurance Audits

A written description of quarterly independent QA performance audits and the technical systems audit is presented below. Quarterly performance audit results are also summarized in **Tables 2-11** through **Table 2-14** for each measurement parameter.

Table 2-7 Second Quarter 2007 Calibration Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Calibration June 19through 22, 2007					
SO_2	Slope	≥ 0.85 and ≤ 1.15	0.99	Pass	The calibration confirmed all air quality systems were reporting measurements to within acceptable limits. * A calibration check was not performed on the O_3 instrument though the instrument passed the subsequent auditor tests.
	Intercept	≤ ±3% full scale	-0.20%	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	1.01	Pass	
	Intercept	≤ ±3% full scale	-0.60%	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	1.01	Pass	
	Intercept	≤ ±3% full scale	-.61%	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	100%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	*	*	
	Intercept	≤ ±3% full scale	*	*	
	Correlation Coef.	≥ 0.9950	*	*	
PM_{10}	Sample Flow	≤ ±10%	0.3%	Pass	
	Total Flow	≤ ±10%	-0.5%	Pass	
	Mass Determination	≤ ±2.5%	1.8%	Pass	
Meteorological Calibration					
Conducting a calibration of meteorological measurement systems is required semiannually and was conducted during the third calendar quarter 2007 and first calendar quarter of 2008.					

Table 2-8 Third Quarter 2007 Calibration Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Calibration August 20 through 23, 2007					
SO_2	Slope	≥ 0.85 and ≤ 1.15	1.02	Pass	The calibration confirmed all air quality systems were reporting measurements to within acceptable limits. * The PM_{10} measurement system was offline and could not be calibrated.
	Intercept	≤ ±3% full scale	-0.002 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	1.04	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	1.04	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	99%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	*	*	
	Total Flow	≤ ±10%	*	*	
	Mass Determination	≤ ±2.5%	*	*	
Meteorological Calibration August 20 through 23, 2007					
10-m Horizontal Wind Speed	Accuracy	≤ ±5%	0.0%	Pass	The solar radiation sensor was replaced during this calibration. The as-left calibration confirmed all meteorological systems were reporting measurements to within acceptable limits.
	Starting Torque	≤ 1 g-cm	0.2 g-cm	Pass	
10-m Horizontal Wind Direction	Accuracy	≤ ±5 deg.	0.9 deg.	Pass	
	Linearity	≤ ±3 deg.	0.0 deg.	Pass	
	Starting Torque	≤ 11.0 g-cm	3.0 g-cm	Pass	
10-m Vertical Wind Speed	Accuracy	≤ ±2.5 m/s	-0.01 m/s	Pass	
	Starting Torque	≤ 1 g-cm	0.1 g-cm	Pass	
10-m Temperature	Accuracy	≤ ±0.5 °C	0.0 °C	Pass	
2-m Temperature	Accuracy	≤ ±0.5 °C	-0.1 °C	Pass	
10-2m Temperature Lapse	Accuracy	≤ ±0.1 °C	-0.01 °C	Pass	
Total Solar Radiation (replacement sensor)	Accuracy	≤ ±25 W/m^2	-3.9 W/m^2	Pass	

.

Table 2-9 Fourth Quarter 2007 Calibration Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Calibration December 11 through 12, 2006					
SO_2	Slope	≥ 0.85 and ≤ 1.15	1.01	Pass	The calibration confirmed all air quality systems were reporting measurements to within acceptable limits.
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	1.02	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	1.02	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	100%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	-0.7%	Pass	
	Total Flow	≤ ±10%	-0.2%	Pass	
	Mass Determination	≤ ±2.5%	0.82%	Pass	
Meteorological Calibration					
Conducting a calibration of meteorological measurement systems is required semiannually and was conducted during the third calendar quarter 2007 and first calendar quarter of 2008.					

Table 2-10 First Quarter 2008 Calibration Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Calibration March 5 through 6, 2008					
SO_2	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	The calibration confirmed all air quality systems were reporting measurements to within acceptable limits with the exception of the PM_{10} instrument. *This failure resulted in the PM_{10} instrument being shipped to Fort Collins for repair and data invalidation as described in **Table 2-2**.
	Intercept	≤ ±3% full scale	0.004 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	98%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	-0.3%	Pass	
	Total Flow	≤ ±10%	-1.6%	Pass	
	Mass Determination	≤ ±2.5%	8.5%	Fail*	
Meteorological Calibration March 5 through 6, 2008					
10-m Horizontal Wind Speed	Accuracy	≤ ±5%	0.03%	Pass	The calibration confirmed all meteorological systems were reporting measurements to within acceptable limits.
	Starting Torque	≤ 1 g-cm	0.2 g-cm	Pass	
10-m Horizontal Wind Direction	Accuracy	≤ ±5 deg.	0.9 deg.	Pass	
	Linearity	≤ ±3 deg.	0.0 deg.	Pass	
	Starting Torque	≤ 11.0 g-cm	9.0 g-cm	Pass	
10-m Vertical Wind Speed	Accuracy	≤ ±2.5 m/s	0.1 m/s	Pass	
	Starting Torque	≤ 1 g-cm	0.2 g-cm	Pass	
10-m Temperature	Accuracy	≤ ±0.5 °C	-0.1 °C	Pass	
2-m Temperature	Accuracy	≤ ±0.5 °C	-0.1 °C	Pass	
10-2m Temperature Lapse	Accuracy	≤ ±0.1 °C	0.03 °C	Pass	
Total Solar Radiation	Accuracy	≤ ±25 W/m^2	-0.16 W/m^2	Pass	

Table 2-11 Second Quarter 2007 Audit Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Audit June 20 through 21, 2007					
SO_2	Slope	≥ 0.85 and ≤ 1.15	0.97	Pass	The audit confirmed all air quality systems were reporting measurements to within acceptable limits.
	Intercept	≤ ±3% full scale	0.002 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	0.93	Pass	
	Intercept	≤ ±3% full scale	0.002 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	0.93	Pass	
	Intercept	≤ ±3% full scale	0.005 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	100%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	0.99	Pass	
	Intercept	≤ ±3% full scale	-0.002 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	-2.0%	Pass	
	Total Flow	≤ ±10%	2.1%	Pass	
	Mass Determination	≤ ±2.5%	1.2%	Pass	
Meteorological Audit June 20 through 21, 2007					
10-m Horizontal Wind Speed	Accuracy	≤ ±5%	0.0%	Pass	*With the exception of solar radiation measurement accuracy failure discussed in **Table 2-1**, the audit confirmed all meteorological monitoring systems were reporting measurements to within acceptable limits.
	Starting Torque	≤ 1 g-cm	0.2 g-cm	Pass	
10-m Horizontal Wind Direction	Accuracy	≤ ±5 deg.	0.8 deg.	Pass	
	Linearity	≤ ±3 deg.	1.0 deg.	Pass	
	Starting Torque	≤ 11.0 g-cm	6.0 g-cm	Pass	
10-m Vertical Wind Speed	Accuracy	≤ ±2.5 m/s	0.05 m/s	Pass	
	Starting Torque	≤ 1 g-cm	0.1 g-cm	Pass	
10-m Temperature	Accuracy	≤ ±0.5 °C	0.08 °C	Pass	
2-m Temperature	Accuracy	≤ ±0.5 °C	0.10 °C	Pass	
10-2m Temperature Lapse	Accuracy	≤ ±0.1 °C	0.03 °C	Pass	
Total Solar Radiation	Accuracy	≤ ±5% full scale	6.3%	Fail*	

Table 2-12 Third Quarter 2007 Audit Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Audit September 4, 2007					
SO_2	Slope	≥ 0.85 and ≤ 1.15	0.97	Pass	The audit confirmed all air quality systems were reporting measurements to within acceptable limits. In addition, a newly installed solar radiation sensor passed audit.
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	0.96	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	0.96	Pass	
	Intercept	≤ ±3% full scale	-0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	100%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	1.00	Pass	
	Intercept	≤ ±3% full scale	-0.003 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	2.4%	Pass	
	Total Flow	≤ ±10%	1.1%	Pass	
	Mass Determination	≤ ±2.5%	0.98%	Pass	
Meteorological Calibration					
Total Solar Radiation	Accuracy	≤ ±5% full scale	1.1%	Pass	
Conducting a meteorological measurement systems audit is required semiannually and was conducted during the second and fourth calendar quarters of 2007.					

Table 2-13 Fourth Quarter 2007 Audit Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Audit November 28 through 29, 2007					
SO_2	Slope	≥ 0.85 and ≤ 1.15	0.95	Pass	The audit confirmed all air quality systems were reporting measurements to within acceptable limits.
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	0.92	Pass	
	Intercept	≤ ±3% full scale	0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	0.93	Pass	
	Intercept	≤ ±3% full scale	0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	100%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	0.99	Pass	
	Intercept	≤ ±3% full scale	-0.003 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	4.9%	Pass	
	Total Flow	≤ ±10%	4.7%	Pass	
	Mass Determination	≤ ±2.5%	1.18%	Pass	
Meteorological Audit November 28 through 29, 2007					
10-m Horizontal Wind Speed	Accuracy	≤ ±5%	0.2%	Pass	The audit confirmed all meteorological systems that could be audited were reporting measurements to within acceptable limits. * The solar radiation measurement system could not be audited due to insufficient solar radiation.
	Starting Torque	≤ 1 g-cm	0.2 g-cm	Pass	
10-m Horizontal Wind Direction	Accuracy	≤ ±5 deg.	1.0 deg.	Pass	
	Linearity	≤ ±3 deg.	0.9 deg.	Pass	
	Starting Torque	≤ 11.0 g-cm	2.0 g-cm	Pass	
10-m Vertical Wind Speed	Accuracy	≤ ±2.5 m/s	0.09 m/s	Pass	
	Starting Torque	≤ 1 g-cm	0.3 g-cm	Pass	
10-m Temperature	Accuracy	≤ ±0.5 °C	0.22 °C	Pass	
2-m Temperature	Accuracy	≤ ±0.5 °C	0.29 °C	Pass.	
10-2m Temperature Lapse	Accuracy	≤ ±0.1 °C	0.08 °C	Pass	
Total Solar Radiation	Accuracy	≤ ±5% full scale	*	*	

Table 2-14 First Quarter 2008 Audit Results

Parameter	QC Check Category	QC Check Criteria	Measured Response	Results (Pass/Fail)	Comments
Air Quality Audit March 4, 2008					
SO_2	Slope	≥ 0.85 and ≤ 1.15	0.96	Pass	The audit confirmed all audited air quality systems were reporting measurements to within acceptable limits. The PM_{10} instrument was offline and could not be audited.
	Intercept	≤ ±3% full scale	0.003 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_X	Slope	≥ 0.85 and ≤ 1.15	0.97	Pass	
	Intercept	≤ ±3% full scale	0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO	Slope	≥ 0.85 and ≤ 1.15	0.97	Pass	
	Intercept	≤ ±3% full scale	0.001 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
NO_2	Converter Eff.	≥ 96%	99.4%	Pass	
O_3	Slope	≥ 0.85 and ≤ 1.15	1.03	Pass	
	Intercept	≤ ±3% full scale	0.000 ppm	Pass	
	Correlation Coef.	≥ 0.9950	1.00	Pass	
PM_{10}	Sample Flow	≤ ±10%	N.A.	N.A.	
	Total Flow	≤ ±10%	N.A.	N.A.	
	Mass Determination	≤ ±2.5%	N.A.	N.A.	
Meteorological Audit					
Conducting meteorological measurement systems audit is required semiannually and was conducted during the fourth 2007 and second calendar quarter of 2008.					

2.5.3.1 Second Quarter 2007

The second quarter 2007 air quality and meteorological measurement system performance audit was conducted by Air Monitoring Services and Technology (AMSTech) June 20 through 21, 2007. Audit results showed all systems were reporting measurements to within required accuracy limits, except for solar radiation. The sensor passed the slope and intercept audit limits criteria, but all of the individual test points had errors greater than 5 percent.

2.5.3.2 Third Quarter 2007

The third quarter 2007 performance audit of the air quality measurement systems was conducted by AMSTech September 4, 2007. Audit results showed all systems were reporting measurements to within required accuracy limits.

2.5.3.3 Fourth Quarter 2007

The fourth quarter 2007 performance audit of the air quality and meteorological measurement systems was conducted by AMSTech November 28 through 29, 2007. Audit results showed all systems were reporting measurements to within required accuracy limits.

2.5.3.4 First Quarter 2008

The first quarter 2008 performance audit of the air quality measurement systems was conducted by AMSTech on March 4, 2008. Audit results showed all systems were reporting measurements to within required accuracy limits.

2.5.3.5 Technical Systems Audit

The annual Technical Systems Audit (TSA) of data handling, validation, processing, reporting procedures, and monitoring station siting and operation at the Nuiqsut Station and at the AECOM Air Resources Laboratory in Fort Collins, Colorado, was conducted during July 2007. TSA results showed the monitoring station has been installed and is operating in accordance with the QAPP and USEPA recommended guidelines. The audit also showed AECOM has the necessary organization, practical field experience, work facilities, and data processing procedures in place to accurately collect and report project ambient air quality and meteorological data.

3.0 Monitoring Data Network Summary

3.1 Air Quality Data Summary

Criteria pollutants monitored as part of the Monitoring Program are NO_2, SO_2, respirable PM_{10}, and O_3. Criteria pollutants are those air pollutants for which ADEC and USEPA have established standards that provide a threshold above which risk to public health and welfare becomes an issue. These standards are referred to as the Alaska Ambient Air Quality Standards (AAAQS) and are typically the same as the national standards (NAAQS) for the pollutants measured. Applicable NAAQS/AAAQS, along with ambient concentrations measured at the Nuiqsut Station, are summarized by pollutant.

3.1.1 Nitrogen Dioxide

Table 3-1 shows the annual average NO_2 concentration was 0.002 ppm, and less than 4 percent of the annual NO_2 AAAQS of 0.053 ppm. The typical NO_2 concentrations are just above instrument detection level. The annual average measured this year is lower than the historical Nuiqsut Station average of 0.004 ppm.

Table 3-1 Measured NO_2 Data Summary, 2007 Annual Data Summary

Monitoring Period	Year	Period Mean (ppm)	Number of Exceedances
2nd Quarter	2007	0.001	None
3rd Quarter	2007	0.002	None
4th Quarter	2007	0.001	None
1st Quarter	2008	0.003	None
Annual	2007	0.002	None

NAAQS/AAAQS: Annual - 0.053 ppm (100 µg/m^3) – Compared to the annual arithmetic mean.

The distribution of average hourly NO_2 concentration by wind direction this year was typical of past years with the magnitude of the highest values lower than the historical average (**Figure 3-1)**. This offset in magnitude is consistent with the difference between the historical and current year's annual average of the hourly concentrations. As shown in **Figure 3-1**, historically, the lowest concentrations are measured when winds transport background air to the Nuiqsut Station (west-southwest clockwise through east southeast). Slightly higher concentrations occur for wind directions that place the station downwind of Nuiqsut (southeast clockwise through southwest wind directions). In general, measured NO_2 concentrations at Nuiqsut are extremely low.

Monthly average NO_2 concentrations are presented in **Figure 3-2**. For this monitoring year, the trend of monthly averaged measured concentrations showed very little seasonal variation. Historically, it is typical to observe increases in monthly averaged NO_2 concentrations during late winter. Both this and the previous year did not show the historical winter peak. The lack of data in February may have affected the appearance of the seasonal trend.

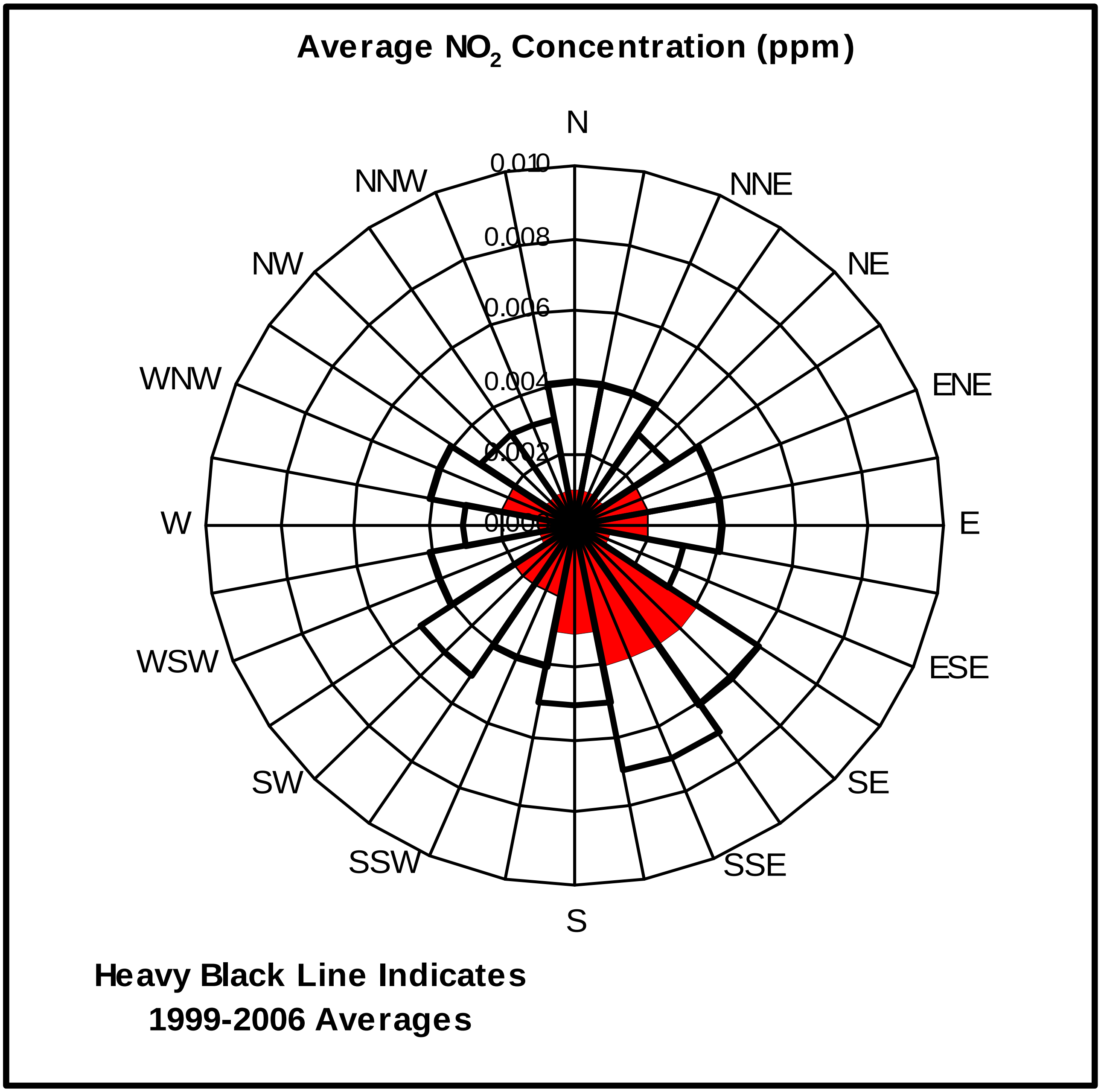


Figure 3-1 Average NO_2 Concentration by Wind Direction, 2007 Annual Data Summary

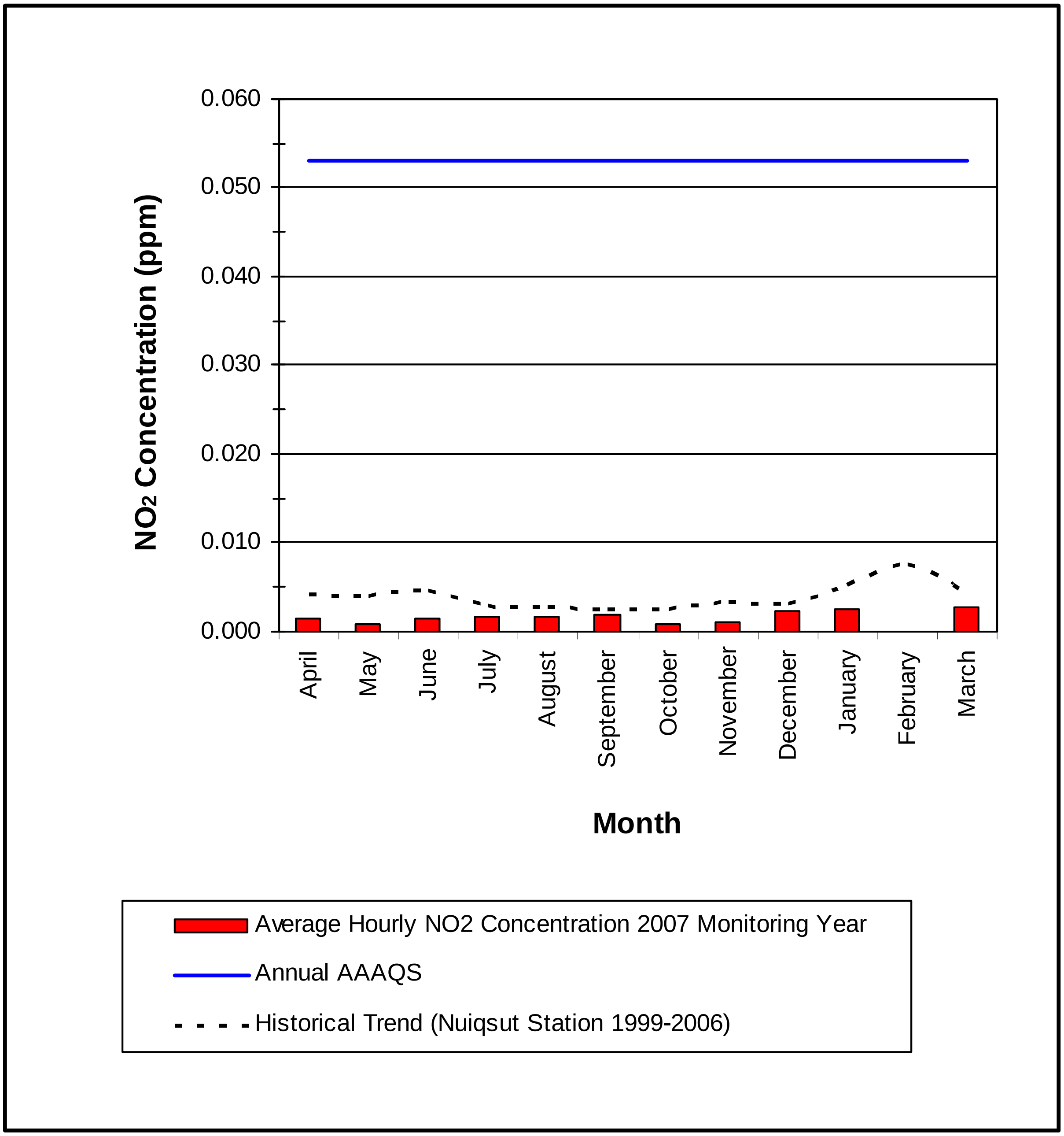


Figure 3-2 Average NO_2 Concentration by Month, 2007 Annual Data Summary

The pattern of higher measured concentrations in late winter has been attributed to differences in atmospheric dispersion characteristics between winter and summer, and potential changes in local emissions. Seasonal differences in atmospheric dispersion characteristics arise because in winter, there is an increase in stable and neutral atmospheric conditions. With the sun up in summer, solar radiation and heating of the surface induces more vertical mixing of the lower atmosphere than in winter, thereby increasing air pollution dispersion. In winter, without the benefit of solar energy, the atmosphere remains relatively stable reducing vertical pollution dispersion. In addition, the increased local use of heating systems and idling vehicles in winter contribute to the NO_2 load.

3.1.2 Sulfur Dioxide

Table 3-2 lists measured maximum 3-hour (running), 24-hour (midnight-to-midnight), and the annual average hourly SO_2 concentrations measured this monitoring year. Concentrations for all averaging periods were near or below instrument detection limit and well below applicable AAAQS. Measured SO_2 concentrations were typical of historical (1999-2006) values.

Table 3-2 Measured SO_2 Data Summary, 2007 Annual Data Summary

Monitoring Period	Year	3-hour (ppm)		24-hour (ppm)		Period Mean (ppm)	Number of Exceedances
		1st High	2nd High	1st High	2nd High		
2nd Quarter	2007	0.000	0.000	0.000	0.000	0.000	None
3rd Quarter	2007	0.001	0.001	0.001	0.001	0.000	None
4th Quarter	2007	0.001	0.001	0.001	0.000	0.000	None
1st Quarter	2008	0.002	0.002	0.002	0.002	0.000	None
Annual	2007	0.002	0.002	0.002	0.002	0.000	None

NAAQS/AAAQS:
- 3-hour - 0.5 ppm (1,300 $\mu g/m^3$) – Rolling average not to be exceeded more than once per year.
- 24-hour - 0.14 ppm – Midnight to midnight average not to be exceeded more than once per year.
- Annual - 0.03 ppm – Compared to the annual arithmetic mean.

Measured 3-hour average SO_2 concentrations were less than 0.003 ppm throughout the monitoring year. The majority of measured SO_2 concentrations were just above the instrument detection limit making it difficult to discuss significant trends in time or with wind direction. There was no single near field or far field measurable SO_2 source observed in the data collected this year. Without identifiable sources, measured concentrations are representative of a regional or global background signature. The low average concentrations measured are consistent with an airshed containing relatively few and widely distributed sources. This trend has been typical of SO_2 measurements since monitoring began.

3.1.3 Respirable Particulate Matter (PM_{10})

Throughout the monitoring project history, the majority of elevated PM_{10} concentrations result from naturally occurring windblown fugitive dust from exposed or disturbed areas local to the Nuiqsut Station. Exposed areas identified in the program are:

- The exposed bank of the Nechelik Channel north northeast through east southeast of the station;
- The exposed gravel mining area southeast of the station;
- Disturbed ground due to residential construction along the utility right-of-way and road southeast through south southeast of the station; and
- To a lesser degree, disturbed ground associated with dirt roads within Nuiqsut south through west southwest of the station.

In addition to these local fugitive sources, in the past, elevated particulate concentrations have also been measured from remote forest and tundra fires. However, during the current monitoring year, there were no periods identified when measured particulate concentrations could be attributed to forest fires. When particulate material from local fugitive dust and smoke is not present, hourly concentrations decrease to near the PSD de minimus levels.

Respirable PM_{10} measured at USEPA standard temperature and pressure, has a 24-hour and annual AAAQS of 150 μg/m^3 and 50 μg/m^3, respectively. As listed in **Table 3-3**, the maximum 24 hour PM_{10} concentration measured during the monitoring year was 354.8 μg/m^3. There were three 24-hr PM_{10} AAAQS exceedances. These exceedances are considered exceptional events and are attributed to local windblown dust based on the high wind speeds and the dust sources located in the easterly direction from which the winds were blowing. The yearly average PM_{10} concentration was 17.7 μg/m^3. This is well below the annual AAAQS of 50 μg/m^3, but above the historical Nuiqsut Station average of 7.6 μg/m^3.

Table 3-3 Measured PM_{10} Data Summary, 2007 Annual Data Summary

Monitoring Period	Year	24-hour (μg/m^3)		Period Mean (μg/m^3)	Number of Exceedances
		1st High	2nd High		
2nd Quarter	2007	0.0	0.0	0.0	None
3rd Quarter	2007	146.5	123.0	18.4	None
4th Quarter	2007	**354.8**	**239.4**	42.8	Three
1st Quarter	2008	14.0	11.0	6.0	None
Annual	2007	**354.8**	**239.4**	17.7	Three

NAAQS/AAAQS:
24 hour – 150 μg/m^3 – Not to be exceeded more than once per year measured from midnight to midnight at USEPA Standard Conditions.
Annual – 50 μg/m^3 – Compared to the 3-year average of the weighted annual arithmetic mean concentration measured at USEPA Standard Conditions.

Figure 3-3 shows annual average hourly PM_{10} concentrations by wind direction measured this year compared to the historical trend. Except for concentrations associated with northeasterly clockwise through easterly wind directions, concentrations for all wind directions were similar to historical annual averages and approximately half the overall annual average. Directional dependence is related to influence of local fugitive dust sources discussed previously.

Figure 3-4 compares the monthly average hourly PM_{10} concentrations measured this year to Nuiqsut Station historical monthly average PM_{10} concentrations. Historical trends show the fourth and first calendar quarters (October through March) typically experience the lowest average hourly PM_{10} concentrations reflecting snow covered conditions that suppress fugitive dust. In contrast, the second and third calendar quarters (April through September) record higher average hourly concentrations as fugitive dust sources become exposed and active. Average hourly concentrations reported by month this year generally followed this trend except in October when concentrations from the exceptional events previously discussed caused anomalously high hourly concentrations. The variability seen throughout this year and compared to previous years is expected considering PM_{10} concentrations are highly dependent on the interplay of many meteorological characteristics such as wind speed and frequency, precipitation, and temperature.

3.1.4 Ozone

Table 3-4 lists measured 8-hour and annual average hourly O_3 concentrations measured during the monitoring year. The AAAQS for O_3 is based on the 3-year average of the fourth highest measured daily maximum 8-hour average O_3 concentration. Because the 4th highest maximum 8-hour average O_3 concentration measured was over the AAAQS, the concentrations measured at the Nuiqsut Station represent an exceedance of the AAAQS.

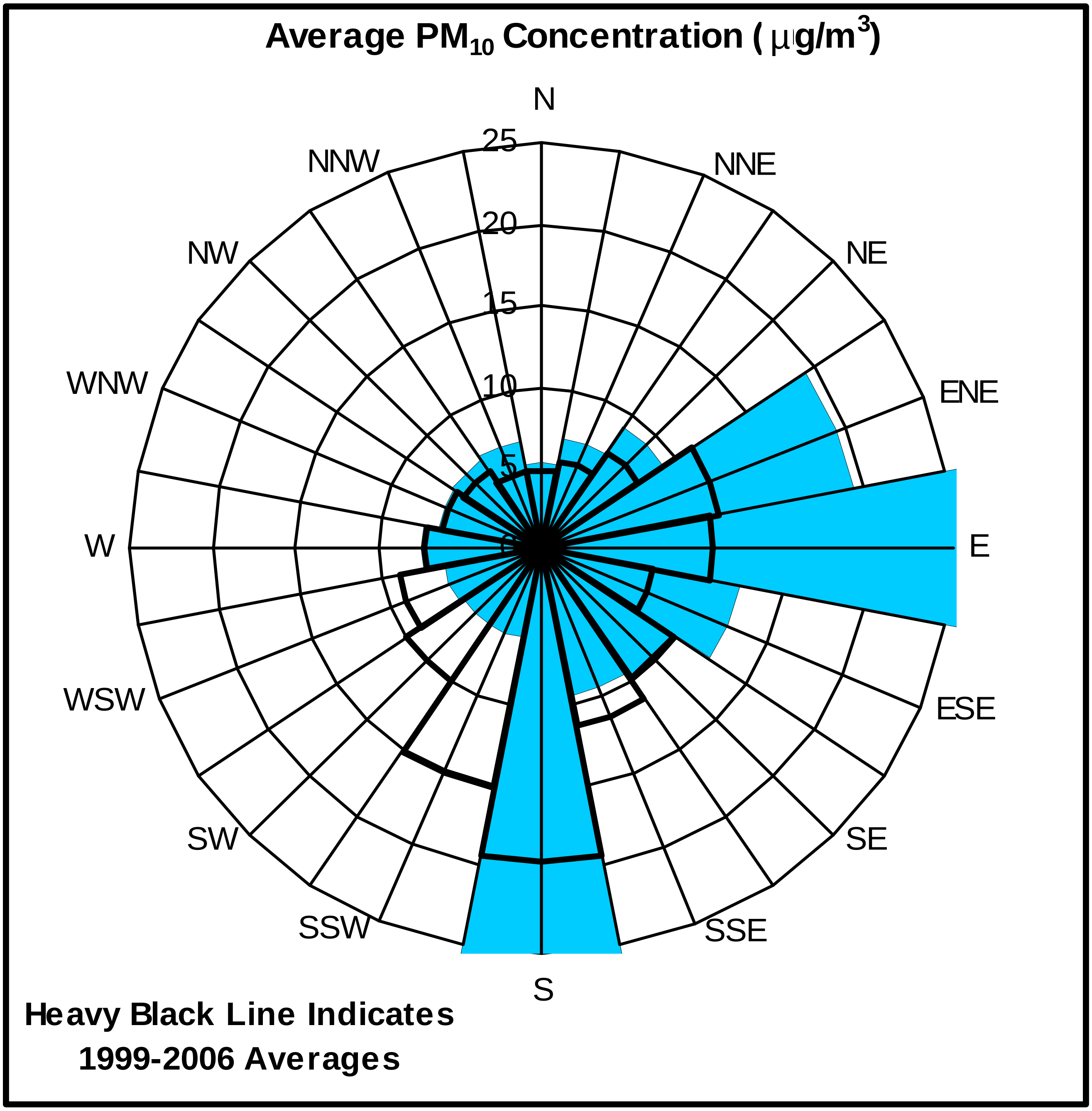
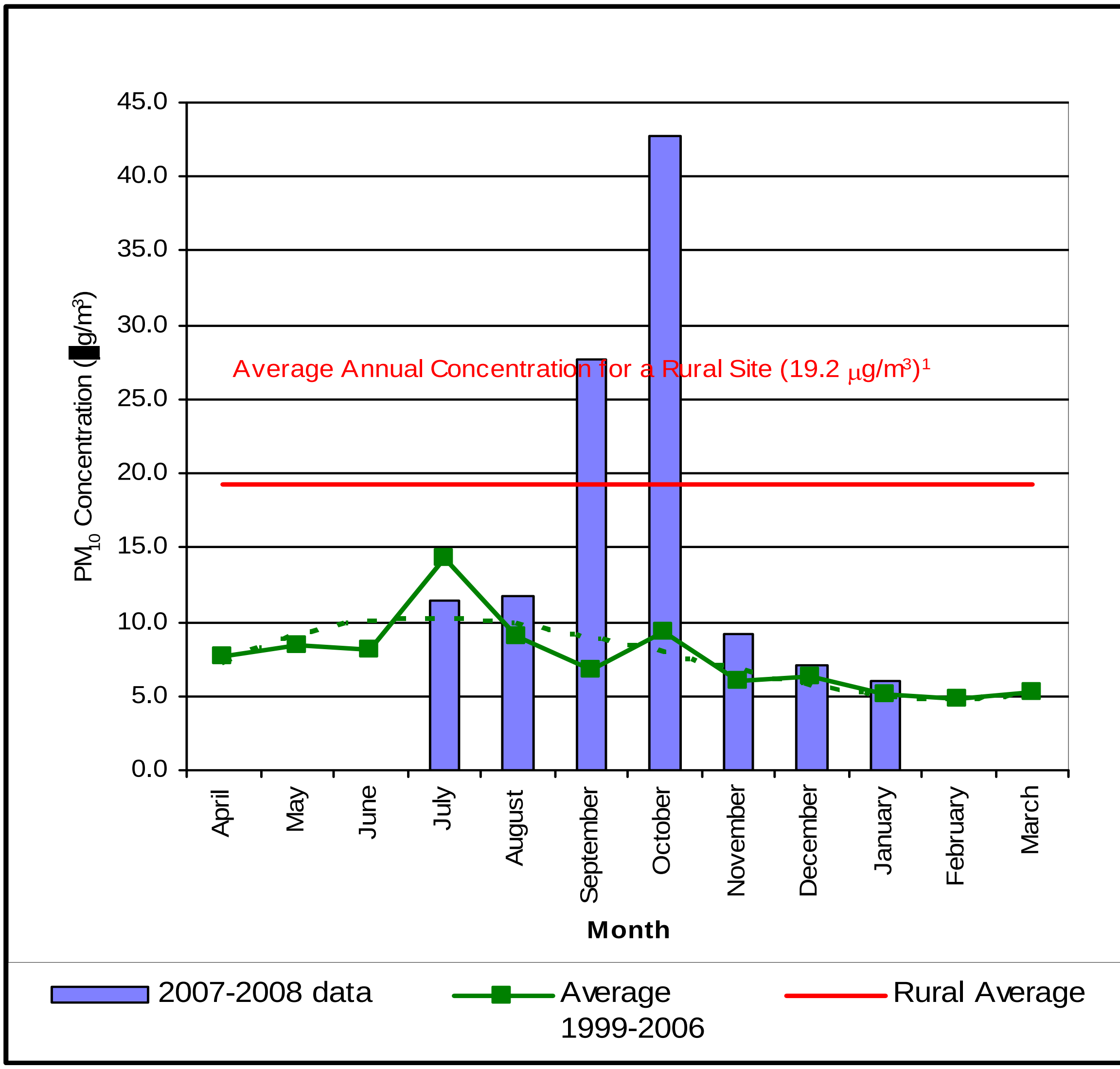


Figure 3-3 Average PM_{10} Concentration by Wind Direction, 2007 Annual Data Summary



[1] Average annual concentration obtained from 153 rural sites in the contiguous United States as summarized in the National Air Quality and Emissions Trend Report, 1999 (USEPA 2001).

Figure 3-4 Average PM_{10} Concentration by Month, 2007 Annual Data Summary

Table 3-4 Measured O_3 Data Summary, 2007 Annual Data Summary

Monitoring Period	Year	8-hour (ppm)			Period Mean (ppm)	Number of Exceedances
		1st High	2nd High	4th High		
2nd Qtr.	2007	0.022	0.022	0.022	0.016	None
3rd Qtr.	2007	**0.139**	**0.139**	**0.127**	0.018	Eight
4th Qtr.	2007	0.036	0.036	0.036	0.027	None
1st Qtr.	2008	0.036	0.036	0.035	0.019	None
Annual	2007	**0.139**	**0.139**	**0.127**	0.021	Eight

NAAQS/AAAQS:
8 hour - 0.08 ppm – Compared to the 3-year average of the fourth highest daily maximum rolling 8 hour average concentrations.

These exceedances were measured on September 13, 2007, hour ending 21:00 through September 14, 2007, hour ending 13:00, when a southerly wind was blowing significant smoke from the Anaktuvuk River tundra fire located approximately 60 to 80 miles south of the Nuiqsut Monitoring station. The fire consumed more than 200,000 acres of tundra from mid-July through September. The measured concentrations were consistent with those previously measured by various research projects conducted in biomass burning plumes from boreal forest fires where O_3 concentrations have been observed to range from 10 to 160 ppb and hourly $PM_{2.5}$ mass was measured up to 340 µg/m^3 (Browell et al. 1994; DeBell et al. 2004; Goode et al. 2000; Taubman et al. 2004; Wotawa and Trainer 2000). Biomass burning plumes typically have less O_3 in relation to CO concentrations than pollution plumes due to the lower levels of reactive nitrogen associated with this type of combustion. However, because biomass burning plumes are subject to the same photochemical processes, given the right meteorological, and burn conditions they can lead to significant O_3 production.

Average O_3 concentrations measured this year are typical of seasonal averages measured on the Alaskan North Slope (Prudhoe Bay, Kuparuk River Unit, and Barrow). In the absence of large combustion sources, strong frontal passages and high solar radiation, ambient O_3 levels will be spatially homogenous and representative of a regional background.

3.2 Meteorological Data Summary

Temperature, wind speed, and wind direction data collected at the Nuiqsut Station during the monitoring year are summarized in the following subsections. Vertical wind speed and solar radiation data also are collected at the Nuiqsut Station, but are not specifically discussed in this section.

3.2.1 Wind Speed and Direction Climatology

The annual Nuiqsut bivariate wind frequency distribution (wind rose) is presented in **Figure 3-5**. Data presented in this figure is consistent with the established North Slope wind climatology and typical of the Nuiqsut bimodal wind direction distribution demonstrated every year since monitoring began. This figure shows winds during the monitoring year were dominated by northeast through easterly (NE-E) and to a lesser degree south southwest through westerly (SSW-W). Winds from these two sectors occurred nearly 80 percent of the total hours this year and are caused by persistent regional weather patterns. Without respect to direction, the mean 10-m wind speed for the monitoring year was 4.2 m/s and the maximum was 19.2 m/s.

The persistence of weather patterns season to season can be inferred from **Figures 3-6** through **3-9**, which present wind roses by calendar quarter. Typical of the Nuiqsut Station wind climatology, the quarterly wind roses collected this year indicate there is a persistence of NE-E all year long. SSW-W winds are present all year long but only become a significant part of the climatology during the winter months. Mean and maximum wind speeds remain fairly constant over all quarters. The quarterly wind rose depictions are augmented by **Tables 3-5** through **3-8**, which present quarterly wind rose data as a percent of valid hours.

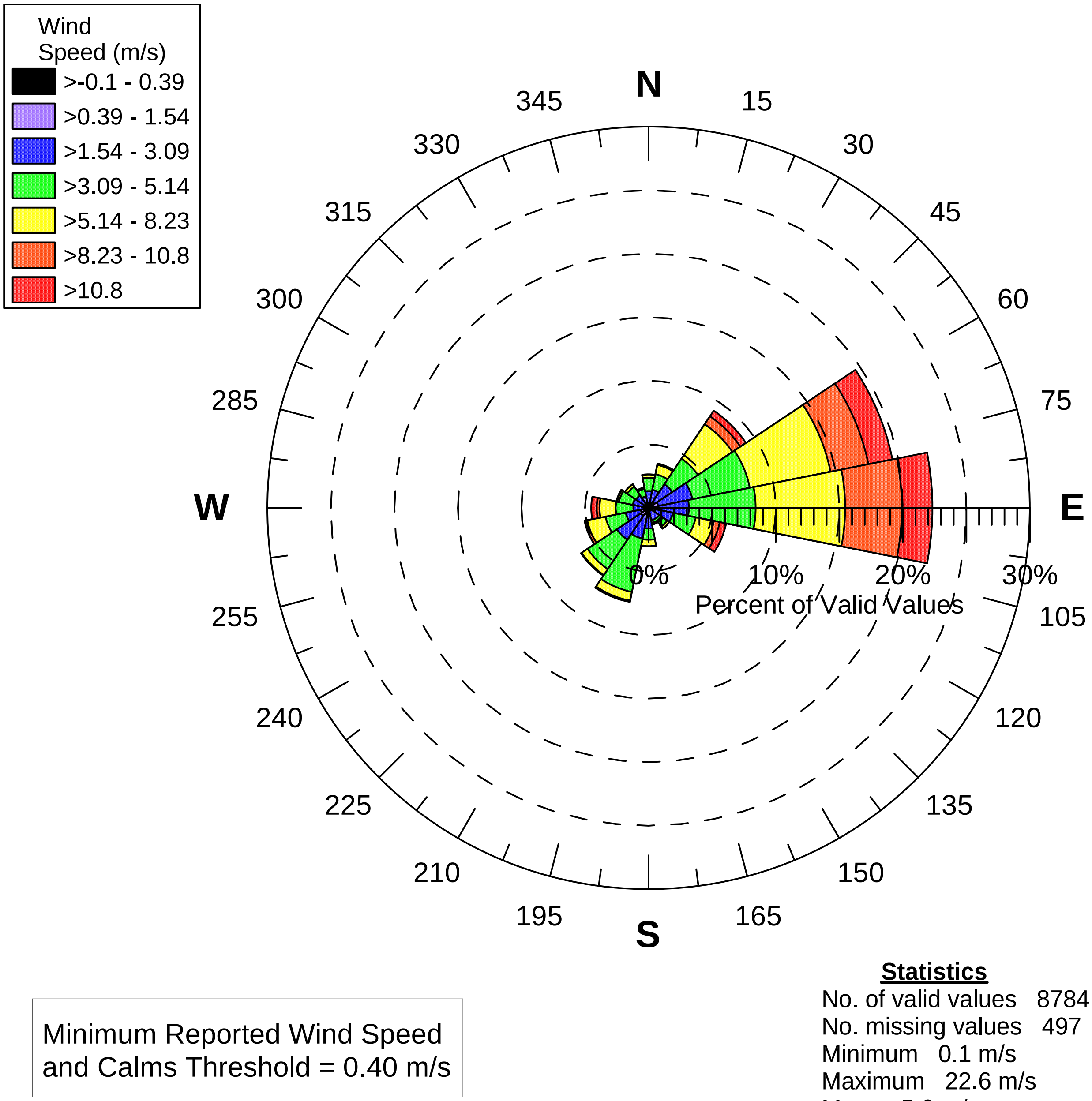


Figure 3-5 2007 Annual Nuiqsut Wind Rose

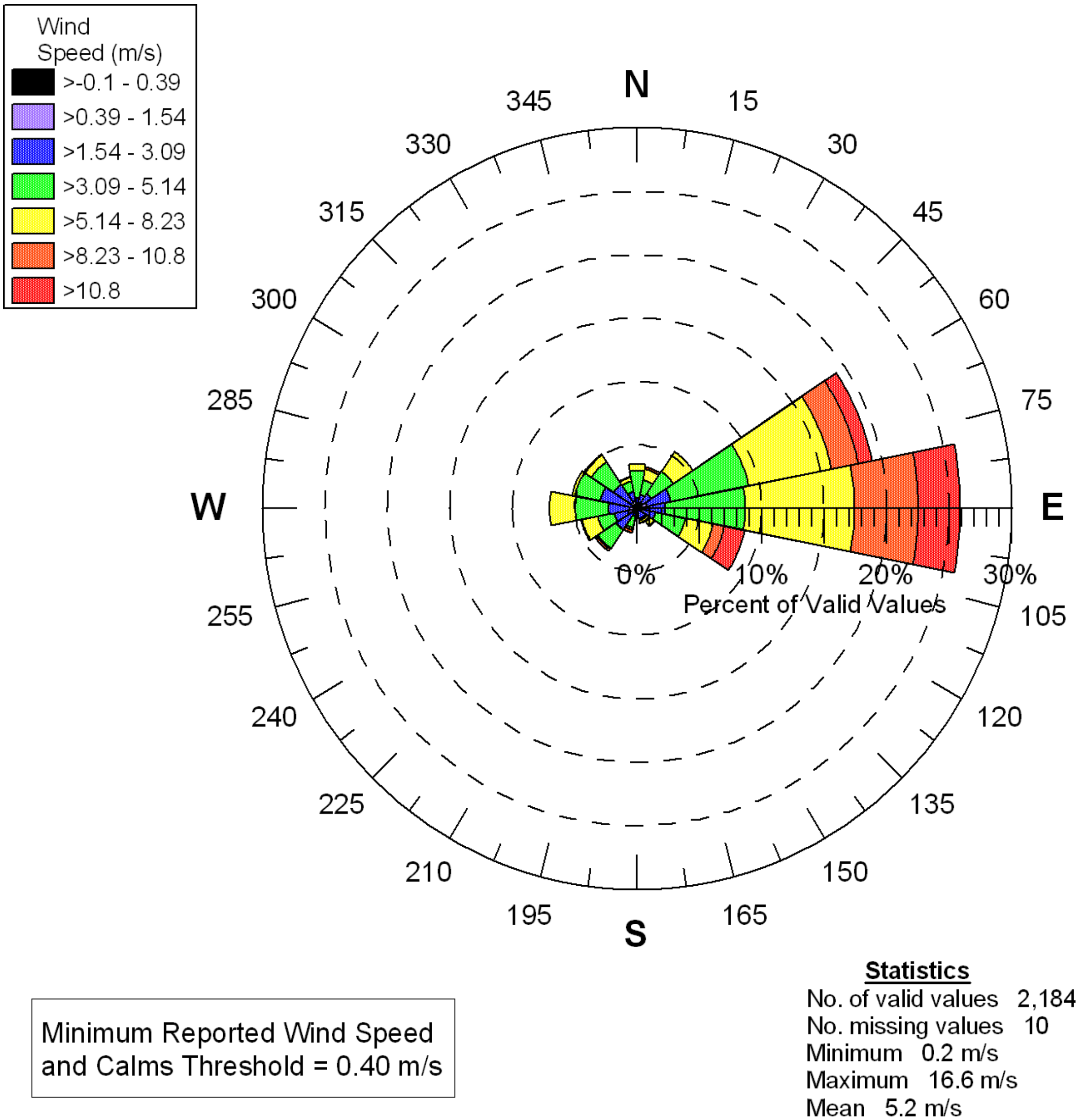


Figure 3-6 Second Quarter 2007 Nuiqsut Wind Rose

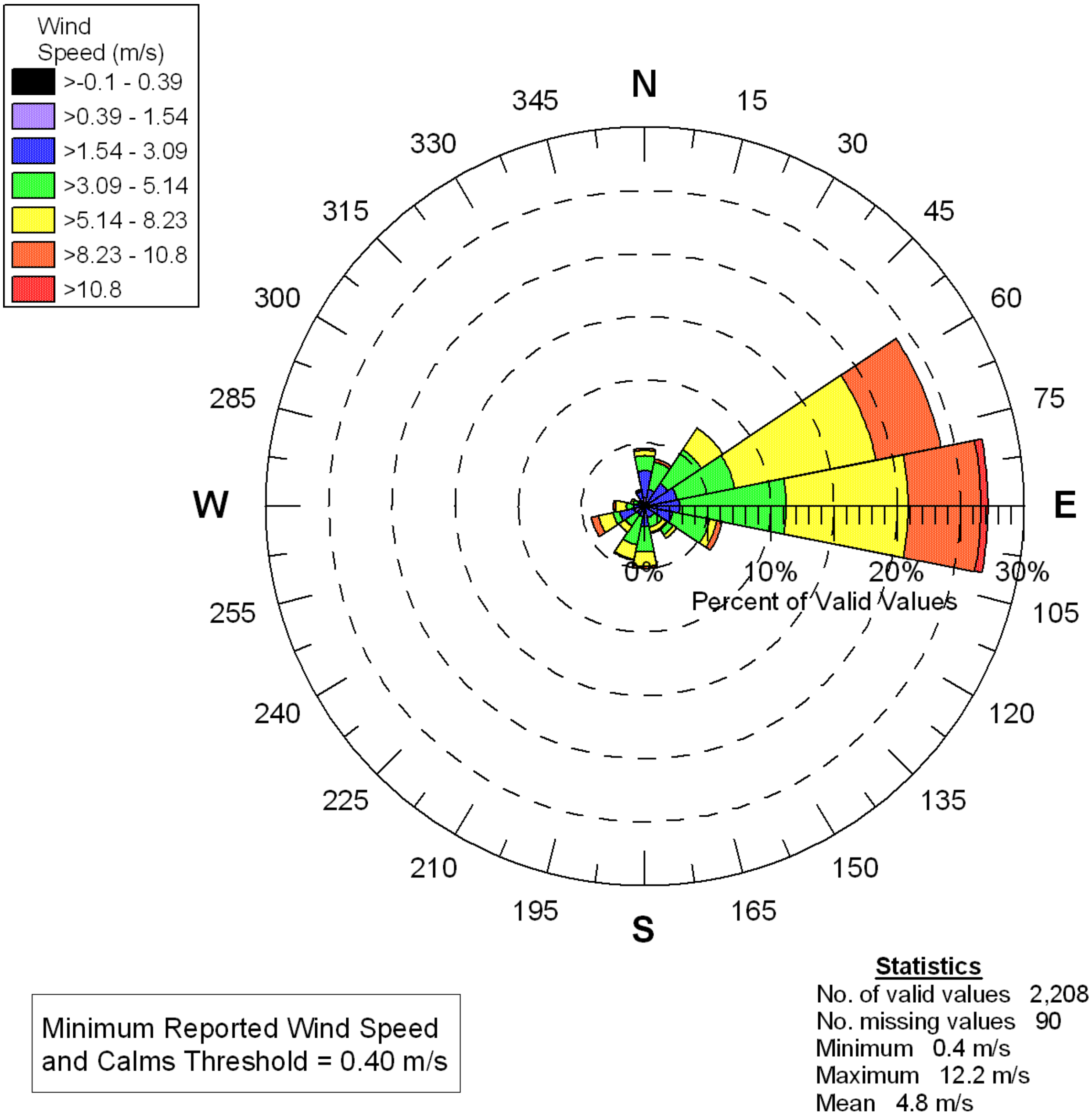


Figure 3-7 Third Quarter 2007 Nuiqsut Wind Rose

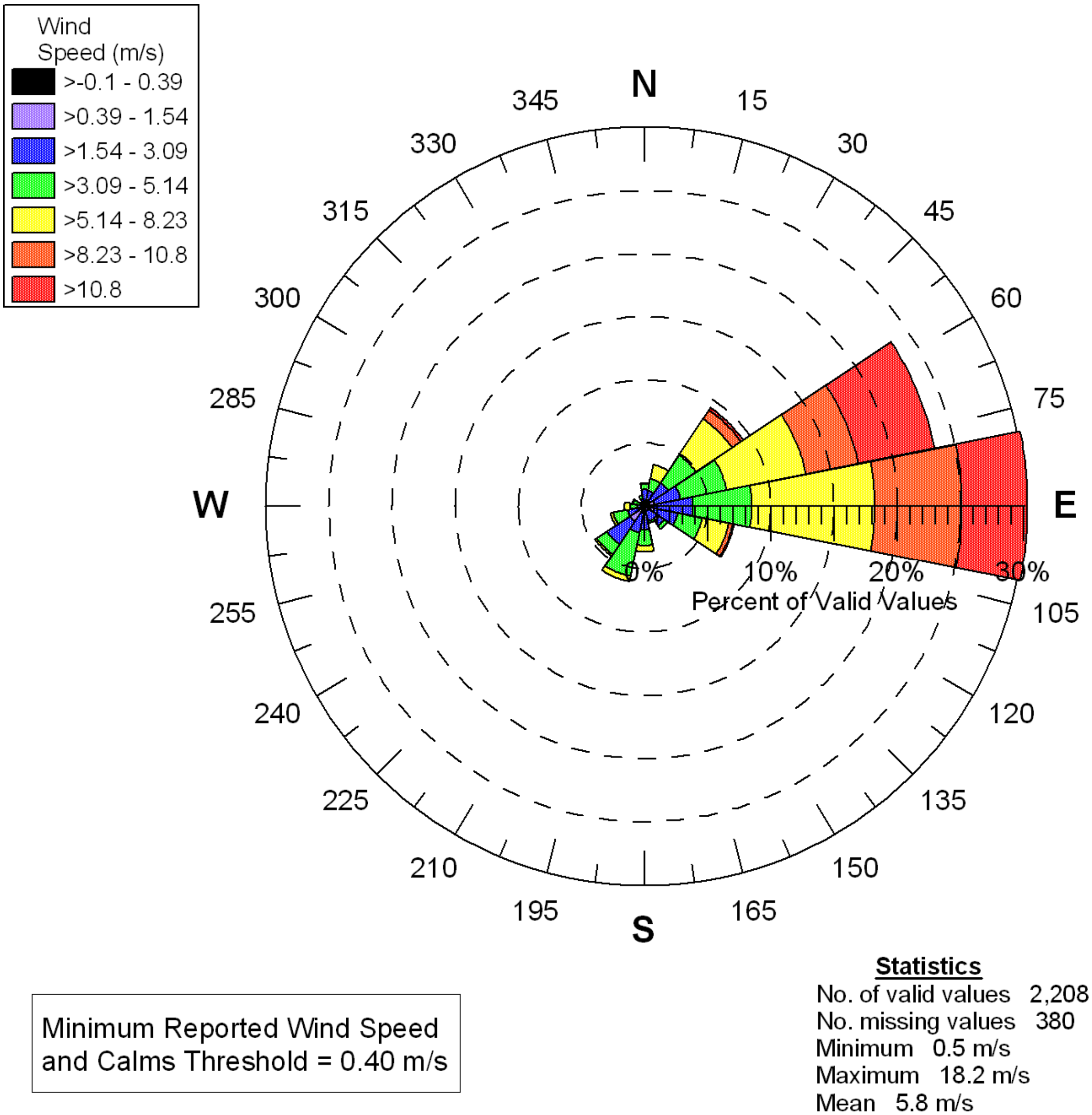
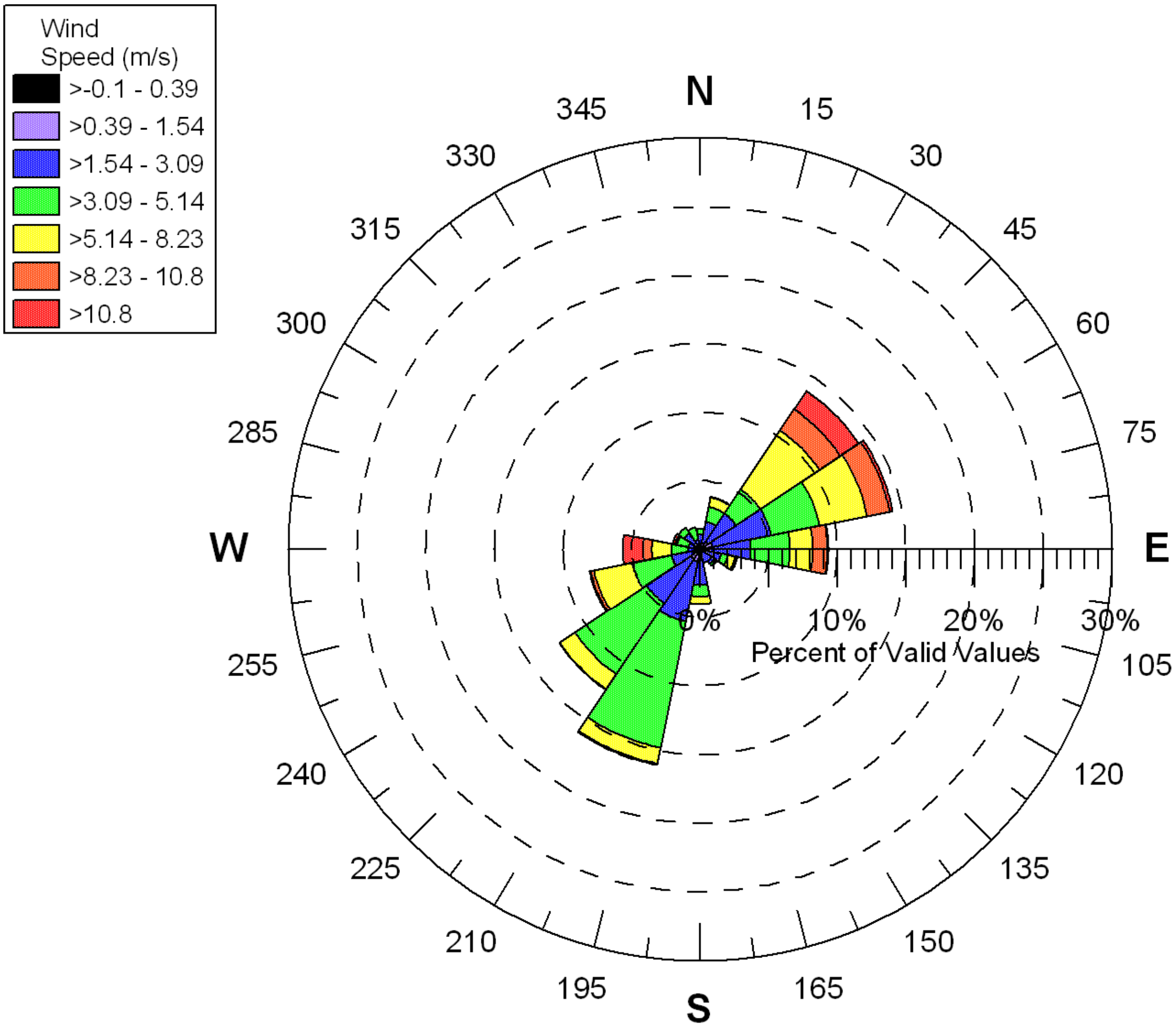


Figure 3-8 Fourth Quarter 2007 Nuiqsut Wind Rose



Minimum Reported Wind Speed and Calms Threshold = 0.40 m/s

Statistics

No. of valid values 2,184
No. missing values 17
Minimum 0.1 m/s
Maximum 22.6 m/s
Mean 4.4 m/s

Figure 3-9 First Quarter 2008 Nuiqsut Wind Rose

Table 3-5 Second Quarter 2007 Wind Direction/Speed Frequency Analysis

Wind Rose Analysis – Percent of Valid Hourly Values (2,184 Valid Hours Used)									
Wind Direction	Wind Speed – m/s								Average Speed
	≤ 0.39	≤ 1.54	≤ 3.09	≤ 5.14	≤ 8.23	≤ 10.8	> 10.8	Total	
N		0.74	1.15	3.08	1.24	0.14	0.00	6.38	4.01
NE		1.10	1.89	5.84	4.37	0.28	0.00	13.51	4.52
E		1.10	3.96	11.41	15.27	7.82	6.07	45.66	6.53
SE		0.55	1.29	1.20	0.92	0.23	0.05	4.27	4.04
S		0.37	0.51	0.14	0.18	0.14	0.00	1.37	3.41
SW		0.97	2.44	3.08	0.51	0.37	0.00	7.39	3.53
W		1.15	3.40	4.0	3.13	0.09	0.00	11.81	3.98
NW		0.78	3.68	4.05	0.97	0.09	0.00	9.60	3.45
CALM	0.28								
Total	0.28	6.76	18.31	32.80	26.59	9.15	6.12	100	

Table 3-6 Third Quarter 2007 Wind Direction/Speed Frequency Analysis

Wind Rose Analysis – Percent of Valid Hourly Values (2,208 Valid Hours Used)									
Wind Direction	Wind Speed – m/s								Average Speed
	≤ 0.39	≤ 1.54	≤ 3.09	≤ 5.14	≤ 8.23	≤ 10.8	> 10.8	Total	
N		0.84	3.21	2.36	0.42	0.34	0.00	7.18	3.33
NE		0.59	3.38	6.00	5.07	0.51	0.00	15.54	4.60
E		0.51	4.98	13.68	18.41	11.06	0.59	49.24	6.13
SE		0.42	2.53	2.11	0.76	0.08	0.00	5.91	3.51
S		0.25	2.11	3.55	2.03	0.17	0.00	8.11	4.28
SW		0.51	1.69	2.70	1.27	0.08	0.00	6.25	3.95
W		0.68	1.60	0.93	1.86	0.76	0.00	5.83	4.76
NW		0.59	0.93	0.25	0.17	0.00	0.00	1.94	2.50
CALM	0.00								
Total	0.00	4.39	20.44	31.59	29.98	13.01	0.59	100	

Table 3-7 Fourth Quarter 2007 Wind Direction/Speed Frequency Analysis

Wind Rose Analysis – Percent of Valid Hourly Values (2,208 Valid Hours Used)									
Wind Direction	Wind Speed – m/s								Average Speed
	≤ 0.39	≤ 1.54	≤ 3.09	≤ 5.14	≤ 8.23	≤ 10.8	> 10.8	Total	
N		0.93	1.37	0.98	0.33	0.00	0.00	3.61	2.84
NE		1.15	3.01	5.36	6.78	1.97	2.41	20.68	5.79
E		1.48	5.20	7.49	15.70	10.28	9.30	49.45	7.01
SE		1.31	2.41	1.04	0.11	0.00	0.00	4.87	2.42
S		1.04	2.74	3.28	0.88	0.00	0.00	7.93	3.35
SW		1.97	3.50	3.12	0.33	0.00	0.00	8.92	2.79
W		0.49	0.71	1.59	0.55	0.00	0.00	3.34	3.67
NW		0.33	0.16	0.55	0.16	0.00	0.00	1.20	3.34
CALM	0.00								
Total	0.00	8.70	19.09	23.41	24.84	12.25	11.71	100	

Table 3-8 First Quarter 2008 Wind Direction/Speed Frequency Analysis

Wind Rose Analysis – Percent of Valid Hourly Values (2,184 Valid Hours Used)									
Wind Direction	Wind Speed – m/s								Average Speed
	≤ 0.39	≤ 1.54	≤ 3.09	≤ 5.14	≤ 8.23	≤ 10.8	> 10.8	Total	
N		0.60	1.38	1.06	0.32	0.00	0.00	3.42	3.02
NE		1.48	5.54	4.52	8.26	3.14	1.75	24.74	5.52
E		1.11	5.81	5.12	2.95	1.62	0.18	16.85	4.30
SE		0.97	1.48	0.37	0.14	0.00	0.00	3.01	2.27
S		1.62	4.15	3.18	1.11	0.05	0.00	10.16	3.15
SW		1.25	7.66	14.63	3.32	0.14	0.00	27.05	3.78
W		0.60	1.20	3.18	3.05	0.88	1.75	10.71	5.97
NW		0.88	1.52	1.62	0.00	0.00	0.00	4.07	2.71
CALM	0.42								
Total	0.42	8.49	28.75	33.69	19.15	5.81	3.68	100	

3.2.2 Temperature Climatology

During the monitoring year, the hourly averaged 2-m ambient temperature reached a maximum of 25.8°C (78.4 degrees Fahrenheit [°F]) on August 11, 2007 and a minimum of -45.1°C (-49.2°F) on January 13, 2008. **Table 3-9** shows the monthly hourly minimum and the hourly maximum.

Table 3-9 Nuiqsut Temperature Climate Summary, 2007 Annual Data Summary

2-meter Temperature (°C)									
	Mean			Extreme					
Month	Maximum Daily (Monthly Average)	Minimum Daily (Monthly Average)	Monthly	Record Highest (Hourly Average)	Year	Day	Record Lowest (Hourly Average)	Year	Day
April 2007	-5.7	-21.0	-13.8	2.5	2002	26	-35.8	2004	2, 3
May 2007	-0.6	-14.7	-7.2	18.5	2002	24	-28.7	2001	1
June 2007	12.0	-0.5	5.1	27.3	2003	29	-5.0	2000	5
July 2007	17.9	4.0	9.1	28.0	2001	16	-1.6	2002	26
August 2007	16.4	2.9	3.6	27.8	1999	5	-3.3	2000	27
September 2007	10.3	-2.3	8.2	23.4	2007	30	-13.6	1999	30
October 2007	-1.2	-13.9	-7.0	7.4	2003	2	-27.2	1999/2004	31/31
November 2007	-4.0	-26.0	-12.6	0.7	2003	6	-35.5	1999	5
December 2007	-8.0	-41.4	-21.6	-2.5	2001/2006	28/2	-42.1	1999	18
January 2008	-1.9	-45.1	-30.4	0.8	2008	20	-43.1	2002	23
February 2008	-9.0	-39.7	-29.0	1.8	2006	16	-45.9	2004	19
March 2008	-11.1	-40.7	-30.6	-3.1	2004	21	-40.3	2006/2007	11/11
2nd Quarter 2007	1.9	-12.1	-5.3	-	-	-	-	-	-
3rd Quarter 2007	14.9	1.6	7.0	-	-	-	-	-	-
4th Quarter 2007	-5.1	-27.1	-13.7	-	-	-	-	-	-
1st Quarter 2008	-7.3	-41.9	-30.0	-	-	-	-	-	-
Monitoring Year	1.1	-19.8	-10.4	28.0	2001	16	-45.9	2004	19

Figure 3-10 compares average hourly temperatures by month measured at Nuiqsut during the current monitoring year to historical data collected at Barrow and the Nuiqsut Station. Summer into fall temperatures at Nuiqsut were slightly warmer than average and winter temperatures were slightly colder. Comparisons are made to Barrow data because that data, collected over a 49-year period, is less likely influenced by interannual variability. It is typical to see Nuiqsut Station temperatures consistently higher than those collected at Barrow from June through September and equal to those measured at Barrow from October through May. Differences typically observed during the summer are in part related to the fact that the Nuiqsut Station is located further inland than Barrow and away from moderating effects of the ocean.

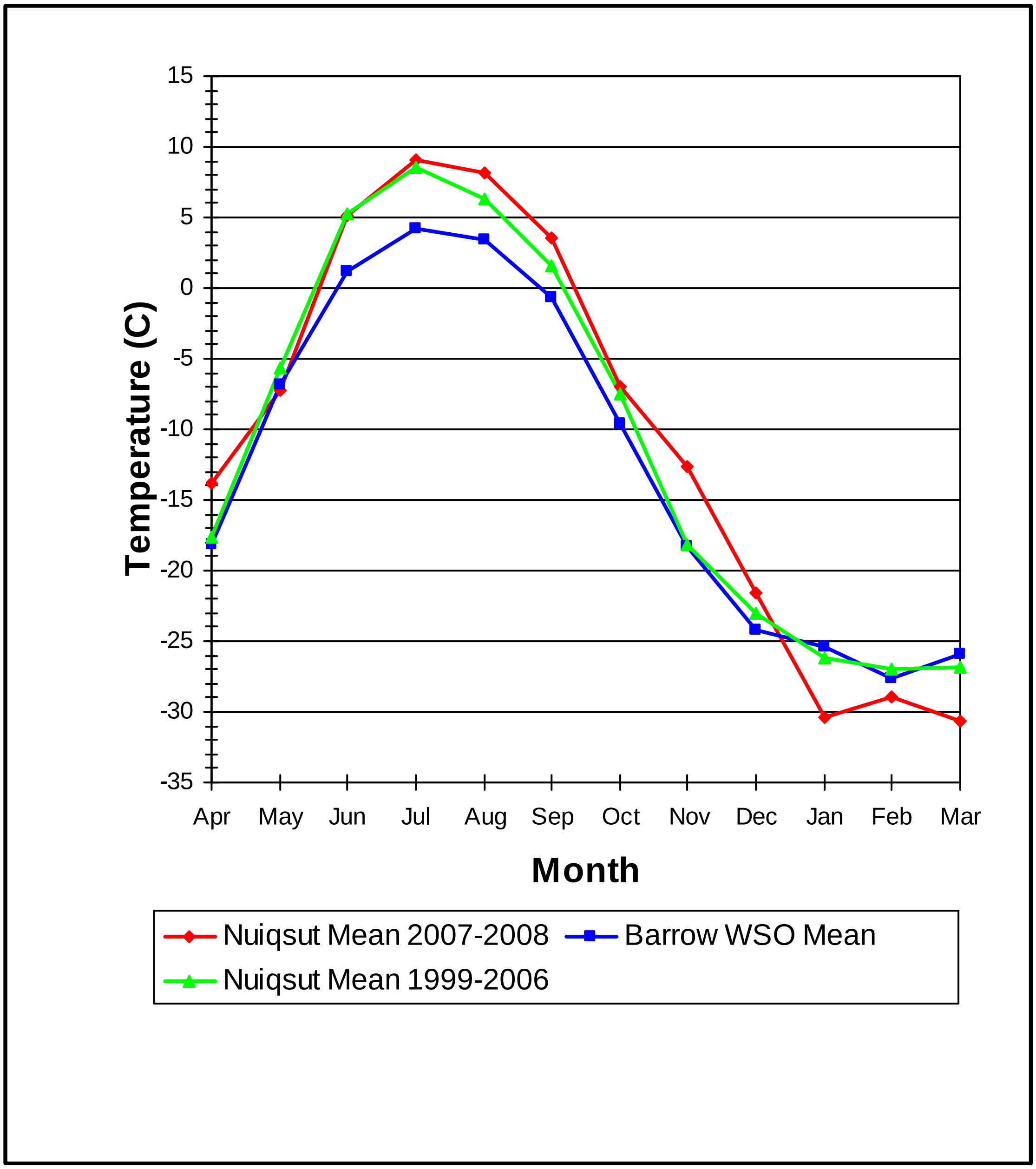


Figure 3-10 Nuiqsut Station Temperature Climatology, 2007 Annual Data Summary

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