

FINAL
NUIQSUT AMBIENT AIR QUALITY MONITORING
PROGRAM ANNUAL DATA REPORT
APRIL 2002 THROUGH MARCH 2003 *FOR*
CONOCOPHILLIPS ALASKA, INC.

Nuiqsut Ambient Air Quality Monitoring Station

Nuiqsut, Alaska

August 2003





**CONOCOPHILLIPS ALASKA, INC.
NUIQSUT AMBIENT AIR QUALITY
MONITORING PROGRAM
ANNUAL DATA REPORT
APRIL 2002 THROUGH MARCH 2003**



SECOR
INTERNATIONAL
INCORPORATED

www.secor.com
4700 McMurtry Drive, Suite 101
Fort Collins, CO 80525
970-226-4040 TEL
970-226-4099 FAX

August 12, 2003

Mr. Bruce St. Pierre
ConocoPhillips Alaska, Inc.
700 G Street
Anchorage, AK 99510-0360

RE: Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report
April 2002 Through March 2003
Nuiqsut, Alaska
SECOR Project No.: 12OT.11481.02.0004

Dear Bruce:

Enclosed for your review and distribution are ten copies of the *Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report: April 2002 Through March 2003*. We expect that copies of the report will be distributed as follows:

- six copies to the North Slope Borough (no data diskettes),
- one copy to the village of Nuiqsut (no data diskette),
- one copy to the ADEC (with data diskette), and
- two copies for CPAI's records (with data diskettes).

Please contact me via phone at (970) 226-4040 ext. 721 or via e-mail (tdamiana@secor.com) if you have any questions or comments regarding this report or any other aspect of the project. I appreciate the opportunity to assist you with this project.

Sincerely,
SECOR International Incorporated

Tom Damiana
Project Manager

TD\dc

EXECUTIVE SUMMARY

This report summarizes data collected at the Nuiqsut Ambient Air Quality Monitoring Station (Nuiqsut Station) during the monitoring year April 1, 2002 through March 31, 2003. The Nuiqsut Station is operated for ConocoPhillips Alaska, Inc. (CPAI) by SECOR International Incorporated (SECOR). It was established to address air quality concerns raised by the citizens of Nuiqsut and the North Slope Borough and has fulfilled the Alaska Department of Environmental Conservation (ADEC) one-year monitoring requirement in the CPAI Alpine construction permit. Official data collection began April 1999.

Dispersion and ambient air quality data collected at the Nuiqsut Station meet quality assurance and data recovery requirements of the United States Environmental Protection Agency (US EPA) Prevention of Significant Deterioration (PSD) program as administered by ADEC and other specific ADEC ambient monitoring quality assurance requirements (ADEC 1996). Protocols used to collect data at the Nuiqsut Station are fully described in the project Monitoring Plan that consists of:

- the original project monitoring plan (SECOR 2000a), approved by ADEC in April 2000;
- the Partisol Addendum to the original monitoring plan (SECOR 2001a), final ADEC approval pending; and
- the draft Expanded Meteorology Addendum to the original monitoring plan (SECOR 2002d), ADEC review pending.

The Nuiqsut Station is equipped to continuously measure:

- nitrogen oxides (NO , NO_2 , and NO_x),
- sulfur dioxide (SO_2),
- inhalable particulate matter less than $10\ \mu\text{m}$ in diameter (PM_{10}),
- 10-meter wind speed, wind direction, and wind direction standard deviation (σ_θ),
- 10-meter vertical wind speed and wind speed standard deviation (σ_w),
- total solar radiation,
- 2- and 10-meter ambient temperature, and
- 10-2 meter ambient temperature difference.

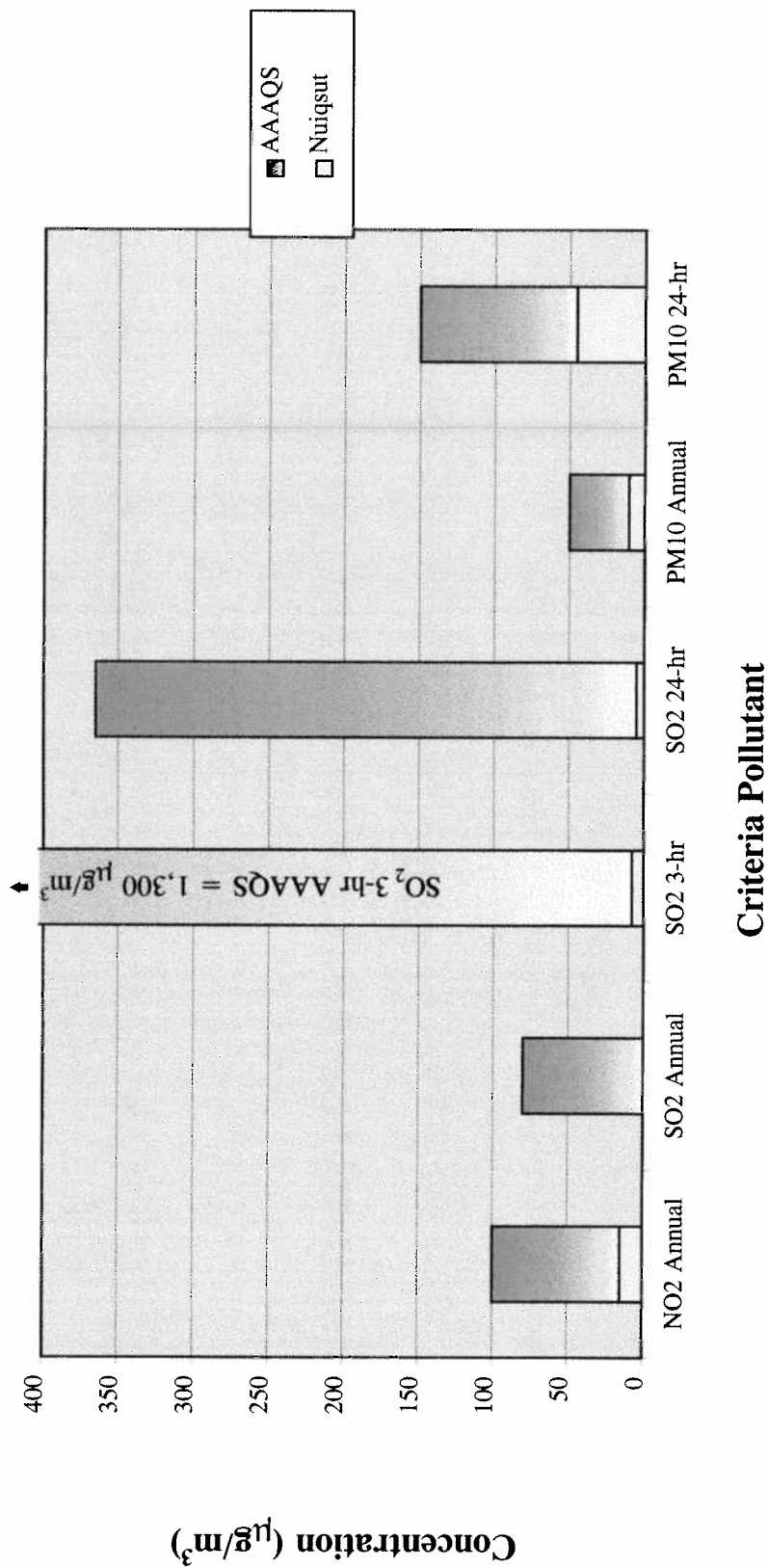
Air quality and meteorological data recovery did not meet project goals for all averaging periods due to instrument malfunctions, weather-related events (frozen sensors), power failures, and operator problems. All issues affecting valid data retrieval have been successfully addressed.

During the monitoring year, monitored NO₂, SO₂, and PM₁₀ concentrations were well below Alaska Ambient Air Quality Standards (AAAQS), which are equivalent to National Ambient Air Quality Standards (NAAQS). Figure 1 and Tables 1 and 2 provide summaries of ambient air quality data collected during the monitoring year compared to previous monitoring years and appropriate AAAQS. As shown in these figures and tables, measured concentrations of all monitored pollutants were well below applicable AAAQS.

The annual average NO₂ concentration was just above instrument detection, and well below applicable AAAQS. As is typically the case, summer seasonal averages were lower than winter seasonal averages. Yearly averages are higher than previous yearly averages. The highest impacts were measured during the winter when winds were from the north-northeast (NNE) to east-northeast (ENE). Elevated concentrations were also measured when winds were from Nuiqsut to the Nuiqsut Station.

Annual averaged and hourly SO₂ data show there was no detectable near-field or far-field SO₂ emission source, indicating measured concentrations are representative of a regional background signature, consistent with the rural environment surrounding the site.

The annual average PM₁₀ concentration was slightly higher compared to previous years but low compared to AAAQS. Data trends observed this year were similar to previous years. Generally, data collected this year shows regional particulate loading is low with elevated particulate levels measured only from naturally occurring wind blown fugitive dust from exposed areas local to the Nuiqsut Station. When fugitive dust from exposed areas is not present (i.e., during winter), hourly concentrations are at or below the instrument detection limit. An objective comparison between data collected with the Partisol and TEOM particulate monitors showed both instruments measure the same trends, with Partisol data consistently biased lower than TEOM data. Partisol particulate monitoring was discontinued during the fourth quarter 2002 as technical objectives of the monitoring were met.



Annual Concentrations are the average for the period April 1, 2002 through March 31, 2003.

FIGURE 1: SUMMARY OF AMBIENT AIR QUALITY DATA APRIL 2002 THROUGH MARCH 2003

TABLE 1

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED GASEOUS POLLUTANT CONCENTRATIONS COMPARED TO
ALASKA AMBIENT AIR QUALITY STANDARDS
APRIL 2002 THROUGH MARCH 2003**

Pollutant	Averaging Period	Maximum Period Average Concentration (ppm)				AAQs (ppm)
		1999-2000	2000-2001	2001-2002	2002-2003	
NO ₂	Annual	0.003	0.003	0.004	0.008	0.053
SO ₂	3-hour	0.010	0.003	0.002	0.003	0.500
	24-hour	0.002	0.001	0.001	0.002	0.140
	Annual	0.000	0.000	0.000	0.000	0.030

TABLE 2

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED PARTICULATE CONCENTRATIONS COMPARED TO
ALASKA AMBIENT AIR QUALITY STANDARDS
APRIL 2002 THROUGH MARCH 2003**

Pollutant	Averaging Period	Maximum Period Average Concentration ¹ ($\mu\text{g}/\text{m}^3$)				AAQs (ppm)
		1999-2000	2000-2001	2001-2002	2002-2003	
PM ₁₀	24-hour ²	222.9	113.4	72.1	43.6 ⁴	150
	24-hour ³	128.4	83.2	68.5	39.1	150
	Annual	8.3	8.4	6.6	9.3	50

¹ Standard conditions

² Maximum 24-hour average concentration

³ Second highest 24-hour average concentration

⁴ On-site observations indicate maximum daily concentration is affected by particulate emissions from a tundra fire near Point Lay, Alaska.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
1.0 INTRODUCTION.....	1-1
1.1 Background/History	1-1
1.2 Project Implementation	1-3
1.2.1 Nuiqsut Station Location	1-6
1.2.2 Project Monitoring Plan	1-6
2.0 STATION PERFORMANCE SUMMARY	2-1
2.1 Significant Project Events	2-1
2.2 Missing, Invalid, and Adjusted Data.....	2-1
2.2.1 NO _x and SO ₂ Data.....	2-4
2.2.2 Continuous PM ₁₀ Data (TEOM)	2-5
2.2.3 24-Hour Integrated Particulate Data (Partisol)	2-5
2.2.4 Meteorological Data.....	2-5
2.3 Network Data Recovery	2-6
2.4 Precision Statistics	2-6
2.4.1 Analytical Lab Quality Assurance Results (Partisol PM ₁₀ Samples).....	2-11
2.5 Data Accuracy	2-13
3.0 MONITORING NETWORK DATA SUMMARY	3-1
3.1 Air Quality Data.....	3-1
3.1.1 Nitrogen Dioxide.....	3-1
3.1.2 Sulfur Dioxide.....	3-7
3.1.3 Respirable Particulate Matter (PM ₁₀) - TEOM Data.....	3-7
3.2 Meteorological Data.....	3-14
3.2.1 Wind Speed and Direction Climatology	3-14
3.2.2 Stability Frequencies.....	3-17
3.2.3 Temperature Climatology	3-21
4.0 REFERENCES.....	4-1

APPENDICES

APPENDIX A	DATA PROCESSING SPECIFICATIONS AND STATISTICAL FORMULAE
APPENDIX B	MINIMUM ACCURACY AND COMPLETENESS GOALS FOR DATA COLLECTION
APPENDIX C	PARTISOL SUPPORT DATA
APPENDIX D	DIGITAL FILE CONTENTS

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Measured Gaseous Pollutant Concentrations Compared to Alaska Ambient Air Quality Standards	iv
2	Measured Particulate Concentrations Compared to Alaska Ambient Air Quality Standards	v
1-1	Measurement Methods	1-4
2-1	Significant Project Events	2-2
2-2	Continuous Air Quality and Meteorological Data Recovery Statistics	2-7
2-3	Annual Data Recovery Statistics for 1999-2003	2-9
2-4	NO ₂ , NO, and SO ₂ Precision Statistics	2-10
2-5	Partisol Precision Statistics	2-12
3-1	Measured NO ₂ , SO, and PM ₁₀ Concentrations	3-2
3-2	Measured 24-Hour PM ₁₀ Concentrations Greater than 20 µg/m ³	3-12
3-3	Temperature Climate Summary	3-23

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
Figure 1: Summary of Ambient Air Quality Data April 2002 through March 2003.....	iii
Figure 1-1: Location of Regional North Slope Oil Fields Relative to Nuiqsut	1-2
Figure 1-2: Regional Map	1-7
Figure 1-3: Local Map	1-8
Figure 1-4: Aerial Photo of Nuiqsut	1-9
Figure 3-1: NO ₂ Frequency Analysis and Average Concentration by Wind Direction.....	3-3
Figure 3-2: Average NO ₂ Concentration by Month.....	3-5
Figure 3-3: Average Hourly NO ₂ Concentration by Wind Direction and Season.....	3-6
Figure 3-4: PM ₁₀ Frequency Analysis and Average Concentration by Wind Direction	3-9
Figure 3-5: Nuiqsut Particulate Climatology.....	3-11
Figure 3-6: Correlation of TEOM to Partisol PM ₁₀ Measurements.....	3-15
Figure 3-7: Annual Wind Rose Analysis.....	3-16
Figure 3-8: Seasonal Wind Rose Analysis	3-18
Figure 3-9: Nuiqsut Stability Class Frequency Distributions.....	3-20
Figure 3-10: Nuiqsut Temperature Climatology	3-22

1.0 INTRODUCTION

This report summarizes and documents operation of the Nuiqsut Station and data collected during the fourth year of monitoring at Nuiqsut, defined by the 12-month monitoring period April 1, 2002 through March 31, 2003. The report has been subdivided into several chapters. Chapter 2 discusses the monitoring network performance. Chapter 3 summarizes air quality and meteorological data collected during the monitoring year. Appendix A contains various statistical formulae used to determine data precision, accuracy, and recovery statistics. Appendix B contains additional data related to minimum accuracy and completeness goals for data collection. Appendix C contains additional data related to Partisol particulate monitor accuracy and precision. Appendix D summarizes contents of the diskette containing validated hourly data for the monitoring year. Please refer to individual quarterly data reports (SECOR 2002b, SECOR 2002c, SECOR 2003a, SECOR 2003b) for additional details.

1.1 Background/History

ConocoPhillips Alaska, Inc. (CPAI), operates an oil and gas exploration and production complex (Alpine Development Project) approximately 14 kilometers north of Nuiqsut on the North Slope of Alaska. The Alpine Development Project consists of a main facility including production modules, an operating camp, and a temporary drilling operation and satellite drilling site approximately 5 kilometers to the west of the main facility.

Representatives of Nuiqsut expressed an interest in characterizing ambient air quality conditions before and after the Alpine Development Project was operational. In response to citizen concerns, CPAI committed to offer direct assistance by implementing the Nuiqsut Ambient Air Quality Monitoring Program in cooperation with the Alaska Department of Environmental Conservation (ADEC), the North Slope Borough, and Nuiqsut. The spirit of this commitment is to better understand local ambient air quality in Nuiqsut. The spatial relation between major North Slope oil fields and Nuiqsut is shown in Figure 1-1.

The monitoring program is primarily designed to characterize ambient air quality at Nuiqsut, but it also fulfilled Condition IV(C) of the Alpine Development Project Construction Permit (Permit #0073-AC060) issued by ADEC. Simply stated, the permit required CPAI to collect at least one year of ambient NO_x, SO₂, PM₁₀, and dispersion meteorology data at Nuiqsut. On March 27, 2001, CPAI informed ADEC by letter (PAI 2001) that the ambient monitoring requirement contained in the construction permit had been met.

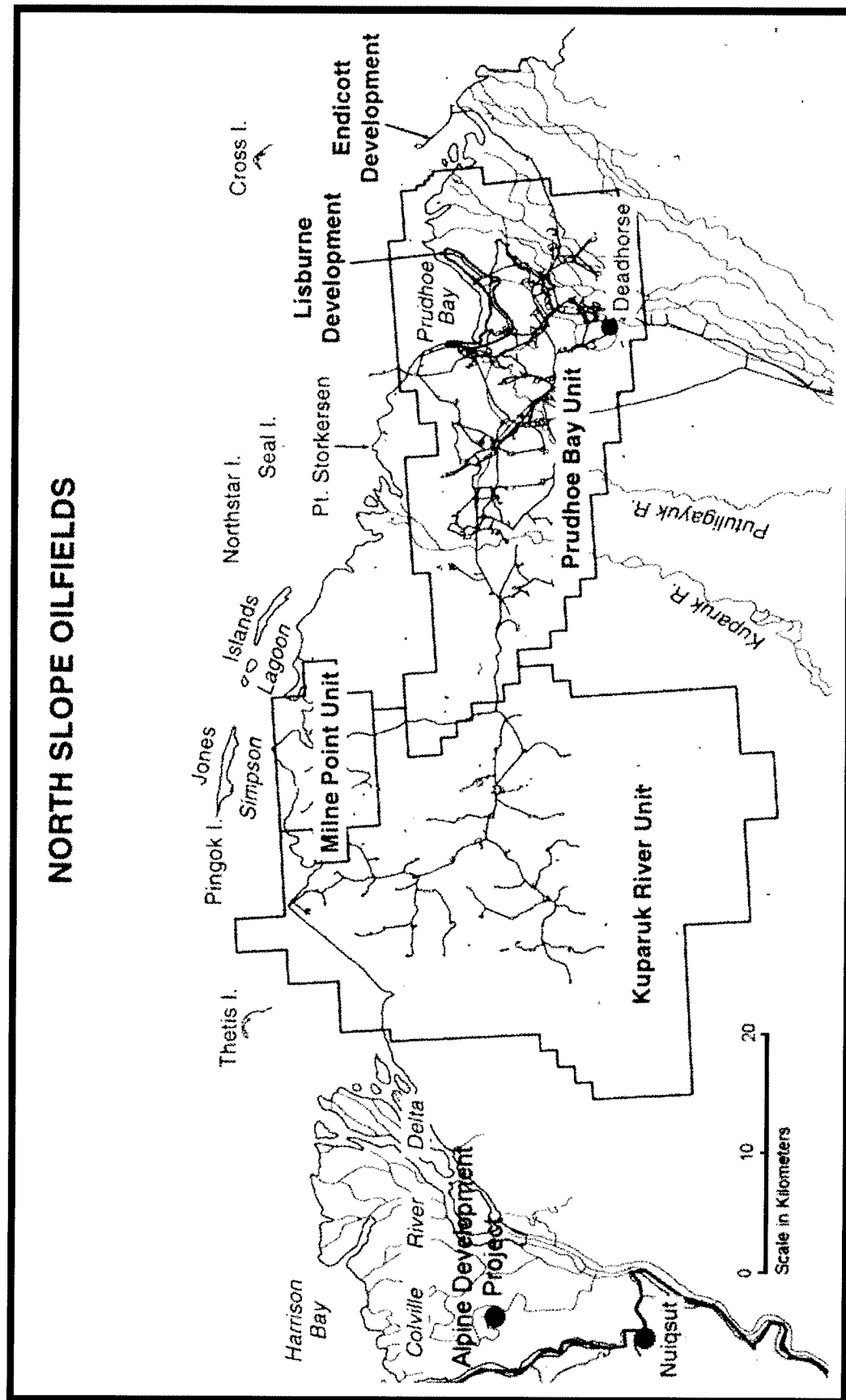


FIGURE 1-1: LOCATION OF REGIONAL NORTH SLOPE OIL FIELDS RELATIVE TO NUIQSUT

The monitoring program consists of an ambient air quality and dispersion meteorology monitoring station within Nuiqsut, with data analysis and support provided from the SECOR Air Resources Laboratory in Fort Collins, Colorado and aid from locally hired on-site technical support. The Nuiqsut Ambient Air Quality Monitoring Station (Nuiqsut Station) was installed in the spring of 1999, and brought online in two phases. Continuous meteorology, ambient NO_x, and ambient SO₂ collection began on April 9, 1999, and ambient PM₁₀ data collection began on April 25, 1999.

The monitoring station configuration has been expanded twice since measurements began in the spring of 1999. On July 14, 2000 the monitoring program was expanded to include measurement of PM₁₀ using a Partisol sequential air sampler to complete the TEOM PM₁₀ monitor. This sampler is a Federal Reference Method for measuring ambient PM₁₀ concentrations. On July 24, 2001 meteorological monitoring was expanded to include additional measurements, consisting of 10-meter temperature, 10-2 meter temperature difference, 10-meter vertical wind speed and vertical wind speed standard deviation, and 2-meter total incoming solar radiation, to further characterize low-level atmospheric stability for use in dispersion modeling.

1.2 Project Implementation

Since inception, the specific technical objectives of the program are to:

- document baseline air quality conditions in Nuiqsut prior to operation of the Alpine Development Project,
- document air quality conditions after the Alpine Development Project becomes operational, and
- meet ambient air quality and meteorological monitoring requirements listed in the Alpine Development Project Permit No. 0073-AC060 (fulfilled).

To meet these 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 program including the quality assurance plan is contained in the ADEC approved monitoring plan (SECOR 2000a) and two monitoring plan addendums (SECOR 2001a, SECOR 2002d).

TABLE 1-1

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASUREMENT METHODS**

Parameter	Suggested Manufacturer/Model	Sample Frequency	Averaging Period	Measurement Range	Lower Detection Limit	Method
Nitrogen oxides (NO _x , NO ₂ , NO)	Thermo Environmental Instruments (TECO) Model 42C	Continuous	1-hour	1 - 500 ppb	0.5 ppb	Chemiluminescence (EPA reference method RFNA-1289-074)
Sulfur Dioxide (SO ₂)	Thermo Environmental Instruments (TECO) Model 43C	Continuous	1-hour	1 - 500 ppb	2 ppb	Pulsed Fluorescence (EPA equivalent method EQSA-0486-060)
Particulate Matter (PM ₁₀)	Rupprecht & Patashnick (R&P) Model 1400a TEOM PM ₁₀	Continuous	1-hour	<5 µg/m ³ to several g/m ³	<5 µg/m ³	Tapered Element Oscillating Microbalance (EPA equivalent method EQPM-1090-079)
Particulate Matter (PM ₁₀)	Rupprecht & Patashnick (R&P) Model 2025 Sequential Air Sampler (Partisol Sampler)	Daily ¹	24-hour	<5 µg/m ³ to several g/m ³	<5 µg/m ³	Gravimetric (EPA reference method RFPS-1298-127)
Wind Speed (10 m)	R.M. Young Wind Monitor AQ - 05305	Continuous	1-hour	0 to 50 m/s	0.2 m/s	Propeller/Magnetically Induced Alternating Current
Wind Direction (10 m)	R.M. Young Wind Monitor AQ - 05305	Continuous	1-hour	0 to 360°	N.A.	Vane/Potentiometer
Sigma-Theta (σ _θ) (10 m)	Campbell Scientific Model 23X	Continuous	1-hour	0 to 103.9°	N.A.	Single Pass Estimator of Wind Direction Standard Deviation Yamartino (1984)

¹ Daily samples from June-October; every 6-day samples from November-May

TABLE 1-1 (CONTINUED)
 NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
 MEASUREMENT METHODS

Parameter	Manufacturer/Model	Sample Frequency	Averaging Period	Measurement Range	Lower Detection Limit	Method
Temperature (2 m)	YSI 44020	Continuous	1-hour	-50°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)
10m-2m Temperature Difference	Campbell Scientific Model 23X	Continuous	1-hour	-100°C to 100°C	N.A.	Numerical Subtraction
Vertical Wind Speed (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/ Alternating Current
Sigma-w (σ_w) (10 m)	Campbell Scientific Model 23X	Continuous	1-hour	N.A.	N.A.	Standard Deviation
Total Solar Radiation (2 m)	Eppley 8-48	Continuous	1-hour	0 to 1,400 W/m ²	<1 W/m ²	Differential thermopile

1.2.1 Nuiqsut Station Location

The station was intentionally sited so that impacts due to oil and gas operations to the north and east could be distinguished from near-field impacts from local Nuiqsut sources located to the south and west. The location of the Nuiqsut Station relative to Nuiqsut and major oil and gas operations is shown in Figure 1-2. A detailed site area map is included in Figure 1-3 to show the site relative to Nuiqsut and near-field sources. This map is augmented by Figure 1-4 that presents an aerial photo of Nuiqsut taken in August 2000.

1.2.2 Project Monitoring Plan

The monitoring plan describes protocols used to collect meteorological and ambient air quality data, which meet the quality assurance (QA) and data recovery requirements of the US EPA Prevention of Significant Deterioration (PSD) program as administered by ADEC and other specific ADEC QA requirements. The original monitoring plan for this project was approved by ADEC in April 2000 (SECOR 2000a). Since that time, the monitoring program has been expanded twice requiring the following two addenda to the original monitoring plan:

- Partisol Addendum - The original monitoring plan was amended to include collocated Federal Reference Method (FRM) particulate monitoring at the Nuiqsut Station. The final Partisol Addendum was submitted to ADEC in January 2001 (SECOR 2001a). ADEC approval of the Partisol Addendum is pending.
- Expanded Meteorology Addendum - The original monitoring plan was amended to expand the meteorological monitoring program. The draft Expanded Meteorology Addendum was submitted to ADEC in March 2002 (SECOR 2002d). ADEC review of the draft Expanded Meteorology addendum is pending.

The original monitoring plan combined with the two addenda are referred to as the Monitoring Plan. Guideline documents cited by the project Monitoring Plan are:

- *Alaska Quality Assurance Manual for Ambient Air Quality Monitoring* (ADEC 1996),
- *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (USEPA 1987),
- *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (USEPA 2000),

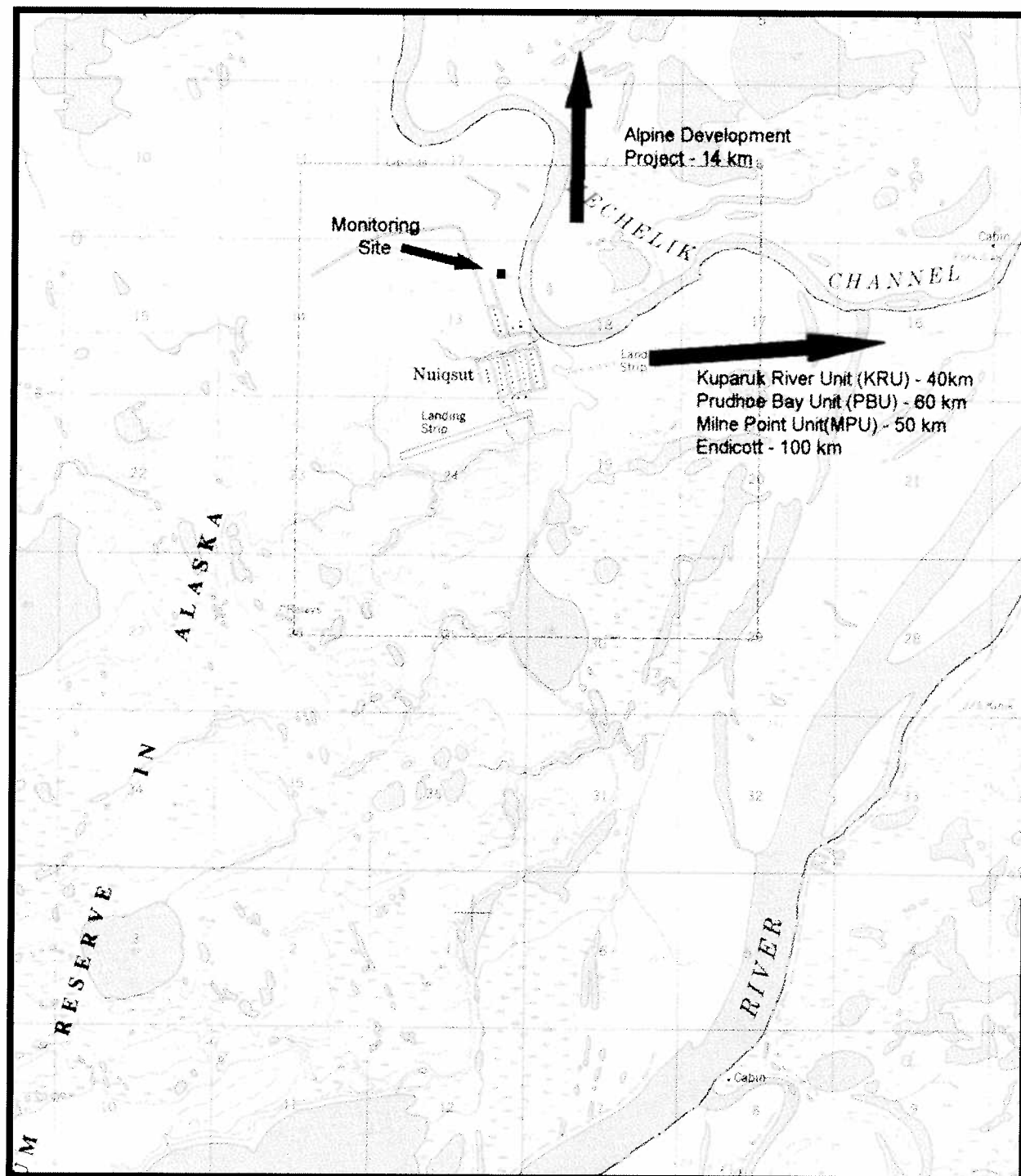


FIGURE 1-2: REGIONAL MAP

ConocoPhillips Alaska, Inc.: Nuiqsut Annual Data Report, April 2002 - March 2003
120T.11481.02.0004

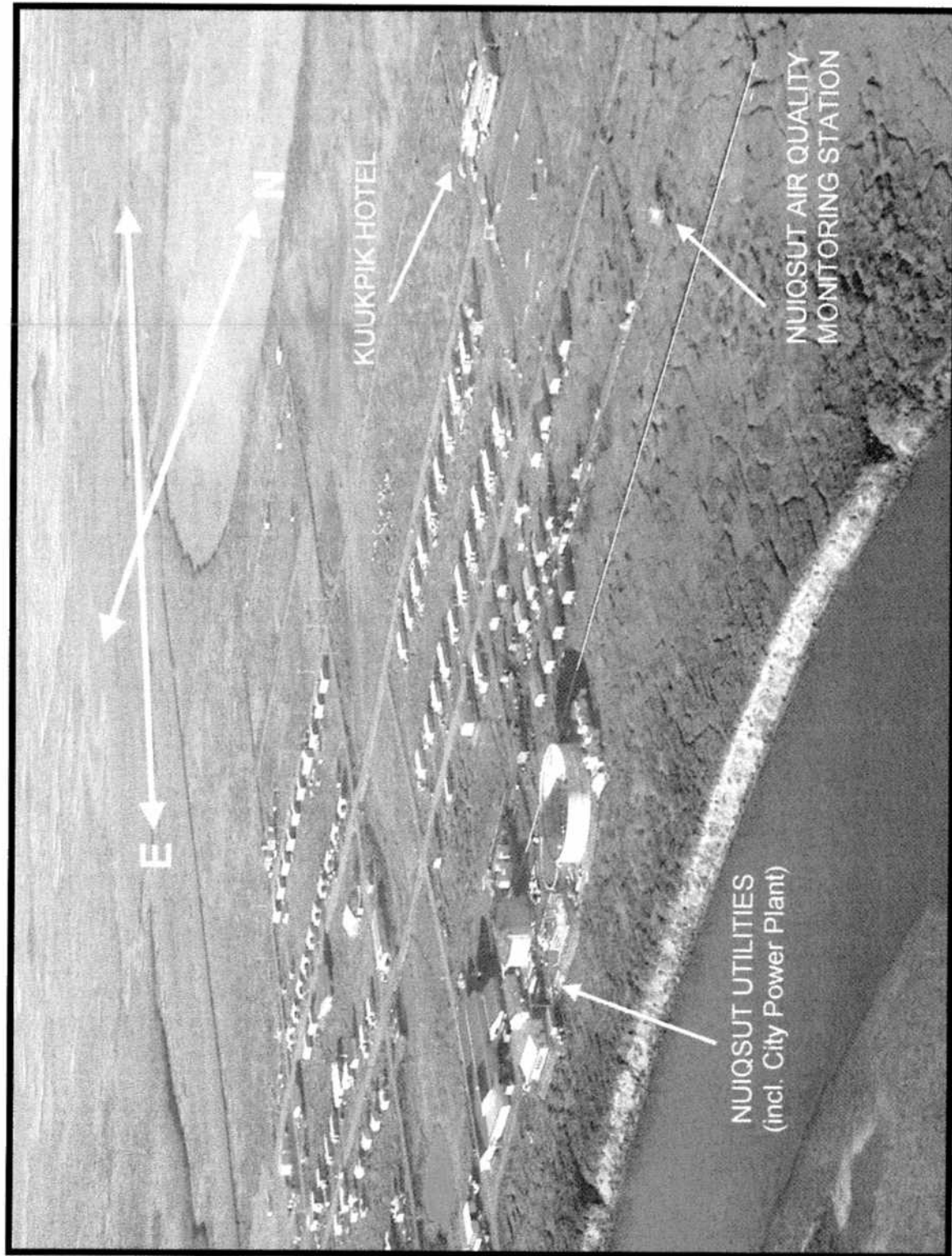


FIGURE 1-4: AERIAL PHOTO OF NUIQSUT

- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II: Ambient Air Specific Methods (Interim Edition)* (USEPA 1994),
- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II: Ambient Air Specific Methods (Interim Edition) Section 2.10: Reference Method for the Determination of Particulate Matter as PM10 in the Atmosphere (Dichotomous Sampler Method)* (USEPA 1990),
- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume IV: Meteorological Measurements* (USEPA 1995a), and *Code of Federal Regulations 40 CFR Part 58--Ambient Air Quality Surveillance*:

Appendix A - *Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)*

Appendix B - *Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring*

Appendix C - *Ambient Air Quality Monitoring Methodology*

Appendix E - *Probe Siting Criteria for Ambient Air Quality Monitoring*

2.0 STATION PERFORMANCE SUMMARY

This chapter presents a summary of events significant to station performance and contributing to data completeness, precision, and accuracy. Methods for determining data completeness, precision, and accuracy are included in Appendix A. Specific goals for data completeness, precision, and accuracy established in the Monitoring Plan are listed in Appendix B. Data recovery for air quality parameters exceeded project goals for most quarters. Exceptions were as follows:

- NO_x data during the third quarter 2002 due to instrument malfunction,
- PM₁₀ as measured by the Partisol, and
- TEOM, NO_x, and SO₂ data recovery during the first quarter 2003 due to equipment failures and poor instrument oversight by the on-site technician.

Data recovery for meteorological parameters exceeded project goals for most months during the monitoring year. Exceptions were as follows:

- horizontal wind speed and wind direction in October due to frozen sensors, and
- vertical wind speed from January through March due to snow loading and a broken propeller.

All of these exceptions are discussed in detail in Section 2.2 and in the appropriate quarterly reports. Data accuracy and precision goals for all parameters were exceeded during the monitoring year except for Partisol field blank precision results (see Section 2.4.1).

2.1 Significant Project Events

Table 2-1 summarizes significant project events for the monitoring year. Detailed discussions of project events affecting data recovery are presented in Section 2.2.

2.2 Missing, Invalid, and Adjusted Data

All hourly SO₂ and NO_x data have been adjusted according to the procedure outlined in USEPA (1998) and described in Appendix A. The adjustment procedure corrects for instrument

TABLE 2-1

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1, 2002 THROUGH MARCH 31, 2003**

Date	Event/Comment
April 10, 2002 through April 27, 2002	NO _x and SO ₂ data are invalid due to sample pump failure.
May 6, 2002 through May 7, 2002	Second quarter 2002 independent quality assurance audit of the air quality and meteorological monitoring systems performed by an AMSTech technician. The audit confirmed all instrumentation was operating within acceptable limits.
July 6, 2002 through July 25, 2002	All NO _x data missing due to an instrument malfunction. A temporary replacement analyzer was installed on July 25. The original analyzer was repaired and reinstalled on September 24.
July 22, 2002	Third quarter 2002 independent quality assurance audit of the air quality monitoring system performed by an AMSTech technician. The audit confirmed all instrumentation was operating within acceptable limits.
July 25 and 26, 2002	Second quarter 2002 calibration of the air quality and meteorological monitoring systems performed by a SECOR technician. The calibration confirmed all instrumentation was operating within acceptable limits.
September 24 and 25, 2002	Third quarter 2002 calibration of the air quality monitoring system performed by a SECOR technician. The calibration confirmed all instrumentation was operating within acceptable limits.
October 8 through October 10, 2002	Fourth quarter 2002 independent quality assurance audit of the air quality and meteorological monitoring systems performed by an AMSTech technician. The audit confirmed all instrumentation was operating within acceptable limits.
December 11 and 12, 2002	Fourth quarter 2002 calibration of the air quality and meteorological monitoring systems performed by a SECOR technician. The calibration confirmed all instrumentation was operating within acceptable limits.

TABLE 2-1 (CONTINUED)

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1, 2002 THROUGH MARCH 31, 2003**

Date	Event/Comment
January 1 through March 31, 2003	TEOM system malfunction. TEOM control unit stopped responding following an extended power failure. Control unit was replaced on April 3, 2003 and data collection resumed.
February 13 through March 31, 2003	SO ₂ data invalid. Pump diaphragm tore following multiple short-duration power failures. The pump was repaired on April 2, 2003.
February 16 through March 31, 2003	Vertical wind speed data invalid. Sensor propeller broke from excessive snow loading. The propeller was replaced on April 2, 2003.
March 1 through April 2, 2003	NO _x data invalid. Site technician inadvertently left the analyzer in the wrong mode during the February 28 site visit. Problem not corrected until April 2, 2003 visit by AMSTech technician.
April 2 through April 3, 2003 ¹	First quarter 2003 independent quality assurance audit of the air quality monitoring system performed by an AMSTech technician. The audit confirmed all instrumentation except the Partisol sampler.
April 9, 2003 ¹	First quarter 2003 calibration of the air quality monitoring system performed by a SECOR technician. The calibration confirmed all instrumentation was operating within acceptable limits.

¹ Audit and calibration delayed due to the unexpected closure of the Kuupik Hotel.

drift based on daily Level I zero/span results. Without adjustment, zero or span drift of the instrumentation could be misinterpreted as low-level concentrations.

After instrument drift corrections are applied, all hourly SO₂ and NO_x data less than 0.000 ppm have been set to 0.000 ppm to conservatively remove negative biases from the data set. Values less than -0.001 ppm are investigated for completeness before adjusting. On occasion, reported hourly average PM₁₀ values are slightly less than zero (usually between 0 µg/m³ and -5 µg/m³). Negative PM₁₀ concentrations usually occur in conjunction with precipitation events or abrupt changes in weather. As described in Appendix A-1 of this report, and Appendix A-1 of the Monitoring Plan, reported PM₁₀ concentrations greater than -10 µg/m³ are valid unless a reason exists to invalidate the data. Measured concentrations of -10 µg/m³ or less are invalidated.

The following sub-sections summarize non-routine data losses for each specific portion of the monitoring network. Additional data losses for the monitoring year include those due to routine network operation and maintenance, calibrations, audits, and precision checks. Additional details pertaining to each event are included in appropriate quarterly data reports.

2.2.1 NO_x and SO₂ Data

Approximately 17 days of NO_x and SO₂ data are missing in April because the sample pump supplying ambient air to the instruments failed. The pump was replaced April 2, 2003 and normal data collection resumed.

Twenty days of NO_x data are missing in July because of an instrument electronic ground fault. A replacement analyzer was installed and calibrated on July 26. The faulty analyzer was repaired offsite and reinstalled on September 24 during the third quarter 2002 calibration.

A brief power failure on October 12, 2002 caused a fixed zero offset shift in the SO₂ output of approximately -0.015 ppm. The offset was corrected with a manual adjustment on December 11, 2002. All SO₂ data for the period were corrected for this offset.

The SO₂ analyzer pump diaphragm ruptured following multiple short-duration power failures on February 13, 2003. SO₂ data was invalid until April 2, 2003, when the problem was corrected.

The NO_x instrument was inadvertently left in the wrong sampling mode following the February 28 site visit by the local on-site technician. Poor on-site technician support kept SECOR from correcting the problem in a timely manner. Without on-site support, the NO_x analyzer was not returned to the correct sampling mode until April 2, 2003.

2.2.2 Continuous PM₁₀ Data (TEOM)

The TEOM continuous PM₁₀ experienced significant problems in the later half of the year. Sixty-seven hours in November and 250 hours in December were invalid because the instrument flow rate was too low to maintain the size selective inlet PM₁₀ cut point. Low flow rates resulted from sampled snow trapped inside the sample inlet blocking the sample stream. Also, TEOM data was not available in January, February and March because of a TEOM control unit failure. The TEOM control unit quit responding following an extended power failure and ultimately had to be replaced. System operation was restored April 3, 2003.

2.2.3 24-Hour Integrated Particulate Data (Partisol)

As designated in the Monitoring Plan, Partisol samples were collected from June 1 through October 31 every day. From November 1 through May 31 samples were collected every six days on the US EPA designated sampling schedule. Several samples were lost due to sample scheduling errors, calibration and audit activities, and filters not being loaded into the instrument on schedule by the on-site technician.

The technical objectives of Partisol particulate monitoring have been satisfied, therefore, sampling was discontinued in December 2002.

2.2.4 Meteorological Data

With the exception of routine maintenance and quality assurance activities, the only losses of meteorological data during the monitoring year were for wind speed measurements (horizontal and vertical) resulting from snow loaded and frozen sensors. The largest losses were for vertical wind speed data during the latter half of February and all of March due to a propeller that broke from snow loading. Data recovery for horizontal wind speed, direction, and standard deviation was poor due to frozen sensors in October.

All 2-meter temperature data collected between July 1 and September 25 was adjusted for high bias spurious electrical noise (i.e. potential radio-frequency interference). Approximately 30 percent of data collected in each month of the third quarter were adjusted. The average adjustment was less than 0.6°C.

2.3 Network Data Recovery

Data recovery percentages for each continuous air quality and meteorological parameter have been calculated according to the procedure discussed in Appendix A, Section A-1. Table 2-2 provides a detailed summary of monthly and quarterly data recovery for each parameter for the current monitoring year. In summary, network data recovery for the year did not achieve project goals for all parameters for all periods (i.e. quarterly for air quality parameters and monthly for meteorological parameters). The reasons for the problems varied but were primarily focused on a lack of cooperation by the on-site technician. This individual has been replaced with a newly trained, committed technician.

A summary of annual data recovery for combined air quality data, combined meteorological data, and all project data for every year since monitoring began is shown in Table 2-3. Annual averages presented in Table 2-3 do not always reflect individual monthly or quarterly data project recovery goals. Refer to annual reports from previous monitoring years for significant monthly and quarterly losses (SECOR 2000b, SECOR 2001b, SECOR 2002a).

2.4 Precision Statistics

Precision statistics have been calculated for the NO_x and SO₂ analyzers based on the method outlined by the US EPA (USEPA 1994) and summarized in Appendix A, Section A-2 of this report.

The NO₂, NO, and SO₂ precision results, shown in Table 2-4, indicate that air quality analyzers operated within tolerances listed in Appendix B, Table B-2. Individual results from each precision check conducted are listed in Appendix A, Table A-1.

Precision of PM₁₀ monitors is evaluated each business day by determining whether the main and bypass flow rates are correct to within ± 2 percent of the respective set points (± 5 percent for the Partisol sampler). This method of determining the monitor precision is recommended as an alternate procedure (USEPA 1995b), provided that the flow meter inside the instrument is stable, reliable, and accurate, and that the flow meter is audited with a flow rate transfer standard at least once every six months. All flow checks for the period indicate that the monitors operated within project specifications, and all quarterly calibrations and audits confirm proper operation of the internal flow meters.

TABLE 2-2
 NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
 CONTINUOUS AIR QUALITY AND METEOROLOGICAL
 DATA RECOVERY STATISTICS
 APRIL 1, 2002 THROUGH MARCH 31, 2003

PARAMETER	APR 2002 (%)	MAY 2002 (%)	JUN 2002 (%)	JUL 2002 (%)	AUG 2002 (%)	SEP 2002 (%)	OCT 2002 (%)	NOV 2002 (%)	DEC 2002 (%)	JAN 2003 (%)	FEB 2003 (%)	MAR 2003 (%)	Q2 2002 (%)	Q3 2002 (%)	Q4 2002 (%)	Q1 2003 (%)	Annual 2002 (%)
Meteorological																	
10-m Wind Speed	99.9	98.7	100.0	99.1	100.0	99.4	85.8	98.5	94.9	91.9	92.4	99.5	99.5	99.5	93.0	94.7	96.7
10-m Wind Direction	99.9	98.7	100.0	99.1	100.0	99.4	87.8	99.9	94.9	97.7	92.4	100.0	99.5	99.5	94.1	96.9	97.5
10-m Sigma-Theta (σ_θ)	99.9	98.7	100.0	99.1	100.0	99.4	87.8	99.9	94.9	97.7	92.4	100.0	99.5	99.5	94.1	96.9	97.5
10-m Vertical Wind Speed	99.9	92.3	100.0	98.9	99.7	93.5	87.2	93.1	89.5	85.3	40.5	0.0	97.3	97.4	89.9	42.0	81.8
10-m Sigma-w (σ_w)	99.9	92.3	100.0	98.9	99.7	93.5	87.2	93.1	89.5	85.3	40.5	0.0	97.3	97.4	89.9	42.0	81.8
10-m Temperature	99.9	98.7	100.0	99.1	100.0	99.9	98.9	99.9	99.1	99.5	99.9	100.0	99.5	99.6	99.3	99.8	99.5
2-m Temperature	99.9	98.7	100.0	99.1	100.0	99.9	98.9	99.9	99.1	99.5	99.9	100.0	99.5	99.6	99.3	99.8	99.5
10-2m Temperature Difference	99.9	98.7	100.0	99.1	100.0	99.9	98.9	99.9	99.1	99.5	99.9	100.0	99.5	99.6	99.3	99.8	99.5
Total Solar Radiation	99.9	98.7	100.0	99.1	100.0	99.9	98.9	100.0	100.0	99.9	99.9	100.0	99.5	99.6	99.6	99.9	99.7
Meteorological Only	99.9	96.9	100.0	99.0	99.9	98.3	92.4	98.2	95.7	95.1	84.2	77.7	98.9	99.1	95.4	85.7	94.8

TABLE 2-2 (CONTINUED)
 NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
 CONTINUOUS AIR QUALITY AND METEOROLOGICAL
 DATA RECOVERY STATISTICS
 APRIL 1, 2002 THROUGH MARCH 31, 2003

PARAMETER	APR 2002 (%)	MAY 2002 (%)	JUN 2002 (%)	JUL 2002 (%)	AUG 2002 (%)	SEP 2002 (%)	OCT 2002 (%)	NOV 2002 (%)	DEC 2002 (%)	JAN 2003 (%)	FEB 2003 (%)	MAR 2003 (%)	Q2 2002 (%)	Q3 2002 (%)	Q4 2002 (%)	Q1 2003 (%)	Annual 2002 (%)
Air Quality																	
Nitrogen Dioxide (NO ₂)	43.6	98.5	99.4	33.3	99.5	95.8	96.6	99.3	98.7	98.0	97.6	0.0	80.7	76.0	98.2	64.1	79.8
Nitric Oxide (NO)	43.6	98.5	99.4	33.3	99.5	95.8	96.6	99.3	98.7	98.0	97.6	0.0	80.7	76.0	98.2	64.1	79.8
Sulfur Dioxide (SO ₂)	43.6	98.5	99.4	97.8	99.5	98.5	96.6	99.3	98.7	98.0	45.1	0.0	80.7	98.6	98.2	47.8	81.5
Particulate (PM ₁₀) (TEOM)	91.0	91.1	99.3	96.4	99.7	99.4	98.1	90.6	65.9	0.0	0.0	0.0	93.8	98.5	84.8	0.0	69.6
Particulate (PM ₁₀) (Partisol)	100.0	100.0	66.7	71.0	74.2	73.3	77.4	100.0	---	---	---	---	75.0	72.8	80.6	---	75.0
Air Quality Only	57.2	96.8	92.9	66.4	94.5	92.6	93.1	97.2	90.5	73.5	60.1	0.0	83.1	84.4	93.6	44.0	77.4
ALL PARAMETERS	86.4	97.1	97.5	87.4	98.0	96.3	92.6	97.9	94.1	88.5	76.8	53.8	94.4	93.8	94.8	72.9	89.1

¹ One in six day Partisol sampling discontinued December 2002.

TABLE 2-3

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
CONTINUOUS AIR QUALITY AND METEOROLOGICAL
ANNUAL DATA RECOVERY STATISTICS
APRIL 1, 1999 THROUGH MARCH 31, 2003**

Parameter	Project Goals (%)	Monitoring Year Data Recovery (%)			
		1999-2000	2000-2001	2001-2002	2002-2003
Air Quality ¹	80 ³	91.9	92.8	94.6	77.5
Meteorological ²	90 ⁴	96.0	98.0	98.6	98.4
All Parameters ^{1,2}	N.A.	94.0	95.4	96.6	88.0

¹ Does not include Partisol monitoring data recovery (optional beginning July 2000).

² Does not include vertical wind speed monitoring data recovery (optional beginning July 2001).

³ Percentage per calendar quarter.

⁴ Percentage per calendar month.

TABLE 2-4

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
NO₂, NO, AND SO₂ PRECISION STATISTICS
APRIL 1, 2002 THROUGH MARCH 31, 2003**

Analyzer	Number of Precision Checks (N)	Average Percent Difference (\bar{d}_j)	Standard Deviation (S_j)	Upper 95% Probability Limit (U₉₅)	Lower 95% Probability Limit (L₉₅)
NO	49	-1.9	4.5	7.0	-10.7
NO ₂	45	1.8	4.9	11.3	-7.8
SO ₂	48	-0.7	3.1	5.4	-6.9

2.4.1 Analytical Lab Quality Assurance Results (Partisol PM₁₀ Samples)

Analytical lab Quality Assurance (QA) is assessed four ways.

1. Replicate Samples - Measurement precision between successive weights of the same filter quantifies potential laboratory (i.e. balance, procedures, handling, etc.) bias introduced into analytical results.
2. Field Blank Samples - Measurement precision of a filter that has been handled exactly like sampled filters, except that it is not sampled, quantifies potential bias associated with filter handling and exposure procedures.
3. Laboratory Blank Samples - Measurement precision of a filter weighed before and after the laboratory conditioning process quantifies potential problems with conditioning procedures.
4. Filter Conditioning Environment - The filter conditioning environment must be maintained so that samples are equilibrated within the ranges and control tolerances listed in Appendix B, Table B-5.

Cumulative analytical lab QA statistics listed in Table 2-5 show that samples analyzed during the monitoring year met minimum precision goals except for field blank samples and the filter conditioning environment.

Field blank sample results listed in Appendix C, Table C-2 indicate filter handling procedures resulted in an unacceptable amount of mass accumulation in many of the field blank samples collected. Steps have been taken to minimize mass accumulation, but the exact source(s) has(have) not been identified. The indicated mass accumulation could potentially introduce a small positive bias in reported Partisol concentration data. However, comparison of 24-hour PM₁₀ concentrations measured by the Partisol with those measured by the TEOM does not corroborate the consistent positive bias indicated by field blanks. See Section 3.1.4 for a discussion of collocated Partisol and TEOM particulate data.

Cumulative analytical lab QA results for each sample analyzed for the monitoring year are presented in Appendix C, Table C-1 through Table C-4.

TABLE 2-5

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
PARTISOL PRECISION STATISTICS
APRIL 2002 THROUGH MARCH 2003**

Type	Number of Precision Checks	Average Difference	Maximum Difference	Precision Goal	
Replicate Samples	39	-1 µg	7 µg	±20 µg	
Field Blanks	30	28 µg	123 µg	±20 µg	
Lab Blanks	9	-3 µg	-9 µg	±20 µg	
Type	No. of Conditioning Periods	Extremes Measured over all Conditioning Periods			Precision Goal
		Max.	Min.	Diff. (Δ) ¹	
Filter Conditioning Temperature (T)	41	23 °C	19 °C	2 °C	15°C ≤ T ≤ 30°C (ΔT ¹ = ±3°C)
Filter Conditioning Humidity (RH)	41	44 %	35 %	7 %	20% ≤ RH ≤ 45% (ΔRH ¹ = ±5%)

¹ ΔT and ΔRH refer to the difference between extreme measurements (maximum – minimum) of temperature and humidity, respectively that occurred during a particular conditioning period.

Note: This table summarizes data presented in Appendix C, Tables C-1 through C-4.

2.5 Data Accuracy

The meteorological and ambient air quality monitoring systems are subjected to periodic calibrations and independent quality assurance performance and systems audits. All calibration and audit equipment is traceable to authoritative standards. The purpose of calibration and performance audit checks are to challenge monitoring systems with known inputs, verifying that each instrument response is accurate to within US EPA-established tolerances.

Consistent with project Monitoring Plan goals, four quarterly calibrations of the air quality monitoring system, and two semi-annual calibrations of the meteorological monitoring system, were performed. In addition to calibrations performed by SECOR, four quarterly independent performance audits of the air quality monitoring system, two semi-annual independent performance audits of the meteorological monitoring system, one annual independent field systems audit, one systems audit of the data handling, validation, processing, and reporting procedures at the SECOR Air Resources Laboratory in Fort Collins, Colorado and an independent systems audit of IML labs, where Partisol filter gravimetric analysis is conducted, were performed by AMSTech during the period.

With the exception of the first quarter 2003 Partisol audit, all calibrations and independent quality assurance performance and systems audits showed the station systems were operating within acceptable limits and that procedures described in the project Monitoring Plan were being followed. The Partisol failed the leak check conducted during the first quarter 2003 audit. Previous quality assurance activities demonstrated that Partisol monitoring was discontinued prior to the leak occurring, so no data was affected. Specific calibration and independent quality assurance audit details, including data forms, can be found in the respective quarterly data reports.

3.0 MONITORING NETWORK DATA SUMMARY

This chapter provides a summary and analysis of air quality and meteorology data collected at the Nuiqsut Station during the monitoring year.

It is useful to discuss seasonal trends when analyzing annual data sets. The notion of seasons typically understood at mid-latitudes loses meaning when applied to latitudes as far north as Nuiqsut. Ambiguity in defining seasons is linked to the fact that, at high northern latitudes, days of 24-hour darkness rapidly give way to days of 24-hour daylight, and freezing temperatures can be experienced during any month of the year. Instead of defining four seasons, the Barrow National Weather Service office suggests this area experiences two seasons, winter and summer, separated by a month of rapid transition in May and October. Therefore, for this report, winter is defined as November through April, and summer as June through September.

3.1 Air Quality Data

Criteria pollutants monitored as part of the Nuiqsut Ambient Air Quality Monitoring Program are nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and respirable particulate less than $10\text{ }\mu\text{m}$ in diameter (PM_{10}). Criteria pollutants are those air pollutants ADEC has 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 the same as the national standards. Applicable AAAQS, along with ambient concentrations measured at the Nuiqsut Station, are presented in Table 3-1 and summarized by pollutant below.

3.1.1 Nitrogen Dioxide

Table 3-1 shows the annual average NO_2 concentration was 0.008 ppm, compared to the annual NO_2 AAAQS of 0.053 ppm. The annual average NO_2 concentration is just above instrument detection level and only 15 percent of the NO_2 AAAQS. The annual average measured this year is higher than the historical Nuiqsut Station average of 0.003 ppm.

The variation of average hourly NO_2 concentration by wind direction this year was typical of past years with an approximate 0.003 ppm average offset, with the exception of north-northeasterly (NNE) through east-northeasterly (ENE) wind directions. As shown in Figure 3-1, the historical trend (heavy black line) shows elevated average hourly concentrations associated with sources located in the village (south-southeast through southwest of the Nuiqsut Station) and lower concentrations associated with directions transporting background air to the

TABLE 3-1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED NO₂, SO₂, AND PM₁₀ CONCENTRATIONS APRIL 1, 2002 THROUGH MARCH 31, 2003

Monitoring Period	Period Average NO ₂ Concentration (ppm)	Maximum 3-hour SO ₂ Concentration ¹ (ppm)	Maximum 24-hour SO ₂ Concentration (ppm)	Period Average SO ₂ Concentration (ppm)	Maximum 24-hour PM ₁₀ Concentration ² (µg/m ³)		Period Average PM ₁₀ Concentration ² (µg/m ³)	
					Standard ³	Actual	Standard ³	Actual
April 2002	0.010 ⁴	0.001 ⁴	0.000 ⁴	0.000 ⁴	36.5	42.2	12.1	14.0
May 2002	0.009	0.002	0.000	0.000	39.0	43.0	13.9	15.2
June 2002	0.008	0.000	0.000	0.000	21.1	22.2	7.7	8.1
July 2002	0.005 ⁴	0.003	0.002	0.001	29.5	31.4	9.1	9.5
August 2002	0.003	0.001	0.000	0.000	43.6 ⁵	45.6 ⁵	10.9	11.5
September 2002	0.003	0.001	0.000	0.000	9.7	10.6	4.6	5.0
October 2002	0.005	0.001	0.000	0.000	26.9	29.0	8.6	9.5
November 2002	0.007	0.001	0.000	0.000	20.6	22.6	7.5	8.5
December 2002	0.009	0.001	0.000	0.000	26.7 ⁴	30.8 ⁴	10.5 ⁴	12.2 ⁴
January 2003	0.011	0.002	0.001	0.000	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷
February 2003	0.022	0.001 ⁴	0.000 ⁴	0.000 ⁴	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷
March 2003	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷	N.A. ⁷
Reporting Period	0.008	0.003	0.002	0.000	43.6	45.6	9.3	10.4
AAQSQ	0.053 ⁶	0.5	0.14	0.03 ⁶	150	N.A.	50 ⁶	N.A.

¹ Running 3-hour average

² Based on continuous particulate (TEOM) data.

³ Standard refers to measured concentrations based on a flow rate corrected from actual conditions to US EPA designated standard conditions by using a pressure of 1 Atmosphere and a temperature of 25°C.

⁴ Based on less than 80 percent data recovery.

⁵ On-site observations indicate maximum daily concentration is affected by particulate emissions from a tundra fire near Point Lay, Alaska. Maximum standard measured 24-hour concentration not affected by the tundra fire is 30.0 µg/m³.

⁶ Annual average

⁷ Instrument off-line, no data collected.

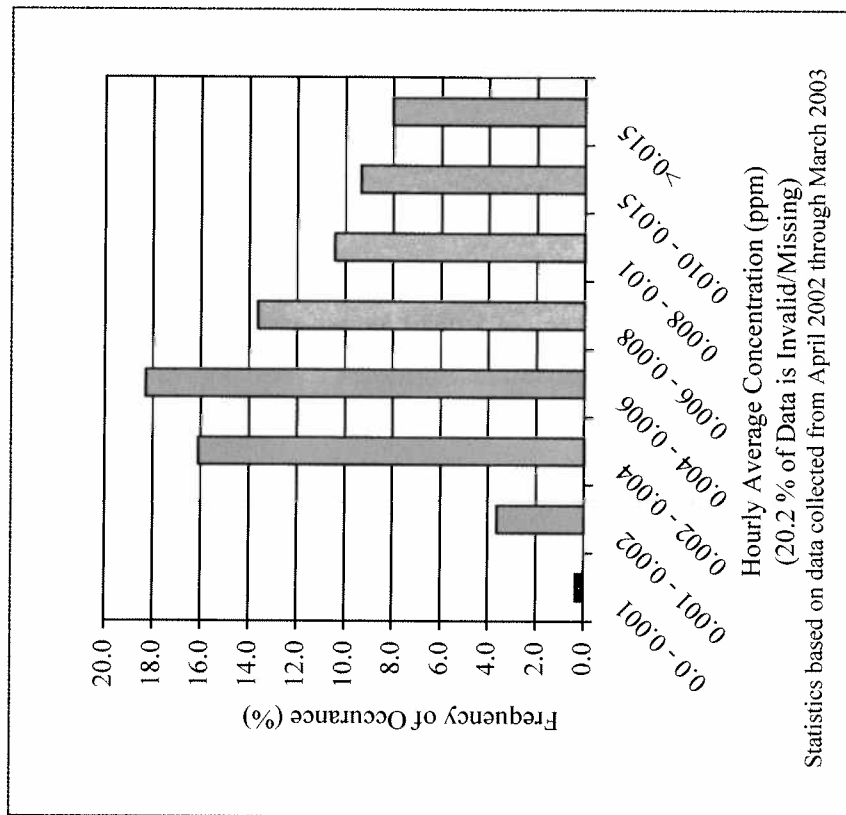
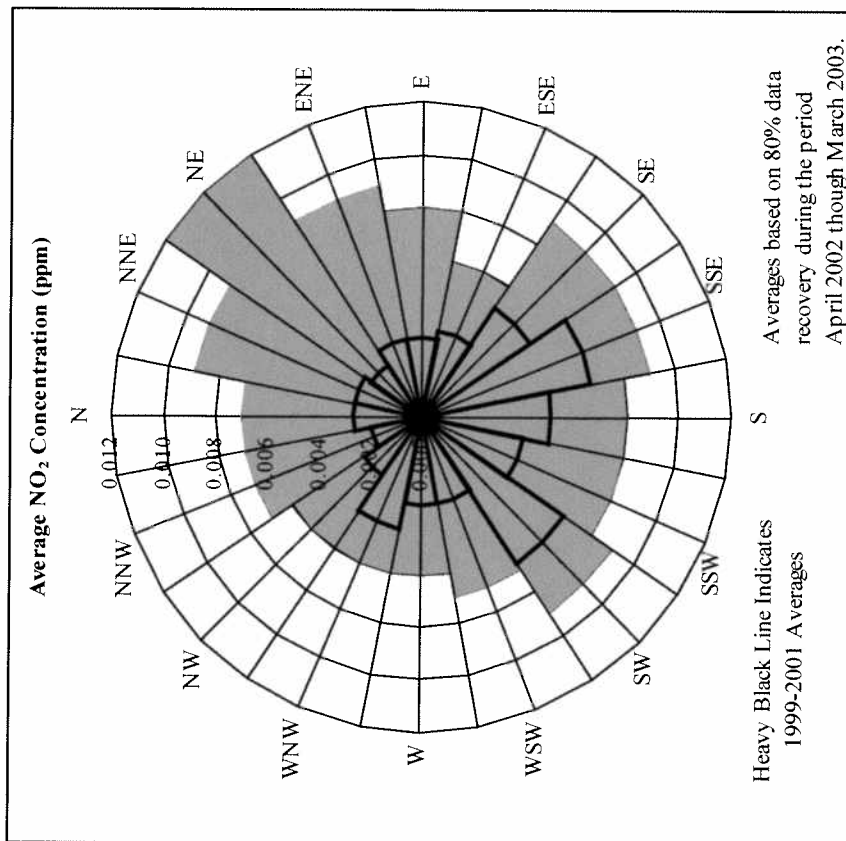


FIGURE 3-1: NO₂ FREQUENCY ANALYSIS AND AVERAGE CONCENTRATION BY WIND DIRECTION

Nuiqsut Station (west-northwest (WNW) to ENE). With the addition of 0.003 ppm, the same trend was seen during the current monitoring year except for NNE through ENE directions. NNE to ENE directions show an additional 0.003 ppm offset for a total of 0.006 ppm above the trend. As will be discussed, the atypical NNE through ENE concentrations occurred during the winter months. These concentrations could be associated with ice road activity and activity around the Nechelik Channel (see First Quarter 2003 report, SECOR 2003b).

The typical average concentration when winds transport background air to the Nuiqsut Station (WNW-ENE wind directions) is 0.003 ppm, as shown by the heavy dark line in Figure 3-1. Figure 3-1 illustrates that higher than normal background concentrations were measured this monitoring year.

Monthly average NO₂ concentrations are presented in Figure 3-2. As the historical trend line shows, it is typical to observe increases in monthly averaged NO₂ concentrations during the winter. The pattern of higher measured impacts in winter is a reflection of the differences in atmospheric dispersion characteristics between winter and summer, rather than changes in source strength or inventory. 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 vertical mixing of the lower atmosphere and diffusion of air pollution. In winter, without the benefit of solar energy, the atmosphere remains relatively stable and vertical dispersion of pollution is limited. This results in higher ground level concentrations of air pollutants in winter than in summer. Consistent with this, Figure 3-2 shows that during the winter months (designated as November through April), the average hourly historical concentration is 0.012 ppm (22 percent of the AAAQS), and during summer months (designated as June through September) historical average hourly concentrations are 0.005 ppm (9 percent of the AAAQS). For this monitoring year, concentrations over the summer months were somewhat consistent with the historical trend; however, concentrations during the winter were higher.

Figure 3-3 refines the analysis presented in Figure 3-2 so that seasonal differences in measured impacts can be observed by wind direction. In addition to illustrating differences in relative magnitude of impacts by direction, this graph also shows that, historically, seasonal differences in average NO₂ concentrations by wind direction (difference between trend lines) are approximately constant. This is consistent with the notion that seasonal differences in concentrations are a result of atmospheric dispersion characteristics, not changes in source strength or inventory. Seasonal changes in source inventory would result in seasonal differences varying by wind direction. This monitoring year, seasonal concentration differences were fairly

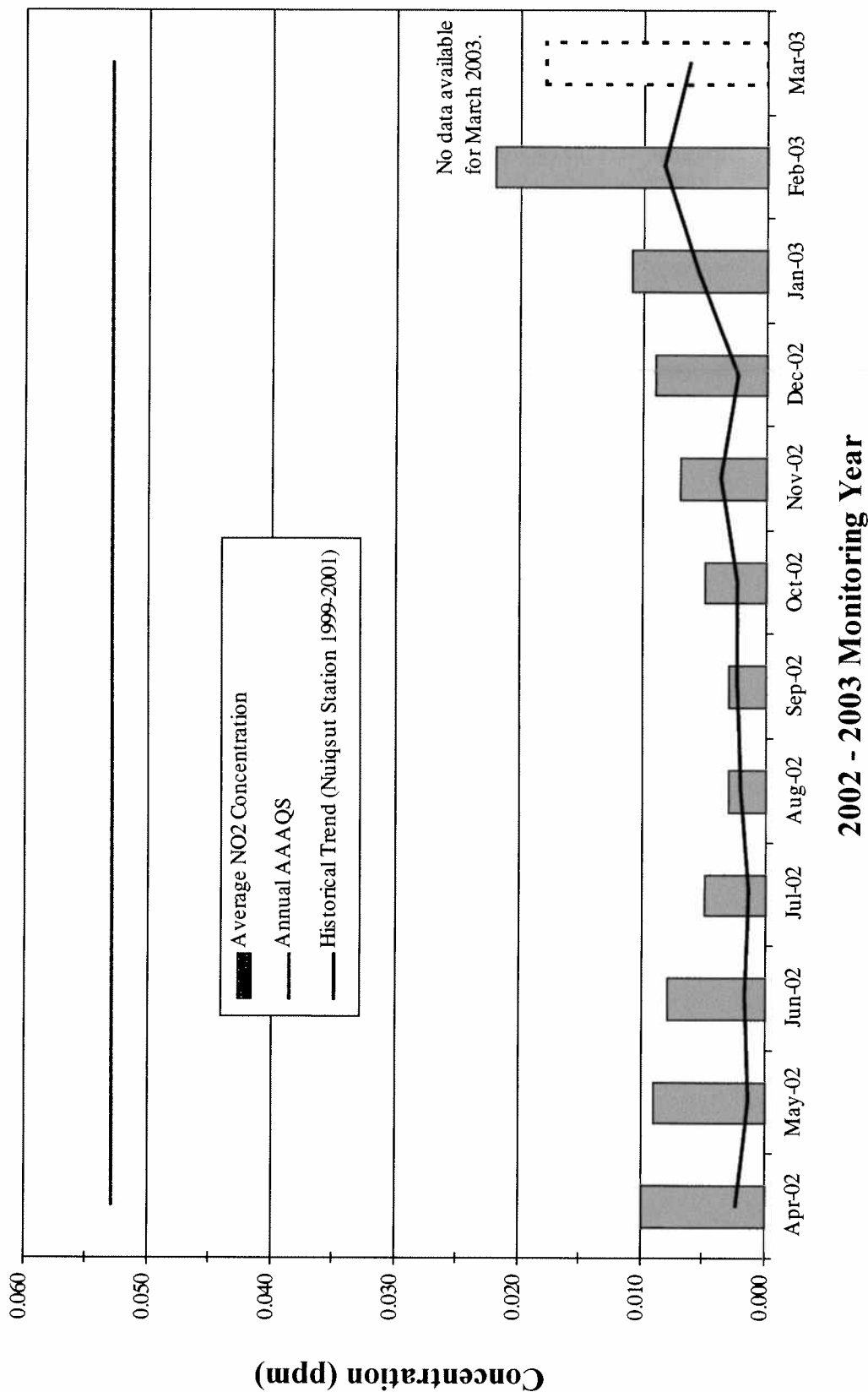


FIGURE 3-2: AVERAGE NO₂ CONCENTRATION BY MONTH

ConocoPhillips Alaska, Inc. / Nuiqsut Annual Data Report: April 2002 - March 2003
120T.11481.02.0004

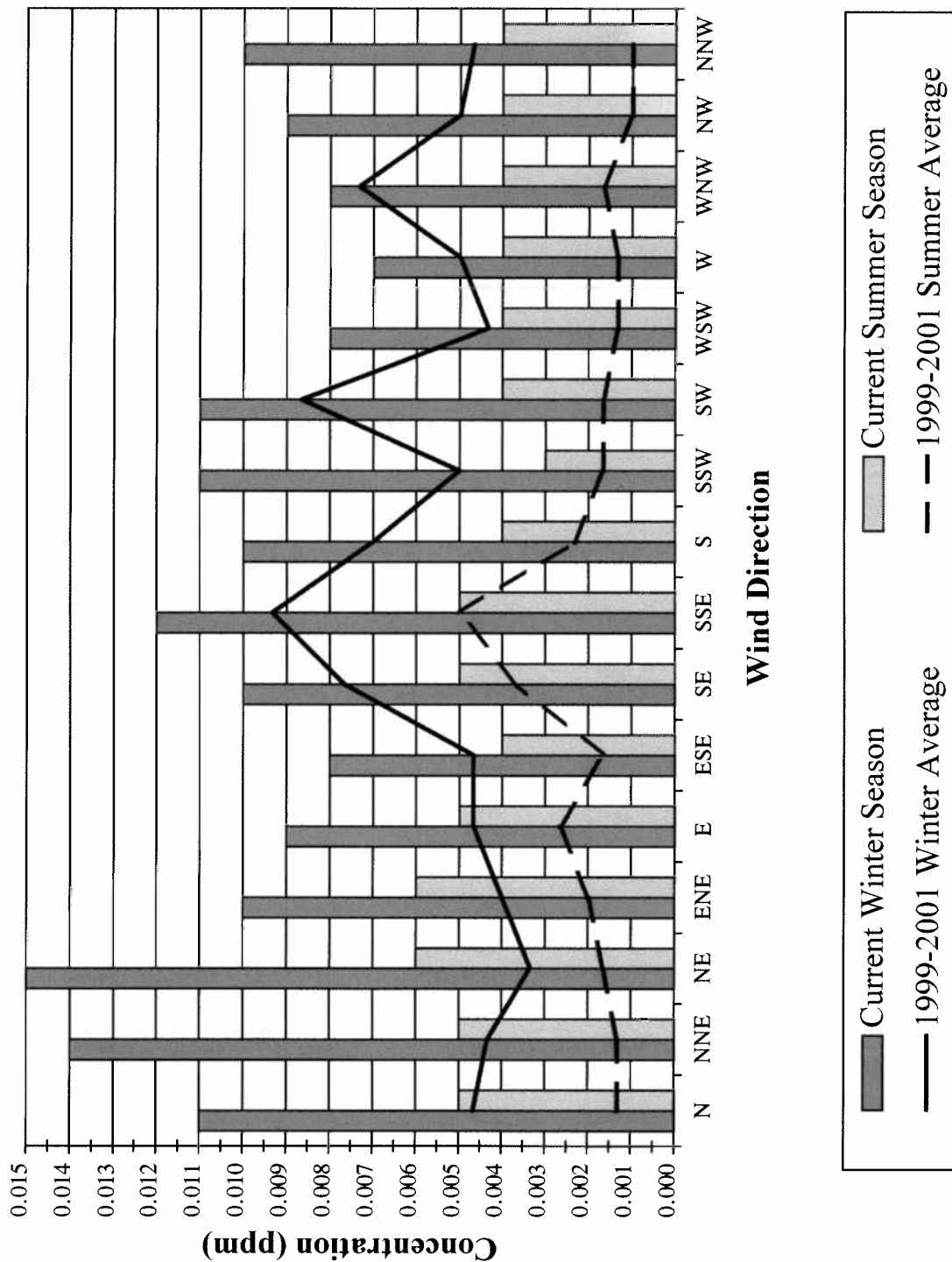


FIGURE 3-3: AVERAGE HOURLY NO₂ CONCENTRATION BY WIND DIRECTION

constant by direction except where they were notably higher in magnitude for NNE-ENE wind directions. The increased seasonal difference for NNE-ENE directions this year indicates the influences of not only atmospheric dispersion characteristics, but also a change in winter source strength or inventory. The source responsible for the seasonal change is unknown but may be traced to ice road activity, which occurs in those directions from the Nuiqsut Station.

3.1.2 Sulfur Dioxide

Table 3-1 lists measured maximum 3-hour (running) and 24-hour (midnight-to-midnight) average SO₂ concentrations for each month, as well as the annual average SO₂ concentration. Concentrations for all three averaging periods were either near or below the instrument detection limit and well below applicable AAAQS. Measured SO₂ concentrations were typical of historical (1999-2001) values.

Measured hourly SO₂ concentrations were less than or equal to 0.002 ppm for 99.8 percent of the time during the monitoring year. No hourly concentrations were greater than 0.003 ppm. The majority of measured SO₂ concentrations were just above the instrument detection limit making it difficult to discuss significant trends. What can be said is that there was no single near-field or far-field source of measurable SO₂ indicated by the data collected. Without identifiable sources, measured concentrations are representative of a regional background signature. The low average concentrations measured are consistent with an airshed containing little industry and few sources. This trend has been typical of SO₂ measurements since monitoring began.

3.1.3 Respirable Particulate Matter (PM₁₀) - TEOM Data

Throughout the monitoring project history, the majority of and highest measured particulate concentrations result from naturally occurring wind blown 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 east-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,
- to a much lesser degree, disturbed ground associated with dirt roads within Nuiqsut south through west-southwest of the station, and
- occasional tundra fires.

When fugitive dust from these sources is not present (i.e., during winter), hourly concentrations are at or below the instrument detection limit.

Respirable particulate matter less than 10 μm in diameter (PM_{10}) measured at US EPA standard temperature and pressure, has a 24-hour and annual AAAQS of $150 \mu\text{g}/\text{m}^3$ and $50 \mu\text{g}/\text{m}^3$. As listed in Table 3-1, the maximum 24-hour PM_{10} concentration measured during the monitoring year was $43.6 \mu\text{g}/\text{m}^3$, which is below the 24-hour AAAQS, and is 60 percent of the maximum 24-hour concentration measured during the previous monitoring year ($72.1 \mu\text{g}/\text{m}^3$). The yearly average PM_{10} concentration was $9.3 \mu\text{g}/\text{m}^3$, which is higher than the average of $6.6 \mu\text{g}/\text{m}^3$ obtained last year and is well below the annual AAAQS of $50 \mu\text{g}/\text{m}^3$. The annual average obtained this year is potentially biased high because a quarter of typically low measurements were not collected. Particulate data was not collected during the first quarter 2003 (see explanation in Section 2.2.2).

The annual averaged PM_{10} concentration shown in Table 3-1 is typical of the low concentrations measured at Nuiqsut since monitoring began. The annual average concentration is lower than the average annual concentration obtained from 153 rural sites listed in the National Air Quality and Emissions Trends Report, 1999 (USEPA 2001). From this report, for rural sites, the annually averaged concentration was $19.2 \mu\text{g}/\text{m}^3$.

Another indication of the low concentrations measured at Nuiqsut is shown in the statistical analysis of the data presented in Figure 3-4. Figure 3-4 frequency analysis shows 45 percent of the measurements (slightly less than the last monitoring year) were at or below $7.5 \mu\text{g}/\text{m}^3$. Again, the high percentage of low measurements is explained by the rural site setting combined with frozen and or snow covered ground for a majority of the year.

Properties of hourly PM_{10} concentrations measured at the Nuiqsut Station averaged by wind direction are shown in Figure 3-4. This analysis shows the following characteristics of the ambient hourly PM_{10} concentrations measured at Nuiqsut this year:

- Slightly elevated hourly concentrations were measured when wind directions were east-northeast through easterly (ENE-E). ENE-E winds are known to transport particulate from the bank of the Nechelik channel to the Nuiqsut Station.
- The highest average hourly concentrations were measured when wind directions were south-southeast (SSE). Based on on-site observations, these elevated measurements appear to be a result of wind blown fugitive dust originating from disturbed ground

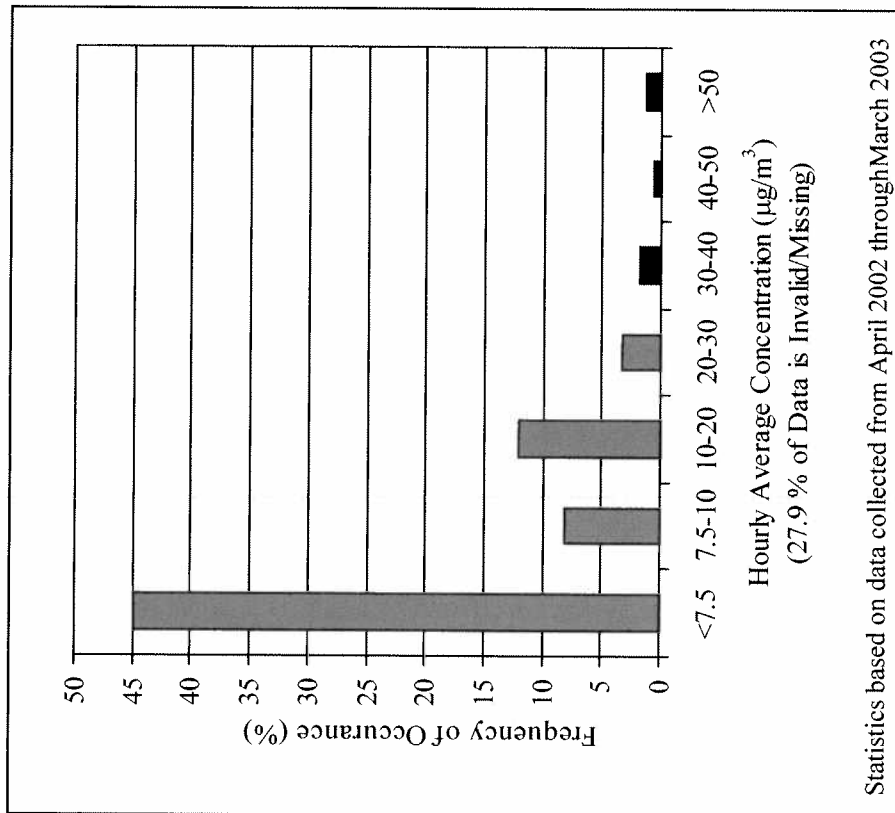
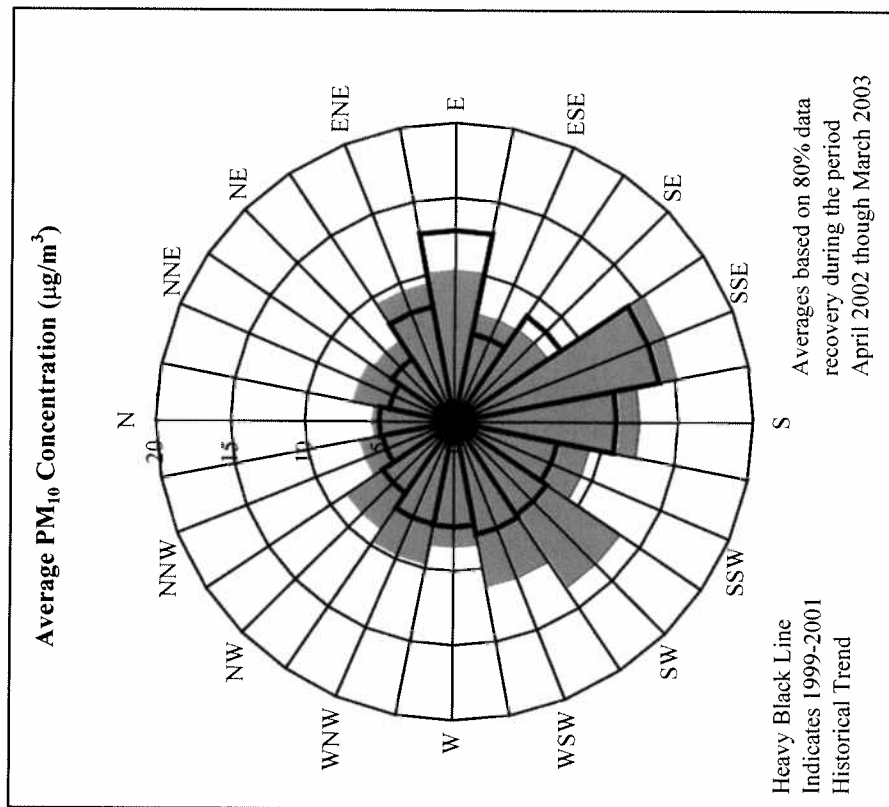


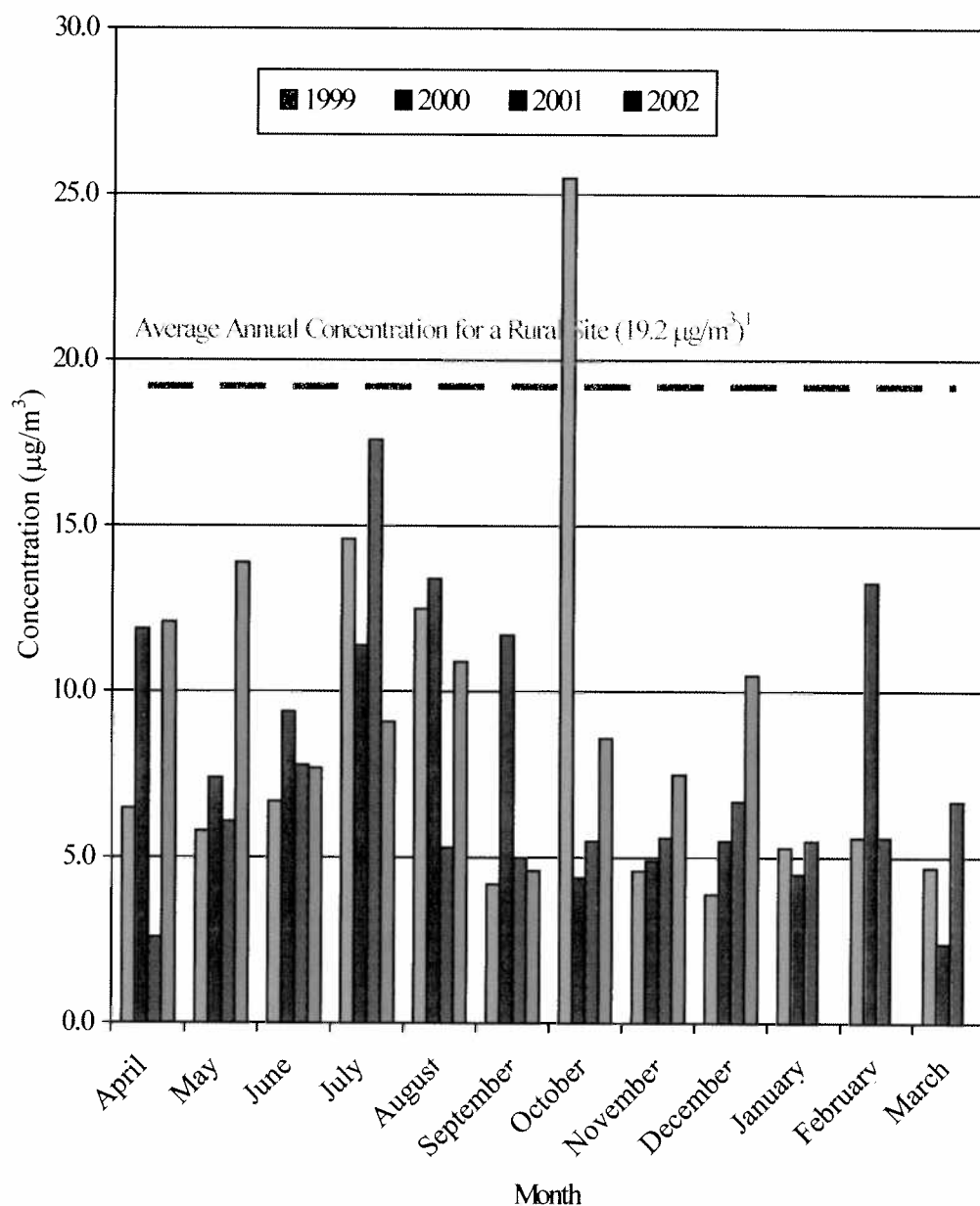
FIGURE 3-4: PM₁₀ FREQUENCY ANALYSIS AND AVERAGE CONCENTRATION BY WIND DIRECTION

- surrounding the utility right-of-way leading south-southeast from the Nuiqsut Station. It is important to note that this PM_{10} average concentration is more a reflection of a small number of actual measurements (140 hours) biased by several unusually high concentrations than it is a notable trend.
- Additionally, elevated average hourly concentrations were measured when wind directions were southwest to west-southwest (SW-WSW). These directions are also associated with fugitive dust from disturbed areas within Nuiqsut being transported to Nuiqsut Station.

Figure 3-5 compares monthly average PM_{10} concentrations by year for each month since monitoring began at Nuiqsut. Generally, PM_{10} concentrations increase over the summer months as the snow thaws and the ground dries, then decrease through the winter, as the ground freezes and becomes snow covered. The variability seen throughout the 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.

This year, exceptions to the general trend are seen in April, May and December. During these months, the instrument was plagued and the data potentially biased by extreme blowing snow events. During these events, snow can be sampled by the instrument, which is then interpreted as particulate loading. Not all the data affected by extreme blowing snow events can be removed from the data because of the ambiguity in identifying contaminated hours at these very low concentrations.

Table 3-2 lists all 24-hour (midnight to midnight) averaged PM_{10} concentrations over $20 \mu g/m^3$ measured during the monitoring year along with corresponding average wind speed and direction measured during the same period. As with the previous monitoring year, top concentrations were distributed between three contributing fugitive sources identified in this report section [The bank of the Nechelik Channel (ENE-ESE), construction to the south of the station (SE-S) and the Nuiqsut populated area (S-NW)]. It is important to note that there were 27 days with 24-hour averaged concentrations higher than $20 \mu g/m^3$ measured this monitoring year compared to 10 days measured during the previous monitoring year. Of those 27 days, 6 occurred in the winter when fugitive sources would not be expected to be active. As discussed, these impacts could be a result of sampled snow.



¹ Average annual concentration obtained from 153 rural sites as summarized in the National Air Quality and Emissions Trends Report, 1999 (USEPA 2001).

FIGURE 3-5: NUIQSUT PARTICULATE CLIMATOLOGY

TABLE 3-2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED 24-HOUR TEOM PM₁₀ CONCENTRATIONS GREATER THAN 20 µg/m³

Ranking	TEOM Measured 24-hour PM ₁₀ Concentration. (µg/m ³)	24-hour Period	Wind Speed Avg/Max (m/s)	Dominant Wind Direction ¹
1	43.6	08/26/02	3.4/5.5	SW-SSW ²
2	39.1	05/28/02	8.2/11.4	E-ESE
3	36.5	04/18/02	8.5/12.8	WSW
4	34.9	05/16/02	3.7/5.4	NW-NNW
5	34.2	08/25/02	3.2/5.5	S-SSE ²
6	30.0	08/14/02	7.4/13.1	SW
7	29.5	07/29/02	5.4/7.8	E
8	29.4	08/27/02	2.8/4.7	S-SSE
9	26.9	10/08/02	10.3/13.4	W-WSW
10	26.7	12/14/2002	5.2/5.9	NNE
11	26.7	05/24/02	3.6/4.8	WSW-W ²
12	25.4	05/17/02	4.8/7.7	ENE-E
13	25.0	05/26/02	9.5/10.8	SW-WSW
14	24.5	04/28/02	4.7/7.1	W-WNW
15	24.5	08/31/02	3.8/6.4	S-SSE ²
16	23.4	05/19/02	7.5/9.7	SSW-SW ²
17	23.0	10/13/02	8.0/10.8	E
18	22.1	10/11/02	8.4/11.8	ENE
19	21.9	05/04/02	8.3/12.2	N-NNE ²
20	21.8	05/14/02	5.8/8.2	SW-WSW ²

¹ Winds were determined to be dominant for the day if winds were from a particular direction or two adjacent directions more than 13 hours per day unless otherwise noted.

² Winds had no dominant direction on this day, but these wind directions are responsible for elevated PM₁₀ measurements.

TABLE 3-2 (CONTINUED)

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED 24-HOUR TEOM PM₁₀ CONCENTRATIONS GREATER THAN 20 µg/m³

Ranking	TEOM Measured 24-hour PM ₁₀ Concentration. (µg/m ³)	24-hour Period	Wind Speed Avg/Max (m/s)	Dominant Wind Direction ¹
21	21.1	06/18/02	6.2/7.9	ENE
22	21.1	08/03/02	4.4/8.5	W-WNW ²
23	20.6	11/27/02	4.8/7.8	WNW-NW ²
24	20.6	04/08/02	7.4/10.5	W-WNW ²
25	20.2	07/16/02	3.4/5.5	E-ESE ²
26	20.1	04/17/02	8.4/12.7	ENE
27	20.0	07/31/02	2.4/4.7	E-ESE ²

¹ Winds were determined to be dominant for the day if winds were from a particular direction or two adjacent directions more than 13 hours per day unless otherwise noted.

² Winds had no dominant direction on this day, but these wind directions are responsible for elevated PM₁₀ measurements.

A detailed statistical analysis of collocated TEOM and Partisol 24-hour averaged measured concentrations was presented in the quarterly data reports. Each report showed measurements are correlated, with TEOM measurements consistently higher than Partisol measurements. The correlation between measurements collected with both instruments for the monitoring year is presented in Figure 3-6. This figure clearly shows that TEOM measurements are higher than Partisol measurements. Though the scatter in the correlation plot is too large to determine an exact correlation, it is clear that TEOM measurements are approximately twice as high as Partisol measurements. Possible explanations for Partisol measurements being biased low, and the large amount of scatter of data plotted in Figure 3-6 include accumulated mass lost from filters during shipping, a systematic bias between instruments due to operational differences, or, more likely, a combination of factors exacerbated by the generally very low concentrations of particulate present in Nuiqsut.

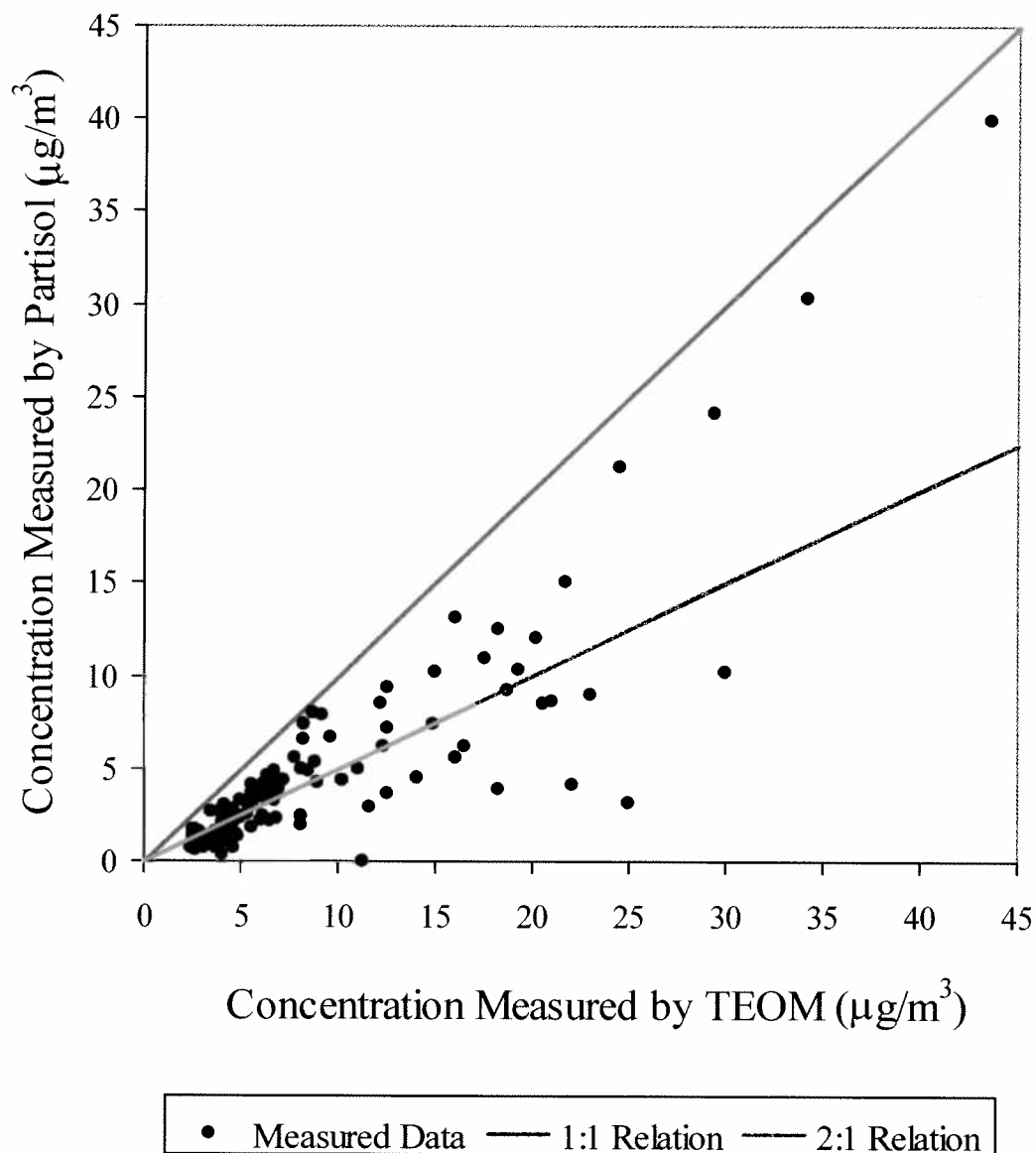
When making comparisons between collocated particulate measurements it must be understood that precision of 24-hour results reported by the TEOM is $\pm 0.5 \mu\text{g}/\text{m}^3$. With this amount of uncertainty in low measurements, TEOM measurements less than $2.5 \mu\text{g}/\text{m}^3$ should not be used for analysis. Generally, only 24-hour concentrations above $20 \mu\text{g}/\text{m}^3$ are used for determining instrument precision using collocated measurements. This monitoring year, there were only four Partisol 24-hour concentrations measured above $20 \mu\text{g}/\text{m}^3$. It is interesting to note that these four measurements come close to a 1:1 correlation, strengthening the conclusion that low measured concentrations lead to the lack of agreement between TEOM and Partisol data.

3.2 Meteorological Data

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

3.2.1 Wind Speed and Direction Climatology

The annual Nuiqsut bivariate wind frequency distribution (wind rose) is presented in Figure 3-7. Data presented in this figure displays the typical Nuiqsut bimodal wind climatology demonstrated every year since monitoring began. This figure shows winds during the monitoring year were dominated by northeast through easterly (NE-E) and south-southwest through westerly (SSW-W) directions, representing nearly 72% of all hours. Data summarized from Figure 3-7 is tabulated below. The tabulated summary shows NE-E winds average slightly higher speeds than SSW-W winds and occur with a slightly higher frequency. Over all wind directions, the mean 10-meter wind speed for the monitoring year was 4.9 m/s and the maximum was 21.7 m/s.



Correlation based on data collected from April 2002 through November 2002.

FIGURE 3-6: COMPARISON BETWEEN PARTISOL AND TEOM PM₁₀ DATA

Nuiqsut Air Quality Monitoring Program - Nuiqsut, AK
WIND ROSE ANALYSIS (PERCENT)
4/ 1/02 through 3/31/03
All Hours

WIND DIRECTION	WIND SPEED (M/S)						TOTAL	AVG SPEED
	<= 1.5	<= 3.1	<= 5.1	<= 8.2	<=10.8	>10.8		
N	0.34	0.96	1.29	0.13	0.00	0.00	2.72	3.08
NNE	0.41	1.61	2.22	0.90	0.07	0.00	5.21	3.69
NE	0.89	1.95	3.65	3.20	0.76	0.25	10.69	4.74
ENE	0.89	1.97	3.92	4.95	3.03	2.62	17.38	6.77
E	0.76	1.49	3.02	3.44	1.42	1.16	11.28	5.98
ESE	0.43	0.96	0.92	0.68	0.09	0.00	3.08	3.69
SE	0.31	0.83	0.51	0.02	0.00	0.00	1.67	2.60
SSE	0.43	0.89	0.33	0.04	0.00	0.00	1.68	2.42
S	0.58	1.61	1.54	0.13	0.00	0.00	3.85	2.94
SSW	0.97	1.90	3.61	1.19	0.01	0.00	7.69	3.56
SW	0.64	1.72	2.42	1.39	0.22	0.17	6.57	4.21
WSW	0.92	1.31	2.39	3.31	1.31	0.40	9.64	5.60
W	0.59	1.35	2.48	3.09	0.65	0.48	8.64	5.40
WNW	0.61	1.13	1.62	1.29	0.30	0.04	4.98	4.25
NW	0.48	0.92	0.64	0.38	0.02	0.00	2.44	3.15
NNW	0.48	0.98	0.67	0.09	0.00	0.00	2.23	2.71
CALM	0.26						0.26	
TOTAL	9.98	21.56	31.22	24.23	7.89	5.11	100.00	

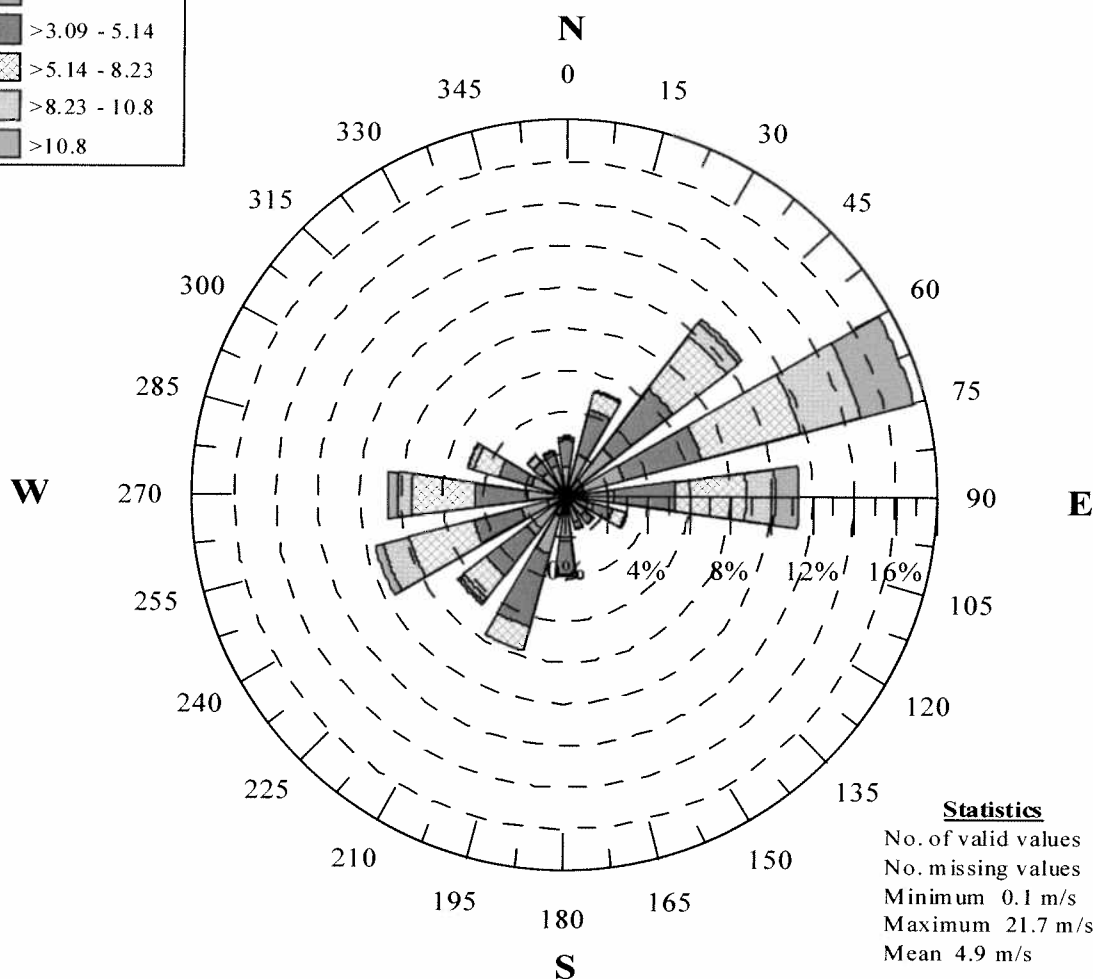
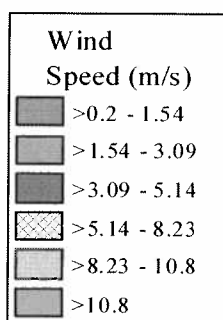


FIGURE 3-7: ANNUAL WIND ROSE ANALYSIS

Wind Speed/ Wind Direction Parameter	April 2002 through March 2003	April 2001 through March 2002	April 2000 through March 2001	April 1999 through March 2000
Frequency of NE-E Winds	39.4%	43.8 %	50.7 %	53.8 %
Frequency of SSW-W Winds	32.5%	29.2 %	22.7 %	22.9 %
Mean Wind Speed over NE-E Winds	6.0 m/s	5.3 m/s	6.0 m/s	6.6 m/s
Mean Wind Speed over SSW-W Winds	4.8 m/s	4.1 m/s	4.6 m/s	4.6 m/s
Mean Hourly Wind Speed	4.9 m/s	4.3 m/s	5.0 m/s	5.3 m/s
Maximum Hourly Wind Speed	21.7 m/s	20.2 m/s	23.7 m/s	20.1 m/s

The wind speed/wind direction summary also provides a comparison of the wind climatology for the current monitoring year compared to those measured in previous years. It is very clear from these statistics that though the mean wind speed this year was slightly higher, there has been very little change in the wind speed and direction climatology over the past four monitoring years. This climatology reflects how persistent weather patterns are as they move across the well-exposed Alaska North Slope Coastal Plain.

The persistence of weather patterns season to season is shown in Figure 3-8. Figure 3-8 allows a comparison between wind roses collected in the winter and summer to assess seasonal differences in the Nuiqsut wind climatology. As was observed during the last three monitoring years, the seasonal wind roses collected this year indicate there is a persistence of NE-E and SSW-W winds all year long. In the winter, this pattern is more defined and is associated with higher wind speeds than the summer.

3.2.2 Stability Frequencies

Estimates of the Pasquill-Gifford (P-G) stability for each hour of the day can be derived in two ways using Nuiqsut Station meteorological data. One procedure, referred to as the Solar Radiation Delta-T (SRDT) method, uses solar radiation and wind speed measurements during the daytime, and 10-2 meter temperature difference and wind speed at night. The other method for estimating P-G stability, referred to as the sigma-theta (σ_θ) method, uses measurements of wind speed and standard deviation of the horizontal wind direction. Both methods are summarized in

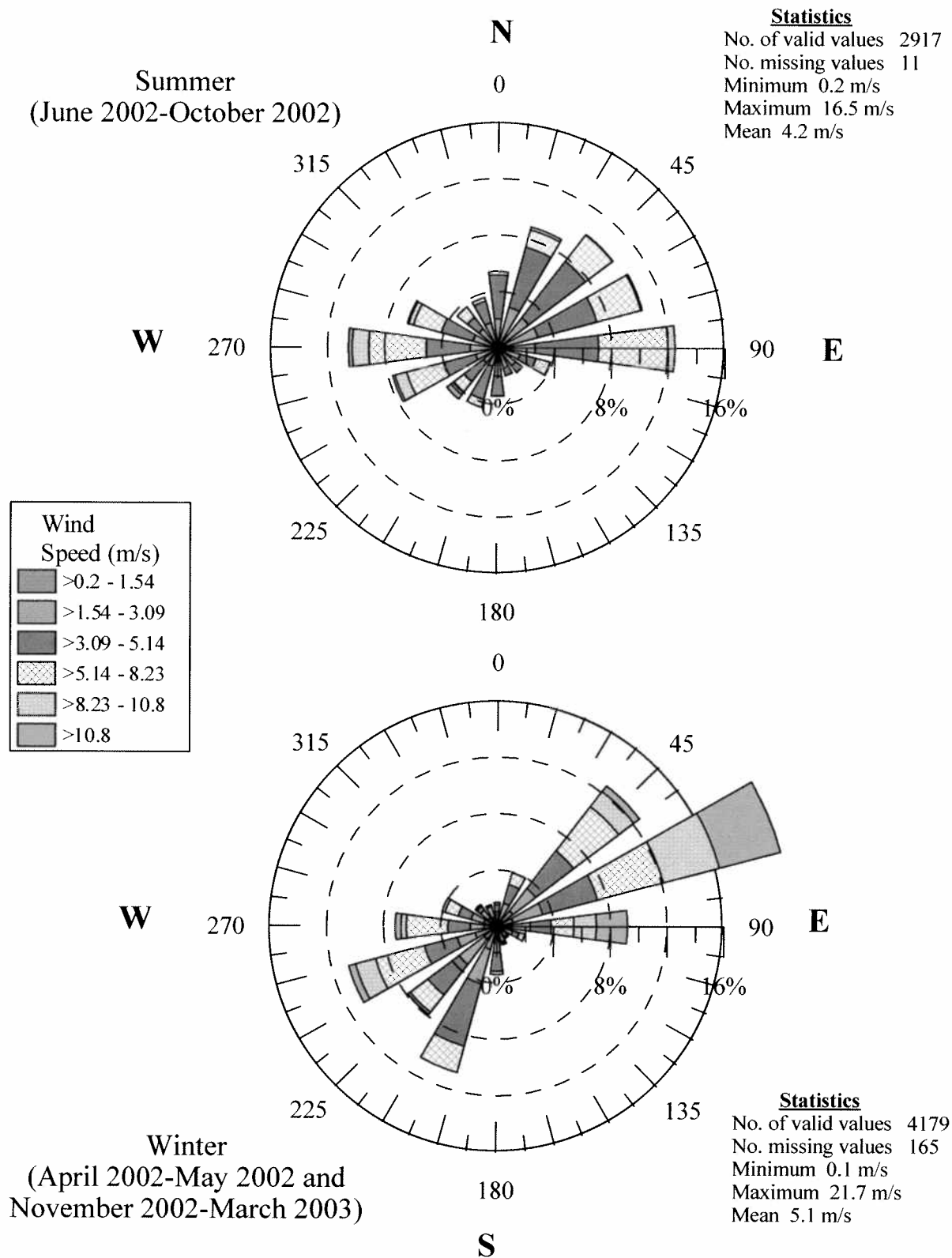


FIGURE 3-8: SEASONAL WIND ROSE ANALYSIS

Appendix A of this report. Derivation of SRDT stability estimates became possible following expansion of the meteorology program on July 24, 2001.

Figure 3-9 illustrates the distribution of the P-G stability classes using the SRDT and σ_0 methods for the period. The SRDT method estimates that neutral conditions occurred 77.2 percent of the time, while stable conditions (slightly stable and stable) occurred 11.8 percent of the time and unstable conditions (unstable and slightly unstable) occurred 11.1 percent of the time. Extremely unstable conditions were not estimated to occur using the SRDT method.

A comparison of the σ_0 method with the SRDT method shows a relative shift in category distribution from neutral to unstable using the σ_0 method. Estimated frequencies of stable conditions are similar for both methods (11.7 percent for σ_0 and 11.8 percent for SRDT). Note that because of the way that the SRDT method determines stability, extremely unstable, unstable, and slightly unstable conditions will not occur during nighttime hours near the winter solstice for the North Slope using this method. Both methods demonstrate that neutral stability conditions dominate, with unstable and stable conditions rarely occurring. Combining this information from the statistics gathered during previous monitoring years yields the following comparison:

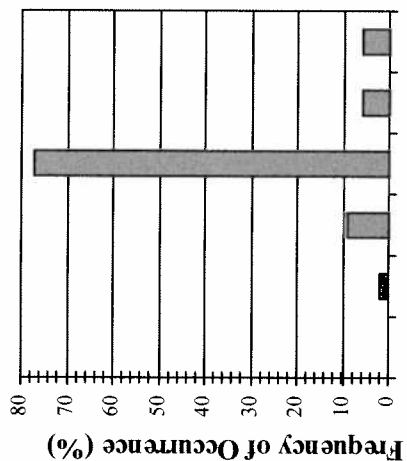
Stability Parameter	April 2002 through March 2003	April 2001 through March 2002	April 2000 through March 2001	April 1999 through March 2000
Frequency of Neutral Conditions (σ_0 Method)	65.2%	63.9 %	66.9 %	70.0%
Frequency of Neutral Conditions (SRDT Method)	77.2%	76.5 % ¹	N.A.	N.A.

¹ Monitoring of parameters necessary to make this assessment (solar radiation and temperature difference) began July 24, 2001. Percentage is based on 5791 valid hours.

NUIQSUT AIR QUALITY MONITORING SITE APRIL 1, 2002 THROUGH MARCH 31, 2003

Calculated using the SRDT Method

Stability Class	Frequency (%)
Extremely Unstable	0.0
Unstable	2.1
Slightly Unstable	9.0
Neutral	77.2
Slightly Stable	5.9
Stable	5.9



Calculated using the Sigma-Theta Method

Stability Class	Frequency (%)
Extremely Unstable	4.8
Unstable	4.6
Slightly Unstable	13.7
Neutral	65.2
Slightly Stable	7.0
Stable	4.7

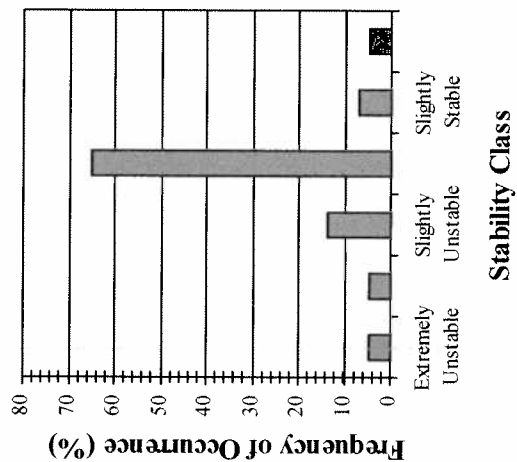


FIGURE 3-9: NUIQSUT STABILITY CLASS FREQUENCY DISTRIBUTIONS

3.2.3 Temperature Climatology

During the monitoring year, the hourly averaged near-surface (2-meter) ambient temperature reached a maximum of 27.0°C (80.6°F) on the afternoon of July 16, 2002 and a minimum of -40.4°C (-40.7°F) in the morning of February 14, 2003. Combining this information with statistics gathered during the last three monitoring years yields the following comparison which shows extremes measured this year are typical of those measured during the last three monitoring years.

Temperature	April 2002 through March 2003	April 2001 through March 2002	April 2000 through March 2001	April 1999 through March 2000
Maximum Hourly Temperature	27.0°C	28.0°C	27.1°C	27.8°C
Minimum Hourly Temperature	-40.4°C	-43.1°C	-43.0°C	-41.5°C

Figure 3-10 compares monthly averaged temperatures measured at Nuiqsut during the current monitoring year to historical data collected at Barrow and the Nuiqsut Station. Comparisons are made to Barrow data because it was collected over a 49-year period and is less likely influenced by interannual variability. With some exceptions, temperatures measured at Nuiqsut this monitoring year were as much as 3° to 5°C higher than those measured historically at Nuiqsut. The warmer than average winter temperatures resulted in ice road construction being delayed until late March and closure occurring only a month later. This observation is also reflected in the developing temperature climatology presented in Table 3-3 that shows that several station temperature maximums were broken this year at the Nuiqsut Station.

Figure 3-10 also shows that data collected at the Nuiqsut Station during the current monitoring year is consistently warmer than the longer term Barrow temperature climatology. This difference has been relatively constant since monitoring began and is in part related to the fact that the Nuiqsut Station is located further inland and away from moderating effects of the ocean compared to Barrow.

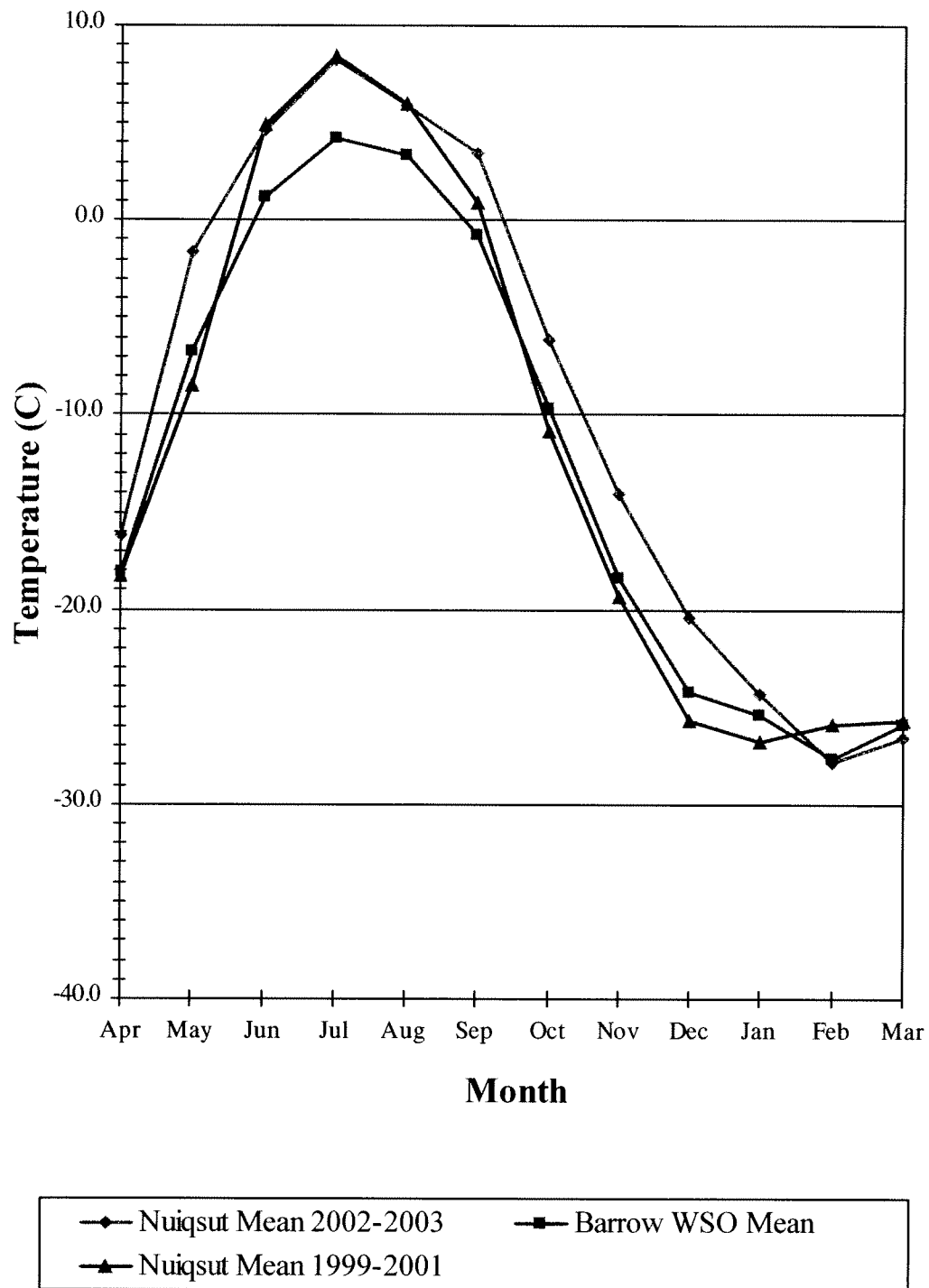


FIGURE 3-10: NUIQSUT TEMPERATURE CLIMATOLOGY

TABLE 3-3

**NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
TEMPERATURE CLIMATE SUMMARY
PERIOD OF RECORD APRIL 9, 1999 THROUGH MARCH 31, 2003**

2-Meter Temperature (°C)									
Month	Mean			Extreme					
	Maximum Daily (Monthly Average)	Minimum Daily (Monthly Average)	Monthly	Record Highest (Hourly Average)	Year	Day	Record Lowest (Hourly Average)	Year	Day
April 2002	-12.1	-21.9	-16.2	2.5	2002	26	-34.0	2000	4
May 2002	2.0	-5.4	-1.6	18.5	2002	24	-28.7	2001	1
June 2002	8.3	0.9	4.6	24.0	2000	25	-5.0	2000	5
July 2002	12.2	3.7	8.2	28.0	2001	16	-1.6	2002	26
August 2002	9.1	2.8	5.9	27.8	1999	5	-3.3	2000	27
September 2002	6.5	1.0	3.4	18.8	2002	5	-13.6	1999	30
October 2002	-4.0	-8.7	-6.1	1.7	2002	3	-27.2	1999	31
November 2002	-11.2	-17.8	-14.1	0.3	2002	1	-35.5	1999	5
December 2002	-17.2	-23.9	-20.4	-2.5	2001	28	-42.1	1999	18
January 2003	-21.2	-27.8	-24.3	-11.7	2003	22	-43.1	2002	23
February 2003	-25.1	-30.5	-27.9	-14.9	2003	8	-43.0	2001	25
March 2003	-23.1	-30.3	-26.6	-8.0	2003	6	-40.0	2003	26
Monitoring Year	-6.3	-13.2	-9.6	28.0	2001		-43.1	2002	

4.0 REFERENCES

- Alaska Department of Environmental Conservation (ADEC). 1996. Alaska Quality Assurance Manual for Ambient Air Quality Monitoring. Revised August 21, 1996.
- _____. 1998. Recent Changes to the PM₁₀ Monitoring Method. Letter from R. Heffern (ADEC) to C. Johnson, (SECOR), dated January 8, 1998.
- SECOR International Incorporated. 2000a. ARCO Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Plan (Revised). April 2000.
- _____. 2000b. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 1999 through March 2000. May 2000.
- _____. 2001a. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Project Addition of Federal Reference Method Particulate Monitoring - Final Addendum. January 2001.
- _____. 2001b. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 2000 through March 2001. May 2001.
- _____. 2002a. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 2001 through March 2002. July 2002.
- _____. 2002b. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Quarterly Report April 2002 through June 2002. August 2002.
- _____. 2002c. ConocoPhillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Quarterly Report July 2002 through September 2002. November 2002.
- _____. 2002d. Phillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Project Expanded Meteorological Monitoring - Draft Addendum. March 2002.
- _____. 2003a. ConocoPhillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Quarterly Report October 2002 through December 2002. February 2003.
- _____. 2003b. ConocoPhillips Alaska Inc. Nuiqsut Ambient Air Quality Monitoring Program Quarterly Report January 2003 through March 2003. May 2003.

- Phillips Alaska, Inc. (PAI). 2001. Letter from M. Stahl (PAI) to J. Baumgartner (ADEC) notifying ADEC that the ambient monitoring requirement contained in the Alpine Construction Permit had been met. Submitted March 27, 2001.
- United States Environmental Protection Agency (USEPA). 1987. Ambient Monitoring Guidelines for Prevention of Significant Deterioration. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-450/4-87-007. May 1987.
- _____. 1990. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II: Ambient Air Specific Methods (Interim Edition) Section 2.10: Reference Method for the Determination of Particulate Matter as PM₁₀ in the Atmosphere (Dichotomous Sampler Method). Office of Research and Development, Research Triangle Park, North Carolina. EPA-600/R-94/038b. April 1990.
- _____. 1994. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Ambient Air Specific Methods (Interim Edition). Office of Research and Development, Research Triangle Park, North Carolina. EPA-600/R-94/038b. April 1994.
- _____. 1995a. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume IV: Meteorological Measurements. Office of Research and Development, Research Triangle Park, North Carolina. EPA-600/R-94/038d. Revised March 1995.
- _____. 1995b. Supplemental Interim Guidance for Quality Assessment of Continuous PM₁₀ Analyzers. Memorandum from W. Mitchell and F. McElroy, Quality Assurance Branch, Air Measurements Research Division, Research Triangle Park, North Carolina. November 1995.
- _____. 1998. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Part 1. Ambient Air Quality Monitoring Program Quality System Development. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-98-004. August 1998.
- _____. 2000. Meteorological Monitoring Guidance for Regulatory Modeling Applications. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-450/4-99-005. February 2000.

_____. 2001. National Air Quality and Emissions Trends Report, 1999. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-01-004. March 2001.

Yamartino, R. J. 1984. A Comparison of Several "Single-Pass" Estimators of the Standard Deviation of Direction. J. Climate Appl. Meteorology, Vol. 23, pp. 1362-1366.