PHILLIPS ALASKA, INC.
NUIQSUT AMBIENT AIR QUALITY
MONITORING PROGRAM
ANNUAL DATA REPORT
APRIL 2001 THROUGH MARCH 2002

Prepared for:

PHILLIPS ALASKA, INC.
Anchorage, Alaska

Prepared by:

SECOR INTERNATIONAL INCORPORATED
Fort Collins, Colorado

July 2002

SECOR
International Incorporated

July 25, 2002

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

Re: *Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 2001 Through March 2002*

Dear Bruce,

Enclosed for your review and distribution are ten copies of the *Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 2001 Through March 2002.* 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 PAI's records (with data diskettes).

Please contact either me or Sims Duggins at (970) 226-4040 (ext 721 or 719) or e-mail (tdamiana@secor.com or sduggins@secor.com) if you have any questions or comments regarding this report or any other aspect of the project. We appreciate the opportunity to assist you with this project.

Sincerely,
SECOR *International Incorporated*

TOM DAMIANA

Tom Damiana
TD/

ref: 12OT.11481.00.0004
enc.: 10 Annual Reports

EXECUTIVE SUMMARY

This report summarizes data collected at the Nuiqsut Ambient Air Quality Monitoring Station (Nuiqsut Station) during the period April 1, 2001 through March 31, 2002. The Nuiqsut Station is operated for Phillips Alaska, Inc. (PAI) by SECOR International Incorporated (SECOR). The ambient monitoring program was established to address air quality concerns raised by the citizens of Nuiqsut and the North Slope Borough. In addition, the PAI Alpine construction permit (Permit # 0073-AC060) requires the operation of an ambient air monitoring station for one year. On March 27, 2001, PAI informed ADEC by letter (PAI 2001) that the ambient monitoring requirement contained in the Alpine permit had been met.

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 (EPA) Prevention of Significant Deterioration (PSD) program as administered by the Alaska Department of Environmental Conservation (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 2000), 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 2002b), ADEC review pending.

The monitoring station is instrumented and equipped to continuously measure the following parameters:

- nitrogen oxides (NO, NO_2, and NO_x),
- sulfur dioxide (SO_2),
- inhalable particulate matter less than 10 μm 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.

Official data collection began on April 9, 1999 for all parameters except PM_{10}, which began on April 25, 1999, and data collected as part of two expansions of the monitoring program. On

July 14, 2000, the monitoring program was expanded to include measurement of PM_{10} using a Partisol sequential air sampler. This sampler is designated as a Federal Reference Method (FRM) for measuring ambient PM_{10} concentrations. On July 24, 2001, the monitoring program was expanded further to add meteorological instrumentation designed to increase usefulness of data collected at Nuiqsut for purposes of regional air quality modeling.

Air quality data recovery exceeded project goals for all quarters except for Partisol PM_{10} sampling during the first quarter of 2002. Meteorological data recovery exceeded project goals for all months except for horizontal and vertical wind speed measurements in December 2001. Data recovery was particularly affected by the following events:

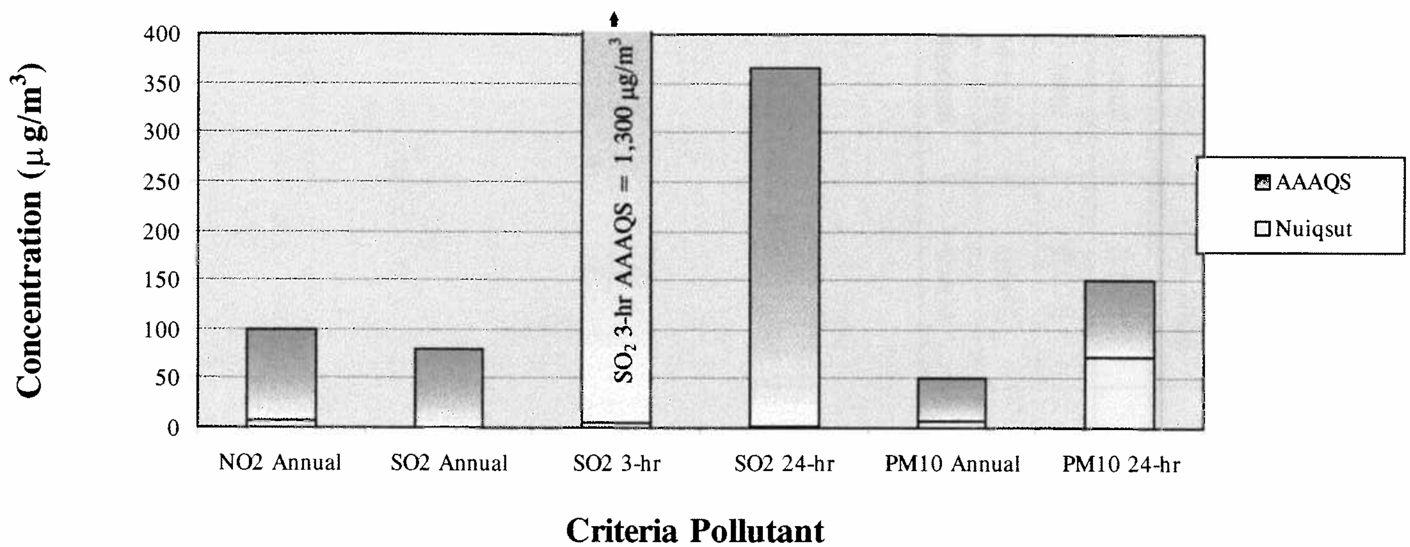
- Freezing precipitation in December 2001.
- Seven Partisol samples collected during the period December 9, 2001 through January 14, 2002 were lost in shipment from Nuiqsut to SECOR.

During the reporting period, monitored NO_2, SO_2, and PM_{10} concentrations were well below Alaska Ambient Air Quality Standards (AAAQS) which are equivalent to the 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 the appropriate AAAQS. As shown in these figures and tables, measured concentrations of all monitored pollutants were well below the applicable AAAQS.

The annual average NO_2 concentration was just above instrument detection, and well below applicable AAAQS. Summer seasonal averages were lower than winter seasonal averages, and only slightly higher than previous yearly averages. The highest impacts were measured when winds were from Nuiqsut to the monitoring site.

Annual period SO_2 data show that there was no single near-field or far-field source of measurable SO_2 identified in the data collected, indicating that measured concentrations are representative of a regional background signature, consistent with the rural environment of the site.

The annual average PM_{10} concentration was low compared to previous years and to the AAAQS despite some high daily impacts that occurred during the summer. In general, data collected this year shows again that the airshed particulate loading is low and the particulate that is present is generally a result of naturally occurring wind blown fugitive dust from exposed areas local to



Annual Concentrations are the average for the period April 1, 2001 through March 31, 2002.

FIGURE 1: SUMMARY OF AMBIENT AIR QUALITY DATA APRIL 2001 THROUGH MARCH 2002

TABLE 2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED PARTICULATE CONCENTRATIONS COMPARED TO
ALASKA AMBIENT AIR QUALITY STANDARDS
APRIL 2001 THROUGH MARCH 2002

Pollutant	Averaging Period	Maximum Period Average Concentration[1] (μg/m³)			AAAQS (ppm)
		1999-2000	2000-2001	2001-2002	
PM_{10}	24-hour[2]	222.9	113.4	72.1	150
	24-hour[3]	128.4	83.2	68.5	150
	Annual	8.3	8.4	6.6	50

1 Standard conditions
2 Maximum 24-hour average concentration
3 Second highest 24-hour average concentration

the monitoring site. Exposed areas identified this monitoring year were the exposed bank of the Nechelik channel east of the Nuiqsut Station, local construction activities east and south of the station, and to a much lesser degree, dirt roads within Nuiqsut. When fugitive dust from these sources is not present (i.e., especially during winter), hourly concentrations are at or below the instrument detection limit.

An objective comparison between data collected with the Partisol monitor and the TEOM monitor showed that though both instruments show the same trends, the Partisol data was consistently biased lower than the TEOM data.

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1.0 INTRODUCTION

In the spring of 1999, Phillips Alaska, Inc. (PAI) established an ambient air quality and meteorological monitoring station in Nuiqsut on the North Slope of Alaska in support of the Alpine Development Project. This report provides an annual summary of data collected at the Nuiqsut Ambient Air Quality Monitoring Station (Nuiqsut Station) for the period April 1, 2001 through March 31, 2002. Please refer to individual quarterly data reports (SECOR 2001b, SECOR 2001c, SECOR 2002a, SECOR 2002c) for additional details.

1.1 Background/History

On January 31, 2001, Phillips Alaska, Inc. (PAI), was issued a revised construction permit (Permit #0073-AC060) to establish an oil and gas exploration and production complex approximately 14 kilometers (km) north of Nuiqsut on the North Slope of Alaska. The project, called the Alpine Development Project, consists of a main site which includes a production facility, an operating camp, and a temporary drilling operation and satellite drilling site approximately 5 km to the west of the main production facility.

In anticipation of the proposed Alpine Development Project, representatives of Nuiqsut expressed an interest in characterizing the baseline ambient air quality conditions in Nuiqsut before and after the Alpine Development Project. In response to citizen concerns, PAI offered direct assistance to implement 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.

Though the program is primarily designed to characterize ambient air quality at Nuiqsut, it also fulfills permit requirements imposed on PAI by ADEC as described in Condition IV(C) of the Alpine Development Project construction permit. Simply stated, the permit requires PAI to collect at least one year of ambient NO_x, SO_2, PM_{10}, and dispersion meteorology data at Nuiqsut. On March 27, 2001, PAI informed ADEC by letter (PAI 2001) that the ambient monitoring requirement contained in the Alpine permit had been met.

To address citizen concerns and fulfill the permit requirements, PAI retained the services of SECOR International Incorporated (SECOR) to implement the Nuiqsut Ambient Air Quality

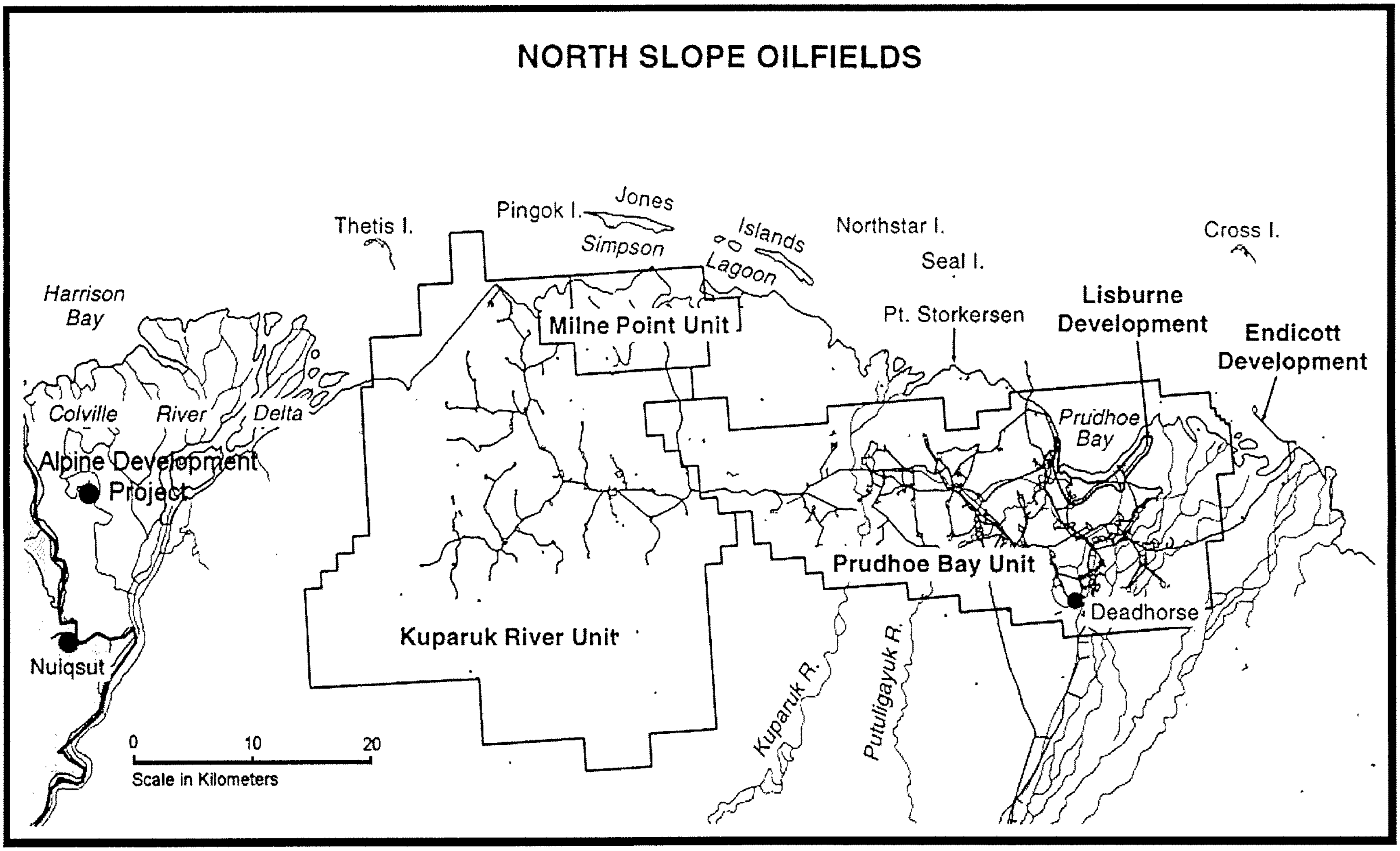


FIGURE 1-1: LOCATION OF REGIONAL NORTH SLOPE OIL FIELDS RELATIVE TO NUIQSUT

Monitoring Program. The program consists of a single ambient air quality and dispersion meteorology monitoring station within Nuiqsut, with data analysis and support provided from SECOR's Fort Collins, Colorado office with the aid of locally hired on-site technical support. The station was installed in the spring of 1999, and brought online in two phases: continuous meteorology, ambient NO_x, and ambient SO_2 collection began on April 9, 1999, while ambient PM_{10} sampling began on April 25, 1999.

Since station commissioning in the spring of 1999, the monitoring program has been expanded twice. On July 14, 2000 the monitoring program was expanded to include measurement of PM_{10} using a Partisol sequential air sampler. This sampler is designated as a Federal Reference Method (FRM) for measuring ambient PM_{10} concentrations. On July 24, 2001 meteorological monitoring was expanded to include additional measurements which are used to estimate atmospheric stability characteristics. This expansion was implemented so that meteorological data collected would better characterize low-level atmospheric stability which in turn could result in more refined predicted impacts from EPA regulatory models when this data is used as an input.

1.2 Project Implementation

Consistent with the goals of the Nuiqsut Ambient Air Quality Monitoring Program, the specific technical objectives of the program are to:

- document current baseline air quality conditions in Nuiqsut prior to operation of the Alpine complex,
- document air quality conditions after the Alpine facility becomes operational, and
- meet the ambient air quality and meteorological monitoring requirements set forth in the Alpine Development Project Permit No. 0073-AC060.

To meet these objectives, the Nuiqsut Station is instrumented and equipped to continuously measure the following parameters:

- nitrogen oxides (NO, NO_2, and NO_x),
- sulfur dioxide (SO_2),
- inhalable particulate matter less than 10 μm 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.

Table 1-1 shows the methods and instruments used to measure these parameters.

1.2.1 Nuiqsut Station Location

The station has been sited so that impacts due to oil and gas operations to the north and east can be distinguished from near-field impacts due to Nuiqsut 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 specific map is included in Figure 1-3 to show the site relative to Nuiqsut and near-field sources. This map is augmented by an aerial photo shown in Figure 1-4. This photo was taken in August 2000.

1.2.2 Project Monitoring Plan

The Monitoring Plan describes the protocols used to collect dispersion meteorology and ambient air quality data which meet the quality assurance (QA) and data recovery requirements of the 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 2000). Since that time, the monitoring program has been expanded twice requiring the following two addendum 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 final 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 2002b). ADEC review of the draft Expanded Meteorology addendum is pending.

The original monitoring plan along 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* (EPA 1987),

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	0-500 ppb	0.5 ppb	Chemiluminescence (EPA reference method RFNA-1289-074)
Sulfur Dioxide (SO_2)	Thermo Environmental Instruments (TECO) Model 43C	Continuous	1-hour	0 – 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 AC
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)	Computed by Data Logger	Continuous	1-hour	0 to 100°	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)
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/AC
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	N/A	Differential thermopile

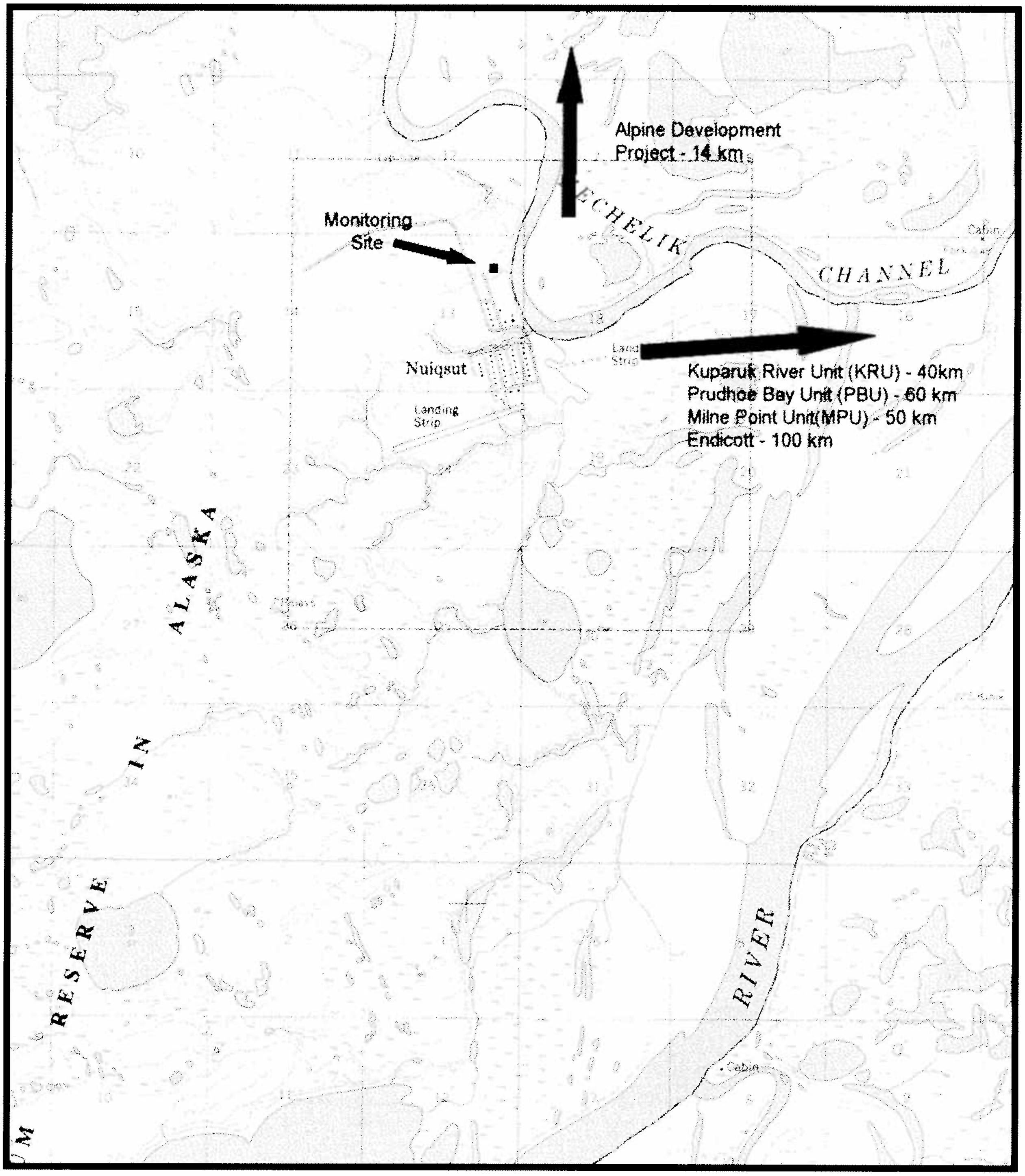


FIGURE 1-2: REGIONAL MAP

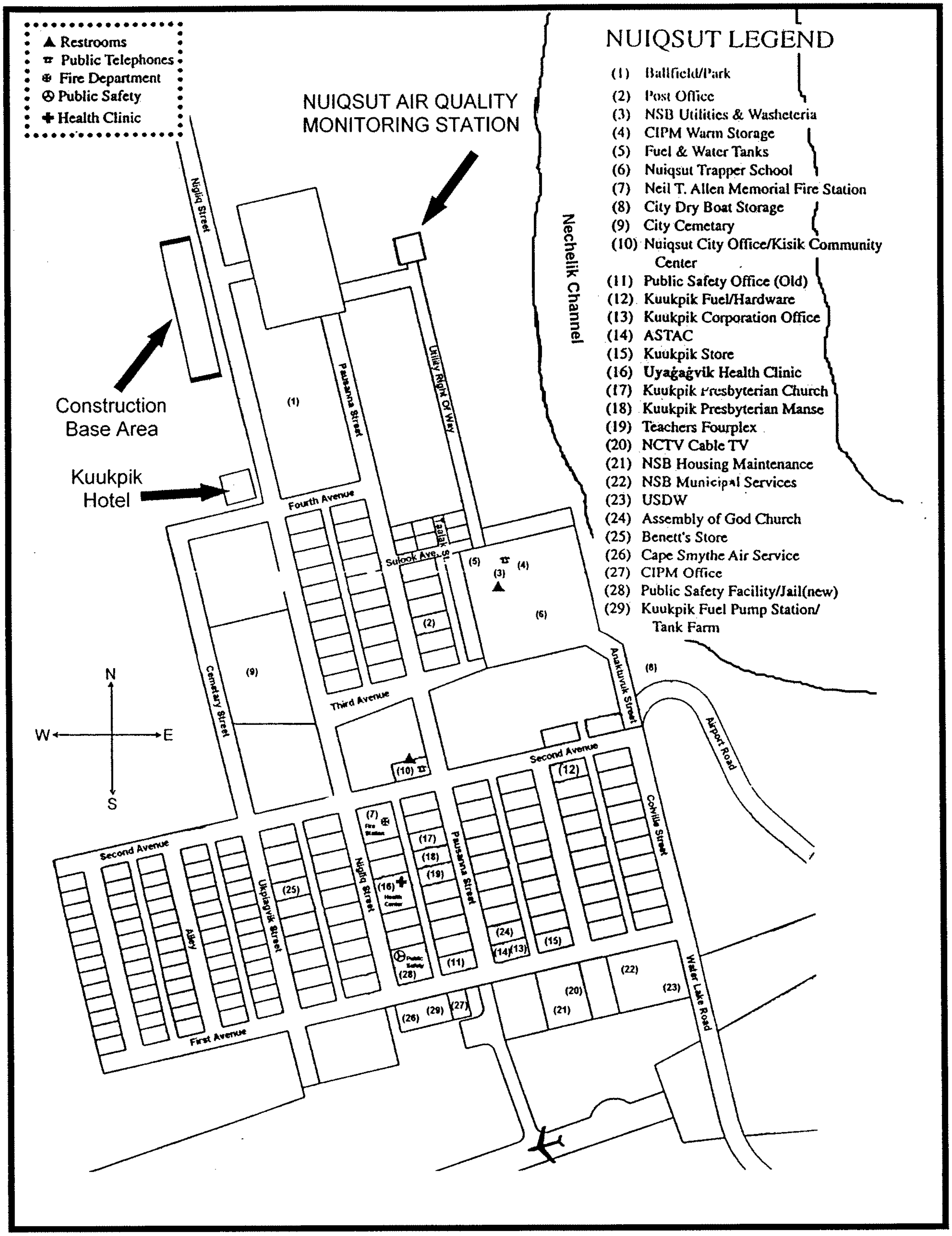


FIGURE 1-3: LOCAL MAP

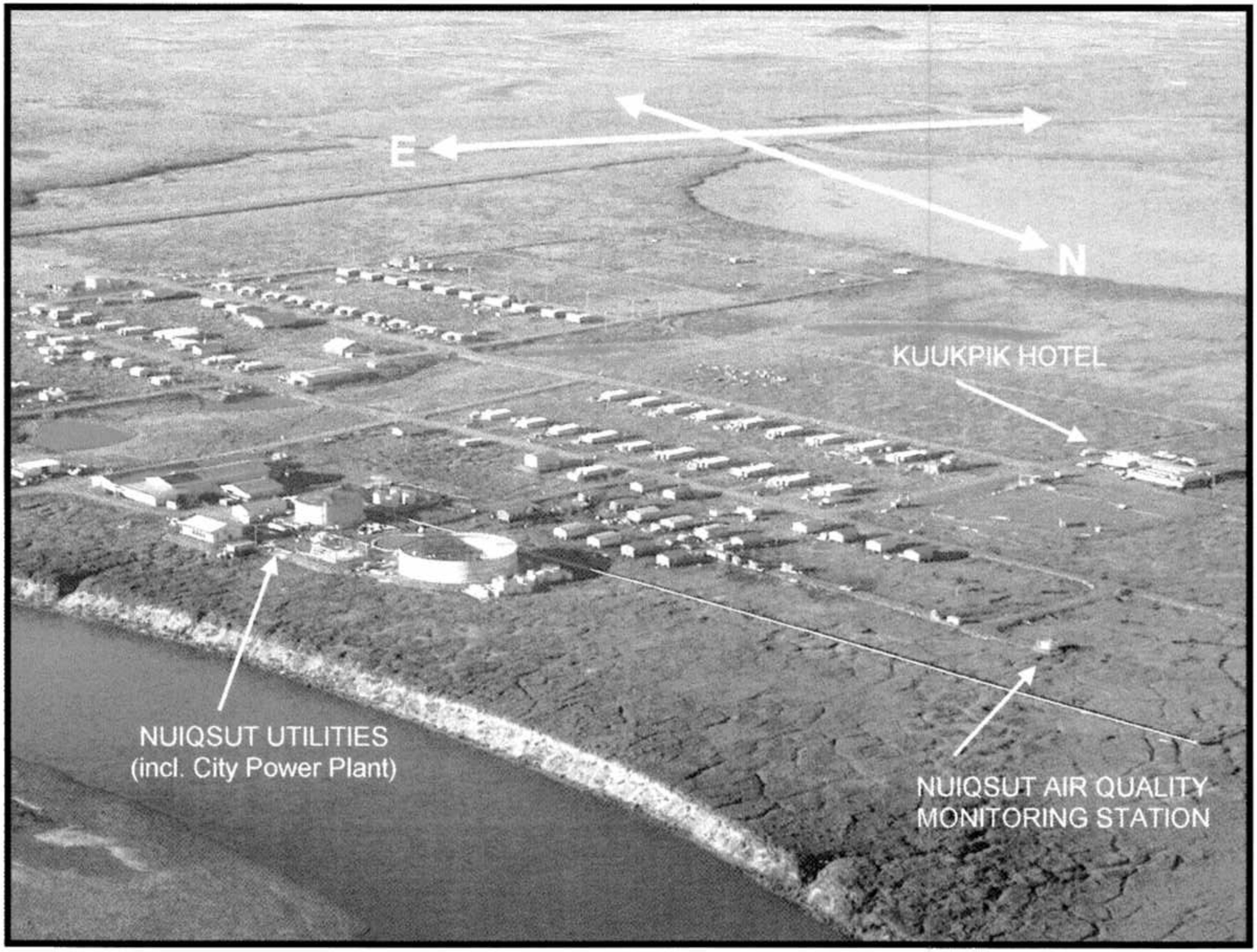


FIGURE 1-4: AERIAL PHOTO OF NUIQSUT

- *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA 2000),

- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II: Ambient Air Specific Methods (Interim Edition)* (EPA 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)* (EPA 1990),

- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume IV: Meteorological Measurements* (EPA 1995), *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*

1.3 Monitoring Report Overview

This report summarizes and documents the operation of the Nuiqsut Station and data collected during the third year of monitoring conducted at Nuiqsut, defined by the 12-month monitoring period April 1, 2001 through March 31, 2002. The report has been subdivided into several chapters. Chapter 2 discusses the performance of the monitoring network. 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 particulate concentration accuracy and precision reported by the Partisol sampler. Appendix C summarizes the contents of the diskette containing validated hourly data for the monitoring year.

2.0 STATION PERFORMANCE SUMMARY

This chapter presents a summary of events significant to station performance and contributing to data completeness, precision, and accuracy. Specific goals for data completeness, precision, and accuracy established in the Monitoring Plan are listed in Tables 2-1 through 2-5 for reference. Data recovery for most parameters exceeded project goals. Exceptions were horizontal and vertical wind speed parameters in December 2001, and PM_{10} as measured by the Partisol in the first quarter 2002. These exceptions are discussed in detail in Section 2.2 and in the appropriate quarterly reports. Except for Partisol field blank precision results (see Section 2.4.1), data accuracy and precision goals for all parameters were exceeded during the monitoring year.

2.1 Significant Project Events

Table 2-6 summarizes significant project events that occurred during the monitoring year. In addition to these significant events, data were lost during routine maintenance visits, power failures, and due to extreme blowing snow events which affected vertical and horizontal wind speed, wind direction, σ_θ, and TEOM PM_{10} data recovery.

2.2 Missing, Invalid, and Adjusted Data

Several routine adjustments have been made to the air quality data during the monitoring year to increase data quality. These data processing procedures are discussed below, and are detailed in Appendix A and in the Monitoring Plan.

- All hourly SO_2 and NO_x data are adjusted according to the procedure outlined in EPA (1998) and described in Appendix A. The adjustment procedure corrects data based on daily Level 1 zero/span and/or calibration results to eliminate instrument zero/span drift as completely as possible from the data. Without adjustment, zero or span drift of the instrumentation could be misinterpreted as low-level concentrations of NO_x or SO_2.

- All hourly SO_2 and NO_x data less than 0.000 ppm but greater than or equal to -0.001 ppm have been set to 0.000 ppm to conservatively remove negative biases from the data set that may remain after instrument drift corrections are applied. Values less than -0.001 ppm are also adjusted to 0.000 ppm but only after investigating for correctness.

TABLE 2-1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MINIMUM ACCURACY AND COMPLETENESS GOALS
METEOROLOGY DATA

Parameter	Accuracy [1]	Completeness [2]
Horizontal Wind Speed	± (0.2 m/s + 5% of observed)	90% per month for 12 consecutive months
Horizontal Wind Direction	± 5 compass degrees (total system accuracy) ± 3 degrees relative to the sensor mount (sensor linearity)	
Vertical Wind Speed	± (0.2 m/s + 5% of observed)	
Total Solar Radiation	± 5% of observed	
Temperature	± 0.5°C	
Temperature Difference	± 0.1 °C	

1 Based on calibrations and independent quality assurance performance audits.

2 Completeness goal is optional for vertical wind speed since these data are optional parameters for dispersion modeling.

TABLE 2-2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MINIMUM PRECISION, ACCURACY, AND COMPLETENESS GOALS
CONTINUOUS AIR QUALITY ANALYZER DATA

Parameter	Precision [1]	Accuracy [2]	Completeness
Nitrogen Oxides and Sulfur Dioxide	±15% of input value Quarterly reported 95% probability limits less than ±15%	±15% of input value Slope ≥ 0.85 and ≤ 1.15 -3% of FS ≤ Intercept ≤ 3% of FS $R^2 > 0.995$ NO_2 converter efficiency > 96%	80% per calendar quarter

[1] Based on precision checks.
[2] Based on calibrations and independent quality assurance performance audits.

TABLE 2-3

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MINIMUM PRECISION, ACCURACY, AND COMPLETENESS GOALS
CONTINUOUS PARTICULATE MONITORING DATA

Parameter	Precision [1]	Accuracy [2]	Completeness
PM_{10}	Main and auxiliary flow rate within ±2% of set points as indicated on monitor display	Main and auxiliary flow rate within ±2% of set points as indicated on monitor display Main flow rate within ±7% of 3.0 ℓ/min as indicated by reference flow device Auxiliary flow rate within ±7% of 13.67 ℓ/min as indicated by reference flow device Total flow rate within ±10% of 16.67 ℓ/min as indicated by reference flow device Mass transducer calibration constant within ±2.5% of factory-set value Temperature within ±1.0°C of actual Pressure within ±1.5% of actual	80% per calendar quarter

1 Based on precision checks.
2 Based on calibrations and independent quality assurance performance audits.

TABLE 2-4

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MINIMUM PRECISION, ACCURACY, AND COMPLETENESS GOALS 24-HOUR INTEGRATED PARTICULATE MONITORING DATA

Parameter	Precision [1]	Accuracy [2]	Completeness
PM_{10}	Flow rate within ±5% of set point as indicated on monitor display	Flow rate within ±5% as indicated on monitor display Flow rate within ±10% of 16.7 ℓ/min as indicated by reference flow device Time within ±5 minutes of actual time Ambient temperature within ±2.0°C of actual Ambient pressure within ±10 mm Hg of actual	80% per calendar quarter

1 Based on precision checks.
2 Based on calibrations and independent quality assurance performance audits.

TABLE 2-5

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MINIMUM PRECISION AND ACCURACY GOALS ANALYTICAL LABORATORY

Parameter	Precision	Accuracy
Filter mass analysis	±20 µg (exposed and unexposed duplicates)	±10 µg (laboratory balance)
Field and laboratory blanks	±20 µg	
Filter conditioning temperature	15°C ≤ T ≤ 30°C (±3°C)	(±1°C)
Filter conditioning relative humidity	20% ≤ RH ≤ 45% (±5%)	(±5%)

TABLE 2-6

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1, 2001 THROUGH MARCH 31, 2002

Date	Event/Comment
April 1, 2001 through April 13, 2001	On February 28, 2001 the mirror assembly inside the SO_2 analyzer degraded to the point that the analyzer had to be taken off-line and shipped to SECOR for repairs. A replacement analyzer was shipped from SECOR and installed on April 13.
May 1, 2001 through May 3, 2001	Second quarter 2001 calibration of the air quality monitoring system and first semi-annual calibration of the meteorological monitoring system performed by a SECOR technician. The calibration showed all systems to be operating within acceptable limits.
May 15, 2001 through May 16, 2001	Second quarter 2001 independent quality assurance audit of the air quality monitoring system and first semi-annual independent quality assurance audit of the meteorological monitoring system performed by AMSTech technician. The audit showed all systems to be operating within acceptable limits.
June 7, 2001 through June 9, 2001	The NO_x analyzer was placed off-line when the ozonator capillary tube became plugged and was replaced.
July 21, 2001	Third quarter 2001 independent quality assurance audit of the air quality monitoring system performed by AMSTech technician. The audit showed all systems to be operating within acceptable limits.
July 23, 2001 through July 24, 2001	Calibration of the air quality and meteorological monitoring system performed by a SECOR technician. The calibration showed all systems to be operating within acceptable limits.
	Expansion of the meteorological monitoring system.
August 16, 2001 through August 20, 2001	All SO_2 data were adjusted for an approximate 0.019 ppm zero offset caused by a faulty power supply.
September 17, 2001 through September 18, 2001	Third quarter 2001 calibration of the air quality monitoring system performed by a SECOR technician. The calibration showed all systems to be operating within acceptable limits.
September 18, 2001 through October 10, 2001	TEOM PM_{10} is invalid. The size selective inlet was not installed on the instrument.
September 17, 2001 through January 8, 2002	TEOM PM_{10} instrument hourly concentrations reported 0.94 percent low due to wrong TEOM calibration constant setting.

TABLE 2-6 (CONTINUED)

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1, 2001 THROUGH MARCH 31, 2002

Date	Event/Comment
September 17, 2001 through January 8, 2002	TEOM PM_{10} instrument hourly concentrations reported 0.94 percent low due to wrong TEOM calibration constant setting.
October 1, 2001 through October 11, 2001	All SO_2 data adjusted for an approximate 0.019 ppm zero offset caused by a faulty power supply.
October 10, 2001 through October 12, 2001	Fourth quarter 2001 independent quality assurance audit of the meteorological and air quality monitoring systems performed by AMSTech technician. The audit showed all systems to be operating within acceptable limits.
November 29, 2001 through December 1, 2001	All SO_2 data adjusted for an approximate 0.023 ppm zero offset caused by a faulty power supply.
December 2, 2001 through December 6, 2001	Vertical wind speed data invalid. Excessive snow loading on the propeller caused it to break.
December 5, 2001 through December 7, 2001	Fourth quarter 2001 calibration of the meteorological and air quality monitoring systems performed by a SECOR technician. The calibration showed all systems to be operating within acceptable limits.
December 8, 2001 through January 14, 2002	All SO_2 data adjusted for an approximate 0.023 ppm zero offset caused by a faulty power supply. The faulty power supply was fixed by replacing the photo-multiplier and main power supplies on February 23, 2002.
December 6, 2001 through March 27, 2002	All temperature data (2 meter, 10 meter and 10-2 meter) adjusted to correct temperature calibration curves.
December 9, 2001 through January 14, 2002	All Partisol samples missing. All samples were collected according to schedule, but were lost in shipping before they could be analyzed.

TABLE 2-6 (CONTINUED)

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1, 2001 THROUGH MARCH 31, 2002

Date	Event/Comment
February 23, 2002 through February 24, 2002	First quarter 2002 independent quality assurance audit of the air quality monitoring systems performed by AMSTech technician. The audit showed all instrumentation except the Partisol PM_{10} sampler to be operating within acceptable limits.
March 27, 2002 through March 28, 2002	First quarter 2002 calibration of the temperature and air quality monitoring systems performed by a SECOR technician. The calibration showed all systems to be operating within acceptable limits following calibration curve adjustment of both the 2 and 10 meter temperature sensors, and after maintenance on the Partisol PM_{10} sampler.

- On occasion, reported hourly average PM_{10} values are slightly less than zero (usually between 0 µg/m^3 and -5 µg/m^3). Negative PM_{10} 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, measured PM_{10} concentrations greater than -10 µg/m^3 are considered valid unless there is a documented reason to invalidate the data. Measured concentrations of -10 µg/m^3 or less are considered invalid.

The following sub-sections summarize non-routine data losses for each specific portion of the monitoring network. Additional data losses 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 SO_2 Data

Premature degradation of the surface of the SO_2 analyzer mirror assembly mirrors caused the analyzer to fail performance limits on February 28, 2001. A replacement analyzer was shipped from SECOR and was installed, calibrated and brought on-line April 13, 2001.

On four occasions from August 2001 through January 2002 the SO_2 analyzer developed a constant zero offset of approximately 0.020 ppm. The offset generally occurred following a site power failure and was fixed by manually adjusting the analyzer. The analyzer main and photomultiplier power supplies were replaced on February 23, 2002 and the problem has not reoccurred.

2.2.2 Continuous PM_{10} Data (TEOM)

PM_{10} concentrations reported by the TEOM were invalidated from mid-September through mid-October because the size selective inlet was not installed on the instrument.

On September 17, 2001, the TEOM calibration constant (K_0) was changed from the factory set value causing concentrations to be reported 0.94 percent low until it was changed back on January 8, 2002. Since the incorrect K_0 value resulted in errors in concentration of less than the instrument accuracy no data was corrected.

Similar to previous years, several, but not an excessive amount of hours of continuous PM_{10} data were lost during the winter of 2001-2002 due to extreme blowing snow events resulting in snow intake into the system. Unlike typical blowing snow events, extreme events affected the operation of the TEOM particulate monitor and data recovery. The effect of these events on instrument operation was discussed in the 2000-2001 annual data report and the appropriate quarterly reports for the 2001-2002 monitoring year.

There were no other major losses of PM_{10} data during the monitoring year.

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 EPA designated sampling schedule.

A total of 196 of 214 scheduled Partisol samples were collected during the monitoring year. Several samples were lost due to sample scheduling errors and filters not being loaded into the instrument on schedule. Additionally, seven valid samples collected from December 9, 2001 through January 14, 2002 were lost in shipping from Nuiqsut to SECOR. No other significant losses of Partisol data occurred during the monitoring year.

2.2.4 Meteorological Data

There were no significant losses of meteorological data during the monitoring year except for wind speed measurements (horizontal and vertical) in December 2001. In December 2001, there were several days of lost horizontal and vertical wind speed data as a result of freezing precipitation and frozen sensors. During one four day period in the beginning of December, excessive snow loading on the vertical wind speed sensor propeller caused it to break. However, losses of data due to frozen sensors was generally low this winter compared to previous years. This is partially a reflection of the responsiveness of the on-site technician who frequently cleared the meteorological tower of snow.

On July 24, 2001 the meteorological monitoring program was expanded to include additional measurements related to atmospheric stability characteristics. This expansion was implemented so that meteorological data collected would better characterize low-level atmospheric stability which in turn could result in more refined predicted impacts from EPA regulatory models when this data is used as an input. The program was expanded to include the following meteorological measurements:

- 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.

The expanded monitoring program is described in an addendum to the original monitoring plan that was submitted to ADEC in March 2002 (SECOR 2002b).

The 10 and 2 meter sensor calibration curve constants were changed during the fourth quarterly calibration conducted on December 6, 2001 and should not have been. The calibration curve constants for both sensors were reset to pre-December 6, 2001 values on March 27, 2002. All affected temperature data was corrected using the pre- and post-December 6, 2001 calibration curve constants.

2.3 Network Data Recovery

Data recovery percentages for each continuous air quality and meteorological parameter have been calculated based on the total number of hours of valid data collected versus the total number of possible hours in the period. Data missing due to routine maintenance, calibrations, quality assurance audits, and data which did not satisfy program criteria for accuracy and quality assurance were considered invalid when calculating data recovery. During the monitoring year, data recovery for all meteorological parameters exceeded the minimum project goal of 90 percent per month for all months except December 2001. Data recovery for all continuous monitored air quality parameters exceeded the minimum goal of 80 percent per calendar quarter. Only supplemental Partisol particulate sampling failed to achieve the 80 percent quarterly goal as previously discussed. Table 2-7 provides a summary of monthly data recovery for each parameter.

2.4 Precision Statistics

Precision statistics have been calculated for the NO_x and SO_2 analyzers based on the method outlined by the EPA (EPA 1993a) and summarized in Appendix A of this report.

The average percent differences ($\bar{d}_j$) between known input concentrations and the observed analyzer responses for the NO_x and SO_2 analyzers have been calculated along with the standard deviation of the percent differences (S_j), and the upper and lower 95 percent probability limits

TABLE 2-7
NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
CONTINUOUS AIR QUALITY AND METEOROLOGICAL
DATA RECOVERY STATISTICS
APRIL 1, 2001 THROUGH MARCH 31, 2002

PARAMETER	APR 2001 (%)	MAY 2001 (%)	JUN 2001 (%)	JUL 2001 (%)	AUG 2001 (%)	SEP 2001 (%)	OCT 2001 (%)	NOV 2001 (%)	DEC 2001 (%)	JAN 2002 (%)	FEB 2002 (%)	MAR 2002 (%)	Q2 2001 (%)	Q3 2001 (%)	Q4 2001 (%)	Q1 2002 (%)	Annual 2001 (%)
Meteorological																	
10-m Wind Speed	100.0	99.2	100.0	96.0	99.7	99.0	98.9	99.6	84.0	97.7	95.4	96.2	99.7	98.2	94.1	96.5	97.1
10-m Wind Direction	100.0	99.2	100.0	96.0	99.7	98.9	99.6	99.9	98.8	97.7	95.4	96.2	99.7	98.2	99.4	96.5	98.5
10-m Sigma-Theta (σ_θ)	100.0	99.2	100.0	95.8	99.7	98.9	99.6	99.9	98.8	97.7	95.4	96.2	99.7	98.1	99.4	96.5	98.4
10-m Vertical Wind Speed	na	na	na	100.0	99.1	86.9	92.9	99.0	78.6	93.0	96.1	96.2	na	93.9	90.1	95.1	92.9
10-m Sigma-w (σ_w)	na	na	na	100.0	99.1	86.9	92.9	99.0	78.6	93.0	96.1	96.2	na	93.9	90.1	95.1	92.9
10-m Temperature	na	na	na	100.0	99.7	99.0	99.6	99.9	98.7	100.0	99.7	96.2	na	99.5	99.4	98.6	99.1
2-m Temperature	100.0	98.9	100.0	96.0	99.7	99.0	99.6	99.9	98.7	100.0	99.7	96.2	99.6	98.2	99.4	98.6	99.0
10-2m Temperature Difference	na	na	na	100.0	99.7	99.0	99.6	99.9	98.7	100.0	99.7	96.2	na	99.5	99.4	98.6	99.1
Total Solar Radiation	na	na	na	100.0	99.7	99.0	100.0	100.0	100.0	100.0	100.0	97.8	na	99.5	100.0	99.3	99.6
Meteorological Only	100.0	99.1	100.0	96.9	99.6	96.3	98.1	99.7	92.8	97.7	97.5	96.4	99.7	97.7	96.8	97.2	97.5

Note: na indicates that the instrumentation was not installed so statistics are not available.

TABLE 2-7 (CONTINUED)
NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
CONTINUOUS AIR QUALITY AND METEOROLOGICAL
DATA RECOVERY STATISTICS
APRIL 1, 2001 THROUGH MARCH 31, 2002

PARAMETER	APR 2000 (%)	MAY 2000 (%)	JUN 2000 (%)	JUL 2000 (%)	AUG 2000 (%)	SEP 2000 (%)	OCT 2000 (%)	NOV 2000 (%)	DEC 2000 (%)	JAN 2001 (%)	FEB 2001 (%)	MAR 2001 (%)	Q2 2000 (%)	Q3 2000 (%)	Q4 2000 (%)	Q1 2001 (%)	Annual 2001 (%)
Air Quality																	
Nitrogen Dioxide (NO_2)	99.0	96.8	93.5	94.8	99.2	98.6	97.4	97.4	97.7	98.7	97.9	95.3	96.4	97.5	97.5	97.3	97.2
Nitric Oxide (NO)	99.0	96.8	93.5	94.8	99.2	98.6	97.4	97.4	97.7	98.7	97.9	95.3	96.4	97.5	97.5	97.3	97.2
Sulfur Dioxide (SO_2)	56.5	96.8	98.9	94.8	99.2	98.5	98.5	99.3	97.7	98.7	98.2	95.3	84.2	97.5	98.5	97.4	94.4
Particulate (PM_{10}) (TEOM)	92.5	98.1	100.0	98.7	99.7	55.4	67.1	87.6	92.6	97.2	88.4	94.1	96.9	84.9	82.4	93.4	89.3
Particulate (PM_{10}) (Partisol)	60.0	83.3	93.3	96.8	100.0	100.0	87.1	100.0	20.0	40.0[1]	80.0	100.0	87.8	98.9	87.9	73.3	91.6
Air Quality Only	85.7	96.5	95.8	95.9	99.5	90.2	89.5	96.3	93.5	96.0	94.9	95.2	92.9	95.3	93.0	95.4	94.2
ALL PARAMETERS	92.7	97.8	97.7	96.4	99.5	97.1	95.0	98.5	93.0	97.2	96.7	96.0	96.6	97.8	95.5	96.6	96.3

[1] All samples leading to low data recovery were collected as scheduled, but were lost in shipping before they could be analyzed.

(U_{95}, L_{95}) based on the total number of precision checks (N) performed during the period. The NO_2, NO, and SO_2 precision results, shown in Table 2-8 and Table A-1 in Appendix A, indicate that the air quality analyzers operated within tolerances listed in Table 2-2.

Precision of the PM_{10} 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 (EPA 1995a), 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.

2.4.1 Analytical Lab Quality Assurance Results

Replicate Samples, Field Blanks, and Laboratory Blanks

Measurement precision between successive weights of the same filter (replicate samples) quantifies potential laboratory (i.e. balance, procedures, handling, etc.) bias introduced into analytical results. Cumulative laboratory replicate statistics are listed in Appendix B, Table B-1. Table B-1 shows that every replicate sample analyzed during the monitoring year has met the minimum precision goal, indicating that current procedures are acceptable.

Measurement precision of a filter which has been handled exactly like sampled filters, except that it is not sampled (field blank), quantifies potential bias associated with filter handling and analysis procedures. Cumulative field blank statistics are listed in Appendix B, Table B-2. All field blank samples collected indicate that filter handling procedures result in mass accumulation. Eight of the 15 field blank samples collected during the monitoring year show that the mass accumulation is outside acceptable limits. In the last quarter of the monitoring year (first quarter 2002), field blank statistics are still showing an accumulation of mass, but most are beginning to show an accumulation within the project precision goal of ±20 μg. Filter handling procedures are improving, but more improvement is needed.

Measurement precision of a filter weighed before and after the laboratory conditioning process (laboratory blank) indicates problems with conditioning procedures. Cumulative laboratory blank statistics are listed in Appendix B, Table B-3. Table B-3 shows that every duplicate sample analyzed during the quarter has met the minimum precision goal, indicating that current procedures are acceptable.

TABLE 2-8

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
NO_2, NO, AND SO_2 PRECISION STATISTICS
APRIL 1, 2001 THROUGH MARCH 31, 2002

Analyzer	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	61	-0.6	2.5	4.3	-5.6
NO_2	59	-1.6	4.5	7.3	-10.5
SO_2	63	0.4	3.1	6.5	-5.7

Filter Conditioning Environment

Filter conditioning statistics for the samples analyzed this quarter are listed in Appendix B, Table B-4. These statistics show that filters have been equilibrated within the ranges and control tolerances listed in Table 2-5.

2.5 Data Accuracy

The meteorological and ambient air quality monitoring systems are subjected to periodic calibrations and independent quality assurance performance audits. All calibration and audit equipment is documented as traceable to authoritative standards. The purpose of these calibration and audit checks is to challenge the monitoring systems with known inputs and to verify that each instrument response is accurate to within EPA-established tolerances. Consistent with the goals of the project Monitoring Plan, four quarterly calibrations of the air quality monitoring system, and two semi-annual calibrations of the meteorological monitoring system, were performed. In addition to these quality assurance activities 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 Fort Collins SECOR office 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 2002 independent quality assurance audit of the Partisol sampler, all calibrations and independent quality assurance audits showed the station systems to be operating within acceptable limits and that procedures described in the project monitoring plan were being followed. The first quarter independent quality assurance audit of the air quality monitoring system found that the Partisol PM_{10} sampler failed the leak check.

A SECOR technician conducted an additional calibration on July 23, 2001 as part of the expansion of the meteorological monitoring system so that station operation could be documented before and after the expansion.

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 as it is 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 at the Nuiqsut Station are nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and respirable particulate less than 10 μm in diameter (PM_{10}). Criteria pollutants are air pollutants that ADEC has established Alaska Ambient Air Quality Standards (AAAQS). These standards provide a threshold above which risk to public health and welfare may become an issue. The applicable AAAQS, along with ambient concentrations measured at the site, are presented in Table 3-1 and summarized by pollutant below.

3.1.1 Nitrogen Dioxide

As shown in Table 3-1. The annual average NO_2 concentration was 0.004 ppm, compared to the annual NO_2 AAAQS of 0.053 ppm and previous year averages of 0.003 ppm in 1999 and 2000. The annual average NO_2 concentration is just above instrument detection and only 7.5 percent of the NO_2 AAAQS.

The highest hourly concentration measured during the monitoring year was 0.027 ppm and was measured under conditions of moderate winds from the southeast on the evening of April 7, 2001. Based on wind direction, magnitude, and timing of the measurement, this impact appears to be associated with near-field emissions from the Nuiqsut power station or a vehicle(s) parked on the utility right of way near the monitoring station. This is further

TABLE 3-1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED NO_2, SO_2, AND PM_{10} CONCENTRATIONS APRIL 1, 2001 THROUGH MARCH 31, 2002

Monitoring Period	Period Average NO_2 Concentration (ppm)	Maximum 3-hour SO_2 Concentration[3] (ppm)	Maximum 24-hour SO_2 Concentration (ppm)	Period Average SO_2 Concentration (ppm)	Maximum 24-hour PM_{10} Concentration[2] ($\mu g/m^3$)		Period Average PM_{10} Concentration[2] ($\mu g/m^3$)	
					Standard	Actual	Standard	Actual
April 2001	0.003	0.001	0.000	0.000	2.9	3.3	2.6	3.0
May 2001	0.002	0.000	0.000	0.000	20.5	22.2	6.1	6.9
June 2001	0.003	0.000	0.000	0.000	19.6	21.1	7.8	8.2
July 2001	0.002	0.000	0.000	0.000	72.1	77.0	17.6	18.3
August 2001	0.002	0.000	0.000	0.000	14.3	14.8	5.3	5.6
September 2001	0.003	0.001	0.000	0.000	11.8	12.4	5.0	5.3
October 2001	0.003	0.001	0.001	0.000	13.6	15.4	5.5	6.4
November 2001	0.004	0.001	0.001	0.000	10.9	12.6	5.6	6.5
December 2001	0.004	0.002	0.001	0.000	13.8	16.4	6.7	8.0
January 2002	0.006	0.002	0.001	0.001	12.1	14.5	5.9	7.2
February 2002	0.007	0.001	0.000	0.000	22.5	26.8	4.9	5.9
March 2002	0.010	0.002	0.001	0.000	13.7	15.6	6.2	7.3
Reporting Period	0.004	0.002	0.001	0.000	72.1	77.0	6.6	7.4
AAAQS	**0.053** [1]	**0.5**	**0.14**	**0.03** [1]	**150**	**n/a**	**50** [1]	**n/a**

1 Annual average
2 Based on continuous particulate (TEOM) data
3 Running 3-hour average

reinforced by the high concentrations of nitrogen oxide (NO) which peaked at 0.097 ppm at the same time. This suggests "fresh" exhaust impacts.

As with previous years, measured hourly NO_2 concentrations were very low this monitoring year, resulting in a yearly average slightly higher than annual averages obtained during the previous two monitoring years. Properties of hourly NO_2 concentrations measured at the Nuiqsut Station averaged by wind direction and a frequency analysis of hourly NO_2 measurements are shown in Figure 3-1. This combined analysis shows the following characteristics of the ambient NO_2 concentrations measured at Nuiqsut during the monitoring year:

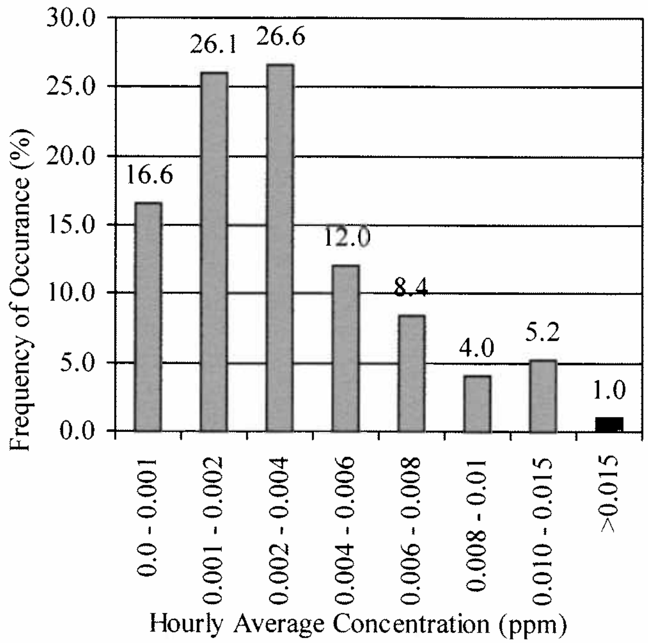
- Concentrations measured when winds transport background air to the monitoring site and Nuiqsut (west-northwesterly through east-northeasterly wind directions) were approximately 0.001 ppm higher this monitoring year compared to 1999 and 2000. The average NO_2 concentration measured over these wind directions was 0.003 ppm, which is slightly lower than the yearly average.

- Generally, NO_2 concentrations measured when winds were transporting air from Nuiqsut toward the monitoring site (southeast through westerly wind directions) were equal to those measured over the same directions during the last monitoring year.

- Similar to the last monitoring year, the highest average NO_2 concentrations were associated with near-field activities occurring in Nuiqsut southeast through southwest of the monitoring station. This trend is a result of the close proximity of fuel combustion sources within Nuiqsut to the monitoring station.

- 17 percent of the hourly measurements were less than or equal to the instrument detection limit of 0.001 ppm.

Monthly average NO_2 concentrations as a percentage of the AAAQS for the monitoring year are presented in Figure 3-2. This figure shows that during winter months (designated as November through April) the average hourly concentration was 0.006 ppm (11 percent of the AAAQS), and during summer months (designated as June through September) average hourly concentrations were 0.003 ppm (6 percent of the AAAQS). Increases in monthly averaged NO_2 concentrations observed during winter has been typical throughout the monitoring program and reflects the increased frequency of stable and neutral dispersion characteristics of the atmosphere in winter.



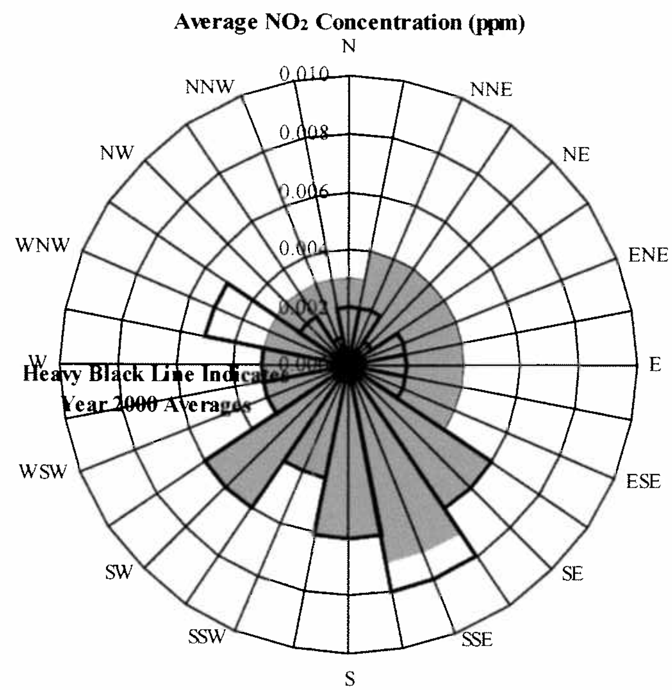


FIGURE 3-1: NO_2 FREQUENCY ANALYSIS AND AVERAGE CONCENTRATION BY WIND DIRECTION

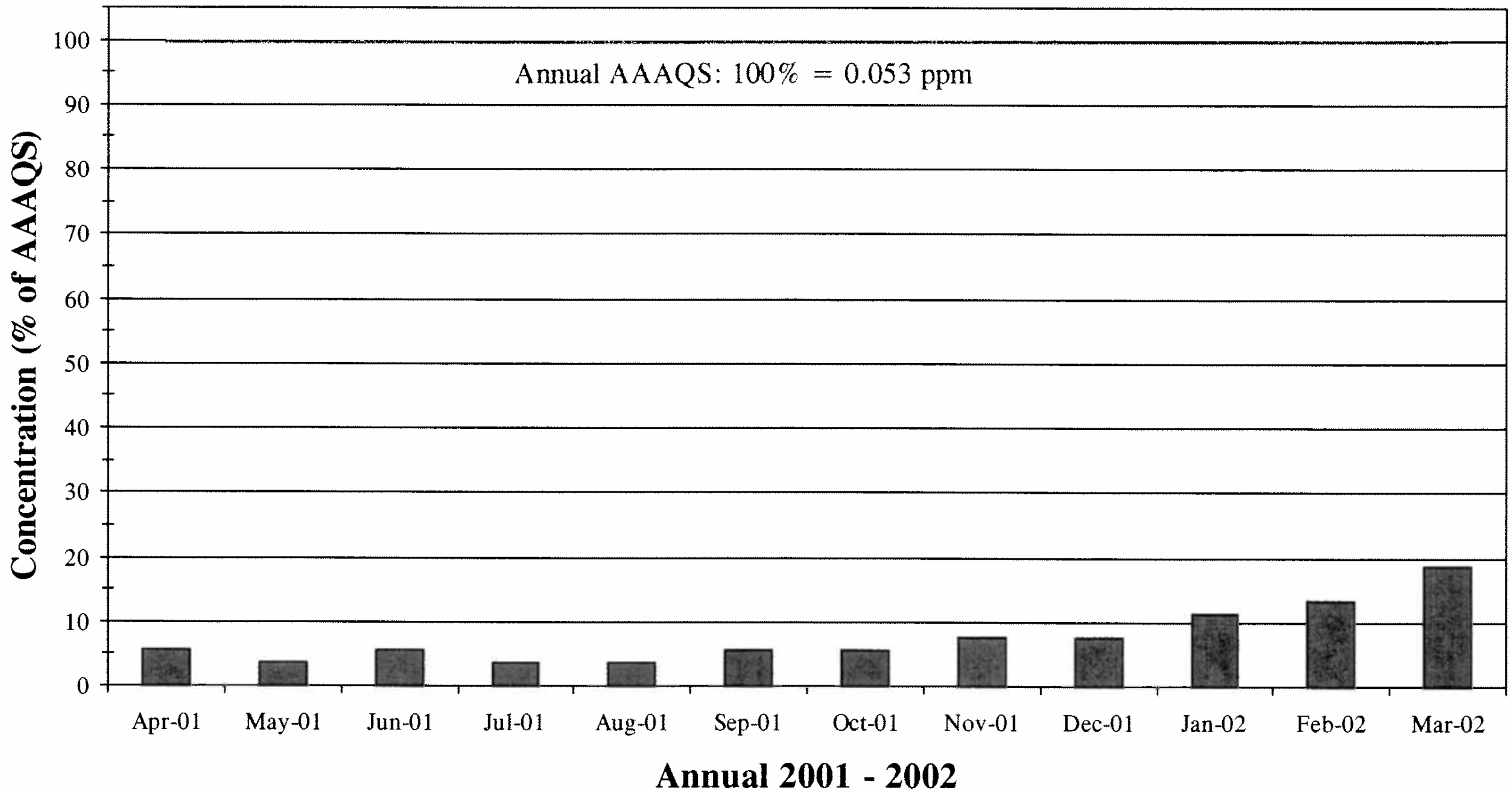


FIGURE 3-2: AVERAGE NO_2 CONCENTRATION BY MONTH

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 seasonal differences in average NO_2 concentrations are not wind direction dependant. The pattern of higher measured impacts in winter is a reflection of the differences in dispersion characteristics of the atmosphere between winter and summer. In summer, the sun is up, 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.

3.1.2 Sulfur Dioxide

There were only 72 hours during the monitoring year when measured SO_2 concentrations were 0.002 ppm or higher. None of these measurements was higher than 0.004 ppm. There was no single near-field or far-field source of measurable SO_2 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.

Table 3-1 lists measured maximum 3-hour (running) and 24-hour (midnight-to-midnight) average SO_2 concentrations for each month, as well as the annual average SO_2 concentration. Concentrations for all three averaging periods were either zero or near the instrument detection limit and were well below the applicable AAAQS. In general, measured SO_2 concentrations are lower than in previous years.

3.1.3 Respirable Particulate Matter (PM_{10}) - TEOM Data

Throughout the history of the monitoring project, the majority and highest measured particulate concentrations have been the result of naturally occurring wind blown fugitive dust from exposed or disturbed areas local to the monitoring site. Exposed areas identified so far 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 southeast through south-southeast of the station, and

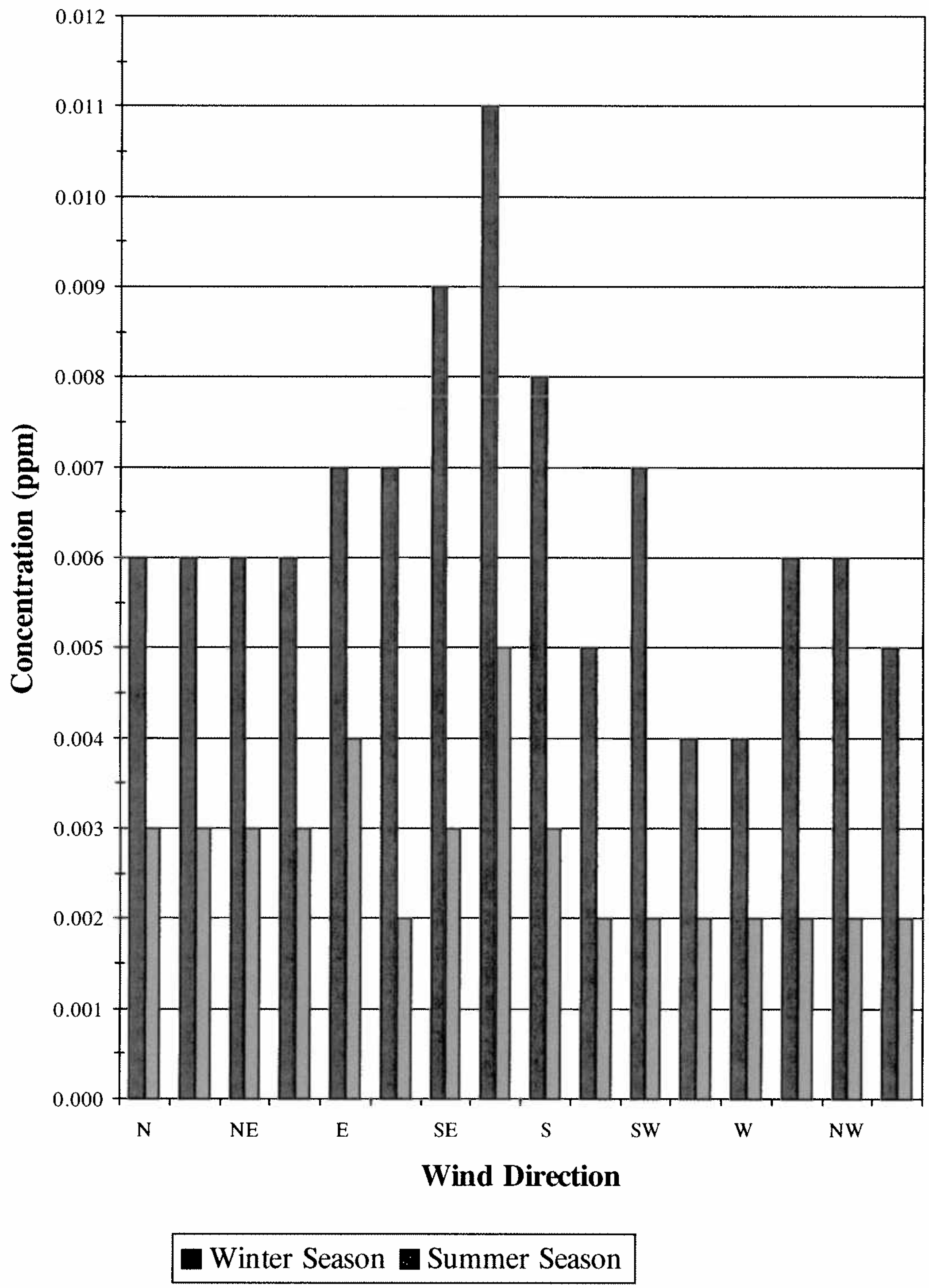


FIGURE 3-3: AVERAGE HOURLY NO_2 CONCENTRATION BY WIND DIRECTION AND SEASON

- to a much lesser degree, disturbed ground associated with dirt roads within Nuiqsut south through west-southwest of the station.

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

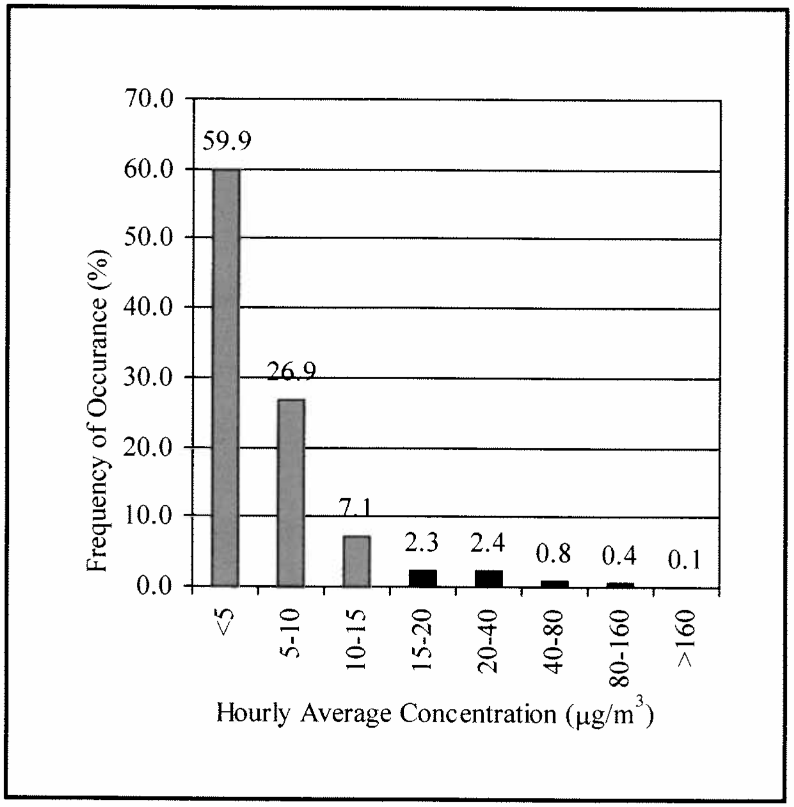
Respirable particulate matter less than 10 μm in diameter (PM_{10}), has a 24-hour (midnight-to-midnight) AAAQS of 150 μg/m^3, and an annual AAAQS of 50 μg/m^3, measured at standard temperature and pressure conditions. As listed in Table 3-1, the maximum 24-hour PM_{10} concentration measured during the monitoring year was 72.1 μg/m^3, which is below the 24-hour AAAQS, and is just under 70 percent of the maximum 24-hour concentration measured during the last monitoring year. The yearly average PM_{10} concentration was 5.7 μg/m^3, which is lower than the average of 8.4 μg/m^3 obtained last year and is well below the annual AAAQS of 50 μg/m^3.

Table 3-1 demonstrates that the annual average concentration is quite low especially when compared to the average annual concentration obtained from the 153 rural sites listed in the National Air Quality and Emissions Trends Report, 1999 (EPA 2001). For rural sites, the typical annually averaged concentration compiled in this summary was 19.2 μg/m^3. The low concentrations measured at Nuiqsut have been typical since monitoring began.

The highest 24-hour PM_{10} concentration of 72.1 μg/m^3 occurred on July 11, 2001, a day with steady east-northeasterly winds and hourly wind speeds in excess of 9 m/s. Measured particulate concentrations on this date were a result of strong winds transporting fugitive dust to the monitoring station from the adjacent thawed, exposed Nechelik channel bank. This conclusion is supported by discussions with Nuiqsut residents and is consistent with the historical data set.

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

- Sixty percent of the measurements (an equal number to the last monitoring year) were at or below 5 μg/m^3, as shown in the frequency analysis. The high percentage of low measurements is explained by the general rural site setting combined with frozen and or snow covered ground for a majority of the year.



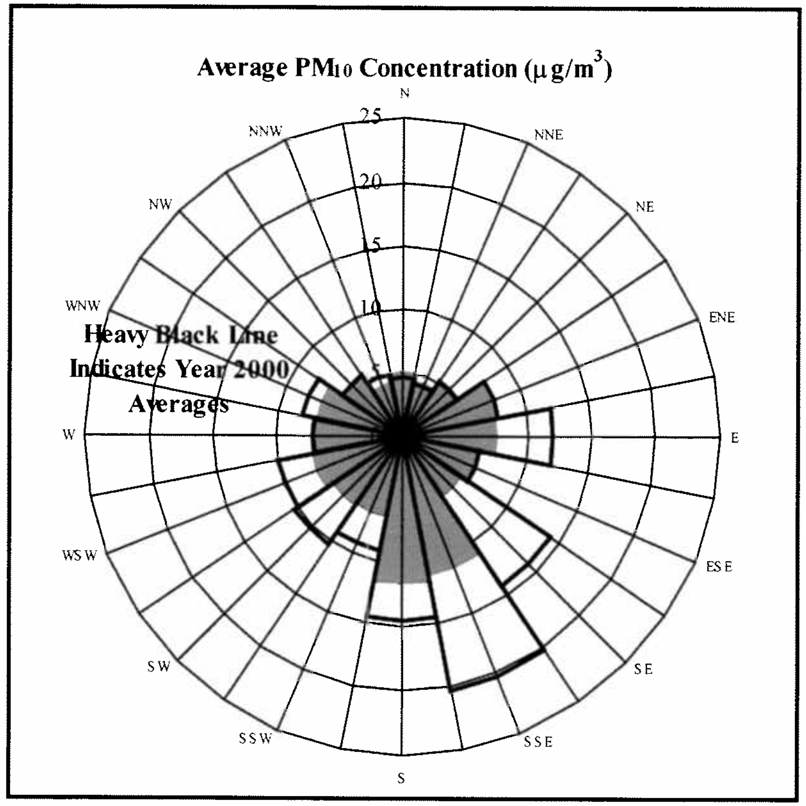


FIGURE 3-4: PM_{10} FREQUENCY ANALYSIS AND AVERAGE CONCENTRATION BY WIND DIRECTION

- 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 monitoring site.

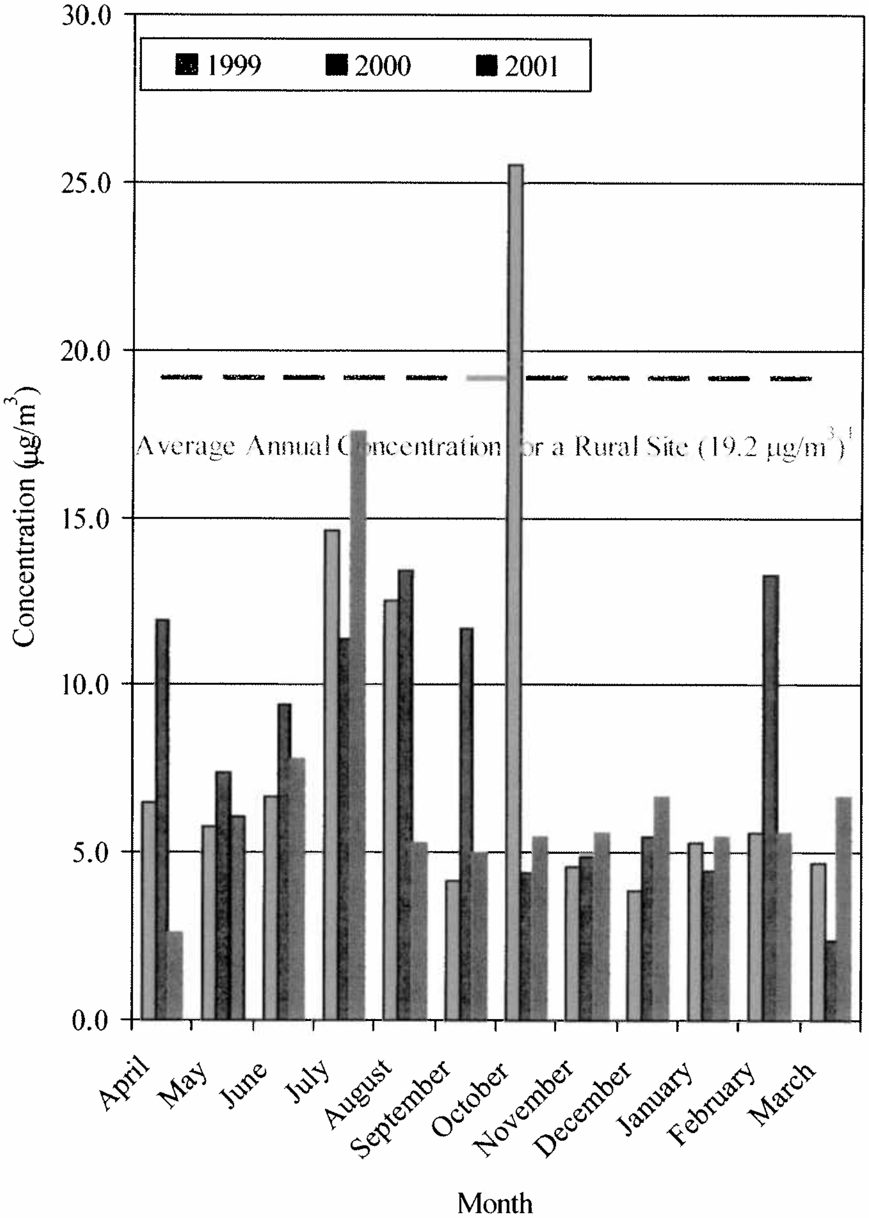
- The highest average hourly concentrations were measured when wind directions were south-southeast through southerly (SSE-S). Based on on-site observations, these elevated measurements appear to be a result of wind blown fugitive dust originating from disturbed ground surrounding house construction occurring along the utility right-of-way leading south-southeast from the monitoring station.

- Average PM_{10} concentrations associated with south-southwest through northeast wind directions are at or just below the average obtained over the monitoring year.

Figure 3-5 shows average monthly PM_{10} concentrations measured during the monitoring year compared to data compiled during the previous two monitoring years. Looking at all the data presented, PM_{10} concentrations measured from June through August are nearly double those measured during any other time of the monitoring year. This doubling is related to the wind blown fugitive dust origin of the PM_{10} measured. About one month after mean temperatures rise above freezing (mid-June), the ground has thawed and starts drying. With the ground exposed and dry, the strong prevailing winds are able to produce wind blown fugitive dust through erosion and transport to the monitoring site. This results in an increase in measured particulate concentrations. Similarly, about a month after mean temperatures drop below freezing (mid-October), the ground becomes frozen and snow covered, and average monthly impacts once again drop to around 10 $\mu g/m^3$.

Comparing the current monitoring year to the previous two monitoring years, Figure 3-5 shows that concentrations measured in April and August 2001 were half of what could be expected based on previous monitoring years. This inter-annual variability 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.

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 evenly balanced between three contributing fugitive sources identified in this report section. [The bank of the Nechelik Channel (ENE-E), construction to the south of the station



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

FIGURE 3-5: NUIQSUT PARTICULATE CLIMATOLOGY

TABLE 3-2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MEASURED 24-HOUR TEOM PM_{10} CONCENTRATIONS GREATER THAN 20 $\mu g/m^3$

Ranking	TEOM Measured 24-hour PM_{10} Concentration. ($\mu g/m^3$)	24-hour Period		Wind Speed Avg/Max (m/s)	Dominant Wind Direction[1]
		Year	Date		
1	72.1	2001	July 11	9.5/11.5	ENE
2	68.5	2001	July 19	4.9/7.9	E-ESE
3	46.7	2001	July 01	6.1/9.4	ENE
4	43.7	2001	July 13	8.4/10.6	ENE
5	40.0	2001	July 16	4.3/6.8	S-SW[2]
6	34.1	2001	July 12	9.2/10.6	ENE
7	27.7	2001	July 14	7.3/8.8	E
8	27.7	2001	July 02	3.7/6.1	WSW[2]
9	22.5	2002	Feb. 25	9.0/13.5	E
10	20.5	2001	May 30	3.9/5.1	SSW-WSW[2]

[1] Winds were determined to be predominant for the day if winds were from a particular direction or two adjacent directions for 13 or more hours in the day unless otherwise noted.

[2] Winds had no dominant direction on this day, but these wind directions are responsible for the elevated PM_{10} measurements.

(SE-S) and the Nuiqsut populated area (S-NNW)]. Though impacts were well distributed, the highest are still associated with the exposed bank of the Nechelik channel. It is important to note that there were only 10 days with 24-hour averaged concentrations higher than 20 $\mu g/m^3$ measured this monitoring year compared to 18 days measured during the previous monitoring year.

3.1.4 Respirable Particulate Matter (PM_{10}) - Partisol Data

One purpose of installing the Partisol sampler is to use data collected by this Federal Reference Method (FRM) in an arctic environment to determine how that data collected correlates to data collected by the TEOM continuous monitor which is a Federal Equivalent Method.

A detailed comparative analysis of collocated TEOM and Partisol 24-hour averaged measured concentrations was presented in each of the quarterly data reports. Each report showed that 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. The scatter in the correlation plot is too large to determine an exact correlation, but it is clear that generally, TEOM measurements are on the order of twice as high as Partisol measurements. Possible explanations for Partisol measurements being biased low 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 which would give rise to the large amount of scatter of data plotted in Figure 3-6.

When making comparisons between collocated particulate measurements realize that precision of 24-hour results reported by the TEOM is ± 0.5 $\mu g/m^3$. With this amount of uncertainty in low measurements, many reported TEOM measurements should not be used to generate comparison statistics. Generally, only 24-hour concentrations above 20 $\mu g/m^3$ are used for determining instrument precision using collocated measurements. This monitoring year, there were only ten TEOM 24-hour concentrations measured above 20 $\mu g/m^3$.

3.2 Meteorological Data

Meteorological data collected at the Nuiqsut monitoring station includes temperature, wind speed, and wind direction.

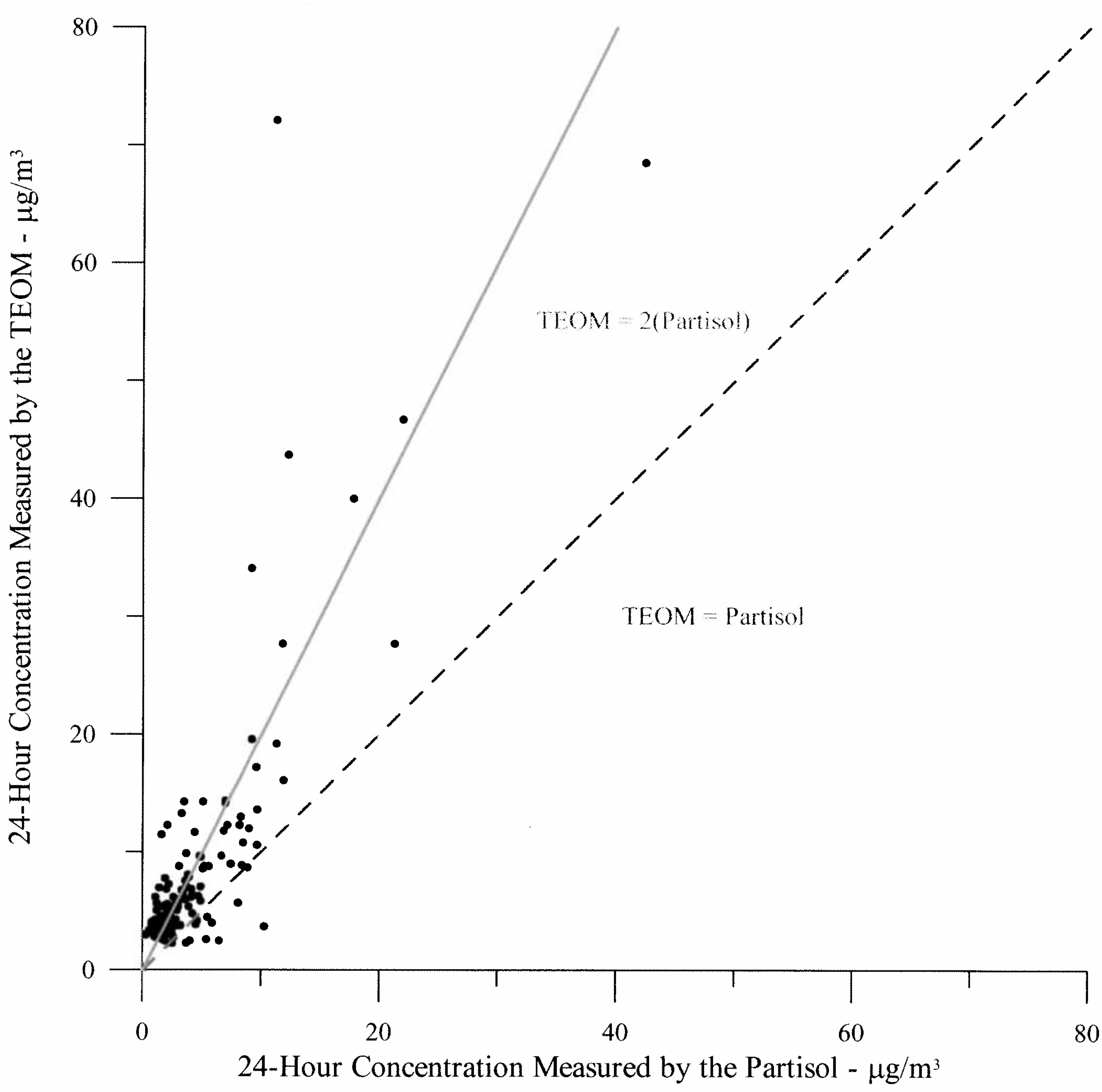


FIGURE 3-6: CORRELATION OF TEOM TO PARTISOL PARTICULATE MEASUREMENTS FOR DATA COLLECTED FROM APRIL 2001 THROUGH MARCH 2002

3.2.1 Wind Speed and Direction Climatology

The annual Nuiqsut bivariate wind frequency distribution (wind rose) is presented in Figure 3-10. This figure shows that winds during the monitoring year were bi-modal, dominated by northeast through easterly (NE-E) winds and by south-southwest through westerly (SSW-W) winds. Summarizing data from the table presented with Figure 3-10, and tabulated below, NE-E winds average slightly higher speeds than SSW-W winds. Combining all wind directions, the mean 10-meter wind speed for the monitoring year was 4.3 m/s and the maximum was 20.2 m/s. The table below provides a comparison of the current monitoring year winds with those measured in previous years.

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

It is very clear from these statistics that though the mean wind speed this year was slightly lower, there has been very little change in the wind speed and direction climatology over the past three monitoring years. This climatology reflects how persistent the 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 3-11. Figure 3-11 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 two monitoring years, the current year seasonal wind roses indicate that there is a persistence of northeasterly through easterly winds all year long.

Nuiqsut Air Quality Monitoring Program - Nuiqsut, AK
WIND ROSE ANALYSIS (PERCENT)
4/ 1/2001 through 3/31/2002
All Hours

WIND DIRECTION	WIND SPEED (M/S) <= 1.5	<= 3.1	<= 5.1	<= 8.2	<=10.8	>10.8	TOTAL	AVG SPEED
N	0.59	1.33	0.87	0.13	0.00	0.00	2.91	2.62
NNE	0.74	2.08	2.10	0.61	0.01	0.00	5.55	3.15
NE	1.47	2.67	3.97	4.29	1.34	0.14	13.88	4.76
ENE	1.26	3.02	5.08	6.28	1.88	1.45	18.96	5.62
E	0.69	1.96	3.13	3.40	1.26	0.49	10.93	5.36
ESE	0.67	0.88	0.86	0.69	0.24	0.00	3.34	3.81
SE	0.42	0.56	0.27	0.06	0.00	0.00	1.32	2.31
SSE	0.45	0.54	0.28	0.00	0.00	0.00	1.27	2.12
S	0.71	1.10	1.12	0.14	0.00	0.00	3.07	2.71
SSW	0.56	2.14	5.45	0.98	0.00	0.00	9.13	3.66
SW	0.82	1.59	3.08	1.19	0.12	0.00	6.79	3.74
WSW	0.92	1.39	2.35	2.02	0.49	0.06	7.23	4.42
W	0.47	1.32	2.13	1.72	0.39	0.02	6.04	4.44
WNW	0.45	1.26	1.41	0.48	0.07	0.00	3.67	3.39
NW	0.49	1.06	0.98	0.26	0.00	0.00	2.79	2.95
NNW	0.59	1.22	0.76	0.28	0.01	0.00	2.87	2.85
CALM	0.26						0.26	
TOTAL	11.55	24.12	33.84	22.52	5.81	2.16	100.00	

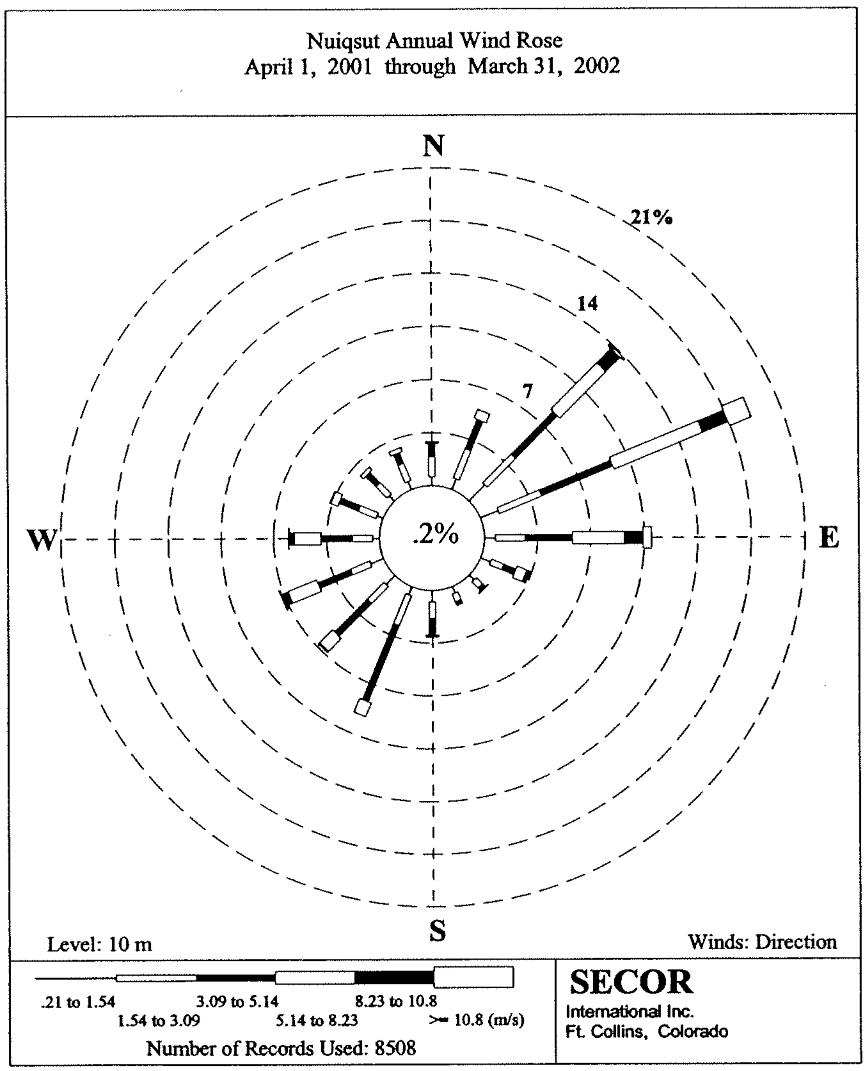


FIGURE 3-7: ANNUAL BIVARIATE WIND ANALYSIS

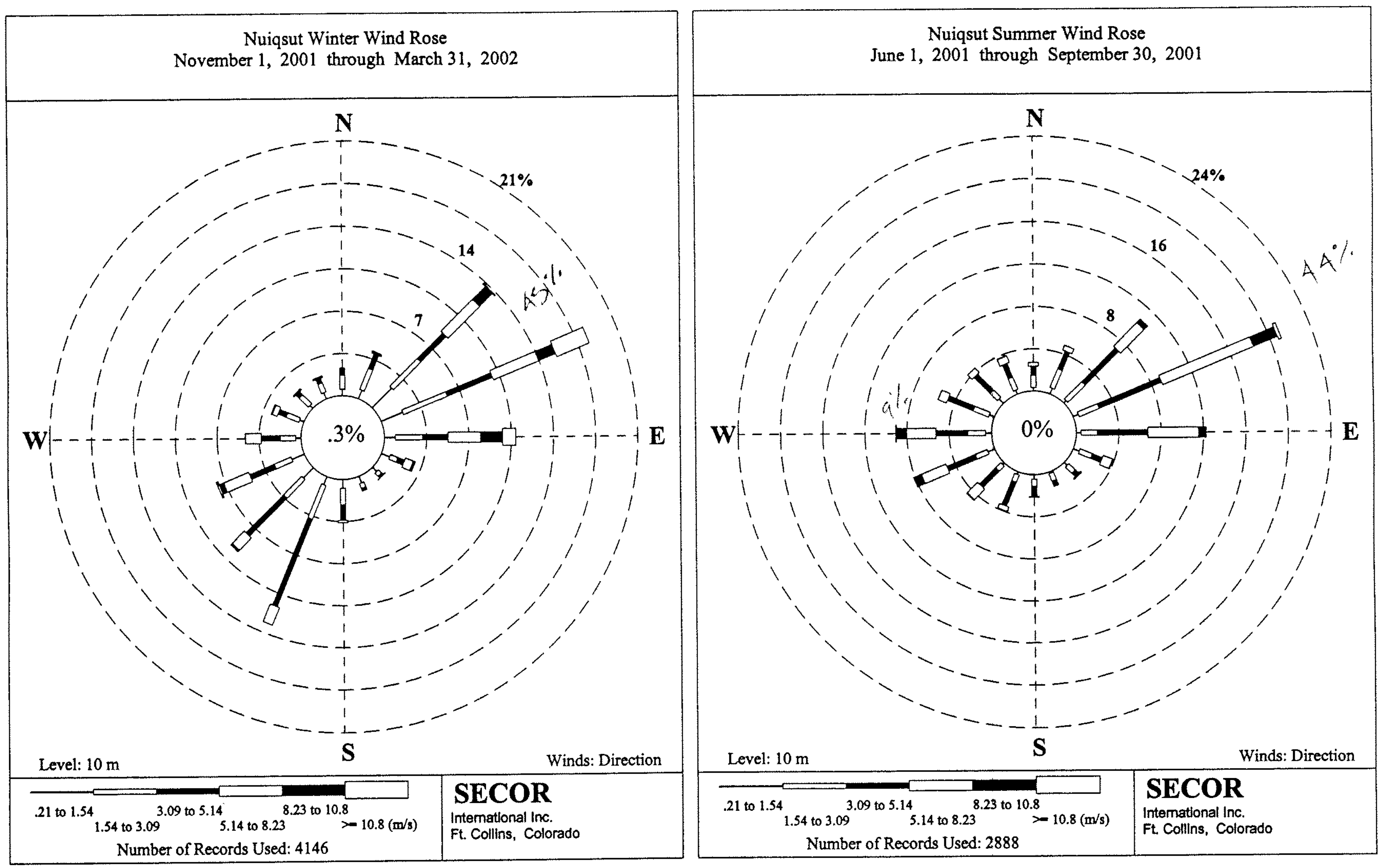


FIGURE 3-8: SEASONAL BIVARIATE WIND ANALYSIS

3.2.2 Stability Frequencies

Estimates of the P-G stability for each hour of the day can be derived in two ways using the Nuiqsut Station meteorological data. One procedure, referred to as the SRDT method, uses solar radiation and wind speed measurements during the daytime, and 10-2 meter temperature difference and wind speed at night to estimate stability. The other method for estimating P-G stability, referred to as the sigma-theta (σ_θ) method, uses measurements of wind speed and the standard deviation of horizontal wind direction to estimate stability. Both methods are summarized in Appendix A of this report. Derivation of SRDT stability estimates became possible following expansion of the meteorology program on July 24, 2001.

Figure 3-12 illustrates the distribution of the P-G stability classes using the SRDT and σ_θ methods for the period. The SRDT method estimates that neutral conditions occurred 76.5 percent of the time, while stable conditions (slightly stable and stable) occurred 18.9 percent of the time and unstable conditions (unstable and slightly unstable) occurred 4.7 percent of the time. Extremely unstable conditions were not estimated to occur using the SRDT method. A comparison of the σ_θ method with the SRDT method reveals a primary difference in a relative shift in estimated categories from neutral to unstable conditions for the σ_θ estimates. Estimated frequencies of stable conditions are similar for both methods (13.7 percent for σ_θ and 18.9 percent for SRDT). Note that because of the way that the SRDT method determines stability, unstable (extremely unstable through slightly unstable) conditions will not occur during nighttime hours, so near the winter solstice unstable conditions will never be estimated for the North Slope using this method. Combining this information from the statistics gathered during the last monitoring year yields the following comparison:

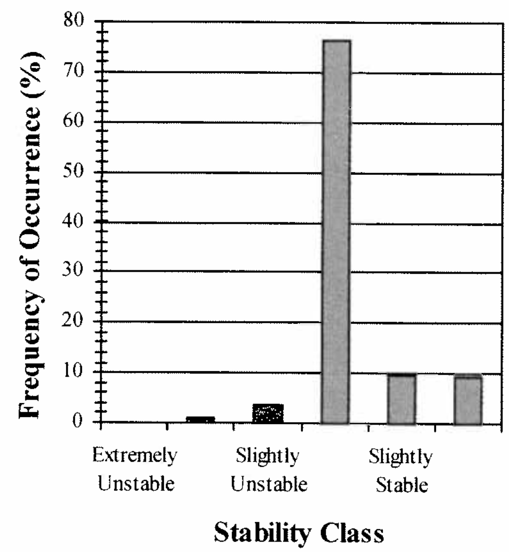
Stability Parameter	Current Monitoring Year April 2001 through March 2002	Monitoring Year April 2000 through March 2001	Monitoring Year April 1999 through March 2000
Frequency of Neutral Conditions (σ_θ Method)	63.9 %	66.9 %	70.0 %
Frequency of Neutral Conditions (SRDT Method)	76.5 %[1]	na	na

[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, 2001 THROUGH MARCH 31, 2002

Calculated using the SRDT Method

Stability Class	Frequency (%)
Extremely Unstable (A)	0.0
Unstable (B)	1.0
Slightly Unstable (C)	3.7
Neutral (D)	76.5
Slightly Stable (E)	9.7
Stable (F)	9.2



Calculated using the Sigma-Theta Method

Stability Class	Frequency (%)
Extremely Unstable (A)	5.7
Unstable (B)	4.4
Slightly Unstable (C)	12.3
Neutral (D)	63.9
Slightly Stable (E)	8.4
Stable (F)	5.3

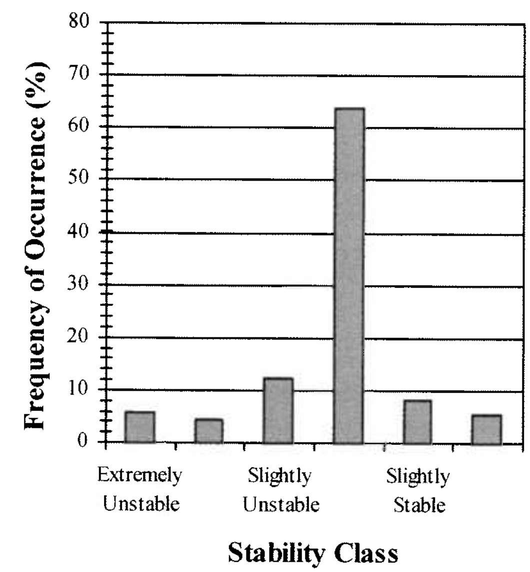


FIGURE 3-9: NUIQSUT STABILITY CLASS FREQUENCY DISTRIBUTIONS

Both methods demonstrate that neutral stability conditions dominate, with unstable and stable conditions rarely occurring.

3.2.3 Temperature Climatology

During the monitoring year, the hourly averaged near-surface ambient temperature reached a maximum of 28.0°C (82.4°F) on the evening of July 16, 2001 and a minimum of -43.1°C (–45.6°F) in the morning of January 23, 2002. Combining this information from the statistics gathered during the last two monitoring years yields the following comparison which shows the extremes measured this year are typical of those measured during the last two monitoring years.

Temperature	Current Monitoring Year April 2001 through March 2002	Monitoring Year April 2000 through March 2001	Monitoring Year April 1999 through March 2000
Maximum Hourly Temperature	28.0°C	27.1°C	27.8°C
Minimum Hourly Temperature	-43.1°C	-43.0°C	-41.5°C

Figure 3-13 compares monthly averaged temperatures measured at Nuiqsut during the monitoring year to the two-year temperature data set collected at the nearby (55 km) Kuparuk River Unit Drill Site 1F (KRU-DS1F) monitoring station from 1990 through 1992. With some exceptions, temperatures measured at Nuiqsut this monitoring year were as much as 3 to 5 degrees Celsius higher than those measured in 1990 through 1992 at KRU-DS1F. Similar differences were observed during the previous two monitoring years. Though a trend is developing which indicates that temperatures measured at Nuiqsut are higher than historically recorded at DS1F, neither data set is long enough to indicate a climatologically significant long-term trend.

Figure 3-13 also shows that data collected at the Nuiqsut Station during the current monitoring year does not match the longer term Barrow temperature climatology. The temperature data presented for Barrow was collected over a 49 year period and is less likely influenced by interannual variability. In general this comparison suggests that Nuiqsut potentially experienced a warmer than normal summer followed by a cooler than normal winter. Results of this trend comparison to the Barrow data has been relatively consistent since the project began and is likely related to the fact that the Nuiqsut Station is located further inland and away from moderating effects of the ocean than at Barrow.

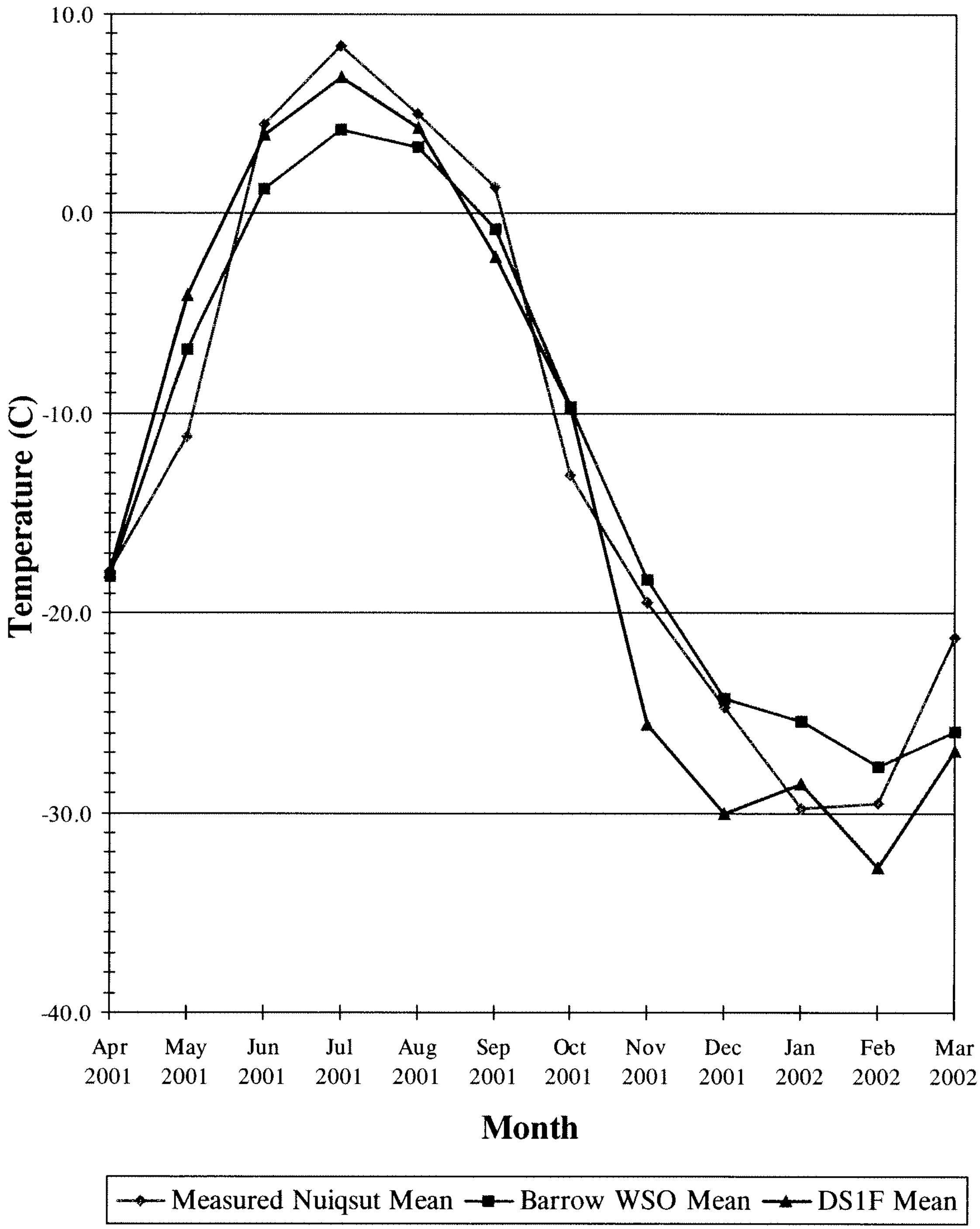


FIGURE 3-10: NUIQSUT TEMPERATURE CLIMATOLOGY

This observation is also reflected in the developing temperature climatology presented in Table 3-3 that shows that several station temperature extremes were broken this year at the Nuiqsut Station. The winter was measurably cooler than was observed historically, and the summer slightly warmer.

TABLE 3-4

NUIQSUT AIR QUALITY PROGRAM
TEMPERATURE CLIMATE SUMMARY
PERIOD OF RECORD APRIL 9, 1999 THROUGH MARCH 31, 2002

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 2001	-14.6	-22.2	-17.9	0.8	2000	30	-34.0	2000	4
May 2001	-8.4	-14.9	-11.2	3.7	2000	29	-28.7	2001	1
June 2001	8.4	0.7	4.5	24.0	2000	25	-5.0	2000	5
July 2001	12.4	4.4	8.4	28.0	2001	16	-1.1	2001	6
August 2001	7.9	2.3	4.9	27.8	1999	5	-3.3	2000	27
September 2001	3.6	-0.5	1.3	18.2	2000	1	-13.6	1999	30
October 2001	-10.4	-16.2	-13.1	0.3	2001	4	-27.2	1999	31
November 2001	-16.1	-23.3	-19.5	-2.7	2000	15	-35.5	1999	5
December 2001	-21.0	-28.6	-24.7	-2.5	2001	28	-42.1	1999	18
January 2002	-26.1	-33.2	-29.8	-6.6	2001	16	-43.1	2002	23
February 2002	-27.0	-31.9	-29.5	-5.4	2001	15	-43.0	2001	25
March 2002	-17.2	-25.3	-21.2	-3.3	2002	17	-39.4	2000	23
Monitoring Year	-8.3	-15.7	-11.4	28.0	2001		-43.1	2002	

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