Pre-Permitting Environmental/ Socio-Economic Data Report Series

Report Series A-Meteorology

Report A-8
Quality Assurance Project Plan

August 2006

Preliminary data. Do not cite or quote.

The Pebble Partnership is providing environmental and socio-economic baseline data collected to inform the development of the Pebble Project to state and federal agencies, project stakeholders and the general public prior to project permitting as part of its commitment to full and open disclosure.

A comprehensive Environmental Baseline Document (EBD) will subsequently be prepared and appended to future project permit applications. The EBD will also be made publicly available when complete.

Prepared for the Pebble Limited Partnership by
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Quality Assurance Project Plan

for the

Pebble Project Meteorological Monitoring Program

Iliamna, Alaska

prepared for

Northern Dynasty Mines Inc.

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August 2006

A. Project Management Elements

A1. Approvals

Mike C. T. Smith — 8·31·06

Mike Smith
NDM Permitting Manager
Northern Dynasty Mines Inc.

Date

Al Trbovich — 8/31/06

Al Trbovich
HCG Permitting Manager
Hoefler Consulting Group

Date

8/31/2006

K. Steven Mackey
HCG Project Manager
Hoefler Consulting Group

Date

Eric Brudie — 8/31/2006

Eric Brudie
HCG Quality Assurance Officer
Hoefler Consulting Group

Date

Bill Walker
ADEC Air Permits Program/Project Supervisor
Alaska DEC

Date

Richard Heffern
ADEC Air Quality Assurance Manager
Alaska DEC

Date

A2. Contents

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A3. Distribution List

The following individuals have been provided a copy of this Quality Assurance Project Plan:

Table A1. Distribution List for Quality Assurance Project Plan

Key Individual/ Title	Organization	Email	Address	Phone
Mike Smith NDM Permitting Manager	Northern Dynasty Mines Inc.	michaels@nothern dynasty.com	3201 C Street, Suite 604 Anchorage, Alaska 99503	(907) 339-2606
Al Trbovich, HCG Permitting Manager	Hoefler Consulting Group	atrbovich @hoeflernet.com	3401 Minnesota Dr., Suite 300 Anchorage, Alaska 99503	(907) 563-2140
Steven Mackey, HCG Project Manager	Hoefler Consulting Group	smackey @hoeflernet.com	3401 Minnesota Dr., Suite 300 Anchorage, Alaska 99503	(907) 563-2129
Eric Brudie, HCG Quality Assurance Auditor	Hoefler Consulting Group	eric @brudie.com	3401 Minnesota Dr., Suite 300 Anchorage, Alaska 99503	(907) 243-0462
Bill Walker, ADEC Air Permits Program/ Construction Permits Supervisor	Alaska Department of Environmental Conservation	Bill_Walker @dec.state.ak.us	410 Willoughby Avenue, Suite 303 Juneau, Alaska 99801	(907) 465-5124
Richard Heffern, ADEC Air Quality Assurance Manager	Alaska Department of Environmental Conservation	Richard_Heffern @dec.state.ak.us	410 Willoughby Avenue, Suite 303 Juneau, Alaska 99801	(907) 465-5111

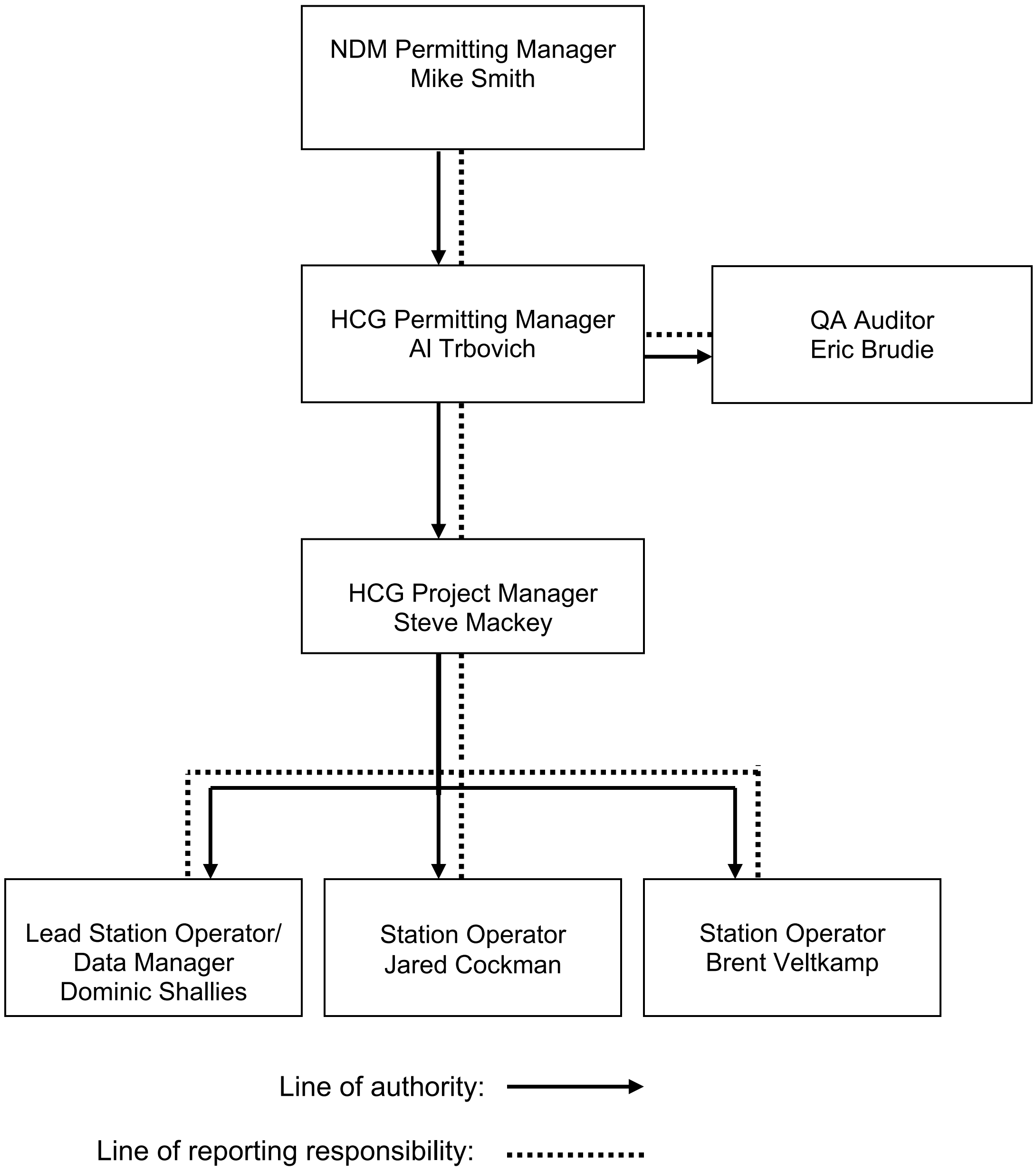
A4. Project/Task Organization

Hoefler Consulting Group (HCG) will support Northern Dynasty Mines Inc. (NDM) in the installation, operation, and maintenance of meteorological monitoring stations for the Pebble Project located near Iliamna, Alaska. Figure A1 provides the organization plan for this project. The key personnel involved with this project and their respective responsibilities are summarized in Table A2. HCG will be responsible for all aspects of air monitoring, database management, and reporting.

Table A2. Pebble Project Meteorological Monitoring Program Key Individuals and Responsibilities

Key Individual	Responsibilities
NDM Permitting Manager	Mike Smith is the permitting manager for the Pebble Project and is responsible for complete program oversight.
HCG Permitting Manager	Al Trbovich is responsible for coordinating the meteorological monitoring program with NDM air permitting requirements.
HCG Project Manager	Steve Mackey is responsible for management of the technical staff conducting the NDM meteorological monitoring program and ensuring that the project is completed within established schedules and budgets.
Quality Assurance Auditors	Eric Brudie is responsible for auditing the validity and accuracy of reported information and coordinating follow-up activities to ensure a defensible data set.
Field/Site Operations	Dominic Shallies, Jared Cockman, and Brent Veltkamp are responsible for installation and routine operation of the monitoring stations.
Data Manager	Dominic Shallies is responsible for maintaining the project databases for all field data and for preparing data reports.

Figure A1. Pebble Project Meteorological Monitoring Program Organizational Chart



A5. Problem Definition/Background and Project Objective

The Pebble Project is a proposed mine for gold, copper, molybdenum, and silver located in southwestern Alaska, north of Lake Iliamna. NDM is conducting baseline environmental studies at the Pebble Project, including meteorological monitoring to support air permitting, environmental studies, and mine design objectives. At least two years of meteorological monitoring is anticipated with a primary objective of collecting meteorological data for supporting future air permit applications required for mining activities, construction and/or roadwork at the proposed mine and port sites.

The meteorological data will be collected in accordance with Prevention of Significant Deterioration (PSD) permit requirements and guidance. While construction of the mine and port infrastructure may not require a PSD permit, the PSD-quality meteorological measurements may also be used for air dispersion modeling required for minor permitting.

A6. Project/Task Description

This study will provide two years of representative surface meteorological observations for use in air quality dispersion modeling in support of the Pebble Project. The meteorological monitoring program will include three PSD-quality stations as follows:

- Mine PSD station (also referred to as the Pebble 1 station)
- Tailings Storage Facility PSD station (also referred to as the Pebble 4 station)
- Port PSD station (also referred to as the Pebble Port station)

The study will collect two years of meteorological data at the proposed Pebble mine area (Mine PSD station) and near the proposed port site (Port PSD station). The study will also provide one year of meteorological monitoring in the proposed tailings storage facility site (Tailings Storage Facility PSD station).

Two other non-PSD meteorological monitoring stations, known as the Pebble 2 and Pebble 3 stations, have also operated in the Pebble area to collect data for mine design purposes. These non-PSD stations are not included as part of this QAPP, as these stations are not intended to provide data for air dispersion modeling.

The meteorological monitoring stations for this project will use PSD quality equipment to monitor the following parameters on an hourly basis:

- Wind speed (meters/second [m/s])
- Wind direction (degrees [°])
- Wind direction standard deviation (sigma-theta [σ_θ])

- Temperature (degrees Celsius [°C])
- Vertical temperature difference (ΔT), 2-meter to 10-meter (degrees Celsius [°C])
- Relative humidity (percent [%])
- Solar radiation (watts per square meter [W/m^2])
- Barometric pressure (millibars [mbar])
- Precipitation (millimeters [mm]) (not included at Port PSD station)
- Evaporation (millimeters [mm]) (not included at Port PSD station)

The meteorological monitoring sites for the Pebble Project were selected in a manner consistent with PSD criteria for surface meteorological data collection. Figure A2 shows a map of the NDM meteorological monitoring sites located in southwest Alaska. On May 24, 2005, the proposed monitoring sites were visited by Alan Schuler and Gerry Guay of Alaska Department of Environmental Conservation (ADEC), Natasha Greaves and Rob Wilson of the United States Environmental Protection Agency (EPA) Region 10, and Al Trbovich and Steve Mackey of HCG. On this date, all parties concurred that the selected sites are the best available locations for carrying out meteorological monitoring representative of the areas proposed for development. Greater details of the monitoring site locations and the proximity of the study areas within defined Alaska land use boundaries are provided in Sections B1 and B9, respectively.

The Pebble Project Meteorological Monitoring Program is expected to run from August 1, 2005 to July 31, 2007 (two years). The first year of PSD monitoring will take place from August 1, 2005 to July 31, 2006. The second year of monitoring will take place from August 1, 2006 to July 31, 2007. The annual reports for this project are scheduled for submission to Northern Dynasty within ninety days following the completion of each year of monitoring. For purposes of data reporting, the two years of monitoring will be split into monitoring quarters as follows:

Year Number 1 (8/1/2005 – 7/31/2006)

Monitoring Quarter A	Aug/Sep/Oct 2005
Monitoring Quarter B	Nov/Dec/Jan 2005-2006
Monitoring Quarter C	Feb/Mar/Apr 2006
Monitoring Quarter D	May/Jun/Jul 2006

Year Number 2 (8/1/2006 – 7/31/2007)

Monitoring Quarter E	Aug/Sep/Oct 2006
Monitoring Quarter F	Nov/Dec/Jan 2006-2007
Monitoring Quarter G	Feb/Mar/Apr 2007
Monitoring Quarter H	May/Jun/Jul 2007

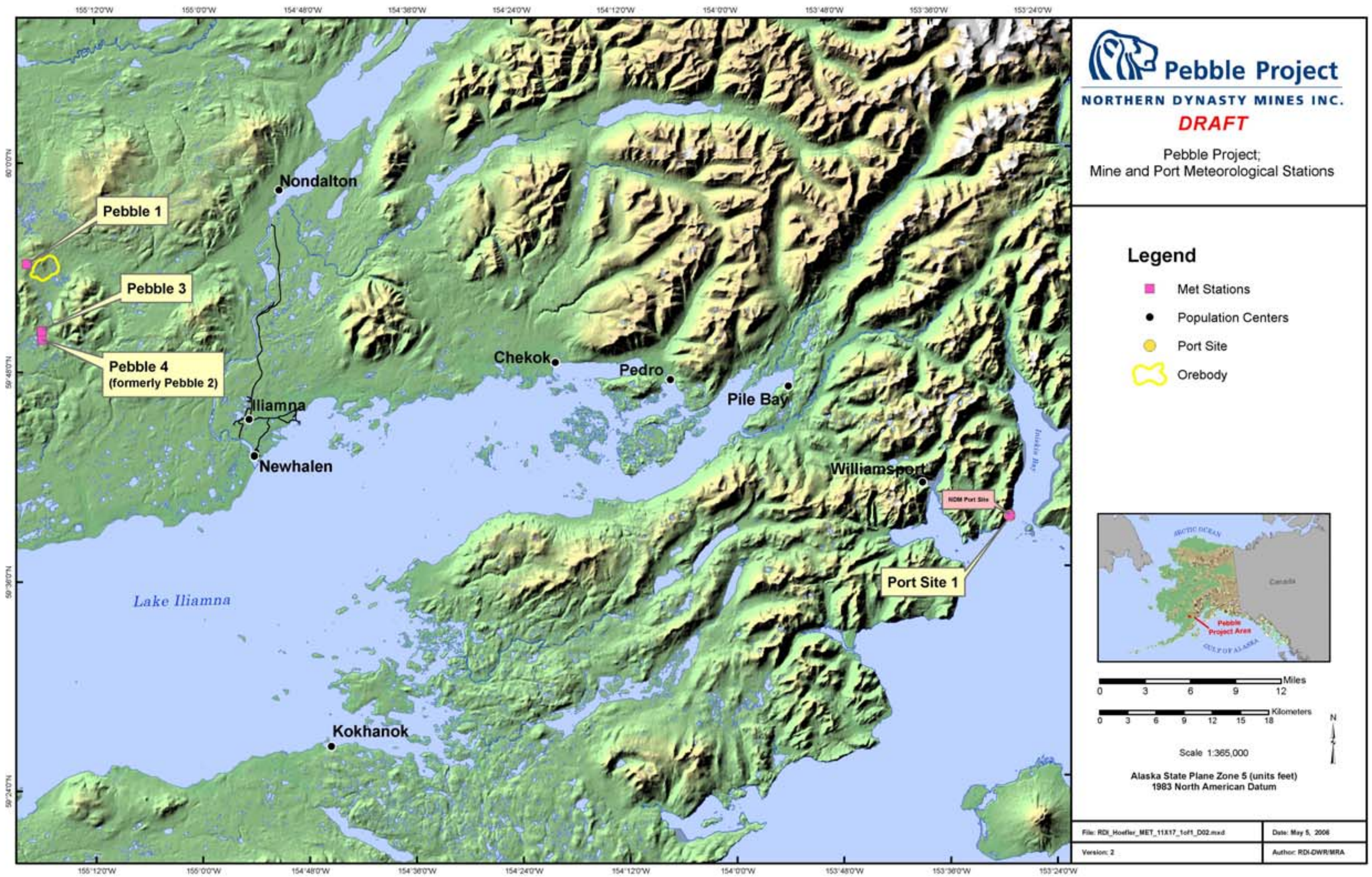
Personnel working on this project will be selected by the HCG project manager and will be fully qualified, trained, and capable of their assigned tasks. Work schedules will be determined by the HCG project manager and will include: (a) daily data reviews, (b) site visits every four to eight weeks, (c) semiannual audits and audit reports, (d) quarterly data summaries, (e) annual data reports, and (f) as needed maintenance and corrective actions. Table A3 provides a provisional work schedule for this monitoring project.

Table A3. Pebble Project Meteorological Monitoring Program Work Schedule

Scheduled Activity	Date
Station Site Selection Visit	May 24, 2005
Installation of the Mine PSD Station (Pebble 1) and the Port PSD Station	June 2005
Training of Station Operators	June 2005
Mine PSD Station and Port PSD Station Initial Systems/Performance Audit and Calibrations	June 11 and June 25, 2005
Start of Two Year Monitoring Period[1]	August 1, 2005
Semiannual Performance Audit and Calibrations	January 15-16, 2006
Tailings Storage Facility PSD Station (Pebble 4) Installation	June 3-10, 2005
First Year of Monitoring Ends	July 31, 2006
Second Year of Monitoring Begins	August 1, 2006
Annual Systems/Performance Audit and Calibrations	July/August 2006
Semiannual Performance Audit and Calibrations	January 2007
Annual Systems/Performance Audit and Calibrations	June 2007
End of Two Year Monitoring Period	July 31, 2007

[1] The start of the PSD monitoring period was delayed until August 1, 2005 to resolve a temperature sensor problem in July 2005.

Figure A2. Pebble Project Area Map



A7. Quality Objectives and Criteria for Measurement of Data

Measurement Quality Objectives (MQOs) and acceptance criteria for the project are defined by the MQOs as prescribed in *EPA Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Sections 3 and 5 (EPA-454/R-99-005), and by the guidelines defined in *EPA Requirements for Quality Assurance Project Plans* Chapter 3, Section A7 (EPA QA/R-5).

Data completeness is a measure of the amount of data actually collected compared with the amount of data that could have been collected, expressed as a percentage. Data completeness for the meteorological sensors is calculated by dividing the number of valid hours of data by the total number of hours during the monitoring period. The Data Quality Objective (DQO) for data completeness during this monitoring project is 90 percent data capture per quarter for every parameter listed in Table A4.

DQOs for the detection capabilities of the meteorological sensors are defined in terms of measurement resolution. The resolution DQOs for this project have been set equal to those put forth in *Meteorological Monitoring Guidance for Regulatory Modeling Applications* Section 5.1 (EPA-454/R-99-005), and are presented in Table A4.

Accuracy is a measure of the proximity of the measurements and the true value. Accuracy includes components of both random error and systematic error associated with instrumental bias. Accuracy will be assessed during performance audits. The accuracy DQOs for the meteorological sensors are presented in Table A4, and have been set equal to those recommended in *Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Section 5.1 (EPA-454/R-99-005).

Detectability, method/comparability, and representativeness are determined by the siting and exposure of the meteorological tower and sensors. The space-time domain and aspects for this specific application--as prescribed in *Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Section 3.1.1 Objective for Siting (EPA-454/R-99-005)--have been considered for each measurement parameter.

Table A4. Summary of DQOs for the Pebble Project Meteorological Monitoring Program

Meteorological Parameter/ Manufacturer and Model	Measurement Method	Manufacturer Specified Accuracy	EPA Required Accuracy[1]	EPA Required Resolution[1]	Detectability/ Data Completeness[1]
Wind Speed (Climatronics F460)	Three-cup anemometer	± 0.07 m/s or ± 1%	± 0.2 m/s or ± 5%	0.1 m/s	90% per monitoring quarter
Wind Direction (Climatronics F460)	Light-weight vane	± 2 degrees	± 5 degrees	1.0 degree	90% per monitoring quarter
Wind Speed (RM Young 05305-AQ)	Light-weight propeller	± 0.2 m/s	± 0.2 m/s or ± 5%	0.1 m/s	90% per monitoring quarter
Wind Direction (RM Young 05305-AQ)	Light-weight vane	± 3 degrees	± 5 degrees	1.0 degree	90% per monitoring quarter
Ambient Temperature & Vertical Temperature Difference (Met One 062MP)	Solid state Thermistor	± 0.05°C	± 0.5°C (Ambient Temperature), ± 0.1°C (Temperature Difference)	0.1°C (Ambient Temperature), 0.02°C (Temperature Difference)	90% per monitoring quarter
Barometric Pressure (Vaisala PTB101B)	Silicon capacitive sensor	± 0.3 mbar	± 3 mbar	0.5 mbar	90% per monitoring quarter
Relative Humidity (Vaisala HMP45C)	Thin-polymer capacitor	± 2% (0-90% range) ± 3% (90-100% range)	± 1.5°C	0.1°C	90% per monitoring quarter
Solar Radiation (Licor LI200X)	Silicon photovoltaic detector	± 5%	± 5%	10 W/m[2]	90% per monitoring quarter
Precipitation (ETI NOAH II)	Water pressure	± 0.25 mm	± 5 mm	0.3 mm	90% per monitoring quarter
Evaportation (Nova Lynx 255-100)	Float mechanism/ sensor	± 0.25%	n/a[3]	n/a[3]	90% per monitoring quarter

[1] Referenced in *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005).
[2] Values are given in terms of dew point temperature in guidance document (EPA-454/R-99-005).
[3] n/a = not applicable.

A8. Training and Certifications

The Pebble Project meteorological monitoring sites require no specific mandated training requirements as stated in *EPA Requirements for Quality Assurance Project Plans* Section A8 (EPA QA/R-5). However, a site-specific health and safety plan was developed in accordance with both HCG and NDM standards. Site-specific training for this project covers activities performed in the field and includes record keeping practices. All HCG and NDM field personnel will attend annual site safety and logistics meetings hosted by NDM. HCG field technicians for this project will receive training on the operation and maintenance of the meteorological sensors and related equipment. Training will be conducted by the HCG project manager or his designees. Site-specific training checklists and site visit memos will document the specific training received by each Field Technician (Appendix B). These documents will be filed and maintained in the project files.

A9. Documents and Records

Documentation and records for this project will include equipment calibration and maintenance records, documentation of quality control/quality assurance activities, routine monitoring data, corrective action and resolution forms, any QAPP revision documentation, and records of HCG field activities (i.e. site visit memos). Appendix B includes example data sheets for the monitoring project. All hard-copy documentation will be stored at the HCG Anchorage office and retained for a period of at least five years from the completion of the project. Electronic data will be stored on various media with full project backups. In addition to any written reports, electronic data collected for this project and data transferred to electronic format will be provided to NDM via CD-ROM or e-mail. Both the original comma delimited raw text file and a spreadsheet format file will be provided.

The final annual reports will be submitted to ADEC and NDM in both hard copy and electronic (PDF) format within 90 days of the conclusion of the monitoring program. Validated data will be submitted to ADEC in the same formats. The annual report will include a brief discussion of any monitoring phenomena, observable trends, quarterly and annual averages for all the measured parameters, statistical summaries for each collected parameter, and wind rose graphics. The reports will also contain any additional documentation, including but not limited to equipment calibration and maintenance records, documentation of quality control/quality assurance activities, routine monitoring data, project data reports, corrective action records, and records of field activities. Examples of these documentation forms are provided in Appendix B. See Section C for an outline of the annual report.

In accordance with ADEC reporting guidelines, quarterly data summaries and annual data reports will be prepared by HCG and provided to NDM and ADEC. Two separate annual data reports will be prepared (one for each monitoring year, not calendar year).

The final annual data reports will conform to format requirements set forth in *PSD Quality Ambient Air Quality & Meteorological Monitoring Annual Data Report Format* (ADEC, March 2005). The annual data reports will be submitted to ADEC after the department has received the QAPP.

In addition to the annual data reports, quarterly data summaries will be prepared by HCG in accordance with the format described in *PSD Quality Ambient Air Quality & Meteorological Monitoring Quarterly Data Summary Format* (ADEC, March 2005) and provided to NDM and ADEC within 30 days after the completion of each calendar quarter. The quarterly data summaries will be submitted to ADEC in conclusion of each monitoring year.

B. Measurement and Data Acquisition

B1. Sampling Process Design

The identified objectives of the Pebble Project Meteorological Monitoring Program are:

- Collect meteorological data necessary to support air permit applications
- Collect data for other environmental purposes (baseline, NEPA)
- Collect data for engineering design of mine and port facilities

To accomplish the monitoring objectives, baseline meteorological monitoring is being performed in both the proposed mine region (two stations) and the proposed port site (one station). The monitoring study is comprised of three PSD quality meteorological monitoring stations, each of which will collect meteorological monitoring data over a period of two years. The three PSD stations are designed and operated to meet the data quality objectives previously outlined in Section A7 of this QAPP.

B1.1 Monitoring Site Locations

The Pebble Project area is located near Iliamna in southwestern Alaska. The mine area stations are located approximately 17 miles northwest of Iliamna and the Port station is located approximately 52 miles east of Iliamna on the eastern shore of Iniskin Bay. The specific station locations are shown in Figure A2.

The meteorological monitoring program consists of a total of three PSD quality meteorological monitoring stations, the Mine PSD Station (Pebble 1), the Tailings Storage Facility PSD Station (Pebble 4), and the Port PSD Station (Pebble Port). An additional non-PSD meteorological monitoring station is being used to collect data for mine design purposes. This non-PSD station was initially located at the Pebble 4 station site from October 2004 through November 2005, and was called the “Pebble 2” station. During November 2005, the Pebble 2 station was relocated 0.6 miles north and renamed “Pebble 3”. Table B1 provides a summary of the location, purpose, and measurement parameters of PSD and non-PSD meteorological monitoring stations for the Pebble Meteorological Monitoring Program. Throughout the remainder of this QAPP, emphasis will be placed on the locations and operation of the PSD meteorological monitoring stations only, as their primary purpose is to provide measurements for air dispersion modeling and air permit applications.

Figure B1 shows a map of the meteorological stations adjacent to the Pebble Project ore body, located approximately 15 to 20 miles west northwest of Iliamna, Alaska. Figures B2 and B3 provide higher resolved maps of the Pebble 1 and Pebble 4 station locations, which are situated atop gradual sloping hills that lie to the west and south, respectively, of the main ore body. The Pebble 1 station is located at a northern edge of a hilltop at 1,600 feet above sea level and overlooks a basin to the west where the Pebble Project ore body is located. The Pebble 4 station is located at 1,200 feet above sea level and overlooks the Pebble 3 station (at 1,000 feet above sea level) and the drainage of Frying Pan Lake, which is located within the area of the proposed mine tailings storage facility.

Figures B4 and B5 are photos of the Pebble 1 station and the surrounding area in the four cardinal directions, respectively. Figures B6 and B7 provide respective photographs of the Pebble 4 station and the surrounding area in the four cardinal directions. Despite the relatively low elevation of the sites, both meteorological stations sit above tree line and are free of natural and man-made obstructions.

Figure B8 is a map of the Pebble Port station. Figure B9 and B10 are photos of the Pebble Port station and the surrounding area in the four cardinal directions, respectively. The Pebble Port station overlooks the western shores of Iniskin Bay at the site of the proposed Pebble Project shipping port.

Table B1. Summary of Pebble Project Meteorological Stations

Station Name	Purpose/ Function[1]	Station Coordinates and Elevation	Monitoring Period	Measured Meteorological Parameters
Pebble 1 (Mine PSD Station)	PSD quality meteorological monitoring for proposed mine site	59° 54' N 155° 20' W 1,600 feet	Aug. 1, 2005 - July 31, 2007	Wind speed Wind direction Wind sigma Temperature Δ Temperature Solar radiation Barometric pressure Precipitation Evaporation
Pebble 2	Non-PSD meteorological monitoring at the proposed mine tailings storage facility site	59° 50' N 155° 18' W 1,200 feet	Jan. 2005 – Nov. 2005	Wind speed Wind direction Wind sigma Temperature Precipitation Evaporation
Pebble 3	Non-PSD meteorological monitoring at the proposed mine tailings storage facility site	59° 50' N 155° 18' W 1,000 feet	Nov. 2005 – July 2007	Wind speed Wind direction Wind sigma Temperature Precipitation Evaporation
Pebble 4 (Tailings Storage Facility PSD Station)	PSD quality meteorological monitoring for proposed mine site	59° 50' N 155° 18' W 1,200 feet	Aug. 1, 2006 – July 31, 2007	Wind speed Wind direction Wind sigma Temperature Δ Temperature Solar radiation Barometric pressure Precipitation Evaporation
Pebble Port (Port PSD Station)	PSD quality meteorological monitoring at proposed port site	59° 39' N 153° 28' W 40 feet	Aug. 1, 2005 - July 31, 2007	Wind speed Wind direction Wind sigma Temperature Δ Temperature Solar radiation Barometric pressure

[1]Each PSD station measures winds at approximately 10-meters height and is operated in accordance to *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005). Non-PSD stations measure wind at 3-meters height and are operated primarily for engineering design.

Figure B1. Pebble Project Mine Area Meteorological Station Locations

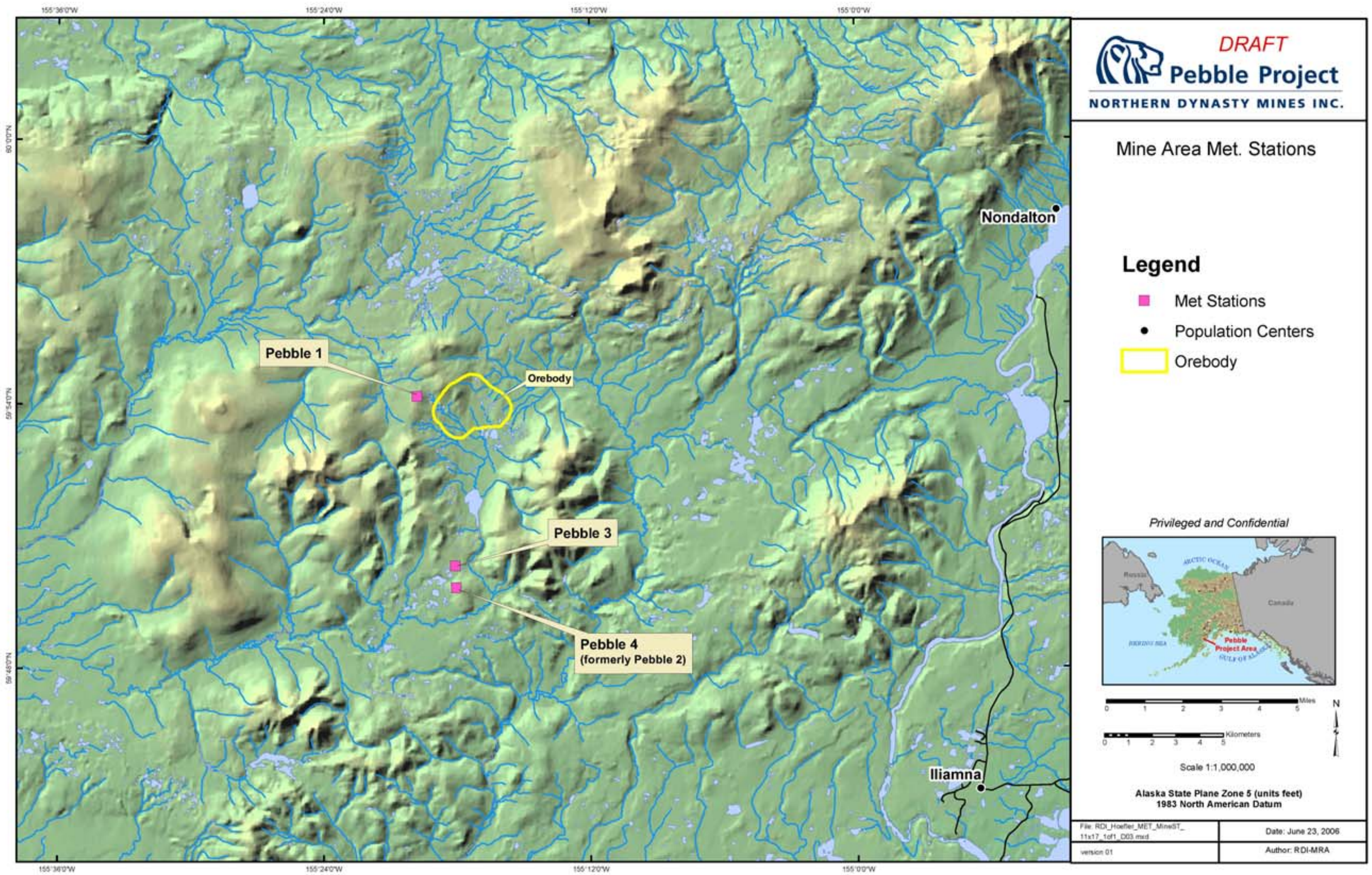


Figure B2. Pebble 1 Meteorological Station Site Map

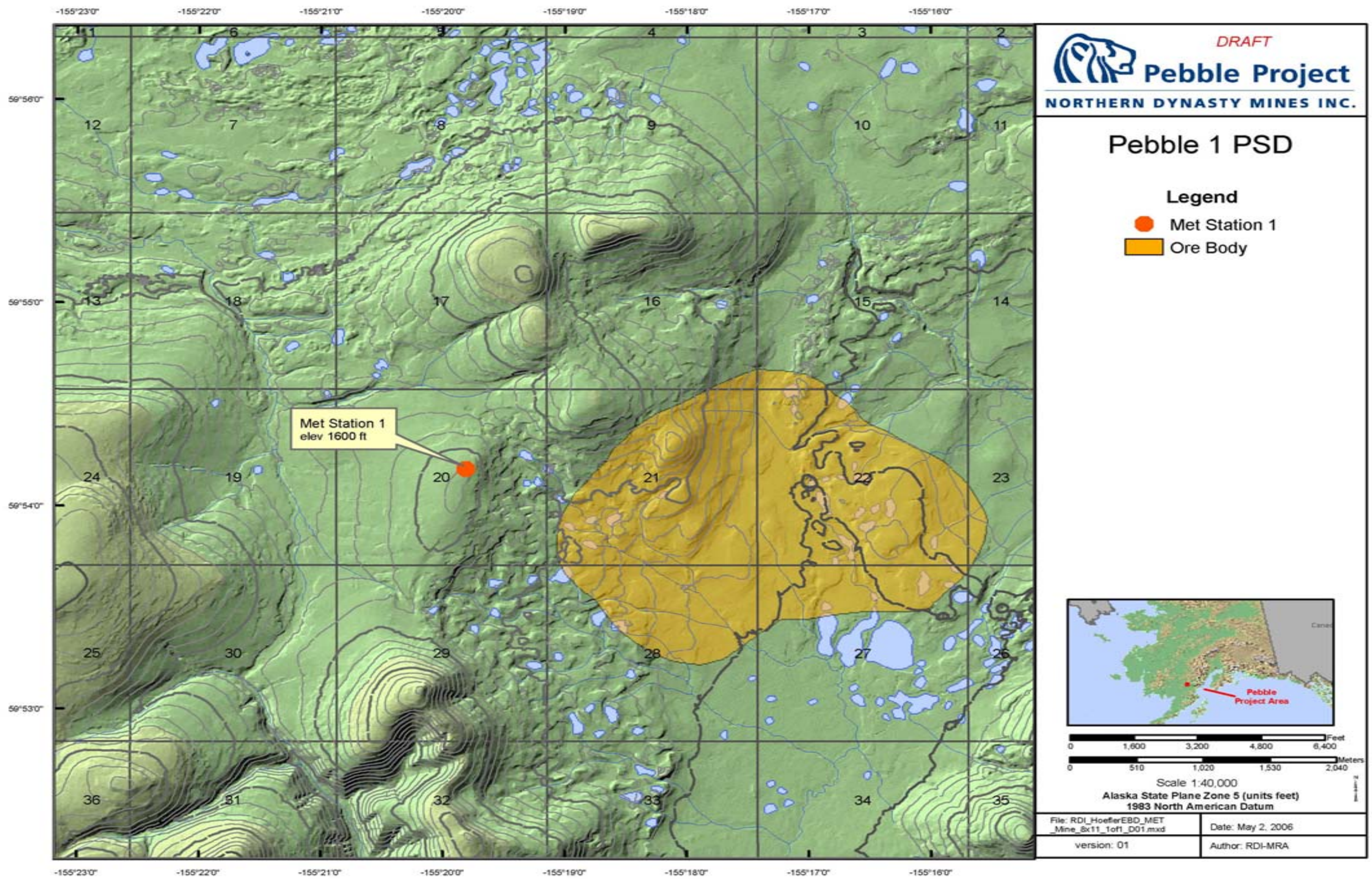


Figure B3. Pebble 4 Meteorological Station Site Map

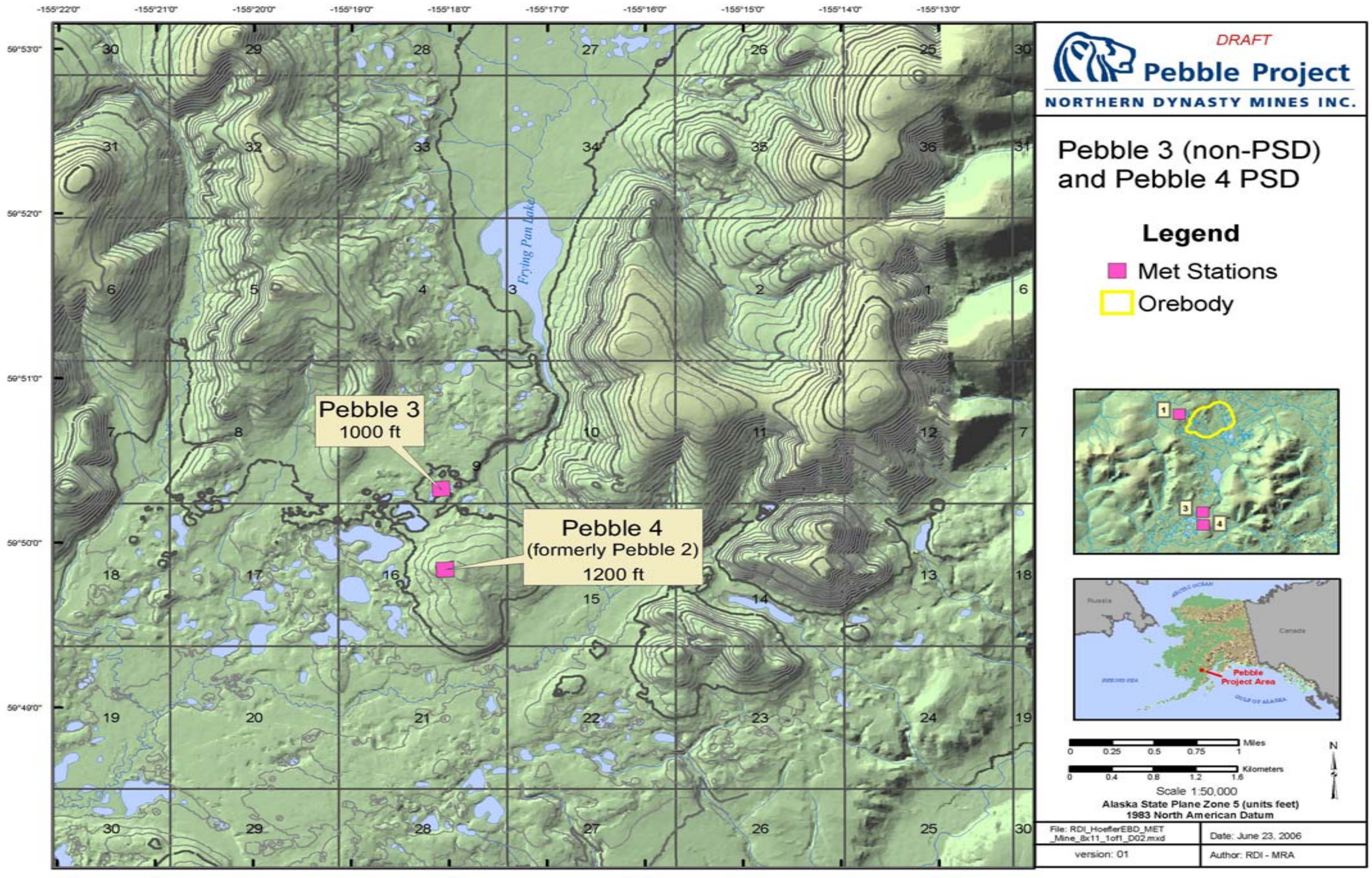


Figure B4. Pebble 1 Meteorological Station

Facing north

Facing south

Facing west

Facing east

Figure B5. Area Surrounding the Pebble 1 Meteorological Station

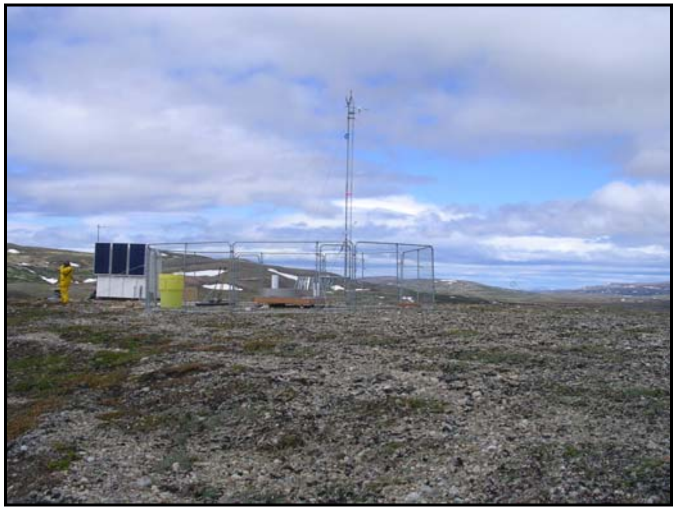
Facing north

Facing south

Facing west

Facing east

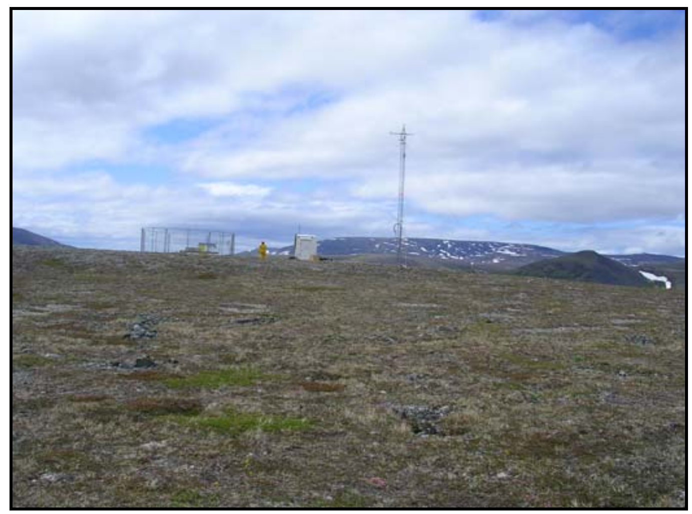
Figure B6. Pebble 4 Meteorological Station



Facing north

Facing south

Facing west



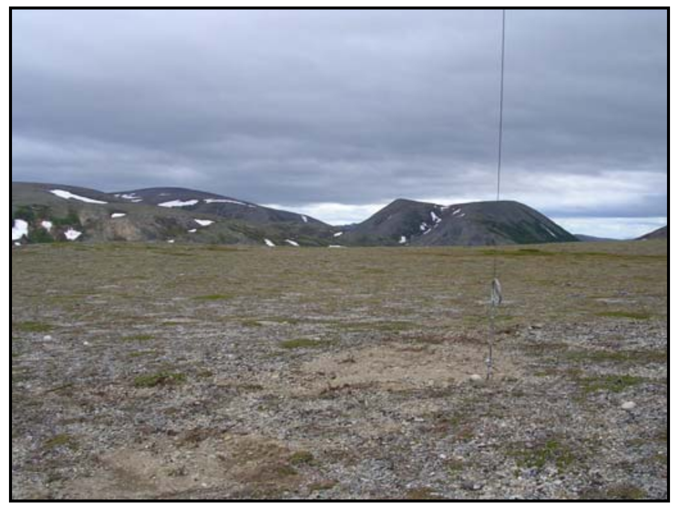
Facing east

Figure B7. Area Surrounding the Pebble 4 Meteorological Station

Facing north

Facing south

Facing west



Facing east

Figure B8. Pebble Project Port Meteorological Station Map

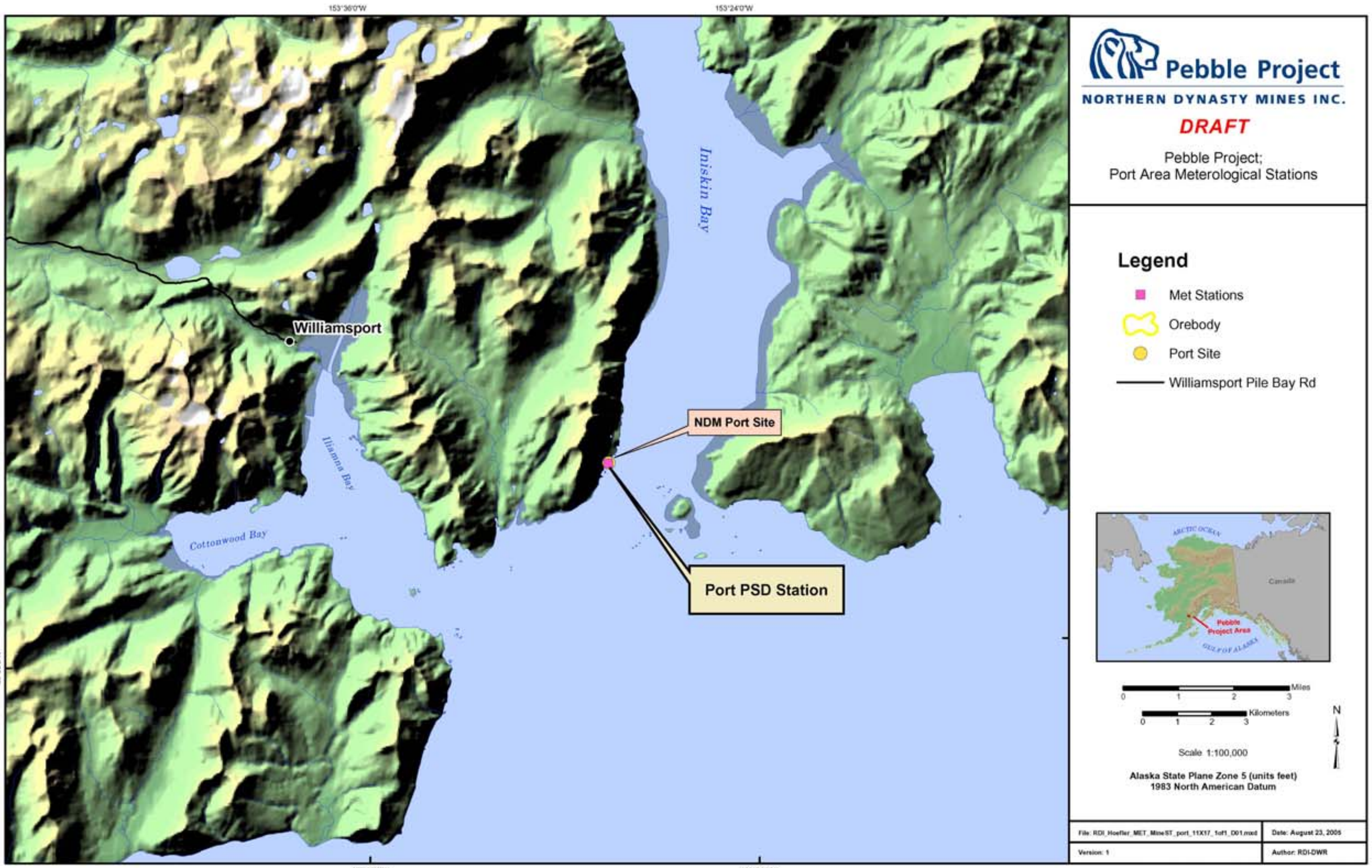
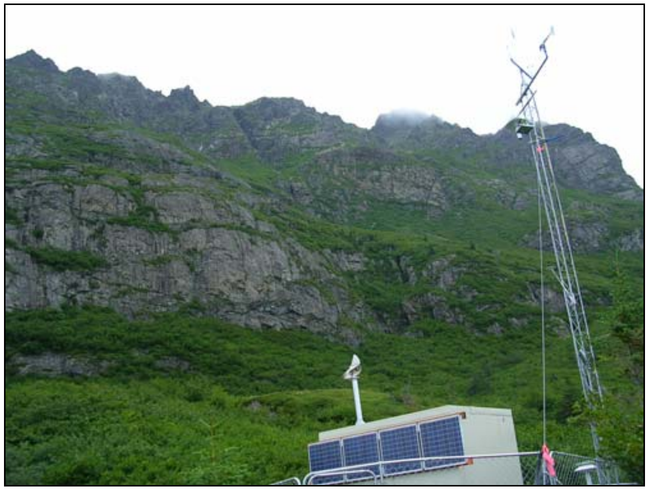


Figure B9. Pebble Port Meteorological Station



Facing north

Facing south

Facing west

Facing east

Figure B10. Area Surrounding the Pebble Port Meteorological Station

Facing north

Facing south

Facing west

Facing east

B2. Sampling Methods Requirements

Measurements will be performed using appropriate monitoring methods to ensure that the data are representative of actual conditions. The following sections address the methods to be used throughout the Pebble Project meteorological monitoring program, instrument installation, and the operational environment of the instruments.

B2.1 Reference and Equivalent Methods

Sensors for the measurement of wind speed, wind direction, ambient temperature, vertical temperature difference, barometric pressure, relative humidity, solar radiation, precipitation, and evaporation will be used to collect meteorological data. Table B2 lists the sensors that will be used, in addition to the manufacturers' specifications and the recommended performance specifications stated in *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005). These sensors will be continuously operated throughout this meteorological program.

Ambient temperature sensors will be mounted at 2 and 10 meters above ground level and used to measure vertical temperature difference, ΔT ("Delta T"). Two collocated wind speed and wind direction sensors will be mounted at 10 meters above ground level. The two wind measurement systems will include: (1) Climatronics F460 sensors as the primary wind sensors, and (2) a RM Young wind monitor as the secondary or back-up wind sensors. Solar radiation, relative humidity, and barometric pressure measurements will be measured at 4, 2, and 1.5 meters above ground level, respectively. At the Pebble 1 and Pebble 4 stations, the evaporation gauge will be mounted on a leveled deck and surrounded with fencing to avoid animal disturbance. The Pebble 1 and Pebble 4 station precipitation gauges will be mounted inside Wyoming-type (see Figure B4) and Alter Shield-type wind screens to prevent blowing snow and excessive winds from causing spurious readings and to improve catch efficiency. Complete descriptions of sensor audit and calibration methods are located in Appendix B.

Table B3 lists the sampling and averaging times for all of the meteorological variables that will be collected throughout this project. Wind speed, wind direction, temperature, solar radiation, evaporation pan level, and relative humidity will be sampled every second, and will be used to determine the mean hourly values of the measured parameters. Discrete precipitation values will be recorded to the datalogger each time the precipitation sensor detects a signal, and subsequently processed to provide measurements of total precipitation per hour. In addition, instantaneous measurements of barometric pressure will be sampled once every hour.

Table B2. Summary of Meteorological Sensors and Performance Specifications

Meteorological Parameter	Measurement Method	Sensor Characteristics	Manufacturer Specification	Guidance Document
Wind Speed - Primary (Climatronics F460)	Three-cup anemometer	Max Operating Range	0 - 65 m/s	0 - 50 m/s
		Starting Speed	0.22 m/s	0.5 m/s
		Accuracy	± 0.07 m/s or 1%	± 0.2 m/s + 5%
		Temperature Range	-40 ºC to +60 ºC	Not Specified
		Distance Constant	Less than 4.0 m (13.1 ft)	5 m
		Measurement Resolution	0.01 m/s	0.1 m/s
Wind Direction - Primary (Climatronics F460)	Precision low-torque potentiometer	Azimuth	0 - 360º	Not Specified
		Starting Speed[1]	0.22 m/s	0.5 m/s
		Accuracy	± 2º	± 5º
		Damping Ratio[1]	>0.4	0.4 to 0.7
		Delay Distance	< 1 m (3.3 ft)	5 m
		Temperature Range	-40 ºC to +60 ºC	Not Specified
		Measurement Resolution	0.1º	1.0º
Wind Speed - Secondary (RM Young 05305-AQ)	Propeller type anemometer	Max Operating Range	0 - 40 m/s	0 - 50 m/s
		Starting Speed	0.4 m/s	0.5 m/s
		Accuracy	± 0.2 m/s or 1%	± 0.2 m/s + 5%
		Temperature Range	-50 ºC to +50 ºC	Not Specified
		Distance Constant	2.1 m	5 m
		Measurement Resolution	0.01 m/s	0.1 m/s
Wind Direction - Secondary (RM Young 05305-AQ)	Precision low-torque potentiometer	Azimuth	0 - 360º	Not Specified
		Starting Speed	0.5 m/s	0.5 m/s
		Accuracy	± 3º	± 5º
		Damping Ratio	>0.4	0.4 to 0.7
		Delay Distance	1.2 m	5 m
		Temperature Range	-50 ºC to +50 ºC	Not Specified
		Measurement Resolution	0.1º	1.0º
Ambient Temperature and Delta T Met One 062-MP)	Solid state thermistor	Accuracy	± 0.05 ºC	± 0.1 ºC
		Time Constant	3.6 sec	1 min
		Temperature Range	-50 ºC to +50 ºC	-40 ºC to +60 ºC
Solar Radiation (Li-Cor LI200X)	Silicon photovoltaic detector	Accuracy	± 5 %	± 5 % of observed
		Time Constant	1 sec	5 sec
		Spectral Response[2]	400 nm to 1,100 nm	285 nm to 2,800 nm
		Temperature Range	-40 ºC to +65 ºC	-20 ºC to +40 ºC
Barometric Pressure (Vaisala PT101B)	Silicon capacitive absolute pressure sensor	Accuracy	± 0.5 mb	± 3 mb
		Temperature Range	-40 ºC to +60 ºC	Not specified
		Measurement Resolution	< 0.5 mb	0.5 mb
		Measurement Range	600 – 1,060 mb	Not specified

[1] At 10º initial angle of attack
[2] Guidance document allows photovoltaic pyranometers when data will be used to estimate stability.

Table B2 (Continued). Summary of Meteorological Sensors and Performance Specifications

Meteorological Parameter	Measurement Method	Sensor Characteristics	Manufacturer Specification	Guidance Document
Relative Humidity (Vaisala HMP45AC)	Capacitance change of a polymer thin film capacitor	Accuracy	± 2 % RH	± 1.5ºC [3]
		Time Constant	15 sec	30 min
		Temperature Range	-40 ºC to +60 ºC	-30 ºC to +30 ºC
		Measurement Resolution	0.1 % RH	0.1 ºC [3]
		Measurement Range	0-100% RH	-30 ºC to +30 ºC
Precipitation (ETI NOAH II)	Pressure of water column above a load cell mechanism	Accuracy	± .254 mm	± 0.5 mm
		Temperature Range	-30 ºC to +50 ºC	Not specified
		Measurement Resolution	± 0.254 mm	0.3 mm
		Measurement Range	0 to 12 in	Not specified
Evaporation (Nova Lynx 255-100)	Change in pressure head determined by float mechanism	Accuracy	± 0.25% over 10" range	Not specified
		Time Constant	1 sec	Not specified
		Temperature Range	0 ºC to 60 ºC	Not specified
		Measurement Resolution	1.0 mm	Not specified
		Measurement Range	3 to 10 in	Not specified

[3] Guidance document specifies values for dew point, not relative humidity.

Table B3. Sampling and Averaging Times for Meteorological Parameters

Meteorological Parameter	Sampling time	Averaging time
Wind Speed	1 sec	1 hr
Wind Direction	1 sec	1 hr
Wind Sigma	1 sec	1 hr
Temperature	1 sec	1 hr
Δ Temperature	1 sec	1 hr
Solar Radiation	1 sec	1 hr
Relative Humidity	1 sec	1 hr
Evaporation	1 sec	1 min
Precipitation[1]	n/a	n/a
Barometric Pressure[2]	1 hr	n/a

[1] Instantaneous precipitation measurements are collected by the datalogger and subsequently summed on an hourly basis.
[2] Instantaneous pressure measurements are sampled once per hour.

B2.2 Environmental Controls

Weatherproof enclosures and/or structures will be installed at each monitoring site for protection of the datalogger, batteries, modem, and barometric pressure sensor. Each monitoring station will be properly grounded to prevent damage from possible lightning strikes. To assure accurate temperature data, each temperature sensor will be mounted within identical fan-aspirated solar radiation shields.

B3. Sample Handling and Custody

Not applicable. No physical samples will be taken as part of this project.

B4. Analytical Methods Requirements

The meteorological sensors to be used for this project meet the specifications and recommendations in *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005) (see Table B2).

B5. Quality Control

Quality Assurance/Quality Control (QA/QC) procedures are required for this project to ensure that the collected meteorological data meet standards of reliability and accuracy. Quality control for this project will follow EPA PSD monitoring requirements presented in *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005) and *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)* (EPA 450/4-87-007).

All monitoring equipment will be acquired from manufacturers whose equipment meets EPA meteorological monitoring guidelines. In no case will inferior equipment be used. The Critical Validation Criteria Table (Table B4) outlines criteria deemed critical to maintaining the integrity of a sample or group of samples. Data that do not meet each and every criterion on the Critical Validation Criteria Table will be invalidated unless compelling reason and justification exist for not doing so. The samples for which one or more of these criteria are not met are invalid unless proven otherwise. The cause for not operating in the acceptable range for each violated criteria will be investigated and future occurrences avoided to reduce the likelihood that additional samples will be invalidated.

The QA/QC Operational Evaluations Table (Table B5) outlines criteria that are important for maintaining and evaluating the quality of the data collection system. Violation of a criterion or a number of criteria may be cause for invalidation of the data. The decision to invalidate data will consider other quality control information that may or may not indicate the data are acceptable. Therefore, a sample or group of samples for which one of these criteria is not met is suspect unless other quality control information demonstrates otherwise. The reason for not meeting the criteria will be investigated, mitigated, and/or justified.

The Systematic Issues Table (Table B6) outlines criteria important for the correct interpretation of the data but that do not usually impact the validity of a sample or group of samples. For example, data quality objectives are included in this table. Not meeting these data quality objectives does not invalidate any of the samples, but may impact the error rate associated with the attainment/non-attainment decision.

Table B4. Meteorological Sensors QA/QC Critical Validation Criteria

Meteorological Sensors Critical Validation Criteria			
Criteria	***Acceptable Range***	***Frequency***	***40 CFR Reference EPA QA Guidance***
Standard Reporting Units		all data	
Wind speed	m/s	"	EPA-454/R-99-005
Wind direction	0-360 degrees	"	"
Temperature	Celsius	"	"
Delta temperature	Celsius	"	"
Barometric pressure	mbar	"	"
Solar radiation	W/m^2	"	"
Equipment			
Wind speed sensor	Meets recommended specs in guidance	Purchase	EPA-454/R-99-005
Wind direction sensor	"	"	"
Temperature sensor	"	"	"
Delta temperature sensor	"	"	"
Barometric pressure sensor	"	"	"
Solar radiation sensor	"	"	"
Completeness			
Annual - all parameters	90% hourly data capture/calendar qtr	1 year (all calendar qtrs)	EPA-450/4-87-007
Hourly avg.-all parameters	>45 min/hourly average	hourly average	"
Calibration			
All sensors calibrated by manufacturer	According to manufacturer specs and within EPA accuracy criteria	Every six months	EPA-454/R-99-005
Performance Audit and Calibration Transfer Standards			
Audit and Calibration Standards	Audit Std independent from Cal Stds	Within std certification freq	EPA-454/R-99-005
Wind speed	Co-located transfer standard	Every 6 months	EPA-454/R-99-005
WS bearing torque meter	"	"	"
Wind direction	"	"	"
WD bearing torque meter	"	"	"
Temperature	"	"	"
Delta temperature	"	"	"
Barometric pressure	"	"	"
Solar radiation	"	"	"
Assessments			
Accuracy **Performance Evaluation**	All sensors	Every six months and within 30 days of site start-up	EPA-454/R-99-005

Table B5. Meteorological Sensors QA/QC Operational Evaluations

Meteorological Sensor Operational Evaluations			
Criteria	***Acceptable Range***	***Frequency***	***40 CFR Reference EPA QA Guidance***
Range Checks			
Data Screening Criteria	EPA Suggested Criteria		(EPA-454/R-99-005)
Wind direction	$0^o \leq WD \leq 360^o$	All data	Section 8.6, Table 8-4
	WD varies ≥ 1°/3 consecutive hrs.	"	"
	WD varies ≥ 10°/18 consecutive hrs.	"	"
Wind speed	0 m/s ≤ WS ≤ 25 m/s	"	"
	WS varies ≥ (0.1m/s)/3 consecutive hrs.	"	"
	WS varies ≥ (0.5m/s)/12 consecutive hrs.	"	"
Temperature	local record low < T < local record high	"	"
	T < 5°C from previous hour	"	"
	T varies > 0.5°C for 12 consecutive hrs	"	"
Temperature difference	daytime ΔT < 0.1°C/m	"	"
	nighttime ΔT > -0.1°C/m	"	"
	ΔT > -3.0°C, ΔT <5.0°C	"	"
Barometric pressure	pressure < 1060 mbar (sea level)	"	"
	pressure > 940 mbar (sea level)	"	"
	pressure varies > 6mb/3hours	"	"
Solar radiation (SR)	nighttime SR = 0	"	"
	daytime SR < max SR for date/latitude	"	"
Calibrations			
All sensors calibrated by manufacturer	According to manufacturer specs	Every six months	EPA-454/R-99-005
WD alignment	WD alignment to true N verified by TSN	"	"
Quality Control (QC) Checks			
Visual inspections			
Wind speed sensor	Moving freely, no visual damage	Each site visit	EPA-454/R-99-005
Wind direction sensor	Moving freely, no visual damage	"	"
Temperature sensor	No visual damage or obstruction	"	"
Delta temperature sensor	No visual damage or obstruction	"	"
Barometric pressure sensor	No visual damage or obstruction	"	"
Solar radiation sensor	No visual damage or obstruction	"	"
Time and Date DAS	DAS time/date agree with NIST time	"	"

Table B5 (Continued). Meteorological Sensors QA/QC Operational Evaluations

Meteorological Sensor Operational Evaluations			
Criteria	***Acceptable Range***	***Frequency***	***40 CFR Reference EPA QA Guidance***
Assessments			
Systems Audit			
Thorough review of entire monitoring system including field systems, data management, and data reporting.		1/year and < 30 days of site start-up	EPA-454/R-99-005
Performance Evaluation			
Wind speed	+/- 0.2 m/s +/- 5%	Every six months and <30 days of site start-up	EPA-454/R-99-005
WS bearing torque threshold	<= 0.5 m/s	"	"
Wind direction	+/- 5 degrees	"	"
WD linearity crossover	+/- 3° (included in +/- 5° above)	"	"
WD bearing torque threshold	<= 0.5 m/s	"	"
Temperature	+/- 0.5 Celsius	"	"
Delta temperature	+/- 0.1 Celsius	"	"
Barometric pressure	+/- 3 mbar	"	"
Solar radiation	+/- 5% of Observed	"	"

Table B6. Meteorological Sensors QA/QC Systematic Issues

Meteorological Sensor Systematic Issues			
Criteria	***Acceptable Range***	***Frequency***	***40 CFR Reference EPA QA Guidance***
Standard Reporting Units			
Wind speed	m/s	all data	EPA-454/R-99-005
Wind direction	0-360 degrees	"	"
Temperature	Celsius	"	"
Delta temperature	Celsius	"	"
Barometric pressure	mbar	"	"
Solar radiation	W/m2	"	"
Assessments			
Systems Audit			
Thorough review of entire monitoring system (field, lab, data, ect.)	In compliance with approved QAPP	Once per year and less than 30 days within site start-up	EPA-454/R-99-005

B6. Instrument/Equipment Testing and Inspection/Maintenance

B6.1 Acceptance Testing

Prior to installation, all equipment will be visually inspected to ensure no physical damage exists. After installation and prior to the beginning of the monitoring period, sensors will be calibrated according to the procedures stated in their respective operating manuals. Acceptance testing procedures will be documented on the appropriate calibration forms (provided in Appendix B). To ensure that the sensors continue to properly operate during the monitoring period, calibration checks of the instruments will be conducted semiannually as outlined in Section C1.1 of this QAPP.

B6.2 Site Surveillance and Equipment Inspection and Maintenance

HCG station operators will visit the monitoring station to inspect the condition of the monitoring equipment every 4 to 8 weeks and as needed. During each visit the following tasks will be conducted:

- Check the tower and sensors for signs of storm damage and/or vandalism;
- Observe the sensors to determine if the units appear to be operational;
- Verify that the wind speed and wind direction sensors are moving freely (which is especially important during periods of freezing rain or snow); and
- Clear snow, ice, or accumulated water from surfaces of sensors.

A check list is used to document work performed during the surveillance visits and will be filed with the site visit memo (Appendix B). In the event that station repairs or modifications become necessary, the HCG project manager will dispatch HCG field personnel to accomplish the necessary work. Table B7 is a list of spare parts for this project that will be stored at the HCG Anchorage office and, in some cases, on site to minimize periods of invalid data collection. HCG staff will review data from the stations at least once every work day to check that meteorological sensors and data acquisition are functioning properly.

B6.3 Preventive Maintenance and Corrective Actions

The procedures and schedule for preventive maintenance outlined in the standard operating procedure (SOP) will be followed for this monitoring program (Appendix B). As needed, the spare parts and/or sensors will be dispatched to the monitoring station for repair or sensor replacement by qualified HCG personnel (see Section A4, Organization Chart).

Table B7. List of Meteorological Equipment Spare Parts

Meteorological Parameter	Manufacturer	Model	Spare Parts
Wind Speed	Climatronics/ RM Young	F460/ 05305AQ	Extra sensor, cups[1], propeller[1], and bearings
Wind Direction	Climatronics/ RM Young	F460/ 05305AQ	Extra sensor, vane[1], and bearings
Ambient Temperature	Met One	062-MP	Spare sensor
Delta Temperature	Met One	062-MP	Pair of matched spare sensors
Barometric Pressure	Vaisala	PT101B	Spare sensor
Relative Humidity	Vaisala	HMP45AC	Spare sensor
Solar Radiation	Li-Cor	LI200X	Spare sensor
Precipitation	ETI	NOAH II	Spare sensor and recommended parts
Evaporation	NovaLynx	255-100	Spare sensor and recommended parts

[1] Stored at HCG Anchorage office and at the monitoring site.

B7. Instrument/Equipment Calibration and Frequency

B7.1 Calibration Frequency

Sensors will be calibrated according to the manufacturers' recommendations by HCG personnel immediately prior to the project start date and on a semiannual basis thereafter. Associated calibration forms, methodology, and calibration SOP are presented in Appendix B.

B7.2 Calibration Equipment

All instruments used for calibrating meteorological sensors will be traceable to a National Institute of Standards and Technology (NIST) transfer standard. Calibration certifications will remain on file at the HCG main office. Specific calibration equipment used, NIST traceability standards, equipment certification frequency, equipment accuracy, and calibration range for each meteorological parameter measured are provided in Table B8. The specifications stated in *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA-600/R-94/038c, September 1994) and *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005), for the calibration parameters are referenced in Table B8 to show compliance with EPA standards.

Table B8. List and Specifications for Calibration Equipment

Meteorological Instrument	Calibration Standard	Calibration Standard Characteristics	Manufacturer Specification	Guidance Document
Wind Speed (Climatronics F460 and RM Young 05305-AQ)	**RM Young 18801 Anemometer Drive**	Range of calibration	0 to 10,000 rpm	0, 2, 5, 10 m/s
		Range of standard	0 to 10,000 rpm	Not Specified
		Accuracy of standard	1.0 rpm	Not Specified
		Calibration Frequency[1]	annually	annually[2]
		NIST traceability method	via RM Young certification	Not Specified
Wind Direction (Climatronics F460 and RM Young 05305-AQ)	**Climatronics F460/ RM Young linearity Test Fixture**	Range of calibration	0 to 360º	Not Specified
		Range of standard	0 to 360º	Not Specified
		Accuracy of standard	0.75º	Not Specified
		Calibration Frequency[1]	n/a	n/a
		NIST traceability method	n/a	n/a
Ambient Temperature and Delta T (Met One 062-MP)	**Control Company Traceable 4000 series thermometer**	Range of calibration	-20º to 400º C	-40º to 60º C
		Range of standard	-50º to 150º C	Not Specified
		Accuracy of standard	± 0.001º C	± 0.1 ºC
		Calibration Frequency[1]	annually	annually[2]
		NIST traceability method	via Control Co. certification	Not Specified
Solar Radiation (LiCor LI200X)	**Co-located Eppley PSP**	Range of calibration[3]	0 to 2000 w/m^2	Not Specified
		Spectral Response[4]	285 to 2800 nm	285 to 2800 nm
		Accuracy of standard	± 0.5 %	± 5 % of observed
		Calibration Frequency[1]	annually	annually[2]
		NIST traceability method	To world radiometric reference via calibration with Eppley Cavity Pyrheliometer	To world radiometric reference
Barometric Pressure (Vaisala PT101B)	**Co-located Pretel AltiPlus A2**	Range of calibration	Ambient condition check (ACC)	ACC
		Range of standard	728 to 1050 mb	Not specified
		Accuracy of standard	± 1 mb	0.2 %
		Calibration Frequency[1]	annually	annually[2]
		NIST traceability method	via Chinook Engineering certification to Ruska Deadweight tester	Not specified
Relative Humidity (Vaisala HMP45AC)	**Co-located Vaisala HMI41**	Range of calibration	Ambient condition check (acc)	ACC
		Range of standard	0-100% RH	Not Specified
		Accuracy of standard	± 2 % RH	± 1.5ºC[5]
		Calibration Frequency[1]	annually	annually[2]
		NIST traceability method	via Vaisala Labs certification with Hyrgo M-3 dewpoint meter	Not specified
Precipitation (ETI NOAH II)	**NovaLynx 260-2595 Tipping Bucket Rain Gauge Calibrator**	Range of calibration	24.66 mm/hr	< 25.0 mm/hr
		Range of standard	0 to 940 ml	n/a
		Accuracy of standard	n/a	Not specified
		Calibration Frequency[1]	n/a	n/a
		NIST traceability method	n/a	n/a
Evaporation (Nova Lynx 255-100)	**Graduated Cylinder**	Range of calibration	3”-9” of H_20 in gauge	Not specified
		Range of standard	n/a	Not specified
		Accuracy of standard	n/a	Not specified
		Calibration Frequency[1]	n/a	Not specified
		NIST traceability method	n/a	n/a

Note: All monitoring instrument calibrations performed every six months.
[1] Refers to calibration frequency of calibration standard/instrument.
[2] Guidance document specifies standard calibration per manufactures’ specifications.
[3] Calibration range for solar radiation will be specific to the time and day of audit.
[4] Guidance document allows use of photovoltaic pyranometers when data will be used to estimate stability.
[5] Guidance document specifies values for dew point, not relative humidity.

B8. Inspection/Acceptance of Supplies and Consumables

All spare parts inventories will be kept up to date by the data manager. Each new spare part will be accepted with the same procedures mentioned in Section B6. Serial numbers for each spare sensor will be recorded by either the data manager or technicians and filed with the data manager. Upon deployment of a replacement part/sensor by site technicians, the make, model, and serial number will be recorded on a Site Visit and System Check form (see Appendix B) or an equivalent site visit memorandum. Each replacement sensor will be calibrated and a performance audit will be completed by technicians to ensure that the senor is properly functioning. The make, model, and serial number of the removed sensor, as well as replacement sensor information, will also be recorded on the performance audit form provided in Appendix B.

Consumable supplies are not expected to be necessary for this project.

B9. Non-direct Measurements

B9.1 Climate History

The Iliamna airport provides the only known comprehensive climate data available near the Pebble Project area. The Pebble Project mine area stations are located approximately 20 miles northwest of the Iliamna airport and the Pebble Port station lies approximately 50 miles to the southeast. Figure B11 shows the daily extreme and average high and low temperatures recorded at Iliamna from November 10, 1939 through 2005. The mean temperature at Iliamna ranges from 3°C (37°F) in January to 30°C (56°F) in July. The record low of -44°C (-47°F) was measured on January 22, 1947 and the record high of 33°C (91°F) was measured on June 27, 1953.

Figure B12 shows the monthly mean precipitation for Iliamna compiled from measurements collected from November 11, 1939 through 2005. Iliamna experiences the most precipitation in August and September with monthly mean precipitation values of 4.62 inches (117 mm) and 4.32 inches (110 mm), respectively. April is typically the driest month and has a monthly mean of 1.08 inches (27 mm) of precipitation.

Figure B13 shows a wind rose based on data collected by the National Weather Service from January 1, 2000 to December 31, 2004 at the Iliamna airport. Prevailing winds typically blow from the north and east. Because the Pebble Project meteorological stations are positioned at significant distances away from the airport and sit at varying elevations relative to the Iliamna airport and each other, the monitoring sites are expected to experience somewhat different meteorological conditions.

Figure B11. Iliamna Daily Extreme and Average High and Low Temperatures

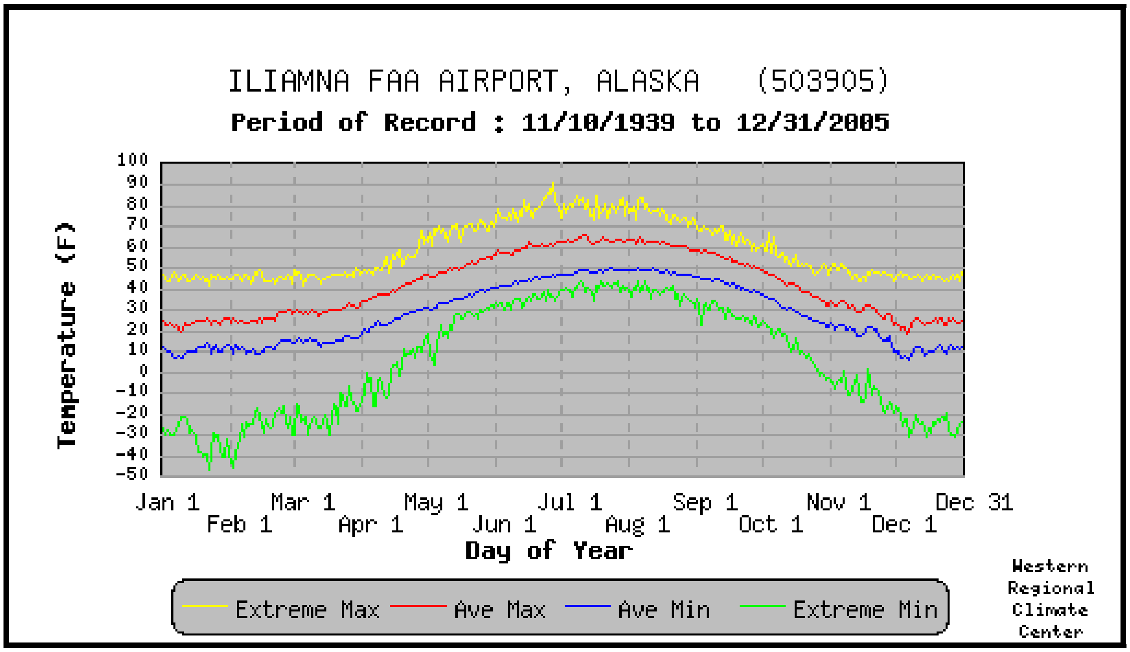


Figure B12. Iliamna Monthly Mean Precipitation

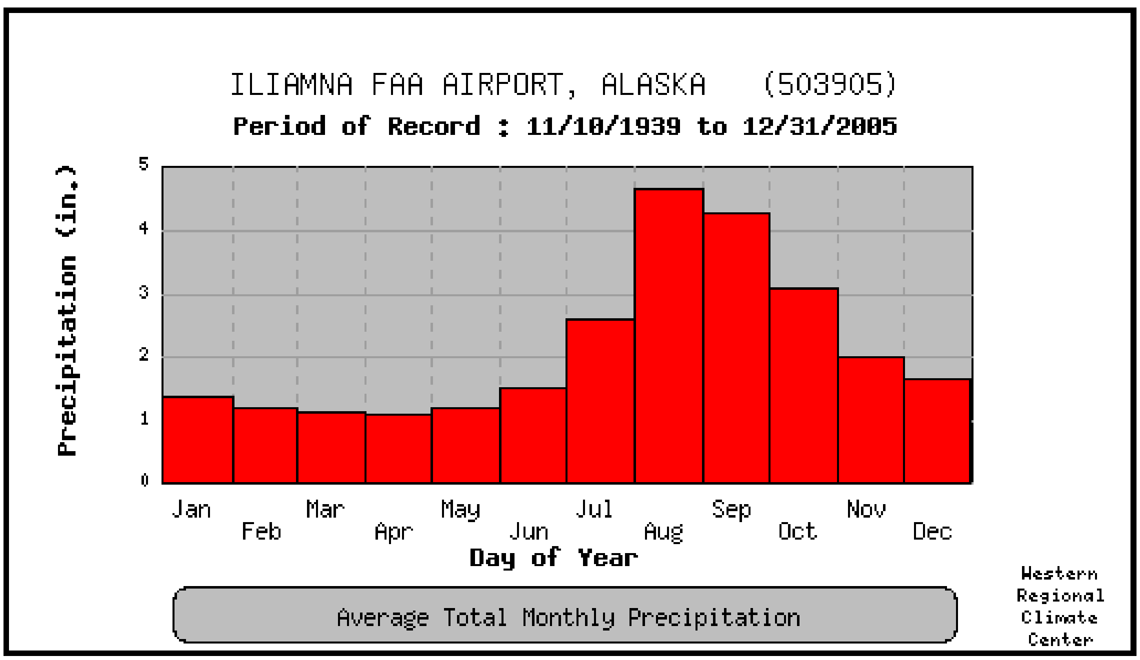
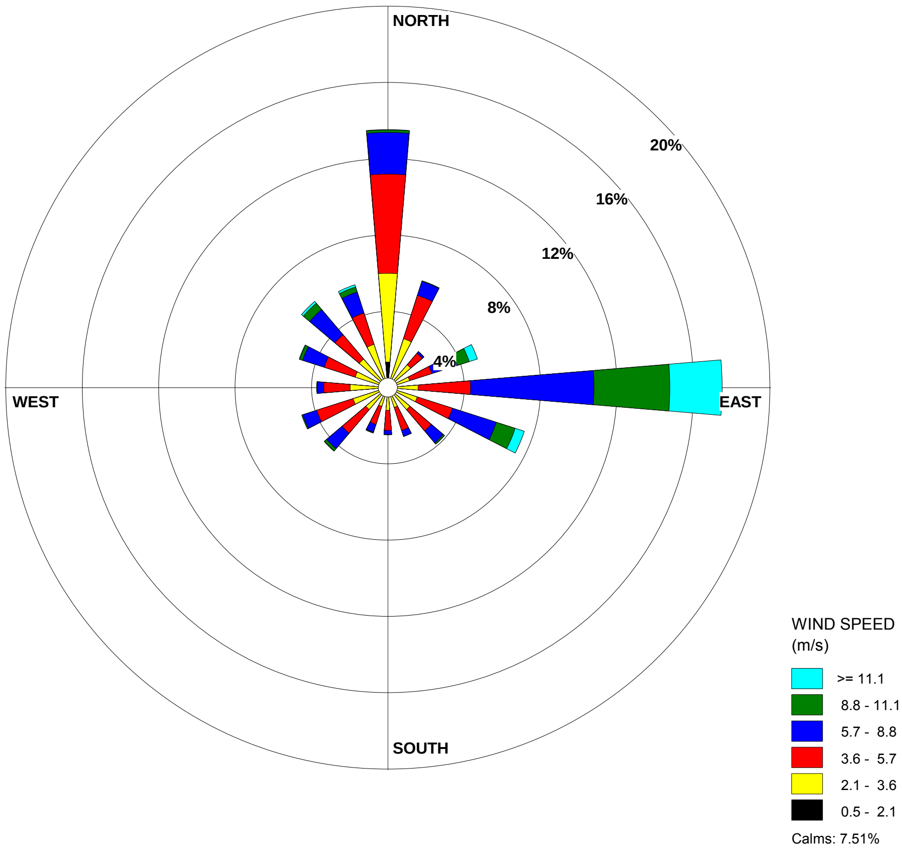


Figure B13. Iliamna Wind Rose

WIND ROSE PLOT: Station #25506 - Iliamna, AK	DISPLAY: Wind Speed Direction (blowing from)



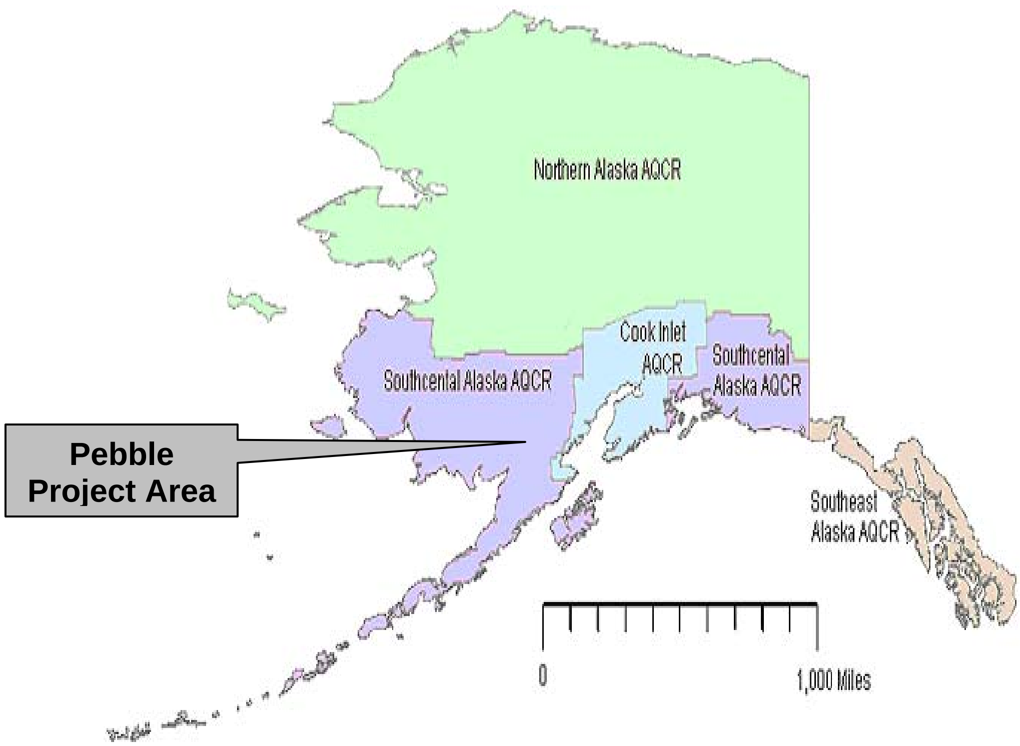
COMMENTS:	DATA PERIOD: 2000-2004 Jan 1 - Dec 31 00:00 - 23:00		
	CALM WINDS: 7.51%	TOTAL COUNT: 43476 hrs.	HOEFLER CONSULTING GROUP
	AVG. WIND SPEED: 4.63 m/s	DATE: 9/1/2005	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

B9.2 Land Use

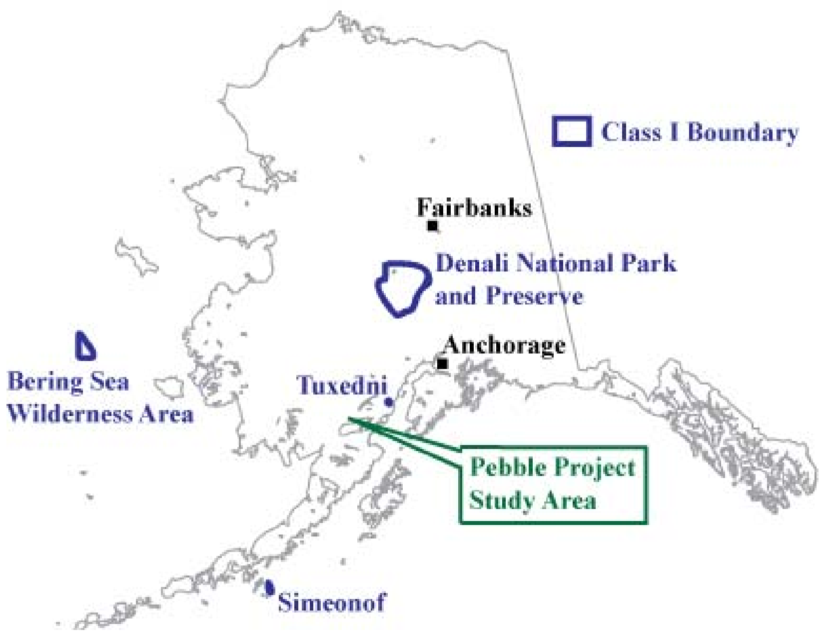
The Pebble Project study area is in a remote region of southwestern Alaska. The Pebble Port location lies within the boundaries of the Cook Inlet Air Quality Control Region (AQCR), as shown in Figure B14. The Pebble Project mine area lies within the boundaries of the Southcentral AQCR, as shown in Figure B14.

Figure B14. Alaska Air Quality Control Regions



The map in Figure B15 shows the Class I areas in Alaska. The map reference to Denali National Park and Preserve is actually "Denali National Park including the Denali Wilderness but excluding the Denali National Preserve", as per 18 AAC 50.015. The Pebble Project area is within a Class II area and has been designated attainment or unclassifiable for all criteria pollutants. The Tuxedni Wilderness Area is the closest Class I area, which lies approximately fifty miles away from the proposed Pebble Port site, and ninety miles away from the Pebble Project mine area.

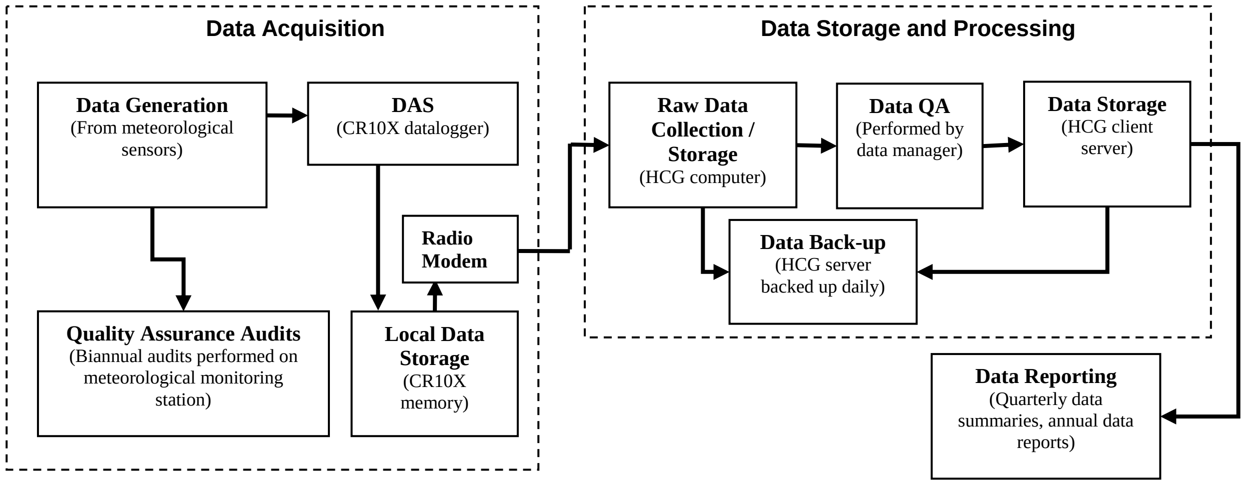
Figure B15. Alaska Class I Areas



B10. Data Management

The proper management of all data associated with this project is critical to assuring the quality and usability of the monitoring results. Therefore, procedures will be implemented to ensure adequate data acquisition, validation, transmission, reduction, reporting, and storage of electronic and hard copy data. Summaries of the procedures to be implemented in the field and in the laboratory for data management are provided in the following sections. Overall data processes are described in Figure B16, the Data Processes Flow Chart.

Figure B16. Data Processes Flow Chart



B10.1 Data Acquisition

Data acquisition will include the daily collection of electronic data, the generation of hand-written or typed audit and calibration records, and the compilation of previously prepared records (e.g., NIST traceability records). A Campbell Scientific CR10X datalogger will be used to collect and store the continuous meteorological data. Freewave wireless and SixNet telephone modems will be used to contact the stations remotely via a designated monitoring computer at HCG's Anchorage office. Station data will be downloaded on a daily basis. Field staff and the station auditor will generate written or typed records. These records will be kept according to the prescribed format. Additional records pertaining to this project that have been generated by other organizations will also be collected and stored at the HCG Anchorage main office as necessary.

B10.2 Data Validation

Meteorological data will be reviewed every work day by the HCG data manager or designated qualified personnel and screened using the recommended criteria in *Meteorological Monitoring Guidelines for Regulatory Modeling Applications* (EPA-454/R-99-005), Table 8-4. Site specific Microsoft Access databases and Excel spreadsheets will be used to store, review, and compare data to EPA critical criteria.

During each site visit, HCG Field Technicians will be responsible for verifying the condition of the monitoring site. All site visits will be documented by means of a site visit memo kept with the project files. Alternately, the site visit may be documented in a designated station log book. These field notes will include the following:

- Time, date, current meteorological conditions, and personnel at the monitoring site;
- Activities completed during visit; and
- As-found and as-left observed conditions of monitoring site equipment.

The data manager or their designee will review all records received from the field. Problems or irregularities in the records will be brought to the attention of HCG Field Technicians for further clarification. If the documentation is not sufficiently defensible, the affected data will be invalidated.

B10.3 Data Transmission

Meteorological data will be collected daily by electronic transmission to the HCG Anchorage office. Original forms, check lists, and other records will be stored upon receipt at the HCG main office until the end of the monitoring period. A description of the equipment implemented in the monitoring site telemetry is included in the above section B10.1.

B10.4 Data Reduction

All electronic calculations and statistical analyses will be performed using standard software packages (e.g., MINITAB, Excel, and WRPLOT view) that can be easily verified and audited. Preliminary data reduction to hourly data averages is performed by the CR10X datalogger.

B10.5 Data Reporting

Data generated for this project will be routinely summarized and presented to NDM as described in Section C2. The data will also be submitted to ADEC for review and approval in anticipation of using the meteorological data to meet the air dispersion modeling requirements for a minor source air construction permit application.

B10.6 Data Storage

All project documentation, records, data, and reports will be maintained at HCG for a period of at least five years from the completion of the project. Electronic data on the HCG servers are backed up at least once daily and will be archived at a minimum of two separate locations.

B10.7 Data Use in Modeling

The meteorological data collected during this project will be used for air dispersion modeling using EPA approved AERMOD and CALPUFF models.

C. Assessments and Oversight

C1. Assessments and Response Actions

Data Quality Assessments will be performed on all collected data. Data reviews will be conducted by HCG staff to determine whether the data are reasonable and representative through an independent audit program. Data that are determined to be unreasonable or unrepresentative will be identified, flagged, and discussed in the data reports. The independent audit program for the Pebble Project will consist of semi-annual performance audits and annual systems audits. The audits will be conducted by HCG staff and will be independent of the staff operating the monitoring network. In addition, audits will be conducted using equipment independent of that used for instrument calibrations. The auditor will use a pre-formatted audit form and follow established audit standard operating procedures provided in Appendix B.

C1.1 Performance Audits

Performance audits of the meteorological sensors will be conducted within thirty days of the project start, semi-annually thereafter, and within thirty days of project completion. Performance audits for meteorological sensors will be conducted by collocating independent meteorological sensors with those being used for the monitoring program. The audit sensors will be provided by the station auditor. Performance audits will serve the monitoring program with a measure of quality assurance for meteorological sensors and a means to produce a defensible data set. The performance audits will be conducted in accordance with the procedures outlined in *Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Section 8 (EPA-454/R-99-005). The QA auditor will conduct the performance audits. An outline for the audit equipment and procedures on all meteorological sensors used for this study is listed in Table C1.

C1.2 Systems Audits

In the *Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Section 8 (EPA-454/R-99-005), and *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)*, Section 7 (EPA-450/4-87-007), EPA recommends that a systems audit be conducted to assess compliance with established regulations governing the collection, analysis, validation, and reporting of meteorological monitoring for PSD. A systems audit is an independent review of program procedures and files to assess conformance to established plans, SOPs, and protocols (see Appendix B). Systems audits for this project will be conducted no later than 30 days after project startup and annually thereafter. The systems audit will evaluate the complete measurement system from data collection through data reporting. The evaluation will also include all off-site data handling and evaluate the management process.

The systems audit is also an on-site qualitative review of the operational procedures of the monitoring program. The audit will ensure that all procedures for the monitoring program (field operations, data reporting, and data management) are being followed and that the data being collected meet the DQOs for the program as described in Section A7. Items reviewed during the systems audit include:

- Quality assurance procedures and documentation;
- Station installation and operation procedures;
- Calibration procedures and documentation for monitoring equipment;
- Documentation of log books and data sheets;
- Completion and documentation of on-site quality assurance procedures; and
- Review of prepared data sets.

After completion of the audit, a debriefing will be conducted with the participants to discuss preliminary audit results. The results of this audit will then be formally compiled in an audit report with observations of strengths and deficiencies, and recommendations for improvements. The audit report will be submitted by the auditor to the NDM and HCG project managers within 30 days. The HCG project manager will ensure that any necessary corrective actions are implemented in a timely manner. Audit forms and further information on system audits are provided in Appendix B.

Table C1. List of Performance Audit Equipment and Procedures

Meteorological Variable	Make/Model	Audit Method	NIST Traceable Audit Tool Used	Frequency of Audit	Procedure
Wind Speed	Climatronics F460/ RM Young 05305-AQ	Synchronous motor comparison	RM Young 18801 Anemometer Drive	Semiannually	See SOP in Appendix B
Wind Direction	Climatronics F460/ RM Young 05305-AQ	Fixed linearity test	Climatronics F460/ RM Young 05305 linearity test fixture	Semiannually	See SOP in Appendix B
Ambient Temperature and Delta T	Met One 062-MP	Co-located temperature immersion bath comparison	Control Company Traceable 4000 series thermometer	Semiannually	See SOP in Appendix B
Solar Radiation	Li-Cor LI200SZ	Co-located sensor comparison	Eppley Labs PSP	Semiannually	See SOP in Appendix B
Barometric Pressure	Vaisala PT101B	Co-located sensor comparison	Pretel Altiplus A2	Semiannually	See SOP in Appendix B
Relative Humidity	Vaisala HMP45ASP	Co-located sensor comparison	Vaisala HMI41	Semiannually	See SOP in Appendix B
Precipitation	ETI NOAH II	Volumetric drip comparison	Nova Lynx 260-2595 Tipping Bucket Rain Gauge Calibrator	Semiannually	See SOP in Appendix B
Evaporation	Nova Lynx 255-100	Water height comparison	Precision Tape Measure	Semiannually	See SOP in Appendix B

C1.3 Corrective Actions

All deficiencies identified during audits and site visits will be recorded and reported to the project manger no later than seven working days of discovery. Corrective actions to rectify deficiencies will be addressed and documented in a Corrective Action Form (see Appendix

B) and on the audit reports. Corrective actions will also be discussed in the annual data reports.

Based on the review of the systems audit, it may be necessary to revise this QAPP. The QAPP revisions will address any project deficiencies stated in the system audit. The project manager and permitting manager will make any necessary changes and the revised QAPP will be submitted to ADEC for approval.

C1.4 QAPP Revisions

After submittal and approval, any needed revisions of the NDM QAPP will be brought to the attention of the HCG project manager. Appropriate actions will be taken on any needed revisions and a revised version of the QAPP will be submitted to ADEC and NDM.

C2. Reports to Management

In accordance with ADEC reporting guidelines, quarterly data summaries and annual data reports will be prepared by HCG and provided to NDM and ADEC. Two separate annual data reports will be prepared, one for each monitoring year. All quarterly data summaries and annual data reports will be submitted to ADEC after ADEC has received the QAPP.

Quarterly data summaries will be prepared by HCG in accordance with the format described in *PSD Ambient Air Quality & Meteorological Monitoring Quarterly Data Summary Format* (ADEC, March 2005) and provided to NDM and ADEC within 30 days after the completion of each calendar quarter.

The final annual data report will conform to format requirements in *PSD Quality Ambient Air Quality & Meteorological Monitoring Annual Data Report Format* (ADEC, March 2005) and be provided to NDM and ADEC within 90 days after completion of the monitoring period. This report will summarize the monitoring data for the entire period, including monthly, quarterly, and annual averages for all measured parameters. This report will also include the following:

- Data capture statistics for the meteorological sensors;
- Explanations for any missing or flagged data;
- Summaries of maintenance activities;
- Results of calibrations and audits;
- Raw data and calculations used for calibrations and audits; and
- Copies of site visit notes.

D. Data Validation and Usability

D1. Data Review, Validation, and Verification Requirements

D1.1 Data Review

As meteorological data are periodically received over the monitoring year, the data manager will review the incoming data and make comparisons to the standards discussed in Section B10.2 of this document. During each quarter, the data will be reviewed again by a certified staff meteorologist to ensure that the data are complete, accurate, and representative and that erroneous data have been removed in preparation for the final data report. All other documentation pertaining to this monitoring project (e.g., trip reports, audit and calibration data sheets) will be reviewed upon receipt to ensure that all forms are completed prior to acceptance and for further use in this project. Table D1 summarizes the data review for this monitoring project.

Table D1. Data Review List for the Pebble Project

Type of Data Generated	Method for Acceptance	Data Review	Review Frequency	Person Responsible for Data Review	Project Specific Calculations
Raw Data	Calibrated DAS	n/a	Every Work Day	Project and data manager	Delta T and Wind Sigma
QA Reviewed Data	Data Review	MS Excel and Access Databases screening for EPA PSD criteria	Each Work Day	Project and data manager	n/a
Quarterly Data Summary	HCG permitting manger review	MS Excel and Access Databases screening for EPA PSD criteria	Quarterly	Project and data manager	Quarterly data capture statistics
Annual Data Report	HCG permitting manger review	MS Excel and Access Databases screening for EPA PSD criteria	Annual	Project and data manager	Quarterly and annual data capture statistics

D1.2 Data Calculations

Meteorological data collected for this project will be used for air dispersion modeling. Atmospheric stability, commonly determined using the solar radiation-delta temperature (SRDT) method, will be calculated using the EPA approved AIRMET Program.

D2. Validation and Verification Methods

Data validation refers to the review process in which data are screened for errors and anomalies. All data for this meteorological monitoring program will be validated only after being screened by the criteria in *Meteorological Monitoring Guidance for Regulatory Modeling Applications,* Table 8-4 (EPA-454/R-99-005).

Semiannual audits and calibrations will be performed on the station to ensure that all sensors are operating within the tolerances suggested by the manufacturer and the EPA. During each site visit, the station operator will be responsible for recording any anomalies or significant events and bringing them to the attention of the data manager. Copies of the site visit memos will also be provided to the data manager.

For this project two types of wind sensors are being used to provide redundant data. The RM Young 05305-AQ wind sensor uses a combined propeller anemometer and vane assembly, and the Climatronics F-460 wind sensor uses a three cup-type anemometer with a separate vane-style wind direction sensor. The RM Young sensor can be somewhat less susceptible to rime ice build-up and is therefore used as a back-up wind measurement sensor. In cases when the Climatronics wind sensor data fails to meet the DQO goal of 90% quarterly data capture, the back-up RM Young wind data will be used, if deemed necessary and applicable. Both the primary and back-up wind sensors will have the same level of quality assurance checks as outlined in Sections B5 and B6.

The data manager will review data at least once each work day to check for irregularities in all measured parameters. Any suspicious data will be investigated.

D3. Reconciliation with User Requirements

The objective of this monitoring program is to collect surface meteorological data needed for engineering design and environmental purposes, including water balance studies, and for the preparation of the air quality construction permit applications for the mine, road, and port sites. Although the mine, road, and port facilities may not require a PSD permit, PSD-quality data will be collected to support the required computer-based dispersion modeling. HCG will conduct an annual or final review at the completion of the monitoring project and report the results obtained during the reporting period. These reports will be compared with the established DQOs to ensure that the scope of the project has been met.

The reconciliation of data for this project will be determined by the data validation and verification process as discussed in Section D2 of this document and based upon the five step Data Quality Assessment (DQA) plan recommended in *Guidance for Data Quality Assessments* (EPA QA/G-9):

1. A review of the DQOs and sampling design will be conducted by the permitting manager to assure meteorological outputs from this program are still applicable. If DQOs have not been developed, the permit manager will specify DQOs before evaluating the data. The permitting manager will also review the sampling design and data collection documentation for consistency with the DQOs.
2. A Preliminary Data Review will be conducted by the permitting manager. The manager will review QA reports, calculate basic statistics, and generate graphs of the data. This information will be used to determine data structure and identify patterns, relationships, or potential anomalies.
3. A statistical test will be selected that is most appropriate for summarizing and analyzing the data, based on the review of the DQOs, the sampling design, and the preliminary data review. The permitting manager will identify the key underlying assumptions that must hold for the statistical procedures to be valid.
4. Given the actual data and other information about the study, the permitting manager will evaluate whether identified assumptions will hold, or whether departures are acceptable.
5. Conclusions from the statistical calculations will be evaluated to determine if the monitoring design and its created data meet the required permits for the statistical test. This determination will be documented, as well as the inferences drawn as a result of these calculations. If the design is to be used again, an evaluation will be made on the performance of the sampling design.

If the preliminary data review reveals that data sets are inconsistent with the DQOs, or the underlying assumptions of the statistical test are not supported by the data and fail to meet the criteria/objectives of this monitoring project, then the permit manager and project manager will reconsider the project design as described in this QAPP.

APPENDIX A
PROGRAM REFERENCES

Alaska Climate Summaries, Western Regional Climate Center, Desert Research Institute, 2004. *http://www.wrcc.dri.edu/summary/climsmak.html*

Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD), (EPA-450/4-87-007)

AQCRs with Established Minor Source Baseline Dates for SO2 (map), WESTAR, 2004. http://www.westar.org/Committees/TDocs/AQCR%20maps/SO2B_24Sept04.pdf

Class I Areas (map), Alaska Department of Environmental Conservation Areas Sources Group, 2004. http://www.state.ak.us/dec/air/anpms/as/rh/rhhome.htm

EPA Requirements for Quality Assurance Project plans (EPA QA/R-5).

Guidance for Data Quality Assessments (EPA QA/G-9)

Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005, EPA, February 2000.

"PSD Quality Ambient Air Quality & Meteorological Monitoring Quarterly Data Summery Format" (ADEC, March 2005)

"PSD Quality Ambient Air Quality & Meteorological Monitoring Annual Data Report Format" (ADEC, March 2005)

Wind Rose Wizard Hourly Observations, 1945-1999, University of Alaska Anchorage School of Engineering, 2001. http://holmes-iv.engr.uaa.alaska.edu/ncar/WindRoseWizard.htm

18 AAC 50, Air Quality Control, Alaska Department of Environmental Conservation, As Amended through July, 2002.

APPENDIX B
STANDARD OPERATION PROCEDURES AND FORMS

APPENDIX B1
STANDARD OPERATION PROCEDURES

Calibration Procedure for Climatronics F460 Wind Speed and Wind Direction Sensors

1.0 Introduction

Calibration of Climatronics F460 type wind speed and wind direction sensors (hereafter referred to as F460 sensors) are calibrated at the factory before receipt. Therefore, the calibration schedule for an F460 sensor requires an initial calibration check, and calibrations every 6 months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

The calibration is comprised of the determination of sensor responses to known input values, maintenance and adjustment of the sensors responses if warranted, and the documentation of all adjustments and responses.

Items required for the calibration of an F460 are as follows:

1. RM Young 18801 (or similar model) anemometer drive
2. Climatronics F460 linearity test fixture
3. PC or similar display module
4. Tripod mounted, survey grade compass and/ or pre-determined bearings to landmarks.
5. F460 manual

The calibration will begin by filling out the first part of the wind speed and wind direction calibration forms, noting the time, date, calibrator, and any witnesses.

1.1 System Inspection

Before determining the initial response of a F460 inspect the cable, cups, vane, and bearings for damage, open the outer cuff of the sensor and look for condensation inside. Note these observations on the Wind Speed Calibration Form.

2.0 Wind Speed Calibration Procedures

2.1 Pre-adjustment System checks

A system response check is performed by the use of an RM Young 18801 (or similar model) anemometer drive. The cups are removed from the sensor shaft and the anemometer drive is attached. The sensor is then challenged at the speeds specified on the Wind Speed Calibration Form. The speeds measured by the datalogger for each specific revolution per minute (rpm) are compared to the calculated values. The equation for calculating wind speed as a function of anemometer drive rpm is given on the Wind Speed Calibration Form.

2.2 Maintenance and Adjustments

At this point the technician should review the performance of the sensor and determine what adjustments are required, if any. All basic maintenance should be performed before any serious adjustment of the sensor, or determination of a new multiplier and/or offset in the datalogger programming. All maintenance and adjustments should follow the guidelines presented by the manufacturer in the F460 instrument manual.

2.3 Post-Adjustment Checks

If any maintenance or adjustments were performed, the steps listed in Section 2.1 of this procedure should be repeated and recorded on the Wind Speed Calibration Form. Results of the post adjustment checks should be closely evaluated. If the output values do not closely match the expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the sensor response. If the sensor is deemed un-repairable by the technician, it should be replaced as soon as possible from the stock of back-up sensors for the monitoring project.

3.0 Wind Direction Calibration Procedures

3.1 Sensor Orientation

After the system is inspected, a check of the wind vane orientation is performed. The two methods for an orientation check of the wind vane are as follows:

<u>Compass</u>

1. Determine declination for the area using a Geomag type program with the most recent models of the earth’s magnetic field.
2. Use a clamp fashioned from a band clamp and rubber tubing to fix the wind vane in various directions. In medium to high winds a vane with the “tail” removed may have to be used as to not damage the wind vane.
3. Using a tripod mounted and leveled, survey grade compass align the compass so that it sights directly at the tail of the wind vane.
4. Obtain readings in each of the four quadrants of the compass.
5. Record the readings from the datalogger and the compass on the Wind Direction calibration form.

<u>Landmark</u>

1. Obtain a GPS point directly under the wind direction sensor.
2. Using a mapping program (eg: TOPO!, allTOPO, or similar) with USGS datasets as its base files, obtain bearings to nearby defined landmarks.
3. Clamp and site the vane tail at the appropriate landmark and record the reading from the datalogger.

3.2 System Linearity Check

Using a Climatronics F460 linearity test fixture test the sensor at 30° intervals. Record the readings from the datalogger at each interval on the Wind Direction Calibration Form and compare to the expected values. If possible, check the linearity of the instrument by fitting a curve and checking the slope, and intercept of the Y = X line. Check to see if the accuracy of the instrument is no more than ± 5° (accuracy) and ≤ 3° mean absolute error (linearity). Mean absolute error is calculated by the the following equation: equation.

$$\sum \frac{|X|}{n}$$

Were *X* is the precision of the instrument at any given degree, and *n*, is the number of measurements taken.

3.3 Maintenance and Adjustment

At this point the technician should review the performance of the sensor and determine what adjustments are required, if any. All basic maintenance should be performed before any serious adjustment of the sensor, or determination of a new multiplier and/ or offset in the datalogger programming. All maintenance and adjustments should follow the guidelines presented by the manufacturer in the F460 instrument manual. If the orientation was incorrect, the alignment of the cross arm will need to be adjusted following the linearity check.

3.4 Post Adjustment Checks

After all maintenance and adjustments have been made, the steps listed in Sections 3.2 and 3.1 of this document should be repeated, respectively. All results should be recorded On the Wind Direction Calibration Form. Results of the post adjustment checks should be evaluated. If the output values do not closely match the expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the sensor response. If the sensor is deemed un-repairable by the technician, it should be replaced as soon as possible from the stock of back-up sensors for the monitoring project.

4.0 Conclusion

At the conclusion of the calibration, complete all calibration forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time which the calibrations for the wind speed and direction sensors began and ended. Sign and date the calibration form under any comments made.

Audit Procedure for Wind Speed and Wind Direction Sensors

1.0 Wind Speed

The required instruments to complete a wind speed audit are a torque watch, and anemometer drive.

The audit procedure is as follows: A system response check is performed by the use of an RM Young 18801 (or similar model) anemometer drive. The cups are removed from the sensor shaft and the anemometer drive is attached. The sensor is then challenged at the speeds specified on the Wind Speed Audit Form. The speeds measured by the datalogger for each specific rpm are compared to the calculated values. The equation for calculating wind speed as a function of anemometer drive rpm is given on the Wind Speed Audit Form. The absolute difference from expected values is then calculated to see if the values agree within ±0.5 mph or 5% of observed.

The starting torque should be measured with a torque watch, and recorded on the Wind Speed Audit Form. If the sensor starting torque is above 0.0049 oz-in the bearings may need to be cleaned, oiled, or replaced.

2.0 Wind Direction

The process for auditing a wind direction sensor is described below:

<u>Compass</u>

1. Determine declination for the area using a Geomag type program with the most recent models of the earth's magnetic field.
2. Use a clamp fashioned from a band clamp and rubber tubing to fix the wind vane in various directions. In medium to high winds a vane with the "tail" removed may have to be used as to not damage the wind vane.
3. Using a tripod mounted and leveled, survey grade compass align the compass so that it sights directly at the tail of the wind vane.
4. Obtain readings in each of the four quadrants of the compass.
5. Record the readings from the datalogger and the compass on the Wind Direction calibration form.

<u>Landmark</u>

4. Obtain a GPS point directly under the wind direction sensor.
5. Using a mapping program (eg: TOPO!, allTOPO, or similar) with USGS datasets as its base files, obtain bearings to nearby defined landmarks.
6. Clamp and site the vane tail at the appropriate landmark and record the reading from the datalogger.

2.1 System Linearity Check

Using a linearity test fixture appropriate for the sensor, test the sensor at 30° intervals. Record the readings from the datalogger at each interval on the Wind Direction Audit Form and compare to the expected values. If possible, check the linearity of the instrument by fitting a curve and checking the slope, and intercept of the Y = X line. Check to see if the accuracy of the instrument is no more than ± 5° (accuracy) and ≤ 3° mean absolute error (linearity). Mean absolute error is calculated by the equation 1.0.

$$\sum \frac{|X|}{n}$$

Were *X* is the precision of the instrument at any given degree, and *n*, is the number of measurements taken.

Calibration Procedure for MetOne 062 Temperature Sensors

1.0 Introduction

MetOne 062 temperature sensors (hereafter referred to as temperature sensors) are calibrated at the factory before receipt. Therefore, the calibration schedule for a temperature sensor requires an initial calibration check, and calibrations every six months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

Equipment required for temperature sensor calibration is as follows:

1. Calibrated, certified, NIST traceable thermometer.
2. Thermal mass unit and or ice, warm, and hot water bath.
3. PC or similar display module.
4. MetOne 062 manual

The calibration should start by completing the top of the Temperature Sensor Calibrations Form.

1.1 System Inspection

Before determining the initial response of the temperature measurement system, inspect the signal cable and sensor for signs of damage and wear. Note these observations in the Temperature Sensor Calibrations Form.

2.0 Pre-adjustment Calibration Procedures

2.1 System Response Check

The system response check is performed by comparing the sensor response with that of a calibrated NIST traceable thermometer for at least three different temperatures. The ideal temperatures to compare the sensors at are cold, warm , and hot. The cold, warm, and hot temperatures should be about 0˚C, 15-25˚C, and 30-40˚C, respectively. These temperatures can be obtained through the use of three small insulated thermoses. An ice bath should be used for the cold temperature range. For the warm and hot temperatures warm and hot water should be used. The thermometer and temperature sensor should be collocated as closely as possible by taping the sensors together. After allowing time for the temperature readings to stabilize, the technician will record the calibration and datalogger values on the Temperature Sensor Calibration Form. If possible, check the linearity of the instrument by fitting a curve and checking the slope, and intercept of the Y = X line. Check to see if the accuracy of the instrument is no more than ± 0.5° (accuracy) and no more than ± 0.1˚ for temperature difference between matched sensors in a delta temperature measurement system. Mean absolute error is calculated by the equation 1.0. Were *X* is the precision of the instrument at any given degree, and *n*, is the number of measurements taken.

$$\sum \frac{|X|}{n}$$

3.0 Maintenance and Adjustments

After performing all system inspections and calibration checks, the results should be reviewed to determine what maintenance and adjustments are needed, if any. Maintenance procedures should follow the manufactures recommendations in the manual provided by the manufacturer. Since a true calibration of the sensor cannot be performed unless the sensor is checked across its full range, a sensor not conforming to the calibrated NIST thermometer will most likely need to be replaced and sent back to the factory for a true calibration.

4.0 Post-adjustment Checks

If maintenance or adjustments were made, the steps listed in Section 2.0 should be repeated and the results recorded in the Temperature Sensor Calibration Form. If the outputs do not agree within the specified limits troubleshooting, maintenance, and adjustments should be performed and noted.

5.0 Conclusion

When the instrument provides the proper response to the expected calibration values, complete the calibration form noting any adjustments, maintenance or repairs made. Sign and date the calibration form underneath any notes made in the comments section.

Audit Procedure for Temperature Sensors

The temperature sensors should be removed from the aspirators and checked at three temperature points. The system response check is performed by comparing the sensor response with that of a calibrated NIST traceable thermometer for at least three different temperatures.

The ideal temperatures to compare the sensors at are cold, warm, and hot. The cold, warm, and hot temperatures should be about 0˚C, 15-25˚C, and 30-40˚C, respectively. These temperatures can be obtained through the use of three small insulated thermoses. An ice bath should be used for the cold temperature range. For the warm and hot temperatures warm and hot water should be used. The thermometer and temperature sensors should be collocated as closely as possible by taping the sensors together. Agitate each thermos to equilibrate the medium and remove any local temperature gradients, then record the audit sensor and datalogger values on the Temperature Sensor Audit Form.

The auditor should then compare all values recorded for the temperature sensors to the standards listed on the Temperature Sensor Audit Form. The standard for temperature sensors is ±0.5˚ of observed, and ±0.1˚ for temperature difference between matched sensors in a delta temperature measurement system.

Field Calibration Check for a Li-Cor LI200X Pyranometer

1.0 Introduction

LiCor LI200X pyranometers (hereafter referred to as pyranometers) are calibrated at the factory before receipt. Therefore, the calibration schedule for a pyranometer requires an initial calibration check, and calibrations every 6 months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

True calibration of a pyranometer is only accomplished in full mid-summer sun, on a perfectly clear day. This calibration should also last 2 full diurnal cycles. Since these conditions are rarely possible to meet in Alaska calibration field checks rather than true calibrations of pyranometers are performed.

A field calibration check is comprised of the comparison of the pre-adjustment responses to the responses obtained from a collocated, calibrated NIST traceable pyranometer, adjusting or performing needed maintenance on the pyranometer, and documentation of all collected data and adjustments made.

Equipment required for calibration is as follows:

1. Calibrated NIST traceable pyranometer.
2. Datalogger capable of the same scan and averaging frequency as the datalogger being used on-site.
3. All associated instrument manuals.

The calibration should be started by completing the top of the Solar Radiation Sensor Calibration Form.

1.1 System Inspection

Before determining the initial response of the solar radiation system, inspect the signal cable and pyranometer. Check the cable for signs of wear. Check that the pyranometer is level and free of dust. Record these findings in the Solar Radiation Sensor Calibration Form.

2.0 Pre-adjustment Systems Check

This check requires that the solar radiation sensor is in it's normal operating mode. The first part of the check consists of totally covering the sensor to exclude all light. Observe and record the output from the datalogger (which should be approximately zero) in the Solar Radiation Sensor Calibration Form. Next check the ambient light condition output for the sensor and calibration sensor. Record these values in the Solar Radiation Sensor Calibration Form.

Pre-adjustment Collocated Transfer Standard (CTS) Check

Set-up and level the CTS as near as practical to the site pyranometer. Record the concurrent values for the site and CTS pyranometer. Ideally, the CTS should be collecting data for the entire time the technician is on-site. These data should be collected at the same scan rate, and averaged at the same interval as the site pyranometer. Ideally a full diurnal cycle of concurrent readings from the site pyranometer and CTS should be taken.

In practice, the calibration technicians time on-site is limited due to the remoteness and access of monitoring sites in Alaska. Therefore, at least four averaging periods of the site and CTS should be used. That is, if the site datalogger is set to record hourly averages of solar radiation data, four hours of data should be taken form the site datalogger and the CTS. Record the solar radiation data, averaging interval, and all other pertinent information in the Solar Radiation Sensor Calibration Form. If possible check the linearity of the instrument by fitting a curve and checking the slope, intercept, and R^2 value of the Y = X line.

3.0 Maintenance and Adjustments

At this point in the field calibration check the technician should review the results of the system inspection, system check, and CTS check to determine if the sensor is operating within its acceptable limits, and establish what maintenance and adjustments are required, if any. Maintenance procedures should follow the manufactures recommendations in the manual provided by the manufacturer. Any maintenance and adjustments performed should be noted in the Solar Radiation Sensor Calibration Form.

4.0 Post-adjustment Checks

If any maintenance or adjustments were performed, the steps listed in Sections 3.0 and 4.0 of this procedure should be repeated and all data noted in the Solar Radiation Sensor Calibration Form. The results of the post-adjustment checks should be evaluated and noted. If the results do not agree within the specified limits troubleshooting, maintenance, and adjustments should be performed and noted. If the site pyranometer cannot be calibrated properly the unit may have to be replaced and sent back to the factory for repair.

5.0 Conclusion

Upon completion of the field calibration check, the Solar Radiation Sensor Calibration Form should be completed. Any adjustments, maintenance or repairs made should be noted. Sign and date the calibration form underneath any notes made in the comments section.

Solar Radiation Sensor Audit Procedure

Performance audits of a solar radiation system require a separate datalogger and a calibrated, NIST traceable pyranometer to serve as a collocated transfer standard (CTS). Procedure for the solar radiation system audit is as follows:

1. Set-up and level the CTS as near as practical to the site pyranometer.
2. Fill in the information of the top portion of the Solar Radiation Audit Form.
3. Record concurrent values for the site and CTS pyranometers for at least four of the site averaging intervals (generally 4 hours).

Ideally a full diurnal cycle of concurrent readings from the site pyranometer and CTS should be taken. However, In general practice the auditors time on-site is limited due to the remoteness and access of monitoring sites in Alaska. Therefore, at least four averaging periods of the site and CTS should be used. That is, if the site datalogger is set to record hourly averages of solar radiation data, four hours of data should be taken form the site datalogger and the CTS. Record the solar radiation data, averaging interval, scan rate, and all other pertinent information in the Solar Radiation Sensor Audit Form.

Calculated the percent difference according to the following equation and record the results in the Solar Radiation Sensor Audit Form.

$$\textbf{\textit{Percent Difference}} = \frac{\textit{(Observed value) - (Audit Value)}}{\textit{(Audit Value)}}$$

If possible check the linearity of the instrument, as compared to the CTS by fitting a curve and checking the slope, and intercept, of the Y = X line. To pass the audit the measures values should be within ±5% of observed (slope) and ±10 Wm^{-2} (intercept).

Calibration Procedure for Vaisala HMP- 45 Type Relative Humidity Sensors

1.0 Introduction

Vaisala HMP-45 type relative humidity sensors (hereafter referred to as relative humidity sensors) are calibrated at the factory before receipt. Therefore, the calibration schedule for a relative humidity sensor requires an initial calibration check, and calibrations every 6 months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

Equipment required for relative humidity sensor calibration is as follows:

1. Calibrated, certified, NIST traceable relative humidity sensor.
2. PC or similar display module.
3. Vaisala HMP-45 type sensor manual

The calibration should be started by completing the top of the Relative Humidity Sensor Calibrations Form.

1.1 System Inspection

Before determining the initial response of the relative humidity measurement system, inspect the signal cable and sensor for signs of damage and wear. Open the sensor cover to look for signs of water condensation on the circuit board. Note these observations in the Relative Humidity Sensor Calibrations Form.

2.0 Pre-Adjustment Sensor and System Check

The system and sensor check of a relative humidity sensor is performed by comparing the sensor response with that of a calibrated NIST traceable relative humidity sensor such as a Vaisala HMI-41, to serve as a collocated transfer standard (CTS). Collocate the CTS as near to the site remative humidity sensor as possible. For aspirated temperature measurements, the sensor should be collocated inside, or just outside the bottom of the aspirator to receive the same amount of airflow and solar shielding as the site relative humidity senor. Five concurrent, instantaneous readings should be recorded, at least minute apart. Record these values on the Relative Humidity Sensor Calibrations Form.

Next calculate the absolute percent difference for each values and record the results in the Relative Humidity Sensor Calibrations Form. These instantaneous values should agree with the values from the CTS within ±5%.

Calculate the dew point temperature for each of the five points taken. Dew point temperature or T_d should be calculated according to the following equation:

Note: this equation is only valid for the following conditions:

$0\ °C < T < 60\ °C$
$0.01 < RH < 1.0$
$0\ °C < T_d < 50\ °C$

Where:

T = temperature in degrees Celsius
RH = is the relative humidity as a fraction (not percent)
T_d = the dew point temperature to be calculated

The formula is:

$$T_d = \frac{b\,\gamma(T, RH)}{a - \gamma(T, RH)}$$

where

$$\gamma(T, RH) = \frac{a\,T}{b + T} + \ln RH$$

and

a = 17.27
b = 237.7 °C

The recommended system accuracy for dew point temperature is ±1.5°C of observed

3.0 Maintenance and Adjustments

After performing all system inspections and calibration checks the results should be reviewed to determine what maintenance and adjustments are needed, if any. Maintenance procedures should follow the manufactures recommendations in the manual provided by the manufacturer. Since a true field calibration of the sensor can rarely be performed any sensor not conforming to the calibrated NIST relative humidity sensor will most likely need to be replaced and sent back to the factory for a true calibration.

4.0 Post-adjustment Checks

If maintenance or adjustments were made, the steps listed in Section 2.0 of this document should be repeated and the results recorded in the Relative Humidity Sensor Calibrations Form. If the outputs do not agree within the specified limits troubleshooting, maintenance, and adjustments should be performed and noted.

5.0 Conclusion

When the instrument provides the proper response to the expected calibration values, complete the calibration form noting any adjustments, maintenance or repairs made. Sign and date the calibration form underneath any notes made in the comments section.

Relative Humidity Sensor Audit Procedure

Equipment needed for a relative humidity sensor audit includes a calibrated, NIST traceable, Vaisala HMI-41 or similar type relative humidity and temperature probe. This probe will serve as a collocated transfer standard (CTS).

The process for relative humidity as dew point audit procedure is as follows:

Collocate a calibrated NIST traceable relative humidity sensor such as a Vaisala HMI-41. Collocate the CTS as near to the site relative humidity sensor as possible. For aspirated temperature measurements, the sensor should be collocated inside, or just outside the bottom of the aspirator to receive the same amount of airflow and solar shielding as the site relative humidity sensor.

After the CTS has been given ample time to equilibrate five concurrent, instantaneous readings should be recorded, at least minute apart. Record these values on the Relative Humidity Sensor Audit Form.

Calculate the dew point temperature for each of the five points taken. Dew point temperature or T_d should be calculated according to the following equation:

Note: this equation is only valid for the following conditions:

$0\ °C < T < 60\ °C$
$0.01 < RH < 1.0$
$0\ °C < T_d < 50\ °C$

Where:

T = temperature in degrees Celsius
RH = is the relative humidity as a fraction (not percent)
T_d = the dew point temperature to be calculated

The formula is:

$$T_d = \frac{b\,\gamma(T, RH)}{a - \gamma(T, RH)}$$

where

$$\gamma(T, RH) = \frac{a\,T}{b + T} + \ln RH$$

and

a = 17.27
b = 237.7 °C

The recommended system accuracy for dew point temperature is ±1.5°C of observed.

Calibration Procedure for an ETI NOAH II Precipitation Gauge

1.0 Introduction

All ETI NOAH II precipitation gauges (hereafter referred to as precipitation gauges) are calibrated at the factory before receipt. Therefore, the calibration schedule for a precipitation gauge requires an initial calibration check, and calibrations every 6 months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

Equipment required for precipitation gauges calibration is as follows:

1. NovaLynx 260-2595 Tipping Bucket Rain Gauge Calibrator or large graduated cylinder.
2. PC or similar display module with P7GACOMM
3. ETI NOAH II manual

The calibration should be started by completing the top of the Precipitation Gauge Calibrations Form.

1.1 System Inspection

Before determining the initial response of the precipitation measurement system, inspect the signal cable and sensor for signs of damage and wear. Note these observations in the Precipitation Gauge Calibrations Form.

2.0 Pre-Adjustment Checks

2.1 System Check

To ensure that the weight measurement assembly (WMA) is functioning, slowly pour an initial amount of water into the gauge and check for a response from the datalogger.

2.2 Gauge Check

A calibration is performed by inputting known amounts of water into the gauge using a NovaLynx 260-2595 Tipping Bucket Rain Gauge Calibrator or large graduated cylinder and checking the system response. Water is usually inputted into the gauge 800mL at a time, across the full range (4-12” liquid in gauge).

Water should be delivered to the gauge slowly, and poured onto the side of the gauge to buffer the flow. This will ensure that the sensitive load cell in the WMA does not become damaged.

After each bottle of water is added to the gauge, the measurement system should be given ample time to read. This value should be noted in the Precipitation Gauge Calibrations Form. The values should agree within ±10% of the expected. If possible check the linearity of the instrument by fitting a curve and checking the slope and intercept of the Y = X line.

3.0 Maintenance and Adjustments

After performing all system inspections and calibration checks the results should be reviewed to determine what maintenance and adjustments are needed, if any. Maintenance procedures should follow the manufactures recommendations in the manual provided by the manufacturer. Due to limited time and marginal weather in the field a true field calibration of the sensor can rarely be performed. Therefore, any sensor not conforming to within ±10% of the expected values will most likely need to be replaced and sent back to the factory for a true calibration.

4.0 Post-adjustment Checks

If maintenance or adjustments were made, the steps listed in Section 2.0 should be repeated and the results recorded in the Precipitation Gauge Calibrations Form. If the outputs do not agree within the specified limits troubleshooting, maintenance, and adjustments should be performed and noted.

5.0 Conclusion

When the instrument provides the proper response to the expected calibration values, complete the calibration form noting any adjustments, maintenance or repairs made. Sign and date the calibration form underneath any notes made in the comments section.

Audit Procedure for an ETI NOAH II Precipitation Gauge

An audit of an ETI NOAH II precipitation gauge is performed by inputting known amount of water into the gauge using a NovaLynx 260-2595 Tipping Bucket Rain Gauge Calibrator or large graduated cylinder. Water is usually inputted into the gauge 800mL at a time, across the full range (4-12" liquid in gauge).

Water should be delivered to the gauge slowly, and poured onto the side of the gauge to buffer the flow. This will ensure that the sensitive load cell in the weight measurement assembly (WMA) does not become damaged. Ample time should be given for the gauge to calculate and read the delivered amount of liquid.

After each bottle of water is added to the gauge, the system measurement should be noted in the Precipitation Gauge Audit Form. The values should agree within ±10% of the expected. If possible check the linearity of the instrument by fitting a curve and checking the slope, intercept, and R^2 of the Y = X line.

Audit procedure is as follows:

1. Fill out the top of the Precipitation Gauge Audit Form noting the prevailing meteorological conditions.

2. Deliver water to the gauge in measured increments across the full range of the gauge, noting the volume delivered, expected and system response, and percent error.

3. Compare the error of the gauge to the limit of ±10%.

For the gauge to pass the audit each point taken must agree to the expected value within ±10%. The slope, intercept, and R^2 value for the Y = X line should also agree within ±10% of expected.

Calibration Procedure for a Nova Lynx 255-100 Evaporation Gauge

1.0 Introduction

All Nova Lynx 255-100 evaporation gauge (hereafter referred to as evaporation gauge gauges) are calibrated at the factory before receipt. Therefore, the calibration schedule for an evaporation gauge requires an initial calibration check, and calibrations every 6 months. Calibrations are also required immediately after any repair, rewiring, adjustment, or replacement of the sensor or any sensor components.

Equipment required for precipitation gauges calibration is as follows:

1. Large graduated cylinder or similar water delivery device
2. Ruler
3. PC or similar display module
4. Nova Lynx 255-100 manual

The calibration should be started by completing the top of the Evaporation Gauge Calibrations Form.

1.1 System Inspection

Before determining the initial response of the precipitation measurement system, inspect the signal cable and sensor for signs of damage and wear. Note these observations in the Evaporation Gauge Calibrations Form.

2.0 Pre-Adjustment Checks

2.1 System Check

To ensure that the float mechanism is functioning, slowly pour an initial amount of water into the gauge and check for a response from the datalogger.

2.2 Gauge Check

A calibration is performed by inputting known amounts of water into the gauge using a large graduated cylinder, measuring the height of the water in the evaporation pan, and checking the system response. Water is usually inputted into the gauge 800mL at a time, across the full range (3-9” liquid in gauge).

After each bottle of water is added to the gauge, the measurement system should be given ample time to read. This value should be noted in the Evaporation Gauge Calibrations Form. Check the linearity of the instrument by fitting a curve and checking the slope and intercept of the Y = X line. These values should agree within ±10% of the expected.

3.0 Maintenance and Adjustments

After performing all system inspections and calibration checks the results should be reviewed to determine what maintenance and adjustments are needed, if any. Maintenance procedures should follow the manufactures recommendations in the manual provided by the manufacturer.

4.0 Post-adjustment Checks

If maintenance or adjustments were made, the steps listed in Section 2.0 should be repeated and the results recorded in the Evaporation Gauge Calibrations Form. If the outputs do not agree within the specified limits troubleshooting, maintenance, and adjustments should be performed and noted.

5.0 Conclusion

When the instrument provides the proper response to the expected calibration values, complete the calibration form noting any adjustments, maintenance or repairs made. Sign and date the calibration form underneath any notes made in the comments section.

Audit Procedure for a Nova Lynx 255-100 Evaporation Gauge

An audit of an Nova Lynx 255-100 evaporation gauge is performed by inputting known amount of water into the gauge using a large graduated cylinder or similar type of water delivery device. Water is usually inputted into the gauge 800mL at a time, across the full range (3-9" liquid in gauge).

Water should be delivered to the gauge slowly and ample time should be given for the gauge to read and calculate the delivered amount of liquid.

After each bottle of water is added to the gauge, the system measurement should be noted in the Evaporation Gauge Audit Form. Check the linearity of the instrument by fitting a curve and checking the slope and intercept of the Y = X line. These values should agree within ±10% of the expected.

Audit procedure is as follows:

4. Fill out the top of the Evaporation Gauge Audit Form noting the prevailing meteorological conditions.

5. Deliver water to the gauge in measured increments across the full range of the gauge, noting the level of water in gauge and system response.

6. Compare the linearity of the gauge to the limit of ±10%.

For the gauge to pass the audit the slope and intercept of the Y = X line should agree within ±10% of expected.

Systems Audit Procedures for the Pebble Project Meteorological Monitoring Program.

1.0 Introduction

A systems audit is an on-site inspection and review of the quality assurance system used for the total measurement system (sample collection, sample analysis, data processing, ect.) for each monitored parameter. Whereas, performance audits are quantitative appraisal, system audits are normally a qualitative appraisal. The standard operating procedures (SOP) in the projects analysis plan should be used as the basis for conducting a system audit. The purpose of a system audit is to determine whether or not the monitoring program has followed the SOP and quality control procedures and listed in the projects analysis plan. It also determines if the data generated are scientifically valid, defensible, and of specified accuracy and precision.

2.0 Audit Items

The following are typical items checked in a systems audit for a PSD Meteorological Monitoring Program:

1. Is the quality assurance organization operational
2. Are there written standard operation procedures (SOP) available for site operation and sampling, and are they being followed?
3. Are there written calibration procedures and schedules, including traceability documentation, and are they being followed?
4. Are there preventative maintenance procedures and are they being followed?
5. Are site logbooks, site checks forms, and other documentation being used and properly completed?

3.0 Audit Goals

The goal of a systems audit is to ass the overall operation of the quality assurance system. System audits generally entail the following procedures:

1. Preparing audit questionnaires for the monitoring site evaluations (F/ST9001.1) and for evaluation of the office activities related to the monitoring (F/ST9001.2).

2. Identifying deficiencies from previous audits and preparing a checklist covering these areas.

3. Arranging entrance interviews and briefing the site operator on the purpose and the scope of the systems audit.

4. Performing the systems audit.

5. Conducting exit interviews and debriefing on the system audit results

6. Preparing and submitting audit reports

7. Following up on report recommendations.

A systems audit will be conducted within 30 days of the commencement of the filed program in order to insure that all of the QA project plans specified procedures have been implemented. An early assessment is designed to prevent the accumulation of a large amount of questionable to invalid data bay quickly uncovering any discrepancies between the project plan and the actual monitoring effort. Thereafter, a systems audit will be conducted yearly.

APPENDIX B2
AUDIT AND CALIBRATION FORMS

METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**

A. DAS TIME AUDIT

DAS TIME vs. NOAA CLOCK			
AST Time	DAS Time	Error Min:Sec	Pass/ Fail?

Instrument Limits: DAS time = Alaska Standard Time (AST) +/- 5 minutes.
Conversions: Winter; (AST) = (DST), Summer; (AST) = (DST) - 1 hr.
Comments:

B. 2M, 10M, and ΔT, TEMPERATURE SENSOR AUDIT

Thermistor **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **Deg C**
Audit Equipment: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **Deg C**
Probe SN: ________

Time:
Begin: ________
End: ________

COLLOCATED THERMISTOR TEST										
Thermal Input			Station Response							
Temp Range	Target Deg C	Input Deg C	2M DAS Deg C	10M DAS Deg C	ΔT DAS Deg C	ΔT Error Deg C	2M Error Deg C	10M Error Deg C	Pass/ Fail?
Hot	35 - 40								
Warm	15 - 25								
Ice Bath	0								
				Max Abs. Error					

Instrument Limits: Max Absolute Error > 0.5˚C (accuracy), Max Absolute Error > 0.1˚C ΔT.
Comments:

C. RELATIVE HUMIDITY SENSOR AUDIT

Site Sensor **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **% RH**
Audit Equipment: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **% RH**
Probe SN: ________

Time:
Begin: ________
End: ________

COLLOCATED RELATIVE HUMIDITY SENSOR TEST							
NIST Readings			Station Response				
Temp Deg C	RH (%)	T_{dp} Deg C	DAS Temp Deg C	DAS RH (%)	DAS T_{dp} Deg C	Error Deg C	Pass/ Fail?
				Max Abs. Error			

Instrument Limits: Max Absolute Error > 1.5˚C Dew Point Temperature
Comments:

C. MAIN HORIZONTAL WIND SPEED SENSOR AUDIT

Height: ________ **Meters**

METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**

Wind Spd Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Cup #:** ________ **Range:** ________ **MPS**
Audit Equipment: **Low Spd:** ________ **Model:** ________ **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________
Audit Equipment: **High Spd:** ________ **Model:** ________ **S.N.#:** ________

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		
Torque:	N/A	gm-cm

SYNCHRONOUS MOTOR TEST					
Input RPM	Input MPS	DAS MPS	Error MPS	Error % Input	Pass/ Fail?
0	0.00				
100	2.94				
200	5.60				
400	10.93				
1000	26.92				
2000	53.57				
	Max Abs. Error				

Time: Begin: ________ End: ________

Instrument Limits: Threshold Torque >0.45 gm-cm (0.00625oz-in). Max Absolute Error > 0.20 MPS @ WS<=5 MPS or > 5% of input @ WS>5 MPS.
Conversions: MPS=RPM/37.522569+0.27; MPH=0.44704*MPS; gm-cm=72*oz-in; Torque=1.8*MPS^2.
Comments:

D. BACKUP HORIZONTAL WIND SPEED SENSOR AUDIT

Height: ________ **Meters**

Wind Spd Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Cup #:** ________ **Range:** ________ **MPS**
Audit Equipment: **Low Spd:** ________ **Model:** ________ **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________
Audit Equipment: **High Spd:** ________ **Model:** ________ **S.N.#:** ________

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		
Torque:	N/A	gm-cm

SYNCHRONOUS MOTOR TEST					
Input RPM	Input MPS	DAS MPS	Error MPS	Error % Input	Pass/ Fail?
0	0.00				
100	0.51				
200	1.02				
400	2.05				
1000	5.12				
2000	10.24				
	Max Abs. Error				

Time: Begin: ________ End: ________

Instrument Limits: Threshold Torque >2.4 gm-cm (0.033oz-in). Max Absolute Error > 0.20 MPS @ WS<=5 MPS or > 5% of input @ WS>5 MPS.
Conversions: Transfer Function for RM Young Model 05305 AQ w/ carbon fiber propeller: m/s = rpm x 0.00512
Comments:

E. HORIZONTAL WIND DIRECTION SENSOR AUDIT

Height: ________ **Meters**

Wind Dir Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Vane #:** ________ **Range:** ________ **Deg**

METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**

Audit Equipment: **Align:** ________ **Model:** ________ **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________
Compass: ________ **Model:** ________ **S.N.#:** ________ **Magnetic Declin:** ________ **E of N**

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		No
Torque:	N/A	gm-cm

IN SITU ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1020 End: 1043

VANE ACCURACY & LINEARITY TEST				
Input Dir	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
South	180.0			
West	270.0			
North	360.0			
East	90.0			
North	360.0			
West	270.0			
South	180.0			
East	90.0			
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1055 End: 1100

BENCH STAND ACCURACY & LINEARITY TEST							
Input Deg	DAS Deg	Error Deg	Pass/ Fail?	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
30.0				330.0			
60.0				355.0			
90.0				30.0			
120.0				60.0			
150.0				90.0			
180.0				120.0			
210.0				150.0			
240.0				180.0			
270.0				**Max Abs. Error**			
300.0				**Mean Abs. Error**			

Time: Begin: ________ End: ________

POST-AUDIT ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: ________ End: ________

Instrument Limits: Threshold Torque >7.1 gm-cm (.0986 oz-in). Max Absolute Error >5° or Mean Absolute Error > 3° from True Azimuth (alignment). Max Absolute Error >5° (accuracy). Mean Absolute Error >3° (linearity).
Conversions: Torque = 28.4*MPS^2 for aluminum vane.
Comments:

F. BACK-UP HORIZONTAL WIND DIRECTION SENSOR AUDIT

Height: ________ **Meters**

Wind Dir Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Vane #:** ________ **Range:** ________ **Deg**
Audit Equipment: **Align:** **Model:** **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________

METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**
Compass: ______ **Model:** ______ **S.N.#:** ______ **Magnetic Declin:** ______ **E of N**

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		No
Torque:	N/A	gm-cm

IN SITU ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1020 End: 1043

VANE ACCURACY & LINEARITY TEST				
Input Dir	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
South	180.0			
West	270.0			
North	360.0			
East	90.0			
North	360.0			
West	270.0			
South	180.0			
East	90.0			
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1055 End: 1100

BENCH STAND ACCURACY & LINEARITY TEST							
Input Deg	DAS Deg	Error Deg	Pass/ Fail?	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
30.0				330.0			
60.0				355.0			
90.0				30.0			
120.0				60.0			
150.0				90.0			
180.0				120.0			
210.0				150.0			
240.0				180.0			
270.0				Max Abs. Error			
300.0				Mean Abs. Error			

Time: Begin: ______ End: ______

POST-AUDIT ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: ______ End: ______

Instrument Limits: Threshold Torque >23.0 gm-cm (.32 oz-in). Max Absolute Error >5° or Mean Absolute Error > 3° from True Azimuth (alignment).
Max Absolute Error >5° (accuracy). Mean Absolute Error >3° (linearity).

Conversions:

Comments:

G. PRECIPITATION GAUGE AUDIT

Height: ______ **Meters**

Precipitation Gauge: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Inches per Hour**
Audit Equipment: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Inches per Hour**
Diameter: ______ **Inches** **Volume Rate** ______ **Ml/mm**

METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**

PRECIPITATION GAUGE VOLUME TEST										
Start Time	Input Vol Ml	Input mm	Data Hour	DAS mm	-Adjust mm	+Adjust mm	Final mm	Error % Input	Pass/ Fail?	Notes
						Max Abs. Error				

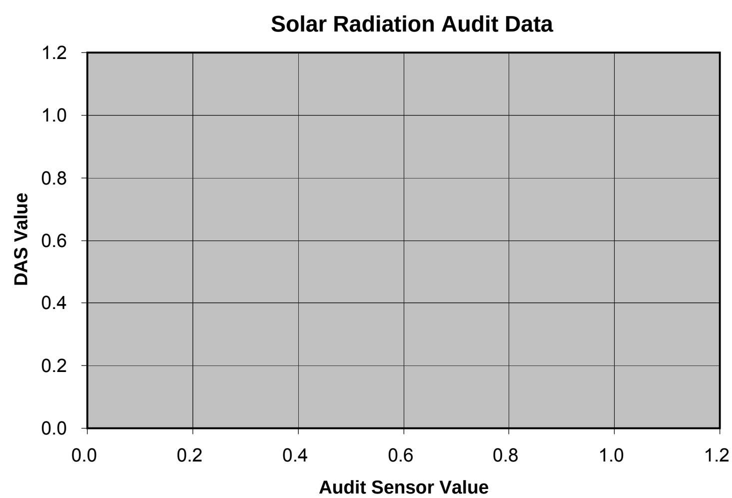
Instrument Limits: Max Absolute Error > 10 % of Input.
Comments:

H. SOLAR RADIATION SENSOR AUDIT

Height: ________ **Meters**

Site Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **W m^{-2}**
Audit Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Range:** ________ **W m^{-2}**

SOLAR RADIATION SENSOR TEST					
DAS Output	Audit Output	C. Fit Data	Error	Error % Input	Pass/ Fail?
		Max Abs. Error			
Intercept		**Slope**			



Time: Begin: ________ End: ________ **Date:** ________

Instrument Limits: Max Absolute Error > 10 % of Input adjusted for slope/intercept.
Comments:

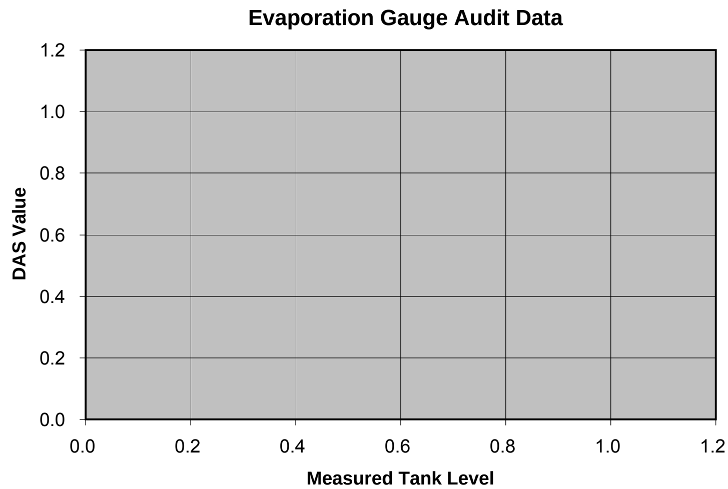
METEOROLOGICAL STATION - INSTRUMENT PERFORMANCE AUDIT

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Auditor: **Witness(s):** **Audit Date:**

F) EVAPORATION GAUGE AUDIT **Height:** _________ **Meters**

Evaporation Gauge: **Make:** ________________ **Model:** ________________ **S.N.#:** ________ **Range:** ________ **mm**
Evaporation Pan: **Make:** ________________ **Model:** ________________ **S.N.#:** ________ **Range:** ________ **mm**

EVAPORATION PAN STAGE HEIGHT TEST					
Tank Level	DAS mm	C. Fit Data	Error mm	Error % Input	Pass/ Fail?
Max Abs. Error					
Intercept		**Slope**			



Time: Begin: ________ End: ________ **Date:** ________

Instrument Limits: Max Absolute Error > 10 % of Input adjusted for slope/intercept.
Comments:

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**

A. DAS TIME CALIBRATION

Instrument Limits: DAS time = Alaska Standard Time (AST) +/- 5 minutes.
Conversions: Winter; (AST) = (DST), Summer; (AST) = (DST) - 1 hr.
Comments:

DAS TIME vs. NOAA CLOCK				
AST Time	DAS Time	Error Min:Sec	Pass/ Fail?	Time Changed?

B. 2M, 10M, and ΔT, TEMPERATURE SENSOR CALIBRATION

Thermistor **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Deg C**
Cal. Equipment: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Deg C**
Probe SN: ______

Time:
Begin: ______
End: ______

COLLOCATED THERMISTOR TEST										
Thermal Input			Station Response							
Temp Range	Target Deg C	Input Deg C	2M DAS Deg C	10M DAS Deg C	ΔT DAS Deg C	ΔT Error Deg C	2M Error Deg C	10M Error Deg C	Pass/ Fail?
Hot	35 - 40								
Warm	15 - 25								
Ice Bath	0								
				Max Abs. Error					

Instrument Limits: Max Absolute Error > 0.5˚C (accuracy), Max Absolute Error > 0.1˚C ΔT.
Comments:

C. RELATIVE HUMIDITY SENSOR CALIBRATION

Site Sensor **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **% RH**
Cal. Equipment: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **% RH**
Probe SN: ______

Time:
Begin: ______
End: ______

COLLOCATED RELATIVE HUMIDITY SENSOR TEST							
NIST Readings			Station Response				
Temp Deg C	RH (%)	T_{dp} Deg C	DAS Temp Deg C	DAS RH (%)	DAS T_{dp} Deg C	Error Deg C	Pass/ Fail?
				Max Abs. Error			

Instrument Limits: Max Absolute Error > 1.5˚C Dew Point Temperature
Comments:

C. MAIN HORIZONTAL WIND SPEED SENSOR CALIBRATION

Height: ______ **Meters**

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**

Wind Spd Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Cup #:** ________ **Range:** ________ **MPS**
Cal. Equipment: **Low Spd:** ________ **Model:** ________ **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________
Cal. Equipment: **High Spd:** ________ **Model:** ________ **S.N.#:** ________

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		
Torque:	N/A	gm-cm

SYNCHRONOUS MOTOR TEST					
Input RPM	Input MPS	DAS MPS	Error MPS	Error % Input	Pass/ Fail?
0	0.00				
100	2.94				
200	5.60				
400	10.93				
1000	26.92				
2000	53.57				
	Max Abs. Error				

Time: Begin: ________ End: ________

Instrument Limits: Threshold Torque >0.45 gm-cm (0.00625oz-in). Max Absolute Error > 0.20 MPS @ WS<=5 MPS or > 5% of input @ WS>5 MPS.
Conversions: MPS=RPM/37.522569+0.27; MPH=0.44704*MPS; gm-cm=72*oz-in; Torque=1.8*MPS^2.
Comments:

D. BACKUP HORIZONTAL WIND SPEED SENSOR CALIBRATION

Height: ________ **Meters**

Wind Spd Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Cup #:** ________ **Range:** ________ **MPS**
Cal. Equipment: **Low Spd:** ________ **Model:** ________ **S.N.#:** ________ **Torque:** ________ **S.N.#:** ________
Cal. Equipment: **High Spd:** ________ **Model:** ________ **S.N.#:** ________

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		
Torque:	N/A	gm-cm

SYNCHRONOUS MOTOR TEST					
Input RPM	Input MPS	DAS MPS	Error MPS	Error % Input	Pass/ Fail?
0	0.00				
100	0.51				
200	1.02				
400	2.05				
1000	5.12				
2000	10.24				
	Max Abs. Error				

Time: Begin: ________ End: ________

Instrument Limits: Threshold Torque >2.4 gm-cm (0.033oz-in). Max Absolute Error > 0.20 MPS @ WS<=5 MPS or > 5% of input @ WS>5 MPS.
Conversions: Transfer Function for RM Young Model 05305 AQ w/ carbon fiber propeller: m/s = rpm x 0.00512
Comments:

E. HORIZONTAL WIND DIRECTION SENSOR CALIBRATION

Height: ________ **Meters**

Wind Dir Sensor: **Make:** ________ **Model:** ________ **S.N.#:** ________ **Vane #:** ________ **Range:** ________ **Deg**

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**
Cal. Equipment: **Align:** ______ **Model:** ______ **S.N.#:** ______ **Torque:** ______ **S.N.#:** ______
Compass: ______ **Model:** ______ **S.N.#:** ______ **Magnetic Declin:** ______ **E of N**

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		No
Torque:	N/A	gm-cm

IN SITU ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1020 End: 1043

VANE ACCURACY & LINEARITY TEST				
Input Dir	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
South	180.0			
West	270.0			
North	360.0			
East	90.0			
North	360.0			
West	270.0			
South	180.0			
East	90.0			
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1055 End: 1100

BENCH STAND ACCURACY & LINEARITY TEST							
Input Deg	DAS Deg	Error Deg	Pass/ Fail?	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
30.0				330.0			
60.0				355.0			
90.0				30.0			
120.0				60.0			
150.0				90.0			
180.0				120.0			
210.0				150.0			
240.0				180.0			
270.0				**Max Abs. Error**			
300.0				**Mean Abs. Error**			

Time: Begin: End:

POST-AUDIT ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: End:

Instrument Limits: Threshold Torque >7.1 gm-cm (.0986 oz-in). Max Absolute Error >5° or Mean Absolute Error > 3° from True Azimuth (alignment).
Max Absolute Error >5° (accuracy). Mean Absolute Error >3° (linearity).
Conversions: Torque = 28.4*MPS^2 for aluminum vane.
Comments:

F. BACK-UP HORIZONTAL WIND DIRECTION SENSOR CALIBRATION

Height: ______ **Meters**

Wind Dir Sensor: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Vane #:** ______ **Range:** ______ **Deg**
Cal. Equipment: **Align:** **Model:** **S.N.#:** ______ **Torque:** ______ **S.N.#:** ______

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**
Compass: ______ **Model:** ______ **S.N.#:** ______ **Magnetic Declin:** ______ **E of N**

TORQUE TEST		
Torque:		gm-cm
Bearing Status:		
Bearings Replaced:		No
Torque:	N/A	gm-cm

IN SITU ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1020 End: 1043

VANE ACCURACY & LINEARITY TEST				
Input Dir	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
South	180.0			
West	270.0			
North	360.0			
East	90.0			
North	360.0			
West	270.0			
South	180.0			
East	90.0			
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: 1055 End: 1100

BENCH STAND ACCURACY & LINEARITY TEST							
Input Deg	DAS Deg	Error Deg	Pass/ Fail?	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
30.0				330.0			
60.0				355.0			
90.0				30.0			
120.0				60.0			
150.0				90.0			
180.0				120.0			
210.0				150.0			
240.0				180.0			
270.0				**Max Abs. Error**			
300.0				**Mean Abs. Error**			

Time: Begin: ______ End: ______

POST-AUDIT ALIGNMENT TEST				
Description	Input Deg	DAS Deg	Error Deg	Pass/ Fail?
	Max Abs. Error			
	Mean Abs. Error			

Time: Begin: ______ End: ______

Instrument Limits: Threshold Torque >23.0 gm-cm (.32 oz-in). Max Absolute Error >5° or Mean Absolute Error > 3° from True Azimuth (alignment). Max Absolute Error >5° (accuracy). Mean Absolute Error >3° (linearity).

Conversions:

Comments:

G. PRECIPITATION GAUGE CALIBRATION

Height: ______ **Meters**

Precipitation Gauge: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Inches per Hour**
Cal. Equipment: **Make:** ______ **Model:** ______ **S.N.#:** ______ **Range:** ______ **Inches per Hour**
Diameter: ______ **Inches** **Volume Rate** ______ **Ml/mm**

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**

PRECIPITATION GAUGE VOLUME TEST										
Start Time	Input Vol Ml	Input mm	Data Hour	DAS mm	-Adjust mm	+Adjust mm	Final mm	Error % Input	Pass/ Fail?	Notes
						Max Abs. Error				

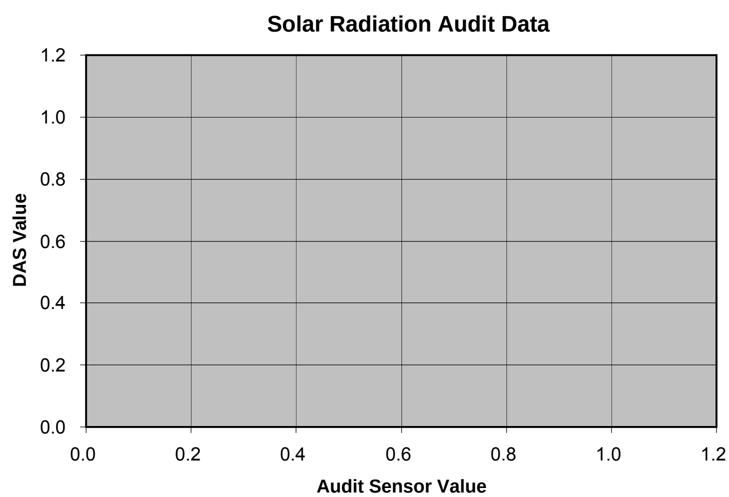
Instrument Limits: Max Absolute Error > 10 % of Input.
Comments:

H. SOLAR RADIATION SENSOR CALIBRATION

Height: _________ **Meters**

Site Sensor: **Make:** _________________ **Model:** __________________ **S.N.#:** ________ **Range:** ________ **W m^{-2}**
Cal. Equipment: **Make:** _________________ **Model:** __________________ **S.N.#:** ________ **Range:** ________ **W m^{-2}**

SOLAR RADIATION SENSOR TEST					
DAS Output	Audit Output	C. Fit Data	Error	Error % Input	Pass/ Fail?
		Max Abs. Error			
Intercept		**Slope**			



Time: Begin: ________ End: ________ **Date:** ________

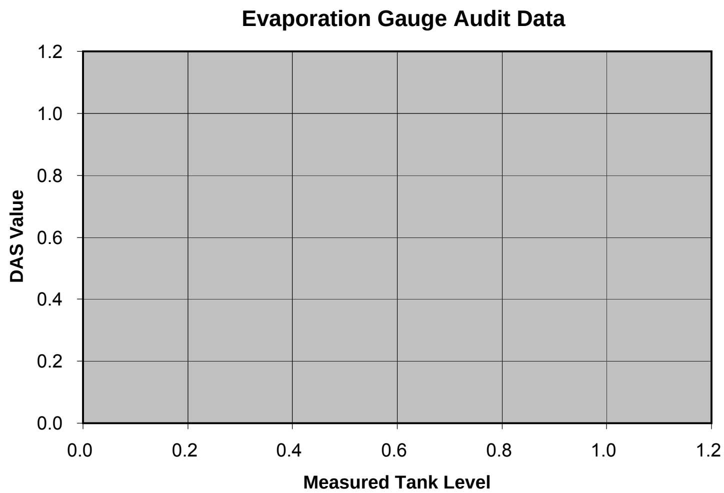
Instrument Limits: Max Absolute Error > 10 % of Input adjusted for slope/intercept.
Comments:

METEOROLOGICAL STATION - INSTRUMENT CALIBRATION

Owner: Northern Dynasty **Operator:** **Alternate:** **Station Site:**
Calibrator: **Witness(s):** **Calibration Date:**
F) EVAPORATION GAUGE CALIBRATION **Height:** _________ **Meters**

Evaporation Gauge: **Make:** _________________ **Model:** __________________ **S.N.#:** _________ **Range:** _________ **mm**
Evaporation Pan: **Make:** _________________ **Model:** __________________ **S.N.#:** _________ **Range:** _________ **mm**

EVAPORATION PAN STAGE HEIGHT TEST					
Tank Level	DAS mm	C. Fit Data	Error mm	Error % Input	Pass/ Fail?
		Max Abs. Error			
Intercept		**Slope**			



Time: Begin: _________ End: _________ **Date:** _________

Instrument Limits: Max Absolute Error > 10 % of Input adjusted for slope/intercept.
Comments:

APPENDIX B3
PROJECT HEALTH AND SAFETY PLAN

Health & Safety Plan

Pebble Project Meteorological Monitoring

November 2004

prepared for

Northern Dynasty Mines, Inc.

prepared by

Hoefler Consulting Group
3401 Minnesota Drive
Suite 300
Anchorage, Alaska 99503
907-563-2137

Table of Contents

1.0 INTRODUCTION

This Health and Safety Plan is a job-specific document presenting a comprehensive plan for compliance with the Hoefler Consulting Group HSE program. Hoefler Consulting Group (HCG) prepared this plan for the Pebble Project Meteorological Monitoring Program.

The plan incorporates a specific breakdown of the project activities, the planned communication and interface provisions that will be followed for the project. The intent is to summarize the scope of work and the associated health and safety issues with a focus on the needs of field personnel and successful execution of the project.

The established procedures found in the Alaska Safety Handbook (ASH) and the safety manual, *Mineral Exploration in Western Canada* are available as reference documents for implementing best practices for all project work activity and pre-job planning. A Phase Hazard Analysis (PHA) addresses the progressive steps of the project plan and field operations. Changes to a work plan or scope, after the plan is developed, poses significant potential for health and safety related incidents.

ANY CHANGE OF CONDITIONS THAT AFFECT THE PLAN WILL REQUIRE A SAFETY “TIME OUT” TO ASSESS HOW THAT CHANGE WILL IMPACT THE JOB AS PLANNED. WHEN ADDITIONAL HAZARDS ARE INTRODUCED INTO A PLANNED PHASE, CONTROLS WILL BE DISCUSSED WITH ALL PARTIES TO ENSURE SAFE EXECUTION DURING THE SAFETY “TIME OUT.”

2.0 SCOPE OF WORK

Two three-meter meteorological stations will be installed and operated at the Pebble Project site. A radio repeating tower is already operating at the project location. Work will include instrument installation, establishing the power supply, and start-up and operation of the monitoring stations. All components are designed for rapid installation of the system in the field.

3.0 PROJECT EXECUTION PLAN

3.1 Phase 1: Mobilization

Mobilization consists of staging all necessary tools and equipment to the site. All equipment and personnel will travel from the base camp to the site via helicopter or snow machine. Prior to commencement of installation, HCG personnel will undergo a site-specific orientation, including familiarization with site facilities and operations personnel. HCG staff will also ensure that the pilot and site manager are aware of their location in the field in the event radio contact is interrupted. A back-up plan for pick-up will be established prior to beginning field work each day.

3.2 Phase 2: Installation

HCG personnel will begin to install equipment upon arrival. Electrical power such as 120 VAC for light hand tools and 12 VDC will be established first. All instrument components are 12 VDC, including heaters, fans, data logger and the cell phone/modem system.

3.3 Phase 3: Operation

Following successful installation of the equipment, initial performance audits and calibrations will be conducted to ensure equipment is operating within EPA and ADEC guidelines. These procedures require approximately one full day of work to complete. Subsequently, the meteorological station will operate unattended for an extended period of time**.** Quarterly audits, calibration, and maintenance will be conducted by HCG staff.

3.4 Phase 4: Demobilization

Demobilization operations consist of packing all tools, safety gear and HCG-owned equipment for transport back to Anchorage. The work area will be cleared of all work-related debris and litter and will be left in an orderly fashion.

4.0 PROJECT SCHEDULE

Installation activities are to be conducted in October 2004 and system upgrades are scheduled to be made in November 2004. Quarterly audits, calibrations and maintenance are scheduled to occur in 2005.

5.0 HAZARD ASSESSMENT

5.1 Health and Safety Risks Identified

The health and safety risks identified for the four defined phases of the project are as follows:

Phase		Personnel	Equipment
Phase 1	Mobilization	Low	Low
Phase 2	Installation	Medium	Medium
Phase 3	Operation	Low	Medium
Phase 4	Demobilization	Low	Low

5.1.1 Phase Hazard Analysis: Phase 1

Project: Pebble Project Meteorological Monitoring

Date: November 2004

Location: Iliamna, Alaska

Phase: Mobilization

Overall Risk Rank: Low

Phase Description: Initial project mobilization of employees, tools, and equipment to installation site.

Activities include:

- Travel to Pebble Project site near Iliamna, Alaska, site-specific orientation, familiarization with site facilities and operations personnel.
- Transporting, lifting, and rigging of tools and equipment.

POTENTIAL HAZARDS		RANK
1.	Lifting hazards	Medium
2.	Muscle strains / overexertion / dehydration / fatigue / hypothermia	Low
3.	Slips or falls from ladder.	Low
4.	Cuts and lacerations-striking against objects, pinch points and protruding objects, trip hazards.	Low
5.	Negative wildlife encounters	Low

Recommended Controls:

1. Ensure crew members understand all project hazards, are familiar with specific lifting equipment used, and utilize proper personal lifting techniques. Follow lifting safe work practices and avoid unsafe work acts. Ensure employees get help to move heavier objects, and utilize move-smart techniques, as well as proper body motion-mechanics when performing physical lifting.

2. Warm up and stretch before lifting or pulling. Drink plenty of water throughout the day. Avoid excessive amounts of coffee, teas, colas, sodas, juices, etc. These liquids will not re-hydrate an individual as well as water. Be prepared for inclement weather. Proper clothing (layered) for outside work activities is essential, and should include at a minimum: thermal underwear, arctic coverall gear, gloves, face mask, heavy socks, appropriately rated cold weather footwear (winter months). Get help with awkward loads. Ensure that employees are given sufficient time to conduct activities at the work site. Do not increase speed of activities. Ensure that employees are given multiple breaks throughout the workday.

3. Ensure footwear is in good repair, and always ensure solid footing. Situate ladders or stepstools on level ground, and use caution when working off the ground. Pay attention to surroundings.

4. Wear proper PPE to prevent personal injury. Anyone working at height will be trained in fall prevention/protection and will be wearing fall protection. Employees are to familiarize themselves with the immediate work area for any given task. Ensure power tools and extension cords are good working order. Visually inspect the equipment before use.

5. Be alert to surroundings. Do not leave food sources out that can attract animals. Carry personal firearms and/or bear mace or be in the company of someone who has firearms and is trained in firearm use.

Note:
A change to a plan after the plan was developed is a major reason for health and safety incidents.

ANY CHANGE OF CONDITIONS THAT AFFECT THE PLAN WILL REQUIRE A SAFETY "TIME OUT" TO ASSESS HOW THAT CHANGE WILL IMPACT THE JOB AS PLANNED. WHEN ADDITIONAL HAZARDS ARE INTRODUCED INTO A PLANNED PHASE, CONTROLS WILL BE DISCUSSED WITH ALL PARTIES TO ENSURE SAFE EXECUTION DURING THE SAFETY "TIME OUT".

Inspections/Audits:
The crew supervisor will review the upcoming work on a daily basis and review a Safety Analysis Form outlining safety procedures, safety equipment usage and the possible hazards associated with the work planned that day. The material will be presented to the crew as a "Tool Box Safety Meeting" prior to the start of work that day.

Possible Crew Members: Dominic Shallies, Jared Cockman, Brent Veltkamp, Chris Lindsey, Eric Brudie, Steve Mackey

Emergency Action Plan:
Provide first aid. Immediately notify Northern Dynasty Mines officials of the situation.

Additional Comments/Changes:

___

___

___

5.1.2 Phase Hazard Analysis: Phase 2

Project:	Pebble Project Meteorological Monitoring
Date:	November 2004
Location:	Iliamna, Alaska
Phase:	Installation
Overall Risk Rank:	Medium
Phase Description:	The meteorological station tripods will be installed at pre-determined field locations. Power will be connected to the instrumentation.

Activities include:

- Installing towers

- Installing/securing a data logger/controller enclosure at ground level
- Connecting 12 VDC electrical power

POTENTIAL HAZARDS		RISK
1.	Lifting Hazards	Medium
2.	Muscle strains / overexertion / dehydration / fatigue / hypothermia	Medium
3.	Slips or falls from ladder.	High
4.	Cuts and lacerations-striking against objects, pinch points and protruding objects	Medium
5.	Electrocution while connecting power supply	Low
6.	Negative wildlife contacts	Low

Recommended Controls:

1. Ensure crew members understand all project hazards, are familiar with the specific lifting equipment used in installation, and utilize proper personal lifting techniques. Follow lifting safe work practices and avoid unsafe work acts. Ensure employees get help to move heavier objects, and utilize move-smart techniques, as well as proper body motion-mechanics when performing physical lifting.

2. Warm up and stretch before lifting or pulling. Drink plenty of water throughout the day. Avoid excessive amounts of coffee, teas, colas, sodas, juices, etc. These liquids will not re-hydrate an individual as well as water. Be prepared for inclement weather. Proper clothing (layered) for outside work activities is essential, and should include at a minimum: thermal underwear, arctic coverall gear, gloves, face mask, heavy socks, appropriately rated cold weather footwear (winter months). Get help with awkward loads. Ensure that employees are given sufficient time to conduct activities at the work site. Do not increase speed of activities. Ensure that employees are given multiple breaks throughout the workday.

3. Ensure footwear is in good repair, and always ensure solid footing. Situate ladders or step stools on level ground and use caution when working off the ground. Pay attention to surroundings.

4. Wear proper PPE to prevent personal injury. Anyone working at height will be trained in fall prevention/protection and will be wearing fall protection. Employees are to familiarize themselves with the immediate work area for any given task.

5. Ensure power tools and extension cords are good working order. Visually inspect the equipment before use.

6. Be alert to surroundings. Do not leave food sources out that can attract animals. Carry personal firearms and/or bear mace or be in the company of someone who has firearms and is trained in the use of firearms.

Note:
A change to a plan after the plan was developed is a major reason for health and safety incidents.

ANY CHANGE OF CONDITIONS THAT AFFECT THE PLAN WILL REQUIRE A SAFETY "TIME OUT" TO ASSESS HOW THAT CHANGE WILL IMPACT THE JOB AS PLANNED. WHEN ADDITIONAL HAZARDS ARE INTRODUCED INTO A PLANNED PHASE, CONTROLS WILL BE DISCUSSED WITH ALL PARTIES TO ENSURE SAFE EXECUTION DURING THE SAFETY "TIME OUT".

Inspections/Audits:
The crew supervisor will review the upcoming work on a daily basis and review a Safety Analysis Form outlining safety procedures, safety equipment usage and the possible hazards associated with the work planned that day. The material will be presented to the crew as a "Tool Box Safety Meeting" prior to the start of work that day.

Possible Crew Members: Dominic Shallies, Jared Cockman, Brent Veltkamp, Chris Lindsey, Eric Brudie, Steve Mackey

Emergency Action Plan:
Provide first aid. Immediately notify Northern Dynasty Mines officials of the situation.

Additional Comments/Changes:
Audits and calibrations are scheduled for the spring and fall. These tests, which will involve two HCG personnel, should take one working day to complete. Various personnel will be involved in these site visits.

5.1.3 Phase Hazard Analysis: Phase 3

Project:	Pebble Project Meteorological Monitoring
Date:	November 2004
Location:	Iliamna, Alaska
Phase:	Operation
Overall Risk Rank:	Low/Medium
Phase Description:	Following successful equipment setup, initial audits and calibrations will be conducted. These activities will take approximately one full work day to complete. Subsequently, the meteorological stations should operate unattended for an extended period of time.

Activities Include:

- Initial calibration and audits
- Periodic calibrations and audits

	POTENTIAL HAZARDS	RISK
1.	Lifting Hazards	Low
2.	Muscle strains / overexertion / dehydration / fatigue / hypothermia	Low
3.	Cuts and lacerations-striking against objects, pinch points and protruding objects	Low
4.	Electrocution	Low
5.	Negative wildlife contacts	Low

Recommended Controls:

1. Ensure crew members understand all project hazards, are familiar with the specific lifting equipment used in installation, and utilize proper personal lifting techniques. Follow lifting safe work practices and avoid unsafe work acts. Ensure employees get help to move heavier objects, and utilize move-smart techniques, as well as proper body motion-mechanics when performing physical lifting.

2. Warm up and stretch before lifting or pulling. Drink plenty of water throughout the day. Avoid excessive amounts of coffee, teas, colas, sodas, juices, etc. These

liquids will not re-hydrate an individual as well as water. Be prepared for inclement weather. Proper clothing (layered) for outside work activities is essential, and should include at a minimum: thermal underwear, arctic coverall gear, gloves, face mask, heavy socks, appropriately rated cold weather footwear (winter months). Get help with awkward loads. Ensure that employees are given sufficient time to conduct activities at the work site. Do not increase speed of activities. Ensure that employees are given multiple breaks throughout the workday.

3. Wear proper PPE to prevent personal injury. Anyone working at height will be trained in fall prevention/protection and will be wearing fall protection. Employees are to familiarize themselves with the immediate work area for any given task.

4. Ensure power tools and extension cords are good working order. Visually inspect the equipment before use.

5. Be alert to surroundings. Do not leave food sources out that can attract animals. Carry personal firearms and/or bear mace or be in the company of someone who has firearms and is trained in firearm use.

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Inspections/Audits:
The crew supervisor will review the upcoming work on a daily basis and review a Safety Analysis Form outlining safety procedures, safety equipment usage and the possible hazards associated with the work planned that day. The material will be presented to the crew as a “Tool Box Safety Meeting” prior to the start of work that day.

Possible Crew Members: Dominic Shallies, Jared Cockman, Brent Veltkamp, Chris Lindsey, Eric Brudie, Steve Mackey

Emergency Action Plan:
Provide first aid. Immediately notify Northern Dynasty Mines officials of the situation.

Additional Comments/Changes:

5.1.4 Phase Hazard Analysis: Phase 4

Project: Pebble Project Meteorological Monitoring

Date: November 2004

Location: Iliamna, Alaska

Phase: Demobilization

Overall Risk Rank: Low

Phase Description: Demobilization consists of packing all tools, equipment and safety gear for transport back to Anchorage. The work area will be cleared of all debris and left in an orderly fashion.

Activities Include:

- Removal of all tools, and unused equipment and materials.
- Clean up and housekeeping at the job site and any other areas utilized as workspace or materials lay-down areas.
- Proper disposal of any waste materials generated during this installation.

	POTENTIAL HAZARDS	RISK
1.	Lifting Hazards	Low
2.	Muscle strains / overexertion / dehydration / fatigue / hypothermia	Medium
3.	Cuts and lacerations-striking against objects, pinch points and protruding objects	Low
4.	Electrocution while demobilizing system	Low
5.	Negative wildlife contacts	Low

1. Ensure crew members understand all project hazards, are familiar with the specific lifting equipment used in installation, and utilize proper personal lifting techniques. Follow lifting safe work practices and avoid unsafe work acts. Ensure employees get help to move heavier objects, and utilize move-smart techniques, as well as proper body motion-mechanics when performing physical lifting.

2. Warm up and stretch before lifting or pulling. Drink plenty of water throughout the day. Avoid excessive amounts of coffee, teas, colas, sodas, juices, etc. These liquids will not re-hydrate an individual as well as water. Be prepared for inclement weather. Proper clothing (layered) for outside work activities is essential, and should include at a minimum: thermal underwear, arctic coverall gear, gloves, face mask, heavy socks, appropriately rated cold weather footwear (winter months). Get help with awkward loads. Ensure that employees are given sufficient time to conduct activities at the work site. Do not increase speed of activities. Ensure that employees are given multiple breaks throughout the workday.

3. Wear proper PPE to prevent personal injury. Anyone working at height will be trained in fall prevention/protection and will be wearing fall protection. Employees are to familiarize themselves with the immediate work area for any given task.

4. Ensure power tools and extension cords are good working order. Visually inspect the equipment before use.

5. Be alert to surroundings. Do not leave food sources out that can attract animals. Carry personal firearms and/or bear mace or be in the company of someone who has firearms and is trained in firearm use.

Note:
A change to a plan after the plan was developed is a major reason for health and safety incidents.

ANY CHANGE OF CONDITIONS THAT AFFECT THE PLAN WILL REQUIRE A SAFETY “TIME OUT” TO ASSESS HOW THAT CHANGE WILL IMPACT THE JOB AS PLANNED. WHEN ADDITIONAL HAZARDS ARE INTRODUCED INTO A PLANNED PHASE, CONTROLS WILL BE DISCUSSED WITH ALL PARTIES TO ENSURE SAFE

EXECUTION DURING THE SAFETY “TIME OUT”.

Inspections/Audits:
The crew supervisor will review the upcoming work on a daily basis and review a Safety Analysis Form outlining safety procedures, safety equipment usage and the possible hazards associated with the work planned that day. The material will be presented to the crew as a “Tool Box Safety Meeting” prior to the start of work that day.

Possible Crew Members: Dominic Shallies, Jared Cockman, Brent Veltkamp, Chris Lindsey, Eric Brudie, Steve Mackey

Emergency Action Plan:
Provide first aid. Immediately notify Northern Dynasty Mines officials of the situation.

Additional Comments/Changes:

6.0 ADDITIONAL SAFETY CONSIDERATIONS

- Field crews must always work in pairs and carry a radio.
- No alcohol or illegal drug consumption is allowed.
- Those who carry epi-pens for allergic reactions are to advise NDM and other members of the field crew so that assistance can be provided if necessary.
- Be aware of the rules regarding the possession of firearms and/or bear mace when traveling to the project area. A weapon must be unloaded before boarding the helicopter and unloaded and securely stored while in camp. The name of the individual bringing a firearm into camp must be given to Richard Moses (NDM Site Manager or his designee) prior to arrival. Permission to carry bear mace must be obtained from the pilot before boarding the helicopter.
- Field crews need to understand the risk of extreme weather and the possibility of staying overnight in the field.

7.0 EMERGENCY CONTACTS & MEDICAL PROCEDURES

7.1 Northern Dynasty Emergency Contact Information

c/o Iliamna Weathered Inn #1 Roadhouse Strip or Box 124 Iliamna, AK 99606 Tel: (907) 571-1872 or 1774 Home: (907) 571-1872 Fax: (907) 571-1789 Email: richardm@hdgold.com	1020-800 West Pender St. Vancouver, B.C. Canada V6C 2V6 Tel: (604) 684-6365 Toll Free: 1-800-667-2114 Fax: (604) 662-8956

Pebble Project Office in Iliamna	**John Baechler:**
Line 1: (907) 571-1788 Line 2: (907) 571-1774 Quest Office: (907) 571-1873 Emergencies: 8:30pm – 6:00am call (907) 571-1872	Home: (907) 571-1878

Project Coordinator in Anchorage	**Anchorage Office Manager**
Northern Dynasty Mines Inc. – Ella Ede Tel: (907) 339-2600 Toll Free: (877) 450-2600 Home: (907) 274-0228 Cell: (907) 229-1780 Email: ellae@northerndynasty.com	Northern Dynasty Mines Inc.– Michelle Brunner Tel: (907) 339-2600 Toll Free: (877) 450-2600 Home: (907) 563-1309 Cell: (907) 632-0163 Email: michelleb@northerndynasty.com

7.2 Local Emergency Medical Services

Iliamna Clinic — Located on the Roadhouse Strip
Telephone: (907) 571-1383

Rene (Health Aid) — Home Telephone: (907) 571-1323

7.3 INTERFACE DOCUMENT

HCG has developed an Interface Document (Table 7-1) that outlines the interface HCG field and office personnel. Serious incidents must be reported immediately, while less serious ones shall be reported within the shift in which the incident occurred. This will include the completion of all necessary forms and documentation.

Interface Document
Table 7-1

Activity	Primary HCG Contact	Secondary HCG Contact
Environmental Non-compliance	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Environmental Incident Reporting	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Unauthorized/unaccompanied individuals on site	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Compliance Audits: Scheduling, developing, conducting	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Emergency Reporting	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Agency Reporting	Steve Mackey (563-2129)	Al Trbovich (563-2140)
Field Installation Activities	Steve Mackey (563-2129)	Al Trbovich (563-2140)

7.4 MEDICAL EMERGENCY PROCEDURES

(1) Contact Northern Dynasty Mines Base Camp in Iliamna by radio or telephone. Radio frequency being used is 151.625 MHz with a 123.000 MHz transmit and receive tone (private line).

(2) Contact Alaska State Troopers Dispatch: (907) 428-7200 (24 hrs/day).

In the event of a major emergency, the Alaska State Troopers will mobilize a response, including contacting the local State Trooper, medical, and rescue personnel.

Information to provide:

- Who you are
- Nature of emergency
- Your location
- Your company and contact number
- Number of victims
- Sex, age and vital signs of patients (if possible)
- Specific injuries

(3) Local emergency support in Iliamna and Newhalen:

- Iliamna State Trooper: (907) 571-1534
- Iliamna Clinic (Health Aid): (907) 571-1383
- Newhalen Clinic: (907) 571-1248
- Iliamna Air Taxi (has air Medivac capability): (907) 571-1245 / (907) 871-1445

APPENDIX B4
PROJECT FORMS

Site Visit & System Check

Date: _____________

Project Title: ________________________________ **Project No.** __________

Name of Inspector: ____

Associated Company: ____

Sate Reason for visit: ____
____
____

____

Check List

Tower:

- ☐ Check tower for stability, ensure that guy wires are taunt and all clamping hardware is in good condition.
- ☐ Check that all sensors are securely mounted to tower. This includes antennas and enclosures.
- ☐ Check for excessive ice build-up on tower and sensor mounts
- ☐ Check for loose instrument cables

Comments: ____
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Sensors:

Wind Direction:

- ☐ Check to see if wind vane is moving freely or fluttering in wind.
- ☐ Check for excessive ice or snow build-up on vane and sensor if so clear the sensor.
- ☐ After clearing ice or snow, check to see if vane can move freely in all directions.

Wind Speed:

- ☐ Check to see that cups are spinning freely.
- ☐ Check for excessive ice or build-up on vane and sensor, if so clear the sensor.
- ☐ After clearing ice or snow, check cups to insure they spin with ease.
- ☐ Clear ice or snow off of wind sensor cross arm.

All other sensors:

- ☐ Check sensor housing or brackets for visible damage.
- ☐ Check all sensor connection and cables to ensure good connections and secured to tower.
- ☐ Clear any ice or snow from sensor brackets and mounts.
- ☐ Check each sensor mount to ensure the sensor is level and secure.

Comments: ____
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Inspector signature: ____

Corrective Action Plan

The corrective action plan is designed to address the many unexpected problems that may arise during the project duration. HCG personnel are instructed to immediately bring any major problems to the attention of the project supervisor. Since many individuals could become involved in the corrective action, the notification is best done by a standard corrective action form.

This Corrective Action Form exists in three parts to address and correct program that occur during routine operation or as a result of performance evaluation and technical systems audits. The three parts are listed below:

- Request for Assistance
- Proposed Corrective Action
- Results of Proposed Corrective Action

It is recommended that all personnel signing the form should feel free to attach other needed material. These forms are stored at the HCG office both in electric and paper format.

Hoefler Consulting Group

Corrective Action Form

Project Title: ________________________________ **Project No.** __________

I. Request for Assistance:

To: ___________________ **From:** ____________________ **Date:** __________

Problem Summary: ____
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____.

II. Proposed Corrective Action

To: ___________________ **From:** ____________________ **Date:** __________

Recommended Action: ____
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____.

III. Results of Proposed Action

To: ___________________ **From:** ____________________ **Date:** __________

Action Results: ____
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____.

Systems Audit Report
For Meteorological Monitoring Programs

Audit Date:
Auditor:
Auditor Affiliation

Interviewees:	Witnesses:

1.0 Monitoring Program Information

Monitoring Site Audited:

Monitoring Site Owner:
Owner Mailing Address:

2.0 Monitoring Program Staff

2.1 Program Staff Organization

- Draw diagram indicating the organizational structure of the monitoring program. Include names and titles.

2.2 Program Staff Training and Experience

Name:
Program Position:
Training/Education/Experience:

Name:
Program Position:
Training/Education/Experience

Name:
Program Position:
Training/Education/Experience:

Name:
Program Position:
Training/Education/Experience:

Name:
Program Position:
Training/Education/Experience:

Name:
Program Position:
Training/Education/Experience:

Name:
Program Position:
Training/Education/Experience:

- How is program staff trained?______

- Who is responsible for training staff?

Does the operator have training manuals or other training related materials available for staff?	Yes No

3.0 General Program Information

3.1 Monitoring Site Description

Monitoring Site Name:

Monitoring Site Location Description:

Indicated by Operator	Determined by Auditor

3.2 Monitoring Site Appearance and Safety

Does the site appear clean, organized and well maintained?	Yes No	Comments:
Does the site appear to be safe and reasonably hazard free?	Yes No	Comments:
Does the site have a shelter for operators?	Yes No	Comments:
Does the site have emergency equipment such as a first aid kit available?	Yes No	Comments:
Does the site have adequate measures to prevent human tampering?	Yes No	Comments:
Does the site have adequate measures to prevent damage from animals?	Yes No	Comments:

3.3 Monitoring Site Surroundings

- Indicate the population density type for the monitoring site.

	Type	Description
	Remote	No nearby development with no nearby population center.
	Rural	Limited development with nearby sparse population.
	Low Suburban	Light industrial development in low population center.
	High Suburban	Light industrial development in high population center.
	Urban	Heavy industrial development in high population center.

3.4 Monitoring Site Equipment Inventory

- List all parameters that are being monitored and their associated instrumentation at the site.

Parameter	Make	Model	Serial No.

- List all instrumentation used in support of the monitoring instrumentation.

Instrument	Make	Model	Serial No.

3.5 Meteorological Instrumentation Siting and Exposure (EPA-454/R-99-005)

Do all sensors appear to be clean, intact, in good condition and well maintained?	Yes No	Comments:
Are all sensors operational, online and reporting data?	Yes No	Comments

3.5.1 Tower

Do all obstructions exist below a 1:10 slope away from the tower base?	Yes No	Comments
Is the height of the tower 10 meters above the ground?	Yes No	Comments:
Is the tower stable and plumb?	Yes No	Comments:
Is the tower protected from lightning?	Yes No	Comments:

3.5.2 Wind Speed and Wind Direction

Is the horizontal distance between the instrument and any obstruction at least 10 times the height of the obstruction?	Yes No	Comments:
Is the instrument 1.5 times the height of the building above the roof or 10 meters above the ground?	Yes No	Comments:
Are the wind speed and wind direction sensors stable and plumb?	Yes No	Comments:
Is the distance of the sensor on the cross arm/mast at least twice the diameter of the tower?	Yes No	Comments:
Is the wind sigma theta collected according to EPA requirements?	Yes No	Comments:

3.5.3 Air Temperature, Air Temperature Difference, and Relative Humidity

Are the sensors mounted over open level ground at least 9 meters in diameter and at least 2 meters above ground?	Yes No	Comments:
Are the two temperature difference probes located at a height of 2 meters and 10 meters above the ground?	Yes No	Comments
Is the ground beneath the temperature sensor natural native material?	Yes No	Comments
Is the site free of any man-made features exist that could create bias temperature data (e.g. asphalt, concrete, exhaust plumes, etc.)?	Yes No	Comments:
Is the site free of any natural made features that could create bias temperature data (e.g. open water, sloping ridge, etc.)?	Yes No	Comments:
Are the temperature sensors protected from the influence of solar radiation?	Yes No	Comments:
Are the sensors located at least four times the distance from the height of the obstruction?	Yes No	Comments:
Are the sensors located at least 30 meters from large paved areas?	Yes No	Comments:
Are the temperature sensors used for differential measurements located in identical aspirated shields?	Yes No	Comments:

3.5.4 Solar Radiation

Is the instrument situated above the plane of any obstructions that could cast shadows on the instrument?	Yes No	Comments:
Is the sensor situated to the south of the tower in order to minimize obstruction from the tower?	Yes No	Comments:

3.5.5 EPA Recommended Instrument Resolutions

Parameter	Equipment Specifications	EPA Resolution Standard	Meets Standard?

3.5.6 Recommended Instrument Accuracy Standards

Parameter	Equipment Specifications	EPA Accuracy Standard	Meets Standard?

3.5.7 EPA Recommended Instrument Response Standards

Parameter	Equipment Specifications	EPA Response Standard	Meets Standard?
Wind Speed			
Threshold:			
Distance Constant:			
Wind Direction			
Threshold:			
Damping Ratio:			
Delay Distance:			
Air Temperature (2 meter)			
Time Constant:			
Air Temperature (10 meter)			
Time Constant:			
Relative Humidity			
Time Constant:			
Range:			
Solar Radiation			
Time Constant:			
Operating Range:			
Spectral Response:			

3.6 Support Instrumentation and Equipment

Is the DAS well protected from the elements with adequate room for maintenance?	Yes No	Comments:
Is the DAS rated for operation in the expected local temperature range?	Yes No	Comments:
Are all sensor signal leads neatly and securely connected to the correct DAS channels?	Yes No	Comments:
Are all components of the DAS operational?	Yes No	Comments:
Is the communications equipment operating correctly?	Yes No	Comments:
Does the DAS system have a stable power supply?	Yes No	Comments:

Is the DAS properly grounded?	Yes No	Comments:
Is the DAS system protected from lightning?	Yes No	Comments:

4.0 Data Processing

4.1 Data Collection

Is the monitoring station polled on a regular basis?	Yes No	Comments:
Is the PM sample run date recorded?	N/A	Comments:
Is the PM sample start time and elapsed time recorded?	N/A	Comments:
Is the PM average flow rate recorded?	N/A	Comments:
Is each PM filter recovered after each run period?	N/A	Comments

- Indicate how the polled data are handled for data processing after being downloaded.

Are procedures in place for backing up raw data?	Yes No	Comments:

- How long are backup raw data files retained?
- How long are archived records retained?

Are hard copies of data being kept in case of computer failure?	Yes No	Comments:

4.2 Data and Sample Handling

Are written procedures for data handling available for the project?	Yes No	Comments:
Are filters properly secured once removed to prevent contamination or tampering?	N/A	Comments:

Are copies of the Site Check Forms being sent to the operator on a regular basis?	N/A	Comments:.
Are Chain-of-Custody forms being used to transmit materials, samples, and/or documents to and from the field?	N/A	Comments:
Are filters folded in half with collection surfaces in contact for transport to the lab?	N/A	Comments:
Are samples maintained in a secure location while awaiting shipment to the laboratory?	N/A	Comments:

- Diagram the data flow from monitoring equipment to submission of final report.

4.3 Data Validation

Are data validation procedures established and in use?	Yes No	Comments:

- Describe data validation procedure.

Are the individuals responsible for data collection separate from those responsible with data validation?	Yes No	Comments:

- Identify those responsible with data validation:

Name:
Position:
Affiliation:

- Identify how periods of missing or invalidated data are handled.

4.4 Data Reporting

Are quarterly and annual data reports being submitted for the site?	Yes No	Comments:
Is qualified staff prior to submittal of data reports making reviews of the report?	Yes No	Comments:

- Identify those person(s) responsible for review of data reports.

Name:
Position:
Affiliation:

4.5 Corrective Actions

Are procedures established for initiating corrective actions within the data processing steps?	Yes No	Comments:

- Describe procedures for tracking and closing corrective actions.

Data Capture (Section 4.5 EPA-454/R-99-005)

- Identify the desired data capture rate for the monitoring data.

Meteorological Monitoring Data Type	Capture Rate

Are the desired data capture rates being met for each data type?	Yes No	Comments:

5.0 Quality Assurance and Quality Control

5.1 Quality Assurance Program Plan

Has a quality assurance program plan (QAPP) been written that describes quality assurance procedures?	Yes No	Comments:
Is a copy of the plan available to field and data processing personnel?	Yes No	Comments:
Has the quality assurance plan been approved by the ADEC?	Yes No	Comments:

- Identify those person(s) responsible for updating the plan and the procedure for updating the plan.

Name:
Position:
Affiliation:

5.1.1 Quality Assurance Assessment Requirements (Section 8.0 EPA-454/R-99-005)

Have adequate audit procedures been identified within the quality assurance plan?	Yes No	Comments:
Does the plan adequately document the correct criteria for accuracy and precision?	Yes No	Comments:

- Indicate the project's correct precision and accuracy limits.

Parameter	***Precision Limit***	***Accuracy Limit***	***Reference***
DAS Time			
Wind Direction			
Wind Speed			
Air Temperature			
Air Temperature Difference			
Relative Humidity			
Solar Radiation			
Barometric Pressure			

5.2.1 Standard Operating Procedures

- Indicate the Standard Operating Procedures that have been developed for the program:

Standard Operating Procedures	
	Installation, Setup, and Checkout
	Site Operations and Calibrations
	Operational Checks and Preventive Maintenance
	Data Collection Protocols
	Data Validation Steps
	Data Archiving

5.2.2 Preventive Maintenance

Does a preventive maintenance program exist for the monitoring program and is the program being followed?	Yes No	Comments:

- Identify those responsible parties for preventive maintenance at the site.

Name:
Position:
Affiliation:

- Identify the preventative maintenance procedures conducted for the site.

5.2.3 Station Documentation

Is the Monitoring/QA plan comprehensive and reflective of the actual installation?	Yes No	Comments:
Does the station have an activity log?	Yes No	Comments:
Does the station have a Site Visit Log and Checklist Form?	Yes No	Comments:
Does the station have an adequate Calibration Report Forms and copies of previous calibrations?	Yes No	Comments:
Does the station have an adequate Operations Manual?	Yes No	Comments:

- Identify the operation manuals present on site.

Description

Are report forms and site logs properly completed and current?	Yes No	Comments:

6.0 Comments and Suggestions

Site Training Check list

This form should be included with the site visit memos. All training is site specific and is to be given by qualified HCG personal only.

Date of Training: _____________

Station Name:________________________________ Project No.________________

Name of Trainer: ____________________________ Position: ___________________

Name of Trainee: ____________________________ Position: ___________________

Nature of Training: ____

Is the trainee HCG personnel? If not specify associated company. Yes ☐ No ☐

Specify company name: _________________________ Position: ___________________

Site surveillances/maintenances visits:

- ☐ Has the specific monitoring project overview and objectives been discussed?
- ☐ Has site location and all safety concerns been discussed in detail?
- ☐ Has the scope of the site surveillances visit been discussed?
- ☐ Have all specific concerns pertaining to meteorological station been discussed.
- ☐ Has all site surveillance visit forms and filling procedures been discussed in detail?
- ☐ Have all site surveillances/maintenances visit task been clearly explained and demonstrate, including all equipment and senor operation, and safety practices pertaining to these tasks?
- ☐ Have all "as left" procedures been explained and demonstrated?

Audit and Calibration Visits:

- ☐ Has the specific monitoring project overview and objectives been discussed?
- ☐ Has the scope of the audit or calibration visit been discussed in detail?
- ☐ Have all specific concerns pertaining to meteorological station including any environmental safety concerns been discussed?
- ☐ Have all the audit or calibration forms, site visit documentation and filling procedures been discussed in detail?
- ☐ Have the functions and operations of each instrument located at the site been explained and demonstrated in detail?
- ☐ Have all audit or calibration task, tests, and recording techniques been clearly explained and demonstrated?
- ☐ Have all safety practices penetrating to the above task been clearly explained and demonstrated?
- ☐ Have all filling procedure and deadlines been discussed in detail?
- ☐ Have all “as left” procedures been explained and demonstrated?

Comments:

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Trainers Signature: ____

Trainees Signature: ____

APPENDIX C
STATEMENT OF QUALIFICATIONS

HOEFLER

CONSULTING GROUP

Air Quality Monitoring Services

Hoefler Consulting Group is an Anchorage-based consulting firm specializing in comprehensive environmental permitting and compliance services for Alaskan industries. Hoefler provides technical services supporting construction and operation of facilities in Alaska’s unique physical, regulatory, and political environment. Hoefler is the leading air quality consulting firm in Alaska. The firm’s staff of 40 professionals provides the following services from our Anchorage offices:

- PSD and non-PSD construction permitting
- Title V operating permitting
- Meteorological and ambient air quality monitoring programs
- Criteria pollutant, HAP, and greenhouse gas emission inventories
- Best available control technology demonstrations
- Air modeling compliance demonstrations
- Risk assessment
- Open burning approvals
- Certified opacity readings
- Source test supervision and support

Summaries of Experience for Key Personnel

ALAN M. TRBOVICH, CCM,
Vice President

Al Trbovich is a Certified Consulting Meteorologist and the Air Quality Team Leader of the Hoefler Consulting Group. He has 26 years of environmental permitting and regulatory compliance experience, and has been providing air quality services to his Alaskan clients throughout the state since 1998. Mr. Trbovich has extensive experience working with all facets of air permitting including construction ("PSD") and operating ("Title V") permitting, meteorological and ambient monitoring, compliance monitoring, source testing, and risk assessments. He is also a specialist in air quality modeling and has conducted ambient air quality and/or visibility modeling studies throughout Alaska. He has also lead numerous multi-disciplinary teams in preparing air permit applications, environmental impact statements, and other environmental studies. Mr. Trbovich holds B.S. and M.S. degrees in Meteorology from the University of Utah.

K. STEVEN MACKEY
Senior Project Manager

Steve Mackey is the Project Manger for the Air Quality Group at Hoefler Consulting group. He has over 20 years of air quality experience in air quality services project management as well as database development and management. His specialties include ambient air monitoring, meteorological monitoring, continuous emission monitoring systems (CEMS), source emissions measurement, and regulatory Compliance. Mr. Mackey holds B.S. degree in mechanical engineering from the University of Washington.

ERIC L. BRUDIE
Air Quality Consultant

Eric Brudie is an independent Air Quality Consultant that works with the Air Quality Group at Hoefler Consulting. He has over 22 years of air monitoring experience in air quality services. Mr. Brudie works with Hoefler Consulting as an independent contractor who specializes in conducting performance and systems audits of numerous PSD quality meteorological monitoring systems. His experiences include designee and operating numerous remote meteorological monitoring systems for the TAGS project, including the LNG terminal site 40-meter remote system. He functioned as a key team member in the preparation and agency approval of the Meteorological Monitoring & QA/QC Plan and the Application for Air Quality Control Permit to Operate with PSD Review for the proposed LNG liquefaction plant. Mr. Brudie holds a B.S. in Geological Engineering from the Colorado School of Mines.

JARED H. COCKMAN

Project Associate

Jared Cockman is a Project Associate with the Air Quality Group at Hoefler Consulting; He has over more than 4 years experience in air monitoring project support. Mr. Cockman holds an EPA Method 9 Visibility Certification for Alaska and his experiences include visible emissions monitoring, meteorological and ambient air quality monitoring, technical support for permit compliance, data management, management information systems, technical writing and editing, and document processing and production. Mr. Cockman holds a B.A. in English Literature from East Carolina University.

BRENT S. VELTKAMP

Associate Scientist

Brent Veltkamp is a Associate Scientist at Hoefler Consulting. He assists in field project support and meteorological monitoring site operations for Air Quality Group. He has over 12 years experience in environmental monitoring and remediation. His specialties include meteorological monitoring station installation and maintenance, maintenance of bioremediation systems, biological fieldwork and sampling techniques, wetland delineation, site assessment, and technical writing and editing. Mr. Veltkamp holds a BS in Biological Science from Colorado State University.

W. DOMINIC SHALLIES

Project Assistant/ Field Technician

Dominic Shallies is a Project Assistant at Hoefler Consulting. He assists in field project support and meteorological monitoring site operations for Air Quality Group. He has over 3 years experience in environmental monitoring and meteorological data collection. His specialties include PSD quality meteorological monitoring station installation and operation, data management, site assessment, and technical writing and editing. Mr. Shallies holds a BS in Environmental Science from the University of Alaska Southeast.