APPENDICES

10A-1	EHS FRAMEWORK STANDARD (NO CHANGE)
10A-2	HAZARD IDENTIFICATION AND RISK ASSESSMENT PROCEDURE (NO CHANGE)
10A-3	CONSTRUCTION RISK MANAGEMENT REPORT (NO CHANGE)
10B	ENVIRONMENTAL PROTECTION PLAN (NO CHANGE)
10C-1	EMERGENCY RESPONSE AND SPILL CONTINGENCY PLAN (NO CHANGE)
10C-2	OIL POLLUTION EMERGENCIES PLAN – MILNE PORT (NO CHANGE)
10C-3	OIL POLLUTION EMERGENCIES PLAN – STEENSBY PORT (NO CHANGE)
10C-4	EXPLOSIVES MANAGEMENT PLAN (NO CHANGE)
10C-5	HAZARDOUS MATERIAL AND HAZARDOUS WASTE MANAGEMENT PLAN (NO CHANGE)
10D-1	AIR QUALITY AND NOISE ABATEMENT MANAGEMENT PLAN (CHANGE)
10D-2	SURFACE WATER, AQUATIC ECOSYSTEMS, FISH AND FISH HABITAT MANAGEMENT PLAN (NO CHANGE)
10D-3	WASTE WATER MANAGEMENT PLAN (NO CHANGE)
10D-4	WASTE MANAGEMENT PLAN (NO CHANGE)
10D-5	WASTE ROCK MANAGEMENT PLAN (NO CHANGE)
10D-6	BORROW PITS AND QUARRY MANAGEMENT PLAN (NO CHANGE)
10D-7	FISH HABITAT COMPENSATION (NO CHANGE)
10D-8	ROADS MANAGEMENT PLAN (CHANGE)
10D-9.1	RAILWAY MAINTENANCE MANAGEMENT PLAN (NO CHANGE)
10D-9.2	RAILWAY EMERGENCY RESPONSE PLAN (NO CHANGE)
10D-10	SHIPPING AND MARINE WILDLIFE MANAGEMENT PLAN (CHANGE)
10D-11	TERRESTRIAL ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN (CHANGE)
10D-12	ENVIRONMENTAL MONITORING PLAN (NO CHANGE)
10D-13	ENVIRONMENTAL EFFECTS MONITORING FRAMEWORK (NO CHANGE)
10D-14	MMER ENVIRONMENTAL EFFECTS MONITORING STUDY DESIGN FRAMEWORK (NO CHANGE)
10E	HEALTH AND SAFETY MANAGEMENT PLAN (NO CHANGE)
10F-1	STAKEHOLDERS ENGAGEMENT PLAN (NO CHANGE)
10F-2	CULTURAL AND HERITAGE RESOURCE PROTECTION PLAN (NO CHANGE)
10F-3	HUMAN RESOURCES MANAGEMENT PLAN (NO CHANGE)
10G	PRELIMINARY CLOSURE AND RECLAMATION PLAN (CHANGE)

APPENDIX 10D-1

AIR QUALITY AND NOISE ABATEMENT MANAGEMENT PLAN

MARY RIVER PROJECT
ENVIRONMENTAL IMPACT STATEMENT

VOLUME 10
ENVIRONMENTAL, HEALTH, AND SAFETY (EHS) MANAGEMENT SYSTEM

APPENDIX 10D-1

AIR QUALITY AND NOISE ABATEMENT MANAGEMENT PLAN

Rev. No.	Revision	Date	Approved
0	Document issued for approval	June 2010	DEC, 2010
1	Document issued for FEIS	Nov 2011	
2	Document revised for FEIS	Jan 2012	
3	2013 Work Plan	May 2013	

VOLUME 10

ENVIRONMENTAL MANAGEMENT

Appendix 10D-1 – AIR QUALITY AND NOISE ABATEMENT MANAGEMENT PLAN

Table of Contents

TABLES

FIGURES

The following figures present the site plans and are contained in EIS Volume 3: Project Description

Figure 3-2.1 Milne Port Site Plan
Figure 3-2.2 Milne Inlet Tote Road
Figure 3-2.3 Mine Site Plan

Note: Figures related to the Railway and Steensby Port will be added once construction begins at these sites.

ABBREVIATIONS

ASL ..... ambient sound level
Baffinland ..... Baffinland Iron Mines Corporation
CCME .....Canadian Council of Ministers of the Environment
CO ..... carbon monoxide
CO_2 .....carbon dioxide
CSL ..... comprehensive sound level
CWS ..... Canada-Wide Standards
dBA ..... decibel-acoustic
DFO ..... Fisheries and Oceans Canada
EHS ..... Environmental, Health, and Safety
EIS ..... environmental impact statement
EPCM ..... engineering, procurement, and construction management
EPP ..... Environmental Protection Plan
ERCB ..... Energy Resources Conservation Board
L_{eq} ..... energy equivalent sound level
LSA ..... Local Study Area
Mary River Project ..... the Project
MTPA ..... million metric tons per annum
NCB ..... balance noise criteria
NIRB ..... Nunavut Impact Review Board
NO_2 .....nitrogen dioxide
NO_X ..... nitrogen oxide emissions
NWT ..... Northwest Territories
O_3 ..... ozone
OSHA ..... Occupational Safety and Health Association
PDA ..... Project Development Area
PM ..... particulate matter
PSL ..... permissible sound level
RSA ..... regional study area
SARA..... *Species At Risk Act*
SO_2 ..... sulphur dioxide
TSP ..... total suspended particulate matter
VEC ..... valued ecosystem component
ZOI ..... Zone of Influence

SECTION 1.0 - INTRODUCTION

1.1 PURPOSE

The Air and Noise Abatement Management Plan provides guidance on management of air emissions and noise from construction and operation activities. The plan includes action to control airborne particulates and noise hazards. It also defines action to mitigate, prevent, or avoid to the extent practical noise nuisance to site personnel and nearby populations. The plan addresses greenhouse gas emissions and includes an assessment of emissions from the complete lifecycle of the product, aimed at improving management of energy and greenhouse gas emissions, building emissions abatement and energy saving considerations into the business decision-making processes.

1.2 REGULATORY REQUIREMENTS

1.2.1 Air Quality Guidelines

There are ambient air quality guidelines for Nunavut for of total suspended particulate matter (TSP) and sulphur dioxide (SO_2) (Department of Sustainable Development, Environmental Protection Service, 2002).

The National Air Quality Objectives, Canada-Wide Standards (CWS) and other Canadian jurisdictions provide guidelines for other air contaminants. The National Objectives are divided into three categories (Health Canada, 2005):

- "***Maximum desirable level*** is the long-term goal for air quality and provides a basis for anti-degradation policy for the unpolluted parts of the country, and for continuing development of control technology."
- "***Maximum acceptable level*** is intended to provide adequate protection against effects on soils, water, vegetation, materials, visibility, personal comfort, and well-being."
- "***Maximum tolerable level*** denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public."

For a comparison of federal objectives, Northwest Territories (NWT) criteria, Nunavut guidelines and CWS, see Section 5. The criteria refer to different averaging periods to account for potential short-term acute exposures and long-term chronic exposures. For dust deposition criteria for the provinces of Alberta and Ontario, see Section 5.

1.2.2 Noise

There are no regulations or guidelines in Nunavut that address environmental noise levels. However, noise has been addressed in recent environmental impact statements (EIS) developed for other mining projects in Nunavut (e.g., Meadowbank Gold Project, Doris North Gold Project, High Lake Project).

1.2.3 Greenhouse Gas Emissions

The Nunavut Climate Change Strategy is outlined in October 2003 by the Department of Sustainable Development. One of the objectives of this strategy is to "encourage Nunavummiut, including government, non-government, industry, and the public to take action to control greenhouse gas emissions through energy management and alternative energy supply technology."

1.3 BAFFINLAND'S COMMITMENTS

Baffinland provides adequate resources to implement and maintain the Health, Safety, and Environment (HSE) Management System, including the necessary human, material, and financial resources.

Baffinland's Sustainable Development Policy is presented in Attachment 1.

Baffinland also made a number of commitments during the Project Certificate review process. These commitments as well as the Terms and Conditions of the Project Certificate applicable to Meteorology, Climate Change, Air Quality and Noise are listed in Attachment 2. The Air Quality and noise Abatement Management Plan provides the mechanism by which Baffinland tracks its compliance to these commitments and Terms and Conditions of the Project Certificate.

1.4 RELATIONSHIP TO OTHER MANAGEMENT PLANS

This plan should be viewed in concert with the following additional plans prepared for the EIS:

- Health, Safety, and Environmental Management Framework
- Environmental Design Guidelines
- EHS Management Framework
- Hazard and Risk Assessment Methodology
- Environmental Protection Plan
- Borrow Pit and Quarry Management Plan
- Road Management Plan
- Abandonment and Reclamation Plan

1.5 UPDATE OF THIS MANAGEMENT PLAN

The Air Quality and Noise Abatement Management Plan is a "living document." It will be regularly updated based on management reviews (see Section 9), incident investigations, regulatory changes, or other Project-related changes.

Note that the present update addresses the early construction phase of the Approved Project. This plan will be updated again once the construction of the railway is underway. Therefore, for this update, references to actions required along the railway or at Steensby Port have been removed.

SECTION 2.0 - TARGETED VECS

Targeted valued ecosystem components (VECs) for the Air Quality and Noise Abatement Management Plan are:

- air quality
- noise
- greenhouse gas emissions and climate change.

2.1 AIR QUALITY

Both gaseous and particulate emissions can result in air contaminants such as TSP, particulate matter (PM_{10}, $PM_{2.5}$), SO_2, nitrogen dioxide (NO_2), and carbon monoxide (CO), which can be measured as concentration of mass of contaminants per volume of air basis ($\mu g/m^3$). Because of gravitational settling and other influences, TSP can be deposited to the earth's surface and potentially accumulate in terrestrial aquatic systems. Here the contaminant is measured as deposition on a mass per area basis (g/m^2). Depending on the composition of TSP, this deposition can range from nuisance to environmental concern. The VEC associated with these contaminants is air quality.

Baseline air quality conditions for the Mary River Project are presented in Attachment 2.

2.1.2 Key Issues and Concerns for Air Quality

For air quality key issues and concerns for the Project are listed in Table 2.1.

2.1.3 Air Quality Metrics

For the Mary River Project, the concerns are mainly TSP, SO_2 and NO_x, and greenhouse gas emissions (GHG). The air quality metrics are thus:

- TSP and total particulate deposition (dustfall)
- sulphur dioxide (SO_2) and NO_2
- GHG emissions.

Table 2-1 Air Quality Key Issues and Concerns for the Project Phases

Project Phase	Issue/Concern	Relevance
Construction	Dust concentration and deposition	Vehicle emissions will occur from transportation of materials and workers to the site. Fugitive emissions will result from earthworks, construction of roads, laydown areas, railway, and other infrastructure.
Operation	Project effect on ambient SO_2 concentrations	The Project will result in an increase in regional emissions of SO_2, a gaseous contaminant. Ambient SO_2 concentrations can increase airway resistance in exercising asthmatics for 10-minute exposures at concentrations of 1000 $\mu g/m^3$ (Legge, 1995).
	Project effect on ambient NO_2 concentrations	The Project will increase regional nitrogen oxide emissions (NO_X). Ambient NO_2 concentrations have shown small, statistically significant, reversible effects for mildly exercising asthmatics for 30-minute exposures at concentrations of 560 $\mu g/m^3$. A direct link between ambient NO_2 exposure and vegetation effects is more difficult to establish.
	Project effect on ambient CO concentrations	The Project will increase regional CO emissions. Ambient CO concentrations can inhibit the blood's ability to carry oxygen to body tissues including vital organs.

	Project effect on regional acid deposition	The Project will result in an increase of NO_X and SO_2 emissions. Ambient NO_X and SO_2 form acidifying chemicals in the atmosphere, and they are removed from the atmosphere by wet and dry removal processes (deposition). The deposition is represented as sulphur and nitrogen deposition.
	Project effect on ambient $PM_{2.5}$ concentrations	Respirable particulate matter ($PM_{2.5}$) and precursor $PM_{2.5}$ emissions are projected to increase due to the Project. Particulates with aerodynamic diameters less than 2.5 µm (i.e., $PM_{2.5}$) are of specific interest because they are linked with adverse human health response. $PM_{2.5}$ can be emitted directly from industrial facilities or can be formed in the atmosphere from precursor emissions.
	Project effect on O_3	Ozone (O_3) can affect the respiratory system. O_3 is not emitted directly. In fact, NO_X will reduce ambient O_3 levels due to reactions with nitrogen oxide emissions. Given the northerly latitude location, the photochemical production of O_3 due to the Project will be negligible and therefore is not addressed.
	Project effects on fugitive dust and metal deposition	Fugitive sources of TSP and metals will include mining, processing, handling, and storage of iron ore. The metal concentration of the ore concentrate will be higher than natural background levels. The ambient concentrations and deposition of metal compounds are therefore evaluated in addition to dust.
	Project effects on greenhouse gas emissions	Combustion of hydrocarbons produces carbon dioxide (CO_2), a greenhouse gas. Given the interest in greenhouse gases relative to potential global warming and climate change, estimates of greenhouse gas emissions are required.
Closure	Dust concentration and deposition	Vehicle emissions will occur from transportation of materials and workers to the site. Fugitive emissions will result from earthworks related to closure.

2.2 NOISE AND VIBRATION

High levels of environmental noise and vibrations can affect people by impairing their enjoyment of using the land. High noise and vibration levels can also affect wildlife, causing changes in behaviour or avoidance of affected areas, for at least temporary periods. Environmental noise and vibration levels are therefore the VEC selected for mitigation and monitoring.

2.2.1 Baseline Noise Levels

Pre-development background atmospheric noise levels are low, ranging from 25 to 35 dBA (refer to Attachment 2). Noise recorded at all three sites consisted mainly of wind, insect, and small animal or bird sounds; at the port sites, noises associated with flowing water and waves were also recorded. Differences between daytime and nighttime were small, and attributed mainly to noise from nearby human activities that couldn't be screened out.

Measured ambient noise levels at all three sites (2007 campaign) were lower than those typically found in remote rural areas, likely because of the lower noise contribution from wind in vegetation for the three sites as opposed to more southerly areas with higher-profile vegetation, more likely to generate wind-related noise.

2.2.2 Key Issues and Concerns for Noise and Vibration

Key issues and concerns for noise and vibration are presented in Table 2.2.

Table 2-2 Summary of Key Issues and Concerns for Noise and Vibration

VEC	Issue Identified and Reason for Selection of VEC	Indicator
Environmental sound levels	• Minimize disturbance of natural terrestrial wildlife use patterns in the region • Minimize impacts on seasonal human dwellings in the area of Milne Inlet	• A-Weighted Sound Levels (L_{eq} dBA)
Environmental vibration levels	• Minimize disturbance of natural terrestrial wildlife use patterns in the region	• Peak vibration levels (mm/s)

2.3 CLIMATE CHANGE AND GREENHOUSE GAS

"Controlling emissions must be done in ways that carefully consider Nunavut's developing economy by minimizing the negative impacts to the economy and, where possible, identify economic opportunities" (Nunavut Climate Change Strategy, October 2003).

At present, arctic-grade diesel fuel is the only economically viable source of energy for the Project. Baffinland is committed, however, to continuing investigation of alternative sources of energy to satisfy Project energy requirements.

As required by the Project Certificate, Baffinland commits to provide feedback on the impacts that climate change might be having on the Project (term and condition no. 2) as such studies are completed.

SECTION 3.0 - MITIGATION MEASURES

3.1 LIFE OF PROJECT MITIGATION MEASURES

Mitigation measures that will be implemented over the life of the Project to minimize identified adverse impacts on air quality, noise, and vibration are outlined in this section.

Procurement Policy

Baffinland`s procurement procedures will incorporate air emissions and noise standards for the purchase of all equipment and machinery used at the Project. Emission and noise standards will be based on Nunavut or Canadian regulatory guidelines, or best available technologies.

Best Management Practices

For all Project phases, Baffinland HSE Management Framework requires application of best management practices for environmental protection.

Fuel Supply

Throughout the life of the project, Baffinland will endeavour to secure sources of fuel low in contaminants (low-sulphur fuel).

Scheduled Maintenance Program

Mobile equipment and stationary combustion equipment (generators, boilers, and waste incinerators) will be subjected to a routine maintenance schedule to ensure that emissions are in line with emission criteria and vendor`s specifications on emissions.

Occupational Health and Safety

At all times, workplace conditions will be in compliance with OSHA standards for workplace ambient air quality and noise. When and where necessary, employees will be provided with hearing protection and respiratory masks for work in dusty environments. Health and safety procedures and standards will be strictly enforced throughout the life of the Project.

Waste Segregation for Incinerator Operation

The incineration of plastic can lead to the formation of dioxin and furans. Where practical, plastic will be separated from the waste stream and disposed of at the landfill. The procurement policy for food stuffs will also target avoidance of using plastics for packaging.

Open-air burning will be limited and allowed only once necessary authorizations have been obtained.

Vehicle Traffic

Vehicle traffic at the mine site and the Tote Road to Milne Port is expected to be the major contributor to dust generation. Dust generation will be more pronounced during summer months and is not likely to be an issue during winter or the freshet period. To minimize dust generated by vehicular traffic during the summer, Baffinland will:

- Use granular material for road construction and maintenance
- Limit speed of vehicle on all roads
- Use dust suppressant as required, and,
- The truck fleet used for the transportation of ore from the Mine Site to Milne Port will be equipped with mechanized roll-on tarp covers.

3.2 CONSTRUCTION AND CLOSURE PHASES

For the construction and closure phases, emissions sources include mobile equipment used for construction and the earthwork activities involved in preparing sites for Project infrastructure, roads, borrow pits, and quarry operations.

Activity-specific mitigation measures are outlined in the following management plans:

- Environmental Protection Plan (EPP)
- Borrow Pit and Quarry Management Plan

- Road Management Plan

The potential air quality impacts resulting from construction, operation, and closure activities are as follows:

- SO_2 and NO_2 levels from mobile equipment are expected to be lower than indicator thresholds during construction and closure activities.
- Elevated dust deposition levels are expected in the immediate vicinity of construction. These levels could occasionally exceed indicator thresholds.

3.2.1 Mitigation Measures for Construction and Closure Phases

Best management practices for dust control will be implemented throughout the construction and closure phases. These best management practices include:

- The use of coarse granular material for road construction
- watering roads, as necessary, to reduce visible plumes when it is practical to do so (e.g., when temperatures are above freezing);
- Using other dust suppressants as appropriate;
- Using well-defined haul routes to minimize disturbed surfaces;
- Limiting traffic to essential use over construction areas;
- Limiting speed over construction areas;
- Minimizing drop distances (i.e., using adjustable stackers) for stockpiling activities.

Implementation of these measures will reduce the magnitude and extent of dust deposition.

3.2.1.1 Anticipated Effectiveness of Mitigation Measures

Dust emissions will primarily derive from traffic onsite, the Tote Road, and the railway construction road during summer months. These sources can be readily controlled because of ease of access. Enforcing strict speed limit for vehicles is expected to minimize dust generation from traffic.

3.2.1.2 Effects of Mitigation Failure or Malfunction

Dust-suppression measures are not prone to failure, as such, but to relative degrees of success. All materials from which dust could be generated are non-reactive and low in contained heavy metals, such that there is no chemical risk to the environment. Dusting of vegetation surfaces has the potential to reduce plant growth rates, but most dust from Project activities will fall in close proximity to roads and well within construction site boundaries.

3.2.1.3 Contingencies

Principal contingencies for dust control are increased frequency of water spraying, and selection of a more effective dust suppressant in the case of road dust. The use of snow fences (or equivalent) along road corridors can also be used to limit dust generation from roads, if necessary.

3.2.2 Conclusions for Construction and Closure Phase

Elevated dust concentrations and deposition levels may occur in the immediate vicinity of roads and construction sites. Implementing best management practices for dust control will limit the magnitude and extent of impacts on air quality.

Given the localized nature of air emissions (mostly from mobile and construction equipment), the construction and closure phases are not expected to have significant impacts on air quality.

3.3 OPERATION PHASE

The ERP phase is limited to the production and shipment of 3.5 Mtpa. The ore will be transported over the Tote Road to Milne port by 140 tonnes trucks. Up to 3.5 Mt of ore will be stockpiled at Milne Port and shipped during the open water season.

3.3.1 Mine Site Air Quality

3.3.1.1 Sources of Air Emissions

Activities likely to have an impact on air quality are:

- Mining activity (blasting);
- Mobile engine operation in and around the mine pit, including shovels, drills, loaders, and trucks;
- Mine haul roads;
- Ore crushing;
- Ores stockpiles (lumps and fines) including stackers,
- Loading of trucks for haulage of ore to Milne Port;
- Waste incinerators exhaust.

As with the construction phase, potential air quality impacts resulting from operation activities include the following:

- SO_2 and NO_2 levels from mobile equipment and power generators are expected to be lower than indicator thresholds during the operation phase.
- Elevated dust deposition levels are expected in the immediate vicinity of the mine, crushing, and stockpile areas. These levels could occasionally exceed indicator thresholds. Since the baseline level is even lower than the indicator thresholds (less than 1 g/m^2/year), the predicted dust deposition, although falls within the indicator threshold (55 g/m^2/year), but is above the baseline levels over a distance. An impact zone at a distance of 14 km from the potential mine development was adopted based on data from Ekati.

3.3.1.2 Mitigation Measures for the Mine Site

Mitigation measures incorporated in the design include:

- Exhaust stacks for power generators will be clustered within one to two stack diameters of each other to enhance plume rise, thereby reducing ground-level concentration of air contaminants.

In addition to these design features, the following will be considered:

- Reducing drop distances to the stockpiles;
- Where possible limiting speed on roads;
- Dust suppression (water or other agent) on roads; and,
- Haulage truck will have a roll-on tarp cover to minimize dusting.

3.3.1.3 Expected Ambient Air Contaminant Concentrations for Mine Site

Airborne contaminant dispersion modelling was carried out as part of the EIS (see EIS Volume 5). For air quality modelling, a 3-km zone was used to define the local study area (LSA) and a 1.5-km zone was used for evaluation of model results against appropriate air quality criteria.

Air quality parameter concentrations in excess of their respective thresholds are predicted, though these exceedences are generally confined to the LSAs and are fully reversible. Effects of the Project on air quality are predicted to be not significant.

3.3.2 Tote Road

A total of 20 road haulage trucks will be required to be in operation to deliver 3.5 Mtpa in the 330 operating days per year. These trucks will be fitted with a roll-on tarp cover to minimize potential dust from the ore. No other specific mitigation measures are provided.

3.3.3 Milne Port

3.3.3.1 Source of Air Emissions

Activities likely to have an impact on air quality are:

- Ore stockpile, loaders, and conveyors;
- Power generation station, including a series of generators operating on diesel, with boilers providing emergency backup heat;
- Waste incinerators;
- Shipping loading activities, specifically ship loading; and,
- Tug boat and ship operation around Milne Port.

3.3.3.2 Mitigation Measures

The main mitigation measures that will be used to minimize dust generation are:

- Reduced vehicle speed on roads;
- Minimize drop distance from stackers.

3.3.3.3 Expected Ambient Air Contaminant Concentrations for Milne Port

Airborne contaminant dispersion modelling was carried out as part of the EIS for the ERP (for the larger Project as well - see EIS Volume 5). For air quality modelling, a 3-km zone was used to define the local study area (LSA) and a 1.5-km zone was used for evaluation of model results against appropriate air quality criteria.

Air quality parameter concentrations in excess of their respective thresholds are predicted, though these exceedances are generally confined to the LSAs and are fully reversible. Effects of the Project on air quality are predicted to be not significant.

3.3.4 Aircraft Operation

Although aircraft will be a source of air emissions, dust, and noise, given the intermittent nature of this source and the short aircraft operation times in the Project area, air quality and noise impacts of aircraft use are expected to be minimal. Dust suppressant will be used on the airstrips as required. No other specific air quality or noise mitigation measures are provided for aircraft operation.

3.3.5 Ships Operation

During the open water season, up to sixty (60) Panamax ore carriers will dock at Milne port In addition to ore carrier operation, a total of two (2) tugs will be operating to assist the ships and resupply barges in navigation at the port.

The potential ambient air quality impacts from ship emissions were assessed in the EIS, using CALPUFF air dispersion model. The ship emissions will be infrequent and transient; and as such only short-term (1-hour) ambient concentrations of SO_2, NOx, and NO_2 were analyzed. The emissions at the port are expected to be within applicable threshold standards.

3.4 NOISE

For all phases of the Project, the major sources of noise will be from:

- Mobile equipment and machinery used for construction and facility maintenance;
- Blasting events in quarries and at the mine;
- Trucks used to haul run-of-mine ore and to haul crushed ore to Milne Port;
- Crushing operation;
- Power plant generators.

Noise modeling was carried out as part of the EIS (see EIS Volume 5). For noise modeling, a Local Study Area (LSA) was defined for both the Mine Site and Steensby Port as an area within 3 km of the potential Project development area (PDA). Noise criteria used for the impact assessment followed ERCB Directive 038 guidelines (see Section 5). This established a limit of 40 dBA, 1.5 km from the PDA. For both sites, the predicted modeling results showed that the 40-dBA limit will not be exceeded beyond the LSA.

In terms of the 1.5-km evaluation zone:

- for Mine Site – to the southwest, the limit of 40 dBA is exceeded at the 1.5-km line by approximately 6 dB at the south end of the area; and,
- for Steensby Site - the limit of 40 dBA is exceeded at the 1.5-km line, but only over water to the southwest.

It should be noted that for the Milne Port site, the construction activities at Milne Port is not evaluated due to the infrequent and short duration nature of the events. Any potential noise impacts are to be mitigated by best practices as discussed in Volume 5 of Final EIS. In addition, any impacts during the operation phase will also be short-term, and infrequent, in relation to movements of oversized equipment through Milne Port down the tote road.

3.4.1 Mitigation Measures for Noise

The primary mitigation measure for noise is to ensure that all mobile equipment is equipped with mufflers and that all mobile equipment and machinery are well-maintained.

3.5 GREENHOUSE GAS EMISSIONS REDUCTION PROGRAM

Once the facilities are in operation and a baseline for GHG emission is established, Baffinland will bench-mark its operation against other similar mining operations and implement a Greenhouse Gas Emission Reduction Program.

SECTION 4.0 - ROLES AND RESPONSIBILITIES

Personnel responsible for the Environment Health and Safety (EHS) on the project are divided into three distinct groups, each with their own representatives and responsibilities. Baffinland Iron Mines Corporation's (Baffinland) senior management is ultimately responsible for all policy creation, while the Baffinland onsite management team is responsible for monitoring and reporting to senior management and regulatory bodies. The respective contractors will each have their own EHS personnel to ensure compliance and implementation of their scope of work with regards to EHS.

4.1 ORGANIZATIONAL CHARTS

Figure 4-1 presents the organization structure for both the construction and operation periods.

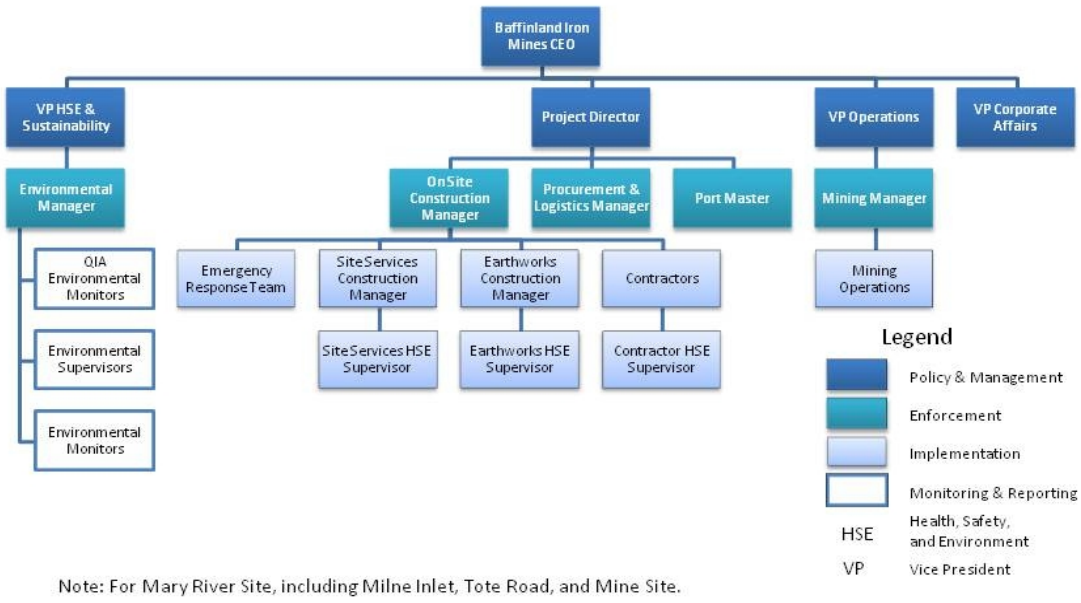

Figure 4-1 Mary River Project Organization Chart

4.2 ENVIRONMENTAL PROJECT TEAM

The roles and responsibilities of the Baffinland personnel and Contractors are described in the tables below.

Table 4-1 Baffinland Iron Mines Corporation Senior Management

Baffinland Iron Mines Corporation Senior Management	
Position	**Responsibilities and Accountabilities**
Project Director	- Reports to Baffinland's CEO - Overall accountability for the Project execution - Allocation of resources (human and financial) for the implementation of Baffinland's commitments and objectives related to health, safety and environment during Construction of the Project - Accountable for on-site environmental, health and safety performance during construction of the Project
VP Operations	- Reports to Baffinland's CEO - Overall accountability for the Operation of the Project once constructed - Allocation of resources (human and financial) for the implementation of Baffinland's commitments and objectives related to health, safety and environment during Operation - Accountable for on-site environmental, health and safety performance during Operation
VP Sustainable Development, Health, Safety and Environment	- Reports to Baffinland's CEO - Establish corporate environmental policies and objectives - Monitors and reports on Baffinland's performance related to environmental, health and safety policies and objectives - Community liaison - Liaise with regulatory authorities - Obtains necessary permits and authorizations - Monitors compliance with terms and conditions of permits and licences - Routine EHS audit of contractor performance while on site
Manager Purchasing and Contract	- Reports to Baffinland's Project Director - Accountable for procurement and purchasing - Ensure that environmental commitments, policies and objectives are included in all contract documents
VP Corporate Affairs	- Reports to Baffinland's CEO - Accountable for external communication (Governments, media, NGO, others) related to Baffinland's press release and overall communication of site incidents/events

Table 4-2 Baffinland Iron Mines Corporation On-Site Management Team

Baffinland Iron Mines Corporation On-Site Management Team	
Construction Manager	- Reports to the Project Director - Responsible for daily on-site management of construction activities - Accountable to the Project director for site environmental, health and safety performance

Baffinland Iron Mines Corporation On-Site Management Team	
	- Organize and provides necessary induction, safety and environmental training for all employees - Ensure that all contractors on-site abide by Baffinland's policies, EHS commitments
Environmental Manager	- Reports to VP EHS & Sustainability - Monitors environmental performance of contractors on site - Monitors compliance with permits, licences and authorizations - Regulatory environmental monitoring and reporting (monthly, annual) - Routine audit of contractor's environmental performance on-site - Initiate/supervise environmental studies - Investigate and reports on accidents and incidents when they occur - Review and update environmental management plans
Environmental Supervisor (s)	- Reports to Environmental Manager - Specific accountabilities for environmental monitoring and reporting - Provides induction and environmental awareness training to new employees and contract workers
Environmental Support Group	- Reports to the Environmental Supervisor - Environmental database management - Various sampling, monitoring and reporting activities as required by permits, licences and environmental management plans - Prepare updates to environmental protection plan and management plans
Environmental Monitors	- Reports to the Environmental Superintendent
QIA Monitors	- Report to Environmental Superintendent - Various monitoring activities on site

Table 4-3 Construction Contractor(s)

Construction Contractor(s)	
Construction Manager	- Reports to the Baffinland's Construction Manager - Accountable for the EHS components of his scope of work - Accountable for implementation of the Construction Environmental Protection Plan - Co-ordination/interaction with Baffinland and Baffinland's Representative Environmental Monitors.
EHS Superviser	- Reports to the Contractor's Construction Environmental Manager - Liaise with Baffinland's Environmental Supervisors and monitors. - Holds daily EHS briefing - Monitors and ensures that Contractor complies with requirements of management plans, terms and conditions of all authorization, licences and permits associated with the Contractor's scope of work - Investigate, reports and follow up on environmental accidents and incident

Construction Contractor(s)	
	- Provides site specific environmental monitoring - Daily supervision of construction activities for environmental performance - Attendance at all environmental meetings/Project meetings (as required). - Routine interaction with construction crews to ensure all construction activities are in compliance with requirements of the CEPP and Contractors Environmental Method Statements. Monitor the environmental permitting status of the Project to ensure that no work proceeds until appropriate and complete permitting is received for the applicable facility.

4.3 TRAINING AND AWARENESS

Staff and subcontractors working onsite will receive environmental training as part of the Site Orientation, to achieve a basic level of environmental awareness understanding of their obligations regarding compliance with regulatory requirements, commitments and best practices.

The Environmental and Safety Leads and contractor supervisors will be provided with this Air Quality and Noise Abatement Management Plan, and will receive additional orientation with respect to the requirements outlined in this Plan. In addition, all supervising level staff and subcontractors will be provided with the Operational Standards (the EPP) as a written guidance for their work.

Targeted environmental awareness training will be provided to both individuals and groups of workers assuming a specific authority or responsibility for environmental management or those undertaking an activity with an elevated high risk of environmental impact. These will be delivered in the form of toolbox/tailgate meetings or other means as appropriate.

Content of the environmental component of the site induction will include, at a minimum:

- Location of environmental sensitivities;
- Location of additional information on environmental matters;
- Due diligence responsibilities;
- Responsibilities related to waste management, minimizing noise as necessary, road traffic rules;
- Principles and necessary steps to avoid encounters with bears or other wildlife and what to do if one such encounter occurs.

With respect to this Air Quality and Noise Abatement Management Plan, Baffinland intends to contract out its air monitoring and noise survey programs. A well-defined scope of work will be developed that will identify:

- Specific locations for sampling;
- Duration of the sampling campaign;
- Analysis required;
- Reporting format and requirement.

A call for tender will be sent to competent contractors, requesting the following:

- Qualification and expertise of the contractor
- Experience in northern climate

- Details of QA/QC for sampling and analysis
- Client references.

4.4 COMMUNICATION

Types of communications for which members of the team will participate include:

- formal written correspondence and meetings with stakeholders
- site visits by community representatives
- design, construction, and planning meetings
- field inspections and monitoring reports disseminated by the Environmental Lead
- electronic communication
- tailgate/toolbox meetings
- formal written correspondence and meetings with government regulatory bodies
- formal environmental awareness training.

Communication will be appropriately recorded and filed for future reference. Where appropriate, copies of communication will be forwarded to the HSE Lead and Vice President Sustainability.

4.5 EXTERNAL COMMUNICATIONS

Effective forms of communication include the proactive notification to external stakeholders of Project activity. Project activity updates will be provided to the communities of North Baffin through various means, including regular meetings, public notices, and radio announcements as appropriate.

Baffinland will endeavour to maintain Community Liaison Offices to assist in this regard. Information on air quality and noise monitoring will be integral to this external communication effort.

SECTION 5.0 - PERFORMANCE INDICATORS AND THRESHOLDS

5.1 AIR QUALITY

Regulatory agencies have identified ambient air quality criteria for the identified indicator contaminants, specifying maximum concentration levels in the atmosphere. In general, these criteria are based on the lowest-observed-level-of-effect and incorporate a safety factor. For this assessment, these criteria were used to define thresholds for the indicator contaminants that, if exceeded, would be considered to be of potential concern.

There are ambient air quality guidelines for Nunavut for TSP and SO_2 (Department of Sustainable Development, 2002). National Air Quality Objectives, CWS, and criteria from other Canadian jurisdictions were selected as the thresholds for the remaining contaminants.

The national objectives are divided into three categories, described as follows (Health Canada, 2005):

- "Maximum desirable level is the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country, and for continuing development of control technology."
- "Maximum acceptable level is intended to provide adequate protection against effects on soil, water, vegetation, materials, visibility, personal comfort, and well-being."
- "Maximum tolerable level denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public."

Table 5.1 presents a comparison of federal objectives, NWT criteria, Nunavut guidelines, and CWS. The criteria refer to different averaging periods to account for potential short-term acute exposures and long-term chronic exposures. Based on the precautionary principle, the most stringent criteria were selected as the threshold for each contaminant indicator.

Table 5-1 Performance Indicators and Thresholds for Air Quality

Contaminant	Averaging Time	Federal Air Quality Objectives			Canada Wide Standard	Nunavut	NWT	Indicator Threshold
		Desirable	Acceptable	Tolerable				
TSP ($\mu g/m^3$)	24 hr	-	120	400	-	120	120	120
	Annual	60	70	-	-	60	60	60
PM_{10} ($\mu g/m^3$)	24 hr	-	-	-	-	-	50*	50
$PM_{2.5}$ ($\mu g/m^3$)	24 hr	-	-	-	30**	-	30	30
SO_2 ($\mu g/m^3$)	1 hr	450	900	-	-	450	450	450
	24 hr	150	300	800	-	150	150	150
	Annual	30	60	-	-	30	30	30
NO_2 ($\mu g/m^3$)	1 hr	-	400	1,000	-	-	-	400
	24 hr	-	200	300	-	-	-	200
	Annual	60	100	-	-	-	-	60
CO ($\mu g/m^3$)	1 hr	15,000	35,000	-	-	-	-	15,000
	8 hr	6,000	15,000	20,000	-	-	-	6,000
O_3 ($\mu g/m^3$)	1 hr	100	160	300	-	-	-	-
	8 hr	-	-	-	127***	-	127	-
	24 hr	30	50	-	-	-	-	-
	Annual	-	30	-	-	-	-	-

*Ontario Interim Ambient Air Quality Criterion (AAQC). Ontario Ministry of the Environment, September 2001.
** Annual 98th percentile 24-hour concentration, averaged over 3 years.
*** Annual 4th highest 8-hour concentration, averaged over 3 years.

Table 5-2 presents dust-deposition criteria for Alberta and Ontario. These criteria appear to be based on nuisance considerations. The Ontario values have been recalculated to the same units as the Alberta criteria. All dust deposition criteria were used to assess the project.

Table 5-2 Dust Deposition Criteria

Average Time	Alberta Residential and Recreational Areas	Alberta Commercial and Industrial Areas	Ontario Ambient Air Quality Criteria	Indicator Threshold
1 month	53 mg/100cm^2/ 30 day	158 mg/100cm^2/30 day	70 mg/100cm^2/30 day	15.8mg/100cm^2/30day
	5.3 g/m^2/30 day	15.8 g/m^2/30 day	7 g/m^2/30 day	5.3 g/m^2/30 day
Annual	-	-	4.6 g/m^2/30 day	55 g/m^2/year
	-	-	55 g/m^2/year	

5.2 NOISE METRICS

Environmental sound levels vary continuously over time. To account for both daily and short-term variations in sound levels, several single numerical descriptors have been developed based on large-scale psycho-acoustic studies of annoyance with environmental noise. These allow sound monitoring to be conducted for a constantly varying sound environment over extended periods, with the results described as a single number that accurately describes the environment.

The single number descriptor commonly used in most international standards for environmental sound measurements is the energy equivalent sound level (L_{eq}). The L_{eq} value, expressed in dBA, is the energy-averaged, A-weighted sound level for the complete measurement interval.

It is the steady, continuous sound level over a given period that has the same acoustic energy as the actual varying sound level over a given period that has the same acoustic energy as the actual varying sound levels occurring over the same period in the measured environment. It is one of the most common and useful predictors of human response to noise, and, is also the noise descriptor used to establish environmental noise criteria. The A-weighting accounts for the frequency content of measured sound based on a frequency response similar to that heard by the human ear.

The noise descriptors specific to this Air Quality and Noise Abatement Management Plan are:

- 24-h A-weighted energy equivalent sound level Leq(24), referred to as daily sound level
- 15-h A-weighted energy equivalent sound level LeqDay or Leq(15), referred to as daytime sound level
- 9-h A-weighted energy equivalent sound level LeqNight or Leq(9), referred to as nighttime sound level
- 1-h A-weighted energy equivalent sound level Leq (1), referred to as hourly sound level.

5.2.1 Noise Guidelines

There are no regulations or guidelines in Nunavut that address environmental noise levels. However, noise has been addressed in recent EIS developed for other mining projects in Nunavut (i.e., Meadowbank Gold Project, Doris North Gold Project, High Lake Project). These projects and other projects in the NWT have adopted ERCB Directive 038 Guidelines (ERCB, 2007) as indicative of what is generally considered acceptable with respect to noise levels from industrial activities in remote areas. Directive D038 guidelines have been adopted for the Mary River Project. For an overview of Directive 038, see Table 5. 3 Energy Resources Conservation Board Directive 038 Guideline.

5.2.2 Noise Limit at Fenceline for Mine Site and Steensby Port

The fenceline is not defined for facilities such as those at the Baffinland sites, where there is no fence or

other fixed facility boundary. For this management plan, the mine area surface lease boundary was used as a proxy for the fenceline. Thus the PSL for these facilities is 40 dBA 1.5 km from the mine lease boundary.

5.2.3 Noise Limit at Milne Port

The seasonal hunt camp located at Milne Inlet site has been considered a dwelling with respect to Directive D038. The PSL for this camp is 40 dBA 1.5 km from the exploration license boundary in all other directions (away from the hunt camp).

5.2.4 Noise Limit for Work Camps

Work camps such as those associated with the Project are specifically excluded from the requirements of Directive D038. These dwellings were considered, however, as it is important for worker health to maintain an adequate sleep environment. Interior noise can be characterized using balance noise criteria (NCB) curves. For sleeping areas in larger complexes, NCB ratings of NCB 28 to NCB 33 are generally accepted. A NCB rating of 33 has been adopted for the Project.

Table 5-3 Energy Resources Conservation Board Directive 038 Guideline

General Format of Directive D038	Directive D038 sets out permissible sound levels (PSLs), which must be met at all dwellings surrounding the Project development. These limits apply to operational noise only. The cumulative sound level from all energy-related (in this case Baffinland-related) development in the area is measured or predicted. This is called the comprehensive sound level (CSL) and is compared against the PSL. The CSL includes background ambient sound levels. The base PSL value is 40 dBA, which is based on a typical rural or remote ambient sound level (ASL) of 35 dBA, plus 5 dBA allowance for the industrial activity (Alberta Environment research showed that in general, people tolerate sound from energy facilities of up to 5 dBA above the ambient sound environment). The PSL can be increased to account for the presence of other industrial or transportation noise sources, such as road and rail traffic, and for the population density of developed areas. In remote pristine areas, an ASL adjustment, based on measured existing sound levels, can be applied, which might reduce PSL at these locations. For areas where there are no dwellings, a sound level limit of 40 dBA 1.5 km from the facility fence is applied.
Dwellings	A dwelling is defined in Directive D038 as a permanently or seasonally occupied residence, including trailer parks and campgrounds in regular consistent use. For assessment, the only dwelling near Baffinland-related activities is a seasonally occupied hunt camp at Milne Inlet. Worker residences, dormitories, and construction camps are specifically excluded as dwellings under Directive D038.
Noise Limit for Remote Area	Where no noise-sensitive receptors are located within 1.5 km of the facility, the CSL from the facility (facility noise plus ambient) must meet a PSL of 40 dBA Leq (night) measured at 1.5 km from the facility fenceline.

If required, mitigation measures such as the following can be adopted:

- berms or barriers near dwellings
- upgraded windows and mandatory air conditioning.

5.2.5 Roads

Noise from these sources will be intermittent, occurring only when vehicles or locomotives pass by. They will be remote from all human receptors.

5.2.6 Air Traffic

Directive D038 provides no guidance on noise from air traffic sources. Aircraft are subject to federal regulations for noise emissions. Noise from aircraft will be intermittent, occurring when aircraft fly by. They will be remote from all human receptors. In addition, where possible, the aircraft is advised to maintain a minimum flying altitude of 2,000 feet when in the air space over the park; except for approach to land, take-off, or for safety reasons.

5.2.7 Construction

Directive D038 noise guideline limits do not apply to construction activities. Instead, good management practices are required to reduce potential noise impacts.

5.3 VIBRATION METRICS

Vibration impacts can be broken down into two zones: terrestrial (above ground, on land) and underwater.

5.3.1 Terrestrial

Human perception of ground-borne vibration can be ranked as follows (Bender, 1996):

- barely to distinctly perceptible - 0.5 to 2.5 mm/s ppv
- distinctly to strongly perceptible - 2.5 to 6.25 mm/s ppv
- strongly perceptible to mildly unpleasant – 6.25 to 25.4 mm/s ppv
- increased potential for structural damage - 12.5 to 25.4 mm/s ppv.

The potential for structural damage increases for airborne vibration overpressure in excess of 120 dB (MOE, 1997).

5.3.2 Underwater

Fisheries and Oceans Canada (DFO) has produced *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* to protect marine wildlife, including fish and marine mammals from underwater vibrations (DFO, 1998).

Highlights of the guideline include the following:

- No explosive is to be knowingly detonated within 500 m of any marine mammal (or no visual contact from an observer using 7 x 35 power binocular).
- No explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e., overpressure) greater than 100 kPa in the swim bladder of a fish.
- No explosive is to be detonated that produces, or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation.

The guideline also presents tables of weight of explosive change versus distance and other estimation methods are provided to determine the potential impacts.

This guideline is relevant mostly for the construction phase of the Project (construction of docking facilities, creek/river crossings).

SECTION 6.0 MONITORING

6.1 METEOROLOGY

Three meteorological stations have been established, at the mine site, Steensby Port, and Milne Port locations. The stations record air temperature, relative humidity, precipitation, wind direction, and wind speed. Data collected from the meteorological stations are establishing a climatic record in key project areas. Details of the auto-stations are presented in Attachment 4 of this Management Plan.

During 2009, each station was retrofitted with new research technology being tested to determine its ability to transfer data remotely in real time.

Tide gauges will also be installed after project approval at Steensby Port and Milne Port to monitor relative sea level and storm (Refer to Attachment 2 – Project Certificate commitments).

6.2 AIR QUALITY MONITORING

Potential sources of project-related effects on air quality include exhaust emissions from vehicles, mining activities, aircraft, generators and other equipment, emissions from camp incinerators, and fugitive dust emissions from road traffic during snow-free periods.

Daily inspection of facilities will ensure strict compliance with this Air Quality and Noise Abatement Management Plan. The EPP outlines detailed procedures for dust-suppression techniques. Training/instruction will be provided to all employees and contractors as required on the use of dust suppressant.

Scheduled maintenance on mobile equipment and stationary equipment will ensure that emissions are in line with vendors` specifications and emission criteria.

6.2.1 Ambient Air Quality Monitoring

Passive and active air quality monitoring will be conducted. Active monitoring will involve measuring TSP in areas of activity at the mine site and Milne Port, as per Terms and Condition #8 (Attachment 2). Passive sampling will include collecting SO_2, NO_2, O_3, and dustfall samples simultaneously. During both construction and operation, the monitoring program will focus on TSP and dust deposition.

Air quality data will be collected via active (TSP) and passive sampling methods (SO_2, NO_2, O_3, and dustfall, including metal deposition). Snow-core sampling will be used to determine dustfall at specified locations. The sampling locations and frequency will be established before the onset of construction and will be revised/updated before start of operation. Tables 6.1 and 6.2 present an overview of the indicators and corrective action to be taken should thresholds be exceeded.

Table 6-1 Air Quality Performance Indicators and Thresholds

Location	Frequency	Indicator	Threshold	Corrective Action
Mine site	Number of sampling locations and frequency to be determined.	SO_2 NO_2 $PM_{2.5}$ TSP	Refer to Table 5.1	Review mitigation measures in place. Review specification on equipment. Review maintenance schedule for combustion equipment.
Milne Port	Number of sampling locations and frequency to be determined.	SO_2 NO_2 $PM_{2.5}$ TSP	Refer to Table 5.1	Review mitigation measures in place. Review specification on equipment. Review maintenance schedule for combustion equipment.

Table 6-2 Dustfall Performance Indicators and Thresholds

Location	Frequency	Indicator	Threshold	Corrective Action
Mine Site		Dustfall	4.6 g/m2/yr	Use dust suppressant. Review mitigation measures in place. Review specification on equipment. Review maintenance schedule for combustion equipment.
Tote Road		Dust fall	4.6 g/m2/yr	Construction of road bed (coarse material) Use of dust suppressant Speed limit for vehicles Ore trucks equipped with roll-on tarp covers
Milne Port		Dustfall	4.6 g/m2/yr	Use dust suppressant. Review mitigation measures in place. Review specification on equipment. Review maintenance schedule for combustion equipment.

6.2.2 Incinerator Emission Testing

Non-hazardous combustible camp waste is disposed of in camp incinerators. Incinerated waste is generally generated from the kitchen and personnel accommodations.

Camp incinerators are installed at each of the camps associated with the mine site, Milne Port (only during construction), and Steensby Port, and each rail camp. Each of these incinerators uses dual-chamber, variable-airflow design technology and is specifically designed for remote camp operations.

These incinerators are capable of meeting the Canadian Council of Ministers of the Environment (CCME), CWS for mercury emissions, and the CCME-CWS for dioxins and furans. The waste incinerators are operated as required. Standard operating procedures have been developed in accordance with manufacturers' recommendations and operators receive training by experienced supervisory personnel. Incinerator ash generated is stored onsite in 200-L drums for future disposal in the onsite landfill.

6.2.3 Expanded regional Study

As per Term and Condition # 7, once the rail project becomes operational, similar land-based monitoring stations will be installed along Foxe Basin and along Hudson Strait.

The purpose of these land-based stations is to provide an expanded study area to capture emissions related to shipping traffic.

6.3 NOISE

The purpose of the monitoring program is to assess the magnitude of noise impacts from Project activities. The main activities expected to cause noise impacts included the mine site camp operations (including vehicles, generators, incinerators), aircraft activities, mining, crushing, and transportation activities related to ore, overburden, and waste rock.

Field activities will be conducted in accordance with the EPP to minimize potential effects on people and wildlife. More specifically, equipment will be operated with modern mufflers, and subjected to regular maintenance. In remote areas, drilling and other site activities will be guided by the presence and response of wildlife.

Table 6.3 presents performance indicators, thresholds, and corresponding corrective action. The site management will also need to ensure certification of noise compliance is current, where applicable.

Table 6-3 Noise Performance Indicators and Thresholds

Location	Frequency	Indicator	Threshold	Corrective Action
Mary River	To be determined	Noise level at fenceline.	40 dBA	Review mitigation measures in place.
Steensby Inlet	To be determined	Noise level at fenceline.	40 dBA	Review mitigation measures in place.

SECTION 7.0 - REPORTING REQUIREMENTS

7.1 REPORTING

Information collected on air quality and noise via the monitoring programs described in Section 6 will be reported annually to the NIRB as per the Terms and Conditions of the Project Certificate.

Specifically, reporting will address:

7.1.1 Air quality

- Report on incinerator testing (as per requirements of Attachment 2 – T&C # 11 and 12)
- Results of passive air quality measurements at the Mine Site and Milne Port (attachment 2, commitment # 61);
- Results of dust deposition monitoring at the Mine Site, along Tote Road, and, Milne Port (Attachment 2, commitment #60).
- Report on land-based monitoring stations.
- Report on exceedances to FEIS predicted air quality predictions.

In accordance with T&C # 8 (Attachment 2), in cases where exceedances are manifested, Baffinland will provide an explanation for the exceedance, a description of planned mitigation, and shall conduct additional monitoring to evaluate the effectiveness of mitigative measures.

7.1.2 Noise

- Report on noise monitoring at camp sites (Attachment 2, T&C #14)

7.1.3 Greenhouse Gas and Climate Change

- Quantity of fuel consumed during the year;
- Submit reports on studies or revised assessment done to validate and update climate change impact predictions (Attachment 2, T&C # 2);
- Calculation of greenhouse gas emissions for the site (Attachment 2, T&C # 9);
- Provide interested parties with evidence of continued initiatives undertaken to reduce greenhouse gas emissions (Attachment 2 - T&C # 3);
- And estimate of marine shipping vessels emissions (refer to Attachment 2, commitment #62)
- Report on efforts made with shipping partners to reduce fuel consumption (refer to Attachment 2, commitment #63)

7.1.4 Meteorological Data

In accordance with Project Certificate Terms and Conditions and other Baffinland commitments (refer to Attachment 2), the following information will also be made available to regulatory agencies (Environment Canada, NRCan, others):

- Tidal information at Port sites (Attachment 2, T&C #1).
- Weather related information (Attachment 2, T&C #5, commitments #58 and 59).

7.2 DOCUMENTATION AND DATA CONTROL

Baffinland's Environmental Lead will coordinate preparation, review, and distribution, as appropriate, of the data and reports required for regulatory purposes.

Execution of some of the monitoring programs detailed in the Air Quality and Noise Abatement Management Plan will be conducted by, or supported by consultants and contractors to Baffinland. Data and reports will be prepared and delivered to Baffinland by its consultants for internal and external distribution and use, as appropriate.

All formalized documents and reports will follow data-control procedures, with revision numbers and revision tracking. Documents and data that are to be issued and liable to change will be controlled to ensure they are approved before issue and that the current issue or revision is known to and available to those requiring them.

7.3 INTERNAL AND EXTERNAL REPORTING

Implementation of monitoring under the Air Quality and Noise Abatement Management Plan results in collection of data and generation of various reports. Whereas there are regulatory requirements for formal monthly and annual reports, including disclosure of issues of non-conformance, internal reporting is used to provide direction to personnel and to provide operational updates to site and corporate management. Internal reporting mechanisms might include weekly environment reports, weekly operations reports, and routine inspection reports. Site-based toolbox and management meetings are also an important internal reporting tool commonly used.

Parks Canada has requested to be provided with regular flight and shipping schedules that can be used to brief visitors to the park. Any changes to the regular schedule that is substantially different will need to be notified to the Parks Canada so that appropriate mitigations can be explored.

7.4 WEB PORTAL FOR STAKEHOLDER ACCESS TO MONITORING INFORMATION

With respect to communicating non confidential monitoring information and or reports (General Term and Condition # 12), Baffinland is in the process of developing a web portal to house this information for access by the general public. The development of the web portal will be on going as monitoring efforts commence and mature over time.

SECTION 8.0 - QA/QC

As per the requirements of Baffinland's EHS Framework (SD-STE-001), regular audits will be undertaken to ensure compliance with the current Air Quality and Noise Abatement Management Plan and that best management practices are implemented. The result of this audit will form the basis for an annual written statement of assurance by management on effectiveness of the Air Quality and Noise Abatement Management Plan.

In terms of the physical sampling, maintenance of sampling station, and analytical services performed by the subcontractor, Baffinland's procurement procedures for these services will ensure that the contractor retained to execute the work has the necessary accreditation, calibration and QA/QC procedures in place.

SECTION 9.0 - ADAPTIVE STRATEGIES

Baffinland is committed to continuous improvement in its work activities in the aim of reducing risks to the environment and improving operational effectiveness. The strategy employed at Baffinland is regular monitoring supported by operational change and adoption of other mitigating measures if warranted.

As per the requirements of Baffinland's HSE Management Framework (SD-STD-001), the company will conduct and document management reviews of its Air Quality and Noise Abatement Management Plan on a regular basis. Such reviews will ensure the integration of monitoring results for the waste management plan are integrated with other aspects of the Project and that necessary adjustments are implemented as required. These reviews also provide a formal mechanism to assess the effectiveness of the management in achieving the company's objectives and maintaining ongoing compliance with Project permits and authorizations.

SECTION 10.0 - REFERENCES

1. Alberta Energy and Utilities Board. 2007. ***Directive 038: Noise Control***, revised February 16, 2007, www.eub.ca.
2. Baffinland, EIS Volume 5, Atmospheric Environment, December 2010
3. Bender, W.L. 1996. ***Report on Estimated Airblast and Blas-Related Vibration at the Lincoln Project, Placer County, California***.
4. Department of Fishers and Oceans. 1998. Guidelines ***for the Use of Explosives In or Near Canadian Fisheries Waters***, Minister of Public Works and Government Services Canada.
5. Government of Nunavut. 2002. ***Environmental Guideline for Dust Suppression***. Department of Sustainable Development, Environmental Protection Service.
6. Government of Nunavut. 2003. ***Nunavut Climate Change Strategy***. October, 2003.
7. Government of Nunavut. Undated. ***Greenhouse Gas Emissions Brochure***, includes Table 1: Annual GHG Emissions from Nunavut Communities (kt CO2e).
8. Environment Canada. 2010a. ***Canada's Greenhouse Gas Inventory***. Available at: http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1. Last updated June 30, 2010.
9. Environment Canada. 2010b. ***National Ambient Air Quality Objectives***.
10. Government of the Northwest Territories. 2002. ***Guideline for Ambient Air Quality Standards in the Northwest Territories***. Dept. of Resources, Wildlife and Economic Development, Environmental Protection Service.
11. Ontario Ministry of Environment. 2008. ***Ontario's Ambient Air Quality Criteria***. Standards and Development Branch. February 2008.

Attachment 1: Sustainable Development Policy

SUSTAINABLE DEVELOPMENT POLICY

At Baffinland Iron Mines Corporation, we are committed to conducting all aspects of our business in accordance with the principles of sustainable corporate responsibility and always with the needs of future generations in mind. Everything we do is underpinned by our responsibility to protect the environment, to operate safely and fiscally responsibly and to create authentic relationships. We expect each and every employee, contractor, and visitor to demonstrate a personal commitment to this policy through their actions. We will communicate the Sustainable Corporate Policy to the public, all employees and contractors and it will be reviewed and revised as necessary on an annual basis.
These four pillars form the foundation of our corporate responsibility strategy:

1. Health and Safety
2. Environment
3. Investing in our Communities and People
4. Transparent Governance

1.0 HEALTH AND SAFETY

- We strive to achieve the safest workplace for our employees and contractors; free from occupational injury and illness from the very earliest of planning stages. Why? Because our people are our greatest asset. Nothing is as important as their health and safety.
- We report, manage and learn from injuries, illnesses and high potential incidents to foster a workplace culture focused on safety and the prevention of incidents.
- We foster and maintain a positive culture of shared responsibility based on participation, behaviour and awareness. We allow our workers and contractors the right to stop any work if and when they see something that is not safe.

2.0 ENVIRONMENT

- We employ a balance of the best scientific and traditional Inuit knowledge to safeguard the environment.
- We apply the principles of pollution prevention and continuous improvement to minimize ecosystem impacts, and facilitate biodiversity conservation.
- We continuously seek to use energy, raw materials and natural resources more efficiently and effectively. We strive to develop pioneering new processes and more sustainable practices.
- We understand the importance of closure planning. We ensure that an effective closure strategy is in place at all stages of project development and that progressive reclamation is undertaken as early as possible to reduce potential long-term environmental and community impacts.

3.0 INVESTING IN OUR COMMUNITIES AND PEOPLE

- We respect human rights and the dignity of others. We honour and respect the unique culture, values and traditions of the Inuit people.
- We contribute to the social, cultural and economic development of sustainable communities adjacent to our operations.
- We honour our commitments by being sensitive to local needs and priorities through engagement with local communities, governments, employees and the public. We work in active partnership to create a shared understanding of relevant social, economic and environmental issues, and take their views into consideration when making decisions.

4.0 TRANSPARENT GOVERNANCE

- We will take steps to understand, evaluate and manage risks on a continuing basis, including those that impact the environment, employees, contractors, local communities, customers and shareholders.
- We ensure that adequate resources are available and that systems are in place to implement risk-based management systems, including defined standards and objectives for continuous improvement.
- We measure and review performance with respect to our environmental, safety, health, socio-economic commitments and set annual targets and objectives.
- We conduct all activities in compliance with the highest applicable legal requirements and internal standards
- We strive to employ our shareholder's capital effectively and efficiently. We demonstrate honesty and integrity by applying the highest standards of ethical conduct.

Tom Paddon
President and Chief Executive Officer
September 2011

Attachment 2: Project Certificate Terms and Conditions

General Term and Conditions

No.	Term and Condition	Comments
G & T # 12	The proponent shall establish a Project-specific web portal or web page as a means of making all non-confidential monitoring and reporting associated with the Project available to the general public. This does not limit what the Proponent may be required to submit to the NIRB or other regulatory authorities to meet reporting requirements.	Refer to Section 7.4.

Meteorology and Climate (including Climate Change)

No.	Term and Condition	Comments
1	The Proponent shall use GPS monitoring or a similar means of monitoring at both port sites and will also use tide gauges at the Steensby Port site to monitor the relative sea levels and storm surges at these sites.	A tide gauge will be installed at Milne Port. Refer to section 7 for reporting.
2	The Proponent shall provide the results of any new or revised assessments and studies done to validate and update climate change impact predictions for the Project and the effects of the Project on climate change in the Local Study Area and Regional Study Area as defined in the Proponent's Final Environmental Impact Statement.	Refer to section 2.3. This will be done in the annual report.
3	The Proponent shall provide interested parties with evidence of continued initiatives undertaken to reduce greenhouse gas emissions.	Refer to Section 7 - Reporting
4	The Proponent shall endeavour to include the participation of Inuit from affected communities and other communities in Nunavut when undertaking climate-change related studies and research.	Ongoing
5	The Proponent shall endeavour to explore and implement reasonable measures to ensure that weather-related information for the various Project sites is readily accessable to the public on a continual basis throughout the life of the Project	Refer to Section 7 - Reporting

Air Quality

No.	Term and Condition	Comments
6	The Proponent shall provide the results of any emissions calculations conducted to determine the level of sulphur dioxide (SO_2) emissions, nitrogen oxide (NO_X) emissions and greenhouse gases generated by the Project using fuel consumption or other relevant criteria as a basis.	Refer to Section 7.

7	The Proponent shall update its Air Quality and Noise Abatement Management Plan to include an expanded regional study area and provide for land-based monitoring stations designed to capture operations phase ship-generated SO_2 and NO_2 emissions through Foxe Basin and along the Hudson Strait.	Refer to section 6 for monitoring and Section 7 for Reporting
8	The Proponent shall demonstrate through monitoring of air quality at the mine site and at the Steensby Inlet Port site that SO_2 and NO_2 emissions remain within predicted levels and, where applicable, within limits established by all applicable guidelines and regulations. In cases where exceedances are manifested, the Proponent shall provide an explanation for the exceedance, a description of planned mitigation, and shall conduct additional monitoring to evaluate the effectiveness of mitigative measures.	Refer to Section 7 for reporting.
9	The Proponent shall provide calculations of greenhouse gas emissions generated by activities at the Steensby Inlet port and other Project sources including aircraft associated with the Project. Calculations shall take into consideration, fuel consumption as measured by Baffinland's purchase and use as well as the fuel use of its contractors and sub-contractors.	Refer to Section 7.
10	The Proponent shall update its Dust Management and Monitoring Plan to address and/or include the following additional items: a) Outline the specific plans for monitoring dust along the first few kilometres of the rail corridor leaving the Mary River mine site. b) Identify the specific adaptive management measures to be considered should monitoring indicate that dust deposition from trains transporting along the rail route is greater than initially predicted.	Section 3 presents mitigation measures Section 6 presents monitoring Section 7 presents reporting
11	The Proponent shall develop and implement an Incineration Management Plan that takes into consideration the recommendations provided in Environment Canada's Technical Document for Batch Waste Incineration (2010).	Refer to Section 6
12	Prior to commencing any incineration of on-site Project wastes, the Proponent shall conduct at least one stack test immediately following the commissioning of each temporary and permanent incinerator.	Refer to section 6

Noise and Vibration

13	The Proponent is encouraged to work with Fisheries and Oceans Canada at the regulatory phase and to take a precautionary approach when selecting the overpressure threshold to be applied to explosives use for the protection of fish and aquatic life.	Refer to the Blasting Management Plan (Type A Water Licence). This plan was developed in consultation with the DFO.
14	The Proponent shall conduct noise and vibration monitoring at Project accommodations sites located at the Mary River mine site, Steensby Inlet Port site, and Milne Inlet Port site. Sampling shall be undertaken during the summer and winter months during all phases	Refer to Section 7 for reporting.

	of Project development.	
15	The Proponent shall collaborate to the extent possible with the Qikiqtani Inuit Association and local Hamlet organizations when undertaking consultation with all affected communities regarding railway operations. During these consultations, it is recommended that the Proponent provide information including video, audio, and photographic representation as well as any other aids (i.e. models) that may enhance the general public's understanding of railway operations, as well as all safety considerations for members of the public who may be travelling around the project area.	The railway is not part of the ERP phase.

Appendix A to NIRB Project Certificate (No: 005) Report

No.	Subject	Commitment	Action
2	Design (Fugitive Dust)	Baffinland is committed to developing and implementing mitigation measures which control fugitive dust emissions.	Refer to section 3 of this Management Plan
3	Operations (Ore Processing and Tailings)	Baffinland will undertake only the physical crushing and screening processing of the ore generated from the Mary River Project within the project area.	Crushing and screening is limited to the Mine Site.
18	Railway (Locomotives)	Baffinland is committed to purchasing the highest tier (per the USA's EPA standards) of locomotive available for use at the Mary River project.	Deferred until approved Project gets under way
32	Marine (Noise)	Baffinland is committed to providing the QIA with a copy of the frequency-noise distribution graph for sound generated by ore ship propellers travelling through ice.	Addressed in Shipping and Marine Mammals Management Plan
40	Monitoring (Abandonment and Restoration)	Baffinland is committed to undertaking environmental effects monitoring during the mine life mine as well as after closure.	Addressed in Abandonment and Reclamation Plan
57	Management Plans	Baffinland is committed to updating its management plans to reflect new information, new practices and changes to operating conditions.	Refer to page 1 for date of update. Refer to Section 9 for commitment to adaptive strategies
58	Meteorology and Climate (Reporting)	Baffinland is committed to contributing to regional monitoring and information gathering.	Refer to Section 7 - Reporting
59	Meteorology and Climate (Reporting)	Baffinland is committed to giving consideration to the sharing of weather data collected for the Mary River Project with Environment Canada to post on its public weather network.	Refer to Section 7 - Reporting
60	Air Quality (Fugitive Dust from Railway Shipping)	Baffinland is committed to monitoring fugitive dust emissions on vegetation along the first few kilometres of the	Refer to Section 6 of this Plan – this commitment is applied to dust monitoring along the

		Railway leaving both terminals (Mary River and Steensby Inlet). This monitoring will be extended if it is identified that other areas of the project site are also being impacted by fugitive dust emissions.	Tote Road.
61	Air Quality (SO2 Emissions)	Baffinland is committed to conducting passive monitoring of SO2 at the Steensby Inlet camp.	Refer to Section 6 of this Plan – this commitment is applied to passive monitoring at Milne Camp.
62	Project Design (Marine Shipping Air Emissions)	Baffinland is committed to estimating marine shipping vessel emissions associated with the Mary River Project.	Refer to Section 7 for reporting
63	Project Design (Greenhouse Gas)	Baffinland and its shipping partners are committed to working with shipyards to reduce fuel consumption by 20% or more.	Refer to Section 7 for reporting
66	Monitoring	Baffinland is committed to the development and implementation of a monitoring program during the construction and other phases of the Mary River Project.	This management plan addressed the air quality and noise components.

Attachment 3: Baseline Project Conditions

Table 2-1 Measured Contaminant Baseline Concentrations for the Mary River Project

Parameter	Baseline Concentration ($\mu g/m^3$)
24-hour TSP	7.0
24-hour PM_{10}	3.8
30-day SO_2	0.262
30-day NO_2	0.188
30-day O_3	52.8

Table 2-2 Baseline Dustfall Deposition Rates

Parameter	Baseline Deposition Rate ($mg/100cm^2$/30 days)
Total Dustfall	0.398

Table 2-3 Baseline Metal Deposition Rates for Selected Metals

Parameter	Baseline Deposition Rate ($\mu g/100cm^2$/30 days)
Al	26.9
Co	0.5
Cr	0.3
Fe	30.6
Mg	23.9
Mn	1.7

Data obtained from the 2007 sampling program were compared with federal and other provincial air quality criteria (see Section 1.2) and with data from other air quality monitoring stations in the Canadian Arctic. Results are shown in Table 2.4 Baseline Ambient Air Quality Monitoring Results, and indicate that concentrations of both TSP and PM10 were well below applicable indicator thresholds.

Table 2-4 Baseline Ambient Air Quality Monitoring Results

Air Quality Parameter	24-h Indicator Threshold	Mary River Sampling Locations			
		1A	1B	2A	2B
Maximum TSP ($\mu g/m^3$)[1]	120	3.5	3.0	**7.0**	5.5
Maximum 24-h PM_{10}, ($\mu g/m^3$)[2]	50	3.0	1.5	1.8	**3.8**
Total dustfall deposition rate (30-day average) ($\mu g/100cm^2$/30d) [3]					
SO_2 (30-day average) ($\mu g/m^3$)[3]	450 (1-h) 150 (24-h) 30 (annual)				
NO_2 (30-day average) ($\mu g/m^3$)[3]	400 (1-h) 200 (24-h) 60				

	(annual)				
O_3 (30-day average) ($\mu g/m^3$)[3]	100 (1-h) 127 (8-h) 30 (24-h) 30 (annual)				
Metal deposition rates (30-day average) $\mu g/100cm^2/30d$ (3)					

NOTES:
[1] – based on 15 samples
[2] – based on 12 days of sampling
[3] – based on 50 days of sampling.
Bold values indicate maximum values selected as baseline concentrations.

Table 2-5 Baseline Ambient Noise Monitoring Results

Site	**L_{eq} (24 h) (dBA)**	**L_{eq} (Day, 15 h) (dBA)**	**L_{eq} (Night, 9 h) (dBA)**	**Minimum L_{eq} (1 h) (dBA)**	**Maximum L_{eq} (1 h)(dBA)**
Mary River	25	25	26	20	34
Milne Inlet	30	31	29	21	35
Steensby Inlet	29	31	26	23	35

Attachment 4: Weather Stations at Project Sites

Weather Stations at Mary River Project Sites
Information on auto weather station maintenance, calibration, and quality assurance procedures

Mary River Project Sites consist of three sites: Milne Inlet, the Mary River Mine Site, and Steensby Inlet. At each site, there are two independent weather stations, but identical at all sites.

The original weather station, installed by Knight-Piesold (north Bay, Ontario) in 2005, was a standard system built on a 10-m tall tower, using instruments from Campbell Scientific. This is the standard Environment Canada configuration. The second weather station system, Vaisala 520, was added in 2010. This system is an integrated weather station mounted on a 3-m tall tripod near the base of the 10-m tower. The Campbell Scientific instruments are logged on a CR10X data logger. . The data from Campbell Scientific unit is downloaded directly during annual site visits.

The Vaisala is connected to a data reporting/storage device from Symboticware called a SymBot. The SymBot enables satellite communication for the Vaisala giving it the ability for remote data reporting. So far this satellite communication only worked well at the Mine and Steensby sites.

The two independent weather stations were intended to be as a transition to retire the Campbell Scientific instruments, and the Vaisala was going to be the new system. The improvements by replacing it with Vaisala would be considerable because of the advantage of a more robust unit, much lower power consumption, and the satellite link through the Symbot. The overlap period between the Campbell Sci and the Vaisala would allow Baffinland to verify that the data collected by the two stations were similar, and would also create data security as the instruments were redundant.

The units on the Campbell Scientific 10-m towers consist of the following instruments:

- temperature/humidity sensor
- PAR sensor
- rain gauge
- high-speed wind speed and direction
- low-speed wind speed and direction (Note: this instrument is not at Steensby site).

These weather stations are illustrated in the three photos below (the 10 m tower could not be fit in one photo).

Photo 1: Campbell Scientific Weather Station – Top of 10-m tower

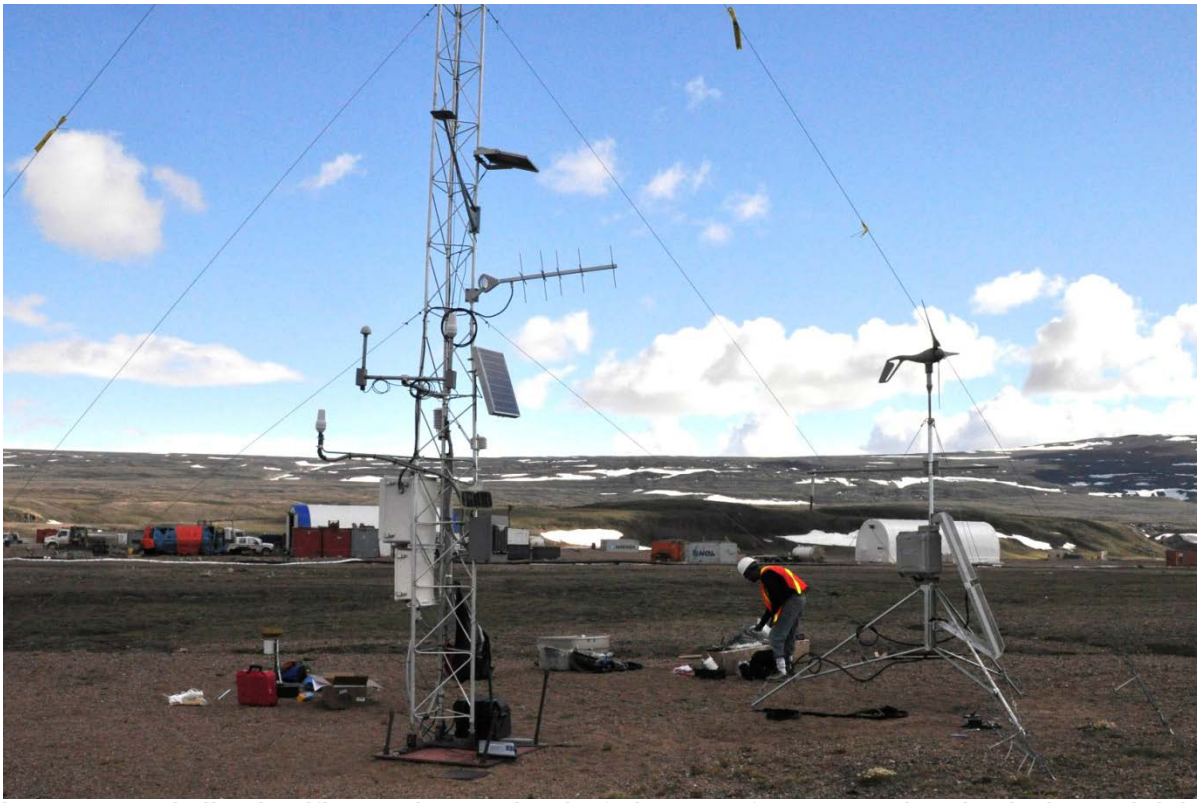

Photo 2: Campbell Scientific Weather Station (Left, bottom of 10-m tower) and Vaisala 520 (Right, 3-m Tripod)

Photo 3: Campbell Scientific Weather Station – Middle of 10-m tower

QA/QC Procedures

Baffinland conducts QA/QC of the data by two means:

1) Analyzing the past data: Baffinland partners with Charles Ramcharan; Associate Professor at Laurentian University. Baffinland has asked Dr. Ramcharan to download, manage and analyze the weather datasets from these two weather stations at all three sites. A report on the data analysis for the Mine Site and Steensby Site was in 2009, when the new Vaisala 520 was installed. This work

was to analyze the five years of existing data that were downloaded from the three weather stations (Milne site was not functioning well) to find any patterns and anomalies. Several erroneous readings were found. This type of QA/QC of the data should be done every year.

2) Comparing and analyzing the weather results obtained from both the Campbell Scientific units and Vaisala 520. This should be done every year, or every time when there are datasets available from both of these instruments.

Annual visual inspection of the instruments will also serve as another means of QA/QC. For example, at midday in the summer readings of -72.0 °C for the temperature probe, readings of 0 PAR for a light sensor can show that the sensors' function were obviously wrong, etc.
More information on the data analysis results can be found in the attached report by Charles Ramcharan, Associate Professor at Laurentian University, entitled "North Baffin Island Intelligent Monitoring Project Report on Long-Term Meteorological Data", 13 Nov 2009.

Maintenance Procedures

Baffinland has subcontracted the firm "Symboticware" to download the weather data and site upkeep annually. During the annual site visit, Symboticware will be responsible for checking the sensors and gauges on the met tower by visual inspection. For example, check to see if a sensor is visibly destroyed, check the compass orientation for the wind direction devices; "trip" the actuator on the Campbell Scientific rain buckets device by hand to make sure that they function properly; inspect the anemometer at low wind speeds; verify that the propeller and wind vane bearing rotate freely, etc.

Symboitcware will notify Baffinland of any repairs required and any parts needs to be ordered for such repair. Also, any sensors/gauges that are due for calibration at the required frequency during the annual visit will also be taken down to be sent to Campbell Scientific for re-calibration.

Calibration Procedures
Calibration is an important part of ensuring accurate measurements. The instruments on the weather stations were calibrated at the factory when purchased and should not require field calibration.
Note: The Symbot is not an equipment for data measurement and therefore does not need calibration.

Campbell Scientific Instruments
Most calibration standards that Campbell Scientific uses have traceability to the National Institute of Standards and Technology (NIST). The NIST traceability of these standards is essential to ensure the validity of the measurements and comparisons made, and to ensure that the accuracy is within acceptable limits. Campbell Scientific recommends the following frequency for their instruments by returning the sensor to Campbell Scientific Inc. for recalibration:

- **Quantum (Par) sensor** (http://www.campbellsci.com/documents/manuals/li190sb.pdf): recalibrate every two years vaisala:
- **Tipping Bucket Rain Gage** (http://www.campbellsci.com/documents/manuals/te525.pdf) - The following field calibration check is advised every 12 months:
    - Field Calibration Check:
    1) Secure a metal can that will hold at least one quart of water.
    2) Punch a very small hole in the bottom of the can.
    3) Place the can in the top funnel of the rain gage and pour 16 fluid ounces (1 pint) of water into the can. (A 16 oz. soft drink bottle filled to within 2.5 inches of the top may be used for a rough field calibration. An exact volume will allow for a more precise calibration).
    4) If it takes less than 45 minutes for this water to run out, the hole in the can is too large.
    5) The following number of tips should occur: TE525, TE525MM 100 ± 3 TE525WS 57 ± 2
    6) Adjusting screws are located on the bottom adjacent to the large center drain hole. Adjust both screws the same number of turns. Rotation clockwise increases the number of tips

per 16 oz. of water; counter clockwise rotation decreases the number of tips per 16 oz. of water. One half turn of both screws causes a 2% to 3% change.

7) Check and re-level the rain gage lid.

- **High speed and Low speed wind speed and wind direction unit** (High Speed - http://www.campbellsci.com/documents/manuals/05103.pdf, and Low Speed - http://www.campbellsci.com/documents/manuals/03002.pdf): The Wind Sentry is fully calibrated before shipment and should require no adjustments. The potentiometer has a life expectancy of fifty million revolutions.

    - Recalibration may be necessary after some maintenance operations. Periodic calibration checks are desirable and may be necessary where the instrument is used in programs which require auditing of sensor performance.

Note: the User manual contains no info on the Temperature and Relative Humidity Sensors (http://www.campbellsci.com/documents/manuals/hmp60.pdf).

Vaisala Instruments

Vaisala recommends the system be sent to their facility for functional testing yearly. Vaisala provides NIST traceable calibrations 10-95% RH and 0-70°C. Viasala recommends the Pressure and temperature sensors be replaced every 2 years.

Attachment 5: Long Term Meteorological Data Report

North Baffin Island Intelligent Monitoring Project
Report on Long-Term Meteorological Data

13 November 2009

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Project Overview

Our objectives were to retrofit three existing weather stations located on a north-south transect across northern Baffin Island with equipment that would allow improved data collection and system support, as well as enable satellite communication. The three stations were located at camps operated by Baffinland Iron Mines Inc. (henceforth, Baffinland). The weather stations had been installed and maintained by an environmental consulting company, Knight-Piesold (North Bay, Ontario) in 2005. The three sites were Milne Inlet (north shore of Baffin Island), Mary River (mid Baffin Island), and Steensby Inlet (south shore of Baffin Island) (Figure 1).

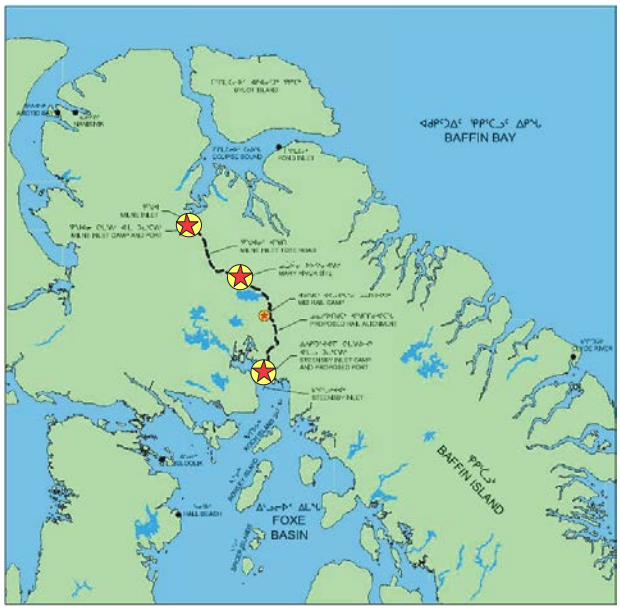

Figure 4. Location of the three study sites across north Baffin Island

Site Description

Two of the sites, Milne Inlet and Steensby Inlet, are rocky, coastal marine habitats and the third, Mary River, is an inland site located on rocky, post-glacial till. All three sites are on a typical tundra terrain with till and exposed bedrock. The two shoreline habitats are close enough to the ocean to be strongly affected by marine weather. The weather station at Steensby Inlet sits on a flat, rocky island about 400 m from shore. It's essentially at sea level. The station at Milne Inlet is on a ridge overlooking the ocean and is about 1 km from the shore and at an elevation of about 90 m above sea level. The Mary River station is far enough from either coast not to be strongly influenced by sea-effect weather. All three stations are far from either artificial or natural obstructions, thus all data for insolation, wind, and temperature should represent normative local conditions.

Installation of the new equipment went well (see the associated report by Symboticware, North Baffin Island Intelligent Monitoring Project – Initial Technical Report). For unknown reasons, the station at Milne Inlet failed to transmit data via satellite shortly after it was retro-fitted. Despite repeated attempts at repair, that station is not transmitting data, although it continues to collect the data. The current functioning of the weather stations does not affect this report as the focus here is on analysis of the five years of existing data that were downloaded from the three weather stations.

Meteorological Variables and Methods

All three weather stations were standard Campbell Scientific (Edmonton, AB) units. They carried sensors for (a) air temperature and humidity, (b) light radiation, (c) light energy, (d) wind speed, (e) wind direction, and (f) rainfall (Table 1). In addition to the data collected by these sensors, the data loggers in the stations (Campbell Sci. model CR10X), also monitored (g) time and date, (h) battery power, and (i) internal temperature. Depending on the variable, data may be averaged over an hour, a day, or by hour then day. Some variables such as the standard deviation of wind direction, dewpoint, and wind chill are calculated based on standard equations that were programmed into the CR10X.

Importantly, there were considerable problems with functioning of the various data probes. No station had all probes working all of the time. Moreover, data collection at the different stations was switched on and off for unknown reasons over the five year study period. As a result, the data were discontinuous and some parameters were severely affected.

The data were processed to eliminate erroneous numbers. The CR10X writes a double line of data at the end of each day (2400). The second of these data lines is incomplete and these lines were eliminated. For most of the sensors, failure was indicated by a value of zero for the measured parameter except for the temperature probe which would return a value of about -72 °C. For the most part, these erroneous temperature readings were eliminated. For Steensby Inlet in 2008 and 2009, the erroneous temperature data were retained in order to illustrate the patterns shown by a failing sensor.

The data are presented as daily values, with each day of the year being numbered from 1 (1 January) to 365 (31 December). In the cases where the raw data were already averaged hourly (e.g., wind speed) these hourly averages were again averaged for each day. For solar radiation, only the noon (1200) readings were used.

Data Analysis

As a result of restrictions caused by damaged probes and non-operation of the data loggers, it was not possible to conduct analyses of long-term trends, or even to statistically compare among the three study sites. The analyses presented below are thus largely descriptive.

Overall System Function

The recording of time of day provided a convenient means of determining when the CR10X units in the weather stations were switched on and collecting data. The data recording times are presented as high-low graphs, wherein for each day (x-axis) a line is drawn between the hour (y-axis) of the start of data collection and the hour of the last collected data point (Figure 2-4). These figures illustrate the maximum potential period of data collection. Due to sensor failures, the data available are a subset of this potential range.

The Mary River station was set up in 2005, a year before the other two. For the first year of operation, the station was switched on only from late spring to early fall, and in 2006 was operated only during the summer (Figure 2). Data collection at the other two stations began in the fall of 2006 and it appeared that those units were left on year-round. We have no explanation for the frequent data outages at all three stations. A shutdown of a few (7-10) days may represent periods when the CR10X datalogger was shut down for data retrieval. It's unclear why this would have been necessary as the unit can record continuously with the data being stored on portable solid-state drives, which can be removed at any time for data download.

In 2009, the Steensby Inlet station was experiencing frequent failure (Figure 3). Perhaps the problem was temperature-related as the unit seemed to improve with the onset of summer. Nevertheless, this station eventually failed when it was retro-fitted in August 2009.

The Milne Inlet station seemed to operate fairly well, except that it was sometimes turned off for no apparent reasons (Figure 4).

Table 1. Explanation of the CR10X data variables. The first number in the storage label is the "port" whereby the data are read on the CR10X.

Final Storage Labels	*Parameter*	*Units or Format*
0,101,5855	signals a new data line	
1,Year_RTM		integer year
1,Day_RTM		integer day
1,Hour_Minute_RTM		9999.999
2,Batt_Volt_AVG		volts
3,Prog_Sig~2,17673		
4,Rain_mm_TOT	rainfall	mm
5,AirTemp_AVG	air temperature	^{o}C
6,RH_MAX	relative humidity	percent
7,RH_MIN	relative humidity	percent
8,Slr_W_AVG	solar radiation	Watts/m^2 (Joules/m^2/s)
9,Slr_kJ_TOT	solar radiation	kilojoules/m^2
10,WS_ms_AVG	average wind speed	m/s
11,WS_ms_MAX	maximum wind speed	m/s
12,WS_ms_MIN	minimum wind speed	m/s
13,WS_ms_S_WVT	average wind speed	m/s
13,WindDir_D1_WVT	wind direction	degrees
13,WindDir_SD1_WVT	std. dev. wind dir.	degrees
14,Tot24	total rainfall	mm
15,TdC_AVG	dew point	^{o}C
16,HI_C_AVG	average heat index	^{o}C
17,SunHrs_TOT	% hours of sunshine	99.99
18,WC_C_AVG	average wind chill	^{o}C
19,WC_C_MAX	maximum wind chill	^{o}C
20,WC_C_MIN	minimum wind chill	^{o}C
21,10218768	unspecified	
22,Year_RTM,19892	repeated entry	
22,Day_RTM	repeated entry	
22,Hour_Minute_RTM	repeated entry	
23,Batt_Volt_MIN~1,6731	repeated entry	
24,Prog_Sig~2,19628	repeated entry	

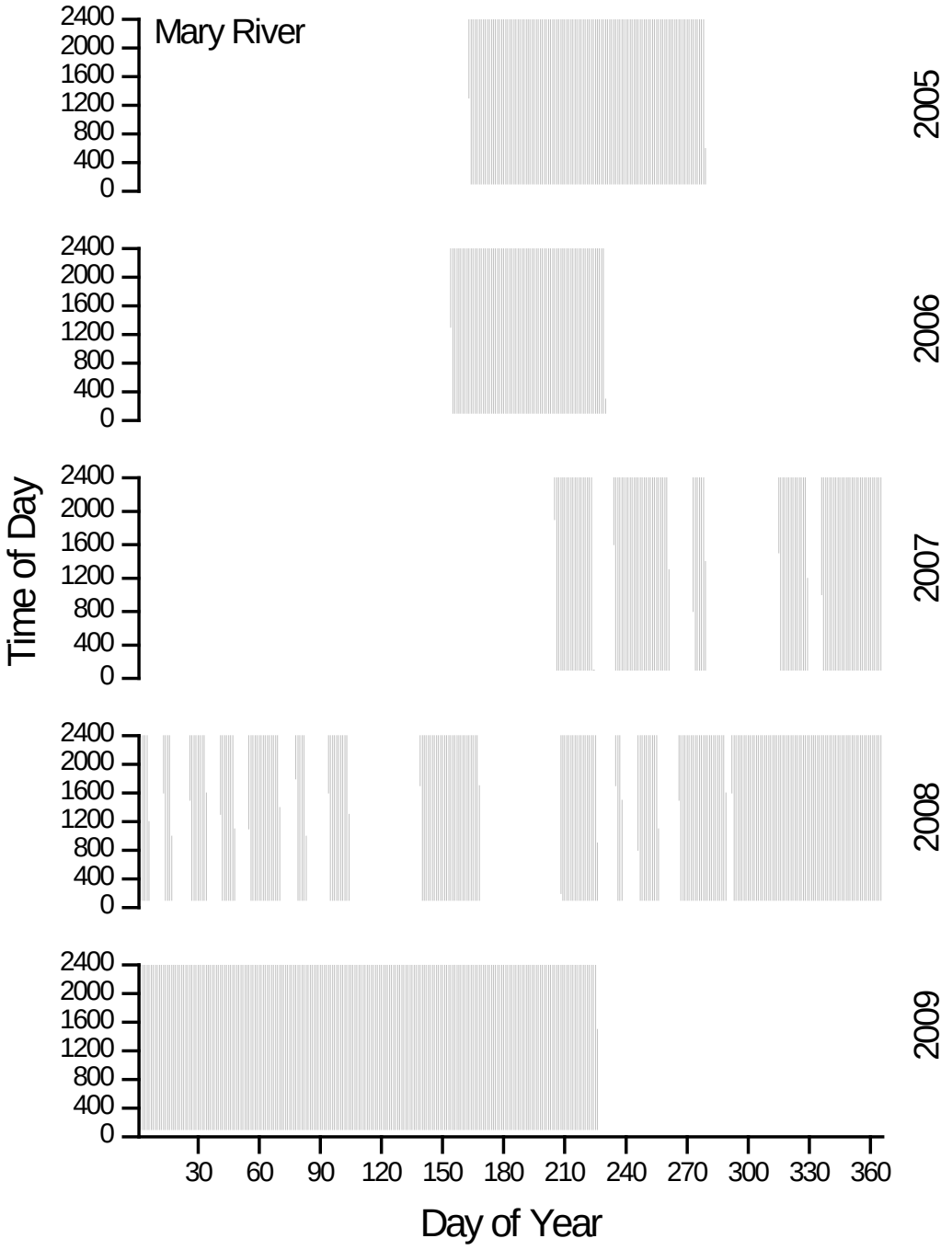

Figure 2. Data collection period for the Mary River station.

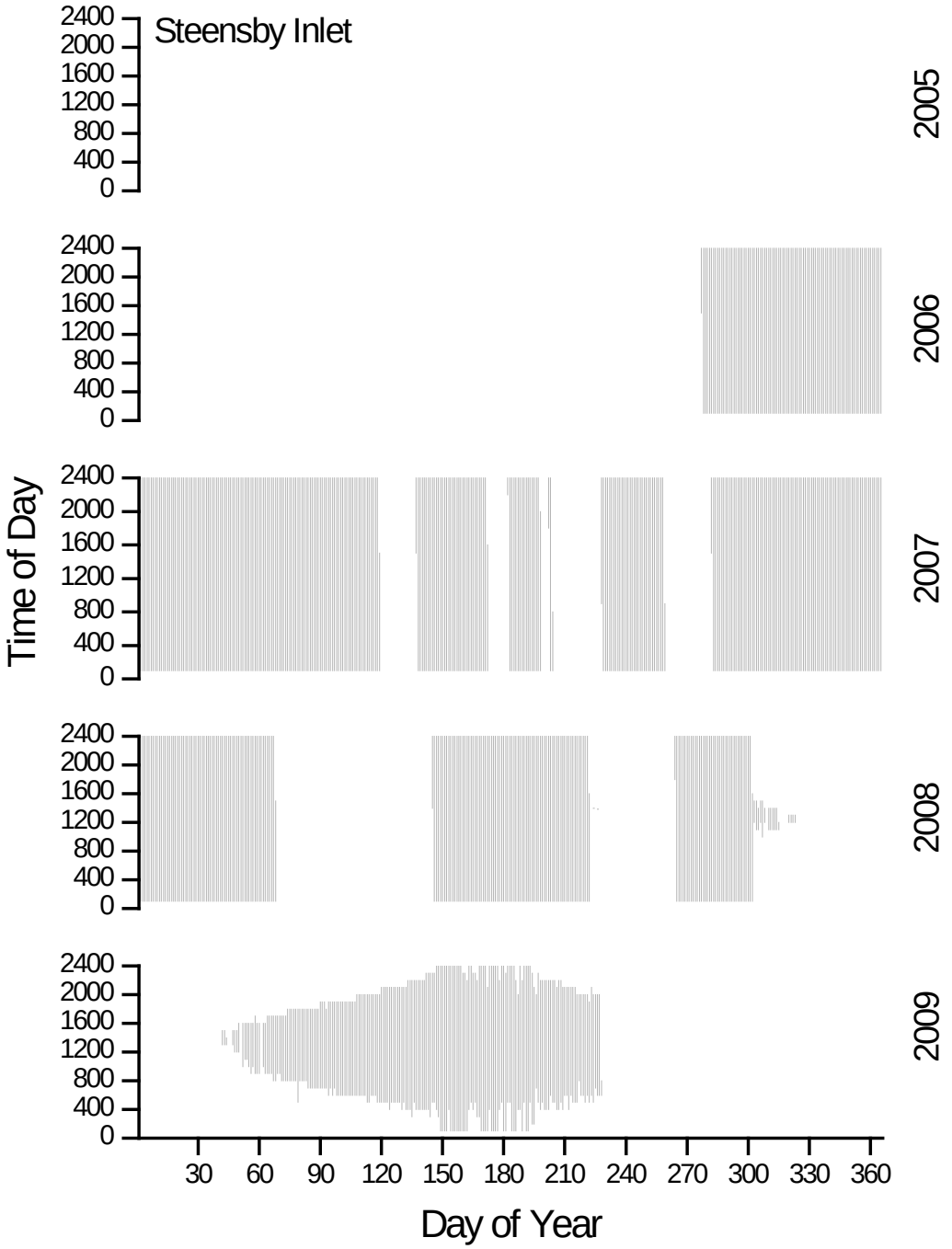

Figure 3. Data collection period for the Steensby Inlet station.

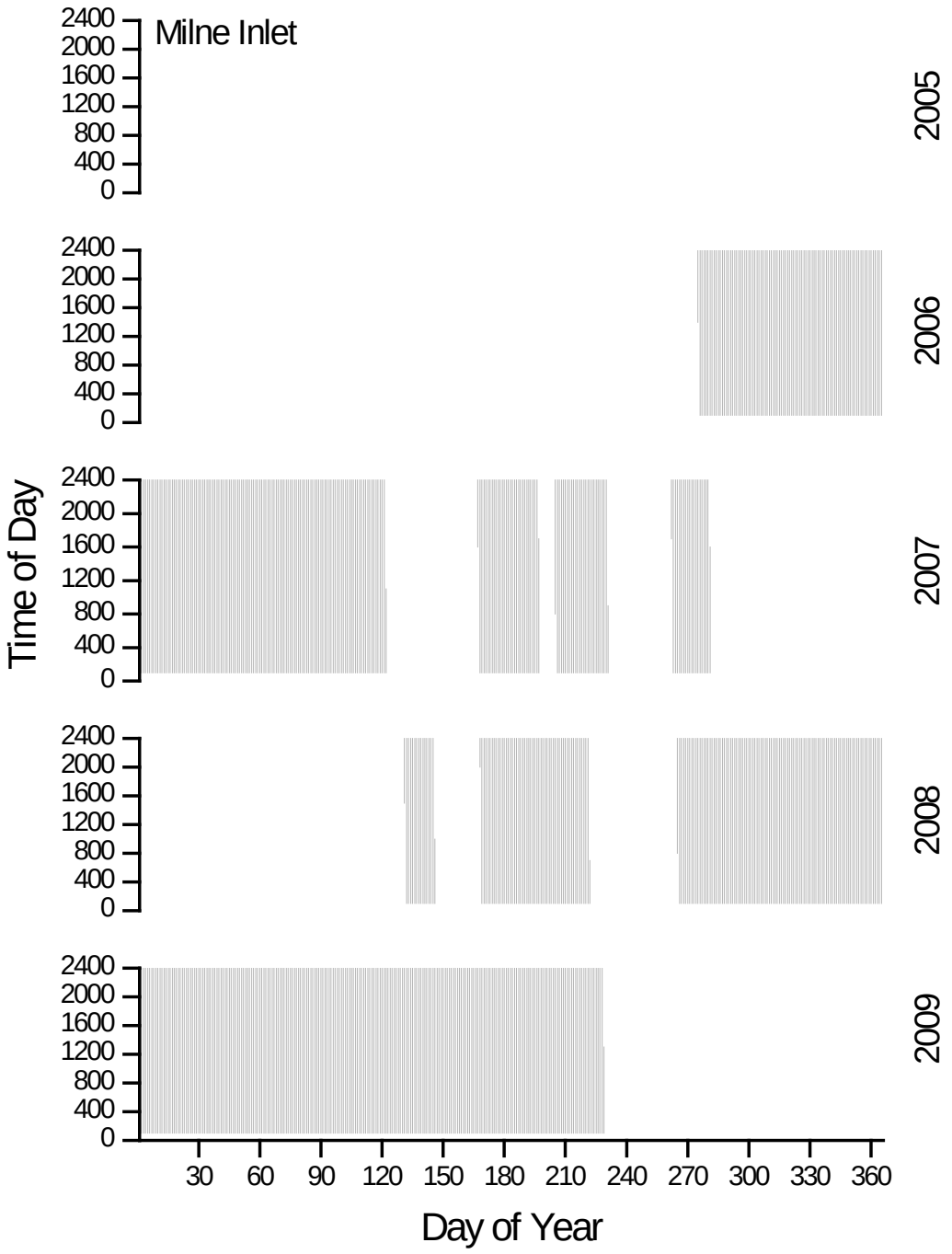

Figure 4. Data collection period for the Milne Inlet station.

Insolation

The weather stations record sunlight as both intensity (W/m^2) and energy ($kJ/m^2/s$), and here we report the former (Figures 5-7). Solar radiation varies with time of year and atmospheric conditions, especially cloud cover. These two factors interact. Solar levels are, of course, low to zero during the peak of winter but can be surprisingly high during a lot of the winter because cloud cover is usually low. Summer brings increased humidity thus cloud cover can reduce summer sunlight. It's mostly cloud cover that causes the high day-to-day variability in solar radiation.

At Mary River, the solar sensor operated every time the unit was turned on, but only until the fall of 2007 (Figure 5). The defective solar sensor was not replaced.

At Steensby Inlet, the solar sensor was installed only in 2007. This sensor was operational every time the unit was turned on. Since the sensor operated continuously, the seasonal pattern of rise and fall of solar radiation in the spring and fall, respectively, can clearly be seen in the 2007 to 2009 data series (Figure 6).

At Milne Inlet, similar patterns in solar radiation were evident as at Steensby Inlet (Figure 7).

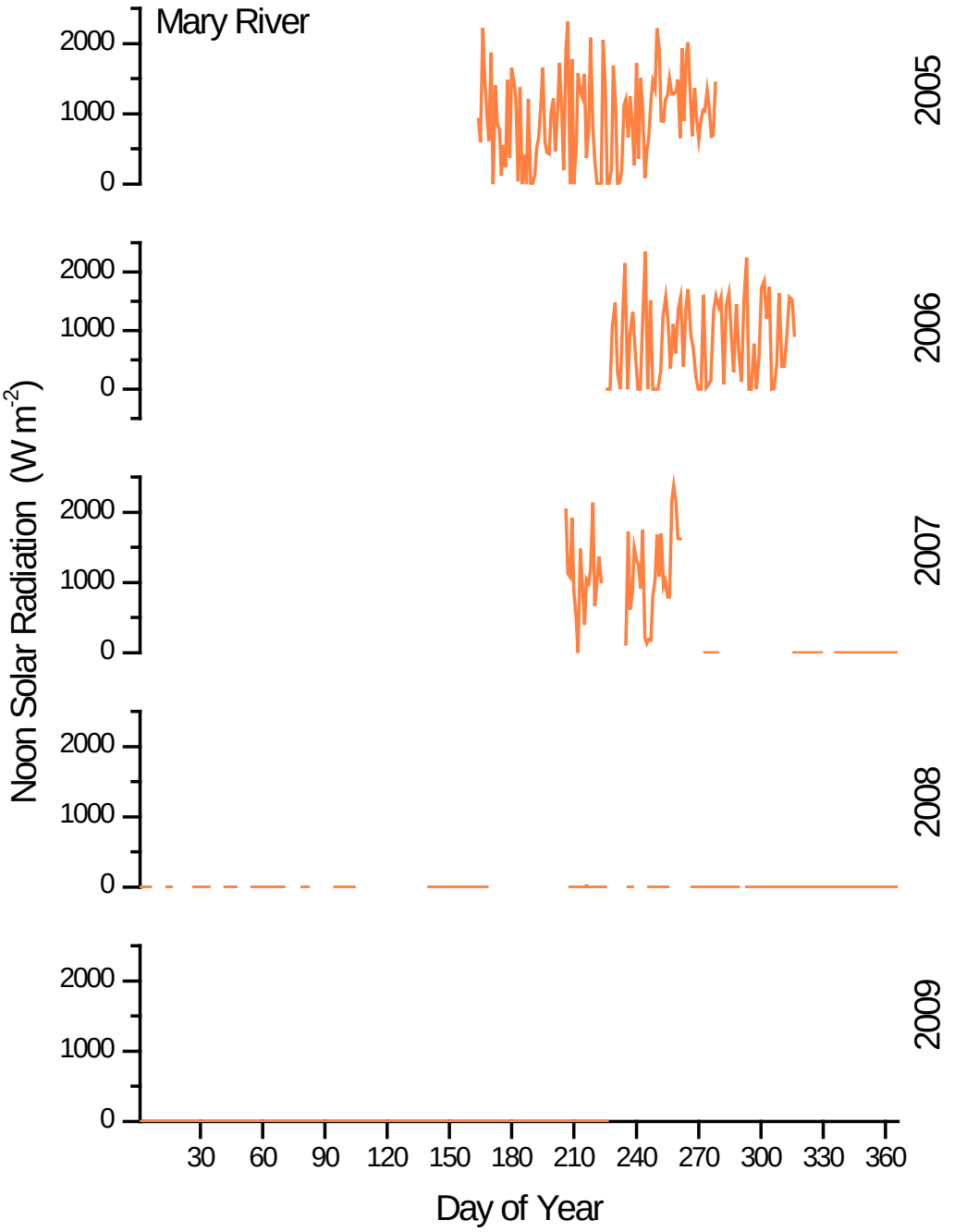

Figure 5. Noon solar radiation at the Mary River station

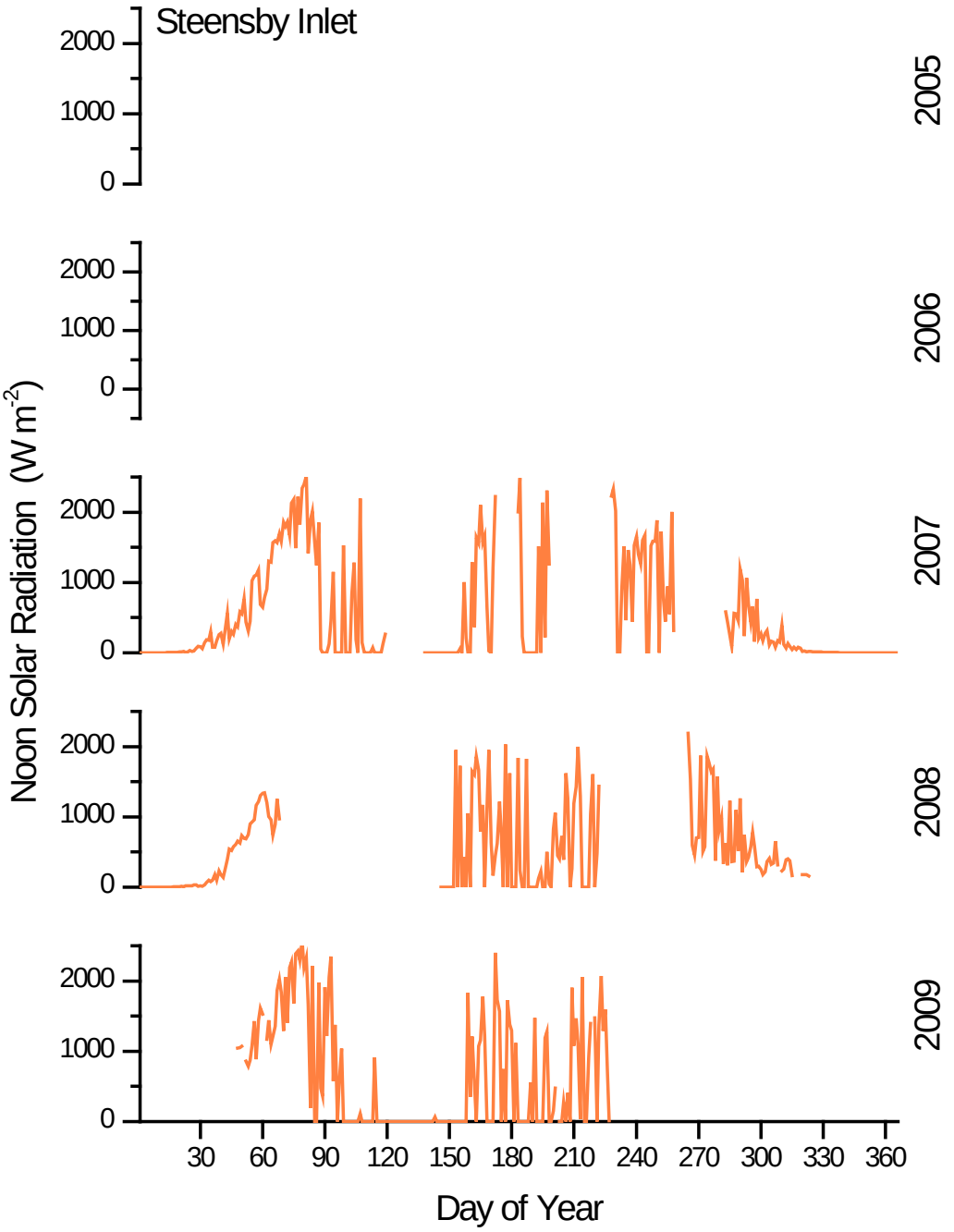

Figure 6. Noon solar radiation at the Steensby Inlet station.

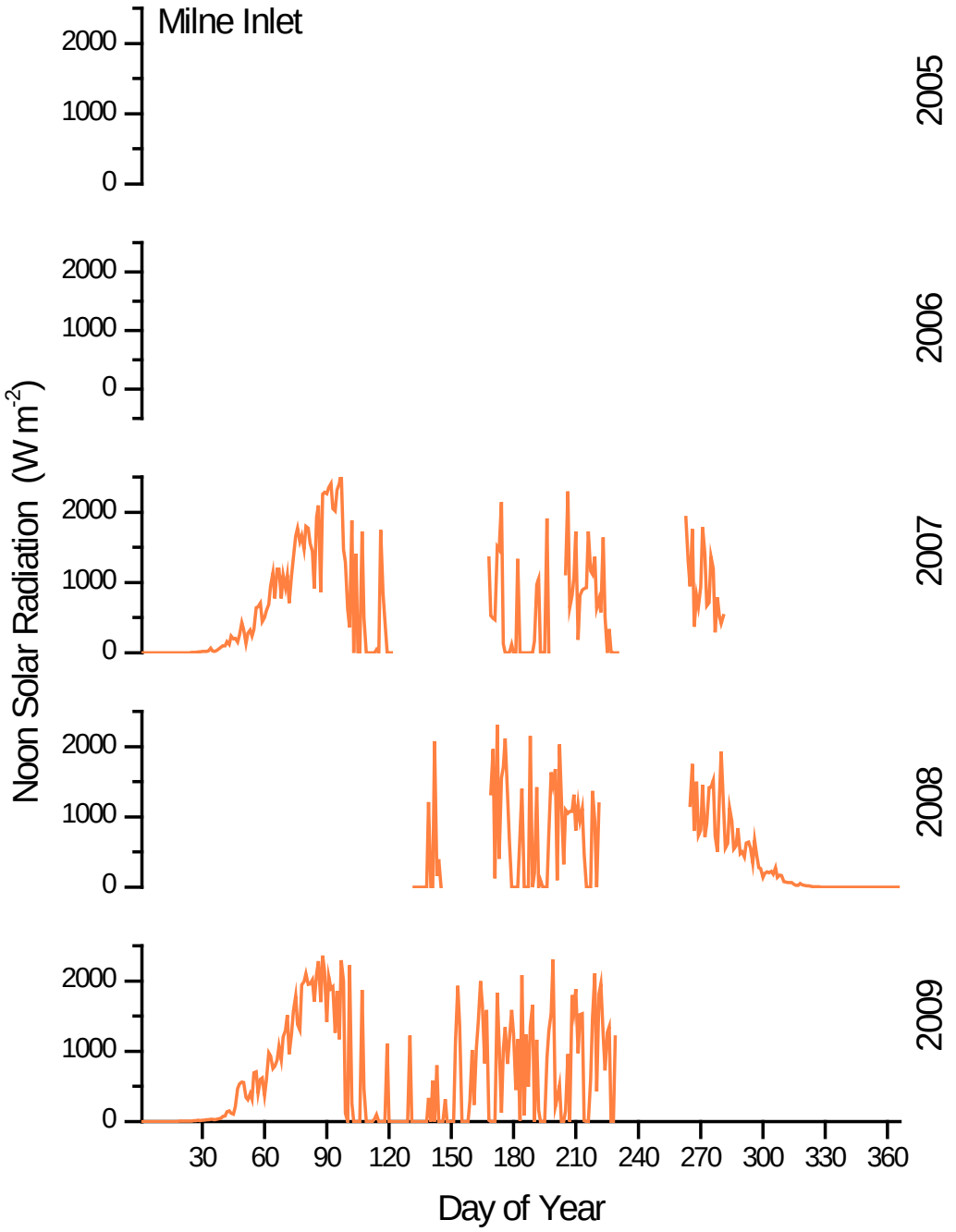

Figure 7. Noon solar radiation at the Milne Inlet station.

Air Temperature

Air temperature was measured by a combined temperature/humidity probe but the humidity data are not shown here. The temperature data were averaged over each day (black lines) with daily minimum (blue lines) and maximum (orange lines) values also shown (Figures 8-10).

Air temperature at the Mary River station was recorded whenever the station was turned on (Figure 8). Each year of data showed the expected seasonal pattern. It's not possible to compare the data among years because the station was too often switched off.

The Steensby Inlet station showed the same seasonality as the Mary River site (Figure 9). However, there was also some low temperature anomalies recorded as the temperature/humidity sensor began to fail in 2007 and 2008, and finally failed completely in 2009.

The Milne Inlet station also showed the seasonal patterns of the other two stations (Figure 10). In this case, the temperature/humidity probe continued to operate from 2006 to 2009. All data gaps were caused by the recording unit being switched off.

In future analyses, it would be interesting to compare temperature variability at the inland site relative to the two shoreline sites. The ocean should provide a moderating influence on air temperature at Steensby and Milne Inlets.

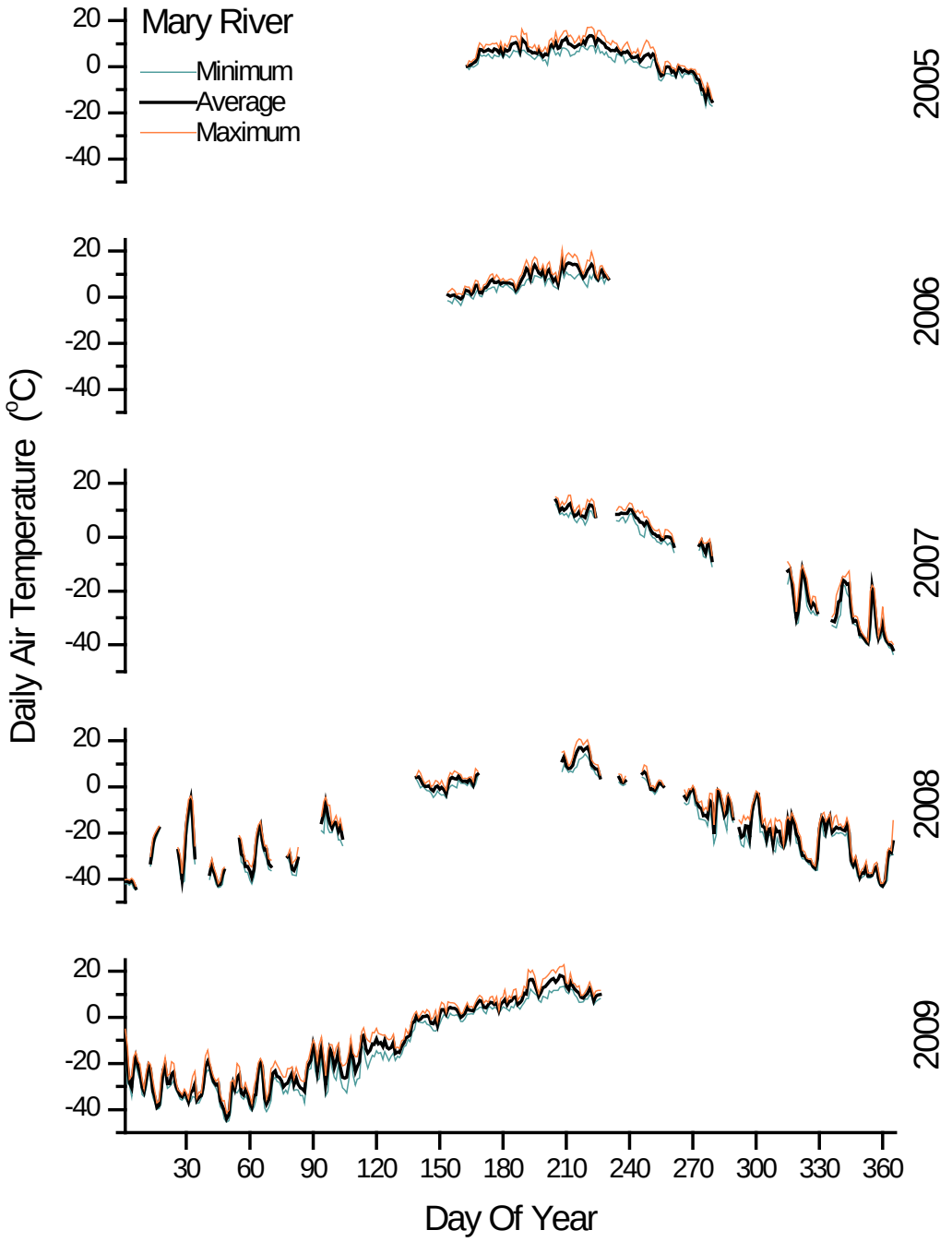

Figure 8. Air temperature at the Mary River station.

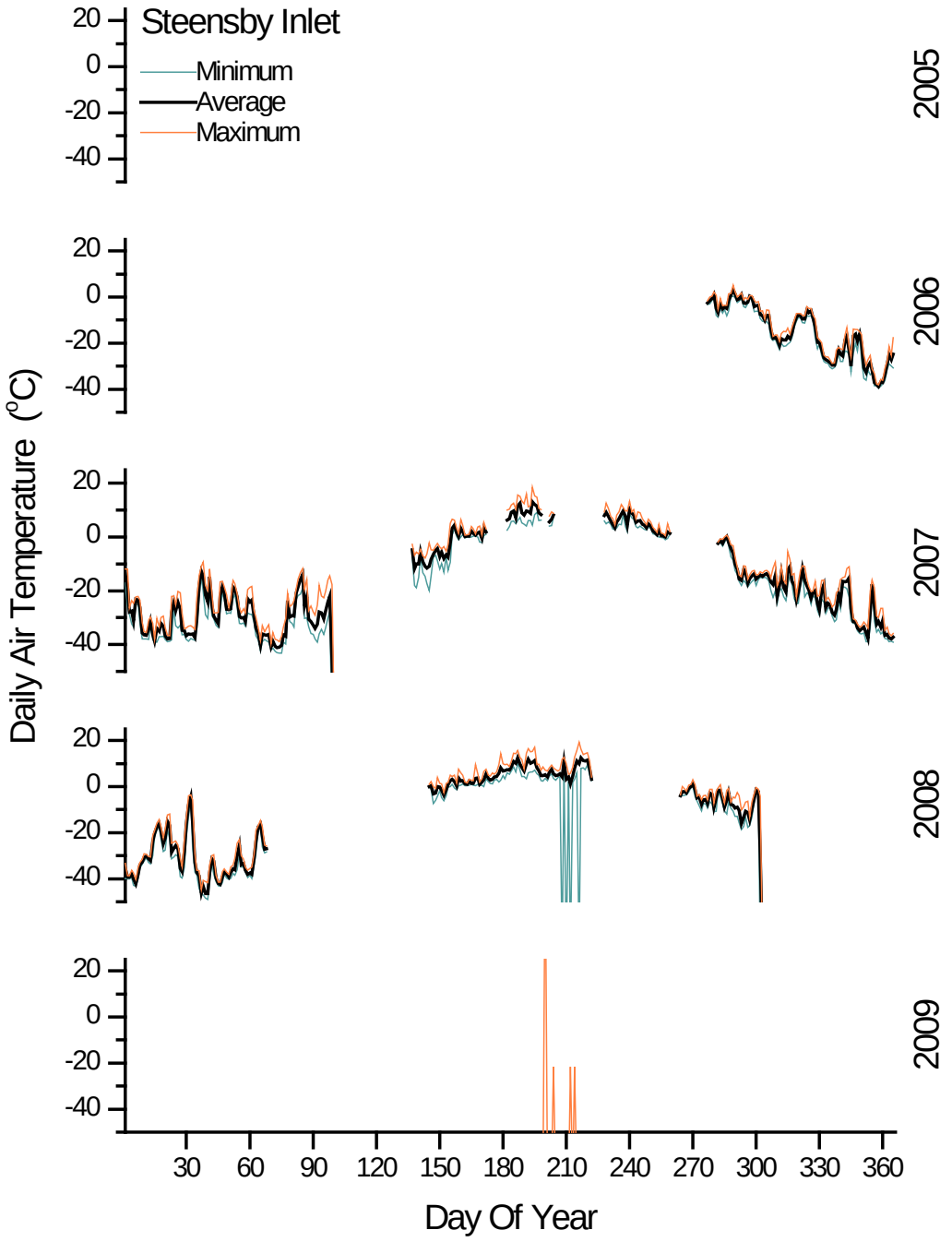

Figure 9. Air temperature at the Steensby station.

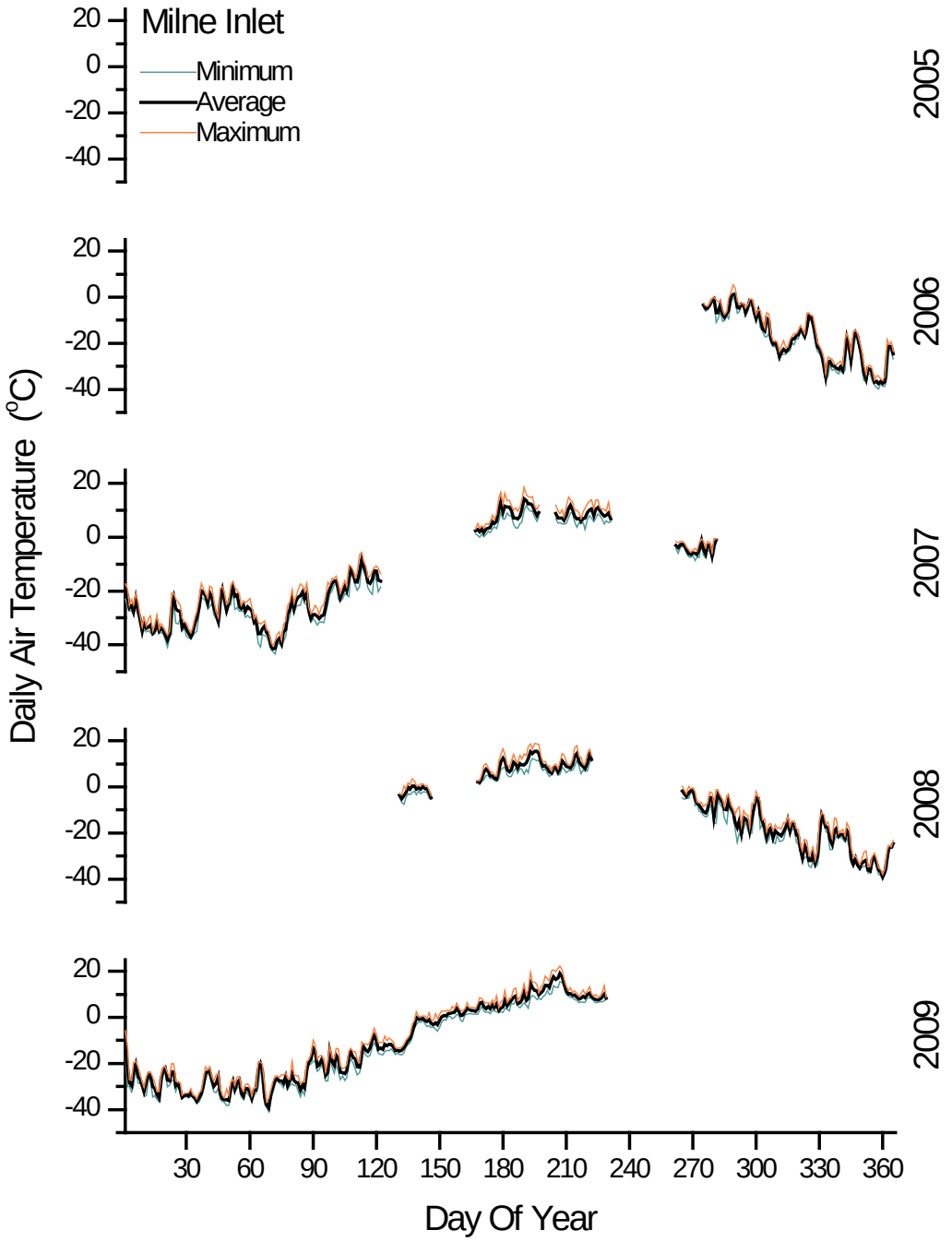

Figure 10. Air temperature at the Milne Inlet station.

Daily Rainfall

Rainfall was recorded by a tipping-bucket collector. This type of sensor can only record rain and is largely inoperable with any dry or semi-dry precipitation (i.e., snow and freezing rain). Thus the data on precipitation are available only from late spring to early fall (Figures 11-13).

Total daily rainfall was highly variable at the Mary River site (Figure 11). For the most part, rain seemed to occur in isolated events ("spates"), not as long-term precipitation. Overall, rainfall was not high which is expected in this fairly arid artic region. In 2008 there were extended periods when the rain gauge reported values of zero even during the summer. Perhaps the gauge was malfunctioning during that time as the Steensby and Milne Inlets stations did record precipitation.

The Steensby Inlet station recorded much more rainfall than the other two sites (Figure 12). (Note the change in y-axis scales between Steensby Inlet and the other two sites.) This coastal, south shore site is clearly in a wetter climate than the other two sites. The temporal pattern of rain seems similar to Mary River and Milne Inlet, however. Rain seems to come at the same frequency at Steensby Inlet, it just rains much more when it does arrive. In 2009 the rain gauge at Steensby Inlet failed, likely due to damage by a polar bear.

Milne Inlet showed very little rainfall but it's unclear whether this was a real pattern or whether the rain gauge was malfunctioning (Figure 13). Comparing Figures 4 (data recording period) and 13 (rainfall) for Milne Inlet indicates that the rain gauge itself was turned off, independently of the recording unit. Were both the data logger and the rain gauge connected, the rainfall data would have shown zeros during freezing periods but we don't see this in the data stream. Eventually, the rain gauge at Milne Inlet failed completely by 2009.

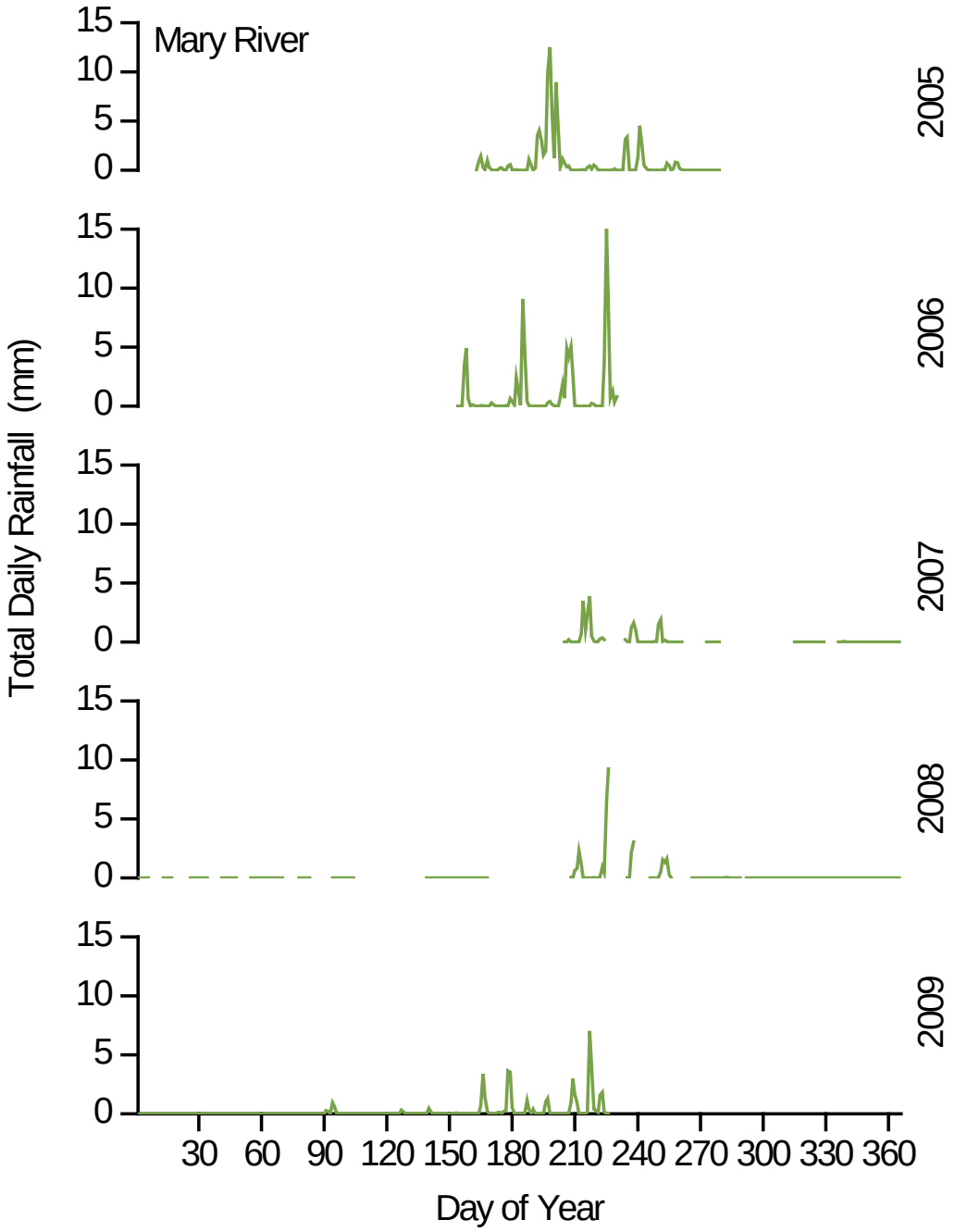

Figure 11. Daily rainfall at the Mary River station.

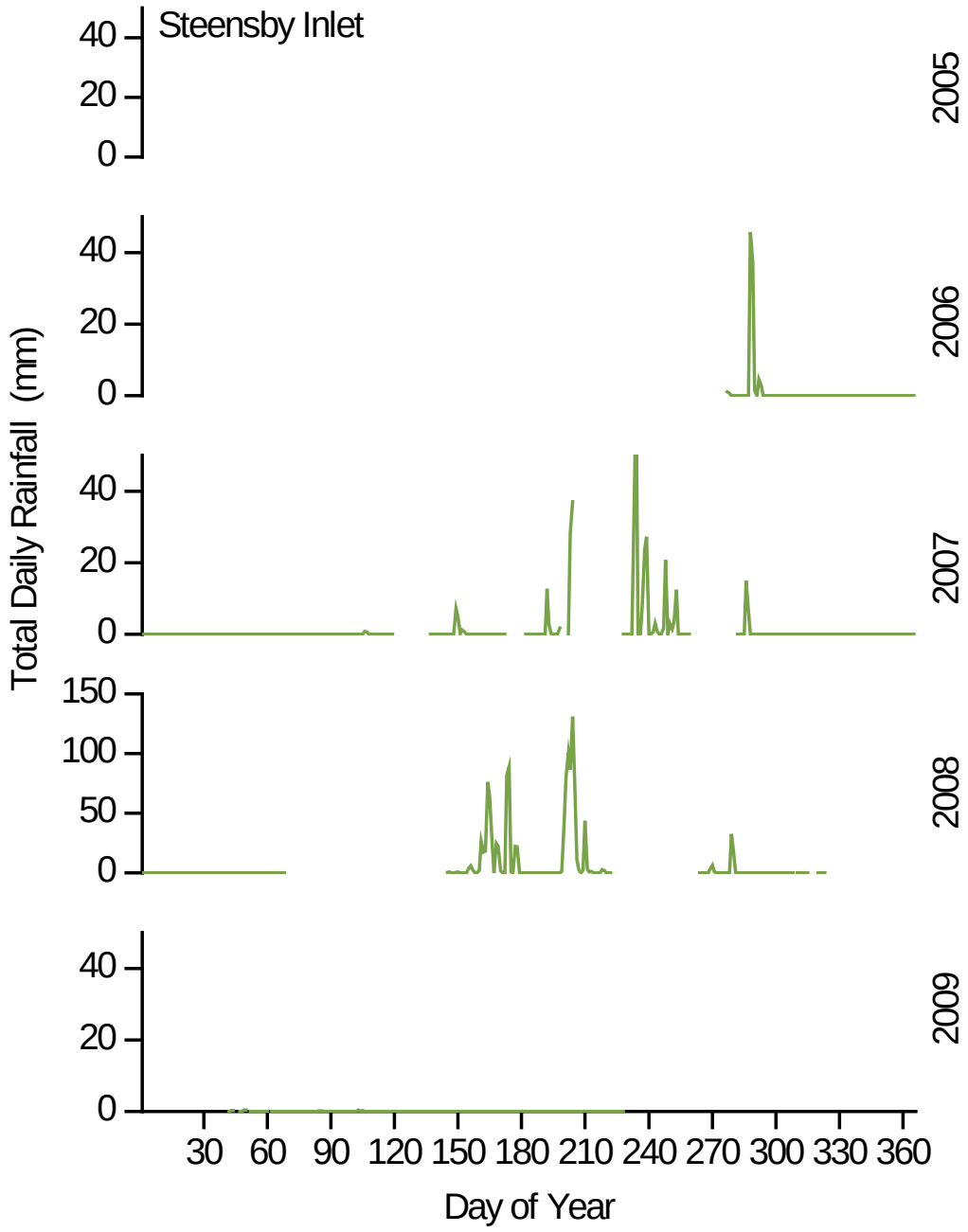

Figure 12. Daily rainfall at the Steensby Inlet station. Note the change in y-axis scale relative to the other figures; 2008 is on yet another scale.

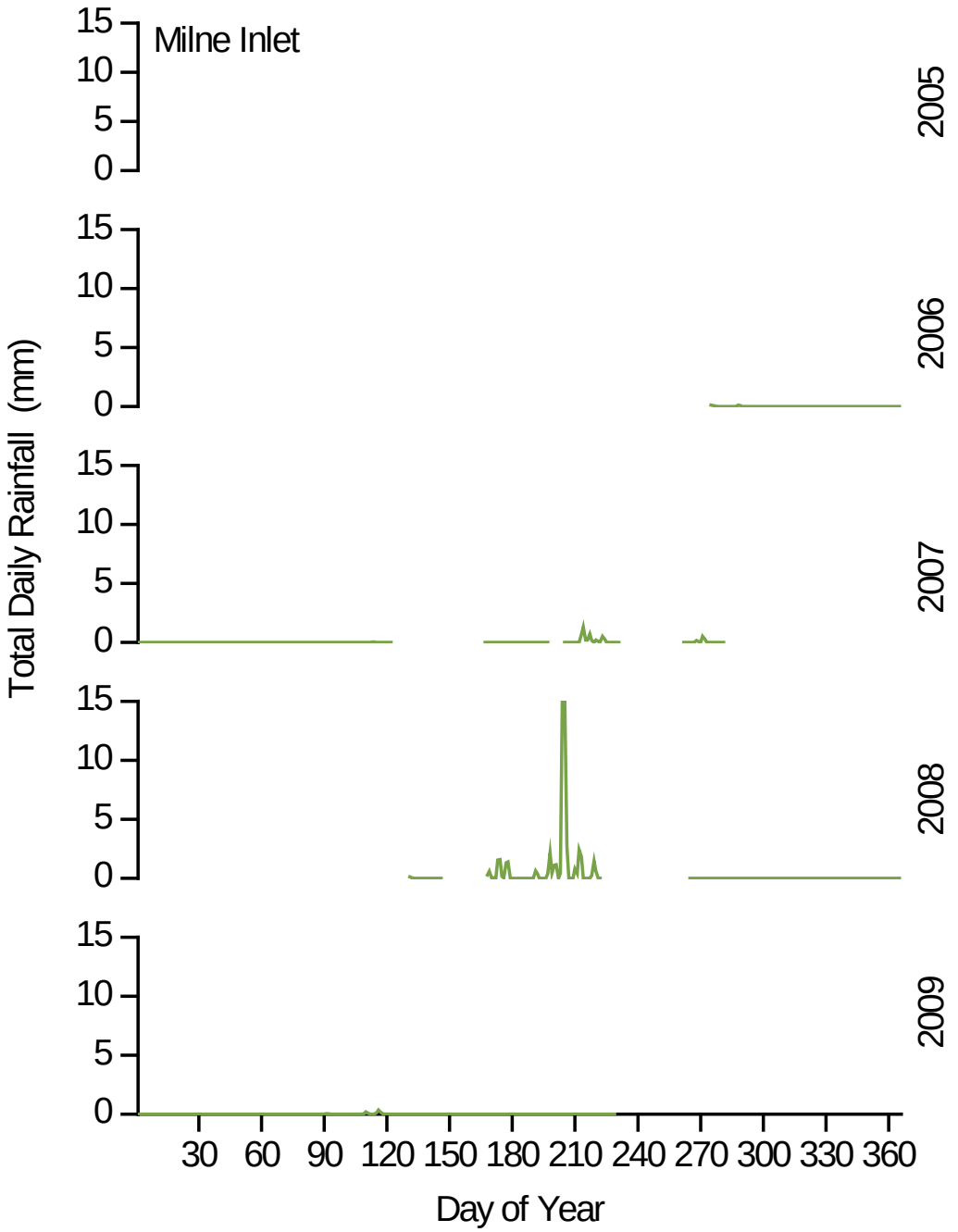

Figure 13. Daily rainfall at the Milne Inlet station.

Wind Speed

Wind speed was averaged over each day. Ordinarily, weather stations carry two different anemometers, one for low (cup style) and one for high (propeller style) wind speeds. The Mary Inlet station had both anemometers but only the high-speed one was connected and operational. The other sites had only high-speed sensors. The use of high-speed sensors is appropriate at these sites as wind speeds are typically high. The landscape is barren and open, thus wind is supported by a large fetch (clear landscape for building force). At all sites, wind speeds would often approach 20 m/s which is equivalent to 72 km/h.

Wind speed at Mary River showed a good data series (Figure 14) as recording occurred whenever the datalogger was switched on. Significant wind (Beaufort Scale values of 4-6) was almost always present, with frequent fluctuations that approached gale-force conditions (Beaufort 6-8).

The Steensby Inlet station also showed a very good data series for wind speed (Figure 15). At this site, wind speed was perhaps a bit more moderate than at Mary River, and did appear to also be a bit less variable.

The Milne Inlet station again had a good data series for wind speed (Figure 16) and seemed more similar to Mary River in terms of the intensity and variability in wind speed. The Milne Inlet station is located atop a high ridge and perhaps experiences higher wind than if it were located at sea level like the Steensby Inlet station.

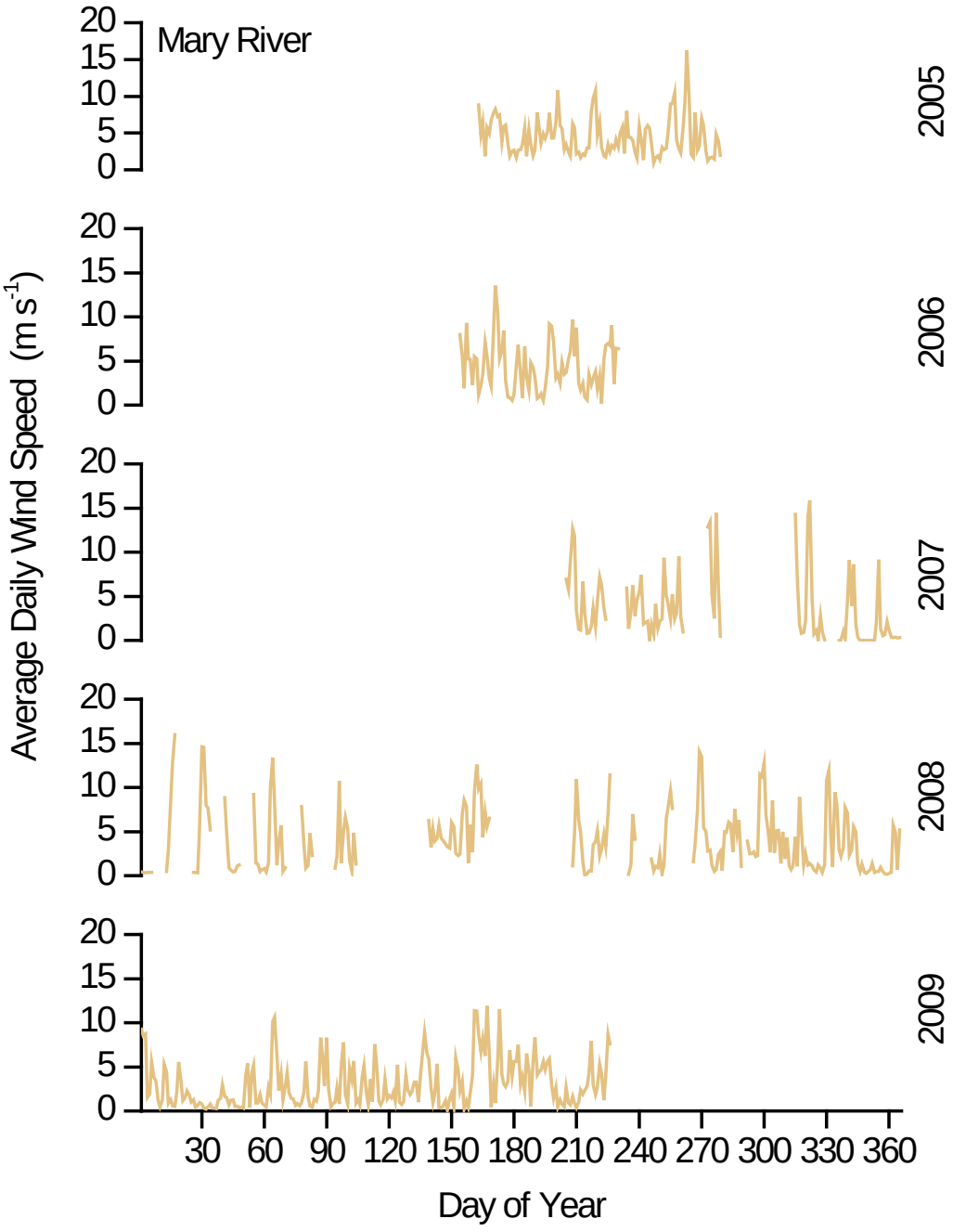

Figure 14. Average daily wind speed at the Mary River station.

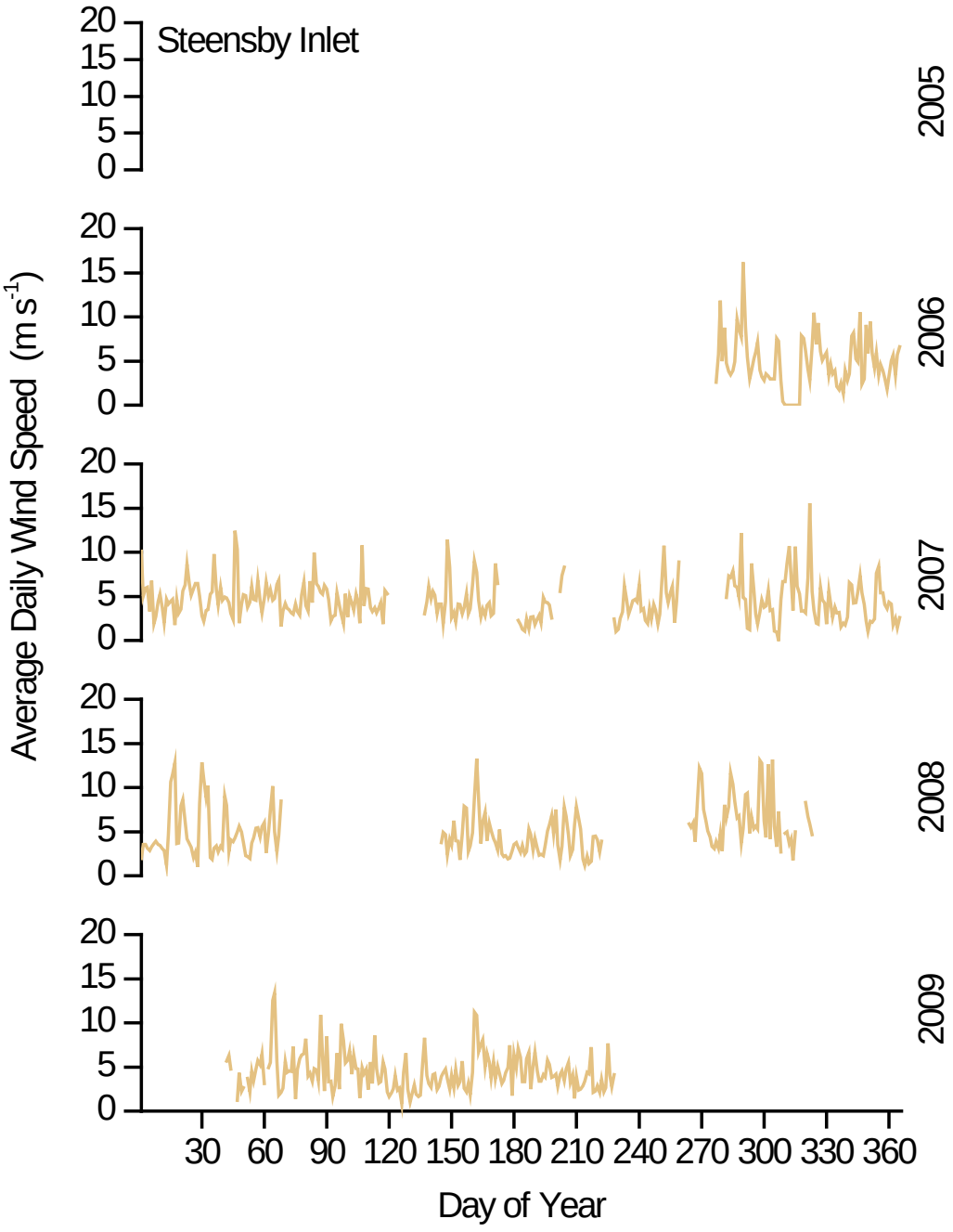

Figure 15: Average daily wind speed at the Steensby Inlet station.

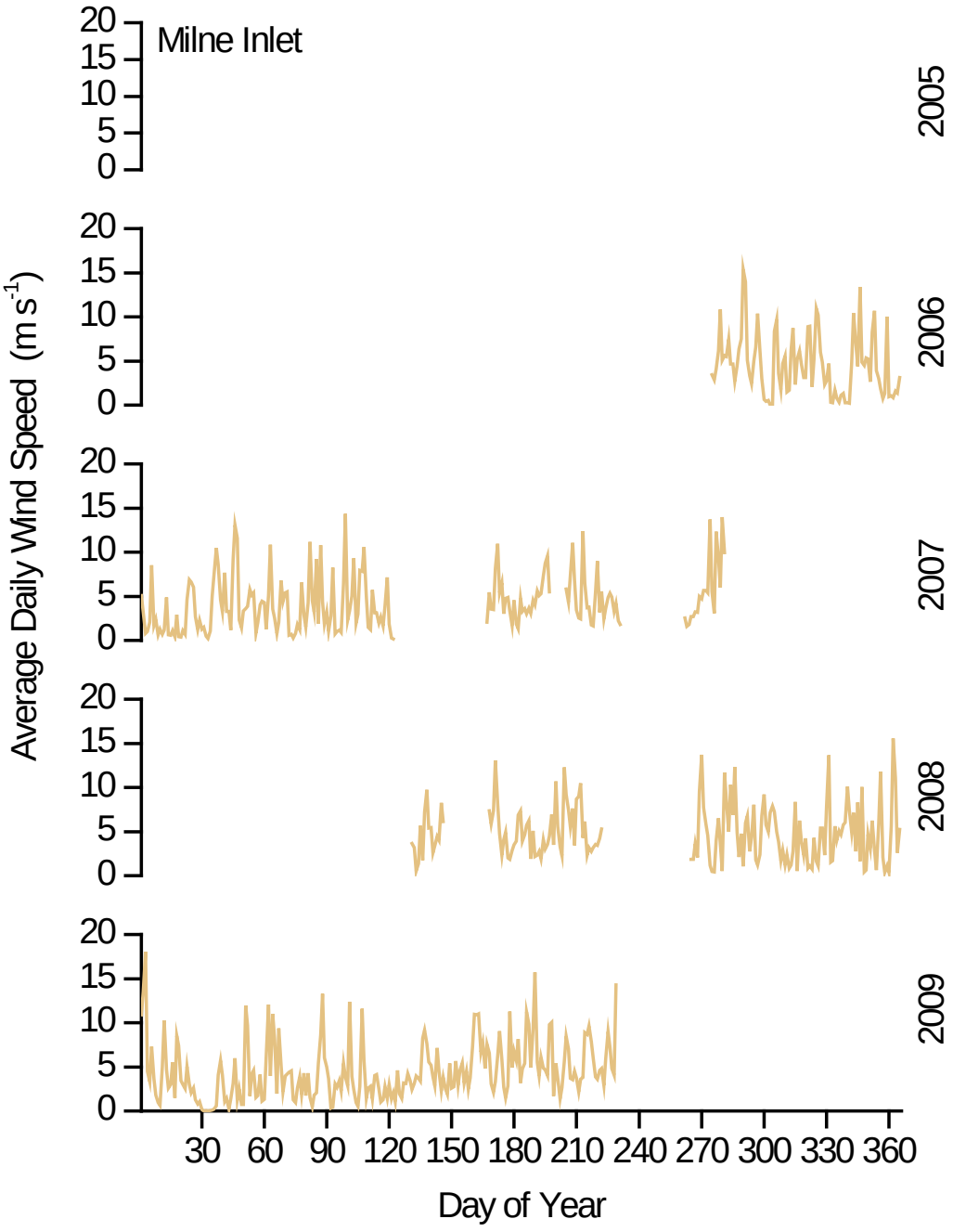

Figure 16: Average daily wind speed at the Milne Inlet station.