APPENDIX E

MINTO CLIMATE BASELINE REPORT

Minto Climate Baseline Report

YESAB Project Proposal Phase V/VI

June 2013

Prepared for:

Minto Explorations Ltd.

EXECUTIVE SUMMARY

The climate in the Minto region is subarctic continental, characterized by long, cold winters and short, cool summers. The area experiences moderate precipitation in the form of rain and snow and a large range of temperatures on a yearly basis with a mean annual temperature below 0°C.

Summary of Meteorological Data

Two meteorological stations installed at the property have recorded wind speed and direction, air temperature, relative humidity, barometric pressure, solar radiation and rainfall in one-hour intervals since September 7, 2005 for the HOBO and October 15, 2010 for the Campbell Scientific station.

Severe rime ice build-up on the HOBO anemometer cups has resulted in extended periods of recorded zero or diminished wind speeds during the winter (EBA 2010). The Campbell Scientific anemometer has been much less prone to icing. Based on the wind record from the two meteorological stations, and excluding periods where the anemometer was iced up, the two predominant wind directions at site are S to SE and N to NW. Average wind speed is 2.64 m/s at 3 meters' height and 2.9 m/s at 10 meters.

The summer period is characterized by temperatures in the range of 10 to 20°C. The winter period is characterized by a much larger day-to-day variation in air temperatures, typically between -10 and -30°C. Diurnal variation in air temperatures tends to be less during the winter period than during the summer. The transitions between winter and summer are characterized by a quick rise or fall in air temperatures. July has been the warmest month on average (14.6°C) while the coldest has been January (−19.1°C). The mean annual air temperature at the site is −1.8°C. The maximum air temperature ever recorded was 30.3°C. The minimum air temperature ever recorded was −43.2°C.

Relative humidity is highest during the winter months (typically in the range of 75to 95%) and lowest during the spring and early summer, typically in the range of 40 to 60%. Relative humidity has a much larger day-to-day variability during the summer. The lowest recorded %RH was 10.25%. The highest was 100%. Annually, mean relative humidity is 71%.

Barometric pressure recorded on-site at 885 m elevation has been converted into a meteorological standard sea-level equivalent. Barometric pressure is slightly higher on average between May and September (above 1009 hPa), and lowest between October and April (below 1006 hPa), with the exception of February. Mean annual sea-level equivalent barometric pressure is 1007.5 hPa.

As would be expected at a latitude of 62.6°N, a strong seasonal pattern in solar radiation is evident, with a maximum being received near the summer solstice in late June (daily maximums on the order of 750 W/m^2), and daily maximums slightly above zero around the winter solstice. The average amount of solar radiation received at the site annually is 111 W/m^2. The highest daily average is received in June (230 W/m^2). The lowest is in December (5 W/m^2).

The tipping bucket rain gauge mechanism used to record precipitation at site is designed to record rainfall. However, wet snow falling into the catch tube and melting in the bucket at temperatures near 0°C would result in an instance of recorded precipitation. In order to provide an accurate estimate of total rainfall only, any recorded precipitation occurring when air temperatures were below zero was omitted from the record (EBA 2010). Based on the cumulative average monthly rainfall, 174.2 mm of rain is expected at site in a single year (EBA 2010). August is the rainiest month with an average rainfall of 51.0 mm. The largest monthly rainfall total was 101.8 mm (July 2011). The largest one-day rainfall was 28.2 mm (August 25, 2008). Rainfall has been recorded in every month of the year.

On October 14, 2011, a snowfall conversion adaptor was installed on the tipping bucket of the Campbell Scientific station; however, the total precipitation record is not long enough yet to provide meaningful statistics. Environment Canada's Canadian climate normals (1971–2000) for Pelly Ranch indicate that on average, annual precipitation occurs 64% as rainfall and 36% as snow. With the assumption that regional precipitation is homogeneous and ignoring any significance of elevation, orographic effects, or valley orientation, the Minto property can be estimated to receive an additional 100 mm of water-equivalent precipitation in the form of snow annually for a total annual precipitation of approximately 274 mm (EBA 2010).

Based on the ten years of snow surveys, the average water-equivalent snow depth remaining on March 1 is 95.0 mm and 96.8 mm on April 1. In four of the seven May surveys, the snowpack had melted entirely by May 1. In the three years where snow remained on the ground on May 1 (1995, 2006, and 2008), the mean snowpack had reduced to 10%, 27%, and 20%, respectively, of the peak measured snowpack in that year. The data indicates that the majority of runoff from snowmelt occurs in April.

No evaporation data has been recorded at the Minto site. Applying Environment Canada's average daily evaporation estimates from Pelly Ranch over the period 1971–1999, corrected for elevation, suggests an annual evaporation rate at site on the order of 400 mm/year (EBA 2010). An instruction for evapotranspiration calculation was incorporated into the Campbell Scientific program and will provide ET estimates starting in July 2012.

Regional Trends

The annual mean temperature has been increasing at Pelly Ranch by 0.06°C per year on average over a 50-year period, corresponding to a total average increase of 3°C between 1957 and 2006. January (winter) mean temperatures have experienced the highest rate of increase (0.13°C per year on average), corresponding to a total average increase of 6.5°C over the 50-year period. The mean annual temperature at Carmacks has been increasing by 0.06°C per year on average, corresponding to a total average increase of 3.0°C between 1964 and 2011. With respect to seasonality, January mean temperatures have been increasing by 0.19°C per year on average, corresponding to a total average increase of 9.3°C from 1964 to 2011. A close correlation between monthly average temperatures recorded at Minto and at Pelly Ranch and Carmacks, as well as the proximity of the stations to the property, suggests that the 50-year trend would also be applicable to the Minto property. Winter temperatures at Minto, however, are approximately 3–5°C higher due to a predominant Yukon winter temperature inversion of +8°C/km up to an elevation of 1200 m (EBA 2010).

Using the average of five Global Climate Models that were found to perform best over Alaska and the Arctic, averages have been calculated using a 50 km buffer around the Minto mine site, and suggest an increase in mean annual temperature of 2.0 to 2.2°C by 2030 and 2.6 to 3.8°C by 2050 from the 1961-1990 baseline.

Environment Canada monthly precipitation records at Pelly Ranch and Carmacks show a general increase in total annual precipitation over the last 60 years of 1.1 mm/year and 1.4 mm/year, on average, respectively, corresponding to an increase in annual precipitation between 1955 and 2006 of between 60 and 80 mm over the region (EBA 2010).

Many GCMs predict increasing mean annual precipitation at high latitudes of North America (Nohara et al. 2006). The Scenarios Network for Alaska and Arctic Planning projections suggest an increase in annual precipitation ranging from 8 to 13% by 2030 and from 12 to 20% by 2050 from the 1961–1990 baseline.

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1 INTRODUCTION

The existing meteorology of the project area and the climate trends and projections of the Minto region of Yukon Territory were described in detail in EBA's report "Minto Mine—2010 Climate Baseline Report." This present report is an update to EBA's 2010 report and includes meteorological data up to July 2012, where available.

2 STUDY BACKGROUND

2.1 CLIMATE ZONE

Minto is located in the subarctic continental climate zone (Köppen climate classification), which is characterized by long, cold winters and short, cool summers. The area experiences moderate precipitation in the form of rain and snow and a large range of temperatures on a yearly basis with a mean annual temperature below 0°C.

2.2 REGIONAL CLIMATE

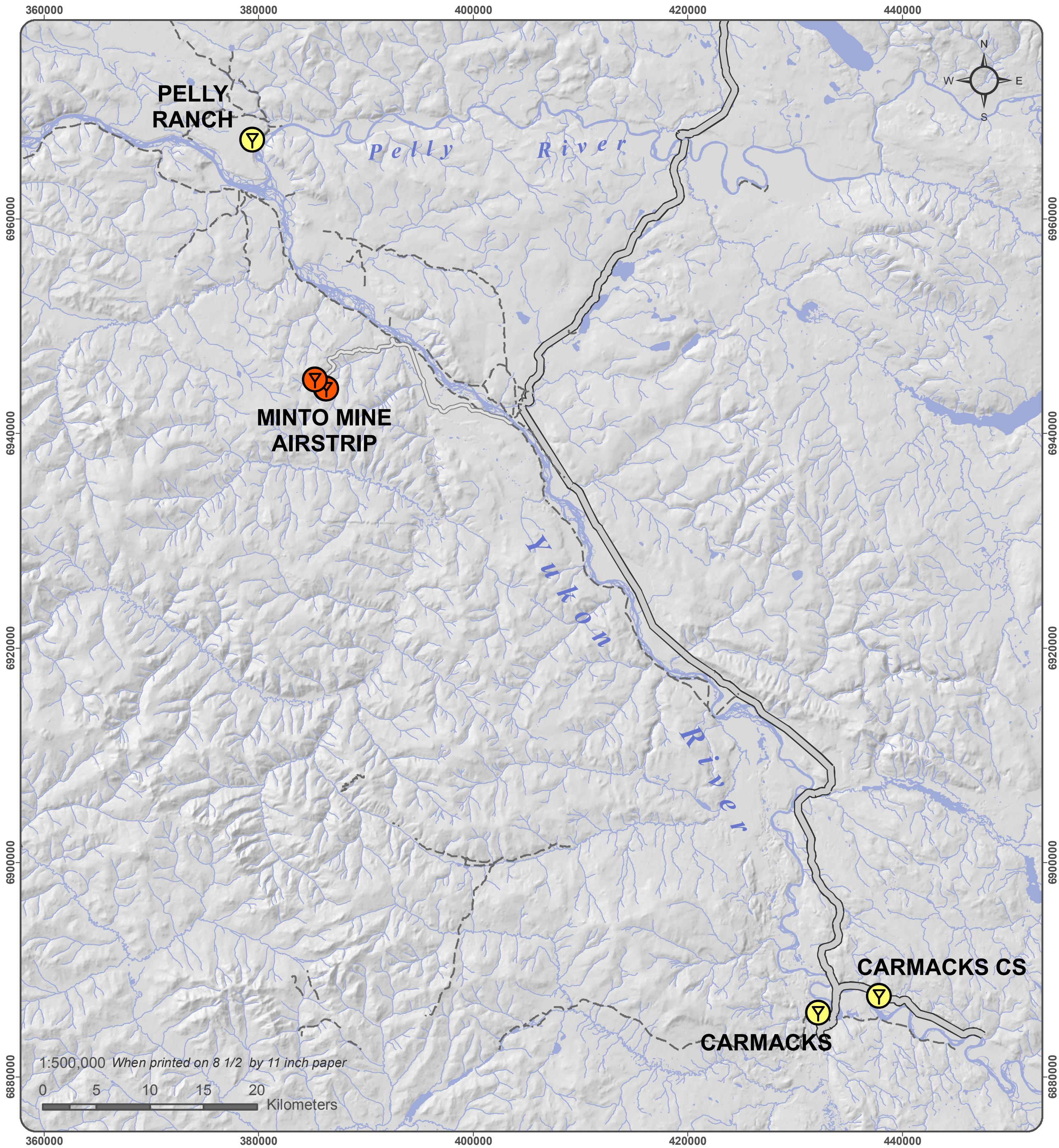
Two Meteorological Service of Canada stations provide a long-term climate record for the region (Figure 2-1). Pelly Ranch (Fort Selkirk – Climate ID#2100880) provides a continuous record of daily air temperatures and precipitation in the form of rainfall and snowfall from March 24, 1956 to February 28, 2007. Carmacks (Climate ID#2100300) provides a continuous record of daily air temperatures and precipitation in the form of rainfall and snowfall from 1963 to 2008. Another station in Carmacks (Climate ID#2100301) provides hourly records of temperature and wind speed and direction and was used to compile the monthly and annual averages from 2006 to 2012 (data from Carmacks station ID#2100300 are incomplete starting in 2006). Coordinates, elevations and distances from Minto are indicated in Table 2-1 below.

Daily data from Pelly Ranch and Carmacks provide the database for 50-year regional trends of temperature and precipitation, which are discussed following the presentation of the Minto meteorological data.

Table 2-1: Meteorological Service of Canada Stations Close to Minto.

Station	Climate ID	Years of data	Latitude	Longitude	Elevation	Distance from Minto
Pelly Ranch	2100880	1956-2007*	62°49'00" N	137°22'00" W	454.20 m	25 km to the NW
Carmacks	2100300	1963-2008	62°06'00" N	136°18'00" W	524.90 m	70 km to the SE
Carmacks CS	2100301	2000-present	62°06'54" N	136°11'31" W	542.90 m	70 km to the SE

** Data after 2007 have undergone only preliminary quality checking and are therefore not used in this report.*



Meteorological Service of Canada Station

Minto Weather Stations

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ACCESS

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FIGURE 2-1 METEOROLOGICAL SERVICE OF CANADA STATION LOCATIONS

JULY 2013

Datum: NAD 83; Projection: UTM Zone 8N

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2.3 LOCAL CLIMATE

To record meteorological parameters on site, a basic meteorological station was established at the Minto Mine site in late September 1993 at an elevation of 884 meters above sea level (masl) and intermittent temperature and precipitation data was collected (HKP 1994).

On September 7, 2005, a HOBO meteorological station on a three-metre tripod was installed by Access Consulting Ltd., with instrumentation to record wind speed and direction, air temperature, relative humidity, barometric pressure, solar radiation and rainfall at a location near camp. On April 11, 2006, the station was relocated to the airstrip (N 62º36'17", W 137º13'19", el. 887 masl). The station (Figure 2-2) has recorded, at hourly sampling intervals, the parameters of: average wind speed and direction; highest three-second wind gust; air temperature; relative humidity; on-site barometric pressure; incident solar radiation and total wet precipitation. Specifications of the installed instrumentation and details of the data collection program are contained in Appendix A.

On October 15, 2010, a Campbell Scientific (CS) meteorological station was installed adjacent to the existing HOBO meteorological station, whose anemometer was damaged by strong winds in May 2010. The other sensors of the HOBO station remained functional during the summer of 2010; therefore, only wind data is missing for the transition period. The Campbell Scientific meteorological station's anemometer was installed on a 10-meter mast, which is the standard height for collecting wind data used in air dispersion models. The other sensors installed on the Campbell Scientific station include a temperature and relative humidity sensor, a pyranometer, a rain gauge and a barometer. A photo of the station is shown in Figure 2-3, with a close-up of some of the instruments in Figure 2-4. Specifications of the installed instrumentation and details of the data collection program are contained in Appendix A.

Meteorological data recorded by the Minto HOBO and Campbell Scientific meteorological stations over a six-and-a-half-year period between September 7, 2005 and July 15, 2012 provides the database for monthly and yearly averages and seasonal observations which are discussed in detail in following sections. Meteorological data were not recorded between May 14, 2009 and July 2, 2009 because of operator error. Gaps in the data record have also occurred from July 16 to 24, 2008 and from August 27 to 31, 2009. The total period of recorded meteorological data was 2428 days on July 31, 2012. Further missing data due to specific instrument malfunction will be noted in the appropriate sections below.

The Campbell Scientific station was down for 21 days in 2010 and 30 days in 2011 because of power issues. The total period of recorded meteorological data was 573 days on July 31, 2012.

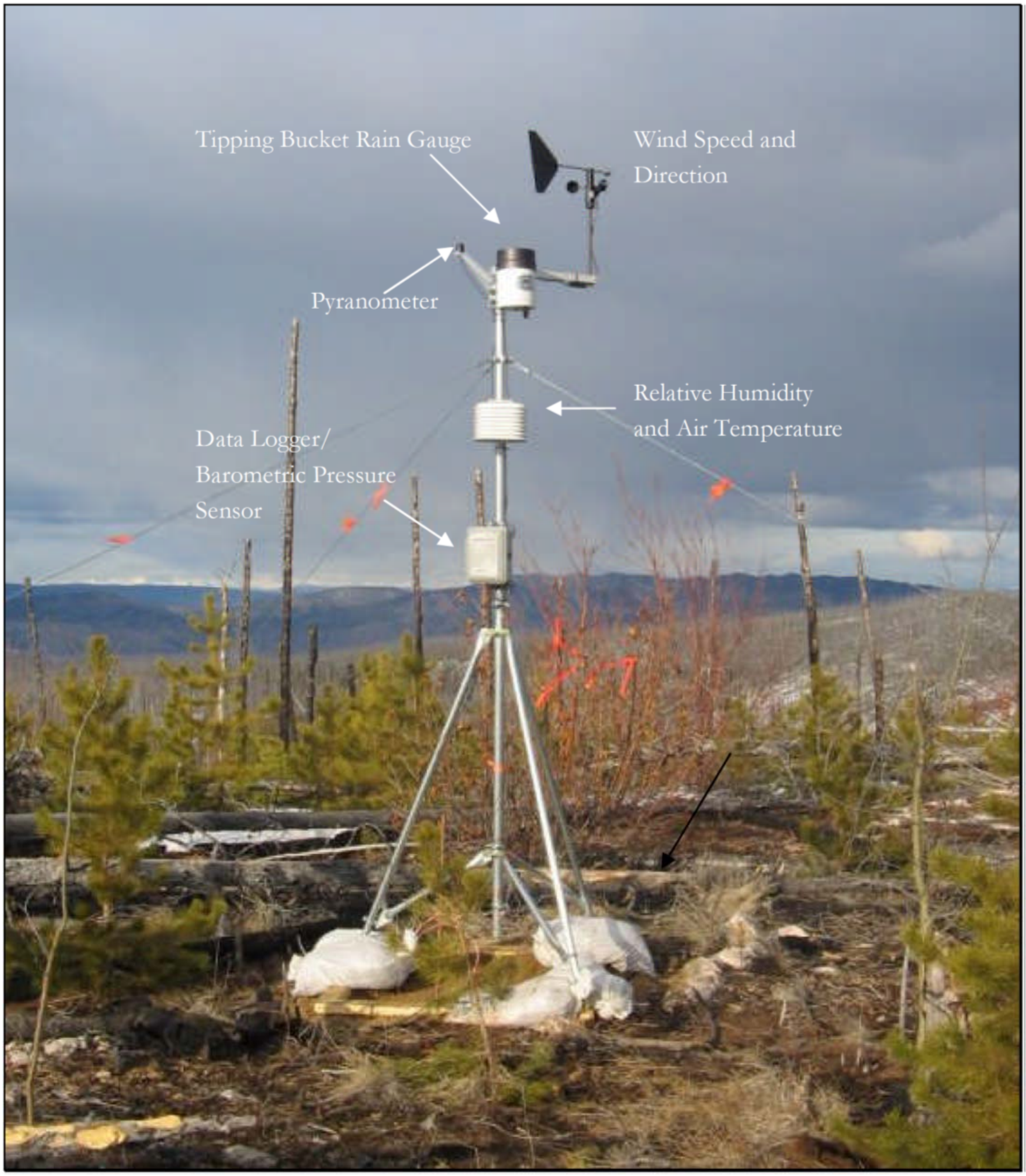


Figure 2-2: HOBO Meteorological Station at Minto *(Source: EBA 2010)*.

Figure 2-3: **Campbell Scientific Meteorological Station at Minto.**

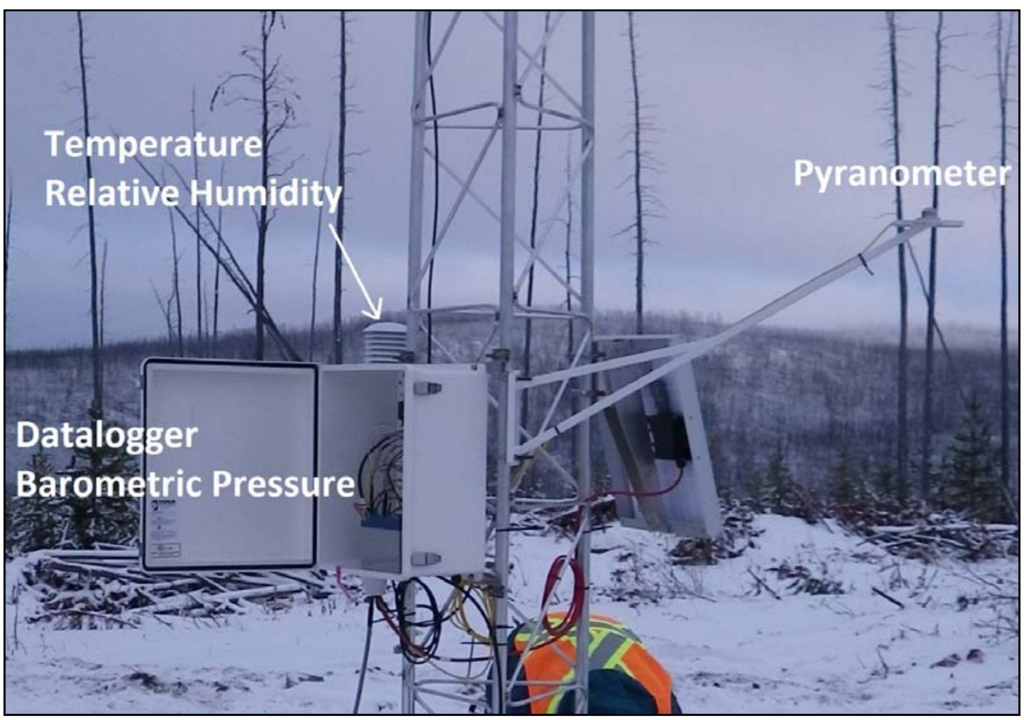


Figure 2-4: **Some of the Instrumentation of the Campbell Scientific Meteorological Station.**

3 METEOROLOGICAL PARAMETERS AND CLIMATE

3.1 AIR TEMPERATURE

3.1.1 Site Observations

Hourly air temperatures have been plotted for the entire period of record for both stations in Figure 3.1. The plot shows a strong sinusoidal seasonal pattern. The summer period, between late-May and early-September, is characterized by temperatures in the range of 10 to 20°C. The winter period, between October and March, is characterized by a much larger day-to-day variation in air temperatures, typically between –10 and –30°C, although winter temperatures in the range of 0 and –40°C are not uncommon. Diurnal variation in air temperatures tends to be less during the winter period than during the summer. The transitions between these seasons are characterized by a quick rise or fall in air temperatures during March/April and mid-September/early-October, respectively.

Table 3-1 contains the average monthly maximum, mean and minimum air temperature as well as the extreme maximum and minimum temperature for each month on record for the HOBO weather station. July has been the warmest month on average (14.6°C) while the coldest has been January (–19.1°C). The mean annual air temperature at the site is −1.8°C. The temperature values in Table 3-1 are calculated based on hourly data from September 8, 2005 to July 31, 2012.

The Campbell Scientific meteorological station has not been operating for long enough to calculate meaningful monthly averages, so monthly data per year is presented in Table 3-2 from October 15, 2010 to July 31, 2012.

Based on the data record, air temperatures would be expected to remain above zero throughout the day between June and September, while between October and March, air temperatures would typically remain below zero. The maximum air temperature ever recorded was 30.3°C on July 29, 2009. The minimum air temperature ever recorded was –43.2 on November 27, 2006 and again on January 8, 2009. Air temperatures in excess of 5°C have been observed in every winter month. Sub-zero temperatures have been recorded every month except July and August.

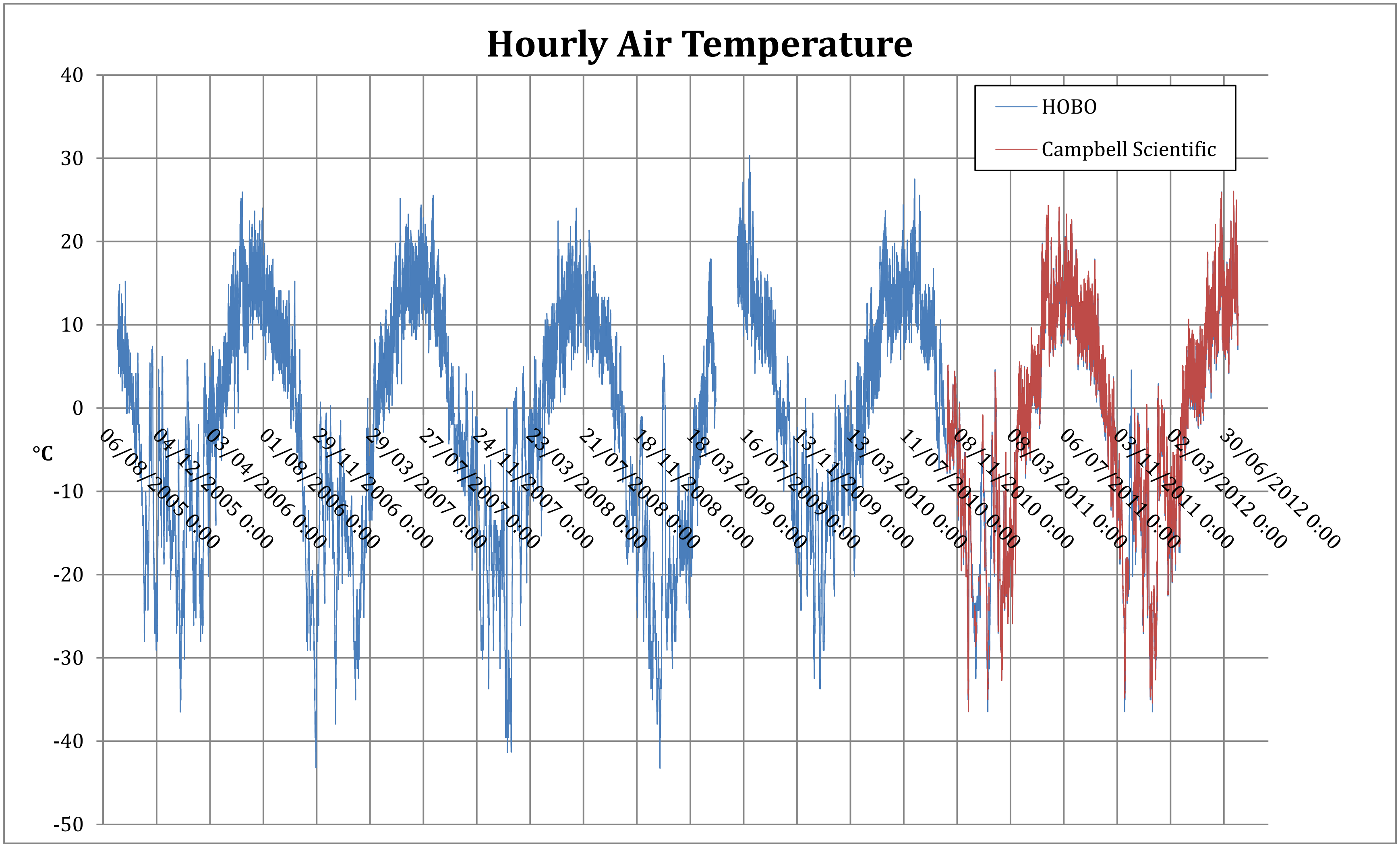


Figure 3-1: **Minto Hourly Air Temperatures 2005–2012.**

Table 3-1: Summary of Minto Monthly Meteorological Observations from HOBO station.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
****Wind**													
Average Wind Speed (m/s)	3.9	6.0	3.8	2.6	3.0	2.6	2.5	2.0	2.5	3.2	5.3	4.0	2.7
*Average Daily Wind Gust (m/s)	8.3	11.7	8.0	5.6	6.3	5.7	5.5	4.6	5.6	11.1	8.7	9.9	7.1
*Peak Wind Gust (m/s)	18.9	16.5	23.8	21.3	20.6	16.1	17.9	17.7	15.8	20.4	19.5	17.3	23.8
Air Temperature													
Extreme Hourly Maximum Temperature (°C)	6.2	5.8	5.4	17.5	23.6	26.0	30.3	27.5	17.9	15.2	7.4	6.2	30.3
Average Daily Maximum (°C)	−16.3	−11.9	−6.1	4.5	11.6	16.7	18.6	15.3	9.9	−0.1	−11.5	−12.9	1.5
Average Daily Mean (°C)	−19.1	−14.6	−9.8	0.7	7.7	12.7	14.6	11.8	6.5	−2.3	−13.7	−15.6	−1.8
Average Daily Minimum (°C)	−21.8	−17.4	−12.9	−3.0	3.7	8.8	10.8	8.2	3.5	−4.4	−10.3	−18.3	−4.4
Extreme Hourly Minimum Temperature (°C)	−43.2	−41.3	−32.5	−15.4	−2.4	−0.6	4.2	2.9	−7.3	−18.8	−43.2	−36.5	−43.2
Relative Humidity													
Average Daily Mean (%)	83	79	68	57	52	57	61	69	71	84	85	83	71
Barometric Pressure (sea level equivalent)													
Average Daily mean (hPa)	1005	1009	1003	1007	1010	1010	1011	1010	1009	1005	1004	1006	1007
Incident Solar Radiation													
Average Daily Flux (W/m^2)	10	41	112	173	219	230	213	165	106	48	14	5	111

Note: Based on average hourly observations between September 8, 2005 and April 30, 2011.
** Gust speeds calculated over three-second intervals.*
*** Based on average hourly observations between September 8, 2005 and April 2, 2010, and excludes periods of ice-affected data.*

Table 3-2: Minto Monthly Meteorological Observations from Campbell Scientific station.

Parameter	Air Temperature (°C)					Wind (m/s)		Relative Humidity (%)	Barometric Pressure (hPa)	Solar Radiation (kW/m2)	Solar Radiation (kW/m2)
	Extreme Hourly Maximum	Average Daily Maximum	Average Daily Mean	Average Daily Minimum	Extreme Hourly Minimum	Average Hourly	Maximum Hourly	Average Hourly	Average Sea Level Equivalent	Average Hourly	Average Hourly
Oct-2010	5.2	−0.7	−3.0	−4.8	−7.6	2.7	13.2	79.7	999.6	38	0.04
Nov-2010	4.4	−6.4	−8.8	−11.0	−20.6	3.5	15.6	85.1	1005.2	11	0.01
Dec-2010	−8.5	−10.0	−19.6	−12.8	−36.4	0.8	6.6	85.5	1014.8	5	0.00
Jan-2011	−0.8	−11.3	−14.8	−14.2	−35.0	2.2	12.6	84.9	n/a	16	0.02
Feb-2011	4.3	−13.2	−17.1	−20.5	−32.7	3.3	15.7	77.8	n/a	38	0.04
Mar-2011	5.6	−7.2	−11.0	−14.5	−25.9	1.9	9.0	58.7	n/a	113	0.11
Apr-2011	9.7	3.5	0.4	−2.8	−7.9	3.2	9.2	57.8	n/a	182	0.18
May-2011	24.3	12.9	9.0	5.2	−2.0	3.7	12.3	53.5	n/a	221	0.22
Jun-2011	24.1	15.7	12.3	9.2	5.0	2.9	10.4	65.2	n/a	202	0.20
Jul-2011	23.3	17.5	13.8	10.7	7.7	2.9	8.9	66.5	n/a	200	0.20
Aug-2011	19.0	14.0	10.4	7.2	4.8	3.5	11.0	70.8	n/a	162	0.16
Sep-2011	17.7	10.9	7.1	3.9	−0.7	3.9	14.3	63.3	n/a	113	0.11
Oct-2011	7.5	1.1	−1.8	−4.4	−13.1	2.3	15.0	80.5	n/a	50	0.05
Nov-2011	−4.0	−15.2	−17.6	−18.9	−34.8	2.3	12.6	84.4	n/a	168	0.17
Dec-2011	0.0	−5.7	−10.5	−9.6	−26.9	2.2	15.4	79.3	n/a	4	0.00
Jan-2012	0.4	−18.1	−21.3	−24.5	−35.4	2.2	9.2	77.1	n/a	8	0.01
Feb-2012	2.7	−4.8	−7.6	−10.3	−23.2	3.5	16.6	73.6	n/a	32	0.03
Mar-2012	5.1	−5.3	−8.8	−12.1	−20.8	1.8	6.1	71.3	997.2	67	0.07
Apr-2012	10.7	6.5	3.2	−0.3	−6.2	2.6	8.5	55.2	1007.9	173	0.17
May-2012	18.7	10.2	6.5	2.7	−2.2	5.0	16.6	51.0	1006.7	215	0.22
Jun-2012	25.9	16.8	12.8	9.0	1.9	3.4	9.2	57.8	1007.9	221	0.22
Jul-2012	26.0	17.9	13.8	9.9	4.2	3.7	10.9	58.6	1010.1	223	0.22

3.1.2 Regional and Future Trends

Meteorological Service of Canada stations located at Pelly Ranch and Carmacks provide a 50-year historical record of monthly averages of daily maximum, mean and minimum air temperatures from which an annual average is determined.

Figure 3-2 illustrates the annual maximum (plotted in red), mean (green) and minimum (blue) air temperatures along with the respective trendlines and slopes at Pelly Ranch between 1957 and 2006. Annual maximums and minimums are calculated as an average of monthly maximum and minimum temperatures for each year. Annual averages are not plotted in years where months with missing data exist.

The plots show a similar trend for all annual averages. The annual mean temperature has been increasing at Pelly Ranch by 0.06°C per year on average over the 50-year period corresponding to a total average increase of 3°C from 1957 to 2006. It is also important to note that the average annual minimum temperature has been increasing at a faster rate than the average annual maximum temperature, thus implying that the average diurnal range has also been decreasing over the same 50-year period.

Figure 3-3 illustrates the average maximum, mean and minimum temperatures for January (blue), April (green) and July (blue) over the same period in order to better illustrate the trend with respect to seasonality. The plot shows that January (winter) mean temperatures have experienced the highest rate of increase (0.13°C per year on average), corresponding to a total average increase of 6.5°C over the 50-year period.

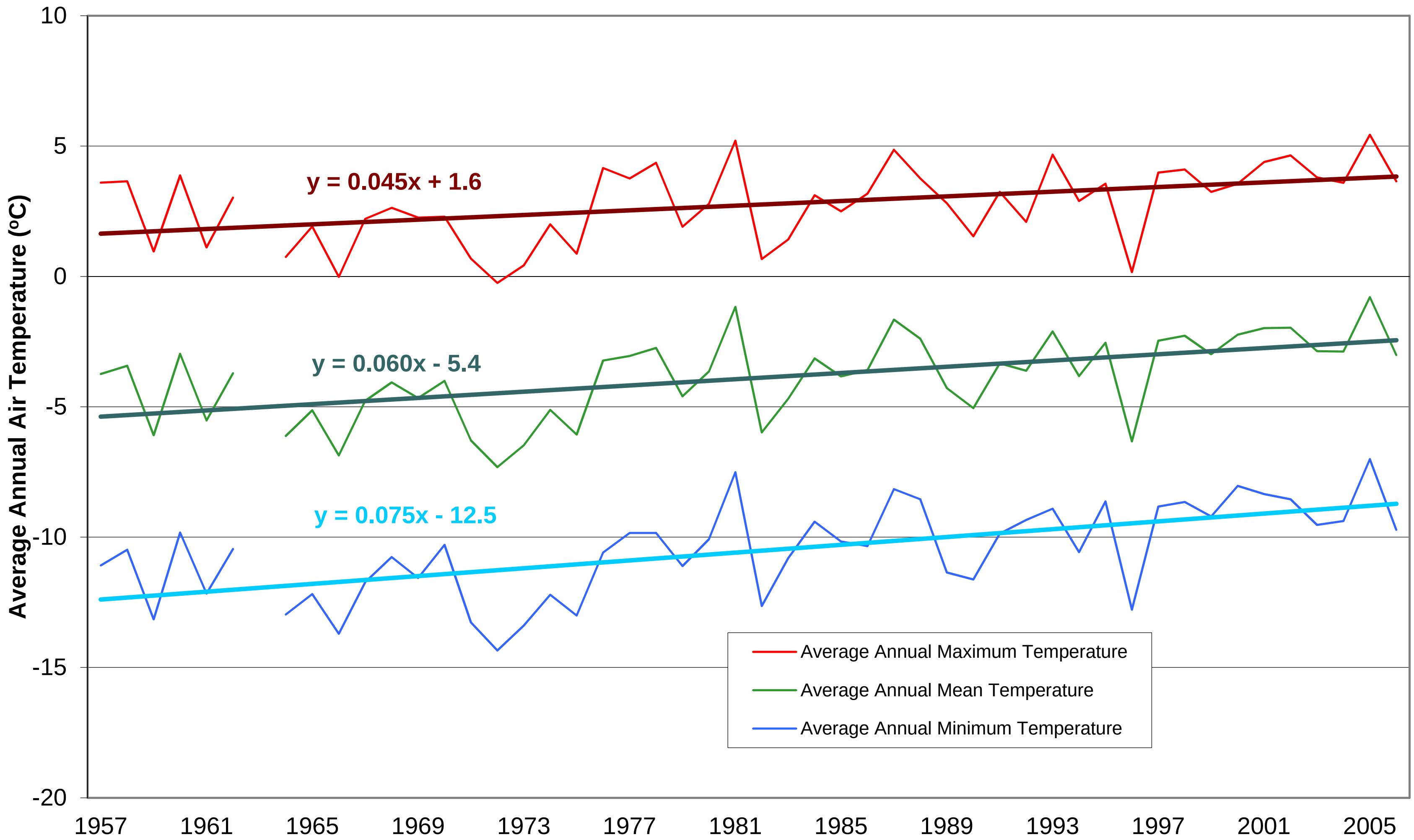


Figure 3-2: **Pelly Ranch Average Annual Air Temperature Trends 1957–**2006 *(Source: Meteorological Service of Canada / EBA 2010).*

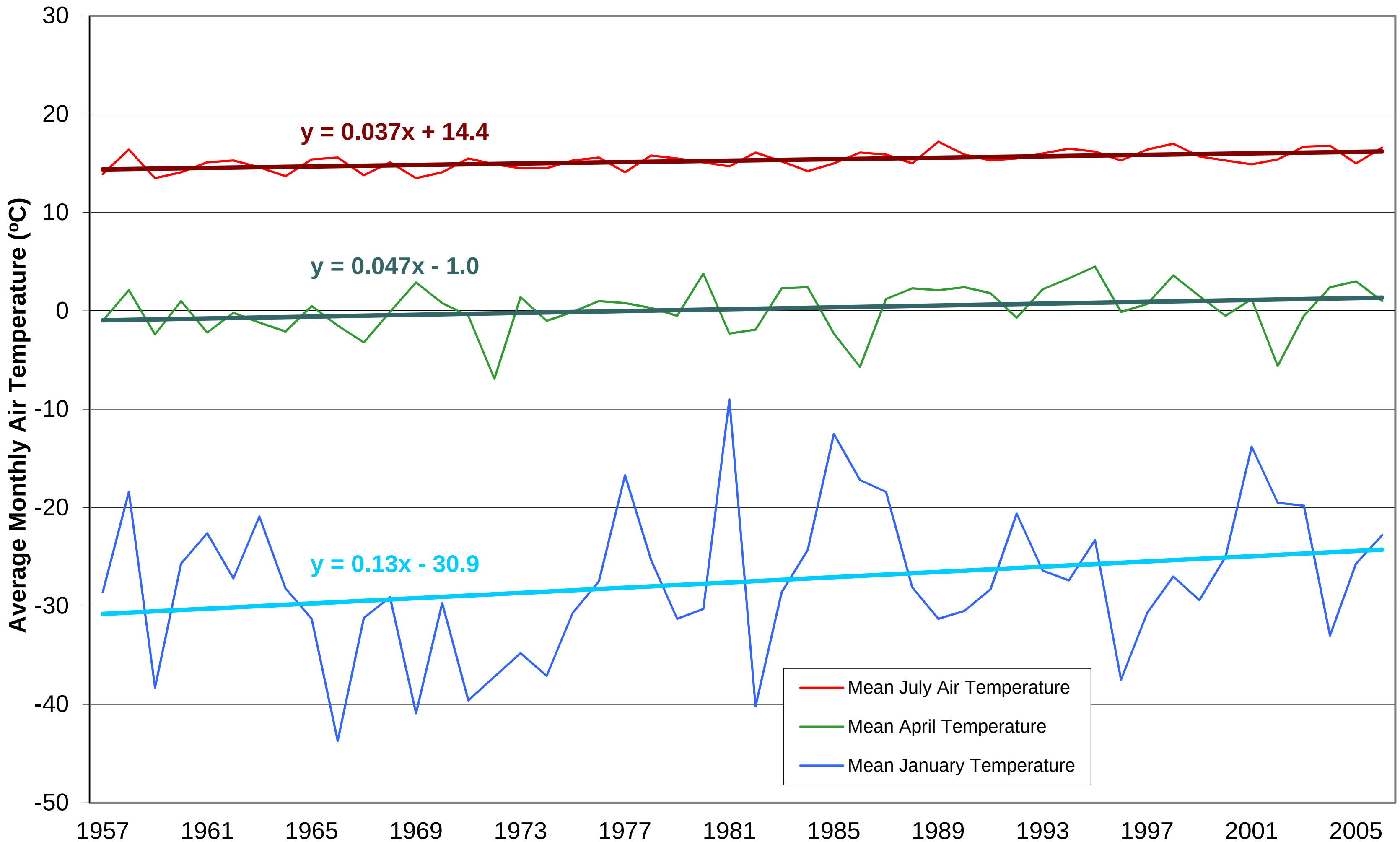


Figure 3-3: Pelly Ranch Seasonal Temperature Trends, January, April, and July 1957–2006 *(Source: Meteorological Service of Canada / EBA 2010).*

The same data plotted for Carmacks, in Figures 3-4 and 3-5 respectively, shows a similar trend. The mean annual temperature has been increasing by 0.063°C per year on average, corresponding to a total average increase of 3.0°C between 1964 and 2011. The 47-year trend shows that the average annual maximum temperature has been increasing at a faster rate on average than the average annual minimum temperatures, which is atypical of the general observed trend in Canada. With respect to seasonality, January mean temperatures have been increasing by 0.19°C per year on average, corresponding to a total average increase of 9.3°C from 1964 to 2011, while July mean temperature has been increasing at a much slower rate of 0.02°C per year on average, corresponding to a total average increase of 1.05°C. The seasonal trend observed in Carmacks is more typical of the general observed trend in Canada.

The proximity of the regional stations to the Minto mine site (25 km and 70 km, respectively) would suggest that the observed trends in annual temperatures are applicable to the Minto region as well. To show the correlation of air temperatures between sites, mean monthly air temperatures recorded at all three sites have been plotted together over the period between October 2005 and July 2012 in Figure 3-6. The data record at Pelly Ranch ends in March 2007. Months where a complete set of daily data does not exist have been omitted from the plot.

The plot shows a close correlation between the three data sets; however, mean winter temperatures are approximately 3–5°C higher at Minto (887 m) than at the regional stations (454 m, 525 m) attributed to a general winter temperature inversion in the Yukon where temperatures increase with height (Wahl et al. 1987). Analysis of a 43-year period of radiosonde data (1958–2000) from Whitehorse shows a long-term average lapse rate of approximately +8°C/ km up to an elevation of 1500 m during the winter (Pinard 2009). The positive sign indicates a warming with elevation, or an inversion.

The data in Figure 3-6 would suggest that based on the past five years of data, the observed 47 and 50-year trends are also applicable to the Minto site although the magnitude of the increase cannot be definitively determined, in particular, during winter months.

Due to an exponential increase in global CO_2 and to other anthropogenic factors, past trends provide only a conservative estimate when predicting temperature increase due to climate change into the future.

Projections from Global Climate Models (GCM) predict continued warming: 0.2°C per decade over the next two decades globally (IPCC 2007). Climate change projections have been obtained from the Northern Climate ExChange, Yukon Research Centre for an analysis of the range of changes in temperature and precipitation projected for the Project area. The projections, produced by the Scenarios Network for Alaska and Arctic Planning cover two emission scenarios – B1, moderate to low climate change and A1B, medium to high climate change, over 2 time-scales – 2030 and 2050 - using the average of five GCMs that were found to perform best over Alaska and the Arctic, and are statistically downscaled to a 2 km resolution over Yukon using the Parameter-elevation on Independent Slopes Model (PRISM) (SNAP, 2011). Averages have been calculated using a 50 km buffer around the Minto mine site, and suggest an increase in mean annual temperature of 2.0 to 2.2°C by 2030 and 2.6 to 3.8°C by 2050 from the 1961-1990 baseline (Figure 3-7).

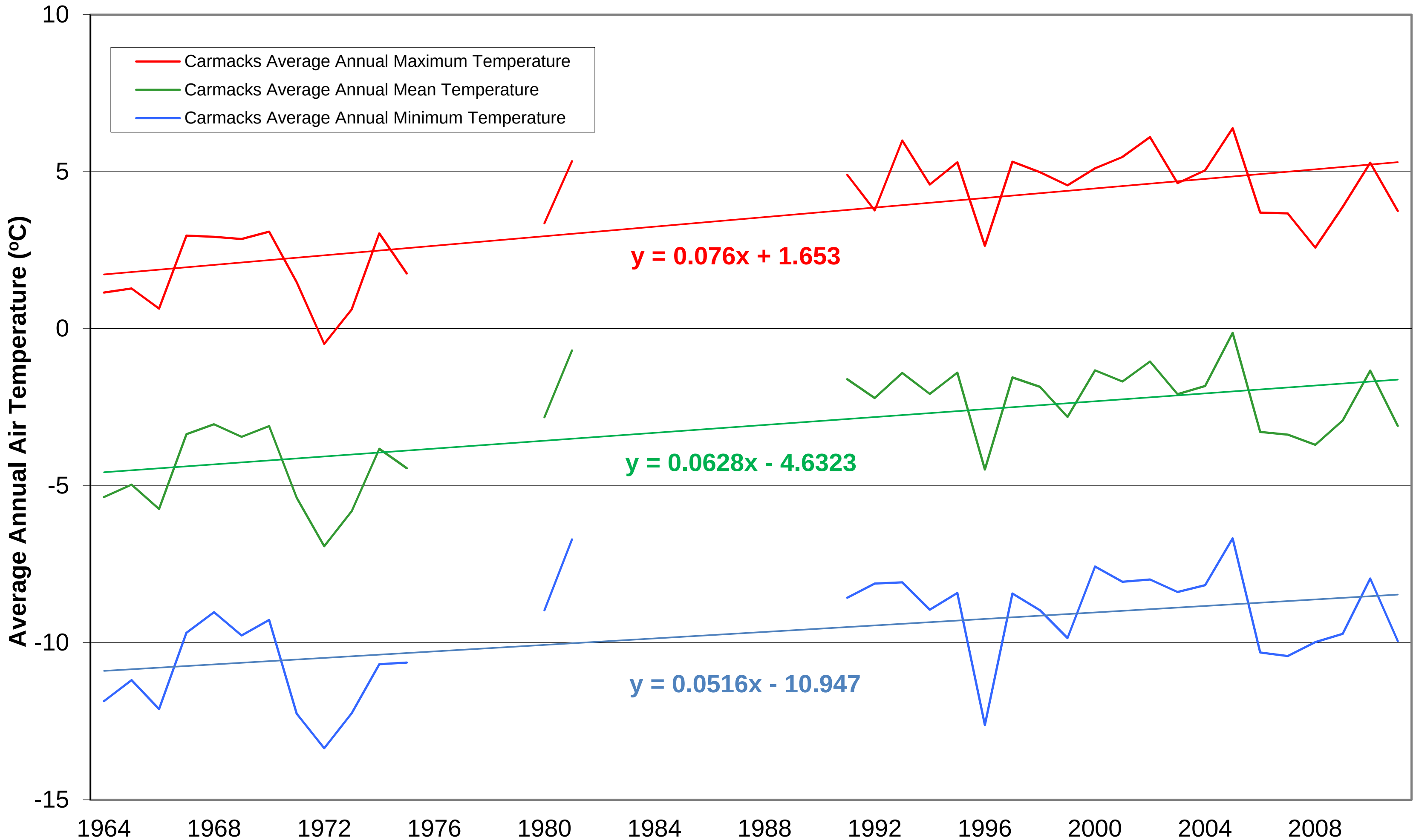


Figure 3-4: Carmacks Annual Temperature Trends 1964–2010 (*Source: Meteorological Service of Canada*).

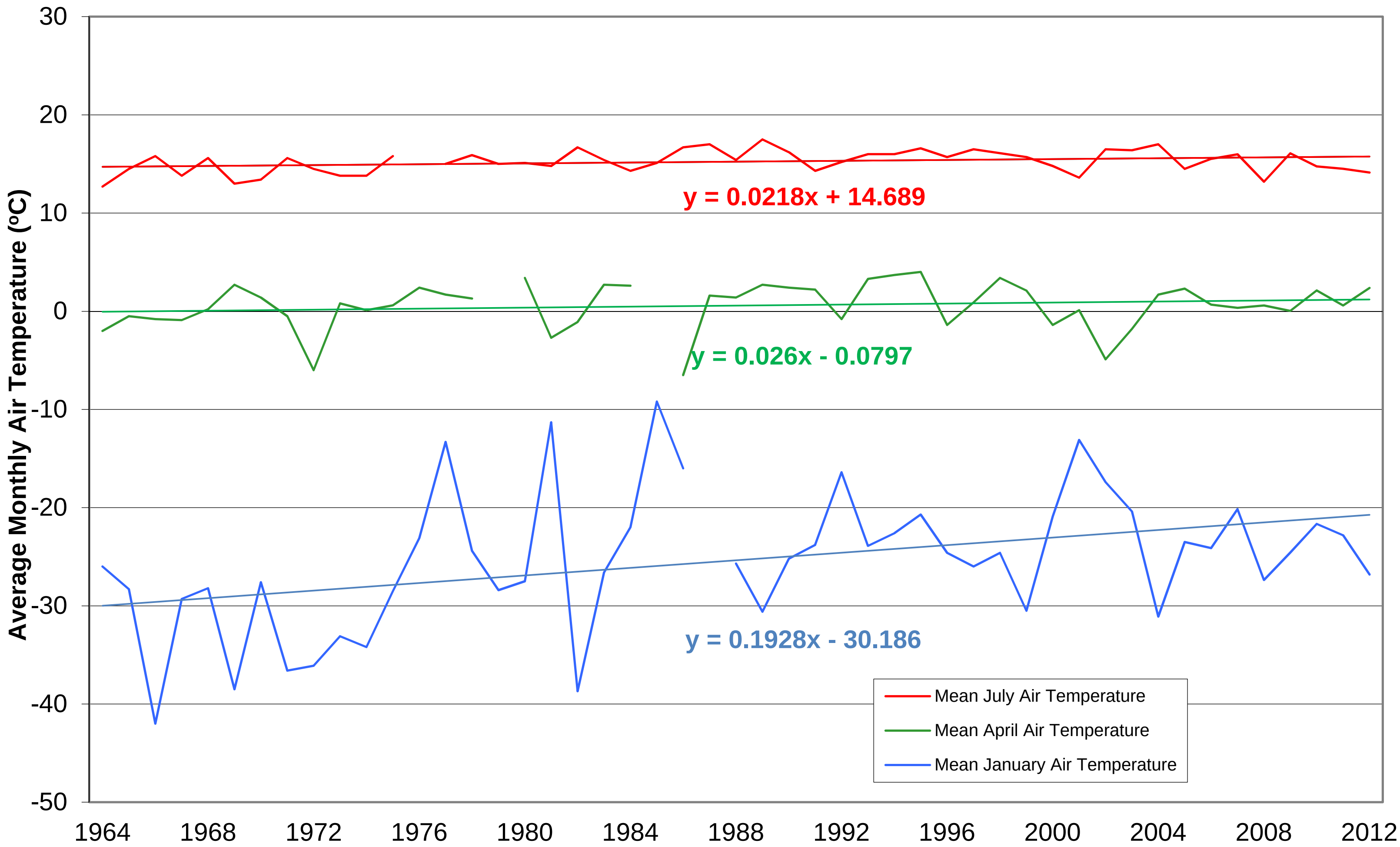


Figure 3-5: Carmacks Seasonal Temperature Trends, January, April, and July 1964–2010 (*Source: Meteorological Service of Canada*).

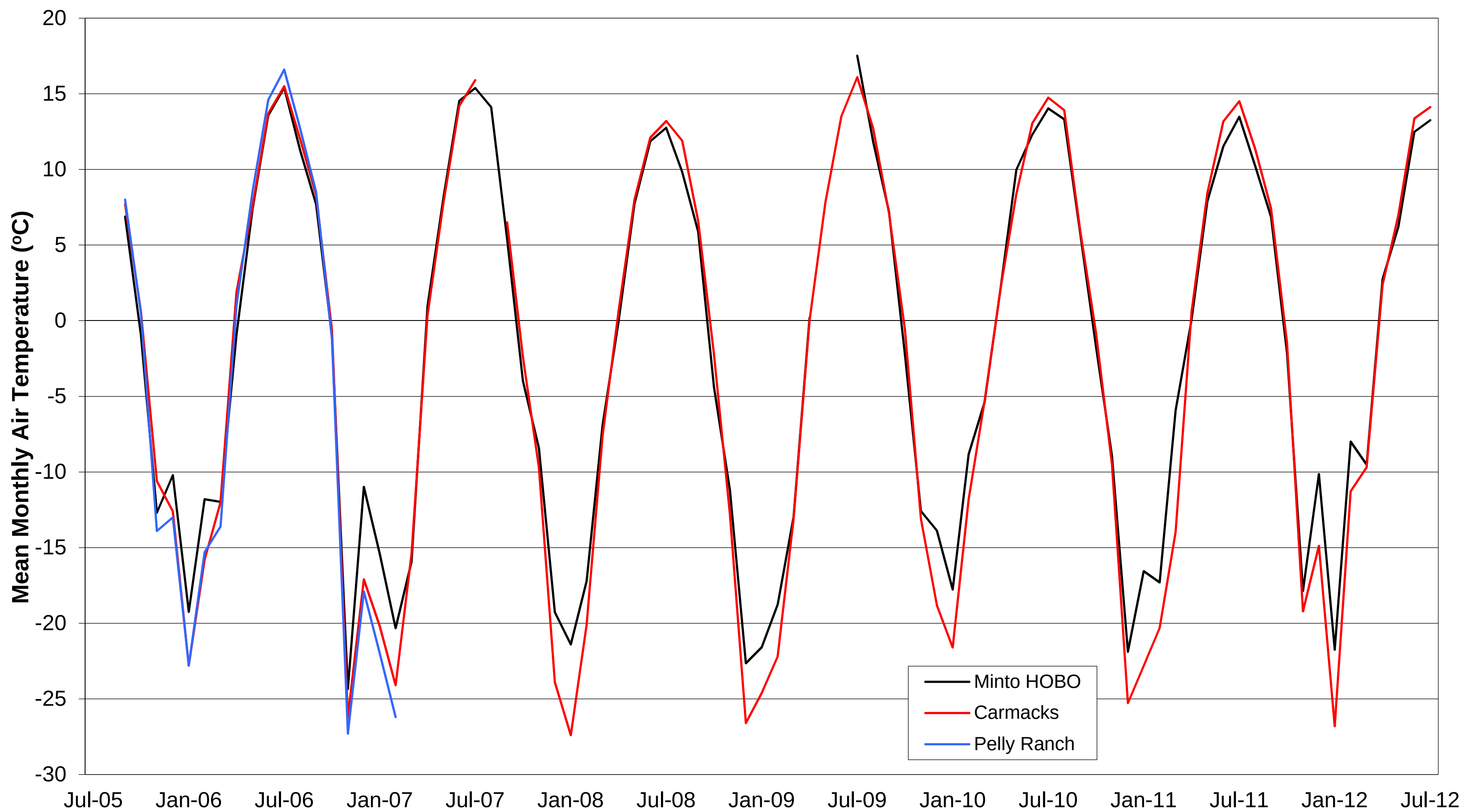
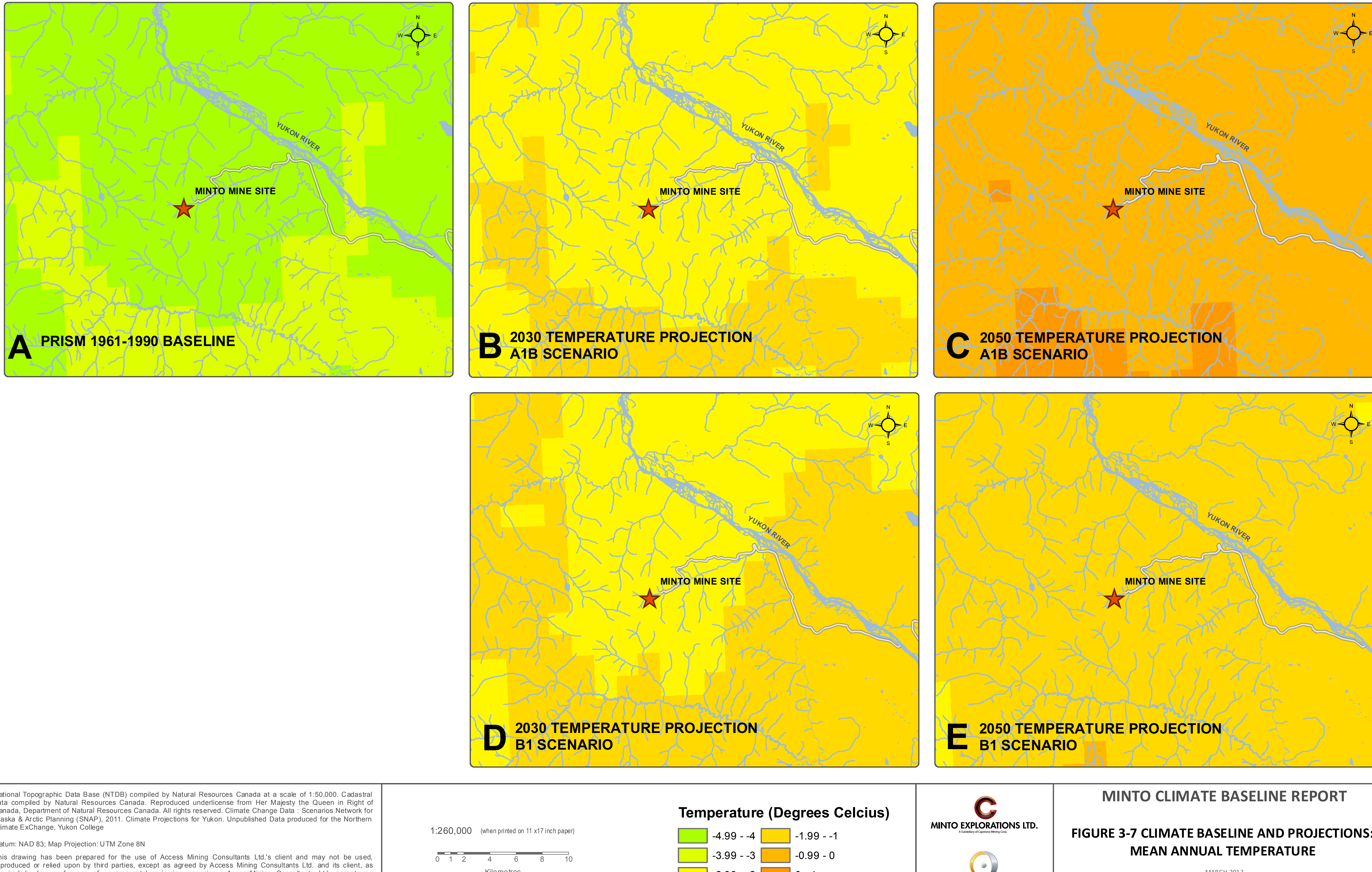


Figure 3-6: Mean Monthly Temperature Comparison Pelly Ranch, Carmacks, & Minto 2005–2011 (*Source: Meteorological Service of Canada*).



National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced underlicense from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved. Climate Change Data : Scenarios Network for Alaska & Arctic Planning (SNAP), 2011. Climate Projections for Yukon. Unpublished Data produced for the Northern Climate ExChange, Yukon College

Datum: NAD 83; Map Projection: UTM Zone 8N

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FIGURE 3-7 CLIMATE BASELINE AND PROJECTIONS: MEAN ANNUAL TEMPERATURE

MARCH 2013

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3.2 WINDS

The average wind speed and direction and the maximum wind gust averaged over a three second period for each hour were recorded by the Minto HOBO meteorological station, at a height of 3 meters above the ground. The anemometer was damaged by strong winds in May 2010, so that represents the extent of the HOBO wind record. Since the HOBO wind sensor was strongly affected by rime icing (see Figure 3-8), much of the record is ice-affected at temperatures below zero.

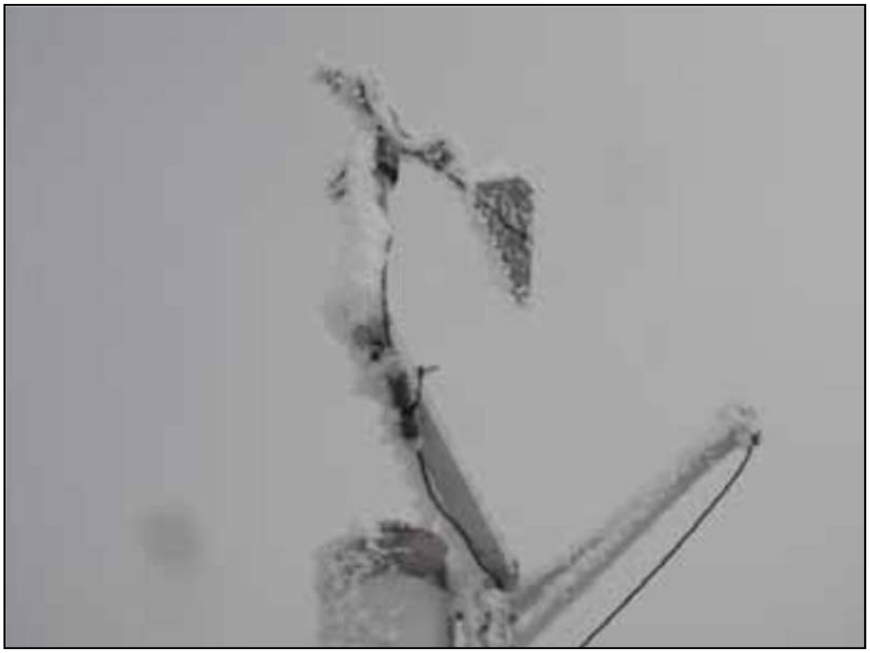


Figure 3-8: Rime Icing Affecting the Minto HOBO Anemometer *(Source*: *EBA 2010*).

Periods when the anemometer cups are not rotating due to ice build-up are recorded as 0 m/s and are easily identified in the record and flagged (for both the HOBO and the Campbell Scientific anemometers). However, ice build-up on the anemometer can result in extended periods of non-zero but diminished wind speeds of varying degree and duration which are difficult to arbitrarily omit from the record. In EBA's *2010 Climate Baseline Report*, all wind speeds and directions recorded below 0°C were flagged and omitted from analysis in order to reduce uncertainty in the data. For consistency, that same approach was kept in the present report for the HOBO wind data, and the values presented in Table 3-1 are only based on wind data recorded at temperatures above zero. Note that this introduces a bias in the winter wind data, as almost exclusively strong southerly winds (associated with warmer temperatures) end up being kept in the winter wind record (as can be observed in Appendix B showing monthly wind plots for the HOBO station). Figure 3-9 shows statistics on the wind data used to compile the summary presented in Table 3-1.

The new Campbell Scientific anemometer is at a height of 10 meters above the ground and was programmed to record wind speed and direction. This anemometer seems to have been much less affected by ice so far, so most of the winter wind data was kept in the record, to provide a general idea of winter wind patterns. It is however important to keep in mind that if some icing occurred on the Campbell Scientific anemometer, winter wind speeds may be underestimated in the record.

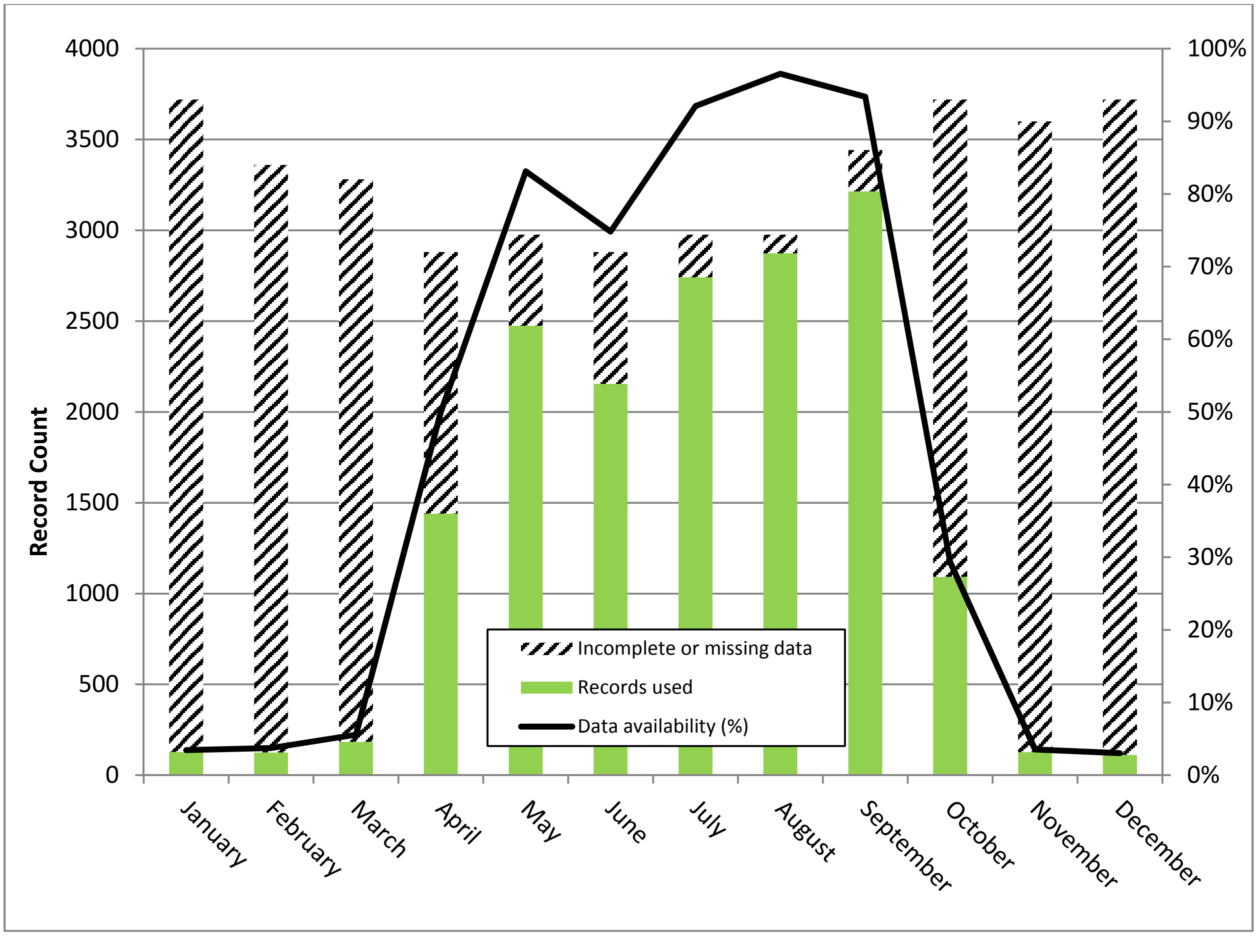


Figure 3-9: HOBO Wind Data Availability Statistics 2005–2010.

3.2.1 Average Wind Speed and Direction

The wind roses in Figures 3-10 and 3-11 are graphic representations of wind observations recorded by the two Minto meteorological stations over the period of record. Because the anemometer height is different on the two stations (3 meters for the HOBO stations and 10 meters for the CS station), the wind data collected by each station was treated separately. Table 3-3 contains information on the data used for each wind rose. It is interesting to note that the record from the two stations is relatively consistent with regard to wind speed and direction, although the Campbell Scientific station generally recorded higher wind speeds and a more southeasterly component while the HOBO displays a more southerly component. This can be explained by the fact that the CS anemometer is higher above the ground (where there is less friction and less turbulence) and that the CS record is missing less data (90.26% data available for CS anemometer versus 42.16% for the HOBO).

Table 3-3 Wind Data Summary Table.

	HOBO	Campbell Scientific
Dates	September 2005 – April 2010	October 2010 – July 2012
Number of hours of data	39531	15726
Average wind speed	2.65 m/s	2.90 m/s
Calm winds count	3227	3346
Calm winds frequency	8.16%	21.28%
Data Available	42.17%	90.26%
Incomplete or missing data count	22862	1532
Total data used	16669	14194

The wind roses illustrate the frequency of occurrence of winds blowing within a specified speed range and compass direction from which winds were observed, expressed as a percentage of the period of record. It illustrates predominant wind directions and the distribution of speeds at which these winds blow.

The wind roses presented in this report groups wind speeds into ranges from 0 to 1 m/s (calm), 1 to 3 m/s, 3 to 5 m/s, 5 to 7 m/s, 7 to 9 m/s, 9 to 11 m/s and > 11 m/s. Wind directions are grouped into 16 compass directions each with a range of 22.5 degrees and denoted as N, NNE, NE, etc. The data is summarized in the wind speed and direction frequency distribution tables located below the wind roses. The color of the section used to display winds in each compass direction is indicative of the wind speed. The length of the colored section represents the percentage of time winds blew at that speed from that particular direction.

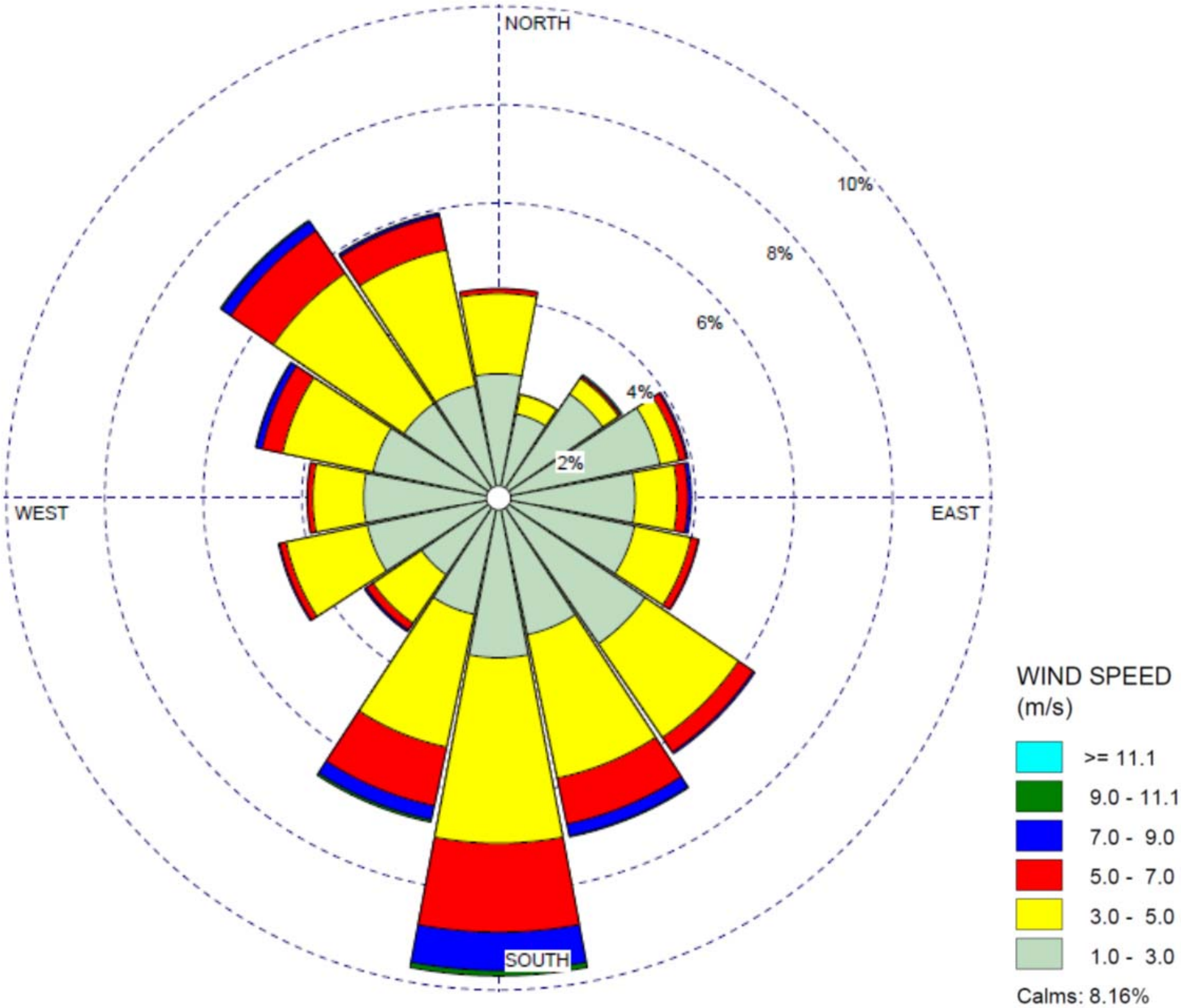


Figure 3-10: Minto HOBO Meteorological Station Wind Plot, September 2005–April 2010.

Table 3-4: Minto HOBO Meteorological Station Wind Frequency Distribution, September 2005–April 2010.

Directions / Wind Classes (m/s)	1.0–3.0	3.0–5.0	5.0–7.0	7.0–9.0	9.0–11.0	>= 11.0	Total (%)
N	2.5	1.6	0.1	0.0	0.0	0.0	1.8
NNE	1.7	0.4	0.0	0.0	0.0	0.0	0.9
NE	2.6	0.4	0.0	0.0	0.0	0.0	1.3
ENE	3.3	0.4	0.1	0.0	0.0	0.0	1.7
E	2.8	0.8	0.2	0.1	0.0	0.0	1.6
ESE	2.8	1.2	0.2	0.0	0.0	0.0	1.8
SE	3.6	2.3	0.4	0.0	0.0	0.0	2.7
SSE	2.8	3.0	0.9	0.2	0.0	0.0	3.0
S	3.2	3.8	1.8	0.8	0.1	0.0	4.1
SSW	2.4	2.7	1.2	0.3	0.1	0.0	2.8
SW	1.9	1.2	0.2	0.0	0.0	0.0	1.4
WSW	2.7	1.7	0.1	0.0	0.0	0.0	1.9
W	2.7	1.0	0.1	0.0	0.0	0.0	1.6
WNW	2.6	1.9	0.4	0.1	0.0	0.0	2.1
NW	2.3	3.2	1.0	0.2	0.0	0.0	2.9
NNW	2.3	2.8	0.7	0.0	0.0	0.0	2.5
Sub-Total	17.9	12.0	3.2	0.8	0.1	0.0	34.0
Calms							8.2
Missing/Incomplete							57.8
Total							100.0

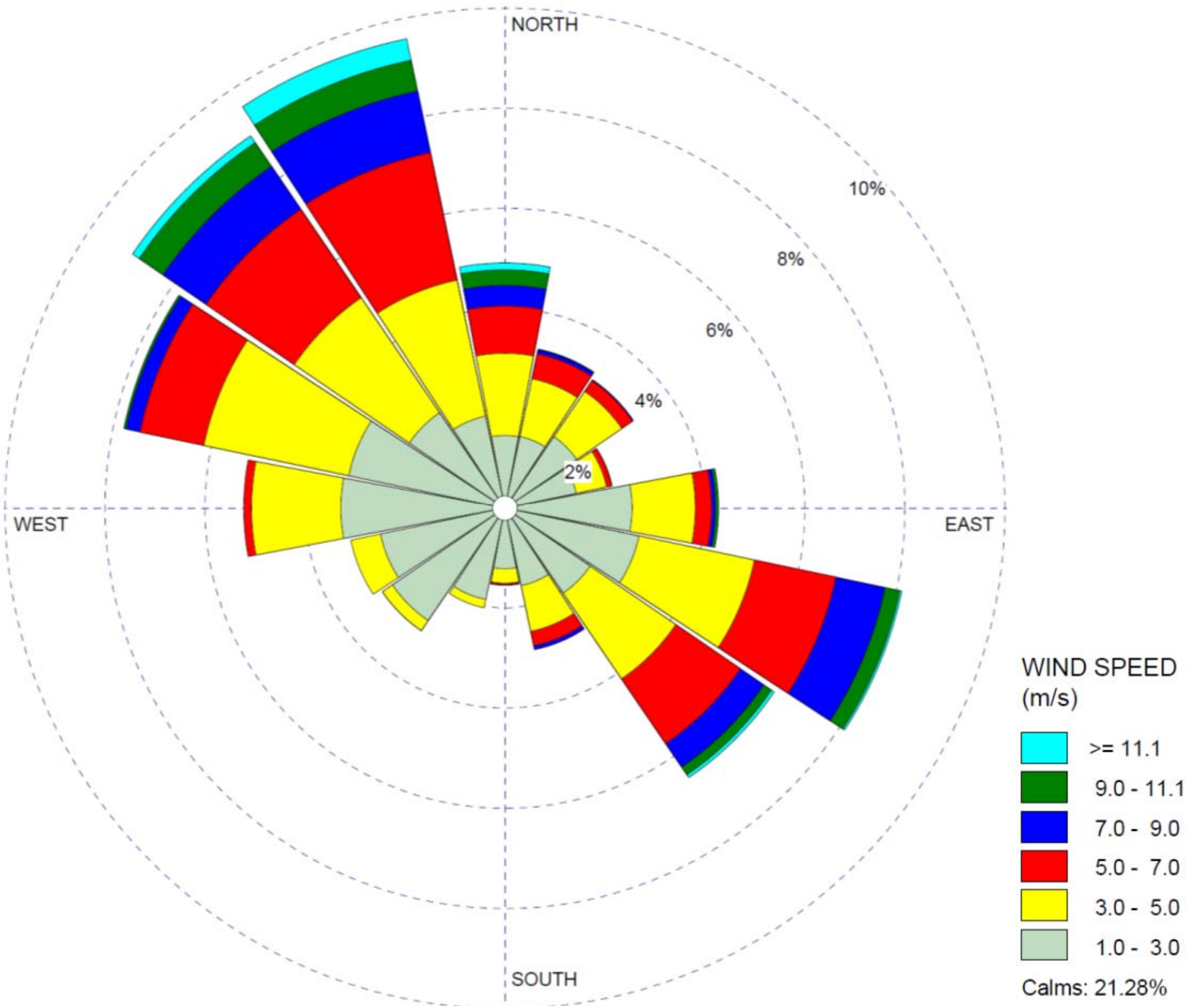


Figure 3-11: Minto Campbell Scientific Meteorological Station Wind Plot, October 2010–July 2012.

Table 3-5: Minto Campbell Scientific Meteorological Station Wind Frequency Distribution, October 2010–July 2012.

Directions / Wind Classes (m/s)	1.0–3.0	3.0–5.0	5.0–7.0	7.0–9.0	9.0–11.0	>= 11.0	Total (%)
N	1.5	1.6	0.9	0.4	0.3	0.1	4.4
NNE	1.5	1.2	0.5	0.1	0.0	0.0	2.9
NE	1.7	1.1	0.3	0.0	0.0	0.0	2.8
ENE	1.5	0.6	0.1	0.0	0.0	0.0	2.0
E	2.5	1.3	0.3	0.1	0.1	0.0	3.8
ESE	2.7	2.4	1.7	1.0	0.3	0.0	7.3
SE	2.1	2.1	1.6	0.6	0.2	0.1	5.9
SSE	1.6	0.9	0.3	0.1	0.0	0.0	2.6
S	1.2	0.3	0.0	0.0	0.0	0.0	1.4
SSW	1.9	0.2	0.0	0.0	0.0	0.0	1.8
SW	2.7	0.2	0.0	0.0	0.0	0.0	2.7
WSW	2.5	0.6	0.0	0.0	0.0	0.0	2.8
W	3.3	1.8	0.2	0.0	0.0	0.0	4.7
WNW	3.2	3.0	1.3	0.3	0.0	0.0	7.0
NW	2.3	2.8	2.1	1.0	0.6	0.2	8.1
NNW	1.9	2.8	2.6	1.2	0.6	0.4	8.6
Sub-Total	30.7	20.5	10.7	4.3	1.9	0.8	69.0
Calms							21.3
Missing/Incomplete							9.7
Total							100.0

Based on the wind record from the two meteorological stations, and excluding periods where the anemometer was iced up, the two predominant wind directions at site are S to SE and N to NW. The cumulative frequency of winds originating from the S and SE (calculated based on 8 wind categories) is 12.42% for the HOBO station and 14.8% for the Campbell Scientific station. The cumulative frequency of winds originating from the N and NW is 8.8% for the HOBO station and 26.2% for the Campbell Scientific station.

The bottom row in the distribution tables (Tables 3-4 and 3-5) totals all recorded wind speeds within the specified speed ranges. Over the period of record, winds have been below 3 m/s 29.9% of the time, of which 8.2% are considered as calm (less than 1 m/s), for the HOBO station and 51.2% of the time, of which 21.3% are considered calm, for the Campbell Scientific station. Note that these percentages are calculated with respect to the entire record and that if we exclude periods of missing data, the ratios are much higher (especially for the HOBO station). Winds have been recorded in excess of 7 m/s over only 0.9% of the HOBO record and 7% of the Campbell Scientific record. As previously mentioned however, this distribution does not account for winter periods where ice on the anemometer may have caused slower winds speeds so non-zero winter wind speeds may be underestimated.

Tables 3-1 and 3-2 display the average wind speed by month based on the period of record for the HOBO and Campbell Scientific stations respectively.

The mean annual wind speed is 2.65 m/s for the HOBO station. A seasonal pattern is evident, with average wind speeds exceeding 4 m/s during the winter months (November through March at temperatures greater than 0°C). During the spring, summer and early fall, wind speeds average less than 3 m/s. Again it is worth noting that the winter wind record is incomplete, and that this may affect observed averages and seasonal patterns.

The Campbell Scientific station does not have a long enough record to calculate meaningful monthly or annual averages, but based on the data collected to date, the average wind speed is 2.9 m/s, and no seasonal pattern is apparent at this point.

3.2.2 Wind Gusts

Table 3-1 also shows the average and maximum recorded three-second wind gust by month for the HOBO weather station. Following the trend observed for average wind speeds, wind gusts are more intense during the spring months (typically in excess of 11 m/s), with the highest value of 13.0 m/s observed in May. Again, the lowest average gust speed (7.3 m/s) is observed in January. The annual mean wind gust speed is 10.3 m/s. The highest three-second gust recorded was 63.5 m/s on April 24, 2009; although higher wind gusts occurring during the winter may not have been recorded.

3.2.3 Future Trends

Projected wind patterns affected by climate change are estimated principally by increasing wind strength and heightened frequency of extreme weather events in Canada (Pearce et al. 2009). Hinzman et al. (2005), found that the number of high wind events (defined as those with peak wind gusts in excess of 25 m/s, and a sustained wind of minimum 20 m/s) in Barrow, Alaska have increased significantly, particularly in winter, from 1970-1980 (mean of 5 events annually) to 1990-2000 (mean of 12 events annually) as a result of synoptic conditions characterized most generally by stronger cyclonic and anti-cyclonic systems.

As wind speeds at the Minto site are relatively low (less than 7 m/s over 90% of the time, Tables 3-4 and 3-5), it is unlikely that the predicted increase in wind speeds will be highly significant in an overall sense; however, instantaneous gusts would be expected to be stronger on occasion with speeds exceeding 25 m/s during peak wind events.

3.3 RELATIVE HUMIDITY

Hourly relative humidity recorded at the site is plotted for the entire period of record in Figure 3-12 and illustrates a seasonal pattern. Relative humidity is highest during the winter months (typically in the range of 75% to 95%) and lowest during the spring and early summer, typically in the range of 40% to 60%; although levels exceeding 90% are not uncommon.

Relative humidity has a much larger day-to-day variability during the summer months. The lowest recorded hourly relative humidity was 10.25% (June 20, 2007). The highest was 100%, on several occasions. Table 3.1 shows the average daily mean %RH by month. Relative humidity is typically greater than 80% between October and February. During the summer months, the daily mean is typically in the range of 50% to 60%, although part of the reason for the lower average is a higher variance. Annually, mean relative humidity is 71%.

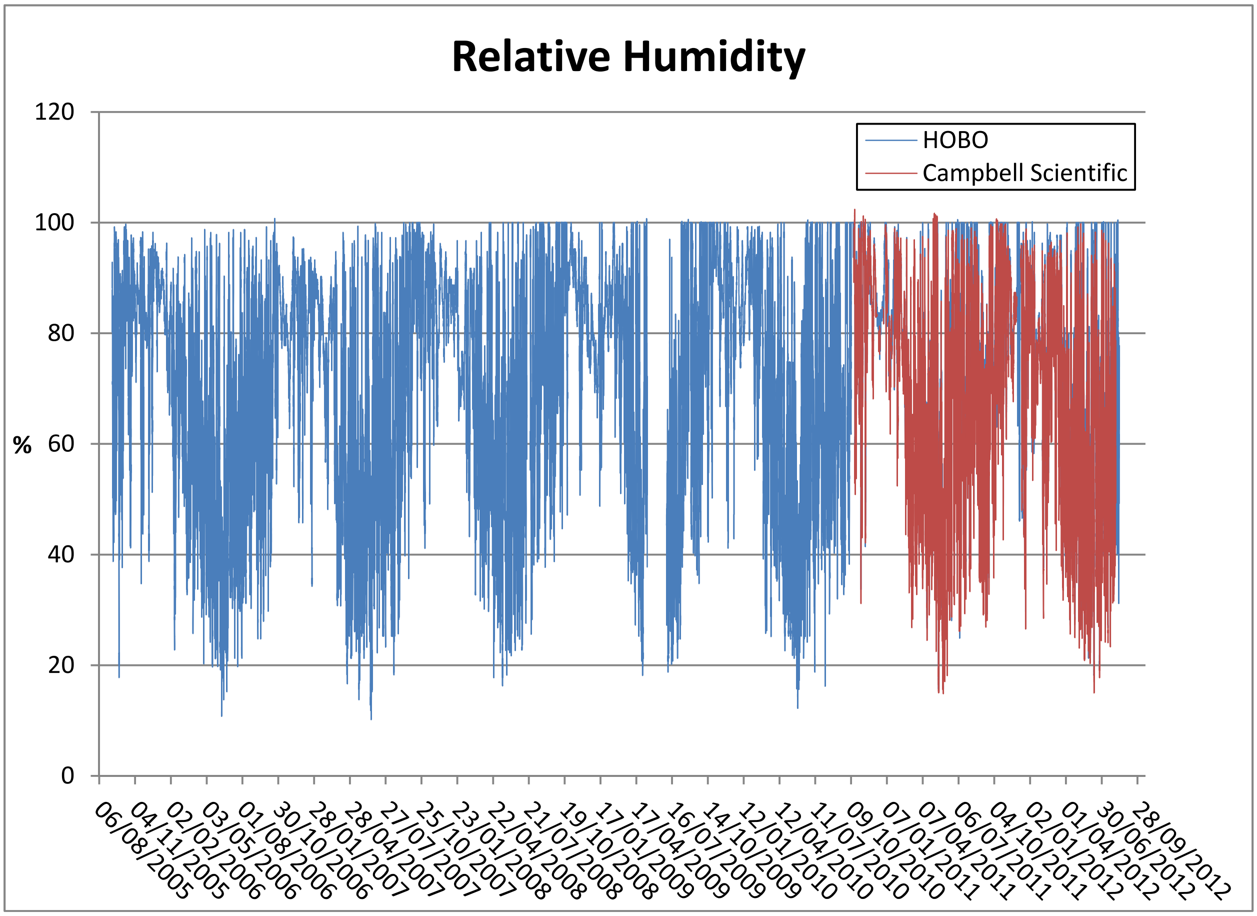


Figure 3-12: Minto Hourly Relative Humidity 2005–2012.

3.4 BAROMETRIC PRESSURE

Barometric pressure recorded on-site at 885 m elevation has been converted into a meteorological standard sea-level equivalent using the formula:

$$BP_{sl} = BP_{el} + 1013.25\left[1 - \left(1 - \frac{h}{44307.69231}\right)^{5.253283}\right]$$

where: BP_{sl} = sea-level equivalent barometric pressure

BP_{el} = barometric pressure recorded at elevation

h = height above sea level (in m)

Hourly sea-level equivalent barometric pressure recorded at the site is plotted for the entire period of record in Figure 3-13. A slight seasonal pattern can be observed with a higher mean during summer than during fall and early winter. Winter is also characterized by a much higher day-to-day variability. Note that the barometric pressure sensor on the Campbell Scientific weather station malfunctioned (possibly as a consequence of low battery voltage) and had to be sent back for repair; hence the data gap between November 12, 2010 and March 4, 2012.

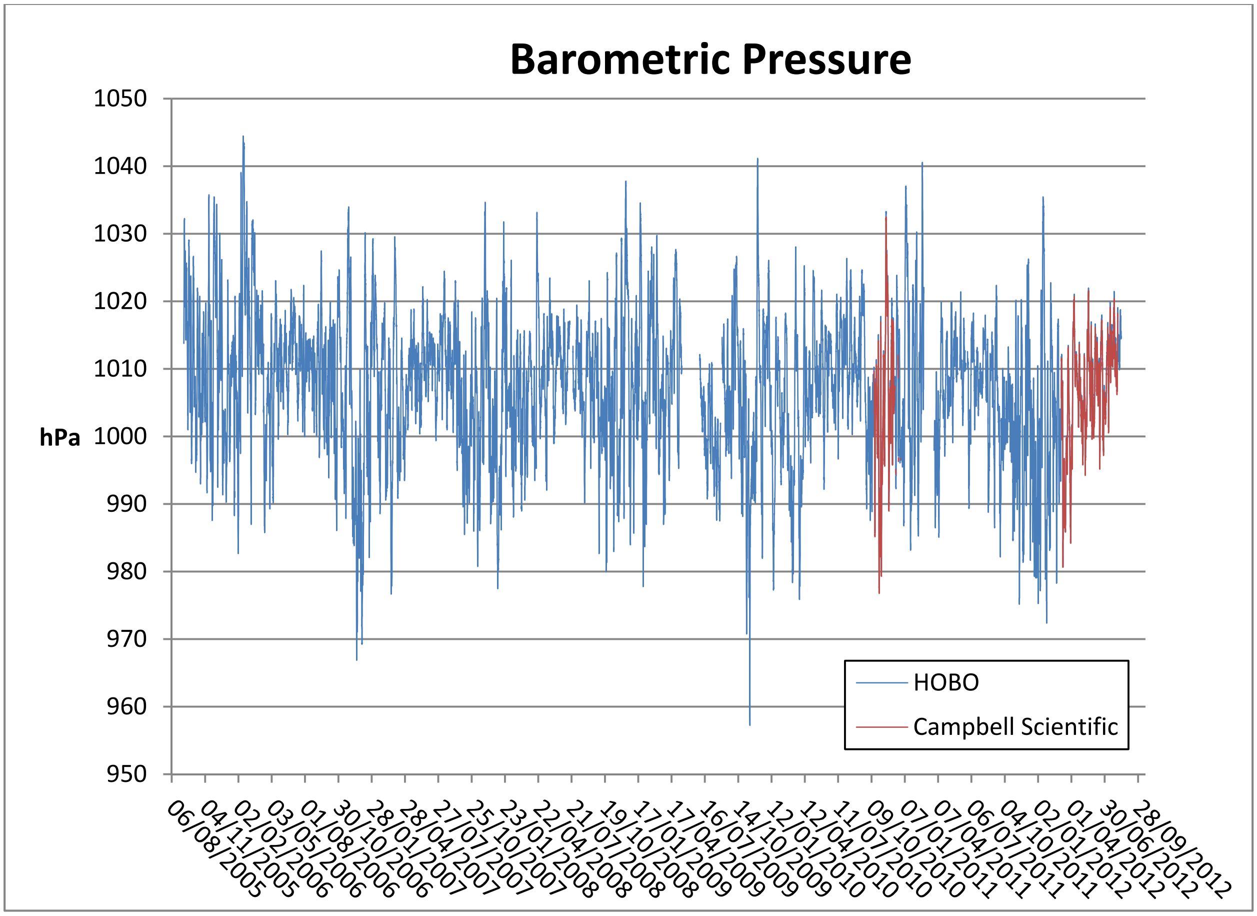


Figure 3-13 Minto Hourly Sea-Level Equivalent Barometric Pressure.

Table 3-1 shows average sea-level equivalent barometric pressure by month at the site. Barometric pressure is slightly higher on average between May and September (above 1009 hPa), and lowest between October and April (below 1006 hPa), with the exception of February. Mean annual sea-level equivalent barometric pressure is 1007.5 hPa.

3.5 SOLAR RADIATION

Hourly solar radiation is plotted for the entire period of record in Figure 3-14. Data is missing between June 15 and July 19, 2006, due to instrument error.

As would be expected at a latitude of 62.6 °N, a strong seasonal pattern is evident, with maximum solar radiation being received near the summer solstice in late June (daily maximums on the order of 750 W/m^2 and up to 1108 W/m^2), and values just slightly above zero around the winter solstice when the site experiences only about 3 hours of direct sunlight per day. Large fluctuations from the general trend during the summer are due to cloud cover.

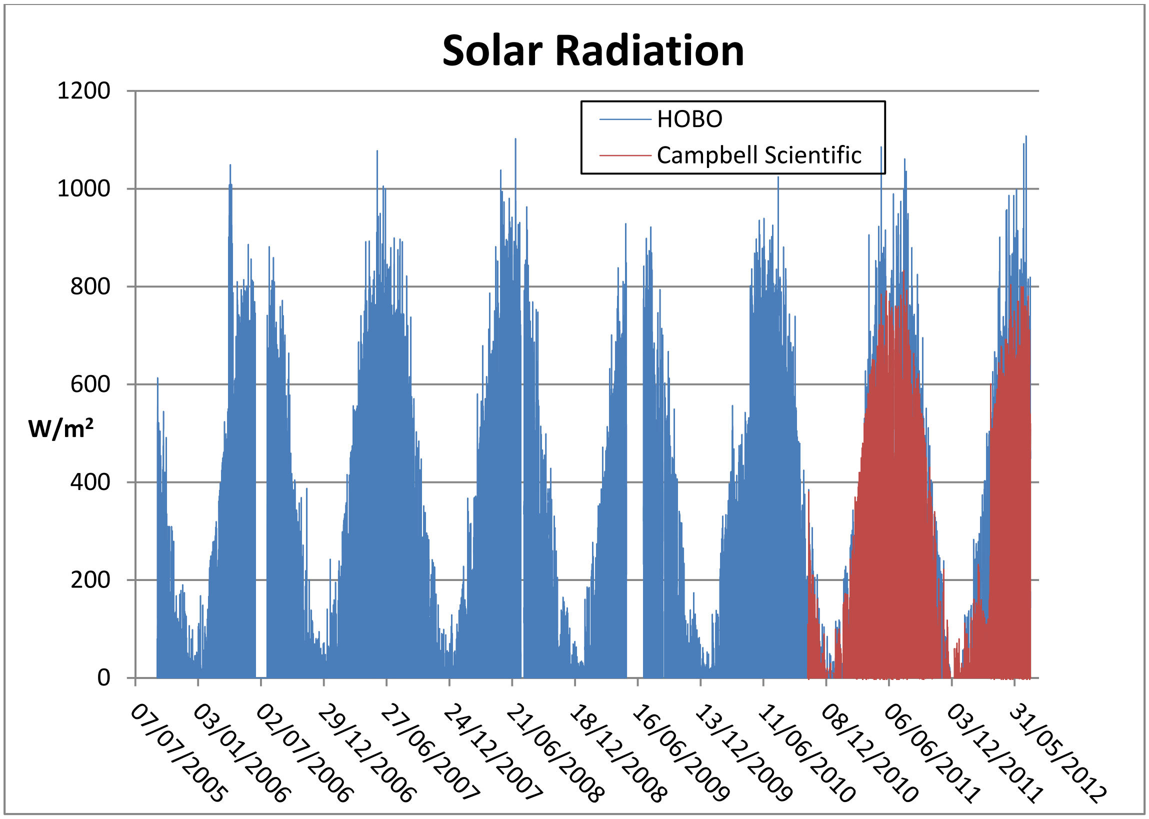


Figure 3-14: Minto Hourly Solar Radiation.

Table 3-1 shows the average amount of solar radiation received each day at the site by month. The highest amount is received on average in June (230 W/m^2). The lowest is in December (5 W/m^2). Mean annual solar radiation is 111 W/m^2.

3.6 PRECIPITATION

3.6.1 Rainfall

The Minto meteorological station has been recording rainfall on site since its installation in September 2005. In addition to the aforementioned gaps in the data record, precipitation data was not recorded between March 30 and April 11, 2006. The HOBO Rain Gauge Smart Sensor measures rainfall with a tipping bucket mechanism where each tip of the bucket is the equivalent of 0.2 mm of rain equivalent and records the number of tips occurring over each hourly interval. Tipping buckets are not designed to record snowfall as precipitation occurring below 0°C will not melt and the tipping mechanism may freeze in prolonged sub-zero temperatures. Also, precipitation recorded at temperatures slightly above zero is of questionable accuracy as the data may be a result of accumulated snow above the gauge falling into the tipping bucket producing an over-reading. Any incidence of precipitation data at temperatures below zero was omitted from the HOBO record as this would not represent any contribution to total rainfall.

The Campbell Scientific station was also recording rainfall only until October 14, 2011, the date on which a snowfall conversion adaptor was installed on the tipping bucket to allow for measurement of total precipitation. The resolution of the Texas Electronic tipping bucket installed on the Campbell Scientific weather station was 0.1 mm without the snowfall conversion adaptor, and became 0.1459 mm after a different funnel was installed to fit with the snowfall conversion adaptor.

Table 3-6 below presents rainfall data from both stations. Note that some discrepancies between the two stations can be explained by missing data (partial months) for one station or the other, and the fact that the Campbell Scientific tipping bucket has a higher resolution. Also note that the monthly averages are calculated based only on the data from the HOBO station as the Campbell Scientific records is not long enough yet to provide meaningful monthly averages. Months in which a partial record exists are shaded in light grey and entire months in which rainfall was not recorded are hashed. Average monthly rainfall is shown at the bottom of the table. Total rainfall by year at the right of the table is the sum of all recorded rainfall over each year. The totals may reflect slightly less than actual annual rainfall in a year where a partial month of data exists. It should be noted that during winter months, although little to no rainfall has been recorded in the table, precipitation in the form of snow most likely would have fallen. The table represents rainfall only and not total precipitation, because of limitations of the installed instrumentation. Table 3-6 shows that based on monthly average rainfall over five years, 174 mm of rainfall is expected on average in a single year. Data collected to date indicates that August has been the rainiest month with an average rainfall of 51.0 mm. The two largest monthly rainfall totals occurred in August 2008 and July 2009 with 100.6 mm and 95.2 mm (101.8mm recorded with the Campbell Scientific tipping bucket), respectively. The table also shows that rainfall has occurred in every month of the year. The maximum recorded daily rainfall for each month, shown at the bottom of the table, shows that the most intense one-day rainfall occurred in August (28.2 mm on August 25, 2008).

Table 3-6: Total Minto Rainfall by Month.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2005	**HOBO**									*21.6*	23.0	11.6	4.6	
2006	**HOBO**	0	*0.4*	*2.8*	0	22.8	35.8	28.6	29.2	12.2	12.2	0	0	144.0
2007	**HOBO**	0.2	0	0.4	5.8	4.6	36.0	47.8	21.0	33.8	11.8	0	0	161.4
2008	**HOBO**	1.2	2.0	0.8	1.8	9.6	26.2	*25.8*	100.6	21.8	6.4	0	0	196.2
2009	**HOBO**	5.2	0	0.8	3.2	*9.2*		*6.1*	*50.8*	7.2	16.6	0	0	*99.1*
2010	**HOBO**	0	0	0	0	7.6	48.8	75.6	46.4	18.0	10.2	0	0	206.6
	CS										*5.2*	0.8	0	
2011	**HOBO**	0	6.0	0	0.2	8.9	*43.8*	95.2	58	15	6.4	0	4.6	238.1
	CS	0	6.4	0.2	0.4	5.3	56	101.8	64.8	15.6	4.4	0	0	254.9
2012	**HOBO**	0	0	0	0.2	8.6	33.4	44.0						
	CS	0.7	1.6	0	0	0.1	31.1	44.8						
Average		**0.9**	**1.2**	**0.7**	**1.6**	**10.2**	**37.3**	**46.2**	**51.0**	**18.5**	**12.4**	**1.7**	**1.3**	**174.2**
Daily Max		**2.4**	**5.1**	**2.6**	**3.0**	**10.2**	**16.9**	**18.0**	**28.2**	**13.0**	**10.0**	**10.8**	**4.4**	**28.2**

Note: indicates a partial month

3.6.2 Total Precipitation

On October 14, 2011, a snowfall conversion adaptor was installed on the tipping bucket of the Campbell Scientific station. It consists of an antifreeze reservoir, over-flow tube, and catch tube. Snow captured in the catch tube dissolves into the antifreeze and the melted snow raises the level of the antifreeze and water solution. The mixture then flows through the over-flow tube into the tipping bucket where it is measured by the tipping bucket mechanism. Note that this system has inherent delays and is not suitable for real-time precipitation measurements. Depending on the temperature of the air and the liquid in the reservoir, the surface tension in the overflow tube and the form of precipitation, the delay ranges from minutes to tens of hours. To avoid this delay in summer precipitation measurements, the adaptor was removed on June 1, 2012. Table 3-7 below presents total precipitations in mm of water-equivalent.

Table 3-7: Minto Total Precipitation by Month.

Month	Total Precipitation (mm of water-equivalent)
Nov-11	*0.2*
Dec-11	*3.9*
Jan-12	9.1
Feb-12	9.9
Mar-12	34.9
Apr-12*	0.0
May-12*	0.15
Jun-12	31.1
Jul-12	58.4

Notes: grey italics indicate a partial month
**Results are suspiciously low - It is suspected that the snowfall conversion adaptor malfunctioned during April and May 2012*

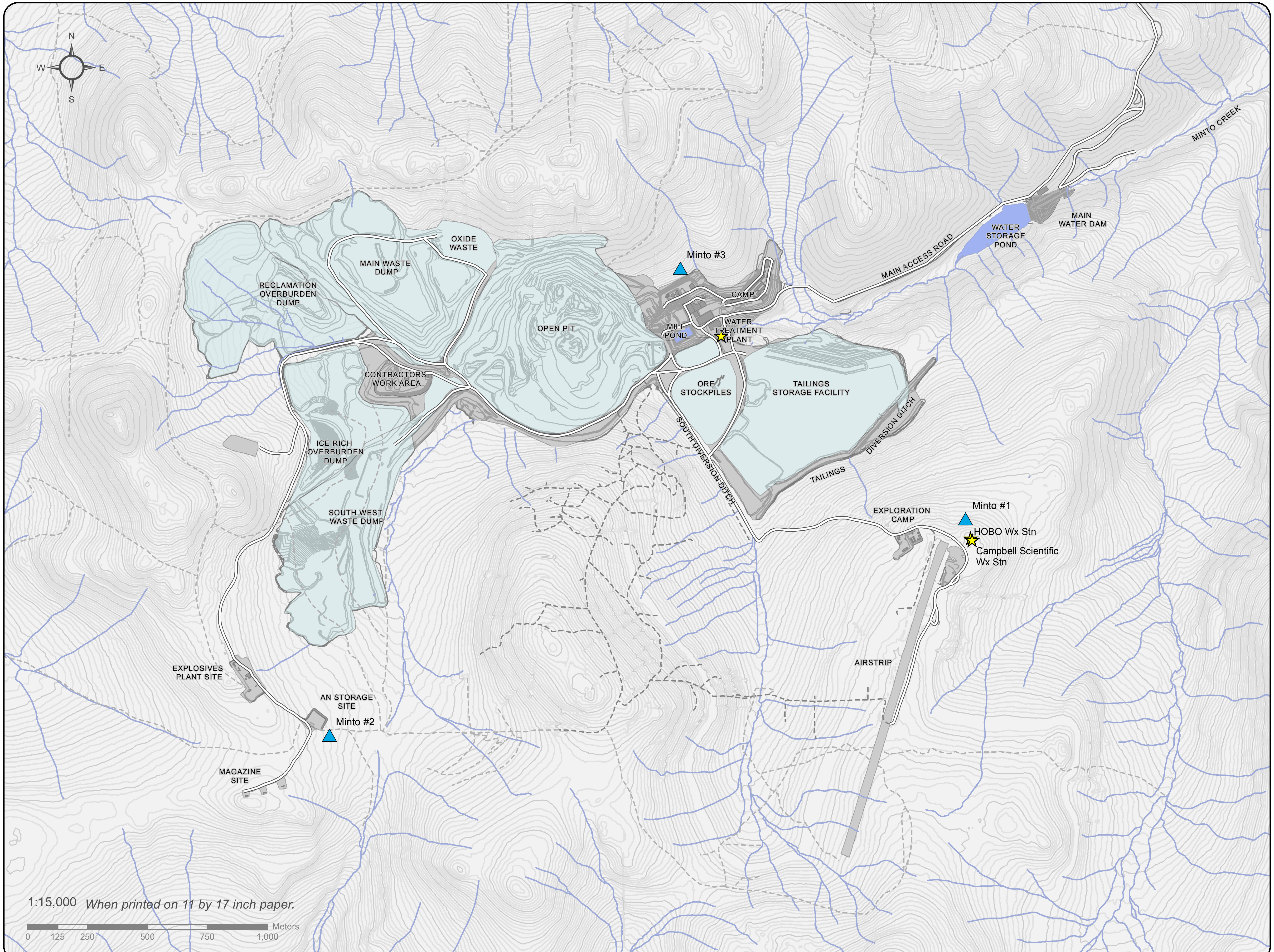
The total precipitation record is not long enough yet to provide meaningful statistics. However, to provide an estimate, Environment Canada's Canadian Climate Normals (1971-2000) for Pelly Ranch indicate that on average, annual precipitation occurs 64% as rainfall and 36% as snow. With the assumption that regional precipitation is homogeneous and ignoring any significance of the 400 m elevation difference between the sites, orographic effects, or valley orientation, the site can be estimated to receive an additional 100 mm of water-equivalent precipitation in the form of snow annually (EBA 2010). The difference in elevation would theoretically result in a larger annual snowfall at Minto than what is observed at Pelly Ranch; however, since many factors can attribute to the occurrence of snowfall (slope aspect, temperature inversions), a simple orographic correlation cannot be accurately determined from nearby records.

3.6.3 Snowpack

Annual snow surveys have been conducted by J. Gibson & Associates in 1994, 1995, 1998, and annually from 2006 to date, at three locations in the Minto Creek catchment area. Minto#1 is located south of the airstrip with a north-facing aspect. Minto#2 is located near the explosives storage area with an east-facing aspect. Minto#3 is located north of the mill with a south-facing aspect. Due to site operations, the snow survey sites were relocated to their present positions in 2007 at the approximate aspects and elevations of the previous sites. Snow sampling Locations are shown on Figure 3-15.

Snow surveys have been conducted on the on the first day of March, April and May, or within 2 days before or after these dates, as conditions allowed. Due to the lack of snow remaining on site by May 1, February snow surveys were begun in 2009 to ensure a consistent annual 3-month record. Snow collection procedures are in accordance with the Snow Survey Sampling Guide (SS13-81) published by the British Columbia Ministry of Environment (Water Management Branch, Surface Water Section).

Table 3-8 shows, as an average of data recorded at all three snow survey stations, the mean snowpack depth (cm), snow density (%) and water-equivalency (mm) on the first day of each month of the survey. Possible errors in the record identified in quality checking of the field data (where the recorded water-equivalency does not equal the product of the recorded snow density and snow depth) have been shaded grey, and retained in the analysis.



MINTO MINE

MINTO CLIMATE BASELINE REPORT

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- Snow Monitoring Stations
- Weather Stations
- Mine Road
- Trail / Exploration Road
- Historic Trail/ Exploration Road
- Watercourse
- Mine Feature Footprint
- Operational Footprint
- Structures
- Waterbody

Site layout and mine feature footprint countour data provided by Minto Explorations Ltd, March 2011 (2011-03-13 Mine As Built to 31Dec10 abp_main_1012.dxf).

Hydrology data provided by Minto Explorations Ltd, May 2009.

General contour data compiled by Minto Explorations Ltd, November 2006

Projection : UTM Zone 8N
Datum: NAD 83

FIGURE 3-15

MINTO SNOW SAMPLING LOCATIONS

ACCESS

JUNE 2013

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(*Last edited by: mducharme; 26/06/2013/13:25 PM*)

Table 3-8: Summary of Minto Snow Survey Data.

Year	February 1			March 1			April 1			May 1		
	Snow Depth (cm)	Snow Density (%)	Water-equivalent (mm)	Snow Depth (cm)	Snow Density (%)	Water-equivalent (mm)	Snow Depth (cm)	Snow Density (%)	Water-equivalent (mm)	Snow Depth (cm)	Snow Density (%)	Water-equivalent (mm)
1994				52.2	17.1	89.7	50.3	18.8	94.3	0.0	n/a	0.0
1995				41.7	13.8	57.3	38.9	14.9	58.0	4.1	*30.7	18.0
1998				37.3	****18.1	65.0	39.3	18.2	70.7	0.0	n/a	0.0
2006				44.7	16.2	72.7	57.4	17.1	97.7	15.4	**34.5	52.7
2007				40.5	16.9	79.3	49.0	20.2	98.7	0.0	n/a	0.0
2008				50.9	17.1	87.0	48.9	***20.0	97.5	10.3	**25.1	34.0
2009	55.6	16.6	92.7	70.2	15.7	110.0	67.4	22.3	150.7	0.0	n/a	0.0
2010	60.5	17.8	107.7	58.1	20.7	120.7	40.4	**13.9	56.0			
2011	57.2	18.7	106.0	70.3	20.1	141.7	52.3	22.8	111.7			
2012	54.7	20.3	111.0	64.6	19.6	127.0	61.3	21.5	132.7			
Mean	**57.0**	**18.4**	**104.4**	**53.0**	**17.5**	**95.0**	**50.5**	**19.5**	**96.8**	**4.3**	**32.6**	**15.0**

All snow surveys performed by J. Gibson & Associates
= possible measurement error

** zero snow recorded at #2 and #3 - density is based on #1 only, average depth and water-equivalent is average of all sites*
*** zero snow at #3, density is an average of snowpack at #1 and #2, average depth and water-equivalent is average of all sites*
**** omitted snow survey site #3 - error in snow depth reading*
***** includes potential measurement error from site 3*

Based on the ten years of snow surveys, the average water-equivalent snow depth remaining on the first day of March and April is 95.0 mm and 96.8 mm, respectively. The data, which slightly underestimates total annual snowfall due to the fact that it fails to account for snow that has melted during the winter, agrees with the annual snowfall estimate from interpolated data recorded at Pelly Ranch, discussed previously.

In four of the seven May surveys, the snowpack had melted entirely by May 1. In the three years where snow remained on the ground on May 1 (1995, 2006, & 2008), the mean snowpack had reduced to 10%, 27%, and 20%, respectively, of the peak measured snowpack in that year. The data indicates that the majority of runoff due to snowmelt occurs in April.

3.6.4 Regional and Future Trends

Global precipitation has increased more than 10% at higher latitudes during the 20th century in the Northern Hemisphere (Hengeveld 1997). However, a study published in 1995 by the Intergovernmental Panel on Climate Change (IPCC) and Environment Canada determined that annual precipitation in Yukon and coastal British Columbia has shown only a slight increase over the last 50 years when compared to eastern regions of North America at higher latitudes (Hengeveld 1997).

Total annual precipitation recorded at Pelly Ranch and Carmacks between 1955 and 2006 were plotted along with the respective trendlines in Figure 3-16 in blue and red, respectively, to illustrate the observed regional trend over central Yukon during the last half of the 20th century. The figure shows a general increase in total annual precipitation over the 50-year period of 1.1 mm/year for Pelly Ranch and 1.4 mm/year at Carmacks, on average. With approximately 300 mm of precipitation per year, this equates to more than a 20% increase. The effects of climate change on precipitation patterns are quite complex as they vary locally. Trends in annual precipitation over the past century are more representative of changes to regional and local precipitation (Trenberth et al. 2007). The proximity of the Environment Canada stations to the mine site would allow for reasonable confidence in assuming that the observed trends for Pelly Ranch and Carmacks are also applicable to the Minto site, excluding regional variability of precipitation events due to orographic effects or valley orientations.

Many GCMs predict increasing mean annual precipitation at high latitudes of North America (Nohara et al. 2006). The Scenarios Network for Alaska and Arctic Planning projections suggest an increase in annual precipitation ranging from 8 to 13% by 2030 and 12 to 20% by 2050 from the 1961–1990 baseline (Figure 3-17).

The International Panel on Climate Change (IPCC) predicts that it is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe, particularly in the high latitudes. “Based on a range of emissions scenarios, a 1-in-20 year annual maximum daily precipitation amount is likely to become a 1-in-5 to 1-in-15 year event by the end of the 21st century in many regions, and in most regions the higher emissions scenarios […] lead to a stronger projected decrease in return period.” (IPCC 2012) Figure 3-18 shows the projected trends for northwestern Canada and Alaska, where a decrease in return period implies more frequent extreme precipitation events. The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different emissions scenarios (B1, A1B and A2).

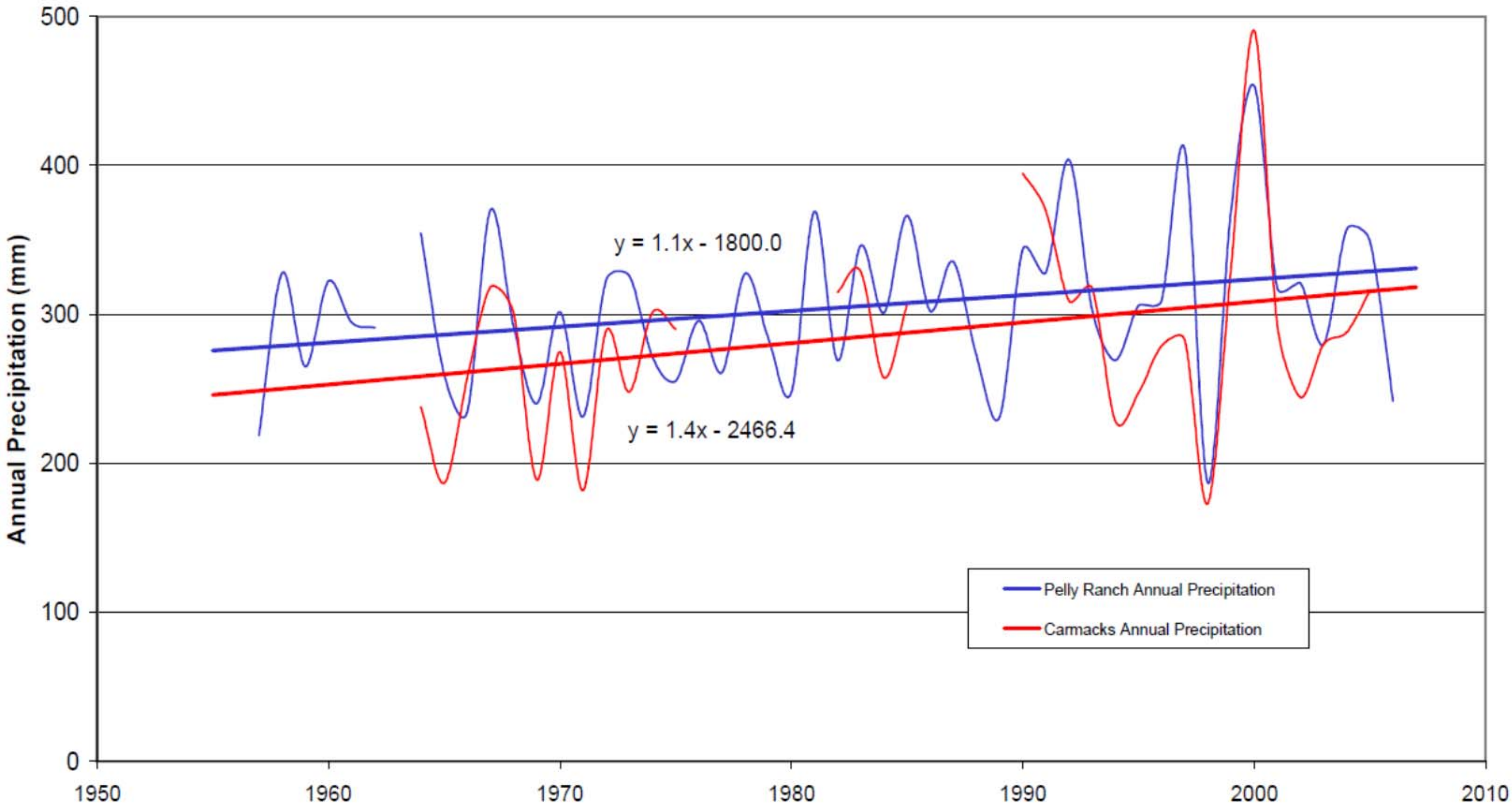
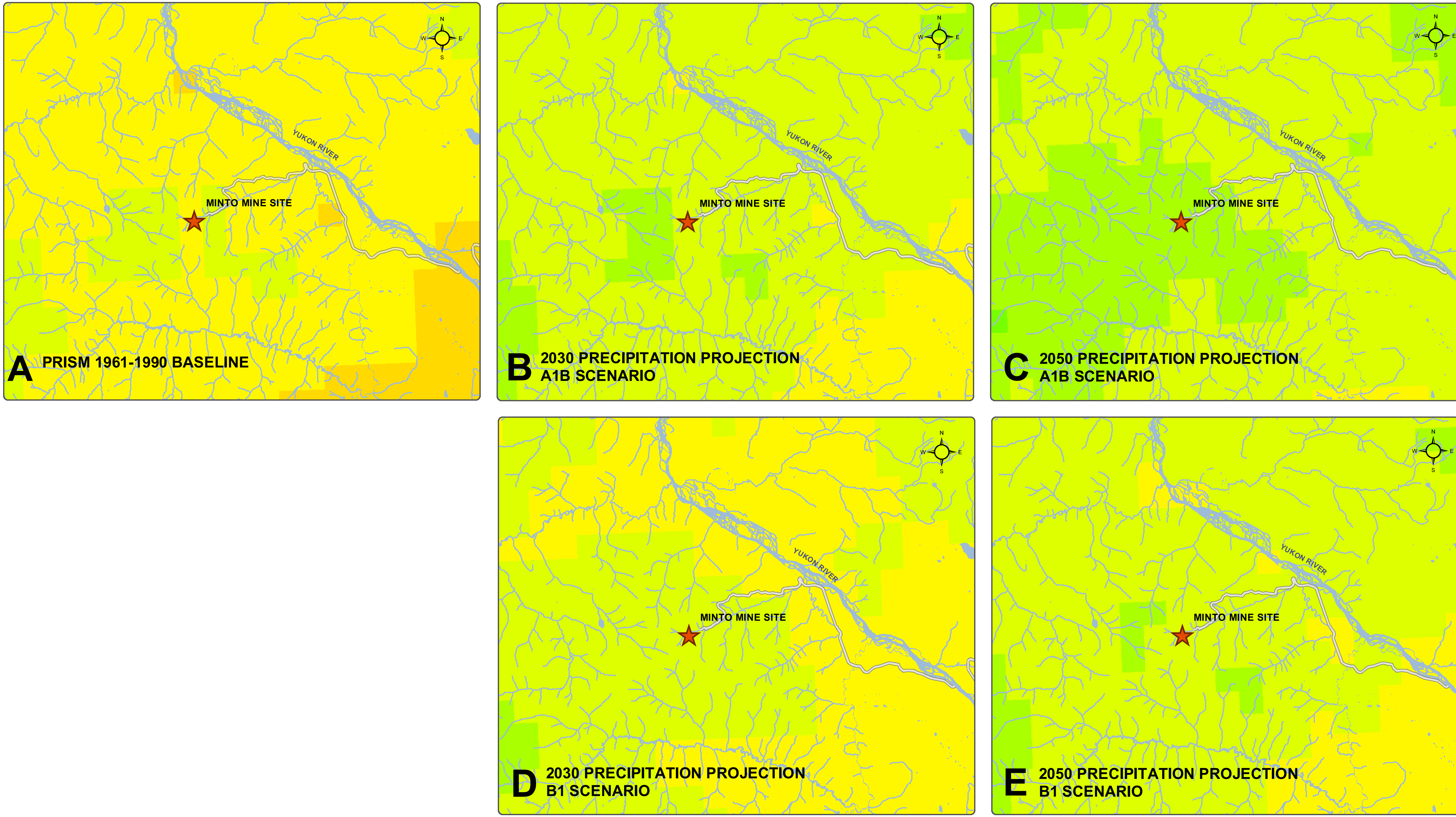


Figure 3-16: Pelly Ranch and Carmacks Annual Precipitation Trend (1955–2006) (Source: *Meteorological Service of Canada/EBA (2010)*).



Datum: NAD 83; Map Projection: UTM Zone 8N

1:260,000 (when printed on 11 x17 inch paper)

0 1 2 4 6 8 10

Kilometres

Precipitation (millimetres)

- 250 - 300
- 300 - 350
- 350 - 400
- 400 - 450
- 450 - 500

MINTO EXPLORATIONS LTD.

ACCESS

MINTO CLIMATE BASELINE REPORT

FIGURE 3-17 CLIMATE BASELINE AND PROJECTIONS: MEAN PRECIPITATION

MARCH 2013

I:\Minto\gis\mxd\Phase_5-6\Permitting\YESAB\Baseline-Appendices\Climate\3-17_Precipitation_Projections_20130327.mxd
(Last edited by: mducharme; 27/03/2013/15:22 PM)

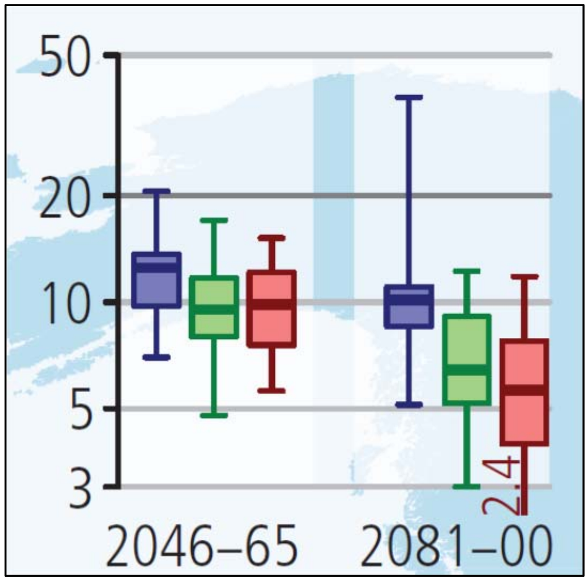


Figure 3-18: Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000) for northwestern Canada and Alaska *(Source: IPCC, 2012)*.

3.7 EVAPORATION

No evaporation records are available for the Minto site. Monthly lake evaporation is reported by Environment Canada for Pelly Ranch over the period 1971–1999 as a mean daily evaporation. The data shows measureable evaporation occurring only between May and September. An estimate of mean annual lake evaporation is determined to be 460 mm for Pelly Ranch by multiplying each month's daily mean by the number of days in the month. The Ministry of Environment's Manual of Operational Hydrology in B.C. suggests a reduction in evaporation with elevation equal to 10% per 350 m elevation rise (HPK 1994). With an elevation difference of slightly over 400 m, the extrapolation would suggest an annual evaporation at site on the order of 400 mm/year.

The extrapolation of past and current trends in observed data and climate scenarios both predict increases in mean temperature and wind speeds. The predicted changes in temperature and wind speed are favourable for increased evaporation, and thus evaporation would be expected to increase over the next fifty years.

4 FOLLOW-UP ON RECOMMENDATIONS

EBA's report "Minto Mine—2010 Climate Baseline Report" listed a number of recommendations that have now been addressed.

One such recommendation was to replace the rotating cup anemometer, which was prone to icing, with a heated-blade type or an acoustic anemometer. A new anemometer was installed in October 2010 with the new Campbell Scientific weather station, at a height of 10 m (as opposed to 3 m previously). The taller mast was not part of EBA's recommendations but it will allow the wind data collected to meet the standards for air dispersion modeling. Although this RM Young anemometer is not heated-blade or acoustic, it has shown to be a lot less prone to icing during its first two winters of operation. It is an "Alpine" model, which is more rugged, corrosion-resistant and designed to operate at temperatures down to −50°C (details are presented in Appendix A).

Another recommendation was to replace the rain gauge with an all-weather gauge that records both rainfall and snowfall as water-equivalent precipitation, in order to obtain a better knowledge of total annual precipitation, previously estimated from data at nearby regional stations. A Campbell Scientific CS705 snowfall adapter was installed on the tipping bucket in October 2011. It consists of an antifreeze reservoir, overflow tube and catch tube. Snow captured in the catch tube dissolves into the antifreeze and the melted snow raises the level of the antifreeze and water solution. The mixture flows through the overflow tube into the tipping bucket where it is measured by the tipping bucket mechanism. The gauge design possesses inherent delays and is not suitable for real time precipitation measurements. A delay of minutes is expected for liquid precipitation—after the gauge receives a minimum volume (~0.03" water at 25°C). A delay of several hours (up to tens) is expected for precipitation in the form of snow. Lightest density snow at very cold air temperatures has the longest delay. All precipitation falling into the catch tube eventually flows through the overflow tube and is measured by the tipping bucket gauge below. The snowfall adapter was removed during summer months to obtain better real-time rain data.

A third recommendation was to install an evaporation pan to quantify the amount of evaporation taking place at the site. Instead, a new instruction that calculates evapotranspiration (ET) based on temperature, RH, wind speed, solar radiation, longitude, latitude, and altitude was added to the weather station's datalogger program in October 2011, but experienced some problems which were fixed in July 2012. This instruction outputs an hourly water loss (in mm) calculated for a short grass crop, as this instruction is geared more towards agricultural applications. However, this ET output will still provide an overall more generalized ET of the surrounding area, where more water loss is associated with high temperature, wind speed, and solar radiation with low RH values compared to a cloudy day with lower temps, wind speed, and higher RH.

Finally, in order to maintain good data quality, it is still recommended that the weather stations be maintained as per manufacturer's recommendations.

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APPENDIX A

MINTO METEOROLOGICAL STATIONS DESCRIPTION

MINTO HOBO METEOROLOGICAL STATION

Site Identification:	**Minto HOBO Station**	Installation Date:	September 18, 2005
Station Coordinates:	North 62° 36' 17"	Tower Height:	3 m
	West 137° 13' 19"	Site Elevation above Sea Level:	887 m

1. STATION DESCRIPTION

The weather station consists of a three-meter tripod with instrumentation to measure wind speed and direction, air temperature, relative humidity, barometric pressure, incident solar radiation, and rainfall (wet-precipitation). The station is powered by four AA batteries. Data is recorded to a HOBO data logger. Data is averaged over the one-hour archiving period and saved to the logger memory. The station has an internal flash memory capacity of 512 Kb.

2. SITE LOCATION

The meteorological station is located approximately 70 meters northeast of the north end of the airstrip. The station sits on the southern ridge of the main river valley and has good exposure in all directions. Surrounding the station are sparse conifers under 2 meters.

3. INSTALLATION NOTES

The tower base supports are fixed to a square wooden frame. Sandbags are used at the base of the tripod legs to help stabilize the station.

The wind anemometer is installed at the top of the tower with the pyranometer and tipping bucket rain gauge fastened on the center pole slightly below. The air temperature/RH sensor is installed inside a radiation shield near the middle of the tower. The barometric pressure sensor is located inside the logger box.

4. RECORDED DATA NOTES

4.1. Winds

Cup revolutions are accumulated every three seconds for the duration of the logging interval (one hour). Wind speed is the average speed for the entire logging interval. Gust speed is the highest three-second wind in the logging interval.

Vector components of wind direction are accumulated every three seconds for the duration of the logging interval. Average direction is calculated from the sum of the vector components over the logging interval, and represents the direction **from** which the wind is blowing.

5. HOBO Station Instrumentation

Instrument	Model	Measuring Range	Sensitivity/Accuracy
Wind Speed and Direction	S-WCA-M003	Speed: 0–44 m/s	Accuracy: ± 0.5 m/s (± 3% 17–30 m/s) Resolution: 0.19 m/s Threshold wind = 0.5 m/s
		Direction: 0–358° (2-degree dead band)	Accuracy: ± 5° Resolution: 1.4°
Relative Humidity/ Air Temperature	Smart Sensor	RH : 0–100%	Accuracy: ± 3%; ± 4% RH (condensing environment) Resolution (at 25°C): 0.5%
		Temp: -40°C–+75°C	Accuracy (at 25°C): ± 0.7°C Resolution (at 25°C): 0.4°C
Barometric Pressure	S-BPA-CM10	660–1070 hPa	Accuracy (at 25°C): ± 1.5 hPa Resolution: 0.1 hPa
Pyranometer	S-LIB-M003	0–1280 W/m^2 Spectral Range: 3001100 m	Accuracy: greater of ± 10 W/m^2 or 5% Resolution: 1.25 W/m^2
Tipping Bucket Rain Gauge	RGA-M0XX RGB-M0xx	0–127 cm/hr	Accuracy: ±1.0% up to 20 mm/hr Resolution : 0.2 mm

MINTO CAMPBELL SCIENTIFIC METEOROLOGICAL STATION

Site Identification:	**Minto Campbell Scientific Station**	Installation Date:	October 15, 2010
Station Coordinates:	North 62° 36' 17"	Tower Height:	10 m
	West 137° 13' 19"	Site Elevation above Sea Level:	887 m

1. STATION DESCRIPTION

The weather station consists of a ten-meter tower with instrumentation to measure wind speed and direction, air temperature, relative humidity, barometric pressure and incident solar radiation. Rainfall (wet-precipitation) is measured with a tipping bucket installed on a separate mounting post, located about 2m away from the main tower. The station is powered by a 12V battery which is recharged by a 20W solar panel. Data is averaged over one-hour and 24-hour archiving periods, and saved to the data logger memory. The logger has an internal flash memory capacity of 2 Mb.

2. SITE LOCATION

The meteorological station is located approximately 70 meters northeast of the north end of the airstrip. The station sits on the southern ridge of the main river valley and has good exposure in all directions. Surrounding the station is sparse growth of conifers under 2 meters. A radius of 30m around the tower is clear of trees.

3. INSTALLATION NOTES

The tower base is anchored into a 91 X 91 X 122 cm concrete block and three guy wires are attached to the tower at a height of about 8 meters. The guy wires are tied to dead man anchors located five meters away from the tower that consist of 3-foot long 6” X 6” timber buried 2–4 feet underground.

The wind anemometer is installed on a cross arm at the top of the tower. The pyranometer is on a mounting arm at a height of about 2 m and is facing southeast. The solar panel faces south and has a tilt angle of 78°. For latitudes between 46° and 65°, the tilt angle is obtained by adding 15° to the latitude. The air temperature/RH sensor is installed inside a radiation shield at a height of about 1.75 m above the ground and faces west. The barometric pressure sensor is located inside the logger box, which is at a height of 1.5 m, on the north-facing side of the tower. To ensure moisture doesn’t affect the instruments in the enclosure, desiccant was placed inside (it should be replaced periodically, when its indicator turns pink). The tipping bucket rain gauge is fastened onto a 1 m-high mounting pole located about 2 m east of the tower.

4. RECORDED DATA NOTES

4.1. Time

All data is recorded in standard time and is not adjusted for daylight saving time.

4.2. Barometric Pressure

The barometric pressure sensor is powered for one minute before the top of each hour, at which time the sensor is polled for a measurement.

The datalogger program includes a correction for elevation and pressure is reported as sea-level-equivalent. The correction formula is as follows:

$$BP_{sl} = BP_{el} + 1013.25\left[1 - \left(1 - \frac{h}{44307.69231}\right)^{5.253283}\right]$$

where: BP_{sl} = sea-level-equivalent barometric pressure

BP_{el} = barometric pressure recorded at elevation

h = height above sea level (in m)

4.3. Winds

Wind data is recorded as wind vector. Output data includes mean horizontal wind speed (S), unit vector mean wind direction (θ1), and standard deviation of wind direction (σ(θ1)). Note that in this case of a wind vector, the wind direction is the direction **towards** which the wind is blowing.

5. Campbell Scientific Station Instrumentation

Instrument	Model	Measuring Range	Sensitivity/Accuracy
Wind Speed and Direction	RM Young 05103AP-10	Speed: 0–60 m/s Gust survival 100 m/s	Accuracy: ± 0.3 m/s Threshold sensitivity = 1.1 m/s
		Direction: 0–355° (5° deadband)	n/a
Relative Humidity/ Air Temperature	HC-S3-XT	RH : 100%	Accuracy: ± 1.5% (at 23°C) Resolution: 0.1%
		Temp: -50°C–+50°C	Accuracy: ± 0.1°C (at 0°C), ± 0.35°C (at ±50°C) Resolution: 0.1°C
Barometric Pressure	RM Young 61302V	500–1100 hPa	Accuracy (at 25°C): ± 0.2 hPa Resolution: 0.01 hPa
Pyranometer	Kipp & Zonen SP Lite 2	Spectral Range: 400–1100 m	Sensitivity: <±2% shift per year
Tipping Bucket Rain Gauge	Texas Electronics TE525M	Infinite in increments of tip (least count) of rainfall	Accuracy: ±1.0% up to 10 mm/hr +0, -3% (10–20 mm/hr) +0, -5% (20–30 mm/hr) Resolution : 0.1 mm
Snowfall Conversion Adaptor	CS705	Depends on tipping bucket	Depends on tipping bucket

APPENDIX B

HOBO MONTHLY WIND PLOTS

WIND ROSE PLOT:

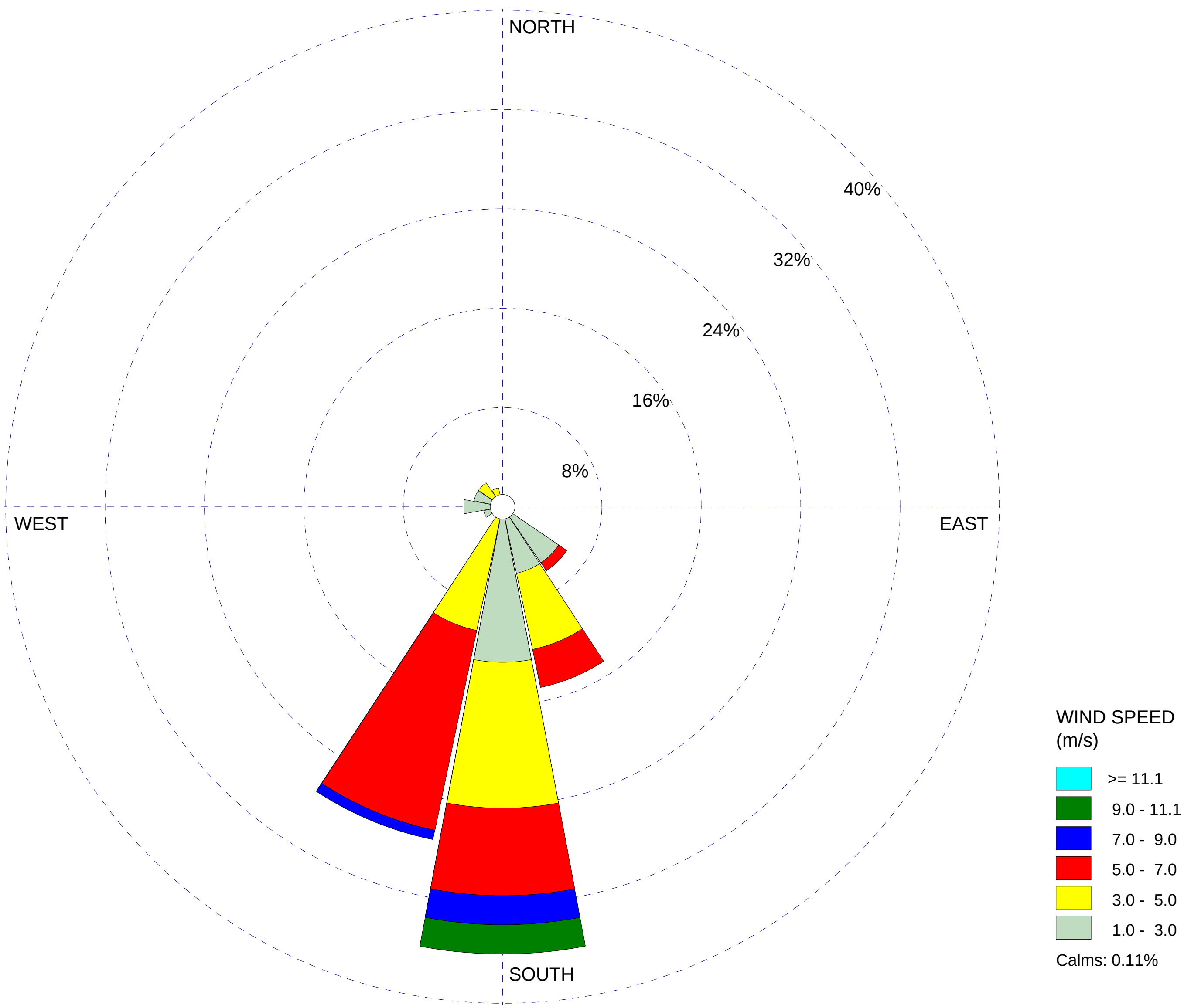
Minto HOBO - January
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 1/14/2009 - 00:00
End Date: 1/20/2009 - 13:00

TOTAL COUNT:	CALM WINDS:
128 hrs.	**0.11%**

AVG. WIND SPEED:

3.94 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

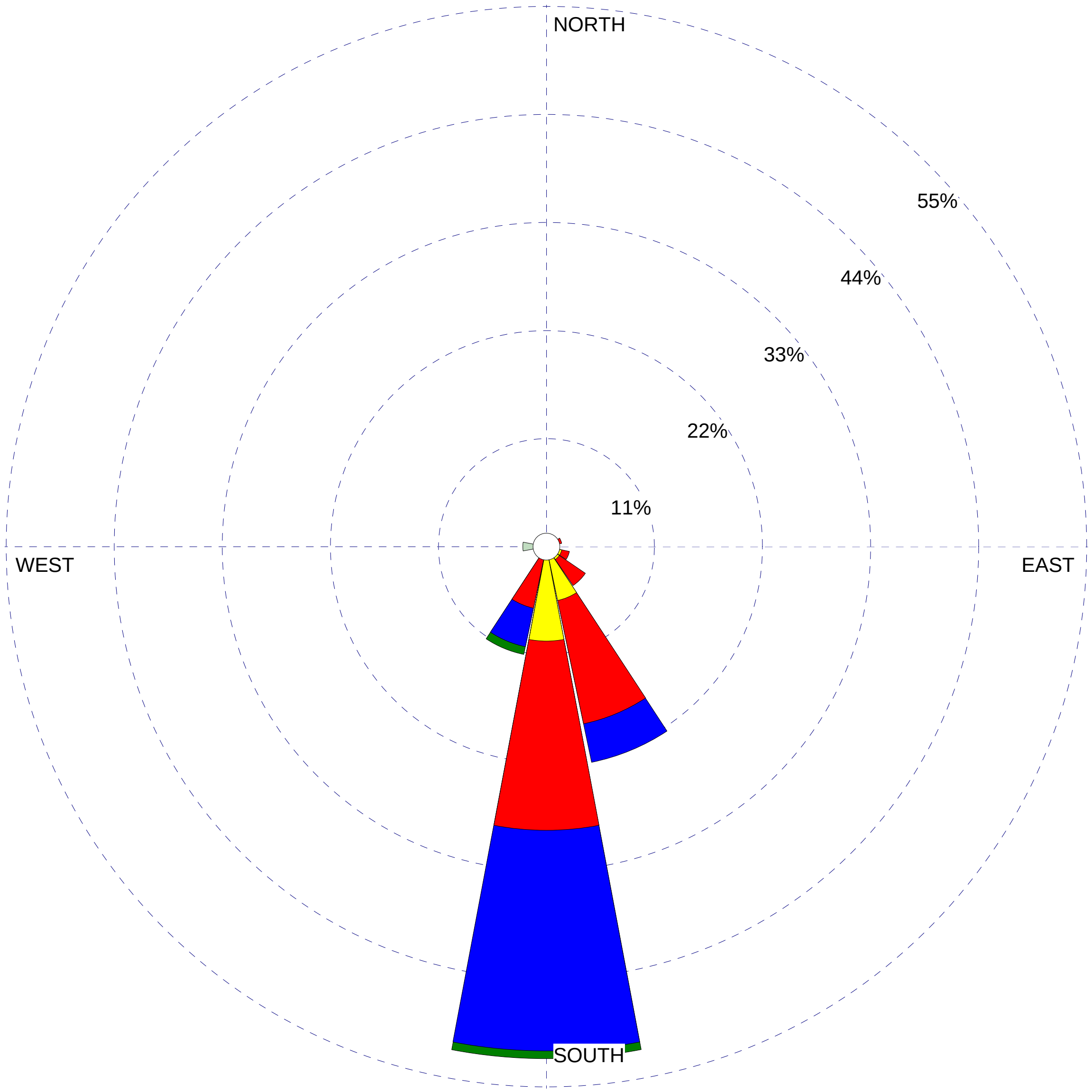
Minto HOBO - February
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



WIND SPEED
(m/s)

- >= 11.1
- 9.0 - 11.1
- 7.0 - 9.0
- 5.0 - 7.0
- 3.0 - 5.0
- 1.0 - 3.0

Calms: 0.06%

DATA PERIOD:

Start Date: 2/10/2006 - 00:00
End Date: 2/28/2010 - 22:00

TOTAL COUNT:	CALM WINDS:
125 hrs.	**0.06%**

AVG. WIND SPEED:

5.97 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

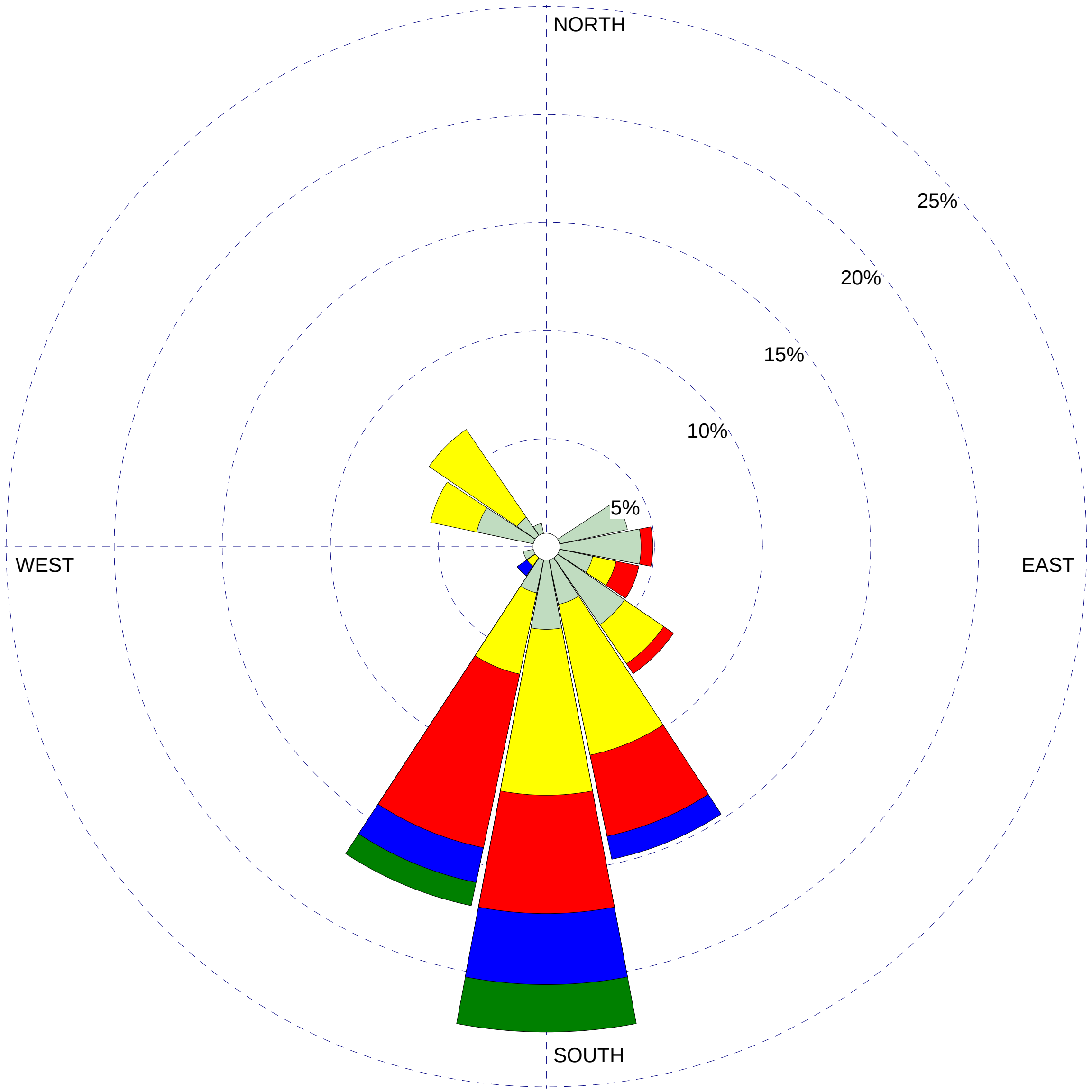
Minto HOBO - March
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



WIND SPEED (m/s)

- >= 11.1
- 9.0 - 11.1
- 7.0 - 9.0
- 5.0 - 7.0
- 3.0 - 5.0
- 1.0 - 3.0

Calms: 0.49%

DATA PERIOD:

Start Date: 3/20/2006 - 11:00
End Date: 3/9/2010 - 14:00

TOTAL COUNT:	CALM WINDS:
183 hrs.	**0.49%**

AVG. WIND SPEED:

3.81 m/s

COMPANY NAME:

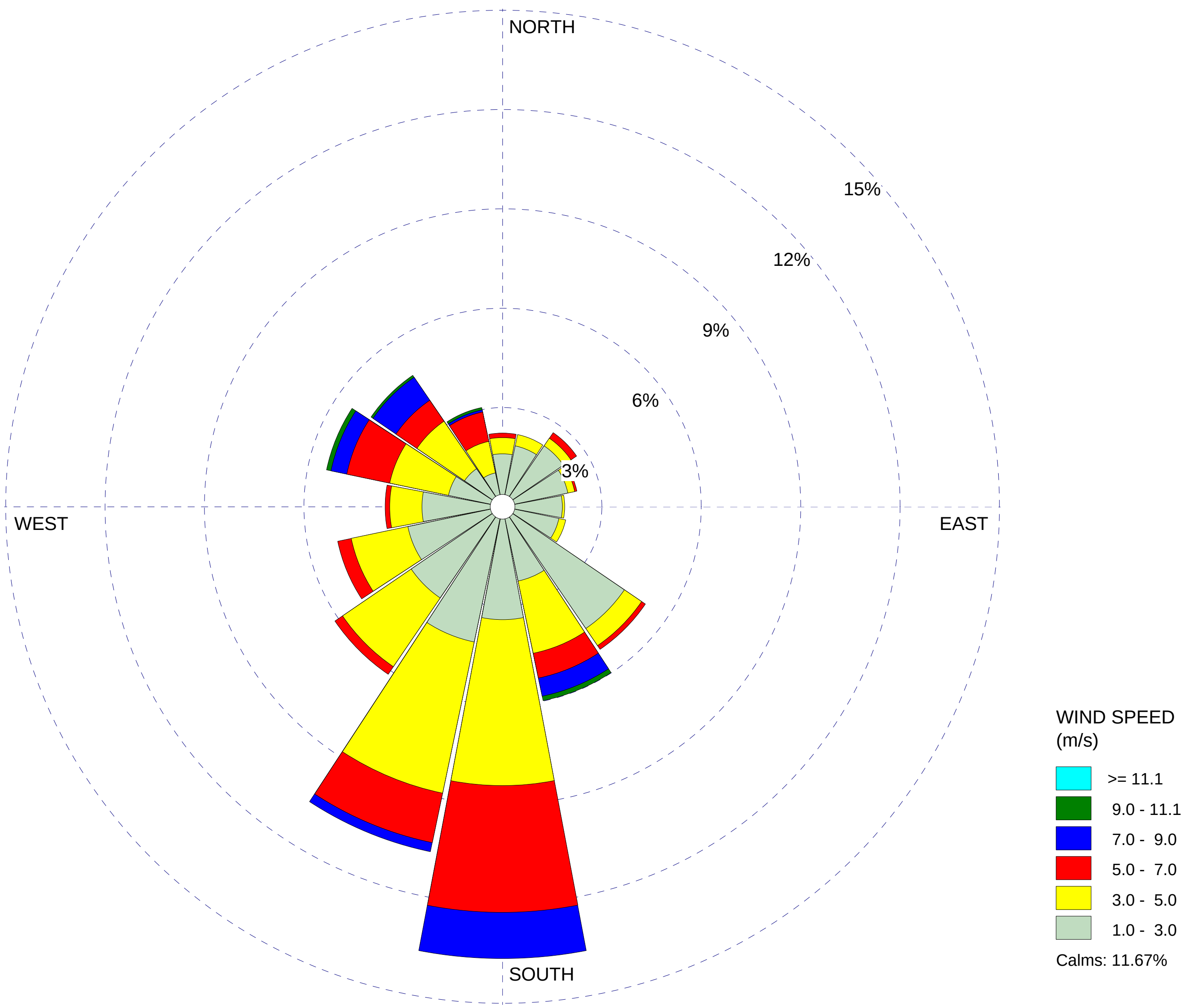
MODELER:

DATE:

10/5/2012

PROJECT NO.:

WIND ROSE PLOT: **Minto HOBO - April September 2005 - April 2010**	DISPLAY: **Wind Speed Direction (blowing from)**	COMMENTS: Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 4/1/2006 - 14:00
End Date: 4/30/2009 - 23:00

TOTAL COUNT:	CALM WINDS:
1440 hrs.	**11.67%**

AVG. WIND SPEED:

2.57 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

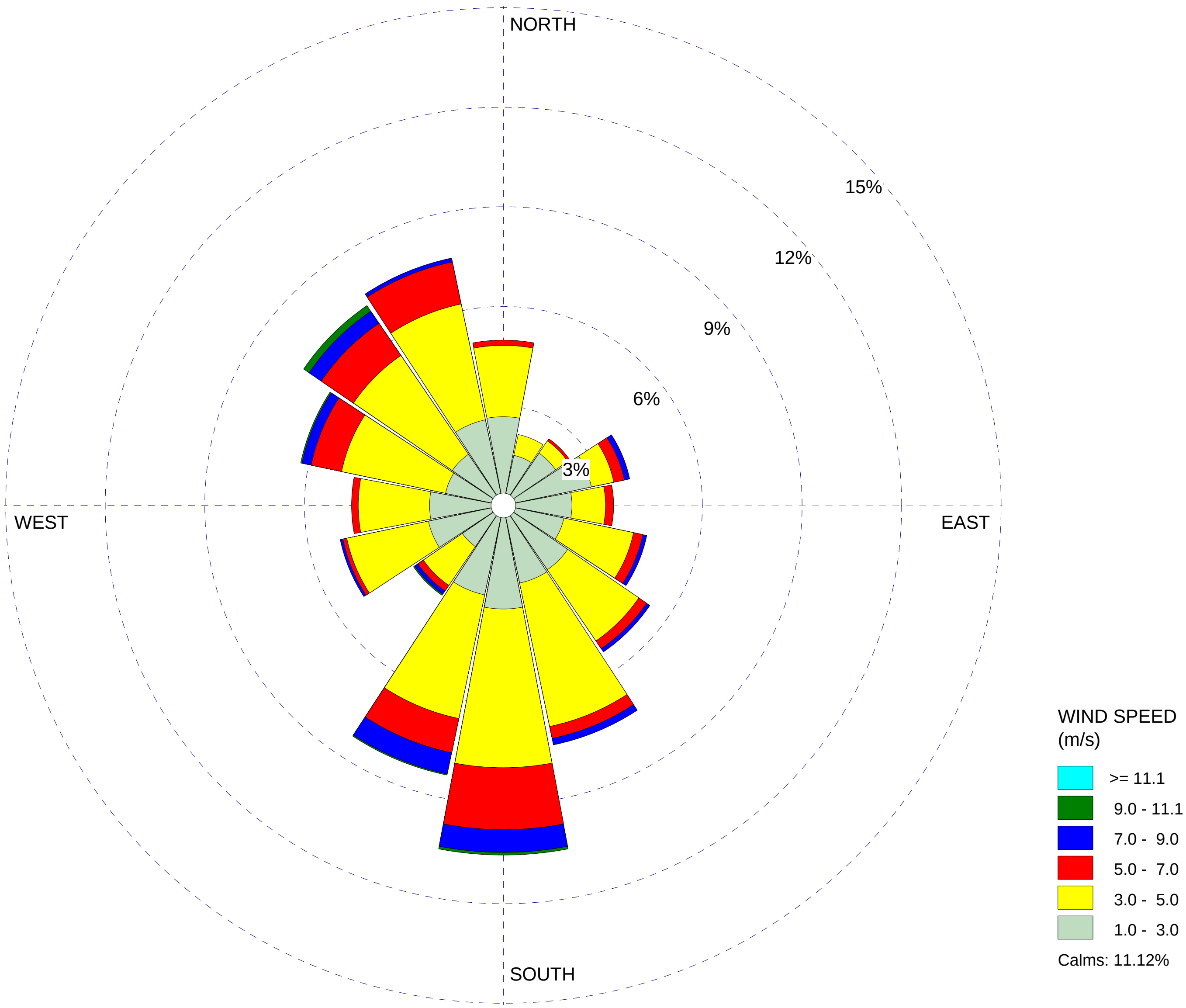
Minto HOBO - May
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 5/1/2006 - 08:00
End Date: 5/14/2009 - 12:00

TOTAL COUNT:	CALM WINDS:
2474 hrs.	**11.12%**

AVG. WIND SPEED:

2.97 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

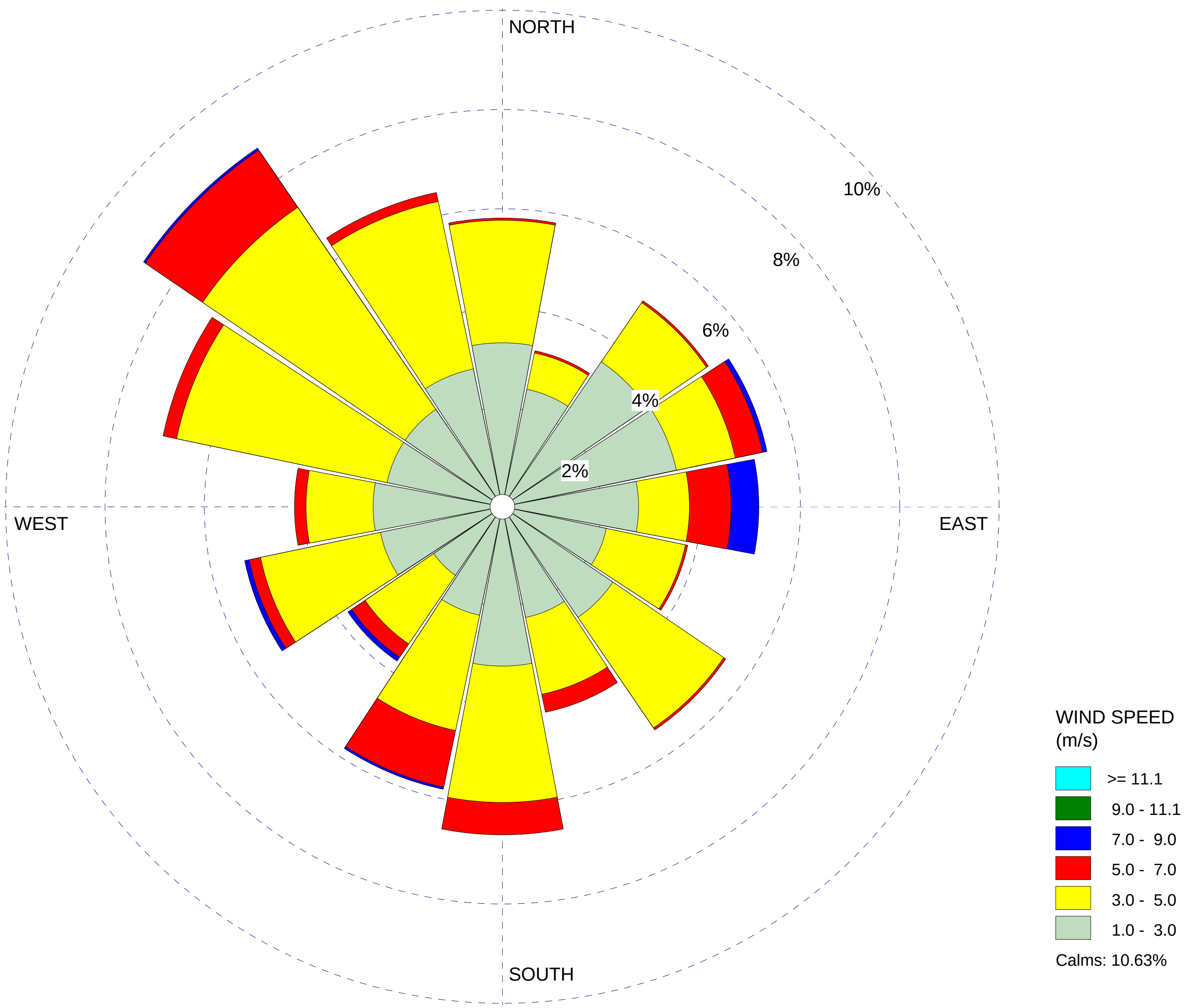
WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

Minto HOBO - June
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

Excludes periods of missing or ice-affected data

DATA PERIOD:

Start Date: 6/1/2006 - 00:00
End Date: 6/30/2008 - 23:00

TOTAL COUNT:

2155 hrs.

CALM WINDS:

10.63%

AVG. WIND SPEED:

2.63 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

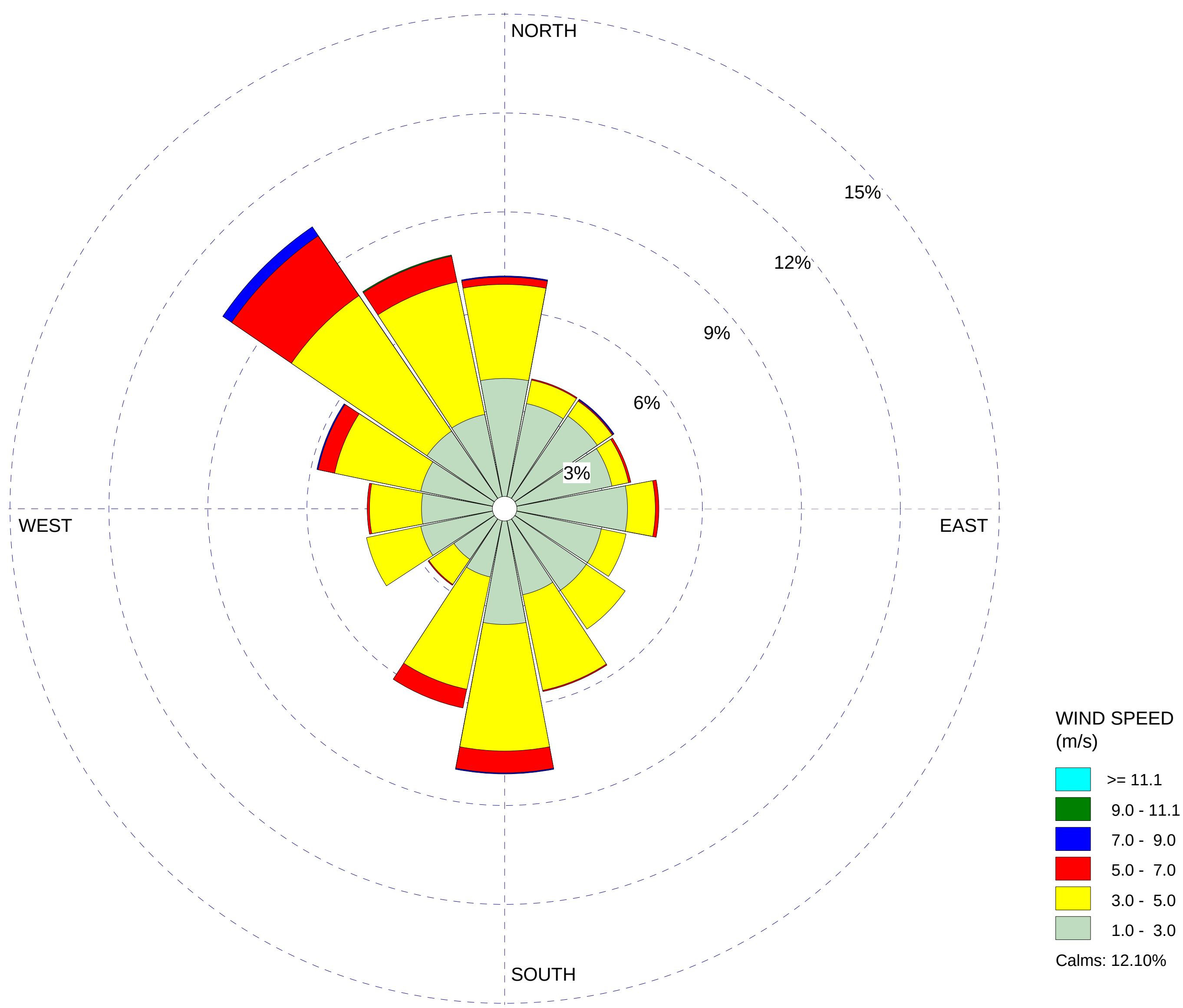
Minto HOBO - July
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 7/1/2006 - 00:00
End Date: 7/31/2009 - 23:00

TOTAL COUNT:	CALM WINDS:
2741 hrs.	**12.10%**

AVG. WIND SPEED:

2.53 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

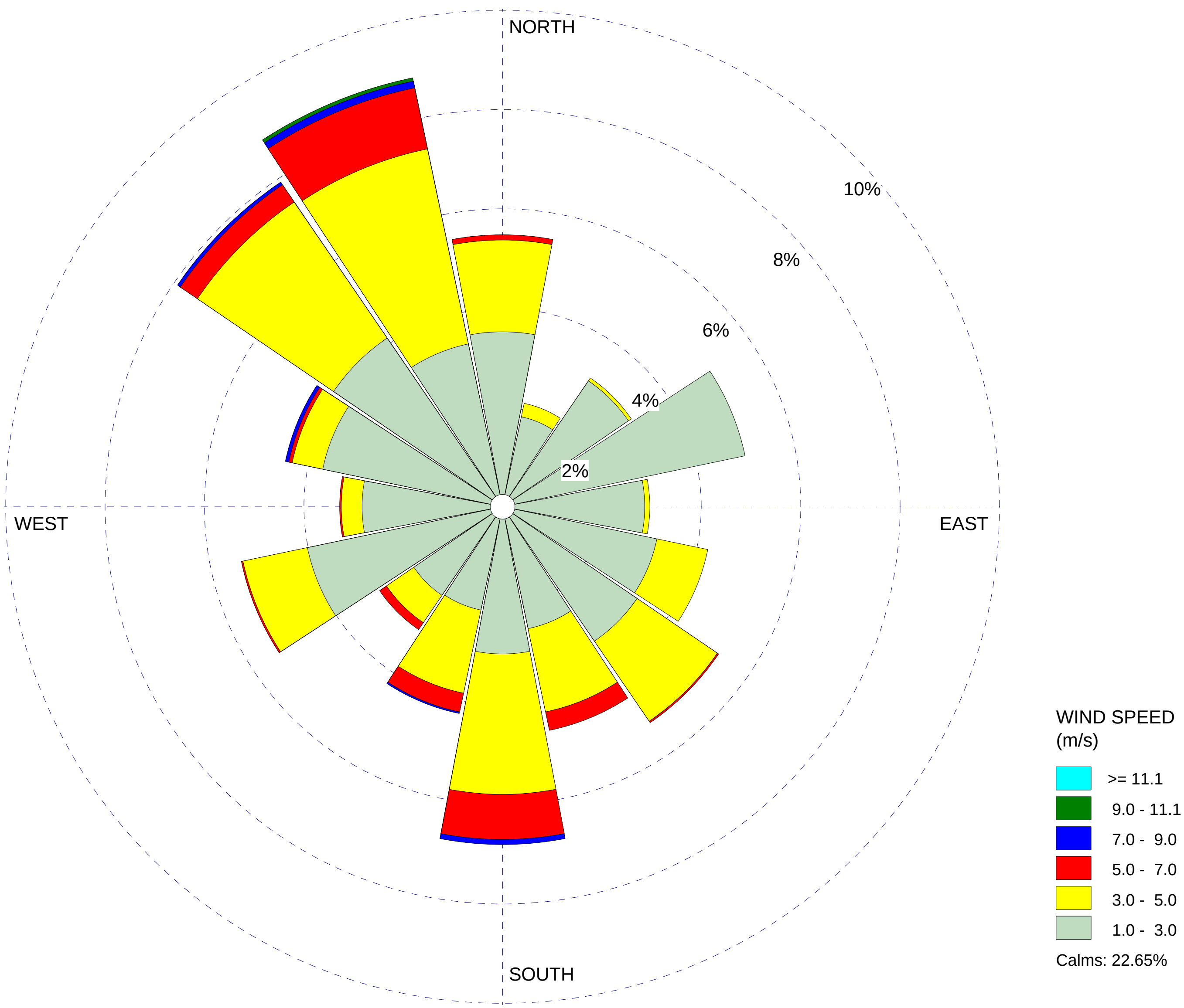
Minto HOBO - August
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 8/1/2006 - 00:00
End Date: 8/31/2009 - 23:00

TOTAL COUNT:	CALM WINDS:
2873 hrs.	**22.65%**

AVG. WIND SPEED:

2.02 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

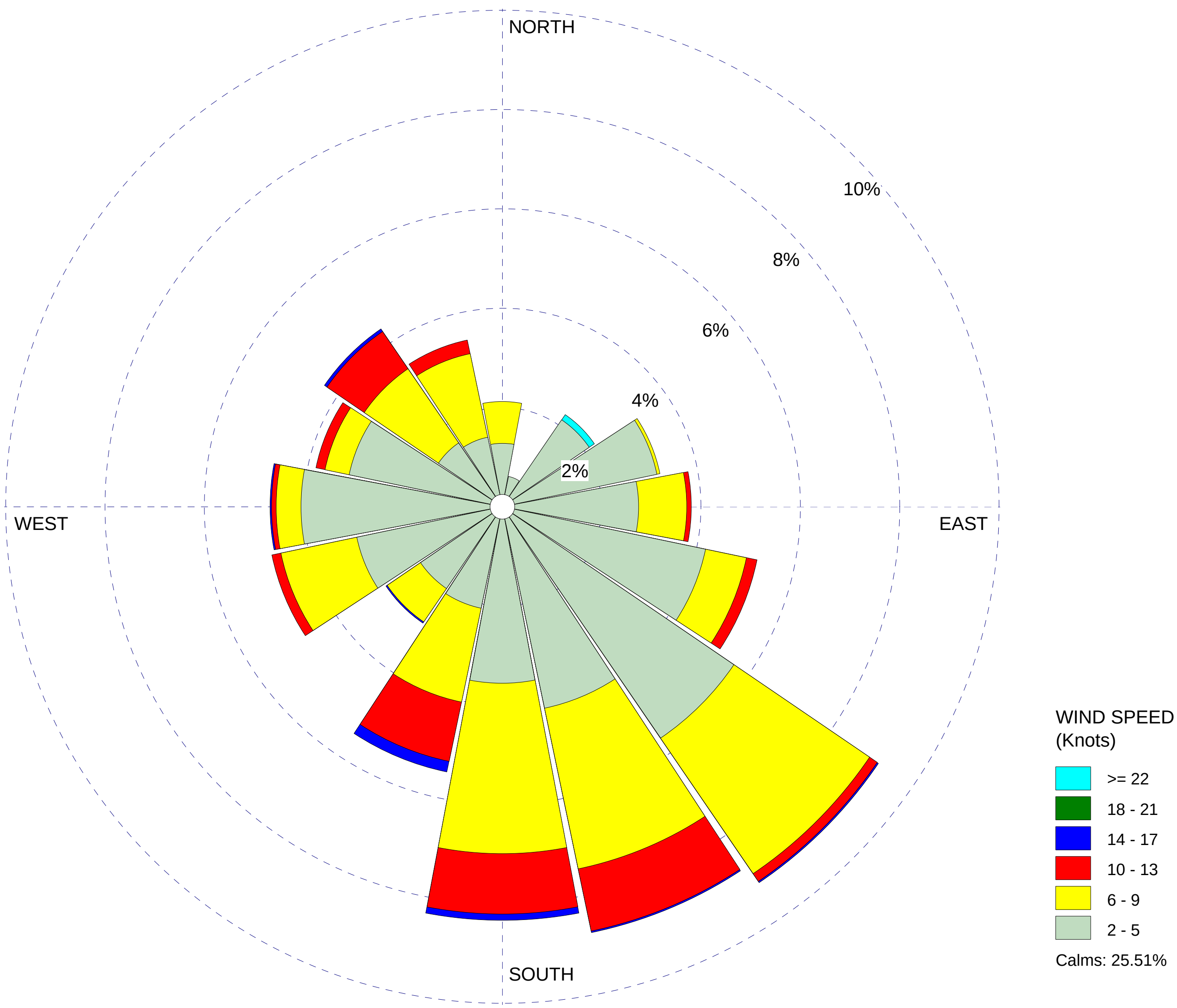
Minto HOBO - September
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 9/7/2005 - 00:00
End Date: 9/30/2009 - 23:00

TOTAL COUNT:	CALM WINDS:
3214 hrs.	**25.51%**

AVG. WIND SPEED:

4.89 Knots

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

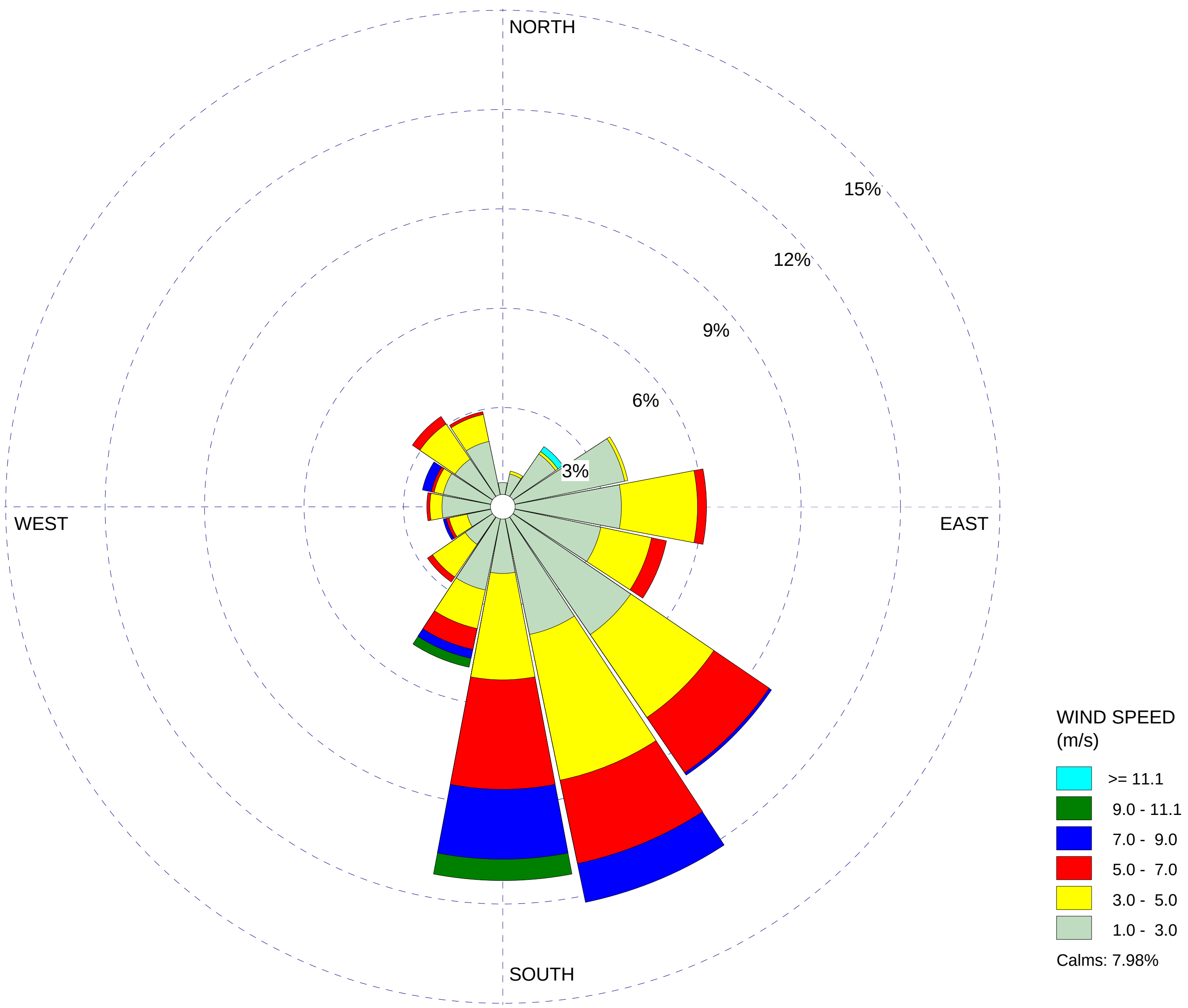
WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

Minto HOBO - October
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

Excludes periods of missing or ice-affected data

DATA PERIOD:

Start Date: 10/1/2005 - 00:00
End Date: 10/26/2009 - 16:00

TOTAL COUNT:	CALM WINDS:
1092 hrs.	**7.98%**

AVG. WIND SPEED:

3.19 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

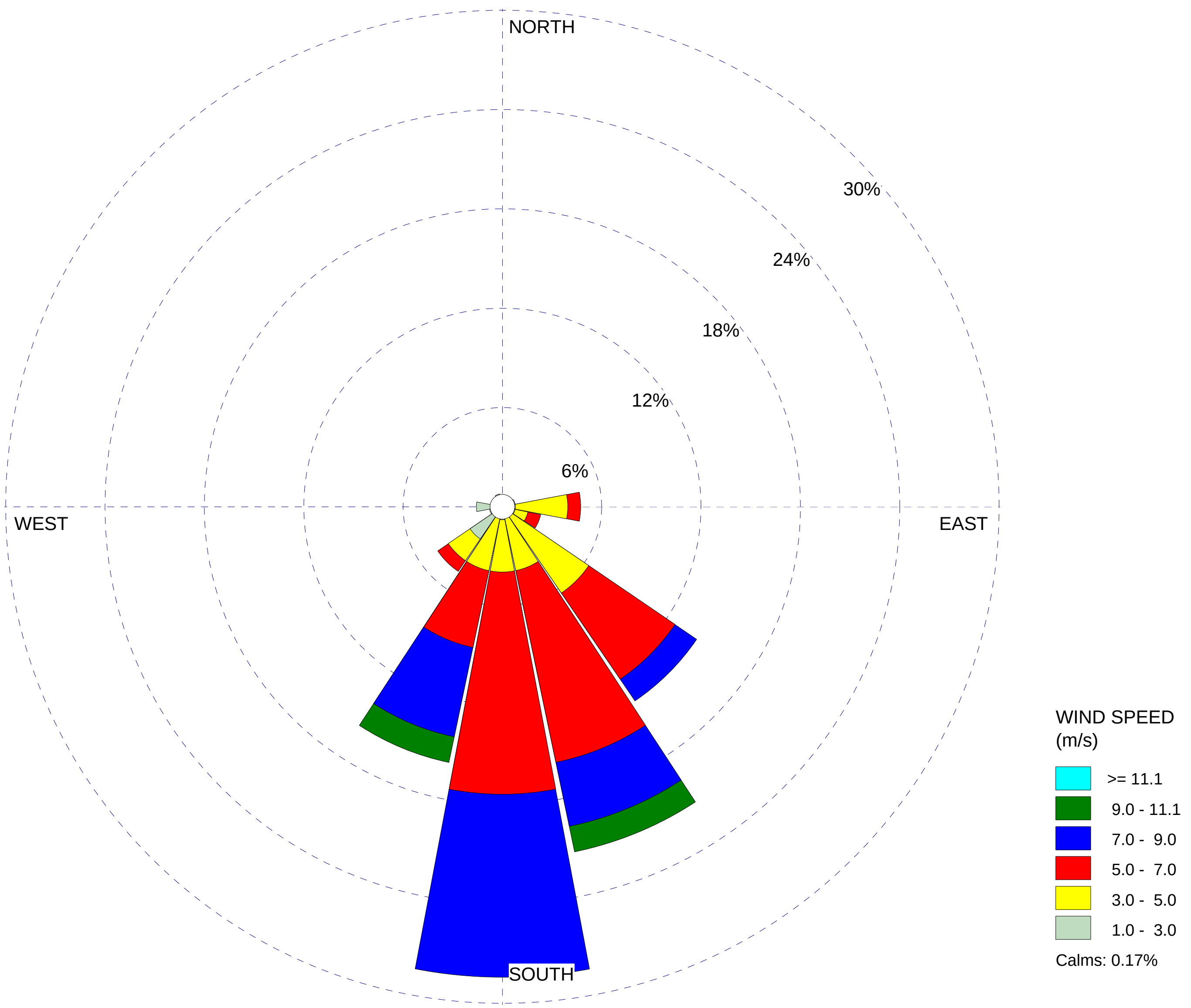
Minto HOBO - November
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 11/17/2005 - 22:00
End Date: 11/14/2007 - 17:00

TOTAL COUNT:	CALM WINDS:
127 hrs.	**0.17%**

AVG. WIND SPEED:

5.33 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WIND ROSE PLOT:

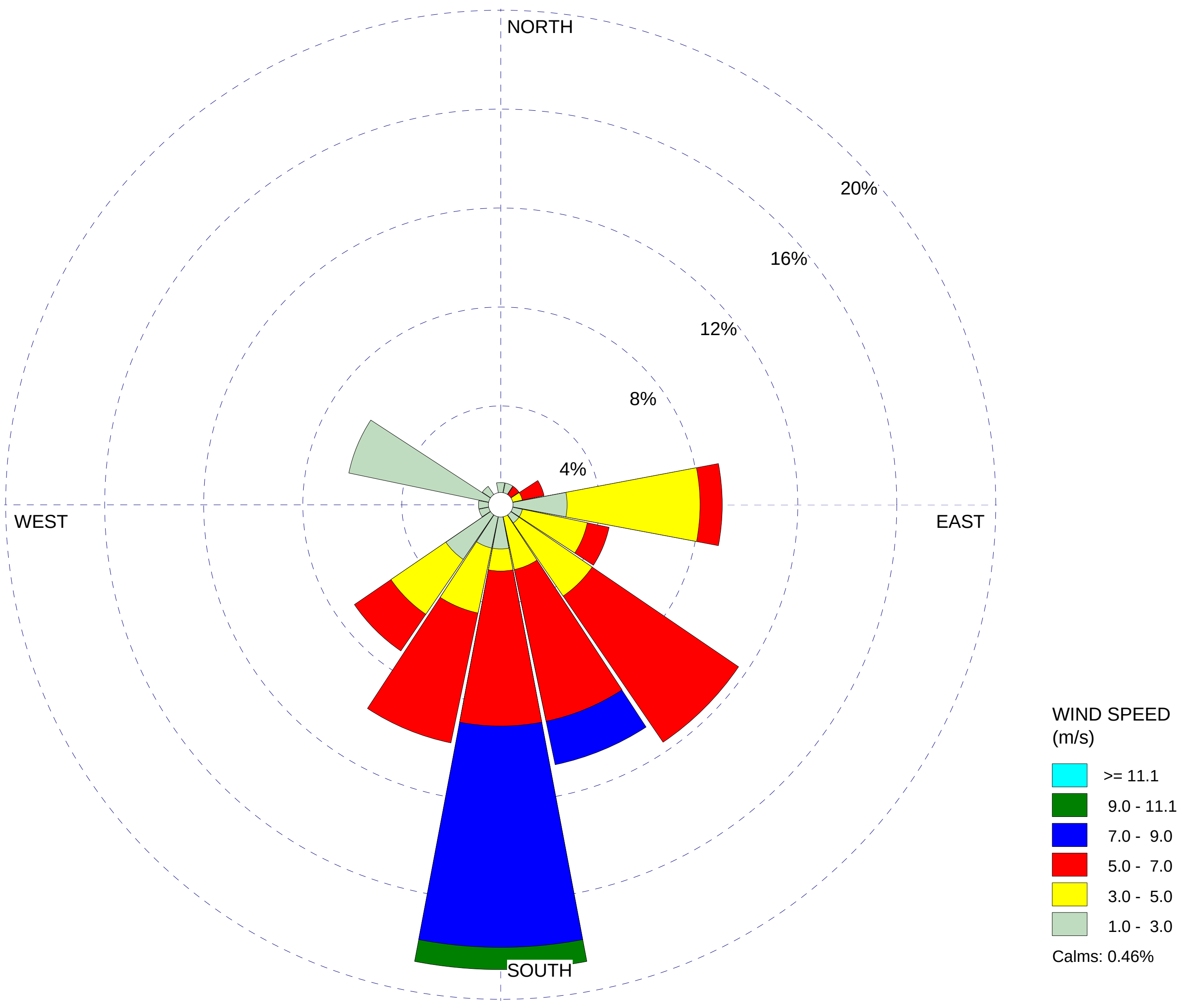
Minto HOBO - December
September 2005 - April 2010

DISPLAY:

Wind Speed
Direction (blowing from)

COMMENTS:

Excludes periods of missing or ice-affected data



DATA PERIOD:

Start Date: 12/7/2005 - 00:00
End Date: 12/2/2009 - 18:00

TOTAL COUNT:	CALM WINDS:
112 hrs.	**0.46%**

AVG. WIND SPEED:

4.01 m/s

COMPANY NAME:

MODELER:

DATE:

10/5/2012

PROJECT NO.:

WRPLOT View - Lakes Environmental Software