



global environmental solutions

# **Meteorological and Air Quality Monitoring for the Pebble Project**

Pebble Project Environmental Baseline Studies Agency Meeting

January 31, 2012



# Introduction

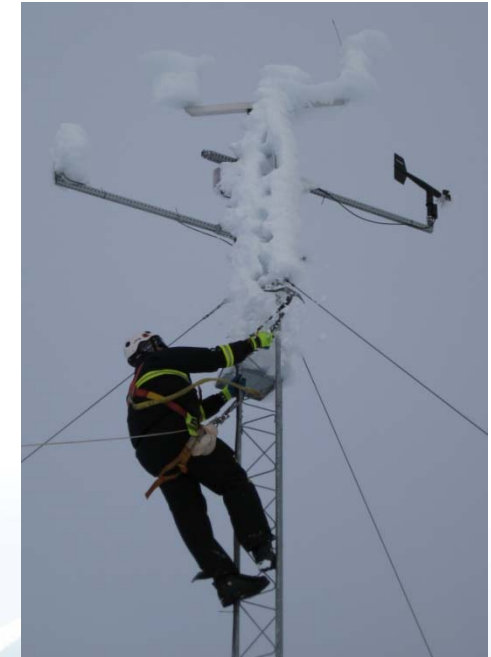
## Baseline Meteorological Monitoring Program

### Objectives – Collect Meteorological Data to Support:

- Air Quality Permit Application
- Other Environmental Studies
- Engineering Design (water balance, etc.)

### PSD vs. non-PSD

- PSD (Prevention of Significant Deterioration) stations collect data in accordance with all EPA and ADEC PSD requirements
- Non-PSD stations are operated primarily to obtain precipitation and evaporation measurements with collected data in accordance with most EPA and ADEC PSD requirements.



# Meteorological Station Nomenclature

Pebble 1 station (PSD 2005 – Current)

Pebble 2 station (Jan – Oct 2005)

Pebble 3 station (Nov 2005 – 2008)

Pebble 4 station (PSD 2006 – 2008)

Pebble 5 station (PSD 2007 – 2009)

Pebble 5A station (2007 – 2009)

Pebble 6 station (PSD 2007 – 2009)

Pebble 7 station (PSD – 2008)

Pebble 8 station (installed Oct 2011)

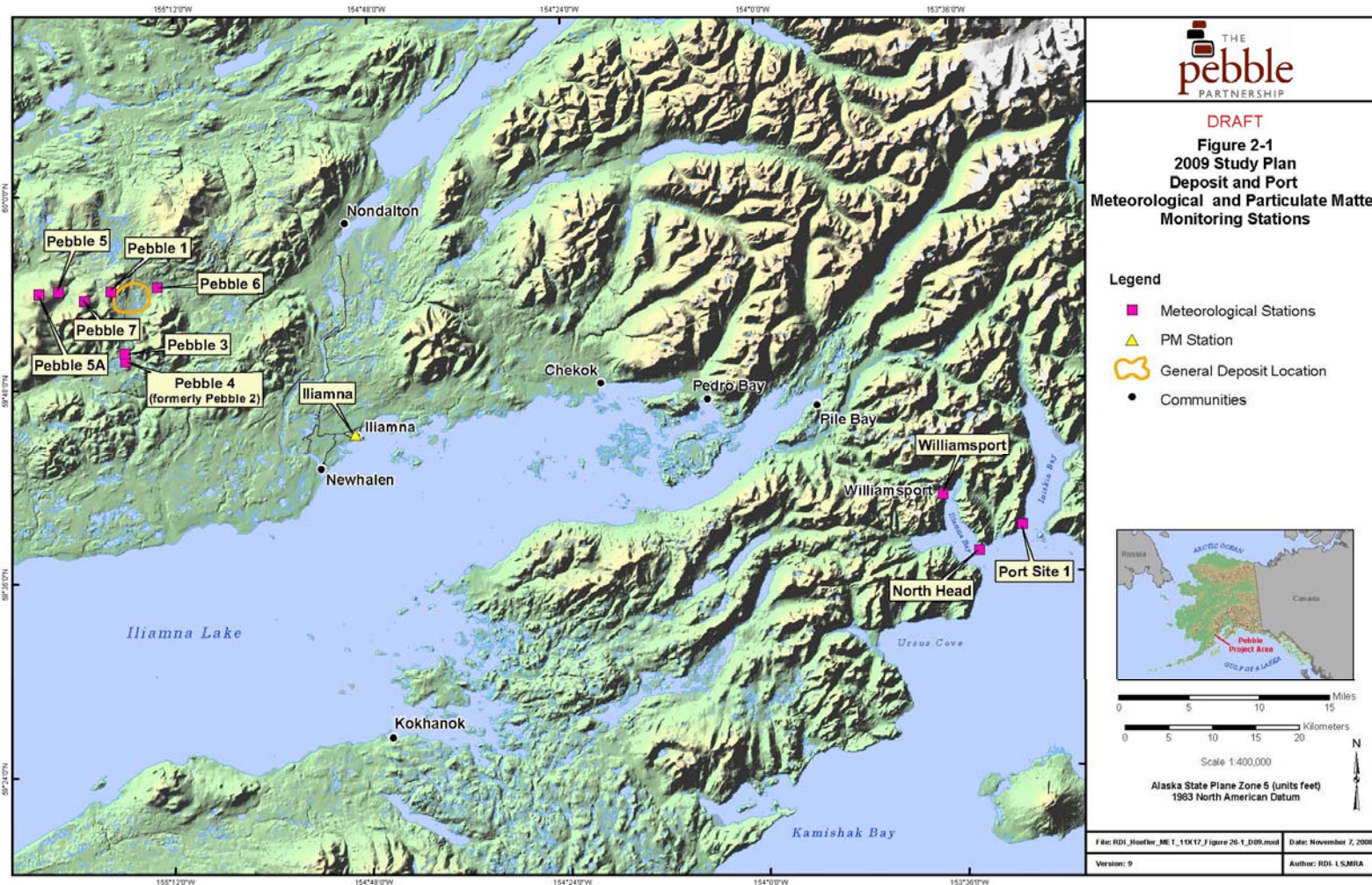
Williamsport (PSD 2007 – 2009)

North Head (PSD 2007 – 2009)

Knoll Head/Port Site 1 (PSD 2005 –  
Current)

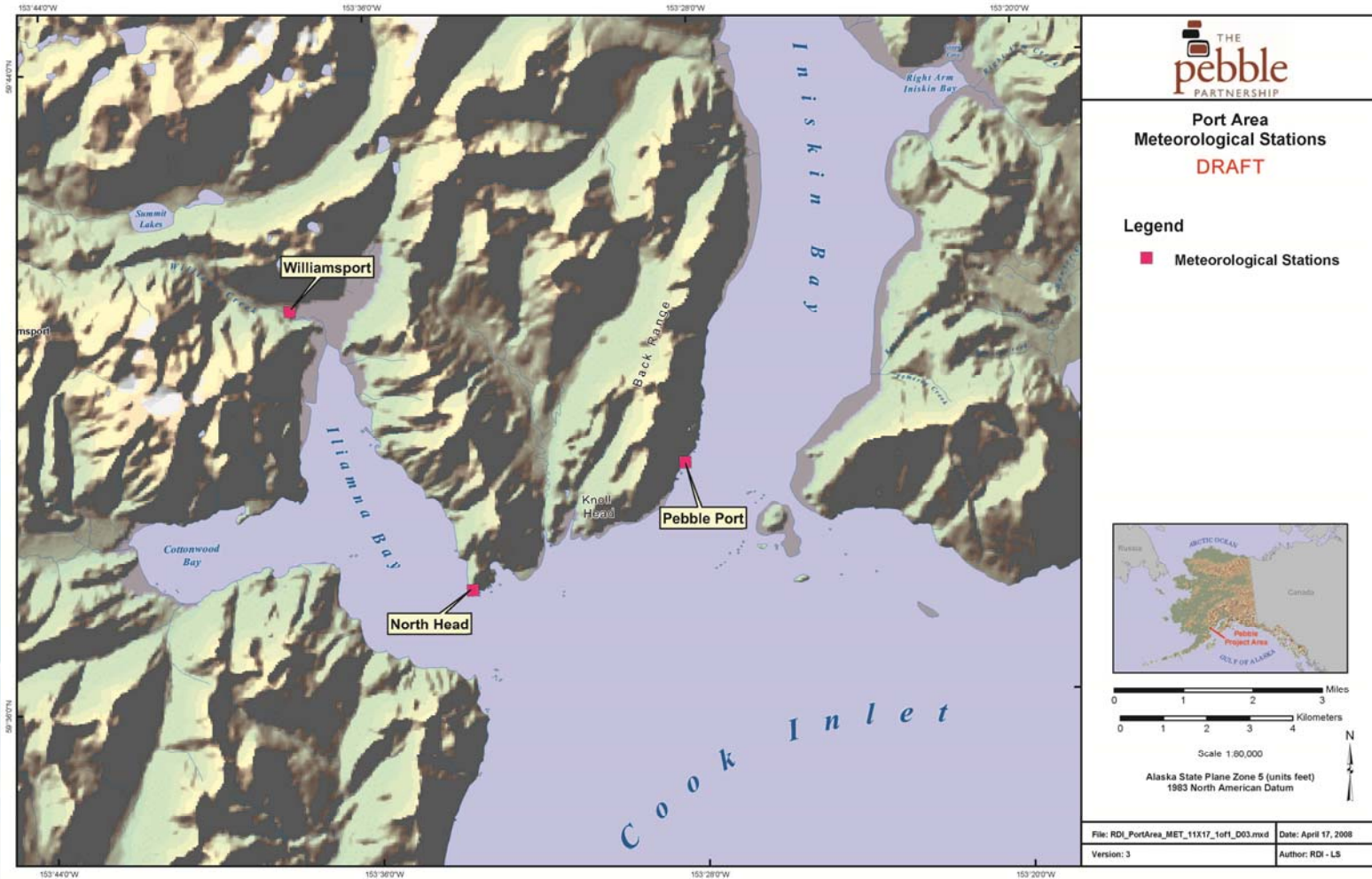


# Meteorological Station Location Map





# Port Area Meteorological Station Location Map

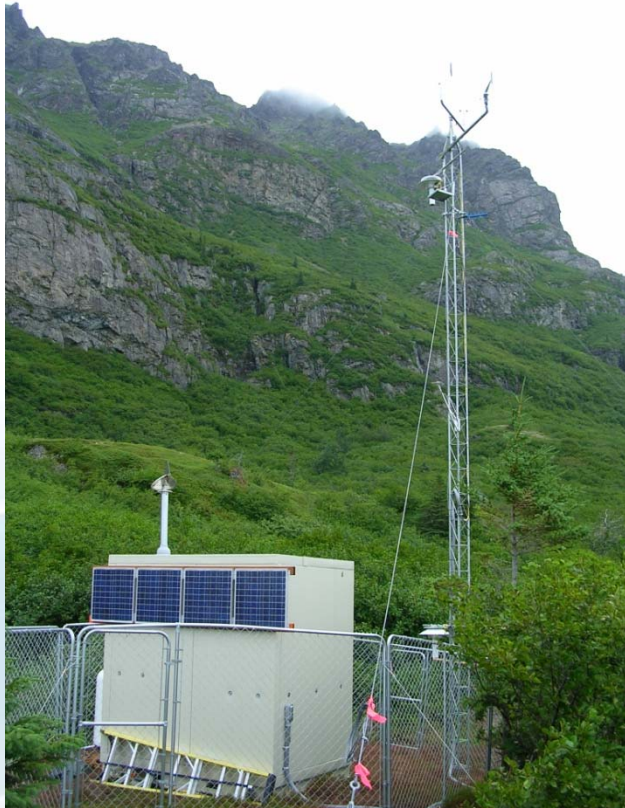


# Meteorological Monitoring Timeline

- Installation of Pebble 1 and Pebble 2 as non-PSD stations
  - October 2004
- Pebble 1 converted to PSD Station
  - June 2005
- Pebble 2 Moved and Reestablished as Pebble 3
  - November 2005
- Installation of Knoll Head /Port1 PSD station
  - June 2005
- Pebble 4 PSD Station Installation Completed
  - June 2006
- Pebble 1 and Knoll Head / Port1 First Annual PSD Monitoring Period
  - August 1, 2005 to July 31, 2006



# Meteorological Monitoring Timeline



- Installation of Pebble 5 and Pebble 5A stations
  - *June / July 2007*
- Installation of Williamsport station
  - *July 2007*
- Installation of Pebble 6 station
  - *August 2007*
- Installation of North Head station
  - *September 2007*
- Installation of PM<sub>10</sub> and PM<sub>2.5</sub> station in Iliamna
  - *August 2008*
- Initiated installation of Pebble 7 station
  - *November 2008*

# Meteorological Monitoring Timeline

- Decommissioned Pebble 3, Pebble 4 and Pebble 7 stations
  - *January 2009*
- Decommissioned Pebble 5, Pebble 6, Williamsport, and North Head stations
  - *January 2010*
- Decommissioned Iliamna Particulate Matter monitoring station
  - *June 2010*
- Installation of Iliamna Ambient Air Quality Monitoring station (same location as previous PM sampling)
  - *September 2011*
- Installation of Pebble 8 (0.75 miles NE of Pebble 1)
  - *September 2011*

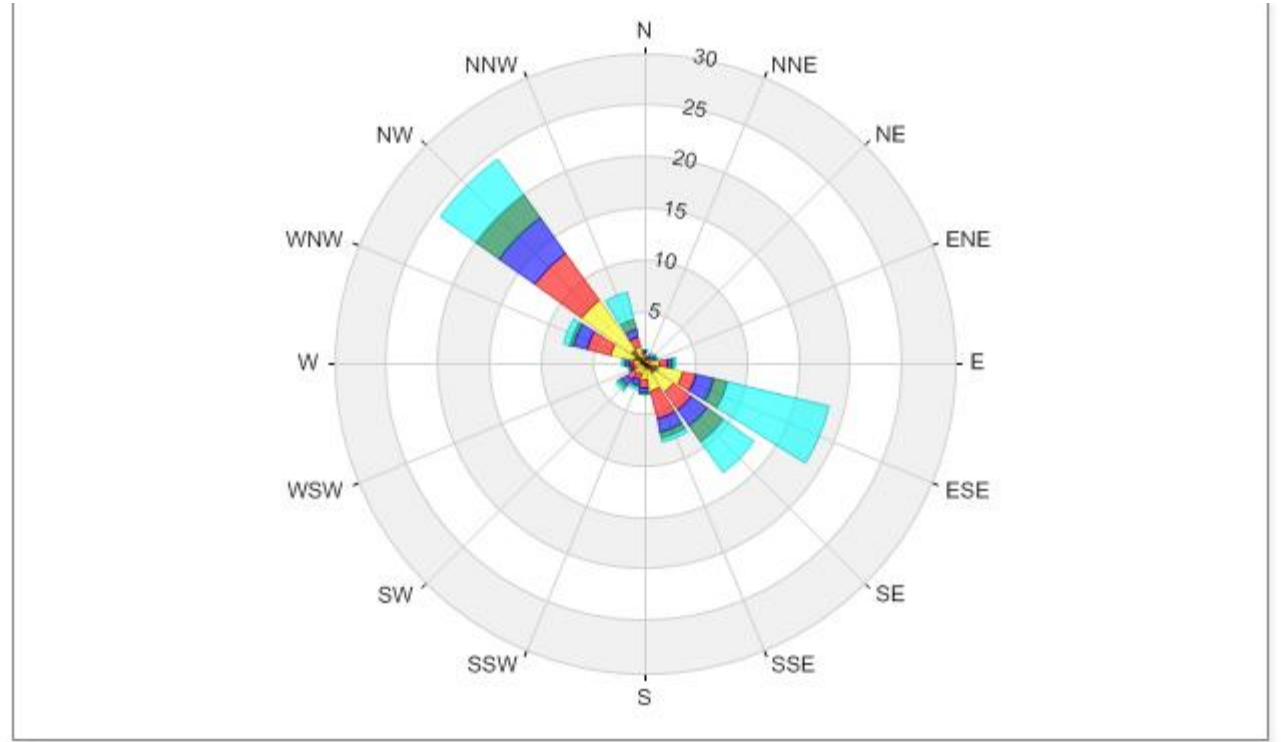


# Meteorological Monitoring Parameters

	Pebble 1	Pebble 3	Pebble 4	Pebble 5	Pebble 5A	Pebble 6	Pebble 7	Pebble 8	WilliamSPORT	North Head	Knoll Head / Port 1
Wind Speed	x	x	x	x	x	x	x	x	x	x	x
Wind Direction	x	x	x	x	x	x	x	x	x	x	x
Air Temperature	x	x	x	x	x	x	x	x	x	x	x
Delta Temperature	x		x	x	x	x	x	x	x	x	x
Solar Radiation	x		x	x		x	x		x	x	x
Barometric Pressure	x		x	x		x	x		x	x	x
Relative Humidity	x		x	x		x	x		x	x	x
Precipitation	x	x	x	x		x	x				x
Evaporation (summer only)	x		x	x		x	x				x

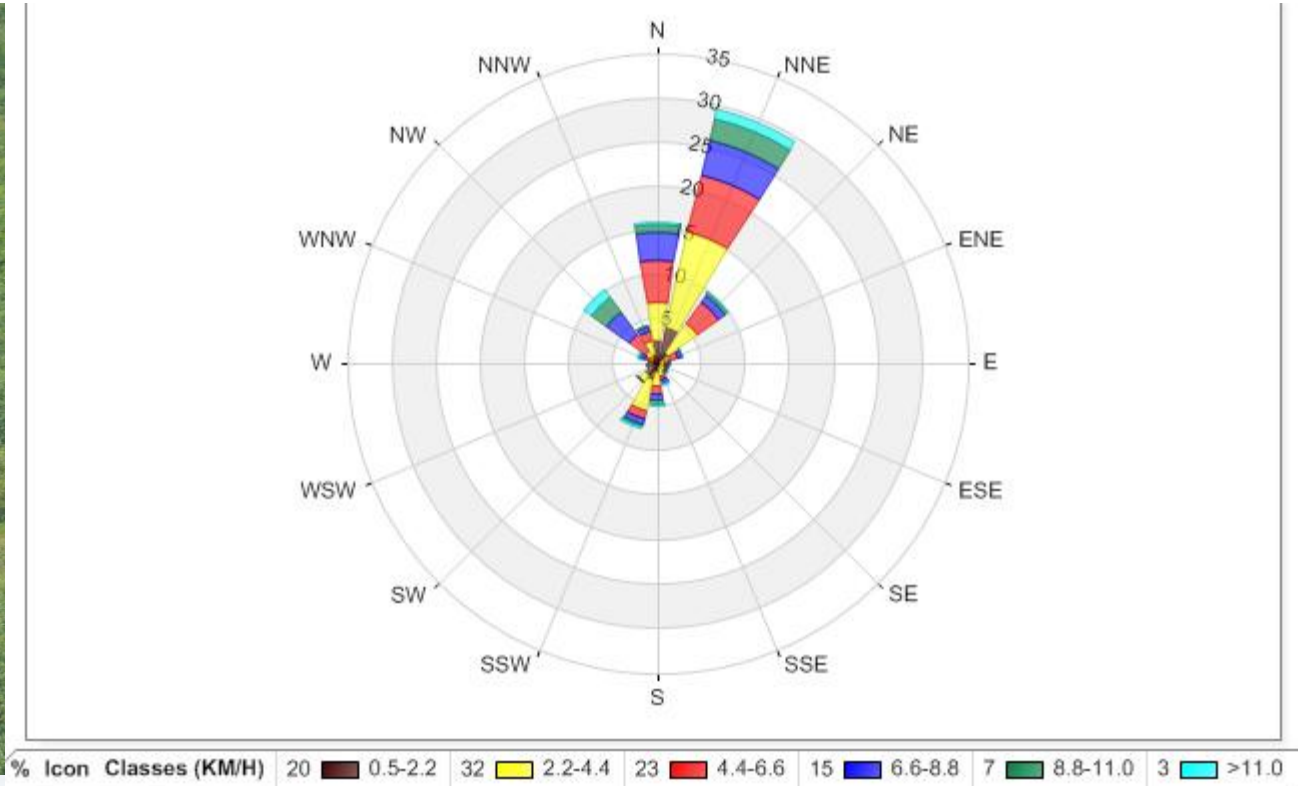
# Pebble 1 Station Wind Rose

## Aug. 2005 – Dec. 2008

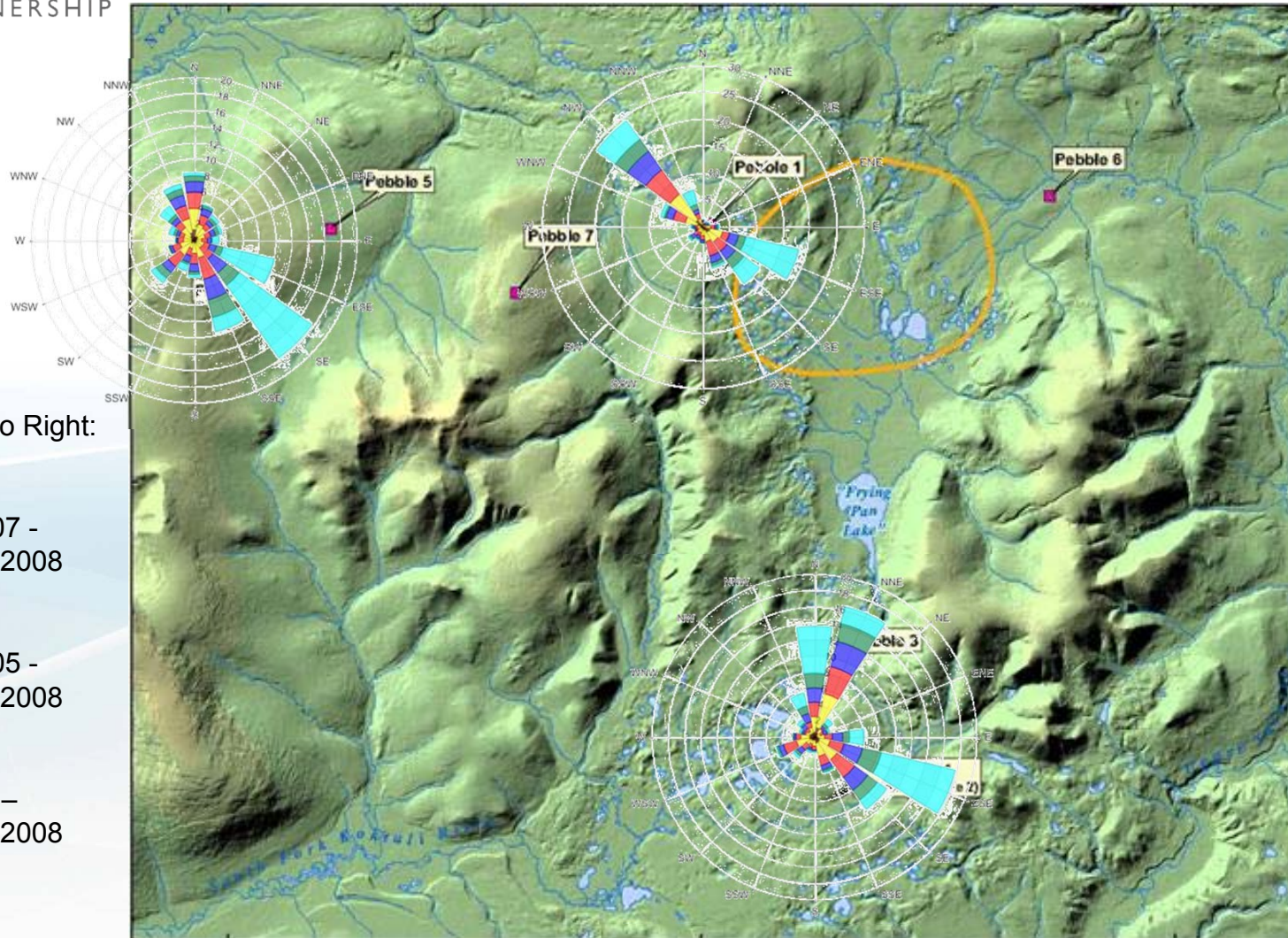


%	Icon	Classes (KM/H)
11		0.5-2.2
22		2.2-4.4
20		4.4-6.6
15		6.6-8.8
9		8.8-11.0
23		>11.0

# Knoll Head / Port 1 Station Wind Rose Aug. 2005 – Dec. 2008



# Pebble Deposit Area Wind Roses



From Left to Right:

Pebble 5A:  
August 2007 -  
December 2008

Pebble 1:  
August 2005 -  
December 2008

Pebble 4:  
June 2006 -  
December 2008

# Wind Speeds

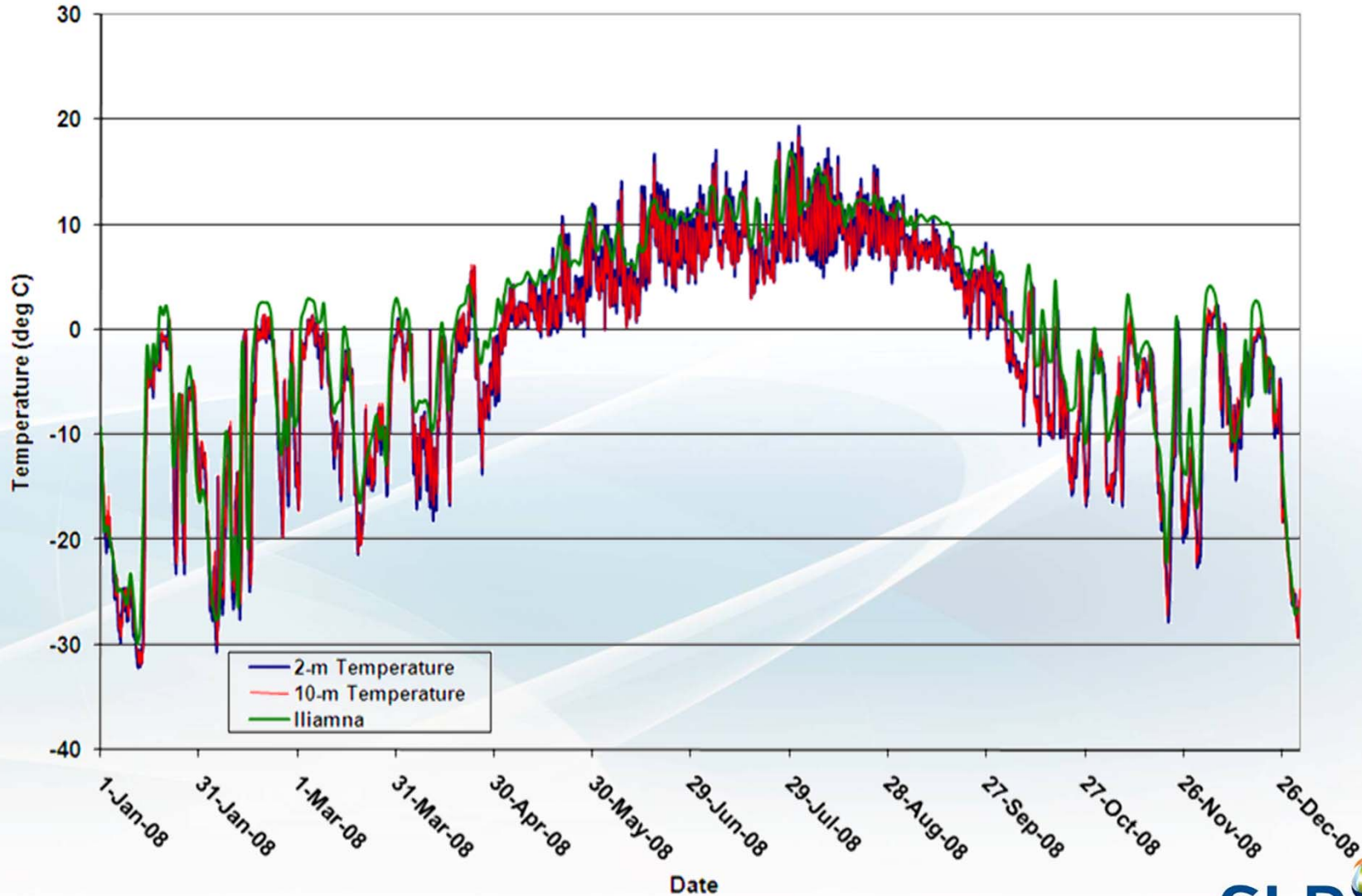
## Hourly Averages – 2005-2008

2005-2008 Pebble Project Wind Speed Data						
Month	Pebble 1			Knoll Head / Port 1		
	Average (m/s)	Max (m/s)	Max (mph)	Average (m/s)	Max (m/s)	Max (mph)
January	8.85	39.99	89.46	6.07	20.42	45.68
February	9.05	30.93	69.19	5.44	20.70	46.30
March	9.33	31.91	71.38	5.49	16.51	36.93
April	8.44	30.31	67.80	5.11	16.12	36.06
May	7.16	29.32	65.59	3.83	12.28	27.47
June	6.61	27.37	61.22	3.33	11.51	25.75
July	5.75	19.98	44.69	3.42	16.01	35.81
August	6.01	21.60	48.32	3.41	14.28	31.94
September	7.07	27.65	61.85	4.25	17.66	39.50
October	6.29	28.80	64.42	5.03	15.46	34.58
November	8.50	30.69	68.65	5.81	16.48	36.86
December	7.21	32.93	73.66	5.87	18.36	41.07

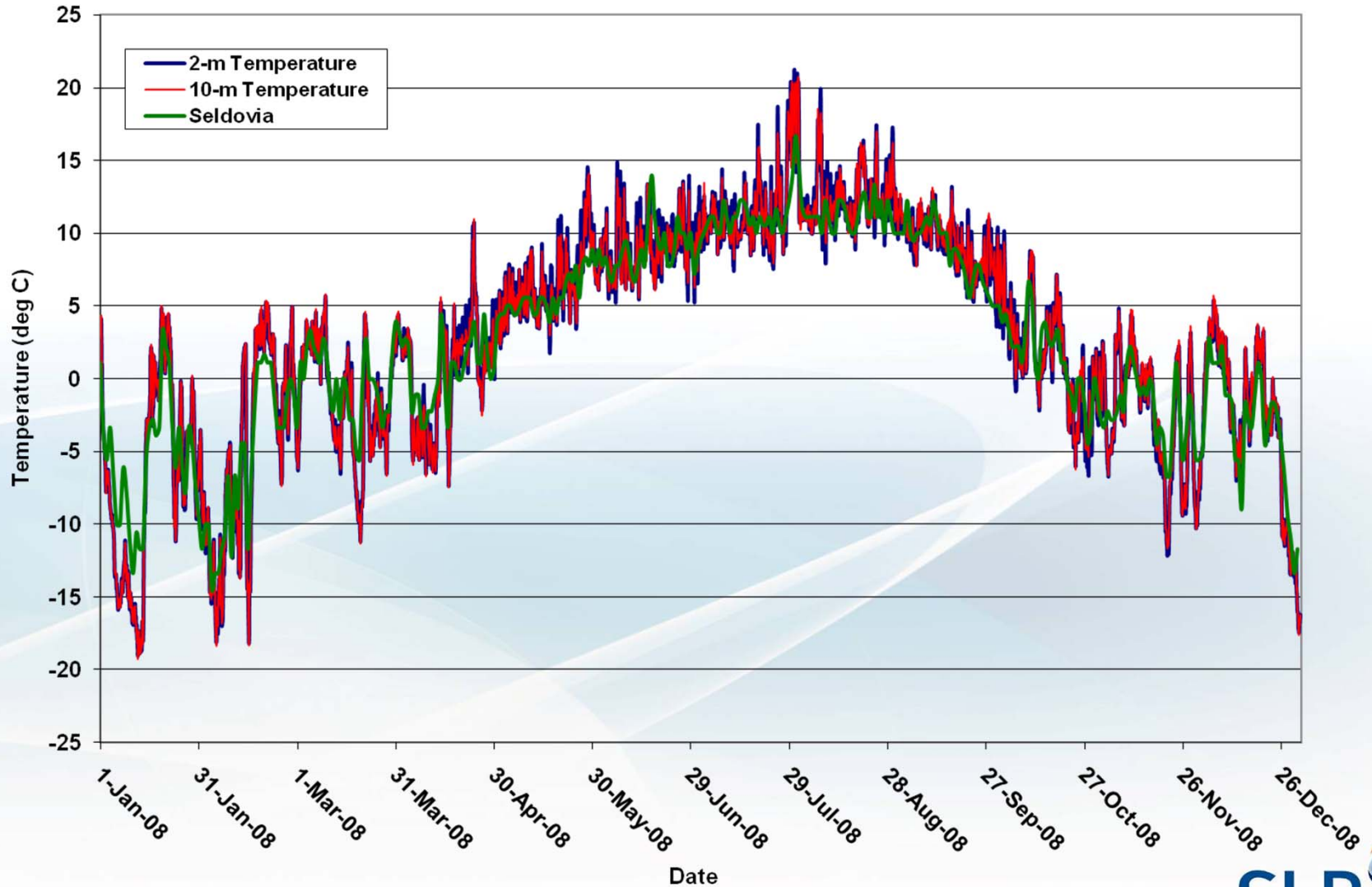
# Air Temperature Hourly Averages – 2005-2008

2005-2008 Pebble Project Surface Temperature Data (°C)						
Month	Pebble 1			Knoll Head / Port 1		
	Average	Minimum	Maximum	Average	Minimum	Maximum
January	-12.81	-35.3	5.42	-6.68	-24.14	8.58
February	-8.98	-31.63	6.37	-3.47	-19.5	10.36
March	-7.54	-28.93	1.34	-1.91	-17.1	5.69
April	-0.89	-18.18	9.24	2.23	-7.37	10.74
May	3.86	-7.17	22.99	6.98	-1.51	17.66
June	7.96	-0.06	21.75	9.90	4.49	25.23
July	10.29	3.00	22.40	12.24	6.56	21.92
August	10.34	2.38	23.63	12.71	7.18	22.61
September	6.53	-2.34	16.10	9.95	3.59	16.96
October	-0.99	-16.81	10.61	3.81	-6.62	12.48
November	-4.41	-27.83	4.14	0.48	-15.66	8.59
December	-5.27	-29.76	3.74	-2.95	-17.42	8.06

# Temperature (Pebble 1 - 2008)



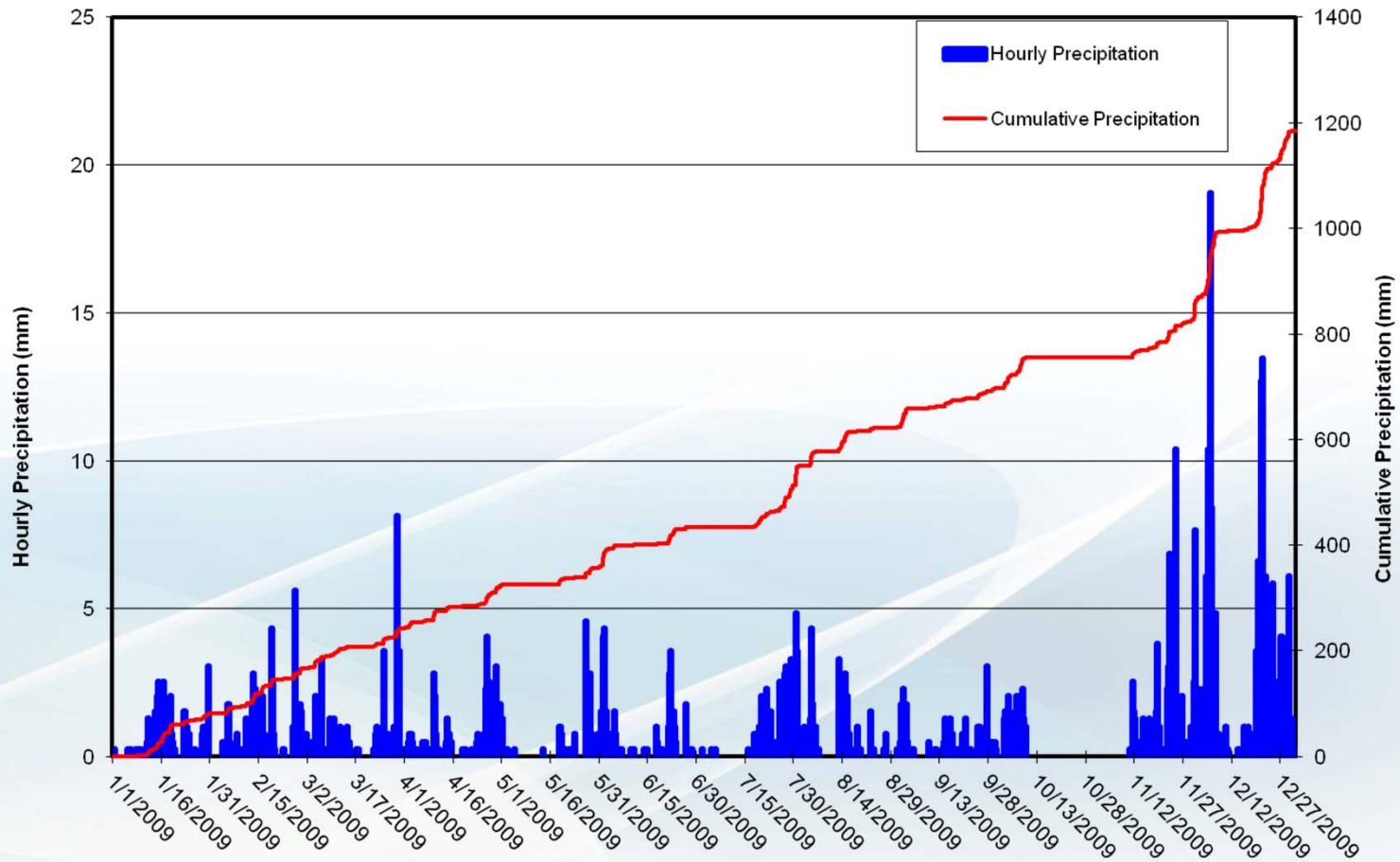
# Temperature (Knoll Head / Port 1 - 2008)



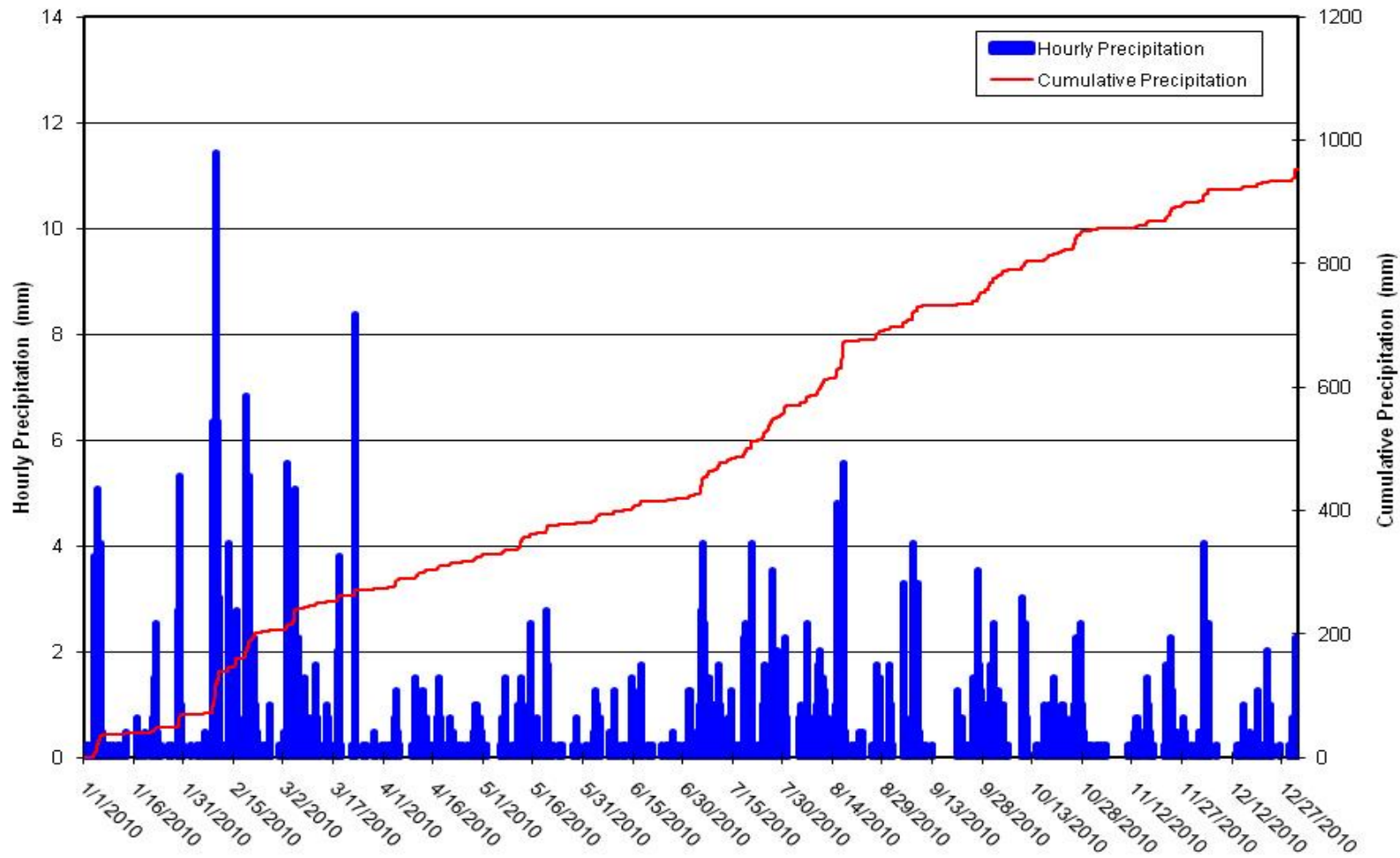
# Precipitation (2009 - 2010)

Pebble Project Precipitation Data												
Month	Pebble 1						Knoll Head / Port 1					
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
	Average (mm/day)		Maximum (mm/day)		Maximum (inches/day)		Average (mm/day)		Maximum (mm/day)		Maximum (inches/day)	
January	2.6	2.3	13.7	19.3	0.5	0.8	4.4	2.0	71.4	17.0	2.8	0.7
February	2.9	4.8	13.7	41.1	0.5	1.6	2.6	4.7	16.3	36.0	0.6	1.4
March	2.5	2.2	11.2	21.3	0.4	0.8	1.2	1.6	6.1	15.0	0.2	0.6
April	2.7	1.8	14.2	10.4	0.6	0.4	2.3	7.7	34.5	52.0	1.4	2.0
May	1.2	1.7	9.1	15.5	0.4	0.6	4.7	0.9	58.7	6.4	2.3	0.3
June	2.4	1.3	24.9	7.6	1.0	0.3	2.9	6.0	22.4	72.1	0.9	2.8
July	3.8	4.9	32.8	22.9	1.3	0.9	10.3	12.4	48.5	66.5	1.9	2.6
August	2.4	4.1	23.9	22.1	0.9	0.9	5.2	3.6	61.7	18.5	2.4	0.7
September	2.5	2.4	20.8	13.7	0.8	0.5	5.9	2.9	43.7	27.9	1.7	1.1
October	1.9	2.7	14.5	13.2	0.6	0.5	8.5	6.1	42.9	33.5	1.7	1.3
November	3.5	1.5	35.8	10.9	1.4	0.4	6.7	4.5	85.1	72.1	3.4	2.8
December	10.4	1.7	56.4	9.9	2.2	0.4	6.1	1.6	65.0	19.3	2.6	0.8

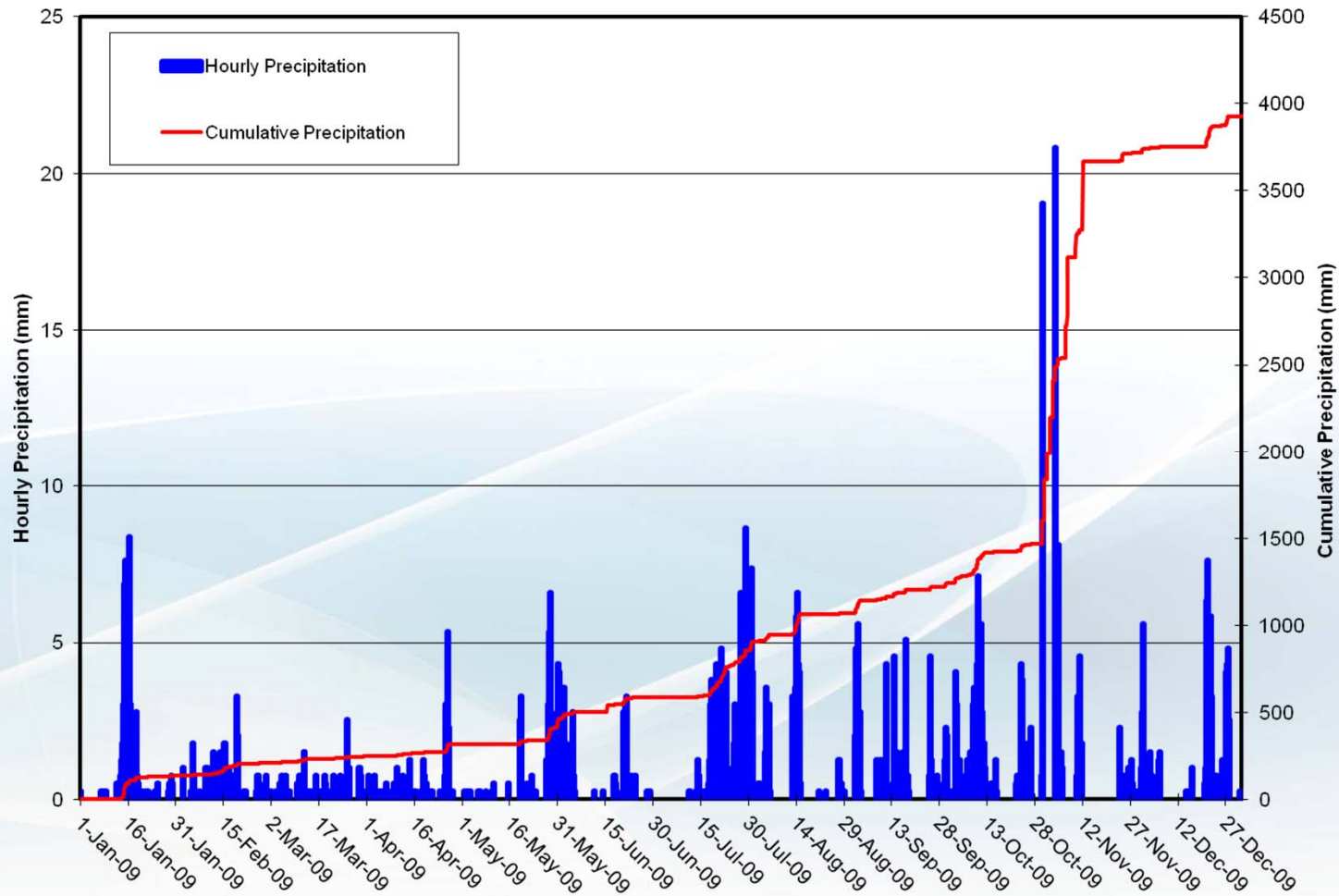
# Precipitation (Pebble 1 - 2009)



# Precipitation (Pebble 1 - 2010)

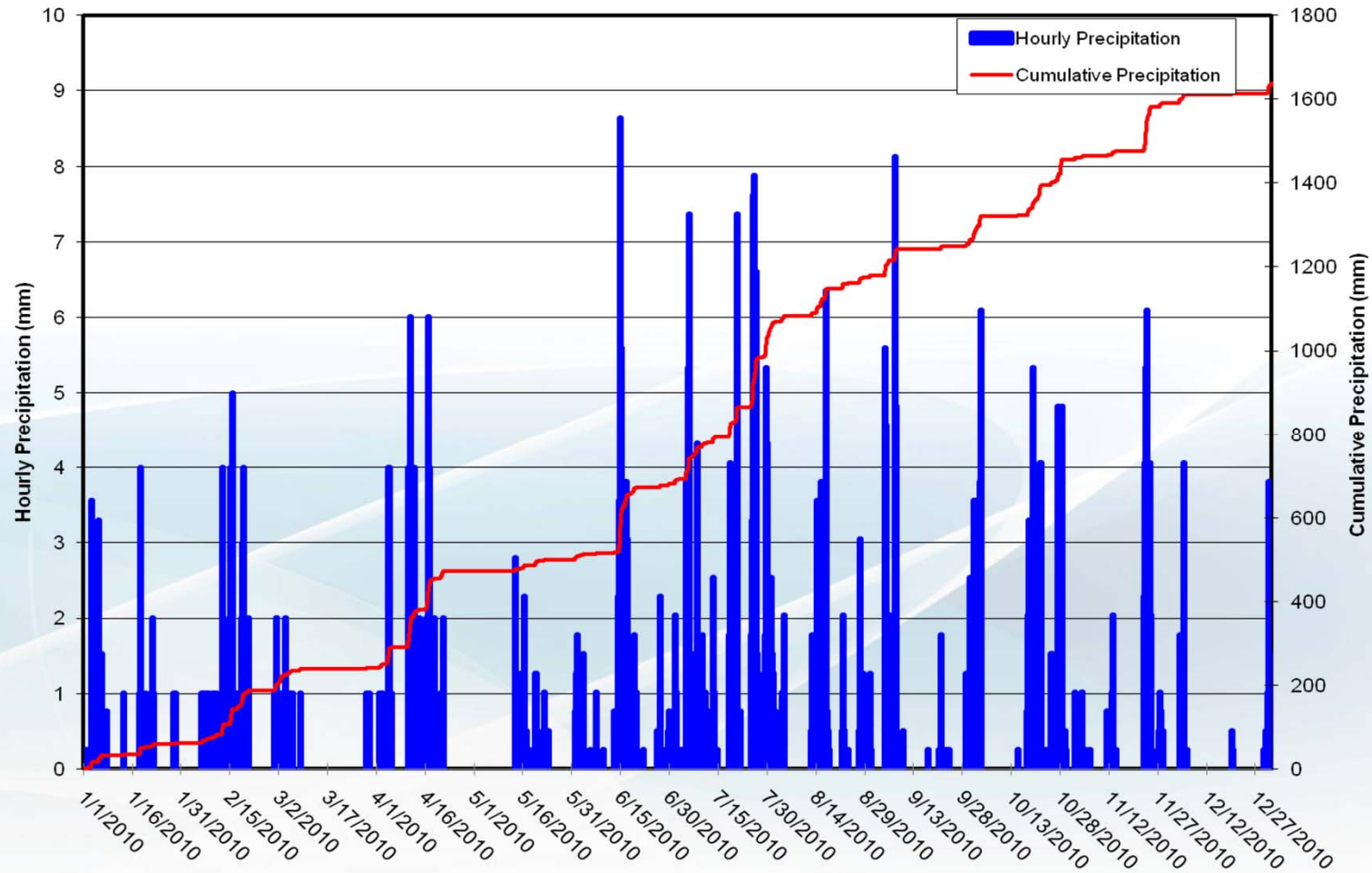


# Precipitation (Knoll Head / Port 1 - 2009)



# Precipitation

## (Knoll Head / Port 1 - 2010)



# Extreme Wind Observations for Station Records 2005-2008 [Metric Units]

	Pebble 1	Pebble 3	Pebble 4	Pebble 5	Pebble 5A	Pebble 6	North Head	Knoll Head / Port 1	Williamsport
Maximum Hourly Wind Speed (m/s)	40.0 (1/07)	22.7 (4/07)	37.6 (3/07)	29.5 (1/08)	40.7 (12/08)	20.1 (11/07)	29.3 (2/08)	20.7 (2/08)	12.7 (10/07)
Maximum Wind Gust (m/s)	54.2 (2/08)	57.6 (1/07)	61.3 (4/07)	56.0 (2/08)	50.6 (8/07)	50.8 (2/08)	43.0 (1/08)	52.2 (8/07)	33.9 (10/07)



# Extreme Wind Observations for Station Records 2005-2008 [English Units]

	Pebble 1	Pebble 3	Pebble 4	Pebble 5	Pebble 5A	Pebble 6	North Head	Knoll Head / Port 1	Williamsport
Maximum Hourly Wind Speed (mph)	89.5 (1/07)	50.8 (4/07)	84.1 (3/07)	66.0 (1/08)	91.0 (12/08)	45.0 (11/07)	65.5 (2/08)	46.3 (2/08)	28.4 (10/07)
Maximum Wind Gust (mph)	121.2 (2/08)	128.8 (1/07)	137.1 (4/07)	125.3 (2/08)	113.2 (8/07)	113.6 (2/08)	96.2 (1/08)	116.8 (8/07)	75.8 (10/07)



# Extreme Temperature Observations for Station Records 2005-2008 [Metric Units]

	Pebble 1	Pebble 3	Pebble 4	Pebble 5	Pebble 5A	Pebble 6	North Head	Knoll Head / Port 1	Williamsport
Maximum Hourly Air Temperature (deg. C)	23.6 (8/05)	24.3 (5/06)	23.0 (8/07)	22.6 (8/07)	17.6 (7/08)	21.3 (7/08)	21.0 (7/08)	25.2 (6/07)	22.2 (7/08)
Minimum Hourly Air Temperature (deg. C)	-35.3 (1/06)	-33.4 (1/06)	-31.1 (1/08)	-32.2 (1/08)	-33.5 (1/08)	-30.7 (1/08)	-24.2 (1/08)	-24.1 (1/06)	-26.2 (1/08)



# Extreme Temperature Observations for Station Records 2005-2008 [English Units]

	Pebble 1	Pebble 3	Pebble 4	Pebble 5	Pebble 5A	Pebble 6	North Head	Knoll Head / Port 1	Williamsport
Maximum Hourly Air Temperature (deg. F)	52.8 (8/05)	54.4 (5/06)	51.4 (8/07)	50.6 (8/07)	39.4 (7/08)	47.6 (7/08)	47.0 (7/08)	56.4 (6/07)	49.7 (7/08)
Minimum Hourly Air Temperature (deg. F)	-79.0 (1/06)	-74.7 (1/06)	-69.6 (1/07)	-72.0 (1/08)	-74.9 (1/08)	-68.7 (1/08)	-54.1 (1/08)	-53.9 (1/06)	-58.6 (1/08)



# Extreme Precipitation Observations for Station Records 2005-2010 [Metric Units]

	Pebble 1	Pebble 4	Pebble 5	Pebble 6	Knoll Head / Port 1
Maximum Daily Precipitation (mm)	59.7 (12/09)	42.8 (9/06)	42.9 (7/09)	35.0 (9/07)	75.2 (1/09)
Maximum Monthly Evaporation (summer only, mm)	127.8 (7/09)	89.8 (6/07)	104.0 (7/09)	93.8 (6/09)	129.4 (8/09)



# Extreme Precipitation Observations for Station Records 2005-2010 [English Units]

	Pebble 1	Pebble 4	Pebble 5	Pebble 6	Knoll Head / Port 1
Maximum Daily Precipitation (in)	2.4 (12/09)	1.7 (9/06)	1.7 (7/09)	1.38 (9/07)	2.96 (1/09)
Maximum Monthly Evaporation (summer only, in)	5.0 (7/09)	3.5 (6/07)	4.1 (7/09)	3.7 (6/09)	5.1 (8/09)

# Particulate Matter Monitoring



# Particulate Matter Monitoring

(Jan 2009 – Dec. 2009)

Pollutant	National and Alaska Air Quality Standards (NAAQS/AAQS)	Averaging Period	Qtr A	Qtr B	Qtr C	Qtr D	Annual Average	24-Hour Standard Design Value
Particulate Matter (microns <math>PM_{2.5}</math>)	Annual Average <math><15.0 \mu g/m^3</math> 24-Hour Standard Design Value <math><35.0 \mu g/m^3</math>	Average (<math>\mu g/m^3</math>)	2.6	3.3	3.7	1.7	2.8	5.7
		1 <sup>st</sup> Highest 24-Hour Average	4.9	6.2	36.8	4.3		
		2 <sup>nd</sup> Highest 24-Hour Average	4.8	5.4	5.8	3.5		
Particulate Matter (microns <math>PM_{10}</math>)	24-Hour Average <math><150.0 \mu g/m^3</math>	Average (<math>\mu g/m^3</math>)	3.2	5.0	5.9	2.3	4.1	N/A
		1 <sup>st</sup> Highest 24-Hour Average	9.3	15.0	42.8	5.8		
		2 <sup>nd</sup> Highest 24-Hour Average	7.9	9.0	14.9	5.3		

## Continued in 2011



*Pebble 1 Meteorological  
Monitoring*

*Knoll Head / Port 1  
Meteorological Monitoring*

*Began Ambient Air Quality  
Monitoring in Iliamna  
(CO, NO<sub>2</sub>, O<sub>3</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, Met)*

*Installed Pebble 8  
Meteorological Monitoring  
(Non-PSD)*