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Report

WHITE BAY CRUISE TERMINAL: AIR QUALITY AND METEOROLOGICAL MONITORING REPORT – MARCH 2016

Port Authority of NSW

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GLOSSARY

Term	Description
AS	Australian Standard
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
BAM	Beta attenuation monitor
EnviroSuite	Pacific Environment's proprietary data management software
EPA	(New South Wales) Environment Protection Authority
$\mu g/m^3$	Micrograms per cubic metre
GLB	Glebe Island berths
GMR	(New South Wales) Greater Metropolitan Region
m/s	Metres per second
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
OEH	(New South Wales) Office of Environment and Heritage
ppb	Parts per billion
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of less than 2.5 micrometres (µm)
QA	Quality assurance
QC	Quality control
SO_2	Sulfur dioxide
TEOM	Tapered element oscillating microbalance
WBCT	White Bay Cruise Terminal
W/m^2	Watts per square metre

1 INTRODUCTION

The Port Authority of NSW has committed to undertaking additional air quality monitoring in the residential area adjacent to the White Bay Cruise Terminal (WBCT), and has worked with NSW Environment Protection Authority (EPA) to determine the parameters to be monitored, an appropriate location for the monitoring station, and the duration of the monitoring programme. The monitored parameters are sulfur dioxide (SO_2) and particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$). The monitoring also includes local wind speed and direction.

The monitoring station samples SO_2 every ten seconds and records data at 5-minute averaging periods. $PM_{2.5}$ is determined as one-hour averages. These data are used to assess compliance with local air quality standards.

The NSW air quality criteria for SO_2 are 712, 570, and 228 µg/m^3 for 10-minute, 1-hour and 24-hour averages respectively (**NSW DEC, 2005**). For $PM_{2.5}$, the National Environment Protection Council (NEPC) released a variation to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) to include, amongst other things, formal standards for $PM_{2.5}$ (**NEPC, 2016**). The AAQ NEPM standard for the 24-hour average is 25 µg/m^3.

Pacific Environment has been commissioned to provide monthly reports for 12 months from September 2015 onwards. Any exceedances of the NSW air quality criteria or the AAQ NEPM standard for ground-level concentrations are being reported and discussed. The $PM_{2.5}$ and SO_2 concentrations at WBCT are being compared with those at monitoring sites around Sydney operated by the NSW Office of Environment and Heritage (OEH). These are located at Bargo, Bringelly, Campbelltown West, Chullora, Earlwood, Liverpool, Richmond and Rozelle.

This report provides the monitoring results for the period from 1 March 2016 to 31 March 2016.

2 METHODOLOGY

The monitoring location has been installed following consultation with the EPA and Leichhardt Municipal Council to measure $PM_{2.5}$ and SO_2, as well as local wind speed and direction.

The monitoring station is located immediately north of WBCT on the corner of Adolphus Street and Grafton Street, Balmain (33.860142° S, 151.187413°E), approximately 14 m above sea level (**Figure 2-1**).

As far as practicable, this site complies with the requirements of *Australian Standard AS/NZS 3580.1.1:2007 - Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment*. The site represents the best available location, but does not fully comply as there are trees within 20 m of the site. The non-compliance is not expected to significantly affect the results from the monitoring station.

Instrument calibration is performed in accordance with relevant Australian Standards and National Association of Testing Authorities (NATA) procedures. Details of the quality assurance procedures, including calibration and equipment maintenance, are given in **Appendix B**.

Figure 2-1: Location of White Bay Cruise Terminal monitoring station and berths

3 MONITORING DATA

The results of the monitoring are presented below and are compared with the EPA ambient air quality criteria. These are 10-minute, 1-hour and 24-hour average concentrations for SO_2, and 24-hour average concentrations for $PM_{2.5}$.

The 24-hour average SO_2 and $PM_{2.5}$ are compared with data from OEH monitoring sites. Polar bivariate plots are also presented that show 5-minute average SO_2 and $PM_{2.5}$ concentrations as a function of wind speed and wind direction.

3.1 Cruise ship days

Cruise ship days in March are shown in **Table 3-1**, which shows that there were seven cruise ship days in March, including one overnight stay.

Table 3-1 Cruise ship days in March

Arrival date and time	Departure date and time	Cruise ship	Berth
4/03/2016 6:13	5/03/2016 17:02	BLACK WATCH	WHT5
8/03/2016 7:49	8/03/2016 16:10	PACIFIC JEWEL	WHT5
9/03/2016 7:25	9/03/2016 16:03	DAWN PRINCESS	WHT5
17/03/2016 7:57	17/03/2016 16:06	PACIFIC JEWEL	WHT5
24/03/2016 7:02	24/03/2016 16:15	PACIFIC JEWEL	WHT5
25/03/2016 6:24	25/03/2016 16:01	NOORDAM	WHT5
28/03/2016 8:47	28/03/2016 17:24	PACIFIC JEWEL	WHT5

3.2 10-minute average sulfur dioxide concentrations

A time-series plot of 10-minute average SO_2 concentrations for March 2016 is shown in **Figure 3-1.**

There was no exceedance of the 10-minute average air quality criterion for SO_2 during the reporting period as all 10-minute-average SO_2 concentrations were less than 65 µg/m^3.

The highest 10-minute average SO_2 concentration (64 µg/m^3) was recorded on 2 March, which occurred when no cruise ships were berthed at WBCT. The second highest average SO_2 concentration also occurred on a day when no cruise ships were berthed at WBCT (23 March 2016). The SO_2 concentrations were low (less than 25 µg/m^3) on all days when cruise ships were berthed at the WBCT.

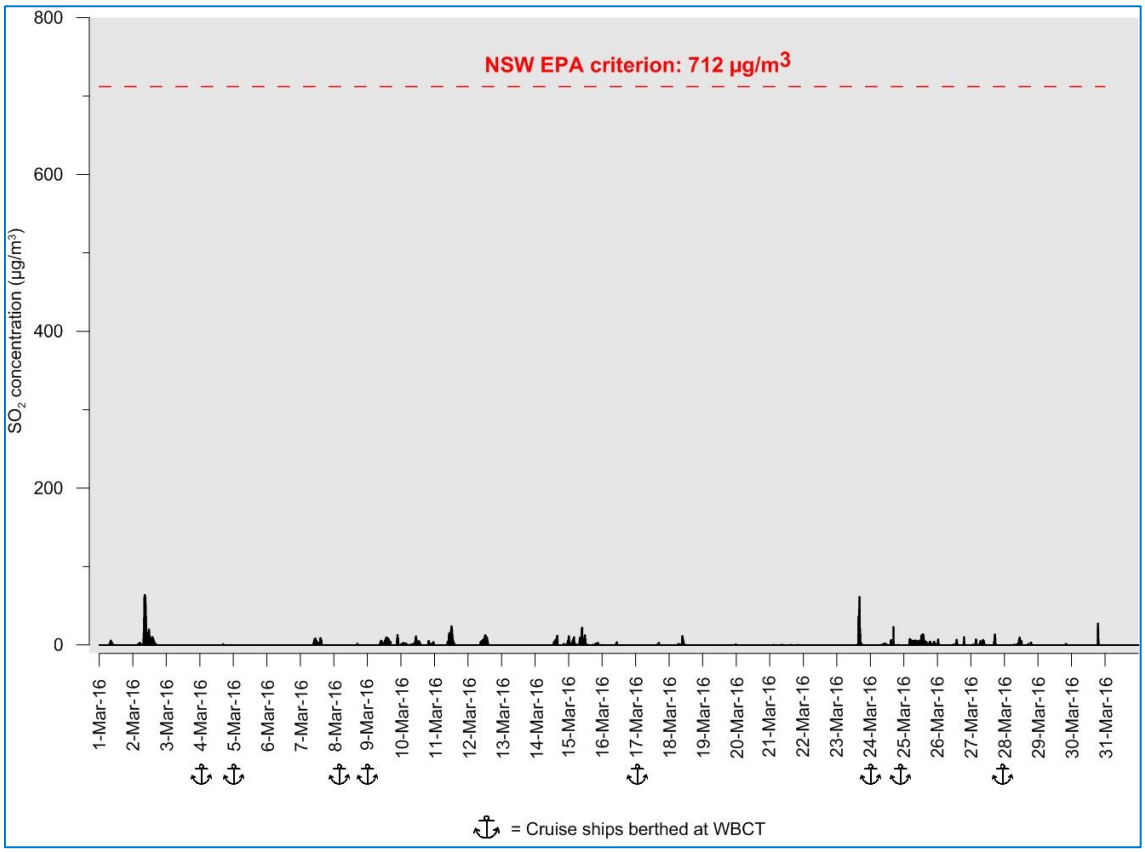


Figure 3-1: 10-minute average SO_2 concentrations for March 2016

3.3 1-hour average sulfur dioxide concentrations

A time series plot of the 1-hour average SO_2 concentration in March 2016 is shown in **Figure 3-2**.

The highest 1-hour average SO_2 concentration (46 µg/m^3) was recorded on 2 March, which occurred when no cruise ships were berthed at WBCT. The SO_2 concentrations were low (less than 15 µg/m^3) on all days when cruise ships were berthed at the WBCT.

No exceedances of the 1-hour air quality criterion for SO_2 were recorded during the reporting period.

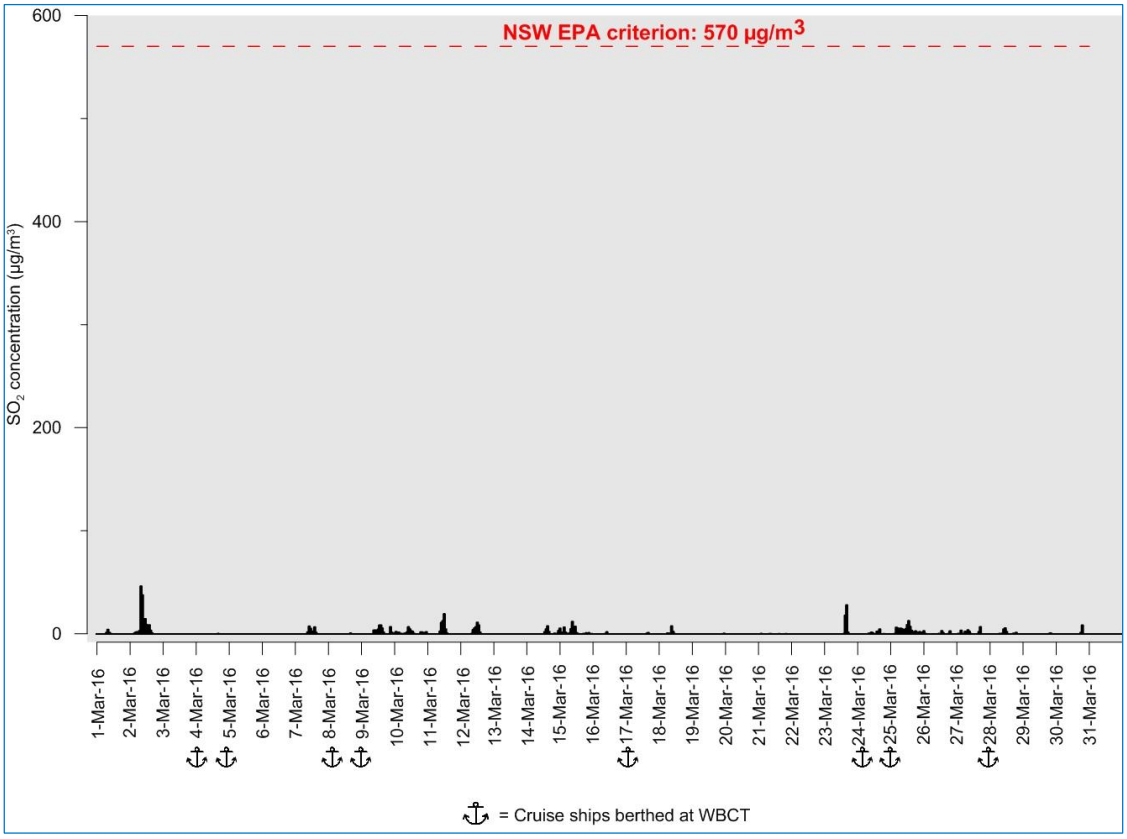


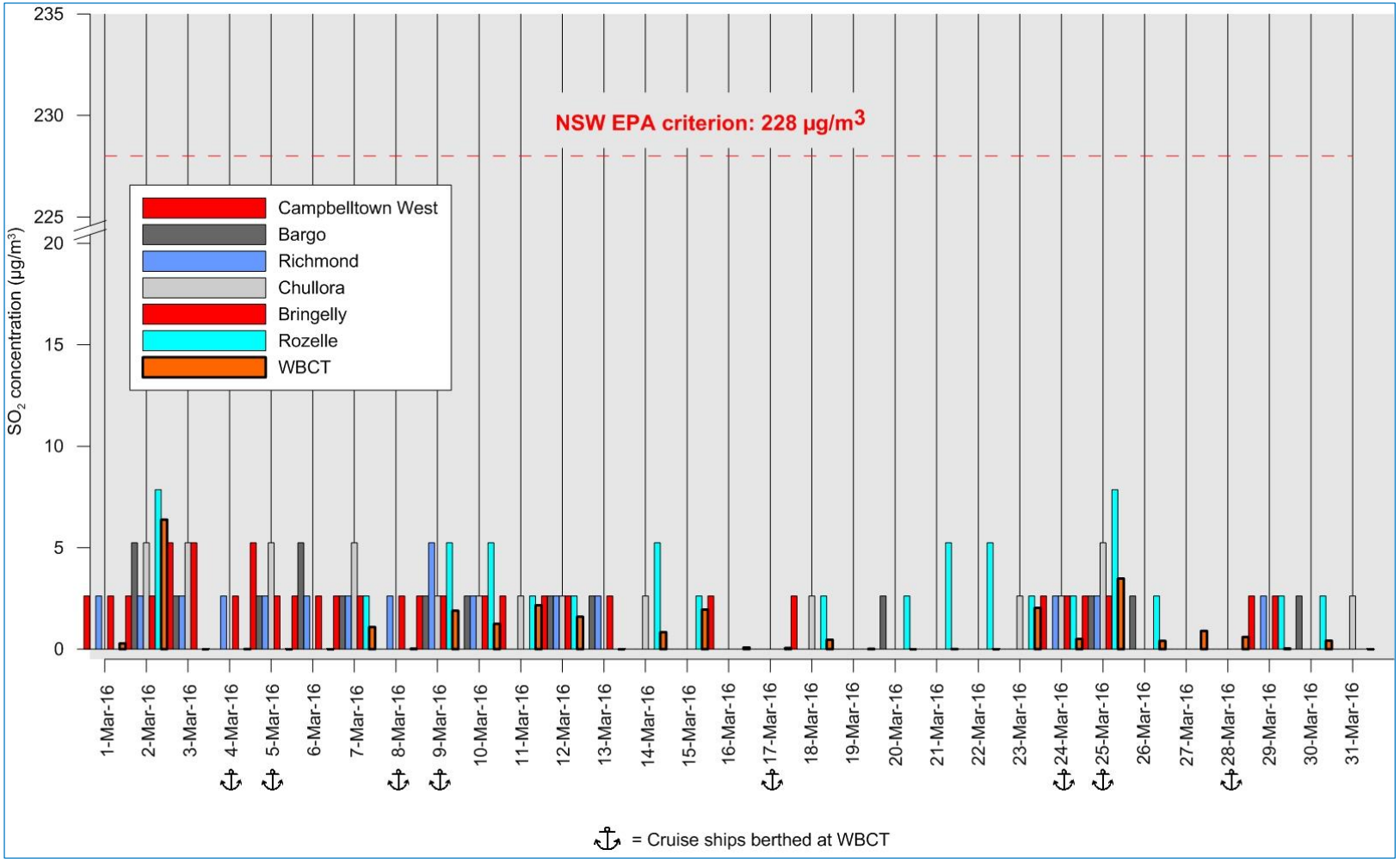
Figure 3-2: 1-hour average SO_2 concentrations for March 2016

3.4 24-hour average sulfur dioxide concentrations

Time-series plots of 24-hour average SO_2 concentrations at WBCT and selected OEH urban background sites in Sydney are shown in **Figure 3-3**. The selected OEH sites that measure SO_2 include Rozelle, Bargo, Bringelly, Campbelltown West, Chullora, Earlwood, Liverpool and Richmond.

During March 2016, 24-hour average SO_2 concentrations at WBCT were very low and less than 10 µg/m^3, including days when cruise ships were berthed at WBCT. 24-hour average SO_2 concentrations at OEH sites, including Rozelle, were higher than at WBCT on many days (including cruise ship days), although still very low compared to the criterion.

No exceedances of the 24-hour air quality criterion for SO_2 were recorded during the reporting period.



[1]Figure 3-3: 24-hour average SO_2 concentrations at WBCT and OEH monitoring sites in March 2016. Note the broken axis from 20 – 225 µg/m³.

3.5 24-hour average $PM_{2.5}$ concentrations

Time-series plots of 24-hour average $PM_{2.5}$ concentrations at WBCT and selected OEH sites are shown in **Figure 3-4**. Of the OEH sites in Sydney, $PM_{2.5}$ is measured at Chullora, Earlwood, Liverpool, Richmond and Rozelle.

The 24-hour average $PM_{2.5}$ concentrations at WBCT were all less than or equal to 15 µg/m^3 during March. The maximum $PM_{2.5}$ concentration (15 µg/m^3) was recorded on 26/2/16 when no cruise ships were berthed at WBCT. Furthermore, $PM_{2.5}$ levels at WBCT followed the general trends at the other stations in Sydney, suggesting that cruise ships do not strongly influence $PM_{2.5}$ levels in the local area.

No exceedances of the 24-hour average NEPM air quality standard for $PM_{2.5}$ were recorded during the reporting period.

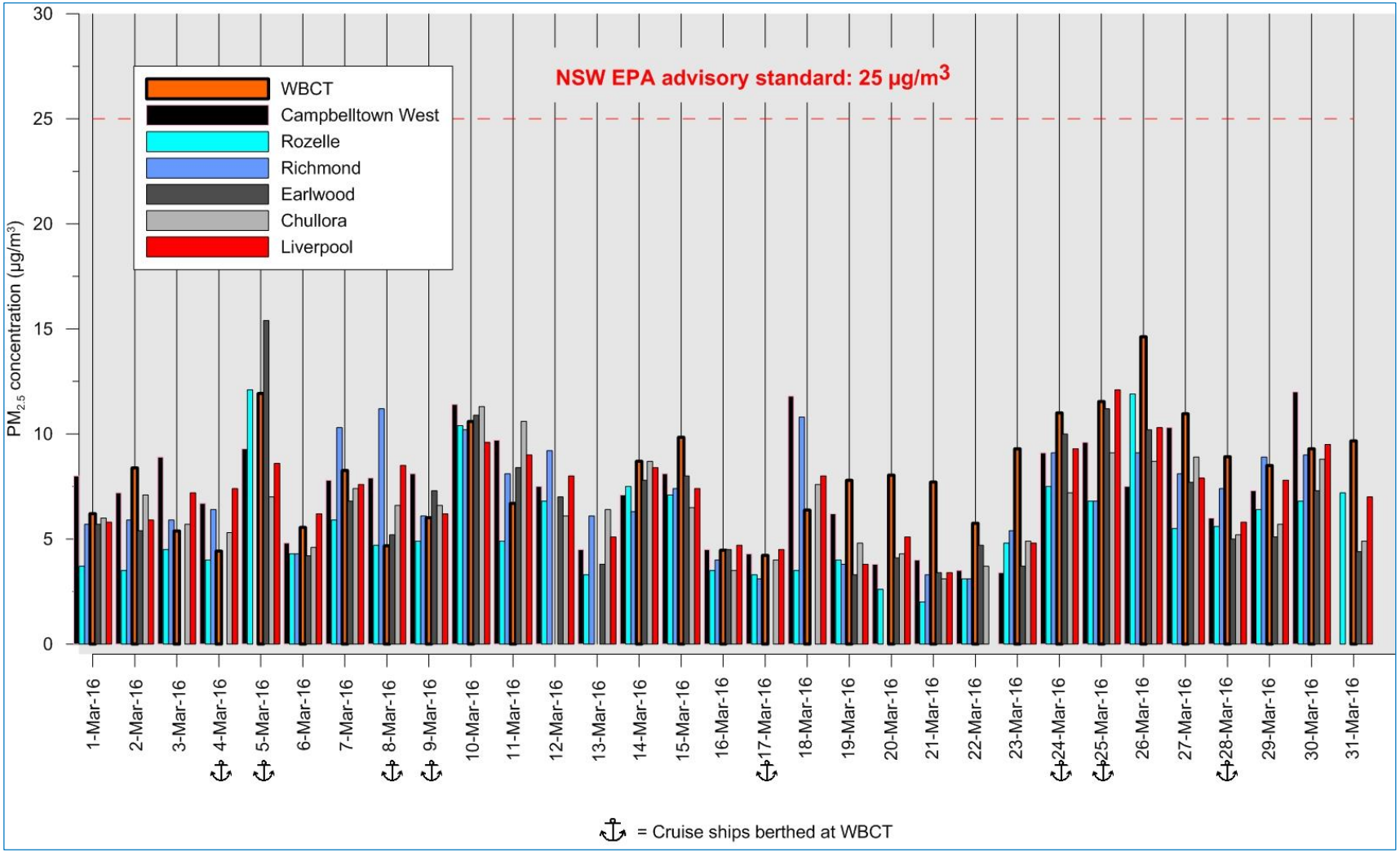


Figure 3-4: 24-hour average $PM_{2.5}$ concentrations at WBCT and OEH sites in March 2016

3.6 Polar bivariate plots

Polar bivariate plots that show 10-minute average SO_2 concentrations and 1-hour average $PM_{2.5}$ as a function of wind speed and wind direction are presented in **Figure 3-5** and **Figure 3-6**. These plots interpolate between data points to show concentrations as a continuous surface and represent the average concentration at a given wind speed and wind direction for the given period. The monitoring station is located at the origin of each plot. Note that there is no 1-hour average air quality criterion for $PM_{2.5}$ referenced in NSW (or elsewhere).

Average SO_2 concentrations (interpolated from 10-minute average values) were higher (around 2 – 3 µg/m³) with moderate (2 – 4 m/s) easterly winds (**Figure 3-5**). These SO_2 concentrations are likely not attributable to cruise ships berthed at WBCT (**Figure 2-1**).

SO_2 concentrations were lower (less than 1 µg/m³) from all other wind directions.

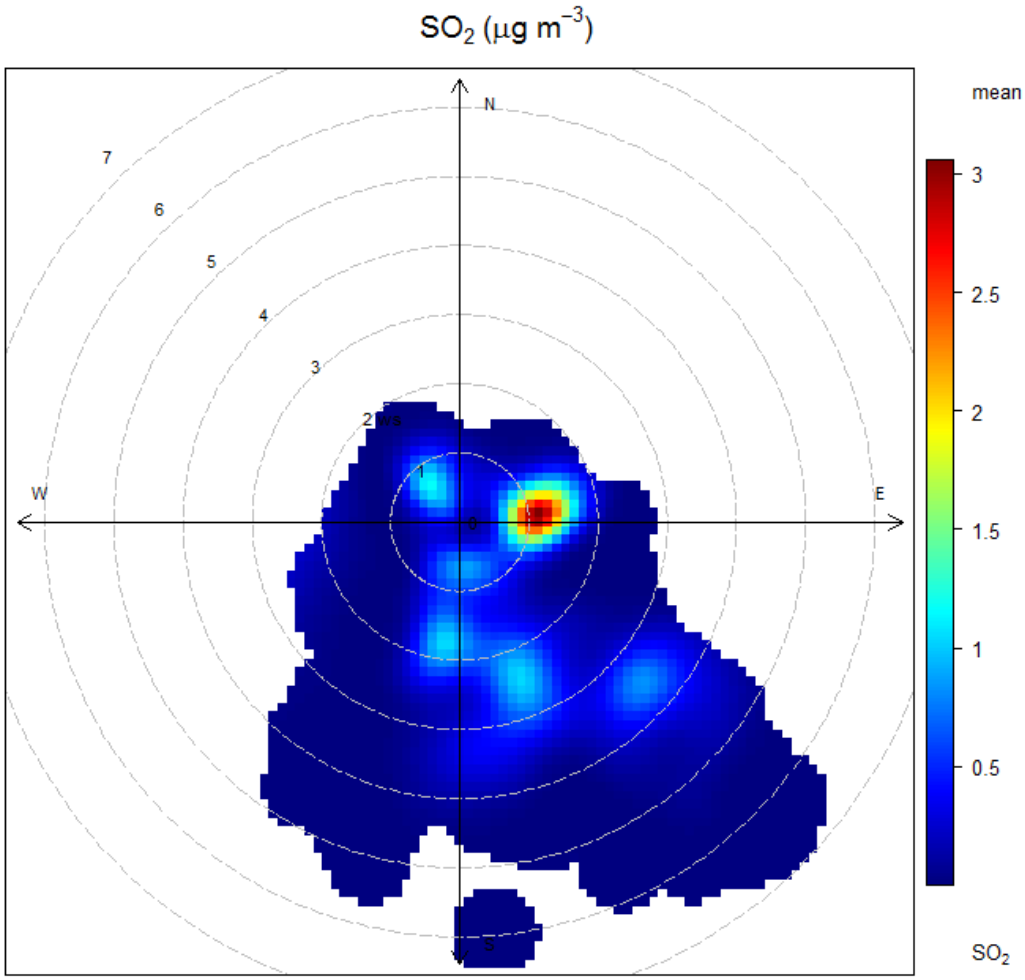


Figure 3-5: Polar bivariate plot for 10-minute average SO_2 concentrations in March 2016

Relatively high $PM_{2.5}$ concentrations (interpolated from 1-hour average values) were recorded (greater than 12 µg/m³) with low-speed north-westerly winds (**Figure 3-6**). These higher $PM_{2.5}$ concentrations are unlikely to be associated with cruise ship emissions from ships berthed at WBCT.

$PM_{2.5}$ concentrations were lower (less than 12 µg/m³) from all other wind directions.

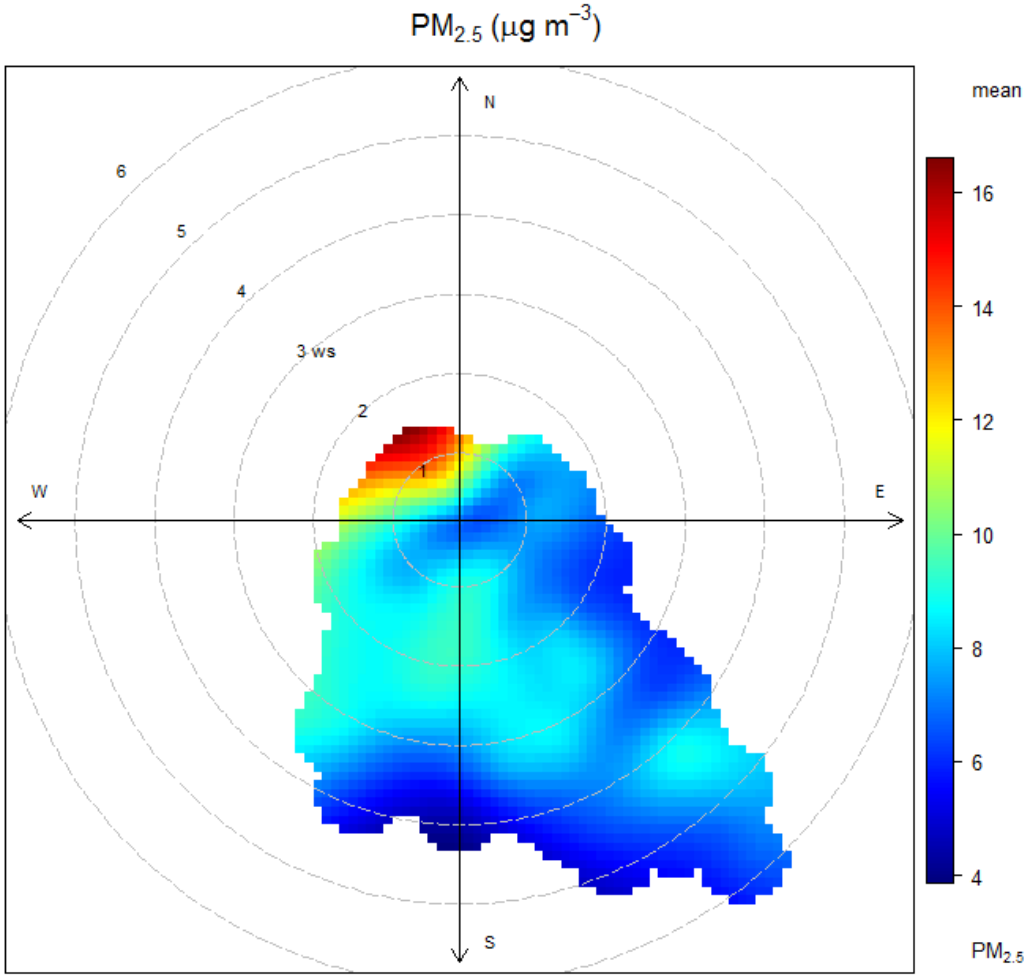


Figure 3-6: Polar bivariate plot for 1-hour average $PM_{2.5}$ concentrations in March 2016

3.7 Summary statistics

Summary statistics for average values of SO_2 and $PM_{2.5}$ concentrations are shown in **Table 3-2**.

No exceedances of NSW EPA air quality criteria or AAQ NEPM standards were recorded for SO_2 or $PM_{2.5}$ during the reporting period.

Table 3-2: Summary statistics for SO_2 and $PM_{2.5}$ concentrations at WBCT

Pollutant:	SO_2			$PM_{2.5}$
Units:		µg/m³		µg/m³
Averaging period:	10 min	1 h	24 h	24 h
Criterion:	712	570	228	25
Mean	1	1	1	8
Median	0	0	0	8
Standard deviation	4	3	1	3
Sample variance	13	10	1	7
Range	64	46	6	9
Minimum	0	0	0	4
Maximum	64	46	6	15
Maximum (cruise ship day)	23	13	3	12

4 REFERENCES

NEPC (2016). National Environment Protection (Ambient Air Quality) Measure as amended.

NSW DEC (2005). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. August, 2005.

Appendix A Monitoring station equipment and technology

A.1 Equipment

Equipment at the WBCT monitoring station and measured parameters are summarised in **Table A-1**.

Table A-1: Parameters and instrumentation for the monitoring station at WBCT

Parameter	Australian Standard	Measurement method	Instrument
Air quality metric			
SO_2	AS 3580.4.1-1990	UV Fluorescence	Serinus 50
$PM_{2.5}$	AS/NZS 3580.9.13-2013	Beta Attenuation Monitor (BAM)[1]	Spirant
Meteorological metric			
Wind speed	AS 3580.14-2011	Ultrasonic	Gill
Wind direction			
Temperature		Temperature sensor	Ecotech Met Station One
Pressure		Barometric pressure sensor	
Relative humidity			
Solar radiation			
Rainfall		Tipping bucket rain gauge	

Equipment that is used in the monitoring station both to meet the relevant Australian Standards and to enable real-time data interrogation/interpretation is outlined in **Table A-2**. All instrumentation was installed in an air conditioned, weather-proof shelter with instrument rack.

Table A-2: Additional equipment provided within air pollution monitoring station

Instrument type / component	Proposed instrument / supplier
Dynamic dilution calibrator	Gascal 1100
Zero air generator	Model 8301
Data Logger	WinAQM
3G Cellular Modem	Netcomm
SO_2 calibration gas bottle	Coregas
Gas bottle regulator	Coregas

There is no current approved method for ambient air quality monitoring of $PM_{2.5}$ contained within the NSW EPA's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*. However, there are Australian Standards that are applicable to this parameter. A beta attenuation monitor (BAM) was installed to measure $PM_{2.5}$, as opposed to a tapered element oscillating microbalance (TEOM) – for the following reasons:

- BAMs have a proven track record as being highly robust and reliable;
- BAM technology is more cost-effective than using TEOMs;
- The use of a BAM removes the known measurement issues associated with using TEOMs for $PM_{2.5}$ monitoring (the TEOM heated inlet is known to remove the semi-volatile component within this size fraction);
- BAM instruments are used for regulatory reporting by the NSW government, and are used for $PM_{2.5}$ monitoring at the following OEH ambient air quality monitoring stations:

- Chullora, Earlwood, Liverpool, Rozelle and Richmond in Sydney;
- All sites in OEH's Upper Hunter Ambient Air Quality Monitoring Network; and
- All NSW Roads and Maritime Services particulate monitoring adopted for the WestConnex M4 East and New M5 projects (twelve locations measuring PM_{10} and $PM_{2.5}$; twenty-four BAMs in total).

A.2 Servicing, maintenance and calibration

Routine preventative maintenance is carried out at one-, three-, six- and twelve-month intervals, as stipulated by the relevant Australian Standards and Pacific Environment's commitment to work to NATA standards. The regular maintenance program includes, but is not limited to:

- Daily remote data check and attend to any fault identified within 24 hours;
- Filter changes;
- Leak checks;
- Single point calibration;
- Multipoint linearity check;
- Visual inspection;
- Cleaning of sample lines and particulate (BAM) inlet head;
- Advanced six and twelve monthly analyser service and overhaul;
- Annual calibration of meteorological sensors; and
- Alignment check for wind speed/direction sensor.
- Remote daily data checks are performed by a Pacific Environment consultant to ensure the integrity of the system.
- A calibrations span value of 500 ppb is used to challenge the SO_2 instrument.

A.3 EnviroSuite

Data from the monitoring station are recorded to a local data logger and then uploaded in near real-time via a secured virtual private network (VPN) to Pacific Environment's proprietary data management software, EnviroSuite. Any instrument or system fault is captured by the data logger and relayed in real time via email and SMS, and/or flagged by EnviroSuite.

Pacific Environment provides and hosts a website that is dedicated to providing air quality and meteorological monitoring data for the project. This web page for reporting data in near real-time, includes a map of the project area, icons showing the locations of monitoring equipment and recent monitoring data readings. Data for comparison with compliance limits are also presented. The web address for this is: https://es2.envirosuite.com/monitoring/pansw/.

As requested by the Port Authority, public-facing data contains a disclaimer, similar to that presented on the OEH air quality monitoring website:

Disclaimer: The data used in the compilation of this page have undergone only preliminary quality assurance checks. These data may require modification during final stages of validation as a result of calibration changes, power failures, instrument failures etc.

Appendix B Quality assurance and control

B.1 National Association of Testing Authorities accreditation

Pacific Environment is pursuing accreditation by the National Association of Testing Authorities (NATA) for the measurement of all ambient air quality and meteorological parameters. All monitoring is being conducted in accordance with the NATA requirements.

B.2 Data storage and ratification

All monitoring and calibration data are stored on a central software system and on a cloud-based server with multiple replicas. The data are also stored internally on the analysers.

Currently, there are no Australian guidelines for the ratification of air quality monitoring data. The data ratification process has therefore been developed in keeping with best practice guidelines from the USEPA and Defra in the UK. The data ratification process involves steps such as:

- Removal of clearly incorrect data.
- Corrections for instrument drift.
- Corrections for offsets.
- Removal of calibration points.
- Removal of data during servicing and maintenance periods.

Appendix C Data availability and summary

Data availability for SO_2 and $PM_{2.5}$ during the reporting period, based on the 5-minute average values, is shown in **Table C-1**. A summary and distributions of measurements for SO_2, $PM_{2.5}$, wind speed and wind direction are shown in **Figure C-1**.

$PM_{2.5}$ data were unavailable from 15:00 on 11 March to 09:00 on 14 March due to a 72 hour zero test that was performed on the instrument.

Table C-1: Data availability and summary statistics for SO_2 and $PM_{2.5}$ (5-minute average reported values)

Statistic	SO_2	$PM_{2.5}$
Possible values	8928	8928
Missing values	338	815
Availability (%)	96.2%	92.2%
Minimum (µg/m³)	0.0	-3.7
Maximum (µg/m³)	88.2	52.3
Mean (µg/m³)	0.9	8.1
Median (µg/m³)	0.0	7.3
95th percentile (µg/m³)	5.5	17.0

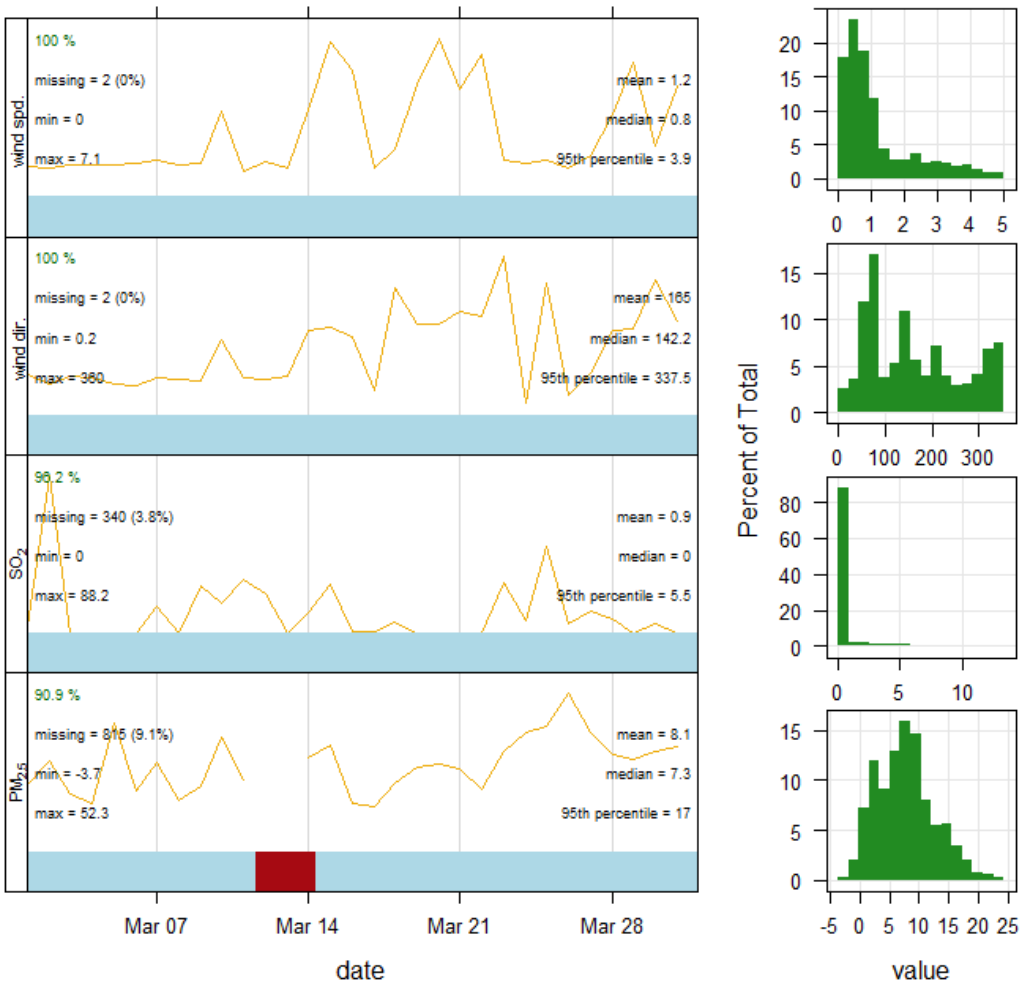


Figure C-1: Output summary and data distribution for 5-minute SO_2 and $PM_{2.5}$ concentrations

Appendix D Wind roses

A wind rose showing the frequency of counts by wind direction for the reporting period are shown in **Figure D-1**. Some guidance on the interpretation of wind roses is provided in **Figure D-2**.

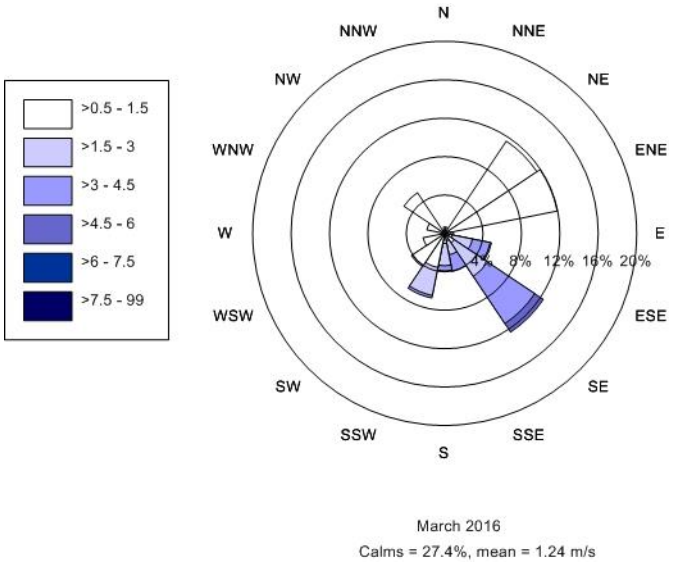


Figure D-1: Wind rose for the WBCT in March 2016

A wind rose shows the frequency of occurrence of winds by direction and strength, presented as 16 bars that correspond to the compass points (N, NNE, NE, etc). The length of each bar represents the frequency of occurrence of winds from that direction, and the colours of the bar sections correspond to wind speed categories, the darker colours representing stronger winds.

In this example, 30% of winds are from the ESE direction, and the winds from this direction have the following speed distribution:

- 10% between 1.5 and 3 m/s
- 10% between 3 and 4.5 m/s
- 7% between 4.5 and 6 m/s
- 3% between 6 m/s and 7.5 m/s

Predominant wind direction

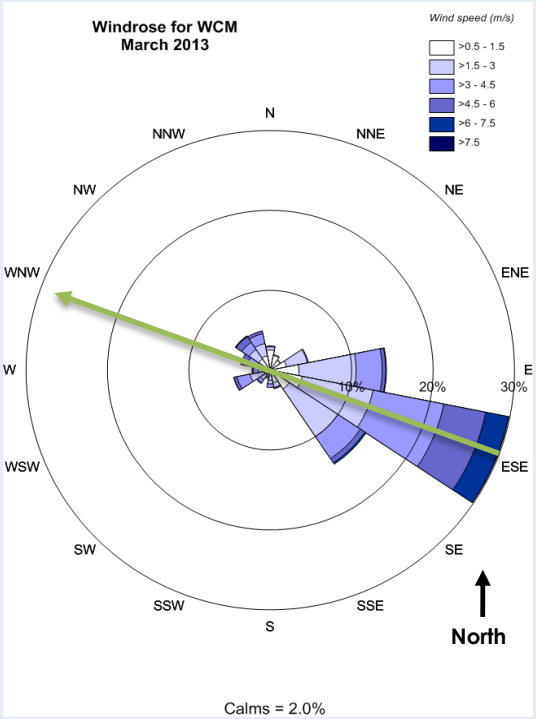


Figure D-2: Interpretation of an example wind rose