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AIR QUALITY IMPACT ASSESSMENT OF THE ABC BIRKENHEAD CEMENT FACILITY – FY 2015

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1.0 INTRODUCTION

AirLabs Environmental Pty Ltd (AirLabs) was commissioned by Adelaide Brighton Cement Limited (ABC) to conduct an air quality assessment of the ABC Birkenhead Cement Plant (the facility) located in Birkenhead, South Australia.

This assessment is based on data obtained during source sampling undertaken by Airlabs during June 2015 (Airlabs Report JUN15093.2, issued on 31st August, 2015). The objective of this assessment is to numerically determine the air quality impacts beyond the facility's boundary. This is achieved by undertaking dispersion modelling.

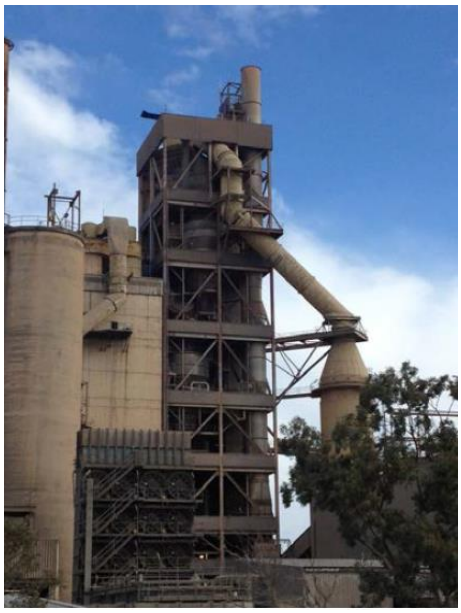
This report presents a brief overview of the assessment methodology, an outline of the regulatory framework and a summary of the findings of the assessment.

2.0 SOURCE LOCATION AND DESCRIPTION

The Birkenhead facility manufactures cement used in the construction and mining industry. Based on previous modelling studies undertaken and Airlabs' knowledge of the facility, the main sources include the licenced Dry Process Kiln Stack (Stack 4A) and the Pre-Calciner Plant Stack (Stack 4B). Source parameters are discussed in the subsequent sections of this report.

Figure 1: Stack 4A and Stack 4B – ABC Birkenhead Facility

Dry Process Kiln Stack (Stack 4A)



Pre-Calciner Plant Stack (Stack 4B)

3.0 REGULATORY GUIDELINES

3.1 National Legislation

In June 1988 (revised in 2003), the National Environment Protection Council (NEPC) developed the Ambient Air Quality National Environmental Protection Measure (NEPM) which set uniform standards for air quality at the national level and included ambient air quality standards for carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), sulphur dioxide, lead and particulate matter with a nominal aerodynamic diameter of less than or equal to 10 microns (PM_{10}). The National Environmental Protection (Air Toxics) Measure (Air Toxics NEPM) includes standards for toxics such as Polycyclic Aromatic Hydrocarbons (PAHs).

3.2 South Australia Legislation

The South Australia EPA (EPA, 2006) specifies Design Ground Level Concentration (DGLC) criteria for the assessment of ground level concentrations of air pollutants for new developments and established facilities. The EPA also recognises the air quality standards set by National Environmental Protection Council under the National Environmental Protection (Ambient Air Quality) Measure (Air NEPM) and National Environmental Protection (Air Toxics) Measure (Air Toxics NEPM).

3.3 Summary of Air Criteria for the Project Goals

The air quality criteria adopted for the Project are summarised in **Table 1**.

Table 1: Air Quality Criteria adopted for the Project

Pollutant	Averaging Period	Criteria (µg/m³)	Source	Environmental Value
Criteria Pollutants				
Nitrogen dioxide (NO_2)	1 hour	113	EPA	Toxicity
Sulfur dioxide (SO_2)	1 hour	450	EPA	Toxicity
Carbon monoxide (CO)	1 hour	29,000	EPA	Toxicity
Particulate matter (PM_{10})	24 hours	50	Air NEPM	Health
Metals, Metalloids and Metal Fumes				
Arsenic and compounds	3 minutes	0.17	EPA	International Agency for Research on Cancer (IARC) Group 1
Antimony and compounds	3 minutes	17	EPA	Toxicity
Barium	3 minutes	17	EPA	Toxicity
Benzene	3 minutes	53	EPA	IARC Group 1 Carcinogen
Beryllium and compounds	3 minutes	0.007	EPA	IARC Group 1 Carcinogen
Cadmium and compounds	3 minutes	0.033	EPA	IARC Group 1 Carcinogen

Pollutant	Averaging Period	Criteria (µg/m³)	Source	Environmental Value
Chromium (III) compounds	3 minutes	17	EPA	Toxicity
Chromium (VI) compounds	3 minutes	0.17	EPA	IARC Group 1 Carcinogen
Copper	3 minutes	6.7	EPA	Toxicity
Iron oxide	3 minutes	170	EPA	Toxicity
Lead	Annual	0.5	Air NEPM	Health
Magnesium oxide fumes	3 minutes	330	EPA	Toxicity
Manganese and compounds	3 minutes	33	EPA	Toxicity
Mercury - inorganic	3 minutes	3.3	EPA	Bioaccumulation
Mercury - organic	3 minutes	0.33	EPA	Bioaccumulation
Nickel and nickel compounds	3 minutes	0.33	EPA	IARC Group 1 Carcinogen
Zinc oxide	3 minutes	170	EPA	Toxicity
Polycyclic Aromatic Hydrocarbons (PAH)				
PAH (as Benzo(a)pyrene)	Annual	0.0003	Air Toxics NEPM	Monitoring investigation level
Acid Gases				
Hydrogen chloride	3 minutes	250	EPA	Toxicity
Halogens				
Chlorine	3 minutes	100	EPA	Toxicity
Fluoride	24 hours	2.9	EPA	Bioaccumulation
	7 days	1.7	EPA	Bioaccumulation
	90 days	0.5	EPA	Bioaccumulation
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDD and PCDF)				
Dioxins and Furans (as TCDD I-TEQ) – Toxic Equivalency based on North Atlantic Treaty Organisation (NATO)	3 minutes	0.0000037	VIC – EPA Gazette S Schedule 240A	Health

4.0 ASSESSMENT METHODOLOGY

In order to predict the impacts from 4A and 4B stacks, dispersion modelling has been used, details of which are presented in this section of the report.

4.1 Meteorological Modelling

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. The local meteorology at the site plays a significant role in understanding the pollutant transport and dispersion mechanisms. For the project, the meteorological model – The Air Pollution Model (TAPM) (Version 4) was used to predict local meteorological data.

TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which is used to predict three-dimensional meteorological data and air pollution concentrations. The model predicts a time-series dataset comprising of parameters like wind speed, wind direction, temperature, pressure, water vapour, cloud, rain, mixing heights, atmospheric stability classes which are essential for dispersion modelling.

The software allows users to generate synthetic observations by referencing in-built databases (e.g. terrain information, synoptic scale meteorological observations, vegetation and soil type etc.) which are subsequently used in generating site-specific hourly meteorological observations.

Details of the TAPM configuration for this Project are outlined in **Table 2.**

Table 2: TAPM Model Configuration for the Project

Parameter	Value
Year of Analysis	2014 (01/01/2014 to 31/12/2014)
Centre of Analysis (Easting, Northing) (m)	271636, 6142852 (UTM Zone 54 S)
Number of grids (spacing)	5 (30km, 10km, 3km, 1km, 0.3km)
Grid dimensions (nx, ny, nz)	25, 25, 25

Meteorological information obtained from TAPM modelling is presented in the form of wind roses. Wind roses are a way of presenting a summary of wind speed and directional data for a particular time and location. Seasonal and diurnal wind roses along with Annual wind roses obtained from TAPM modelling are presented in **Figure 2** and **Figure 3**, respectively.

Figure 2: TAPM generated Seasonal Wind Roses for Modelled Meteorological Year - 2014

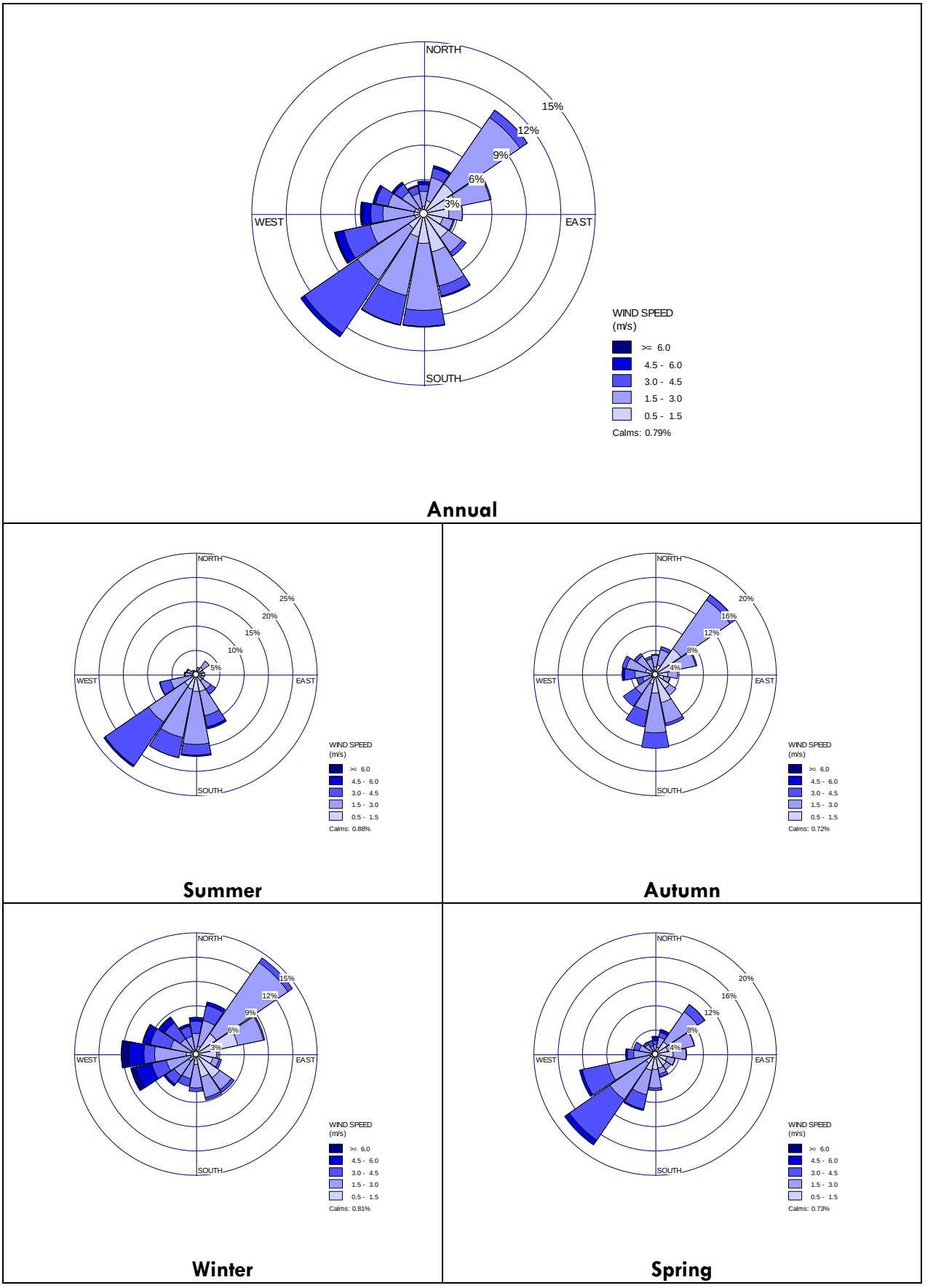
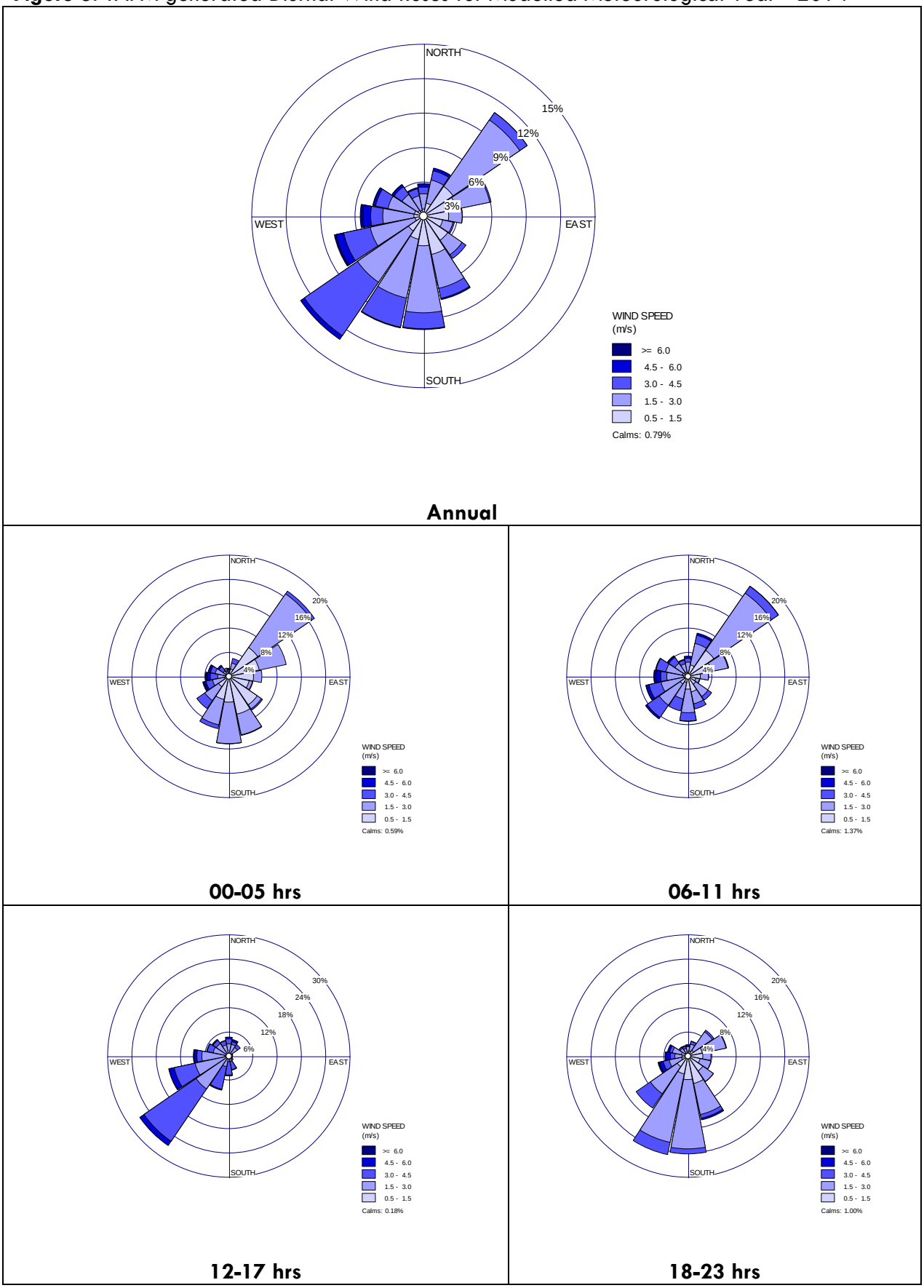


Figure 3: TAPM generated Diurnal Wind Roses for Modelled Meteorological Year - 2014



From the wind roses shown in **Figure 2** and **Figure 3**, the following observations are made:

- Wind flow is predominantly from the south, south-westerly sectors;
- Light to moderate wind speeds (1.5 – 4.5 m/sec) are observed for most of the year;
- Distinct seasonal variation is observed, with the spring and summer seasons characterised by south, south-westerly flow whereas the wind flow is more scattered during the winter and autumn seasons;
- On a daily cycle, highest wind speeds are typically observed during the afternoon period (12 – 17 hrs) mainly from the south-westerly direction (Refer to **Appendix A** for seasonal and diurnal wind speed frequency distribution analyses); and
- Lowest wind speeds are typically observed during the late night (18 – 23 hrs) and early morning (00 – 05 hrs) periods.

4.2 Emission Rates and Source characteristics

Stack testing was conducted in June 2015 (Airlabs Report JUN15093.2 - Birkenhead 4A & 4B Stack Report, issued on 131st August, 2015) to sample the emission rates and source characteristics from Stacks 4A and 4B. Dispersion modelling parameters obtained from the stack testing undertaken in June 2015 are presented in **Table 3**.

Table 3: Stack Parameters (Stack 4A and Stack 4B)

Parameter	Stack 4A	Stack 4B
Sampling Date	18th – 19th June 2015	19th – 20th June 2015
Stack height (m)	75.5	96
Stack diameter (m)	3.23	3.0
Stack temperature (°C)	100	103
Exit velocity (m/s)	19.3	18.4

Emission rates obtained from the sampling undertaken in June 2015 and used in the dispersion modelling assessment are presented in **Table 4**.

Table 4: Modelled Emission Rates (Stack 4A and Stack 4B)

Pollutant	Emission Rates (g/s)	
	Stack 4A 18th – 19th June 2015	**Stack 4B** 19th – 20th June 2015
Criteria Pollutants		
Oxides of nitrogen (as NO_2) - Minimum	22.6 (1)	12.9 (1)
Oxides of nitrogen (as NO_2) - Average	27.9 (1)	15.2 (1)
Oxides of nitrogen (as NO_2) - Maximum	33.9 (1)	17.5 (1)
Sulfur dioxide (SO_2)	4.3	0.17 (2)
Carbon monoxide (CO)	13.8	16.3
Particulate matter (PM_{10})	0.16	0.11
Metals, Metalloids and Metal Fumes		
Arsenic and compounds	0.0000083 (2)	0.000013 (2)
Antimony and compounds	0.000033 (2)	0.000012 (2)
Barium	0.000060	0.000078
Benzene	0.0050 (2)	0.013
Beryllium and compounds	0.0000067 (2)	0.000012 (2)
Cadmium and compounds	0.000017 (2)	0.0000017 (2)
Chromium (III) compounds	0.00022	0.00016
Chromium (VI) compounds	0.000022	0.000016
Copper oxide	0.0020	0.00011
Iron oxide	0.015	0.020
Lead	0.00012	0.000032
Magnesium oxide fumes	0.0063	0.013
Manganese and compounds	0.00018	0.00032
Mercury - inorganic	0.0000060	0.0000085
Mercury - organic	0.00082	0.00020
Nickel and nickel compounds	0.00020	0.00013
Zinc oxide	0.0016	0.00070
Polycyclic Aromatic Hydrocarbons (PAH)		
PAH (as Benzo (a)pyrene)	0.0000012	0.00000067
Acid Gases		
Hydrogen chloride	0.48	0.18
Halogens		
Chlorine	0.0037	0.0045
Fluoride	0.0067	0.010
	0.0067	0.010
	0.0067	0.010

Notes:

(1): It is to be noted that the modelled emission rates for nitrogen dioxide (NO_2) are 30% of the measured emissions rates for oxides of nitrogen (NO_X) based on assumed photochemical NO_X to NO_2 conversion rate of 30% (Katestone, 2012)

(2): Where the measured results were less than the detection limit, the detection limit was used for modelling purposes.

4.3 Dispersion Modelling

AUSPLUME (V6) dispersion model was used in conjunction with prognostic meteorological data obtained from TAPM for predicting impacts from Stack 4A and Stack 4B. AUSPLUME is a steady state Gaussian dispersion model, developed by the Victorian Environmental Protection Agency (Vic-EPA). Ground level concentrations at sensitive receivers in the surrounds of the facility were predicted based on stack parameters (**Table 3**) and stack emission rates (**Table 4**) and assessed for compliance by comparing the predicted ground level concentrations with the air quality criteria (**Table 1**).

Buildings in the vicinity of the sources play a major role in pollutant dispersion as they may create zones of strong turbulence and enhance downward mixing resulting in higher ground-level concentrations. For the Project, the building downwash effect from both the stacks were determined using the US Building Input Program – Plume Rise Model Enhancements (BPIP -PRIME) which is a utility program built into the AUSPLUME (V6) dispersion model. Results obtained from the dispersion modelling are presented in the following sections.

5.0 RESULTS AND DISCUSSION

Predicted ground level concentrations of all air pollutants from Stack 4A and Stack 4B are outlined in **Table 5**.

Table 5: Dispersion Modelling Results from Stack 4A and Stack 4B

Pollutant	Averaging Period	Criteria (µg/m³)	Max Predicted Impacts Outside Facility Boundary	
			Conc. (1) (µg/m³)	% of Criteria
Criteria Pollutants				
Oxides of nitrogen (as NO_2) – Minimum	1 hour	113	48.4	43%
Oxides of nitrogen (as NO_2) - Average	1 hour	113	59.0	52%
Oxides of nitrogen (as NO_2) - Maximum	1 hour	113	70.4	62%
Sulfur dioxide (SO_2)	1 hour	450	6.6	1.5%
Carbon monoxide (CO)	1 hour	29000	40.2	0.1%
Particulate matter (PM_{10})	24 hours	50	0.2	0.4%
Metals, Metalloids and Metal Fumes				
Arsenic and compounds	3 minutes (2)	0.17	0.0001	0.05%
Antimony and compounds	3 minutes (2)	17	0.0002	0.001%
Barium	3 minutes (2)	17	0.0005	0.003%
Benzene	3 minutes (2)	53	0.07	0.1%
Beryllium and compounds	3 minutes (2)	0.007	0.0001	1.0%
Cadmium and compounds	3 minutes (2)	0.033	0.00008	0.2%
Chromium (III) compounds	3 minutes (2)	17	0.002	0.009%
Chromium (VI) compounds	3 minutes (2)	0.17	0.0001	0.1%

Pollutant	Averaging Period	Criteria (µg/m³)	Max Predicted Impacts Outside Facility Boundary	
			Conc. (1) (µg/m³)	% of Criteria
Copper oxide	3 minutes (2)	6.7	0.009	0.1%
Iron oxide	3 minutes (2)	170	0.1	0.08%
Lead	Annual	0.5	0.000013	0.003%
Magnesium oxide fumes	3 minutes (2)	330	0.08	0.02%
Manganese and compounds	3 minutes (2)	33	0.002	0.006%
Mercury - inorganic	3 minutes (2)	3.3	0.0001	0.002%
Mercury - organic	3 minutes (2)	0.33	0.004	1.2%
Nickel and nickel compounds	3 minutes (2)	0.33	0.001	0.4%
Zinc oxide	3 minutes (2)	170	0.009	0.005%
Polycyclic Aromatic Hydrocarbons (PAH)				
PAH (as Benzo(a)pyrene)	Annual	0.0003	0.0000002	0.05%
Acid Gases				
Hydrogen chloride	3 minutes (2)	250	2.7	1.1%
Halogens				
Chlorine	3 minutes (2)	100	0.03	0.03%
Fluoride	24 hours	2.9	0.007	0.2%
	7 days	1.7	0.003	0.2%
	90 days	0.5	0.002	0.5%

Notes:

(1): The 99.9th percentile concentrations are reported as the maximum concentrations

(2): 3-minute average concentrations were estimated from predicted hourly averages using the CSIRO Peak to Mean Scaling approach

From the results outlined in **Table 5**, it is observed that ground level concentrations of all pollutants are well below their respective criteria. From all the modelled pollutants, highest concentrations were observed for NO_2, with their maximum 1-hour average concentrations predicted outside the facility boundary ranging from 43% to 62% of the air quality criteria for lower bound and upper bound emission rates, respectively.

As mentioned earlier, the NO_2 emissions were conservatively estimated by assuming that 30% of total NO_X emissions released would be converted to NO_2 (Katestone, 2012). For visual illustration, the highest 1-hour average NO_2 concentration isopleths for lower, average and upper bound emission rates are presented in **Figure 4** , **Figure 5** and **Figure 6**, respectively.

With respect to PM_{10}, It is to be noted that the 24-hour average concentrations have been conservatively determined by assuming that all the particulates released from Stack 4A and Stack 4B would be in the PM_{10} size range.

Figure 4: Predicted Maximum Ground Level Concentrations of NO_2 (µg/m^3) (1 hour averaging period) based on lower bound of emission rates

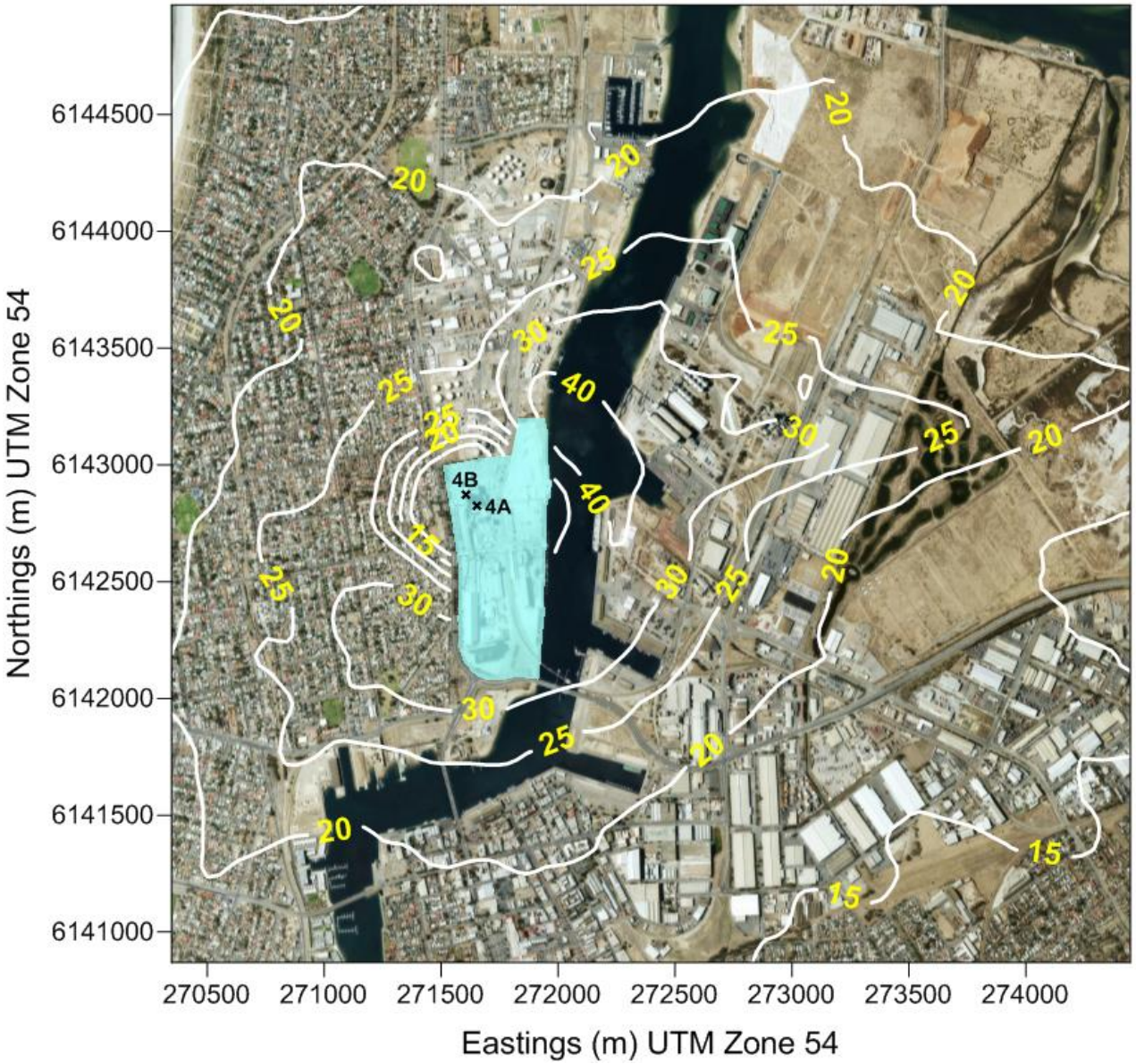


Figure 5: Predicted Maximum Ground Level Concentrations of NO_2 (µg/m^3) (1 hour averaging period) based on average emission rates

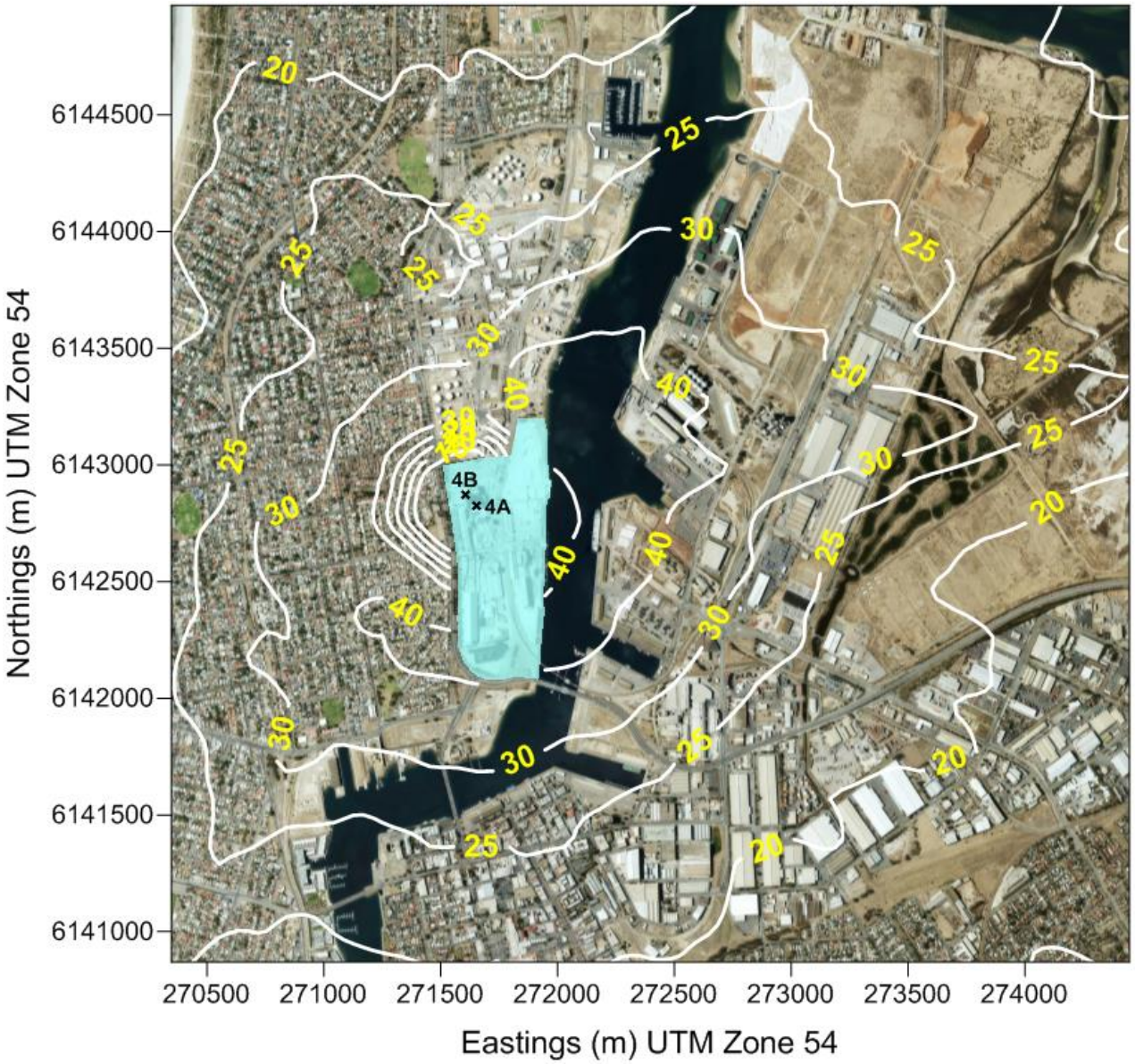
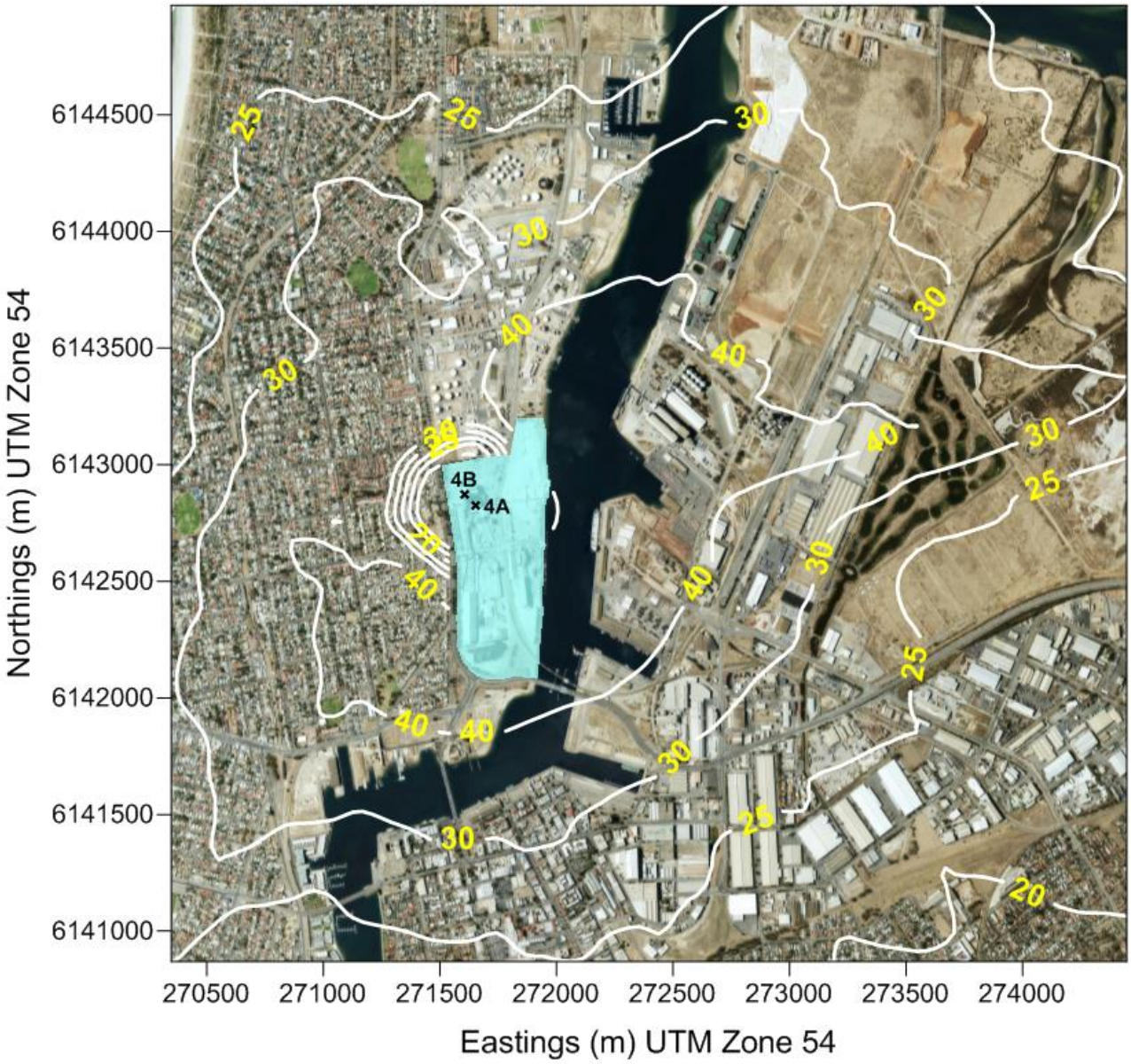


Figure 6: Predicted Maximum Ground Level Concentrations of NO_2 (µg/m^3) (1 hour averaging period) based on upper bound of emission rates



Please note that the coloured area in **Figure 4 , Figure 5** and **Figure 6,** represent the Birkenhead Facility Precincts

6.0 CONCLUSIONS

The AUSPLUME (V6) Gaussian plume dispersion model, in conjunction with TAPM generated meteorological data, was used to predict the ground level concentrations of various air contaminants outside the boundaries of the Adelaide Brighton Cement facility in Birkenhead. Emission rates considered in this assessment were based on results from stack testing conducted by Airlabs Environmental during June 2015 (Airlabs Report JUN15093.2, issued on 31st August, 2015).

Results from the dispersion modelling (**Table 5**) show that all the modelled pollutants are below their respective regulatory criteria, indicating that there were no air quality issues observed from the operation of Stacks 4A and 4B.

7.0 REFERENCES

AirLabs Environmental (2015) Test report No: JUN15093.2 *Air Emissions Monitoring of Release Points 4A & 4B At Adelaide Brighton Cement Ltd In Birkenhead*, 18th – 20th June, 2014. Prepared for Adelaide Brighton Cement. 31st August, 2015.

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Katestone Environmental (2012) Job No: 12006 *Air Quality Impact Assessment of the ABC Birkenhead Cement Plant during May 2012*, 20 August, 2012.

NEPM (1998): National Environment Protection Measure for Ambient Air Quality. National Environment Protection Council.

NEPM (2004): National Environmental Protection (Air Toxics) Measure. National Environmental Protection Council.

Victoria Environmental Protection Agency (VIC-EPA) Air Quality Guidelines – VIC EPA Gazette S 240 Schedule A

APPENDIX A

2014 TAPM MODELLED METEOROLOGICAL DATASET – WIND SPEED FREQUENCY DISTRIBUTION ANALYSIS (SEASONAL AND DIURNAL CYCLE)

Figure A-1: Seasonal Wind Speed Frequency Distribution for the 2014 TAPM Modelled Meteorological Dataset for the Birkenhead Facility

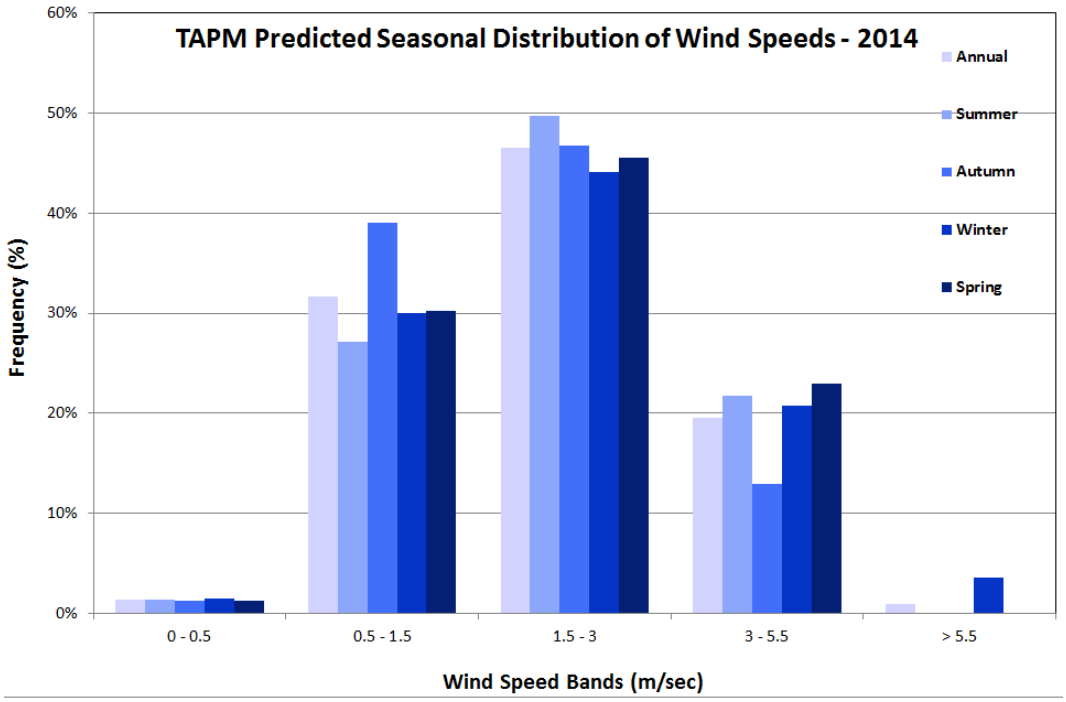

Figure A-2: Diurnal Wind Speed Frequency Distribution for the 2014 TAPM Modelled Meteorological Dataset for the Birkenhead Facility