



NATURAL VENTILATION STATEMENT
36-40A CULWORTH AVENUE, KILLARA

WB326-01F02(REV2)- NV REPORT

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Prepared for:

36-40a Culworth Avenue, Killara

4/3 The Postern

Castlecrag, NSW 2068

DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This report is in relation to the proposed development located at 36-40a Culworth Avenue, Killara, and presents an opinion on the on the natural ventilation performance and characteristics of the various residential units of the subject development.

The conclusions of this report are drawn from our extensive experience in this field and are based on Option B of the latest architectural drawings prepared by the project architect Mackenzie Architects, received 22nd March, 2012. The results of the study have been compared against the wind-driven natural ventilation criteria detailed in the State Environmental Planning Policy No. 65 (SEPP65). This report addresses only the general wind effects and any localised effects that are identifiable by visual inspection. Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind-driven natural ventilation effects. Note that wind tunnel modelling for these units will be required to verify the natural ventilation performance of the abovementioned units of the development.

The results of the study are compared to the wind-driven natural ventilation criteria detailed in the State Environment Planning Policy No. 65 (SEPP65), which requires that 60% of the residential units within a development should achieve effective cross ventilation. Hence, **61%** of residential units within the subject development are deemed to satisfy the natural ventilation provisions in SEPP65

The development has been further assessed to consider other design aspects which can generate natural ventilation through an apartment to achieve a level of natural ventilation equivalent to that of a double aspect apartment. This review includes taking into account wind tunnel test results for other developments previously investigated where single aspect units were able to meet the requirements for natural ventilation. These also considered the effect of the orientation and external façade profile. It has been found from wind tunnel modelling of similar apartment configurations, that certain configurations of single aspect units are able to meet the requires for natural ventilation.

Should the abovementioned design aspects provide adequate wind-driven natural ventilation characteristics, **77%** of residential units that may potentially perform on par with at least one deemed to comply unit within the development. Furthermore 56% of the kitchens within the development will have access to natural ventilation.

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1 WIND CLIMATE OF THE SYDNEY REGION

Natural ventilation for a residential unit is most beneficial during the summer months of the year, when the occupants of the unit are most likely to open the windows of their unit and also when the cooling effect of airflow through the unit is most effective.

The Sydney region is governed by three principle wind directions, and these can potentially affect the subject development. These winds prevail from the north-east, south and west. A summary of the principal time of occurrence of these winds throughout the year is presented in Table 1 below. This summary is based on an analysis of wind rose data obtained by the Bureau of Meteorology from Kingsford Smith Airport between 1939 and 2000. The wind roses are attached in the appendix of this report.

Natural ventilation is more beneficial for the occupant of a development during the warmer months of the year. An analysis of the Sydney wind climate data for the 6 warmer months of the year (October to March), indicates that the north-easterly and southerly winds dominate for this time of year, while the westerly winds are more predominant during the winter months. The north-easterly winds account for 39% of all occurrences during the warmer months, while the southerly winds account for 43% of all occurrences for these months.

Table 1 Principle Time of Occurrence of Winds for Sydney

<i>Month</i>	<i>Wind Direction</i>		
	<i>North-Easterly</i>	<i>Southerly</i>	<i>Westerly</i>
<i>January</i>	X	X	
<i>February</i>	X	X	
<i>March</i>	X	X	
<i>April</i>		X	X
<i>May</i>			X
<i>June</i>			X
<i>July</i>			X
<i>August</i>			X
<i>September</i>		X	X
<i>October</i>	X	X	
<i>November</i>	X	X	
<i>December</i>	X	X	

A directional plot of the annual and weekly recurrence winds for the Sydney region is shown in Figure 1 below. The frequency of occurrence of these winds is also shown in Figure 1. This plot has been produced based on an analysis of recorded wind speed data obtained from Sydney Airport from 1939 to 2008.

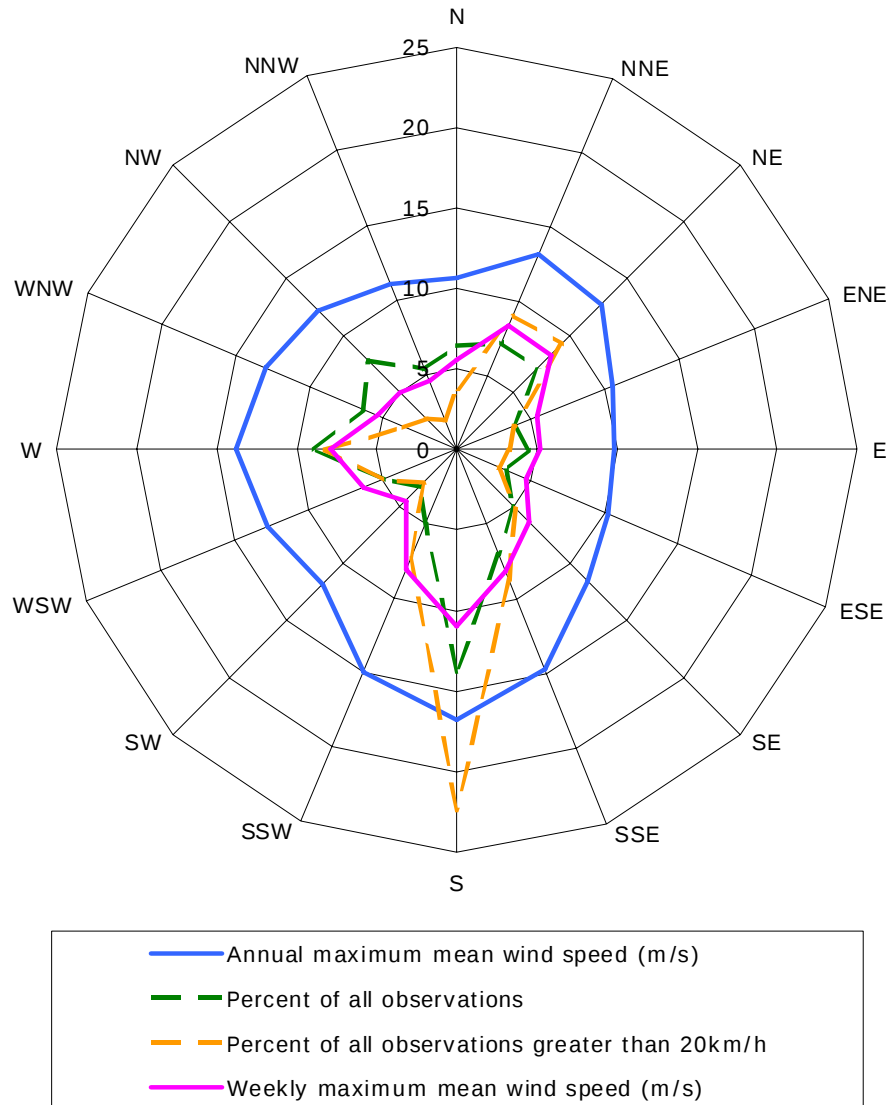


Figure 1 Annual and Weekly Recurrence Mean Wind Speeds, and Frequencies of Occurrence, for the Sydney Region (based on 10 minute mean observations from Kingsford Smith Airport from 1939 to 2008, corrected to open terrain at 10m)

2 NATURAL VENTILATION CRITERIA

Natural ventilation of indoor areas can be used to improve both the level of occupant comfort and the air quality of an internal space. Natural ventilation is beneficial in improving occupant comfort during the warmer months of the year when the occupants will generally have windows and doors open, while during the winter months it is considered primarily beneficial for air quality purposes. The predominant wind directions for the Sydney region has been analysed in Section 1.0. From this analysis, only the north-easterly and southerly winds should be considered as the predominant wind directions that contribute to natural ventilation for occupant comfort purposes, since these are the predominant wind directions during the warmer months of the year. The westerly winds are predominant during the cooler winter months and would be beneficial for air quality purposes.

The NSW State Environmental Planning Policy No. 65 (SEPP65) specifies that for a development to be considered naturally ventilated, at least 60% of the individual units within the development must be considered to be naturally ventilated. Unit configurations such as double-ended (cross-over) or corner unit can achieve effective natural ventilation as shown in Figures 2 and 3 which are taken from SEPP65 guideline. For all other unit configurations to be considered to be naturally ventilated, it is required that they perform to the minimum performance of a double-ended (cross-over) unit or corner unit, with effective openings either on orthogonal aspects or opposite aspects.

In addition to the analysis for SEPP65 compliance, an assessment for natural ventilation is presented based on principles derived from our experience numerous wind tunnel tests of residential developments. This alternative assessment is based on a set of criteria which can determine the number of units which are expected to achieve similar performance to those units that are deemed to satisfy the SEPP65 requirements. This alternative set of criteria considers the predominant wind directions for the area during the warmer months of the year as well as the ability of the façade profile to create sufficient pressure differentials between openings to the living and bedroom spaces that will generate wind flow. A comparison between the measured wind tunnel tests technique for natural ventilation and full-scale testing published by Peddie and Rofail (2011) demonstrated a close comparison.

The level of performance of a residential apartment is dependant on a number of key aspects. Windtech has formulated a set of key criteria as an alternative approached based off our detailed experience, this is detailed as follows:

- (i) The individual unit needs to have openings located either on orthogonal aspects or opposite aspects. **(SEPP65 Requirement)**
- (ii) One of the aspects of the individual unit needs to have openings which are either normal or orthogonal to the north-easterly direction, with minimal obstruction. For a single-aspect unit only the orthogonal case is considered (this criterion must be used in conjunction with criteria (iv)).

(iii) One of the aspects of the individual unit needs to have openings which are either normal or orthogonal to the southerly direction, with minimal obstruction. For a single-aspect unit only the orthogonal case is considered (this criterion must be used in conjunction with criteria (iv)).

(iv) The façade of the single aspect unit with window openings to the habitable rooms needs to be stepped (in or out) by at least 2 metres. The setback in the window opening locations needs to be such that it can generate a positive pressure at one opening and a neutral or negative pressure at the other opening. Note for this to be effective, one component should be located approximately in line to the building profile.

(v) ANSI/ASHRAE 62.1-2010, Ventilation for Acceptable Indoor Air Quality. The American ventilation standard provides recommendations for the location of spaces from an operable wall opening depending on the dwellings opening configuration and ceiling height (H):

- **Single Side Opening**, for spaces with operable openings on one side, a maximum distance of 2H from the operable openings.
- **Double Side Opening**, for spaces with operable openings on two opposite sides, a maximum distance of 5H from an opening.
- **Corner Openings**, for spaces with operable openings on two adjacent sides, a maximum distance of 5H along a line between two openings which are furthest apart.

Based on the above set of criterion, the expected level of natural ventilation for each dwelling is derived from the following combinations:

If the dwelling satisfies **Criterion i**, it is deemed to satisfy the requirements of SEPP65 and be considered naturally ventilated.

If the dwelling satisfies **all five criteria** then it is considered to have **exceptional** natural ventilation characteristics.

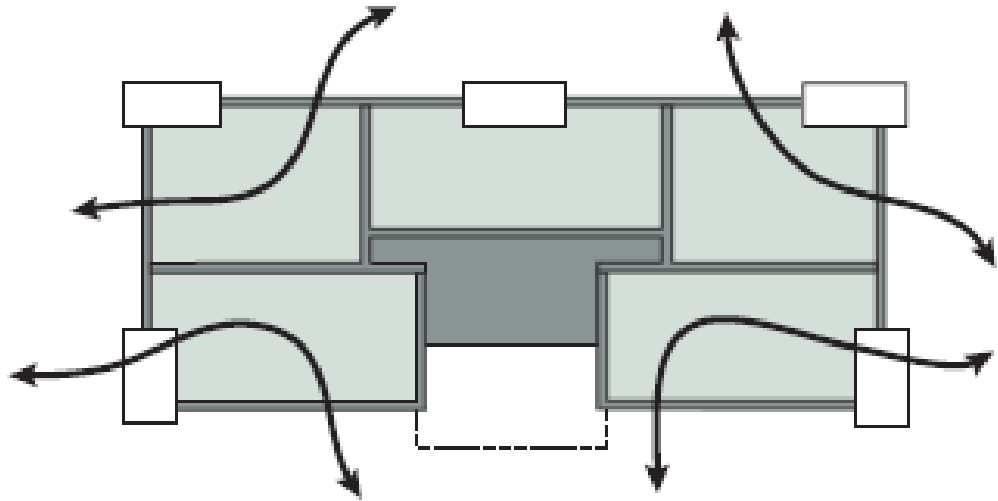
If the dwelling satisfies **Criterion i** as well as **Criterion ii, iii and v** then it is considered to have **commendable** natural ventilation characteristics

If the dwelling satisfies **Criterion i and v** as well as either **Criterion ii or iii**; or **Criterion iv and v** and either **Criterion ii or iii** then it is considered to have **very good** natural ventilation characteristics.

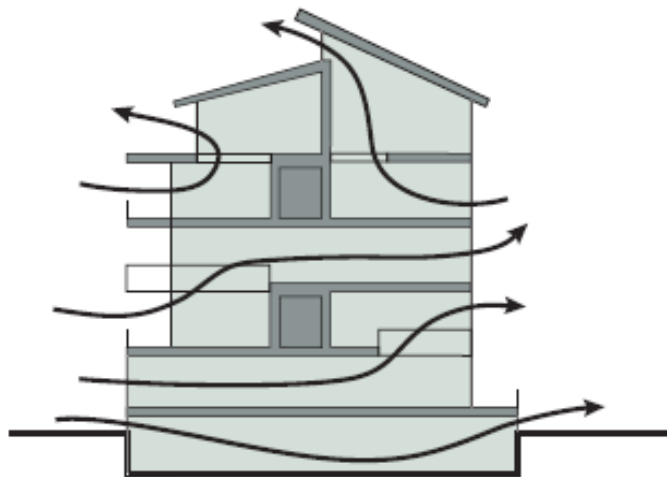
If the dwelling satisfies **Criterion i** only, or if the unit satisfies **Criterion iv** as well as **Criterion ii or iii** then it is considered to have **good** natural ventilation characteristics.

If the dwelling satisfies **Criterion v** and either **Criteria ii or iii** only then it is considered to have **below average** natural ventilation characteristics.

If the dwelling satisfies none of the abovementioned criteria or **Criterion ii, iii or iv** only, then it is deemed to have **poor** natural ventilation characteristics.



**Figure 2: Units Achieving Effective Natural Ventilation
(floor plan of a typical residential building)**



**Figure 3: Units Achieving Effective Natural Ventilation
(section elevation of a typical residential building)**

3 DESCRIPTION OF THE PROPOSED DEVELOPMENT AND SURROUNDINGS

The proposed development site consists of 57 residential dwellings spanning across five levels above ground. Two basement levels dedicated to car-parking is also proposed. Openings are proposed on all aspects of the subject development.

The subject site is located within the residential district of Killara and is bounded by Culworth Avenue to the east and Powell Street to the north and Lorne Avenue to the south. Directly north and south of the site are multi storey developments currently under construction and the North Shore and Western train line to the east. Further surrounding the site in all directions are low rise residential dwellings. There is a general rise towards the west in the local land topography of the site. Aerial image of the site are shown in the Figure 4 below.



Figure 4 Aerial Image of the Site Location

4 RESULTS OF THE ANALYSIS

The natural ventilation assessment for the development took into account the predominant wind directions for the Sydney region, the interaction between the wind and the building morphology in the area. As discussed in Section 2.0, the westerly winds are not considered as effective in natural ventilation performance, since for the Sydney region these winds predominantly occur during the winter months, when wind-driven natural ventilation would not be considered desirable for the occupants of the development. Other important features which were taken into account for the assessment include the distances between the proposed building floor plan and orientation, as well as the landform surrounding the site.

4.1 Initial Results from Analysis

The results for the natural ventilation characteristics for the various residential units within the proposed development are presented in the following tables for the two residential towers of the development. The analysis of the wind-driven natural ventilation characteristics considers the living space of the various residential units of the proposed development and potential for natural ventilation through this space. The indicated unit numbers in these tables correspond to the unit numbering scheme as indicated in the latest architectural drawings. Each residential unit is compared to the five basic criteria detailed in Section 2.0 of this report.

Table 2: Natural Ventilation Results

Unit Number	Satisfies Criteria					Natural Ventilation Rating
	Criterion (i)	Criterion (ii)	Criterion (iii)	Criterion (iv)	Criterion (v)	
U.01	NO	NO	YES	YES	YES	Very Good
U.02	YES	NO	YES	YES	YES	Very Good
U.03	YES	NO	YES	YES	YES	Very Good
U.04	NO	NO	NO	NO	YES	Below Average
U.05	NO	NO	NO	NO	YES	Below Average
U.06	YES	YES	YES	NO	YES	Commendable
U.07	YES	YES	YES	NO	YES	Commendable
U.08	NO	YES	NO	NO	YES	Below Average
U.09	YES	YES	NO	NO	YES	Very Good
U.10	NO	YES	NO	NO	YES	Below Average
U.11	NO	YES	NO	NO	YES	Below Average
U.12	YES	YES	YES	NO	YES	Commendable
U.13	YES	NO	YES	NO	YES	Very Good
U.14	NO	NO	YES	YES	YES	Very Good
U.15	YES	NO	YES	YES	YES	Very Good
U.16	YES	NO	YES	NO	YES	Very Good
U.17	NO	NO	NO	NO	YES	Below Average
U.18	NO	NO	NO	NO	YES	Below Average

Unit Number	Satisfies Criteria					Natural Ventilation Rating
	Criterion (i)	Criterion (ii)	Criterion (iii)	Criterion (iv)	Criterion (v)	
U.19	YES	YES	YES	NO	YES	Commendable
U.20	YES	YES	YES	NO	YES	Commendable
U.21	NO	YES	NO	NO	YES	Below Average
U.22	YES	YES	NO	NO	YES	Very Good
U.23	NO	YES	NO	NO	YES	Below Average
U.24	YES	YES	YES	NO	YES	Commendable
U.25	NO	YES	NO	YES	YES	Very Good
U.26	NO	YES	NO	YES	YES	Very Good
U.27	NO	NO	YES	YES	YES	Very Good
U.28	YES	NO	YES	YES	YES	Very Good
U.29	YES	NO	YES	YES	YES	Very Good
U.30	NO	NO	NO	NO	YES	Below Average
U.31	YES	YES	NO	YES	YES	Very Good
U.32	YES	YES	YES	NO	YES	Commendable
U.33	YES	YES	YES	NO	YES	Commendable
U.34	YES	YES	NO	YES	YES	Very Good
U.35	YES	YES	NO	NO	YES	Very Good
U.36	NO	YES	NO	NO	YES	Below Average
U.37	YES	YES	YES	NO	YES	Commendable
U.38	NO	YES	NO	YES	YES	Very Good
U.39	NO	YES	NO	YES	YES	Very Good
U.40	NO	YES	NO	NO	YES	Below Average
U.41	YES	NO	YES	YES	YES	Very Good
U.42	YES	YES	YES	YES	YES	Exceptional
U.43	YES	YES	NO	YES	YES	Very Good
U.44	YES	YES	YES	NO	YES	Commendable
U.45	YES	YES	YES	NO	YES	Commendable
U.46	YES	YES	NO	YES	YES	Very Good
U.47	YES	YES	NO	NO	YES	Very Good
U.48	YES	YES	YES	NO	YES	Commendable
U.49	NO	YES	NO	NO	YES	Below Average
U.50	NO	YES	NO	YES	YES	Very Good
U.51	YES	YES	YES	YES	YES	Exceptional
U.52	YES	YES	YES	YES	YES	Exceptional
U.53	YES	YES	YES	NO	YES	Commendable
U.54	YES	YES	YES	NO	YES	Commendable
U.55	YES	YES	NO	YES	YES	Very Good
U.56	YES	YES	YES	YES	YES	Exceptional
U.57	NO	YES	NO	YES	YES	Very Good

4.2 Summary of the Results based upon the Natural Ventilation Criteria

After the initial analysis was conducted, it was found that **61%** (35 units) of the residential units within the subject development will comply with the SEPP65 requirements for natural ventilation due to the effective use of corner and double ended units with openings located either on orthogonal aspects or opposite aspects; such as the upper level maisonette units (31, 34, 43, 46) with effective openings on the northern aspect allowing air flow through the unit and exhausted at the higher level clerestory opening on the southern aspect facilitated by convective currents.

The development has been further assessed to consider other design aspects which can generate natural ventilation through an apartment to achieve a level of natural ventilation equivalent to that of a double aspect apartment. This review included taking into account wind tunnel test results for other developments previously investigated where single aspect units were able to meet the requirements for natural ventilation, Peddie and Rofail (2011). These studies also considered the effect of the orientation and the external façade profile. It has been found from wind tunnel modelling of similar apartment configurations, certain configurations of single aspect units are able to meet the requires for natural ventilation. This is subject to the following specifications for the single aspect units:

The external surface of the single aspect unit needs to be at an obtuse angle with respect to a predominant wind direction for the warmer part of the year (for the Sydney region these are the north-easterly or southerly winds)

The façade of the single aspect unit with window openings to the living area needs to be stepped (in or out) by at least 2 metres. The setback in the window opening locations needs to be such that it can generate a positive pressure at one opening and a neutral or negative pressure at the other opening. To achieve this, obstructions to the prevailing wind direction to the stepped out portion will need to be avoided.

The performance of units which display these two characteristics will generally meet the requirements for air flow through a unit for natural ventilation subject to layout of the internal partitions and doors. Based on the abovementioned parameters it is expected **77%** (44 units) of the residential units within the subject development will display adequate natural ventilation characteristics due to the location and orientation of operable windows and internal layout. Hence the proposed development site is expected to satisfy the 60% SEPP65 requirement for residential units to be display adequate natural ventilation characteristics. Wind tunnel modelling for these units will be required to verify the natural ventilation performance of the abovementioned units of the development. Furthermore 56% of the kitchens within the development will have access to natural ventilation.

Note that the residential units deemed to be 'Below Average' is in terms of the natural ventilation criteria as outlined in Section 2.0 of this report. These residential units will comply with the Building Code of Australia (BCA) Deemed to satisfy provisions for Natural Ventilation (BCA Volume 1 Section F4.5 and F4.6) and the internal amenity impacts from these residential units are expected to be minor or negligible.

5 CONCLUSION

An assessment of the natural ventilation characteristics the various residential units of the proposed development known as located at 36-40a Culworth Avenue, Killara has been undertaken. The conclusions of this report are drawn from our extensive experience in this field and are based on Option B of the latest architectural drawings prepared by the project architect Mackenzie Architects, received 22nd March, 2012. This report addresses only the general wind effects and any localised effects that are identifiable by visual inspection. Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind-driven natural ventilation effects. Note that wind tunnel modelling for these units will be required to verify the natural ventilation performance of the abovementioned units of the development.

The results of the study are compared to the wind-driven natural ventilation criteria detailed in the State Environment Planning Policy No. 65 (SEPP65), which requires that 60% of the residential units within a development should achieve effective cross ventilation. Hence, **61%** of residential units within the subject development are deemed to satisfy the natural ventilation provisions in SEPP65.

The development has been further assessed to consider other design aspects which can generate natural ventilation through an apartment to achieve a level of natural ventilation equivalent to that of a double aspect apartment. This review includes taking into account wind tunnel test results for other developments previously investigated where single aspect units were able to meet the requirements for natural ventilation. These also considered the effect of the orientation and external façade profile. It has been found from wind tunnel modelling of similar apartment configurations, that certain configurations of single aspect units are able to meet the requires for natural ventilation.

Should the abovementioned design aspects provide adequate wind-driven natural ventilation characteristics, **77%** of residential units that may potentially perform on par with at least one deemed to comply unit within the development. Furthermore 56% of the kitchens within the development will have access to natural ventilation.

6 REFERENCES

ANSI/ASHRAE 55-2011, Thermal Environmental Conditions for Human Occupancy, Atlanta: American Society of Heating, Refrigeration and Air-conditioning Engineers.

ANSI/ASHRAE 62.1-2011, Ventilation for Acceptable Indoor Air Quality, Atlanta: American Society of Heating, Refrigeration and Air-conditioning Engineers.

AS1668.2-2002, The used of ventilation and air conditioning in buildings, Part 2: Ventilation design for indoor air contaminant control (excluding requirements for the health aspects of tobacco smoke exposure), Standards Australia

Aynsley R.M., Melbourne W. and Vickery B.J., (1977) Architectural Aerodynamics, Architectural Science Series, pp192-203.

Peddie K.M. and Rofail A.W., 2010, 'Designing for Natural Ventilation for Tall Residential Buildings', 2011 CTBUH World Conference, Seoul, Korea, October 10-12, 2011

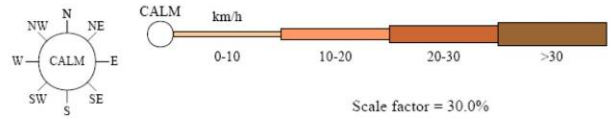
Peddie K.M. and Rofail A.W., 2010, 'Application of Natural Ventilation for Commercial Developments' 14th Australasian Wind Engineering Society Workshop, Canberra, August 5-6, 2010

APPENDIX A - WIND ROSES FOR THE SYDNEY REGION

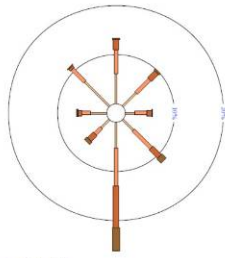
WIND FREQUENCY ANALYSIS (in km/h)

SYDNEY AIRPORT AMO STATION NUMBER 066037

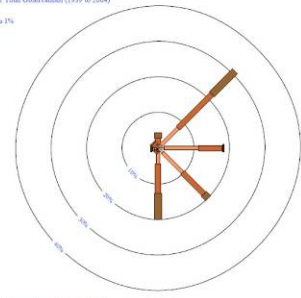
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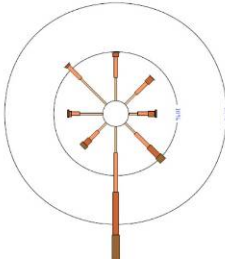
9 am Jan
1933 Total Observations (1939 to 2004)
Calm 1%



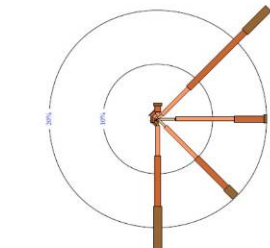
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1941 Total Observations (1939 to 2004)
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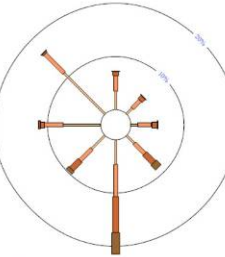
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1783 Total Observations (1939 to 2004)
Calm 13%



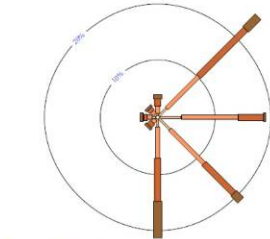
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1776 Total Observations (1939 to 2004)
Calm 1%



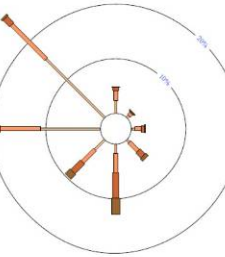
9 am Mar
1958 Total Observations (1939 to 2004)
Calm 14%



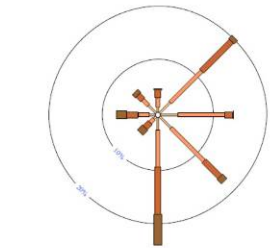
3 pm Mar
1773 Total Observations (1939 to 2004)
Calm 2%



9 am Apr
1963 Total Observations (1939 to 2004)
Calm 14%



3 pm Apr
1961 Total Observations (1939 to 2004)
Calm 2%



Wind directions are divided into eight compass directions. Calm has no direction.

An asterisk (*) indicates that calm is less than 1%.

An observed wind speed which falls precisely on the boundary between two divisions (eg 10 km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.



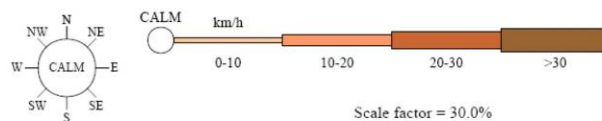
Australian Government
Bureau of Meteorology

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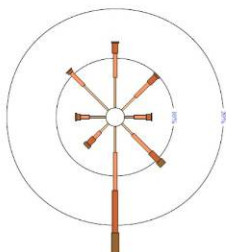
WIND FREQUENCY ANALYSIS (in km/h)

SYDNEY AIRPORT AMO STATION NUMBER 066037

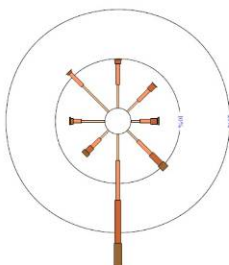
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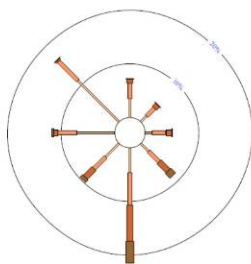
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1925 Total Observations (1939 to 2004)
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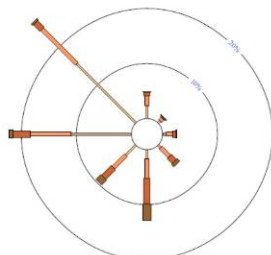
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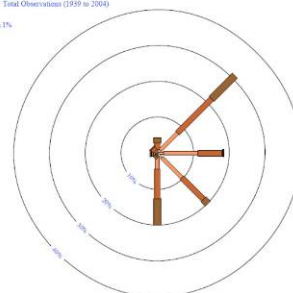
9 am Mar
1963 Total Observations (1939 to 2004)
Calm 14%



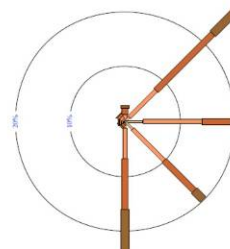
9 am Apr
1963 Total Observations (1939 to 2004)
Calm 14%



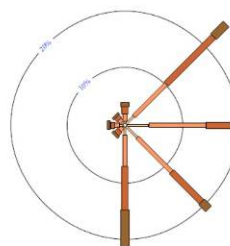
3 pm Jan
1541 Total Observations (1939 to 2004)
Calm 1%



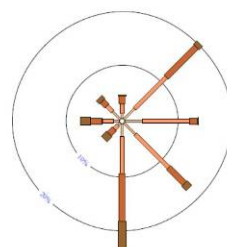
3 pm Feb
1776 Total Observations (1939 to 2004)
Calm 1%



3 pm Mar
1776 Total Observations (1939 to 2004)
Calm 2%



3 pm Apr
1663 Total Observations (1939 to 2004)
Calm 2%



Wind directions are divided into eight compass directions. Calm has no direction.

An asterisk (*) indicates that calm is less than 1%.

An observed wind speed which falls precisely on the boundary between two divisions (eg 10km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.



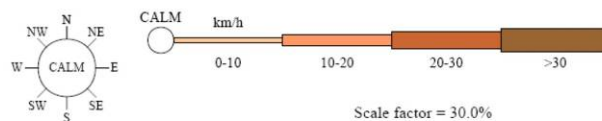
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WIND FREQUENCY ANALYSIS (in km/h)

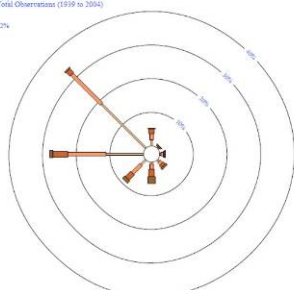
SYDNEY AIRPORT AMO STATION NUMBER 066037

Latitude: -33.94 ° Longitude: 151.17 °



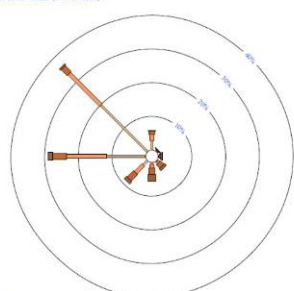
8 am Mar
2011 Total Observations (1939 to 2004)

Calm 12%



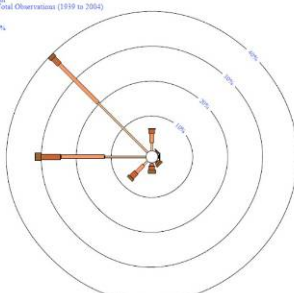
9 am Jan
1936 Total Observations (1939 to 2004)

Calm 9%



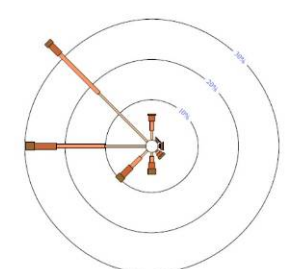
8 am Jul
1997 Total Observations (1939 to 2004)

Calm 9%



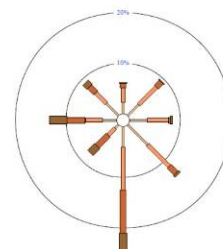
9 am Aug
2000 Total Observations (1939 to 2004)

Calm 8%



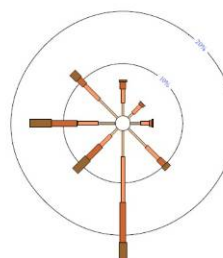
3 pm Mar
2011 Total Observations (1939 to 2004)

Calm 6%



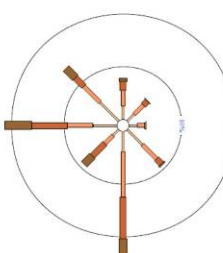
3 pm Jan
1941 Total Observations (1939 to 2004)

Calm 7%



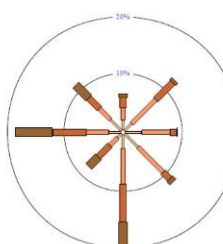
3 pm Jul
2006 Total Observations (1939 to 2004)

Calm 6%



3 pm Aug
2006 Total Observations (1939 to 2004)

Calm 2%



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