Grocon Group

31 Wheat Road Sydney

Wind Effect Statement

Vipac Engineers & Scientists Ltd
279 Normanby Road, Private Bag 16
Port Melbourne VIC 3207
Australia
t. +61 3 9647 9700 | **f.** +61 3 9646 4370
www.vipac.com.au

Document No.
30N-12-0016-TNT-259075-4

23 July 2013

DOCUMENT CONTROL

31 Wheat Road Sydney Wind Effect Statement	
DOCUMENT NO.: 30N-12-0016-TNT-259075-4	**LIBRARY CODE:**
PREPARED FOR: Level 18 420 George Street Sydney NSW 2000 **Contact:** Justin Clark ☎: +61 2 8249 7000 Fax: +61 2 9247 7768	**PREPARED BY:** Vipac Engineers & Scientists Ltd 279 Normanby Road, Private Bag 16 Port Melbourne VIC 3207 **Contact:** Zhuyun Xu ☎: +61 3 9647 9700 Fax: +61 3 9646 4370

PREPARED BY:

Eric Yuen Project Engineer	3 December 2015

REVIEWED BY:

Dr. Zhuyun Xu Senior Wind Consultant	3 December 2015

RELEASED BY:

Matthew Joll Wind Group Leader	3 December 2015

REVISION HISTORY:

Revision No.	Date Issued	Reason/Comments
0	08 Aug 2012	Initial Issue
1	5 Dec 2012	Drawings Updated
2	19 Dec 2012	Minor Amendments
3	23 July 2013	Drawings Updated
4	3 Dec 2015	Drawings Updated

DISTRIBUTION:

Copy No._____	Location
1	Vipac - Project/Client File
2	Original

KEYWORDS:

NOTE: This is a controlled document within the document control system. If revised, it must be marked SUPERSEDED and returned to the Vipac QA Representative.

EXECUTIVE SUMMARY

Grocon Group has commissioned Vipac Engineers and Scientists Ltd to prepare a statement of wind effects for the pedestrian areas in and adjacent to the proposed **"The Ribbon" redevelopment at 31 Wheat Road, Sydney, NSW**. This appraisal is based on Vipac's experience as a wind engineering consultancy.

The updated drawings of the proposed development were supplied by **HASSELL** and dated 21st October 2015.

The findings of this study can be summarised as follows:

- The proposed development would be expected to have wind conditions within the recommended walking criterion in all ground level areas with the proposed design.
- Wind conditions in the entrance areas would be expected to fulfil the recommended criterion for standing with the proposed design and recommended windscreens.

As a general statement, educating occupants about wind conditions at high-level terraces during high-wind events and tying down loose furniture are highly recommended.

The assessments provided in this report are made based on experience of similar situations in Sydney and around the world. As with any opinion-based appraisal, it is possible that an assessment of wind effects might be in error, where it is based on experience only as without a wind tunnel model testing, certainty is difficult to qualify. Vipac recommends a wind tunnel test to verify the assessment.

TABLE OF CONTENTS

1. INTRODUCTION

Vipac Engineers & Scientists Ltd was commissioned by **Grocon Group** to carry out an appraisal of wind effects in pedestrian areas in and adjacent to the proposed **"The Ribbon" redevelopment at 31 Wheat Road, Sydney, NSW.**

Strong winds in pedestrian areas are frequently encountered in central business districts of cities around the world; including Sydney, Melbourne and Brisbane. Wind characteristics such as the mean speed, turbulence and ambient temperature determine the extent of disturbance to users of pedestrian areas. These disturbances can cause both comfort and safety problems and require careful consideration to mitigate successfully.

The city of Sydney has specific requirements for Central Sydney to ensure both safety and comfort is maintained when a site is redeveloped. The draft Development Control Plan (2010) outlines:

> *The shape, location and height of buildings are to be designed to satisfy wind criteria for public safety and comfort at ground level. The useability of open terraces on buildings also depends on comfortable conditions being achieved.*

More specifically, the DCP stipulates to ensure public safety and comfort the maximum wind criteria are to be met by new buildings:

- 10 metres/second in retail streets,
- 13 metres/seconds along major pedestrian streets, parks and public places,
- 16 metres/second in all other streets.

The proposed project is a refurbishment of the previous Imax Theatre Sydney. The site is bounded by Harbour Street to the east, park lands to the west, the M4 western distributor freeways to the south and the north - as shown in Figure 1.

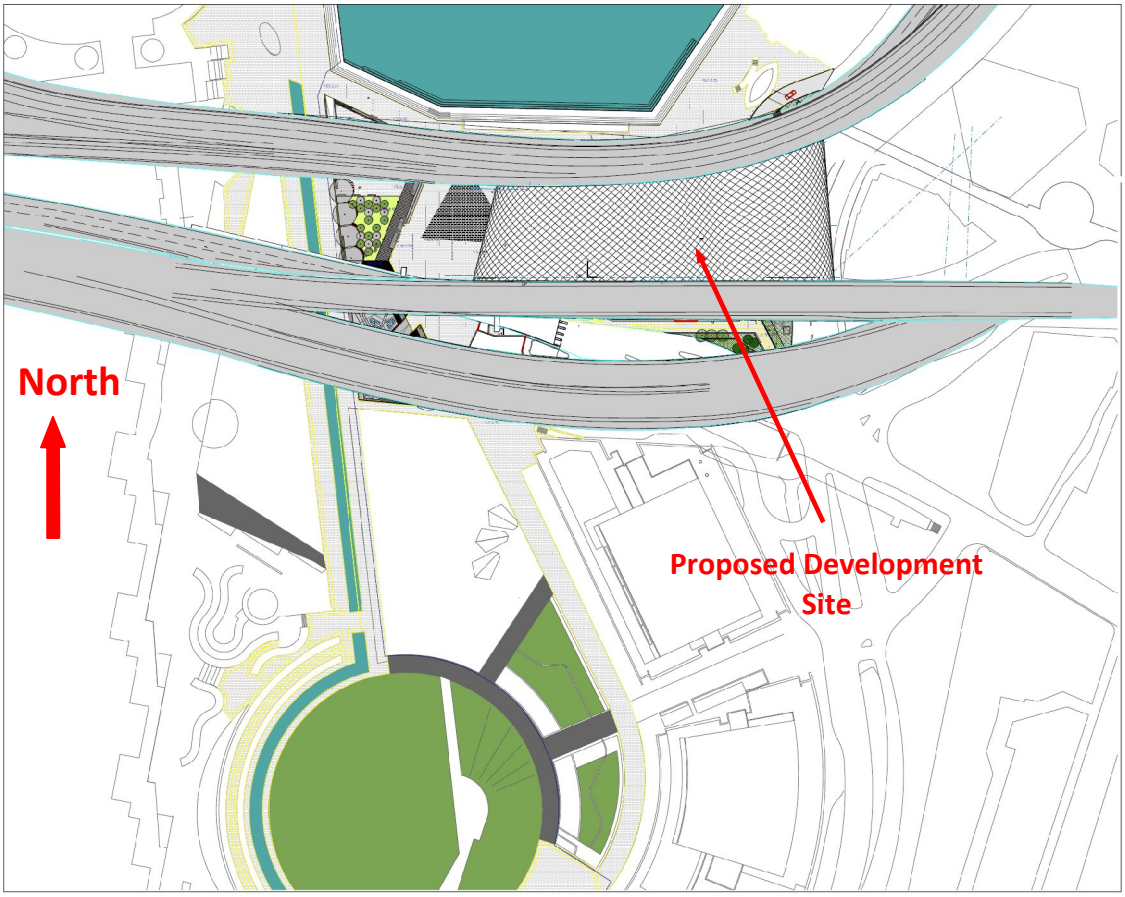


Figure 1: Upper Site Plan of the proposed Development at 31 Wheat Road, Sydney

The proposed refurbishment is a 24-storey office tower (a 4-storey podium plus a 20-storey commercial tower). The maximum height from the street level is 90 m. Figure 2 is the South Elevation showing the overall height.

This report details the opinion of Vipac as an experienced wind engineering consultancy regarding the wind effects in ground level public areas and access-ways in and adjacent to the development as proposed. No wind tunnel testing has been carried out for this Development. Vipac has carried out wind tunnel studies on a large number of developments of similar shape and having similar exposure to that of the proposed refurbishment. These serve as a valid reference for the prediction of wind effects. Empirical data for typical buildings in boundary layer flows has also been used to estimate the likely ground level wind conditions adjacent to the proposed refurbishment [2] & [3].

The original drawings of the proposed refurbishment were supplied by **HASSELL** and dated July 2012. The updated drawings were supplied in November 2015. A complete list of updated drawings supplied is provided in Appendix C of this report.

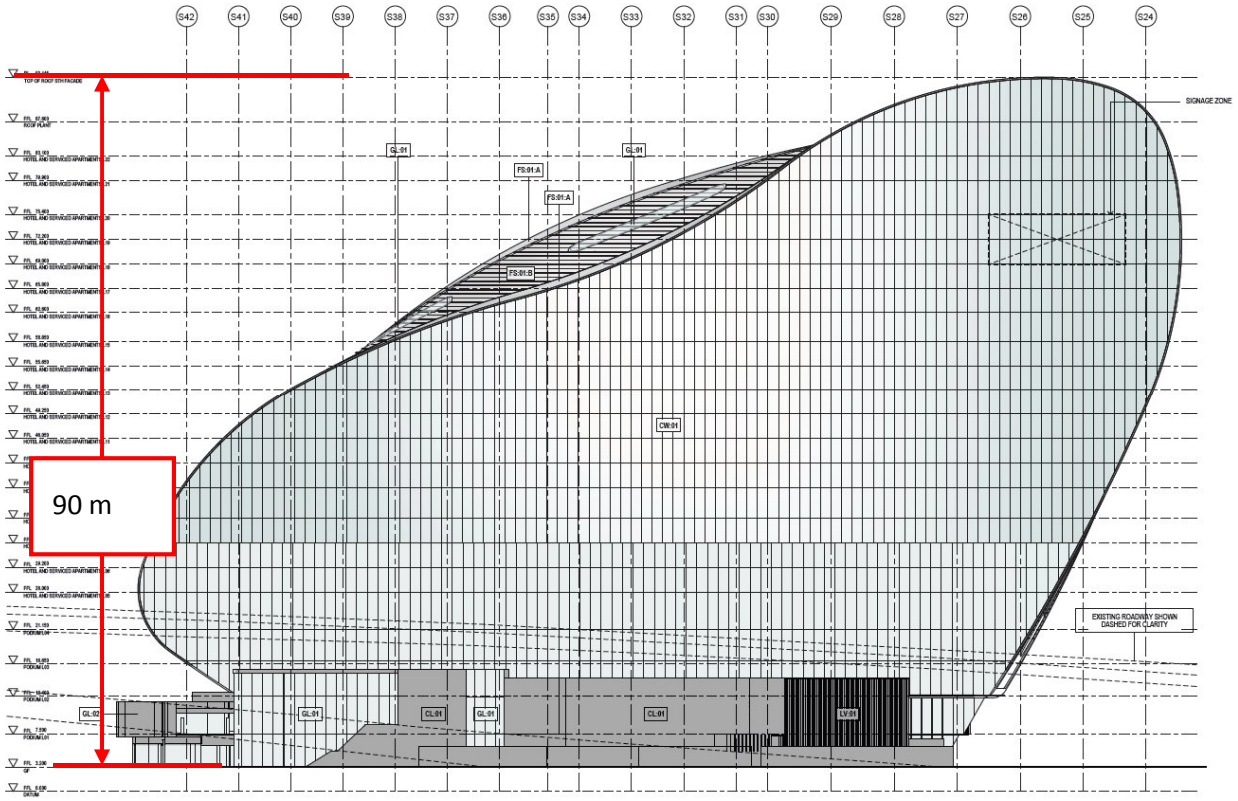


Figure 2: South Elevation of the proposed Development at 31 Wheat Road, Sydney

2. ANALYSIS APPROACH

In assessing whether a proposed development is likely to generate adverse wind conditions in adjacent ground level areas, Vipac has considered five main points:

- The exposure of the proposed development to wind
- The regional wind climate
- The geometry and orientation of the proposed development
- The interaction of flows with adjacent developments
- The assessment criteria, determined by the intended use of the public areas affected by wind flows generated or augmented by the proposed development.

The pedestrian wind comfort at specific locations around a site may be assessed by predicting the worst annual 3-second wind gust expected at that location. The location may be deemed generally acceptable for its intended use if the annual 3-second gust is within the threshold values noted in Section 2.5. Where Vipac predicts that a location would not meet its appropriate comfort criterion, the use of wind control devices and/or local building geometry modifications to achieve the desired comfort rating may be recommended. For complex flow scenarios or where predicted flow conditions are well in excess of the recommended criteria, Vipac recommend scale model wind tunnel testing to determine the type and scope of the wind control measures required to achieve acceptable wind conditions.

2.1. SITE EXPOSURE

The proposed refurbishment is bounded by Harbour Street to the east, park lands to the west, and the M4 western distributor freeways to the south and the north. Within a 1.5 km radius of the site of the proposed development there are built up areas of high-rise developments for north through east to southeast directions. Sydney harbor is north of the site.

Immediately adjacent developments are shown in Figure 3a. To the north there is a body of water that leads to Sydney Harbor. To the east there is a middle rise building and further east, the built-up areas of Sydney CBD. To the west, there are park lands and further west, some middle rise developments. To the south, there is a 9-storey Darling Quarter development built few years ago. A picture taken in the front of Imax theatre (project site) with a panorama view from west to east is shown in Figure 3b.

The site of the proposed development is therefore considered to be within a Terrain Category 2 for a sector of 340-360 azimuth degrees and a Terrain Category 4 (Urban terrain) for 360(0)-90-160 azimuth degrees and Terrain Category 3 for other directions [1] (see Figure 4).

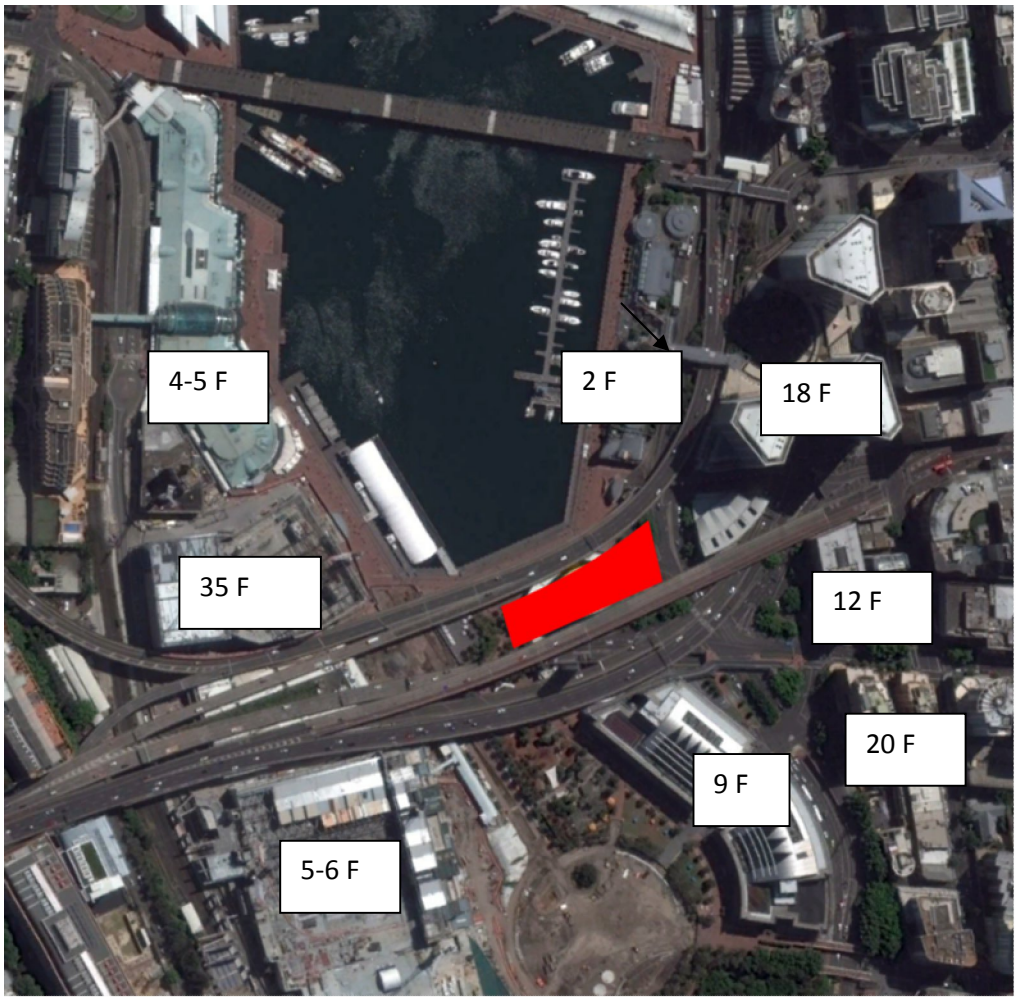


Figure 3a: Immediately adjacent surroundings and their number of storeys

West **North** **East**

Figure 3b: Panorama viewing from west to east at the front of project site (photo courtesy of Henky Mantophani)

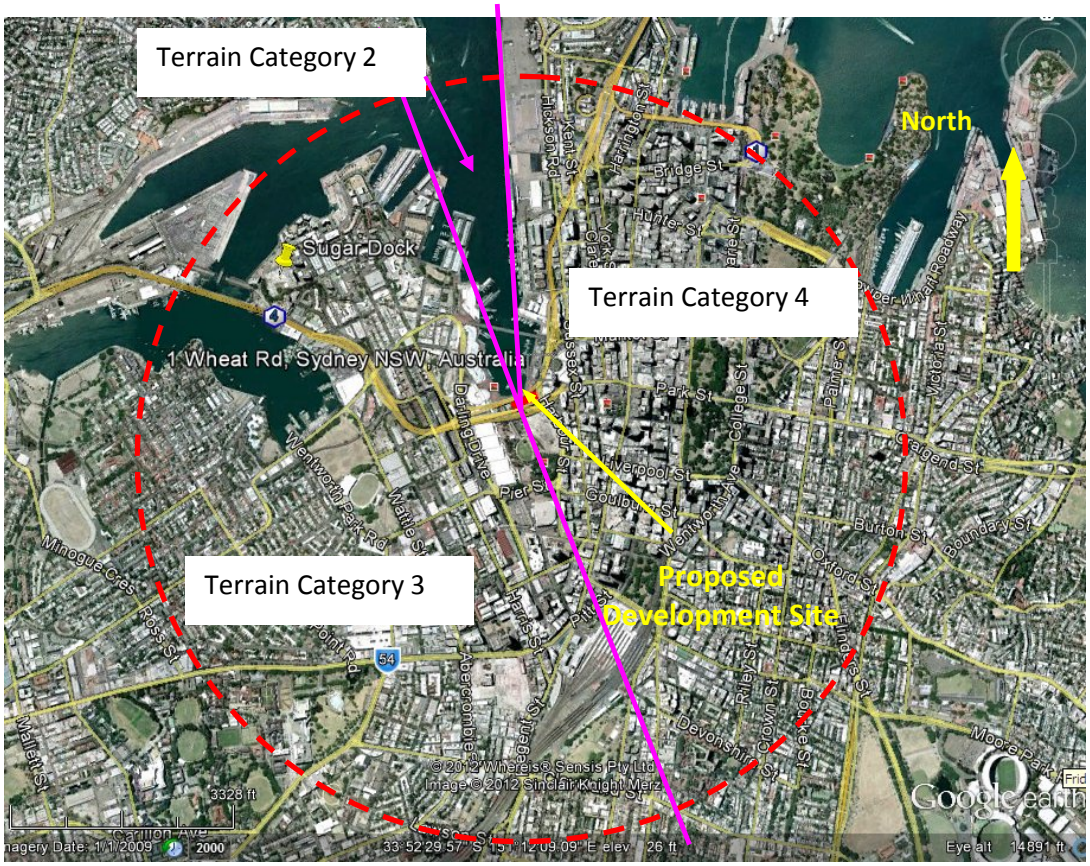


Figure 4: Terrain Category for approaching wind directions to the site

2.2. REGIONAL WIND CLIMATE

The mean and gust wind speeds have been recorded in the Sydney area for over 30 years. These data have been analysed and the directional probability distribution of wind speeds have been determined. The directional distribution of hourly mean wind speed at the gradient height with a probability of occurring once per year (i.e. 1 year return period) is shown in Figure 5. The wind data at this free stream height is common to all Sydney city sites and may be used as a reference to assess ground level wind conditions at the site.

The winds from the west are strongest, followed by those from the south, then the winds from the north-east.

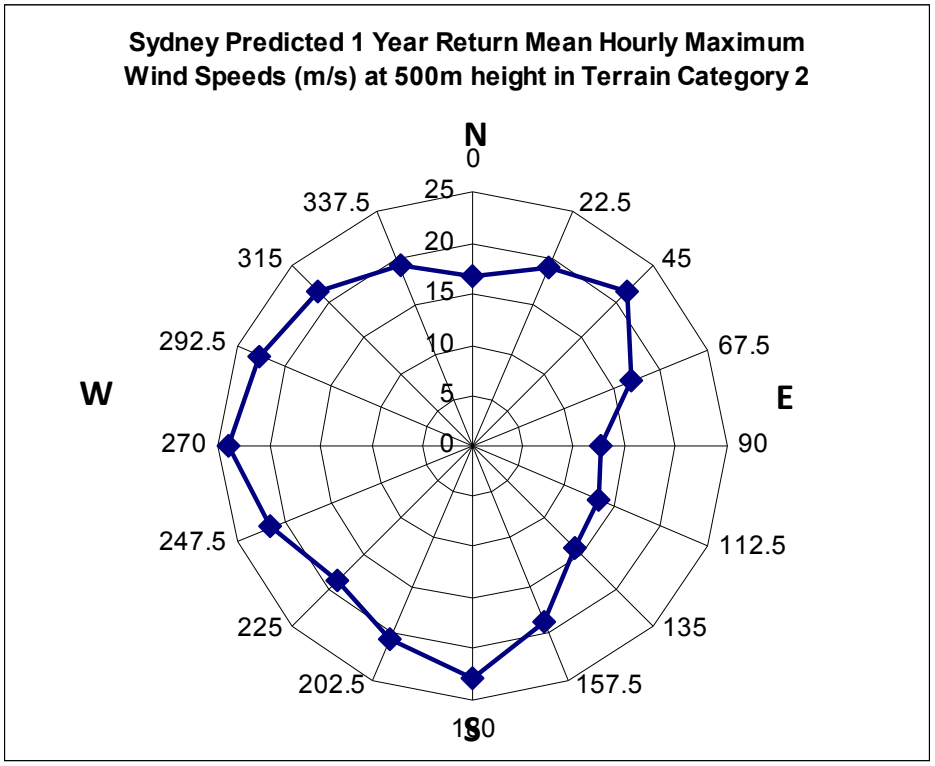


Figure 5: Directional Distribution of Annual Return Period Mean Hourly Wind Velocities (m/s) at Gradient Height for Sydney

2.3. BUILDING GEOMETRY AND ORIENTATION

The proposed refurbishment is a 24-storey office tower (a 4-storey podium plus a 20-storey commercial tower). The maximum height above street level is approximately 90 m. The building orientation is shown in Figure 6. The building plan is about 126 m by 65 m with a longer axis running in the east-west direction.

There are ground level pedestrian walkways around all sides of the proposed development, with parklands to the west. Some of the major building entrances are indicated at several locations in Figure 6.

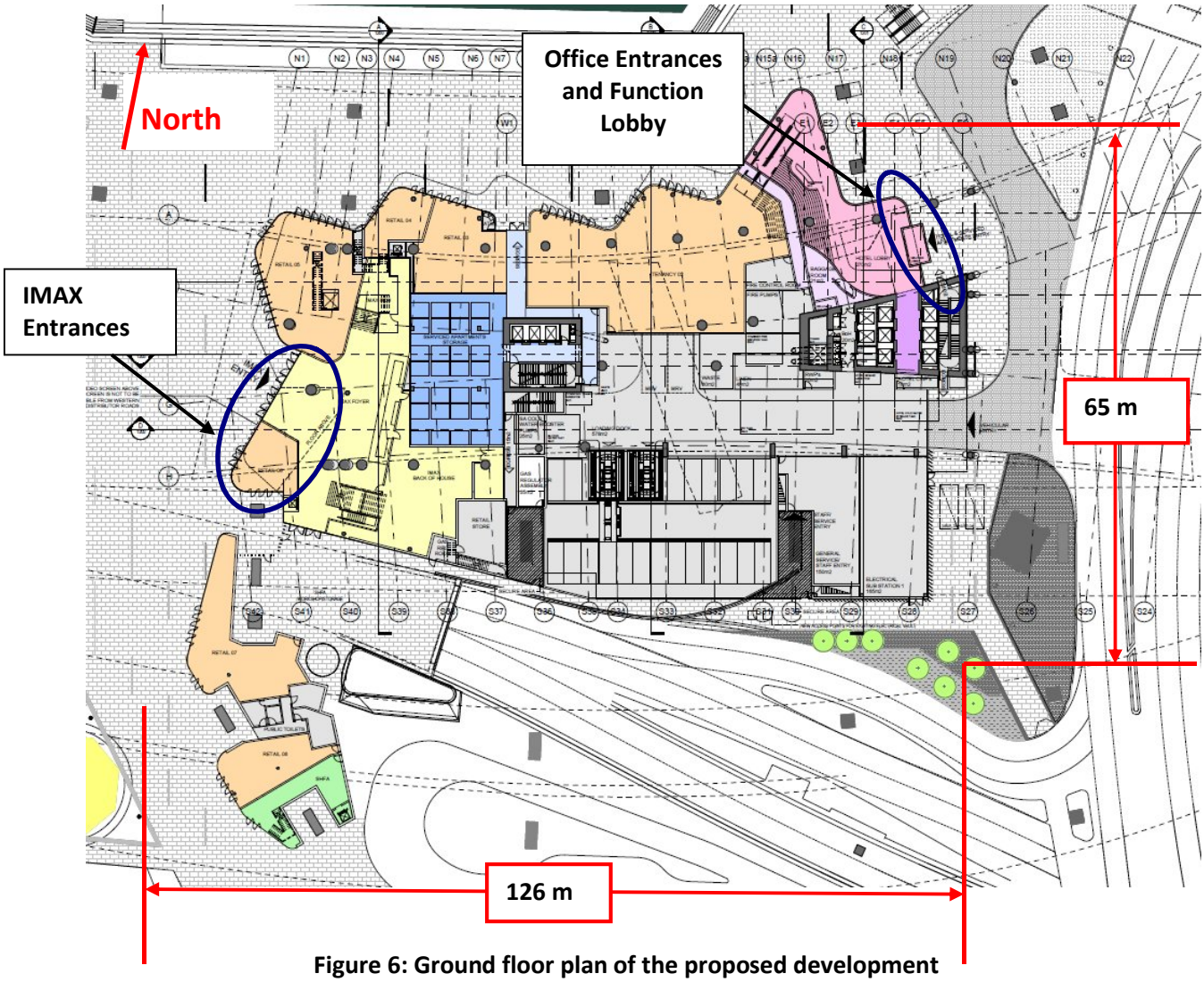


Figure 6: Ground floor plan of the proposed development

2.4. FLOW INTERACTIONS WITH ADJACENT DEVELOPMENTS

As shown in Figure 3 the immediately adjacent surroundings, especially the M4 western distributor freeways, will provide good shelter in all directions for ground level winds. When the wind approaches from the north or the south, there are down wash flow conditions on the façades of the proposed development facing these directions. However, most down wash flows are blocked by the podium roof and have minor effects on the ground floor.

2.5. ASSESSMENT CRITERIA

Vipac's assessment criteria for pedestrian wind comfort are based on some consensus of international opinion.

A set of annual maximum peak 3-second gust velocities is derived from meteorological data for the geographical location under consideration for each wind direction to be assessed. For each wind direction, the regions where the wind speed criteria may be exceeded are then considered.

Most people will consider a site completely unacceptable for a given activity if the mean and/or gust speeds exceed the annual maximum wind speed criterion for that activity. Studies have shown that if the annual wind speed criterion were exceeded, the site would also be considered excessively windy for that activity during more moderate winds [4].

Therefore, the suitability of any site for a particular usage can be reasonably assessed by predicting the annual maximum wind speed (for a given direction) and comparing it to the following criteria:

The threshold gust speed criteria are:

Condition	Annual Maximum Gust	Result on Perceived Pedestrian Comfort
Safety	>23m/s	Unsafe (frail pedestrians knocked over)
Walking	<16m/s	Acceptable for Walking (steady steps for most pedestrians)
Standing	<13m/s	Acceptable for Standing (window shopping, vehicle drop off, queuing)
Sitting	<11m/s	Acceptable for Sitting (outdoor café's, pool area, gardens)

Table 1 – Gust Wind Comfort and Safety Criteria

In a similar manner, a set of hourly mean speed criteria with a 1% probability of occurrence are also applicable to ground level areas in and adjacent to the proposed development. An area should be within both the relevant mean and gust limits in order to satisfy the particular human comfort and safety criteria in question.

The threshold mean speed criteria are:

Condition	Mean, 1% of Time	Result on Perceived Pedestrian Comfort
Safety	>15m/s	Unsafe (frail pedestrians knocked over)
Walking	<10m/s	Acceptable for Walking (steady steps for most pedestrians)
Standing	<7m/s	Acceptable for Standing (window shopping, vehicle drop off, queuing)
Sitting	<5m/s	Acceptable for Sitting (outdoor café's, pool area, gardens)

Table 2 – Mean Wind Comfort and Safety Criteria

The specific requirements for Central Sydney, as stipulated in the Development Control Plan (2010) have been taken into consideration when determining the wind criteria for the proposed pedestrian areas. The DCP states that the maximum wind criteria that are to be met by new buildings (including refurbishments):

- 10 metres/second in retail streets,
- 13 metres/second along major pedestrian streets, parks and public places,
- 16 metres/second in all other streets.

The proposed development is located at the areas where the DCP requires a 16 m/s maximum annual wind speed. The wind criterion of walking is recommended for the footpath in this study (see Table 3 below).

2.5.1. Use of Adjacent Pedestrian Occupied Areas & Recommended Comfort Criteria

The following table lists the specific areas adjacent to the proposed development and the corresponding recommended criteria (see also Figure 7).

Area	Specific location	Recommended Criteria
Public Footpaths	Around the proposed development	Walking
Building entrances	Several locations (Figure 7)	Standing
Balconies	Hotel and Serviced Apartments Level 1 to Level 12	Walking (*refer to notes in Section 2.5.2*)

Table 3 – Recommended application of criteria

2.5.2. Building Balcony/Terrace Recommended Criterion Discussion

Vipac recommends as a minimum, the building balconies/terraces (Commercial tower up to level 12) meet the criterion for walking since,

- these areas are not public spaces;
- the use of these areas is optional; and
- many similar developments in Sydney and other Australian capital cities experience wind conditions on balconies/terraces and elevated deck areas in the vicinity of the criterion for walking.

Vipac wishes to clearly state that meeting the walking criterion on elevated recreation areas will not guarantee that occupants will find wind conditions in these areas acceptable at all times.

In our experience, outdoor recreation areas should almost meet the criterion for sitting comfort in order that the majority of reasonable people consider such areas acceptable for their intended use from a wind point-of-view. Wind conditions over this criterion will tend to result in a reduction in amenity of the area.

This perception may be due to:

- the cooling effect of the wind on the human body (particularly for pool deck areas),
- the removal of lightweight items such as towels, serviettes, newspapers, lightweight furniture (eg. plastic banana lounges),
- difficulty hearing others speak.

Wind conditions meeting the criterion for walking may still result in the following adverse effects whilst the roof top area is unoccupied:

- the removal of lightweight furniture during storms,
- the removal of some water from pools during storms.

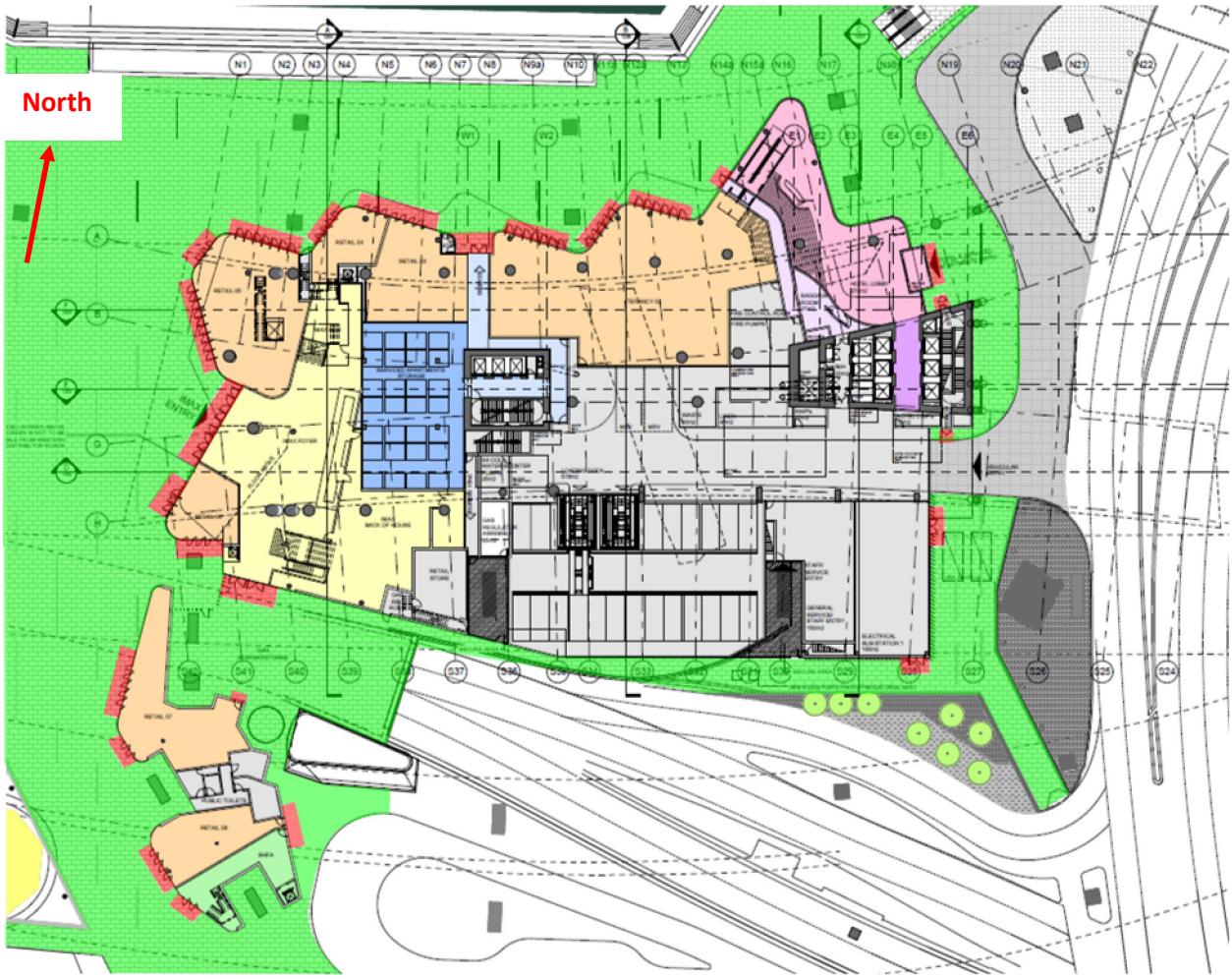


Figure 7: Schematic plan view of the proposed development with recommended wind criteria overlaid on adjacent ground level areas

3. PEDESTRIAN LEVEL WIND EFFECTS AND RECOMMENDATIONS

3.1. *Key points:*

- The proposed development is considered likely to have wind conditions on the adjacent ground floor public walkways that fulfil the recommended criteria for walking with proposed design.
- Vipac predicts wind conditions on the building entrances on the north and east sides would be close to, or in excess of the standing criterion.

3.2. Ground level

The proposed development is likely to fulfil walking criterion at all footpath areas on the ground level and fulfil the standing criterion at many entrance areas. However, the main entrance areas on the east side would be expected to have wind condition close to, or in excess of, the standing criterion for northerly and southerly winds. The entrance areas on the north side of the building would be expected to have wind conditions in excess of the standing criterion for northerly winds.

3.3. Recommendations

Vipac predicts that the proposed development will generate the wind conditions to likely fulfil the walking criterion for footpath areas and standing criterion for many entrance areas. However, main entrance areas on the north and west sides may experience the wind conditions close to/exceeding the recommended standing criterion. Windscreens are recommended for these areas (Figure 8).

Furthermore, educating occupants about wind conditions on these terraces during high-wind event and tying down loose furniture are highly recommended.

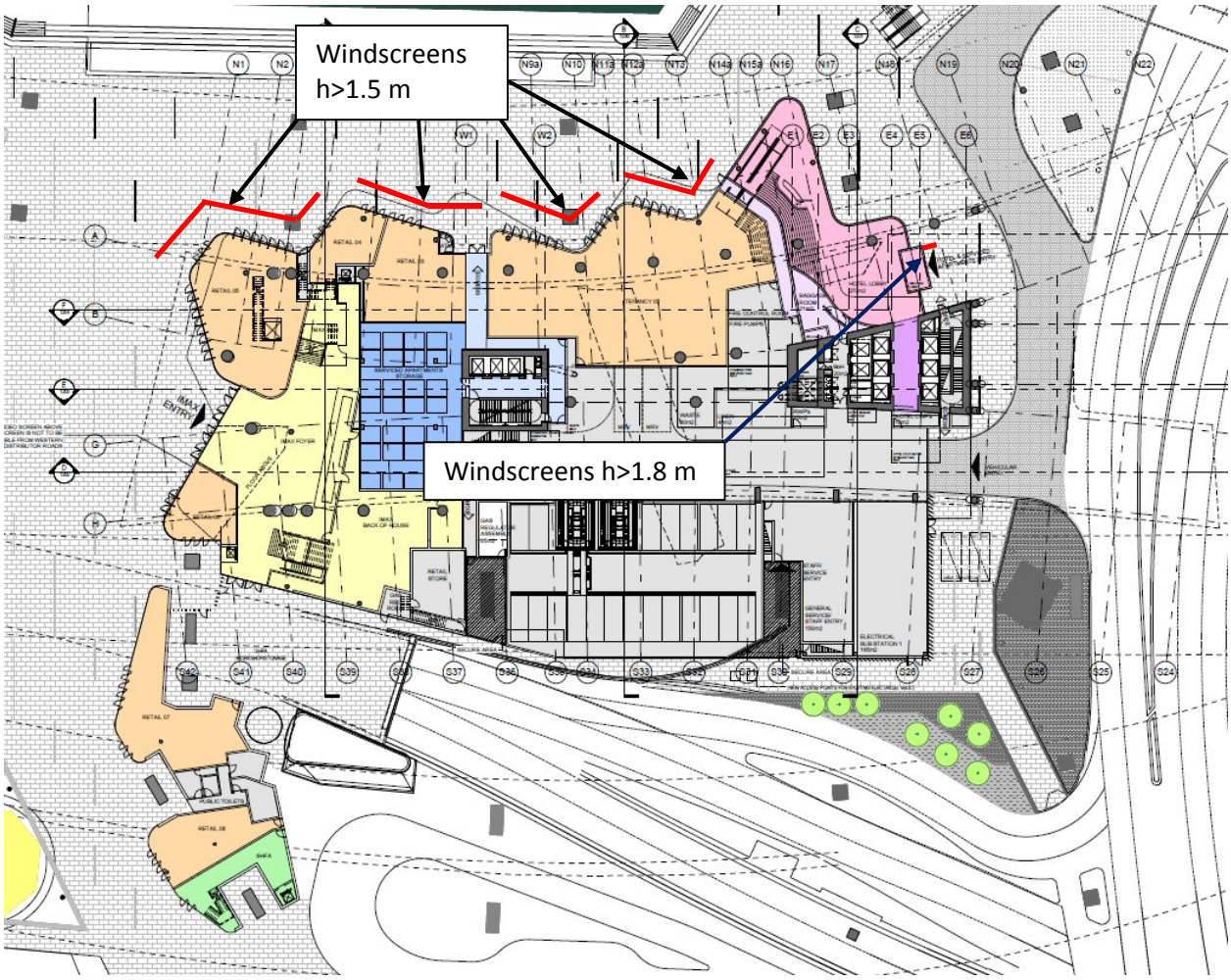


Figure 8: Wind control measures on the ground level outdoor seating and main entrance areas

4. CONCLUSION

An appraisal of the likely wind conditions in and adjacent to the proposed development at **31 Wheat Road, Sydney** has been made.

Vipac has carefully considered the form and exposure of the proposed development, nominated criteria for various ground level areas according to their function, made calculations using empirical data and referred to past experience to produce our opinion of likely ground level wind conditions adjacent to the proposed development.

The proposed development would be expected to have wind conditions within the walking criterion in all ground level areas with the proposed design.

Wind conditions in the entrance areas would be expected to fulfil the recommended criterion for standing with the proposed design **and recommended windscreens**.

As a general statement, educating occupants about wind conditions at high-level terraces during high-wind events and tying down loose furniture are highly recommended.

The assessments provided in this report have been made based on experience of similar situations in Sydney and around the world. As with any opinion, it is possible that an assessment of wind effects based on experience and without wind tunnel model testing may be in error. Vipac recommends a wind tunnel test to verify the assessment.

This Report has been Prepared

For

Grocon Group

By

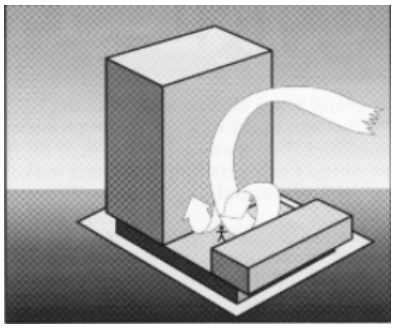
VIPAC ENGINEERS & SCIENTISTS LTD.

APPENDIX A - ENVIRONMENTAL WIND EFFECTS

Atmospheric Boundary Layer

As wind flows over the earth it encounters various roughness elements and terrain such as water, forests, houses and buildings. To varying degrees, these elements reduce the mean wind speed at low elevations and increase air turbulence. The wind above these obstructions travels with unattenuated velocity, driven by atmospheric pressure gradients. The resultant increase in wind speed with height above ground is known as a wind velocity profile. When this wind profile encounters a tall building, some of the fast moving wind at upper elevations is diverted down to ground level resulting in local adverse wind effects.

The terminology used to describe the wind flow patterns around the proposed development is based on the aerodynamic mechanism, direction and nature of the wind flow.



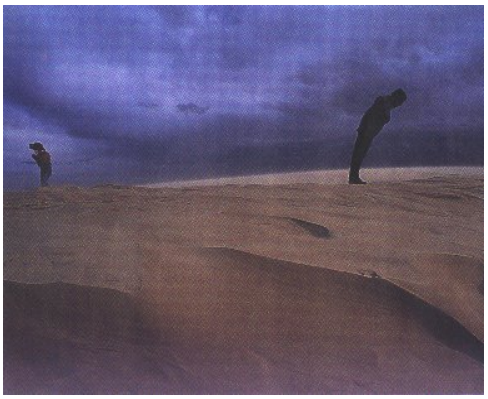
Downwash – refers to a flow of air down the exposed face of a tower. A tall tower can deflect a fast moving wind at higher elevations downwards.

Corner Accelerations – when wind flows around the corner of a building it tends to accelerate in a similar manner to airflow over the top of an aeroplane wing.

Flow separation – when wind flowing along a surface suddenly detaches from that surface and the resultant energy dissipation produces increased turbulence in the flow. Flow separation at a building corner or at a solid screen can result in gusty conditions.

Flow channelling – the well-known “street canyon” effect occurs when a large volume of air is funnelled through a constricted pathway. To maintain flow continuity the wind must speed up as it passes through the constriction. Examples of this might occur between two towers, in a narrowing street or under a bridge.

Direct Exposure – a location with little upstream shielding for a wind direction of interest. The location will be exposed to the unabated mean wind and gust velocity. Piers and open water frontage may have such exposure.



APPENDIX B - REFERENCES

[1] *Structural Design Actions, Part 2: Wind Actions*, Australian/New Zealand Standard 1170.2:2010

[2] *Wind Effects on Structures* E. Simiu, R Scanlan, Publisher: Wiley-Interscience

[3] *Architectural Aerodynamics* R. Aynsley, W. Melbourne, B. Vickery, Publisher: Applied Science Publishers

[4] *Criteria for Environmental Wind Conditions*, W. H. Melbourne, Jour. Industrial Aerodynamics, Vol. 3, 241-249,1978

APPENDIX C – DRAWING LIST

Preliminary drawings

File Name	Size	Type	Date
1 Wheat Road_ FINAL DRAW...	17,366 KB	Adobe Acrobat Doc...	7/31/2012 7:46 PM

Updated drawings

Drawing Number	Title	Date
ARC-HSL-DD-1100	Ground Floor	21.10.15
ARC-HSL-DD-1101	Podium L01	21.10.15
ARC-HSL-DD-1102	Podium L02	21.10.15
ARC-HSL-DD-1103	Podium L03	21.10.15
ARC-HSL-DD-1104	Podium L04	21.10.15
ARC-HSL-DD-1105	Hotel and Serviced Apartments L01 and L02	21.10.15
ARC-HSL-DD-1106	Hotel and Serviced Apartments L03 and L04	21.10.15
ARC-HSL-DD-1107	Hotel and Serviced Apartments L05 and L06	21.10.15
ARC-HSL-DD-1108	Hotel and Serviced Apartments L07 and L08	21.10.15
ARC-HSL-DD-1109	Hotel and Serviced Apartments L09 and L10	21.10.15
ARC-HSL-DD-1110	Hotel and Serviced Apartments L11 and L12	21.10.15
ARC-HSL-DD-1111	Hotel and Serviced Apartments L13 and L14	21.10.15
ARC-HSL-DD-1112	Hotel and Serviced Apartments L15 and L16	21.10.15
ARC-HSL-DD-1112.1	Hotel L17 and L18	21.10.15
ARC-HSL-DD-1113	Hotel L19 and Roof	21.10.15