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Vipac Engineers & Scientists

LegPro 45 Pty Ltd

253-267 Pacific Hwy, North Sydney

Wind Impact Assessment

30N-18-0186-TNT-6750203-1

10 September 2018

Report Title: Wind Impact Assessment **Job Title: 253-267 Pacific Hwy, North Sydney**	
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2		

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EXECUTIVE SUMMARY

LegPro 45 Pty Ltd commissioned Vipac Engineers and Scientists Ltd to prepare a statement of wind effects for the ground level areas adjacent to the proposed development at **253-267 Pacific Hwy, North Sydney.** This appraisal is based on Vipac's experience as a wind-engineering consultancy.

Drawings of the proposed development were provided by **PTW Architects** in **September 2018**. The findings of this study can be summarized as follows:

With the proposed design:

- The adjacent footpaths would be expected to have wind levels exceeding the walking comfort criterion. We recommend curving the tower corners to suppress vortex shedding.
- The wind conditions at the building entrances are expected to be within the recommended standing comfort criterion, considering the proposed awning along Pacific Hwy and West Street, and the setback designs for main lobby entrances.
- The tower rooftop communal terrace is expected to have wind levels exceeding the recommended walking comfort criterion. We recommend increasing the balustrade to ≥ 1.8 m to shield this area from adverse wind conditions.

As a general statement, educating occupants about wind conditions at open terrace/balcony areas during high-wind events and fixing loose, lightweight furniture on the terrace 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 experimental validation may not account for all complex flow scenarios in the vicinity. Vipac recommends a scaled model wind tunnel test to verify the predictions and determine the optimal wind control strategies.

TABLE OF CONTENTS

1 INTRODUCTION

LegPro 45 Pty Ltd commissioned Vipac Engineers and Scientists Ltd to prepare a statement of wind effects for the ground level areas adjacent to the proposed development at **253-267 Pacific Hwy, North Sydney.** This appraisal is based on Vipac's experience as a wind-engineering consultancy.

The proposed development has 18 storeys and the site is bounded by Pacific Hwy to the west, Church Lane to the east, West Street to the north and an existing development to the south (see Figure 1). The west elevation is shown in Figure 2 with the maximum building height of approximately 68 m. The surrounding developments within a 4km radius are low rise suburban dwellings with taller buildings of North Sydney and the Sydney CBD to the south; and the Parramatta River to the SE and SW. (Figure 3).

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 adjacent to the development as proposed. No wind tunnel testing has been carried out for this development at this stage. 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 development. These serve as a valid reference for the prediction of wind effects for this development. Empirical data for typical buildings in boundary layer flows has also been used to estimate likely ground level wind conditions adjacent to the proposed development [2] & [3].

Drawings of the proposed development were provided by **PTW Architects** in **September 2018** as listed in Appendix C of this report.

Figure 1: Aerial view of the proposed development site

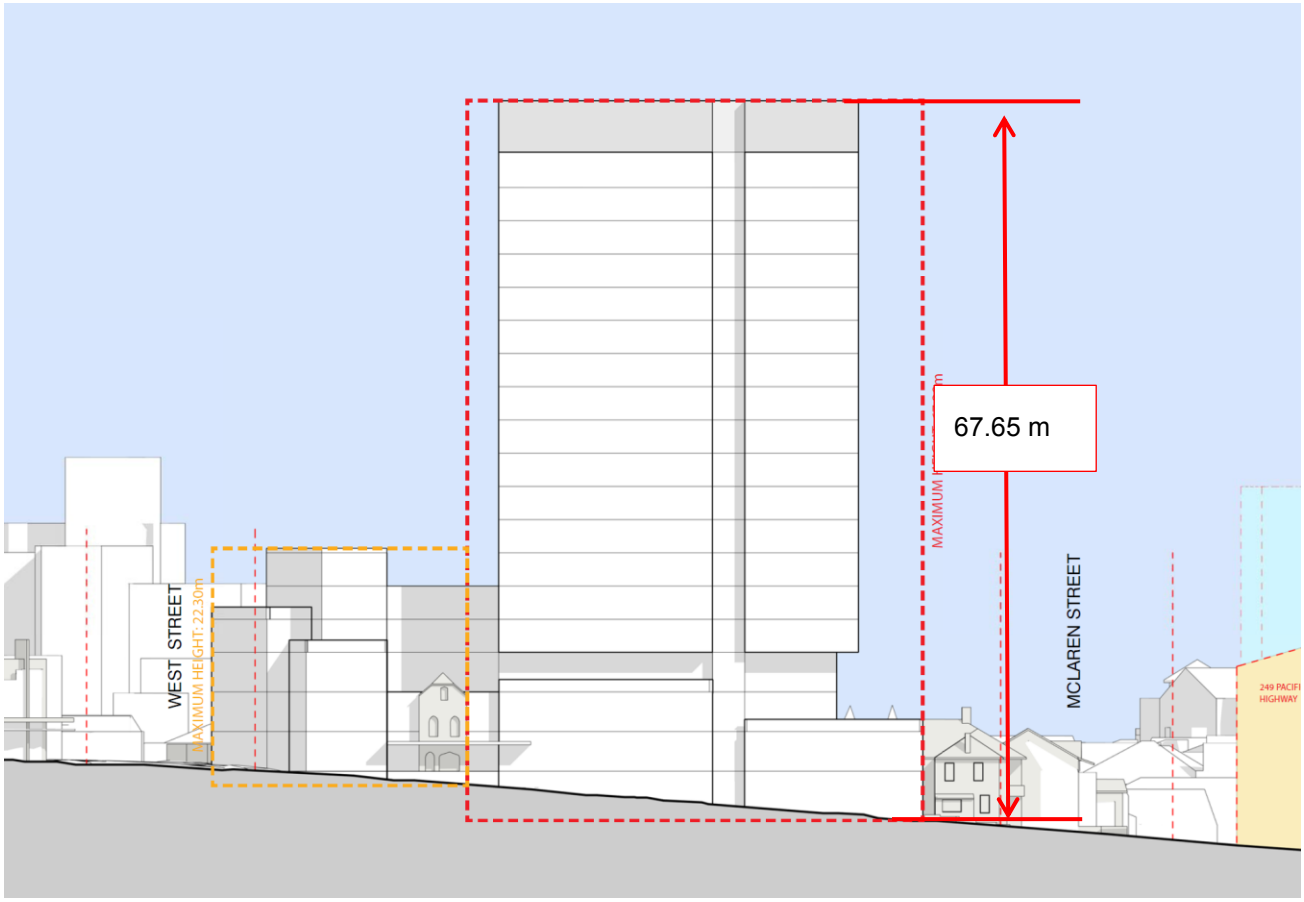


Figure 2: West massing elevation

2 ANALYSIS APPROACH

When considering whether a proposed development is likely to generate adverse wind conditions in adjacent ground level areas, Vipac considers 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. For cases where Vipac predicts that a location would not meet its appropriate comfort criterion we may recommend the use of wind control devices and/or local building geometry modifications to achieve the desired comfort rating. For complex flow scenarios or where predicted flow conditions are well in excess of the recommended criteria, Vipac recommends 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 surrounding developments within a 4km radius are low rise suburban dwellings with taller buildings of North Sydney and the Sydney CBD to the south; and the Parramatta River to the SE and SW. For the current study, the site of the proposed development is considered to be Terrain Category 2.5 for wind directions SE to SSE and SSW to W; Terrain Category 3.5 for southerly wind directions and Terrain Category 3 for all other wind directions [1] (see Figure 3).

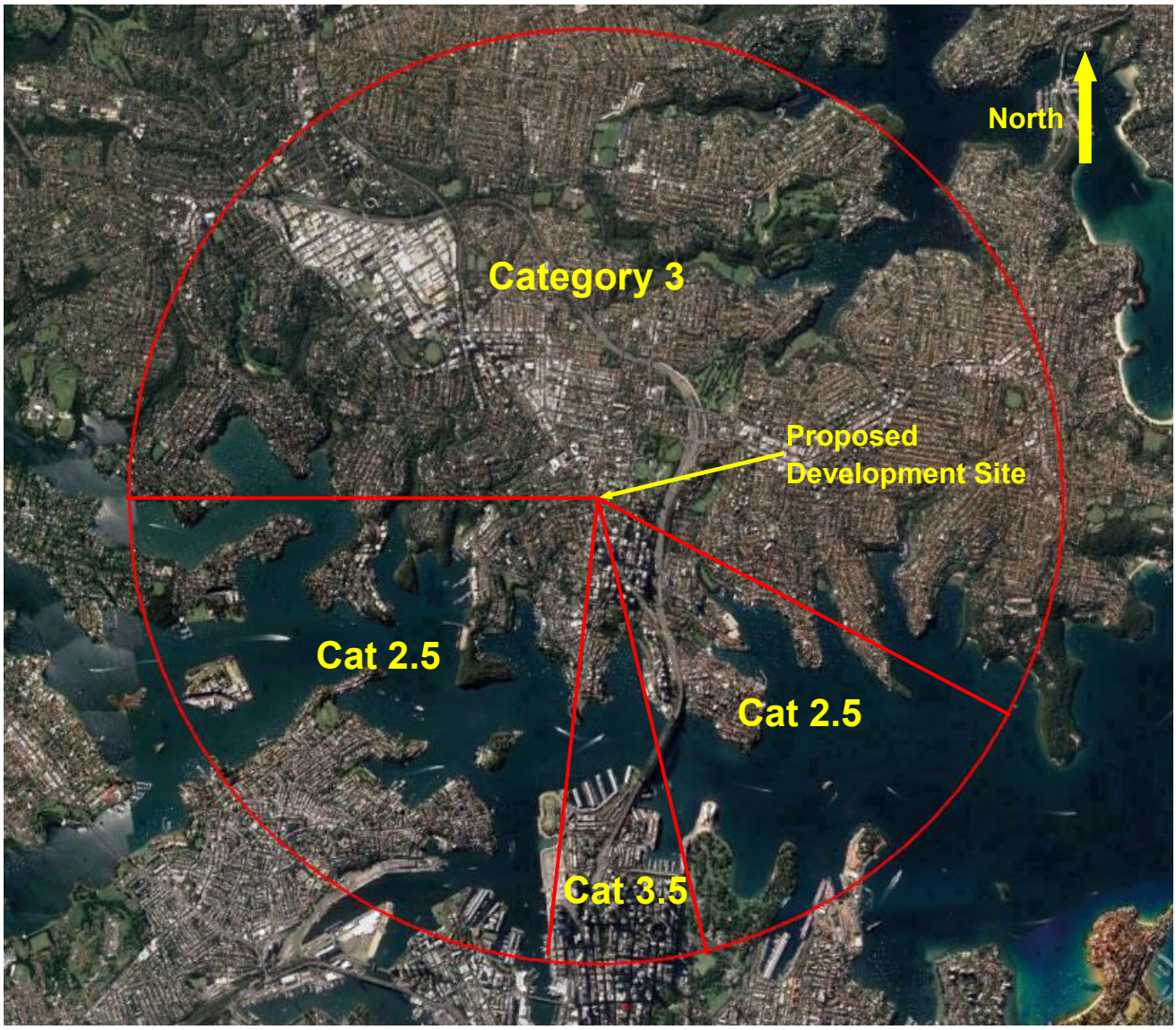


Figure 3: Assumed terrain categories for wind speed estimation.

2.2 REGIONAL WIND CLIMATE

The mean and gust wind speeds have been recorded in the Sydney area for 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 4. The wind data at this free stream height are common to all Sydney city sites and may be used as a reference to assess ground level wind conditions at the site. Figure 4 indicates that the stronger winds can be expected from the south to north-westerly directions, followed by south, then North Easterly directions.

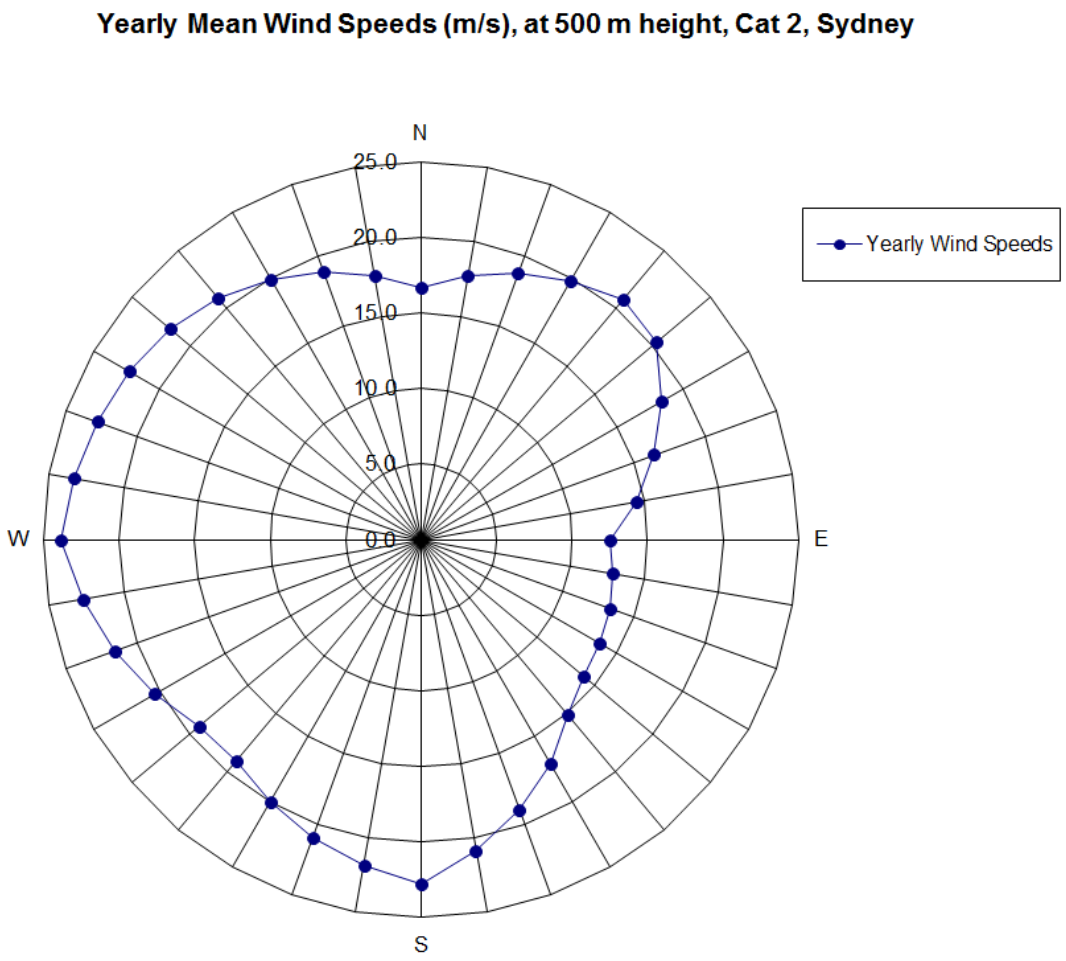


Figure 4: Directional Distribution of Annual Return Period Maximum Mean Hourly Wind Velocities (m/s) at gradient height in Sydney.

2.3 BUILDING GEOMETRY AND ORIENTATION

The ground level plan of the proposed development is shown in Figure 5 with the approximate dimensions.

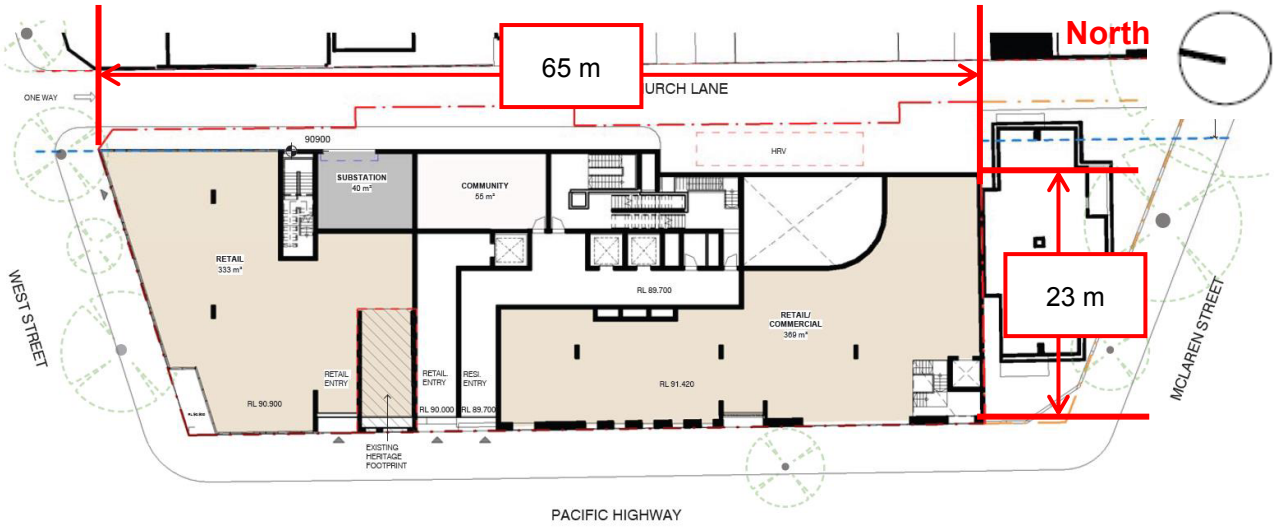


Figure 5: Ground floor plan of the proposed development with the approximate dimensions

2.4 FLOW INTERACTIONS WITH ADJACENT DEVELOPMENTS

The buildings immediately adjacent to the proposed development site, with their approximate heights are shown in Figure 6.

The proposed development is surrounded by low rise buildings (1-2 storeys) in all directions; with 42 m building to the north and a 20 m building to the south. There are some future buildings to the south that can be seen in Figure 8.

The prevailing winds are from the south, west and NE. The ground level areas are exposed to these winds channelling along Pacific Hwy.

The North Sydney CBD is to the south of the site as shown in Figure 7 and Figure 8 which will offer some reduction in the mean velocity of winds from the southerly sector.

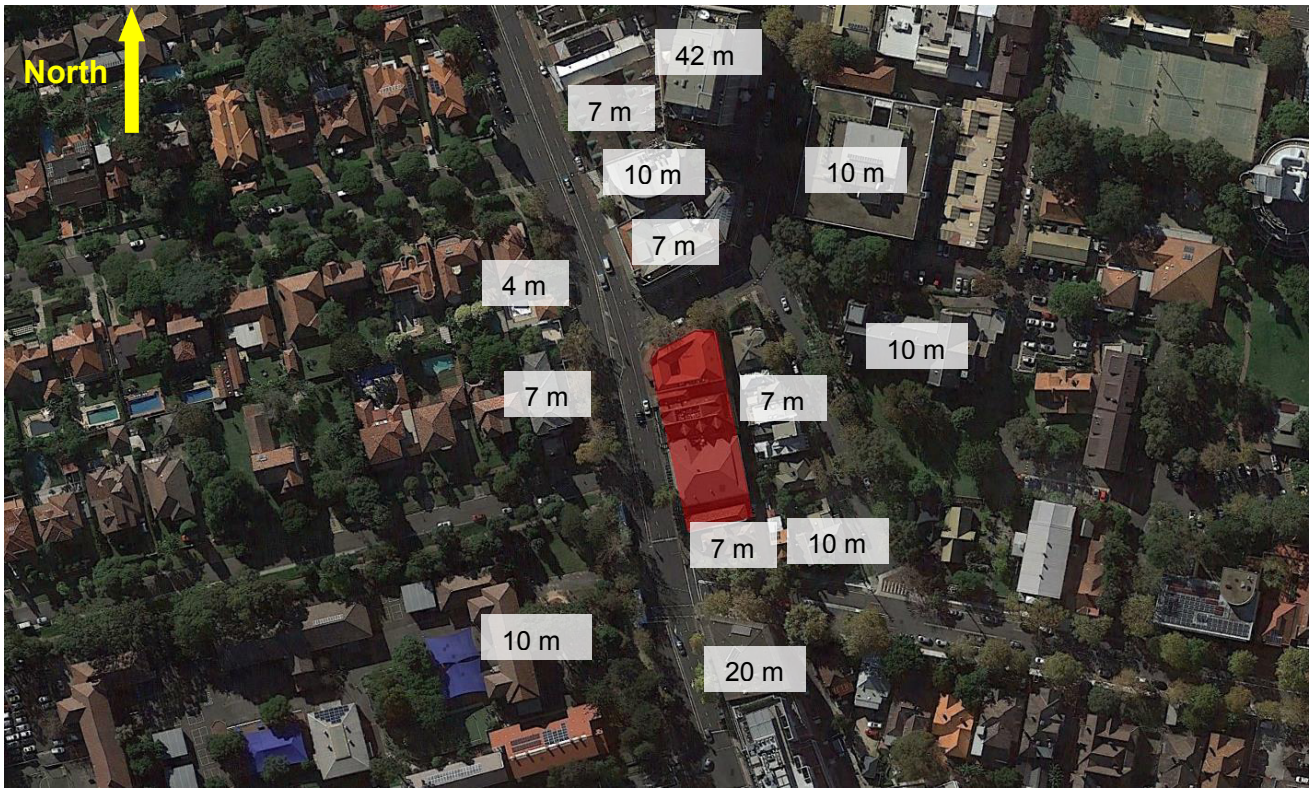


Figure 6 : Immediately adjacent buildings and their approximate number of storeys (F)

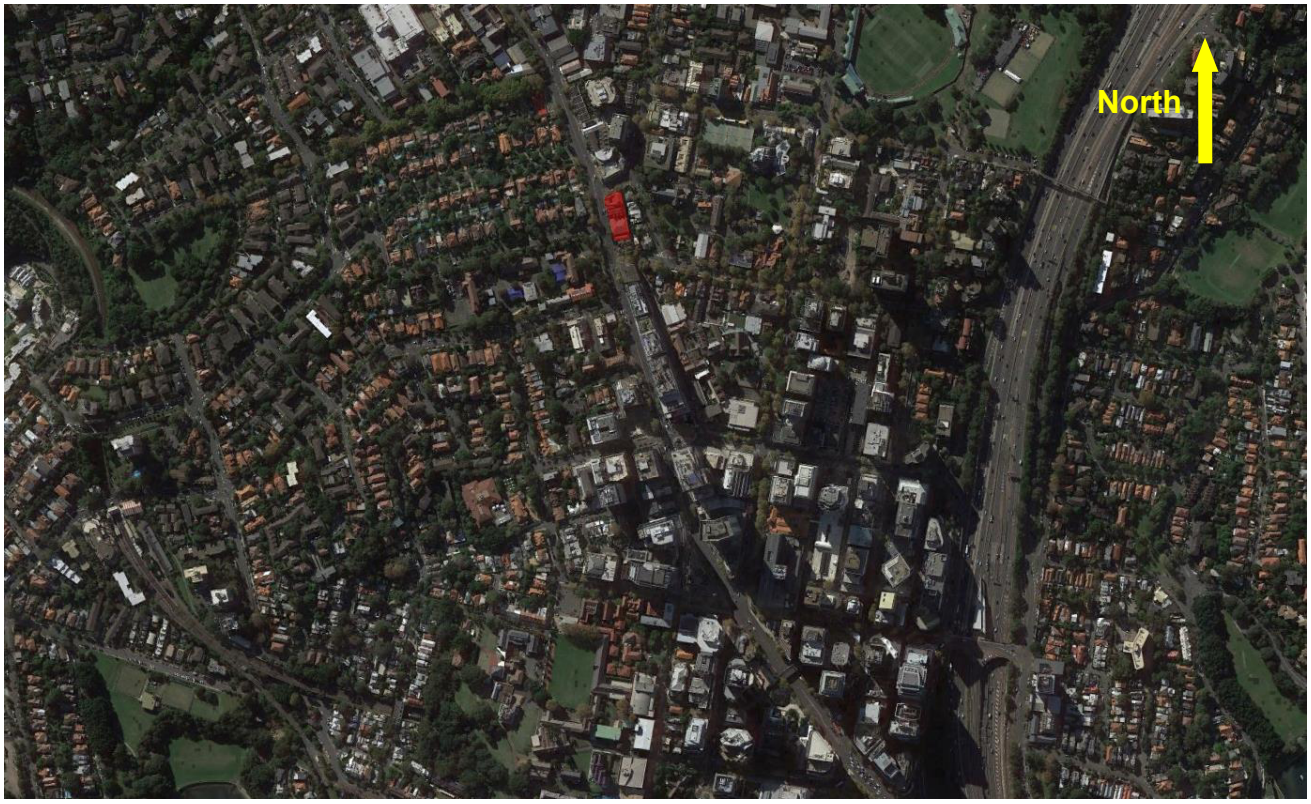


Figure 7: Satellite image showing the North Sydney CBD to the south

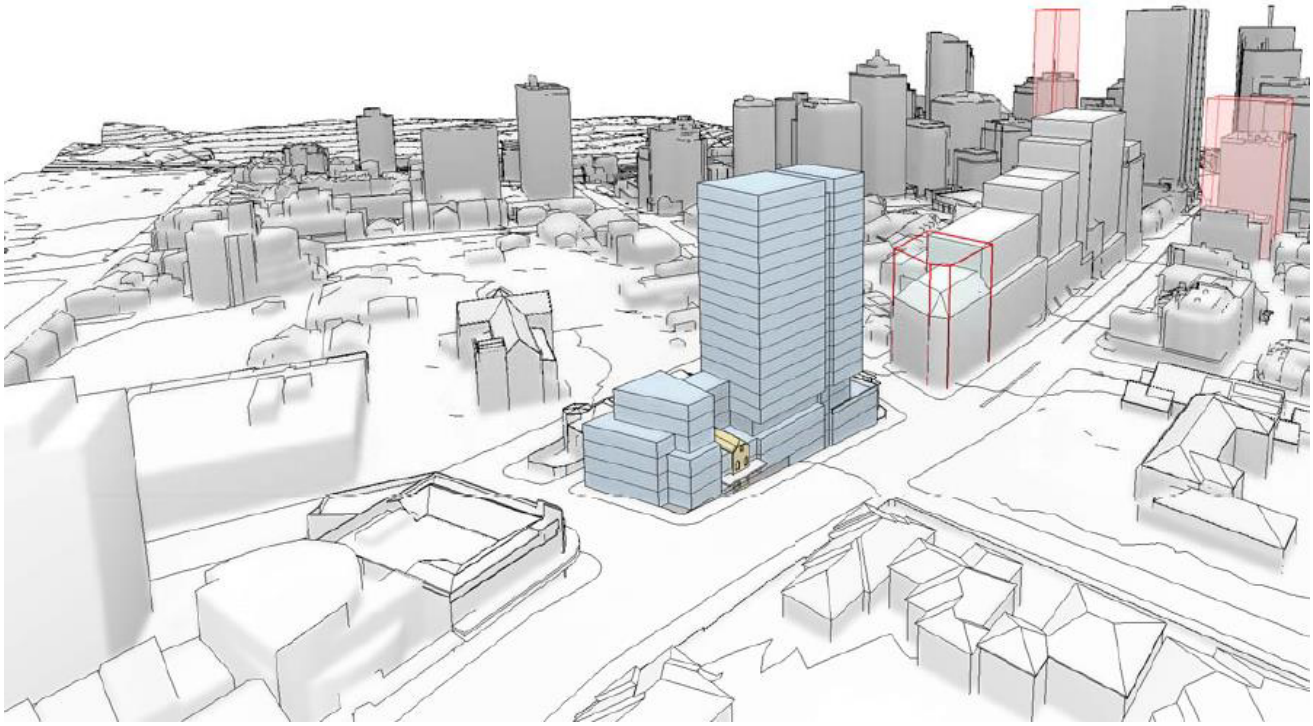


Figure 8: Perspective view from the northwest

2.5 ASSESSMENT CRITERIA

With some consensus of international opinion, pedestrian wind comfort is rated according to the suitability of certain activities at a site in relation to the expected annual peak 3-second gust velocity at that location for each wind direction. Each of the major areas around the site are characterized by the annual maximum gust wind speeds. Most patrons would consider a site generally unacceptable for its intended use if it were probable that during one annual wind event, a peak 3-second gust occurs which exceeds the established comfort threshold velocity (shown in Table 1). If that threshold is exceeded once per year then it is also likely that during moderate winds, noticeably unpleasant wind conditions would result, and the windiness of the location would be considered as unacceptable.

Table 1: Recommended Wind Comfort and Safety Gust Criteria

Annual Maximum Gust Speed	Result on Perceived Pedestrian Comfort
>23m/s	Unsafe (frail pedestrians knocked over)
<20m/s	Acceptable for **fast walking** (waterfront or particular walking areas)
<16m/s	Acceptable for **walking** (steady steps for most pedestrians)
<13m/s	Acceptable for **standing** (window shopping, vehicle drop off, queuing)
<11m/s	Acceptable for **sitting** (outdoor cafés, gardens, park benches)

In a similar manner, a set of hourly mean velocity criteria (see Table 2) with a 0.1% 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.

Table 2: Recommended Wind Comfort and Safety Mean Criteria

Mean Speed in 0.1% of Time	Result on Perceived Pedestrian Comfort
>15m/s	Unsafe (frail pedestrians knocked over)
<13m/s	Acceptable for **fast walking** (waterfront or particular walking areas)
<10m/s	Acceptable for **walking** (steady steps for most pedestrians)
<7m/s	Acceptable for **standing** (window shopping, vehicle drop off, queuing)
<5m/s	Acceptable for **sitting** (outdoor cafés, gardens, park benches)

The Beaufort Scale is an empirical measure that related the wind speed to observed conditions on the land and sea. Table 3 describes the categories of the Beaufort Scale. The comparison between these observed conditions and the comfort criteria described above can be found in Table 4.

Table 3: Beaufort Scale - empirical measure relating wind speed to observed conditions on land

Beaufort Number	Descriptive Term	Wind Speed at 1.75 m height (m/s)	Specification for Estimating Speed
0	Calm	0-0.1	
1	Light Air	0.1-1.0	No noticeable wind
2	Light Breeze	1.1-2.3	Wind felt on face
3	Gentle Breeze	2.4-3.8	Hair disturbed, clothing flaps, newspapers difficult to read
4	Moderate Breeze	3.9-5.5	Raises dust and loose paper; hair disarranged
5	Fresh Breeze	5.6-7.5	Force of wind felt on body, danger of stumbling when entering a windy zone
6	Strong Breeze	7.6-9.7	Umbrellas used with difficulty, hair blown straight, difficult to walk steadily, sideways wind force about equal to forwards wind force, wind noise on ears unpleasant
7	Near Gale	9.8-12.0	Inconvenience felt when walking
8	Gale	12.1-14.5	Generally impedes progress, great difficulty with balance in gusts
9	Strong Gale	14.6-17.1	People blown over

Table 4: Comparison between Mean comfort criteria and the observed conditions

Comfort Criteria	Beaufort Scale Equivalent
Safety	9 – Strong Gale
Walking	5 – Fresh Breeze
Standing	4-5 – Moderate to Fresh Breeze
Sitting	<4 – Moderate Breeze

2.6 USE OF ADJACENT PEDESTRIAN OCCUPIED AREAS & RECOMMENDED COMFORT CRITERIA

The following table lists the specific areas adjacent to the development and the corresponding recommended criteria. These are shown in Figure 9.

Table 5: Recommended application of criteria

Area	Specific location	Recommended Criteria
Public Footpaths and Access ways	Along the footpaths on Pacific Hwy, Church Lane and West Street (Figure 9)	Walking
Building Entrance	Various locations at ground level	Standing
Communal Terrace Areas	Tower Rooftop	Walking (see discussion below)

2.6.1 APARTMENT BALCONY AND ROOFTOP AREAS RECOMMENDED CRITERION DISCUSSION

Vipac recommends as a minimum that apartment balcony/rooftop terrace areas meet the criterion for walking since:

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

However, it should be noted that meeting the walking criterion on elevated recreation areas will be no guarantee that occupants will find wind conditions in these areas acceptable at all times.

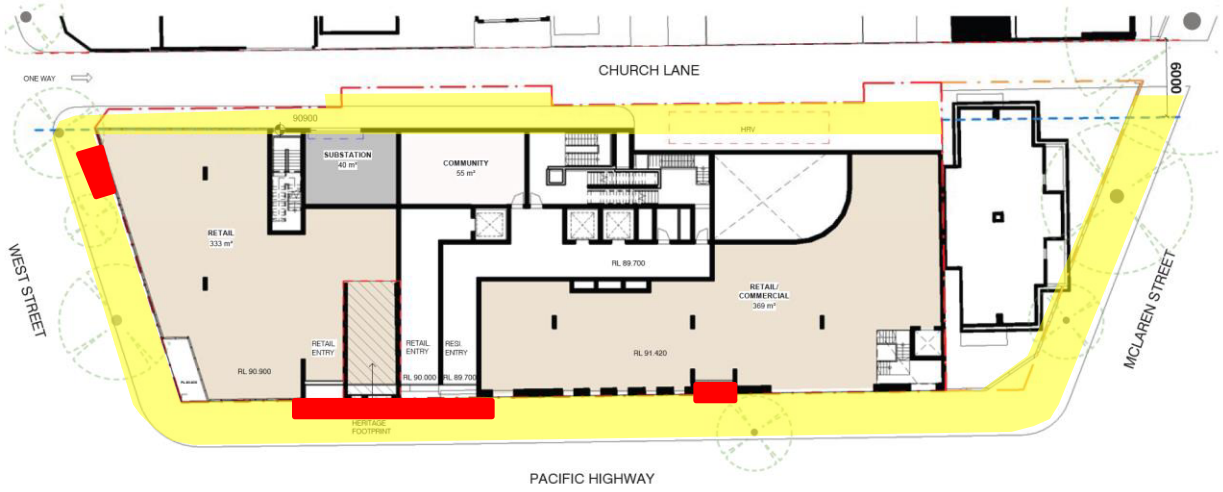


Figure 9: Ground floor plan of the proposed development with the recommended wind criteria overlaid.

3 PEDESTRIAN LEVEL WIND EFFECTS

3.1 DISCUSSION

Ground Floor

Wind conditions at the footpath areas along Church Lane and West Street are expected be within the criterion for walking comfort. However, along Pacific Hwy, corner acceleration of southerly and northerly winds would be expected to result in elevated wind levels on the footpaths near the tower corners. Recommendations have been made in this regard in the following section.

Downwash of westerly winds and flow channelling along Pacific Hwy is expected to result in high wind levels along this frontage. The main building and retail entrances have incorporated a setback design within the envelope of the building which will create a calm wind environment in these areas. Additionally, an awning has been incorporated along Pacific Hwy and West Street that will assist in shielding the entrances along these frontages.

Communal Terraces

The communal terrace on the tower rooftop is above any shielding influence of the surrounding buildings and is expected to have wind levels exceeding the recommended walking comfort criteria. We recommend increasing the balustrade height to ≥ 1.8 m to shield this area from wind from all directions.

Additionally, landscaping can be incorporated to help shield these areas from westerly, southerly and north-easterly winds.

Balconies General

Whilst wind conditions on the balconies of the proposed development will frequently be acceptable for outdoor recreation, during moderate to strong winds, conditions in these areas may exceed human comfort criteria. Balcony areas on similar developments in many major Australian capital cities typically experience similar elevated wind conditions. High exposure, corner acceleration flows and standing vortices would sometimes preclude these areas from use for outdoor recreation. The incorporation of wintergarden designs for the balconies would achieve improved wind environment for these areas.

3.2 RECOMMENDATIONS

After careful consideration of the areas at the base of the proposed development, Vipac predicts that the proposed development will present some changes to existing wind conditions in adjacent ground level areas. It is expected that with the proposed massing, wind levels may exceed the walking comfort criterion on Pacific Hwy. We recommend curving the SW and NW corners of the 18 storey tower to supress vortex shedding and reduce these corner acceleration effects as detailed in Figure 10.

The rooftop communal terrace is expected to have wind levels exceeding the walking comfort criterion. We recommend increasing the balustrade height to ≥ 1.8 m to shield this area from adverse winds as detailed in Figure 11.

As a general statement, common to all developments of this height, educating occupants about wind conditions at high-level terraces/balconies during high-wind events and tying down lightweight furniture are highly recommended.

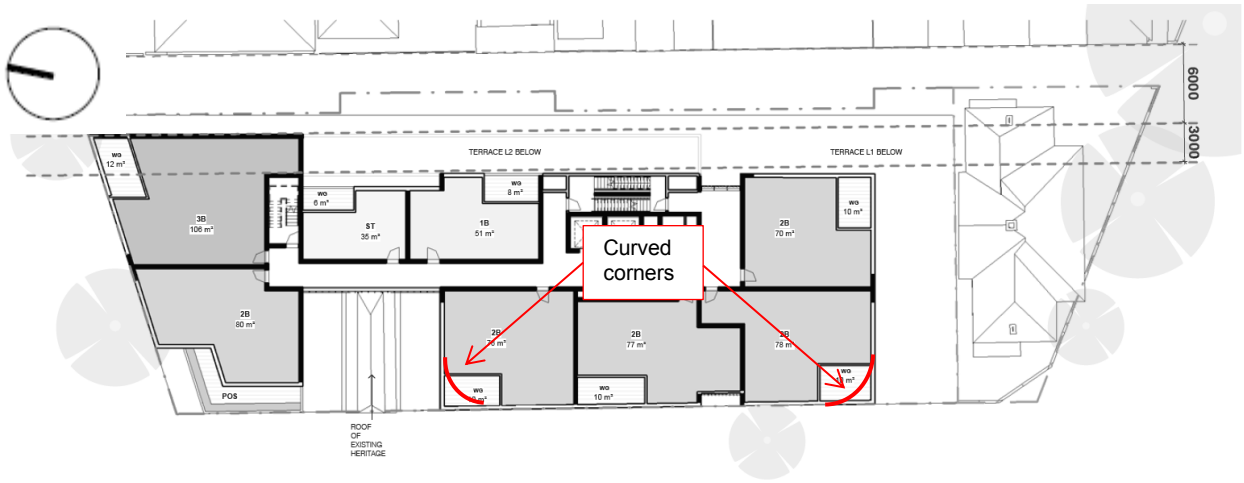


Figure 10: Recommended wind control measure for the ground level

Figure 11: Recommended wind control treatment for the communal rooftop terrace

4 CONCLUSIONS

An assessment of the likely wind conditions at pedestrian level of the proposed development at 253-267 Pacific Hwy, North Sydney has been made.

Vipac has carefully considered the form and exposure of the proposed development, nominated criteria for various public areas according to their function and referred to past experience to produce our opinion of likely wind conditions. Based on this assessment, the following conclusions are drawn:

With the proposed design:

- The adjacent footpaths would be expected to have wind levels exceeding the walking comfort criterion. We recommend curving the tower corners to suppress vortex shedding.
- The wind conditions at the building entrances are expected to be within the recommended standing comfort criterion, considering the proposed awning along Pacific Hwy and West Street, and the setback designs for main lobby entrances.
- The tower rooftop communal terrace is expected to have wind levels exceeding the recommended walking comfort criterion. We recommend increasing the balustrade to ≥ 1.8 m to shield this area from adverse wind conditions.

As a general statement, educating occupants about wind conditions at open terrace/balcony areas during high-wind events and fixing loose, lightweight furniture on the terrace 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 experimental validation may not account for all complex flow scenarios in the vicinity. Vipac recommends a scaled model wind tunnel test to verify the predictions and determine the optimal wind control strategies.

This Report Has Been Prepared

For

LegPro 45 Pty Ltd

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

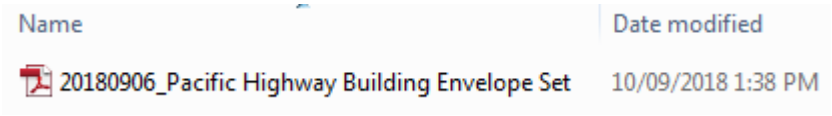
[1] *Structural Design Actions, Part 2: Wind Actions*, Australian/New Zealand Standard 1170.2:2011

[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

Appendix C: DRAWING LIST

Received September 2018:



Received August 2018:

Name	Drawing No.	Date
OPTION 3 SUMMARY	PP-00-9002	16/05/2018
EAST MASSIN ELEVATION 1	O3-00-2005	16/05/2018
STREET VIEW 3	O3-35-0006	16/05/2018
AERIAL VIEWS	O3-35-0007	16/05/2018