FINAL REPORT

614-632 HIGH STREET

PENRITH, NSW

WIND ENVIRONMENT DESKTOP ASSESSMENT

PROJECT # 1904013
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SUBMITTED TO

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1. INTRODUCTION

RWDI Australia Pty Ltd (RWDI) was retained to assess the pedestrian wind environment for the proposed development located at 614-632 High Street in Penrith, NSW (Image 1). This qualitative assessment is based on the following:

- A review of regional long-term meteorological data;
- Amended Architectural and Landscape drawings received by RWDI in May 2022;
- Wind-tunnel tests undertaken by RWDI in the region;
- Our engineering judgement and knowledge of wind flows around buildings[1-3]; and,
- Use of proprietary software developed by RWDI (Windestimator[2]) for estimating the potential wind conditions around generalised building forms.

This approach provides a screening-level estimation of potential wind conditions on and around the development. Conceptual wind control measures to improve the wind comfort are also discussed in the report, where necessary.

Note that other wind issues, such as those related to cladding and structural wind loads, air quality, door operability, etc., are not considered in the scope of this assessment.

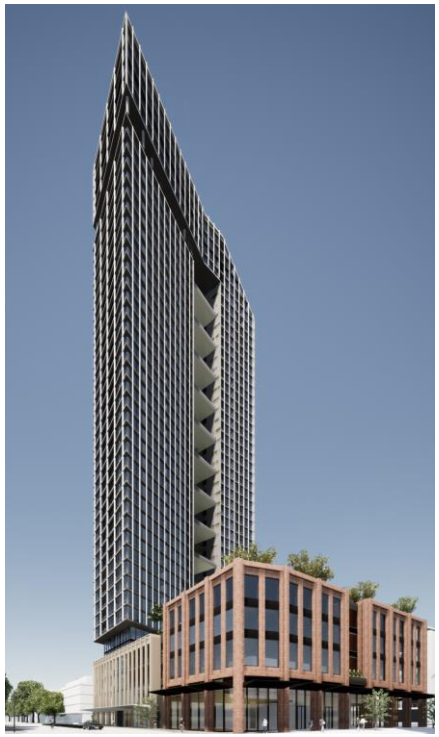


Image 1: Concept Rendering

1. H. Wu and F. Kriksic (2012). "Designing for Pedestrian Comfort in Response to Local Climate", *Journal of Wind Engineering and Industrial Aerodynamics*, vol.104-106, pp.397-407.
2. H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004), "Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions", *ASCE Structure Congress 2004,* Nashville, Tennessee.
3. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), "Experience with Remedial Solutions to Control Pedestrian Wind Problems", *10th International Conference on Wind Engineering*, Copenhagen, Denmark.

2. BUILDING AND SITE INFORMATION

The proposed development consists of a mixed-use building bound by the High Street to the north and Union Lane to the south in Penrith, NSW (Image 2). The site is currently vacant and is surrounded by a mix of low and mid-rise residential and commercial buildings in most directions.

The proposed development consists of ground floor retail and commercial space, with carpark areas located in the podium. A single residential tower is proposed above the podium as part of the design and is located towards the eastern end of the site, with a total height of 44 storeys above ground level. The proposed pedestrian laneway to the east of the site connects Union Lane to High Street with entrance to residential and lift lobby also provided within this laneway.

The key outdoor areas of interest for this assessment include the pedestrian footpaths and other publicly accessible areas as well as the communal amenities within and around the development site. Commentary has been provided based on indicative and assumed usage of the spaces. Conceptual wind control measures are also discussed where deemed necessary.

Image 2: View of Existing Site and Surrounding
(Image Source: Nearmap)

3. METEOROLOGICAL DATA

The site is located approximately 3 km from the nearby Penrith Lakes Weather Station. However, it is noted that the period of high-quality wind data available only after 2010 which is typically less than that required to establish long-term climate statistics. Therefore, wind data from the Richmond RAAF Base (18 km to the north-northeast), the closest station with a sufficiently long period of record, was also consulted. Prevailing winds at this location are, however, heavily influenced by the mountains to its north, east and west.

The distributions of wind frequency and directionality for the summer (Nov-Apr) and winter (May-Oct) seasons at these two stations are shown in Image 3. At Richmond, winds from the southwest and northeast are common all year with the southeasterly winds being more frequent in the summer and the westerlies in winters. The limited data at Penrith Lakes confirms the predominance of the south-southwesterly sector winds and shows similar seasonal variance to northwesterly winds. Winds from the east appear to be less common, likely due to the topographic variance between the two sites.

Based on the available data, south-southwesterly winds which align with the proposed tower form are expected to be one of the main drivers of wind conditions on site. The current analysis method has accounted for this and all other predominant wind directions.

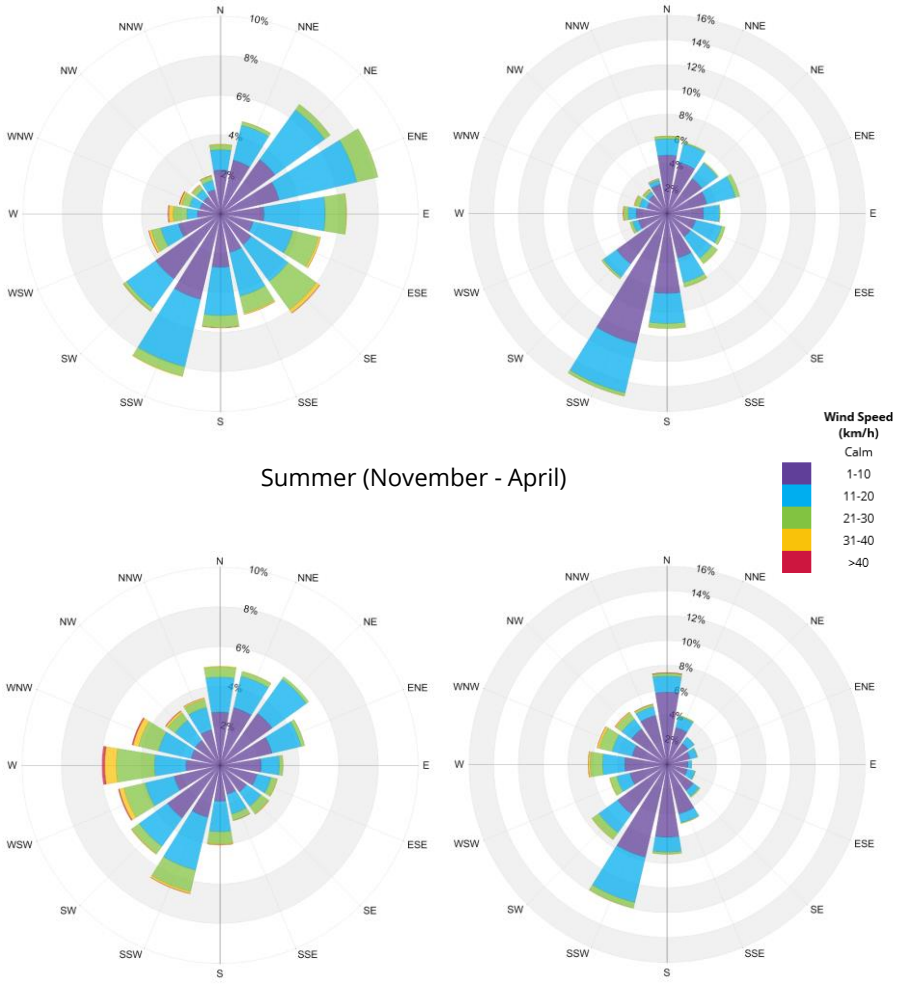


Image 3: Directional Distribution of Winds

4. PEDESTRIAN WIND CRITERIA

RWDI comfort pedestrian wind criteria and the Australasian Wind Engineering Society (AWES)-recommended safety criteria are consulted for this study. The RWDI criteria has been developed by through research and consulting practice since 1974. They have also been widely accepted by municipal authorities and by the building design and city planning community.

4.1 Pedestrian Safety

Pedestrian safety is associated with excessive gust wind speeds that can adversely affect a pedestrian's balance and footing. If strong winds that can affect a person's balance (**83 km/h**) occur more than 0.1% of the time or 9 hours per year, the wind conditions are considered severe.

4.2 Pedestrian Comfort

Wind comfort levels are categorised by typical pedestrian activities:

- **Sitting (≤ 10 km/h)**: Calm or light breezes desired for outdoor seating areas where one can read a paper without having it blown away.
- **Standing (≤ 14 km/h)**: Gentle breezes suitable for main building entrances and bus stops.
- **Strolling (≤ 17 km/h)**: Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park.
- **Walking (≤ 20 km/h)**: Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.
- **Uncomfortable**: None of the comfort categories are met.

Wind conditions are considered suitable for sitting, standing, strolling or walking if the associated wind speeds are expected for at least four out of five days (80% of the time). Wind control measures are typically required at locations where winds are rated as uncomfortable or they exceed the wind safety criterion.

These criteria for wind forces represent average wind tolerance. They are sometimes subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can also affect people's perception of the wind climate.

For the proposed development, wind speeds comfortable for walking or strolling are appropriate for sidewalks and, and lower wind speeds comfortable for standing are required for building entrances where pedestrians may linger. Wind speeds comfortable for sitting are appropriate for podium rooftop terraces, especially during the summer when these areas are used more often.

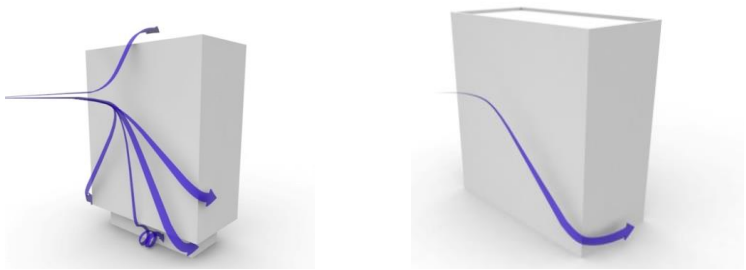
5.1 Background

Predicting wind speeds and occurrence frequencies around a building is a complex process and involves the combined assessment of building geometry, orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Over the years, RWDI has conducted thousands of wind-tunnel model studies and CFD assessments on pedestrian wind conditions around buildings, yielding a broad knowledge base of potential flow behaviour. In some situations, this knowledge and experience, together with literature, allow for a reliable, consistent and efficient desktop estimation of pedestrian wind conditions without wind-tunnel testing.

The proposed tower is significantly taller than the immediate surrounding buildings. Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. Downwashing flow (see Image 4a) is the main cause for increased wind activity at the grade level. Oblique winds also cause wind accelerations around the exposed building corners (see Image 4b). If these building / wind combinations occur for prevailing wind direction, there is a greater likelihood of increased wind activity.

Podium structures under towers are beneficial for wind control, as these reduce the direct impact of any downwashing winds from the towers to the grade level (Image 4c). Stepping the windward façade (4d) is also a positive design strategy that can be used for wind control. However, increased wind activity will be created on any planned podium terraces.

Given the local wind climate and integration of the podium for the proposed development, it is our opinion that the wind safety criterion will be met at all areas on and around the buildings. Detailed discussions on the potential wind comfort conditions at key pedestrian areas are provided in the following sections.



a) Downwashing Flow

b) Corner Acceleration

c) Large Podium

d) Stepped Facade

Image 4: General Wind Flow Patterns

5.2 Existing Site Conditions

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The site is currently vacant and surrounded by low- to mid-rise buildings in most directions (Image 2). As a result, appropriate wind conditions are anticipated on and around the existing site, including public sidewalks, laneways and building entrances. These are expected to meet the wind comfort and safety criteria throughout the year. The current exposure of the site leads to some direct exposure of the prevailing winds in the region.

5.3 Proposed Site Conditions

The proposed development includes several positive design features with consideration for the prevailing winds. The site currently has mid-rise apartment buildings located on the southern side of Union Lane, with generally low-rise built forms in the remaining directions. However, it is noted that adjacent approved Penway Place developments will provide further shielding to the various laneways and podium-level amenities from the prevailing south to south-westerly winds.

The proposed tower form is also strategically located to the east side of the site with a large podium covering the majority of the western aspect. This will assist in reducing the direct impact of downwashing westerly winter winds on the ground level areas (Image 5). The alignment of the podium height with the surrounding existing and proposed built forms will also minimise the potential effect of downwash from the podium component.

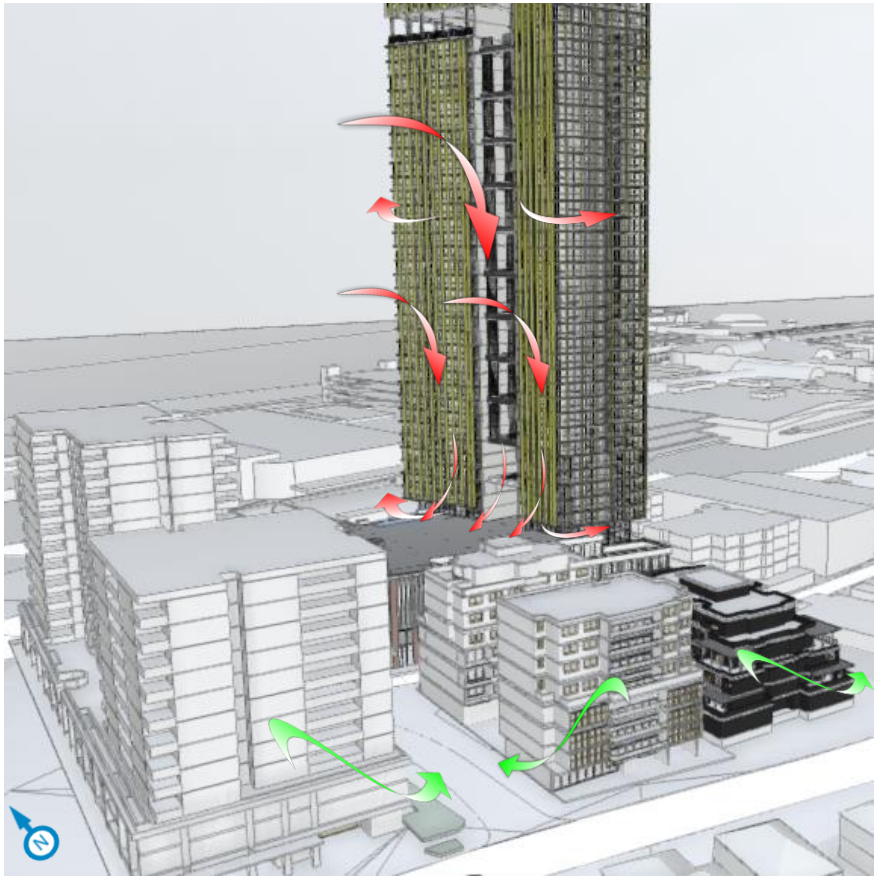

Image 5: Podium/Tower Setback for Wind Control and Shelter to the Podium and Street Fronts due to Neighbouring Buildings

5.3 Proposed Site Conditions (Continued)

Sidewalks

The sidewalks around the perimeter of the site benefit from the shielding from the surrounding built forms, as well as the proposed design of the development. As noted earlier, the tower is situated at the eastern side of the site with a north-south alignment. This aligns the tower form with the local wind climate with benign winds from the easterly sector, while the narrow aspect to the north-south direction will minimise downwash potential from the prevailing winds. Furthermore, the large podium area will help to break-up the prevailing winds and capture any downwashed westerly winds (indicated in Image 5).

The podium also includes carpark areas, which extend to the perimeter of the podium. The inclusion of a porous façade design to these carpark levels will enable winds to pass through these floors, minimising the potential of downwash from the podium section of the development. Furthermore, this will aid in the natural ventilation of the carpark areas, reducing the reliance on mechanical ventilation for exhausts. The inclusion of proposed awning structure is also a positive design feature and is likely to considerably improve ground level wind conditions with the proposed street trees along High Street, Eat Street, and the pedestrian laneway further assisting in the grade level winds, especially from a greater masterplan precinct perspective.

Building Entrances

The primary residential entrance is located at the northeastern corner of the development with entrances to the retail and commercial spaces located along the other aspects (Image 6). These are generally shielded from prevailing winds due to neighbouring buildings. Review of the landscape drawings indicates that the proposed tree planting within the pedestrian laneway will assist in buffering any winds that might be redirected up the laneway space. The proposed landscaping along High Street will also provide shielding to the entrances situated here from prevailing north-easterly sector winds.

Image 6: Ground Level Entrances

5.3 Proposed Site Conditions (Continued)

The commercial lobby entrance is located along the western aspect and is expected to be somewhat exposed to the prevailing south to south-westerly winds that can be redirected by the neighbouring buildings to the south of the project site. The porous podium carpark façade and the use of an awning structure will likely aid in reducing the downwashed winds from the podium. However, inclusion of street trees, similar to those noted in the landscape concept will aid in reducing the prevailing winds being directed along this street front.

Level 4 Podium Terrace

The Level 4 podium terrace is designed to be an outdoor communal space that will include areas of active use, social and dining spaces, and pool areas. The area is generally shielded from direct wind exposure due to neighbouring buildings. However, some redirected southerly winds might channel through the space. The proposed landscaping along the southern boundary of the terrace is likely to provide shielding from these winds.

The proposed tower is also expected to downwash and redirect the westerly winds towards the terrace space, as indicated in Image 5. These winter winds can significantly impact the outdoor wind and thermal comfort of the terrace. The inclusion of dense tree planting at the base of the tower will aid in breaking up the prevailing winds. Therefore, additional trees are recommended adjacent to the pool area (Image 7). The trees should be planted in clusters spaced such that the canopies can interact and work together to buffer the expected wind flows.

Image 7: Additional Landscape Recommendations

5.3 Proposed Site Conditions (Continued)

Doorstep Terraces – Western Tower Aspect

Communal open spaces have been incorporated into the tower design via a recess in the tower form in the middle of the western aspect. These doorstep terraces are designed to create outdoor communal spaces at roughly every 3 levels with void space above. The spaces are intended to be used as breakout space for the occupants on the adjacent levels. The inset nature of these terraces will generally protect these spaces from uncomfortable wind conditions. There remains a need for consideration of possible recirculation of the prevailing south-westerly winds in this space given the height and width of the recess. But the proposed inclusion of dense landscaping at the northern and southern ends adjacent to the western façade will aid in breaking up this effect, in conjunction with the landscape trellis up the vertical aspects of these recessed spaces (Image 8).

Private Balconies and Terraces

The development consists of a favourable floor plan with most private balconies inset within the tower form achieving wind comfort throughout the year. The corner balconies, particularly those located at the southwest corner of Levels 4-9, are exposed to the regional winds that can accelerate around these spaces. Provisions for impermeable balustrades and screening along one of the corners for the corner balconies is recommended to mitigate potentially unfavourable wind conditions.

Image 8: Proposed Landscape Trellis Concept and Location along the Western Aspect Communal Spaces

5.3 Proposed Site Conditions (Continued)

Level 38 Sky Garden

The Sky Garden on Level 38 of the proposed tower is located towards the northern side of building with a double height void above and 2m high balustrades on the eastern and western perimeters. The space is generally exposed to high wind speeds due to the elevated nature of the terrace with the prevailing regional winds likely to funnel through the space. The landscape drawings indicate the use of landscaped trellis features along the eastern and western aspects of the terrace (Image 9). Interspersed vegetation has also been incorporated in the terrace design and is beneficial in further diffusing any winds infiltrating the space. It is to be noted that the perimeter landscaped trellis should maintain a porosity of 50% to be effective in mitigation high winds.

Private Balconies Levels 40-43

The private terraces located along the southern aspect of Levels 40-43 are generally exposed to high wind speeds due to the elevated nature of these spaces. Furthermore, the southwesterly and northeasterly sector winds prevalent in the region can accelerate around the corners of these space, potentially leading to high localised wind activity. Therefore, it is recommended to retain the corner screening and inter-apartment partition screens to reduce the movement of wind within these spaces.

Image 9: Concept Rendering Indicating the Perimeter Landscaped Trellis and Dense Vegetation that will enhance Wind Comfort

6. SUMMARY

Wind conditions on and around the proposed development located at 614-632 High Street in Penrith NSW are discussed in this report. This qualitative assessment is based on the review of local wind climate and the current design of the proposed development. The impact of the surrounding buildings and local land topography has also been considered. The assessment is based on our experience with wind tunnel testing and CFD analysis of similar buildings within the region.

The proposed development includes several positive design features such as the location and layout of the tower form to account for the prevailing winds, articulated tower design, inset balconies and terraces, landscaping elements throughout and over the site, and an extensive awning structure wrapping around the development. The site also benefits from shielding of the prevailing winds at the lower levels from the existing built forms as well as the approved nearby developments to the south and west of the subject site. As a result, suitable wind conditions are expected in areas immediately around the main building entrances, all sidewalks and within the various balconies and terraces.

Wind control measures and recommendations have also been discussed in the report and are expected to improve the comfort of spaces within and around the development site. Design advice has also been provided to ensure comfortable wind amenity is achieved for private balconies and terraces.

Note that this qualitative approach provides a screening-level estimation of potential wind conditions around the site and offers conceptual wind control measures and design advice suitable for early design of developments. The conceptual wind control measures can be further refined through quantitative testing and modelling. Suitable conditions of consent can be added to any approval to ensure such refinement occurs within the CC phase of the development.

7. APPLICABILITY OF RESULTS

The assessment discussed in this report pertain to the proposed development in accordance with the drawings received in May 2022. In the event of any significant changes to the design, construction or operation of the building or addition of surroundings in the future, RWDI could provide an assessment of their impact wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.

Statement of Limitations

This report entitled Pedestrian Wind Assessment, dated June 03, 2022 was prepared by RWDI Australia Pty Ltd ("RWDI"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared. Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.