FINAL REPORT

614-632 HIGH STREET

PENRITH, NSW

WIND ENVIRONMENT DESKTOP ASSESSMENT

RWDI PROJECT #1904013
NOVEMBER 20, 2019

SUBMITTED TO

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1. INTRODUCTION

RWDI Anemos Ltd. (RWDI) was retained by Urban Apartments to assess the pedestrian wind environment for the proposed development 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;
- Architectural and Landscape drawings received by RWDI on November 18, 2019;
- Wind-tunnel tests undertaken by RWDI in the surrounding areas;
- Our engineering judgement and knowledge of wind flows around buildings[1-3]; and,
- Use of 3D software developed by RWDI (Windestimator[2]) for estimating the potential wind conditions around generalized building forms.

This approach provides a screening-level estimation of potential wind conditions on and around the development. Conceptual wind control measures to improve wind comfort are recommended, where necessary. In order to quantify these conditions or refine any conceptual mitigation measures, physical scale-model tests in a boundary-layer wind tunnel will be undertaken. 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 will consist of a mixed-use building situated on the south side of High Street centrally between John Tipping Grove and Worth Street in Penrith (Image 2a and 2b). The site is currently empty, and surrounded a mix of low and mid-rise buildings in most directions.

The development will include ground floor retail and commercial space, with 3 levels of carpark areas located in the podium. A single residential tower is proposed as part of the design in the north-south direction, along the eastern aspect of the site, 44 storeys above ground. (Image 2b).

Key pedestrian areas on and around the proposed development include residential, office, and retail entrances at grade, public sidewalks, and the landscaped roof of the podium (Images 3a and 3b).

Image 2a: View of Existing Site and Surrounding (Photo Courtesy of Google Earth)

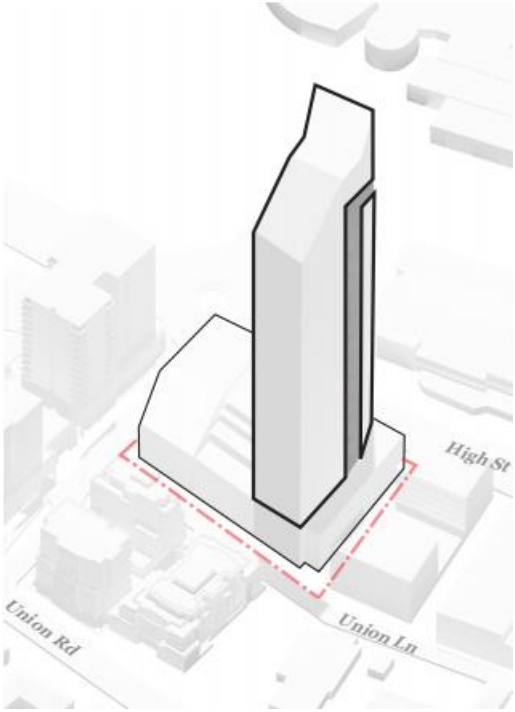


Image 2b: View of Proposed Development and Surroundings

2. BUILDING AND SITE INFORMATION

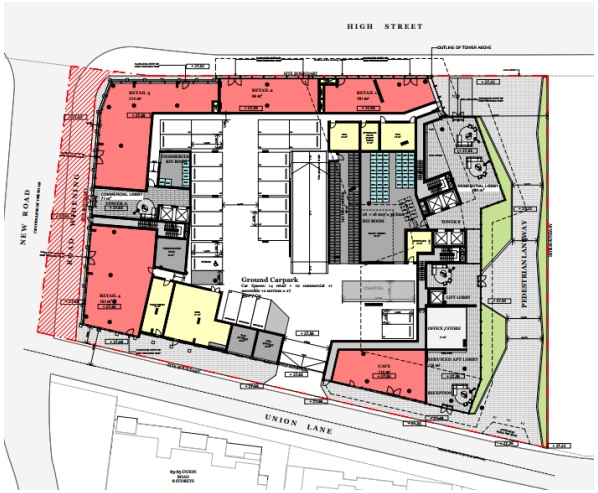


Image 3a: Ground Floor Plan

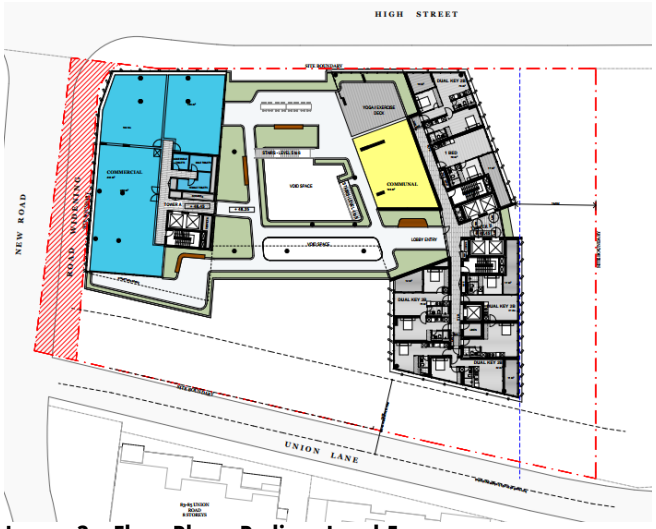


Image 3c: Floor Plan - Podium Level 5

Image 3b: Floor Plan – Podium Level 4

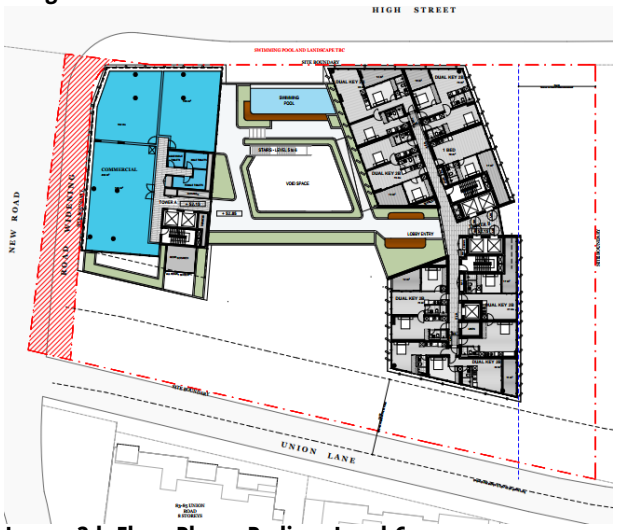


Image 3d: Floor Plan – Podium Level 6

3. METEOROLOGICAL DATA

The site is located approximately 3 km from the nearby Penrith Lakes Weather Station. However it is noted that it has a shorter period of high quality data available at this station (since 2010), less than typically referenced to establish long-term climate statistics. As such, data at 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 however are heavily influenced by the mountains to its north, east and west.

The distributions of wind frequency and directionality for the summer (November through April) and winter (May through October) seasons at these two stations are shown in Image 4. At Richmond, winds from the southwest and northeast are common all year, and southeasterly winds also frequent in the summer. The limited data at Penrith Lakes confirms the predominance of south-southwesterly 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 mentioned above.

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 these and all other wind directions.

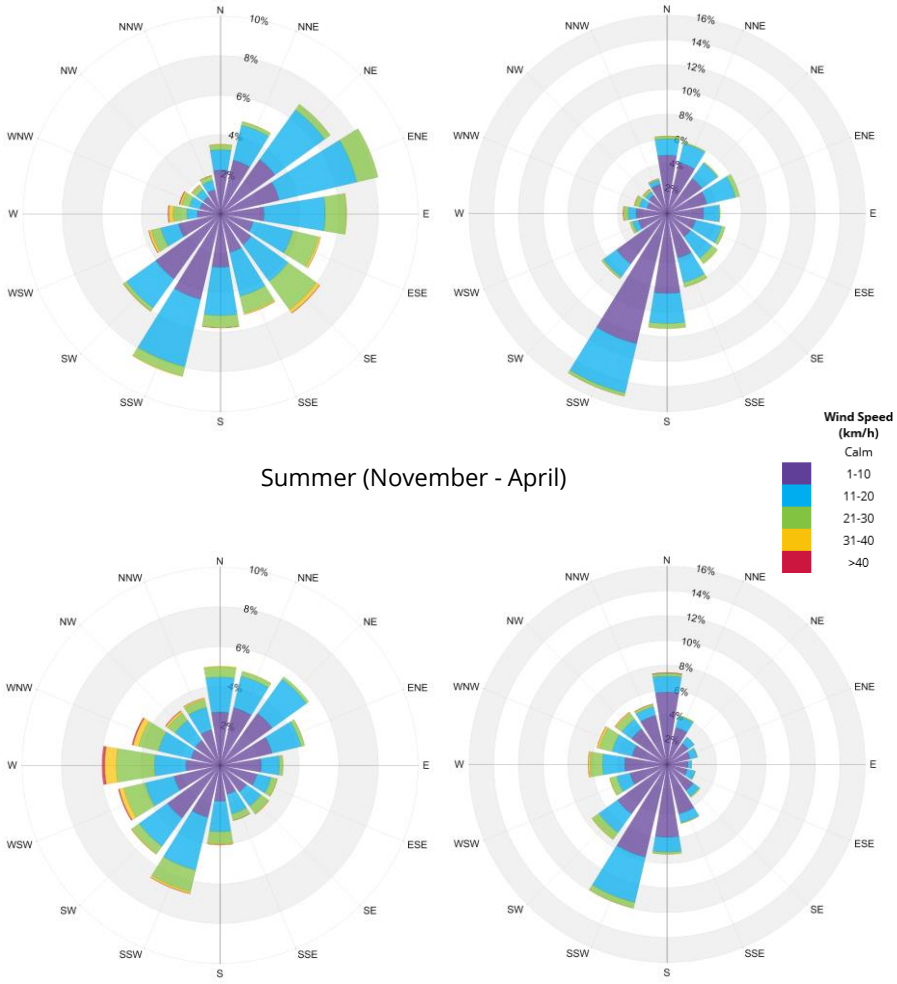


Image 4: Directional Distribution of Winds

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 categorized 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. PEDESTRIAN WIND CONDITIONS

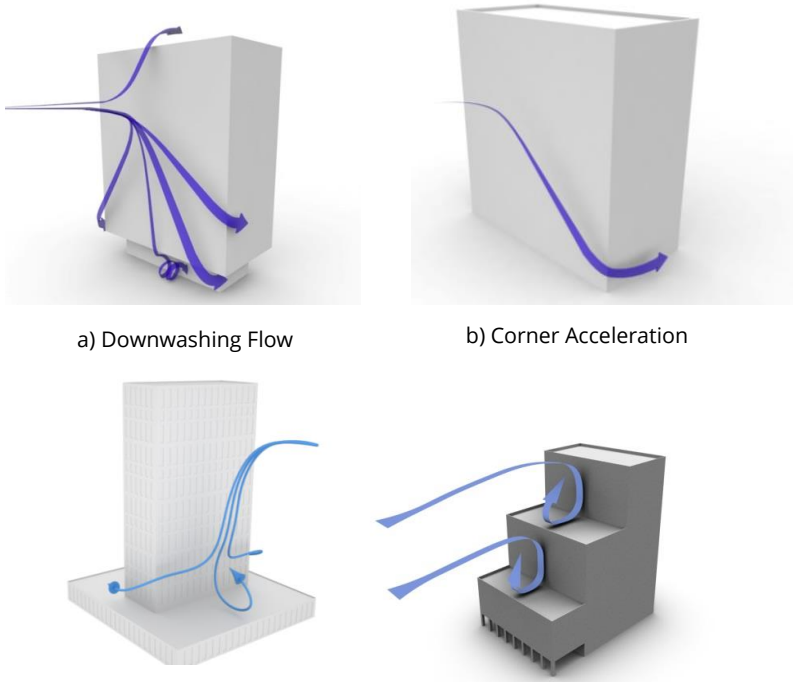
5.1 Background

Predicting wind speeds and occurrence frequencies is complicated. It involves 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 regarding pedestrian wind conditions around buildings, yielding a broad knowledge base. This knowledge has been incorporated into RWDI's proprietary software that allows, in many situations, for a qualitative, screening-level numerical estimation of pedestrian wind conditions without wind tunnel testing.

The proposed tower form 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 5a) 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 5b). If these building/wind combinations occur for prevailing winds, there is a greater potential for increased wind activity.

Podium structures under towers are beneficial for wind control, as they reduce the direct impact of any downwashing winds from the towers to the grade (Image 5c). Stepping the windward façade (5d) is also a positive design strategy that can be used for wind control. However, increased wind activity will be created on the podium terraces.

Given the local wind climate and integration of the stepped podium of 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 5: General Wind Flow Patterns

5.2 Existing Wind Conditions

The site is currently empty 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. They 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 Future Wind 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 development will provide further shielding from the prevailing south to south-westerly winds. The proposed tower form has been placed on the eastern side of the site, with a large articulated podium covering the majority of the western aspect. This will assist in reducing the direct impact of downwashing winds on the ground level areas (Image 6). The alignment of the podium height with the surrounding existing and proposed built forms will also minimize the potential effect of downwash from the podium component.

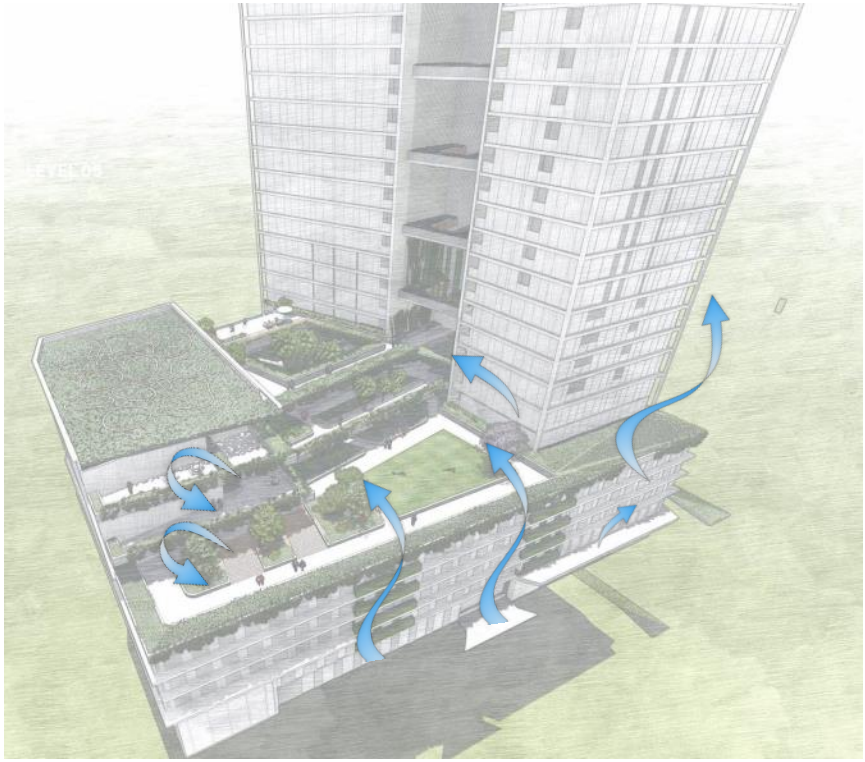


Image 6: Podium/Tower Setback for Wind Control

5.3 Future Wind 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.

The tower form of the development has been positioned at the eastern side of the site with a north-south alignment. As noted in Section 3, this aligns with the local wind climate with benign winds from the easterly sector, while the narrow aspect to the north-south direction will minimize downwash potential. Furthermore, the large podium area, which is articulated and stepped in design will help to break-up the prevailing winds and also capture any downwashed winds from the western sector.

The podium design also notes carpark areas on Levels 1 to 3, 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, minimizing the downwash potential 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 street trees around the perimeter of the site will also further assist in the ground plan winds, especially from a greater masterplan precinct perspective.

Building Entrances

The main entrances are generally located along the northern and western aspects for retail, and eastern and western for commercial and residential lobbies.

The retail tenancies along the northern aspect includes recessed areas for the entrance locations, which will provide additional shielding for patrons. Consideration for single aspect openings for the corner retail tenancies to have openings located away from corners to benefit the internal wind conditions.

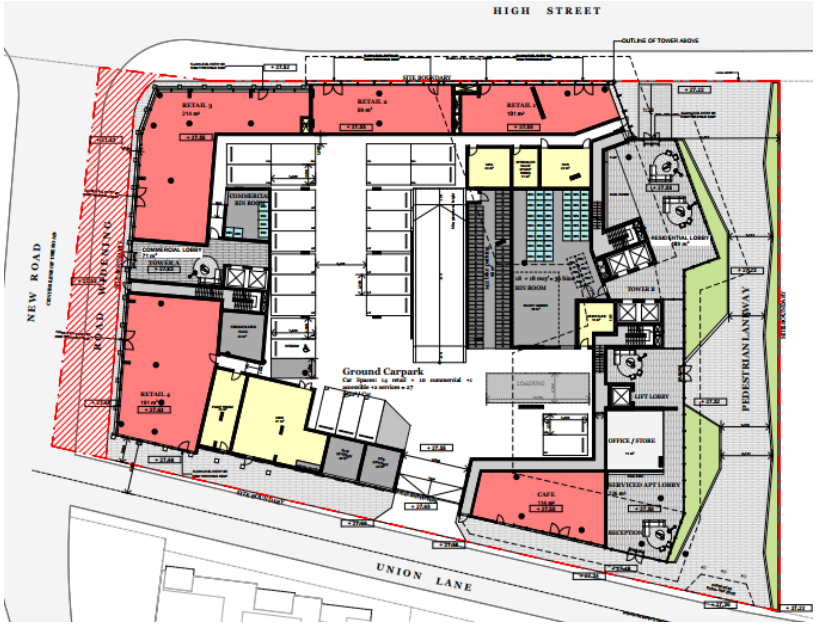


Image 6: Ground Level Entrances

5.3 Future Wind Conditions (Continued)

The residential lobby entrance is located along the eastern aspect of the podium, which will be less exposed to the prevailing winds. The inclusion of tree planning within the shared laneway will further improve conditions and mitigate any of the prevailing winds which may be directed up this laneway space. 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. The porous podium carpark façade will aid in reducing the downwashed winds from the podium, however inclusion of street trees, similar to that noted in the landscape concept will aid in reducing the prevailing winds being directed along this street front.

Outdoor Podium Areas – Levels 4, 5 and 6

A series of stepped and overlapping outdoor terrace spaces are proposed for the podium rooftop areas of the development, predominantly on the western side of the site. This will include areas of active use, social and dining space, food and growing spaces. Level 7 will consist purely of a green roof, but will not accessible to occupants.

Level 4

Outdoor areas are generally proposed in the central area which will; be largely covered by Level 5, while a small communal deck is proposed on the eastern aspect. The inclusion of dense tree planting around the perimeter of the floor will aid in breaking up the prevailing winds. These should be planted in clusters spaced such that the canopies can interact and work together to buffer the expected winds. Consideration for dense hedge planting or porous screening is recommended along the southern aspect of the central space. This will be important to breakup the direct southerly winds which may otherwise funnel through this open floor. Likewise, the inclusion of landscaped zones throughout the floor and along the northern aspect will help buffer the flow potential through this space (Image 7c).

Level 5

The Level 5 space will be largely covered by the floor above, with openings generally to the north and south, as well as the central void. The inclusion of dense hedge planting and vertical landscape elements (Image 7a) on the southern aspect will aid in breaking-up the prevailing winds. Furthermore, the location of longer duration activities including the dining space on the northern aspect corresponds to less significant wind directions.

Level 6

The top level of the podium can be expected to be exposed to the prevailing winds, as well as potential downwashed winds from the tower component of the development. The positioning of the social space to the west, away from areas potentially exposed to downwashed winds is beneficial, as is using the areas primarily for garden spaces instead of long duration stays, in-line with the expected conditions. Clusters of tree planting and dense hedges throughout will encourage the winds to move over this space and improve the wind comfort conditions for occupants (Image 7b).

5.3 Future Wind Conditions (Continued)

Communal Open Spaces – 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. This will create outdoor communal spaces at roughly every 3 levels with void space above. These spaces are intended to be used as breakdown spaces for the occupants on the adjacent levels.

Consideration will need to be made for the recirculation of the prevailing south-westerly winds in this space given the height and width of the recess. The proposed inclusion of dense landscaping at the northern and southern corners 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 7a: Proposed Landscape Trellis

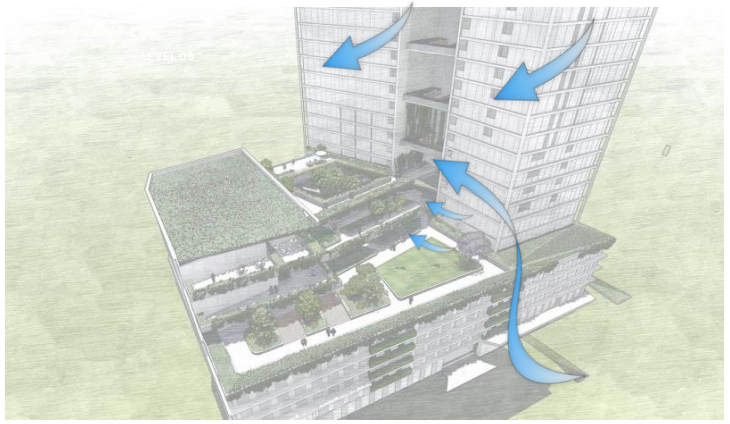


Image 7b: Section View of Podium Terrace Areas

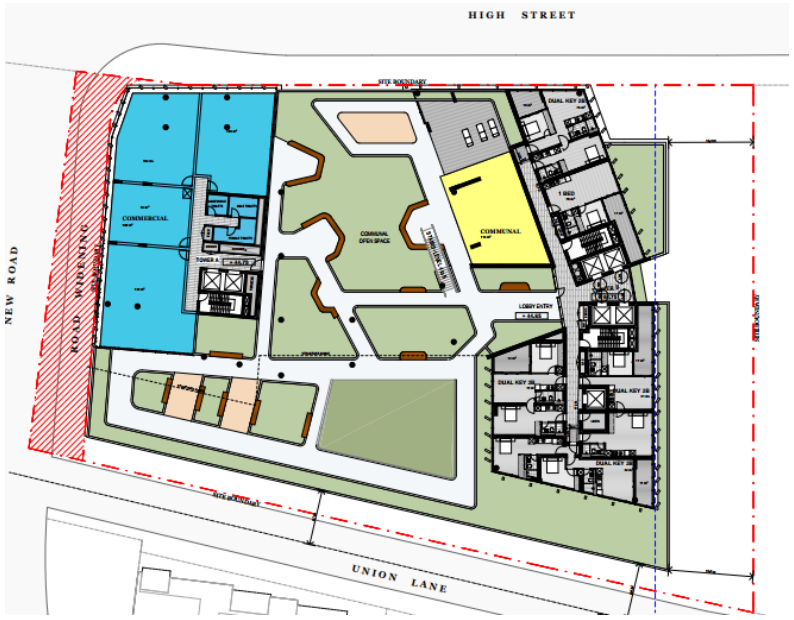


Image 7c: Level 4 Landscape Areas

5. PEDESTRIAN WIND CONDITIONS

Image 7: Examples of Planters/Screens for Exposed Entrances, Additional Landscaping for Through-site Link and Tall Guardrails and Partitions for Daycare Terrace

6. SUMMARY

Wind conditions on and around the proposed development at 614-632 High Street in Penrith, NSW are discussed in this report. Our qualitative assessment was based on the local wind climate, the current design of the proposed development, existing surrounding buildings and our experience with wind tunnel testing of similar buildings.

The proposed development includes several positive design features such as the location and layout of the tower form to account for the prevailing winds, stepped and articulated form of the podium, inclusion of porous façade to the carpark levels, landscaping throughout and over the site as well as recessed entrances. 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 wester of the site. As a result, suitable wind conditions are expected in areas immediately around the main building entrances, all sidewalks and the landscaped area on the roof of the podium.

These conditions should be assessed and quantified through wind tunnel testing, which can also be used to refine any wind control solutions, if necessary.

7. APPLICABILITY OF RESULTS

The assessment presented in this report are for proposed development at 614-632 High Street in Penrith NSW was based on the architectural design drawings and documents received by RWDI on November 18, 2019.

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 on the pedestrian wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.