85-97 WATERLOO ROAD

MACQUARIE PARK, NSW

PEDESTRIAN WIND ASSESSMENT

PROJECT # 2305660

SEPTEMBER 06, 2023

SUBMITTED TO

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DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Initial	07/07/2023	AMC	HK
B	Update for latest design, SEARS and Standard text included	25/08/2023	AMC	HK
C	Added standard text and consultant declaration Reviewed DA Set	06/09/2023	AMC	HK/KP

RWDI

RWDI is a team of highly specialised consulting engineers and scientists working to improve the built environment through three core areas of practice: building performance, climate engineering and environmental engineering. More information is available at www.rwdi.com.

QUALITY ASSURANCE

RWDI Australia Pty Ltd operates a Quality Management System which complies with the requirements of AS/NZS ISO 9001:2015. This management system has been externally certified by SAI Global and Licence No. QEC 13457 has been issued for the following scope: The provision of consultancy services in acoustic engineering, air quality and wind engineering; and the sale, service, support and installation of acoustic monitoring and related systems and technologies.

Certified System
Quality
ISO 9001
SAI GLOBAL

1. INTRODUCTION

This Pedestrian Wind Assessment is submitted to the Department of Planning and Environment (DPE) in support of a State Significant Development Application (SSDA) (SSD-52604208) for a new build-to-rent housing (BTR) development at 85-97 Waterloo Road, Macquarie Park (the site).

The proposed development will specifically comprise the following:

- Site preparation and excavation;
- Construction of a new build-to-rent development comprising six new BTR buildings ranging between 10 to 20 storeys and a new 3 storey amenities building, known as the 'Club House'. Specifically, the following is proposed:
  - 3,491 m^2 of non-residential floor area at ground level, including commercial and retail uses,
  - 59,222 m^2 of build-to-rent housing, including a total of 736 dwellings,
  - 4,142 m^2 of communal residential amenity facilities located throughout the building.
- Provision of a new public park at the centre of the site as well as several through site links to facilitate activation and pedestrian movement throughout the site.
- Shared basement carparking, comprising a total of 671 car parking spaces, 65 bicycle spaces, and 0 motorcycle spaces.
- Vehicular access for residential and retail uses is provided from both Banda Road and Khartoum Road, while loading services can only be accessed via Banda Road.
- Associated landscaping and public domain works; and
- Augmentation of, and connection to, existing utilities as required.

For a detailed project description refer to the Environmental Impact Statement prepared by Ethos Urban.

Relevant SEARs

This Pedestrian Wind Assessment addresses the following relevant Secretary's Environmental Assessment Requirements (SEARs) set out in the Table 1 below.

SEARS	Location in Report
C5 Environment Amenity Assess amenity impacts on the surrounding locality, including lighting impacts, reflectivity, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and **wind impacts**. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated.	Section 6

2. SITE LOCATION AND CONTEXT

The site is located at 85-97 Waterloo Road, Macquarie Park and is within the City of Ryde Local Government Area. The site is legally described as Lot 1 in DP 1259121 and Lot 2 in DP 1249920 and has a total area of approximately 21,730sqm. It is owned by Goodman and currently comprises the Macquarie Corporation Centre.

The site is situated within the Waterloo Park Precinct under the Macquarie Park Place Precinct Strategy. It is located approximately 350m south of the Macquarie University Station and 750m north-west of the Macquarie Park Metro Station. A summary of the surrounding development is provided below:

- North-east: The site is bounded by Banfield Road to the immediate north-east. Generally, the development to the north-east comprises commercial, light industrial and business park uses.
- South-east: The site is bounded by Khartoum Road to the south-east. Beyond that is a range of commercial and light industrial uses for a range of tenants. Further and approximately 750m south-east is the Macquarie Park Metro Station.
- North-west: The site is bounded by Banda Road to the north-west. Immediately across from the site is a high-density residential development. Further north-west is the Macquarie Centre, and Macquarie University Metro Station and Campus (350m).
- South-west: The site is bounded by Waterloo Road to the south-west. Directly adjacent to the road and opposite the site are a range of development uses, including residential, commercial, retail, and light industrial.

Image 1 below provides an aerial context map of the site.

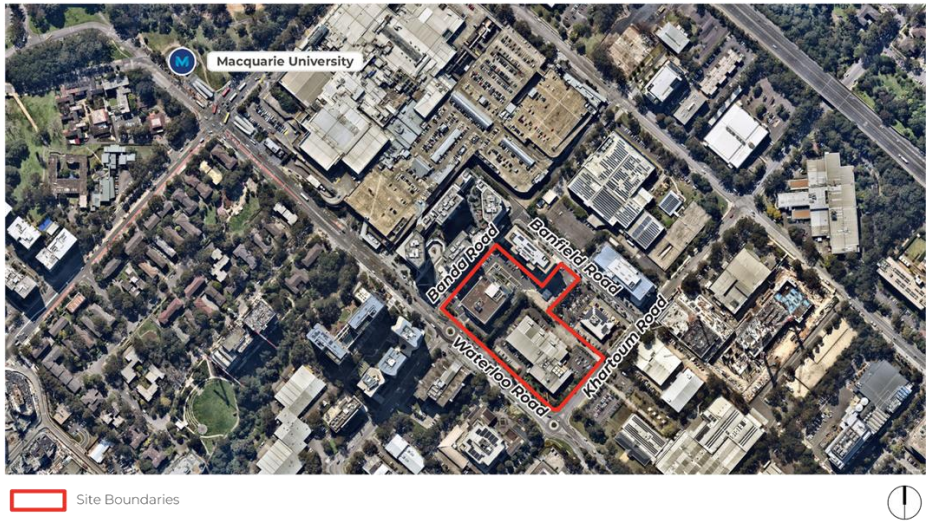


Image 1: Aerial Map of the Site and Surrounding Context

3. METHODOLOGY

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. This knowledge and experience, together with literature, allows for a reliable, consistent and efficient desktop estimation of pedestrian wind conditions without wind-tunnel testing or detailed CFD studies.

This qualitative approach provides a screening-level estimation of potential wind conditions and offers conceptual wind control measures to improve wind comfort, where deemed necessary. In order to quantify and confirm the predicted conditions or to refine any of the suggested conceptual wind control measures, physical scale model tests in a boundary-layer wind tunnel would be required.

RWDI's assessment is based on the following:

- A review of the regional long-term meteorological data;
- Drawings of the development received by RWDI in Aug and September 2023.
- Wind-tunnel studies, CFD simulations, and desktop assessments undertaken by the microclimate team for projects in the region;
- Our engineering judgement, experience, and expert knowledge of wind flows around buildings[1, 2]; and,
- Pedestrian Wind Comfort Criteria as set out in City of Ryde Development Control Plan (2014).

Note that other microclimate issues such as those relating to cladding and structural wind loads, door operability, building air quality, noise, vibration, etc. are not part of the scope of this assessment.

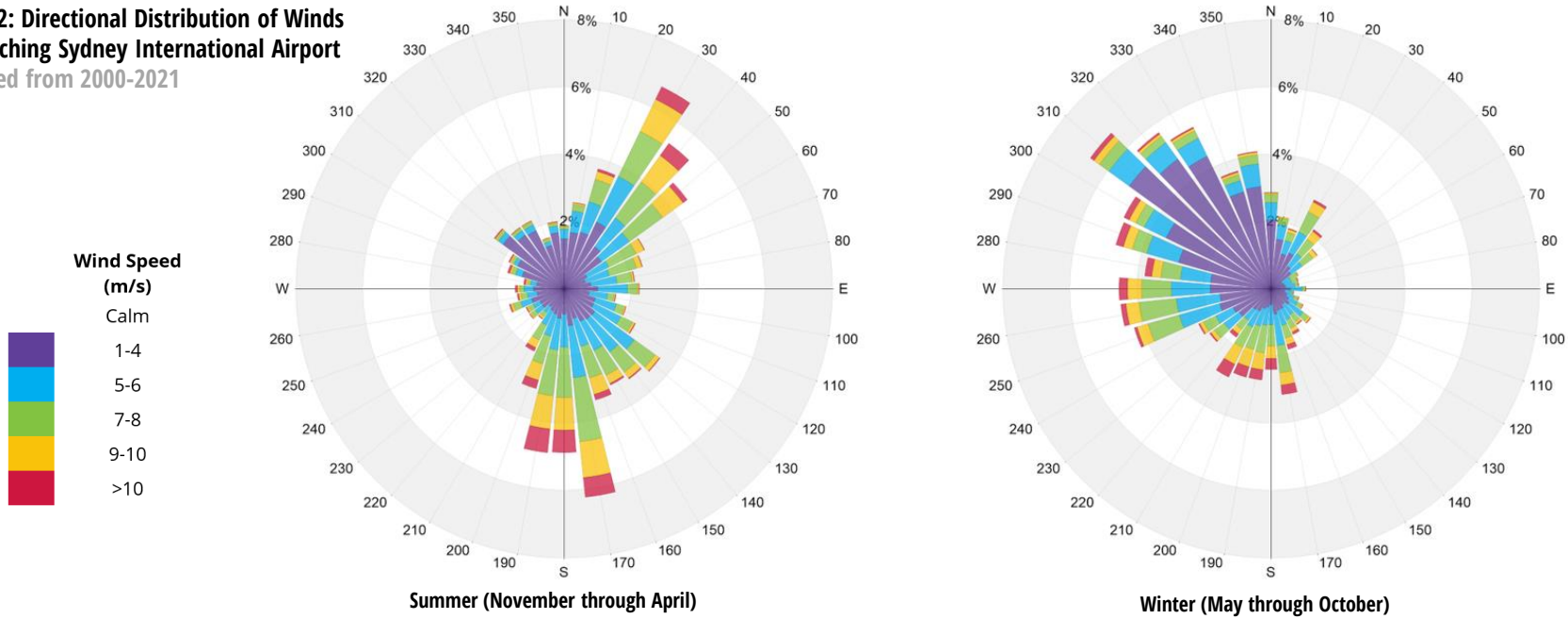
1. H. Wu and F. Kriksic (2012). "Designing for Pedestrian Comfort in Response to Local Climate", Journal of Wind Engineering and Industrial Aerodynamics, vol.104-106, pp.397-407.
2. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), "Experience with Remedial Solutions to Control Pedestrian Wind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

4. METEOROLOGICAL DATA

Meteorological data recorded at Sydney International Airport from 2000 to 2021 were used as a reference for wind conditions in the area. The distributions of wind frequency and directionality for the summer (November through April) and winter (May through October) seasons are shown in Image 2. The records indicate that winds from the northeast and the southern sectors are predominant during the summer season. Wind from the west and northwest directions are predominant in the winter season and can have an impact on the perceived outdoor thermal comfort of a space.

Strong winds of a mean speed greater than 8 m/s measured at the airport (at an anemometer height of 10 m) occur more often in the summers than in the winters. During both seasons, strong winds from the southerly directions are common whereas winds from the northeast during summers and west to northwest during winters are also prevalent. These winds could potentially be the source of uncomfortable / unsafe wind conditions, depending on the site exposure or development design.

Image 2: Directional Distribution of Winds Approaching Sydney International Airport
Recorded from 2000-2021



5. PEDESTRIAN WIND CRITERIA

5.1 Safety Criterion

Pedestrian safety is associated with excessive gusts 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. These are assessed qualitatively in the assessment and are usually coincident with areas of high wind activity as noted in the report.

5.2 Pedestrian Comfort Criteria

The City of Ryde Development Control Plan (2014) sets out standards for compliance to facilitate a comfortable environment for designated pedestrian activities. The standards detail the requirements related to pedestrian wind comfort, with the objective of mitigating adverse wind effects generated by tall buildings. The standard requires that a new building must not cause mean wind speed around it to exceed the category for the intended use of the area, as set out in Image 3.

The criteria are similar to those proposed by Davenport (1972) and are based on Gust Equivalent Mean Wind Speeds which are the most objective measure to assess comfort in built-up environs. The criteria are also equivalent to RWDI Pedestrian Wind Comfort criteria with the categories defined above based on the equivalent RWDI categories.

Note that wind conditions are assessed at a typical pedestrian chest height and are considered suitable for the intended use of the space if the associated mean winds are expected for at least 80% of the time. Furthermore, note that these criteria for wind forces represent average wind tolerance. These are sometimes subjective with regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. also affecting people's perception of the wind climate.

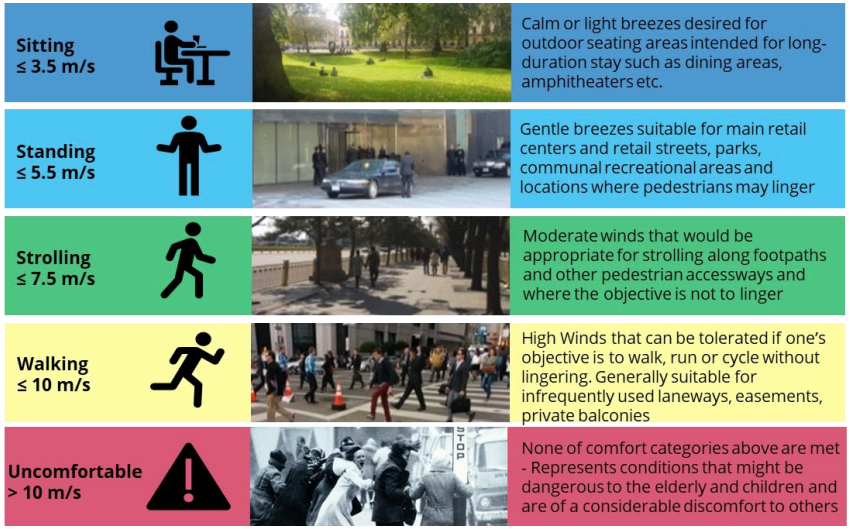


Image 3: Pedestrian Wind Comfort Criteria

6. RESULTS AND DISCUSSION

6.1 General Wind Flow around Buildings

In our discussion of wind conditions on and around the proposed development, reference may be made to the following generalised wind flows (see Image 4). If these building / wind combinations occur for prevailing winds, there is a greater potential for increased wind activity and uncomfortable or potentially unsafe conditions. Design details such as setting back a tower from the edges of a podium for a prevailing wind direction, deep canopies close to ground level, wind screens / tall trees with dense landscaping, etc. can help reduce high wind activity. The choice and effectiveness of these measures would depend on the exposure and orientation of the site with respect to the prevailing wind directions and the size and massing of the proposed buildings.

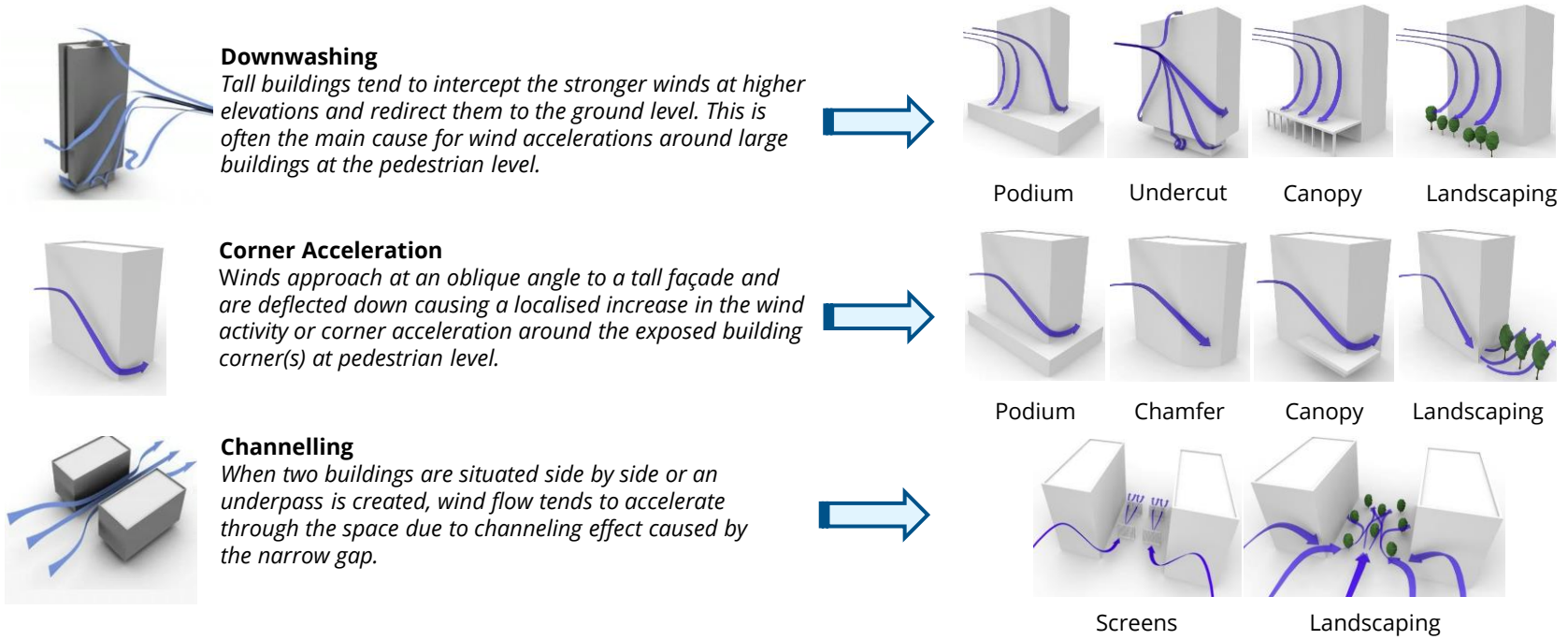


Image 4: General Wind Flow around Buildings with Examples of Common Wind Measures

6.2 Site Exposure and Existing Site Conditions

The existing site is currently occupied by low-rise commercial buildings that are not likely to have a significant impact on the overall wind environment of the area. The primary driver of the local wind microclimate are, therefore, the surrounding mid- to high-rise buildings of the precinct. The exposure of the site to the regional prevailing winds is indicated in Image 5. Following key observations can be made regarding the existing site conditions based on current exposure to the regional winds:

- The high-rise Prime Macquarie Park and Park One Apartment buildings significantly reduce the overall exposure to winter winds. However, it is important to consider potential channelling effects between these tower blocks which can particularly affect the Banda/Waterloo corner. Conditions here can range from active use to uncomfortable. Additionally, wind conditions can be influenced by the unique topography along Waterloo Road especially due to the steep change in elevation towards Khartoum Road. These winds can have an impact on the wind amenity at the corner of Khartoum Road and Waterloo Road with conditions likely to be suitable for active use here during winters.
- The staggered arrangement of the mid-rise existing buildings in the southern direction acts as a buffer and is likely to reduce the impact of winds from the south. As a result, the overall influence of these winds on ground level areas surrounding the existing site will be significantly reduced.
- The presence of Macquarie Corporate Centre (MCC) and the mid-rise 8 Khartoum Road Building provides an effective buffer to the northeast sector winds. However, it is important to note that there may still be wind channeling between these buildings which can impact the conditions along Banfield Road and within the existing parking area (Building D in the proposed case). Additionally, at the corner of Banfield Road and Banda Road, the channelling of northeast winds between MCC and the Prime Macquarie Park buildings results in high winds. This area can experience varying conditions ranging from active use to potentially uncomfortable conditions during the windier times of the year.

The dense landscaping within and around the existing site is likely to provide a significant buffer to the approaching winds. Areas in immediate vicinity of dense tree clusters are likely to be relatively comfortable.

6. RESULTS AND DISCUSSION

Macquarie Corporate Centre (MCC) likely to provide protection to Buildings A and B. Building F alignment can cause some high wind impacts on street level. Building D likely exposed to channelling of winds between MCC and 8 Khartoum Road. Winds also likely to channel between MCC and Prime Macquarie Park Buildings impacting conditions along Banda Road.

Prime Macquarie Park Buildings likely to provide a high buffer to the NW winter winds.

Some buffer to south winds with staggered mid-rise buildings likely to offer shielding to ground level areas.

Park One Apartments likely to provide high buffer to the westerly winter winds. Some ground level impacts expected from winds channelling between Park One and Prime Buildings with local rise in topography adding to the overall impact.

Image 5: Exposure of Site to Regional Prevailing Winds
Left: Summer | Right: Winter

6.3 Proposed Site Conditions

The interactions of the regional prevailing winds with the proposed massing and expected wind flow patterns on the local ground level are shown in Image 6a-6c. Key interactions are noted below with expected wind conditions shown in Image 7:

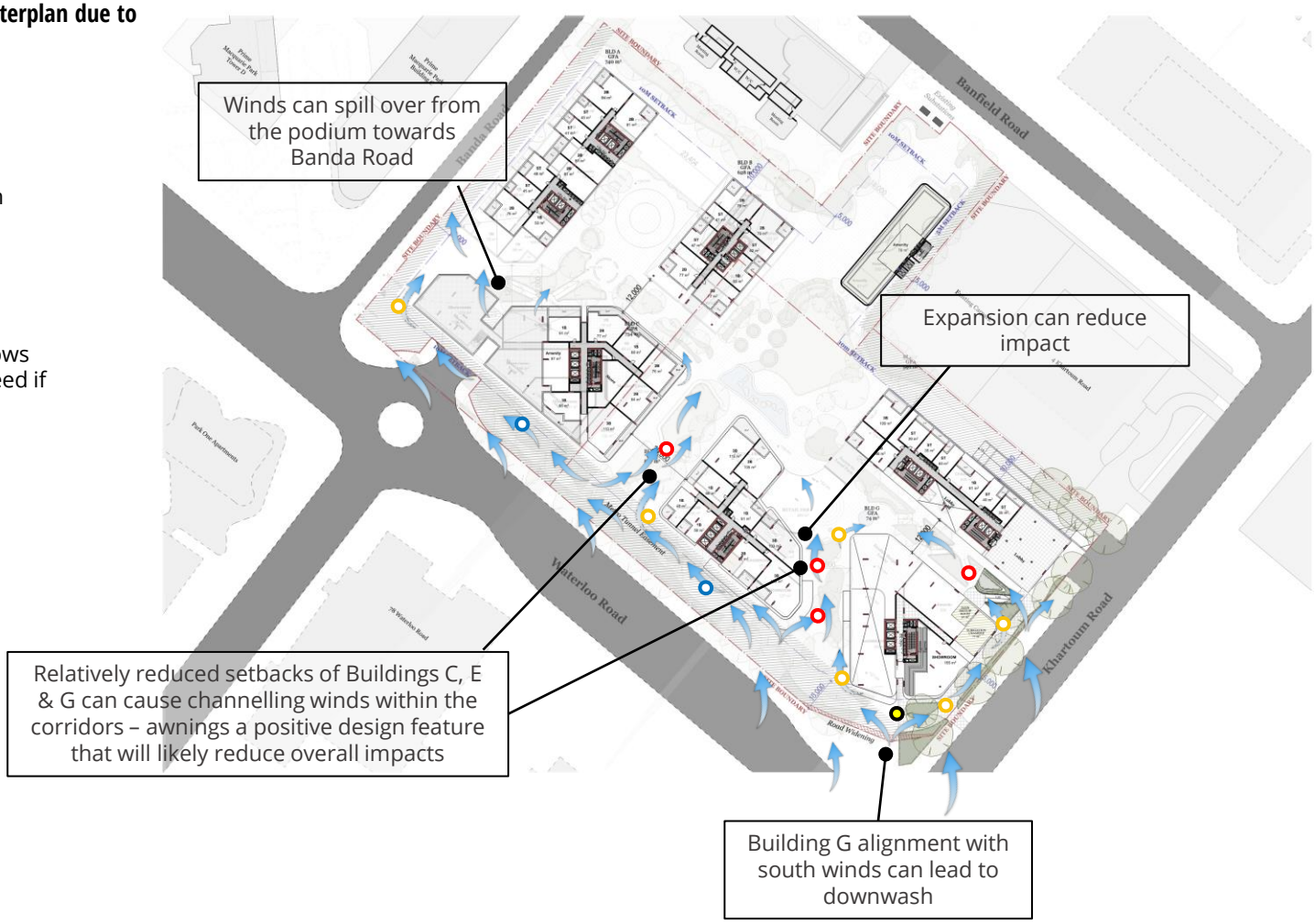
- The relative position of the taller towers along Waterloo Road can intercept the southerly winds which can then impact ground level conditions. Noting the awnings along Waterloo for Buildings C, E, and G, the overall impact will likely be reduced. However, wind channeling within the corridors can adversely affect overall comfort for the commercial areas between the buildings. Moreover, localised corner wind acceleration effects are anticipated around exposed corners of the buildings. Given the relative prevalence of these winds throughout the year, it is expected that the exposed areas will generally experience higher levels of windiness through the year.
- The anticipated impact of northeasterly winds on most areas surrounding the site is expected to be comparable to the existing site conditions. However, it is important to consider the relative alignment of Building F in relation to these winds. This alignment can result in downwash and corner wind acceleration effects leading to localised hotspots at the building corners. Additionally, these winds can affect the overall comfort of the retail space located between Buildings C and E, potentially impacting the usability of the space during windier times of the year.
- Similar to the existing site, the impact of winter winds will be limited with most areas shielded from these winds. However, it is important to note that the corner of Waterloo Road and Banda Road may experience high winds making it unsuitable for passive use. This is primarily attributed to the direct exposure to the winds that channel through from the Prime Macquarie Park and Park One Apartment buildings.
- Regional winds are likely to impact the amenity of the rooftop terraces. The westerly and southerly winds can impact the wind conditions within Building C Levels 3 & 5 terraces. Similarly, the Level 6 & 15 terraces of Building G are exposed to the southerly winds. Wind conditions within these spaces can range from active use to uncomfortable due to the relative height and exposure. It is understood that these spaces will be developed during the detailed design stage of the project.
- Private balconies that are inset within the planform of the buildings benefit from a single aspect design and are expected to have comfortable conditions throughout the year. The corner balconies of the various buildings will likely be exposed to stronger wind effects, particularly from Levels 6 and above. Corner balconies of Buildings A & B will likely be comfortable due to shielding from neighbouring buildings.

6. RESULTS AND DISCUSSION

Image 6a: Expected Wind Flow Patterns within the Proposed Masterplan due to Southerly Sector Winds

General Wind Effects

- Corner Acceleration
- Channeled Winds
- Downwash Winds
- Streaming Wind Flows Tend to pick up speed if left uninterrupted

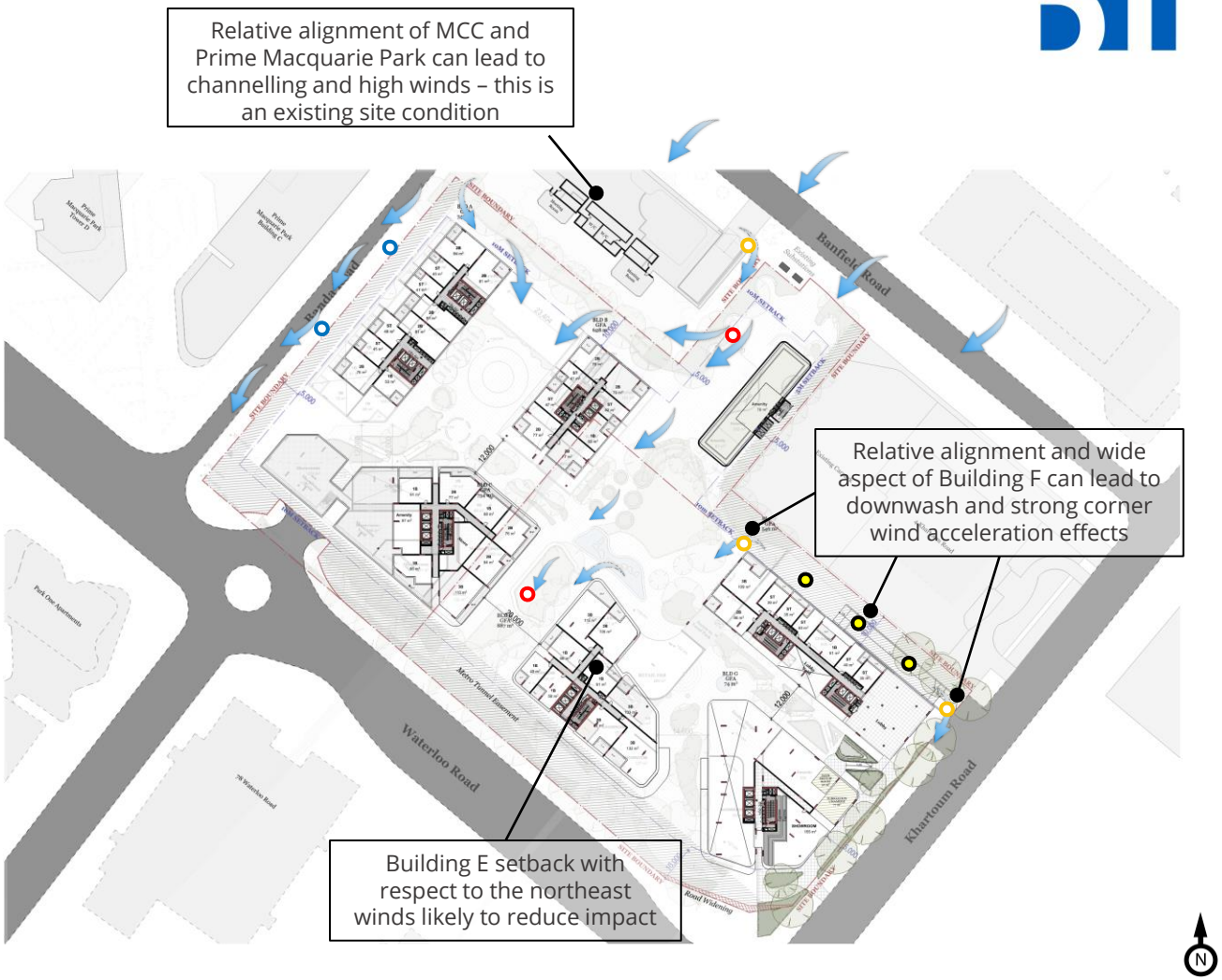


6. RESULTS AND DISCUSSION

Image 6b: Expected Wind Flow Patterns within the Proposed Masterplan due to Northeasterly Sector Winds

General Wind Effects

- Corner Acceleration
- Channeled Winds
- Downwash Winds
- Streaming Wind Flows Tend to pick up speed if left uninterrupted

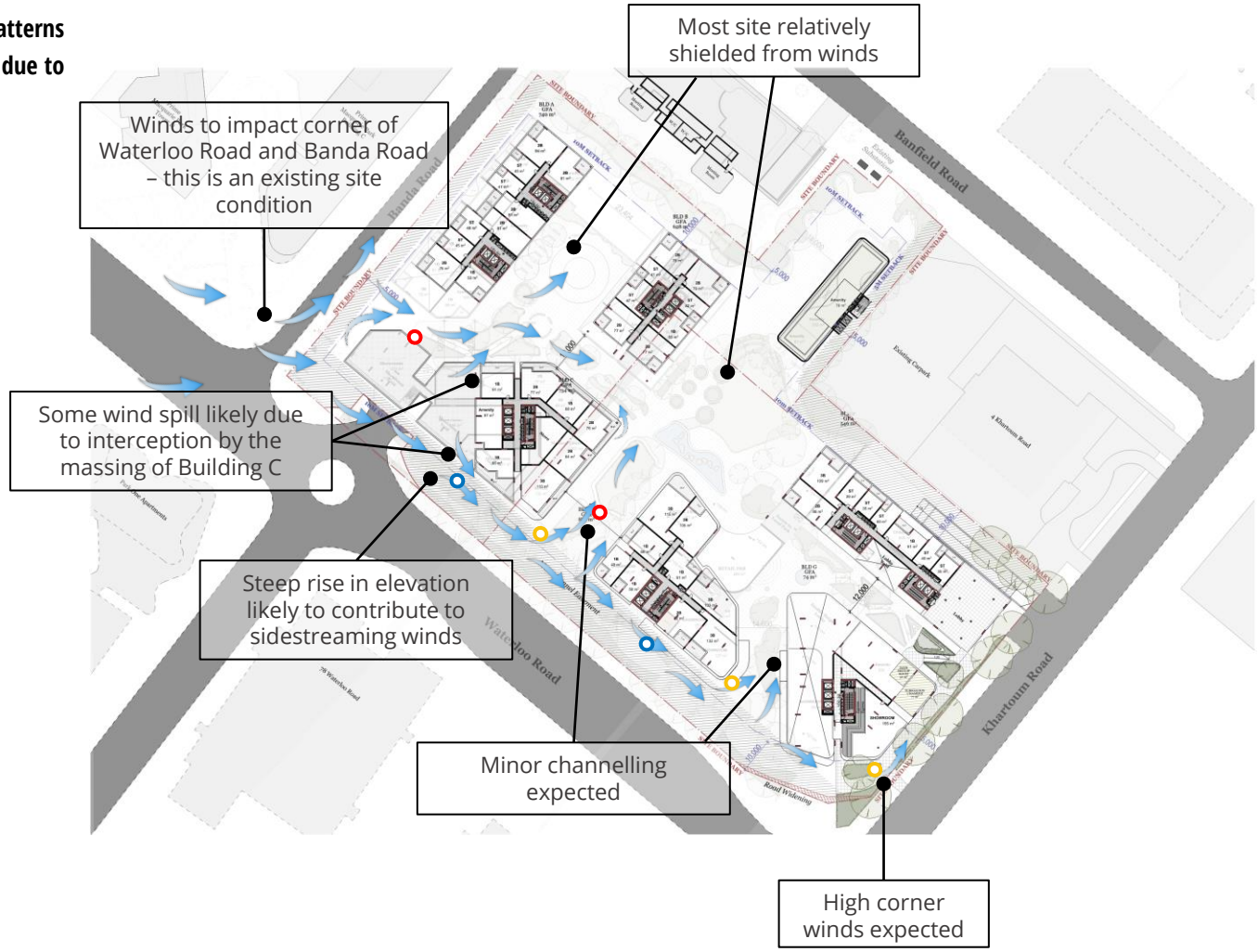


6. RESULTS AND DISCUSSION

Image 6c: Expected Wind Flow Patterns within the Proposed Masterplan due to Westerly Sector Winds

General Wind Effects

- Corner Acceleration
- Channeled Winds
- Downwash Winds
- Streaming Wind Flows Tend to pick up speed if left uninterrupted



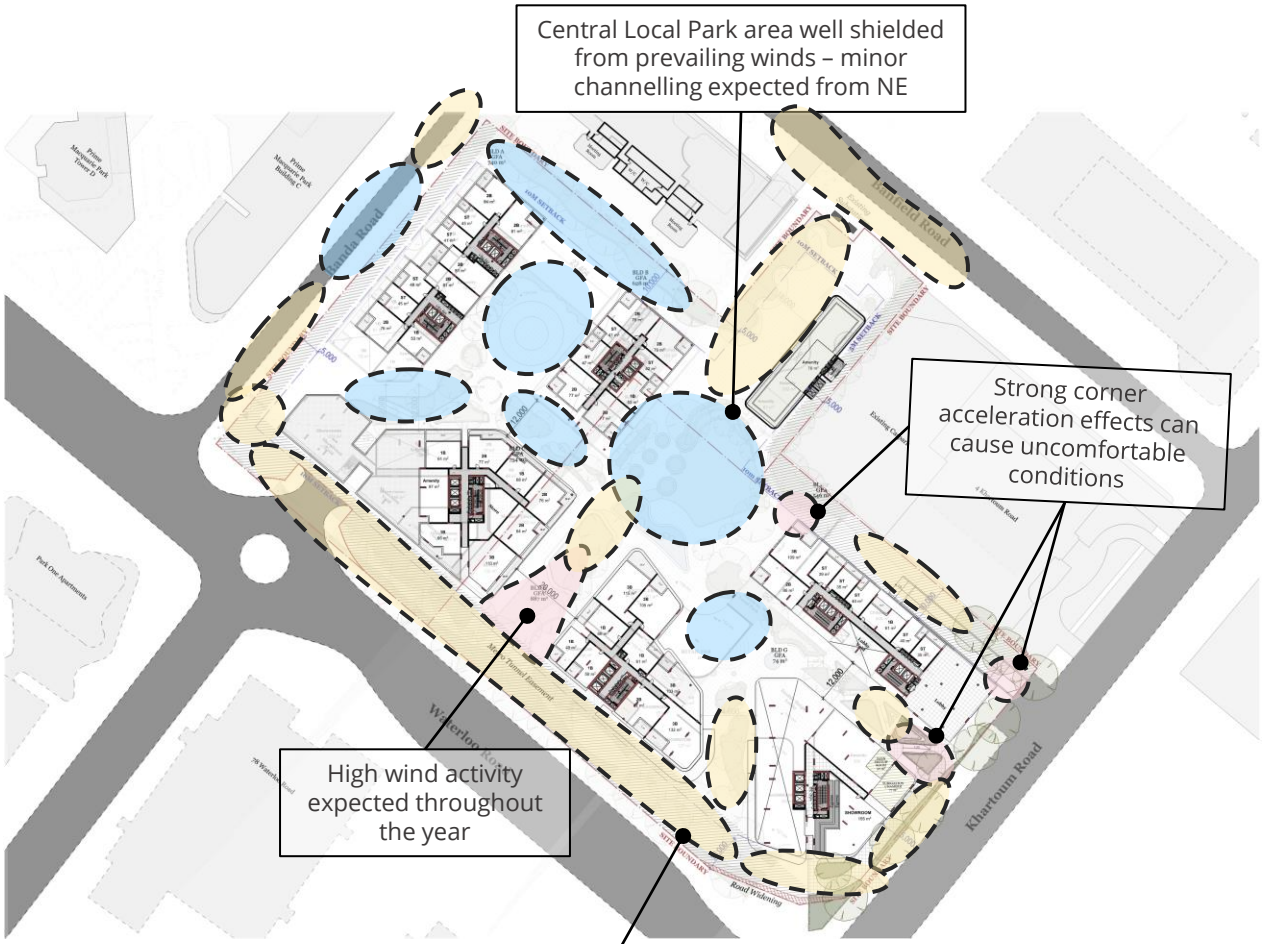
6. RESULTS AND DISCUSSION

Image 7: Expected Wind Conditions on Local Ground Level

A — Generally calm and well-sheltered areas suitable for passive activation. Potential fo overheating or accumulation of pollutants if wind flows are too low.

B — Moderately windy. Likely to be suitable for active use. Too windy for comfortable amenity use unless mitigation measures are implemented.

C — Windy with potential for localised strong winds. Likely to be uncomfortable during the windier times of the year



Note:
Wind conditions noted here are based on the existing surrounding context and do not take into account the impact of vegetation around the site. It is understood that the region is rapidly developing and key wind interactions might vary in the future due to neighbouring buildings. Vegetation will also likely reduce overall wind impacts.

6.4 Design Advice

Based on the discussions provided, the following design advice and wind control measures can be implemented within the design to further improve overall wind amenity (examples shown in Images 8 and 9):

- Podium setbacks and awnings can reduce the intensity of downwashed winds on the ground level. These should be maintained along Waterloo Road. It is important to close any gaps between the awnings to avoid winds spilling over and impacting ground level conditions. These are particularly recommended for all awnings along Waterloo Road (e.g., gap in Building E awning should be filled). Dense tree clusters should be located where the awnings terminate to filter the winds further.
- Impermeable awning or dense landscaping is recommended along the northern aspect of Building F to mitigate downwash.
- It is understood that the development site will be landscaped with numerous trees along all street fronts and within the through-site links and corridors. Plantings with large crowns and dense foliage, complemented with underplanting to prevent wind flows from accelerating under the crowns, will help reduce wind activity immediately around these areas. Dense clusters located at the building corners should also be retained. Wind conditions at most areas are expected to be comfortable with the inclusion of landscaping.
- Any outdoor seating areas should correspond to favourable wind locations such as the internal local park or the amenity areas between Buildings A & B. Locating the seating areas away from corners is also recommended. The retail space between Buildings C & E will benefit from localised screening for any outdoor seating areas.
- Similarly, primary lobby entrances should be located in favourable wind locations or recessed into the building planform to provide protection to patrons exiting controlled indoor environments.
- Vertical articulation in the form of recesses or protrusions in the tower and podium form or vertical screening elements at corners can reduce the impact of winds considerably and are recommended for the Waterloo Road front of the buildings.
- The corner balconies of Buildings C, E, F, & G (Levels 6 and above) will benefit from increased or full-height end screens.
- All rooftop terraces will benefit from high perimeter screening (1500 – 1800 mm). Localised canopies or trees with dense interlocking foliage are also recommended further in from the perimeter to capture the recirculating winds. Additional hard and soft landscaping elements are also recommended within the terraces to provide buffer to the winds. Any seating areas should incorporate screening to provide protection from strong winds expected on the upper rooftop terraces.

6. RESULTS AND DISCUSSION

Image 8: Examples of Wind Control Measures for Ground Level and Public Domain Spaces

6. RESULTS AND DISCUSSION

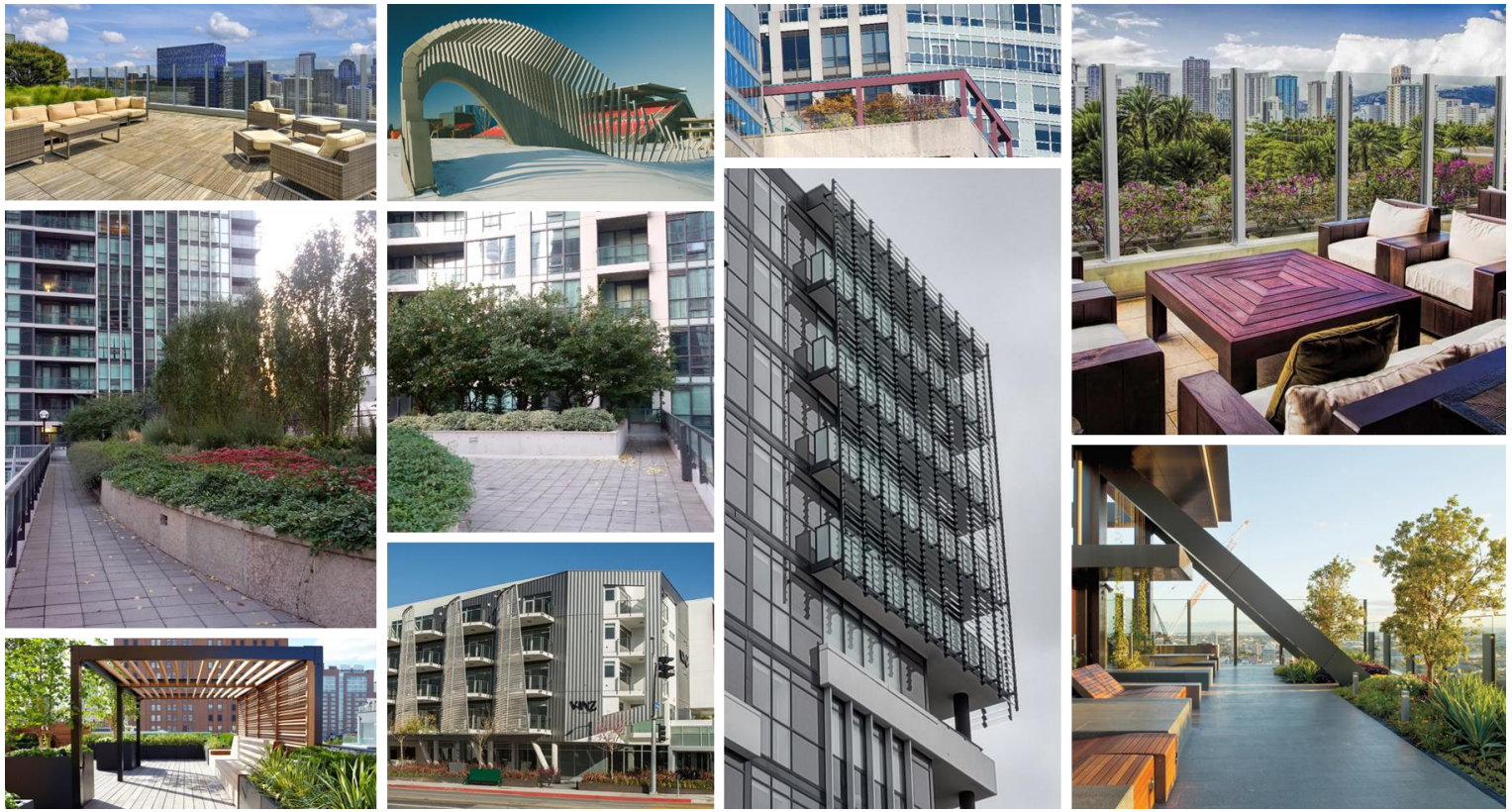


Image 9: Examples of Wind Control Measures for Balconies and Upper-Level Amenities

7. SUMMARY

Wind conditions on and around the proposed development located at 85-97 Waterloo Road in Macquarie Park, NSW are discussed in this report. The 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 (including future proposed buildings) and the 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.

Conceptual wind flows around the proposed precinct are discussed in the report for the prevailing wind directions to identify key wind sensitive areas. Design advice in the form of conceptual mitigation measures and built-form response are also presented. It is to be noted that the mitigation options discussed in this report are based on the assumptions and flow activity noted here. These will be refined further once the design and programming of the precinct has advanced further.

The architectural drawings submitted for Development Application (DA) review, received by RWDI in September 2023, have also been reviewed. Upon examination, it has been determined that the content and design recommendations outlined in the report remain relevant and applicable.

Predicting outdoor wind conditions around a building is a complex process that involves the combined assessment of building geometry and orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Computational Fluid Dynamics is a useful tool in this regard as it not only combines the impact of these various parameters but can also provide a visual reference for the merits of a particular design of the building. The CFD study can also be layered with a thermal comfort component to provide a more holistic understanding of total human comfort within and around the development site. Undertaking such an assessment can provide an exceptional level of insight into the combination of unique factors that impact a person's comfort, including activity level and clothing, ambient temperature, humidity, wind exposure, solar radiation, and how the space will be used. The information gained can be used to better plan the usage of outdoor spaces. Considering the early design stage of the precinct, this study is highly recommended.

8. APPLICABILITY OF ASSESSMENT

The assessment discussed in this report pertains to the proposed development in accordance with the drawings and information received in August 2023. The DA architectural set received on 3 September 2023 has also been reviewed. 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 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 '*85-97 Waterloo Road Pedestrian Wind Assessment*', dated 06 September 2023, 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.

6 September 2023

Consultant Declaration Form

PROJECT DETAILS	
PROJECT NAME	
Application number	SSD-52604208
Address of subject land	85-97 Waterloo Road, Macquarie Park
Lot / DP	Lot 1 in DP 1259121 and Lot 2 in DP 1249920
APPLICANT DETAILS	
Applicant name	Goodman
Applicant address	1-11 Hayes Road, Rosebery NSW 2018
REPORT DETAILS	
Name of report this declaration relates	**85-97 Waterloo Road, Macquarie Park – Pedestrian Wind Assessment**
Report reference no.	**20230906 RWDI 2305660 RPT Microclimate 85-97WaterlooRd**
Report date	**06/09/2023**
Company name (inc. ABN / ACN)	**RWDI Australia Pty Ltd. (ABN 86 641 303 871)**
Author name	**Aman Choudhry**
Author qualifications	**Senior Microclimate Engineer, PhD, MIEAust**
Author address	**Suite 602, Level 6, 80 William Street, Woolloomooloo NSW 2011**
DECLARATION BY CONSULTANT	
Name	**Henry Kuo**
Registration no.	**3731458**
Organisation registered with	**Engineers Australia**
Declaration	The undersigned declares that this **Pedestrian Wind Assessment**: • has been prepared in accordance with the following legislative requirements: - **SSD-52604208** - **City of Ryde Development Control Plan** • contains all available information relevant to the environmental assessment of the development, activity or infrastructure to which the EIS relates; • does not contain information that is false or misleading; • addresses the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project; • identifies and addresses the relevant statutory requirements for the project, including any relevant matters for consideration in environmental planning instruments; • has been prepared having regard to the Department's State Significant Development Guidelines; • contains a simple and easy to understand summary of the report, including: - the condition of the existing environment; - the ability to avoid, mitigate and/or offset the impacts of the project having regards to: - mitigation measures incorporated into the detailed design of the project (e.g. changes to the project area, project layout and design, key uses and activities carried out on site, timing) - other mitigation measures that will be implemented - any negotiated agreements or offsets proposed to address any residual impacts of the project following mitigation • the scale and nature of the predicted impacts, including any cumulative impacts, and whether these impacts will comply with the relevant statutory requirements, standards or performance measures;

PROJECT DETAILS	
	• key uncertainties associated with the assessment (e.g. lack of baseline data, doubts about the effectiveness of the proposed mitigation measures, limitations of the methodology used to predict impacts, lack of agreed criteria for evaluating impacts); • the proposed measures to deal with these uncertainties (e.g. monitoring, review, further technical investigation, staging, adaptive management).
Signature	
Date	**06/09/2023**