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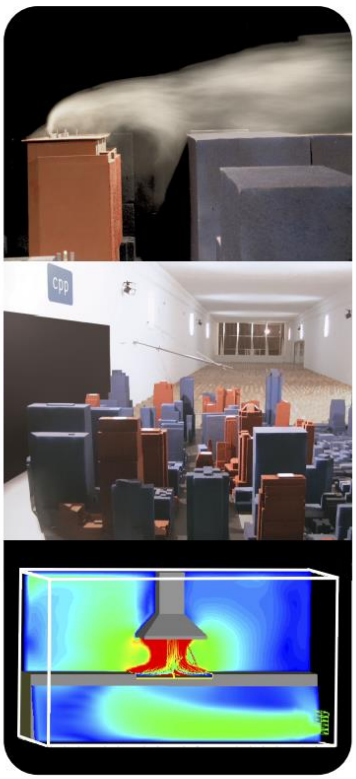
FINAL REPORT



Wind Assessment for:

MACQUARIE CENTRE REDEVELOPMENT STAGE 1: CONCEPT DA

17 Herring Rd, North Ryde

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Prepared for:

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EXECUTIVE SUMMARY

This report provides an opinion based qualitative assessment of the impact of the proposed Macquarie Centre redevelopment on the local pedestrian-level wind environment in and around the development. This assessment is based on knowledge of the local Sydney wind climate and previous wind-tunnel test on similar sized developments.

The environmental wind conditions around the proposed development are expected to be suitable for pedestrian walking from a comfort perspective and pass the distress criterion with reference to the Lawson pedestrian wind acceptability criterion. The location, orientation relative to the prevailing wind directions, geometry, and podium setback are expected to provide significant protection to the ground level plane from downwash flows.

Due to the number of entrances to the central semi-enclosed space, there will always be internal flow through the development. Further wind assessments will be undertaken at detailed design phase to ameliorate the wind impacts in public areas, including entrances and laneways, to meet the intended use of the space. Depending upon the final key usage, such as for pedestrian thoroughfare or for use as an outdoor café, amelioration measures may be required to improve any high winds speeds through the space, which would be addressed during detailed design. To quantify the qualitative advice, a wind tunnel test would also be required.

Wind tunnel testing would be required to quantify the wind conditions at the site for comparison with the wind criteria contained in the City of Ryde Council DCP. This is most effectively conducted during detailed design.

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
16/11/15	Initial release	KF	GSW	GSW
03/12/15	Minor changes	KF	GSW	GSW
08/12/15	Minor changes	KF	GSW	GSW

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1. CLIENT PROVIDED INTRODUCTION

BACKGROUND

This report has been prepared on behalf of AMP Capital (AMPC) in support of a Stage 1 Development Application (DA) for the mixed use redevelopment of Macquarie Shopping Centre (Macquarie Centre). The Stage 1 DA seeks concept approval for the redevelopment of Macquarie Centre by establishing:

- Building envelopes and design parameters for future development on the site, including the proposed uses within the podium and tower components.
- The distribution of floor space across the site.
- Future pedestrian and vehicle connections to and within the site.

This report supports the proposed future expansion of Macquarie Centre in relation to the pedestrian level wind environment.

SITE DESCRIPTION

Macquarie Centre is approximately 11.25 hectares in area and is located at the corner of Waterloo Road, Herring Road and Talavera Road, Macquarie Park. The site is legally described as Lot 100 in DP 1190494.

The site is bound by Herring Road to the north west, Talavera Road to the north east, commercial uses to the south east and Waterloo Road to the south west. Located within the Macquarie Park Corridor, the site has excellent access to public transport, situated immediately adjacent the Macquarie University Railway Station and the Herring Road Bus Station. Located between the M2 Hills Motorway and Epping Road, the site also enjoys excellent vehicle connectivity.

Macquarie Centre was originally constructed in 1981. The centre has undergone various stages of redevelopment and extensions. A major refurbishment occurred in 2000, 2003 and most recently in 2014, creating a fresh food court, David Jones expansion, addition of second full line supermarket (Coles), a value supermarket (Aldi), with new speciality food and convenience stores. Today Macquarie Centre is the largest shopping centre in NSW and the 8th largest shopping centre in Australia and includes a wide range of retail, entertainment and service offerings.

The shopping centre currently spans five levels accommodating 368 stores, including major retailers such as David Jones, Myer, Target, Big W, Aldi, Coles and Woolworths. The centre also houses a large number of mini major international retails stores including H&M, Zara, Uniqlo, Forever 21, GAP and Sephora. A number of entertainment offerings exist in the centre including a cinema complex and ice skating rink. The site currently has a gross floor area of 170,850m2 and accommodates 4,755 car spaces.

DEVELOPMENT PROPOSAL

The Stage 1 DA seeks concept approval for the mixed use redevelopment of Macquarie Centre under s.83B of the Environmental Planning & Assessment Act 1979. The first stage will seek concept approval only for:

- Mixed use development to enable a range of land uses. The final mix of land uses will be subject to and determined under the relevant Stage 2 detailed DAs.
- Building envelopes for the proposed basement, expanded podium and tower forms.
- The four tower envelopes fronting Herring Road will have maximum heights ranging from 90m and 120m above existing ground level. The building envelope for Tower 1 is of sufficient dimensions to accommodate alternate tower forms.
- Maximum additional gross floor area (GFA) of 148,000sqm.
- The new retail podium along Herring Road will replace the existing structure. This will provide an active frontage with separate pedestrian entries to Herring Road and the creation of a vibrant atrium space.
- The creation of 'Station Plaza' between the train station and shopping centre, framed by active uses and a landmark building known as the "Shard".
- The building envelopes for the proposed basement and upper levels of the expanded podium will accommodate a maximum of 2,175 additional car spaces.
- New vehicle and pedestrian access points.

The Stage 1 DA does not seek approval for

- Any works, including demolition, excavation, construction and public domain improvements.
- The final arrangement of land uses.
- Layout, mix and number of residential units.
- A specific number of car spaces (as this will be determined having regard to the final mix of land uses).
- The design of the building exteriors including facades and roofs.
- Public domain and landscape design.

Such approvals will be sought via subsequent development applications following receipt of development consent for the Stage 1 DA.

The overview of the indicative mix of land uses within the proposed building envelopes is identified in Table 1 below.

Table 1: Overview of indicate mix of land uses

Component	Proposed
Basement	Loading docks, car parking and associated vehicle circulation, waste rooms, utilities, future connection to existing train station (subject to consent from RailCorp) and retail premises.
Podium	Retail premises, commercial premises, food and drink premises, entertainment facilities, recreation facilities (indoor), recreation area, car parking and associated vehicle circulation, community uses (subject to further discussions with Council) and communal open space associated with the towers.
Tower 1	Mixed use development comprising commercial premises and/or residential accommodation and/or serviced apartments above a retail podium.
Towers 2, 3 and 4	Mixed use development comprising residential accommodation and/or serviced apartments above a retail podium.

Figure 1: Aerial photograph looking north

2. INTRODUCTION

Cermak Peterka Petersen Pty. Ltd. has been engaged by AMP Capital Investors Ltd. to provide an opinion based assessment of the impact of the proposed Macquarie Centre redevelopment. The proposed development where wind impacts are being assessed is along the Herring Road frontage of Macquarie Centre; a central shopping hub in the local area, and shown in Figure 2. This assessment is appropriate for the requirements of the City of Ryde Council DCP. To quantify the qualitative advice, a wind-tunnel test would be required during detailed design.

The proposed development consists of 4 commercial and residential towers, Figure 3, the tallest of which is 37 storeys rising to a height of approximately 120 m above ground level. This report considers the impact of Tower 1 being developed as a residential tower and as a larger commercial tower, extending across the south-west laneway from Macquarie University train station, Figure 4. Locally, there are no significant topographical changes in any direction for several hundred meters. Wind conditions in this area are known to be windy, and the architectural design of this proposed development will have a significant impact on the local wind climate.

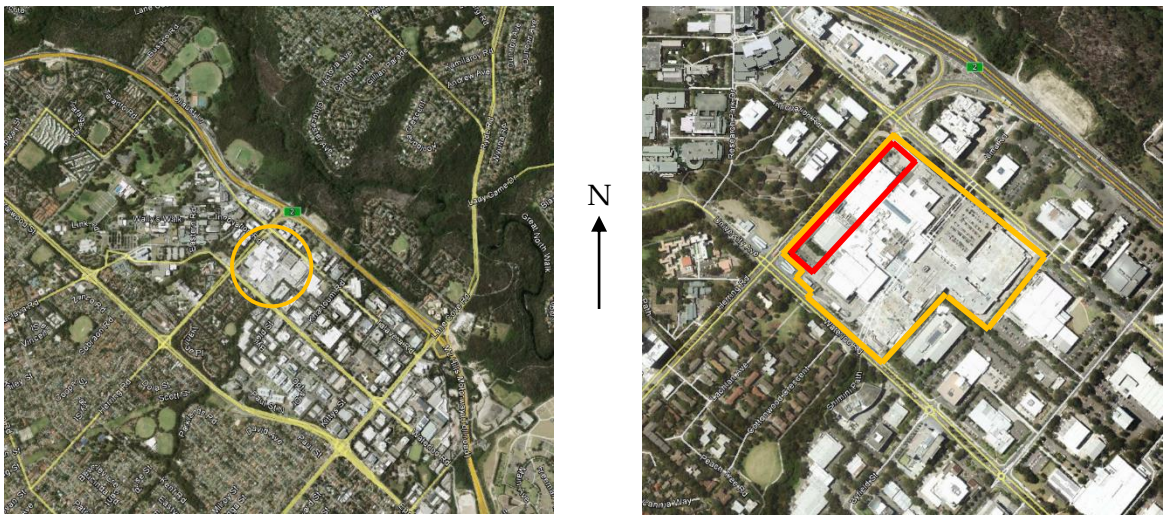

Figure 2: Aerial view of the proposed development site (Google Earth, 2015)

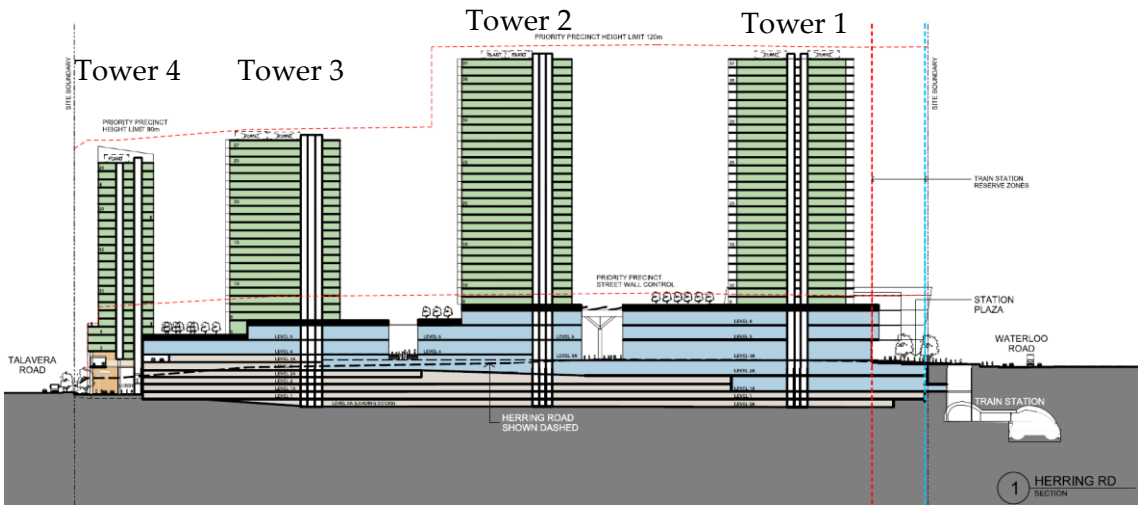

Figure 3: Herring Road elevation of proposed development

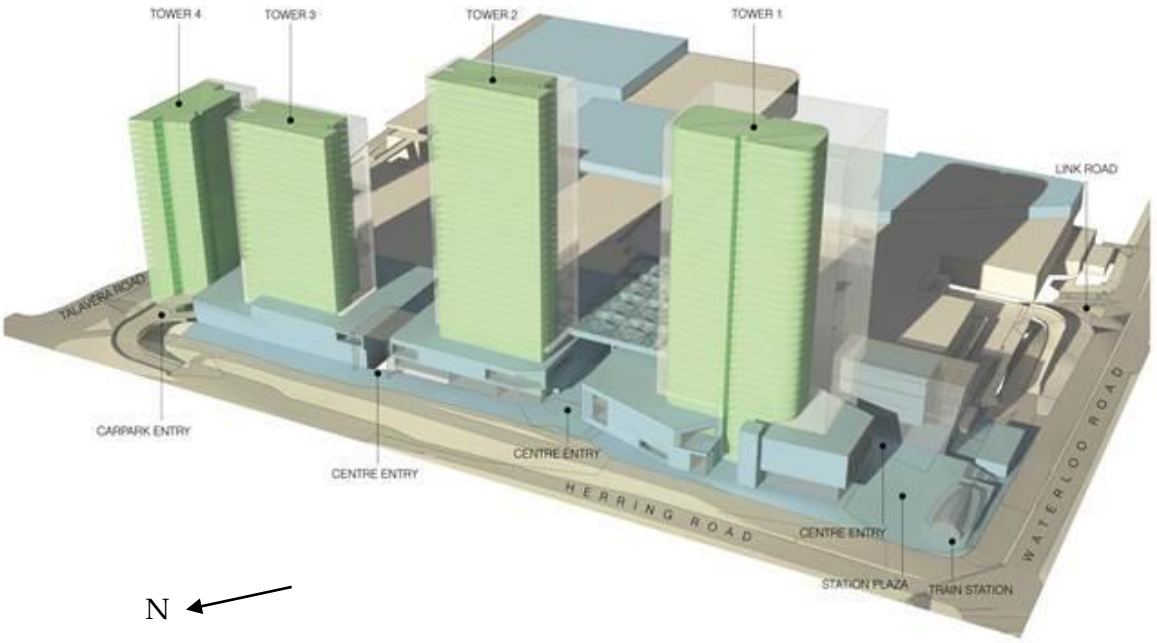

Figure 4: Overview of the plan with Tower 1 as a residential tower (green) and as an office tower (shaded)

3. BANKSTOWN WIND CLIMATE

The proposed development lies approximately 20 km north-east of the Bankstown Airport Bureau of Meteorology anemometer. The wind rose for Bankstown airport is shown in Figure 5. The prevailing strong winds at Bankstown Airport come from the south-east and west quadrants. Macquarie Park is closer to the coast than Bankstown Airport and would therefore experience slightly more summer sea breezes from the north-east.

Winds from the south-east, which tend to be cold, are often caused by frontal systems that can last several days and occur throughout the year. Winds from the west tend to be the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year, but are reduced in frequency in summer, and can be cold or warm depending on the inland conditions. The prevailing wind directions associated with rain are from the south and west quadrants. This wind assessment is focused on these prevailing wind directions.

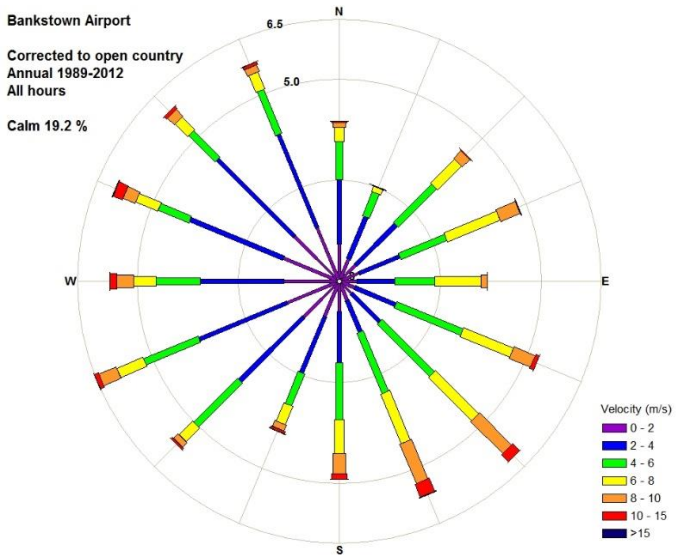

Figure 5: Wind rose for Bankstown Airport corrected to open country terrain

From a wind perspective, Bankstown Airport is relatively mild, with an average wind speed at 10 m reference height of approximately 3 m/s (6 kt, 10.8 kph), five percent of the time the mean wind speed is approximately 8.5 m/s (17 kt, 31 kph), and 0.6% of the time (once per week) wind speed is approximately 12 m/s (12 kt, 43 kph). Converting the five and 0.6 percent of the time mean wind speed to typical pedestrian level at the site using Standards Australia (2011) would result in about 5.4 m/s (10.5 kt, 19.5 kph) and 7.6 m/s (15 kt, 27 kph). Comparing these with the comfort criteria of Table 2 and Table 3 indicates that pre-existing winds at any Bankstown location with a similar built environment surrounding the proposed development site would be classified as acceptable for 'footpaths and other pedestrian accessways', and pedestrian standing. Specific building massing of the proposed development and their interaction with approaching wind flows will dictate the actual wind environment at the site and the resulting wind acceptability levels; these are explored in detail below.

4. ENVIRONMENTAL WIND SPEED CRITERIA

It is generally accepted that wind speed and the rate of change of wind velocity are the primary parameters that should be used in the assessment of how wind affects pedestrians. Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. Despite the apparent differences in numerical values and assumptions made in their development, it has been found that when these are compared on a probabilistic basis, there is remarkably good agreement.

The City of Ryde development control plan (DCP) conditions wind tunnel testing, and has wind assessment criteria based on the maximum allowable wind velocities, Table 2. Wind tunnel testing would be required to quantify wind conditions at the site against these criteria and is best conducted during detailed design.

AREA CLASSIFICATION	LIMITING WEEKLY MAXIMUM GUST-EQUIVALENT MEAN	LIMITING ANNUAL MAXIMUM GUST
Outdoor dining areas, amphitheatres etc	3.5 m/s	10 to 13 m/s
Main retail centres and retail streets, parks, communal recreational areas	5.5 m/s	13 m/s
Footpaths and other pedestrian accessways	7.5 m/s	16 m/s
Infrequently used laneways, easements, private balconies	10 m/s	23 m/s

Table 2: City of Ryde DCP Wind Acceptability Criterion

As well as the specific City of Ryde wind criteria, which are based on the work of Isyumov and Davenport (1975) and Melbourne (1978), the wind assessment criteria used in this study are based upon the research of Lawson (1990), which is described in Table 3 for both pedestrian comfort and distress. The benefits of these from a comfort perspective is that the 5% of the time event is appropriate for a precinct to develop a reputation from the general public. The criteria based on the mean wind speeds define when the steady component of the wind causes discomfort, whereas the GEM wind speeds define when the wind gusts cause discomfort.

Table 3: Pedestrian comfort criteria for various activities

Comfort (max. wind speed exceeded 5% of the time)	
<2 m/s	Outdoor dining
2 - 4 m/s	Pedestrian sitting (considered to be of long duration)
4 - 6 m/s	Pedestrian standing (or sitting for a short time or exposure)
6 - 8 m/s	Pedestrian walking
8 - 10 m/s	Business walking (objective walking from A to B or for cycling)
> 10 m/s	Uncomfortable
Distress (max. wind speed exceeded 0.022% of the time, twice per annum)	
<15 m/s	General access area
15 - 20 m/s	Acceptable only where able bodied people would be expected; no frail people or cyclists expected
>20 m/s	Unacceptable

The wind speed is either an hourly mean wind speed or a gust equivalent mean (GEM) wind speed. The GEM wind speed is equal to the 3 s gust wind speed divided by 1.85.

5. WIND FLOW MECHANISMS

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 6; this flow mechanism is called *downwash* and causes the windiest conditions at ground level on the windward corners and sides of the building. In Figure 6, smoke is being released into the wind flow to allow the wind speed, turbulence, and direction to be visualised. The image on the left shows smoke being released across the windward face, and the image on the right shows smoke being released into the flow at about third height in the centre of the face.

Techniques to mitigate the effects of downwash winds on pedestrians include the provision of horizontal elements, the most effective being a podium to divert the flow away from pavements and building entrances. Awnings along street frontages perform a similar function and the larger the horizontal element the more effective it will be in diverting the flow.

Channelling occurs when the wind is accelerated between two buildings or along straight streets with buildings on either side.

Figure 6 shows the wind at mid and upper levels on a building being accelerated substantially around the corners of the building. When balconies are located on these corners they are likely to be breezy, and will be used less by the owner due to the regularity of stronger winds. Owners quickly become familiar with when and how to use their balconies. If the corner balconies are deep enough, articulated, or have regular partition privacy fins, then local calmer conditions can exist.

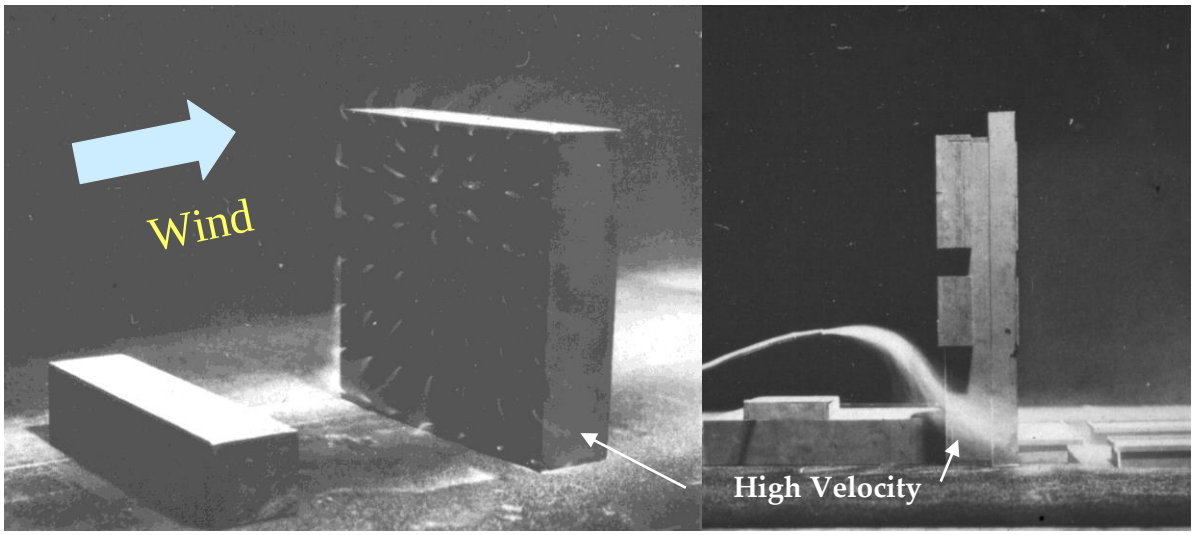

Figure 6: Flow visualisation around a tall building

6. ENVIRONMENTAL WIND ASSESSMENT

The proposed development is located on top of Macquarie Centre, Figure 2, consisting of a 4 prismatic towers of varying height. The entrance to Macquarie Centre will be redeveloped, with the addition of open entrances along the south-west and north-east façade. The ground floor of the development and a view of the exposed entrances are shown in Figure 4 and Figure 7.

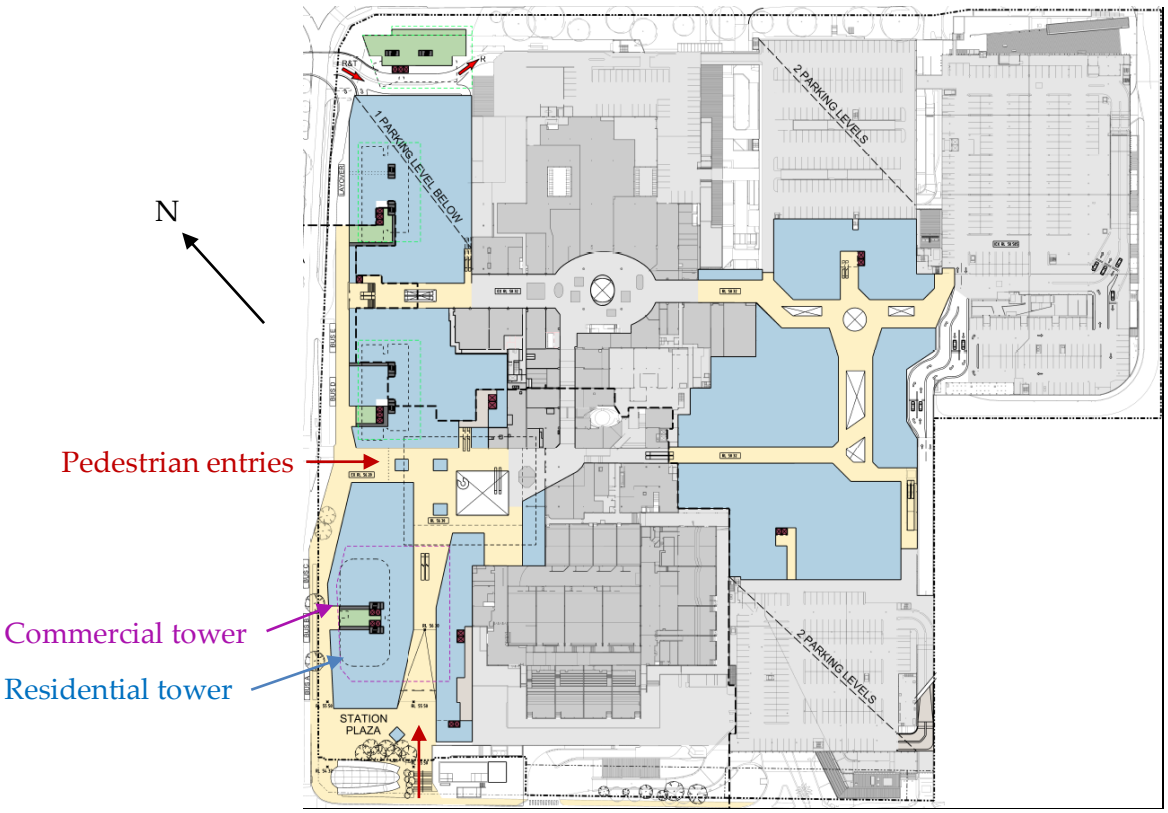

Figure 7: Ground floor of redeveloped section

Winds from south-east

Winds from south-east quadrant are relatively unimpeded when reaching the site. The relatively widely spaced nature of the towers will distribute the wind between and around the buildings, inducing downwash from the broad facades, and channelling flow between the buildings. It is considered that Towers 1, 3, and 4, have sufficient podium setback to minimise downwash onto the pedestrian walkways. However, the south-west façade of Tower 2 does not have a sufficient tower setback from the podium edge, and will induce downwash along the pedestrian accessway from Herring Road to the shopping centre. The added high level roof along the laneway entry between Towers 1 and 2 from Herring Road will assist in preventing downwash reaching ground level in both the residential and commercial design cases; the degree of roof extension would depend on the intended use of the space, e.g. café seating or main accessway. In addition, this roof would provide protection to pedestrians from rain. Care needs to be taken during detailed design of the glass roof to ensure that a suitable wind climate

is developed for the intended use of the space, namely that winds are able to flow under the roof at high level under the roof without significant re-circulation towards the ground level of the shopping complex.

The impact of the Tower 1 design would be expected to be slight for winds from this direction, with the commercial design directing more flow under the roof and through the laneway to Herring Road and across the Station Plaza.

Winds from south-west

With the commercial tower design, the wind conditions through the semi-outdoor area will be highly dependent on the pedestrian access route under the tower. If there is an open link with constant cross-sectional area under the tower, or for the residential tower design, winds from the south-west will be funnelled through the south-west entrance to the shopping centre from Station Plaza. The pressure difference between the Station Plaza and Herring Road entries will induce flow through the development. As the laneway narrows, the wind speed will increase. This is expected to create relatively windy conditions through this space. The wind conditions under the commercial tower will be faster than the residential tower. However, with the inclusion of a glass roof along this laneway, the wind conditions are expected to improve and facilitates the ability to seal the laneway during strong wind events. Without any mitigation procedures, the south-west entrance corridor is expected classified as suitable as a pedestrian accessway.

The ground level around Tower 4 is expected to be calm, since it lies in the immediate wake of the other three towers.

Winds from north-west

Winds from the north-west tend to be occur in winter, and are therefore colder in nature. These winds will funnel through the open north-west entrance to the shopping centre, and accelerate around the corner towards the south-west entrance. The north-west laneway entrance is expected to be windier along the north-east wall, though wind conditions may be locally improved for outdoor cafes through the placement of local fins. Without any mitigation procedures, the north-west entrance corridor is expected to be suitable for pedestrian walking.

Winds from north-east

Winds from the north-east occur on hot summer afternoons, decreasing in magnitude with sunset. Tower 4 lies at the forefront of the development, and shields the other buildings from these winds. The entrance to the underground carpark is well protected from any downwash flows. Furthermore, the surrounding areas along Talavera Rd is quite sparse and contains low pedestrian traffic. As a result, the ground level around Tower 4 is expected to be suitable for pedestrian standing.

Qualitatively, integrating the expected wind conditions around the site with the wind climate, it is considered that wind conditions around the site would be classified as acceptable for pedestrian standing or walking under Lawson from a comfort perspective and pass the distress criterion under the stated wind mitigation procedures. Without any mitigation procedures, particularly around the open entrances, the maximum wind speeds are likely to exceed the maximum limits as specified by the City of Ryde DCP Wind Acceptability Criterion, as would the majority of locations in the Sydney area.

Localised windy conditions are expected around the site particularly along the open north-west and south-west entrances leading onto Herring Rd and Waterloo Rd, respectively. Wind conditions in the central covered area would be expected to meet the pedestrian sitting criterion close to the perimeter. Wind conditions could be improved through local treatment during detailed design. For such a large development with several similar sized towers and a unique open space leading into the shopping centre, it would be recommended to conduct a wind-tunnel test to confirm the qualitative findings and quantify the wind conditions in and around the site during detailed design.

7. CONCLUSIONS

Cermak Peterka Petersen Pty. Ltd. has provided an opinion based assessment of the impact on the local wind environment of the proposed Macquarie Centre redevelopment. With the commercial tower design and without any wind mitigation measures, wind speeds are expected to be higher around and inside the south-west entrance than for the residential tower design. With the proposed wind mitigation measures, wind conditions around the development are expected to be suitable for pedestrian walking activities and pass the distress criterion under Lawson. To quantify the qualitative advice, a wind-tunnel test would be required during detailed design.

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