WIND ENGINEERING CONSULTANTS

QUALITATIVE WIND ASSESSMENT
CPP PROJECT 20148
31 JULY 2024

The Landmark Quarter

St Leonards, NSW

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Executive Summary

A qualitative assessment of the The Landmark Quarter development to be built in St Leonards, NSW was conducted to provide a qualitative assessment of the surrounding pedestrian wind environment. The assessment was based on the local wind climate, CPP's experience in the region and on comparable projects, and the characteristics of the proposed development.

CPP has previously completed a qualitative assessment of the pedestrian wind conditions around the proposed development in June 2022. The towers of the development assessed in this report remain similar in ground floor configuration and tower planform to the previously assessed configuration, with the most significant difference from a wind perspective being the addition of several floors increasing the height of the proposed towers. As the general shape of the towers has not changed, the mechanisms leading to accelerated flow around the development remain largely the same, with the additional height expected to generate some additional downwash off the tower façade which will lead to an increase in accelerated flow at ground level. From a comfort and safety perspective, this increase in the amount of downwash flow is not expected to be significantly noticeable compared to the previously assessed configuration, and the conclusions of this report remain largely the same.

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Contents

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1. Introduction

GENERAL INFORMATION

The assessment of the wind environment around developments can ensure adverse impacts are minimized and inform designers about the suitability of outdoor areas for their intended uses. Where necessary, design modifications can be made, or intervention measures added to mitigate areas with the potential for excessive wind speeds.

The proposed development is located in St Leonards, approximately six kilometres to the north of the Sydney CBD. The surrounding terrain is comprised primarily of low-rise suburban development to the south, with the mid-rise developments of St Leonards business district and train station to the north, Figure 1.

The proposed development is comprised of three medium-rise structures, reaching a maximum height of about 84.5 m above ground level, Figure 2. As these towers are larger than most of the surrounding structures, the addition of the proposed development is expected to have some impact on the local wind conditions, and the extents are broadly discussed in this report.

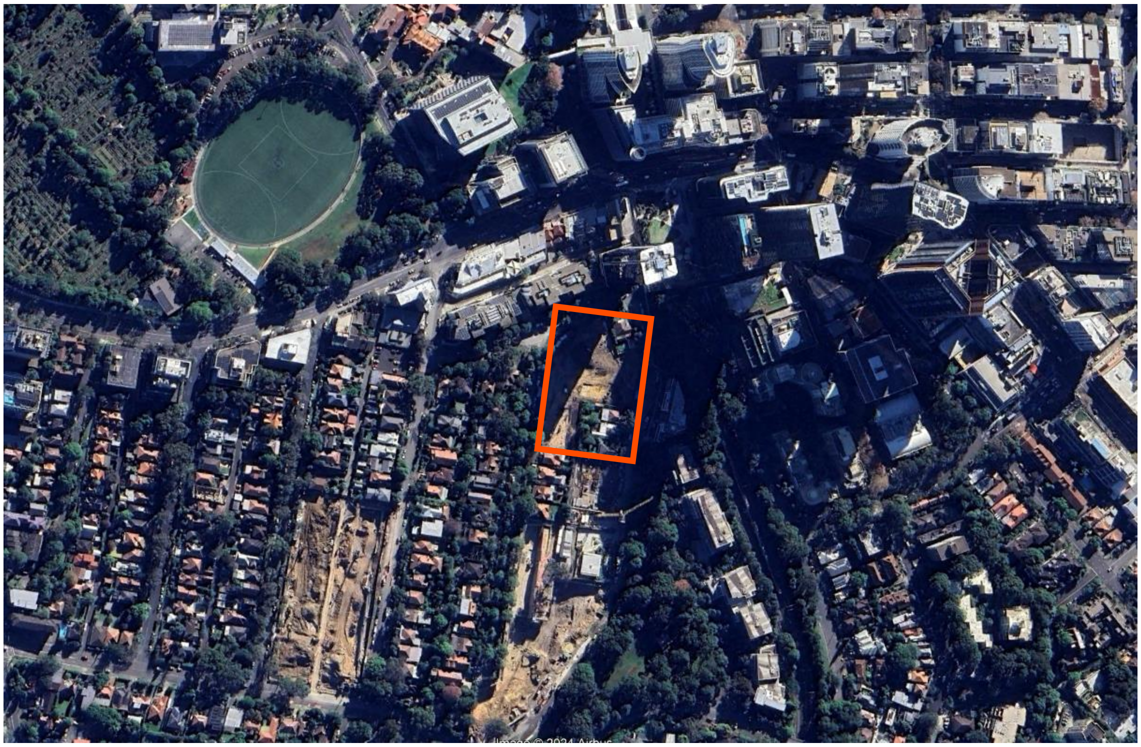

Figure 1: Aerial view of proposed development site (Google Earth, 2020)

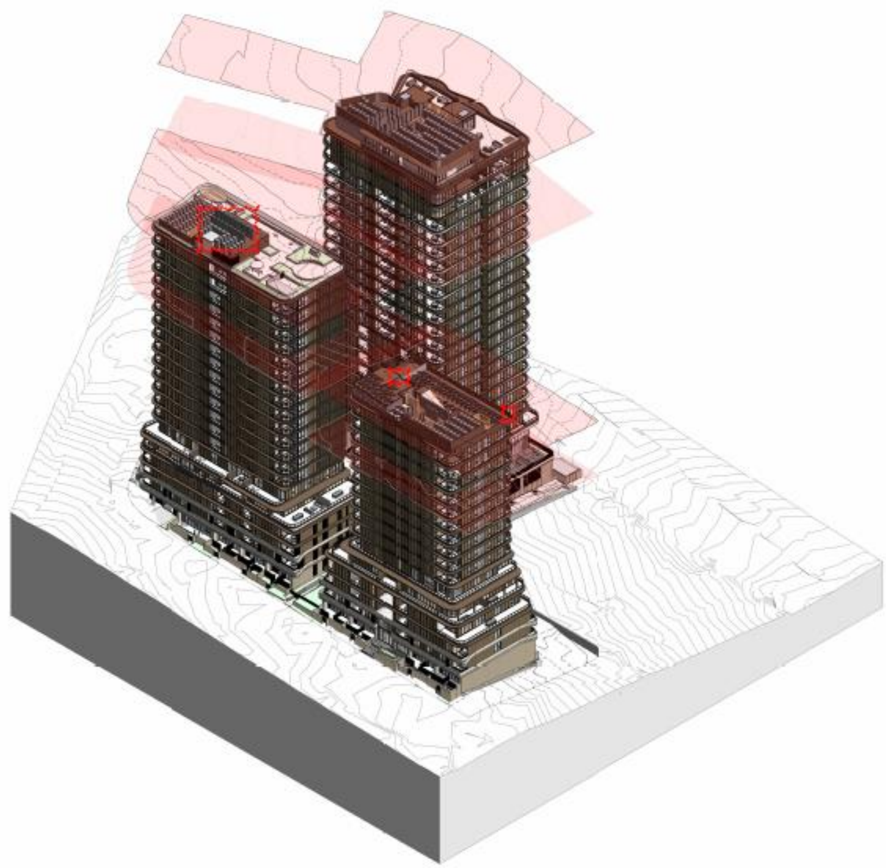

Figure 2: Isometric view of proposed development

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2. Wind Climate

The proposed development lies approximately 14 km to the north of the Sydney Airport Bureau of Meteorology anemometer, which provides the best source of historical wind data for the project. To enable a qualitative assessment of the wind environment, the wind frequency and direction information measured by the Bureau of Meteorology at a standard height of 10 m from 1995 – 2022 have been used in this analysis.

The wind rose for Sydney Airport is shown in Figure 3. The arms of the wind roses point in the direction from where the wind is blowing from, the width and color of the arm represent the wind speed, and the length of the arm indicates the percent of the time that the wind blows for that combination of speed and direction.

The distribution and frequency of winds on an annual basis were analyzed to assess the project with regards to wind comfort and safety. As can be seen from the wind rose in Figure 3, winds from the north-east, south and west directions are predominant. This wind assessment is structured around these prevailing wind directions.

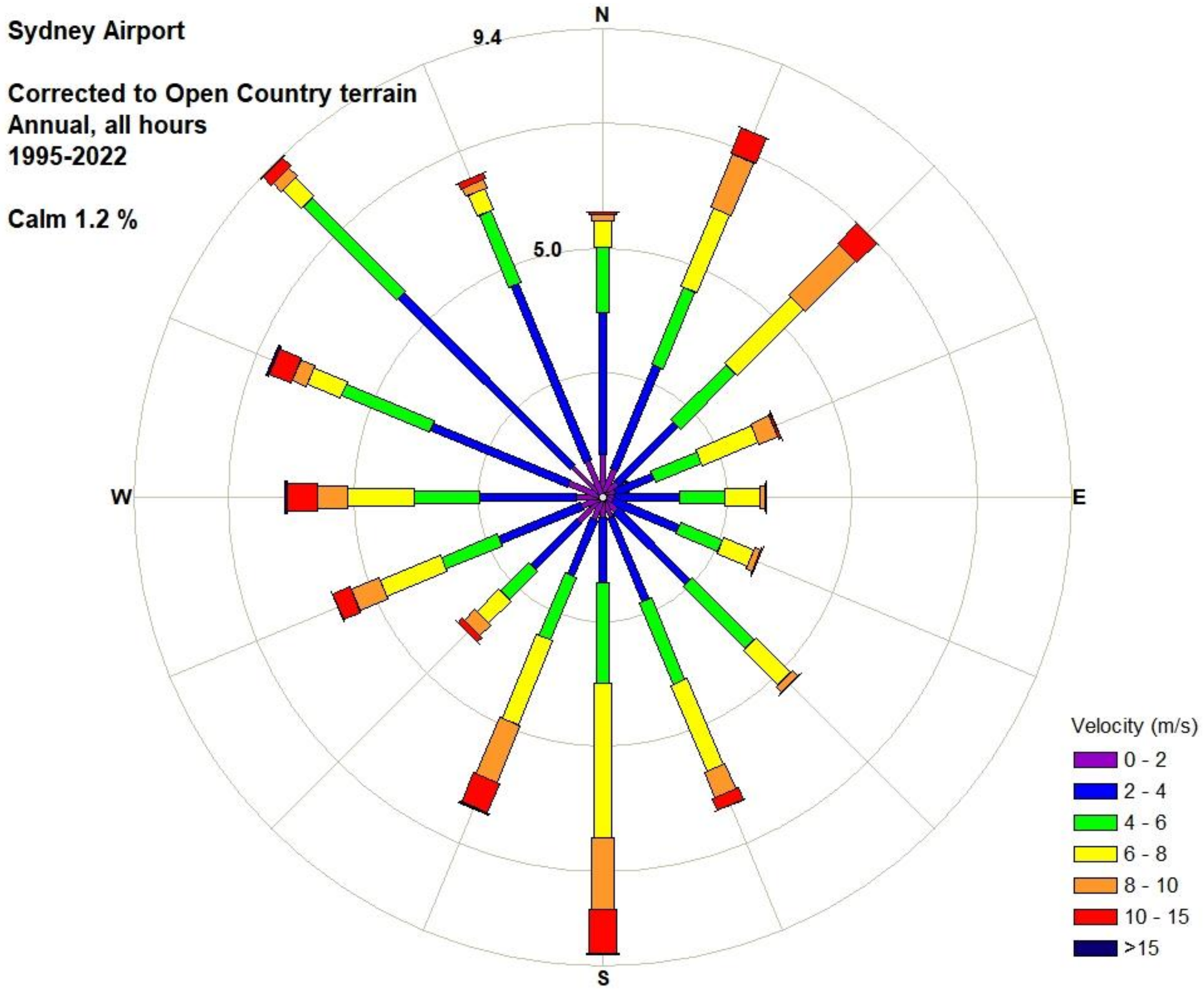

Figure 3: Probability of Wind Speeds by Direction, Sydney Airport – (1995 – 2022, All Hours)

3. Wind Assessment Criteria

A number of researchers have suggested quantitative methods for assessing wind comfort and safety based on estimated wind speeds and local climate statistics. These criteria provide a means of evaluating the wind amenity of location based on the frequency of threshold wind speeds, noting that pedestrians will tolerate higher wind speeds for a shorter time period than lower speeds. The comfort criteria also allow planners to assess the usability, with respect to the wind environment, of different locations for various purposes.

Lane Cove Council DCP (2013) specifies that developments should not result in wind speeds exceeding 13 m/s along major streets and public places, and 16 m/s in all other streets. It is assumed that this is a once per year (0.01% of the time) 3 second gust wind speed, and is intended to be interpreted as a comfort, rather than a distress requirement, with the 13 m/s requirement seen as generally acceptable for short-term stationary activities (e.g. café dining) and the 16 m/s requirement as generally acceptable for pedestrian walking in public accessways (Melbourne, 1978). CPP uses a modified form of the widely-accepted pedestrian-level wind criteria developed by Lawson (1990). Lawson's criteria are divided into separate categories of comfort and distress (safety). Assessment using the Lawson criteria provides a similar classification as using once per annum gust criteria (0.022% of the time), however also provides significantly more information regarding the serviceability wind climate.

A once per annum gust wind speed may not be representative of the day-to-day pedestrian wind conditions around the site from a comfort perspective. To address this limitation, the criteria of Lawson used in this study provides a similar comfort classification as the criterion of Melbourne assumed to be referenced by the Lane Cove DCP but gives significantly more information regarding serviceability wind climate.

Lawson's criteria are based on wind speeds exceeded 5% of the time, and are described as categories for comfort ranging from 'Pedestrian Sitting' to 'Business Walking', allowing planners to judge the usability of locations for various intended purposes. The criteria also include a distress rating, for safety assessment, which is based on occasional (once or twice per year) wind speeds, to identify locations where wind speeds may be hazardous to pedestrians.

The categories and criteria are specified in Table 1. In general, wind conditions comfortable for Sitting and Standing are considered appropriate for areas such as entrances where pedestrians are likely to gather for longer durations, while wind conditions comfortable for Casual Walking and Business Walking are more appropriate for sidewalks where pedestrians are actively in transit. Locations rated as Uncomfortable are generally less suitable for most pedestrian activities and wind control solutions are often sought. Whether mitigation is needed at a location depends upon the intended pedestrian use of the location.

Satisfaction of the safety rating is generally required for areas accessible to the general public. A rating of 'Able-Bodied' may be acceptable for areas with managed access or where pedestrians are unlikely to be present under adverse conditions.

Pedestrians' perception of wind can often be subjective and vary depending on regional difference in wind climate and thermal conditions, as well as by individual. Calibration to the local wind environment should be taken into account when evaluating predicted wind comfort conditions. Note that the ratings of 'Uncomfortable' and 'Safety' are the words of the published wind criteria and applicability may vary by project and location.

Table 1: Wind Comfort and Safety criteria (after Lawson, 1990)

COMFORT RATING	U_{EQUIV}*	DESCRIPTION
Dining**	< 2 m/s	Calm / light breezes suitable for outdoor restaurant uses, seating areas, and other amenities based on CPP experience.
Sitting	2-4 m/s	Calm or light breezes suitable for long duration seating areas, and other amenities.
Standing	4-6 m/s	Gentle breezes suitable for sitting for shorter periods, main entrances and bus stops where pedestrians may linger.
Pedestrian Walking	6-8 m/s	Moderate winds appropriate for window shopping and strolling along a downtown street, or park.
Business Walking	8-10 m/s	Relatively high speeds that can be tolerated if one's objective is to walk, run, or cycle.
Uncomfortable	> 10 m/s	Strong winds unacceptable for all pedestrian activities; wind mitigation is typically required.

*U_{Equiv} = Max (U_{Mean}, U_{Gust} / 1.85).
*U_{Equiv} speeds are based on an annual exceedance of 5% (~8 hours / week) assessed over all hours.
** For regular outdoor dining, and in semi-enclosed spaces, it has been the experience of CPP that the comfort rating of Sitting may be windier than desired and a comfort criterion of 4 m/s or less may be more applicable.

SAFETY RATING	U_{EQUIV}*	DESCRIPTION
Pass	< 15 m/s	Meets wind safety criterion.
Able-Bodied	15-20 m/s	Acceptable where only able-bodied people would be expected; not acceptable for frail persons or cyclists
Fail	>20 m/s	Excessive wind speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is often required.

* U_{Equiv} = Max (U_{Mean}, U_{Gust} / 1.85).
*U_{Equiv} speeds are based on an annual exceedance of 0.022% (~2 / year or 1 / season) assessed over all hours.

4. Assessment

SITE DESCRIPTION

The development site is surrounded by low-rise buildings to the south, and low- to mid-rise commercial developments to the north. Topography immediately surrounding the site is relatively flat from a wind perspective although the general fall in terrain to the south-west will provide some increase in wind speeds from those directions. Noteworthy is that winds in such surrounds tend to experience less channelling than areas with many tall structures, with local effects instead being dictated by exposed buildings and their relation to prevailing strong wind directions. Several wind flow mechanisms such as downwash and channelling flow are described in Appendix A and the effectiveness of some common wind mitigation measures are described in Appendix B

The subject site is located on a block bounded by Holdsworth Avenue to the west and Canberra Avenue to the east. The proposed development consists of three prismatic towers with near rectangular planforms. A ground floor plan is shown in Figure 4.

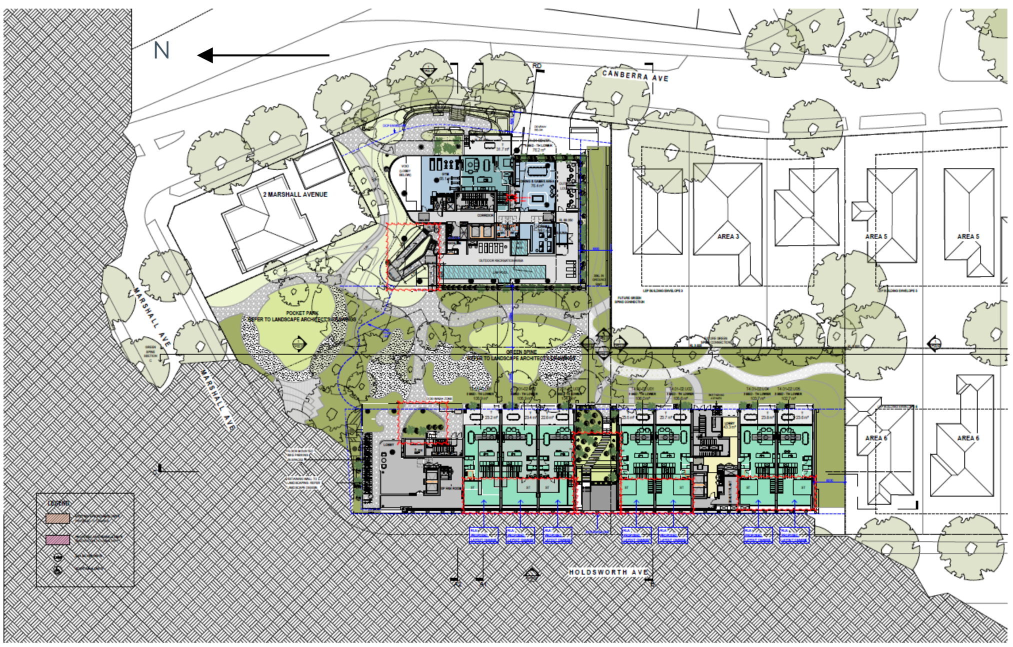

Figure 4: Ground floor plan of proposed development

WINDS FROM THE NORTH-EAST

Winds from the north quadrant will approach over the mid- and high-rise buildings of St Leonards CBD. The proposed development receives some more immediate shielding from winds from the north by the similarly sized tower at 13 Marshall Avenue adjacent to the development. For winds from the north-east, flow would be expected to flow downward off the exposed north façade of tower 1 in the form of downwash before accelerating around the base corners of the tower. The undercut of the tower 1 planform from Ground to Level 2, as shown in Figure 5, would be beneficial in keeping some downwash from tower 1 above the ground plane in the Green Link Park between the towers. From a Lawson comfort perspective, wind conditions on the ground plane would be expected to be suitable for pedestrian walking activities.

For winds from the north quadrant, conditions around the proposed development site along Canberra Avenue, Marshall Avenue and Holdsworth Avenue are expected to pass the safety/distress criterion.

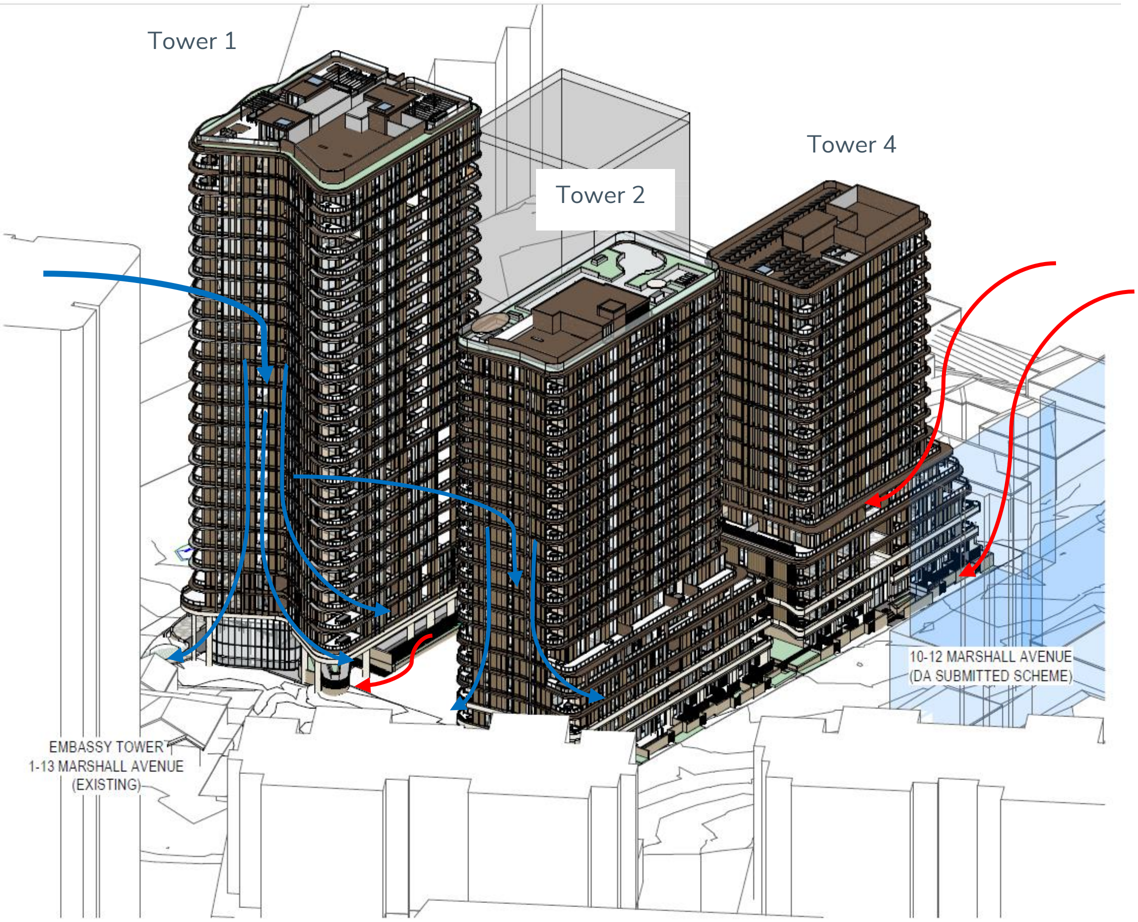

Figure 5: Structures and massing within the proposed development, north-west isometric view

WINDS FROM THE SOUTH

Winds from the south quadrant will pass over upstream residential housing of St Leonards and Wollstonecraft. Slightly stronger conditions resulting from downwash off the south façades of Tower 1 and Tower 4 would be anticipated close to building corners at ground level on the windward side and would contribute to channelled flow through the Green Link Park which is in alignment with southerly winds. The undercut in Tower 1, along with dense foliage and landscaping in the Green Link Park will assist in dispersing stronger gusts that reach the ground plane. For winds from the south, conditions the Green Link Park would be expected to be suitable for pedestrian walking style activities under the Lawson criteria, in line with expected use as a public accessway.

Wind conditions along Canberra Avenue, Marshall Avenue and Holdsworth Avenue are expected to be suitable for use as pedestrian accessways and below the safety criterion. The undercut terrace and amenity level on Tower 1 would see increased wind speeds as flow downward from the south façade of the tower accelerates through the space, with conditions expected to be suitable for pedestrian walking style activities from a comfort perspective. Mitigation in the form of an awning around the south-west tower corner could assist to redirect downwash flow horizontally around the tower would be recommended if this space is to be used for longer term stationary activities such as outdoor dining. For winds from the south quadrant, wind conditions at most locations around the site are expected to pass the safety/distress criterion.

WINDS FROM THE WEST

Winds from the west quadrant will pass over the residential housing of St Leonards and are relatively unimpeded upon reaching the proposed development site. These winds have the potential to impact upper levels of the broad western facades of Towers 2 and 4, flow downward in the form of downwash. The tapered west façade will provide some dispersion to downwash flow and ground-level pedestrian wind conditions along Holdsworth Avenue are expected to be suitable only for pedestrian walking from a Lawson comfort perspective.

Wind conditions on the ground plane of the Green Link Park and along Canberra Avenue will receive some shielding from the Towers 2 and 4 massing.

Strong wind conditions would exist on ground level between Towers 2 and 4 as winds impinging on the western facades of the towers are accelerated through the gap between them. If this area is intended for stationary type activities, amelioration in the form of tall vertical screening on the western and eastern sides of the gap would be recommended.

For winds from the west quadrant, ground level wind conditions around the proposed development site are expected to pass the safety/distress criterion.

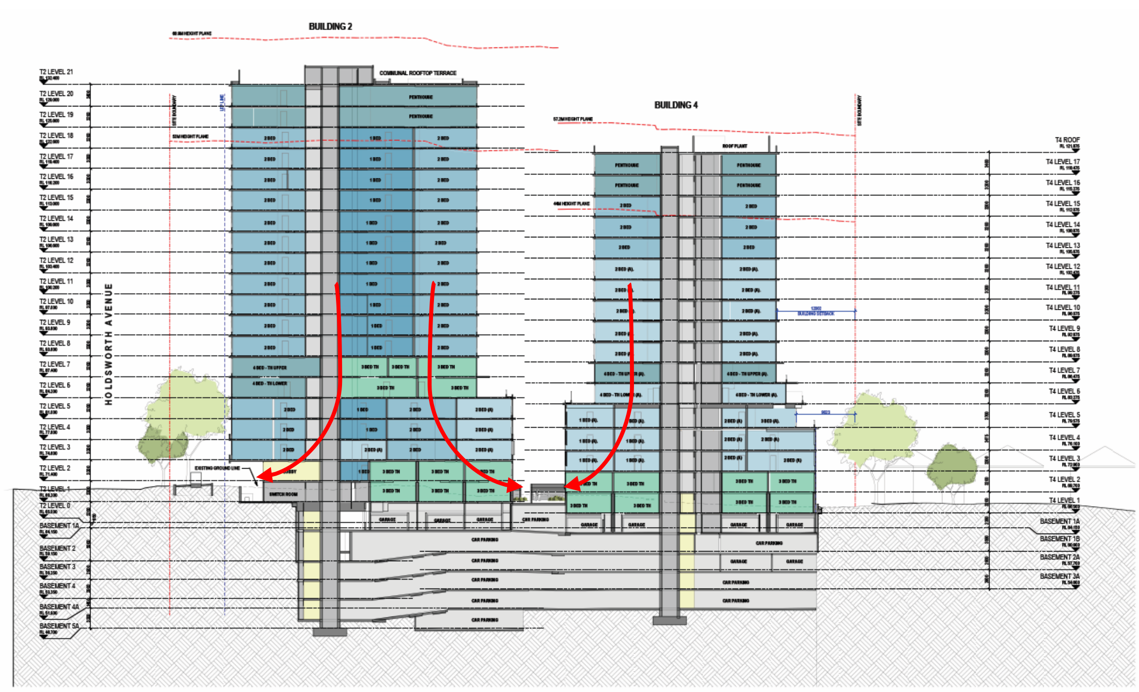

Figure 6: Flow paths through tower gap and undercroft, Towers 2 and 4, west elevation

SUMMARY – PUBLIC DOMAIN

From a pedestrian comfort perspective, the wind environment around the proposed development site is likely to be classified as acceptable for pedestrian walking under Lawson criteria. Localised amelioration measures would be suggested if calmer wind comfort conditions in these areas are desired. All locations would be expected to satisfy the safety/distress criterion.

WIND CONDITIONS WITHIN THE DEVELOPMENT

BALCONIES

Private balcony terraces are located throughout the development. Wind conditions within the recessed balcony spaces are expected to be mostly calm given the wind shielding they receive from the building massing. Balconies located on building corners or protruding from the façade are more exposed, and can experience strong cross flows. For exposed balcony areas it would be recommended to include vertical screening, to allow calm areas to exist for a greater period of time. Over time residents tend to learn the usability of their balconies based on the seasonal weather conditions.

5. Conclusion

Cermak Peterka Petersen Pty. Ltd. has provided a qualitative assessment of the impact of the proposed St Leonards South, project on the local wind environment in and around the development site. Being slightly larger than most surrounding structures, the proposed development will have some effect on the local wind environment.

Pedestrian wind comfort levels surrounding the site at ground level would be suitable for public accessways. Local amelioration would likely be necessary for areas intended for long-term stationary activities such as outdoor café-style dining.

Wind conditions at the Lawson walking criterion are expected throughout the building gaps between the towers due to a combination of downwash and channelling wind flows. Localised amelioration measures would be suggested if calmer wind comfort conditions in these areas are desired.

All locations would be expected to satisfy the safety/distress criterion. To quantify the wind conditions around the site, a wind-tunnel test would be recommended during detailed design.

References

Lawson, T.V. (1990), “The Determination of the Wind Environment of a Building Complex before Construction” Department of Aerospace Engineering, University of Bristol, Report Number TVL 9025.

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Appendix A – Wind Flow Mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure A1 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 A1smoke 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 A2 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.

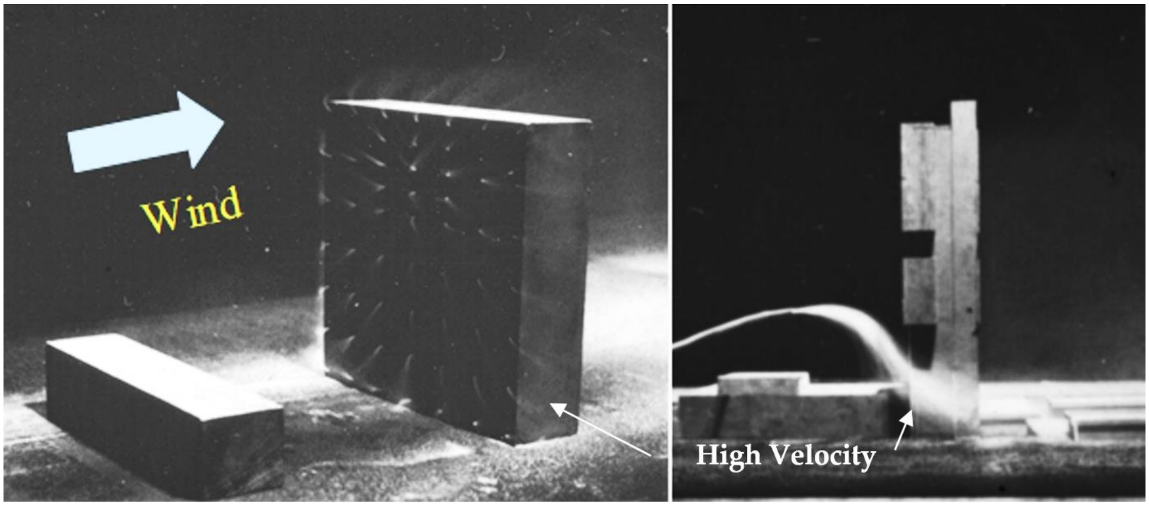

Figure A1: Flow visualisation around a tall building.

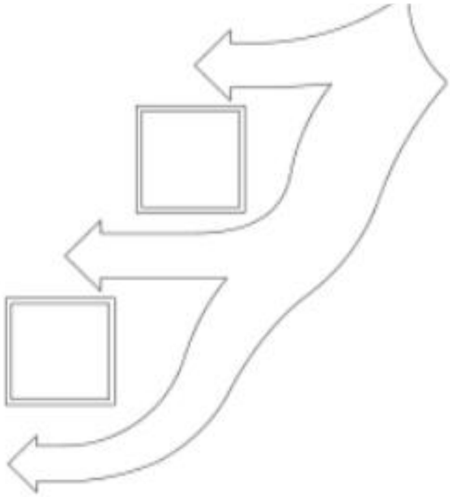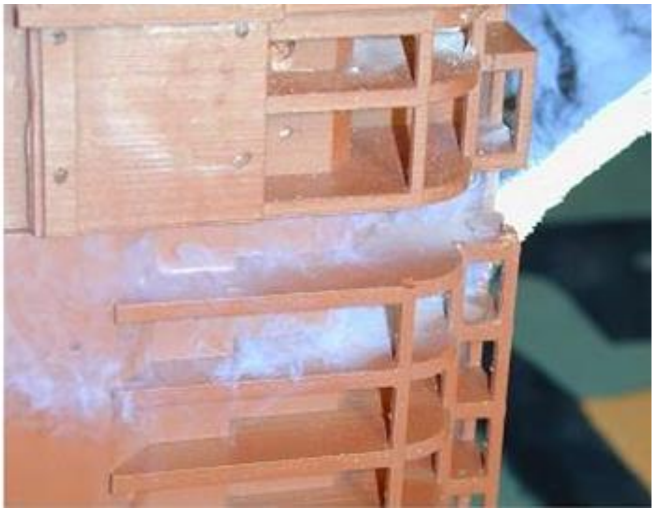

Figure A2: Channelling between buildings (L) and visualisation through corner balconies (R).

Appendix B - Wind Impact Planning Guidelines

It is well known that the design of a building will influence the quality of the ambient wind environment at its base. Below are some suggested wind mitigation strategies that should be adopted into precinct planning guidelines and controls (see also Cochran, 2004).

Building form – Canopies

A large canopy may interrupt the flow as it moves down the windward face of the building. This will protect the entrances and sidewalk area by deflecting the downwash at the second storey level, Figure B1. However, this approach may have the effect of transferring the breezy conditions to the other side of the street. Large canopies are a common feature near the main entrances of large office buildings.

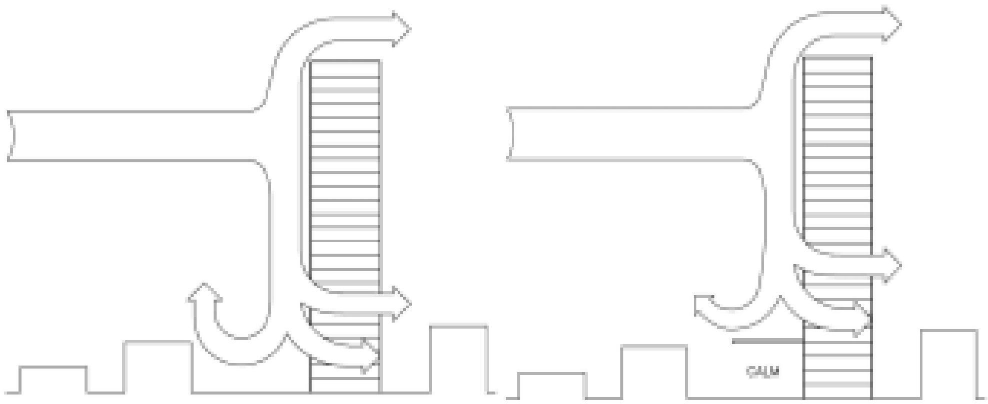

Figure B1: Canopy Windbreak Treatment. (L) Downwash to street level may generate windy conditions for pedestrians. (R) A large canopy is a common solution to this pedestrian-wind problem at street level.

Building form – Podiums

The architect may elect to use an extensive podium for the same purpose, Figure B2, if it complies with the design mandate. This is a common architectural feature for many major projects, but it may be counterproductive if the architect wishes to use the podium roof for long-term pedestrian activities, such as a pool or tennis court.

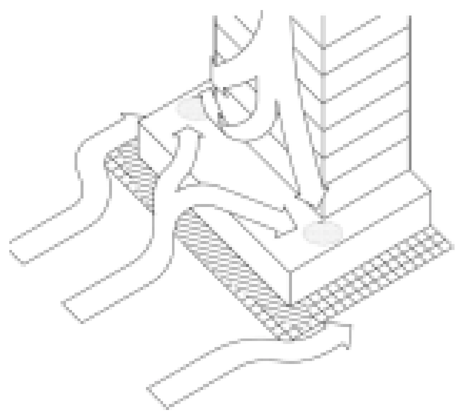

Figure B2:The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

Building form – Arcades

Another massing issue, which may be a cause of strong ground-level winds, is an arcade or thoroughfare opening from one side of the building to the other. This effectively connects a positive pressure region on the windward side with a negative pressure region on the lee side; a strong flow through the opening often results, Figure B3. The uninvitingly windy nature of these open areas is a contributing reason behind the use of arcade airlock entrances (revolving or double sliding doors).

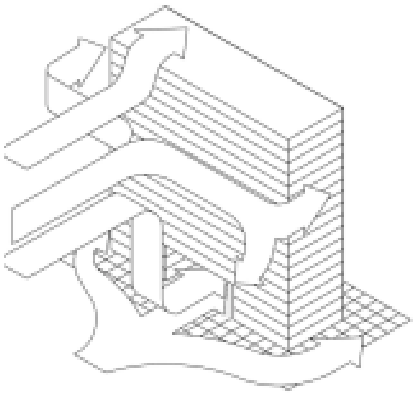

Figure B3: An arcade or open column plaza under a building frequently generates strong pedestrian wind condition.

Building form – Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure B4(L). In some cases, a canopy may not be necessary with this scenario, depending on the local geometry and directional wind characteristics. The same undercut design at a building corner is usually quite unsuccessful, Figure B4 (R), due to the accelerated flow mechanism described in Figure B1 and the ambient directional wind statistics. If there is a strong directional wind preference, and the corner door is shielded from those common stronger winds, then the corner entrance may work. However, it is more common for a corner entrance to be adversely impacted by this local building geometry. The result can range from simply unpleasant conditions to a frequent inability to open the doors.

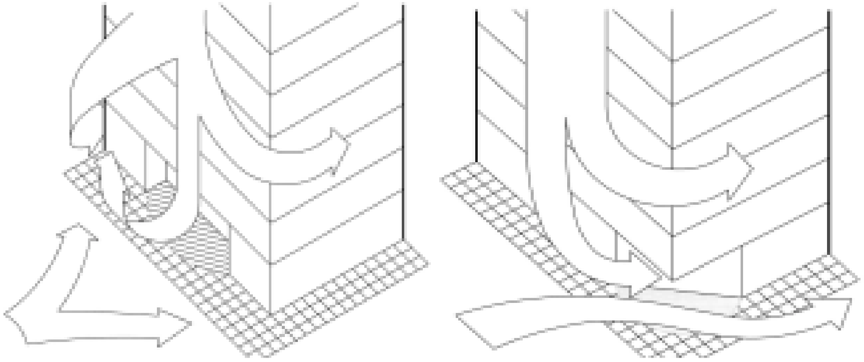

Figure B4: Alcove Windbreak Treatment. (L) A mid-building alcove entrance usually results in an inviting and calm location. (R) Accelerated corner flow from downwash often yields an unpleasant entrance area.

Building form – Façade profile and balconies

The way in which a building's vertical line is broken up may also have an impact. For example, if the floor plans have a decreasing area with increased height the flow down the stepped windward face may be greatly diminished. To a lesser extent the presence of many balconies can have a similar impact on ground level winds, although this is far less certain and more geometry dependent. Apartment designs with many elevated balconies and terrace areas near building ends or corners often attract a windy environment to those locations. Mid-building balconies, on the broad face, are usually a lot calmer, especially if they are recessed. Corner balconies are generally a lot windier and so the owner is likely to be selective about when the balcony is used or endeavours to find a protected portion of the balcony that allows more frequent use, even when the wind is blowing.

Use of canopies, trellises, and high canopy foliage

Downwash Mitigation – As noted earlier, downwash off a tower may be deflected away from ground-level pedestrian areas by large canopies or podium blocks. The downwash then effectively impacts the canopy or podium roof rather than the public areas at the base of the tower, Figure B2. Provided that the podium roof area is not intended for long-term recreational use (e.g. swimming pool or tennis court), this massing method is typically quite successful. However, some large recreational areas may need the wind to be deflected away without blocking the sun (e.g. a pool deck), and so a large canopy is not an option. Downwash deflected over expansive decks like these may often be improved by installing elevated trellis structures or a dense network of trees to create a high, bushy canopy over the long-term recreational areas. Various architecturally acceptable ideas may be explored in the wind tunnel prior to any major financial commitment on the project site.

Horizontally accelerated flows between two tall towers may cause an unpleasant, windy, ground-level pedestrian environment, which could also be locally aggravated by ground topography. Horizontally accelerated flows that create a windy environment are best dealt with by using vertical porous screens or substantial landscaping. Large hedges, bushes or other porous media serve to retard the flow and absorb the energy produced by the wind. A solidity ratio (i.e. proportion of solid area to total area) of about 60-70% has been shown to be most effective in reducing the flow's momentum. These physical changes to the pedestrian areas are most easily evaluated by a model study in a boundary-layer wind tunnel.

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