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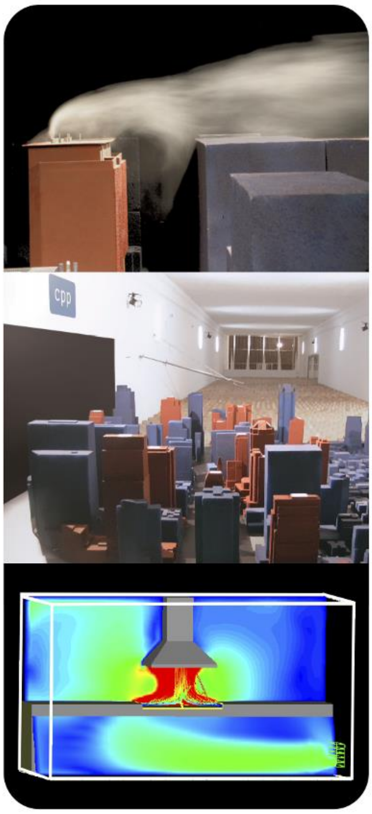
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

FINAL REPORT



Wind Assessment for:

SANCTUARY, WENTWORTH POINT MASTERPLAN

14-16 Hill Rd
Wentworth Point
Sydney, Australia

Prepared for:

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Introduction

Cermak Peterka Petersen Pty. Ltd. has been engaged by Sekisui House to provide an opinion based assessment of the impact of the proposed Sanctuary development at 14-16 Hill Road, Wentworth Point on the pedestrian level local wind environment.

The site is located approximately 13 km to the north-west of the Sydney CBD, adjacent to the Sydney Olympic Park precinct. The subject site occupies 9.4 ha on the Parramatta River, orange zone in Figure 1. The site is to be developed in stages into a master-planned residential community, Figure 2. The intent of this report is to assess the general massing of the masterplan design from the perspective of pedestrian wind comfort and safety, and give generic guidance on potentially windy areas and suggested amelioration. This report is based on knowledge of the local wind climate, results of wind tunnel testing at nearby sites, and planned features of the proposed development.

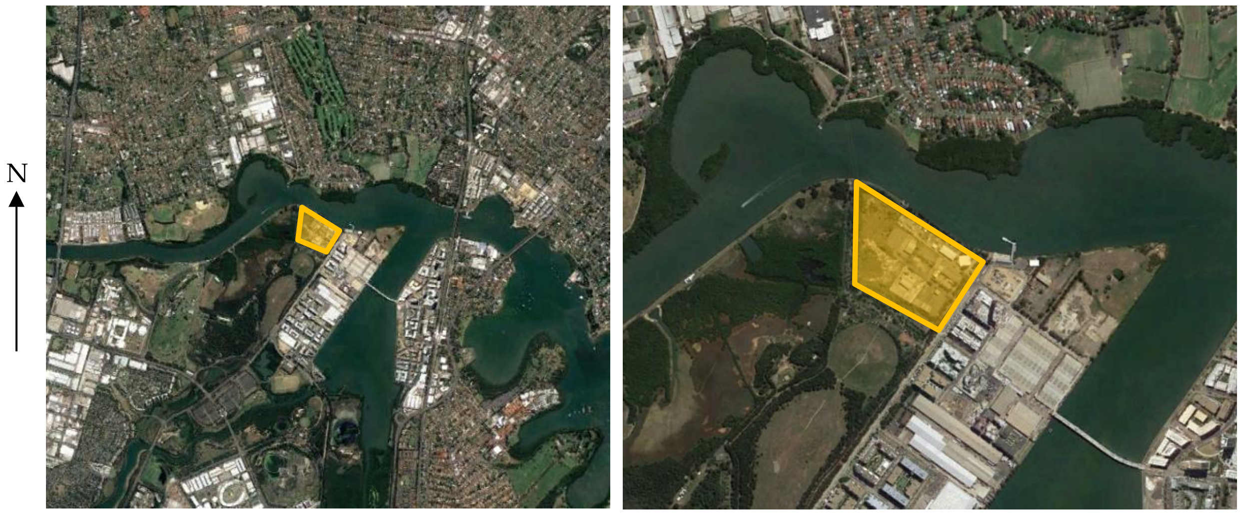


Figure 1: Location of the proposed development (L), Aerial view of site (Google Earth, 2016)

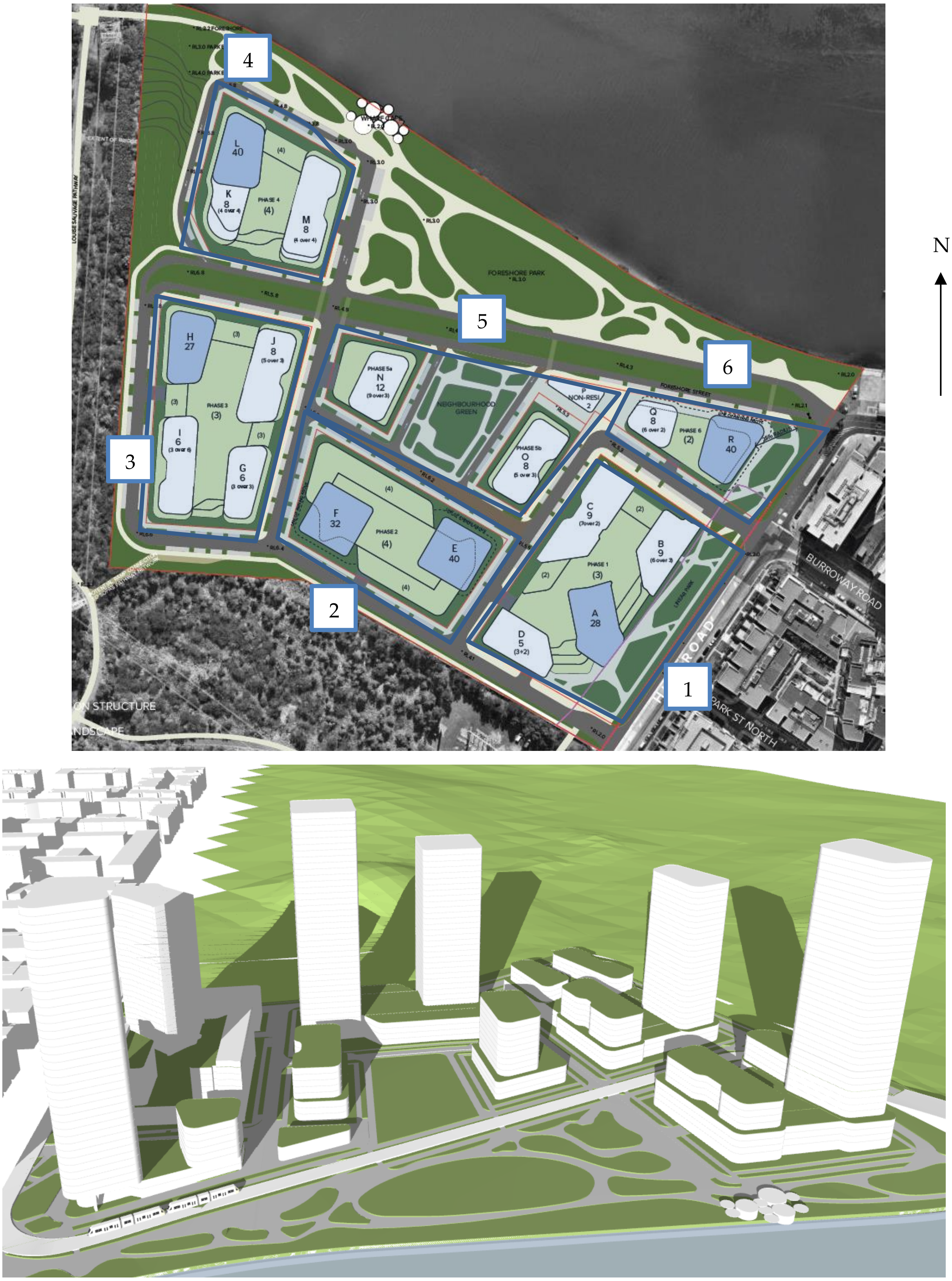


Figure 2: Masterplan with buildings and heights indicated (T), Perspective view from the north (B)

Wind Climate

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 at Bankstown Airport from 1993 to 2015 have been used in this analysis, Figure 3. Bankstown Airport is located approximately 14 km to the south-west of the proposed development and is considered to be representative of prevailing incident winds at the site, being located a similar distance inland. The prevailing strong winds at Bankstown Airport come from the south-east and west quadrants. This wind assessment is focused on these prevailing wind directions.

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.

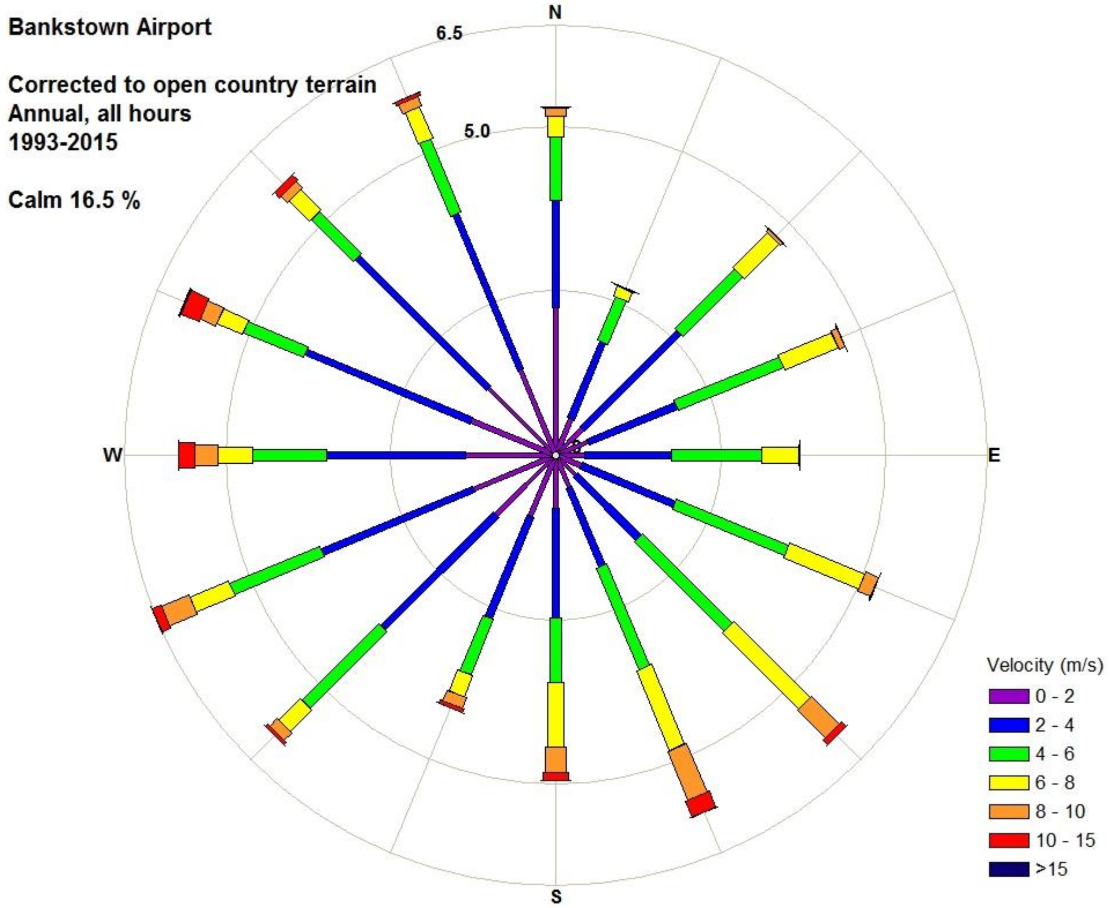


Figure 3: Wind rose for Bankstown Airport

From a wind perspective, conditions at Bankstown Airport are relatively mild, with an average wind speed at 10 m reference height of approximately 3 m/s (6 kt, 10.8 kph). The 5 percent of the time the mean wind speed is approximately 8.5m/s (17 kt, 31 kph). Converting to typical pedestrian level at the site using Standards Australia (2011) would result in a 5 percent mean wind speed of about 5.4 m/s (11 kt, 20 kph). Comparing this with the comfort criteria of Table 1, wind conditions at nearby built-up locations would be expected to be classified as suitable for short-term stationary activity. The specific wind environment around the subject development will be dictated by the interaction of the proposed building massing with approaching wind flows and are the resulting conditions and acceptability levels are explored in detail below.

Wind Flow Mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 4; this flow mechanism is called downwash and causes the windiest conditions at ground level on the windward and sides of the building. In Figure 4 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.

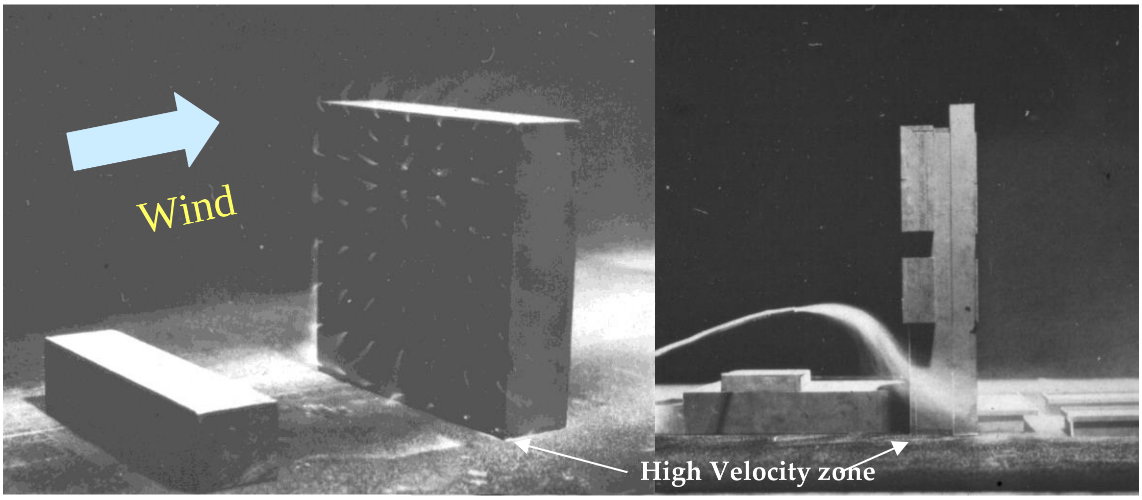


Figure 4: Flow visualisation around a tall building

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 deeper the horizontal element generally 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.

Further discussion of key mechanisms relevant to masterplan design may be found in Appendix A.

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. Over the years, a number of researchers have added to the knowledge of wind effects on pedestrians by suggesting criteria for comfort and safety. Because pedestrians will tolerate higher wind speeds for a smaller period of time than for lower wind speeds, these criteria provide a means of evaluating the overall acceptability of a pedestrian location. A location can further be evaluated for its intended use, such as for an outdoor café or footpath.

The development area is subject to the wind criteria specified in the Wentworth Point Development Control Plan (DCP) (2014). Under the DCP, buildings are to be designed to minimise wind impacts on open spaces, recreation areas, and residential balconies. Furthermore, the areas immediately surrounding the proposed buildings are subject to a maximum wind speed of 16 m/s. The DCP does not specify whether this is a mean or gust wind speed nor the frequency of occurrence throughout the year. It is expected that this is derived from the work of Melbourne (1978), which specifies that this is a maximum 3 s gust wind speed in an hour, occurring for 0.1% of the year from each direction. There are few locations in Sydney that would meet this criterion without some shielding to improve the wind conditions.

The work of Melbourne (1978), is based on an infrequent gust event, which may not adequately characterise the general wind conditions at a site. To overcome this limitation, the wind assessment criteria used in the current study are based upon the research of Lawson (1990), described in Table 1 for both pedestrian comfort and distress. The benefits of these criteria over many in the field are that they use both a mean and gust equivalent mean (GEM) wind speeds to assess the suitability of specific locations. 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. The level and severity of these comfort categories can vary based on individual preference, so calibration to the local wind environment for all wind directions is recommended when evaluating with Lawson ratings. From the perspective of classifying locations based on their suitability for various activities, the criteria of Lawson and Melbourne have been found to generally agree, though the Lawson criteria provide additional information on the serviceability of the wind climate.

Table 1: Pedestrian comfort criteria for various activities

Comfort (maximum of mean or gust equivalent mean (GEM†.) wind speed exceeded 5% of the time)	
< 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 (maximum of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	Not to be exceeded more than two times per year (or one time per season) for general access
<20 m/s	Not to be exceeded more than two times per year (or one time per season) where only able bodied people would be expected; frail or cyclists would not be expected

The wind speed is either a 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.

Environmental Wind Assessment

The proposed residential development is located on the southern bank of the Parramatta River. The area to the east and south of the site is occupied by a number of closely spaced medium to high- rise residential developments. To the west and south west is a region of parkland, and to the north is the Parramatta River, Figure 1. Topography surrounding the site is predominantly flat from a wind perspective. Wind conditions in this area of Sydney are relatively mild, with testing at nearby sites indicating most locations on the ground plane are suitable for pedestrian standing under Lawson. Areas of interest from a pedestrian wind perspective include the main building entrances around the site, pedestrian through-links and thoroughfares, and communal courtyard area and park areas. A discussion of common wind issues relevant to masterplan design is found in Appendix A.

The masterplan comprises a total of 18 buildings, denoted A-R in Figure 2. For clarity, these have been grouped into six areas (Blocks 1-6) for this assessment.

Block 1 – Buildings A-D

This section comprises a 2-storey residential tower (Building A) and adjacent smaller residential buildings B (6 storeys), C (6 storeys), and D (3 storeys), arranged around a central courtyard. This section is the subject of a previous qualitative assessment – see Cermak Peterka Petersen (2017).

Figure 5: Block 1

Winds from the south-east approach the site over a section of the Parramatta River and a region of relatively dense, medium rise residential developments. The orientation of Building A relative to winds from this quadrant is expected to produce some downwash, creating relatively strong wind conditions at the southern and northern-most corners of the tower. The undercut area near the main entry to the tower is expected to locally accelerate the flow, however the planned vertical screening elements in this area will allow reasonably calm conditions near the lobby entry. Winds from the south-east will be channelled into the spaces between Buildings A, B, and D, and some acceleration of flow over the embankment between the buildings would also be expected. These areas are likely to be unsuitable for long-term stationary activity without local amelioration measures, however conditions would be acceptable for their use as a pedestrian thoroughfare as planned. Mostly calm conditions would be expected elsewhere at the site during winds from this direction.

Winds from the west approach over the Parramatta River and relatively open parkland, reaching the site mostly unobstructed. Winds from the west quadrant will impinge orthogonally on the upper portion of Building A, generating downwash and causing relatively windy conditions around the windward corners. Flow would likely be accelerated and directed along the south-west tower façade, contributing to strong breezes between Buildings A and D. Slightly higher velocities would also be expected near the south-western corner of Building D and between buildings A and C, though the main building entries to the east and south-east are expected to be calm. The communal podium area is also expected to experience mostly calm conditions during winds from the west, assisted by planned landscaping and screening. The pedestrian footpaths on the north side of block 1 are mostly well shielded by the surrounding structures, and would be expected to experience calm conditions.

Block 2 – Buildings E-F

Buildings E and F are square towers located at the southern edge of the masterplan area.

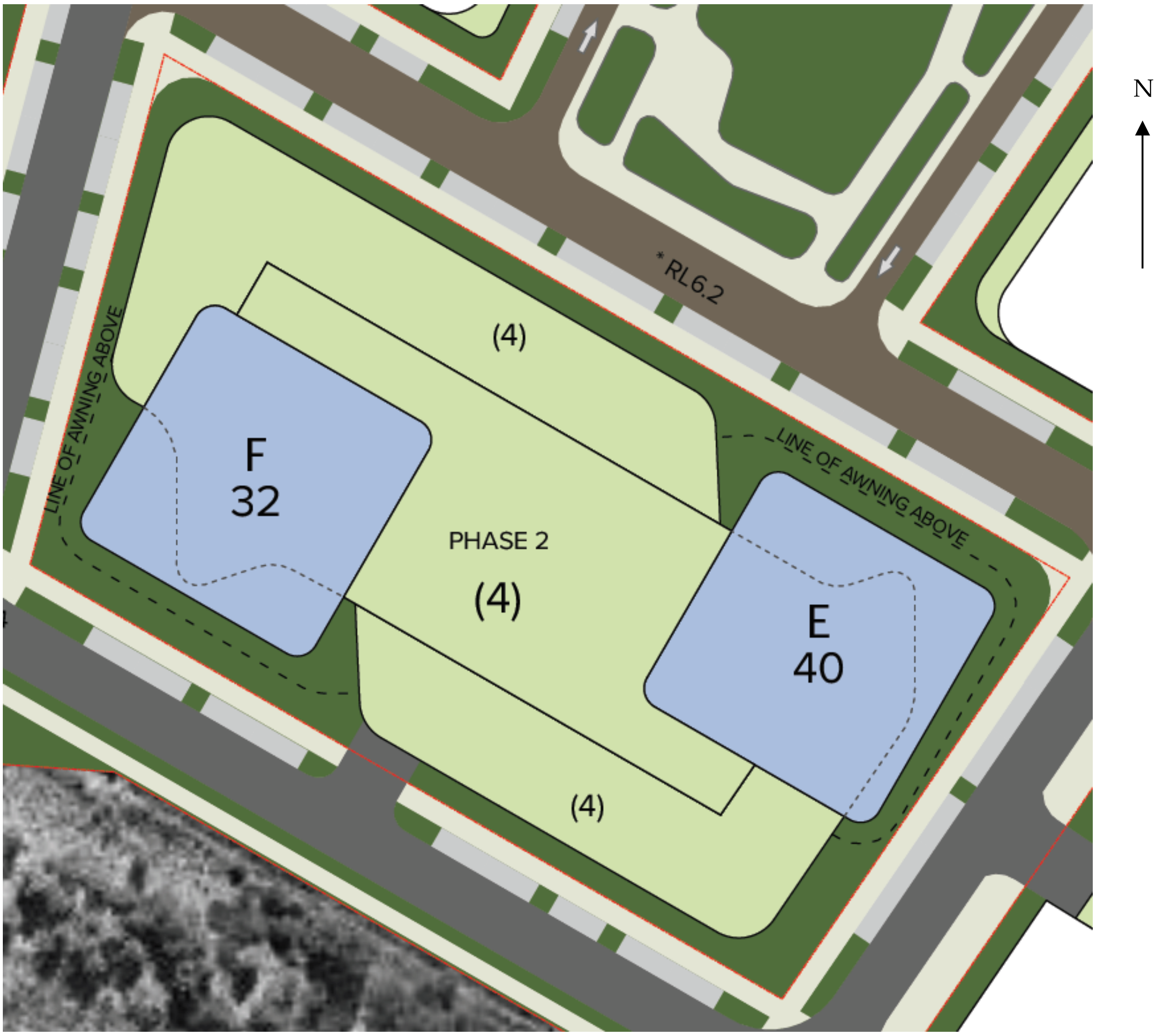


Figure 6: Block 2

Winds from the south-east quadrant will impinge obliquely on the facades of the two towers, which will help to limit downwash on the ground plane. Similarly, the alignment of the towers will encourage winds from the west to traverse the facades horizontally rather than generating vertical flow. The inclusion of large horizontal awnings around the base of each tower as indicated in Figure 6 will be effective in limiting the impacts of the towers on pedestrian locations. Some incoming flow may be compressed into the undercroft features at the east and west of the block and accelerate across these corners. (see Appendix A). Although the effects are not expected to be severe, it would be suggested to ensure entrances or seating areas in these locations are recessed from these flow paths or protected by vertical screening or landscaping elements. The presence of the two towers is likely to slightly increase wind speeds on the pedestrian footpaths in their vicinity, though these areas will be suitable for their intended use.

As the towers are relatively closely spaced, there is potential for channelled flow in the area between them, which will combine with downwash effects to produce relatively strong velocities on the podium roof. This area will also be susceptible to stronger breezes at an elevated height and is expected to experience windy conditions. If the area is to be used as a recreation or leisure space, it would be recommended to provide horizontal awnings or canopies around the tower bases, as well as distributed landscaping and localised screening across the podium roof.

Block 3- Buildings G-J

The south-western section of the masterplan consists of three low-rise and a single tower, connected by townhouses on three sides and arranged around a raised central courtyard.

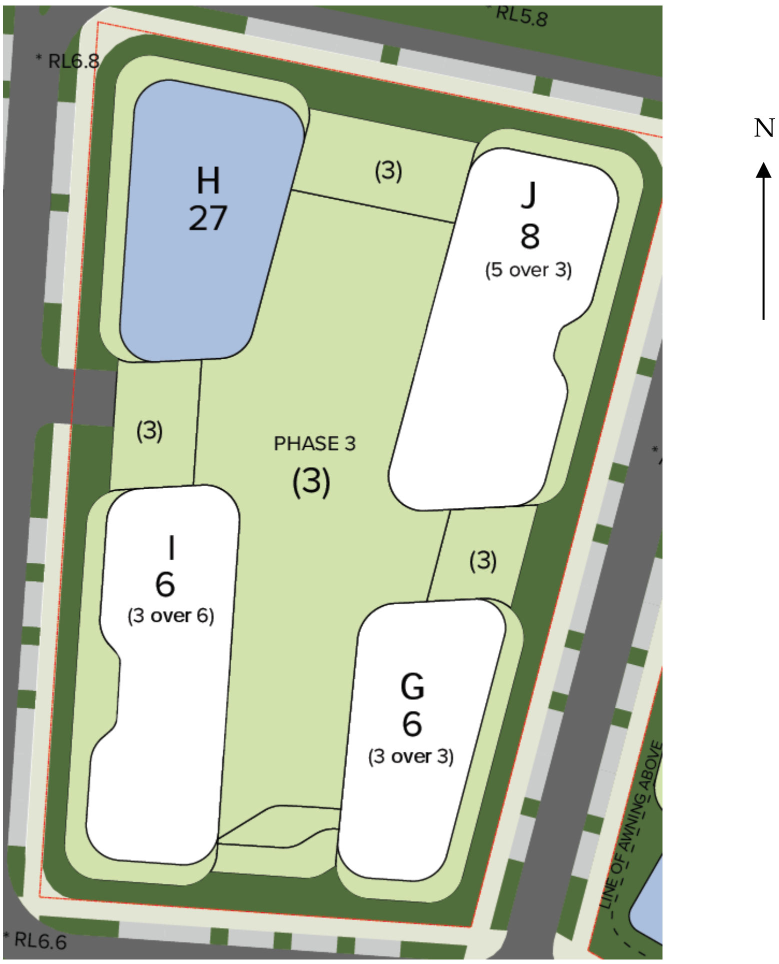


Figure 7: Block 3

Much of block 3 is generally shielded from winds from the south east and east by the massing of the masterplan. The general orientation and arrangement of neighbouring buildings will encourage flow from the south-east to pass to the south of buildings G and I, producing slightly stronger conditions along this frontage and across the south-west corner of the block. The remainder of outdoor areas would experience mostly calm conditions during winds from this quadrant.

Winds from the west will impinge on the broad sides of buildings I and H, generating slightly stronger velocities at the windward corners of the block. This effect will be exacerbated by downwash from the taller tower, which will most strongly affect the north-west corner of the block. The setback of the upper levels from the podium edge will minimise the impact to ground level, and conditions would be suitable for pedestrian walking around the perimeter of the block. The internal courtyard will experience calm conditions during winds from the west, as will locations along the eastern perimeter. The southern edge of the block is reasonably exposed to winds from the west, and landscaping or screening elements to protect entrances would be suggested here.

Block 4 - Building K-M

The north-west corner of the masterplan is occupied by a similar quadrilateral arrangement of a single tower and three lower buildings around a raised courtyard.

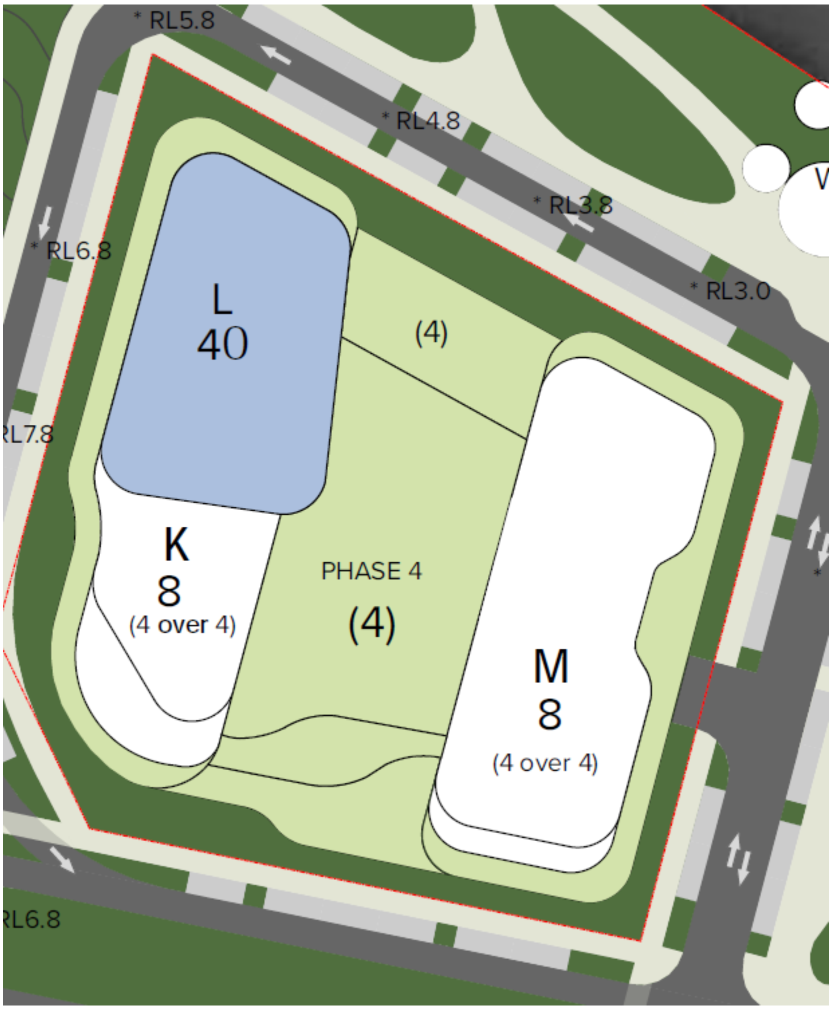


Figure 8: Block 4

Winds from the south-east will be attenuated by the general massing of the precinct, slightly reducing wind impacts for this area. The setback of the larger buildings from the podium edge and from the podium to pedestrian footpaths will minimise any wind impacts. As with other areas of the masterplan, it would be recommended to avoid placing entrances near building corners, and provide overhead protection to locations intended for frequent occupation.

Some flow will be channelled to the south of block 4 during winds from the west. Mitigation in the form of landscaping and planting would be recommended to improve conditions, though more permanent screening would likely be required if long-term stationary activity is intended along this corridor. The courtyard area is expected to experience mostly calm conditions for most of the time. The area to the north of the block is expected to experience relatively strong winds, being exposed to the open region of the Parramatta River, though similar conditions are likely to currently exist.

Block 5 – Buildings N-P, Neighbourhood Green and Community Facilities

Block 5 is nested within the masterplan on the northern side, and consists of medium rise buildings with parkland between and to the north.

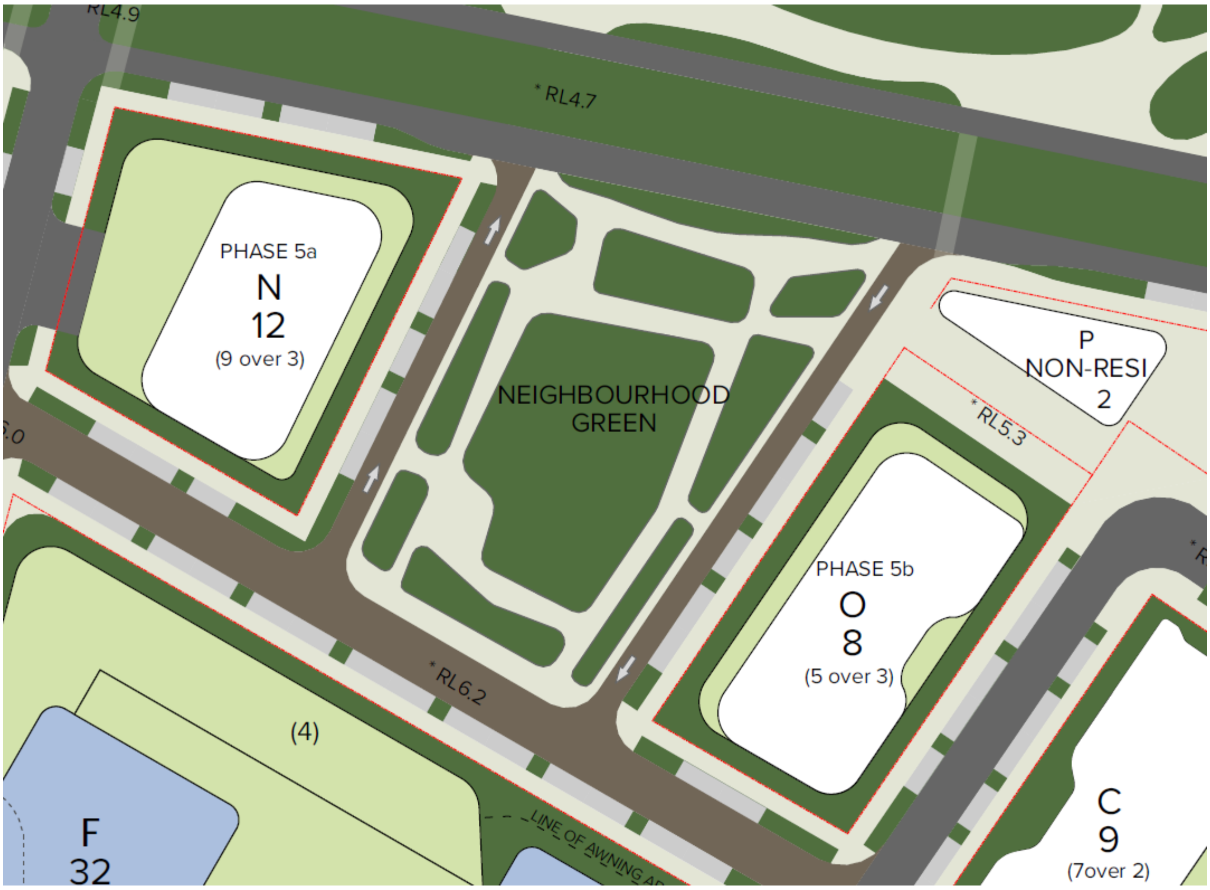


Figure 9: Block 5

The location and size of the buildings in this region relative to the surrounding masterplan will allow for reasonably amenable wind conditions. Some flow would be expected to channel between Buildings O and E during winds from the south-east, and between buildings O and C during wind from the south. This will promote slightly higher velocities at the southern end of Building O, though conditions are likely to remain acceptable for a public accessway.

The moderate channelling effect between blocks 3 and 4 channelled winds will contribute to slightly stronger conditions at the north-east of building N. Some local amelioration would likely be necessary if long-term stationary or outdoor dining activities are intended at this location, though conditions are expected to be suitable for a pedestrian thoroughfare. Similar advice would apply across the whole block, as adjacent areas in several directions are mostly free of obstructions.

Block 6 – Buildings Q-R

At the north-east corner of the site is a 40-storey tower, building R, linked to building Q by a 2-storey podium.

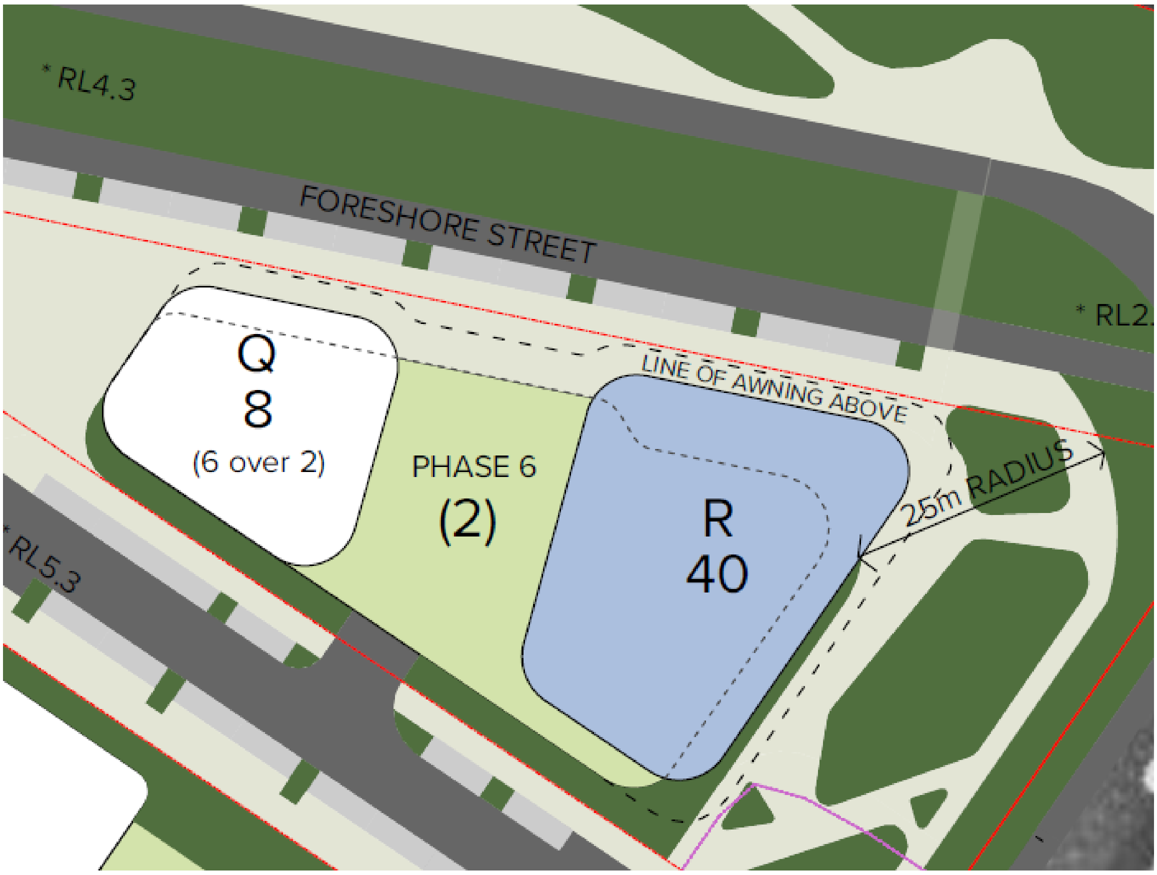


Figure 10: Block 6

The broad side of Building R is oriented normal to incoming wind from the south-east, and a significant proportion of flow will be directed towards the ground, generating relatively strong wind speeds at the tower base. The colonnade and overhead awning along the eastern side of Building R will provide protection to pedestrians. Some flow through the undercut north-eastern corner would still be expected. The massing of the neighbouring buildings in block 1 will provide shielding from direct winds from the southern quadrant for some of block 6.

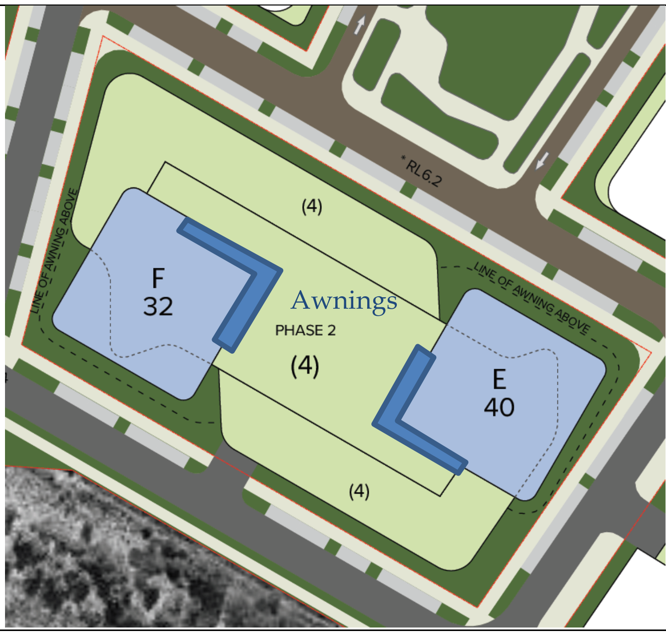
Building Q is not expected to significantly affect wind conditions in the areas around it.

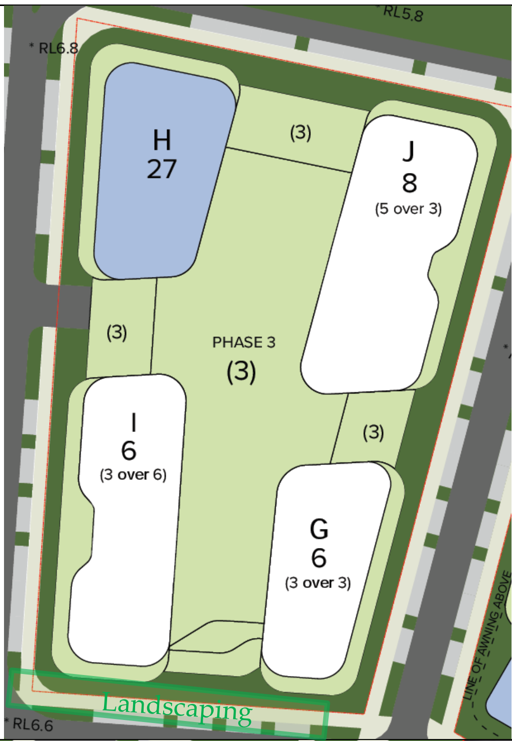
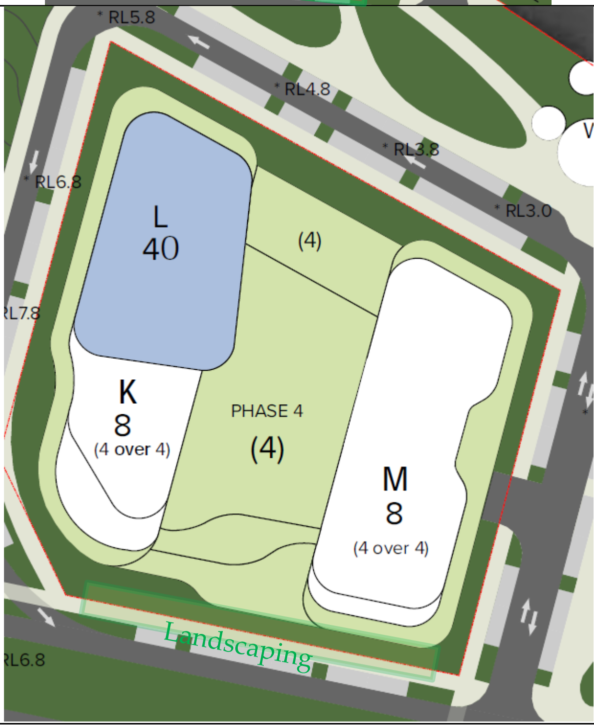
Downwash from Building R would be expected to affect the podium roof during winds from the west, though the ground plane area will be protected by the street level awning. The podium area would also experience strong conditions, and protection in the form of an awning at the base of the tower would be suggested as well as distributed landscaping and localised screening.

Summary

Estimated Lawson comfort ratings and suggested amelioration treatments for each block are summarised in Table 1. Recommendations for mitigation measures should be treated as generic indications of location and extent, rather than as a design solution. Other approaches for mitigation may be preferred depending on location and surrounds, for example, a colonnade or undercroft instead of an awning. Architectural solutions for wind mitigation are dictated primarily by the intended use of particular spaces and may be developed in detailed design stages.

Table 2: Wind comfort and suggested mitigation summary

Area	Expected Lawson Comfort Rating	Recommendations	Diagram
Block 1	Pedestrian Walking around perimeter and in narrow areas between buildings. Pedestrian Standing for most locations in internal courtyard	See Cermak Peterka Petersen (2017)	
Block 2	Pedestrian Walking around perimeter, Pedestrian Walking to Business Walking near base of towers.	Awnings, Landscaping/planting between towers. Recess entries for provide screening to undercroft areas	

Block 3	Pedestrian walking near north-west and south-west corners. Pedestrian Standing elsewhere.	Landscaping along southern perimeter	
Block 4	Pedestrian Walking to Business Walking along southern edge and at base of Building L. Pedestrian Standing to Pedestrian Walking elsewhere	Landscaping along southern perimeter of block	
Block 5	Pedestrian standing to Pedestrian Walking	None, though local screening and/or landscaping would be required for areas intended for long-term stationary or outdoor dining activities.	NA

Block 6	Pedestrian Standing to Pedestrian Walking.	None, though local treatments via landscape design would be suggested for the north-west undercroft	NA

<u>Other Comments</u>

Private balconies are located throughout the development. Wind conditions within the balconies are expected to be mostly calm provided they are recessed within the façade. Balconies located on building corners or protruding from the façade are typically more exposed, and can experience strong cross flows. For exposed balconies it would be recommended to include vertical fins and/or screens, to allow calm areas to exist for a larger portion of time. Over time residents tend to learn to determine the usability of their balconies based on the seasonal weather conditions.

The inclusion of double sliding or revolving doors at entrances can assist in preventing pressure-driven flows from arising in lobbies. Furthermore, isolating the lift core from areas linked to external pressures will assist in mitigating any potential stack effect flows through tower lift cores associated with thermal and pressure stratification. Horizontal awnings are an effective means of mitigating downwash flows and preventing wind-driven rain from entering doorways. These would be recommended for locations of high foot traffic near the larger buildings, such as main entries. A number of locations have been identified where there is inadequate separation of taller towers from the ground plane. As the masterplan currently details the general massing and layout of buildings only, it is expected that these areas will be addressed during detailed design stages.

Conclusions

Cermak Peterka Petersen Pty. Ltd. has provided an opinion based assessment of the impact of the proposed development at Sanctuary, Wentworth Point, Sydney on the local wind environment. Our summary assessment of the proposed development is as follows:

In the context of the surrounding landscape and built environment, the proposed masterplan development is relatively exposed to prevailing winds, and will have some impact on the local pedestrian-level wind environment. Some locations will experience an increase in wind speeds, while others will become calmer. Most locations would be expected to experience conditions consistent with Pedestrian Standing or Pedestrian Walking comfort classification under Lawson. A number of locations would not be expected to meet the conservative 16 m/s requirement specified by the Wentworth Point DCP in either the proposed configuration or existing site. Some locations have been identified as likely to experience stronger conditions, for which amelioration measures have been suggested. The extent of these measures depends on the intended use of the space, and could be developed further in detailed design stages.

Wind tunnel testing would be necessary to quantify the advice provided herein, and for development of detailed amelioration measures.

References

NSW Department of Planning (2014), Wentworth Point Precinct Development Control Plan 2014.

Melbourne, W.H., (1978), Criteria for environmental wind conditions, *J. Industrial Aerodynamics*, **3**, 241-249.

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.

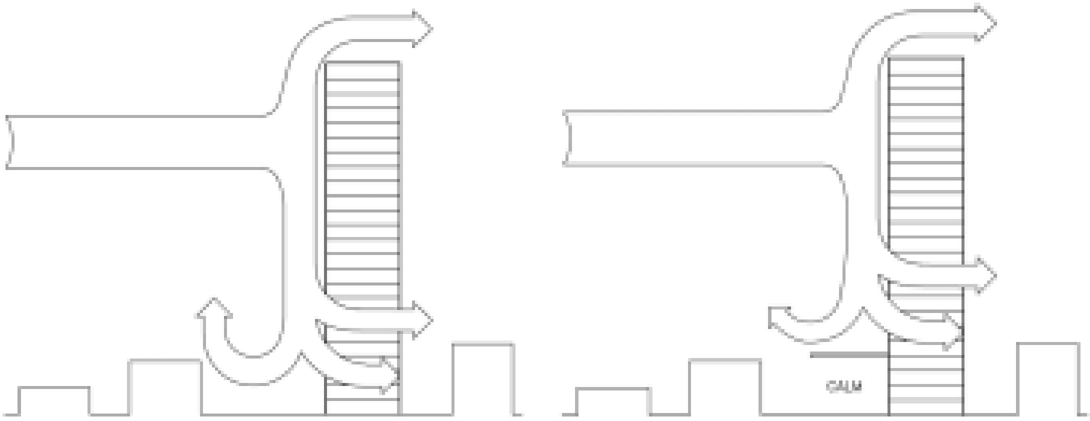
Cermak Peterka Petersen (2017), Wind Assessment for: Sanctuary, Wentworth Point. *CPP11424_Sanctuary Wentworth Point_REP_DS_R02*

Appendix A: 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 CPP Publication).

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 11. 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 major office buildings.



Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings.

A large canopy is a common solution to this pedestrian-wind problem at street level.

Figure 11: Canopy Windbreak Treatment.

Building form - Podiums

The architect may elect to use an extensive podium for the same purpose if there is sufficient land and it complies with the design mandate, Figure 12. This is a common architectural feature for many major projects in recent years, 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.

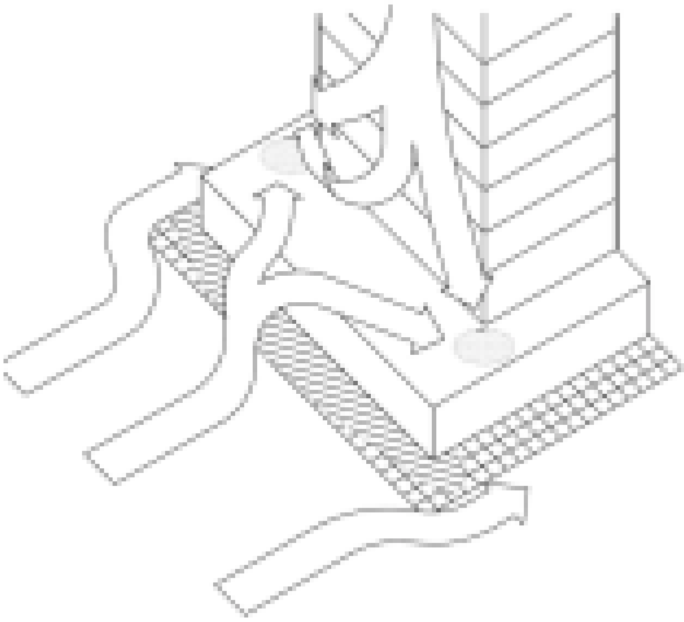


Figure 12: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

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 13. The uninvitingly windy nature of these open areas is a contributing reason behind the use of arcade airlock entrances (revolving or double sliding doors).

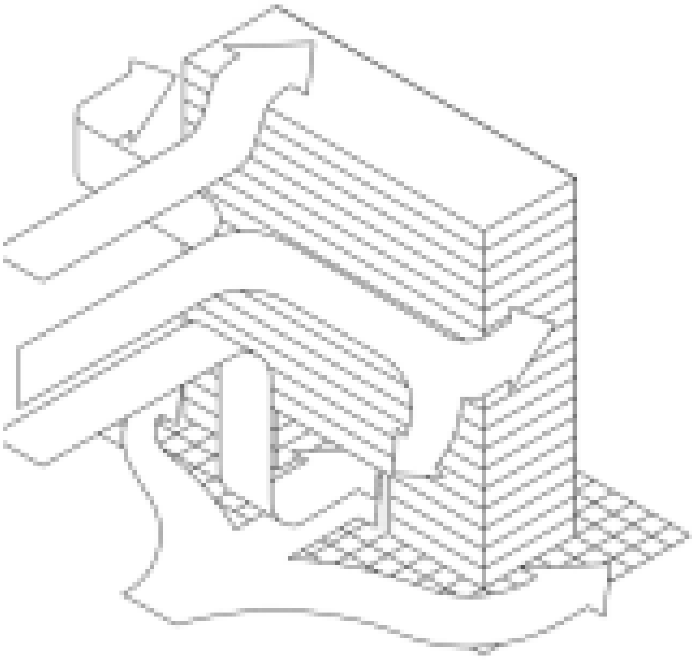
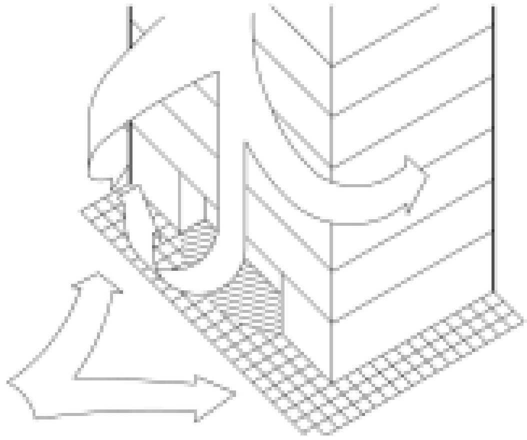


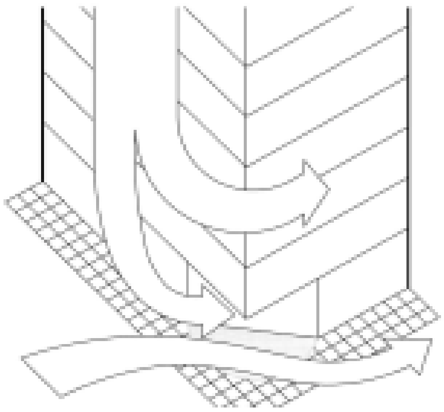
Figure 13: An arcade or open column plaza under a building frequently generates strong pedestrian wind conditions.

Building form - Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure 14. 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 14. This is due to the accelerated flow mechanism described in Figure 11and Figure 12, and the ambient directional wind statistics. If there is a strong directional wind preference (e.g., northeast, southerly or westerly winds at the site), 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.



A mid-building alcove entrance usually results in an inviting and calm location.



Accelerated corner flow from downwash often yields an unpleasant entrance area.

Figure 14: Alcove Windbreak Treatment.

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 12. 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 (Rouse, 1950). These physical changes to the pedestrian areas are most easily evaluated by a model study in a boundary-layer wind tunnel.