WIND IMPACT ASSESSMENT REPORT

APPENDIX K

Sydney Metro City & Southwest:
Crows Nest
Over Station Development

Wind Impact Assessment Report

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Amendment Record

Changes made to this document since its last revision, which affect its scope or sense, are marked in the right margin by a vertical bar (|).

Date	Rev	Amendment Description	By
	A	*Draft*	*Kevin Peddie*
	B	*Updated in response to Sydney Metro comments*	*Kevin Peddie*
21/10/19	*0*	*Final draft*	*Kevin Peddie*
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Executive Summary

RWDI Anemos Ltd. (RWDI) have been instructed by Sydney Metro to undertake a review of Appendix U - Wind Impact Assessment Report (prepared by Metron) as exhibited with the Crows Nest SSD Application. Following exhibition, Sydney Metro are proposing an amended scheme to address issues raised during exhibition.

The bulk form massing changes between the Exhibited SSD OSD Design and Amended SSD OSD Design are primarily limited to Site A. The Exhibited SSD OSD Design featured two towers atop a large podium, whereas the Amended SSD OSD Design features a single form which steps upwards from southeast to northwest.

A review of the Amended SSD OSD Design scheme with regards to the potential wind impacts to the surrounding areas, with comparison to the Exhibited SSD OSD Design noted that while the single tower form over Site A is expected to increase the potential wind impact along Pacific Highway frontage, the built form measures including articulated façade, awning details, porous carpark facade and stepped southern aspect will result in minimal difference to the noted conditions. Furthermore, the noted stepped southern aspect of Site A adjacent to Hume Street and setback on is expected to improve conditions on Hume Street compared to the exhibited design due to the increased built form separation between the two sites.

The Amended SSD OSD Design of Site B and C is noted to be largely the same in the overall built form. The design for Site B has incorporated a setback at the podium level while also incorporating the carpark levels at this location, which will largely benefit the potential downwash effects. Site C, while largely unchanged in the bulk massing, has integrated porous recessed terrace areas which will assist in breaking up the southerly and north-easterly winds to the street level.

The Amended SSD OSD Design for the Crows Nest Over Station Development is expected to provide similar or improved wind conditions to the surrounding areas compared to the Exhibited SSD OSD Design scheme previously submitted.

1.0 Introduction

1.1 Purpose of this report

This report supports the Response to Submissions Report (Submissions Report) for the concept State Significant Development application (concept SSD Application) submitted to the Department of Planning, Industry and Environment (DPIE) pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act.

Sydney Metro is seeking to secure concept approval for a mixed use development comprising three buildings above the Crows Nest Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for building envelopes and land uses, maximum building heights, maximum gross floor areas, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of the development.

The station and public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by DPIE on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for commercial premises and residential accommodation with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). The development is, therefore, State significant development for the purposes of Section 4.36 of the EP&A Act.

A Wind Impact Assessment Report (2018) was prepared as Appendix U of the Environmental Impact Statement for the concept SSD Application to specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued on 26 September 2018. Following Exhibition of the Environmental Impact Statement, the design of the OSD has responded to issues raised in submissions. The purpose of this report is to identify those changes in the Amended OSD Scheme and to assess the impacts of changes with regards to wind.

1.2 Changes between the Exhibited Scheme and Amended Scheme

In response to the submissions made on the Exhibited Scheme, the following changes have been made to the concept SSD Application under what is termed the Amended Scheme:

- Changes to the building envelope
- Changes in proposed land use on each site
- Reduction in car parking numbers
- Inclusion of an articulation zone
- Clarification on the provision of social infrastructure

- Amendments to the Design Guidelines

These changes are described in further detail in Chapter 7 of the Submissions Report. The western elevation of the Amended Scheme is shown below, with a summary of the changes between the Exhibited Scheme and Amended Scheme provided in the table below.

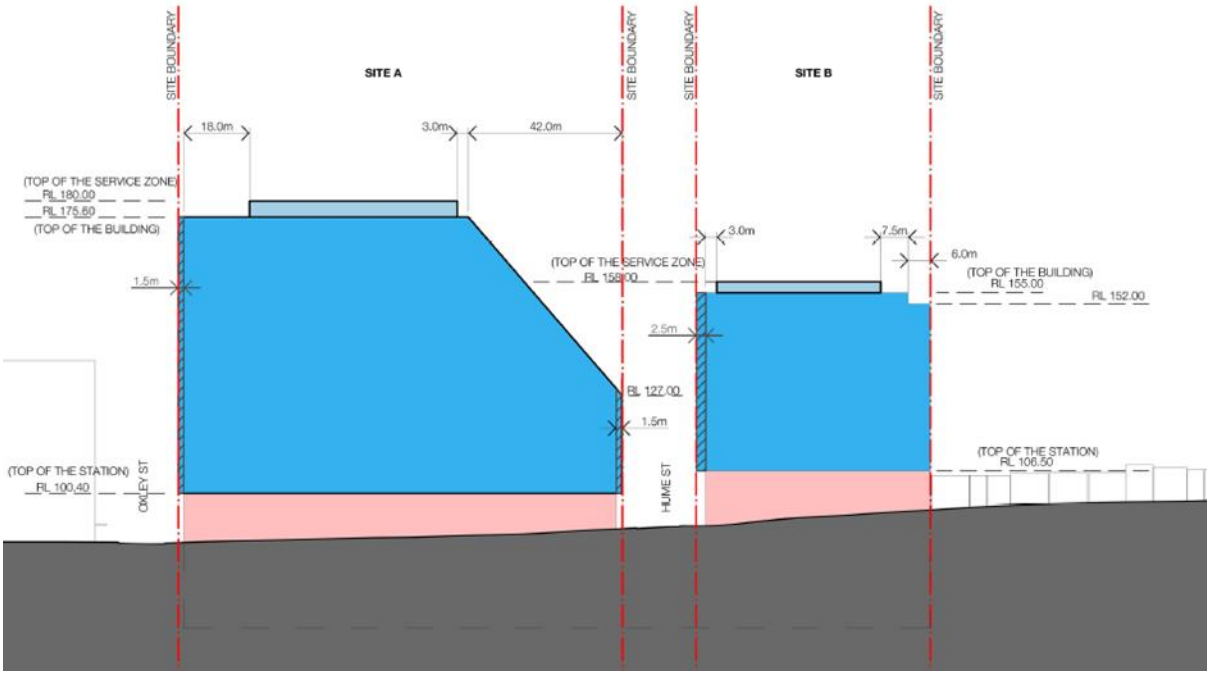


Figure 1 – West elevation of the building envelope under the Amended Scheme, showing CSSI Approval (pink) and OSD components (blue)

Table 1: Changes to overall concept scheme per site under the Exhibited Scheme and Amended Scheme (excluding station GFA)

	Exhibited Scheme[1]	Amended Scheme[1]
Site A		
Land Use	Residential[2]	Commercial
GFA	37,500m^2	40,207m^2
Max height – top of roof (RL)	183	175.6
Max height – top of services zone (RL)	188	180
FSR - OSD	9.67:1	10.4:1
Non-residential FSR - OSD	0.7:1	10.4:1
Car parking	125	46
Site B		
Land Use	Tourist / visitor accommodation	Residential
Max height – top of roof (RL)	155	155
Max height – top of services zone (RL)	158	158
GFA	15,200m^2	12,685m^2
FSR - OSD	8.12:1	6.8:1
Non-residential FSR - OSD	8.12:1	0.1:1
Car parking	25	55
Site C		
Land Use	Commercial[2]	Commercial
Max height – top of roof (RL)	127	127
Max height – top of services zone (RL)	132	132
GFA	2,700m^2	3,031m^2
FSR – OSD	4.44:1	4.9:1
Non-residential FSR - OSD	4.44:1	4.9:1
Car parking	0	0

[1] GFA figures exclude GFA attributable to the station and station retail space approved under the CSSI approval
[2] The Exhibited Scheme included a provisional option for social infrastructure GFA to be located on Site A or Site C inclusive of the GFA figures nominated above.

The revised concept SSD Application (SSD-9579) under the Amended Scheme seeks approval for the following:

- Maximum building envelopes for Sites A, B and C, including street wall heights and setbacks as illustrated in the plans prepared by Crows Nest Design Consortium for Sydney Metro at Appendix A to the Submissions Report
- Maximum building heights:
  - **Site A:** RL 175.60 metres or equivalent of 21 storeys (includes two station levels and conceptual OSD space in the podium approved under the CSSI Approval)
  - **Site B:** RL 155 metres or equivalent of 17 storeys (includes two station levels and conceptual OSD space approved under the CSSI Approval)
  - **Site C:** RL 127 metres or 9 storeys (includes two station levels and conceptual OSD space approved under the CSSI Approval).

***Note 1**: the maximum building heights defined above are measured to the top of the roof slab and exclude building parapets which will be resolved as part of future detailed SSD Application(s)*

- Maximum height for a building services zone on top of each building to accommodate lift overruns, rooftop plant and services:
  - **Site A:** RL 180 or 4.4 metres
  - **Site B:** RL 158 or 3 metres
  - **Site C:** RL 132 or 5 metres.

***Note 1**: the use of the space within the building services zone is restricted to non-habitable floor space.*

***Note 2**: for the purposes of the concept SSD Application, the maximum height of the building envelope does not make provision for the following items, which will be resolved as part of the future detailed SSD Application(s):*

  - *Communication devices, antennae, satellite dishes, masts, flagpoles, chimneys, flues and the like, which are excluded from the calculation of building height pursuant to the standard definition in NSLEP 2013*
  - *Architectural roof features, which are subject to compliance with the provisions in Clause 5.6 of NSLEP 2013, and may exceed the maximum building height, subject to development consent.*

- Maximum gross floor area (GFA) of 56,400 square metres for the OSD comprising the following based on the proposed land uses:
  - ***Site A:** Commercial office premises - maximum 40,300 square metres*
  - ***Site B:** Residential accommodation - maximum of 13,000 square metres*
  - ***Site C:** Commercial office premises - maximum of 3,100 square metres.*

***Note:** GFA figures exclude GFA attributed to the station and station retail space approved under the CSSI Approval*

- minimum non-residential floor space for the OSD across combined Sites A, B and C of 43,505 square metres
- the use of conceptual areas associated with the OSD which have been provisioned for in the Crows Nest station box (CSSI Approval) including areas above ground level (i.e. OSD lobbies and associated spaces)
- a maximum of 101 car parking spaces on Sites A and B associated with the proposed commercial and residential uses
- modulation and expression of built forms within an articulation zone extending to the property boundary
- loading, vehicular and pedestrian access arrangements
- strategies for utilities and services provision
- strategies for managing stormwater and drainage
- a strategy for the achievement of ecological sustainable development
- a public art strategy
- indicative signage zones
- a design excellence framework
- the future subdivision of parts of the OSD footprint, if required.

2.0 Sydney Wind Climate

Meteorological data recorded at Sydney Kingsford Smith International Airport, for the period from 1995 to 2018, were used as a reference for wind conditions in the area. The annual distribution of wind frequency and directionality is shown in Figure 2a. Distributions for summer (November through April) and winter (May through October) seasons are shown in Figure 2b.

When all wind data is considered, winds are frequent from the north-northeast, northeast, south-southeast and south directions during the summer months. During the winter, winds from the west-southwest through northwest and the southerly directions. Strong winds of a mean speed greater than 30 km/h measured at the airports (at an anemometer height of 10 m) occur more often in the summer (10.6%) than in the winter (8.0%). During both seasons, strong winds from the southerly direction are predominant. Winds from these directions could potentially be the source of uncomfortable or even severe wind conditions, depending on the site exposure or development design. The analysis methods have accounted for this and all winds directions.

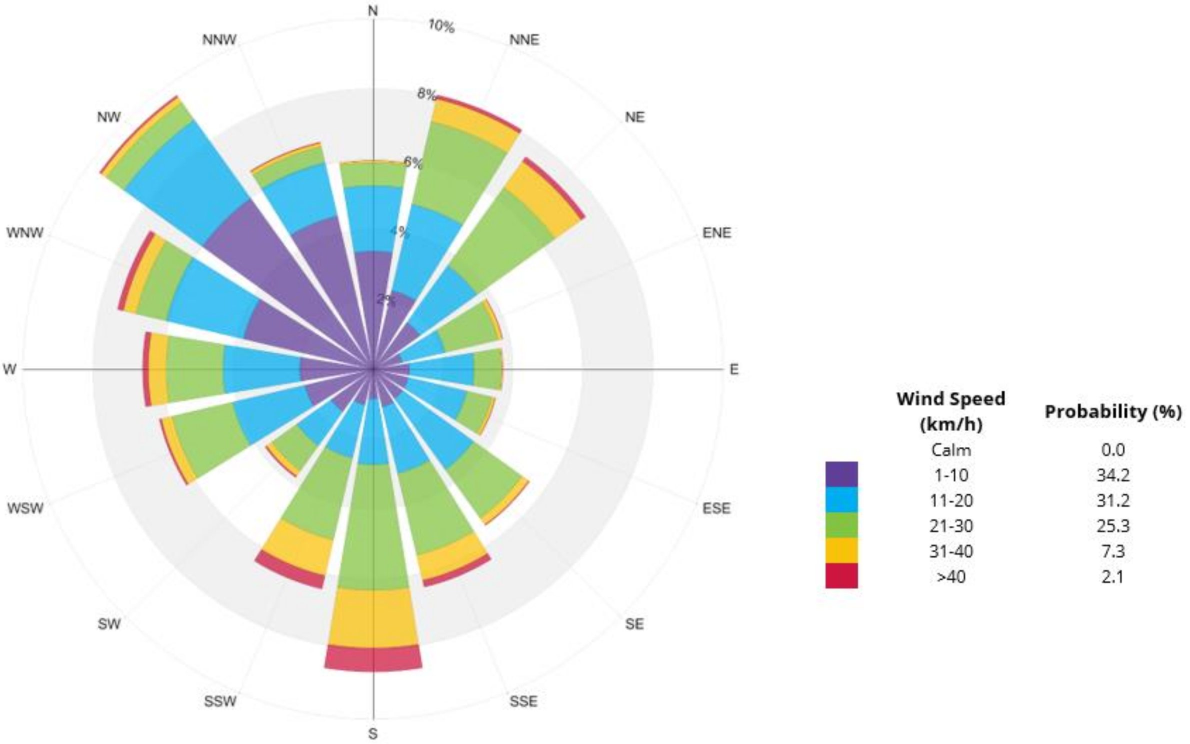


Figure 2a: Directional distribution of annual winds approaching Sydney Airport (1995-2018)

Figure 2b: Directional distribution of seasonal winds approaching Sydney Airport (1995-2018)

3.0 Environmental Wind Speed Criteria

The RWDI pedestrian wind comfort criteria, which has been developed by RWDI through research and consulting practice since 1974, are used in the current study. These criteria have been widely accepted by municipal authorities as well as by the building design and city planning community. They are somewhat subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can affect a person’s perception of the wind climate. Therefore, comparisons of wind speeds for the existing and proposed building configurations are the most objective way in assessing local pedestrian wind conditions. In general, the combined effect of mean and gust speeds on pedestrian comfort can be quantified by a Gust Equivalent Mean (GEM). Safety criteria reference the Australasian Wind Engineering Society (AWES) recommended criteria. These are summarised in Table 2.

Table 2: Pedestrian wind criteria

Comfort Category	GEM Speed (km/h)	Description
Sitting	< 10	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away
Standing	< 14	Gentle breezes suitable for main building entrances, bus stops, and other places where pedestrians may linger
Strolling	< 17	Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park
Walking	< 20	Relatively high speeds that can be tolerated if one’s objective is to walk, run or cycle without lingering
Uncomfortable	> 20	Strong winds of this magnitude are considered a nuisance for all pedestrian activities, and wind mitigation is typically recommended

Notes:
(1) GEM speed = max (mean speed, gust speed/1.85); and
(2) GEM speeds listed above are based on a seasonal exceedance of 20% of the time between 6:00 and 23:00.

Safety Criterion	Gust Speed (km/h)	Description
Exceeded	> 83	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

Notes:
(1) Based on an annual exceedance of 9 hours or 0.1% of the time for 24 hours a day; and,
(2) Only gust speeds need to be considered in the wind safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential safety impact on pedestrians.

A few additional comments are provided below to further explain the wind criteria and their applications.

- Both mean and gust speeds can affect pedestrian comfort and their combined effect is typically quantified by a Gust Equivalent Mean (GEM) speed, with a gust factor of 1.85.
- Instead of standard four seasons, two periods of summer (November to April) and winter (May to October) are adopted in the wind analysis, because in a moderate climate such as that found in Sydney, there are distinct differences in pedestrian outdoor behaviours between these two-time periods.
- Nightly hours between midnight and 6 AM are excluded from the wind analysis for comfort since limited usage of outdoor spaces is anticipated, while wind safety analysis is conducted for a 24-hour period.
- A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.
- Only gust wind speeds need to be considered in the wind safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential safety impact on pedestrians.
- These criteria for wind forces represent average wind tolerance. They are somewhat subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can also affect people's perception of the wind climate. Comparisons of wind speeds for different building configurations are the most objective way in assessing local pedestrian wind conditions.

The criteria used in the Appendix U - Wind Impact Assessment Report for the Exhibited SSD OSD were the Lawson Criteria, which are based on a 5% exceedance, whereas the RWDI criteria are based on a 20% exceedance (e.g., one day of five). RWDI's consulting practice has demonstrated this to be more relatable than the 5% from Lawson, as are the use of km/hr as opposed to m/s. The criteria are largely similar when converted to common frequency of return and mean wind velocity, which is shown in the 1998 paper by Soligo, Irwin, Williams, and Schuyler (see Reference 5). Table 3 below shows that the RWDI criteria are very similar to, though slightly more conservative than the 1990 Lawson criteria when considered on a common frequency of return and units.

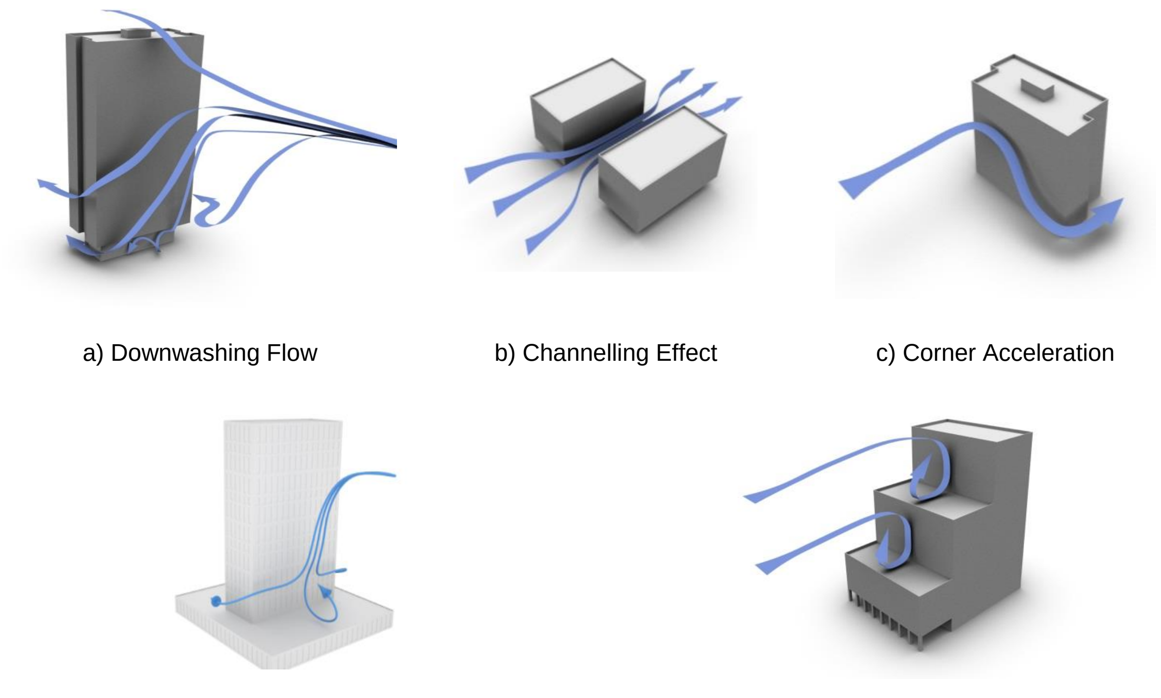
Table 3: Comparison of pedestrian wind criteria

	Pedestrian Level Wind Criteria Converted to a Common Frequency of Return (20%) and Mean Wind Velocity (km/hr)		
	Sitting 20%	Standing 20%	Walking 20%
T.V. Lawson (1990)	10.6	15.8	21.1
RWDI	10	14	20

4.0 Wind Flows Around Buildings

Tall buildings tend to intercept stronger winds at higher elevations and redirect them to the ground level. Such a Downwashing Flow (Image 3a) is the main cause for increased wind activity around tall buildings at the pedestrian level. When two buildings are situated side by side, wind flows tend to accelerate through the space between the buildings due to the Channelling Effect (3b). Oblique winds also cause wind accelerations around the exposed building corners (Image 3c). If these building/wind combinations occur for prevailing winds, there is a greater potential for increased wind activity and uncomfortable conditions.

Podium structures under towers are beneficial for wind control, as they reduce the direct impact of any downwashing winds from the towers to the grade (Image 3d). Stepping the windward façade (3e) is also a positive design strategy that can be used for wind control. However, increased wind activity will be created on the podium terraces. This review makes reference to these wind conditions when describing the anticipated wind environment.



a) Downwashing Flow

b) Channelling Effect

c) Corner Acceleration

d) Large Podium

e) Stepped Facade

Figure 3: Typical wind flow patterns

5.0 Massing Changes and Impact on Environmental Wind

The bulk form massing changes between the Exhibited SSD OSD Design and Amended SSD OSD Design are primarily limited to Site A. The Exhibited SSD OSD Design featured two towers atop a large podium, whereas the Amended SSD OSD Design features a single form which steps upwards from southeast to northwest. Comparisons of the exhibited and amended massing is shown in Figures 4 and 5.

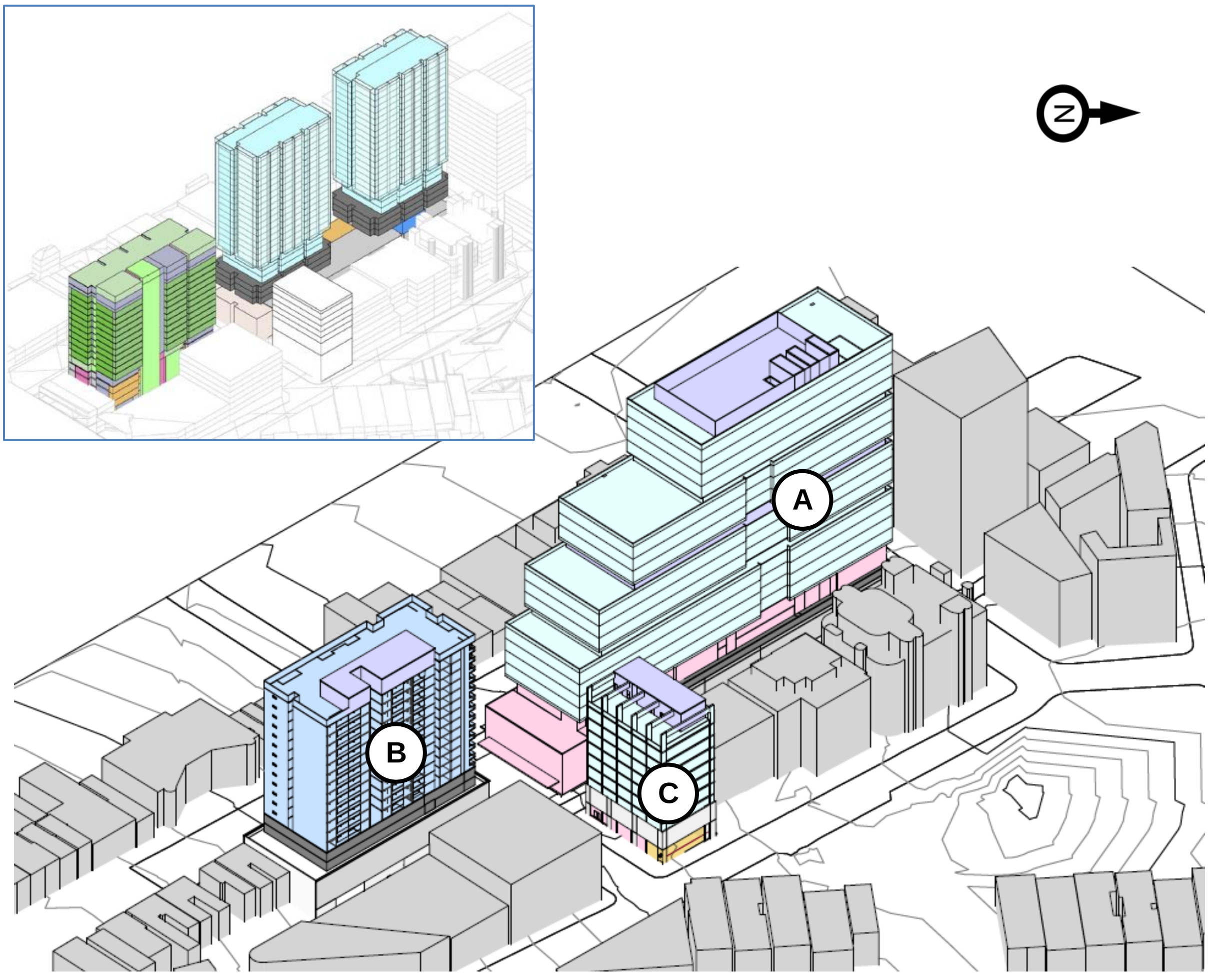


Figure 4: East View of Exhibited SSD OSD Design (top left inset) and Amended SSD OSD Design (bottom right)

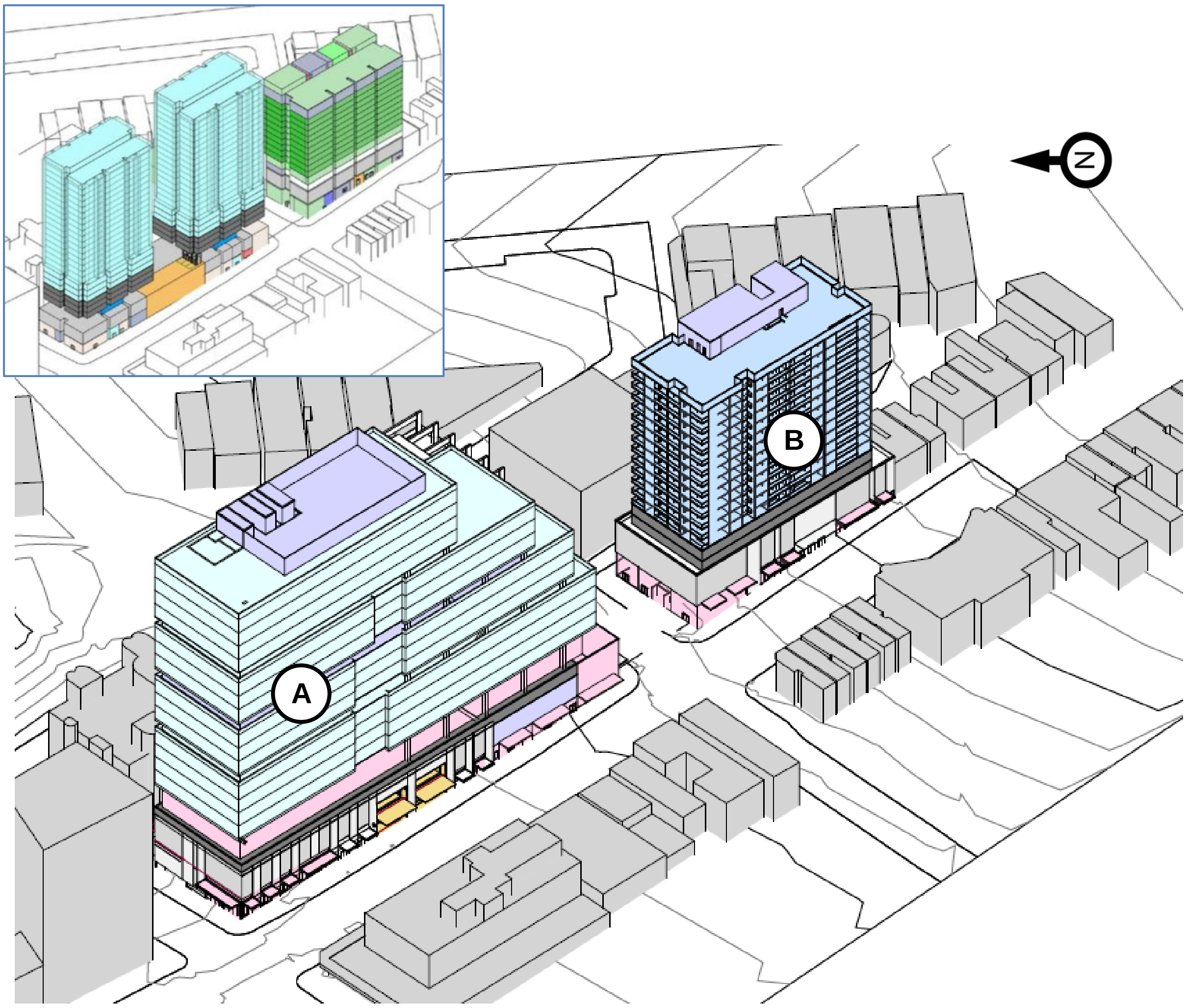


Figure 5: West View of Exhibited SSD OSD Design (top left inset) and Amended SSD OSD Design (bottom right)

Figure 6: Southern View of Amended SSD OSD design

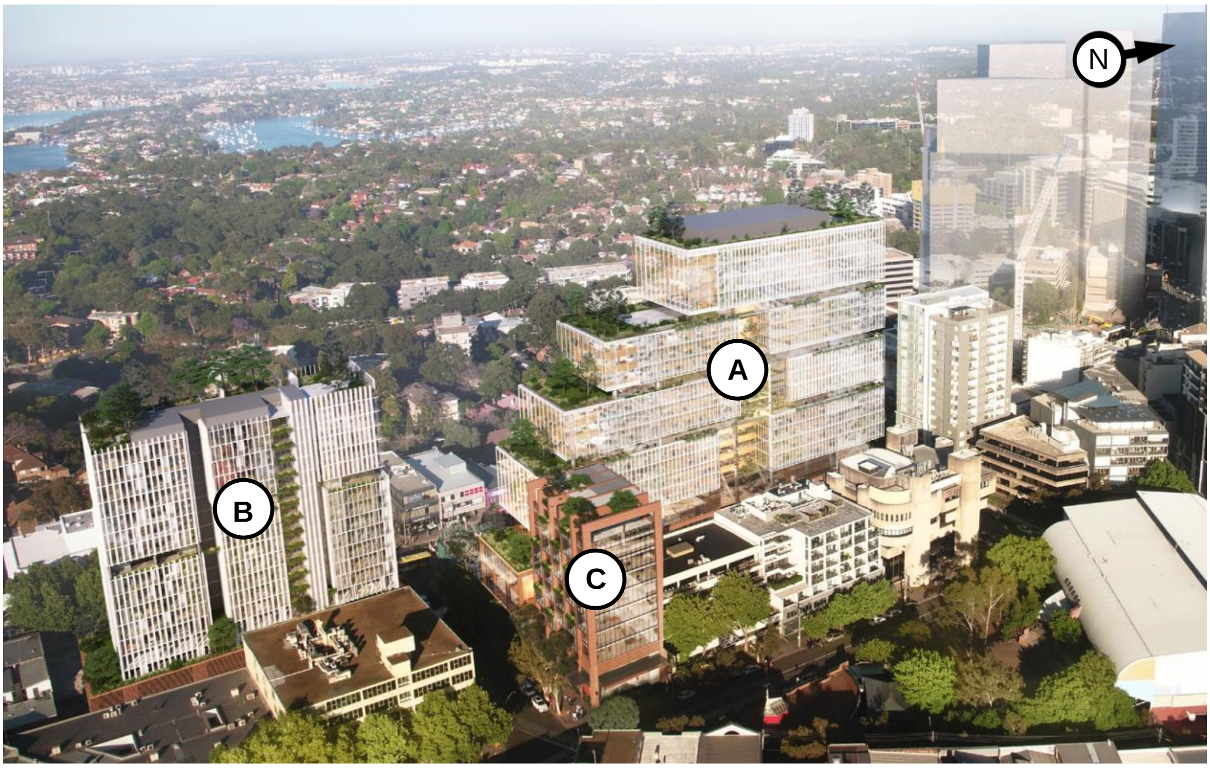


Figure 7: Eastern View of Amended SSD OSD design

The proposed changes of the Amended SSD OSD Design for the site are expected to have some impact to the pedestrian wind conditions previously outlined for the Exhibited SSD OSD Design, noted as follows:

- The joining of Site A into a single tower form is expected to increase the redirection of the westerly winds to the ground plane along the Pacific Highway. The noted awnings along the Pacific Highway, the porous façade to the carpark on Level 2 and articulated form of the western aspect will assist in breaking up these wind effects. The street trees along the Pacific Highway will be of further benefit.
- The previously noted effect of the north-easterly winds funnelling between Site A and B is expected to be reduced due to the stepped southern aspect of the built form and increased separation between Sites A and B on Hume Street.
- Clarke Lane is still expected to experience strong wind effects as noted for the Exhibited SSD OSD design, with some benefit expected from the articulated eastern façade. Uses along the laneway are noted to be predominantly for back of house on both sides of the lane, hence are not sensitive uses to wind conditions.
- Site B includes a setback at Level 2 from the podium façade on all aspects, which will assist in breaking up any downwashed winds from the Tower built form above. Furthermore, the inclusion of a porous façade to the carpark on Levels 2 and 3 will increase the benefit of the set by allowing wind to pass through these levels, while also providing natural ventilation to the carpark areas.
- Site C has increased in height by one floor, largely restricted to the northern half of the built form. The overall built form design is largely unchanged between the Existing and Amended design schemes. The Amended SSD OSD design however does incorporated façade articulation as well as porous terrace areas at the lower levels on the southern aspect. articulated design of the development. This is expected to provide further improved wind conditions over the Existing OSD SSD design by helping to breakup the southerly and north-easterly winds.
- The conditions resulting from other winds are not expected to change significantly from those anticipated with the Exhibited SSD OSD Design.

6.0 Conclusion

The bulk form massing changes noted in the Amended SSD OSD Design for the Crows Nest Over Station Development is expected to provide similar or improved wind conditions to the surrounding areas compared to the Exhibited SSD OSD Design scheme previously submitted.

A review of the Amended SSD OSD Design scheme with regards to the potential wind impacts to the surrounding areas, with comparison to the Exhibited SSD OSD Design noted that while the single tower form over Site A is expected to increase the potential wind impact along Pacific Highway frontage, the built form measures including articulated façade, awning details, porous carpark facade and stepped southern aspect will result in minimal difference to the noted conditions. Furthermore, the noted stepped southern aspect of Site A adjacent to Hume Street and the tower being set-back on the podium is expected to improve conditions on Hume Street compared to the exhibited design due to the increased built form separation between the two sites.

The Amended SSD OSD Design of Site B and C is noted to be largely the same in the overall built form. The design for Site B has incorporated a setback at the podium level while also incorporating the carpark levels at this location, which will largely benefit the potential downwash effects. Site C, while largely unchanged in the bulk massing, has integrated porous recessed terrace areas which will assist in breaking up the southerly and north-easterly winds to the street level.

Wind conditions to the surrounding areas associated with the proposed Crows Nest Over Station Development will be verified through wind tunnel modelling as the design develops to ensure that conditions are suitable for use by pedestrian around the site.

7.0 References

1) ASCE Task Committee on Outdoor Human Comfort (2004). Outdoor Human Comfort and Its Assessment, 68 pages, American Society of Civil Engineers, Reston, Virginia, USA.

2) Williams, C.J., Hunter, M.A. and Waechter, W.F. (1990). "Criteria for Assessing the Pedestrian Wind Environment," Journal of Wind Engineering and Industrial Aerodynamics, Vol.36, pp.811-815.

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4) Soligo, M.J., Irwin, P.A., and Williams, C.J. (1993). "Pedestrian Comfort Including Wind and Thermal Effects," Third Asia-Pacific Symposium on Wind Engineering, Hong Kong.

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6) Williams, C.J., Wu, H., Waechter, W.F. and Baker, H.A. (1999). "Experiences with Remedial Solutions to Control Pedestrian Wind Problems," Tenth International Conference on Wind Engineering, Copenhagen, Denmark.

7) Lawson, T.V. (1973). "Wind Environment of Buildings: A Logical Approach to the Establishment of Criteria", Report No. TVL 7321, Department of Aeronautic Engineering, University of Bristol, Bristol, England.

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11) Williams, C.J., Wu, H., Waechter, W.F. and Baker, H.A. (1999). "Experiences with Remedial Solutions to Control Pedestrian Wind Problems," Tenth International Conference on Wind Engineering, Copenhagen, Denmark.