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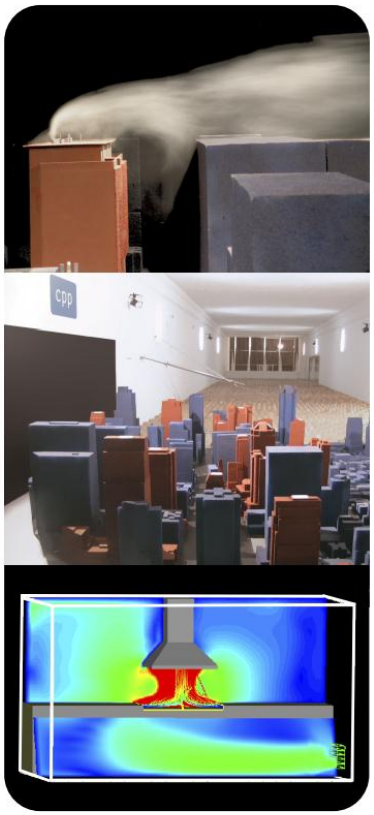
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

FINAL REPORT



Wind Impact Assessment for:
BARANGAROO SOUTH BUILDINGS R8 & R9
Sydney, NSW, Australia
CPP Project: 6847
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INTRODUCTION

Synopsis

This report supports a Project Application (MP11_0002) submitted to the Minister for Planning pursuant to Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Application seeks approval for construction of two residential flat buildings (known as Buildings R8 and R9) and associated works at Barangaroo South as described in the Overview of Proposed Development section of this report.

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease Project Management and Construction (Australia) Pty. Ltd. to provide an opinion based assessment of the impact of a proposed new development at Barangaroo South Buildings R8 & R9, Sydney, on the local pedestrian level wind environment. This work follows on from previous wind tunnel testing on the Barangaroo Masterplan and relevant extracts from the full report have been included herein.

Barangaroo is located on the north western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks, and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Central and Barangaroo South. The R8 and R9 Project Application Site area is located within Barangaroo South as shown in Figure 1. The Project Application Site extends over land generally known and identified in the approved Concept Plan as Block X.

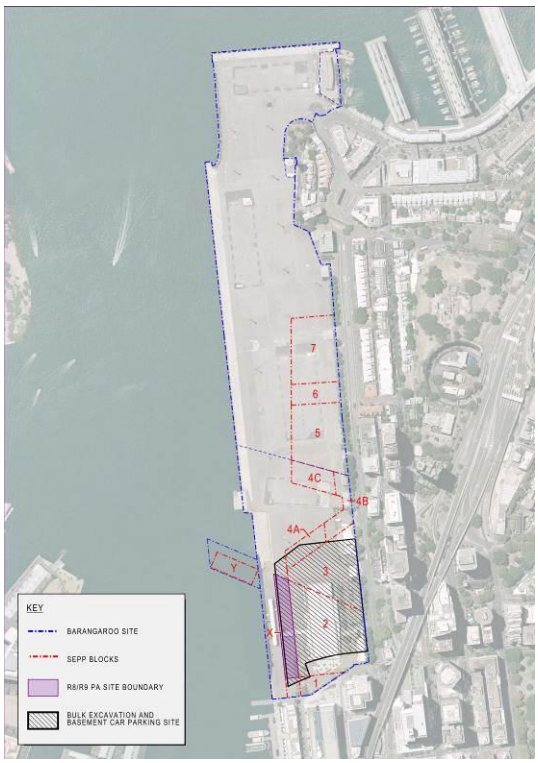


Figure 1: R8 and R9 residential building project application aerial site location plan

Sydney Wind Climate

The proposed development lies approximately 11 km to the north of Sydney Airport Bureau of Meteorology anemometer. The wind rose for the airport is shown in Figure 2 and is considered to be representative of prevailing winds at the site. It is evident that the prevailing winds from coastal Sydney come from the north-east, south, and west. Winds from the north-east tend to be summer sea breezes and bring welcome relief on summer days. Winds from the south tend to be cold and tend to be associated with frontal systems that can last several days and occur throughout the year. Winds from the west are the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year and can be cold or warm depending on the inland conditions.

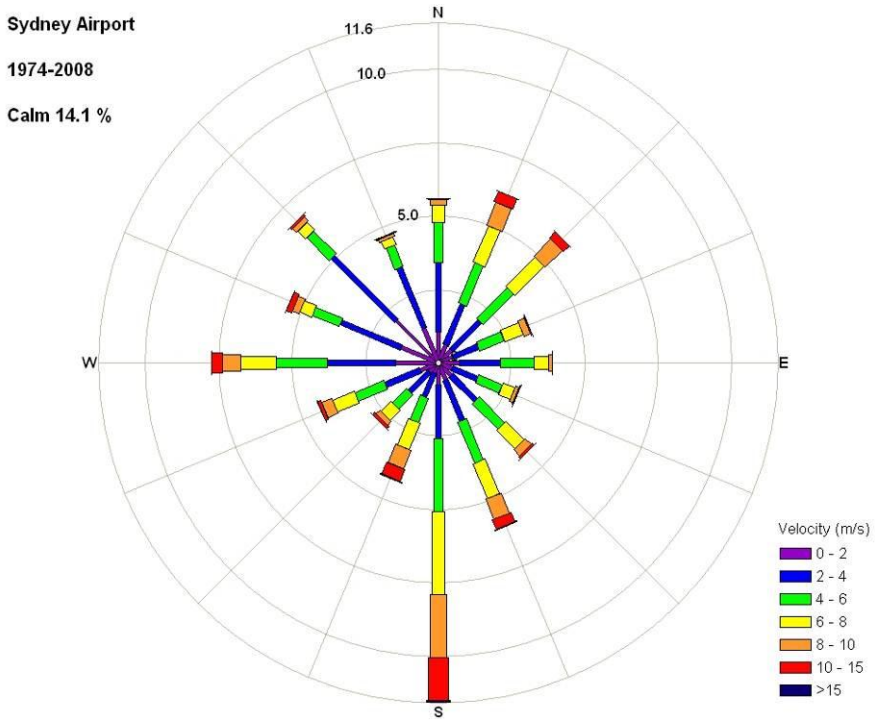


Figure 2: Wind rose for Sydney Airport

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 wind assessment criteria in the Sydney City Council development control plan (DCP) are based on the work of Melbourne (1978) and relate to a once per annum gust wind speed. These criteria yield no direct information on the mean wind climate or the percent of year that serviceability winds occur, which are of most use to town planners and architects. The wind assessment criteria used herein are those of Lawson (1990), which are 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 speed 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.

Sydney is relatively windy, with an average wind speed at 10 m reference height of approximately 4 m/s (8 kt, 14 kph), and five percent of the time the mean wind speed is in excess of 9.5 m/s (18 kt, 34 kph). Converting the five percent of the time wind speed to typical pedestrian level at the site would result in about 6.0 m/s (12 kt, 22 kph). Comparing this with the comfort criteria of Table 1 indicates that the locale would be acceptable for pedestrian walking; hence any recreational outdoor activity requires significant shielding from prevailing wind directions.

Table 1: Pedestrian comfort criteria for various activities

Comfort (maximum 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 (maximum 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 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.

Wind Flow Mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 3; this flow mechanism is called downwash and causes the windiest conditions at ground level on the windward and sides of the building. In Figure 3 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.

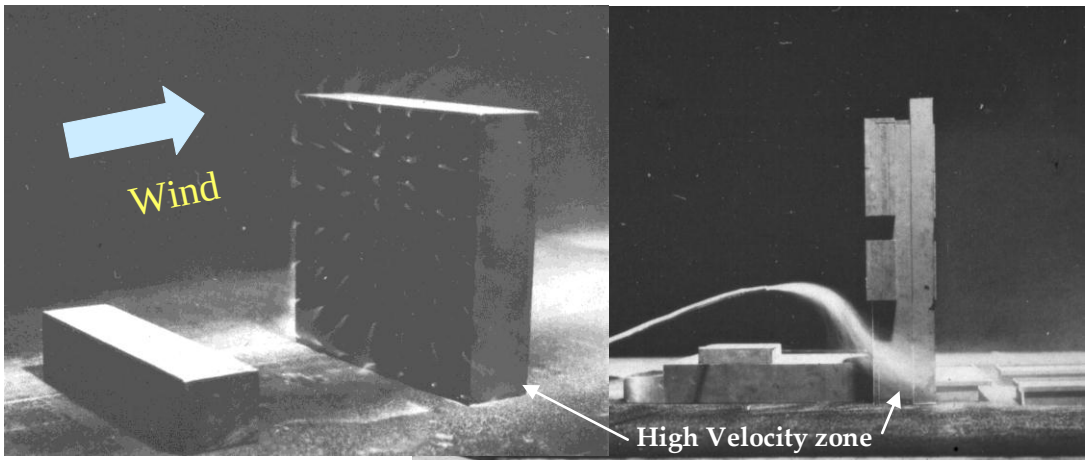


Figure 3: Flow visualisation around a tall building

ENVIRONMENTAL WIND ASSESSMENT

Barangaroo is located on the north western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks, and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants.

The R8 and R9 Project Application Site area is located within Barangaroo South as shown in Figure 1 and Figure 4. The Project Application Site extends over land generally known and identified in the approved Concept Plan as Block X. The immediate topography surrounding the site is essentially flat with the city rising to the east of the Barangaroo South site.

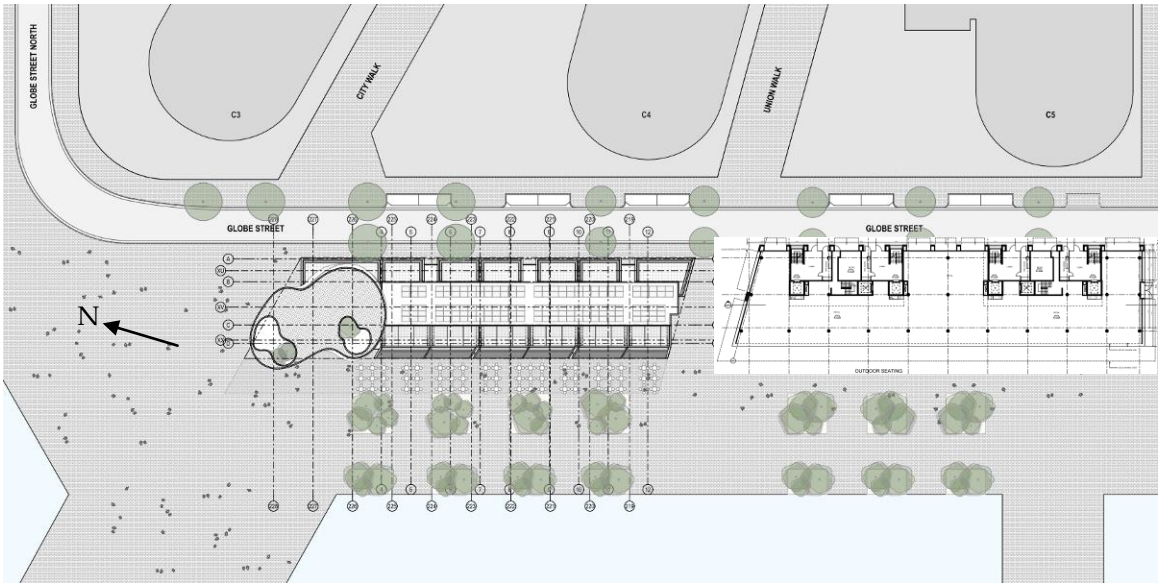


Figure 4: Ground floor plan

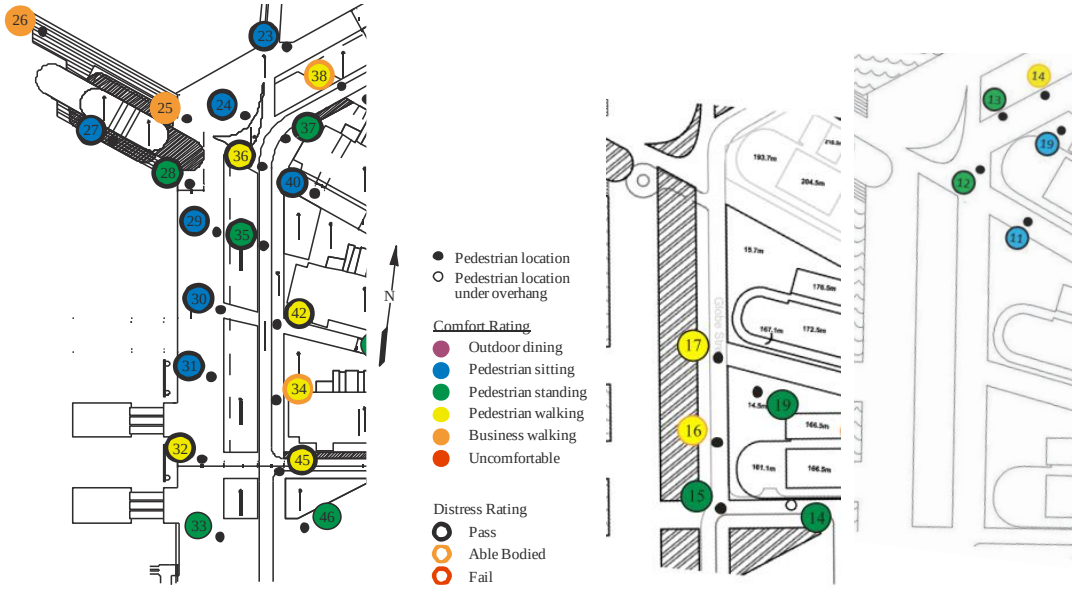
The proposed buildings R8 and R9 have a maximum height approximately 37 m above ground level, Figure 5. Wind tunnel testing has been carried out around the building in a previous Masterplan as reported in CPP report number 5362 Barangaroo Masterplan dated November 2010. Additional testing has been conducted for the application processes for buildings C3 and

C5 as the geometry of the large towers changed considerably. The results of this testing are reported in CPP reports 5362 Barangaroo Building C3 dated October 2011, and 5362 Barangaroo Building C5 dated November 2011. A photograph of the wind tunnel model and important results from the study are reproduced in Figure 6 and Figure 7 respectively. The general massing and orientation of the large towers has remained similar between the tests as has the wind climate, which is governed by these buildings. The results to the west of buildings R8 and R9 from the Masterplan tests are expected to be representative of the wind environment around buildings R8 and R9.

Figure 5: West elevation of the proposed development

a. Masterplan testing November 2010 b. C3 and C5 testing October 2011

Figure 6: Photograph of the Barangaroo model in the CPP wind tunnel



a. Masterplan November 2010 b. C5 November 2011 c. C3 October 2011

Figure 7: Pedestrian wind speed measurement locations with comfort/distress ratings

The Barangaroo South development site is exposed to prevailing winds from the south and west. The massing of the commercial towers C3, C4, and C5, and a large hotel building extending into Darling Harbour, Figure 6, significantly influences the wind climate to the north of Building R8. Being in such close proximity to these significantly larger buildings, Buildings R8 and R9 will only influence the wind environment in the immediate vicinity.

It is evident from Figure 7 that the wind climate around the site is acceptable for use as a main public accessway and meets the distress criterion at all close locations except for the area on Globe Street to the east of building R9. The wind climate at this location is dictated by the massing of building C5 during winds from the south quadrant. The wind environment along the west site of the Buildings R8 and R9 is suitable for pedestrian sitting, and is expected to be similar to the wind environment in the King Street Wharf precinct to the south.

Winds from the north-east tend to be lifted over the buildings, due to the orientation of the street grid in the city, with a component being locally directed along the streets based on the dominant larger buildings. The massing of the city and topography to the east of the site offers significant protection to Barangaroo South, hence the wind environment is expected to be suitable for use as a main pedestrian accessway and meet the walking criterion.

Winds from the south are currently channelled along Kent, Shelley and Lime Streets by the taller CBD buildings to the south. The large commercial building C5 to the south of Barangaroo South generates a significant amount of downwash, which is directed along Globe Street. Building C5 is the primary reason for the windy conditions measured along Globe Street. The foreshore is protected from the downwash winds by Buildings R8 and R9, however the rooftop terraces of R9, Figure 8, will correspondingly experience windy conditions. The provision of awnings along the Globe Street frontage of buildings R8 and R9 will offer protection to pedestrians at ground level. The provision of the solar array on R9 will offer some protection to users under these elements.

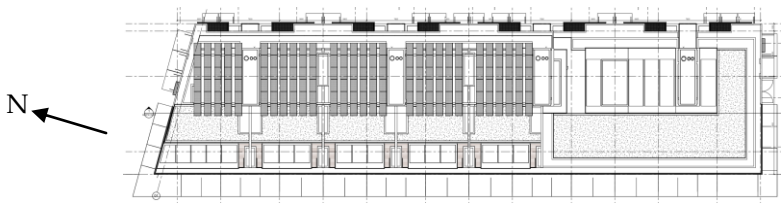


Figure 8: Building R9 rooftop terrace floor plan

Winds from the west are currently channelled and accelerated up the rises of Margaret and Erskine Streets. The inclusion and orientation of building R8 and R9 will offer protection to the outdoor seating areas to the west of the buildings as the flow will slow on approach to the buildings, before accelerating over the roof and around the building corners creating slightly windier conditions. However, the presence of the larger towers to the east and the hotel to the west will continue to dominate the wind environment. The hotel to the west and building C3 produce significant downwash generating windy conditions to the north of Building R8, Figure 7. This area is classified for pedestrian walking and meets the distress criterion. During winds from the west, wind conditions around the site are expected to be suitable for pedestrian standing activities. The accelerated flow over the roof will create windy conditions on the rooftop terrace of Building R9.

Due to the location of the proposed buildings in the Barangaroo South precinct, the proposed developments will assist in producing an acceptable wind environment along the Darling Harbour foreshore. As with the King Street Wharf precinct to the south, this foreshore area will

be suitable for pedestrian sitting activities. Wind conditions along Globe Street are expected to be windy, but this is primarily due to commercial tower C5. The provision of awnings and landscaping along Globe Street will assist in providing a wind environment suitable for pedestrian walking activities.

The rooftop terrace of Building R9, Figure 8, is exposed to accelerated flow from most wind directions. It is considered that specific locations on the rooftop terrace would be suitable for pedestrian sitting activities for about 60% of time. For specific wind directions, the articulation and accessibility of the space means that small calmer areas would be generated regardless of wind direction without additional amelioration measures. The inclusion of additional vertical or horizontal screening elements would evidently increase potential for calmer areas on the terrace for certain wind directions. Terrace users would soon understand the local wind environmental conditions and use the space accordingly.

CONCLUSIONS

Cermak Peterka Petersen Pty. Ltd. has provided an opinion based assessment of the impact of the proposed Barangaroo South Buildings R8 & R9 development on the local wind environment. These buildings are significantly smaller and from a wind perspective sit within the wind climate generated by the larger commercial towers on the site. The wind conditions around the development are expected to be suitable for use as a main public accessway.

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.

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