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By email
20 September 2022

DPT Operator Pty. Ltd. and DPPT Operator Pty. Ltd.
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Our ref 284908-27

Dear Mark,

Cockle Bay Park Redevelopment– Environmental Wind Conditions

Further to our recent discussions, please find herein a brief report on the environmental wind conditions for pedestrian safety and comfort in and around the proposed Cockle Bay Park redevelopment precinct.

The summary wind conditions were reported in Arup (2021). Testing was completed without planting or landscaping elements that cannot be relied on in an extreme event thereby presenting the worst-case scenario. All locations meet the pedestrian walking comfort criterion, which meets the accessibility requirements for the space.

Whist there is full compliance with the internationally recognised Australasian Wind Engineering Society (2014) and Lawson (1990) wind criterion for pedestrian safety, three locations in the open area to the north of the site slightly exceed the City of Sydney (2016) wind safety criterion. These measurement locations are representative of the wind conditions over a larger area. During strong wind events only the walkways across the open parkland would be used by pedestrians. It is expected that the wind conditions across the open parkland could be locally improved with the inclusion of structural or landscaping elements. For example, the provision of horizontal canopies over the pedestrian walkways would provide significant local wind, rain, and solar protection to pedestrians. Due to the relatively minor exceedances of the safety criterion, such amelioration would be expected to offer sufficient protection to the pedestrian thoroughfares to pass the City of Sydney safety criterion. Further wind tunnel testing would be undertaken prior to the issue of the relevant Construction Certificate to confirm that as safe a wind environment as possible is achieved.

This report discusses the relevant directional wind conditions, safety criteria, and potential amelioration.

Wind conditions

A summary of the wind conditions assessed to the City of Sydney comfort and safety criterion reported in Arup (2021) are reproduced in Figure 1. For each location, identified by the number inside the circle, the central and circumferential colour relates to pedestrian comfort and safety respectively. The annotated number beside the test location is the 0.5 s gust wind speed that would occur for 0.017% of the time. It is evident that the safety wind speed in the open area to the north of the development are similar.

Directional information is provided in Figure 2 for the 3 locations that slightly exceed the safety criterion as well as Location 7, which just passes the criterion. In these plots, the symbols show the directional wind speed ratio increasing in speed from the centre of the plot. The contour dashed lines represent the wind climate associated with the comfort and safety criteria (grey line). It is evident that the windy directions at all three locations are for winds from the south-west quadrant, with winds from the north-west affecting Location 2.

Locations 5 and 11 in the northern parkland, are affected by winds from the south-west quadrant with downwash flow from the sharp-edged tower discharging across this open area. The results at these locations are representative of the wind conditions across the open northern lawn area, where wind speeds would be similar to those measured. The safety exceedances are a function of the isolated tower massing causing the flow to wrap around the tower. The typical flow pattern for winds from the south-west are illustrated in Figure 3 illustrating the volume of displaced air moving around the obstruction. Typically, the larger the obstruction the faster the resulting flow at ground level to the side of the obstruction. Note that this is a transient event and that all locations in the affected ground level zone would not experience a gusting event at the same time during a single storm event, or from the same direction. This is evident from directional results in Figure 2 showing that the wind directions exceeding the safety criterion are slightly different at the various test locations. Except for main pedestrian thoroughfares, these open areas would not be used during strong wind events.

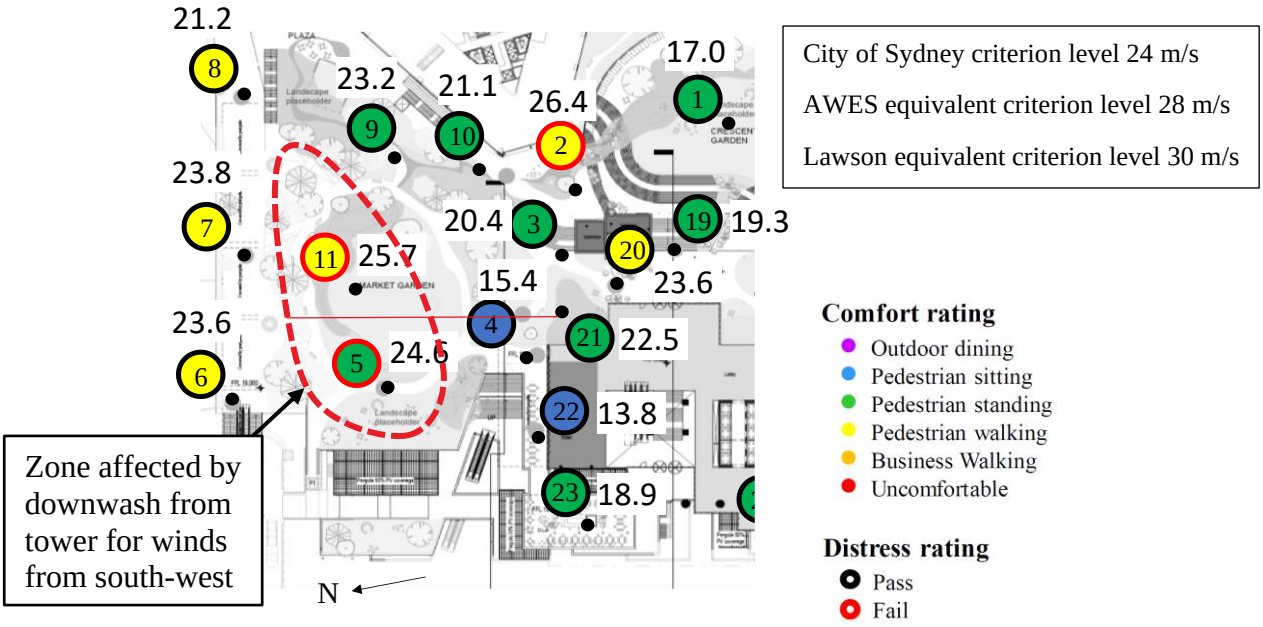

Figure 1: Extract of environmental wind conditions for comfort and safety assessed to the City of Sydney Planning Scheme 2016-2036 wind criteria

Location 2 is located in the narrow gap between the proposed tower and Darling Park Tower 1. The flow through this constriction is generated by pressure-driven flow through the high-rise buildings on the fringe of the CBD massing. For winds from the south-west and north-west the flow would be travelling to the north and south respectively. This exceedance is expected to be localised at the narrow gap between the buildings and could be ameliorated through local treatments such as a pooling water feature to ensure people would not be using the space during a strong wind event, or vertical balustrades to dissipate the flow in this area. Potential local treatments would be developed during further wind assessment to be carried out prior to the issue of the relevant Construction Certificate.

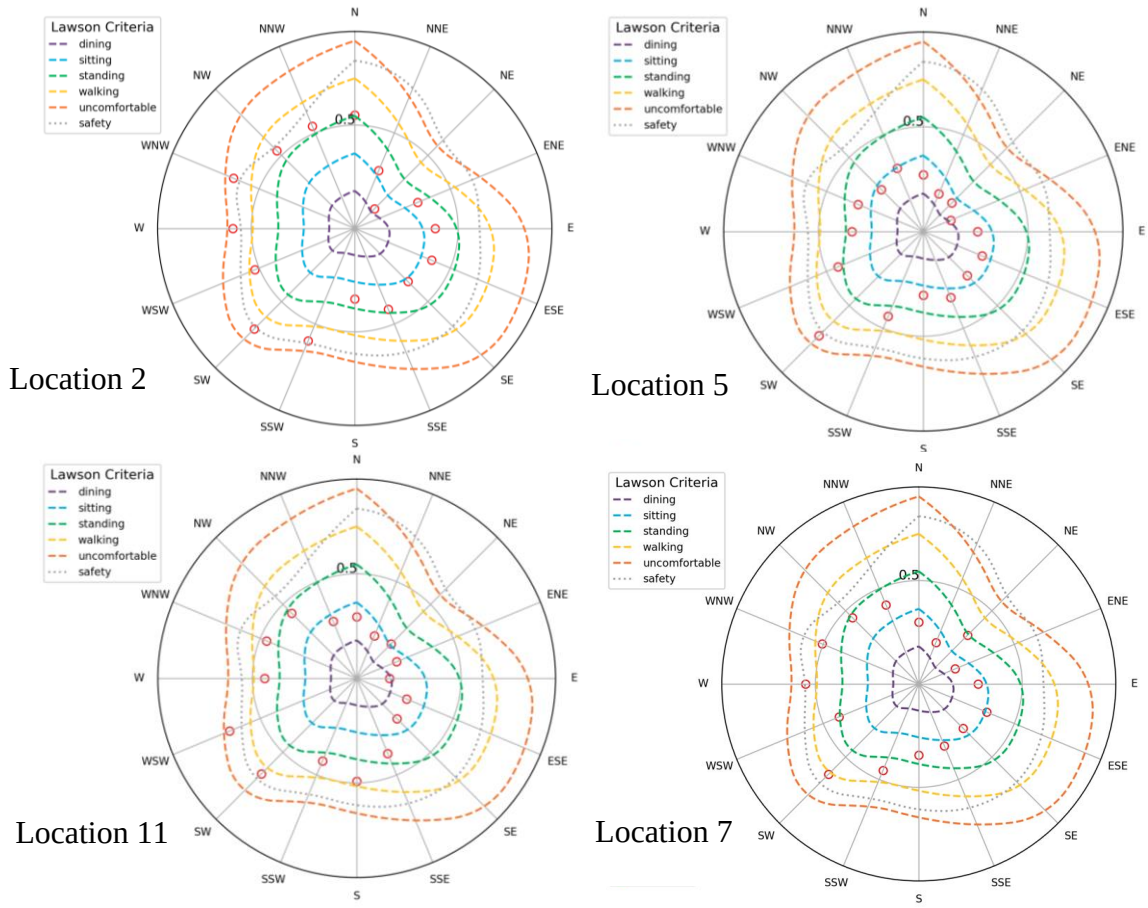

Figure 2: Directional results for Locations 2, 5, 11, and 7

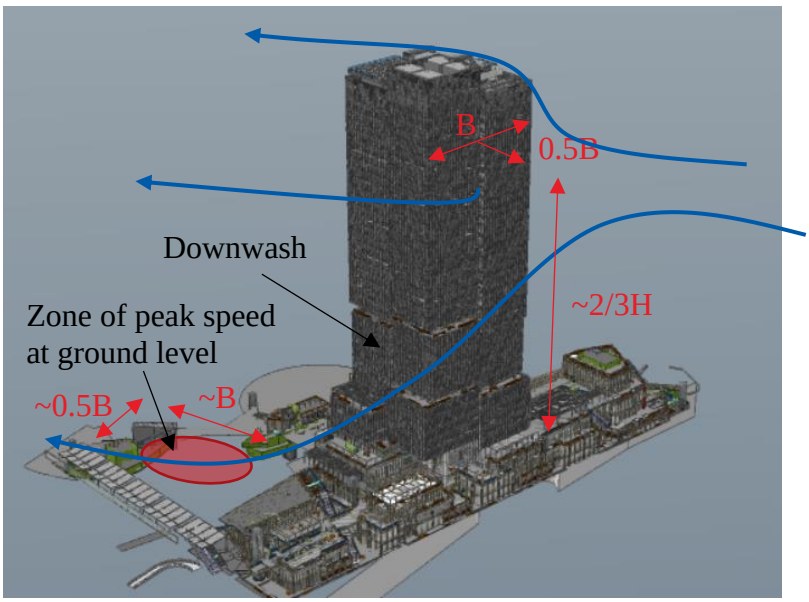

Figure 3: Sketch of typical flow pattern for high-rise building with oblique incident wind direction

Wind safety criterion

The City of Sydney wind safety criterion is a pass/fail measure aimed at protecting pedestrians from being blown over, particularly into dangerous areas such as onto live carriageways. The wind speed to destabilise a person depends on the size and frailty of the person as well as the activity being undertaken.

Historically, wind safety criteria for pedestrians have been related to either the **1 hour mean** wind speed, or the **3 s gust** wind speed occurring in an hour. The 3 s gust is an historic anomaly and is considered too long for pedestrian safety, e.g. at 15 m/s the size of the gust would be about 45 m, which is considerably larger than a person. Practically the rate of change of wind speed with distance significantly impacts how people are impacted by wind; for example, walking around a corner from calm to strong wind conditions compared with general strong wind conditions across a large open area. As wind-tunnel testing takes measurements at discreet locations, it is impractical to look at the gradient of wind speed with distance and all criterion are based on measurements at a specific location.

There are no defined wind criteria for comfort or safety for the Cockle Bay Park redevelopment precinct. The City of Sydney Planning Scheme 2016-2036 wind criteria were used in the environmental wind assessment. The safety criterion is defined as:

*For pedestrian **safety**, the annual maximum **0.5 s gust** wind speed occurring in any hour between 6 am and 10 pm should be less than 24 m/s. This represents a probability of occurrence of 0.017%.*

The reduction in gust duration to **0.5 s** from **3 s** used in other wind safety criteria has been well received in the wind engineering community. Previous City of Sydney wind criteria were only based on pedestrian comfort and not safety.

The 0.5 s duration gust is about 8% faster than the 3 s gust and is a function of the size of turbulence in the flow. A probabilistic comparison of various internationally used wind criteria is presented in Figure 4: the criteria associated with mean/GEM (gust equivalent mean) wind speeds have been multiplied by the standard 1.85 to transfer from a 1 hour mean to a 3 s gust; and the 24 m/s City of Sydney 0.5 s gust has been divided by 1.08. The highlighted red area encompasses the range of wind conditions covering the various safety criteria. It is evident that the City of Sydney safety criterion is at the lower (conservative) end of the range.

The Australasian Wind Engineering Society (AWES) is a professional body of wind engineering researchers and practitioners who published a pedestrian level guideline for safety in 2014. The safety criterion developed was based on the pioneering work of Melbourne (1978) and is a peak 3 s gust wind speed in an hour for 0.1% of the time. To align the safety criteria, the equivalent peak 3 s gust wind speed in an hour at 0.017% of the time would be about 26-27 m/s, Figure 4, resulting in the 0.5 s gust wind speed of 28-29 m/s.

Another widely used safety criterion is that of Lawson (1990), which has been adopted in London, UK as is defined as a 15 m/s **mean wind speed** occurring for 0.022% of the time. This is equivalent to a 0.5 s gust wind speed in an hour occurring for 0.017% of the time of about 30 m/s.

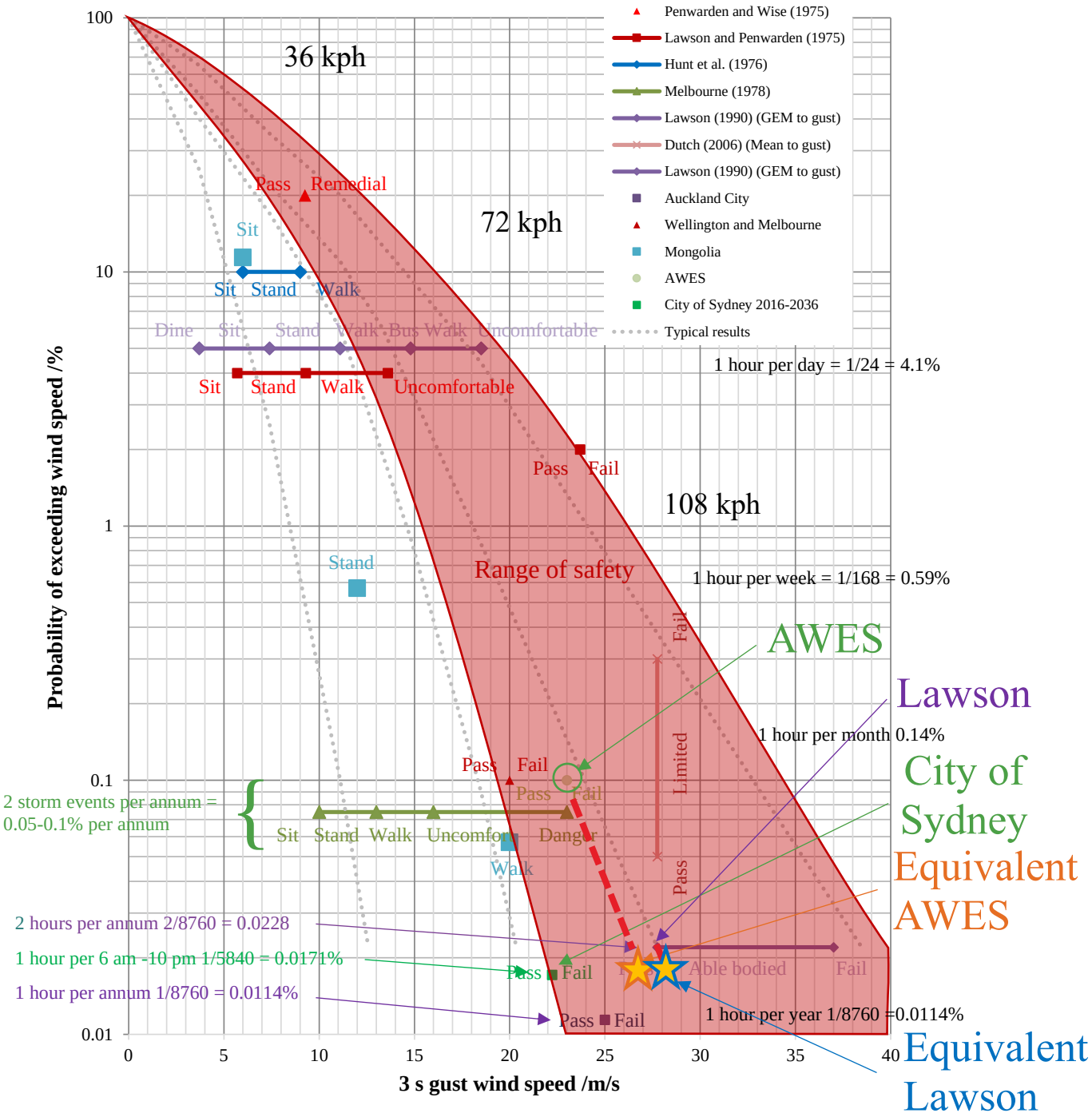

Figure 4: Probabilistic comparison between wind criteria based on 3 s gust wind speed

Consultation

Arup met with City of Sydney on 4 May 2022 to discuss matters relating to the project, including wind assessment and mitigation. The findings of the exhibited wind assessment (Arup, 2021) were discussed including the noted exceedances. City of Sydney feedback during this meeting was positive and appreciated that the exceedances were minor, and appreciated the explanation of the safety criterion as described in the previous section.

Council replied positively following the meeting and submission of presented material stating:

In regards to the wind issue, we note that your wind engineer has amended the safety criterion to 28 m/s as opposed to a 24 m/s for a once per annum 0.5 s gust event. Accordingly, all 3 points that failed our safety criteria would now pass the revised safety limit. We appreciate that our DCP does not legally apply to State Significant Development and the design is not able to be amended now such as rounding corners of the edges of the tower, however, every effort needs to be made to ensure that significant landscaping be provided to help mitigate wind gusts.

Any local landscaping would typically improve the wind conditions.

Discussion

From the above information it is evident that the strong wind conditions across the site are caused by the tower form and exposed nature to the west, resulting in similar safety wind conditions across the open parkland area to the north. Reducing the overall size of the affected area would require a significant architectural redesign, such as rounding the western corners of the tower.

The measured wind conditions are better than, or similar to, those measured around other western Sydney CBD developments. From a safety perspective, the wind conditions measured at all locations passed a number of internationally recognised safety criteria without any landscaping. As the measured locations experiencing strong wind events are in a large open area where people could not be blown onto vehicular traffic, and apart from the main pedestrian thoroughfares would not be used during strong wind events, the wind conditions in the parkland would be considered acceptable from a safety perspective. The provision of horizontal canopies over the pedestrian walkways would provide significant wind, rain, and solar protection to pedestrians. Due to the relatively minor exceedances of the safety criterion in the parkland, such amelioration would offer sufficient local protection to the pedestrian thoroughfares to pass the City of Sydney safety criterion.

The results of assessing the three windiest locations against a range of safety criterion are presented in Table 1. It is evident that the three locations would all pass the AWES and Lawson criteria.

Table 1: Safety classification with various safety criterion

Location (Peak 0.5 s gust occurring in an hour for 0.017% of time)	Wind safety criterion		
	City of Sydney (24 m/s)	AWES (28 m/s)	Lawson (30 m/s)
2 (26.4 m/s)	Fail	Pass	Pass
5 (24.6 m/s)	Fail	Pass	Pass
11 (25.7 m/s)	Fail	Pass	Pass

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Date	20 September 2022

We note that further wind tunnel testing will be undertaken prior to the issue of the relevant Construction Certificate for public domain/landscaping construction in order to demonstrate that wind speeds are safe. Any further wind mitigation measures required within the public domain and landscaping arising from this testing would be presented to the Design Integrity Panel prior to the issue of the relevant Construction Certificate.

I trust this is of assistance, please do not hesitate to contact me if you would like to discuss.

Yours sincerely

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Associate Principal

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References

Arup (2021), Cockle Bay Park Redevelopment, Environmental wind assessment, dated 01 October 2021.

Australasian Wind Engineering Society (2014), Guidelines for Pedestrian Wind Effects Criteria.

City of Sydney (2016), Central Sydney Planning Strategy 2016-2036.

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, J. Wind Engineering and Industrial Aerodynamics, Vol.3, No.2-3, pp.241-249.