Mirvac Residential (NSW) Developments Pty. Ltd.

Artarmon Road and Richmond Avenue, Willoughby, Building K

Environmental Wind Assessment

Wind

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Executive summary

Arup have been commissioned by Mirvac to provide an experienced-based impact assessment of the proposed Building K development at 15 Richmond Avenue, Willoughby on the pedestrian level wind conditions for comfort and safety in and around the site.

It is considered that the inclusion of Building K within the Masterplan would have a minimal impact on the surrounding wind conditions. The inclusion of the low-rise Building K on the south-west corner of the entire Masterplan site would be expected to have a slight beneficial impact on the local wind conditions in the precinct compared with the approved Masterplan scheme by encouraging flow over the buildings for winds from the south.

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions around Building K would be classified as suitable for pedestrian standing. All locations around Building K are expected to meet the safety criterion.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, which is not considered necessary for a development of this size close to large buildings. Any modelling would be best conducted during detailed design.

Disclaimer

This assessment of the site environmental wind conditions is presented based on engineering judgement. In addition, experience from more detailed simulations have been used to refine recommendations. No detailed simulation, physical or computational study has been made to develop the recommendations presented in this report.

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1 Overview

The Channel Nine Campus at 6-30 Artarmon Road, Willoughby is subject to a Part 3A Concept Plan Approval (MP10_0198 MOD 2) (Concept Plan Approval) that was approved by the Minister for Planning on 31 January 2019. The Concept Plan Approval provides for redevelopment of the site into 460 residential dwellings across nine buildings, along with small-scale non-residential uses.

In February 2020 Mirvac entered into an agreement with Euro Properties and Lotus Property Fund No. 8 (LEPC9) to acquire the Channel Nine Campus site. Mirvac simultaneously entered into a separate agreement with TX Australia Pty. Ltd. to acquire the approximate 2,132 m^2 site directly to the south of the Channel Nine Campus known as Lot 11 DP1162507 at 15 Richmond Avenue, Willoughby that currently accommodates a 233 m tall transmission tower.

Mirvac are applying to the NSW Department of Planning, Industry & Environment to modify the current Concept Plan Approval to incorporate the transmission tower site within the Approval to permit redevelopment into a tenth residential building while maintaining the existing 460 residential dwelling approval.

The Concept Plan amendment will include removal of the existing transmission tower and redevelopment of Lots 11 and 12 into a five storey residential flat building. The building height, scale, and open space across the Channel Nine Campus site at 6-30 Artarmon Road is proposed to remain consistent with the existing Concept Plan Approval.

2 Introduction

Mirvac have engaged Arup to provide a qualitative environmental wind assessment for the proposed development at the Channel Nine Studios on Artarmon Road and the transmission tower site on Richmond Avenue. This report outlines the assessment and subsequent recommendations for wind engineering services related to pedestrian wind comfort and safety on the ground level in particular the impact of the additional building to the south-west of the site.

3 Site description

The consolidated site is located on the block bounded by Artarmon Road, Scott Street, Walter Street, and Richmond Avenue, Figure 1. Building K is located in the Transmission Tower site to the south-west corner of the Channel 9 site. The site is surrounded by suburbia in all directions and sits on a ridge with a maximum drop of about 30 m to the freeway to the south.

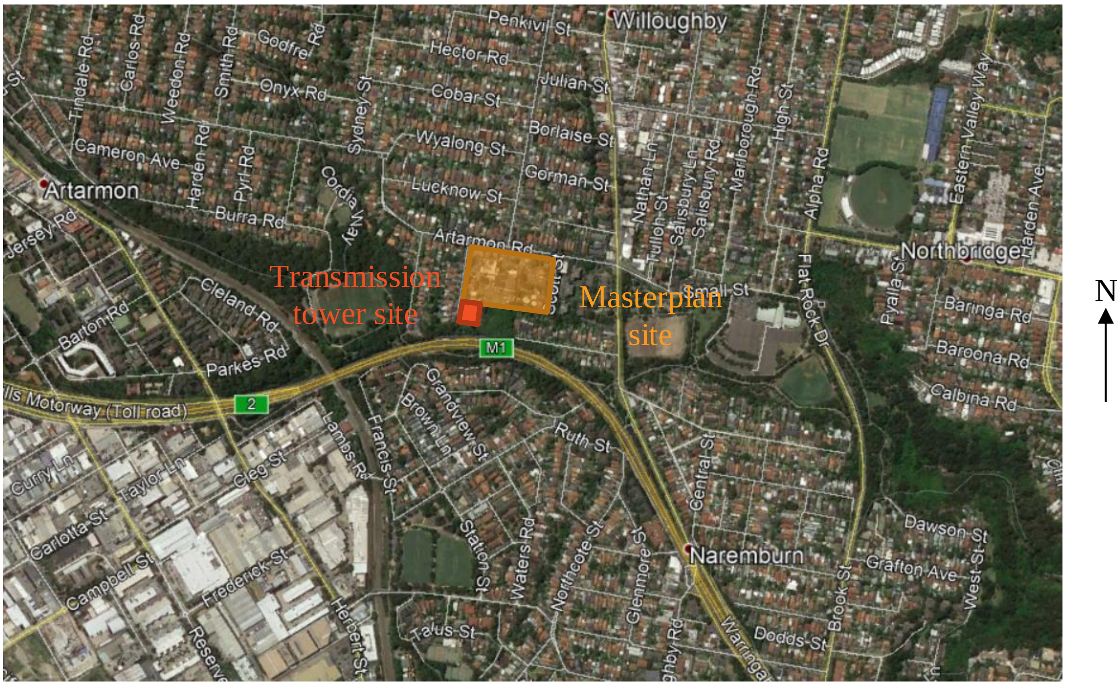

Figure 1: Site location (source: Google Maps)

The entire Masterplan development consists of 10 separate buildings across the site, identified as Buildings A-K in Figure 2. The buildings are all medium-rise, with Buildings D and E rising to a maximum height of about 30 m above ground level, Figure 3. Building K is a five-storey building located in the south-west corner of the site rising to a maximum of about 16 m above ground level. Pedestrian traffic around Building K would be expected to be localised to residents.

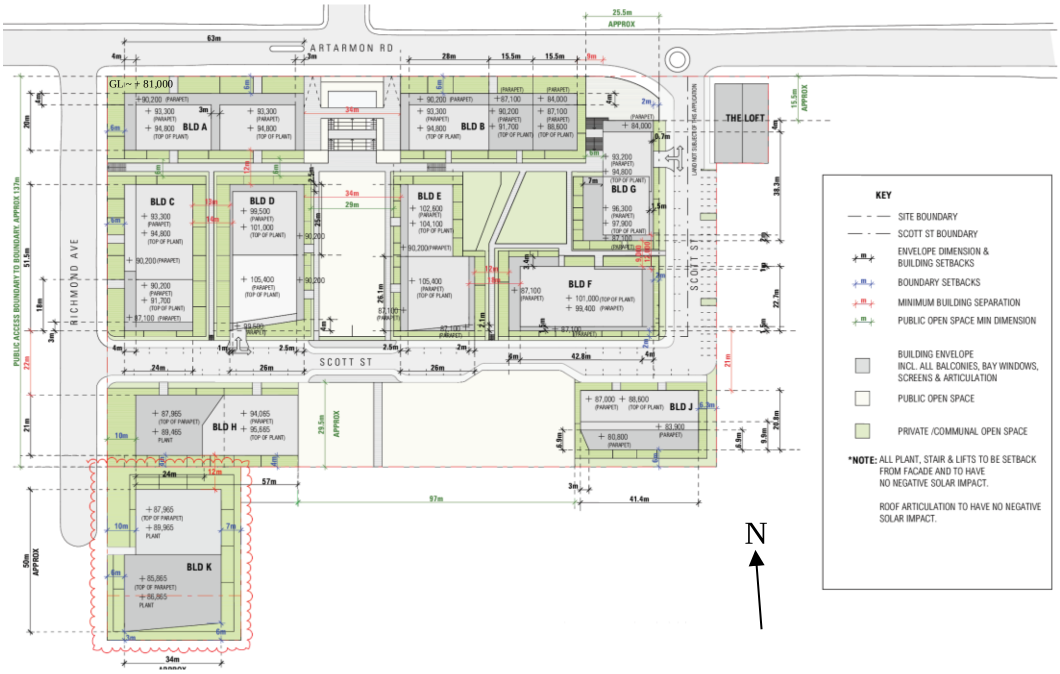

Figure 2: Site plan of buildings across the site

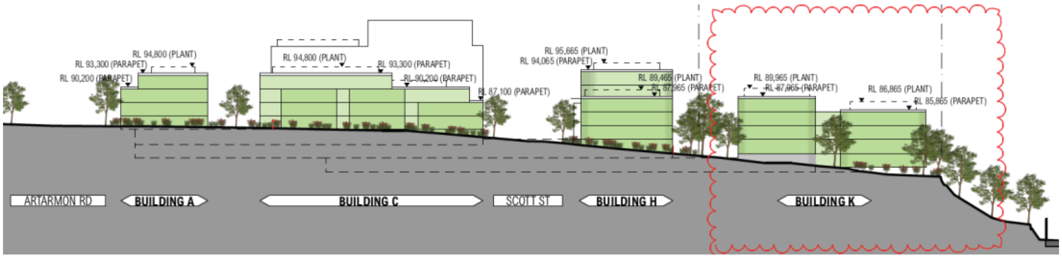

Figure 3: Richmond Avenue elevation

4 Wind assessment

4.1 Local wind climate

Weather data recorded at Sydney Airport by the Bureau of Meteorology has been analysed for this project. The anemometer is located about 16 km to the south of the site. The wind rose showing probability of wind speed with direction is presented in Figure 4. The arms of the wind rose point in the direction from where the wind is coming from. The directional wind speeds measured here are considered representative of the incident wind conditions at the site.

It is evident from Figure 4 that the prevailing wind directions are from north-east, south, and west quadrants. The measured mean wind speed is about 4.5 m/s, and the 5% exceedance mean wind speed is about 9.5 m/s.

A general description on flow patterns around buildings is given in Appendix 1

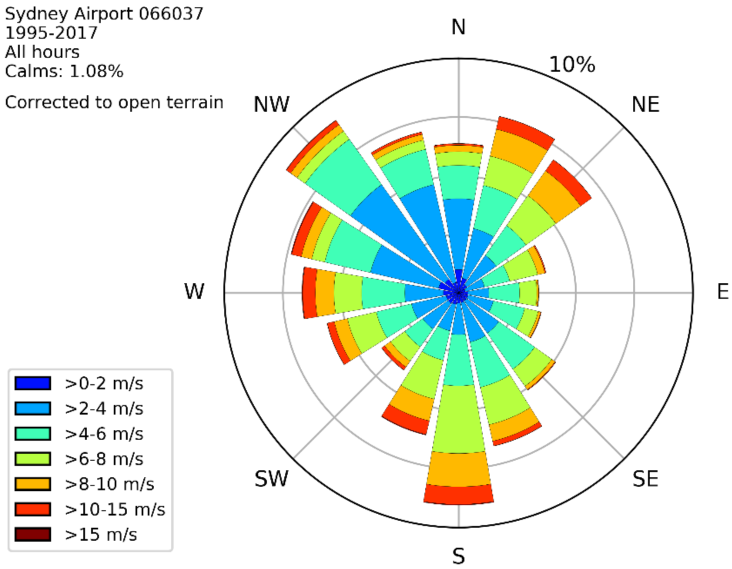

Figure 4: Wind rose showing probability of time of wind direction and speed

4.2 Specific wind controls

Wind comfort is generally measured in terms of wind speed and rate of change of wind speed, where higher wind speeds and gradients are considered less comfortable. Air speed has a large impact on thermal comfort and are generally welcome during hot summer conditions. This assessment is focused on wind speed in terms of mechanical comfort.

There have been many wind comfort criteria proposed, and a general discussion is presented in Appendix 2.

Willoughby Council has no specific wind controls for the site. The wind controls used in this wind assessment are based on the work of Lawson (1990) as described in Figure 13 and Table 1. These criteria are the basis for the current City of Sydney Draft Planning Strategy 2016-2036.

Table 1: Pedestrian comfort criteria for various activities

Comfort (max. of mean or GEM (Gust Equivalent Mean) wind speed exceeded 5% of the time)	
<2 m/s	Dining
2-4 m/s	Sitting
4-6 m/s	Standing
6-8 m/s	Walking
8-10 m/s	Objective walking or cycling
>10 m/s	Uncomfortable
Safety (max. of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	General access
<20 m/s	Able-bodied people (less mobile or cyclists not expected)

With reference to the measured climate data at the airport, transferring the 5% of the time mean wind speed to ground level with similar roughness conditions around the site would be about 6 m/s. This wind speed would classify the existing wind conditions on the site on the boundary of pedestrian standing and walking, which from current experience is considered appropriate.

4.3 Predicted wind conditions on ground plane

This section of the report outlines the predicted wind conditions in and around the site based on the local climate, topography, and building form. The massing of the proposed development is significant compared with the surrounding buildings, and will therefore have an impact on the local wind conditions. The development is adjacent to surrounding low-rise buildings to the north, east, and west.

Winds from the north-east

Winds from the north-east cross low-rise suburbia before reaching the site. The low-rise nature of Buildings A, B, and G along Artarmon Road combined with the drop in topography to the south, and the irregular spacing of the buildings across the precinct would encourage the flow to rise over the roofs of the taller buildings. Building K on the south-west corner would be shielded by the larger approved Masterplan buildings and would have minimal impact on the surrounding wind conditions.

Winds from the south

The development is exposed to winds from the south, which would be accelerated up the local topography to the crest at the southern edge of the development.

The stepped nature of Buildings J and K would encourage the flow over the roofs of the taller buildings to the north. The inclusion of Building K would be expected to improve the wind conditions around the southern corners of Building H. Buildings H and K offer shielding to the courtyard area between Buildings C and D.

Winds from the west

Winds from the west cross suburban with undulating topography before reaching the site. The low-rise Buildings A, C, H, and K along Richmond Avenue are a good design feature to encourage the lifting of the incident flow over the taller buildings to the east. Stronger flows can be expected on the western corners of Buildings A, C, H, and K.

Summary

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions around the site would be classified as suitable for pedestrian standing. Localised windy conditions would be expected around the western corners for winds from the south and west quadrants, but would be shielded by winds from the other directions. The overall wind conditions around Building K would be similar to the existing conditions. The wind conditions are considered suitable for the intended use of the space.

All locations would be expected to pass the safety criterion.

The inclusion of Building K would be expected to have a slight positive impact on the wind conditions across the Masterplan precinct.

5 References

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Appendix 1: Wind flow mechanisms

An urban environment generates a complex wind flow pattern around closely spaced structures, hence it is exceptionally difficult to generalise the flow mechanisms and impact of specific buildings as the flow is generated by the entire surrounds. However, it is best to start with an understanding of the basic flow mechanisms around an isolated structure.

Isolated building

When the wind hits an isolated building, the wind is decelerated on the windward face generating an area of high pressure, Figure 5, with the highest pressure at the stagnation point at about two thirds of the height of the building. The higher pressure bubble extends a distance from the building face of about half the building height or width, whichever is lower. The flow is then accelerated down and around the windward corners to areas of lower pressure, Figure 5. This flow mechanism is called **downwash** and causes the windiest conditions at ground level on the windward corners and along the sides of the building.

Rounding the building corners or chamfering the edges reduces downwash by encouraging the flow to go around the building at higher levels. However, concave curving of the windward face can increase the amount of downwash. Depending on the orientation and isolation of the building, uncomfortable downwash can be experienced on buildings of greater than about 6 storeys.

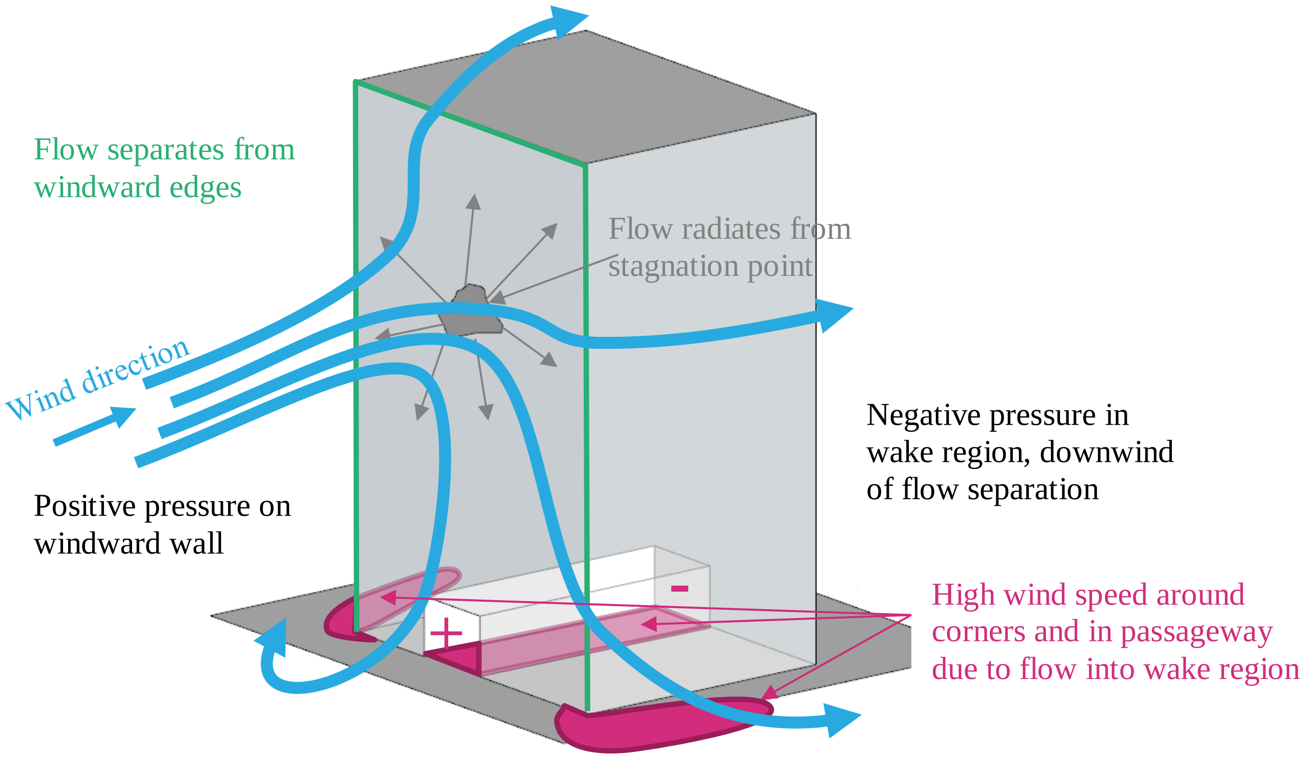

Figure 5 Schematic wind flow around tall isolated building

Techniques to mitigate the effects of downwash winds at ground level include the provision of horizontal elements, the most effective being a podium to divert the downward flow away from pavements and building entrances, but this will generate windy conditions on the podium roof, Figure 11. Generally, the lower the podium roof and deeper the setback from the podium edge to the tower improves the ground level wind conditions. The provision of an 8 m setback on an isolated building is generally sufficient to improve ground level conditions, but is highly dependent on the building isolation, orientation to prevailing wind directions, shape and width of the building, and any plan form changes at higher level.

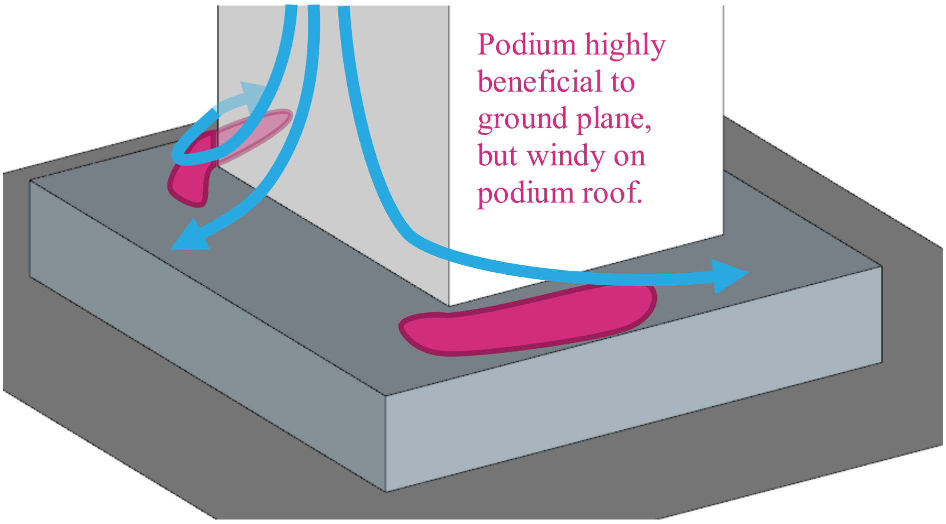

Figure 6 Schematic flow pattern around building with podium

Awnings along street frontages perform a similar function as a podium, and generally the larger the horizontal projection from the façade, the more effective it will be in diverting downwash flow, Figure 7. Awnings become less effective if they are not continuous along the entire façade, or on wide buildings as the positive pressure bubble extends beyond the awning resulting in horizontal flow under the awning.

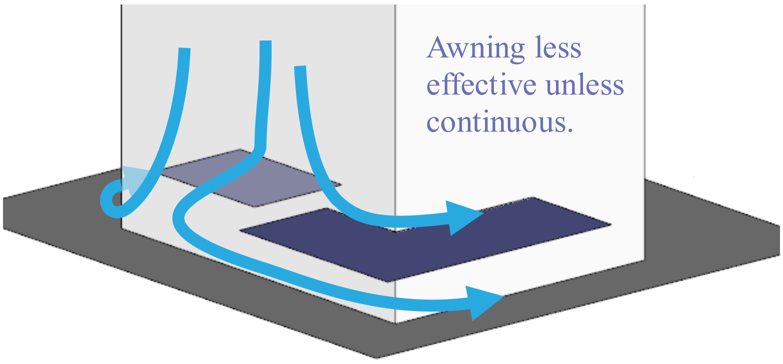

Figure 7 Schematic flow pattern around building with awning

It should be noted that colonnades at the base of a building with no podium generally create augmented windy conditions at the corners due to an increase in the pressure differential, Figure 8. Similarly, open through-site links through a building cause wind issues as the environment tries to equilibrate the pressure generated at the entrances to the link, Figure 5. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 9. This area is in a region of high pressure and therefore the is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions, Figure 9.

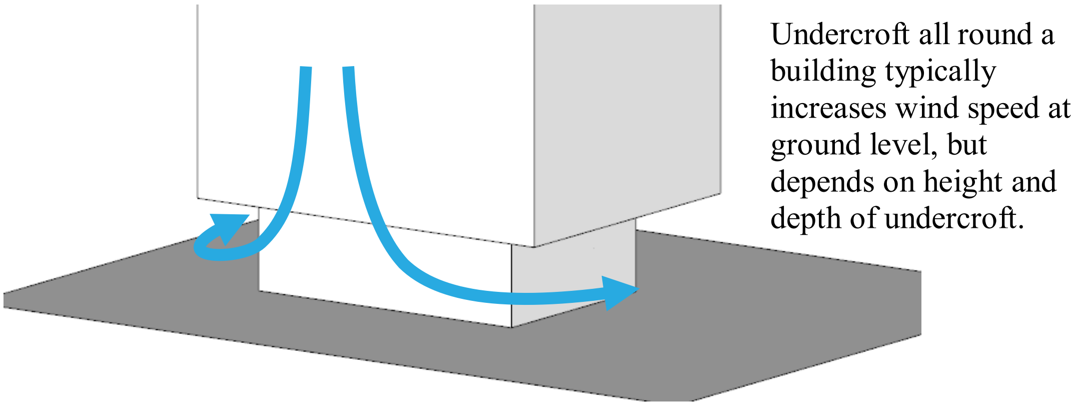

Figure 8 Schematic of flow patterns around isolated building with undercroft

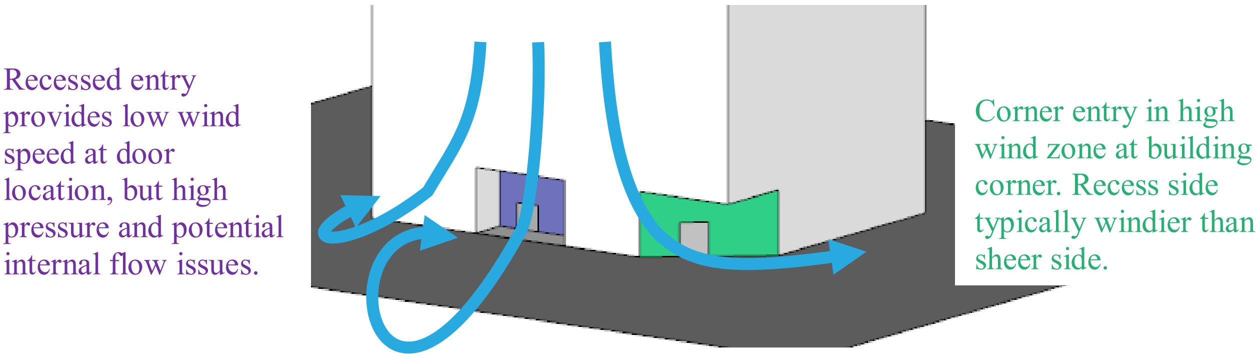

Figure 9 Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 10. If the building is taller, more of the wind impacting on the exposed section of the building is likely to be drawn to ground level by the increase in height of the stagnation point, and the additional negative pressure induced at the base. If the upwind buildings are of similar height then the pressure around the building will be more uniform hence downwash is typically reduced with the flow passing over the buildings.

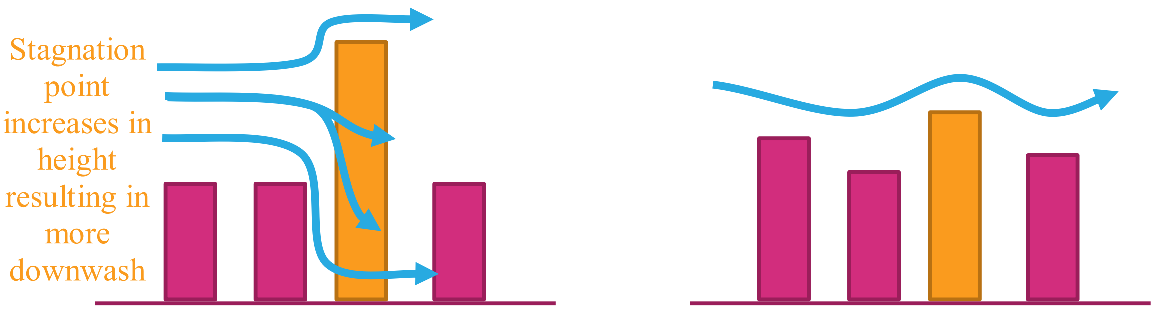

Figure 10 Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 11.

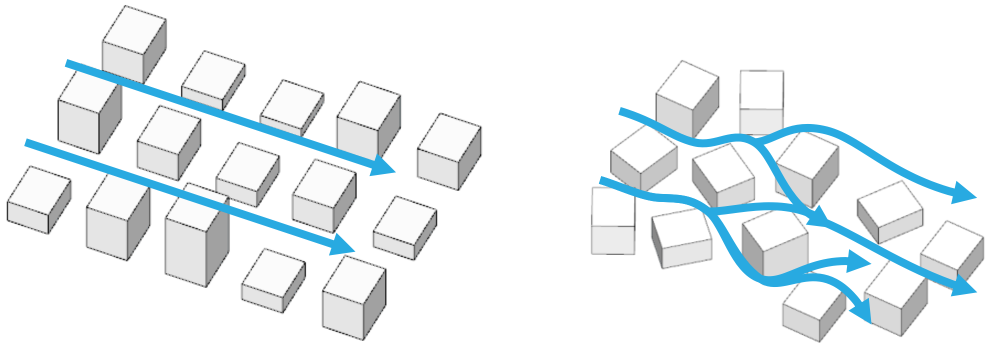

Figure 11 Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 11(L), particularly on the edge of built-up areas where the approaching flow is diverted around the city massing and channelled along the fringe by a relatively continuous wall of building facades. This is generally the primary mechanism driving the wind conditions for this perimeter of a built-up area, particularly on corners, which are exposed to multiple wind directions. The perimeter edge zone in a built-up area is typically about two blocks deep. Downwash is more important flow mechanism for the edge zone of a built-up area with buildings of similar height.

As the city expands, the central section of the city typically becomes calmer, particularly if the grid pattern of the streets is discontinued, Figure 11(R). When buildings are located on the corner of a central city block, the geometry becomes slightly more important with respect to the local wind environment.

Single barriers and screens

The wind flow pattern over a vertical barrier is illustrated in Figure 12, showing there will be recirculation zones near the windward wall and in the immediate lee of the barrier. The typical extent of these recirculation zones relative to the height of the barrier, h, is illustrated in Figure 12. These regions are not fixed but fluctuate in time. The mean wind speed in the wake areas drops significantly compared with the incident flow. With increasing distance from the barrier the flow pattern will resort to the undisturbed state. Typically the mean velocity and turbulence intensity at barrier height would be expected to be within 10% of the free stream conditions at 10 times the height of the structure downwind from the barrier.

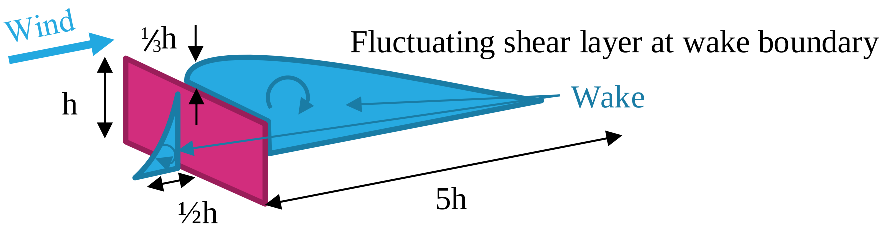

Figure 12: Sketch of the flow pattern over an isolated structure

Appendix 2: Wind speed criteria

General discussion

Primary controls that are used in the assessment of how wind affects pedestrians are the wind speed, and rate of change of wind speed. A description of the effect of a specific wind speed on pedestrians is provided in Table 2. It should be noted that the turbulence, or rate of change of wind speed, will affect human response to wind and the descriptions are more associated with response to mean wind speed.

Table 2 Summary of wind effects on pedestrians

Description	Speed (m/s)	Effects
Calm, light air	0–2	Human perception to wind speed at about 0.2 m/s. Napkins blown away and newspapers flutter at about 1 m/s.
Light breeze	2–3	Wind felt on face. Light clothing disturbed. Cappuccino froth blown off at about 2.5 m/s.
Gentle breeze	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps.
Moderate breeze	5–8	Raises dust, dry soil. Hair disarranged. Sand on beach saltates at about 5 m/s. Full paper coffee cup blown over at about 5.5 m/s.
Fresh breeze	8–11	Force felt on body. Limit of agreeable wind on land. Umbrellas used with difficulty. Wind sock fully extended at about 8 m/s.
Strong breeze	11–14	Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	14–17	Inconvenience felt when walking.
Gale	17–21	Generally impedes progress. Difficulty with balance in gusts.
Strong gale	21–24	People blown over by gusts.

Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. These have all generally been developed around a 3 s gust, or 1 hour mean wind speed. During strong events, a pedestrian would react to a significantly shorter duration gust than a 3 s, and historic weather data is normally presented as a 10 minute mean.

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 some agreement between the various criteria. However, a number of studies have shown that over a wider range of flow conditions, such as smooth flow across water bodies, to turbulent flow in city centres, there is less general agreement among. The downside of these criteria is that they have seldom been benchmarked, or confirmed through long-term measurements in the field, particularly for comfort conditions. The wind criteria were all developed in temperate climates and are unfortunately not the only environmental factor that affects pedestrian comfort.

For assessing the effects of wind on pedestrians, neither the random peak gust wind speed (3 s or otherwise), nor the mean wind speed in isolation are adequate. The gust wind speed gives a measure of the extreme nature of the wind, but the mean wind speed indicates the longer duration impact on pedestrians. The extreme gust wind speed is considered to be suitable for safety considerations, but not necessarily for serviceability comfort issues such as outdoor dining. This is because the instantaneous gust velocity does not always correlate well with mean wind speed, and is not necessarily representative of the parent distribution. Hence, the perceived ‘windiness’ of a location can either be dictated by strong steady flows, or gusty turbulent flow with a smaller mean wind speed.

To measure the effect of turbulent wind conditions on pedestrians, a statistical procedure is required to combine the effects of both mean and gust. This has been conducted by various researchers to develop an equivalent mean wind speed to represent the perceived effect of a gust event. This is called the ‘gust equivalent mean’ or ‘effective wind speed’ and the relationship between the mean and 3 s gust wind speed is defined within the criteria, but two typical conversions are:

$$U_{GEM} = \frac{(U_{mean} + 3 \cdot \sigma_u)}{1.85} \text{ and } U_{GEM} = \frac{1.3 \cdot (U_{mean} + 2 \cdot \sigma_u)}{1.85}$$

It is evident that a standard description of the relationship between the mean and impact of the gust would vary considerably depending on the approach turbulence, and use of the space.

A comparison between the mean and 3 s gust wind speed criteria from a probabilistic basis are presented in Figure 13 and Figure 15. The grey lines are typical results from modelling and show how the various criteria would classify a single location. City of Auckland has control mechanisms for accessing usability of spaces from a wind perspective as illustrated in Figure 13 with definitions of the intended use of the space categories defined in Figure 14.

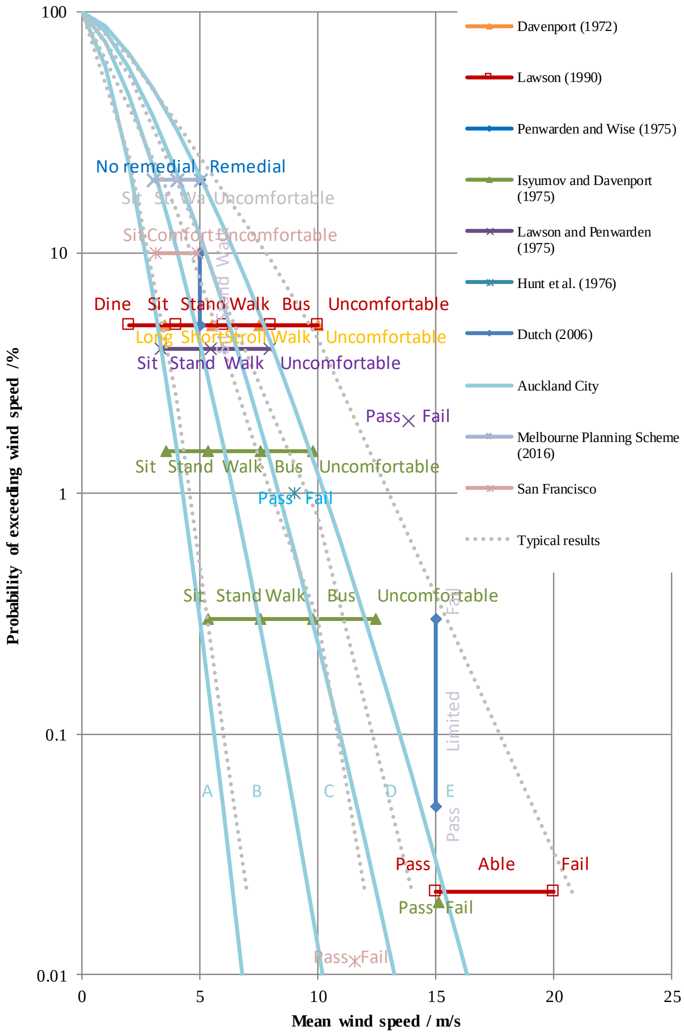

Figure 13 Probabilistic comparison between wind criteria based on mean wind speed

Category A	Areas of pedestrian use or adjacent dwellings containing significant formal elements and features intended to encourage longer term recreational or relaxation use i.e. public open space and adjacent outdoor living space
Category B	Areas of pedestrian use or adjacent dwellings containing minor elements and features intended to encourage short term recreation or relaxation, including adjacent private residential properties
Category C	Areas of formed footpath or open space pedestrian linkages, used primarily for pedestrian transit and devoid of significant or repeated recreational or relaxational features, such as footpaths not covered in categories A or B above
Category D	Areas of road, carriage way, or vehicular routes, used primarily for vehicular transit and open storage, such as roads generally where devoid of any features or form which would include the spaces in categories A - C above.
Category E	Category E represents conditions which are dangerous to the elderly and infants and of considerable cumulative discomfort to others, including residents in adjacent sites. Category E

Figure 14: Auckland Utility Plan (2016) wind categories

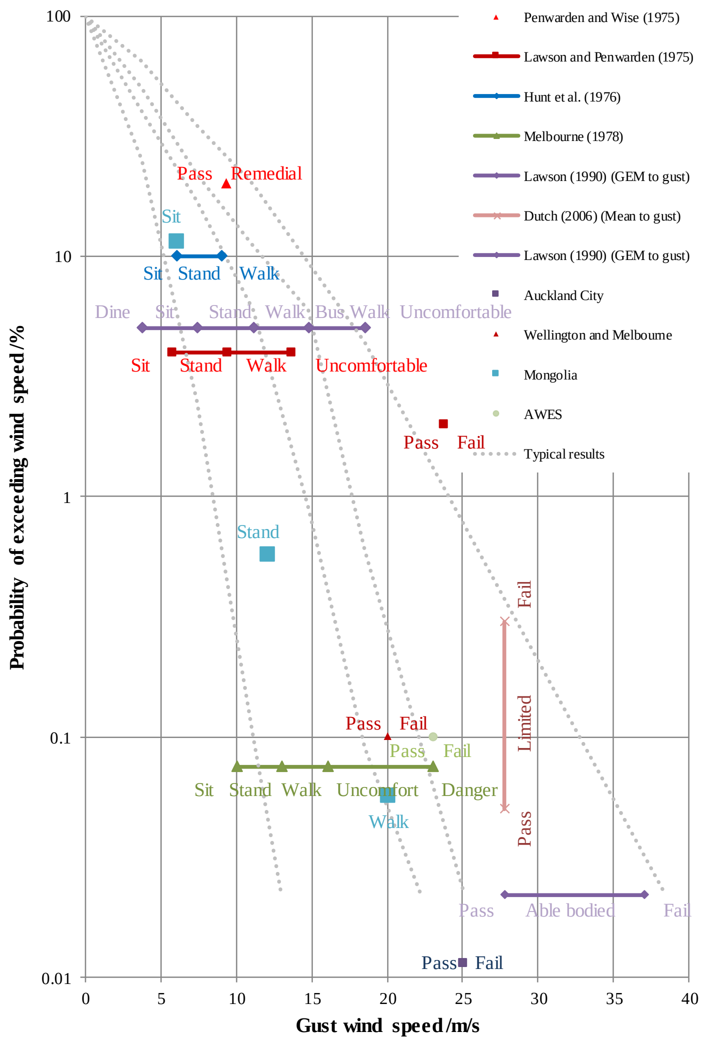

Figure 15 Probabilistic comparison between wind criteria based on 3 s gust wind speed

Appendix 3: Reference documents

In preparing the assessment, the following documents have been referenced to understand the building massing and features.

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