Longhurst

Edgecliff Centre

Environmental Wind Assessment

Wind

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Job number 274377-05

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Executive summary

Arup have been commissioned by Longhurst to provide an experienced-based impact assessment of the proposed Edgecliff Centre developmenton the pedestrian level wind conditions for comfort and safety in and around the site. It is considered that the proposed development would have a minor impact on the wind conditions to the north of the site with a greater impact to the south and west.

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions at the majority of locations around the site would be classified as suitable for pedestrian walking, with some locations at the upper bound of this level. In general, the wind conditions on the ground plane would be expected to meet the safety criterion, with conditions close to the corners to be about the safety criterion level. Wind conditions on the pedestrian accessible terrace areas would be expected to exceed the safety criterion. Any quantified exceedances of the criterion would be able to be ameliorated through local treatments during detailed design, or operational management of the terrace space. Appropriate local amelioration for wind sensitive areas such as outdoor seating areas or pool, would be developed during detailed design to improve the wind conditions.

Benefits of the design from a pedestrian level wind perspective include the significant tower setbacks from the podium edge to the north, east, and west, and the tower curved corners to reduce the impacts of downwash flow.

To quantify the qualitative advice provided in this report, numerical or physical modelling of the development would be required, which is best conducted during detailed design. It would be recommended to conduct such studies for this development.

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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.

1 Introduction

This qualitative environmental wind assessment report has been prepared on behalf of Longhurst Investments No. 1 Pty. Ltd. in support of a planning proposal for the Edgecliff Centre (the site). The planning proposal will support amendments to the Woollahra Local Environmental Plan 2014 in order to facilitate the future redevelopment of the site for a mixed-use development comprising retail/commercial/medical uses podium and residential tower.

Specifically, in order to facilitate the future redevelopment of the site for the intended purpose, the planning proposal seeks to:

- Increase the maximum Height of Buildings development standard and
- Increase the maximum Floor Space Ratio development standard.

The planning proposal is supported by an indicative development concept. The concept is indicative only and has been prepared for the sole purpose of demonstrating that the planning proposal can deliver a viable scheme within the amended controls being proposed.

The indicative development scheme includes:

- Commercial, retail, medical/wellness facilities and residential.
- Provision for a publicly accessible open green space at podium level.
- Introduction of public community space.
- Revitalisation and enhancement of the existing intermodal and transport interchange within the site.
- Public domain improvements at ground level including a new plaza and permeable transit interchange entry way; and
- Improvements to existing vehicular access and loading dock arrangement.

This report outlines the assessment and subsequent recommendations for wind engineering services related to pedestrian wind comfort and safety on the ground level.

2 Site description

The proposed Edgecliff Centre site is located to the west of the block bounded by New South Head Road, Ocean Street, and New McLean Street, Figure 1. The site is generally surrounded by low-rise buildings in all directions, with nearby isolated medium- to high-rise buildings to the east and north respectively. The site is located on complex topography from a wind perspective, dropping steeply to the south-west and north-east, dropping gently to the north, while rising gently to the south-east.

Figure 1 Site location (source: Google Maps 2019)

The existing building on the site rises to a maximum height of about 32 m above ground level along New South Head Road to the north of the site, with a two-storey car park to the south.

The proposed development consists of a porous mixed-use podium rising to a maximum height of about 34 m above ground level along New South Head Road. The podium has a roof-top terrace at about 27 m above New South Head Road ground level providing a similar frontage to the north. To the south of the site, a single slender residential tower rises to about 165 m above New McLean Street ground level, Figure 2. The tower portion is essentially prismatic of irregular planform, Figure 3. The tower is set back from the podium edge by about 45 m to the north, 13 m to the east, 0 m for the lower 14 storeys and 4.5 m for the upper levels to the south, and 15 m to the west, Figure 3. The land immediately to the south of the site, is primarily for vehicles, with pedestrian access along the pavement to the immediate north of New McLean Street.

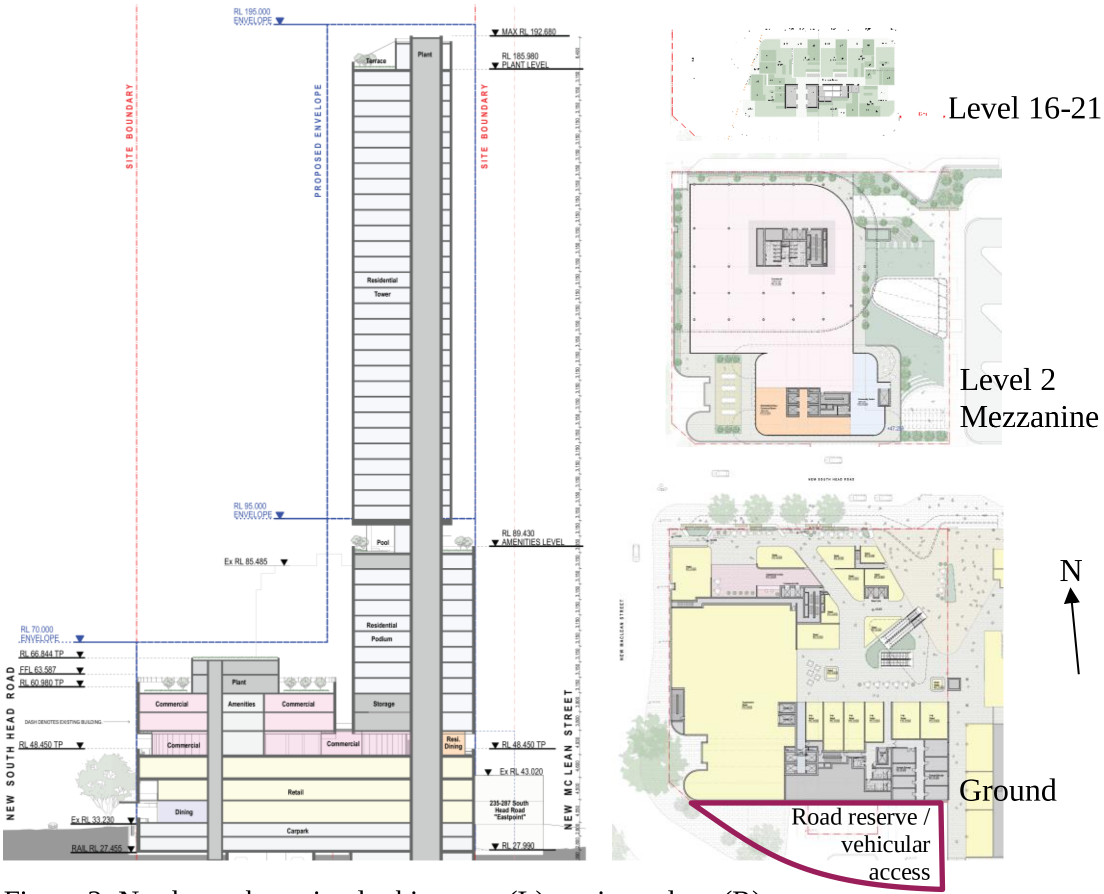

Figure 2: North-south section looking east (L), various plans (R)

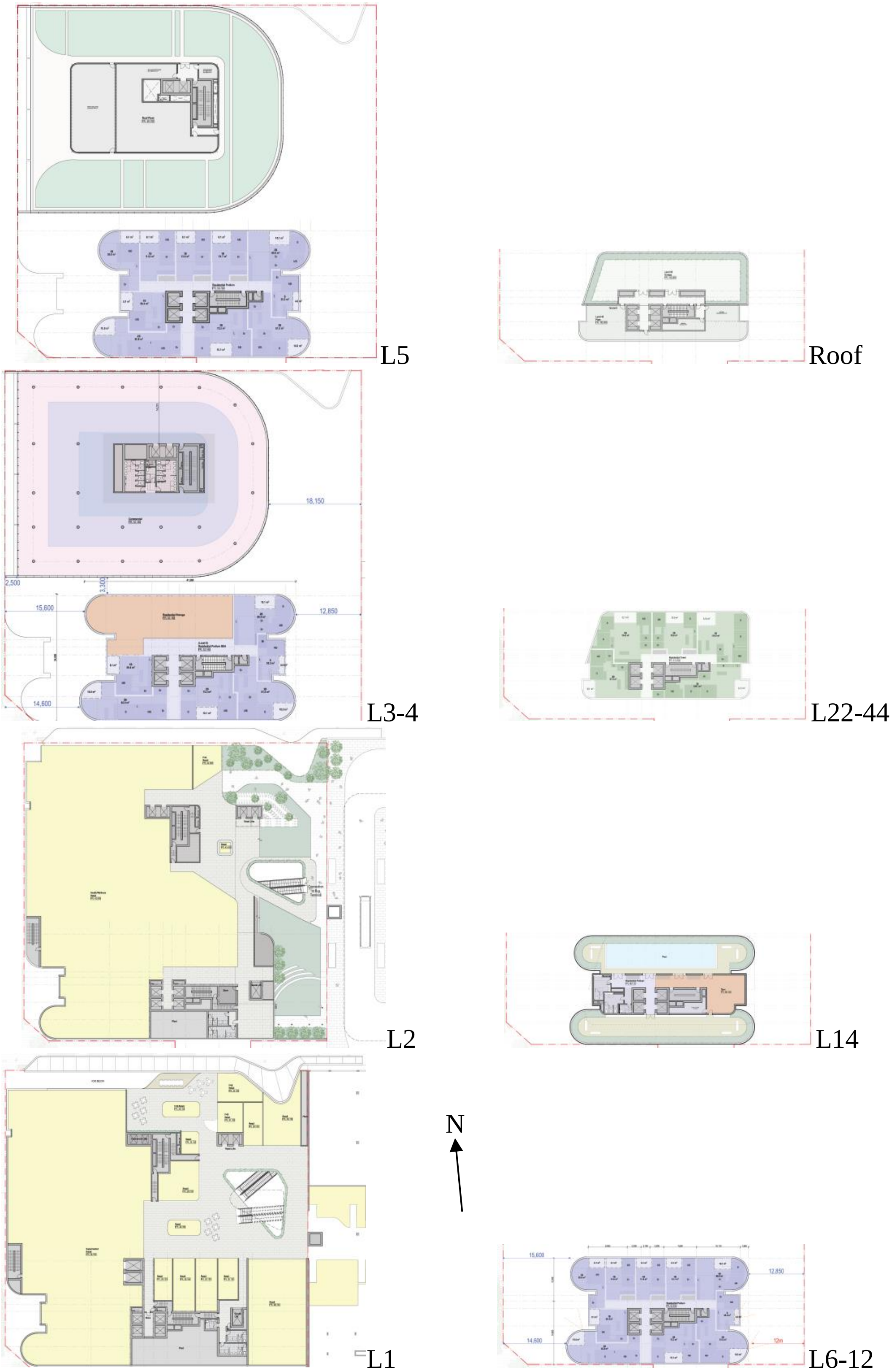

Figure 3: Additional plans: podium (L), tower (R)

3 Wind assessment

3.1 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 10 km to the south-west of the site. 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, due to close proximity to the site.

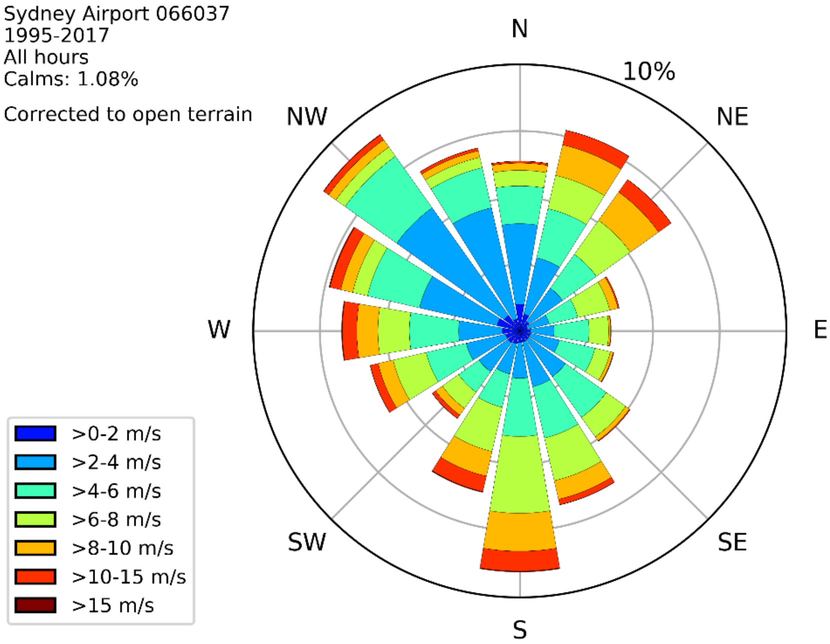

Figure 4. Wind rose showing probability of time of wind direction and speed

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

Strong summer winds occur mainly from the south quadrant and the north-east. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer. Moderate intensity winds from the north-east tend to bring cooling relief on hot summer afternoons typically lasting from noon to dusk. These are small-scale temperature driven effects; the larger the temperature differential between land and sea, the stronger the wind.

Winter and early spring strong winds typically occur from the north-west, and west quadrants. West quadrant winds provide the strongest winds affecting the area throughout the year and tend to be associated with large scale synoptic events that can be hot or cold depending on inland conditions.

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

3.2 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.

Woollahra 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.

Table 1 Pedestrian comfort criteria for various activities

Comfort (max. of mean or GEM 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)

Transferring the measured 5% of the time wind speed to ground level around the site would result in a mean wind speed of about 6 m/s. Form Table 1 these conditions would be classified as on the border of pedestrian standing and walking. From knowledge of the wind conditions in the locale, this would be a correct classification for the area.

3.3 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 overall massing of the proposed development is larger than the existing development and surrounding buildings, and will therefore have a measurable impact on the local wind conditions making some areas calmer and other areas windier depending on the incident wind direction as discussed below.

Winds from the north-east

Winds from the north-east would cross the harbour before accelerating up the local topography from Double Bay before reaching the site. The north face of the building would direct the incident flow to the west into New McLean Street. The proposed north façade of the podium is similar in massing to the existing building and the tower is set back about 45 m from New South Head Road, and therefore would have minimal impact on the wind conditions in pedestrian trafficable areas around the site. The wind conditions to the south of the tower along New McLean Street would be expected to increase slightly due to flow being drawn into the wake of the tower.

Winds from the south

The site is exposed to winds from the south, which would accelerate up the local topography. The broad face of the tower is perpendicular to the incident wind direction and would therefore induce downwash flow, as described in Appendix 1. The lack of tower setback from the podium edge below Level 14 and the minimal setback above this level would offer little resistance to downwash flow reaching ground level. However, significant benefits of the design to reduce the wind effects on the ground plane include:

- the curved southern corners of the towers, which encourages more horizontal flow around the towers reducing the amount of downwash,
- the significant tower setbacks from the east and west edges of the podium, diverts a portion of the flow across the podium roof rather than descending to ground level,
- the road reserve to the immediate south of the site providing a protected buffer zone to the pedestrian footpaths along New McLean Street,
- the rise in topography to the north along New McLean Street would reduce the amount of downwash, and
- the retention of any mature trees around the site would further mitigate the wind conditions.

The Level 3 pedestrian connection to the bus terminal outside the site boundary is exposed to the downwash flow. Wind conditions along the accessway are expected to be relatively windy. These conditions could be ameliorated during detailed design with local protection such as a canopy roof, vertical barriers to the west of the walkway, or landscaping.

Further to the east along New McLean Street, pedestrians would be further from the building line in slightly calmer conditions, due to the road reserve and vehicular entrances and the neighbouring building line.

Winds from the west

Winds from the west are slightly accelerated up the local topography before reaching the site. The western façade of the development has increased in size, which would direct more flow along New South Head Road and New McLean Street. Windier locations would be experienced around the western corners.

The west aspect of tower is relatively narrow with rounded corners, which would encourage horizontal flow around the tower thereby reducing downwash reaching ground level. The large tower setback to the west and the small tower setback from the south at Level 14 would be expected to redirect a large component of the downwash flow before reaching ground level. The road reserve acts as a separation between the fastest winds close to the building and the pedestrian trafficable area. Stronger windy conditions are expected along New McLean Street.

Winds more from the north-west would generate downwash along the long north face of the tower. The downwash flow would be redirected by the Level 2 Mezzanine terrace to the north and east before reaching ground level. The to the east and west of the tower. The wind conditions along the terrace accessway are expected to be relatively windy. These conditions could be ameliorated during detailed design with local protection such as a canopy roof, vertical barriers to the west of the walkway, or landscaping.

Summary

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions at the majority of locations around the site would be classified as suitable for pedestrian walking, with locations on the western corners being at the upper end of this classification. These wind conditions would be considered suitable for the intended use of the space.

Local amelioration is expected to be required for any outdoor café areas around the development particularly on the south-west corner. These would typically take the form of permanent or temporary porous screens perpendicular to the façade, or more enclosed booths to create localised calm areas.

4 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.

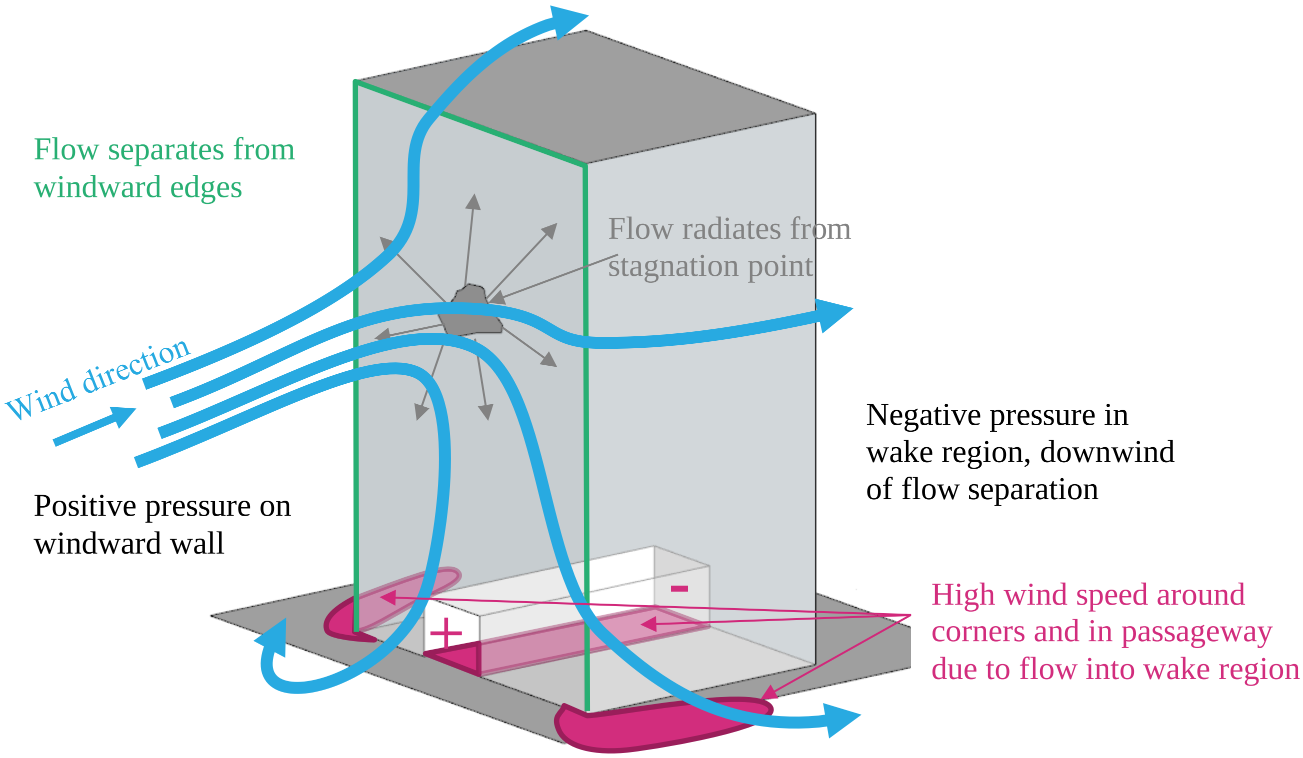

Figure 5 Schematic wind flow around tall isolated building

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.

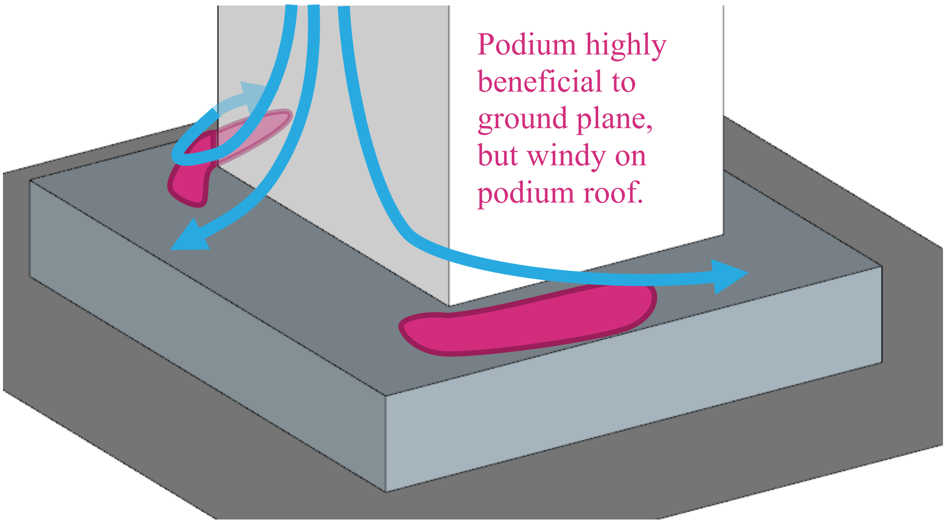

Figure 6 Schematic flow pattern around building with podium

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.

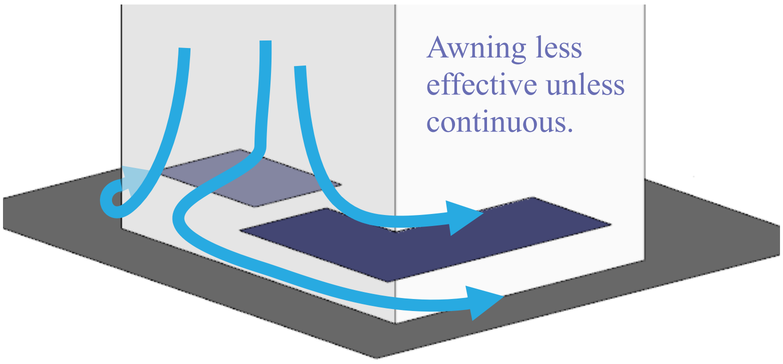

Figure 7 Schematic flow pattern around building with awning

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.

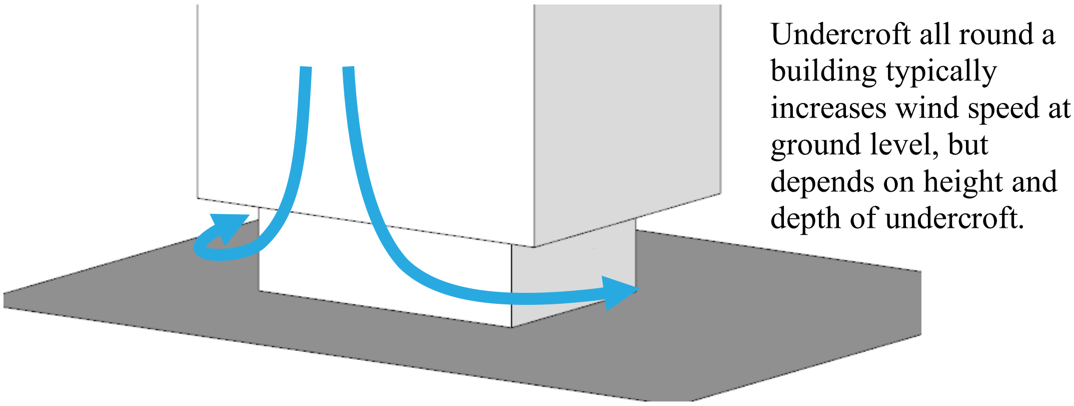

Figure 8 Schematic of flow patterns around isolated building with undercroft

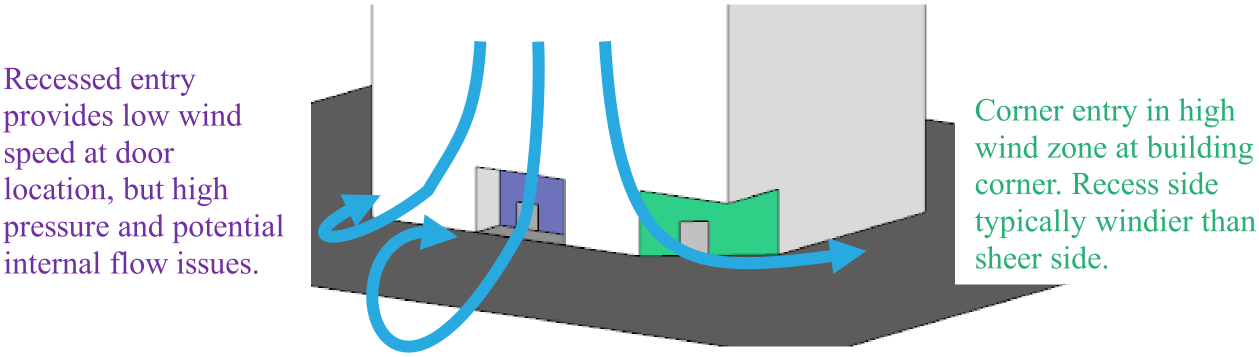

Figure 9 Schematic of flow patterns around isolated building with ground articulation

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.

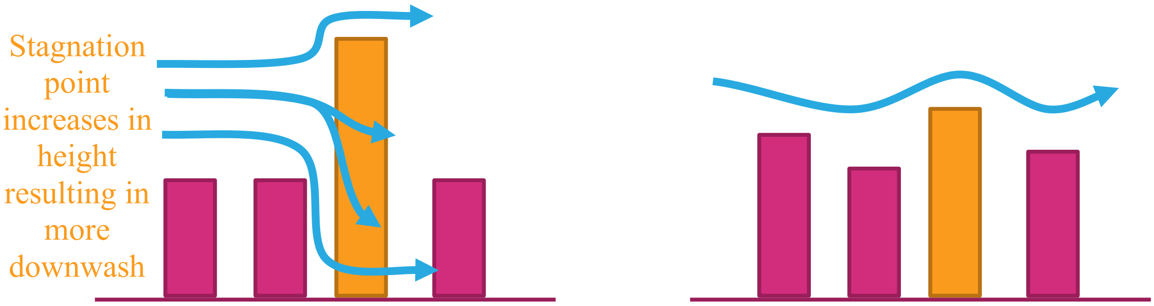

Figure 10 Schematic of flow pattern interference from surrounding buildings

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.

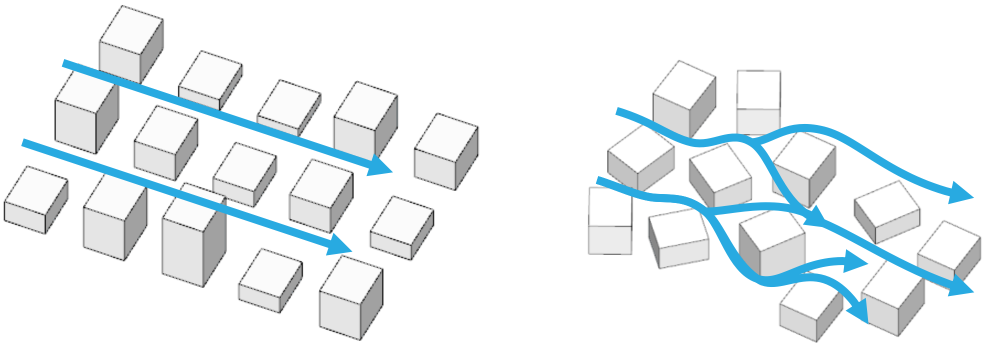

Figure 11 Schematic of flow patterns through a grid and random street layout

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.

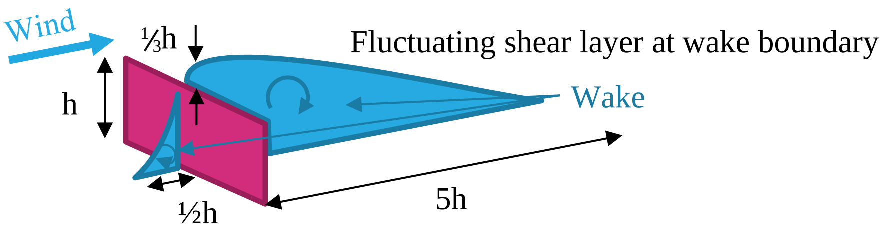

Figure 12: Sketch of the flow pattern over an isolated structure

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:

$$U_{GEM} = \frac{(U_{1\ hour\ mean} + 3 \cdot \sigma_u)}{1.85} \quad \text{and} \quad U_{GEM} = \frac{1.3 \cdot (U_{1\ hour\ mean} + 2 \cdot \sigma_u)}{1.85}$$

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.

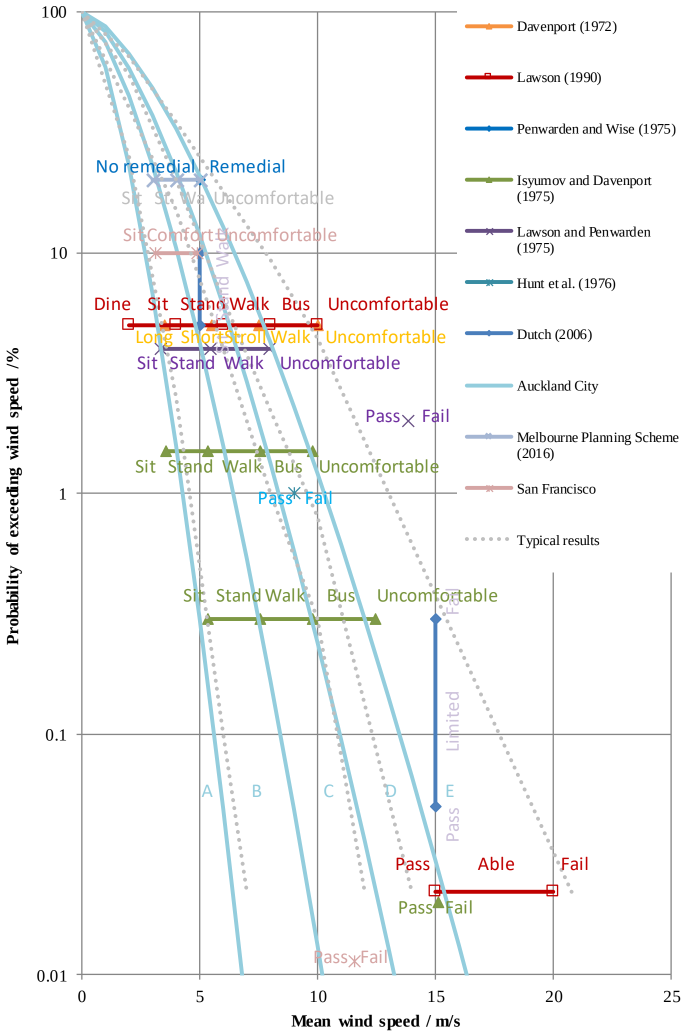

Figure 13 Probabilistic comparison between wind criteria based on mean wind speed

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

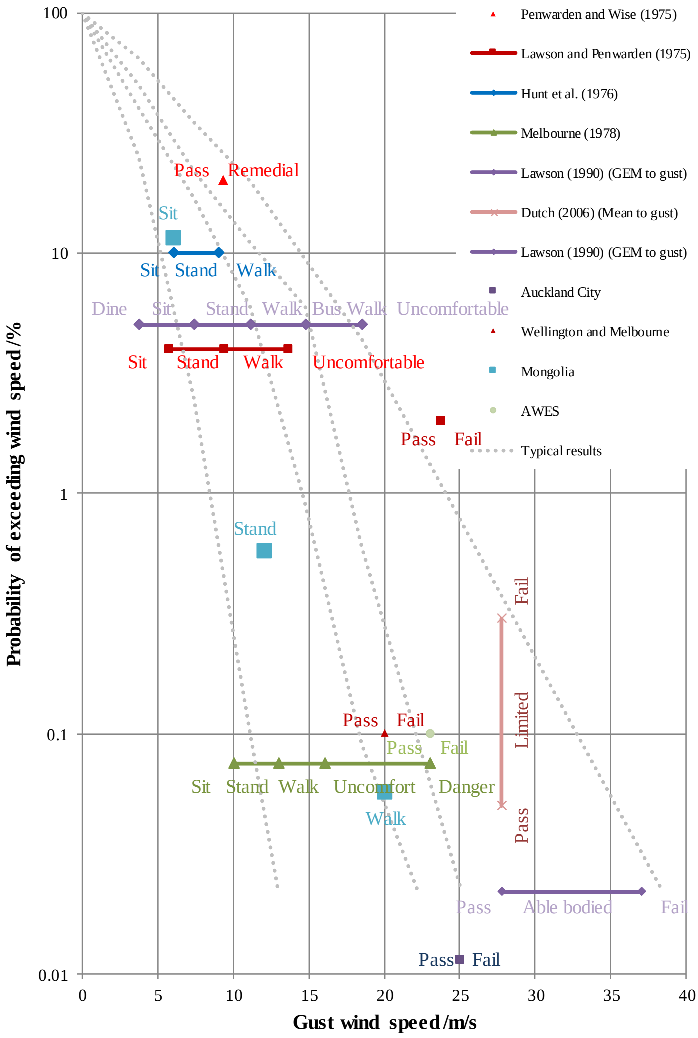

Figure 15 Probabilistic comparison between wind criteria based on 3 s gust wind speed

Appendix 3: Reference documents

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

200402_Edgecliff Full Architectural Package.pdf