Jarre Pty. Ltd.

Gosford Gateway

Environmental Wind Assessment

Wind

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Executive Summary

Arup have been commissioned by Jarre Pty. Ltd. to provide an experienced-based impact assessment of the proposed Gosford Gateway development on the pedestrian level wind conditions for comfort and safety in and around the site.

The three tower mixed-use development is proposed in the heart of Gosford. The towers are significantly taller than the surrounding buildings hence are exposed to all prevailing wind directions. The proposed development would therefore have a measurable impact on the local wind conditions in and around the site.

Qualitatively, integrating the expected directional wind conditions around the site with the wind climate, it is considered that wind conditions for comfort at the majority of locations around the site would be classified as suitable for pedestrian standing, with a number of locations being classified as suitable for pedestrian walking. These classifications are considered suitable for intended use of space as a transient thoroughfare.

It is considered that all locations within the proposed development would meet or slightly exceed the safety criterion.

To quantify the qualitative advice provided in this report, numerical or physical modelling would be required and would be recommended for this significant development.

Contents

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 Client provided text

The proposed State Significant Development Application seeks concept development approval for the redevelopment of the Gosford Gateway Centre.

The concept development application will be subject to subsequent Development Applications with development approvals required for each stage.

The concept development proposes three mixed use towers and a public plaza in the centre. The development will be constructed in stages.

Full details of the proposal are included in the Environmental Impact Statement prepared by Barker Ryan Stewart.

2 Introduction

Jarre Pty. Ltd.. have engaged Arup to provide a qualitative environmental wind assessment for the proposed Gosford Gateway development. This report addresses the Secretary's Environmental Assessment Requirements key issue No. 6 in relation to the pedestrian wind conditions for comfort and safety on the ground level in and around the site:

- Assess the environmental and residential amenity impacts associated with the proposal, including solar access, acoustic impacts, visual privacy, view loss, overshadowing, lighting impacts, and wind impacts. A high level of environmental amenity must be demonstrated.

The Development Control Plan for Gosford City requires a qualitative wind report for developments with height greater than 14 m, and a qualitative report for developments with height greater than 48 m. Despite the maximum height of the proposed development exceeding the threshold level, a qualitative report has been prepared for this initial submission with the knowledge that quantification of the wind climate is likely to be conditioned. The more detailed study has been delayed to ensure that the final development geometry is tested. Numerical or physical modelling would be conducted to quantify the wind conditions during detailed design.

3 Site description

Gosford Gateway is located to the east of Gosford Station to the north of the block bounded by Faunce, Watt, Erina, and Mann Streets, Figure 1. The site is surrounded by low- to mid-rise buildings in all directions with open water to the south, and wooded areas to the east and west. The site is about 15 m above the sea level, sited between the higher topography of Rumbalara Reserve to the east, and President's Hill to the west. Figure 1(B).

Figure 1: Site location (T), view looking north (B) source: Google Earth (2018) (cont.)

Figure 1: Site location (T), view looking north (B) source: Google Earth (2018)

The proposed development consists of three buildings, Figure 2 and Figure 3. The maximum height of the development is about 115 m above ground level. The three towers are setback by 8-12 m from the external perimeter edge of the 3-4 storey podiums. There are open laneways between the three towers.

Figure 2. Floor plans at various levels

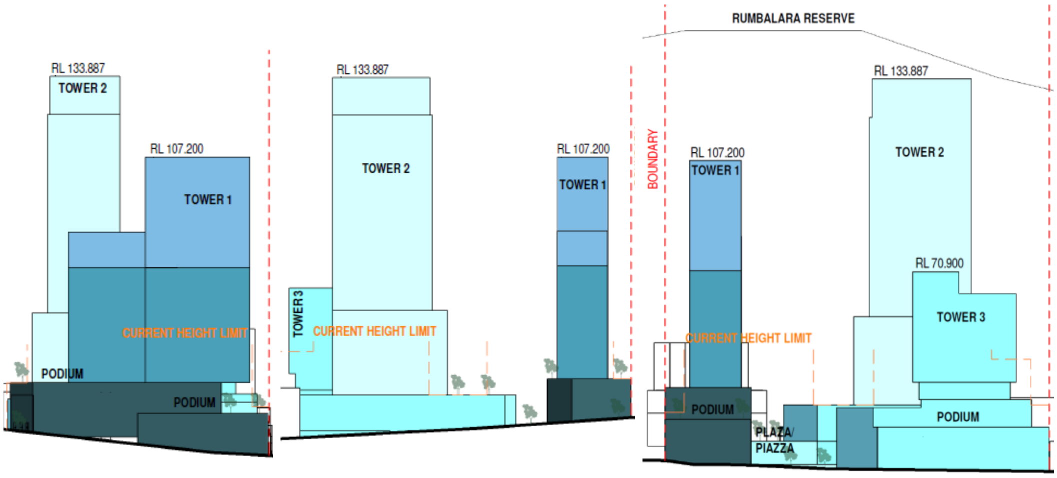

Figure 3. North (L), east (C), and west (R) elevations

4 Wind assessment

4.1 Local wind climate

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a height of 10 m at Gosford from 2013 to 2017 have been used in this analysis, Figure 4. The anemometer is located in Hylton Moore Park about 2 km to the south-east of the site. The arms of the wind rose point in the direction from where the wind is coming from. The available anemometer data in the Gosford area are influenced by the topographical features. The directional wind speeds measured here are considered most representative of the incident wind conditions at the site, due to the relative openness of the anemometer and close proximity to the site.

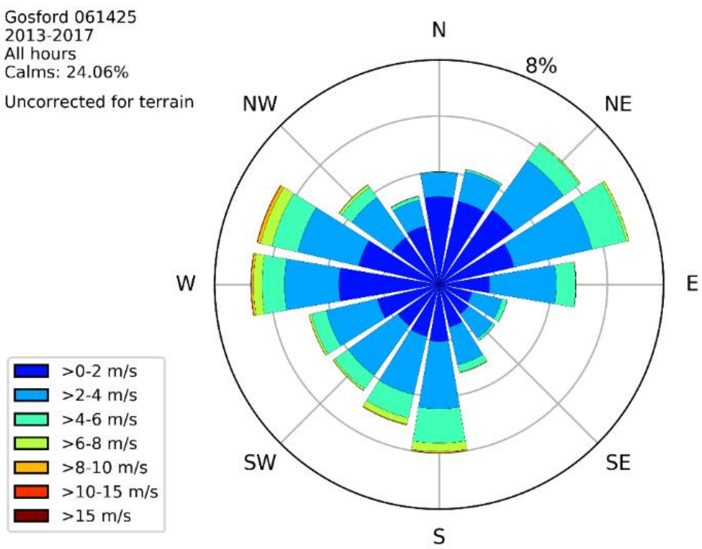

Figure 4. Wind rose showing probability of time of wind direction and speed

It is evident from Figure 4 that the prevailing wind directions are from the north-east, south, and west quadrants with stronger winds from the west and south directions. The measured mean wind speed of 1.7 m/s is low, and the 5% exceedance mean wind speed is 5 m/s. It should be noted that the data have only been collected for limited number of years; however, it would be expected that the incident wind conditions at the site would have a similar distribution. The measured wind conditions are calm (i.e. < 1 m/s) for about a quarter of the time in a typical year.

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

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.

There are no known 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 14 and

Table 1. Converting the wind climate to the typical site location, the mean wind speed exceeded 5% of the time would be approximately 4.5 m/s at pedestrian level and therefore classified as suitable for pedestrian standing.

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)

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 for winds from the north-east, south, and west quadrants. The proposed buildings are essentially isolated as they are taller than the surrounding buildings and President's Hill, and approaching the height of the Rumbalara Reserve.

It is worth noting that for multiple large buildings in close proximity, the highest wind speeds would be typically expected around the outside corners of the compound shape by the incident flow being redirected, and in the narrow gaps between buildings where the flow mechanism is driven by the pressure differential between either end of the gap with the fasted wind speed at the narrowest section.

Winds from the north-east

Winds from the north-east would impinge on the north-east corners of Towers 1 and 2, which would encourage horizontal flow around the towers reducing the amount of downwash. The large tower setbacks to the north and west of the development will offer significant protection to the ground plane particularly in the public square, whilst increasing the wind speed on the podium levels.

The orientation of the buildings is expected to produce windy conditions on the narrow laneway from Watt Street to the public square. The tapering of this laneway is considered good from a wind perspective by localising the strong wind conditions to the narrow section and allowing it to expand and slow in the wider section. For this wind direction, the tall towers would offer shielding to the public plaza and the laneway to the south of the site.

Winds from the south

Winds from the south will impinge on the southern faces of all three towers inducing downwash that would be directed along Mann and Watt Streets. The large tower setback from the podium edge to the east and west, and the Tower 1 notch above podium level would reduce the amount of downwash reaching ground level. The wind conditions on the east side of Watt Street opposite Tower 2, and to the west of Mann Street near Faunce Street would be windy. The downwash from the smaller Tower 3 would be expected to be dissipated by the large podium before reaching ground level.

The narrow laneway between Towers 2 and 3 would be expected to be windy as would the narrow laneway to Watt Street, and the north-west corner of the plaza square close to Tower 1. Localised amelioration in these areas could be included to improve the wind conditions.

For this wind direction, the towers would offer shielding to the areas to the immediate north of the towers and a significant portion of the public square.

Winds from the west

Winds from the west are relatively undisturbed on reaching the site with the open area of Burnes Park. These winds will impinge on the west faces of all three towers inducing downwash. The relatively narrow face of Tower 1 would encourage more horizontal flow around the tower thereby reducing the amount of downwash reaching ground level. The large tower setbacks from the podium edge would improve the wind conditions at ground level. The small tower setback to the south of Tower 1, would not prevent the downwash traversing the public square and discharging to the laneway to Watt Street.

The orientation of Tower 2 and interaction with the flow around Tower 3 would be expected to direct flow along the vehicular laneway between the low-rise buildings to the east of Watt Street.

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 standing and walking type activities with windier locations in the narrow sections of the pedestrians laneway to the south and Watt Street. The predicted final wind comfort classification is depicted in Figure 5; any areas not marked are classified as suitable for standing. These classifications are considered to be suitable for intended use of spaces as transient thoroughfares. If these areas are to be intended for more sedentary recreational activities then local amelioration would be required and developed through detailed design.

It is considered that all locations within the proposed development would meet or only slightly exceed the safety criterion.

Figure 5. Wind comfort classification at ground level in and around the site

5 Additional Advice

To improve the wind conditions in the Public Square, the podium to Tower 1 could be wrapped around to form more of a protected public courtyard area, Figure 6.

Figure 6. wind mitigation strategies

6 References

City of Auckland, (2016), Auckland Unitary Plan Operative.

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City of Melbourne (2017), Melbourne Planning Scheme.

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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 7, 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 7. 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.

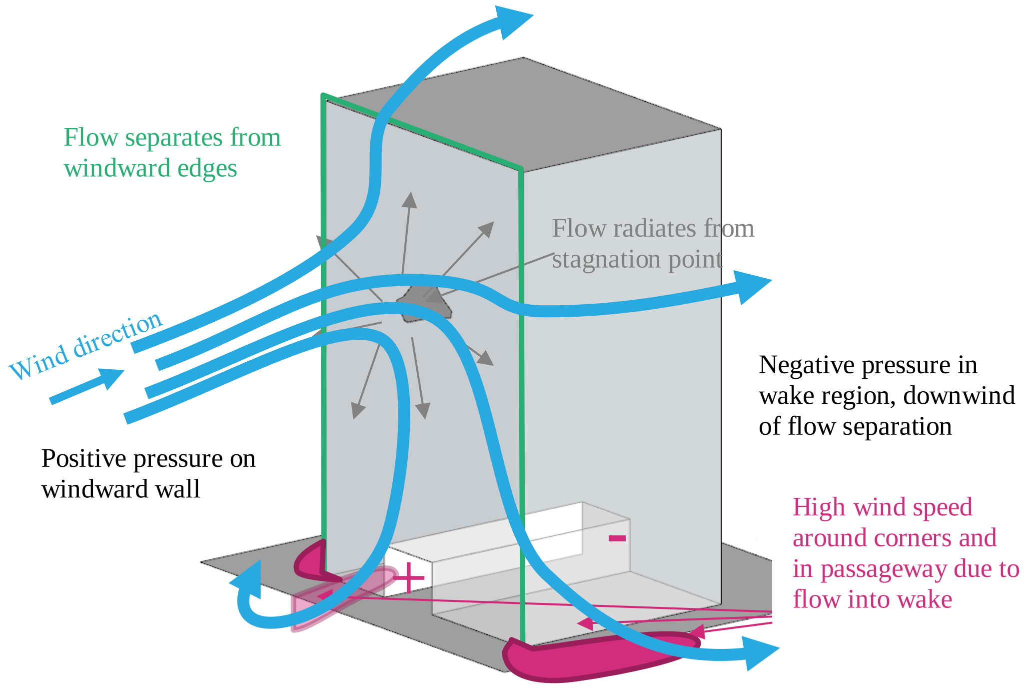

Figure 7. Schematic wind flow around tall isolated building

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.

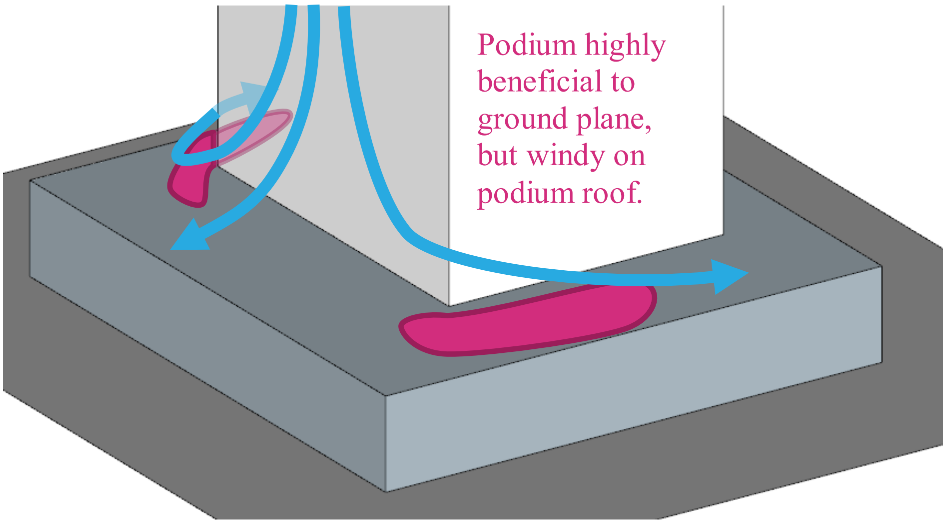

Figure 8. Schematic flow pattern around building with podium

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 9. 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.

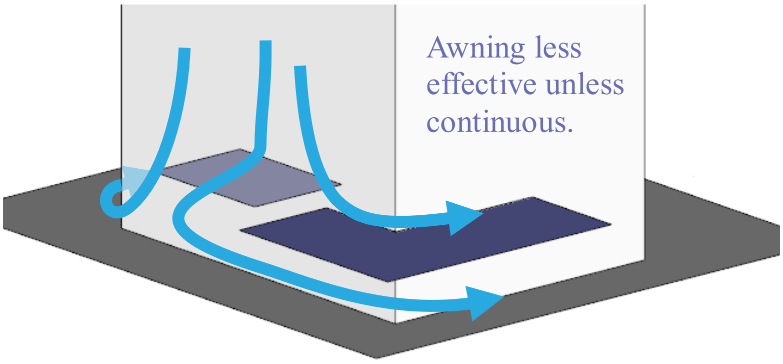

Figure 9. Schematic flow pattern around building with awning

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 10. 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 7. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 11. 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 11.

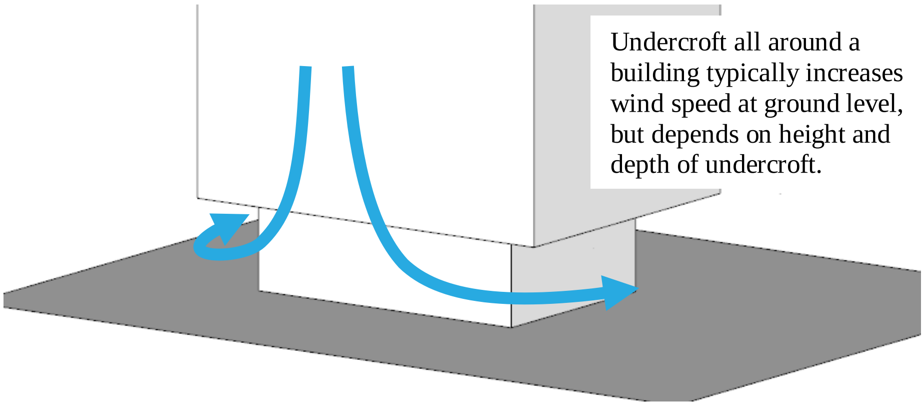

Figure 10. Schematic of flow patterns around isolated building with undercroft

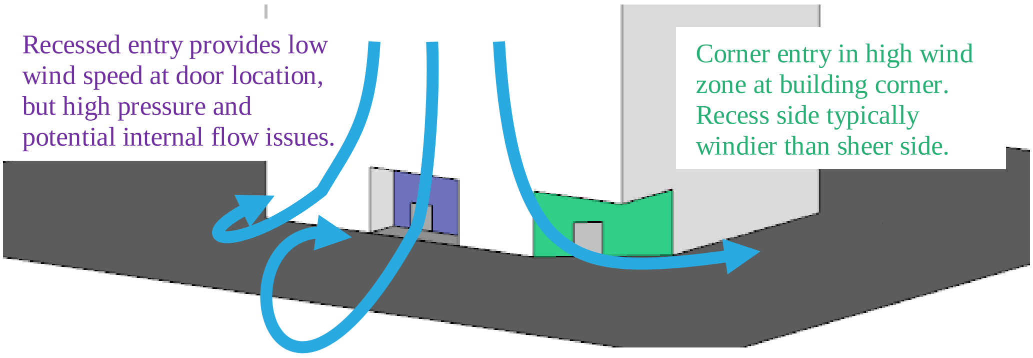

Figure 11. Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 12. 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.

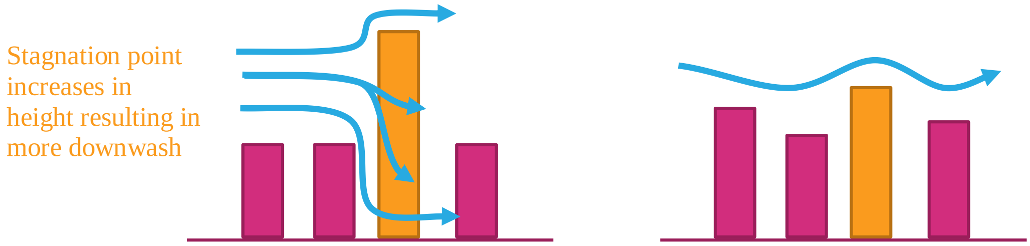

Figure 12. Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 13.

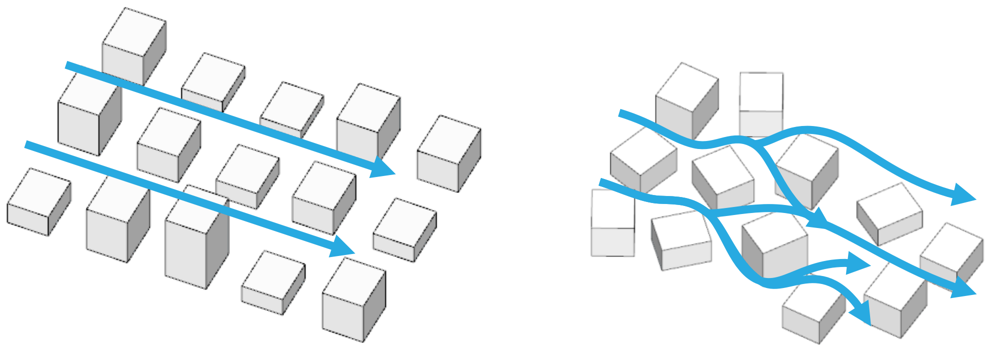

Figure 13. Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 13(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 13(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.

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:

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

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 14 and Figure 16. 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 14 with definitions of the intended use of the space categories defined in Figure 15.

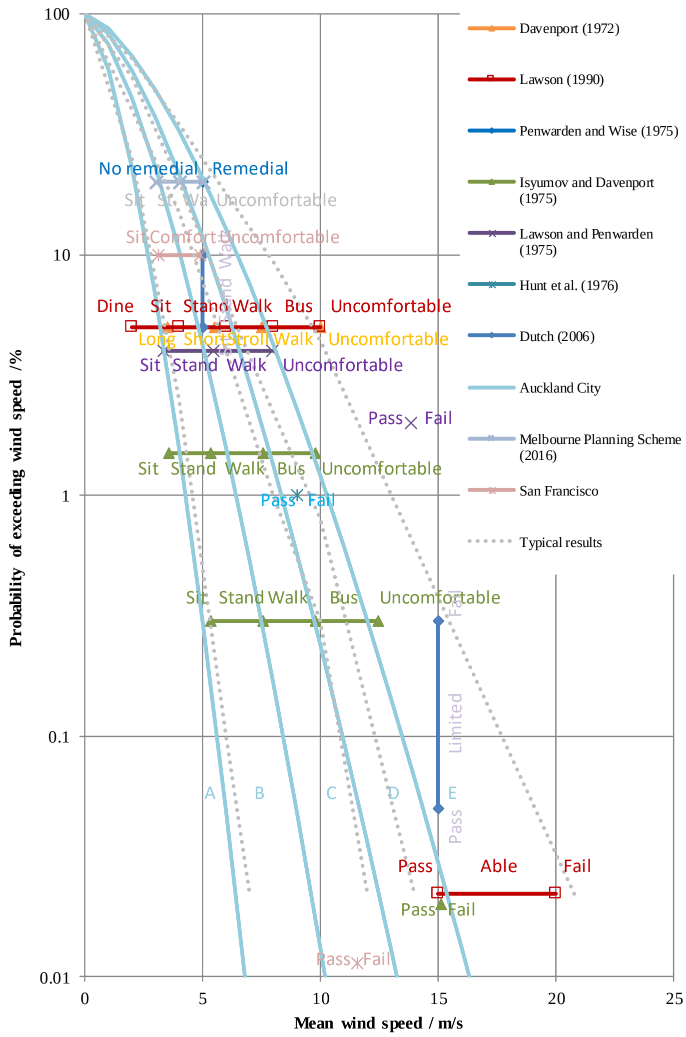

Figure 14. Probabilistic comparison between wind criteria based on mean wind speed

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 15. Auckland Utility Plan (2016) wind categories

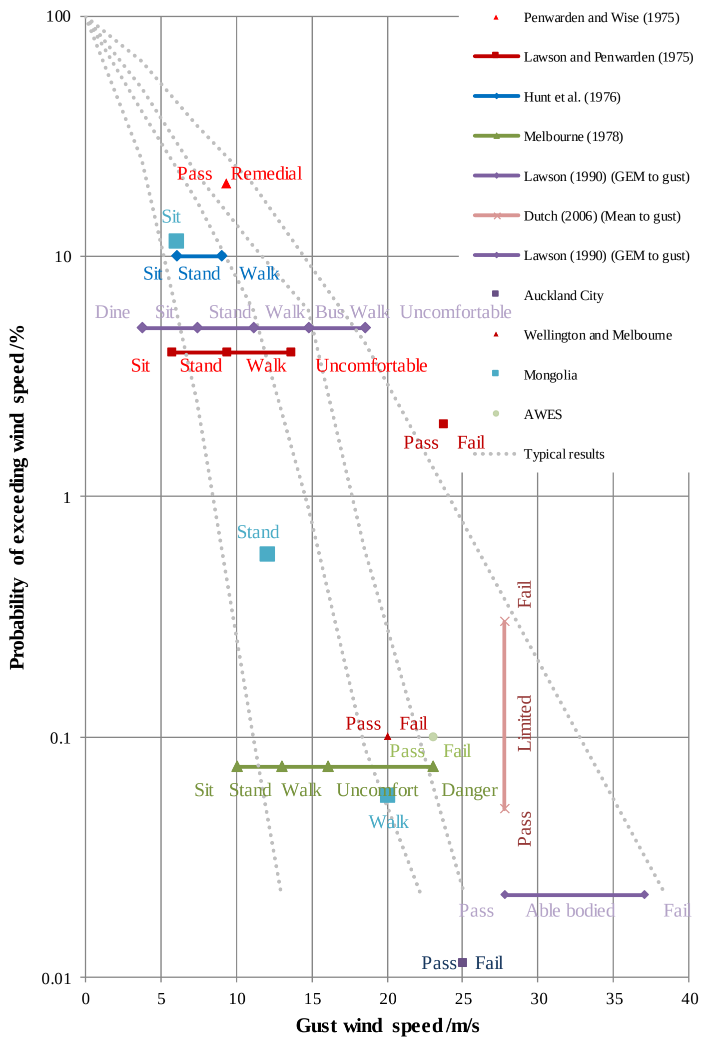

Figure 16. Probabilistic comparison between wind criteria based on 3 s gust wind speed

Appendix 3. Reference documents

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

191213 SEARs Request ADG .pdf