CUNDALL

Westfield Liverpool ELP

Wind Effects Report for DA

Scentre Group

Job No: 1023089

Doc Ref: 1023089-RPT-ESD-001

Revision: B

Revision Date: 25 July 2019

Project title	Westfield Liverpool ELP	Job Number
Report title	Wind Effects Report for DA	1023089

Document Revision History

Revision Ref	Issue Date	Purpose of issue / description of revision
—	17 June 2019	Draft for review
A	25 June 2019	Issue for DA
B	25 July 2019	Issue for DA, updated drawings

Document Validation (latest issue)

25/07/2019

X

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25/07/2019

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25/07/2019

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Executive Summary

Cundall have been engaged by Scentre Group to assess the wind impact of the proposed Westfield Liverpool ELP redevelopment and new office building located on Elizabeth Drive in Liverpool, NSW. This Wind Effects Report has been prepared to respond to the objectives described in Section 4.5.1 Wind Mitigation of Part 4 of Liverpool City Council's Liverpool Development Control Plan (LDCP) 2008 to demonstrate that:

- New developments satisfy nominated wind standards and maintain comfortable conditions for pedestrians.
- Moderate breezes are able to penetrate the streets of Liverpool City Centre.

We have qualitatively considered the impacts of the proposed development on pedestrians within the precinct and adjoining streets and public spaces. The assessment looked at the local site, proposed building design and local wind climate. The key factors which influence the wind microclimate in the area were investigated including:

- The proposed building form and height.
- The nature and distribution of wind obstructions surrounding the site.
- The proximity to nearby existing buildings, outdoor retail areas and pedestrian areas.
- Wind mitigation design features, such as podiums, awnings, overhangs and rooftop shelters.

The wind conditions in the surrounding streets and public plaza opposite are not expected to be significantly different to the existing wind conditions currently experienced by pedestrians using these spaces. The building design includes awnings, canopies, overhangs and balconies, as well as a podium, which can help to mitigate potential negative impacts from wind. Wind conditions around the site are expected to be appropriate for use at ground level and podium terrace level.

In summary, the proposed Westfield Liverpool Office and ELP redevelopment design as shown on the DA drawings is considered to respond appropriately to wind comfort objectives of Liverpool City Council.

Further analysis, if required, to refine the wind mitigation strategies can be undertaken during design development.

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1.0 Introduction

1.1 Project background

Cundall have been engaged by Scentre Group to assess the wind impact of the proposed Westfield Liverpool ELP redevelopment and new office building located on Elizabeth Drive in Liverpool, NSW.

The project is a development on the existing Westfield Liverpool, which consists of:

- upgrade to the retail entry forecourt
- new entertainment, leisure and dining precinct on level 3 and 4
- a new eight-storey commercial tower and ground level lobby entry.

1.2 LDCP Wind Mitigation requirements

Section 4.5 of Part 4 of Liverpool City Council's Liverpool Development Control Plan (LDCP) 2008 sets out the wind requirements as follows:

4.5.1 Wind Mitigation

Background

Windy conditions can cause discomfort and be dangerous to pedestrians, and downdrafts from buildings can inhibit the growth of street trees. Conversely, moderate breezes that penetrate streets can enhance pedestrian amenity and disperse vehicle emissions and air conditioning plant exhausts.

Objectives

Wind mitigation measures must:

1. *Ensure that new developments satisfy nominated wind standards and maintain comfortable conditions for pedestrians.*
2. *Ensure that the moderate breezes are able to penetrate the streets of Liverpool City Centre.*

Controls

1. *Design all new buildings to meet the following maximum wind criteria:*
   a) *10m/second in retail streets;*
   b) *13m/second along major pedestrian streets, parks and public places; and*
   c) *16m/second in all other streets.*
2. *Submit a Wind Effects Report with the DA for all buildings greater than 35m in height.*
3. *Submit results of a Wind Tunnel Testing report for buildings over 48m in height.*

1.3 Site location

The Westfield Liverpool site is in the heart of a major commercial centre, which is approximately 35 kilometres inland and southwest of the Sydney CBD. Figure 1.1, Figure 1.2 and Figure 1.3 below show google earth images of the site and its context.

There are low density residential areas surrounding the site to the north, west and southwest, whilst there are low to mid-rise retail units to the south and east. Further afield are Brickmakers Creek to the west, Bigge Park to the southeast, and Georges River to the south and east. An appreciation of the site context is important to the consideration of the local winds for the development.

Figure 1.1 – Aerial view of the proposed site location highlighted in blue

Figure 1.2 – Close up aerial view of the proposed site location highlighted in blue

Figure 1.3 – Site showing surrounding streets and spaces. The red box indicates the approximate extent of the redevelopment works.

1.4 Proposed development

Figure 1.4 and

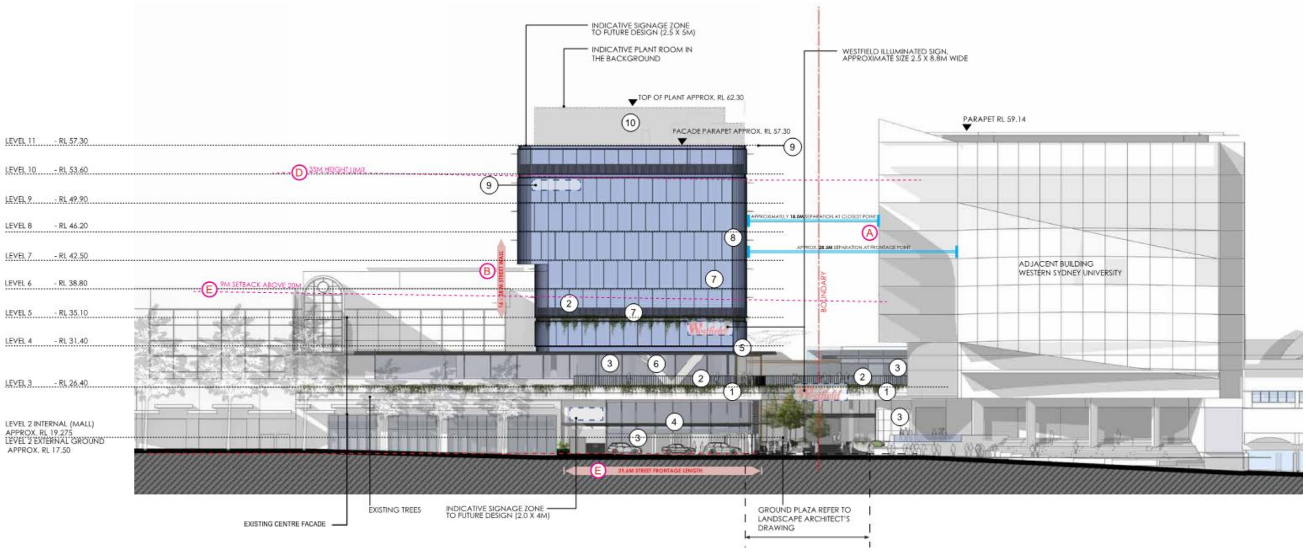


Figure 1.5 show the proposed design and the surrounding areas. Key considerations with regards to wind impacts are the following:

- The new office building.
- The new Entertainment and Leisure Precinct (ELP) area.
- The adjacent existing Western Sydney University (WSU) tower building.
- The surrounding roads and public park.

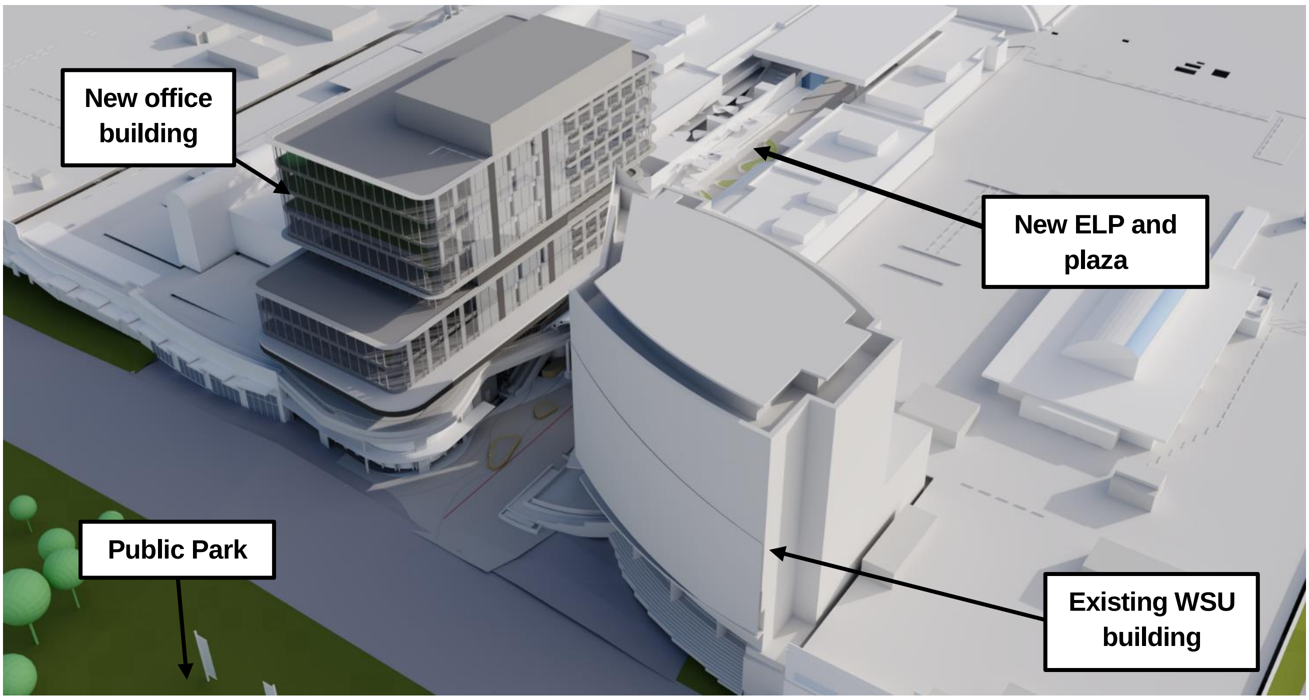


Figure 1.4 – 3D render of proposed development

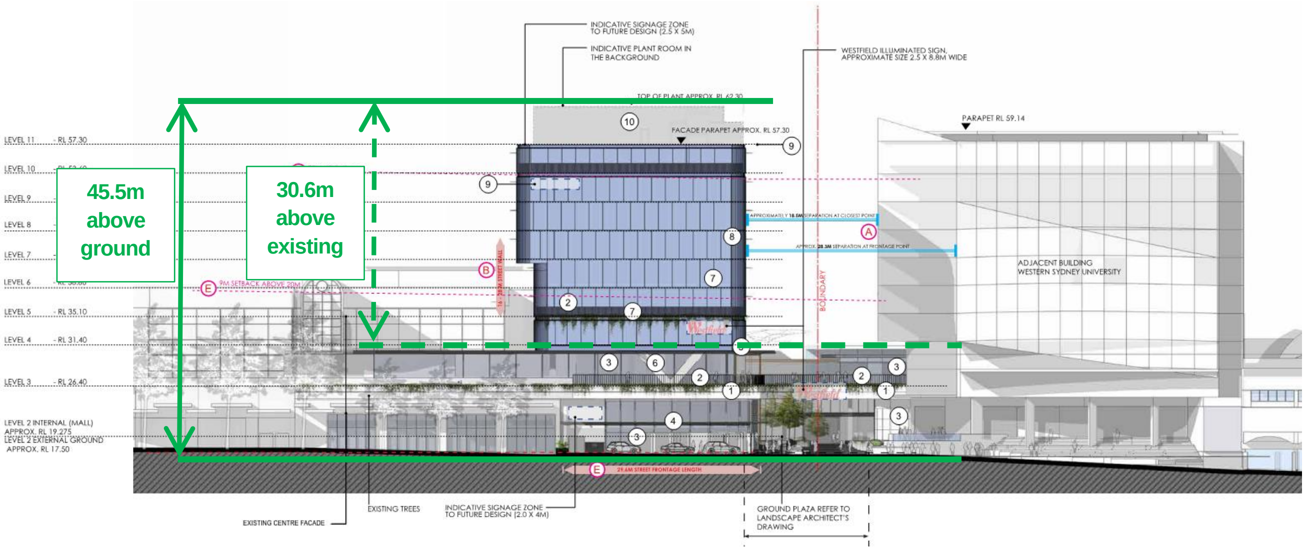


Figure 1.5 – South elevation of proposed development

The proposed development is greater than 35m in height and therefore requires a Wind Effects Report for DA (this report). However, as the proposed development is less than 48m in height a Wind Tunnel Testing report is not required, as per the LDCP.

1.5 Wind Impact of adjacent WSU building

As can be seen, the proposed development will be approximately the same height as the existing adjacent Western Sydney University (WSU) building. This building was opened in June 2018 and provides context for the wind impacts of the proposed office building. The *Statement of Environmental Effects for 124 Macquarie Street* dated May 2015 contained the following Wind Impact statement:

5.4.4 Wind Impact

The DCP requires a Wind Report for building with a height greater than 35m. The height of the proposal varies as a function of the topography. As shown in the elevations, when measured from the ground existing ground level the façade of the proposal partially extends just above 35m in height. A Wind Report has not been prepared on the grounds that:

- *The proposal represents a minor variation to the 35m height standard.*
- *Buildings in the immediate area have a height of three storeys or less, reducing the likelihood of cumulative impacts and permitting breezes to penetrate the city centre.*
- *The roof garden has been designed to protect users by incorporating sheltering devices, including the use of mature trees and physical screening.*
- *As demonstrated in the section drawings the façade incorporates breaks to dissipate downdrafts.*

A revised DA for the building, for the change in use from office to education, was submitted to Liverpool City Council in 2017. Appendix H of Statement of Environmental Effects for the amended DA application for this building dated 16 May 2017 stated the following related to DCP compliance:

5.4 Wind Mitigation

A Wind Effects Report is not considered necessary in this instance on the grounds that:

- *The proposed addition is setback behind the approved VNE glazing. Additional adverse wind impacts are not likely to be generated from this addition.*
- *Buildings in the immediate area have a height of three storeys or less, reducing the likelihood of cumulative impacts and permitting breezes to penetrate the city centre.*

This is useful background information and suggests that a new office building in the same location is unlikely to have a significant impact on the surrounding streets or breezes into Liverpool City Centre. However, rather than relying on a comparison between the two buildings we have undertaken a wind effects study which is described in the following sections of the report.

1.6 Reference documents

The following resources were used throughout this verification exercise:

- Drawings, models and documentation – a list of which is contained in Appendix A.

1.7 Disclaimer

The following assessment is based on drawings provided by Scentre Group and is a desktop study based on Cundall's prior experience.

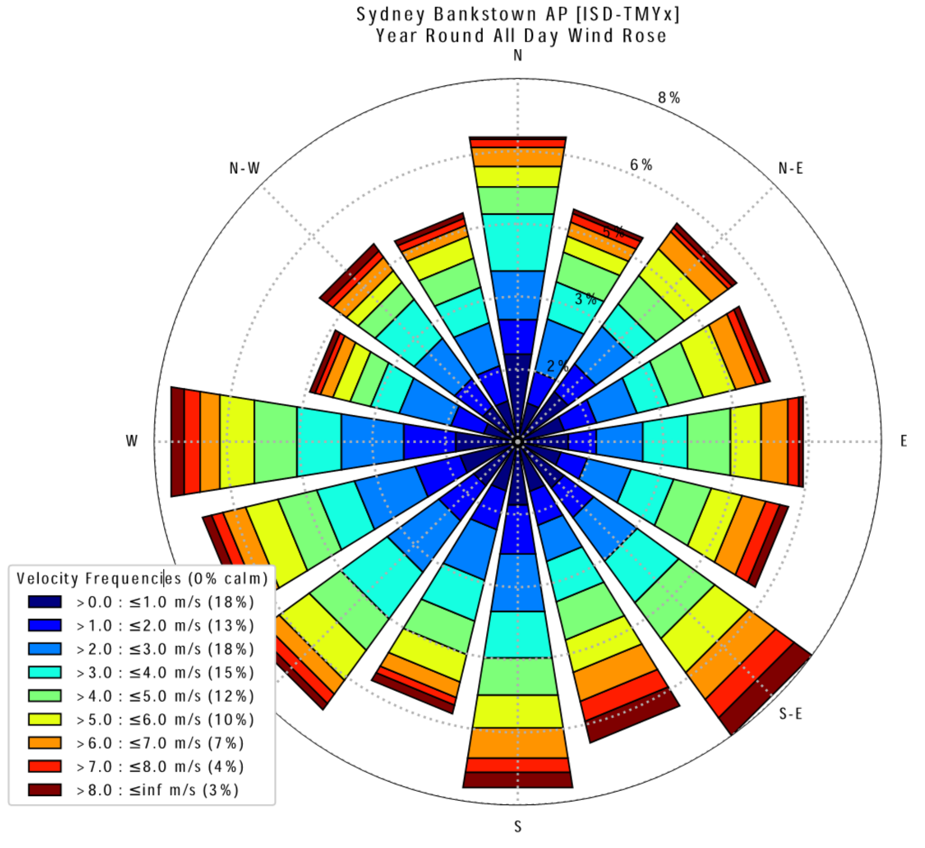
No Computational Fluid Dynamic modelling or wind tunnel testing has been carried out as a part of this assessment. To quantify the advice provided in this qualitative report it is recommended that computer-based simulation and / or wind tunnel testing be carried out at later design stages.

Whilst the report may focus on key areas of the building design, the results should be reviewed in whole and the reader must consider all results shown within and around the building. Cundall will not take responsibility or accept liability for the use/interpretation of this report by any third party. This assessment does not use gust speeds and is not a quantitative assessment of pedestrian safety. It is also not an assessment of wind pressure, façade pressure or structural loading.

2.0 Local wind climate

The wind conditions across the development site will be driven by the NSW climate prevailing winds. The wind environment in this report using the AUS Sydney Bankstown climate file Typical Meteorological Year (TMY) file. The Bankstown Airport data provides the nearest detailed local weather observation for the site.

Figure 2.1 shows an annual wind rose. This is a graphical representation of the wind conditions for a typical year. The wind roses for each season of the year are shown in Figure 2.2. These show the prevailing wind direction, speed and frequency for summer, autumn, winter and spring and are broken down into morning, afternoon, evening and night.



The wind rose diagram shows three key pieces of information

- Wind direction
- Wind strength
- Wind frequency

Colour shows wind strength i.e. yellow is 5.0-6.0 m/s

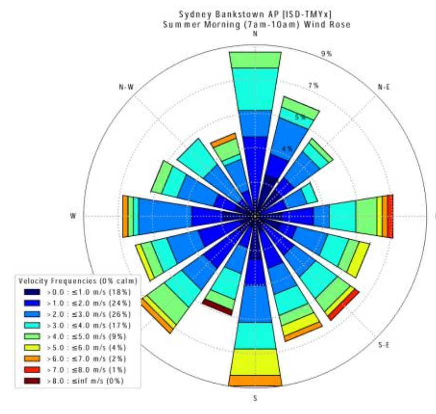
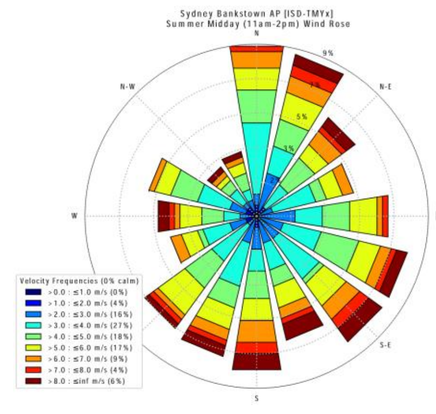
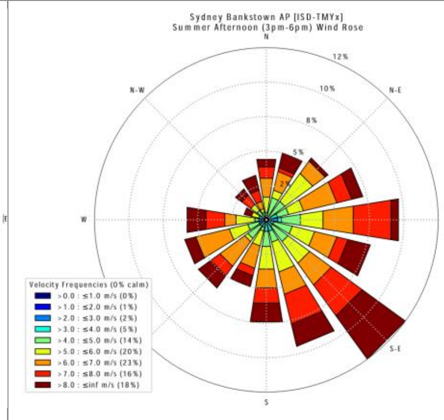
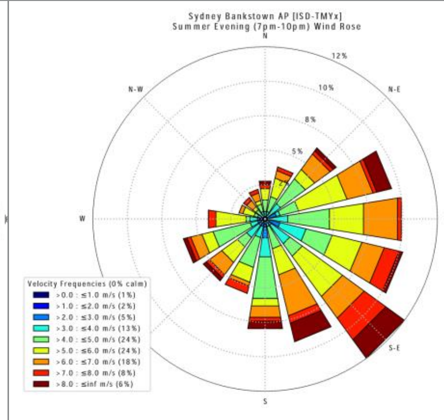
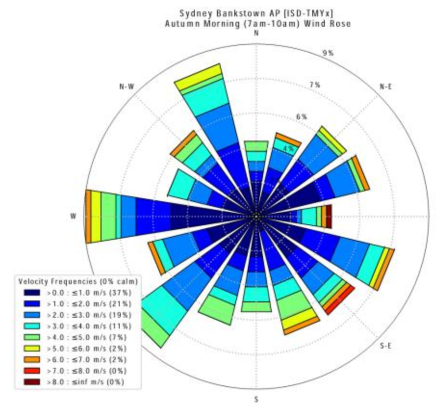
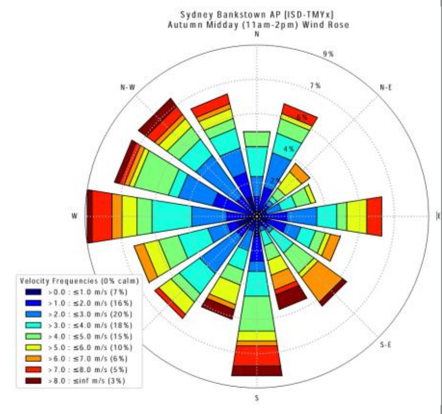
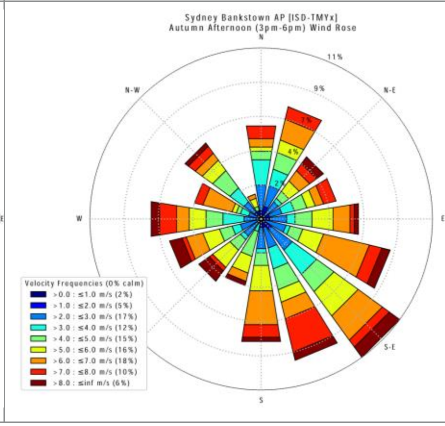
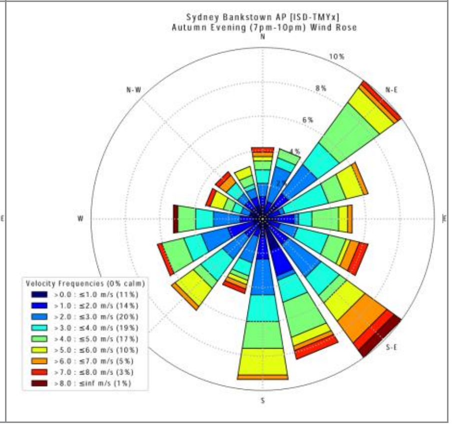
Length of each wedge indicates a fraction of time.

See an 8 m/s wind is a Force 5, known as a fresh breeze and can cause small trees to sway.

Figure 2.1 – Wind rose – a full year wind profile

As illustrated in the wind roses below, it can be seen that Bankstown Airport has a strong prevailing south / south-easterly wind throughout the year in the afternoons, whilst the mornings appear to have less strong winds tending to arrive from all directions.

Occasional northerly winds occur throughout the year which are less frequent. It should be noted that these northerly winds, although not as common as westerly, southerly and south-westerly winds, generally occur as a result of storm activity and as such can be stronger in intensity when they do occur.

	Morning	Midday	Afternoon	Evening
Summer				
Autumn				

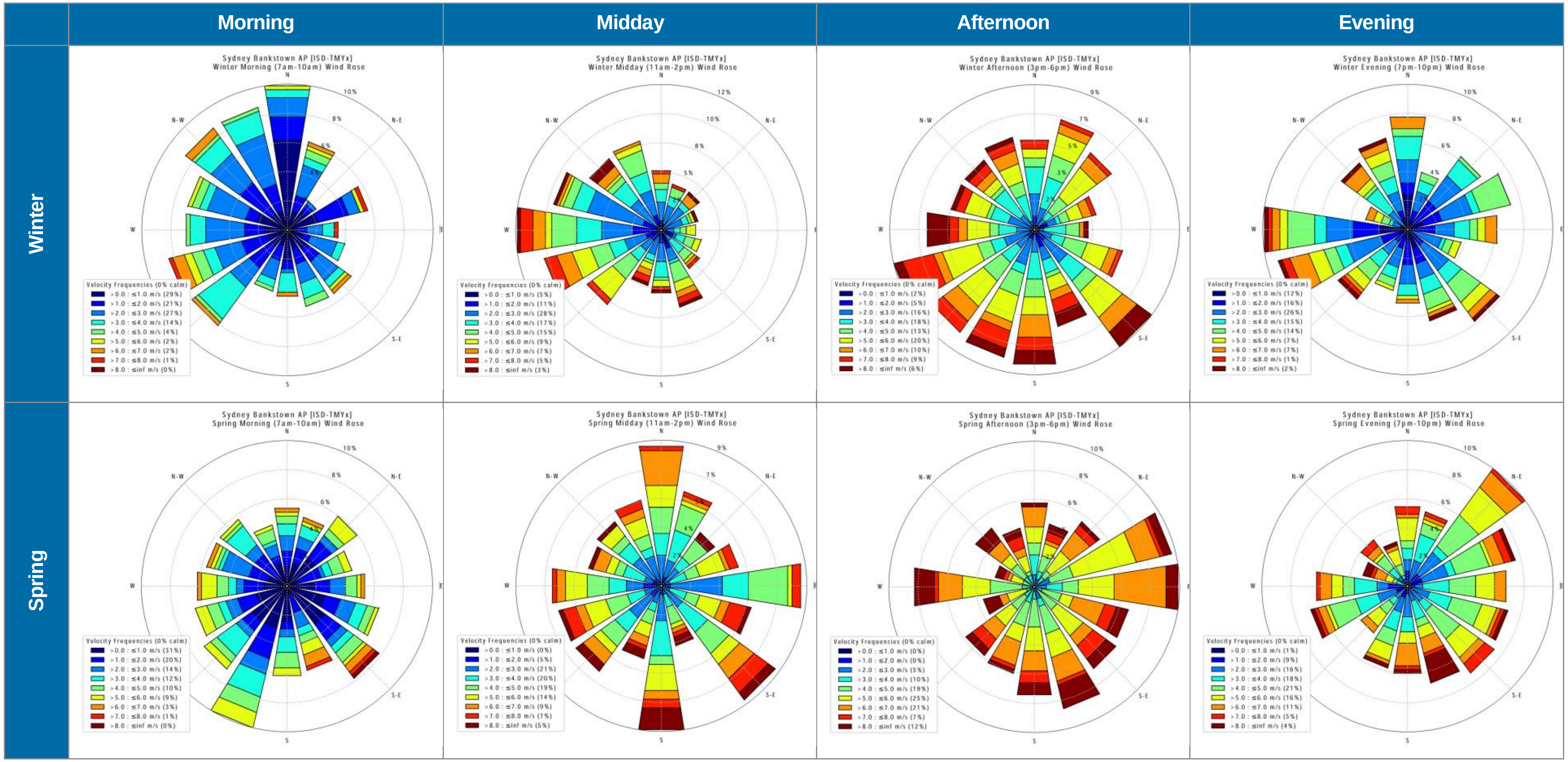


Figure 2.2 – Wind rose – for each time of the day and season.

3.0 Environmental wind speed criteria

Wind speed and frequency of wind occurrence are the primary parameters used in the assessment of pedestrian wind impact. Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. Despite the apparent differences in numerical values and assumptions made in their development, it has been found that when these are compared on a probabilistic basis, there is generally good agreement.

3.1 The Beaufort Scale

Wind criteria for pedestrian comfort are related to the Beaufort Wind Scale which is described in along with relative conditions in order to aid in relating the scale to everyday occurrences.

Table 3.1 The Beaufort scale for wind strength and comparison with commonly sensed outcomes

Force	knots	Km/h	m/s	Name	Relative Conditions
0	<1	<2	0 - 0.5	Calm	Smoke rises vertically
1	1 - 3	1 - 5	0.5 - 1.5	Light air	Smoke drifts and leaves rustle
2	4 - 6	6 - 11	1.5 - 3	Light breeze	Wind felt on face
3	7 - 10	12 - 19	3 - 5.5	Gentle breeze	Flags extend, leaves move
4	11 - 16	20 - 29	5.5 - 8	Moderate breeze	Dust, leaves and loose paper lifted
5	17 - 21	30 - 39	8 - 11	Fresh breeze	Small trees sway
6	22 - 27	40 - 50	11 - 14	Strong breeze	Large tree branches move, wires whistle
7	28 - 33	51 - 61	14 - 17	Near gale	Whole trees in motion, inconvenience in walking.
8	34 - 40	62 - 74	17 - 21	Gale	Difficult to walk against wind, small branches blown off tree.
9	41 - 47	76 - 87	21 - 24	Strong gale	Minor structural damage may occur (shingles blown off roofs).

**note; Green outline indicates focus for Liverpool Development Control Plan (LDCP) 2008 requirements*

3.2 Lawson's Criteria

This report refers to the Lawson Criteria developed over a period of some 30 years at the University of Bristol in the UK. These criteria are probably the most widely used in environmental impact assessments across the UK and Australia and are also specified as the urban comfort criteria adopted in the many council guidelines.

Six usage categories are defined by the criteria which are summarised in . The usage categories represent varying levels of activity as well as duration of that activity.

“Tolerable” conditions indicate a level at which pedestrians will be conscious of the wind but will put up with it. Conditions that are tolerable for a particular activity can be improved upon but don’t require remedial action if conflicting design constraints make this impossible or uneconomical.

“Unacceptable” conditions indicate that wind strength and potential duration will not be tolerated by pedestrians.

Conditions are “Unacceptable” or “Tolerable” based on the percentage of time that the points tested exceed the Beaufort force on a per usage basis. For example, if a sitting type area exceeds Beaufort 3 (3 m/s) for more than 1% of the time assessed, then this area may be considered uncomfortable for sitting type activities.

Table 3.2 Summary of Lawson's Criteria for various space usage categories

Description	Letter	Unacceptable	Tolerable
Road and Car Parks	A	6% > Beaufort 5	2% > Beaufort 5
Business Walking	B	2% > Beaufort 5	2% > Beaufort 4
Pedestrian Walk-through	C	4% > Beaufort 4	6% > Beaufort 3
Pedestrian Standing	D	6% > Beaufort 3	6% > Beaufort 2
Entrance Doors	E	6% > Beaufort 3	4% > Beaufort 2
Sitting	F	1% > Beaufort 3	4% > Beaufort 2

**note; Green outline indicates focus for Liverpool Development Control Plan (LDCP) 2008 requirements*

4.0 Wind flow mechanisms

Fluid flows such as air/wind is driven from high pressure to low pressure regions much the same way as current flows from higher voltage to lower voltage and water flows in a river from a higher level to a lower level.

As the wind moves around a building it broadly tends to convert its kinetic energy (motion) into pressure. Upstream faces where the wind strikes the building may form a stagnation region where the pressure is the highest. Downstream faces experience lower pressure in the turbulent wake of the building. This pressure differential from the windward to the leeward sides of the building has the potential to drive high velocity air (wind) through or around the building.

After far field wind mitigation, building massing has the largest impact on the local wind environment of any development and is usually the most significant controllable variable. The building forms will typically depend focused on the architect's aesthetic aspirations, client's objectives and budget. Given these constraints, it may be difficult to reform the massing with a larger focus on wind impacts.

The wind will tend to follow the path of least resistance to get from the higher-pressure region to the lower pressure. Thus, if there is a narrow passageway or pedestrian arcade connecting the windward side of the building to the leeward side then a lot of air may be forced into this space potentially creating a wind tunnelling problem in this area. Wind effects may be reduced by either:

a) increasing the wind resistance through the passageway; or
b) providing an alternative, more favourable path for the wind to take.

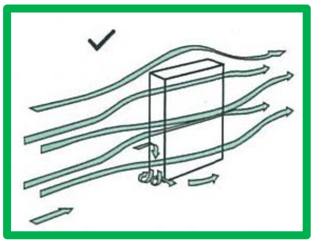
Wind resistance can be increased by adopting 90-degree bends, wing-walls and podium levels or awnings above the entrance to reduce the potential for downwash to create high pressures on the windward side.

For an isolated building a large portion of the wind is accelerated down and around the windward corners. This is called downwash and causes the windiest conditions at ground level on the windward and sides of the building. Techniques to mitigate the effects of downwash winds on pedestrians include the provision of horizontal elements, the most effective being a podium to divert the flow away from pavements and building entrances. Awnings along street frontages perform a similar function and the deeper the horizontal element generally the more effective it will be in diverting the flow.

Winds at mid and upper levels on a building are accelerated substantially around the corners of the building. When balconies or external terraces are located on these corners, they are likely to be breezy and will be used less by the owners due to the regularity of stronger winds. Owners quickly become familiar with when and how to use their balconies. If the corner balconies are deep enough, articulated, or have regular partition privacy fins then local calmer conditions can exist.

Below are some examples[1] of wind flow around buildings and the best practices to increase wind comfort:

Orientate the long axis parallel to the prevailing wind. Avoid large flanking walls facing the prevailing.



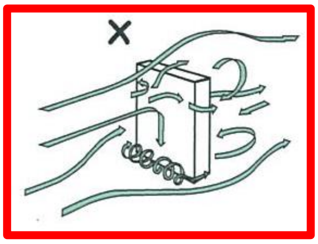


Figure 4.1 – Illustration of the effect of orientation and massing

[1] Wind Microclimate Around Buildings' p. 8, 2011 Digest DG 520, BRE Press and IHS

Use podiums to prevent downwash reaching ground level. Avoid large cubical buildings with plain façades.

Figure 4.2 – Illustration of the podiums

Avoid potential issues with transverse wake flow using finger blocks on the rear face.

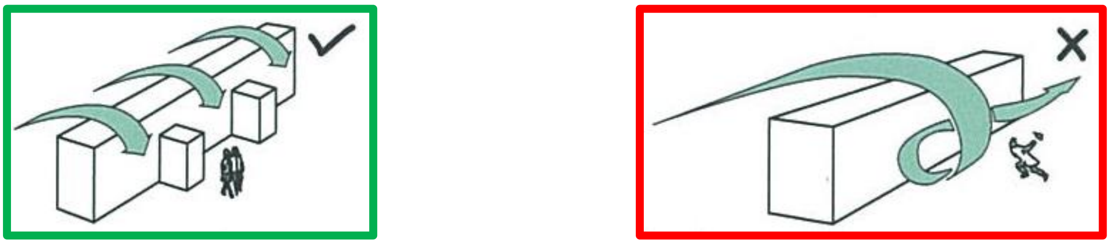


Figure 4.3 – Illustration of the effect of finger blocks

Use large canopies to mitigate downwash. However, be aware that this can trap and accelerate horizontal flows.

Figure 4.4 – Illustration of the effect of awnings

Avoid funnel-like gaps between buildings and passageways beneath buildings at ground level.

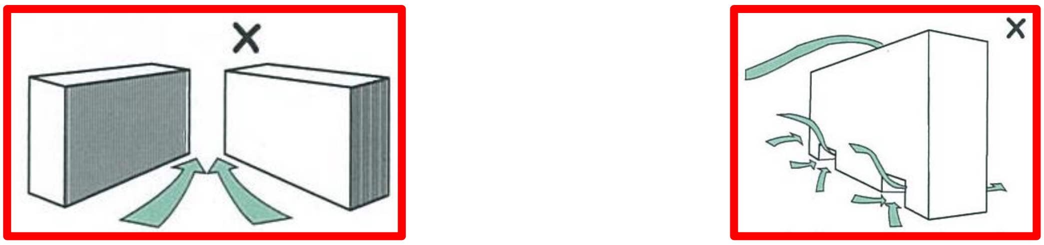


Figure 4.5 – Illustration of the effect of funnelling and tunnelling

Group buildings so that the height differential is minimised; ideally, the protruding building height should be less than twice the average height.

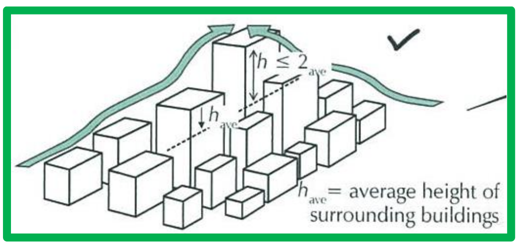
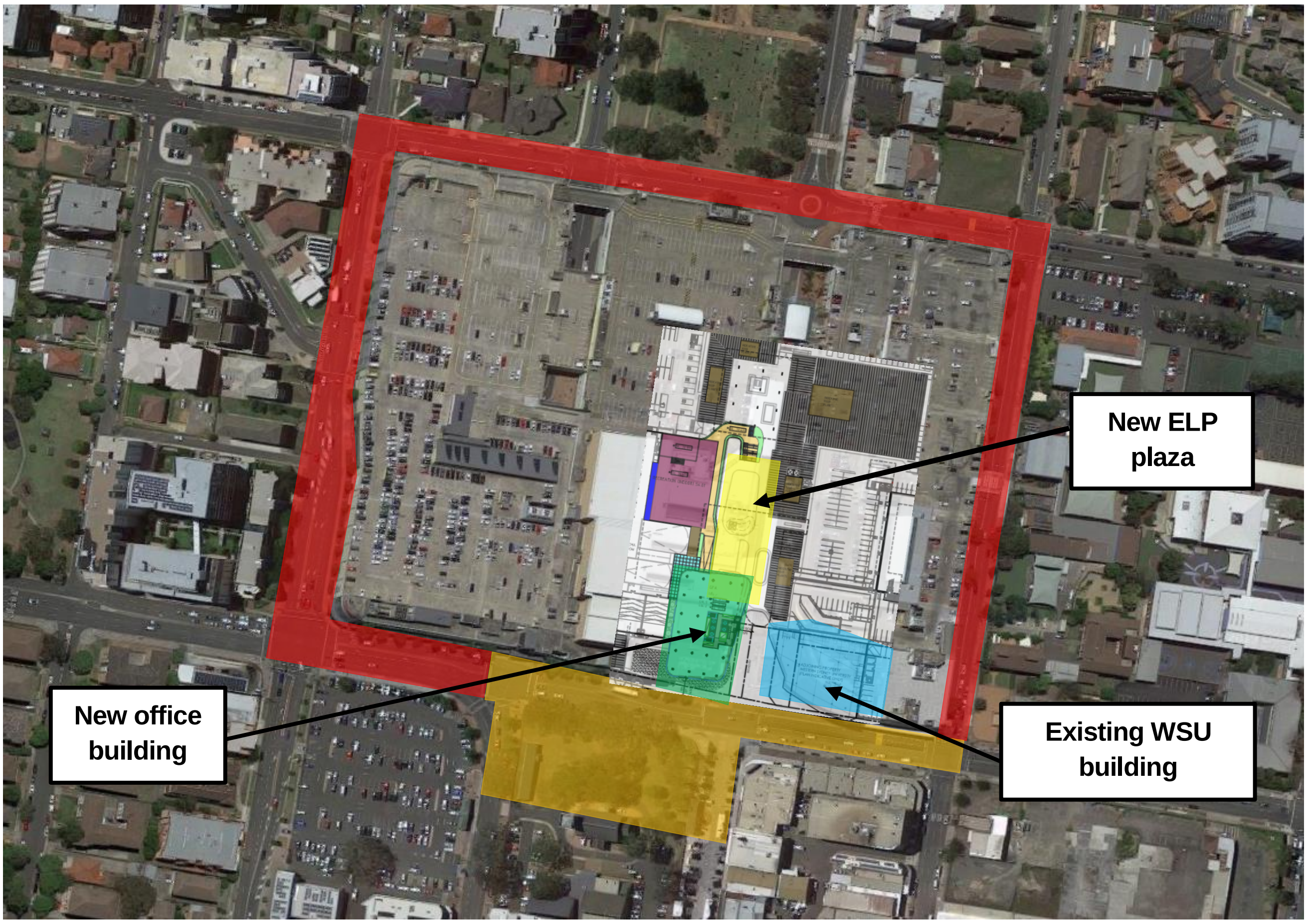


Figure 4.6 – Illustration of the effect of height differentials

5.0 Environmental wind assessment

5.1 Pedestrian zones

Figure 5.1 below shows the various pedestrian zones around and within the proposed development as per Section 4.5.1 of Part 4 of the Liverpool Development Control Plan 2008.



New office building

Existing WSU building

Type	DCP Wind Criteria
Retail street	10 m/s
Major pedestrian street, parks & public places	13 m/s
All other streets	16 m/s

Figure 5.1 – Site area showing street types and DCP wind criteria

5.2 Prevailing winds

The following assessment has considered the site factors, proposed building design and the prevailing winds. The two predominant prevailing wind directions appear to be westerly winds (particularly in the morning and midday times of the day) and the south-easterly winds (particularly in the afternoons and evenings). We have reviewed the proposed development against these two predominant prevailing wind patterns.

5.2.1 South-easterly wind

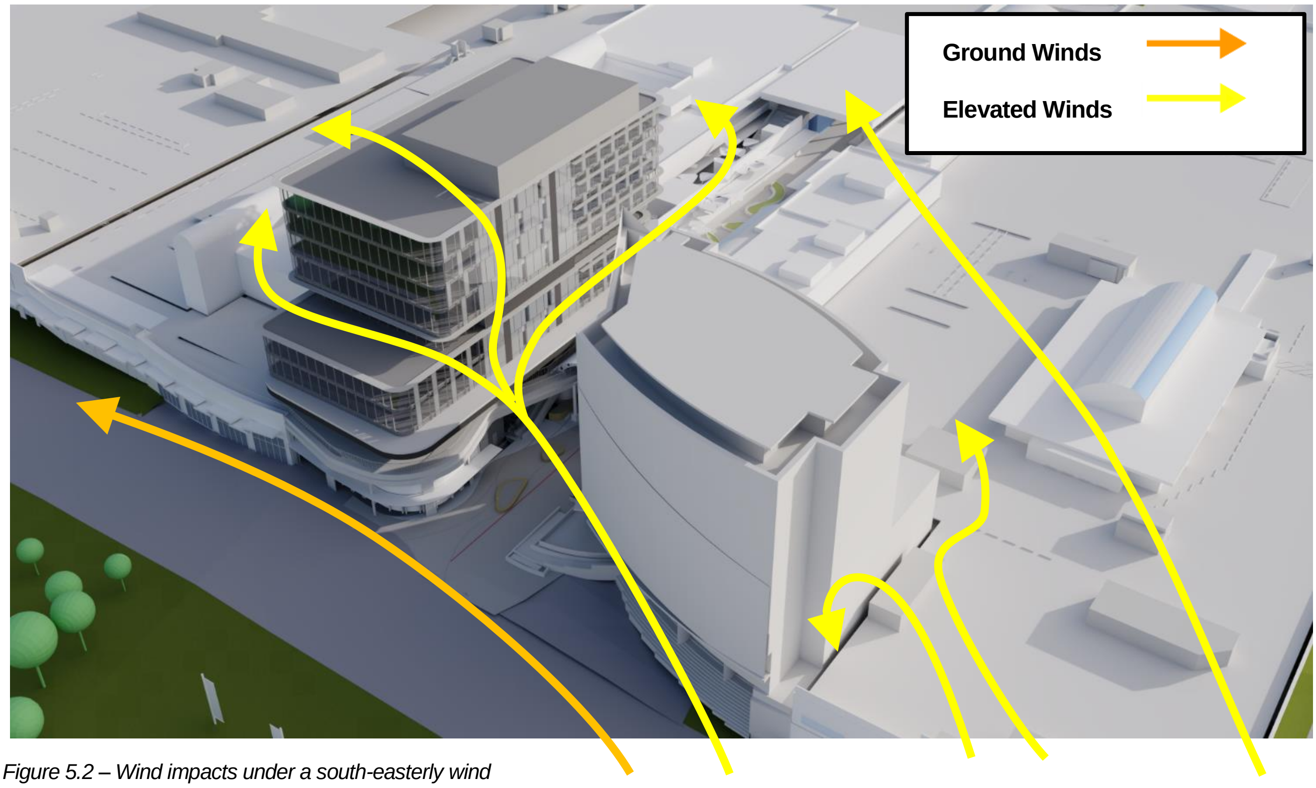


Figure 5.2 – Wind impacts under a south-easterly wind

Figure 5.2 above is an axonometric perspective that illustrates the effect of a south-easterly winds on the building and the local wind environment. There is little to obstruct or slow down the south easterly winds arriving at the site before they reach the WSU building. There are some low to mid-rise buildings including the Liverpool Police Station and Liverpool Court House, however, the prevailing winds will generally arrive unopposed over Georges River and Bigge Park.

The existing WSU tower is likely directing south-easterly winds on Elizabeth Drive and adjacent car park space. The WSU building is also likely to provide protection the proposed development, including the new entrance on ground level and the new ELP space.

Due to the distance of the tower from the other streets (shown in red in Figure 5.1) and the existing 3 storey Westfield street frontage to each of these streets, they will remain unaffected by the addition of the proposed office building.

5.2.2 Westerly wind

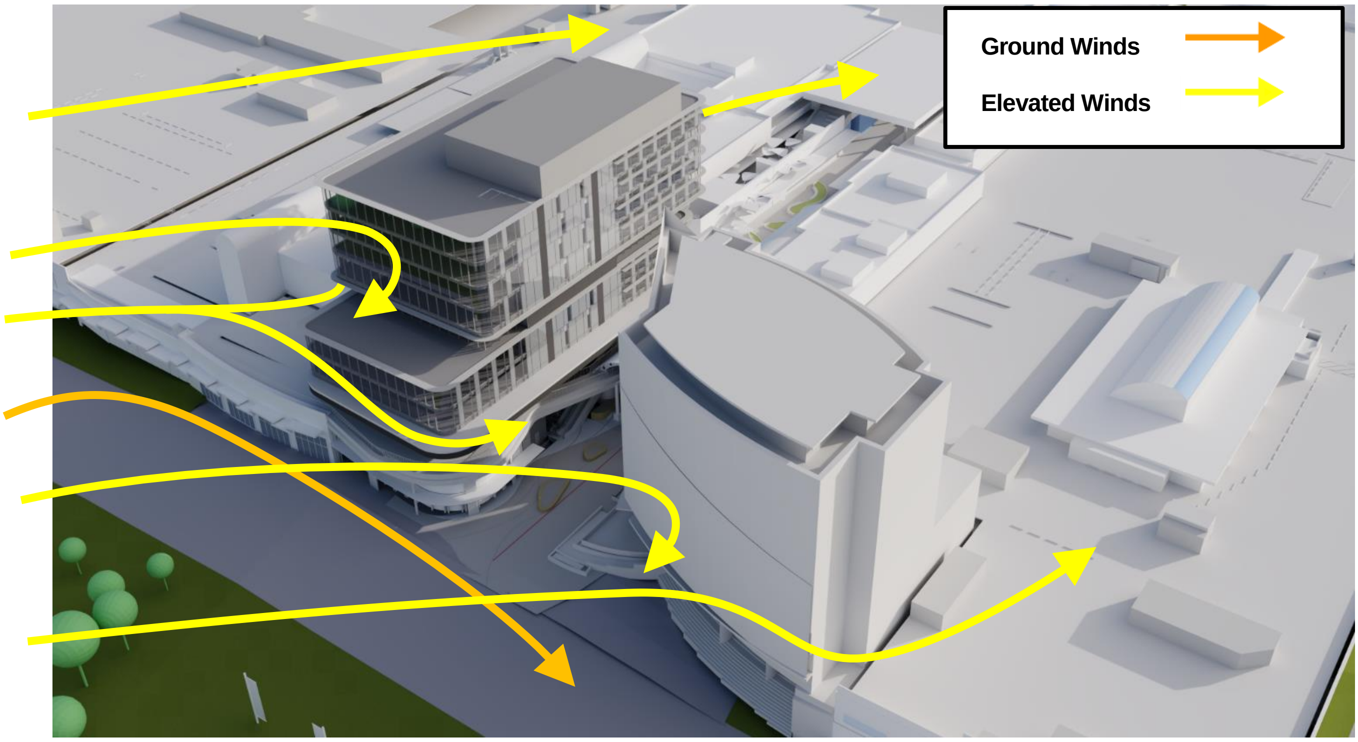


Figure 5.3 – Wind impacts under a westerly wind

Figure 5.3 above is an axonometric perspective that illustrates the effect of westerly winds on the building and the local wind environment. There is little to obstruct or slow down prevailing westerly winds against the building, as there are either open spaces or low-rise residential buildings which are unlikely to reduce wind speeds. There is a mid-rise building on the opposite side of Bathurst St, however, this will also have minimal impact for reducing winds speeds on the Westfield Liverpool development.

Upon reaching the site, it is expected that the flow impinging on the exposed western facade of the proposed office tower would induce downwash and also flow around the building to move across the existing car parks. As these are vehicular spaces and transient spaces, tolerable comfort levels for wind are generally higher. The height of the building above Level 4, which effectively covers the whole city block and could be considered to be ground level from a downwash perspective, is under 35m and downwash due to this height difference is not expected to be significant.

The proposed development is also likely to reduce flow from westerly winds for the new entrance, the new ELP area and the adjacent WSU building. The downwash from westerly winds are expected to be directed onto the podium level car parking areas and retail roof areas reducing effects of prevailing winds onto Elizabeth Drive.

Due to the distance of the tower from the other streets (shown in red in Figure 5.1) and the existing 3 storey Westfield street frontage to each of these streets, they will remain unaffected by the addition of the proposed office building.

5.2.3 Other wind directions

Due to the distance of the tower from the other streets (shown in red in Figure 5.1) and the existing 3 storey Westfield street frontage to each of these streets, they will remain unaffected by the addition of the proposed office building.

5.3 Incorporated mitigation measures

The below summarises the key wind mitigation features that the proposed Westfield Liverpool ELP and new office development currently has incorporated into its proposed design:

- The tower is orientated to reduce the effects of the predominant south-easterly and westerly winds will have on the building users and the surrounding environment. As these are Liverpool's most common wind direction this will be a benefit in wind mitigation on the site, particularly to the plaza area on Level 4.
- Viewing the building in section, the office building's form is composed of two parts, a tower and a 3-storey podium, which will reduce potential downwash reaching the streets at ground level.
- The office building steps back from Elizabeth Street at Level 6 further reducing the potential for downwash at Elizabeth Street.
- In plan, the current tower design has curved corners to allow prevailing south-easterly and westerly winds to pass more easily. This will help prevent winds accelerating around the tower which can cause low pressure turbulence and transverse flows.
- Awnings exist on the north side for the ground level, which will reduce the effects of potential downwash.
- The proposed balconies will also help prevent downwash onto the ground level walkways and onto the accessible podium terrace.
- The proposed design has an accessible podium terrace and the tower will help shield easterly and westerly winds respectively.
- The WSU building to the southeast of the development may help shield strong afternoon winds from the south east reaching the podium and the ELP of the proposed Westfield Liverpool building.
- To mitigate wind funnelling between the two buildings from southerly winds affecting users on the ELP plaza, a glazed screen is provided to the edge of the Level 4 plaza to deflect winds upwards away from pedestrians.
- The buildings on Level 4 and 5 surround the ELP plaza and provide substantial shielding from prevailing winds. Furthermore, a high-level canopy provides further protection from rain, sun and wind.

6.0 Conclusion

The proposed ELP and office building at Westfield Liverpool has been assessed for wind impacts on pedestrians in the local environment.

This Wind Impact Study has qualitatively assessed the building against the objectives in Section 4.5.1 of Part 4 of the LCP and has described how the tower and ELP plaza design has incorporated design elements which will reduce the impacts that the wind may cause on the building users and the local environment. The design includes a podium, awnings, overhangs and canopies to mitigate potential negative impacts from wind. The tower is also orientated in a beneficial direction which will also help ensure that prevailing winds from the southeast in the afternoons will pass smoothly over and around the building as much as possible.

Given that the height and street frontage of the proposed office is of a similar scale to the adjacent WSU building, the proposed development will not significantly affect the current local wind conditions. At some locations, the proposed development should improve wind conditions for certain directions whilst possibly increasing wind speeds at others, however these will not be significant. In general, the comfort of pedestrians in the surrounding streets is unlikely to be impacted compared to current conditions and the new ELP plaza on the podium is quite well protected from westerly and south-easterly prevailing winds.

The proposed design is considered to respond appropriately to standard wind mitigation principles and the locations within and surrounding the proposed development (retail streets, pedestrian streets, parks & public spaces, and other streets) should meet the relevant wind mitigation objectives set out in Section 4.5.1 of Part 4 of the LCP.

In order to quantify the advice provided in this qualitative report computer-based simulation and/or wind tunnel testing could be carried out in the detailed design stages should this be deemed necessary.

Appendices

Appendix A List of reference documents

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Table 6.1 Drawings and models used for developing the analysis

Drawing Number / File name	Drawing Title	Revision	Date Issued
00.02	SITE PLAN	A	01.11.2018
01.01	EXISTING & DEMO LEVEL 1 (BASEMENT LEVEL)	A	01.11.2018
01.02	EXISTING & DEMO LEVEL 2 (GROUND LEVEL)	A	01.11.2018
01.03	EXISTING & DEMO LEVEL 2 MEZZANINE	A	01.11.2018
01.04	EXISTING & DEMO LEVEL 3	A	01.11.2018
01.05	EXISTING & DEMO ROOF LEVEL	A	01.11.2018
02.01	PROPOSED LEVEL 1 (BASEMENT LEVEL)	A	01.11.2018
02.02	PROPOSED LEVEL 2 (GROUND LEVEL)	A	01.11.2018
02.03	PROPOSED LEVEL 2 MEZZANINE	A	01.11.2018
02.04	PROPOSED LEVEL 3	A	01.11.2018
02.05	PROPOSED LEVEL 4	A	01.11.2018
02.06	PROPOSED LEVEL 7 OFFICE AND RETAIL ROOF PLAN	A	01.11.2018
02.07	PROPOSED LEVEL 4-12 TYPICAL OFFICE PLAN	A	01.11.2018
02.08	PROPOSED DEVELOPMENT STAGING DIAGRAM	A	01.11.2018
03.01	SOUTH ELEVATION & SECTION A	A	01.11.2018
03.02	SECTION B & C	A	01.11.2018
04.01	ELIZABETH DRIVE ENTRY VIEW	A	01.11.2018
05.01	SHADOW DIAGRAM WINTER - 21 JUNE	A	01.11.2018
05.02	SHADOW DIAGRAM SUMMER - 21 DEC	A	01.11.2018
190604 LIV ELP.skp	Sketchup File		06.06.2019
2018-09-27_Liverpool - Arch Design Statement	Development Application – Architectural Design Statement	-	01.09.2018
Response to Council RfI_April 2019_DH (002)	DA Response to Council	-	01.04.2019

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