

# 71-89 CHANDOS ST 58-64 ATCHISON ST, ST LEONARDS

## Qualitative Wind Assessment

### Prepared for:

TWT Property Group Pty Ltd  
c/- Smart Design Studio  
14 Stokes Avenue  
Alexandria NSW 2015

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## BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with TWT Property Group Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

## DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30344-R01-v1.0	7 July 2022	Mark Hobday	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy
610.30344-R01-v1.0	14 March 2022	Mark Hobday	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy
610.30344-R01-v1.0	11 March 2022	Mark Hobday	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy
610.30344-R01-v1.0	16 April 2021	Mark Hobday	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy
610.30344-R01-v1.0	15 June 2021	Mark Hobday	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy

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## EXECUTIVE SUMMARY

SLR Consulting Pty Ltd (SLR) has been engaged by TWT Property Group Pty Ltd to undertake a qualitative wind assessment of the proposed 12 storey 71-89 Chandos Street, mixed use development. This assessment will form part of the application to North Sydney Council.

71-89 Chandos Street is situated to the north of Atchison Lane and bounded by Chandos Street, Oxley Street and Atchison Lane to the north, east and south respectively, with 55-69 Chandos Street located west of the site. Surrounds of the site are predominantly medium to high rise development to the south and west, and medium to low rise developments to the north and east. Immediate surrounds around the site will create medium shielding for the development.

Prevailing wind directions of interest in Sydney are from northeast, south, southeast and west quadrants. Their seasonal variation is described in **Section 2** of this report.

### Existing Wind Environment

Existing street level wind conditions in the vicinity of the site could be close to or greater than 16 m/s “walking comfort” criterion for some prevailing wind directions, resulting from channelling of winds along aligning streets.

### Future Wind Environment

In terms of the future wind environment with the proposed development, the following features of the development are noted as being of most significance:

- The winds along the surrounding footpaths should remain at similar levels providing appropriate landscaping is employed.
- Horizontal wind breaks are recommended over building entries and pedestrian pathways, to protect against potential downwash from the high-level development.
- Vertical windbreaks are recommended to the upper-level communal open spaces as a result of adverse upper level wind conditions.
- Vertical windbreaks are recommended to the residential private corner balconies on one aspect of the balcony to reduce the impact of corner accelerating winds.

*Taking into account all of the above, it is believed that the proposed Development will likely comply with the adopted wind acceptability criteria at pedestrian and public access locations within and around the Development.*

The above analysis has been made on the basis of our best engineering judgment and on the experience gained from scale model wind tunnel testing or computational fluid dynamics analysis of a range of developments. The conclusions of this SLR report could be quantified using wind tunnel testing or computational fluid dynamics analysis.

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# 1 Introduction

SLR Consulting Pty Ltd (SLR) has been engaged by TWT Property Group Pty Ltd to undertake a qualitative wind assessment of the proposed 12 storey 71-89 Chandos Street, mixed use development. This assessment will form part of the application to North Sydney Council.

## 1.1 Site and Surrounds

### 71-89 Chandos St

71-89 Chandos Street is located in St Leonards, approximately 400m east of St Leonards Train Station, situated to the north of Atchison Lane and bounded by Chandos Street, Oxley Street and Atchison Lane to the north, east and south respectively, with 55-69 Chandos Street located west of the site. Surrounds of the site are predominantly medium to high rise development to the south and west, and medium to low rise developments to the north and east. Immediate surrounds around the site will create medium shielding for the development.

Figure 1 Site Location



Image: Nearmap, 7 April 2021

## 1.2 Development Description

### 71-89 Chandos Street

The proposed development will comprise a 12-storey building, inclusive of:

- 2 basement levels with residential parking and commercial parking;
- Ground level with residential lobby, commercial lobby and retail space;
- Commercial office space for Levels 1;
- Residential apartments from Levels 2 to 11;
- Communal Open space on level 12; and
- Roof with plant space and lift overrun.

Perspective View from North is shown in **Figure 2**.

**Figure 2 Elevation North**



Image: Proposed Development.



## 2 Sydney Wind Climate

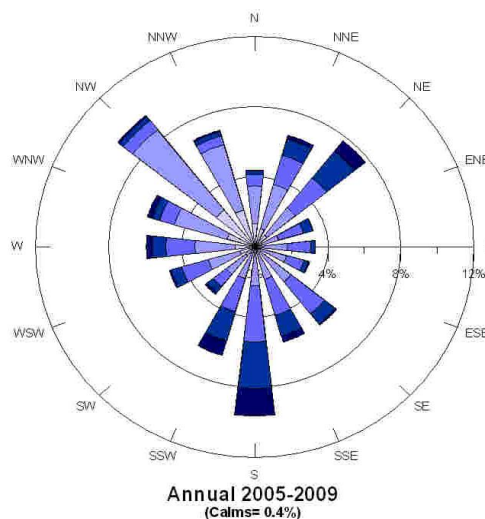
The data of interest in this study are the annual extreme, mean hourly wind speeds and largest gusts experienced throughout the year, how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney wind seasons.

### 2.1 Seasonal Winds

In relation to key characteristics of the Sydney Region Wind Climate (refer wind roses provided in Appendix A) relevant to the wind impact assessment of the proposed development, we note that Sydney is affected by two primary wind seasons:

- Summer winds occur mainly from the northeast, southeast and south.
  - While northeast winds are the more common prevailing wind direction (occurring typically as offshore land-sea breezes), southeast and south winds generally provide the strongest gusts during summer.
- Winter/Early Spring winds occur mainly from the west and the south.
  - West quadrant winds (southwest to northwest) provide the strongest winds during winter and in fact for the whole year.

**Figure 3 Annual Sydney Wind Rose for years 2005-2009**



The figure above shows the stronger winds in dark blue from the northeast, south and west.



## 2.2 Wind Exposure at the Sites – the “Local” Wind Environment

Close to the ground, the “regional” wind patterns described above are affected by the local terrain and topography.

- Some lower-level shielding from landscaping and vegetation along neighbouring streets.
- Significant shielding from high-level built environment to the south clockwise around to the west.
- Shielding from medium level development to the remainder of wind directions.
- Some potential for wind channelling along neighbouring streets.

## 3 Wind Acceptable Criteria

### 3.1 Standard Local Government Criteria

The choice of suitable criteria for evaluating the acceptability of particular ground level conditions has been the subject of relatively recent research. The acceptability criteria that have been developed from this research and currently referenced by most Australian Local Government Development Control Plans have been summarised below in **Table 1**.

**Table 1 Standard Local Government Wind Acceptability Criteria**

Type of Criteria	Limiting Gust Wind Speed Occurring Once Per Year	Activity Concerned
Safety	24 m/s	Knockdown in Isolated Areas
	23 m/s	Knockdown in Public Access Areas
Comfort	16 m/s	Comfortable Walking
	13 m/s	Standing, Waiting, Window Shopping
	10 m/s	Dining in Outdoor Restaurant

The primary objectives relating to the above wind impact criteria are as follows:

- The general objective is for annual 3-second gust wind speeds to remain at or below the so-called 16 m/sec “Walking Comfort” criterion. Whilst this magnitude may appear somewhat arbitrary, its value represents a level of wind intensity which the majority of the population would find unacceptable for comfortable walking on a regular basis at any particular location.
- In many urban locations, either because of exposure to open water conditions or because of street “canyon” effects, etc., the 16 m/s “Walking Comfort” level may already be currently exceeded. In such instances a new development should ideally not exacerbate existing adverse wind conditions and, wherever feasible and reasonable, ameliorate such conditions.

It can be seen in **Table 1** that the recommended limiting wind speeds for spaces designed for activities such as seating, outdoor dining, etc., are lower than for “walking comfort”.

### 3.2 Practical Application of Wind Criteria

The criteria provided in **Table 1** should not be viewed as “hard” numbers as the limiting values were generally derived from subjective assessments of wind acceptability. Such assessments have been found to vary with the height, strength, age, etc., of the pedestrian concerned.

A further factor for consideration is the extent of windy conditions, and some relaxation of the above criteria may be acceptable for small areas under investigation provided the general site conditions satisfy the relevant criteria.

Finally, it is noted that the limiting wind speed criteria in **Table 1** are based on the maximum wind gust occurring (on average) once per year. Winds at all other times, i.e. monthly winds, weekly winds, etc., would be of lesser magnitude. So for example, a location with a maximum annual gust of 10 m/sec would experience winds throughout the year of a generally very mild nature, conducive to stationary activities (seating, dining, etc).

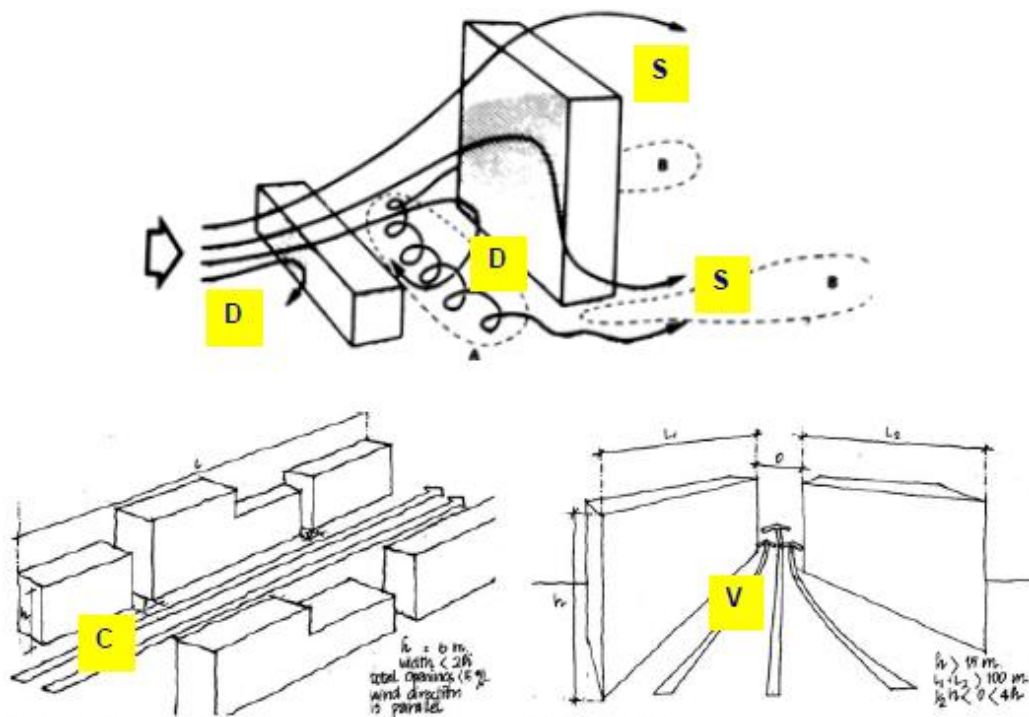
## 4 Building-Wind Interaction – Some General Observations

The impact of wind flowing past buildings has well known general impacts at ground level – refer **Figure 4**:

- **Downwash winds “D”** are the winds which impact on the windward face of a building and are then deflected downwards to ground level in a vertical direction
- Accelerating **Shearflow winds “S”** are the winds which experience an acceleration as they pass by the building edges and roof, as the wind flow moves around and past the building

In general, the taller the building, the more pronounced the impact on ground level winds. Local building details can also influence winds in the immediate vicinity; eg building undercrofts are often associated with local acceleration of winds.

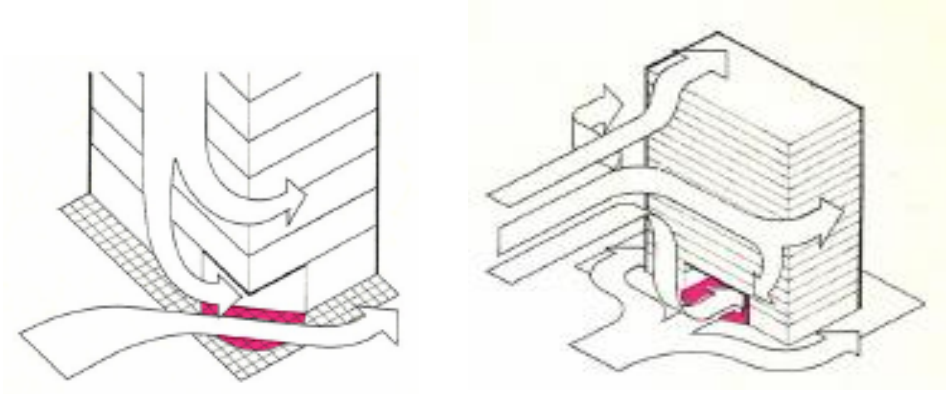
**Figure 4** Wind Flow Patterns past Regular Shaped Buildings



The grouping of buildings can also have an impact on resulting pedestrian winds – refer **Figure 4**:

- **Canyon Effect winds “C”** result when there are rows of parallel buildings (especially taller ones) where the gaps in between line up with prevailing wind directions.
- **Venturi Effect winds “V”** result when wind flow is forced to pass between two converging buildings or groups of buildings with a resulting increase in flow.
- **“Undercroft”** effect is a well-known adverse building-wind characteristic as depicted in the generic building wind effect diagrams shown in **Figure 5**. The winds are induced towards the negative pressure area within the undercroft, creating concentrated adverse wind flow through undercrofts.

**Figure 5 Undercroft Wind**



**Building Undercrofts (left) and Building Cross-Façade Openings (right) can induce concentrated adverse wind flow past and through a building.**

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## 5 Wind Impact of the Proposed Development

### 5.1 Existing Winds – Wind Impact and Effects

Existing street level wind conditions in the vicinity of the site could be close to or greater than 16 m/s “walking comfort” criterion for some prevailing wind directions, resulting from channelling of winds along aligning streets. The surrounding built environment which consists of significant high-rise buildings to some orientations, offers some protection to the majority of wind directions. The existing winds reflect the surrounding built environment as of 7 April 2021.

#### Northeast Winds

Dense medium to lower-level shielding is provided to the northeast, consisting of medium-rise development immediately surrounding the site with low-rise residential housing beyond that. Additionally, northeast winds are generally mild and the potential for exceedance of the 16 m/s criterion along pedestrian pathways is low, i.e. occurrences, if any, are likely to be very infrequent.

#### Southerly Winds

Shielding to the immediate south of the site is generally high-rise development. Considering this, there should be large levels of protection against winds occurring from the south. There remains some risk for channelling of winds between buildings, particularly along Oxley Street and it is likely winds could exceed 16 m/s along associated pedestrian pathways even with existing landscaping.

#### Westerly Winds

There is some high-level shielding provided via the neighbouring high-rise buildings. Potential for wind channelling along Chandos Street, Atchison Street and Atchison Lane is present, there is some existing landscaping around vicinity of the site but there may be exceedances of the 16 m/s criterion along neighbouring pathways.

#### Upper-Level Winds

Due to the similar heights of buildings in the area the existing upper-level area are shielded from the south and the west but exposed on the north and east elevations. Existing upper-level wind conditions at the site are likely to exceed the 13 m/s “standing” comfort criterion for some prevailing wind directions at elevations above the height limits of surrounding buildings and where there is potential for channelling between those surrounding buildings.

### 5.2 Future Winds – Predicted Wind Flow Patterns

The following sections analyse the expected impacts of the proposed development on the pedestrian wind environment in the adjacent streetscape.

The wind impact of the proposed development is described by examining the impact of prevailing wind conditions on all public access areas of interest within and external to the development.

Areas of interest (i.e. surrounding footpaths, primary entry points, internal public access areas, seating and dining areas, etc) are identified in **Figures 6-11**.

### 5.2.1 71-89 Chandos Street Winds

Figure 6 71-89 Chandos Street Areas of Interest Ground Level

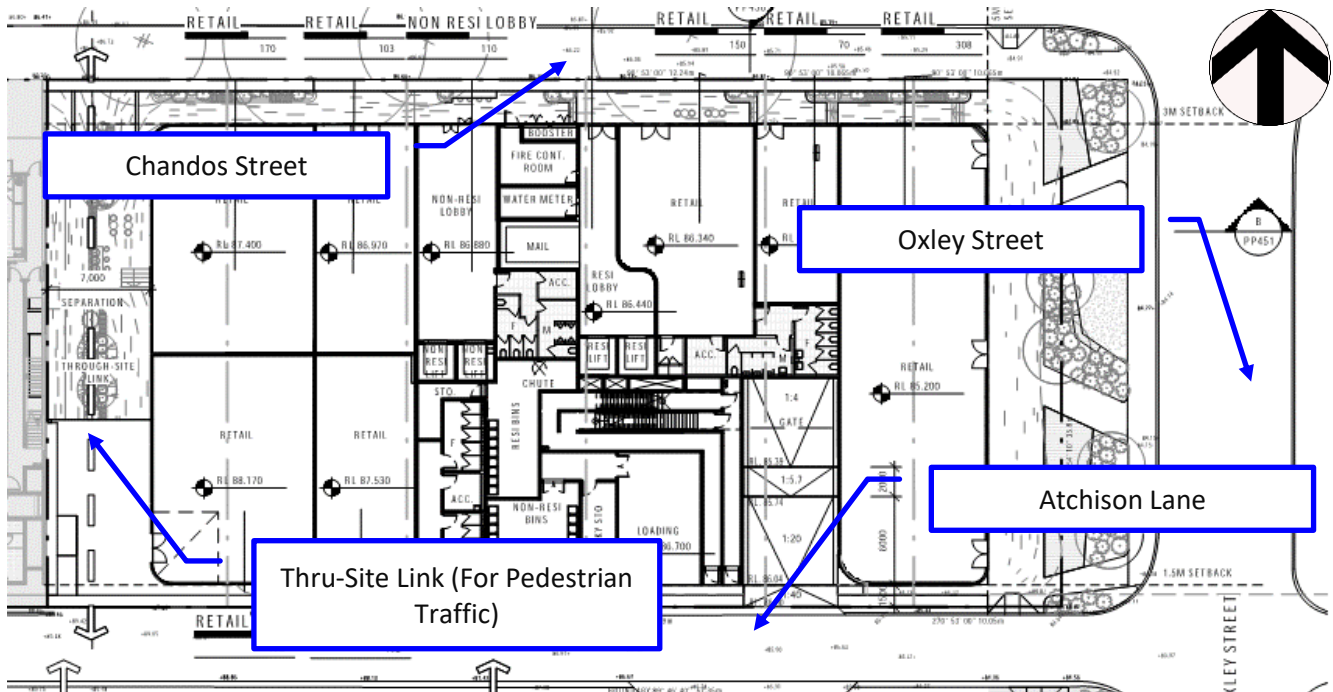
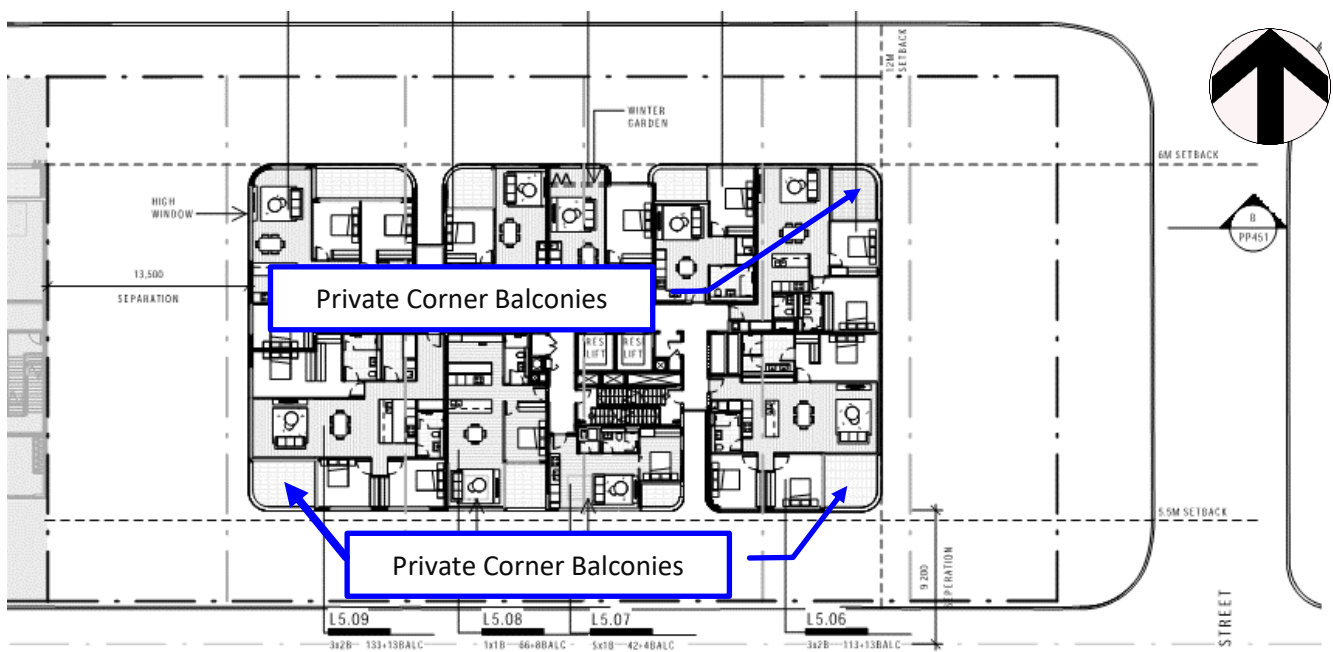
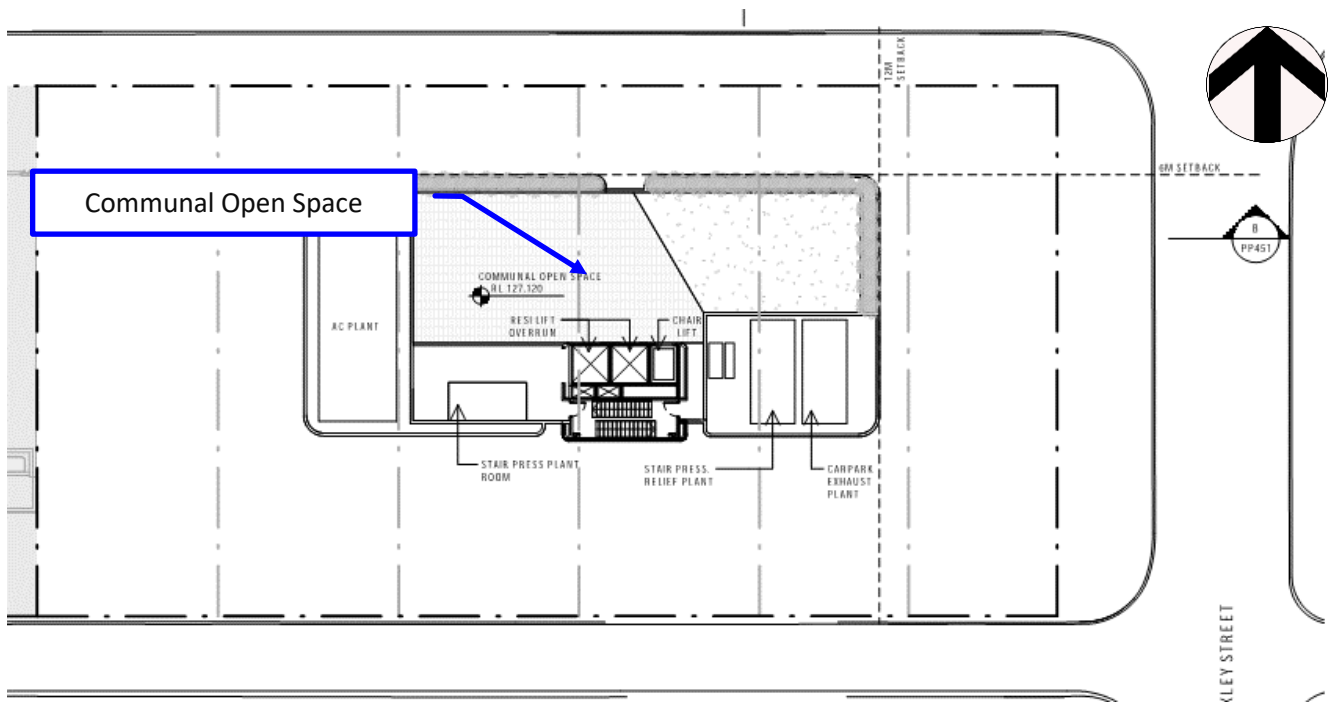


Figure 7 71-89 Chandos Street Areas of Interest Typical Levels



**Figure 8 71-89 Chandos Street Roof Level Communal Open Space**



## 5.2.2 71-89 Chandos Street Winds

### 5.2.2.1 Northeast Winds

Location	Wind Impact
Chandos Street	Target Level: 16 m/s Potential impact here is likely to be <b>less than target level</b> :  Key Factors: <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Oxley Street	Target Level: 16 m/s Potential impact here is likely to be <b>less than target level</b> :  Key Factors: <ul style="list-style-type: none"> <li>• Shielding from existing and proposed landscaping.</li> <li>• Potential for channelling between buildings.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Atchison Lane	Target Level: 16 m/s Potential impact here is likely to be <b>less than target level</b> :  Key Factors: <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from the development itself.</li> </ul>



Location	Wind Impact
Building Entries	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>less than target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from the development itself.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Thru-Site Link (For Pedestrian Traffic)	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from the development itself.</li> </ul>
Roof Level Communal Open Space	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Shielding from proposed landscaping.</li> </ul>
Private Corner Balconies	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Potential for corner accelerated winds.</li> </ul>

### 5.2.2.2 South and Southeast Winds

Location	Wind Impact
Chandos Street	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from the development itself.</li> </ul>
Oxley Street	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level</b>:</p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Potential for channelling between buildings.</li> </ul>

Location	Wind Impact
Atchison Lane	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> </ul>
Building Entries	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Some shielding from the development itself.</li> <li>• Potential for channelling between buildings.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Thru-Site Link (For Pedestrian Traffic)	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Potential for channelling between buildings.</li> </ul>
Roof Level Communal Open Space	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Shielding from proposed landscaping.</li> </ul>
Private Corner Balconies	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level.:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Shielding from upstream buildings.</li> <li>• Potential for corner accelerated winds.</li> </ul>

### 5.2.2.3 Westerly Winds

Location	Wind Impact
Chandos Street	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Shielding provided through setback from levels above.</li> </ul>

Location	Wind Impact
Oxley Street	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from the development itself.</li> </ul>
Atchison Lane	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Building Entries	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> <li>• Some shielding from the development itself.</li> <li>• Potential for channelling between buildings.</li> <li>• Shielding provided through setback from levels above.</li> </ul>
Thru-Site Link (For Pedestrian Traffic)	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>less than target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Shielding from upstream buildings.</li> <li>• Shielding from existing and proposed landscaping.</li> </ul>
Roof Level Communal Open Space	<p>Target Level: 13 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Shielding from proposed landscaping.</li> </ul>
Private Corner Balconies	<p>Target Level: 16 m/s                      Potential impact here is likely to be <b>close to or exceeding the target level.:</b></p> <p>Key Factors:</p> <ul style="list-style-type: none"> <li>• Stronger upper level winds.</li> <li>• Shielding from upstream buildings.</li> <li>• Potential for corner accelerated winds.</li> </ul>

## 6 Wind Amelioration Recommendations

On the basis of the expected wind impacts outlined in previous four sections, recommendations for wind break features are made in areas where winds are expected to

- Approach or exceed 13 m/s or 16 m/s depending on the designed use for that area.

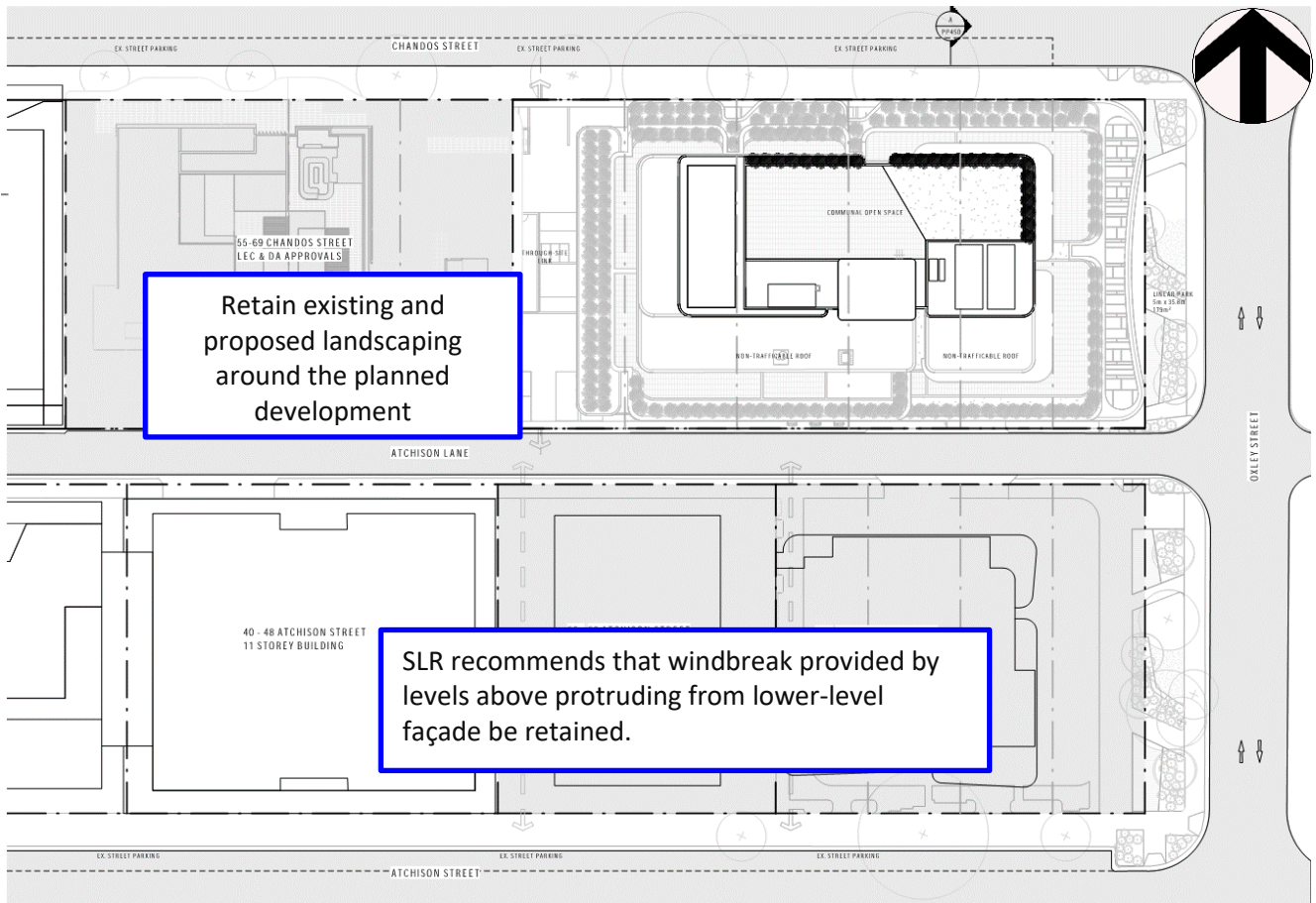
These wind mitigation recommendations are summarised in **Table 2**.

**Table 2 Recommended Wind Mitigation**

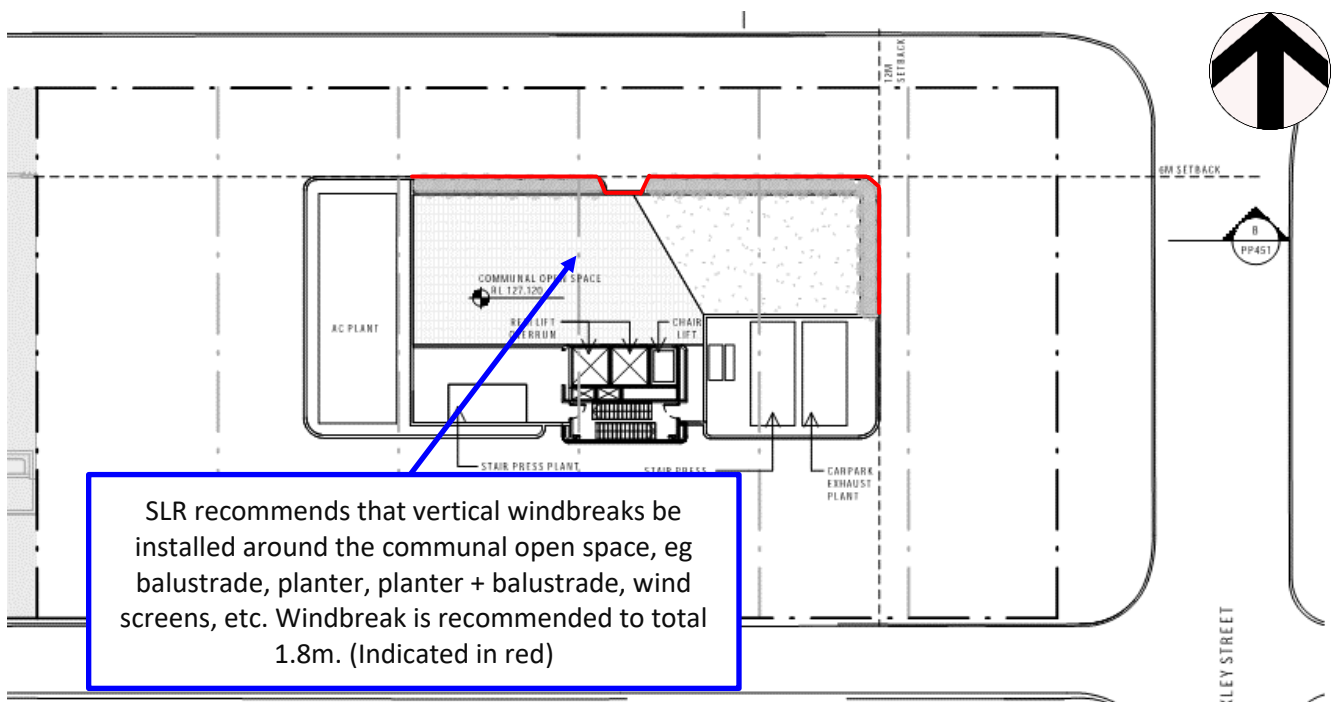
Location of Interest	Wind Impact Potential	Windbreak Treatment/Recommendation
Chandos Street	<b>Moderate – High</b> Winds could be above 16 m/s for west, northeast winds.	<b>Mitigation Required</b> SLR recommends that windbreak provided by levels above protruding from lower level façade be retained. Additional landscaping should be added to further protect against downwash and channelling winds. Landscaping should have a canopy height of 3m and be densely foliated evergreen species.
Oxley Street	<b>Moderate – High</b> Winds could be above 16 m/s for northeast, south and southeast winds.	<b>Mitigation Required</b> SLR recommends that windbreak provided by levels above protruding from lower level façade be retained. Additional landscaping should be added to further protect against downwash and channelling winds. Landscaping should have a canopy height of 3m and be densely foliated evergreen species.
Atchison Lane	<b>Moderate</b> Winds could be above 16 m/s for westerly winds. <i>This is an existing condition.</i>	<b>No Mitigation Required</b> Additional landscaping could further protect against adverse winds. Landscaping should have a canopy height of 3m and be densely foliated evergreen species.

Location of Interest	Wind Impact Potential	Windbreak Treatment/Recommendation
Building Entries	<p><b>Moderate – High</b>                      Winds could be above 13 m/s for northeast, west, south and southeast winds.</p>	<p><b>Mitigation Required</b>                      SLR recommends that windbreak provided by levels above protruding from lower level façade be retained.                      Additional landscaping could further reduce wind speeds.                      It is recommended that retail retains an entrance from a single façade aspect to remove the potential for pressure induced winds impacting the space.</p>
Thru-Site Link (For Pedestrian Traffic)	<p><b>Moderate – High</b>                      Winds could be above 16 m/s for south winds</p>	<p><b>No Mitigation Required</b>                      Additional landscaping could further reduce wind speeds.</p>
Roof Level Communal Open Space	<p><b>Moderate-High</b>                      Winds could be above 13 m/s for north, south and southeast winds</p>	<p><b>Mitigation Required</b>                      SLR recommends that vertical windbreaks be installed around the communal open space, eg balustrade, planter, planter + balustrade, wind screens, etc.                      Windbreak is recommended to be 1.8m in height.</p>
Private Corner Balconies	<p><b>High</b>                      Winds should be below 16 m/s for all prevailing wind directions.</p>	<p><b>Mitigation Required</b>                      SLR recommends that residential private corner balconies have a full height screen included on one aspect of the balcony to reduce the impact of corner accelerating winds.</p>

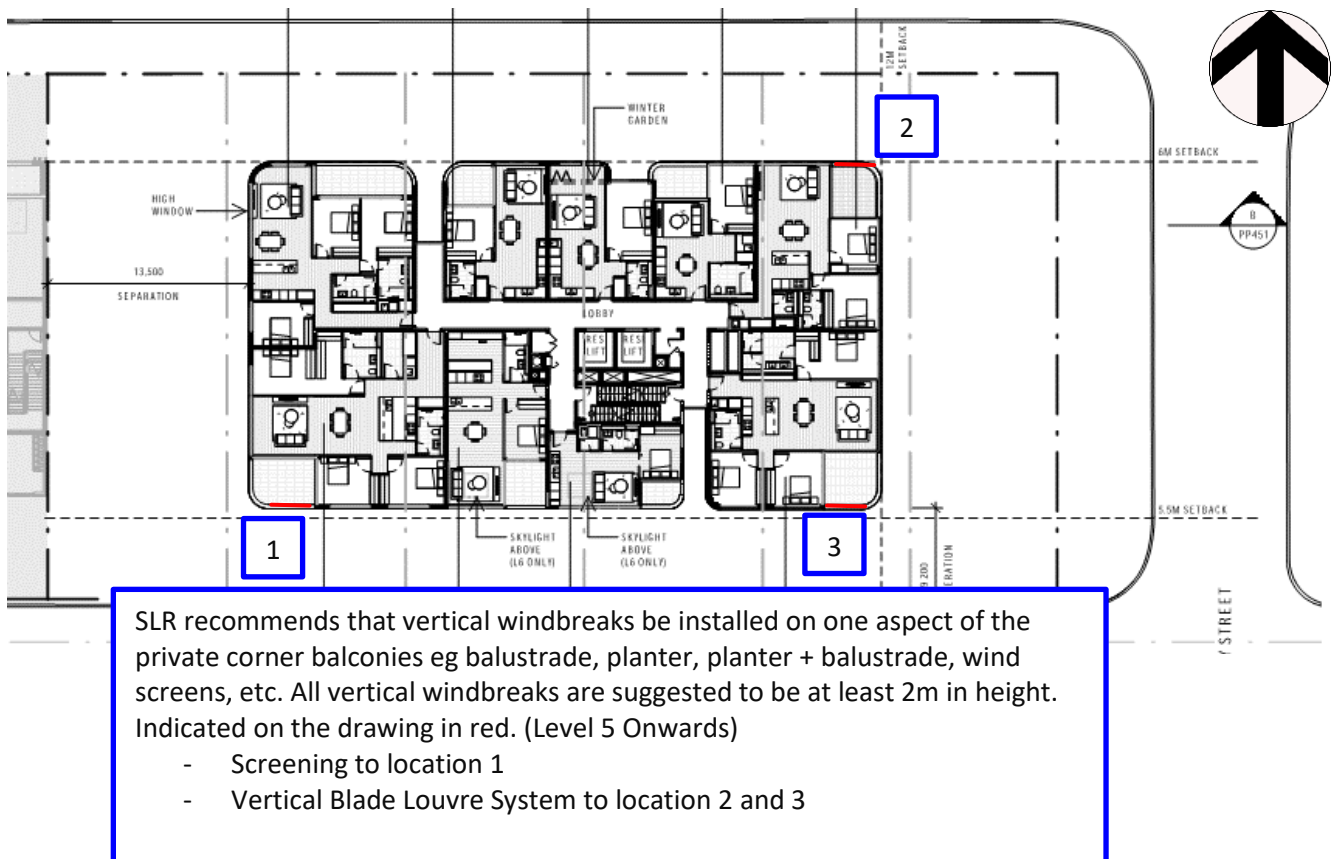
**Figure 9 Mitigation Recommendations Ground Level**



**Figure 10 Mitigation Recommendations Communal Open Spaces**



**Figure 11 Mitigation Recommendations Typical Private Corner Balconies (Level 5 Onwards)**





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## 7 Conclusion

SLR Consulting Pty Ltd (SLR) has been engaged by TWT Property Group Pty Ltd to undertake a qualitative wind assessment of the proposed 12 storey 71-89 Chandos Street, mixed use development. This assessment will form part of the application to North Sydney Council.

71-89 Chandos Street is situated to the north of Atchison Lane and bounded by Chandos Street, Oxley Street and Atchison Lane to the north, east and south respectively, with 55-69 Chandos Street located west of the site. Surrounds of the site are predominantly medium to high rise development to the south and west, and medium to low rise developments to the north and east. Immediate surrounds around the site will create medium shielding for the development.

Prevailing wind directions of interest in Sydney are from northeast, south, southeast and west quadrants. Their seasonal variation is described in **Section 2** of this report.

### Existing Wind Environment

Existing street level wind conditions in the vicinity of the site could be close to or greater than 16 m/s “walking comfort” criterion for some prevailing wind directions, resulting from channelling of winds along aligning streets.

### Future Wind Environment

In terms of the future wind environment with the proposed development, the following features of the development are noted as being of most significance:

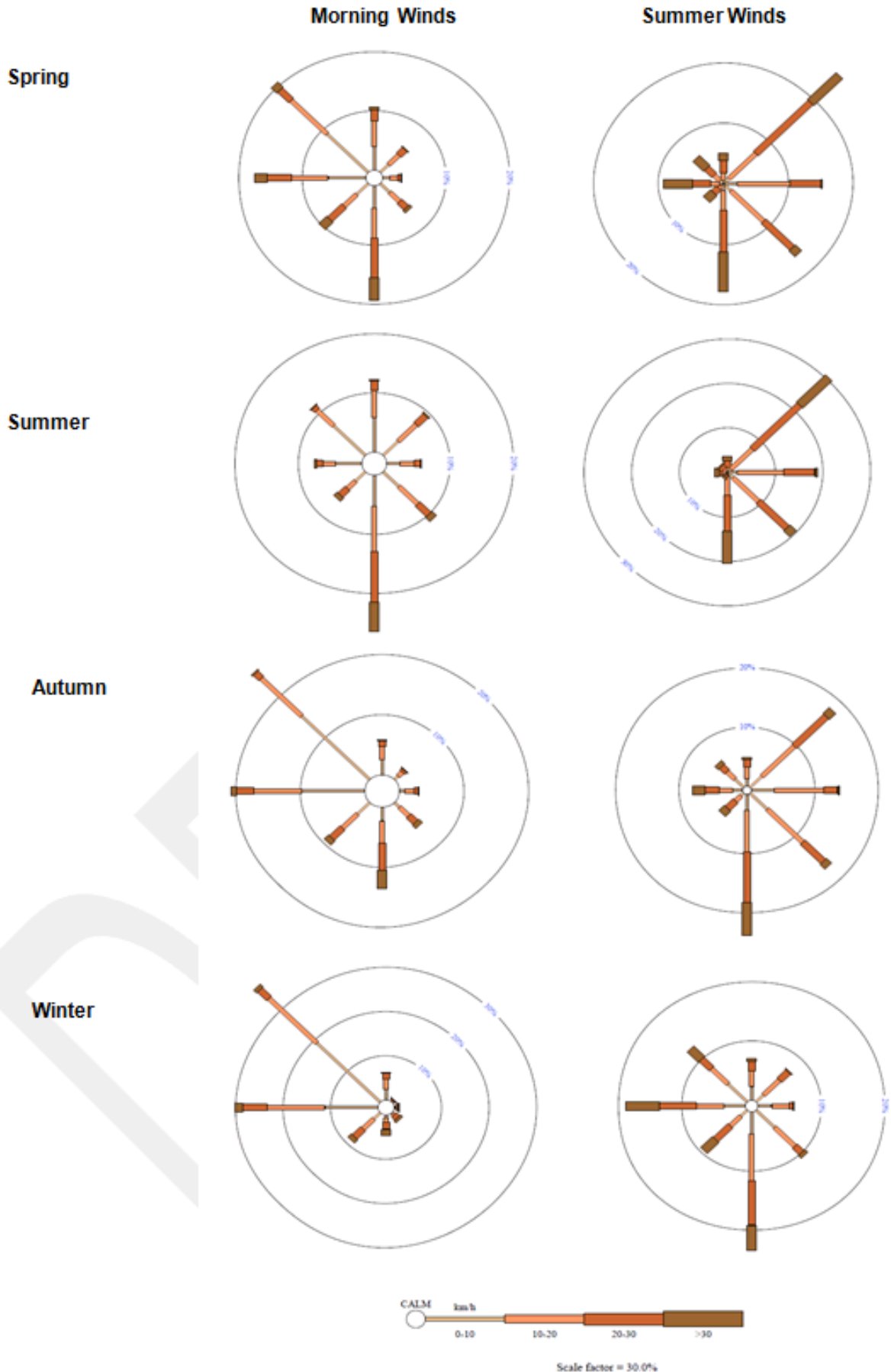
- The winds along the surrounding footpaths should remain at similar levels providing appropriate landscaping is employed.
- Horizontal wind breaks are recommended over building entries and pedestrian pathways, to protect against potential downwash from the high-level development.
- Vertical windbreaks are recommended to the upper-level communal open spaces as a result of adverse upper level wind conditions.
- Vertical windbreaks are recommended to the residential private corner balconies on one aspect of the balcony to reduce the impact of corner accelerating winds.

*Taking into account all of the above, it is believed that the proposed Development will likely comply with the adopted wind acceptability criteria at pedestrian and public access locations within and around the Development.*

The above analysis has been made on the basis of our best engineering judgment and on the experience gained from scale model wind tunnel testing or computational fluid dynamics analysis of a range of developments. The conclusions of this SLR report could be quantified using wind tunnel testing or computational fluid dynamics analysis.

# APPENDIX A

## Sydney Wind Roses



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