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Discovery Point, Wolli Creek

Environmental Winds

Wind Tunnel Study - STAGE 1

Report Number 610.10073-R1

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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Discovery Point Pty Ltd (DPPL) to assess the local wind environment within and around Stage 1 of the proposed Discovery Point Development, Wolli Creek, via an Environmental Wind Tunnel Study.

The assessment has been performed using a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions throughout the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and patrons and occupants of the complex itself.

Discovery Point is located at Wolli Creek and is bounded by the Princes Highway on the east, Magdalene Terrace on the south, the Illawarra Rail Line on the west and Cooks River to the north. The immediate surrounding premises consist of several medium/high rise residential buildings and low rise warehouses to the south west. The development site is located within the southwest portion of Discovery Point. Construction of three buildings (Greenbank, Verge and Vine), of the Discovery Point development located to the east of the Stage 1 site are underway or complete.

The Stage 1 development comprises:

- Building 1C
  - Specialty retail (approximately 650m^2), lying over four parking basement levels, and
  - Thirteen levels of residential development and a Roof Garden
- Building 1B
  - Ground floor retail (including a supermarket) plus loading dock and basement parking; and
  - One level of residential development and podium roof top terrace

Sydney Winds

The Sydney wind climate is characterised by dominant (prevailing) northeast and southerly winds in spring-summer and mainly westerly and southerly winds during winter.

Wind Impact of the Proposed Development

In the absence of any wind mitigation treatments, locations within and surrounding the site have the potential to experience increased wind speeds, in some cases exceeding the standard once per year 16 m/s walking comfort criterion – recommended in the Concept Plan Wind Report as the appropriate compliance standard for wind comfort. This occurs when winds which have a relatively high frequency of occurrence coincide with building geometry conditions conducive to accelerated windflow, eg building corners, and in particular upstream building conditions, eg south quadrant winds accelerating between the Greenbank and Proximity buildings, southwest winds accelerating around the western façade of the Proximity building, etc.

The wind tunnel testing showed that, once landscaping and additional awning treatments were taken into account, potential adverse wind conditions within and surrounding the site, ie winds over 16 m/s, could be adequately mitigated. These treatments have already been incorporated for the site.

On the basis of the above, we believe that the Stage 1 development will comply with standard wind acceptability criteria for all public areas surrounding the site.

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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Discovery Point Pty Ltd (DPPL) to assess the local wind environment within and around Stage 1 of the proposed Discovery Point Development, Wolli Creek, via an Environmental Wind Tunnel Study.

The assessment has been performed using a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions throughout the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and occupants of the development itself.

1.1 Location of the Development Site

Discovery Point is located at Wolli Creek and is bounded by the Princes Highway on the east, Magdalene Terrace on the south, the Illawarra Rail Line on the west and Cooks River to the north. The immediate surrounding premises consist of several medium/high rise residential buildings and low rise warehouses to the southwest.

The development site (refer **Figure 1**) is located within the southwest portion of Discovery Point. Construction of three buildings (Greenbank, Verge and Vine), of the Discovery Point development located to the east of the Stage 1 site are underway or complete. This report assesses the wind environment of the proposed Stage 1 building to be developed at the site.

Figure 1 Discovery Point Site Location

1.2 Description of the Overall Discovery Point Concept Plan

The proposed Discovery Point Concept Plan comprises of mixed-use building envelopes with maximum heights ranging from RL 42.7 to RL 79.65, to be progressively constructed. **Figure 2** shows the proposed Concept Plan for the Discovery Point development in Orange and existing buildings in White. Stage 1 is located along Discovery Point Place to the west of Brodie Spark Drive.

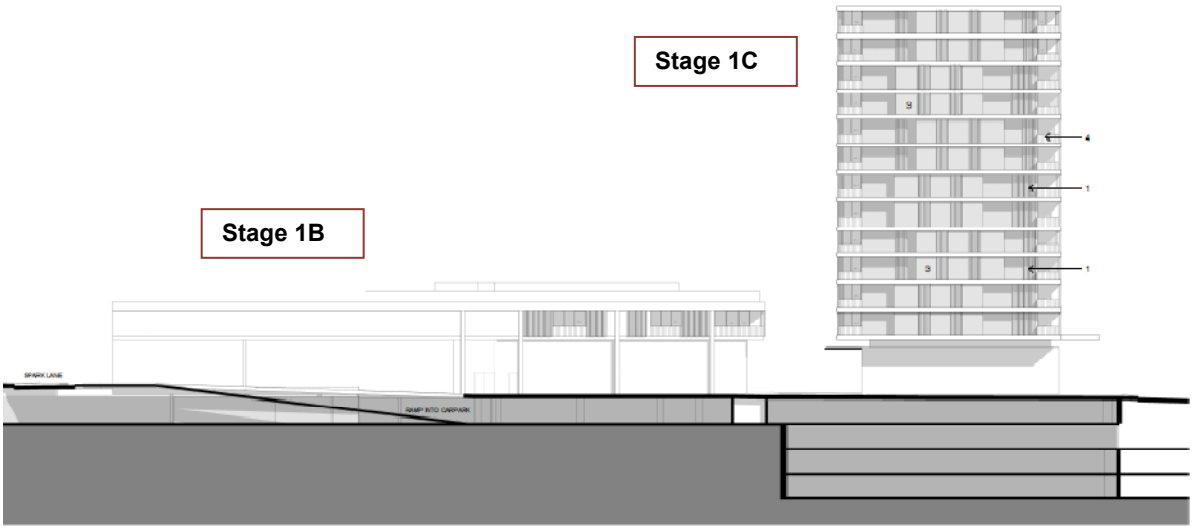
Figure 2 Discovery Point Concept Plan

1.3 Description of Stage 1

The Stage 1 development comprises:

- Building 1C (corner of Discovery Point Place and Brodie Spark Drive)
  - Specialty retail (approximately 650m^2), lying over four parking basement levels, and
  - Thirteen levels of residential development and a Roof Garden
- Building 1B (Discovery Point Place)
  - Ground floor retail (including a supermarket) plus loading dock and basement parking; and
  - One level of residential development and podium roof top terrace

Figure 3 Stage 1 Elevation (viewed from the south)



2 SYDNEY'S WIND CLIMATE

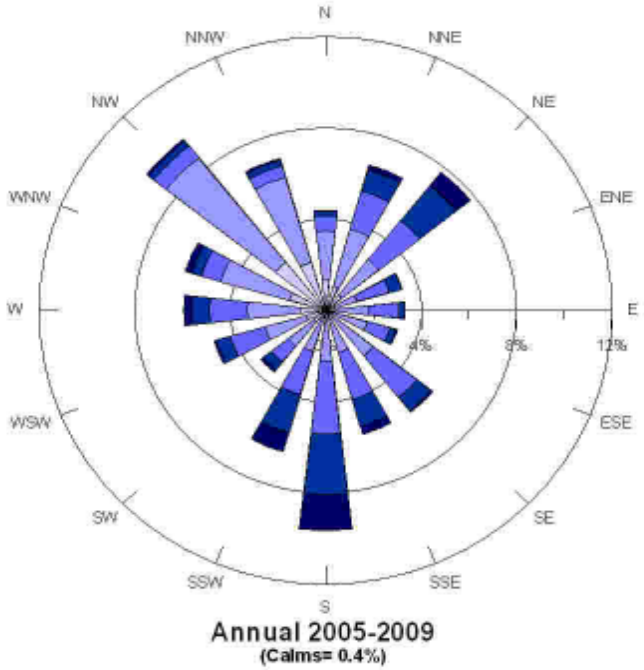
The data of interest in this study are the annual, extreme mean hourly wind speeds and largest gusts experienced throughout the year, how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney wind seasons.

2.1 Seasonal Variations of Sydney's Regional Wind Climate

The key characteristics of Sydney's Regional Wind Climate are shown in the **Figure 4** wind rose, taken from Bureau of Meteorology met data recorded at Sydney Airport. The corresponding seasonal wind roses (refer **Attachment A**) show that Sydney is affected by two primary wind seasons:

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

Figure 4 Sydney Airport (Bureau of Meteorology Station) Annual Wind Rose



2.2 Wind Exposure at the Site – the "Local" Wind Environment

Close to the ground, the "regional" wind patterns described above are affected by the local terrain, topography and built environment, which all influence the "local" wind environment.

- The development site currently receives moderate to good shielding at lower and mid levels from the low and medium-rise developments surrounding the site from the south clockwise around to the northeast.
- The site is somewhat more exposed to winds from east to southeast quadrant due to the low lying over-water terrain in close proximity to the proposed development in this direction.

3 WIND ACCEPTABILITY CRITERIA

3.1 Standard Local Government Wind 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, including those of Sydney City Council, 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 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/sec "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 Application of Standard Local Government 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 satisfies 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, ie 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 much lower and hence generally mild nature, conducive to stationary activities (seating, dining, etc

4 WIND TUNNEL TEST METHODOLOGY

4.1 Simulation of Natural Wind

Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied and compromises need to be made. In this type of wind tunnel test it is possible to waive strict adherence to the full range of similarity parameters.

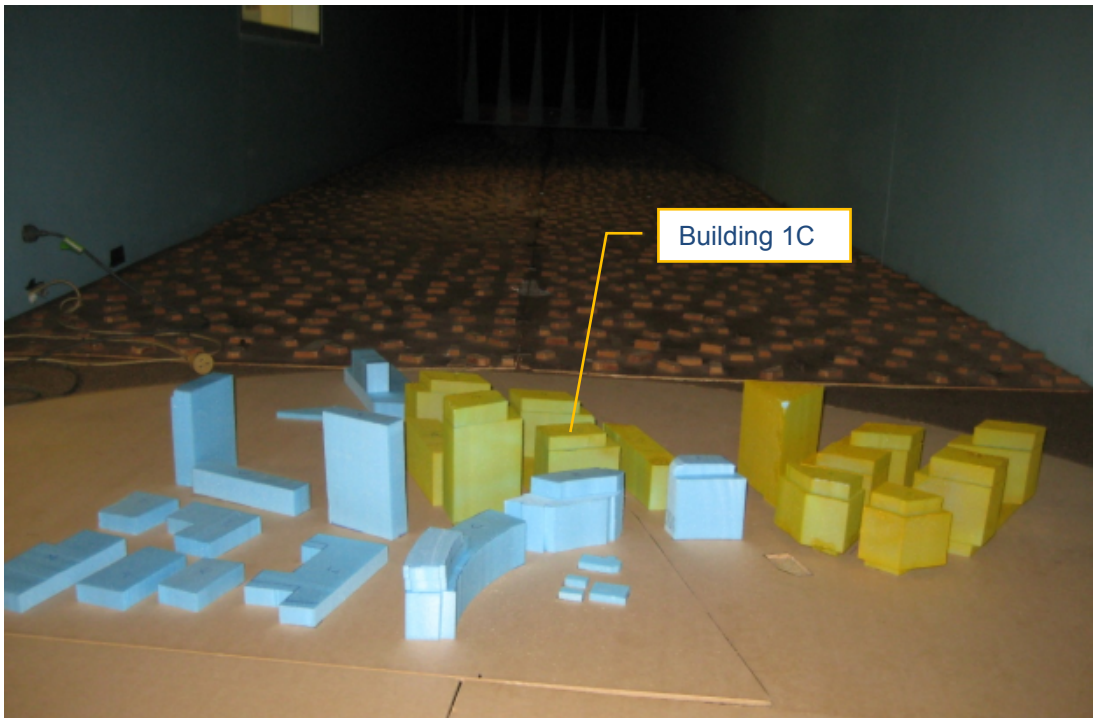
- The wind tunnel test has been carried out using a geometric length scale of 1:400 for all dimensions (standard wind tunnel test scaling) and by scaling the boundary layer approach wind in the wind tunnel to the same scale as in the atmosphere.

The approach wind was modelled by matching terrain category conditions for all wind directions. In the wind tunnel, this is achieved by an upstream trip fence and a 15-metre fetch of appropriate roughness elements. The upstream profile conditions simulated in the present study is a Terrain Category 3 due to the medium density suburban surroundings.

To take into account the influence of the immediate surrounding physical environment, all neighbouring buildings and local topography within a 400 m radius around the site were included in the purpose-built 1:400 scale *"proximity model"* used for the test. The proximity model details included in the test turntable simulate existing building conditions as of December 2010 and all buildings of Discovery Point Concept Plan.

Note that the existing and proposed landscapes were not included in the baseline wind tunnel model. The wind mitigation provided by proposed landscape is assessed afterwards to check if areas of high windflow are properly mitigated. Refer also the discussion in **Section 5** for further explanation of this methodology.

Figure 5 Scaled Development Model in Wind Tunnel (viewed from the east)



4.2 Test Method - Sensor Locations

In the wind tunnel testing, Irwin wind sensors were positioned at the locations shown in **Figure 6**. These locations were chosen as potentially susceptible to adverse wind conditions, eg near building corners, or represent locations of interest throughout the development, eg near primary building entrances. The test locations were concentrated around Building 1C, as it would be expected that the highest localised wind impacts would occur close to the surfaces of the taller of the Stage 1 buildings.

Figure 6 Wind Tunnel Test Sensor Locations

4.3 Methodology Used in the Testing

The present study involved examining the following building geometry:

- BASELINE Testing – In this configuration winds at ground level Locations 1 to 10 above were examined WITHOUT any wind mitigation features (other than already planned building awnings) in place, eg there was no landscaping added to the test model
- Additional testing was carried out at selected angles of interest, the “WITH MITIGATION” option - representing the building environment with wind amelioration options targeting specific wind conditions at various locations around the site, primarily in the form of landscaping and building canopies.

4.4 Data Processing

The wind speeds at the locations of interest are measured in the wind tunnel using Irwin sensors. The reader is referred to publication: LTR-LA-242 “A Simple Omni-Directional Sensor for Wind Tunnel Studies of Pedestrian Level Winds” (Irwin, National Aeronautical Establishment, Ottawa, Canada, May 1980) for a full description of this technique and validation of Irwin sensor data using hot-wire anemometry.

Wind speeds in the wind tunnel are measured at a height corresponding to approximately chest height (1.5 m) in full scale.

The velocities are recorded as dimensionless ratios of the mean and gust ground level velocity to a mean reference wind speed at a height of about 500 m above ground level. The data is then processed using the directional wind speed information derived from Sydney's wind climate to yield ground level wind speeds as a function of annual return period and directional mean reference wind speed.

Wind speed measurements were taken at 10°intervals. The zero wind direction is from the north, with east at 90°, south at 180°, etc.

The ground level wind speeds thus incorporate both the building and topographical aspects of the location as well as the directional probability of wind speed for Sydney.

The results have been computed on a one-year return period basis, i.e. the storm wind event which is equalled or exceeded once per year, on average, using Sydney statistical wind data.

4.5 Sample Test Result

An example of the test results and interpretation of these results is shown in **Figure 7**, illustrating the peak annual mean and representative gust wind speeds at:

Sensor:	Location No 8 (refer **Figure 6**Figure 6)
Configuration:	“Baseline” – ie no added wind mitigation
Location:	Midway along west facing façade (ground level)
Directions:	North is at 0°, East is at 90°, South is at 180°, etc.

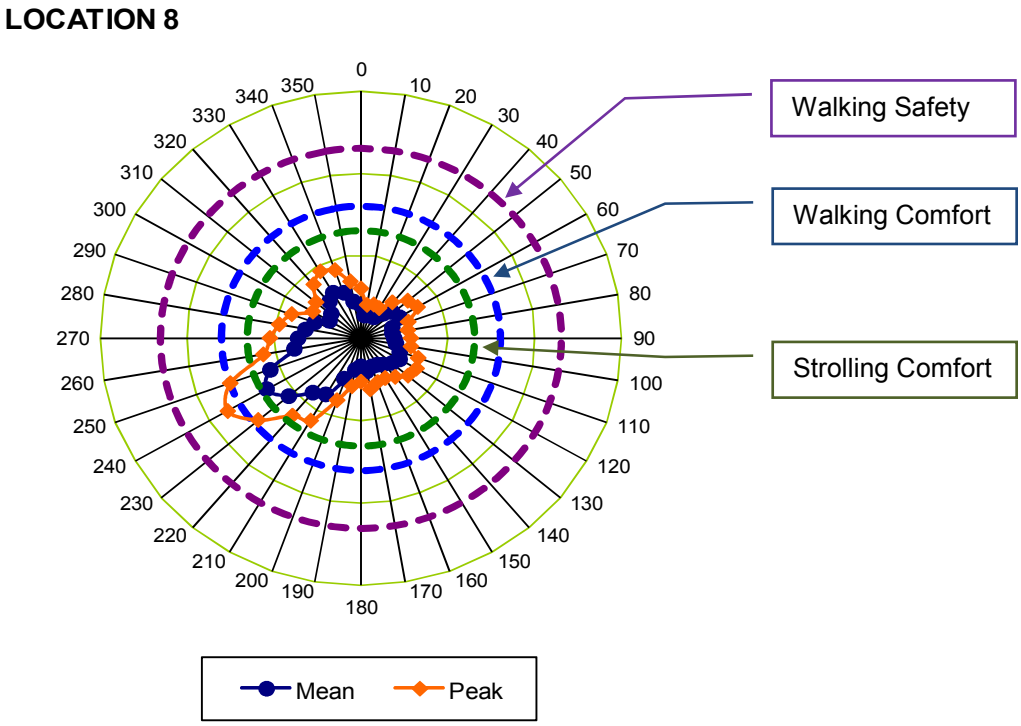
The wind tunnel test results are plotted in polar form which shows the variation of:

Mean wind speed (ie average speed)	“navy blue” data points, and
Gust wind speed	“orange” data points.

The polar diagram also includes three circumferential lines representing criteria for:

Public Safety	- 23 m/sec (mauve)
Walking Comfort	- 16 m/sec (blue), and
Strolling Comfort	- 13 m/sec (green).

Figure 7 Sample Polar Plot Test Result – Location 8 – NO WIND MITIGATION



It can be seen that the peak gust winds are strongest at Location 8 from the southwest, where winds are not shielded by upstream buildings and are deflected back down to ground level off the western façade of the building. There would also be a small degree of wind channelling of the resulting flow between Buildings 1C and 1B in this area. For many other directions, the building itself provides significant blockage to winds at this location.

At Location 8, peak gust winds WITH NO MITIGATION:

- Are well within the 13 m/sec strolling criterion for almost all wind directions.
- Exceed the 16 m/sec walking comfort criterion for the southwest direction
- Are below the 23 m/sec public safety criterion for all wind directions

5 TEST RESULTS

5.1 Overview – "Baseline" Wind Impact with No Mitigation

It is instructive to review overall maximum gust speeds in the absence of wind mitigation measures, in particular without landscaping. These test results provide an insight as to the approach angles resulting in potential adverse wind conditions and the potential magnitude of such adverse conditions. This information can then be used to develop effective mitigation options such as landscaping, canopies, awnings, etc. **Table 2** gives the peak annual gust wind speeds predicted to occur at the wind monitoring locations for the "Baseline" environment scenario.

Table 2 Annual Peak Gust Speeds (m/sec) at all Sensor Locations – NO Wind Mitigation

Sensor Location No. and Description (refer Figure 6)		"Baseline" Peak Annual Gust (m/sec)
1	Northeast corner of Building 1C	11.5
2	Mid-way along eastern façade (closer to northeast corner)	10.5
3	Eastern façade (closer to southeast corner)	20.5
4	Southern façade corner of Building 1C close to southeast	25.5
5	Mid-way along southern façade	24
6	Southwest corner of Building 1C	18
7	Mid-way along western façade (closer to southwest corner)	17
8	Mid-way along western façade (closer to northwest corner)	17.5
9	Northwest corner of Building 1C	17
10	Mid-way along northern façade	16.5

Note 1: Values in the Table have been rounded off to the nearest 0.5 m/s. Experimental error in results is +/-0.5 m/s
Note 2: Wind speed predictions greater than 16 m/s are right-justified in the table

WITHOUT mitigation, there are two locations where wind speeds have the potential to exceed the 23 m/s public safety criterion – Locations 4 and 5.

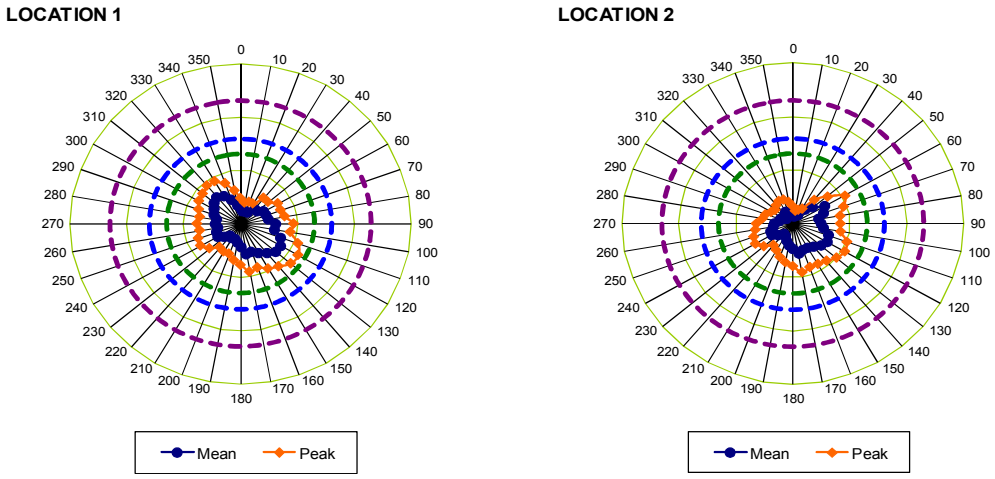
Similarly, a number of locations have the potential, WITHOUT mitigation, to exceed the 16 m/s walking comfort criterion in the "Baseline" configuration. Almost all of these are associated with the impact of southwest winds where windflow acceleration around nearby buildings combined with downwash off the building itself causes a localised increase in wind speed.

5.2 Sensor Locations 1 and 2 – refer Figure 8

The “Baseline” wind speeds at Locations 1 and 2 indicate the following wind conditions.

- Winds for all wind directions are below the 13 m/sec strolling criterion.
- This is due primarily to the shielding provided to the proposed development by the adjacent similar height Verge Building.
- Winds at Location 1 are highest for southeast winds able to impact on the local area as they pass around the northern façade of the Verge building.

Figure 8 Baseline Winds for Locations 1 and 2 (No Wind Mitigation Simulation)



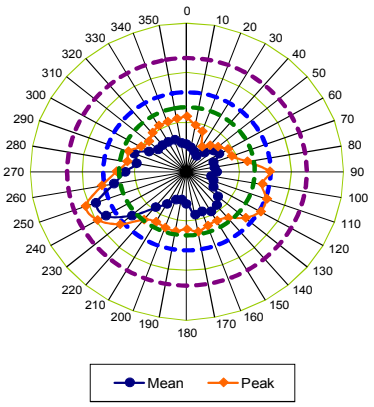
5.3 Sensor Locations 3 and 6 to10 – refer Figure 9

The “Baseline” wind speeds at Locations 3 and 6-10 indicate the following wind conditions.

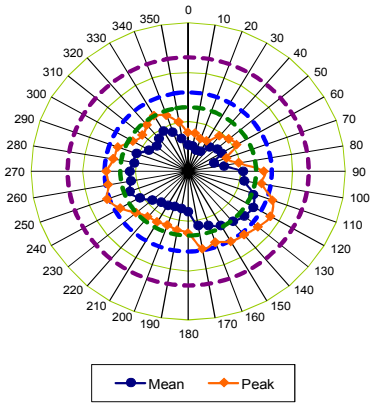
- Winds for many wind directions are below the 13 m/sec strolling criterion.
- All of these locations have a limited set of oncoming wind directions where winds have the potential to exceed the 16 m/sec walking comfort criterion.
- In the case of Locations 3 and 6, exceedance of the 16 m/sec criterion occurs for both south-southeast and southwest winds.
- In the case of Locations 7-9, exceedance of the 16 m/sec criterion only occurs for southwest winds.
- In the case of Location 10, exceedance of the 16 m/sec criterion occurs only occurs for south-southeast winds.
- The instances of higher winds occur as a result of windflow accelerating past upstream buildings and then deflected off the building’s own facades coupled with some mild wind channelling between Buildings 1C and 1B.

Figure 9 Baseline Winds for Locations 3 and 6-10 (No Wind Mitigation Simulation)

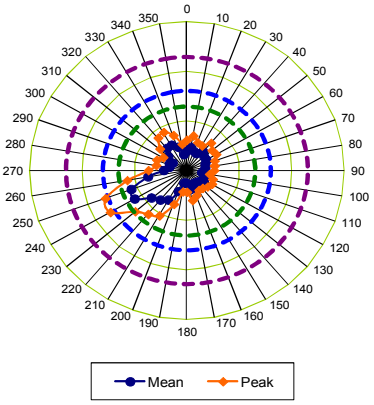
LOCATION 3



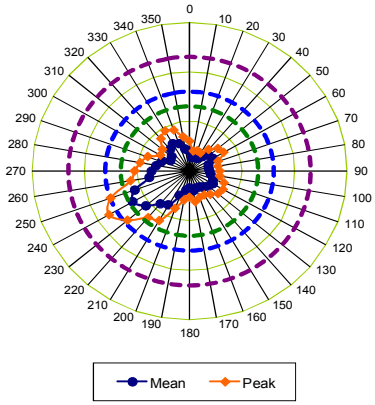
LOCATION 6



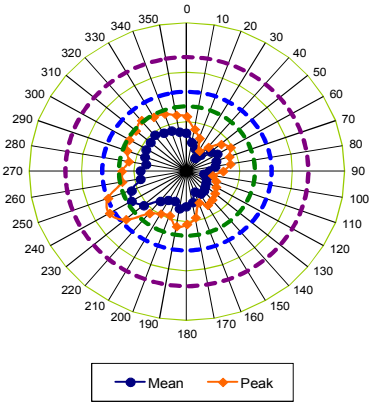
LOCATION 7



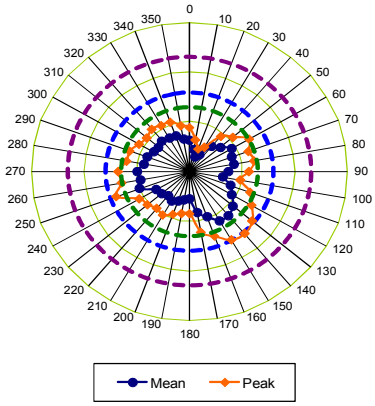
LOCATION 8



LOCATION 9



LOCATION 10

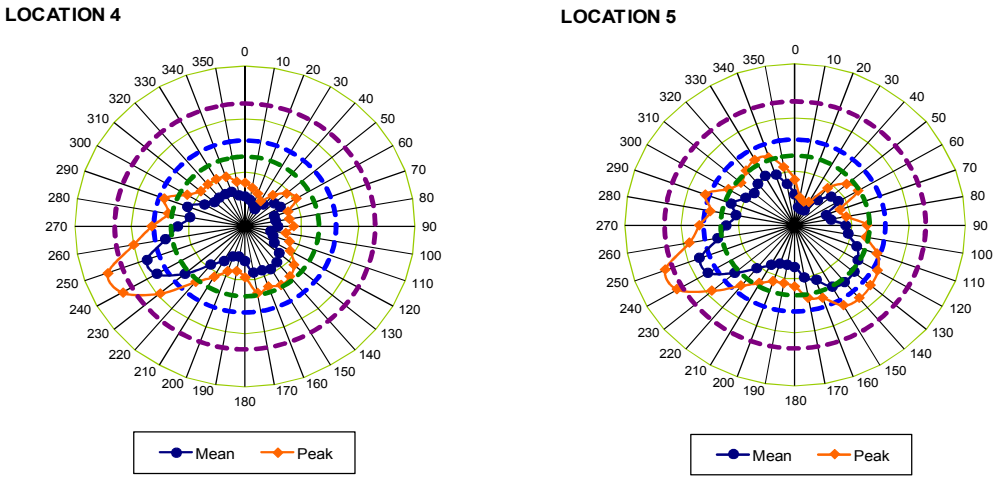


5.4 Sensor Locations 4 and 5 – refer Figure 10

The “Baseline” wind speeds at Locations 4 and 5 indicate the following wind conditions.

- Winds for many wind directions are below the 13 m/sec strolling criterion.
- All of these locations have a limited set of oncoming wind directions where winds have the potential to exceed the 16 m/sec walking comfort criterion and even the 23 m/sec safety criterion.
- In the case of Location 4, exceedance of the 16 m/sec and 23 m/sec criteria occurs for southwest winds.
- In the case of Location 5, exceedance of the 16 m/sec criterion also occurs for southeast winds.
- Adverse winds at these locations appear to occur for winds approaching the site and accelerating in between Greenbank and Proximity buildings upstream or accelerating around the western façade of Proximity.

Figure 10 Baseline Winds for Locations 4 and 5 (No Wind Mitigation Simulation)



5.5 Winds Surrounding Building 1B

Building 1B is a low-rise building and would be expected to have only a modest impact (if any at all) on surrounding winds.

- The wind tunnel tests indicate that the greatest impact would be expected to occur between Buildings 1B and 1C, especially for southwest winds which are accelerated as they pass initially by upstream buildings and then experience mild channelling between Buildings 1B and 1C.
- Locations elsewhere around Building 1B would be expected to lie below the 16 m/sec walking comfort criterion for all wind directions.

6 MITIGATION TREATMENTS

Section 5 provided guidance as to the areas where the adopted wind acceptability criterion had the potential to be exceeded and an indication as to the likely local optimum wind treatment strategy, ie whether the wind condition of interest is likely to arise from accelerating winds which require vertical windbreaks (such as landscaping) or downwash winds which require horizontal windbreaks (such as awnings, canopies).

Primary Wind Conditions of Concern

Two wind conditions of primary concern are revealed in **Section 5**:

- Winds can approach Stage 1 Building 1C and accelerate in between the Greenbank and Proximity buildings upstream prior to reaching the site. They are then prone to acceleration effects at the southeast corner of the development (Location 4) and sideways downwash off the eastern and southern facades of Building 1C.
- Winds are also able to approach the Stage 1 site after accelerating past the western façade of the Proximity building. They are then prone to acceleration effects at the Building 1C's southwest corner (Location 6) and sideways downwash off its western façade coupled with mild wind channelling between Buildings 1C and 1B.

These wind conditions represent both a horizontal acceleration of winds and vertical downwash winds generated by the deflection of winds off the relevant building façades.

Recommended Wind Mitigation

- Landscaping throughout these areas
- Additional protection provided to building entry points in the form of canopies, awnings, etc.

Landscaping (Already Planned)

Significant landscaping has already been planned for the development, in particular to the southwest of Building 1B (which includes a large Jacaranda Tree – refer "J" in **Figure 11**).

Figure 11 Landscaping Plan for the Stage 1 Precinct

Mitigation Wind Testing WITH Landscaping

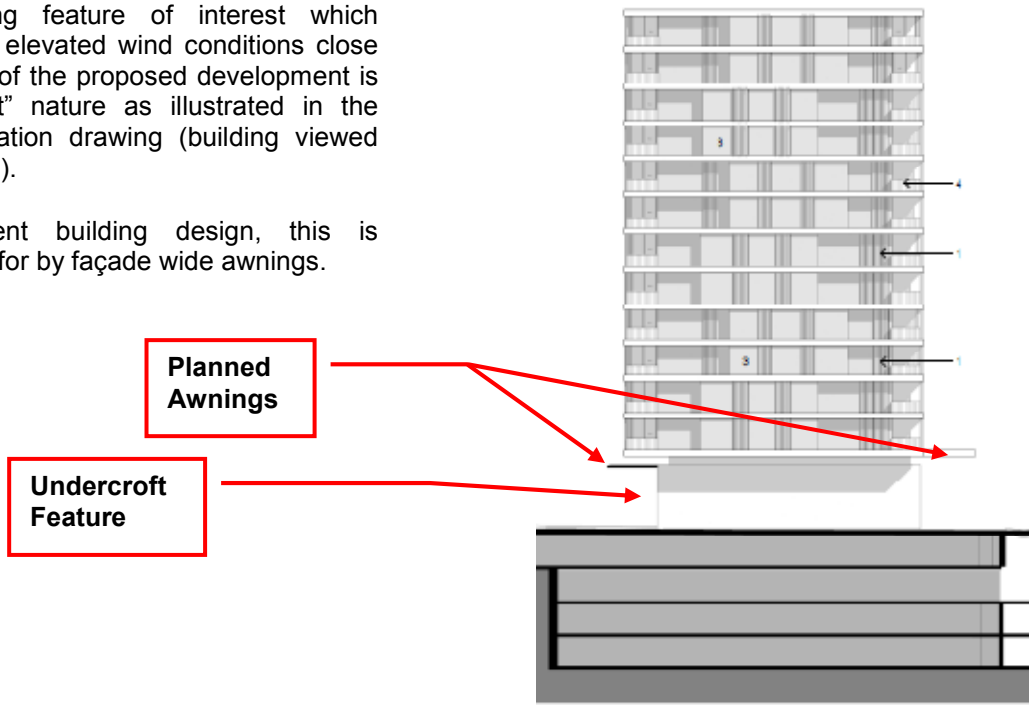
Simulated landscaping was added to the wind tunnel model corresponding roughly to the configuration shown in **Figure 9** and additional tests undertaken at selected wind directions (worst case wind directions). The wind speeds at most locations dropped to below the 16 m/s walking comfort criterion.

Locations still showing potential exceedances were located primarily along the southwest facing façade under oncoming southwest winds.

Additional Mitigation

The remaining feature of interest which contributes to elevated wind conditions close to the façade of the proposed development is its "undercroft" nature as illustrated in the adjacent elevation drawing (building viewed from the south).

In the current building design, this is compensated for by façade wide awnings.



The above awnings were NOT included in the "Baseline" (ie NO mitigation) wind tunnel testing, thereby allowing the testing to reveal the potential for the undercroft design feature to impact upon local winds.

Limited additional testing was carried out for selected southwest wind directions with the additional of a full façade-width awning along the western façade of the building. Wind speeds as Locations 6-8 reduced even further (ie compared to the "with" landscaping tests).

The positive impact of awnings protecting undercroft areas would be expected to apply to the southern and eastern facades.

- The awnings surrounding the building on the eastern, southern and western facades should be maximised in terms of their extent around the perimeter and distance out from the façade wherever feasible and aesthetically in line with the planned building form, especially along the southern façade of Building 1C.

7 SUMMARY

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The assessment has been performed using a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions throughout the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and patrons and occupants of the complex itself.

In the absence of any wind mitigation treatments, locations surrounding the site (primarily around Building 1C) have the potential to experience increased wind speeds, in some cases exceeding the standard once per year 16 m/s walking comfort criterion.

This occurs when winds which have a relatively high frequency of occurrence also coincide with building geometry conditions conducive to accelerated windflow, eg building corners, and in particular upstream building conditions, eg south quadrant winds accelerating between the Greenbank and Proximity buildings, southwest winds accelerating around the western façade of the Proximity building, etc.

The wind tunnel testing showed that, once landscaping and additional awning treatments was taken into account, potential adverse wind conditions within and surrounding the site, ie winds over 16 m/s, could be adequately mitigated.

These treatments have already been incorporated for the site. The important role of landscaping and building awnings was highlighted in the testing.

On the basis of the above, we believe that the proposed development will comply with standard wind acceptability criteria for all public areas surrounding the site.

8 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Discovery Point Pty Ltd. 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 Consulting.

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

Sydney Airport – Seasonal Wind Roses