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Ref: 94-20-DE-LET-02
26th May 2022

Milligan Group Pty Ltd
321 Riley Street
Surry Hills NSW 2010
Attn: Jarrod White

15-23 Hunter Street and 105-107 Pitt Street, Sydney
Environmental Wind Conditions Studies

Environmental Wind Speed Measurements have been conducted by MEL Consultants Pty Ltd in support of a Planning Proposal to amend the *Sydney Local Environmental Plan 2012* (Sydney LEP). This study has been prepared on behalf of Milligan Group Pty Ltd and relates to an amalgamated site at 15-23 Hunter Street and 105-107 Pitt Street.

The results of the wind tunnel model study of the environmental wind conditions for the development have been reported in MEL Consultants Report 94-20-WT-ENV-01 Rev1 dated 11th April 2022. This wind tunnel modelling was based upon the Proposed tower built according to architectural model provided by Bates Smart on 29th September 2021.

As per the requirements of the Sydney DCP the measured wind conditions were measured and compared with respect to the defined wind safety and comfort standards and compared with respect to the Sydney DCP Base Case in terms of achieving an equivalent or better spatially averaged wind speed for the evaluation (as per the methodology outlined in Schedule 12 of the Sydney DCP, Section 12.2, Procedure B)

The results of the wind tunnel study indicated the Proposed development met the relevant wind safety requirements and was shown to achieve a wind comfort speed of 3.89m/s compared to 3.90m/s for the Base configuration at a selected number of Test Location points surrounding the development site.

At the request of City of Sydney an additional study was requested using Computational Fluid Dynamics (CFD) to compare the wind comfort between the Base Case (which now included the internal laneway) and the Proposed Configuration and, if required, refine the built form of the Proposed development to achieve equivalence or better. The evaluation area was agreed to be identical to that utilised for the Sky View Factor (SVF) evaluation area and 16 wind directions were simulated. The CFD study was conducted in May 2022.

The results of the CFD study results in the Proposed Configuration achieving a mean annual wind comfort speed of 2.45m/s compared to 2.47m/s for the DCP Base Case. The figure below presents the result and shows an illustration of the SVF evaluation area used in the CFD study.

ALL WIND DIRECTIONS PEDESTRIAN MEAN ANNUAL WIND COMFORT SPEED
(Averaged over Sky View Area as Requested by City of Sydney)

Averaging Area	DCP Baseline	Proposal
Sky View	2.47m/s	2.45m/s

Yours sincerely,

J. Kostas
MEL Consultants Pty Ltd

Project Name: Planning Proposal - 15-23 Hunter Street and 105-107 Pitt Street, Sydney
Project Description: Amendments to the Sydney Local Environmental Plan 2012 and the Sydney Development Control Plan 2012
Submitted to: City of Sydney Council
On Behalf of: Milligan Group Pty Ltd and its subsidiary FT Sydney Pty Ltd as trustee for FT Sydney Unit Trust.

This Environmental Wind Speed Measurements Report 94-20-WT-ENV-01 has been prepared by MEL Consultants Pty Ltd in support of a Planning Proposal to amend the *Sydney Local Environmental Plan 2012* (Sydney LEP). This report has been prepared on behalf of Milligan Group Pty Ltd (the Proponent) and its related entities and consultants, representatives and agents and FT Sydney Pty Ltd as trustee for FT Sydney Unit Trust. It relates to an amalgamated site at 15-23 Hunter Street and 105-107 Pitt Street (the site).

The purpose of this Planning Proposal is to amend the site's Floor Space Ratio (FSR) development standard, and the Maximum Building Height to align with the Martin Place Sun Access Plane contained within the concurrent Central Sydney Planning Proposal.

This Planning Proposal supports the City of Sydney Council's draft Central Sydney Planning Strategy (Draft CSPS) by unlocking additional employment generating floor space within a designated tower cluster. The proposed Sydney LEP amendment is part of the broader redevelopment plan for the site to facilitate a new commercial office tower. It will also facilitate significant public benefits through additional site activation and embellishment of the public domain.

The Planning Proposal is accompanied by amendments to the Sydney Development Control Plan 2012 (Sydney DCP). The site specific DCP amendments reflect the proposed outcome to provide a podium tower scheme.
This is reflected in the accompanying reference design prepared by Bates Smart which serves as a baseline proof of concept for this Planning Proposal. This 2,108m^2 strategic site presents a unique opportunity to deliver a landmark premium commercial office tower that will exhibit design excellence and offer significant employment opportunities for global Sydney.

The uplift being sought is consistent with the strategic intent of the draft CSPS, which contains the City's requirements and expectations for projects pursuing this pathway. Following the Planning Proposal, the planning approval pathway involves a competitive design process and a detailed Development Application. As such, this report reflects the concept stage of the proposal, and may be embellished as the detailed design and required works evolve.

ENVIRONMENTAL WIND SPEED MEASUREMENTS ON A WIND TUNNEL MODEL OF THE 15-23 HUNTER STREET AND 105-107 PITT STREET, SYDNEY

By

E. Chong

&

J. Kostas

SUMMARY

Wind tunnel tests have been conducted on a 1/400 scale model of the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney. The model of the Development within surrounding buildings was tested in a simulated upstream boundary layer of the natural wind to determine likely environmental wind conditions. These wind conditions have been related to the Sydney Design Control Plan 2012 and assessed with respect to the Safety standard as well as the Walking, Standing and Sitting comfort standards.

The ground level wind conditions in the surrounding streetscapes and within the development for the Proposed Configuration have been shown to satisfy the standing comfort standard for all Test Locations, with many locations satisfy the sitting comfort standard. The wind comfort standard achieved has been shown to be generally similar for all configurations.

The ground level wind conditions for the Existing Configuration have been presented at all Test Locations for comparison.

For the Proposed Configuration, the wind conditions on the Podium Terrace of the development have been shown to be within the sitting comfort standards. However the wind conditions on the Rooftop Terrace have been shown to fail the safety standard at Test Locations R1 and R3.

Wind mitigation strategies have been developed for the Rooftop Terrace and have been shown to improve the wind conditions to meet the safety criterion at all Test Locations on the roof top terraces as well as meeting the standing and/or sitting comfort standards at these Test Locations.

The wind conditions at all Test Locations on the ground, podium, and rooftop levels (with mitigation strategies) have been shown to satisfy the safety standard.

MEL CONSULTANTS
Report 94-20-WT-ENV-01 Rev1

15-23 HUNTER STREET & 105-107 PITT STREET, SYDNEY
ENVIRONMENTAL WIND TUNNEL MODELLING

MEL CONSULTANTS REPORT NO: **94-20-WT-ENV-01 Rev1**

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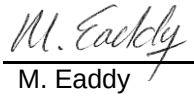

M. Eaddy
Managing Director Date: 14 February 2022

REVISION HISTORY

Revision No:	Date Issued	Reason/Comment
0	14 February 2022	Initial issue
1	29 March 2022	Amended test locations

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APPENDIX A

1. INTRODUCTION

The proposed development at 15-23 Hunter Street and 105-107 Pitt Street will be located on the corner of Hunter and Pitt Street in the central zone of the Sydney CBD.

The immediate surrounding terrain is dominated by high-rise commercial buildings of Sydney CBD and in the far field the surrounding terrain includes suburban housing and the open waters of Circular Quay and Darling Harbour, as shown in Figure 1.

Figure 1. Location of the development site within the context of the Sydney CBD. A 300m radius centred around the site is indicated in the figure.

A previous wind tunnel model study of the Existing Configuration, Base Case Envelope, and Proposed Configuration (May 2020) of 15-23 Hunter Street and 105-107 Pitt Street Development was carried out in May 2020. The result of this study is presented in MEL Report 94-20-WT-ENV-00 Rev.2.

Milligan Group Pty Ltd has commissioned another wind tunnel study to provide environmental wind conditions in and around a new updated Proposed Configuration of the 15-23 Hunter Street and 105-107 Pitt Street Development, and if required, to develop wind amelioration features to achieve conditions satisfying the target environmental wind criteria. These tests were carried out in the MEL Consultants 400kW Boundary Layer Wind Tunnel during December, 2021.

2. ENVIRONMENTAL WIND CRITERIA

The advancement of wind tunnel testing techniques, using large boundary layer flows to simulate the natural wind, has facilitated the prediction of wind speeds likely to be induced around a development. To assess whether the predicted wind conditions are likely to be acceptable or not, some form of criteria are required. The Sydney Design Control Plan (2012) has defined wind comfort standards for the assessment of the wind conditions in Sydney City. The definition of the standards is as follows:

Wind Safety Standard is an annual hourly maximum peak 0.5 second gust wind speed measured between 6am and 10pm Eastern Standard Time of 24 meters per second.

Wind Comfort Standard is an hourly mean wind speed for each wind direction, with probability of exceedance less than 5% per annum (averaged over all wind directions) measured between 6am and 10pm Eastern Standard Time (equivalent to 292 hours per annum), of equal to or less than:

- 4 metres/second for sitting areas
- 6 metres/second for standing areas
- 8 metres/second for walking areas

Mean wind speed means the maximum of:

- Hourly mean wind speed, or
- Gust equivalent mean wind speed (gust wind speed divided by 1.85)

It is noted that the above Safety standard is assessed for each wind direction while the above Comfort standards are pass/fail criteria as they only assess the summation of probabilities of exceedance across all wind directions to determine whether a location passes or fails the threshold criterion. There may be cases that the Test Locations pass the all directions combined criterion but still fail the same criterion when applied correctly for a particular wind direction. For completeness, this report will provide data for each Test Location as a function of wind direction in Appendix A.

The Sydney DCP uses the definition of mean wind speed as based on the hourly wind speed so the probabilities will be determined from the hourly wind data for an applicable automatic weather station for the City of Sydney. The probability data used have been corrected for the approach terrain at the location of the automatic weather station (in this case Sydney Airport) and referenced to 10m in Terrain Category 2. This is the standard reference height of AS/NZS1270.2:2011.

3. MODEL AND EXPERIMENTAL TECHNIQUES

A 1/400 scale model of the proposed 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney was constructed from digital 3D model provided by Bates Smart Architects on 29 September 2021.

The scale model of the development and surrounding buildings was tested in a model of the natural wind generated by flow over roughness elements augmented by vorticity generators at the beginning of the wind tunnel working section. The surrounding buildings include all built and under construction buildings in the immediate vicinity. The basic natural wind model was for flow over suburban terrain, the characteristics of which are given in Figure 2. The surrounding wind tunnel model of all significant buildings, out to a minimum radius of 300m, modified the approach wind model for the presence of the surrounding buildings.

The techniques used to investigate the environmental wind conditions and the method of determining the local criteria are given in detail in Reference 2. In these tests measurements in the Development areas are inside separated regions and peak velocity squared ratios were required to make conclusions about likely wind conditions. In summary, measurements were made of the peak gust wind velocity with a hot wire anemometer at various stations and expressed as a squared ratio with the mean wind velocity at a scaled reference height of 300m. This gives the peak velocity squared ratio

$$\left(\hat{V}_{local} / \overline{V}_{300m}\right)^2$$

as shown in Figure A1.

Wind tunnel velocity measurements were made for an equivalent 1 hour period in full scale and filtered to provide an equivalent full scale 3 second gust wind speed. Photographs of the models as tested in the wind tunnel are shown for each of the configurations in Figures 3 and 4.

4. DISCUSSION OF RESULTS

Velocity measurements were made at various locations around the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney for different wind directions at 22.5° intervals for the **Proposed Configuration** (Preferred Building Envelope).

For comparison purposes the results will be presented for the following model configurations:

- **Existing Configuration**
- **Base Case Configuration** (Schedule 11 Scheme)

As discussed in Section 2, the Sydney Design Control Plan wind comfort criteria are pass/fail criteria based on an assessment of the summation of probabilities for all wind directions combined. Therefore, to assess the wind conditions the exceedances will be presented in tabular form in Tables 1 – 7. For completeness these data are also provided in Appendix A as a function of wind direction and compared with the pedestrian criteria based on gust wind speeds. The Ground and Upper Levels Terrace are shown in Figures 5a to 5d. The following sections detail the results for the various areas tested.

4.1 Summary of Results

To assist with the assessment of the wind conditions, summaries of the wind criteria achieved for all wind directions at each Test Location in the surrounding streetscapes, and terraces have been provided using a colour code system in the following figures:

Existing Configuration	Figure 6
Base Case Configuration	Figure 7
Proposed Configuration	Figures 8 to 11
Proposed Configuration with mitigation	Figure 12

Different colours have been used to represent the wind criteria achieved at each test location.

4.2 Pitt Street

The wind conditions along Pitt Street for the Proposed Configuration have been shown to satisfy the sitting comfort standard at all presented Test Locations. The wind comfort standard achieved at all Test Locations has been shown to be similar for the Existing Configuration, Base Case Envelope and Proposed Configuration.

The wind conditions for the Existing Configuration and Base Case Envelope, have been presented for all Test Locations for comparison. The standards satisfied have been presented in Table 1.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 1: Pedestrian Wind Comfort and Safety – Pitt Street

Test Location	Configuration	Wind Comfort Standard				wind speed
		Sitting	Standing	Walking	Safety	
3	Existing	2.35%	0.14%	0.00%	Pass	3.65
	Base Case	3.14%	0.24%	0.02%	Pass	3.94
	Proposed	2.76%	0.15%	0.00%	Pass	3.98
4	Existing	0.20%	0.00%	0.00%	Pass	2.69
	Base Case	0.48%	0.02%	0.00%	Pass	2.81
	Proposed	0.64%	0.03%	0.00%	Pass	3.07
5	Existing	0.30%	0.00%	0.00%	Pass	2.47
	Base Case	1.72%	0.12%	0.01%	Pass	3.38
	Proposed	3.69%	0.37%	0.01%	Pass	3.94
6	Existing	0.97%	0.05%	0.00%	Pass	3.12
	Base Case	1.08%	0.05%	0.00%	Pass	3.16
	Proposed	1.07%	0.05%	0.00%	Pass	3.27
7a	Existing	1.87%	0.20%	0.01%	Pass	3.21
	Base Case	1.49%	0.12%	0.00%	Pass	3.17
	Proposed	2.94%	0.42%	0.03%	Pass	3.65
8	Existing	2.17%	0.28%	0.01%	Pass	3.49
	Base Case	1.50%	0.11%	0.00%	Pass	3.26
	Proposed	3.55%	0.68%	0.06%	Pass	3.70
9	Existing	1.29%	0.06%	0.00%	Pass	3.45
	Base Case	0.73%	0.02%	0.00%	Pass	3.30
	Proposed	1.47%	0.07%	0.00%	Pass	3.51
10	Existing	0.89%	0.03%	0.00%	Pass	3.45
	Base Case	4.31%	0.39%	0.05%	Pass	4.09
	Proposed	3.67%	0.45%	0.02%	Pass	4.06
11	Existing	0.50%	0.00%	0.00%	Pass	2.74
	Base Case	0.25%	0.00%	0.00%	Pass	2.62
	Proposed	0.72%	0.01%	0.00%	Pass	3.02
all Pitt St	Existing	1.17%	0.09%	0.00%	**average**	**3.14**
	Base Case	1.63%	0.12%	0.01%		**3.30**
	Proposed	2.28%	0.25%	0.02%		**3.58**

4.3 Hunter Street

The wind conditions for the Proposed Configuration along Hunter Street have been shown to satisfy the standing comfort standard at all Test Locations, with conditions at most Test Locations also satisfying the sitting comfort standard.

The wind conditions for the Existing Configuration and Base Case Envelope, have been presented for all Test Locations for comparison. The standards satisfied have been presented in Table 2.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 2: Pedestrian Wind Comfort and Safety – Hunter Street

Test Location	Configuration	Wind Comfort Standard				wind speed
		Sitting	Standing	Walking	Safety	
15	Existing	4.84%	1.19%	0.27%	Pass	4.39
	Base Case	4.64%	0.99%	0.20%	Pass	4.37
	Proposed	4.95%	0.99%	0.19%	Pass	4.48
16	Existing	7.11%	2.47%	0.82%	Pass	4.84
	Base Case	6.37%	1.87%	0.52%	Pass	4.64
	Proposed	6.73%	1.85%	0.46%	Pass	4.76
18	Existing	1.89%	0.16%	0.01%	Pass	3.44
	Base Case	2.03%	0.18%	0.01%	Pass	3.61
	Proposed	1.73%	0.11%	0.01%	Pass	3.61
19	Existing	1.77%	0.21%	0.01%	Pass	3.19
	Base Case	0.96%	0.05%	0.00%	Pass	3.01
	Proposed	2.35%	0.17%	0.01%	Pass	3.30
21	Existing	0.27%	0.00%	0.00%	Pass	2.71
	Base Case	1.90%	0.14%	0.01%	Pass	3.41
	Proposed	1.36%	0.08%	0.00%	Pass	3.38
22	Existing	6.49%	1.09%	0.14%	Pass	4.81
	Base Case	5.00%	0.73%	0.09%	Pass	4.46
	Proposed	4.68%	0.72%	0.09%	Pass	4.33
23	Existing	0.22%	0.00%	0.00%	Pass	2.44
	Base Case	0.49%	0.01%	0.00%	Pass	2.61
	Proposed	0.20%	0.00%	0.00%	Pass	2.74
24	Existing	2.00%	0.08%	0.00%	Pass	3.91
	Base Case	3.61%	0.23%	0.01%	Pass	4.30
	Proposed	2.91%	0.15%	0.01%	Pass	4.05
26	Existing	1.61%	0.08%	0.00%	Pass	3.53
	Base Case	1.81%	0.09%	0.00%	Pass	3.77
	Proposed	1.91%	0.10%	0.00%	Pass	3.70
all Hunter St	Existing	2.91%	0.59%	0.14%	average	**3.70**
	Base Case	2.98%	0.48%	0.09%		**3.80**
	Proposed	2.98%	0.46%	0.09%		**3.82**

4.4 George Street

The wind conditions along George Street for the Proposed Configuration have been shown to satisfy the standing comfort standard at all presented Test Locations, with conditions at Test Location 32 satisfying the sitting comfort standard.

The wind conditions for the Existing Configuration and Base Case Envelope, have been presented for all Test Locations for comparison. The standards satisfied have been presented in Table 3.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 3: Pedestrian Wind Comfort and Safety – George Street

Test Location	Configuration	Wind Comfort Standard				wind speed (m/s)
		Sitting	Standing	Walking	Safety	
31	Existing	3.47%	0.51%	0.04%	Pass	3.92
	Base Case	11.86%	3.45%	0.77%	Pass	6.05
	Proposed	8.83%	2.10%	0.42%	Pass	5.45
32	Existing	4.78%	0.98%	0.15%	Pass	4.20
	Base Case	4.30%	0.82%	0.12%	Pass	4.02
	Proposed	3.75%	0.71%	0.10%	Pass	4.03
all George St	Existing	4.13%	0.74%	0.10%		**4.06**
	Base Case	8.08%	2.13%	0.45%	**average**	**5.04**
	Proposed	6.29%	1.41%	0.26%		**4.74**

4.5 Laneway

The Proposed Configuration includes a Laneway through the ground level which connects Pitt and Hunter Streets. Additional measurements were made along this Laneway and the wind conditions have been shown to satisfy the sitting comfort standard at all Test Locations.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 4: Pedestrian Wind Comfort and Safety – Laneway

Test Location	Configuration	Wind Comfort Standard				wind speed (m/s)
		Sitting	Standing	Walking	Safety	
37	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.79%	0.04%	0.00%	Pass	2.76
38	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.22%	0.01%	0.00%	Pass	2.30
39	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.57%	0.02%	0.00%	Pass	2.55
40	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.00%	0.00%	0.00%	Pass	1.68
41	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.01%	0.00%	0.00%	Pass	1.74
42	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.01%	0.00%	0.00%	Pass	1.95
43	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.16%	0.00%	0.00%	Pass	2.44
all Laneway	Existing	N/A	N/A	N/A	average	N/A
	Base Case	N/A	N/A	N/A		N/A
	Proposed	0.25%	0.01%	0.00%		**2.20**

4.6 Average Pedestrian Level Wind Speeds

The average wind conditions along Pitt, Hunter and George Streets for the Existing Configuration, Base Case Configuration and Proposed Configuration have been summarised in Table 5, below, along with global averages of the wind comfort levels and speeds across these measured areas.

Table 5: Pedestrian Wind Comfort and Safety – all pedestrian level locations

Test Location	Configuration	Wind Comfort Standard				wind speed (m/s)
		Sitting	Standing	Walking	Safety	
Pitt St	Existing	1.60%	0.21%	0.03%	Pass	3.14
	Base Case	1.93%	0.20%	0.02%	Pass	3.30
	Proposed	2.74%	0.37%	0.03%	Pass	3.58
Hunter St	Existing	3.55%	0.66%	0.13%	Pass	3.70
	Base Case	3.14%	0.50%	0.09%	Pass	3.80
	Proposed	3.23%	0.50%	0.08%	Pass	3.82
George St	Existing	4.77%	1.10%	0.22%	Pass	4.06
	Base Case	6.04%	1.57%	0.34%	Pass	5.04
	Proposed	5.41%	1.27%	0.25%	Pass	4.74
Laneway	Existing	N/A	N/A	N/A	N/A	N/A
	Base Case	N/A	N/A	N/A	N/A	N/A
	Proposed	0.25%	0.01%	0.00%	Pass	2.20
all pedestrian level locations	Existing	3.30%	0.66%	0.13%	average	**3.63**
	Base Case	3.70%	0.76%	0.15%		**4.05**
	Proposed	3.79%	0.71%	0.12%		**4.04**

4.7 Podium Terrace

The wind conditions for the Proposed Configuration (including a 1.2m high balustrade) on the podium level terrace have been shown to satisfy the sitting comfort standard at Test Locations T1 to T5. The wind conditions at these Test Locations were shown to pass the Safety criterion for all wind directions. The standards satisfied have been presented in Table 6.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 6: Wind Comfort and Safety – Podium Terrace

Test Location	Configuration	Wind Comfort Standard				wind speed (m/s)
		Sitting	Standing	Walking	Safety	
T1	Proposed	3.96%	0.59%	0.04%	Pass	4.09
T2	Proposed	4.23%	1.27%	0.27%	Pass	3.20
T3	Proposed	2.76%	0.25%	0.01%	Pass	3.71
T4	Proposed	0.54%	0.00%	0.00%	Pass	2.57
T5	Proposed	0.93%	0.02%	0.00%	Pass	2.72
all Podium Terrace	Proposed				**average**	**3.26**

4.8 Rooftop Terrace

The wind conditions for the Proposed Configuration (including a 1.2m high balustrade) at the Rooftop Terrace have been shown to satisfy the walking criterion at all Test Locations but fail the safety standard at Test Locations R1 and R3.

Two mitigation strategies have been explored, with the primary goal of improving the wind conditions to satisfy the safety standard. The first mitigation strategy involved increasing the height of the balustrade to 1.8m shown in Figure 13. While this was shown to improve the wind conditions at Test Locations R1 and R3, the conditions were still shown to fail the safety standard at these locations.

The wind conditions at Test Locations R1 and R3 were shown to improve to meet the safety standard with the inclusion of solid, 1.8m high screens at the northeast and northwest corners. The placement of these wind mitigation features are shown schematically in Figure 13. This mitigation strategy was also shown to improve the wind conditions to meet the sitting and standing criteria at certain Test Locations.

The standards satisfied have been presented in Table 7.

The wind conditions are a function of wind direction based on the gust criteria for Sydney as presented in Appendix A. It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for all wind directions.

Table 7: Wind Comfort and Safety – Rooftop Terrace

Test Location	Configuration	Wind Comfort Standard				wind speed (m/s)
		Sitting	Standing	Walking	Safety	
R1	Proposed	25.98%	14.44%	7.61%	FAIL	9.67
	Proposed + 1.8m balustrade	16.18%	6.16%	2.17%	FAIL	6.84
	Proposed + Screens + 1.8m balustrade	4.28%	0.52%	0.06%	Pass	4.13
R2	Proposed	18.09%	5.84%	1.46%	Pass	7.09
	Proposed + 1.8m balustrade	19.50%	6.24%	1.86%	Pass	7.29
	Proposed + Screens + 1.8m balustrade	7.84%	1.52%	0.21%	Pass	5.03
R3	Proposed	23.61%	9.99%	3.78%	FAIL	8.21
	Proposed + 1.8m balustrade	21.07%	9.21%	3.65%	FAIL	7.70
	Proposed + Screens + 1.8m balustrade	6.65%	1.33%	0.22%	Pass	4.51
R4	Proposed	18.05%	6.36%	2.00%	Pass	6.81
	Proposed + 1.8m balustrade	14.33%	4.79%	1.63%	Pass	6.37
	Proposed + Screens + 1.8m balustrade	6.05%	1.63%	0.51%	Pass	4.30
R5	Proposed	14.15%	5.13%	1.56%	Pass	6.54
	Proposed + 1.8m balustrade	11.19%	3.31%	0.91%	Pass	5.84
	Proposed + Screens + 1.8m balustrade	2.75%	0.26%	0.02%	Pass	4.04
all Roof Top Terraces	Proposed				**average**	**7.67**
	Proposed + 1.8m balustrade					**6.81**
	Proposed + Screens + 1.8m balustrade					**4.40**

5. CONCLUSIONS

Wind tunnel tests have been conducted on a 1/400 scale model of the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney. The model of the Development within surrounding buildings was tested in a simulated upstream boundary layer of the natural wind to determine likely environmental wind conditions. These wind conditions have been related to the Sydney Design Control Plan 2012 and assessed with respect to the Safety standard as well as the Walking, Standing and Sitting comfort standards.

The ground level wind conditions in the surrounding streetscapes and within the development for the Proposed Configuration have been shown to satisfy the standing comfort standard for all Test Locations, with many locations satisfy the sitting comfort standard. The wind comfort standard achieved has been shown to be generally similar for all configurations.

The ground level wind conditions for the Existing Configuration have been presented at all Test Locations for comparison.

For the Proposed Configuration, the wind conditions on the Podium Terrace of the development have been shown to be within the sitting comfort standards. However the wind conditions on the Rooftop Terrace have been shown to fail the safety standard at Test Locations R1 and R3.

Wind mitigation strategies have been developed for the Rooftop Terrace and have been shown to improve the wind conditions to meet the safety criterion at all Test Locations on the roof top terraces as well as meeting the standing and/or sitting comfort standards at these Test Locations.

The wind conditions at all Test Locations on the ground, podium, and rooftop levels (with mitigation strategies) have been shown to satisfy the safety standard.

J. Kostas

REFERENCES

1. W. H. Melbourne, Criteria for environmental wind conditions, Journal of Industrial Aerodynamics, Volume 3, 1978, pp. 241-249
2. W. H. Melbourne, Wind environment studies in Australia, Journal of Industrial Aerodynamics, Volume 3, 1978, pp. 201-214

FIGURES

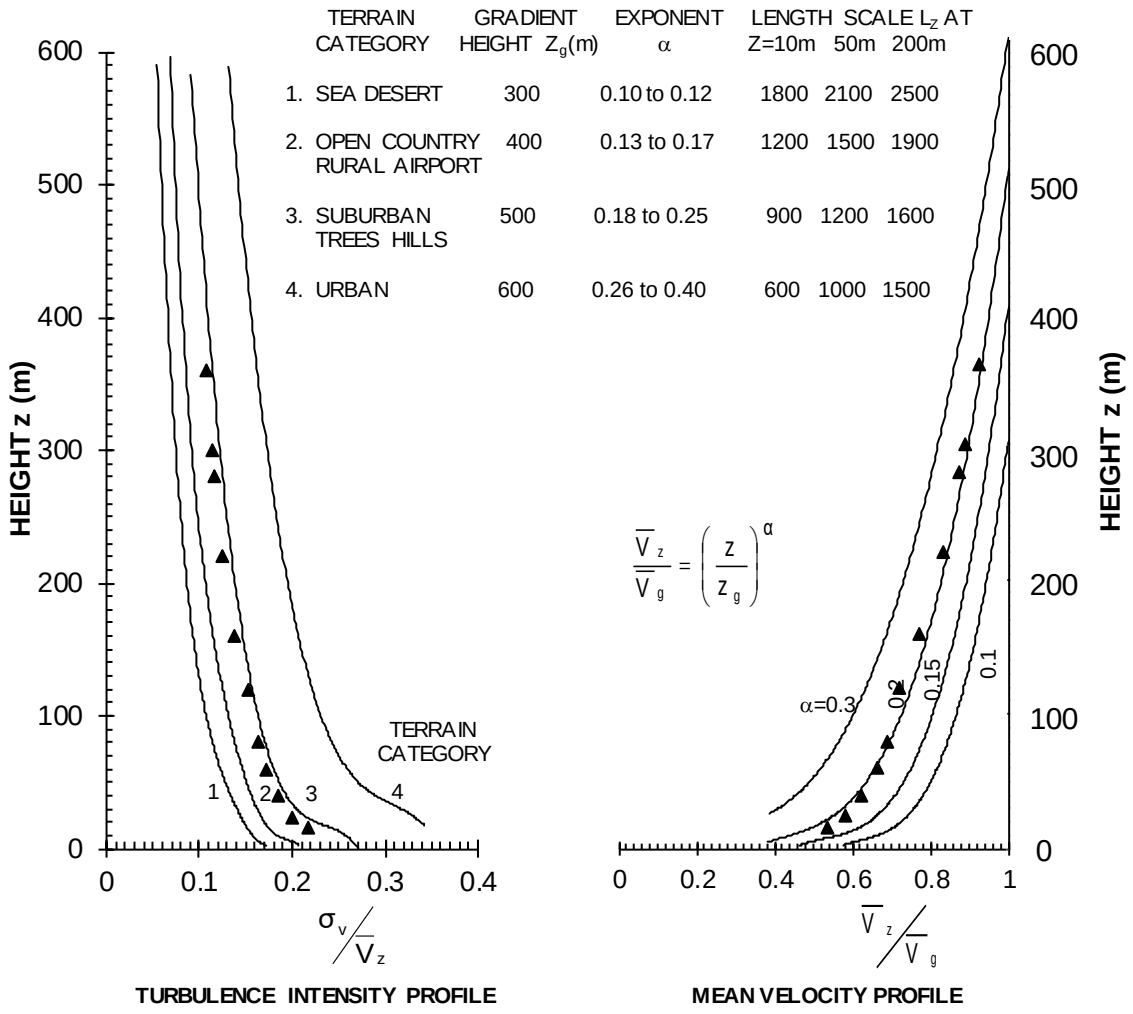


Figure 2 – 1/400 scale TC3 boundary layer turbulence intensity and mean velocity profiles in the MEL Consultants Boundary Layer Wind Tunnel 4.8m x 2.2m working section, scaled to full scale dimensions.

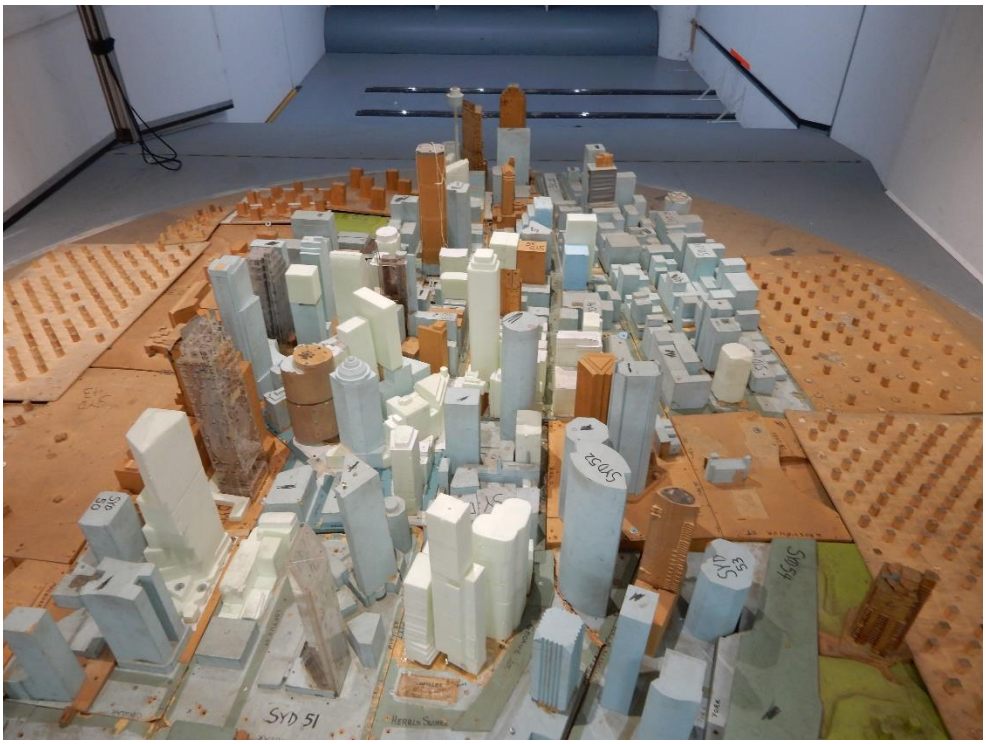


Figure 3 – View from the north of the 1/400 scale Proposed Configuration model of the 15-23 Hunter Street and 105-107 Pitt Street, Sydney in the wind tunnel.

Figure 4 – View from the southwest of the 1/400 scale Proposed Configuration model of the 15-23 Hunter Street and 105-107 Pitt Street, Sydney in the wind tunnel.

Figure 5a - Ground level Test Locations on the streetscapes around the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney.

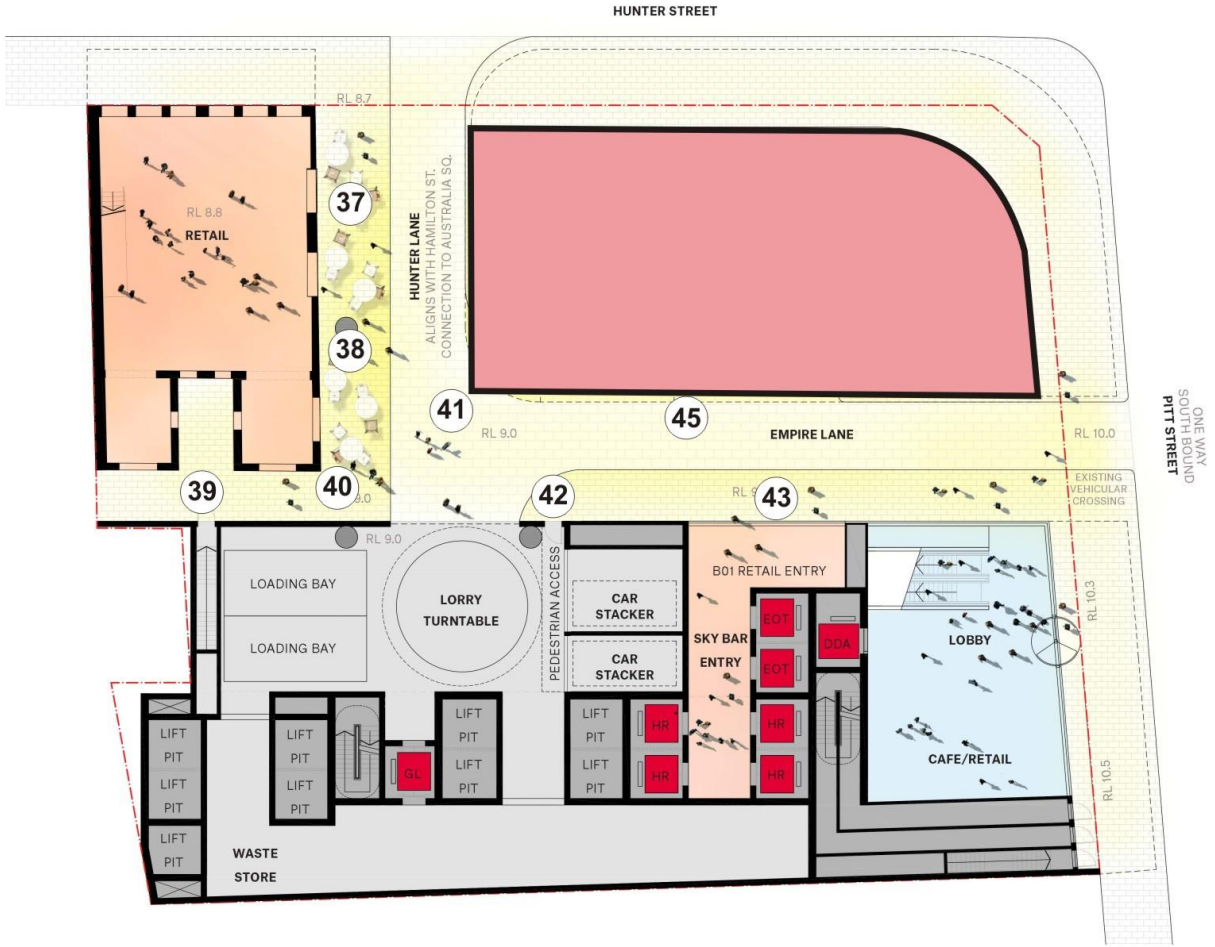


Figure 5b - Ground level Test Locations around the internal Laneway of 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney.

Figure 5c - Podium Terrace Test Locations of the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney.

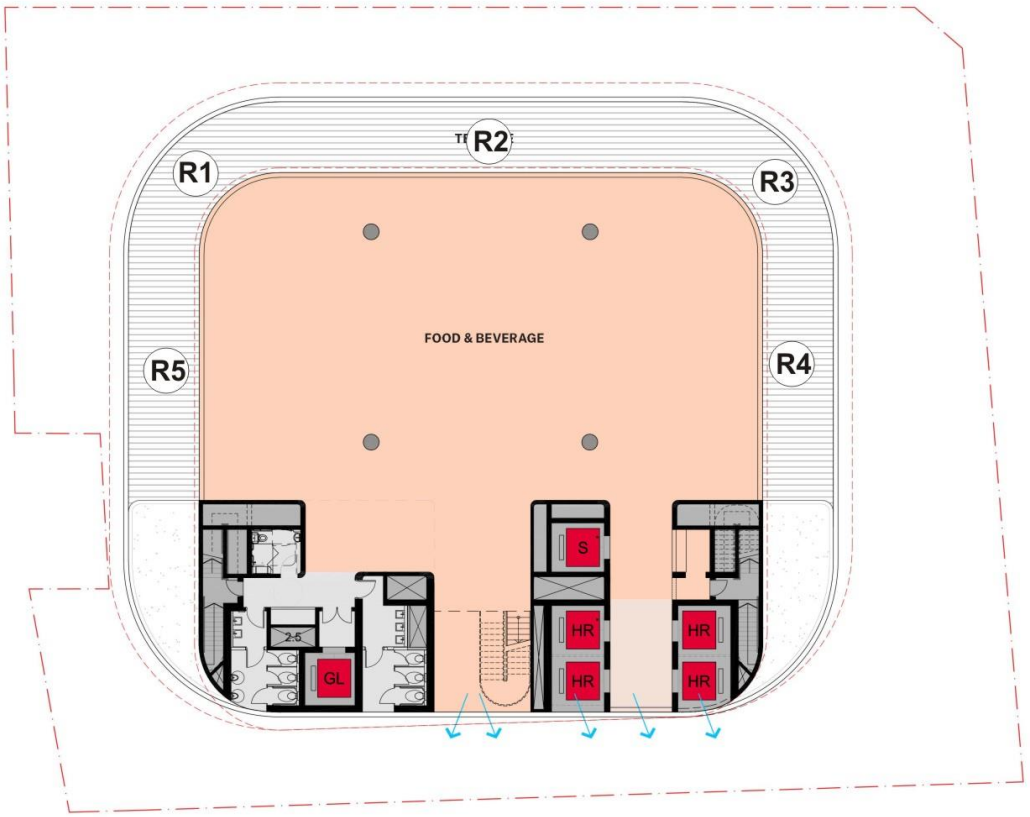


Figure 5d - Rooftop Terrace Test Locations of the 15-23 Hunter Street and 105-107 Pitt Street Development, Sydney.

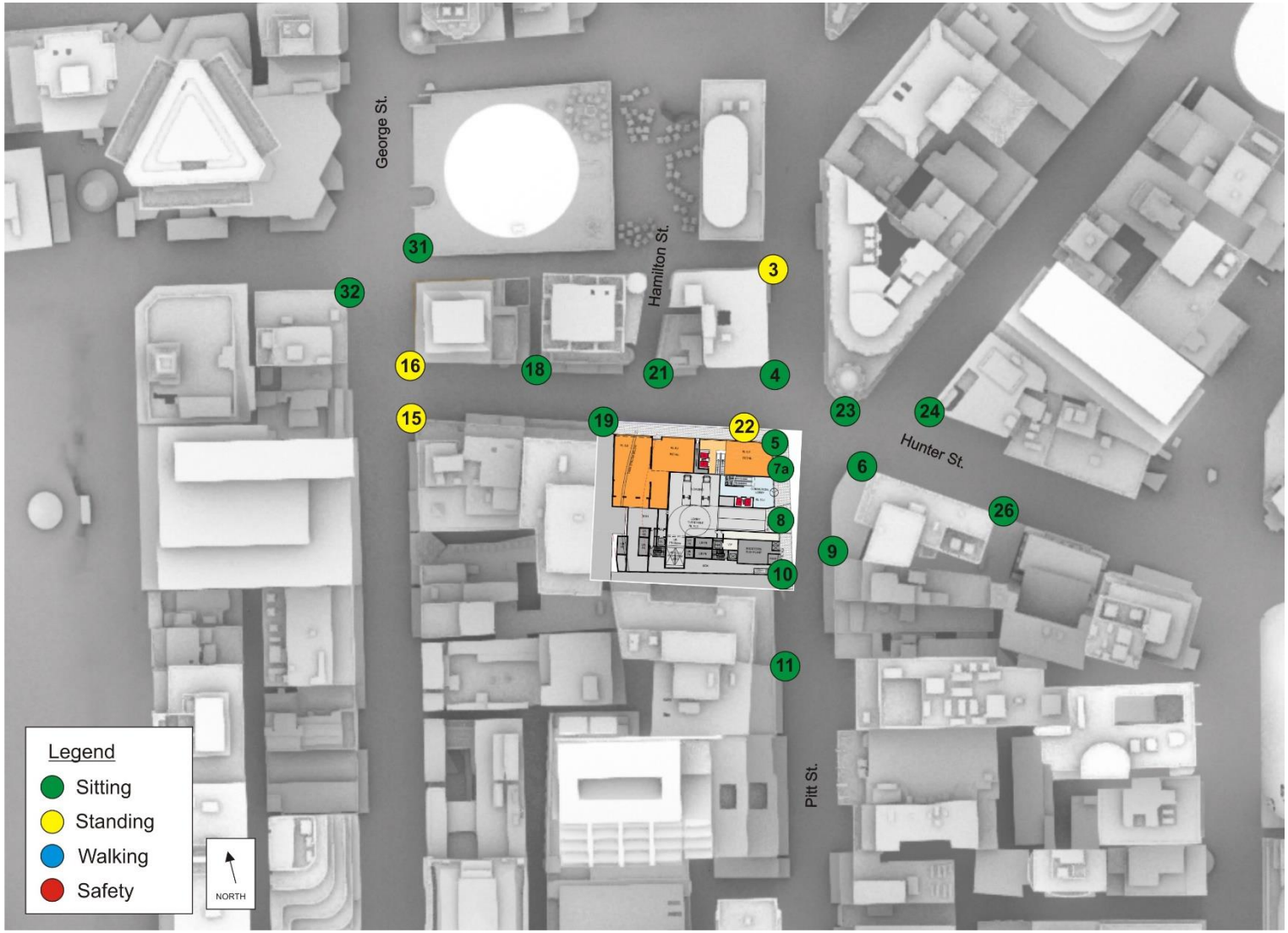


Figure 6 – Summary of ground level wind conditions for the Existing Configuration for 360° of wind direction.

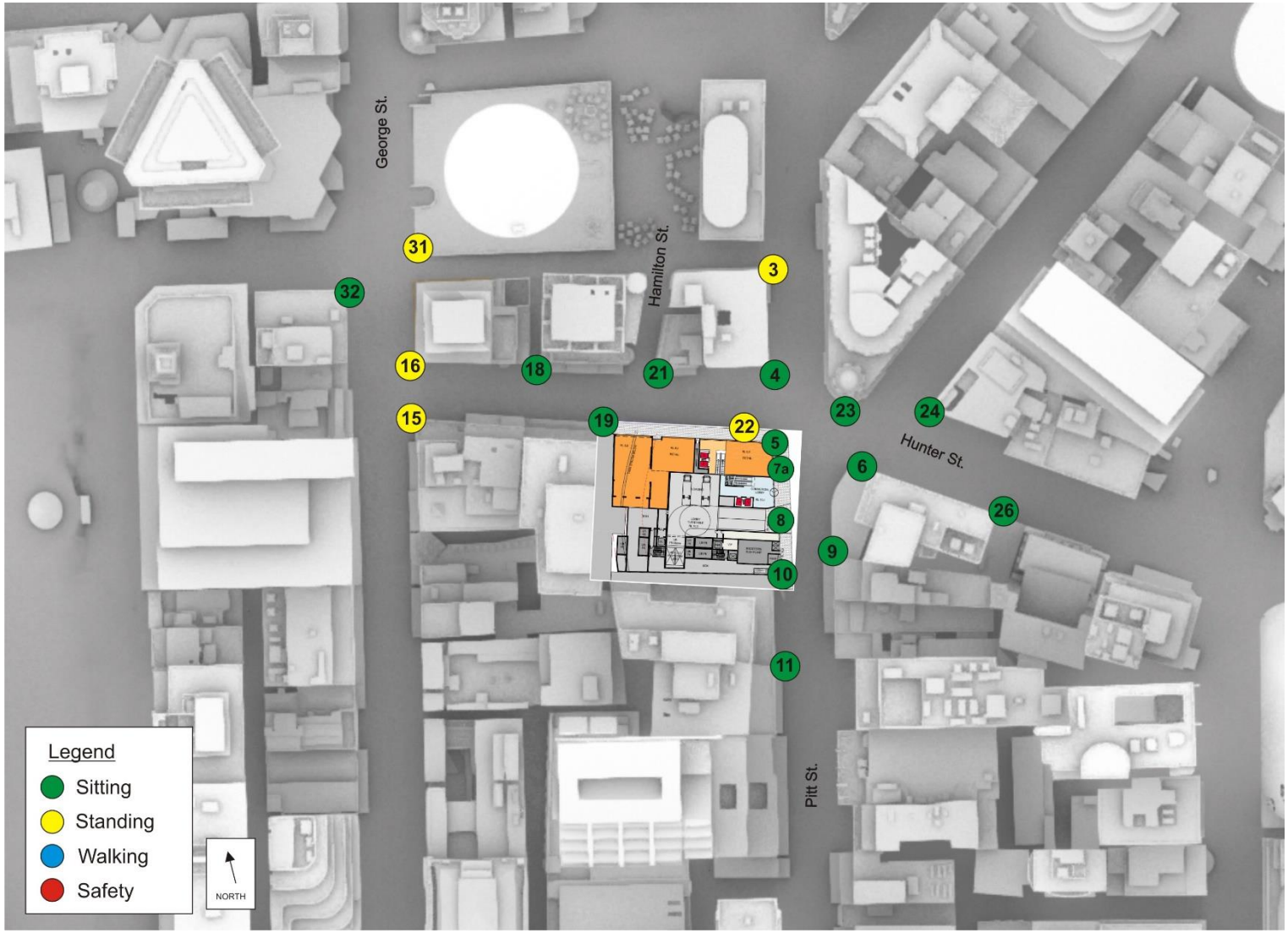


Figure 7 – Summary of ground level wind conditions for the Base Case Configuration for 360° of wind direction.

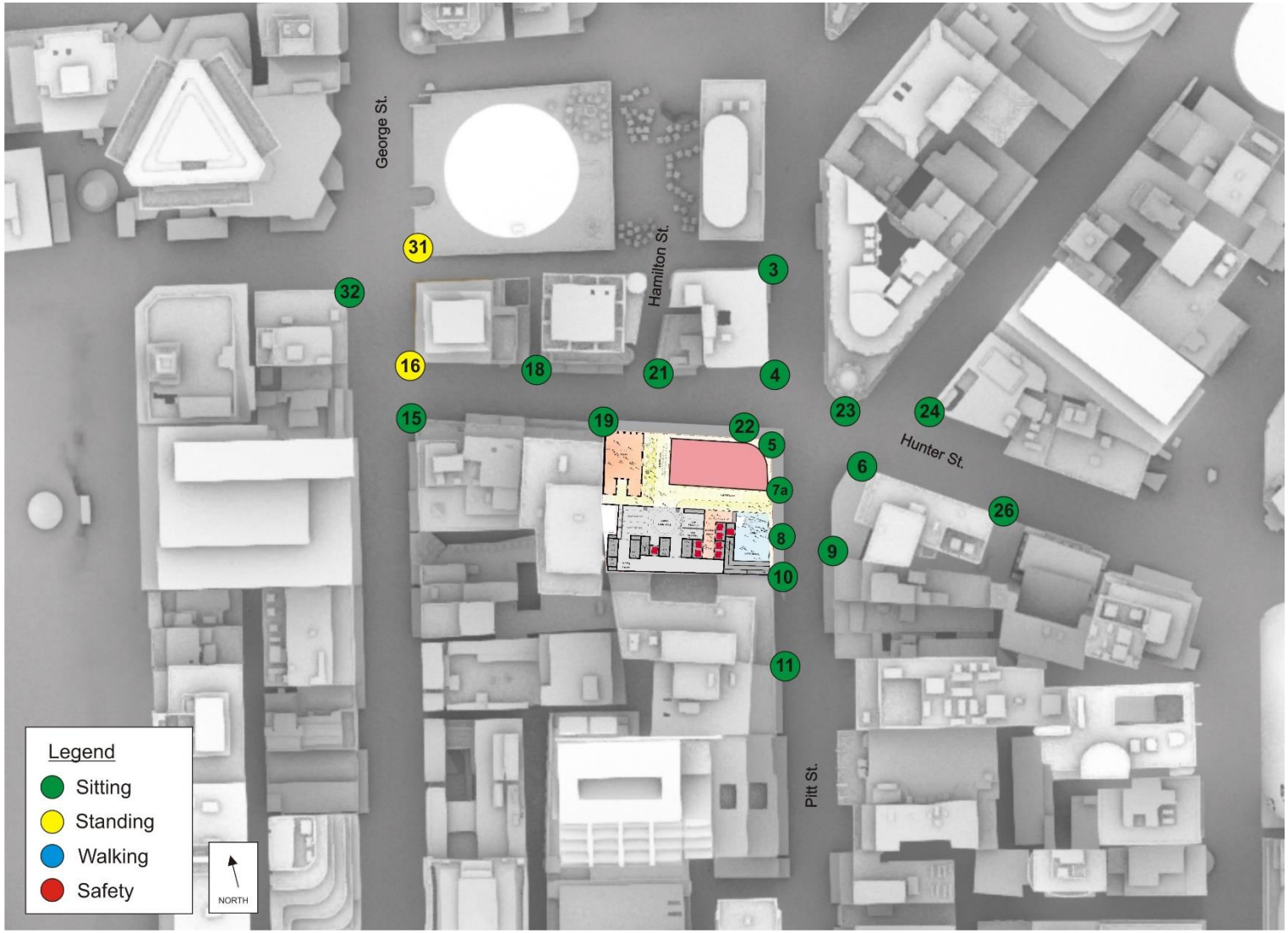


Figure 8 – Summary of ground level wind conditions on the surrounding streetscapes for the Proposed Configuration for 360° of wind direction.

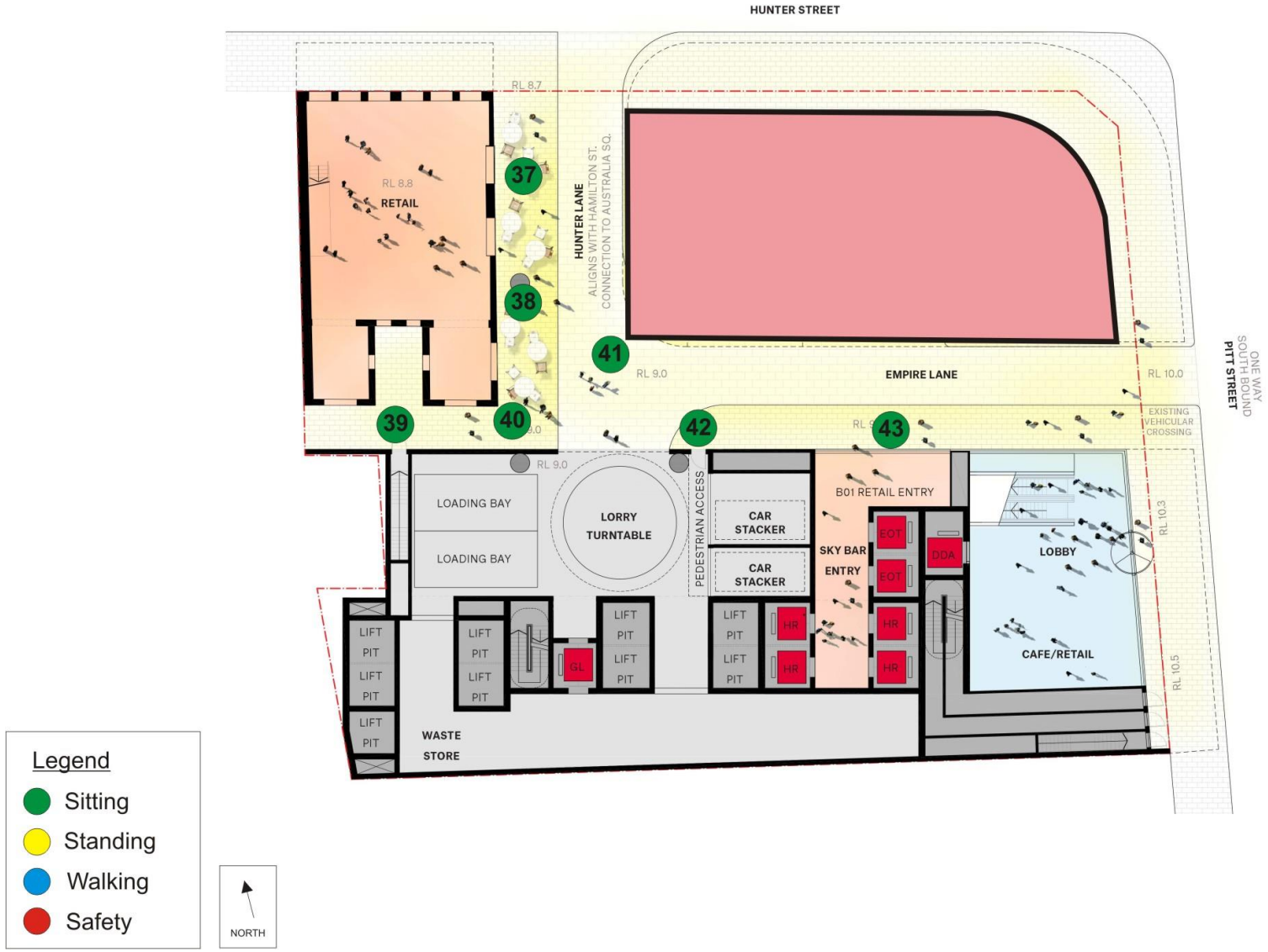


Figure 9 – Summary of ground level wind conditions on the internal Laneway for the Proposed Configuration for 360° of wind direction.

Figure 10 – Summary of Podium Terrace wind conditions for the Proposed Configuration with 1.2m balustrade for 360° of wind direction.

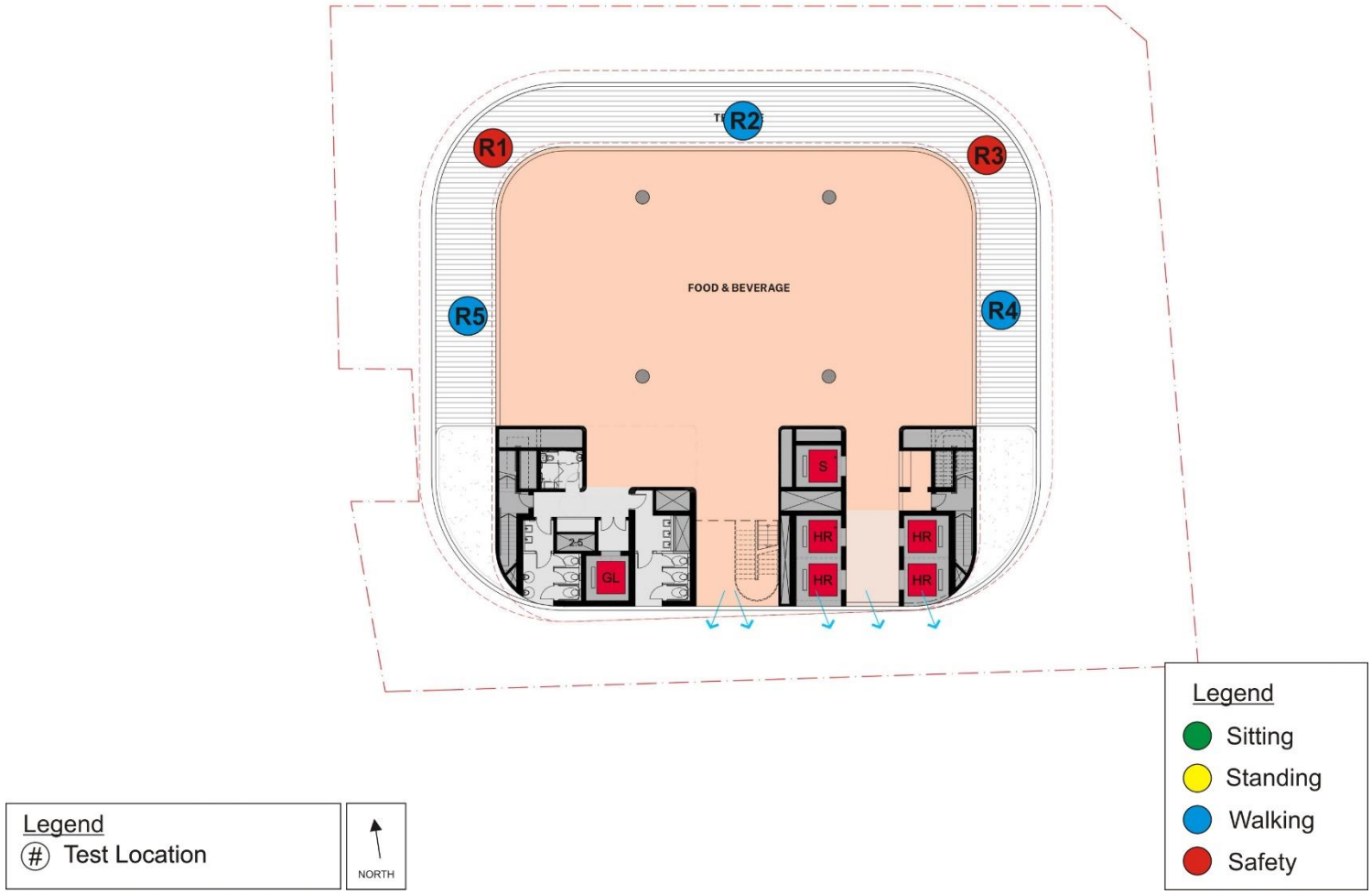


Figure 11 – Summary of Rooftop Terrace wind conditions for the Proposed Configuration with 1.2m balustrade for 360° of wind direction.

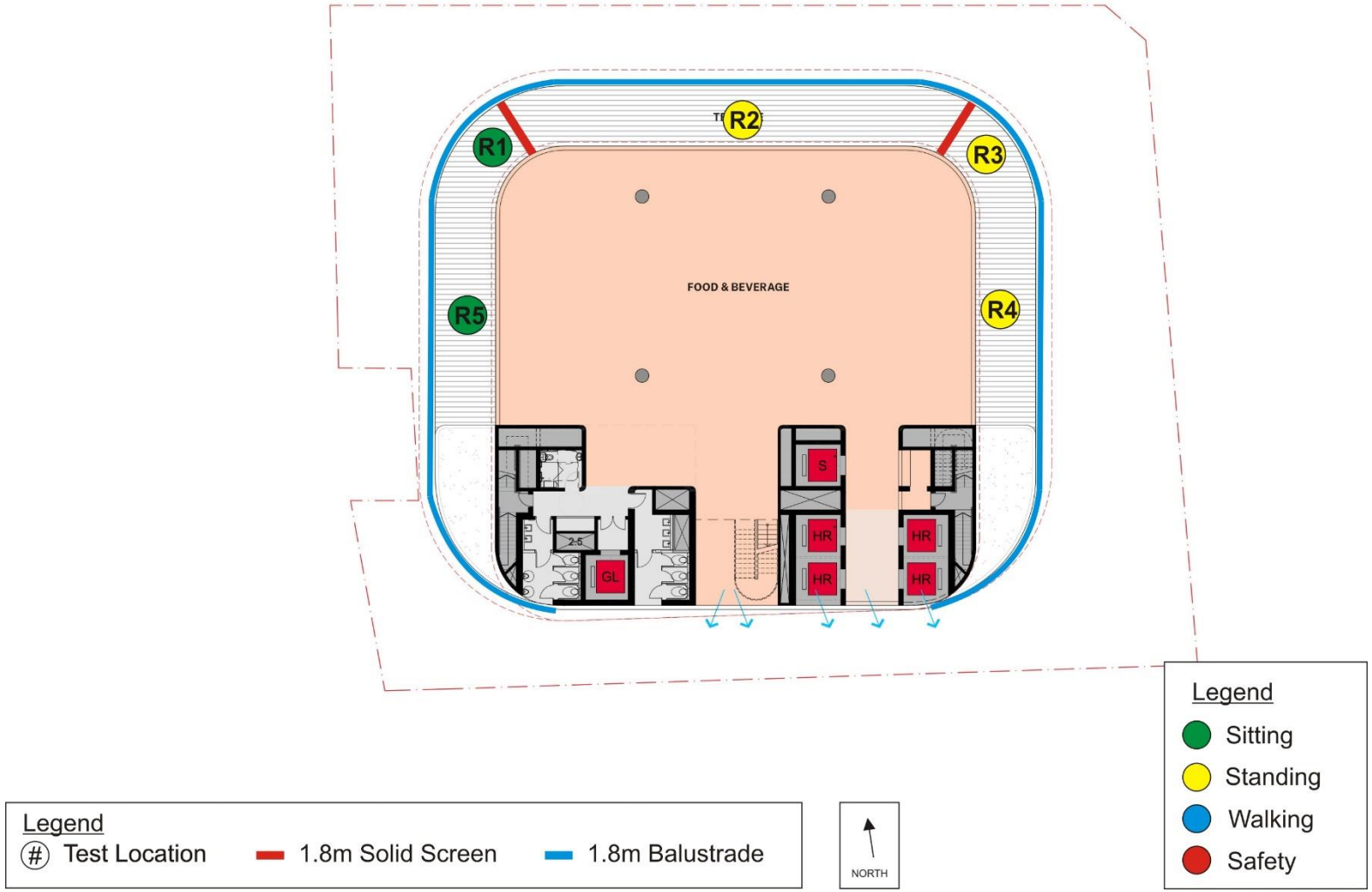


Figure 12 – Summary of Rooftop Terrace wind conditions for the Proposed Configuration with 1.8m balustrade and 1.8m solid screens for 360° of wind direction.

Appendix A

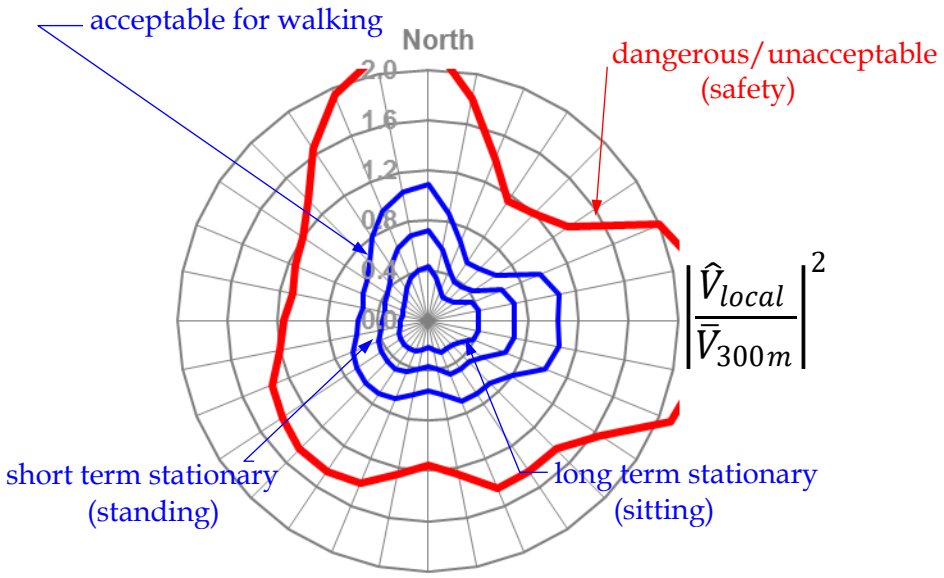


Figure A1 - Environmental wind criteria for Sydney as a function of wind direction expressed in terms of peak velocity pressure ratio.

Test Location

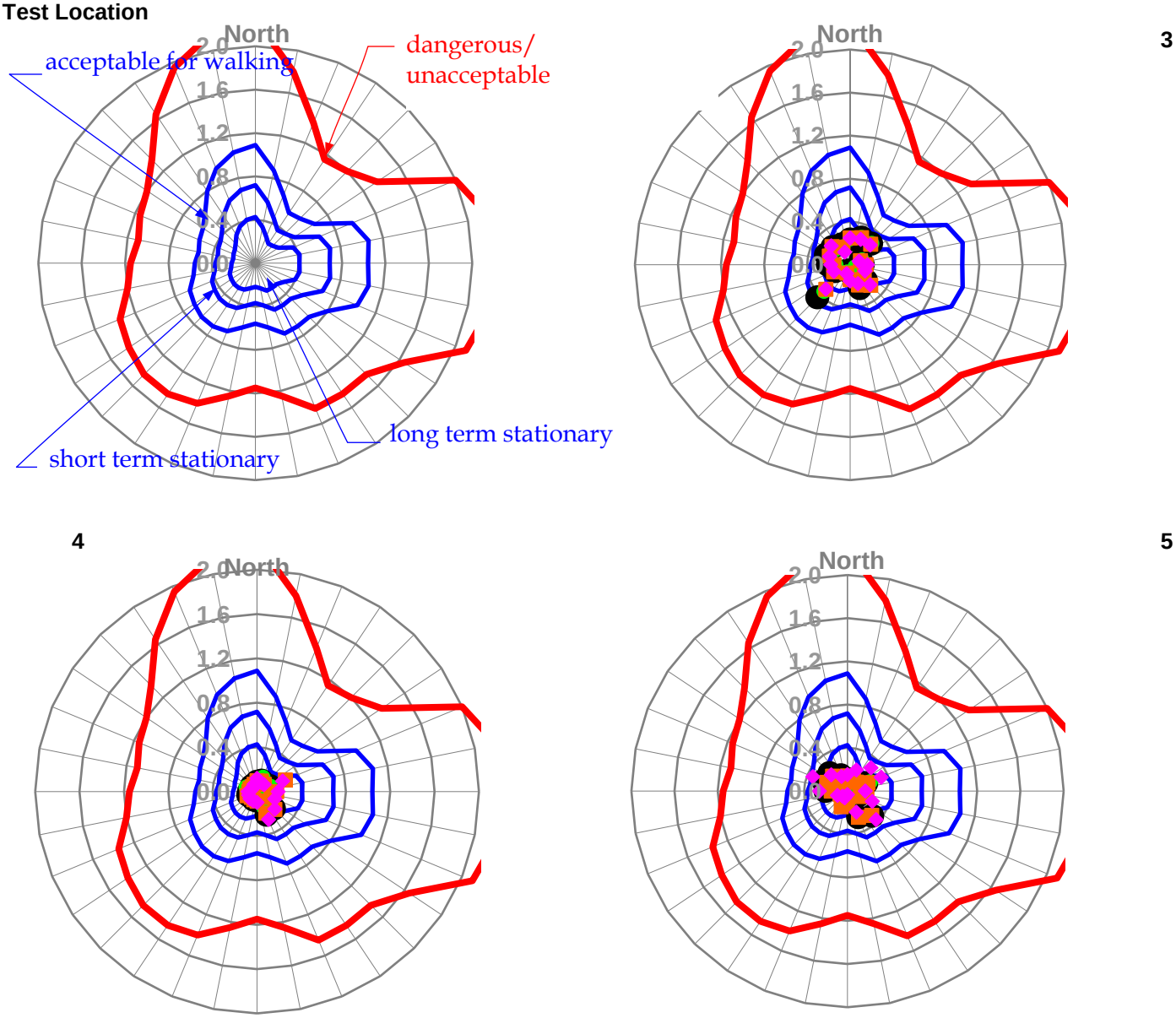
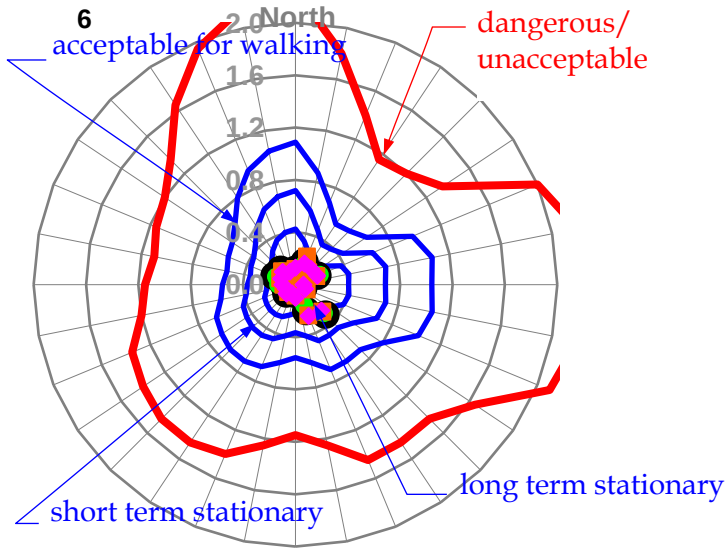
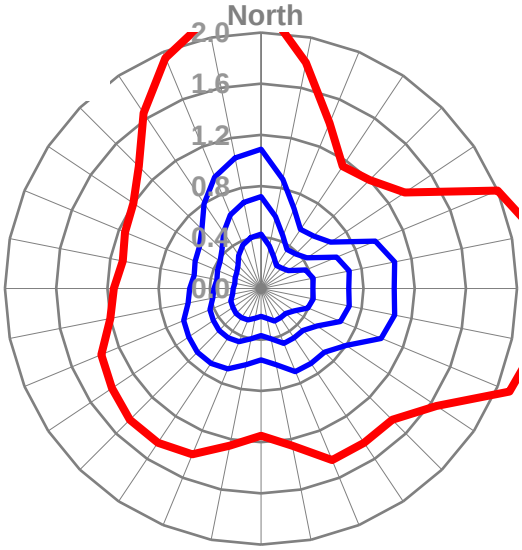


Figure A2 - Pitt Street

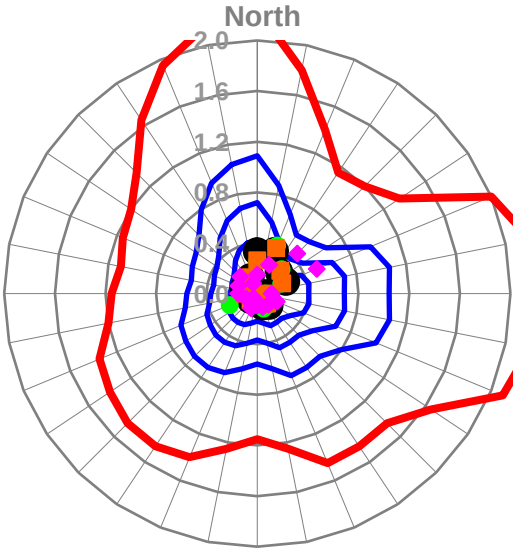
Test Location

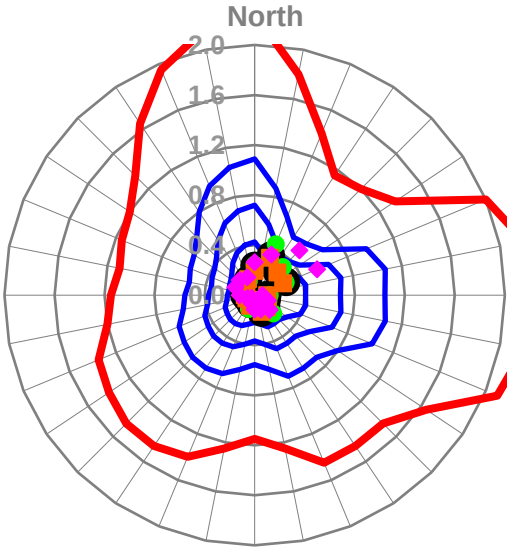
6





7a





8

Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Base Configuration
Existing Configuration
Proposed Configuration

Figure A3 - Pitt Street - continued

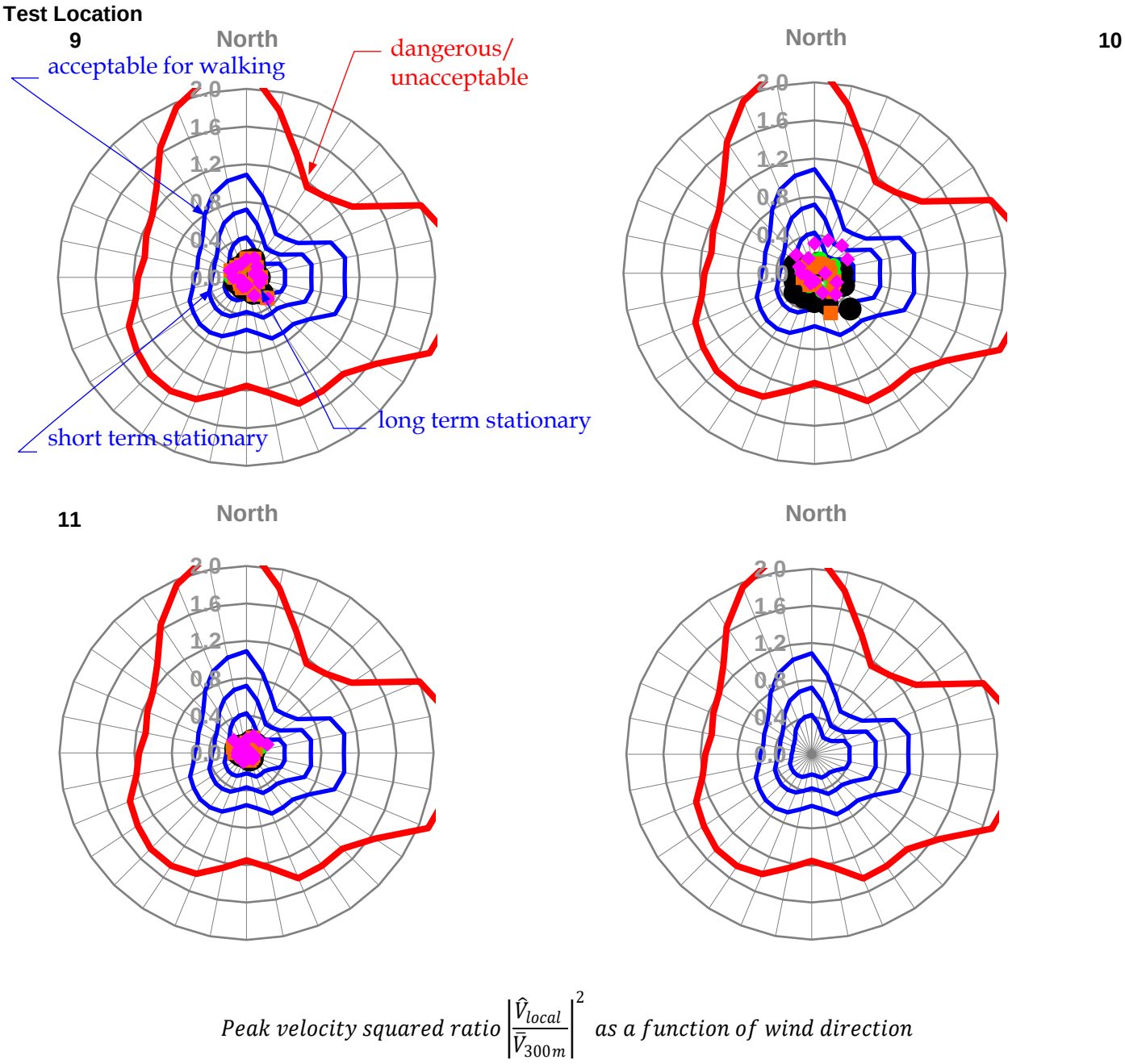


Figure A4 - Pitt Street - continued

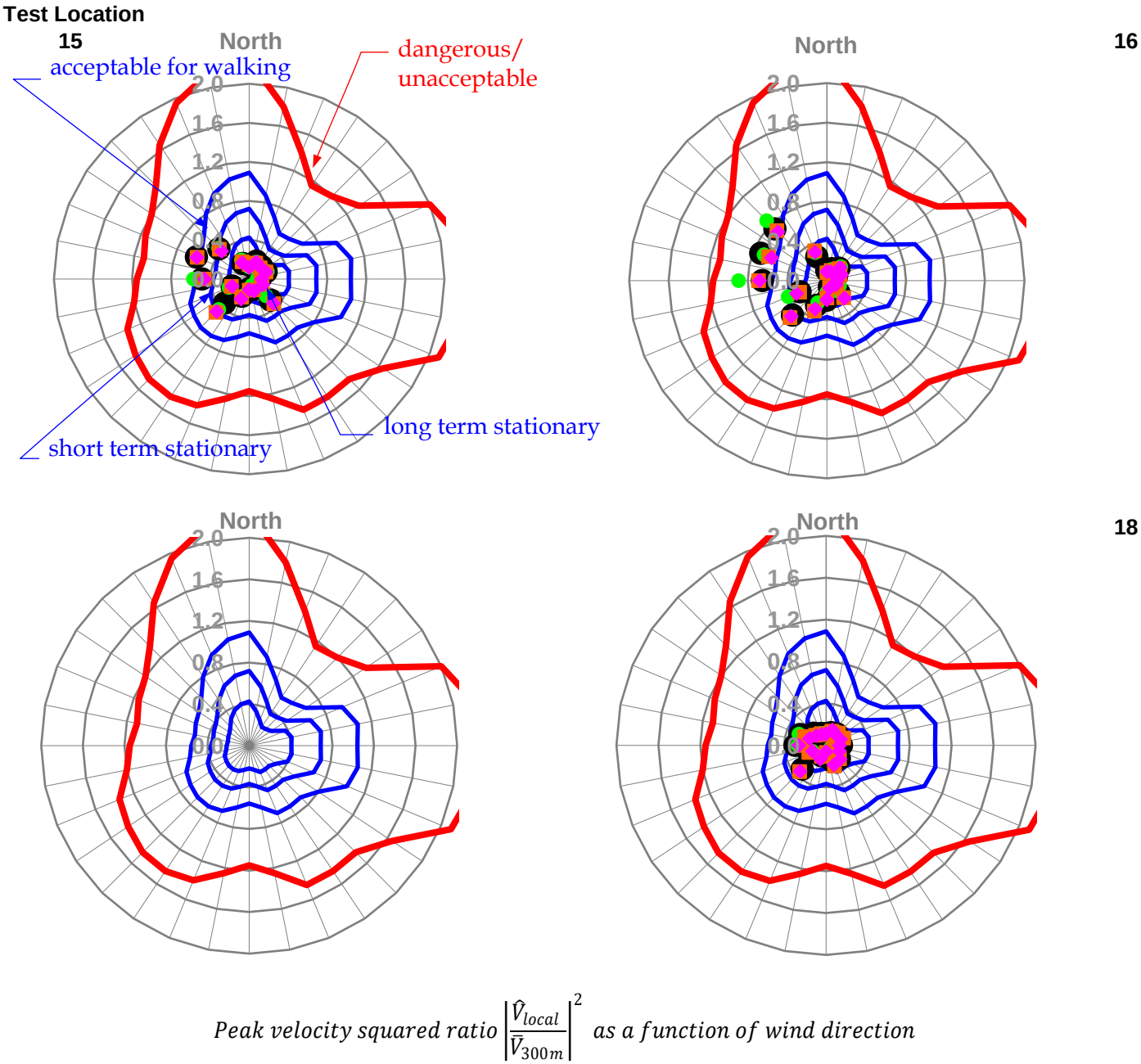


Figure A5 - Hunter Street

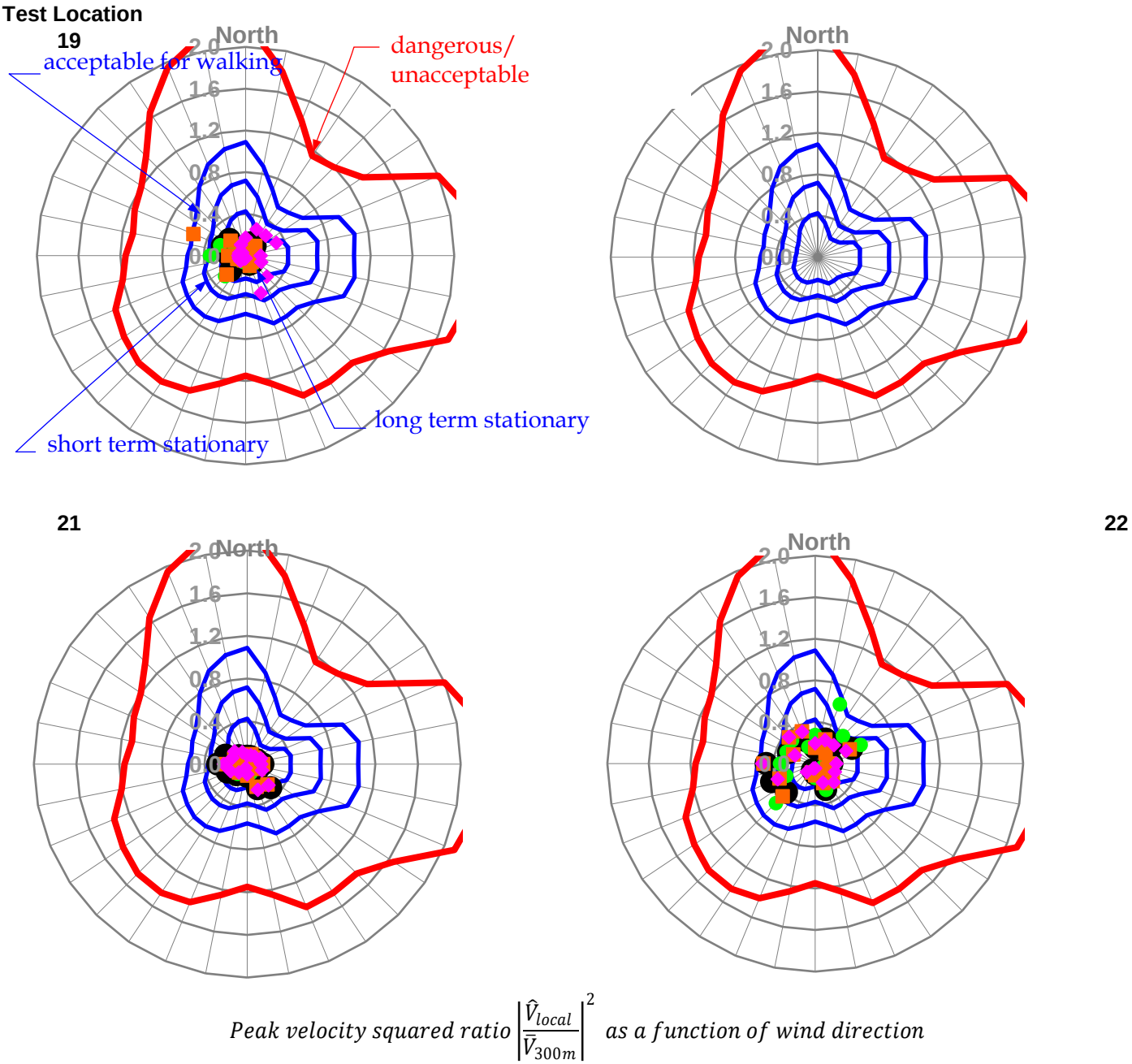
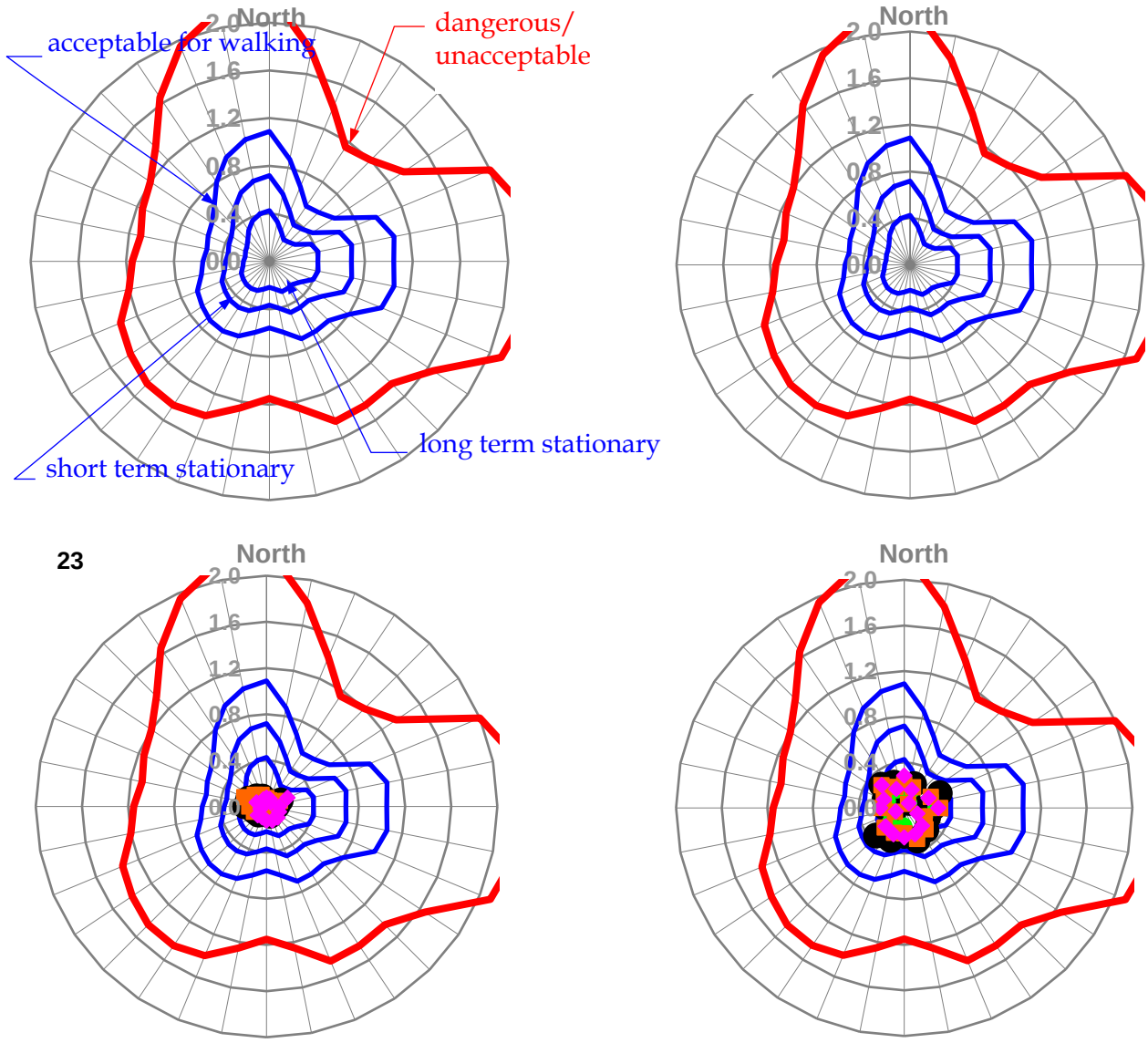


Figure A6 - Hunter Street - continued

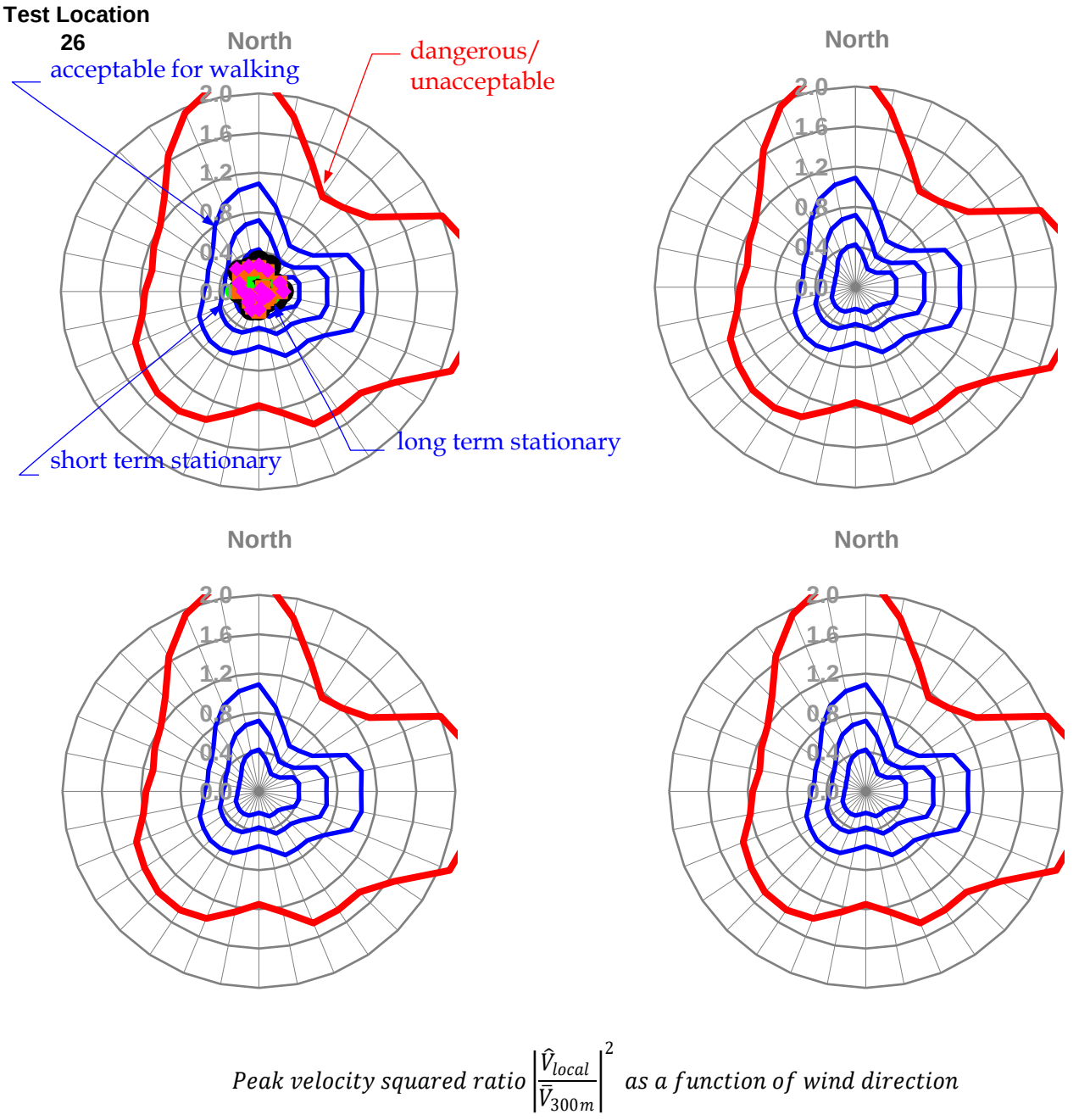
Test Location



Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Base Configuration	●
Existing Configuration	●
Proposed Configuration	◆

Figure A7 - Hunter Street - continued

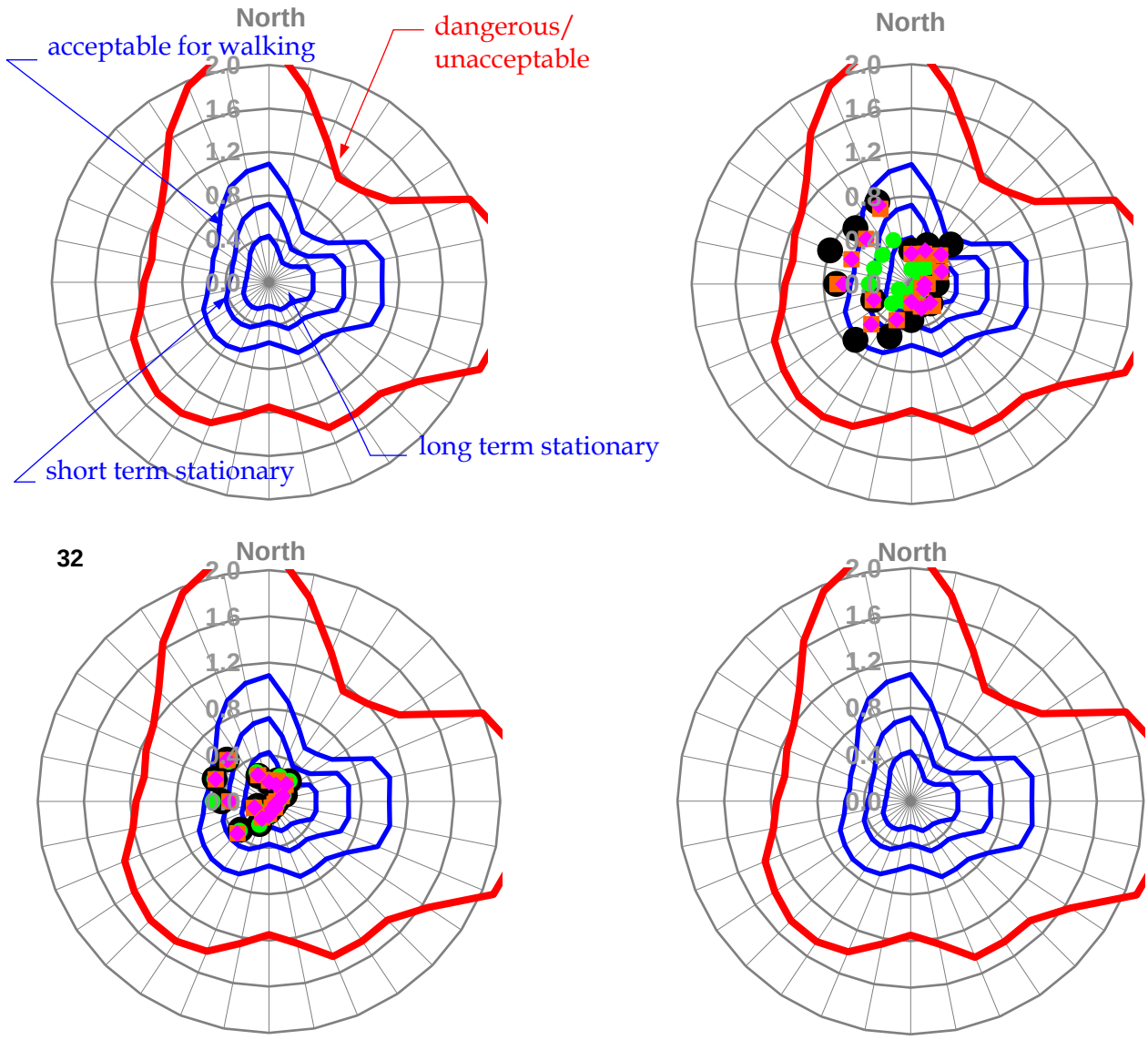


Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Base Configuration	●
Existing Configuration	●
Proposed Configuration	◆

Figure A8 - Hunter Street - continued

Test Location



Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Base Configuration	●
Existing Configuration	●
Proposed Configuration	◆

Figure A9 - George Street

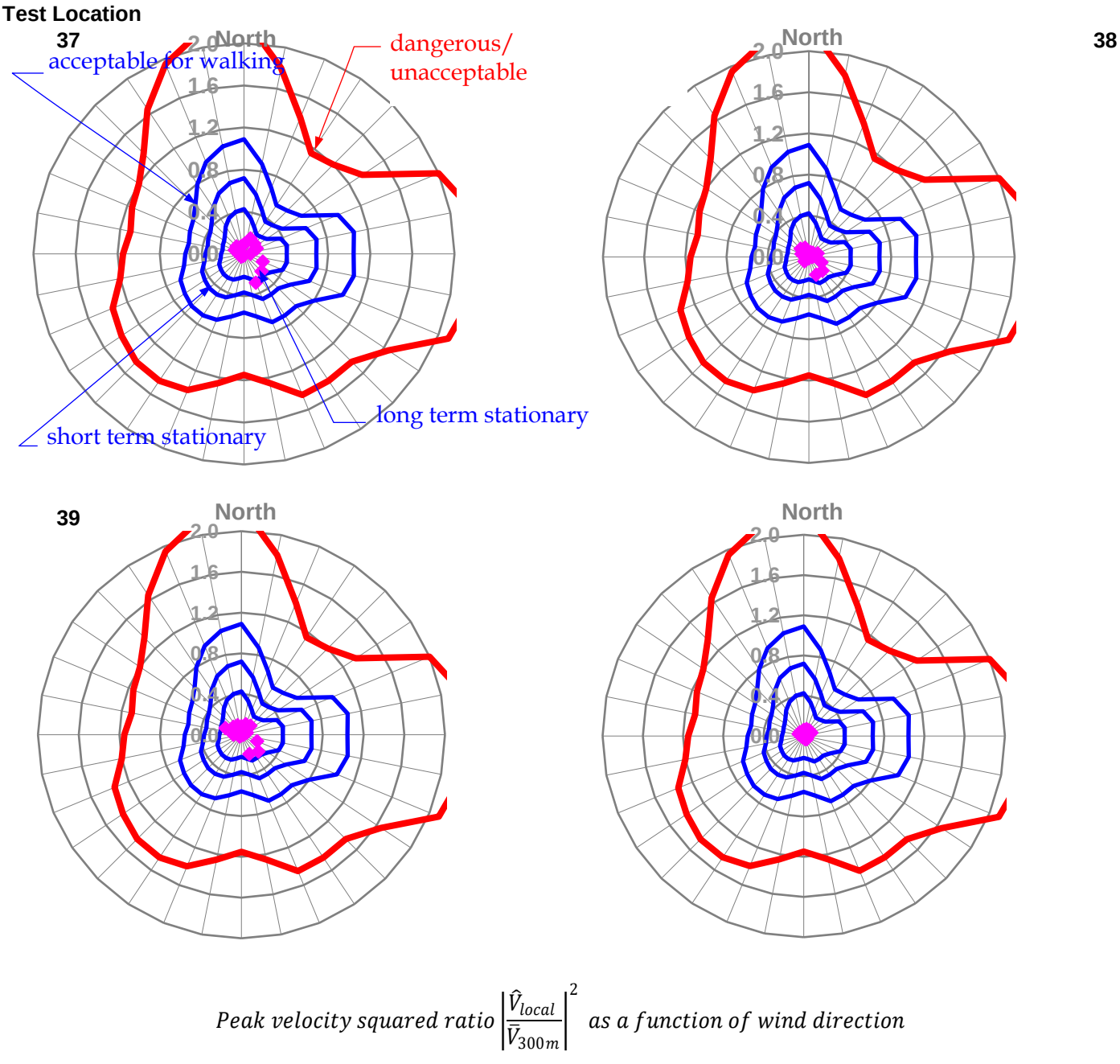


Figure A10 - Hunter and Empire Lanes

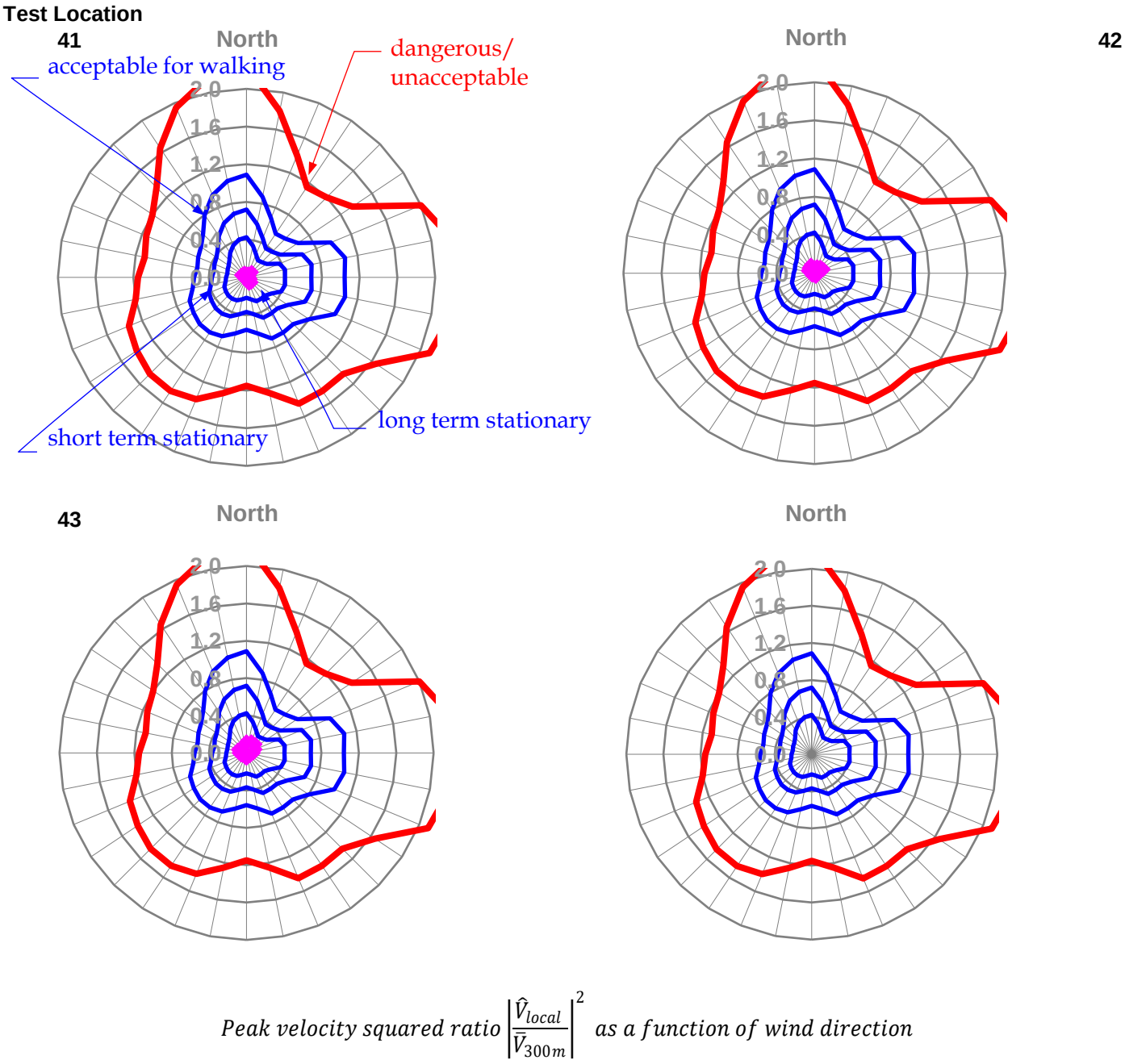


Figure A11 - Hunter and Empire Lanes - continued

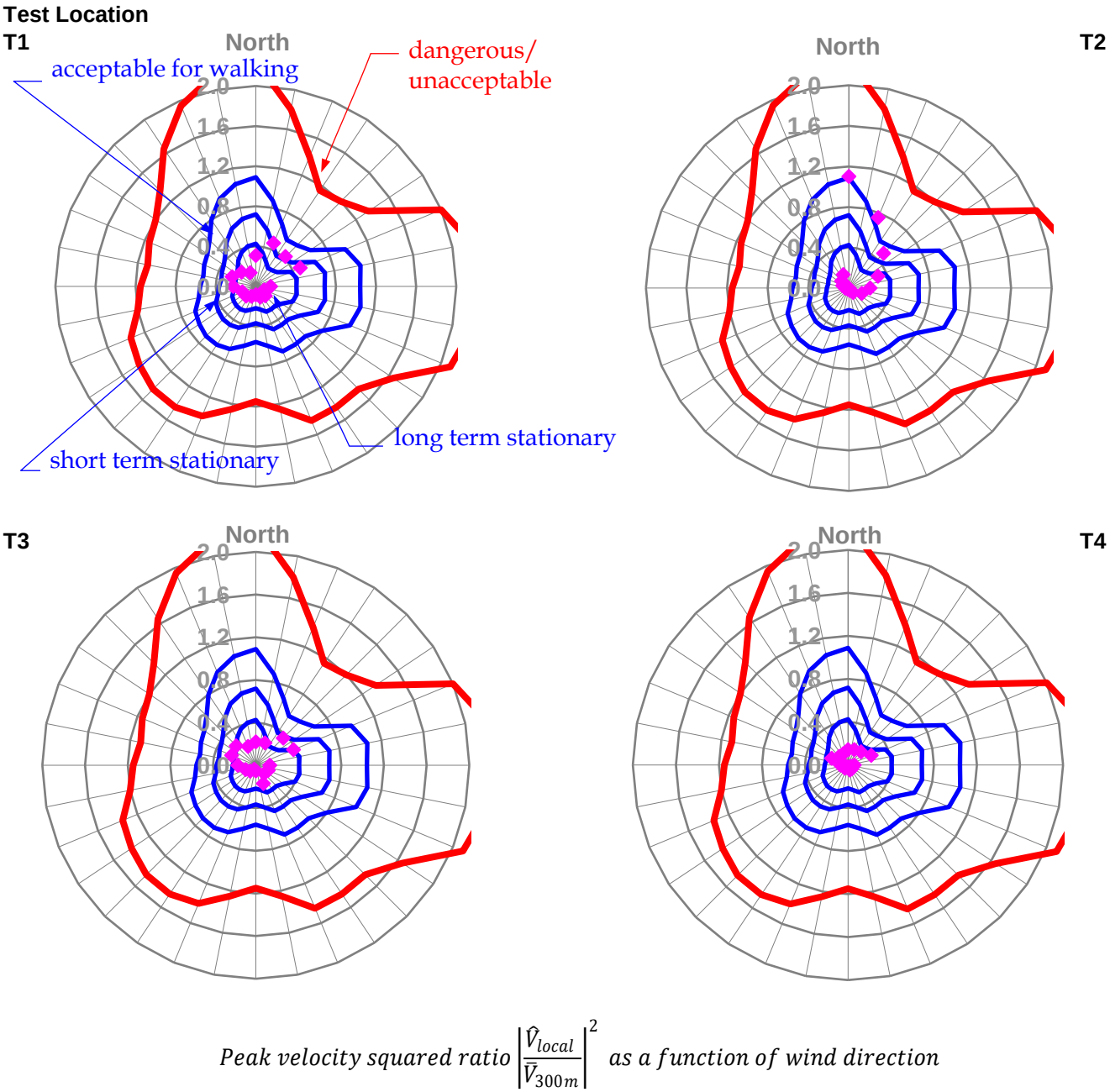
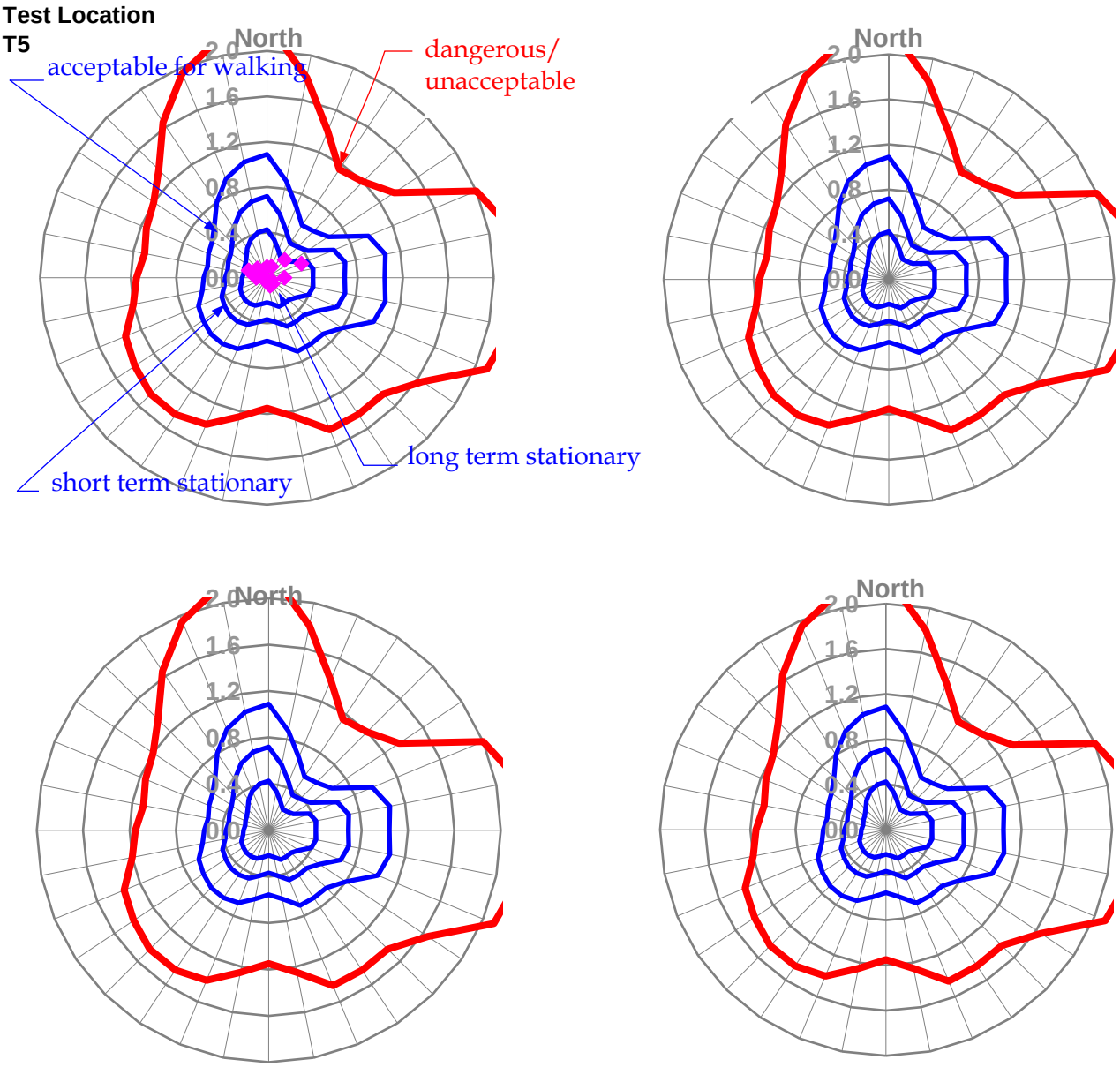


Figure A12 - Podium Terrace



Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration

Figure A13 - Podium Terrace - continued

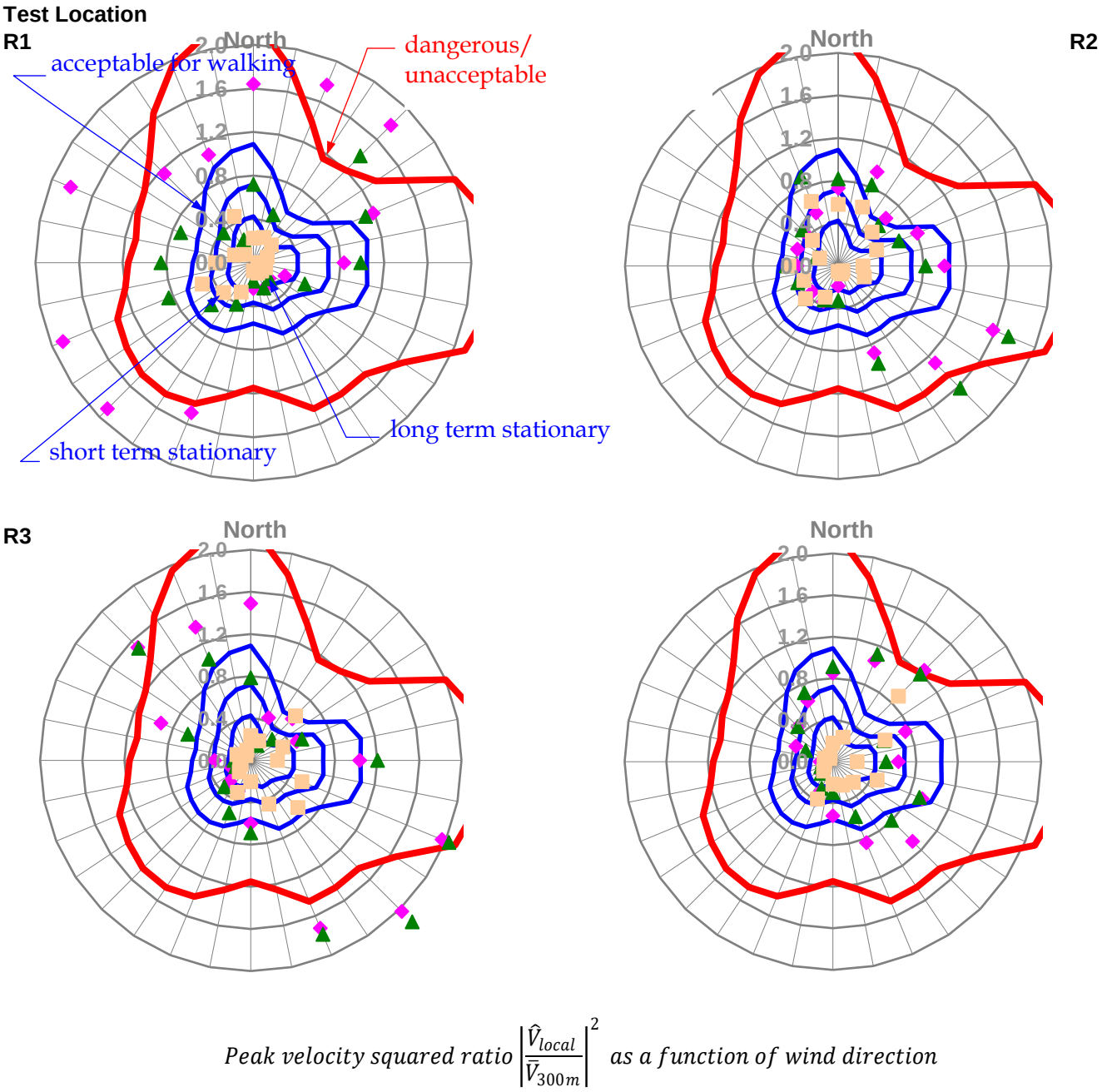
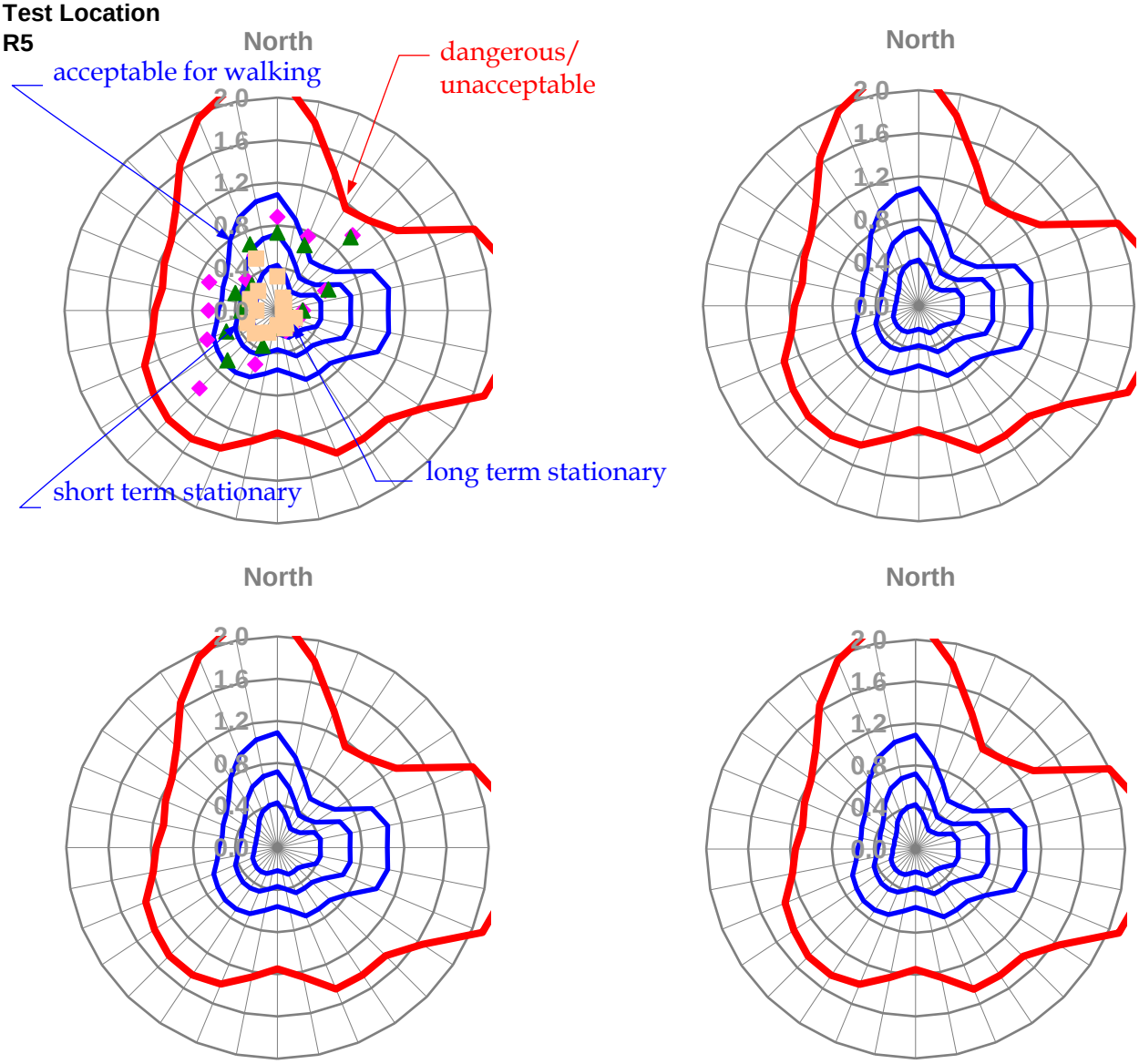


Figure A14 - Rooftop Terrace

Test Location
R5



Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration
Proposed Configuration + 1.8m balustrade
Proposed Configuration + 1.8m balustrade + 1.8m solid screens

Figure A15 - Rooftop Terrace

Description of measurement location	Location	Wind Comfort						Wind Safety					
		Annual						Annual					
		Speed (m/s)			Category			Speed (m/s)			Category		
		Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed
	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert the wind comfort category that corresponds to the applicable wind comfort speed.			Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert wind safety category that corresponds to the applicable wind safety speed.		
Pitt Street	**3**	3.65	3.94	3.98	Sitting	Sitting	Sitting	10.50	10.80	10.06	Pass	Pass	Pass
Pitt Street	**4**	2.69	2.81	3.07	Sitting	Sitting	Sitting	6.77	8.01	8.75	Pass	Pass	Pass
Pitt Street	**5**	2.47	3.38	3.94	Sitting	Sitting	Sitting	7.45	9.65	11.58	Pass	Pass	Pass
Pitt Street	**6**	3.12	3.16	3.27	Sitting	Sitting	Sitting	9.30	9.56	8.85	Pass	Pass	Pass
Pitt Street	**7a**	3.21	3.17	3.65	Sitting	Sitting	Sitting	11.62	10.88	13.17	Pass	Pass	Pass
Pitt Street	**8**	3.49	3.26	3.70	Sitting	Sitting	Sitting	12.02	10.56	14.05	Pass	Pass	Pass
Pitt Street	**9**	3.45	3.30	3.51	Sitting	Sitting	Sitting	9.20	8.20	9.47	Pass	Pass	Pass
Pitt Street	**10**	3.45	4.09	4.06	Sitting	Standing	Standing	8.30	12.20	12.59	Pass	Pass	Pass
Pitt Street	**11**	2.74	2.62	3.02	Sitting	Sitting	Sitting	7.87	7.33	8.61	Pass	Pass	Pass
Average:		3.14	3.30	3.58	Sitting	Sitting	Sitting	9.23	9.69	10.79	Pass	Pass	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

Description of measurement location	Location	Wind Comfort						Wind Safety					
		Annual						Annual					
		Speed (m/s)			Category			Speed (m/s)			Category		
		Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed
	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert the wind comfort category that corresponds to the applicable wind comfort speed.			Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert wind safety category that corresponds to the applicable wind safety speed.		
Hunter Street	**15**	4.39	4.37	4.48	Standing	Standing	Standing	15.08	15.02	14.96	Pass	Pass	Pass
Hunter Street	**16**	4.84	4.64	4.76	Standing	Standing	Standing	18.88	16.71	16.47	Pass	Pass	Pass
Hunter Street	**18**	3.44	3.61	3.61	Sitting	Sitting	Sitting	10.38	10.83	10.18	Pass	Pass	Pass
Hunter Street	**19**	3.19	3.01	3.30	Sitting	Sitting	Sitting	11.64	9.63	10.45	Pass	Pass	Pass
Hunter Street	**21**	2.71	3.41	3.38	Sitting	Sitting	Sitting	7.70	10.51	9.37	Pass	Pass	Pass
Hunter Street	**22**	4.81	4.46	4.33	Standing	Standing	Standing	14.25	13.70	14.26	Pass	Pass	Pass
Hunter Street	**23**	2.44	2.61	2.74	Sitting	Sitting	Sitting	7.74	8.58	6.87	Pass	Pass	Pass
Hunter Street	**24**	3.91	4.30	4.05	Sitting	Standing	Standing	8.97	9.81	10.05	Pass	Pass	Pass
Hunter Street	**26**	3.53	3.77	3.70	Sitting	Sitting	Sitting	10.29	9.42	9.89	Pass	Pass	Pass
Average:		3.70	3.80	3.82	Sitting	Sitting	Sitting	11.66	11.58	11.39	Pass	Pass	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

Description of measurement location	Location	Wind Comfort						Wind Safety					
		Annual						Annual					
		Speed (m/s)			Category			Speed (m/s)			Category		
		Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed
	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert the wind comfort category that corresponds to the applicable wind comfort speed.			Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert wind safety category that corresponds to the applicable wind safety speed.		
George Street	**31**	3.92	6.05	5.45	Sitting	Walking	Standing	12.43	17.57	15.72	Pass	Pass	Pass
George Street	**32**	4.20	4.02	4.03	Standing	Standing	Standing	14.01	13.98	13.89	Pass	Pass	Pass
Average:		4.06	5.04	4.74	Standing	Standing	Standing	13.22	15.78	14.81	Pass	Pass	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

Description of measurement location	Location	Wind Comfort						Wind Safety					
		Annual						Annual					
		Speed (m/s)			Category			Speed (m/s)			Category		
		Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed
	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert the wind comfort category that corresponds to the applicable wind comfort speed.			Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert wind safety category that corresponds to the applicable wind safety speed.		
Laneway	**37**	N/A	N/A	2.76	N/A	N/A	Sitting	N/A	N/A	9.13	N/A	N/A	Pass
Laneway	**38**	N/A	N/A	2.30	N/A	N/A	Sitting	N/A	N/A	7.26	N/A	N/A	Pass
Laneway	**39**	N/A	N/A	2.55	N/A	N/A	Sitting	N/A	N/A	8.10	N/A	N/A	Pass
Laneway	**40**	N/A	N/A	1.68	N/A	N/A	Sitting	N/A	N/A	5.54	N/A	N/A	Pass
Laneway	**41**	N/A	N/A	1.74	N/A	N/A	Sitting	N/A	N/A	5.47	N/A	N/A	Pass
Laneway	**42**	N/A	N/A	1.95	N/A	N/A	Sitting	N/A	N/A	5.92	N/A	N/A	Pass
Laneway	**43**	N/A	N/A	2.44	N/A	N/A	Sitting	N/A	N/A	7.21	N/A	N/A	Pass
Average:		N/A	N/A	2.20	N/A	N/A	Sitting	N/A	N/A	6.95	N/A	N/A	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

	Location	Wind Comfort						Wind Safety					
		Annual						Annual					
		Speed (m/s)			Category			Speed (m/s)			Category		
		Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed	Existing	Base Case	Proposed
Description of measurement location	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert the wind comfort category that corresponds to the applicable wind comfort speed.			Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.			Insert wind safety category that corresponds to the applicable wind safety speed.		
Pitt Street		3.14	3.30	3.58	Sitting	Sitting	Sitting	9.23	9.69	10.79	Pass	Pass	Pass
Hunter Street		3.70	3.80	3.82	Sitting	Sitting	Sitting	11.66	11.58	11.39	Pass	Pass	Pass
George Street		4.06	5.04	4.74	Standing	Standing	Standing	13.22	15.78	14.81	Pass	Pass	Pass
Average :		3.63	4.05	4.04	Sitting	Sitting	Sitting	11.37	12.35	12.33	Pass	Pass	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

Description of measurement location	Location	Wind Comfort								Wind Safety							
		Annual								Annual							
		Speed (m/s)				Category				Speed (m/s)				Category			
					Proposed				Proposed				Proposed				Proposed
	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.				Insert the wind comfort category that corresponds to the applicable wind comfort speed.				Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.				Insert wind safety category that corresponds to the applicable wind safety speed.			
Podium Terraces	T1				4.09				Standing				12.78				Pass
Podium Terraces	T2				3.20				Sitting				15.73				Pass
Podium Terraces	T3				3.71				Sitting				11.87				Pass
Podium Terraces	T4				2.57				Sitting				8.22				Pass
Podium Terraces	T5				2.72				Sitting				9.31				Pass
Average:					3.26				Sitting				11.58				Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded

	Location	Wind Comfort								Wind Safety							
		Annual								Annual							
		Speed (m/s)				Category				Speed (m/s)				Category			
			Proposed	Proposed + 1.8m balustrade	Proposed + screens + 1.8m balustrade		Proposed	Proposed + 1.8m balustrade	Proposed + screens + 1.8m balustrade		Proposed	Proposed + 1.8m balustrade	Proposed + screens + 1.8m balustrade		Proposed	Proposed + 1.8m balustrade	Proposed + screens + 1.8m balustrade
Description of measurement location	#	Insert mean wind speed in m/s exceeded 5% of the time between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.				Insert the wind comfort category that corresponds to the applicable wind comfort speed.				Insert pedestrian safety wind speed in m/s. This is the annual maximum 0.5 second gust wind speed between 6am and 10pm. Insert a result for each location tested for existing conditions, proposed planning envelope and base case compliant envelope.				Insert wind safety category that corresponds to the applicable wind safety speed.			
Rooftop Terraces	R1		9.67	6.84	4.13		Uncomfortable	Walking	Standing		28.49	23.25	12.57		Exceeded	Pass	Pass
Rooftop Terraces	R2		7.09	7.29	5.03		Walking	Walking	Standing		18.98	21.31	14.01		Pass	Pass	Pass
Rooftop Terraces	R3		8.21	7.70	4.51		Uncomfortable	Walking	Standing		23.82	24.64	15.28		Pass	Exceeded	Pass
Rooftop Terraces	R4		6.81	6.37	4.30		Walking	Walking	Standing		22.00	21.52	18.63		Pass	Pass	Pass
Rooftop Terraces	R5		6.54	5.84	4.04		Walking	Standing	Standing		19.72	19.47	10.50		Pass	Pass	Pass
Average:			7.67	6.81	4.40		Walking	Walking	Standing		22.60	22.04	14.20		Pass	Pass	Pass

Wind comfort categories (m/s)

≤ 4	Sitting
4.1 - 6	Standing
6.1 - 8	Walking
> 8	Uncomfortable

Wind safety categories (m/s)

≤ 22	Pass
> 22; ≤ 24	Pass
> 25	Exceeded