ENVIRONMENTAL WIND SPEED MEASUREMENTS ON A WIND TUNNEL MODEL OF 607-623 COLLINS STREET DEVELOPMENT, MELBOURNE

By

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and

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SUMMARY

Wind tunnel tests have been conducted on a 1/400 scale model of the proposed 607-623 Collins Street development. The model of the development within surrounding buildings and with no existing or future street trees, 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 freestream mean wind speed at a reference height of 300m and compared with criteria developed for the Melbourne region as a function of wind direction.

The ground level wind conditions for the Proposed Configuration in the streetscapes and immediate surrounds of the development have been shown to satisfy the walking criterion, with many Test Locations satisfy the standing and sitting criteria.

The wind conditions for the Proposed Configuration on the Level 7 Rooftop Bar have been shown to satisfy the standing criterion. The wind conditions for the Proposed Configuration on the Upper Level Terraces have been shown to achieve the sitting to walking criteria.

The wind conditions for the Proposed Configuration on the ground and upper levels pass the safety criterion at all Test Locations. The Existing Configuration wind conditions have been presented for comparison.

MEL CONSULTANTS

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607-623 COLLINS STREET, MELBOURNE
ENVIRONMENTAL WIND TUNNEL MODELLING

MEL CONSULTANTS REPORT NO: 183-21-WT-ENV-02

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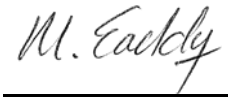

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1 INTRODUCTION

The proposed 607-623 Collins Street Development would be a mixed-used (Commercial, Hotel and Residential) tower, approximately 145m in height. The development site is located at the southeast corner of the intersection of Collins Street and Spencer Street.

A wind tunnel model study was commissioned by Six Two Three Developments Pty Ltd to undertake measurements of environmental wind conditions around the proposed 607-623 Collins Street development and, if necessary, to develop wind amelioration features to achieve conditions satisfying the recommended environmental wind criteria.

These tests were carried out in the MEL Consultants 400kW Boundary Layer Wind Tunnel during March, 2023.

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 Design Development Overlay (DDO10) applicable to the development site defines wind safety and comfort criteria. The definition of the criteria is as follows:

Unsafe wind conditions means the hourly maximum 3 second gust which exceeds 20 metres/second from any wind direction considering at least 16 wind directions with the corresponding probability of exceedance percentage.

Comfortable wind conditions means a mean wind speed from all wind directions combined with probability of exceedance less than 20% of the time, equal to or less than:

- 3 metres/second for sitting areas
- 4 metres/second for standing areas
- 5 metres/second for walking areas

Mean wind speed means the maximum of:

- Hourly mean wind speed, or
- Gust equivalent mean wind speed (3 second gust wind speed divided by 1.85)

The above comfort criteria are pass/fail criteria which assess the integrated probability of all wind directions to determine whether a location passes or fails the threshold criterion. The safety criterion is a pass/fail criterion based upon exceedance of the wind speed for any one wind direction. For completeness, this report will provide data for each Test Location as a function of wind direction in Appendix A.

The DDO10 does not provide any methodology or worked example as how to obtain the ‘from all wind directions combined’. Therefore, to obtain the probability for all wind directions combined we will apply the methodology described in Melbourne (1978) to determine the probability for all wind directions. The guidelines use 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 Melbourne City. The probability data used have been corrected for the approach terrain at the location of the automatic weather station and referenced to 10m in Terrain Category 2. This is the standard reference height of AS/NZS1170.2:2021.

3 MODEL AND EXPERIMENTAL TECHNIQUES

A 1/400 scale model of the 607-623 Collins Street development was constructed from 3D architectural drawings provided by Carr Architects dated 23rd February 2023.

The 1/400 scale model of the 607-623 Collins Street 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 basic natural wind model was for flow over suburban terrain, the characteristics of which are given in Figure 1. The surrounding wind tunnel model of all significant buildings, out to a minimum radius of 400m, 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

$$\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$$

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 model as tested in the wind tunnel are shown in Figures 2 and 3. The Test Locations within the development and surrounding streetscapes are shown in the diagrams presented in Figures 4a to 4d.

The wind tunnel study has been undertaken to exceed the requirements of the Australasian Wind Engineering Society Quality Assurance Manual for Wind Tunnel Studies.

4 DISCUSSION OF RESULTS

The wind tunnel model study of the environmental wind conditions around 607-623 Collins Street development has been undertaken for 2 configurations as follows:

- Existing Configuration
- Proposed Configuration

The Existing Configuration consists of the existing heritage building located on the proposed site.

The Proposed Configuration would be an approximately 145m high tower as defined by the drawings provided by Carr Architects dated 23rd February 2023.

Velocity measurements were made at various locations around the 607-623 Collins Street development for different wind directions at 22.5° intervals. As discussed in Section 2, the DDO10 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 – 6. 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.

4.1 Summary of Results

A summary of the highest wind criteria satisfied at each Test Location in the surrounding streetscapes have been summarised using a colour code system in the following figures:

- Existing Configuration	Figure 5a
- Proposed Configuration	Figures 5b to 5e

Different colours have been used to represent the wind criteria achieved at the respective Test Locations.

4.2 Spencer Street

The wind conditions for the Proposed Configuration along Spencer Street (Test Locations 1 to 16) have been shown to satisfy the walking criterion, with many Test Locations satisfying the standing criterion. These criteria achieved have been presented in Table 1 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 1: Pedestrian Wind Comfort and Safety – Spencer Street

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
1	Existing	8%	2%	1%	Pass
	Proposed	11%	3%	1%	Pass
2	Existing	33%	17%	8%	Pass
	Proposed	34%	19%	9%	Pass
3	Existing	44%	29%	17%	Pass
	Proposed	47%	32%	19%	Pass
4	Existing	27%	15%	8%	Pass
	Proposed	32%	19%	11%	Pass
5	Existing	13%	5%	2%	Pass
	Proposed	17%	7%	3%	Pass
6	Existing	33%	19%	11%	Pass
	Proposed	42%	27%	15%	Pass
7	Existing	27%	14%	7%	Pass
	Proposed	28%	14%	7%	Pass
8	Existing	15%	5%	2%	Pass
	Proposed	17%	6%	2%	Pass

Table 2-continued: Pedestrian Wind Comfort and Safety – Spencer Street

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
9	Existing	26%	13%	7%	Pass
	Proposed	34%	20%	10%	Pass
10	Existing	39%	24%	13%	Pass
	Proposed	36%	21%	12%	Pass
11	Existing	22%	12%	6%	Pass
	Proposed	26%	13%	6%	Pass
12	Existing	22%	12%	6%	Pass
	Proposed	35%	20%	10%	Pass
13	Existing	26%	12%	6%	Pass
	Proposed	31%	16%	8%	Pass
14	Existing	17%	7%	3%	Pass
	Proposed	20%	8%	3%	Pass
15	Existing	19%	8%	3%	Pass
	Proposed	29%	15%	8%	Pass
16	Existing	25%	12%	5%	Pass
	Proposed	32%	17%	8%	Pass

Note: green – pass criteria, orange – failed criteria

4.3 Collins Street

The wind conditions for the Proposed Configuration along Collins Street (Test Locations 17 to 24) have been shown to satisfy the walking criterion, with many Test Locations satisfying the standing criterion. These criteria achieved have been presented in Table 2 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 2: Pedestrian Wind Comfort and Safety – Collins Street

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
17	Existing	36%	20%	10%	Pass
	Proposed	39%	23%	14%	Pass
18	Existing	15%	5%	2%	Pass
	Proposed	13%	6%	2%	Pass
19	Existing	27%	13%	5%	Pass
	Proposed	22%	8%	3%	Pass
20	Existing	31%	17%	9%	Pass
	Proposed	33%	18%	9%	Pass
21	Existing	32%	17%	9%	Pass
	Proposed	23%	13%	7%	Pass
22	Existing	33%	17%	8%	Pass
	Proposed	24%	14%	8%	Pass
23	Existing	26%	12%	5%	Pass
	Proposed	26%	13%	6%	Pass
24	Existing	11%	3%	<1%	Pass
	Proposed	16%	5%	1%	Pass

Note: green – pass criteria, orange – failed criteria

4.4 Flinders Lane and Laneway

The wind conditions for the Proposed Configuration along Flinders Lane and Laneway (Test Locations 25 to 28) have been shown to satisfy the sitting criterion. The wind criteria achieved have been presented in Table 3 as well as the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 3: Pedestrian Wind Comfort and Safety – Flinders Lane and Laneway

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
25	Existing	3%	<1%	<1%	Pass
	Proposed	7%	2%	<1%	Pass
26	Existing	19%	9%	3%	Pass
	Proposed	17%	8%	4%	Pass
27	Existing	17%	6%	2%	Pass
	Proposed	17%	9%	4%	Pass
28	Existing	8%	2%	<1%	Pass
	Proposed	19%	7%	2%	Pass

Note: green – pass criteria, orange – failed criteria

4.5 Level 5 Terrace

The wind conditions for the Proposed Configuration on Level 5 Terrace (Test Locations Pa and P2) have been shown to satisfy the standing criterion. These criteria achieved have been presented in Table 4.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 4: Pedestrian Wind Comfort and Safety – Level 5 Terrace

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
P1					
	Proposed	20%	10%	4%	Pass
P2					
	Proposed	32%	18%	10%	Pass

Note: green – pass criteria, orange – failed criteria

4.6 Level 7 Terraces

The wind conditions for the Proposed Configuration on Level 7 Rooftop Bar (Test Locations T1 to T4), which included an approximately 3.2m high parapet, have been shown to satisfy the standing criterion. The wind conditions for the Proposed Configuration on Level 7 Terrace (Test Locations T5 and T6), have been shown to satisfy the standing criterion. These criteria achieved have been presented in Table 5.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 5: Pedestrian Wind Comfort and Safety – Level 7 Terraces

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
T1					
	Proposed	24%	13%	7%	Pass
T2					
	Proposed	15%	7%	3%	Pass
T3					
	Proposed	23%	10%	3%	Pass
T4					
	Proposed	22%	10%	4%	Pass
T5					
	Proposed	8%	2%	1%	Pass
T6					
	Proposed	32%	17%	9%	Pass

Note: green – pass criteria, orange – failed criteria

4.7 Level 38 Terrace

The wind conditions for the Proposed Configuration on Level 38 Terrace (Test Locations H1 to H4), have been shown to satisfy the standing criterion. These criteria achieved have been presented in Table 6.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A. It is noted that at each test location the directional specific wind conditions may be lower or higher than those of the tabulated results averaged over all wind directions.

Table 6: Pedestrian Wind Comfort and Safety – Level 38 Terrace

Test Location	Configuration	Wind Comfort Criteria			
		Sitting	Standing	Walking	Safety
H1					
	Proposed	31%	18%	10%	Pass
H2					
	Proposed	15%	5%	2%	Pass
H3					
	Proposed	27%	16%	8%	Pass
H4					
	Proposed	28%	14%	6%	Pass

Note: green – pass criteria, orange – failed criteria

5 CONCLUSIONS

Wind tunnel tests have been conducted on a 1/400 scale model of the proposed 607-623 Collins Street development. The model of the development within surrounding buildings and with no existing or future street trees, 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 freestream mean wind speed at a reference height of 300m and compared with criteria developed for the Melbourne region as a function of wind direction.

The ground level wind conditions for the Proposed Configuration in the streetscapes and immediate surrounds of the development have been shown to satisfy the walking criterion, with many Test Locations satisfy the standing and sitting criteria.

The wind conditions for the Proposed Configuration on the Level 7 Rooftop Bar have been shown to satisfy the standing criterion. The wind conditions for the Proposed Configuration on the Upper Level Terraces have been shown to achieve the sitting to walking criteria.

The wind conditions for the Proposed Configuration on the ground and upper levels pass the safety criterion at all Test Locations. The Existing Configuration wind conditions have been presented for comparison.

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April 2023

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

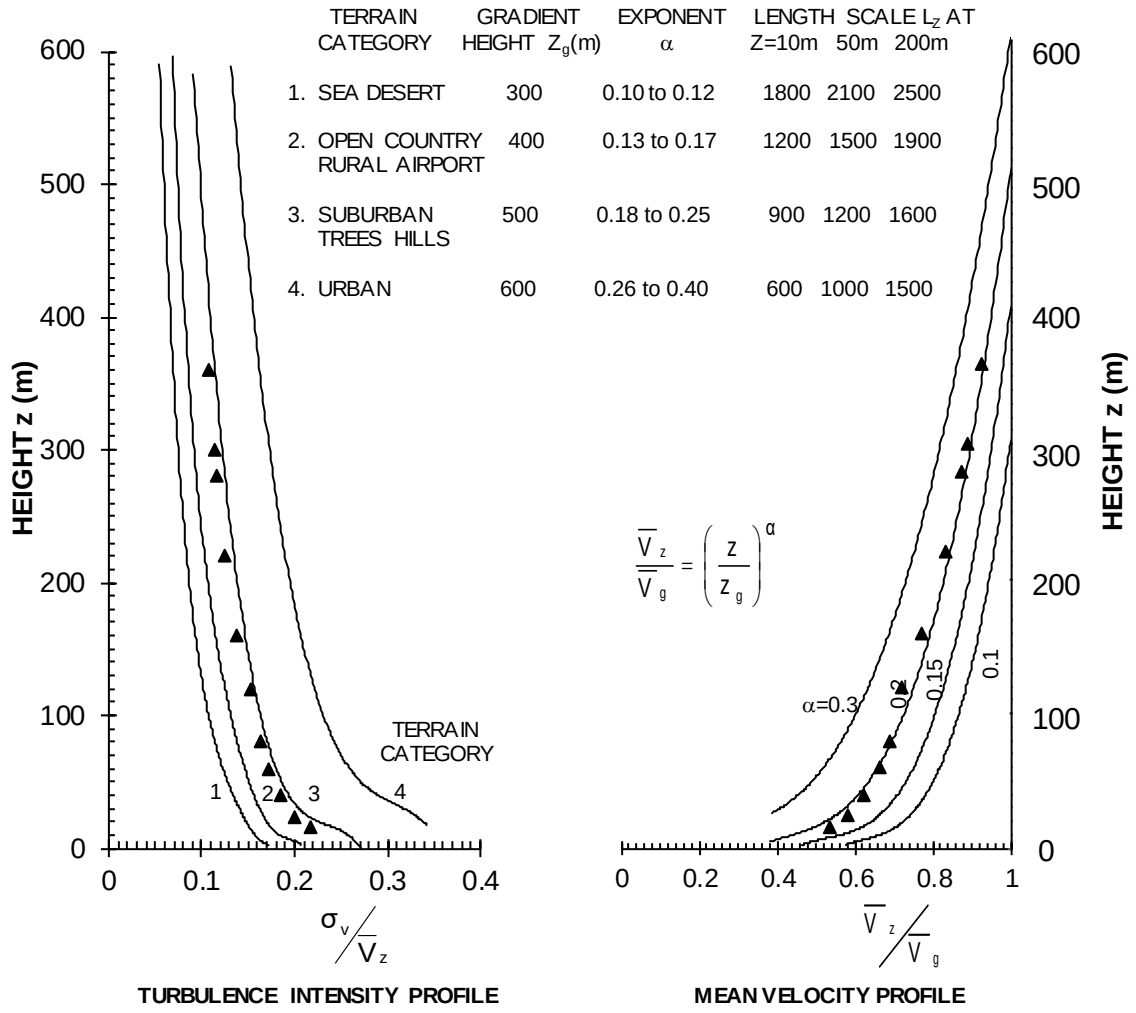


Figure 1 - 1/400 scale TC3 boundary layer turbulence intensity and mean velocity profiles in the MEL Consultants Boundary Layer Wind Tunnel 4.8m x 2.2m working section, scaled to full scale dimensions

Figure 2 – View from the southwest of the 1:400 scaled model of the Proposed Configuration of the 607-623 Collins Street Development and surrounds in the wind tunnel.

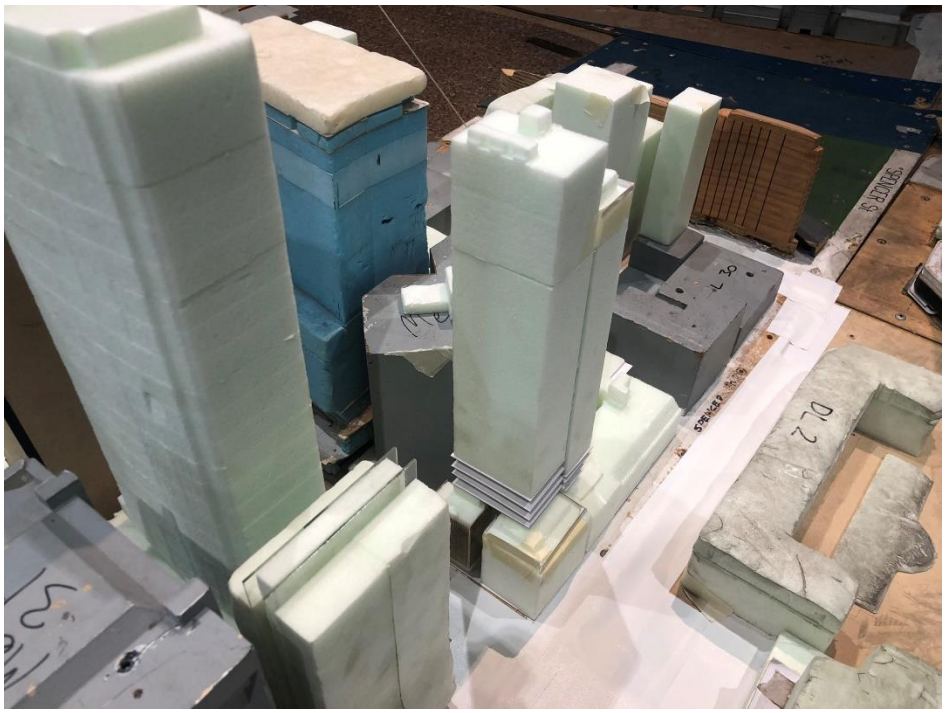


Figure 3 – View from the northwest of the 1:400 scaled model of the Proposed Configuration of the 607-623 Collins Street Development and surrounds in the wind tunnel.

Figure 4a - Ground Level Streetscapes Test Locations for the 607-623 Collins Development.

Legend

(#) Test Location

NORTH

Figure 4b – Level 5 Terrace Test Locations for the 607-623 Collins Development.

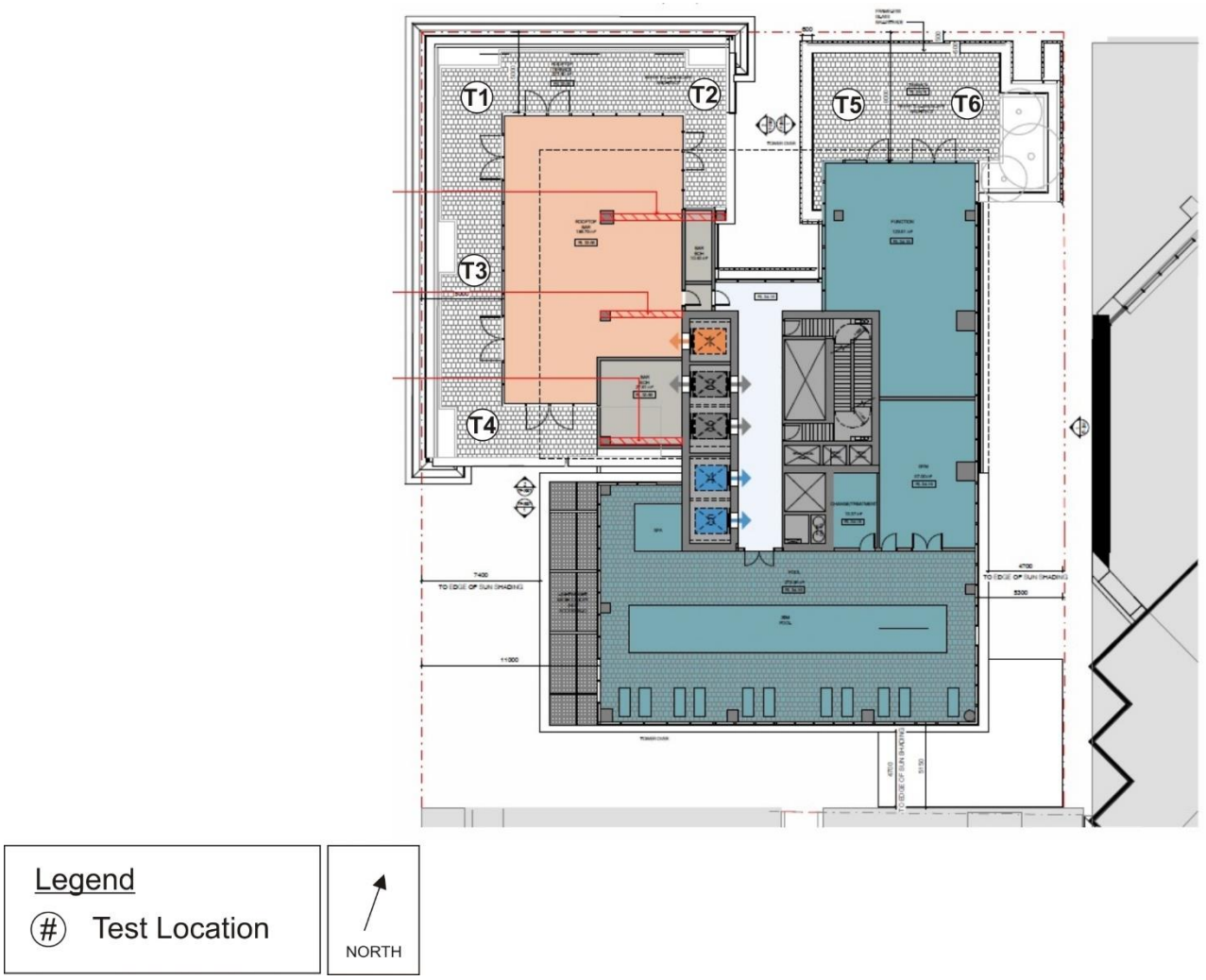


Figure 4c – Level 7 Terraces Test Locations for the 607-623 Collins Development.

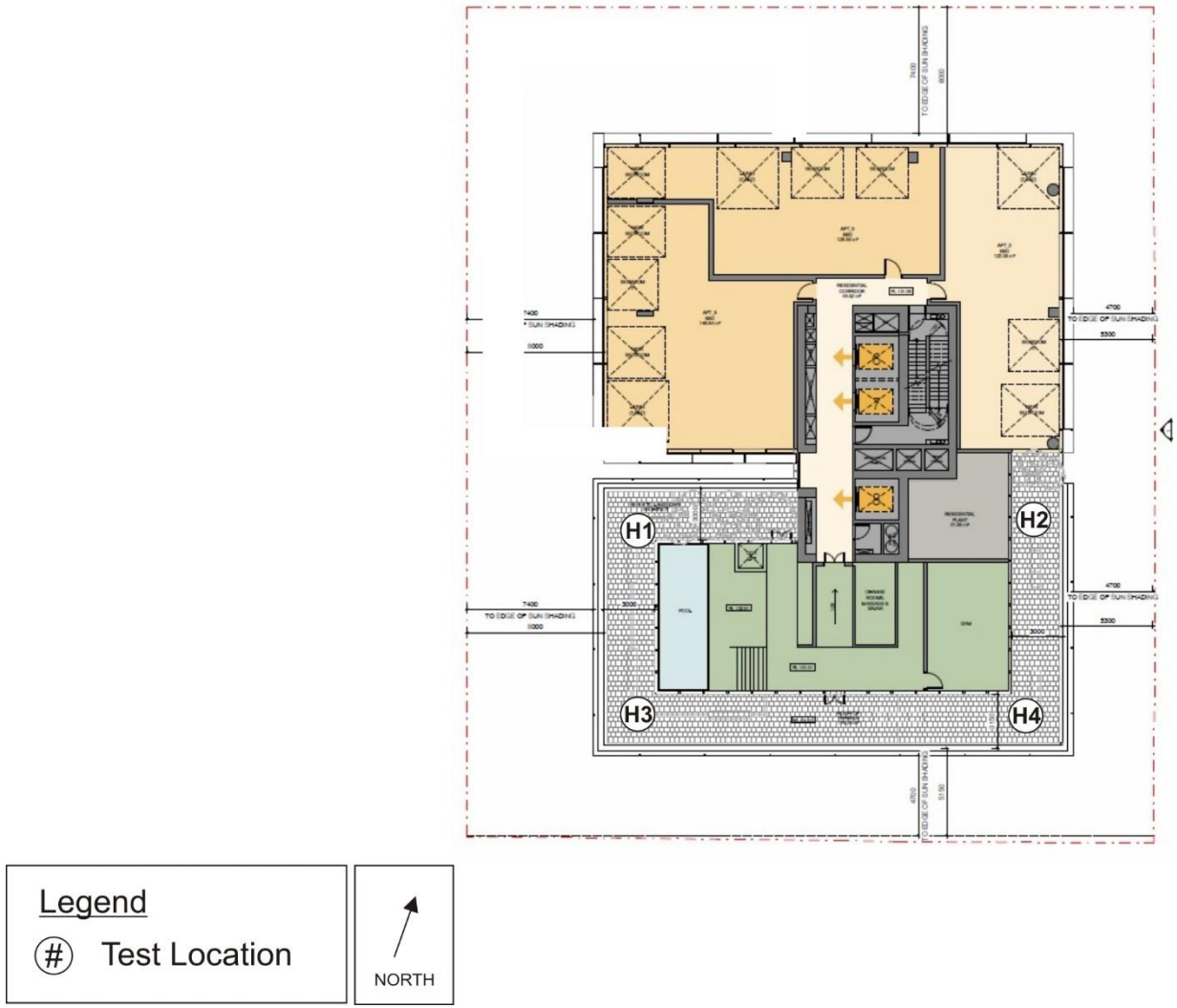


Figure 4d – Level 38 Terrace Test Locations for the 607-623 Collins Development.

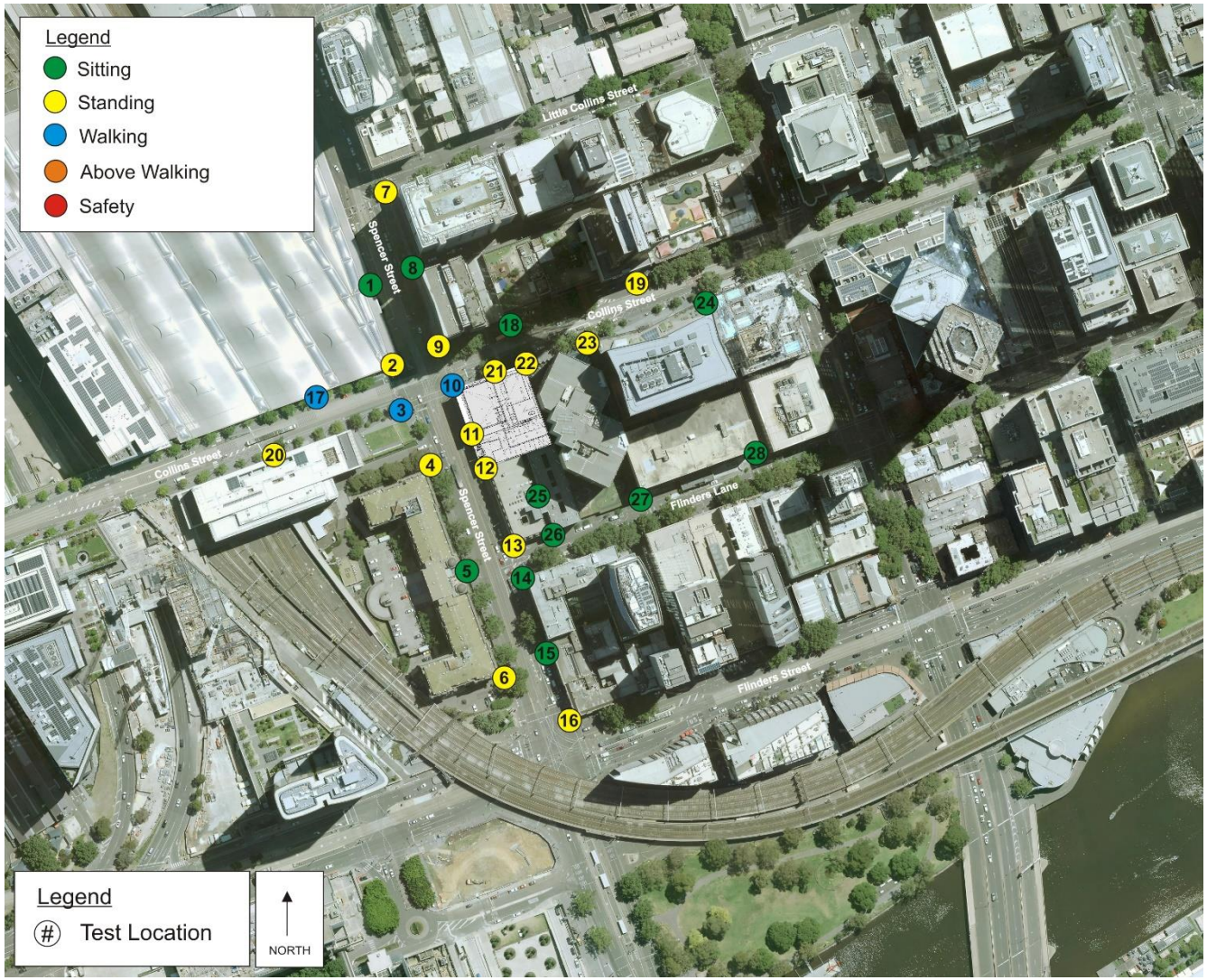


Figure 5a - Summary of wind conditions for the Existing Configuration on the streetscapes around the 607-623 Collins Development.

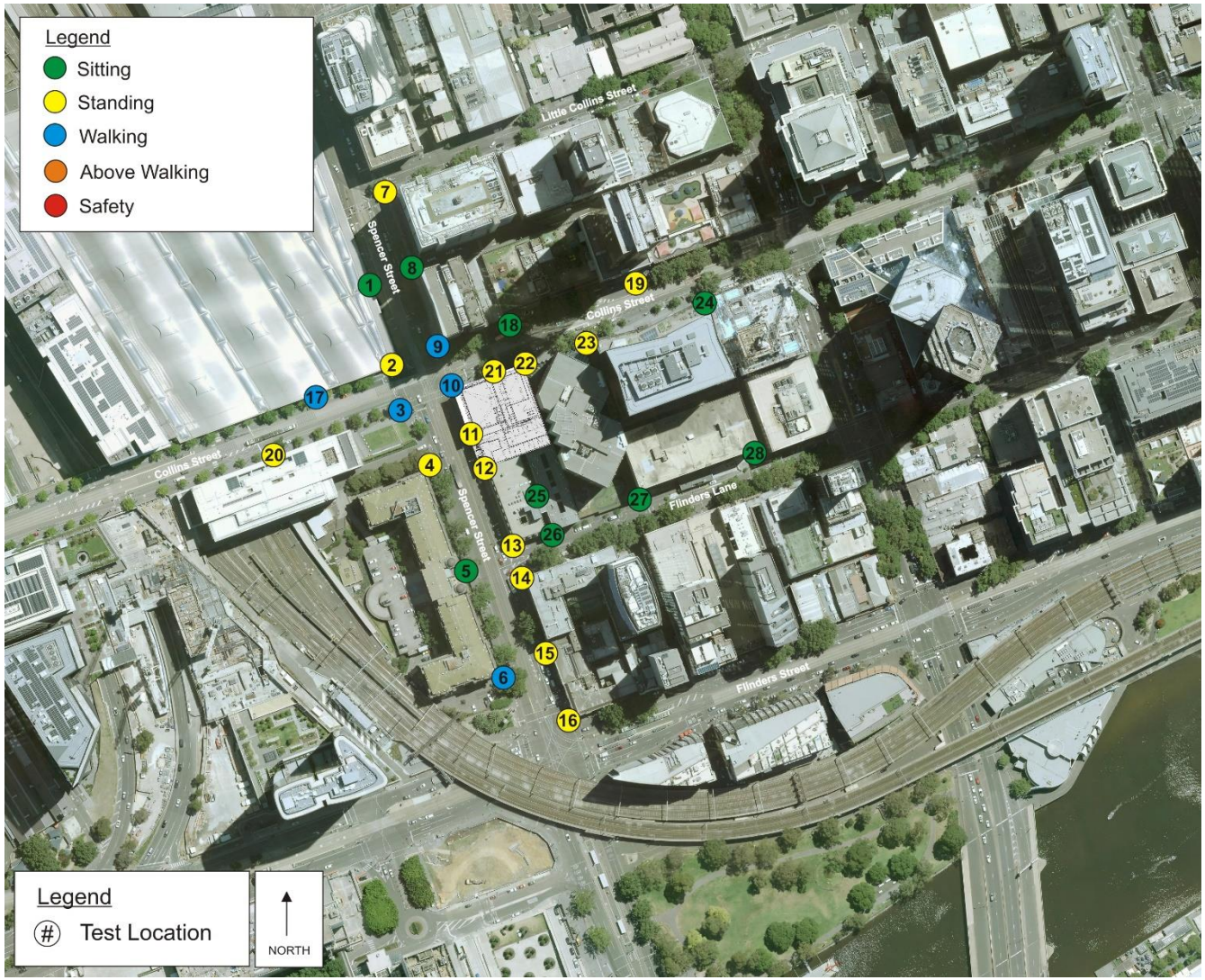


Figure 5b - Summary of wind conditions for the Proposed Configuration on the streetscapes around the 607-623 Collins Development.

Figure 5c - Summary of wind conditions for the Proposed Configuration on the Level 5 Terrace of the 607-623 Collins Development.

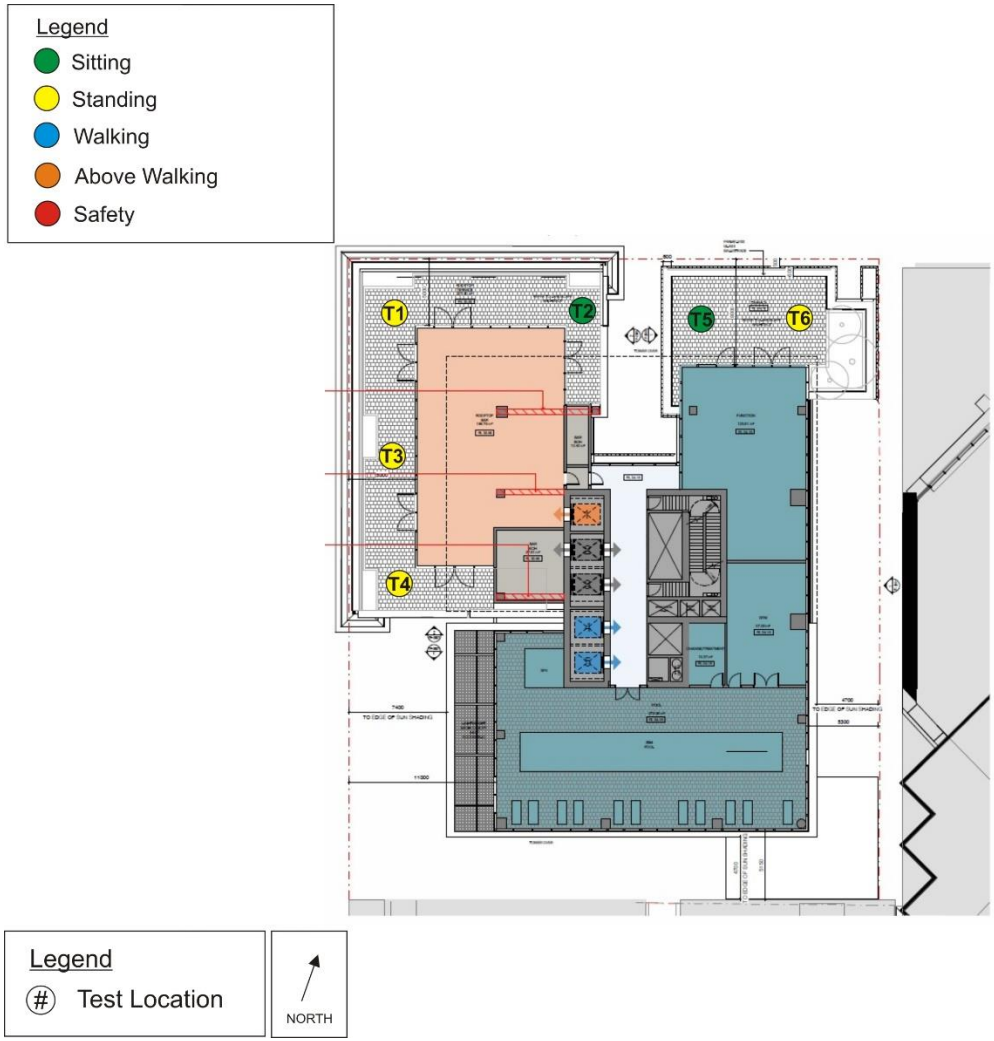


Figure 5d - Summary of wind conditions for the Proposed Configuration on the Level 7 Terraces of the 607-623 Collins Development.

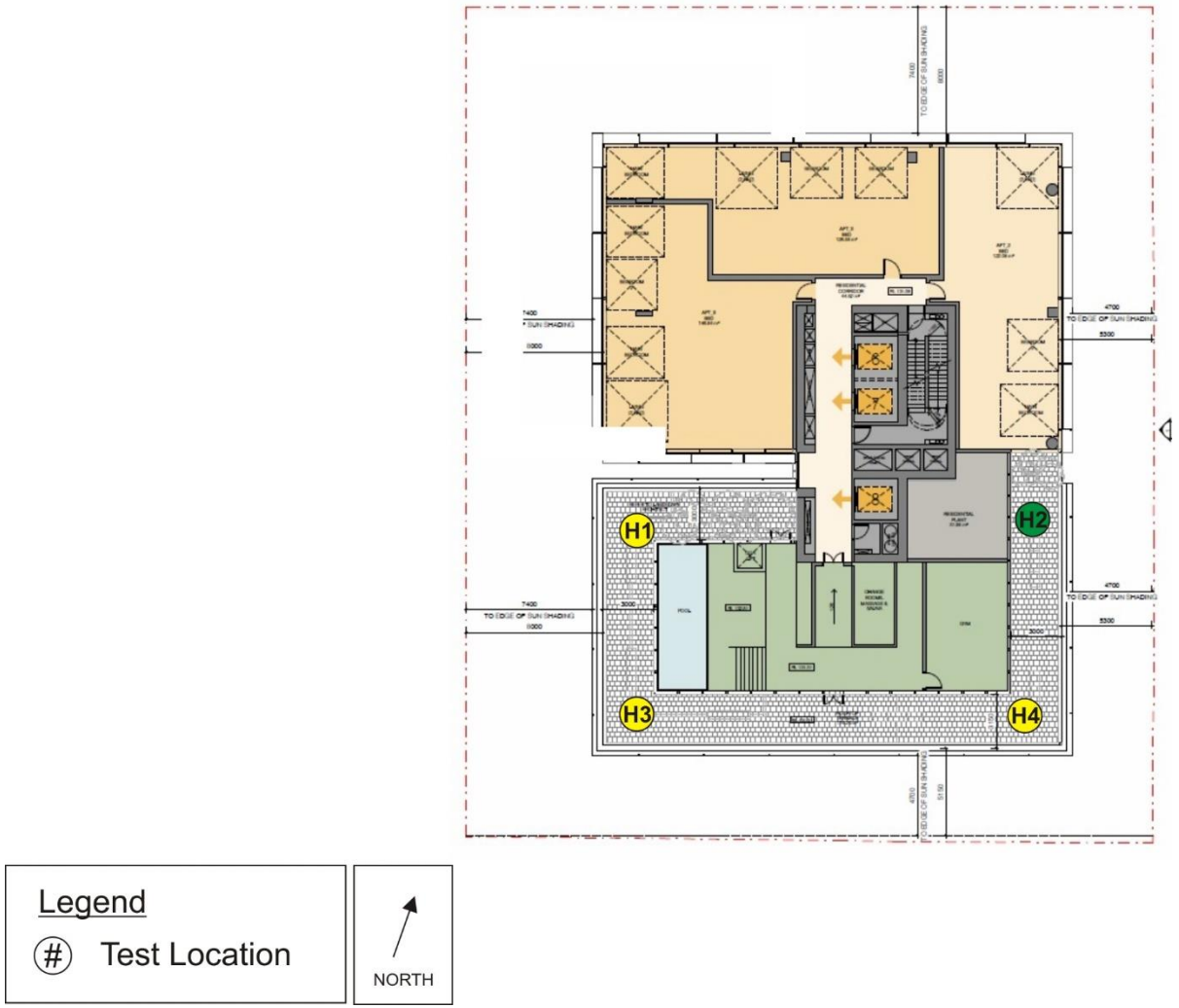


Figure 5e - Summary of wind conditions for the Proposed Configuration on the Level 38 Terrace of the 607-623 Collins Development.

APPENDIX A – TEST LOCATION 3 SECOND GUST WIND CRITERIA PLOTS AS A FUNCTION OF WIND DIRECTION

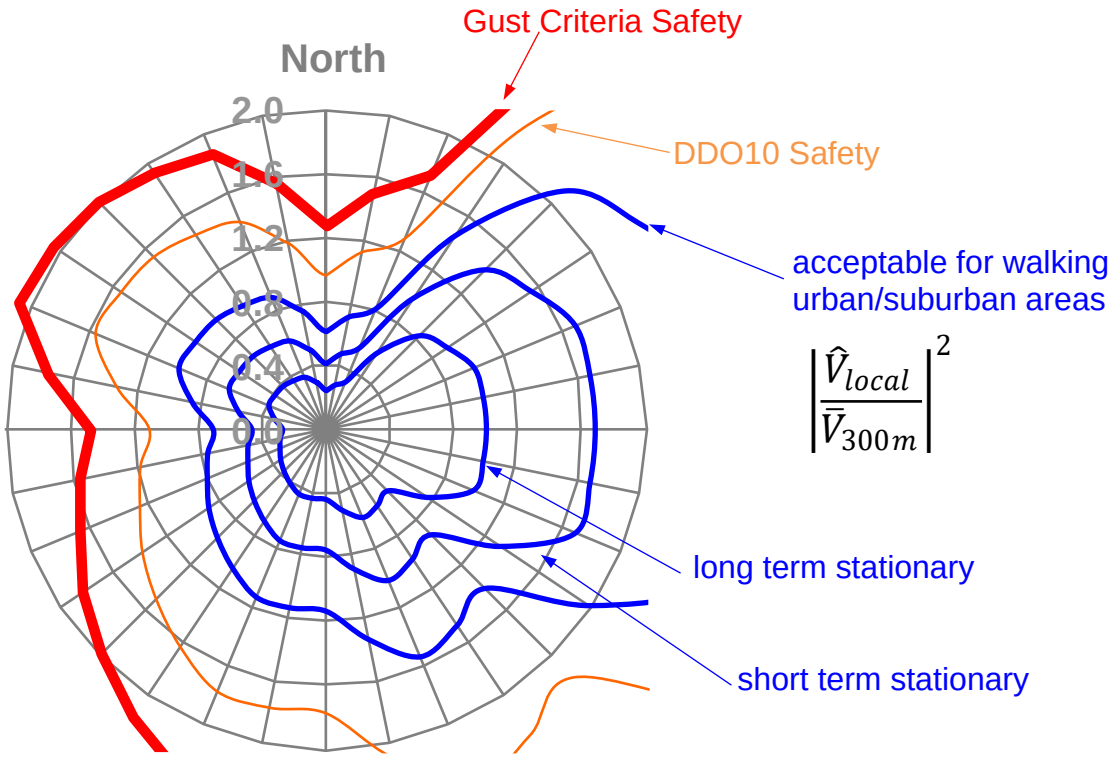
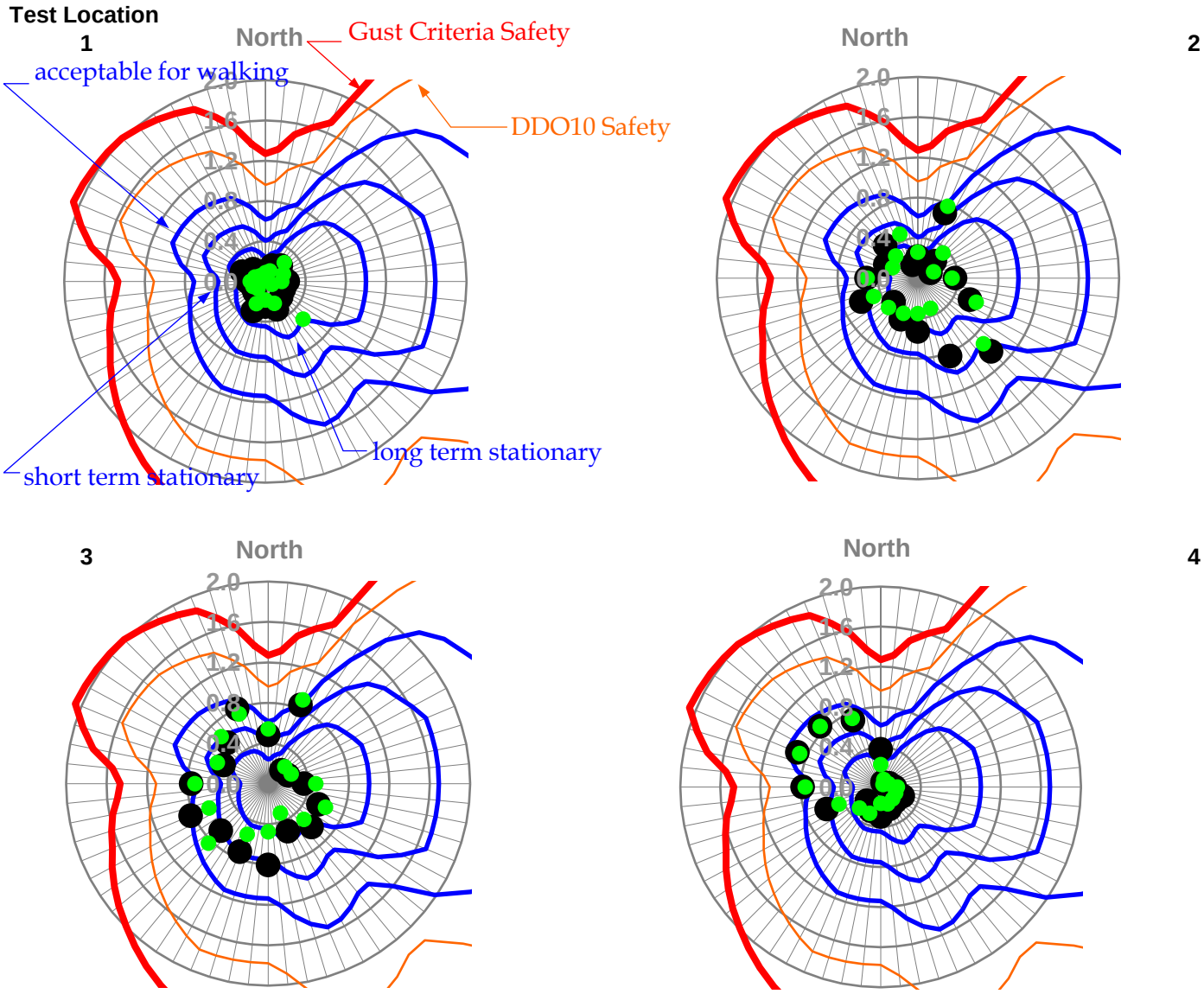


Figure A1 - Environmental wind criteria for Melbourne as a function of wind direction based on a 3 second gust (0.1% probability of exceedance)



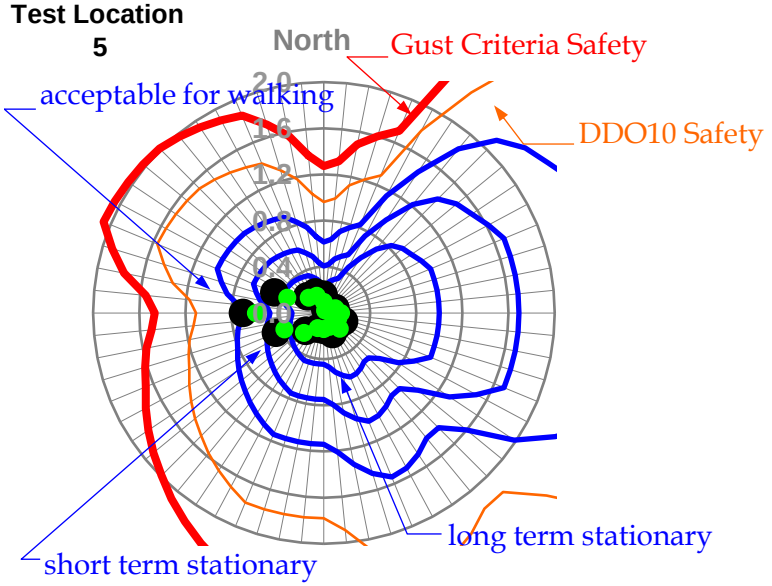
Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration ●
Existing Configuration ●

Appendix A2 - Spencer Street

Test Location

5



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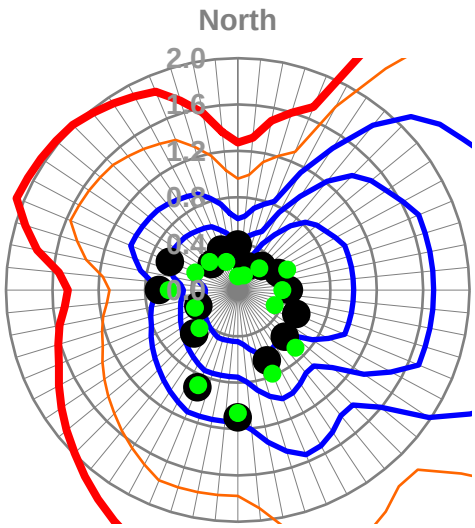

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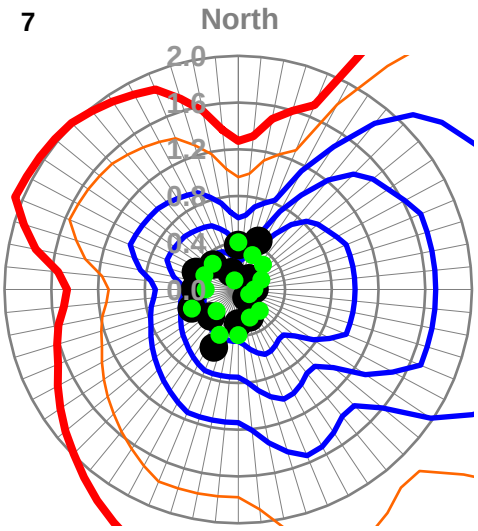

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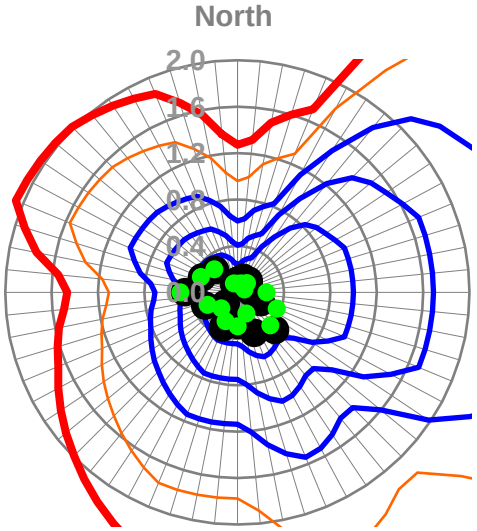


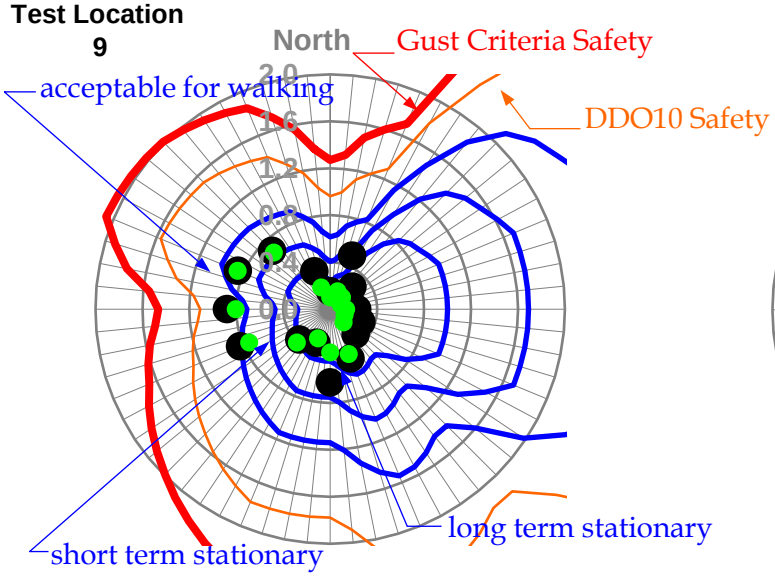
Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration
Existing Configuration

Appendix A3 - Spencer Street - continued

Test Location

9



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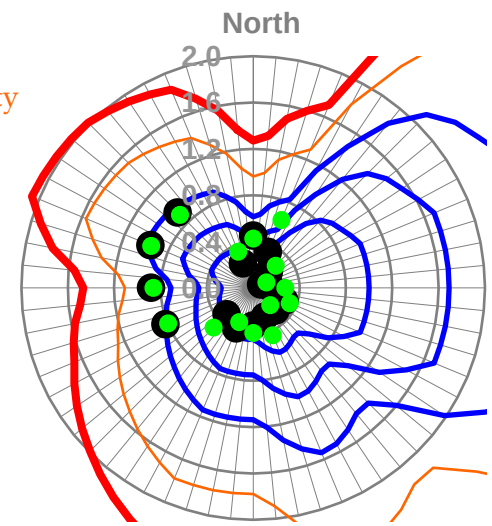

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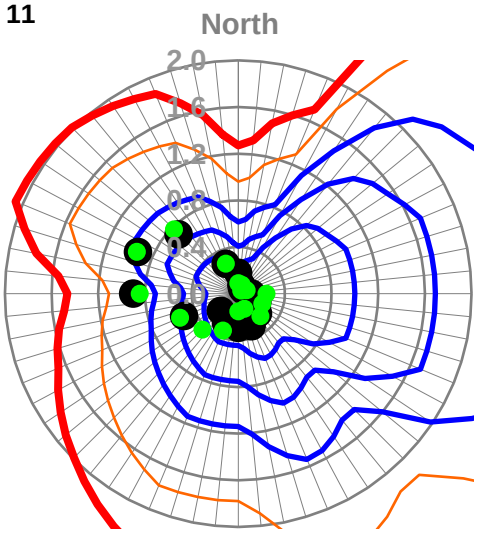

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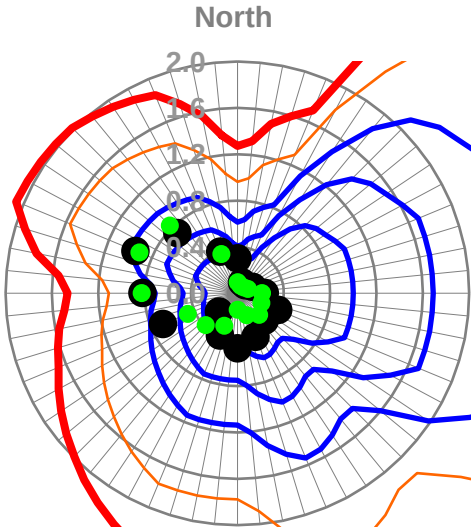

Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration
Existing Configuration

Appendix A4 - Spencer Street - continued

Test Location

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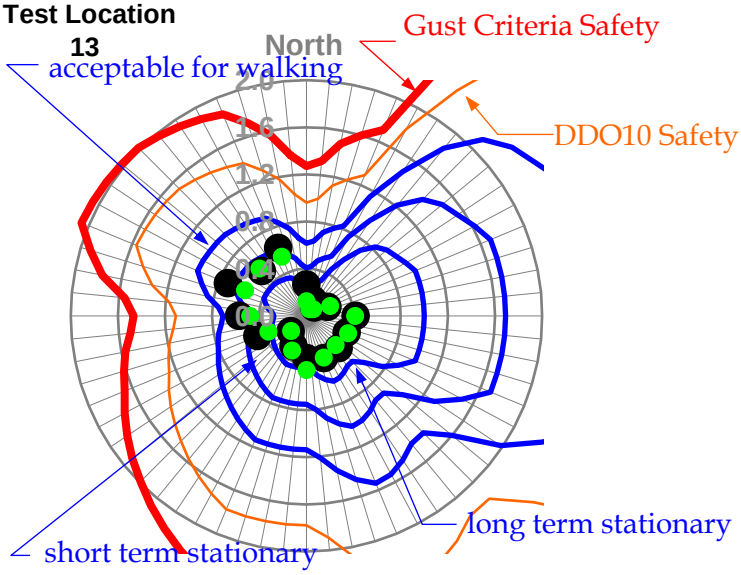

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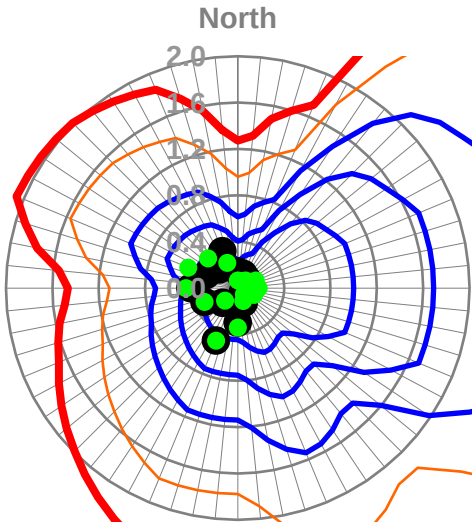

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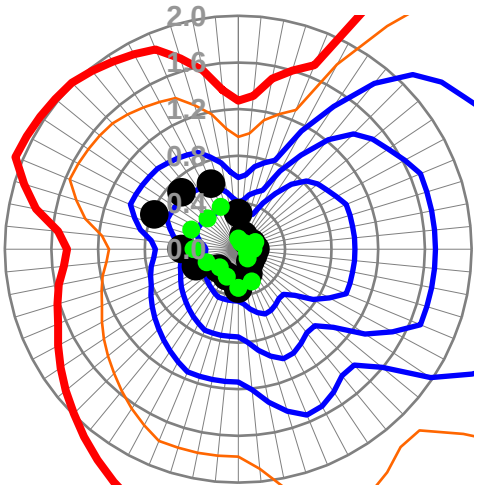
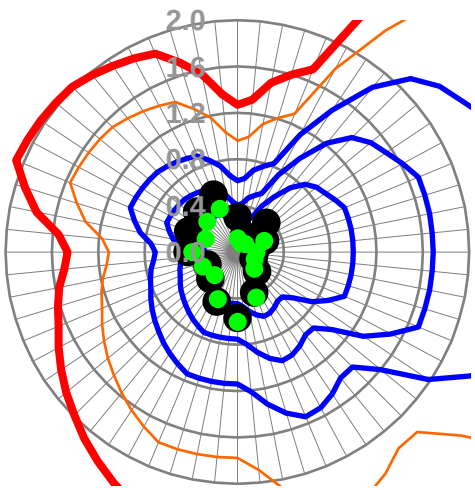


16

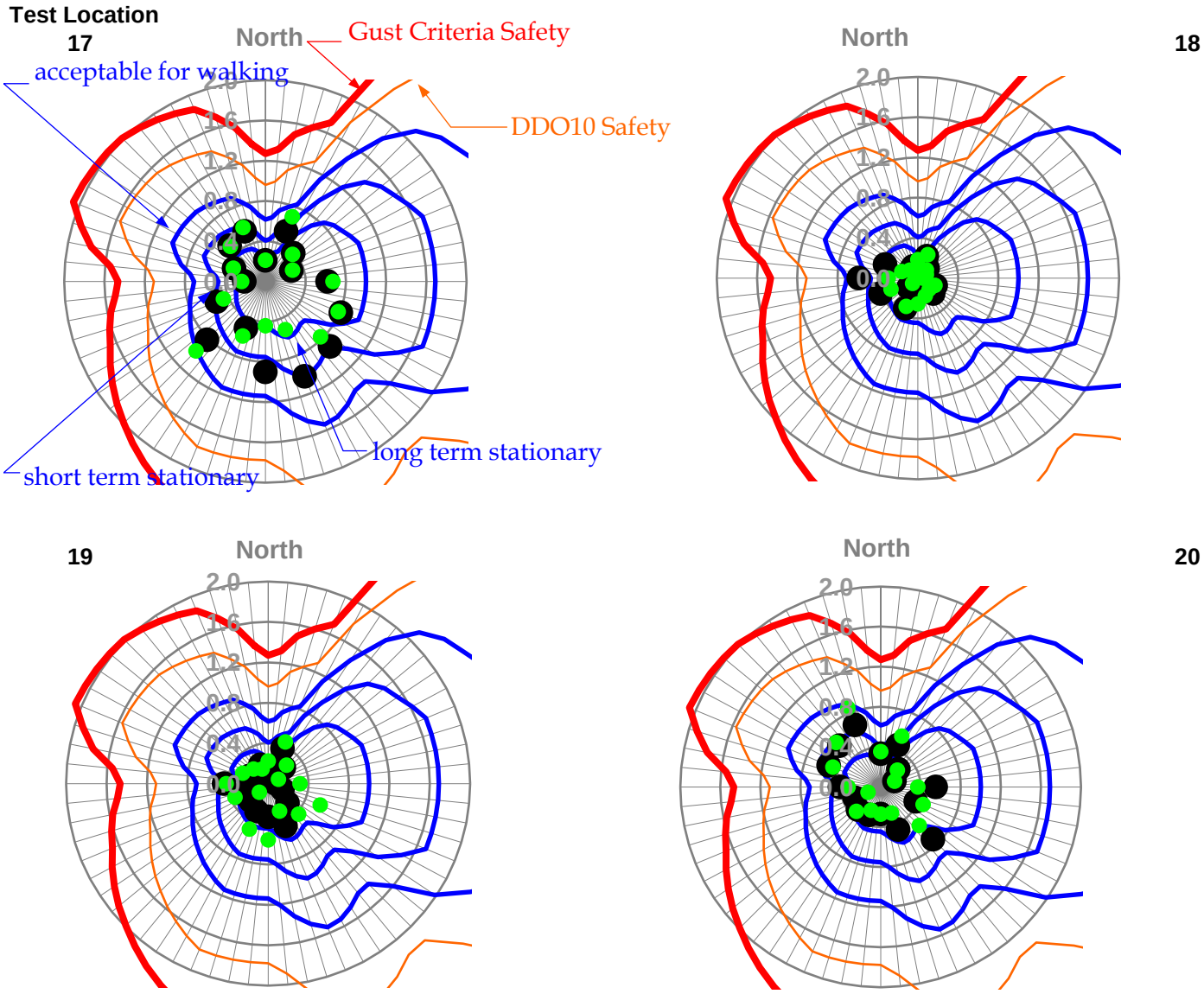


Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration

Existing Configuration

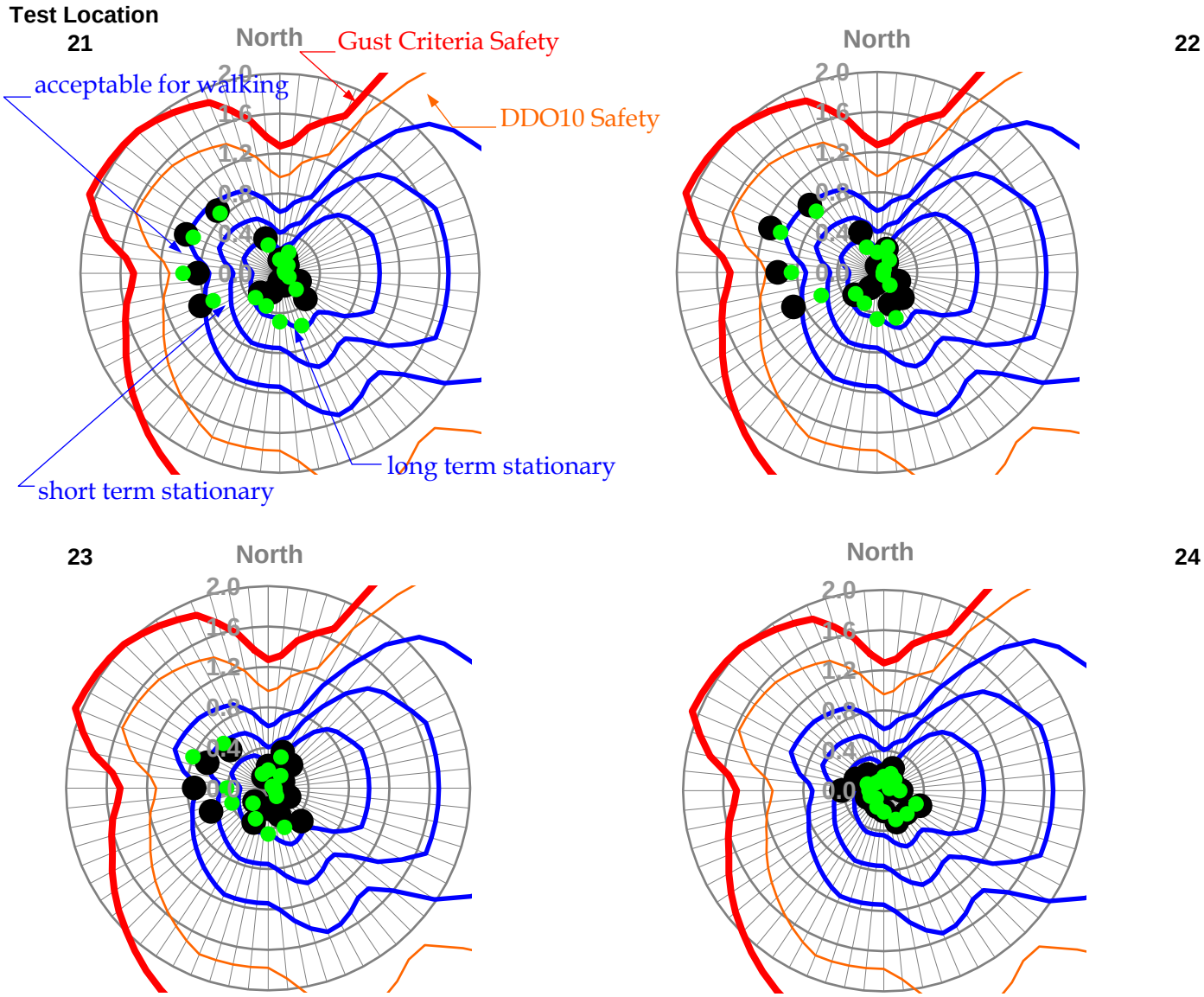
Appendix A5 - Spencer Street - continued



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

Proposed Configuration ●
Existing Configuration ●

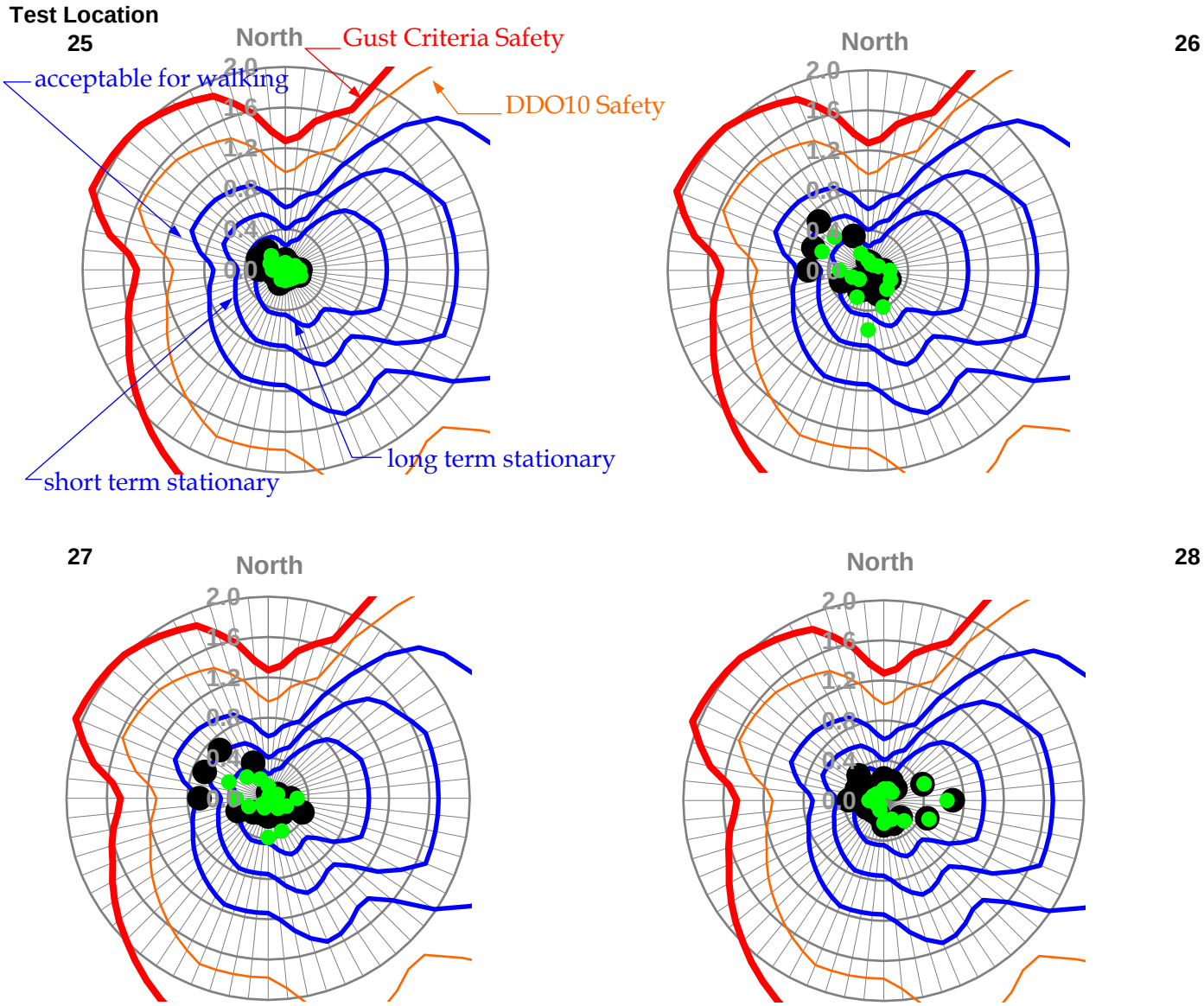
Appendix A6 - Collins Street



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

Proposed Configuration	●
Existing Configuration	●

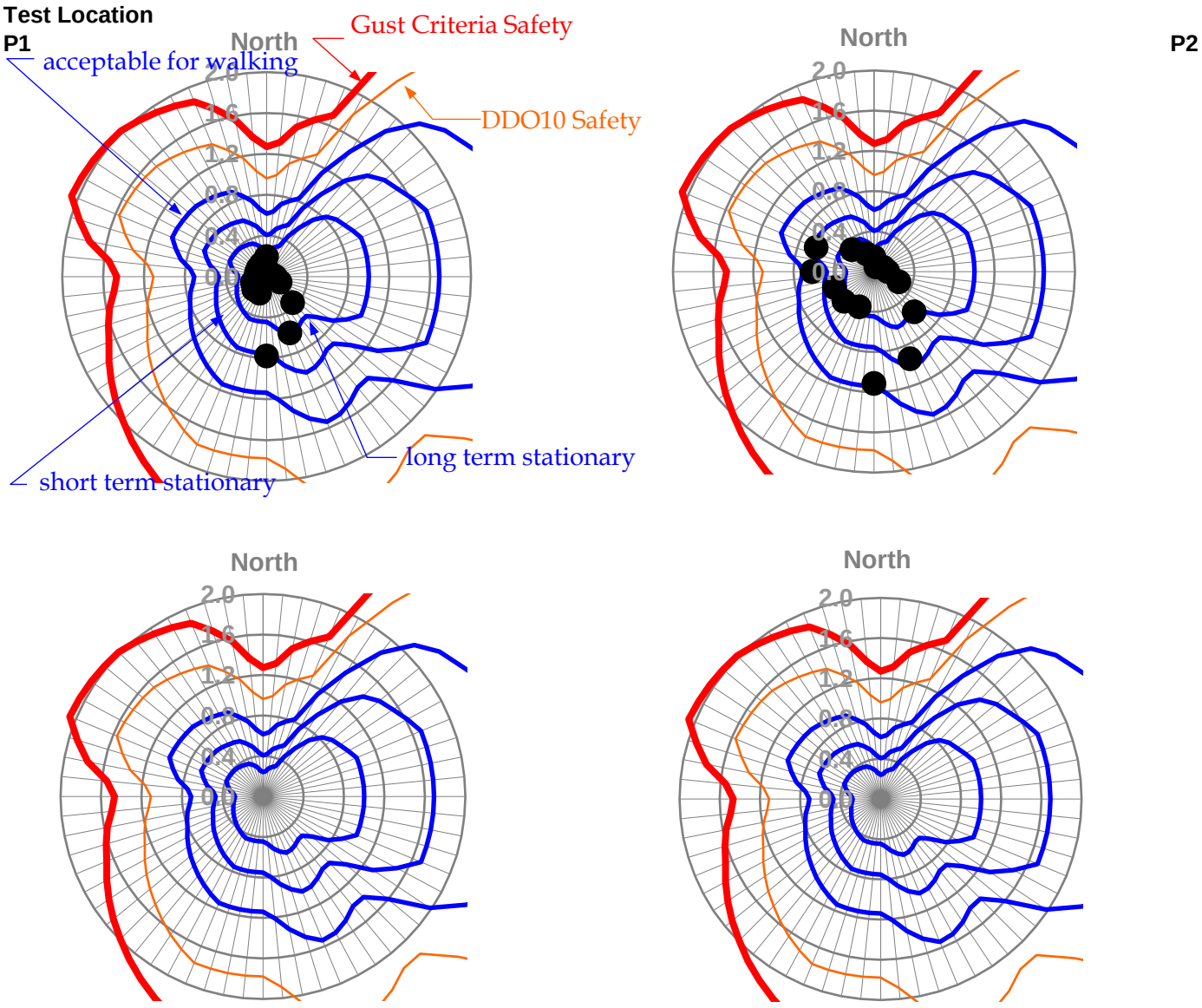
Appendix A7 - Collins Street - continued



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

Proposed Configuration ●
Existing Configuration ●

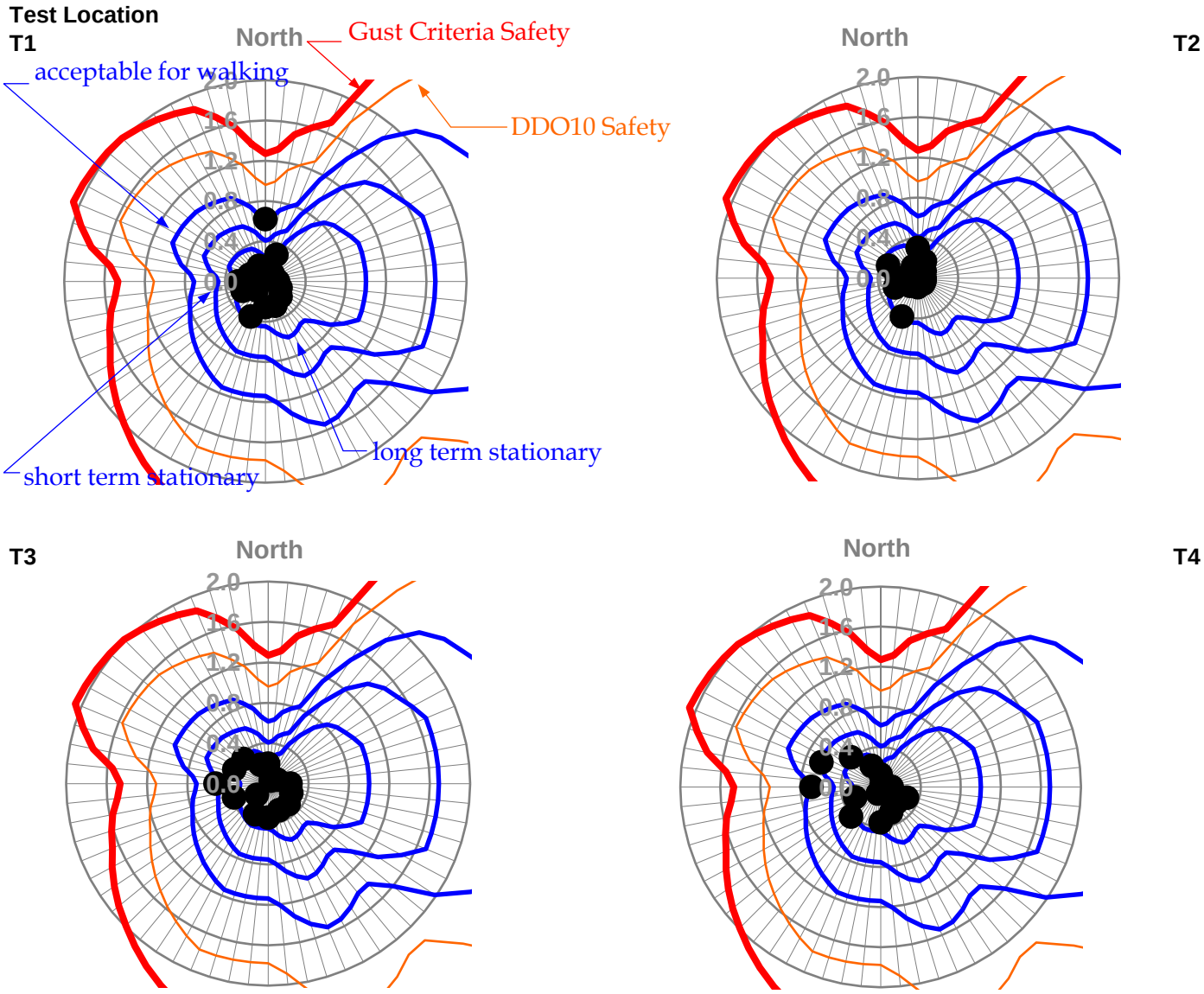
Appendix A8 - Flinders Lane and Laneway



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

Proposed Configuration

Appendix A9 - Level 5 - Terrace

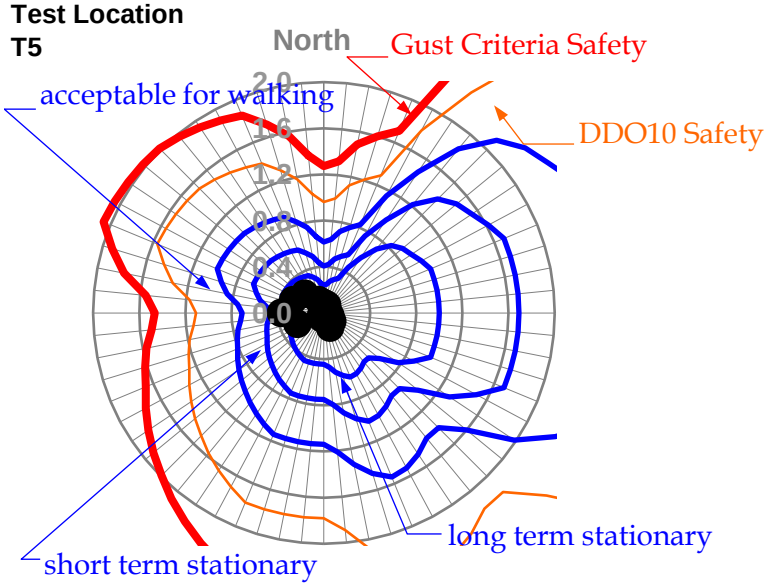


Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

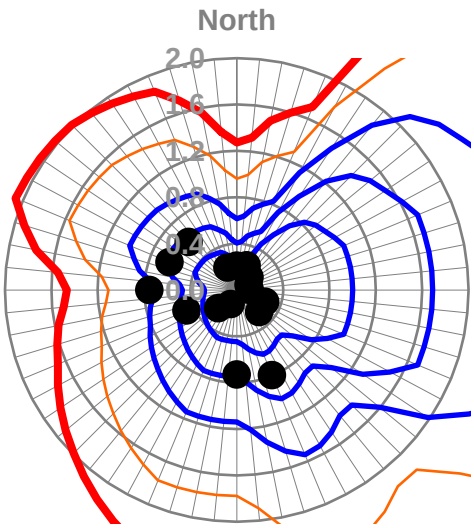
Proposed Configuration ●

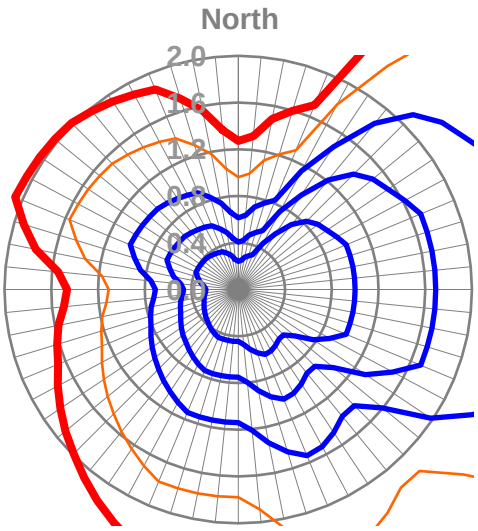
Appendix A10 - Level 7 - Terraces

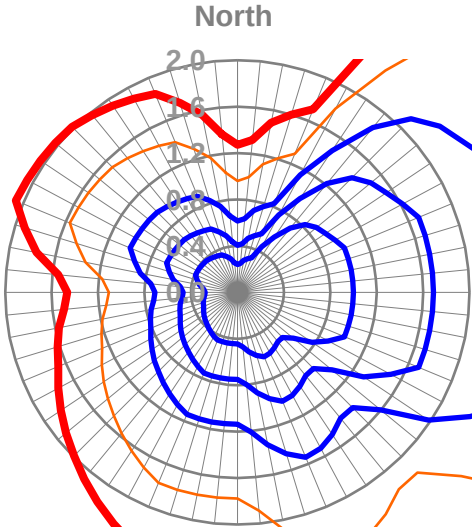
Test Location
T5



T6







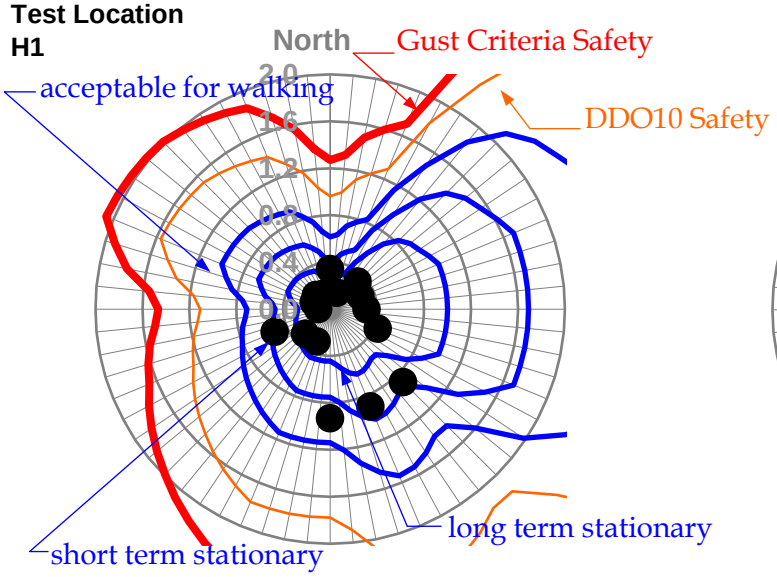
Peak velocity squared ratio $\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$ *as a function of wind direction*

Proposed Configuration ●

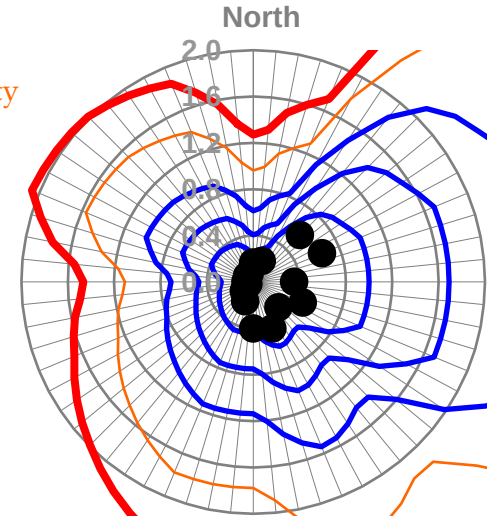
Appendix A11 - Level 7 - Terraces - continued

Test Location

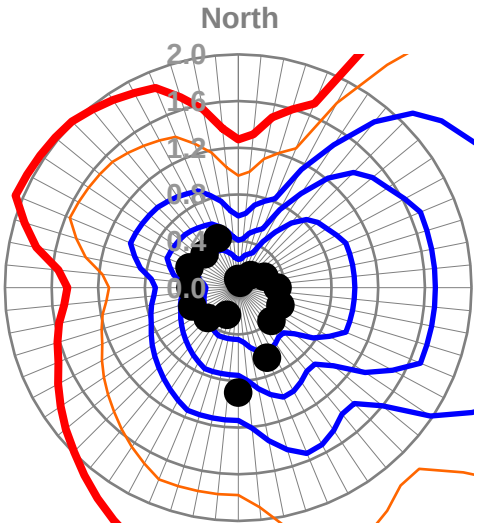
H1



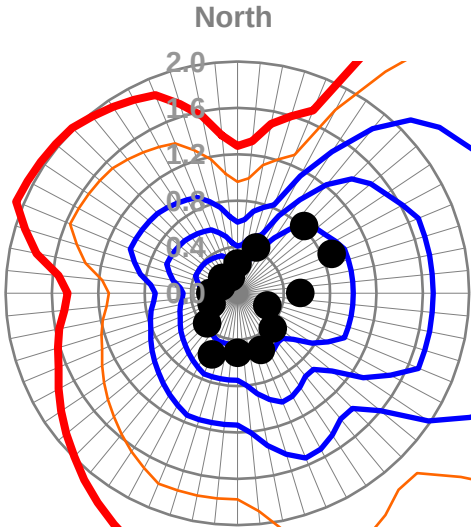
H2



H3



H4



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

Proposed Configuration ●

Appendix A12 - Level 38 - Terrace