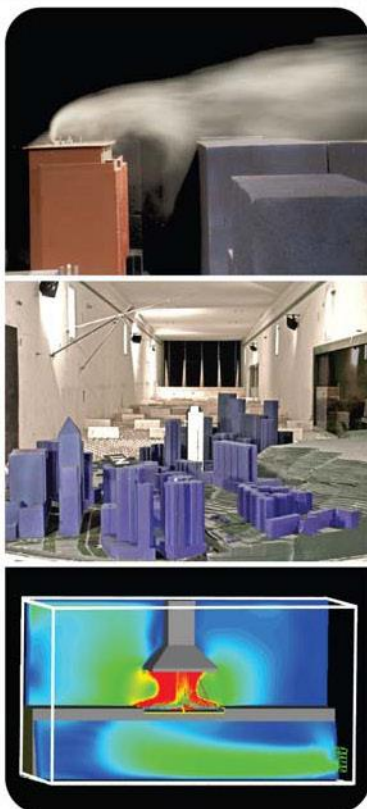


Final Report



Wind Tunnel Tests for:

472-486 PACIFIC HIGHWAY

St Leonards, Australia

CPP Project 8121

Prepared for:

Mirvac Projects Pty. Ltd.

Level 26, 60 Margaret Street

Sydney

NSW 2000

Australia

Prepared by:

Kenneth Fung, Engineer

Graeme Wood, Director

December 2015

CPP

Unit 2, 500 Princes Highway
St. Peters, NSW 2044, Australiainfo-syd@cppwind.com
www.cppwind.com

EXECUTIVE SUMMARY

Detailed wind tunnel studies were conducted to assess pedestrian wind comfort in and around the proposed 472-486 Pacific Highway development, St Leonards, Australia. Previous wind tunnel testing considered locations distributed around various configurations of the proposed 472-486 Pacific Highway development with potential wind mitigation measures, and Friedlander Place was identified as an area of concern. This report focuses specifically on the effect of various mitigation procedures and building configurations on the pedestrian wind environment along Friedlander Place, with several points tested along Nicholson Lane.

A model of the project was fabricated to a 1:300 scale and centred on a turntable in the wind tunnel. Replicas of surrounding buildings within a 430 m radius were constructed and placed on the turntable. Measurements of winds likely to be experienced by pedestrians were made with a hot-film anemometer at a total of 76 locations in various configurations for 16 wind directions each. The measurements were combined with wind statistics to produce results of wind speed versus the percentage of time that wind speed is exceeded for each location.

Testing in the existing configuration confirmed that the wind conditions are windy for the intended use of Friedlander Place as an outdoor café style precinct. As expected, the proposed development of large buildings in a relatively exposed windy area exacerbated the existing wind conditions. Through testing in various configurations, it has been shown that with appropriate amelioration measures, the wind conditions in Friedlander Place are similar or calmer than existing conditions. The placement of vertical barriers and planting of extra trees throughout Friedlander Place proved to be the most effective amelioration measure in creating locally calm wind conditions required for outdoor café style activities. Wind conditions with both the proposed developments at 472 and 504 Pacific Highway were slightly worse than those with only the proposed 472 Pacific Highway development. Wind conditions along Nicholson Lane are classified as suitable for use as a main public accessway.

Wind conditions on the upper level recessed balconies were shown to be suitable for their intended use without any additional amelioration. The wind conditions on lower balconies around the development were tested and reported in CPP (2014) for the initial development application. Wind conditions on these balconies were found to be suitable for their intended purpose. The current design includes more inset balconies and additional screening, which would further improve the wind conditions on these balconies.

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
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TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	ii
LIST OF TABLES	iii
LIST OF SYMBOLS.....	iv
1. INTRODUCTION.....	1
2. THE WIND TUNNEL TEST	2
3. ENVIRONMENTAL WIND CRITERIA	6
4. DATA ACQUISITION AND RESULTS	7
4.1 Velocities.....	7
4.1.1 Velocity Profiles.....	7
4.1.2 Pedestrian Winds	7
5. DISCUSSION.....	10
5.1 Configuration 1A: Existing wind conditions	11
5.2 Configurations 2A, 3A, 4A – Proposed building configurations without mitigation	12
5.3 Configurations B, C, D – Mitigation with predominantly horizontal elements.....	14
5.4 Configuration E, F – Mitigation with predominantly vertical elements	15
6. CONCLUSIONS.....	18
7. REFERENCES	19
Appendix 1: Additional Photographs of the CPP Wind Tunnel Model.....	20
Appendix 2: Pedestrian Wind Speed Measurements.....	23
Appendix 3: Directional Wind Results.....	31

LIST OF FIGURES

Figure 1: Schematic of the closed circuit wind tunnel.....	2
Figure 2: Mean velocity and turbulence profiles approaching the model.....	3
Figure 3: General turntable layout for 472-486 Pacific Highway development and surroundings	3
Figure 4: Photograph of the model in the CPP wind tunnel from the south – Configuration 1A	4
Figure 5: Photograph of the model from the north-east – Configuration 2A.....	4
Figure 6: Photograph of the model from the south – Configuration 3A.....	5
Figure 7: Photograph of the model from the north – Configuration 4A	5
Figure 8: Wind rose for Sydney Airport.....	8
Figure 9: Pedestrian wind speed measurements – Existing	11
Figure 10: Pedestrian wind speed measurements – Configuration 2A, proposed 472 PH only.....	12
Figure 11: Pedestrian wind speed measurements – Configuration 3A, proposed 504 PH only.....	13
Figure 12: Pedestrian wind speed measurements – Configuration 4A, both proposed 472 & 504 PH	13
Figure 13: Level 31 balcony wind speed measurements – Configuration 2A	14
Figure 14: Pedestrian wind speed measurements – Configuration 2E	16
Figure 15: Pedestrian wind speed measurements – Configuration 4E	16
Figure 16: Pedestrian wind speed measurements – Configuration 2F.....	17
Figure 17: Pedestrian wind speed measurements – Configuration 4F.....	17
Figure 18: Existing site viewed from the top	20
Figure 19: Close up view of Configuration B from the west	20
Figure 20: Close-up of Configuration C from the south-west	21

Figure 21: Close-up of Configuration D from the north-east.....	21
Figure 22: Close-up of Configuration E from the south-west.....	22
Figure 23: Close-up of Configuration F from the south-west.....	22

LIST OF TABLES

Table 1: Configurations for data acquisition.....	1
Table 2: Testing configurations and number of associated test points per configuration.....	1
Table 3: Summary of Lawson criteria	6
Table 4: Summary of wind effects on people, Penwarden (1973)	9
Table 5: Summary of wind conditions in various configurations	10

LIST OF SYMBOLS

D	Characteristic dimension (building height, width, etc.), m
n	Mean velocity profile power law exponent
T_u	Turbulence intensity, U_{rms}/U
U	Local mean velocity, m/s
U_{ref}	Reference velocity at reference height z_{ref} , m/s
U_{pk}	Peak wind speed in pedestrian studies, m/s
U_{rms}	Root-mean-square of fluctuating velocity, m/s
z	Height above surface, m
ν	Kinematic viscosity of approach flow, m ² /s
$\sigma(\)$	Standard deviation of $(\)$, $=(\)'_{rms}$
ρ	Density of approach flow, kg/m ³
$(\)_{max}$	Maximum value during data record
$(\)_{min}$	Minimum value during data record
$(\)_{mean}$	Mean value during data record
$(\)_{rms}$	Root mean square about the mean

1. INTRODUCTION

Pedestrian acceptability of footpaths, entrances, plazas, and terraces is often an important design parameter of interest to the building owner and architect. Assessment of the acceptability of the pedestrian level wind environment is desirable and more appropriate during the project design phase so that modifications can be made, if necessary, to create wind conditions suitable for the intended use of the space.

Techniques have been developed that permit boundary layer wind tunnel modelling of buildings to determine wind speeds in pedestrian areas. This report includes wind tunnel test procedures, test results, and a discussion of test results obtained. Table 1 and Table 2 summarises the model configurations, test methods, and data acquisition parameters used. All data collection was performed in accordance with Australasian Wind Engineering Society (2001), and American Society of Civil Engineers (1999, 2006). Analytical methods such as computational fluid dynamics (CFD) are not capable, except in very simple geometries, to estimate wind pressures, frame loads, or windiness in pedestrian areas.

Table 1: Configurations for data acquisition

<i>General Information</i>	
Model length scale	1:300
Surrounding model radius (full-scale)	430 m
Reference height (full-scale)	200 m AGL
Approach Terrain Category	Terrain Category 3
<i>Study Information</i>	
Number of test locations	76
Wind directions	16 wind directions in 22.5° increments from 0° (north)

Table 2: Testing configurations and number of associated test points per configuration

Configuration		1. Existing 472 and 504 Pacific Highway (PH), Figure 4	2. Proposed 472 PH, existing 504 PH, Figure 5	3. Existing 472 PH, proposed 504 PH, Figure 6	4. Proposed 472 PH and 504 PH, Figure 7
A	Existing surrounds, no trees or amelioration	6	9	6	7
B	New surrounds with café, wall, awning, and trees	-	5	-	5
C	As B, with 3 m high roof over Friedlander Place	-	5	-	5
D	As C, with extended roof over Friedlander Place	-	5	-	5
E	As B, with 2.5 m vertical barriers and extra trees	-	5	-	5
F	As B, with extra trees and landscaping	-	4	-	4

2. THE WIND TUNNEL TEST

Modelling of the aerodynamic loading on a structure requires special consideration of flow conditions to obtain similitude between the model and the prototype. A detailed discussion of the similarity requirements and their wind tunnel implementation can be found in Cermak (1971, 1975, 1976). In general, the requirements are that the model and prototype be geometrically similar, that the approach mean velocity and turbulence characteristics at the model building site have a vertical profile shape similar to the full-scale flow, and that the Reynolds number for the model and prototype be equal. Due to modelling constraints, the Reynolds number cannot be made equal and the Australasian Wind Engineering Society Quality Assurance Manual (2001) suggests a minimum Reynolds number of 50,000, based on characteristic width and wind velocity at the top of the model; in this study, the modelled Reynolds number was over 50,000.

The wind tunnel test was performed in the boundary layer wind tunnel shown in Figure 1. The wind tunnel test section is 3.0 m wide, by 2.4 m high with a porous slatted roof for passive blockage correction. This wind tunnel has a 21 m long test section, the floor of which is covered with roughness elements, preceded by a vorticity generating fence and spires. The spires, barrier, and roughness elements were designed to provide a modelled atmospheric boundary layer approximately 1.2 m thick with a mean velocity and turbulence intensity profile similar to that expected to occur in the region approaching the modelled area. The approach wind characteristics used for the model test are shown in Figure 2 and are explained more fully in Section 4.1.1.

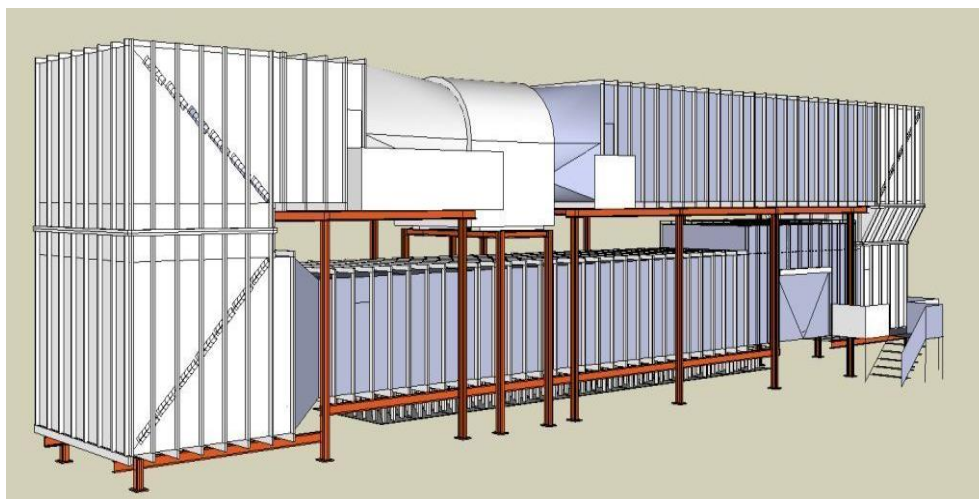


Figure 1: Schematic of the closed circuit wind tunnel

A model of the proposed development and surrounds to a radius of 430 m was constructed at a scale of 1:300, Figure 3. The model scale was consistent with the modelled atmospheric flow, permitted a reasonable test model size with an adequate portion of the adjoining environment to be included in a proximity model, and was within wind tunnel blockage limitations.

Significant variations in the building surface were formed into the model. The models were mounted on the turntable located near the downstream end of the wind tunnel test section, Figure 4 to Figure 7. The turntable permitted rotation of the modelled area for examination of wind speeds from any approach wind direction. Additional photos of the testing are presented in Appendix 1.

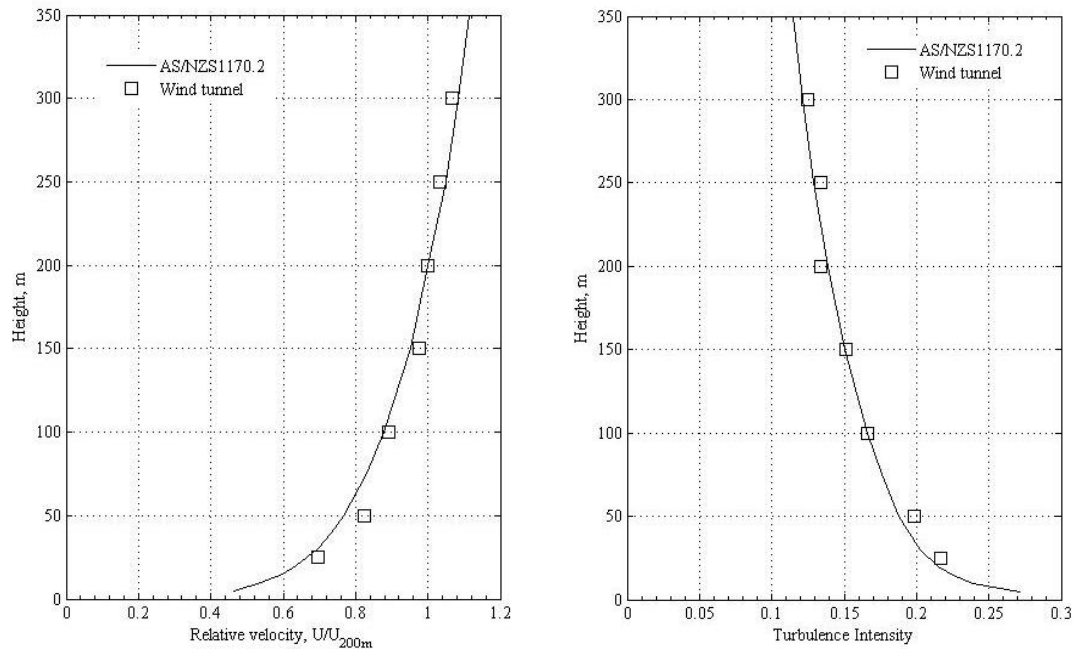


Figure 2: Mean velocity and turbulence profiles approaching the model

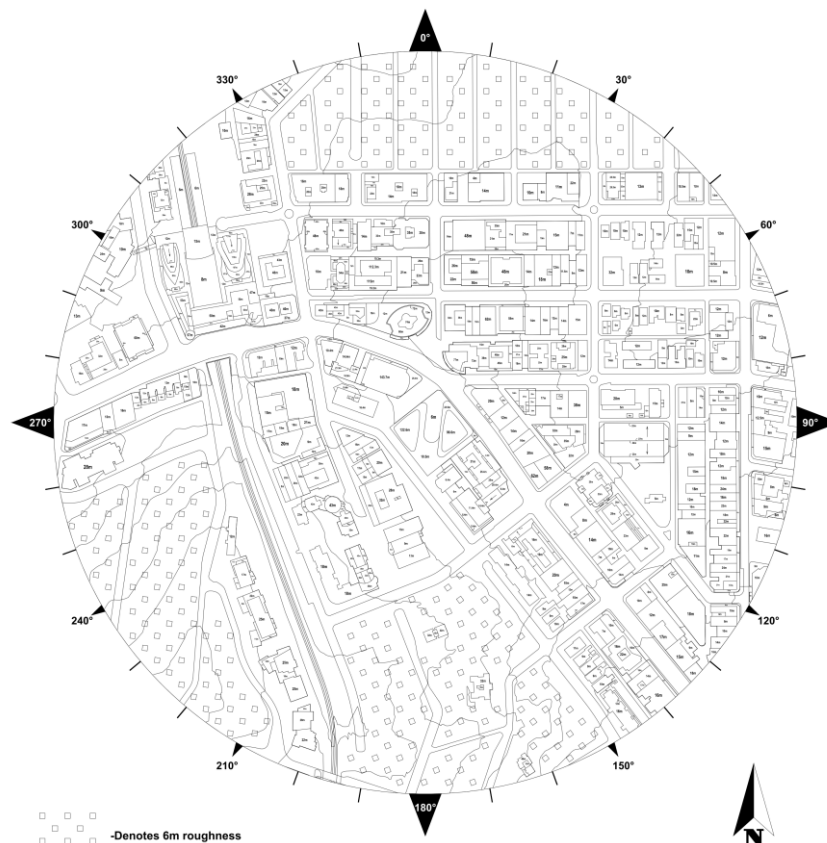


Figure 3: General turntable layout for 472-486 Pacific Highway development and surroundings



Figure 4: Photograph of the model in the CPP wind tunnel from the south – Configuration 1A

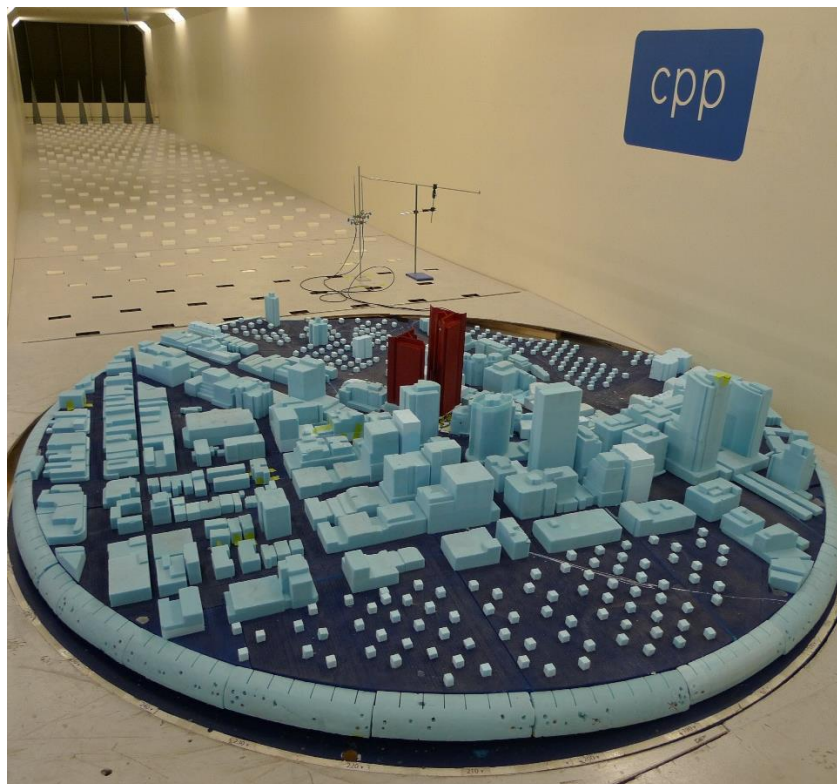


Figure 5: Photograph of the model from the north-east – Configuration 2A



Figure 6: Photograph of the model from the south – Configuration 3A

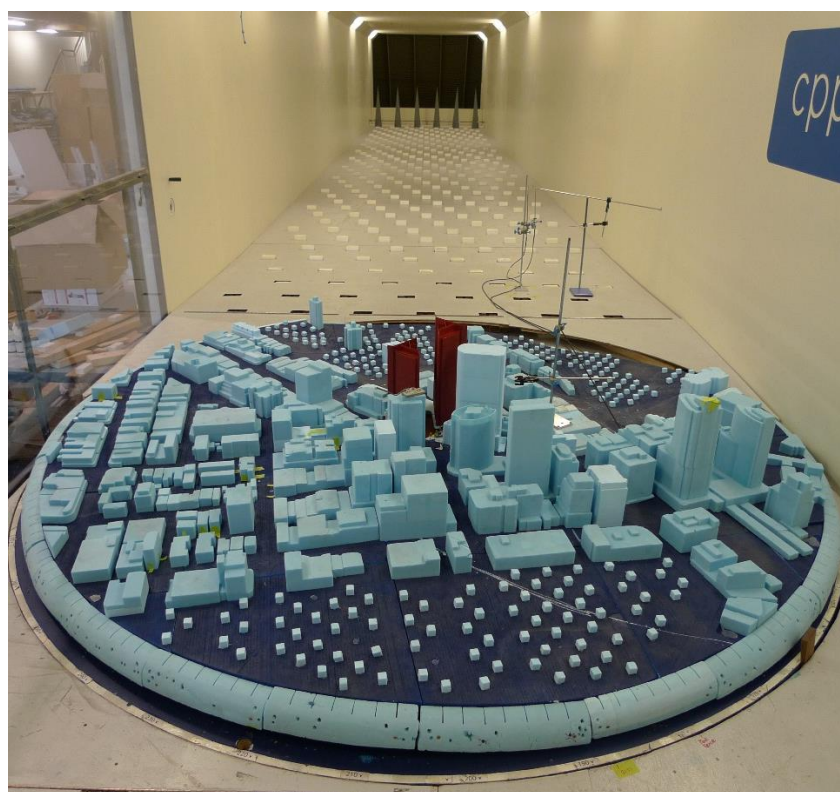


Figure 7: Photograph of the model from the north – Configuration 4A

3. ENVIRONMENTAL WIND CRITERIA

Lane Cove Council do not have specific environmental wind criterion. However, over the years, a number of researchers have added to the knowledge of wind effects on pedestrians by suggesting criteria for comfort and safety. Because pedestrians will tolerate higher wind speeds for a smaller period of time than for lower wind speeds, these criteria provide a means of evaluating the overall acceptability of a pedestrian location. Also, a location can be evaluated for its intended use, such as for an outdoor café or a footpath. One of the most widely accepted set of criteria was developed by Lawson (1990), which is described in Table 3.

Lawson's criteria have categories for discomfort, based on wind speeds exceeded five percent of the time, allowing planners to judge the usability of locations for various intended purposes ranging from "Business walking" to "Pedestrian sitting". The level and severity of these comfort categories can vary based on individual preference, so calibration to the local wind environment is recommended when evaluating the Lawson ratings. The criteria also include a distress rating, for safety assessment, which is based on occasional (once or twice per year) wind speeds¹. In both cases, the wind speed used the larger of a mean or gust equivalent-mean (GEM) wind speed. The GEM is defined as the peak gust wind speed divided by 1.85; this is intended to account for locations where the gustiness is the dominant characteristic of the wind.

Table 3: Summary of Lawson criteria

Comfort (maximum of mean or gust equivalent mean (GEM ⁺) wind speed exceeded 5% of the time)	
< 4 m/s	Pedestrian Sitting (considered to be of long duration)
4 - 6 m/s	Pedestrian Standing (or sitting for a short time or exposure)
6 - 8 m/s	Pedestrian Walking
8 - 10 m/s	Business Walking (objective walking from A to B or for cycling)
> 10 m/s	Uncomfortable
Distress (maximum of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	not to be exceeded more than two times per year (or one time per season) for general access area
<20 m/s	not to be exceeded more than two times per year (or one time per season) where only able bodied people would be expected; frail or cyclists would not be expected

Note: ⁺ The gust equivalent mean (GEM) is the peak 3 s gust wind speed divided by 1.85.

¹ The rating of "uncomfortable" in Table 3 is the word of the acceptance criteria author and may not apply directly to any particular project. High wind areas are certainly not uncomfortable all the time, just on windier days. The word uncomfortable, in our understanding, refers to acceptability of the site by pedestrians for typical pedestrian use; i.e., on the windiest days, pedestrians will not find the areas "acceptable" for walking and will tend to avoid such areas if possible. The distress rating fail indicates some unspecified potential for causing injury to a less stable individual who might be blown over. The likelihood of such events is not well described in the literature and is likely to be strongly affected by individual differences, presence of water, blowing dust or particulates, and other variables in addition to the wind speed.

4. DATA ACQUISITION AND RESULTS

4.1 Velocities

Velocity profile measurements were taken to verify that appropriate boundary layer flow approaching the site was established and to determine the likely pedestrian level wind climate around the test site. Pedestrian wind measurements and analysis are described in Section 4.1.2. All velocity measurements were made with hot-film anemometers, which were calibrated against a Pitot-static tube in the wind tunnel. The calibration data were described by a King's Law relationship (King, 1914)

4.1.1 Velocity Profiles

Mean velocity and turbulence intensity profiles for the boundary layer flow approaching the model are shown in Figure 2. Turbulence intensities are related to the local mean wind speed. These profiles have the form as derived from Standards Australia (2011) and are appropriate for the approach conditions.

4.1.2 Pedestrian Winds

Wind speed measurements were recorded at 76 locations to evaluate pedestrian comfort in and around the project site. Summary results for all configurations are presented in Appendix 2.

Previous wind tunnel testing considered 31 locations distributed around the proposed development with and without mitigation measures, and it was found that unfavourable wind conditions for the intended use of the space existed along Friedlander Place. This report focuses specifically on the effect of various mitigation procedures and proposed building configurations on the pedestrian wind environment along Friedlander Place, Table 2. Several points were tested for the existing buildings at 472 and 504 Pacific Highway to provide a benchmark for comparison of the existing environmental wind conditions with the expected wind conditions around various configurations of the proposed developments.

Wind speed measurements were made at the model scale equivalent of 1.5 to 2.1 m above the ground surface for 16 wind directions at 22.5° intervals. Locations were chosen in conjunction with the design team to investigate areas of concern. The hot-film signal was sampled for a period corresponding to one hour in prototype. All wind speed data were digitally filtered to obtain the two to three second running mean wind speed at each point; this is the minimum size of a gust affecting a pedestrian and used as the basis for the various assessment criteria.

These local wind speeds, U , were normalised by the tunnel reference velocity, U_{ref} . Mean and turbulence statistics were calculated and used to calculate the normalised effective peak gust using:

$$\frac{U_{pk}}{U_{ref}} = \frac{U + 3 \cdot U_{rms}}{U_{ref}}$$

The mean and gust equivalent mean velocities relative to the free stream wind tunnel reference velocity at a full-scale elevation of 200 m are plotted in polar form in Appendix 3. The graphs show wind speed magnitude and the approach wind direction for which that velocity was measured. The polar plots aid in visualisation of the effects of the nearby structures or topography, the relative significance of various wind azimuths, and whether the mean or gust is of greater importance.

To enable a quantitative assessment of the wind environment, the wind tunnel data was combined with wind frequency and direction information measured by the Bureau of Meteorology at a standard height of 10 m at Sydney Airport from 1995 to 2013, Figure 8. From these data, directional criterion lines for the Lawson rating wind speeds have been calculated and included on the polar plots in Appendix 3; this gives additional information regarding directional sensitivity at each location.

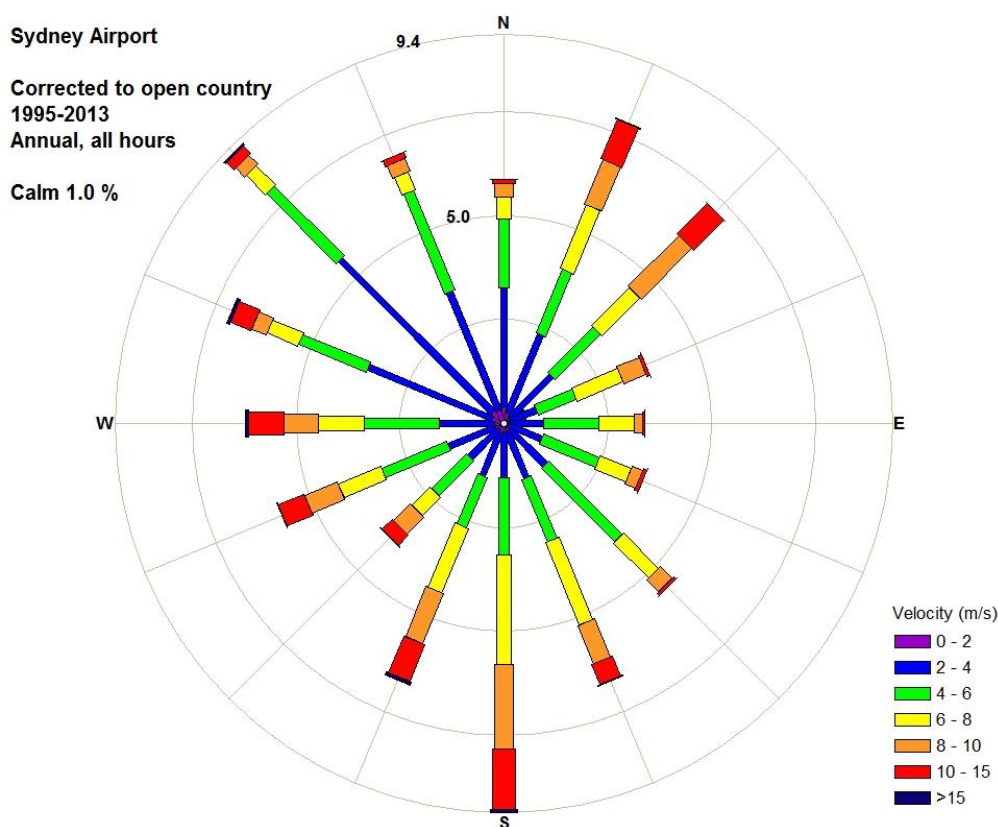


Figure 8: Wind rose for Sydney Airport

The Lawson criteria considers the integration of the velocity measurements with local wind climate statistical data summarized in Figure 8 to rate each location. From the cumulative wind speed distributions for each location, the percentage of time each of the Lawson comfort rating wind speeds are exceeded are presented in tabular form under the polar plots in Appendix 3. In addition to the Lawson rating wind speeds, the percentage of time that 2 m/s is exceeded is also reported. This has been provided as it has found that the limiting wind speed for long-term stationary activities such as fine outdoor dining should be about 2 to 2.5 m/s rather than 4 m/s. Interpretation of these wind levels

can be aided by the description of the effects of wind of various magnitudes on people. The earliest quantitative description of wind effects was established by Sir Francis Beaufort in 1806, for use at sea; the Beaufort scale is reproduced in Table 4 including qualitative descriptions of wind effects.

The tables in Appendix 3 additionally provide the wind speed exceeded 5% and 0.022% of the time for direct comparison with the Lawson comfort and distress criteria and the associated Lawson ratings for both mean, GEM, and combined wind speeds. Colour coded summaries of pedestrian comfort and safety with respect to the Lawson criteria are presented in Appendix 2 for each test location for the various configurations, which are further summarised in Table 5. The implications of the important results are discussed in Section 5.

Table 4: Summary of wind effects on people, Penwarden (1973)

Description	Beaufort Number	Speed (m/s)	Effects
Calm, light air	0, 1	0–2	Calm, no noticeable wind.
Light breeze	2	2–3	Wind felt on face.
Gentle breeze	3	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps
Moderate breeze	4	5–8	Raises dust, dry soil, and loose paper. Hair disarranged.
Fresh breeze	5	8–11	Force of wind felt on body. Drifting snow becomes airborne. Limit of agreeable wind on land.
Strong breeze	6	11–14	Umbrellas used with difficulty. Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	7	14–17	Inconvenience felt when walking.
Gale	8	17–21	Generally impedes progress. Great difficulty with balance in gusts.
Strong gale	9	21–24	People blown over by gusts.

5. DISCUSSION

The wind climatology chart of Figure 8 indicates that the most frequent strong winds are from the south, and to a lesser extent, the west and north-east. The locations tested around the development site are susceptible to winds from different directions, depending on the relative location of the point tested to the geometry of development. The influence of wind direction on the suitability of a location for an intended purpose can be ascertained from the graphs in Appendix 3.

The primary conclusions of the pedestrian study can be understood by reviewing the colour coded images in Appendix 2, which depict the locations selected for investigation of pedestrian wind comfort around the site along with the Lawson criteria rating for both comfort and distress. The results for all configurations are further summarised for simple comparison in Table 5. It should be noted that the comfort criteria are based on 95% of the time that the mean wind speed is below specific wind speed levels. The central colour of the plots in Appendix 2 indicates the comfort rating for the location, and the colour of the outer ring indicates whether the location passes the distress criterion. Mitigation measures are likely to be required for any orange and red locations, and may be necessary for other locations depending on the intended use of the space. Although conditions may be classified as acceptable, there may be certain wind directions that cause regular strong events, and these can be determined by an inspection of the plots in Appendix 3.

A summary of the wind conditions along Friedlander Place and Nicholson Lane in various surround configurations are presented in Table 5. The colour coding is the same as Appendix 2. For the intended use of Friedlander Place, Locations 1 to 4 in each row should have as many blue cells as possible.

Table 5: Summary of wind conditions in various configurations

Configuration		Location								
		Friedlander Place				Nicholson Lane			Balconies	
		1	2	3	4	5	6	7	8	9
1. Existing 472 and 504 PH	A					-			-	-
	A	x	x	X	x	x				
2. Proposed 472 PH and existing 504 PH	B	x	x	x			-	-	-	-
	C	x	x				-	-	-	-
	D						-	-	-	-
	E						-	-	-	-
	F			x		-	-	-	-	-
	F			x		-	-	-	-	-
3. Existing 472 PH and proposed 504 PH		A	x	X	X	-			-	-
4. Proposed 472 and 504 PH	A	x	X	x	x				-	-
	B	x	X	x			-	-	-	-
	C		X	x			-	-	-	-
	D		x	x			-	-	-	-
	E		x				-	-	-	-
	F			x		-	-	-	-	-
	F			x		-	-	-	-	-

Locations: 1-5 (Friedlander Place), 6-7 (Nicholson Lane), 8-9 (Tower 2 Level 31 Balconies)

Comfort Rating: ■ Outdoor dining ■ Pedestrian Sitting ■ Pedestrian Standing ■ Pedestrian Walking ■ Business Walking ■ Uncomfortable

Distress Rating: Pass unless other marked. x: Able Bodied X: Fail

Table 2, which provided a description of the testing configurations and number of associated test points per configuration configurations, has been reproduced below for convenience.

1. Existing 472 and 504 Pacific Highway (PH), Figure 4		2. Proposed 472 PH, existing 504 PH, Figure 5	3. Existing 472 PH, proposed 504 PH, Figure 6	4. Proposed 472 PH and 504 PH, Figure 7	1. Existing 472 and 504 Pacific Highway (PH), Figure 4
A	Existing surrounds, no trees or amelioration	6	9	6	7
B	New surrounds with café, wall, awning, and trees	-	5	-	5
C	As B, with 3 m roof over Friedlander Place	-	5	-	5
D	As C, with extended roof over Friedlander Place	-	5	-	5
E	As B, with 1.5 m vertical barriers and extra trees	-	5	-	5
F	As B, with extra trees and landscaping	-	4	-	4

5.1 Configuration 1A: Existing wind conditions

Existing wind conditions throughout Friedlander Place are generally classified as satisfactory for pedestrian standing or pedestrian walking activities, Figure 9. All locations pass the Lawson distress criterion.

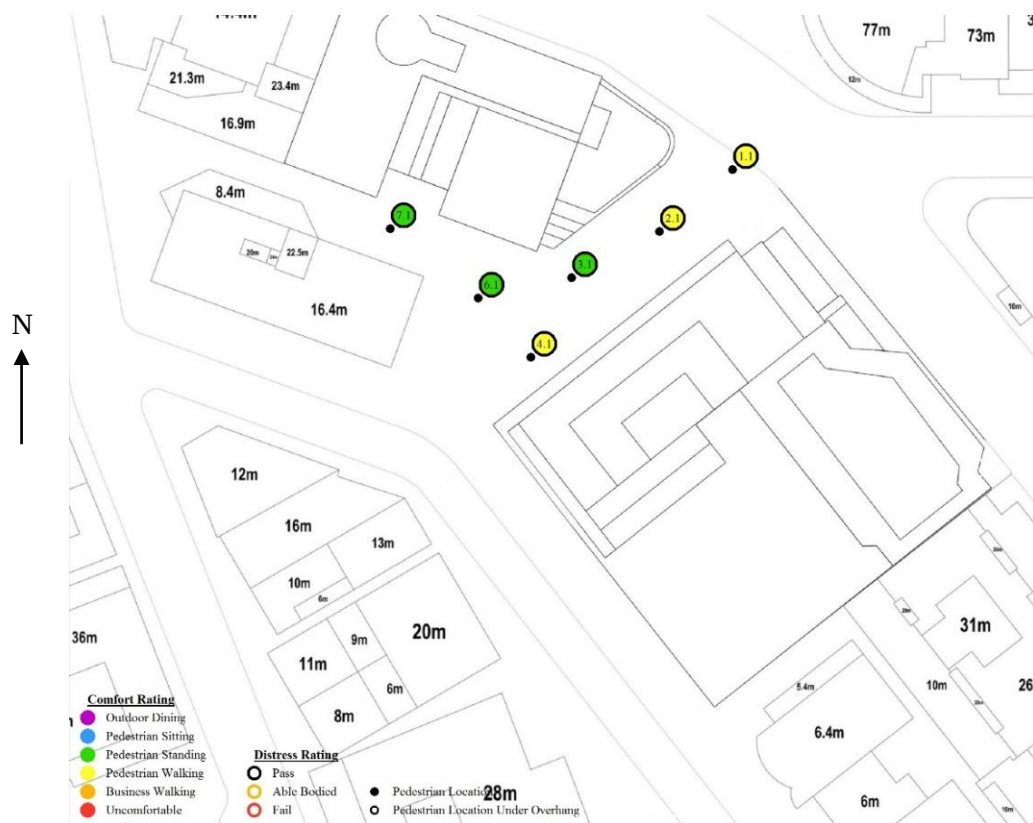


Figure 9: Pedestrian wind speed measurements – Existing

5.2 Configurations 2A, 3A, 4A – Proposed building configurations without mitigation

Without any mitigation, all 3 of the proposed development configurations produce strong wind conditions around Friedlander Place, Figure 10 to Figure 12. At best, the outdoor café area to the west, is classified as suitable for business walking from a comfort perspective and exceeds the Lawson distress criterion. At the centre of the outdoor courtyard, the area is classified as uncomfortable and fails the distress criterion. The polar plots in Appendix 3 show that for each proposed building configuration without mitigation, the central courtyard will generally only be suitable for pedestrian dining less than 30% of the time. Mitigation procedures are therefore necessary to meet the intended use of the space for pedestrian dining and pedestrian sitting. The proposed amelioration configurations are listed in Table 2.

Measurements along Nicholson Lane yielded pedestrian walking level wind conditions and passed the Lawson distress rating for each building configuration. No amelioration for this area is necessary and the results with the proposed buildings are only slightly windier than the existing configuration.

The balcony wind conditions on Level 31 of Tower 2 were tested in Configuration 2A, and passed the Lawson distress criterion, Figure 13. The balcony on the east façade of Tower 2 is suitable for pedestrian sitting about 85% of the time. The balcony on the south-west façade of Tower 2 is suitable for pedestrian sitting in excess of 95% of the time. The wind conditions on these inset and screened balconies are considered exceptionally good for a location at such a height above ground level. Residents will rapidly determine when the environmental conditions are suitable for their intended use of the space. The wind conditions are not expected to change with the addition of 504 Pacific Highway.

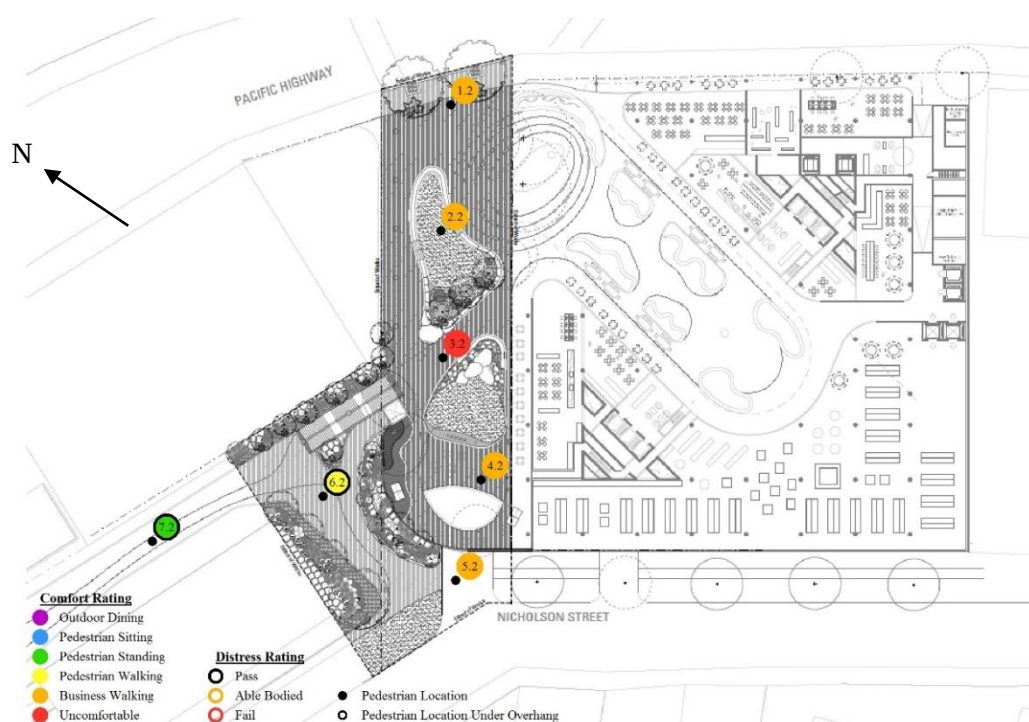


Figure 10: Pedestrian wind speed measurements – Configuration 2A, proposed 472 PH only



Figure 11: Pedestrian wind speed measurements – Configuration 3A, proposed 504 PH only

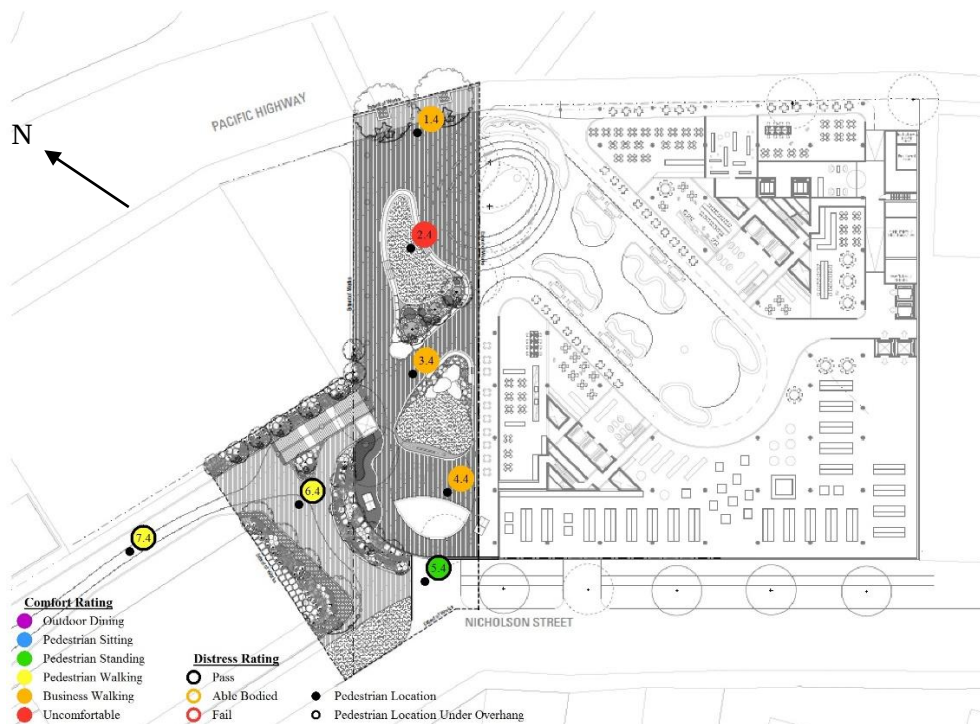


Figure 12: Pedestrian wind speed measurements – Configuration 4A, both proposed 472 & 504 PH



Figure 13: Level 31 balcony wind speed measurements – Configuration 2A

5.3 Configurations B, C, D – Mitigation with predominantly horizontal elements

The pedestrian wind conditions with various mitigation measures for Configuration 2 (proposed 472 and existing 504 Pacific Highway) and Configuration 4 (proposed 472 and 504 Pacific Highway) are shown in Appendix 2. Existing landscaping has been included in the models. From inspection of these results and the summary in Table 5, it is evident that Configuration B improves the wind conditions from Configuration A, but does not provide the required classification of pedestrian sitting which would be necessary for the intended use of this space. Each subsequent amelioration measure improves the ground level wind conditions, with Configuration D producing the calmest wind conditions along Friedlander Place with several locations suitable for pedestrian sitting activities. It should be noted that the roof over the café did not fully seal the area to the west of the café and the horizontal flows are being driven through this gap and up the revised pedestrian staircase location. Closing the gap, and pitching the roof would be expected to further improve the wind conditions by making the space more enclosed.

Prevailing winds from the south accelerate around the west corner of Tower 2, and are the main source of the strong wind conditions in Friedlander Place. The overhead roof in Configurations C and D, while preventing downwash onto ground level, does little to mitigate horizontal channelled flow. Consequently, while these amelioration options have offered considerable improvement in the wind conditions, they are still insufficient to meet the required classification of pedestrian sitting or dining in Friedlander Place.

5.4 Configuration E, F – Mitigation with predominantly vertical elements

The pedestrian wind speed conditions with mitigation procedures involving further landscaping for Configuration 2 (proposed 472 and existing 504 Pacific Highway) and Configuration 4 (proposed 472 and 504 Pacific Highway) are shown in Figure 14 to Figure 17. From inspection of these results and the summary in Table 5, it is clear that the distribution of the 2.5 m high vertical screens and additional trees in Configuration E offers the greatest improvement in the environmental wind conditions as it lifts the ground level horizontal flows, creating locally calm wind conditions suitable for pedestrian sitting activities. Configuration F, while improving the wind conditions from Configurations A and B, is not sufficient for the intended use of the space, and is suitable for pedestrian sitting about 70% of the time. The environmental wind conditions along Friedlander Place in this configuration may be improved if the shrubs are increased from 1.5 m to at least 2 m in height. Furthermore, additional landscaping should be placed at the top of the escalators leading up to Friedlander Place to break up the horizontal channelled flows.

The results indicate that the wind conditions are windier for Configuration 4, with both the proposed 472 and 504 Pacific Highway developments, than Configuration 2, with only the proposed 472 Pacific Highway development. This is as expected as winds from the south-west quadrant will be more channelled through Friedlander Place. It should be noted that the final form of 504 Pacific Highway is currently unknown and the overall massing model has been used.

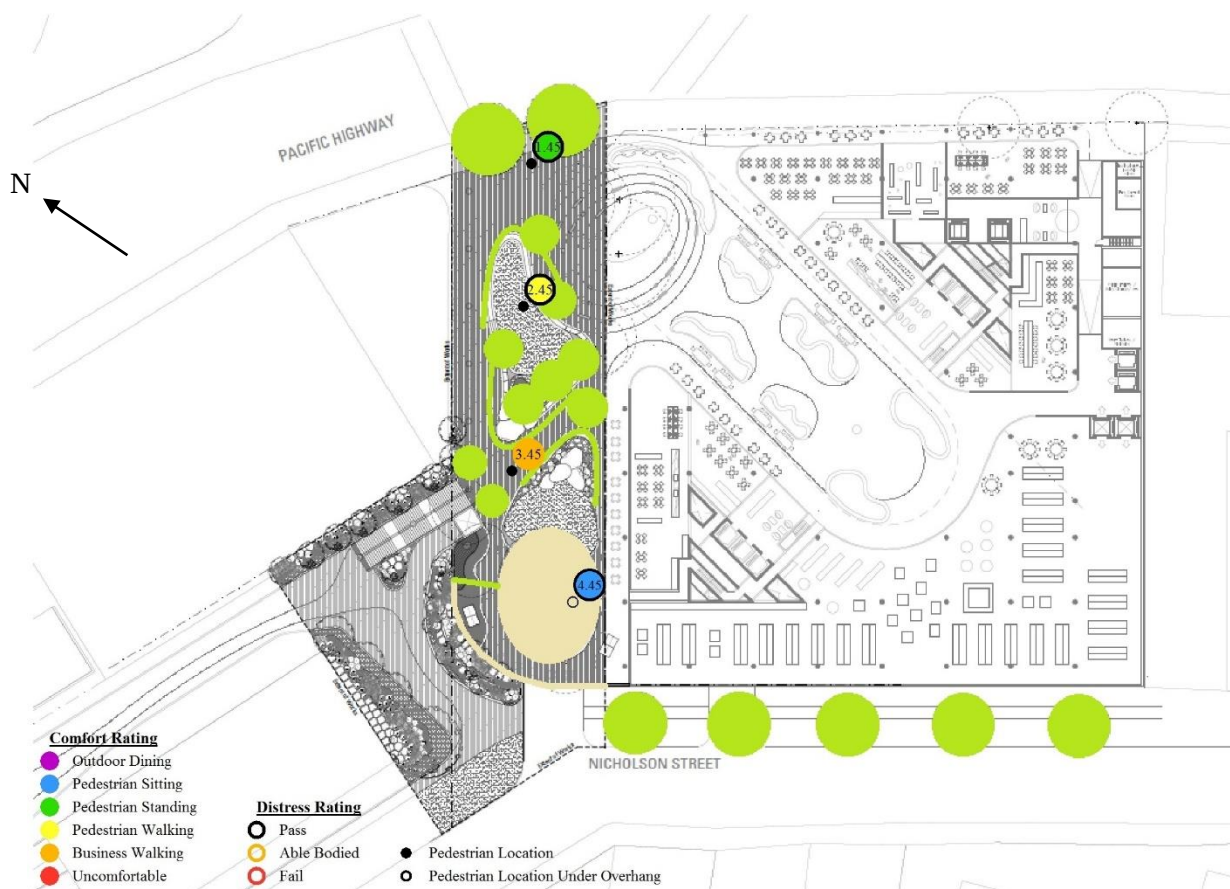
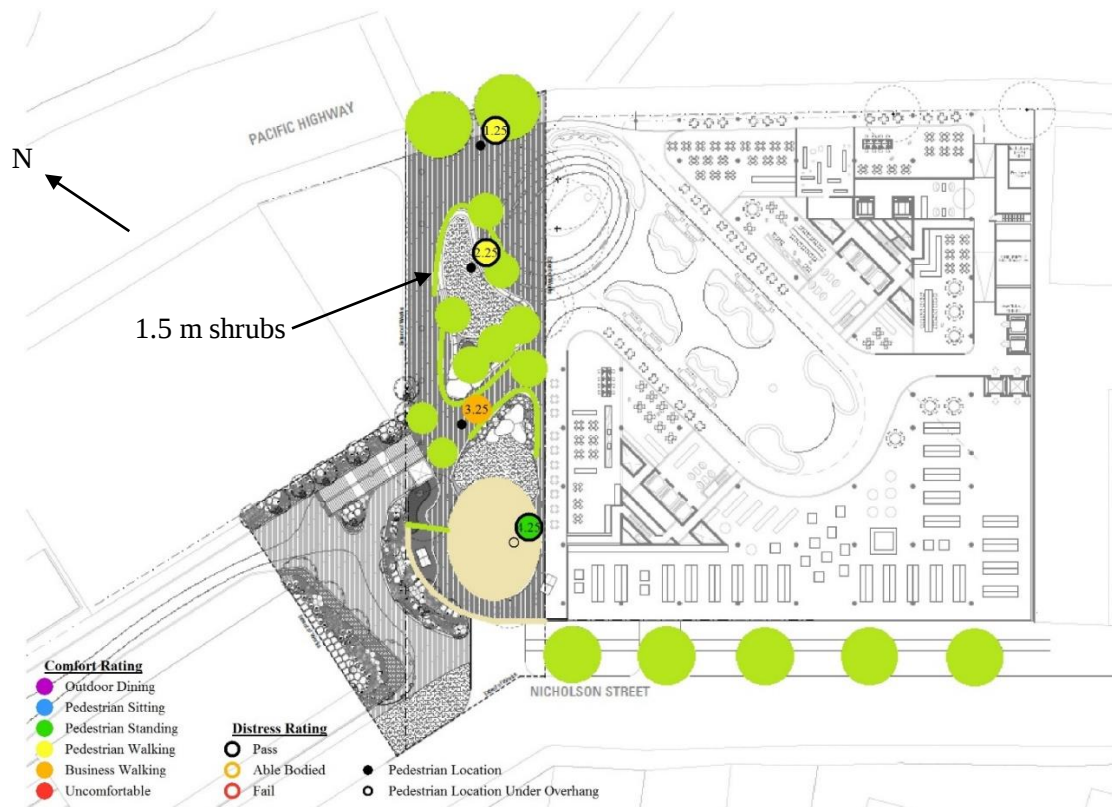
Photographs of the landscaping used in Configurations E and F, as well as the mitigation procedures used in the previous configurations, can be seen in Appendix 1.



Figure 14: Pedestrian wind speed measurements – Configuration 2E



Figure 15: Pedestrian wind speed measurements – Configuration 4E



6. CONCLUSIONS

A wind tunnel study at ground plane of the public domain around the 472-486 Pacific Highway development site was conducted to assess pedestrian wind comfort. The additional wind measurements of winds likely to be experienced by pedestrians were made with a hot-film anemometer at a total of 76 locations for 16 wind directions each. Tests were conducted in various configurations in order to discern the specific impact of building combinations and amelioration effects on the wind conditions along Friedlander Place and Nicholson Lane. The test locations were taken in appropriate locations to study the intended use of the space including outdoor eating areas and pedestrian accessways. The measurements were combined with wind climate statistics to produce results of wind speed versus the percentage of time that wind speed is exceeded for each location.

The proposed developments of 472-486 Pacific Highway and 504 Pacific Highway are expected to have an impact on the wind amenity in Friedlander Place. Without mitigation, the impact of any combination of the larger buildings causes the area to experience windier conditions than existing. Mitigation in the form of vertical screens and the placement of extra trees throughout Friedlander Place has been shown to improve the wind conditions in the area envisioned for an outdoor café. Introducing further mitigation measures involving landscaping along Friedlander Place is also likely to improve wind conditions to a level similar to, or better than, the existing wind environment.

Wind conditions with only the proposed 472 Pacific Highway were generally calmer than the wind conditions with both the proposed 472 and 504 Pacific Highway and appropriate mitigation measures have been shown to improve the wind conditions compared with existing conditions.

7. REFERENCES

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Appendix 1: Additional Photographs of the CPP Wind Tunnel Model



Figure 18: Existing site viewed from the top

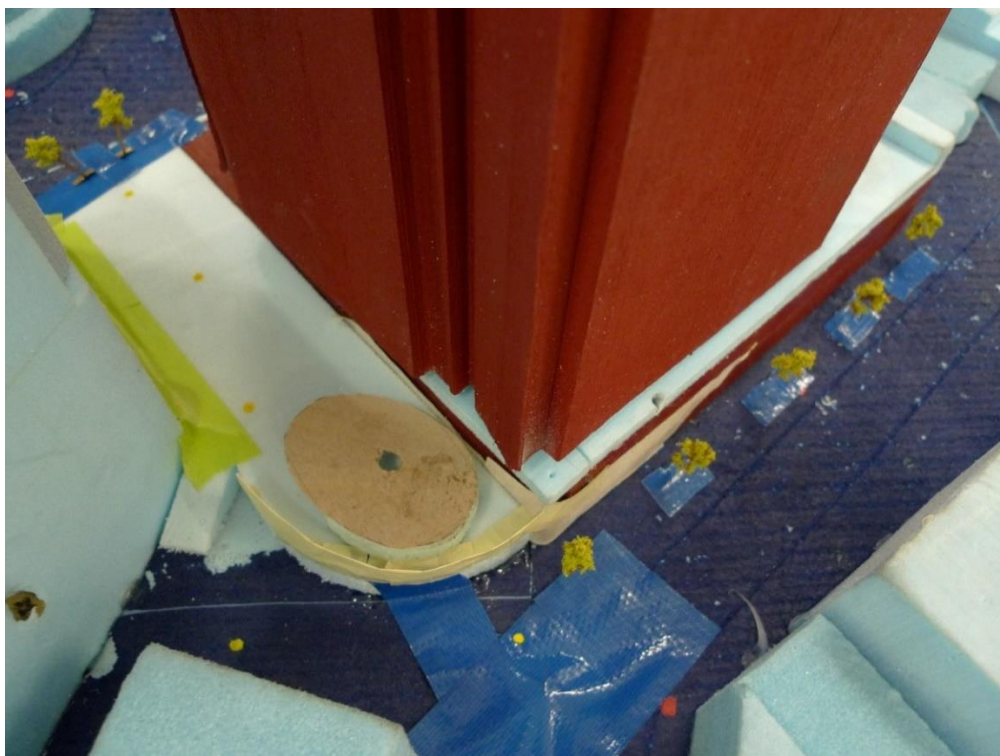


Figure 19: Close up view of Configuration B from the west



Figure 20: Close-up of Configuration C from the south-west



Figure 21: Close-up of Configuration D from the north-east



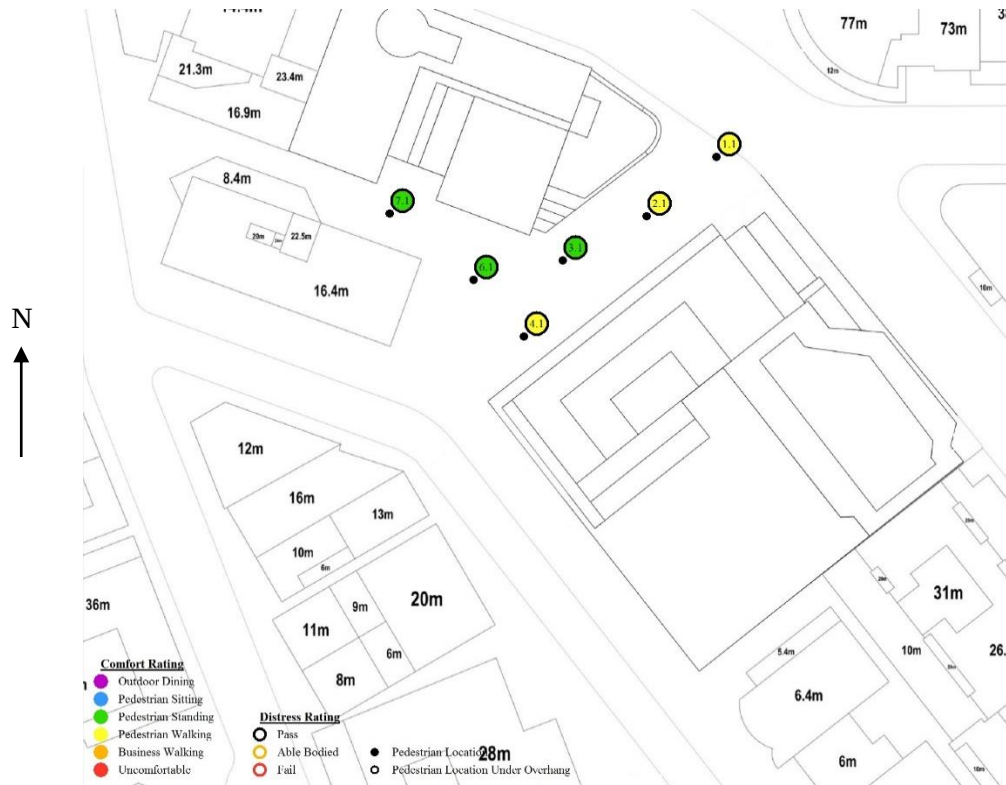
Figure 22: Close-up of Configuration E from the south-west



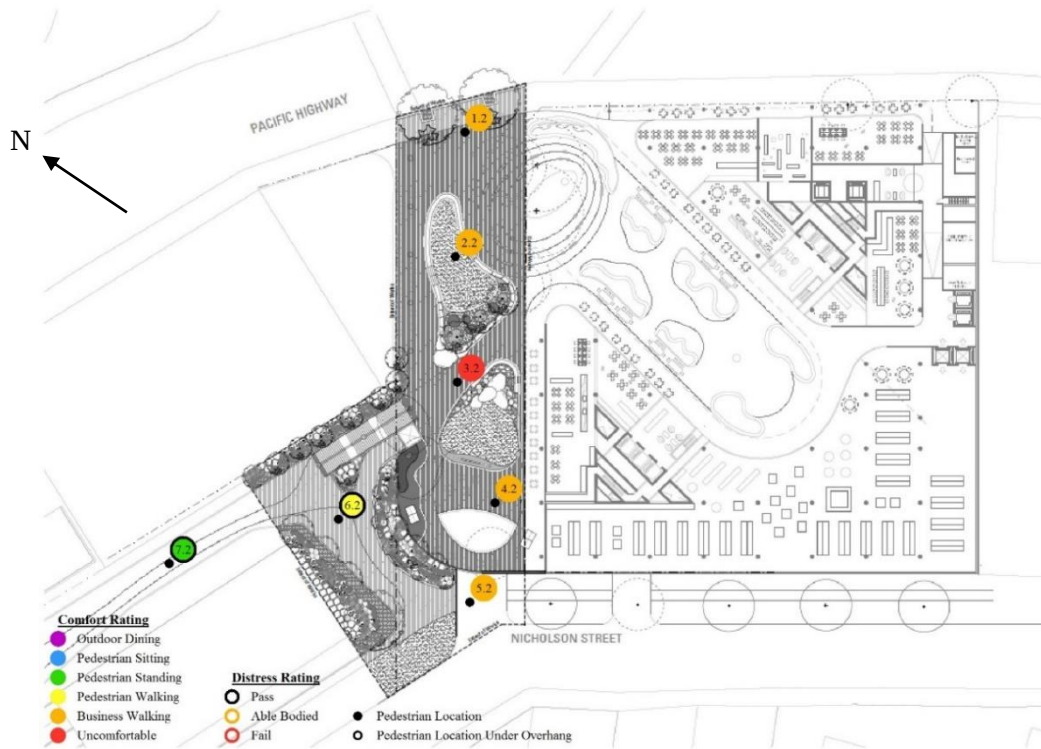
Figure 23: Close-up of Configuration F from the south-west

Appendix 2: Pedestrian Wind Speed Measurements

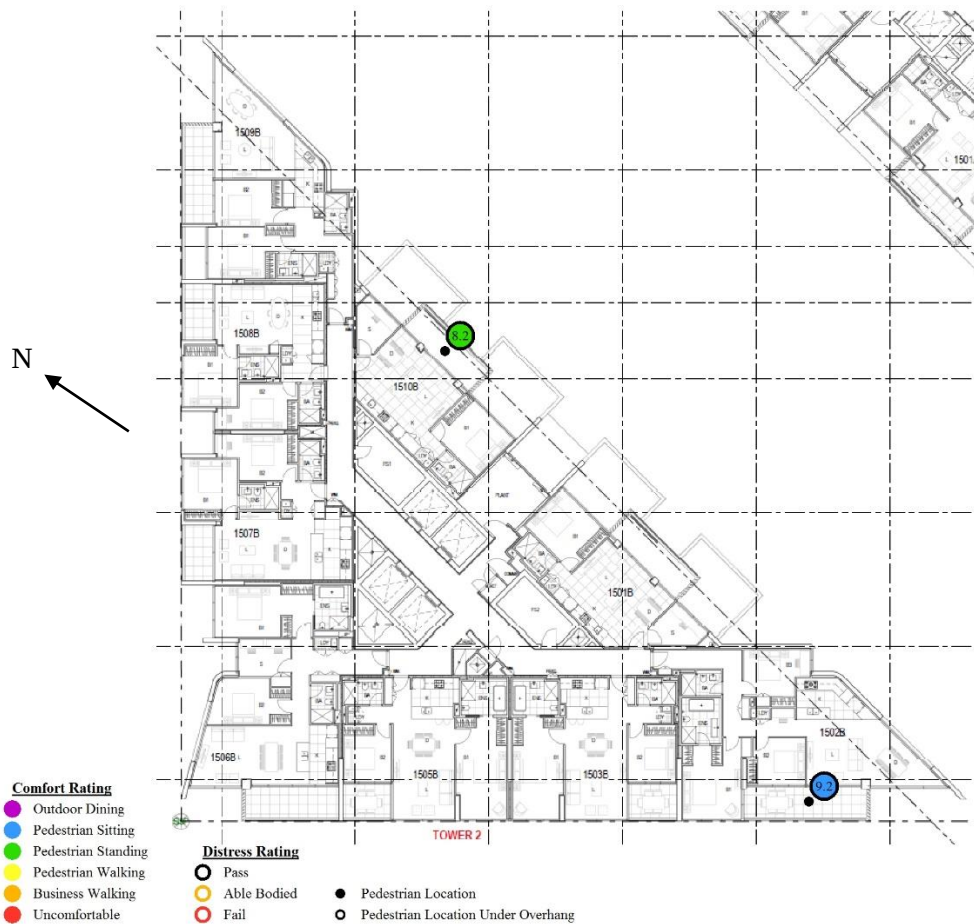
Configuration 1A



Configuration 2A (Ground)



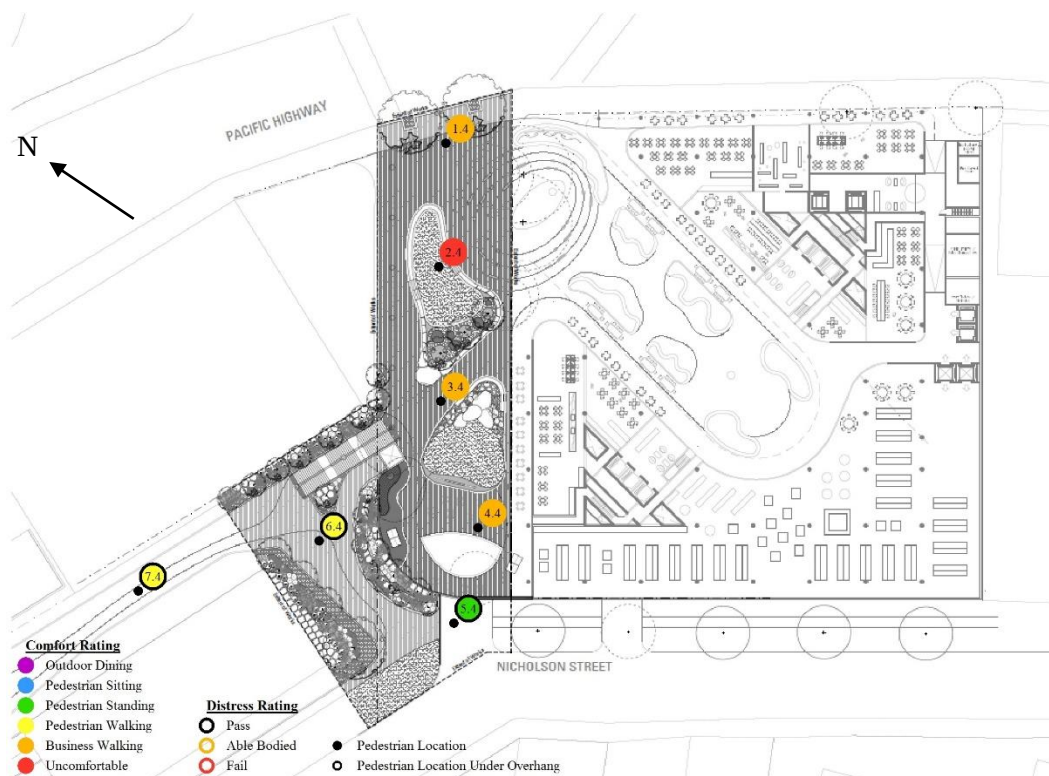
Configuration 2A (Balcony)



Configuration 3A



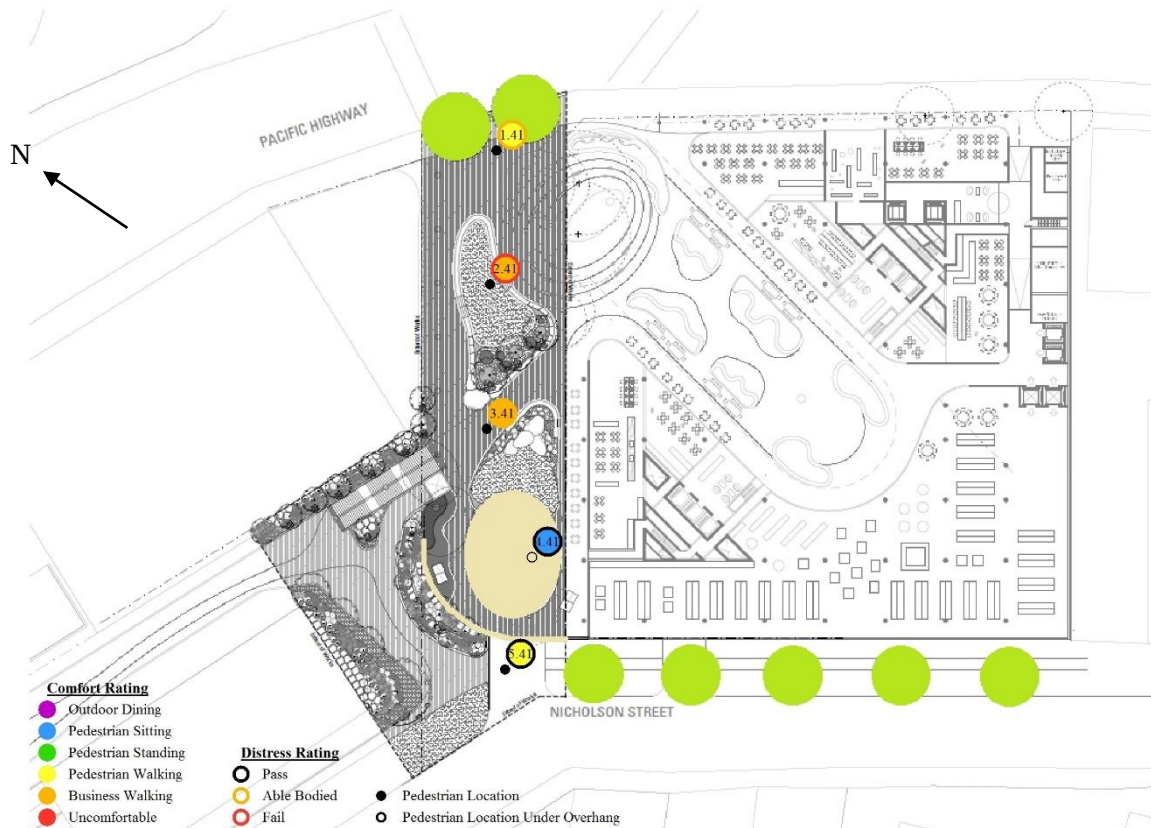
Configuration 4A



Configuration 2B



Configuration 4B



Configuration 2C



Configuration 4C



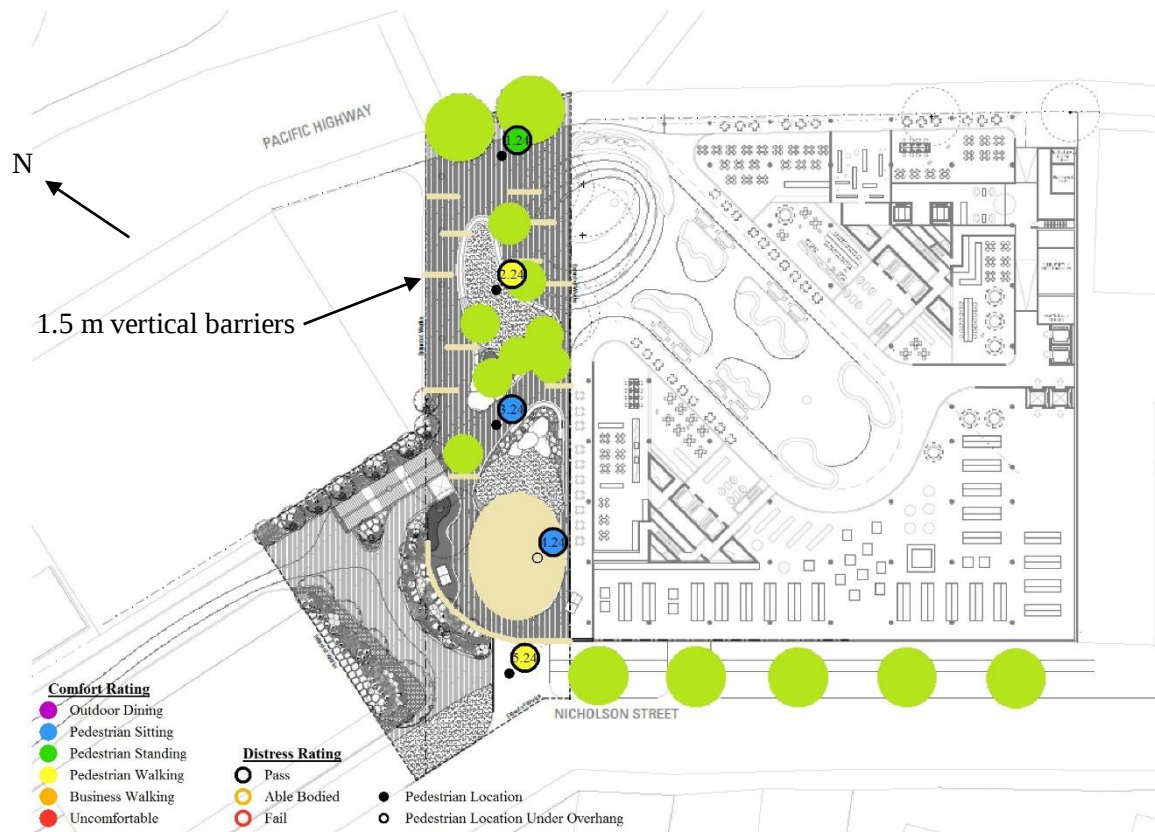
Configuration 2D



Configuration 4D



Configuration 2E



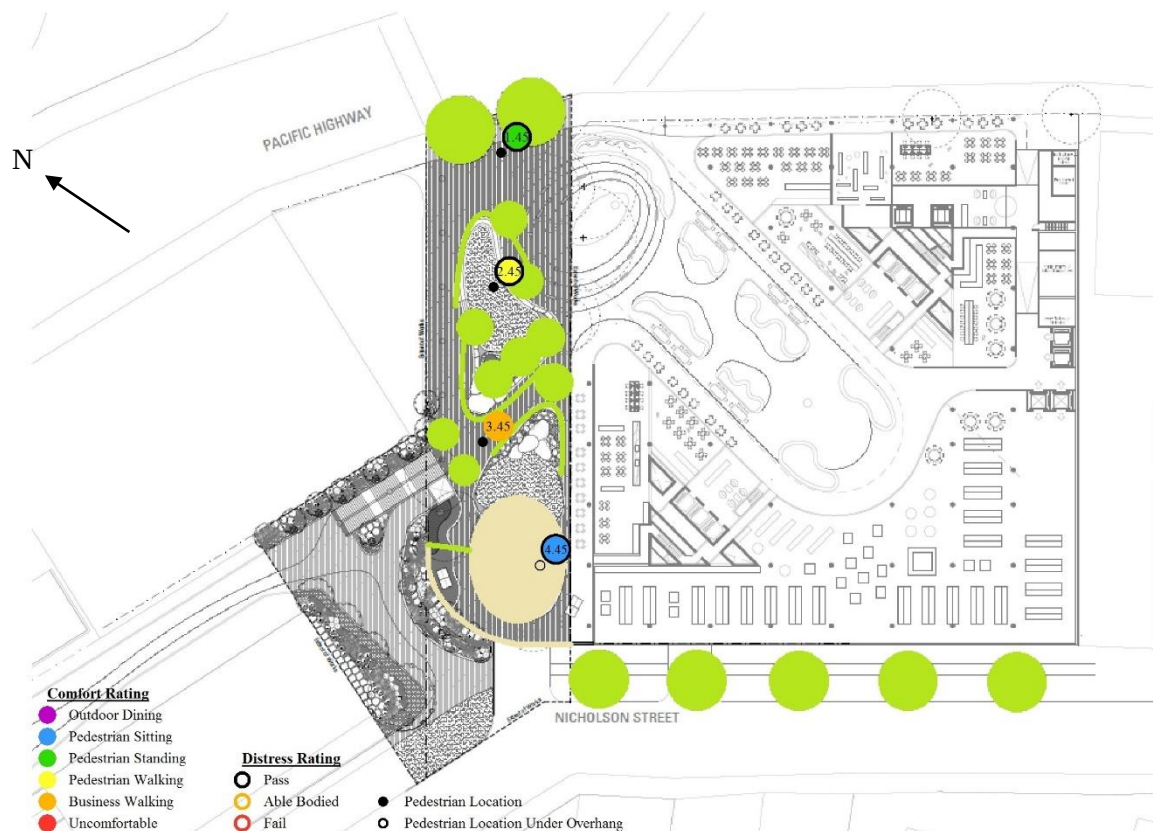
Configuration 4E



Configuration 2F



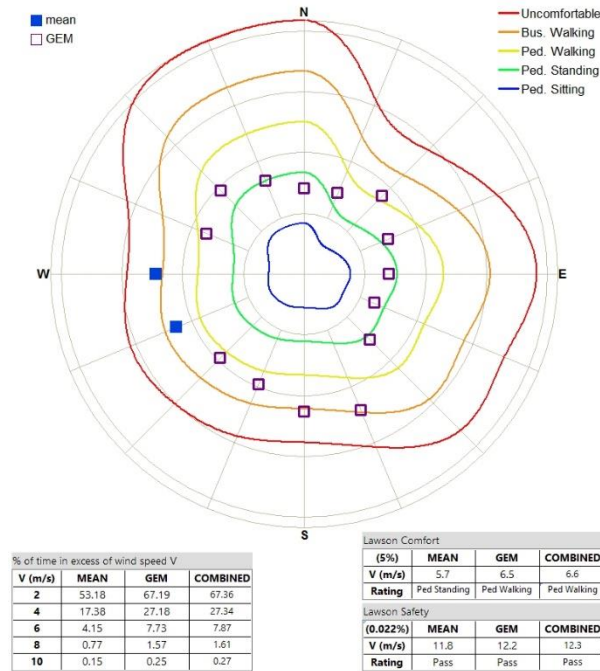
Configuration 4F



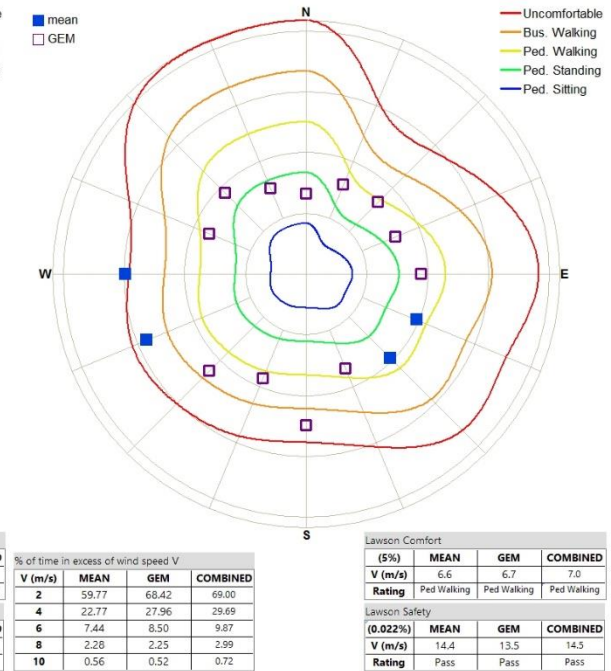
Appendix 3: Directional Wind Results

Configuration 1A

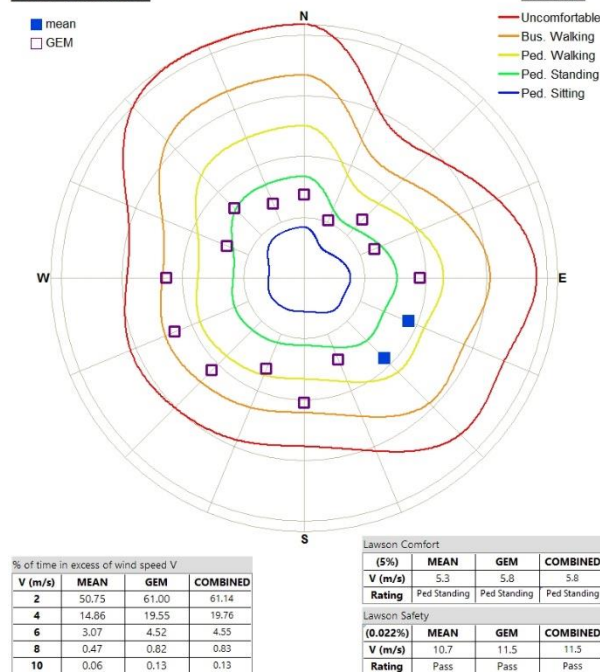
LOCATION 1.1



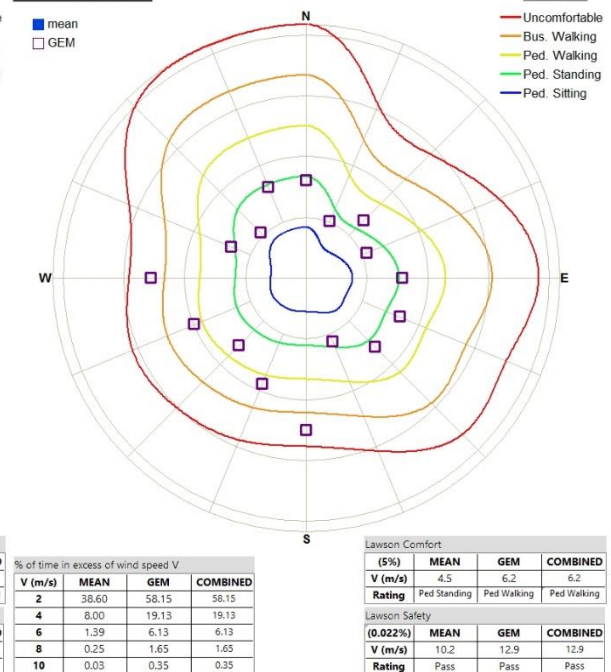
LOCATION 2.1



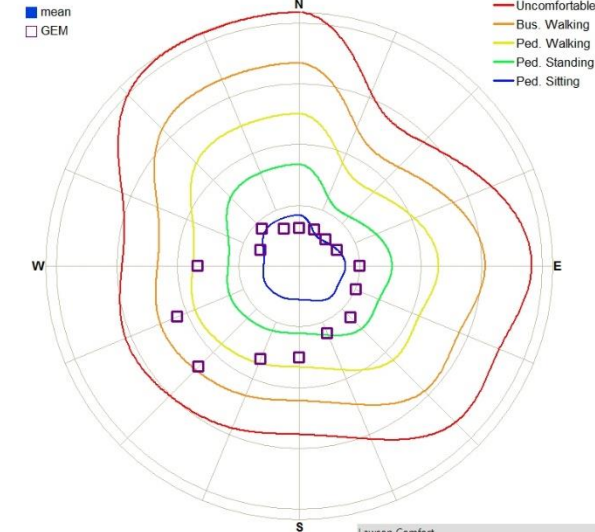
LOCATION 3.1



LOCATION 4.1



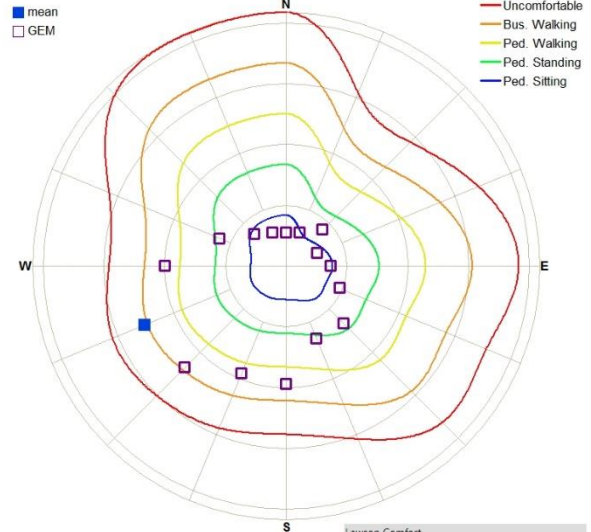
LOCATION 6.1



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	24.67	36.46	36.46
4	4.95	10.07	10.07
6	1.02	2.14	2.14
8	0.15	0.34	0.34
10	0.02	0.06	0.06

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.9	4.9	4.9
Rating	Ped. Sitting	Ped. Standing	Ped. Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.9	10.8	10.8
Rating	Pass	Pass	Pass

LOCATION 7.1

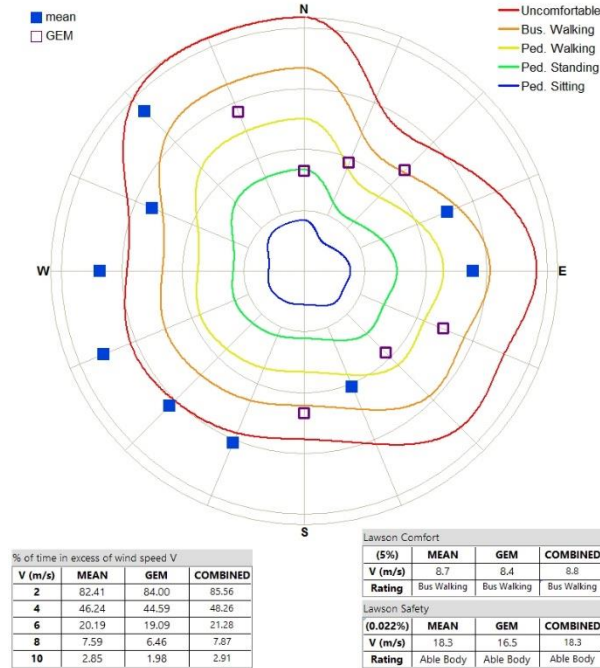


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	31.05	41.43	41.46
4	9.99	15.48	15.62
6	2.38	4.34	4.50
8	0.44	0.77	0.83
10	0.08	0.12	0.14

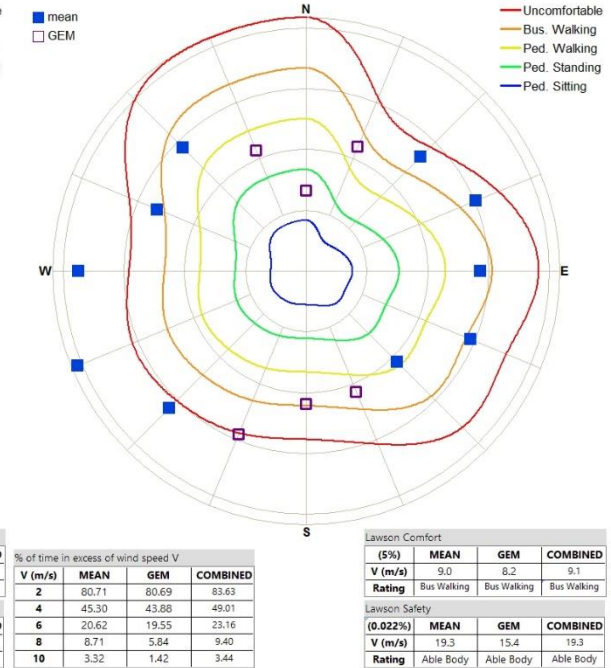
Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.0	5.8	5.8
Rating	Ped. Standing	Ped. Standing	Ped. Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.7	11.7	12.0
Rating	Pass	Pass	Pass

Configuration 2A

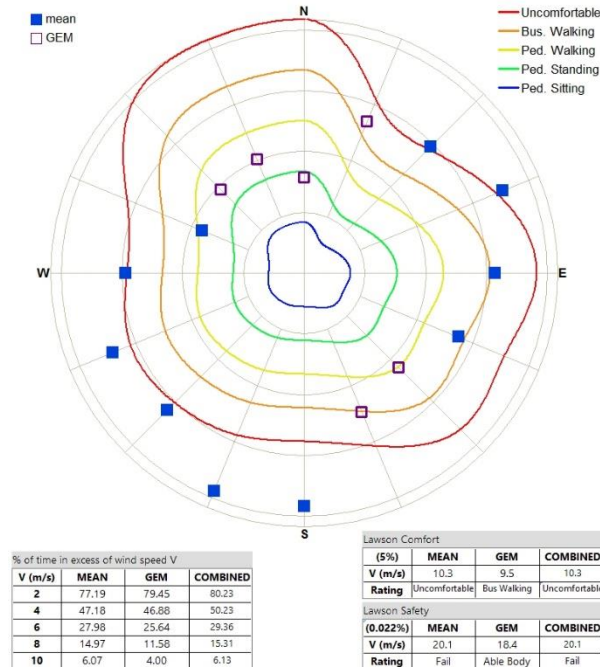
LOCATION 1.2



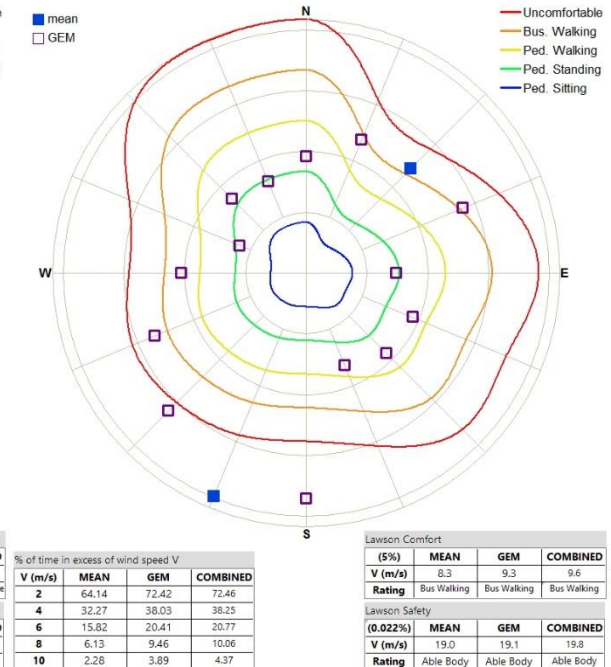
LOCATION 2.2

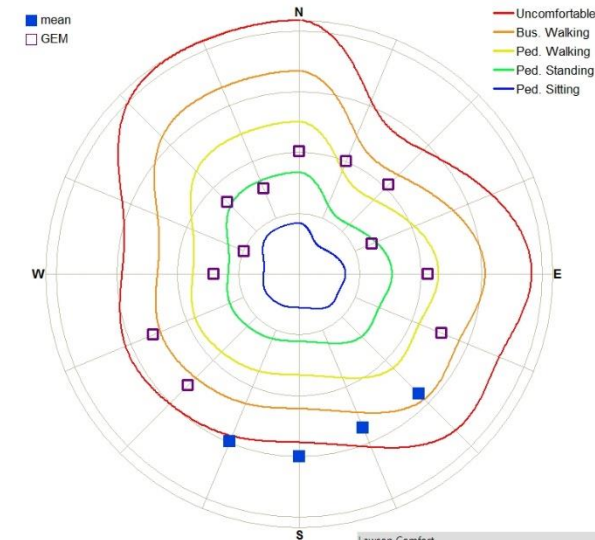


LOCATION 3.2



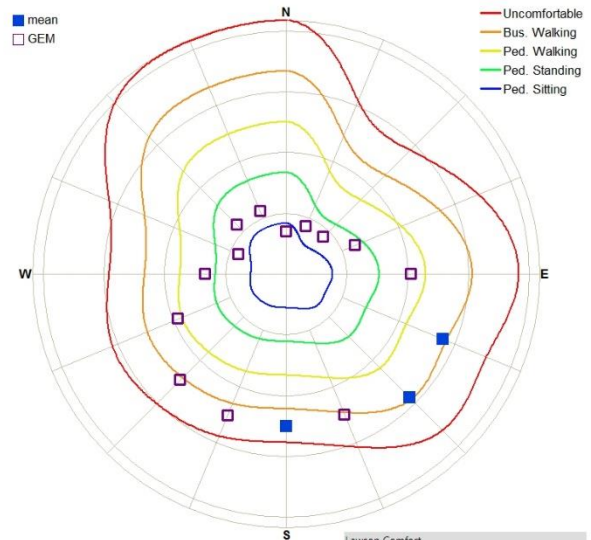
LOCATION 4.2



LOCATION 5.2

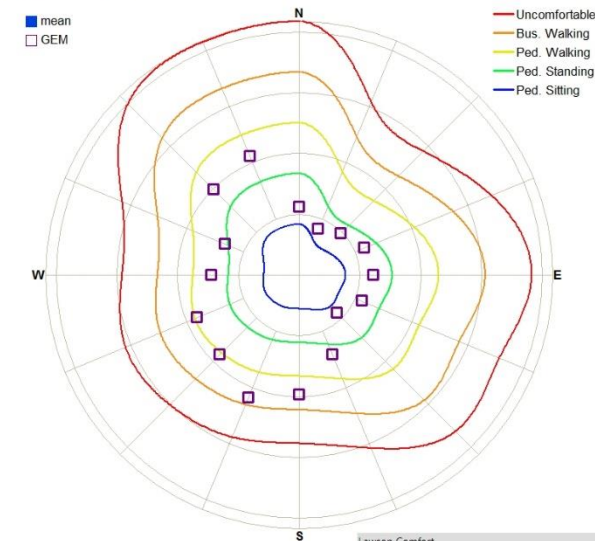
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	62.56	69.33	69.93
4	32.20	35.44	37.68
6	13.68	13.03	16.71
8	4.74	3.14	5.40
10	1.41	0.62	1.53

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.8	7.3	8.1
Rating	Ped Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.5	13.8	15.7
Rating	Able Body	Pass	Able Body

LOCATION 6.2

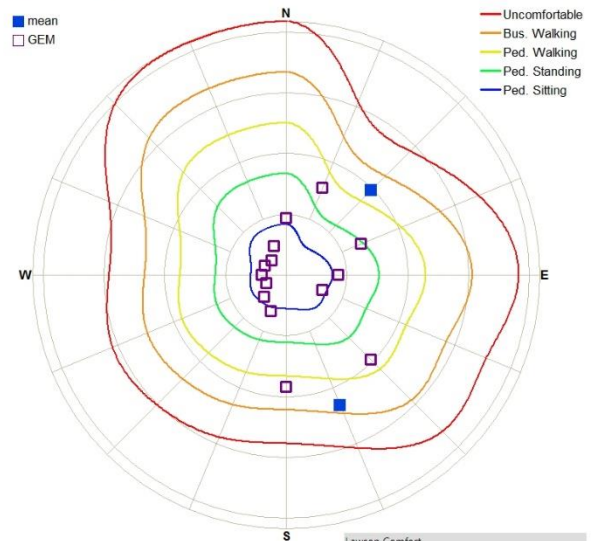
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	45.74	53.91	54.06
4	23.09	26.12	26.84
6	8.89	9.56	10.21
8	2.28	2.41	2.66
10	0.41	0.45	0.49

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.8	6.9	7.0
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.0	13.1	13.2
Rating	Pass	Pass	Pass

LOCATION 7.2

% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	39.87	53.30	53.30
4	8.99	15.43	15.43
6	1.45	3.46	3.46
8	0.15	0.52	0.52
10	0.02	0.07	0.07

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	4.7	5.5	5.5
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.7	11.0	11.0
Rating	Pass	Pass	Pass

LOCATION 8.2

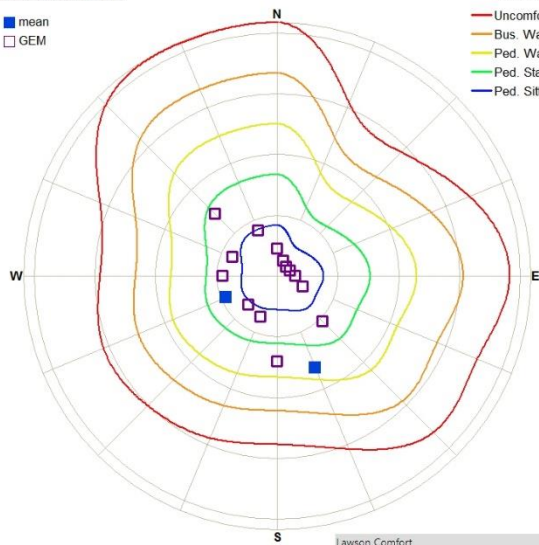
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	31.07	33.69	34.22
4	11.19	13.46	14.56
6	2.33	2.18	3.15
8	0.30	0.21	0.38
10	0.03	0.02	0.04

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.1	5.2	5.5
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.2	9.8	10.4
Rating	Pass	Pass	Pass

LOCATION 9.2

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus. Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

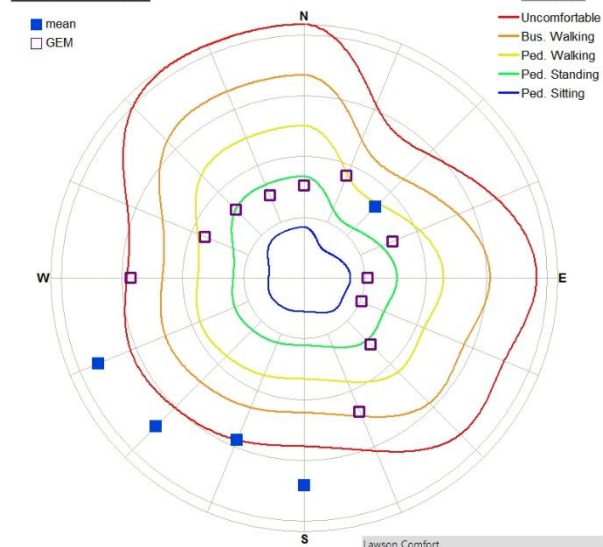


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	17.80	22.51	22.83
4	2.32	3.36	3.69
6	0.16	0.23	0.28
8	0.01	0.01	0.01
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	3.6	3.7
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.3	7.5	7.7
Rating	Pass	Pass	Pass

Configuration 3A

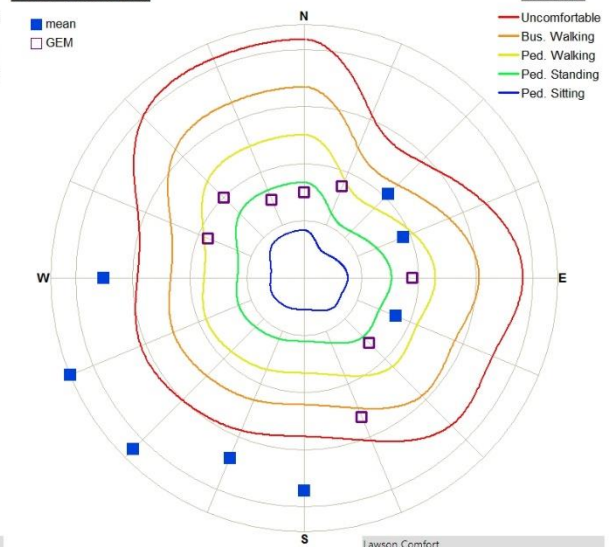
LOCATION 1.3



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	56.93	66.38	66.82
4	31.47	34.03	35.67
6	16.29	15.45	17.83
8	8.19	5.91	8.67
10	3.26	1.87	3.39

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	9.0	8.2	9.1
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.0	16.1	18.1
Rating	Able Body	Able Body	Able Body

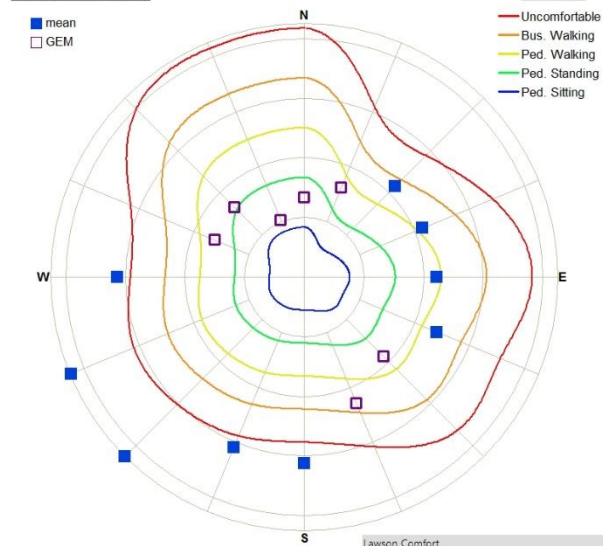
LOCATION 2.3



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	69.03	72.78	73.62
4	39.85	38.49	41.61
6	22.65	18.49	23.21
8	12.77	7.92	12.91
10	6.54	2.95	6.58

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	10.6	8.9	10.8
Rating	Uncomfortable	Bus Walking	Uncomfortable
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	21.2	17.3	21.2
Rating	Fail	Able Body	Fail

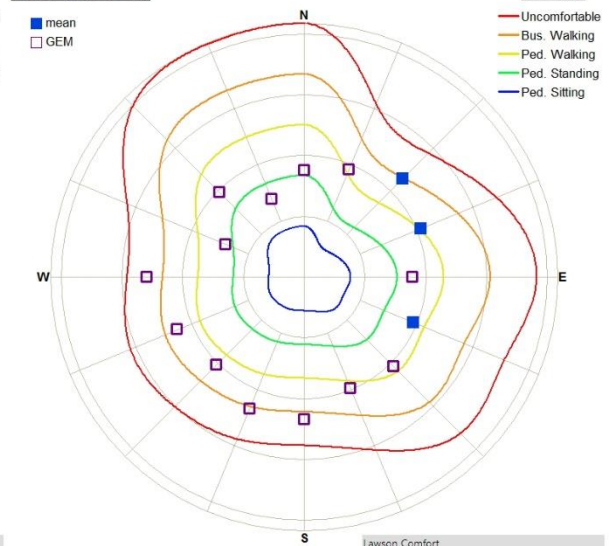
LOCATION 3.3



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	66.63	69.63	70.74
4	38.47	37.65	41.46
6	20.05	16.28	20.95
8	9.51	6.48	9.69
10	4.27	2.22	4.29

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	9.6	8.4	9.6
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	20.3	17.0	20.3
Rating	Fail	Able Body	Fail

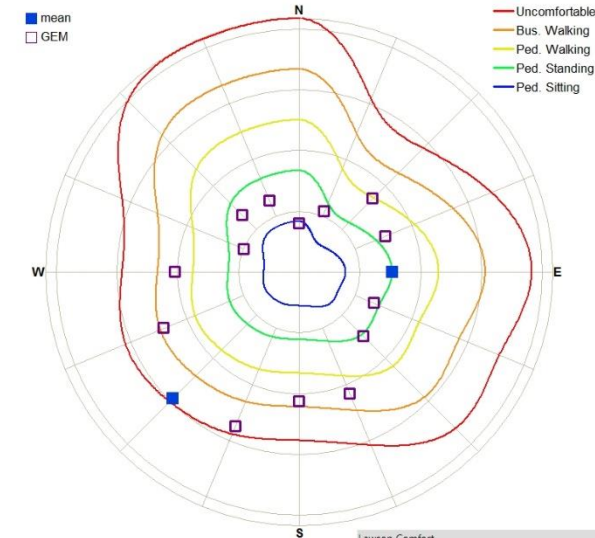
LOCATION 4.3



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	63.62	71.39	71.73
4	27.25	33.03	33.74
6	7.35	9.88	10.82
8	1.21	2.08	2.33
10	0.14	0.38	0.40

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.4	6.9	7.0
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.4	12.9	12.9
Rating	Pass	Pass	Pass

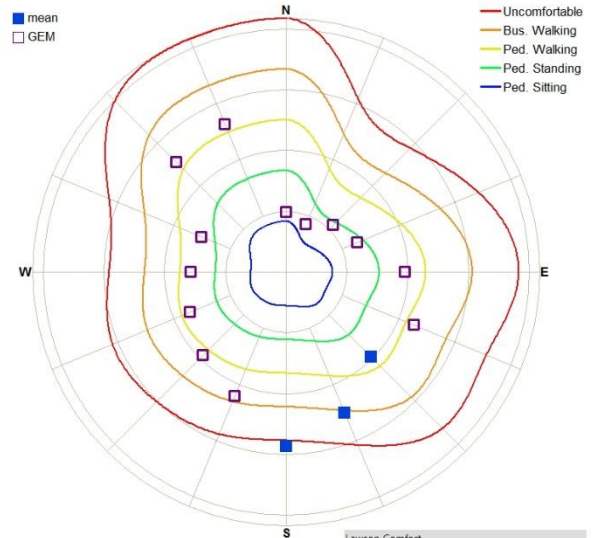
LOCATION 6.3



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	49.87	58.90	59.06
4	19.97	25.59	25.79
6	6.71	8.62	8.77
8	1.64	2.13	2.25
10	0.39	0.47	0.52

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.4	6.8	6.8
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.6	13.7	14.0
Rating	Pass	Pass	Pass

LOCATION 7.3

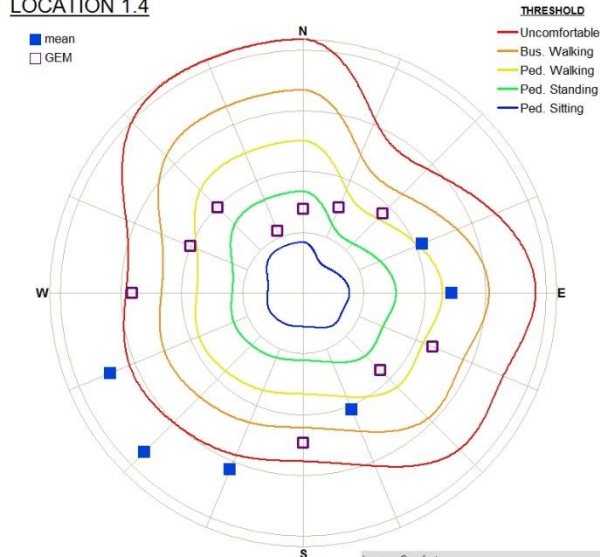


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	56.53	66.95	67.56
4	21.55	24.54	26.57
6	8.46	7.09	9.75
8	2.72	1.58	3.01
10	0.72	0.27	0.80

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.9	6.4	7.1
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.4	12.7	14.3
Rating	Pass	Pass	Pass

Configuration 4A

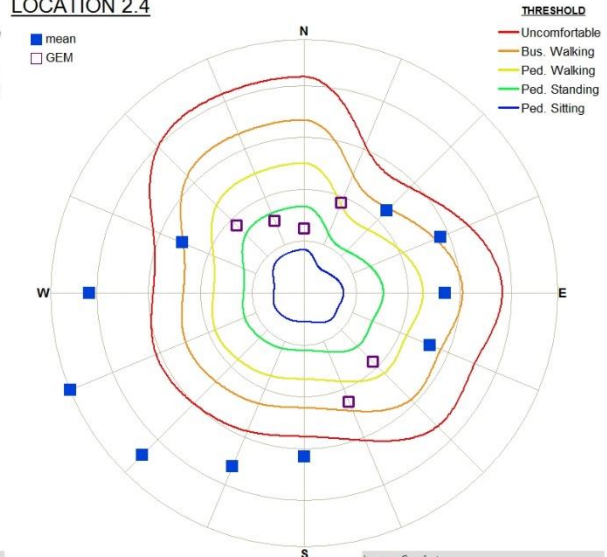
LOCATION 1.4



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	65.98	71.87	72.28
4	34.79	36.76	38.08
6	14.35	14.73	15.84
8	5.75	5.33	6.27
10	2.02	1.70	2.19

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.2	8.0	8.4
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	17.2	16.3	17.3
Rating	Able Body	Able Body	Able Body

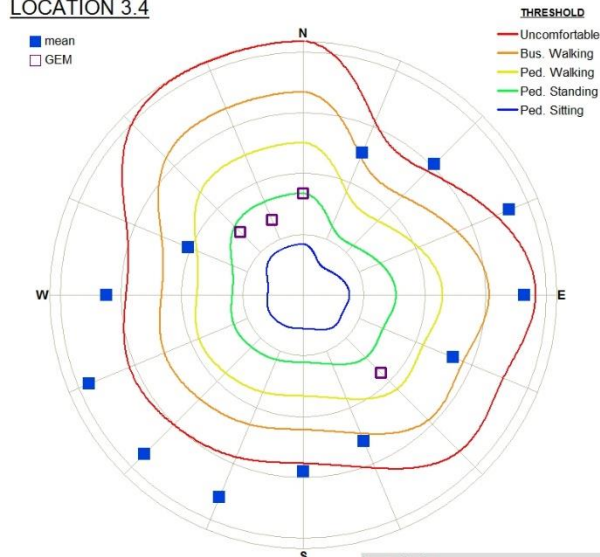
LOCATION 2.4



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	72.01	74.84	76.46
4	45.69	43.60	47.81
6	25.91	21.13	26.67
8	13.35	8.91	13.48
10	6.88	3.40	6.90

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	10.8	9.1	10.8
Rating	Uncomfortable	Bus Walking	Uncomfortable
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	23.2	18.1	23.2
Rating	Fail	Able Body	Fail

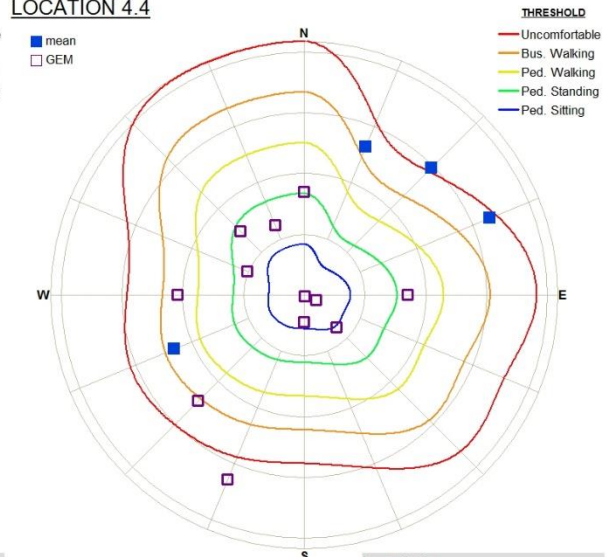
LOCATION 3.4



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	72.75	73.68	75.96
4	46.05	44.49	49.11
6	28.62	23.10	28.70
8	13.90	8.14	13.91
10	4.89	2.19	4.89

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	9.9	8.7	9.9
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.8	16.2	18.8
Rating	Able Body	Able Body	Able Body

LOCATION 4.4

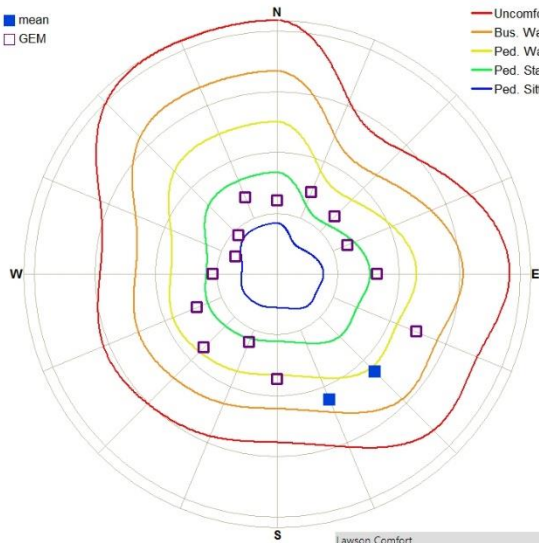


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	40.93	46.90	47.55
4	24.11	24.28	23.45
6	13.27	12.10	13.68
8	5.41	3.90	5.64
10	1.36	0.94	1.46

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.1	7.5	8.1
Rating	Bus Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.3	15.6	15.6
Rating	Able Body	Able Body	Able Body

LOCATION 5.4

■ mean
□ GEM

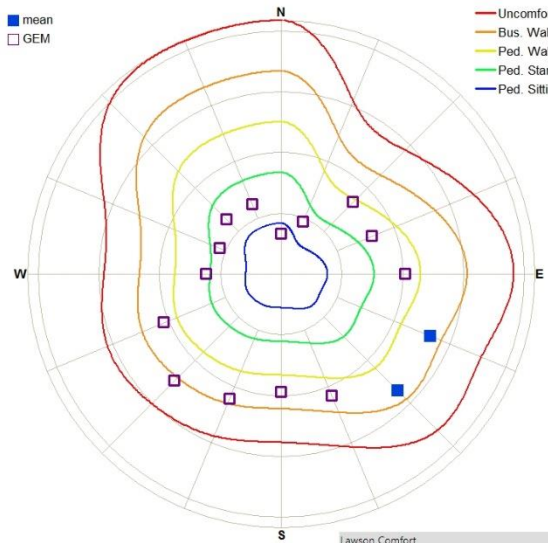


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	42.94	52.86	53.13
4	12.27	15.45	16.51
6	2.05	2.20	2.68
8	0.26	0.24	0.34
10	0.02	0.02	0.03

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.0	5.2	5.3
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.1	9.8	10.3
Rating	Pass	Pass	Pass

LOCATION 6.4

■ mean
□ GEM

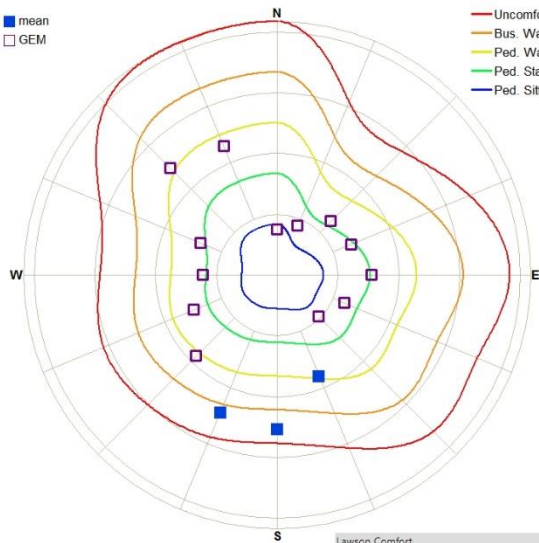


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	47.95	57.85	58.00
4	16.82	26.42	27.15
6	2.74	6.26	6.72
8	0.38	1.01	1.15
10	0.04	0.15	0.16

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.3	6.2	6.3
Rating	Ped Standing	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.5	11.7	11.8
Rating	Pass	Pass	Pass

LOCATION 7.4

■ mean
□ GEM

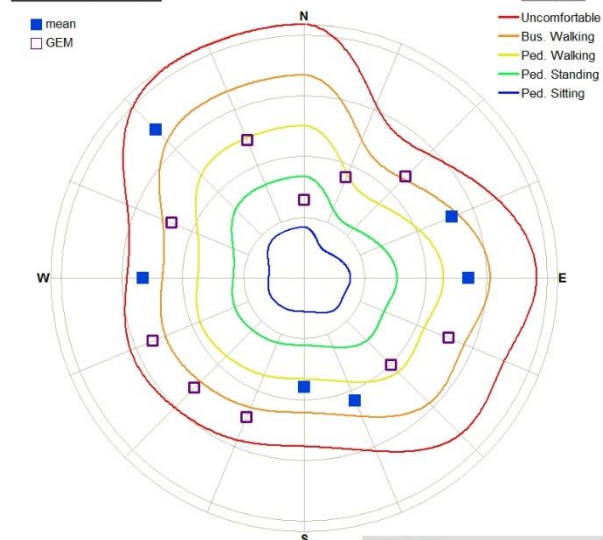


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	47.62	57.96	58.63
4	15.86	17.14	19.33
6	6.15	4.06	6.71
8	1.73	0.71	1.85
10	0.35	0.12	0.38

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.3	5.7	6.4
Rating	Ped Walking	Ped Standing	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.1	11.8	13.2
Rating	Pass	Pass	Pass

Configuration 2B

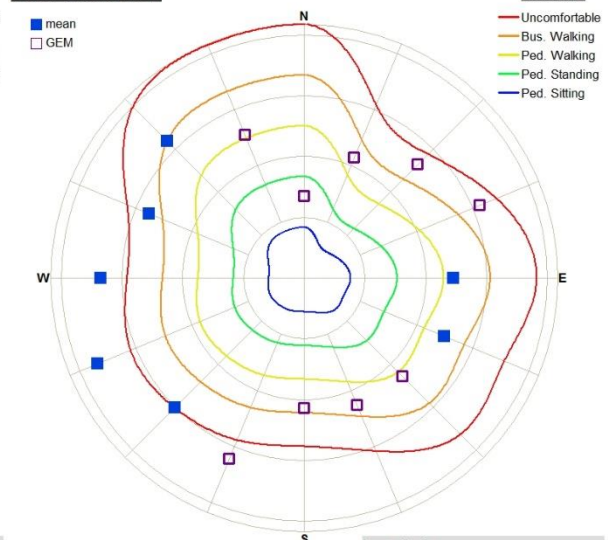
LOCATION 1.21



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	78.25	80.32	81.69
4	37.92	38.50	41.00
6	12.39	13.62	14.93
8	2.90	3.35	3.84
10	0.71	0.72	0.90

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.2	7.4	7.5
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.5	14.1	15.7
Rating	Able Body	Pass	Able Body

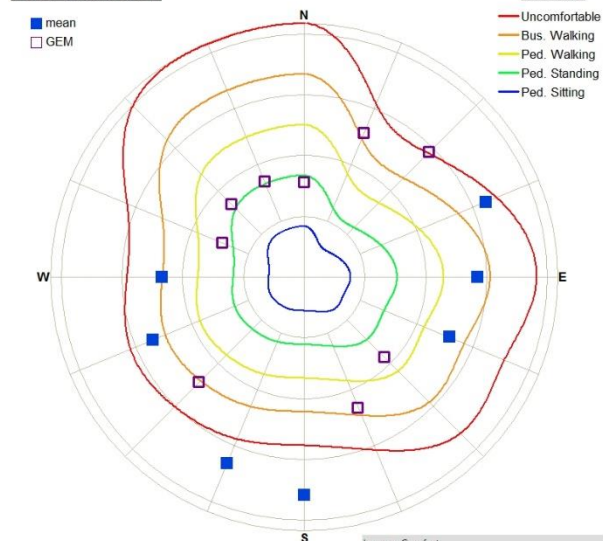
LOCATION 2.21



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	81.09	83.01	84.89
4	43.56	45.28	49.21
6	18.14	20.30	22.72
8	6.90	6.58	8.90
10	2.35	1.67	3.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.5	8.4	8.9
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	17.6	16.0	17.8
Rating	Able Body	Able Body	Able Body

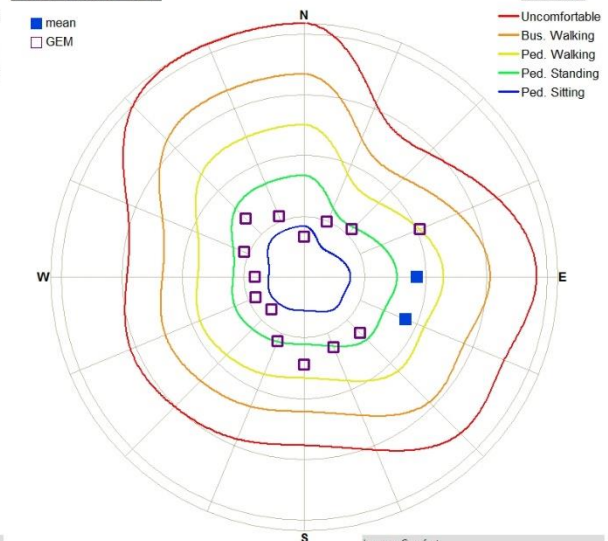
LOCATION 3.21



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	69.46	74.69	75.37
4	40.69	42.23	43.95
6	21.96	21.39	23.55
8	9.85	8.68	10.49
10	3.43	2.58	3.55

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	9.2	8.9	9.3
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.1	16.8	18.1
Rating	Able Body	Able Body	Able Body

LOCATION 4.21



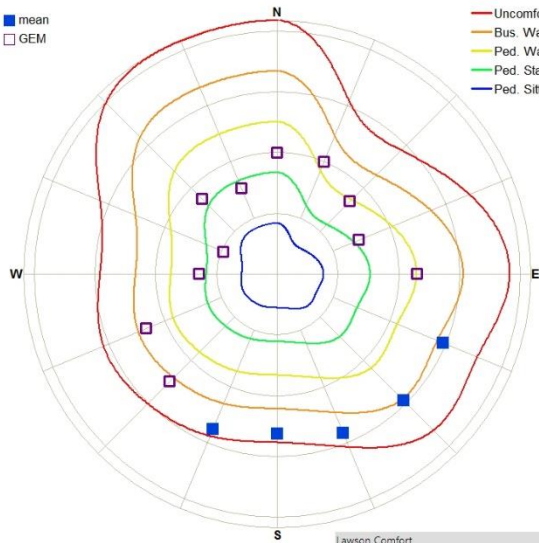
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	33.40	41.91	42.05
4	3.78	6.46	6.61
6	0.16	0.43	0.46
8	0.00	0.01	0.01
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.7	4.2	4.2
Rating	Ped Sitting	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.1	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 5.21

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus. Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

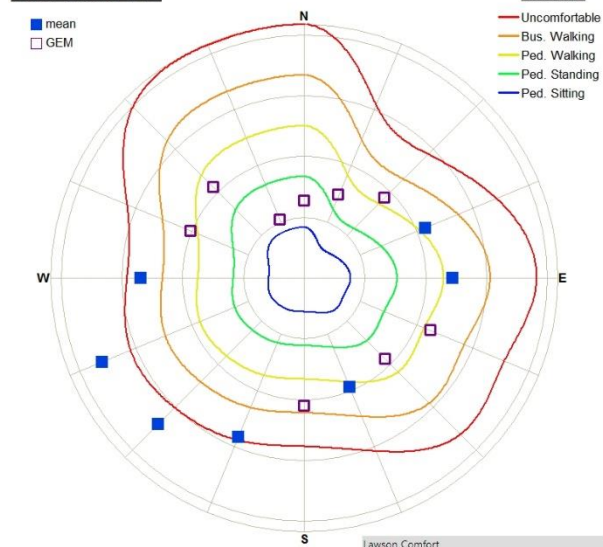


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	61.13	68.41	69.12
4	30.31	33.80	36.50
6	12.35	10.15	14.20
8	3.72	2.05	4.03
10	0.85	0.34	0.91

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.5	6.9	7.6
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.1	12.6	14.3
Rating	Pass	Pass	Pass

Configuration 4B

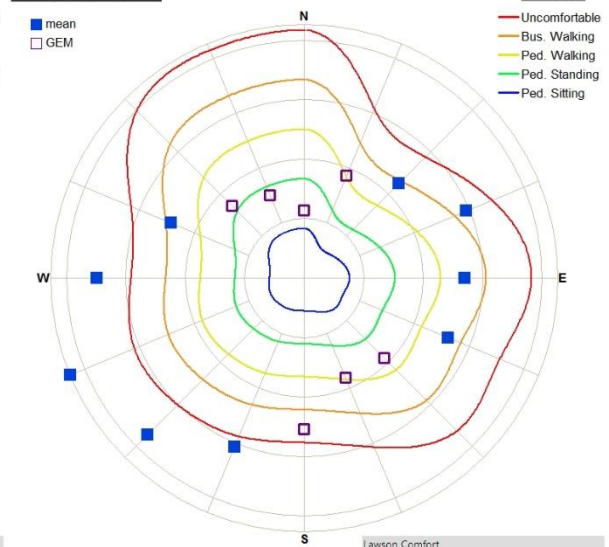
LOCATION 1.41



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	65.34	71.37	72.00
4	32.80	33.87	36.06
6	11.92	11.70	13.36
8	4.60	3.28	4.93
10	1.64	0.83	1.68

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.8	7.3	7.9
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	17.0	14.6	17.0
Rating	Able Body	Pass	Able Body

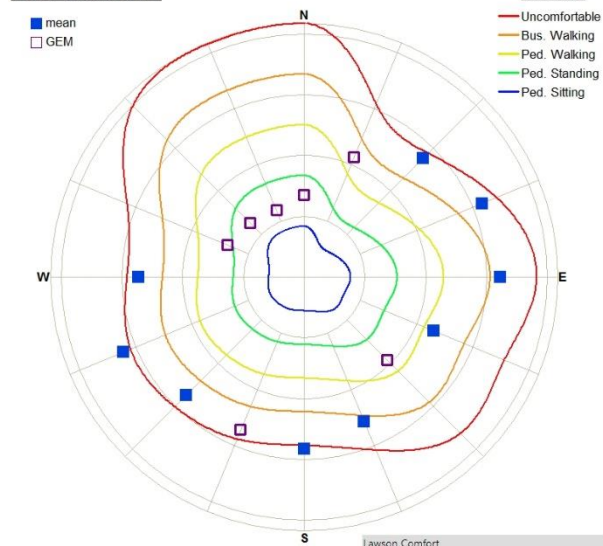
LOCATION 2.41



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	68.89	72.90	74.49
4	40.02	39.69	43.31
6	20.03	17.16	21.24
8	8.61	5.72	8.97
10	3.55	1.62	3.66

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	9.2	8.2	9.2
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	20.1	16.1	20.1
Rating	Fail	Able Body	Fail

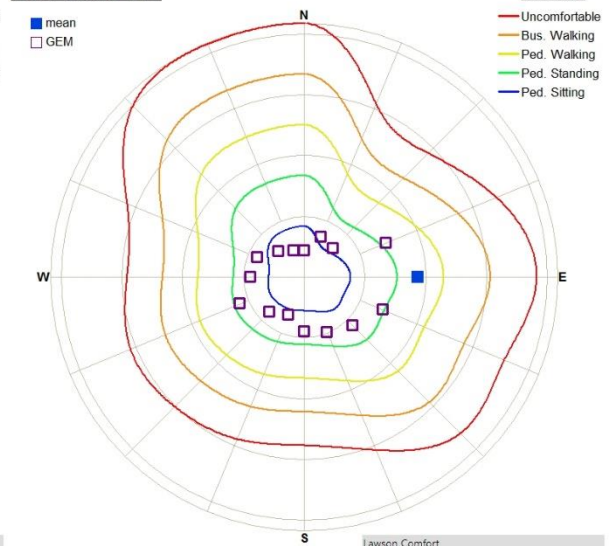
LOCATION 3.41



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	67.64	69.40	70.15
4	42.12	40.31	42.93
6	21.48	18.75	21.81
8	7.53	5.49	7.68
10	1.89	1.22	1.94

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.6	8.1	8.6
Rating	Bus Walking	Bus Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.6	14.8	15.6
Rating	Able Body	Pass	Able Body

LOCATION 4.41



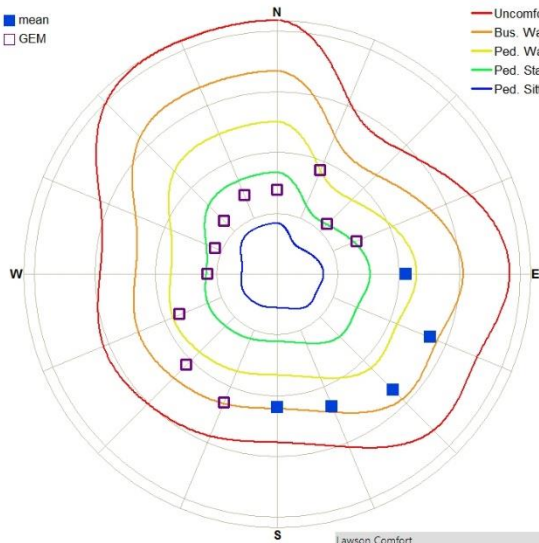
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	14.50	25.48	25.33
4	0.73	1.41	1.49
6	0.03	0.04	0.04
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	2.7	3.2	3.3
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.2	6.3	6.4
Rating	Pass	Pass	Pass

LOCATION 5.41

■ mean
□ GEM

THRESHOLD
 — Uncomfortable
 — Bus. Walking
 — Ped. Walking
 — Ped. Standing
 — Ped. Sitting

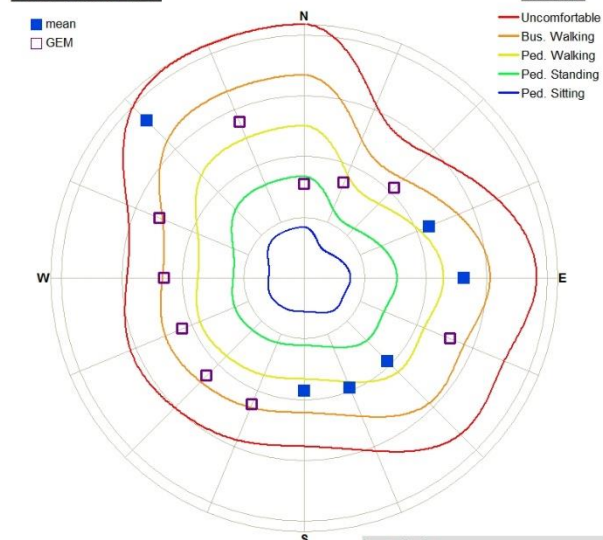


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	51.00	60.30	60.69
4	22.64	25.63	27.14
6	6.29	6.10	7.36
8	1.19	0.98	1.40
10	0.16	0.13	0.19

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.3	6.2	6.5
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.6	11.5	11.9
Rating	Pass	Pass	Pass

Configuration 2C

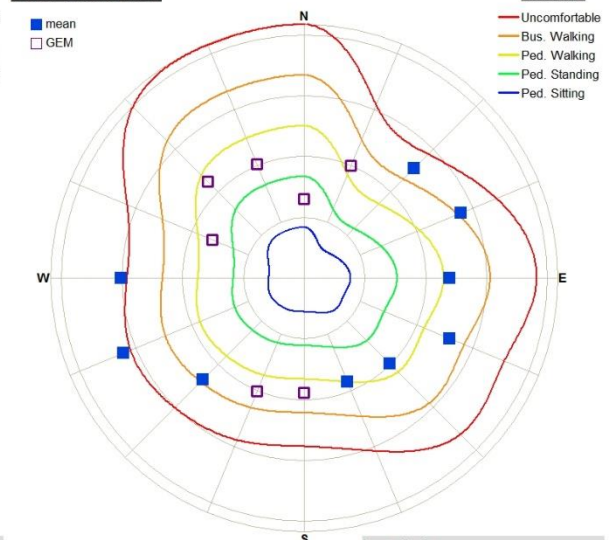
LOCATION 1.22



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	77.19	80.40	81.69
4	34.30	35.29	37.97
6	8.91	9.66	10.94
8	1.89	2.14	2.47
10	0.52	0.47	0.68

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.7	6.8	7.0
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	16.1	13.9	16.2
Rating	Able Body	Pass	Able Body

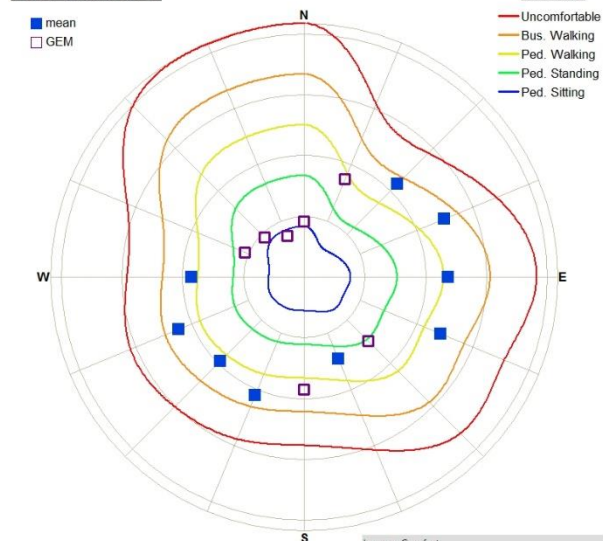
LOCATION 2.22



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	71.47	75.58	76.17
4	32.20	34.91	37.38
6	12.01	11.94	14.15
8	3.62	2.61	3.87
10	0.93	0.51	0.95

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.4	7.1	7.5
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.3	13.4	15.3
Rating	Able Body	Pass	Able Body

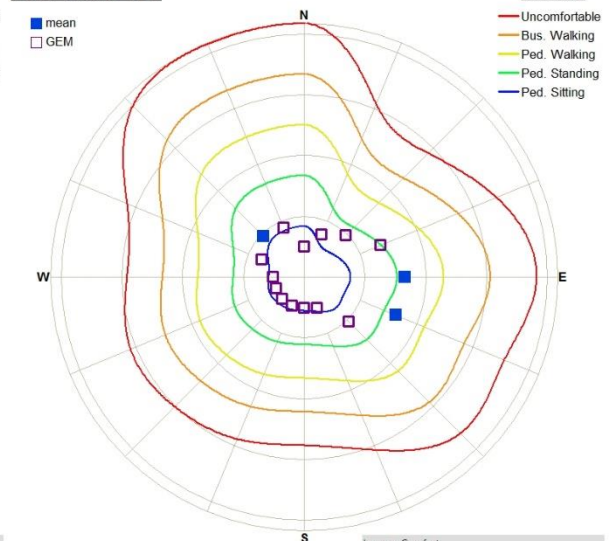
LOCATION 3.22



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	58.49	56.93	59.69
4	25.87	21.86	26.51
6	6.66	4.18	6.83
8	0.86	0.38	0.88
10	0.08	0.03	0.08

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.3	5.8	6.3
Rating	Ped Walking	Ped Standing	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.9	10.1	10.9
Rating	Pass	Pass	Pass

LOCATION 4.22



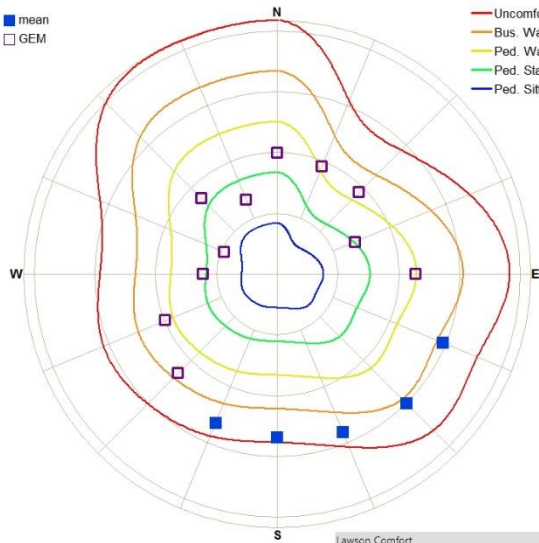
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	13.00	15.39	16.44
4	0.91	0.52	1.00
6	0.04	0.00	0.04
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	2.8	2.8	3.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.2	5.4	6.2
Rating	Pass	Pass	Pass

LOCATION 5.22

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus. Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

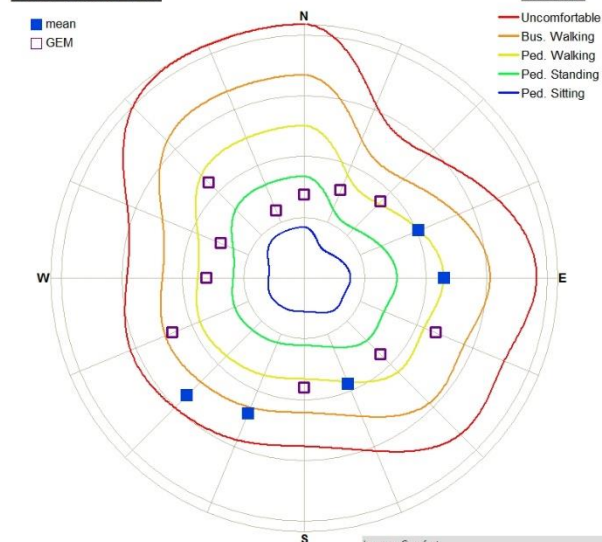


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	61.10	66.82	67.56
4	30.91	32.83	35.69
6	12.28	9.54	13.87
8	3.66	1.78	3.87
10	0.85	0.26	0.88

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.4	6.8	7.6
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.1	12.3	14.1
Rating	Pass	Pass	Pass

Configuration 4C

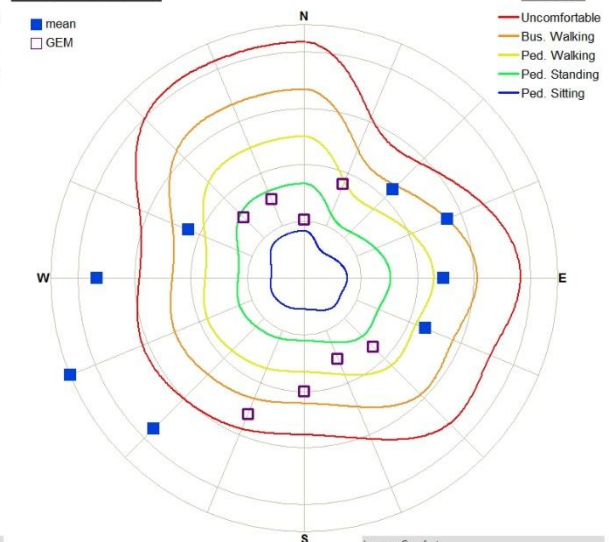
LOCATION 1.42



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	59.93	66.03	66.65
4	24.61	26.78	28.30
6	5.43	5.76	6.87
8	1.02	0.90	1.27
10	0.20	0.14	0.25

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.0	6.1	6.3
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.5	11.9	12.8
Rating	Pass	Pass	Pass

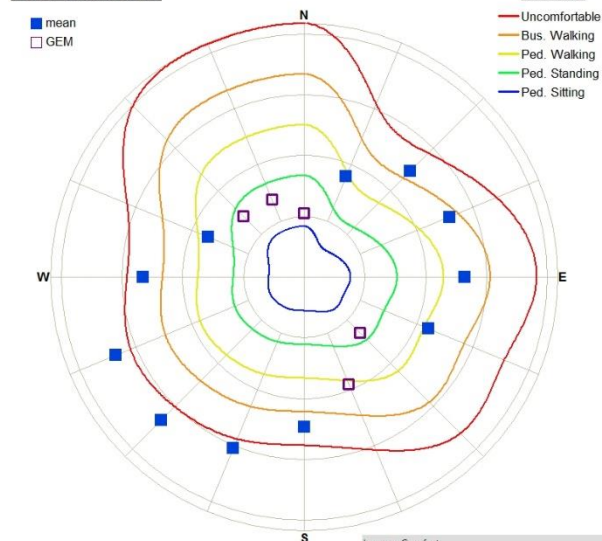
LOCATION 2.42



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	66.15	70.21	71.48
4	33.88	34.99	38.42
6	15.35	13.13	16.93
8	6.96	4.45	7.20
10	3.41	1.45	3.45

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.8	7.7	8.9
Rating	Bus Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	21.1	16.4	21.1
Rating	Fail	Able Body	Fail

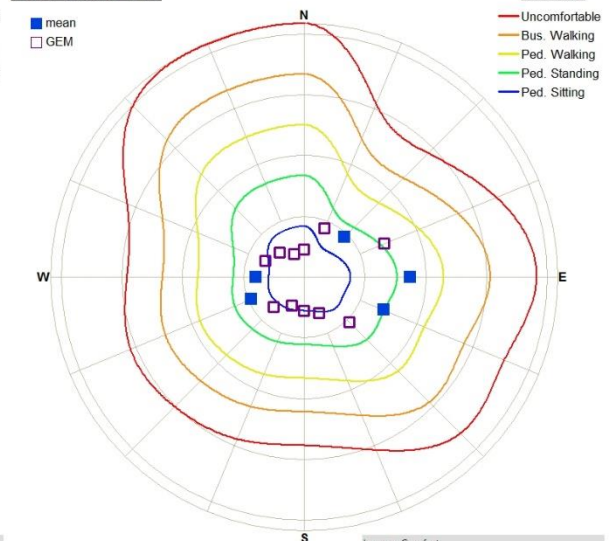
LOCATION 3.42



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	66.65	66.68	66.63
4	37.67	32.57	37.96
6	17.49	11.40	17.52
8	5.94	2.89	5.95
10	1.78	0.63	1.78

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.2	7.2	8.2
Rating	Bus Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	16.2	14.0	16.2
Rating	Able Body	Pass	Able Body

LOCATION 4.42



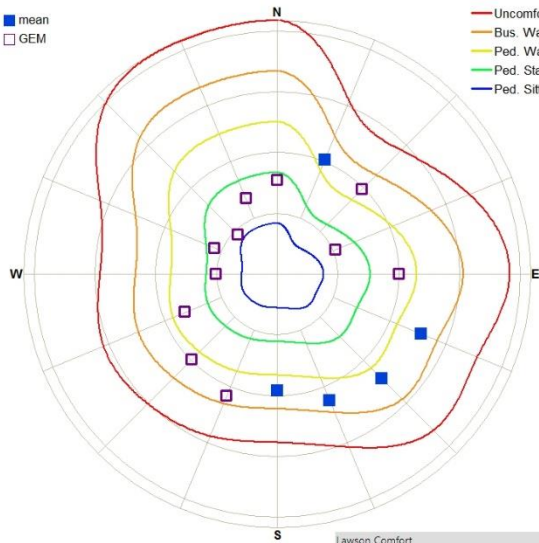
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	17.04	18.09	19.58
4	0.84	0.62	1.00
6	0.02	0.00	0.02
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.0	2.9	3.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.0	5.5	6.0
Rating	Pass	Pass	Pass

LOCATION 5.42

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus. Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

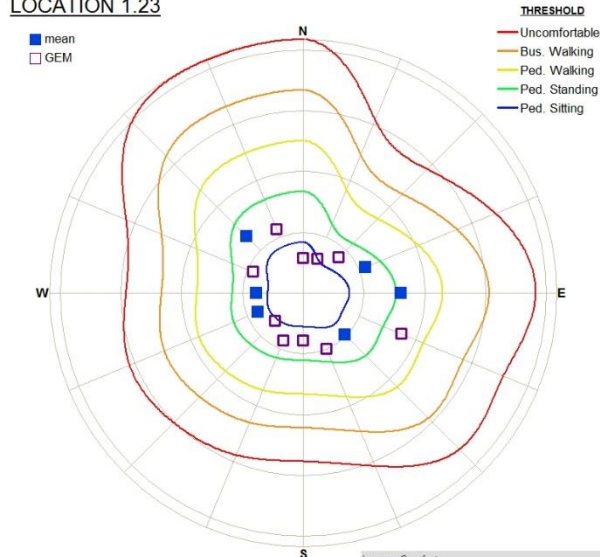


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	51.11	59.81	60.38
4	22.65	25.33	27.38
6	5.01	5.49	6.58
8	0.61	0.65	0.82
10	0.07	0.06	0.09

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.0	6.1	6.2
Rating	Ped Standing	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.8	10.8	11.1
Rating	Pass	Pass	Pass

Configuration 2D

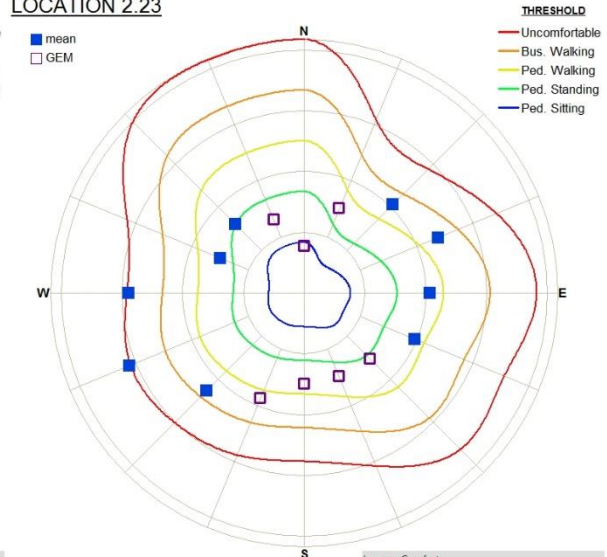
LOCATION 1.23



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	20.97	23.73	25.30
4	1.07	1.01	1.26
6	0.07	0.06	0.08
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.0	3.0	3.1
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.6	6.5	6.6
Rating	Pass	Pass	Pass

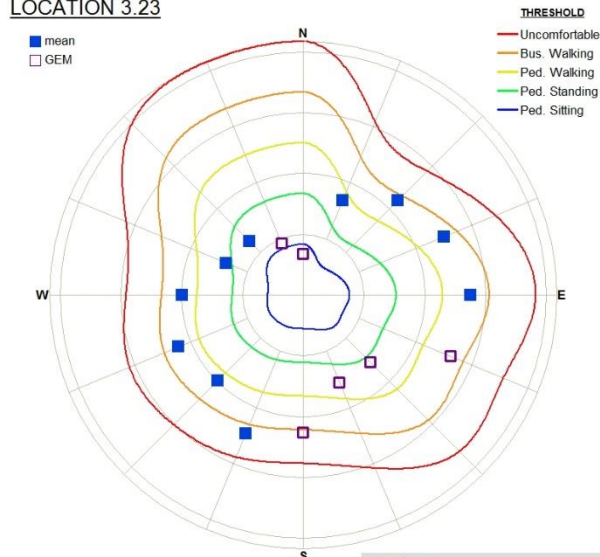
LOCATION 2.23



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	58.58	61.72	63.91
4	21.23	22.65	25.85
6	7.43	5.27	8.15
8	2.17	1.03	2.25
10	0.64	0.22	0.65

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.6	6.0	6.7
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.8	12.4	14.8
Rating	Pass	Pass	Pass

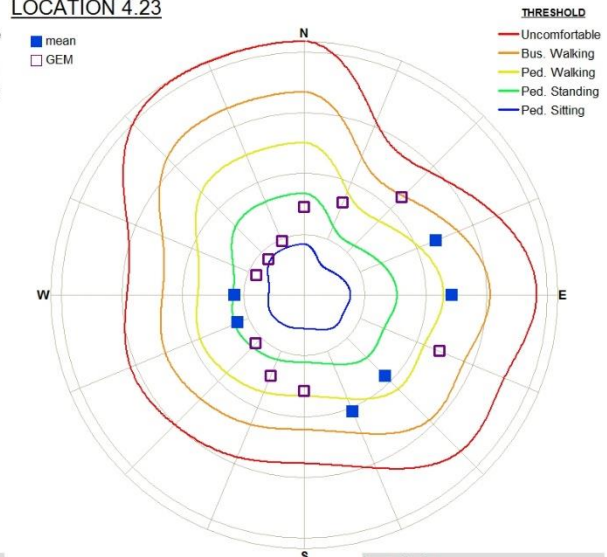
LOCATION 3.23



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	62.54	59.63	63.17
4	30.54	26.36	30.98
6	9.86	6.65	10.06
8	1.77	1.28	1.84
10	0.24	0.19	0.25

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.8	6.3	6.8
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.3	12.2	12.4
Rating	Pass	Pass	Pass

LOCATION 4.23



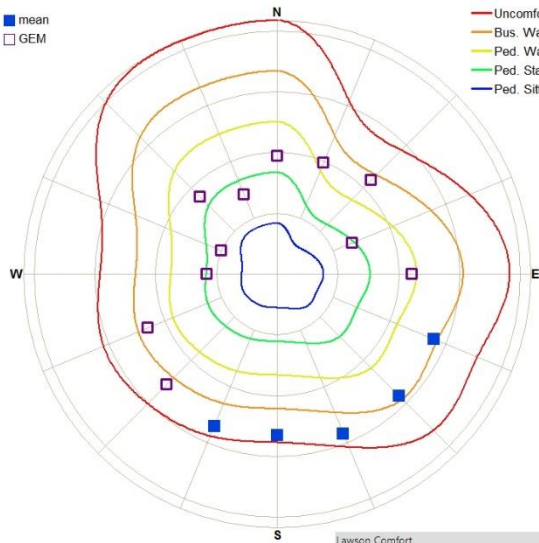
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	49.54	53.97	54.90
4	17.20	18.62	20.21
6	3.18	3.77	4.46
8	0.29	0.47	0.56
10	0.01	0.02	0.03

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.5	5.7	5.8
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.7	10.0	10.2
Rating	Pass	Pass	Pass

LOCATION 5.23

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus. Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

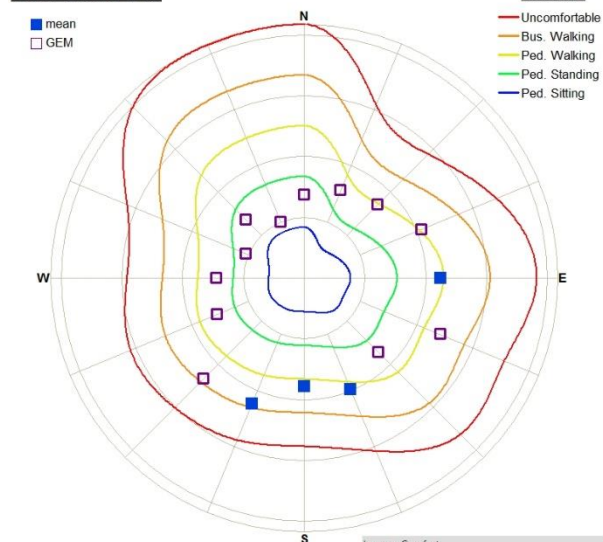


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	61.24	67.92	66.66
4	31.21	33.81	36.66
6	11.99	11.00	15.09
8	3.55	2.12	4.09
10	0.82	0.32	0.89

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.4	7.0	7.6
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.1	12.6	14.2
Rating	Pass	Pass	Pass

Configuration 4D

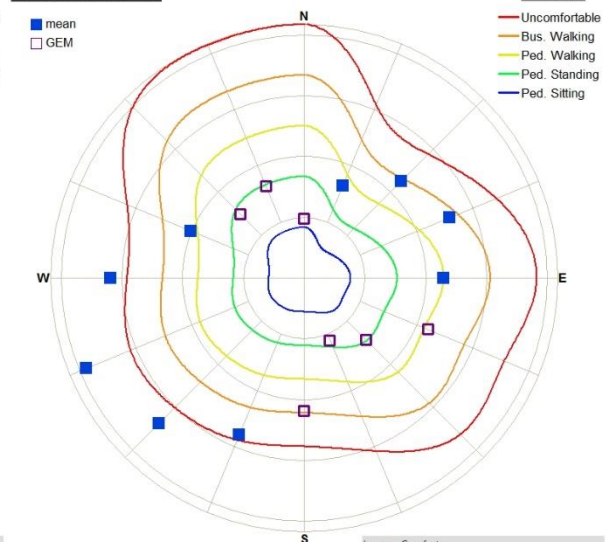
LOCATION 1.43



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	55.26	60.07	60.34
4	20.61	22.72	24.11
6	3.54	3.85	4.48
8	0.49	0.51	0.65
10	0.05	0.06	0.09

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.6	5.7	5.9
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.8	10.9	11.2
Rating	Pass	Pass	Pass

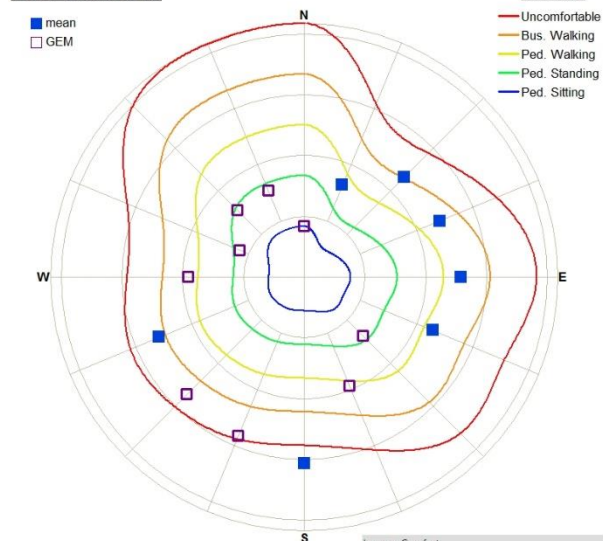
LOCATION 2.43



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	60.31	67.14	66.89
4	30.50	31.20	33.45
6	13.90	11.42	16.01
8	5.65	3.19	6.09
10	2.07	0.81	2.12

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.2	7.3	8.3
Rating	Bus Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.3	14.6	18.3
Rating	Able Body	Pass	Able Body

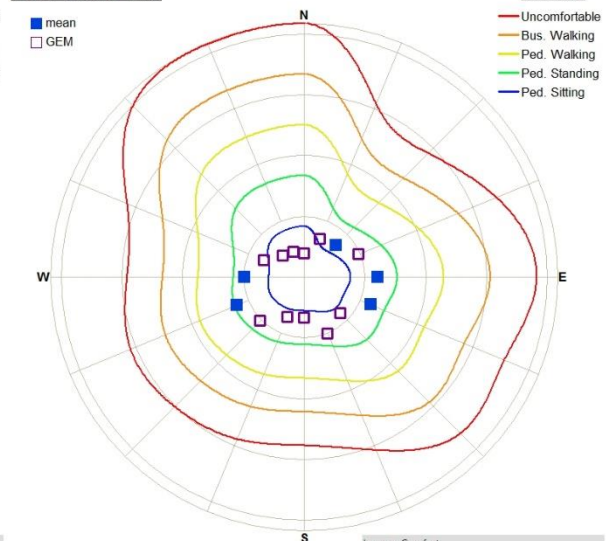
LOCATION 3.43



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	62.51	64.98	66.40
4	32.35	31.35	34.37
6	14.58	12.47	15.39
8	4.72	4.16	4.93
10	1.34	1.25	1.42

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.8	7.6	7.9
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.6	15.3	15.7
Rating	Able Body	Able Body	Able Body

LOCATION 4.43



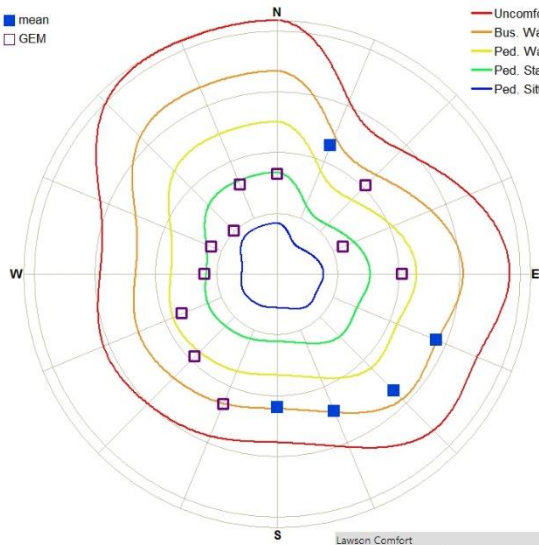
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	15.90	18.60	20.20
4	0.47	0.42	0.55
6	0.01	0.01	0.01
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	2.7	2.7	2.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.6	5.4	5.6
Rating	Pass	Pass	Pass

LOCATION 5.43

■ mean
□ GEM

THRESHOLD
— Uncomfortable
— Bus Walking
— Ped. Walking
— Ped. Standing
— Ped. Sitting

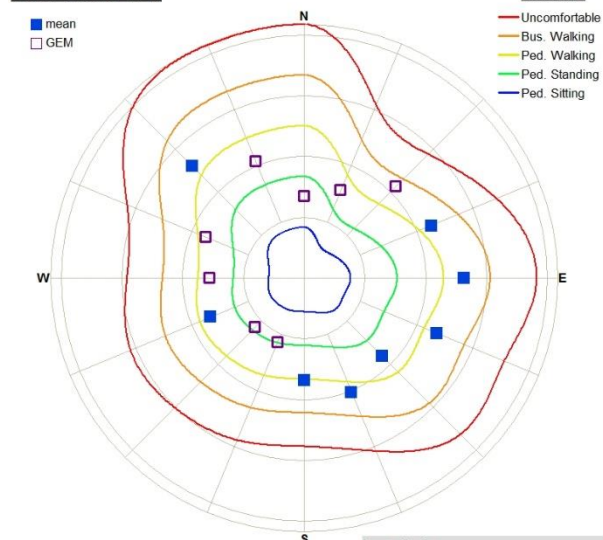


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	54.47	63.70	64.42
4	27.39	29.93	31.79
6	8.23	8.26	9.78
8	1.50	1.28	1.79
10	0.21	0.16	0.24

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.6	6.5	6.8
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.8	11.7	12.1
Rating	Pass	Pass	Pass

Configuration 2E

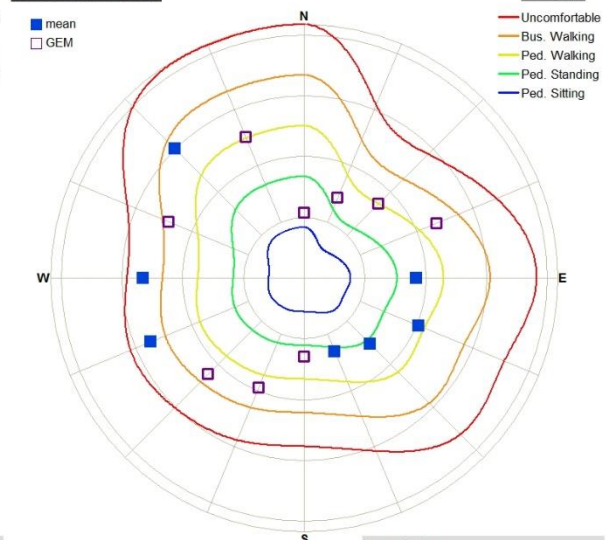
LOCATION 1.24



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	62.09	68.31	69.39
4	21.57	22.24	24.45
6	4.22	4.35	5.24
8	0.50	0.50	0.66
10	0.09	0.06	0.10

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.8	5.8	6.0
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.5	10.6	11.6
Rating	Pass	Pass	Pass

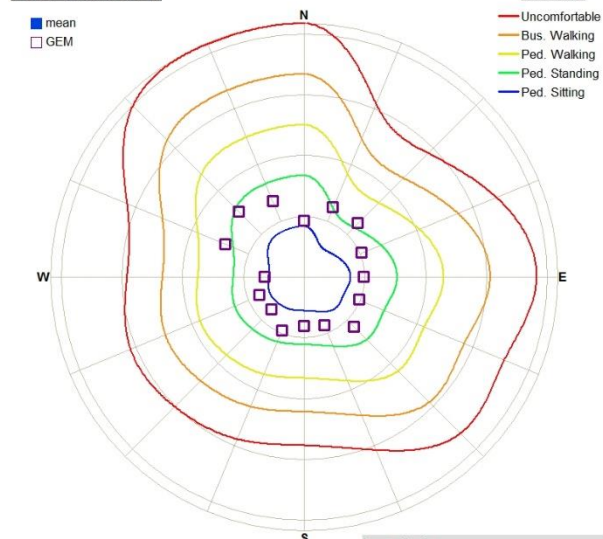
LOCATION 2.24



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	70.94	71.98	73.86
4	24.25	24.03	26.63
6	6.92	6.64	7.85
8	2.07	1.51	2.26
10	0.55	0.35	0.59

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.4	6.3	6.6
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.5	12.9	14.5
Rating	Pass	Pass	Pass

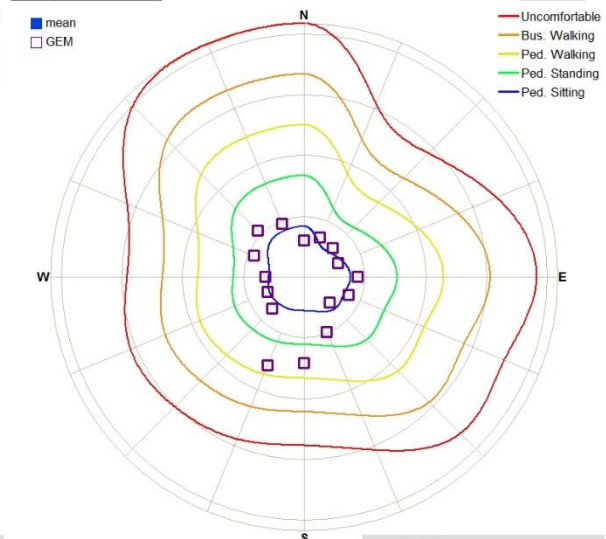
LOCATION 3.24



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	19.69	31.40	31.40
4	0.55	2.35	2.35
6	0.02	0.12	0.12
8	0.00	0.01	0.01
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	2.9	3.4	3.4
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.9	7.0	7.0
Rating	Pass	Pass	Pass

LOCATION 4.24



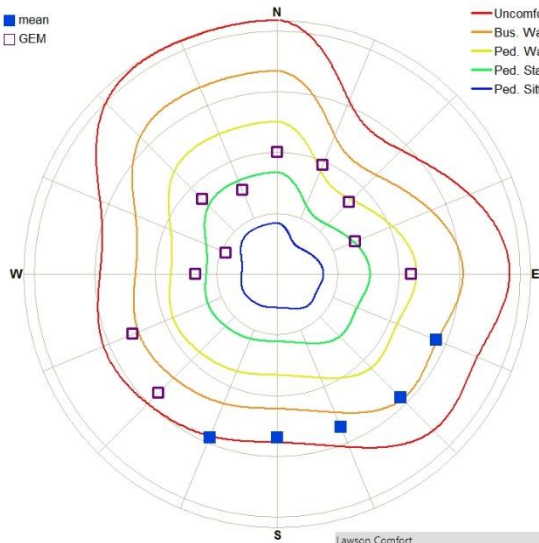
% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	16.08	21.81	21.81
4	2.53	3.61	3.61
6	0.13	0.28	0.28
8	0.00	0.01	0.01
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	3.4	3.6	3.6
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.1	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 5.24

■ mean
□ GEM

THRESHOLD
 — Uncomfortable
 — Bus. Walking
 — Ped. Walking
 — Ped. Standing
 — Ped. Sitting

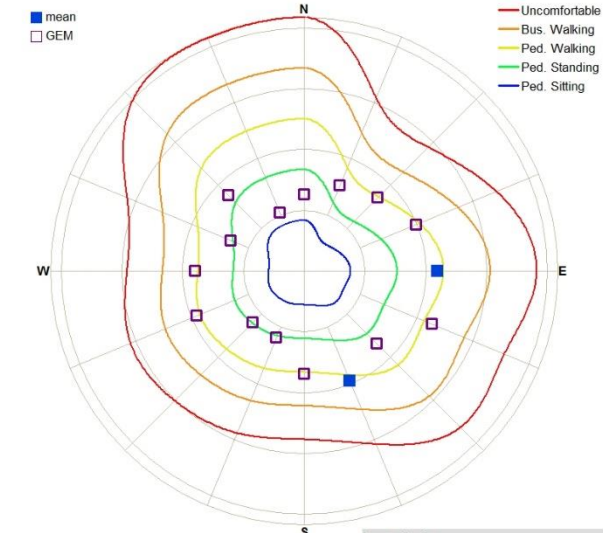


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	60.61	68.47	69.10
4	30.34	34.28	36.76
6	12.68	11.37	14.93
8	3.95	2.70	4.47
10	0.96	0.55	1.13

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.5	7.1	7.8
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.6	13.6	14.8
Rating	Pass	Pass	Pass

Configuration 4E

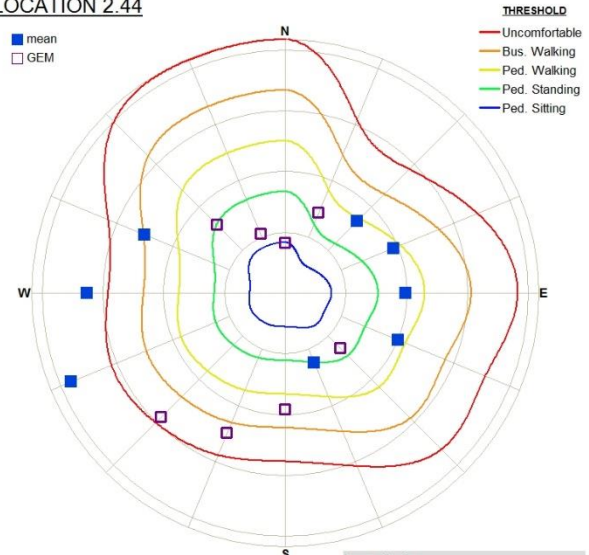
LOCATION 1.44



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	52.65	60.29	60.61
4	14.68	19.83	20.69
6	1.61	2.55	2.81
8	0.14	0.23	0.27
10	0.01	0.01	0.01

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.0	5.4	5.5
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.2	9.6	9.7
Rating	Pass	Pass	Pass

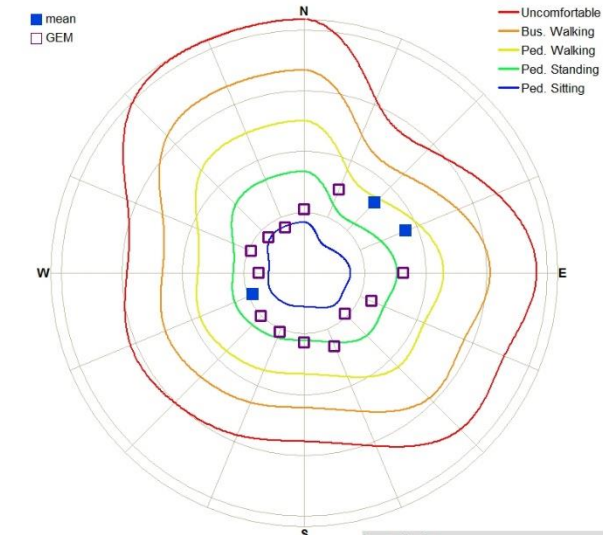
LOCATION 2.44



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	60.71	64.82	65.41
4	25.59	28.68	30.34
6	8.99	10.49	11.47
8	4.02	4.00	4.76
10	1.64	1.40	1.84

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	7.3	7.5	7.8
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	17.9	16.6	17.9
Rating	Able Body	Able Body	Able Body

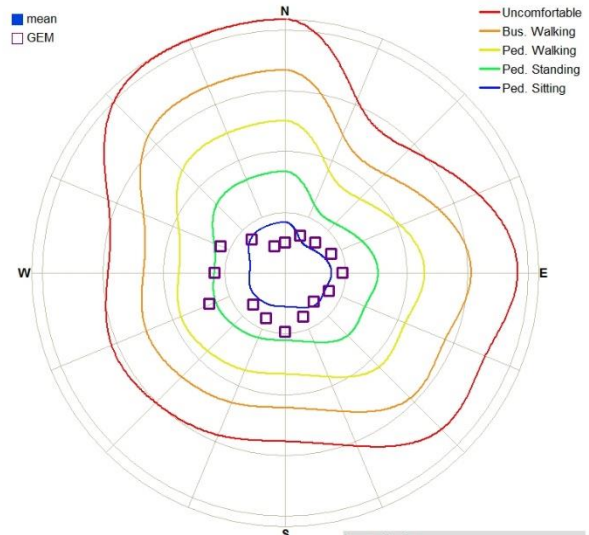
LOCATION 3.44



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	34.27	39.04	39.43
4	5.69	5.85	6.79
6	0.30	0.17	0.33
8	0.00	0.00	0.00
10	0.00	0.00	0.00

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	4.1	4.1	4.2
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.2	6.8	7.2
Rating	Pass	Pass	Pass

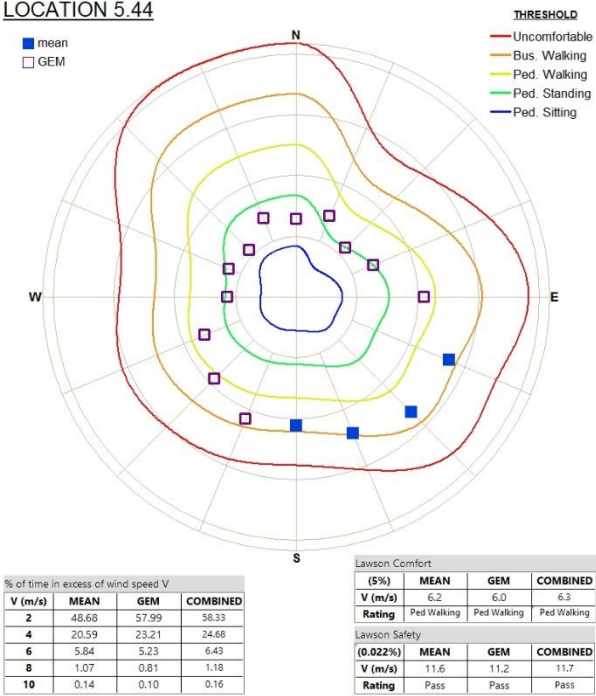
LOCATION 4.44



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	11.11	20.76	20.76
4	0.25	1.29	1.29
6	0.00	0.04	0.04
8	0.00	0.00	0.00
10	0.00	0.00	0.00

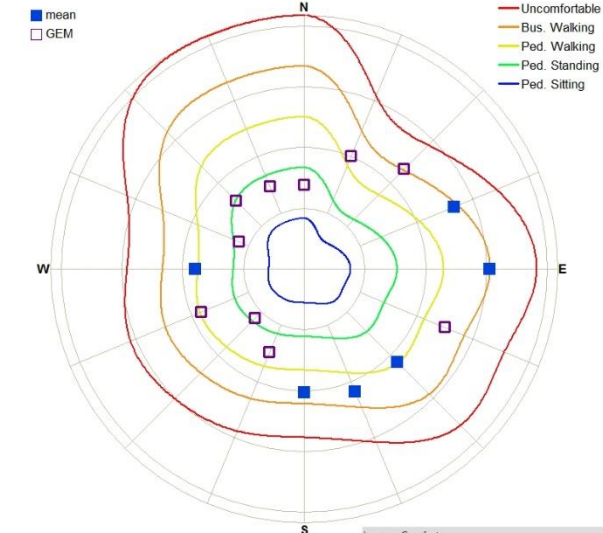
Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	2.4	3.0	3.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.1	6.4	6.4
Rating	Pass	Pass	Pass

LOCATION 5.44



Configuration 2F

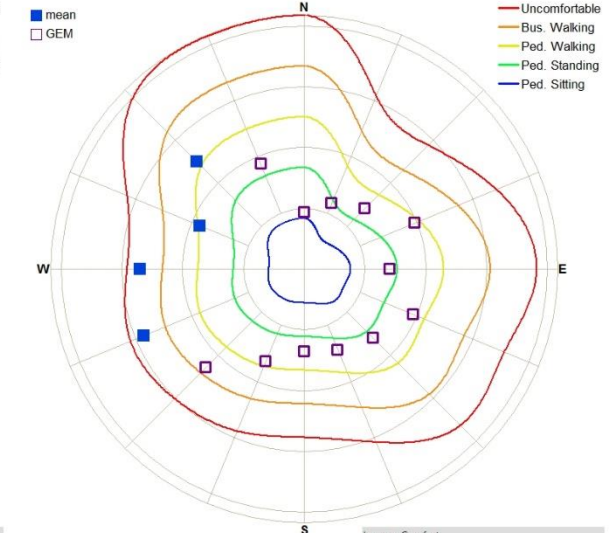
LOCATION 1.25



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	60.44	64.28	65.33
4	27.97	27.11	30.50
6	8.06	6.64	8.89
8	1.20	0.80	1.30
10	0.11	0.06	0.12

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.5	6.2	6.6
Rating	Ped Walking	Ped Walking	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.3	10.6	11.3
Rating	Pass	Pass	Pass

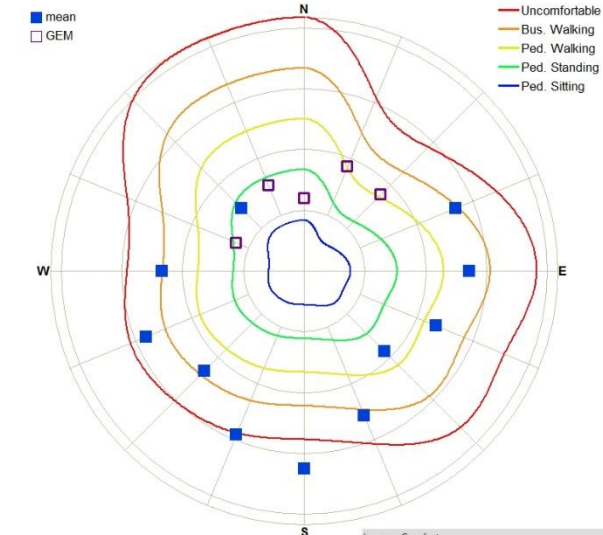
LOCATION 2.25



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	58.91	65.69	67.79
4	15.76	18.67	20.70
6	5.31	4.17	5.91
8	1.76	0.89	1.83
10	0.46	0.17	0.47

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.0	5.7	6.2
Rating	Ped Walking	Ped Standing	Ped Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.8	12.0	13.8
Rating	Pass	Pass	Pass

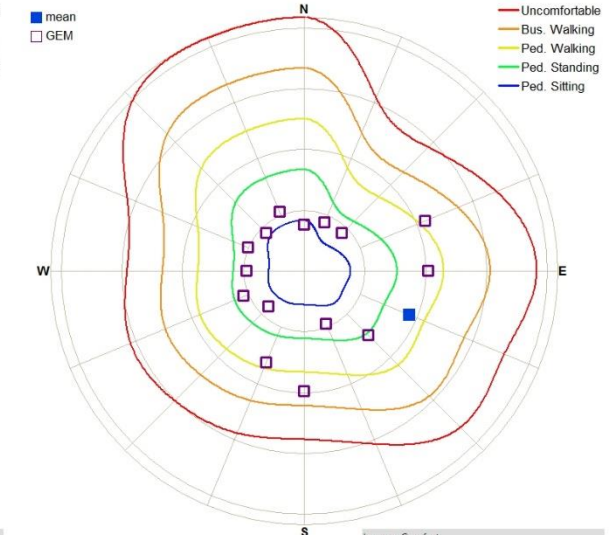
LOCATION 3.25



% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	66.78	67.60	69.04
4	36.88	35.03	38.33
6	16.74	13.64	17.29
8	6.23	4.01	6.26
10	1.99	1.08	1.99

Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	8.3	7.6	8.3
Rating	Bus Walking	Ped Walking	Bus Walking
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	16.5	14.9	16.5
Rating	Able Body	Pass	Able Body

LOCATION 4.25

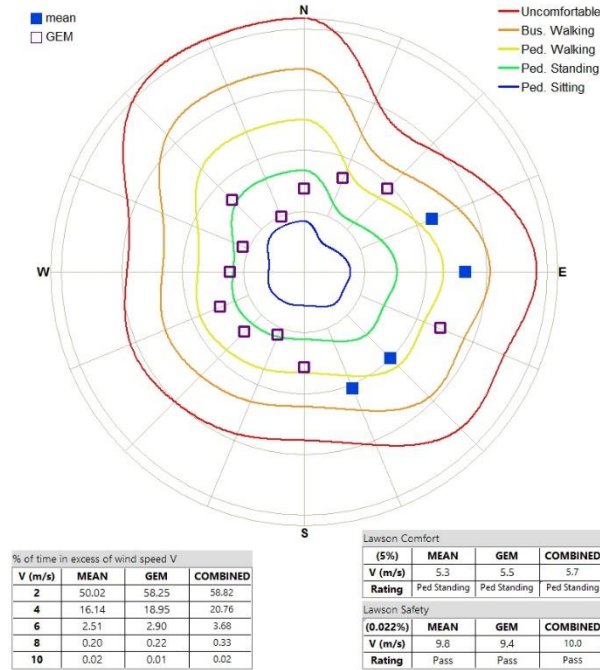


% of time in excess of wind speed V			
V (m/s)	MEAN	GEM	COMBINED
2	30.53	41.77	41.84
4	6.54	11.15	11.27
6	0.74	2.00	2.02
8	0.05	0.20	0.20
10	0.00	0.02	0.02

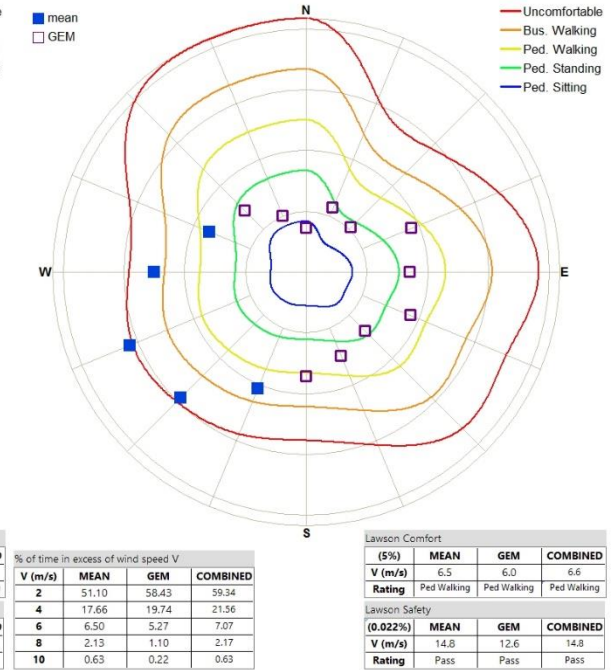
Lawson Comfort			
(5%)	MEAN	GEM	COMBINED
V (m/s)	4.2	5.0	5.0
Rating	Ped Standing	Ped Standing	Ped Standing
Lawson Safety			
(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.6	9.9	9.9
Rating	Pass	Pass	Pass

Configuration 4F

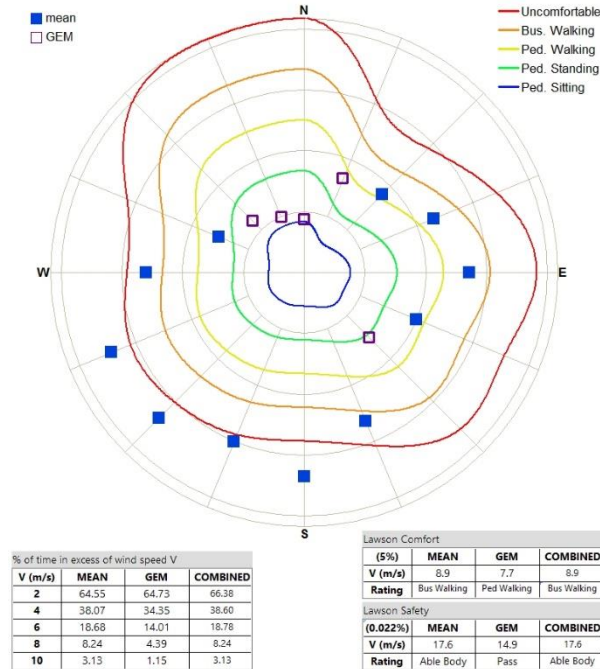
LOCATION 1.45



LOCATION 2.45



LOCATION 3.45



LOCATION 4.45

