PEDESTRIAN WIND ENVIRONMENT STUDY

CENTRAL COAST QUARTER – NORTH TOWER, GOSFORD

WF011-02F02(REV2)- WE REPORT

AUGUST 24, 2021

Prepared for:

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30 YEARS OF EXCELLENCE IN WIND ENGINEERING

DOCUMENT CONTROL

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August 24, 2021	Insert reference to SEARs	2	RL	AFM	TH

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EXECUTIVE SUMMARY

This Pedestrian Wing Environment Study report is submitted to the Department of Planning, Industry and Environment (DPIE) on behalf of the SH Gosford Residential and in support of an application for SSD application number 23588910 at 26-30 Mann Street, Gosford. The SSDA seeks consent for:

- Demolition of the existing retaining wall on site.
- Removal of three trees located at the site interface with Baker Street.
- Excavation to a depth of approximately 1.3m to accommodate the proposed ground floor structure.
- Earthworks to level the site in readiness for the proposed building.
- Construction of a 25-storey (26 level) mixed-use building, comprising:
    - 621sqm of retail GFA.
    - 136 apartments, equating to 13,263sqm of residential GFA.
    - Four parking levels for 181 cars, with vehicular access from Baker Street.
    - Storage areas and services.
    - Communal open space.
- Publicly accessible through site link, including stairs, walkways, public lift, public art and landscaping.

This report addresses the Planning Secretary's Environmental Assessment Requirements (SEARs) Item 6 - Environmental and Residential Amenity (Doc. Ref.: SSD-23588910). To ensure a high level of environmental amenity is demonstrated, this report presents the results of a detailed investigation into the wind environment impact of the proposed development known as the Central Coast Quarter - North Tower, located at 26-30 Mann Street, Gosford.

Testing was performed at Windtech's boundary layer wind tunnel facility. The wind tunnel has a 3.0m wide working section and a fetch length of 14m, and measurements were taken from 16 wind directions at 22.5 degree increments. Testing was carried out using a 1:300 detailed scale model of the development. The effects of nearby buildings and land topography have been accounted for through the use of a proximity model which represents an area with a radius of 375m.

Peak gust and mean wind speeds were determined at selected critical outdoor trafficable locations within and around the subject development. Wind velocity coefficients representing the local wind speeds are derived from the wind tunnel and are combined with a statistical model of the regional wind climate (which accounts for the directional strength and frequency of occurrence of the prevailing regional winds) to provide the equivalent full-scale wind speeds at the site. The wind speed measurements are compared with criteria for pedestrian comfort and safety, based on Gust-Equivalent Mean (GEM) and annual maximum gust winds, respectively.

The model was tested in the wind tunnel without the effect of any forms of wind ameliorating devices such as screens, balustrades, etc., which are not already shown in the architectural drawings. The effect of vegetation was also excluded from the testing. Both the future and the existing site conditions were tested for comparison and in accordance with Concept SSDA Condition C27 a). The scenarios tested are outlined as follows:

- With only the existing surrounding buildings and the north tower proposed development. In this report, this test case is referred to as the "Proposed Scenario".
- With the inclusion of the southern towers. In this report, this test case is referred to as the "Future Scenario".
- Without the southern and northern towers (vacant plot). In this report, this test case is referred to as the "Existing Scenario".

The results of the initial wind tunnel study indicate that the majority of trafficable outdoor locations within and around the development will experience strong winds that will exceed the relevant criteria for comfort and/or safety. Mitigation measures have been shown below to address Concept SSDA Condition C27 c).

The ground floor has been tested with the inclusion of the following treatments:

- 2m high 30% porous screen along southern edge of stairs leading from ground floor to Level 2.
- 3-4m high densely foliating evergreen trees in the planter area at the southern end of stairs between ground floor and Level 1.
- 2.4m high impermeable screen at between the two southern columns, north of the stairs.
- 50% Porous façade for the carpark perimeter at the north-east corner of the development (Ground to Level 3 inclusive).

In addition, two treatment options were tested to mitigate the strong winds in the café seating areas along the western aspect of the development at ground floor, as described below:

Treatment Option 1:

- 1.2m high impermeable screens around each seating area, with screens connecting to columns.

Treatment Option 2:

- 2.4m high impermeable screens extending from each column.

For the above-ground areas of the development that are experiencing strong winds, the following in-principle treatments are described:

Level 2:

- 2m high 30% porous hoarding until southern towers are built.
- Incorporate impermeable screen on top of southern planter box for a combined height of 1.8m.

- Increase intertenancy screen height to at least 2m.

Level 3:

- Increase intertenancy screen height to at least 2m.
- Retain screen on top of planter for a total height of 1.3m
- Retain south-west corner as non-accessible to occupants.

Level 4:

- Incorporate 3m baffle screen arrangement throughout communal area on eastern side of towers.
- Retain screen on top of planter for a total height of 1.2m.
- Retain canopy structure at the southern terrace.
- Option 1: Remove access from private terrace into public terrace at south-west corner.
- Option 2: Include an impermeable screen along passageway to meet canopy structure.

Level 21:

- Retain screen on top of perimeter planter for a total height of 1.8m
- Include 1.5-2m high densely foliating evergreen vegetation at the east and west of the communal open space.

Level 24:

- Retain standard height impermeable balustrade for the western balcony.

As a general note, the use of loose glass-tops and light-weight sheets or covers (including loose BBQ lids) is not appropriate on high-rise outdoor terraces and balconies. Furthermore, lightweight furniture is not recommended unless it is securely attached to the balcony or terrace floor slab.

With the inclusion of these treatments to the final design, it is expected that wind conditions for all outdoor trafficable areas within and around the development will be suitable for their intended uses, thereby satisfying Concept SSDA Condition C27 b).

CONTENTS

1 INTRODUCTION

This Pedestrian Wing Environment Study report is submitted to the Department of Planning, Industry and Environment (DPIE) on behalf of the SH Gosford Residential and in support of an application for SSD application number 23588910 at 26-30 Mann Street, Gosford. The SSDA seeks consent for:

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    - 621sqm of retail GFA.
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    - Four parking levels for 181 cars, with vehicular access from Baker Street.
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This report addresses the Planning Secretary's Environmental Assessment Requirements (SEARs) Item 6 - Environmental and Residential Amenity (Doc. Ref.: SSD-23588910). To ensure a high level of environmental amenity is demonstrated, this report presents the results of a detailed investigation into the wind environment impact of the proposed development known as the Central Coast Quarter - North Tower, located at 26-30 Mann Street, Gosford.

A wind tunnel study has been undertaken to determine wind speeds at selected critical outdoor trafficable areas within and around the subject development. The test procedures followed for this wind tunnel study were based on the guidelines set out in the Australasian Wind Engineering Society Quality Assurance Manual (AWES-QAM-1-2019), ASCE 7-16 (Chapter C31), and CTBUH (2013).

A scale model of the development was prepared, including the surrounding buildings and land topography. Testing was performed at Windtech's boundary layer wind tunnel facility. The wind tunnel has a 3.0m wide working section and a fetch length of 14m, and measurements were taken from 16 wind directions at 22.5 degree increments. The wind tunnel was configured to the appropriate boundary layer wind profile for each wind direction. Wind speeds were measured using either Dantec hot-wire probe anemometers or pressure-based wind speed sensors, positioned to monitor wind conditions at critical outdoor trafficable areas of the development.

The model was tested in the wind tunnel without the effect of any forms of wind ameliorating devices such as screens, balustrades, etc., which are not already shown in the architectural drawings. The effect of vegetation was also excluded from the testing. The wind speeds measured during testing were combined with a statistical model of the regional wind climate to provide the equivalent full-scale wind speeds at the site. The measured wind speeds were compared against appropriate criteria for pedestrian comfort and safety, and in-principle treatments have been recommended for any area which was exposed to strong winds. These treatments could be in the form of retaining vegetation that is already proposed for the site, or including additional vegetation, screens, awnings, etc. Note however that, in accordance with the AWES Guidelines (2014), only architectural elements or modifications are used to treat winds which represent an exceedance of the existing wind conditions and exceed the safety limit.

2 WIND TUNNEL MODEL

Wind tunnel testing was carried out using a 1:300 scale model of the development and surroundings. The study model incorporates all necessary architectural features on the façade of the development to ensure an accurate wind flow is achieved around the model, and was constructed using a Computer Aided Manufacturing (CAM) process to ensure that a high level of detail and accuracy is achieved. The effect of nearby buildings and land topography has been accounted for through the use of a proximity model, which represents a radius of 375m from the development site. Photographs of the wind tunnel model are presented in Figures 1. Plans of the Proposed and Future Scenarios are provided in Figures 2.

Figure 1a: Photograph of the Wind Tunnel Model (Proposed Scenario - view from the west)

Figure 1b: Photograph of the Wind Tunnel Model (Proposed Scenario - view from the north-east)

Figure 1c: Photograph of the Wind Tunnel Model (Proposed Scenario - view from the south-east)

Figure 1d: Photograph of the Wind Tunnel Model (Proposed Scenario - view from the south-west)

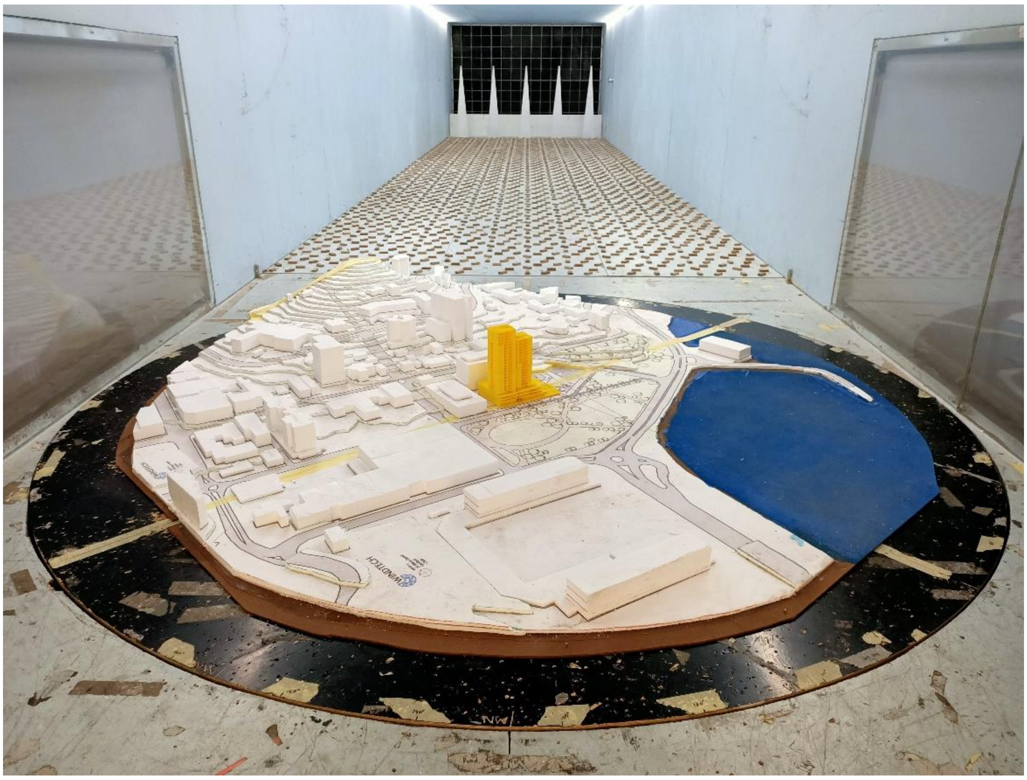

Figure 1e: Photograph of the Wind Tunnel Model (Proposed Scenario - view from the north-west)

Figure 1f: Photograph of the Wind Tunnel Model (Future Scenario - view from the south-west)

Figure 1g: Photograph of the Wind Tunnel Model (Future Scenario - view from the north-east)

Figure 1h: Photograph of the Wind Tunnel Model (Future Scenario - view from the south-east)

Figure 1i: Photograph of the Wind Tunnel Model (Future Scenario - view from the south-west)

Figure 1j: Photograph of the Wind Tunnel Model (Future Scenario - view from the north-west)

Figure 1k: Photograph of the Wind Tunnel Model (Existing Scenario - view from the west)

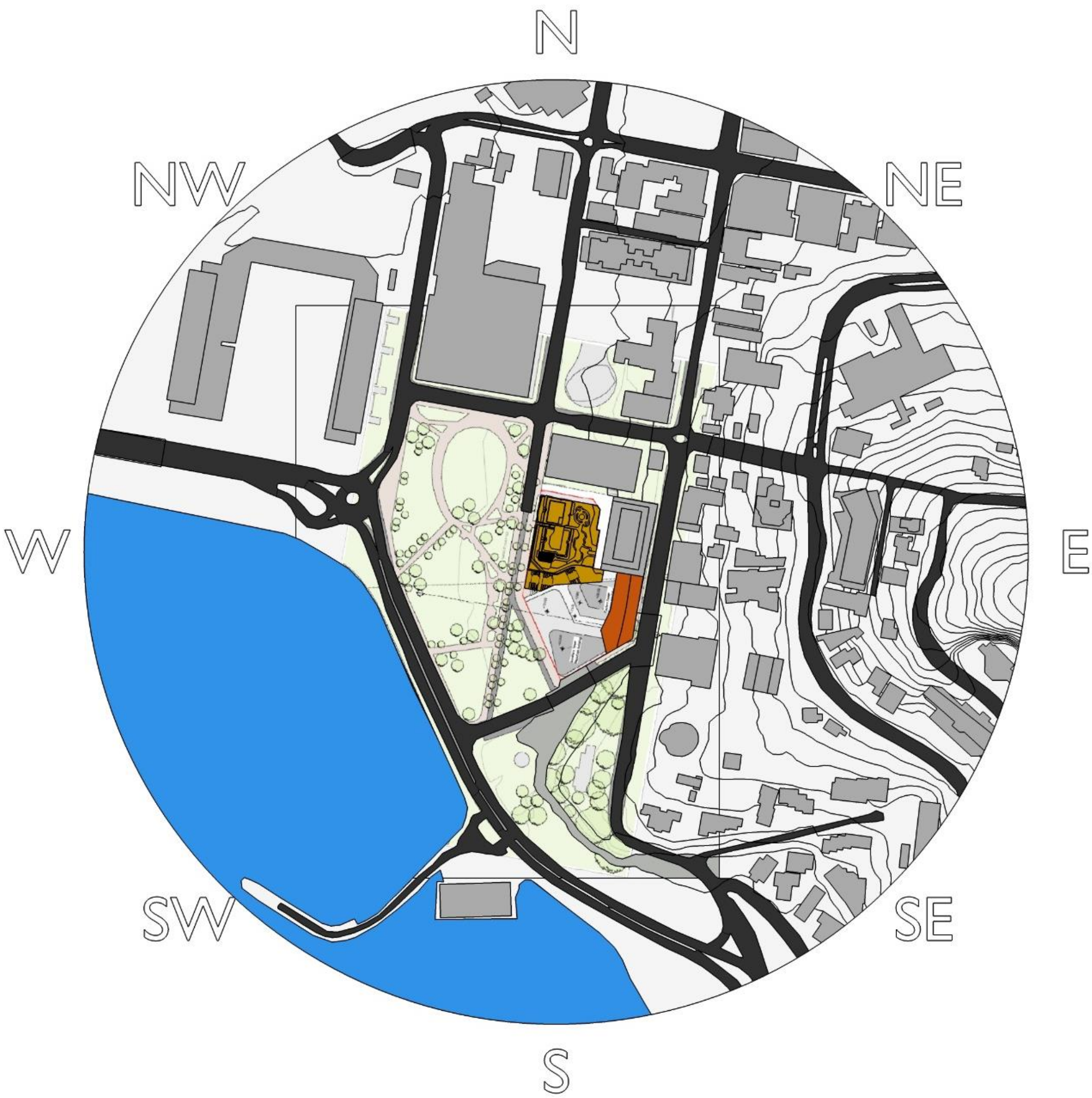

Figure 2a: Proximity Model Plan (Proposed Scenario)

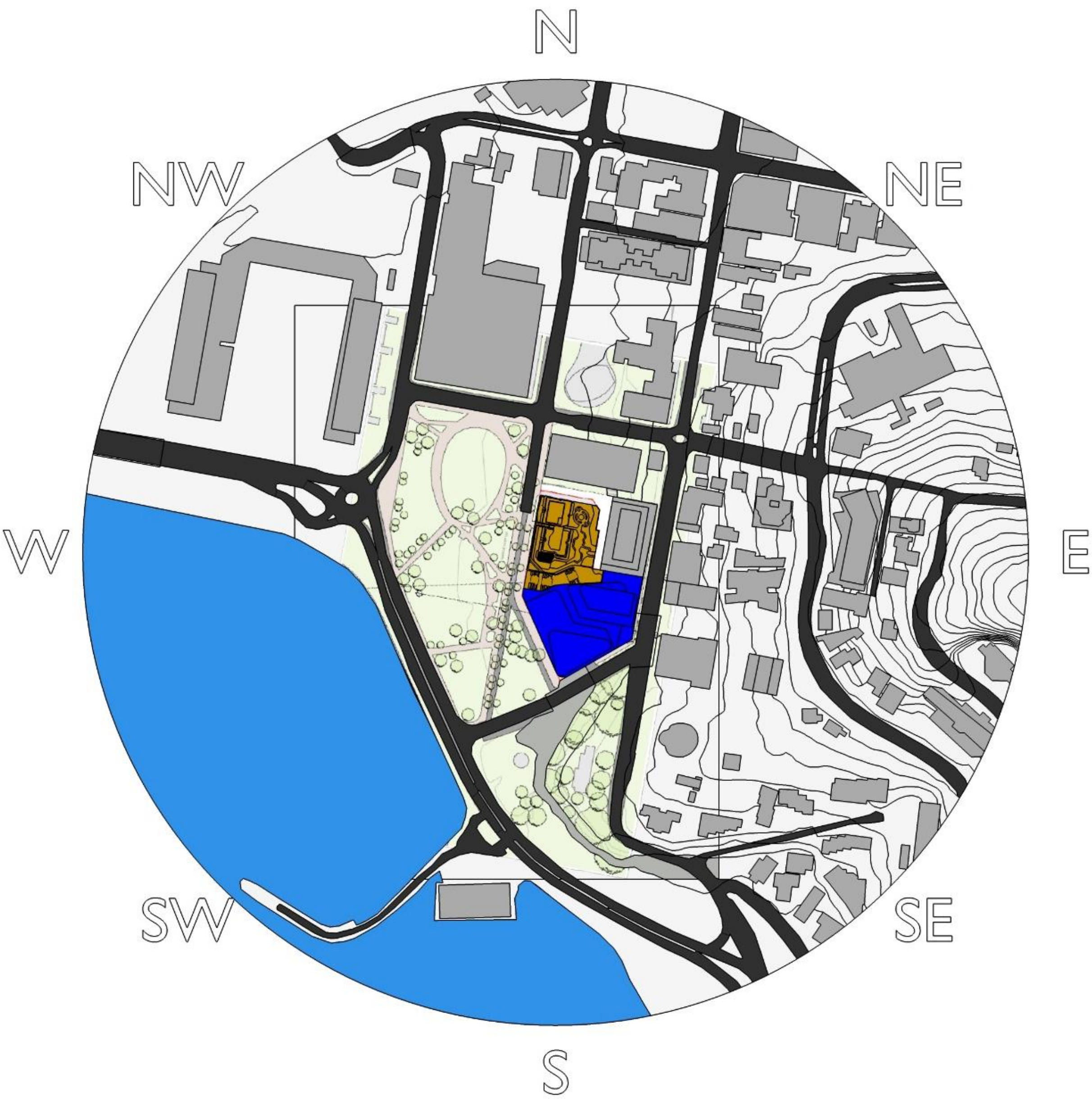

Figure 2b: Proximity Model Plan (Future Scenario)

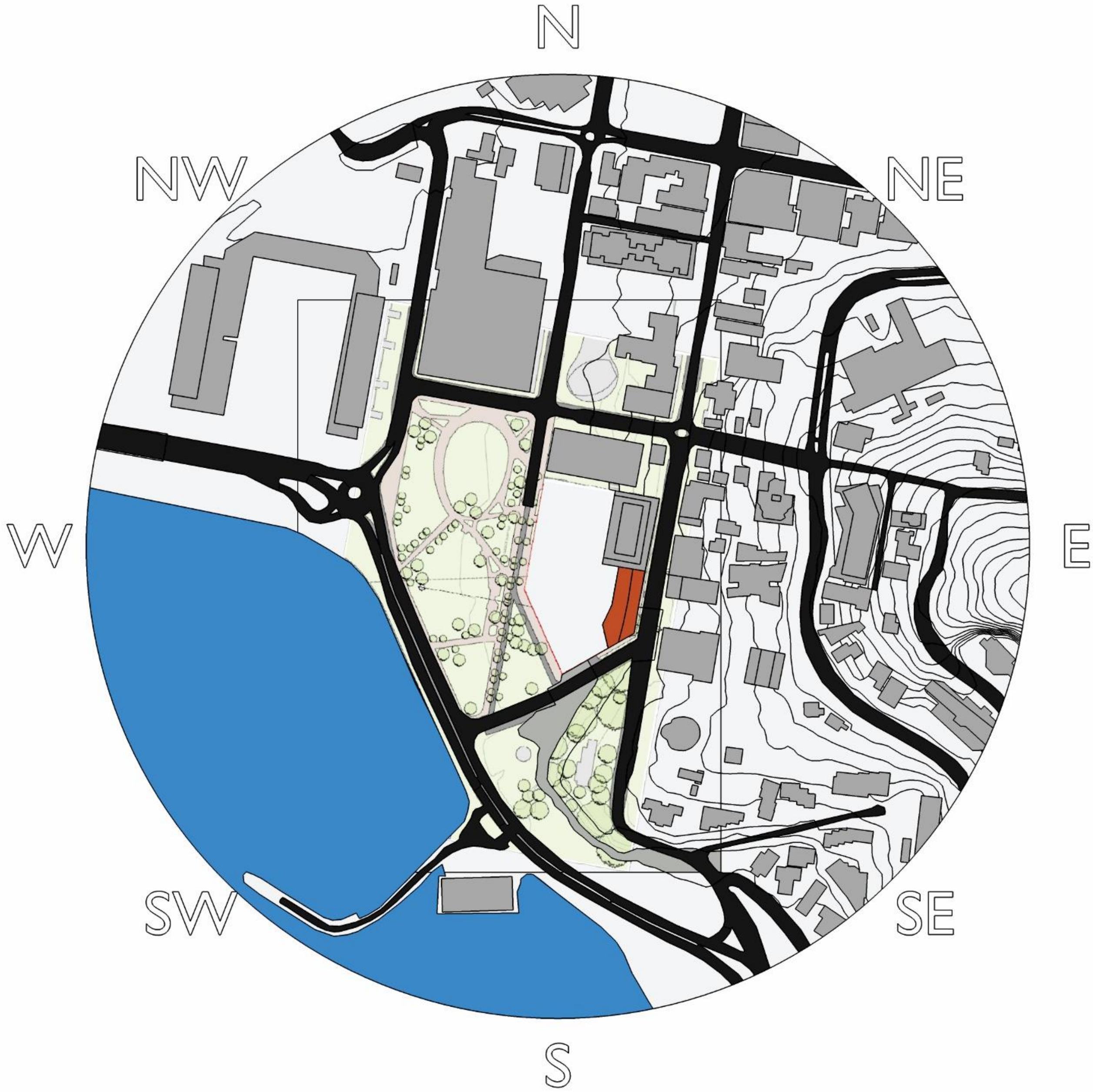

Figure 2c: Proximity Model Plan (Existing Scenario)

3 BOUNDARY LAYER WIND PROFILES AT THE SITE

The roughness of the surface of the earth has the effect of slowing down the wind near the ground. This effect is observed up to the boundary layer height, which can range between 500m to 3km above the earth's surface depending on the roughness of the surface (ie: oceans, open farmland, etc). Within this range the prevailing wind forms a boundary layer wind profile.

Various wind codes and standards and other publications classify various types of boundary layer wind flows depending on the surface roughness z_0. Descriptions of typical boundary layer wind profiles, based on D.M. Deaves and R.I. Harris (1978), are summarised as follows:

- Flat terrain (0.002m < z_0 < 0.003m). Examples include inland water bodies such as lakes, dams, rivers, etc, and the open ocean.
- Semi-open terrain (0.006m < z_0 < 0.01m). Examples include flat deserts and plains.
- Open terrain (0.02m < z_0 < 0.03m). Examples include grassy fields, semi-flat plains, and open farmland (without buildings or trees).
- Semi-suburban/semi-forest terrain (0.06m < z_0 < 0.1m). Examples include farmland with scattered trees and buildings and very low-density suburban areas.
- Suburban/forest terrain (0.2m < z_0 < 0.3m). Examples include suburban areas of towns and areas with dense vegetation such as forests, bushland, etc.
- Semi-urban terrain (0.6m < z_0 < 1.0m). Examples include centres of small cities, industrial parks, etc.
- Urban terrain (2.0m < z_0 < 3.0m). Examples include centres of large cities with many high-rise towers, and also areas with many closely-spaced mid-rise buildings.

The boundary layer wind profile does not change instantly due to changes in the terrain roughness. It can take many kilometres (at least 100km) of a constant surface roughness for the boundary layer wind profile to achieve a state of equilibrium. Hence an analysis of the effect of changes in the upwind terrain roughness is necessary to determine an accurate boundary layer wind profile at the development site location.

The proximity model accounts for the effect of the near field topographic effects as well as the influence of the local built forms. To account for further afield effects, an assessment of the upwind terrain roughness has been undertaken based on the method given in AS/NZS1170.2:2011, using a fetch ranging from 20 to 60 times the study reference height (as per the recommendation by AS/NZS1170.2:2011). An aerial image showing the surrounding terrain is presented in Figure 3 for a range of 2.4km from the edge of the proximity model used for the wind tunnel study. The resulting mean and gust terrain and height multipliers at the site location are presented in Table 1, referenced to the study reference height (which is approximately half the height of the subject development since typically we are most interested in the wind effects at the ground plane). Details of the boundary layer wind profiles at the site are combined with the regional wind model (see Section 4) to determine the site wind speeds.

Table 1: Approaching Boundary Layer Wind Profile Analysis Summary (at the study reference height)

Wind Sector (degrees)	Terrain and Height Multiplier $k_{tr,T=1hr}$ (hourly)	$k_{tr,T=10min}$ (10min)	$k_{tr,T=3s}$ (3sec)	Turbulence Intensity I_v	Equivalent Terrain Category (AS/NZS1170.2:2011 naming convention)
0	0.65	0.69	1.08	0.216	3.0
30	0.66	0.69	1.08	0.216	3.0
60	0.66	0.69	1.08	0.216	3.0
90	0.66	0.69	1.08	0.216	3.0
120	0.75	0.79	1.14	0.175	2.4
150	0.86	0.89	1.21	0.139	1.7
180	0.86	0.89	1.21	0.138	1.7
210	0.78	0.82	1.17	0.163	2.2
240	0.70	0.73	1.11	0.198	2.8
270	0.70	0.74	1.11	0.197	2.7
300	0.65	0.69	1.07	0.221	3.0
330	0.65	0.69	1.08	0.216	3.0

NOTE: These terrain and height multipliers are to be applied to a basic regional wind speed averaged over 3-seconds. Divide these values by 1.10 for a basic wind speed averaged over 0.2-seconds, 0.69 for a basic wind speed averaged over 10-minutes, or 0.66 for a basic wind speed averaged over 1-hour.

For each of the 16 wind directions tested in this study, the approaching boundary layer wind profiles modelled in the wind tunnel closely matched the profiles listed in Table 1. Plots of the boundary layer wind profiles used for the wind tunnel testing are presented in Appendix D of this report.

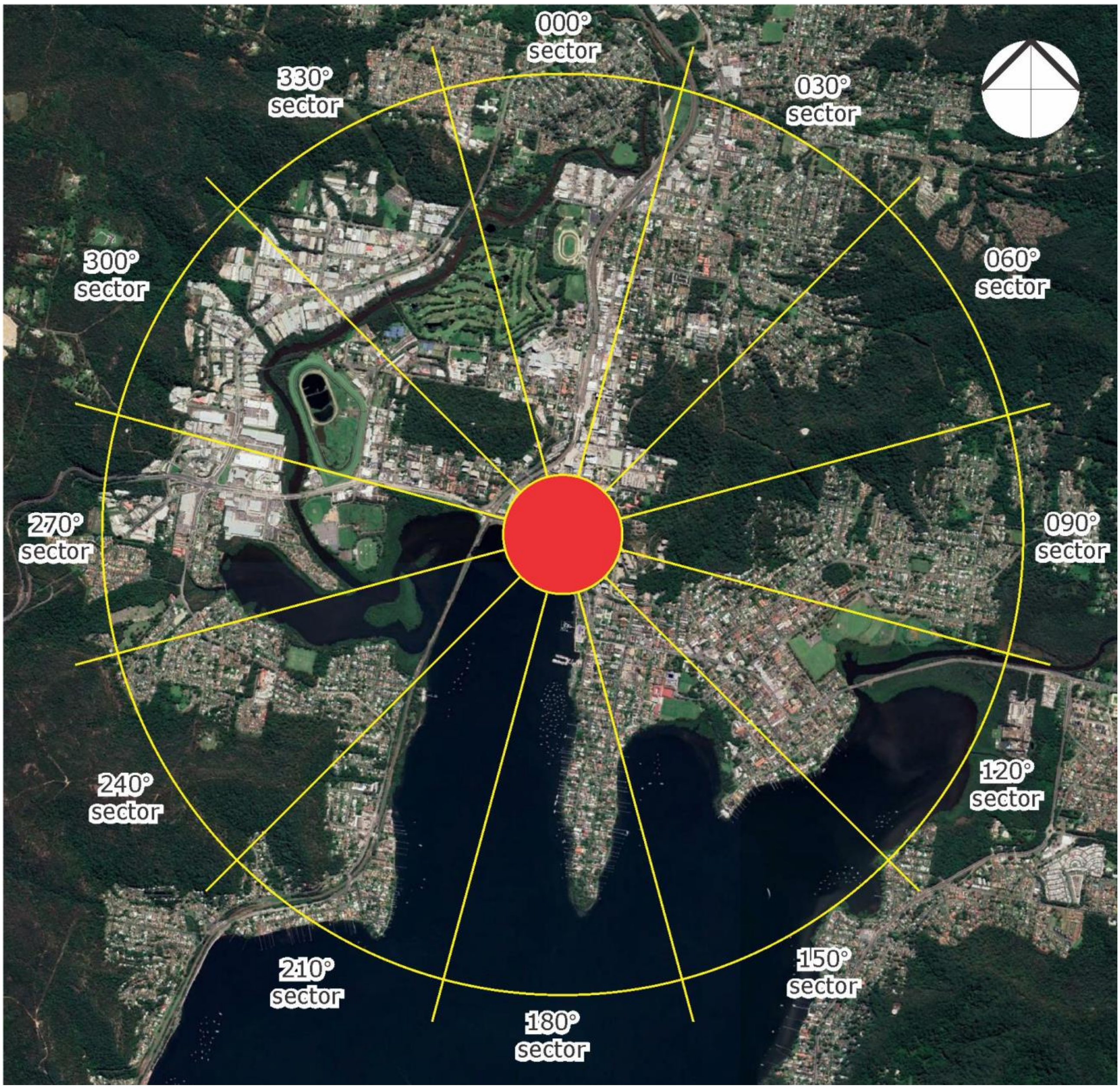

Figure 3: Aerial Image of the Surrounding Terrain (radius of 2.4km from the edge of the proximity model)

4 REGIONAL WIND MODEL

The regional wind model used in this study was determined from an analysis of measured directional mean wind speeds obtained at the meteorological recording station located at Norah Head AWS. Data was collected from 1995 - 2015 and corrected so that it represents winds over standard open terrain at a height of 10m above ground for each wind direction. From this analysis, directional probabilities of exceedance and directional wind speeds for the region are determined. The directional wind speeds are summarised in Table 2. The directional wind speeds and corresponding directional frequencies of occurrence are presented in Figure 4.

The data indicates that, for the weekly and annual return periods, the Central Coast region is governed by three principle wind directions, and these can potentially affect the subject development. These winds prevail from the north to north-east, south to south-east and west to north-west directions. This trend is repeated in the meteorological data from Sydney Airport. The most frequently occurring winds for the region are the southerly winds, followed by the north-easterly and westerly winds. The southerly winds are the strongest for the region.

The recurrence intervals examined in this study are for exceedances of 5% (per 90 degree sector) of the pedestrian comfort criteria using Gust-Equivalent Mean (GEM) wind speeds, and annual maximum wind speeds (per 22.5 degree sector) for the pedestrian safety criterion. Note that the 5% probability wind speeds presented in Table 2 are only used for the directional plot presented in Figure 4 and are not used for the integration of the probabilities.

Table 2: Regional Directional Wind Speeds (hourly means, at 10m height in standard open terrain) (m/s)

Wind Direction	5% Exceedance	Annual Maximum
N	6.8	10.6
NNE	8.3	11.1
NE	8.1	10.5
ENE	5.8	8.5
E	5.0	8.7
ESE	5.2	9.7
SE	7.0	11.7
SSE	9.8	14.1
S	11.8	16.9
SSW	10.2	15.8
SW	6.5	11.7
WSW	6.4	9.1
W	6.5	10.4
WNW	5.7	9.2
NW	5.5	9.6
NNW	5.3	10.6

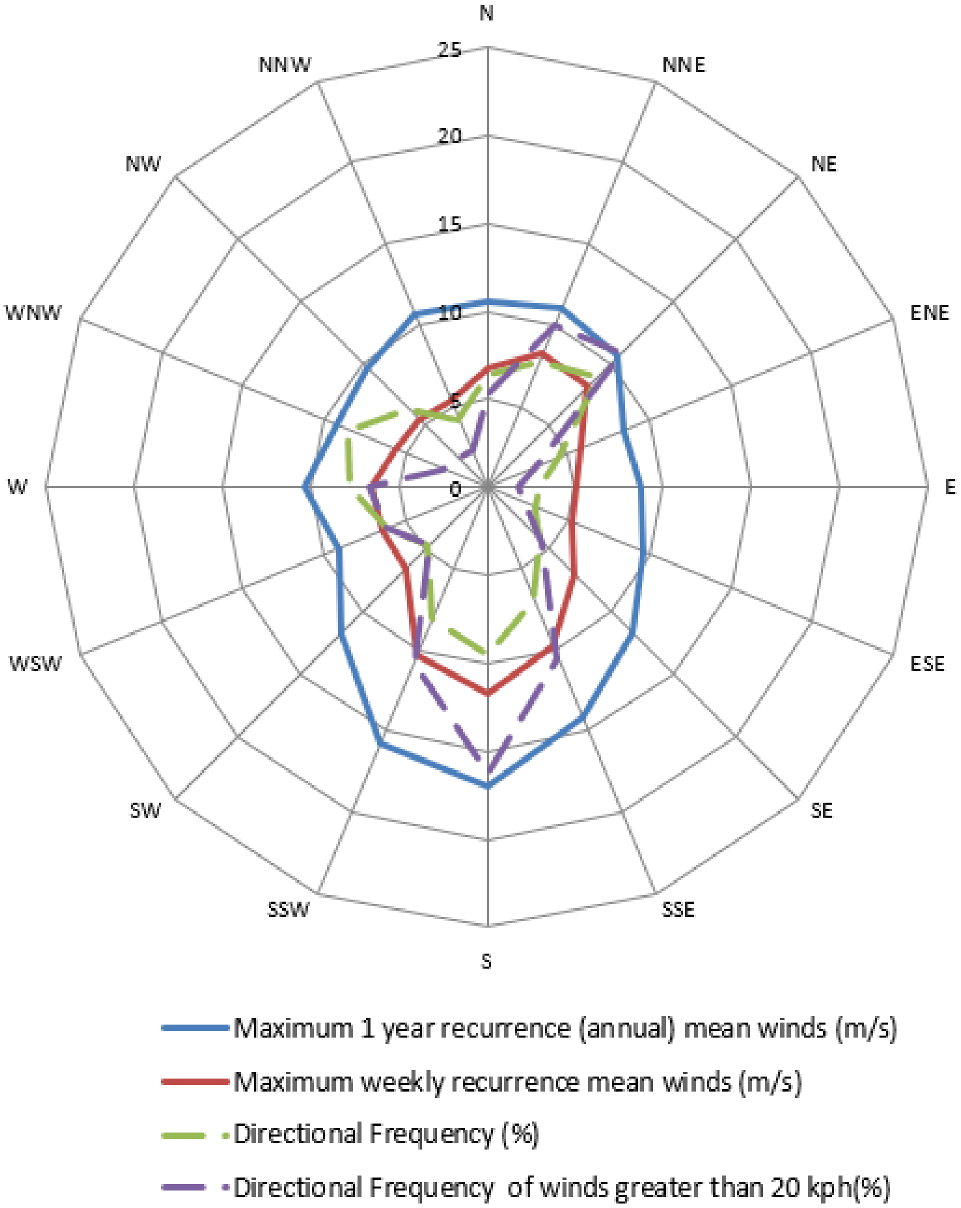

Figure 4: Annual and 5% Exceedance Hourly Mean Wind Speeds, and Frequencies of Occurrence, for the Central Coast Region (at 10m height in standard open terrain)

5 PEDESTRIAN WIND COMFORT AND SAFETY

The acceptability of wind conditions for an area is determined by comparing the measured wind speeds against an appropriate criteria. This section outlines how the measured wind speeds were obtained, the criteria considered for the development, as well as the critical trafficable areas that were assessed and their corresponding criteria designation.

5.1 Measured Wind Speeds

Wind speeds were measured using either Dantec hot-wire probe anemometers or pressure-based wind speed sensors, positioned to monitor wind conditions at critical outdoor trafficable areas of the development. The reference mean free-stream wind speed measured in the wind tunnel, which is at a full-scale height of 200m and measured 3m upstream of the study model.

Measurements were acquired for 16 wind directions at 22.5 degree increments using a sample rate of 1,024Hz. The full methodology of determining the wind speed measurements at the site from either the Dantec Hot-wire probe anemometers or pressure-based wind speed sensors is provided in Appendix B. Based on the results of the analysis of the boundary layer wind profiles at the site (see Section 3), and incorporating the regional wind model (see Section 4), the data sampling length of the wind tunnel test for each wind direction corresponds to a full-scale sample length ranging between 30 minutes and 1 hour. Research by A.W. Rofail and K.C.S. Kwok (1991) has shown that, in addition to the mean and standard deviation of the wind being stable for sample lengths of 15 minutes or more (full-scale), the peak value determined using the upcrossing method is stable for sample lengths of 30 minutes or more.

5.2 Wind Speed Criteria Used for This Study

For this study the measured wind conditions of the selected critical outdoor trafficable areas are compared against two sets of criteria; one for pedestrian safety, and one for pedestrian comfort. The safety criterion is applied to the annual maximum gust winds, and the comfort criteria is applied to Gust Equivalent Mean (GEM) winds. In accordance with ASCE (2003), the GEM wind speed is defined as follows:

$$GEM = max\left(\bar{V}, \frac{\hat{V}}{1.85}\right) \quad (5.1)$$

where:

$\bar{V}$ is the mean wind speed.

$\hat{V}$ is the 3-second gust wind speed.

For pedestrian safety, the safety limit criterion of 23m/s applies to 3-second duration annual maximum gust winds for all areas, in accordance with W.H. Melbourne (1978).

For pedestrian comfort, the A.G. Davenport (1972) criteria are used in conjunction with the GEM wind speed using a 5% probability of exceedance. Research by A.W. Rofail (2007) has shown that the A.G. Davenport (1972) criteria, used in conjunction with a GEM wind speed, has proven over time and through field observations to be the most reliable indicator of pedestrian comfort. A more detailed comparison of published criteria has been provided in Appendix A. The criteria considered in this study are summarised in Tables 3 and 4 for pedestrian comfort and safety, respectively. The results of the wind tunnel study are presented in the form of directional plots attached in Appendix C of this report. For each study point there is a plot of the GEM wind speeds using the comfort criteria, and a plot for the annual maximum gust wind speeds using the safety criterion.

Table 3: Comfort Criteria (from A.G. Davenport, 1972)

Classification	Description	Maximum 5% Exceedance GEM Wind Speed (m/s)
Short Exposure	Short duration stationary activities (generally less than 1 hour), including window shopping, waiting areas, etc.	5.5
Comfortable Walking	For pedestrian thoroughfares, private swimming pools, most communal areas, private balconies and terraces, etc.	7.5

Table 4: Safety Criterion (from W.H. Melbourne, 1978)

Classification	Description	Annual Maximum Gust Wind Speed (m/s)
Safety	Safety criterion applies to all trafficable areas.	23

5.3 Layout of Study Points

For this study a total of 38 study point locations were selected for analysis in the wind tunnel. This includes the following:

- 12 study points on Ground Floor along the pedestrian footpaths and trafficable areas around the site.
- 3 study points on Level 2.
- 5 study points on Level 3.
- 9 study points on Level 4.
- 4 study points on the rooftop terrace (Level 21).
- 5 study points on the tower balconies (Level 19, 23, and 24).

The locations of the various study points tested for this study, as well as the target wind speed criteria for the various outdoor trafficable areas of the development, are presented in Figures 5 in the form of marked-up plans. It should be noted that only the most critical outdoor locations of the development have been selected for analysis.

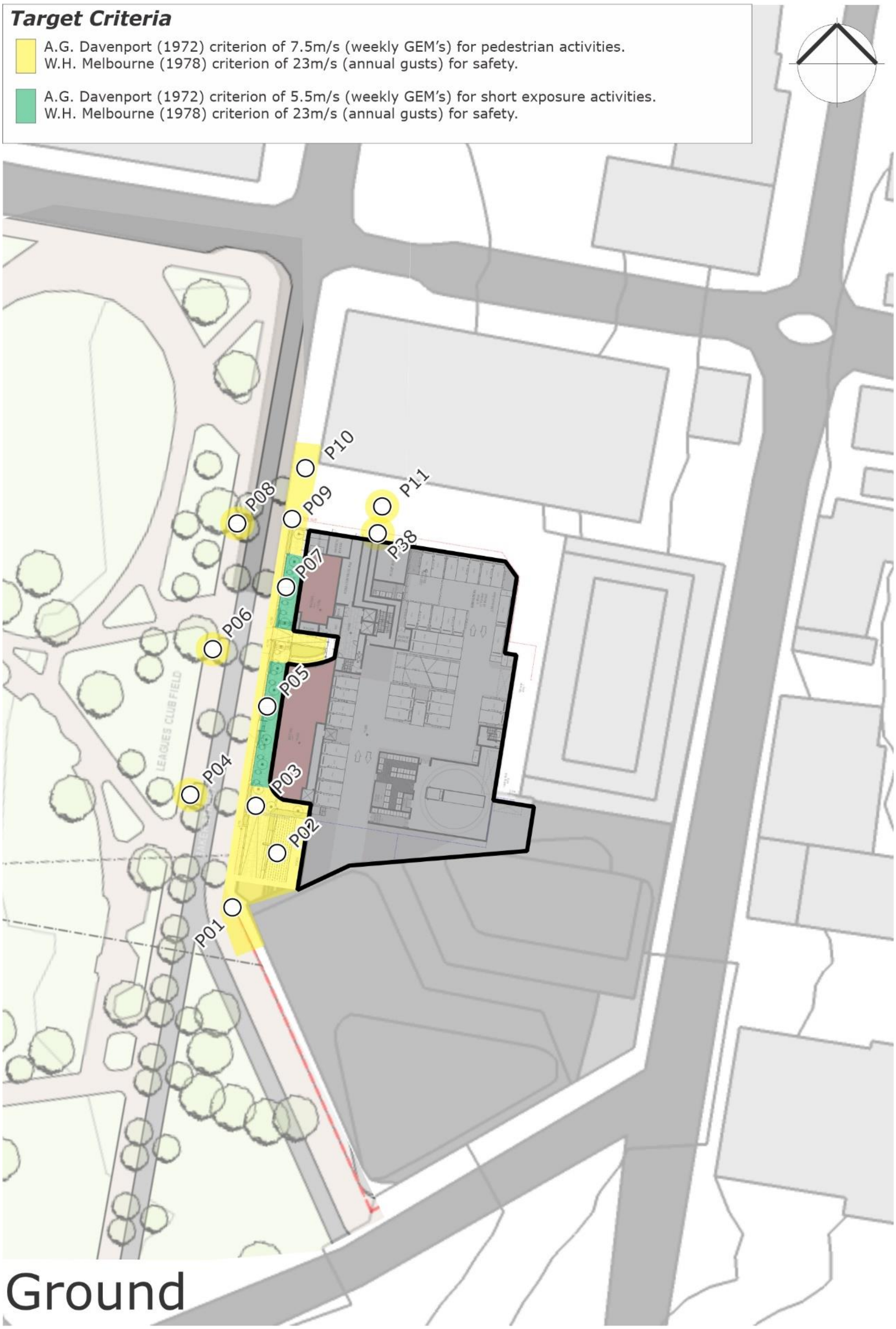

Figure 5a: Study Point Locations and Target Wind Speed Criteria – Ground Plan

Figure 5b: Study Point Locations and Target Wind Speed Criteria – Level 2 Plan

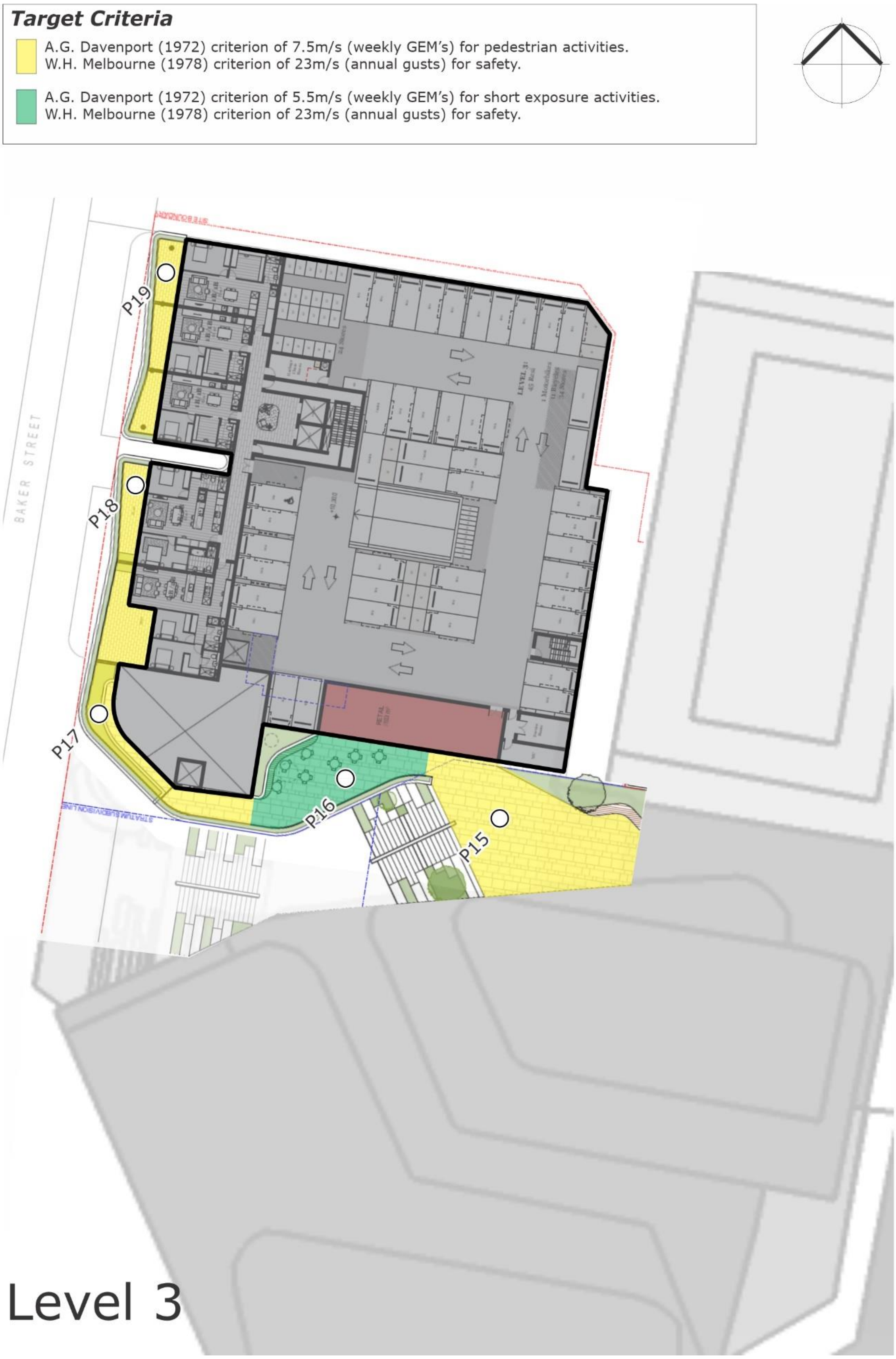

Figure 5c: Study Point Locations and Target Wind Speed Criteria – Level 3 Plan

Figure 5d: Study Point Locations and Target Wind Speed Criteria – Level 4 Plan

Figure 5e: Study Point Locations and Target Wind Speed Criteria – Level 19 Plan

Figure 5f: Study Point Locations and Target Wind Speed Criteria – Level 21 Plan

Figure 5g: Study Point Locations and Target Wind Speed Criteria – Level 23 Plan

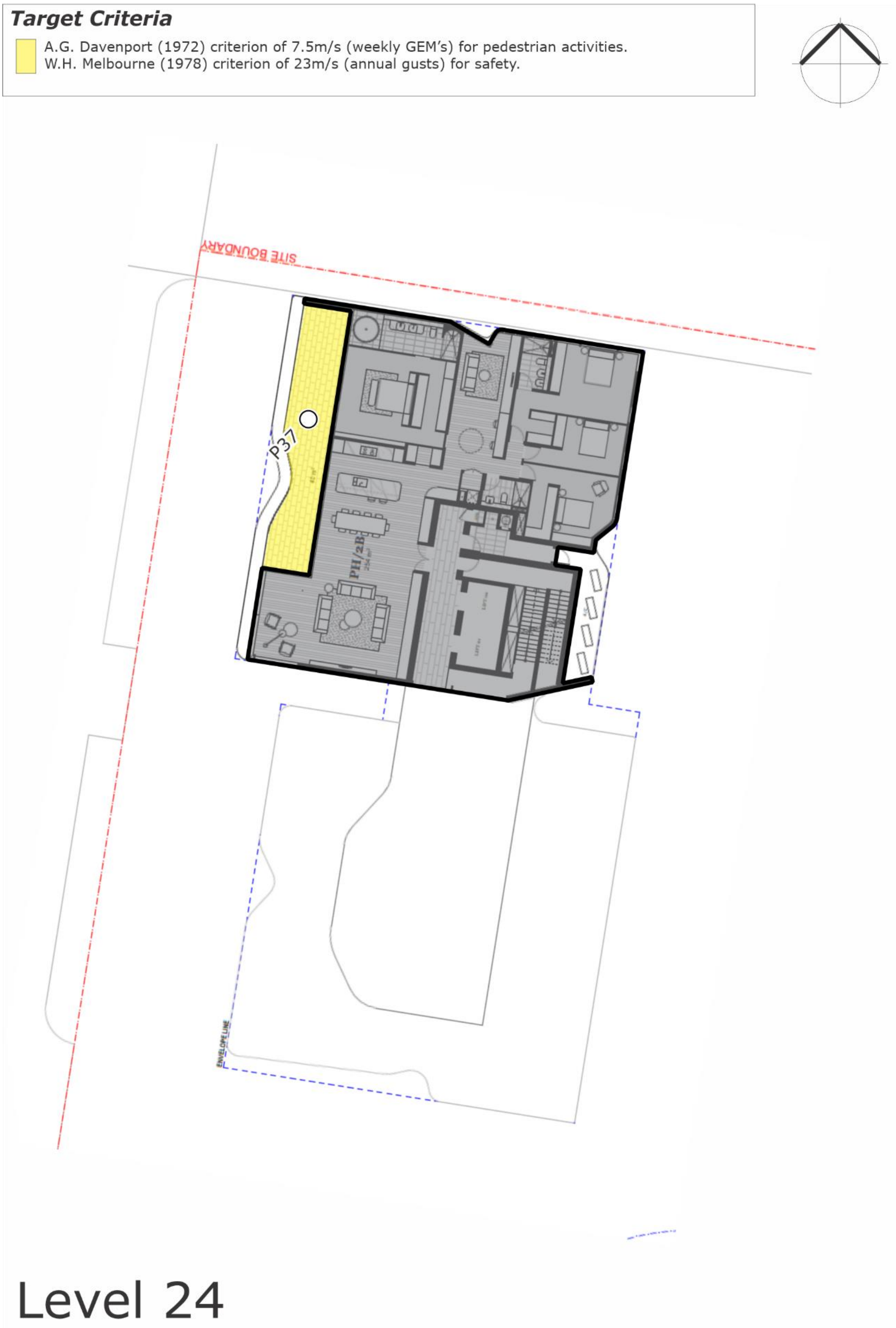

Figure 5h: Study Point Locations and Target Wind Speed Criteria – Level 24 Plan

6 RESULTS AND DISCUSSION

The results of the wind tunnel study are presented in the form of directional plots in Appendix C for all study point locations, summarised in Tables 5 and 6, and shown on marked-up plans in Figures 6. The wind speed criteria that the wind conditions should achieve are also listed in Tables 5 and 6 for each study point location, as well as in Figures 5. Mitigation measures have been shown below and in Figures 7 to address the Concept SSDA Condition C27 c).

The results of the initial wind tunnel study indicate that the majority of trafficable outdoor locations within and around the development will experience strong winds that will exceed the relevant criteria for comfort and/or safety. The ground floor has been tested with the inclusion of the following treatments:

- 2m high 30% porous screen along southern edge of stairs leading from ground floor to Level 2.
- 3-4m high densely foliating evergreen trees in the planter area at the southern end of stairs between ground floor and Level 1.
- 2.4m high impermeable screen at between the two southern columns, north of the stairs.
- 50% Porous façade for the carpark perimeter at the north-east corner of the development (Ground to Level 3 inclusive).

In addition, two treatment options were tested to mitigate the strong winds in the café seating areas along the western aspect of the development at ground floor, as described below:

Treatment Option 1:

- 1.2m high impermeable screens around each seating area, with screens connecting to columns.

Treatment Option 2:

- 2.4m high impermeable screens extending from each column.

For the above-ground areas of the development that are experiencing strong winds, the following in-principle treatments are described:

Level 2:

- 2m high 30% porous hoarding until southern towers are built.
- Incorporate impermeable screen on top of southern planter box for a combined height of 1.8m.
- Increase intertenancy screen height to at least 2m.

Level 3:

- Increase intertenancy screen height to at least 2m.
- Retain screen on top of planter for a total height of 1.3m

- Retain south-west corner as non-accessible to occupants.

Level 4:

- Incorporate 3m baffle screen arrangement throughout communal area on eastern side of towers.
- Retain screen on top of planter for a total height of 1.2m.
- Retain canopy structure at the southern terrace.
- Option 1: Remove access from private terrace into public terrace at south-west corner.
- Option 2: Include an impermeable screen along passageway to meet canopy structure.

Level 21:

- Retain screen on top of perimeter planter for a total height of 1.8m
- Include 1.5-2m high densely foliating evergreen vegetation at the east and west of the communal open space.

Level 24:

- Retain standard height impermeable balustrade for the western balcony.

As a general note, the use of loose glass-tops and light-weight sheets or covers (including loose BBQ lids) is not appropriate on high-rise outdoor terraces and balconies. Furthermore, lightweight furniture is not recommended unless it is securely attached to the balcony or terrace floor slab.

With the inclusion of these treatments to the final design, it is expected that wind conditions for all outdoor trafficable areas within and around the development will be suitable for their intended uses, thereby satisfying Concept SSDA Condition C27 b).

Figure 6a: Wind Tunnel Results – Proposed Scenario - Ground Floor
(results shown without treatments applied)

Figure 6b: Wind Tunnel Results – Proposed Scenario – Level 2
(results shown without treatments applied)

Figure 6c: Wind Tunnel Results – Proposed Scenario – Level 3
(results shown without treatments applied)

Figure 6d: Wind Tunnel Results – Proposed Scenario – Level 4
(results shown without treatments applied)

Figure 6e: Wind Tunnel Results – Proposed Scenario – Level 19
(results shown without treatments applied)

Figure 6f: Wind Tunnel Results – Proposed Scenario – Level 21
(results shown without treatments applied)

Figure 6g: Wind Tunnel Results – Proposed Scenario – Level 23
(results shown without treatments applied)

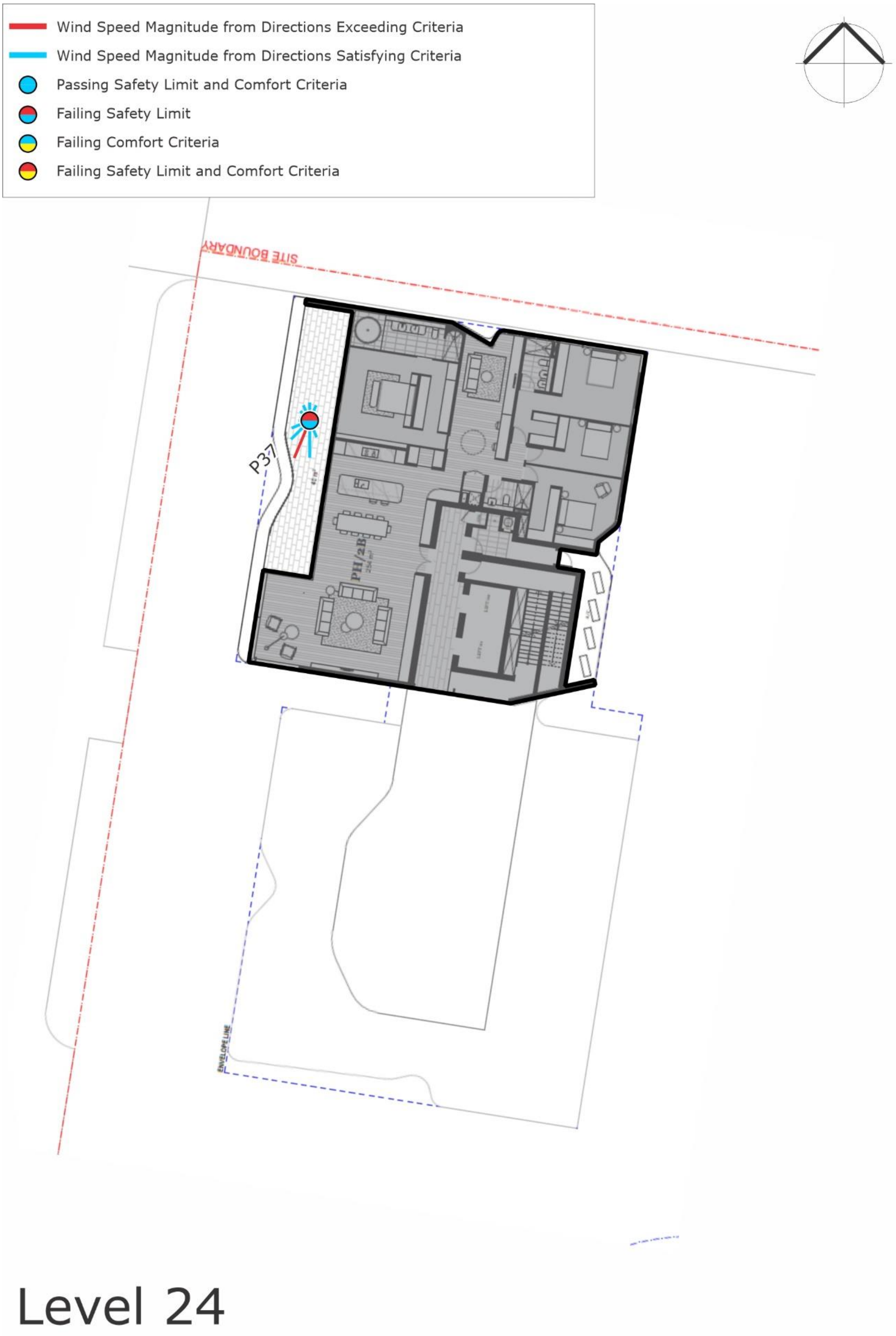

Figure 6h: Wind Tunnel Results – Proposed Scenario – Level 24
(results shown without treatments applied)

Figure 6i: Wind Tunnel Results – Future Scenario – Ground Floor
(results shown without treatments applied)

Figure 6j: Wind Tunnel Results – Future Scenario – Level 2
(results shown without treatments applied)

Figure 6k: Wind Tunnel Results – Future Scenario – Level 3
(results shown without treatments applied)

Figure 6l: Wind Tunnel Results – Future Scenario – Level 4
(results shown without treatments applied)

Figure 6m: Wind Tunnel Results – Future Scenario – Level 19
(results shown without treatments applied)

Figure 6n: Wind Tunnel Results – Future Scenario – Level 21
(results shown without treatments applied)

Figure 60: Wind Tunnel Results – Future Scenario – Level 23
(results shown without treatments applied)

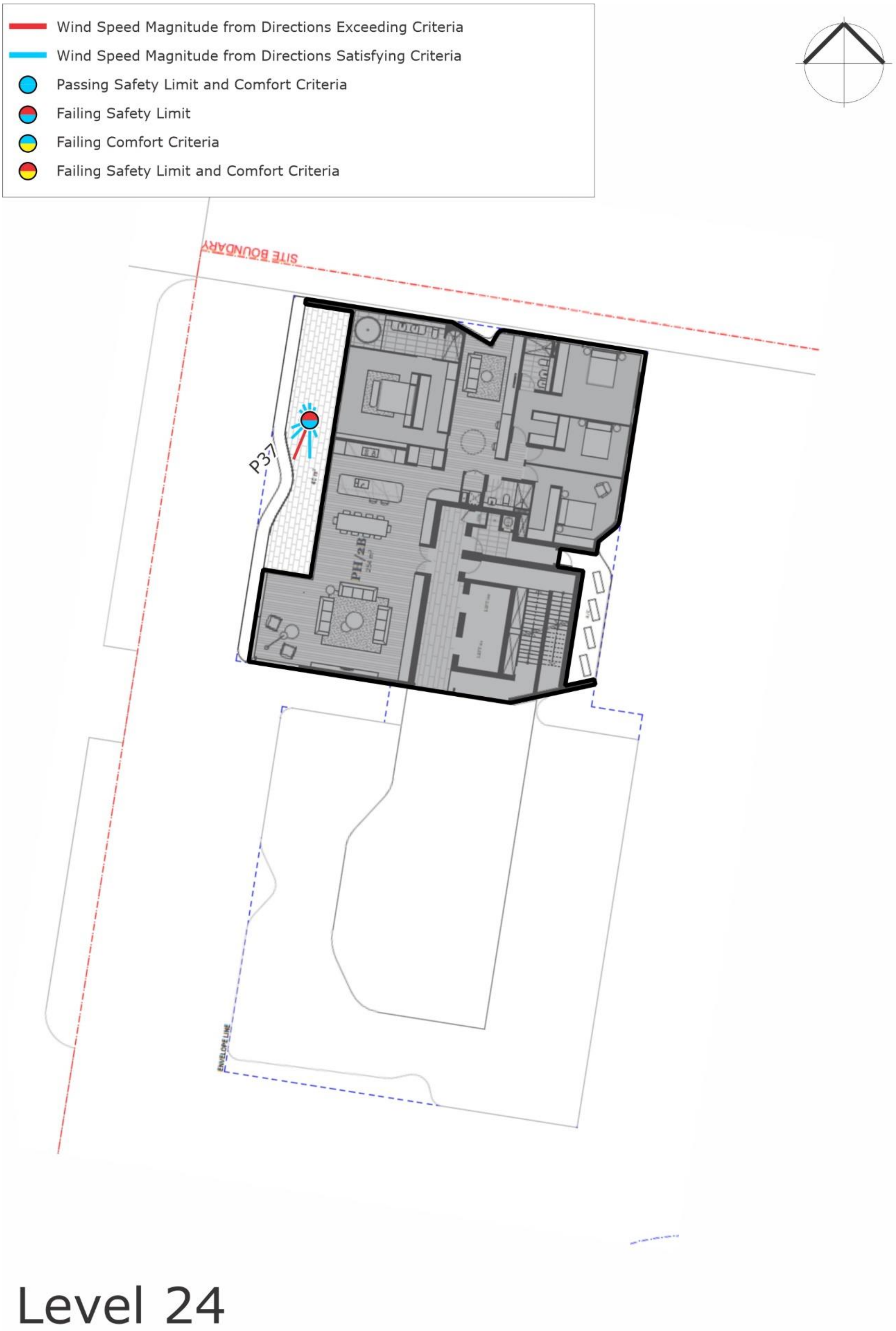

Figure 6p: Wind Tunnel Results – Future Scenario – Level 24
(results shown without treatments applied)

Table 5: Wind Tunnel Results Summary – Proposed Scenario

Study Point	GEM (5% exceedance) Criterion (m/s)	GEM Results (%)	GEM Grade	Annual Gust Criterion (m/s)	Annual Gust Results (m/s)	Annual Gust Grade	Final Result	Description of Treatment
P01	7.5	15%	Fail	23	28	Fail	Fail	Better than or equivalent to existing conditions.
Existing		19%	Fail		34	Fail	Fail	
P02	7.5	9%	Fail	23	27	Fail	Fail	2m porous screen along southern edge of stairs and 3-4m evergreen trees in planter area.
P03	7.5	25%	Fail	23	40	Fail	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		23%	Fail		38	Fail	Fail	
P04	7.5	23%	Fail	23	33	Fail	Fail	Better than or equivalent to existing conditions.
Existing		22%	Fail		37	Fail	Fail	
P05	5.5	27%	Fail	23	36	Fail	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		30%	Fail		38	Fail	Fail	
P06	7.5	24%	Fail	23	36	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		21%	Fail		36	Fail	Fail	
P07	5.5	20%	Fail	23	29	Fail	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		24%	Fail		31	Fail	Fail	
P08	7.5	25%	Fail	23	46	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		23%	Fail		39	Fail	Fail	
P09	7.5	29%	Fail	23	39	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		20%	Fail		35	Fail	Fail	
P10	7.5	13%	Fail	23	26	Fail	Fail	Better than or equivalent to existing conditions.
Existing		21%	Fail		41	Fail	Fail	
P11	7.5	17%	Fail	23	25	Fail	Fail	Make northern driveway only accessible to motorists and keep pedestrian path strictly along building edge.
Existing		4%	Pass		24	Fail	Fail	
P12	7.5	16%	Fail	23	32	Fail	Fail	2m porous screen along the southern boundary of stairs.
P13	5.5	26%	Fail	23	33	Fail	Fail	Impermeable screen on top of planter box for a combined height of 1.8m.
P14	5.5	31%	Fail	23	41	Fail	Fail	Impermeable screen on top of planter box for a combined height of 1.8m.
P15	7.5	2%	Pass	23	20	Pass	Pass	
P16	5.5	16%	Fail	23	20	Pass	Fail	Impermeable screen on top of planter at a total height of 1.3m.
P17	7.5	22%	Fail	23	41	Fail	Fail	Make area non-accessible to occupants.
P18	7.5	4%	Pass	23	24	Fail	Fail	Increase intertenancy screen height to greater than 2m.
P19	7.5	2%	Pass	23	18	Pass	Pass	

Study Point	GEM (5% exceedance)			Annual Gust			Final Result	Description of Treatment
	Criterion (m/s)	Results (%)	Grade	Criterion (m/s)	Results (m/s)	Grade		
P20	5.5	26%	Fail	23	26	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P21	5.5	31%	Fail	23	32	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P22	5.5	36%	Fail	23	36	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P23	5.5	35%	Fail	23	38	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P24	5.5	19%	Fail	23	22	Pass	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P25	5.5	19%	Fail	23	21	Pass	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P26	5.5	25%	Fail	23	27	Fail	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P27	7.5	4%	Pass	23	25	Fail	Fail	Make area non-accessible or include a screen along footpath that connects to the canopy.
P28	7.5	4%	Pass	23	20	Pass	Pass	
P29	7.5	< 1%	Pass	23	11	Pass	Pass	
P30	7.5	< 1%	Pass	23	8	Pass	Pass	
P31	7.5	< 1%	Pass	23	12	Pass	Pass	
P32	5.5	23%	Fail	23	33	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating vegetation 1.5-2m high.
P33	5.5	33%	Fail	23	31	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P34	5.5	22%	Fail	23	34	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P35	5.5	13%	Fail	23	25	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P36	7.5	< 1%	Pass	23	9	Pass	Pass	
P37	7.5	4%	Pass	23	25	Fail	Fail	Standard height impermeable balustrade.
P38	7.5	9%	Fail	23	24	Fail	Fail	Porous carpark façade.
Existing		4%	Pass		24	Fail	Fail	

Table 6: Wind Tunnel Results Summary – Future Scenario

Study Point	GEM (5% exceedance) Criterion (m/s)	GEM Results (%)	GEM Grade	Annual Gust Criterion (m/s)	Annual Gust Results (m/s)	Annual Gust Grade	Final Result	Description of Treatment
P01	7.5	20%	Fail	23	35	Fail	Fail	To be addressed during the design and construction of the southern phase.
Existing		19%	Fail		34	Fail	Fail	
P02	7.5	8%	Fail	23	28	Fail	Fail	2m porous screen along southern edge of stairs and 3-4m evergreen trees in planter area.
P03	7.5	14%	Fail	23	33	Fail	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		23%	Fail		38	Fail	Fail	
P04	7.5	23%	Fail	23	35	Fail	Fail	Better than or equivalent to existing conditions.
Existing		22%	Fail		37	Fail	Fail	
P05	5.5	21%	Fail	23	27	Fail	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		30%	Fail		38	Fail	Fail	
P06	7.5	19%	Fail	23	31	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		21%	Fail		36	Fail	Fail	
P07	5.5	15%	Fail	23	23	Pass	Fail	2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		24%	Fail		31	Fail	Fail	
P08	7.5	23%	Fail	23	41	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		23%	Fail		39	Fail	Fail	
P09	7.5	28%	Fail	23	39	Fail	Fail	Better than or equivalent to existing conditions with inclusion of 2.4m screen between southern columns and either Option 1 or 2 treatments.
Existing		20%	Fail		35	Fail	Fail	
P10	7.5	14%	Fail	23	28	Fail	Fail	Better than or equivalent to existing conditions.
Existing		21%	Fail		41	Fail	Fail	
P11	7.5	22%	Fail	23	30	Fail	Fail	Make northern driveway only accessible to motorists and keep pedestrian path strictly along building edge.
Existing		4%	Pass		24	Fail	Fail	
P12	7.5	14%	Fail	23	23	Pass	Fail	2m porous screen along the southern boundary of stairs.
P13	5.5	26%	Fail	23	33	Fail	Fail	Impermeable screen on top of planter box for a combined height of 1.8m.
P14	5.5	25%	Fail	23	34	Fail	Fail	Impermeable screen on top of planter box for a combined height of 1.8m.
P15	7.5	10%	Fail	23	28	Fail	Fail	2m porous screen along the southern boundary of stairs.
P16	5.5	14%	Fail	23	17	Pass	Fail	Impermeable screen on top of planter at a total height of 1.3m.
P17	7.5	15%	Fail	23	36	Fail	Fail	Make area non-accessible to occupants.
P18	7.5	3%	Pass	23	21	Pass	Pass	
P19	7.5	2%	Pass	23	18	Pass	Pass	

Study Point	GEM (5% exceedance)			Annual Gust			Final Result	Description of Treatment
	Criterion (m/s)	Results (%)	Grade	Criterion (m/s)	Results (m/s)	Grade		
P20	5.5	18%	Fail	23	21	Pass	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P21	5.5	18%	Fail	23	22	Pass	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P22	5.5	29%	Fail	23	29	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P23	5.5	37%	Fail	23	41	Fail	Fail	3m screen design and impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P24	5.5	15%	Fail	23	23	Pass	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P25	5.5	21%	Fail	23	26	Fail	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P26	5.5	20%	Fail	23	24	Fail	Fail	Impermeable screen on southern perimeter planter box to be a combined height of 1.2m.
P27	7.5	14%	Fail	23	35	Fail	Fail	Make area non-accessible or include a screen along footpath that connects to the canopy.
P28	7.5	4%	Pass	23	21	Pass	Pass	
P29	7.5	< 1%	Pass	23	10	Pass	Pass	
P30	7.5	< 1%	Pass	23	9	Pass	Pass	
P31	7.5	< 1%	Pass	23	11	Pass	Pass	
P32	5.5	21%	Fail	23	28	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating vegetation 1.5-2m high.
P33	5.5	28%	Fail	23	28	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P34	5.5	24%	Fail	23	32	Fail	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P35	5.5	11%	Fail	23	22	Pass	Fail	Impermeable perimeter screen 1.8m high and densely foliating evergreen vegetation 1.5-2m high.
P36	7.5	< 1%	Pass	23	9	Pass	Pass	
P37	7.5	4%	Pass	23	26	Fail	Fail	Standard height impermeable balustrade.
P38	7.5	5%	Pass	23	21	Pass	Pass	
Existing		4%	Pass		24	Fail	Fail	

Note that, for any study points listed in these tables with two rows of results data, the second row is for the existing site conditions. The test results shown in these tables are without any treatments applied. If treatment is required, the treatment is described within these tables.

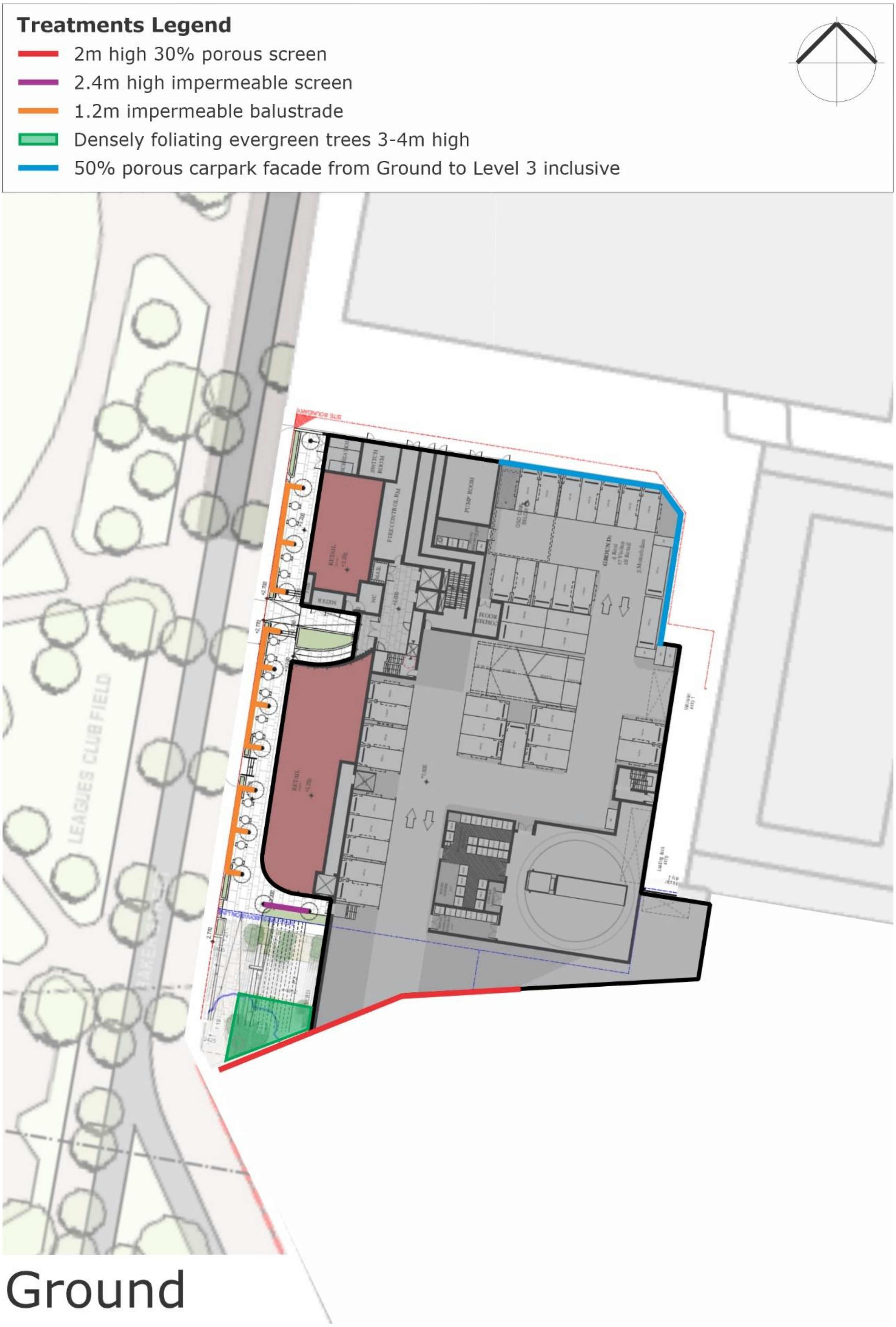

Figure 7a: Tested Treatments – Ground Level Plan (Option 1)

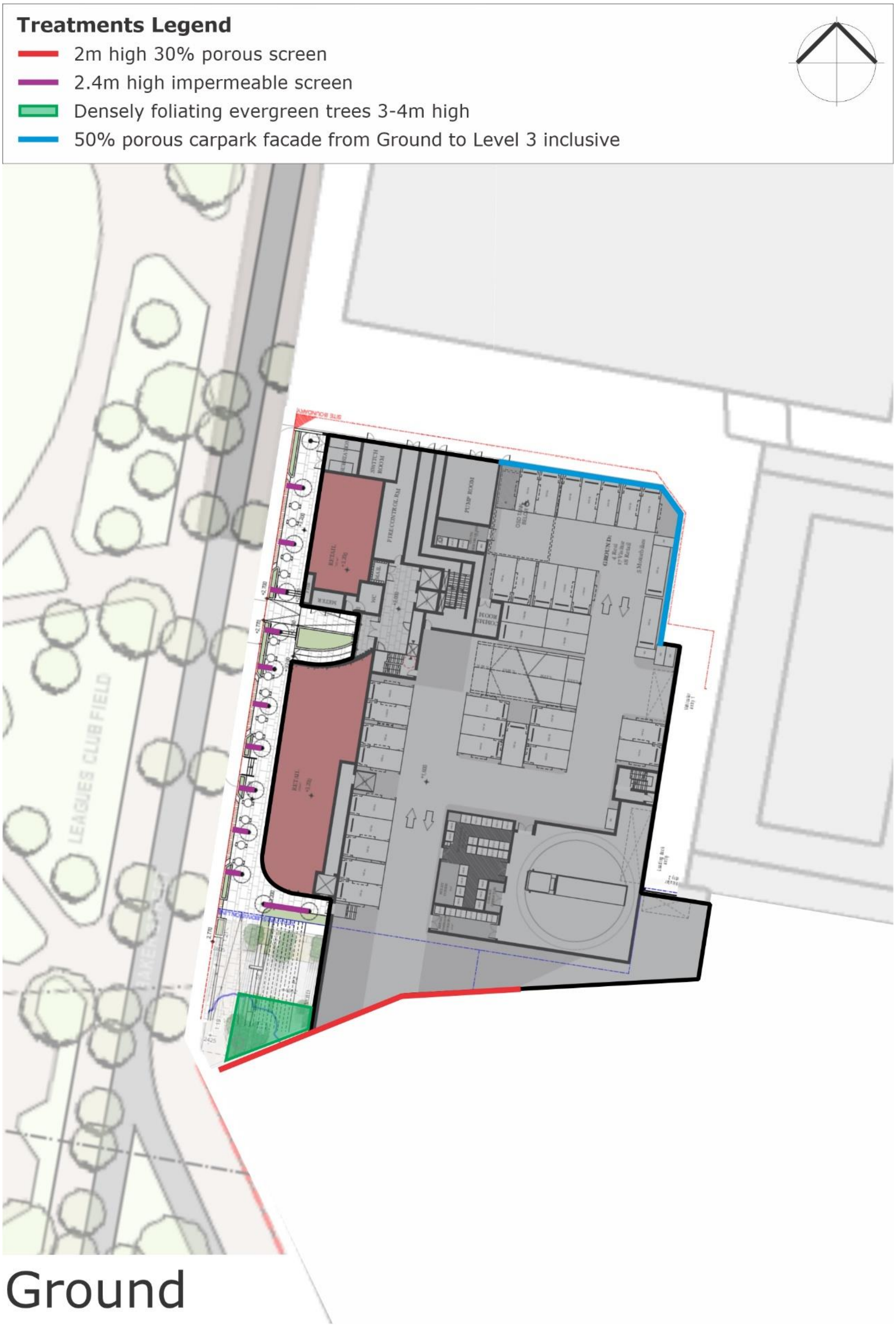

Figure 7b: Tested Treatments – Ground Level Plan (Option 2)

Figure 7c: Suggested Treatments – Level 2 Plan

Figure 7d: Suggested Treatments – Level 3 Plan

Figure 7e: Suggested Treatments – Level 4 Plan

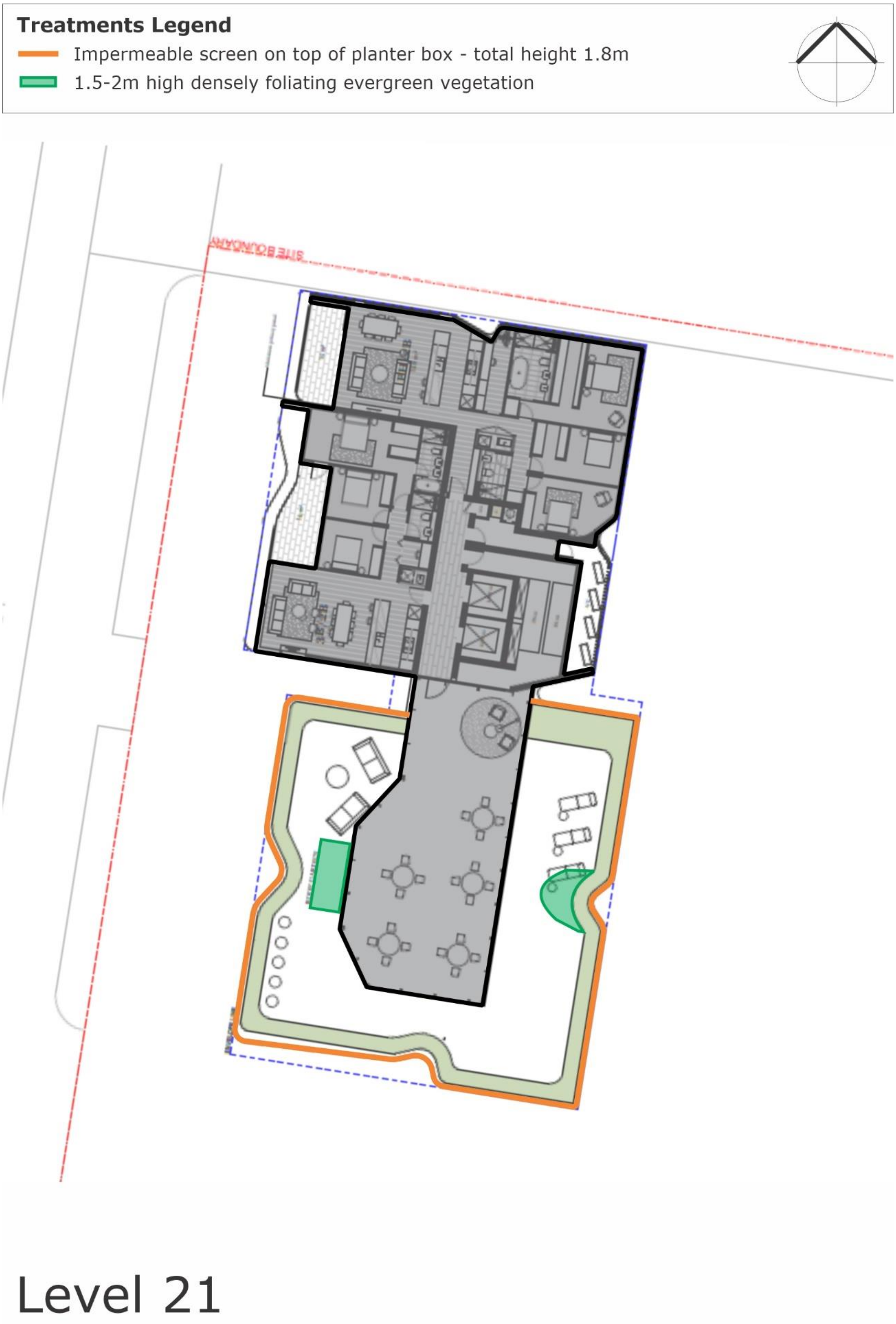

Figure 7f: Suggested Treatments – Level 21 Plan

Figure 7g: Suggested Treatments – Level 24 Plan

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APPENDIX A PUBLISHED ENVIRONMENTAL CRITERIA

A.1 Wind Effects on People

The acceptability of wind in an area is dependent upon the use of the area. For example, people walking or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Quantifying wind comfort has been the subject of much research and many researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, and A.D. Penwarden, have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities. This section discusses and compares the various published criteria.

A.2 A.D. Penwarden (1973) Criteria for Mean Wind Speeds

A.D. Penwarden (1973) developed a modified version of the Beaufort scale which describes the effects of various wind intensities on people. Table A.1 presents the modified Beaufort scale. Note that the effects listed in this table refers to wind conditions occurring frequently over the averaging time (a probability of occurrence exceeding 5%). Higher ranges of wind speeds can be tolerated for rarer events.

Table A.1: Summary of Wind Effects on People (A.D. Penwarden, 1973)

Type of Winds	Beaufort Number	Hourly Mean Wind Speed (m/s)	Effects
Calm	0	0 - 0.3	
Calm, light air	1	0.3 - 1.6	No noticeable wind
Light breeze	2	1.6 - 3.4	Wind felt on face
Gentle breeze	3	3.4 - 5.5	Hair is disturbed, clothing flaps, newspapers difficult to read
Moderate breeze	4	5.5 – 8.0	Raises dust, dry soil and loose paper, hair disarranged
Fresh breeze	5	8.0 – 10.8	Force of wind felt on body, danger of stumbling
Strong breeze	6	10.8 – 13.9	Umbrellas used with difficulty, hair blown straight, difficult to walk steadily, wind noise on ears unpleasant
Near gale	7	13.9 – 17.2	Inconvenience felt when walking
Gale	8	17.2 - 20.8	Generally impedes progress, difficulty balancing in gusts
Strong gale	9	20.8 – 24.5	People blown over

A.3 A.G. Davenport (1972) Criteria for Mean Wind Speeds

A.G. Davenport (1972) also determined a set of criteria in terms of the Beaufort scale and for various return periods. Table A.2 presents a summary of the criteria based on a probability of exceedance of 5%.

Table A.2: Criteria by A.G. Davenport (1972)

Classification	Activities	5% exceedance Mean Wind Speed (m/s)
Walking Fast	Acceptable for walking, main public accessways.	7.5 - 10.0
Strolling, Skating	Slow walking, etc.	5.5 - 7.5
Short Exposure Activities	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas.	3.5 - 5.5
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants & theatres and in parks.	0 - 3.5

A.4 T.V. Lawson (1975) Criteria for Mean Wind Speeds

In 1973, T.V. Lawson, while referring to the Beaufort wind speeds of A.D. Penwarden (1973) (as listed in Table A.1), quoted that a Beaufort 4 wind speed would be acceptable if it is not exceeded for more than 4% of the time, and that a Beaufort 6 wind speed would be unacceptable if it is exceeded more than 2% of the time. Later, in 1975, T.V. Lawson presented a set of criteria very similar to those presented in A.G. Davenport (1972) (as listed in Table A.2). These criteria are presented in Table A.3 and Table A.4 for safety and comfort respectively.

Table A.3: Safety Criteria by T.V. Lawson (1975)

Classification	Activities	Annual Mean Wind Speed (m/s)
Safety (all weather areas)	Accessible by the general public.	0 – 15
Safety (fair weather areas)	Private areas, balconies/terraces, etc.	0 – 20

Table A.4: Comfort Criteria by T.V. Lawson (1975)

Classification	Activities	5% exceedance Mean Wind Speed (m/s)
Business Walking	Objective Walking from A to B.	8 - 10
Pedestrian Walking	Slow walking, etc.	6 - 8
Short Exposure Activities	Pedestrian standing or sitting for short times.	4 – 6
Long Exposure Activities	Pedestrian sitting for a long duration.	0 - 4

A.5 W.H. Melbourne (1978) Criteria for Gust Wind Speeds

W.H. Melbourne (1978) introduced a set of criteria for the assessment of environmental wind conditions that were developed for a temperature range of 10°C to 30°C and for people suitably dressed for outdoor conditions. These criteria are presented in Table A.5, and are based on maximum gust wind speeds with a probability of exceedance of once per year.

Table A.5: Criteria by W.H. Melbourne (1978)

Classification	Activities	Annual Gust Wind Speed (m/s)
Limit for Safety	Completely unacceptable: people likely to get blown over.	23
Marginal	Unacceptable as main public accessways.	16 - 23
Comfortable Walking	Acceptable for walking, main public accessways	13 - 16
Short Exposure Activities	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas.	10 - 13
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants & theatres and in parks.	0 - 10

A.6 Comparison of the Published Wind Speed Criteria

W.H. Melbourne (1978) presented a comparison of the criteria of various researchers on a probabilistic basis. Figure A.1 presents the results of this comparison, and indicates that the criteria of W.H. Melbourne (1978) are comparatively quite conservative. This conclusion was also observed by A.W. Rofail (2007) when undertaking on-site remedial studies. The results of A.W. Rofail (2007) concluded that the criteria by W.H. Melbourne (1978) generally overstates the wind effects in a typical urban setting due to the assumption of a fixed 15% turbulence intensity for all areas. It was observed in A.W. Rofail (2007) that the 15% turbulence intensity assumption is not real and that the turbulence intensities at 1.5m above ground is at least 20% and in a suburban or urban setting is generally in the range of 30% to 60%.

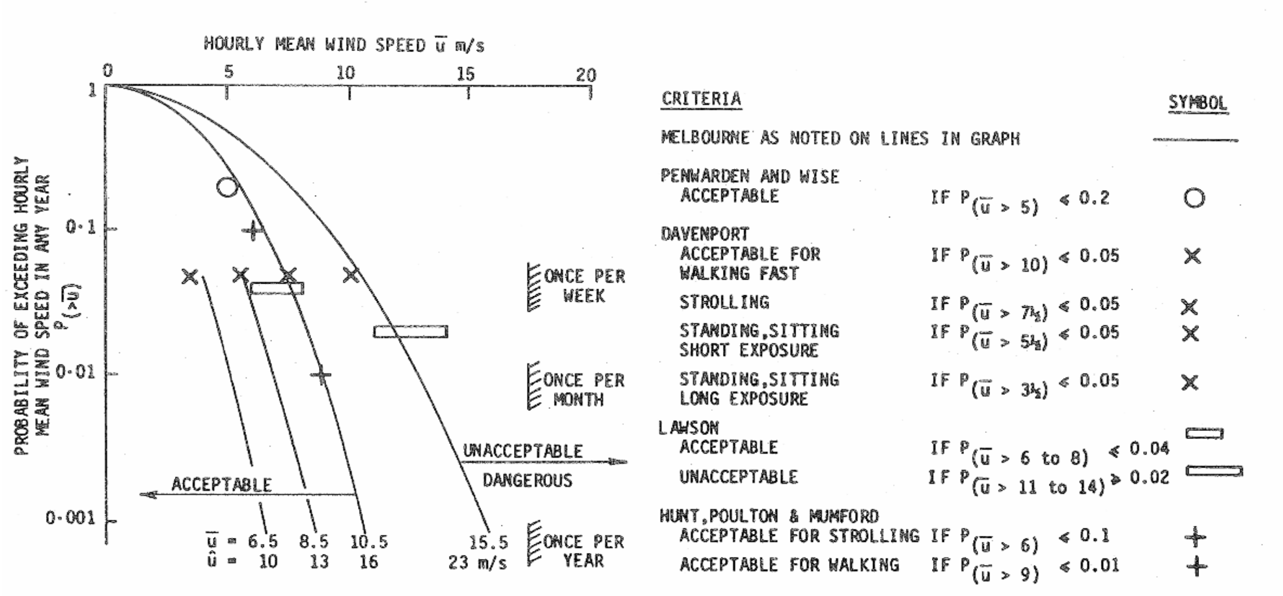

Figure A.1: Comparison of Various Mean and Gust Wind Environment Criteria, assuming 15% turbulence and a Gust Factor of 1.5 (W.H. Melbourne, 1978)

A.7 References relating to Pedestrian Comfort Criteria

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APPENDIX B DATA ACQUISITION

The wind tunnel testing procedures utilised for this study were based on the guidelines set out in the Australasian Wind Engineering Society Quality Assurance Manual (AWES-QAM-1-2019), ASCE 7-16 (Chapter C31), and CTBUH (2013). The wind speed measurements for the wind tunnel study were determined as coefficients using data acquired by either Dantec hot-wire probe anemometers or pressure-based wind speed sensors and converted to full-scale wind speeds using details of the regional wind climate obtained from an analysis of directional wind speed recordings from the local meteorological recording station(s).

B.1 Measurement of the Velocity Coefficients

The study model and proximity model were setup within the wind tunnel which was configured to the appropriate boundary layer profile, and the wind velocity measurements were monitored using either Dantec hot-wire probe anemometers or pressure-based wind speed sensors at selected critical outdoor locations. The wind velocity results presented in this study for each study point are representative of wind at a full-scale height of approximately 1.5m above ground/slab level. In the case of the Dantec hot-wire probe anemometers, the support of the probe is mounted such that the probe wire is vertical as much as possible to ensure that the measured wind speeds are independent of wind direction along the horizontal plane. In addition, care was taken in the alignment of the hot-wire probe wire and in avoiding wall-heating effects.

Wind speed measurements were made in the wind tunnel for 16 wind directions, at 22.5° increments. Data was acquired for each wind direction using a sample rate of 1024Hz. The sample length was determined to produce a full-scale sample time that is sufficient for this type of study. In the case of the pressure-based wind speed sensors, the phase lag between the various channels where data is acquired simultaneously is within 10% of a typical pressure cycle, and the signal is low-pass filtered at 500Hz and then digital filtering is applied over this range to provide an unbiased response from the pressure measurement system (A.W. Rofail, 2004).

The mean, gust and standard deviation velocity coefficients were determined from the data acquired in the wind tunnel. The gust velocity coefficients were also derived for each wind direction from by the following relation:

$$\hat{C}_V = \bar{C}_V + g \cdot \sigma_{C_V} \qquad \text{B.1}$$

where:

$\hat{C}_V$ is the gust velocity coefficient.

$\bar{C}_V$ is the mean velocity coefficient.

g is the peak factor, taken as 3.0 for a 3-sec gust and 3.4 for a 0.5-sec gust.

σ_{C_V} is the standard deviation of the velocity coefficient measurement.

In the case of a Dantec hot-wire probe anemometer, the velocity coefficient is obtained as follows:

$$C_V = \frac{C_{V,study}}{C_{V,200m}} \quad \text{B.2}$$

where:

$C_{V,study}$ is the velocity coefficient measurement obtained from the Dantec hot-wire probe anemometer at the study point location.

$C_{V,200m}$ is the velocity coefficient measurement obtained from the Dantec hot-wire probe anemometer at the free-stream reference location at 200m height upwind of the model in the wind tunnel.

However, in the case of the pressure-based wind speed sensors, these are determined from the measured differential mean, standard deviation and maximum pressure coefficients obtained from the wind speed sensor. For this analysis all calculations are performed on the square root of the differential pressure measurements. The velocity coefficient at the pressure-based wind speed sensor location is then calculated as follows:

$$C_V = \frac{\alpha + \beta\sqrt{\Delta p}}{V_{200m}} \quad \text{B.3}$$

where:

C_V is the velocity coefficient measurement at the study point location.

α is a calibration coefficient for the pressure-based wind speed sensor.

β is a calibration coefficient for the pressure-based wind speed sensor.

Δp is the differential pressure obtained from the pressure-based wind speed sensor at the study point location.

V_{200m} is the wind speed at the free-stream reference location of 200m height (full-scale) in the wind tunnel, which is determined directly in the wind tunnel using a pitot static probe.

B.2 Calculation of the Full-Scale Results

The full-scale results determine if the wind conditions at a study location satisfy the designated criteria of that location. More specifically, the full-scale results need to determine the probability of exceedance of a given wind speed at a study location. To determine the probability of exceedance, the measured velocity coefficients were combined with a statistical model of the local wind climate that relates wind speed to a probability of exceedance. Details of the wind climate model are outlined in Section 4 of the main report.

The statistical model of the wind climate includes the impact of wind directionality as any local variations in wind speed or frequency with wind direction. This is important as the wind directions that produce the highest wind speed events for a region may not coincide with the most wind exposed direction at the site.

The methodology adopted for the derivation of the full-scale results for the maximum gust and the GEM wind speeds are outlined in the following sub-sections.

B.3 Maximum Gust Wind Speeds

The full-scale maximum gust wind speed at each study point location is derived from the velocity coefficient using the following relationship:

$$V_{study} = V_{ref,RH}\left(\frac{k_{200m,tr,T=1hr}}{k_{RH,tr,T=1hr}}\right)C_V \qquad \text{B.4}$$

where:

V_{study} is the full-scale wind speed at the study point location.

$V_{ref,RH}$ is the full-scale reference wind speed at the study reference height. This value is determined by combining the directional wind speed data for the region (detailed in Section 4) and the upwind terrain and height multipliers for the site (detailed in Section 3).

$k_{200m,tr,T=1hr}$ is the hourly mean terrain and height multiplier at the free-stream reference location of 200m height.

$k_{RH,tr,T=1hr}$ is the hourly mean terrain and height multiplier at the study reference height (Section 3).

C_V is the velocity coefficient, obtained from either Equation B.2 (in the case of Dantec hot-wire probe anemometers) or Equation B.3 (in the case of pressure-based wind speed sensors).

The value of $V_{ref,RH}$ varies with each prevailing wind direction. Wind directions where there is a high probability that a strong wind will occur have a higher directional wind speed than other directions. To determine the directional wind speeds, a probability level must be assigned for each wind direction. These probability levels are set following the approach used in AS/NZS1170.2:2011, which assumes that the major contributions to the combined probability of exceedance of a typical load effect comes from only two 45 degree sectors.

B.4 Maximum Gust-Equivalent Mean Wind Speeds

The contribution to the probability of exceedance of a specified wind speed (ie: the desired wind speed for pedestrian comfort, as per the criteria) was calculated for each wind direction. These contributions are then combined over all wind directions to calculate the total probability of exceedance of the specified wind speed. To calculate the probability of exceedance for a specified wind speed a statistical wind climate model was used to describe the relationship between directional wind speeds and the probability of exceedance. A detailed description of the methodology is given by T.V. Lawson (1980).

The criteria used in this study is referenced to a probability of exceedance of 5% of a specified wind speed.

B.5 References relating to Data Acquisition

American Society of Civil Engineers (ASCE), ASCE-7-16, 2016, “Minimum Design Loads for Buildings and Other Structures”.

Australasian Wind Engineering Society, QAM-1, 2019, “Quality Assurance Manual: Wind Engineering Studies of Buildings”, edited by Rofail A.W., et al.

Council on Tall Buildings and Urban Habitat (CTBUH), 2013, “Wind tunnel testing of high-rise buildings”, CTBUH Technical Guides.

Lawson, T.V., 1980, “Wind Effects on Buildings - Volume 1, Design Applications”. Applied Science Publishers Ltd, Ripple Road, Barking, Essex, England.

Rofail A.W., Tonin, R., and Hanafi, D., 2004, “Sensitivity of frequency response to type of tubing”, Australasian Wind Engineering Workshop, Darwin.

Standards Australia and Standards New Zealand, AS/NZS 1170.2, 2011, “SAA Wind Loading Standard, Part 2: Wind Actions”.

APPENDIX C DIRECTIONAL PLOTS OF WIND TUNNEL RESULTS

C.1 Details of tested treatments

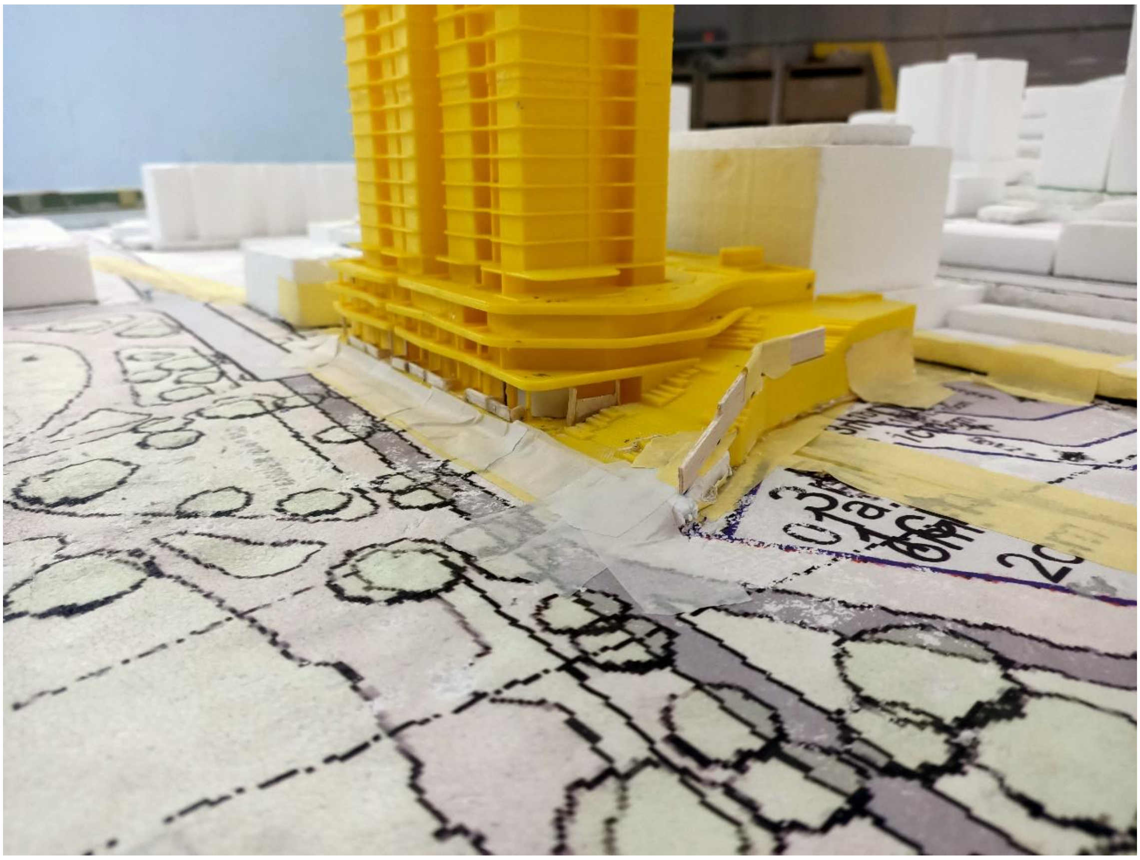


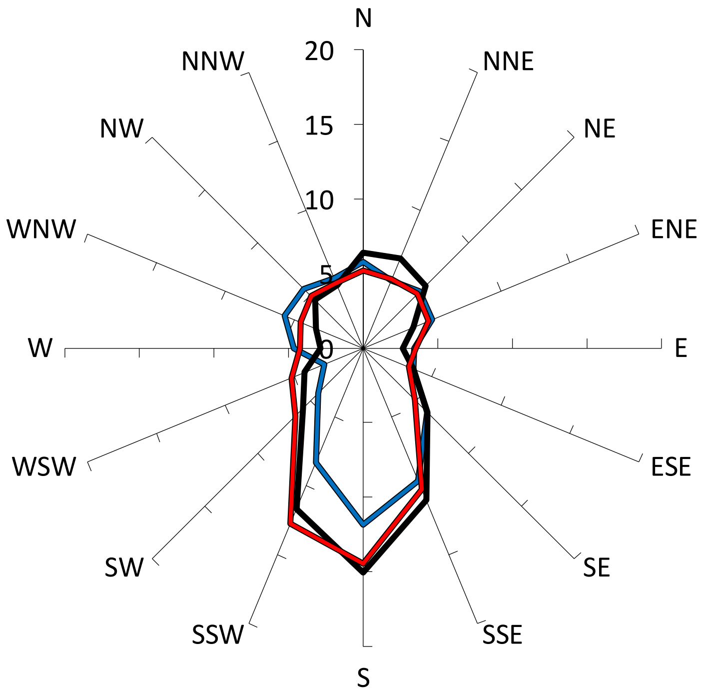
Figure C.1: Photograph of the Wind Tunnel Model with Option 1 café seating treatments, 2m high impermeable screen along southern edge of stairs and 3m high impermeable hoarding at Level 2, 2.4m high impermeable screen between southern columns

Figure C.2: Photograph of the Wind Tunnel Model with porous carpark facade

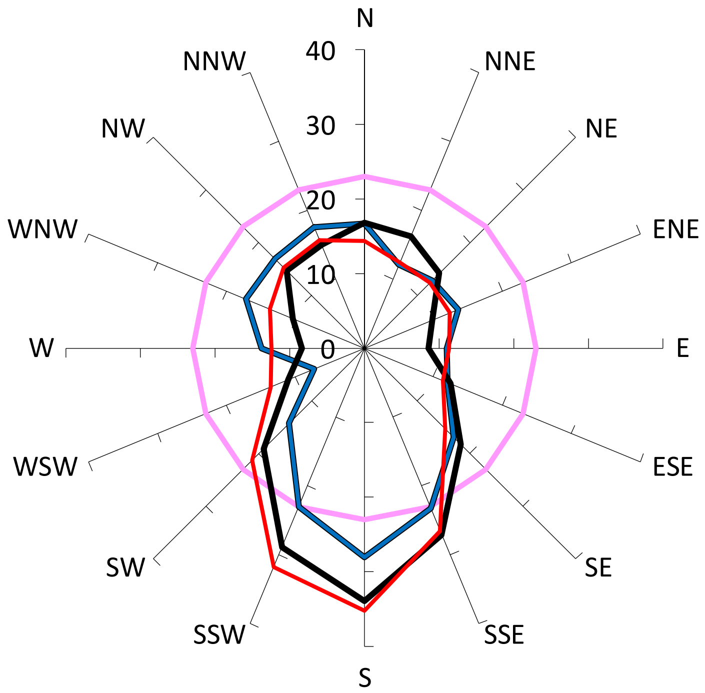
Figure C.3: Photograph of the Wind Tunnel Model with Option 2 café seating treatments, 2m high 30% porous screen running along southern edge from ground to Level 2, 3-4m high trees in planter area

Results for P01

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

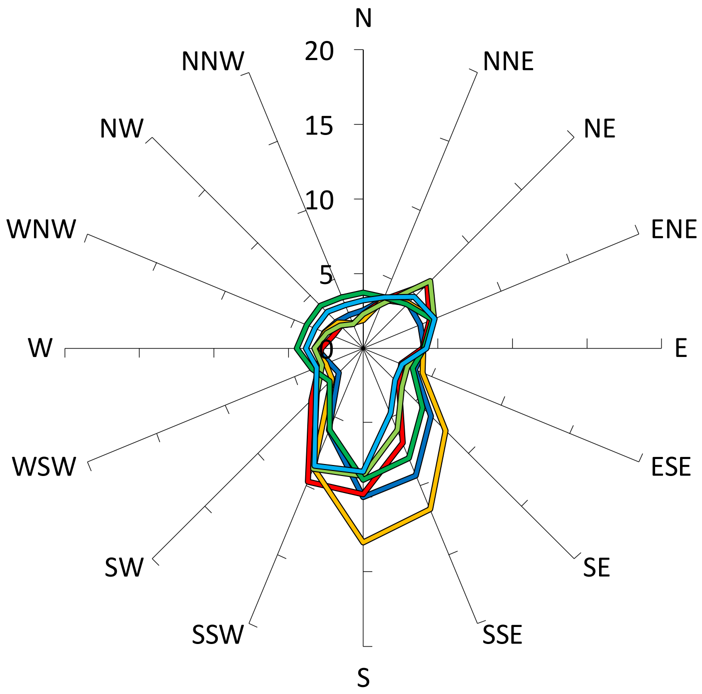


Safety Limit: 23m/s

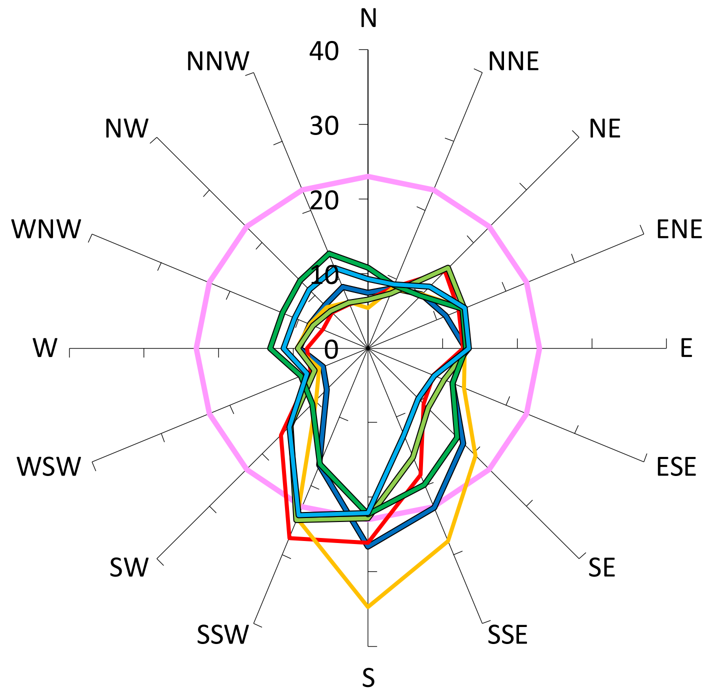
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	15%	28
Existing Scenario.	19%	34
With future massings and proposed development, no vegetation or other treatments.	20%	35

Results for P02

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

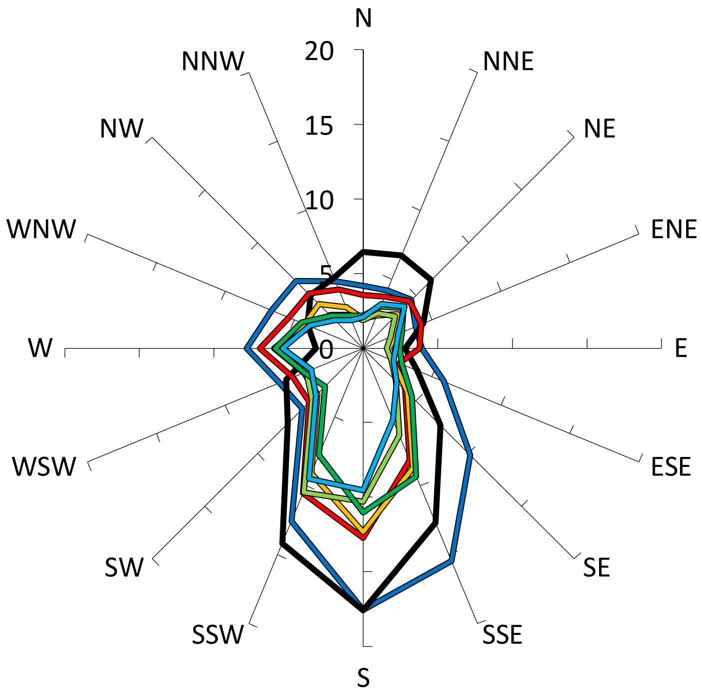


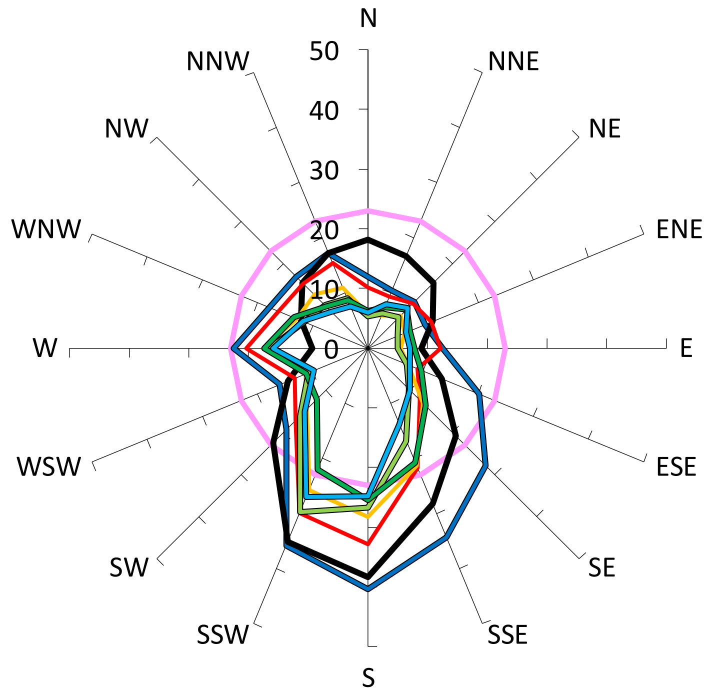
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	9%	27
With future massings and proposed development, no vegetation or other treatments.	8%	28
Proposed scenario with 2m high impermeable screen along southern edge of stairs and 3m high impermeable hoarding at Level 2.	16%	35
Future scenario with 2m high impermeable screen along southern edge of stairs and 3m high impermeable hoarding at Level 2.	5%	25
Proposed scenario with 2m high porous screen running along southern edge of stairs from ground to Level 2, 3-4m high trees in planter area.	6%	22
Future scenario with 2m high porous screen running along southern edge of stairs from ground to Level 2, 3-4m high trees in planter area.	4%	24

Results for P03

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





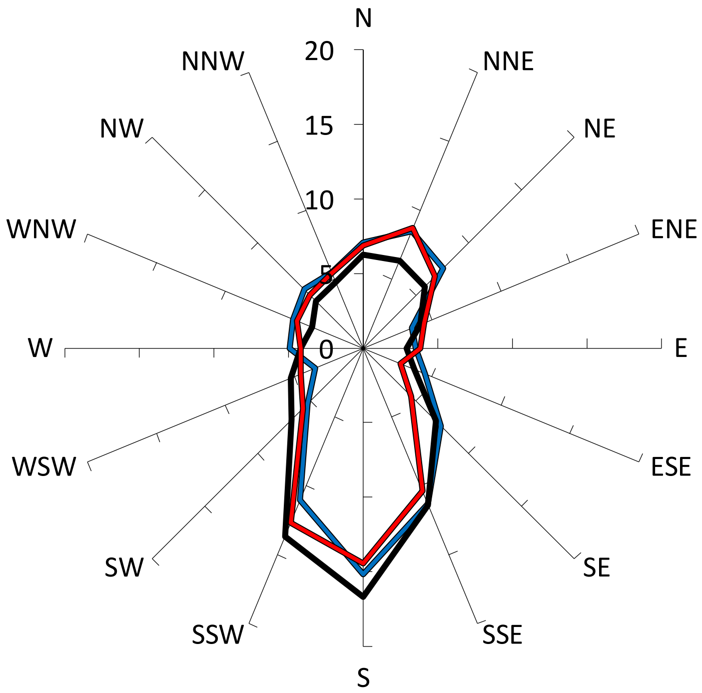
Comfort Criteria: 7.5m/s with 5% probability of exceedence

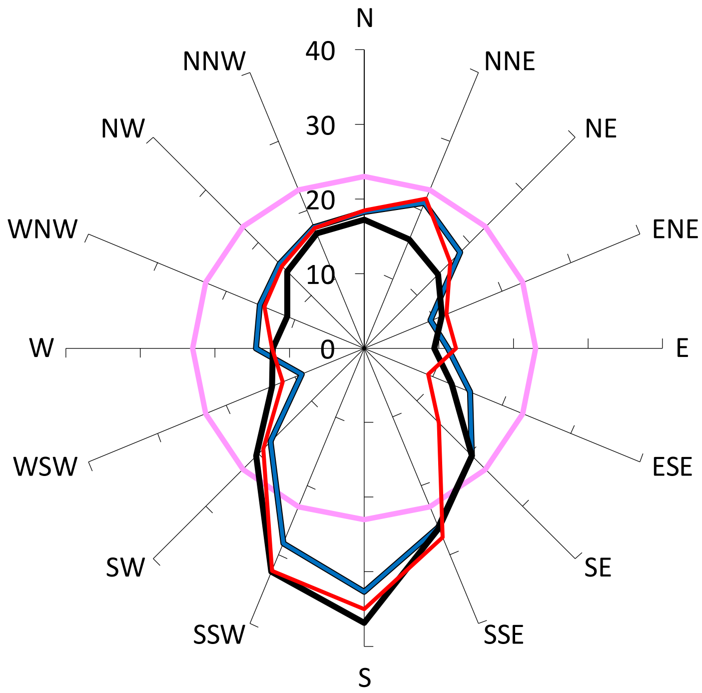
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	25%	40
Existing Scenario.	23%	38
With future massings and proposed development, no vegetation or other treatments.	14%	33
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	13%	28
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	9%	30
Proposed scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	12%	25
Future scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	7%	27

Results for P04

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





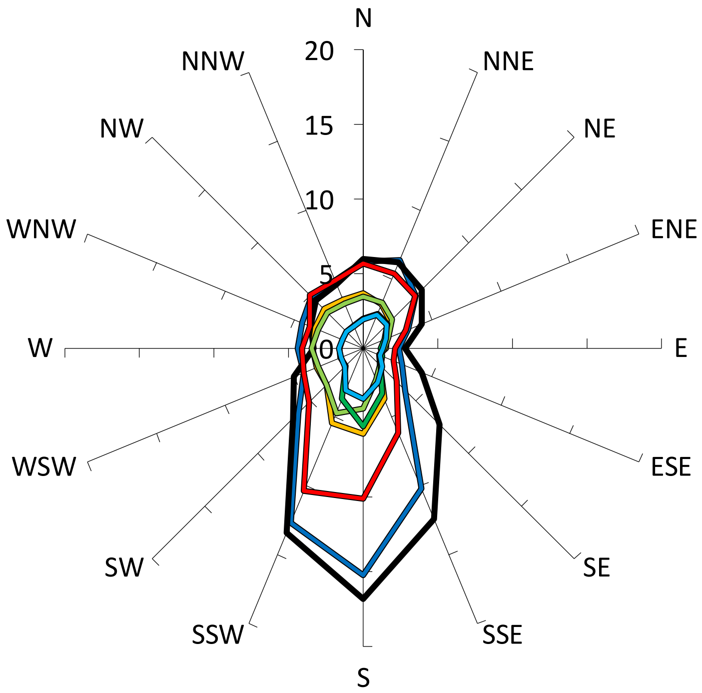
Comfort Criteria: 7.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

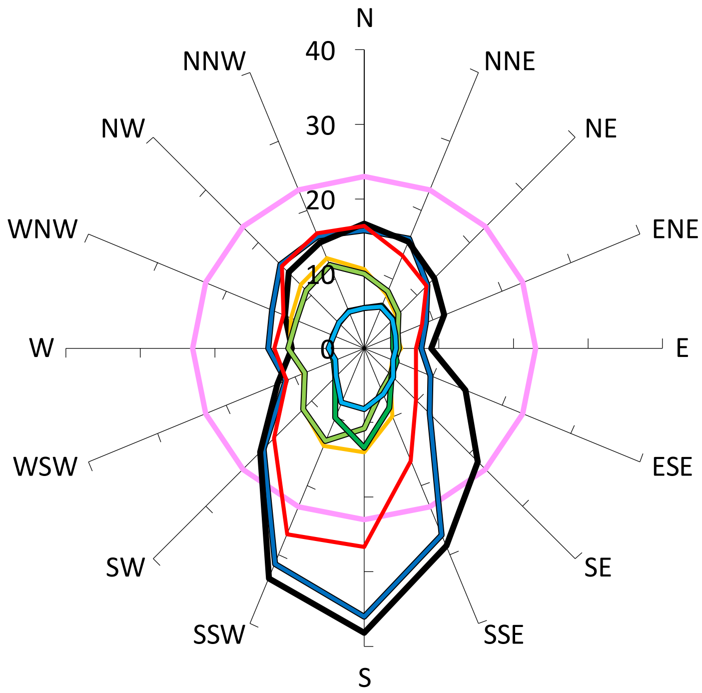
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	23%	33
Existing Scenario.	22%	37
With future massings and proposed development, no vegetation or other treatments.	23%	35

Results for P05

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 5.5m/s with 5% probability of exceedence

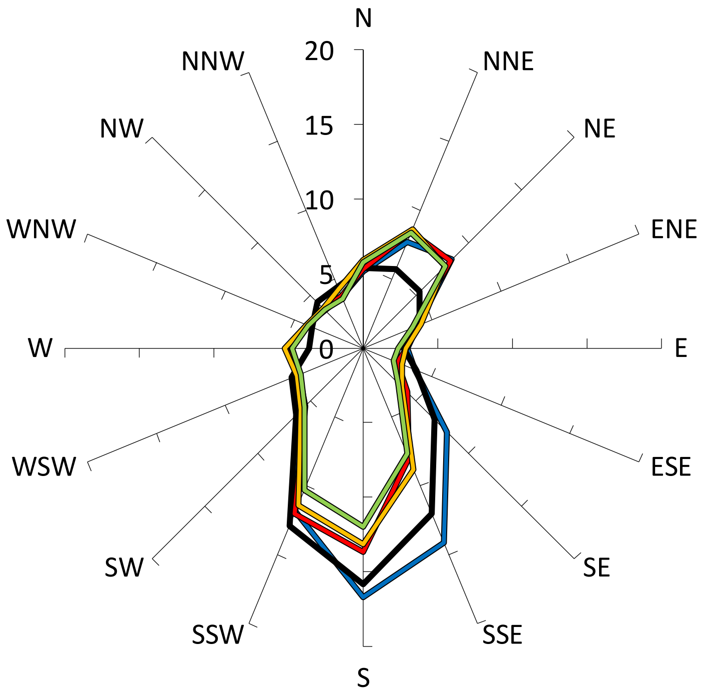


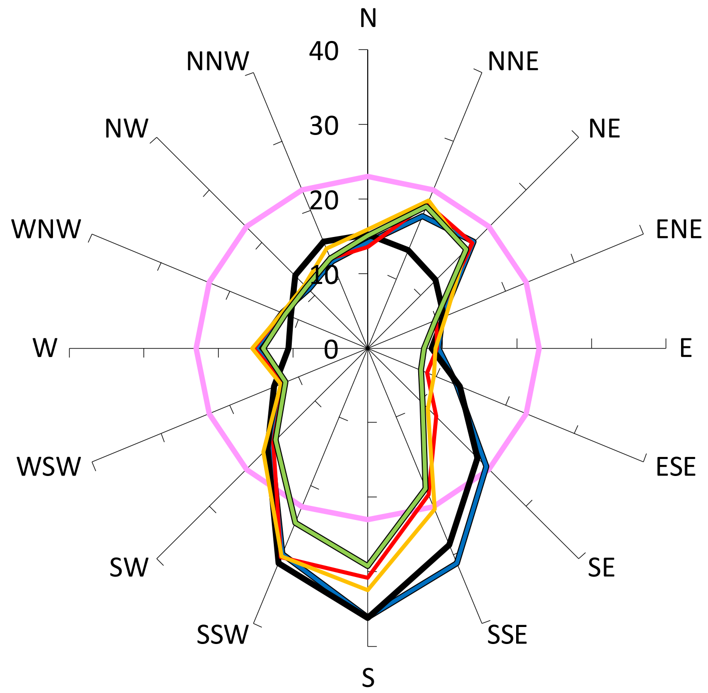
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	27%	36
Existing Scenario.	30%	38
With future massings and proposed development, no vegetation or other treatments.	21%	27
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	4%	14
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	2%	13
Proposed scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	1%	13
Future scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	< 1%	8

Results for P06

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





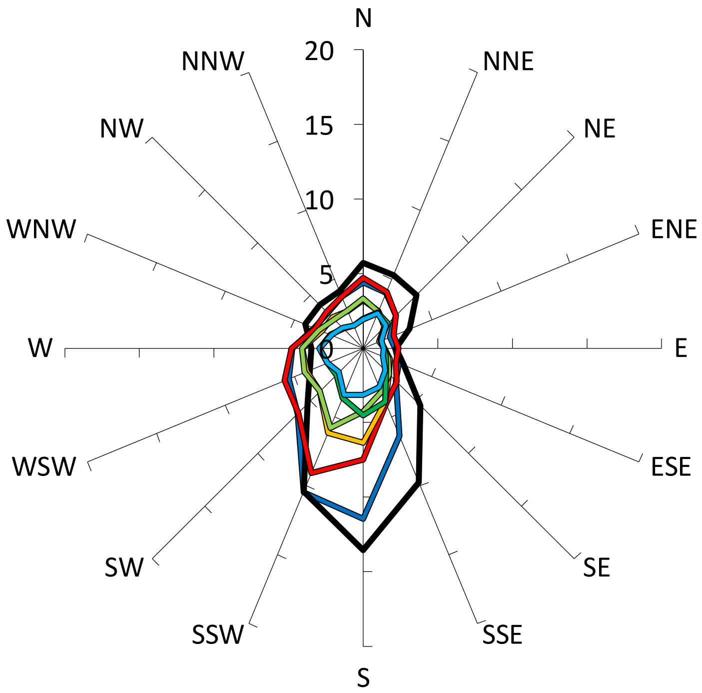
Comfort Criteria: 7.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

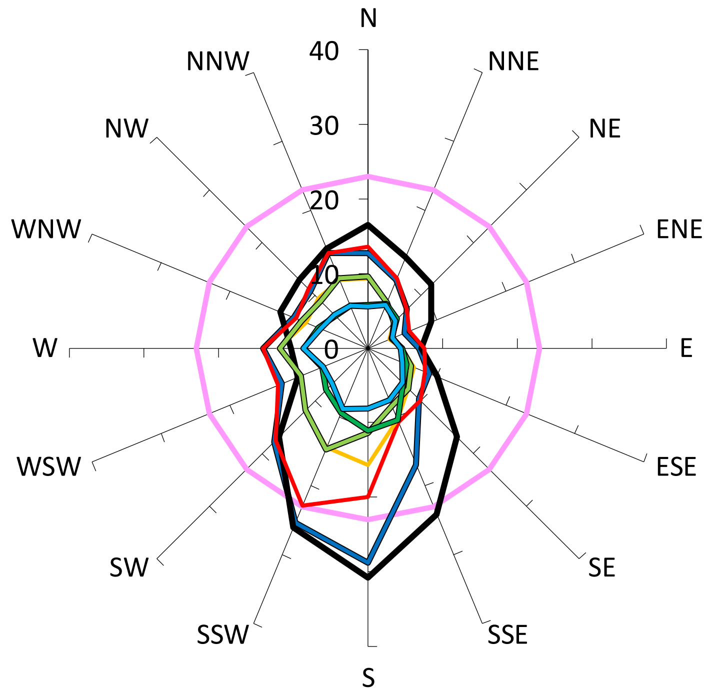
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	24%	36
Existing Scenario.	21%	36
With future massings and proposed development, no vegetation or other treatments.	19%	31
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	19%	32
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	16%	29

Results for P07

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 5.5m/s with 5% probability of exceedence

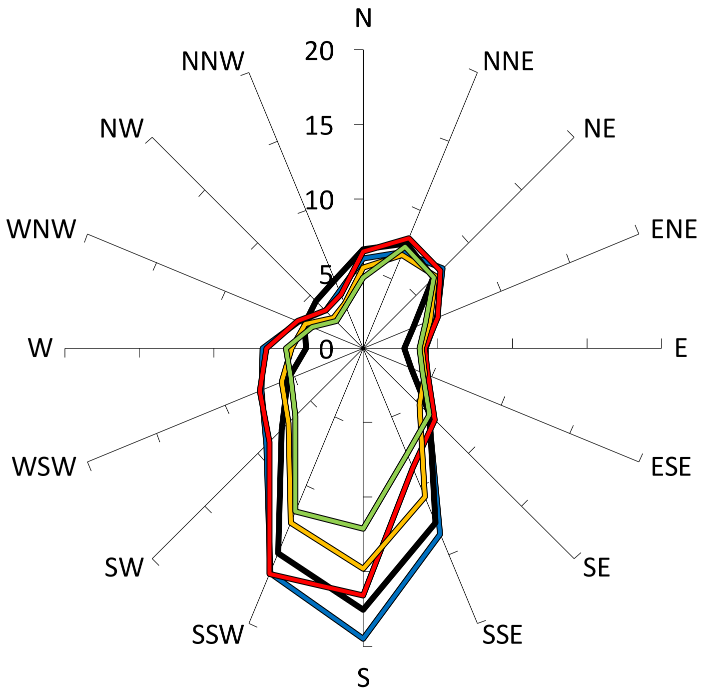


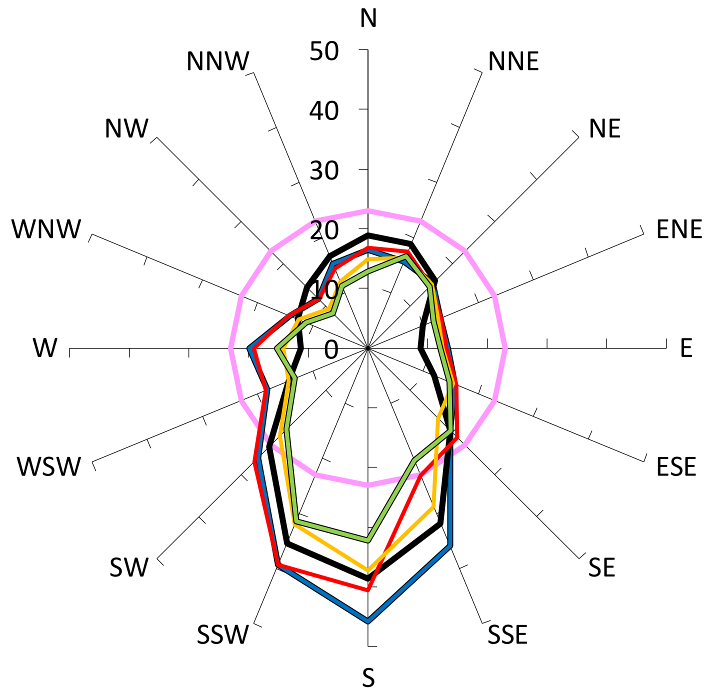
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	20%	29
Existing Scenario.	24%	31
With future massings and proposed development, no vegetation or other treatments.	15%	23
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	5%	16
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	3%	15
Proposed scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	1%	11
Future scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	< 1%	9

Results for P08

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





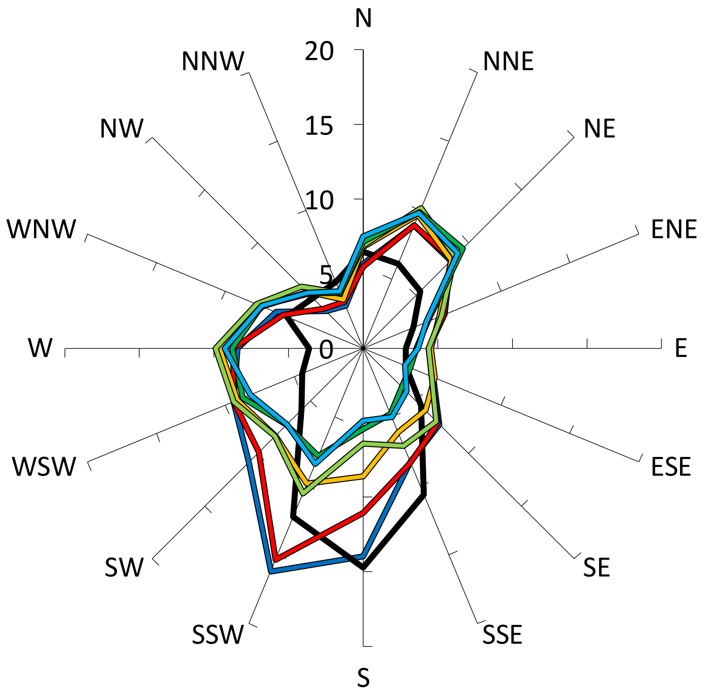
Comfort Criteria: 7.5m/s with 5% probability of exceedence

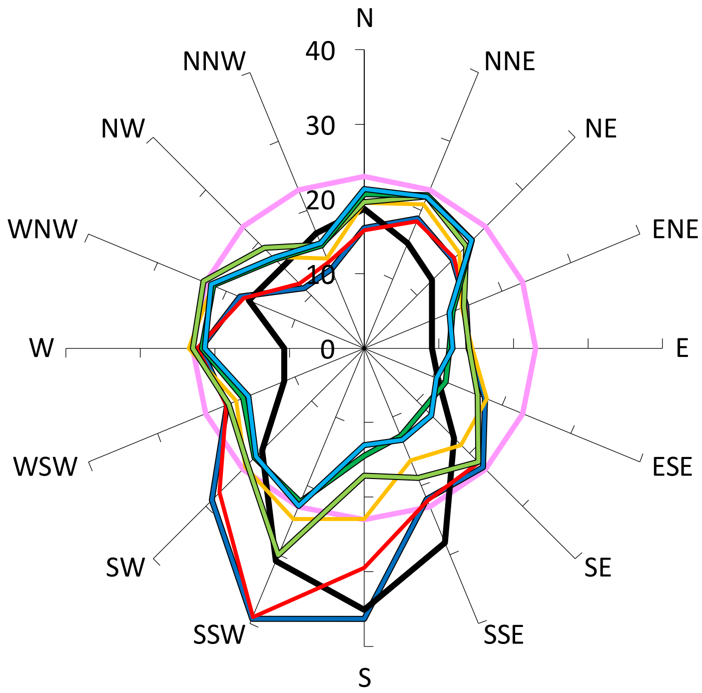
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	25%	46
Existing Scenario.	23%	39
With future massings and proposed development, no vegetation or other treatments.	23%	41
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	21%	37
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	16%	32

Results for P09

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





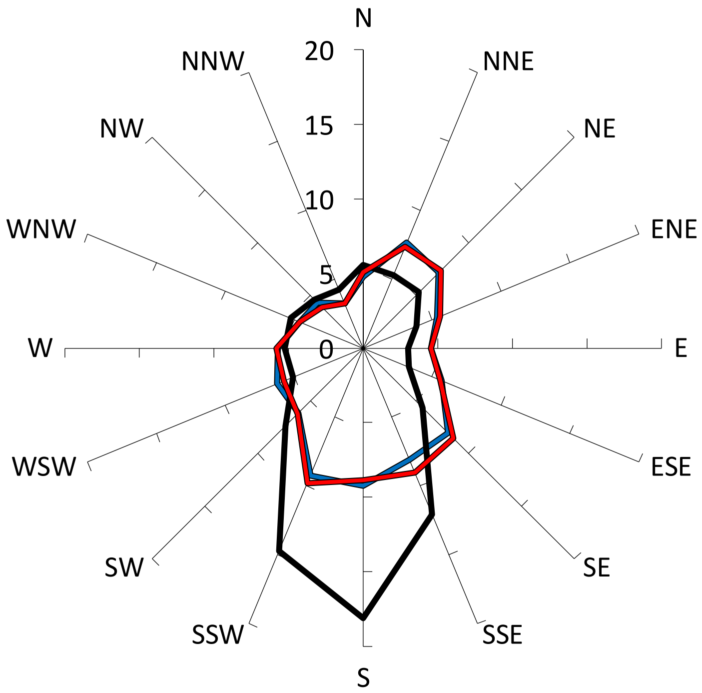
Comfort Criteria: 7.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

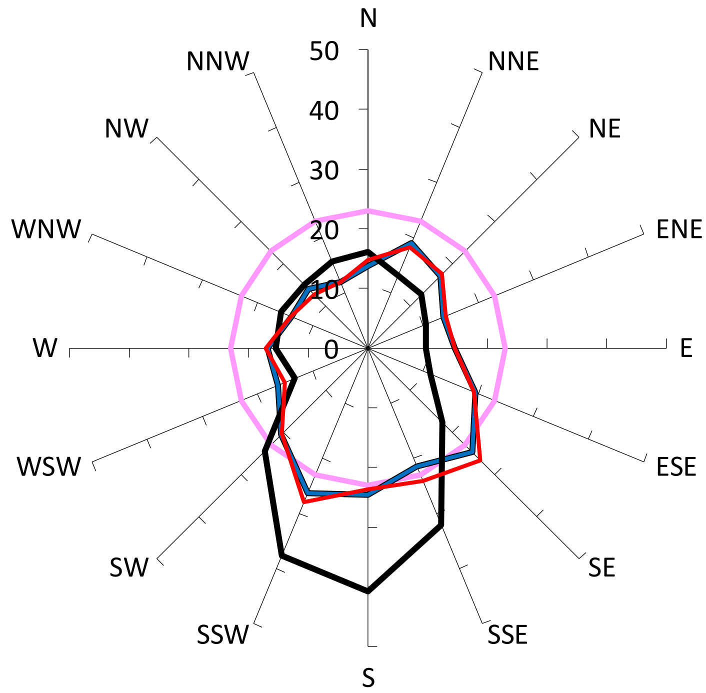
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	29%	39
Existing Scenario.	20%	35
With future massings and proposed development, no vegetation or other treatments.	28%	39
Proposed scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	22%	25
Future scenario with 2.4m screen at southern columns. 1.2m screens extending from each column along western façade and 1.2m screen along western edge.	24%	30
Proposed scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	20%	22
Future scenario with 2.4m screen at southern columns. 2.4m screens extending from each column along western façade.	19%	23

Results for P10

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

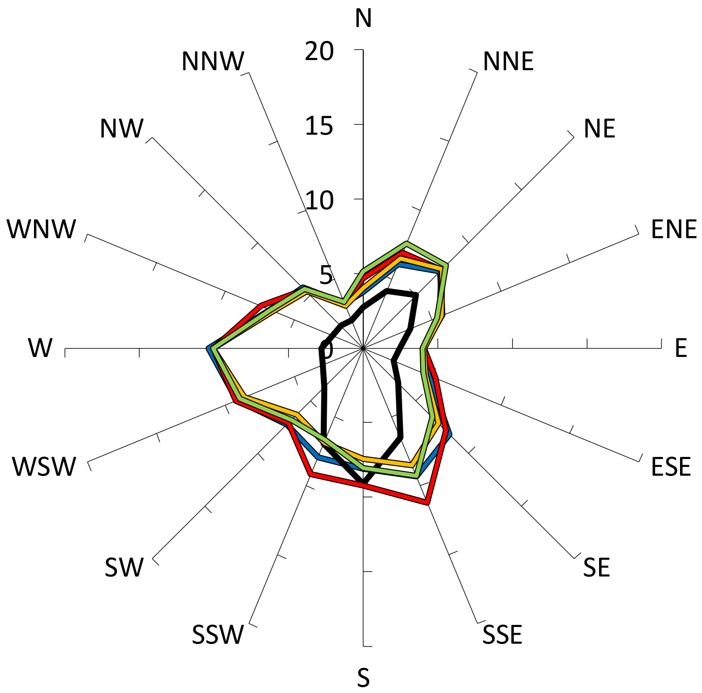


Safety Limit: 23m/s

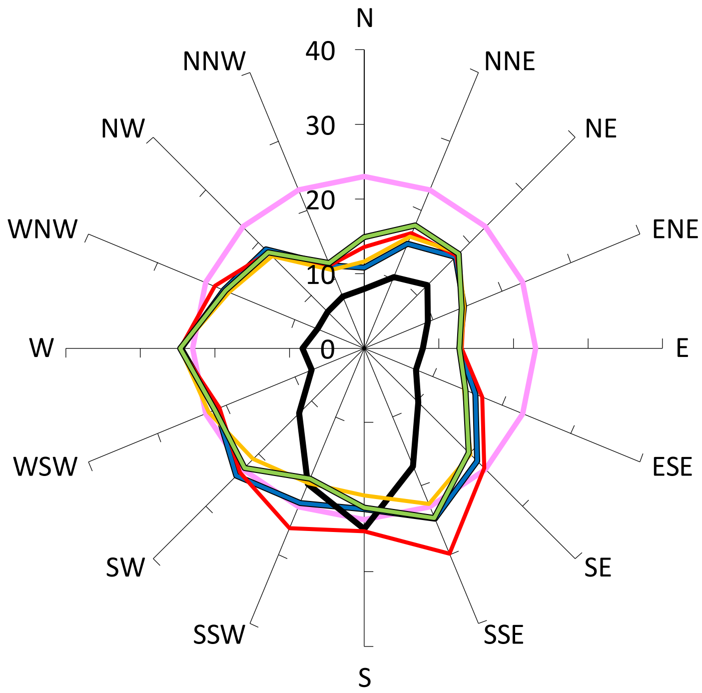
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	13%	26
Existing Scenario.	21%	41
With future massings and proposed development, no vegetation or other treatments.	14%	28

Results for P11

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

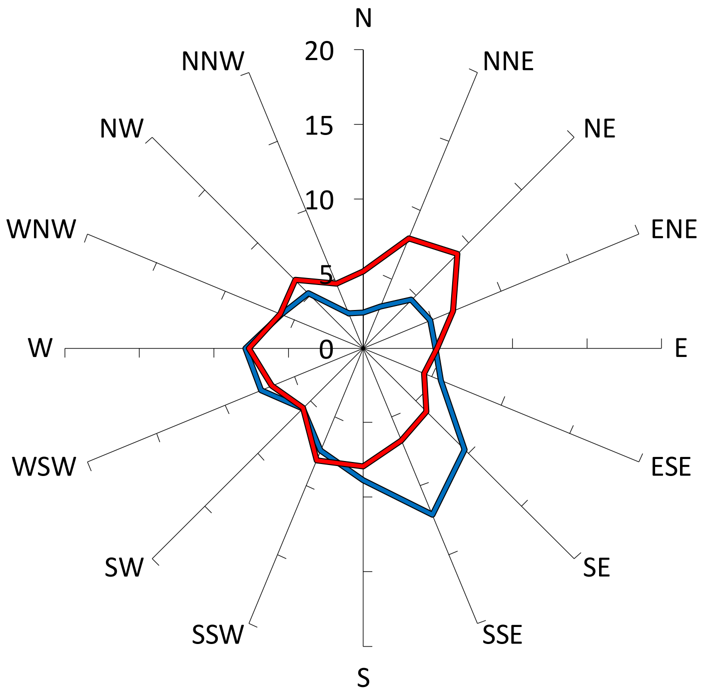


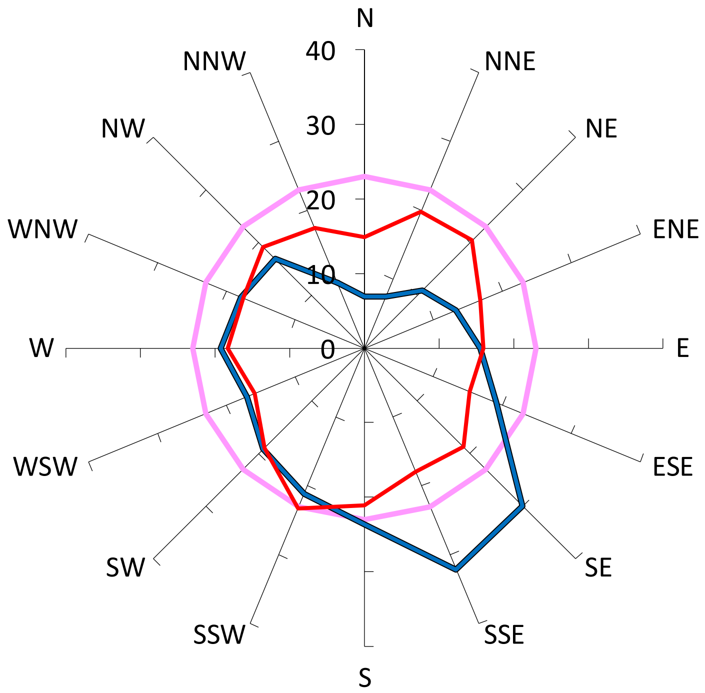
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	17%	25
Existing Scenario.	4%	24
With future massings and proposed development, no vegetation or other treatments.	22%	30
Proposed scenario with porous carpark façade.	13%	25
Future scenario with porous carpark façade.	16%	25

Results for P12

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





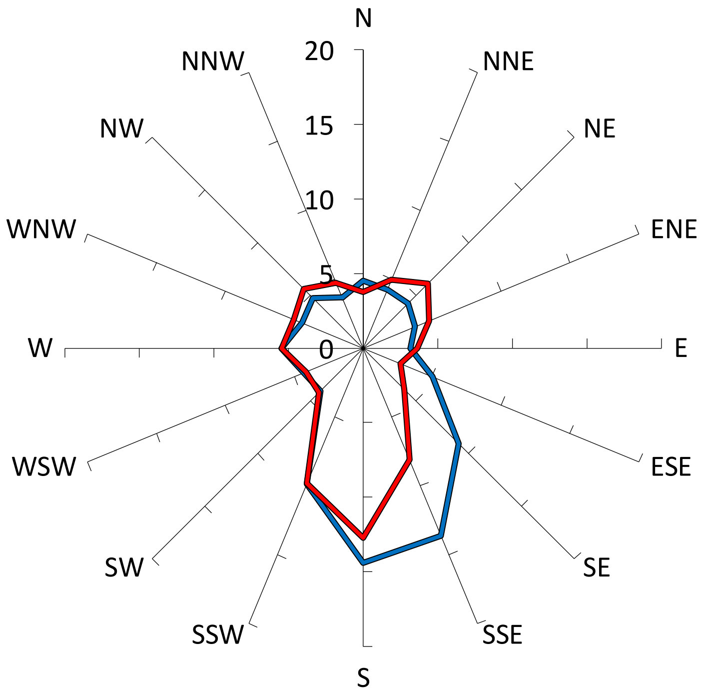
Comfort Criteria: 7.5m/s with 5% probability of exceedence

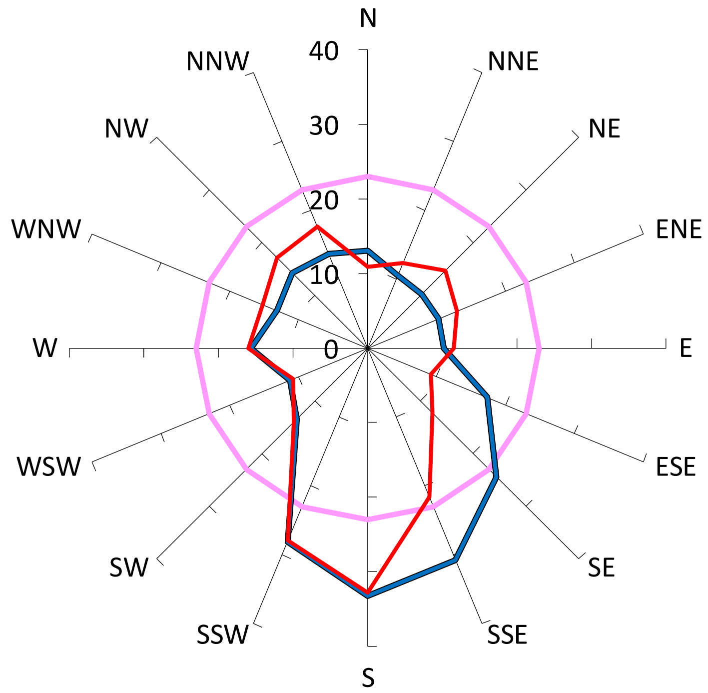
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	16%	32
With future massings and proposed development, no vegetation or other treatments.	14%	23

Results for P13

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





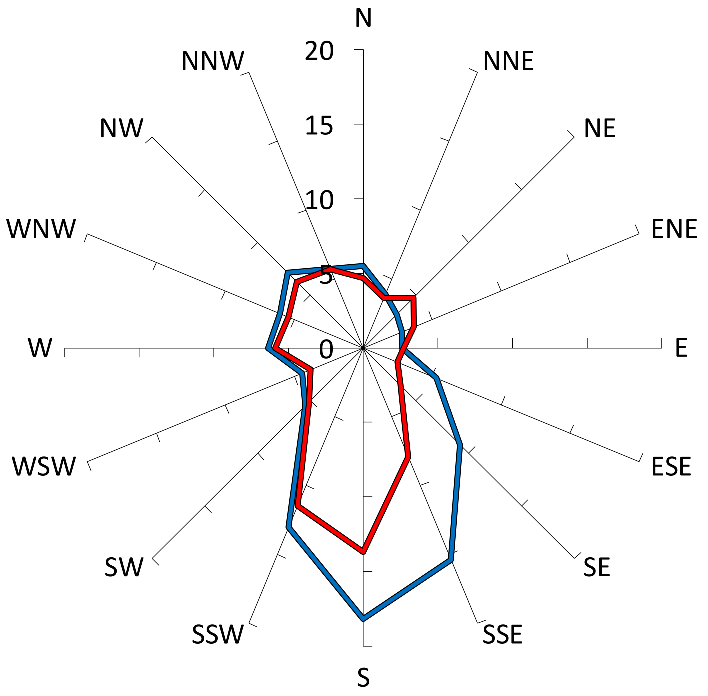
Comfort Criteria: 5.5m/s with 5% probability of exceedence

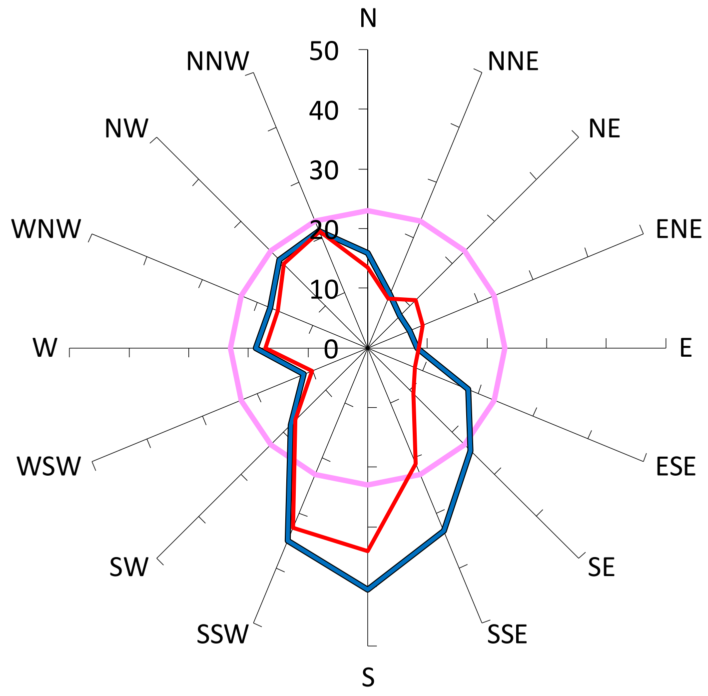
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	26%	33
With future massings and proposed development, no vegetation or other treatments.	26%	33

Results for P14

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





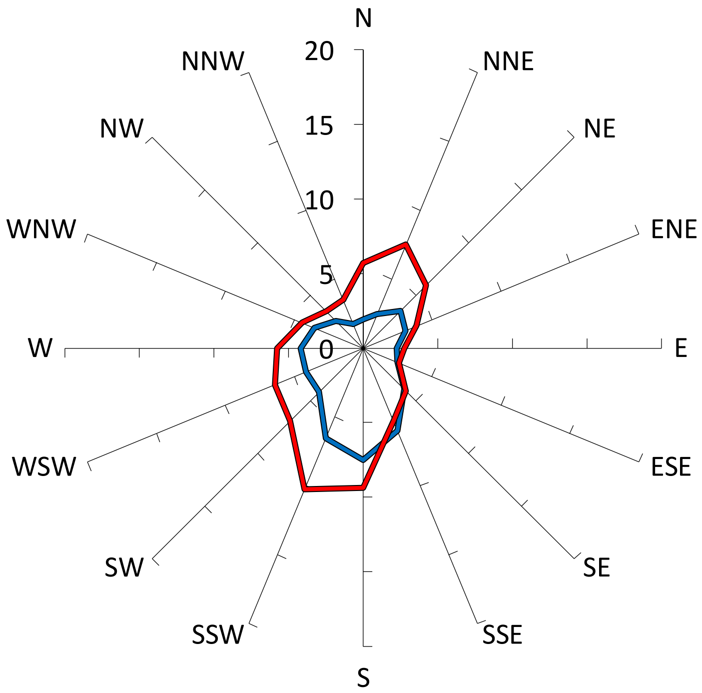
Comfort Criteria: 5.5m/s with 5% probability of exceedence

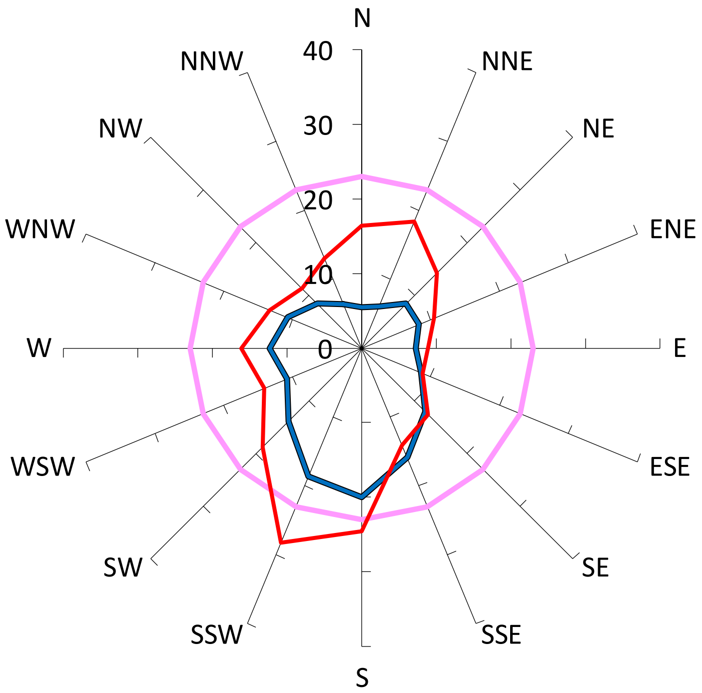
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	31%	41
With future massings and proposed development, no vegetation or other treatments.	25%	34

Results for P15

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





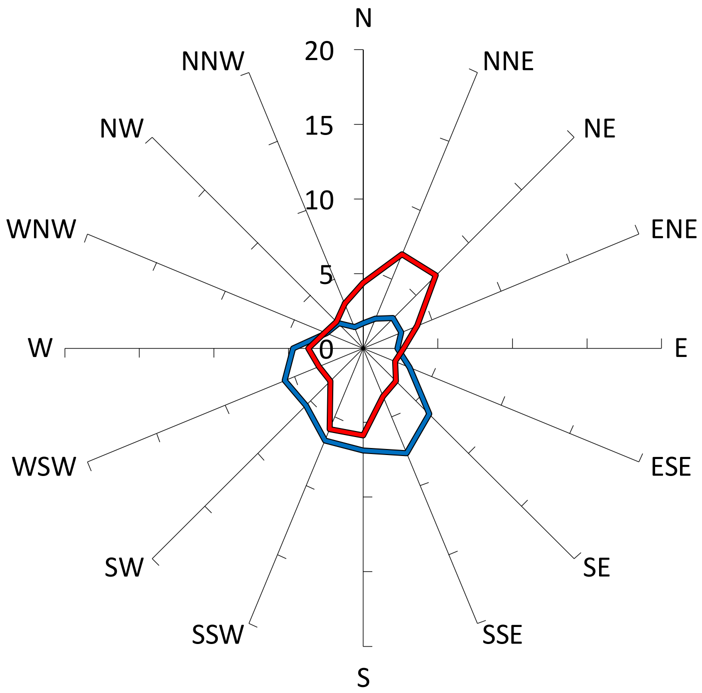
Comfort Criteria: 7.5m/s with 5% probability of exceedence

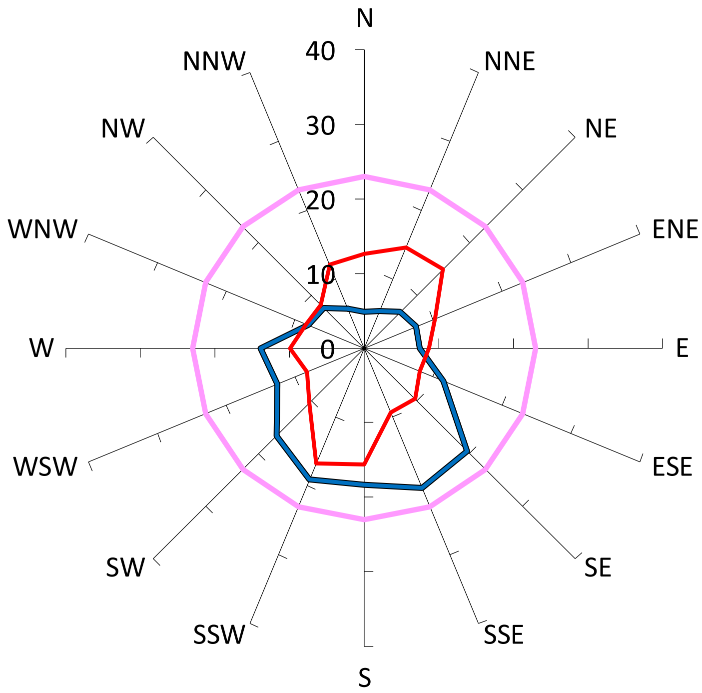
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	2%	20
With future massings and proposed development, no vegetation or other treatments.	10%	28

Results for P16

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





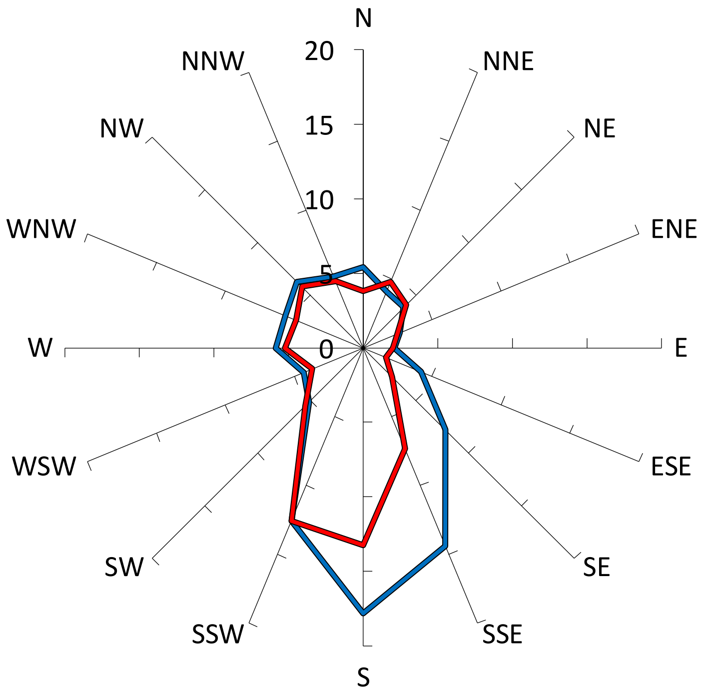
Comfort Criteria: 5.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

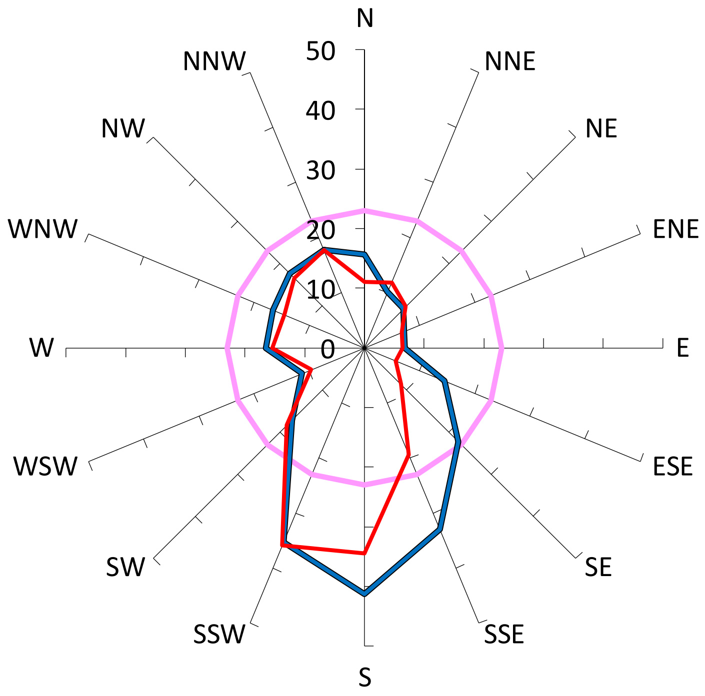
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	16%	20
With future massings and proposed development, no vegetation or other treatments.	14%	17

Results for P17

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

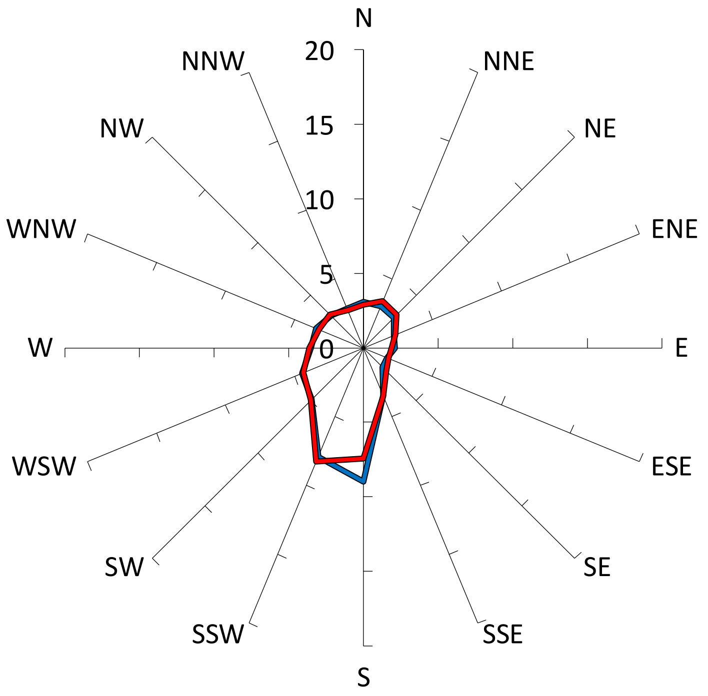


Safety Limit: 23m/s

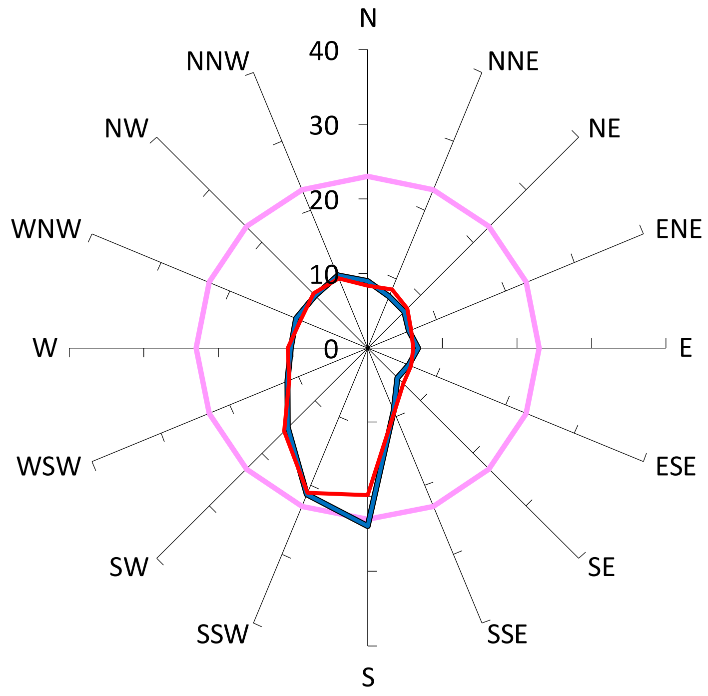
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	22%	41
With future massings and proposed development, no vegetation or other treatments.	15%	36

Results for P18

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

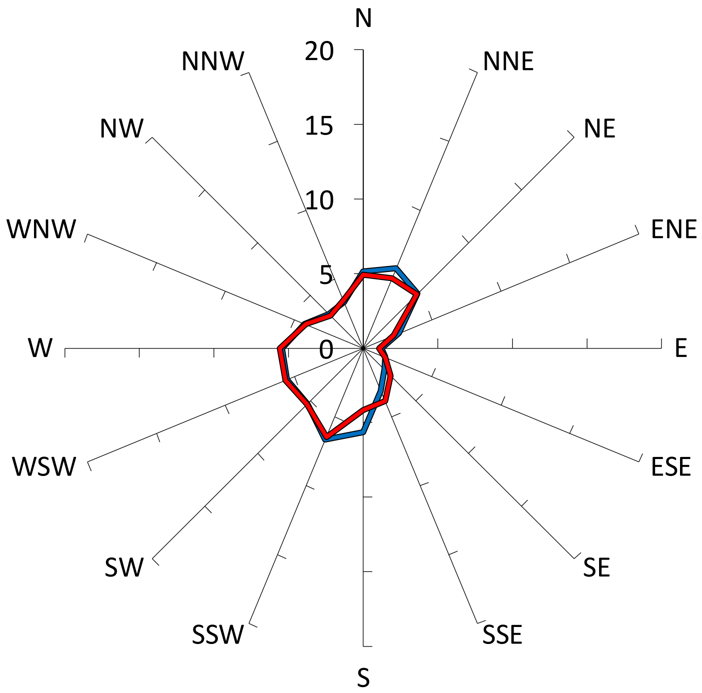


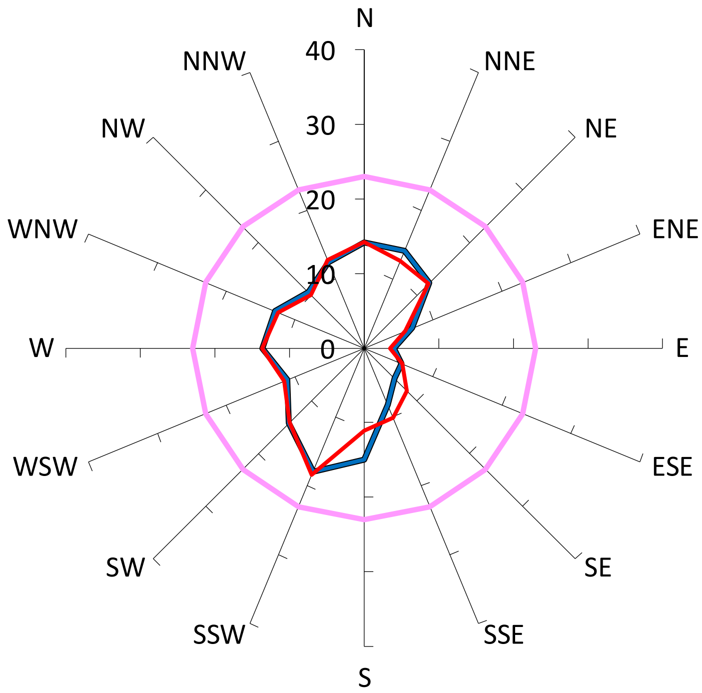
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	4%	24
With future massings and proposed development, no vegetation or other treatments.	3%	21

Results for P19

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





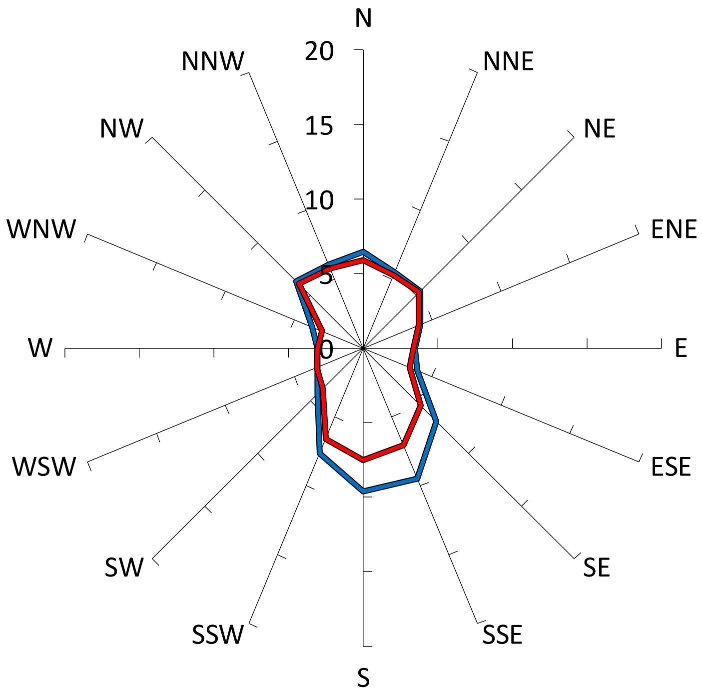
Comfort Criteria: 7.5m/s with 5% probability of exceedence

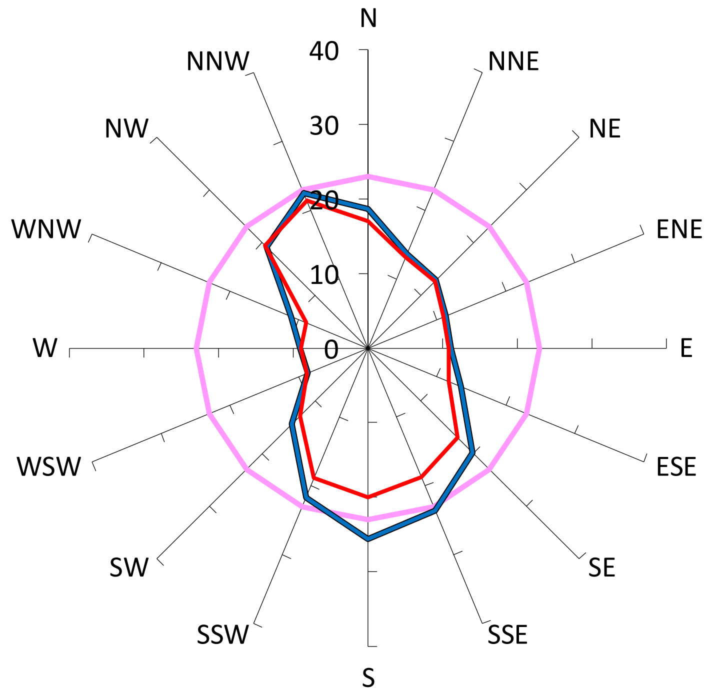
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	2%	18
With future massings and proposed development, no vegetation or other treatments.	2%	18

Results for P20

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





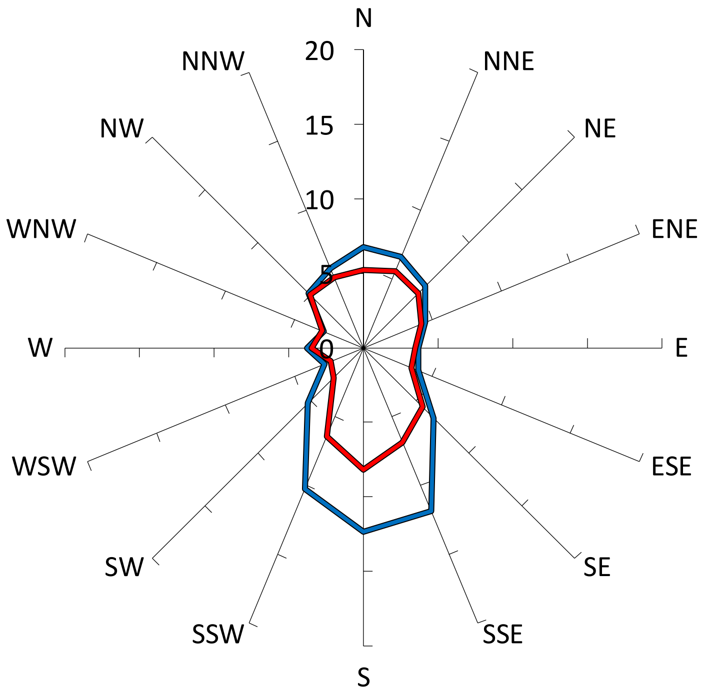
Comfort Criteria: 5.5m/s with 5% probability of exceedence

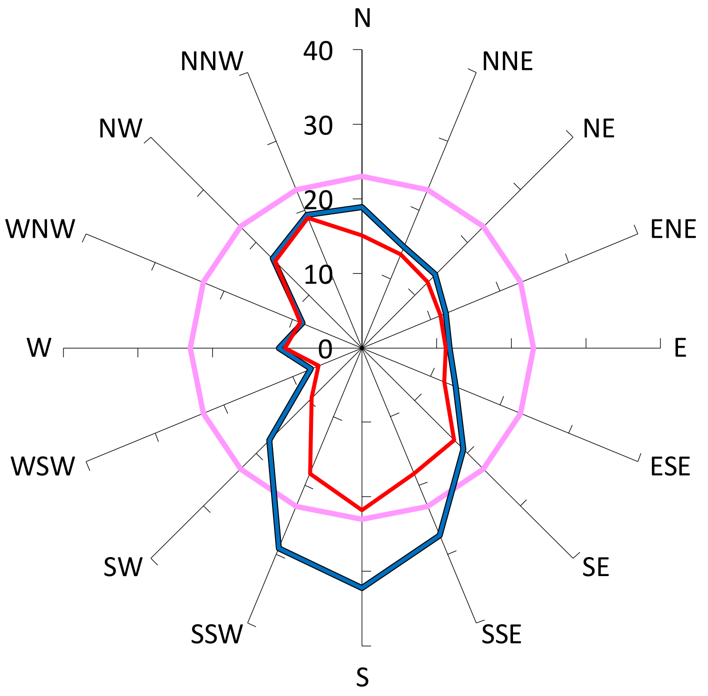
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	26%	26
With future massings and proposed development, no vegetation or other treatments.	18%	21

Results for P21

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





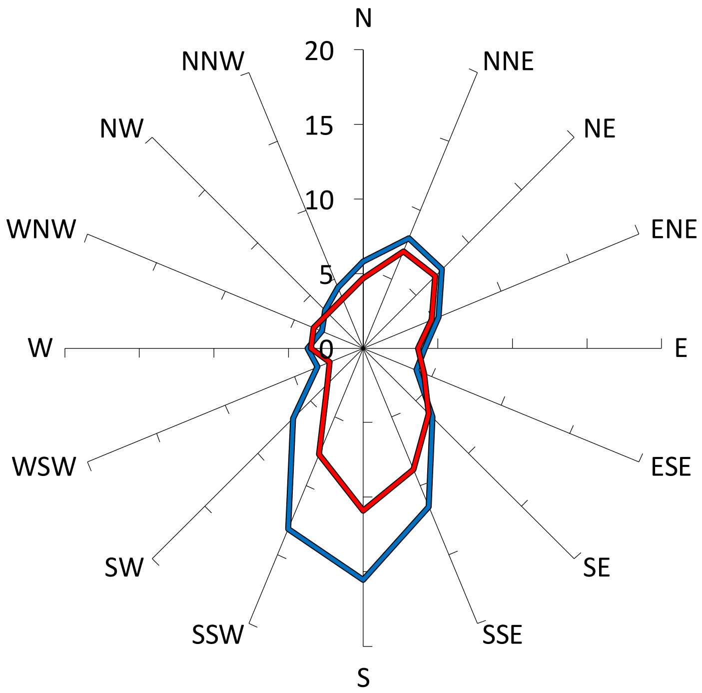
Comfort Criteria: 5.5m/s with 5% probability of exceedence

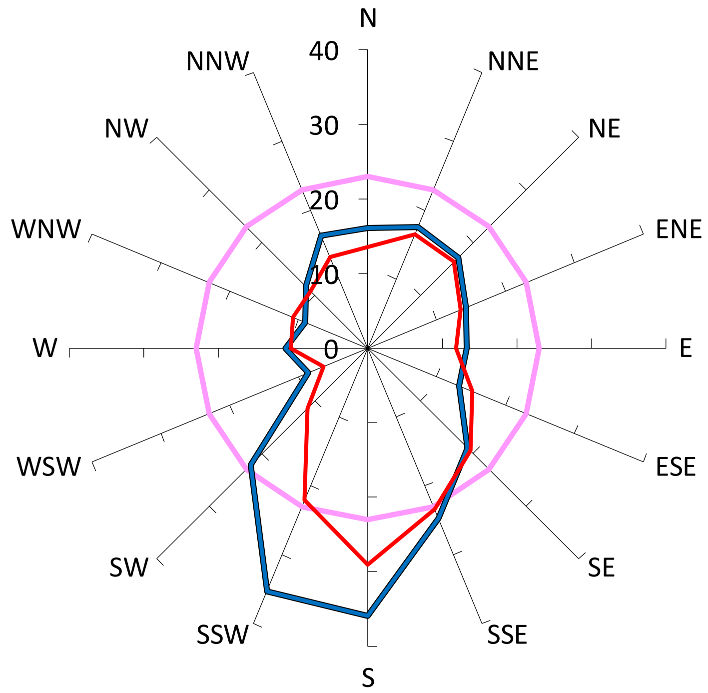
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	31%	32
With future massings and proposed development, no vegetation or other treatments.	18%	22

Results for P22

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





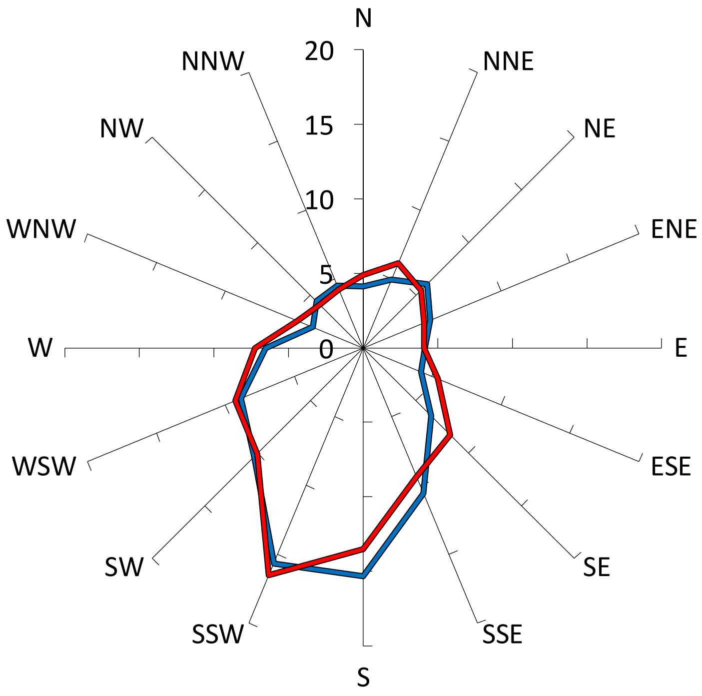
Comfort Criteria: 5.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

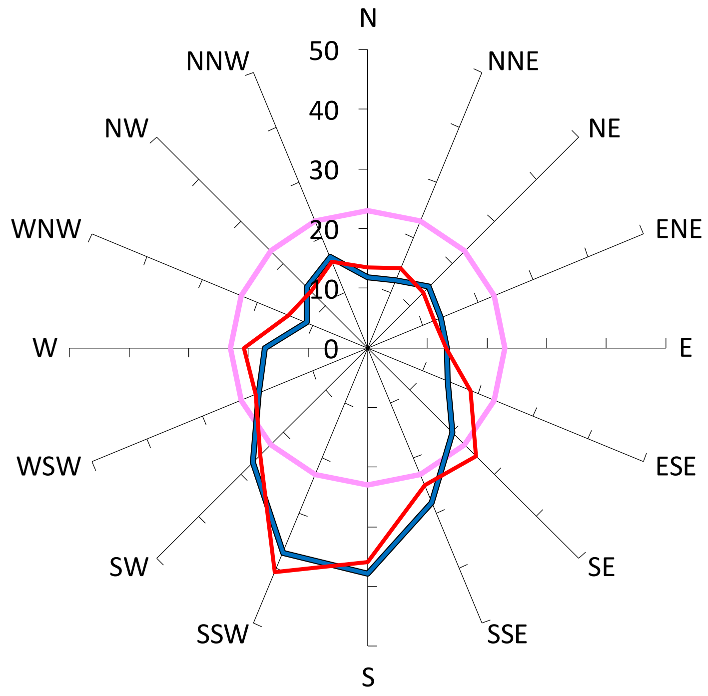
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	36%	36
With future massings and proposed development, no vegetation or other treatments.	29%	29

Results for P23

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 5.5m/s with 5% probability of exceedence

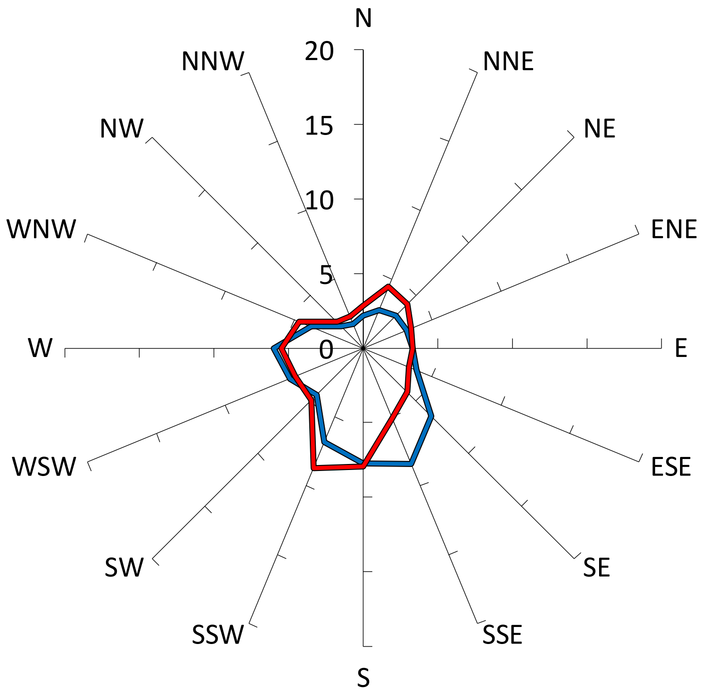


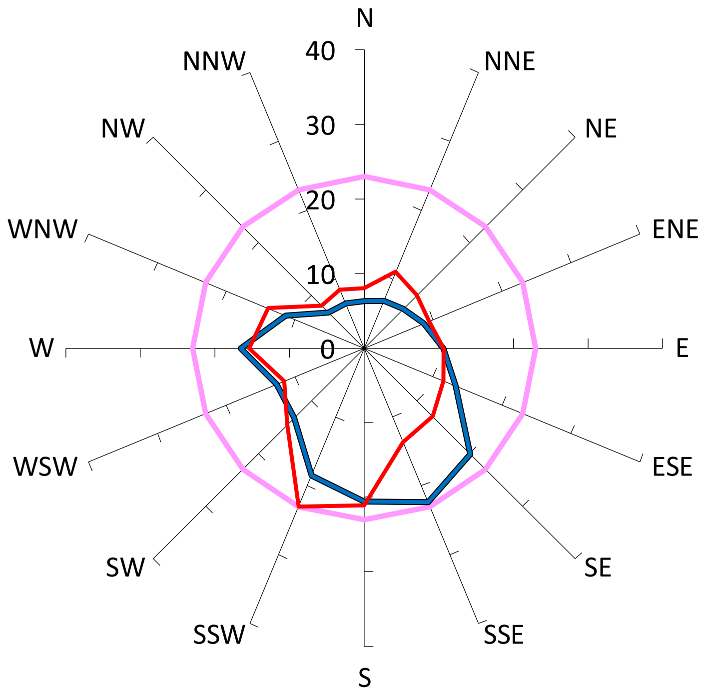
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	35%	38
With future massings and proposed development, no vegetation or other treatments.	37%	41

Results for P24

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





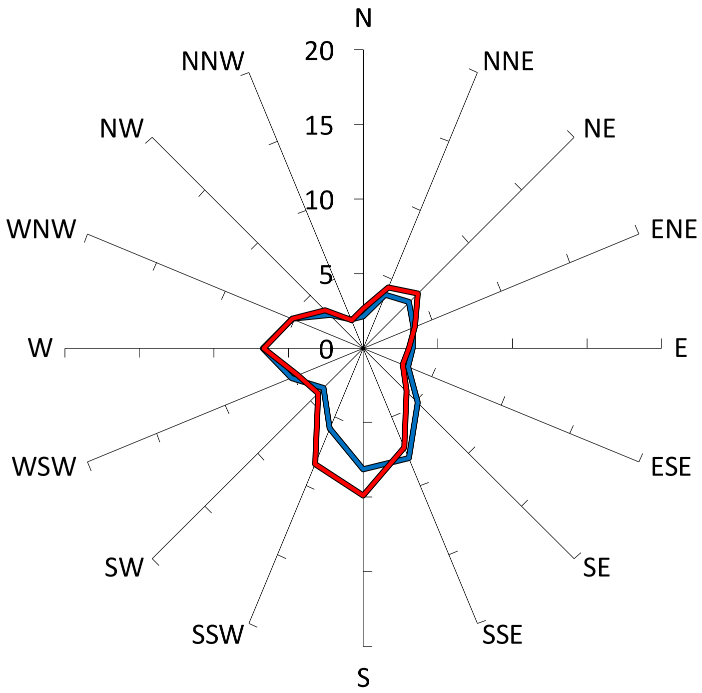
Comfort Criteria: 5.5m/s with 5% probability of exceedence

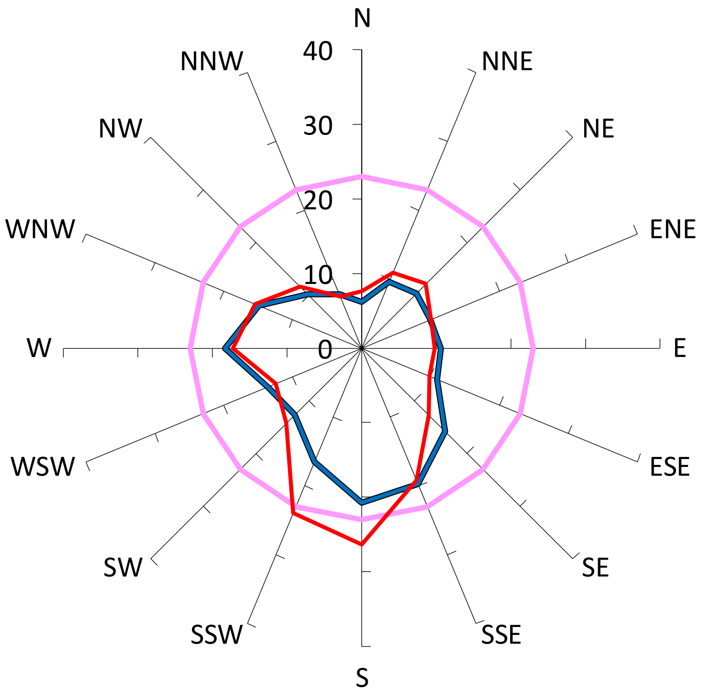
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	19%	22
With future massings and proposed development, no vegetation or other treatments.	15%	23

Results for P25

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





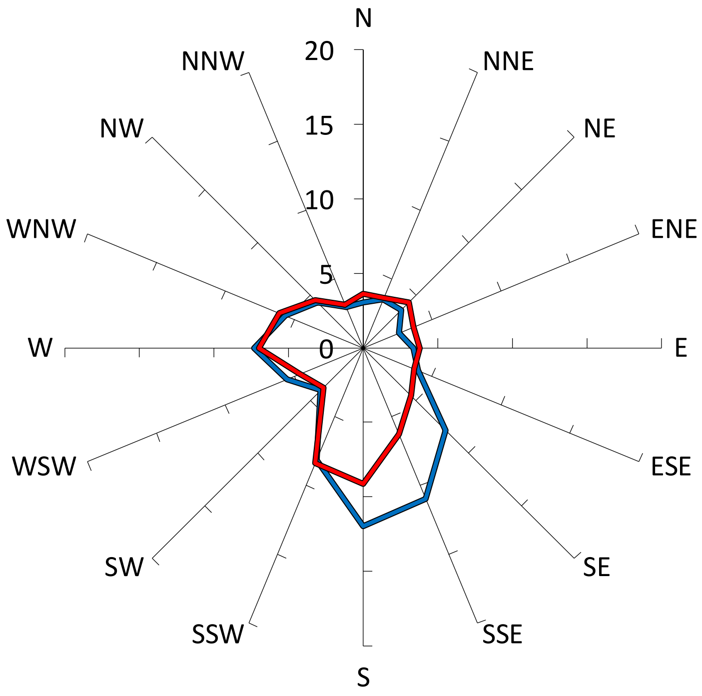
Comfort Criteria: 5.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

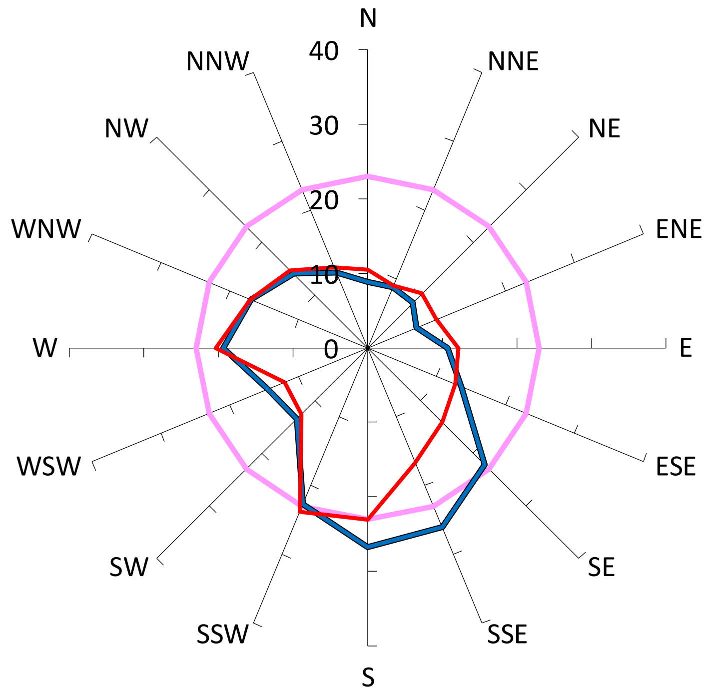
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	19%	21
With future massings and proposed development, no vegetation or other treatments.	21%	26

Results for P26

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 5.5m/s with 5% probability of exceedence

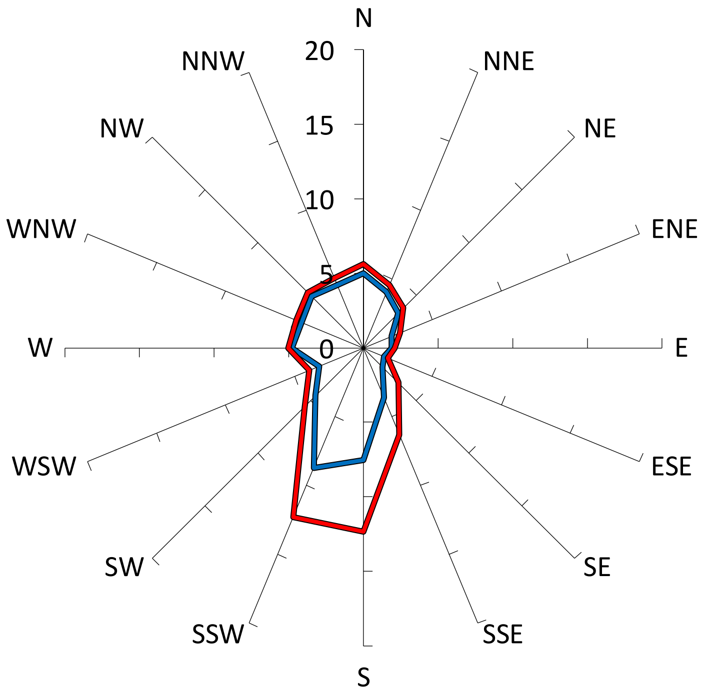


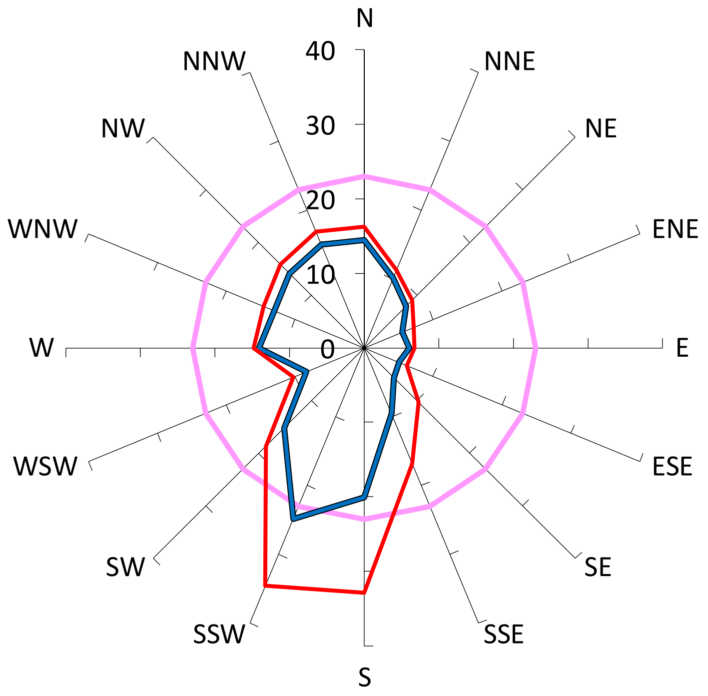
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	25%	27
With future massings and proposed development, no vegetation or other treatments.	20%	24

Results for P27

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





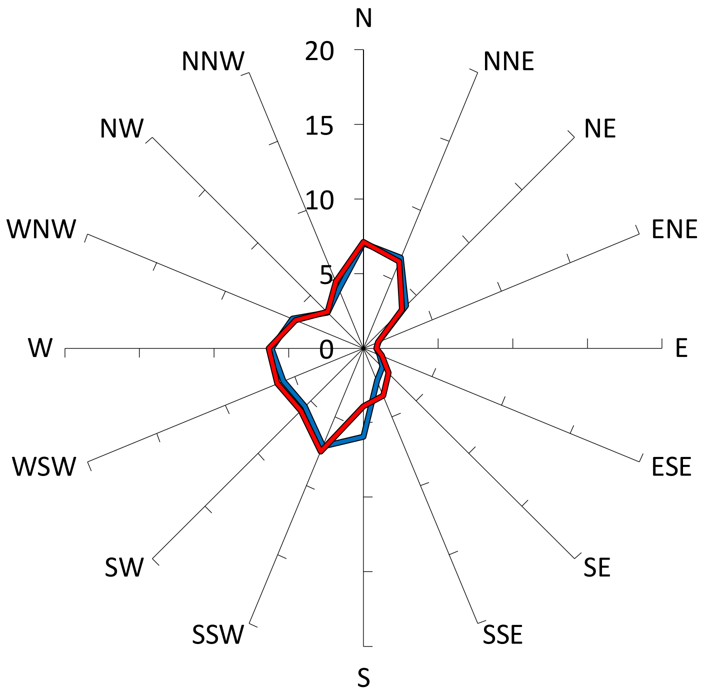
Comfort Criteria: 7.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

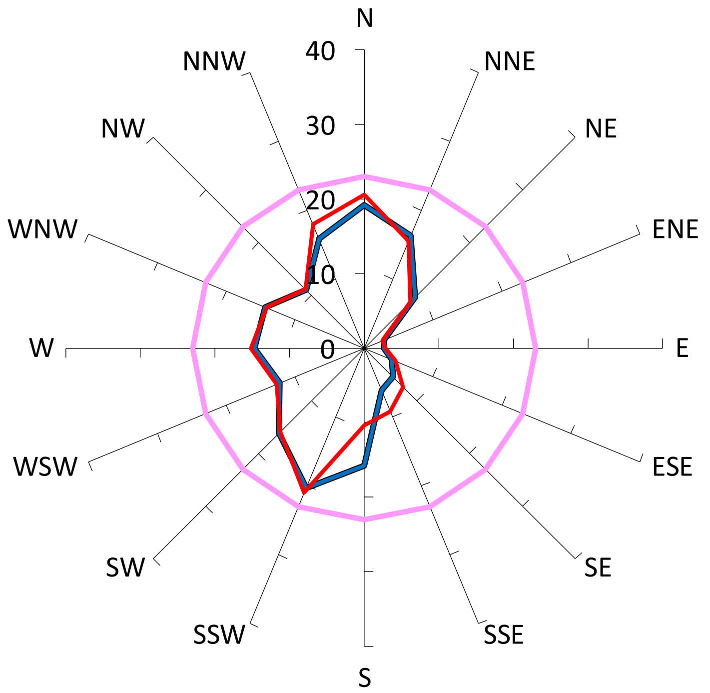
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	4%	25
With future massings and proposed development, no vegetation or other treatments.	14%	35

Results for P28

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

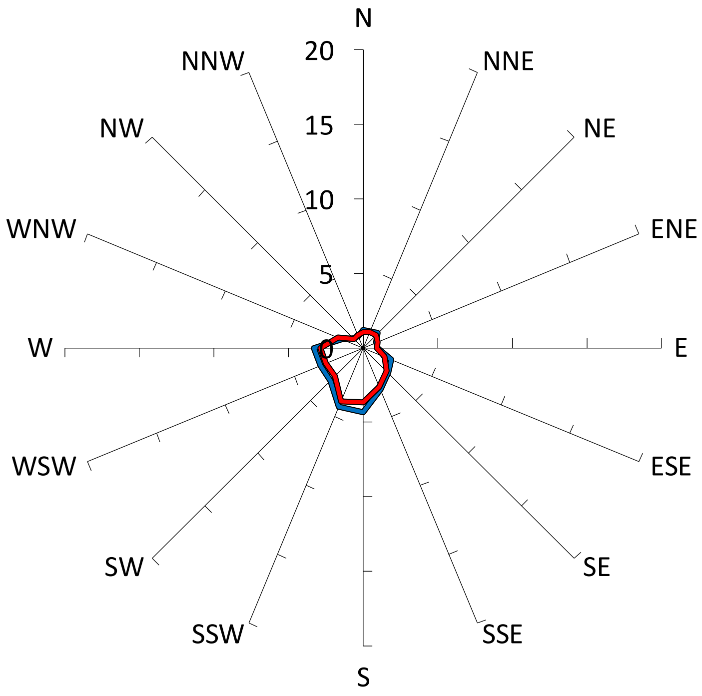


Safety Limit: 23m/s

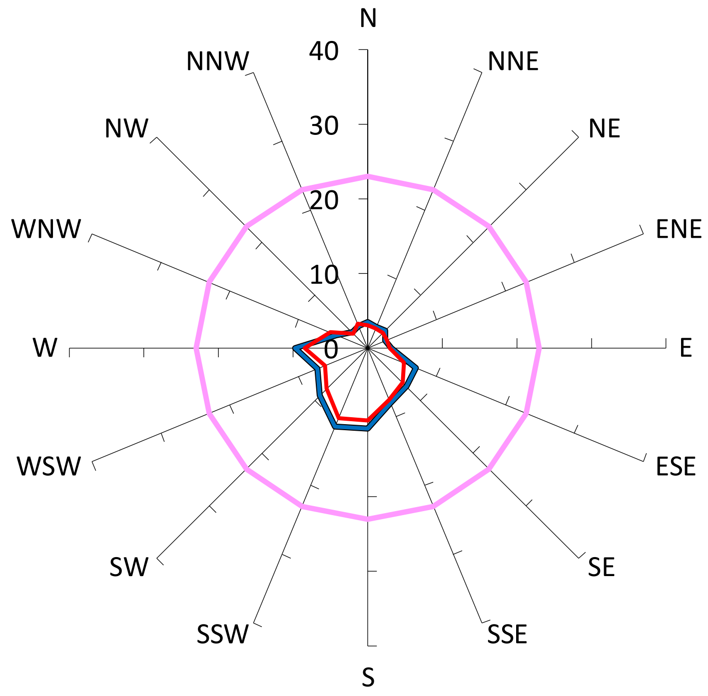
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	4%	20
With future massings and proposed development, no vegetation or other treatments.	4%	21

Results for P29

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 7.5m/s with 5% probability of exceedence

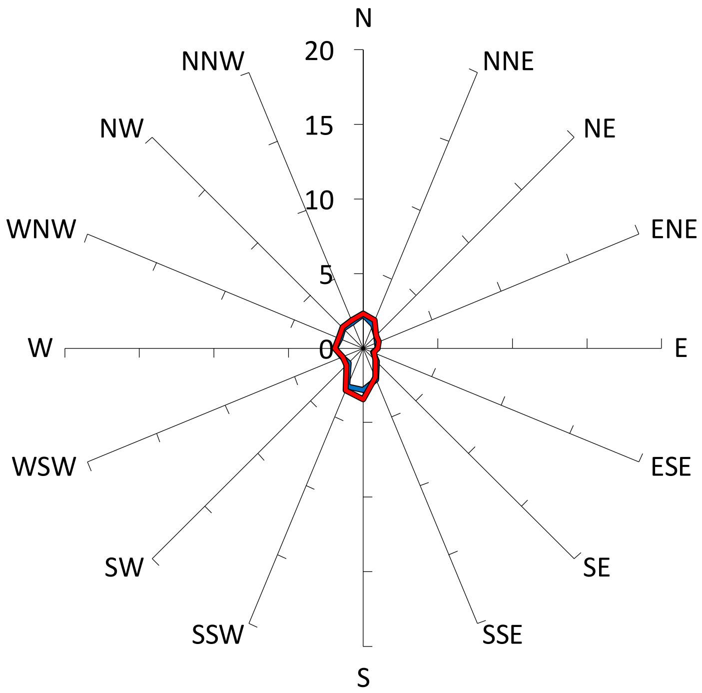


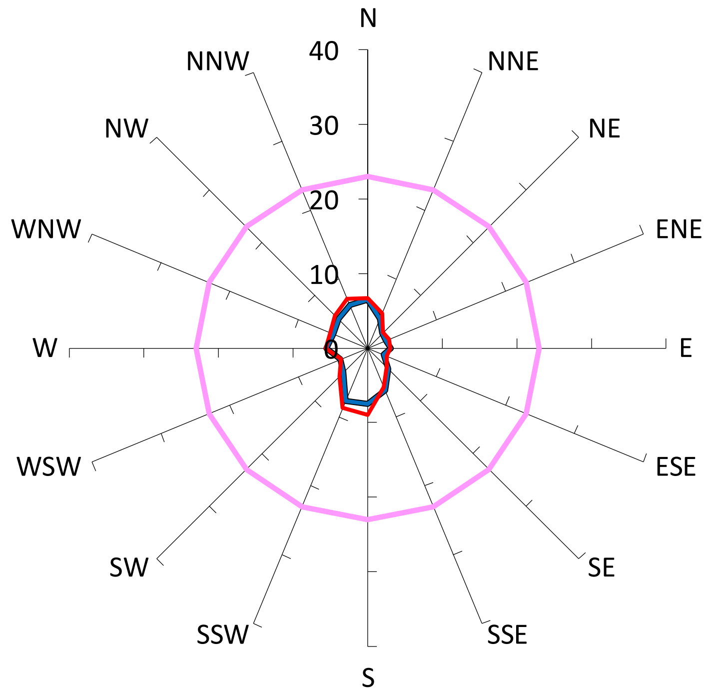
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	< 1%	11
With future massings and proposed development, no vegetation or other treatments.	< 1%	10

Results for P30

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





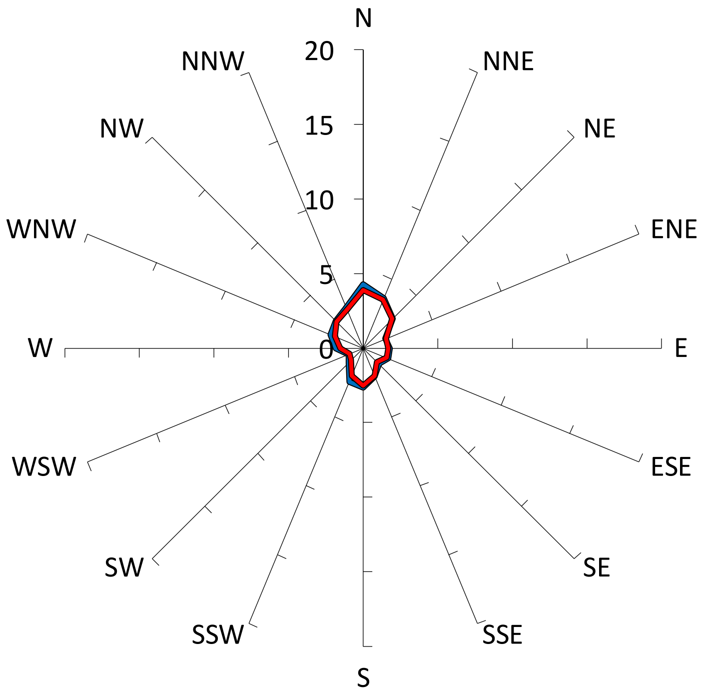
Comfort Criteria: 7.5m/s with 5% probability of exceedence

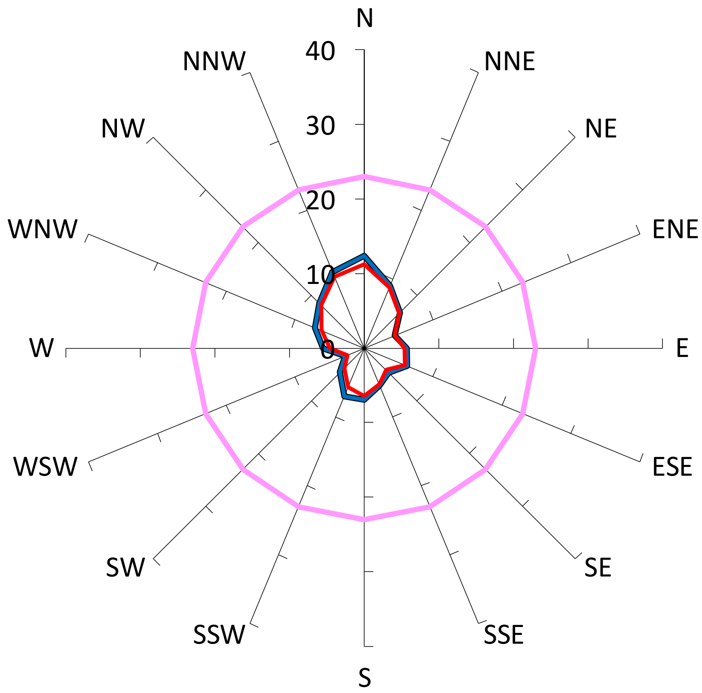
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	< 1%	8
With future massings and proposed development, no vegetation or other treatments.	< 1%	9

Results for P31

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





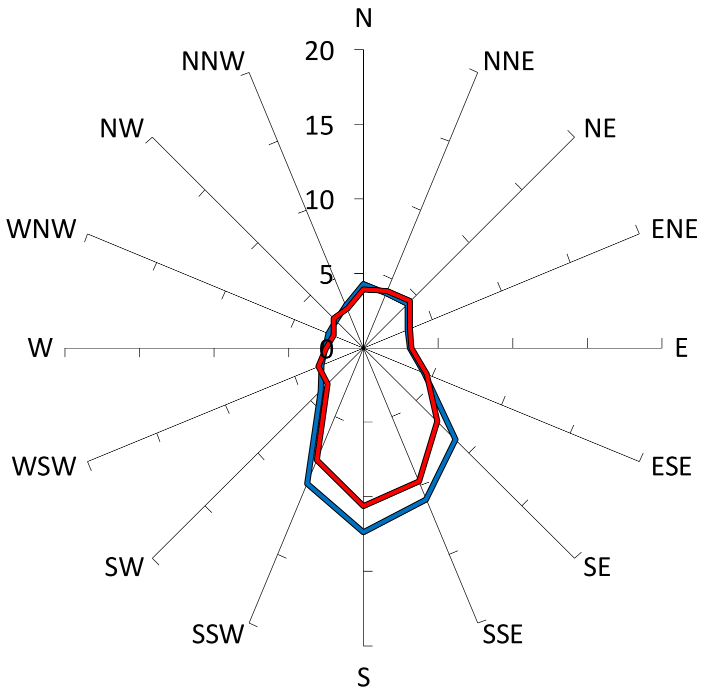
Comfort Criteria: 7.5m/s with 5% probability of exceedence

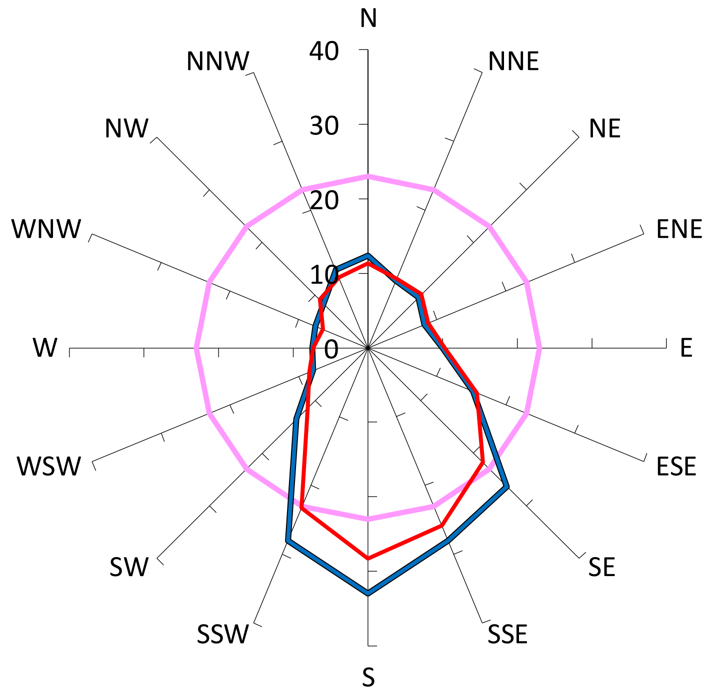
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	< 1%	12
With future massings and proposed development, no vegetation or other treatments.	< 1%	11

Results for P32

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





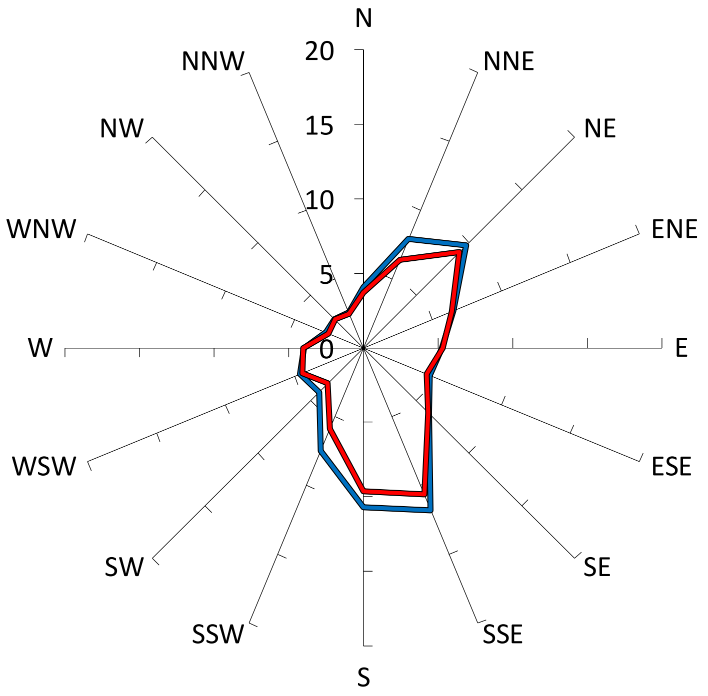
Comfort Criteria: 5.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

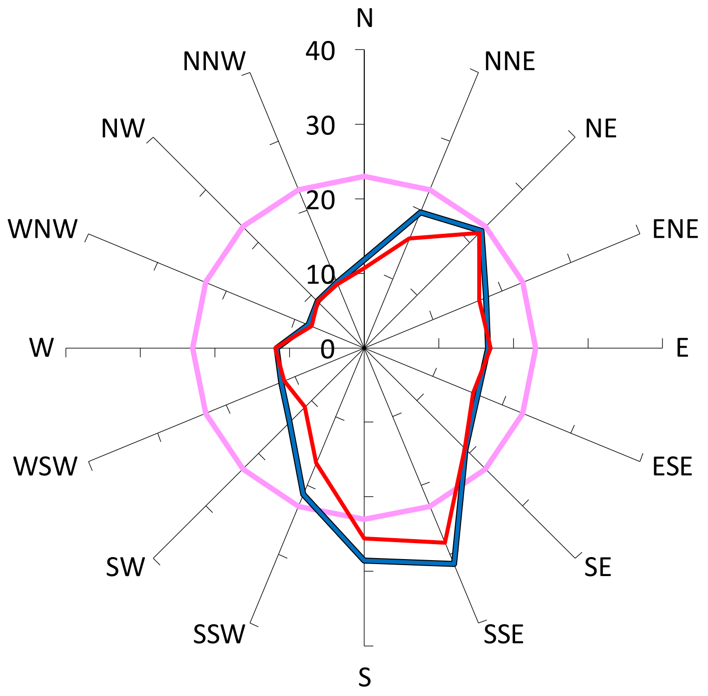
Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	23%	33
With future massings and proposed development, no vegetation or other treatments.	21%	28

Results for P33

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



Comfort Criteria: 5.5m/s with 5% probability of exceedence

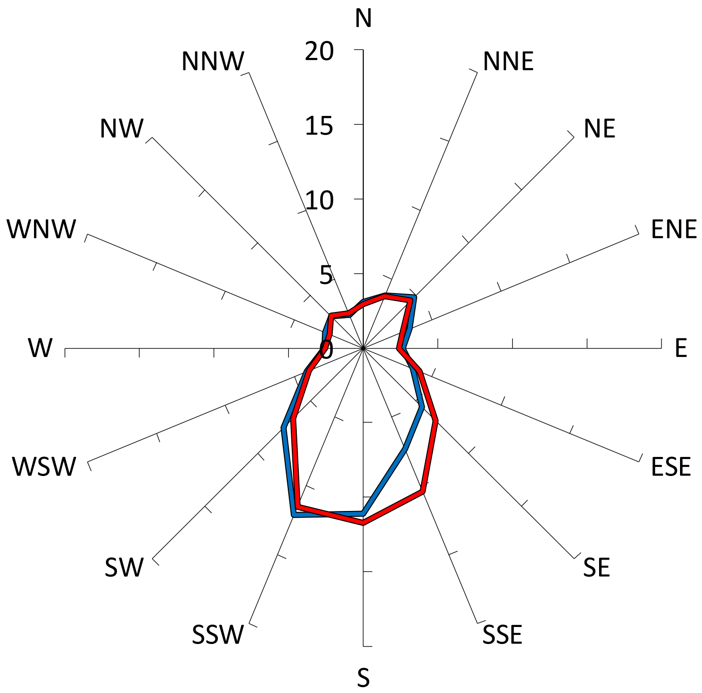


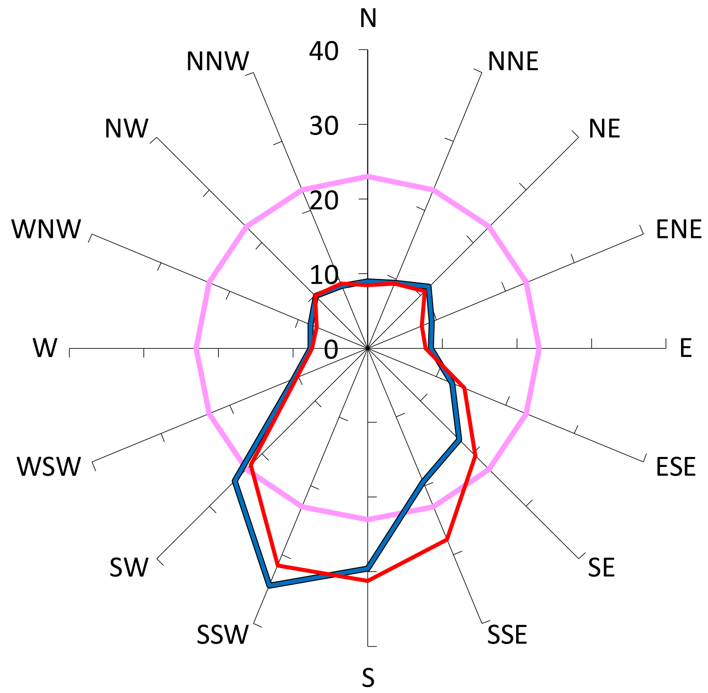
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	33%	31
With future massings and proposed development, no vegetation or other treatments.	28%	28

Results for P34

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





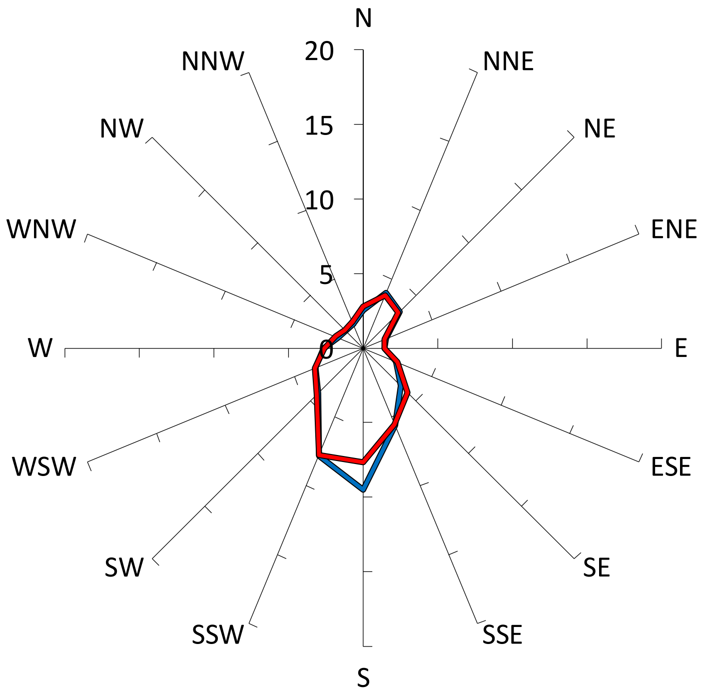
Comfort Criteria: 5.5m/s with 5% probability of exceedence

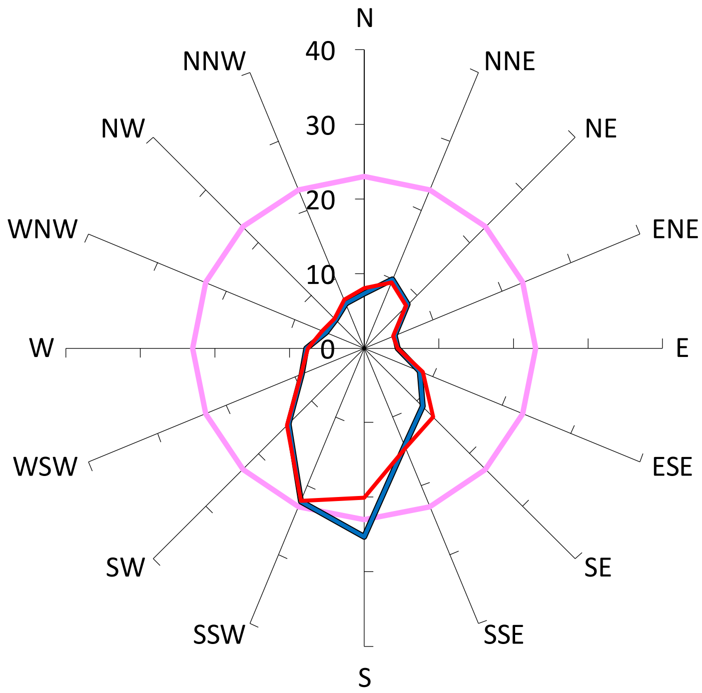
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	22%	34
With future massings and proposed development, no vegetation or other treatments.	24%	32

Results for P35

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





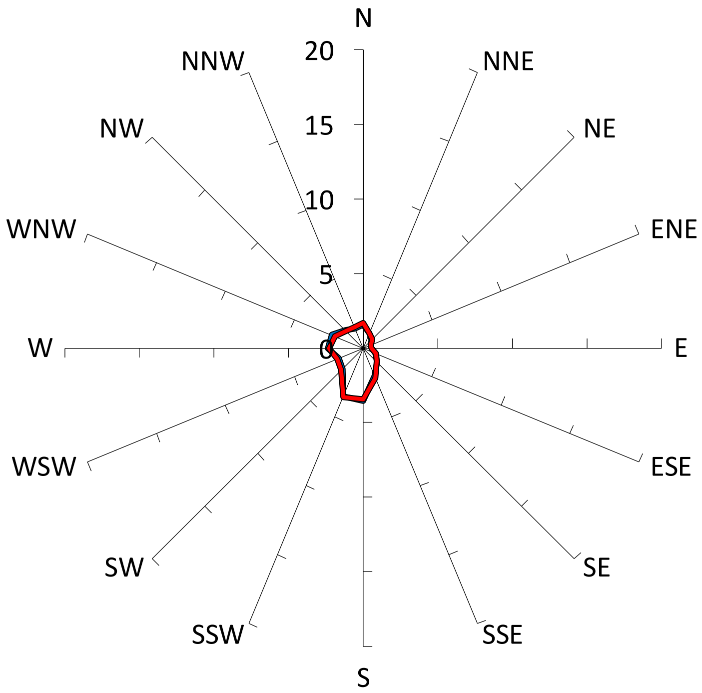
Comfort Criteria: 5.5m/s with 5% probability of exceedence

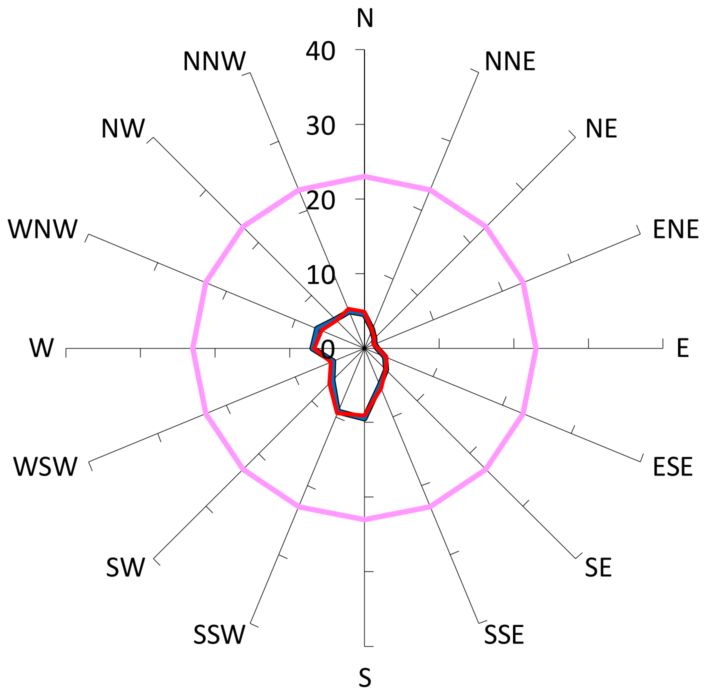
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Short Exposure Activities (5.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	13%	25
With future massings and proposed development, no vegetation or other treatments.	11%	22

Results for P36

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





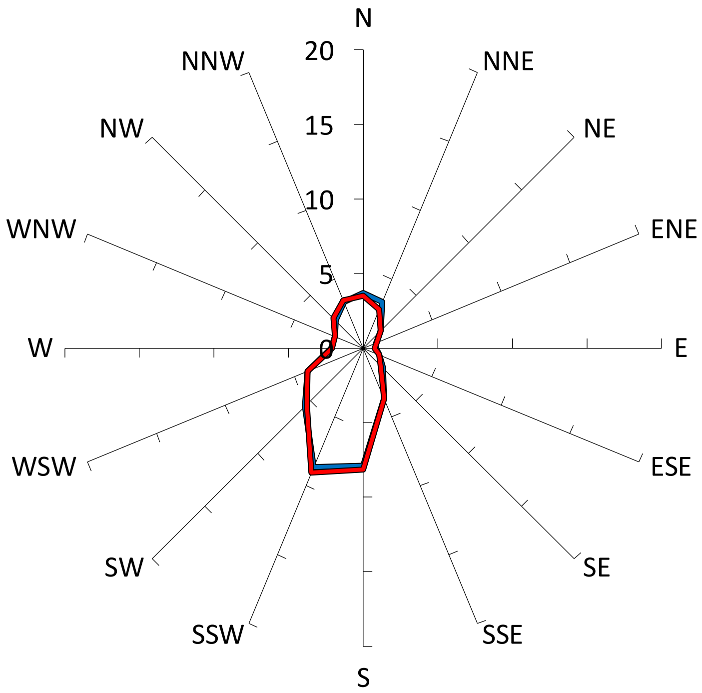
Comfort Criteria: 7.5m/s with 5% probability of exceedence

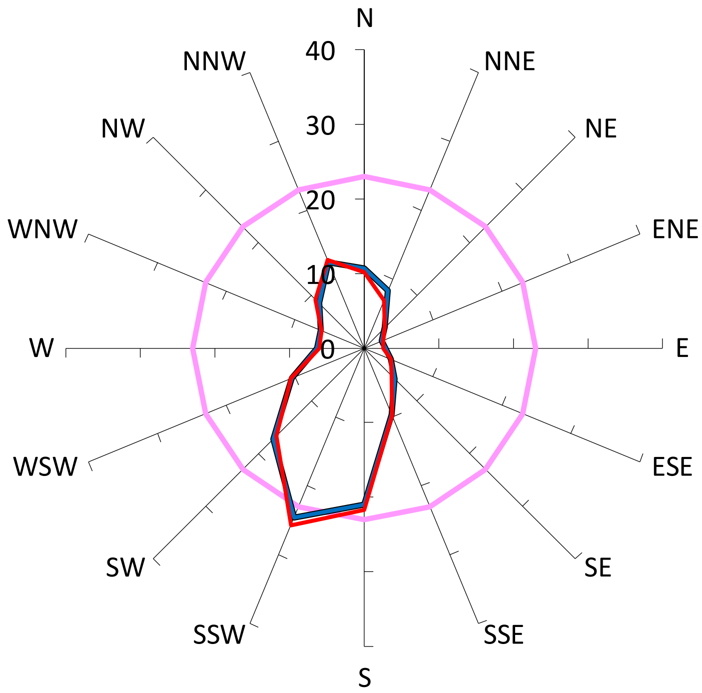
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	< 1%	9
With future massings and proposed development, no vegetation or other treatments.	< 1%	9

Results for P37

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)





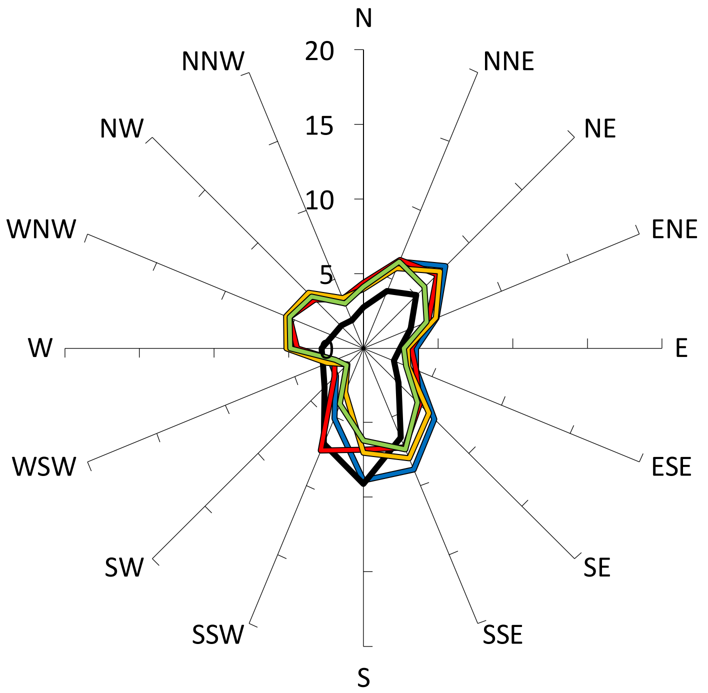
Comfort Criteria: 7.5m/s with 5% probability of exceedence

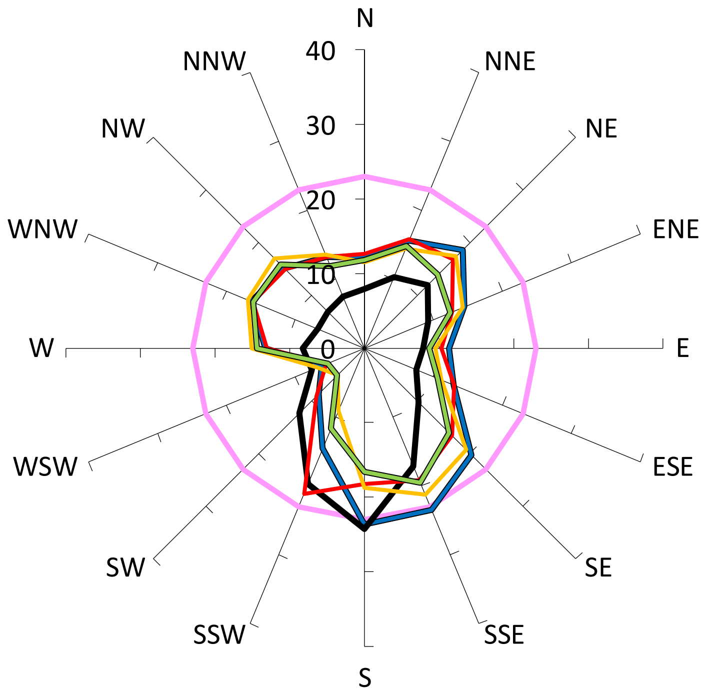
Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	4%	25
With future massings and proposed development, no vegetation or other treatments.	4%	26

Results for P38

Gust Equivalent Mean (m/s)	Maximum Gust (m/s)



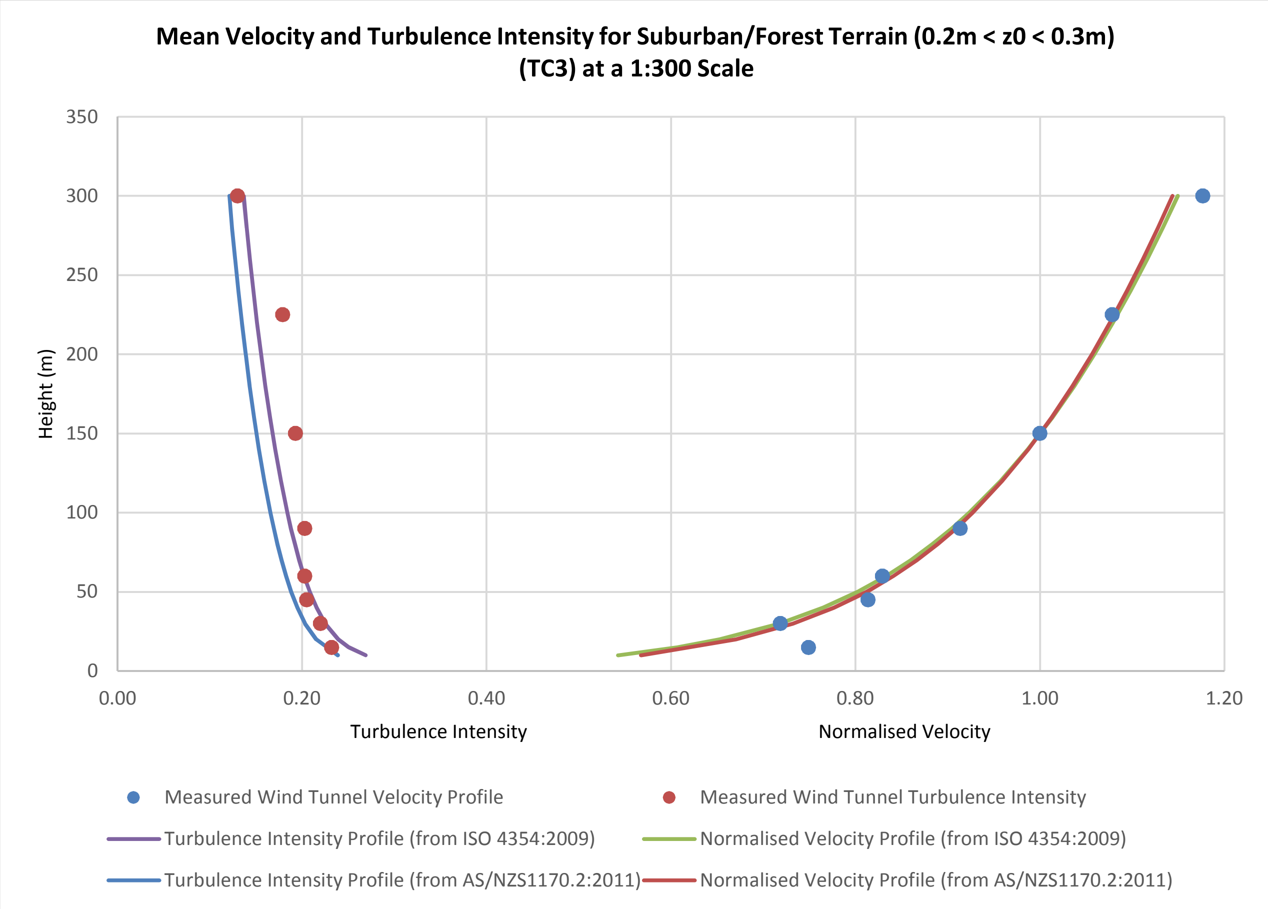


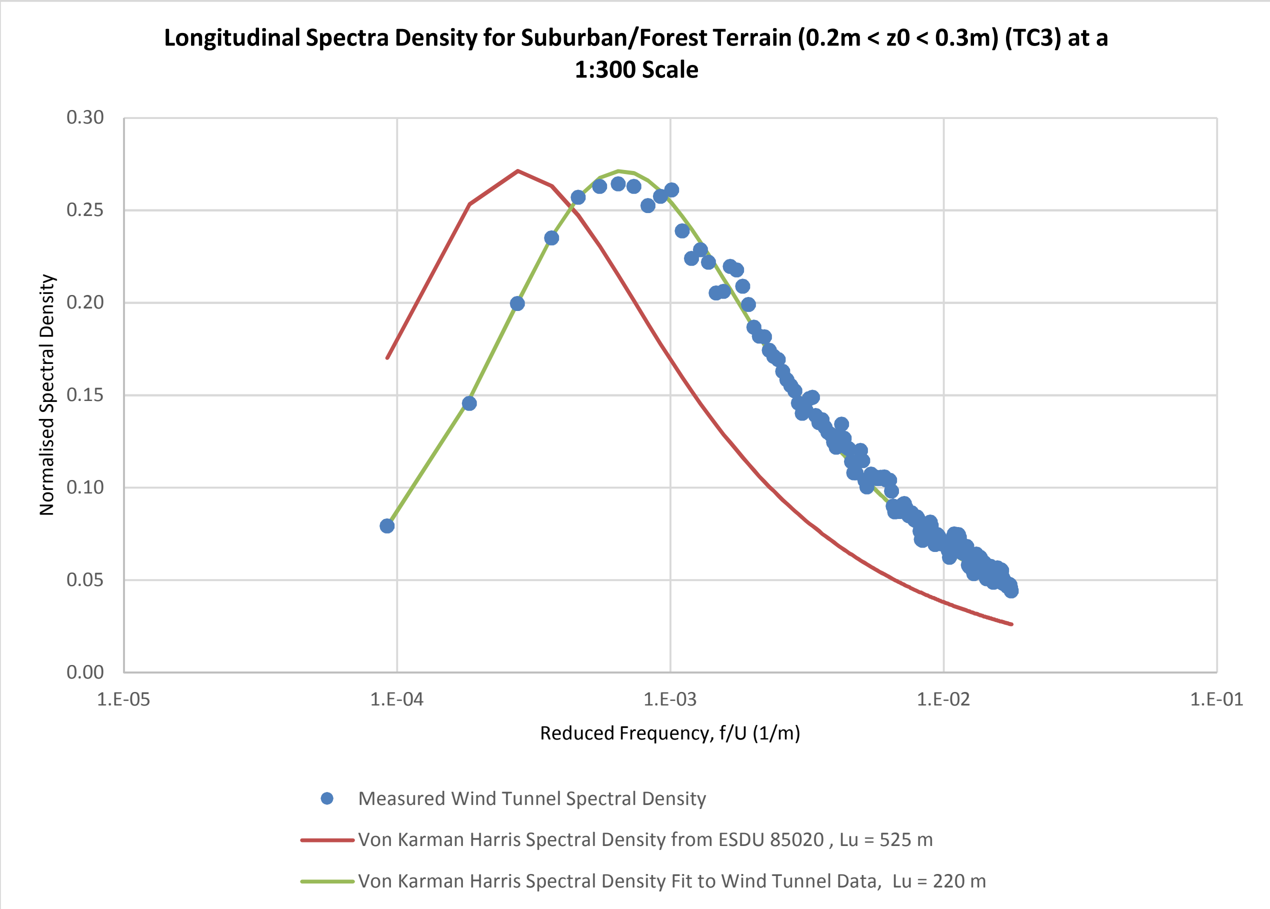
Comfort Criteria: 7.5m/s with 5% probability of exceedence

Safety Limit: 23m/s

Description	GEM Prob of Exceed %	Peak Gust m/s
Criterion: Comfortable Walking Activities (7.5m/s). Safety Limit (23m/s).	5%	23
With development "as proposed", no vegetation or other treatments.	9%	24
Existing Scenario.	4%	24
With future massings and proposed development, no vegetation or other treatments.	5%	21
Proposed scenario with porous carpark façade.	5%	21
Future scenario with porous carpark façade.	3%	20

APPENDIX D VELOCITY AND TURBULENCE INTENSITY PROFILES


Mean Velocity and Turbulence Intensity for Suburban/Forest Terrain (0.2m < z0 < 0.3m) (TC3) at a 1:300 Scale
Height (m)
350
300
250
200
150
100
50
0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Turbulence Intensity
Normalised Velocity
Measured Wind Tunnel Velocity Profile
Measured Wind Tunnel Turbulence Intensity
Turbulence Intensity Profile (from ISO 4354:2009)
Normalised Velocity Profile (from ISO 4354:2009)
Turbulence Intensity Profile (from AS/NZS1170.2:2011)
Normalised Velocity Profile (from AS/NZS1170.2:2011)


Longitudinal Spectra Density for Suburban/Forest Terrain (0.2m < z0 < 0.3m) (TC3) at a 1:300 Scale
Normalised Spectral Density
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
Reduced Frequency, f/U (1/m)
Measured Wind Tunnel Spectral Density
Von Karman Harris Spectral Density from ESDU 85020 , Lu = 525 m
Von Karman Harris Spectral Density Fit to Wind Tunnel Data, Lu = 220 m