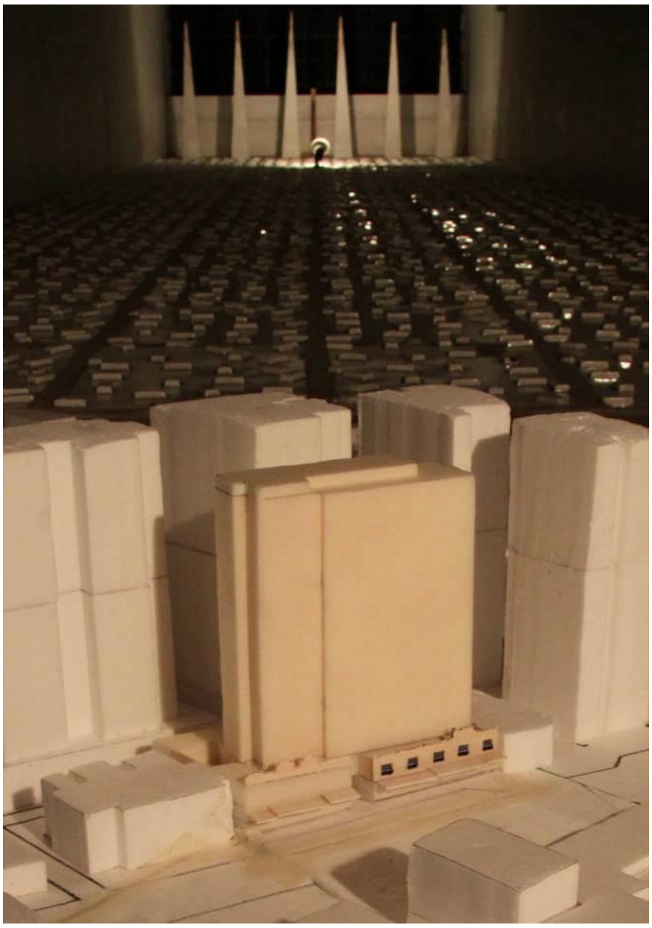

PEDESTRIAN WIND ENVIRONMENT STUDY

IGLU, 60-78 REGENT STREET, REDFERN

WC246-04F01(REV2)- WE REPORT

11 MAY 2015

Prepared for:

Iglu No. 204 Pty Ltd

Level 21, Deutsche Bank Place,

126 Phillip Street

Sydney, NSW 2000

WINDTECH Consultants Pty Ltd ABN 72 050 574 037
Head Office: 19 Willis Street Wolli Creek NSW 2205 Australia
P +61 2 9567 0722 **E** reception@windtech.com.au **W** www.windtech.com.au

Sydney | Singapore | New York | Shanghai | London | Mumbai | Melbourne | Abu Dhabi

DOCUMENT CONTROL

Date	Revision History	Non-Issued Revision	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
31/03/2015	Initial.	-	0	JD	TR	TR
08/04/2015	Update for comments	-	1	JD	TR	TR
11/05/2015	Update for impact on surrounding building balconies	-	2	JD	TR	TR

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EXECUTIVE SUMMARY

This report presents the results of a detailed investigation into the wind environment impact of the proposed development located at 60-78 Regent Street, Redfern. Testing was performed using Windtech's boundary layer wind tunnel, which has a 2.6m wide working section and has a fetch length of 14m. Measurements were carried out using a 1:300 scale detailed model of the development, which has been constructed based on the latest available architectural drawings prepared by project architect Bates Smart, received during March 2015. The effect of nearby buildings and land topography has been accounted for through the use of a proximity model, which represents a radius of approximately 375m from the development site.

Peak gust and mean wind speeds were measured at selected critical outdoor trafficable locations within 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. These wind speed measurements are compared with criteria for pedestrian comfort and safety, based on gust wind speeds which are representative of an annual recurrence, and Gust-Equivalent Mean (GEM) wind speeds which are representative of approximately a weekly recurrence. Comparison is also made with the wind speed criteria detailed in Section 3.2.6 of the Sydney Development Control Plan 2012. The existing wind conditions for the pedestrian footpaths around the site have also been tested to determine the impact that the proposed development.

The model of the proposed development 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. If the results of the study indicate that any area is exposed to strong winds, then in-principle ameliorative treatment(s) are recommended in this report and have been formulated based on our extensive experience in the field of wind engineering. These treatments could be in the form of vegetation that is already proposed for the site, and/or additional trees, shrubs, screens, awnings, etc.

The results of the study indicate that treatments are required for certain locations to achieve the desired criteria for pedestrian comfort and safety, summarised as follows:

Ground Floor Option 1:

- Extend the proposed Level 1 awning above the existing laneway along the north-western boundary of the site, so that it meets with the Level 1 soffit above the through-site link and the southern podium section.

Ground Floor Option 2:

- Extend the proposed Level 1 awning above the existing laneway in line with the existing building aspect, so that it meets with the northern face of the southern podium section.
- Include an impermeable screen extending from the Level 1 awning to meet with the Level 2 slab above the entrance to the through-site link.

Level 1 Option 1:

- Two staggered impermeable baffle screens extending from the ground to the soffit in the barbeque area under the northern aspect of the tower.

Level 1 Option 2:

- Two impermeable baffle screens extending from the ground to the soffit in the barbeque area under the northern aspect of the tower, in an L-shaped configuration.

With the inclusion of either Option 1 or Option 2 treatments to the final design, the results of this study indicate that wind conditions for all outdoor trafficable areas within and around the proposed development are expected to be acceptable for their intended uses.

The impact of the proposed development on wind conditions at the adjoining apartments at 157 Redfern Street and 7-9 Gibbons Street was also tested. The results of the study indicate the measured wind conditions for all of the potentially impacted trafficable outdoor areas within the adjacent developments satisfy their applicable wind comfort criterion and in most cases are better than the existing conditions.

CONTENTS

1 WIND CLIMATE FOR THE SYDNEY REGION

The Sydney region is governed by three principle wind directions, and these can potentially affect the subject development. These winds prevail from the north-east, south and west. A summary of the principal time of occurrence of these winds throughout the year is presented in Table 1 below. This summary is based on a detailed analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained at the meteorological station located at Kingsford Smith Airport by the Bureau of Meteorology (recorded from 1939 to 2008). The data was corrected to represent winds in standard open terrain at a height of 10m above ground. From this analysis, directional plots of the 10-minute mean winds for the Sydney region is also determined (as shown in Figure 1), which are representative of approximately the weekly and annual recurrences. The frequency of occurrence of these winds is also shown in Figure 1.

As shown in Figure 1, the southerly winds are by far the most frequent wind for the Sydney region, and are also the strongest. As indicated in Table 1, the westerly winds occur most frequently during the winter season for the Sydney region, and although they are typically not as strong as the southerly winds, they are usually a cold wind since they occur during the winter and hence can be a cause for discomfort for outdoor areas. North-easterly winds occur most frequently during the warmer months of the year for the Sydney region, and hence are usually welcomed within outdoor areas since they are typically not as strong as the southerly or westerly winds.

Table 1: Principle Time of Occurrence of Winds for Sydney

Month	Wind Direction		
	North-Easterly	Southerly	Westerly
January	X	X	
February	X	X	
March	X	X	
April		X	X
May			X
June			X
July			X
August			X
September		X	X
October	X	X	
November	X	X	
December	X	X	

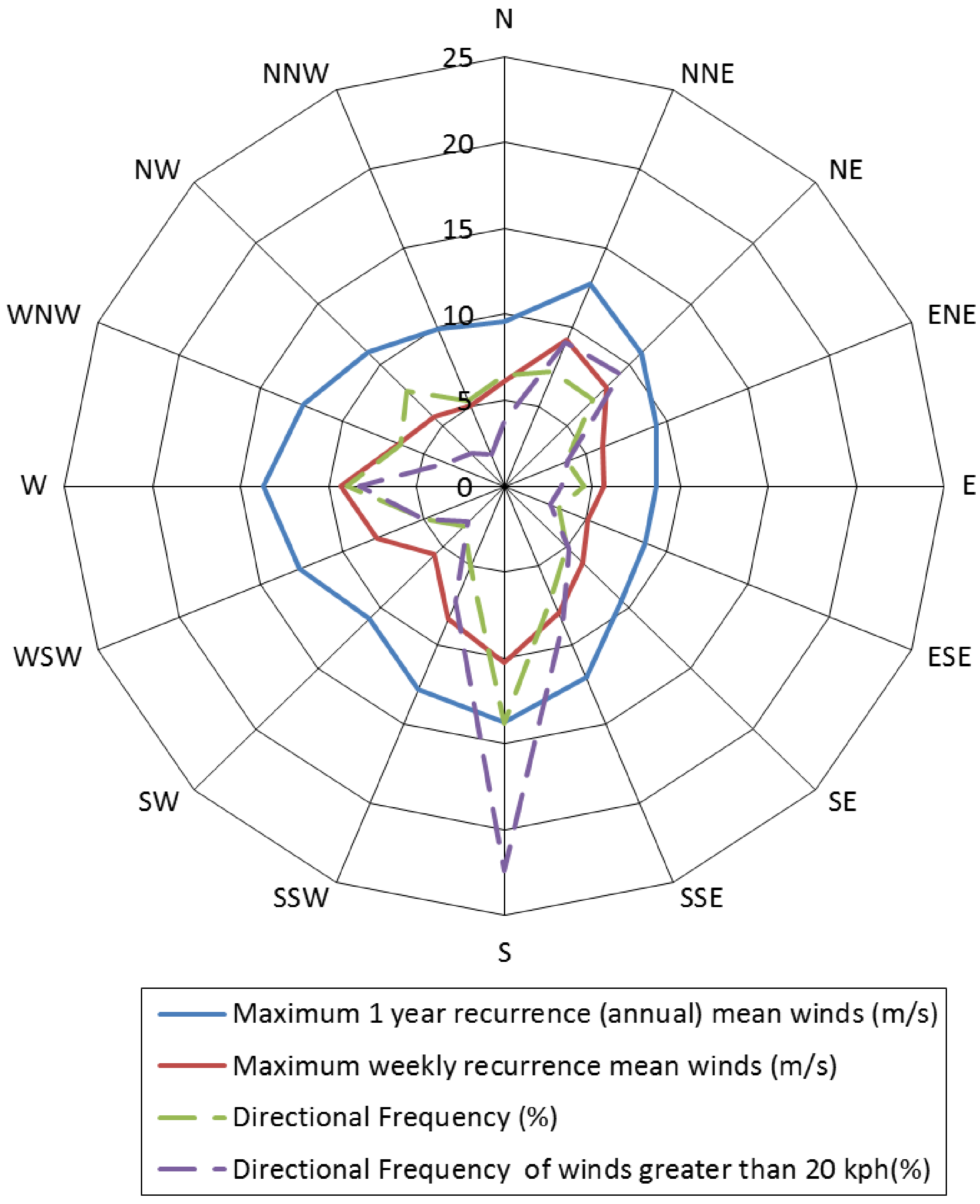

Figure 1: Annual and Weekly Recurrence Mean Wind Speeds, and Frequencies of Occurrence, for the Sydney Region (based on 10-minute mean observations from Kingsford Smith Airport from 1939 to 2008, corrected to open terrain at 10m)

2 THE WIND TUNNEL MODEL

Wind tunnel testing was undertaken to obtain accurate wind speed measurements at selected critical outdoor locations within and around the development using a 1:300 scale model. The study model incorporates all necessary architectural features on the development to ensure an accurate wind flow is achieved around the model, and has been constructed based on the latest available architectural drawings prepared by the project architect Bates Smart, received March 2015. A proximity model has also been constructed and represents the surrounding buildings and significant topographical effects within a diameter of 375m, centred on the development site. Photographs of the wind tunnel model are presented in Figures 2a to 2g on the following pages. Figures 3a to 3f show photos of the wind tunnel model including the detailed models of the adjacent developments at 157 Redfern Street and 7-9 Gibbons Street.

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. If the results of the study indicate that any area is exposed to strong winds, in-principal treatments have recommended. These treatments could be in the form of vegetation that is already proposed for the site, and/or additional trees, shrubs, screens, awnings, etc.

Figure 2a: Photograph of the Wind Tunnel Model (view from the south)

Figure 2b: Photograph of the Wind Tunnel Model (view from the east)

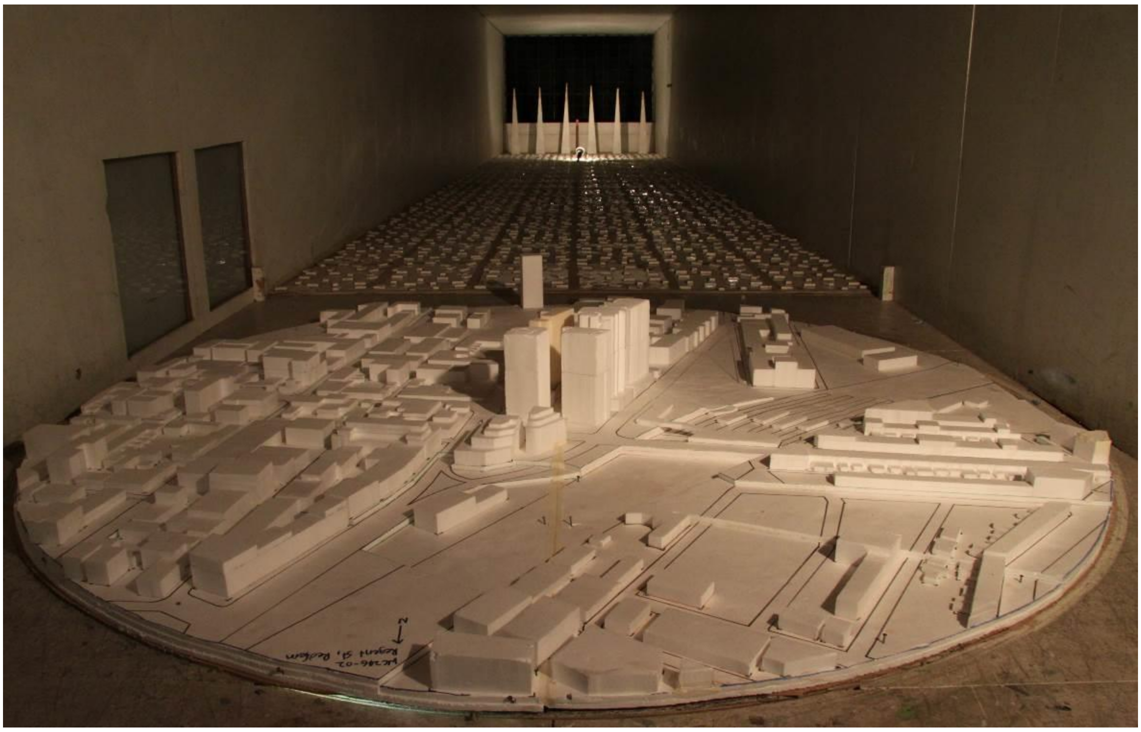

Figure 2c: Photograph of the Wind Tunnel Model (view from the north)

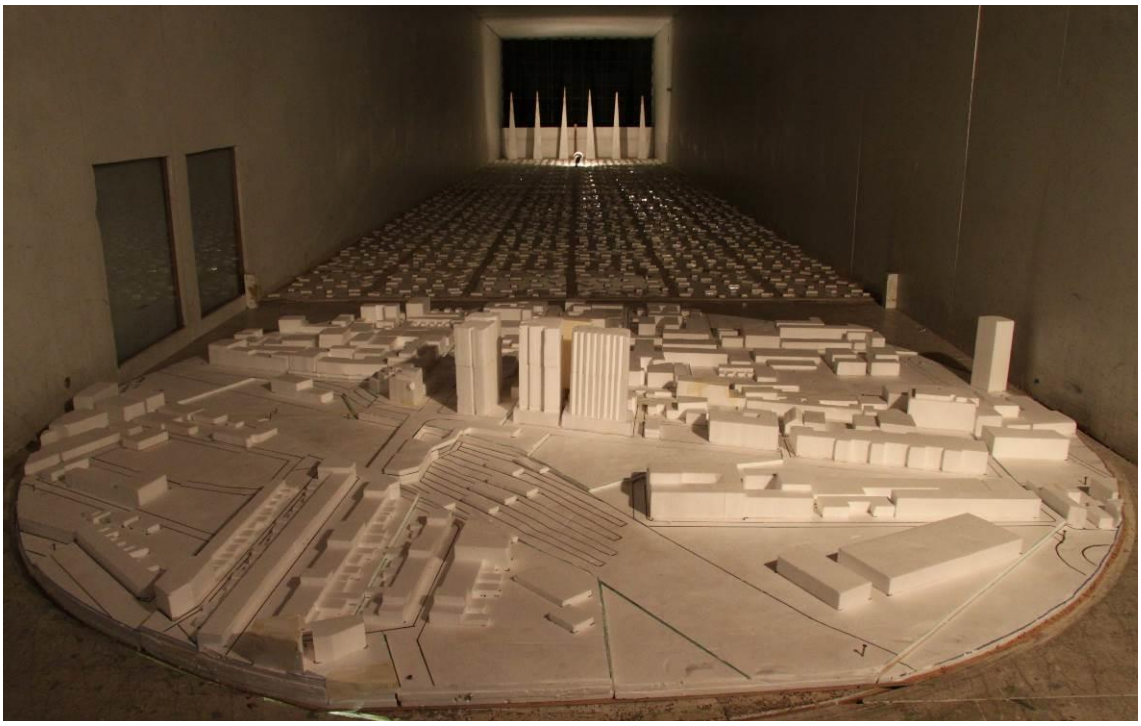

Figure 2d: Photograph of the Wind Tunnel Model (view from the west)

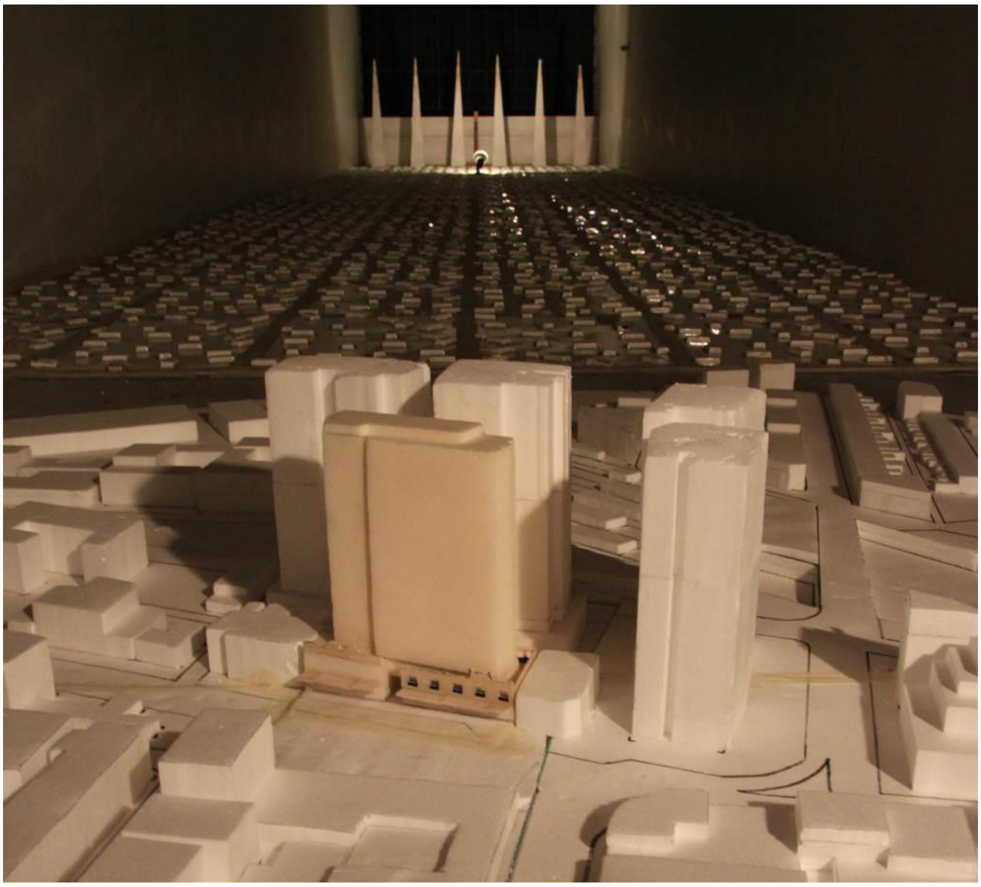

Figure 2e: Photograph of the Wind Tunnel Model (view from the east)

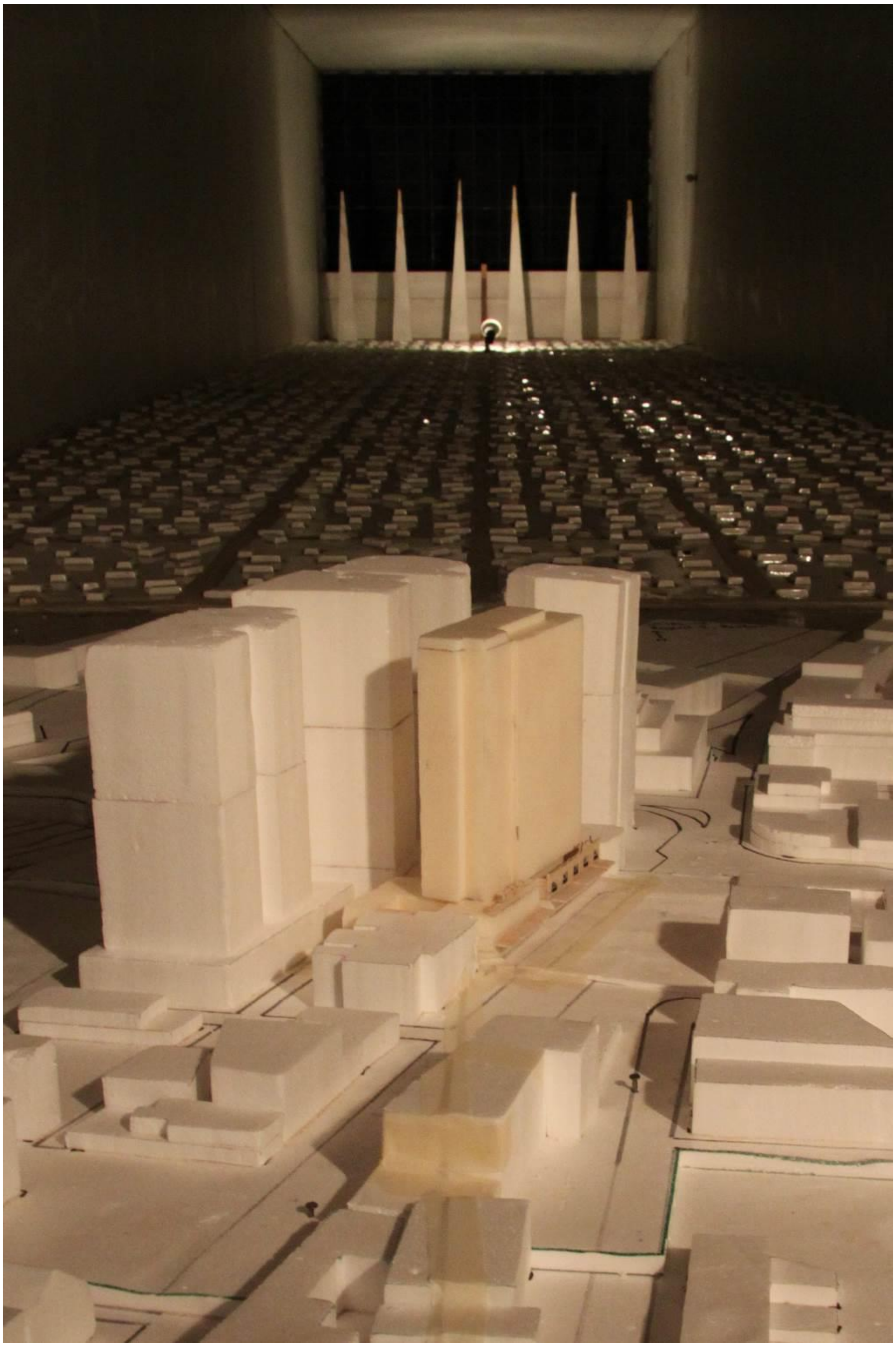

Figure 2f: Photograph of the Wind Tunnel Model (view from the south)

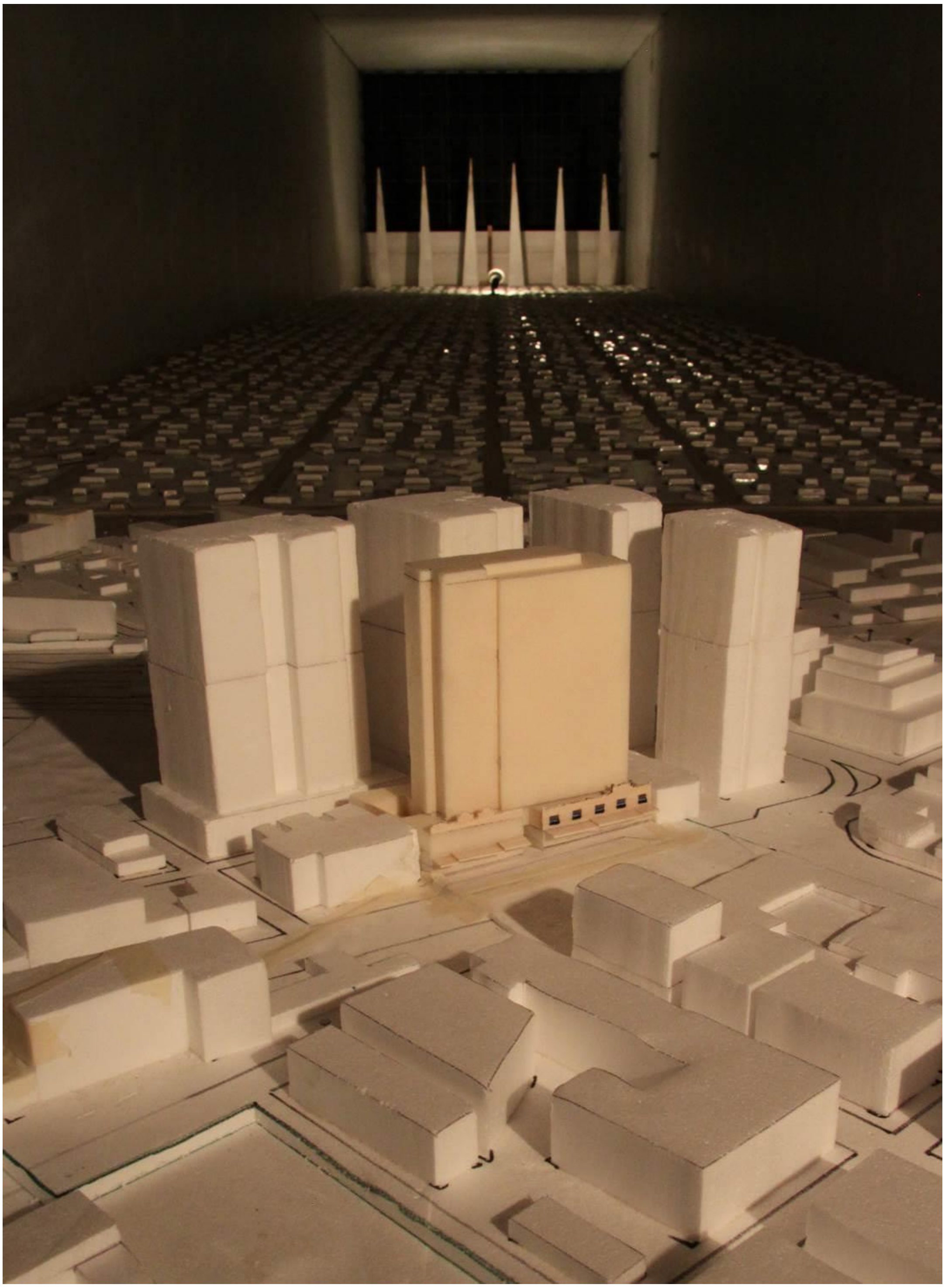

Figure 2g: Photograph of the Wind Tunnel Model (view from the south-east)

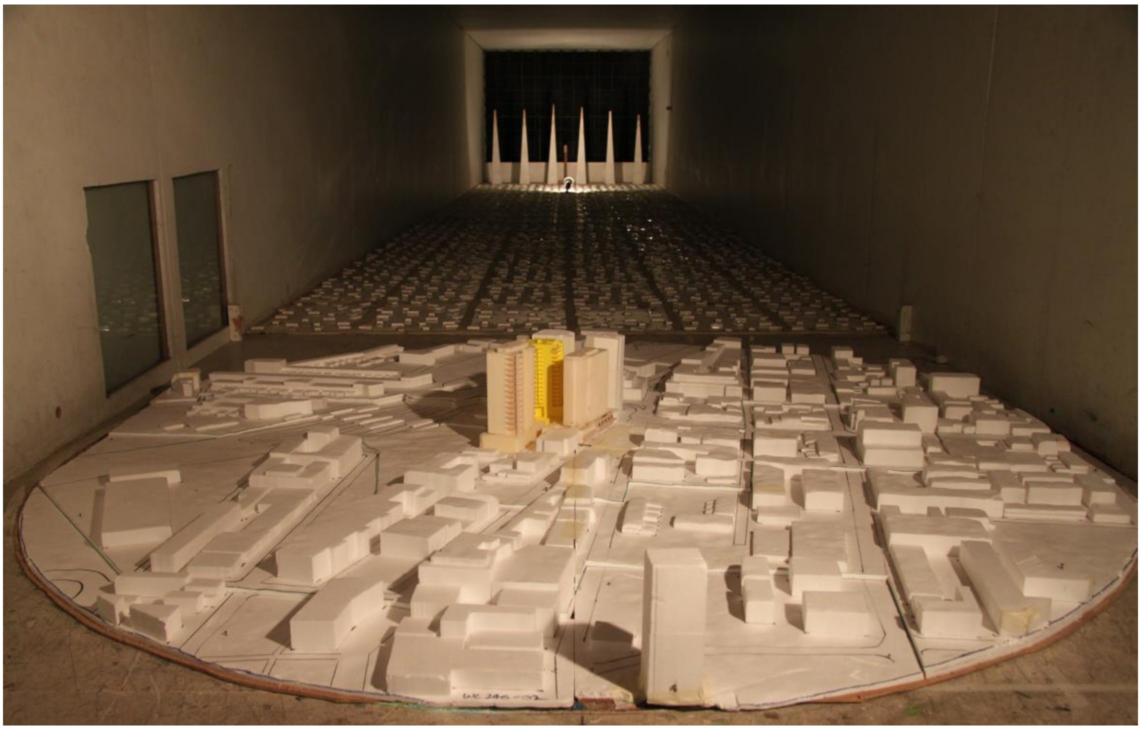

Figure 3a: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the south)

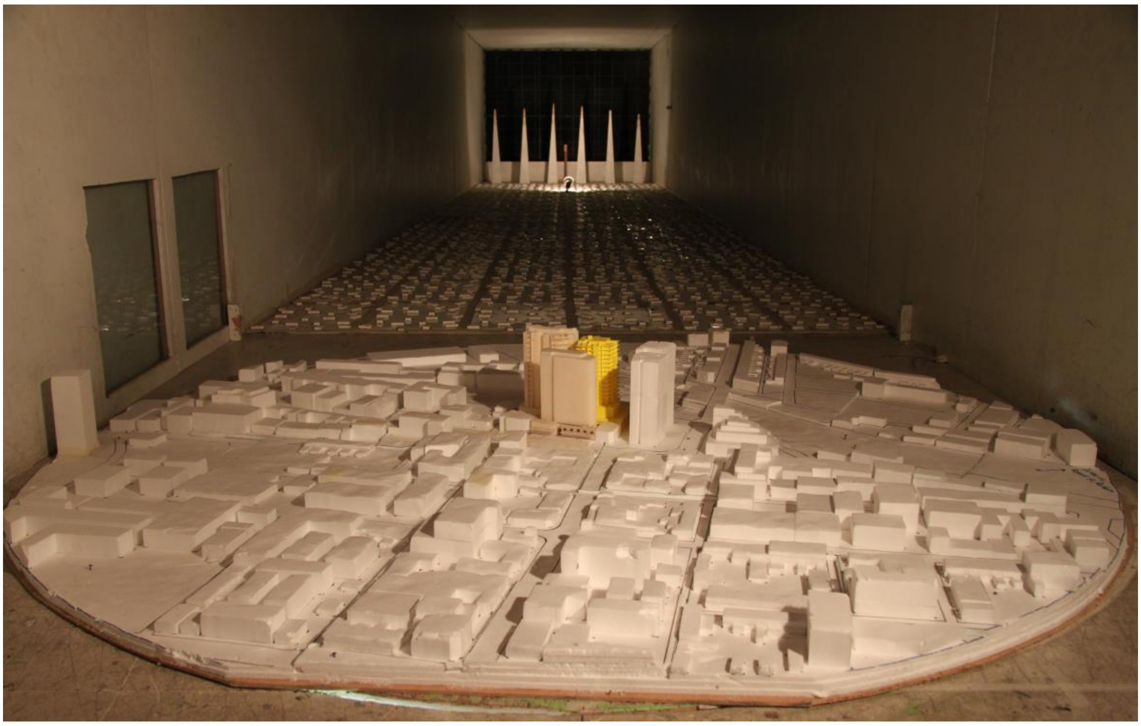

Figure 3b: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the east)

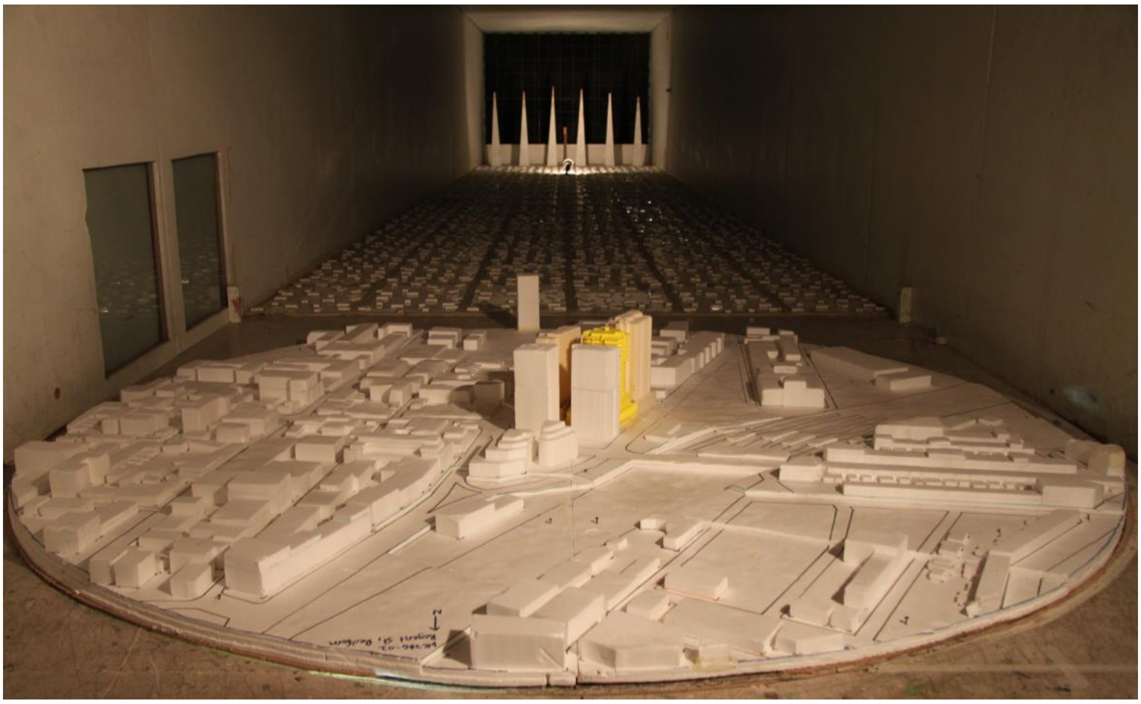

Figure 3c: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the north)

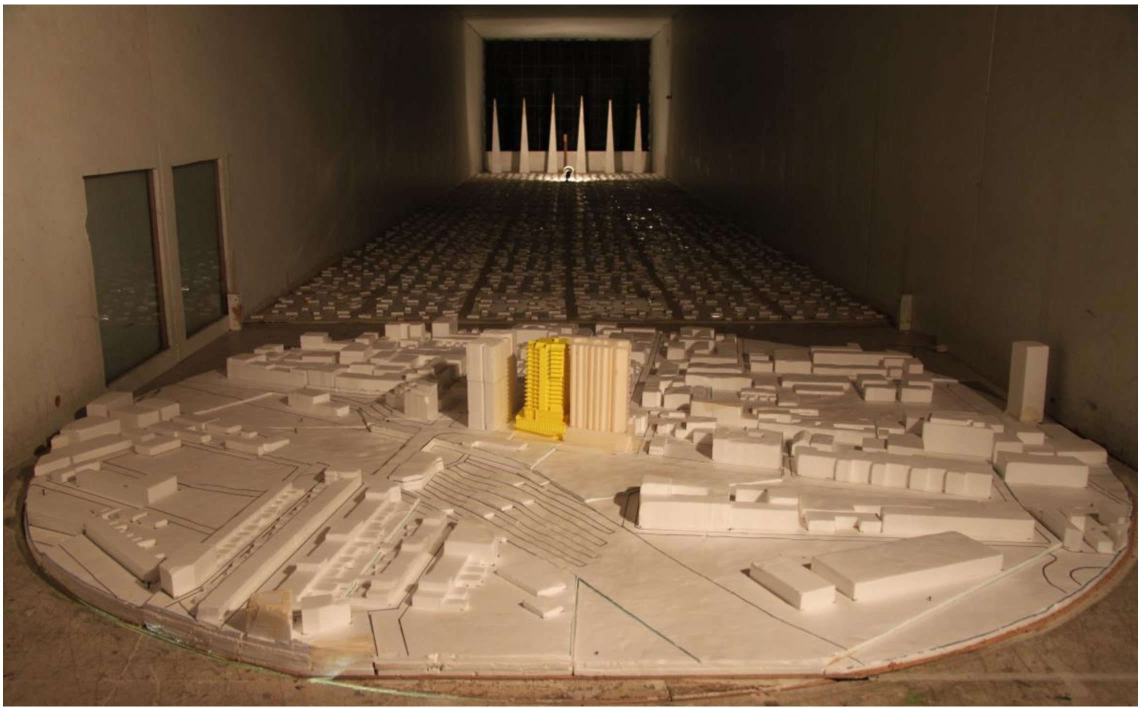

Figure 3d: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the west)

Figure 3e: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the east)

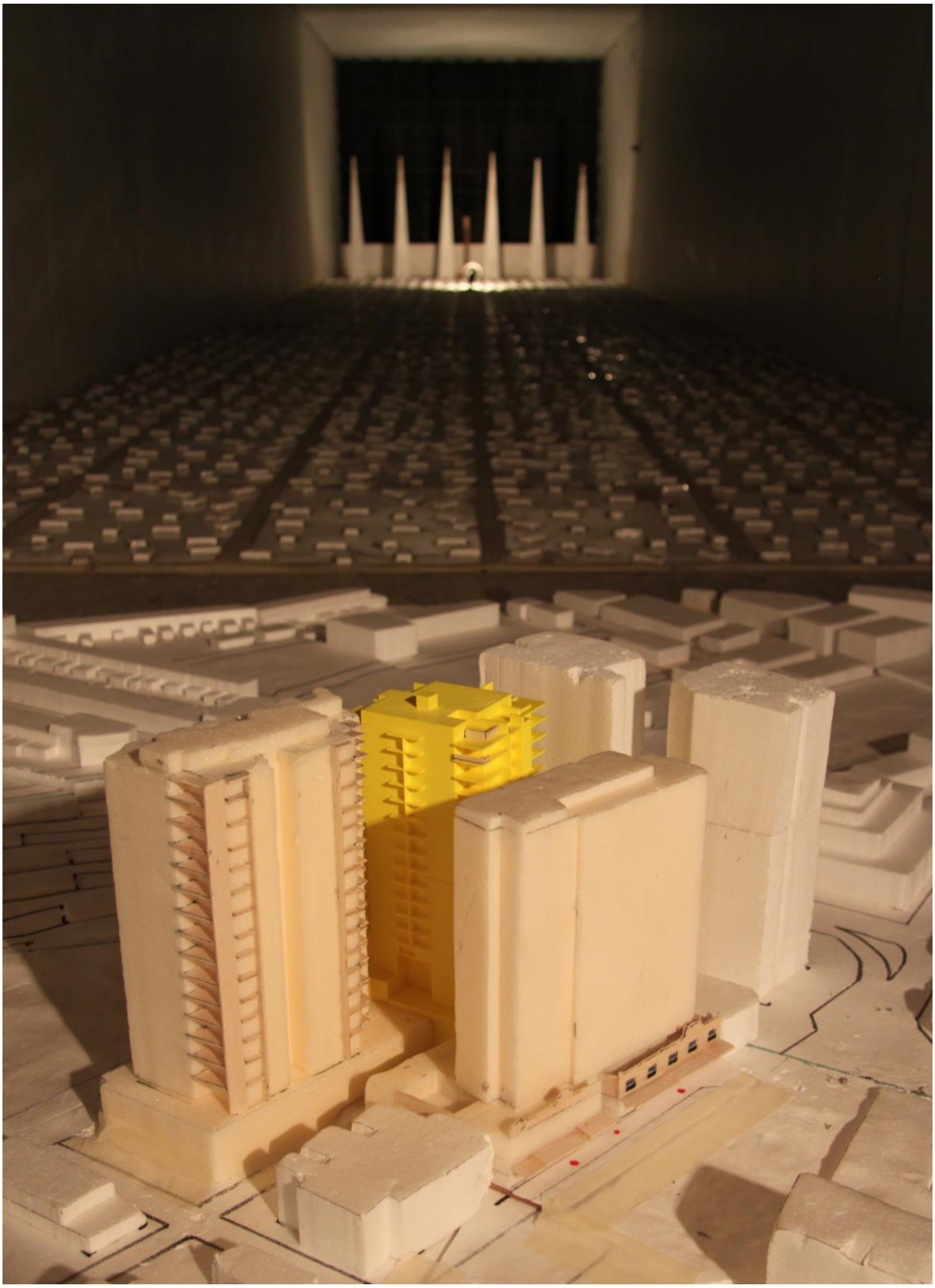

Figure 3f: Photograph of the Wind Tunnel Model with Detailed Adjacent Developments (view from the south-east)

3 BOUNDARY LAYER WIND FLOW MODEL

Testing was performed using Windtech's boundary layer wind tunnel, which has a 2.6m wide working section and has a fetch length of 14m. The model was placed in the appropriate standard boundary layer wind flow for each of the prevailing wind directions for the wind tunnel testing. The type of wind flow used in a wind tunnel study is determined by a detailed analysis of the surrounding terrain types around the subject site. Details of the analysis of the surrounding terrain for this study are provided in the following pages of this report.

The roughness of the earth's surface has the effect of slowing down the prevailing wind near the ground. This effect is observed up to what is known as 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, dense urban cities, etc). Within this range, the prevailing wind forms what is known as a *boundary layer wind profile*.

Various wind codes and standards classify various types of boundary layer wind flows depending on the surface roughness. However, it should be noted that the 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 profile to achieve a state of equilibrium. Descriptions of the standard boundary layer profiles for various terrain types are summarised as follows (as per the definitions in AS/NZS1170.2:2011):

- **Terrain Category 1.0:** Extremely flat terrain. Examples include enclosed water bodies such as lakes, dams, rivers, bays, etc.
- **Terrain Category 1.5:** Relatively flat terrain. Examples include the open ocean, deserts, and very flat open plains.
- **Terrain Category 2.0:** Open terrain. Examples include grassy fields and plains and open farmland (without buildings or trees).
- **Terrain Category 2.5:** Relatively open terrain. Examples include farmland with scattered trees and buildings and very low-density suburban areas.
- **Terrain Category 3.0:** Suburban and forest terrain. Examples include suburban areas of towns and areas with dense vegetation such as forests, bushland, etc.
- **Terrain Category 3.5:** Relatively dense suburban terrain. Examples include centres of small cities, industrial parks, etc.
- **Terrain Category 4.0:** Dense urban terrain. Examples include CBD's of large cities with many high-rise towers, and areas with many closely-spaced mid-rise buildings.

For this study, the shape of the boundary layer wind flows over standard terrain types is defined as per ISO4354:2009. These are summarised in Table 2, referenced to the study reference height of 30m above ground.

Table 2: Terrain and Height Multipliers, Turbulence Intensities, and Corresponding Roughness Lengths, for the Standard ISO4354:2009 Boundary Layer Profiles (at the study reference height)

Terrain Category	Terrain and Height Multipliers			Turbulence Intensity	Roughness Length (m)
	$k_{tr,T=3600s}$ *(hourly)*	$k_{tr,T=600s}$ *(10-minute)*	$k_{tr,T=3s}$ *(3-second)*	I_v	$z_{0,r}$
1.0	0.90	0.93	1.23	0.120	0.003
1.5	0.85	0.88	1.19	0.137	0.01
2.0	0.78	0.82	1.15	0.157	0.03
2.5	0.70	0.74	1.10	0.186	0.1
3.0	0.62	0.66	1.03	0.224	0.3
3.5	0.51	0.55	0.95	0.291	1
4.0	0.38	0.42	0.84	0.407	3

An analysis of the effect of changes in the upwind terrain roughness was carried out for each of the wind directions studied. This has been undertaken based on the method given in AS/NZS1170.2:2011, which uses a "fetch" length of 40 times the study reference height. However, it should be noted that this "fetch" commences *beyond* a "lag distance" area, which has a length of 20 times the study reference height (in accordance with AS/NZS1170.2:2011), so the actual "fetch" of terrain analysed is the area between 20 and 60 times the study reference height away from the site. An aerial image showing the surrounding terrain is presented in Figure 4 for a radius of 1.8km from the edge of the wind tunnel proximity model. The resulting mean and gust terrain and height multipliers at the site location are presented in Table 3, referenced to the study reference height.

For each of the 16 wind directions tested in this study, the approaching boundary layer wind profiles modelled in the wind tunnel matched the model scale and the overall surrounding terrain characteristics beyond the 375m radius of the proximity model. Plots of the wind tunnel boundary layer wind profiles are presented in Appendix B of this report.

Table 3: Directional Terrain and Height Multipliers at the Site (at the study reference height, as per the AS/NZS1170.2:2011 boundary layer transition methodology)

Wind Sector (degrees)	$k_{tr,T=3s}$ (3-second gust)	$k_{tr,T=600s}$ (10-minute mean)	$k_{tr,T=3600s}$ (hourly mean)
0	0.95	0.55	0.51
30	0.96	0.56	0.52
60	1.03	0.65	0.61
90	1.07	0.70	0.67
120	1.02	0.65	0.61
150	0.95	0.55	0.51
180	0.95	0.55	0.51
210	0.95	0.55	0.51
240	1.02	0.64	0.60
270	1.03	0.66	0.62
300	0.95	0.55	0.51
330	1.01	0.63	0.59

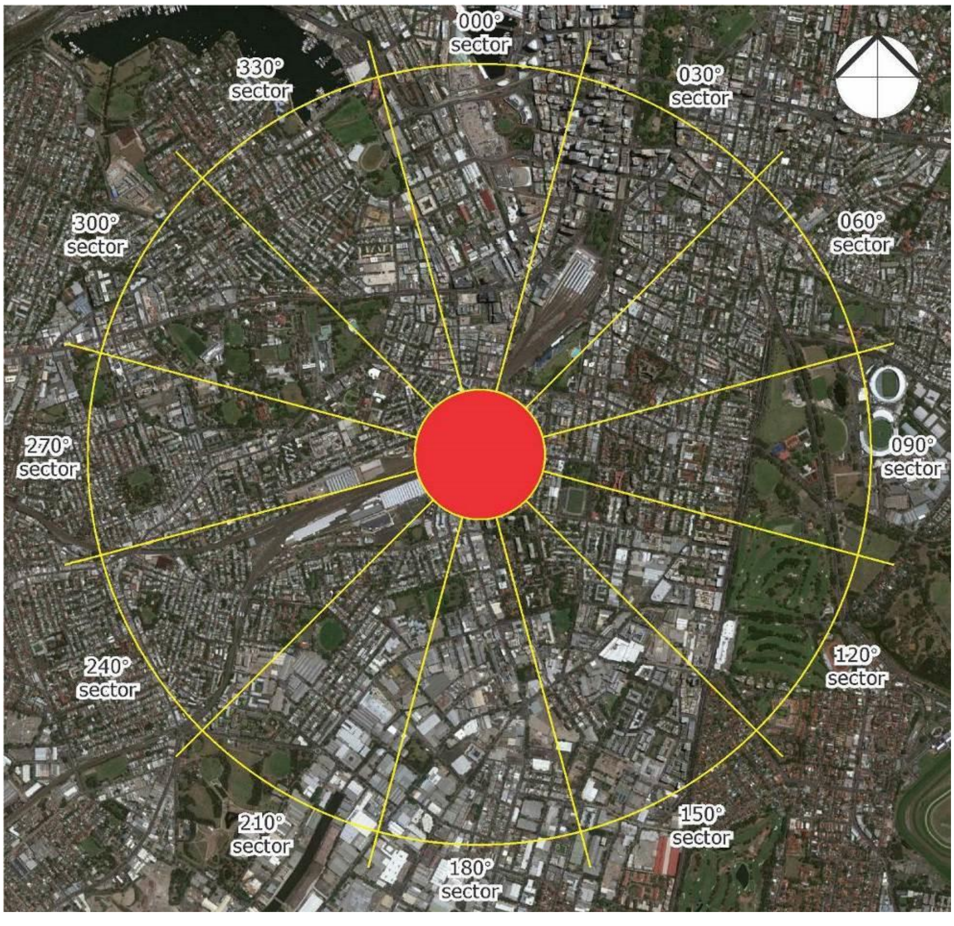

Figure 4: Aerial Image of the Surrounding Terrain
(radius of 1.8km from the edge of the proximity model, which is coloured red)

4 ENVIRONMENTAL WIND SPEED CRITERIA

4.1 Wind Effects on People

The acceptability of wind in any area is dependent upon its use. For example, people walking or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Various other researchers, such as Davenport, Lawson, Melbourne, Penwarden, etc, have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities. These are discussed in the following sub-sections of this report.

4.1.1 Penwarden (1975) Criteria for Gust Wind Speeds

The following table developed by Penwarden (1975) is a modified version of the Beaufort Scale, and describes the effects of various wind intensities on people. Note that the applicability column related to wind conditions occurring frequently (approximately once per week on average). Higher ranges of wind speeds can be tolerated for rarer events.

Table 4: Summary of Wind Effects on People (after Penwarden, 1975)

Type of Winds	Beaufort Number	Gust Wind Speed (m/s)	Effects
Calm, light air	1	0 - 1.5	Calm, no noticeable wind
Light breeze	2	1.6 - 3.3	Wind felt on face
Gentle breeze	3	3.4 - 5.4	Hair is disturbed, Clothing flaps
Moderate breeze	4	5.5 - 7.9	Raises dust, dry soil and loose paper - Hair disarranged
Fresh breeze	5	8.0 – 10.7	Force of wind felt on body
Strong breeze	6	10.8 – 13.8	Umbrellas used with difficulty, Hair blown straight, Difficult to walk steadily, Wind noise on ears unpleasant.
Near gale	7	13.9 – 17.1	Inconvenience felt when walking.
Gale	8	17.2 - 20.7	Generally impedes progress, Great difficulty with balance.
Strong gale	9	20.8 – 24.4	People blown over by gusts.

4.1.2 Davenport (1972) Criteria for Mean Wind Speeds

Davenport (1972) had also determined a set of criteria in terms of the Beaufort Scale and for various return periods. The values presented in Table 5 below are based on a frequency of exceedance of approximately once per week (a probability of exceedance of 5%).

Table 5: Criteria by Davenport (1972)

Classification	Activities	95 Percentile Maximum Mean (approximately once per week)
Walking Fast	Acceptable for walking, main public accessways.	7.5 m/s < $\overline{V}$ < 10.0 m/s
Strolling, Skating	Slow walking, etc.	5.5 m/s < $\overline{V}$ < 7.5 m/s
Short Exposure Activities	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas.	3.5 m/s < $\overline{V}$ < 5.5 m/s
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants & theatres and in parks.	$\overline{V}$ < 3.5 m/s

4.1.3 Lawson (1975) Criteria for Mean Wind Speeds

In 1973, Lawson quotes that Penwarden's Beaufort 4 wind speeds (as listed in Table 4) would be acceptable if it is not exceeded for more than 4% of the time; and a Beaufort 6 as being unacceptable if it is exceeded more than 2% of the time. Later, in 1975, Lawson presented a set of criteria very similar to those of Davenport's. These are presented in Tables 6 and 7.

Table 6: Safety Criteria by Lawson (1975)

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

Table 7: Comfort Criteria by Lawson (1975)

Classification	Activities	95 Percentile Maximum Mean (approximately once per week)
Business Walking	Objective Walking from A to B.	8 m/s < $\overline{V}$ < 10m/s
Pedestrian Walking	Slow walking, etc.	6 m/s < $\overline{V}$ < 8 m/s
Short Exposure Activities	Pedestrian standing or sitting for short times.	4 m/s < $\overline{V}$ < 6 m/s
Long Exposure Activities	Pedestrian sitting for a long duration.	$\overline{V}$ < 4 m/s

4.1.4 Melbourne (1978) Criteria for Gust Wind Speeds

Melbourne (1978) introduced a set of criteria for the assessment of environmental wind conditions, which were developed for a temperature range of 10°C to 30°C and for people suitably dressed for outdoor conditions. These criteria are based on peak annual maximum gust wind speeds, and are outlined in Table 8 below. It should be noted that this criteria tends to be more conservative than criteria suggested by other researchers.

Table 8: Criteria by Melbourne (1978)

Classification	Human Activities	Annual Maximum Gust
Limit for safety	Completely unacceptable: people likely to get blown over.	$\hat{V} > 23$m/s
Marginal	Unacceptable as main public accessways.	23 m/s > $\hat{V}$ > 16 m/s
Comfortable Walking	Acceptable for walking, main public accessways	16 m/s > $\hat{V}$ > 13 m/s
Short Exposure Activities	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas.	13 m/s > $\hat{V}$ > 10 m/s
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants & theatres and in parks.	10 m/s > $\hat{V}$

4.2 Comparison of the Various Wind Speed Criteria

The criteria by Melbourne (1978) mentioned in Table 8, and criteria from other researchers, are compared on a probabilistic basis in Figure 5. This indicates that the criteria by Melbourne (1978) are quite conservative. This was also observed by Rofail (2007) when undertaking on-site remedial studies, who concluded that the criteria by Melbourne (1978) generally overstates the wind effects in a typical urban setting, which is caused by Melbourne's assumption of a fixed 15% turbulence intensity for all areas. This value tends to be at the lower end of the range of turbulence intensities, and the Rofail (2007) study found that, in an urban setting, the range of the *minimum* turbulence intensities is typically in the range of 20% to 60%.

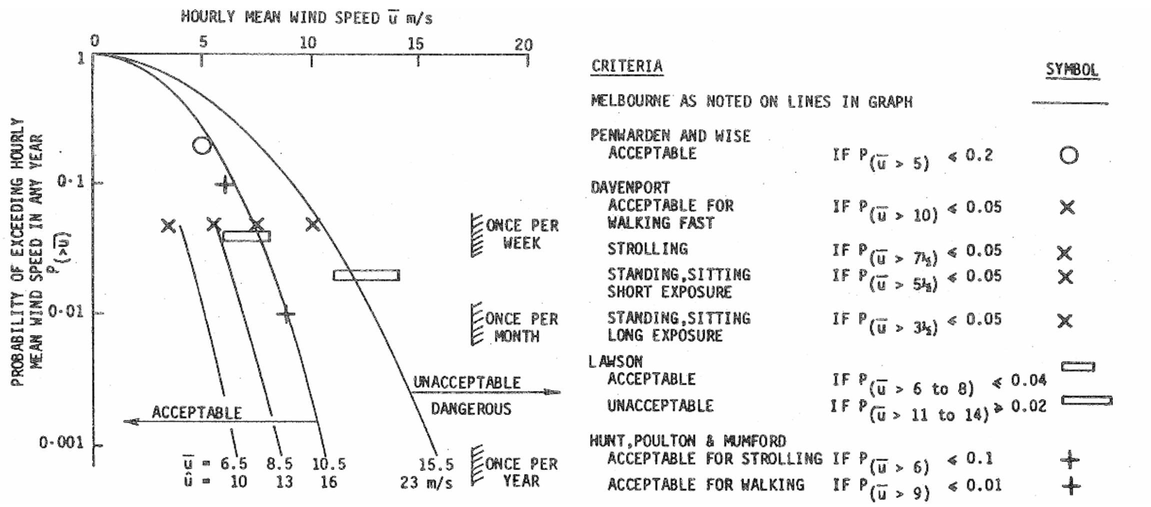

Figure 5: Comparison of Various Mean and Gust Wind Environment Criteria, assuming 15% turbulence and a Gust Factor of 1.5 (after Melbourne, 1978)

4.3 Wind Speed Criteria Used for This Study

For this study, the measured wind conditions for the various critical outdoor trafficable areas within and around the subject development are compared against two sets of criteria. For comfort, the Davenport (1972) criteria are used in conjunction with a weekly maximum Gust Equivalent Mean (GEM) wind speed (defined below). The safety limit criterion by Melbourne (1978) of 23m/s for the annual maximum peak gust wind speeds is also used. Note that the Davenport (1972) criteria, used in conjunction with a Gust Equivalent Mean (GEM) wind speed (defined below), has proven over time, and through field observations, to be the most reliable indicator of pedestrian comfort (Rofail, 2007). Note also that the safety limit criterion by Melbourne (1978) of 23m/s for annual maximum peak gust wind speeds is also applied to all areas.

Section 3.2.6 of the Sydney Development Control Plan 2012 requires that the annual maximum peak gust wind speed for the public footpaths along Regent Street and through the site is 16m/s for the annual maximum gust wind speeds, and hence the measured wind conditions for these pedestrian footpaths are also compared to this requirement in this study.

The existing site conditions for the pedestrian footpaths along Regent Street and William Lane have also been tested as part of this study to determine the impact of the subject development. If it is found that the existing conditions exceed the relevant criteria, then the target wind speed for that area with the inclusion of the proposed development is to at least match the existing site conditions.

The basic criteria for a range of outdoor activities are described as follows:

- **Long Exposure:** 3.5m/s weekly maximum GEM wind speeds.
- **Short Exposure:** 5.5m/s weekly maximum GEM wind speeds.
- **Comfortable Walking:** 7.5m/s weekly maximum GEM wind speeds.
- **Fast Walking:** 10.0m/s weekly maximum GEM wind speeds.
- **Safety Limit:** 23.0m/s annual maximum gust wind speeds
- **Public Footpaths:** 16m/s annual maximum gust wind speeds (as per the Sydney DCP 2012 requirement).
- **Existing Site Conditions:** Where relevant, if the existing site conditions exceed the relevant wind speed criteria, then the target wind speed for that area with the inclusion of the proposed development is to at least match the existing site conditions.

The results of the wind tunnel study are presented in the form of directional plots attached in Appendix A of this report. Each study point has 2 plots (one comparing to the modified version of the Davenport (1972) criteria for the weekly maximum GEM wind speeds, and the other comparing to the Melbourne (1978) criteria for the annual maximum peak gust wind speeds).

Notes:

- The GEM is defined as the maximum of the mean wind speed and the gust wind speed divided by a gust factor of 1.85.
- The gust wind speed is defined as 3.5 standard deviations from the mean.
- Long Exposure applies typically to outdoor dining areas in restaurants, amphitheatres, etc.
- Short Exposure applies typically to areas where short duration stationary activities are involved (less than 1 hour). This includes window shopping, waiting areas, etc.
- Comfortable Walking applies typically to areas used mainly for pedestrian thoroughfares. This also includes private swimming pools and communal areas.
- Fast walking applies typically to car parks, laneways, infrequently used public pedestrian thoroughfares and parks, balconies, private terraces etc.
- In all areas, the wind conditions are also checked against the safety limit.

5 TEST PROCEDURE AND METHODOLOGY

5.1 Measurement of the Velocity Coefficients

Testing was performed using Windtech's boundary layer wind tunnel facility, which has a 2.6 m wide working section and has a fetch length of 14m. The test procedures followed for the wind tunnel testing performed for this study generally adhere to the guidelines set out in the Australasian Wind Engineering Society Quality Assurance Manual (AWES-QAM-1-2001), ASCE-7-10 (Chapter C31), and CTBUH guidelines.

The model of the subject development was setup within the wind tunnel, and the wind velocity measurements were monitored using Dantec hot-wire probe anemometers at selected critical outdoor locations at a full-scale height of approximately 1.5m above ground/slab level. The probe support for each study location was mounted such that the probe wire was vertical as much as possible, which ensures that the measured wind speeds are independent of wind direction along the horizontal plane. In addition, care was taken in the alignment of the probe wire and in avoiding wall-heating effects. Wind speed measurements are made in the wind tunnel for 16 wind directions, at 22.5° increments. The output from the hot-wire probes was obtained using a National Instruments 12-bit data acquisition card. A sample rate of 1,024Hz was used, which is more than adequate for he given frequency band. The signal was low pass filtered at 32Hz, which results in the peak gust being the equivalent of a 2 to 3 second gust (which is what the criteria for pedestrian comfort and safety are based upon).

The mean and the maximum 3-second duration peak gust velocity coefficients are derived from the wind tunnel test by the following relation:

$$\hat{C}_V = \overline{C}_V + g.\sigma_V \qquad (4.1)$$

where: $\hat{C}_V$ is the 3-second gust velocity coefficient.

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

g is the gust factor, which is taken to be 3.5.

σ_V is the standard deviation of the velocity measurement.

The mean free-stream wind speed measured in the wind tunnel for this study was approximately 10.8m/s. Note that the measurement location for the mean free-stream wind speed is at a height of 200m at the upwind edge of the proximity model. A sample length of 12 seconds was used for each wind direction tested, which is equivalent to a minimum sample time of approximately 34 minutes in full-scale for the annual maximum gust wind speeds, which is suitable for this type of study.

5.2 Calculation of the Full-Scale Results

To determine if the wind conditions at each study point location will satisfy the relevant criteria for pedestrian comfort and safety, the measured velocity coefficients need to be combined with information about the local wind climate. The aim of combining the wind tunnel measurements with wind climate information is to determine the probability of exceedance of a given wind speed at the site. The local wind climate is normally described using a statistical model, which relates wind speed to a probability of exceedance. Details of the wind climate model used in this study are outlined in Section 1.

A feature of this process is to include the impact of wind directionality, which includes any local variations in wind speed or frequency with wind direction. This is important as the wind directions which produce the highest wind speed events for a region may not coincided with the most wind exposed direction at the site.

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

5.2.1 Annual Maximum Gust Wind Speeds

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

$$V_{study} = V_{ref,RH} \left(\frac{k_{200m,tr,T=3600s}}{k_{RH,tr,T=3600s}} \right) C_V \qquad (4.2)$$

V_{study} is the full-scale wind velocity at the study point location, in m/s.

$V_{ref,RH}$ is the full-scale reference wind speed at the upwind edge of the proximity model at the study reference height. This value is determined by combining the directional wind speed data for the region (detailed in Section 1) and the upwind terrain and height multipliers for the site (detailed in Section 3).

$k_{200m,tr,T=3600s}$ is the hourly mean terrain and height multiplier at 200m for the standard terrain category setup used in the wind tunnel tests.

$k_{RH,tr,T=3600s}$ is the hourly mean terrain and height multiplier at the study reference height (see Table 3).

C_V is the velocity coefficient measurement obtained from the hot-wire anemometer, which is derived from the following relationship:

$$C_V = \frac{C_{V,study}}{C_{V,200m}} \qquad (4.3)$$

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

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

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 will 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.

5.2.2 Weekly Maximum Gust-Equivalent Mean Wind Speeds

The contribution to the probability of exceedance of a specified wind speed (i.e.: the desired wind speed for pedestrian comfort, as per the criteria) is 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 Lawson (1980).

The criteria of Davenport (1972), which is used in this study, is referenced to a probability of exceedance of 5% of a specified wind speed and is representative of approximately a weekly recurrence interval.

5.3 Layout of Study Points

For this study a total of 19 study point locations have been selected for analysis of the proposed development in the wind tunnel. These include 12 study points on the ground level and 7 study points on the public communal outdoor areas on Level 1. The locations of the various study points tested for this study are presented in Figures 6a and 6b in the form of a marked-up plan drawings. It should be noted that only the most critical outdoor locations of the development have been selected for analysis.

A further 18 study points were selected for analysis of the impact of the proposed development on the adjoining apartments at 157 Redfern Street and 7-9 Gibbons Street. The locations of these study points are presented in figures 7a-7h. It should again be noted that only the most critical outdoor locations of these developments have been selected for analysis.

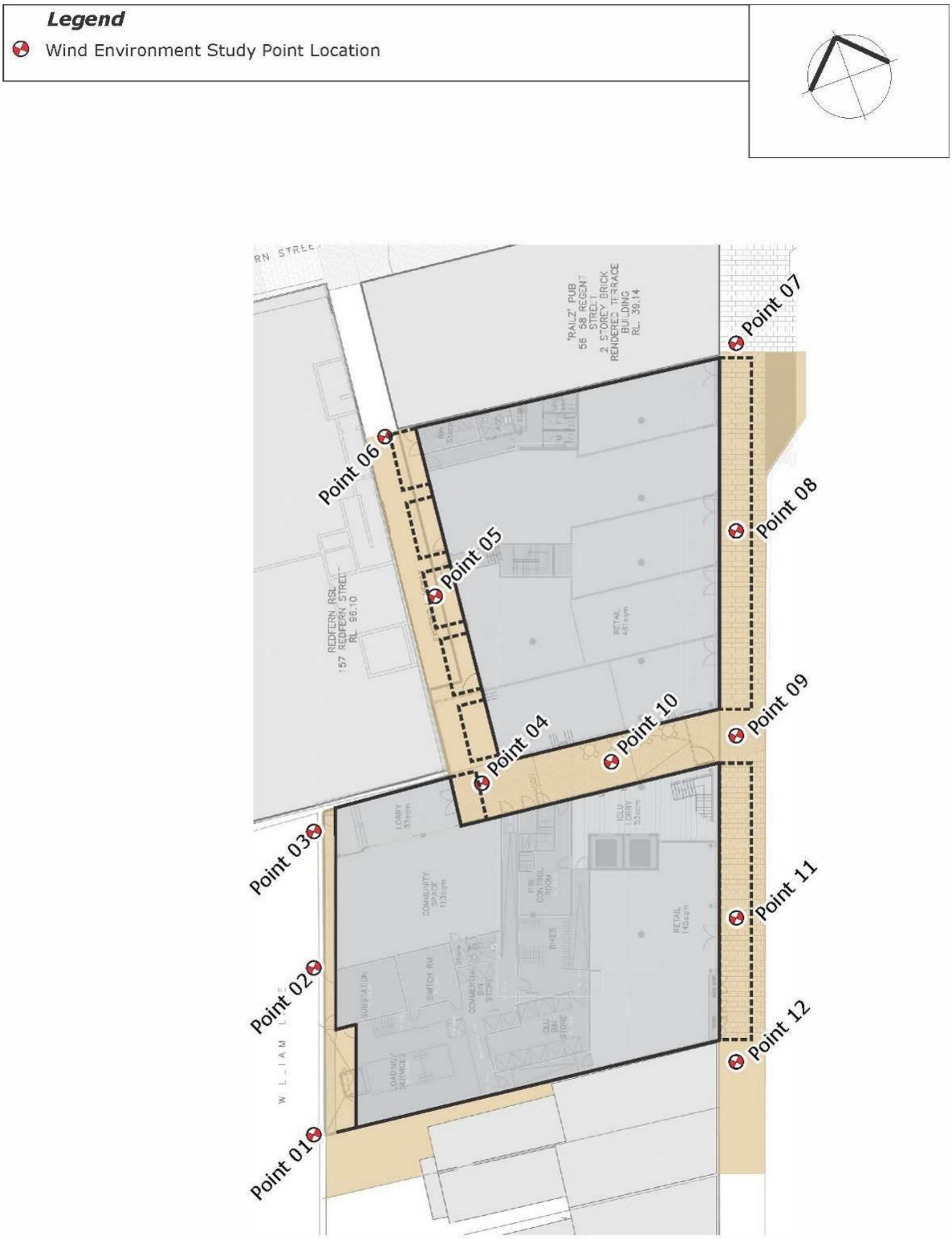

Figure 6a: Study Point Locations – Ground Level

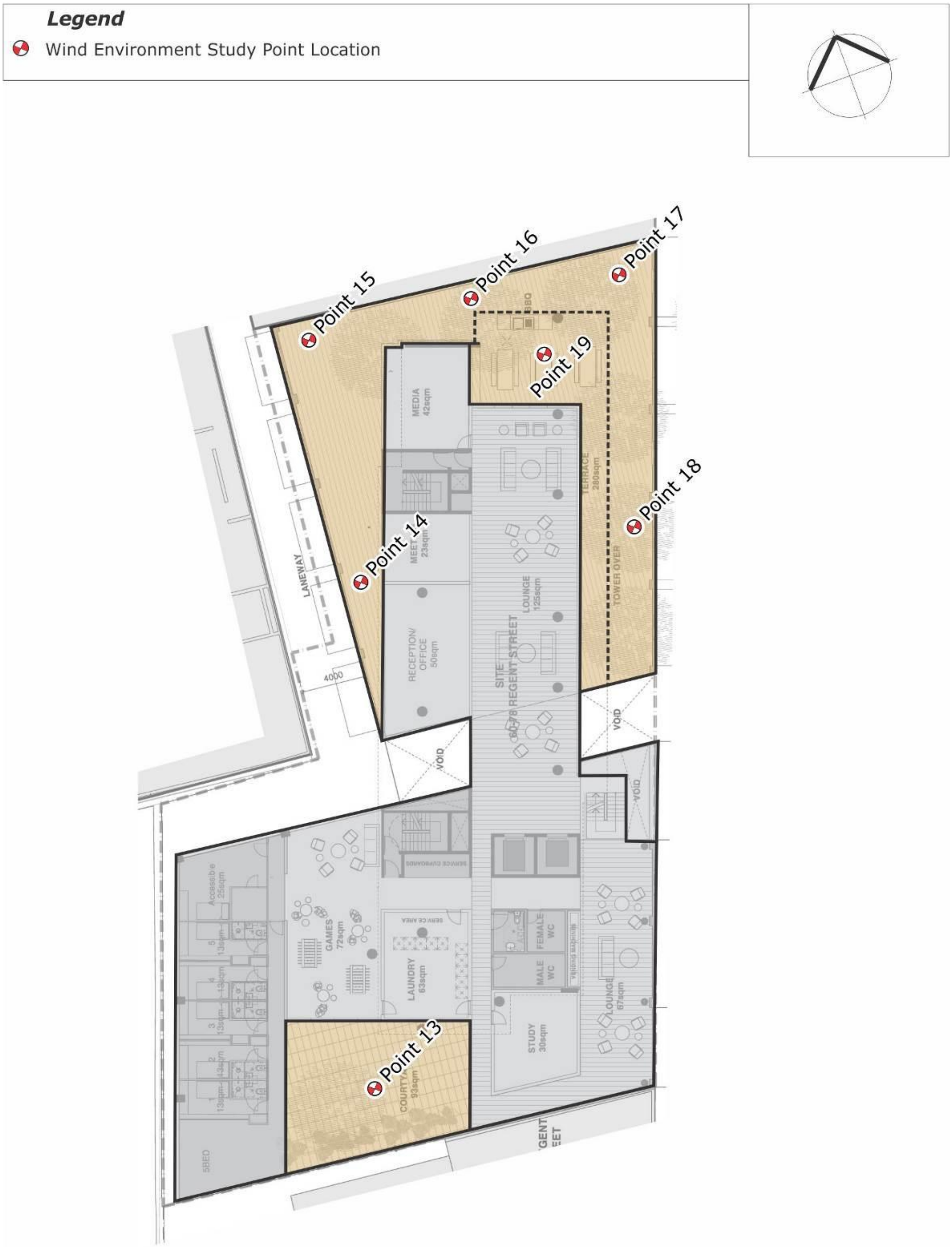

Figure 6b: Study Point Locations – Level 1

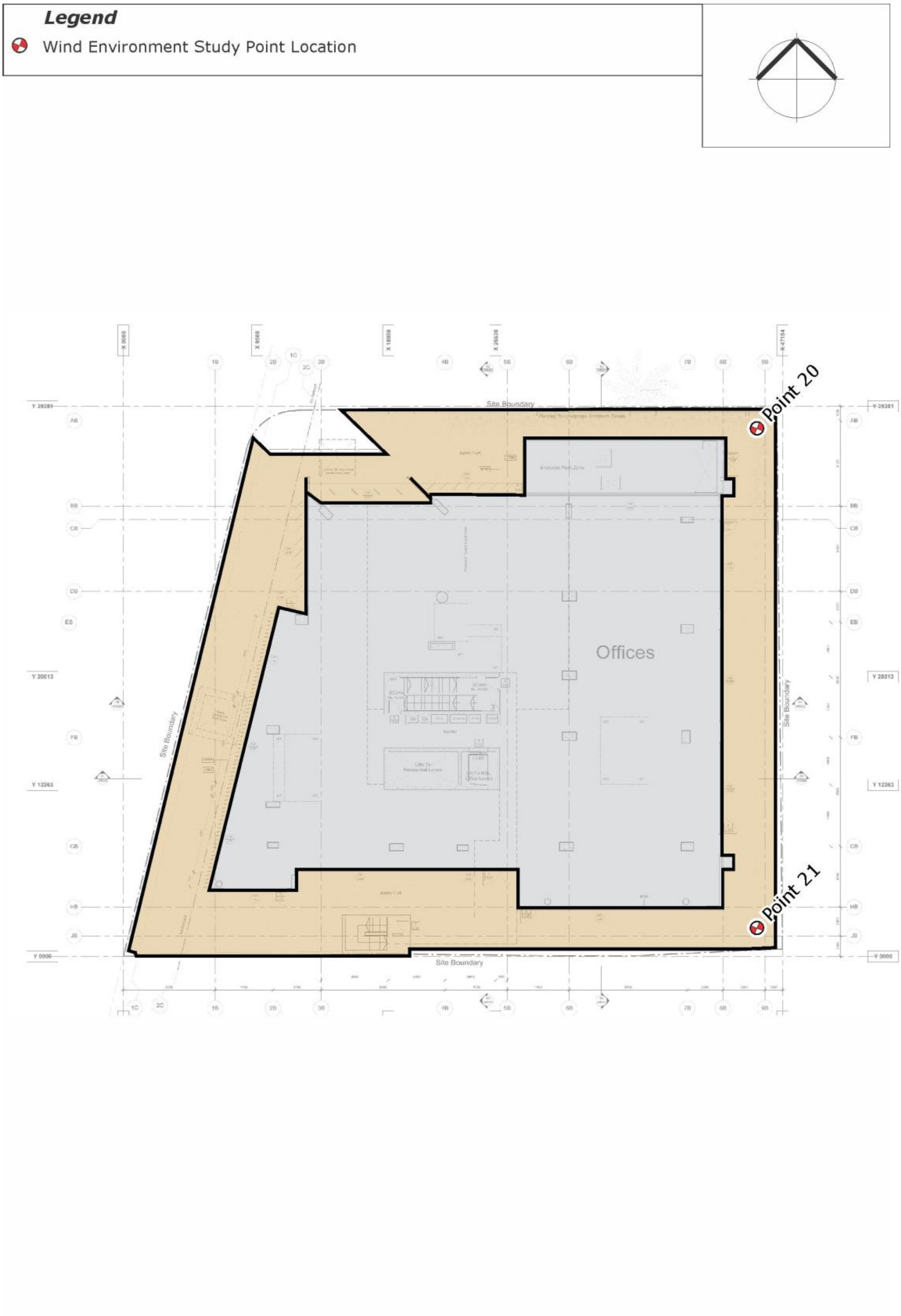

Figure 7a: Study Point Locations – 157 Redfern Street Level 4

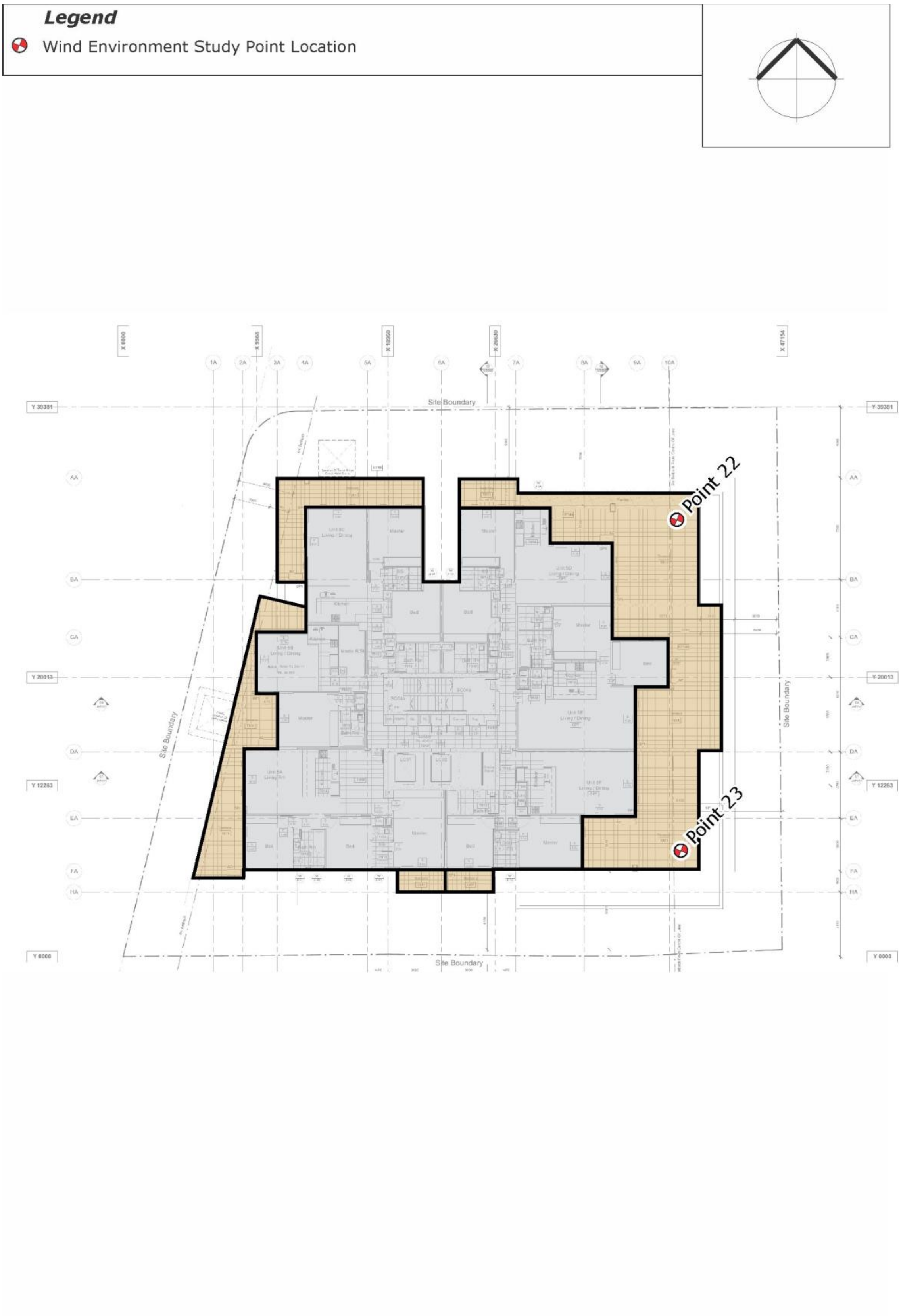

Figure 7b: Study Point Locations – 157 Redfern Street Level 5

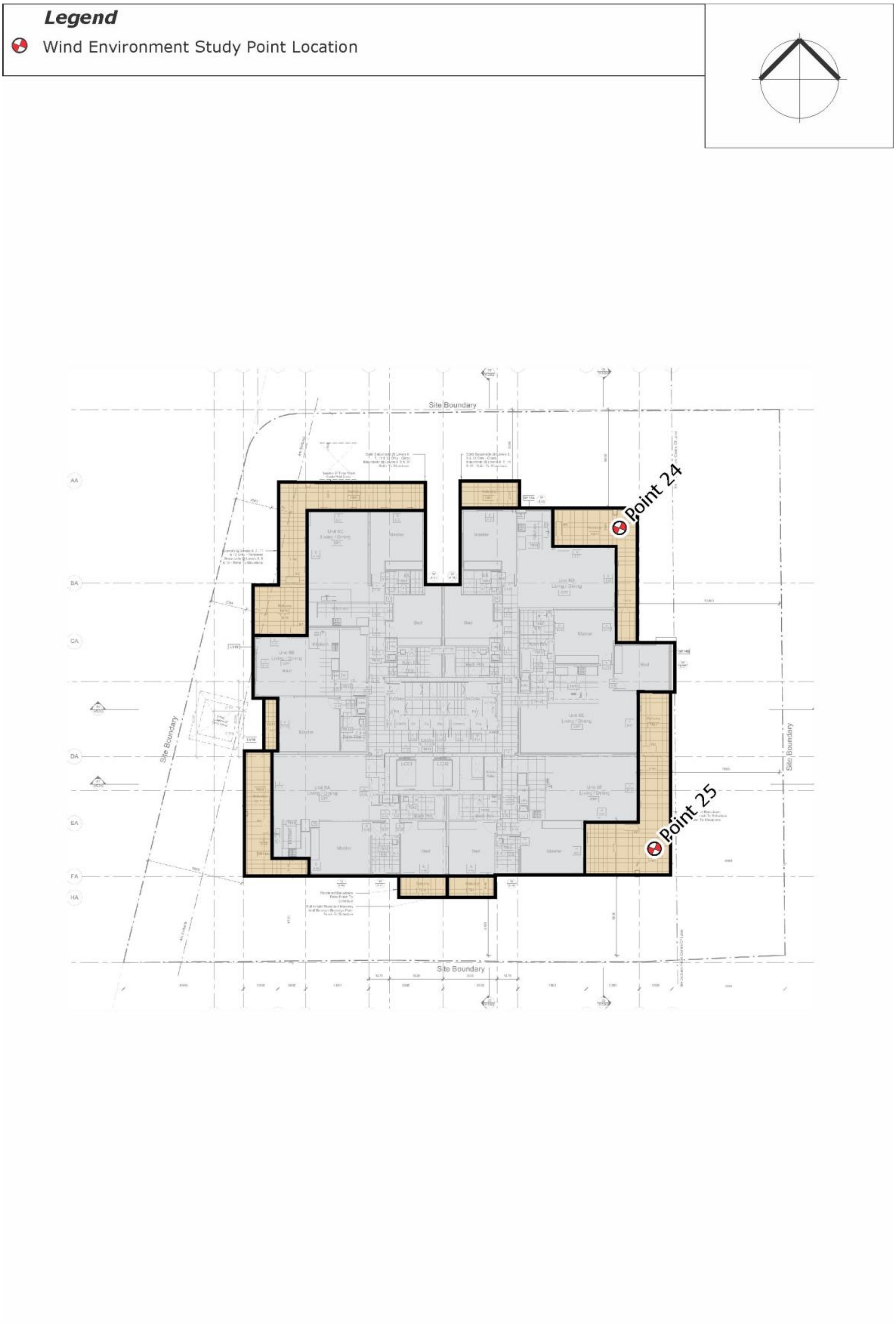

Figure 7c: Study Point Locations – 157 Redfern Street Level 6

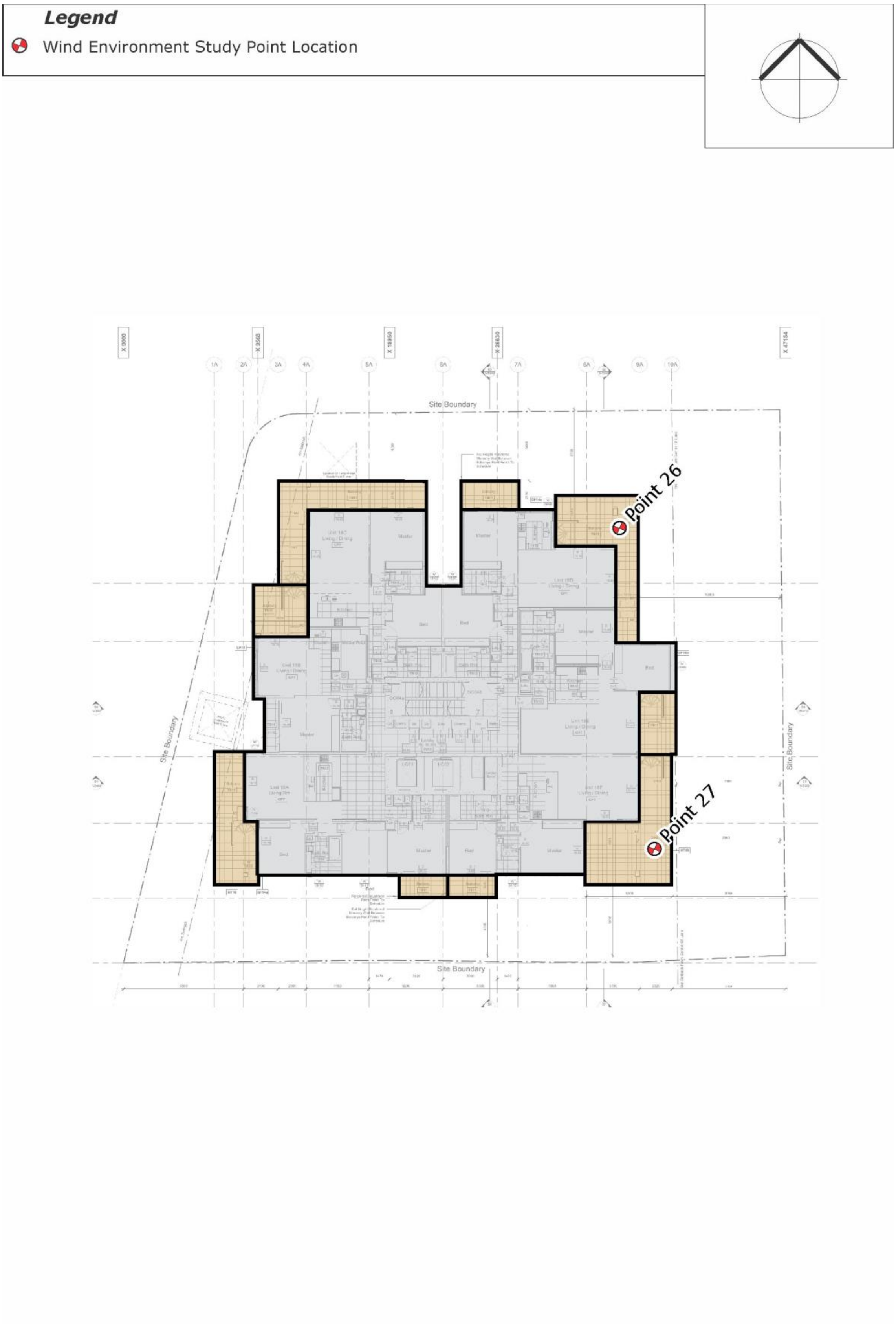

Figure 7d: Study Point Locations – 157 Redfern Street Level 18

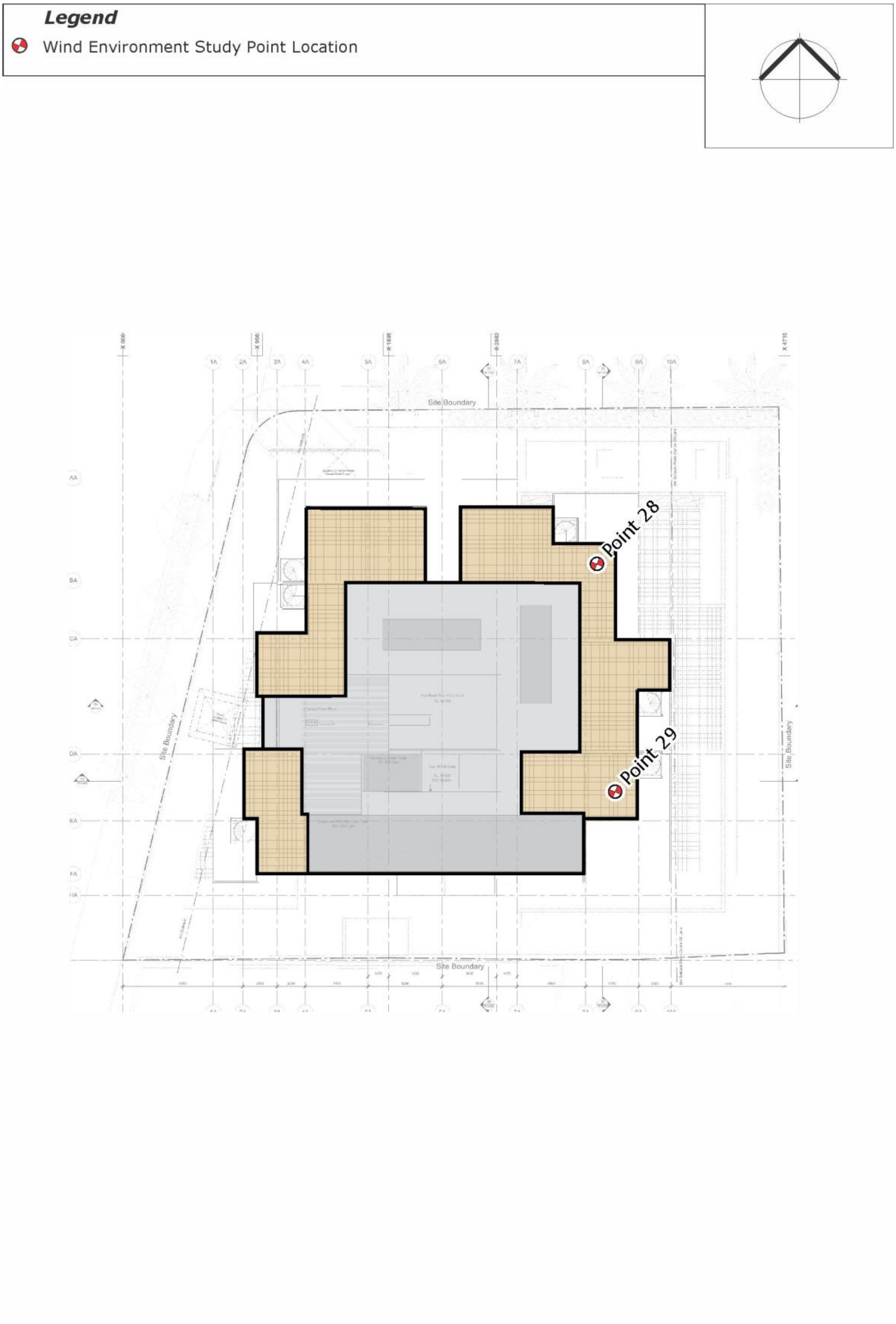

Figure 7e: Study Point Locations – 157 Redfern Street Roof

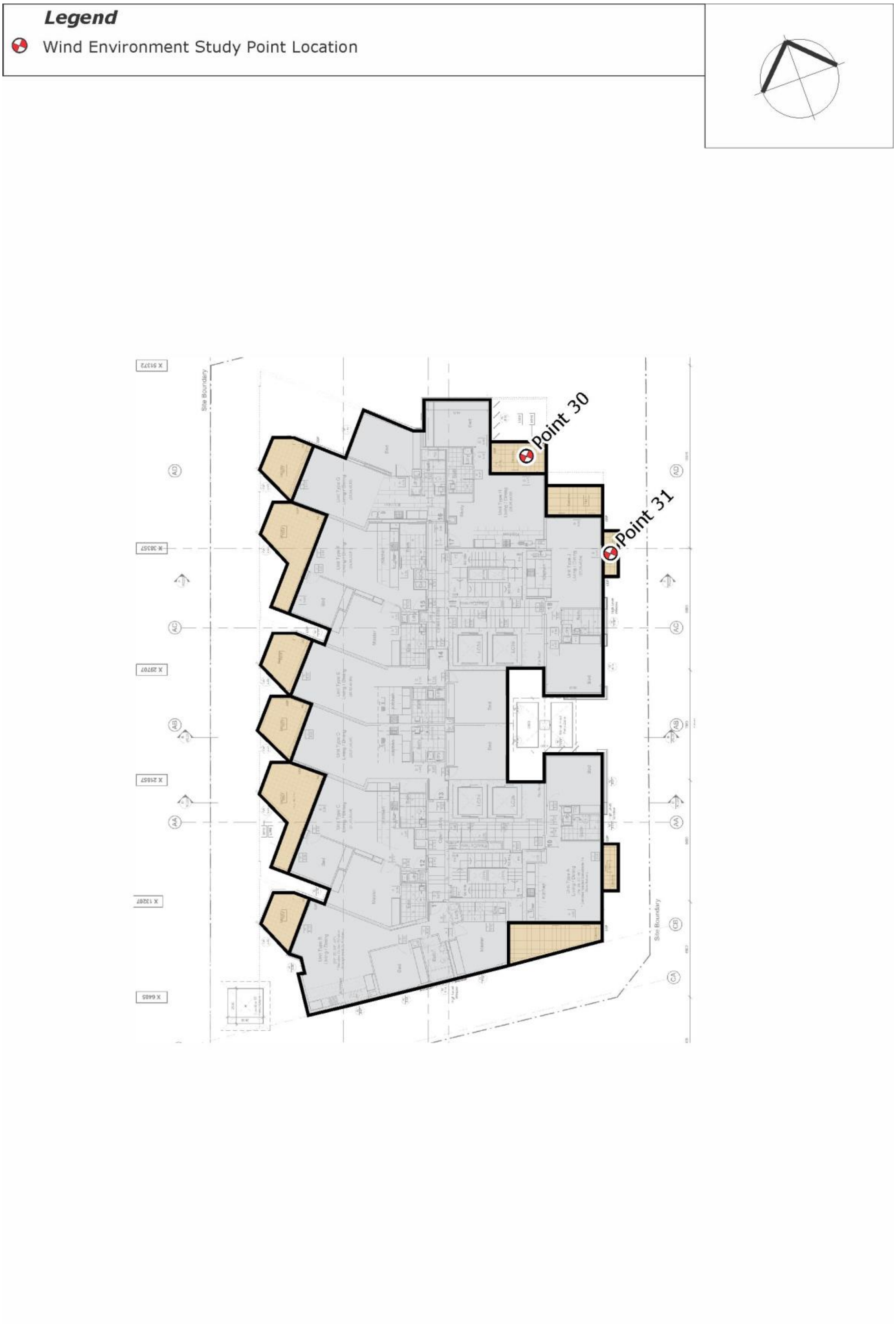

Figure 7f: Study Point Locations – 7-9 Gibbons Street Level 5

Legend

Wind Environment Study Point Location

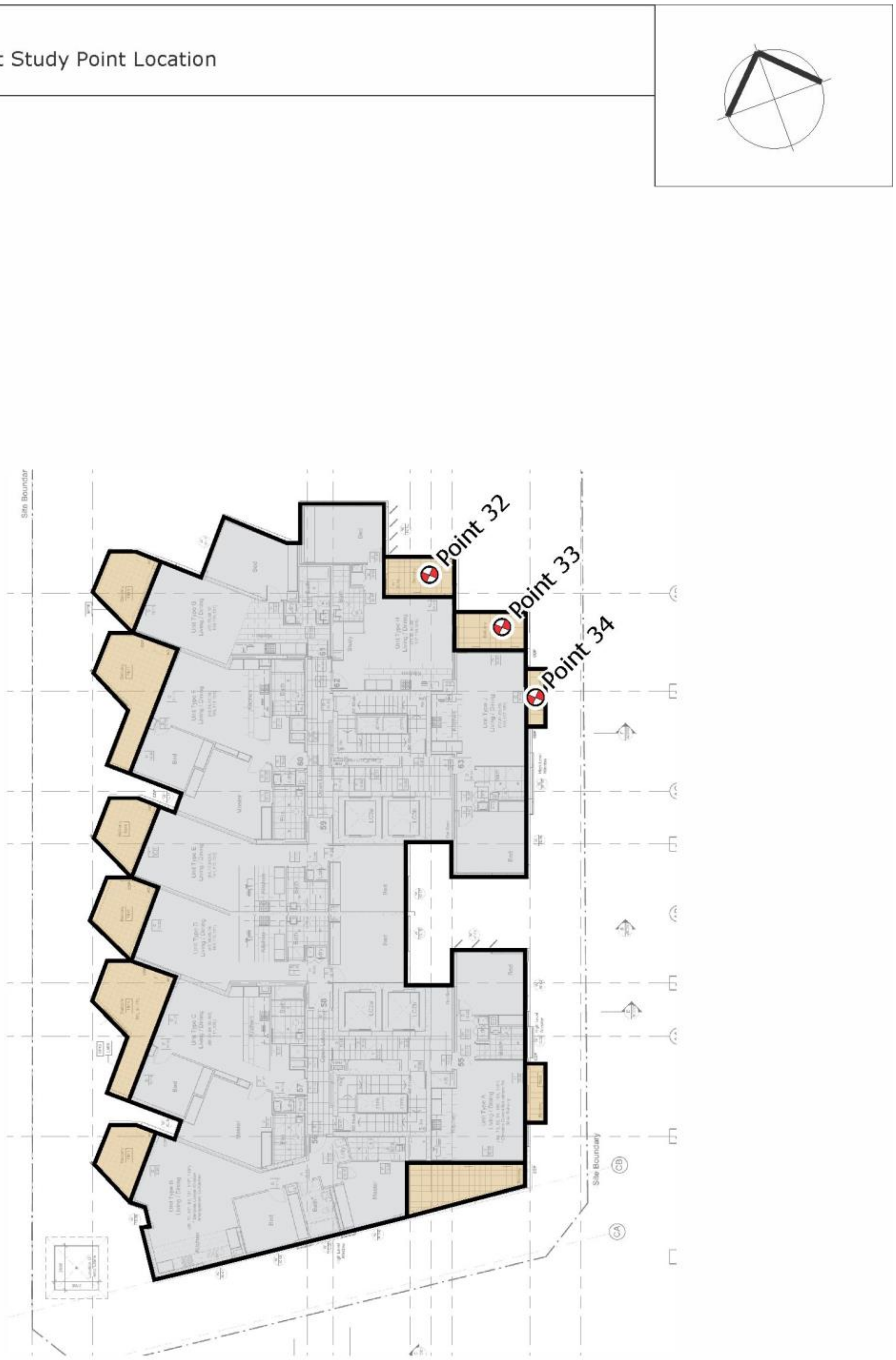

Figure 7g: Study Point Locations – 7-9 Gibbons Street Level 17

Legend

Wind Environment Study Point Location

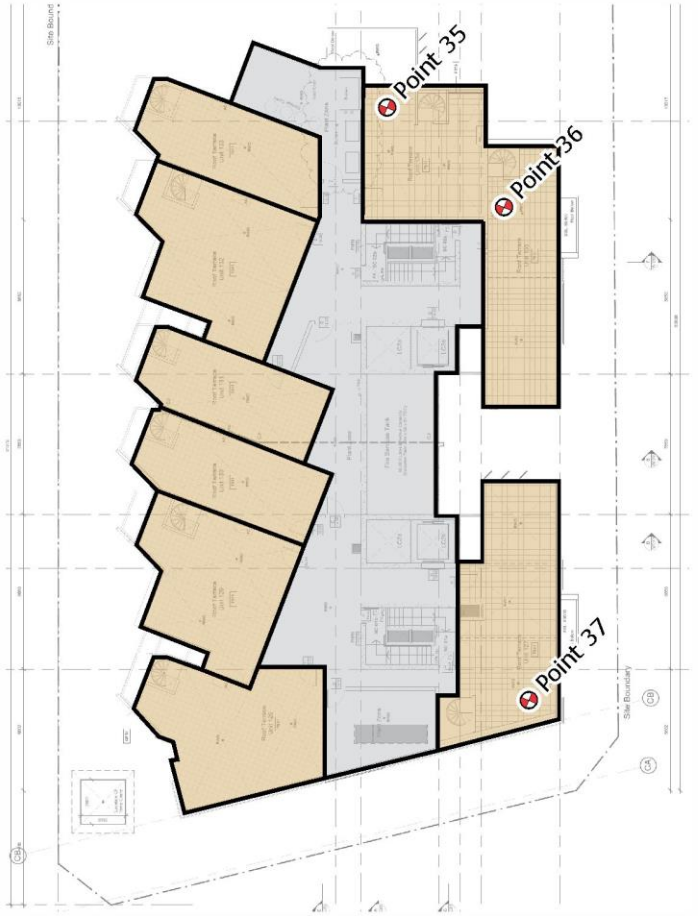

Figure 7h: Study Point Locations – 7-9 Gibbons Street Roof

6 RESULTS AND DISCUSSION

The model of the proposed development 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. If the results of the study indicate that any area is exposed to strong winds, in-principal treatments have been recommended. These treatments could be in the form of vegetation that is already proposed for the site, and/or additional trees, shrubs, screens, awnings, etc. Note also that the existing site conditions have also been tested for the pedestrian footpaths around the site to determine the impact that the proposed development.

The results for all study points locations are presented in the form of directional plots in Appendix A, and are summarised in Table 9 below. The wind speed criteria that the wind conditions should achieve are also listed in Table 9 for each study point location, along with the performance relative to the existing site conditions (where relevant).

The results of the study indicate the measured wind conditions within the majority of the trafficable outdoor areas within the development satisfy their applicable wind comfort criterion, with the exclusion of Point 09 and Point 16. Two options for in-principal treatments have been recommended for these locations, summarised as follows:

Ground Floor Option 1:

- Extend the proposed Level 1 awning above the existing laneway along the north-western boundary of the site, so that it meets with the Level 1 soffit above the through-site link and the southern podium section.

Ground Floor Option 2:

- Extend the proposed Level 1 awning above the existing laneway in line with the existing building aspect, so that it meets with the northern face of the southern podium section.
- Include an impermeable screen extending from the Level 1 awning to meet with the Level 2 slab above the entrance to the through-site link.

Level 1 Option 1:

- Two staggered impermeable baffle screens extending from the ground to the soffit in the barbeque area under the northern aspect of the tower.

Level 1 Option 2:

- Two impermeable baffle screens extending from the ground to the soffit in the barbeque area under the northern aspect of the tower, in an L-shaped configuration.

At Point 1 it is noted that the wind conditions marginally exceed the existing site conditions, however this is a localised increase and the conditions will still satisfy the criteria for pedestrian comfort and safety. Hence the wind conditions at this location are considered suitable for the intended use of that area.

Hence, with the inclusion of either Option 1 or Option 2 treatments to the final design, the results of this study indicate that wind conditions for all outdoor trafficable areas within and around the proposed development are expected to be acceptable for their intended uses.

Table 9: Results Summary

Study Point	Desired Criterion (m/s)		Treatment Necessary to Pass?	Better than or equivalent to existing conditions?	Description of Suggested Treatment
	Weekly GEM	Annual Peak			
Point 001	7.5	23.0	NO	NO	Refer to the discussion above.
Point 002	7.5	23.0	NO	YES	
Point 003	7.5	23.0	NO	YES	
Point 004	5.5	23.0	NO	N/A	
Point 005	7.5	23.0	NO	YES	
Point 006	7.5	23.0	NO	YES	
Point 007	7.5	23.0	NO	YES	
Point 008	7.5	23.0	NO	YES	
Point 009	7.5	23.0	YES	YES	See Figure 8a/8b.
Point 010	5.5	23.0	NO	N/A	
Point 011	7.5	23.0	NO	YES	
Point 012	7.5	23.0	NO	YES	
Point 013	5.5	23.0	NO	N/A	
Point 014	5.5	23.0	NO	N/A	
Point 015	5.5	23.0	NO	N/A	
Point 016	5.5	23.0	YES	N/A	See Figure 8c/8d.
Point 017	5.5	23.0	NO	N/A	
Point 018	5.5	23.0	NO	N/A	
Point 019	5.5	23.0	NO	N/A	

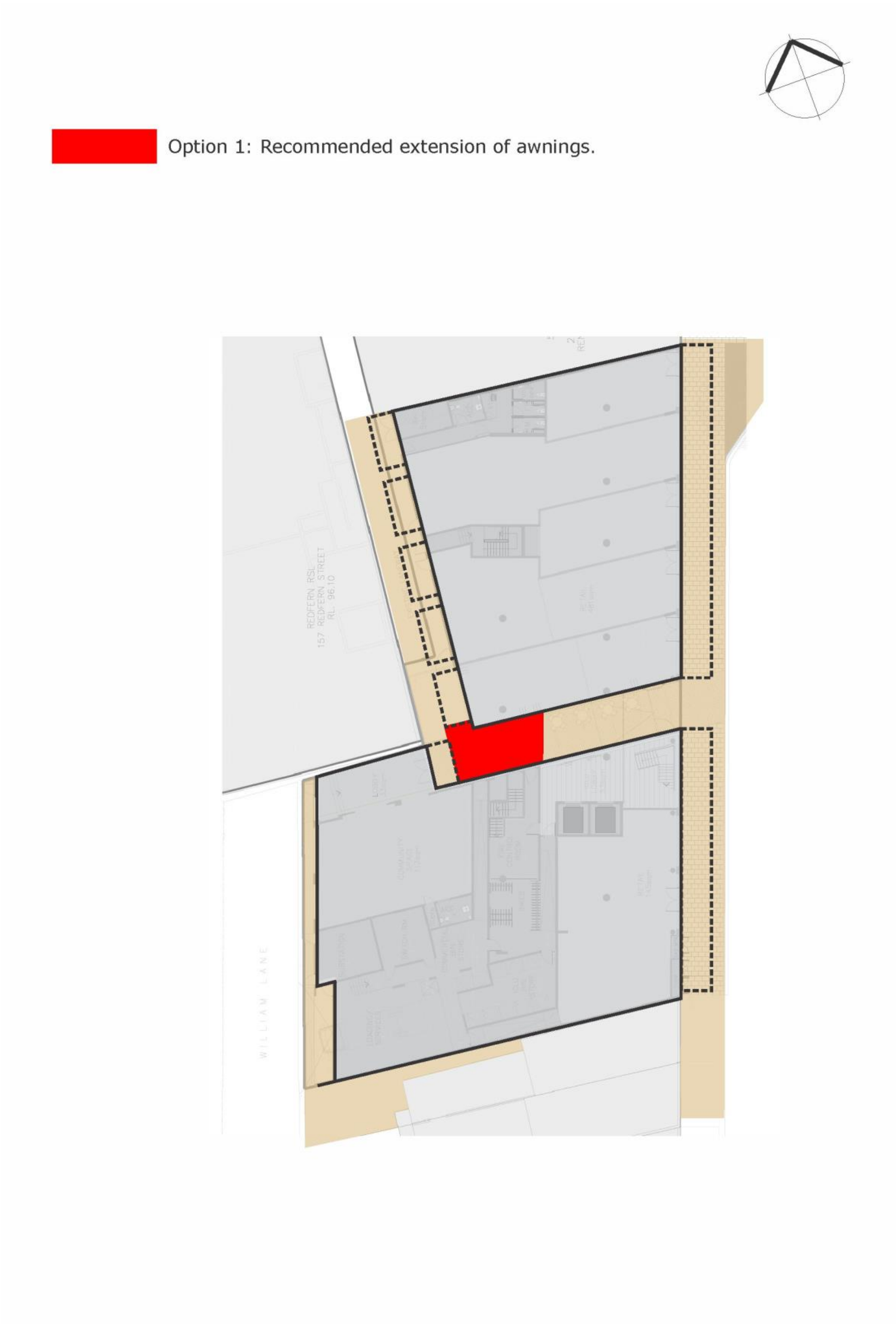

Figure 8a: Recommended Treatments – Ground Level, Option 1

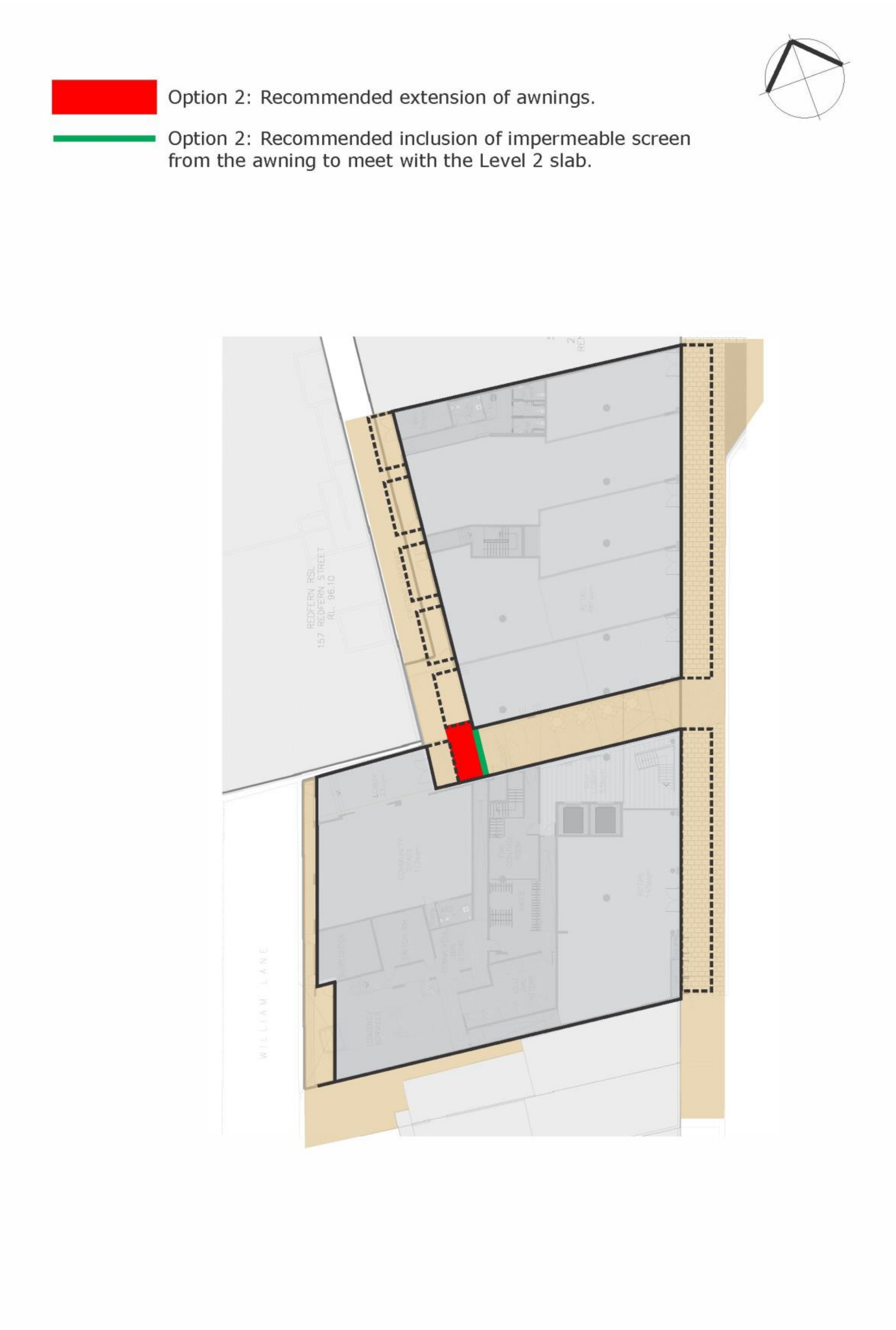

Figure 8b: Recommended Treatments – Ground Level, Option 2

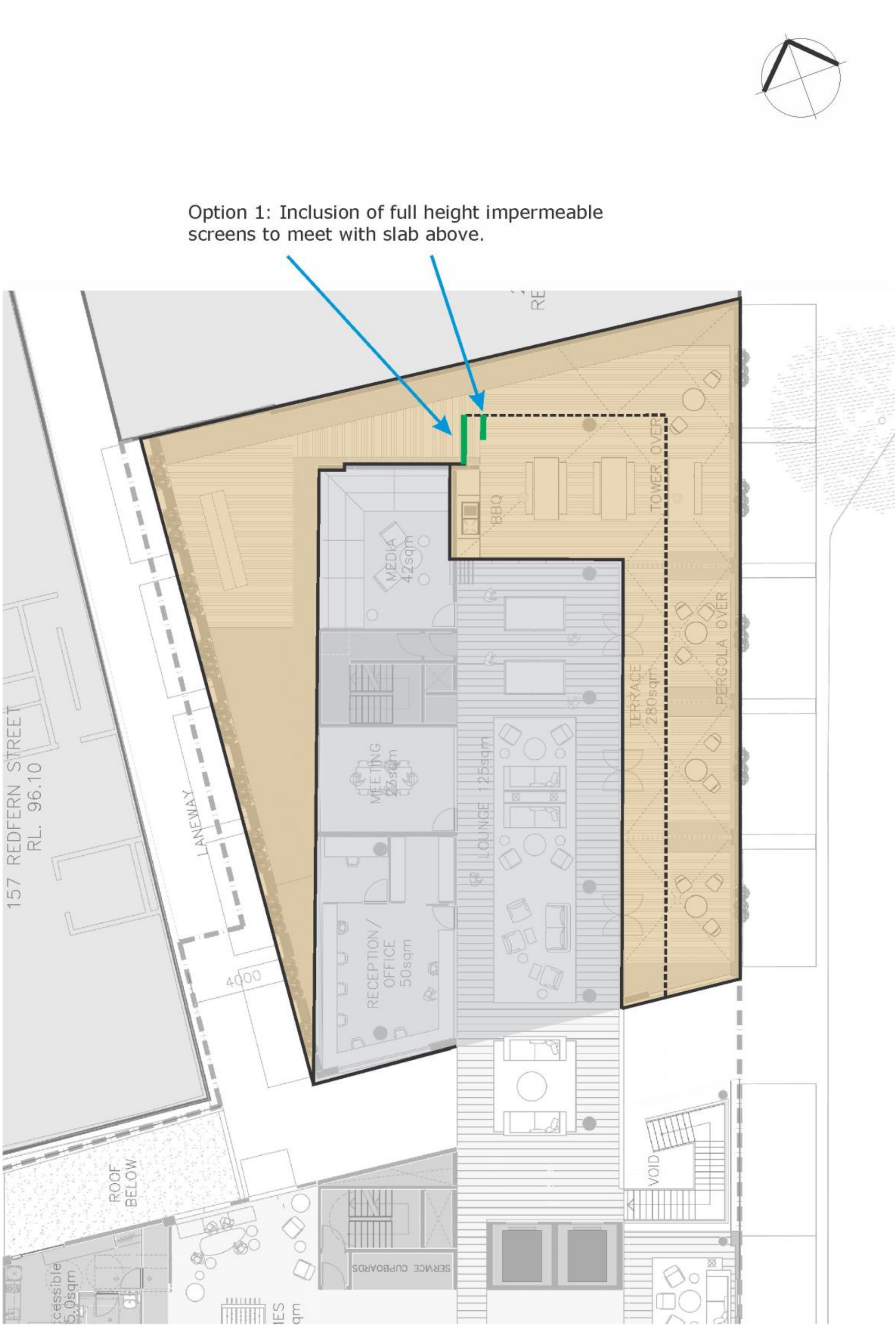

Figure 8c: Recommended Treatments – Level 1, Option 1

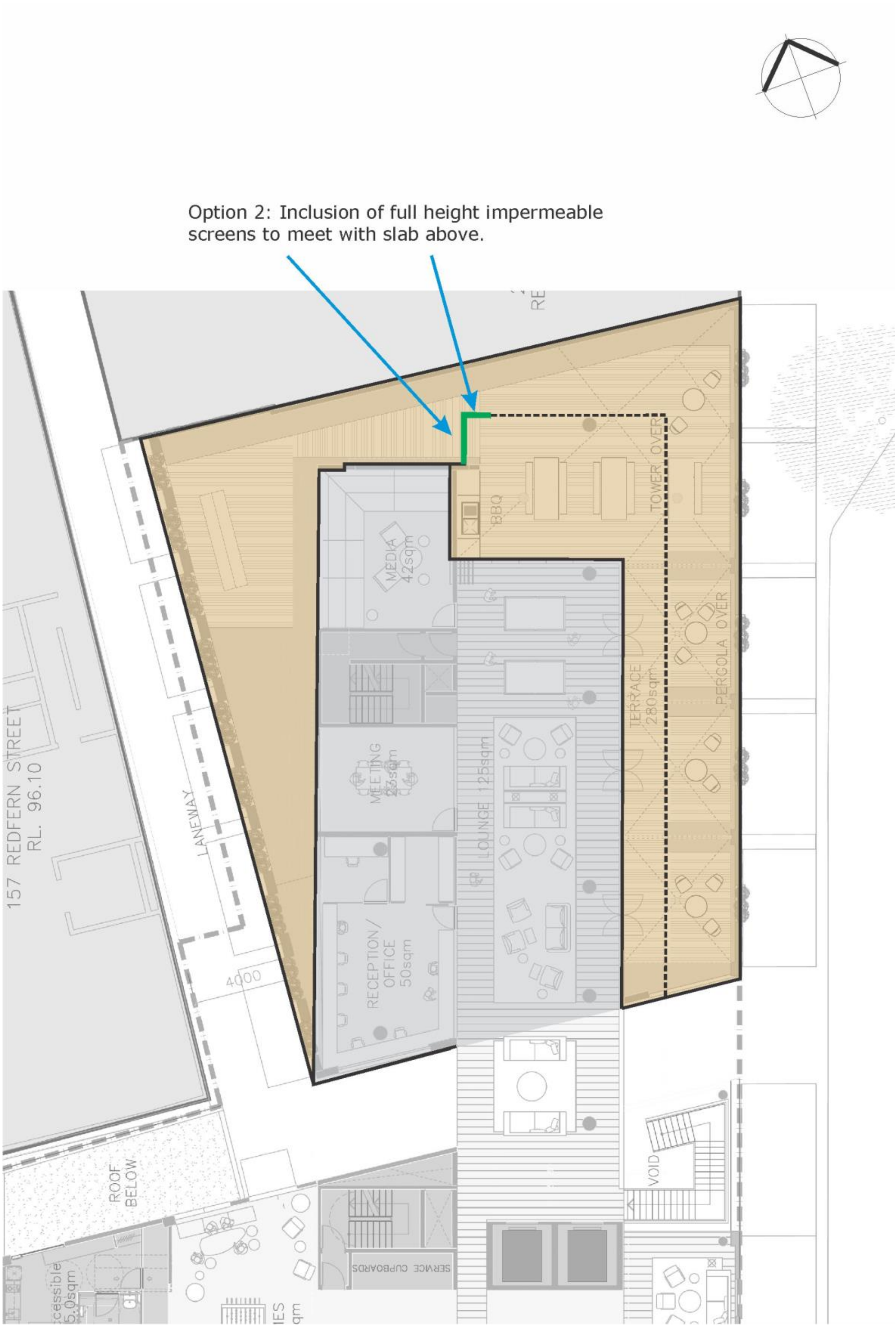

Figure 8d: Recommended Treatments – Level 1, Option 2

6.1 Impact of Proposed Development on Adjacent Apartments

The model of the proposed development was tested in the wind tunnel with detailed models of the existing developments at 157 Redfern Street and 7-9 Gibbons Street. Existing site conditions were also tested so that the impact of the proposed development on these adjacent developments could be assessed.

The results for all study point locations are presented in the form of directional plots in Appendix A, and are summarised in Table 10 below. The wind speed criteria that the wind conditions should achieve are also listed in Table 10 for each study point location, along with the performance relative to the existing site conditions. It should be noted that balcony areas are only required to meet the safety criteria for annual peak wind speeds.

The results of the study indicate the measured wind conditions for all of the potentially impacted trafficable outdoor areas within the adjacent developments satisfy their applicable wind comfort criterion and in most cases are better than the existing conditions.

Table 10: Impact on Adjacent Apartments Results Summary

Study Point	Desired Criterion (m/s)		Treatment Necessary to Pass?	Better than or equivalent to existing conditions?	Description of Suggested Treatment
	Weekly GEM	Annual Peak			
Point 020	7.5	23.0	NO	YES	
Point 021	7.5	23.0	NO	NO	
Point 022	7.5	23.0	NO	NO	
Point 023	7.5	23.0	NO	YES	
Point 024	N/A	23.0	NO	YES	
Point 025	N/A	23.0	NO	NO	
Point 026	N/A	23.0	NO	YES	
Point 027	N/A	23.0	NO	NO	
Point 028	N/A	23.0	NO	YES	
Point 029	N/A	23.0	NO	YES	
Point 030	N/A	23.0	NO	YES	
Point 031	N/A	23.0	NO	YES	
Point 032	N/A	23.0	NO	YES	
Point 033	N/A	23.0	NO	YES	
Point 034	N/A	23.0	NO	NO	
Point 035	N/A	23.0	NO	YES	
Point 036	N/A	23.0	NO	NO	
Point 037	N/A	23.0	NO	YES	

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APPENDIX A - DIRECTIONAL PLOTS OF THE WIND TUNNEL RESULTS

Measured Wind Speeds at Point 001

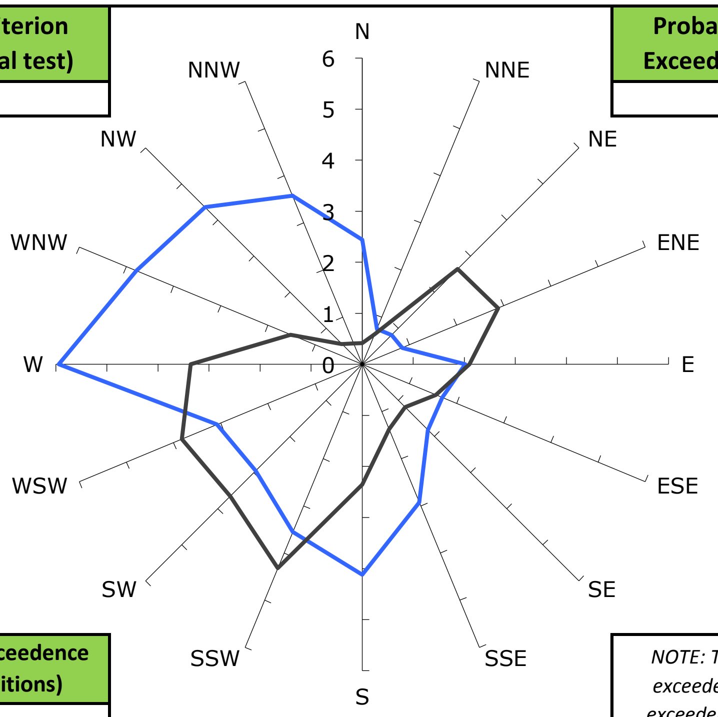
Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)

1%

Probability of Criterion Exceedence (final retest)

N/A



Desired Criterion

7.5m/s

Prob. of Criterion Exceedence (existing site conditions)

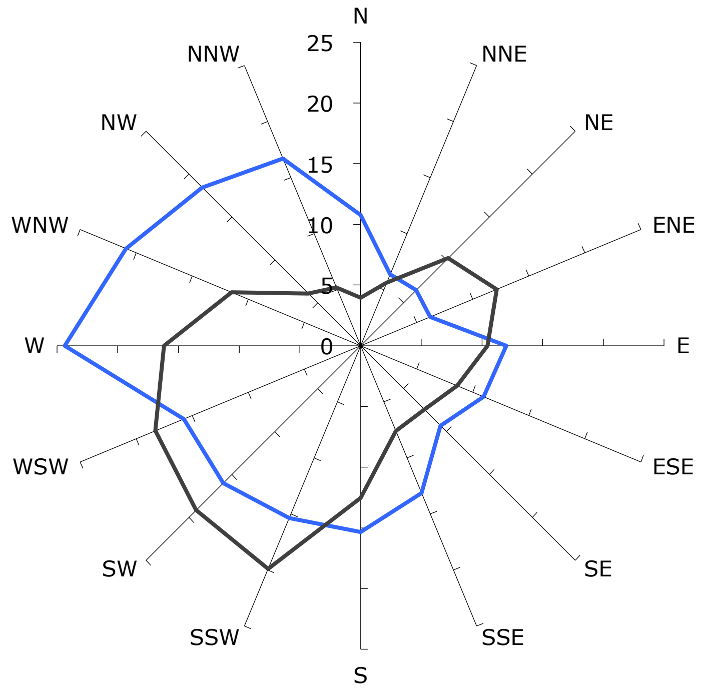
0%

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Gust (m/s)



Desired Criterion

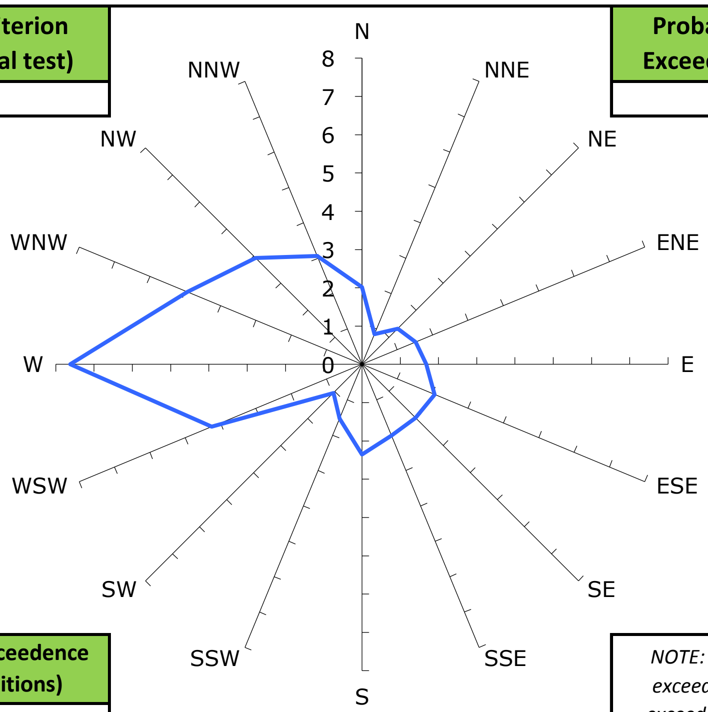
23m/s

Measured Wind Speeds at Point 002

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
1%

Probability of Criterion Exceedence (final retest)
N/A



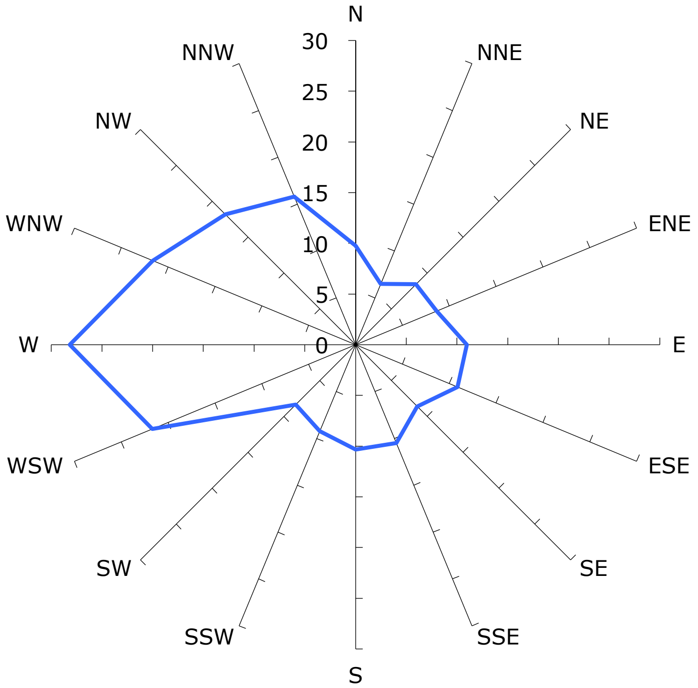
Desired Criterion
7.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



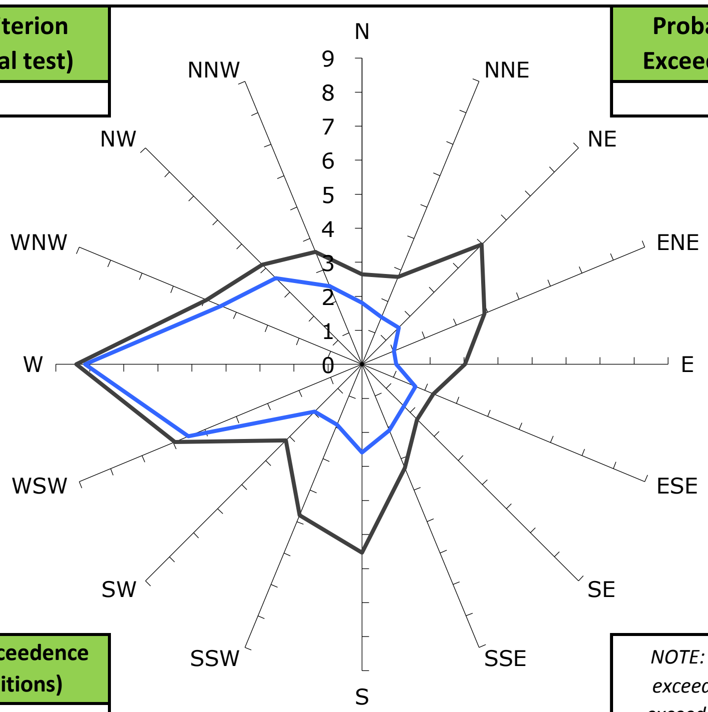
Desired Criterion
23m/s

Measured Wind Speeds at Point 003

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
1%

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
2%

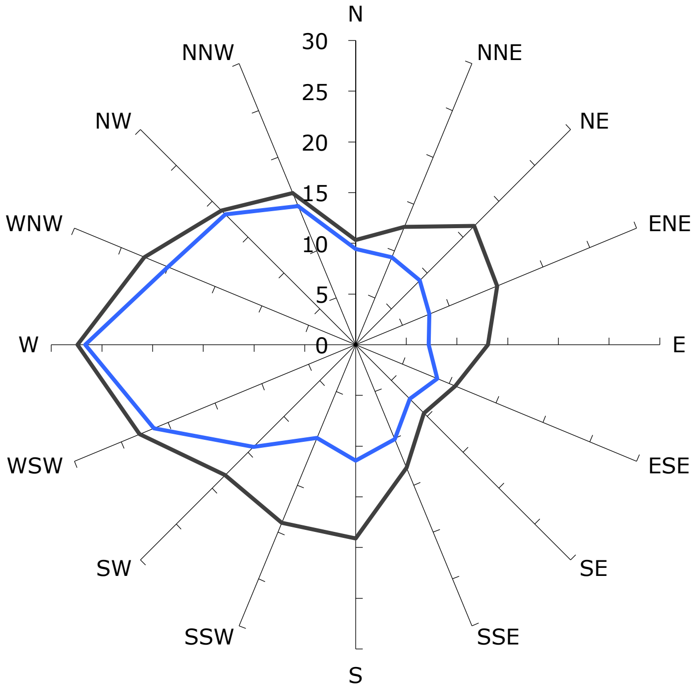
Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Gust (m/s)

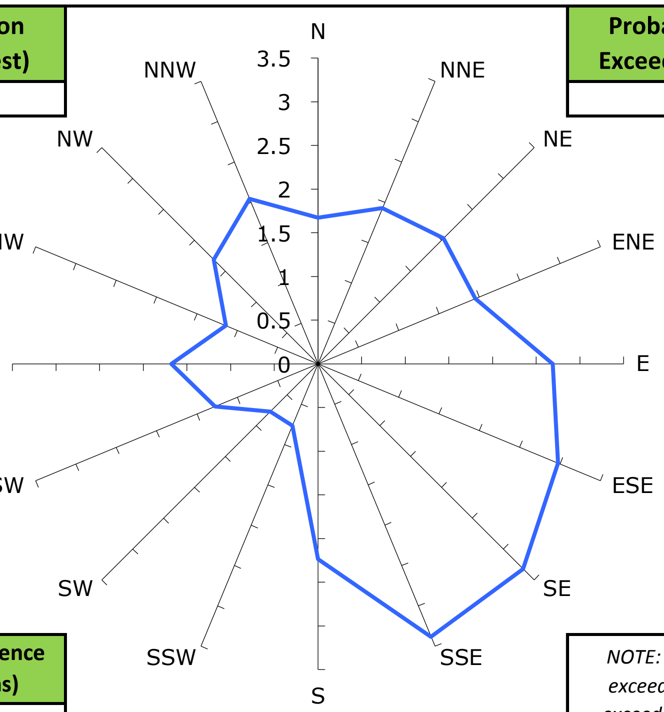


Desired Criterion
23m/s

Measured Wind Speeds at Point 004

Weekly Maximum GEM (m/s)

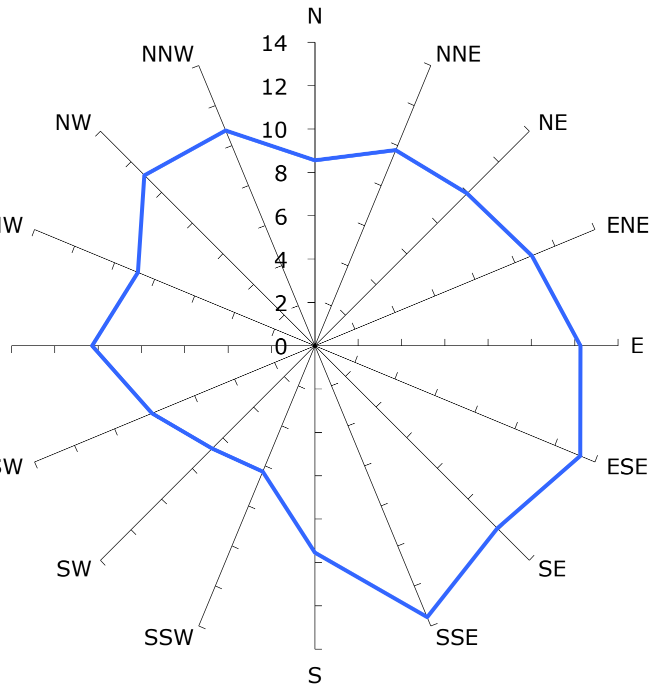
Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)	Prob. of Criterion Exceedence (existing site conditions)	Desired Criterion
0%	N/A	N/A	5.5m/s



NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



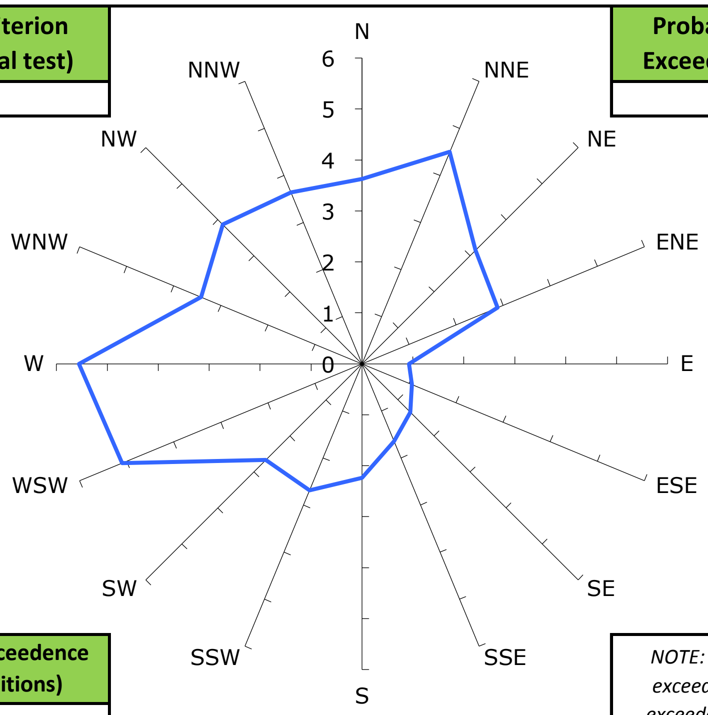
Desired Criterion
23m/s

Measured Wind Speeds at Point 005

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%

Probability of Criterion Exceedence (final retest)
N/A



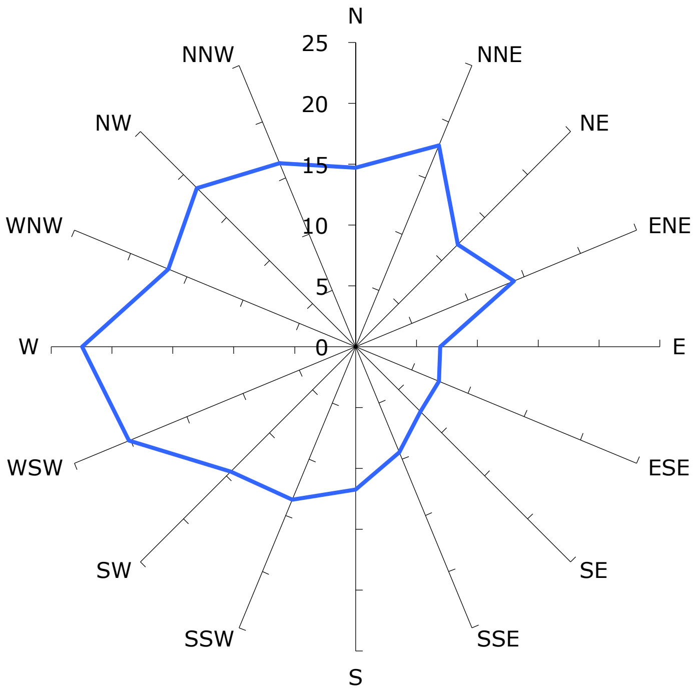
Prob. of Criterion Exceedence (existing site conditions)
N/A

Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



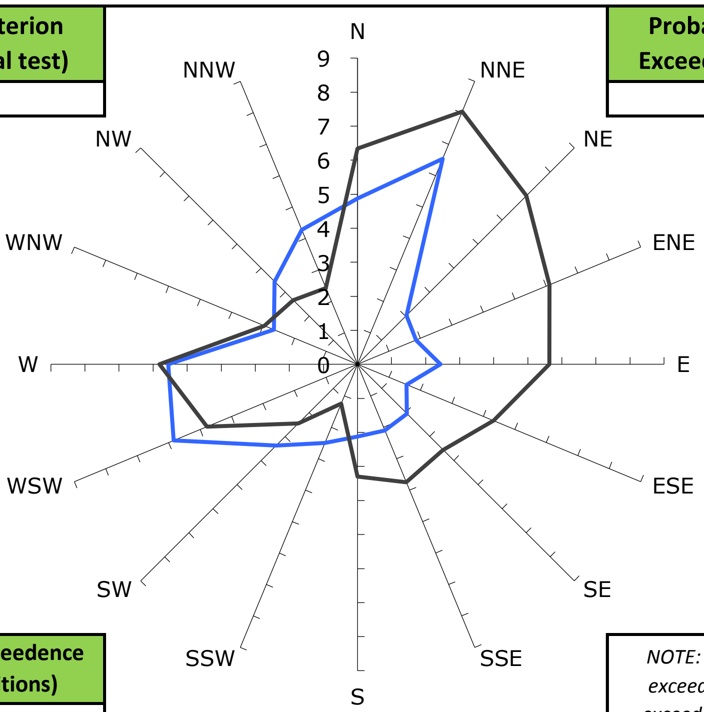
Desired Criterion
23m/s

Measured Wind Speeds at Point 006

Probability of Criterion Exceedence (initial test)
1%

Probability of Criterion Exceedence (final retest)
N/A

Weekly Maximum GEM (m/s)



Prob. of Criterion Exceedence (existing site conditions)
5%

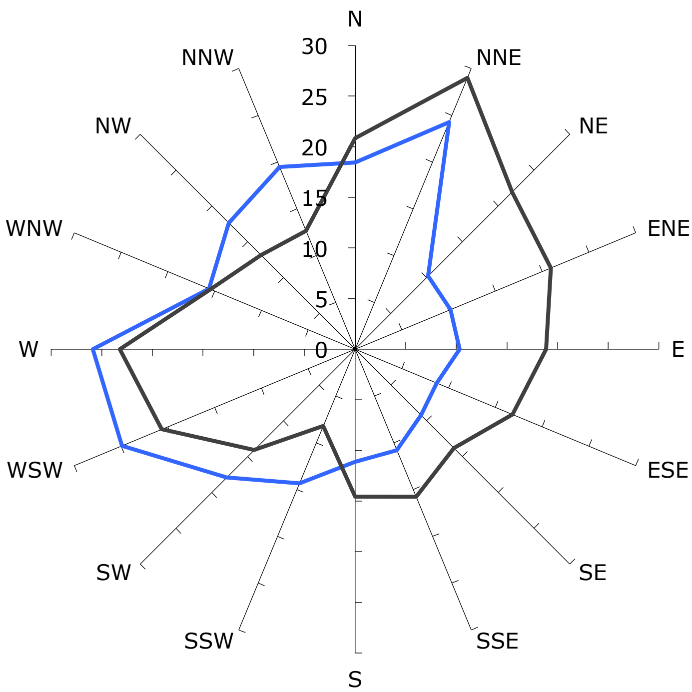
Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Gust (m/s)

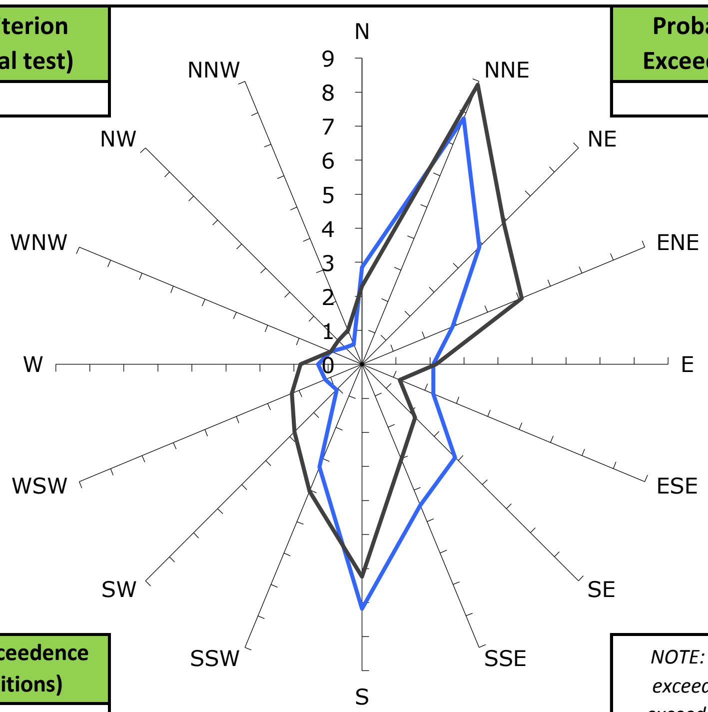


Desired Criterion
23m/s

Measured Wind Speeds at Point 007

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
3%



Probability of Criterion Exceedence (final retest)
N/A

Desired Criterion
7.5m/s

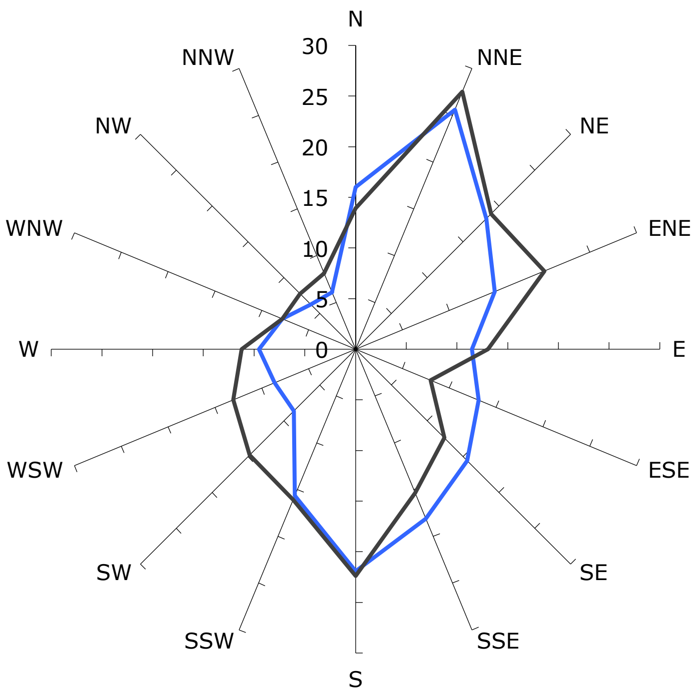
Prob. of Criterion Exceedence (existing site conditions)
3%

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Maximum Gust (m/s)



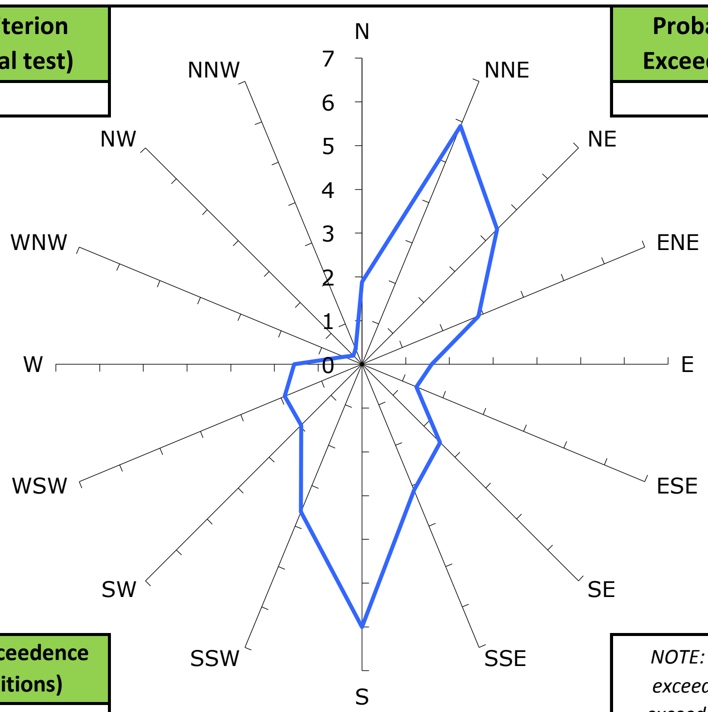
Desired Criterion
23m/s

Measured Wind Speeds at Point 008

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%

Probability of Criterion Exceedence (final retest)
N/A



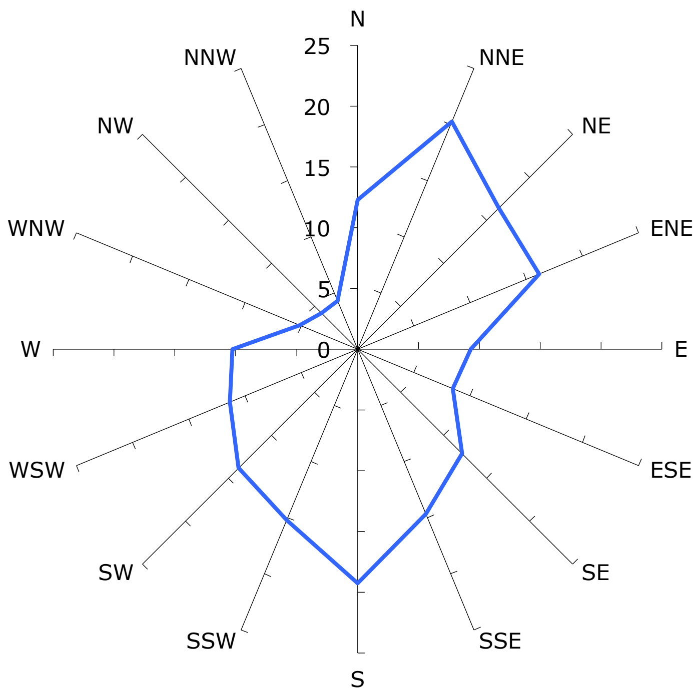
Prob. of Criterion Exceedence (existing site conditions)
N/A

Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



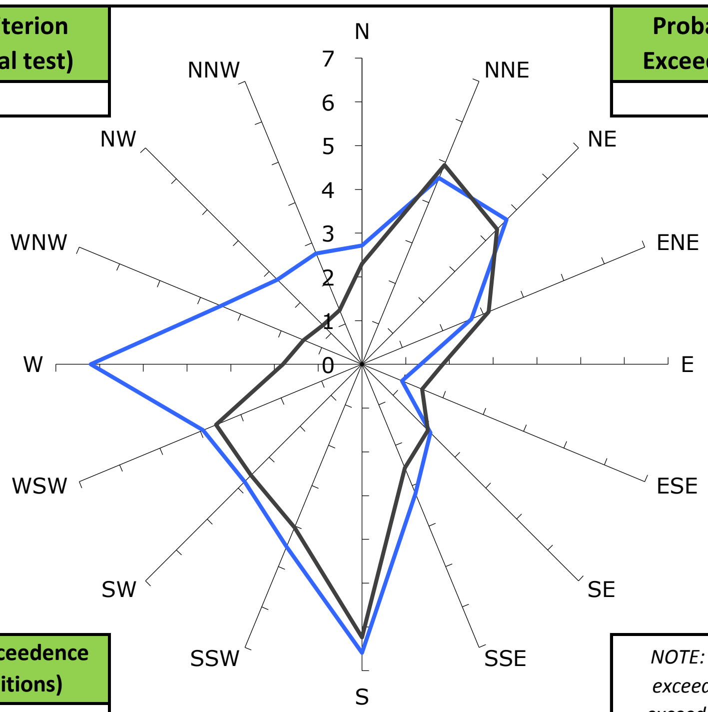
Desired Criterion
23m/s

Measured Wind Speeds at Point 009

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
1%

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
0%

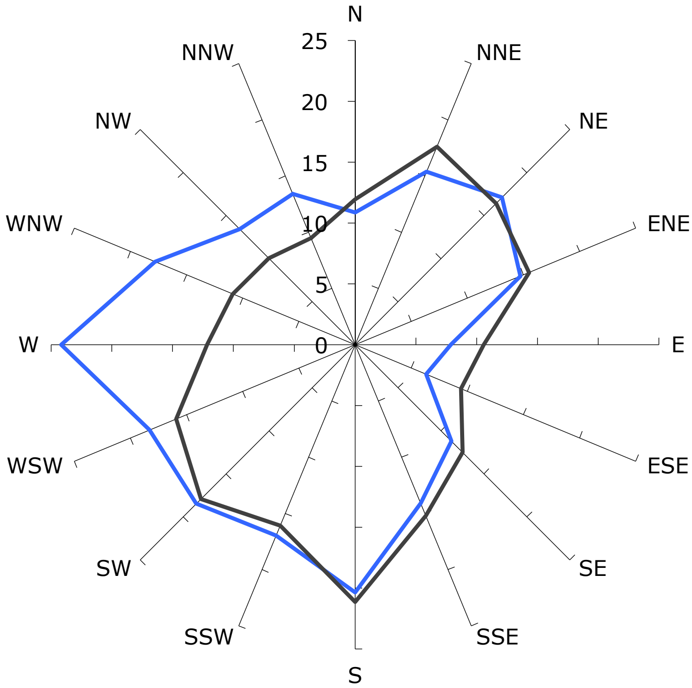
Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Gust (m/s)



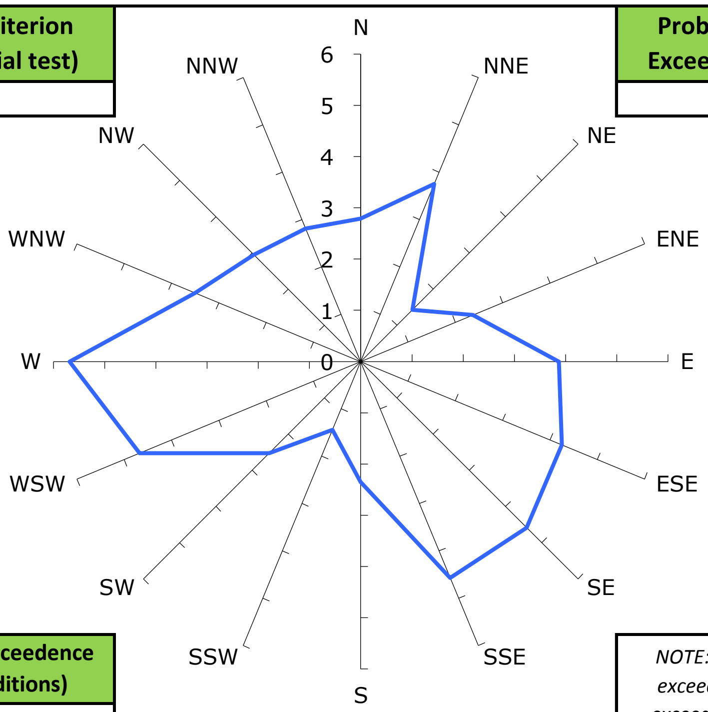
Desired Criterion
23m/s

Measured Wind Speeds at Point 010

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
3%

Probability of Criterion Exceedence (final retest)
N/A



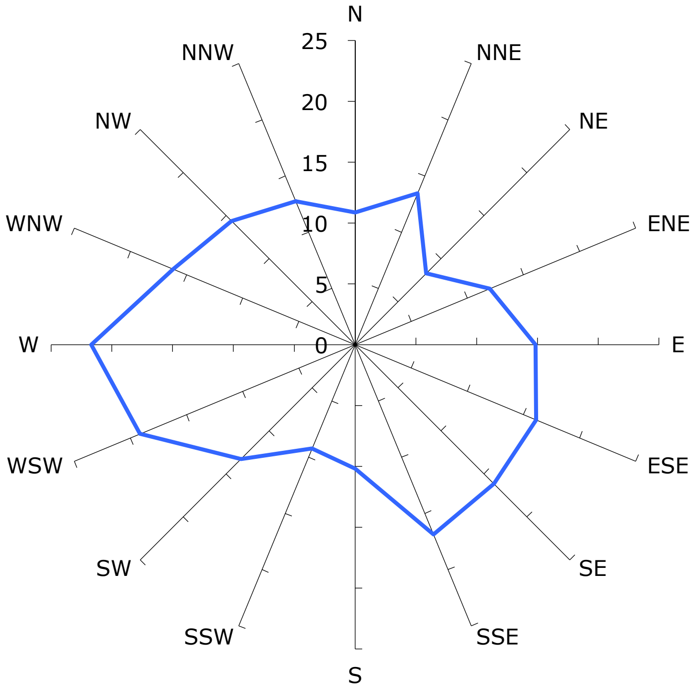
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)

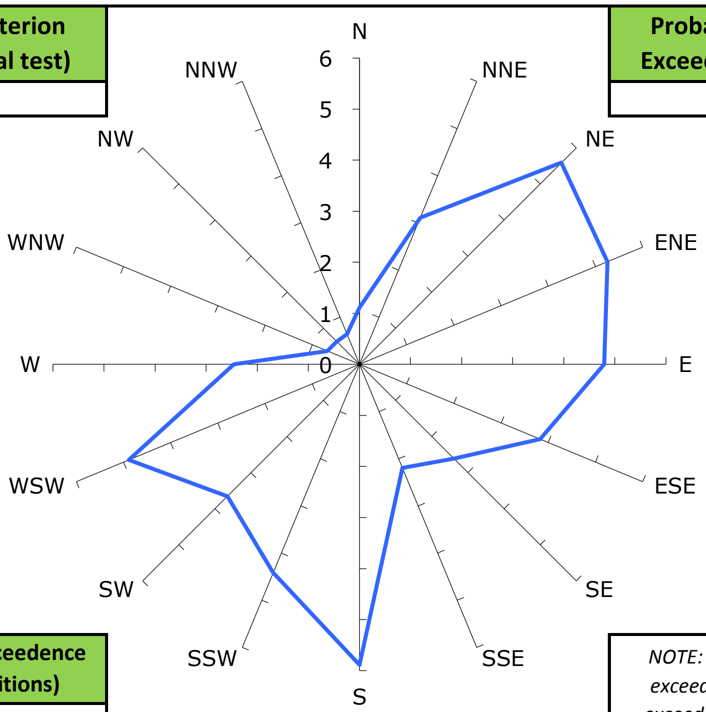


Desired Criterion
23m/s

Measured Wind Speeds at Point 011

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
1%



Probability of Criterion Exceedence (final retest)
N/A

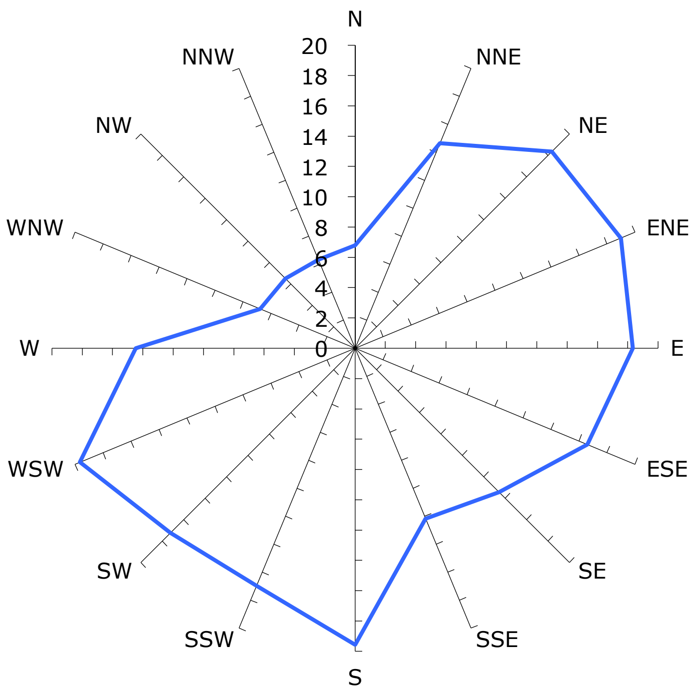
Prob. of Criterion Exceedence (existing site conditions)
N/A

Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)

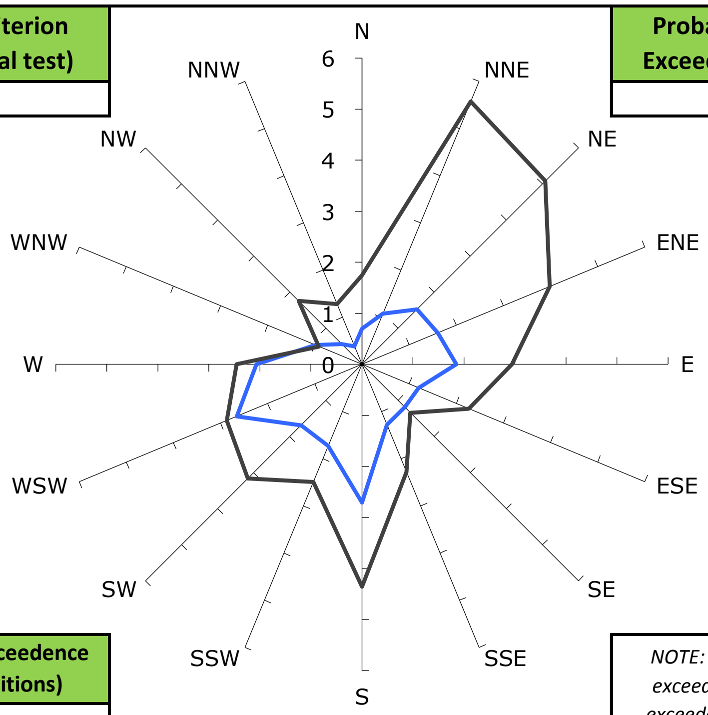


Desired Criterion
23m/s

Measured Wind Speeds at Point 012

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%



Probability of Criterion Exceedence (final retest)
N/A

Desired Criterion
7.5m/s

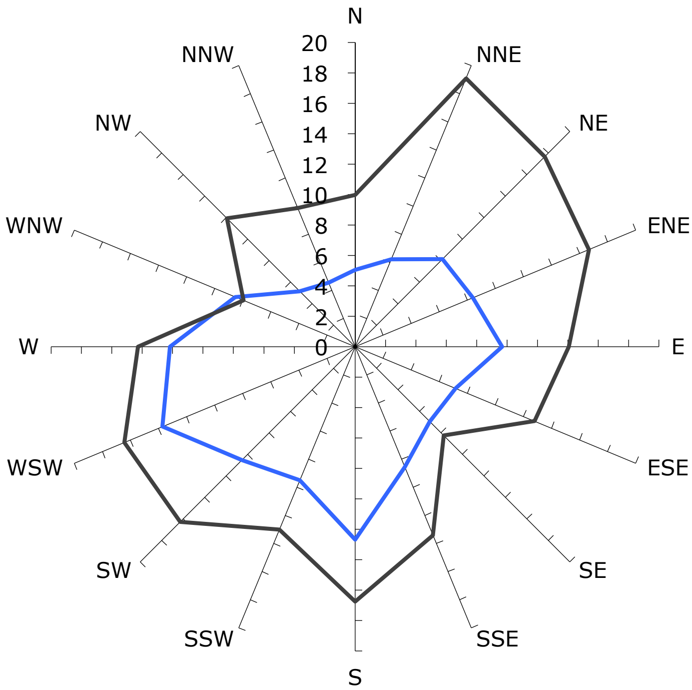
Prob. of Criterion Exceedence (existing site conditions)
0%

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing site conditions.

Annual Maximum Gust (m/s)

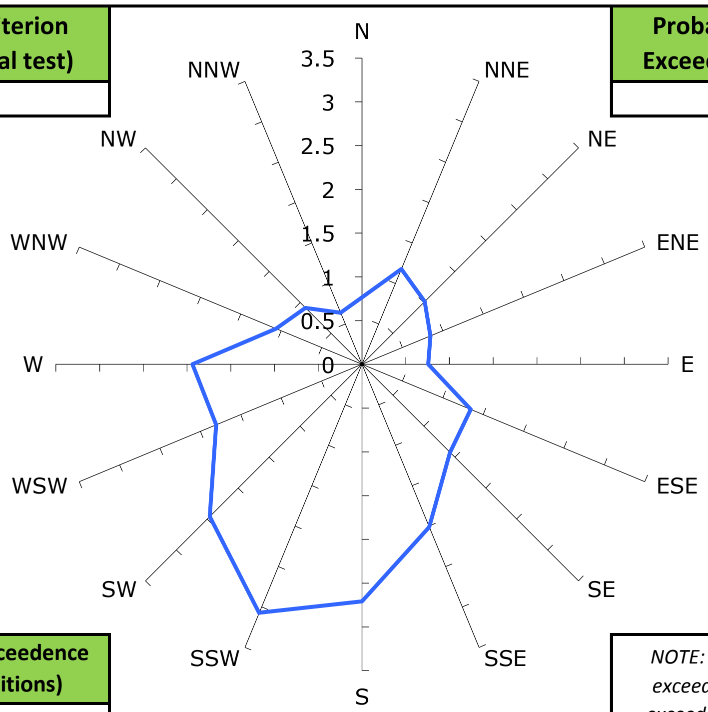


Desired Criterion
23m/s

Measured Wind Speeds at Point 013

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)
0%	N/A



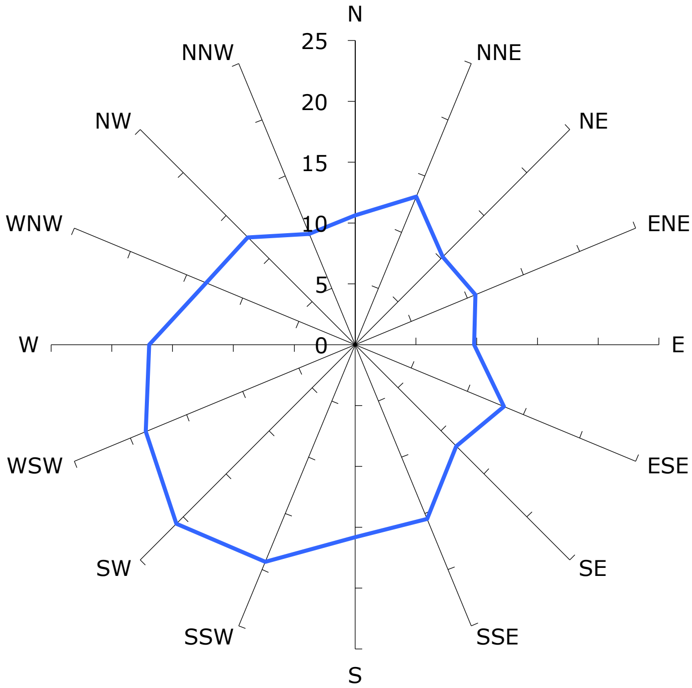
Prob. of Criterion Exceedence (existing site conditions)
N/A

Desired Criterion
5.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)

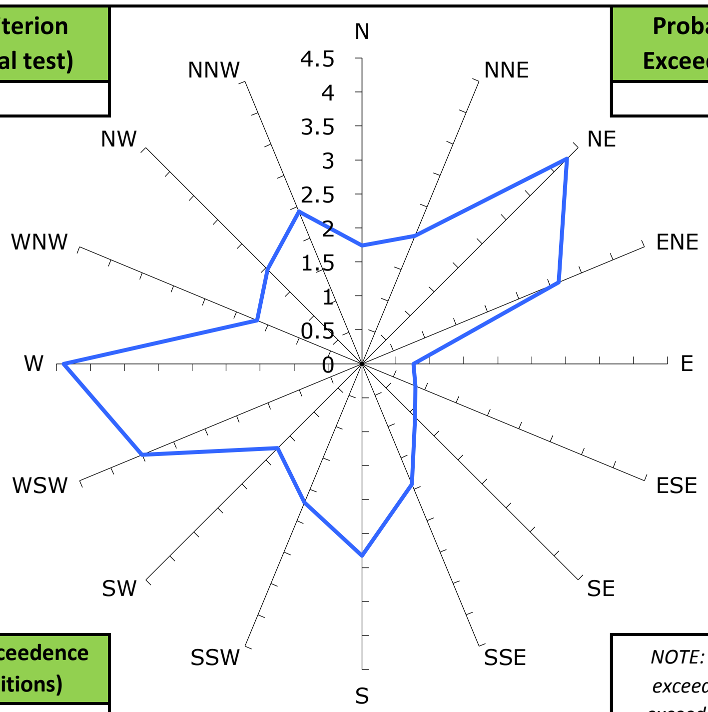


Desired Criterion
23m/s

Measured Wind Speeds at Point 014

Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)
0%	N/A

Weekly Maximum GEM (m/s)



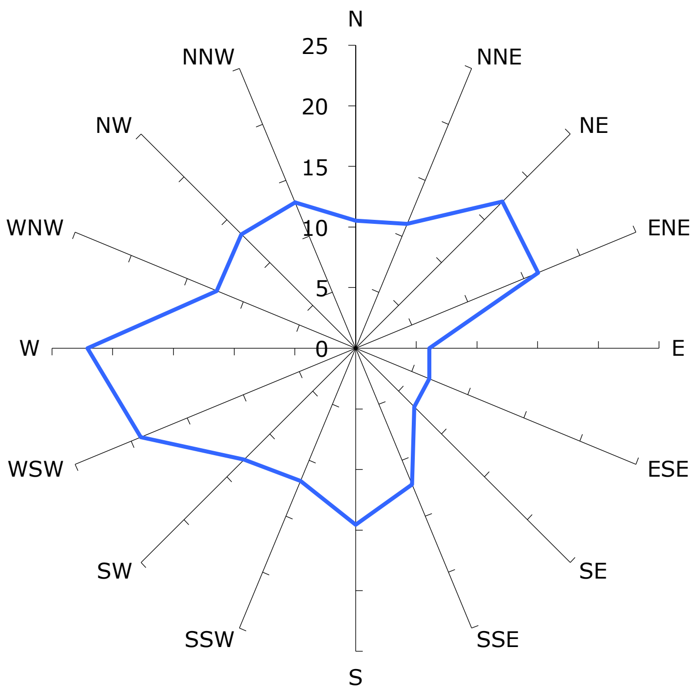
Prob. of Criterion Exceedence (existing site conditions)
N/A

Desired Criterion
5.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Maximum Gust (m/s)

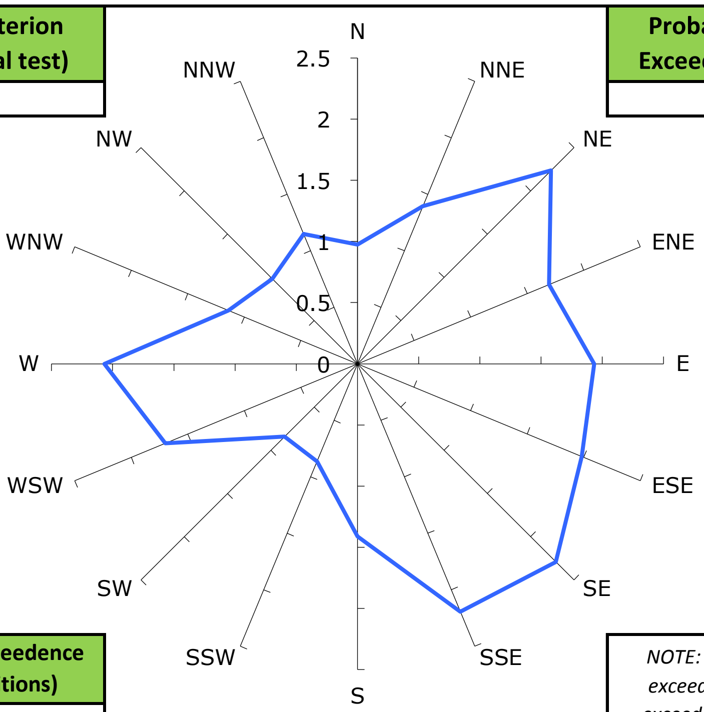


Desired Criterion
23m/s

Measured Wind Speeds at Point 015

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%



Probability of Criterion Exceedence (final retest)
N/A

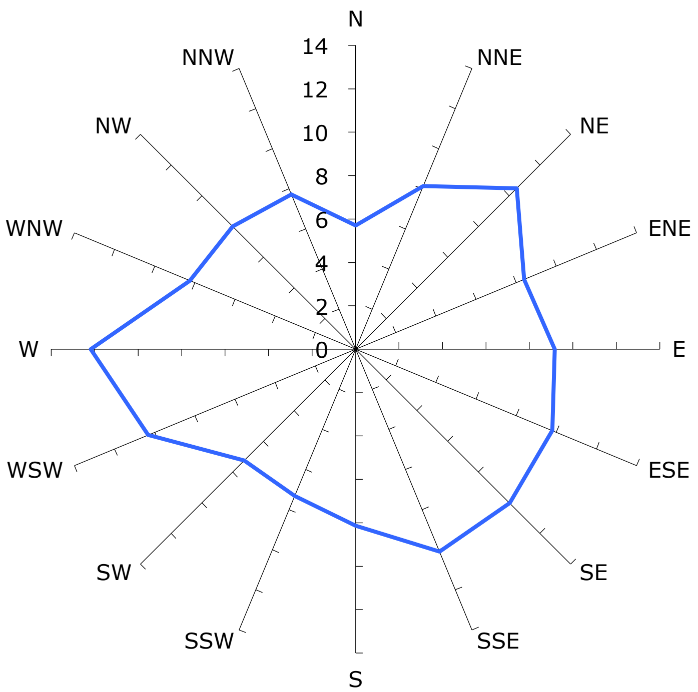
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)

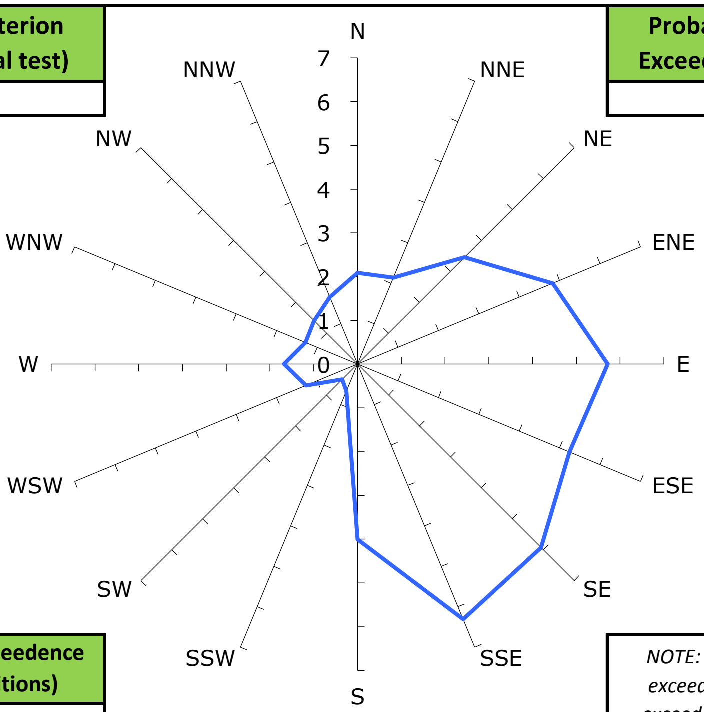


Desired Criterion
23m/s

Measured Wind Speeds at Point 016

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
7%



Probability of Criterion Exceedence (final retest)
N/A

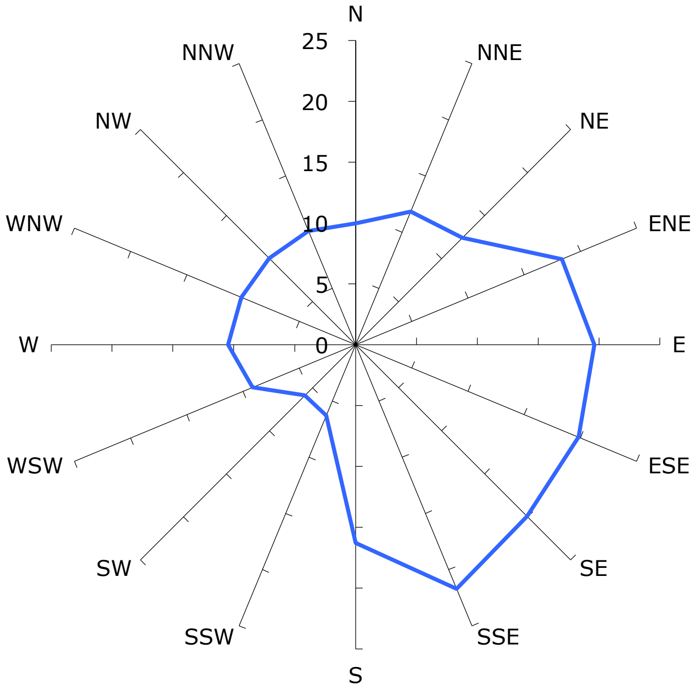
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Maximum Gust (m/s)



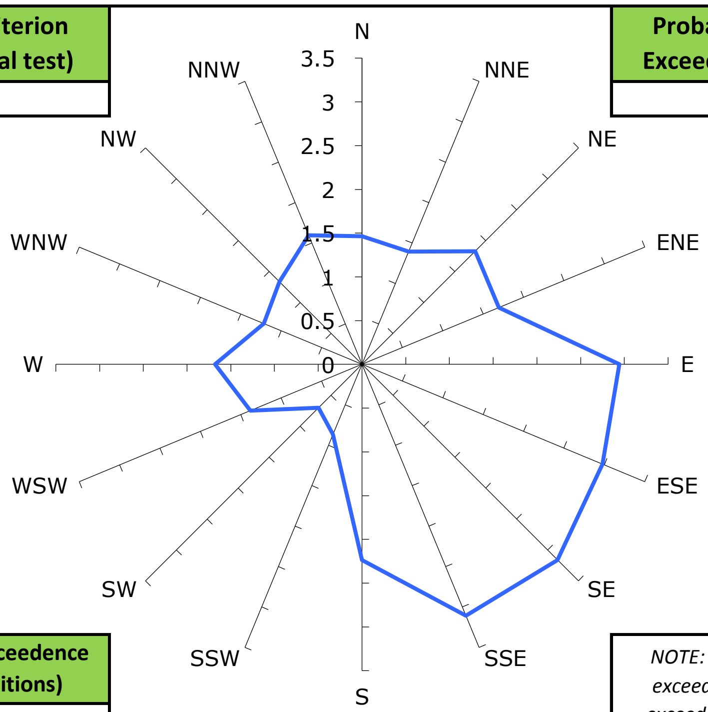
Desired Criterion
23m/s

Measured Wind Speeds at Point 017

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%

Probability of Criterion Exceedence (final retest)
N/A



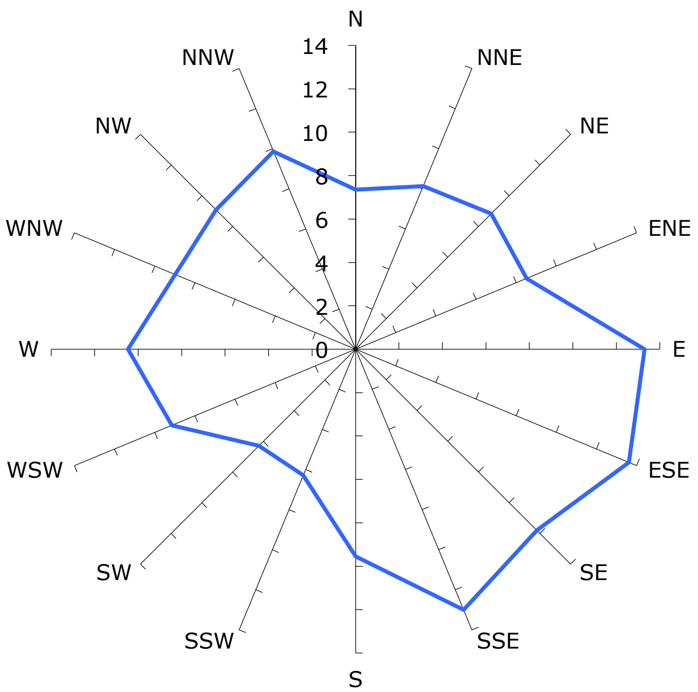
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



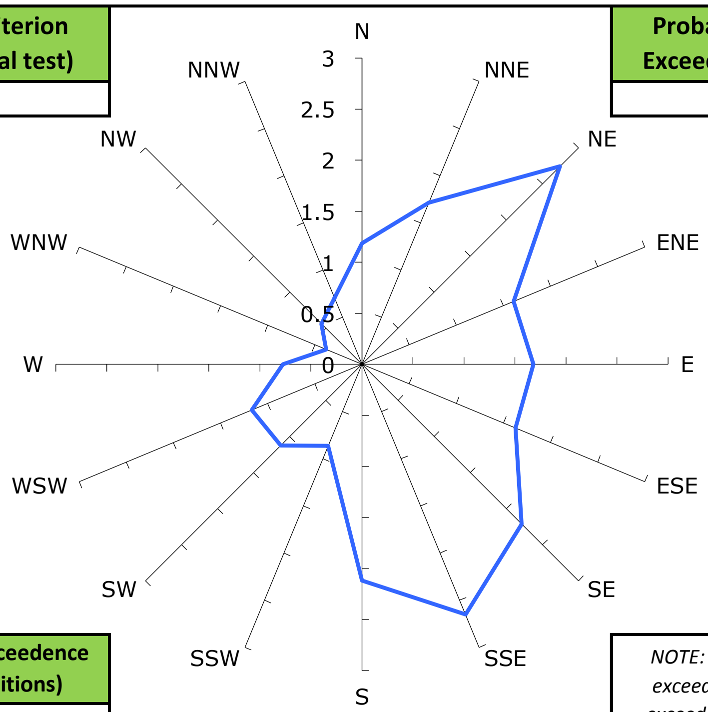
Desired Criterion
23m/s

Measured Wind Speeds at Point 018

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
0%

Probability of Criterion Exceedence (final retest)
N/A



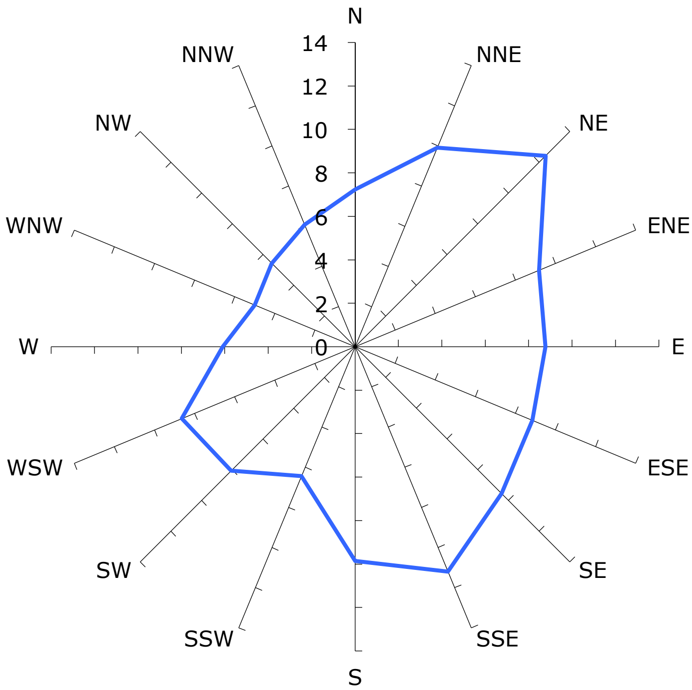
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



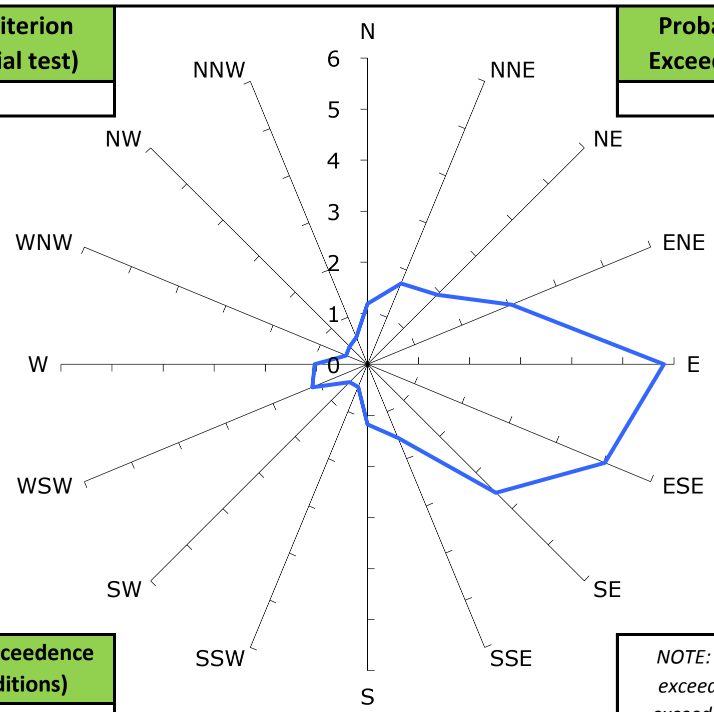
Desired Criterion
23m/s

Measured Wind Speeds at Point 019

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
3%

Probability of Criterion Exceedence (final retest)
N/A



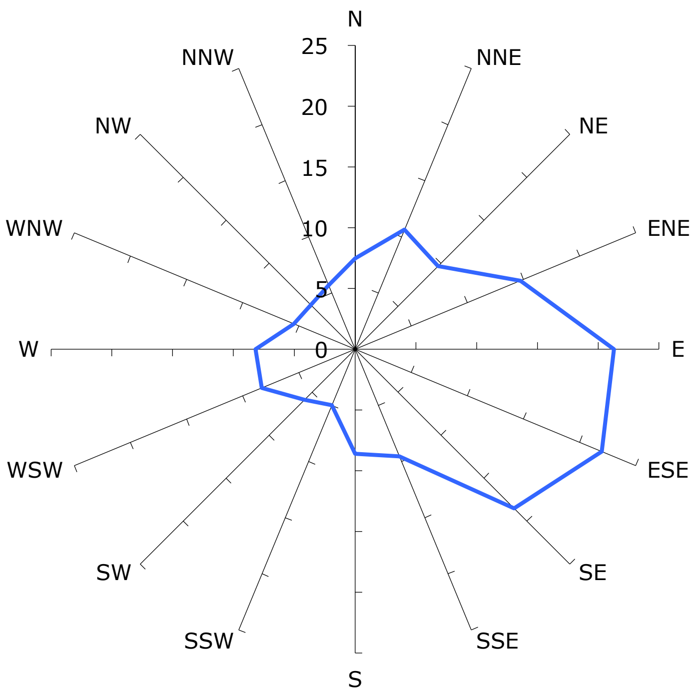
Desired Criterion
5.5m/s

Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Annual Maximum Gust (m/s)



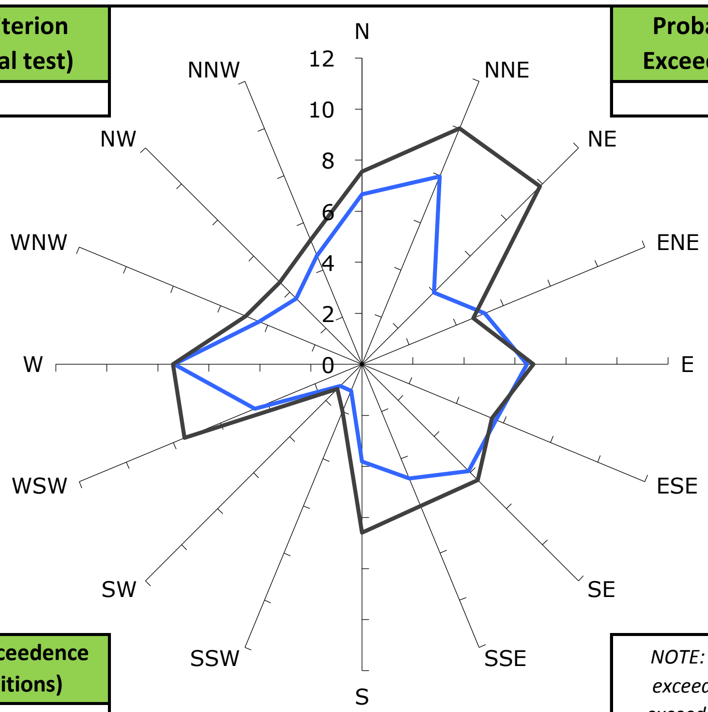
Desired Criterion
23m/s

Measured Wind Speeds at Point 020

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
6%

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
11%

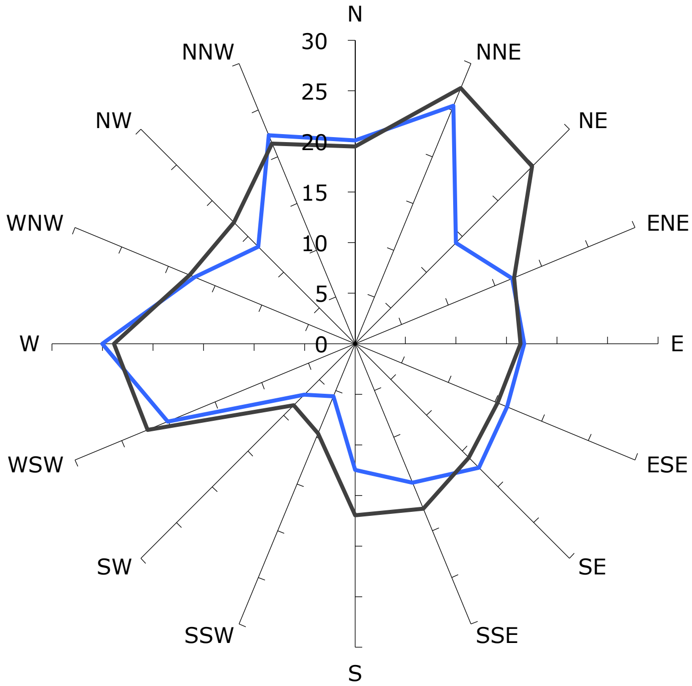
Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



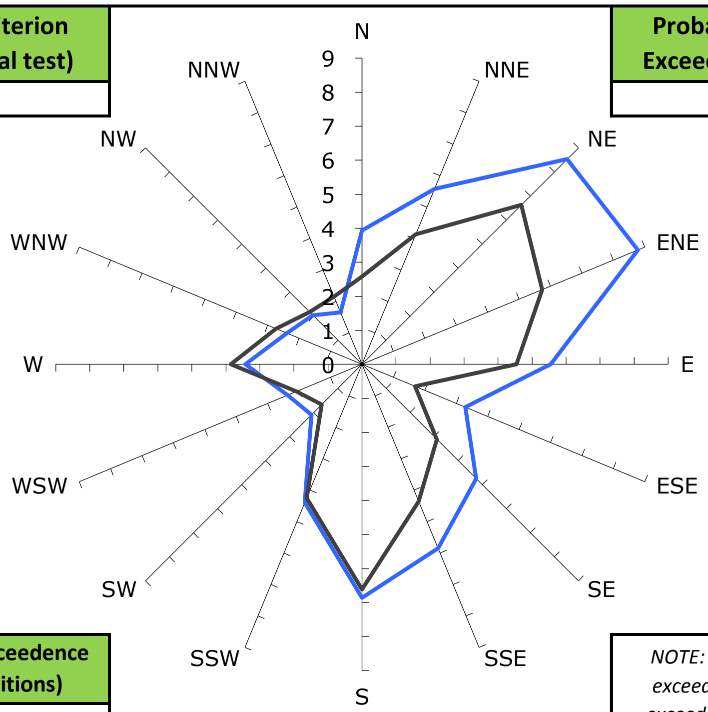
Desired Criterion
23m/s

Measured Wind Speeds at Point 021

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
6%

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
7.5m/s

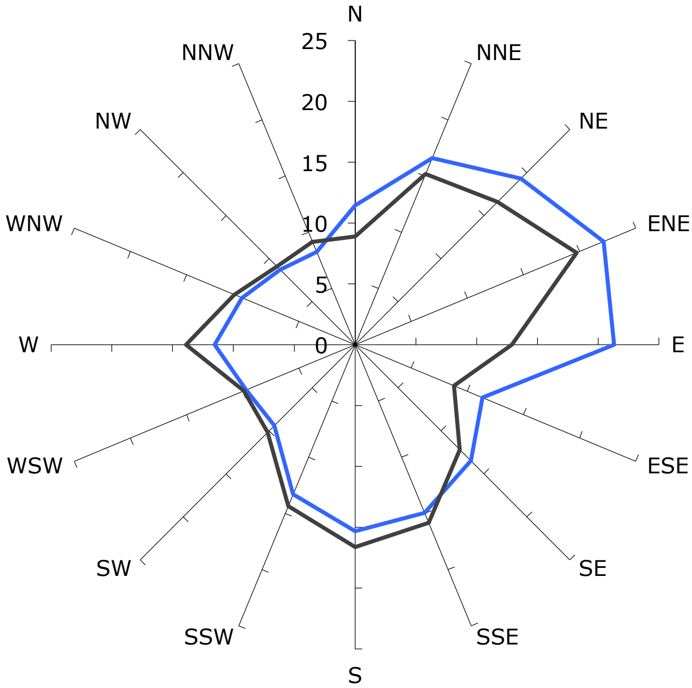
Prob. of Criterion Exceedence (existing site conditions)
2%

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



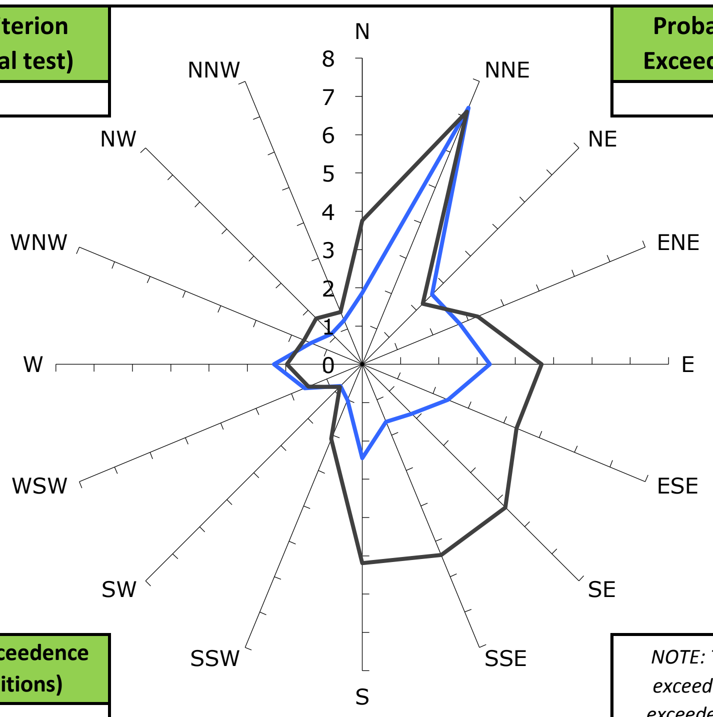
Desired Criterion
23m/s

Measured Wind Speeds at Point 022

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
1%

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
7.5m/s

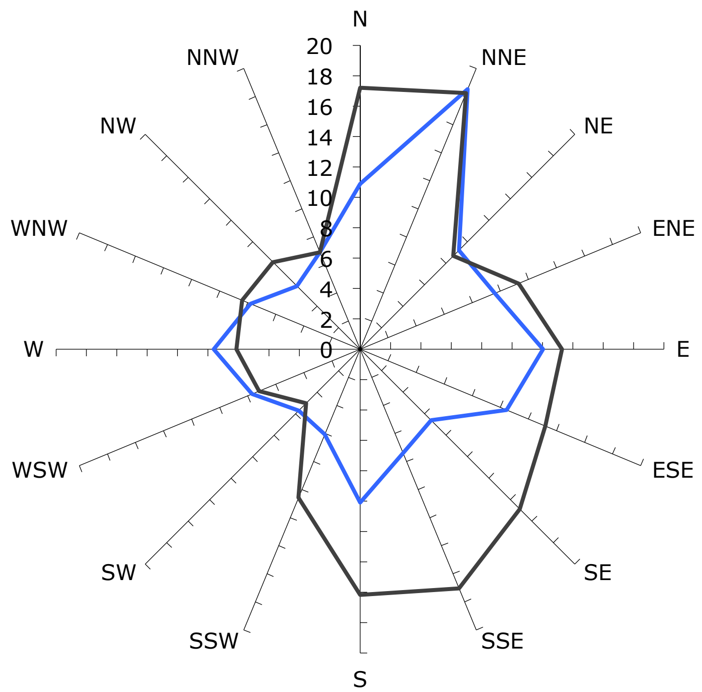
Prob. of Criterion Exceedence (existing site conditions)
2%

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)

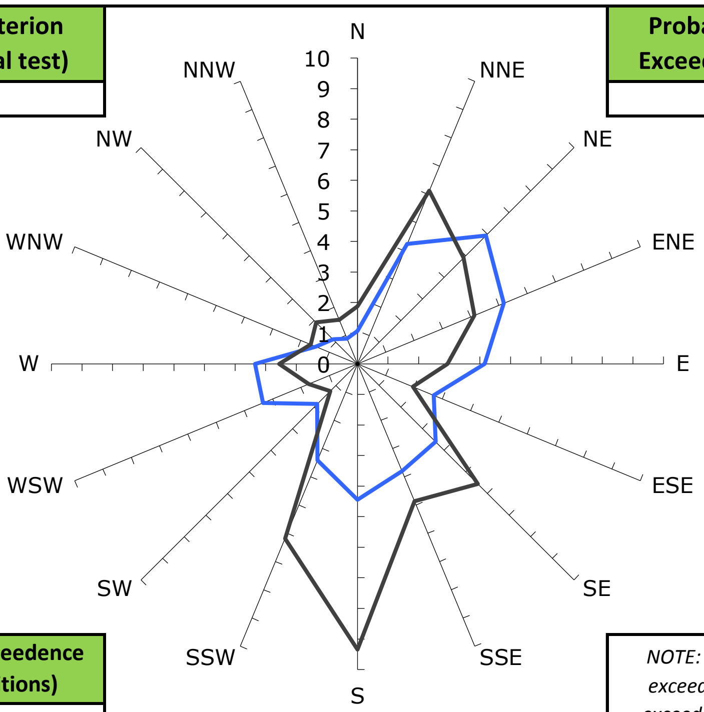


Desired Criterion
23m/s

Measured Wind Speeds at Point 023

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)
1%	N/A



Prob. of Criterion Exceedence (existing site conditions)
5%

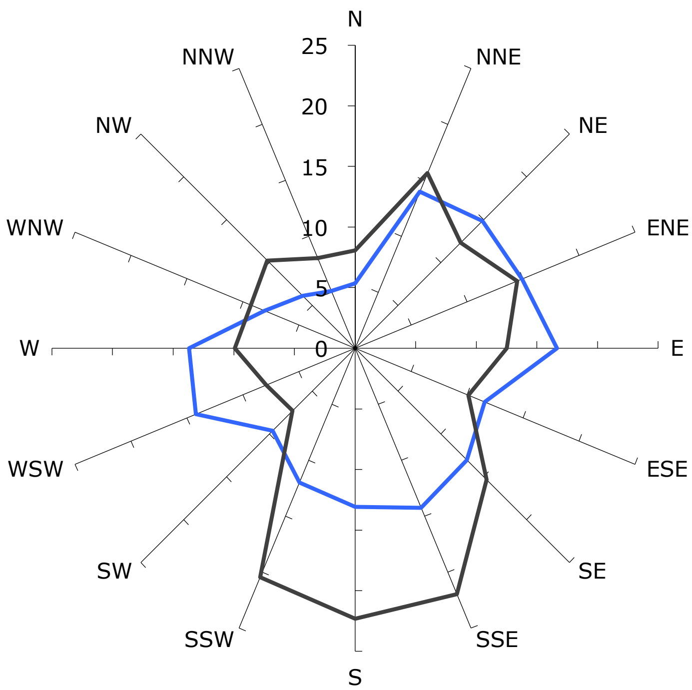
Desired Criterion
7.5m/s

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)

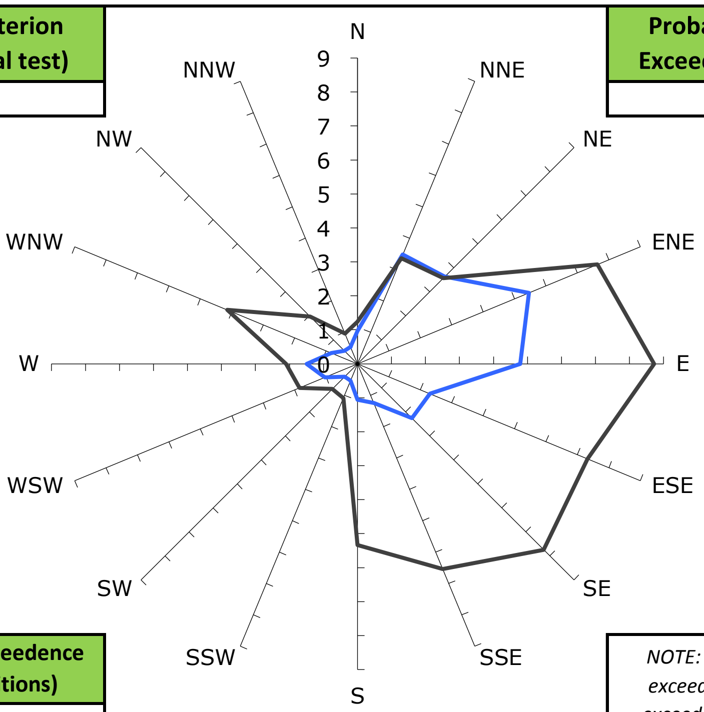


Desired Criterion
23m/s

Measured Wind Speeds at Point 024

Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)
N/A	N/A

Weekly Maximum GEM (m/s)



Prob. of Criterion Exceedence (existing site conditions)
N/A

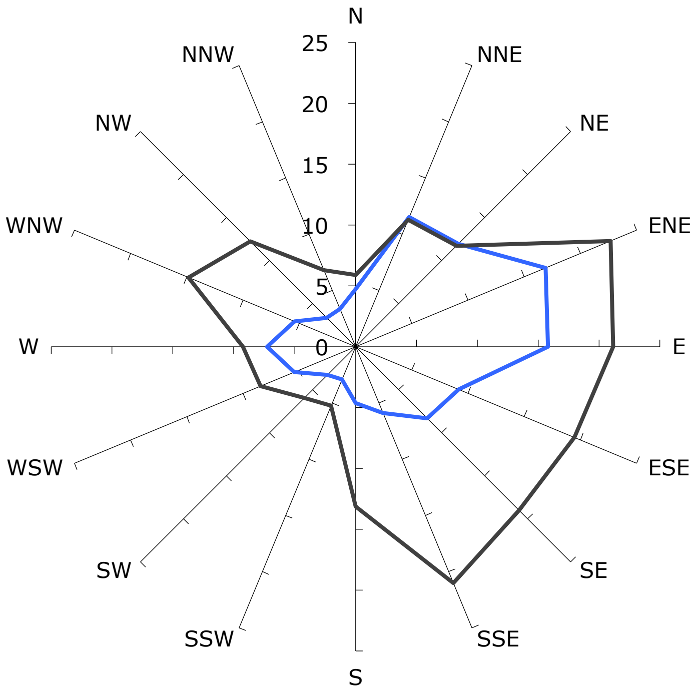
Desired Criterion
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



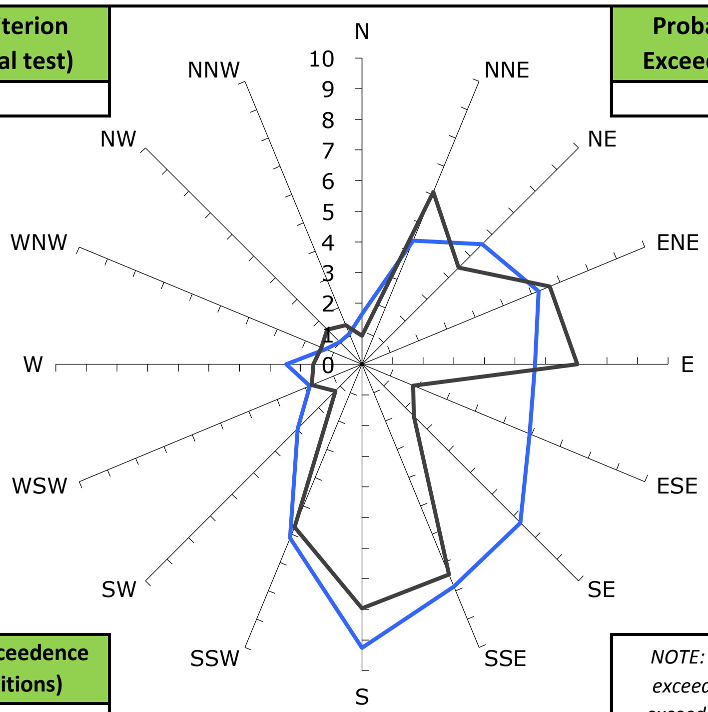
Desired Criterion
23m/s

Measured Wind Speeds at Point 025

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

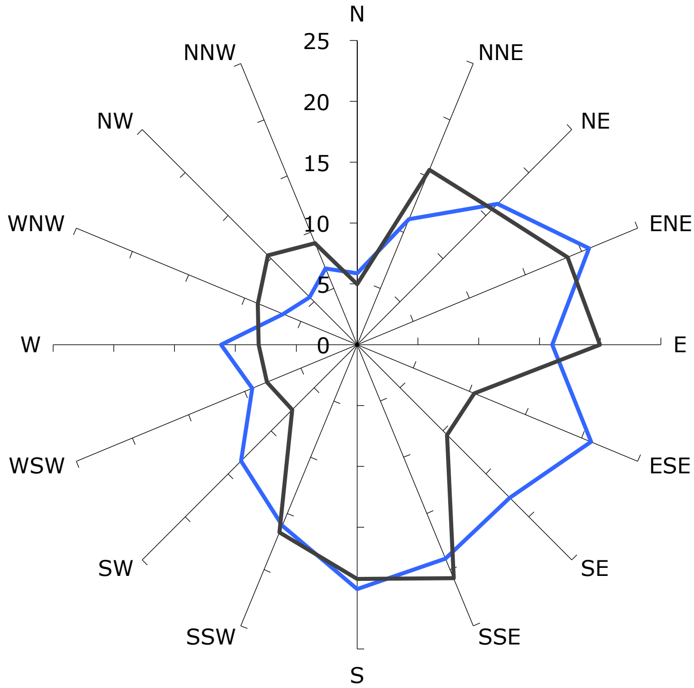
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



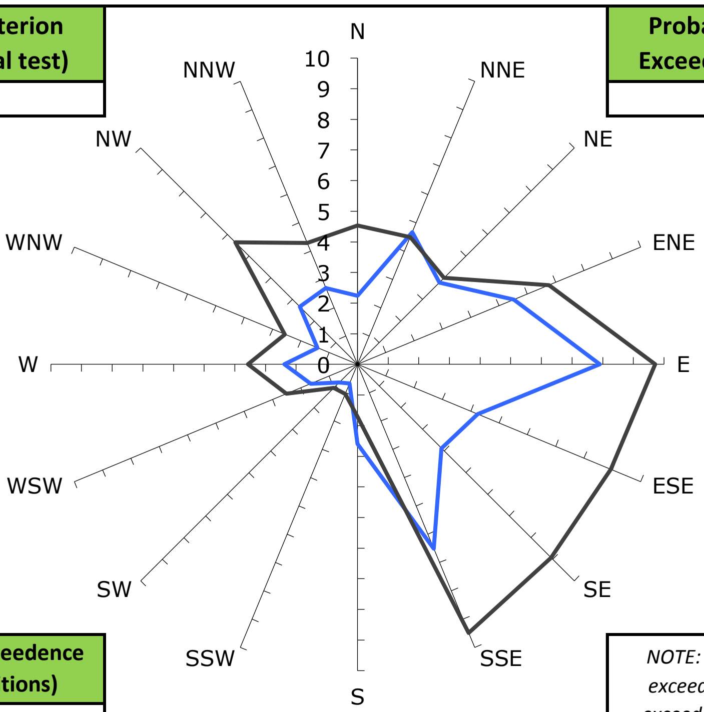
Desired Criterion
23m/s

Measured Wind Speeds at Point 026

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

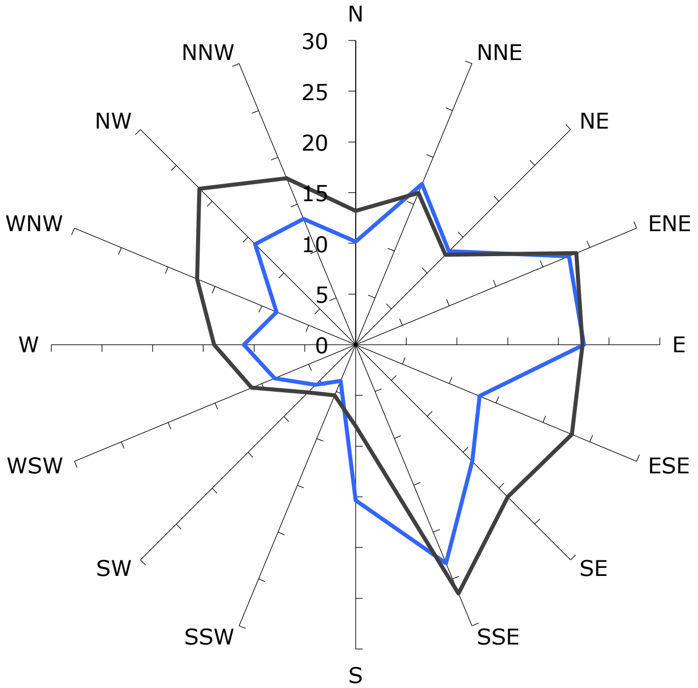
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



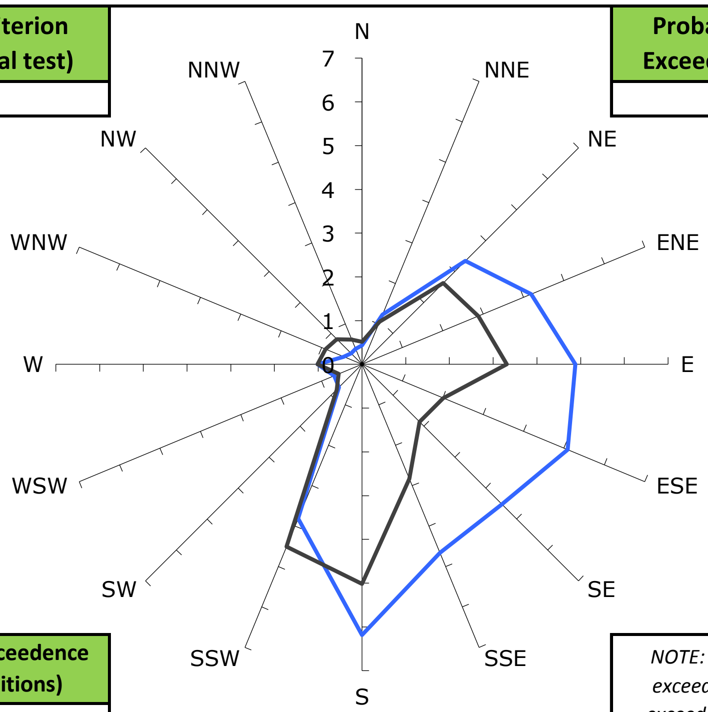
Desired Criterion
23m/s

Measured Wind Speeds at Point 027

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

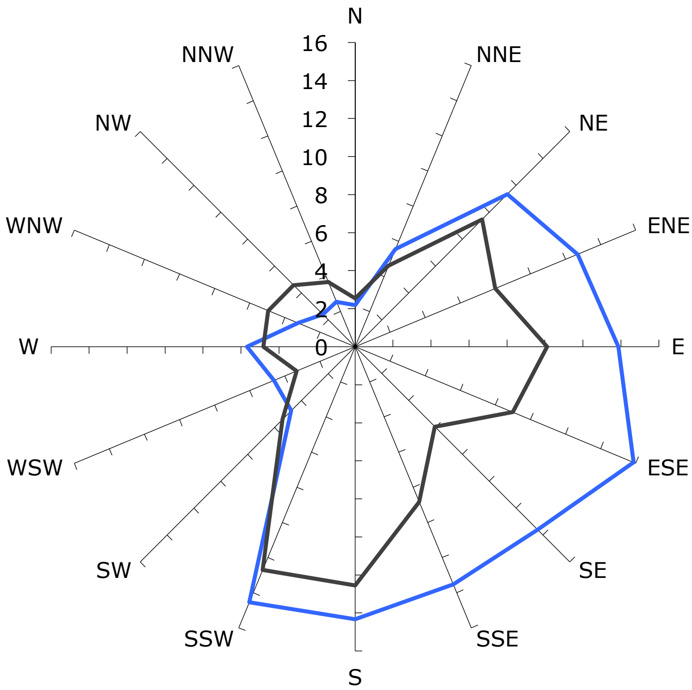
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", including effect of balustrades.

Existing Site Conditions, including effect of balustrades.

Annual Maximum Gust (m/s)



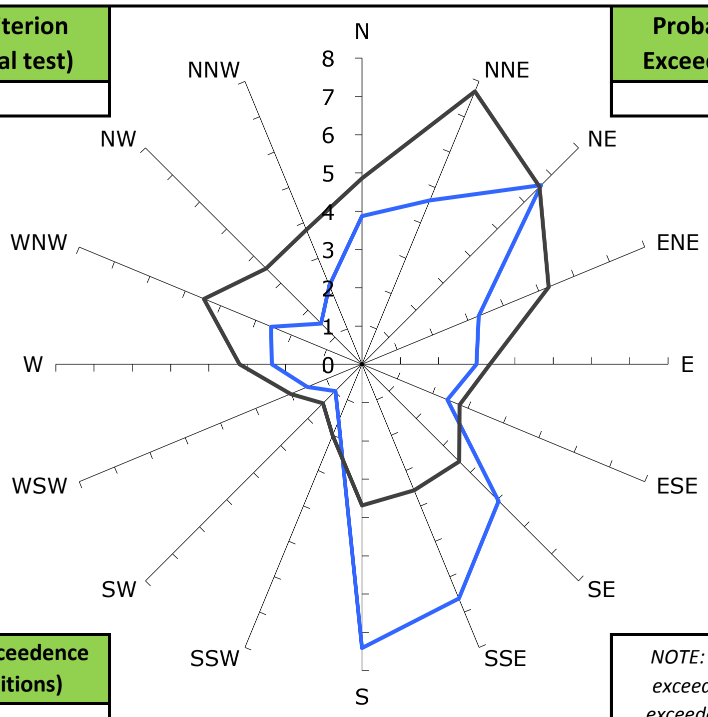
Desired Criterion
23m/s

Measured Wind Speeds at Point 028

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
N/A

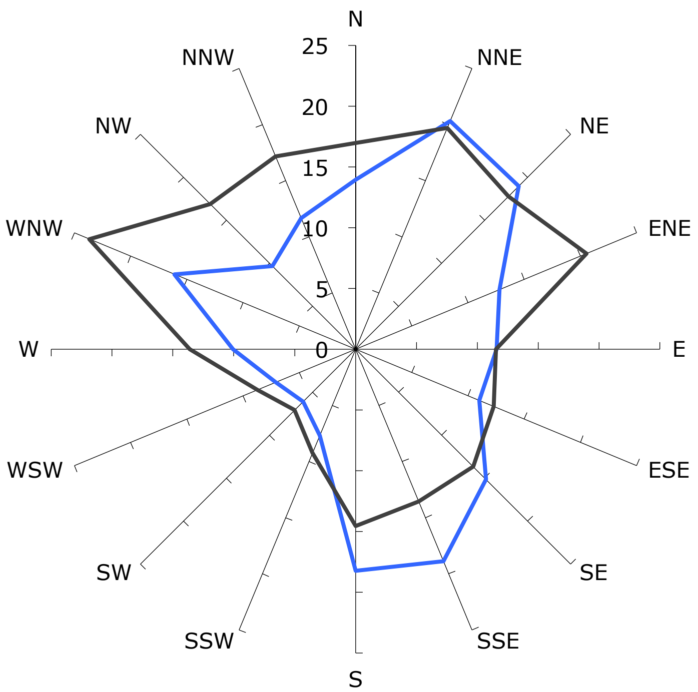
Desired Criterion
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)

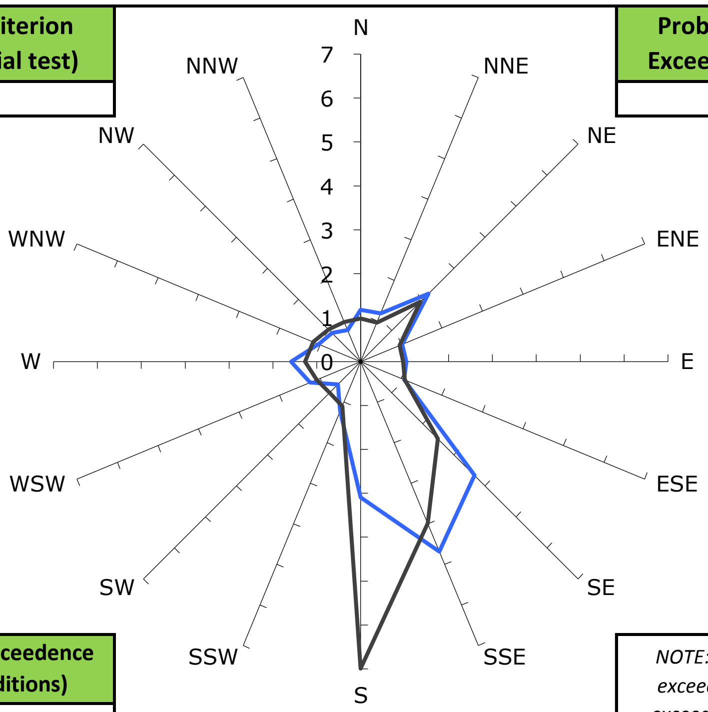


Desired Criterion
23m/s

Measured Wind Speeds at Point 029

Weekly Maximum GEM (m/s)

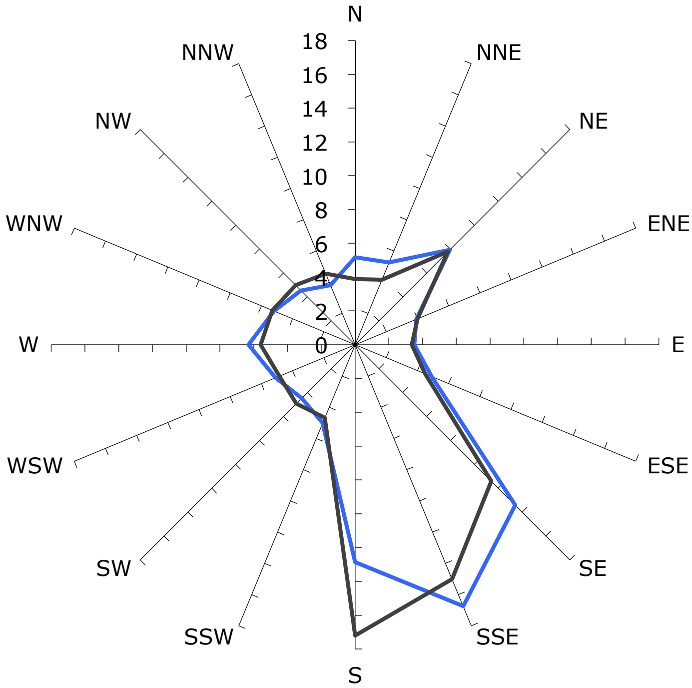
Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)	Prob. of Criterion Exceedence (existing site conditions)	Desired Criterion
N/A	N/A	N/A	N/A



NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", including effect of balustrades.
Existing Site Conditions, including effect of balustrades.

Annual Maximum Gust (m/s)



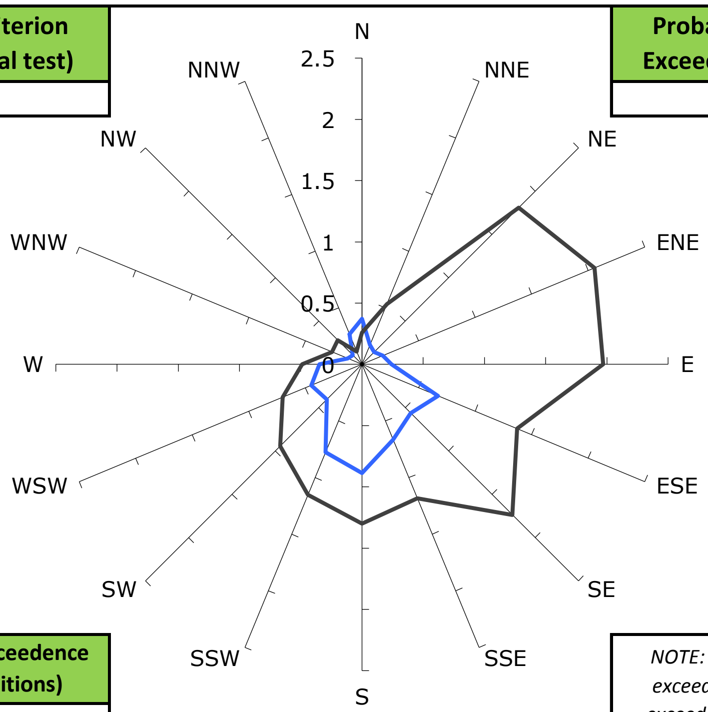
Desired Criterion
23m/s

Measured Wind Speeds at Point 030

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

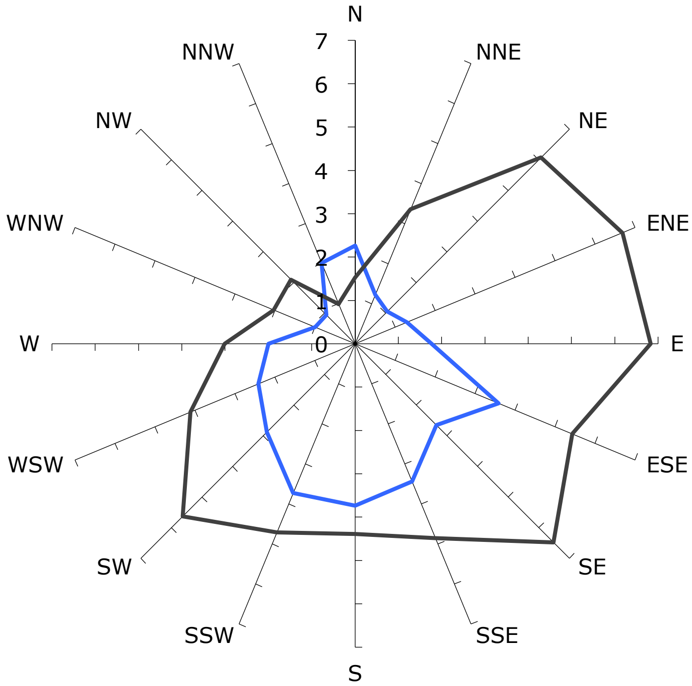
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



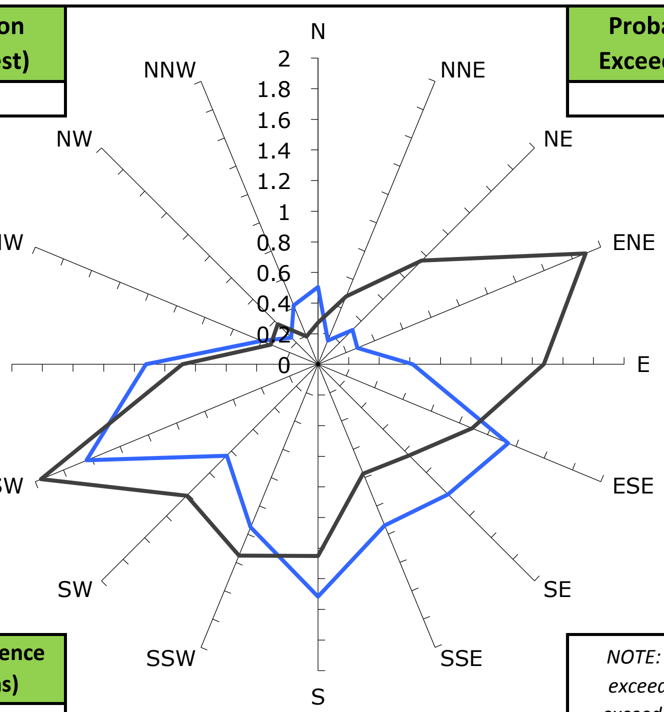
Desired Criterion
23m/s

Measured Wind Speeds at Point 031

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

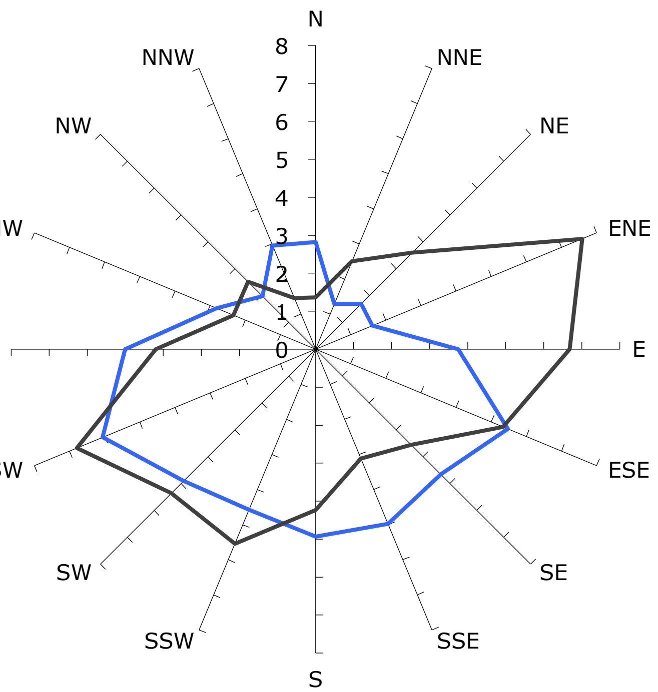
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



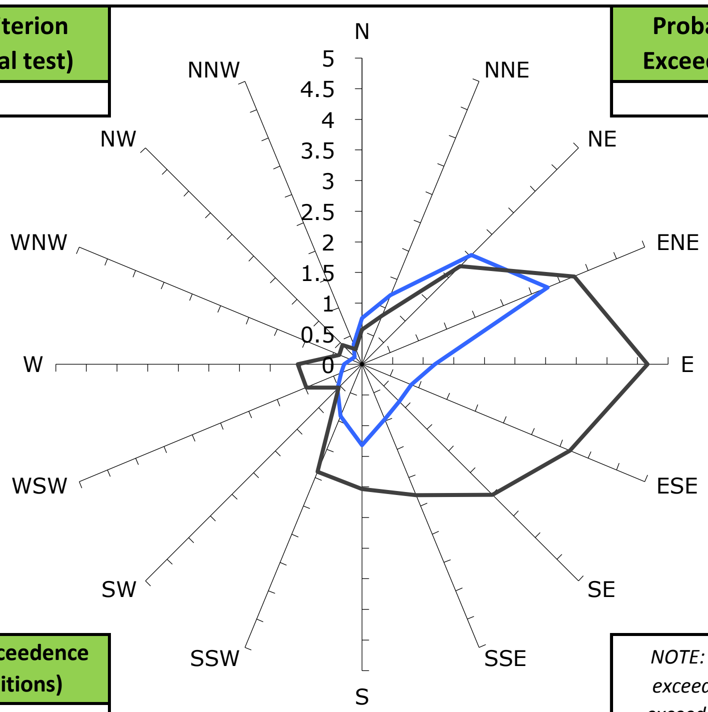
Desired Criterion
23m/s

Measured Wind Speeds at Point 032

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
N/A

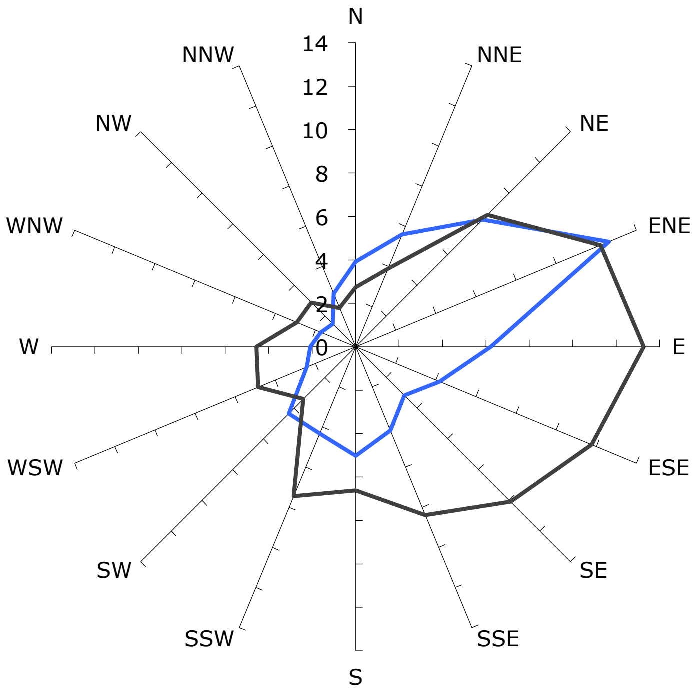
Desired Criterion
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



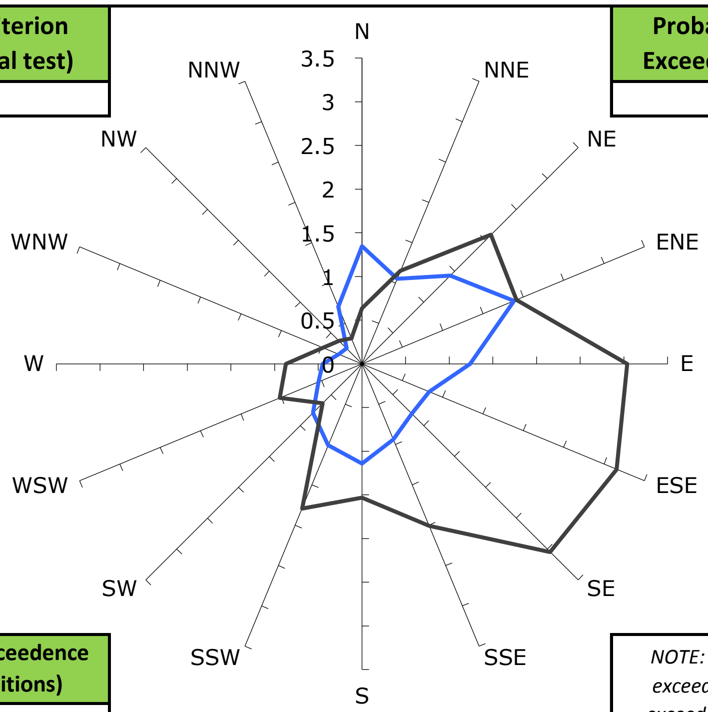
Desired Criterion
23m/s

Measured Wind Speeds at Point 033

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

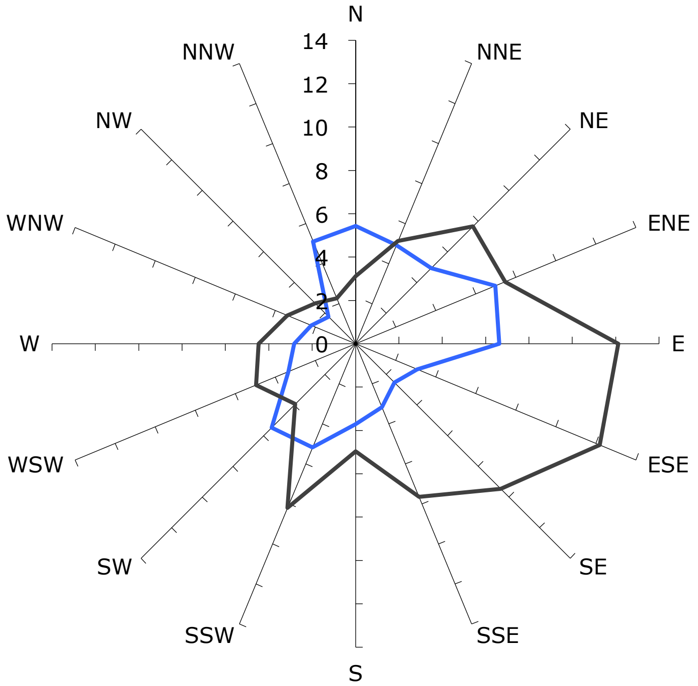
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)

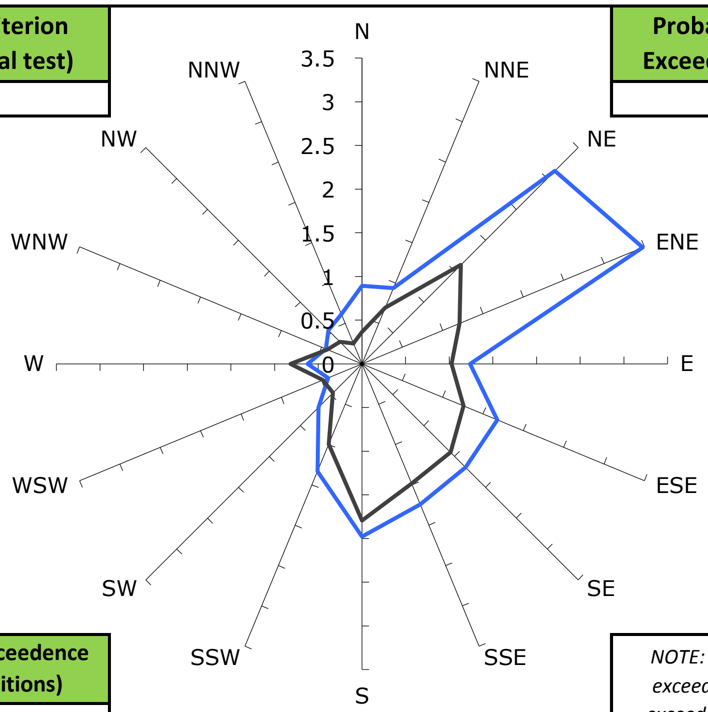


Desired Criterion
23m/s

Measured Wind Speeds at Point 034

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)	Probability of Criterion Exceedence (final retest)
N/A	N/A



Desired Criterion
N/A

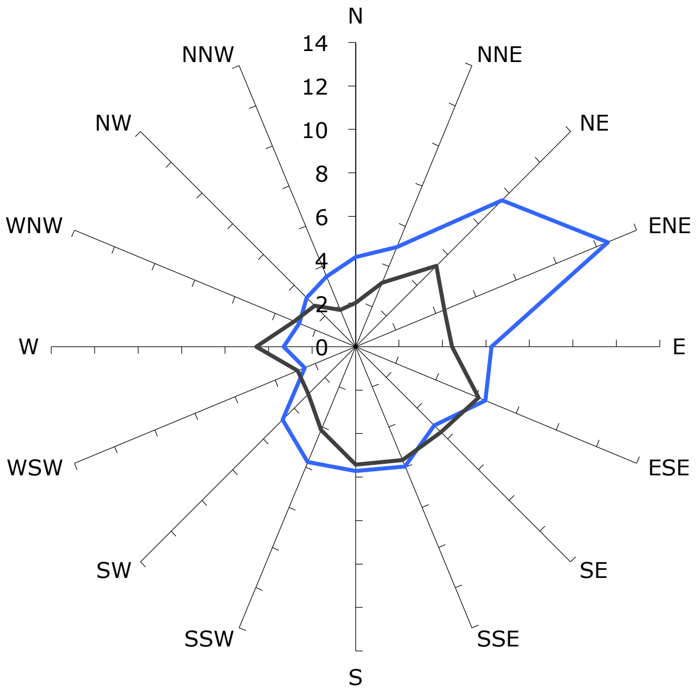
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Maximum Gust (m/s)



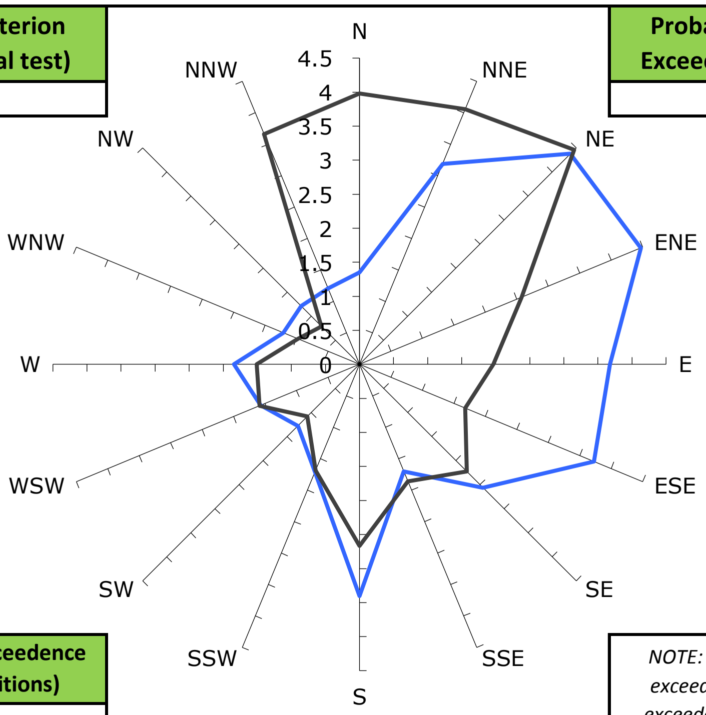
Desired Criterion
23m/s

Measured Wind Speeds at Point 035

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Prob. of Criterion Exceedence (existing site conditions)
N/A

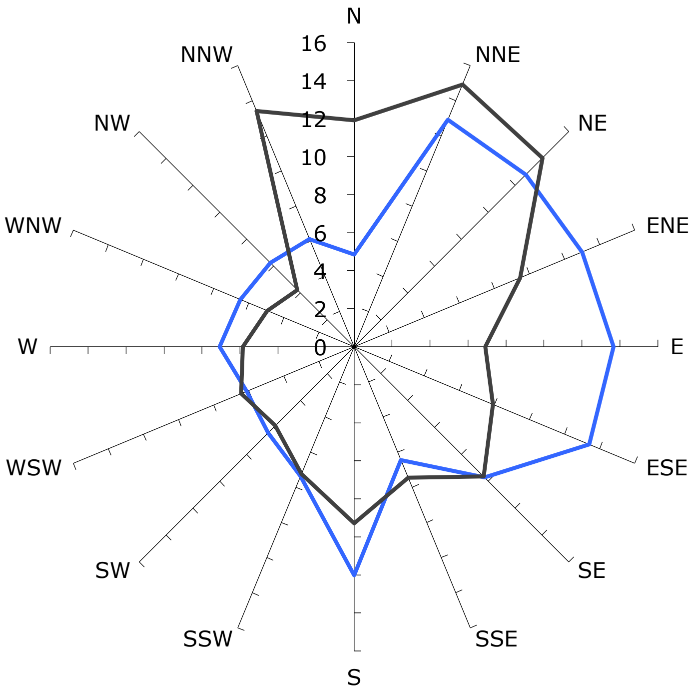
Desired Criterion
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)



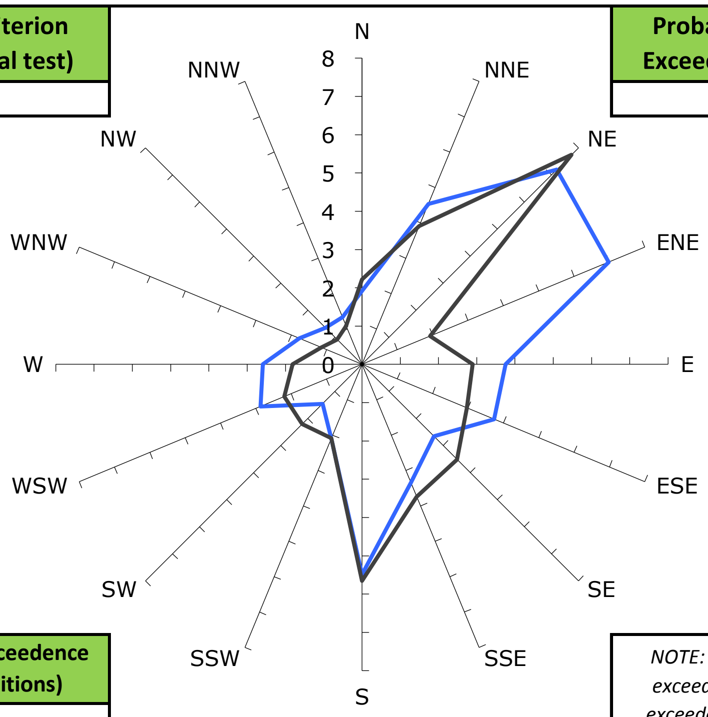
Desired Criterion
23m/s

Measured Wind Speeds at Point 036

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A

Probability of Criterion Exceedence (final retest)
N/A



Desired Criterion
N/A

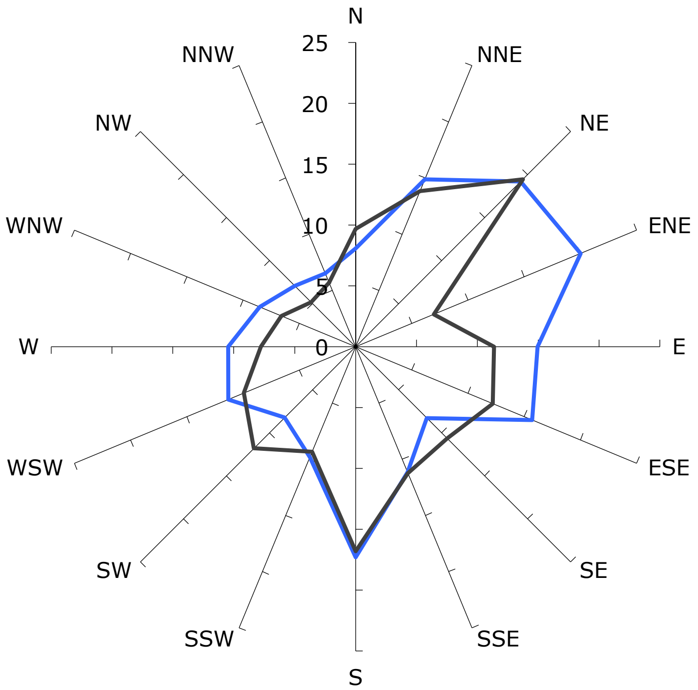
Prob. of Criterion Exceedence (existing site conditions)
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

Existing Site Conditions.

Annual Maximum Gust (m/s)

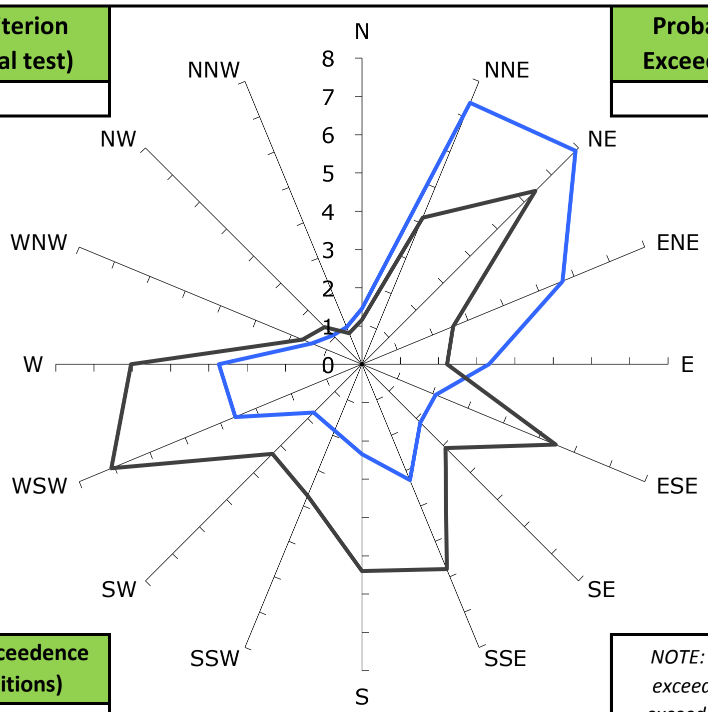


Desired Criterion
23m/s

Measured Wind Speeds at Point 037

Weekly Maximum GEM (m/s)

Probability of Criterion Exceedence (initial test)
N/A



Probability of Criterion Exceedence (final retest)
N/A

Prob. of Criterion Exceedence (existing site conditions)
N/A

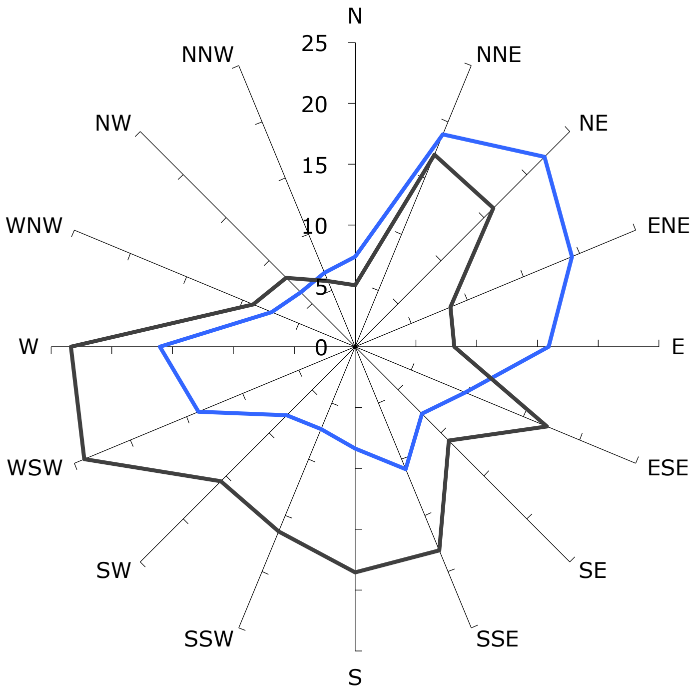
Desired Criterion
N/A

NOTE: The desired criterion is exceeded if the probability of exceedence is greater than 5%

With development "as proposed", no vegetation or other treatments.

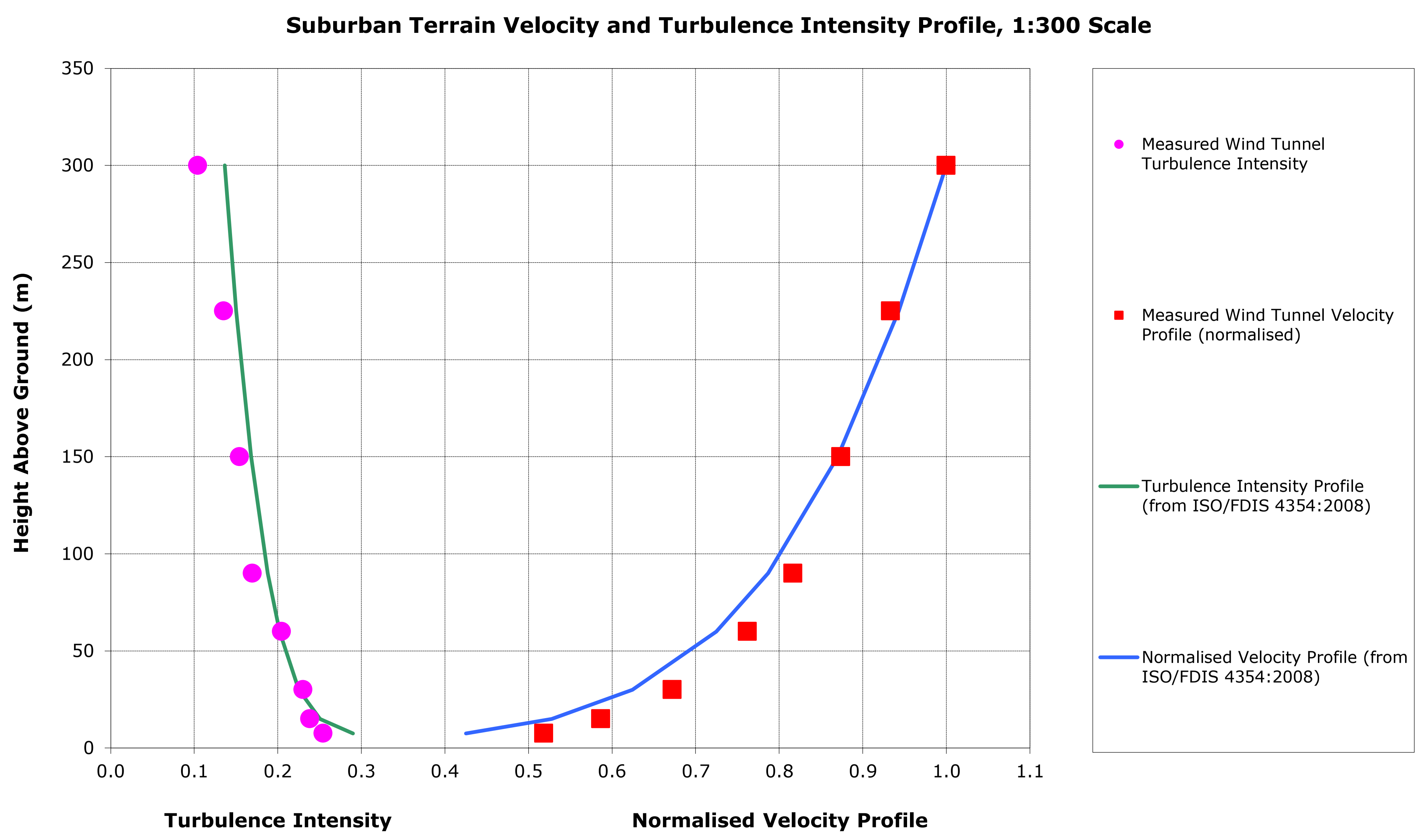
Existing Site Conditions.

Annual Maximum Gust (m/s)

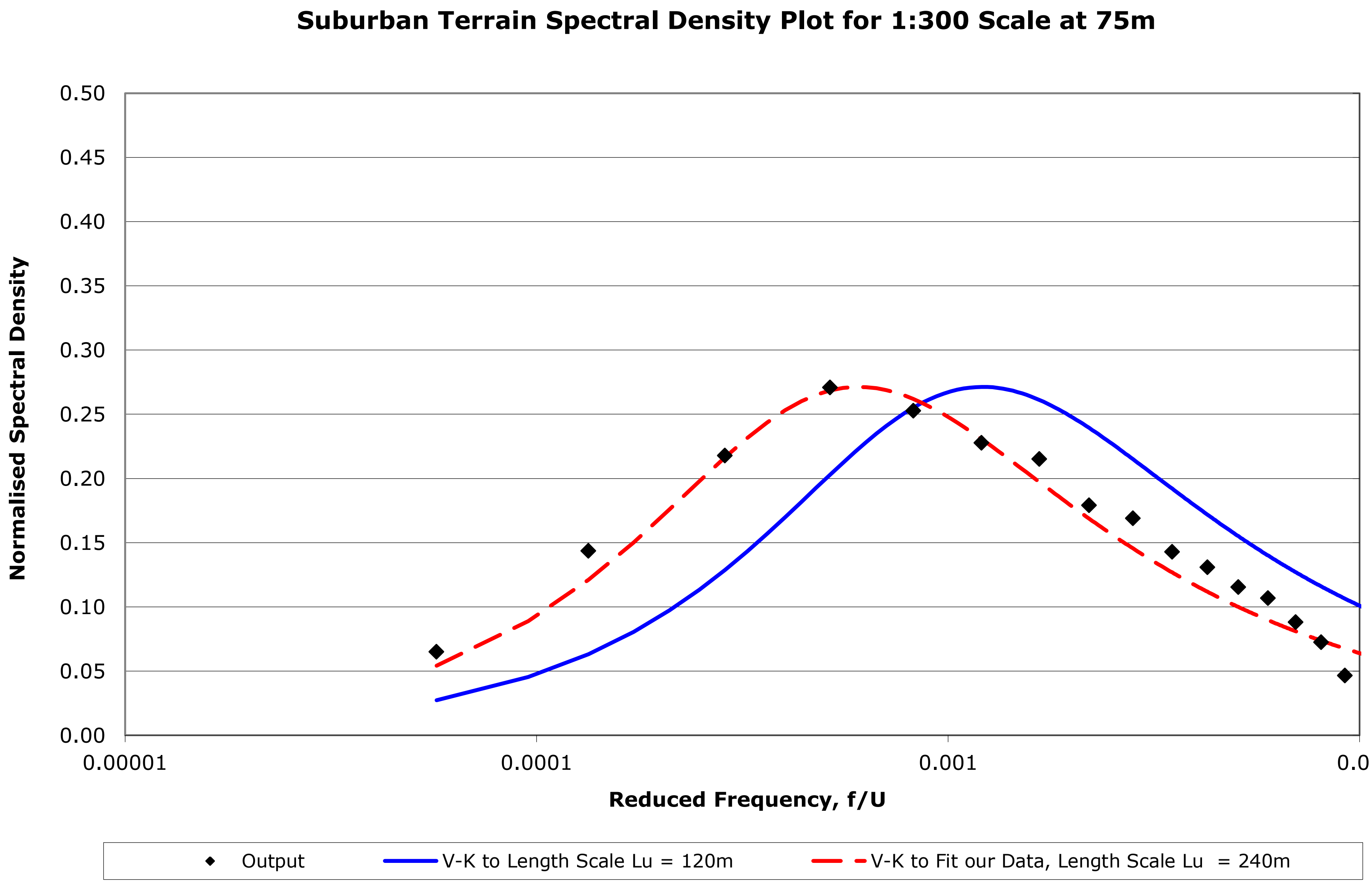


Desired Criterion
23m/s

APPENDIX B - VELOCITY AND TURBULENCE INTENSITY PROFILES



Suburban Terrain Velocity and Turbulence Intensity Profile, 1:300 Scale
Height Above Ground (m)
350
300
250
200
150
100
50
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
Turbulence Intensity
Normalised Velocity Profile
Measured Wind Tunnel Turbulence Intensity
Measured Wind Tunnel Velocity Profile (normalised)
Turbulence Intensity Profile (from ISO/FDIS 4354:2008)
Normalised Velocity Profile (from ISO/FDIS 4354:2008)


Suburban Terrain Spectral Density Plot for 1:300 Scale at 75m
Normalised Spectral Density
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00001
0.0001
0.001
0.01
Reduced Frequency, f/U
Output
V-K to Length Scale Lu = 120m
V-K to Fit our Data, Length Scale Lu = 240m