Vipac Engineers and Scientists Limited
279 Normanby Rd, Port Melbourne, VIC 3207, Australia
Private Bag 16, Port Melbourne, VIC 3207, Australia
t. +61 3 9647 9700 | **f.** +61 3 9646 4370 | **e.** melbourne@vipac.com.au
w. www.vipac.com.au | A.B.N. 33 005 453 627 | A.C.N. 005 453 627

Vipac Engineers & Scientists

Grocon Constructors Pty Ltd

The Ribbon, Darling Harbour

Pedestrian Level Winds - Wind Tunnel Test

30N-19-0065-TRP-6763732-1

16 August 2019

Report Title: Pedestrian Level Winds - Wind Tunnel Test **Job Title: The Ribbon, Darling Harbour**	
DOCUMENT NO: 30N-19-0065-TRP-6763732-1 **PREPARED FOR:** Grocon Constructors Pty Ltd Legion House, Level 4 161 Castlereagh St Sydney, New South Wales, 2000, Australia **CONTACT:** Andrew Petracic **Tel:** +61 2 8249 7000 **Fax:**	**REPORT CODE:** TRP **PREPARED BY:** Vipac Engineers and Scientists Limited 279 Normanby Rd, Port Melbourne, VIC 3207, Australia **Tel:** +61 3 9647 9700 **Fax**: +61 3 9646 4370
PREPARED BY: Author: Matthew Beames Project Engineer	Date: 16 Aug 2019
REVIEWED BY: Reviewer: Zhuyun Xu Senior Wind Consultant	Date: 16 Aug 2019
AUTHORISED BY: Eric Yuen Wind Engineer	Date:16 Aug 2019

REVISION HISTORY

Revision No.	Date Issued	Reason/Comments
0	31 Jul 2019	Initial Issue
1	16 Aug 2019	Minor Amendments
2		

DISTRIBUTION

Copy No._____	**Location**	
1	Project	
2	Client (PDF Format)	Uncontrolled Copy
3		

KEYWORDS:

EXECUTIVE SUMMARY

Vipac Engineers & Scientists Ltd (VIPAC) has been commissioned by **Grocon Constructors Pty Ltd** to perform an assessment of pedestrian level winds for the proposed **The Ribbon** development at **31 Wheat Rd, Sydney NSW**.

This study addresses DA Condition B67 (B6 of SSD 7388), which states:

Condition	**Report Ref**
Prior to issue of a Construction Certificate for Stage 2, an updated wind assessment is required, including wind tunnel modelling, to demonstrate acceptable amenity levels for: *(a) walking in all ground level areas throughout the public domain;*	Section 7, Appendix A
(b) standing at building entrances; and	Section 7, Appendix A
(c) seating in all potential outdoor seating areas.	Section 7, Appendix A
The wind assessment shall be updated to provide additional method(s)/treatments(s) to achieve the above comfort levels, if required	Section 7.1 (Figures 15 & 16)

This study examines the wind effects expected adjacent to the proposed development, based on 1:400 scale-model wind tunnel testing. The model was constructed to drawings supplied by **Hassell** in **Feb to Jun 2019.** A list of the drawings used to construct the model is provided in Appendix B of this report.

All testing was carried out in the Boundary Layer Wind Tunnel Facility of Vipac Engineers & Scientists Ltd in Melbourne during July 2019.

The subject building and surrounding developments covering a circular area of a 500 m radius were modelled at 1:400 scale. The approaching mean and turbulent flows of Terrain Category 2 for a sector of 340-350 azimuth degrees, Terrain Category 3.5 (Urban terrain) for 0(360)-150 azimuth degrees and Terrain Category 3 for other directions (160-330) [1] Atmospheric Boundary Layer were modelled based on Australian Standard AS 1170.2-2011.

The findings of this study are summarized as follows:

- With the proposed design and without any landscaping, the development would generate wind conditions that satisfy the safety criterion at all test locations.
- With the proposed design, the development would generate wind conditions that satisfy the comfort criteria at most of test locations. For some areas where the criterion was exceeded, severity of the comfort criterion due to the proximity of the site to the waterfront was discussed. Vipac believes that these areas would have acceptable wind environment.
- The proposed development would not generate significant adverse wind impact in the adjacent footpath areas.

TABLE OF CONTENTS

1 INTRODUCTION

Vipac Engineers & Scientists Ltd (VIPAC) has been commissioned by **Grocon Constructors Pty Ltd** to carry out an assessment of pedestrian wind effects for the proposed **The Ribbon** development at 31 Wheat Rd, Sydney, NSW.

This study addresses DA Condition B67, which states:

B67 **The wind assessment submitted to satisfy Condition B6 of SSD 7388 endorsed by the Secretary on 3 November 2017 shall be reviewed and updated to reflect the building as modified under SSD 7388 MOD 6.**

While Condition B6 of SSD 7388 states the following:

"Prior to issue of a Construction Certificate for Stage 2, an updated wind assessment is required, including wind tunnel modelling, to demonstrate acceptable amenity levels for:

(a) walking in all ground level areas throughout the public domain;
(b) standing at building entrances; and
(c) seating in all potential outdoor seating areas.

The wind assessment shall be updated to provide additional method(s)/treatments(s) to achieve the above comfort levels, if required. Should additional measures be required on the building facades, a statement from the architect shall be provided certifying that the mitigation measures have been integrated into the design of the building and maintain the integrity of the facades and overall building design.

The updated wind assessment, modelling, amended plans and architectural statement shall be submitted for the Secretary's approval"

The city of Sydney has specific requirements for Central Sydney to ensure both safety and comfort is maintained when a site is redeveloped. The draft Development Control Plan (2010) outlines:

> *The shape, location and height of buildings are to be designed to satisfy wind criteria for public safety and comfort at ground level. The useability of open terraces on buildings also depends on comfortable conditions being achieved.*

More specifically, the DCP stipulates to ensure public safety and comfort the maximum wind criteria are to be met by new buildings:

- 10 metres/second in retail streets,
- 13 metres/seconds along major pedestrian streets, parks and public places,
- 16 metres/second in all other streets.

1.1 SITE OF THE PROPOSED DEVELOPMENT

The proposed refurbishment is a 24-storey mixed use building (a 2 storey retail podium with hotel and serviced apartments on the levels above). The maximum height from the street level is 90.3 m. The proposed refurbishment is bounded by Harbour Street to the east, park lands to the west, and the M4 western distributor freeways to the south and the north. Drawings of the proposed development were supplied to Vipac by **Hassell in Feb to June 2019**. A list of drawings supplied is provided in Appendix B of this report. The South Elevation of the development is shown in Figure 1 the ground floor plan of the proposed development is shown in Figure 2.

An aerial view indicating the exposures to the proposed development is shown in Figure 3.

This report details the pedestrian level wind assessment results of the tests carried out on a 1:400 scale model of the proposed development in Vipac's Boundary Layer Wind Tunnel in Melbourne. The results show the wind effects in ground level public areas of the development as proposed. All tests were conducted in Vipac's Boundary Layer Wind Tunnel Laboratory in Melbourne, during July 2019.

The pedestrian wind environment study of the development was conducted using omnidirectional pressure sensor techniques to predict wind velocities. The study investigated safety and comfort in ground level pedestrian access-ways nearby the project.

The test model of the proposed development was constructed based on the drawings supplied by **Hassell**. Figure 4 and Figure 5 show the 1:400 scale models in the wind tunnel. A list of all the drawings used for model construction is included in the Appendix B of this report.

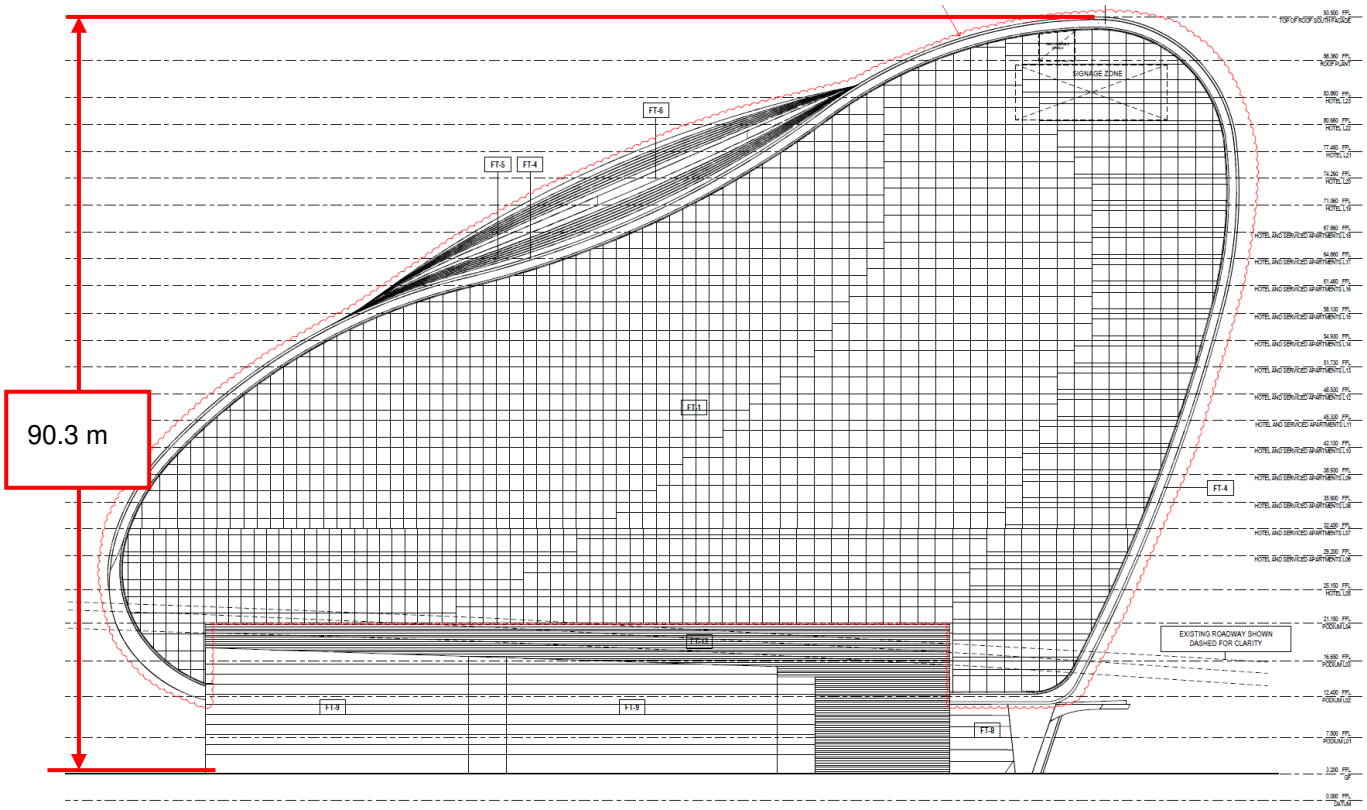


Figure 1: South elevation of the proposed development showing the approximate height of the building.

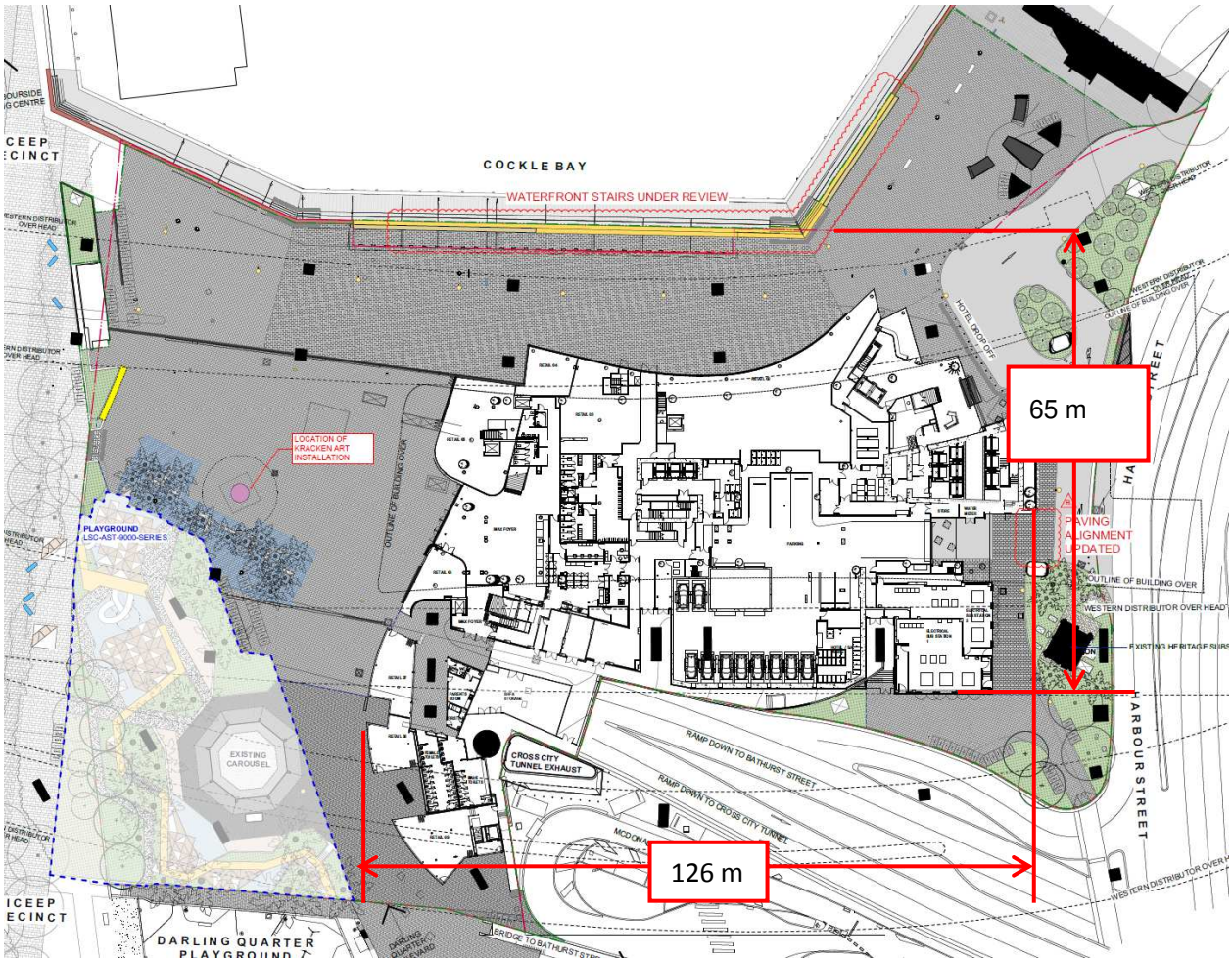


Figure 2: Ground level plan of the proposed development with approximate site dimensions.

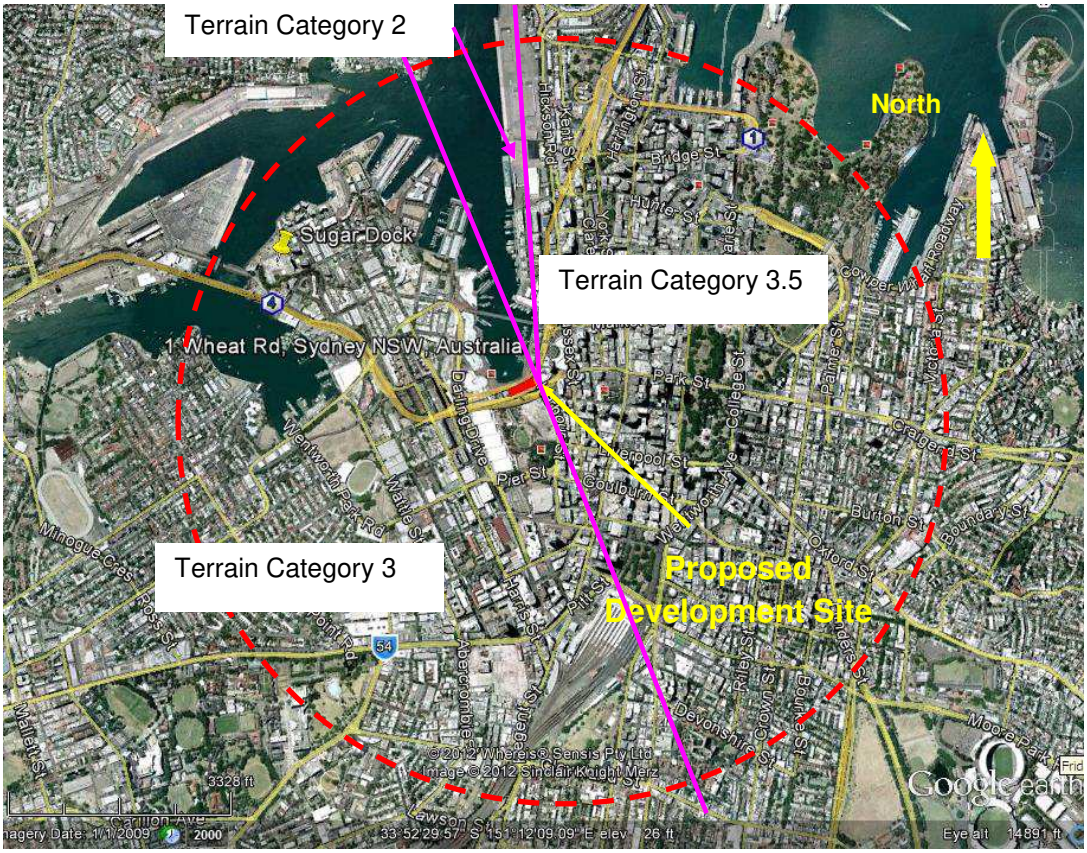


Figure 3: Assumed terrain roughness for wind speed estimation.

Figure 4: Overall view from the north of the 1:400 model of the proposed development in the wind tunnel.

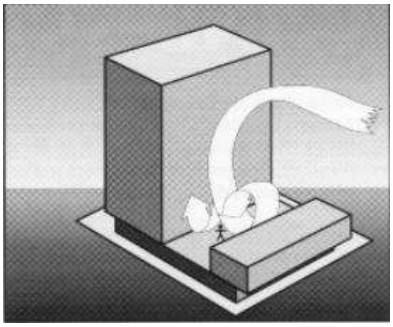
Figure 5: Close up view of the 1:400 model of the proposed development in the wind tunnel (proposed design).

1.2 ENVIRONMENTAL WIND EFFECTS

Atmospheric Boundary Layer

As wind flows over the earth it encounters various roughness elements and terrain such as water, forests, houses and buildings. To varying degrees, these elements reduce the mean wind speed at low elevations and increase air turbulence. The wind above these obstructions travels with unattenuated velocity, driven by atmospheric pressure gradients. The resultant increase in wind speed with height above ground is known as a wind velocity profile. When this wind profile encounters a tall building, some of the fast moving wind at upper elevations is diverted down to ground level resulting in local adverse wind effects.

The terminology used to describe the wind flow patterns around the proposed Development is based on the aerodynamic mechanism, direction and nature of the wind flow.



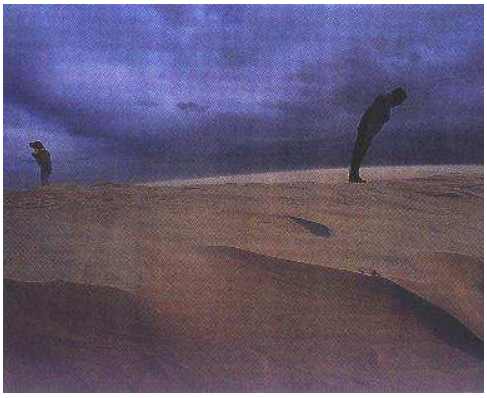
Downwash – refers to a flow of air down the exposed face of a tower. A tall tower can deflect a fast moving wind at higher elevations downwards.

Corner Accelerations – when wind flows around the corner of a building it tends to accelerate in a similar manner to airflow over the top of an aeroplane wing.

Flow separation – when wind flowing along a surface suddenly detaches from that surface and the resultant energy dissipation produces increased turbulence in the flow. Flow separation at a building corner or at a solid screen can result in gusty conditions.

Flow channelling – the well-known “street canyon” effect occurs when a large volume of air is funnelled through a constricted pathway. To maintain flow continuity the wind must speed up as it passes through the constriction. Examples of this might occur between two towers, in a narrowing street or under a bridge.

Direct Exposure – a location with little upstream shielding for a wind direction of interest. The location will be exposed to the unabated mean wind and gust velocity. Piers and open water frontage may have such exposure.



2 SYDNEY WIND CLIMATE

The mean and gust wind speeds have been recorded in the Sydney area for over 30 years. These data have been analysed and the directional probability distribution of wind speeds have been determined. The directional distribution of hourly mean wind speed at the gradient height, with a probability of occurring once per year (i.e. 1 year return period) is shown in Figure 6. The wind data at this free stream height is common to all Sydney sites and may be used as a reference to assess ground level wind conditions at the development site.

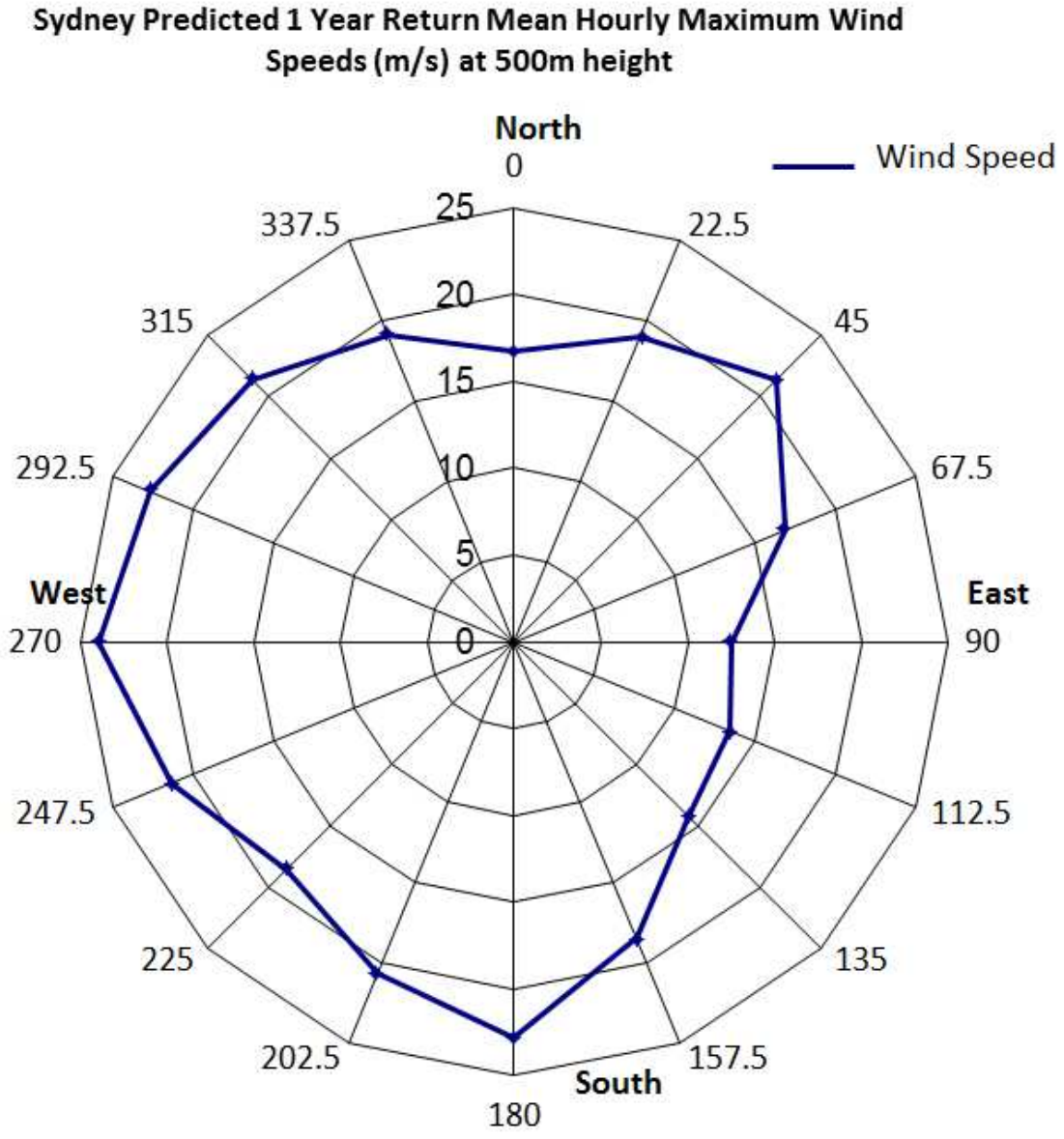


Figure 6: Directional Distribution of Annual Return Period Mean Hourly Wind Velocities (m/s) at the gradient height for Sydney.

3 ASSESSMENT CRITERIA

Vipac's assessment criteria for pedestrian wind comfort are based on some consensus of international opinion. A set of annual maximum peak 3-second gust velocities is derived from meteorological data for the geographical location under consideration, for each wind direction to be assessed. For all of these possible wind directions and speeds, the regions where each of the wind speed criteria may be exceeded are then considered.

Most people will consider a site unacceptable for a given activity if the mean and/or gust velocities in that area during the annual maximum wind event exceed the annual maximum wind speed criterion for that activity. The site would also be likely to be considered excessively windy for that activity during more moderate winds.

The threshold *gust* velocity criteria are:

Table 1: Recommended Wind Comfort and Safety Gust *Criteria.*

Annual Maximum Gust Speed	**Result on Perceived Pedestrian Comfort**
>23m/s	Unsafe (frail pedestrians knocked over)
<20m/s	Acceptable for **fast walking** (waterfront or particular walking areas)
<16m/s	Acceptable for **walking** (steady steps for most pedestrians)
<13m/s	Acceptable for **standing** (window shopping, vehicle drop off, queuing)
<11m/s	Acceptable for **sitting** (outdoor cafés, gardens, park benches)

In a similar manner, a set of hourly mean velocity criteria with a 0.1% probability of occurrence are also applicable to ground level areas in and adjacent to the proposed development. An area should be within both the relevant mean and gust limits in order to satisfy the particular human comfort and safety criteria in question.

The threshold *mean* velocity criteria are:

Table 2: Recommended Wind Comfort and Safety Mean *Criteria.*

Mean wind speed exceeded 0.1% of the time	**Result on Perceived Pedestrian Comfort**
>15m/s	Unsafe (frail pedestrians knocked over)
<13m/s	Acceptable for **fast walking** (waterfront or particular walking areas)
<10m/s	Acceptable for **walking** (steady steps for most pedestrians)
<7m/s	Acceptable for **standing** (window shopping, vehicle drop off, queuing)
<5m/s	Acceptable for **sitting** (outdoor cafés, gardens, park benches)

The specific requirements for Central Sydney, as stipulated in the Development Control Plan (2010) have been taken into consideration when determining the wind criteria for the proposed pedestrian areas. The DCP states that the maximum wind criteria that are to be met by new buildings (including refurbishments):

- 10 metres/second in retail streets,
- 13 metres/second along major pedestrian streets, parks and public places,
- 16 metres/second in all other streets.

The proposed development is located at the areas where the DCP requires a 16 m/s maximum annual wind speed. The wind criterion of walking is recommended for the footpath in this study.

3.1 APPLICABLE CRITERIA

The following table lists the specific areas adjacent to the proposed development and the corresponding recommended criteria (see also Figure 7).

Table 3: Recommended application of criteria

Area	Specific location	Recommended Criteria
Public Thoroughfares	Around the Proposed Development (Figure 7)	Walking
Playground	Southwest of the building	Walking
Building entrances	Several locations (Figure 7)	Standing
Areas not intended as public thoroughfares	On the SE corner of the development (due to proximity to substation, sewer pump station and loading dock entry, traffic noise from Western Distributor etc.)	Fast Walking

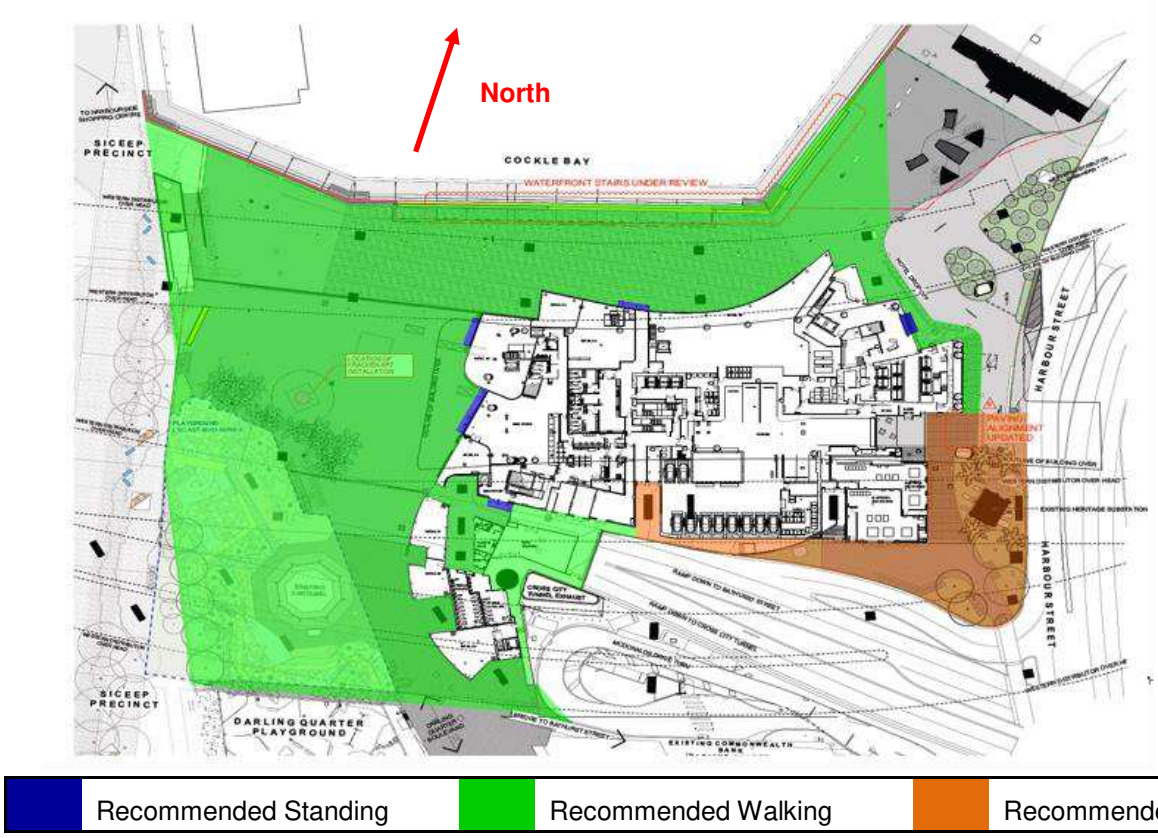


Figure 7: Plan view of the ground floor with the recommended wind criteria overlaid.

4 WIND TUNNEL SIMULATION

4.1 SIMILARITY REQUIREMENTS

The validity of wind tunnel testing relies on the similarity between model and full-scale parameters. This requires undistorted length scaling (i.e. geometric similarity), similarity of flow parameters (i.e. kinematic similarity) and finally similarity of pressures and forces.

Complete similarity is usually impossible to obtain because of the competing requirements of the various non-dimensional parameters, (e.g. Reynolds Number, Rossby Number and Richardson Number). Some requirements (i.e. Reynolds Number equality) can be waived for sharp edged structures immersed in a neutrally stable atmospheric boundary layer and geometric and kinematic similarity suffice. These are the requirements specified in Section C1.4, AS/NZS 1170.2 Supplement 1: 2011 [4] and are employed in this study.

4.2 APPROACH WIND SIMULATION

The wind effects tests were carried out in the 3m wide × 2m tall × 16m long Boundary Layer Wind Tunnel at Vipac Engineers and Scientists Ltd in Melbourne. The Boundary Layer Wind Tunnel is designed to simulate the flow incident on a proposed development by modelling the upstream terrain characteristic roughness. To this end, an estimate of the upstream terrain properties for the development has been made and reproduced in the wind tunnel.

The approaching mean and turbulent flows of the Atmospheric Boundary Layer for the terrain category was modelled based on Australia Standard AS 1170.2-2011 (Figure 3). The wind tunnel calibration velocity and turbulence intensity profile for Terrain Category 2 for a sector of 340-350 azimuth degrees, Terrain Category 3.5 (Urban terrain) for 0(360)-150 azimuth degrees and Terrain Category 3 for other directions (160-330) are shown in Figure 8, Figure 9 and Figure 10. These represent the wind velocity and turbulence intensity profile approaching the model of the development. Closer to the ground the wind moves more slowly but with increased turbulence. The simulated approach is indicative of full-scale planetary boundary layer velocity and turbulence intensity profiles. Velocity correction factors were used to adjust the measured wind speed to ensure that the ratio of mean roof-height to reference height wind speed in the wind tunnel matches expected full-scale values.

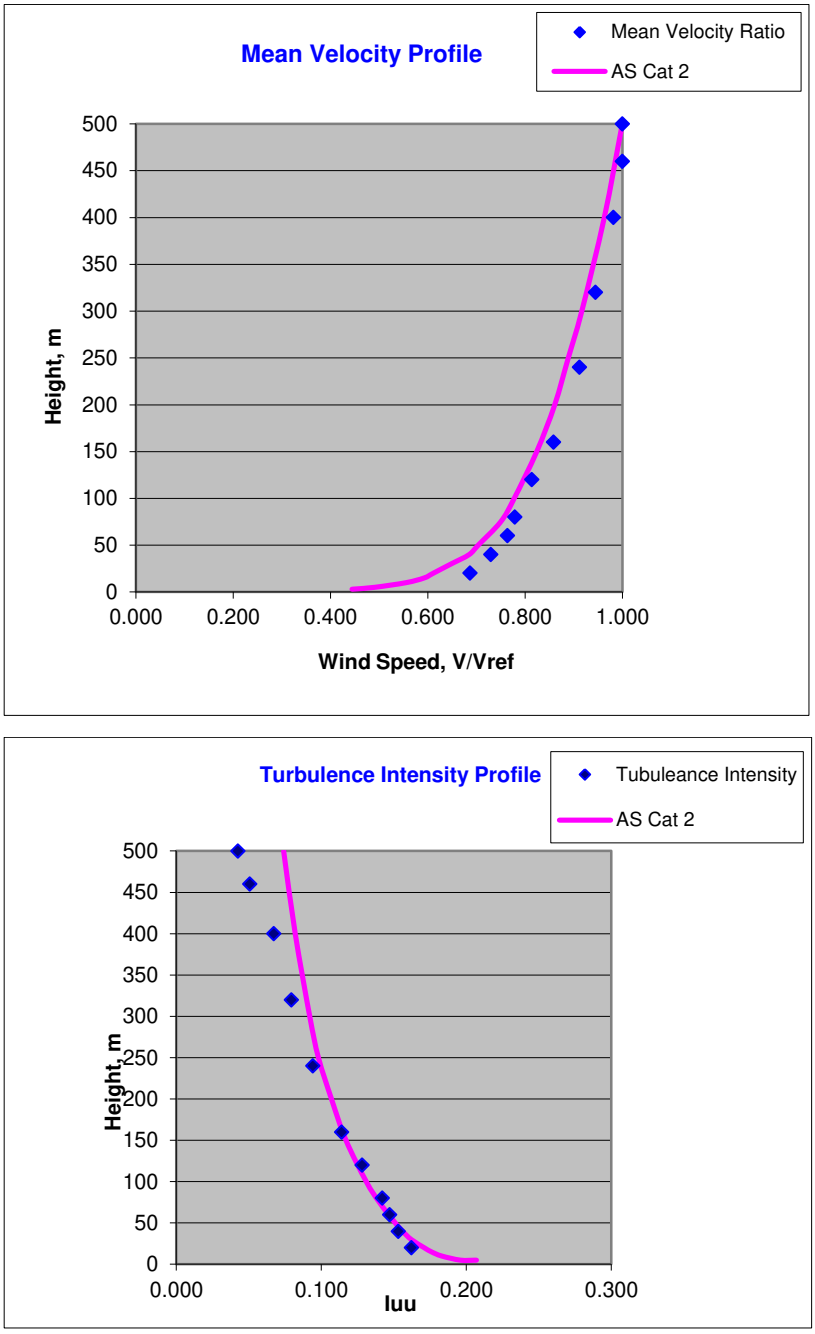
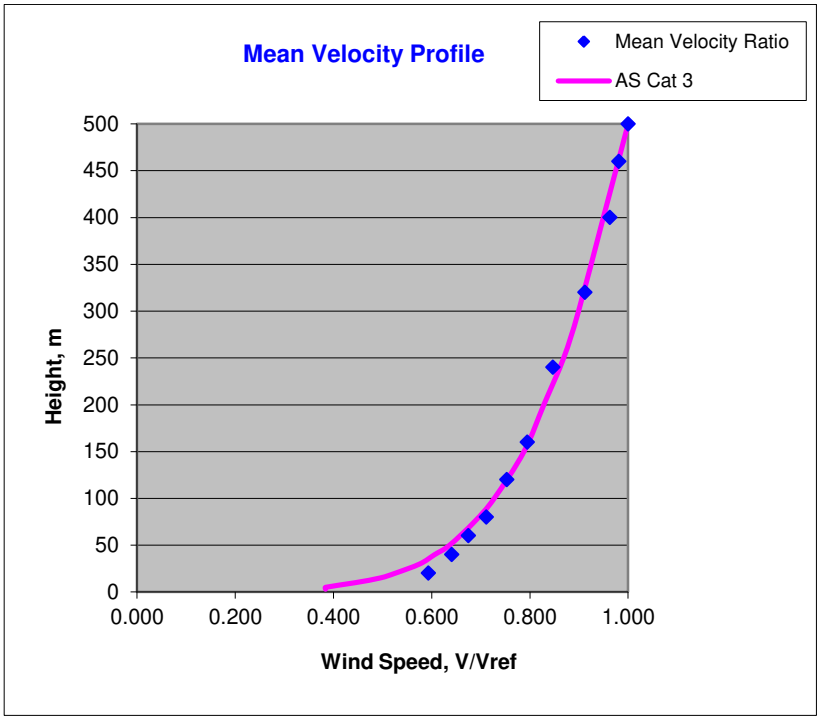


Figure 8: Mean Velocity and Turbulence Intensity Profiles for Terrain Category 2 (1:400 scale).



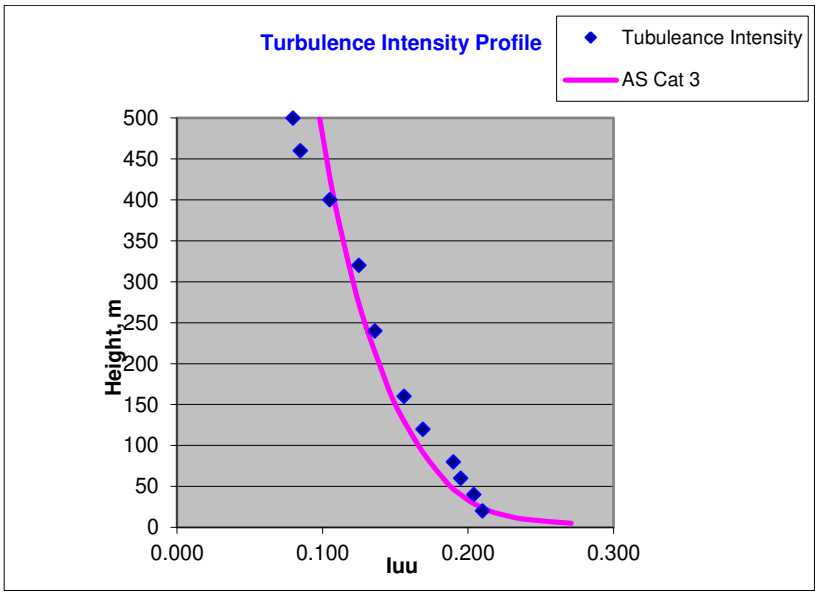
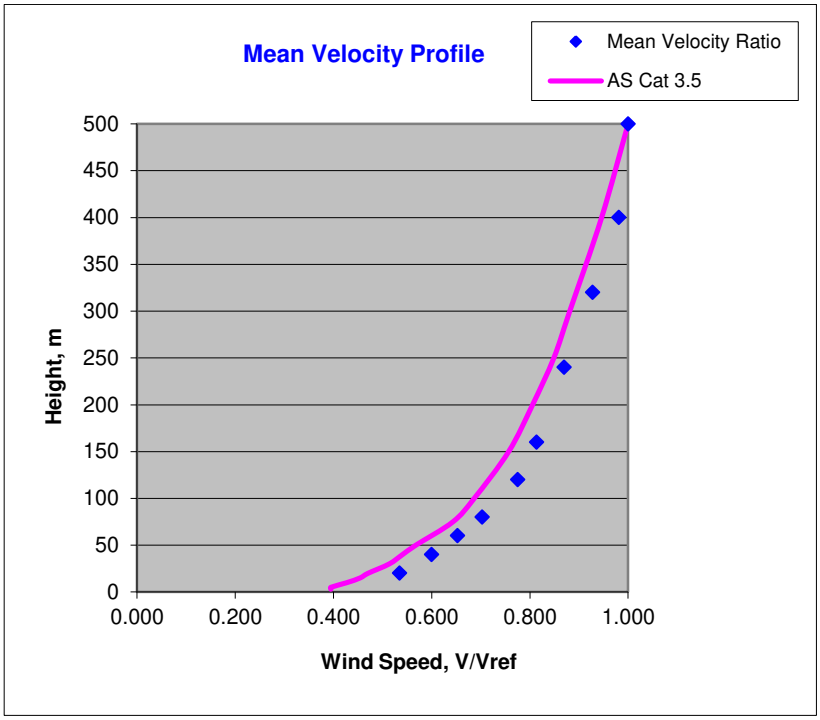


Figure 9: Mean Velocity and Turbulence Intensity Profiles for Terrain Category 3 (1:400 scale).



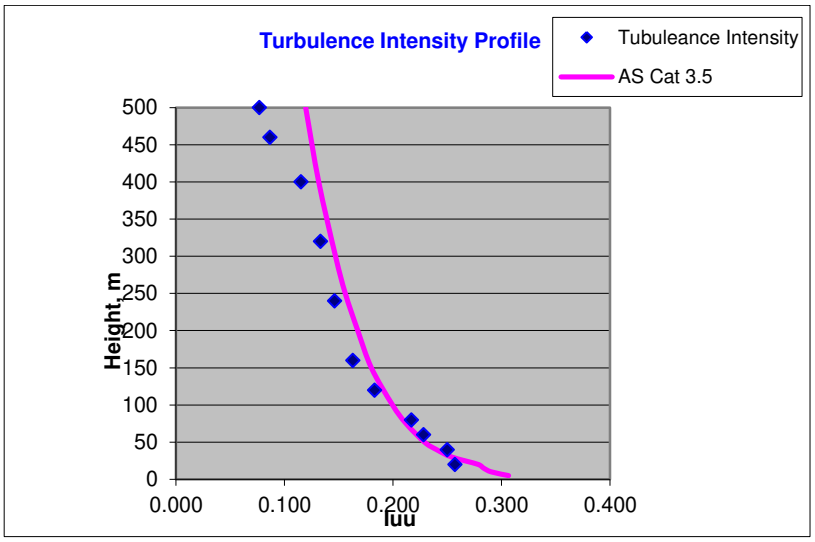


Figure 10: Mean Velocity and Turbulence Intensity Profiles for Terrain Category 3.5 (1:400 scale).

5 TEST PROCEDURE

The pedestrian level wind environment at the footpaths, entrances were assessed using omnidirectional pressure sensor tests (point method).

5.1 OMNIDIRECTIONAL PRESSURE SENSORS

Velocity measurements were made using Irwin sensors (omnidirectional pressure sensors) installed at several locations on the ground level footpath areas, entrances and functional balcony areas of the proposed development. The test was initially conducted without any landscaping. The proposed landscaping was then included in some areas where the recommended criteria were exceeded. Additional wind mitigation measures were then included in order to ensure all areas met the recommended wind speeds.

The distribution of Irwin sensors has allowed the determination of the variation in velocity sufficient to capture the changes in velocity distribution that can typically occur over such areas. The resolution of measurement locations is in accordance with that prescribed in the Wind Tunnel Testing Quality Assurance Manual of the Australasian Wind Engineering Society.

PVC tubes with 1.5 mm internal diameter linked the Irwin sensors to pressure transducer device using a tuned arrangement to prevent harmonic fluctuations.

Velocity measurements were obtained at 10° wind azimuth increments starting from 0° (north) for a full 360° circle. The sampling time is determined based on the similarity criteria and corresponds to a total time of one hour in full scale. Statistical analysis was carried out on the signals for the mean and standard deviation. All velocity coefficients derived from the wind tunnel were converted to velocities by integrating the data with the Sydney wind climate and corresponding to a 1-year return period design wind speeds.

6 PEDESTRIAN LEVEL WIND ASSESSMENT

The pedestrian level wind assessment of the public thoroughfares, building entrances, and adjacent pedestrian areas of the proposed development was determined using omnidirectional pressure sensors.

A total of 38 sensors were used in order to provide a quantitative measure of the ground level wind speeds at various locations around the development. The tests were conducted for full 360° with 10° resolution.

The sensor locations are shown in Figure 11

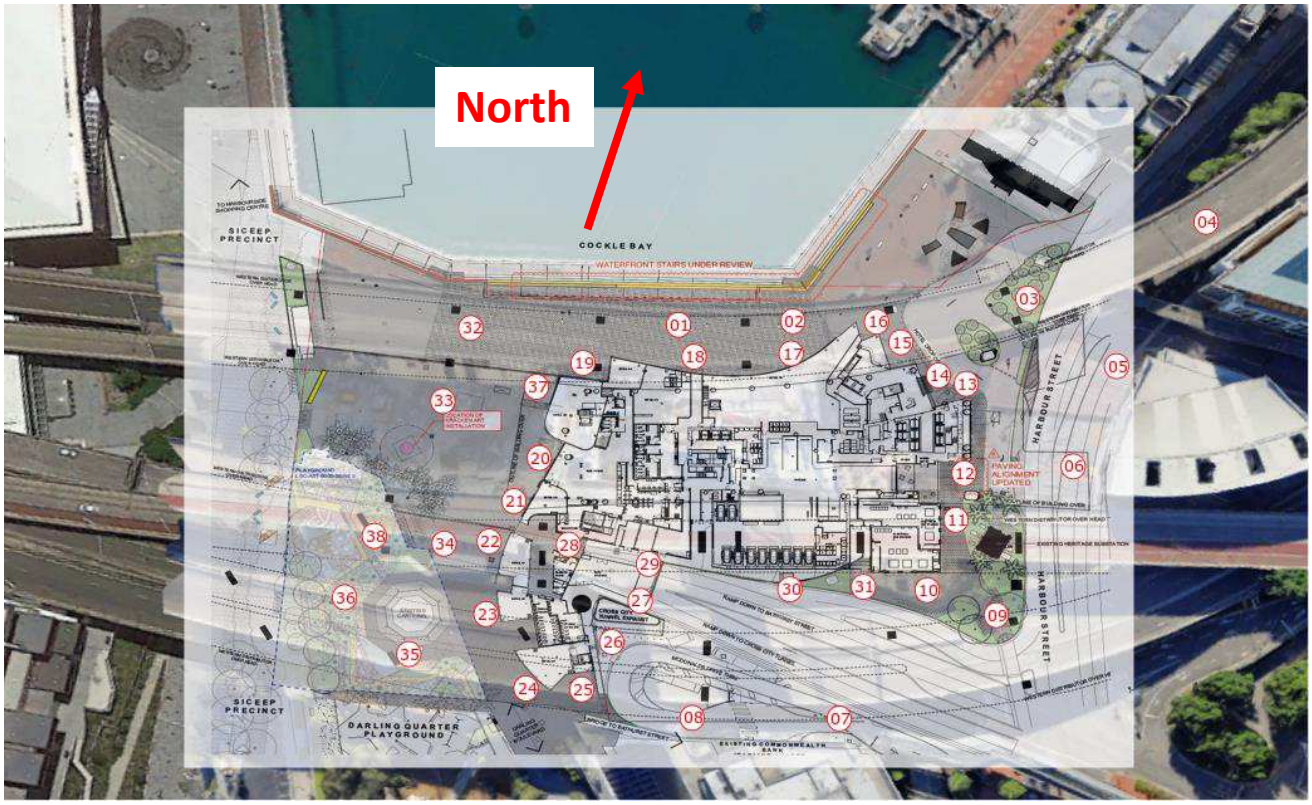


Figure 11: Sensor Locations and Numbers.

7 RESULTS AND DISCUSSION

The pedestrian wind environment in the footpaths and building entrance areas was assessed using omnidirectional pressure sensor tests. These results are presented as polar plots for the gust wind speeds and are shown in Appendix C of this report. Figure 12 shows an example of these plots. In the Figure, the colour circles represent the velocities for the different criteria and the three sets of symbols with lines represent the test predicted gust velocity for the 36 directions. The title of the plot also indicates the sensor number and the required criterion for this location.

Figure 12 shows that at location 14 (entrance to hotel lobby area) the existing conditions (blue data set) are within the standing criterion, however once the proposed building is in place, wind speeds in this location are reduced to within the more stringent sitting criterion.

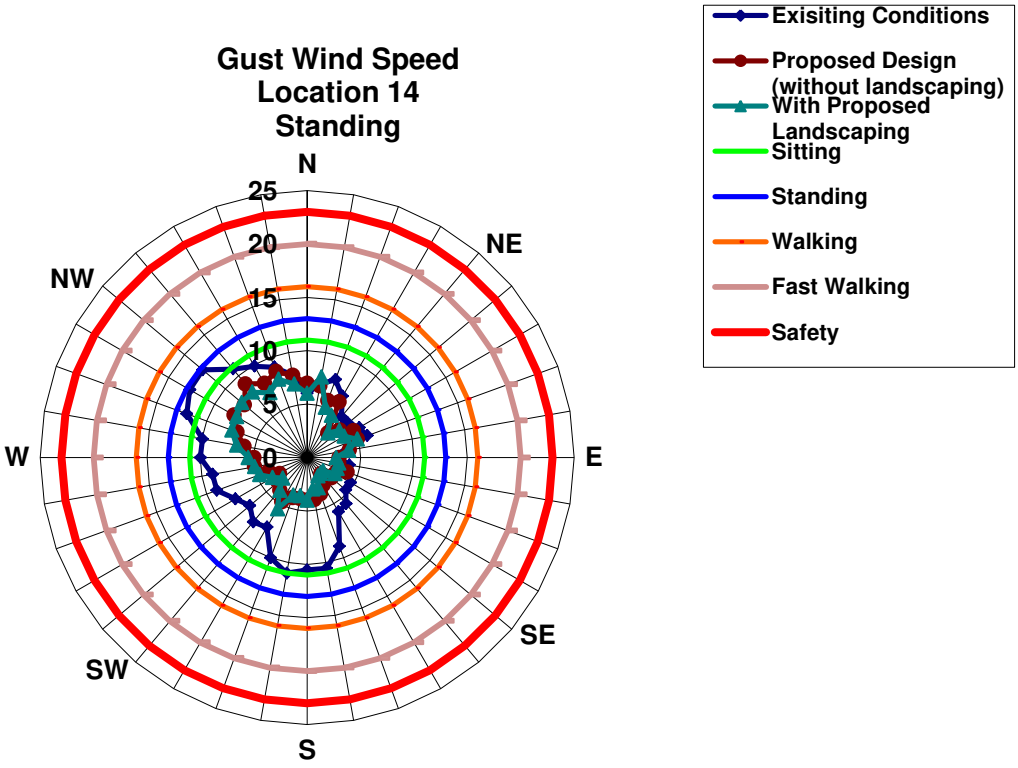


Figure 12: Polar plot showing the wind gust compared with safety and other comfort criteria (Location 14).

Two main types of tests were conducted during the testing:

1) **Safety test:** without any landscaping.
2) **Comfort test:** performed with proposed landscaping

An empty site configuration was also tested as a reference.

Based on the tests conducted, the following points were observed:

SAFETY CRITERION

Test results showed that the proposed development would not generate any safety issues for the pedestrian level wind environment.

COMFORT CRITERIA

Public Thoroughfares at Ground Floor

The wind conditions at the public domain thoroughfares were measured to have wind speeds within the recommended walking comfort criterion with the exception of locations 21, 22, 32 and 33.

Locations 32 and 33 were found to be similar to existing wind conditions of fast walking. Vipac deems this to be acceptable due to the proximity of the site to the waterfront. As such no recommendations were made for these areas.

Locations 21 and 22 were found to exceed the recommended walking comfort criterion. Further analysis as determined that the exceedances of Location 21 and 22 occur approximately once per month. Due to the proximity of the proposed development to waterfront and as a non-primary pedestrian thoroughfare, we recommended the criterion for this area to be relax to fast walking. As such, no recommendations for wind amelioration were made.

Playground area

With the proposed design, the playground is measured to have wind speeds within the recommended walking criterion; some areas fulfil the more stringent standing comfort criterion.

Building Entrances

With the proposed design, all main building entrances were measured to have wind speeds within the recommended standing criterion for all wind directions

Neighbouring Footpaths

With the proposed design, the neighbouring footpaths and areas not intended as public thoroughfares were measured to have wind speeds within the recommended fast walking criterion. Note that, Vipac uses fast walking criterion to assess the wind conditions for these areas due to several factors, including the lower accuracy requirement of the surrounding building models (<10%) compared to the target building model (<2%).

8 CONCLUSIONS

Vipac carried out wind tunnel testing to determine the likely pedestrian level wind effects for the proposed **The Ribbon** development at **31 Wheat Rd, Sydney, NSW.**

Wind conditions were assessed based on internationally accepted comfort and safety criteria. Based on the test results, the following conclusions are drawn:

- With the proposed design and without any landscaping, the development would generate wind conditions that satisfy the safety criterion at all test locations.
- With the proposed design, the development would generate wind conditions that satisfy the comfort criteria at most of test locations. For some areas where the criterion was exceeded, severity of the comfort criterion due to the proximity of the site to the waterfront was discussed. Vipac believes that these areas would have acceptable wind environment.
- The proposed development would not generate significant adverse wind impact in the adjacent footpath areas.

This report has been prepared

for

Grocon Constructors Pty Ltd

by

Vipac Engineers & Scientists Ltd

APPENDIX A – REFERECNCES

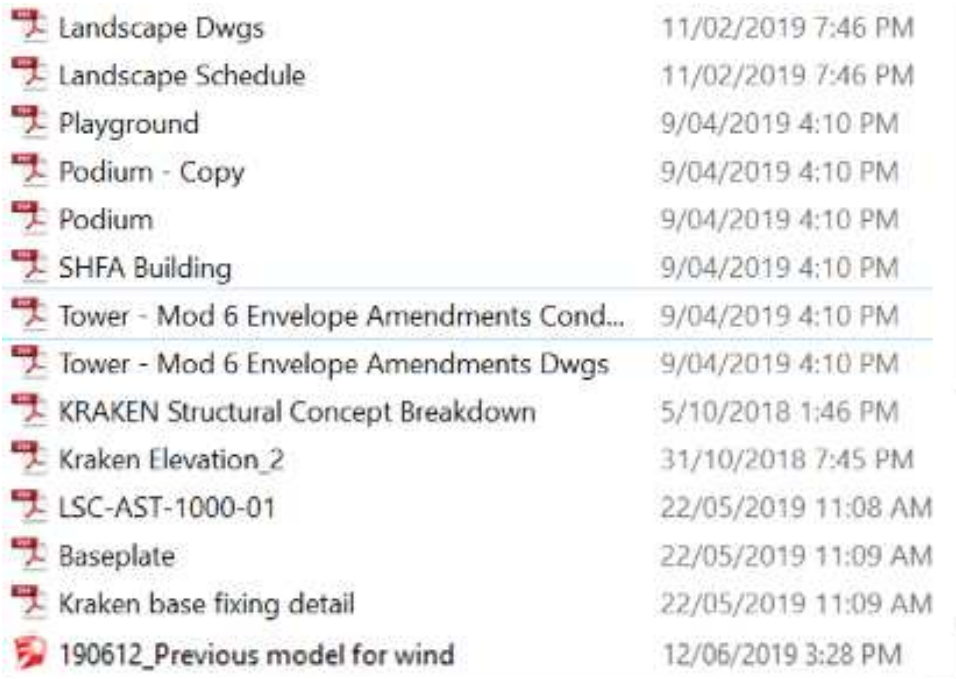
1) Australian/New Zealand St andard 1170.2:2011, Wind actions

2) Melbourne, W. H., “Criteria for Environmental Wind Conditions”, Jour. Industrial Aerodynamics, Vol. 3, 241-249,1978

3) Australian Wind Engineering Society, “Cladding Pressure and Environmental Wind Studies” Quality Assurance Manual, 1994

4) AS/NZS 1170.2 Supplement 1: 2011

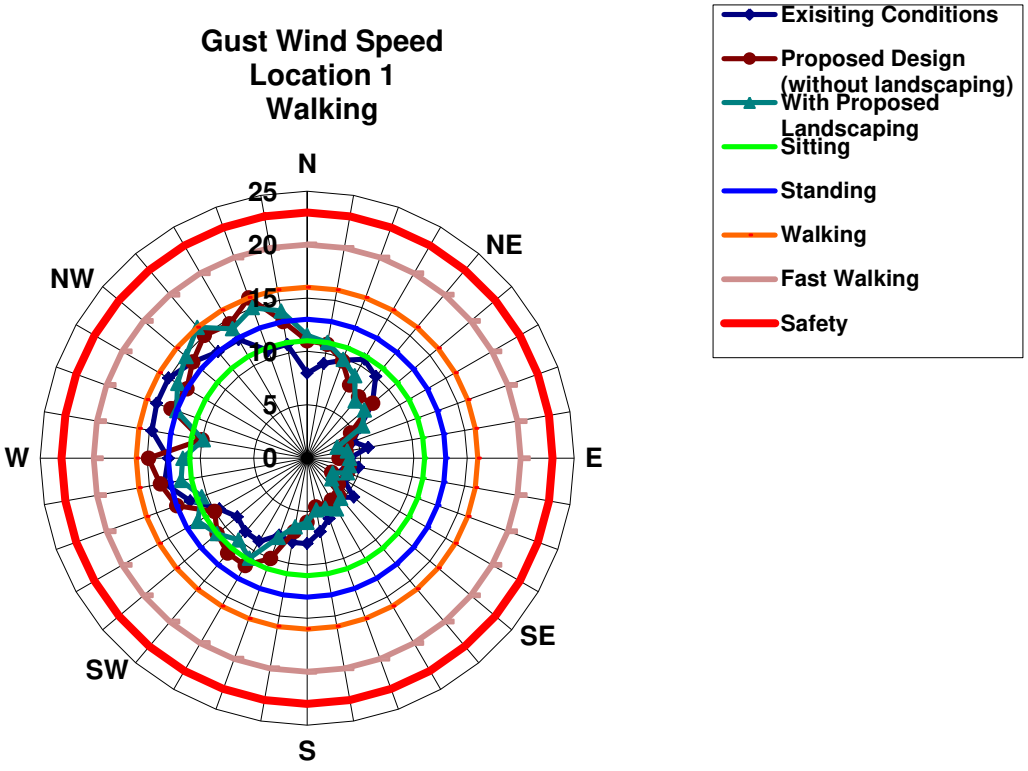
APPENDIX B – DRAWING LIST

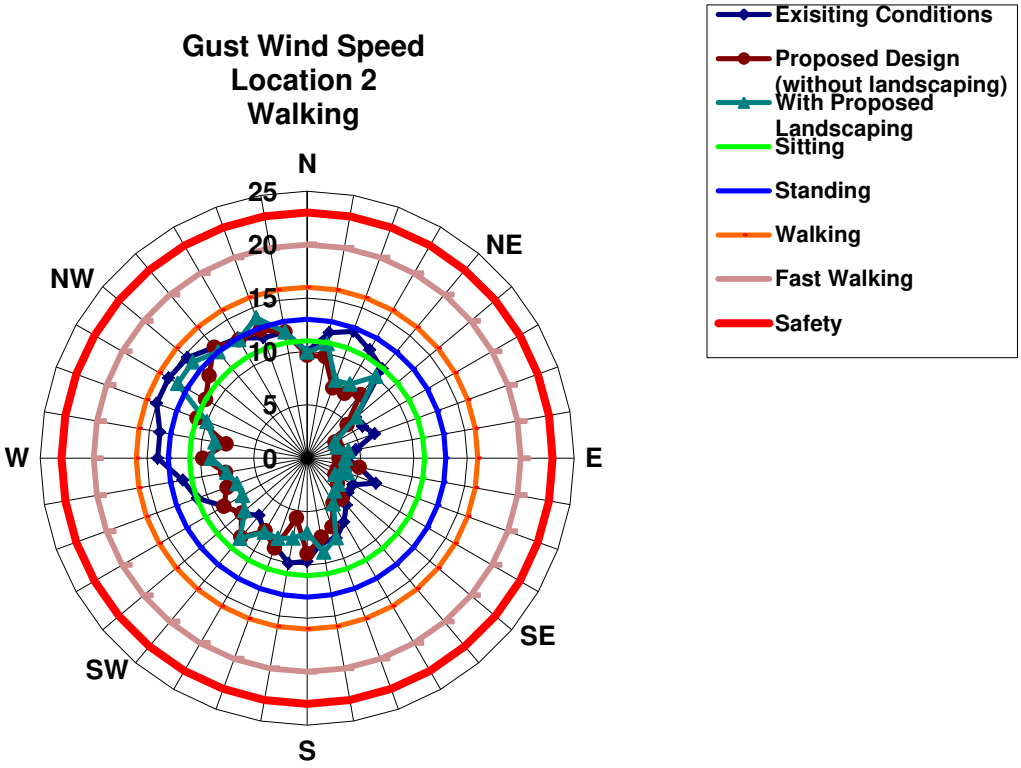


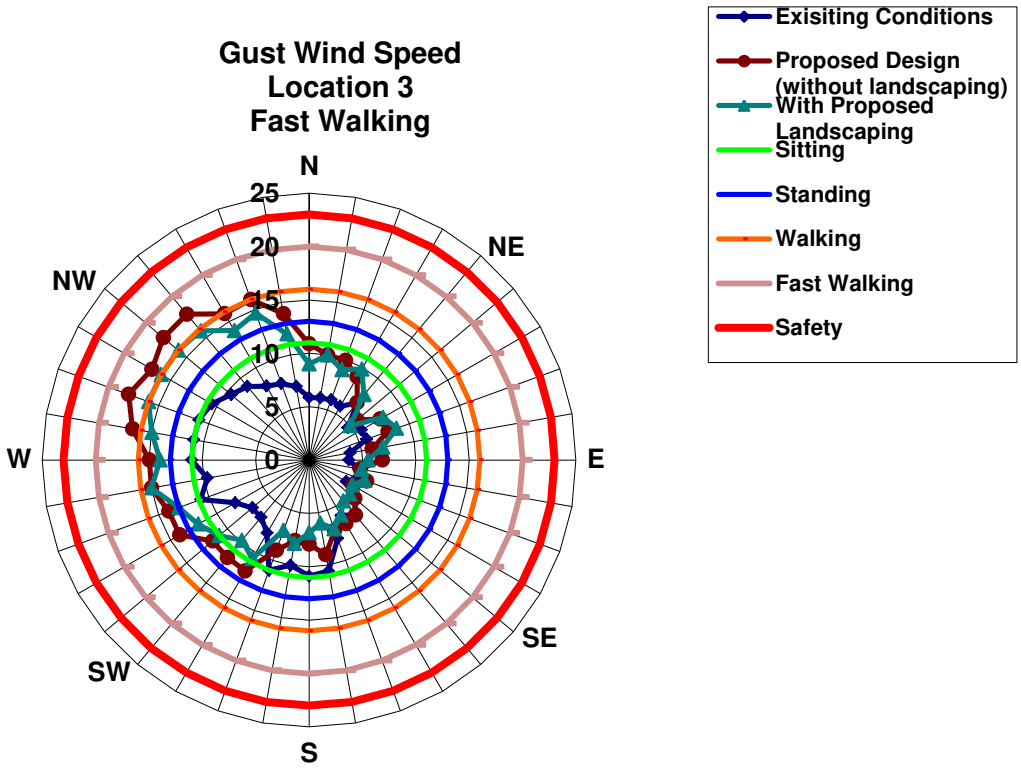
Landscape Dwgs	11/02/2019 7:46 PM
Landscape Schedule	11/02/2019 7:46 PM
Playground	9/04/2019 4:10 PM
Podium - Copy	9/04/2019 4:10 PM
Podium	9/04/2019 4:10 PM
SHFA Building	9/04/2019 4:10 PM
Tower - Mod 6 Envelope Amendments Cond...	9/04/2019 4:10 PM
Tower - Mod 6 Envelope Amendments Dwgs	9/04/2019 4:10 PM
KRAKEN Structural Concept Breakdown	5/10/2018 1:46 PM
Kraken Elevation_2	31/10/2018 7:45 PM
LSC-AST-1000-01	22/05/2019 11:08 AM
Baseplate	22/05/2019 11:09 AM
Kraken base fixing detail	22/05/2019 11:09 AM
190612_Previous model for wind	12/06/2019 3:28 PM

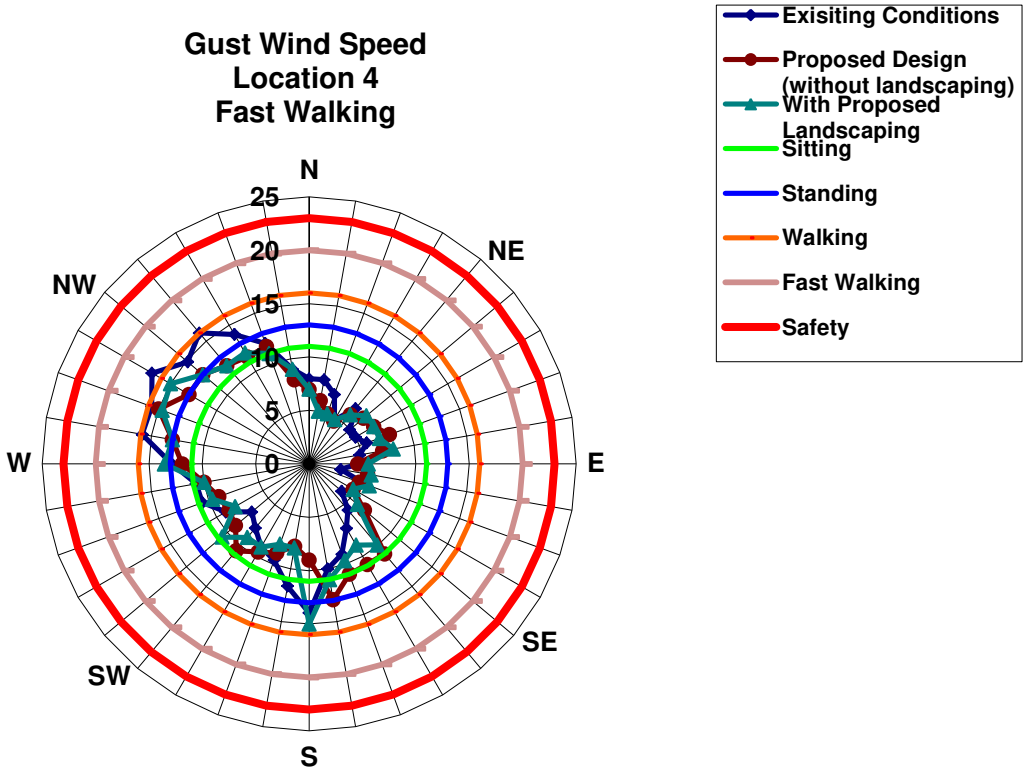
APPENDIX C - POLAR PLOTS OF MEASURED WIND SPEEDS

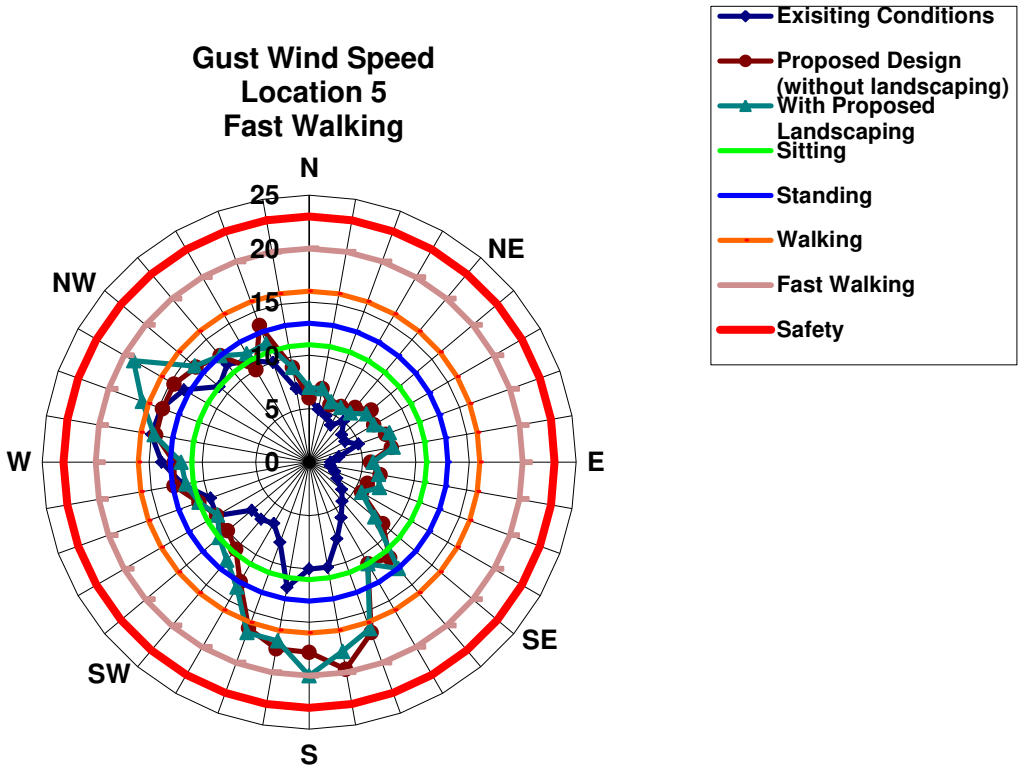
Note: Only gust wind speeds for all test locations are presented.

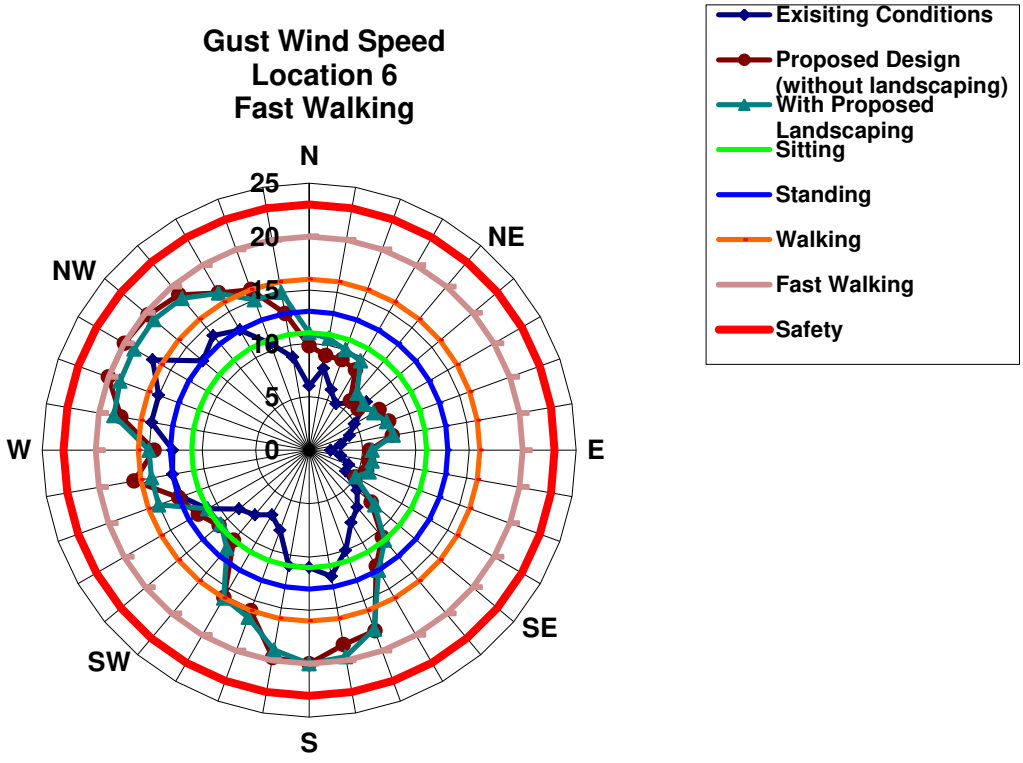


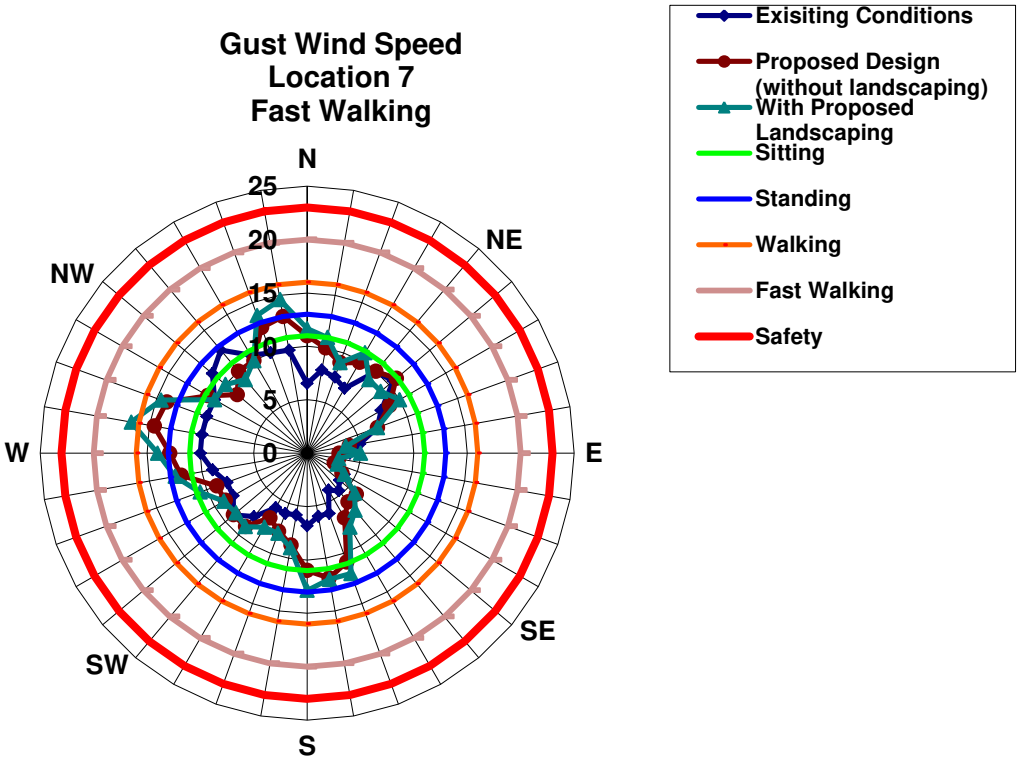


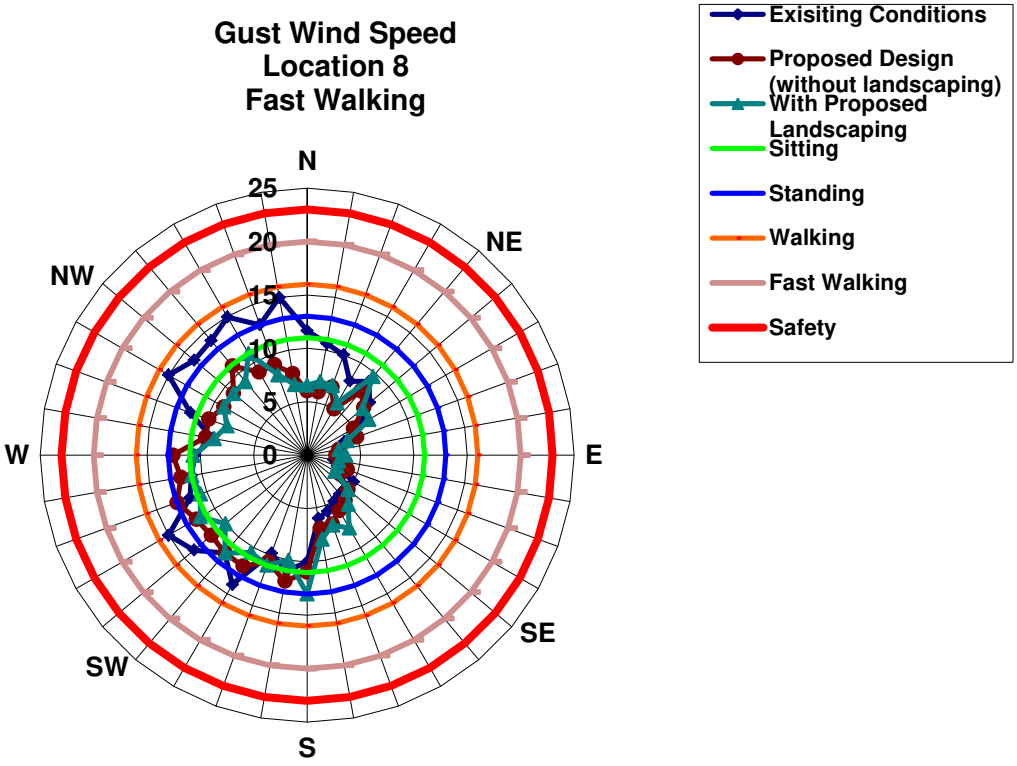

Gust Wind Speed
Location 3
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

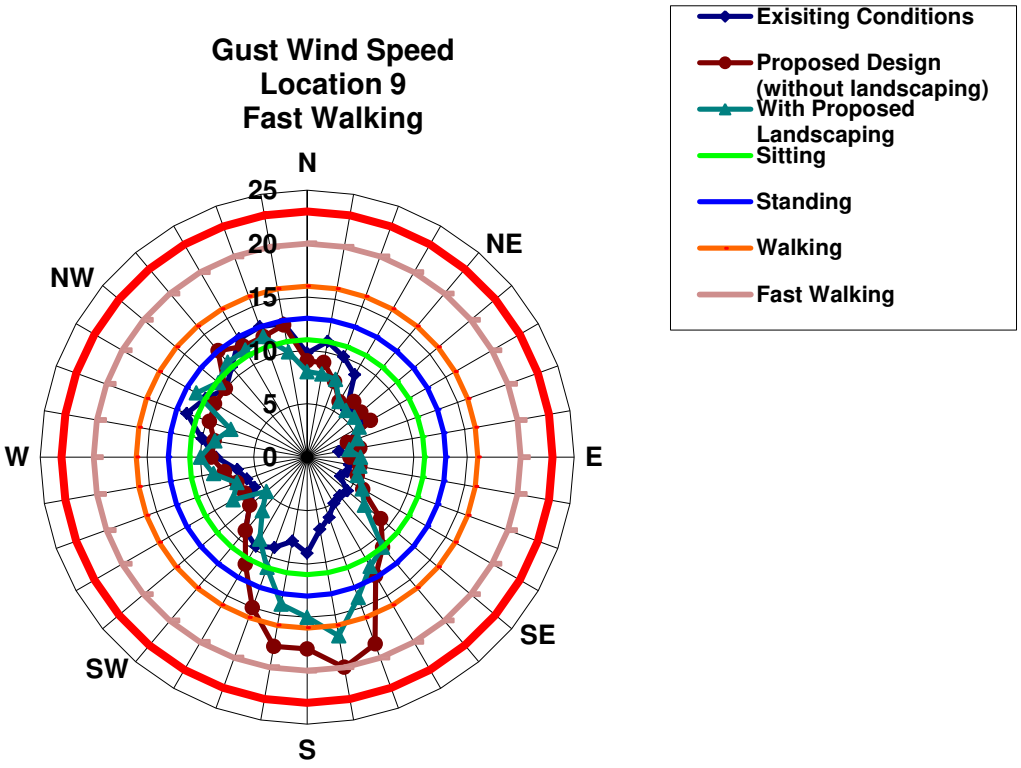

Gust Wind Speed
Location 4
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

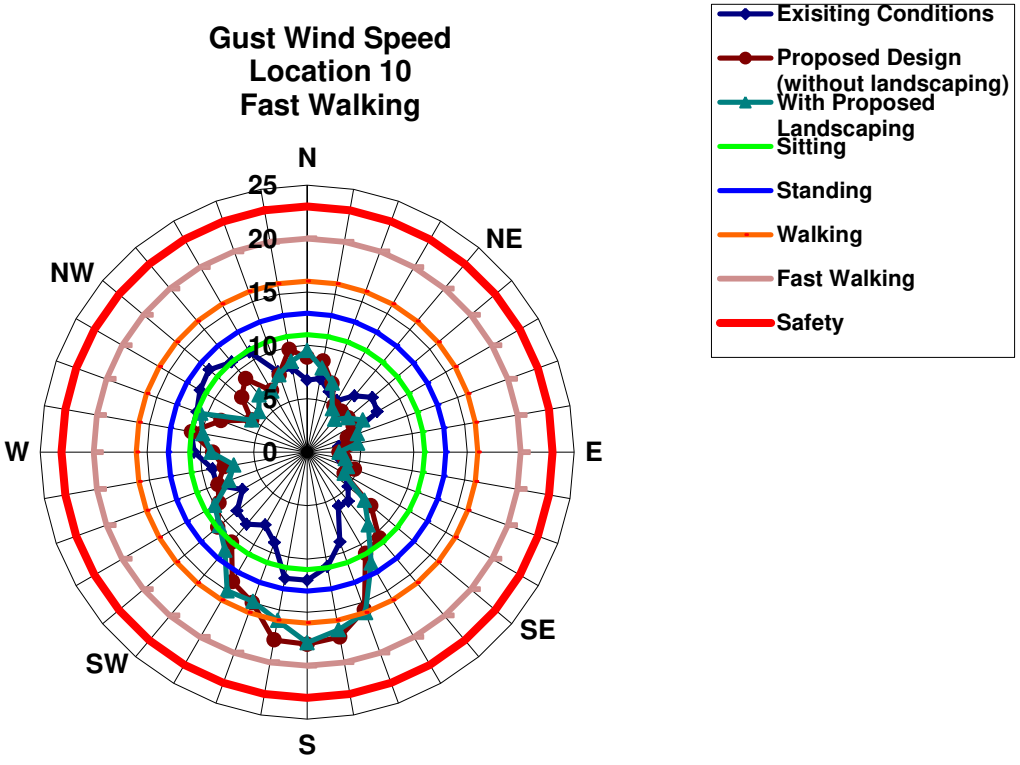

Gust Wind Speed
Location 5
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

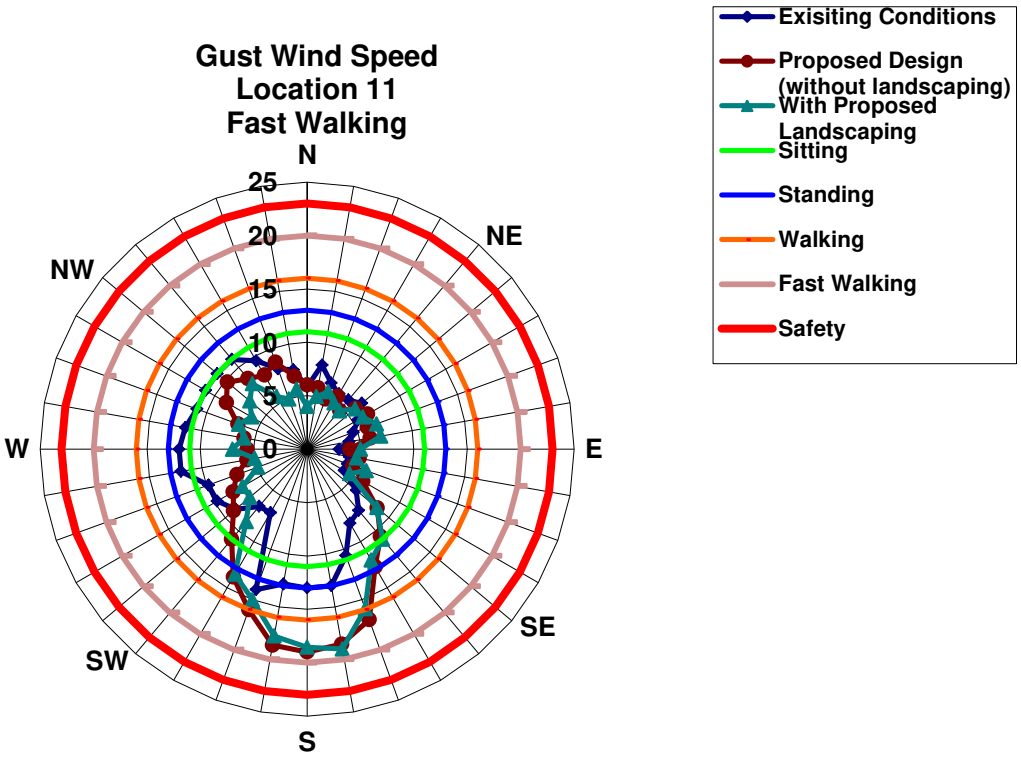

Gust Wind Speed
Location 6
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

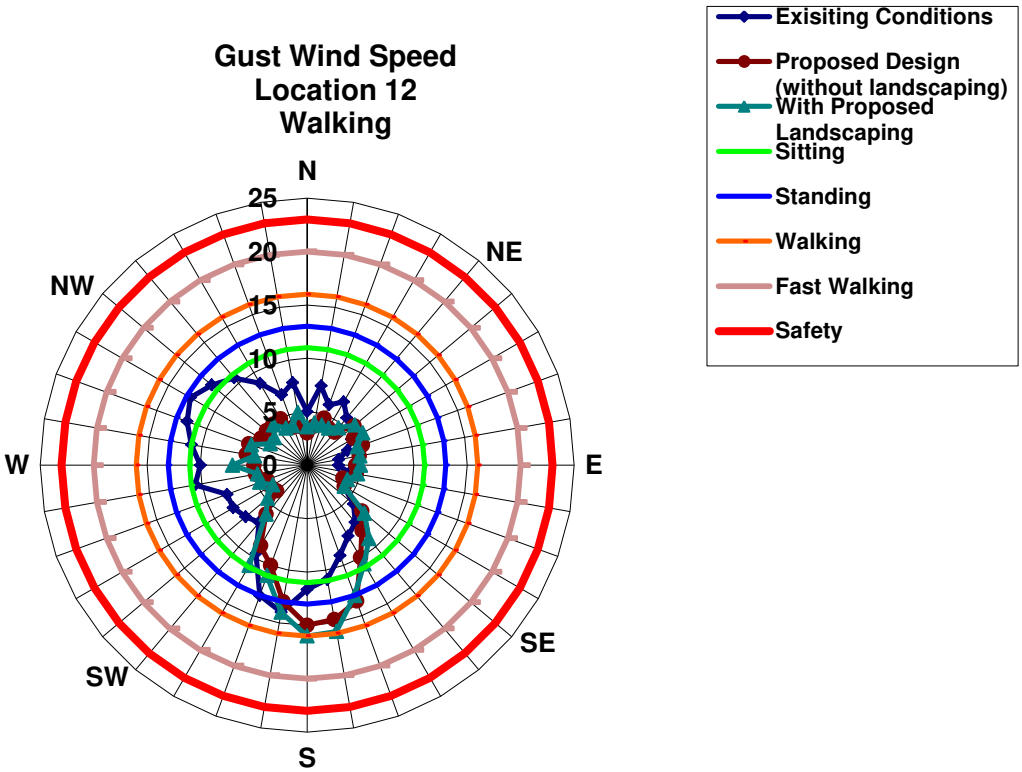

Gust Wind Speed
Location 7
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

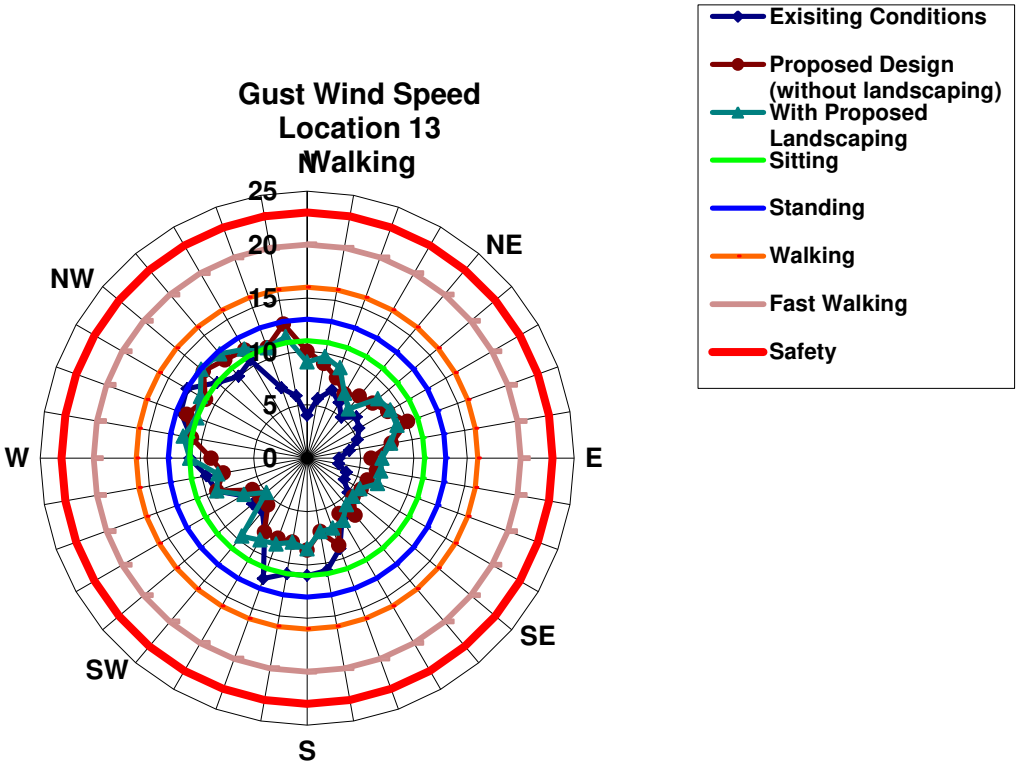

Gust Wind Speed
Location 8
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

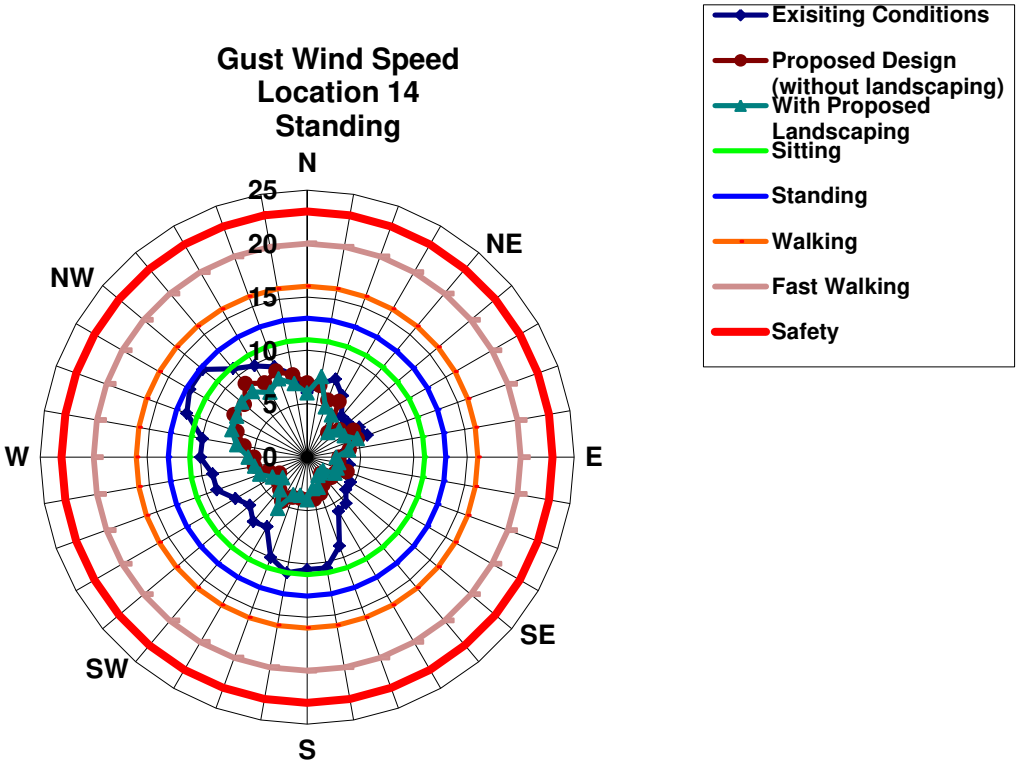

Gust Wind Speed
Location 9
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking

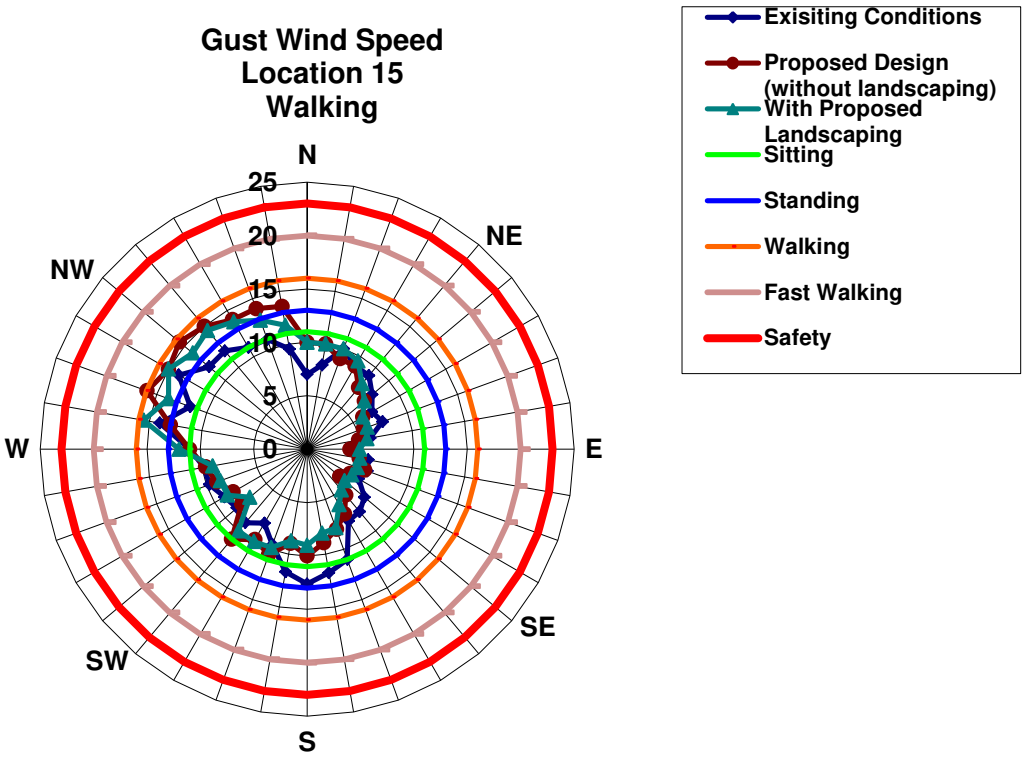

Gust Wind Speed
Location 10
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

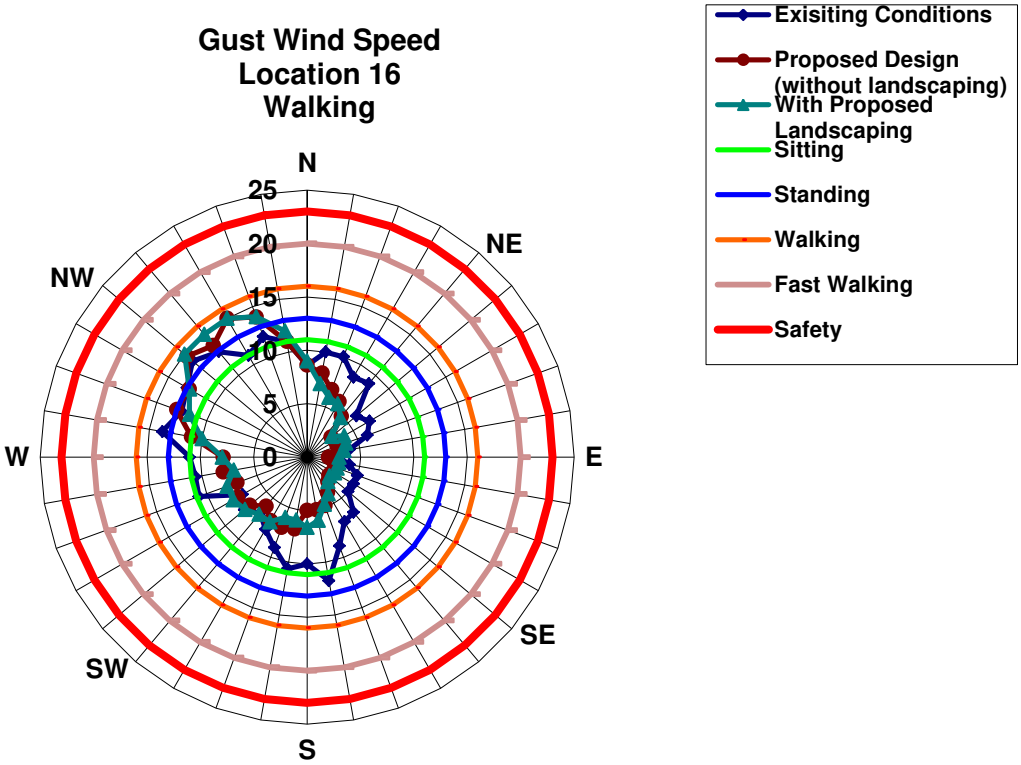

Gust Wind Speed
Location 11
Fast Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

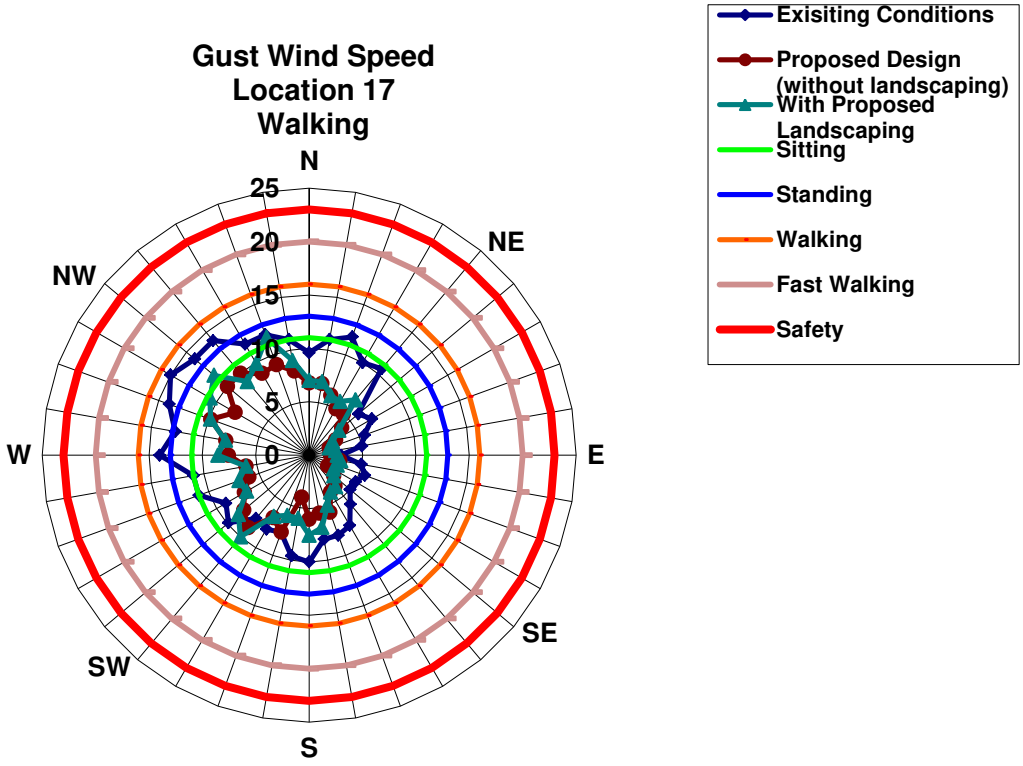

Gust Wind Speed
Location 12
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

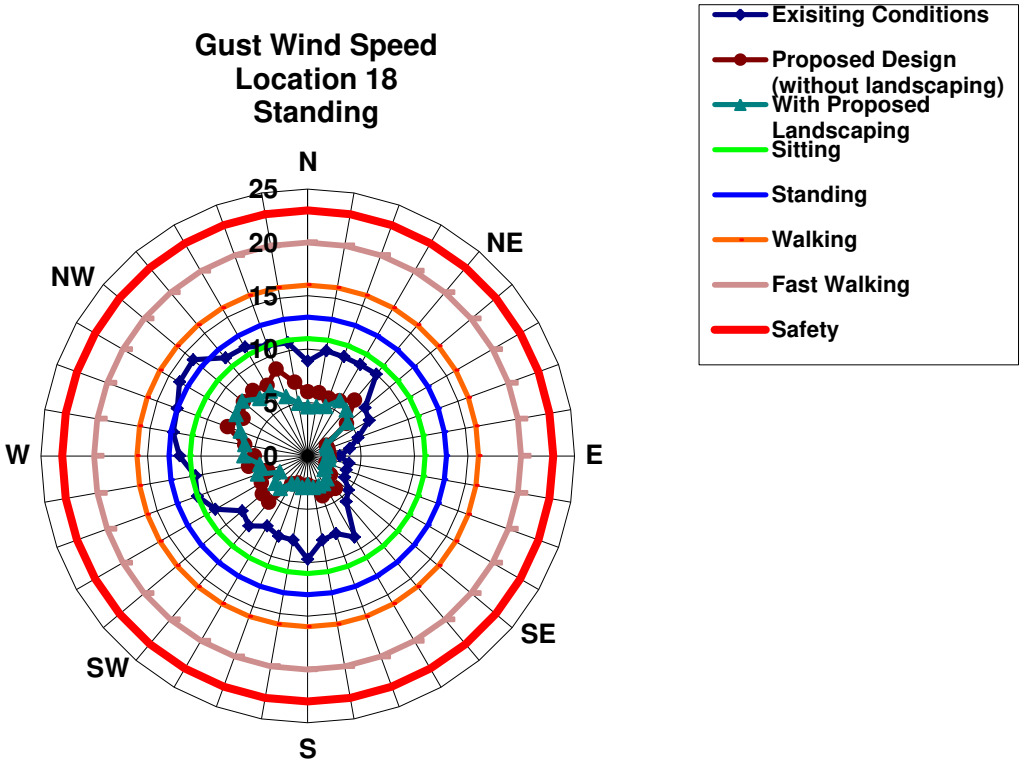

Gust Wind Speed
Location 13
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

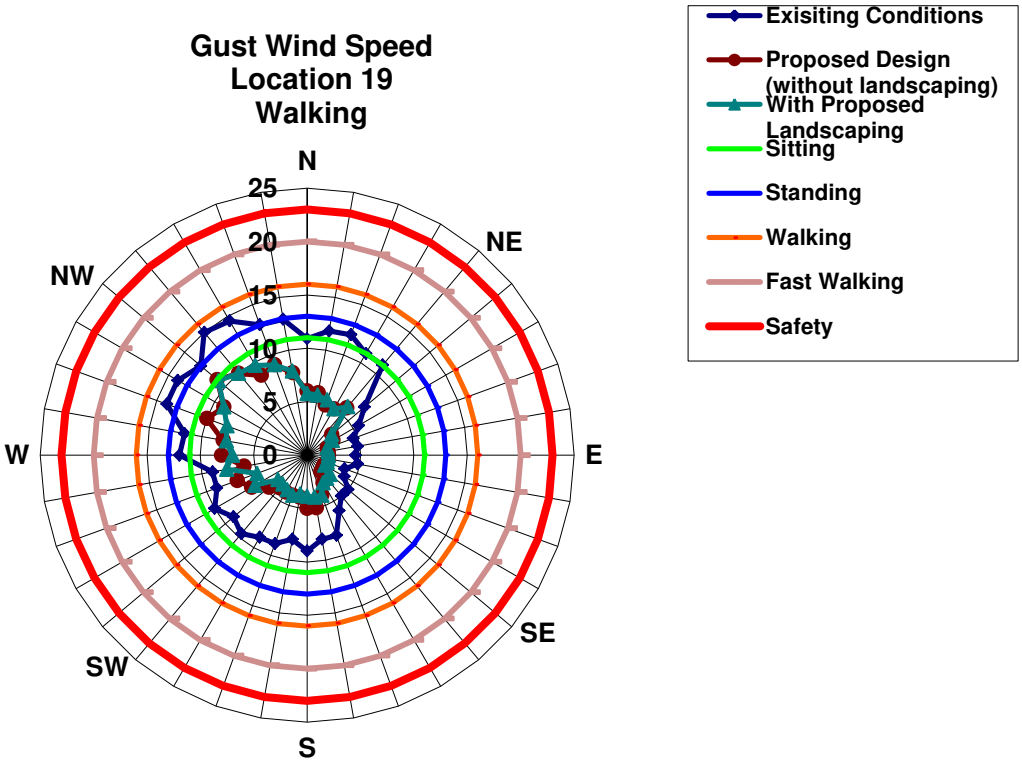

Gust Wind Speed
Location 14
Standing
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

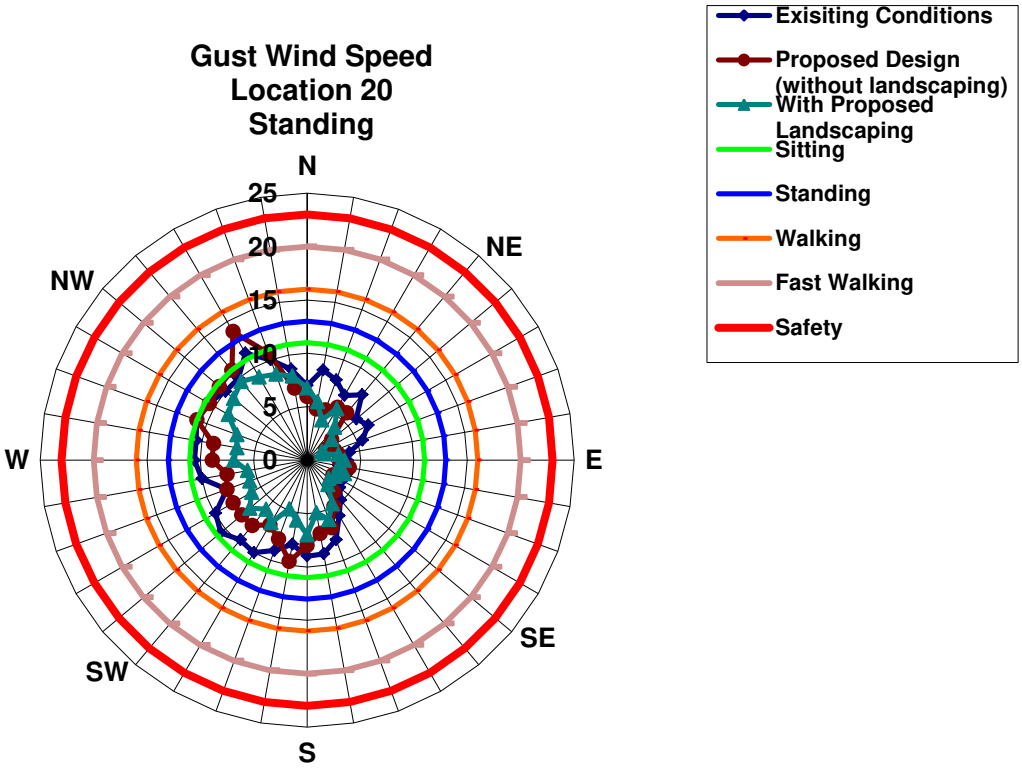

Gust Wind Speed
Location 15
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

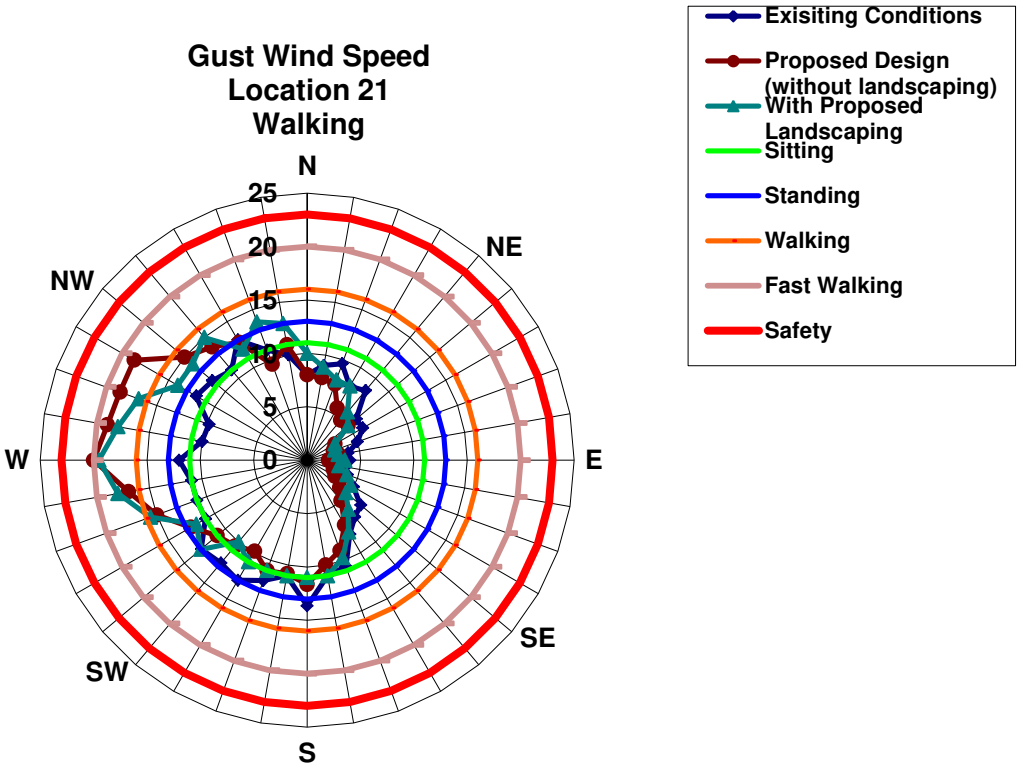

Gust Wind Speed
Location 16
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

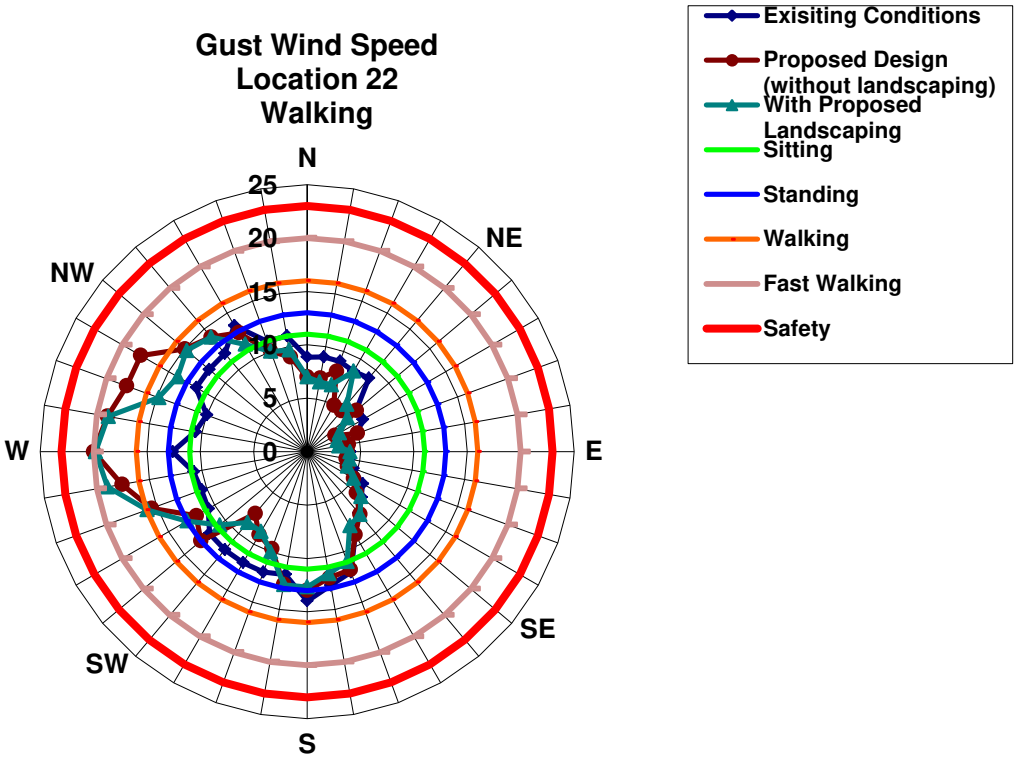

Gust Wind Speed
Location 17
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

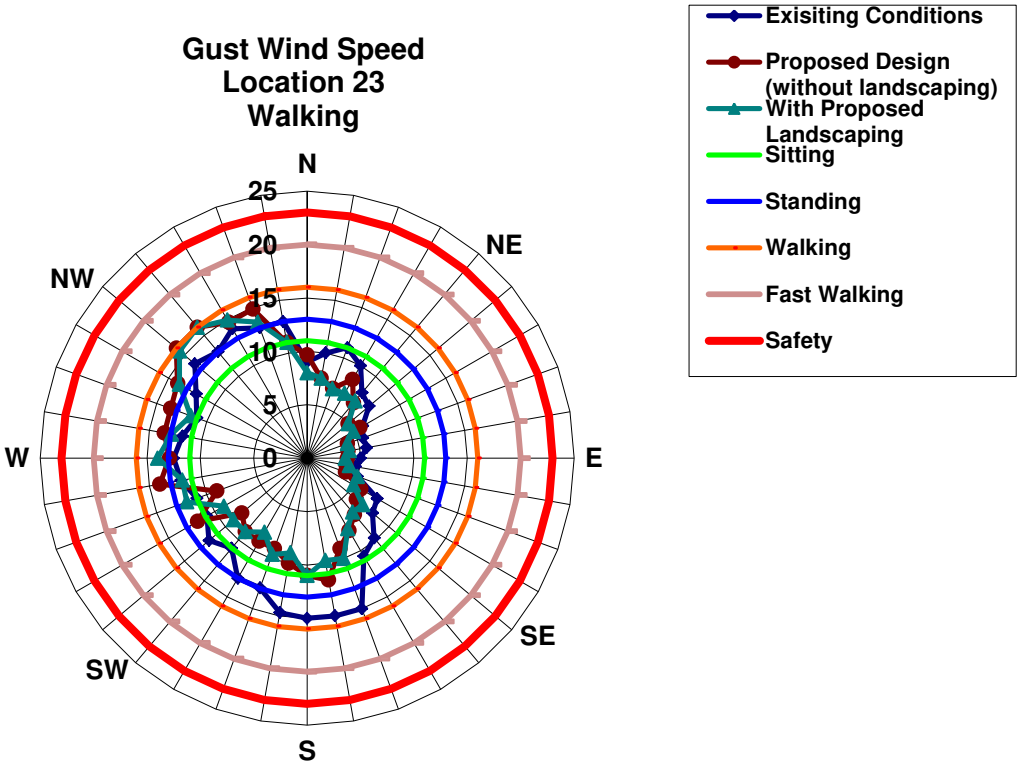

Gust Wind Speed
Location 18
Standing
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

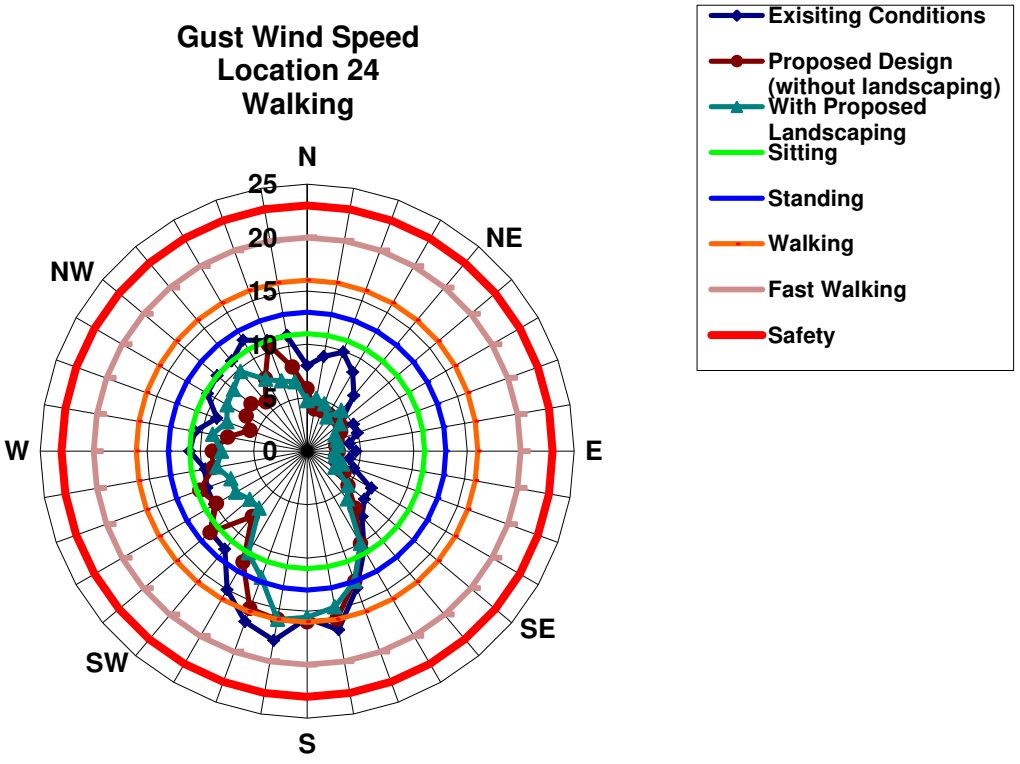

Gust Wind Speed
Location 19
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

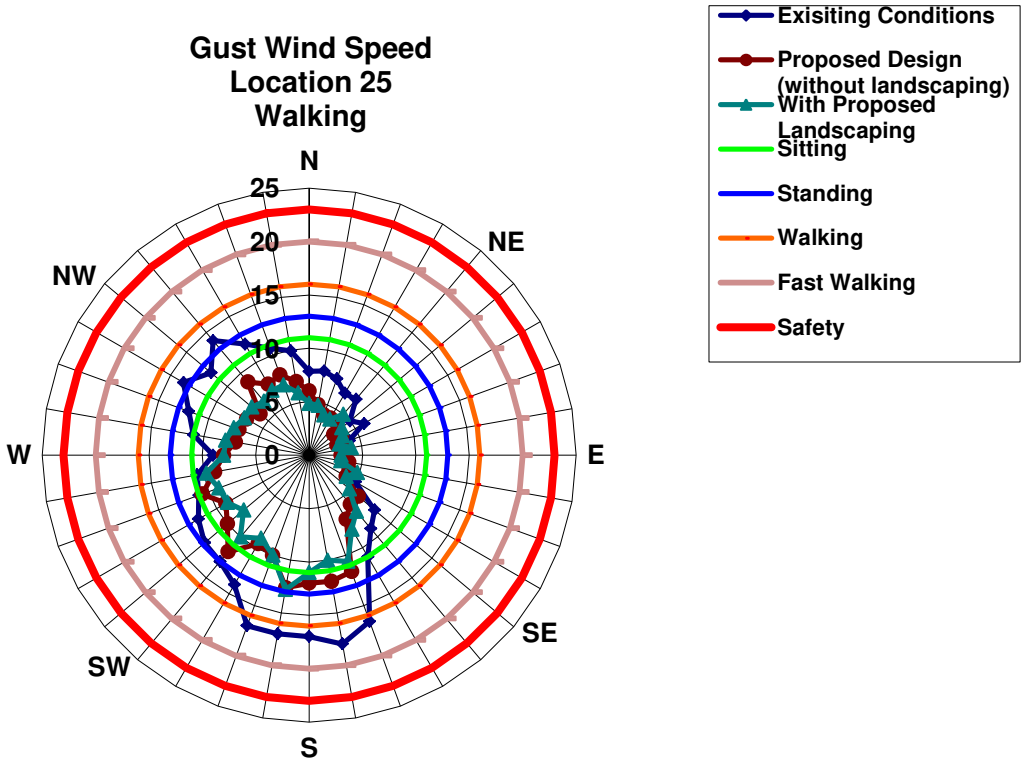

Gust Wind Speed
Location 20
Standing
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

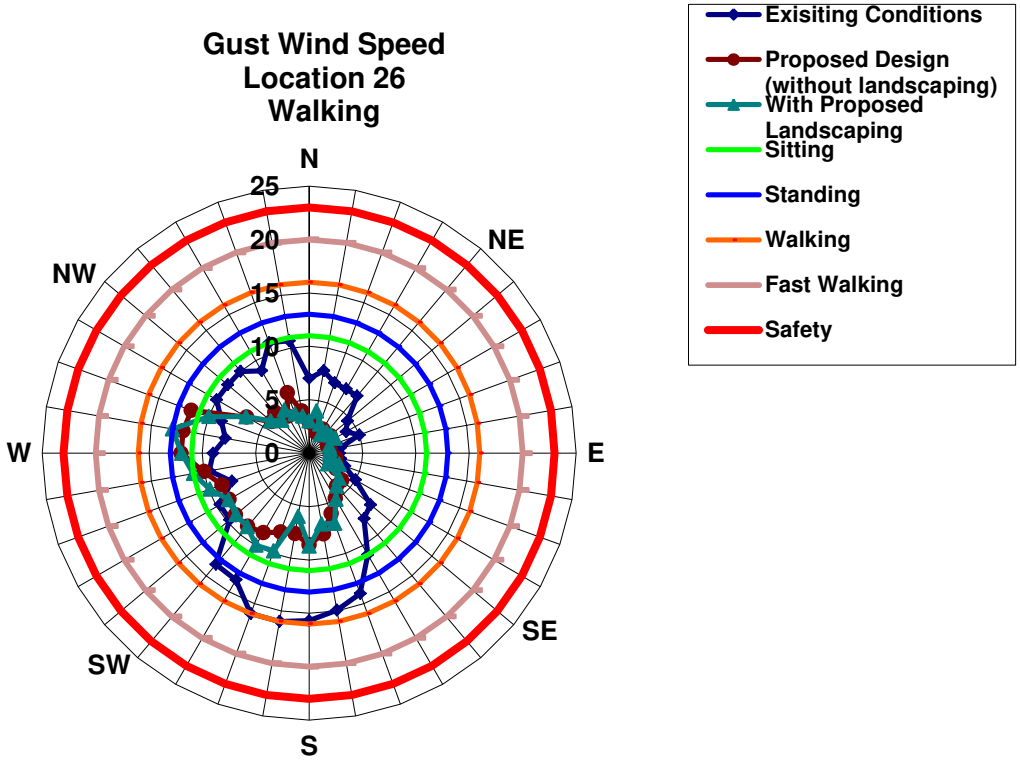

Gust Wind Speed
Location 21
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

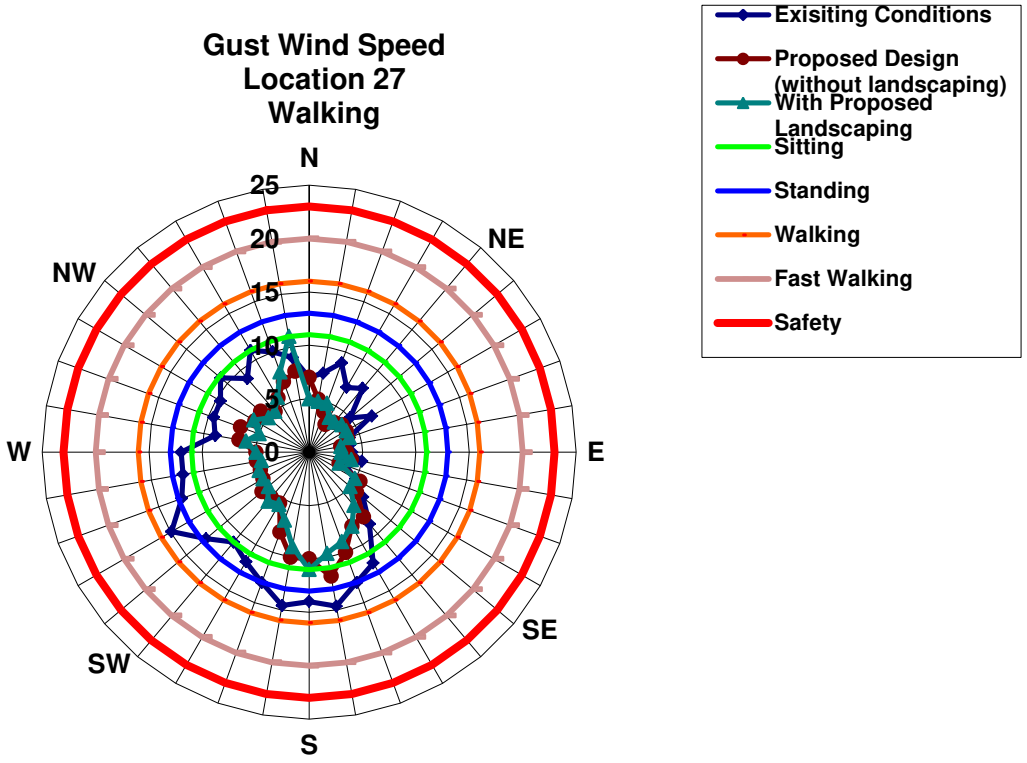

Gust Wind Speed
Location 22
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

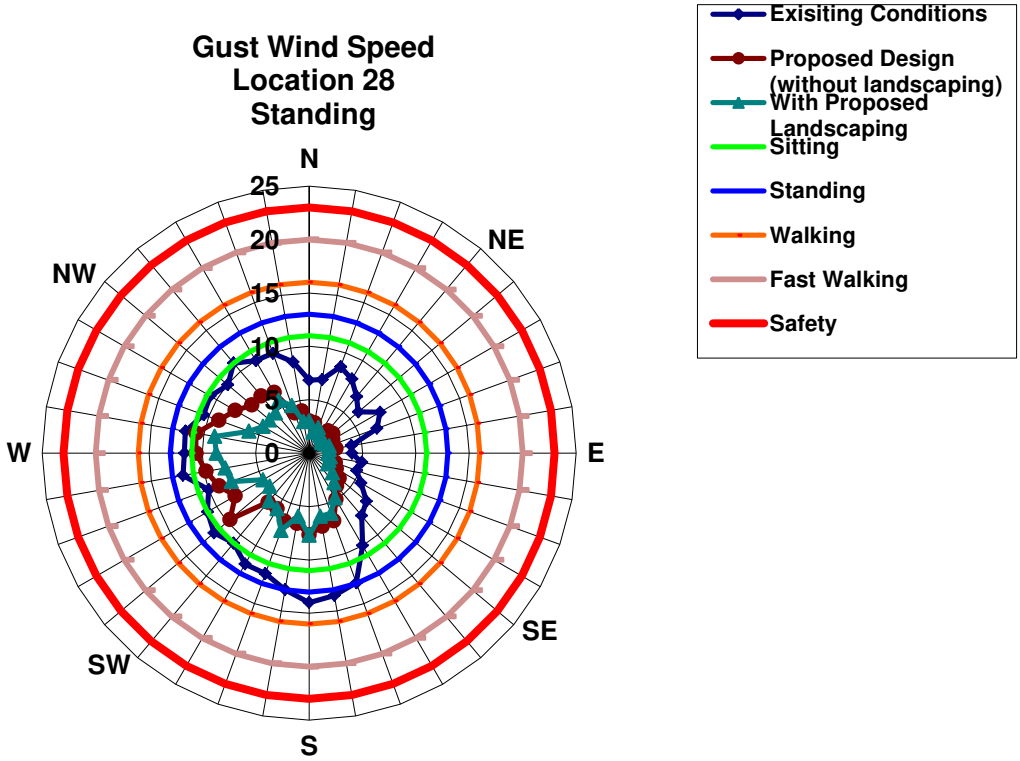

Gust Wind Speed
Location 23
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

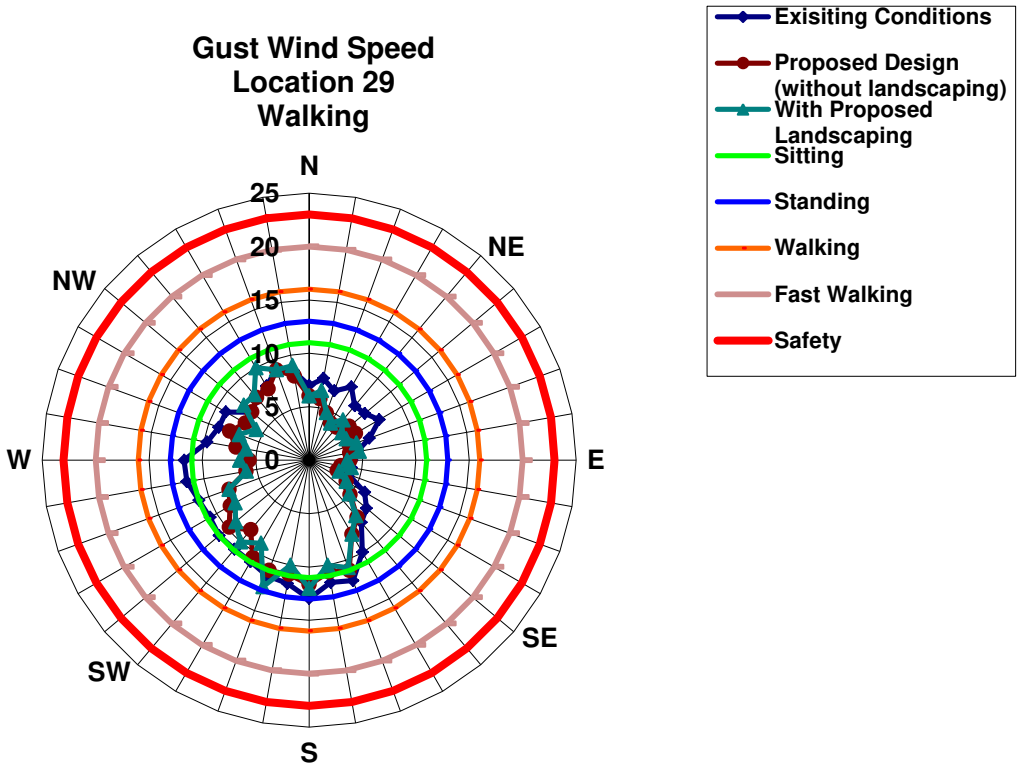

Gust Wind Speed
Location 24
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

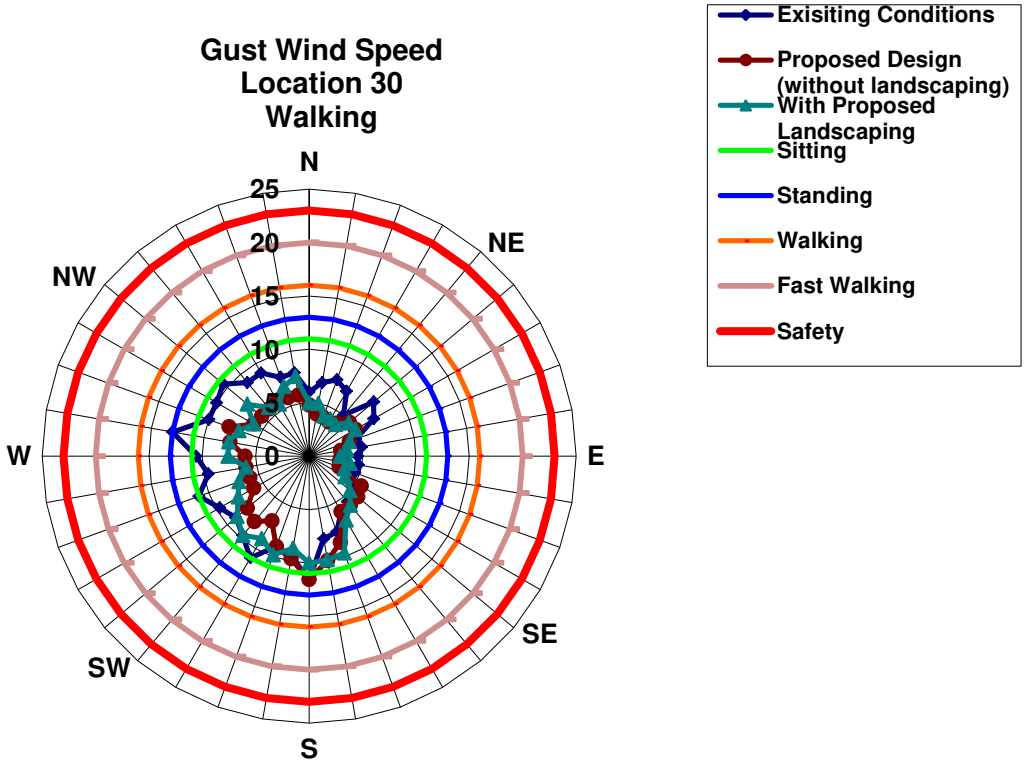

Gust Wind Speed
Location 25
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

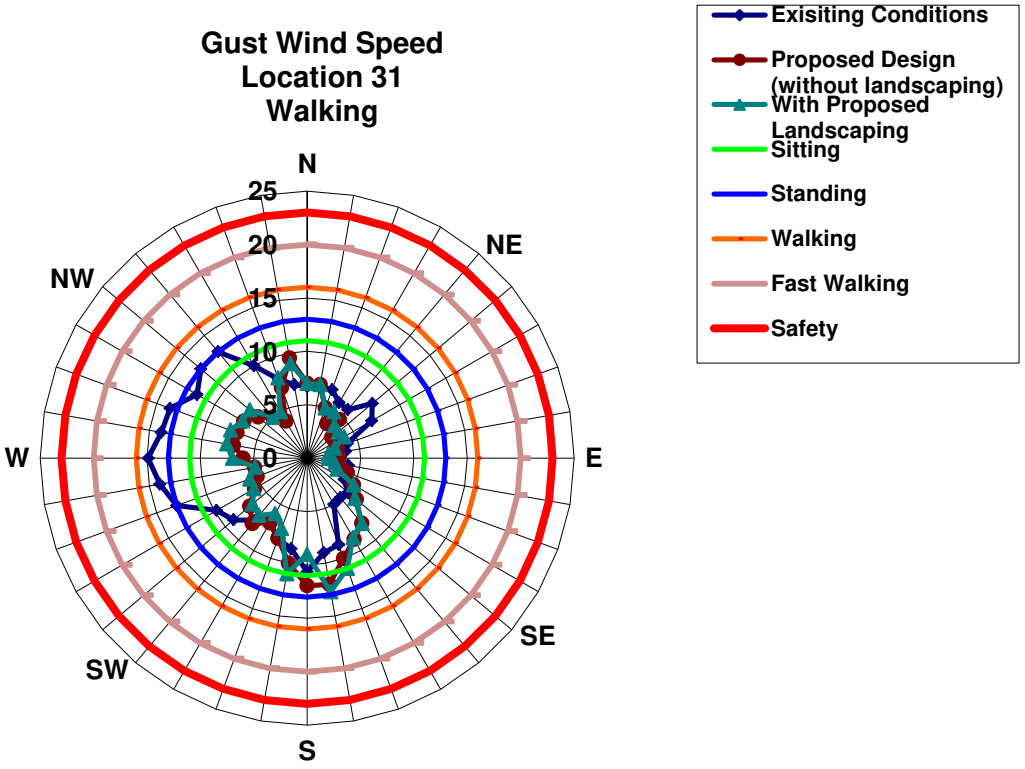

Gust Wind Speed
Location 26
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

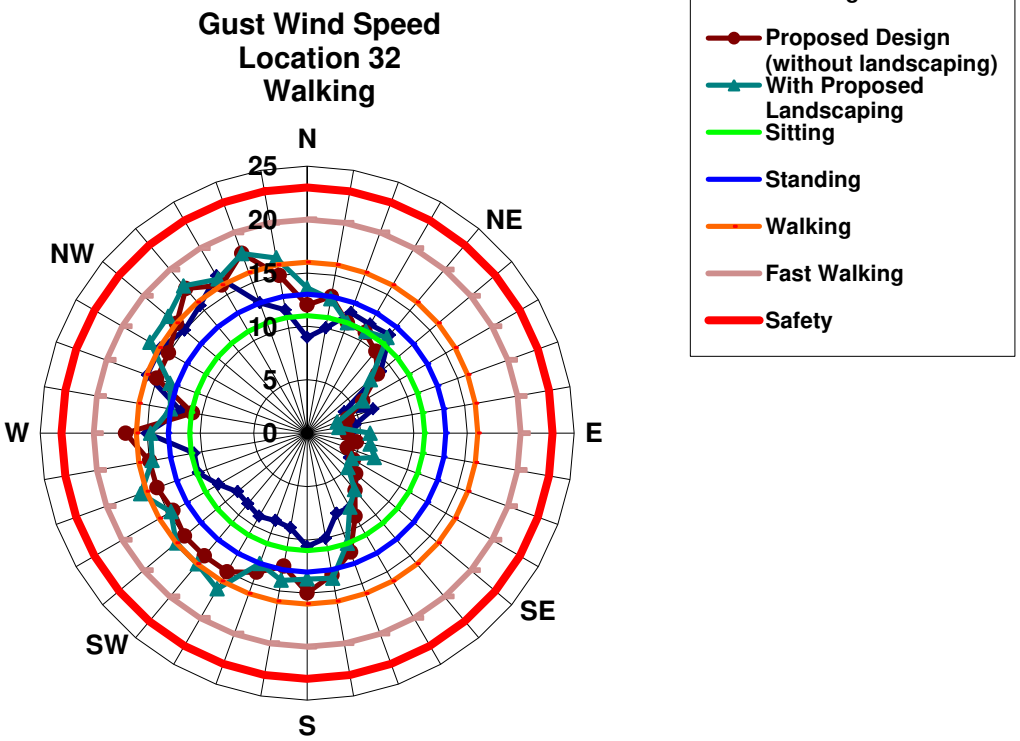

Gust Wind Speed
Location 27
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

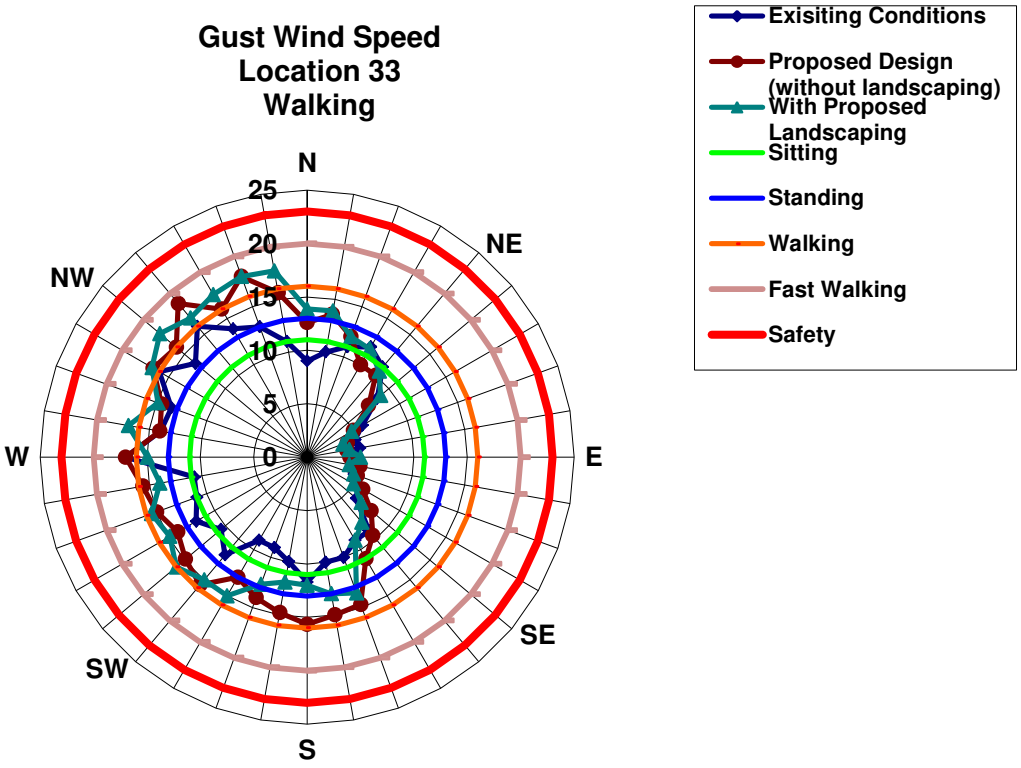

Gust Wind Speed
Location 28
Standing
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

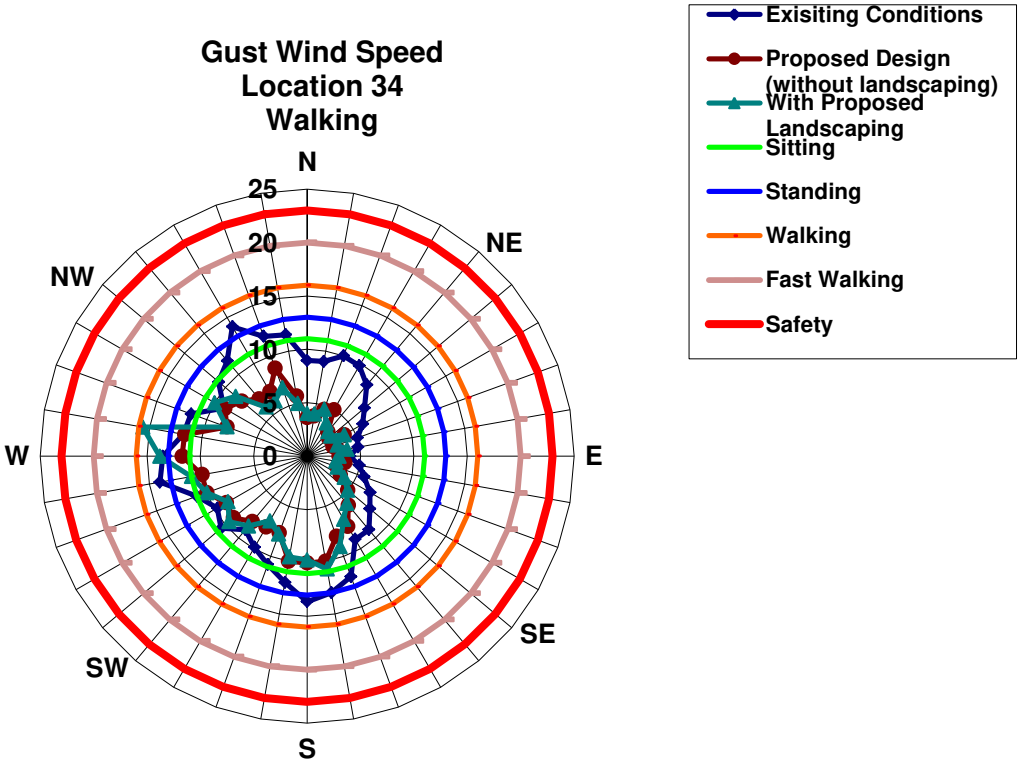

Gust Wind Speed
Location 29
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

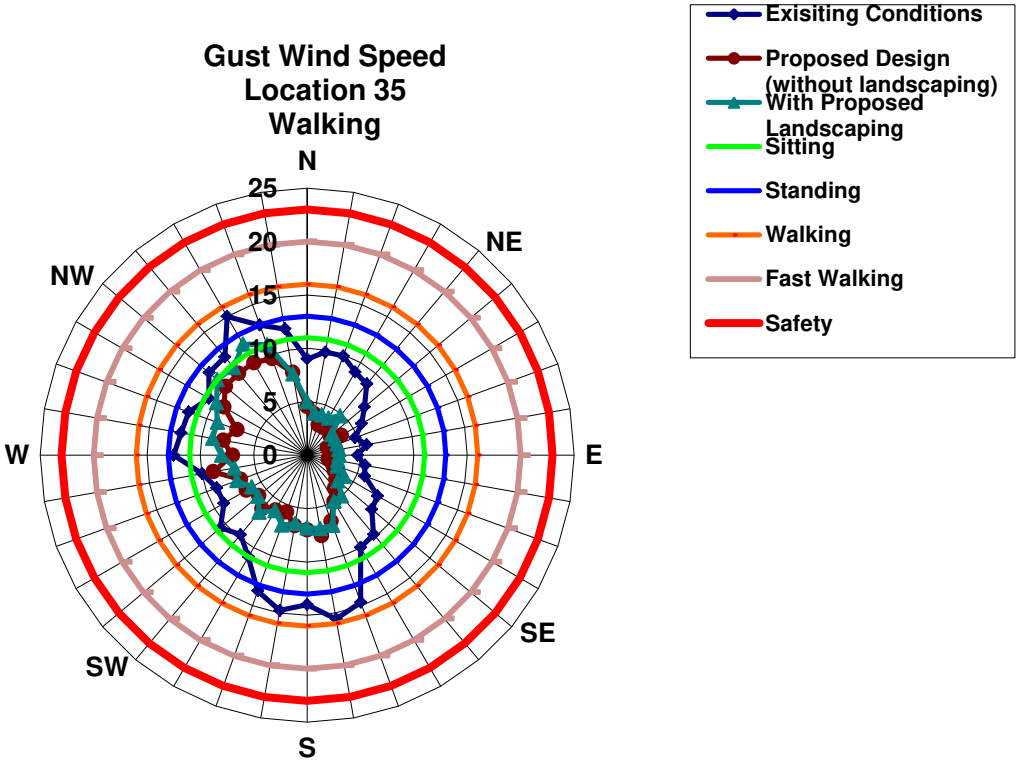

Gust Wind Speed
Location 30
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

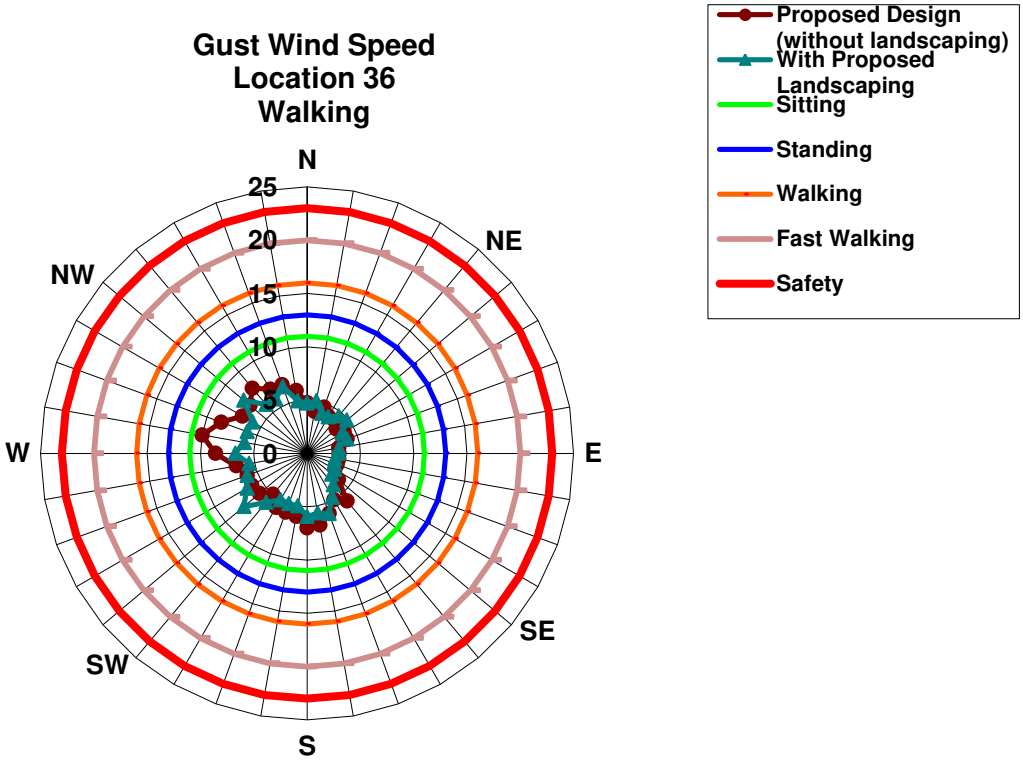

Gust Wind Speed
Location 31
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

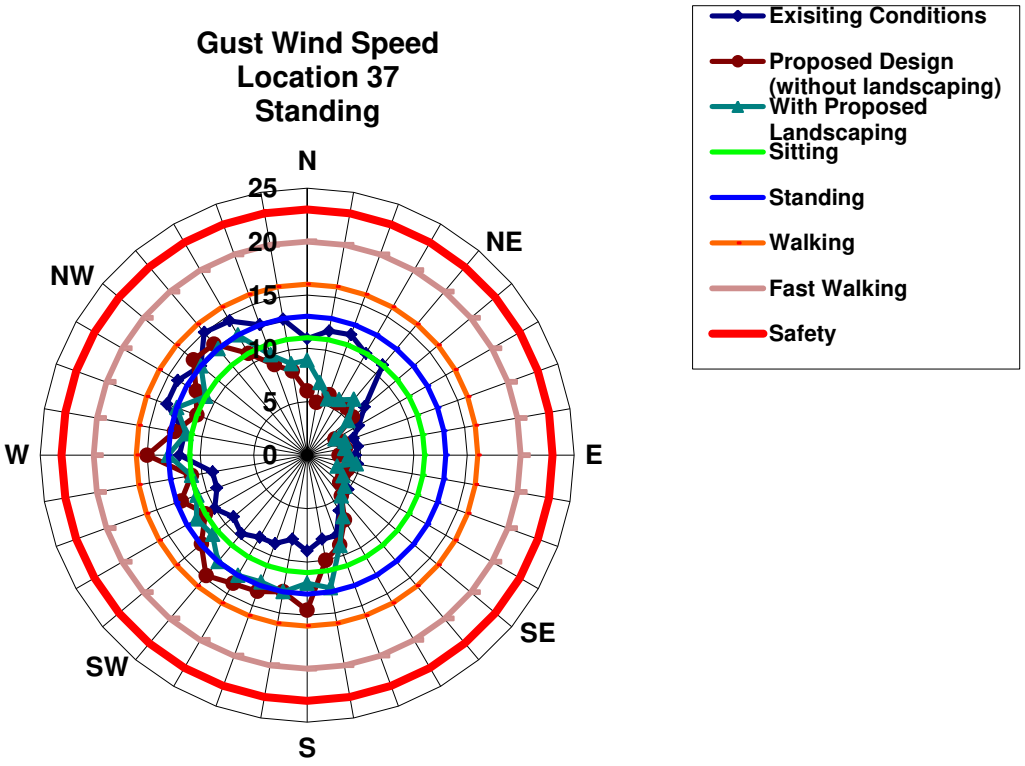

Gust Wind Speed
Location 32
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety

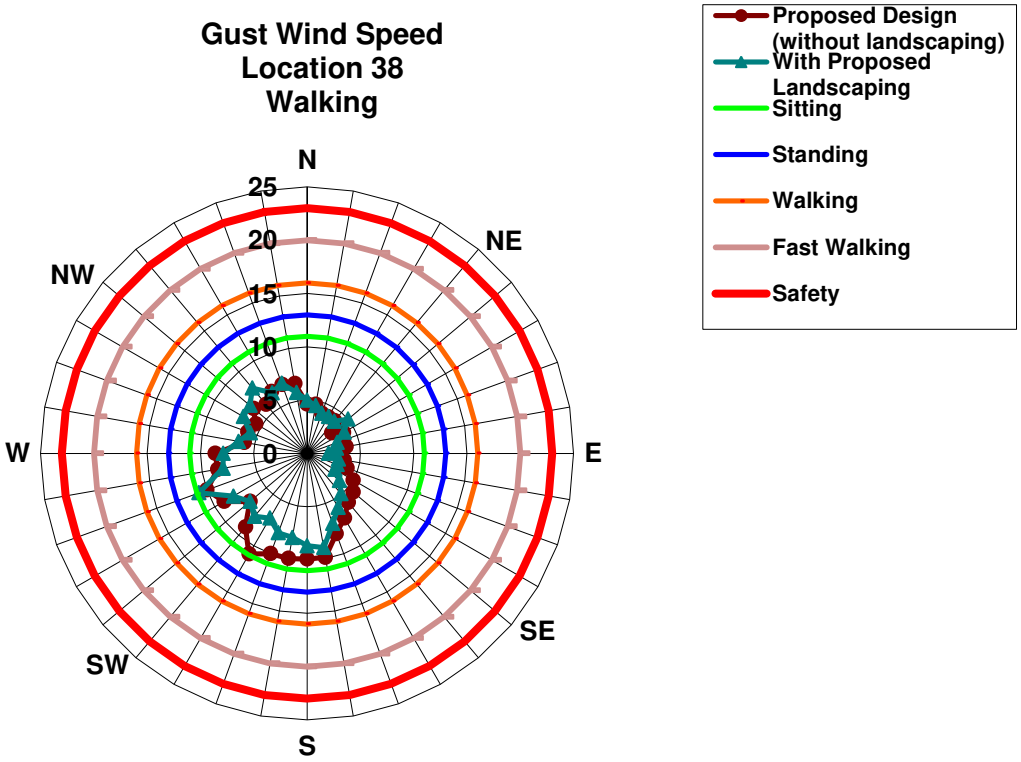

Gust Wind Speed
Location 33
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety


Gust Wind Speed
Location 34
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety


Gust Wind Speed
Location 35
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety


Gust Wind Speed
Location 36
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety


Gust Wind Speed
Location 37
Standing
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Exisiting Conditions
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety


Gust Wind Speed
Location 38
Walking
N
NE
E
SE
S
SW
W
NW
25
20
15
10
5
0
Proposed Design (without landscaping)
With Proposed Landscaping
Sitting
Standing
Walking
Fast Walking
Safety