

New Space Project Management Pty Ltd

194-214 Oxford Street & 2 Nelson Street,
Bondi Junction

Pedestrian Level Winds - Wind Tunnel Test



30N-24-0515-TRP-100971-2

14 July 2025

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Executive Summary

This wind report has been prepared by Vipac Engineers & Scientists to accompany a State Significant Development Application (SSDA) for a shop top housing development at 194-214 Oxford Street, 2 Nelson Street and part of Osmund Lane, Bondi Junction. The site is made up of nine (9) lots. The legal description of the site is outlined in Table 1.

Table 1 Legal Description

Property Address	Title Description
194 Oxford Street Bondi Junction	Lot 10 in DP260116
196 Oxford Street Bondi Junction	Lot 11 in DP260116
198 Oxford Street Bondi Junction	Lot 12 in DP 260116
200 Oxford Street Bondi Junction	Lot 13 in DP260116
204 Oxford Street Bondi Junction	Lot 16 in DP68010 Lot 1 in DP79947
214 Oxford Street Bondi Junction	Lot 1 in DP708295
2 Nelson Street Bondi Junction	Lot 1 in DP583228
Part of Osmund Lane	Lot 1 in DP1300781

This report has been prepared to address the Secretary's Environmental Assessment Requirements (**SEARs**) issued for the project (SSD-77175998).

A scaled model was constructed based on drawings supplied by **SJB** in **March 2025**. The proposed development and surrounding buildings covering a circular area of approximately 500m radius were modelled at a **1:400** scale. The approaching mean and turbulent flows of the Terrain Category 2.5 (for 0°-50°, 190°-280° & 330°-360° azimuth degrees), and Terrain Category 3 (for all other directions) Atmospheric Boundary Layer were modelled based on Australia Standard AS 1170.2-2021.

The present wind tunnel tests were carried out in the Boundary Layer Wind Tunnel Facility of Vipac in Melbourne during March 2025.

The findings of the study are summarised as follows:

- With the proposed design, the development fulfils the recommended criterion for **safety** at all test locations.
- With the proposed design, the development fulfils the recommended criterion for **walking** in all footpath locations
- **With the proposed design and recommendations**, the development fulfils the recommended **standing** comfort criterion in all entrance locations.
- With the proposed design, the communal roof terrace on level 11 is expected to fulfil the recommended walking comfort criterion; some more sheltered areas on the terrace are expected to meet the more stringent sitting or standing wind comfort criterion.
- The proposed development would not generate a significant adverse impact on the footpaths across Osmund Lane, Nelson Street and Oxford Street.
- Areas on the terrace are expected to meet the more stringent sitting or standing wind comfort criterion.
- The proposed development is expected to fulfil the recommended criteria for **Walking** at all private balconies, including the amenity of the balconies on Levels 12 and 13 of Building A and Levels 12 to 16 of Building B.

The proposed development would not cause a significant adverse impact on the adjacent areas.

As a general statement, common to all new developments, educating occupants about wind conditions at high-level terraces/balconies during high-wind events and tying down loose furniture are highly recommended.

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1 Introduction

Following a design excellence competition, development consent was granted to DA-400/2021 (herein, referred to as the parent development consent) which authorised demolition of existing buildings and the construction of a shop top housing development comprising ground floor retail and 10 storeys of residential apartments above the retail podium, across two tower buildings (herein referred to as Building A and Building B). Subsequently, a DA (DA-360/2023) was approved on 28 August 2024 which amended the Basement Levels 4, 3, 2 and 1 and the Ground Floor Level of the approved development under the parent development consent.

The proposed SSDA generally seeks approval for the redevelopment of 194-214 Oxford Street, 2 Nelson Street and part of Osmund Lane, Bondi Junction, proposing to retain key design principles in accordance with the parent consent. The proposal will provide additional residential dwellings, in accordance with the in-fill affordable housing provisions under the *State Environmental Planning Policy (Housing) 2021* and incorporate a 30% increase in Gross Floor Area (GFA) and building height.

The development of the site has physically commenced pursuant to the development consent, with demolition and excavation completed. Construction Certification has been obtained and construction is intended to continue for the lower portion of the building (up to Level 8).

Simultaneously with the construction of the lower parts of the building, the proponent seeks approval for new works to the remaining levels of the building (above level 9) as well as the internal fit out and servicing for the whole of the building (Basement to Level 16).

It is intended that the relationship between the approval of the SSDA and the existing consents be managed through the imposition of a condition pursuant to s 4.17(1)(b) of the EP&A Act and lodgement of a Notice of Modification pursuant to cl. 67 of the EP&A Regulation to ensure consistency across all development consents.

Specifically, this SSDA seeks development consent for:

Proposed New Works Subject of this SSDA:

- Construction of Levels 9 – 16 of the residential towers including Buildings A (Western Tower) and Building B (Eastern Tower) comprising:
 - Building A (Western Tower, Residential Levels 9 -13) – with a maximum height of 43.6m
 - Building B (Eastern Tower, Residential Levels 9 -16) – with a maximum height of 54.0m
 - Communal open space on Level 11 (Building A)
 - Plant and lift overrun
 - Public Domain Works
- Internal fit out of Levels 09 - 16

Proposed Amendments to Existing Parent Development Consent

- Internal fit out from Basement Levels 01 - 04
- Internal fit out from Ground Level to Level 08
- The allocation of 1,708m² of affordable housing on Levels 1,2 and 3 of Building A and Building B
- Additional services to overall development including an additional plant area at ground floor and an addition of a second substation.
- Basement services, including additional parking spaces and updated storage and waste storage areas
- Awning over the ground retail along Oxford St and addition of a glazing window to create visual continuation from the neighbouring retail.

Cumulative Development (Existing Parent Development Consent and Subject SSDA)

- Construction of a shop-top housing development, comprising a podium with ground floor retail, two residential towers (Building A and Building B) as well as four levels of basement parking and associated public domain works.
 - The delivery of a total of 11,288m² of GFA.
 - 467m² of retail GFA.

- 85 apartments, equating to a total residential GFA of 10,792m² including 1,708m² (17 apartments) of affordable housing GFA.
- 29m² GFA for communal amenities, incl. WC, steam room and sauna
- The apartments will comprise the following mix:
 - 1 bedroom 2 (2%)
 - 2 bedroom 35 (42%)
 - 3 bedroom 48 (56%)
- 4 levels of basement for 124 car parking spaces and 45 motorbike parking spaces, with vehicular access from Osmund Lane.
- Storage areas and services.
- Communal open space and associated landscaping.

Purpose of this Report

The purpose of the project is to facilitate the delivery of (market and affordable) housing at a strategically located site and to deliver a built form outcome that is consistent with the outcomes of the design competition.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 25/10/2024 and issued for the SSDA (SSD-77175998). Specifically, this report has been prepared to respond to the SEARs requirement issued below.

Table 2 – SEARs requirements.

Item	Description of Requirement	Section Reference (this Report)
5. Environmental Amenity	Pedestrian Wind Environment Assessment Assess amenity impacts on the surrounding locality, including lighting impacts, reflectivity, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and <i>wind impacts</i>. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated.	Full Report

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, during March 2025. The results show the wind effects in ground level public areas adjacent to the development as proposed.

The pedestrian wind environment study of the development was conducted using Omni-directional pressure sensor techniques to predict wind velocities. The study investigated safety and comfort in ground level pedestrian access-ways, entrances and terrace areas.

Drawings of the proposed development were supplied to Vipac by **SJB** in **March 2025**. A complete list of the drawings supplied is provided in Appendix B of this report. Figure 1 & Figure 2 show the 1:400 scale building with the surrounding models in the wind tunnel.



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

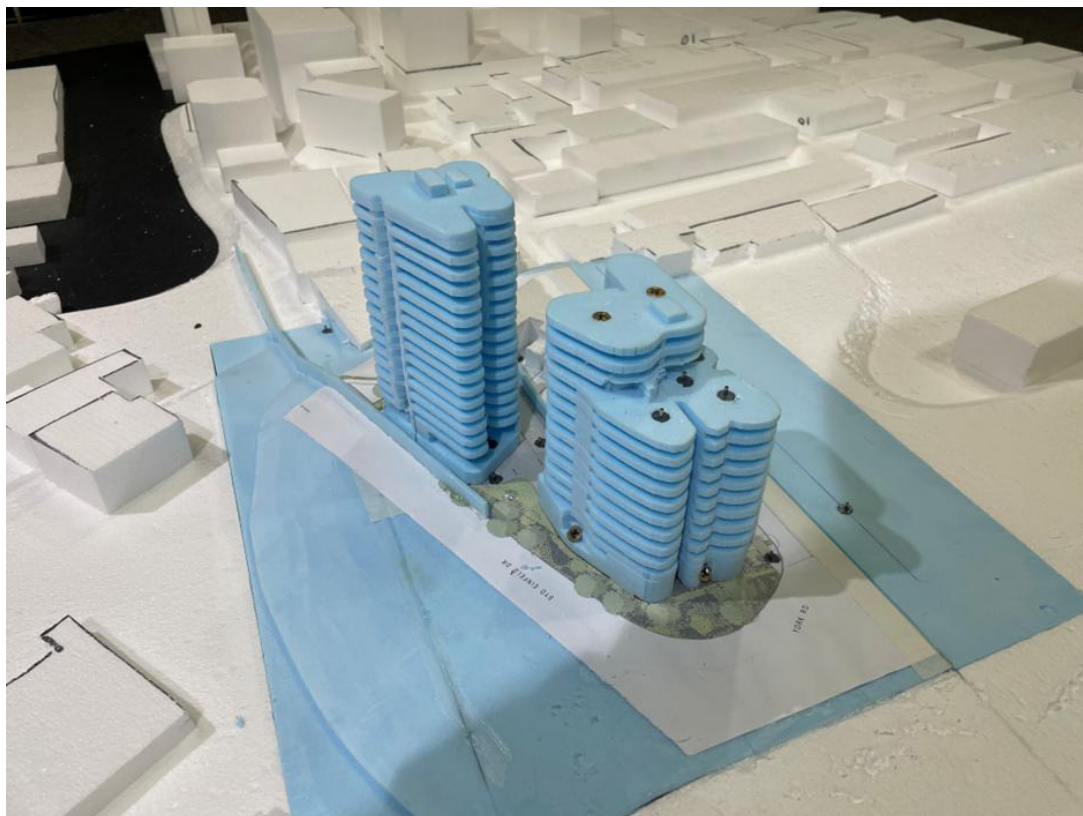


Figure 2: Close up view from northwest of the 1:400 scaled model in the wind tunnel.

2 The Site

The site is located at 194-214 Oxford Street and 2 Nelson Street, Bondi Junction within the Waverley LGA. The site is comprised of multiple allotments and is legally described as:

- 194-214 Oxford Street:
 - Lot 10, 11, 12, 13 & 16 / DP 260116,
 - Lot 1 / DP 708295,
 - Lot 1 / DP 79947, and
- 2 Nelson Street:
 - Lot 1 / DP 583228.
- Part of Osmund Lane (Lot 1 in DP1300781)

The land size is 2,480m² (2,599.1m² including the land beneath Osmund Lane) with a northern frontage to Sydney Enfield Drive, an eastern frontage to Nelson Street, a southern frontage to Oxford Street and western frontage to York Road.

2.1 Surrounding Context

The immediate urban context surrounding the site is characterised by a mix of commercial, retail, residential, and recreational land uses with Centennial Park located to the west and south-west of the site.

The site is in proximity to the Bondi Junction shopping and transport hub to the east, comprising Bondi Junction Westfield Shopping Centre, a pedestrian shopping mall and Bondi Junction Train Station. The site is located within the Western Precinct of Bondi Junction. The site is closely located to two (2) bus stops recognised as ID 202260 'Oxford St before York Rd' approximately 57m from the site and ID 202238 'Oxford St after York Rd' approximately 96m from the site. The site is in proximity to the Bondi Junction Train Station being within 800m from the site (5-minute walk).

The lot at 2 Nelson Street contains a local landscape heritage item I506 'Norfolk Pine-Landscape'. The remainder of the site has recently been demolished in accordance with the existing development consents.

The site will be progressively developed under the existing approvals and the remaining works will be the subject of this application.

The lot at 2 Nelson Street contains a local landscape heritage item I506 'Norfolk Pine-Landscape'. The remainder of the site has recently been demolished in accordance with the existing development consents.

A satellite image of the proposed development site is shown in Figure 3 and the South elevation of the development shown in Figure 4. The ground level plan of the proposed development is shown in Figure 5.

Considering the immediate surroundings and terrain, the site of the proposed development is assumed to be within Terrain Category 2.5 for 0°-50°, 190°-280° & 330°-360° azimuth degrees and Terrain Category 3 for all other wind directions (Figure 6).



Figure 3: Aerial view of the proposed development site in red.



Figure 4: North elevation view of the proposed development with its approximate height in meters.

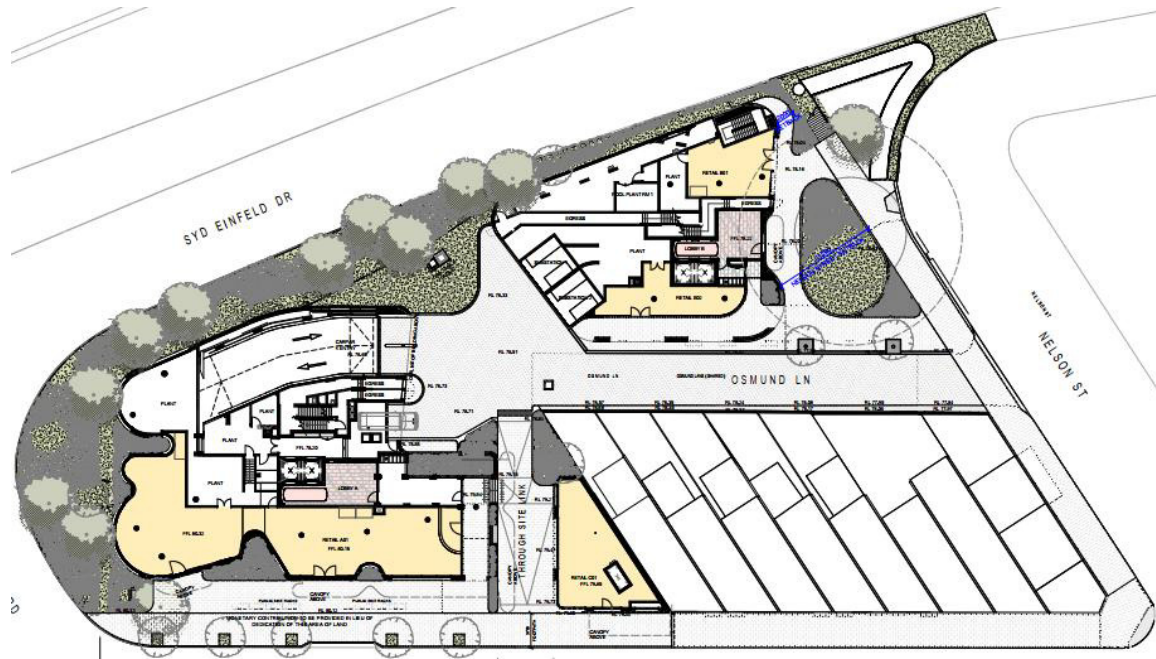


Figure 5: Ground level plan of the proposed development.



Figure 6: Assumed terrain categories for wind speed estimation.

2.2 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 un-attenuated 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.

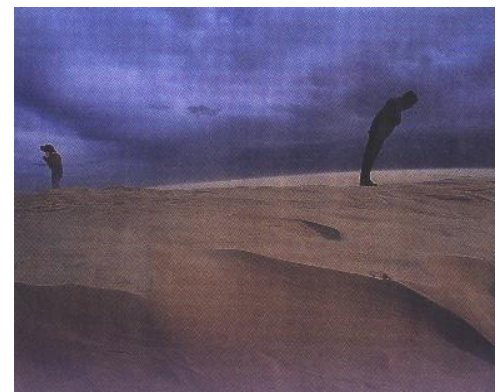
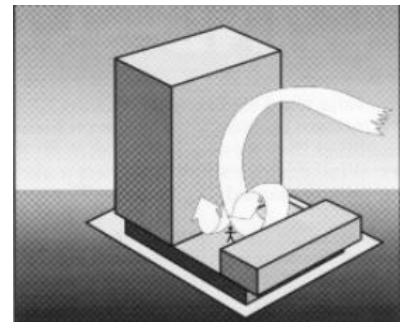
Downwash – refers to a flow of air down the exposed face of a tower. A tall tower can deflect a fast moving wind at higher elevations downwards.

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.



3 Regional 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 once per year (i.e. 1 year return period) and with a probability of occurring 5% of the time are shown in Figure 7. 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.

**Hourly Mean Wind Speeds (m/s), once per year and 0.5% of the time,
at 500 m height, Cat 2, Sydney**

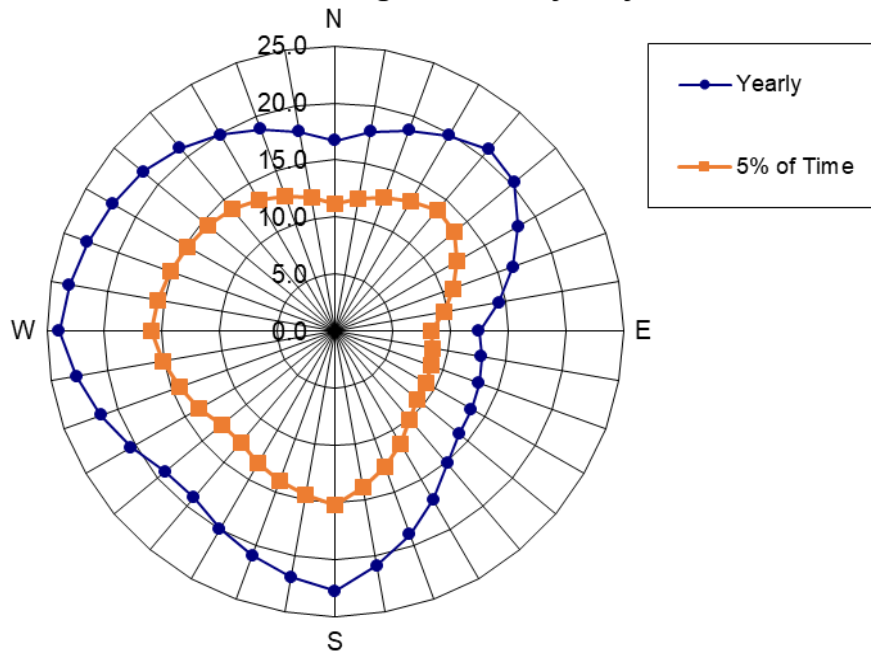


Figure 7: Directional Distribution of Mean Hourly Wind Velocities (m/s) of Annual Return Period and 5% of time at the gradient height for Sydney.

4 Assessment Criteria

The wind comfort criteria from the Central Sydney Planning Strategy has been applied to this study. The document recommends the following wind safety and comfort criteria (Table 3):

Table 3: Wind Criteria summarized from Central Sydney Planning Strategy

Measurements	Result on Perceived Pedestrian Comfort
Peak wind speed (0.5 second gust) once per year, ≤24m/sec for any direction*.	Accepted international criterion for human safety to avoid a healthy pedestrian losing balance
Hourly mean wind speed*, 5% of the time exceedance, ≤8m/sec , for any directions.	Acceptable for walking (steady steps for most pedestrians)
Hourly mean wind speed, 5% of the time exceedance, ≤6m/sec , for any directions.	Acceptable for standing (wind shopping, vehicle drop off)
Hourly mean wind speed, 5% of the time exceedance. ≤4m/sec , for any directions.	Acceptable for sitting (outdoor cafes, gardens, park benches)

*Note: Hourly Mean wind speed is the maximum of mathematical mean or Gust equivalent mean (Gust divided by 1.85).

The wind speed assessment is undertaken for winds occurring between 6am and 10pm (AEST).

4.1 Use of Adjacent Pedestrian Occupied Areas & Recommended Comfort Criteria

The following Table 4, lists the specific recommended criteria for the various areas of the proposed development.

Table 4: Recommended application of the criteria.

Area	Specific Location	Recommended Criteria
Public Footpaths and Access ways	Within and around the proposed development on Nelson Street and Oxford Street and adjoining pedestrian link to the south (Figure 8)	Walking
Building Entrances	Entrances to the residential lobby or retail spaces (Figure 8)	Standing
Communal Terraces	Level 1 (Figure 9) and Level 11 (Figure 10)  Recommended to fulfil Walking  Recommended to fulfil Standing	Standing (See discussion below)
Private Balconies/Terraces	Various levels of the buildings (Figure 9 - Figure 12)	Walking (See discussion below)

4.1.1 Terrace / Balcony Recommended Criterion Discussion

Vipac recommends as a minimum that terrace areas meet the criterion for walking since:

- these areas are not public spaces;
- the use of these areas is optional;
- many similar developments in Sydney and other Australian capital cities experience wind conditions on balconies and elevated deck areas in the vicinity of the criterion for walking.

However, it should be noted that meeting the walking criterion on elevated recreation areas will be no guarantee that occupants will find wind conditions in these areas acceptable at all times.

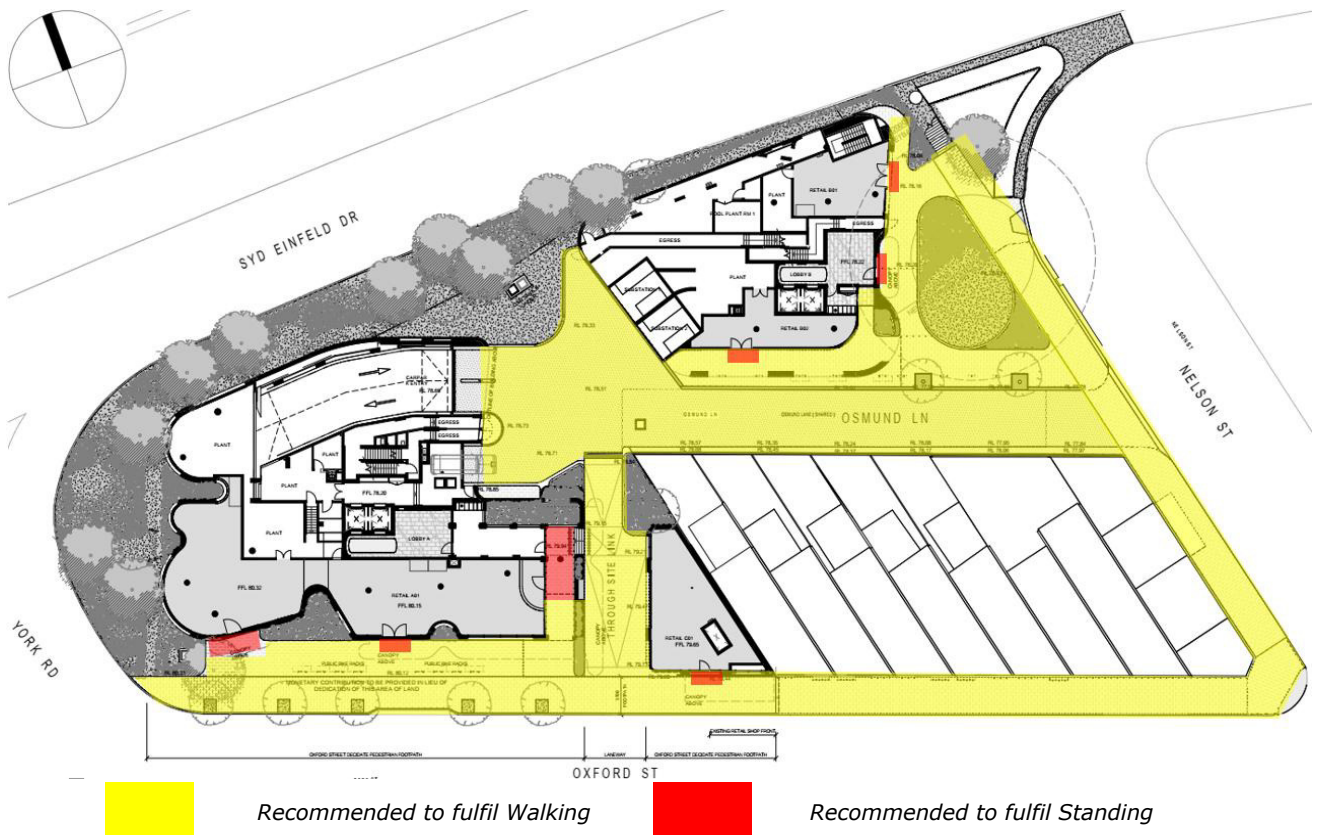
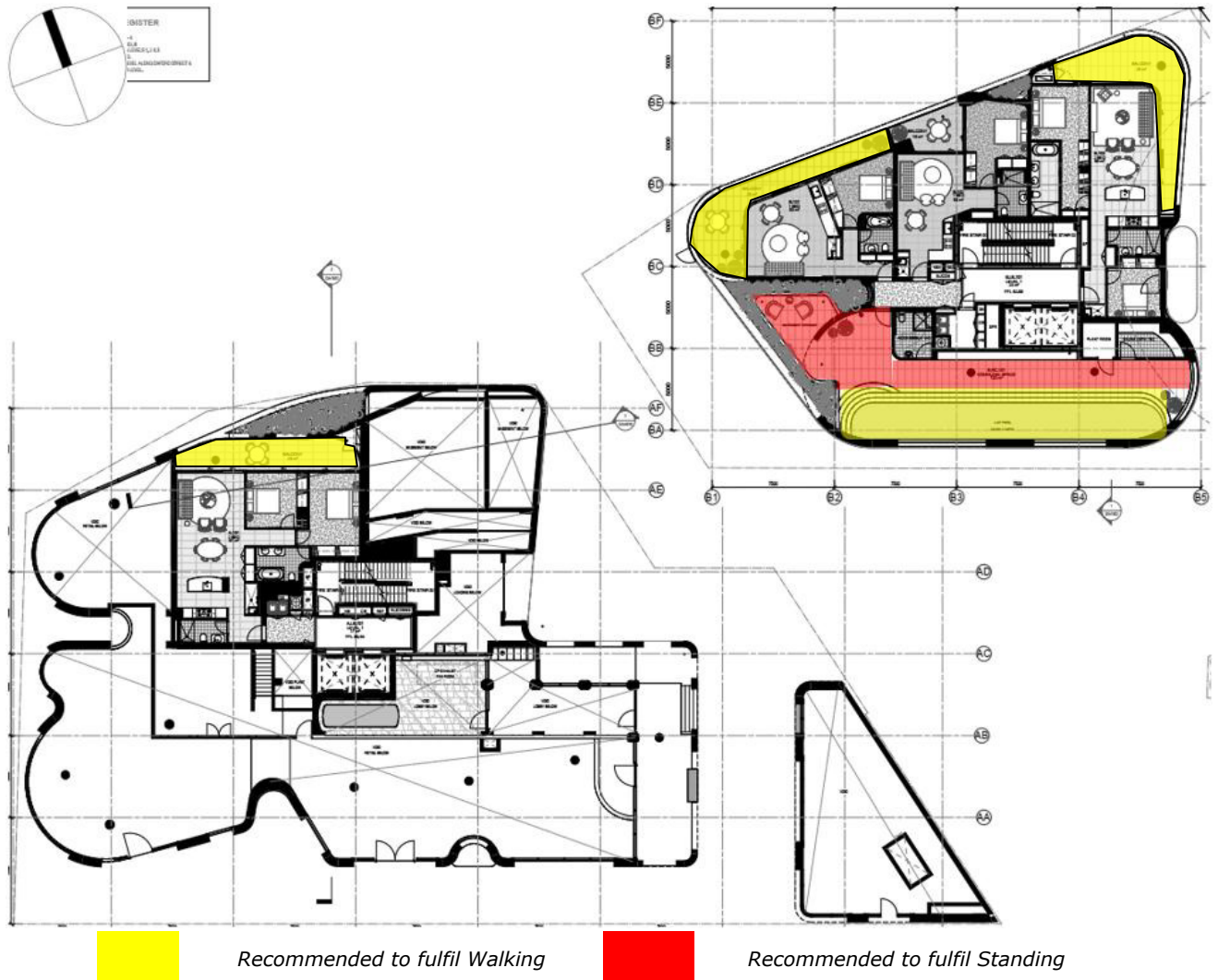


Figure 8: Ground level plan of the proposed development with the recommended wind criteria overlaid.



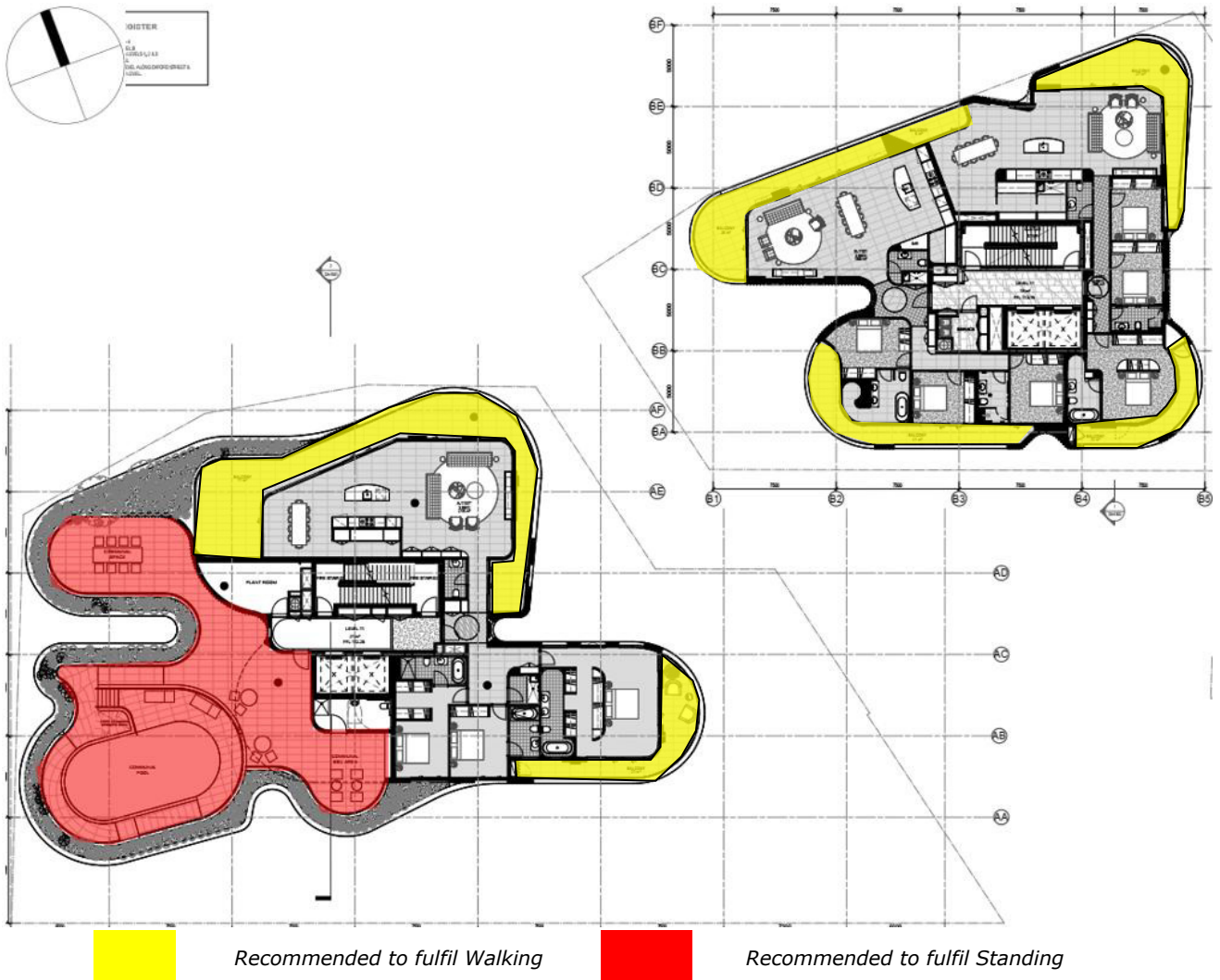


Figure 10: Level 11 floor plan with recommended wind criteria overlaid.

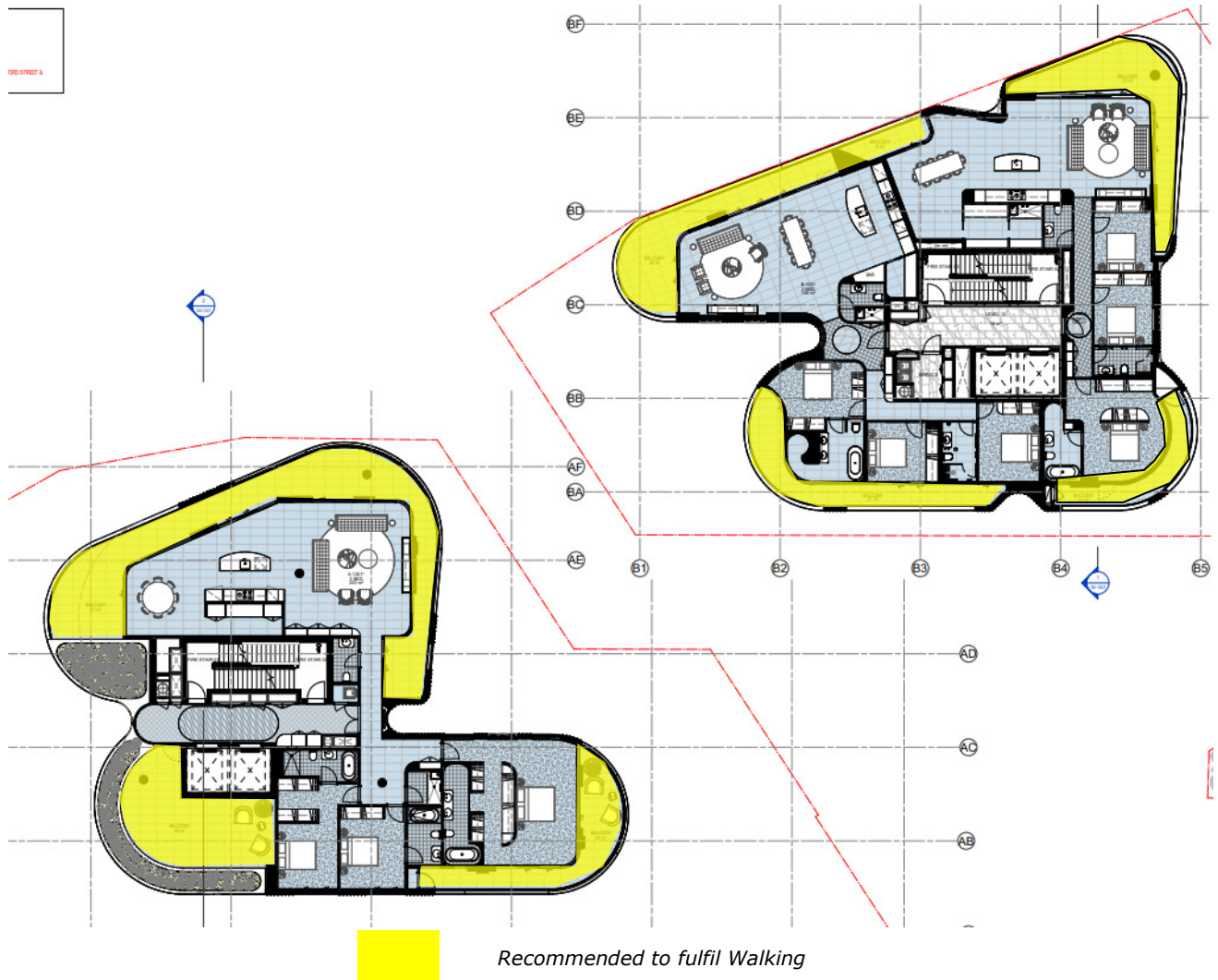


Figure 11: Level 12 and 13 floor plans with recommended wind criteria overlaid.

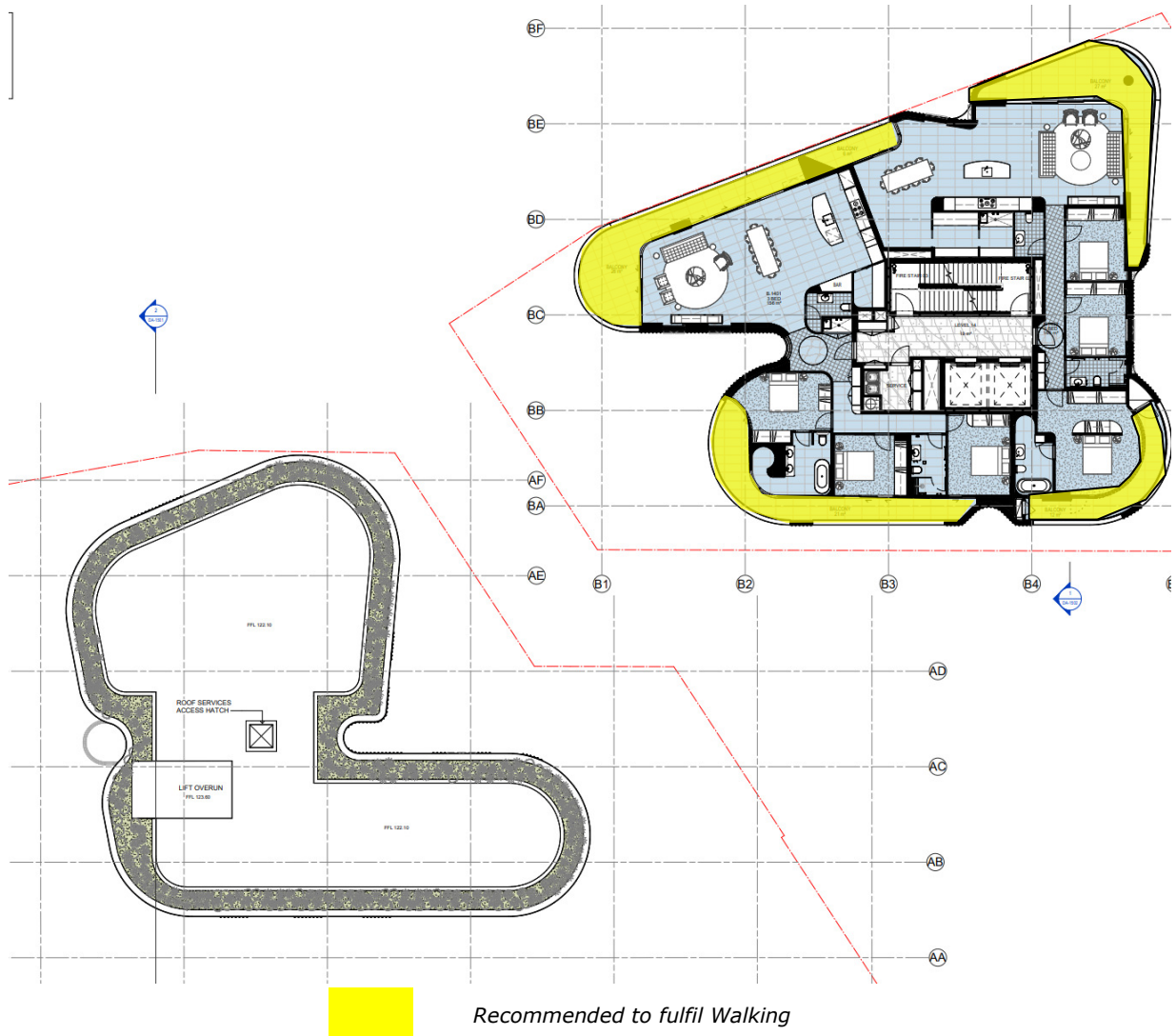


Figure 12: Level 14 - 16 floor plans with recommended wind criteria overlaid.

5 Wind Tunnel Simulation

5.1 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.

5.2 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 Terrain Categories 2.5 and 3 Atmospheric Boundary Layers based on different exposures were modelled based on Australia Standard AS 1170.2-2021. The wind tunnel calibration velocity and turbulence intensity profiles for Terrain Categories 2.5 and 3 are shown in Figure 13 and Figure 14. These represent the wind velocity and turbulence intensity profiles 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 are 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.

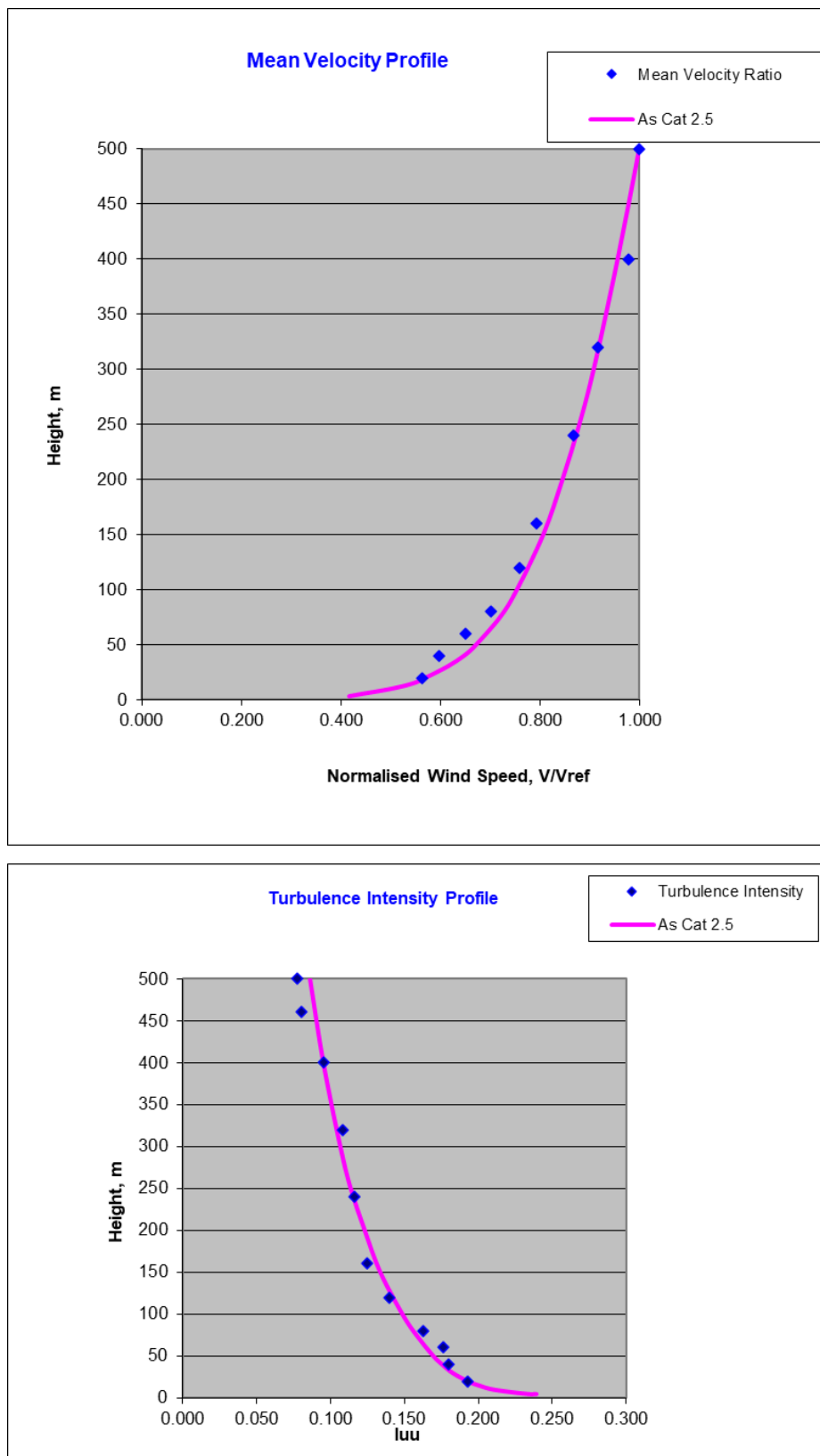


Figure 13: Mean Velocity and Turbulence Intensity Profiles for Terrain Category 2.5 (1:400 scale).

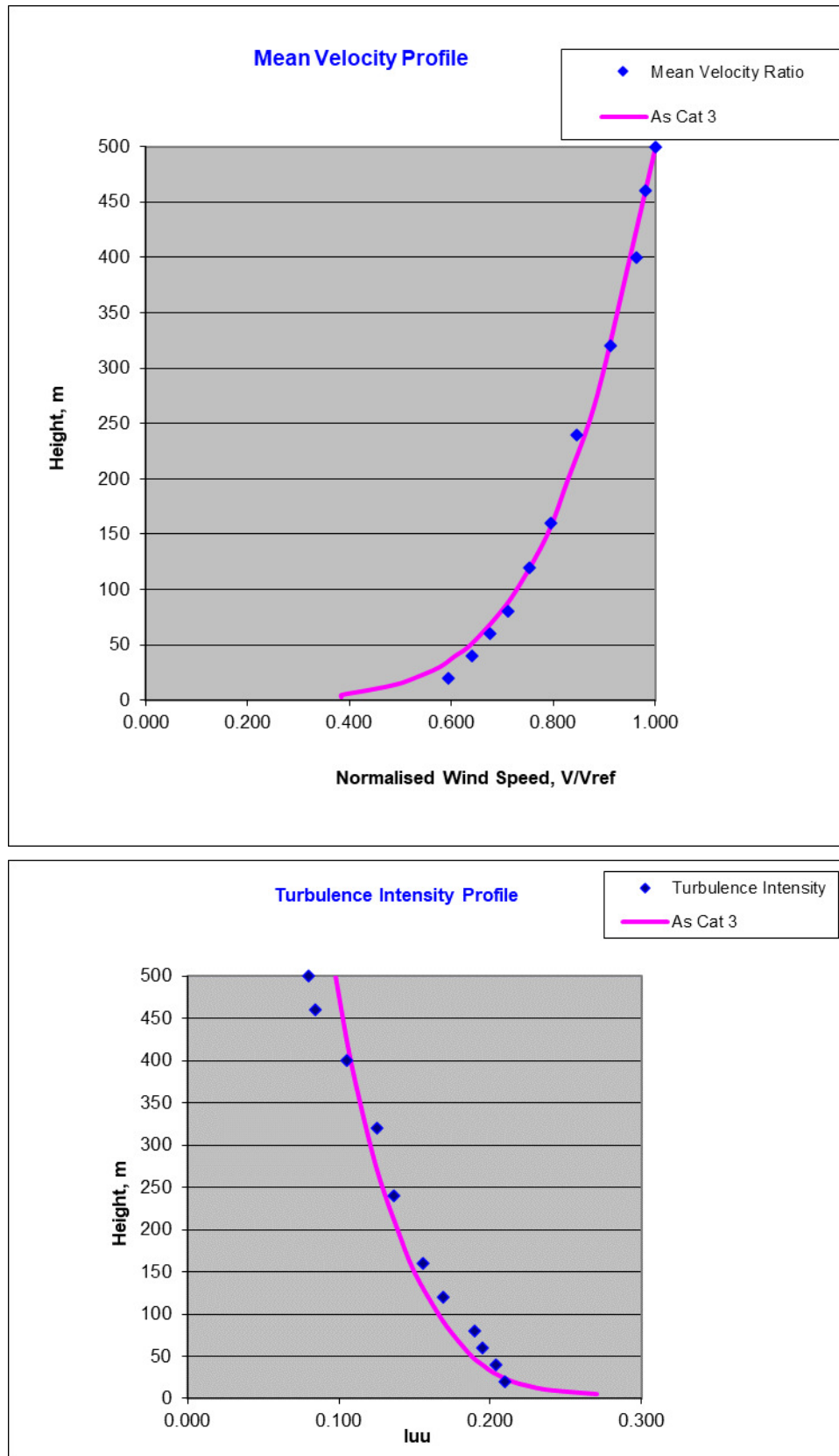


Figure 14: Mean Velocity and Turbulence Intensity Profiles for Terrain Category 3 (1:400 scale).

6 Test Procedure

The pedestrian wind environment in the adjacent footpath areas along Nelson Street, Oxford Street, Osmund Lane, Sydney Einfeld Drive and communal terrace areas were assessed using Omni-directional pressure sensor measurements [4].

Velocity measurements were made using Irwin sensors (Omni-directional pressure sensors) installed at different locations at the adjacent ground level footpath areas and podium level of the proposed development. The test was conducted without any landscaping. 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 1.3 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 regional wind climate and corresponding to design wind speeds with a probability of one per year exceedance for safety criterion assessment and 5% of the time for comfort criterion assessment.

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 footpaths and garden. The sensor locations are shown in Figure 15 to Figure 17.

Ground Level

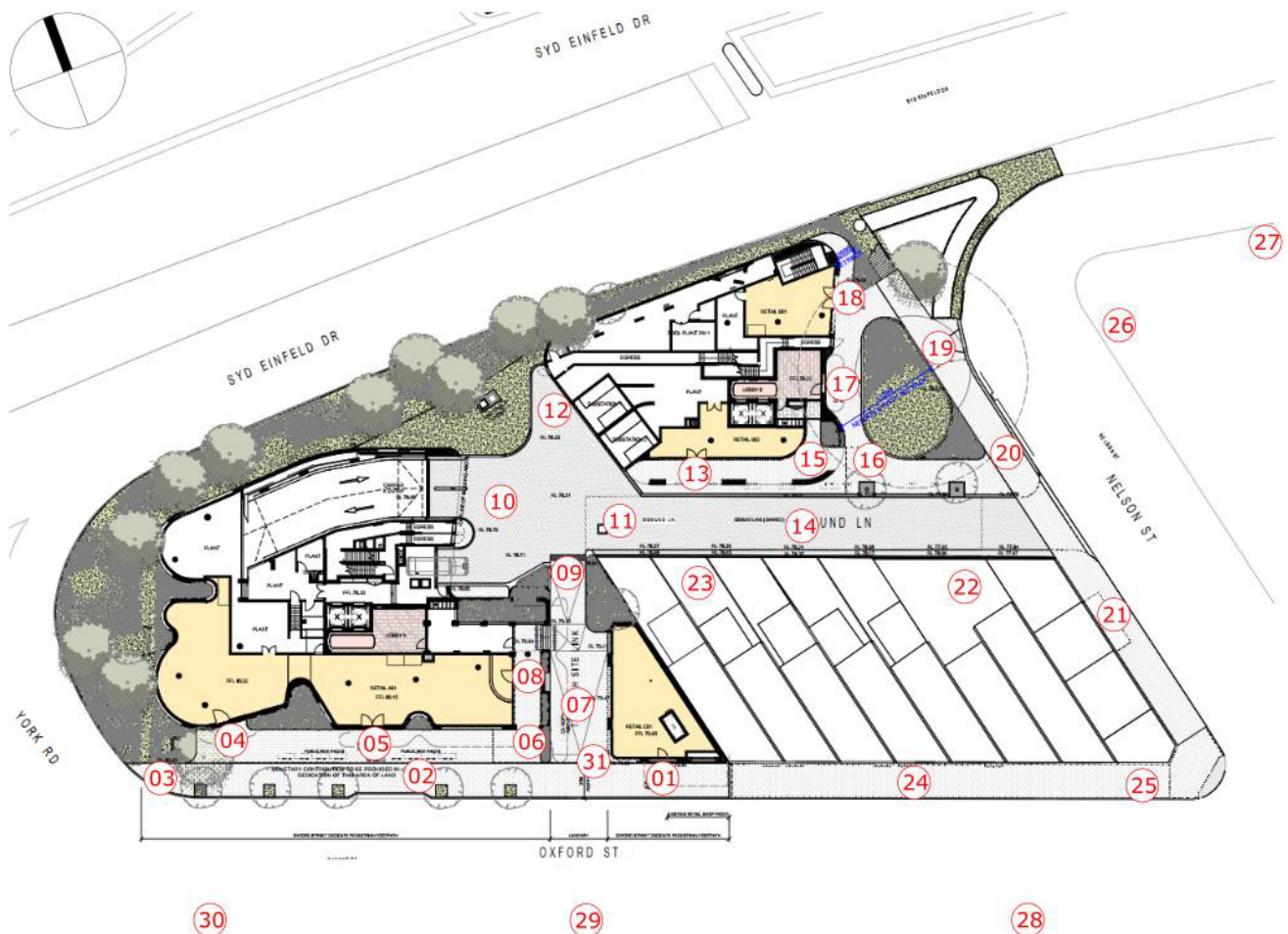


Figure 15: Sensor numbers and locations on the ground level.

Level 1

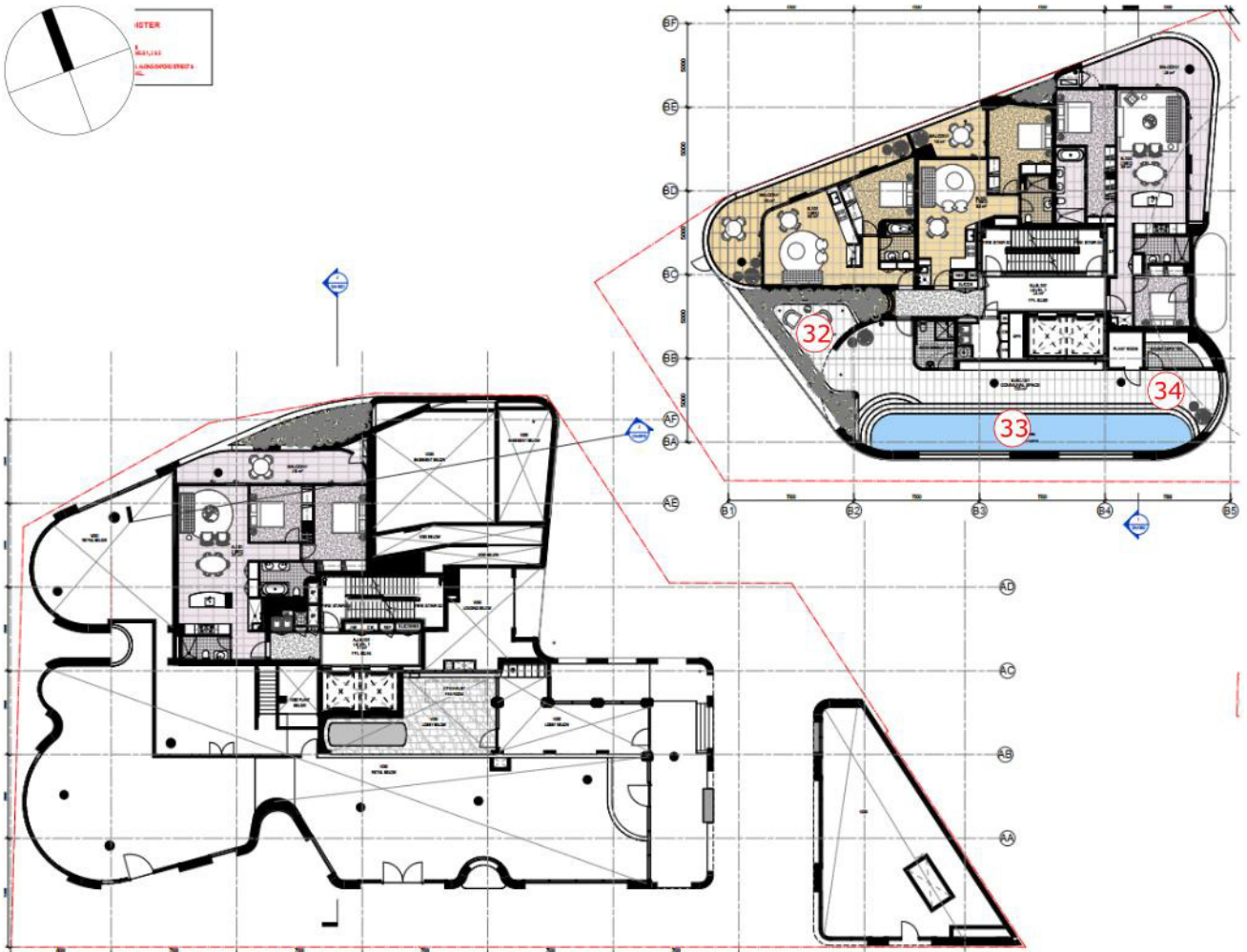


Figure 16: Sensor numbers and locations on Level 1.

Level 11

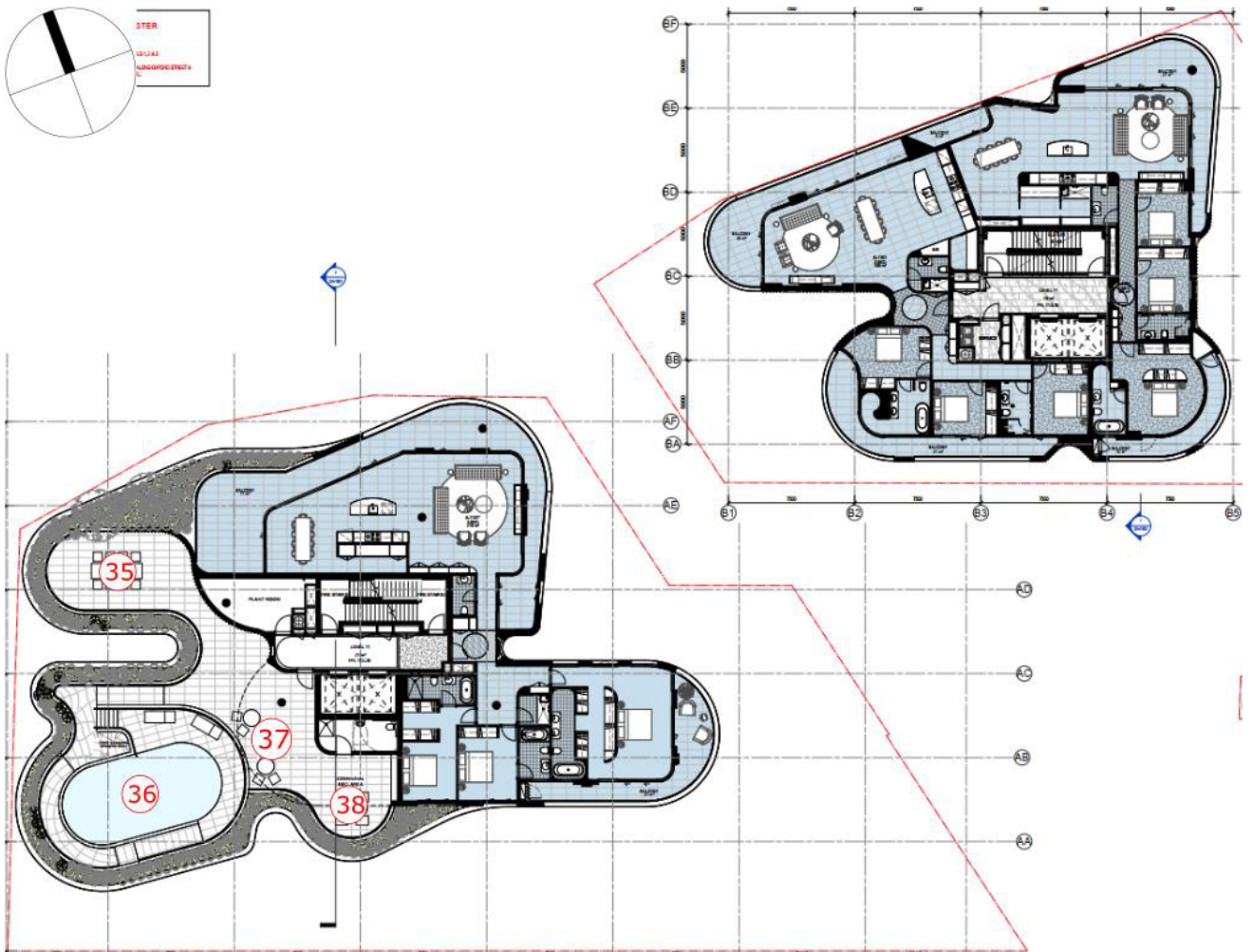


Figure 17: Sensor numbers and locations on Level 11.

7 Results and Discussion

The pedestrian wind environment in the footpath, main entrances and outdoor communal terraces were assessed using omnidirectional pressure sensor tests.

Two configurations were conducted, namely:

- 1) **Existing:** a reference configuration with the existing development to represent existing conditions (Figure 18).
- 2) **Proposed:** test with the proposed development and existing surrounding developments (Figure 19).

The tests were conducted without any landscaping at the ground level.

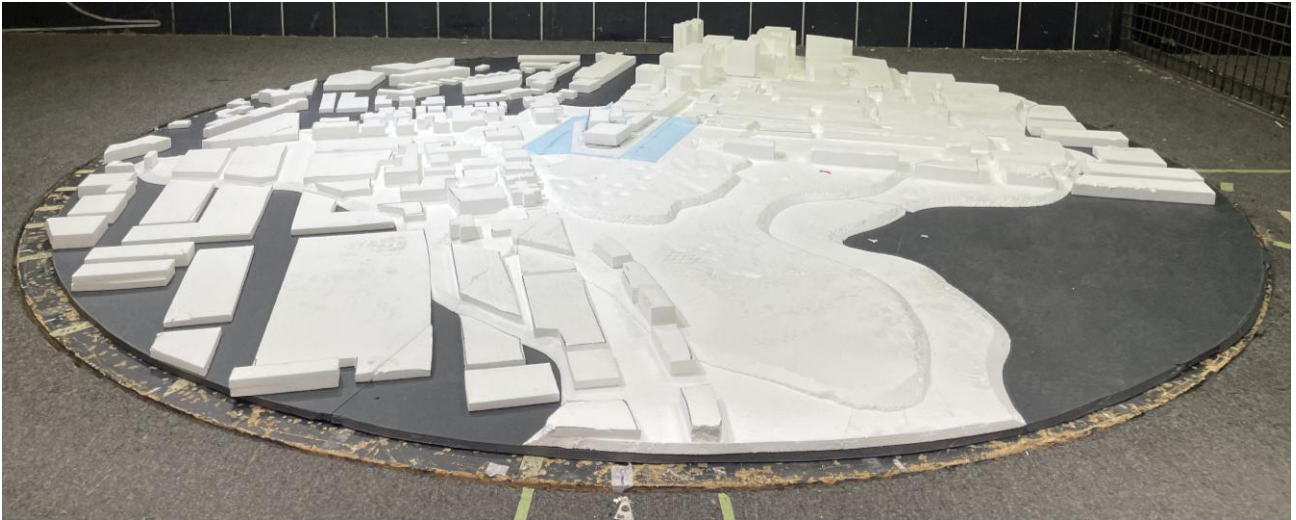


Figure 18: Overall view of the proposed development model from the east in the wind tunnel (Existing).

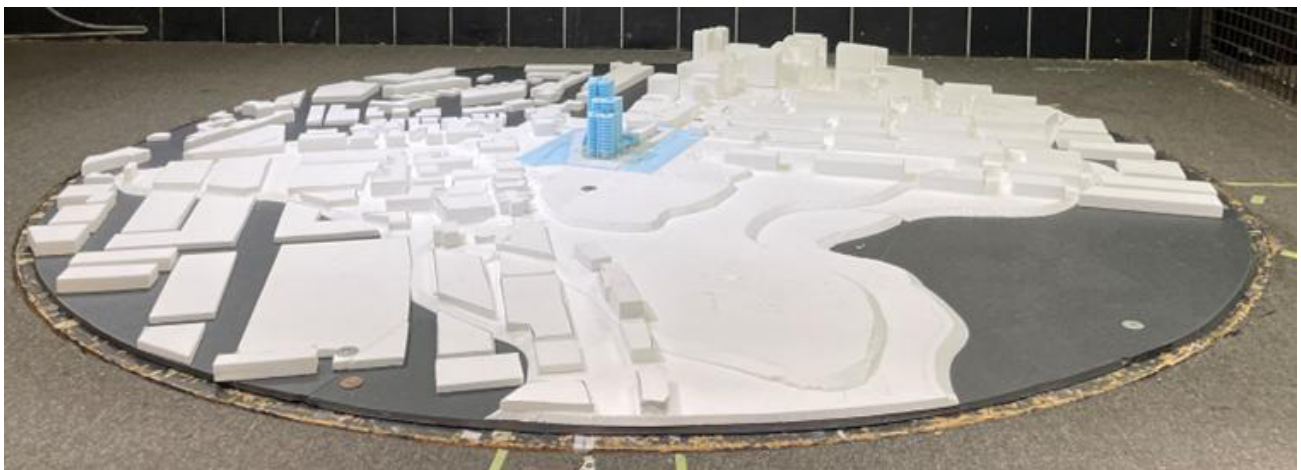


Figure 19: Overall view of the proposed development model from the east in the wind tunnel (Proposed).

The test results are presented as polar plots for the gust wind speeds appended in Appendix C of this report. Figure 20 shows an example of these plots. In the figure, the red circle represents the velocities for the safety criterion and the set of data points represent the different test configurations and the predicted gust wind speeds for the 36 directions for Location 12.

The plot shows that with the proposed design, Location 12 was within the recommended safety criterion for the Proposed configuration. This location also measured windspeeds within the recommended walking comfort criterion (Figure 21).

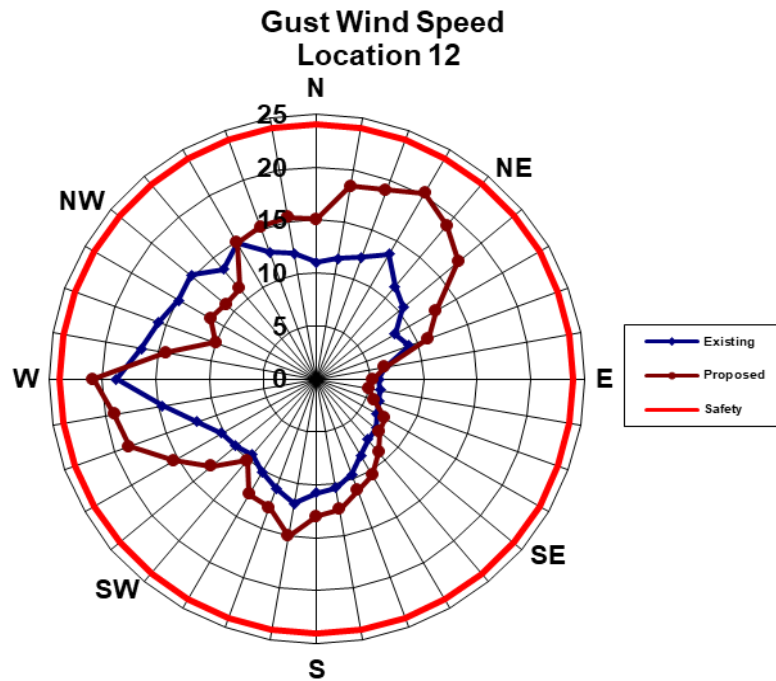


Figure 20: Polar plot showing the wind speed compared with safety criteria (Location 12).

Figure 21 and Figure 22 show the comparison between the comfort criteria and predicted hourly mean wind speeds (maximum of statistic mean and GEM). In these figures, the colour lines represent the threshold velocities for the different criteria and the data series (bars) represent the predicted values of the mean velocities. For all wind direction combination, the up-crossing prediction method described in Appendix D was used in the study.

Comfort Criteria

Mean wind speed (5% probability)

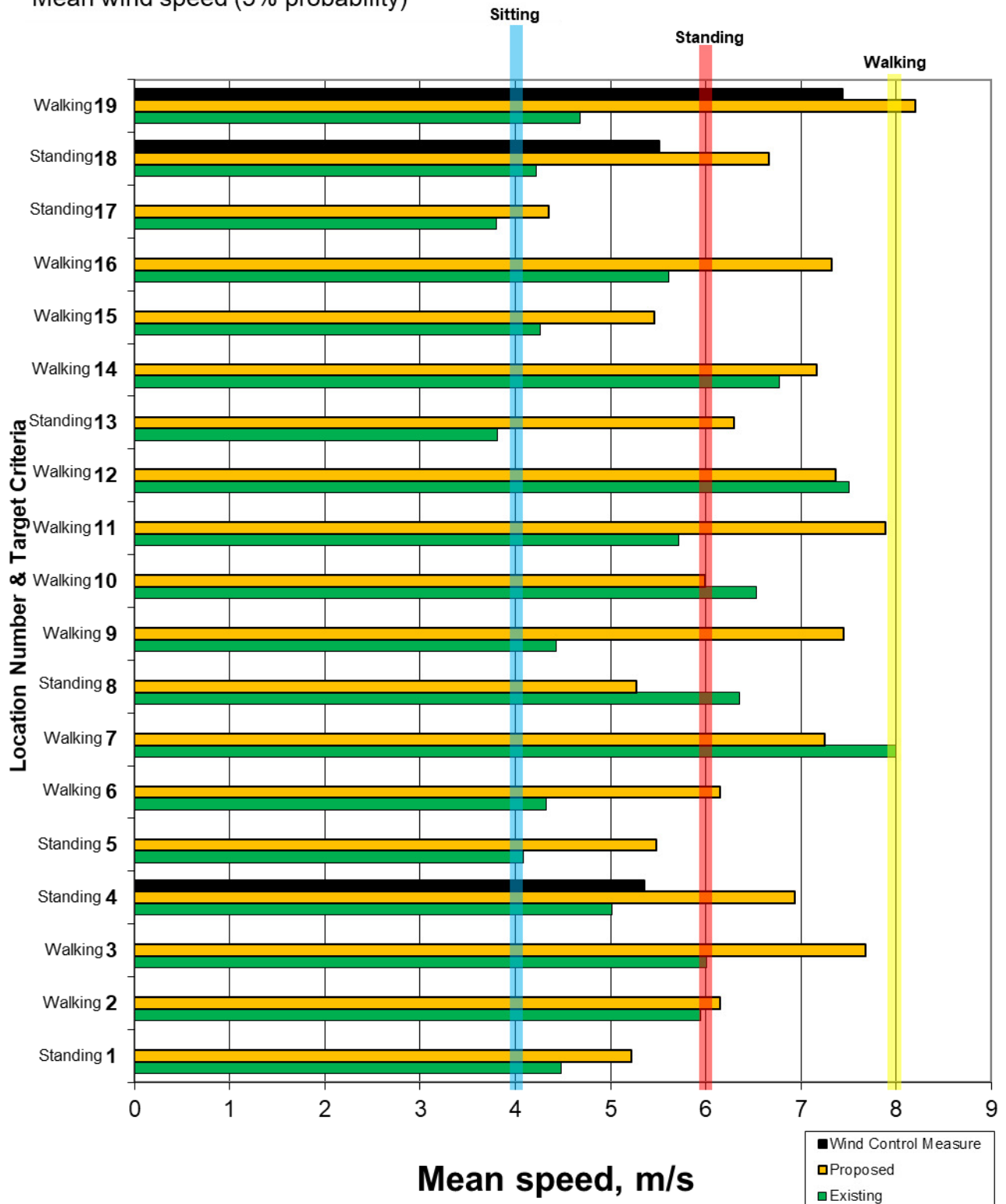


Figure 21: Bar plot showing the wind speed compared with comfort criteria (Locations 1 - 19).

Comfort Criteria

Mean wind speed (5% probability)

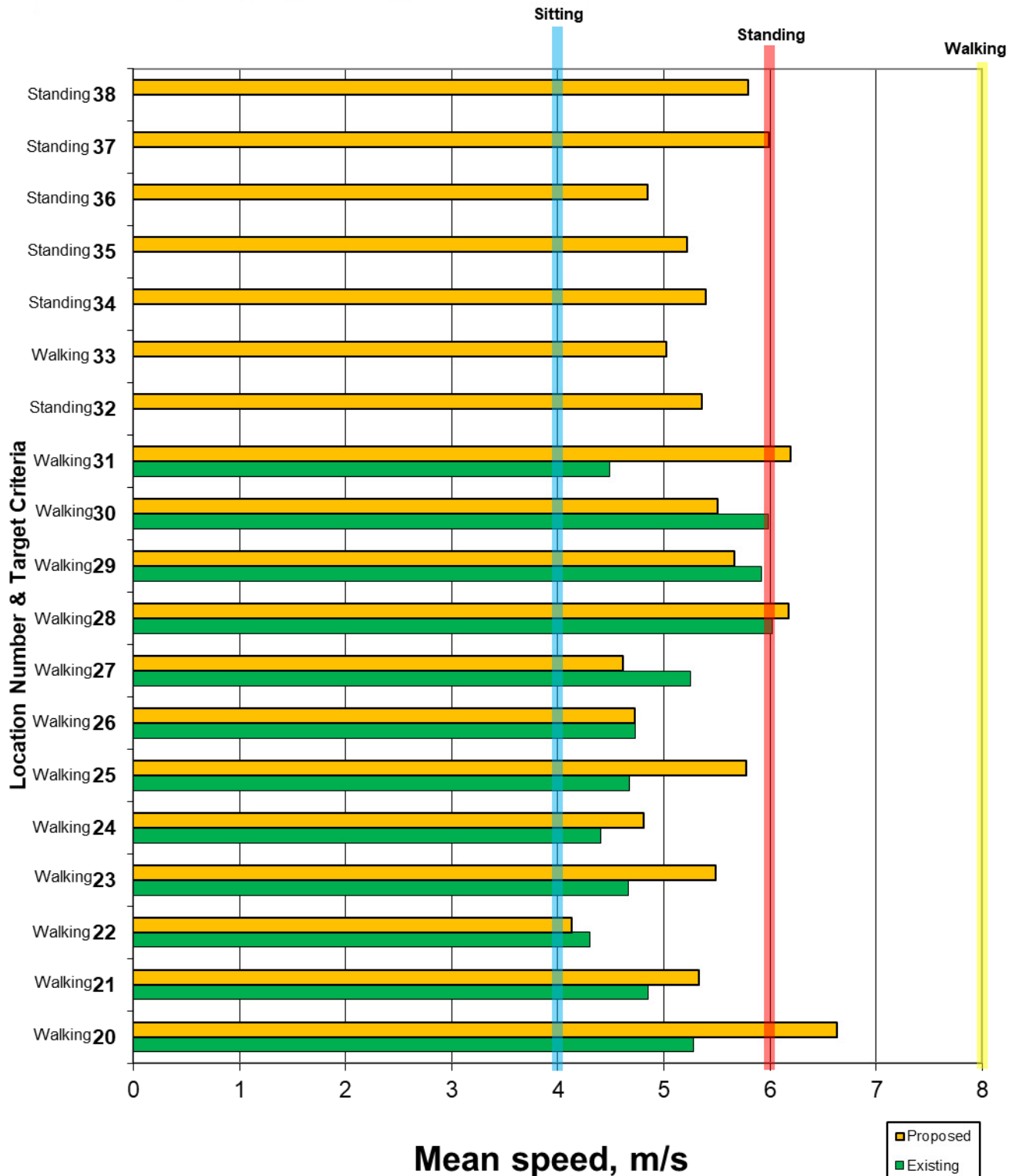


Figure 22: Bar plot showing the wind speed compared with comfort criteria (Locations 20 - 38).

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

7.1 Safety Criterion Test

All locations within the immediate vicinity of the proposed development measured gust windspeeds within the recommended safety criterion for the Proposed configuration. As such, no recommendations for wind amelioration were provided.

7.2 Comfort Criteria

Tests were performed with the colonnades and canopies at their proposed locations

7.2.1 Pedestrian Footpaths

Locations 1-21 & 24-31

Most locations within the immediate vicinity of the proposed development measured windspeeds within the recommended walking comfort criterion for the Proposed configuration.

Location 19 exceeded this criterion, adverse wind from the southwest. As such, 2m high landscaping is recommended southwest of this area (Figure 23).

7.2.2 Building Entrances

Locations 1, 4, 5, 8, 13, 17 & 18

Most locations within the immediate vicinity of the proposed development measured windspeeds within the recommended standing comfort criterion for the Proposed configuration.

Locations 4 and 18 exceeded this criterion, with adverse winds coming in from the west and northeast respectively. As such, 2m high landscaping is recommended around these areas (Figure 23).

Location 13 also exceeded this criterion for the Proposed configuration. As such, this entrance is recommended to be setback by 1m (Figure 23).

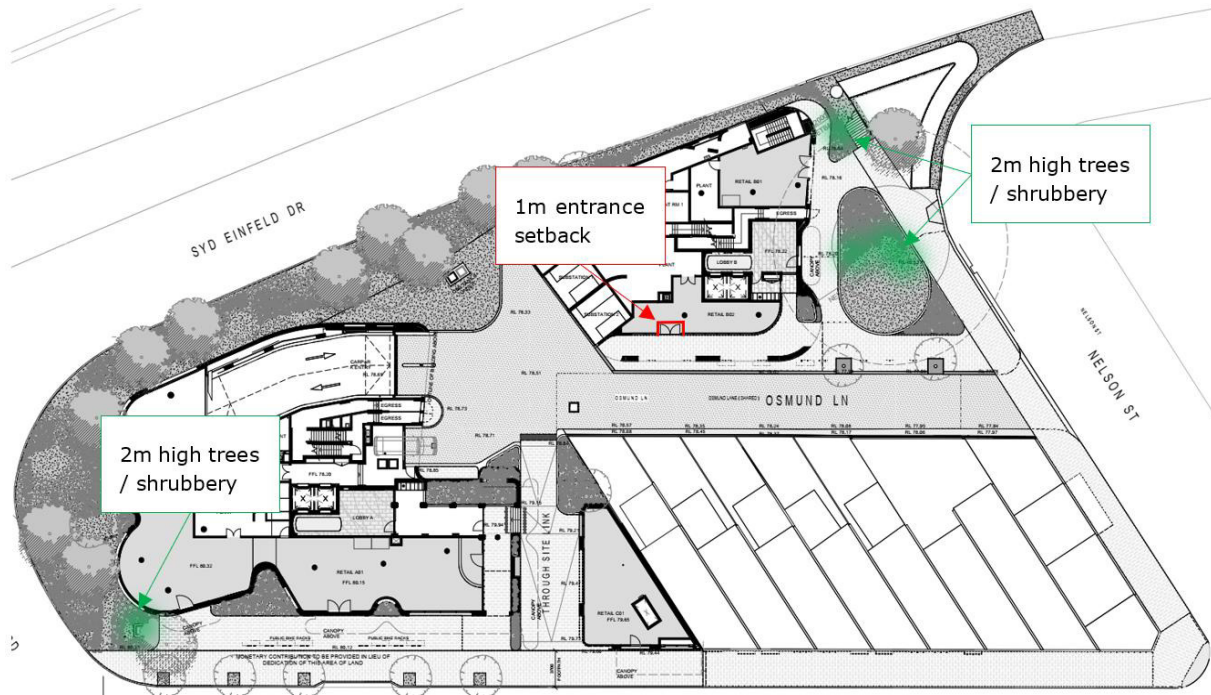


Figure 23: Wind amelioration measure overlaid on the ground floor plan.

7.2.3 Communal Terrace

7.2.3.1 Level 1

Locations 32-34

Tests were performed with 1.2m high solid balustrades

All locations measured windspeeds within the recommended standing comfort criterion for the Proposed configuration. As such, no recommendations for wind amelioration were provided.

7.2.3.2 Level 11

Tests were performed with 1.2m high solid balustrades

All locations measured windspeeds within the recommended standing comfort criterion for the Proposed configuration. As such, no recommendations for wind amelioration were provided.

7.2.4 Private balconies

There is no measurement on the private balconies on the various levels of the buildings. However, the wind conditions at all private balconies are expected to meet the recommended walking comfort criterion and safety criterion as long as 1.2 m high balustrade on the outer perimeter be proposed.

8 Conclusion

Vipac has carried out an assessment of the pedestrian level winds for the proposed development at **194-214 Oxford Street & 2 Nelson Street, Bondi Junction** based on a scaled wind tunnel test.

The findings of the study are summarised as follows:

The proposed design of the development:

- fulfils the recommended criterion for **Safety** at all test locations;
- fulfils the recommended criterion for **Walking** at all footpath locations **with the recommendations**;
- fulfils the recommended criterion for **Standing** at all building entrances **with the recommendations**; and
- fulfils the recommended criteria for **Standing** at all communal terraces.
- fulfils the recommended criteria for **Walking** at all private balconies including the amenity of the balconies on Levels 12 and 13 of Building A and Levels 12 to 16 of Building B.

The proposed development would not cause significant adverse impact to the adjacent areas.

As a general statement, common to all new developments, educating occupants about wind conditions at high-level terraces/balconies during high-wind events and tying down loose furniture are highly recommended.

Appendix A References

1. Australian/New Zealand Standard 1170.2:2021, Wind actions
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Appendix B Drawing List

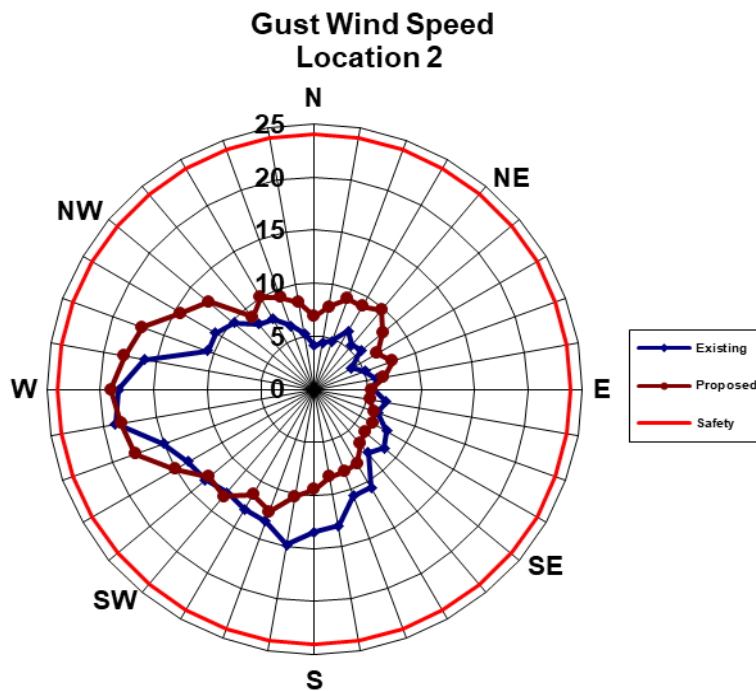
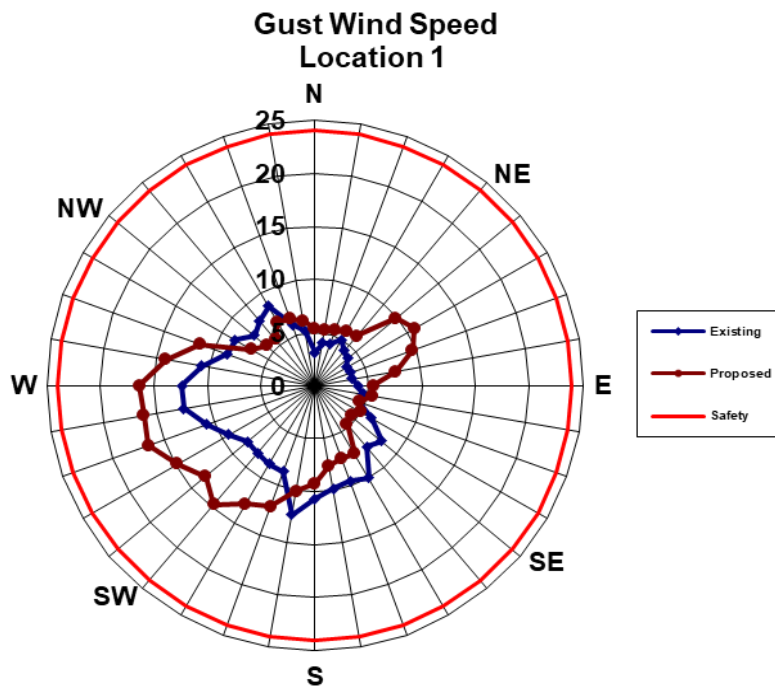
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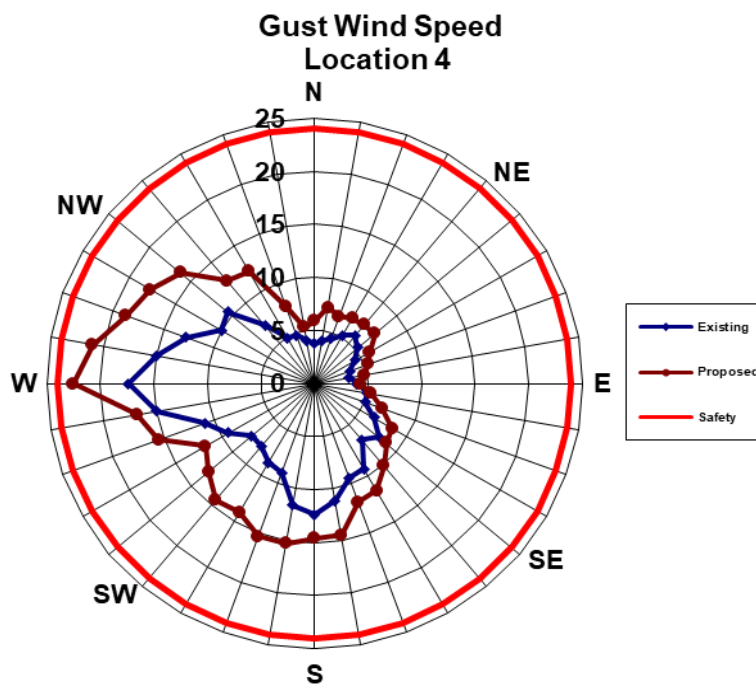
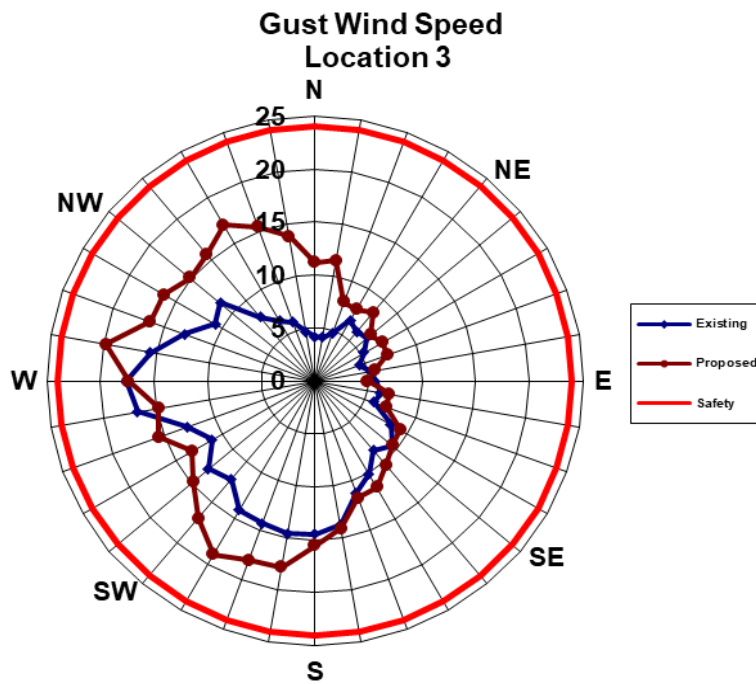
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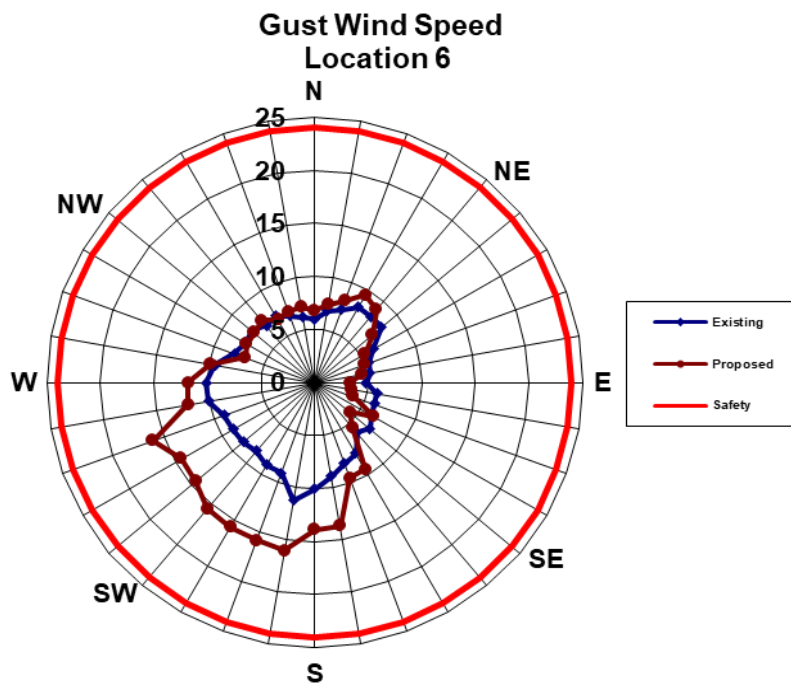
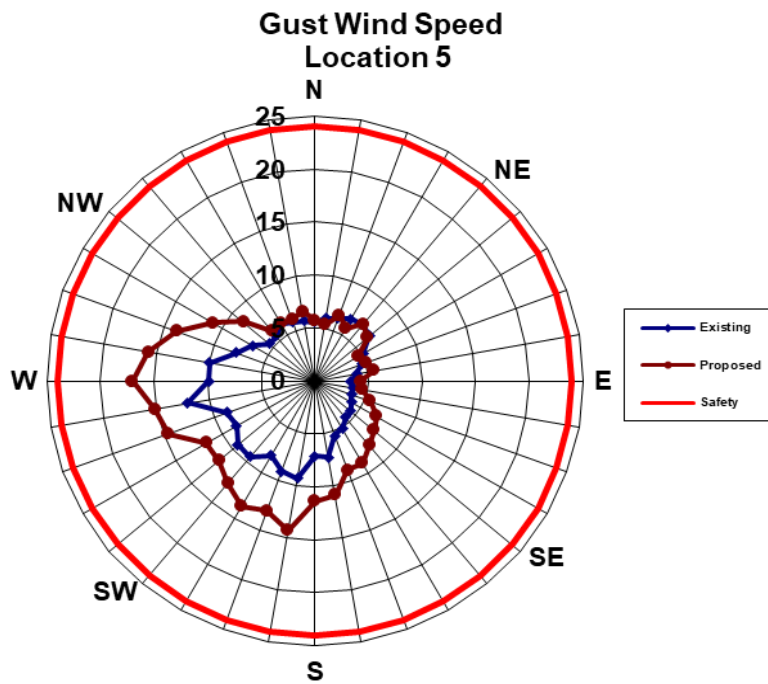
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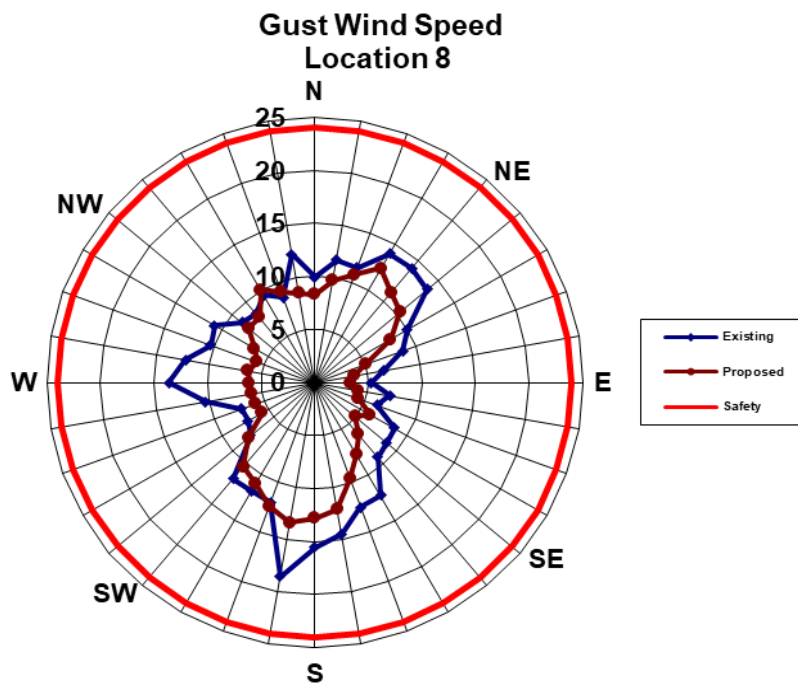
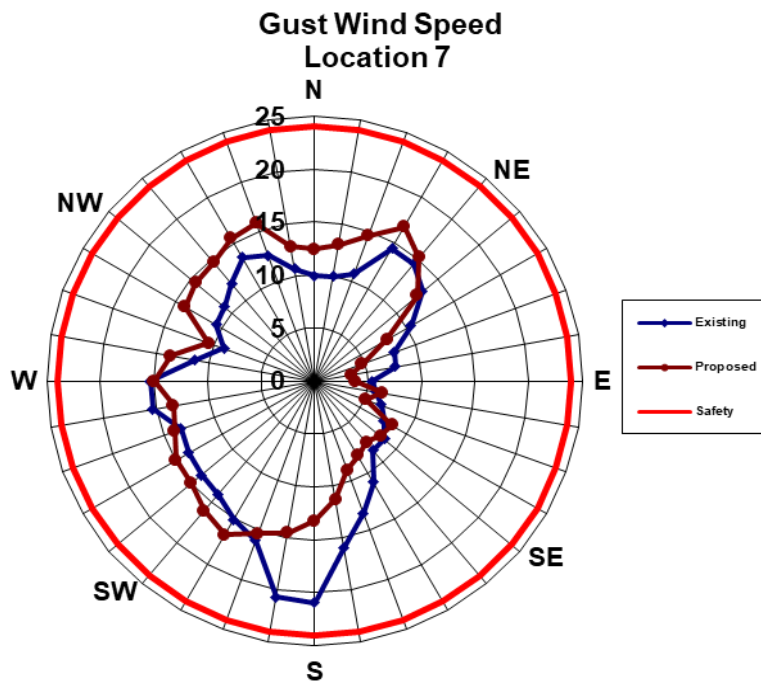
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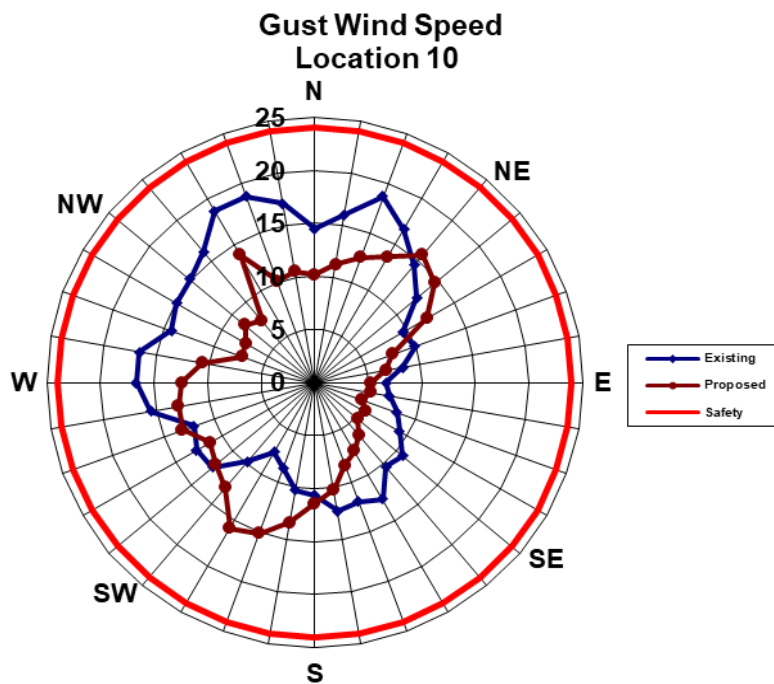
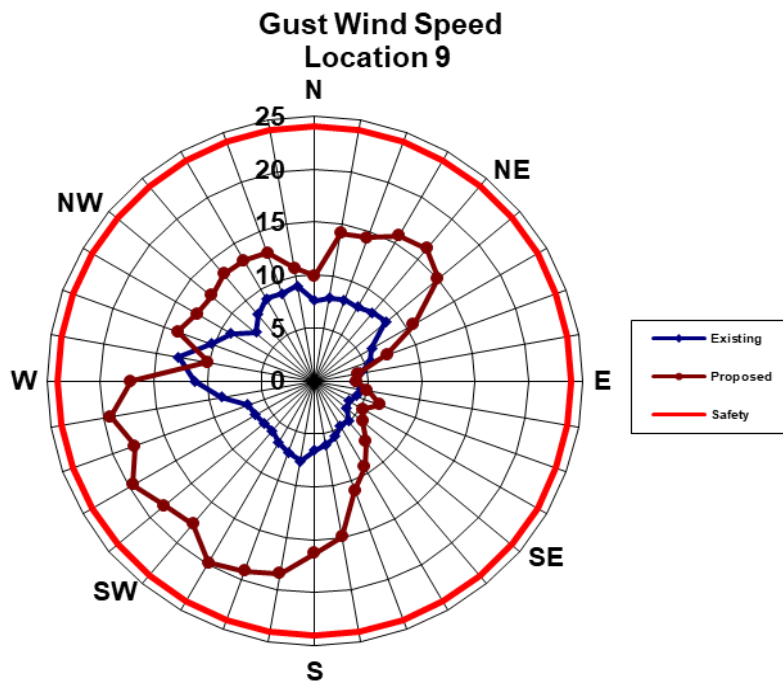
Appendix C Omni Polar Plots – Gust Wind Speeds (Safety Criterion)

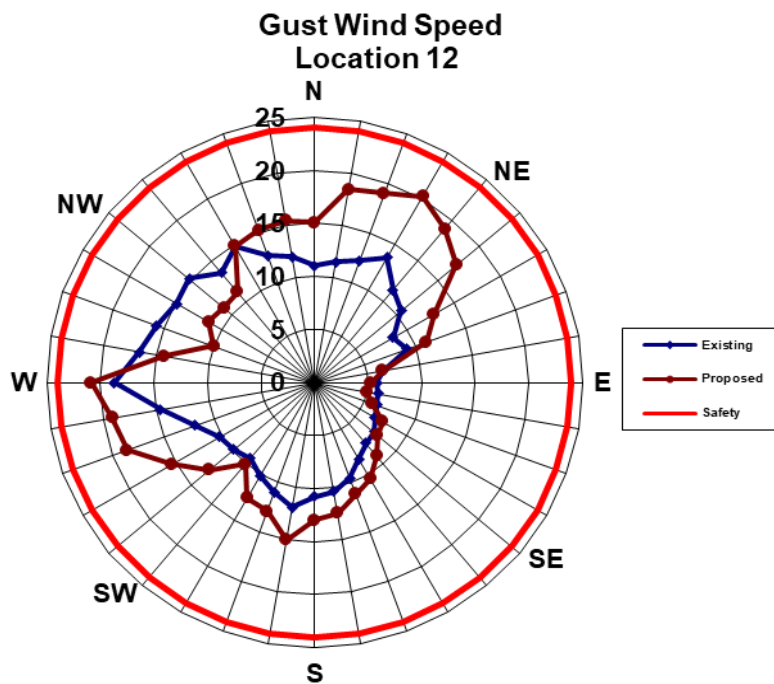
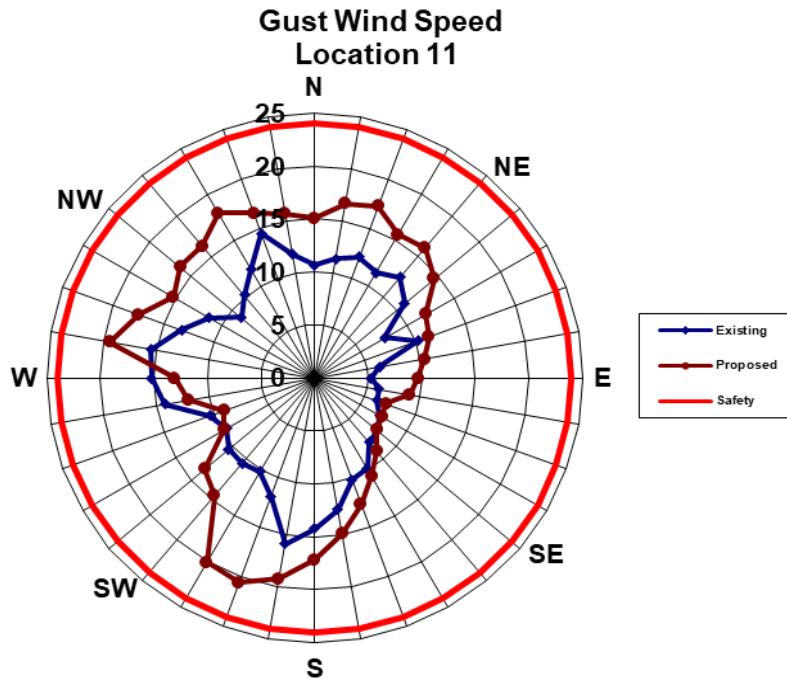


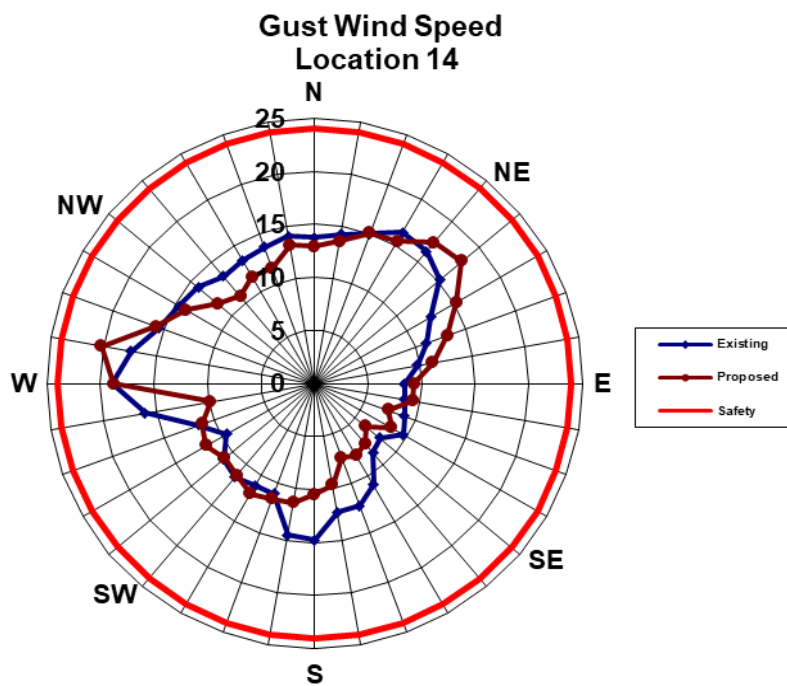
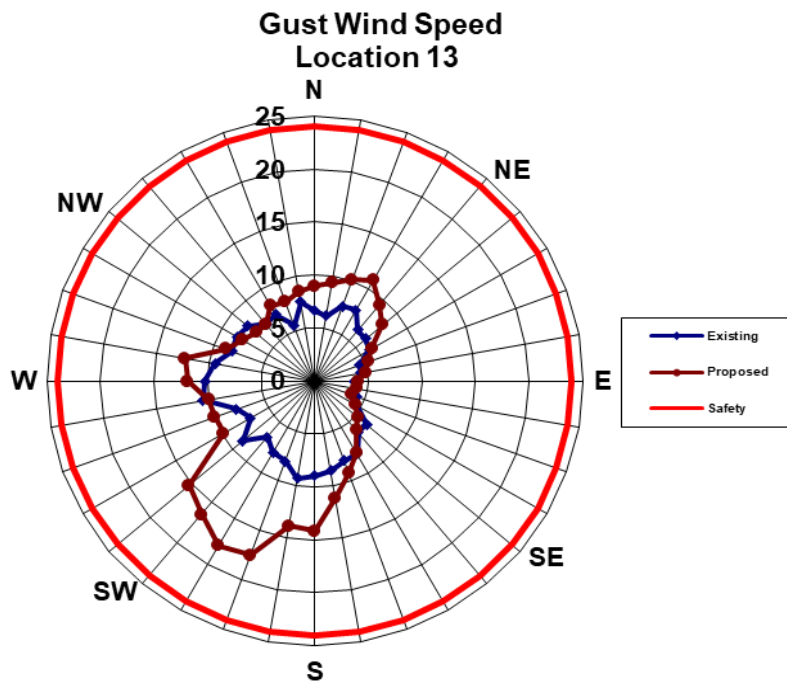


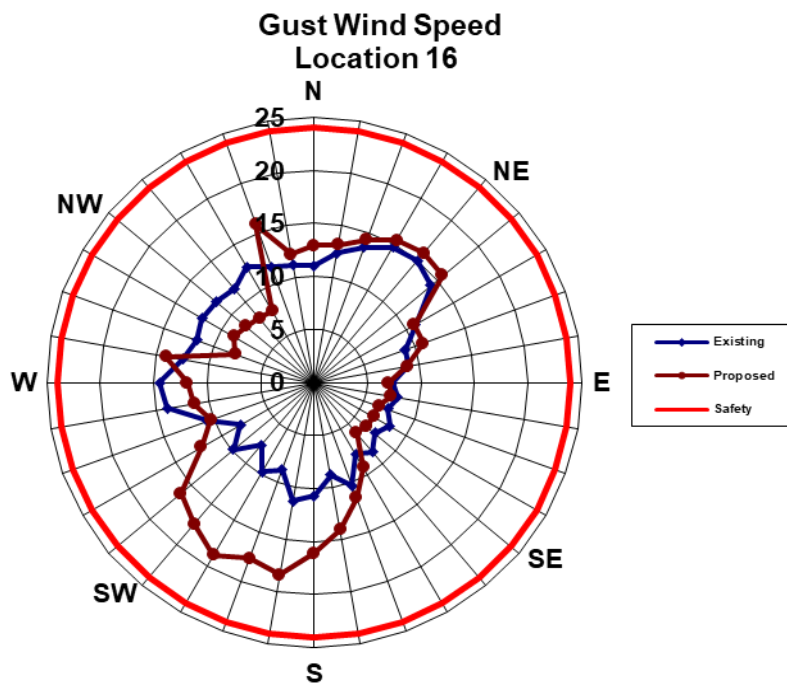
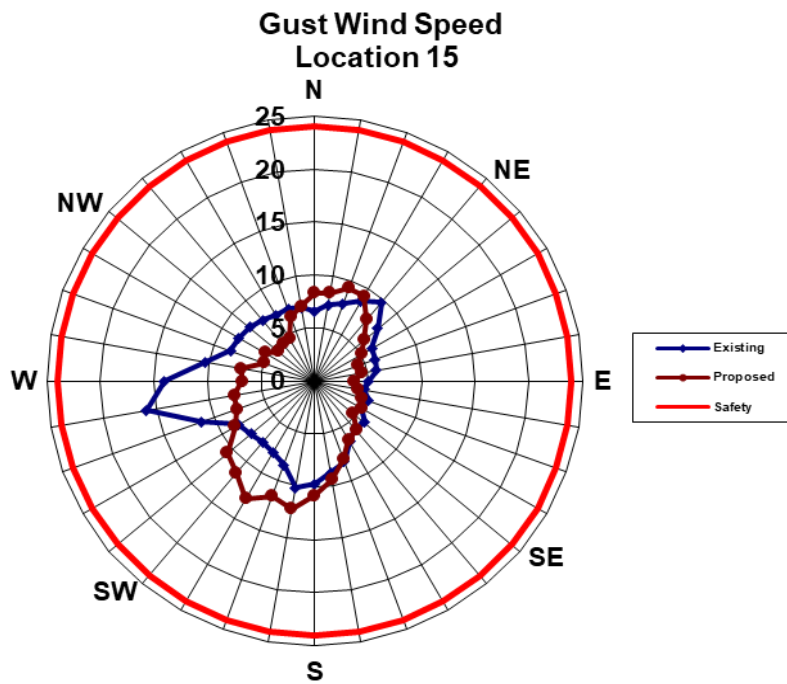


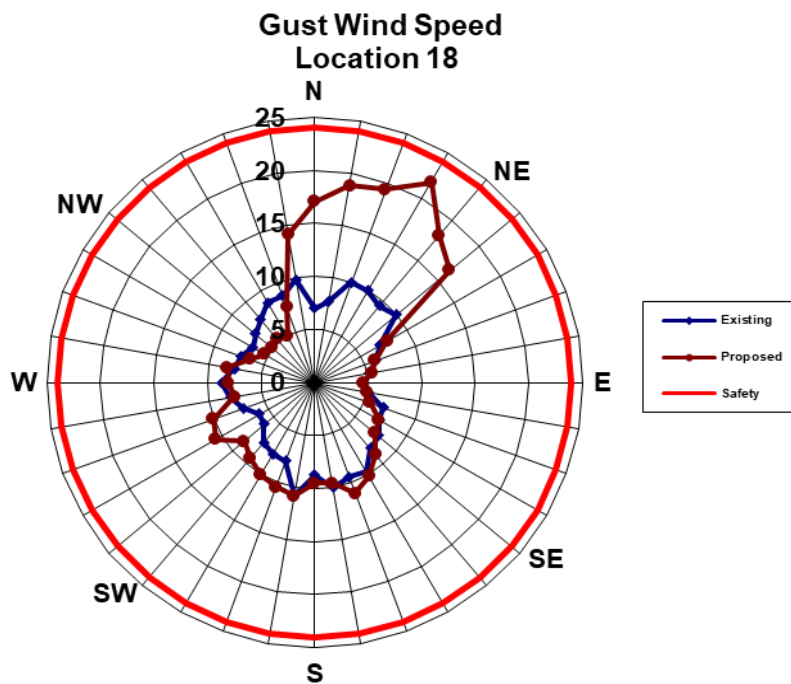
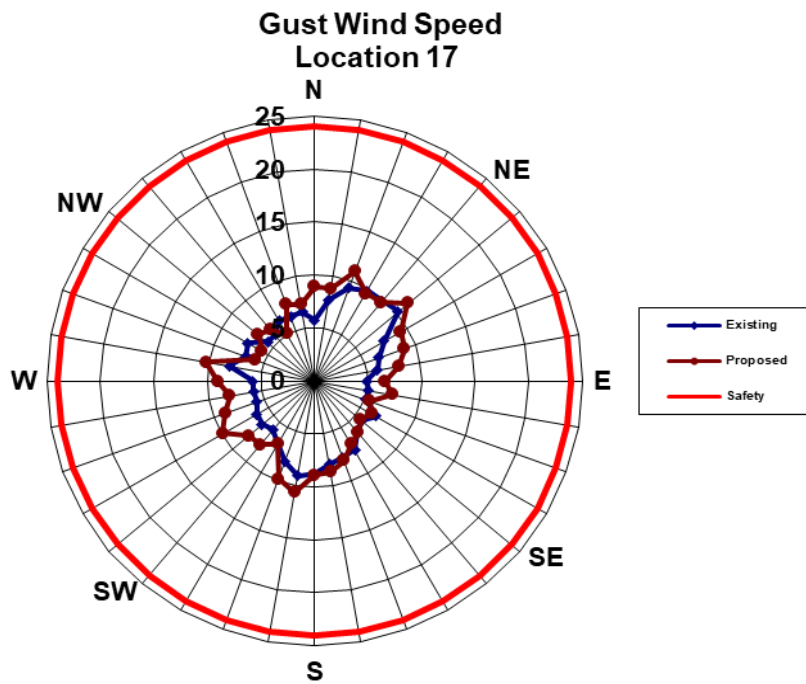


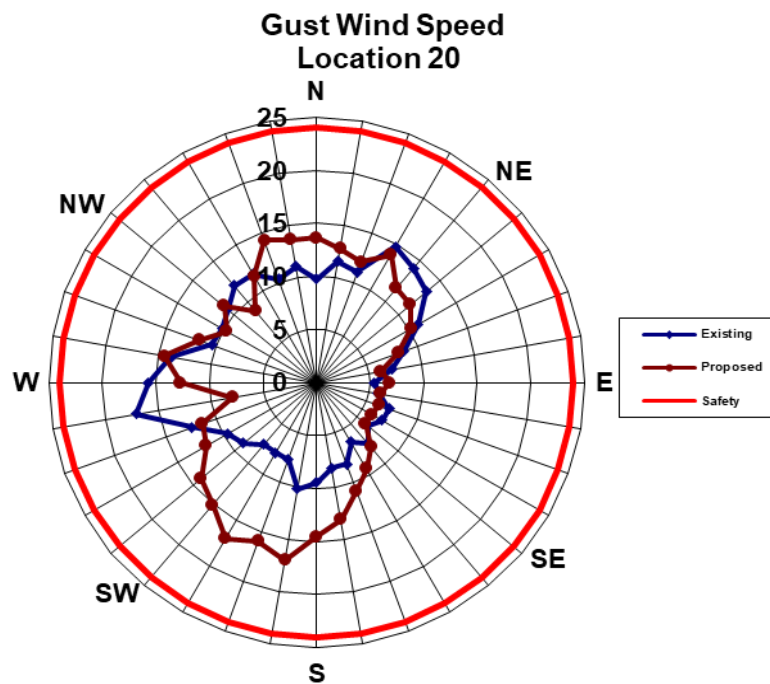
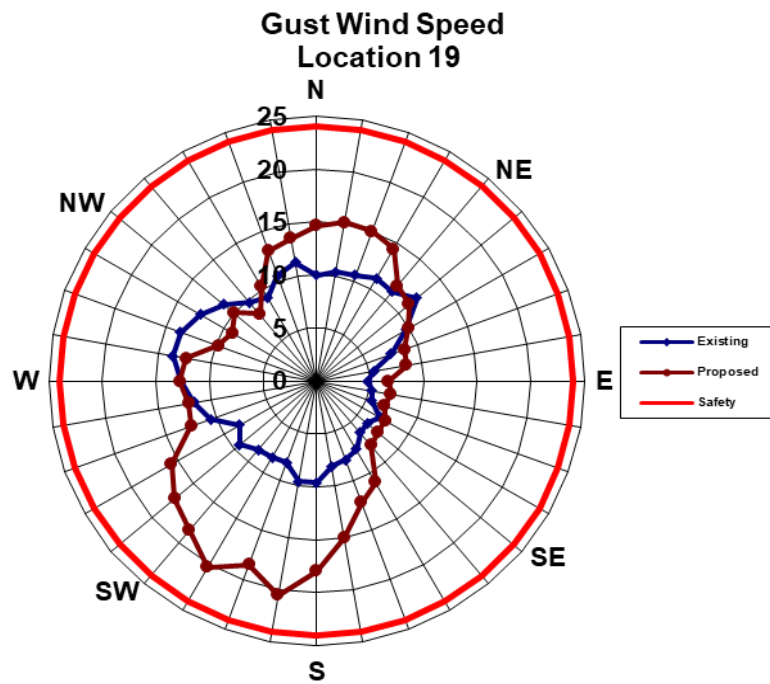


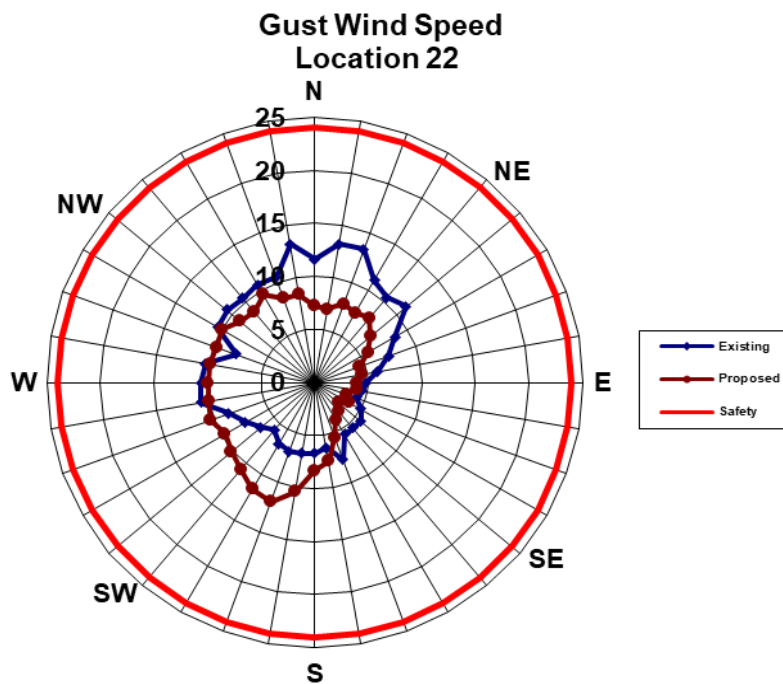
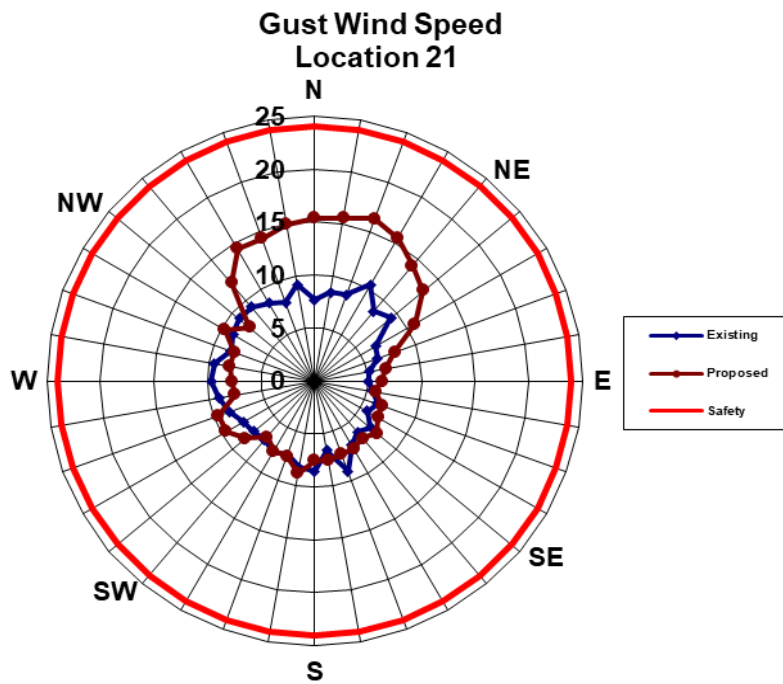


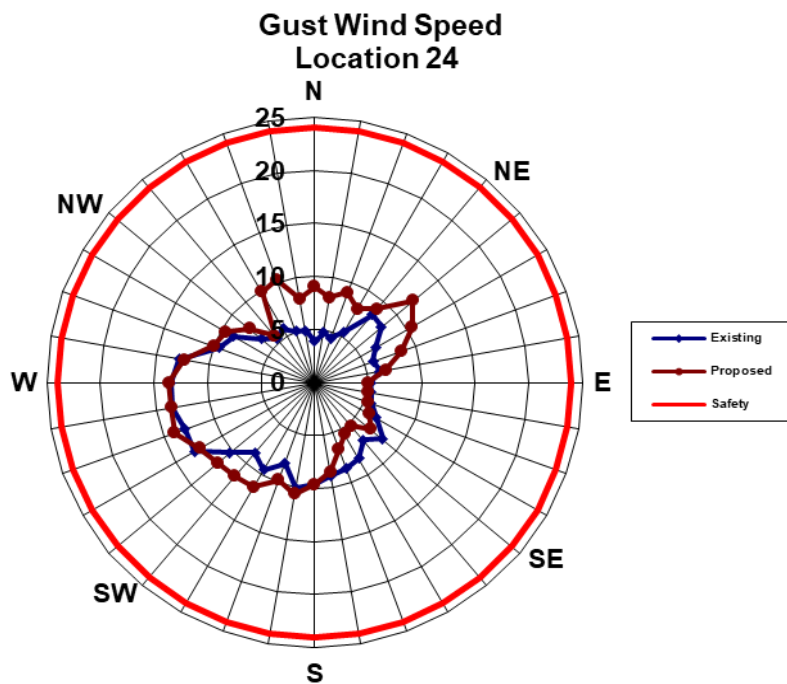
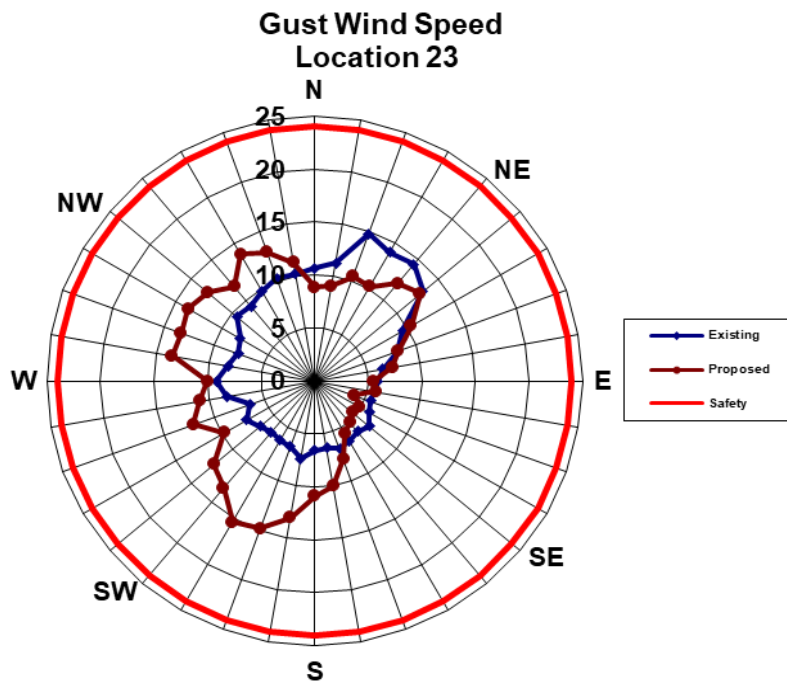


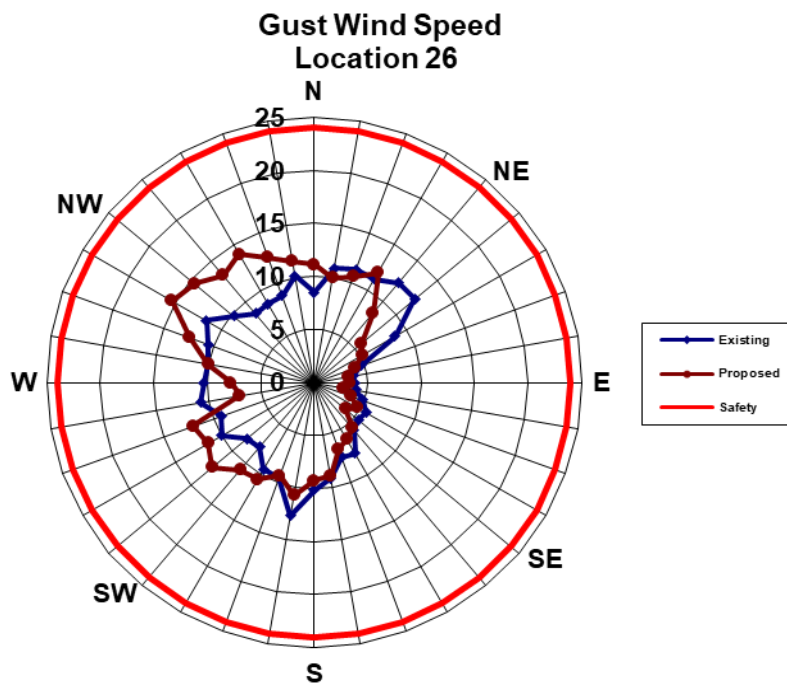
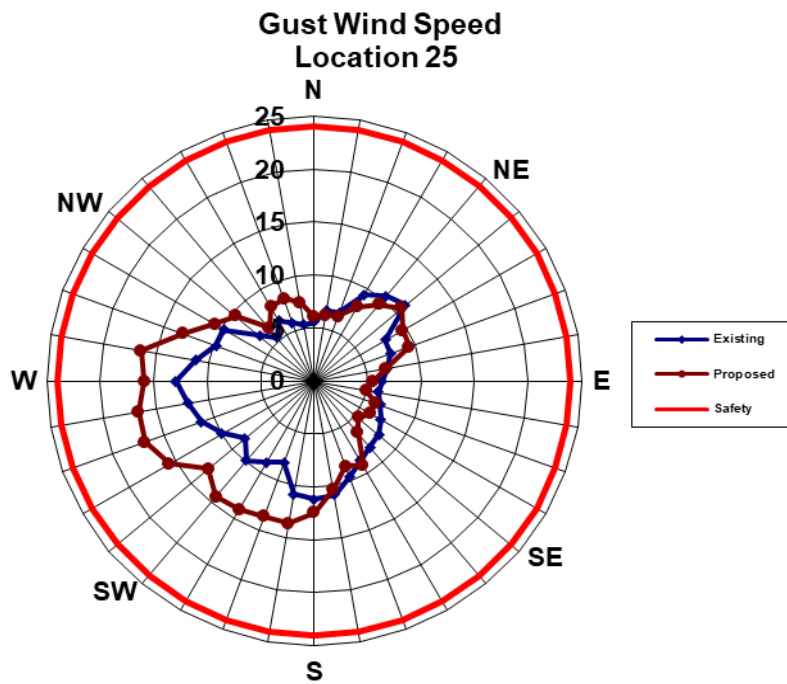


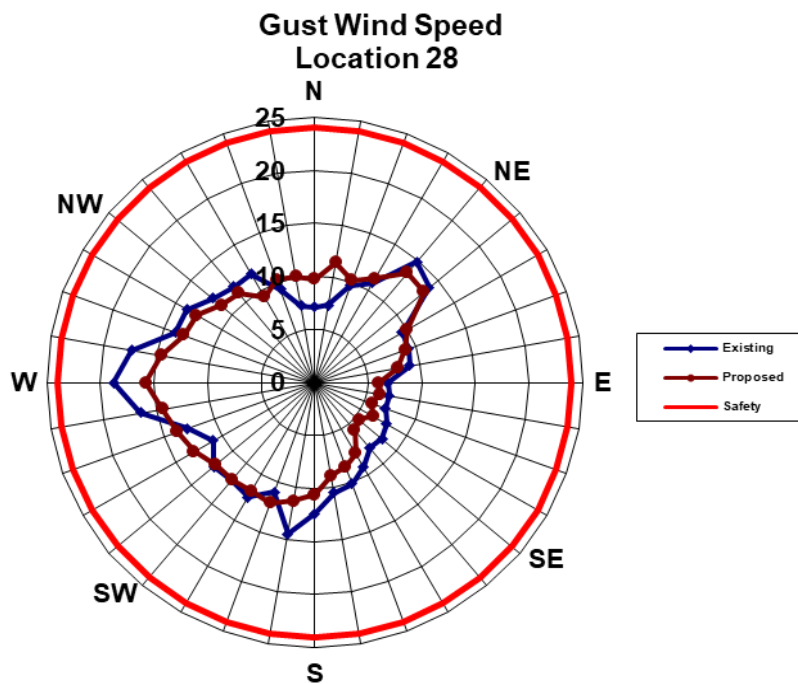
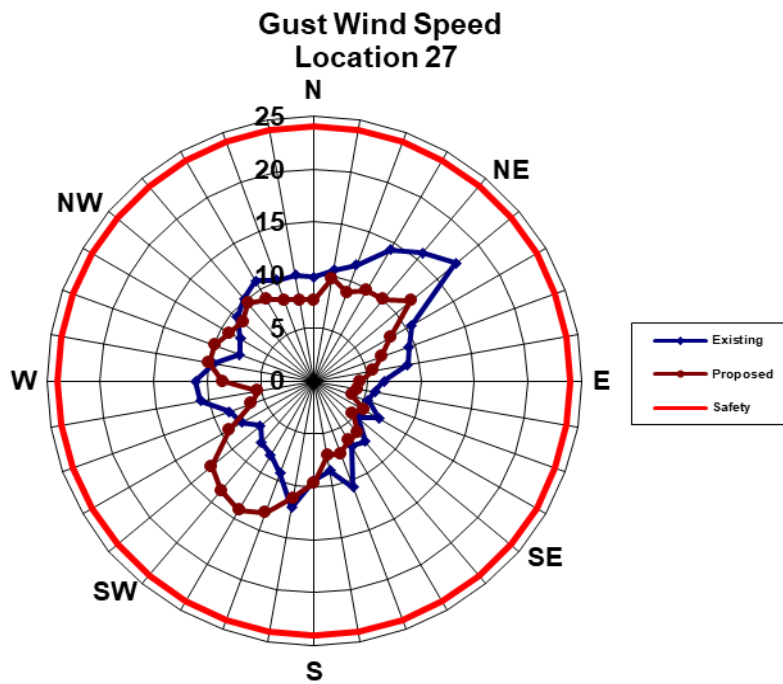


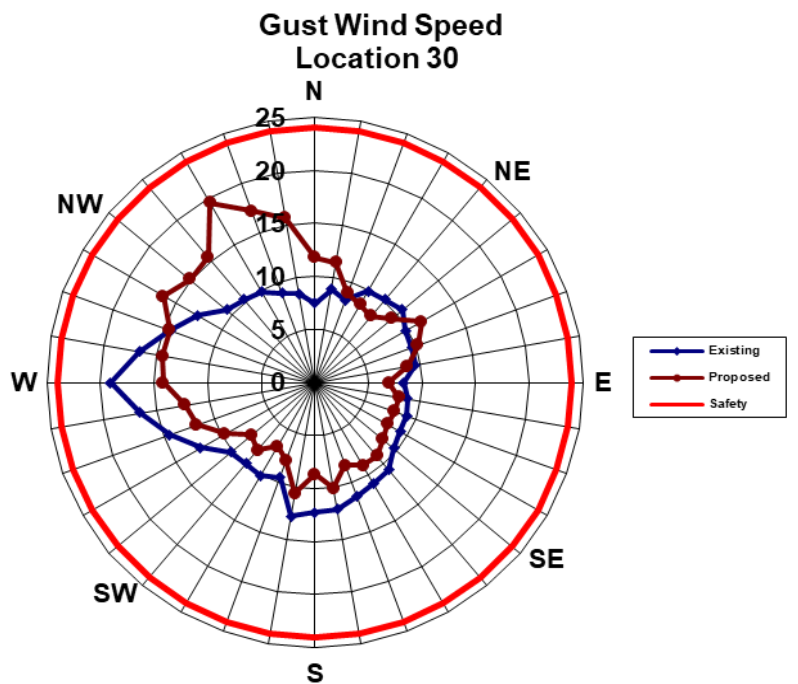
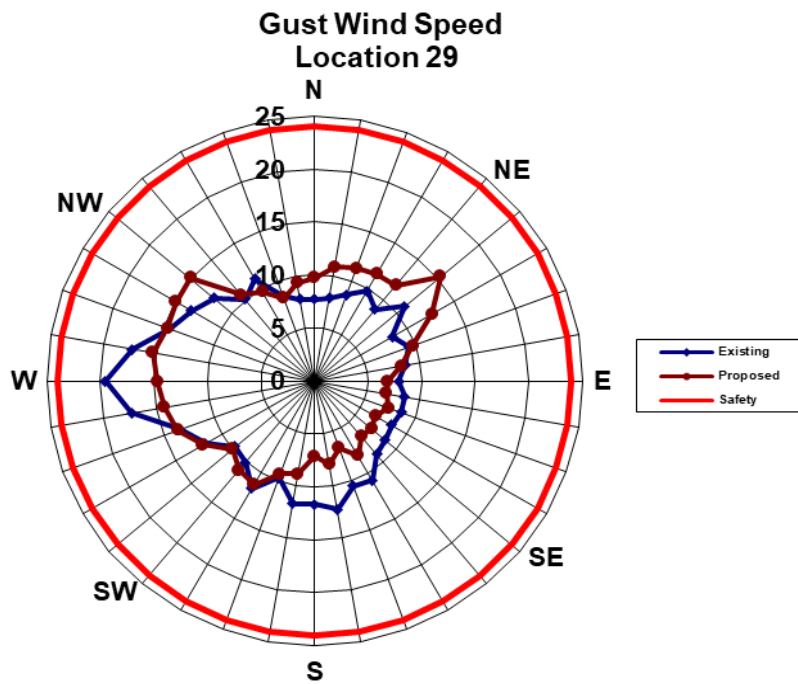


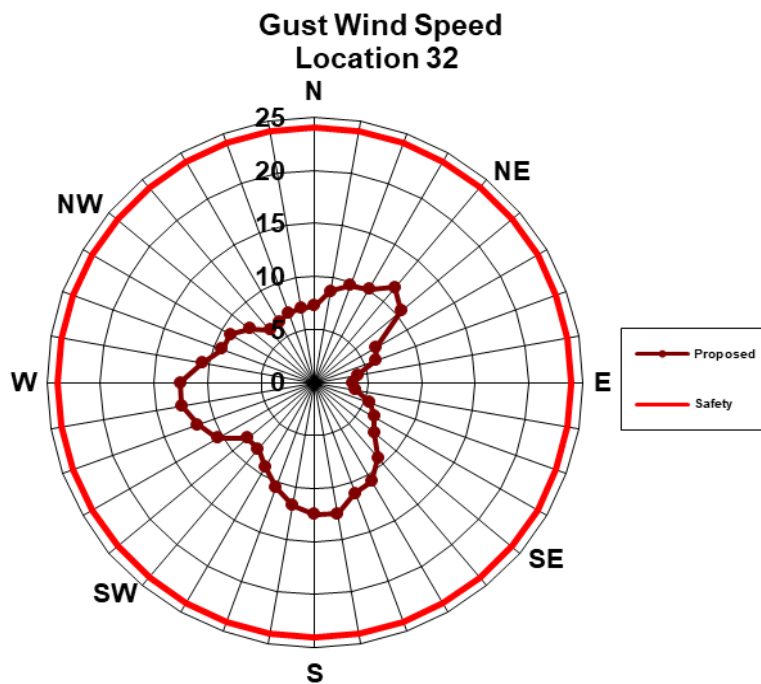
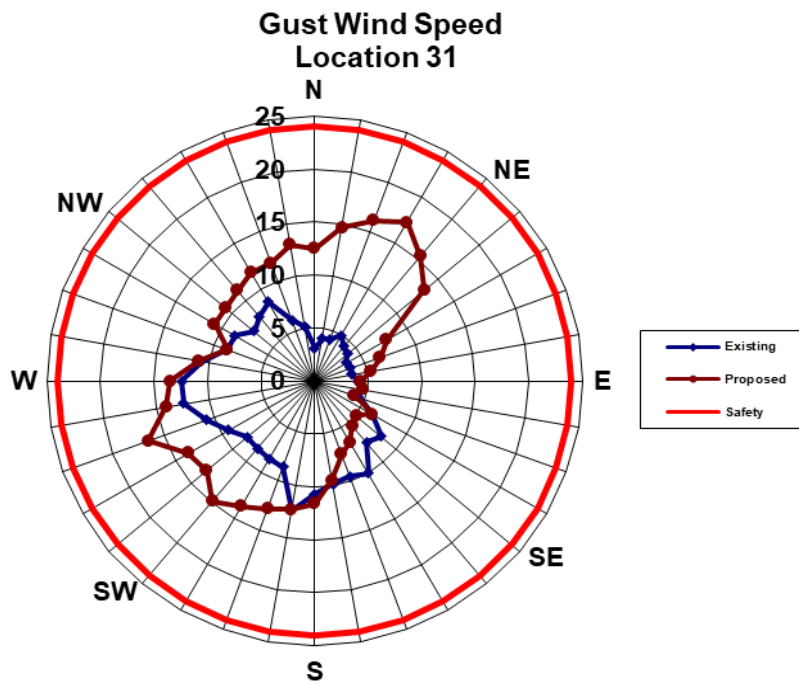


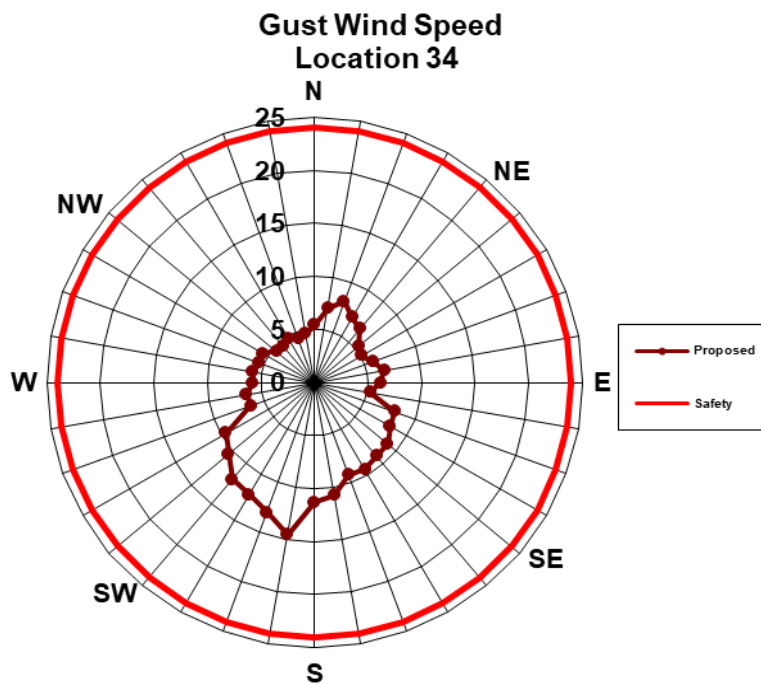
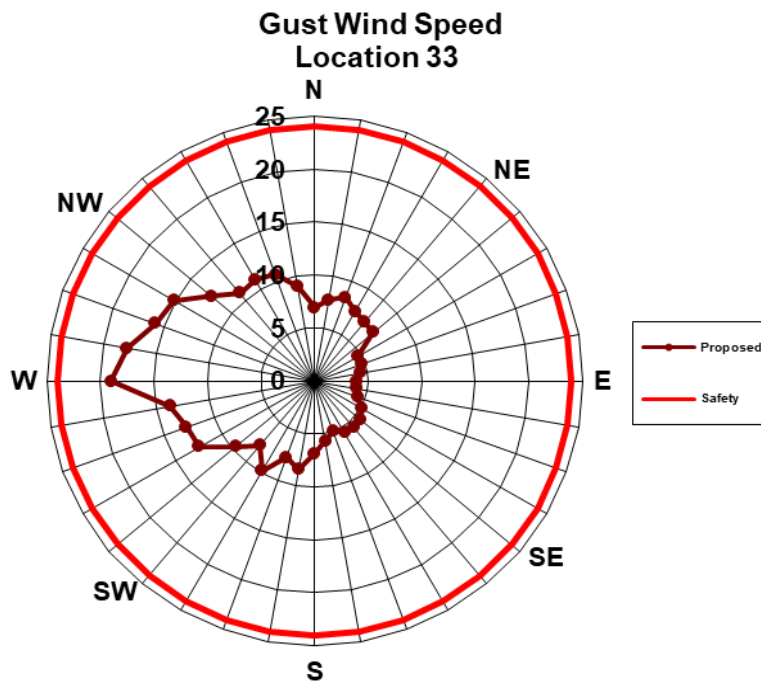


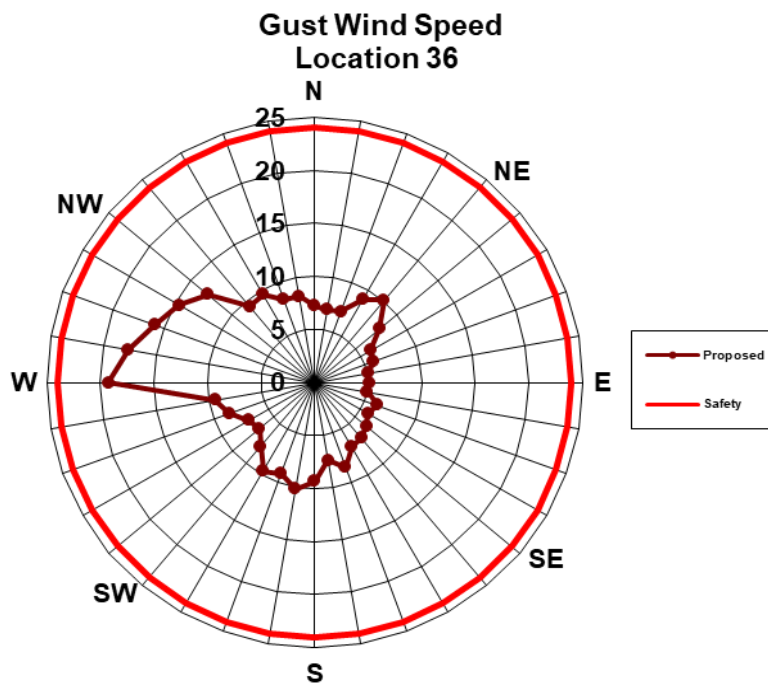
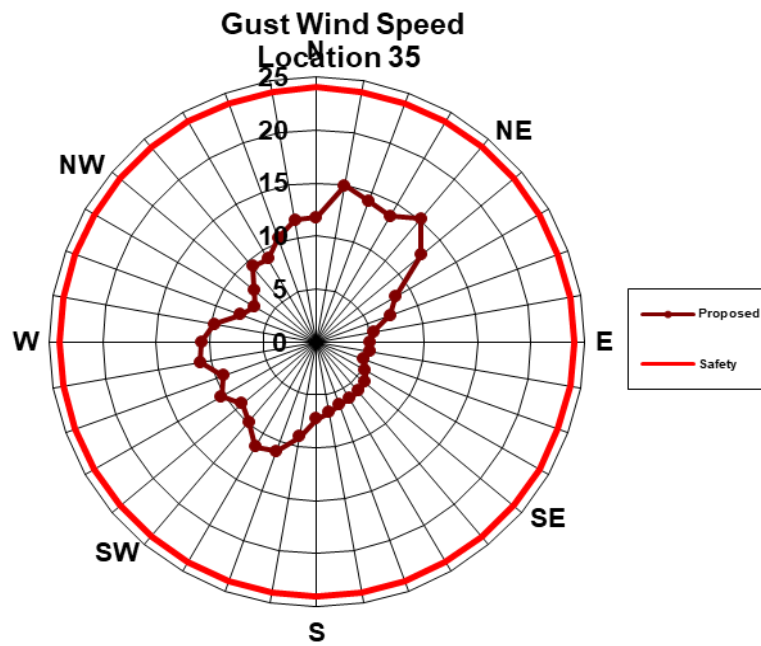


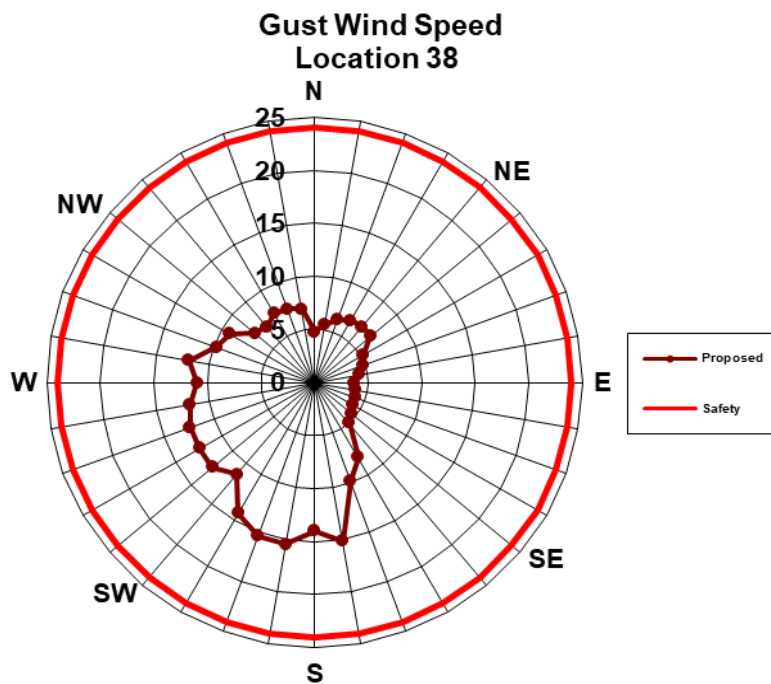
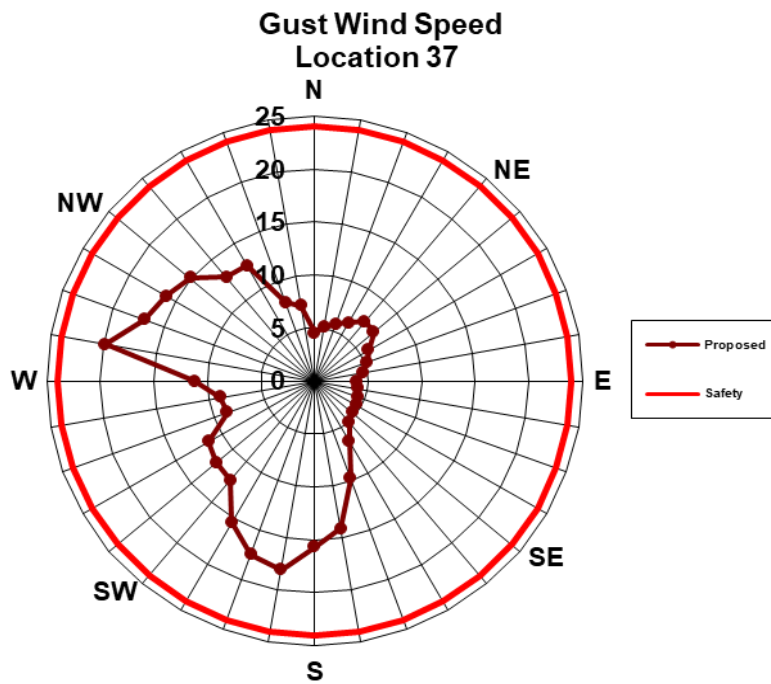












Appendix D Up-crossing Prediction

The up-crossing method was used at Boundary Layer Wind Tunnel Laboratory, University of Western Ontario decades ago and adapted at VIPAC recently. The methodology is based on the following theory.

The expected number of excursions beyond a level x per unit time, or the rate of crossing with positive slope, according to Rice's theory (D.2), is given by:

$$N_x(x) = \int_0^{\infty} \dot{x} p(x, \dot{x}) d\dot{x} \quad (1)$$

where $\dot{x}$ is the rate of change of x and $p(x, \dot{x})$ is the joint probability density function of x and $\dot{x}$. For a stationary random process, x and $\dot{x}$ are statistically independent, thus

$$p(x, \dot{x}) = p(x) p(\dot{x}) \quad (2)$$

For a Gaussian process,

$$\int_0^{\infty} \dot{x} p(\dot{x}) d\dot{x} = \frac{\sigma_{\dot{x}}}{\sqrt{2\pi}} \quad (3)$$

where $\sigma_{\dot{x}}$ is the standard deviation of $\dot{x}(t)$. Thus, the crossing rate now becomes

$$N_x(x) = \frac{\sigma_{\dot{x}}}{\sqrt{2\pi}} p(x) \quad (4)$$

The statistical frequency or the cycling rate of process $x(t)$ is defined as

$$\nu = \frac{1}{2\pi} \frac{\sigma_{\dot{x}}}{\sigma_x} \quad (5)$$

Substituting this in equation (4) yields

$$N_x(x) = \sqrt{2\pi} \nu \sigma_x p(x) \quad (6)$$

Extending Rice's theory, Davenport (D.3) has shown that for a two-dimensional variable, $x = x(V, \alpha)$, the crossing rate of a particular boundary $x = x_1$ becomes:

$$N_x(x) = \sqrt{2\pi} \nu \sigma \int_0^{2\pi} \sqrt{1 + \left(\frac{dV_1}{V_1 d\alpha} \right)^2} p_V(V_1, \alpha) d\alpha \quad (7)$$

where $x_1 = x(V_1, \alpha)$ and $p_V(V, \alpha)$ is the joint probability density function of V and α .

Approximating the probability distribution of the wind speed V and the direction α by a generalized Weibull distribution,

$$p_V(>V, \alpha) = A(\alpha) e^{-|V/C(\alpha)|^{K(\alpha)}} \quad (8)$$

the probability density function of V and α becomes

$$p_V(V, \alpha) = A(\alpha) \frac{K(\alpha)}{C(\alpha)} \left(\frac{V}{C(\alpha)} \right)^{K(\alpha)-1} e^{-|V/C(\alpha)|^{K(\alpha)}} d\alpha \quad (9)$$

Hence the crossing rate of a particular boundary $x_1 = x_1(V_1, \alpha)$ from Equation (7) becomes:

$$N_x(x_1) = \sqrt{2\pi} \nu \sigma \int_0^{2\pi} \left\{ 1 + \frac{dV_1}{V_1 d\alpha} \right\}^{\frac{1}{2}} A(\alpha) \frac{K(\alpha)}{C(\alpha)} \left(\frac{V}{C(\alpha)} \right)^{K(\alpha)-1} e^{-|V/C(\alpha)|^{K(\alpha)}} d\alpha \quad (10)$$

The cycling rate, ν , and the standard deviation, σ , in Equation (10) are taken as those of the wind speed, V , regardless of direction; namely they are based on the marginal statistical properties of V and $\dot{V}$. With ν expressed in terms of occurrences per annum, $N_x(x_1)$ gives the yearly crossing rate.

The return period, or the average interval of time between events during which the response equals or exceeds the response boundary $x = x_1$, is the inverse of the crossing rate of that boundary. Consequently, from Equation (10) the return period for the response level $x = x_1$ in years is taken as

$$R_x(x_f) = \frac{1}{N_x(x_f)} \quad (11)$$

The risk of exceeding the response level associated with the return period $R_x(x_f)$ in a time period L is:

$$r(x_f) = 1 - \left(1 - \frac{1}{R_x(x_f)} \right)^L \quad (12)$$

From the above equation, the risk of exceeding x_f within a time interval of $L = R_x(x_f)$ is approximately 63 percent.

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- [D.3] Davenport, A.G., "The Prediction of Risk Under Wind Loading", 2nd International Conf. on Structural Safety and Reliability (ICOSSAR), Sept. 1977, Munich Germany.