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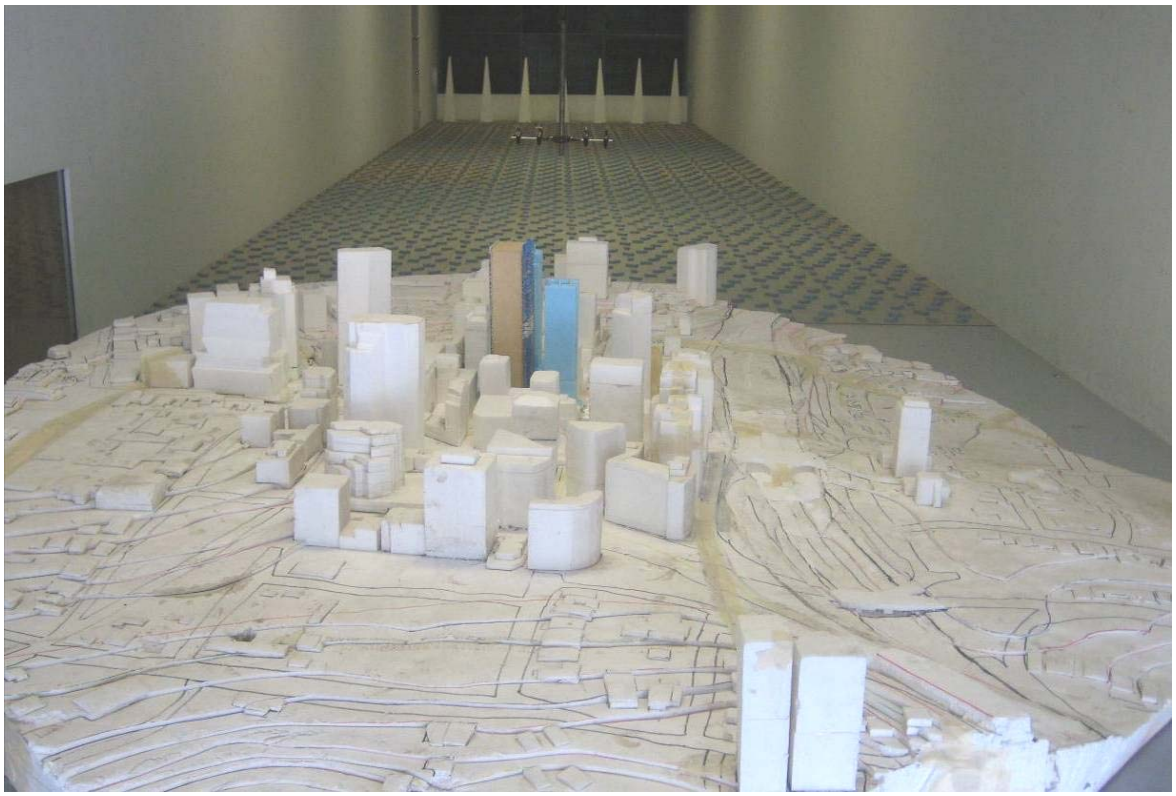

Pedestrian Wind Environment Study

for the proposed development at

88 Walker Street & 77-81 Berry Street, North Sydney

April 06, 2009

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Table of Contents

1.0 Executive Summary

This report presents the results of a detailed investigation into the wind environment impact in relation to the proposed development at 88 Walker Street & 77-81 Berry Street, located in North Sydney.

The proposed development consists of two towers. The office building is bounded by Little Spring Street to the east, Spring Street to the south, Denison Street to the west and an adjacent building to the north. The hotel building is bounded by Walker Street to the east, adjacent building to the south, Little Spring Street to the west and adjacent buildings to the north. The office building is connected to the hotel building by a link bridge over Little Spring Street.

Wind speed measurements were carried out using a 1:400 scale model of the development. A surrounds model incorporating the neighbouring buildings and local land topography was placed around the model of the proposed development. The surrounds model extends to a radius of 500m from the site. Testing was performed using Windtech's blockage tolerant boundary layer wind tunnel facility, which has a 3.0m wide work section and has a fetch length of 14m.

Peak gust wind speeds were measured and related to reference velocities at a height of 200m upstream of the proximity model. Wind speed velocity coefficients representing the local wind speeds are derived from the wind tunnel and are combined with the meteorological data for this region to provide the equivalent full-scale wind speeds. These wind speed measurements are compared with criteria for long and short duration stationary activities and for pedestrian comfort, based on annual maximum peak wind speeds and weekly maximum Gust Equivalent Mean (GEM) wind speeds, and where appropriate against the existing site wind conditions.

The results of this study indicate that wind conditions for most of the outdoor areas of the site, including all ground level areas, will require treatments to be implemented to be acceptable for their intended uses. Many treatments have been investigated in this study to treat the adverse winds affecting the outdoor areas of the proposed development. A set of treatments have been recommended in this report to ameliorate these effects, and are summarised as follows:

- A strategic layout of densely foliating trees for the ground level and Restaurant Level areas within and around the development site.
- The addition of wind deflectors/awnings 1 level high above the street level at the northern and southern aspects of the driveway within the podium of development.
- 1.2m high impermeable balustrades along the perimeter of the two terrace areas on the Restaurant Level of the development.
- Awning above street level along Walker Street and maintaining existing parapet on neighbouring building.

Note that for vegetation to be effective in mitigating adverse winds, particularly westerly winds which tend to occur predominantly during the winter months for

the Sydney region, the trees along Denison Street and Spring Street should be of a densely foliating evergreen species as indicated in the report.

With the recommended treatments included into the final design of the development, the wind conditions within and around the proposed development site will be acceptable for their intended uses.

2.0 Model Description

2.1 Model of the Study Building and Surrounds

Wind speed measurements were carried out using a 1:400 scale model of the development. A surrounds model incorporating the neighbouring buildings and local land topography was placed around the study building model. The surrounds model extends to a radius of 500m from the site. Photographs of the wind tunnel model with the proposed and existing development are presented in Figures 1a to 1i.

The proposed development consists of two towers. The office building is bounded by Little Spring Street to the east, Spring Street to the south, Denison Street to the west and an adjacent building to the north. The hotel building is bounded by Walker Street to the east, adjacent buildings to the south, Little Spring Street to the west and adjacent buildings to the north. The office building is connected to the hotel building by a link bridge over Little Spring Street.

The model was placed in a suburban terrain boundary layer wind flow based on the Deaves and Harris (1978) model. The reference wind speeds were corrected for changes in the upstream building morphology and land topography.

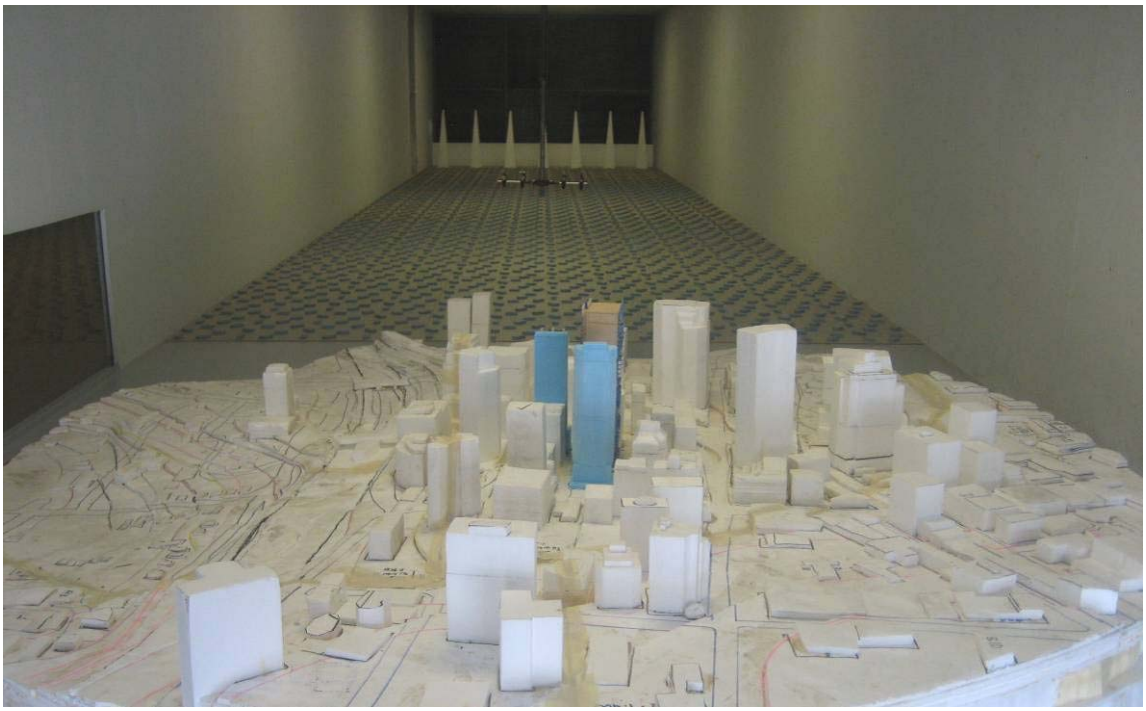

Figure 1a: Photograph of the Model in the Wind Tunnel (view from the North – with the inclusion of the proposed development)

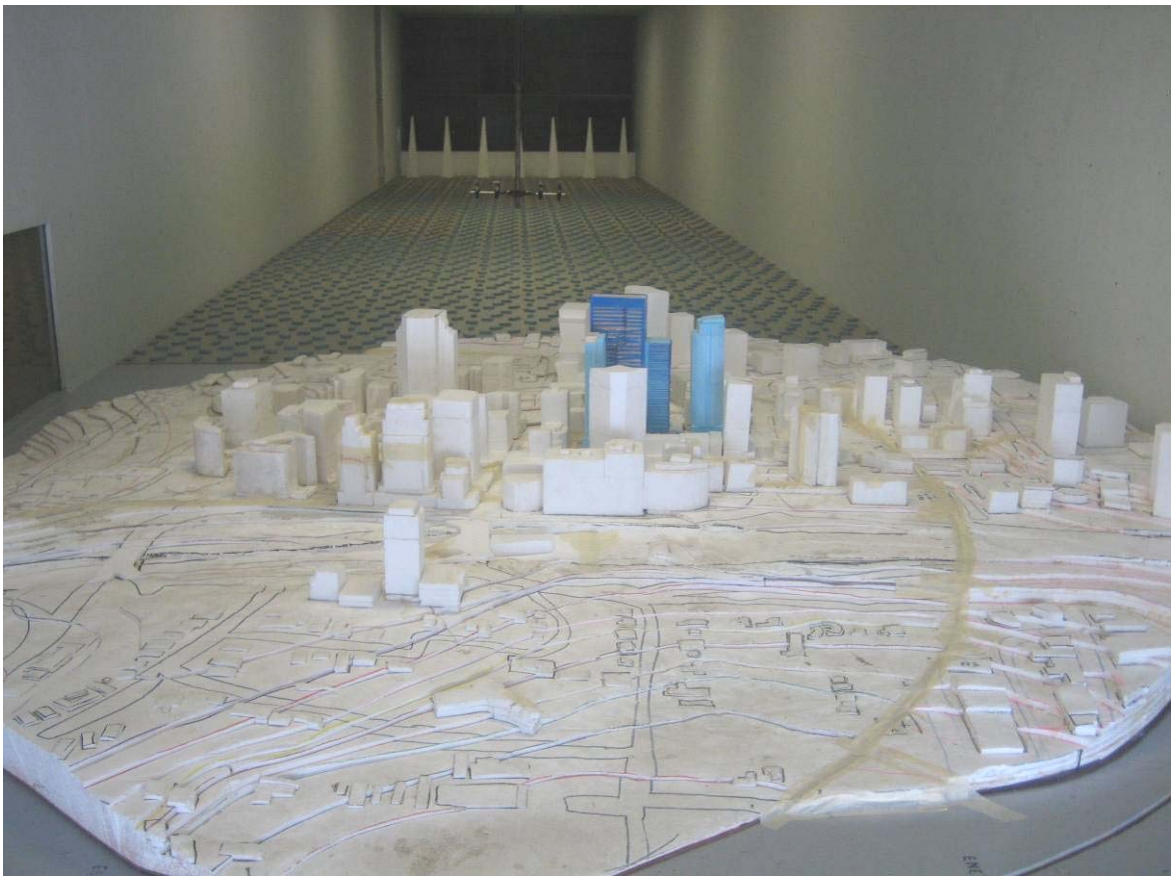

Figure 1b: Photograph of the Model in the Wind Tunnel
(view from the East - with the inclusion of the proposed development)

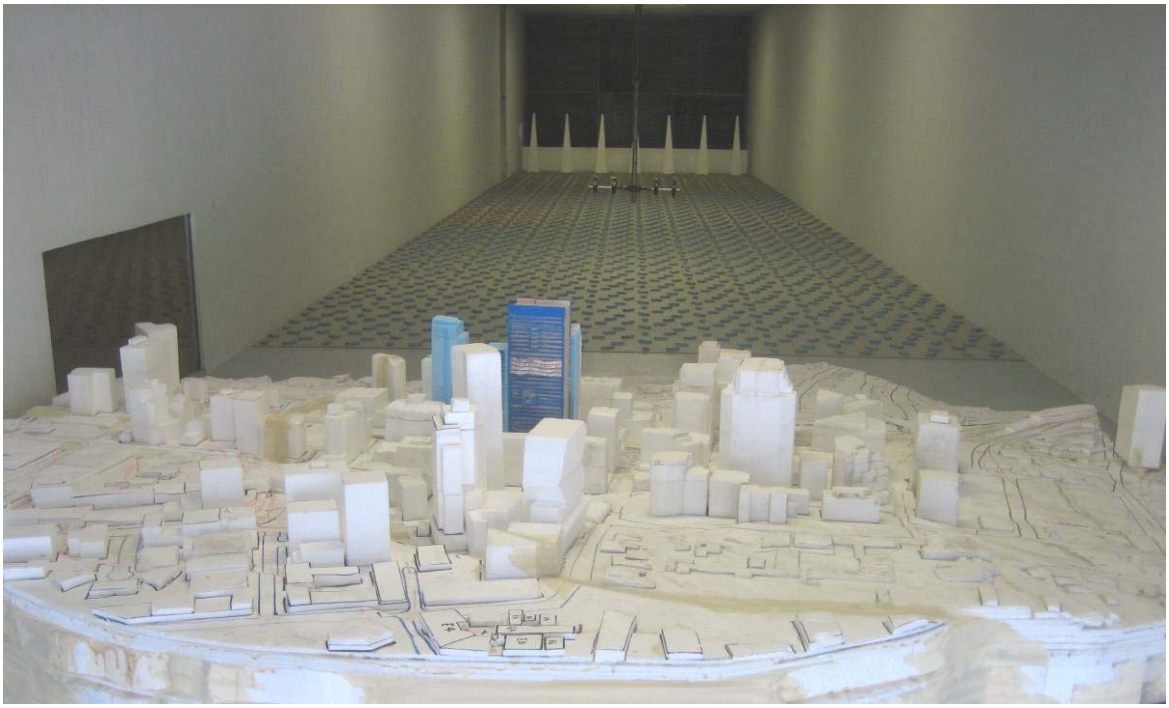

Figure 1c: Photograph of the Model in the Wind Tunnel
(view from the West - with the inclusion of the proposed development)

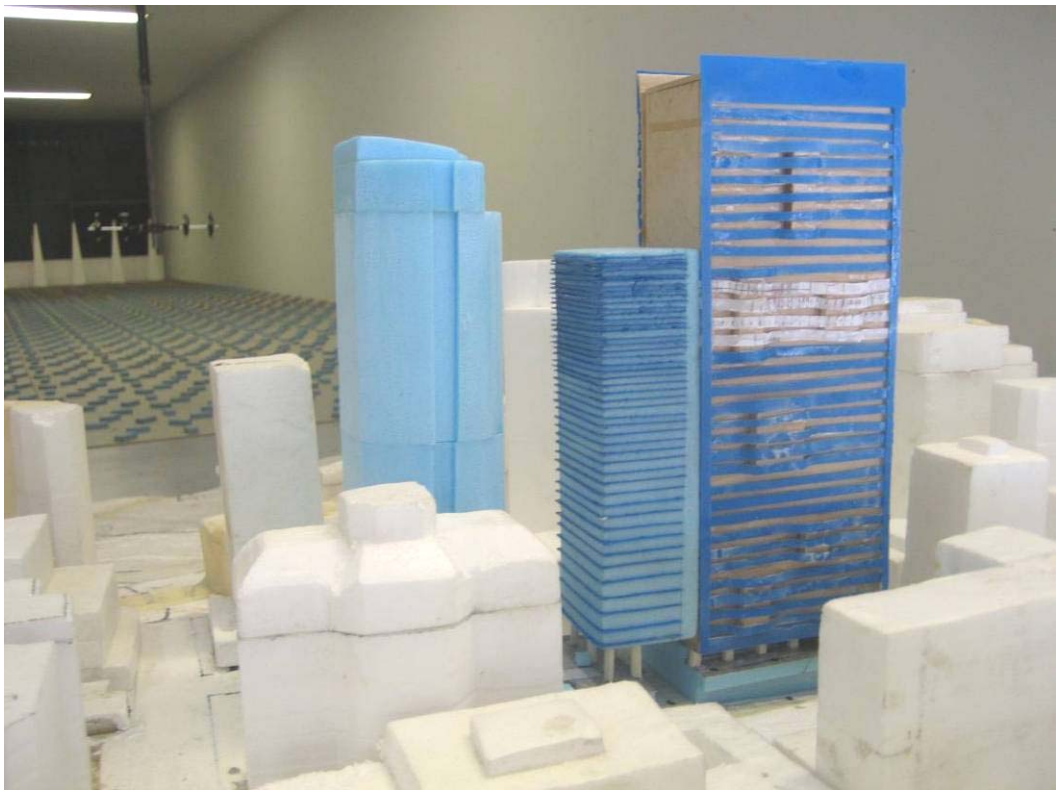

Figure 1d: Photograph of the Model in the Wind Tunnel
(close-up view of the proposed development, from the North-West)

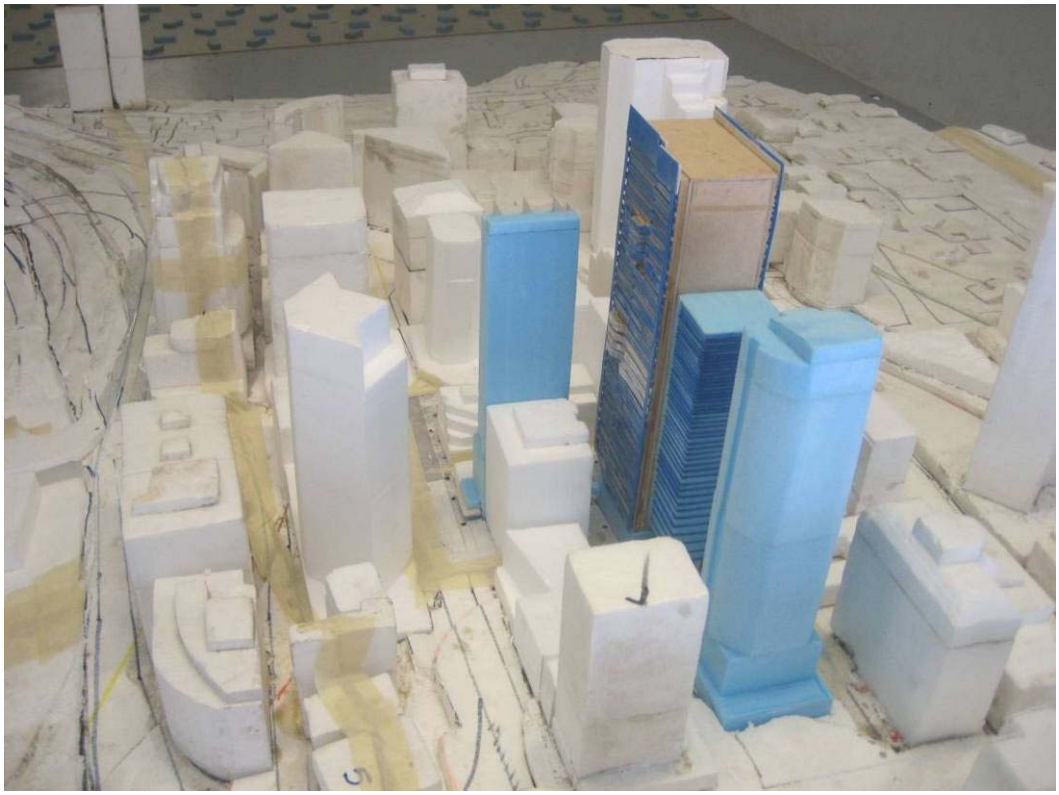

Figure 1e: Photograph of the Model in the Wind Tunnel
(close-up view of the proposed development, from the South-West)

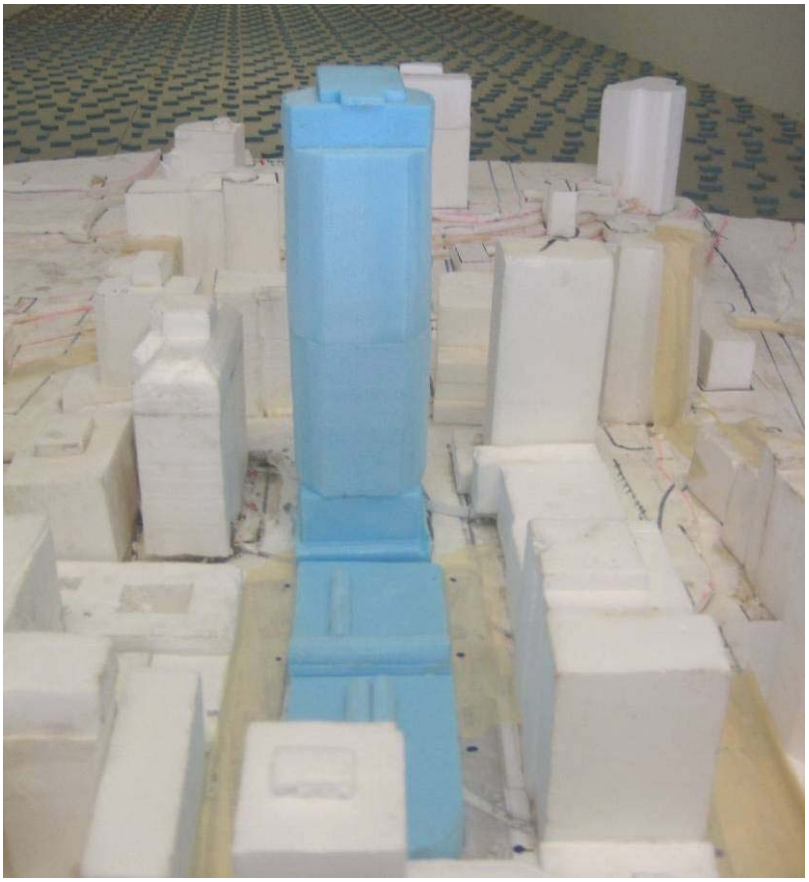

Figure 1f: Photograph of the Model in the Wind Tunnel
(close-up view from the South – existing site model)

Figure 1g: Photograph of the Model in the Wind Tunnel
(close-up view from the East – existing site model)

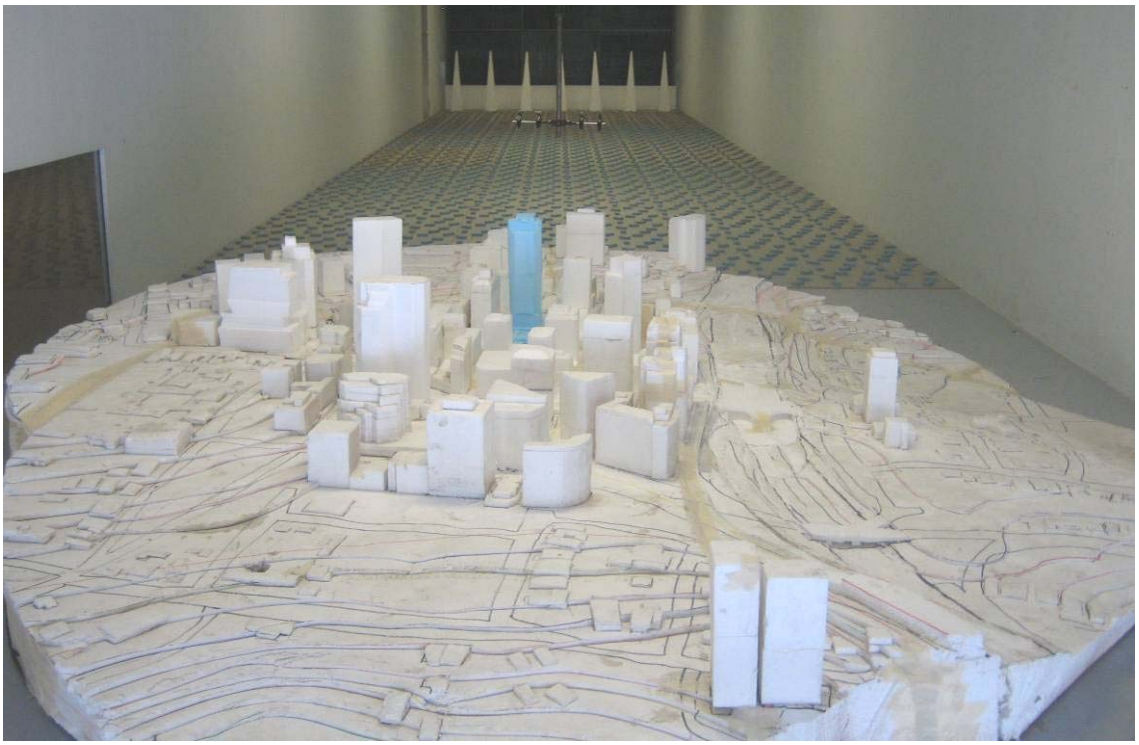

Figure 1h: Photograph of the Model in the Wind Tunnel
(view from the South – existing site model)

Figure 1i: Photograph of the Model in the Wind Tunnel
(view from the South – existing site model)

2.2 Wind Climate Model

The tower reference height used for this study is 150m. The boundary layer wind flows matched the model scale and the overall surrounding terrain characteristics beyond the 500m radius of the physical surrounds model tested in the wind tunnel for each wind direction tested. For the fetch beyond the extent of the surround model the wind profiles are simulated based on the Deaves and Harris model (1978). The wind profile shape is calculated based on an analysis of the surrounding terrain for each wind direction tested. Figure 2 shows an aerial image of the site and surrounds for a radius of 40h from the site, where h is the reference height of the tower. Hence, for this project, the fetch length is 6.0km. The terrain types indicated in Figure 2 are classified as open, suburban or urban.

The length of each terrain type, and the distance each terrain type is from the site, is analysed for each wind direction tested. When the wind travels from one terrain type to another, the mean velocity profile does not change instantly. A lag occurs, and is measured as a distance by the following formula, which is adapted from Davenport et al (1997):

$$x_i = z_{0,r}\left[\frac{z}{0.3z_{0,r}}\right]^{1.25} \qquad (2.1)$$

where x_i is the lag length caused by the change in terrain type.

z is the height above ground.

$z_{0,r}$ is the larger of the two roughness lengths of the two terrain types (see Table 1).

The wind profile for each wind direction is calculated using the lag distance equation above, and the site terrain analysis data measured from the image shown in Figure 2.

For example, for wind coming from 67.5 degrees (an east-north-easterly wind), it is assumed that the approaching wind profile at the edge of the study zone (6.0km from the site for this study) is the standard Deaves and Harris (1978) open terrain profile, since this is coming from over water and open terrain. The wind continues over the open terrain until, approximately 4.2km from the site, the wind reaches the suburban terrain of Balmoral. This is where the Deaves and Harris (1978) suburban terrain is most appropriate. The wind profile then begins to adapt from the open terrain profile to the suburban terrain profile as it passes over Mosman, Cremorne and Neutral Bay. However, by the lag distance equation, at a height of 250m above ground, the profile requires 6.7km to fully change to the standard Deaves and Harris (1978) suburban terrain profile. Hence, by the time the wind reaches the site, at a height of 250m above ground, the profile is only 63% developed into the suburban wind profile from the open wind profile. At the building height, it is 100% developed into the suburban wind profile. The wind profile plot in Appendix B for wind angle 67.5 degrees shows that, by the time the wind reaches the site, the profile has already adapted to the standard suburban terrain profile for heights below the building height, and above this it is still adapting into the suburban terrain profile from the open terrain profile. The wind profiles used for this study are shown in Appendix B of this report for each wind direction tested.

Table 1: Mean and Gust Terrain and Height Multipliers and Turbulence Intensity at Building Height, and the Corresponding Roughness Length for the Standard Deaves & Harris Profiles (1978) (150m)

Terrain Description	$\overline{M}_{(z,cat)}$ at BH	$M_{(z,cat)}$ at BH	Turbulence Intensity	Roughness Length (m) $z_{0,r}$
Flat	0.97	1.31	0.095	0.002
Open	0.89	1.27	0.117	0.02
Suburban	0.78	1.21	0.150	0.2
Dense Urban	0.62	1.11	0.210	2

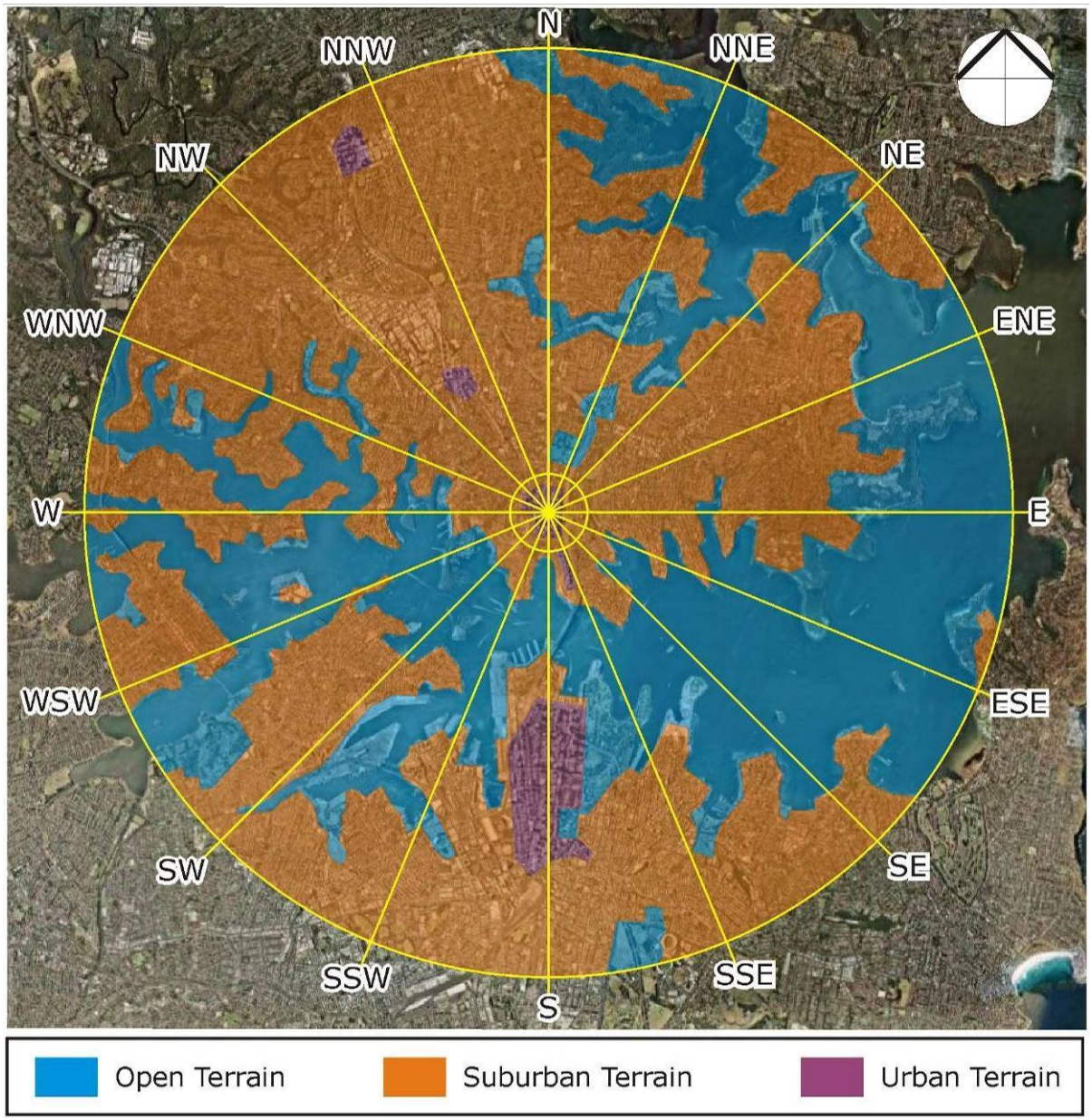

Figure 2: Aerial Image of the Site and Surrounds – 6.0km Radius (terrain category types also indicated)

3.0 Test Procedure

Testing was performed in Windtech's blockage tolerant boundary layer wind tunnel facility. No correction is required for blockage effects. The mean free stream wind speed at the reference height in the tunnel is approximately 11 m/sec. This corresponds to a velocity scale range of approximately 1:1.3 to 1:2.1 for the annual maximum peak wind speeds. Hence the sample length in the model scale of 12 seconds is equivalent to a range of approximately 38 minutes to 63 minutes in full-scale for the annual maximum peak wind speeds, which is suitable for this type of study.

A detailed analysis involving sixteen wind directions at 22.5 degrees intervals was carried out. This procedure provides comprehensive information about the wind environment to be expected for the various wind directions.

The freestream and test-location air currents were monitored using a pair of Dantec hot wire probe anemometers. The probe support was set vertically as much as possible. This 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.

The output from both probes was obtained using a National Instruments 12-bit data acquisition card. The signal was low-pass filtered at 32 Hz and results in peak gust being the equivalent of the 2 to 3 second gust on which the criteria are based. A sample rate of 1000 samples per second was used, which is more than adequate for the given frequency band.

The mean and the maximum 3 second duration peak gust coefficients were obtained. The largest qualifying single peak was taken as the maximum gust velocity. To ensure that the largest measured peak is not a 'false' peak, the maximum peak would not qualify if it is more than 25% greater than the average of the second and third largest peaks. Any non-qualifying peak is replaced by the average of the second and third largest peaks. The measured mean and gust wind speeds are compared against the appropriate criteria for each of the outdoor areas tested.

For each of the sixteen wind directions, peak gust and mean wind speeds were measured at selected points at a full-scale height of approximately 1.5m and were normalised by the mean value at a reference scale height of 200m up-wind of the model. The reference velocity measurements are used to relate the mean and peak wind speed measurements to actual mean and gust velocities, based on available meteorological data for Sydney.

The directional distributions of the statistical mean hourly wind speeds for Sydney, corrected for suburban terrain (Terrain Category 3, as defined by AS/NZS 1170.2:2002) and a reference height of 200m are shown in Figure 3.

The meteorological data for Sydney was analysed statistically from frequency of occurrence tables prepared by the National Climate Centre, which are based on continuous data collected at 3 hour intervals over 53 years, ending March 1992. Data was collected from the Sydney Airport Observation Office at a height of 6 metres.

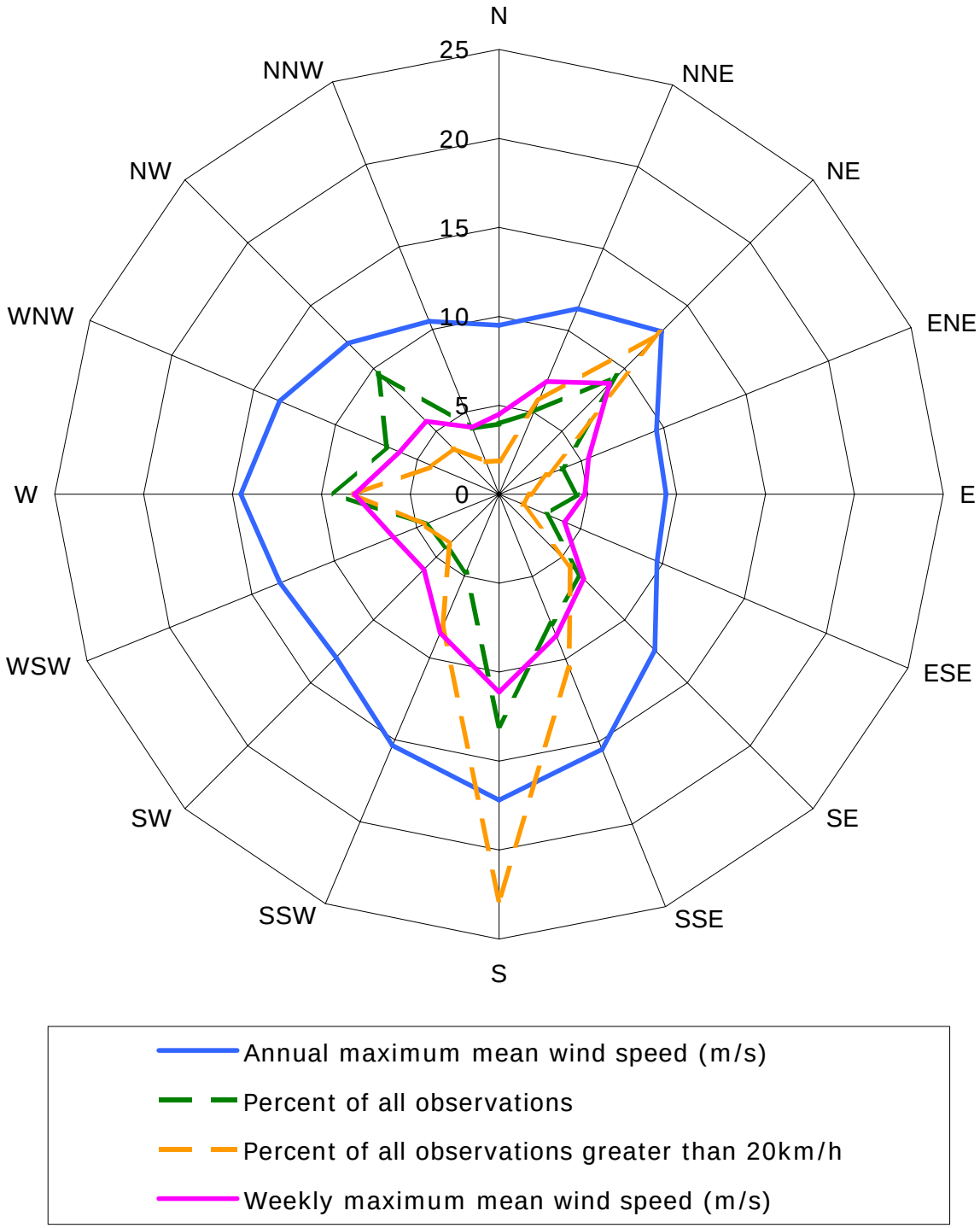

Figure 3: Reference Wind Speeds and Frequencies for Sydney (based on 3 hourly mean observations at Kingsford Smith Airport, from 1939 to 1992, corrected for 10m height in open terrain)

4.0 Environmental Wind Speed Criteria

The three principal wind directions affecting this development prevail from the North-East, South and West. Table 2 is a summary of the principal time of occurrence of these winds. A full set of wind roses for the Sydney region, obtained from Sydney Airport (1939 to 2000) at 9am and 3pm for each month throughout the year, are attached in Appendix C of this report.

Table 2: Principle Time of Occurrence of Wind for the Sydney Region

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	

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. The following table (see Table 3), 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 3: Summary of Wind Effects on People (after Penwarden, 1975)

Type of Winds	Beaufort Number	Mean 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***.

Lawson (1973) quotes that Beaufort 4 wind speeds (6 to 8m/s means) would be acceptable if it is not exceeded for more than 4% of the time; and a Beaufort 6 (11 to 14m/s means) as being unacceptable if it is exceeded more than 2% of the time.

4.1 Davenport's Criteria for Mean Wind Speeds

Davenport (1972) had also come up with a set of criteria in terms of the Beaufort Scale and for various return periods. The values presented in Table 4 below are based on a frequency of exceedance of once per week (a probability of exceedance of 5%).

Table 4: Criteria by Davenport (1972)

Classification	Human Activities	95 Percentile Maximum Mean (once per week)
Walking Fast	Acceptable for walking, main public accessways	10 m/s > *u* > 7.5 m/s
Strolling, Skating	Slow walking, etc.	7.5 m/s > *u* > 5.5 m/s
Short Exposure Activities	Generally acceptable for walking & short duration stationary activities such as window-shopping, standing or sitting in plazas.	5.5 m/s > *u* > 3.5 m/s
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants & theatres and in parks.	3.5 m/s > *u*

4.2 Lawson's Criteria for Mean Wind Speeds

Later, Lawson (1975) came up with a set of criteria very similar to those of Davenport's. These are presented in Tables 5a and 5b, below.

Table 5a: Safety Criteria by Lawson (1975)

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

Table 5b: Comfort Criteria by Lawson (1975)

Classification	Human Activities	95 Percentile Maximum Mean (once per week)
Business Walking	Objective Walking from A to B	10 m/s > *u* > 8m/s
Pedestrian Walking	Slow walking, etc.	8 m/s > *u* > 6 m/s
Short Exposure Activities	Pedestrian Standing or sitting for a short time	6 m/s > *u* > 4 m/s
Long Exposure Activities	Pedestrian sitting for a long duration	4 m/s > *u*

4.3 Melbourne's Criteria for Peak Wind Speeds

Melbourne (1978) introduced a set of criteria for the assessment of environmental wind conditions. These criteria were developed for temperatures in the range from 10^{O}C to 30^{O}C and for people suitably dressed for outside temperature conditions. These criteria are based on peak gust wind speeds. Melbourne's criteria are outlined in Table 5 below. This set of criteria tends to be more conservative than criteria suggested by other researchers such as those indicated in Figure 4.

Table6: Criteria by Melbourne (1978)

Classification	Human Activities	Annual Maximum Gust
Limit for safety	Completely unacceptable: people likely to get blown over.	*u* > 23m/s
Marginal	Unacceptable as main public accessways.	23 m/s > *u* > 16 m/s
Comfortable Walking	Acceptable for walking, main public accessways	16 m/s > *u* > 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 > *u* > 10 m/s
Long Exposure Activities	Generally acceptable for long duration stationary activities such as in outdoor restaurants and theatres and in parks.	10 m/s > *u*

4.4 Comparison of the Various Wind Speed Criteria

The criteria mentioned in Table 6, as well as other criteria, are compared on a probabilistic basis in Figure 4, below.

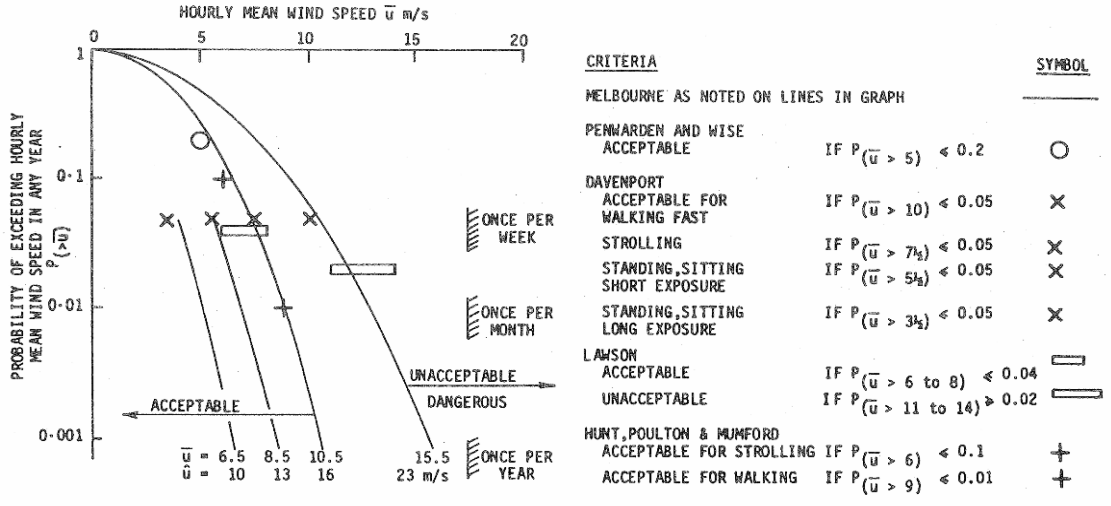

Figure 4: Comparison of Various Mean and Gust Wind Environment Criteria, assuming 15% turbulence and a Gust Factor of 1.5 (after Melbourne, 1978)

However, a comparative study presented by Ratcliff and Peterka (1990) based on measurements taken from a total of 246 locations in various urban situations tends to indicate that the criteria suggested by Melbourne (1978) can be considerably more conservative than the other criteria set out above. The results are in indicated in Figure 5. This agrees with our own observations (Rofail, 2007). This discrepancy in the criteria by Melbourne is due to the assumption of a fixed 15% turbulence intensity for all areas, which in our experience tends to be at the lower end of the range of turbulence intensities.

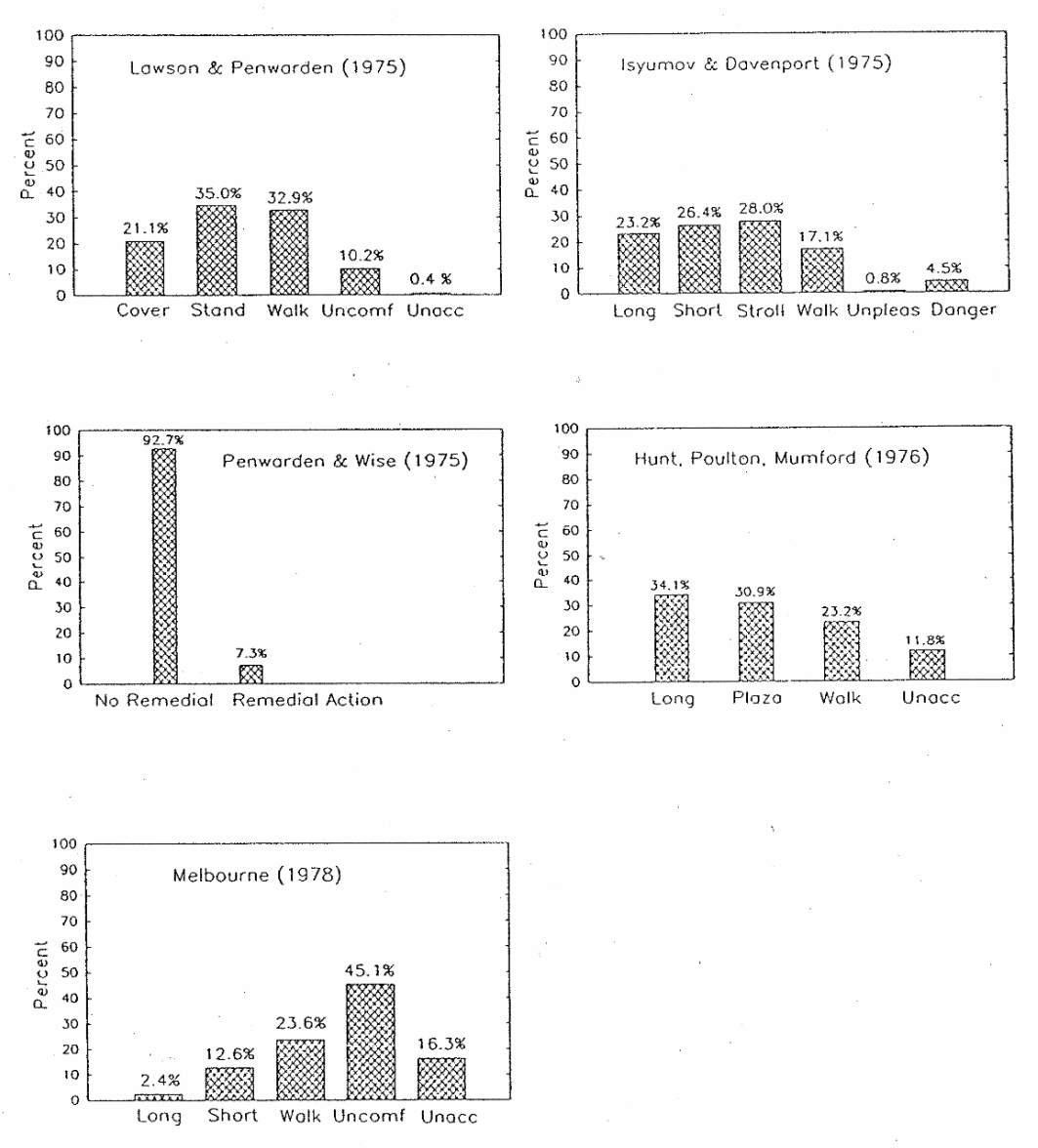

Figure 5: Distribution of Pedestrian Wind Comfort over Five Criteria for 246 locations examined in the Wind Tunnel (after Ratcliff & Peterka, 1990)

4.5 Wind Speed Criteria for the North Sydney CBD

For this study, the local wind climate has been compared against the existing wind conditions and the annual maximum peak wind speed criteria, as required by the North Sydney Development Control Plan (DCP). These are partly based on criteria by Melbourne (1978). The wind comfort criteria used for this study are as follows;

- Wind conditions for all pedestrian accessible ground level areas within and around the proposed development should not exceed the existing wind conditions, or if they do they should not exceed 13m/s for the annual maximum peak wind speeds (as specified in the North Sydney DCP).
- Wind conditions for private balconies and terraces of the proposed development should satisfy the safety limit of 23m/s for the annual maximum peak wind speeds. If a terrace is used frequently as a communal area for all occupants of the development, the short exposure criterion of 5.5m/s for the weekly maximum Gust Equivalent Mean (GEM) wind speeds should also be satisfied.

Note that the abovementioned Gust Equivalent Mean (GEM) wind speed (defined below), in conjunction with the Davenport criteria (see Section 4 of this report), has proven over time and through field observations to be the most reliable indicator of pedestrian comfort. The most reliable source of data for field observation results are obtained when undertaking remedial wind environment studies. Note that the Safety Limit criterion by Melbourne (1978) of 23m/s for annual maximum peak wind speeds is also applied to all areas. This criterion is used for most areas of Australia and around the world, unless stipulated otherwise by the local government authority.

Notes:

- The GEM is defined as the maximum of the following:
    - Mean wind speed
    - 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 criterion applies typically to outdoor dining areas in restaurants, amphitheatres, etc.
- Short Exposure criterion applies typically to areas where short duration stationary activities are involved (less than 1 hour). This includes parks and landscaped areas, swimming pool, window shopping, waiting and drop-off areas.
- Comfortable Walking criterion applies typically to main pedestrian thoroughfares.
- Fast walking criterion applies typically to infrequently used laneways, balconies, private terraces etc.
- In all areas, the wind conditions are also checked against the safety limit.

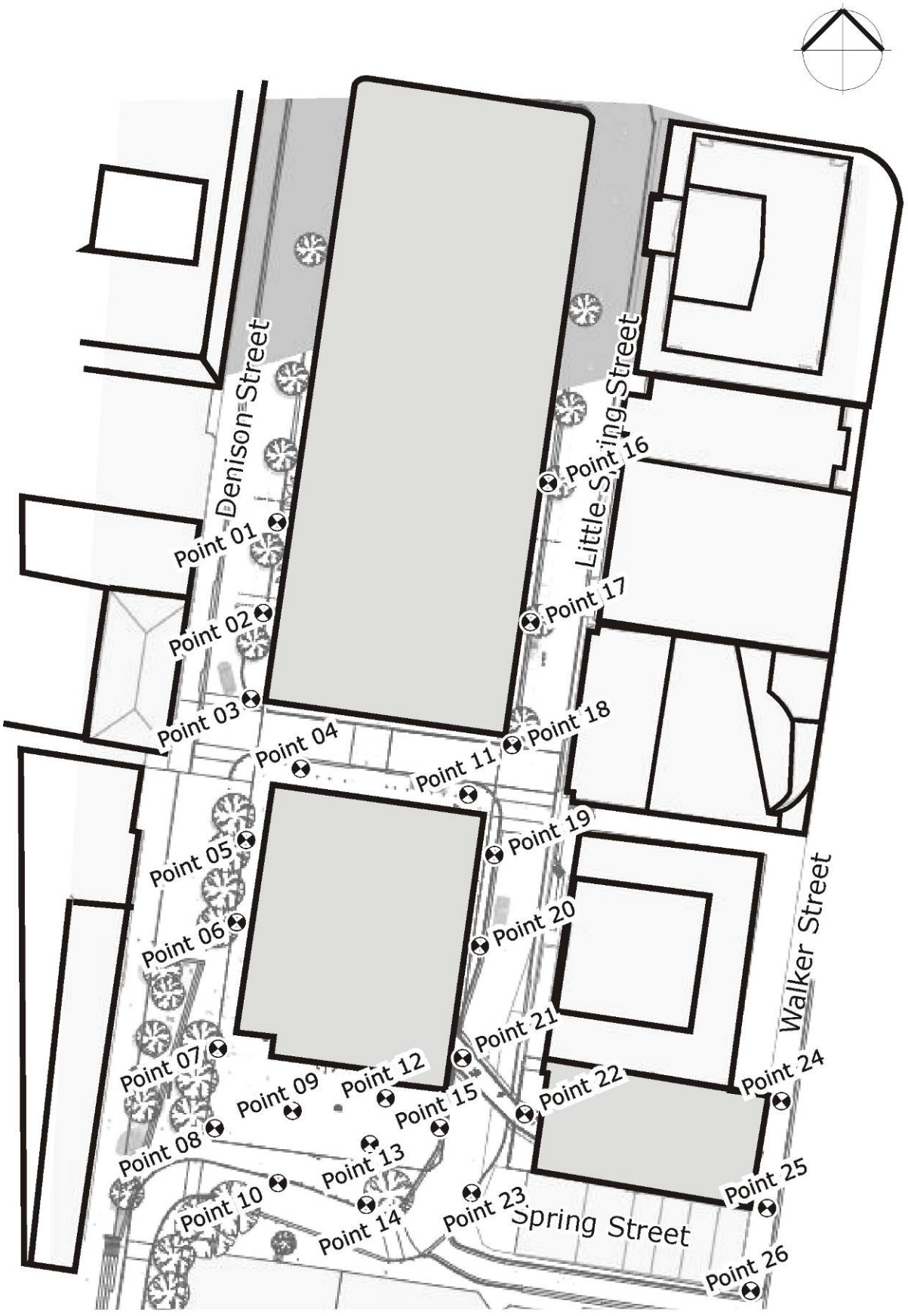

Figure 6a: Study Point Locations - Ground Level

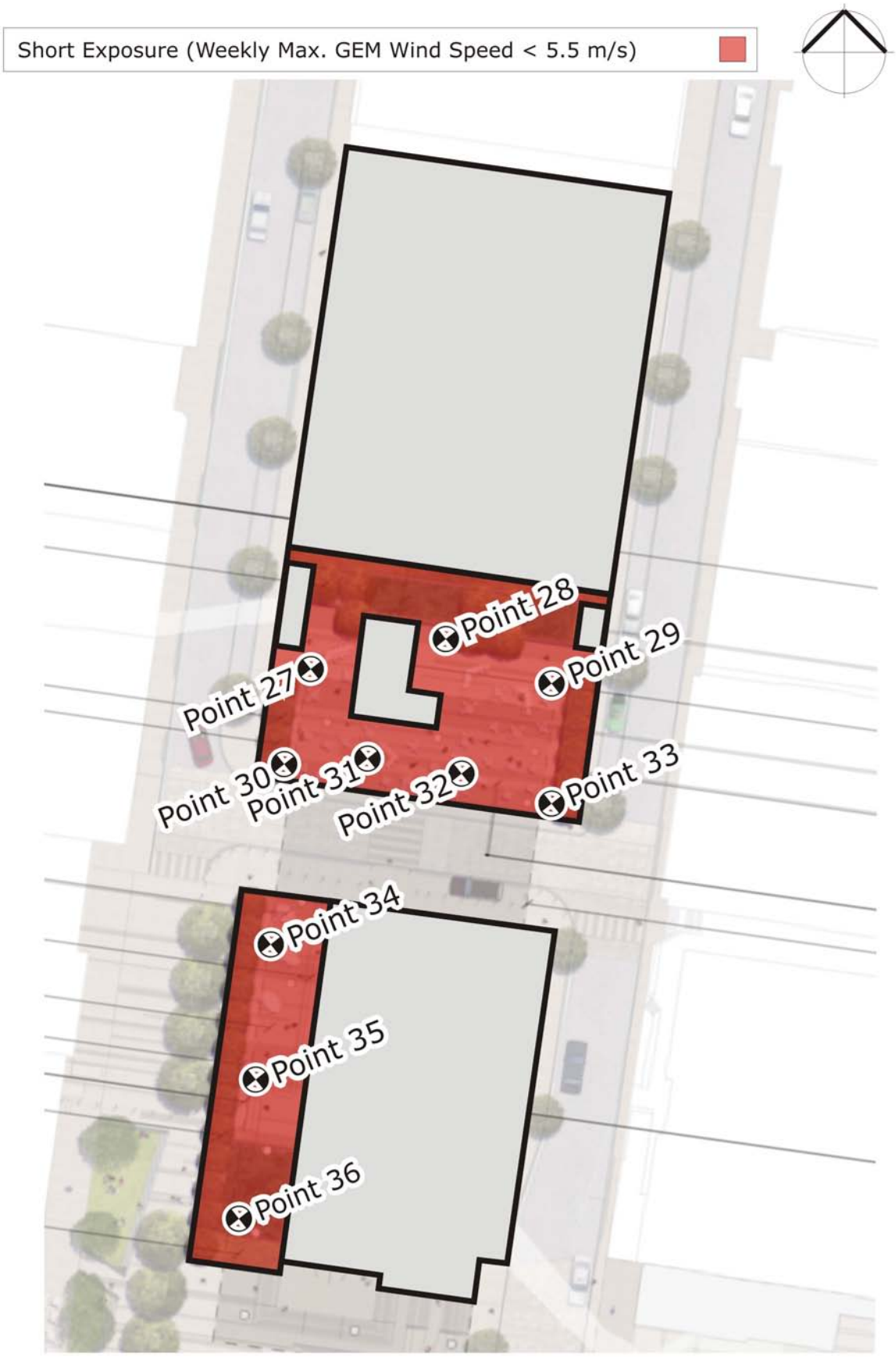

Figure 6b: Study Point Locations - Restaurant Level (recommended wind comfort criteria also shown)

5.0 Results of Study

A detailed study of wind activity around and within the various outdoor areas of the proposed development was carried out. A total of 36 study locations were chosen for detailed analysis as shown in Figures 6a and 6b. These include 26 ground level test point locations and 10 test point locations on various terrace areas on the Restaurant Level of the development.

Initially the wind conditions around the existing site were measured. The wind conditions within and around the proposed development were then measured and compared with the existing results. It should be noted that the initial tests of the proposed development were undertaken without the effect of any forms of wind ameliorating devices such as balustrades, screens, and trees. For areas not achieving the appropriate wind conditions retesting was undertaken with various forms of ameliorative treatments until an effective outcome was reached.

Plots of results of the local directional wind speeds for the various test locations, as derived from the wind tunnel tests, are presented in the attached Appendix A. These results were assessed using the annual maximum peak wind speed criteria, as required by the North Sydney Development Control Plan (DCP), as outlined in Section 4.5 of this report, for the public areas of the development. The weekly maximum GEM wind speeds are also presented for the private areas of the development. If existing conditions already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for the subject development are not to result in an exceedence of the existing wind speeds.

5.1 Pedestrian Areas along Denison Street

The Study Points

Test Points 1 to 3 and 5 to 8 are used to monitor the ground level wind conditions of the pedestrian footpath areas along Denison Street on the western perimeter of the proposed development. The location of each Test Point is shown in Figure 6a.

Applicable Criteria

Test Points 1 to 3 and 5 to 8 represent the ground level pedestrian areas along Denison Street that are accessible by pedestrians. These areas are primarily used as pedestrian thoroughfares. If existing wind conditions for these areas already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for these areas with the proposed development are not to result in an exceedence of the existing wind speeds.

Results and Recommendations

The initial test results indicate that wind conditions at all of these study point locations will exceed their recommended wind comfort criterion. Retests were undertaken with the addition of the vegetation scheme indicated in the

architectural drawings. The results of the retest indicate that the vegetation scheme was effective in mitigating the adverse wind conditions for most of these study point locations.

Additional tests were performed for Test Points 6 to 8, which are still exposed to adverse westerly to southerly winds, with the addition of the densely foliating trees in a layout as indicated in Figure 7a. The result of these retests indicates that the additional densely foliating trees will be effective in mitigating the adverse winds affecting these locations, ameliorating the wind speed to levels below those of existing wind comfort conditions. Hence with the strategic layout of densely foliating trees as indicated in Figure 7a, the wind conditions for the pedestrian footpath areas along Denison Street along the western side of the site will be acceptable.

5.2 Pedestrian Areas along the Driveway across the Site

The Study Points

Test Points 4 and 11 are used to monitor the ground level wind conditions of the pedestrian footpath areas along the driveway across the site, which cuts through the podium of the proposed development. The location of each Test Point location is shown in Figure 6a.

Applicable Criteria

Test Points 4 and 11 represent the ground level pedestrian areas along the driveway across the proposed development site from Denison Street to Little Spring Street. These areas are primarily used as pedestrian thoroughfares. If existing wind conditions for these areas already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for these areas with the proposed development are not to result in an exceedence of the existing wind speeds.

Results and Recommendations

The initial test results for Test Points 4 and 11 indicate this area of the site is exposed to strong westerly and north-easterly winds being downwashed and funnelled through the driveway which cuts through the podium and under the main tower across the site. Test Point 4 and 11 were retested with the addition of an awning on the northern and southern aspects of the Driveway at Level 1. The result of these retests indicates that this wind deflector/awning will be effective in mitigating the adverse north-easterly and south-easterly winds from being downwashed to this location, however the results also indicated that there will be no improvement to the adverse westerly winds in these locations. An additional tree was modelled at the south-western corner of the Driveway, as indicated in Figure 7a. Points 4 and 11 were retested, and the results indicated that with an awning on the southern and northern aspects of the Driveway along with an additional densely foliating evergreen tree at the south-western corner of the Driveway, wind conditions at these locations will be equivalent to the existing conditions, and are acceptable.

5.3 Pedestrian Areas along Spring Street

The Study Points

Test Points 9 to 10, 12 to 15 are used to monitor the ground level wind conditions of the pedestrian footpath areas along Spring Street at the southern end of the proposed development. The location of each Test Point location is shown in Figure 6a.

Applicable Criteria

Test Points 9 to 10, 12 to 15 represent the ground level pedestrian areas along Spring Street that are accessible by pedestrians. These areas are primarily used as pedestrian thoroughfares. If existing wind conditions for these areas already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for these areas with the proposed development are not to result in an exceedence of the existing wind speeds.

Results and Recommendations

The initial test results indicate that wind conditions at all of these study point locations will exceed their recommended wind comfort criterion. Retests were undertaken with the addition of the trees in the locations indicated in the architectural drawings. The results of the retest indicate that the trees are effective in mitigating the adverse wind conditions at Test Point 9 so that they are within 13m/s for the annual maximum gust wind speeds. The retest results for Point 10 indicated that wind conditions will be improved compared to the existing wind conditions at this location. Hence, with the addition of the trees in the locations as indicated in the architectural drawings, wind conditions at Points 9 and 10 will be acceptable.

The results of the retest indicate that the vegetation scheme was not effective in ameliorating the adverse westerly to southerly and north-easterly winds at Test Points 12 to 15. The locations were again retested, this time with the addition of a row of densely foliating trees along the southern boundary of Spring Street of the proposed development as indicated in Figure 7a. The results of these retests indicate that the additional densely foliating trees were effective in mitigating the wind conditions affecting Test Points 12 to 15. These Test Points locations will now satisfy their applicable short exposure wind comfort criterion and be suitable for its intended use. Hence these treatments are recommended to be included into the final design of the proposed development.

5.4 Pedestrian Areas along Little Spring Street

The Study Points

Test Points 16 to 23 are used to monitor the ground level wind conditions of the pedestrian footpath areas along Little Spring Street of the proposed development. The location of each Test Point location is shown in Figure 6a.

Applicable Criteria

Test Points 16 to 23 represent the ground level pedestrian areas along Little Spring Street that are accessible by pedestrians. These areas are primarily used as pedestrian thoroughfares. If existing wind conditions for these areas already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for these areas with the proposed development are not to result in an exceedence of the existing wind speeds.

Results and Recommendations

The initial test results indicate that only Test Point 20 will satisfy its recommended short exposure wind comfort criterion without the need for additional treatments. The remaining study points, located along Little Spring Street and underneath the bridge link, are exposed to adverse north-easterly and westerly to southerly winds. These locations were again retested, this time with the addition of a row of densely foliating trees along Little Spring Street as indicated in Figure 7a. The results of these retests indicate that the additional densely foliating trees were effective in mitigating the wind conditions at Test Points 16 to 19, and 22. These Test Point locations will now satisfy their applicable short exposure wind comfort criterion and these areas will be suitable for its intended use. The retest indicated the wind conditions at Test Points 21and 23 still exceeded the short exposure wind comfort criterion, however the wind conditions were ameliorated to wind speeds below those of the corresponding existing wind conditions. Hence, with the recommended treatments as indicated in Figure 7a, wind conditions along the pedestrian footpaths of Little Spring Street will be acceptable.

5.5 Pedestrian Areas along Walker Street

The Study Points

Test Points 24 to 26 are used to monitor the ground level wind conditions of the pedestrian footpath areas along Walker Street at the eastern side of the proposed development. The location of each Test Point location is shown in Figure 6a.

Applicable Criteria

Test Points 24 to 26 represent the ground level pedestrian areas along Walker Street that are accessible by pedestrians. These areas are primarily used as pedestrian thoroughfares. If existing wind conditions for these areas already exceed the criteria of the North Sydney DCP of 13m/s for the annual maximum peak wind speeds, then wind conditions for these areas with the proposed development are not to result in an exceedence of the existing wind speeds.

Results and Recommendations

The initial test results indicate that wind conditions at all of these study point locations will exceed their recommended wind comfort criterion. Retests were undertaken with the existing trees at the corner of Walker and Springs Streets. The results of the retest indicate that the vegetation scheme was

effective in mitigating the adverse westerly to southerly winds at a Test Points 24 and 25, and that the measured wind speeds will be better than the corresponding existing wind conditions at these locations.

The results of the retest for Test Point 26 indicate that this location was still exposed to adverse westerly to southerly winds. The Test Point was again retested with the addition of another densely foliating tree north of the point. The result of this retest indicates that the additional densely foliating tree will be effective in mitigating the adverse winds affecting Point 26, and the measured wind speed is better than the measured existing wind conditions at this location.

As the existing trees along Walker Street are of a deciduous species, alternative treatment options were sought to ameliorate the adverse westerly winds which occur during the winter months. The inclusion of the existing 1.2m high impermeable parapet on the neighbouring building to the south and an awning on Level 1 of the proposed development were tested. With these treatments, the wind conditions along Walker Street during the winter months when the deciduous streets are not effective in wind mitigation, will be better than the measured existing wind conditions at this location. The existing deciduous trees will be effective in mitigating the adverse southerly winds, while the existing parapet on the neighbouring building and proposed awning will be effective in mitigating the adverse westerly winter winds.

Hence, with the inclusion of the trees in the locations indicated in Figure 7a, wind conditions along the pedestrian footpath of Walker Street will be acceptable with the addition of the proposed development.

5.6 Restaurant Level Terrace Areas

The Study Points

Test Points 27 to 36 are used to monitor the wind conditions on the various terrace areas on the Restaurant Level of the proposed development. The locations of the Test Point locations are shown in Figure 6c.

Applicable Criteria

Test Points 27 to 33 represent the communal garden terrace areas on the Restaurant Level. These areas are accessible by tenants of the development and are used primarily as an outdoor dining area. Hence the appropriate wind comfort criterion to be satisfied for this area is the short exposure criterion of 5.5m/s for weekly maximum GEM wind speeds.

The appropriate wind comfort criteria for these areas are also indicated in Figure 6b. Note that the safety limit of 23m/s for annual maximum peak wind speeds should also be satisfied for all study points.

Results and Recommendations

The initial test results indicate that only Test Point 35 will satisfy the recommended short exposure wind comfort criterion for that area without the need for additional treatments.

The wind conditions for the outdoor dining area indicate that the area is exposed to strong north-easterly and westerly winds. This area was retested with the addition of a 1.2m high impermeable balustrade along the perimeter of the terrace as well as the trees and shrubs in the landscaping plan, as indicated in Figure 7b. A 1.2m high impermeable balustrade was also added to the perimeter of the proposed terrace along the western side of the development to assist in mitigating the adverse winds affecting that area.

The results of the retests indicate that the 1.2m high impermeable balustrade and landscaping plan were effective in ameliorating the adverse wind conditions to these areas. Hence it is recommended that the impermeable balustrades and landscaping plan be included into the final design of the proposed development, and that with this recommendation these areas will be suitable for their intended uses.

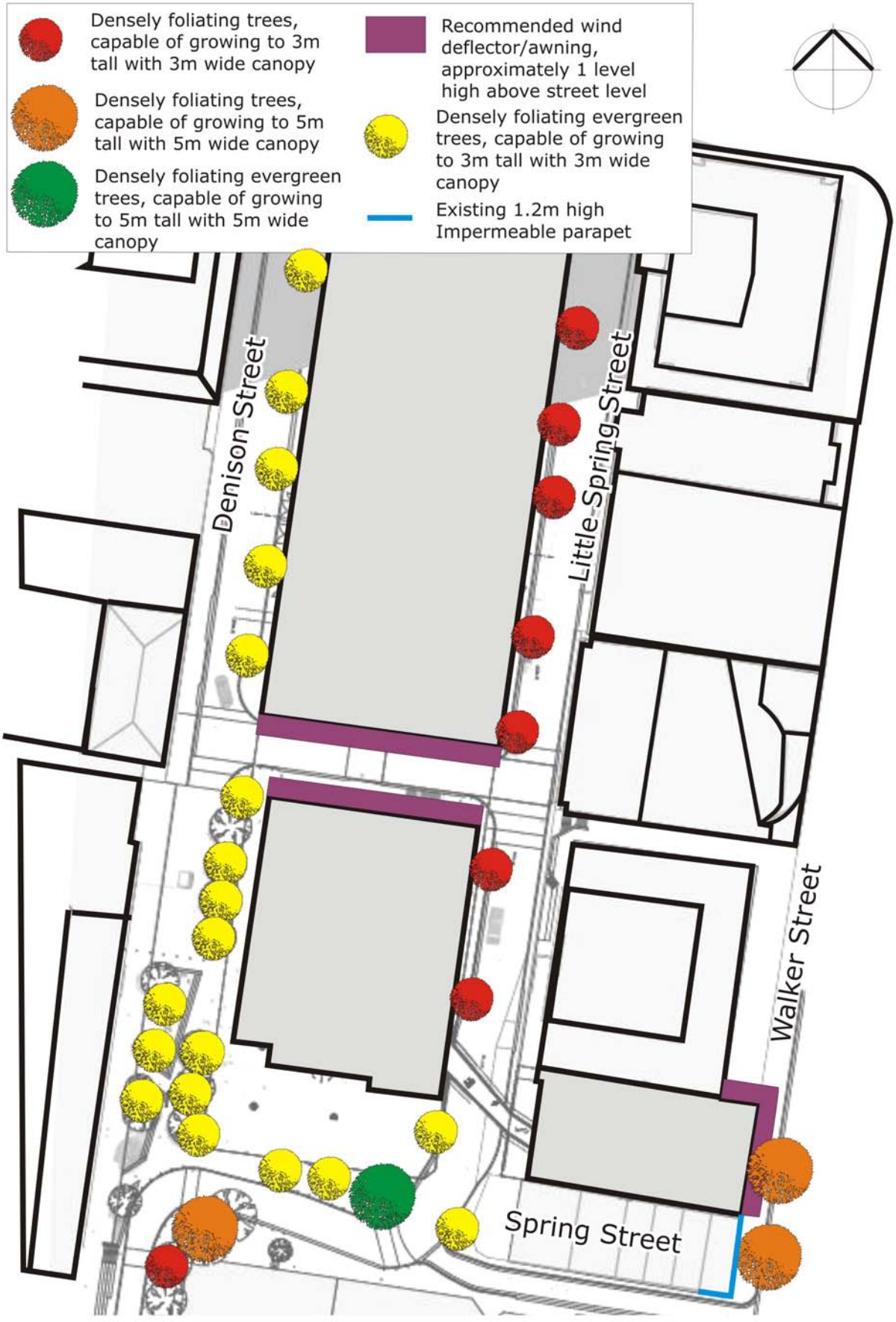

Figure 7a: Recommended Treatments for the Ground Level

Figure 7b: Recommended Treatments for the Restaurant Level

6.0 Conclusion

A wind tunnel study has been carried out to investigate the wind environment effects pertaining to development at 88 Walker Street & 77-81 Berry Street, located in North Sydney.

The results of this study indicate that wind conditions for most of the outdoor areas of the site, including all ground level areas, will require treatments to be implemented to be acceptable for their intended uses. Many treatments have been investigated in this study to treat the adverse winds affecting the outdoor areas of the proposed development. A set of treatments have been recommended in this report to ameliorate these effects, and are summarised as follows:

- A strategic layout of densely foliating trees for the ground level and Restaurant Level areas within and around the development site.
- The addition of wind deflectors/awnings 1 level high above the street level at the northern and southern aspects of the driveway within the podium of development.
- 1.2m high impermeable balustrades along the perimeter of the two terrace areas on the Restaurant Level of the development.
- Awning above street level along Walker Street and maintaining existing parapet on neighbouring building.

Note that for vegetation to be effective in mitigating adverse winds, particularly westerly winds which tend to occur predominantly during the winter months for the Sydney region, the trees along Denison Street and Spring Street should be of a densely foliating evergreen species as indicated in the report.

With the recommended treatments included into the final design of the development, the wind conditions within and around the proposed development site will be acceptable for their intended uses.

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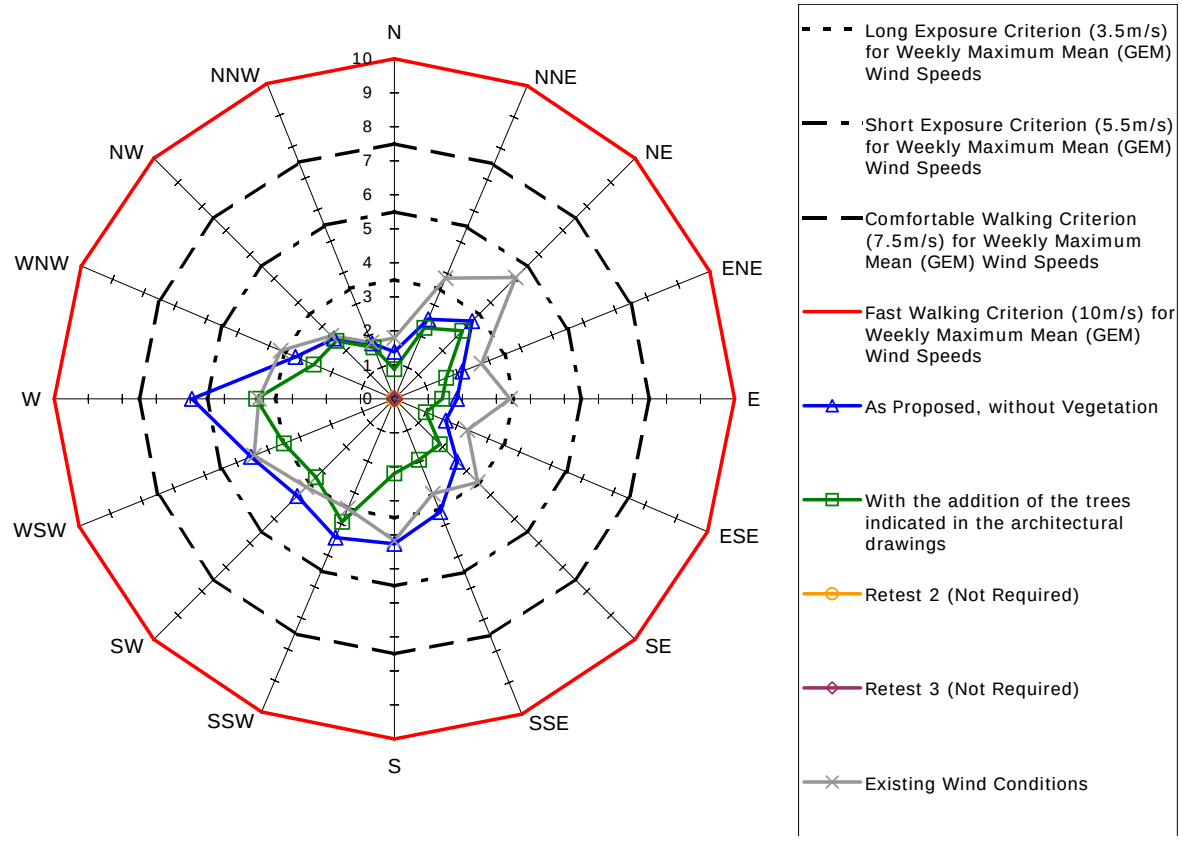
Appendix A

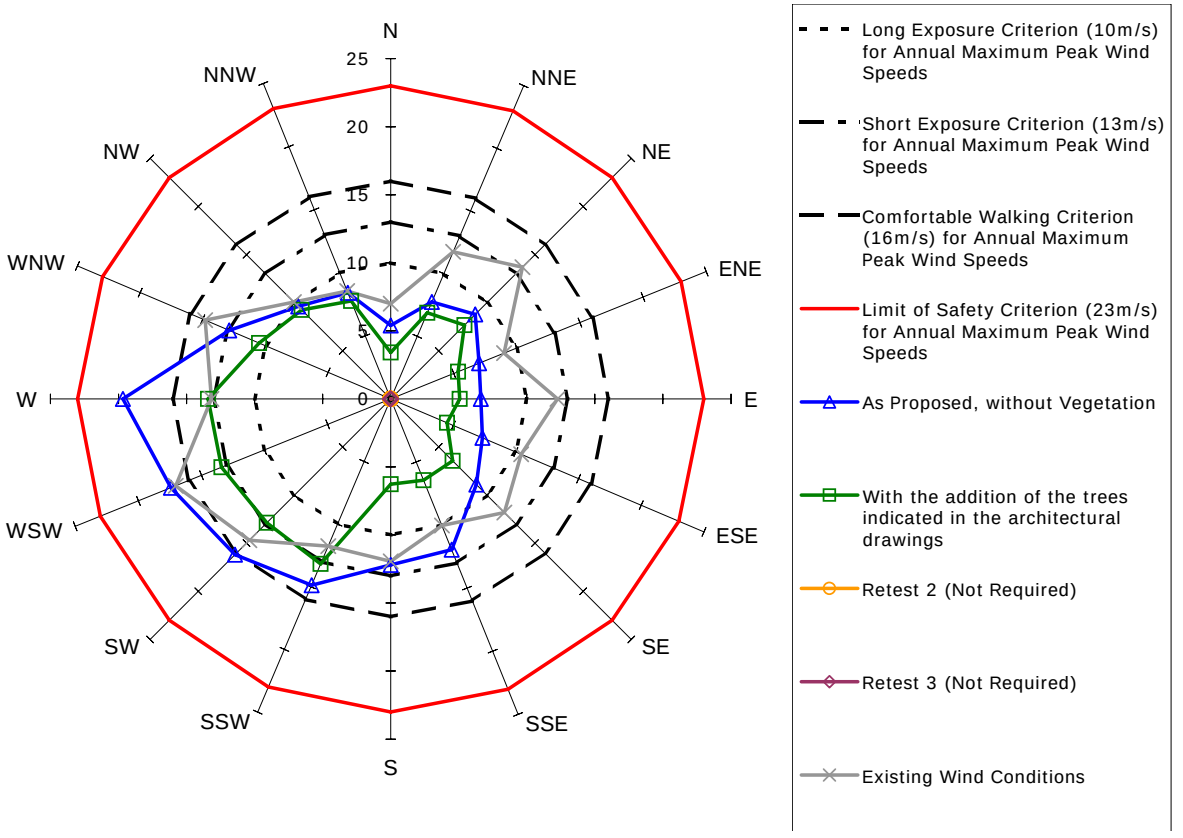
Plots of Wind Tunnel Results

Measured Wind Speeds at Point 01

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

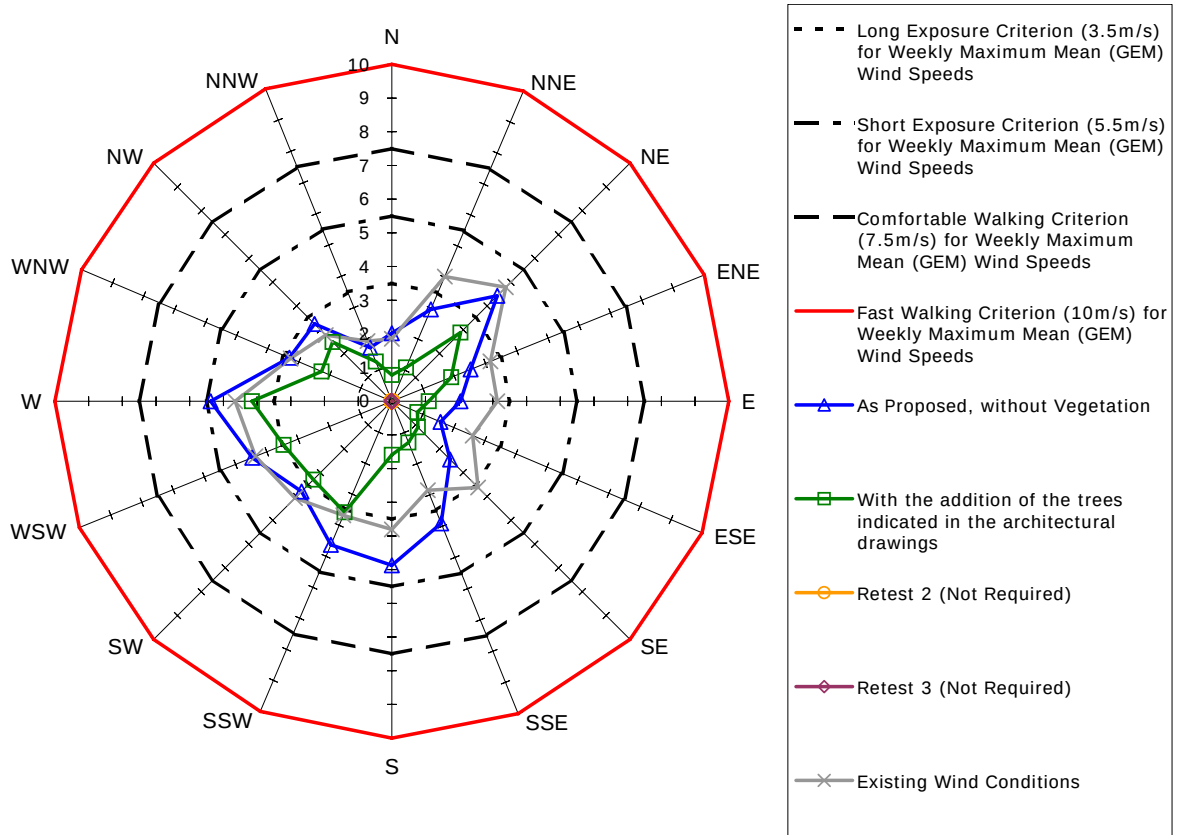


Annual Maximum Gust Wind Speeds (m/s)

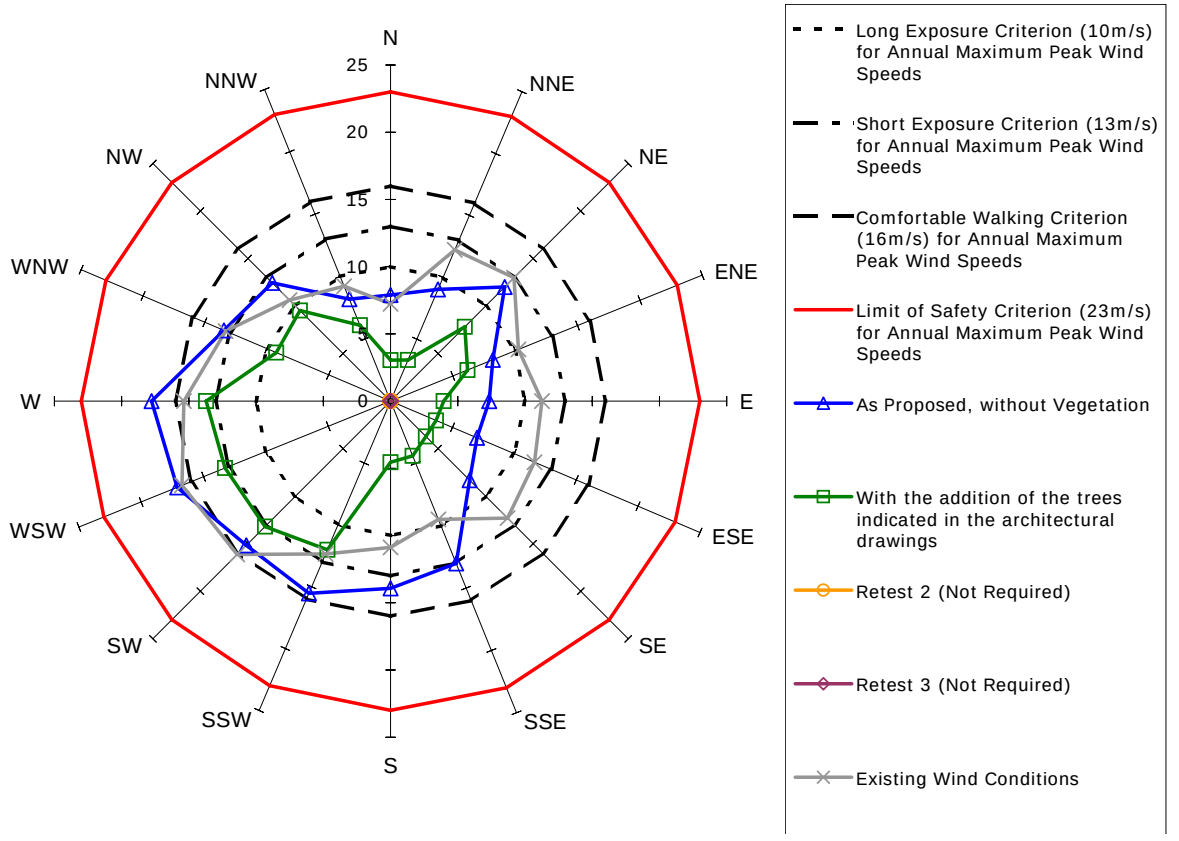


Measured Wind Speeds at Point 02

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

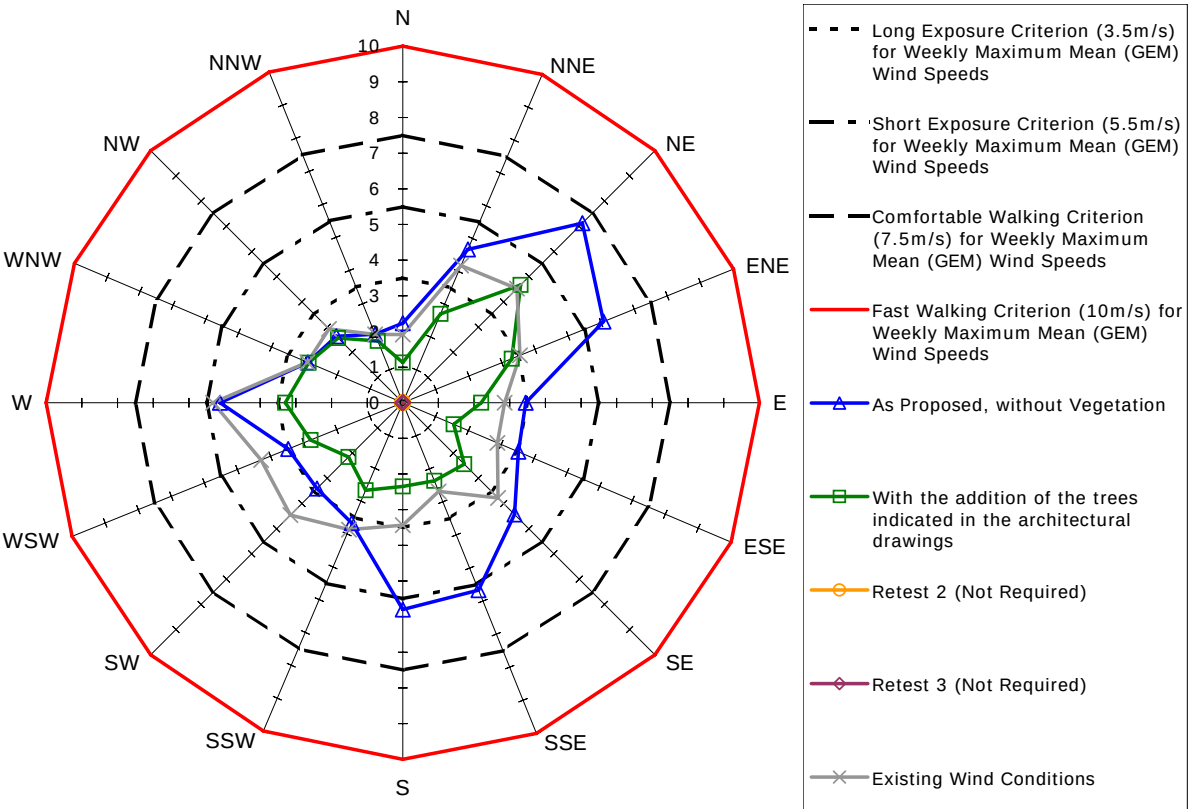


Annual Maximum Gust Wind Speeds (m/s)

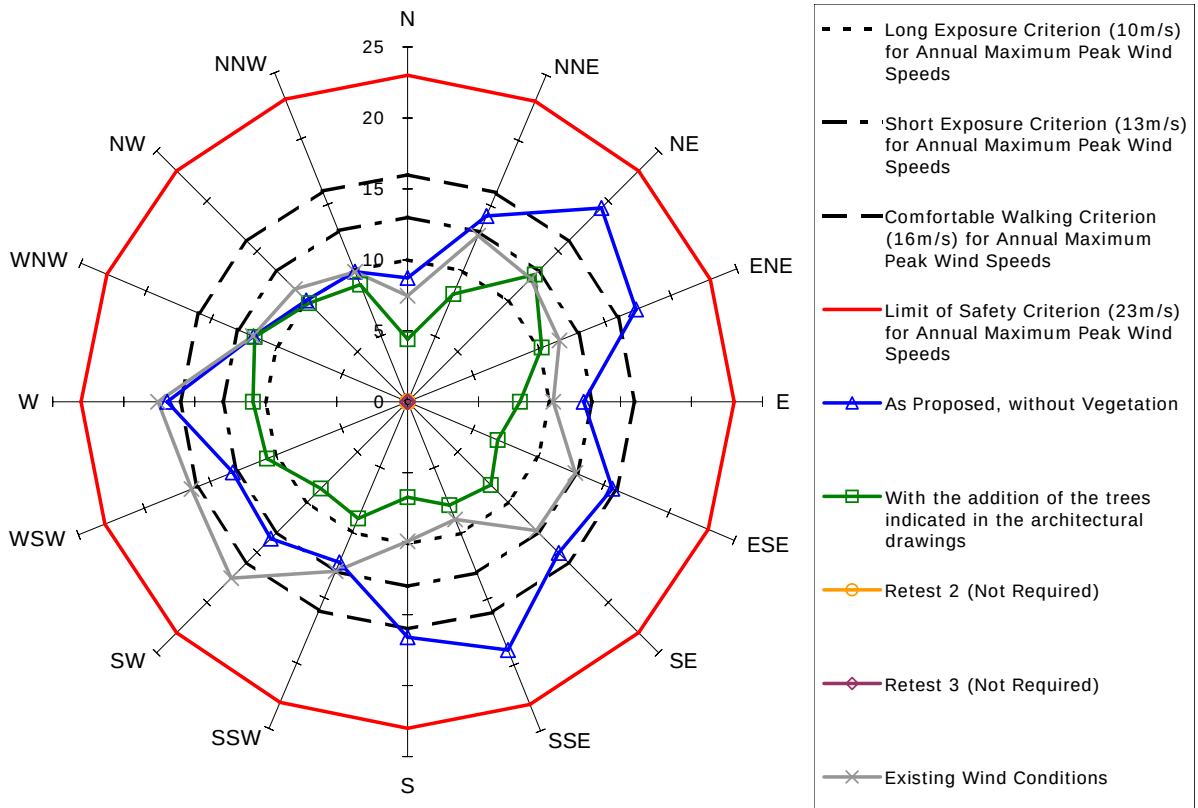


Measured Wind Speeds at Point 03

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

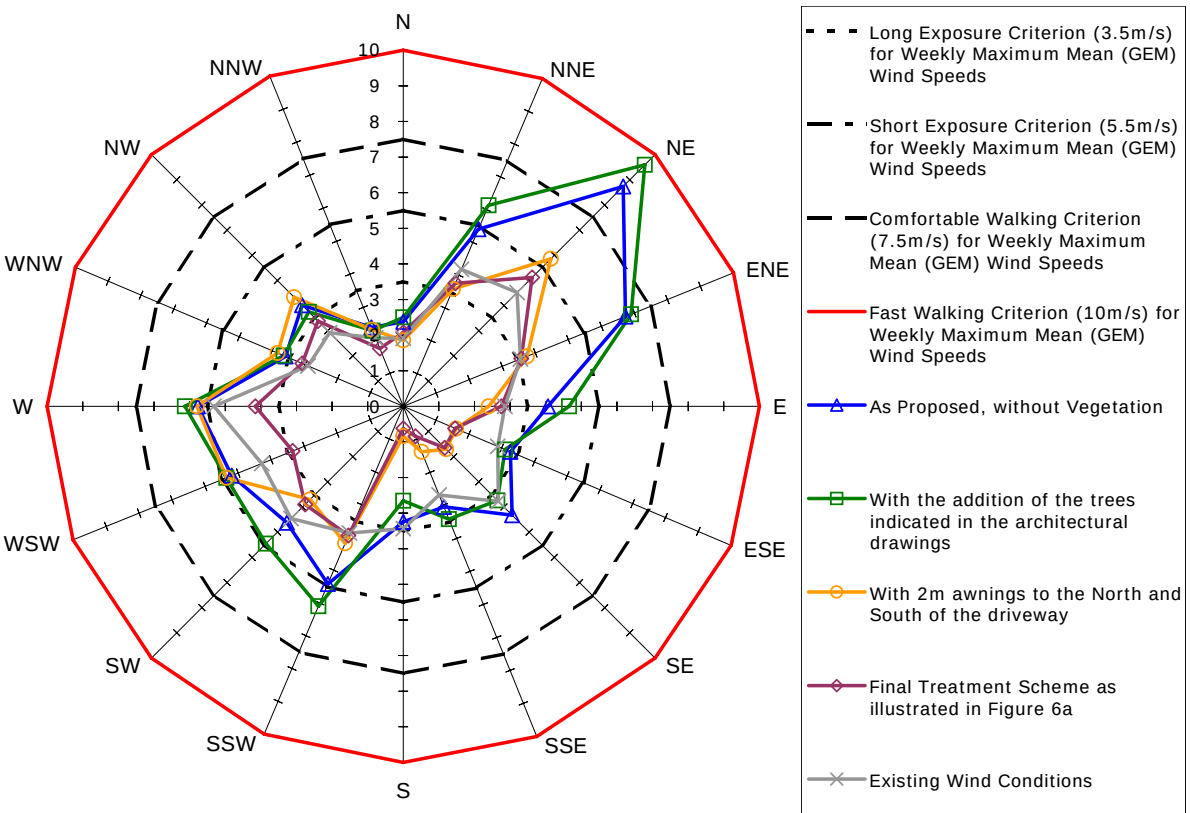


Annual Maximum Gust Wind Speeds (m/s)

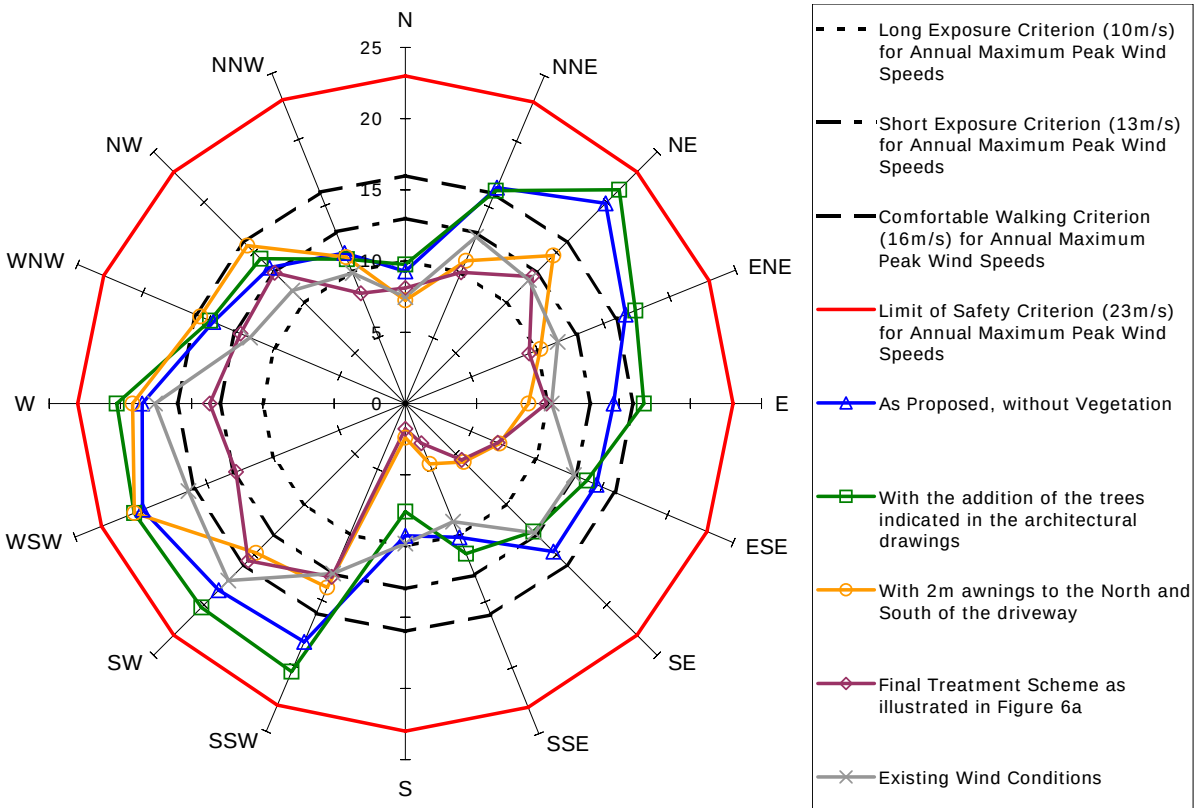


Measured Wind Speeds at Point 04

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

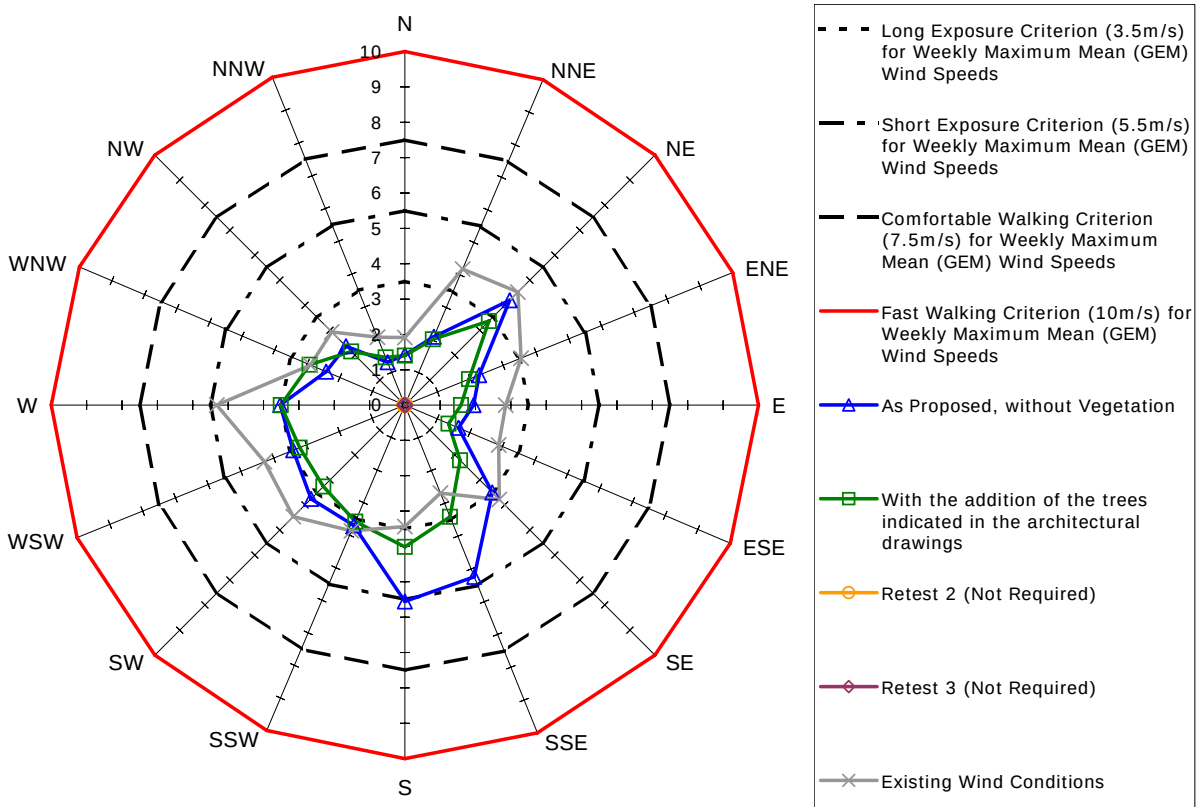


Annual Maximum Gust Wind Speeds (m/s)

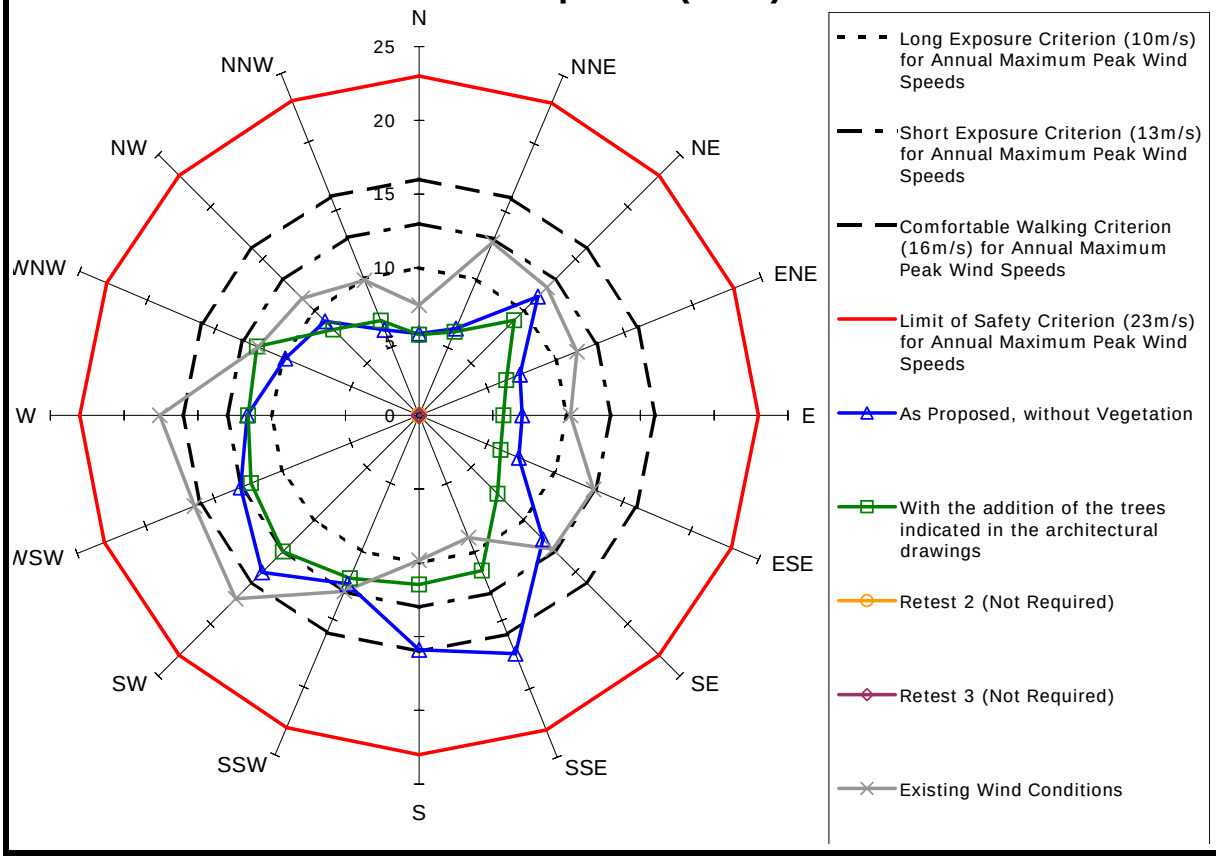


Measured Wind Speeds at Point 05

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

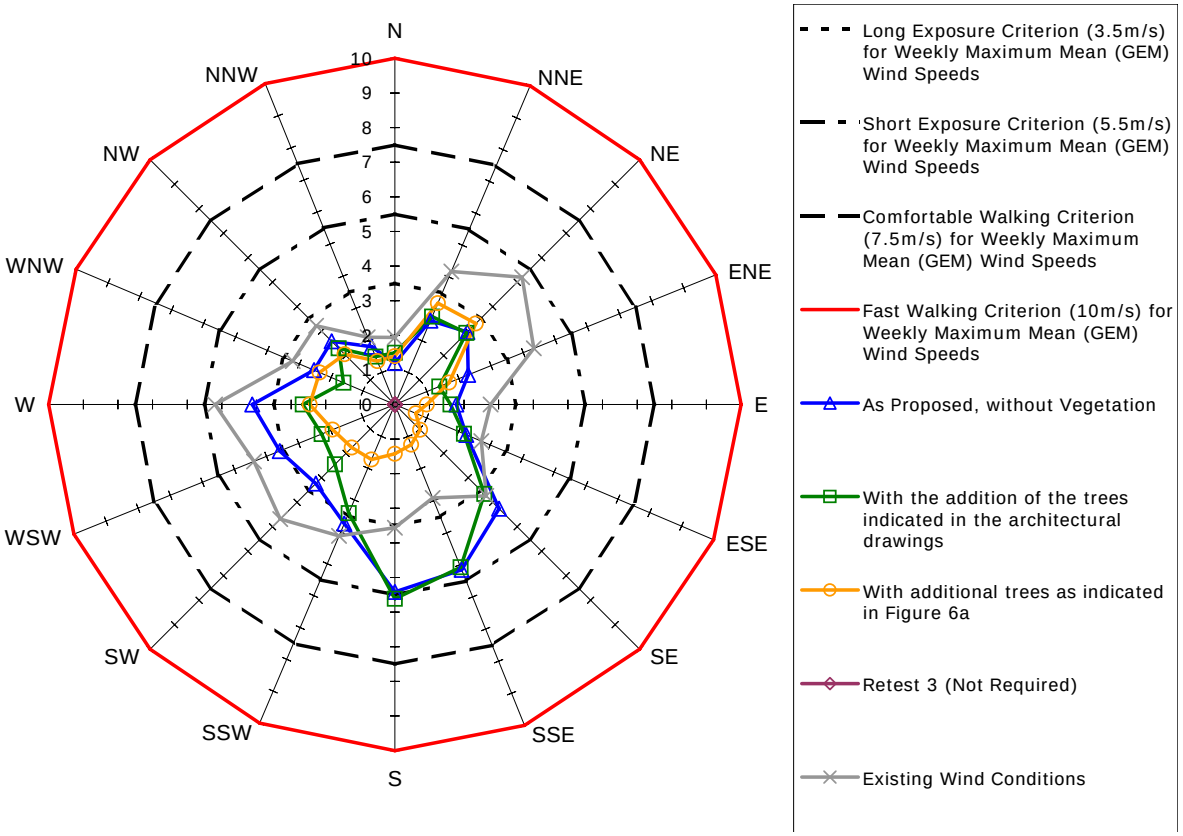


Annual Maximum Gust Wind Speeds (m/s)

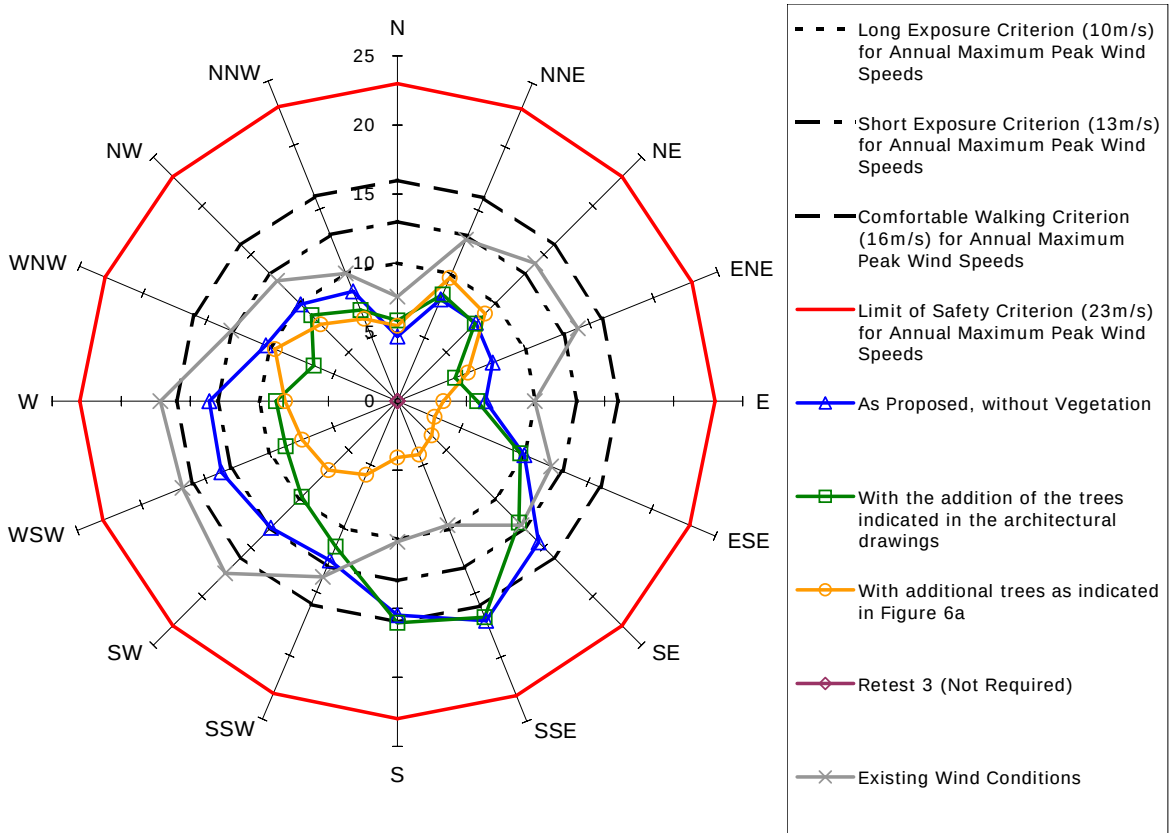


Measured Wind Speeds at Point 06

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

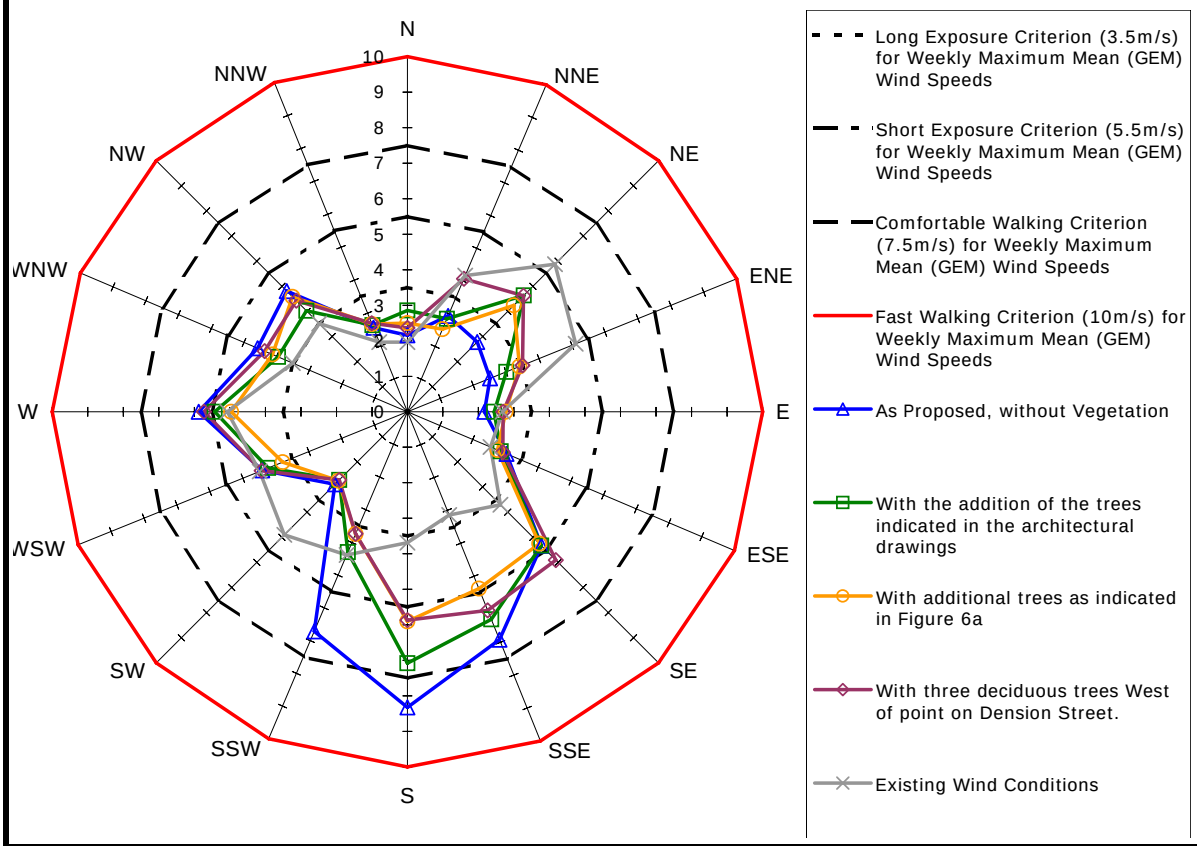


Annual Maximum Gust Wind Speeds (m/s)

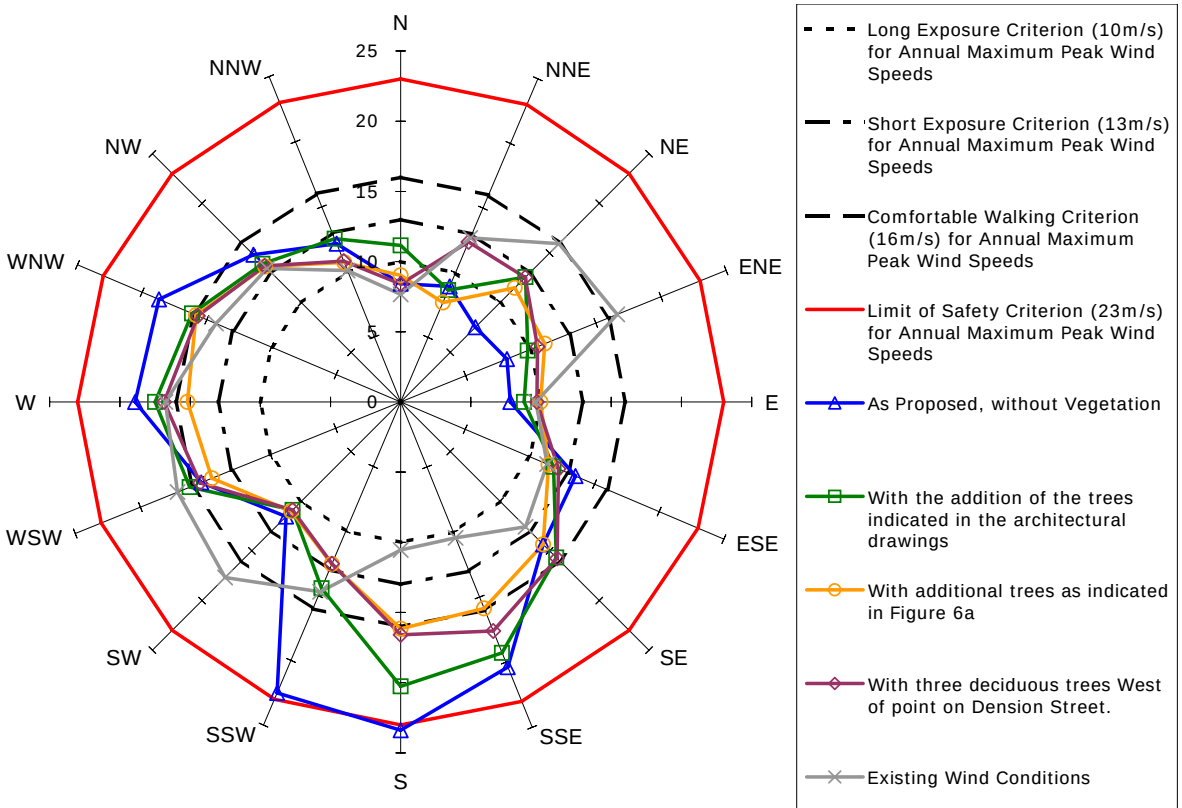


Measured Wind Speeds at Point 07

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

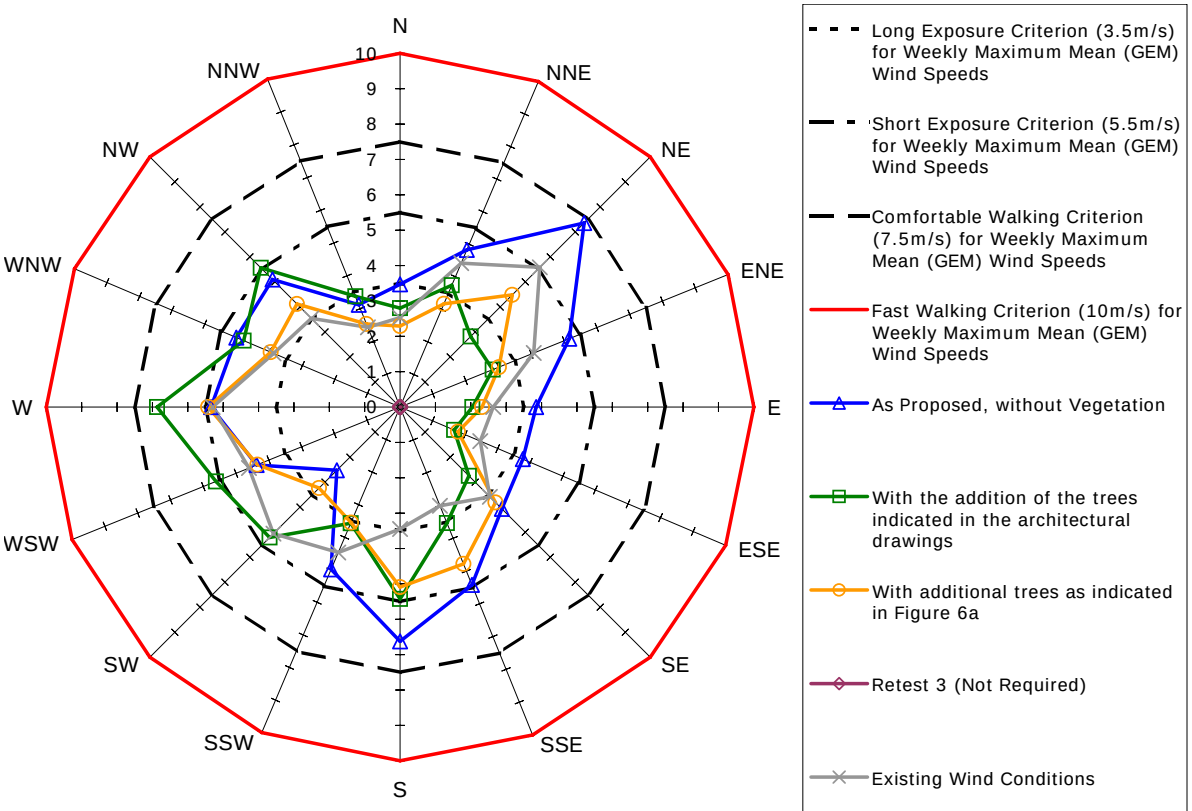


Annual Maximum Gust Wind Speeds (m/s)

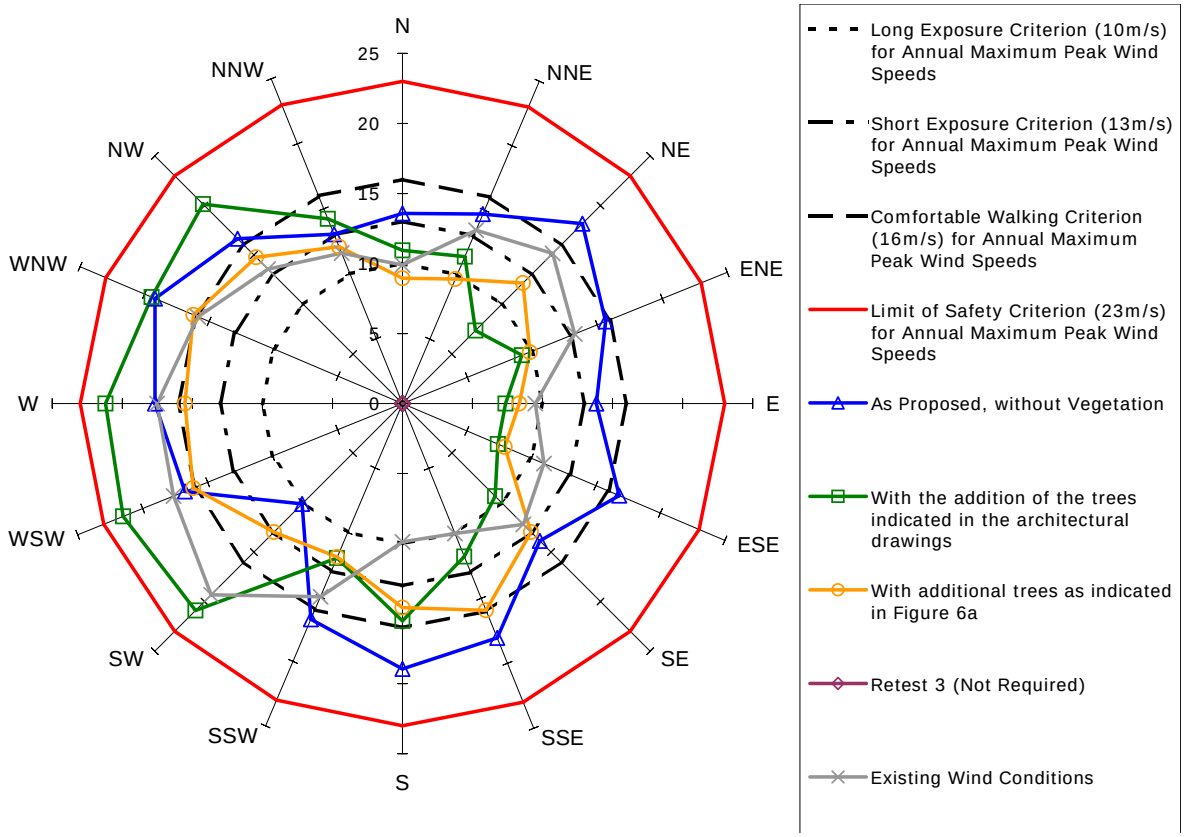


Measured Wind Speeds at Point 08

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

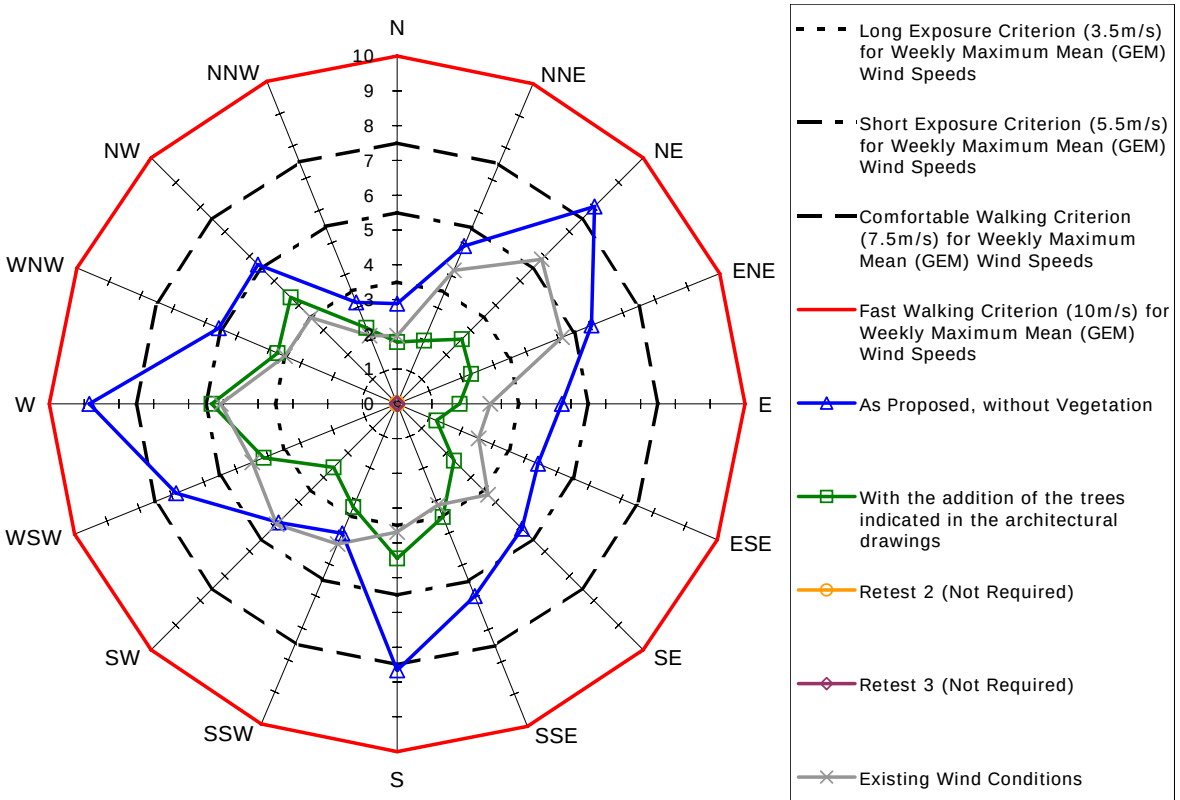


Annual Maximum Gust Wind Speeds (m/s)

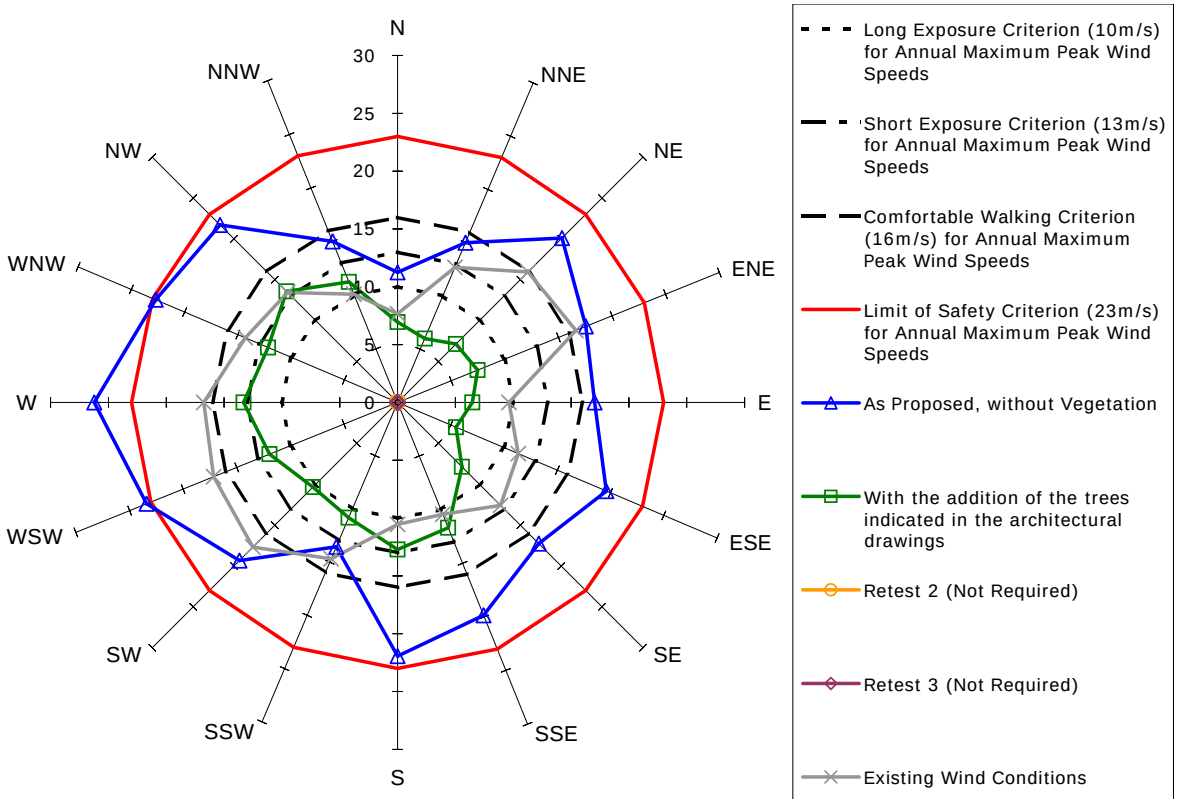


Measured Wind Speeds at Point 09

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

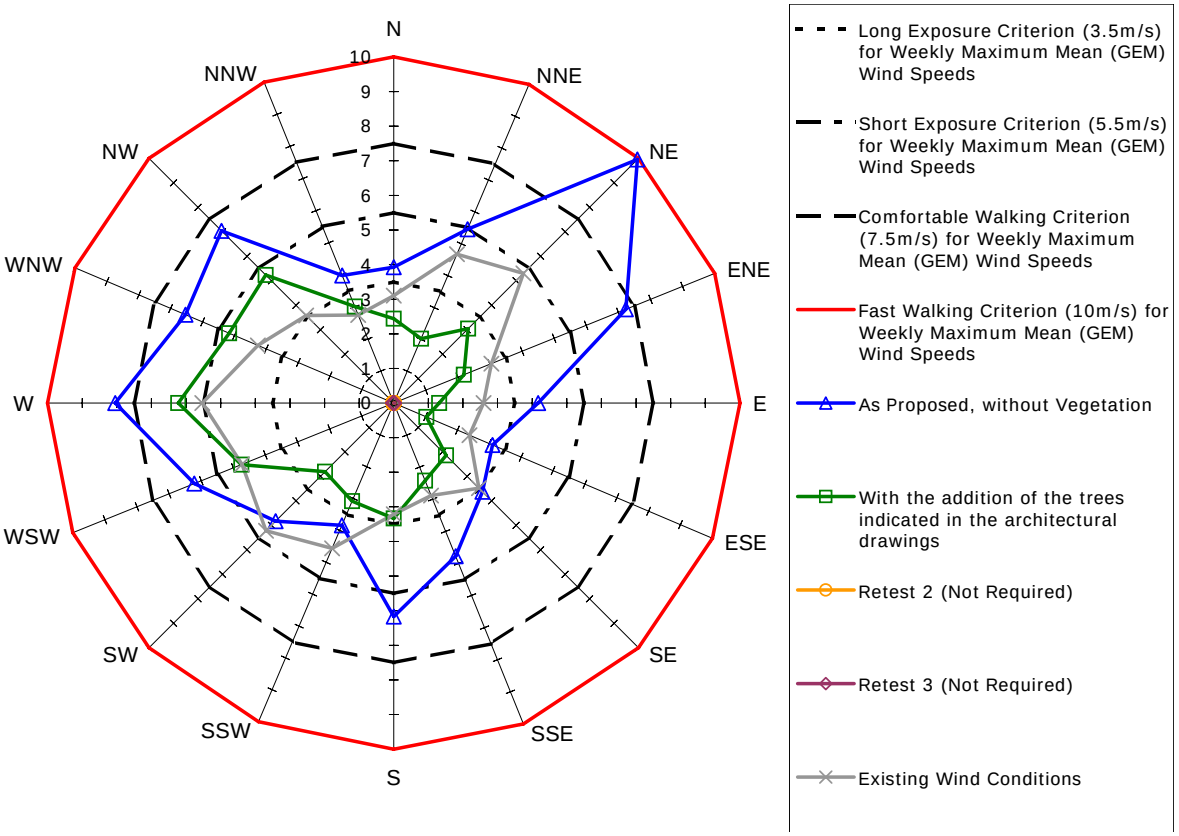


Annual Maximum Gust Wind Speeds (m/s)

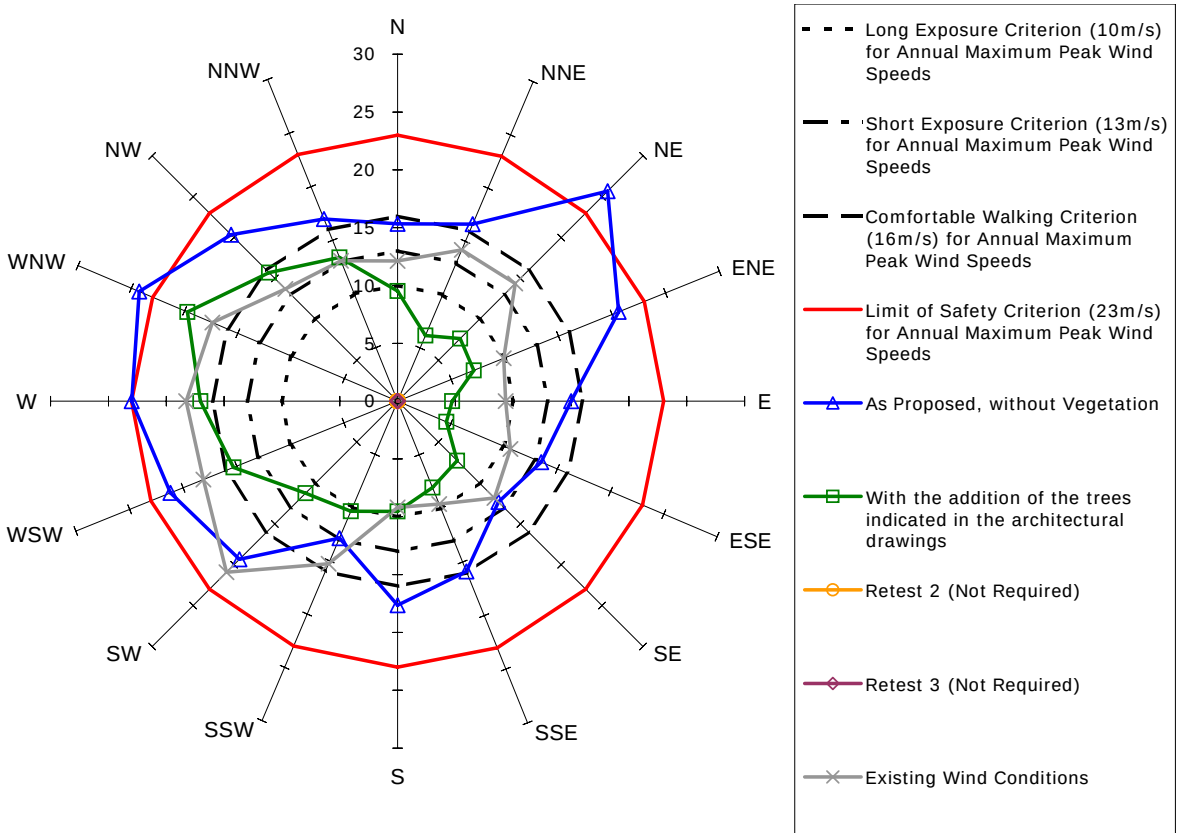


Measured Wind Speeds at Point 10

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

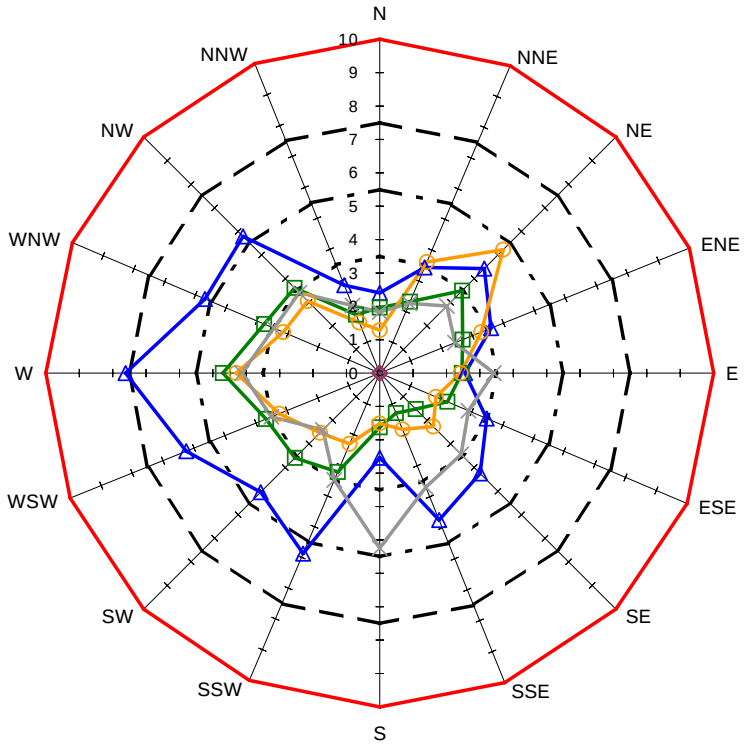


Annual Maximum Gust Wind Speeds (m/s)



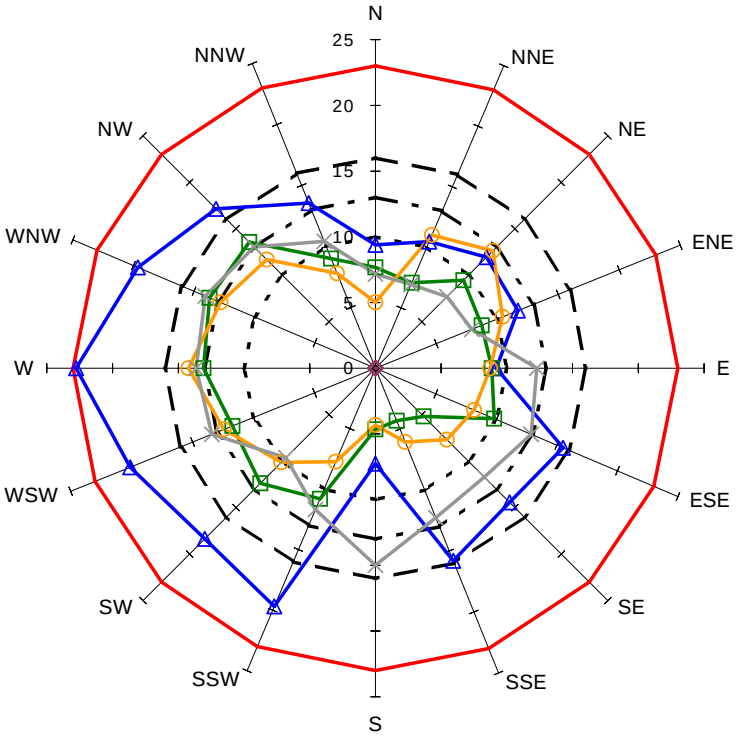
Measured Wind Speeds at Point 11

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)



- Long Exposure Criterion (3.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Short Exposure Criterion (5.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Comfortable Walking Criterion (7.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Fast Walking Criterion (10m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- As Proposed, without Vegetation
- With awnings across the laneway as indicated in Figure 6a
- Final Treatment Scheme as illustrated in Figure 6a
- Retest 3 (Not Required)
- Existing Wind Conditions

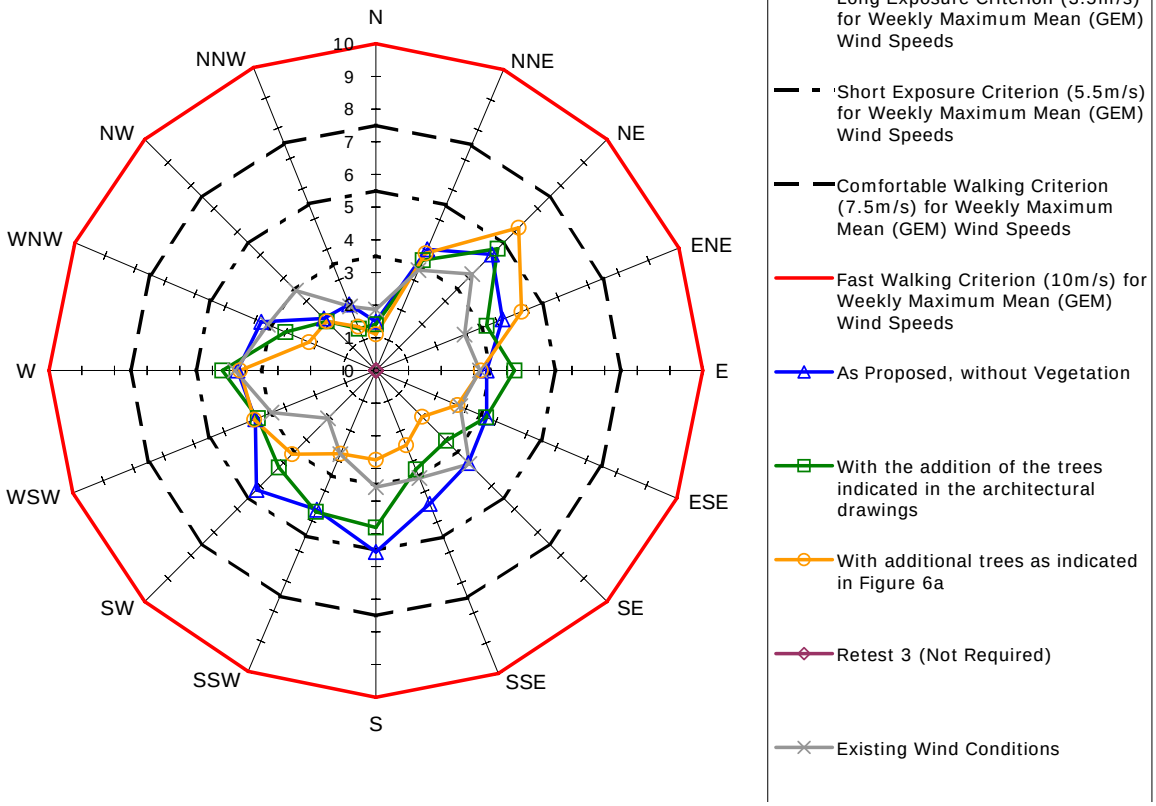
Annual Maximum Gust Wind Speeds (m/s)



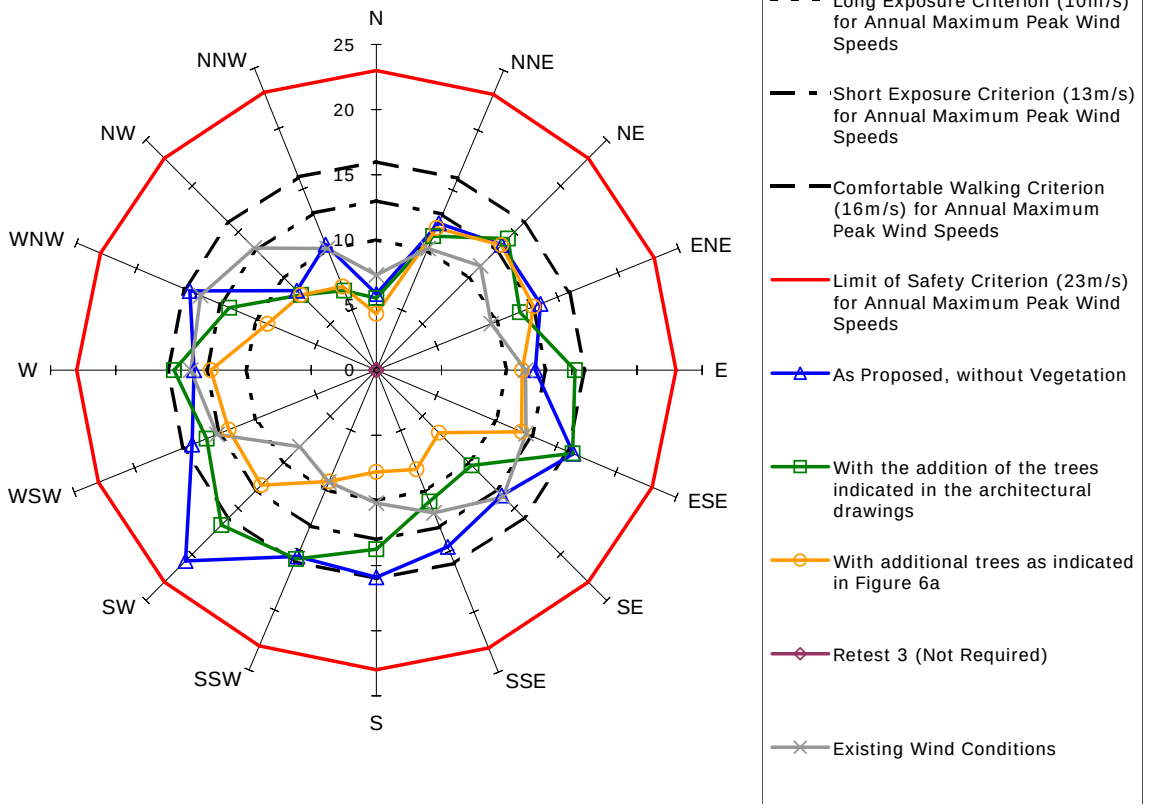
- Long Exposure Criterion (10m/s) for Annual Maximum Peak Wind Speeds
- Short Exposure Criterion (13m/s) for Annual Maximum Peak Wind Speeds
- Comfortable Walking Criterion (16m/s) for Annual Maximum Peak Wind Speeds
- Limit of Safety Criterion (23m/s) for Annual Maximum Peak Wind Speeds
- As Proposed, without Vegetation
- With awnings across the laneway as indicated in Figure 6a
- Final Treatment Scheme as illustrated in Figure 6a
- Retest 3 (Not Required)
- Existing Wind Conditions

Measured Wind Speeds at Point 12

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

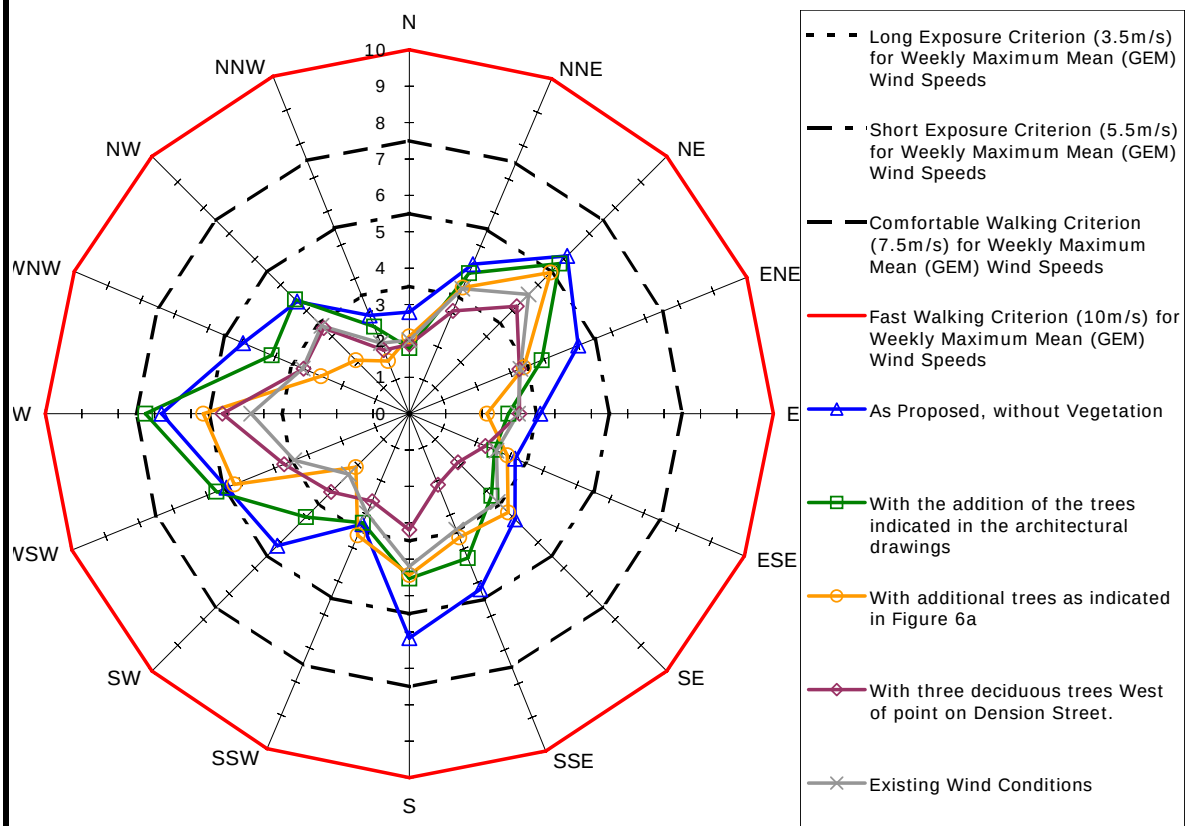


Annual Maximum Gust Wind Speeds (m/s)

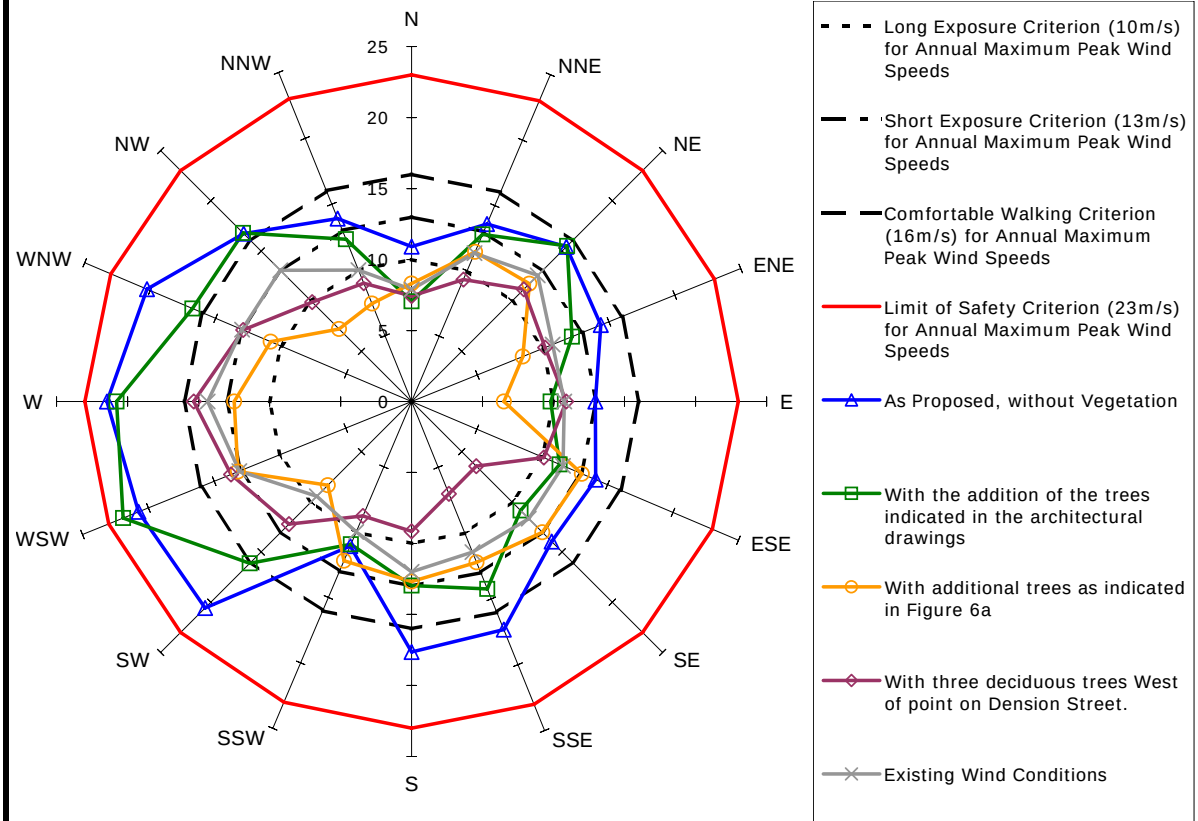


Measured Wind Speeds at Point 13

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

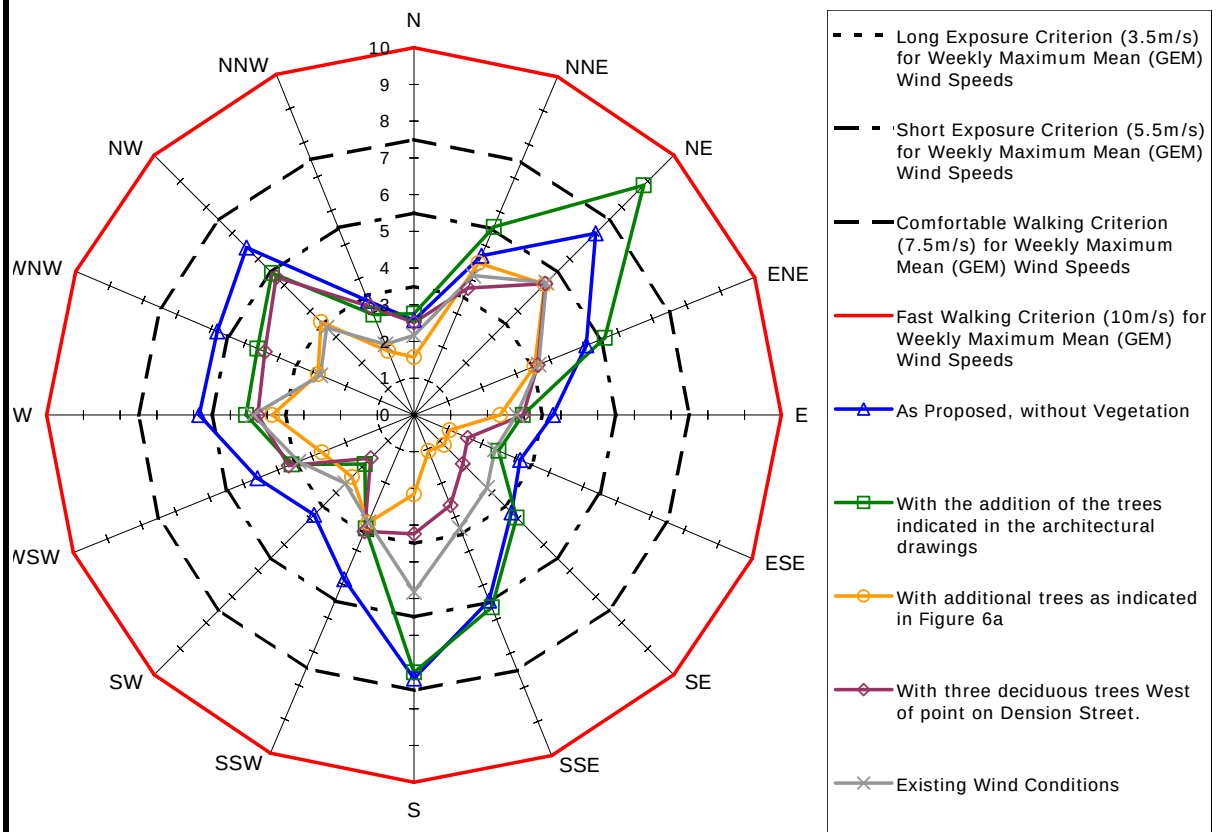


Annual Maximum Gust Wind Speeds (m/s)

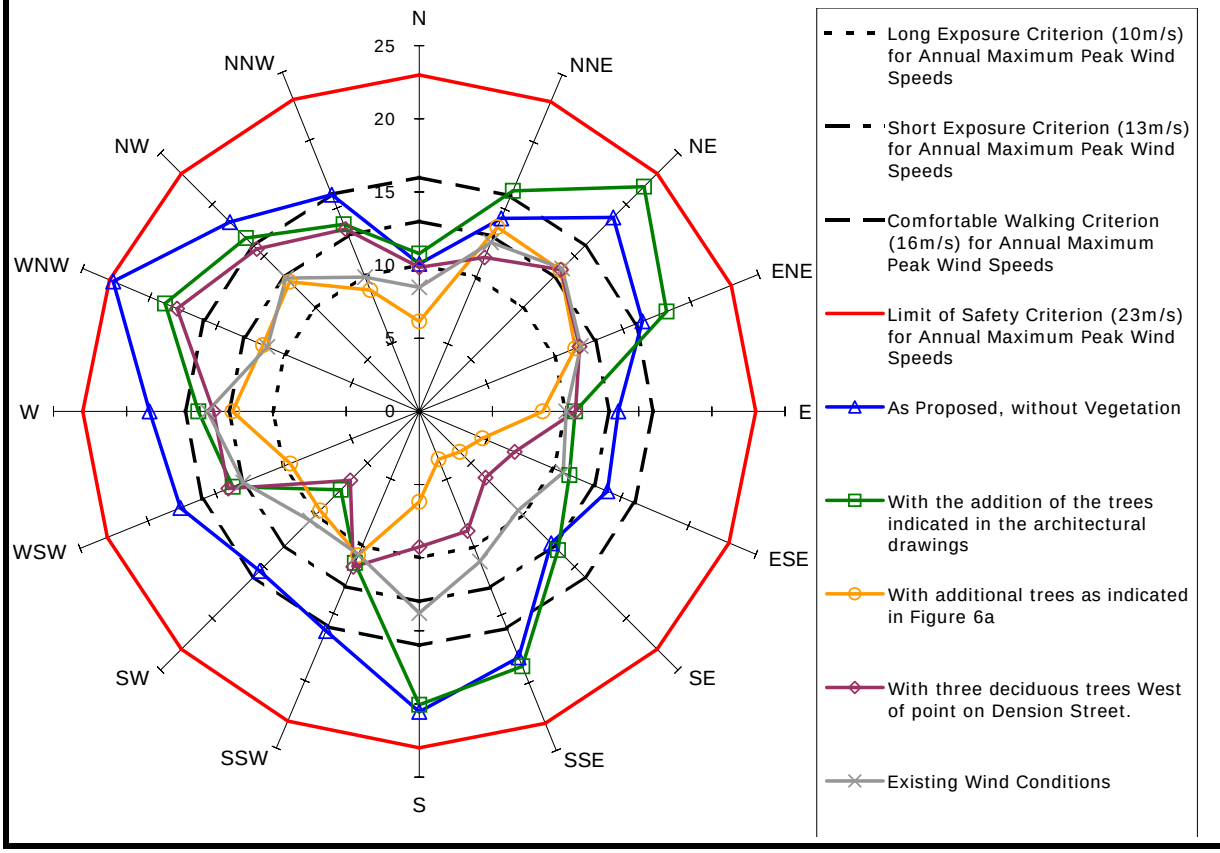


Measured Wind Speeds at Point 14

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

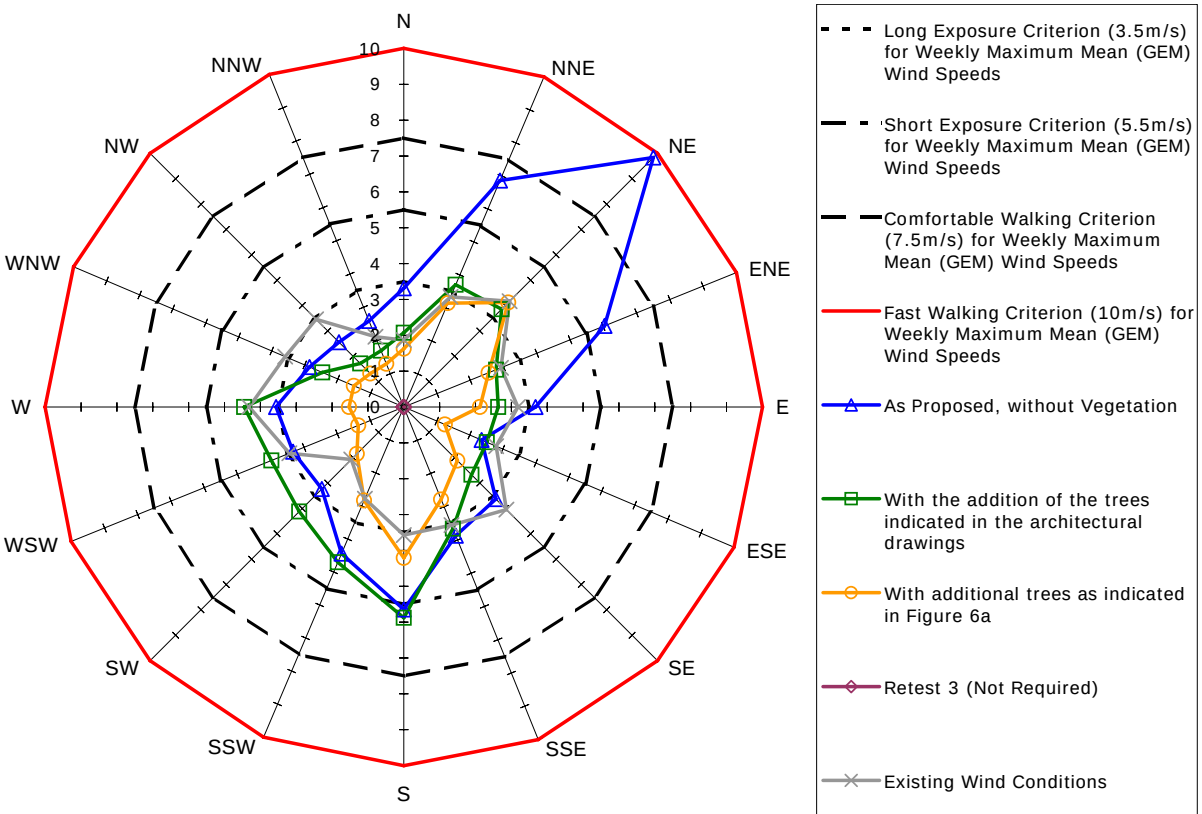


Annual Maximum Gust Wind Speeds (m/s)

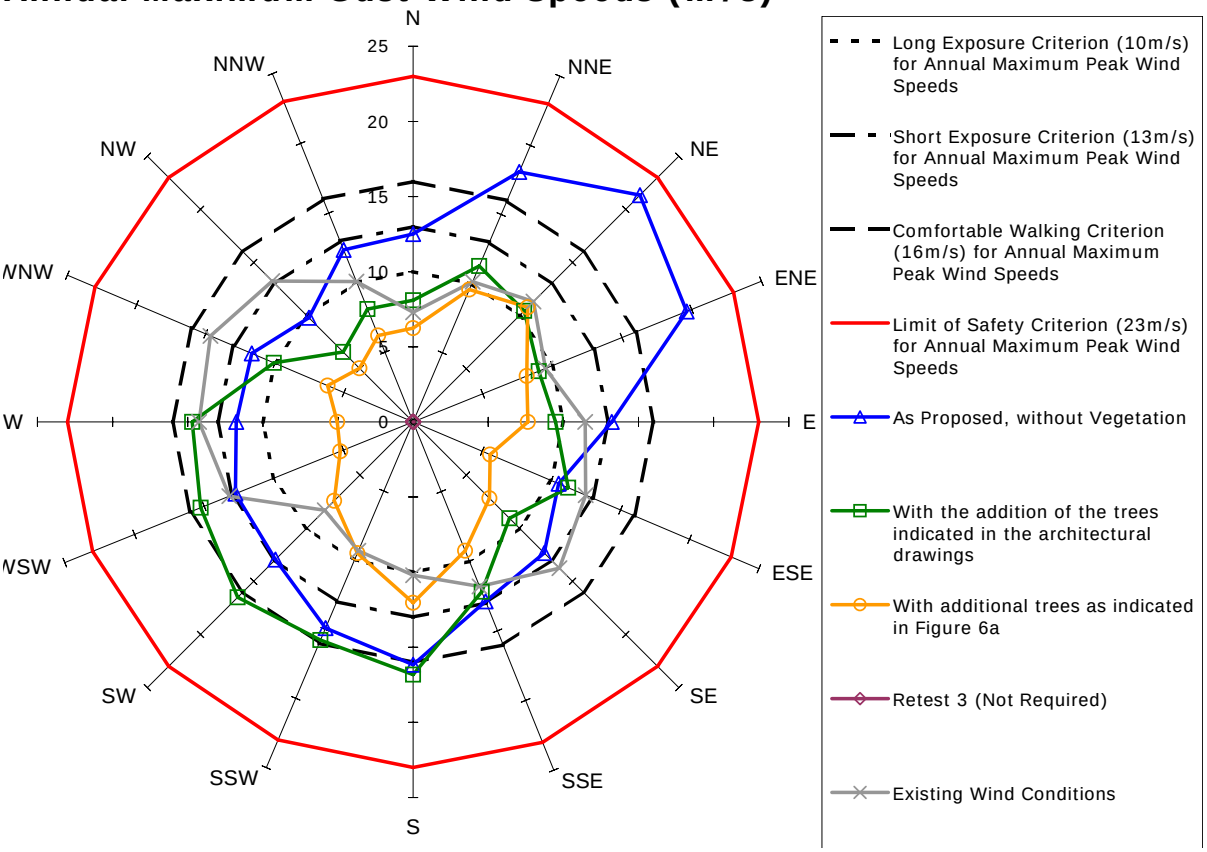


Measured Wind Speeds at Point 15

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

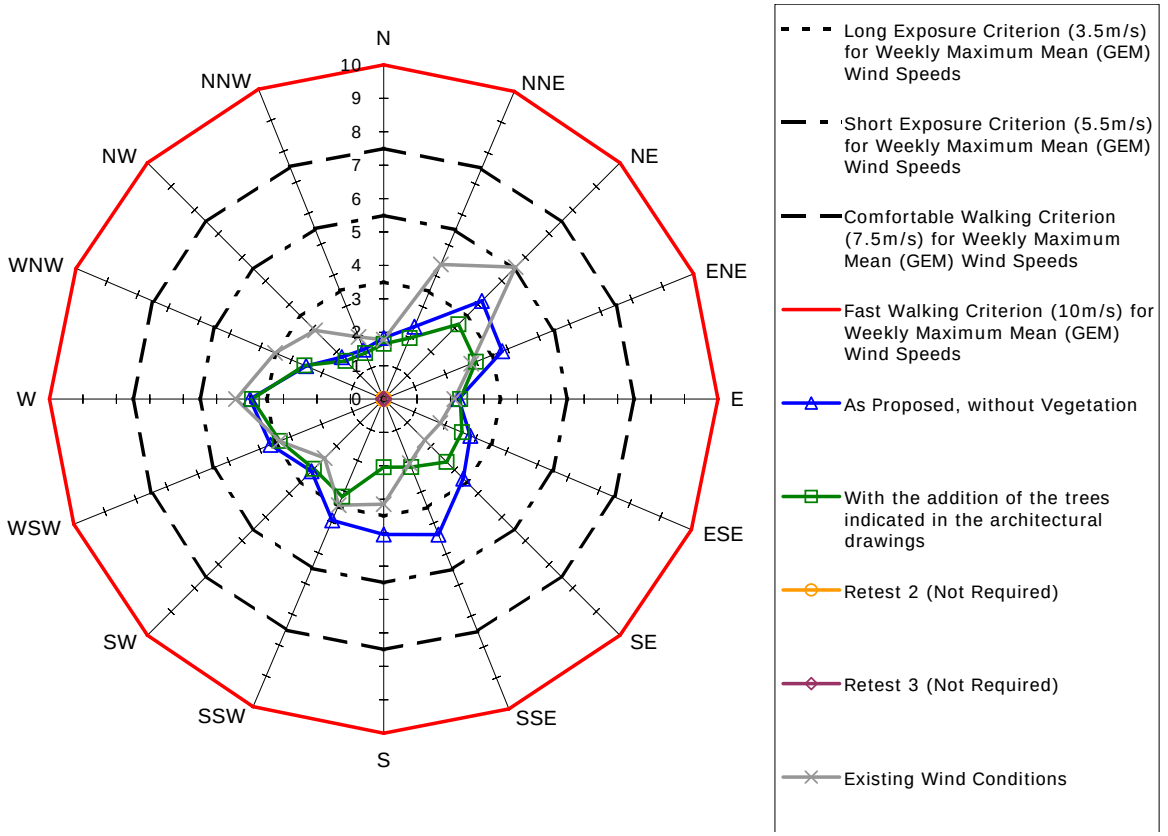


Annual Maximum Gust Wind Speeds (m/s)

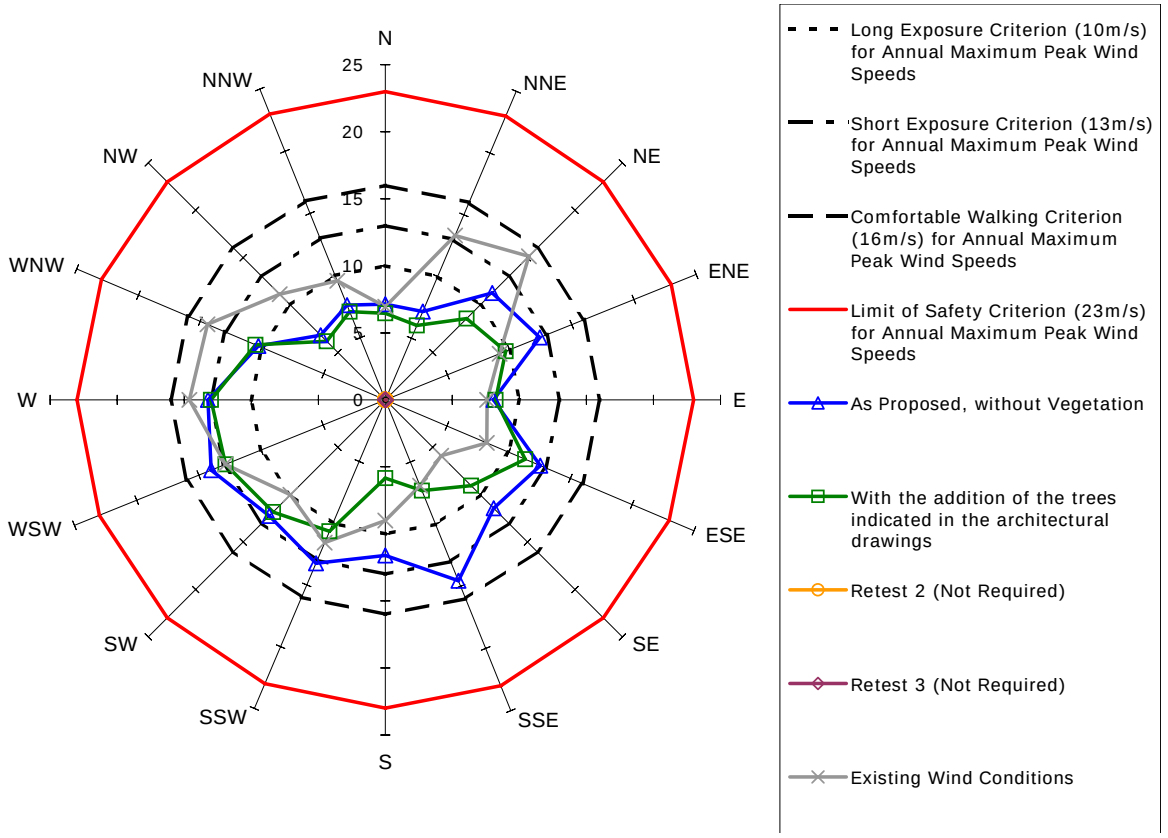


Measured Wind Speeds at Point 16

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

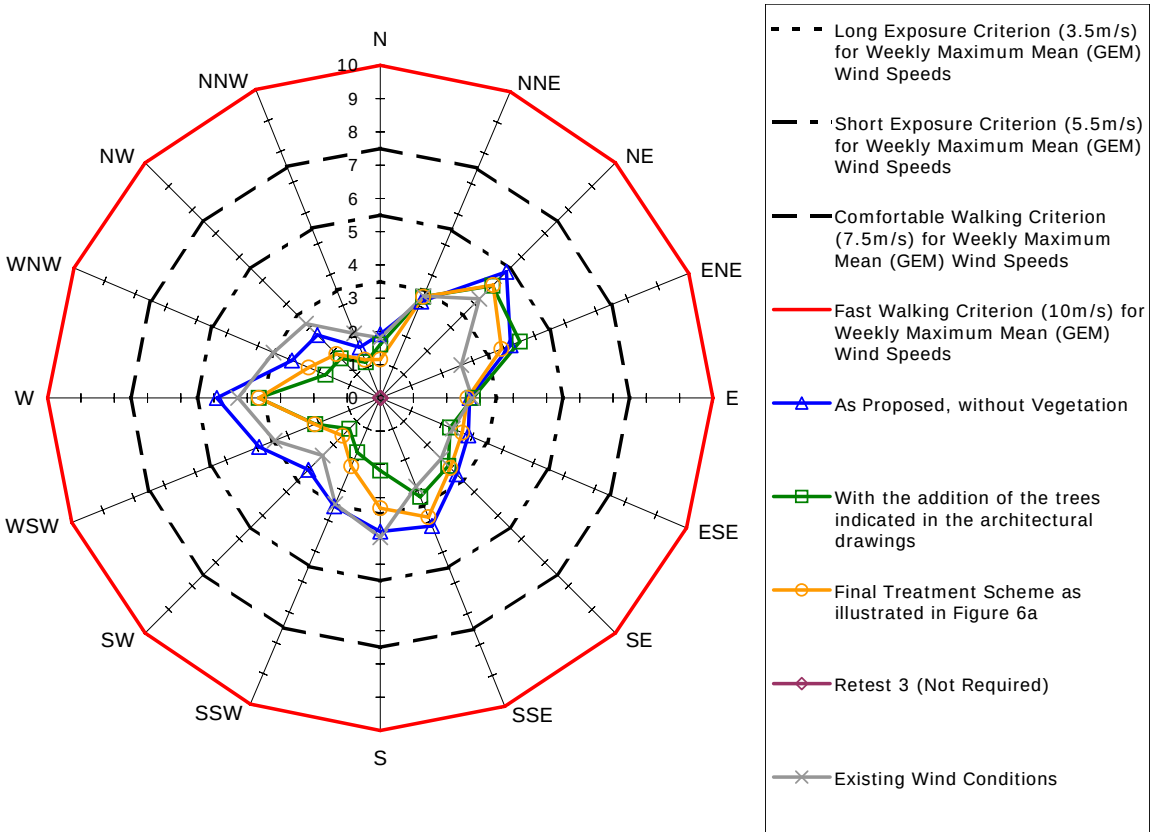


Annual Maximum Gust Wind Speeds (m/s)

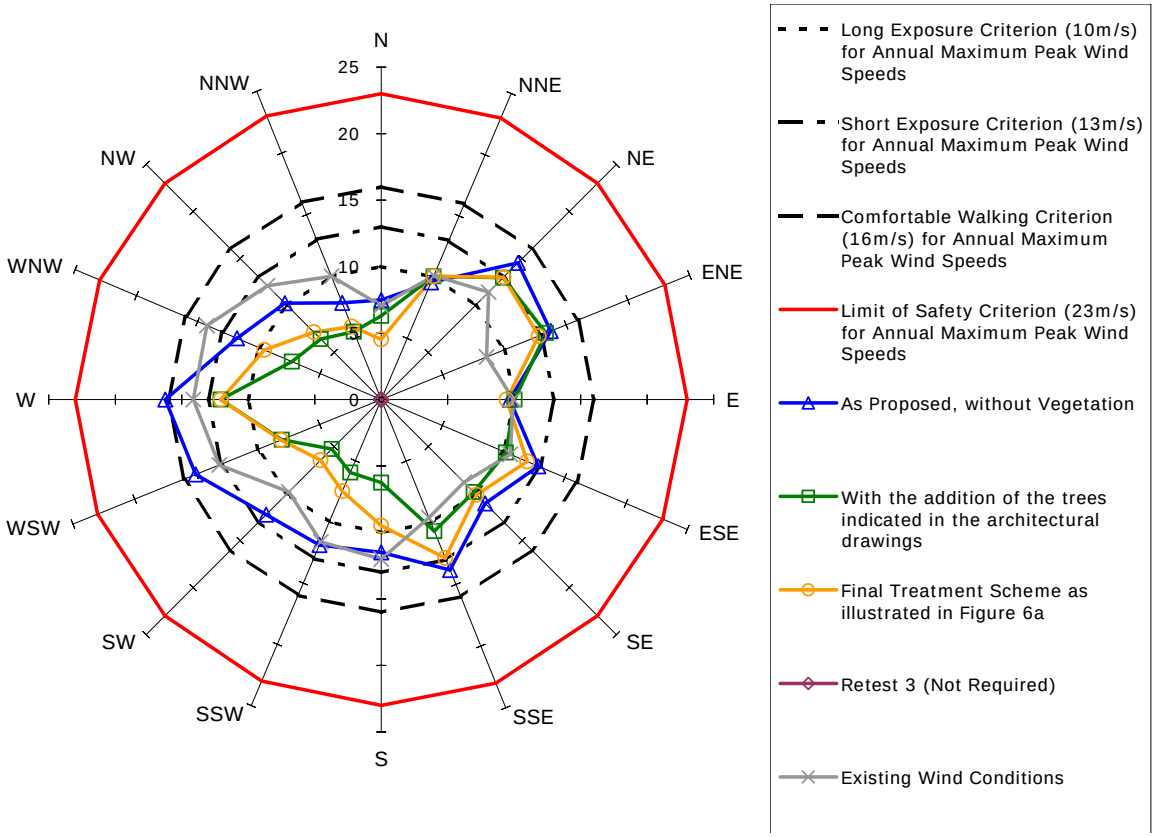


Measured Wind Speeds at Point 17

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

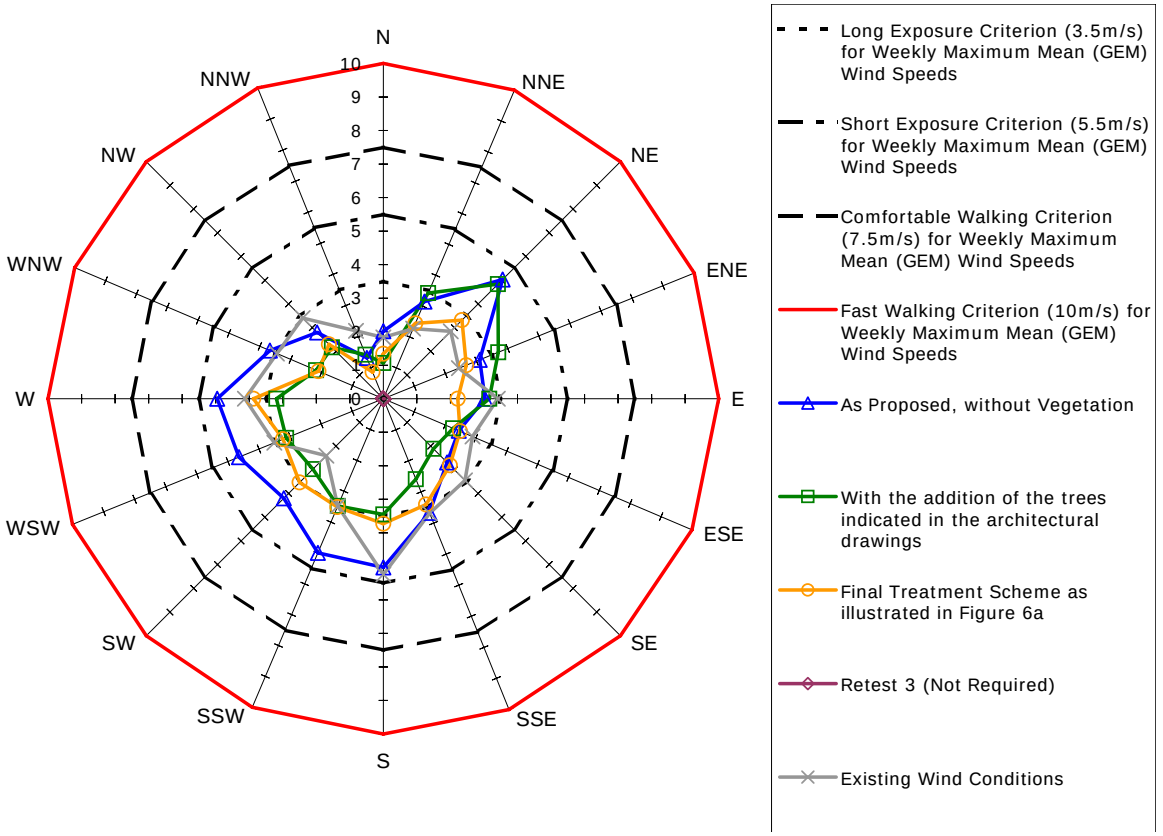


Annual Maximum Gust Wind Speeds (m/s)

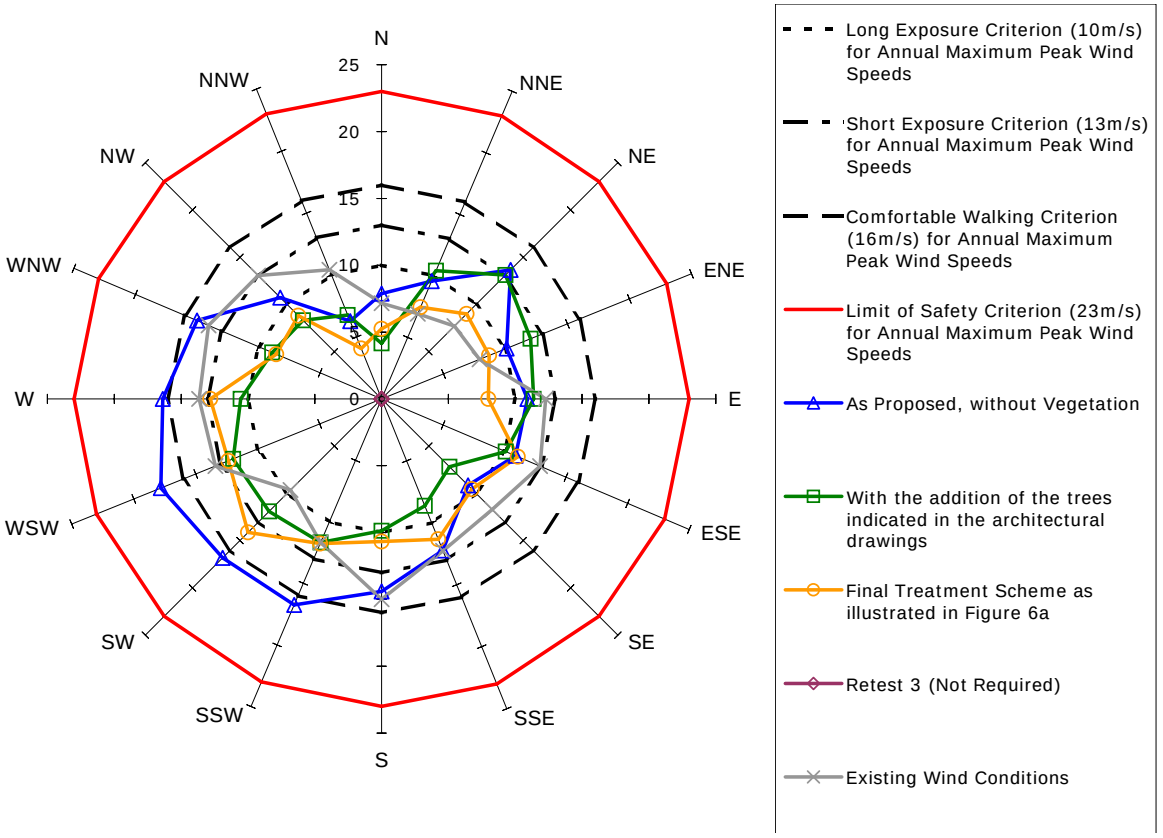


Measured Wind Speeds at Point 18

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

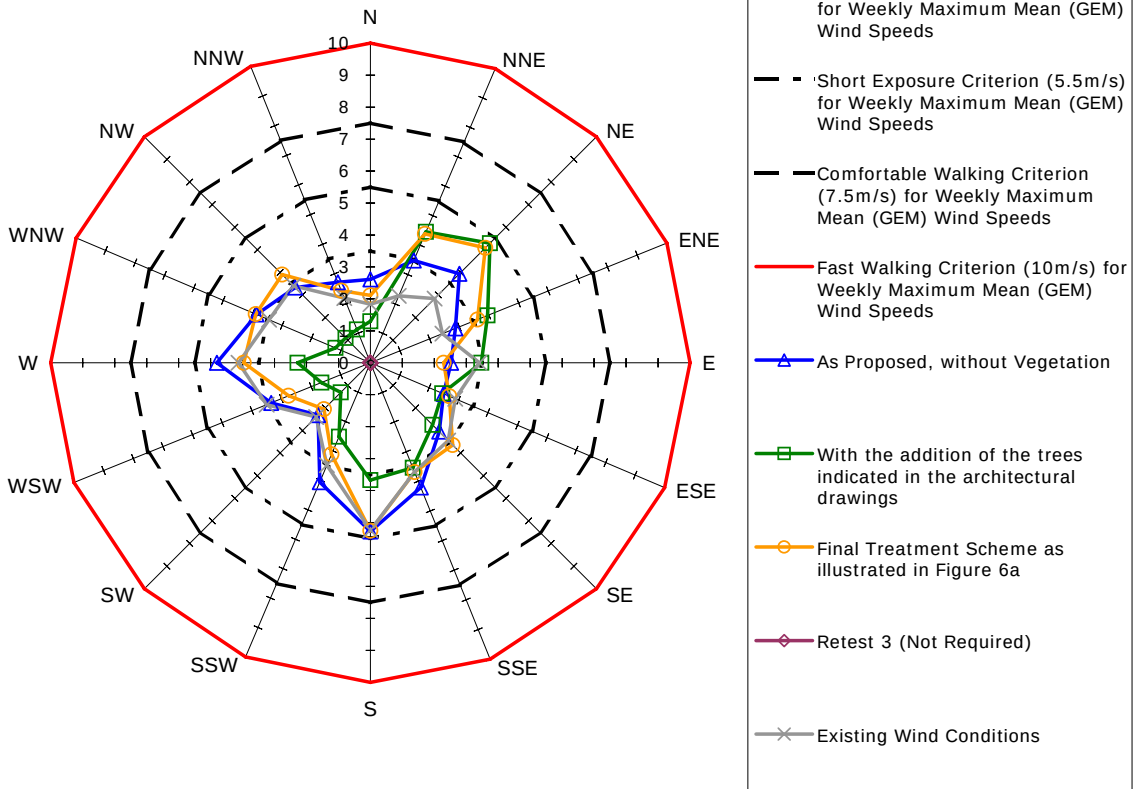


Annual Maximum Gust Wind Speeds (m/s)

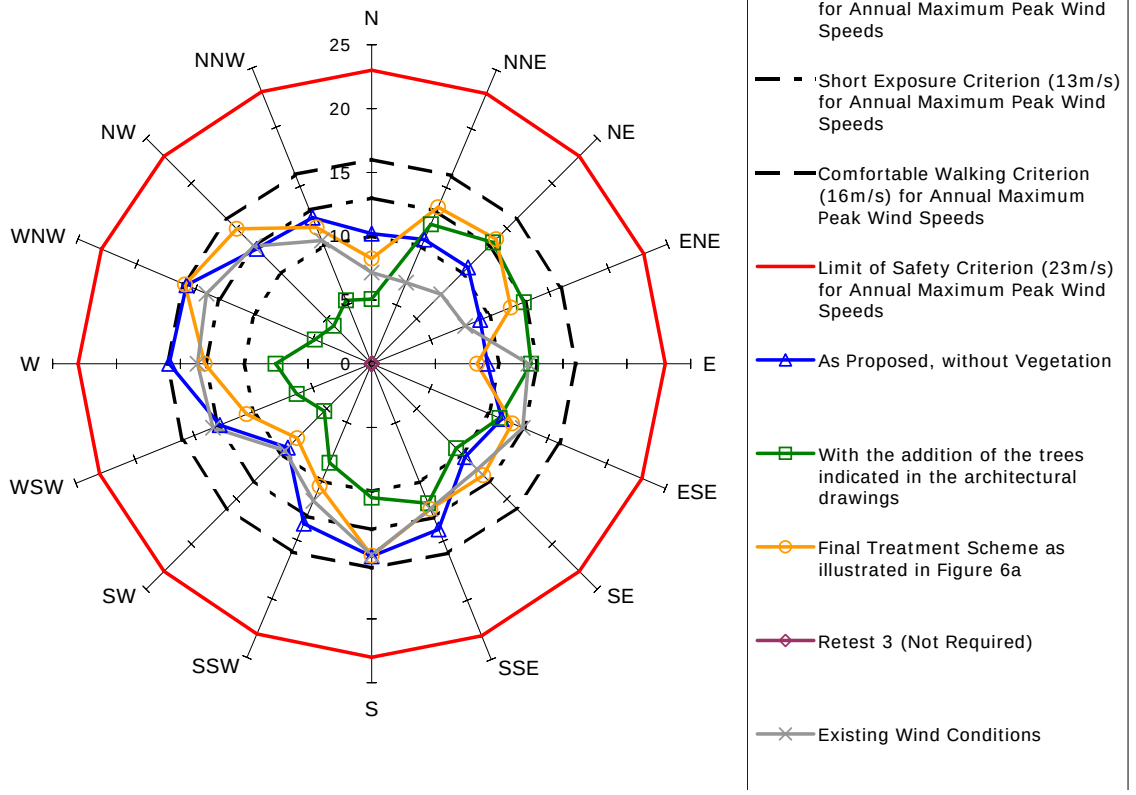


Measured Wind Speeds at Point 19

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

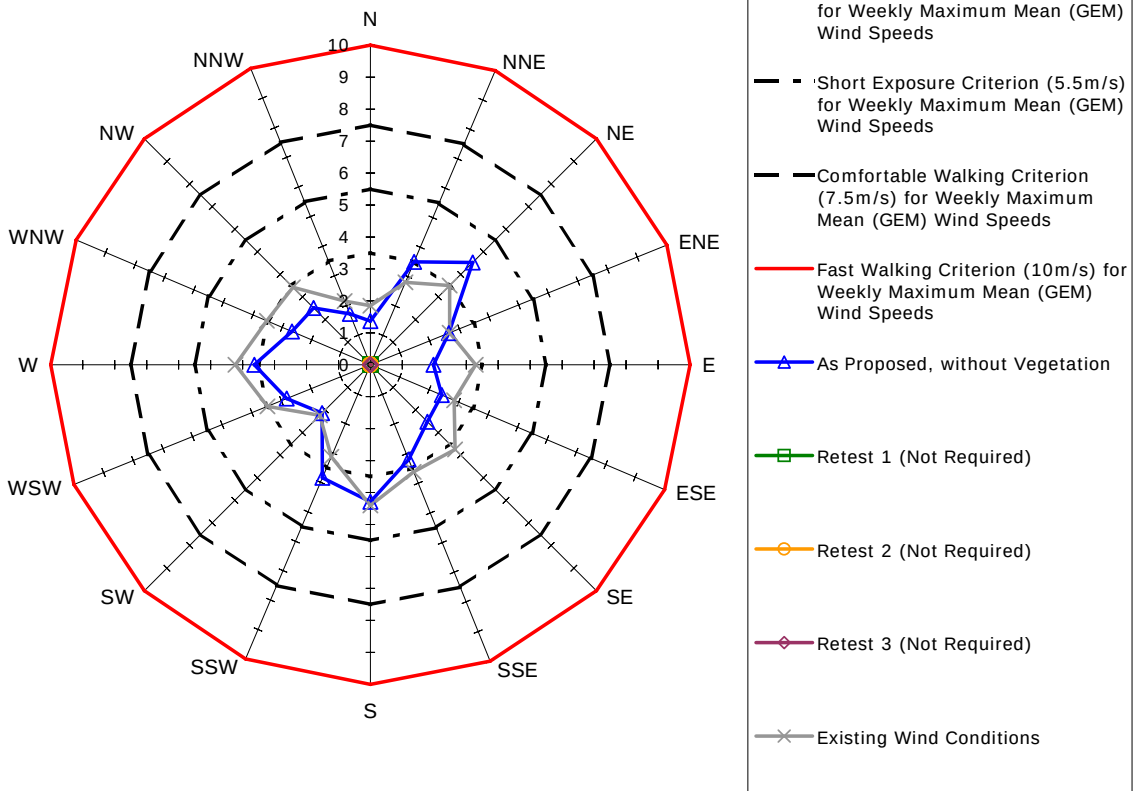


Annual Maximum Gust Wind Speeds (m/s)

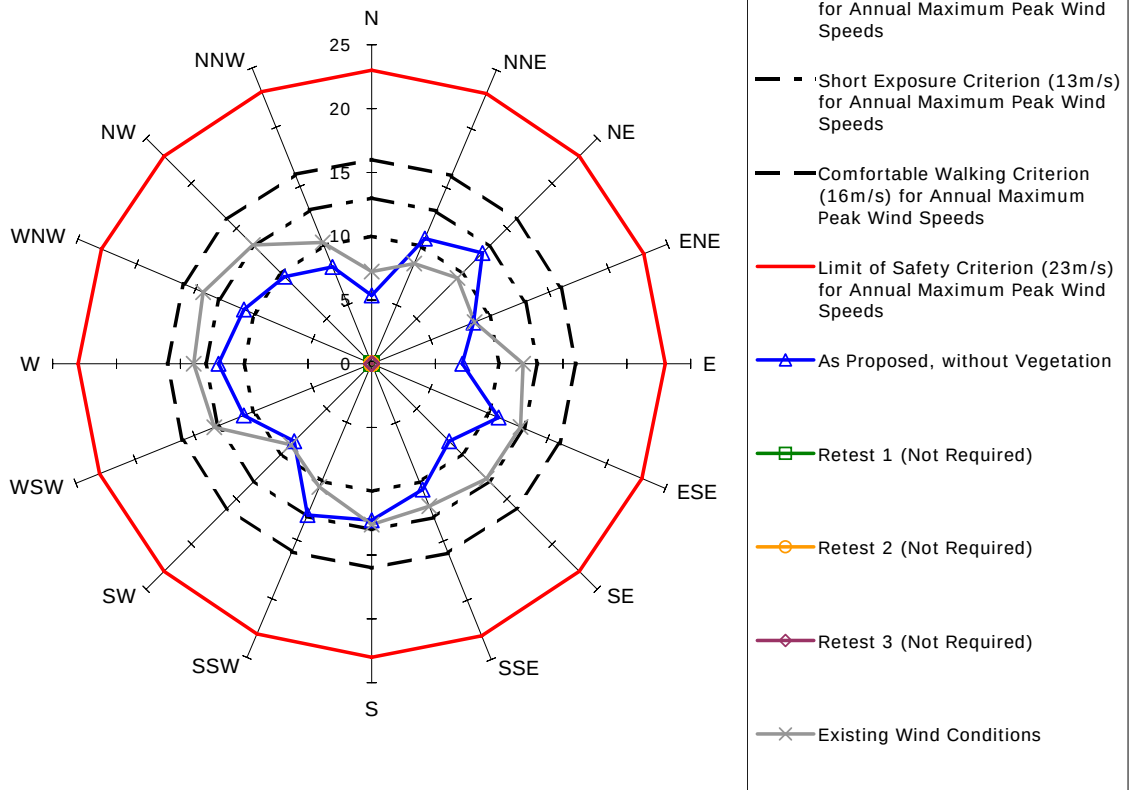


Measured Wind Speeds at Point 20

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

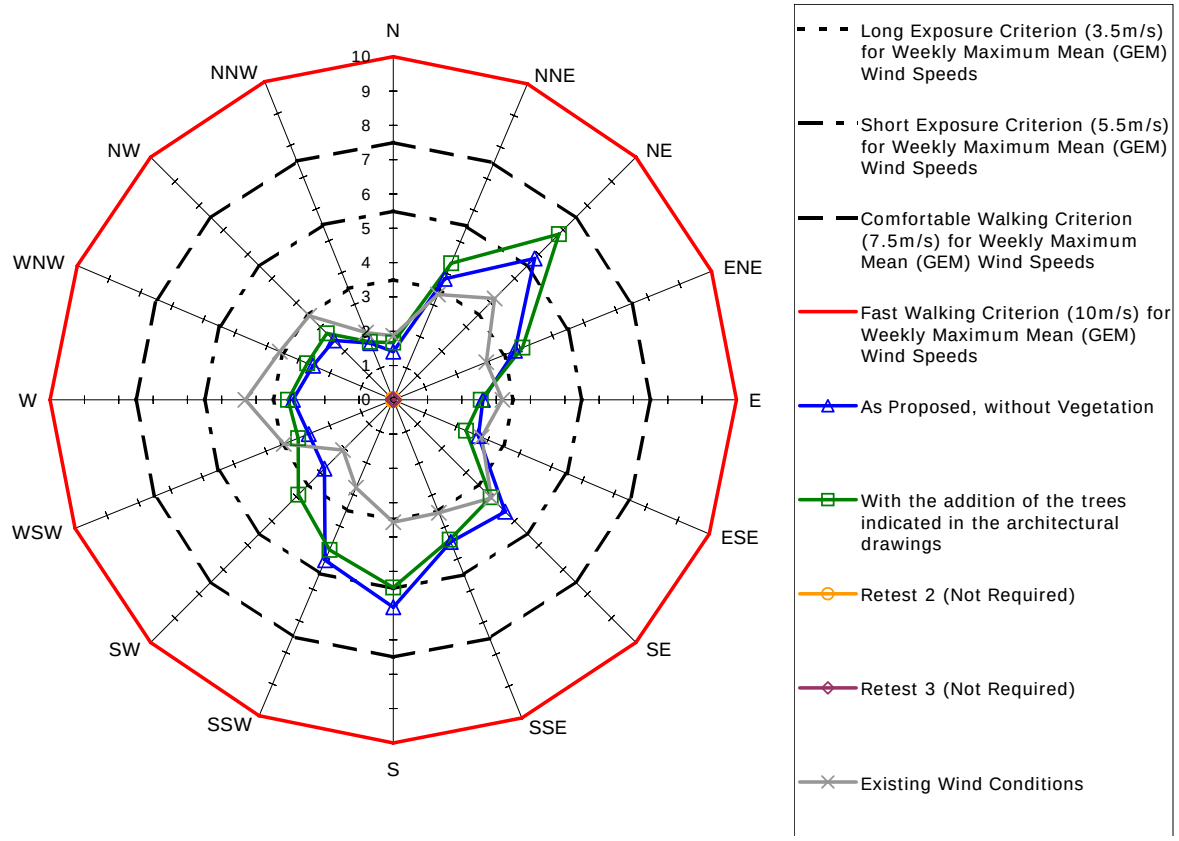


Annual Maximum Gust Wind Speeds (m/s)

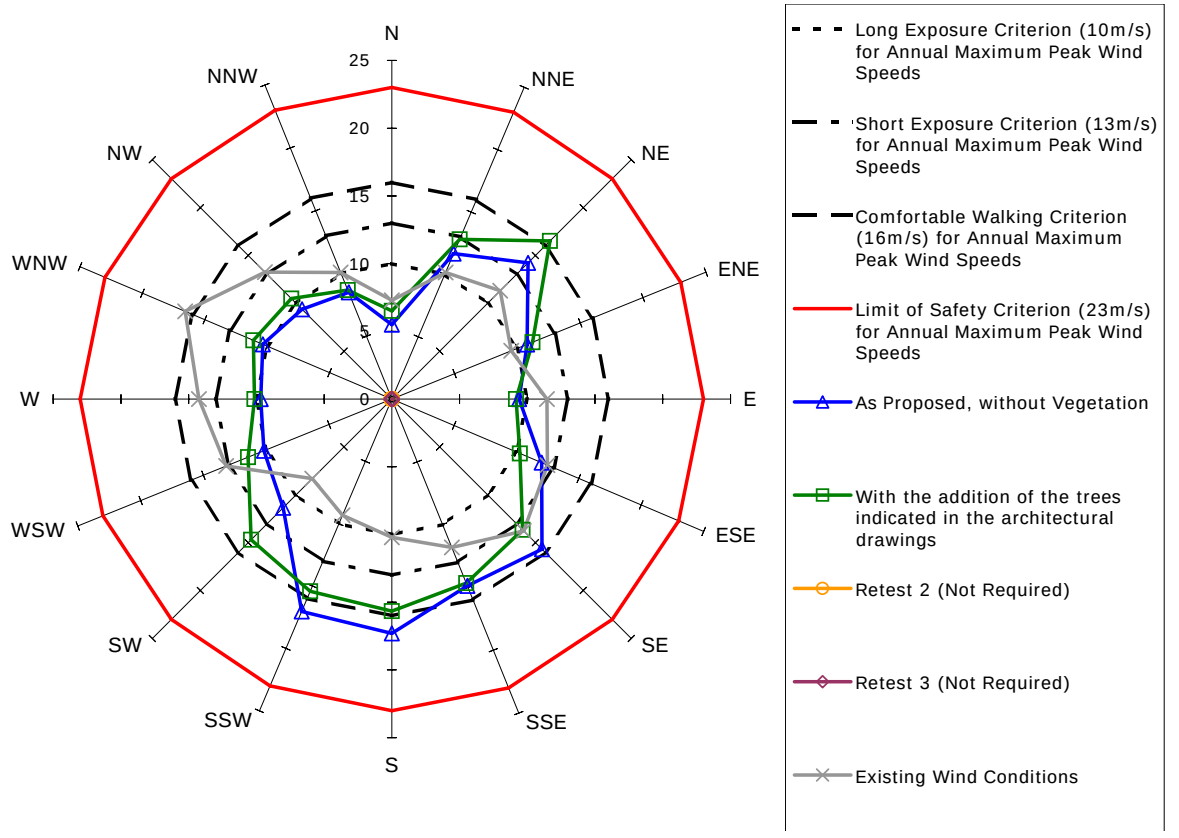


Measured Wind Speeds at Point 21

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

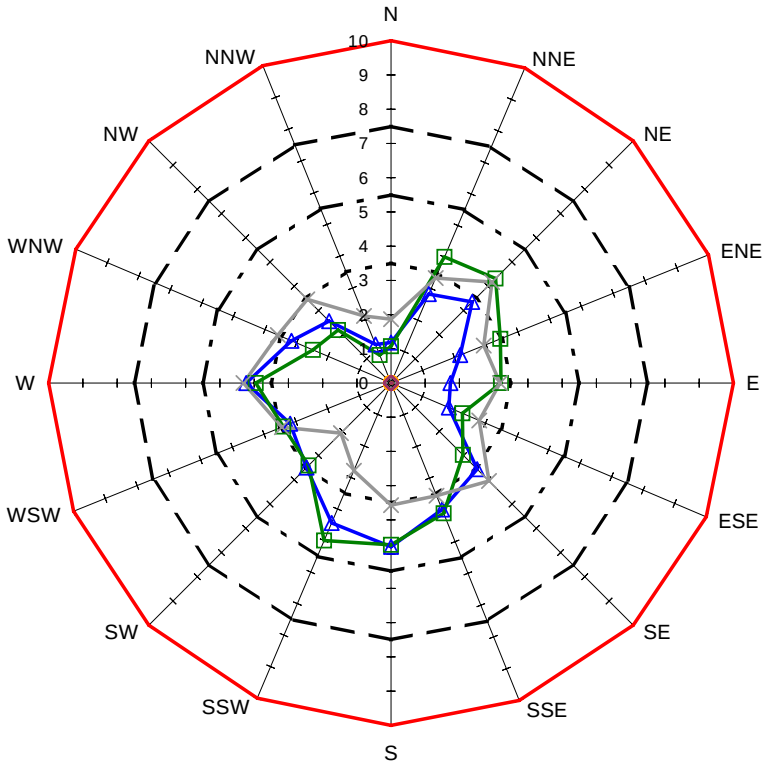


Annual Maximum Gust Wind Speeds (m/s)



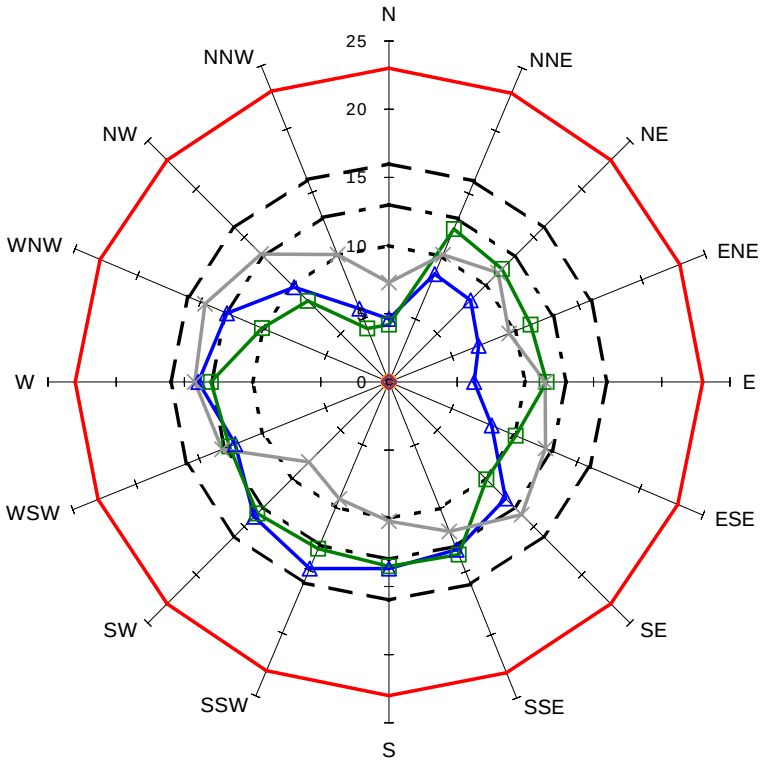
Measured Wind Speeds at Point 22

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)



- Long Exposure Criterion (3.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Short Exposure Criterion (5.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Comfortable Walking Criterion (7.5m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- Fast Walking Criterion (10m/s) for Weekly Maximum Mean (GEM) Wind Speeds
- As Proposed, without Vegetation
- With the addition of the trees indicated in the architectural drawings
- Retest 2 (Not Required)
- Retest 3 (Not Required)
- Existing Wind Conditions

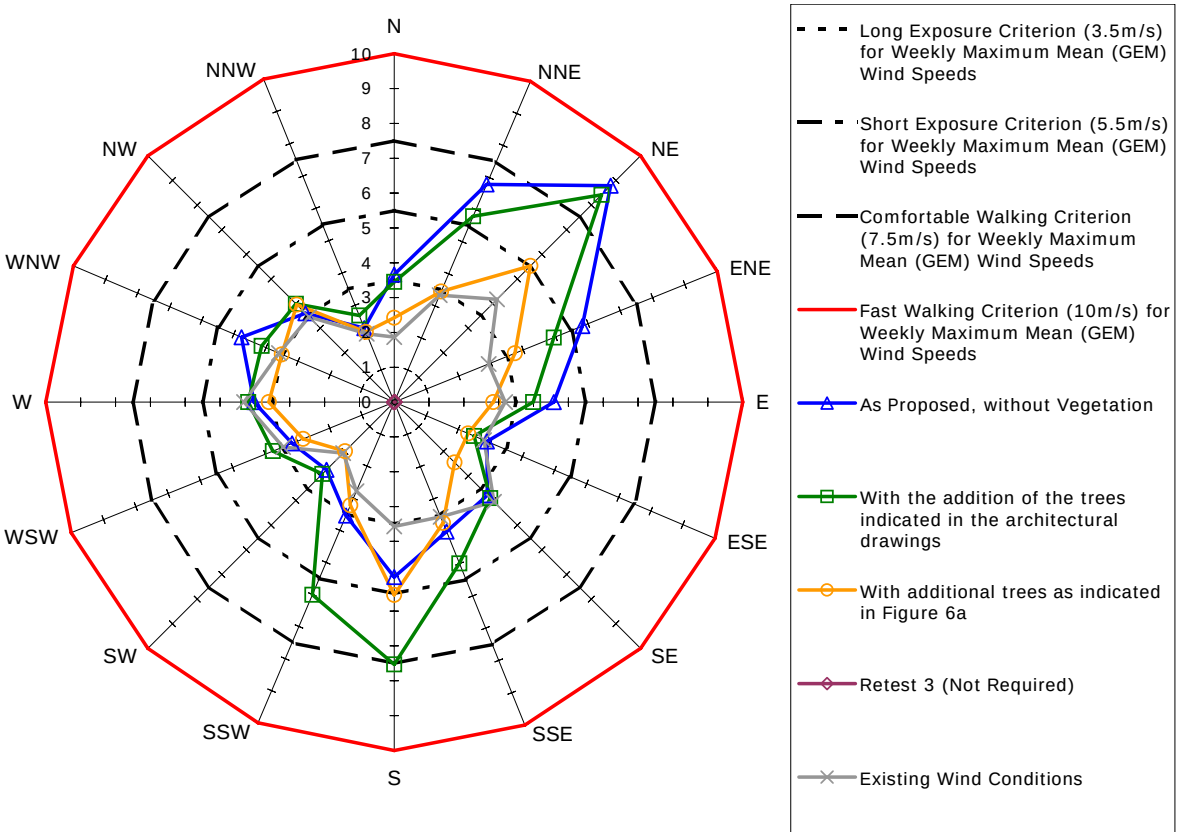
Annual Maximum Gust Wind Speeds (m/s)



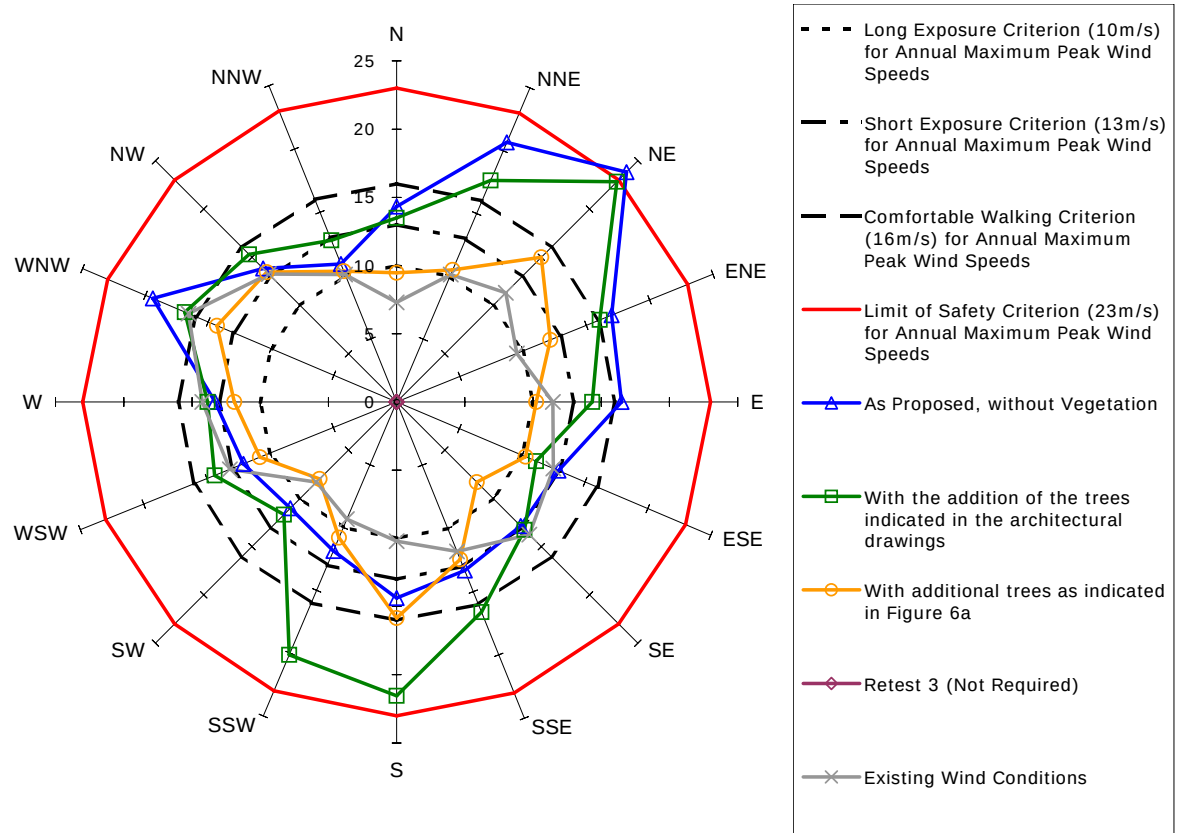
- Long Exposure Criterion (10m/s) for Annual Maximum Peak Wind Speeds
- Short Exposure Criterion (13m/s) for Annual Maximum Peak Wind Speeds
- Comfortable Walking Criterion (16m/s) for Annual Maximum Peak Wind Speeds
- Limit of Safety Criterion (23m/s) for Annual Maximum Peak Wind Speeds
- As Proposed, without Vegetation
- With the addition of the trees indicated in the architectural drawings
- Retest 2 (Not Required)
- Retest 3 (Not Required)
- Existing Wind Conditions

Measured Wind Speeds at Point 23

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

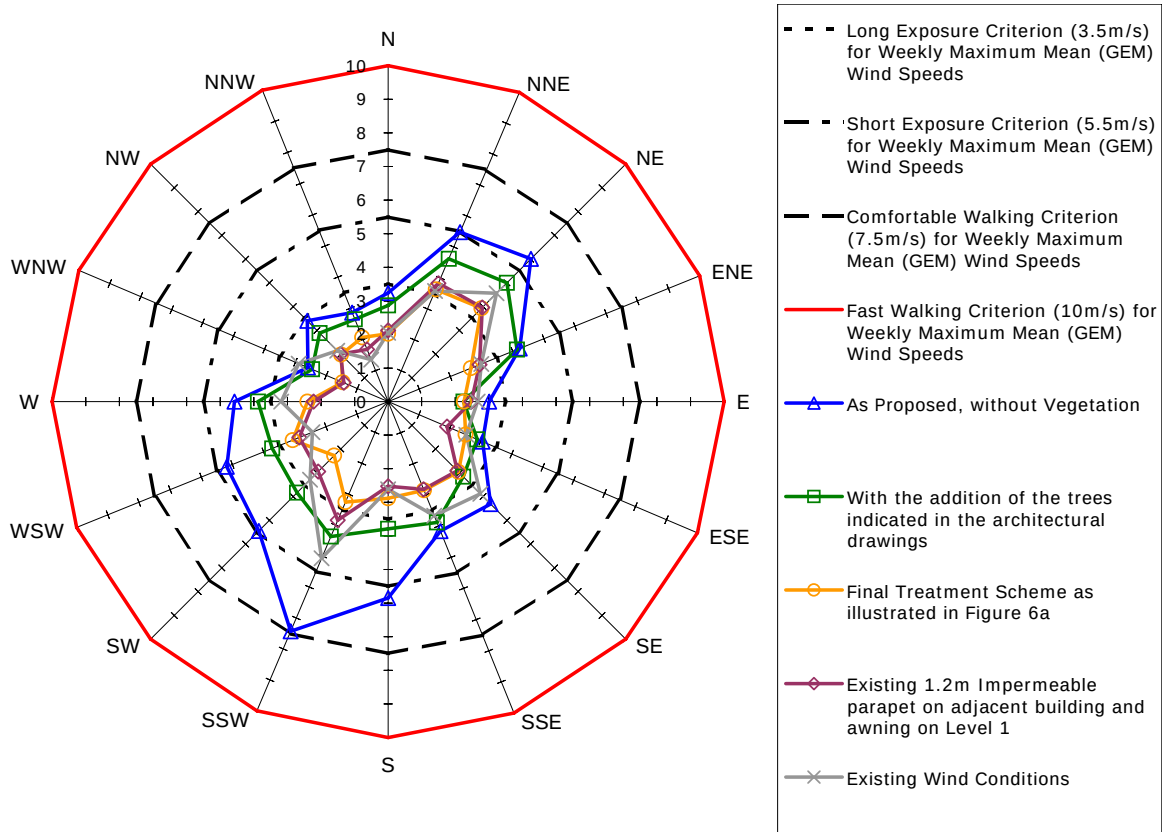


Annual Maximum Gust Wind Speeds (m/s)

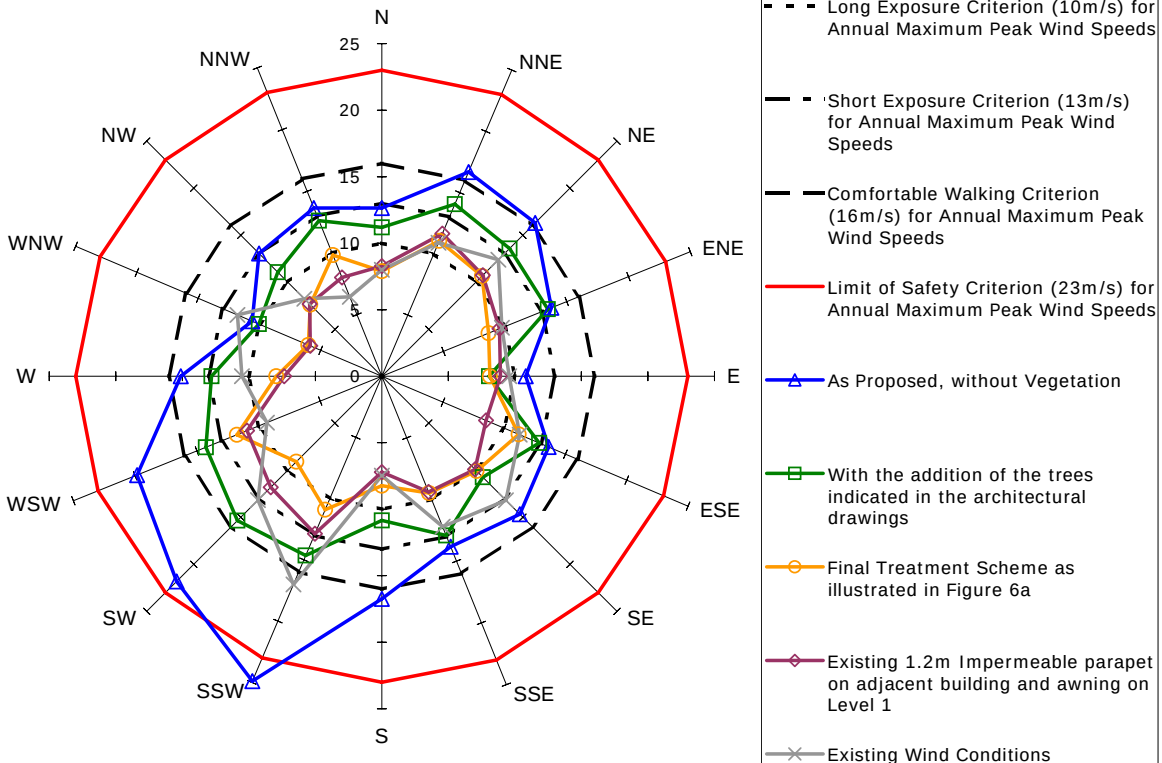


Measured Wind Speeds at Point 24

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

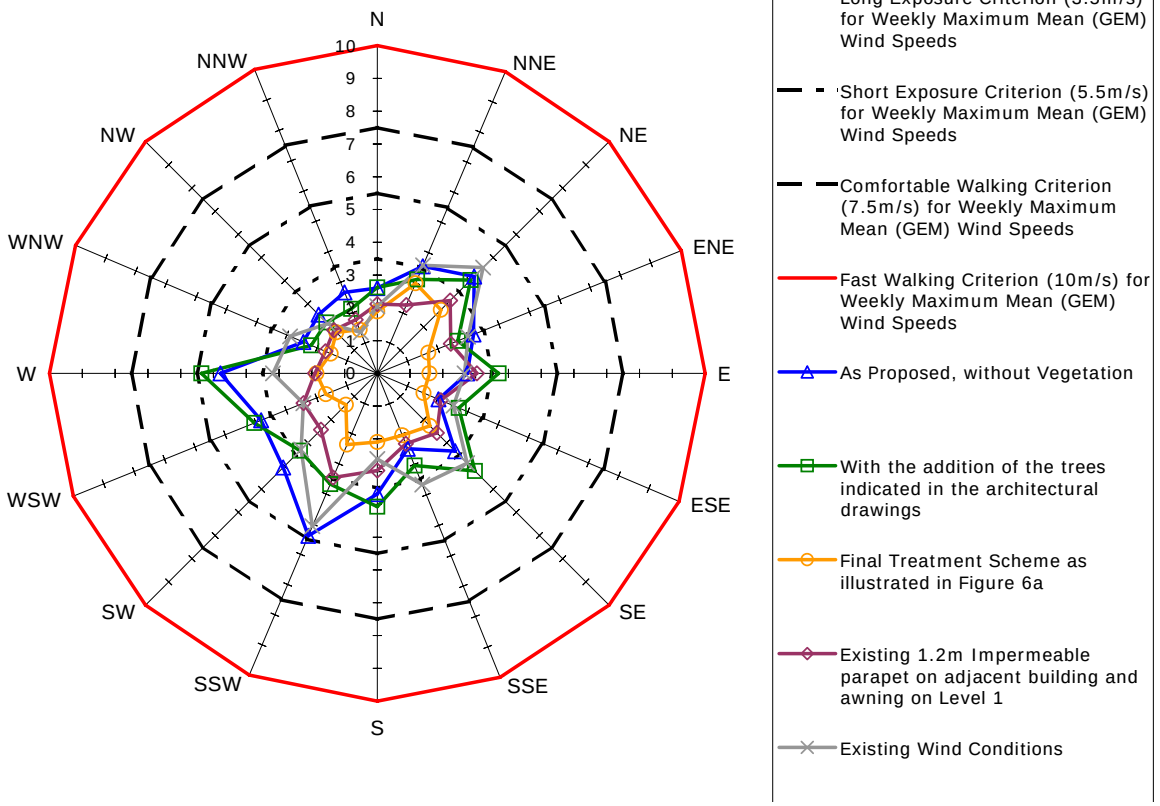


Annual Maximum Gust Wind Speeds (m/s)

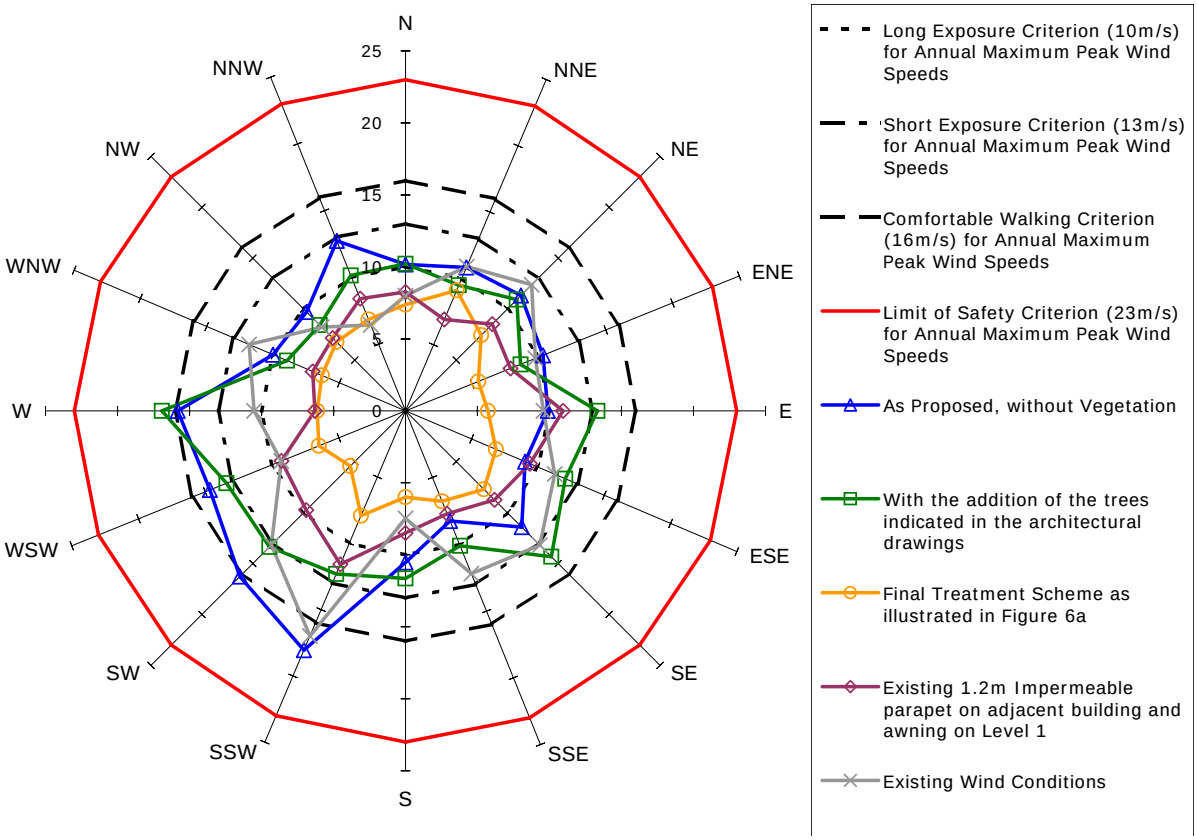


Measured Wind Speeds at Point 25

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

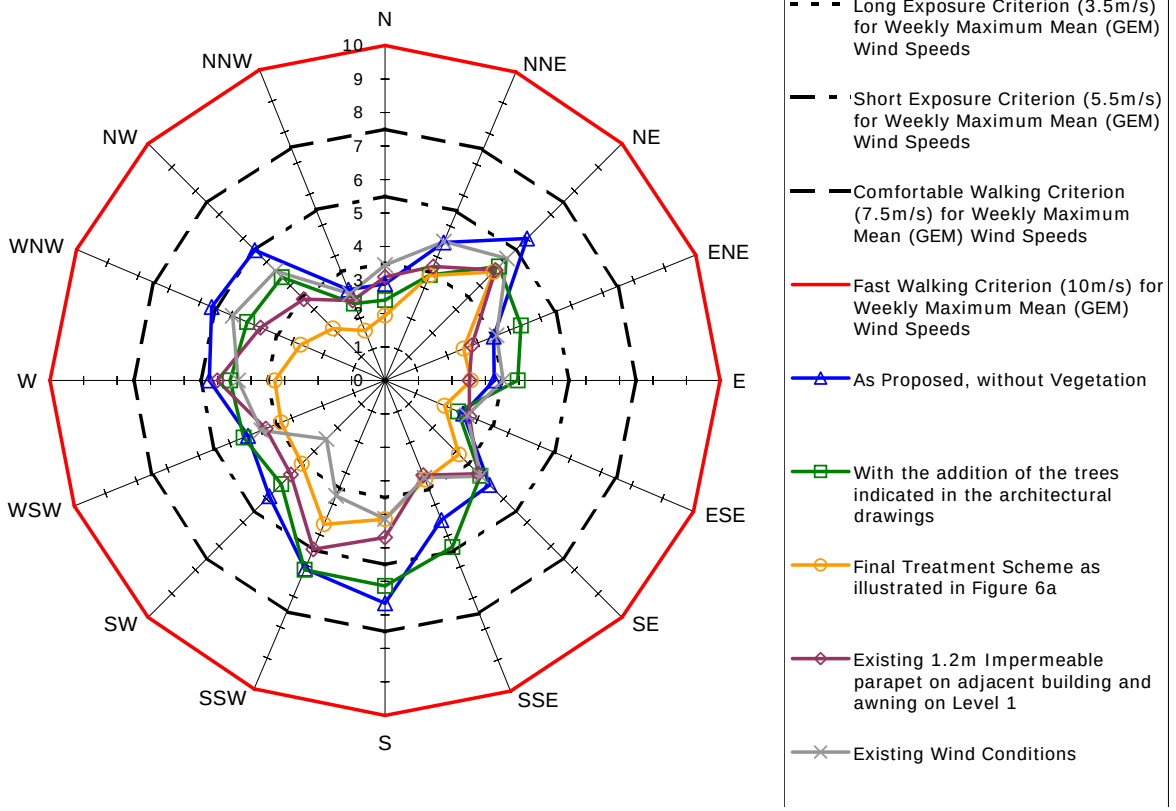


Annual Maximum Gust Wind Speeds (m/s)

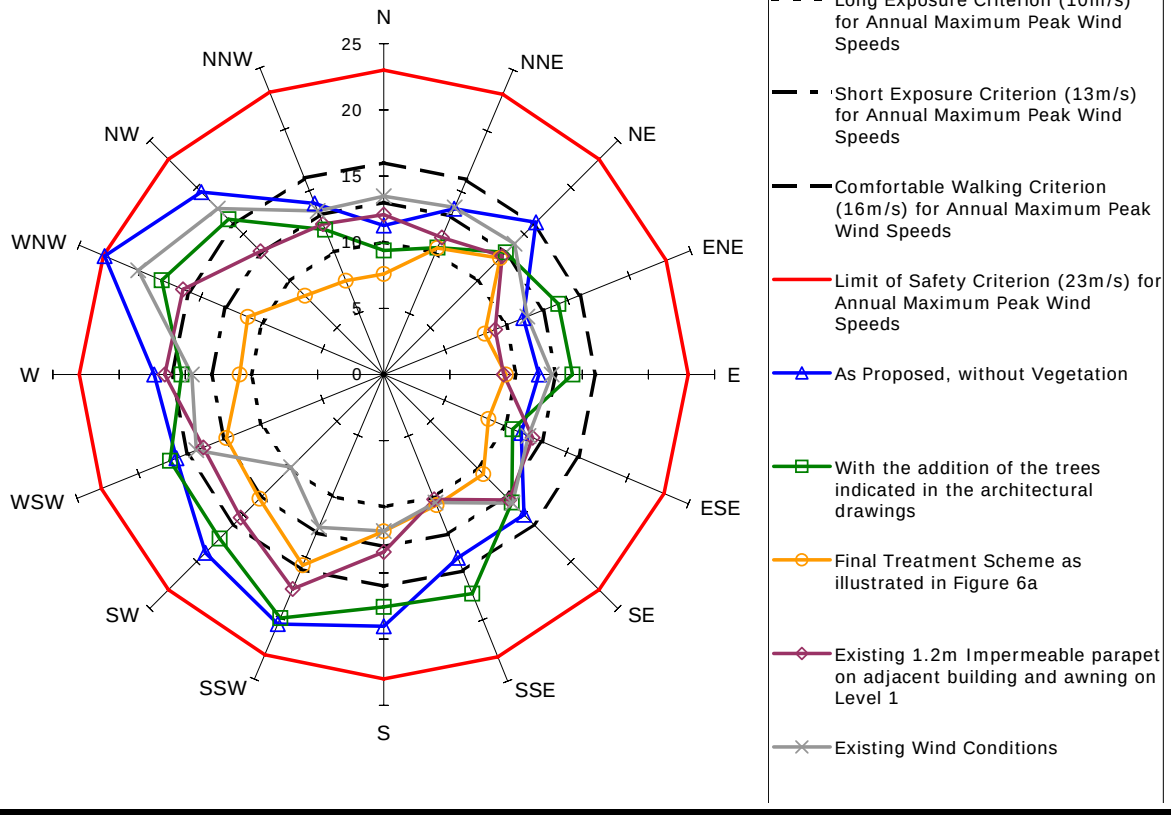


Measured Wind Speeds at Point 26

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

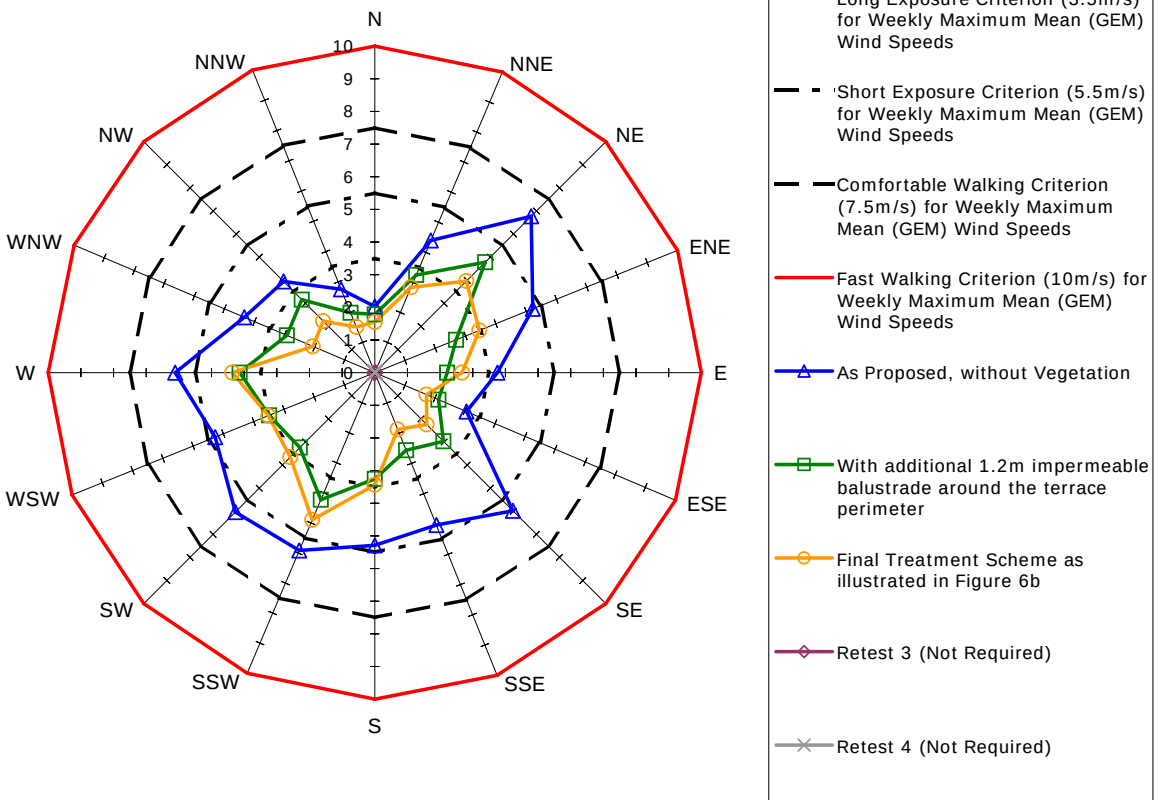


Annual Maximum Gust Wind Speeds (m/s)

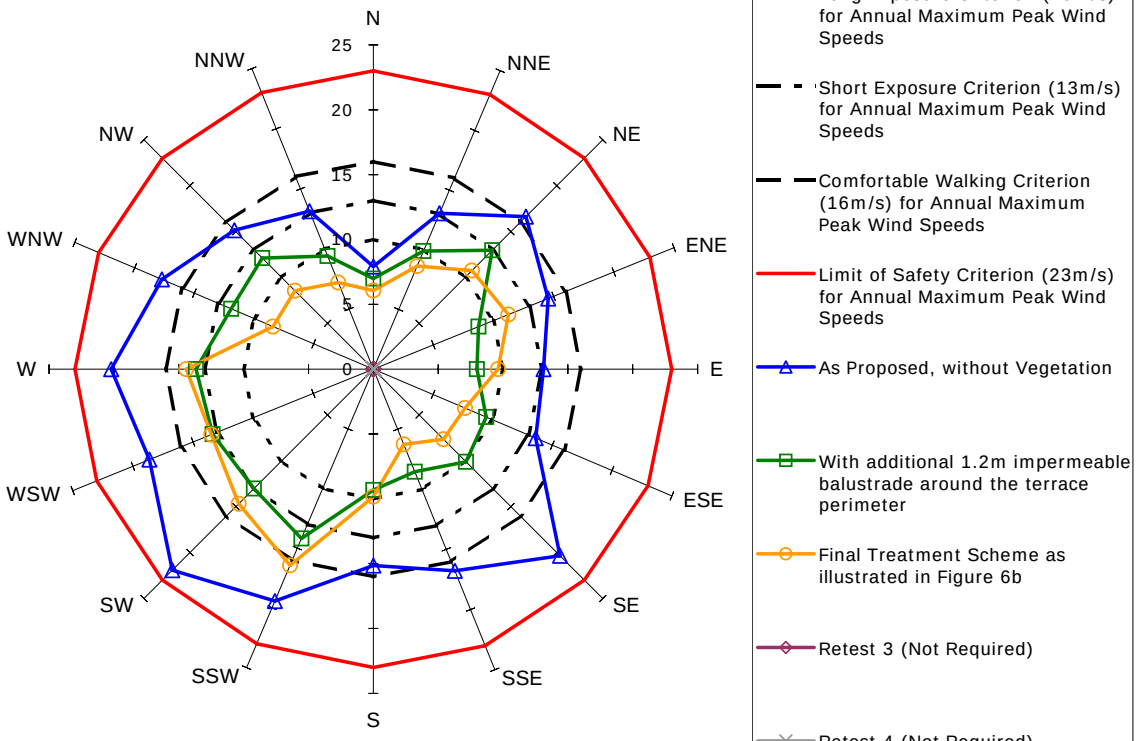


Measured Wind Speeds at Point 27

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

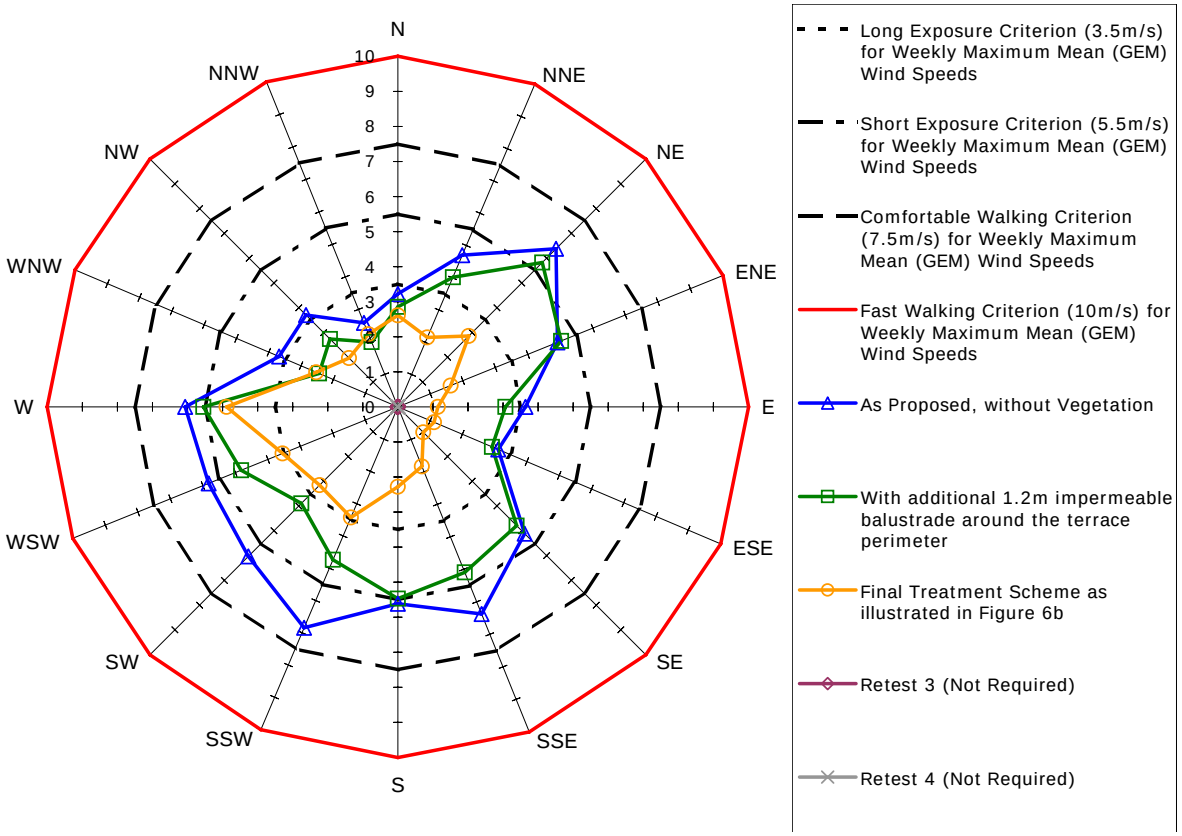


Annual Maximum Gust Wind Speeds (m/s)

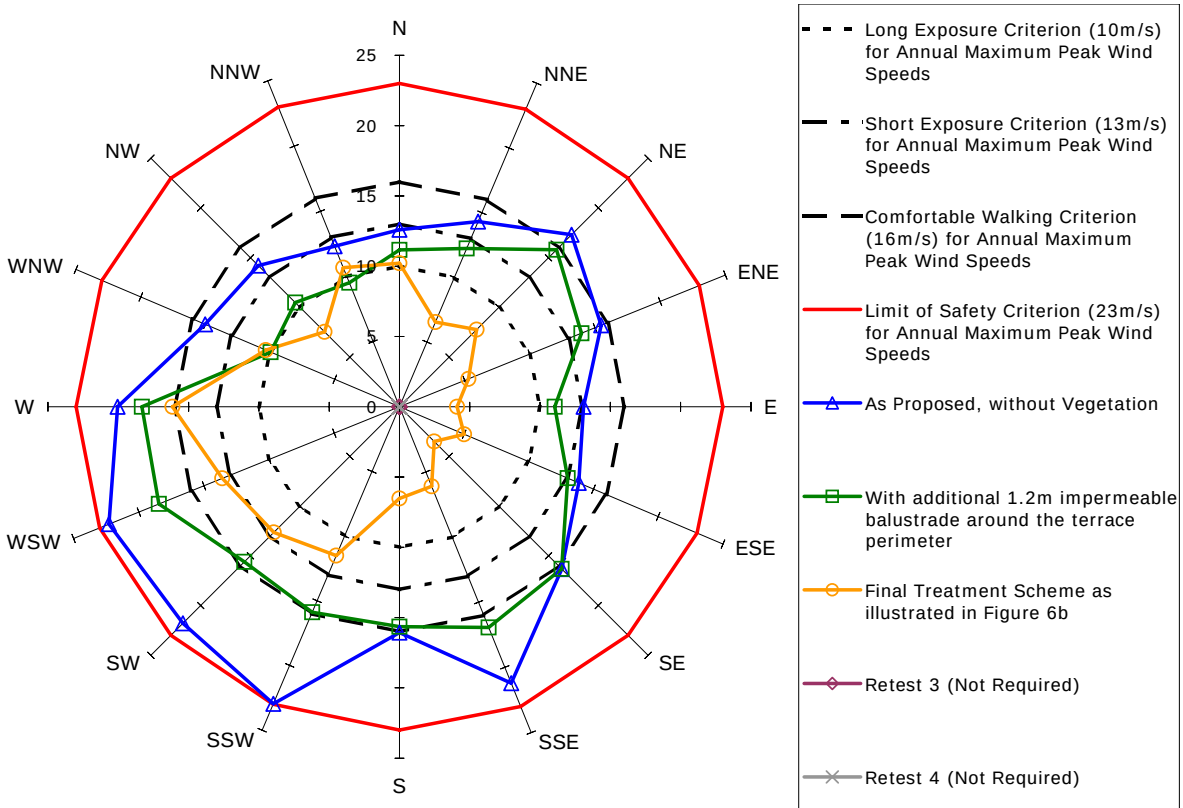


Measured Wind Speeds at Point 28

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

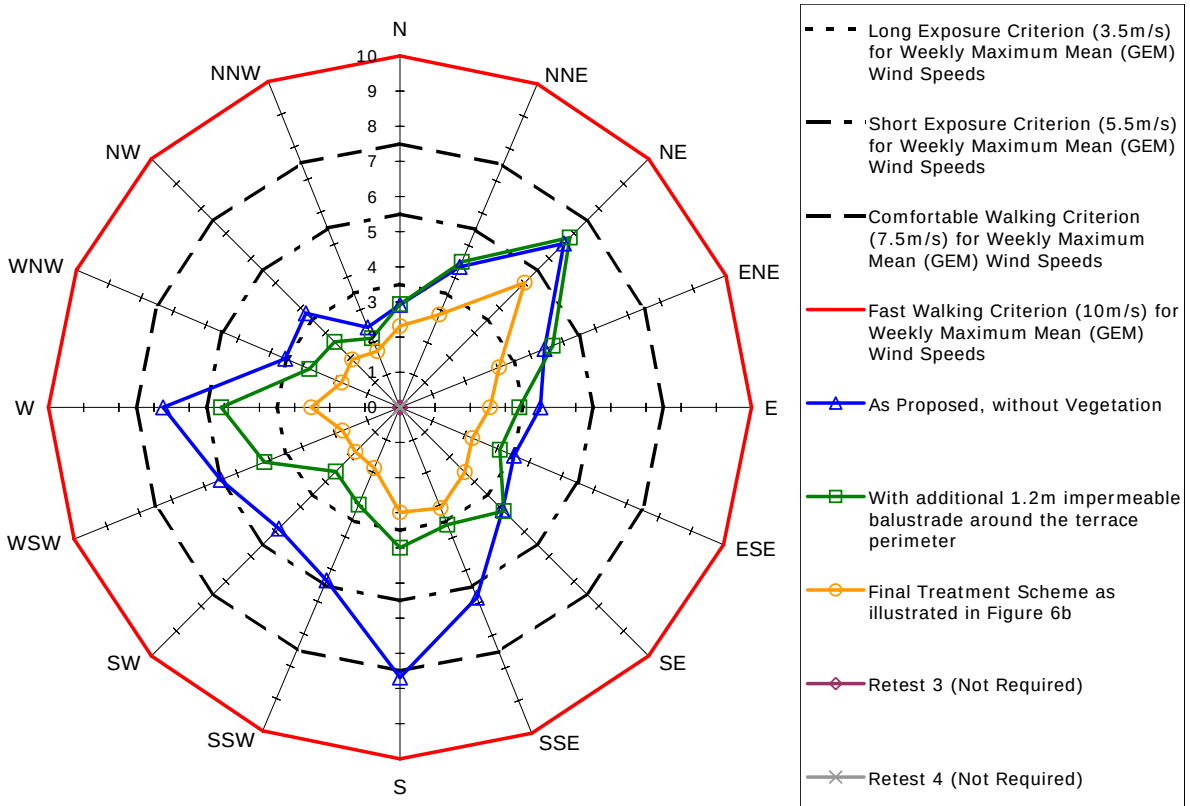


Annual Maximum Gust Wind Speeds (m/s)

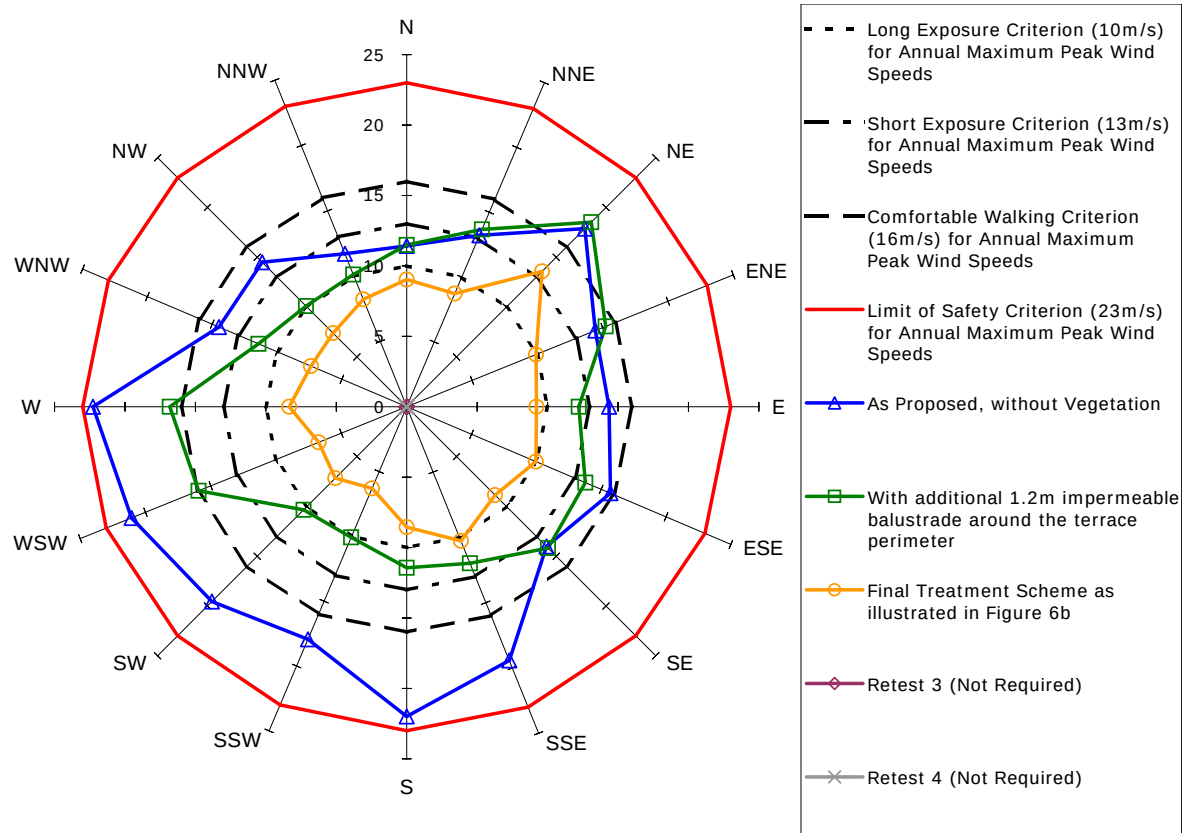


Measured Wind Speeds at Point 29

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

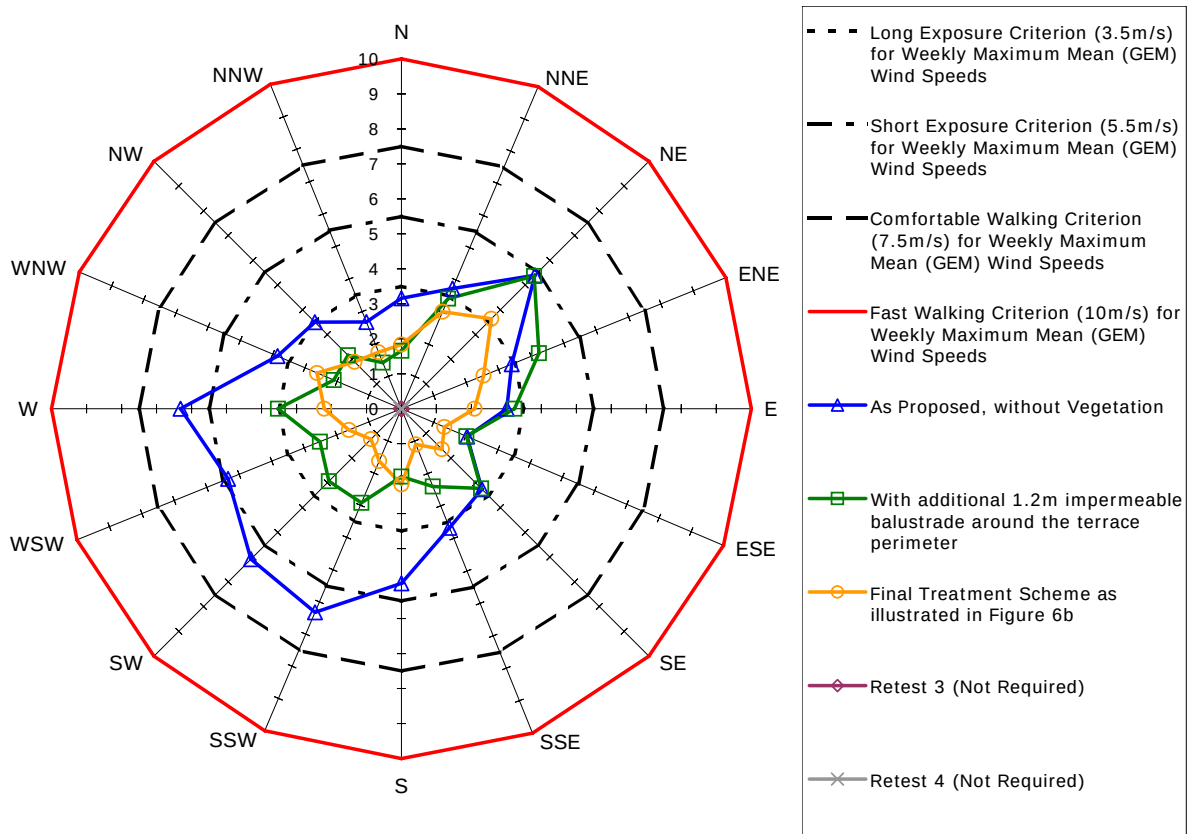


Annual Maximum Gust Wind Speeds (m/s)

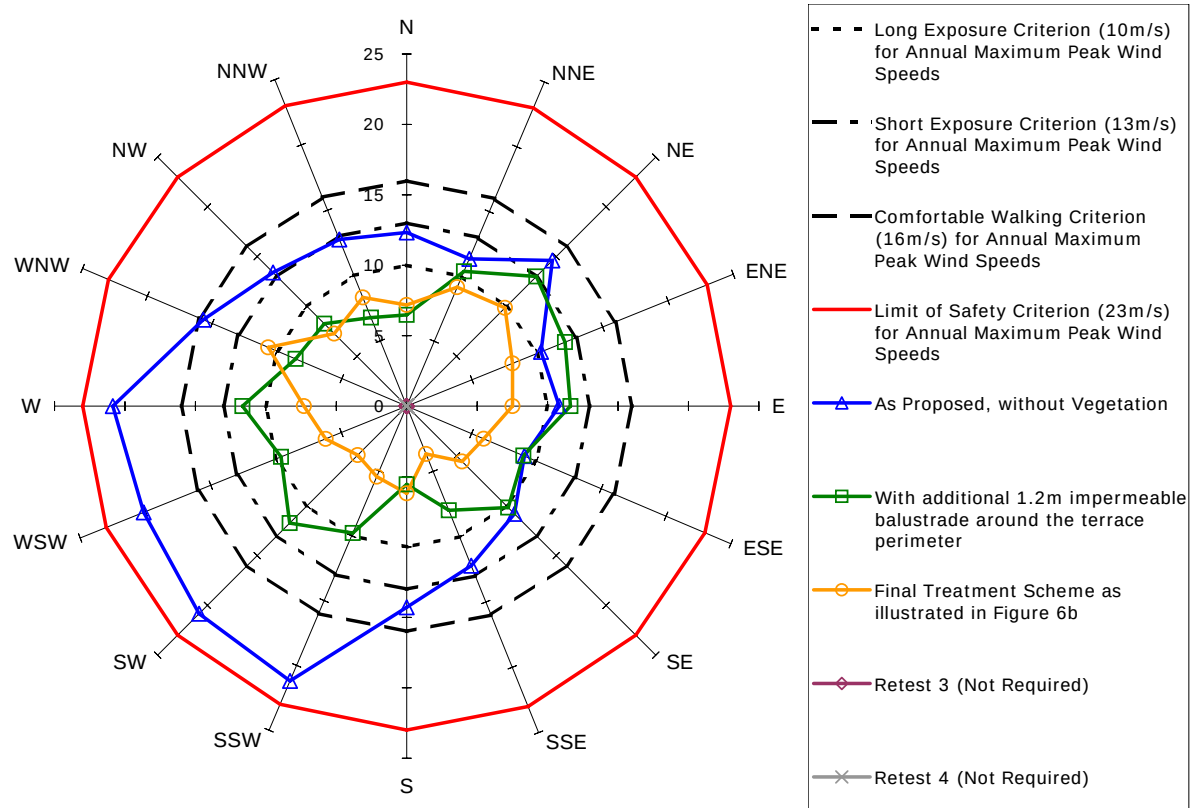


Measured Wind Speeds at Point 30

Weekly Maximum Gust Equivalent Mean Wind Speeds (m/s)

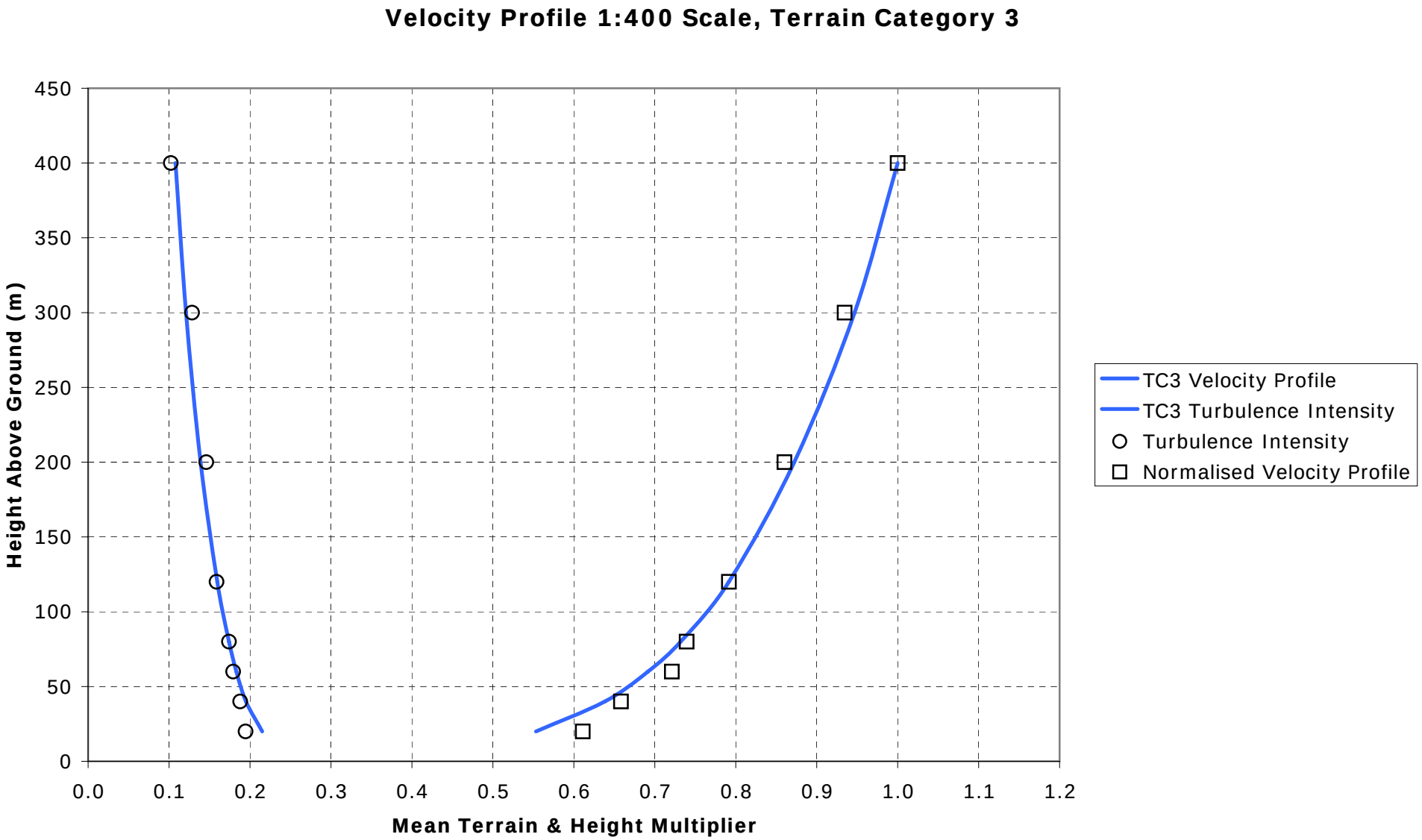


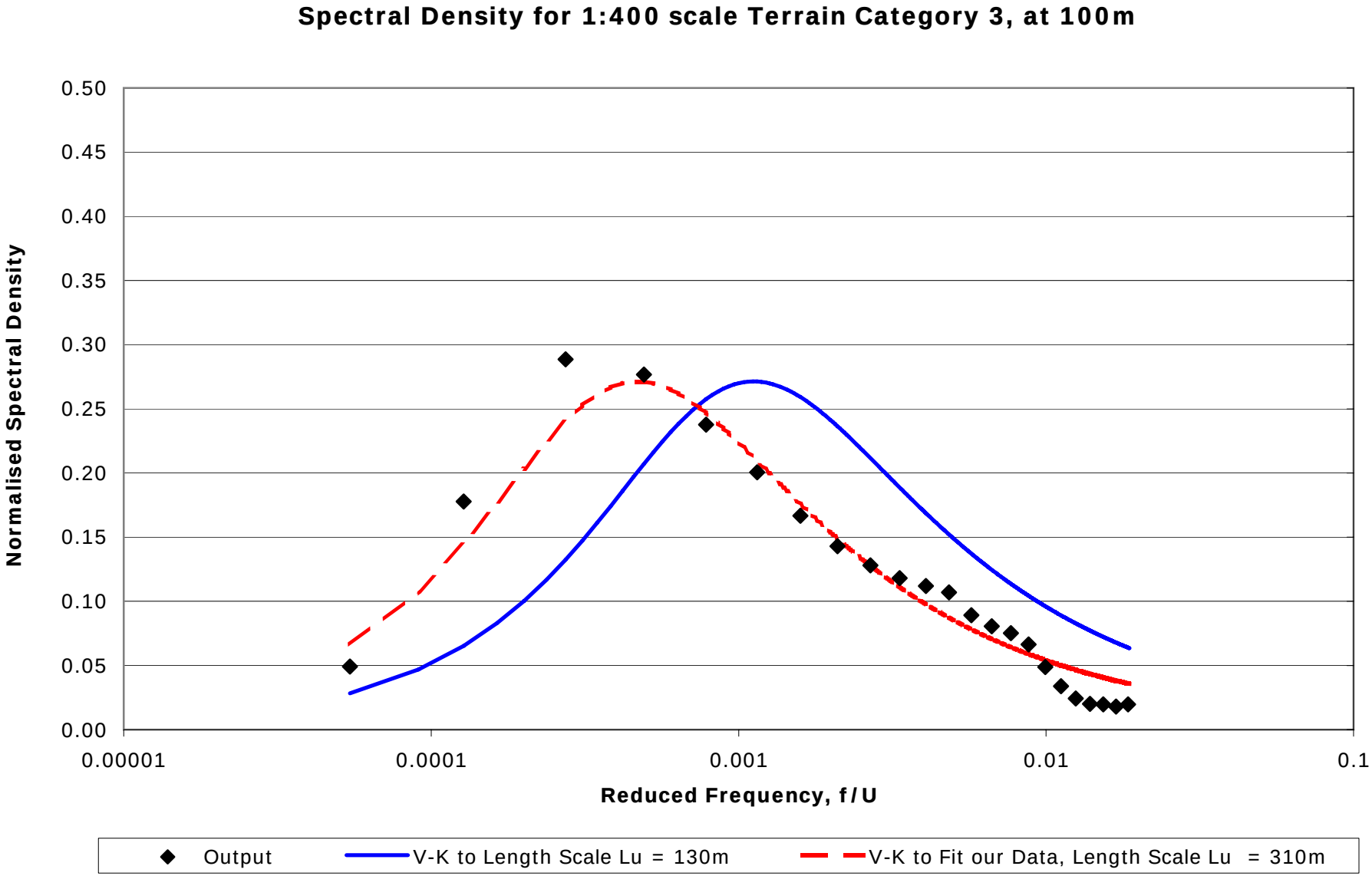
Annual Maximum Gust Wind Speeds (m/s)

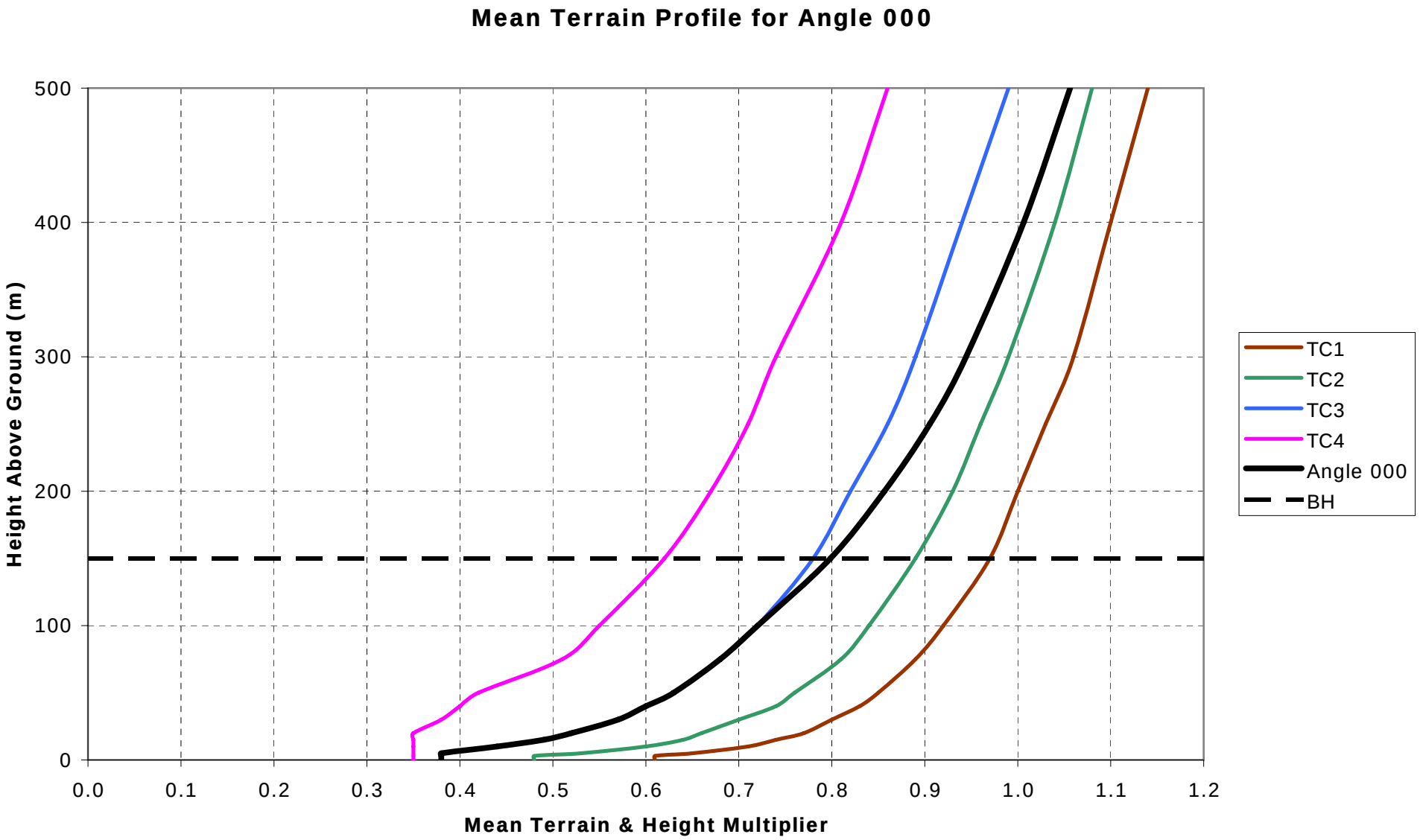


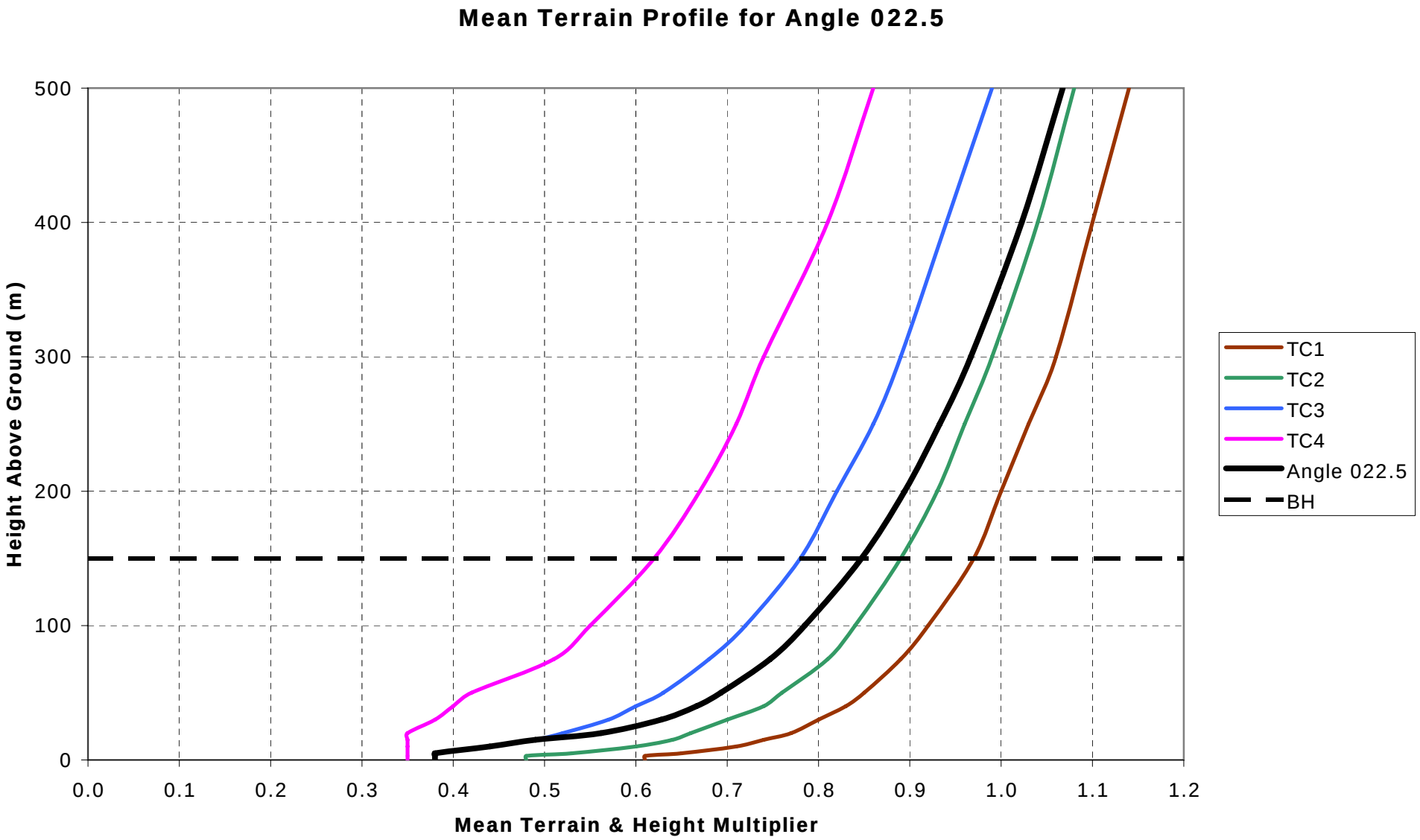
Appendix B

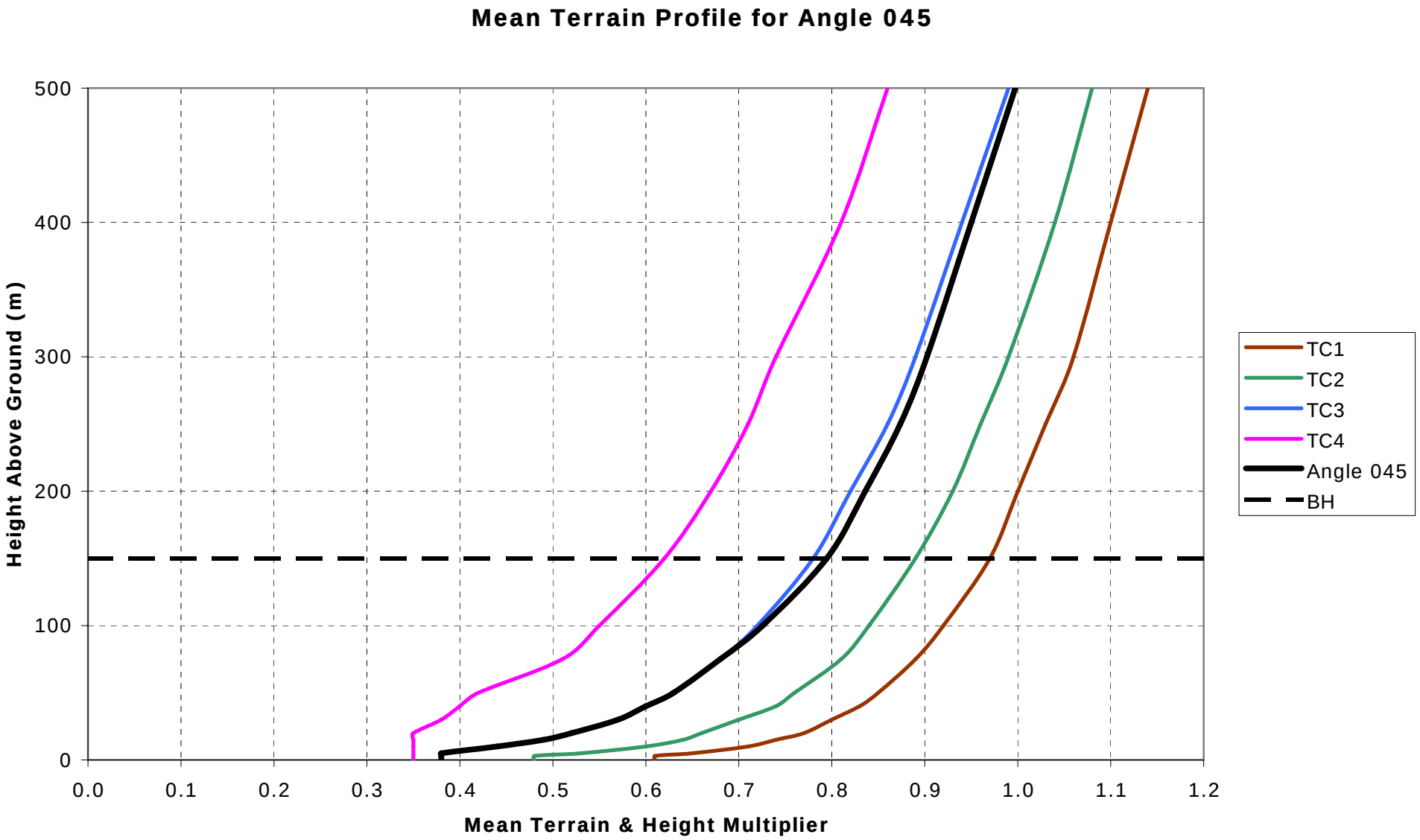
Wind Tunnel Boundary Layer Profile

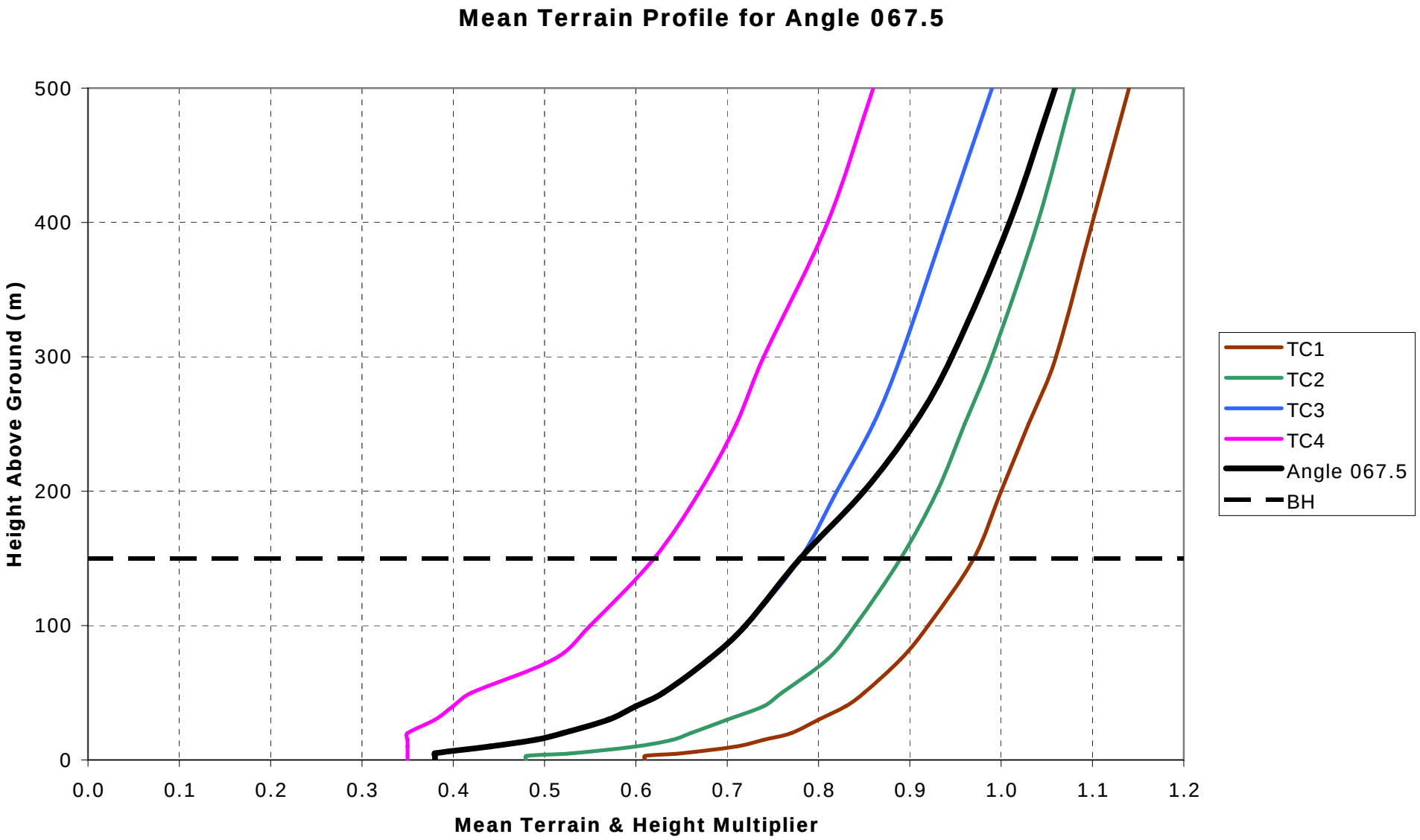

Velocity Profile 1:400 Scale, Terrain Category 3
Height Above Ground (m)
450
400
350
300
250
200
150
100
50
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC3 Velocity Profile
TC3 Turbulence Intensity
Turbulence Intensity
Normalised Velocity Profile

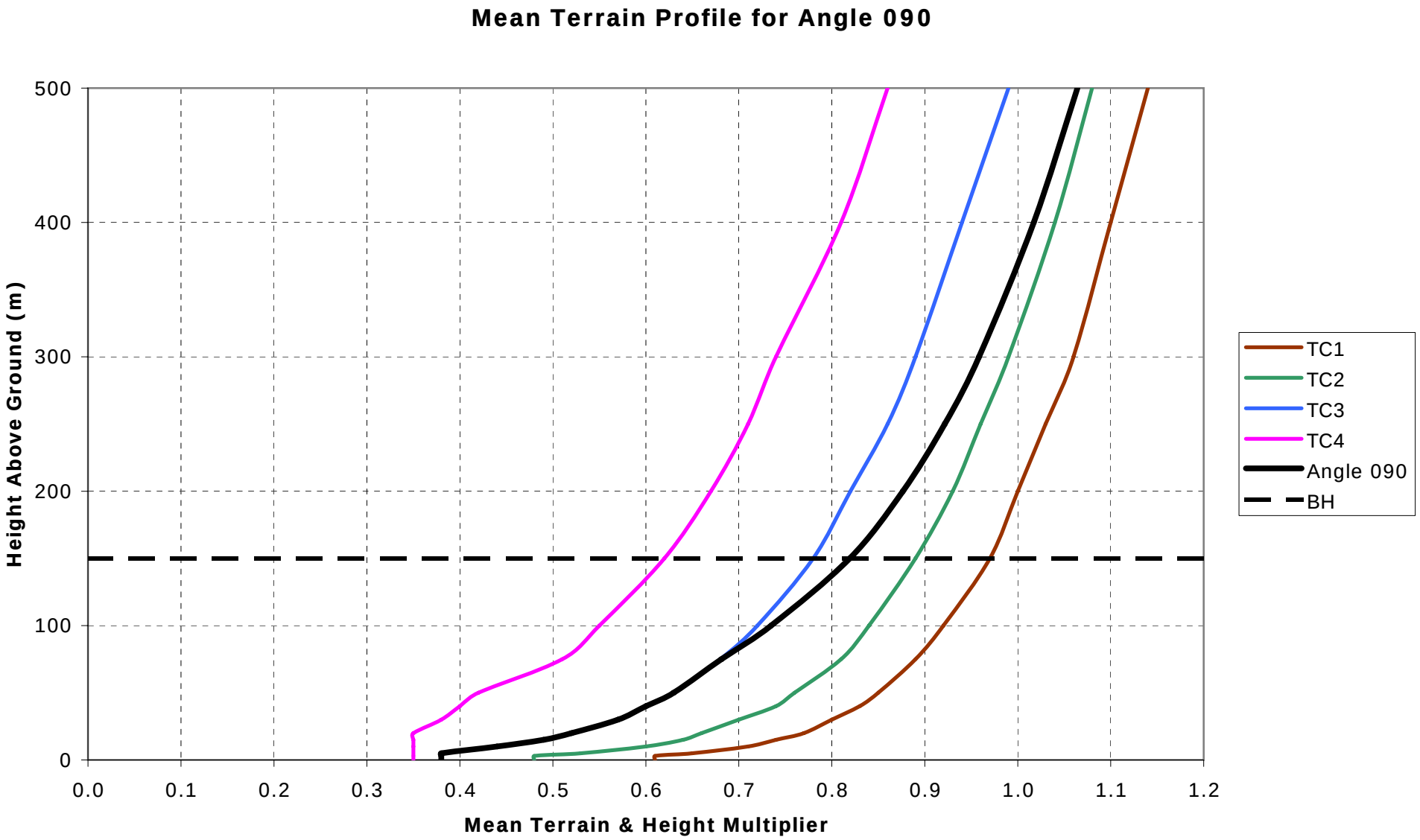

Spectral Density for 1:400 scale Terrain Category 3, at 100m
Normalised Spectral Density
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00001
0.0001
0.001
0.01
0.1
Reduced Frequency, f/U
Output
V-K to Length Scale Lu = 130m
V-K to Fit our Data, Length Scale Lu = 310m

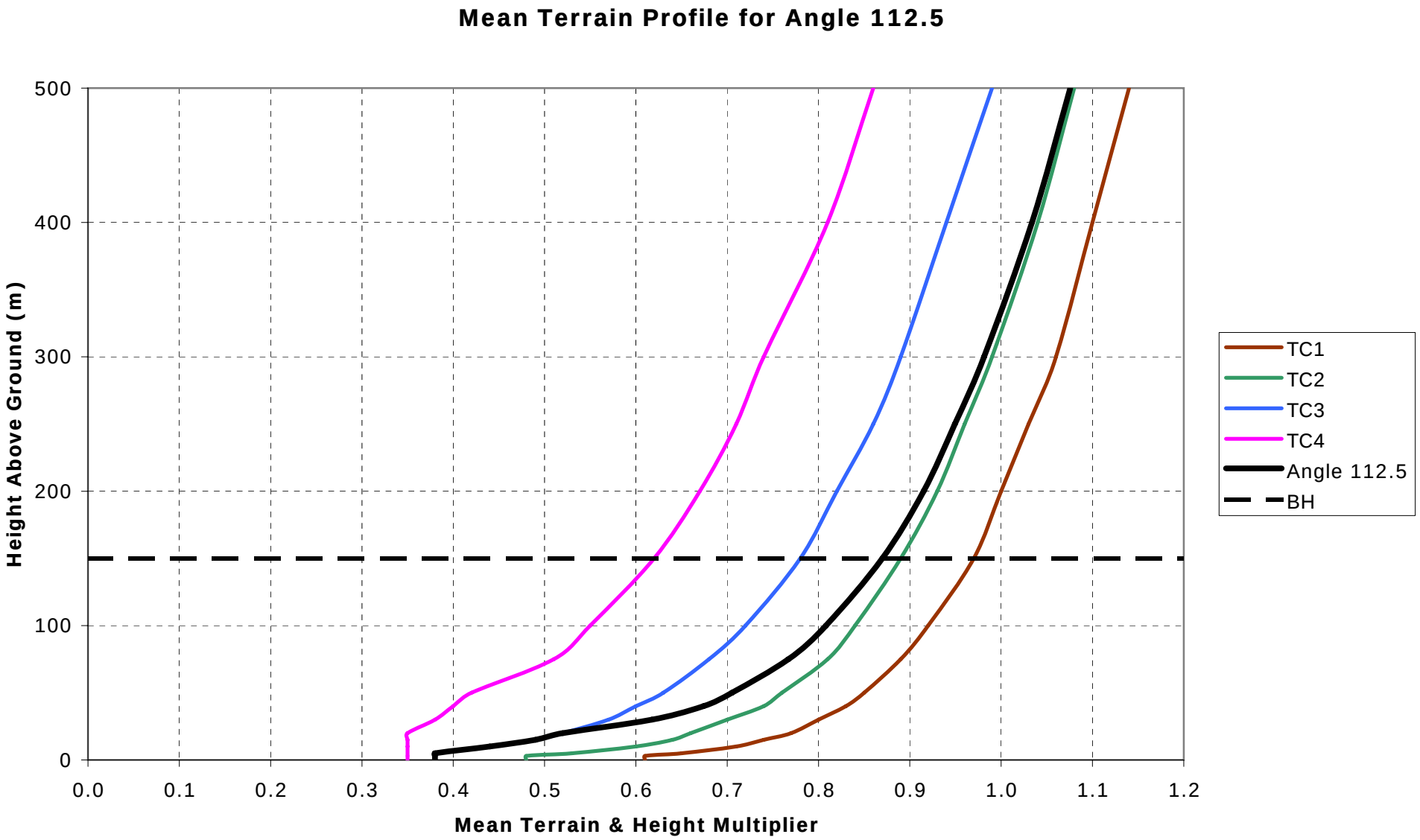

Mean Terrain Profile for Angle 000
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 000
BH

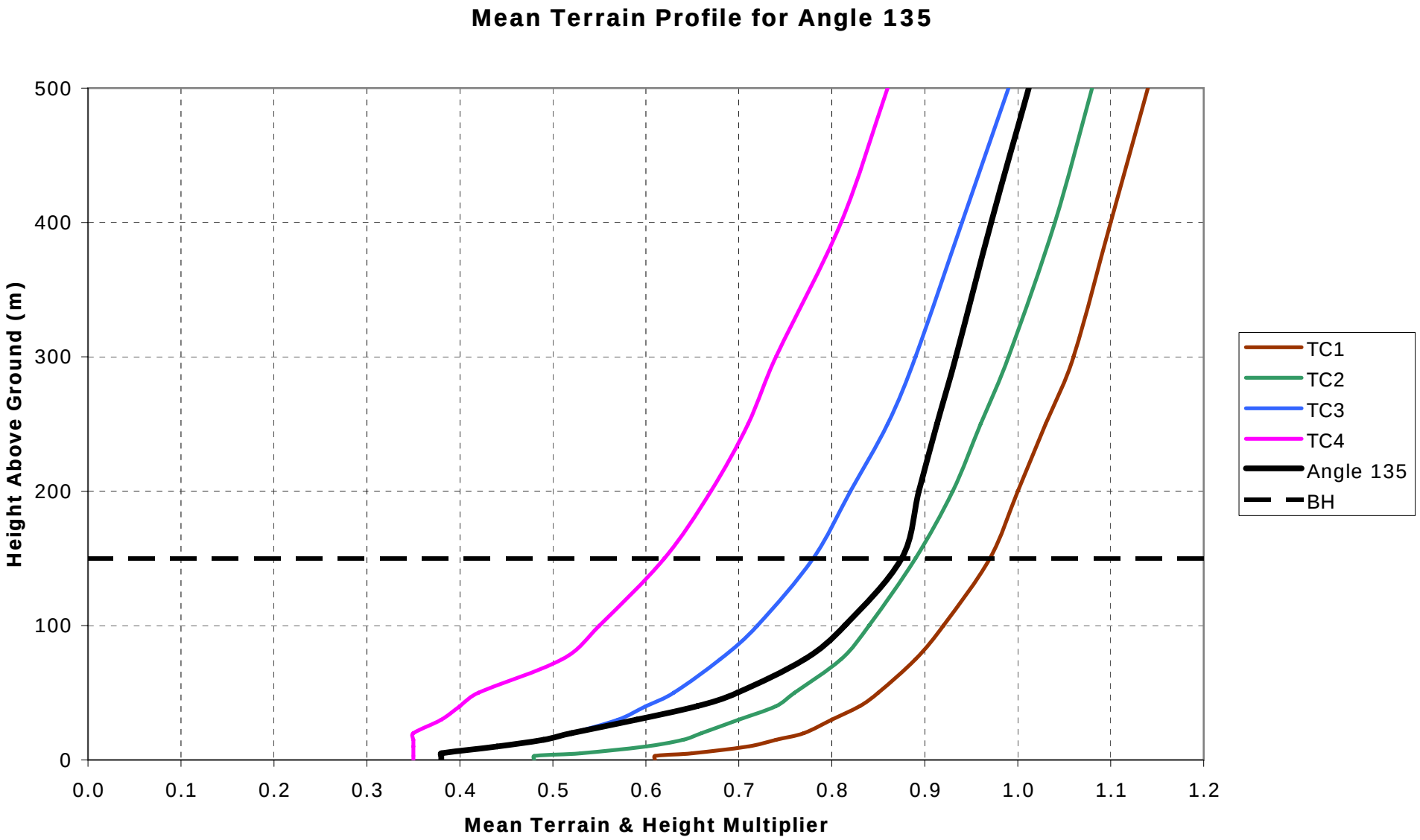

Mean Terrain Profile for Angle 022.5
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 022.5
BH

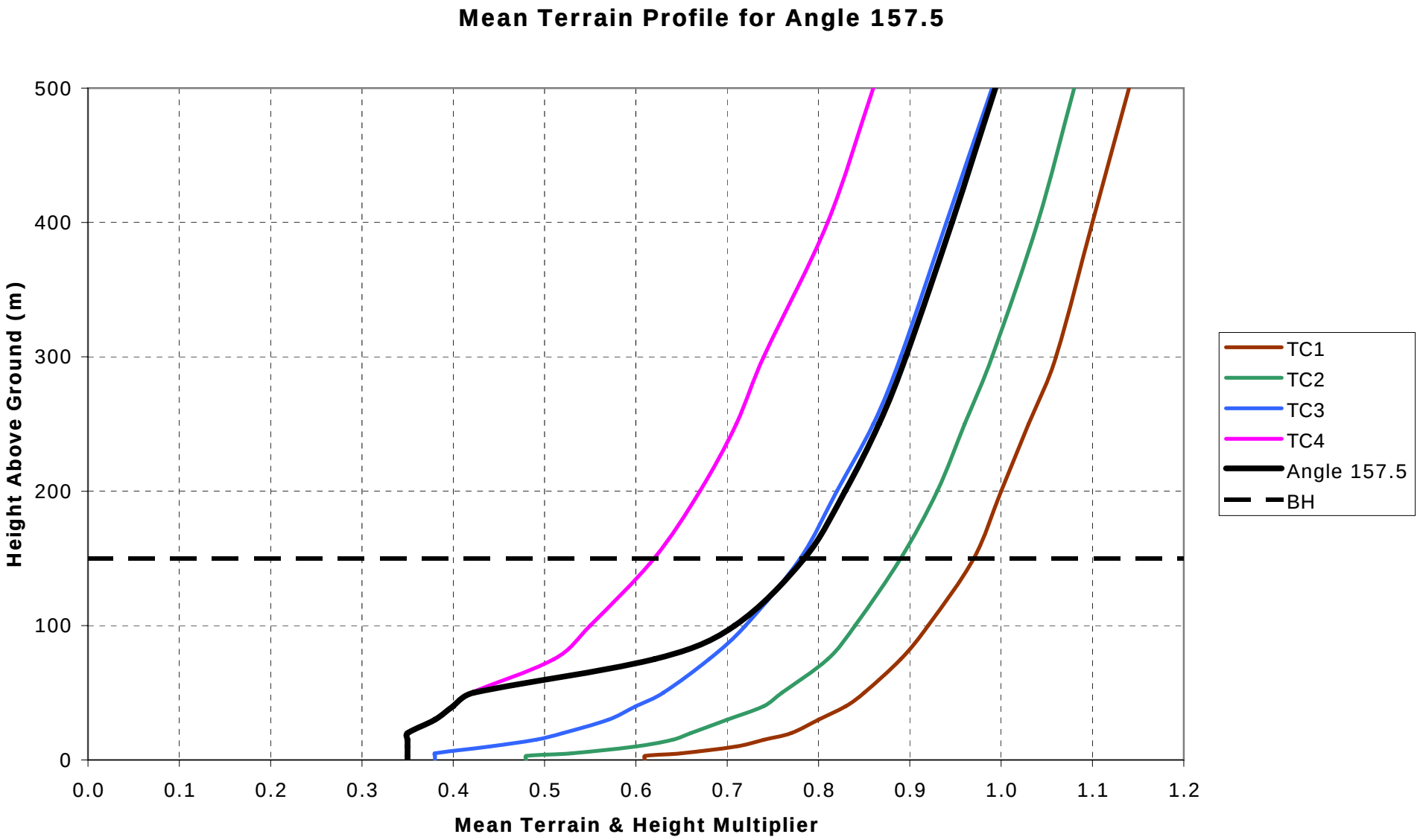

Mean Terrain Profile for Angle 045
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 045
BH

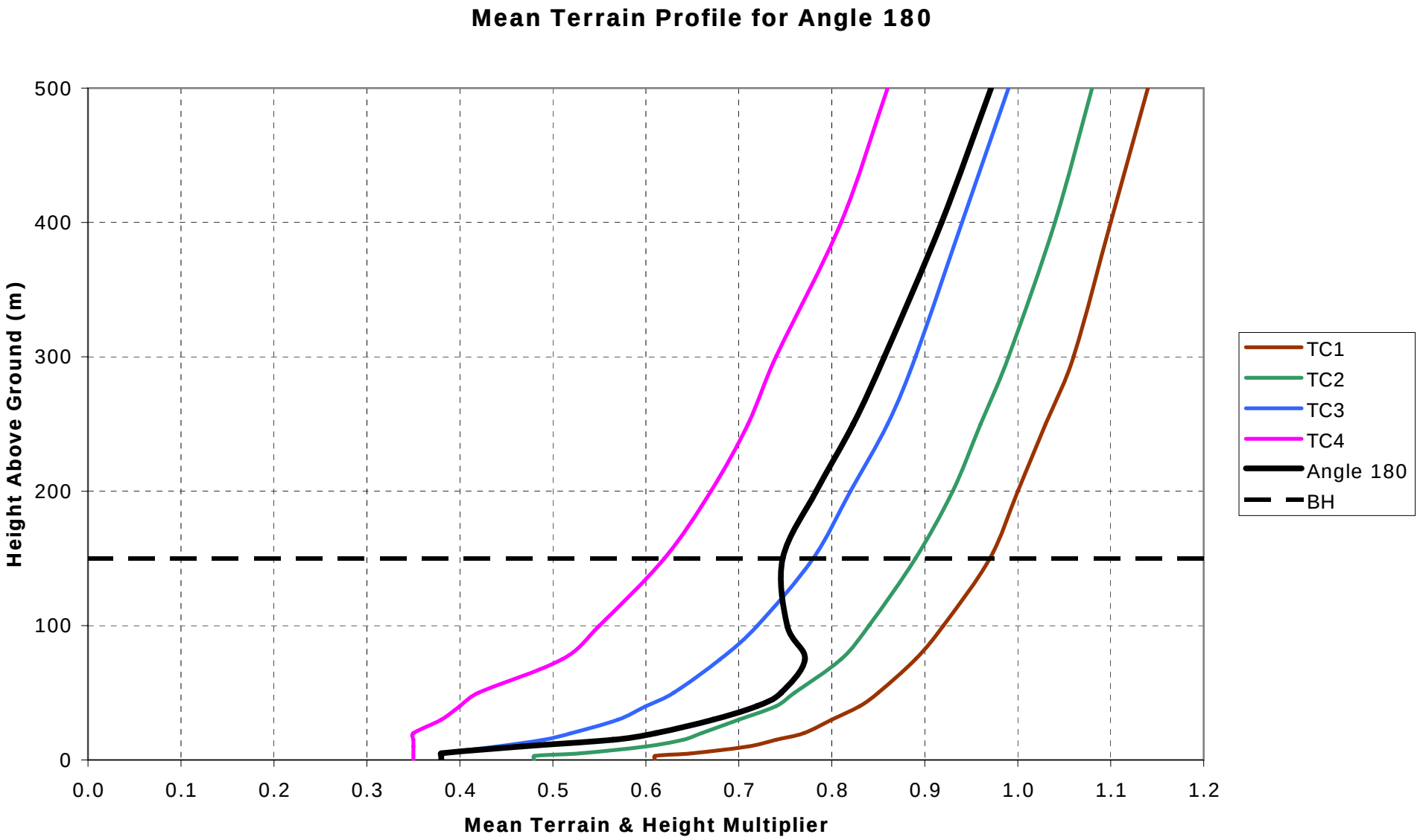

Mean Terrain Profile for Angle 067.5
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 067.5
BH

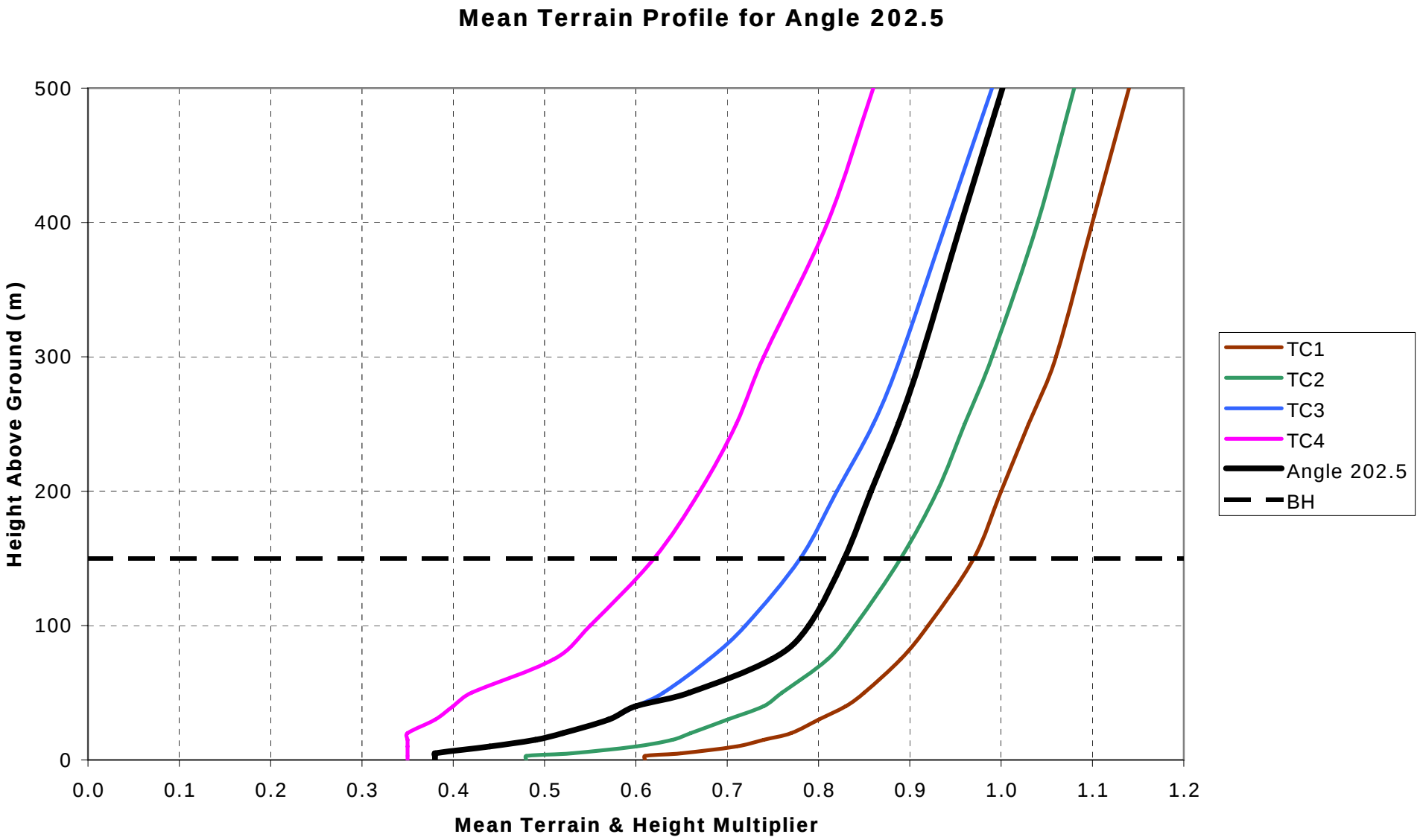

Mean Terrain Profile for Angle 090
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 090
BH

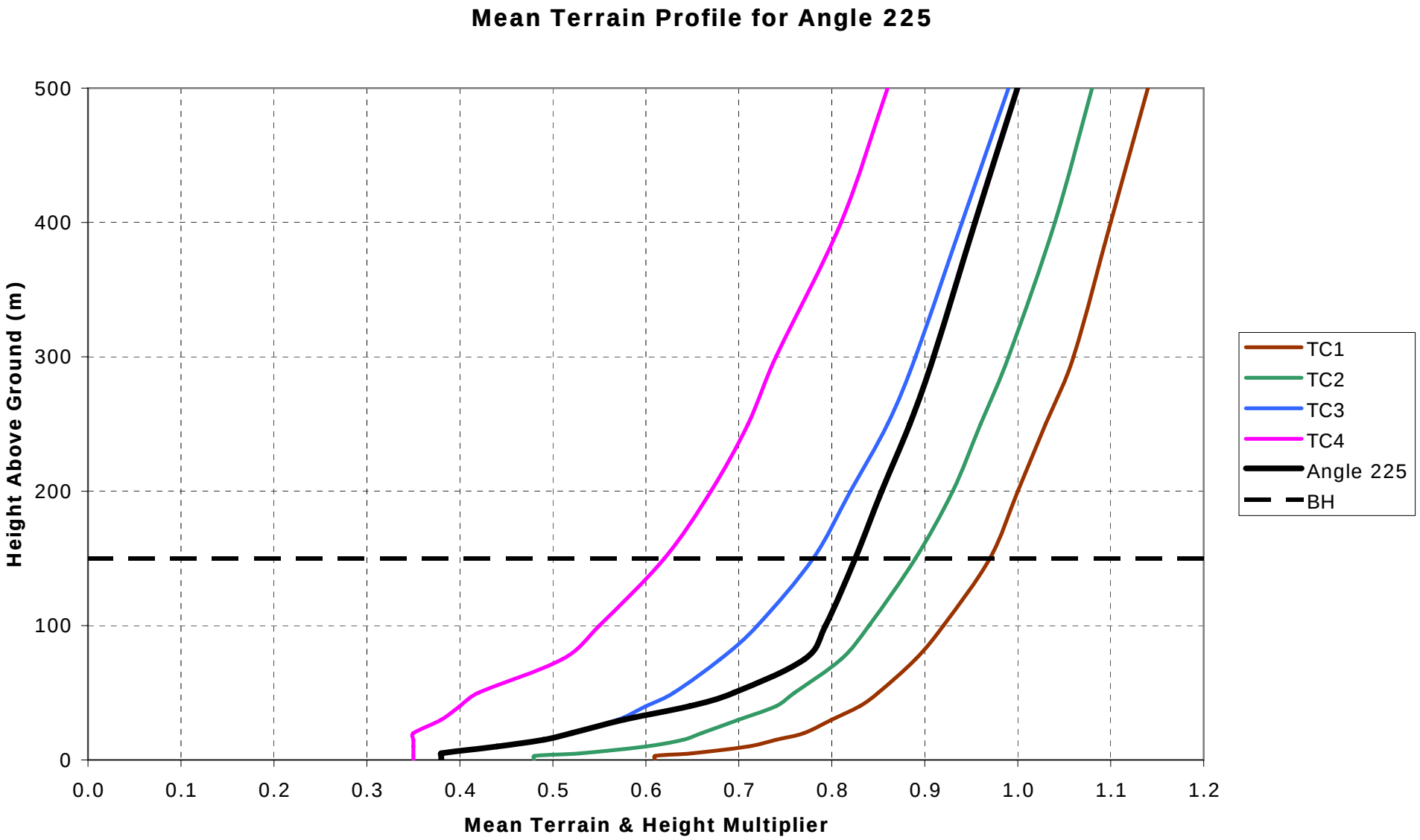

Mean Terrain Profile for Angle 112.5
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 112.5
BH

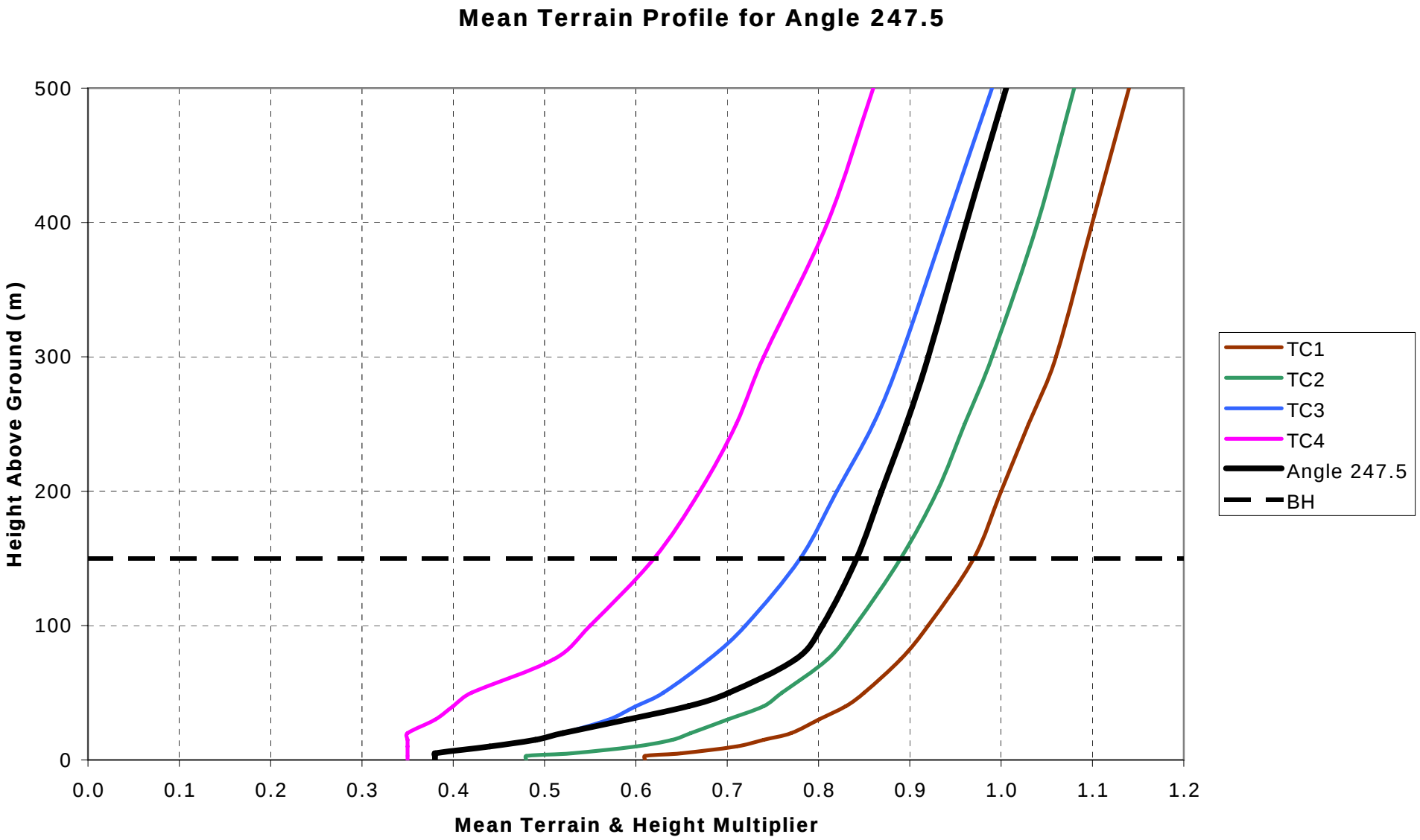

Mean Terrain Profile for Angle 135
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 135
BH

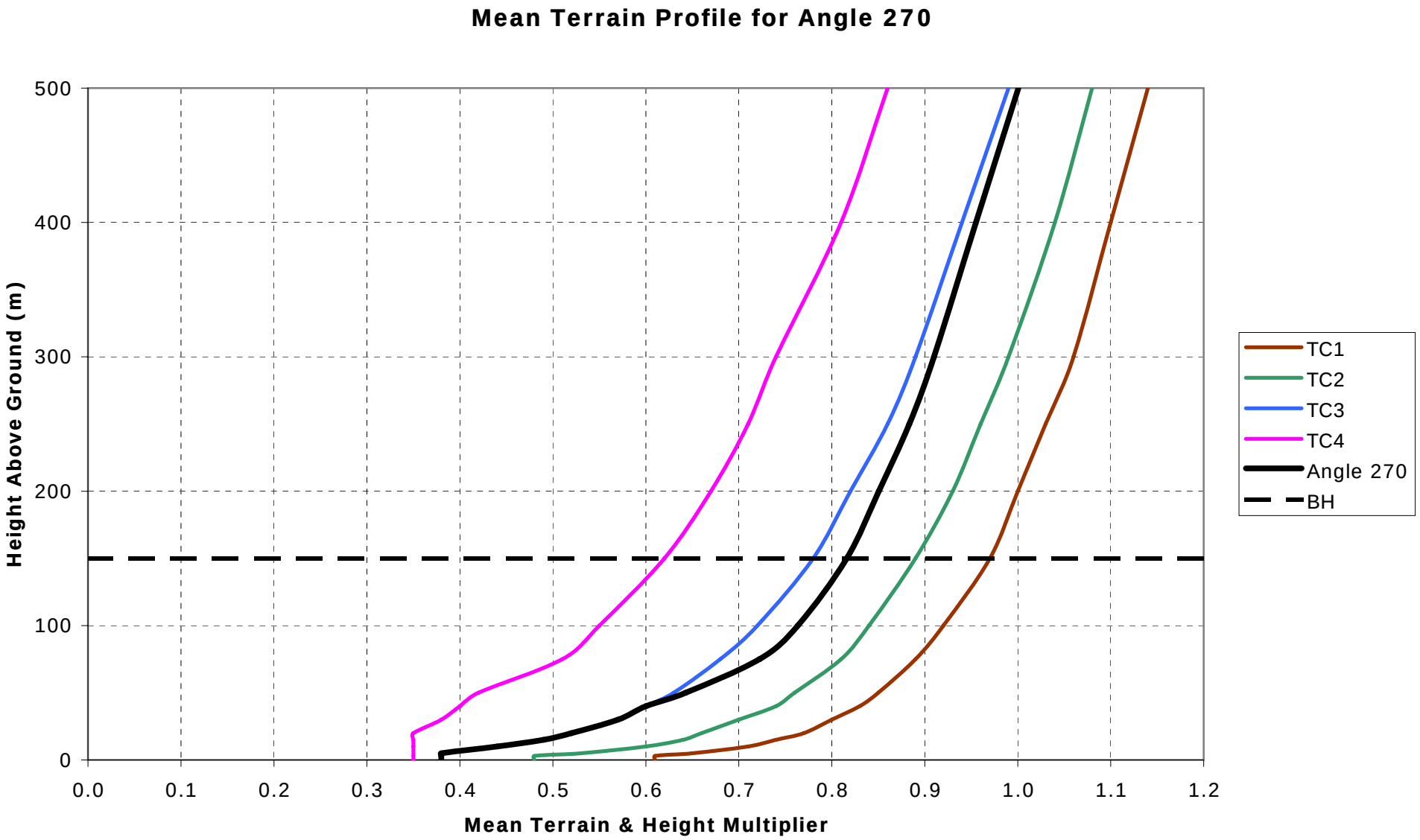

Mean Terrain Profile for Angle 157.5
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 157.5
BH

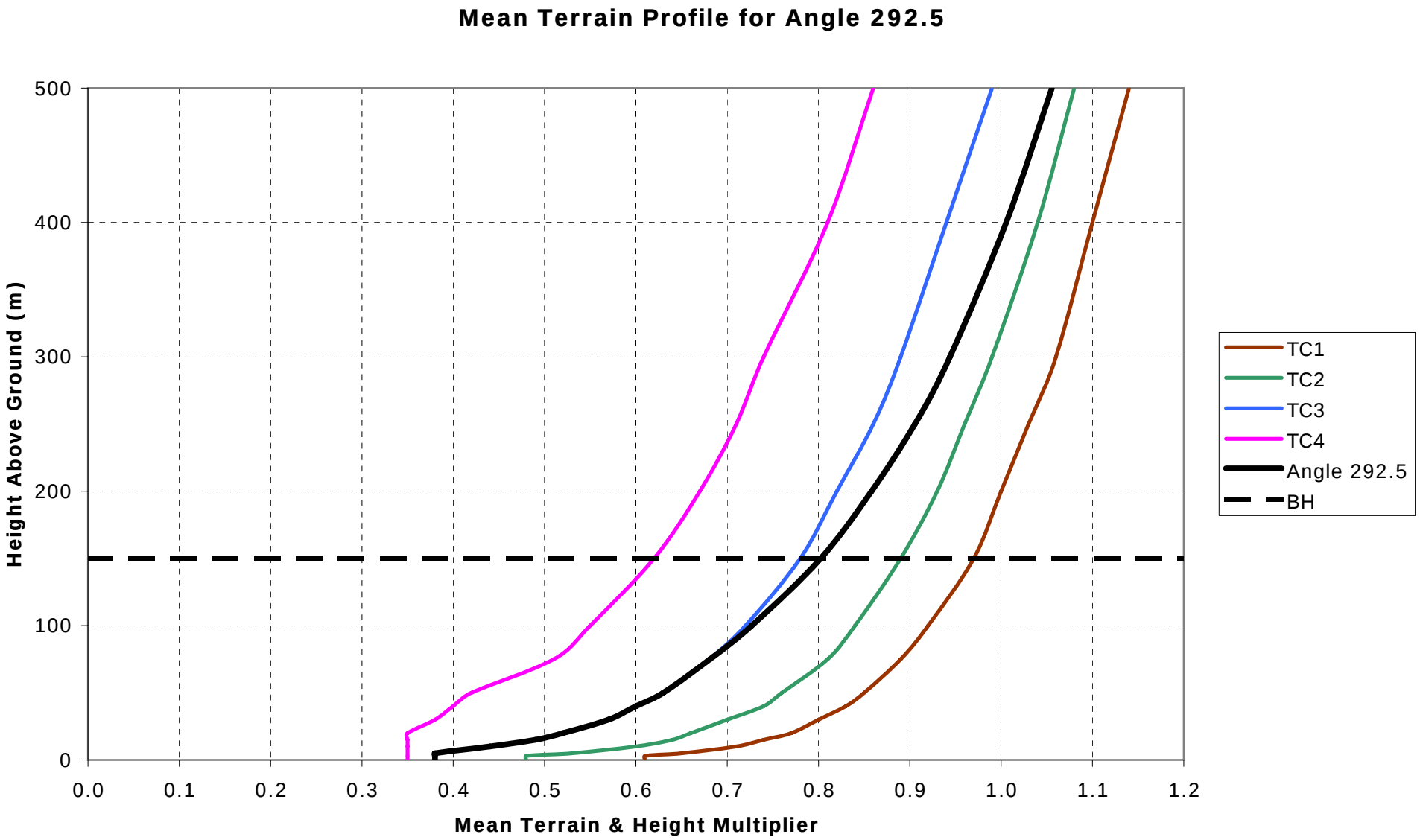

Mean Terrain Profile for Angle 180
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 180
BH

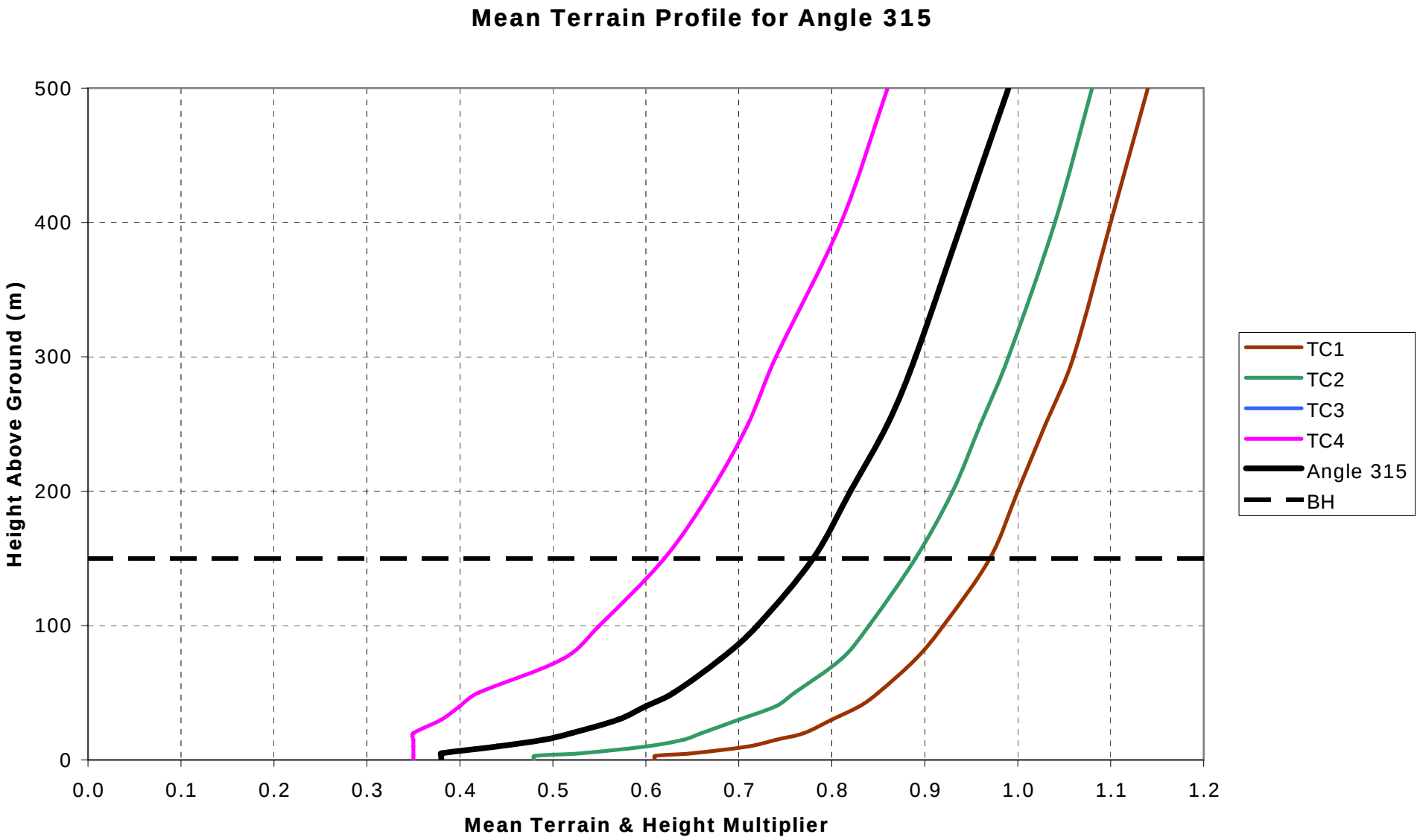

Mean Terrain Profile for Angle 202.5
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 202.5
BH

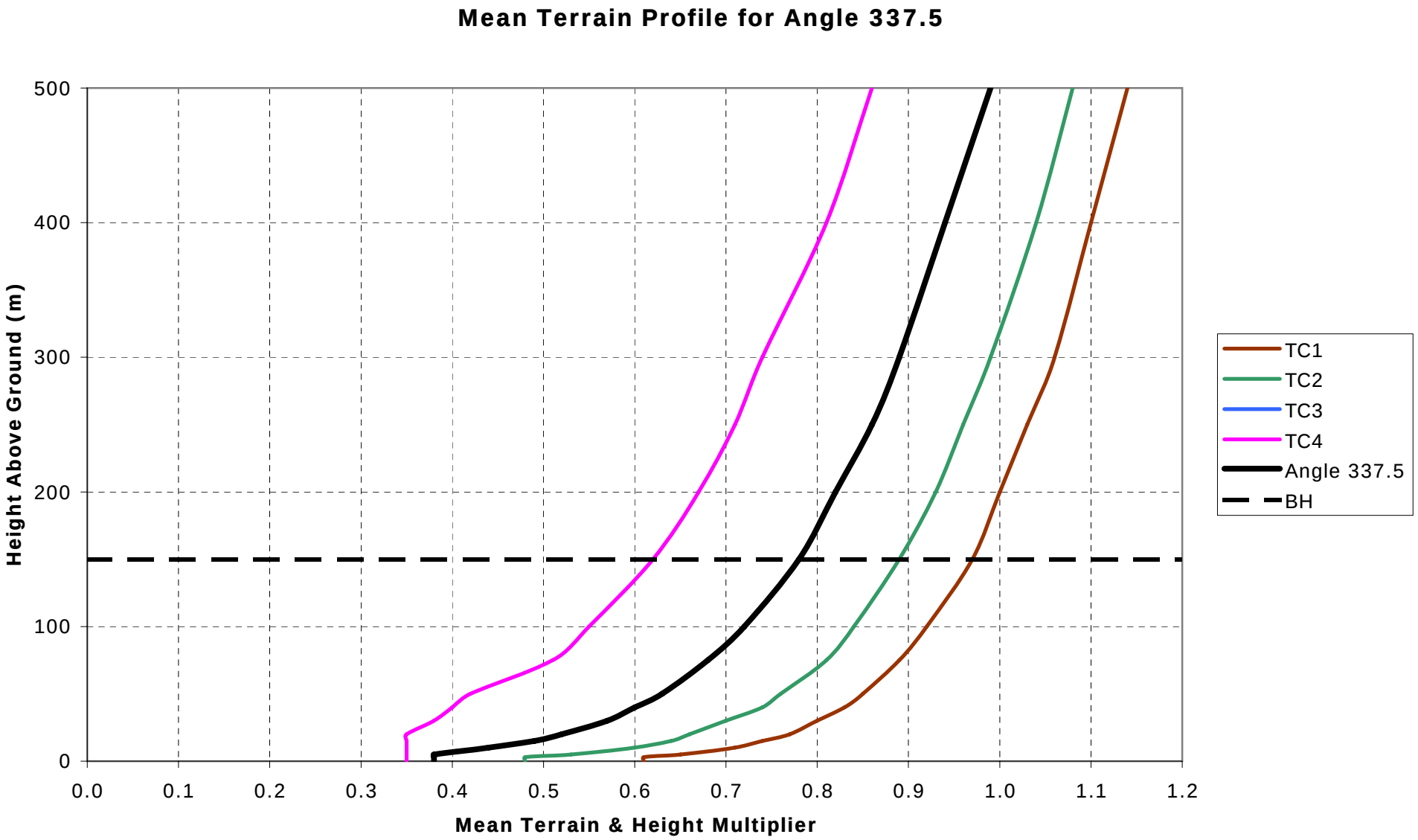

Mean Terrain Profile for Angle 225
Height Above Ground (m)
500
400
300
200
100
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 225
BH


Mean Terrain Profile for Angle 247.5
Height Above Ground (m)
500
400
300
200
100
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
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 247.5
BH


Mean Terrain Profile for Angle 270
Height Above Ground (m)
500
400
300
200
100
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
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 270
BH


Mean Terrain Profile for Angle 292.5
Height Above Ground (m)
500
400
300
200
100
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
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 292.5
BH


Mean Terrain Profile for Angle 315
Height Above Ground (m)
500
400
300
200
100
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
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 315
BH


Mean Terrain Profile for Angle 337.5
Height Above Ground (m)
500
400
300
200
100
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
1.2
Mean Terrain & Height Multiplier
TC1
TC2
TC3
TC4
Angle 337.5
BH

Appendix C

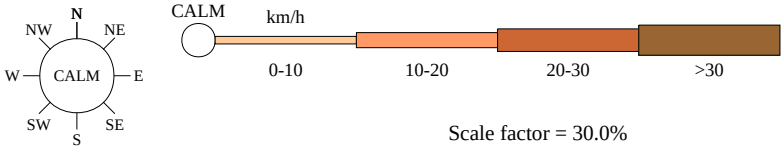
Wind Roses for the Sydney Region

Sydney Airport, 1939-2000

WIND FREQUENCY ANALYSIS (in km/h)

SYDNEY AIRPORT AMO STATION NUMBER 066037

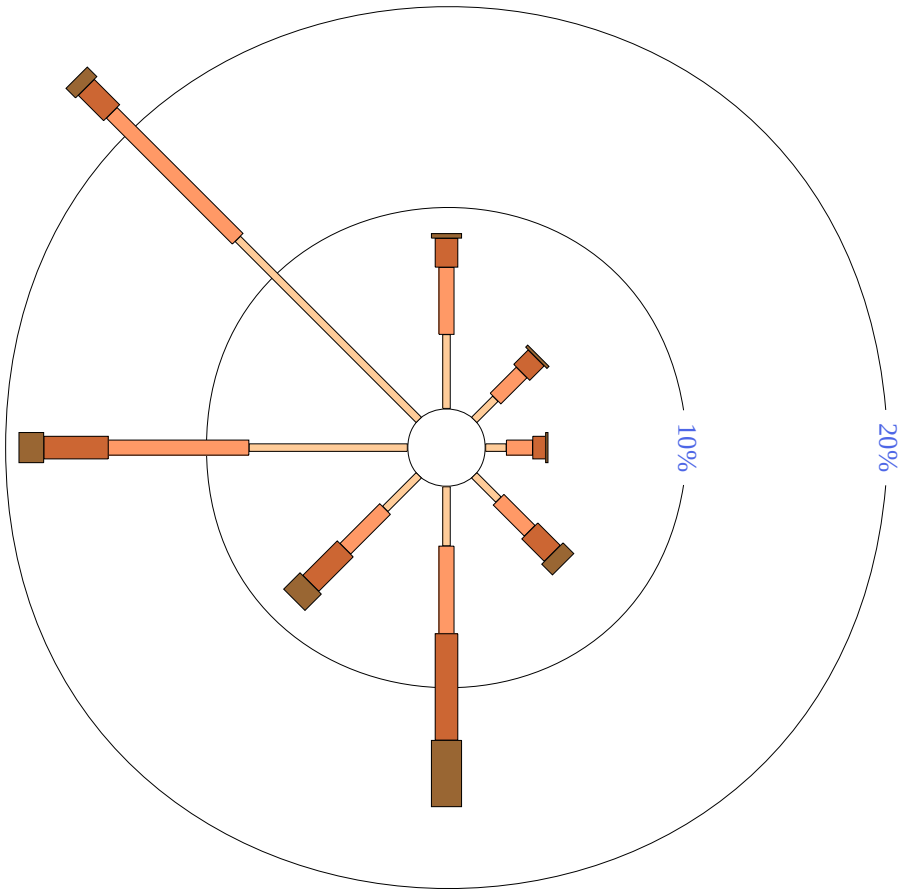
Latitude: -33.94 ° Longitude: 151.17 °



Scale factor = 30.0%

9 am
23333 Total Observations (1939 to 2004)

Calm 10%

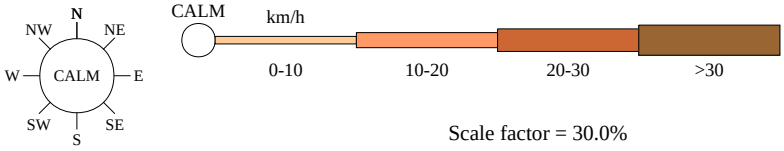


Wind directions are divided into eight compass directions. Calm has no direction.
An asterisk (*) indicates that calm is less than 1% .
An observed wind speed which falls precisely on the boundary between two divisions (eg 10km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.

WIND FREQUENCY ANALYSIS (in km/h)

SYDNEY AIRPORT AMO STATION NUMBER 066037

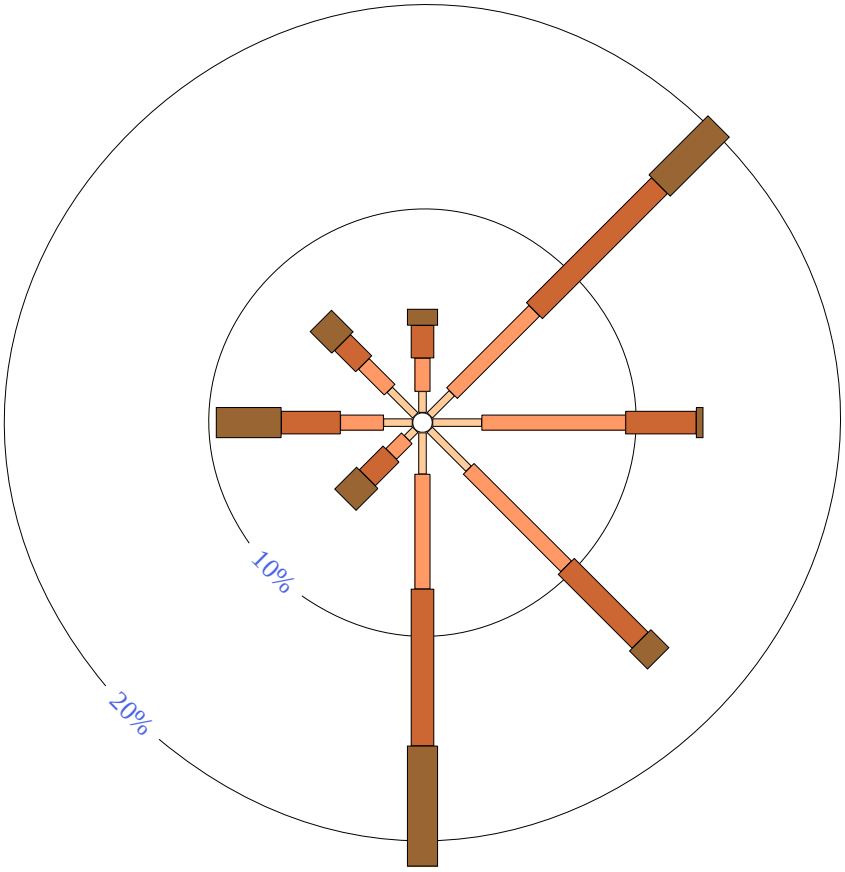
Latitude: -33.94 ° Longitude: 151.17 °



Scale factor = 30.0%

3 pm
23407 Total Observations (1939 to 2004)

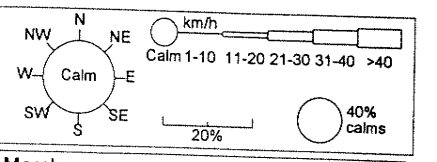
Calm 2%



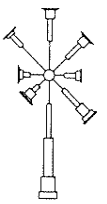
Wind directions are divided into eight compass directions. Calm has no direction.
An asterisk (*) indicates that calm is less than 1% .
An observed wind speed which falls precisely on the boundary between two divisions (eg 10km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.

Wind Roses using available data between 1939 and 2000 for SYDNEY AIRPORT AMO

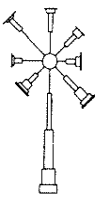
Site Number 066037 • Locality: SYDNEY AIRPORT • Opened Jan 1929 • Still Open
Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m



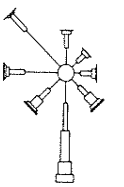
9 am January 1933 observations



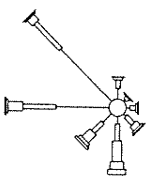
9 am February 1755 observations



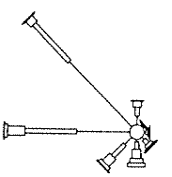
9 am March 1922 observations



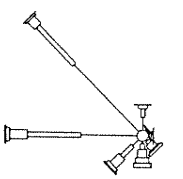
9 am April 1834 observations



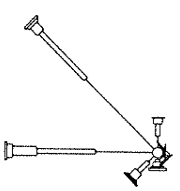
9 am May 1866 observations



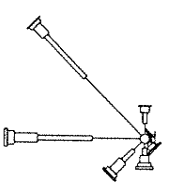
9 am June 1806 observations



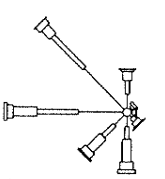
9 am July 1873 observations



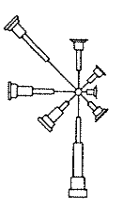
9 am August 1876 observations



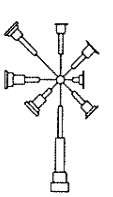
9 am September 1814 observations



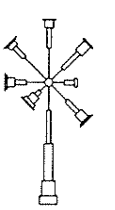
9 am October 1901 observations



9 am November 1835 observations

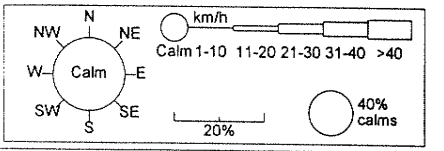


9 am December 1906 observations

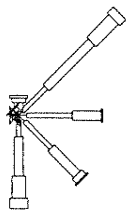


Wind Roses using available data between 1939 and 2000 for SYDNEY AIRPORT AMO

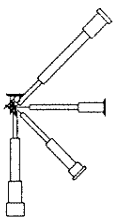
Site Number 066037 • Locality: SYDNEY AIRPORT • Opened Jan 1929 • Still Open
Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m



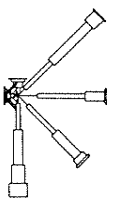
3 pm January 1939 observations



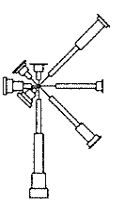
3 pm February 1771 observations



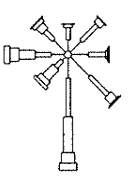
3 pm March 1925 observations



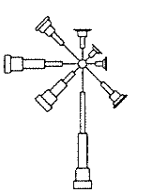
3 pm April 1832 observations



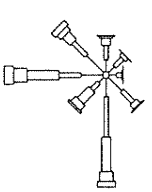
3 pm May 1877 observations



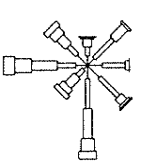
3 pm June 1821 observations



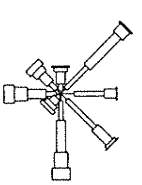
3 pm July 1882 observations



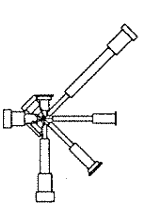
3 pm August 1882 observations



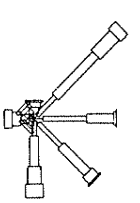
3 pm September 1811 observations



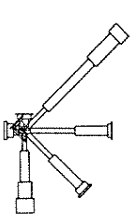
3 pm October 1904 observations



3 pm November 1839 observations



3 pm December 1906 observations



Prepared by Climate and Consultancy Section in the New South Wales Regional Office of the Bureau of Meteorology
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