THEAKSTON ENVIRONMENTAL

Consulting Engineers • Environmental Control Specialists

REPORT

PEDESTRIAN LEVEL WIND STUDY

1470 Williamsport Drive

Mississauga, Ontario

1470 Williamsport Holdings Inc.

REPORT NO. 25247wind **October 17, 2025**

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The mixed-use Development proposed by 1470 Williamsport Holdings Inc. for their property municipally known as 1470 Williamsport Drive, located to the northeast of the intersection of Bloor Street and Dixie Road, in the City of Mississauga, has been assessed for environmental standards with regard to pedestrian level wind velocities relative to comfort and safety. The pedestrian level wind and gust velocities measured for the eighty-four (84) locations tested are within safety criteria and most are within the comfort criteria described within.

The Development involves a proposal to remove the 6 storey building on site, and construct two 12 storey buildings connected via a 6 storey podium. The proposed Development is, for all intents and purposes, surrounded to prevailing windward directions by a suburban mix of mainly low to mid-rise residential, commercial, and institutional buildings, with related open lands and parking areas. These surrounds present a varied terrain to approaching winds, limiting the wind's opportunity to accelerate on approach from several directions, and exacerbating them from others.

Urban developments provide surface roughness, which induces turbulence that can be wind friendly, while suburban settings similarly, though to a lesser extent, prevent wind from accelerating as the wind's boundary layer profile thins at the pedestrian level. Conversely, open settings afford wind the opportunity to accelerate. High-rise buildings typically exacerbate wind conditions within their immediate vicinity, to varying degrees, by redirecting wind currents to the ground level and along streets and open areas. Transition zones from open, and/or suburban, to urban settings often prove problematic, as winds exacerbated by relatively more open settings are redirected to flow over, around, down, and between buildings.

The proposed Development penetrates winds that formerly flowed over the site, the increased blockage relative to the existing setting causing wind to redirect to flow over the building, without consequence, and/or, depending upon the angle of incidence, around, or down the building towards the pedestrian level, as downwash. The Development features wind friendly design elements such as a podium, narrow façades, stepped façades, landscaping, and others, which when considered in concert, moderate wind at the pedestrian level. This results in generally moderate changes to the impending wind climate realised at the site with inclusion of the proposed and future Developments, relative to the existing setting.

With inclusion of the proposed and future Developments, ground level winds at some locations will improve, with localized areas of higher pedestrian level winds, resulting in wind conditions that generally remain comfortable and appropriate to the areas' intended purposes throughout the year. A localised uncomfortable winter rating is noted to the north of the proposed Development in the proposed setting, however the rating is near the transition to walking conditions and improves to walking in the future setting as well as with consideration of existing surrounding vegetation as noted in the Appendix Figure C Table. The relationship between surface roughness and wind is also discussed in the Appendix and shown graphically in Figure A of the same section.

Where mitigation was necessary, it was achieved through the incorporation of the following design features:

- a podium
- narrow façades
- stepped façades
- notches
- wind screens
- fencing
- landscaping

and others, that were included in the proposed Development's massing and landscape design. Where possible, the proposed mitigative features were included in the model in order to achieve appropriate conditions.

The proposed Development will realize wind conditions acceptable to a typical suburban context.

Respectfully submitted,

Nicole Murrell, M.Eng, P. Eng.

Paul Kankainen, M.A.Sc.

Stephen Pollock, P. Eng.

2. INTRODUCTION

Theakston Environmental Consulting Engineers, Fergus, Ontario, were retained by 1470 Williamsport Holdings Inc., to study the pedestrian level wind environment for their proposed Development located at 1470 Williamsport Drive, in the City of Mississauga, as shown on the Aerial Photo in Figure 2a. The Development involves a proposal to remove the existing 6 storey apartment building currently on site, and construct two 12 storey buildings connected via a 6 storey podium, in the configuration shown in Figure 2b. BDP Quadrangle provided architectural drawings for the proposed Development. The co-operation and interest of the Client and their sponsors in all aspects of this study is gratefully acknowledged.

The specific objective of the study is to determine areas of higher-than-normal wind velocities induced by the shape and orientation of the proposed buildings and surroundings. The wind velocities are rated in accordance with the safety and comfort of pedestrians, notably at entrances to the buildings, sidewalks, courtyards on the property, as well as other buildings in the immediate vicinity.

In order to obtain an objective analysis of the wind conditions for the property, the wind environment was tested in three configurations. The existing configuration included the building currently on site as well as existing and approved buildings in the surrounding area. The proposed configuration replaced the existing building with the proposed Development. The future configuration was tested at the request of the City planner and includes the development proposed at 3480 Havenwood Drive. Mitigation procedures were assessed during these tests to determine their impact on the various wind conditions.

The laboratory techniques used in this Pedestrian Level Wind Study are established procedures that have been developed specifically for analyses of this kind. The methodology, summarized herein, describes criteria used in the determination of pedestrian level wind conditions. The facilities used by Theakston are ideal for observance of the Development at various stages of testing, and the development of wind mitigation measures, if necessary.

3. OBJECTIVES OF THE STUDY

1. To quantitatively assess, by model analyses, the pedestrian level wind environment under existing conditions and future conditions with the Development.

2. To assess mitigative solutions.

3. To publish a Consultant's report documenting the findings and recommendations.

4. METHOD OF STUDY

4.1 General

The Theakston Environmental wind engineering facility was developed for the study of, among other sciences, the pedestrian level wind environment occurring around buildings, with focus on the safety and comfort of pedestrians. To this end, physical scale models of proposed Development sites, and immediate surroundings, are built, instrumented, and tested at the facility with resulting wind speeds measured for different wind directions at various locations likely to be frequented by pedestrians. This quantitative analysis provides predictions of wind speeds for various probabilities of occurrence and for various percentages of time that are ultimately weighted relative to a historical range of wind conditions and provided to the client.

The techniques applied to wind and other studies carried out at the facility, utilise a boundary layer wind tunnel and/or water flume (Figure 1). The testing facility has been developed for these kinds of environmental studies, and has been adapted with equipment, testing procedures and protocols, in order to provide results comparable to full scale. Theakston's Boundary Layer Wind Tunnel, which lends itself well to the simultaneous acquisition of large data streams, was used to measure the wind environment at the site while the water flume, which is excellent for flow visualisation, can be used to help understand problematic wind flow conditions.

The purpose of this Pedestrian Level Wind Study is to evaluate the pedestrian level wind speeds for a full range of wind directions. To accomplish this, the wind's mean speed boundary layer profiles are simulated and applied to a site-specific model under test, instrumented with differential pressure probes at locations of interest. During testing, pressure readings are taken over a one-hour model scale period, at a full-scale height of approximately 1.5m and correlated to mean and gust wind speeds, expressed as ratios of the gradient wind speed.

The mean and gust wind speeds at the eighty-four (84) points tested were subsequently combined with the design probability distribution of gradient wind speed and direction, (wind statistics) recorded at Airports in the vicinity, to provide predictions of the full-scale pedestrian level wind environment. Predictions of the full-scale pedestrian level wind environment are presented as the Gust Equivalent Mean (GEM) wind speed exceeded 20% of the time, based on the winter and summer seasons in Figures 6a and 6b. Criterion employed by Theakston Environmental was developed by others and us and published in the attached references. The methodology has been applied to over 800 projects on this continent and abroad.

4.2 Meteorological Data

The wind climate for the Mississauga region that was used in the analysis was based on historical records of wind speed and direction measured at Pearson International Airport for the period between 1980 and 2023. The meteorological data includes hourly wind records and annual extremes. The analysis of the hourly wind records provides information to develop the statistical climate model of wind speed and direction. From this model, predicted wind speeds regardless of wind direction for various return periods can be derived. The record of annual extremes was also used to predict wind speeds at various return periods. Based on the analysis of the hourly records, the predicted hourly-mean wind speed at 10m, corrected for a standard open exposure definition, is 25 m/s for a return period of 50 years.

4.3 Statistical Wind Climate Model

For the analysis of the data, the wind climate model is converted to a reference height of 500*m* using a standard open exposure wind profile. The mean-hourly wind speed at a 500*m* reference height used for this study is 45.6*m/s* for a return period of 50 years. The corresponding 1-year return period wind speed at the 500*m* height is 36*m/s*.

The design probability distribution of mean-hourly wind speed and wind direction at reference height is shown for Pearson International Airport in Figure 5. Winter and summer seasonal distributions are shown. From this it is apparent that winds can occur from any direction, however, historical data indicates the directional characteristics of strong winds are from the north through west to southwest and said winds are most likely to occur during the winter.

4.4 Wind Simulation

To simulate the correct macroclimate, the upstream flow passes over conditioning features placed upstream of the model, essentially strakes and an appropriately roughened surface, as required to simulate the full-scale mean speed boundary layer approach flow profiles occurring at the site.

4.5 Pedestrian Level Wind Velocity Study

A physical model of the proposed Development and pertinent surroundings, including existing buildings, roadways, pathways, terrain, and other features, was constructed to a scale of 1:400. The model is based upon information gathered during a virtual site visit to the proposed Development site, and surrounding area. BDP Quadrangle provided architectural drawings. City of Mississauga aerial photographs were also used in development of the model to ensure the model reasonably represents conditions at the proposed Development. The model is constructed on a circular base so that, by rotation, any range of wind directions can be assessed. Structures and features that are deemed to have an impact on the wind flows are included upwind of the scale model.

In these studies, the effects of wind were analysed using omni-directional wind velocity probes that are placed on the model and located at the usual positions of pedestrian activity. The probes measure both mean and fluctuating wind speeds at a height of approximately 1.5m. During testing, the model sample period is selected to represent 1hr of sampling time at full scale. The velocities measured by the probes are recorded by a computerized data acquisition system and combined with historical meteorological data via a post-processing program.

4.6 Pedestrian Comfort Criteria

The assignment of pedestrian comfort takes into consideration pedestrian safety and comfort attributable to mean and gust wind speeds. Gusts have a significant bearing on safety, as they can affect a person's balance, while winds flowing at or near mean velocities have a greater influence upon comfort.

Figure 6 presents results for the Comfort Categories, which are based upon the two seasons and calculated as the Gust Equivalent Mean (GEM) wind speed exceeded 20% of the time, based on wind events occurring between 6:00 and 23:00. Gust Equivalent Mean (GEM) wind speed is the maximum of either mean wind speed or gust wind speed divided by 1.85. These speeds are directly related to the pedestrian comfort at a particular point. The overall comfort ratings, for existing, proposed, and future configurations are depicted in Figure 7. A comparison of pedestrian level comfort conditions for each probe is shown in a table in Figure 10. Table 1, below, summarizes the comfort criteria used in the presentation of the results depicted in Figures 6 and 7.

Table 1: Comfort Criteria

ACTIVITY	Gust Equivalent Mean Wind Speed Exceeded 20% of the Time	Description
COMFORT	***km/h***	
Sitting	0-10	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away.
Standing	0-15	Gentle breezes suitable for main building entrances and bus stops.
Walking	0-20	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.
Uncomfortable	>20	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended.

The effects of mean and gust wind conditions are described as suitable for Sitting, Standing, or Walking when said categories are realised 80% of the time, or greater. The Uncomfortable category encompasses wind conditions that exceed Walking criteria. For a point to be rated as suitable for Sitting, for example, the GEM wind conditions must not exceed 10*km/h*, more than 20% of the time. Thus, in the plots (Figure 6), the upper limit of each bar ends within the range described by the comfort category. For sitting, the rating would include conditions ranging from calm up to wind speeds that would rustle tree leaves or wave flags slightly, as presented in the Beaufort Scale included in the Appendices. As the name infers, the category is recommended for outdoor space where people might sit for extended periods.

The Standing category is slightly more tolerant of wind, including GEM wind speeds from calm up to 15*km/h,* occurring at least 80% of the time. In this situation, the wind would rustle tree leaves and, on occasion, move smaller branches while flags flap. This category would be suitable for locations where people might sit for short periods or stand in relative comfort. The Walking category includes wind speeds from calm up to 20*km/h,* occurring more than 80% of the time. These winds would set tree limbs in motion, lift leaves, litter and dust, and the locations are suitable for activity areas. The Uncomfortable category covers a broad range of wind conditions that are generally a nuisance for most activities, including wind speeds above 20*km/h* occurring more than 20% of the time.

In Figure 6, the probe locations are listed along the bottom of the chart; beneath the graphical representation of the GEM Wind Speed exceeded 20% of the time. Along the right edge of the plot the comfort categories are shown. The background of the plot is lightly shaded in colours corresponding to the categories shown in Table 1. Each category represents a 5*km/h* (or more) interval. The location is rated as suitable for Sitting, Standing, Walking, or Uncomfortable, if the bar extends into the corresponding interval.

The charts represent the average person's response to wind force. Effects such as wind chill and humidex (based on perception) are not considered. Also clothing is not considered, since clothing and perceived comfort varies greatly among the population. There are many variables that contribute to a person's perception of the wind environment beyond the seasonal variations presented. While people are generally more tolerant of wind during the summer months, than during the winter, due to the wind cooling effect, people become acclimatized to a particular wind environment. Persons dwelling near the shore of an ocean, large lake or open field are more tolerant of wind than someone residing in a sheltered wind environment.

4.7 Pedestrian Safety Criteria

Safety criteria are also included in the analysis to ensure that strong winds do not cause a loss of balance to individuals occupying the area. The safety criteria are based upon gust wind speeds exceeded nine times per year, using annual wind data recorded 24 hours daily, as shown in Table 2. Both the Comfort and Safety Criteria are based on those described in the City's Terms of Reference for Wind.

Table 2: Safety Criteria

ACTIVITY	Gust Wind Speed Exceeded 9 Times per year	Description
SAFETY	***km/h***	
Pass	0 - 90	Acceptable gust speeds that will not adversely affect a pedestrian's balance and footing.
Exceeding	>90	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

4.8 Pedestrian Comfort Criteria – Seasonal Variation

The level of comfort perceived by an individual is highly dependent on seasonal variations of climate. Perceived comfort is also specific to each individual and depends on the clothing choices. The comfort criterion that is being used averages the results across the general population to remove effects of individuals and clothing choices, however, seasonal effects are important. For instance, a terrace or outdoor amenity space may have limited use during the winter season but require acceptable comfort during the summer.

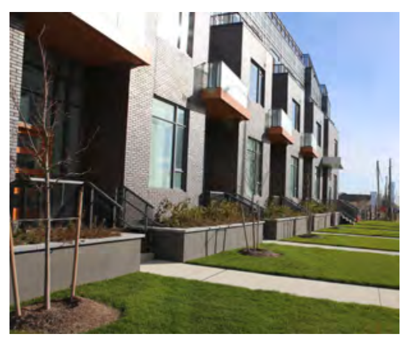
When compared to the annual average wind speed, winter winds are about 9% higher and summer winds are about 9% lower.

4.9 Wind Mitigation Strategies

Wind mitigative features such as podiums, setbacks, stepped façades, balconies, notches, overhangs, canopies, and others, assist in discouraging downwash associated with prevailing winds. These features deflect portions of said winds around buildings at elevations well above the pedestrian level, and moderate upsets to wind conditions with inclusion of new developments. Additional mitigative features may also be applied for localised areas that experience conditions that are inappropriate for the intended use. These features, discussed below, add roughness into wind streamlines and protect exposed areas from high pedestrian level winds.

Entrances to buildings may be mitigated by locating them away from building corners and through recessing the entrances into the façades of the building. Additional mitigative features such as railings, canopies, coarse plantings, porous wind screens, and others, would further assist in mitigating said areas. Examples of these wind mitigation measures are shown below.





Examples of Wind Mitigative Measures at Entrances (recessed entrances, railings, canopies, raised planters, coniferous trees).

Activity areas such as Outdoor Amenity Spaces may similarly be mitigated through implementation of 1.8m – 2.4m high perimeter wind screens, trellises, raised planters, coarse plantings, and others, situated about the spaces as practical. Examples of these wind mitigative measures are shown below.

Examples of Wind Mitigative Measures at Activity Spaces (wind screens, raised planters, trellises)

The model was assessed with selected mitigation strategies during these tests to determine their impact on the various wind conditions. Further testing may be required in order to determine the effectiveness of any additionally proposed wind mitigative features, if desired.

5. RESULTS

5.1 Study Site and Test Conditions

Proposed Development

The proposed Development occupies a portion of the block of lands bound by Williamsport Drive to the northwest, Havenwood Drive to the northeast, Bloor Street to the southeast, and Dixie Road to the southwest, in the City of Mississauga. The site is currently occupied by a 6 storey apartment building and surface parking, which will be removed to accommodate the proposed Development. The site and its immediate surrounds are shown in Figure 2a.

The proposed Development involves construction of two 12 storey buildings connected via a 6 storey podium. The Main Residential Entrance to the proposed Development is accessed along the northwestern façade, via Williamsport Drive. Outdoor Amenity Spaces are proposed to the southeast of the building at-grade, as well as on the 2nd level along the southeastern façade, and the 7th level between the buildings. The site plan is presented in Figure 2b.

Where possible, proposed mitigative features were included on the massing model. This includes fencing along the southwestern, southeastern, and northeastern property lines, wind screens along the Williamsport frontage, screens between private patios at-grade, and a decorative wind wall at the northernmost corner of the site.

View of the existing conditions at the proposed Development site looking east from Williamsport Drive (Google).

Surrounding Area

The proposed Development site, for all intents and purposes, is surrounded to prevailing windward directions by a suburban mix of low through mid-rise residential, commercial, and institutional buildings, and associated open spaces, as indicated in Figure 2a.

Lands to the immediate north of the site are occupied by an 8 storey residential building at 1485 Williamsport Drive. There is a proposal to develop that site to include a 10 storey building to the southwest of the existing building, at 3480 Havenwood Drive, and this was included in the future scenario at the request of the City planner. Lands to the west of the subject site are occupied by a low-rise residential building and lands to the southwest are occupied by low-rise commercial spaces. Lands to the south through east of the site are occupied by mid-rise slab-style buildings with surrounding open areas. Low-rise residential neighbourhoods mainly dominate the surrounds beyond in all directions, with a few high-rise residential buildings to the southwest of the site.

In summary, suburban development mainly comprised of low through mid-rise residential, commercial, and institutional buildings dominate lands to all compass points relative to the subject site. The suburban landscape has mitigative effects upon the wind climate to varying degrees, providing surface roughness that generally reduces the wind's energy at the pedestrian level.

Figures 2a and 2b depict the site and its immediate context. The site model, shown in Figure 3, is built to a scale of 1:400.

Macroclimate

For the proposed Development, the upstream wind flow during testing was conditioned to simulate an atmospheric boundary layer passing over suburban terrain. The terrain within the site's immediate vicinity was incorporated into the proximity model. Historical meteorological data recorded from Toronto Pearson International Airport was used in this analysis. For studies in the City of Mississauga, the data is presented for two seasons, winter and summer; the resulting wind roses are presented as mean velocity and percent frequency in Figure 5. The mean velocities presented in the wind roses are measured at an elevation of 10m. Thus, representative ground level velocities at a height of 2m, for an urban macroclimate, are 52% of the mean values indicated on the wind rose (for suburban and rural macroclimates the values are 63% and 78% respectively). The macroclimate for the area varies, with the terrain types associated with wind direction, resulting in what is generally considered suburban terrain.

Winter (November through April) has the higher mean velocities with prevailing winds from the north through west to southwest, as indicated in Figure 5a. Summer (May through October) has lower mean wind velocities with similar prevailing winds from the north through west, with a southeasterly component, as indicated in Figure 5b. Reported pedestrian comfort ratings generally pertain to winter conditions, unless stated otherwise.

5.2 Pedestrian Level Wind Velocity Study

On the site model, eighty-four (84) wind velocity measurement probes were located around the proposed Development and other buildings and activity areas to determine conditions related to comfort and safety. Figure 4 depicts probe locations at which pedestrian level wind velocity measurements were taken in the existing, proposed and future scenarios. For the existing setting, the subject buildings and mitigative features were removed, and the "existing" site model retested with the current site. For the future setting, the proposed building at 3480 Havenwood Drive was added to the model.

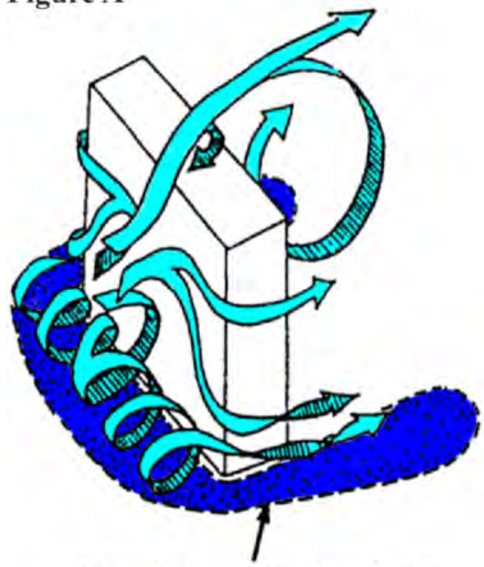
Measurements of pedestrian level mean and gust wind speeds at the various locations shown were taken over a period equivalent to one hour of measurements at full-scale. The mean ground level wind velocity measured is presented as a ratio of gradient wind speed, in the plots of Figure B in the Appendix, for each point in the existing and proposed scenarios. These relative wind speeds are presented as polar plots in which the radial distance for a particular wind direction represents the wind speed at the location for that wind direction, expressed as a ratio of the corresponding wind speed at gradient height. They do not assist in assessing wind comfort conditions until the probability distribution gradient wind speed and direction are applied.

The design probability distribution gradient wind speed and direction, taken from historical meteorological data for the area (see Figure 5) was combined with pedestrian level mean and gust wind speeds measured at each point to provide predictions of the percentage of time a point will be comfortable for a given activity. These predictions of mean and maximum or "gust" wind speeds are provided for winter and summer in Figures 6a and 6b, respectively. A table comparing comfort and safety ratings for each probe is provided in Figure 10.

The ratings for a given location are conservative by design; when the existing surroundings and proposed buildings' fine massing details and actual landscaping are taken into consideration, the results tend toward a more comfortable site than quantitative testing alone would indicate.

Venturi action, scour action, downwash, and other factors, as discussed in the Appendix on wind flow phenomena, can be associated with large buildings, depending on their orientation and configuration. These serve to increase wind velocities. Open areas within a heavily developed area may also encounter high wind velocities. Consequently, wind force effects are common in heavily built-up areas. The Development site is open to a predominantly suburban setting to prevailing and remaining compass points with winds flowing over and between low through high-rise buildings and open spaces. As such, the surroundings can be expected to influence wind at the site to varying degrees. Note: Probes are positioned at points typically subject to windy conditions in an urban environment to determine the worst-case scenario.

Figure A



Area of Strong Surface Wind

High-rise buildings may exacerbate wind conditions within their immediate vicinity, to varying degrees, by redirecting wind currents to the ground level and along streets and open areas. In general, wind will split upon impact with a high-rise building, with portions flowing down the face of the building to the pedestrian level as downwash, where it is deflected, or otherwise redirected to flow along the building and around its corners, creating localized zones of increased pedestrian level wind (Figure A). Conversely, points situated to the leeside, or in the wake of buildings will often enjoy an improvement in pedestrian comfort. As such, it is reasonable to expect inclusion of the proposed development will alter wind conditions under specific wind directions and velocities from those of the existing site condition, resulting in an improvement over the existing conditions at some points, with more windy conditions at others.

5.3 Review of Probe Results

The probe results, as follows, were clustered into groups comprised of Public Street Conditions, Internal Site Conditions, Pedestrian Entrance Conditions, and Outdoor Amenity Space Conditions. The measurement locations are depicted in Figure 4 and the resulting pedestrian comfort conditions are listed in Figures 6a and 6b in winter and summer and for the existing, proposed, and future configurations. The results are also graphically depicted for the existing, proposed, and future configurations in Figures 7a – 7f, and compared in a table in Figure 10. The following discusses anticipated wind conditions and suitability for the points' intended use.

Public Street Conditions

Bloor Street

Probes 1 through 18 were located along Bloor Street within the zone of influence of the proposed Development. Their locations are depicted in Figure 4, the comfort ratings are listed for the seasons in Figures 6a and 6b and depicted in Figures 7a through 7f. In the existing setting, the probes along Bloor Street indicate conditions suitable for standing in the summer and standing or walking through the winter season.

With inclusion of the proposed Development a realignment of winds was noted along Bloor Street. This can be attributed to the proposed Development causing a realignment of winds that reduces apparent wind effects at the pedestrian level for several wind directions, but causes an increase to winds for others, as indicated in the Appendices Figure B, Ground Level Wind Velocity Plots presented as a ratio of gradient wind velocity. Increased winds are attributed to the proposed Development redirecting winds through downwash and other phenomena, to flow along portions of Bloor Street. Conversely, improvements in wind conditions can be attributed to the proposed Development effectively reducing the propensity for specific winds being deflected to flow along the street and over the areas.

The changes were overall fairly subtle, with the street remaining suitable for standing throughout the summer in the proposed and future settings. In the winter, probes 7, 13, and 15 realised sufficient improvements in northwesterly through westerly winds in the proposed setting to change the ratings from walking to standing. Probes 4, 6, 14, and 16 conversely realised subtle increases in winds in the proposed setting, changing the winter ratings from standing to walking. The future configuration resulted in improvements in the winter, changing probes 10 and 11 from walking in the existing and proposed settings to standing in the future, and probes 14 and 16 similarly changed back to standing from walking in the proposed.

With inclusion of the proposed Development, fairly similar conditions were noted along Bloor Street, resulting in conditions that remains suitable for the intended use throughout the year in the proposed and future settings. The relatively subtle changes are a reasonable expectation given the proposed and future Developments are fairly set back from Bloor Street.

With inclusion of the proposed and future Developments, Bloor Street passes the pedestrian level wind velocity safety criteria, as described in Section 4.7 and depicted in Figure 9.

Williamsport Drive

Probes 19 through 43 were located along Williamsport Drive within the zone of influence of the proposed Development. The existing comfort conditions along Williamsport Drive are suitable for walking or standing in the winter and mainly standing in the summer, with the exception of summer walking conditions at probes 35 and 39.

With inclusion of the proposed Development a realignment of winds was noted along portions of Williamsport Drive. Areas of the street to the northeast and west of the site realise blockage from mainly easterly and westerly winds, sufficient to improve the winter ratings from walking to standing at probes 20, 21, 23, 42, and 43 and the summer ratings from standing to sitting at probes 22 and 24. Conversely, localised areas of the street proximate to the proposed Development realise increases in winds, changing the seasonal ratings from standing to walking at probes 27 through 30 and 32 in the winter and probes 32, 33, 34, 36, and 37 in the summer. Probe 34 similarly changes from walking to uncomfortable in the winter season, however the rating is relatively near the transition to walking conditions and is expected to be suitable for the intended use. While newly planted vegetation is not accepted as a form of mitigation in Mississauga, a test was run including existing mature trees on the northwest side of Williamsport Drive that resulted in walking conditions through the winter; the data is shown in the Appendix Figure C Table. We believe the inclusion of the existing mature trees in the area is more representative of the conditions that will be realised at this probe (Please note: this is also a temporary condition, and the conditions at probe 34 further improve to a walking rating with inclusion of the future development at 3480 Havenwood Drive).

In the future setting, Williamsport Drive realises very similar conditions to the proposed setting, with a few exceptions. Inclusion of the future development was sufficient to improve the uncomfortable winter rating at probe 34 to walking, and the seasonal walking ratings to standing at probes 30 and 40 in the winter and probes 32, 36, and 37 in the summer.

With inclusion of the proposed and future Developments, Williamsport Drive remains comfortable and suitable for the intended use throughout the year. Where the uncomfortable condition is realised in the proposed setting, consideration of existing mature trees in the area will result in more comfortable conditions than reported, as shown in the Appendix Figure C Table, and the conditions also improve to a walking rating with inclusion of the future neighbouring development.

With inclusion of the proposed Development, Williamsport Drive passes the pedestrian level wind velocity safety criteria, as described in Section 4.7 and depicted in Figure 9.

Havenwood Drive

Probes 44 through 46 were located along Havenwood Drive within the zone of influence of the proposed Development. In the existing setting, the street realises conditions suitable for standing throughout the year. With inclusion of the proposed Development, probe 44 realised subtle increases in winds to change the winter rating to walking, however in the future setting the rating changed back to standing.

As such, Havenwood Drive remains suitable for the intended use throughout the year in the proposed and future scenarios. Consideration of design and landscape elements that were too fine to include in the massing model will result in more comfortable conditions than reported.

Havenwood Drive also passes the pedestrian level wind velocity safety criteria, as described in Section 4.7 and depicted in Figure 9.

Internal Site Conditions

Probes 47 through 50 were located along a walkway adjacent to the driveway and southwest façade of the proposed Development. The area is protected from portions of the wind climate however it is exposed to winds that are directed to flow down and around the proposed Development and as such is rated for standing in the summer and standing or walking through the winter in the proposed and future settings. The area will be suitable for the intended use as a walkway/driveway area and will realise more comfortable conditions with consideration of fine design and landscape elements.

Probes 58 through 61 were similarly located along a walkway along the northeast property line. The northernmost portion of the area, probe 58, is exposed to large portions of the dominant westerly and easterly wind climate that are directed to flow around the northern corner of the proposed Development. A mitigation plan was prepared for the area including a sign element at the northmost corner of the site, as well as fencing along the northeastern property line and wind screens along the Williamsport Drive frontage, resulting in conditions rated for walking through the winter and standing in the summer in the proposed and future scenarios. The other probes along the walkway realise more comfortable conditions, suitable for standing year-round at probes 59 and 60, and sitting year-round at probe 61, with the exception of winter standing conditions in the proposed setting. The area will be comfortable for the intended use as a walkway.

Probes 83 and 84 were also located along a walkway connecting the at-grade outdoor amenity area to the driveway area along the southeastern edge of the site. The area is rated for sitting in the summer, and standing in the winter in the proposed and future settings, with the exception of probe 83 that realises winter sitting conditions in the future setting. The area will be comfortable for the intended use.

The above-noted internal site areas pass the pedestrian level wind velocity safety criteria, as described in Section 4.7 and depicted in Figure 9.

Pedestrian Entrance Conditions

Probe 54 was situated adjacent to the Main Entrance to the proposed Development, accessed via Williamsport Drive. In both the proposed and future configurations the entrance is rated suitable for standing in the winter and sitting in the summer and will be comfortable and suitable for the intended use throughout the year.

Probes 51 through 53, 55 through 57, and 75 through 80 were located adjacent to the entrances/patio areas of units located at-grade. The private patio/entrance areas feature wind screens separating the units that were included in the massing model. The areas are mainly rated suitable for sitting throughout the year in both the proposed and future settings, with the exception of localised standing conditions at probe 55 in the winter and probes 51 and 57 throughout the year (with summer sitting conditions at probe 51 in the future setting). As such, the at-grade unit patio/entrances will be comfortable and suitable for the intended uses throughout the year.

Wind conditions comfortable for standing are preferable at building entrances, while conditions suitable for walking are suitable for walkways. The various Entrances to the proposed Development will be comfortable and suitable for the intended uses throughout the year. The entrances to the proposed Development also pass the pedestrian level wind velocity safety criteria.

Outdoor Amenity Space Conditions

An Outdoor Amenity Space is proposed at-grade along the southeast facade of the proposed Development, as represented by probes 62 through 68. The area is fairly well protected from the majority of the dominant wind climate by the proposed Development and surrounds, resulting in conditions suitable for sitting in the summer and sitting or standing through the winter season. Probe 63 realises summer standing conditions in the proposed setting that are at the transition to sitting conditions, improve to sitting in the future setting, and will further improve with consideration of fine design and landscaping features such as plantings in the area. The area will be seasonally comfortable and suitable for the intended use.

An Outdoor Amenity Space and Terraces are proposed along the southeastern façade of the proposed Development on the 2nd level, as represented by probes 69 through 74. The model was tested with 1.8m high perimeter screens around the spaces. The areas are well protected from the majority of the wind climate and as such are rated suitable for sitting throughout the summer in the proposed and future settings. As such, the 2nd level Outdoor Amenity Space and Terraces will be comfortable and suitable for the intended uses.

An Outdoor Amenity Space is similarly proposed on the 7th level between the buildings, as represented by probes 81 and 82. The area was tested with 2.0m high screens around the space. The space is exposed to winds flowing down and around the buildings and through the gap between, resulting in conditions rated suitable for standing through the summer in both the proposed and future settings. Subsequent to testing, additional mitigation was proposed for the space including raising the perimeter wind screens to 2.4m in height. Trellises and porous windscreens as deemed appropriate will be incorporated into the final design. With consideration of the proposed mitigation plan, the area will realise more comfortable conditions than reported that are expected to be seasonally suitable for the intended use.

The Outdoor Amenity Spaces pass the pedestrian level wind velocity safety criteria.

5.4 Summary

The observed wind velocity and flow patterns at the proposed Development are largely influenced by approach wind characteristics that are dictated by the surrounding areas to prevailing and less dominant wind directions. These surroundings moderate wind flow in streamlines near the pedestrian level, resulting in generally comfortable conditions in the existing setting, with localised windier conditions proximate to high-rise buildings and gaps in between in the surrounds. Historical weather data recorded at Toronto Pearson International Airport indicates that winds of a mean wind speed greater than 30 km/h occur approximately 15 percent of the time during the winter months and 7 percent of the time during the summer.

With inclusion of the proposed and future Developments, ground level winds at some locations will improve, with localized areas of higher pedestrian level winds, resulting in wind conditions that generally remain comfortable and appropriate to the areas' intended purposes throughout the year. A localised uncomfortable winter rating is noted to the north of the proposed Development in the proposed setting, however the rating is near the transition to walking conditions and improves to walking in the future setting as well as with consideration of existing surrounding vegetation as noted in the Appendix Figure C Table. The relationship between surface roughness and wind is also discussed in the Appendix and shown graphically in Figure A of the same section.

Where possible, mitigation was proposed and included in the model in order to achieve appropriate conditions.

The proposed Development will realize wind conditions acceptable to a typical suburban context.

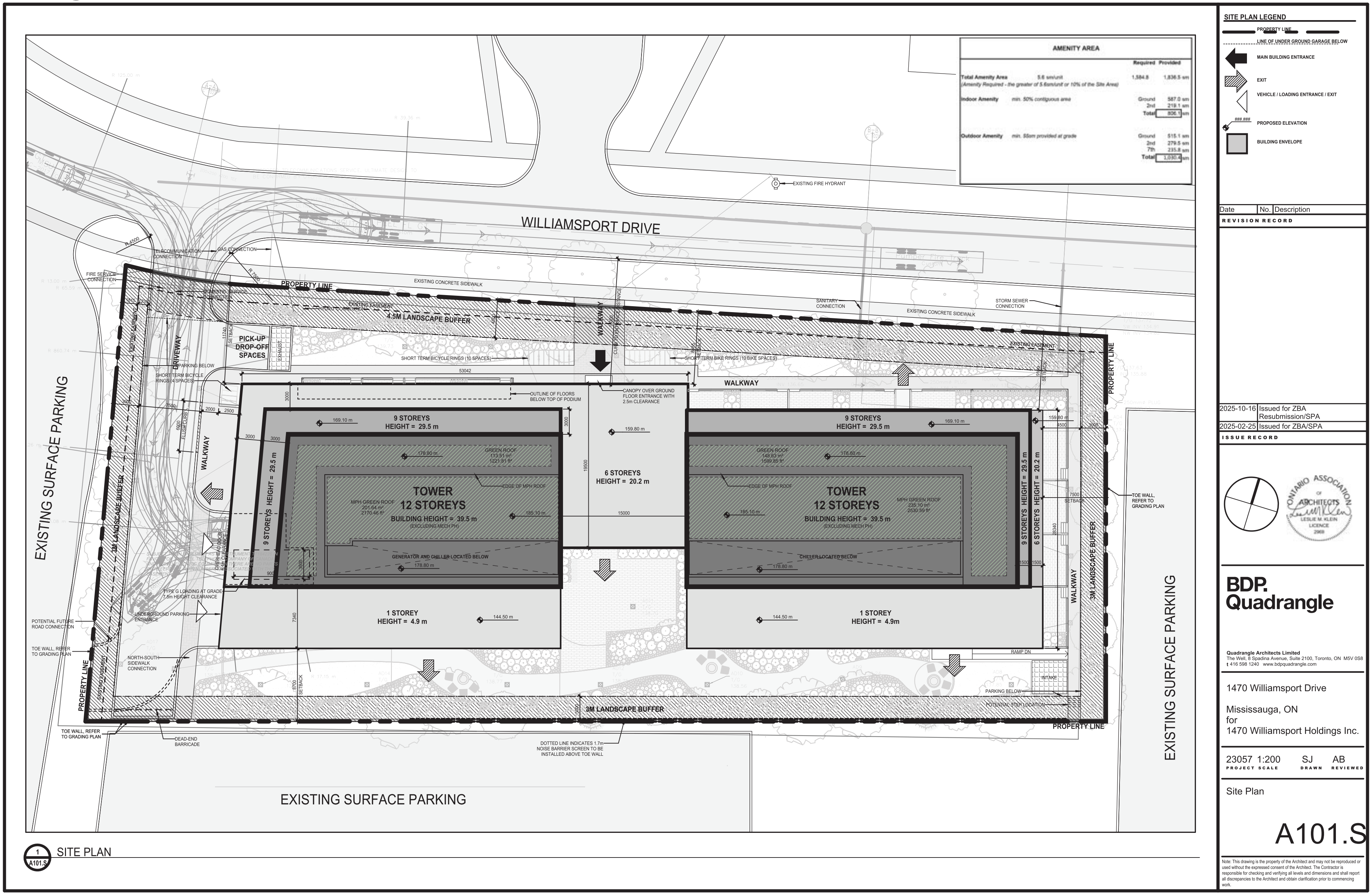
6. FIGURES

Figure 1: Laboratory Testing Facility

Figure 2a: Site Aerial Photo

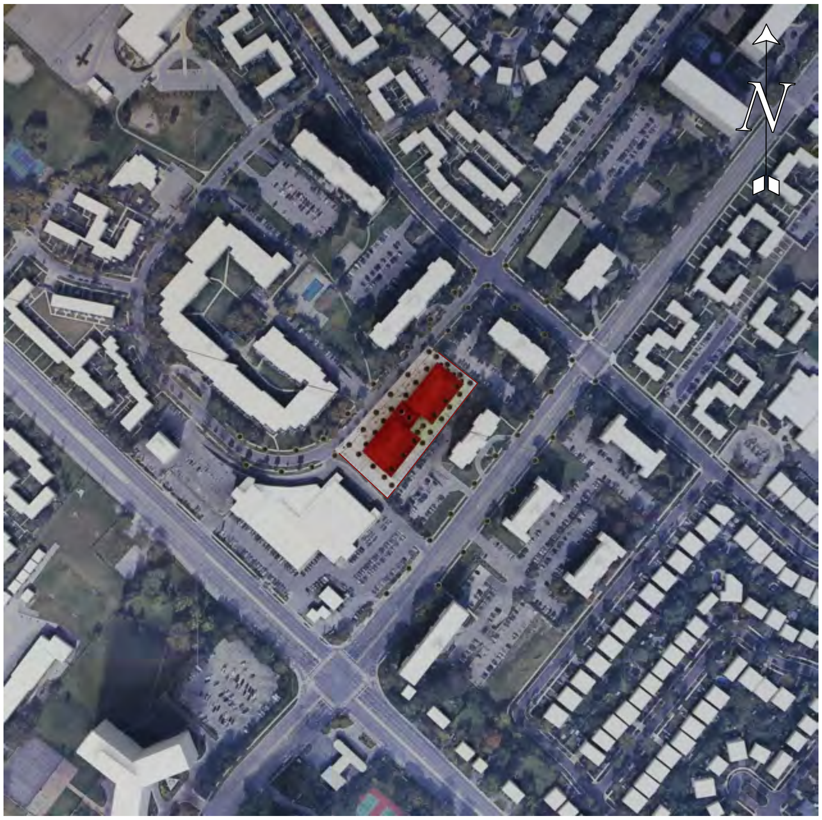
Theakston
Environmental

Figure 2b: Site Plan



Theakston Environmental

Figure 3: 1:400 Scale model of test site



a) Overall view of model - Proposed Site

b) Close-up view of model - Proposed Site

Figure 4: Location plan for pedestrian level wind velocity measurements.

Figure 5a: Winter Wind Rose - Pearson International Airport

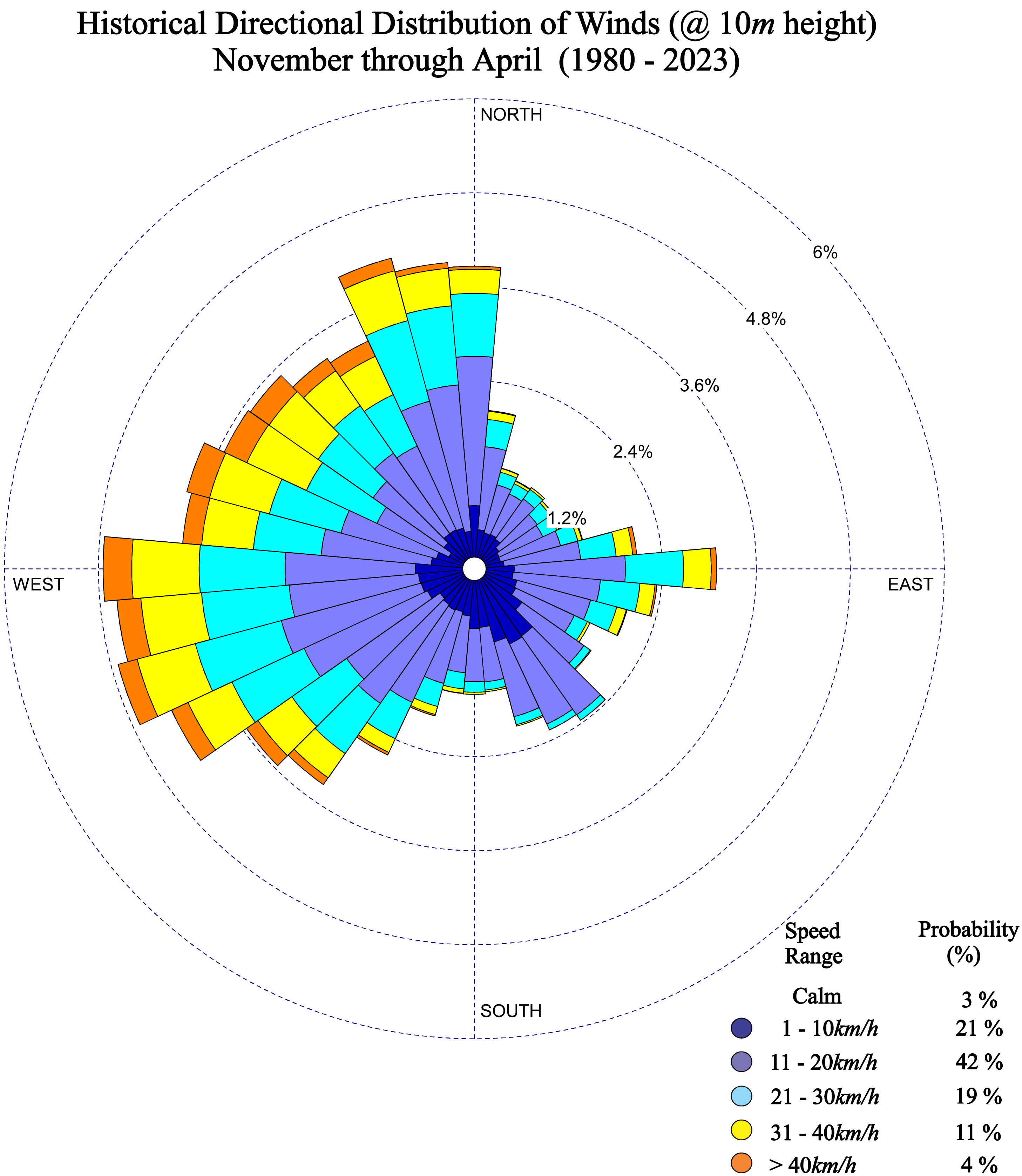
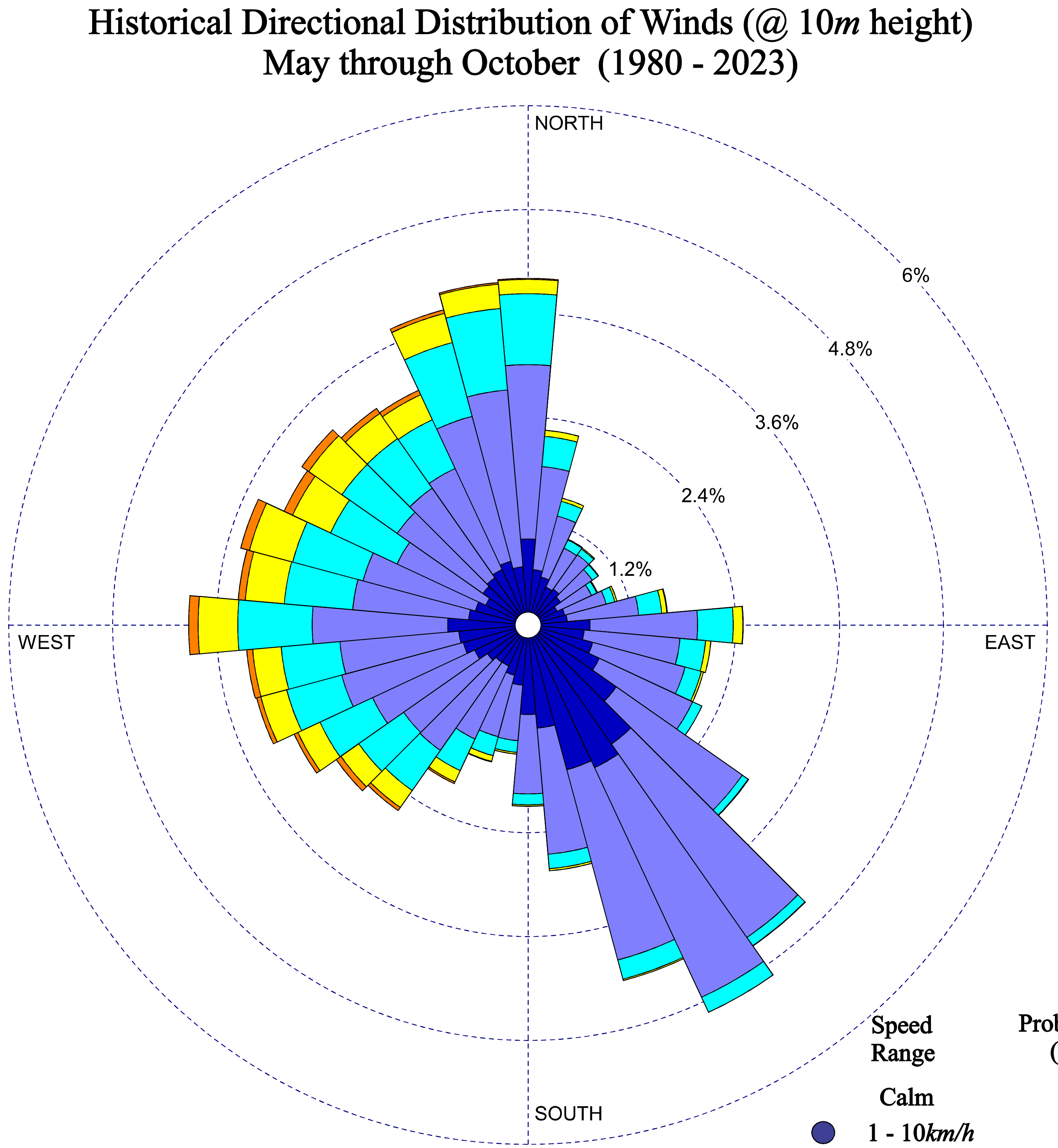


Figure 5b: Summer Wind Rose - Pearson International Airport



Speed Range	Probability (%)
Calm	4 %
1 - 10*km/h*	28 %
11 - 20*km/h*	46 %
21 - 30*km/h*	15 %
31 - 40*km/h*	6 %
> 40*km/h*	1 %

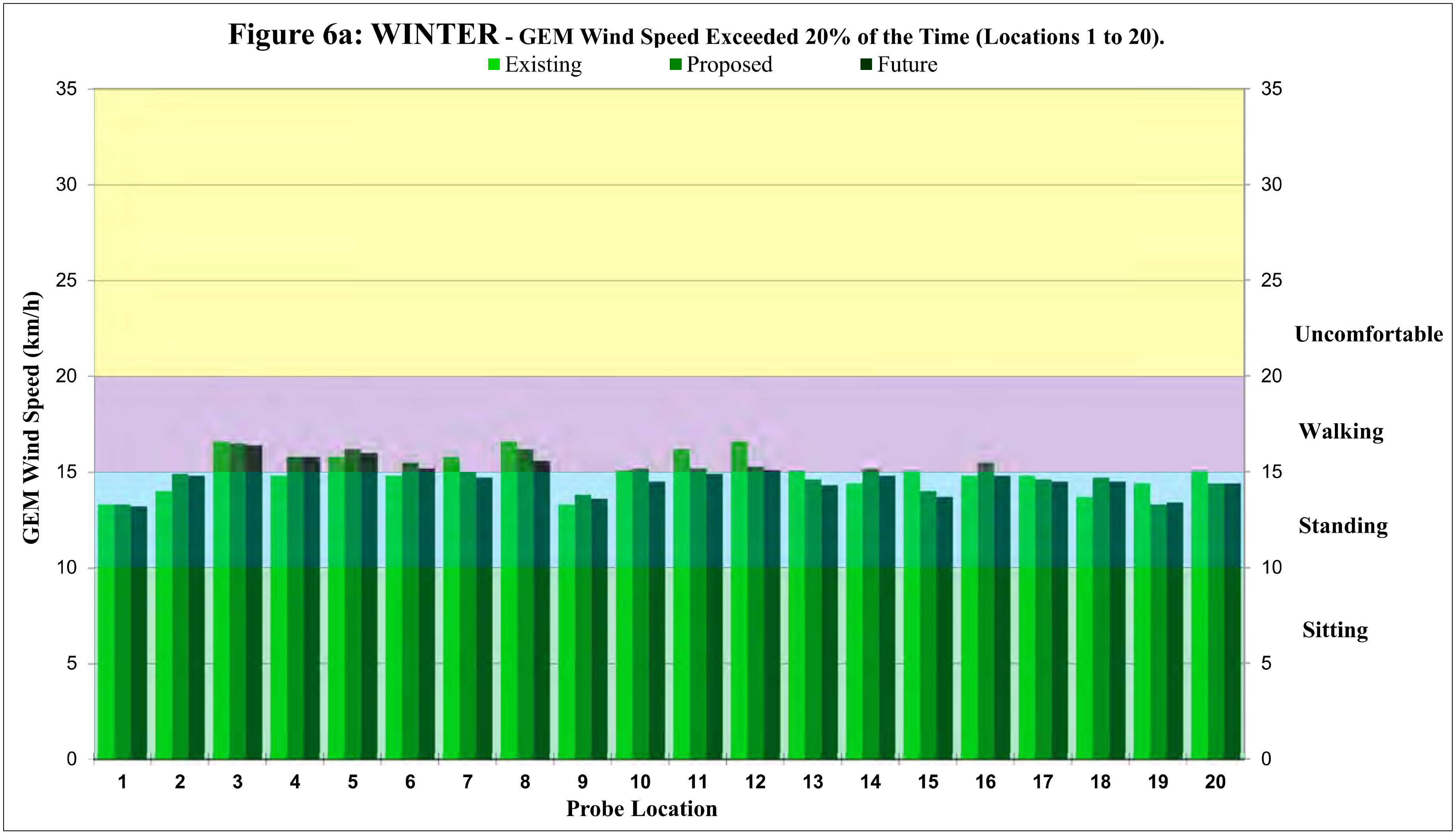


Figure 6a: WINTER - GEM Wind Speed Exceeded 20% of the Time (Locations 1 to 20).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
5
10
15
20
25
30
35
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

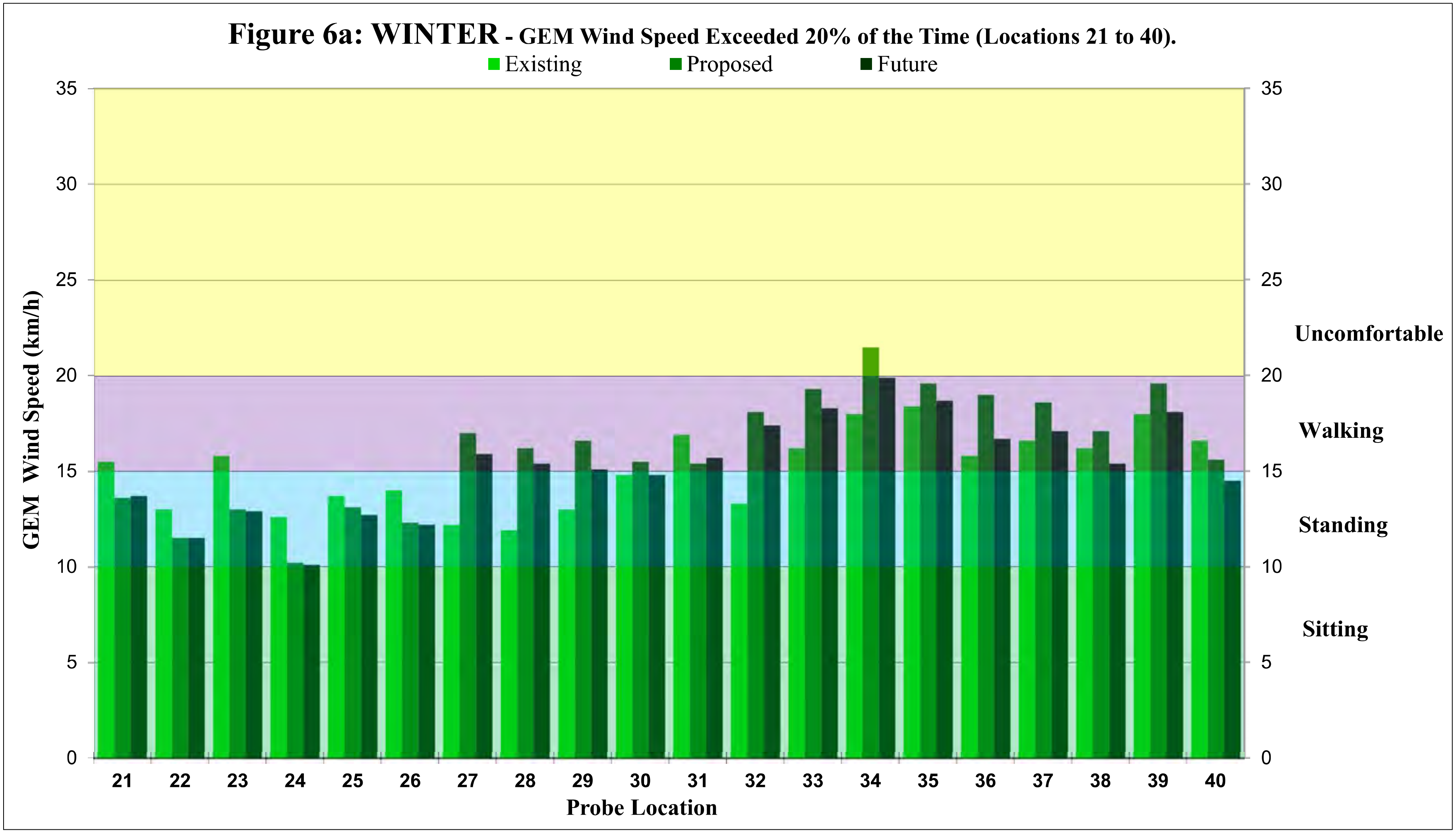


Figure 6a: WINTER - GEM Wind Speed Exceeded 20% of the Time (Locations 21 to 40).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting

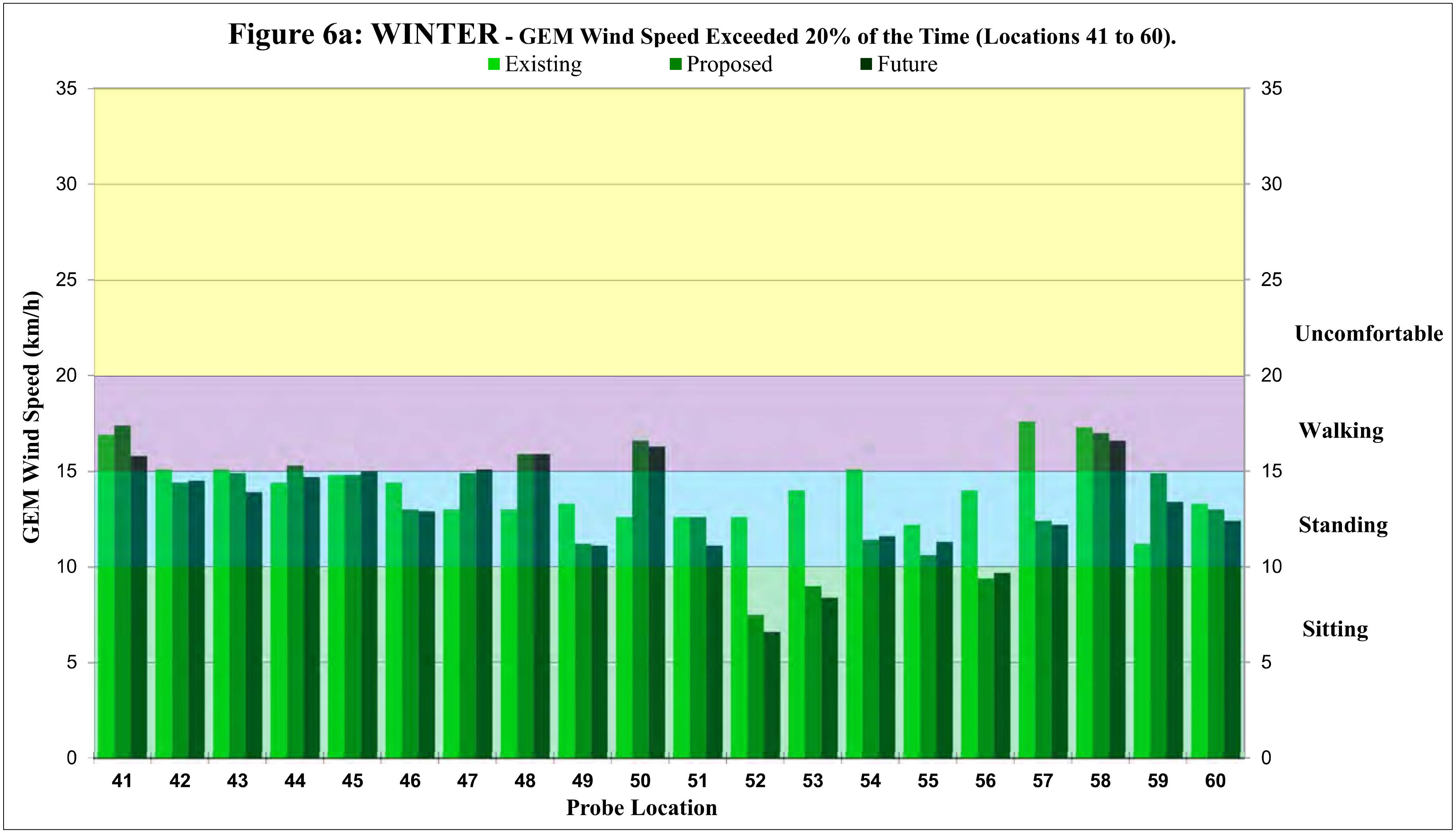


Figure 6a: WINTER - GEM Wind Speed Exceeded 20% of the Time (Locations 41 to 60).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
5
10
15
20
25
30
35
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

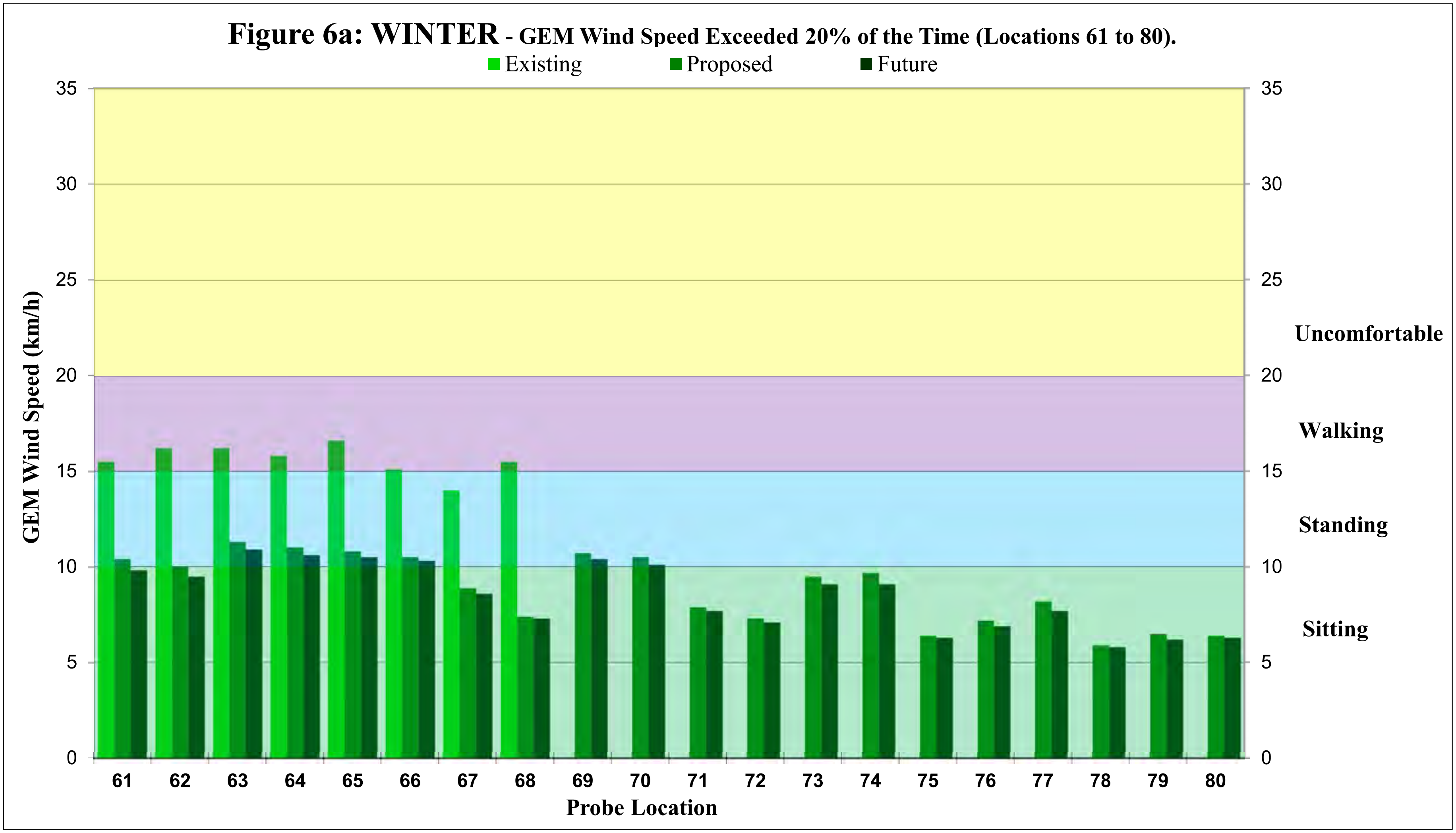


Figure 6a: WINTER - GEM Wind Speed Exceeded 20% of the Time (Locations 61 to 80).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
5
10
15
20
25
30
35
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80

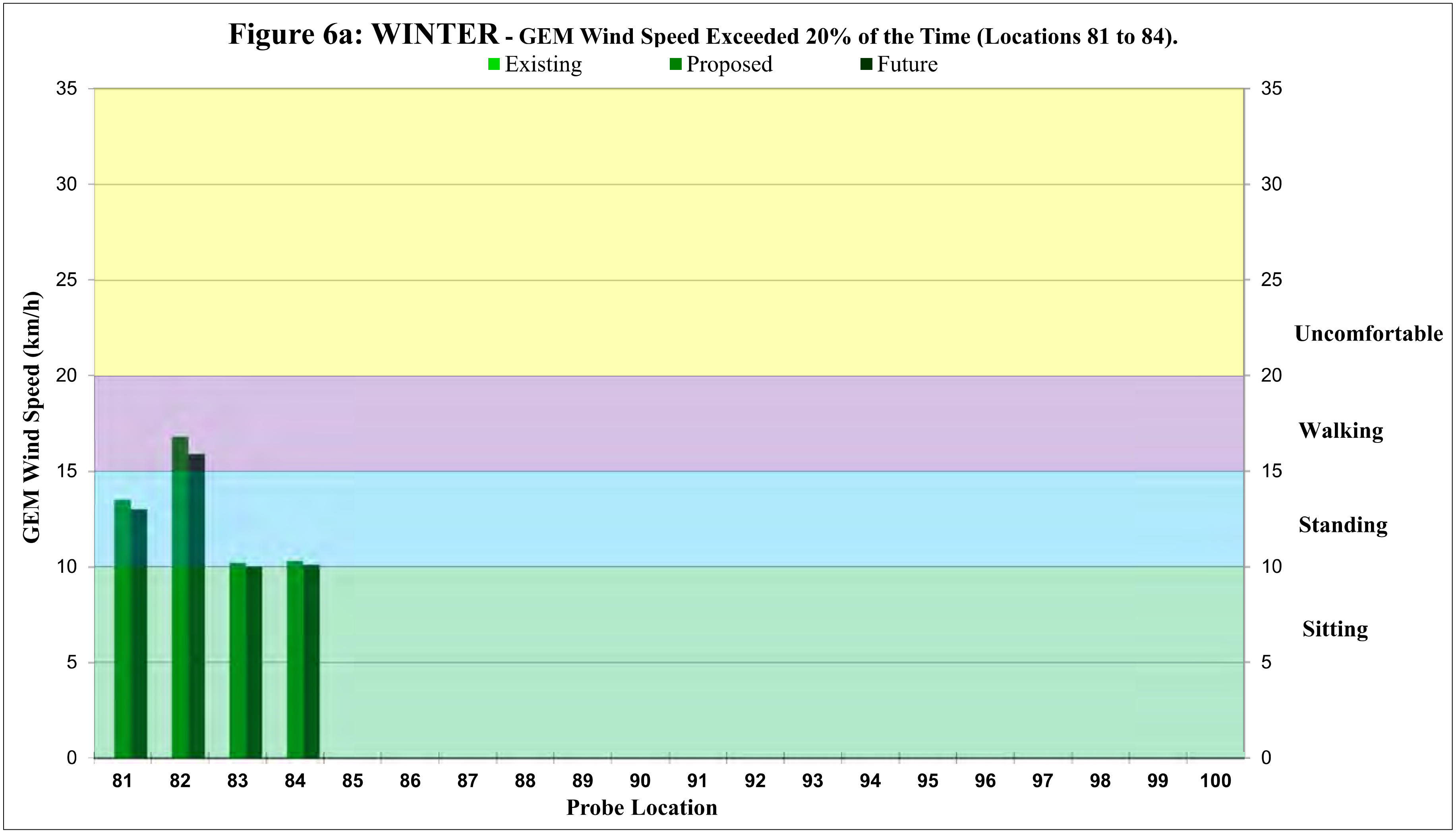


Figure 6a: WINTER - GEM Wind Speed Exceeded 20% of the Time (Locations 81 to 84).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
5
10
15
20
25
30
35
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

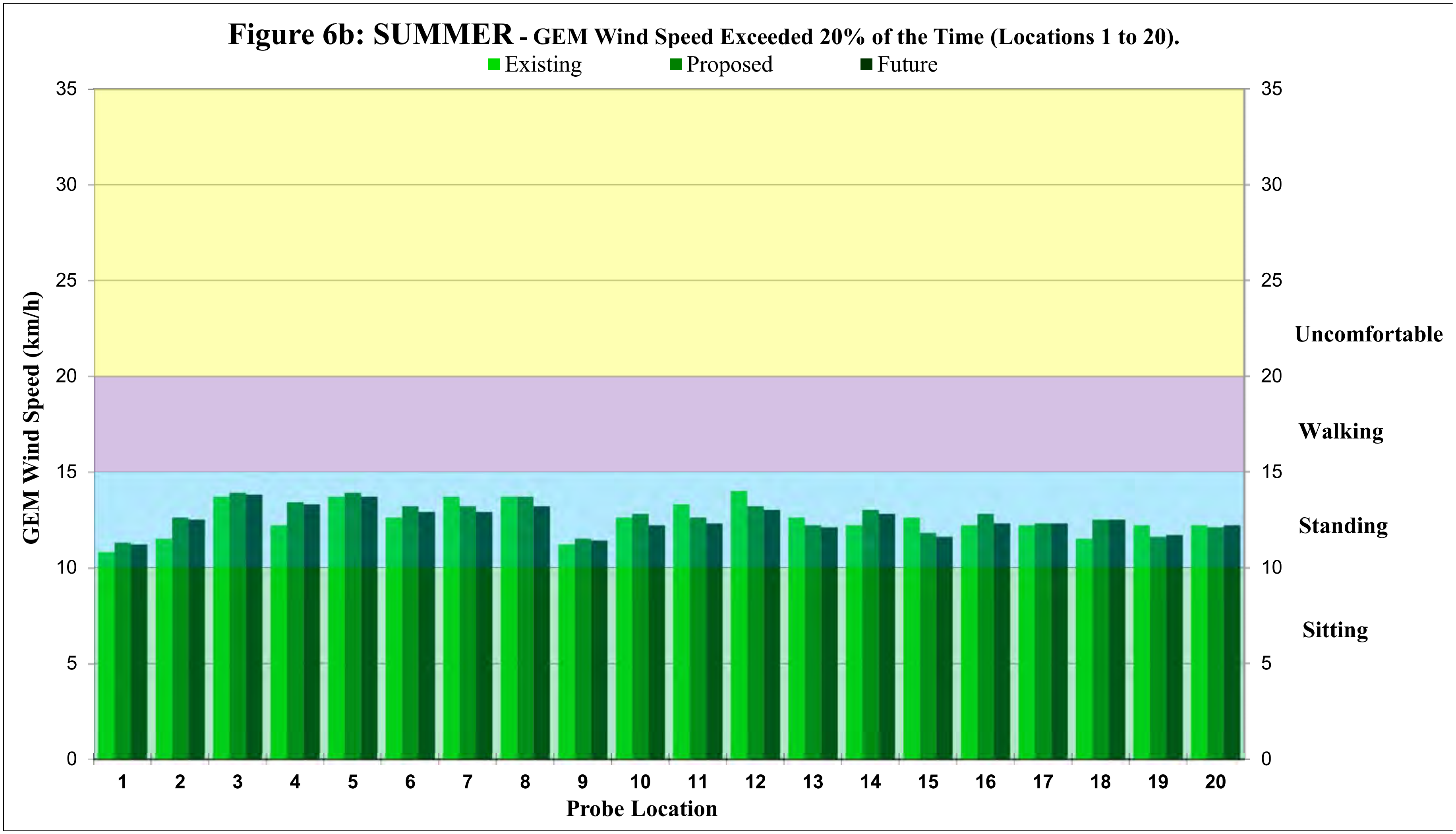


Figure 6b: SUMMER - GEM Wind Speed Exceeded 20% of the Time (Locations 1 to 20).
Existing
Proposed
Future
GEM Wind Speed (km/h)
0
5
10
15
20
25
30
35
Uncomfortable
Walking
Standing
Sitting
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Probe Location

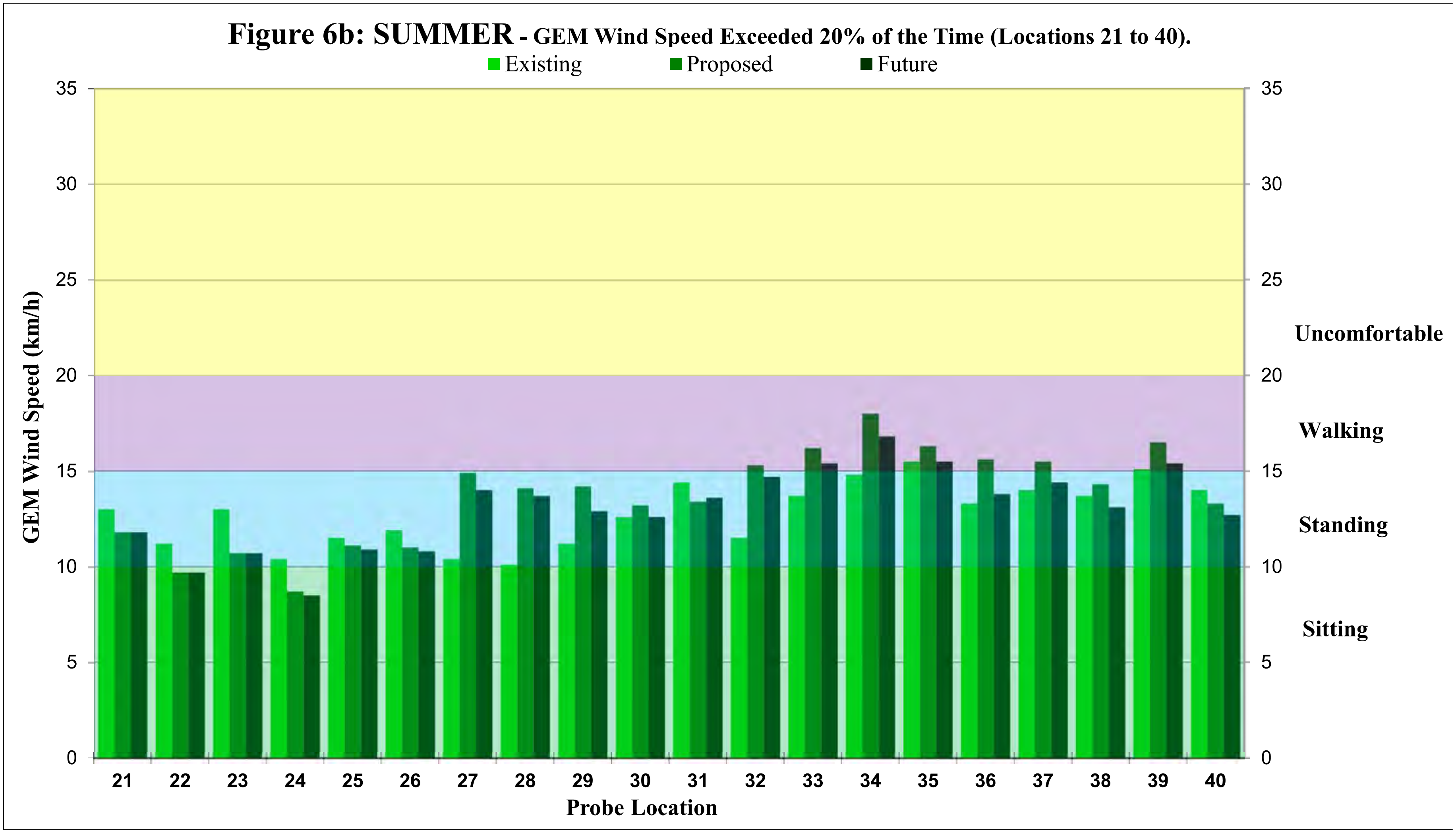


Figure 6b: SUMMER - GEM Wind Speed Exceeded 20% of the Time (Locations 21 to 40).
Existing
Proposed
Future
GEM Wind Speed (km/h)
Probe Location
Uncomfortable
Walking
Standing
Sitting
0
5
10
15
20
25
30
35
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

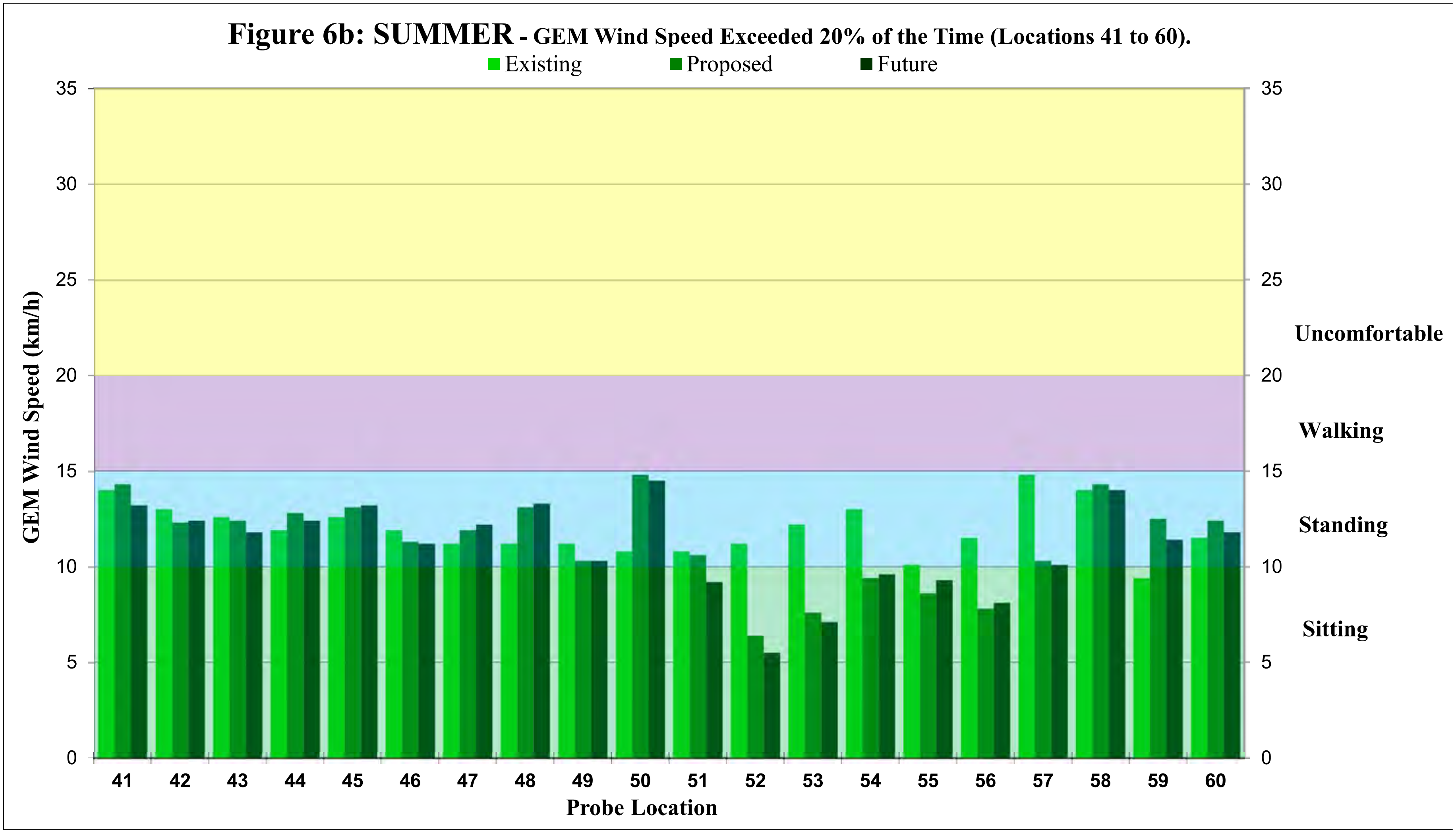


Figure 6b: SUMMER - GEM Wind Speed Exceeded 20% of the Time (Locations 41 to 60).
Existing
Proposed
Future
GEM Wind Speed (km/h)
0
5
10
15
20
25
30
35
Uncomfortable
Walking
Standing
Sitting
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Probe Location

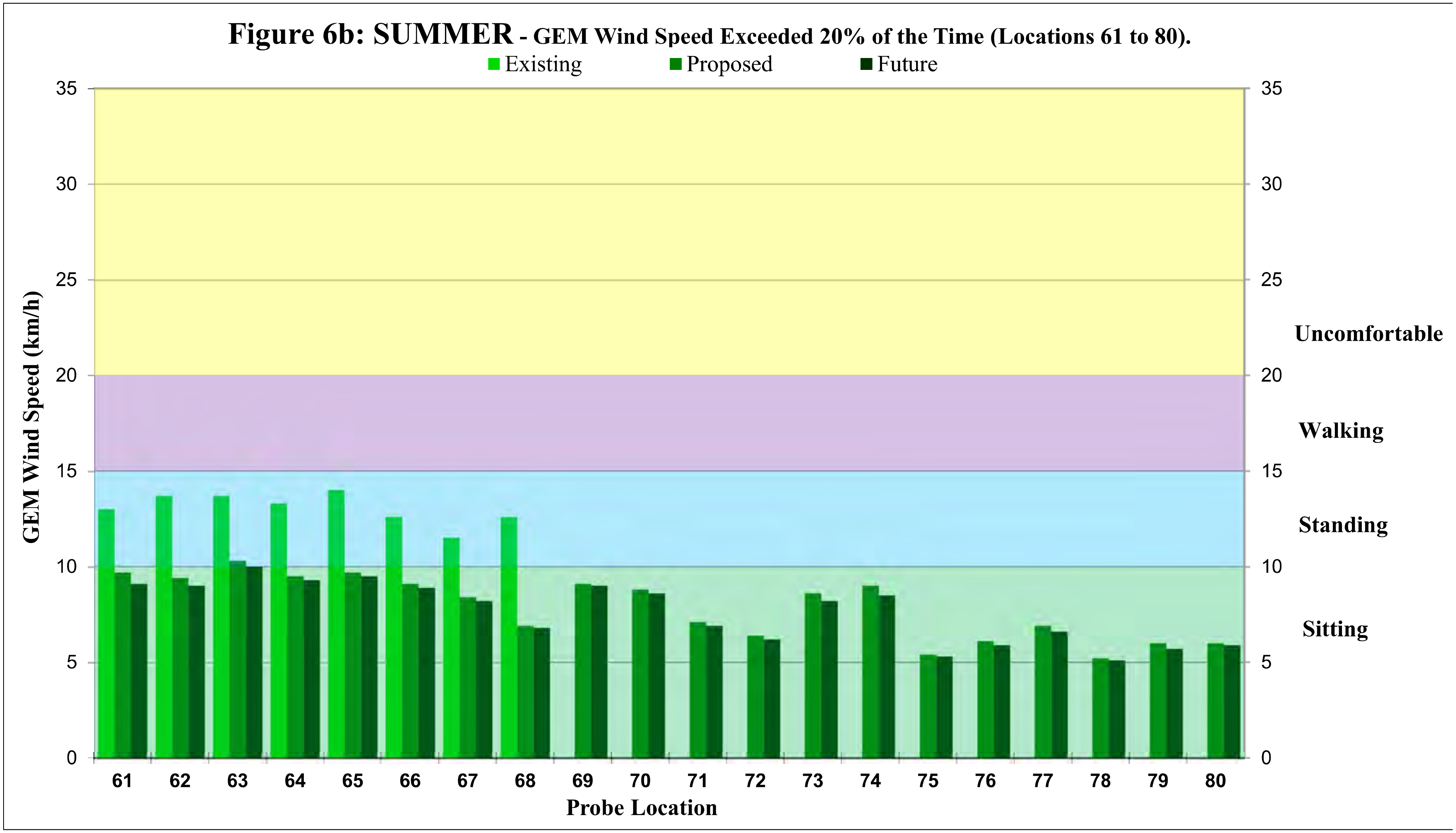


Figure 6b: SUMMER - GEM Wind Speed Exceeded 20% of the Time (Locations 61 to 80).
Existing
Proposed
Future
GEM Wind Speed (km/h)
35
30
25
20
15
10
5
0
Uncomfortable
Walking
Standing
Sitting
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
Probe Location

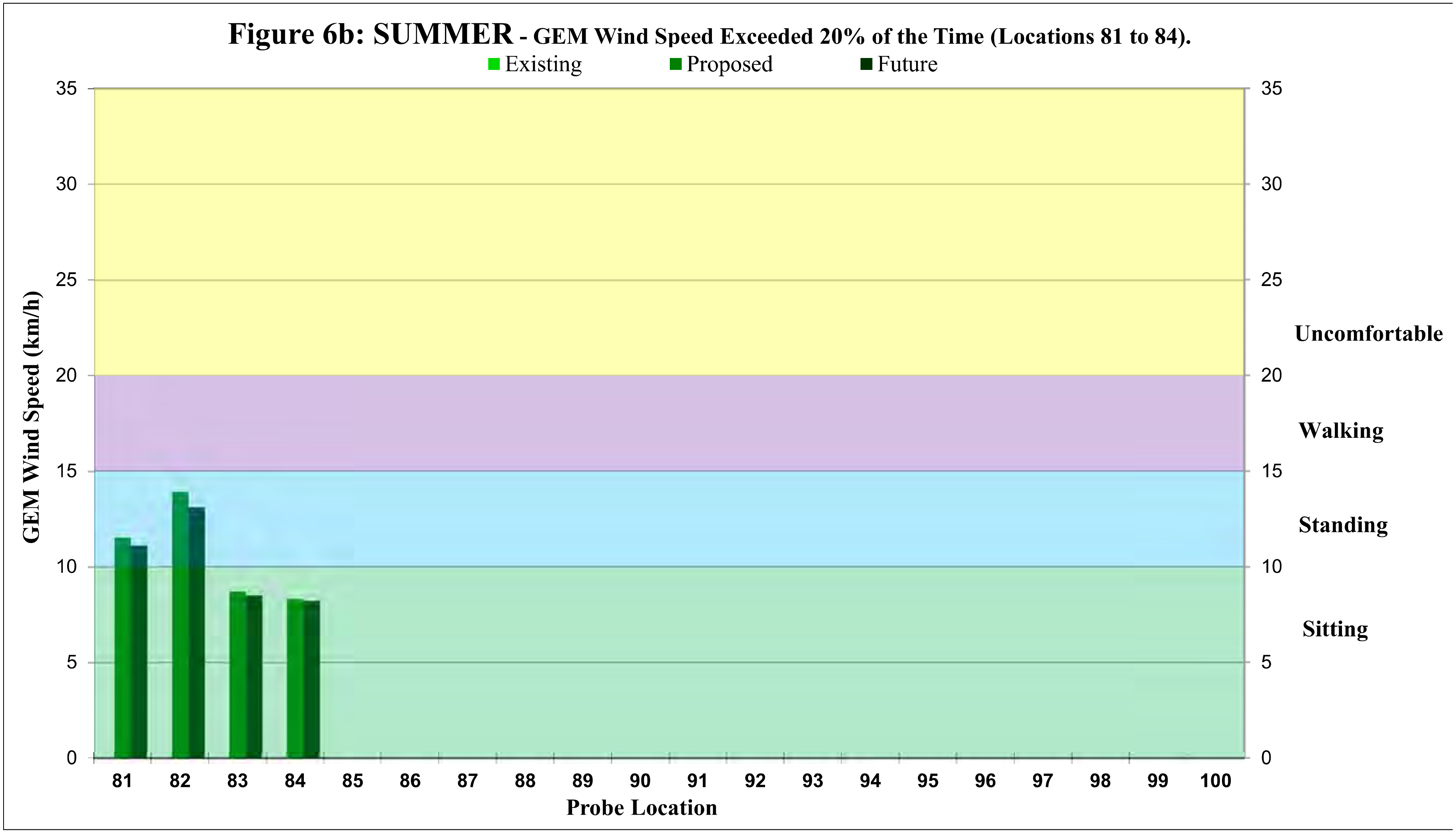
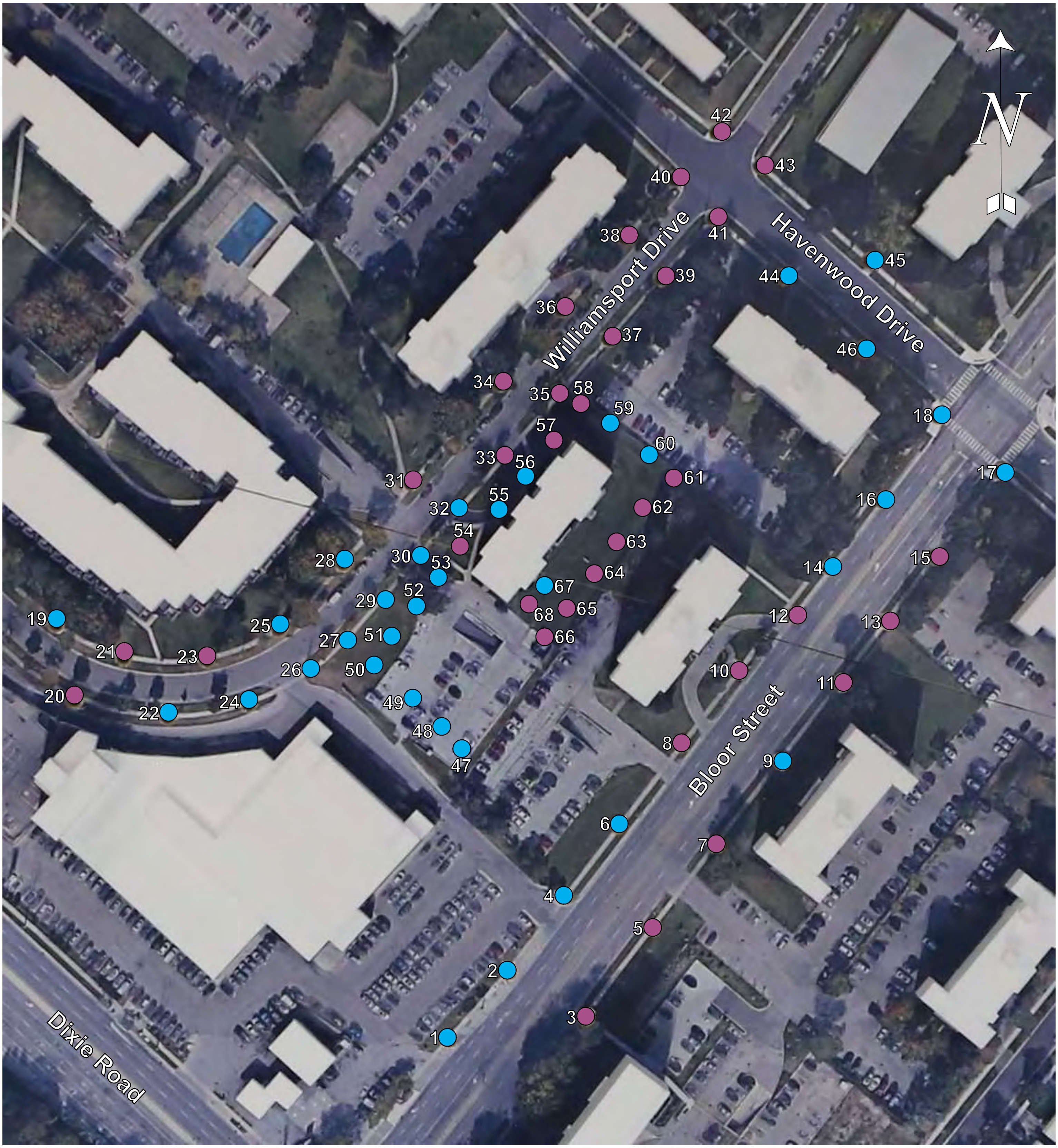


Figure 6b: SUMMER - GEM Wind Speed Exceeded 20% of the Time (Locations 81 to 84).
Existing
Proposed
Future
GEM Wind Speed (km/h)
0
5
10
15
20
25
30
35
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
Probe Location
Uncomfortable
Walking
Standing
Sitting

Figure 7a: Pedestrian level wind velocity comfort categories.



Comfort Categories - Winter - Existing

Sitting Standing Walking Uncomfortable

Figure 7b: Pedestrian level wind velocity comfort categories.

Comfort Categories - Winter - Proposed

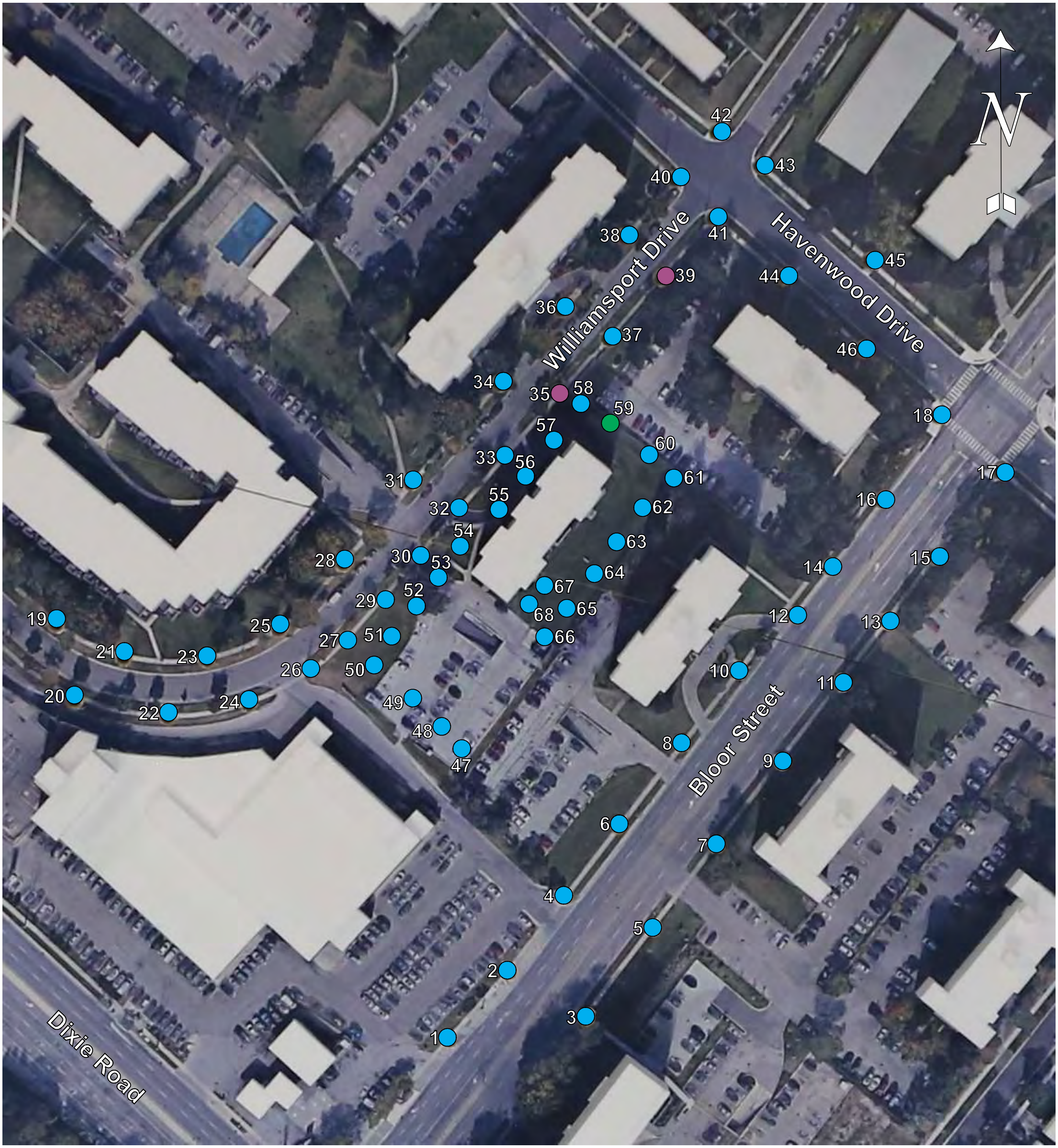
Sitting Standing Walking Uncomfortable

Figure 7c: Pedestrian level wind velocity comfort categories.

Comfort Categories - Winter - Future

Sitting Standing Walking Uncomfortable

Figure 7d: Pedestrian level wind velocity comfort categories.



Comfort Categories - Summer - Existing

Sitting Standing Walking Uncomfortable

Theakston Environmental

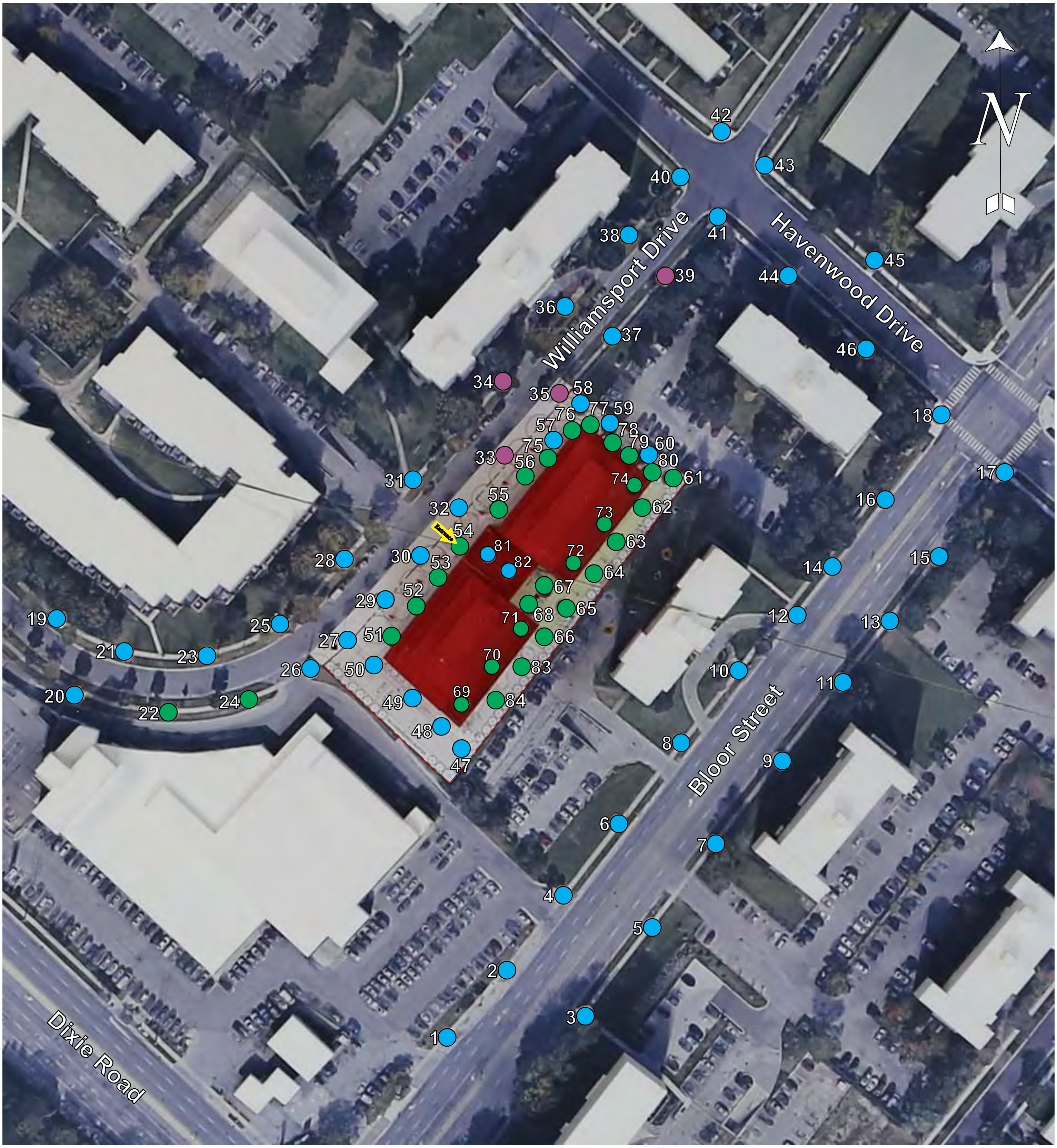
Figure 7e: Pedestrian level wind velocity comfort categories.

Comfort Categories - Summer - Proposed

Sitting Standing Walking Uncomfortable

Theakston
Environmental

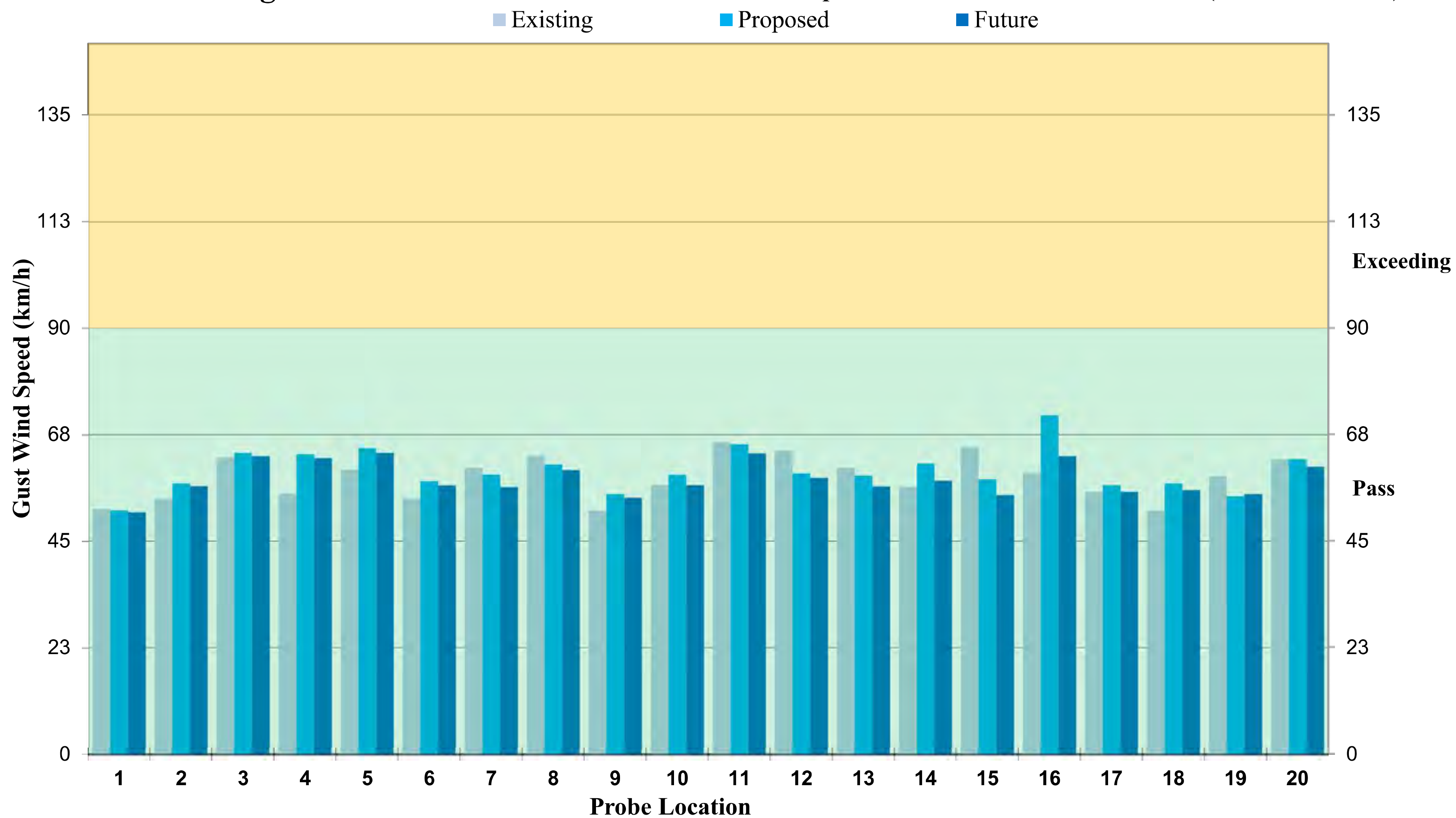
Figure 7f: Pedestrian level wind velocity comfort categories.



Comfort Categories - Summer - Future

Sitting Standing Walking Uncomfortable

Figure 8: SAFETY CRITERIA - Gust Wind Speed Exceeded Nine Times Per Year (Locations 1 to 20).



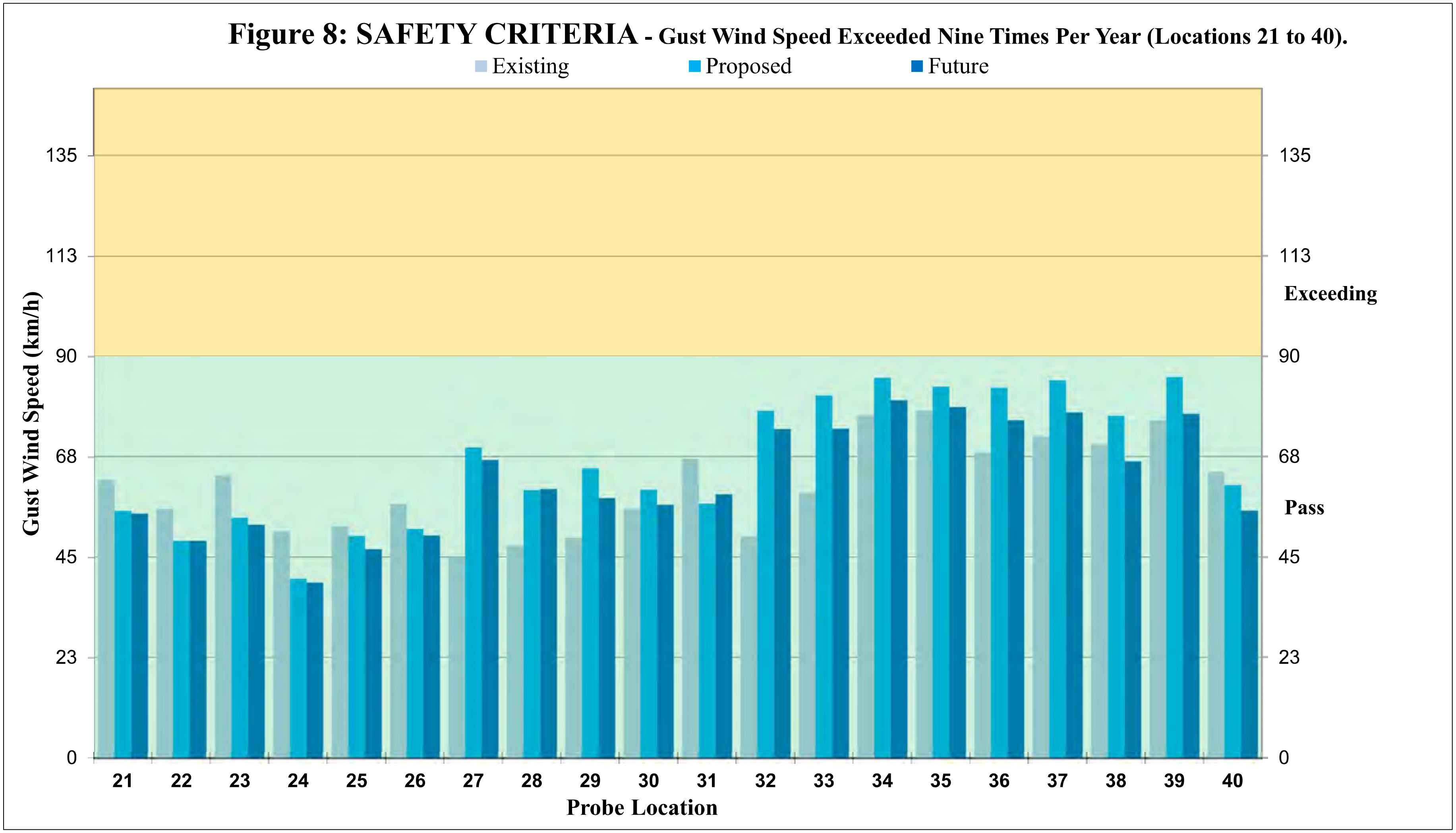


Figure 8: SAFETY CRITERIA - Gust Wind Speed Exceeded Nine Times Per Year (Locations 21 to 40).
Existing
Proposed
Future
Gust Wind Speed (km/h)
135
113
90
68
45
23
0
Exceeding
Pass
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Probe Location

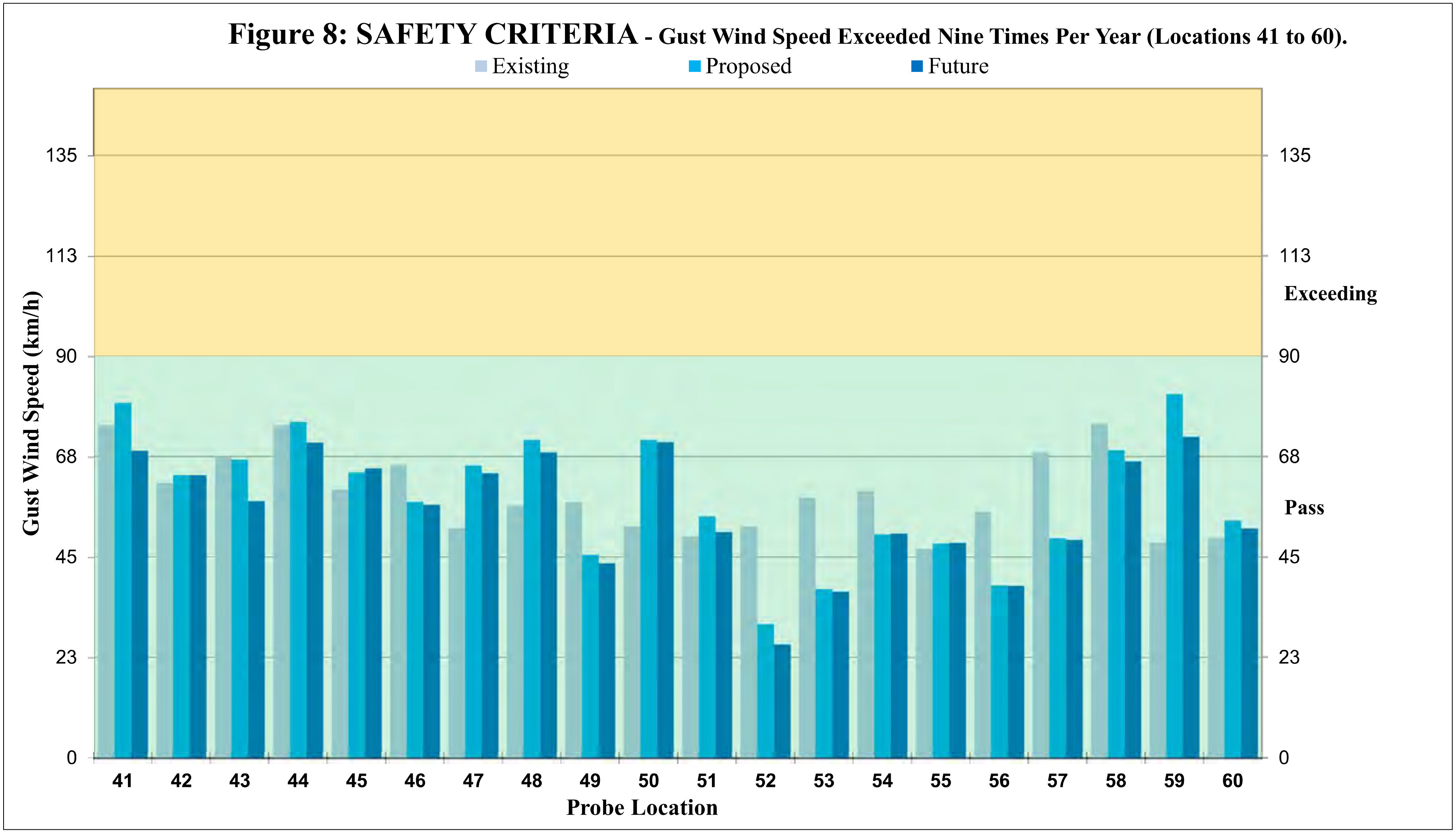


Figure 8: SAFETY CRITERIA - Gust Wind Speed Exceeded Nine Times Per Year (Locations 41 to 60).
Existing
Proposed
Future
Gust Wind Speed (km/h)
135
113
90
68
45
23
0
Exceeding
Pass
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Probe Location

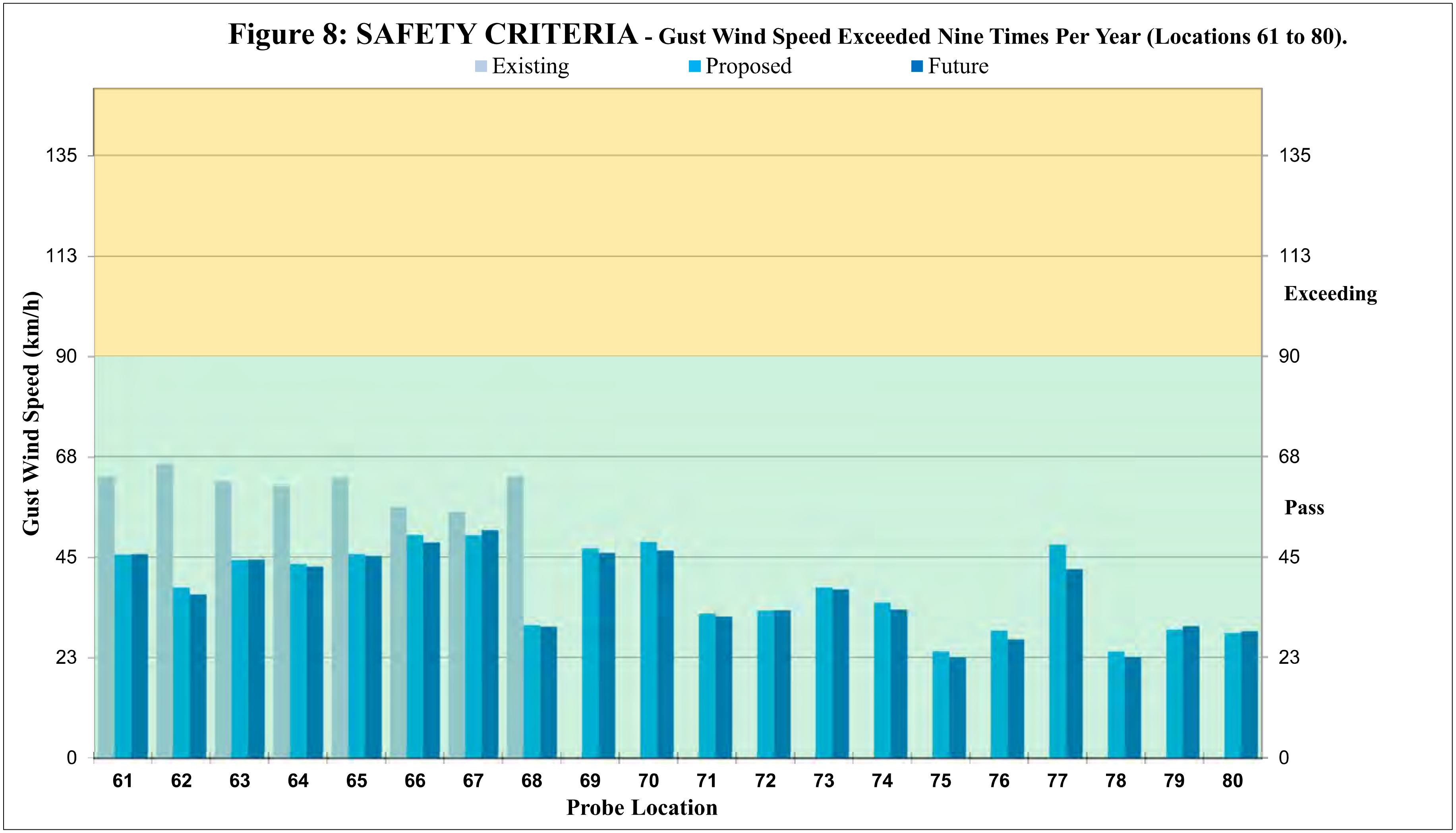


Figure 8: SAFETY CRITERIA - Gust Wind Speed Exceeded Nine Times Per Year (Locations 61 to 80).
Existing
Proposed
Future
Gust Wind Speed (km/h)
135
113
90
68
45
23
0
Exceeding
Pass
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
Probe Location

Figure 8: SAFETY CRITERIA - **Gust Wind Speed Exceeded Nine Times Per Year (Locations 81 to 84).**

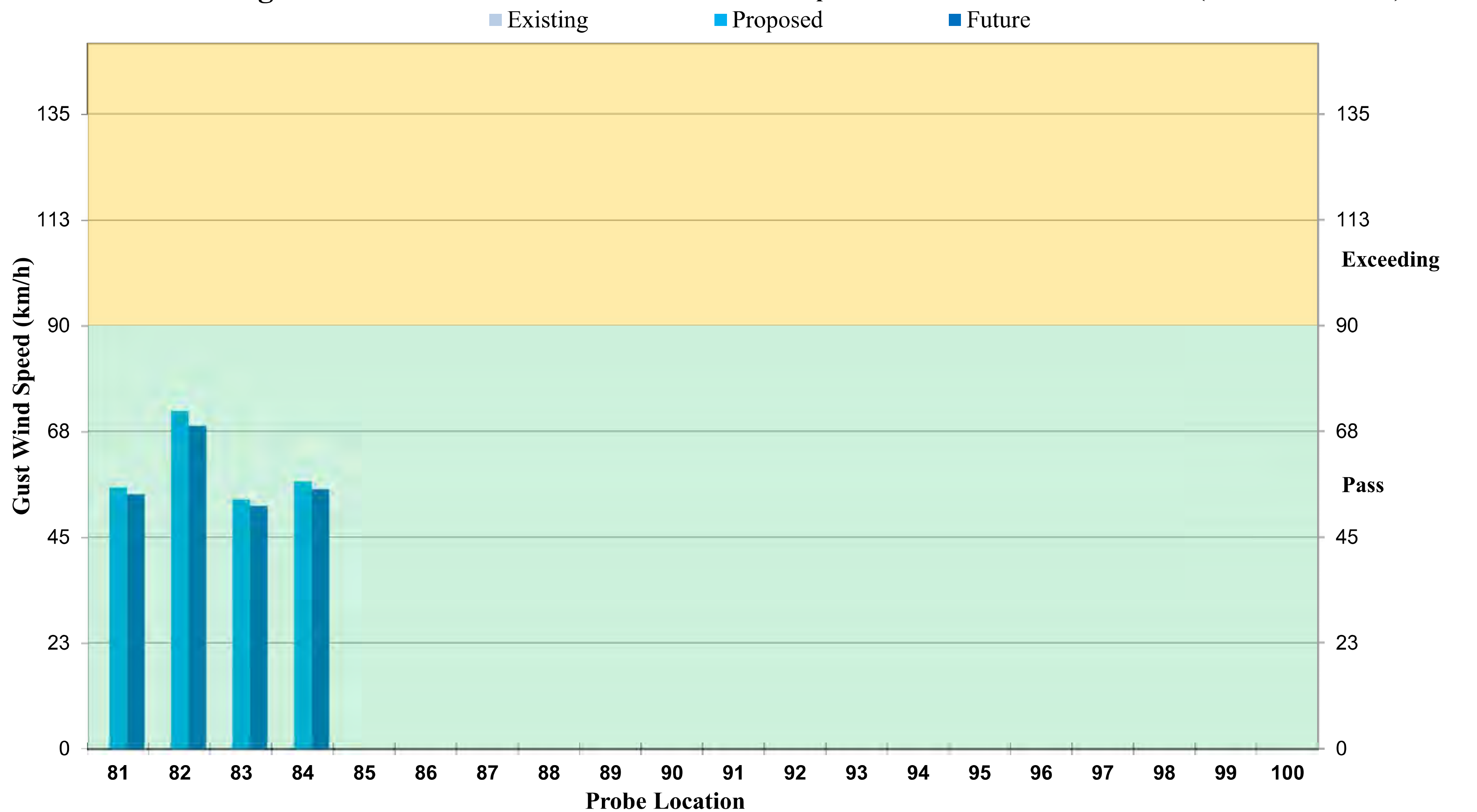
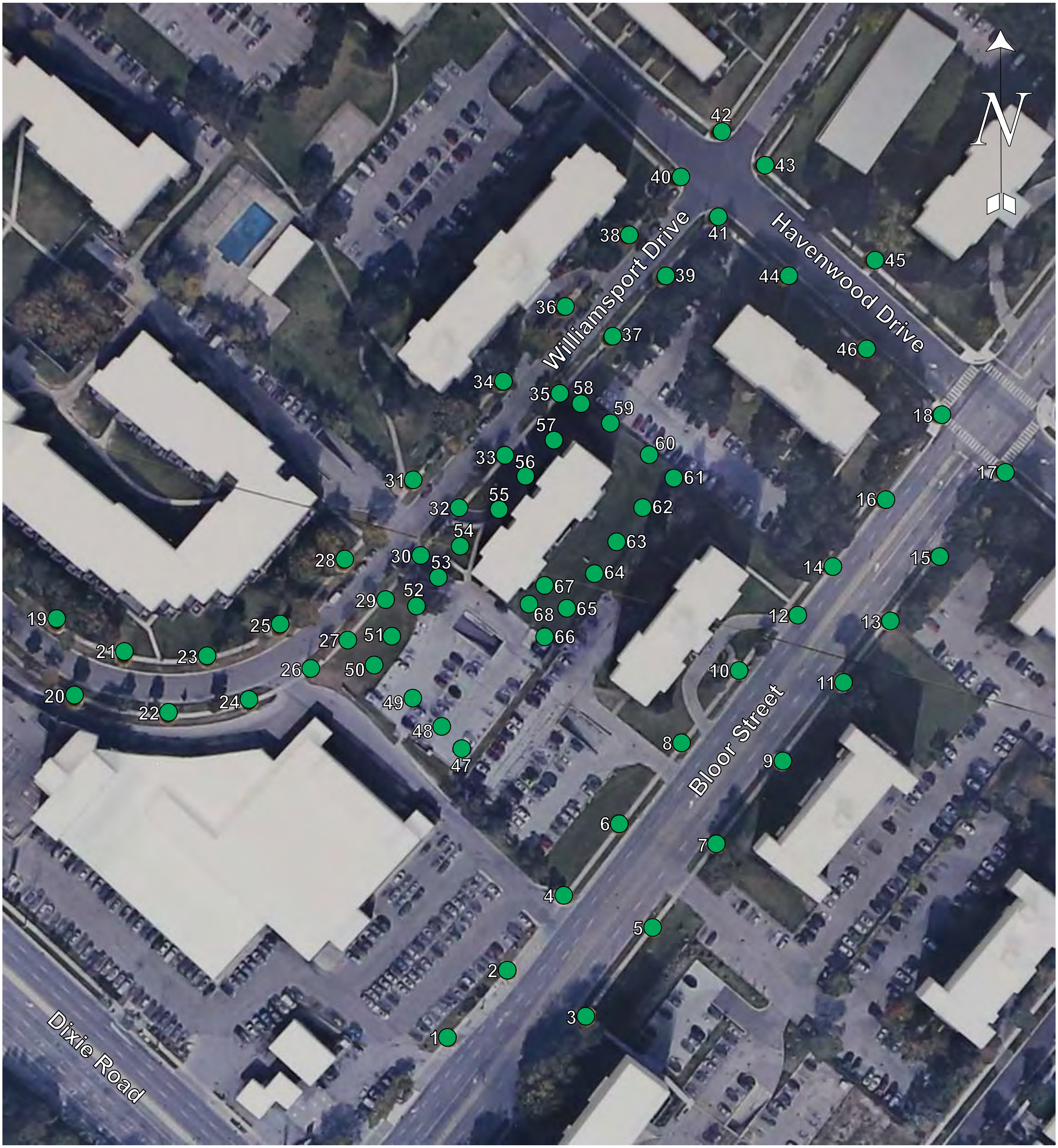


Figure 9a: Pedestrian level wind velocity safety criteria.



Safety Criteria - Existing

Pass Exceeding

Figure 9b: Pedestrian level wind velocity safety criteria.

Safety Criteria - Proposed

Pass Exceeding

Theakston Environmental

Figure 9c: Pedestrian level wind velocity safety criteria.

Safety Criteria - Future

Pass Exceeding

Figure 10: Pedestrian Level Wind Comfort and Safety Comparison Table.

	GEM Speed (km/h)						Gust Speed (km/h)		
	Winter			Summer			Safety		
Probe	Existing	Proposed	Future	Existing	Proposed	Future	Existing	Proposed	Future
1	13.3	13.3	13.2	10.8	11.3	11.2	51.8	51.5	51.1
2	14.0	14.9	14.8	11.5	12.6	12.5	54.0	57.2	56.6
3	16.6	16.5	16.4	13.7	13.9	13.8	62.6	63.6	63.0
4	14.8	15.8	15.8	12.2	13.4	13.3	55.1	63.4	62.5
5	15.8	16.2	16.0	13.7	13.9	13.7	60.1	64.6	63.6
6	14.8	15.5	15.2	12.6	13.2	12.9	54.0	57.7	56.8
7	15.8	15.0	14.7	13.7	13.2	12.9	60.5	59.0	56.4
8	16.6	16.2	15.6	13.7	13.7	13.2	63.0	61.2	60.0
9	13.3	13.8	13.6	11.2	11.5	11.4	51.5	54.9	54.2
10	15.1	15.2	14.5	12.6	12.8	12.2	56.9	59.0	56.8
11	16.2	15.2	14.9	13.3	12.6	12.3	65.9	65.4	63.5
12	16.6	15.3	15.1	14.0	13.2	13.0	64.1	59.3	58.4
13	15.1	14.6	14.3	12.6	12.2	12.1	60.5	58.8	56.6
14	14.4	15.2	14.8	12.2	13.0	12.8	56.5	61.4	57.8
15	15.1	14.0	13.7	12.6	11.8	11.6	64.8	58.1	54.7
16	14.8	15.5	14.8	12.2	12.8	12.3	59.4	71.6	63.0
17	14.8	14.6	14.5	12.2	12.3	12.3	55.4	56.8	55.4
18	13.7	14.7	14.5	11.5	12.5	12.5	51.5	57.2	55.8
19	14.4	13.3	13.4	12.2	11.6	11.7	58.7	54.5	55.0
20	15.1	14.4	14.4	12.2	12.1	12.2	62.3	62.3	60.7
21	15.5	13.6	13.7	13.0	11.8	11.8	62.3	55.3	54.7
22	13.0	11.5	11.5	11.2	9.7	9.7	55.8	48.6	48.6
23	15.8	13.0	12.9	13.0	10.7	10.7	63.4	53.7	52.2
24	12.6	10.2	10.1	10.4	8.7	8.5	50.8	40.1	39.3
25	13.7	13.1	12.7	11.5	11.1	10.9	51.8	49.7	46.8
26	14.0	12.3	12.2	11.9	11.0	10.8	56.9	51.3	49.8
27	12.2	17.0	15.9	10.4	14.9	14.0	45.0	69.5	66.7
28	11.9	16.2	15.4	10.1	14.1	13.7	47.5	59.9	60.2
29	13.0	16.6	15.1	11.2	14.2	12.9	49.3	64.9	58.2
30	14.8	15.5	14.8	12.6	13.2	12.6	55.8	60.0	56.7
31	16.9	15.4	15.7	14.4	13.4	13.6	67.0	57.0	59.0
32	13.3	18.1	17.4	11.5	15.3	14.7	49.7	77.8	73.6
33	16.2	19.3	18.3	13.7	16.2	15.4	59.4	81.2	73.8
34	18.0	21.5	19.9	14.8	18.0	16.8	76.7	85.1	80.1
35	18.4	19.6	18.7	15.5	16.3	15.5	77.8	83.2	78.6
36	15.8	19.0	16.7	13.3	15.6	13.8	68.4	82.9	75.6
37	16.6	18.6	17.1	14.0	15.5	14.4	72.0	84.6	77.4
38	16.2	17.1	15.4	13.7	14.3	13.1	70.2	76.6	66.4
39	18.0	19.6	18.1	15.1	16.5	15.4	75.6	85.3	77.1
40	16.6	15.6	14.5	14.0	13.3	12.7	64.1	61.1	55.4
41	16.9	17.4	15.8	14.0	14.3	13.2	74.5	79.5	68.8
42	15.1	14.4	14.5	13.0	12.3	12.4	61.6	63.4	63.3
43	15.1	14.9	13.9	12.6	12.4	11.8	67.3	66.8	57.5
44	14.4	15.3	14.7	11.9	12.8	12.4	74.5	75.2	70.6
45	14.8	14.8	15.0	12.6	13.1	13.2	60.1	64.0	64.9
46	14.4	13.0	12.9	11.9	11.3	11.2	65.5	57.3	56.7
47	13.0	14.9	15.1	11.2	11.9	12.2	51.5	65.5	63.8
48	13.0	15.9	15.9	11.2	13.1	13.3	56.5	71.2	68.4
49	13.3	11.2	11.1	11.2	10.3	10.3	57.2	45.5	43.6
50	12.6	16.6	16.3	10.8	14.8	14.5	51.8	71.2	70.7

	GEM Speed (km/h)						Gust Speed (km/h)		
	Winter			Summer			Safety		
Probe	Existing	Proposed	Future	Existing	Proposed	Future	Existing	Proposed	Future
51	12.6	12.6	11.1	10.8	10.6	9.2	49.7	54.1	50.6
52	12.6	7.5	6.6	11.2	6.4	5.5	51.8	30.0	25.4
53	14.0	9.0	8.4	12.2	7.6	7.1	58.3	37.8	37.3
54	15.1	11.4	11.6	13.0	9.4	9.6	59.8	50.1	50.3
55	12.2	10.6	11.3	10.1	8.6	9.3	46.8	48.0	48.2
56	14.0	9.4	9.7	11.5	7.8	8.1	55.1	38.6	38.6
57	17.6	12.4	12.2	14.8	10.3	10.1	68.4	49.2	48.8
58	17.3	17.0	16.6	14.0	14.3	14.0	74.9	68.9	66.4
59	11.2	14.9	13.4	9.4	12.5	11.4	48.2	81.5	71.9
60	13.3	13.0	12.4	11.5	12.4	11.8	49.3	53.2	51.4
61	15.5	10.4	9.8	13.0	9.7	9.1	63.0	45.5	45.6
62	16.2	10.0	9.5	13.7	9.4	9.0	65.9	38.2	36.6
63	16.2	11.3	10.9	13.7	10.3	10.0	61.9	44.3	44.4
64	15.8	11.0	10.6	13.3	9.5	9.3	60.8	43.4	42.9
65	16.6	10.8	10.5	14.0	9.7	9.5	62.6	45.7	45.3
66	15.1	10.5	10.3	12.6	9.1	8.9	56.2	49.9	48.2
67	14.0	8.9	8.6	11.5	8.4	8.2	55.1	49.9	51.0
68	15.5	7.4	7.3	12.6	6.9	6.8	63.0	29.7	29.4
69	0.0	10.7	10.4	0.0	9.1	9.0	0.0	47.0	45.9
70	0.0	10.5	10.1	0.0	8.8	8.6	0.0	48.3	46.4
71	0.0	7.9	7.7	0.0	7.1	6.9	0.0	32.3	31.6
72	0.0	7.3	7.1	0.0	6.4	6.2	0.0	33.0	33.1
73	0.0	9.5	9.1	0.0	8.6	8.2	0.0	38.2	37.8
74	0.0	9.7	9.1	0.0	9.0	8.5	0.0	34.8	33.2
75	0.0	6.4	6.3	0.0	5.4	5.3	0.0	23.9	22.5
76	0.0	7.2	6.9	0.0	6.1	5.9	0.0	28.5	26.5
77	0.0	8.2	7.7	0.0	6.9	6.6	0.0	47.8	42.3
78	0.0	5.9	5.8	0.0	5.2	5.1	0.0	23.8	22.6
79	0.0	6.5	6.2	0.0	6.0	5.7	0.0	28.8	29.5
80	0.0	6.4	6.3	0.0	6.0	5.9	0.0	28.0	28.4
81	0.0	13.5	13.0	0.0	11.5	11.1	0.0	55.5	54.1
82	0.0	16.8	15.9	0.0	13.9	13.1	0.0	71.8	68.7
83	0.0	10.2	10.0	0.0	8.7	8.5	0.0	53.0	51.6
84	0.0	10.3	10.1	0.0	8.3	8.2	0.0	56.8	55.2
85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Comfort (km/h)				Safety (km/h)	
0 - 10	Sitting	15 - 20	Walking	0 - 90	Pass
10 - 15	Standing	20 +	Uncomf	90 +	Exceed

7. APPENDIX

BACKGROUND AND THEORY OF WIND MOVEMENT

During the course of a modular analysis of an existing or proposed site, pertinent wind directions must be analysed with regard to the macroclimate and microclimate. In order for the results of the study to be valid, the effects of both climates must be modelled in test procedures.

Macroclimate

Wind velocity, frequency and directions are used in tests with models to establish part of the macroclimate. These variables are determined from meteorological data collected at the closest weather monitoring station. This information is used in the analysis of the site to establish upstream (approach) wind and weather conditions.

When evaluating approach wind velocities and characteristic profiles in the field it is necessary to evaluate certain boundary conditions. At the earth's surface, "no slip" conditions require the wind speed to be zero. At an altitude of approximately one kilometre above the earth's surface, the motion of the wind is governed by pressure distributions associated with large-scale weather systems. Consequently, these winds, known as "geostrophic" or "freestream" winds, are independent of the surface topography. In model simulation, as in the field, the area of concern is the boundary layer between the earth's surface and the geostrophic winds. The term boundary layer is used to describe the velocity profile of wind currents as they increase from zero to the geostrophic velocity.

The approach boundary layer profile is affected by specific surface topography upstream of the test site. Over relatively rough terrain (urban) the boundary layer is thicker and the wind speed increases rather slowly with height. The opposite is true over open terrain (rural). The following power law equation is used to represent the mean velocity profile for any given topographic condition:

$$\frac{U}{U_F} = \left(\frac{z}{z_F}\right)^a$$

where U = wind velocity (m/s) at height z (m)
a = power law exponent
and subscript $_F$ refers to freestream conditions

Typical values for a and z_F are summarized below:

Terrain	a	z_F (m)
Rural	0.14 - 0.17	260 - 300
Suburban	0.20 - 0.28	300 - 420
Urban	0.28 - 0.40	420 - 550

Wind data is recorded at meteorological stations at a height z_{ref}, usually equal to about 10m above grade. This historical mean wind velocity and frequency data is often presented in the form of a wind rose. The mean wind velocity at z_{ref}, along with the appropriate constants based on terrain type, are used to determine the value for U_F, completing the definition of the boundary layer profile specific to the site. The following Figure shows representations of the boundary layer profile for each of the above terrain conditions:

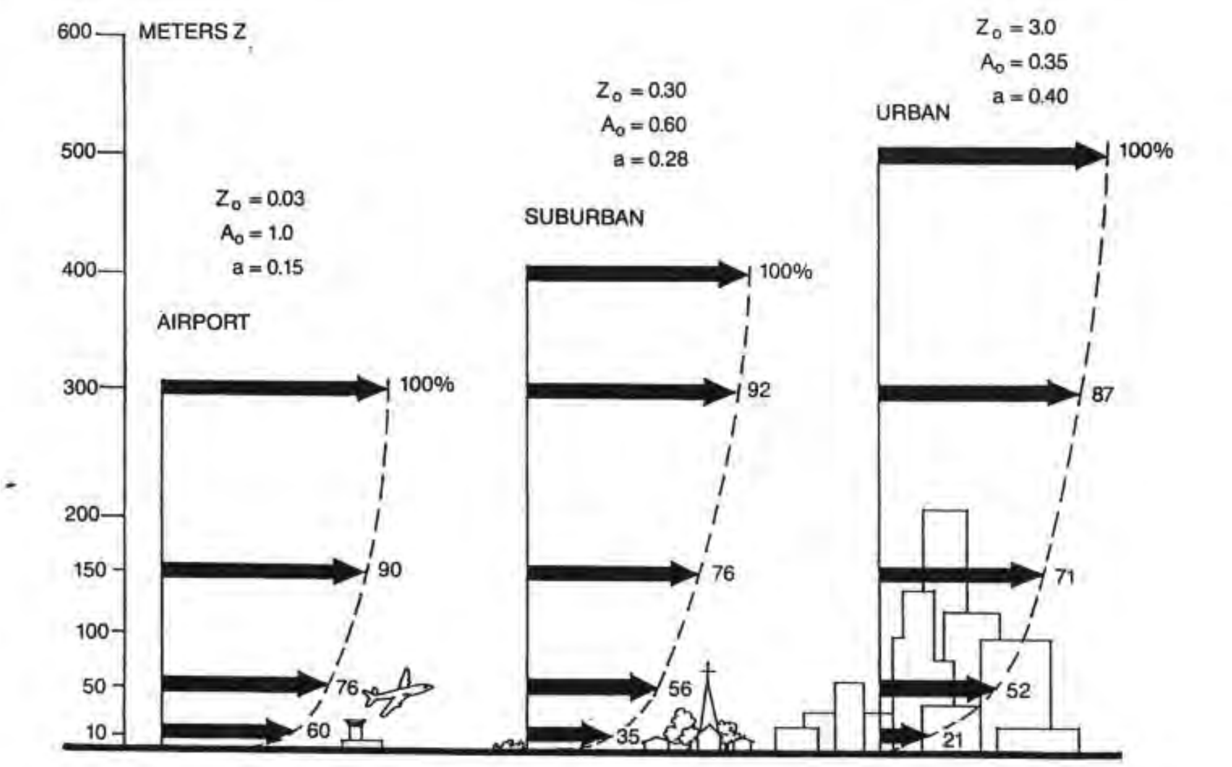


Figure A: Mean wind speed profiles for various terrain (from ASHRAE 1989).

For the above velocity profiles, ground level velocities at a height of $z = 2m$, for an urban macroclimate are approximately 52% of the mean values recorded at the meteorological station at a height equal to $z_{ref} = 10m$. For suburban and rural conditions, the values are 63% and 78% respectively. Thus, for a given wind speed at z_{ref} open terrain or fields (rural) will experience significantly higher ground level wind velocities than suburban or urban areas.

When a boundary layer wind flows over one terrain onto another, the boundary layer profile shape rapidly changes to that dictated by the new terrain. If the preceding wind flow is over rough suburban terrain and an open area is encountered a rapid increase in ground level winds will be realized. A similar effect will occur when large low-density residential areas are demolished to accommodate high-rise developments. The transitional open area will experience significantly higher pedestrian level winds than the previous suburban setting. Once the high-rise development is established, ground level winds will moderate with localized areas of higher pedestrian level winds likely to occur. Pedestrian level wind velocities respond to orientation and shape of the development and if the site is not appropriately engineered or mitigated, pedestrian level wind may be problematic.

Microclimate

The specific wind conditions related to the study site are known as the microclimate, which are dictated mainly by the following factors:

- The orientation and conformation of buildings within the vicinity of the site.
- The surrounding contours and pertinent landscape features.

The microclimate establishes the effect that surrounding buildings or landscape features have on the subject building and the effect the subject building has on the surrounds. For the majority of urban test sites the proper microclimate can be established by modelling an area of $300m$ in radius around the subject building. If extremely tall buildings are present then the study area must be larger, and if the building elevations are on the order of a few floors, smaller areas will suffice to establish the required microclimate.

General Wind Flow Phenomena

Wind flow across undulating terrain contains parallel streamlines with the lowest streamline adjacent to the surface. These conditions continue until the streamlines approach vertical objects. When this occurs there is a general movement of the streamlines upward ("Wind Velocity Gradient") and as they reach the top of the objects turbulence is generated on the lee side. This is one of the reasons for unexpected high wind velocities as this turbulent action moves to the base of the objects on the lee side.

Other fluid action occurs through narrow gaps between buildings (Venturi Action) and at sharp edges of a building or other vertical objects (Scour Action). These conditions are predictable at selected locations but do not conform to a set direction of wind as described by a macroclimate condition. In fact, the orientation and conformation of buildings, streets and landscaping establish a microclimate.

Because of the "Wind Velocity Gradient" phenomena, there is a "downwash" of wind at the face of buildings and this effect is felt at the pedestrian level. It may be experienced as high gusty winds or drifting snow. These effects can be obviated by windbreak devices on the windward side or by canopies over windows and doors on the lee side of the building.

The intersection of two streets or pedestrian walkways have funnelling effects of wind currents from any one of the four directions and is particularly severe at corners if the buildings project to the street line or are close to walkways.

Some high-rise buildings have gust effects as the wind velocities are generated suddenly due to the orientation and conformation of the site. Since wind velocities are the result of energy induced wind currents the solution to most problems is to reduce the wind energy at selected locations by carefully designed windbreak devices, often landscaping, to blend with the surrounds.

The Beaufort Scale is often used as a numerical relationship to wind speed based upon an observation of the effects of wind. Rear-Admiral Sir Francis Beaufort, commander of the Royal Navy, developed the wind force scale in 1805, and by 1838 the Beaufort wind force scale was made mandatory for log entries in ships of the Royal Navy. The original scale was an association of integers from 0 to 12, with a description of the effect of wind on the behaviour of a full-rigged man-of-war. The lower Beaufort numbers described wind in terms of ship speed, mid-range numbers were related to her sail carrying ability and upper numbers were in terms of survival. The Beaufort Scale was adopted in 1874 by the International Meteorological Committee for international use in weather telegraphy and, with the advent of anemometers, the scale was eventually adopted for meteorological purposes. Eventually, a uniform set of equivalents that non-mariners could relate to was developed, and by 1955, wind velocities in knots had replaced Beaufort numbers on weather maps. While the Beaufort Scale lost ground to technology, there remains the need to relate wind speed to observable wind effects and the Beaufort Scale remains a useful tool.

Abbreviated Beaufort Scale

Beaufort Number	Description	Wind Speed			Observations
		km/h	*m/s*	h=2*m* for Urban *m/s*	
2	Slight Breeze	6-11	1.6-3.3	< ~2	Tree leaves rustle; flags wave slightly; vanes show wind direction; small wavelets or scale waves.
3	Gentle Breeze	12-19	3.4-5.4	< ~3	Leaves and twigs in constant motion; small flags extended; long unbreaking waves.
4	Moderate Breeze	20-28	5.5-7.9	< ~4	Small branches move; flags flap; waves with whitecaps.
5	Fresh Breeze	29-38	8.0-10.7	< ~6	Small trees sway; flags flap and ripple; moderate waves with many whitecaps.
6	Strong Breeze	39-49	10.8-13.8	< ~8	Large branches sway; umbrellas used with difficulty; flags beat and pop; larger waves with regular whitecaps.
7	Moderate Gale	50-61	13.9-17.1	< ~10	Sea heaps up, white foam streaks; whole trees sway; difficult to walk; large waves.
8	Fresh Gale	62-74	17.2-20.7	> ~10	Twigs break off trees; moderately high sea with blowing foam.
9	Strong Gale	75-88	20.8-24.4		Branches break off trees; tiles blown from roofs; high crested waves.

Wind speeds indicated above, in *km/h* and *m/s*, are at a reference height of 10 metres, as are the wind speeds indicated on the Figure 5 wind roses. The mean wind speeds at pedestrian level, for an urban climate, would be approximately 56% of these values. The 3rd column for wind speed is shown for reference, at a height of 2*m*, in an urban setting. The approximate Comfort Category Colours are shown above. The relationship between wind speed and height relative to terrain is discussed in the appendices.

Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

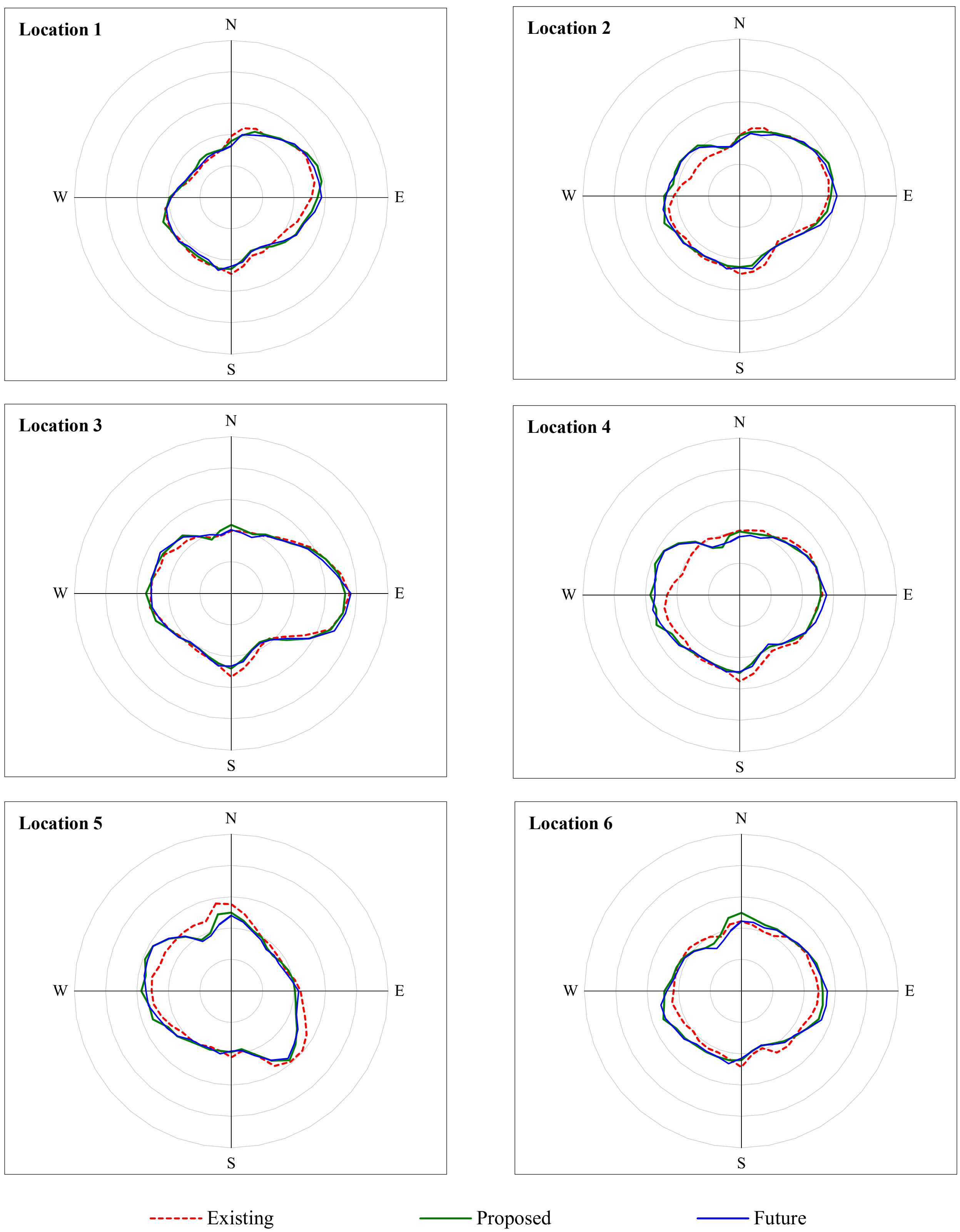


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

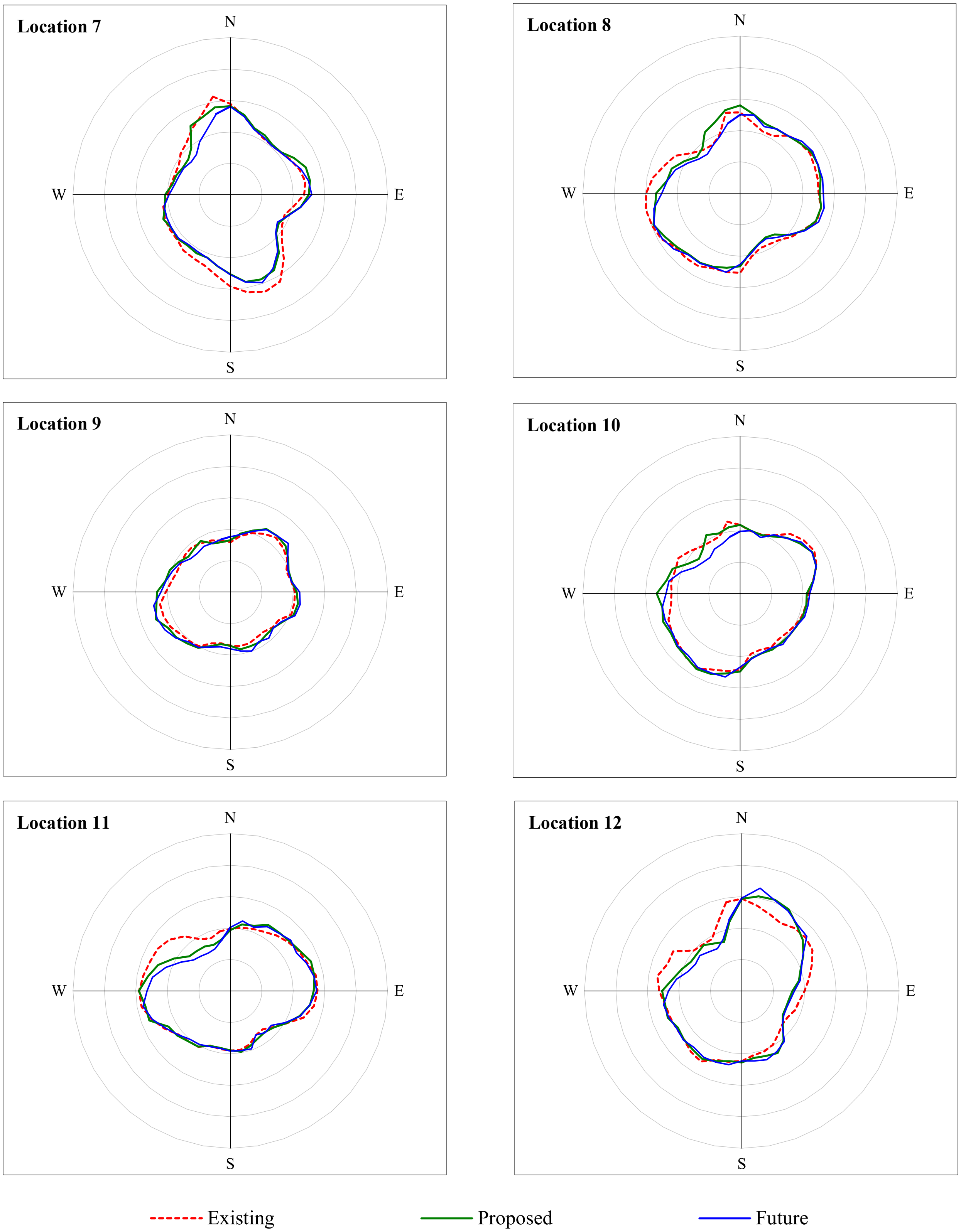


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

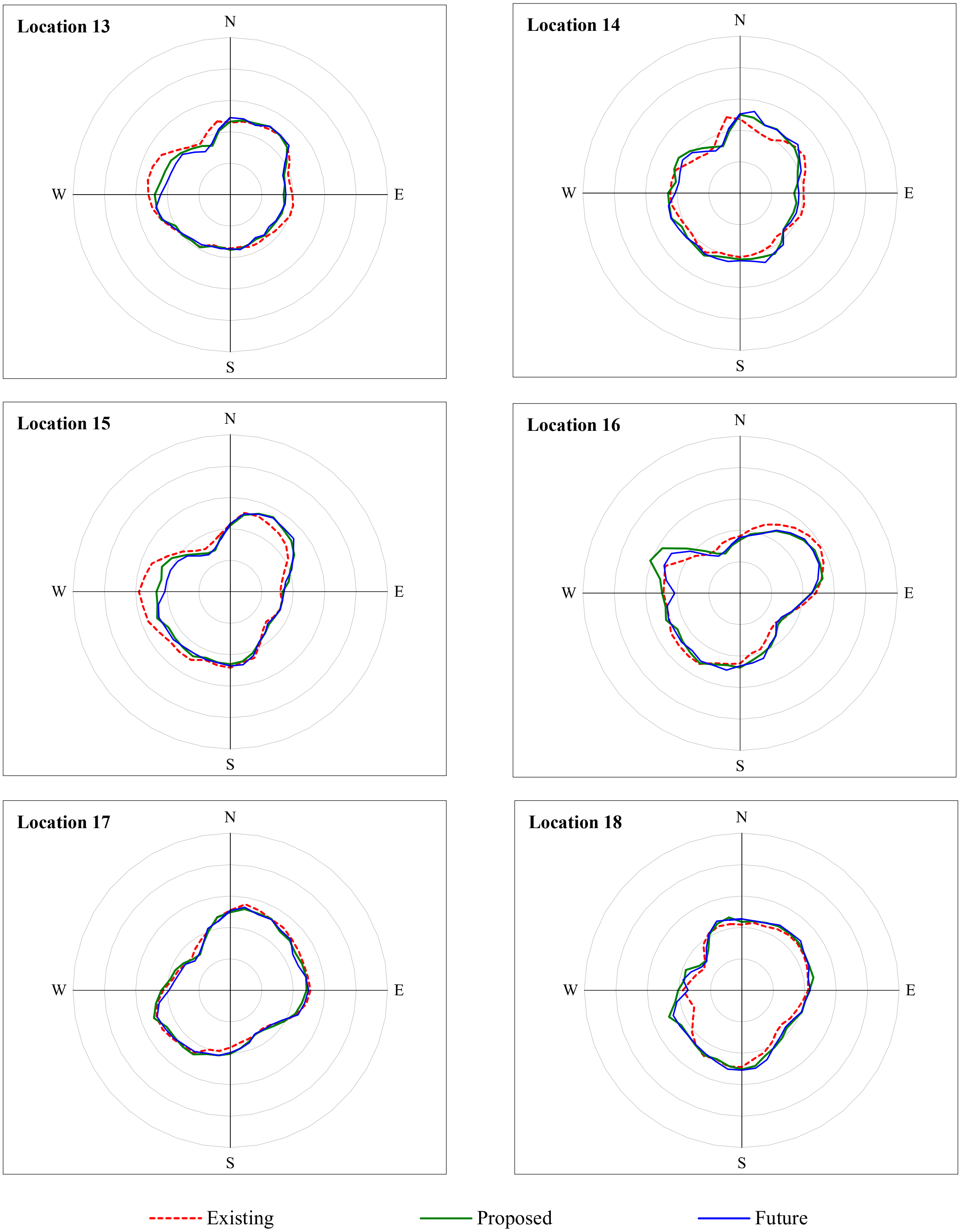


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

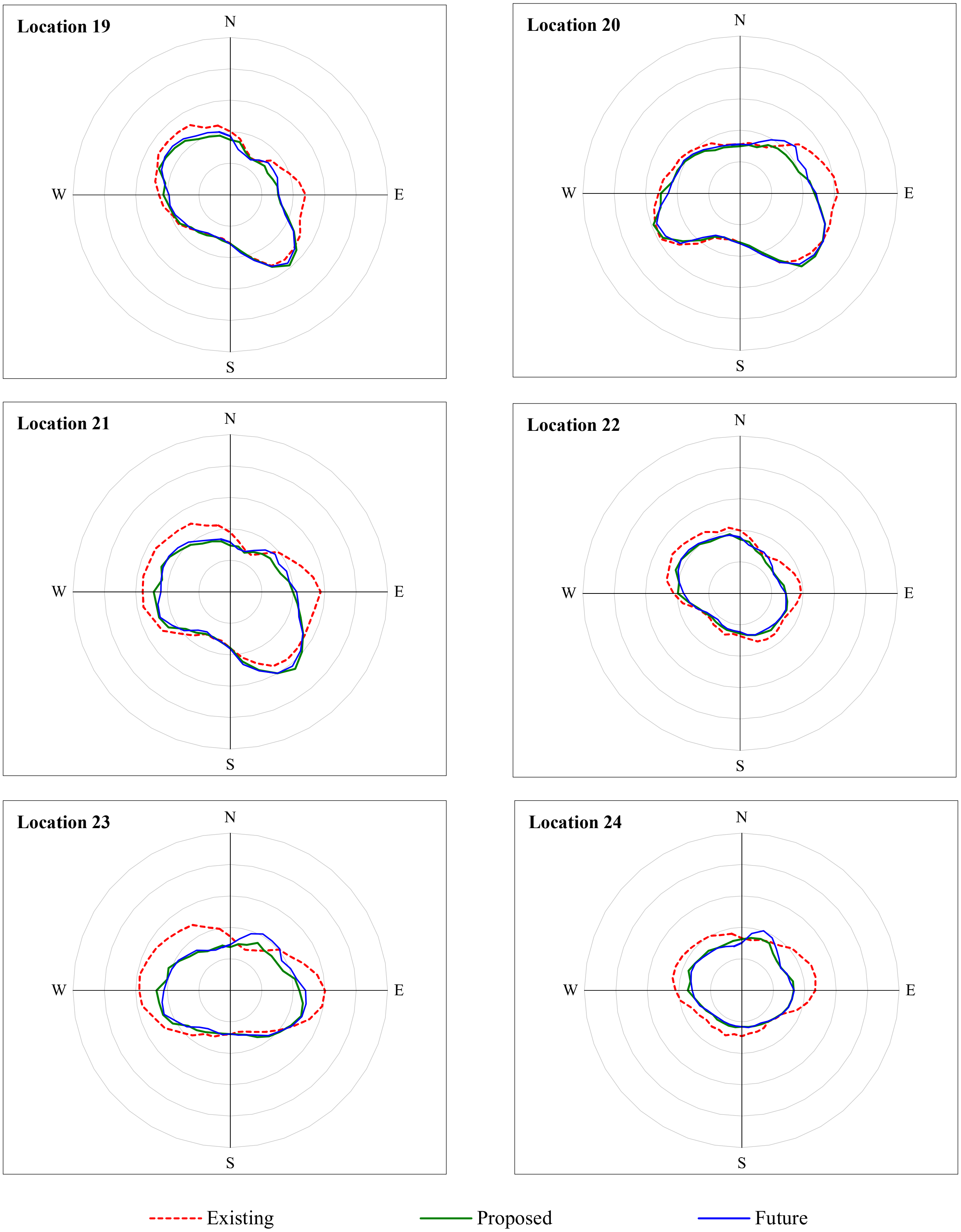


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

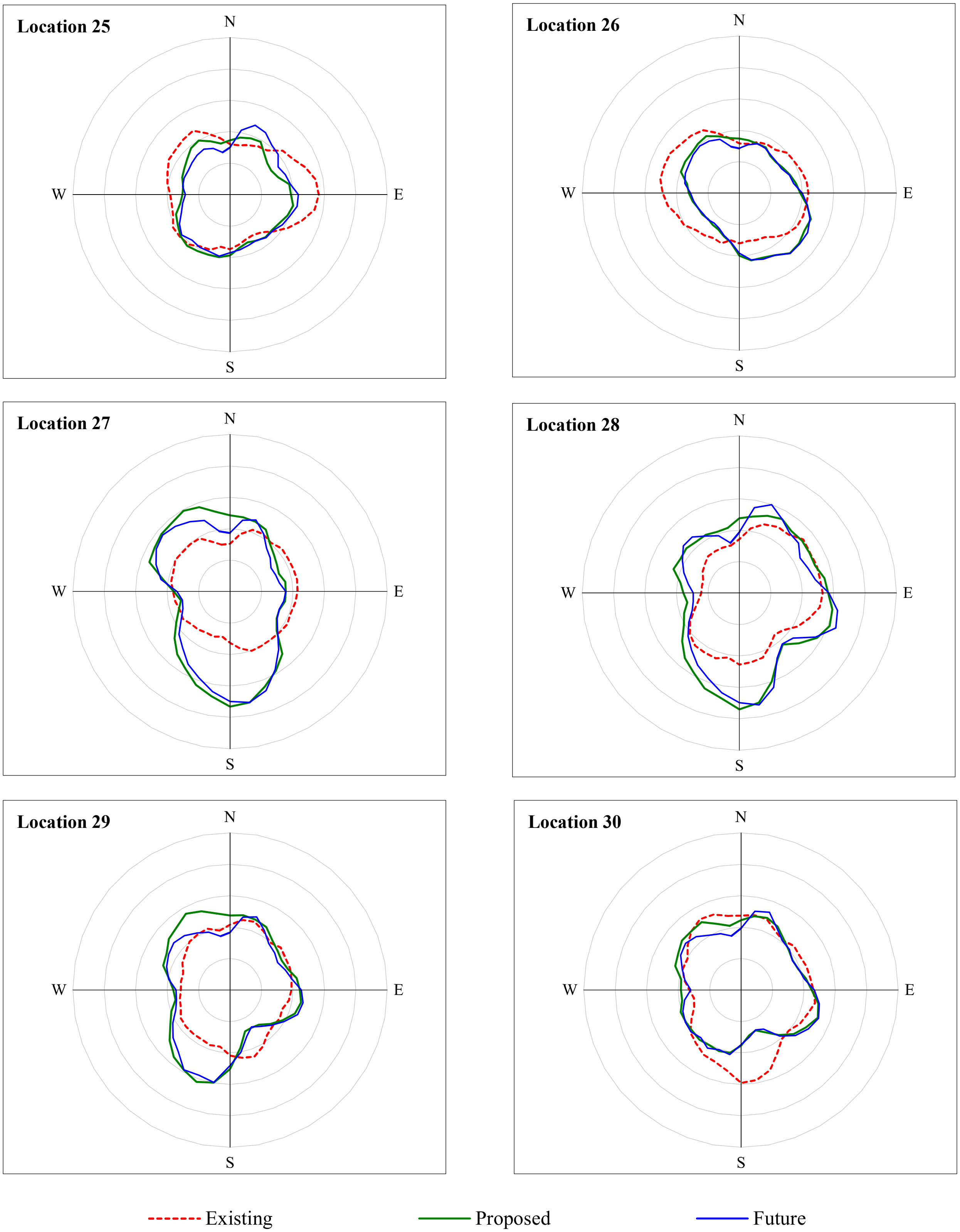


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

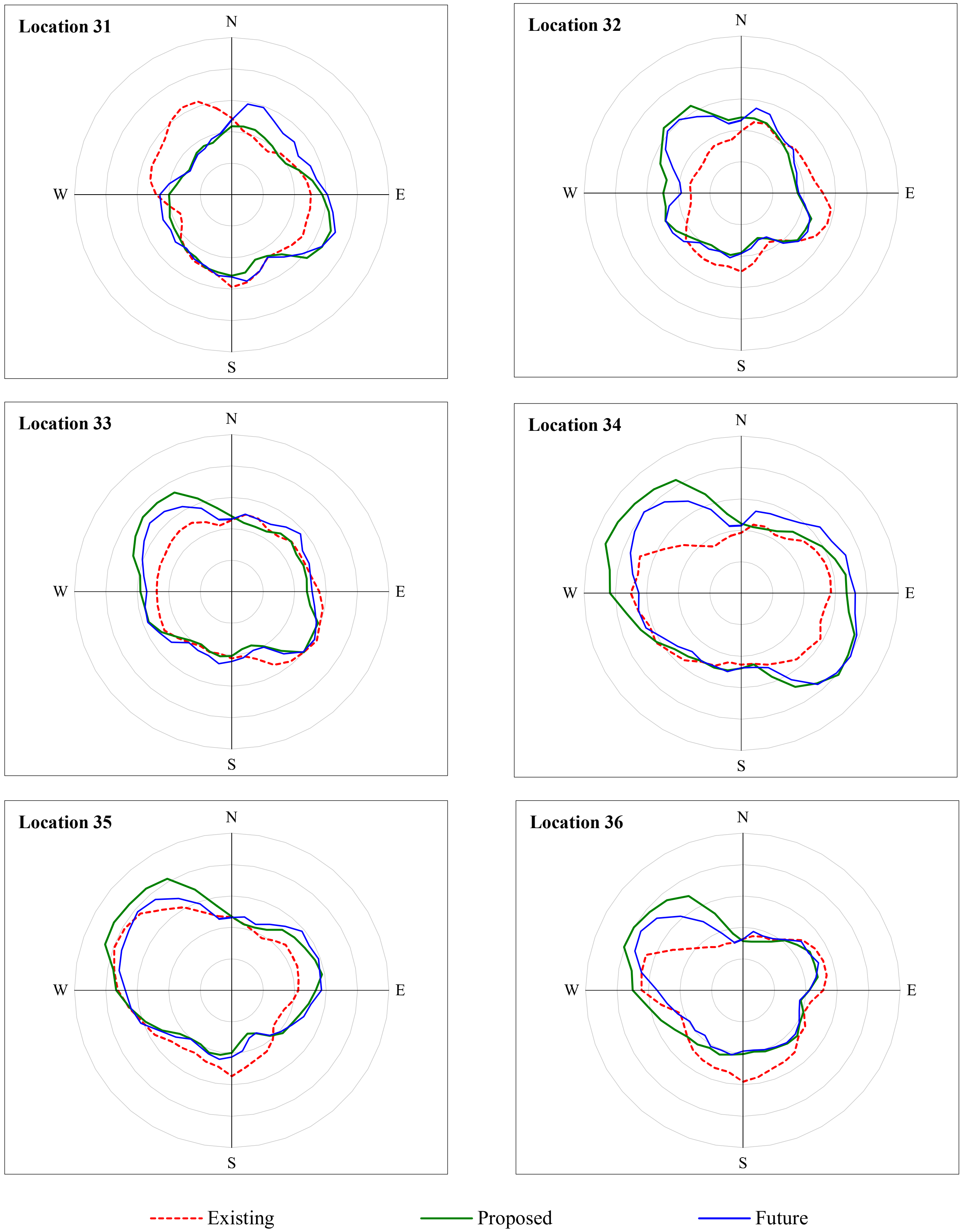


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

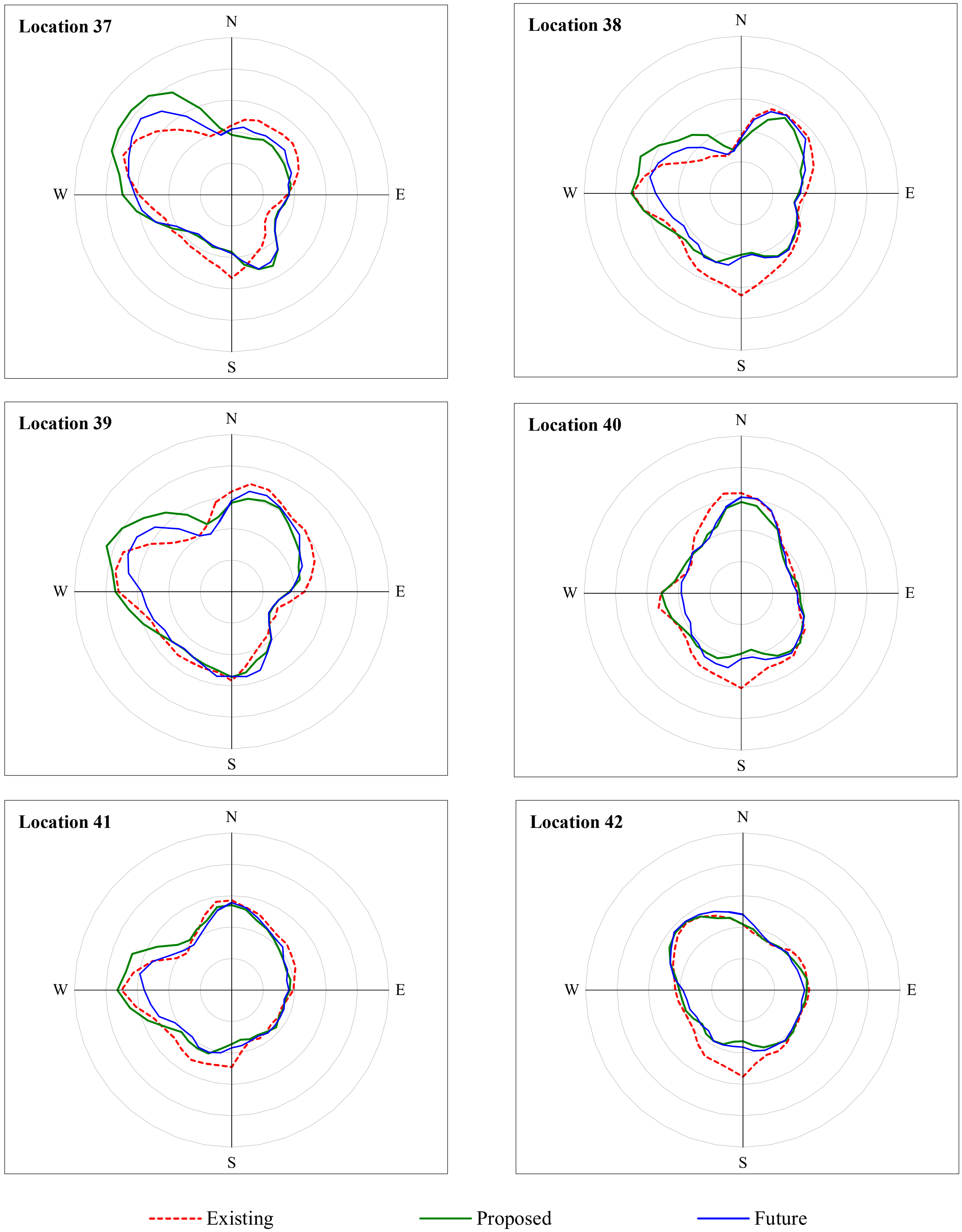


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

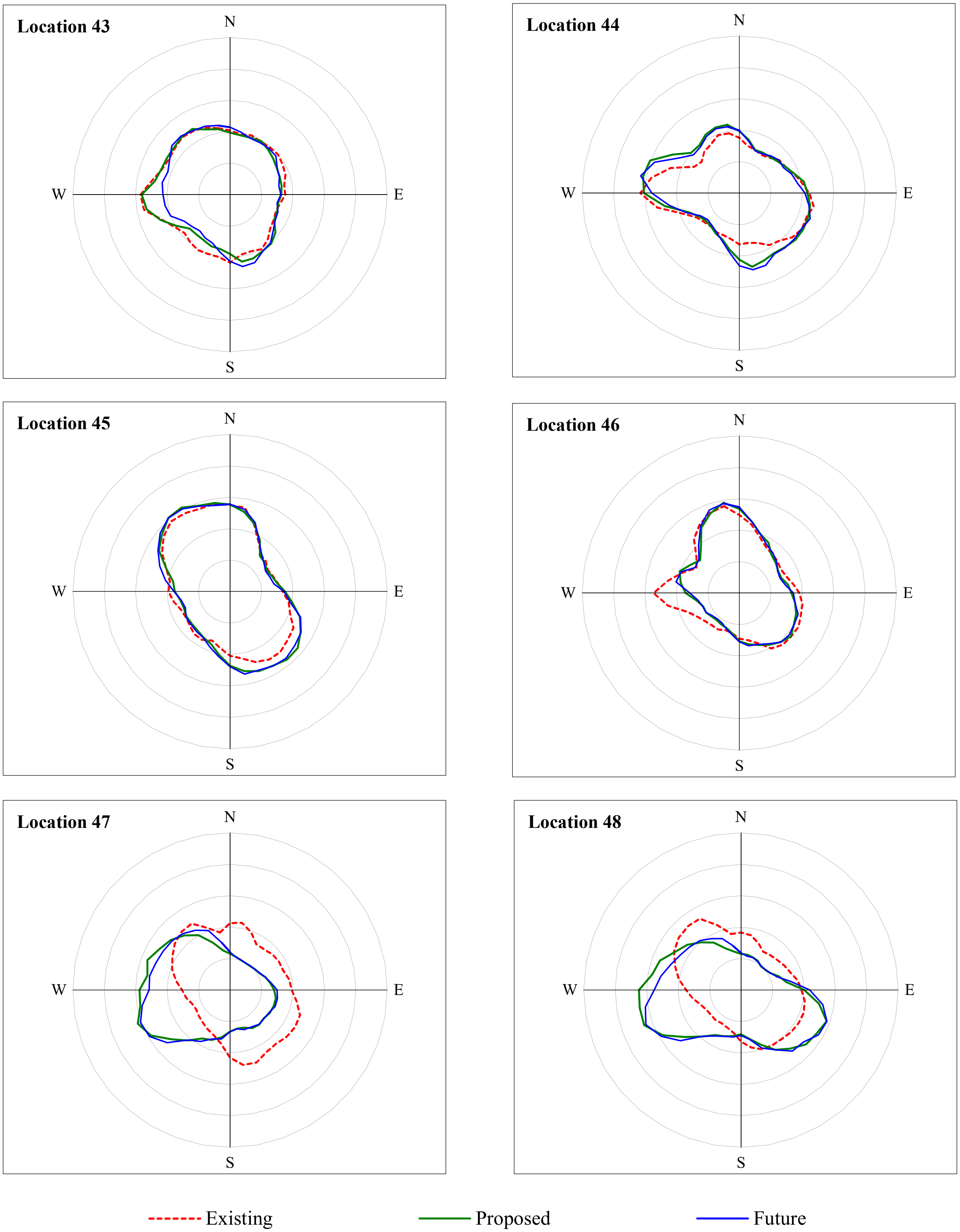


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

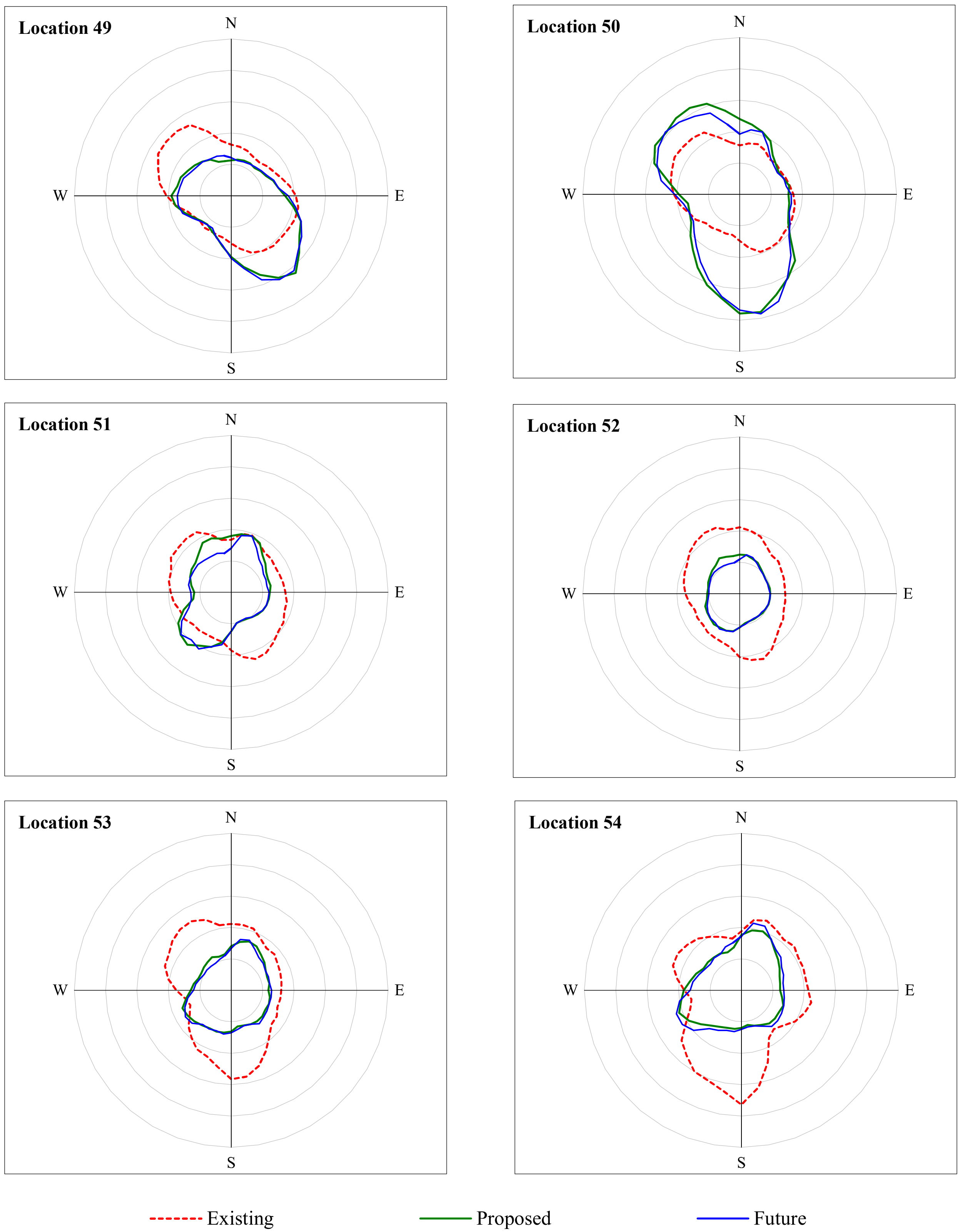


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

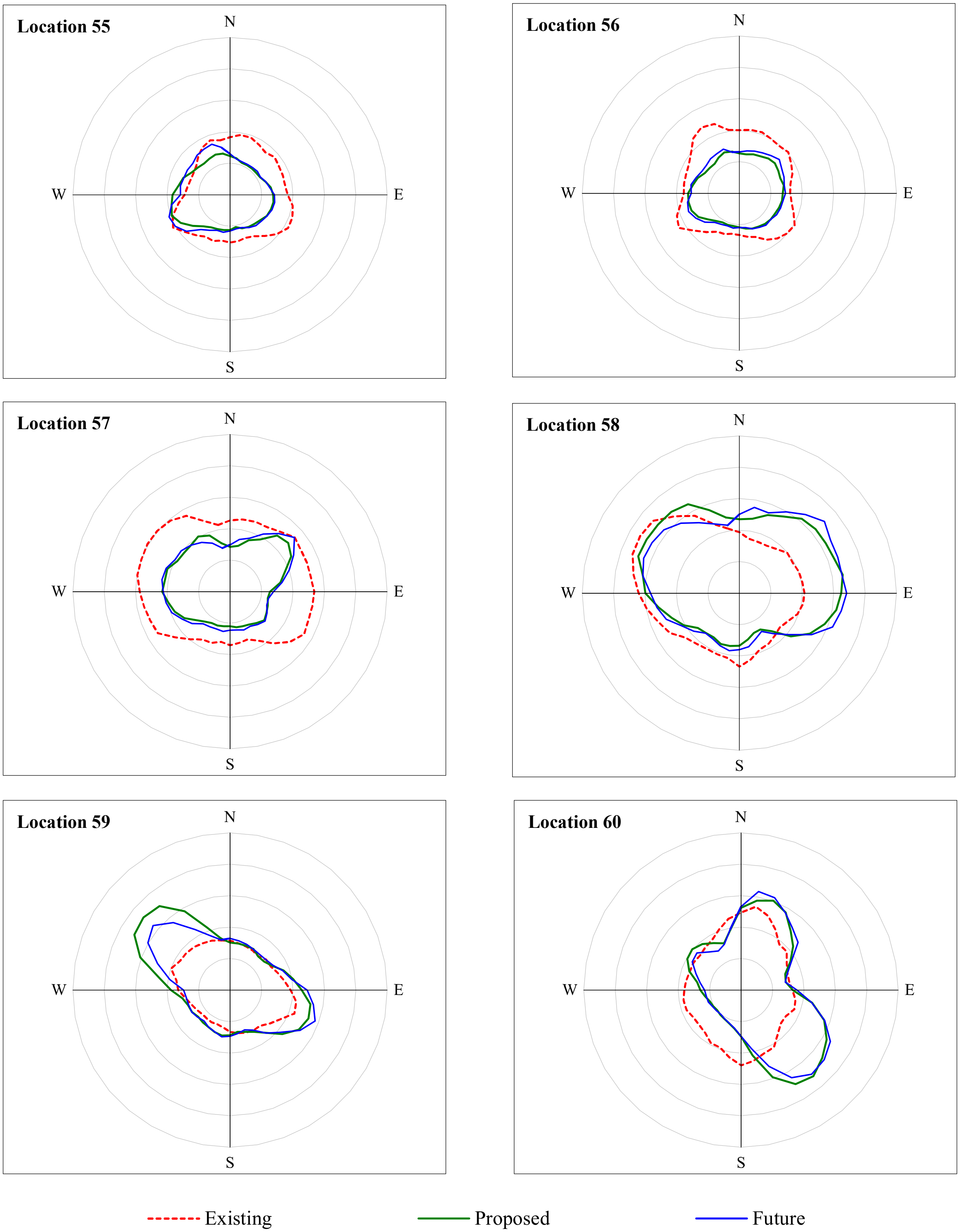


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

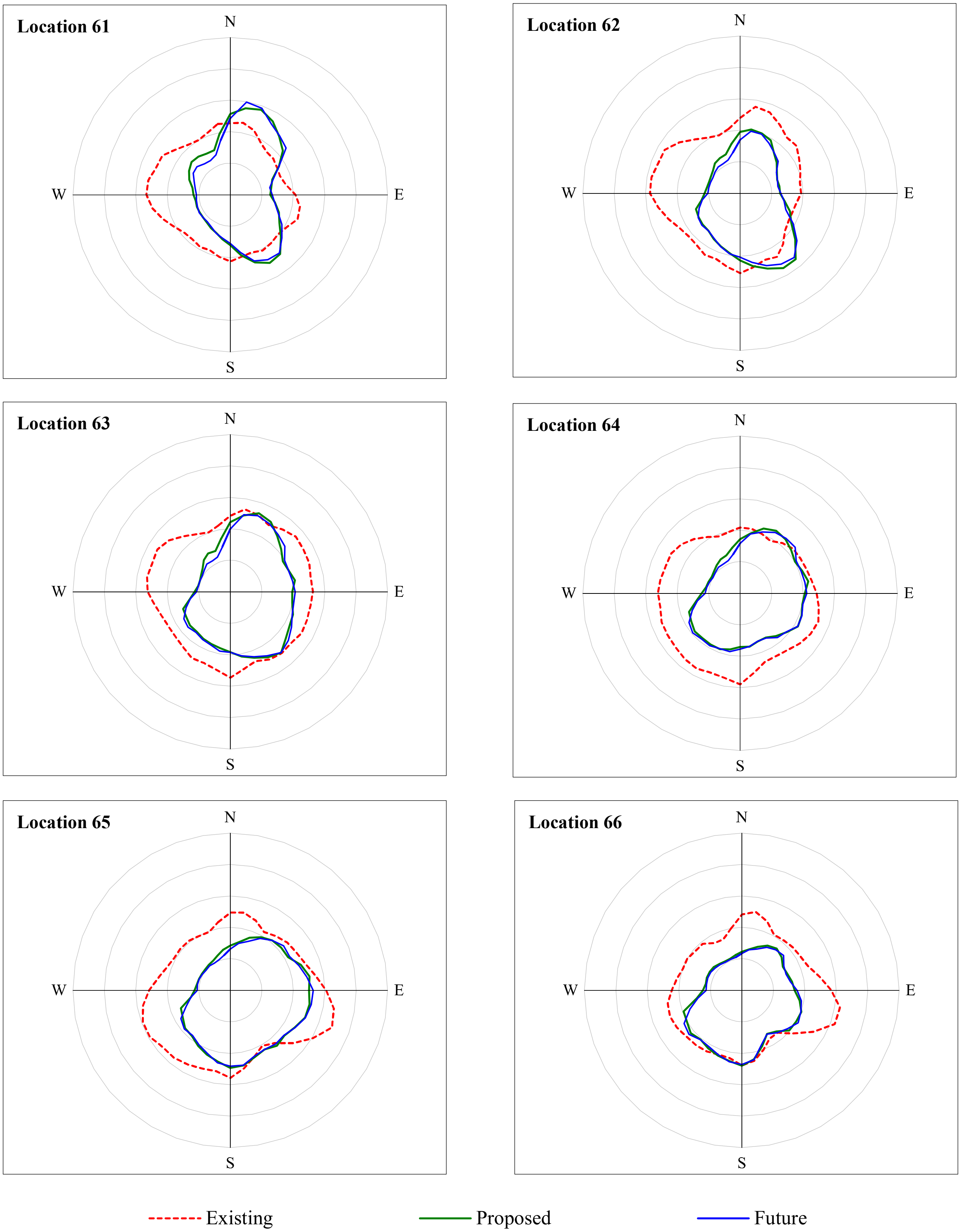


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

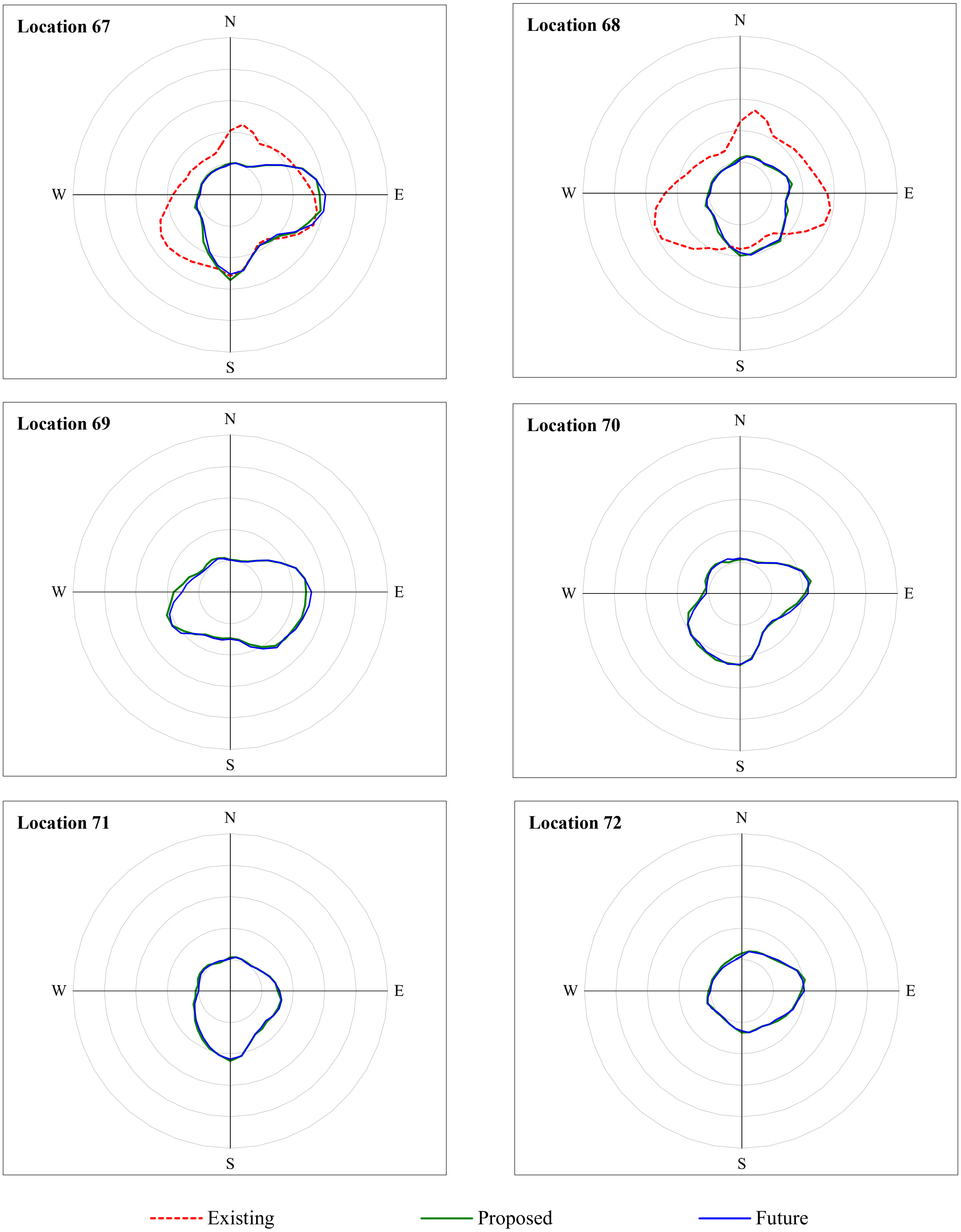


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

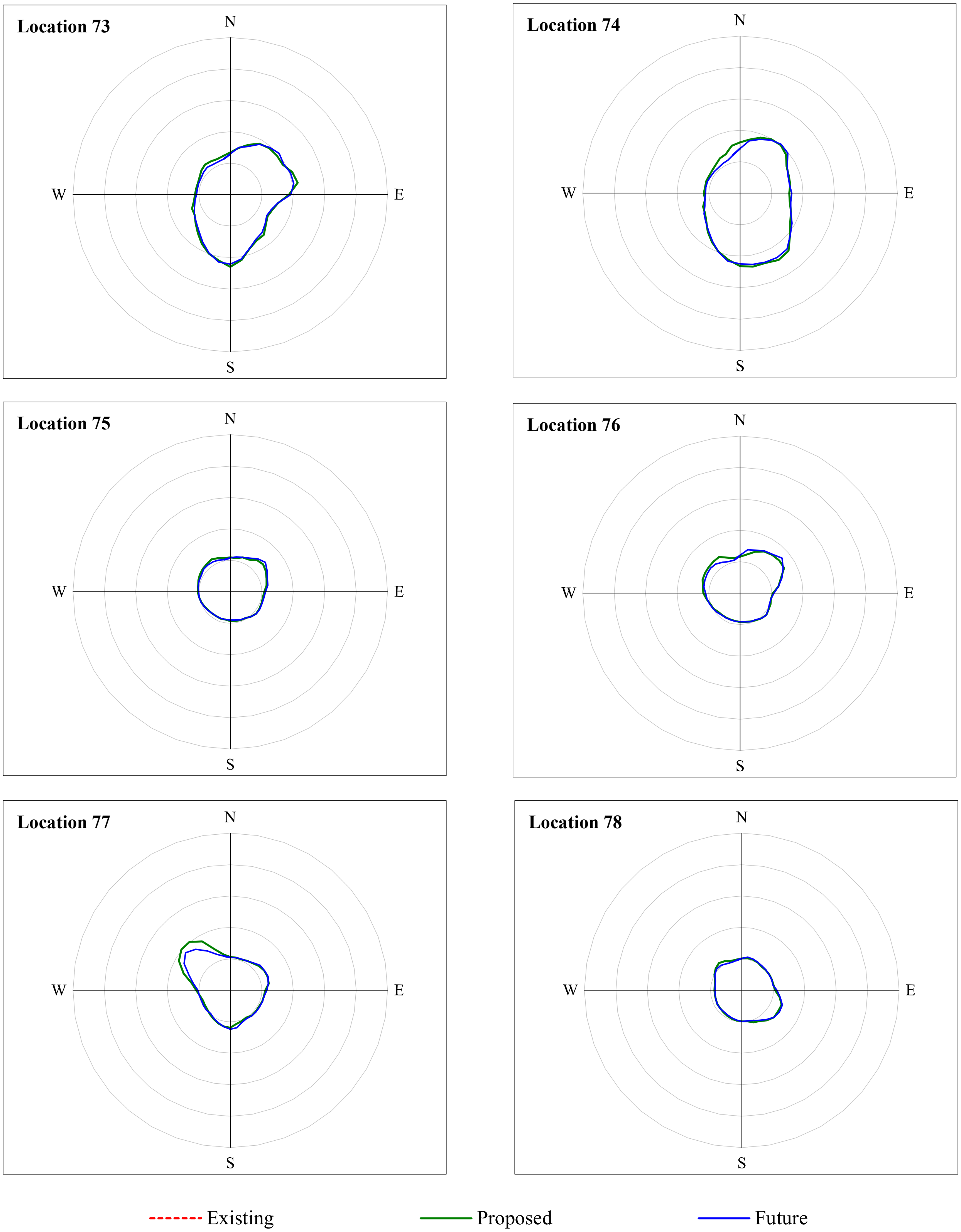


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

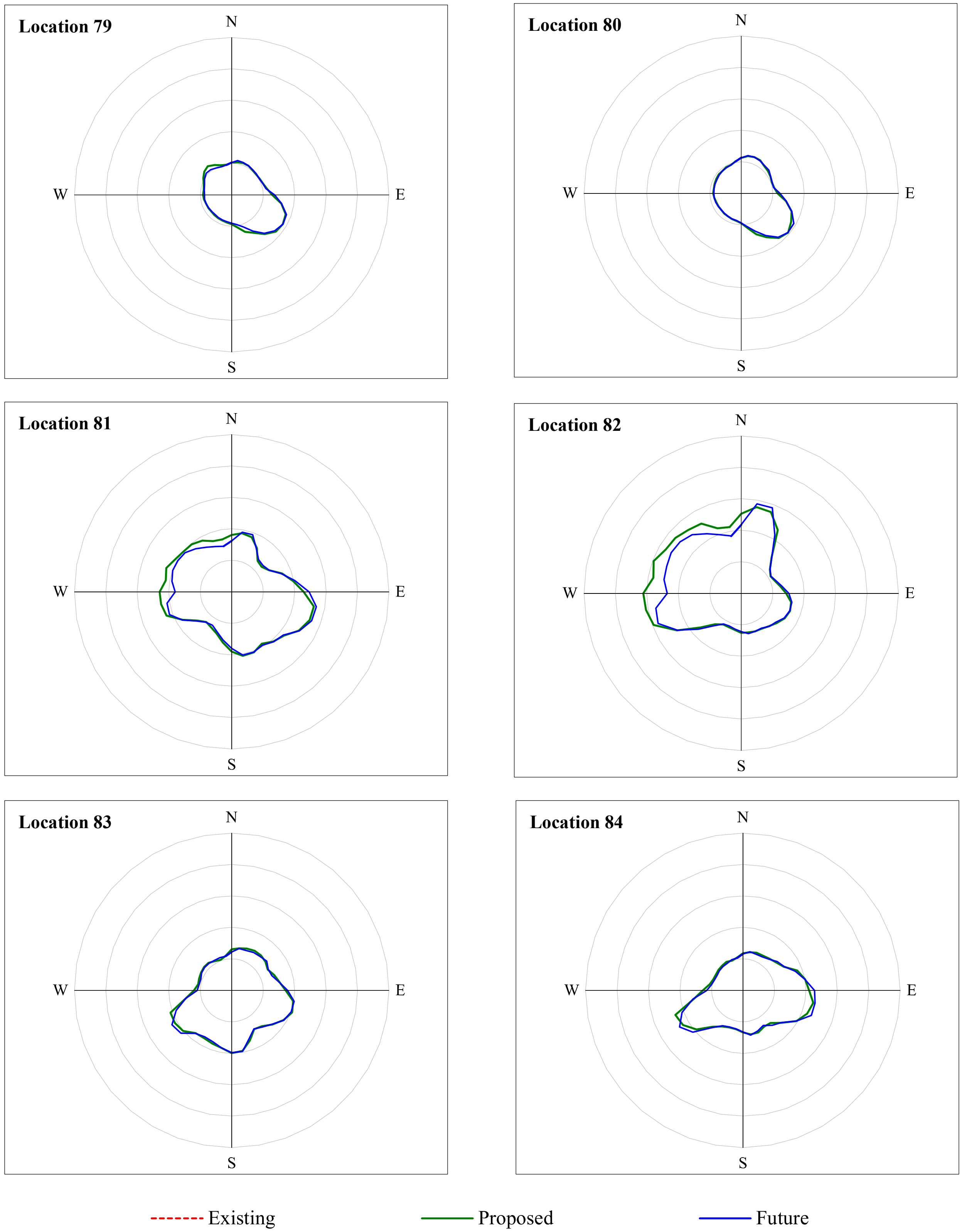


Figure C: Pedestrian Level Wind Comfort and Safety Comparison Table - With and Without Trees.

	GEM Speed (km/h)						Gust Speed (km/h)		
	Winter			Summer			Safety		
	Proposed	Proposed	Future	Proposed	Proposed	Future	Proposed	Proposed	Future
Probe	no trees	w/ trees	w/ trees	no trees	w/ trees	w/ trees	no trees	w/ trees	w/ trees
1	13.3	13.2	13.2	11.3	11.3	11.2	51.5	50.4	51.5
2	14.9	14.8	14.7	12.6	12.5	12.5	57.2	55.7	57.1
3	16.5	16.3	16.4	13.9	13.8	13.8	63.6	62.2	63.4
4	15.8	15.8	15.8	13.4	13.4	13.2	63.4	63.4	63.7
5	16.2	16.2	15.9	13.9	13.9	13.7	64.6	63.9	64.1
6	15.5	15.3	15.1	13.2	13.1	12.9	57.7	56.6	57.0
7	15.0	15.0	14.5	13.2	13.2	12.7	59.0	59.3	55.5
8	16.2	16.1	15.5	13.7	13.6	13.0	61.2	60.7	59.9
9	13.8	13.6	13.6	11.5	11.4	11.4	54.9	53.6	55.0
10	15.2	14.9	14.3	12.8	12.5	12.1	59.0	57.9	57.2
11	15.2	14.9	14.9	12.6	12.3	12.4	65.4	64.4	64.3
12	15.3	15.1	15.0	13.2	13.0	13.0	59.3	59.3	59.0
13	14.6	14.1	14.1	12.2	11.8	11.9	58.8	57.0	56.9
14	15.2	14.8	14.8	13.0	12.7	12.7	61.4	59.6	58.4
15	14.0	13.7	13.6	11.8	11.6	11.5	58.1	56.9	55.4
16	15.5	15.1	14.5	12.8	12.5	12.1	71.6	69.5	61.6
17	14.6	14.5	14.4	12.3	12.3	12.2	56.8	56.2	55.4
18	14.7	14.7	14.4	12.5	12.5	12.3	57.2	57.1	55.4
19	13.3	13.1	13.4	11.6	11.5	11.7	54.5	54.4	54.8
20	14.4	14.2	14.3	12.1	12.0	12.0	62.3	60.6	60.3
21	13.6	13.4	13.5	11.8	11.7	11.7	55.3	54.8	54.4
22	11.5	11.4	11.4	9.7	9.6	9.6	48.6	49.5	48.6
23	13.0	12.7	12.5	10.7	10.5	10.4	53.7	52.7	50.9
24	10.2	9.8	9.9	8.7	8.2	8.4	40.1	39.4	38.7
25	13.1	12.4	12.3	11.1	10.6	10.5	49.7	45.8	45.3
26	12.3	12.0	12.2	11.0	10.7	10.9	51.3	48.3	50.7
27	17.0	16.8	15.8	14.9	14.8	14.0	69.5	68.9	66.7
28	16.2	15.8	14.9	14.1	13.9	13.4	59.9	59.9	59.6
29	16.6	16.2	14.7	14.2	13.9	12.6	64.9	63.6	57.2
30	15.5	15.3	14.5	13.2	13.1	12.4	60.0	60.6	56.5
31	15.4	15.2	15.2	13.4	13.0	13.1	57.0	56.8	58.6
32	18.1	18.6	17.4	15.3	15.7	14.7	77.8	79.2	73.4
33	19.3	19.2	18.3	16.2	16.2	15.4	81.2	80.9	73.0
34	21.5	19.7	18.7	18.0	16.7	15.9	85.1	81.4	75.6
35	19.6	19.3	18.4	16.3	16.0	15.3	83.2	83.7	78.4
36	19.0	17.8	16.5	15.6	14.4	13.5	82.9	82.0	76.6
37	18.6	18.0	16.8	15.5	15.1	14.3	84.6	83.8	76.6
38	17.1	16.4	15.1	14.3	13.7	12.9	76.6	76.8	66.7
39	19.6	19.2	18.0	16.5	16.2	15.4	85.3	85.3	76.0
40	15.6	15.7	14.4	13.3	13.4	12.6	61.1	62.6	55.3
41	17.4	17.3	15.6	14.3	14.3	13.1	79.5	80.9	67.3
42	14.4	14.5	14.3	12.3	12.3	12.3	63.4	64.5	63.1
43	14.9	14.9	13.9	12.4	12.4	11.8	66.8	67.5	57.4
44	15.3	15.0	14.4	12.8	12.5	12.2	75.2	76.5	69.6
45	14.8	14.8	14.8	13.1	13.0	13.1	64.0	64.0	64.7
46	13.0	13.4	12.7	11.3	11.4	11.1	57.3	58.6	56.1
47	14.9	14.9	15.2	11.9	12.0	12.3	65.5	64.4	63.9
48	15.9	15.9	16.1	13.1	13.3	13.4	71.2	70.1	68.8
49	11.2	11.4	11.2	10.3	10.6	10.4	45.5	45.5	43.7
50	16.6	16.3	16.3	14.8	14.7	14.6	71.2	68.9	70.7
51	12.6	12.0	11.2	10.6	10.0	9.3	54.1	52.5	49.2
52	7.5	7.3	6.7	6.4	6.3	5.6	30.0	29.6	25.3
53	9.0	8.6	8.3	7.6	7.3	7.1	37.8	36.0	36.4
54	11.4	11.4	11.7	9.4	9.5	9.7	50.1	50.1	49.9
55	10.6	10.9	11.3	8.6	8.9	9.3	48.0	48.0	47.4
56	9.4	9.6	9.8	7.8	8.0	8.1	38.6	38.8	38.6
57	12.4	12.2	12.3	10.3	10.2	10.2	49.2	48.6	48.8
58	17.0	16.7	16.4	14.3	14.0	13.8	68.9	67.5	66.1
59	14.9	14.7	13.1	12.5	12.3	11.2	81.5	78.8	69.2
60	13.0	13.0	12.1	12.4	12.3	11.6	53.2	52.3	51.4
61	10.4	10.2	9.7	9.7	9.5	9.1	45.5	45.6	46.7
62	10.0	9.8	9.5	9.4	9.3	8.9	38.2	37.7	36.9
63	11.3	11.0	10.8	10.3	10.1	9.9	44.3	44.6	45.5
64	11.0	10.7	10.6	9.5	9.4	9.3	43.4	41.9	42.7
65	10.8	10.5	10.4	9.7	9.4	9.4	45.7	44.2	44.1
66	10.5	10.3	10.3	9.1	8.9	8.9	49.9	46.8	47.2
67	8.9	8.7	8.6	8.4	8.2	8.2	49.9	49.7	49.4
68	7.4	7.3	7.3	6.9	6.8	6.8	29.7	28.8	28.9
69	10.7	10.6	10.3	9.1	9.1	9.0	47.0	45.5	45.1
70	10.5	10.3	10.2	8.8	8.7	8.6	48.3	46.1	45.4
71	7.9	7.8	7.7	7.1	6.9	6.9	32.3	31.6	31.2
72	7.3	7.2	7.2	6.4	6.3	6.3	33.0	31.5	32.4
73	9.5	9.3	9.1	8.6	8.4	8.2	38.2	36.5	37.7
74	9.7	9.5	9.0	9.0	8.9	8.4	34.8	34.2	33.3
75	6.4	6.3	6.3	5.4	5.4	5.3	23.9	23.9	22.2
76	7.2	7.1	7.0	6.1	6.0	5.9	28.5	27.6	26.7
77	8.2	8.0	7.5	6.9	6.7	6.4	47.8	43.5	39.2
78	5.9	5.7	5.8	5.2	5.0	5.1	23.8	21.8	21.9
79	6.5	6.3	6.3	6.0	5.8	5.7	28.8	28.7	28.5
80	6.4	6.3	6.3	6.0	6.0	5.9	28.0	27.6	27.5
81	13.5	13.4	13.0	11.5	11.4	11.2	55.5	55.4	53.1
82	16.8	16.6	16.1	13.9	13.8	13.3	71.8	70.7	68.7
83	10.2	10.2	10.2	8.7	8.6	8.6	53.0	50.3	51.2
84	10.3	10.2	10.2	8.3	8.2	8.2	56.8	53.6	54.6
85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Comfort (km/h)				Safety (km/h)	
0 - 10	Sitting	15 - 20	Walking	0 - 90	Pass
10 - 15	Standing	20 +	Uncomf	90 +	Exceed

8. REFERENCES

Canadian Climate Program. Canadian Climate Normals, 1961-1990. Documentation for Diskette-Based Version 2.0E (in English) Copyright 1993 by Environment Canada.

Cermak, J.E., "Applications of Fluid Mechanics to Wind Engineering A Freeman Scholar Lecture." Journal of Fluids Engineering, (March 1975), 9-38.

Davenport, A.G."The Dependence of Wind Loads on Meteorological Parameters." International Seminar on Wind Effects on Buildings and Structures, Ottawa, 1967.

-----"An Approach to Human Comfort Criteria for Environmental Wind Conditions." Colloquium on Building Climatology, Stockholm, Sweden, September, 1972.

-----"The Relationship of Wind Structure to Wind Loading." Symposium on Wind Effects on Buildings and Structures, Teddington, 1973.

-----and N. Isyumov. "The Application of the Boundary Layer Wind Tunnel to the Prediction of Wind Loading." Proceedings of International Seminar on Wind Effects on Buildings and Structures, Ottawa, 1967.

-----and N. Isyumov. "The Application of the Boundary Layer Wind Tunnel to the Prediction of Wind Loading." International Research Seminar on Wind Effects on Buildings and Structures, Toronto: University of Toronto Press, 1968.

-----and T. Tschanz. "The Response of Tall Buildings to Wind: Effect of Wind Direction and the Direction Measurement of Force." Proceedings of the Fourth U.S.National Conference on Wind Engineering Research, Seattle, Washington, July 1981.

-----Isyumov, N. "Studies of the Pedestrian Level Wind Environment at the Boundary Layer Wind Tunnel Laboratory University of Western Ontario." Journal of Industrial Aerodynamics, (1978), 187-200.

-----and A.G.Davenport. "The Ground Level Wind Environment in Built-up Areas." Proceedings of the Fourth International Conference on Wind Effects on Buildings and Structures, London, England: Cambridge University Press, 1977, 403-422

-----M.Mikitiuk, C.Harding and A.G.Davenport. "A Study of Pedestrian Level Wind Speeds at the Toronto City Hall, Toronto,Ontario." London, Ontario: The University of Western Ontario, Paper No.BLWT-SS17-1985, August 1985.

Milles, Irwin and John E. Freund. Probability and Statistics Engineers, Toronto: Prentice-Hall Canada Ltd., 1965.

National Building Code of Canada, Ottawa: National Research Council of Canada, 1990.

Simiu, Emil, Wind Induced Discomfort In and Around Buildings. New York: John Wiley & Sons, 1978.

Surry, David, Robert B.Kitchen and Alan Davenport, "Design Effectiveness of Wind Tunnel Studies for Buildings of Intermediate Height." Canadian Journal of Civil Engineering 1977, 96-116.

Theakston, F.H., "Windbreaks and Snow Barriers." Morgantown, West Virginia, ASAE Paper No. NA-62-3d, August 1962.

------"Advances in the Use of Models to Predict Behaviour of Snow and Wind", Saskatoon, Saskatchewan: CSAE, June 1967.

Gagge, A.P., Fobelets, A.P., Berglund, L.G., “A Standard Predictive Index of Human Response to the Environment”, ASHRAE Transactions, Vol. 92, p709-731, 1986.

Gagge, A.P., Nishi, Y., Nevins, R.G., “The Role of Clothing in Meeting FEA Energy Conservation Guidelines”, ASHRAE Transactions, Vol. 82, p234-247, 1976.

Gagge, A.P., Stolwijk, J.A., Nishi, Y., “An Effective Temperature Scale Based on a Simple Model of Human Physiological Regulatory Response”, ASHRAE Transactions, Vol. 77, p247-262, 1971.

Berglund, L.G., Cunningham, D.J., “Parameters of Human Discomfort in Warm Environments”, ASHRAE Transactions, Vol. 92, p732-746, 1986.

ASHRAE, “Physiological Principles, Comfort, and Health”, ASHRAE Handbook - 1981 Fundamentals, Chapter 8, Atlanta, American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc., 1981,

ASHRAE, “Airflow Around Buildings”, ASHRAE Handbook - 1989 Fundamentals, Chapter 14, Atlanta, American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc., 1989,