THEAKSTON ENVIRONMENTAL

Consulting Engineers • Environmental Control Specialists

REPORT

PEDESTRIAN WIND STUDY

Pinnacle Watergarden Drive
Phase 4 - Part 2, (Buildings 3 & 4)
Phase 5, (Buildings 1, 2 & 3)

MISSISSAUGA, ONTARIO

Pinnacle International (Ontario) Ltd.

REPORT NO. 17349wind **May 22, 2018**

An International Reputation for Excellence

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1. CONCLUSIONS AND RECOMMENDATIONS

The mixed-use Development proposed by Pinnacle International (Ontario) Ltd. for parts of the property municipally known as Part of Lot 1, Concession 1, West of Hurontario Street, in the City of Mississauga, has been assessed for environmental standards with regard to pedestrian level wind relative to comfort and safety. The pedestrian level wind and gust velocities predicted for the locations tested are within the safety criteria and most are within the comfort criteria described within the following report.

The Development involves a proposal to construct 30, 35, 50, 38 and 50 storey buildings including connective 3 storey podiums and wings of various heights. The proposed Development's residential entrances, vehicular drop-off and access to the underground parking is via a central courtyard and/or driveways along the northwest development boundary connecting with Hurontario Street to the northeast and Foursprings Avenue to the southeast, which connects with Eglinton Avenue West, and Watergarden Drive, that dissects the site connecting Four Springs Road with Hurontario Street. The Proposed Development is part of a development plan comprised of 11 buildings and 14 blocks of townhouses, with the townhomes and 2 buildings built, 4 buildings under construction and the remaining buildings in various stages of approval.

The Development is, for all intents and purposes, surrounded to prevailing windward directions by an urban/suburban mix of institutional, residential and commercial development, related open areas, and mature vegetation. These buildings and related open areas have a sympathetic relationship with the pending wind climate.

Urban development provides turbulence inducing surface roughness that can be wind friendly, while open settings afford wind the opportunity to accelerate as the wind's boundary layer profile thickens at the pedestrian level, owing to lack of surface roughness. 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 to urban, and to a lesser degree suburban, settings may prove problematic, as winds exacerbated by the relatively more open settings are redirected to flow over, around, and between urban buildings.

These phenomena were observed at the site with winds that have opportunity to accelerate over the relatively open lands associated with Eglinton Avenue West, Hurontario Street, Cooksville Creek and green fields beyond. This relatively open setting, along with similarly open lands to the east, cumulatively account for the moderately windy conditions observed in the existing setting on and about the Development site. With inclusion of the proposed Development, winds that formerly flowed over the existing lands are redirected, tending to split with portions flowing over, around and down the proposed buildings' façades. At the pedestrian level, the winds redirect to travel horizontally along the buildings, around the corners and beyond, creating minor windswept areas and, on occasion, uncomfortable conditions at or near the buildings' corners and in the gaps between the subject and neighbouring buildings, and these conditions are primarily attributable to the setting, whereby the Proposed Development penetrates winds that formerly flowed over the existing lands.

Winds emanating from remaining compass points are more effectively mitigated, though to varying degrees, by the local surrounds, and as such, upon impact with the proposed, tend to split, flowing over, and to a lesser extent around and down the building's faces. At the pedestrian level, the winds redirect to travel horizontally along the ground, around the corners and beyond, with less significant influence upon pedestrian comfort conditions.

These phenomena result in:

- wind conditions along **Eglinton Avenue West** adjacent to the proposed Development that are slightly improved,
- wind conditions at the windiest points along **Hurontario Street** that are uncomfortable on the occasion of high ambient westerly winds, however, the area remains suitable for the intended purpose upon consideration of massing features that were too fine to incorporate into the model, and a mitigative landscape design,
- a realignment of winds along **Watergarden Drive** whereby windy conditions along the southwest portion of the street in the existing setting move to along the northeast portion in the proposed, however, the areas remain suitable for the intended purpose upon consideration of massing features that were too fine to incorporate into the model, and a mitigative landscape design,
- pedestrian comfort conditions at the **Main Entrances,** that are appropriate to the intended purpose,
- seasonally appropriate comfort conditions at the proposed **Amenity Space**, with incorporation of wind mitigation design features.

Comfort conditions expected at the proposed Development site are improved, relative to the existing setting, and considered acceptable to the urban context. Where mitigation was recommended, it was achieved through: parapet walls, stepped façades, overhangs, canopies, balconies, porous fencing, landscaping, plantings, and others, that were incorporated into the proposed Development's massing and landscape design.

Respectfully submitted,

Stephen Pollock, P. Eng.   Paul Kankainen, M.A.Sc.

2. INTRODUCTION

Theakston Environmental Consulting Engineers, Fergus, Ontario, were retained by Pinnacle International (Ontario) Ltd., to study the pedestrian level wind environment for their proposed Residential Development occupying a portion of a block of lands situated to the southwest of Hurontario Street, northwest of Eglinton Avenue West, southeast of Salishan Circle, and northeast of Four Springs Avenue. The Development will be located in the City of Mississauga, with the site as depicted on the Aerial Photo in Figure 2a. The Development involves a proposal to build towers, including a 3 storey podium, and wings at various heights, in the configuration shown in Figure 2b.

Alex Marshall, MSc, MCIP, RPP, Development Manager, Pinnacle International (Ontario) Ltd., initiated the request, and Richmond Architects Ltd. provided drawings. 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 two configurations. The existing configuration included existing and proposed buildings in the surrounding area. The proposed configuration included the Development's subject buildings. Mitigation procedures were assessed during these tests to determine their impact on the various wind conditions.

The laboratory techniques used in this 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

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. Predictions of wind speeds for various probabilities of occurrence and for various percentages of time are then 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 open channel water flume, the ultimate known as the "Snow and Wind Simulator", in which flowing water is conditioned to represent wind movement (Figure 1). This procedure is based on the fact that air (wind) is a fluid and obeys all the principles and laws contained in Fluid Mechanics and Hydraulics disciplines. The open channel water flume and boundary layer wind tunnel have been developed for these kinds of environmental studies, and have been adapted with equipment, testing procedures and protocols, in order to provide results comparable to full scale. The water flume test is a particularly useful tool where visual examination and qualitative analysis are advantageous in decision making, whereas the Boundary Layer Wind Tunnel lends itself well to the simultaneous acquisition of large data streams.

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 of time, at a full-scale height of approximately 2m and correlated to mean and gust wind speeds, expressed as ratios of the gradient wind speed.

The mean and gust wind speeds at the forty (40) points tested were subsequently combined with the design probability distribution of gradient wind speed and direction, (wind statistics) recorded at Toronto Pearson International Airport, to provide predictions of the full-scale pedestrian level wind environment. The statistical wind data graphically depicted in Figure 5 indicates the mean wind speed and directionality of winds analysed for annual, winter, spring, summer and fall seasons. Historical weather data presented as mean wind speeds in Figure 5 wind roses indicate that winds exceeding 30km/h occur approximately 13 percent of the time during the winter months and 4 percent of the time during the summer. Winds can occur from any direction, however, historical data indicates wind from the northerly and westerly quadrants dominate the winter, with westerly directions most significant, and winds from the north through west to southwesterly are predominant during the summer months with northerly and westerly directions most significant. Spring winds are mainly from the north to southwest sector and fall winds approach predominately from north through west to southerly directions.

Predictions of the full-scale pedestrian level wind environment are presented as a percentage of time that is comfortable for a given activity, based on wind annually and for the seasons in Figures 6a through 6e. Criterion employed by Theakston Environmental was developed by others and us and published in the attached references. The methodology has been applied to thousands of projects on this continent and abroad.

Wind Simulation

To simulate the correct macroclimate, the upstream flow is conditioned and passes over a roughened surface that develops the full-scale mean speed boundary layer approach flow profiles occurring at the site. Conditioning features placed upstream of the modelled site simulate full-scale wind conditions, thus creating the appropriate macroclimate.

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 1:500. The model is based upon information gathered during a site visit to the proposed Development site, and surrounding area. Richmond Architects Ltd. provided architectural drawings. City of Mississauga context drawings and 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 full-scale height of 2*m* above the local grade. During testing, the model sample period is selected to represent 1*hr* 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.

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. The effects of mean and gust wind conditions are weighted, combined and are plotted in Figures 6a through 6e for predicted comfort conditions.

Figures 7a – 7j are a representation of the percentage of time that a given point is comfortable for a given activity. The activities are described as suitable for Sitting or Standing or Walking over 80% of the time. In order for a point to be rated as suitable for Sitting, for example, the wind conditions must be less than 10 km/h. 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 wind speeds from calm up to 14km/h. In this situation, the wind would rustle tree leaves and, on occasion, move smaller branches while flags would be partially extended. 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 19km/h. 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, including wind speeds above 19km/h.

In the Figures, the probe locations and test configuration are listed along the bottom of the chart, beneath the graphical representation of the percentage of time that the winds are expected to fall within each category. The location is rated as suitable for sitting, standing or walking if the appropriate bar extends above the 80% level and is Uncomfortable if the bar for the category extends above 20%. Activities other than those indicated by the rating can take place at the points of interest, however, the time period will be less, as indicated in the percentage of time in the chart's abscissa axis. For example, a point that is rated as uncomfortable may be suitable for walking 75% of the time, standing 60% of the time and sitting 45% of the time.

The charts represent the average person's response to wind for the seasons. 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.

5. RESULTS

Study Site and Test Conditions

Proposed Development

The Development occupies the northeast portion of a block lands situated to the west of the intersection of Hurontario Street with Eglinton Avenue West. The subject site is currently vacant, and occupies the northeast portion of the North Block, which is Part 2 of the 4th Phase of the Pinnacle Development, and the South Block, which is Phase 5. The proposal for the North Block is for construction of 50 and 38 storey towers, denoted Building 3 and Building 4 respectively. The towers are stepped at various levels and feature a 3 storey connective podium and 5 storey wings, the buildings presenting a "C" shaped massing open to Part 1 of Phase 4. The South Block is comprised of 30, 35 and 50 storey towers, denoted Buildings 1 through 3, respectively, with a 3 storey podium and 5 and 10 storey connective wings. The towers are similarly stepped at various levels, Tower 3 has curved façades, and the combined massing is "L" shaped, in the configuration shown in Figure 2b. Four Springs Avenue, Watergarden Drive and Littlecreek Road provide circulation about the site.

The Development, located in the City of Mississauga, is depicted in the Aerial Photo in Figure 2a. Note: Mississauga's street orientation is relative to the Lake Ontario Shoreline resulting in east/west orientated streets in the subject area being offset by approximately 50 degrees north.

Surrounding Area

The most noteworthy buildings in the immediate surroundings, by proximity are the earlier phases of the development that include the "Amber", which is currently under construction as Phase 3, comprised of 26 and 23 storey Buildings with a connective podium, and to the immediate southeast of the proposed. Further southeast, fronting Eglinton Avenue West, the "Crystal" is complete and comprised of 28 and 24 storey buildings including a 4 storey connective podium. Phase 2 occupies a block of lands to the southwest and is comprised of 14 - 3 storey townhouse blocks with Cooksville Creek and related lands creating the site's boundary. Phase 4, The Perla Development occupies the northwest portion of Block 2, lands situated to the west of the intersection of Hurontario Street with Eglinton Avenue West. The proposal is for construction of 15 and 34 storey residential towers, respectively denoted Building 1 and Building 2, including a 3 storey podium, and Amenities Space at grade.

Significant surroundings removed from the site include a 10 storey apartment building situated to the northwest at 20 Ceremonial Drive, with townhomes followed by Cooksville Creek Public School and detached dwellings with progression to the southwest. To the northeast, across Hurontario Street, the Hurontario Street & Nahani Way development site is proposed to include a 33 storey residential tower with 2 storey townhomes planned along the northeasterly side of the site, fronting the balance of Nahani Way and the future Belbin Street. To the southeast and east of the abovementioned, also proposed along Hurontario Street, Summit Eglinton Inc. proposes to build Townhouses and Semi Detached Units on lands along the northwest and northeast extremities of the site, removed from Hurontario Street, with high-rise to the southeast and southwest with the latter fronting Hurontario Street. To the southeast of Eglinton Avenue West, and southwest of Hurontario Street lay several large residential buildings that are well spaced with parking, green space and Cooksville Creek related lands with townhomes and lower density residential farther to the southwest along Eglinton Avenue West.

Macroclimate

For the proposed Development, the upstream wind flow during testing was conditioned to simulate an atmospheric boundary layer passing over urban/suburban terrain. The terrain within the site's immediate vicinity was incorporated into the proximity model. Historical meteorological data recorded from the Toronto Pearson International Airport was used in this analysis. For studies in the City of Mississauga, the data is presented annually and for four seasons and 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 10*m*. Thus, representative ground level velocities at a height of 2*m*, 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 this area is dependent upon wind direction and varies with direction between suburban and urban.

Winter (November 16 to March 31) has the highest mean velocities of the seasons with prevailing winds from the north and west, with significant components from north through west to southwest as indicated in Figure 5b. Summer (June 16 to September 15) has the lowest mean wind velocities of the seasons with prevailing winds from north through west to southerly as indicated in Figure 5d. Spring and Fall winds tend to be more moderate and emanate from the north through west to southwest. Reported pedestrian comfort ratings generally pertain to annual conditions, unless stated otherwise.

Pedestrian Level Wind Velocity Study

Pedestrian level wind velocity measurement probes were located on the site model. The instrumented areas include the street frontages adjacent to the proposed Development, placed at approximately 10m spacing, as well as other buildings and activity areas, and the test data was used 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 and proposed scenarios. For the existing setting, the subject building was removed and the "existing" site model retested.

Measurements of pedestrian level mean and gust wind speeds at the various locations shown were taken over a period of time 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 of the Appendices, 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 is 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 on an annual and seasonal basis in Figures 6a-6e.

The ratings for a given location are conservative by design, and those ratings that are Uncomfortable, when close to a transition between Walking and Uncomfortable, will not pose a problem from a pedestrian comfort point of view. 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 an urban/suburban setting to prevailing and remaining compass points with winds flowing over and between buildings. As such, the surroundings can be expected to influence wind at the site to varying degrees. It should be noted that the probes are positioned at points typically subject to windy conditions in an urban environment in order to determine the worst-case scenario.

Review of Probe Results

The probe results, as follows, were clustered into groups comprised of Public Street Conditions, Interior Courtyard and Sidewalk Conditions, Pedestrian Entrance Conditions, and Outdoor Amenity Areas. The measurement locations are depicted in Figure 4 and are listed in Figures 6a through 6e, annually and for the seasons, for the existing and proposed configurations. The results are also graphically depicted for the existing and proposed configurations in Figures 7a – 7j. The following discusses anticipated wind conditions and suitability for the points' intended use.

Public Street Conditions

Hurontario Street

Hurontario Street is orientated in a near northwest – southeast direction and is approximately perpendicular to Eglinton Avenue West and the intersecting roads circulating adjacent to the site. Probes 1 through 16 were located along Hurontario Street within the zone of influence of the proposed Development, as indicated in Figure 4, and of these probe locations, all but locations 10, 14, 15, and 16 indicate annual wind conditions that are suitable for walking in the existing setting, the latter suitable for standing. The ratings are partially attributable to westerly through southwesterly winds that are exacerbated upon approach by the currently open development site, the lack of turbulence inducing roughness affording winds opportunity to accelerate on approach.

The ratings can also be partially attributed to winds approaching in approximate alignment with the street, the open approach of the street, related boulevards, and low-rise commercial buildings, affording winds approaching the site from the southeasterly portion of the prevailing wind climate opportunity to accelerate on approach. Similarly, easterly winds approach from over low-rise commercial buildings with related parking and farmlands, an open setting that affords wind opportunity to accelerate.

With inclusion of the Proposed Development it is a reasonable expectation that portions of Hurontario Street, within proximity to the Proposed Development, will realize an improvement in pedestrian level comfort with winds from specific directions. This was apparent at most locations, the points realising a subtle improvement in predicted pedestrian comfort, however, the annual comfort ratings were unchanged, with exception. Probe locations 3, 7, 8, and 9 realised sufficient improvement to change annual comfort categories from walking to standing. Other probe locations also realised an improvement, however, this was not sufficient to change ratings on an annual basis. The improvements realised can be attributed to the proposed development presenting increased blockage to winds, resulting in the observed leeward effect, however, the realignment of winds associated with insertion of tall buildings into a suburban/urban setting invariably causes a realignment of winds that can result in localised uncomfortable conditions, on occasion.

From the mean ground level wind velocity presented as a ratio of gradient wind speed, in the plots of Figure B in the Appendix, it is apparent that most of these points realise an improvement over the existing setting with inclusion of the Proposed Development for specific wind directions, however, there are directions from which the wind is exacerbated. Should that direction coincide with dominant wind directions, as indicated in Figure 5's wind roses, relatively more windy conditions can be expected. As such, the more windy conditions predicted at probe location 2, situated at the north corner of the North Block and is subject to winds that formerly flowed over the open lands of the existing site being redirected to flow around the subject and neighbouring building and, with winds from specific directions, to the pedestrian level, result in an occasionally uncomfortable rating.

The above-mentioned, considered in concert with massing features and landscaping that were too fine to be incorporated into the site and surroundings, and urban intensification of land to the northeast of Hurontario Street will result in further improvement, likely sufficient to bring the annual uncomfortable rating to walking. During the winter months, uncomfortable winds on occasion are an acceptable pedestrian comfort condition. All points are suitable for activities requiring longer exposure times during the summer.

Eglinton Avenue West

Probes 17 and 18 were located along the above-named street within the zone of influence of the proposed Development. The test locations indicate a relatively comfortable setting in the existing environment, with probe location 18 predicted as comfortable, suitable for standing annually and location 17 suitable for walking, and as such are suitable to the respective areas' intended purposes. The Proposed Development is removed from Eglinton Avenue West and as a result only subtle changes were noted with its inclusion, however, the change was sufficient to change the annual comfort rating for location 17 from walking to standing. Probe location 18 was unchanged.

Watergarden Drive

Probes 19 through 25 were located along Watergarden Drive. In the existing setting said points display an annual rating as suitable for walking with the exception of point 22, which is proximate to the Hurontario Street intersection and was rated as suitable for standing. During the winter months the southwest end of the street will be uncomfortable on the occasion of high ambient winds. These conditions are often typical of an area in transition whereby the insertion of urban buildings into an open/suburban setting results in localised windy conditions with improvement realised to areas removed from said development. These conditions generally improve with further urban intensification and/or build out.

With inclusion of the Proposed Development the aforementioned transition is observed with probe locations 19, 20, 23 and 24, situated along the southwest portion of the street realising a substantial improvement. While said improvement was not sufficient to change the annual comfort ratings it was sufficient to change the winter comfort ratings from uncomfortable to walking. Conversely, probe locations 21 and 25 realised an increase in windiness that was sufficient to change their annual comfort ratings from walking to uncomfortable.

During the winter months point 22, situated in the gap between the Proposed buildings, was predicted uncomfortable on the occasion of strong winter winds emanating from the southwesterly and northeasterly quadrants. Several of the points are near the transition between walking and uncomfortable, and will be suitable for Walking or better during the winter months approximately 75% to 77% of the time, 80% being the transition from uncomfortable to walking. The points are subject to winds that formerly flowed over the open lands of the existing site being redirected to flow around the subject buildings and, with winds from specific directions, to the pedestrian level, resulting in more windy conditions.

Mitigation of downwash conditions is well understood and was applied through design whereby canopies, balconies and overhangs, porous fencing, as well as other design features, were employed, as discussed in the Conclusions and Recommendations Section of this report. These, considered in concert with massing features that were too fine to be incorporated into the surroundings, indicate that Watergarden Drive remains suitable for its intended purpose, within acceptable pedestrian comfort criteria for the winter months, and suitable for activities requiring longer exposure times during the summer.

Salishan Circle

Probe 26 was located along the above named street within the zone of influence of the proposed Development. The test location indicates a relatively comfortable setting in the existing environment, with the probe location predicted as comfortable, suitable for walking annually and during the winter months, and suitable to the area's intended purpose.

The additional wind blockage created by the Proposed Development to winds that formerly flowed over the open area induced a significant improvement in wind conditions along Salishan Circle, proximate to the Proposed Development, changing the annual and winter comfort rating from walking to standing.

Interior Courtyard and Sidewalk Conditions

Probes 32 and 33 were placed along the sidewalk proximate to the southwest side of the Development's North Block. The analysis indicates conditions that are respectively suitable for walking and standing annually, in the existing setting. Probe 32 improved with inclusion of the proposed development, but remained unchanged annually, probe 33 realised an increase in windiness that was sufficient to change the rating to walking annually. During the winter probe 32 changes from uncomfortable to walking while 33 remains unchanged as suitable for walking. The predicted comfort levels at these points are attributed to the Proposed Development causing a realignment of winds, sheltering the area proximate to probe 32 from the prevailing wind climate and partially exposing the area about probe 33. The areas are appropriate to their intended purposes.

Probes 31 and 39 were respectively located within the internal courtyards of the North and South Blocks. Said Points realised moderately windy conditions in the existing setting, suitable for standing or walking on an annual basis. With inclusion of the proposed Development a realignment of winds was noted, whereby the proposed Development obstructed portions of the wind climate that formerly flowed over the area, causing point 39 to change comfort ratings to Standing. Point 40 was situated on the grounds to the south of the South Block and remains comfortable, suitable for standing on an annual basis.

Pedestrian Entrance Conditions

Probes 27 through 30 were placed along the sidewalk adjacent to the principle Entrances to the North Block and probes 34 through 38 were similarly placed proximate to the Residential Entrances to the South Block. The probe locations exhibit moderately windy conditions in the existing setting that are attributable to exposure to what is considered the relatively open setting and as such will afford wind opportunity to accelerate on approach.

With the inclusion of the proposed Development, the wind is deflected over, and/or around the building podium resulting in the entrances being in the building's aerodynamic shade regions, for most wind directions and as such will realise comfortable conditions, suitable for standing, and as such appropriate to the intended purpose, with exception. Probes 27, 28, and 29, placed at entrances serving the North Block, were rated as suitable for walking on an annual basis. However, the predicted comfort ratings are for the most part mid to low-range in the walking category, and as such the will be suitable for standing during the summer months and well into the spring and fall. With consideration of the Development's and neighbouring buildings fine design features, and landscaping, and incorporation of entrance vestibules, the entrances will be comfortable and suitable to the intended purpose, most of the time.

Probes 34 and 37, placed along the sidewalks adjacent to entrances serving the South Block, were also rated as suitable for walking on an annual basis, however, the predicted comfort rating for probe 34 is near the threshold to uncomfortable. The entrance is removed from the corner and set into a recessed area and as such is removed from winds deflected to flow along the Watergarden Drive boulevards and sidewalk, and as such, will be more comfortable than the ratings indicate. As such the entrance will be comfortable, and suitable to its intended purpose much of the time. Probe 37 was mid to low-range in the walking category, similar to those of the North Block, and as such will realise comfortable conditions, suitable to the areas' intended purpose. The remaining entrances are rated as suitable for standing on an annual basis.

Wind conditions comfortable for standing are preferable at building entrances, while conditions suitable for walking are suitable for sidewalks. Conditions at the proposed main residential and commercial entrances and related walkways are considered comfortable, with the above noted exception, and suitable to the intended purpose. Consideration of existing and proposed surface roughness features too fine to incorporate into the massing model will further improve the comfort ratings.

Outdoor Amenity Areas

Outdoor amenity areas are situated atop the podiums between the towers, as indicated in Figure 2b. The spaces will be susceptible to winds from specific directions being deflected to flow down, around and through the towers, resulting in windy, though not inordinate wind conditions, and are predicted suitable for walking during the summer months, under normal to high ambient wind conditions. Under strong or gusty wind conditions, portions of the Amenity Spaces proximate to the towers will be susceptible to winds and windy, however, the areas are expected to realise seasonally appropriate conditions some of the time.

The analysis was conducted without the subject and neighbouring buildings' fine design features or existing and proposed hard and soft landscape features in place. As such, we reasonably expect prevailing pedestrian comfort conditions will be better than those predicted.

A mitigation plan is recommended for the amenity spaces, if activities requiring longer exposure times are desired. This might be accomplished with a landscaping plan for the rooftop amenity spaces that includes appropriately engineered windscreens, railings, trellises, coarse vegetation, and others, which considered cumulatively, will further improve wind conditions in the residential amenity area, making them more suitable to the intended purpose.

Summary

The observed wind velocity and flow patterns at the Development are largely influenced by approach wind characteristics that are dictated by the urban/suburban mix of residential and commercial development, related open areas, and mature vegetation mitigating the wind, to different degrees, on approach. Historical weather data indicates that strong winds of a mean wind speed greater than 30 km/h occur approximately 13 percent of the time during the winter months and 4 percent of the time during the summer. Once the subject site is developed, ground level winds at several locations will improve, with occasional localized areas of higher pedestrian level winds. The relationship between surface roughness and wind is discussed in the Appendix and shown graphically in Figure A of the same section.

Consideration of existing and proposed building features too fine to incorporate into the massing model, along with recommended mitigation through the implementation of the landscape plan, will improve the predicted comfort ratings beyond those reported herein, resulting in conditions suitable for the intended use.

6. FIGURES:

Figure 1: Laboratory Testing Facility

Figure 2a: Site Aerial Photo

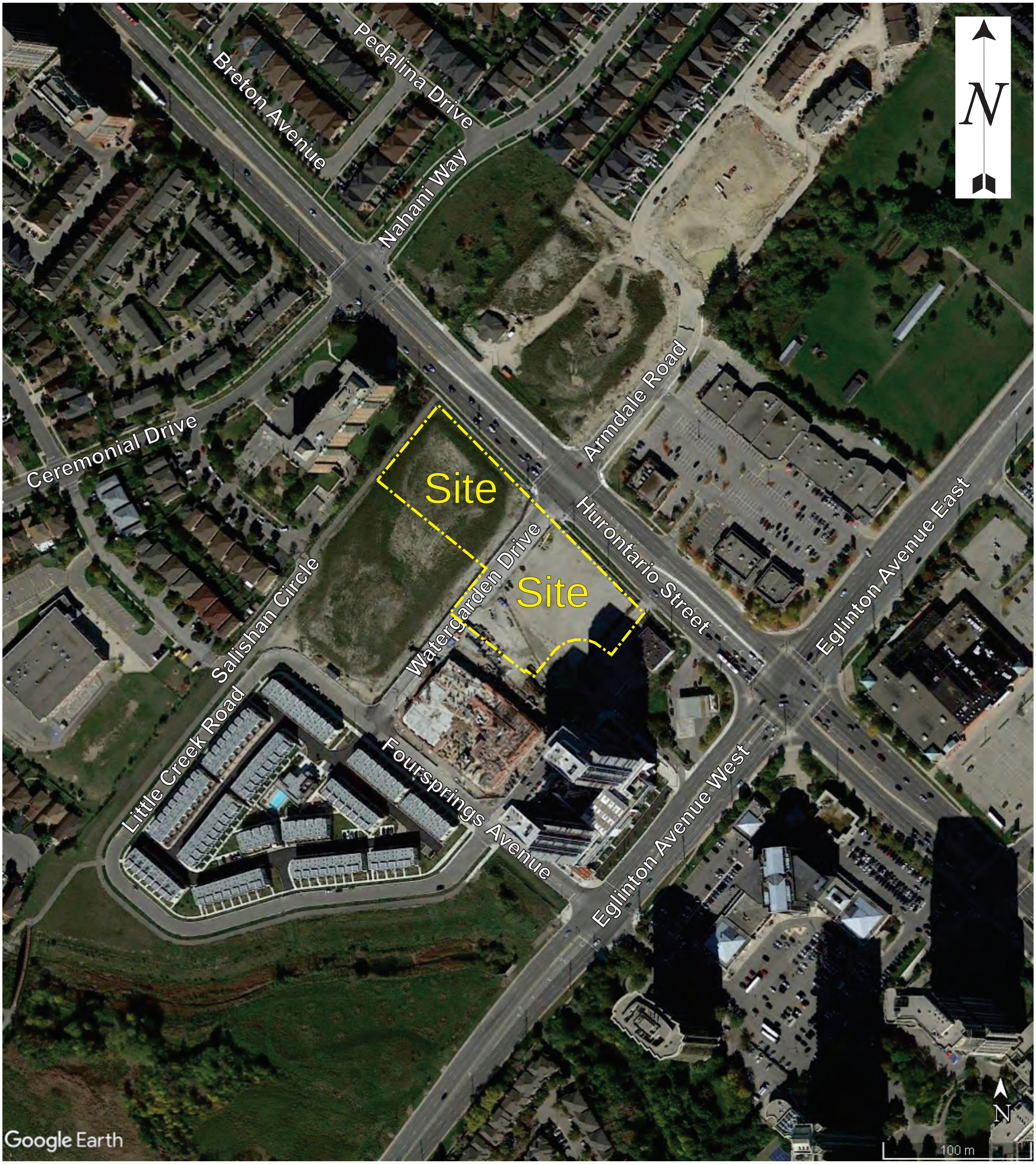


Figure 2b: Site Plan

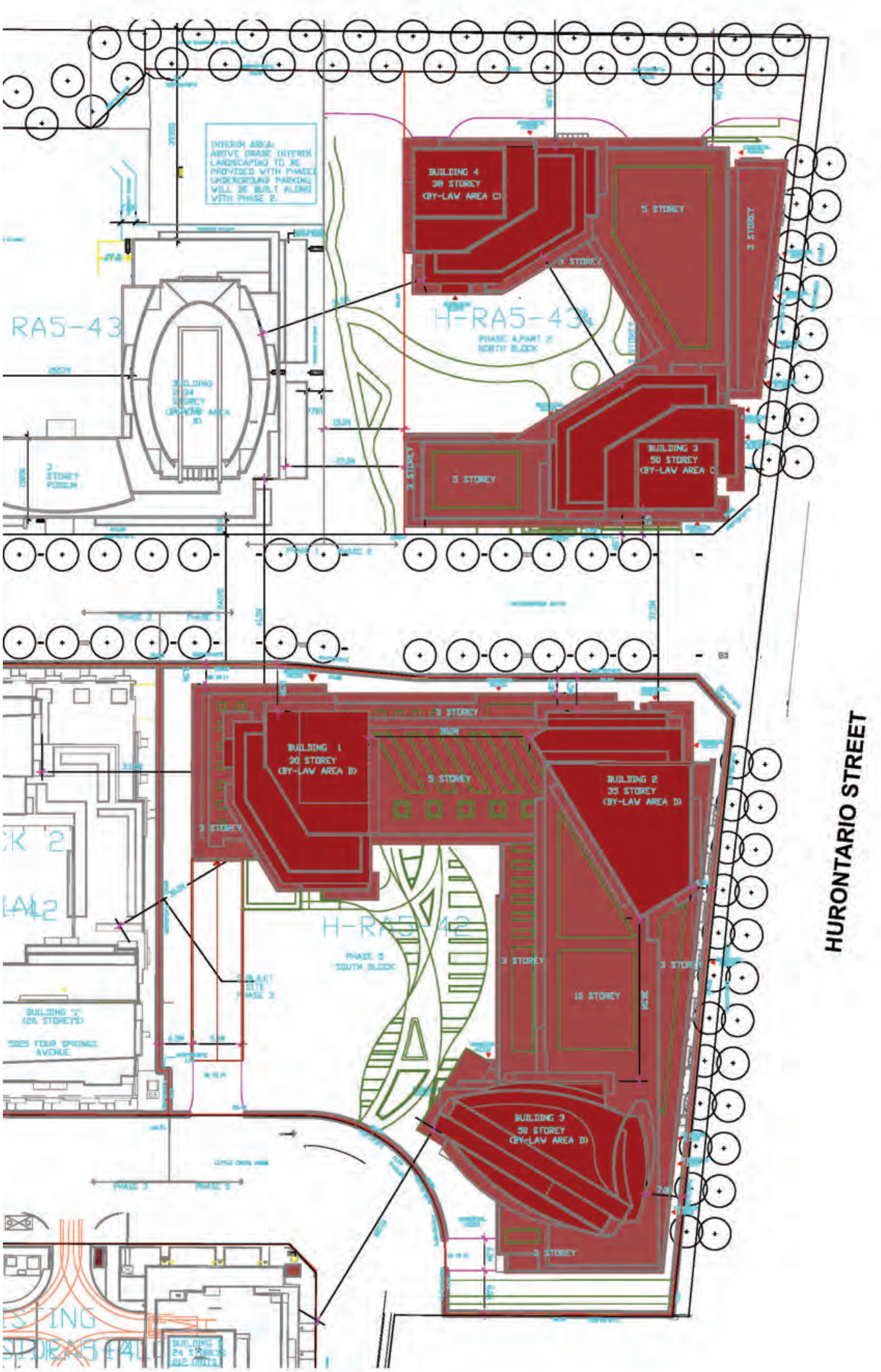
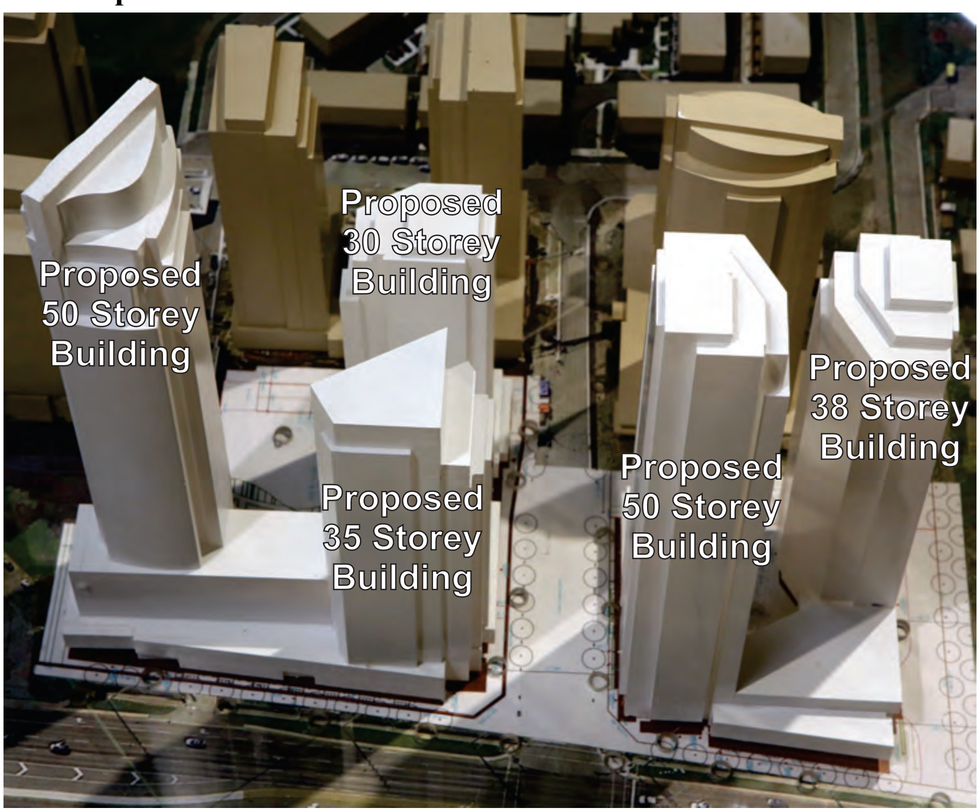


Figure 3: 1:500 Scale model of test site

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.

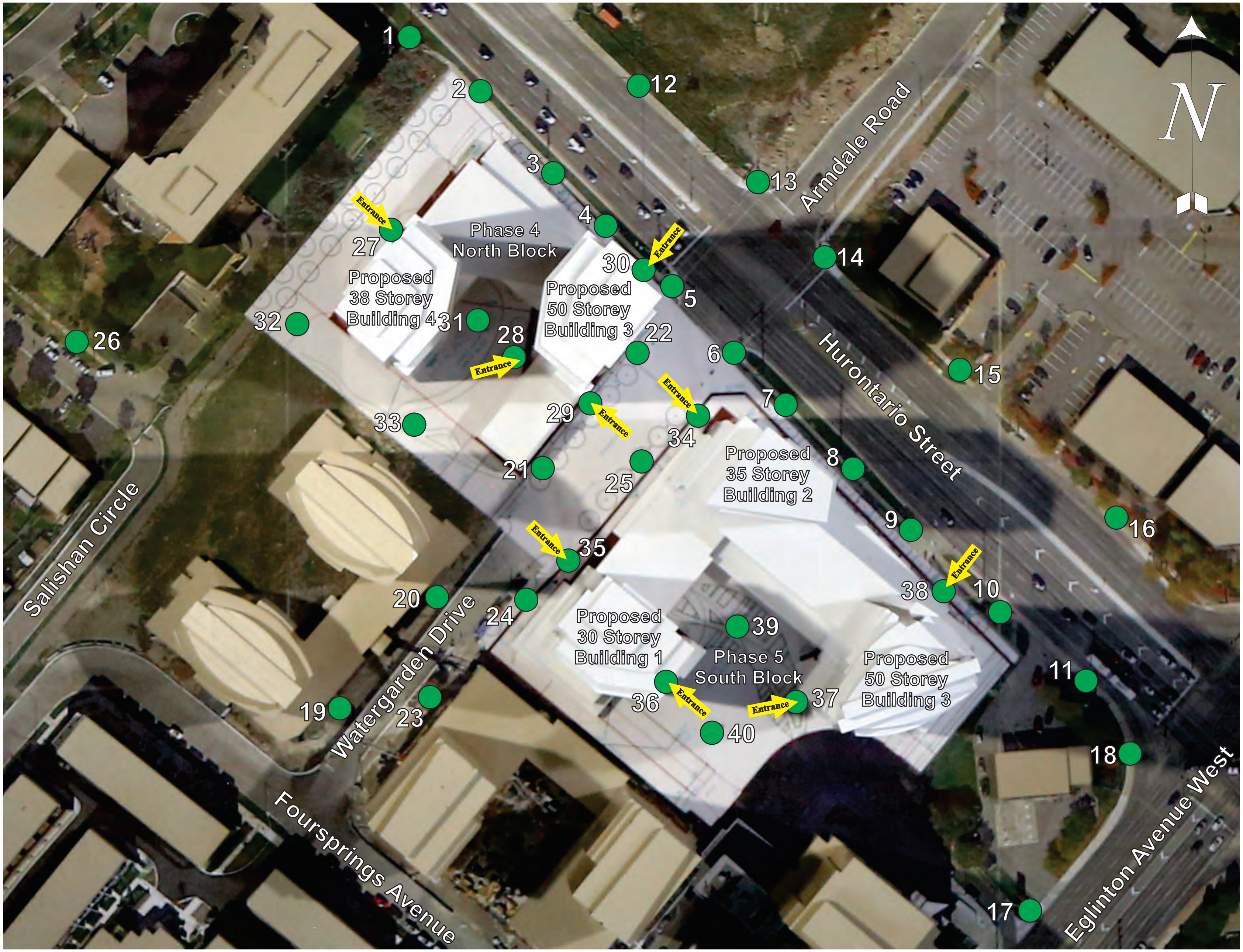
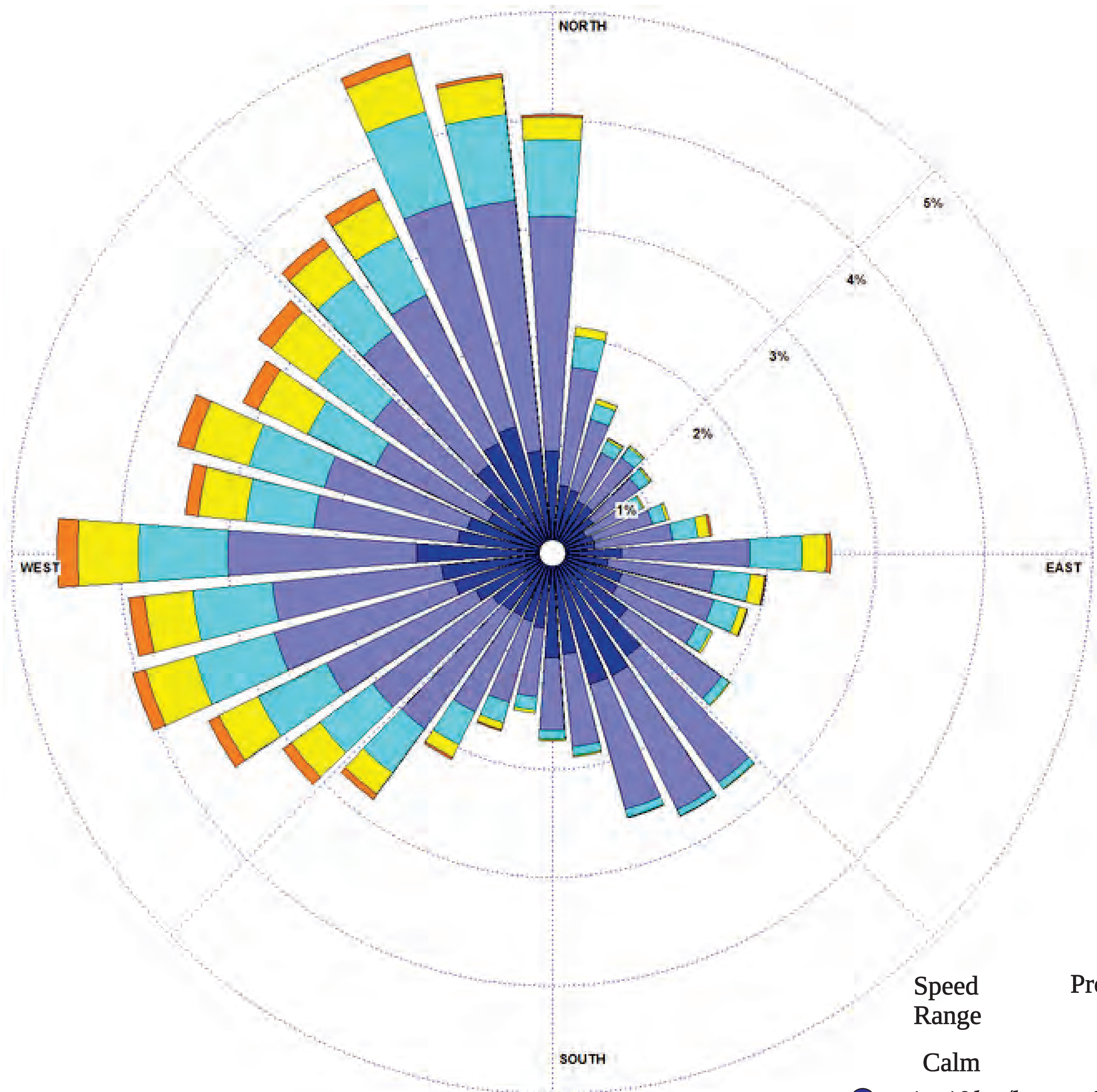


Figure 5a: Annual Wind Rose - Pearson International Airport.

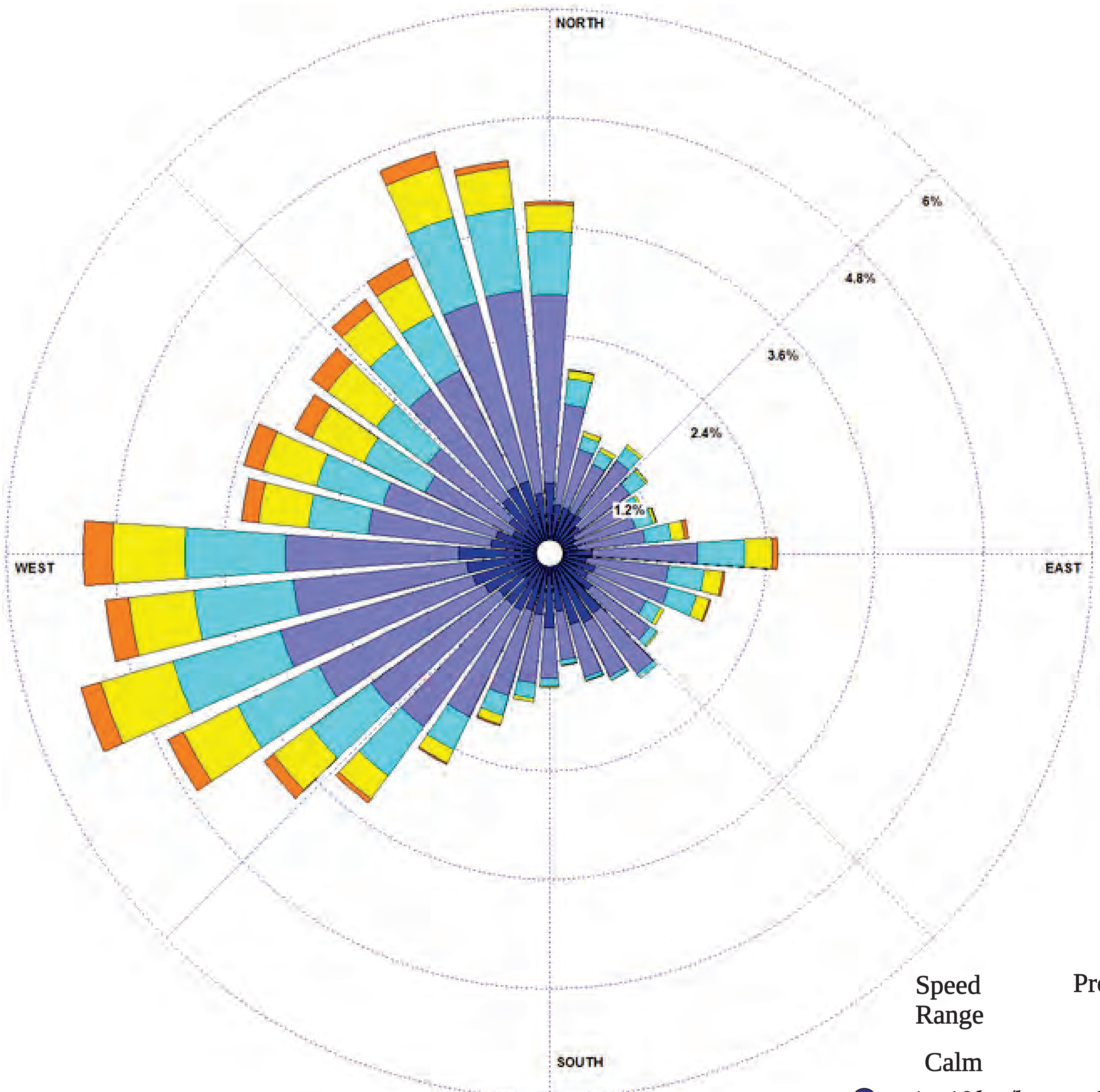
Historical Directional Distribution of Winds (@ 10*m* height)
(1980 - 2012)



Speed Range	Probability (%)
Calm	6%
1 - 10*km/h*	29%
11 - 20*km/h*	42%
21 - 30*km/h*	14%
31 - 40*km/h*	7%
> 40*km/h*	2%

Figure 5b: Winter Wind Rose - Pearson International Airport.

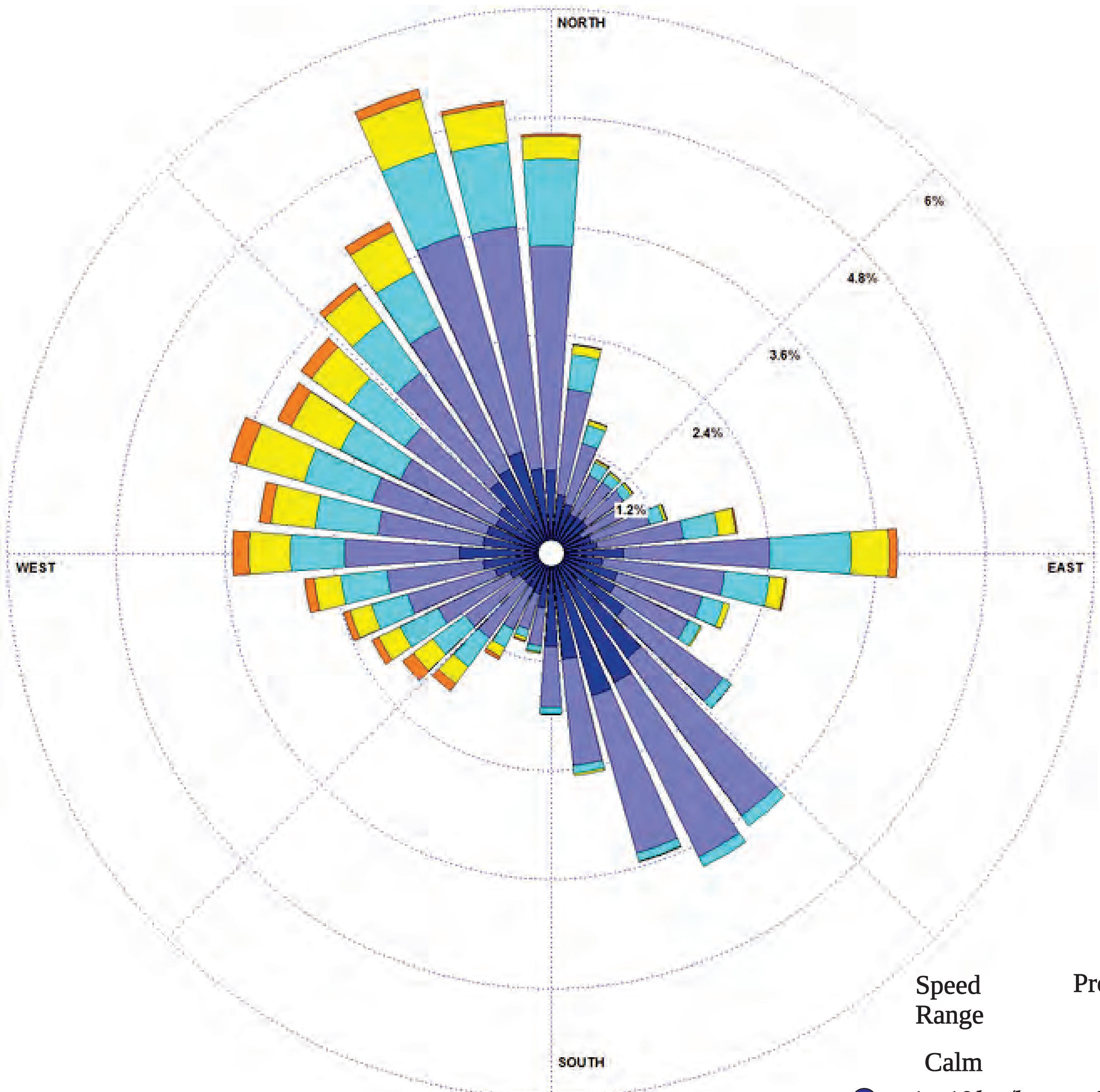
Historical Directional Distribution of Winds (@ 10*m* height)
November 16 through March 31 (1980 - 2012)



Speed Range	Probability (%)
Calm	5%
1 - 10*km/h*	23%
11 - 20*km/h*	42%
21 - 30*km/h*	17%
31 - 40*km/h*	10%
> 40*km/h*	3%

Figure 5c: Spring Wind Rose - Pearson International Airport.

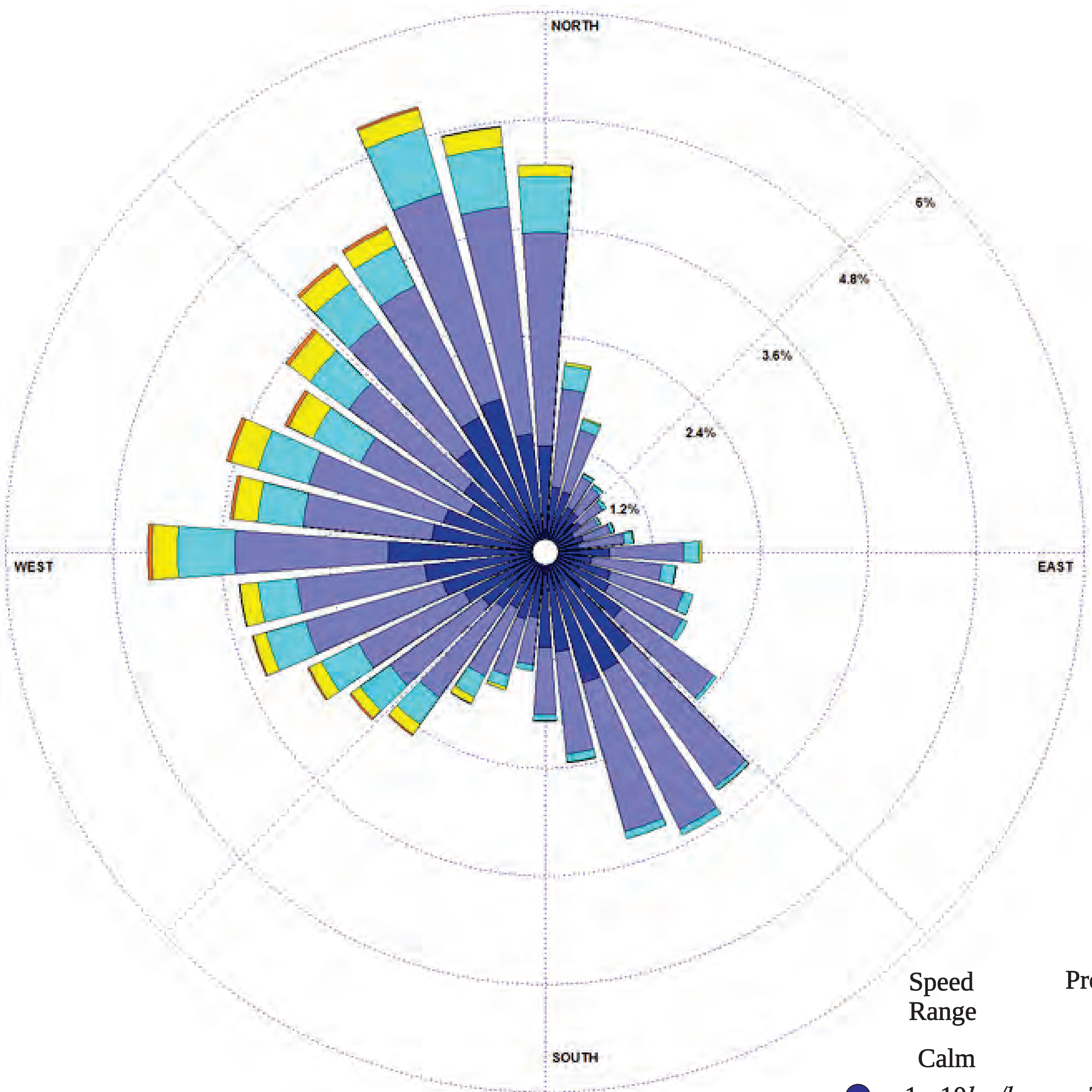
Historical Directional Distribution of Winds (@ 10*m* height)
April 1 through June 15 (1980 - 2012)



Speed Range	Probability (%)
Calm	6%
1 - 10*km/h*	28%
11 - 20*km/h*	42%
21 - 30*km/h*	14%
31 - 40*km/h*	8%
> 40*km/h*	2%

Figure 5d: Summer Wind Rose - Pearson International Airport.

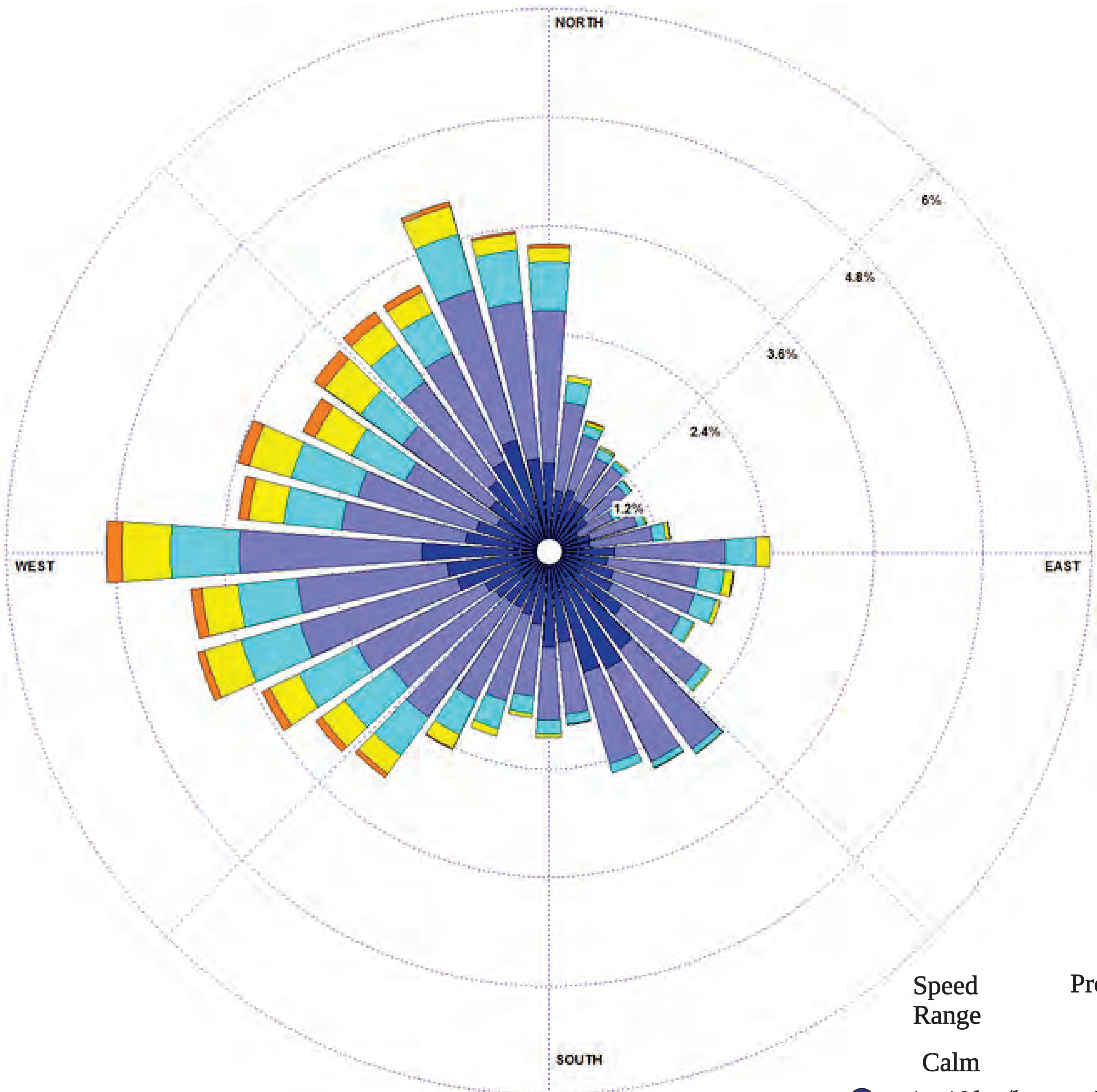
Historical Directional Distribution of Winds (@ 10*m* height)
June 16 through September 15 (1980 - 2012)



Speed Range	Probability (%)
Calm	7%
1 - 10*km/h*	36%
11 - 20*km/h*	43%
21 - 30*km/h*	10%
31 - 40*km/h*	4%
> 40*km/h*	<1%

Figure 5e: Fall Wind Rose - Pearson International Airport.

Historical Directional Distribution of Winds (@ 10*m* height)
September 16 through November 15 (1980 - 2012)



Speed Range	Probability (%)
Calm	7%
1 - 10*km/h*	31%
11 - 20*km/h*	41%
21 - 30*km/h*	13%
31 - 40*km/h*	6%
> 40*km/h*	2%

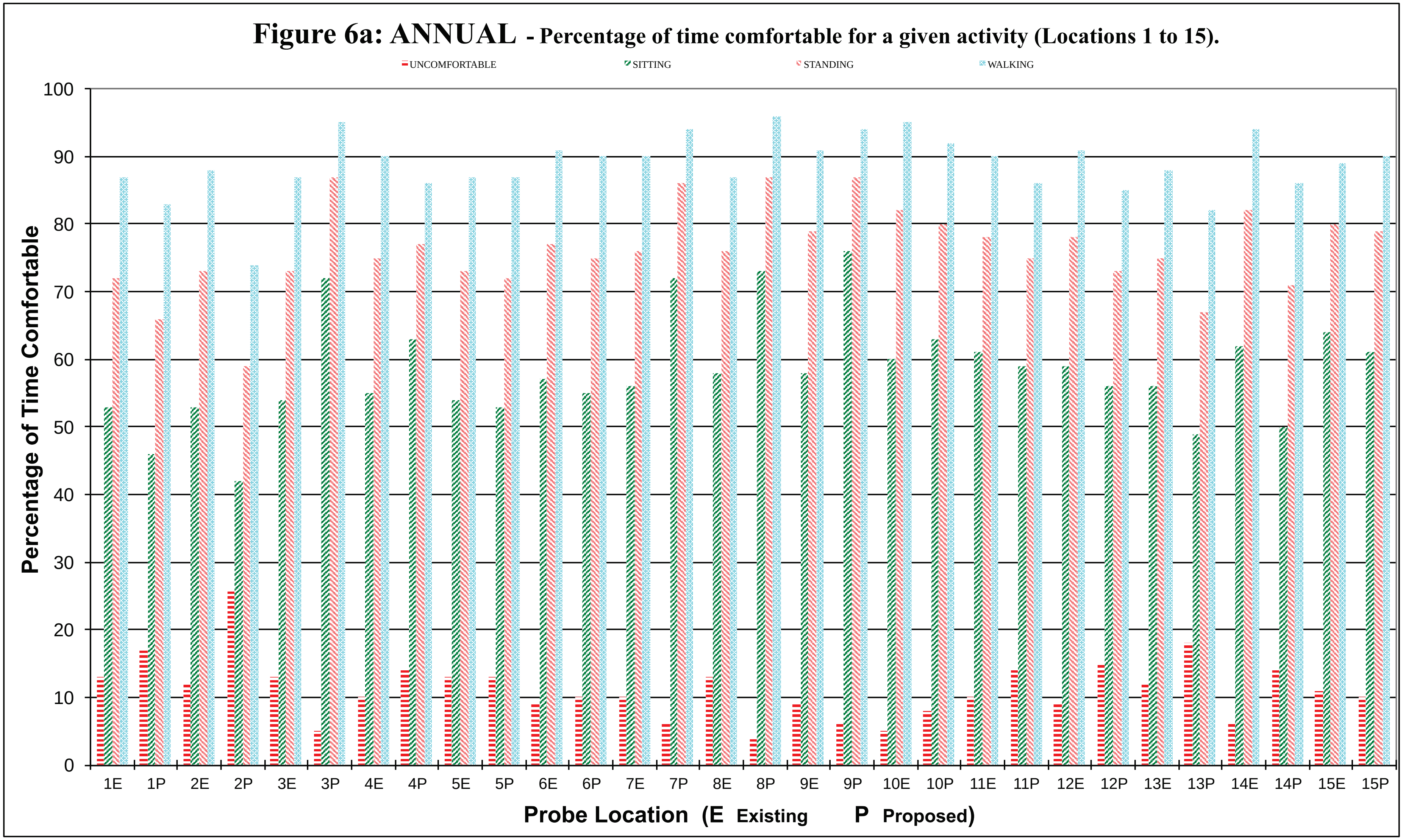


Figure 6a: ANNUAL - Percentage of time comfortable for a given activity (Locations 1 to 15).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
100
90
80
70
60
50
40
30
20
10
0
1E 1P 2E 2P 3E 3P 4E 4P 5E 5P 6E 6P 7E 7P 8E 8P 9E 9P 10E 10P 11E 11P 12E 12P 13E 13P 14E 14P 15E 15P
Probe Location (E Existing P Proposed)

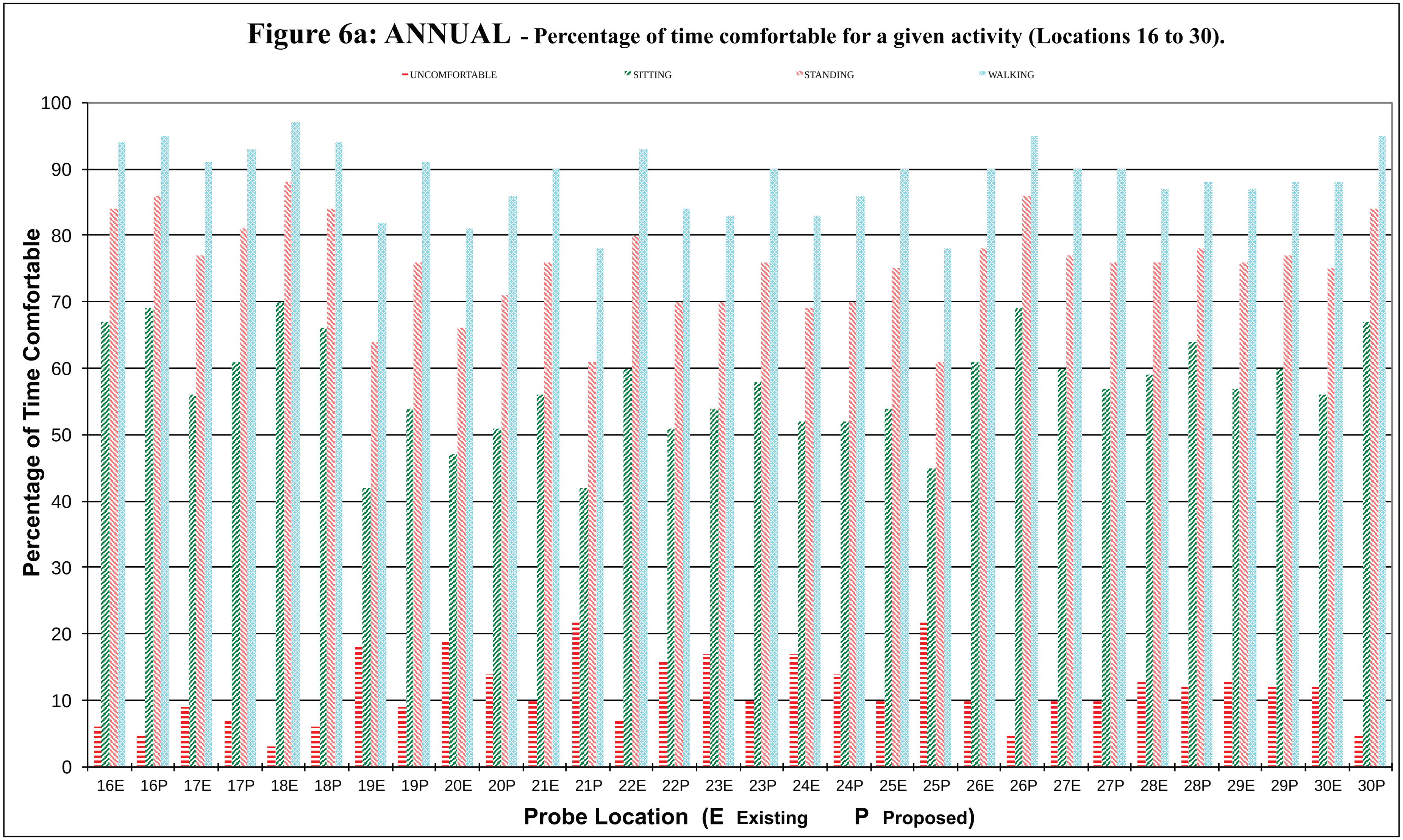


Figure 6a: ANNUAL - Percentage of time comfortable for a given activity (Locations 16 to 30).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
16E 16P 17E 17P 18E 18P 19E 19P 20E 20P 21E 21P 22E 22P 23E 23P 24E 24P 25E 25P 26E 26P 27E 27P 28E 28P 29E 29P 30E 30P
Probe Location (E Existing P Proposed)

Figure 6a: ANNUAL - Percentage of time comfortable for a given activity (Locations 31 to 40).

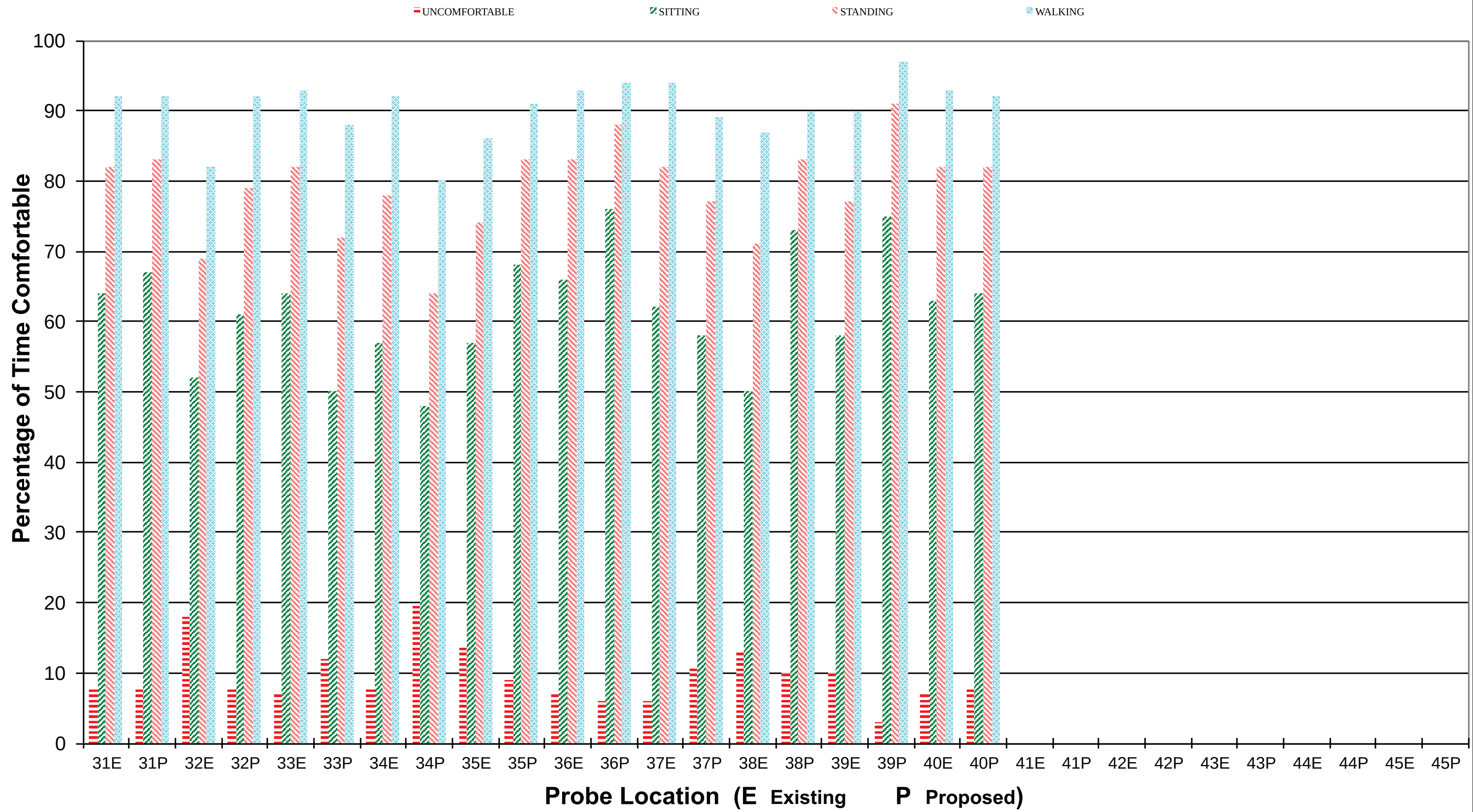
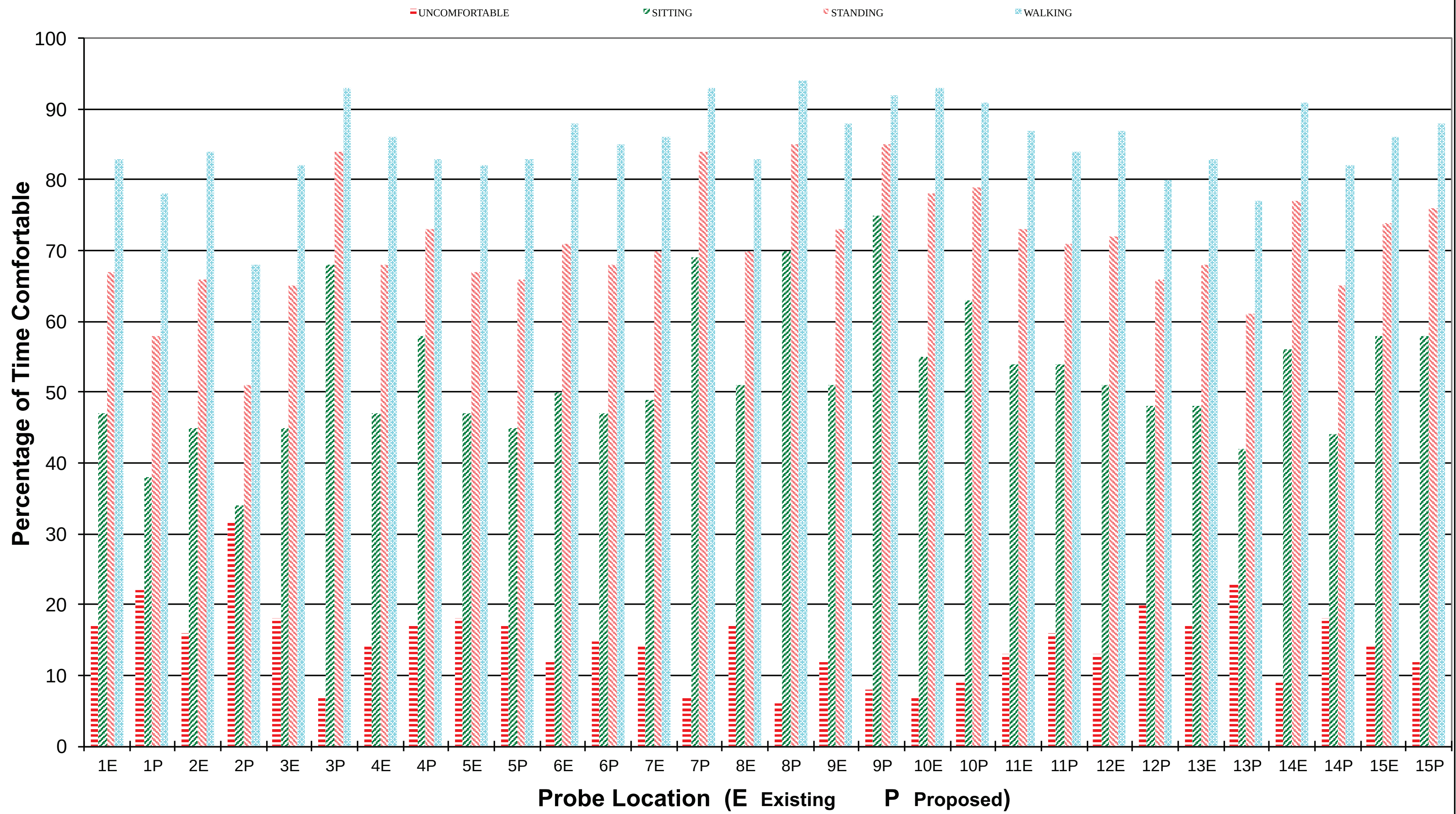


Figure 6b: WINTER - Percentage of time comfortable for a given activity (Locations 1 to 15).



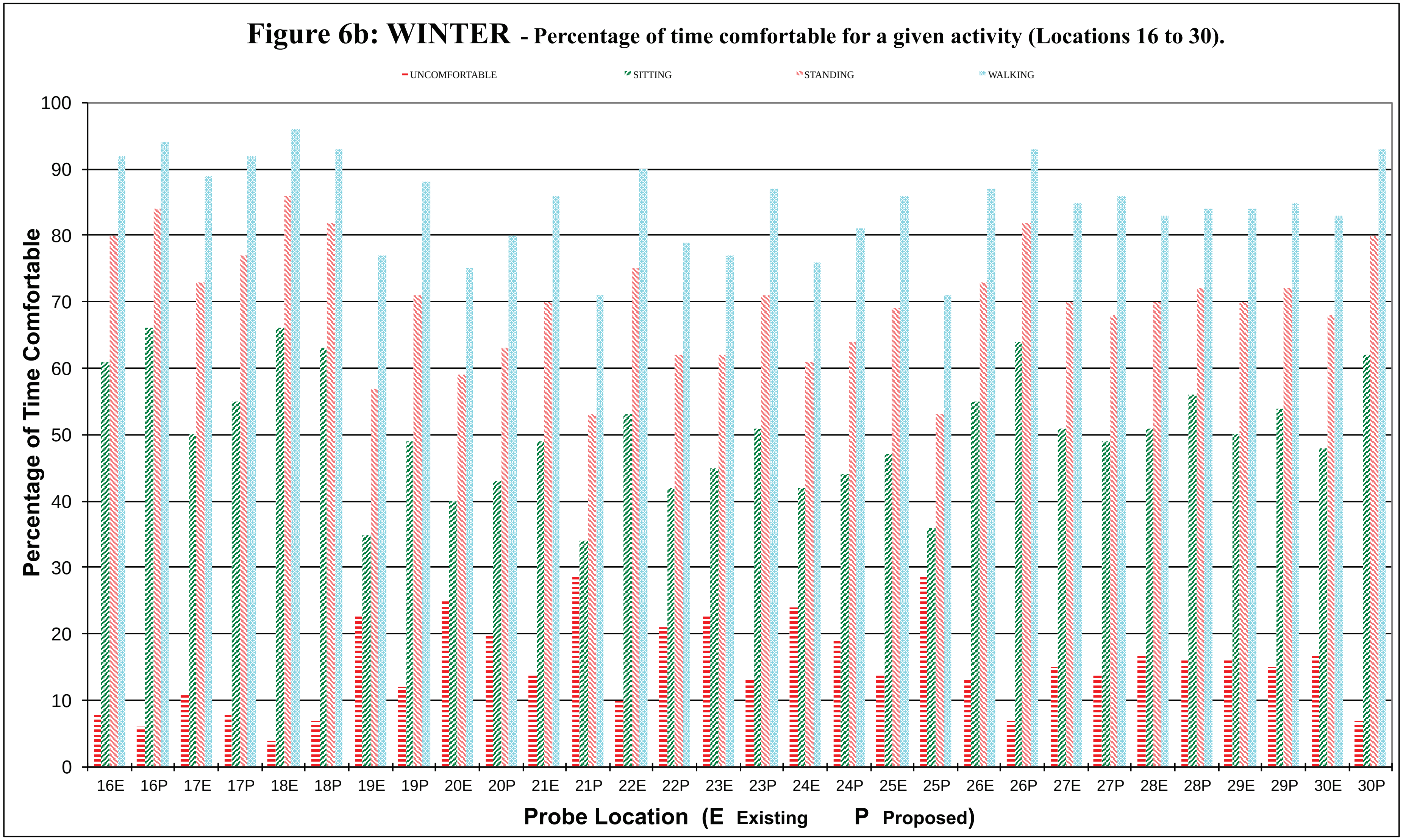


Figure 6b: WINTER - Percentage of time comfortable for a given activity (Locations 16 to 30).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
16E 16P 17E 17P 18E 18P 19E 19P 20E 20P 21E 21P 22E 22P 23E 23P 24E 24P 25E 25P 26E 26P 27E 27P 28E 28P 29E 29P 30E 30P
Probe Location (E Existing P Proposed)

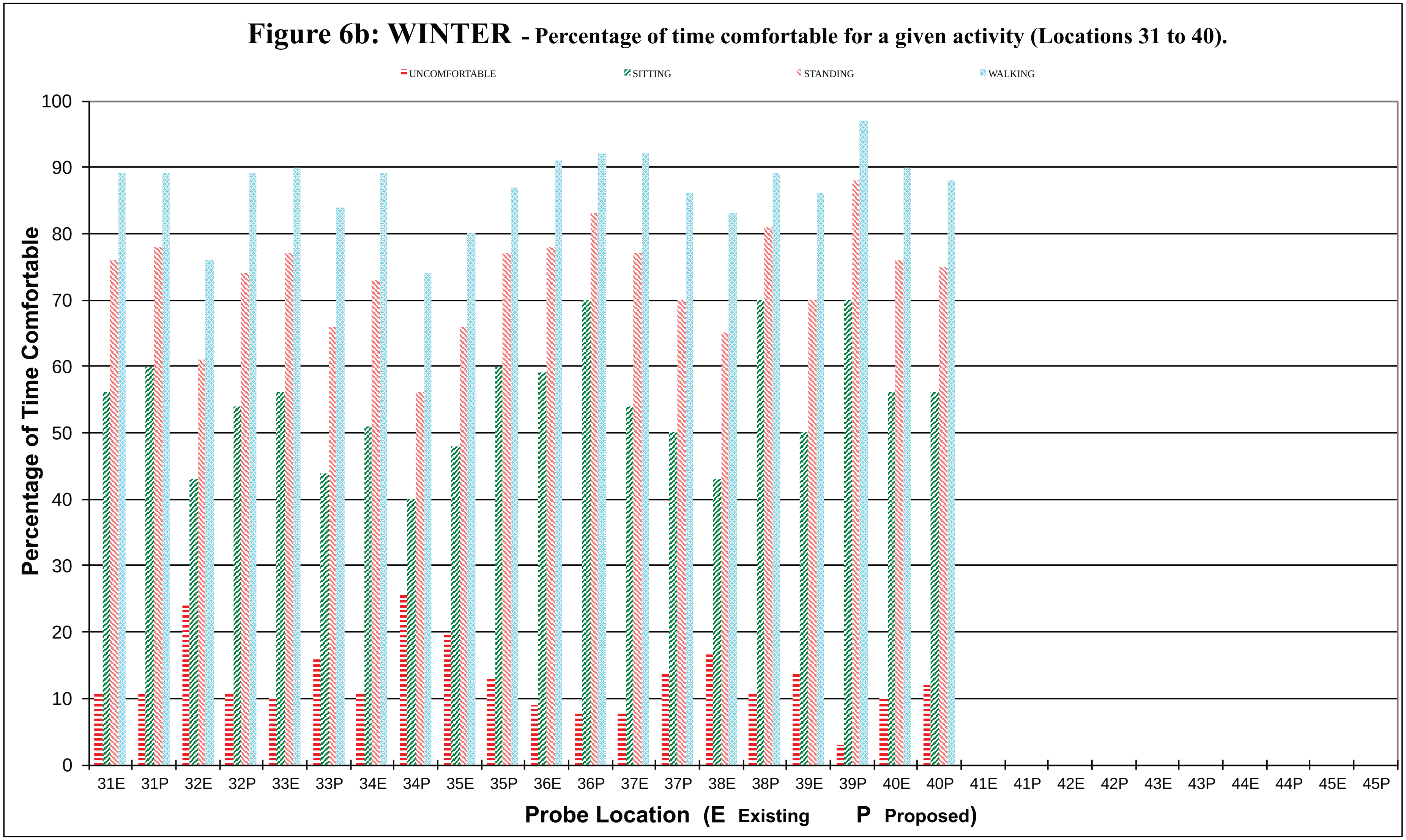


Figure 6b: WINTER - Percentage of time comfortable for a given activity (Locations 31 to 40).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
100
90
80
70
60
50
40
30
20
10
0
31E 31P 32E 32P 33E 33P 34E 34P 35E 35P 36E 36P 37E 37P 38E 38P 39E 39P 40E 40P 41E 41P 42E 42P 43E 43P 44E 44P 45E 45P
Probe Location (E Existing P Proposed)

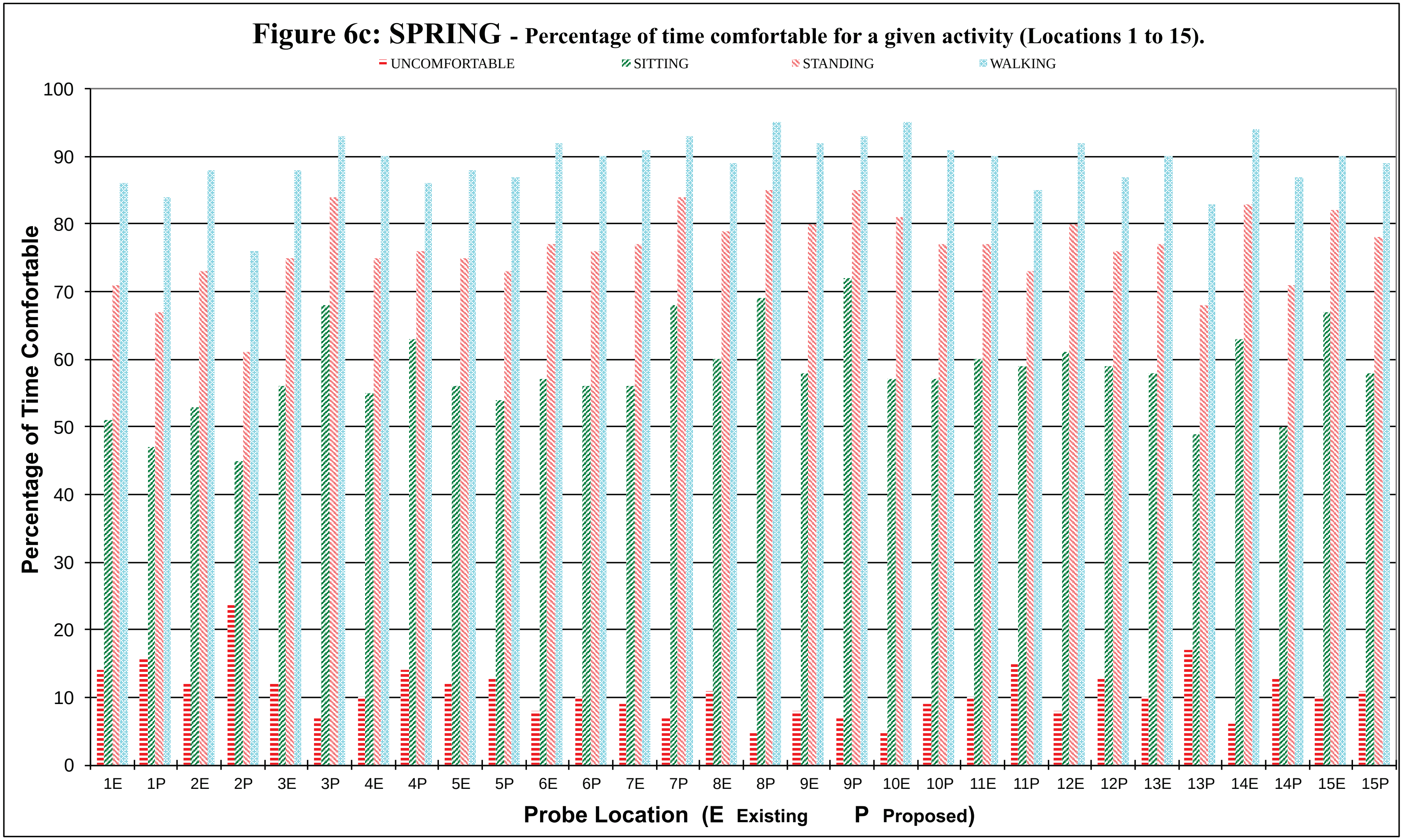


Figure 6c: SPRING - Percentage of time comfortable for a given activity (Locations 1 to 15).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
1E
1P
2E
2P
3E
3P
4E
4P
5E
5P
6E
6P
7E
7P
8E
8P
9E
9P
10E
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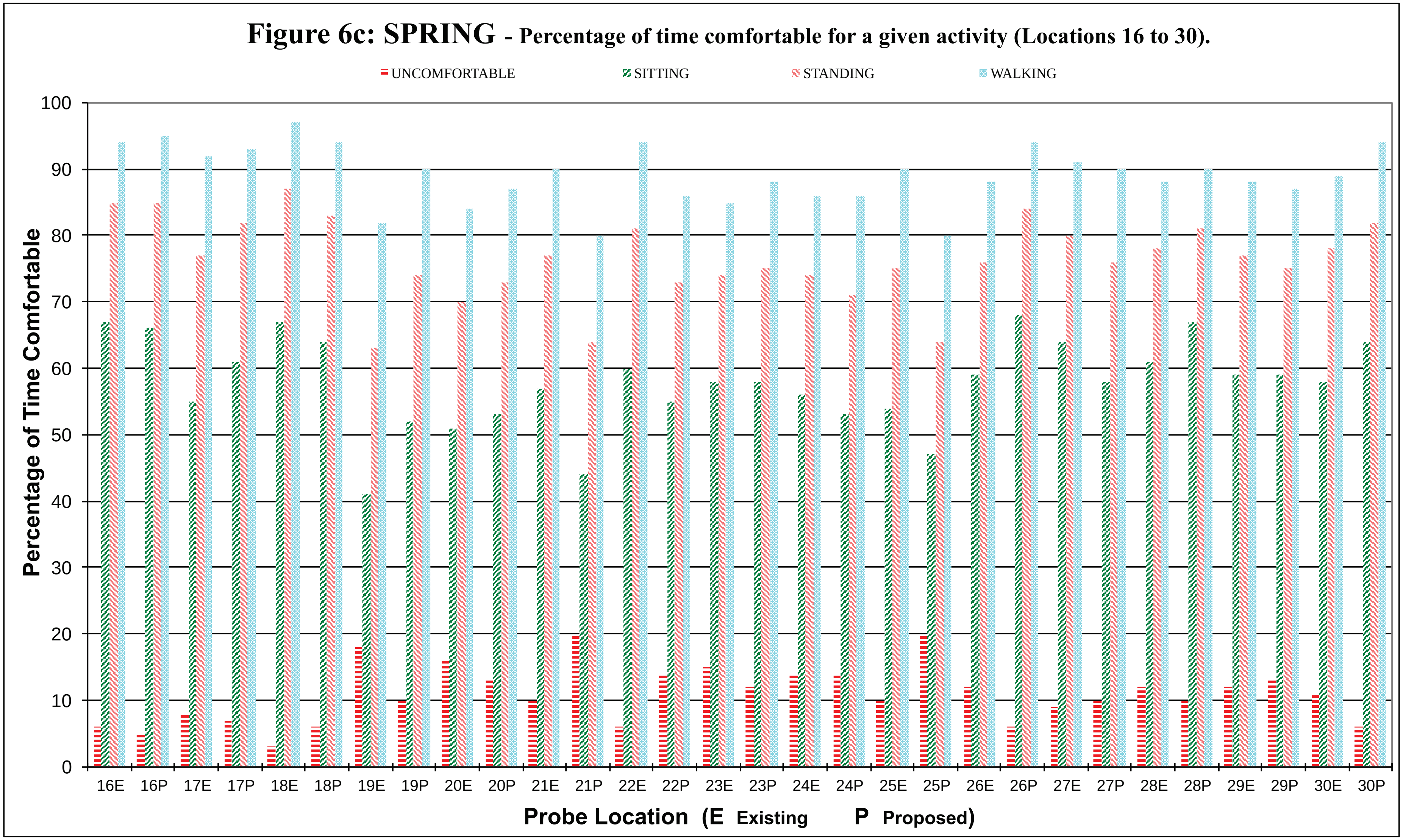
11E
11P
12E
12P
13E
13P
14E
14P
15E
15P
Probe Location (E Existing P Proposed)



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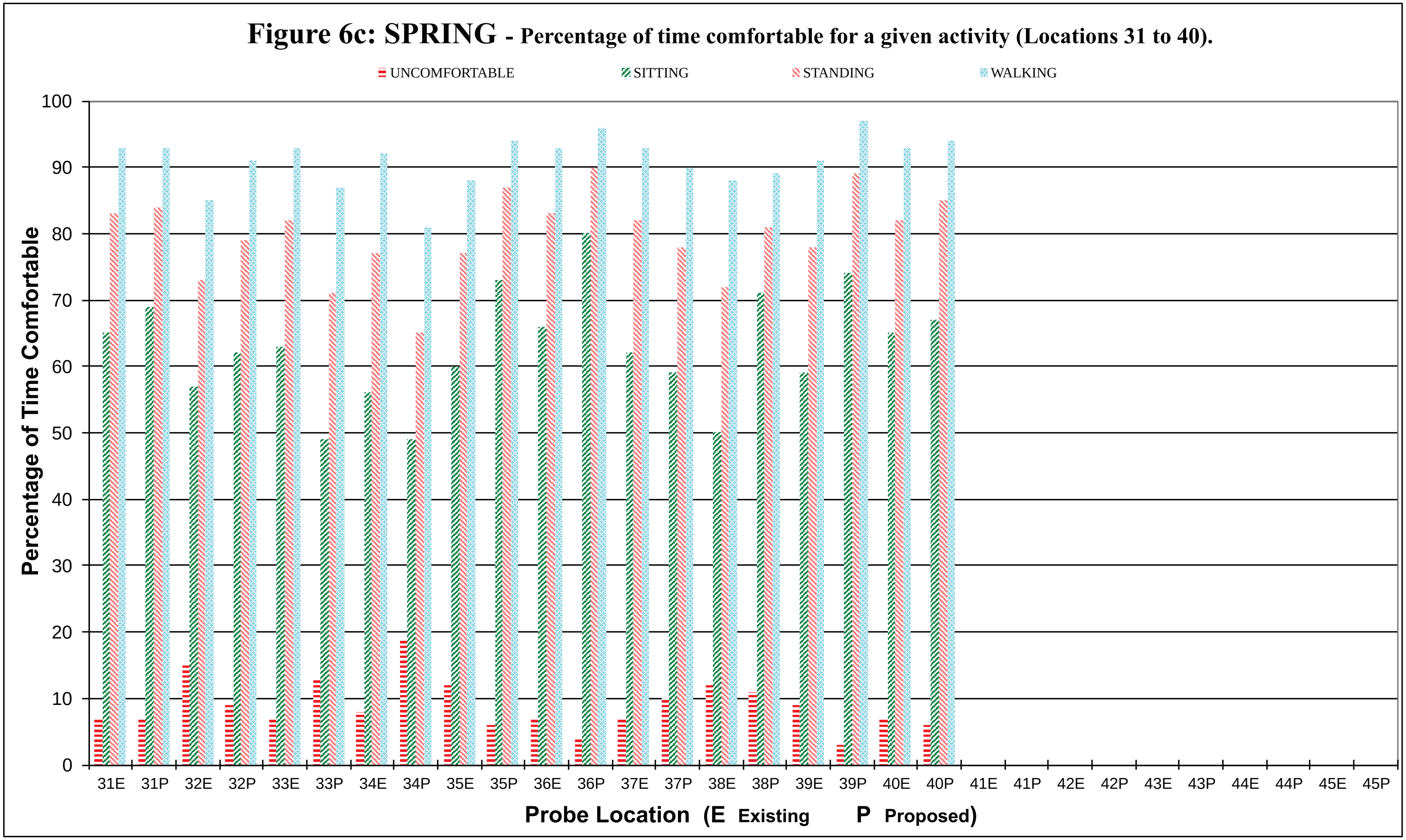


Figure 6c: SPRING - Percentage of time comfortable for a given activity (Locations 31 to 40).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
31E 31P 32E 32P 33E 33P 34E 34P 35E 35P 36E 36P 37E 37P 38E 38P 39E 39P 40E 40P 41E 41P 42E 42P 43E 43P 44E 44P 45E 45P
Probe Location (E Existing P Proposed)

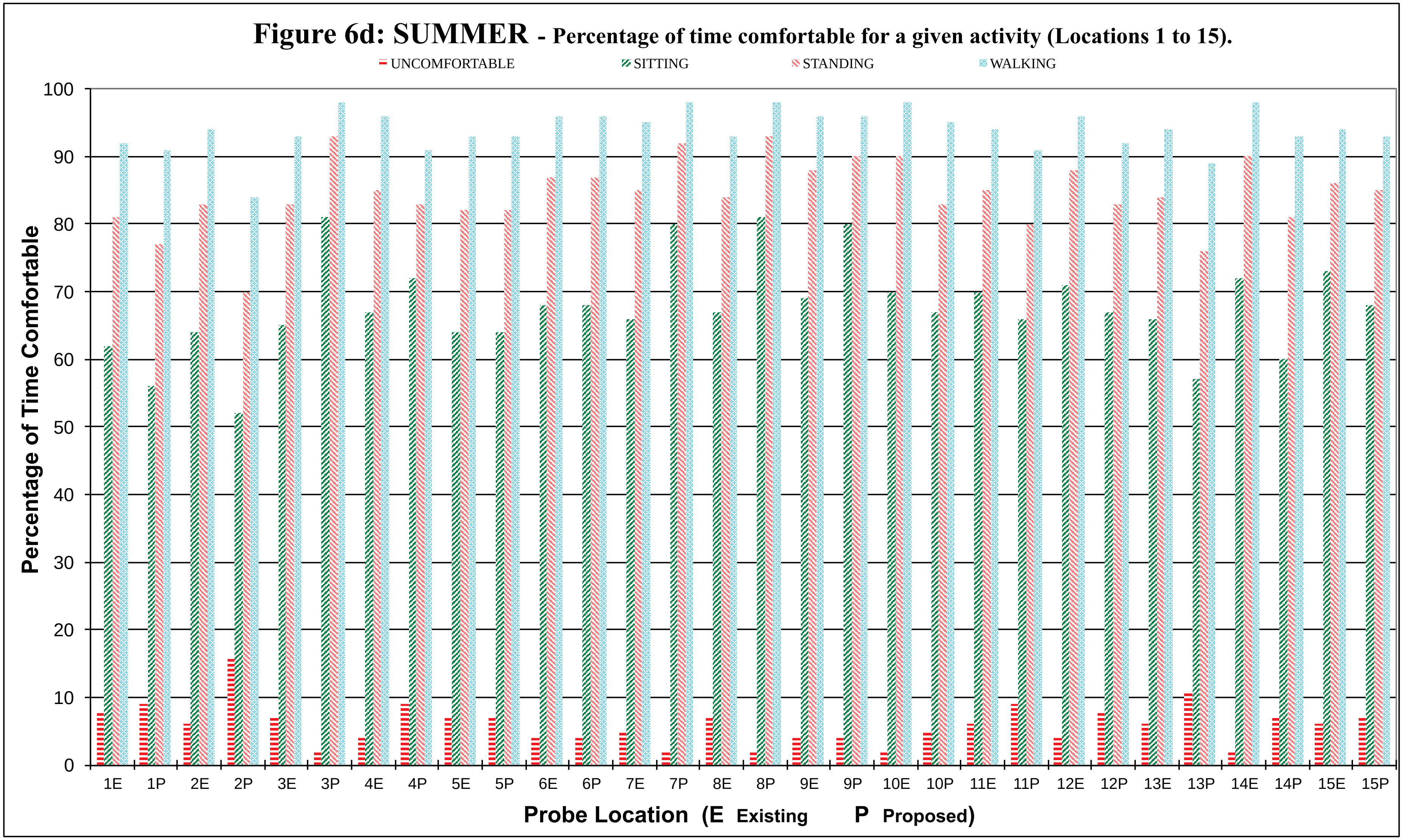


Figure 6d: SUMMER - Percentage of time comfortable for a given activity (Locations 1 to 15).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
1E 1P 2E 2P 3E 3P 4E 4P 5E 5P 6E 6P 7E 7P 8E 8P 9E 9P 10E 10P 11E 11P 12E 12P 13E 13P 14E 14P 15E 15P
Probe Location (E Existing P Proposed)

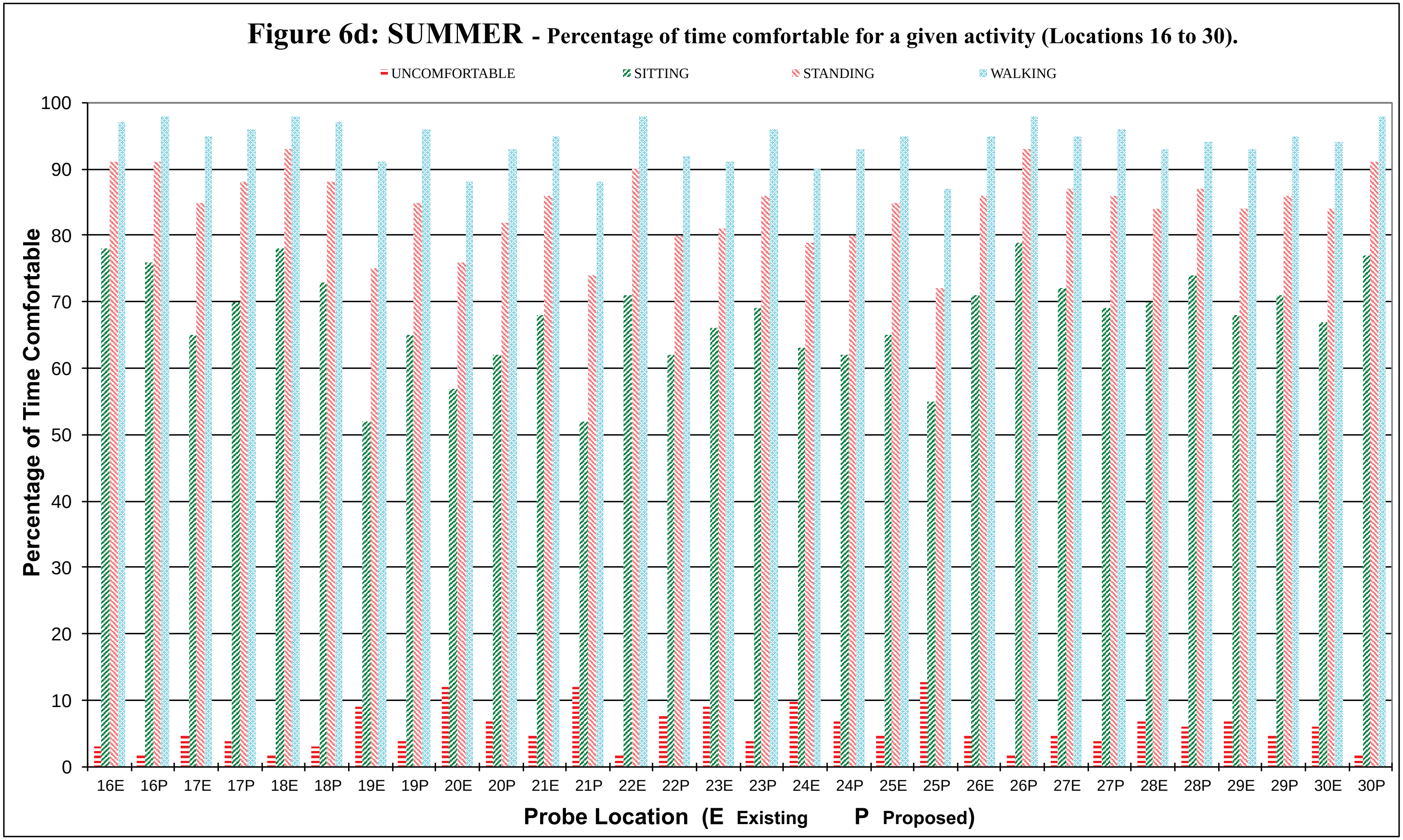


Figure 6d: SUMMER - Percentage of time comfortable for a given activity (Locations 16 to 30).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
16E 16P 17E 17P 18E 18P 19E 19P 20E 20P 21E 21P 22E 22P 23E 23P 24E 24P 25E 25P 26E 26P 27E 27P 28E 28P 29E 29P 30E 30P
Probe Location (E Existing P Proposed)

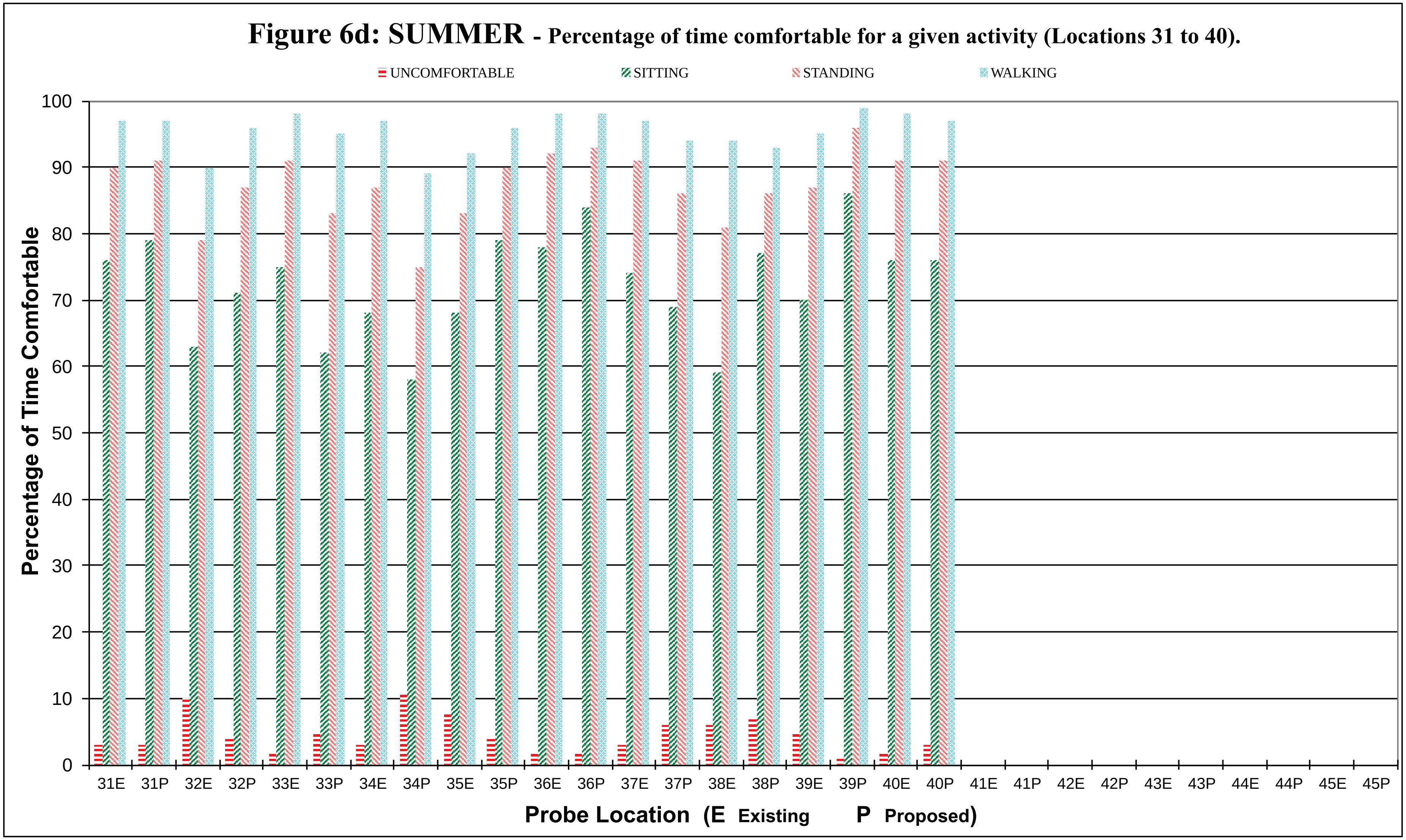


Figure 6d: SUMMER - Percentage of time comfortable for a given activity (Locations 31 to 40).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
31E 31P 32E 32P 33E 33P 34E 34P 35E 35P 36E 36P 37E 37P 38E 38P 39E 39P 40E 40P 41E 41P 42E 42P 43E 43P 44E 44P 45E 45P
Probe Location (E Existing P Proposed)

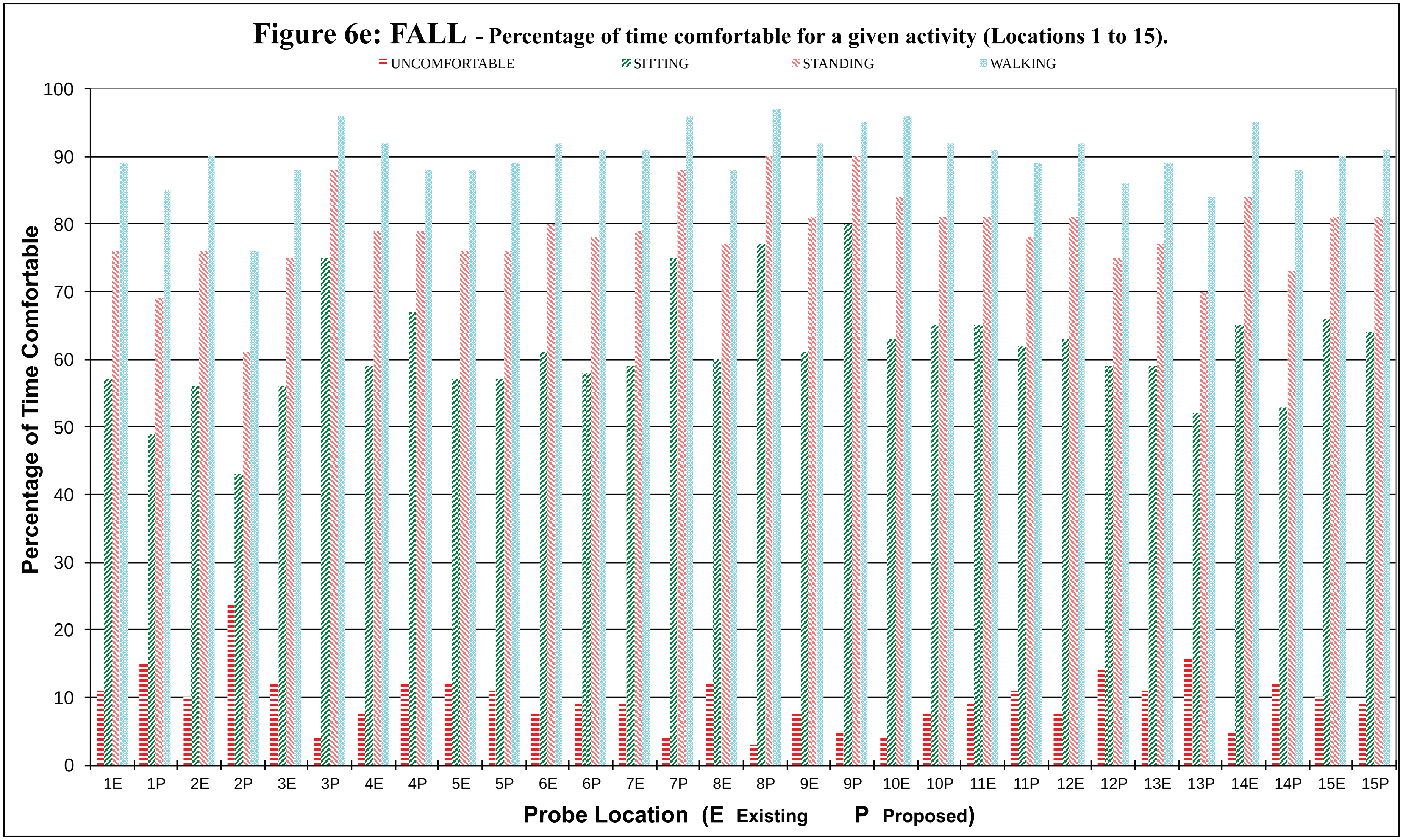
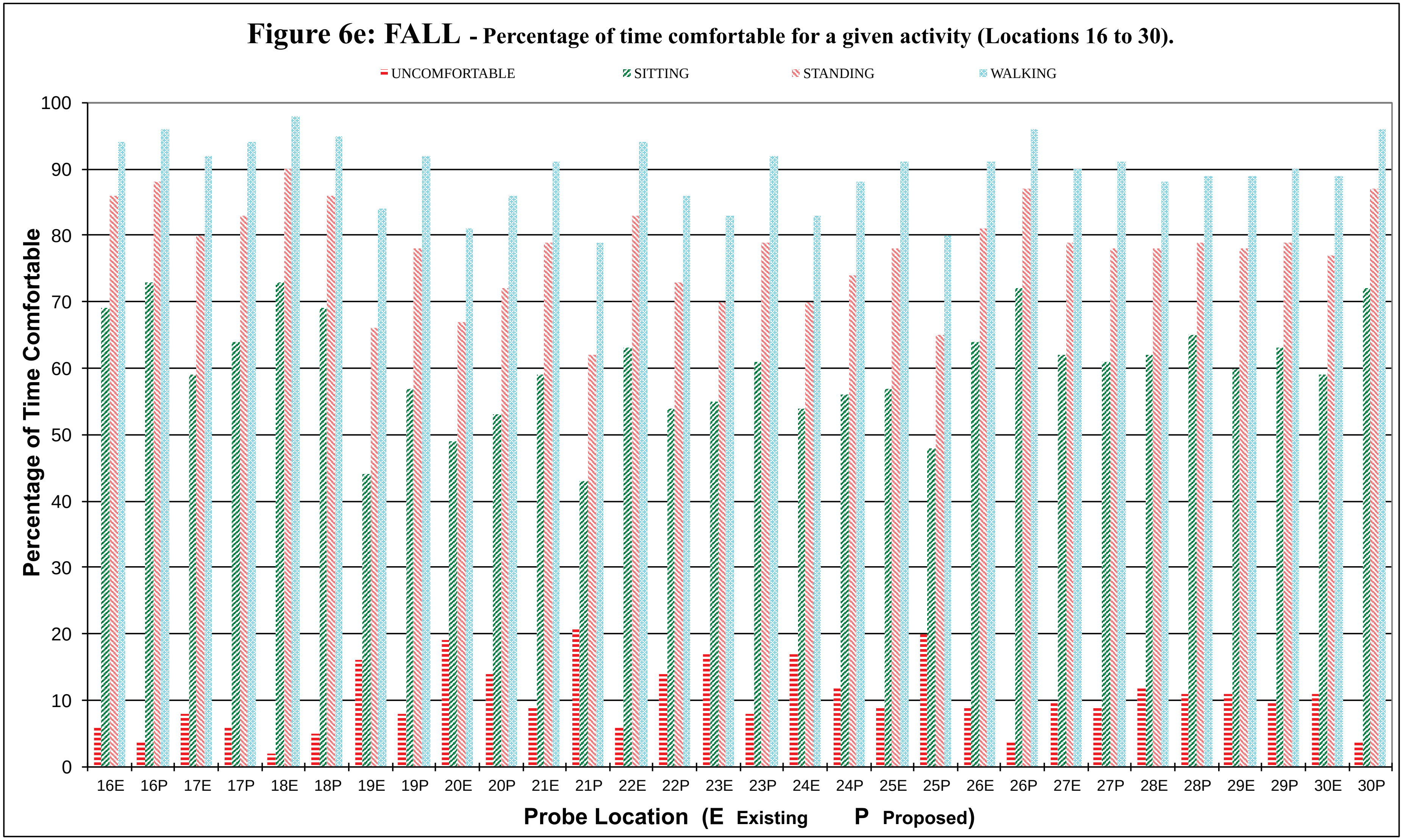


Figure 6e: FALL - Percentage of time comfortable for a given activity (Locations 1 to 15).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
0
10
20
30
40
50
60
70
80
90
100
1E
1P
2E
2P
3E
3P
4E
4P
5E
5P
6E
6P
7E
7P
8E
8P
9E
9P
10E
10P
11E
11P
12E
12P
13E
13P
14E
14P
15E
15P
Probe Location (E Existing P Proposed)



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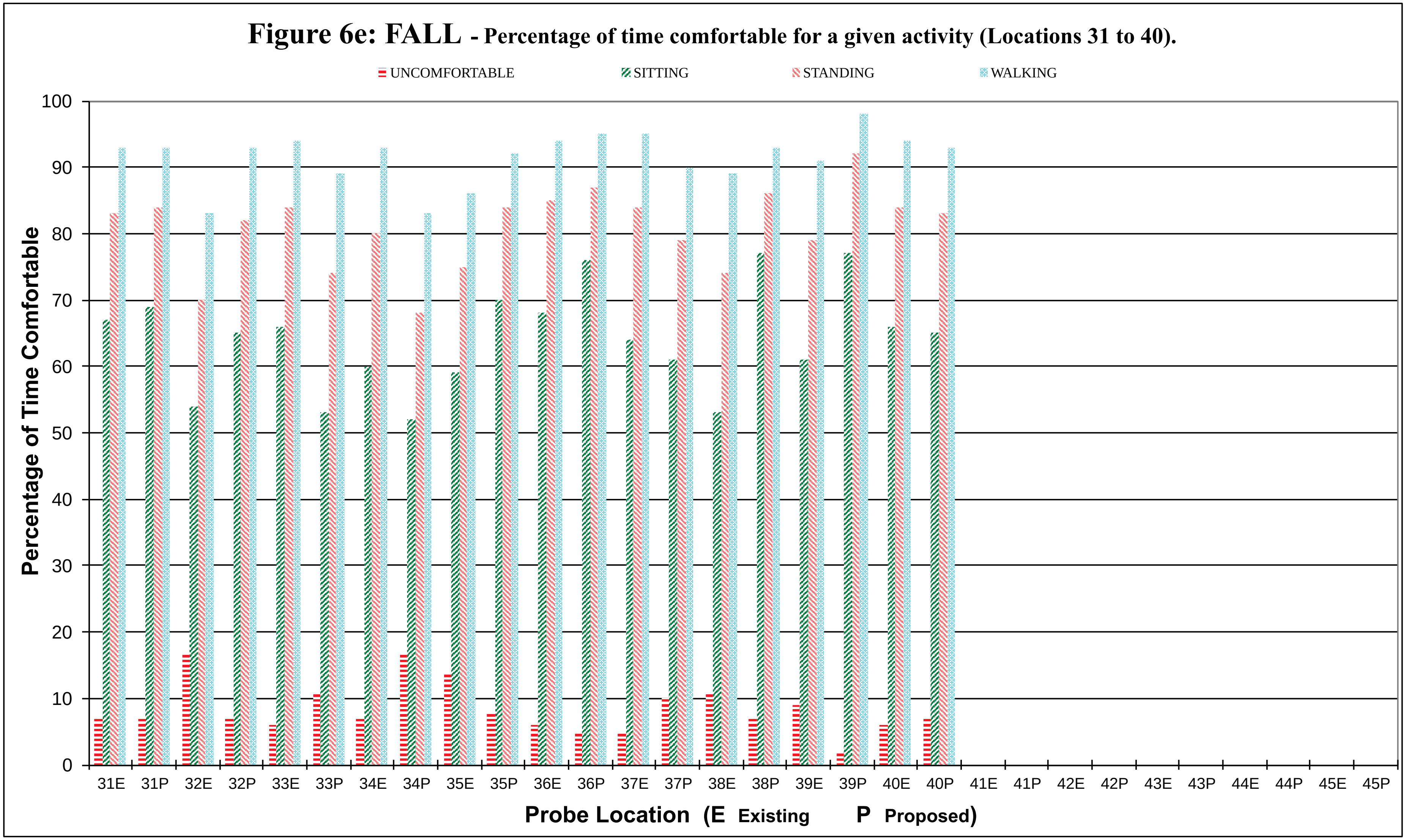
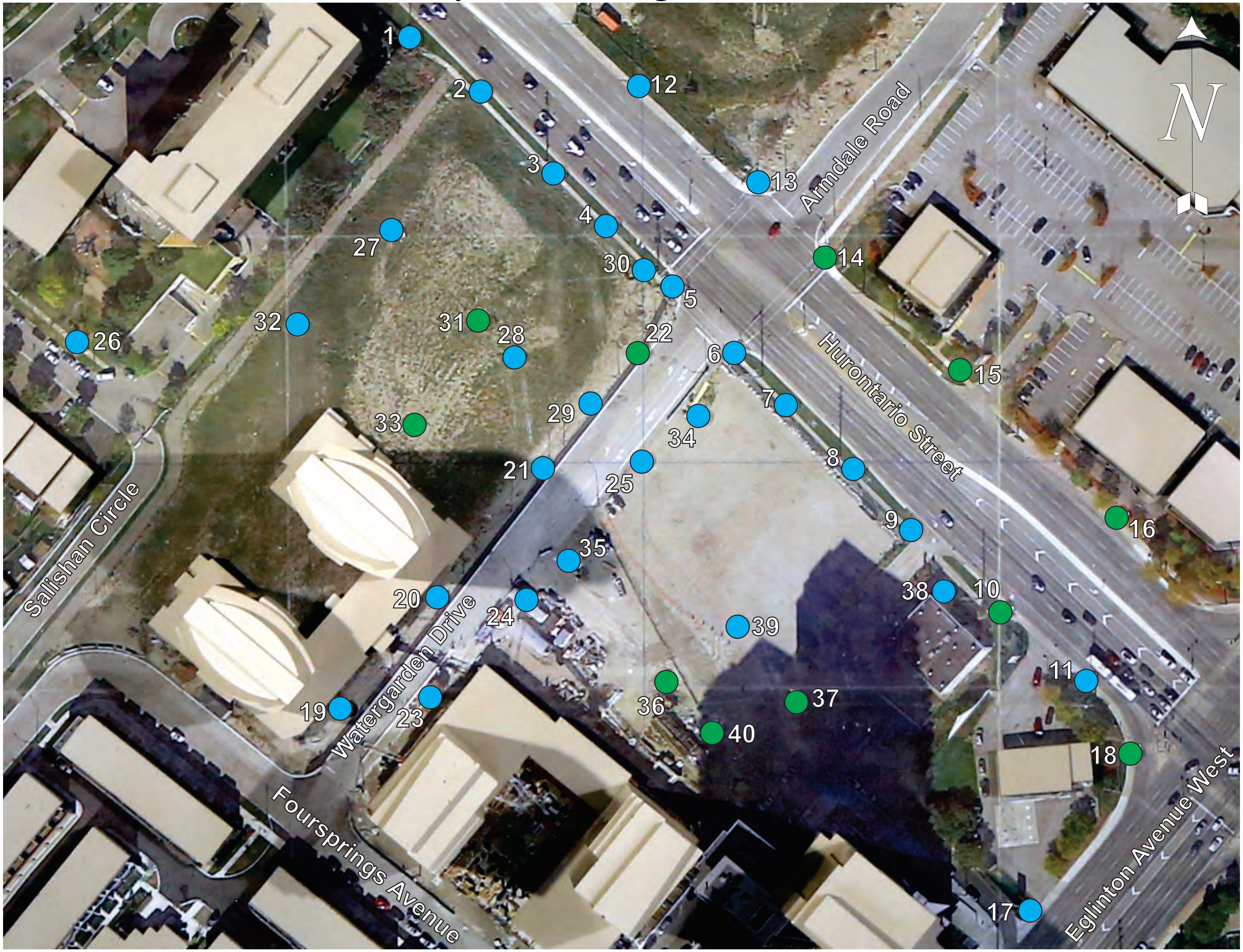


Figure 6e: FALL - Percentage of time comfortable for a given activity (Locations 31 to 40).
UNCOMFORTABLE
SITTING
STANDING
WALKING
Percentage of Time Comfortable
100
90
80
70
60
50
40
30
20
10
0
31E 31P 32E 32P 33E 33P 34E 34P 35E 35P 36E 36P 37E 37P 38E 38P 39E 39P 40E 40P 41E 41P 42E 42P 43E 43P 44E 44P 45E 45P
Probe Location (E Existing P Proposed)

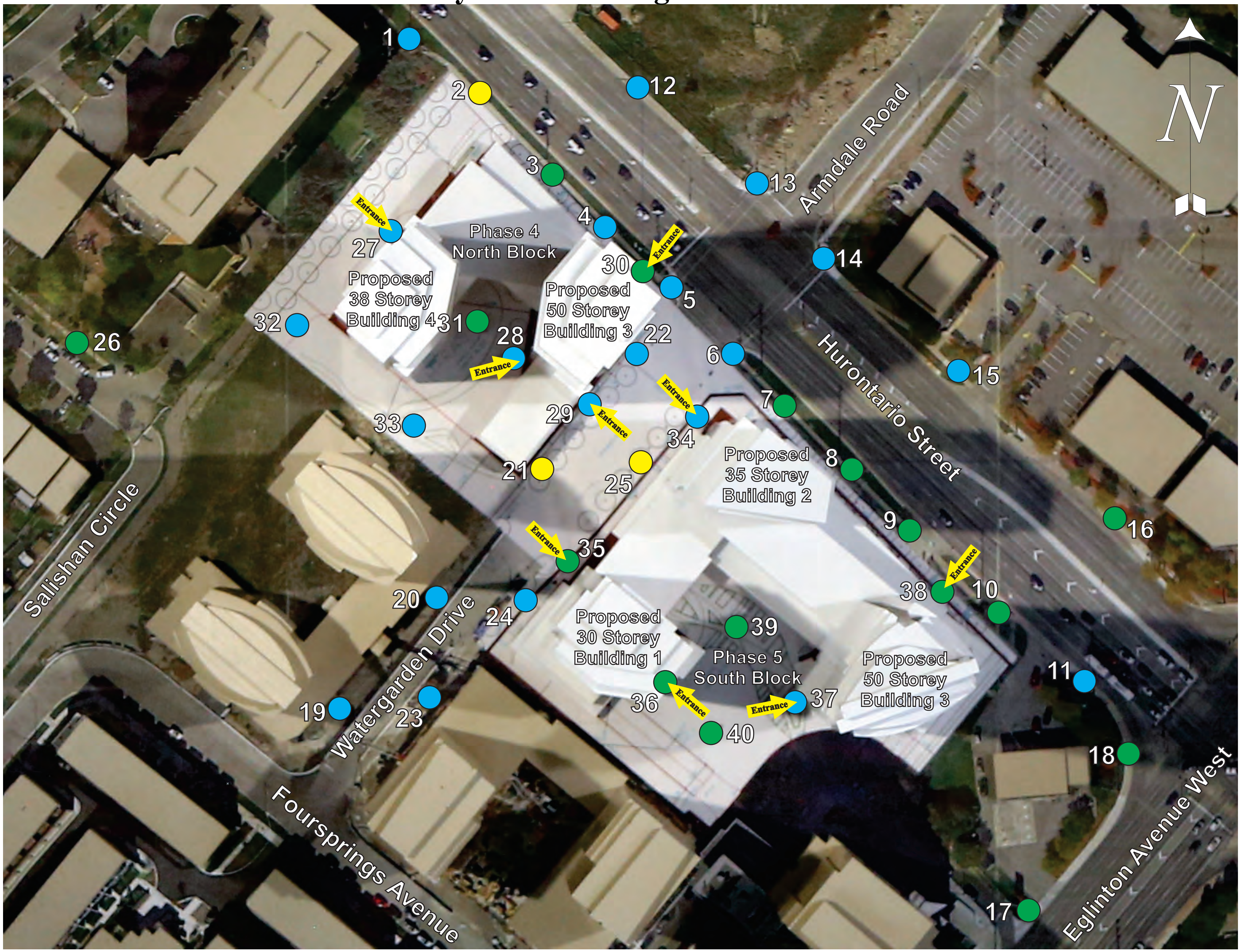
Figure 7a: Pedestrian level wind velocity comfort categories.



Comfort Categories - Annual - Existing

Sitting Standing Walking Uncomfortable

Figure 7b: Pedestrian level wind velocity comfort categories.



Comfort Categories - Annual - Proposed

Sitting Standing Walking Uncomfortable

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Figure 7c: Pedestrian level wind velocity comfort categories.

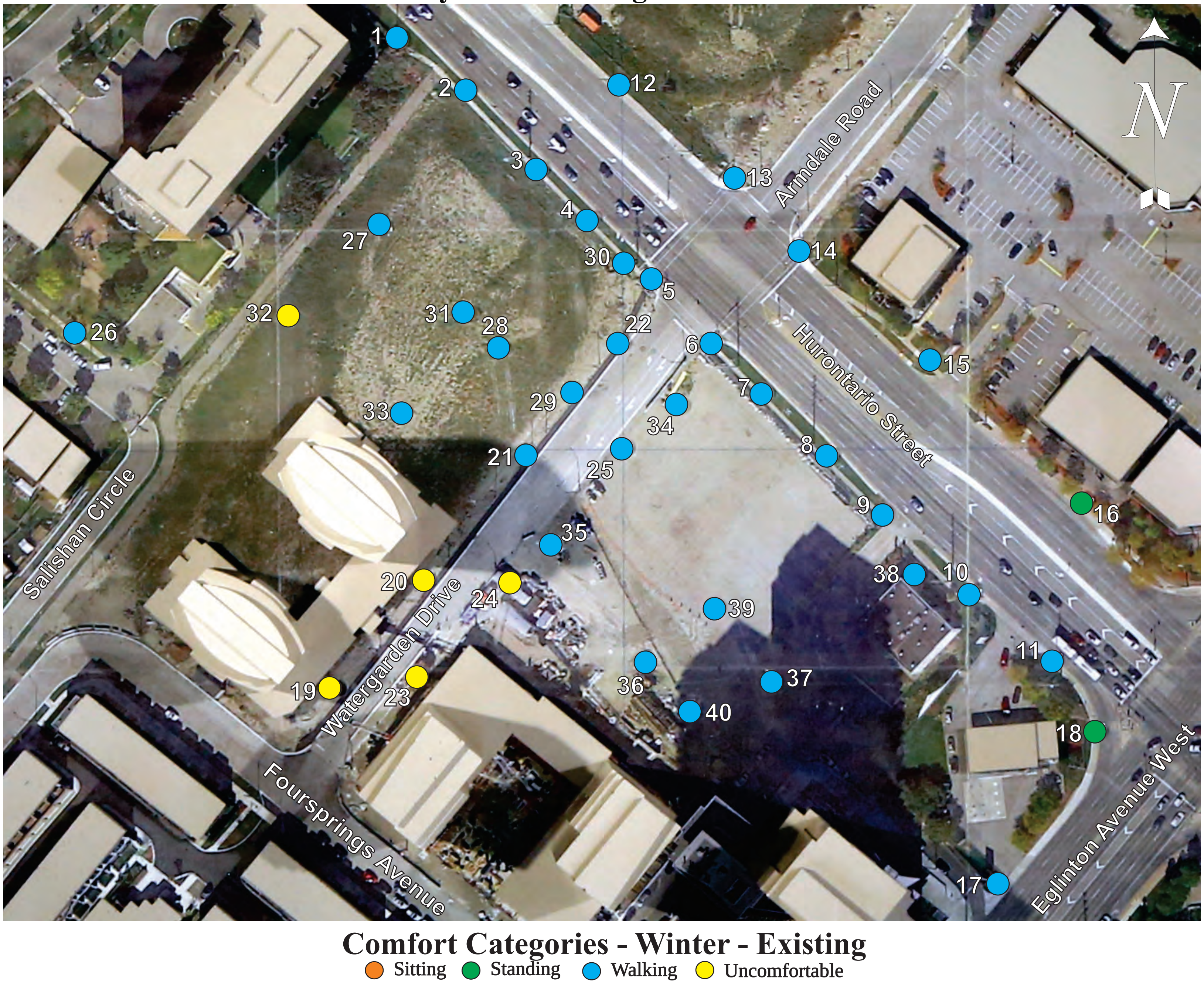

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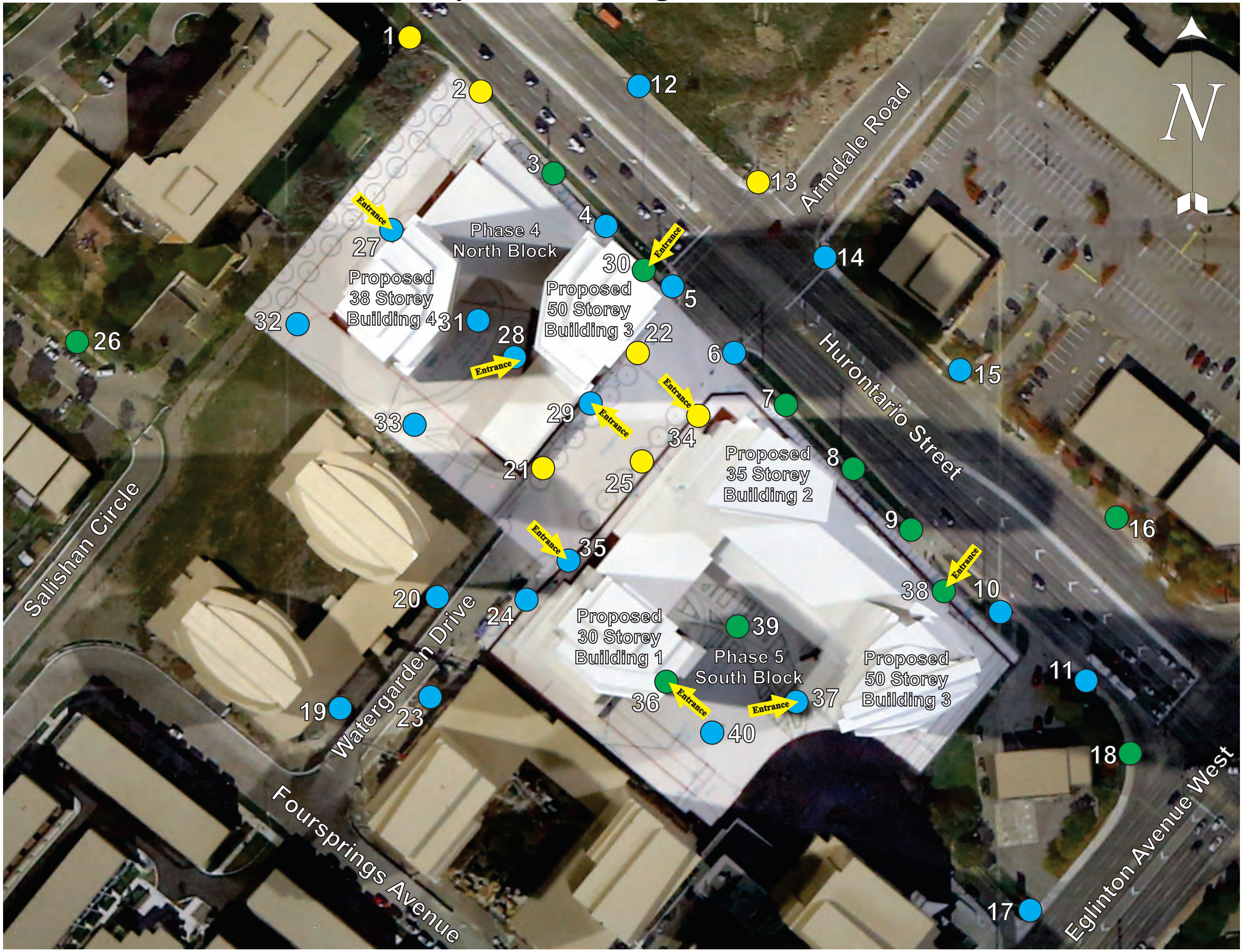
Figure 7d: Pedestrian level wind velocity comfort categories.



Comfort Categories - Winter - Proposed

Sitting Standing Walking Uncomfortable

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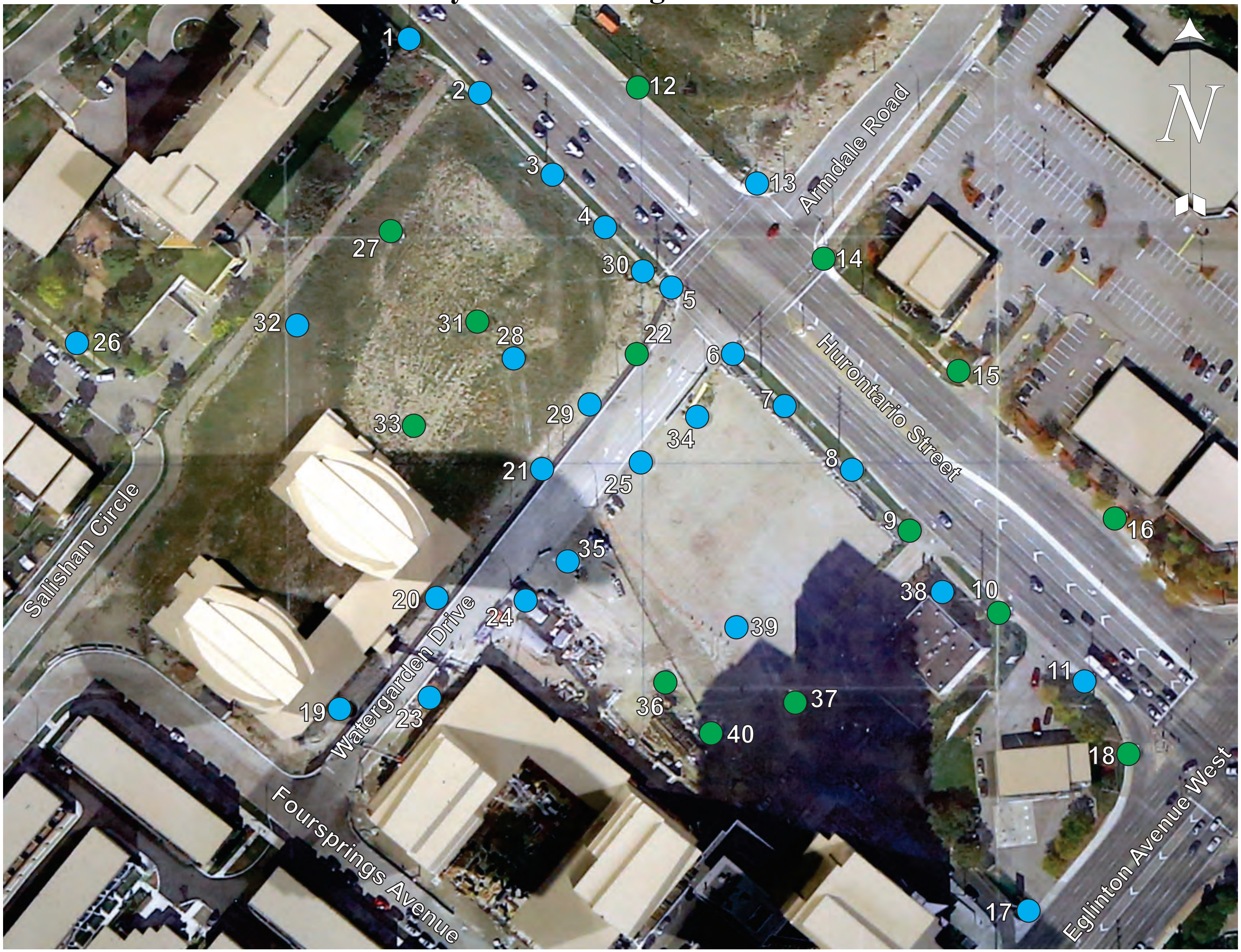
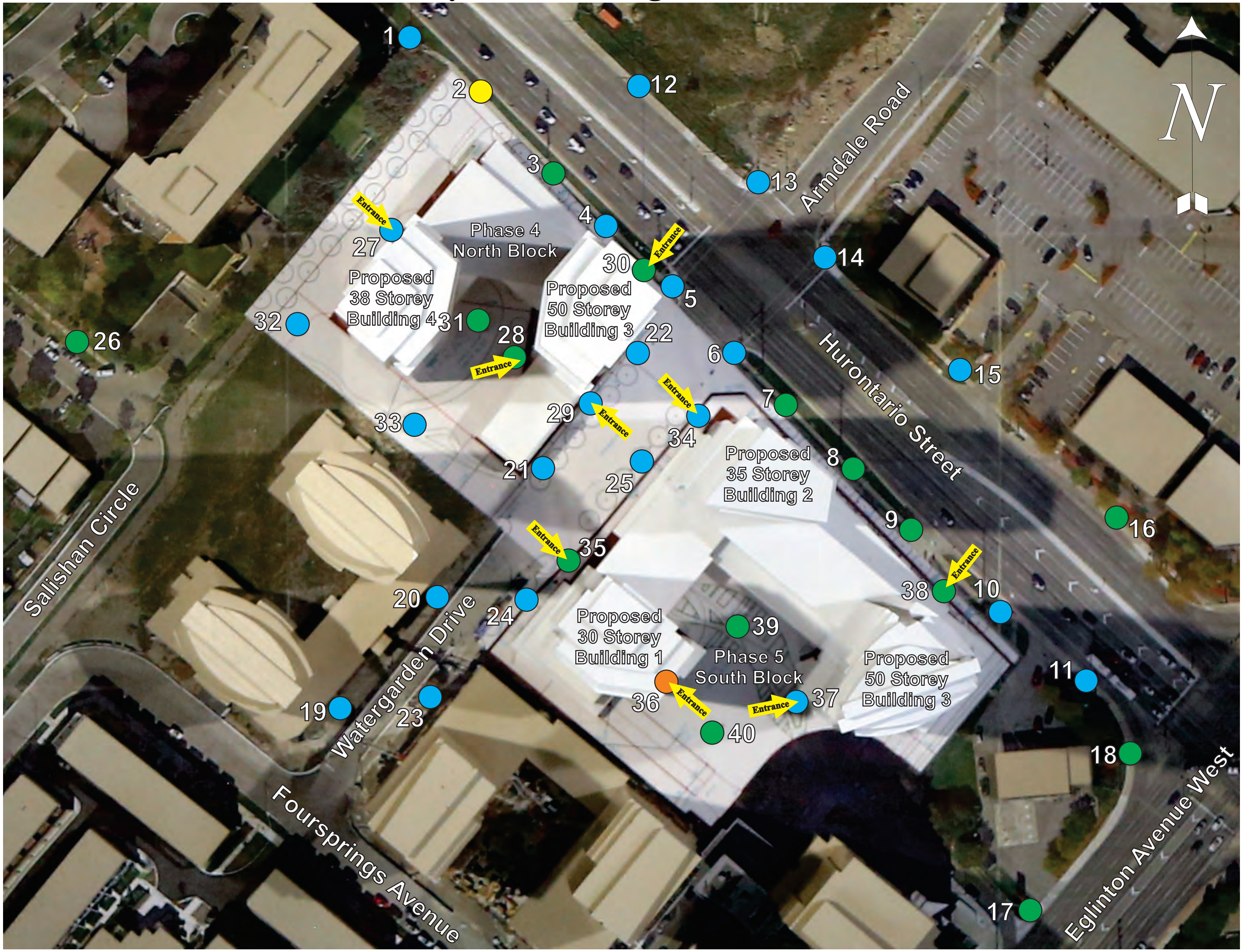
Figure 7e: Pedestrian level wind velocity comfort categories.



Comfort Categories - Spring - Existing

Sitting Standing Walking Uncomfortable

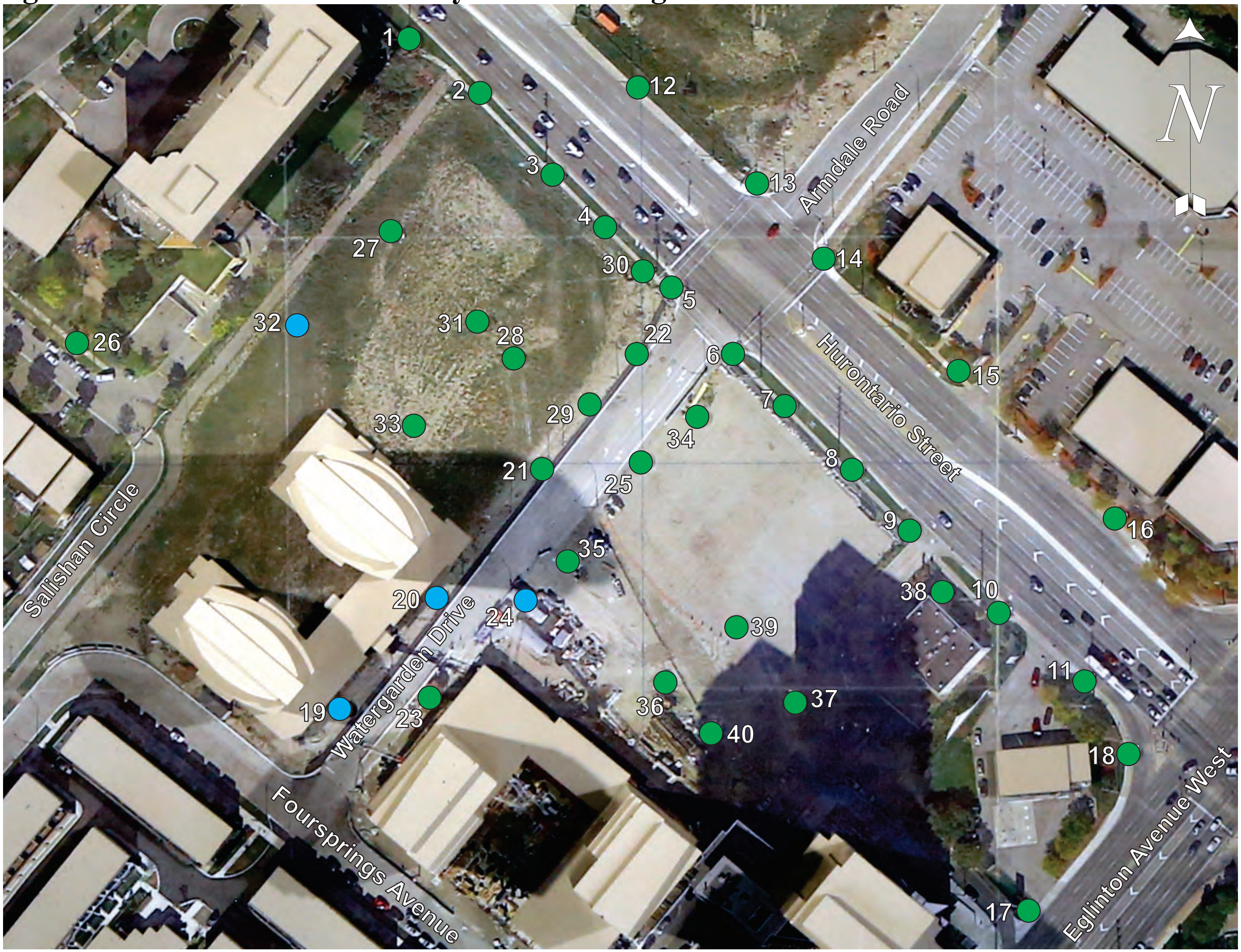
Figure 7f: Pedestrian level wind velocity comfort categories.



Comfort Categories - Spring - Proposed

Sitting Standing Walking Uncomfortable

Figure 7g: Pedestrian level wind velocity comfort categories.



Comfort Categories - Summer - Existing

Sitting Standing Walking Uncomfortable

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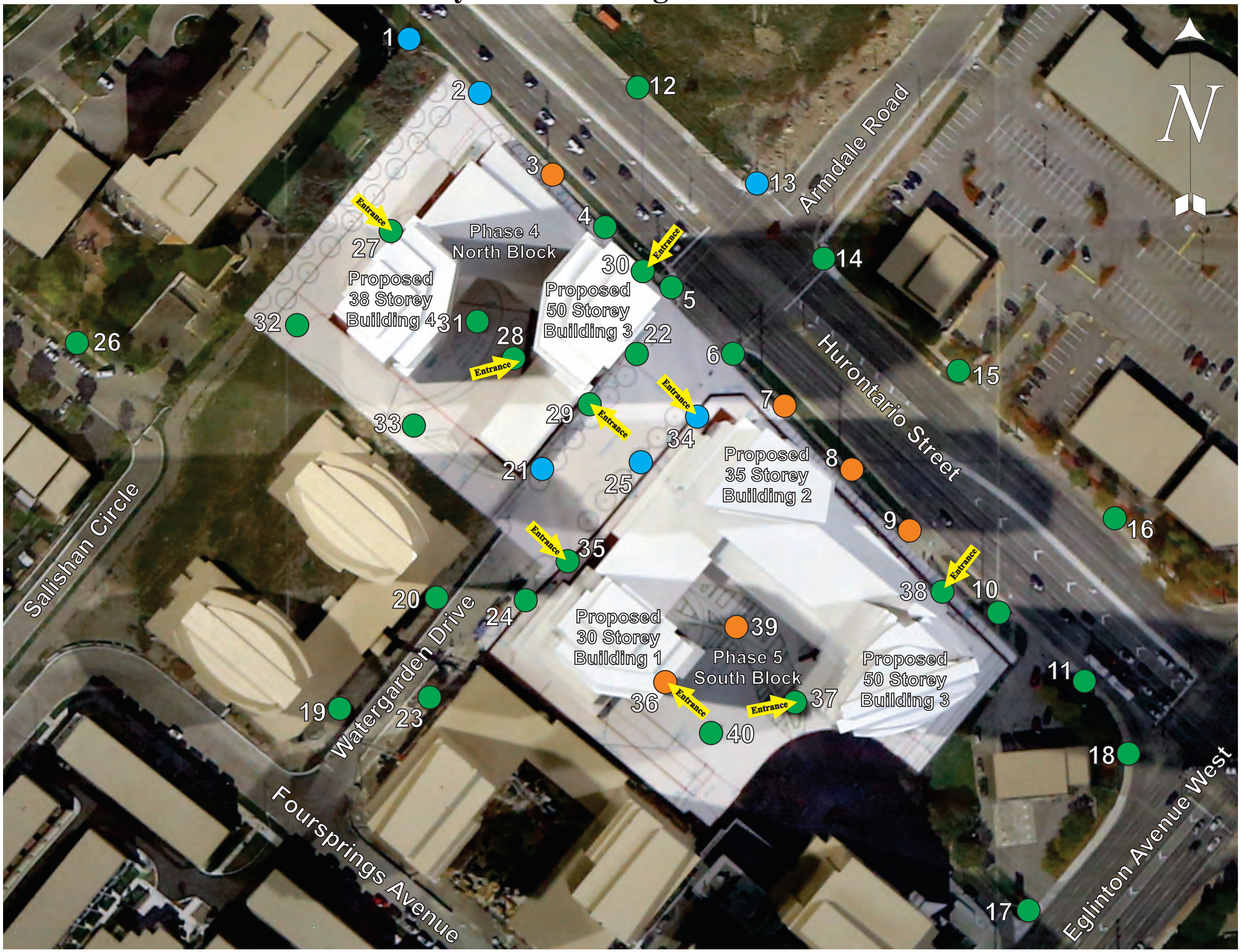
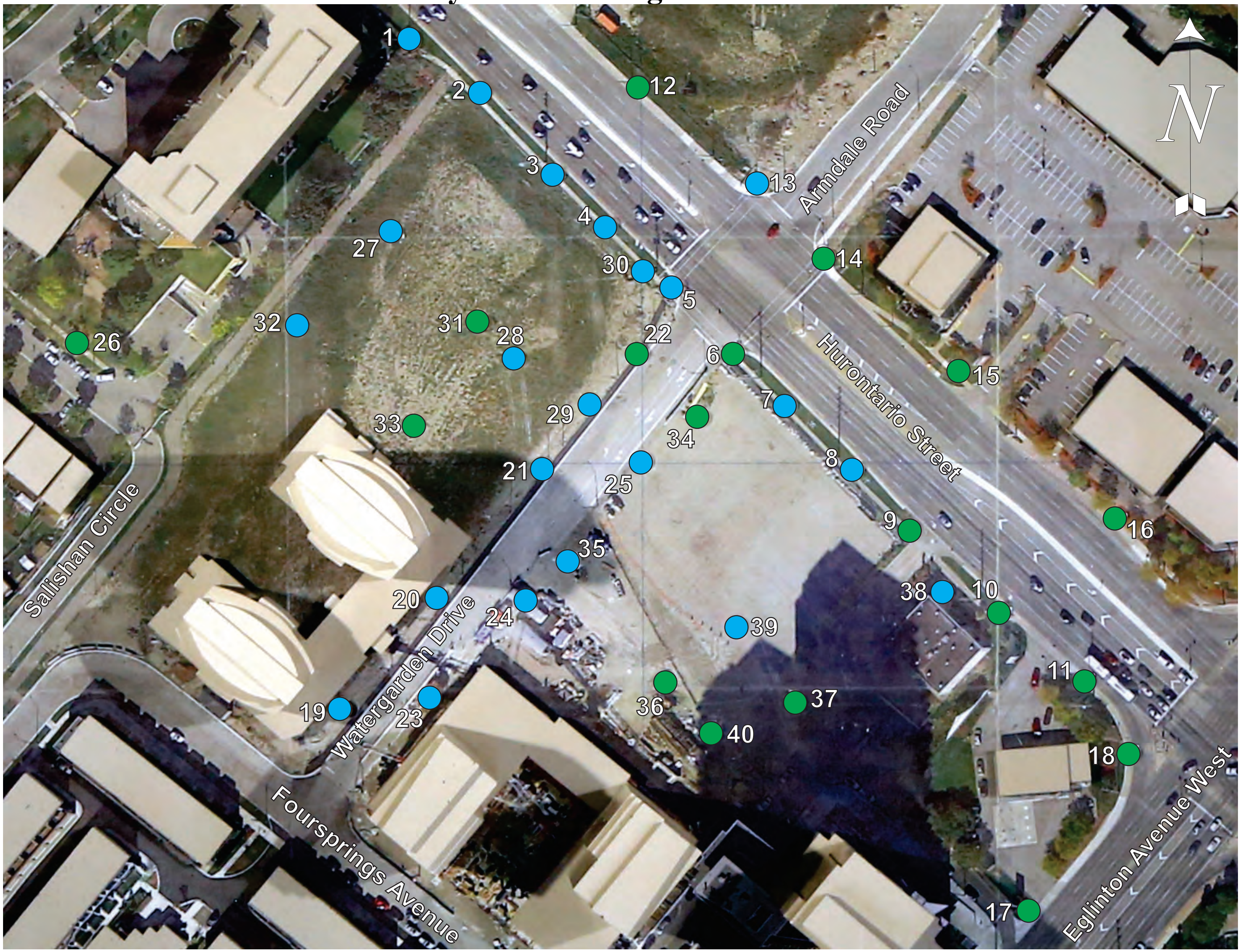
Figure 7h: Pedestrian level wind velocity comfort categories.



Comfort Categories - Summer - Proposed

Sitting Standing Walking Uncomfortable

Figure 7i: Pedestrian level wind velocity comfort categories.



Comfort Categories - Fall - Existing

Sitting Standing Walking Uncomfortable

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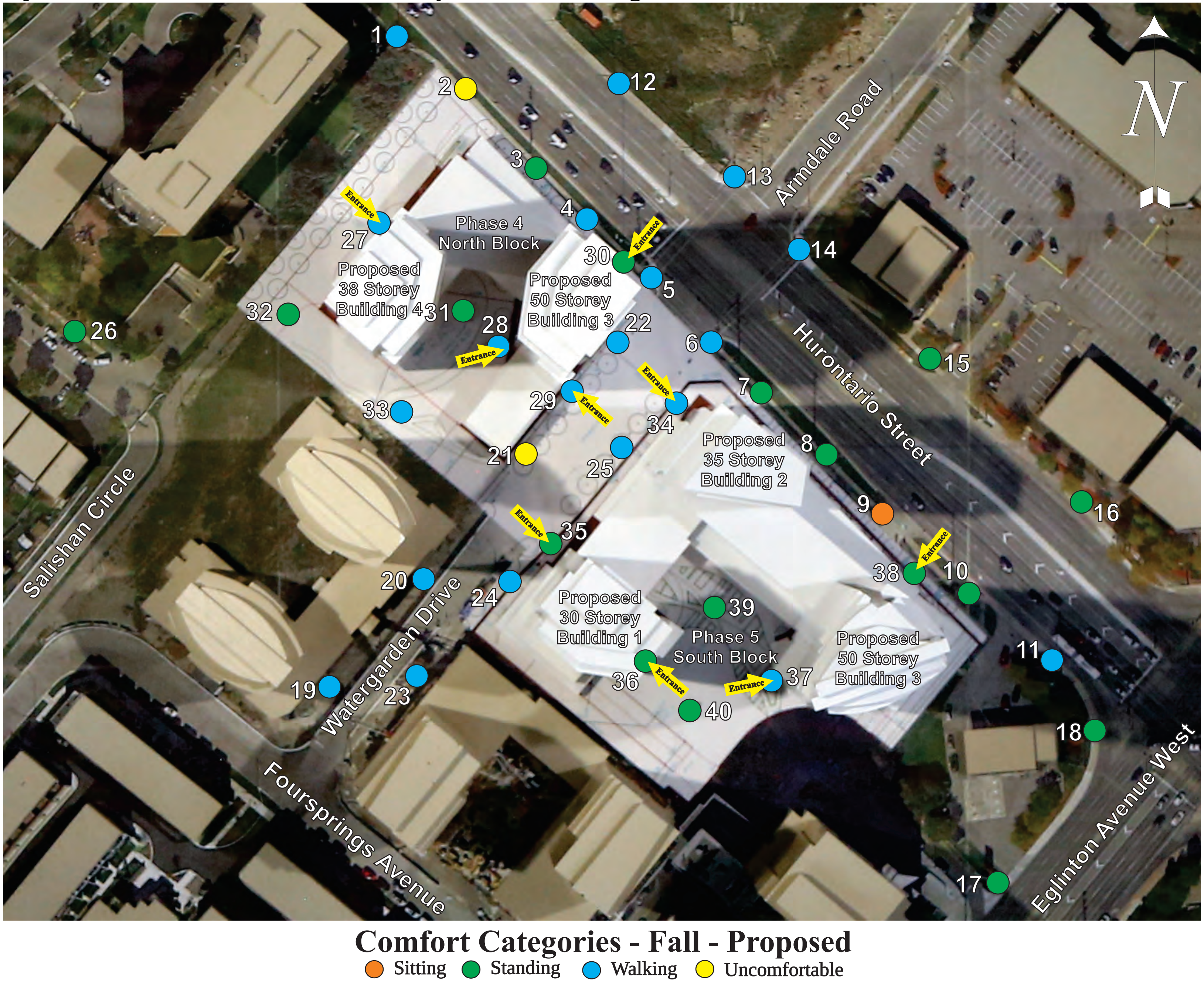
Figure 7j: Pedestrian level wind velocity comfort categories.



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:

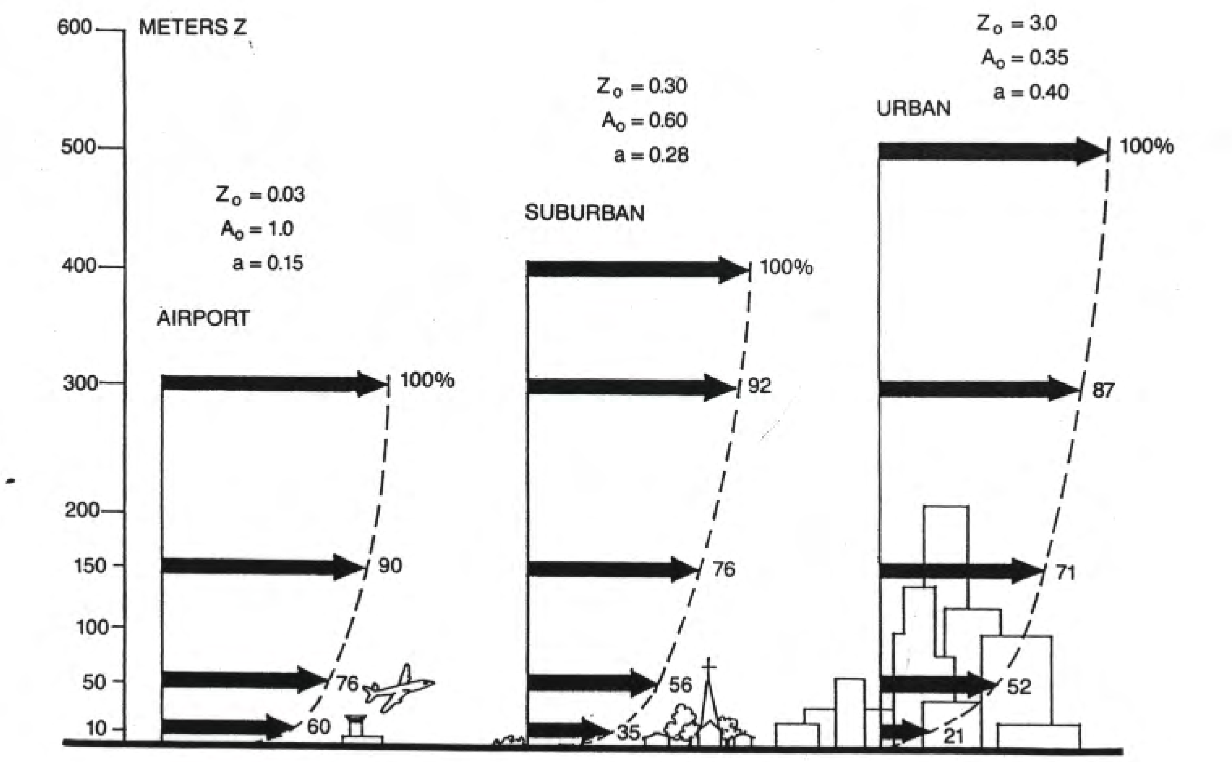


Figure A: Mean wind speed profiles for various terrain (from ASHRAE 1989).

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.

The Beaufort Scale

Beaufort Number	Description	Wind Speed			Observations
		mph	km/h	Knots	
0	Calm	0	0	0	Tree leaves don't move; smoke rises vertically; sea is calm, mirror like.
1	Light Air	1-3	1-5	1-3	Tree leaves don't move; smoke drifts slowly; direction of wind shown by smoke, not by vane; sea is lightly rippled.
2	Slight Breeze	4-7	6-11	4-6	Tree leaves rustle; flags wave slightly; vanes show wind direction; small wavelets or scale waves.
3	Gentle Breeze	8-12	12-19	7-10	Leaves and twigs in constant motion; small flags extended; long unbreaking waves.
4	Moderate Breeze	13-18	20-29	11-16	Small branches move; flags flap; waves with whitecaps.
5	Fresh Breeze	19-24	30-38	17-21	Small trees sway; flags flap and ripple; moderate waves with many whitecaps.
6	Strong Breeze	25-31	39-50	22-27	Large branches sway; umbrellas used with difficulty; flags beat and pop; larger waves with regular whitecaps.
7	Moderate Gale	32-38	51-61	28-33	Sea heaps up, white foam streaks; whole trees sway; difficult to walk; large waves.
8	Fresh Gale	39-46	62-74	34-40	Twigs break off trees; moderately high sea with blowing foam.
9	Strong Gale	47-54	75-86	41-47	Branches break off trees; tiles blown from roofs; high crested waves.
10	Whole Gale	55-63	87-101	48-55	Some trees blown down; damage to buildings; high churning white seas and exceptionally high waves hiding ships from view.
11	Storm	64-74	102-120	56-63	Widespread damage to trees and buildings; mountainous waves. Sea covered in white foam.
12	Hurricane	75+	120+	64+	Severe and extensive damage.

Wind speeds indicated above are at a reference height of 10 metres, as are the wind speeds indicated on the Figure 6 wind roses. The mean wind speeds at pedestrian level would be approximately 80% of these values. The relationship between wind speed and height relative to terrain is discussed in the appendices.

The table below correlates the Beaufort Scale with the average pedestrian comfort response as listed in Figure 7a – 7d, of the report, which provide an indication of the safety and comfort of pedestrians. The scale reflected on the figures takes into consideration the area around the subject building and in the immediate vicinity of the subject building, as affected by the wind patterns induced by the location, orientation and configuration of the proposed structure. At each point, as the wind velocity increases, the comfort level decreases. Also, at lower temperatures, relative comfort level might be expected to be reduced by one Beaufort number for every 20 degrees Celsius reduction in temperature, however, this is not applied to the wind driven results provided.

		Relative Comfort		
Activity	Areas Applicable	Perceptible	Tolerable	Uncomfortable
Occasional Use	Sidewalks	6	7	8
Walking	Sidewalks, Parking Lots	5	6	7
Strolling	Parks, Entrances	4	5	6
Standing, Sitting, Short exp.	Parks, Plaza areas	3	4	5
Standing, Sitting, Long exp.	Outdoor Restaurants	2	3	4
Representative criteria for acceptability			< 1 occn./week	< 1 occn./month

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

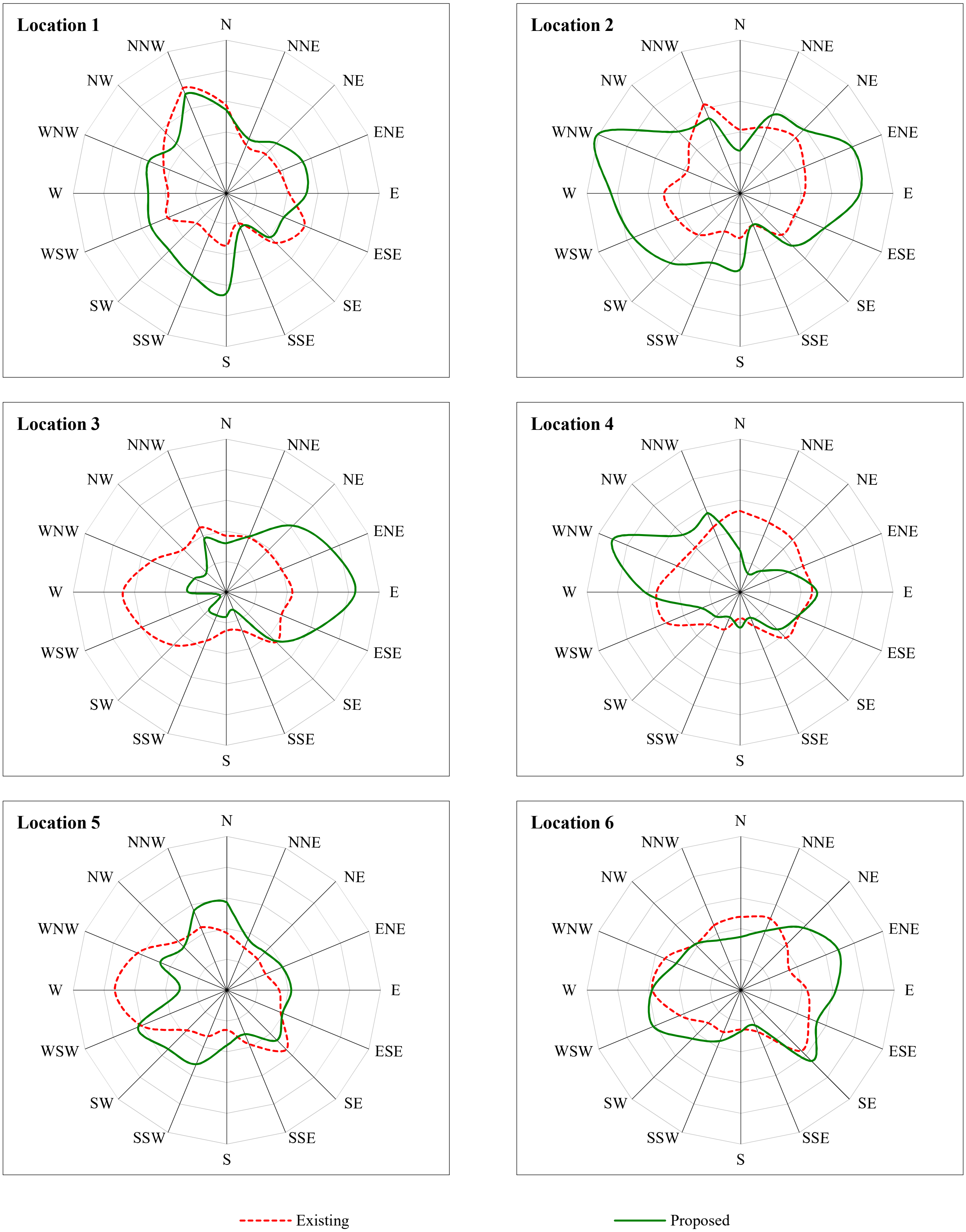


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

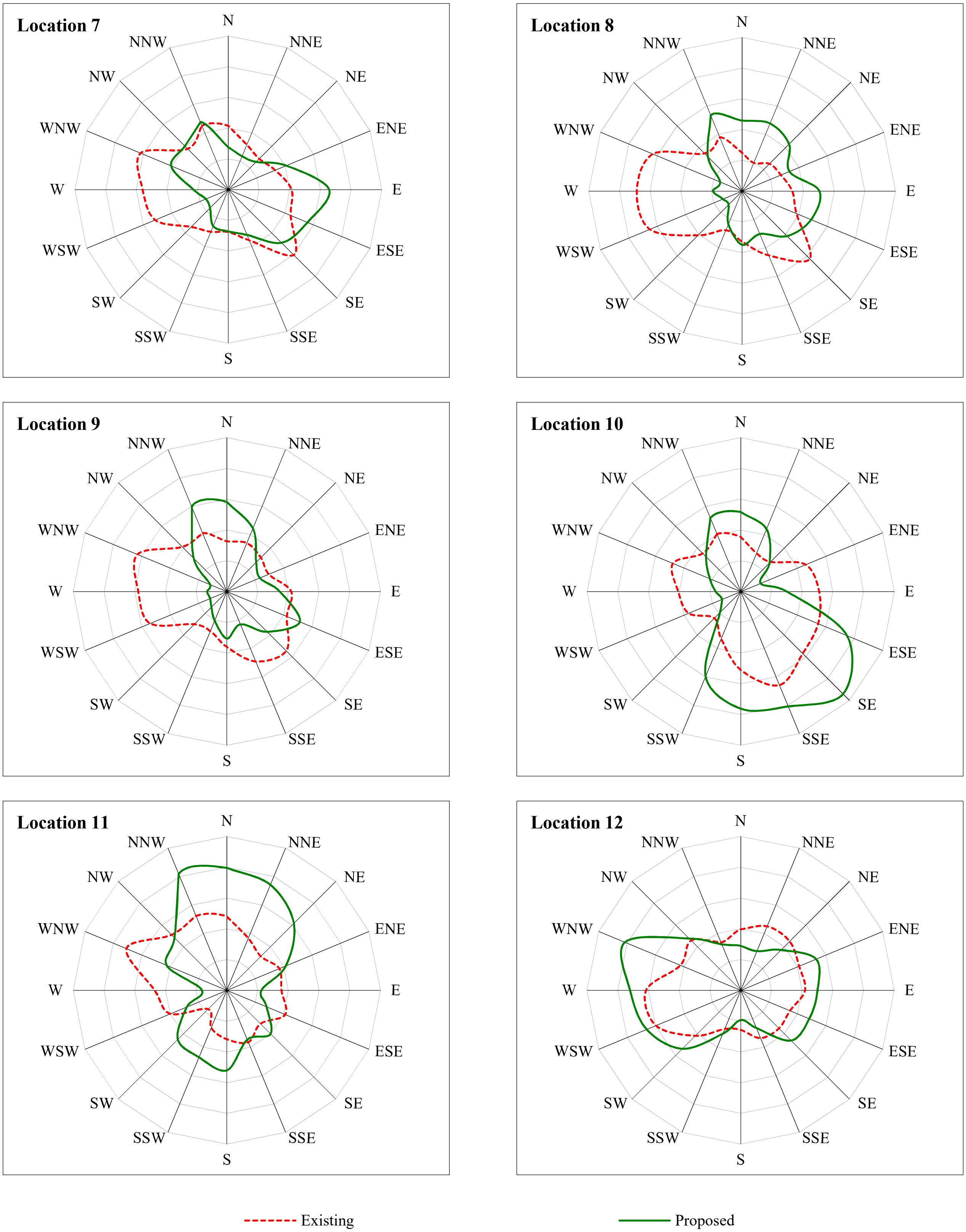


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

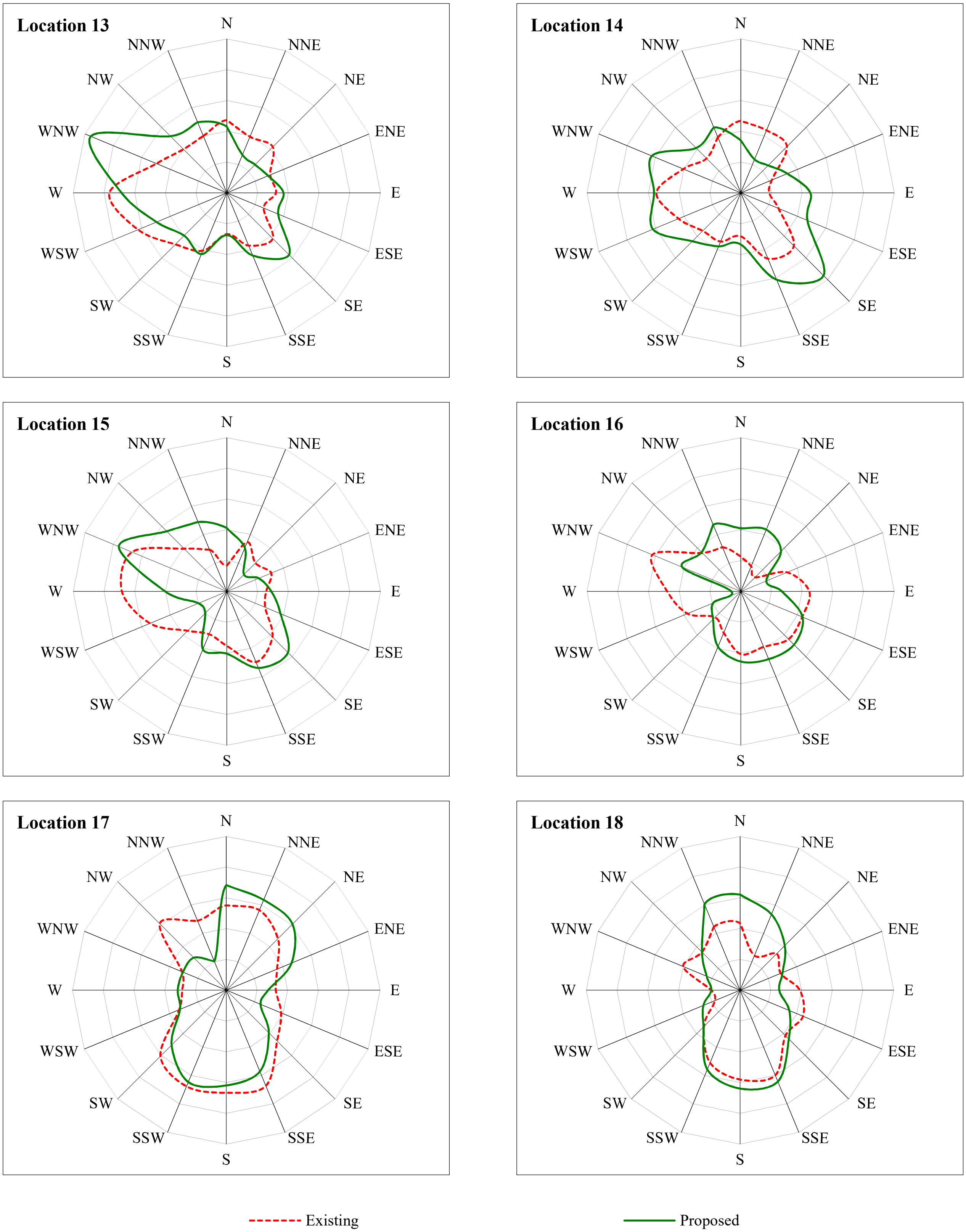


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

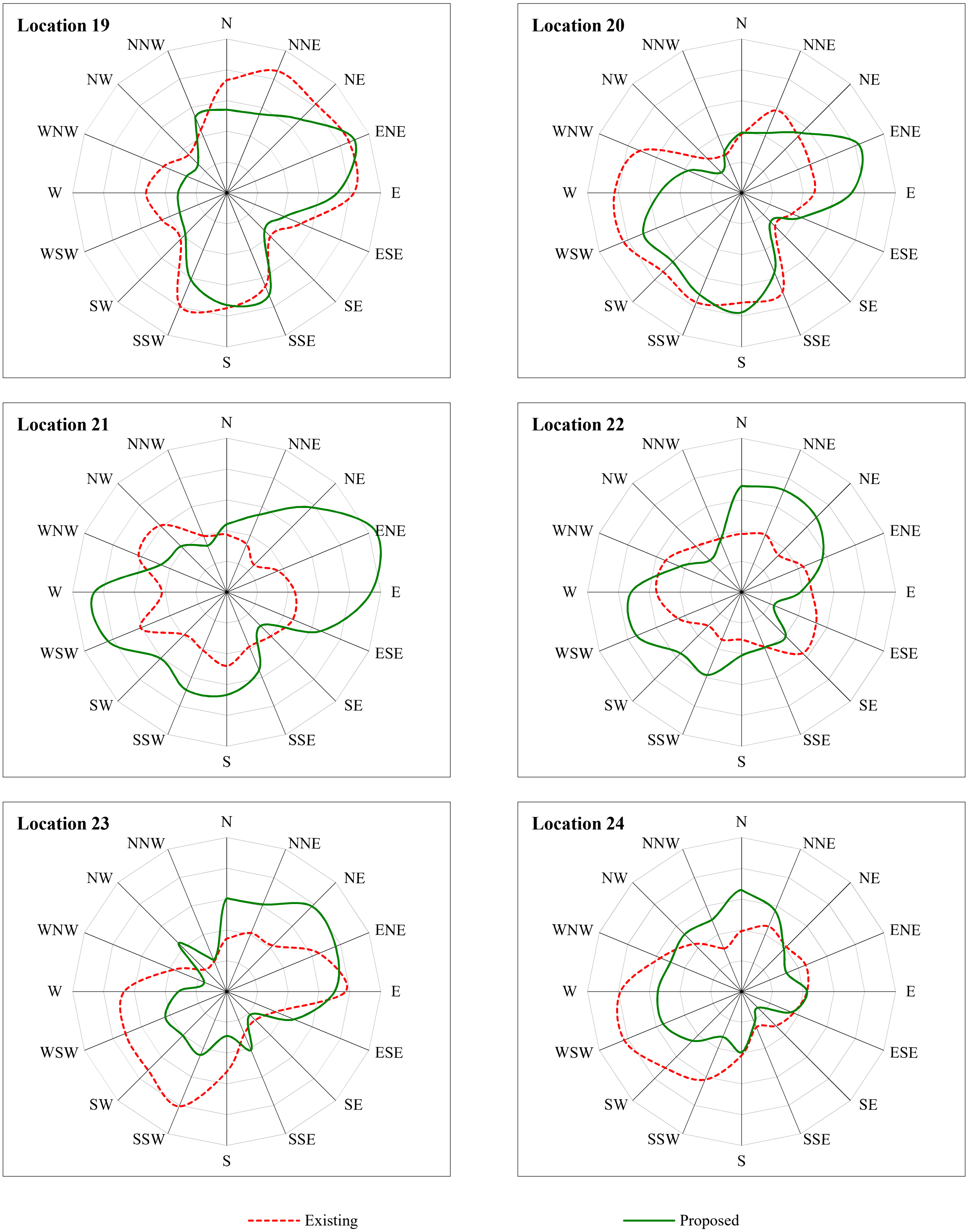


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

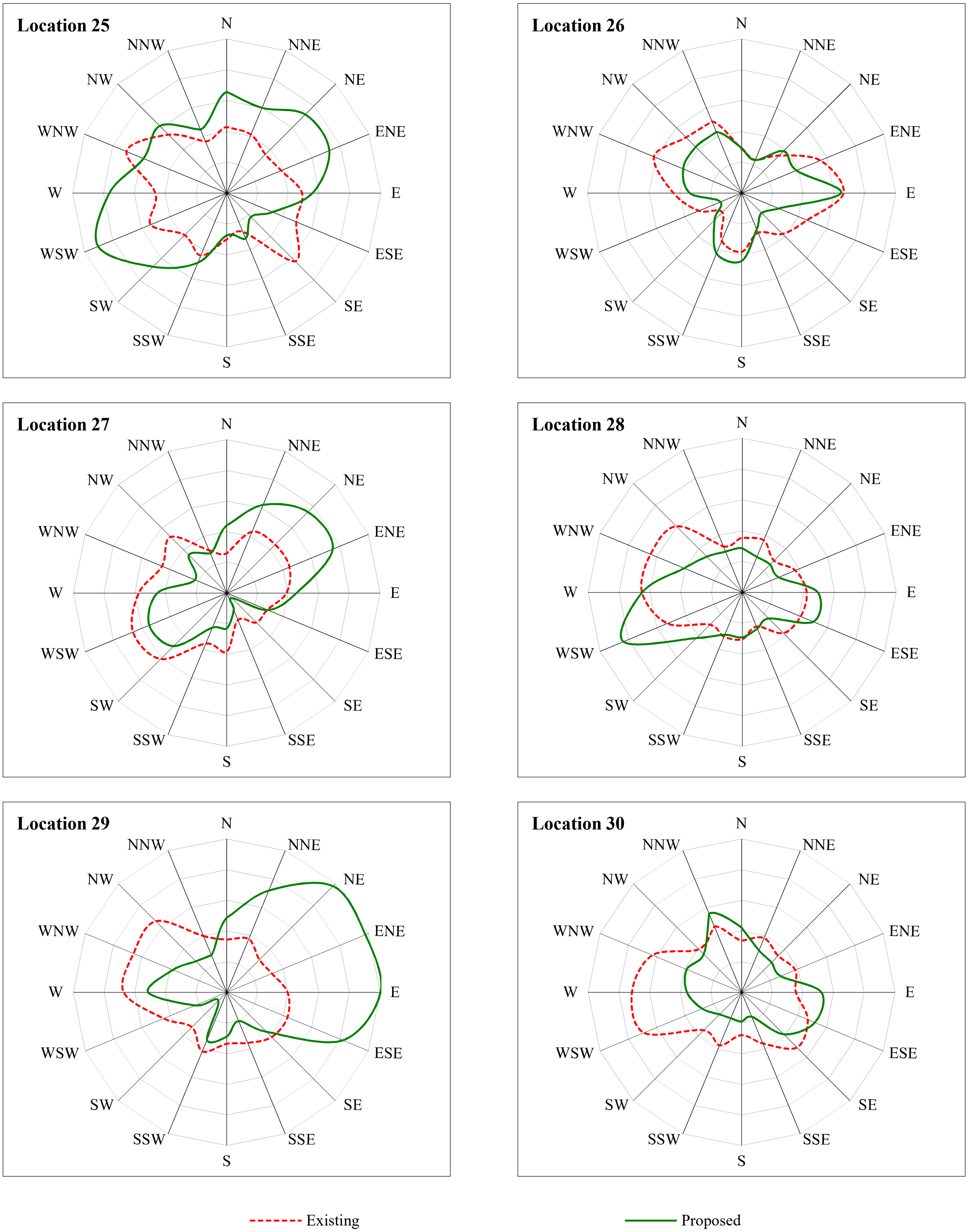


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.

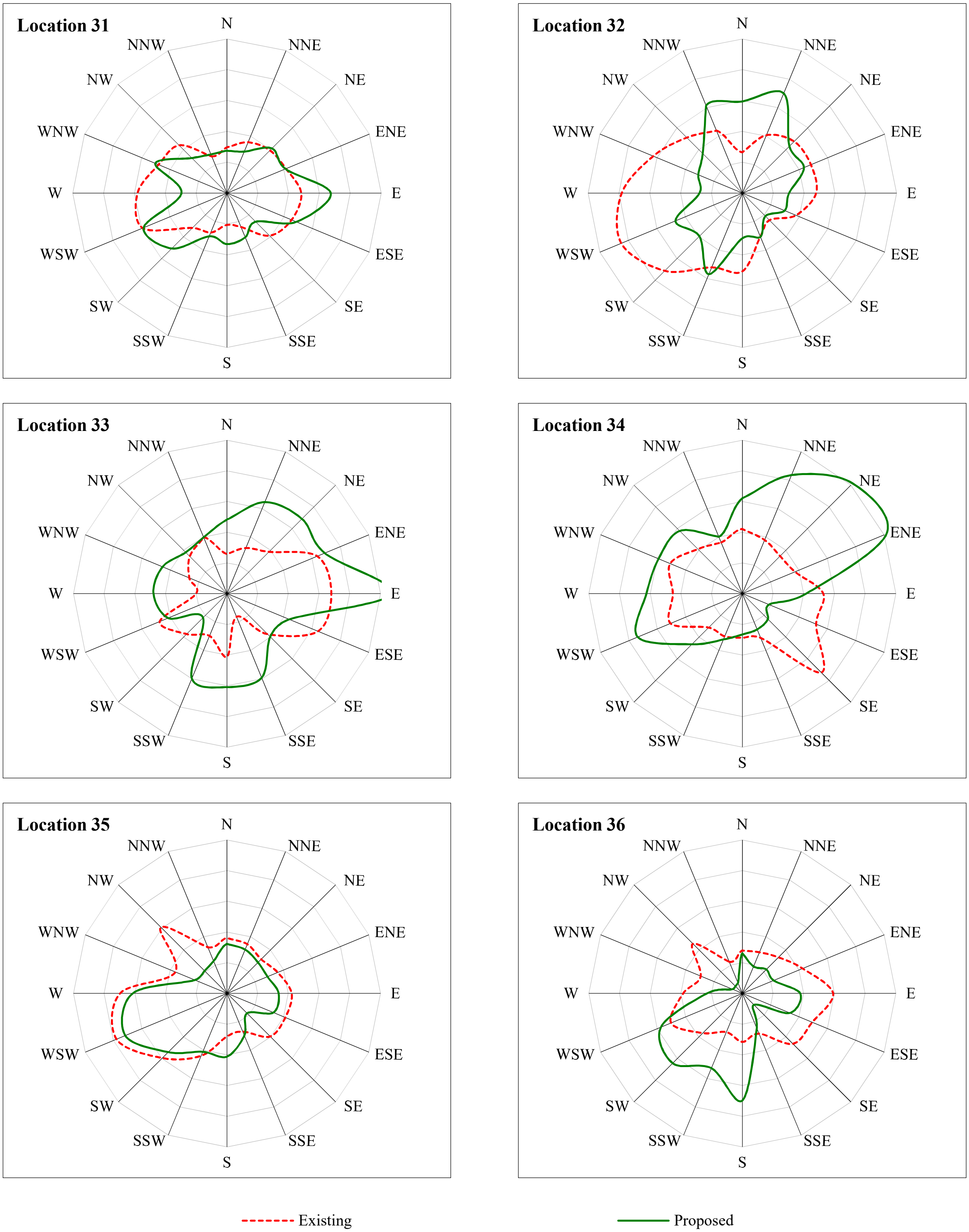
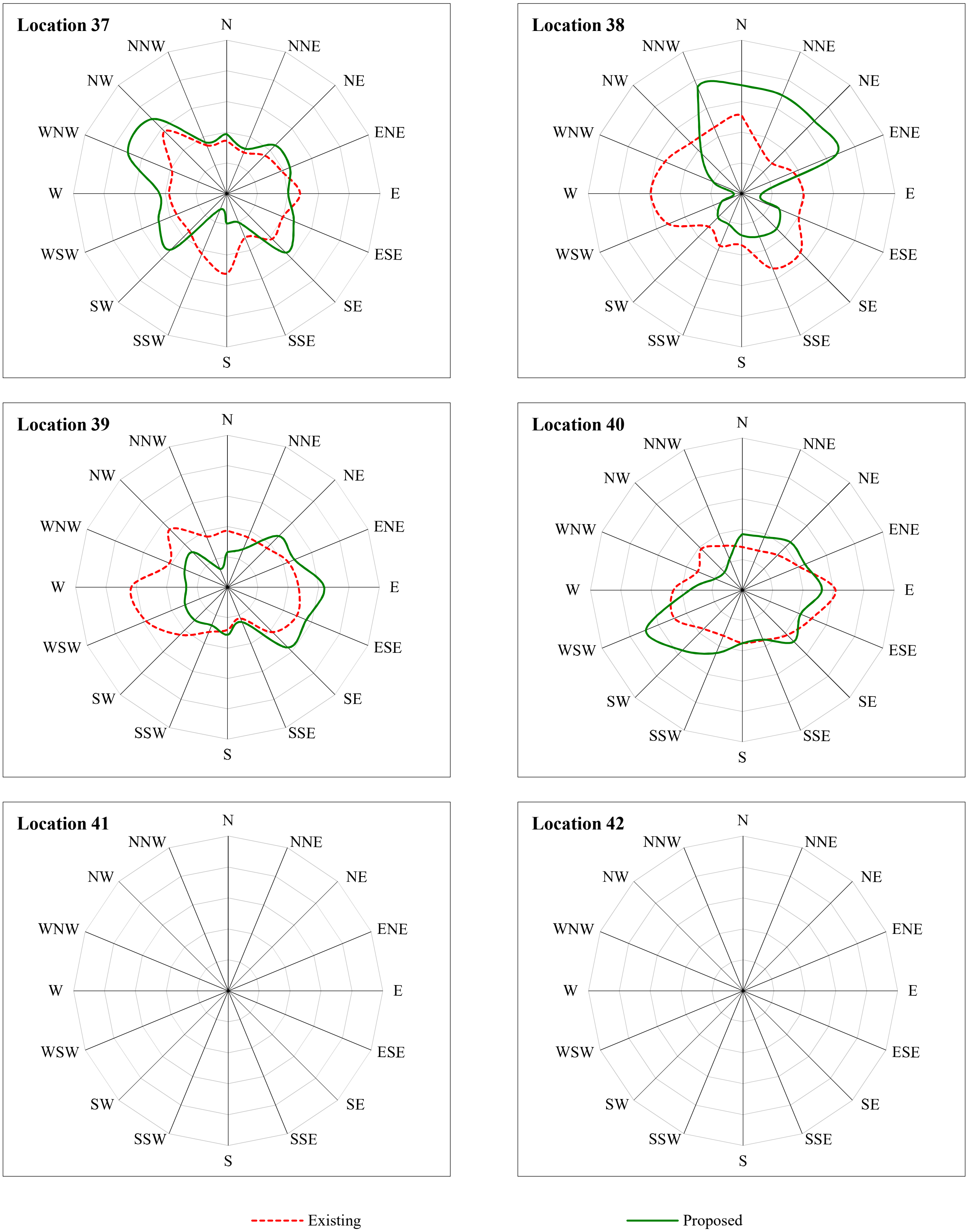


Figure B : Ground level wind velocity as a ratio of gradient wind velocity.



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