THEAKSTON ENVIRONMENTAL
Consulting Engineers • Environmental Control Specialists

REPORT

CFD PEDESTRIAN LEVEL WIND ASSESSMENT

1771 Jane Street

Toronto, Ontario

Medallion Corporation

REPORT NO. 25215wind **October 14, 2025**

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1. EXECUTIVE SUMMARY

The Development proposed by Medallion Corporation for their property municipally known as 1771 Jane Street, in the City of Toronto, has been assessed for environmental standards with regard to pedestrian level wind velocities relative to comfort and safety. Based upon our analysis, wind conditions on and around the proposed Development site in the existing setting are considered mainly suitable for sitting or standing year-round, with localised walking conditions throughout the year and localised uncomfortable winter conditions proximate to corners of mid-rise buildings.

The proposed Development involves construction of 12 storey buildings to the north and south of the existing 14 storey building on site. The Main Residential Entrances to the proposed buildings are located along the southern façades, accessed via an internal driveway and Marshlynn Avenue. Outdoor Amenity Spaces are proposed along the northern façade of the southern building at the 2nd level, and along the eastern façade of the northern building at the 3rd level.

The Development site is, for all intents and purposes, surrounded by a suburban mix of low through high-rise residential buildings, low-rise commercial buildings, mature vegetation, and open spaces. The proposed Development will have a sympathetic relationship with the pending wind climate. Urban development provides turbulence inducing surface roughness that can be wind friendly, while open, and to a lesser degree, suburban 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. Transition zones from open and/or suburban to urban settings can prove problematic, as winds exacerbated by relatively more open settings are redirected to flow over, around, down, and between buildings.

The proposed Development redirects 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 façades towards the pedestrian level, as downwash. The Development features stepped podiums, building overhangs, and canopies that intercept downwash, deflecting a portion of said flows around the building at elevations above the pedestrian level. These mitigative design features, when considered in concert, further moderate wind.

Based upon this analysis, wind conditions on and around the proposed Development are predicted to, in many cases, remain similar to the existing setting or improve with the inclusion of the proposed Development. Localised areas of increased pedestrian level winds are noted to the immediate north and southwest of the proposed Development site, however conditions at the site and surrounds generally remain comfortable and appropriate to the areas' intended purposes throughout the year. Localised uncomfortable conditions are noted to the immediate north and southwest of the proposed Development through the winter and spring seasons, however consideration of fine design details and the proposed mitigative features in these areas will result in more comfortable conditions than reported. The relationship between surface roughness and wind is discussed in the Background and Theory of Wind Movement section and shown graphically in Figure A of the same section.

Mitigation plans are recommended for the 2nd and 3rd level Outdoor Amenity Spaces in order to improve conditions beyond those reported, and will be explored through future submissions.

The proposed Development is predicted to realise wind conditions acceptable to a typical suburban context, based on this preliminary Computational Fluid Dynamics analysis.

Respectfully submitted,

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2. INTRODUCTION

Medallion Corporation retained Theakston Environmental to analyze the pedestrian level wind environment for the proposed Development at 1771 Jane Street, in the City of Toronto, as shown in Figure 1. The Development involves a proposal to construct 12 storey buildings to the north and south of the existing 14 storey building on site, in the configuration shown in Figure 2. Arcadis Architects provided architectural drawings. The co-operation and interest of the Client and their sponsors in all aspects of this project is gratefully acknowledged.

The specific objective of the analysis is to determine areas of higher-than-normal wind velocities induced by the shape and orientation of the proposed Development 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 in the immediate vicinity.

To obtain an objective analysis of the wind conditions for the property, the wind environment was tested in two configurations. The existing configuration included the current site with the existing buildings as well as neighbouring proposed developments in the surrounding area. The proposed configuration included the subject 1771 Jane Street Development.

The computational studies used in this Pedestrian Level Wind Assessment 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.

3. OBJECTIVES OF THE ASSESSMENT

1. To quantitatively assess, by computational fluid dynamic (CFD) simulation, the pedestrian level wind environment under existing conditions and proposed conditions with the Development in accordance with the City of Toronto's Terms of Reference.

2. To assess mitigative solutions in necessary cases.

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

4. METHOD OF ASSESSMENT

4.1 General

The Theakston Environmental wind engineering facility was developed for the analysis of, among other sciences, the pedestrian level wind environment occurring around buildings, with focus on the safety and comfort of pedestrians. Accurate digital models of the proposed Development site, and the immediate surroundings are built, and studied computationally using software by Meteodyn Inc., with resulting wind speeds stored for a surface spanning the areas likely to be frequented by pedestrians. This qualitative 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 using this method, utilise the computational fluid dynamics (CFD) program. The testing method has been developed for these kinds of environmental studies, and has been adapted with specific settings, testing procedures and protocols, accordingly.

The purpose of this Pedestrian Level Wind Assessment 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. Gust Equivalent Mean (GEM) values are extracted from the software for existing and proposed built scenarios, which accounts for sixteen (16) wind directions, at a surface that is uniformly at 1.5 m level above the ground in the entire field.

The wind speeds at the areas of interest were subsequently combined with the design probability distribution of gradient wind speed and direction (wind statistics) recorded at Pearson International Airport, to provide predictions of the full-scale pedestrian level wind environment. Predictions of the full-scale pedestrian level wind environment are presented as the GEM wind speed exceeded 20% of the time, based on the four seasons, which can be found in Figures 5a – 5h.

4.2 Meteorological Data

The wind climate for the Toronto 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.

4.3 Statistical Wind Climate Model

The design probability distribution of mean-hourly wind speed and wind direction at reference height is shown for Pearson International Airport in Figure 4. Seasonal distributions are shown for the four seasons from the hours of 6:00 to 23:00 (Figures 4a – 4d). From this, it is apparent that winds can occur from any direction; however, historical data indicates the directional characteristics of strong winds are north through west to southwest and said winds are most likely to occur during the winter and spring seasons.

4.4 Pedestrian Level Wind Velocity Assessment and Computational Setup

A digital model was created of the proposed Development and pertinent surroundings, including the existing buildings. The model is based upon information gathered from client drawings and Google Earth. Arcadis Architects provided the architectural drawings. The structures and features that would have an impact on the wind flows are included in the digital model. The existing and proposed scenarios have both been simulated in the commercially available wind simulation software by Meteodyn Inc.

A three dimensional 'mesh' is created of varying size, appropriate to the distance from the development area. In these studies, a section plane was placed at a height of 1.5m from the ground (typical level of pedestrian activity) to extract simulated GEM wind speeds. These wind speeds are an ensemble average wind speed and hence more representative of the wind microclimate in the development area. The velocities obtained from the simulation are recorded and combined with historical meteorological data via post-processing.

4.5 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 5 presents results for the Comfort Categories, which are based upon the two seasons and calculated at the Gust Equivalent Mean (GEM) wind speed that is exceeded 20% of the time, based upon wind events occurring between 6:00 and 23:00. The GEM wind speed is the greater of the mean wind speed or the gust wind speed divided by 1.85. The gust wind speed is obtained as the sum of the local mean speed and the product of the peak factor and rms (i.e. mean + peak factor * rms). The peak factor is assumed to be 3.0 following the Gaussian distribution assumption and the rms was recalculated from the local turbulent kinetic energy obtained from the CFD simulation. These speeds are directly related to the pedestrian comfort at a particular point. Table 1, below, summarizes the comfort criteria used in the presentation of the results depicted in Figure 5. The comfort criteria are based on those prescribed in the City of Toronto's Terms of Reference for Wind.

Table 1: Comfort Criteria

ACTIVITY	Gust Equivalent Mean Speed Exceeded 20% of the Time	Description
COMFORT	***km/h***	
Sitting	0-10	Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.
Standing	0-15	Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated.
Walking	0-20	Relatively high speeds that can be tolerated during intentional walking, running and other active movements.
Uncomfortable	>20	Strong winds, considered a nuisance for most activities.

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 wind conditions must not exceed 10km/h, more than 20% of the time. 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 Background and Theory of Wind Movement section. 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 15km/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 20km/h, occurring at least 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 20km/h occurring more than 20% of the time.

The figures represent the average person's response to wind force for the four seasons. Effects such as wind chill and humidex (based on perception) are not considered. 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. People dwelling near the shore of an ocean, large lake or open field are more tolerant of wind than people residing in a sheltered wind environment.

4.6 Pedestrian Safety Criteria

An estimate of safety criteria exceedances are also included in the analysis to predict areas where strong wind gusts may occur. The estimate is based upon the gust wind speed exceeded nine times per year, or 0.1% of the time annually, based on 24 hour a day weather data. The safety criteria are shown below in Table 2. CFD modelling is limited in its ability to predict gust wind speeds and areas of concern, should they arise, may require further wind tunnel analysis. The estimated safety ratings for the existing and proposed settings are depicted in Figure 6.

Table 2: Safety Criteria

ACTIVITY	Gust Wind Speed Exceeded 9 Times per year	Description
SAFETY	***km/h***	
Exceeded	>90	Excessive gust speeds that can adversely affect safety and a pedestrian's balance and footing. Wind mitigation is typically required.

4.7 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 clothing choices. The comfort criterion 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.

5. RESULTS

5.1 Project Site and Test Conditions

Proposed Development

The proposed Development is located at 1771 Jane Street, in the City of Toronto, and occupies a portion of the block of land bound by Lawrence Avenue West to the south, Jane Street to the west, Queens Drive to the north, and Black Creek Drive to the east. The proposed Development site is currently occupied by two low-rise buildings at the north of the site that will be removed, and a 14 storey residential building that will remain with a 1 storey commercial podium extending to the south that will be partially removed.

The proposed Development involves construction of 12 storey residential buildings to the north and south of the existing 14 storey building on site, with commercial spaces at-grade. The Main Residential Entrances to the proposed buildings are located along the southern façades, accessed via an internal driveway and Marshlynn Avenue. Vehicular access to the site is provided via a private driveway connecting with Jane Street between the existing building and proposed building to the north, and running along the eastern property line to connect with Marshlynn Avenue. Outdoor Amenity Spaces are proposed along the northern façade of the southern building at the 2nd level, and along the eastern façade of the northern building at the 3rd level.

The proposed Development is in a configuration as shown in Figure 2.

Surrounding Area

The proposed Development site is surrounded by a mix of low through high-rise residential and commercial buildings, mature vegetation, and open spaces, as indicated in Figure 1.

The Development site is predominantly surrounded by low-rise residential neighborhoods to the northwest through south to east, with low-rise commercial buildings fronting Jane Street and Lawrence Avenue West. Mature vegetation and open lands associated with Upwood Greenbelt occupy lands to the east through northeast of the site, with further low-rise residential neighbourhoods dominating the lands beyond. Mid through high-rise residential buildings occupy lands to the north of the site, fronting the east side of Jane Street. Approved Developments at 1683 Jane Street and 337-349 Queens Drive were included in the model of the surrounds.

The surrounding lands present a relatively coarse terrain that will moderate pedestrian level winds approaching the site, whereas more open surrounding lands allow winds the opportunity to accelerate as they approach. Figure 1 depicts the site and its immediate surrounds. The site plan is shown in Figure 2 and the computational geometry model is shown in Figure 3.

Macroclimate

For the proposed Development, the upstream wind flow during calculation 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 at Pearson International Airport was used in this analysis. The data is split up into four seasons, winter, spring, summer, and fall, and the resulting wind roses are presented as mean velocity and percent frequency in Figures 4a- 4d. 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 1.5*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 predominantly suburban.

Winter (December through February) 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 5a. Spring (March through May) has the second highest mean wind velocities and the prevailing winds tend to be from the North to West quadrant (Figure 5b). Summer (June through August) has the lowest mean wind velocities of the seasons with prevailing winds from north through west to south as indicated in Figure 5c. During the fall, (September through November) the possible directions for prevailing winds include the North to Southwest sector (Figure 5d). Reported pedestrian comfort conditions pertain to the winter season, unless stated otherwise.

5.2 Pedestrian Level Wind Velocity Assessment

In the computational model, the full wind field measuring 480m in radius was studied to determine conditions related to comfort and safety. For the existing setting, the subject buildings were removed, and the "existing" site model recalculated with the current site.

The design probability distribution gradient wind speed and direction, taken from historical meteorological data for the area (see Figure 4) 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 a seasonal basis in Figures 5a – 5h.

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

Venturi action, scour action, downwash and other factors, as discussed in the Background and Theory of Wind Movement section, 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 exposed to a predominantly suburban setting to prevailing and remaining compass points with winds flowing over and between low through high-rise buildings, mature vegetation, and open spaces. As such, the surroundings can be expected to influence wind at the site to varying degrees.

5.3 Review of CFD Results

The areas of interest are areas surrounding the proposed Development, including Public Streets, Neighbouring Sites, Internal Site Areas, Pedestrian Entrances, and Outdoor Amenity Spaces. The pedestrian level comfort results are graphically depicted for the four seasons in Figures 5a – 5h and estimated safety results are graphically depicted in Figures 6a and 6b. The following discusses anticipated wind conditions and suitability for the areas' intended uses.

Public Street Conditions

Jane Street

In the existing setting, the contour results along Jane Street within the zone of influence of the proposed Development site indicate wind conditions that are generally suitable for standing, with localised sitting conditions in the summer and fall. The predominantly low-rise surrounds deflect winds to flow up and over the area, resulting in the generally comfortable existing conditions.

With inclusion of the proposed Development, a realignment of winds was noted along portions of Jane Street. Improvements in wind conditions were noted to the immediate west of the site along Jane Street, sufficient to change the conditions in these areas from standing to sitting throughout the year. This can be attributed to the proposed buildings providing increased blockage relative to the existing setting for portions of the wind climate.

Conversely, localised increases in winds were noted with the inclusion of the proposed Development proximate to the northwest and southwest corners of the site. This was sufficient to change the conditions at the northwest corner of the site along Jane Street to suitable for walking in the winter, and localised areas at the southwest corner to suitable for walking throughout the year. This can be attributed to the proposed Development redirecting winds that formerly flowed over the open or low-rise areas of the site to flow down and around the proposed buildings and ultimately along adjacent portions of Jane Street. The proposed Development incorporates wind-friendly design components including moderate height, stepped conditions, columns, building overhangs, and others which will reduce the propensity for downwash and moderate winds. Subsequent to testing, mitigation plans were also prepared for the site, including wind screens adjacent to the southwestern corner and a fence along the northern property line that will improve conditions beyond those reported.

As such, inclusion of the proposed Development will result in a realignment of winds along Jane Street with localized changes in wind conditions, however the street remains suitable for its intended purpose throughout the year and consideration of fine design and landscape elements that were too fine to include in the computational model, such as the above-noted mitigation plan, will result in more comfortable conditions than those reported.

With inclusion of the proposed Development, Jane Street remains within the pedestrian level wind velocity safety criteria, as depicted in Figures 6a and 6b.

Marshlynn Avenue

Marshlynn Avenue is mainly rated suitable for standing year-round in the existing setting, with the exception of localised walking conditions in the winter adjacent to the site, and localised sitting conditions in the summer and fall.

In the proposed setting, portions of the wind climate are directed to flow down and around the proposed 12 storey building at the south end of the site, resulting in localised windier conditions along Marshlynn Avenue adjacent to the site. As such, areas proximate to the intersection with Jane Street become suitable for walking year-round, with very localised uncomfortable conditions proximate to the southwest corner of the proposed Development through the winter and spring. Subsequent to testing, a mitigation plan was prepared for the area, including wind screens proximate to the southwestern corner of the site, that are expected to improve the conditions beyond those reported.

Marshlynn Avenue will remain suitable for the intended use with inclusion of the proposed Development, with the above-noted exception. Consideration of fine design and landscape elements that were too fine to include in the computational model, such as the above-noted mitigation plan, will result in more comfortable conditions than those reported. Marshlynn Avenue remains within the pedestrian level wind velocity safety criteria with inclusion of the proposed Development, as depicted in Figures 6a and 6b.

Sonnet Court

In the existing setting, Sonnet Court is rated for sitting or standing year-round. In the proposed setting, the area realises additional blockage from dominant westerly through northwesterly winds, sufficient to improve the conditions to tend more towards sitting throughout the year. Sonnet Court remains suitable for the intended use throughout the year and passes safety criteria.

William Street, Patika Avenue, MacDonald Avenue, Hearne Avenue

The above-mentioned surrounding streets are rated suitable for sitting or standing throughout the year in the existing setting. With inclusion of the proposed Development, these streets realise similar conditions to the existing setting, with general improvements resulting in larger areas rated for sitting throughout the year. As such, the above-mentioned streets will remain suitable for the intended use throughout the year and pass the pedestrian level wind safety criteria.

Neighbouring Site Conditions

The surrounding properties to the northwest through west, south, and east of the site realise similar conditions to the existing setting with inclusion of the proposed Development, generally suitable for sitting or standing year-round.

Lands to the immediate north of the site are somewhat windy in the existing setting, rated for mainly walking throughout the year, with some standing conditions through the summer and fall and localised uncomfortable conditions through the winter. In the proposed setting, winds will be redirected to flow down and around the proposed 12 storey building at the north of the site and through the gap between the site and the mid-rise building to the north resulting in windier conditions in the area. As such, uncomfortable conditions are realised in the gap through the winter and spring. The area's general use is a driveway and the entrance to the neighbouring building is recessed into a notch in the façade and will be protected from these wind conditions. Consideration of landscaping in the area such as the proposed fence along the northern property line of the proposed Development, as well as surrounding trees, will moderate winds, resulting in more comfortable conditions than reported.

The neighbouring site areas remain within the pedestrian level wind velocity safety criteria as depicted in Figures 6a and 6b.

Internal Site Conditions

Internal site areas are generally predicted to be suitable for sitting or standing year-round, with localized areas rated suitable for walking. The walking areas are generally noted proximate to the southwestern corner and along the northern property line, as noted above, as well as between the existing 14 storey building and proposed 12 storey building to the north. The windier conditions can generally be attributed to the proposed Development redirecting winds to flow down the façades of the proposed buildings, around the corners, and through gaps in between. The internal site areas are generally predicted suitable for the intended uses throughout the year, with localised uncomfortable conditions off-site to the north of the site and southwest of the site, as noted above. Subsequent to testing, mitigation plans were prepared for these areas, including wind screens adjacent to the southwestern corner of the site, as well as a fence along the northern property line. Consideration of these mitigative features are expected to result in more comfortable conditions than reported.

As such, internal site conditions are predicted comfortable and suitable for their intended uses, and consideration of fine design and landscape elements, noted above, will result in more comfortable conditions than reported adjacent to the site.

With the inclusion of the proposed Development, internal site conditions remain within the pedestrian level wind velocity safety criteria as depicted in Figures 6a and 6b.

Pedestrian Entrance Conditions

The Main Entrance to the existing building on site is located along the western façade beneath a large canopy. The area is fairly well protected from winds and as such is rated for sitting year-round in both the existing and proposed settings, and remains suitable for the intended use.

The Main Entrance to the proposed northern building is located along the southern façade. The area is exposed to easterly and westerly winds, however it is located beneath an overhang of the building above and is well protected from portions of the northerly and southerly wind climate, resulting in conditions rated for sitting in the summer and standing through the remainder of the year. As such, the Main Entrance to the proposed northern building will be comfortable and suitable for its intended use year-round.

The Main Entrance to the proposed southern building is similarly located along the southern façade. The area is located beneath an overhang of the building above, and is fairly well protected from large portions of the wind climate, resulting in conditions rated for sitting throughout the year. As such, the Main Entrance to the proposed southern building will be comfortable and suitable for its intended use year-round.

Commercial Entrances to the proposed northern building are located along the western façade, fronting Jane Street. The area is suitable for standing throughout the year and as such the entrances will be comfortable and suitable for the intended use.

Wind conditions comfortable for standing, or better, are preferable at building entrances, while conditions suitable for walking are suitable for sidewalks. The entrances to the existing and proposed buildings will be comfortable for the intended uses in the proposed configuration and pass the pedestrian level wind velocity safety criteria as depicted in Figures 6a and 6b.

Outdoor Amenity Space Conditions

Outdoor Amenity Space is proposed on the 2nd level of the southern building, atop the step in the northern façade. The model was tested with 1.5m high screens around the perimeter of the space, and point analysis was performed within the CFD model to determine the conditions realized above the pedestrian level for the area. The space is exposed to winds flowing down and around the proposed southern building and existing building to the north, and ultimately through the gap between. As such, the space is predicted suitable for standing in the summer, and walking in the shoulder seasons, with the exception of standing conditions at the westmost portion of the space. A mitigation plan is recommended for the space in order to achieve more comfortable conditions than reported, and may include raising the height of the perimeter wind screens, dense coniferous vegetation, raised planter beds, trellises, porous wind screens, and/or others throughout the space. This will be further explored through future submissions.

An Outdoor Amenity Space is similarly proposed on the 3rd level of the northern building, atop a step in the eastern façade. The model was tested with 1.5m high screens around the perimeter of the space, and point analysis was performed within the CFD model to determine the conditions realized above the pedestrian level for the area. The space is fairly well protected from the majority of the dominant westerly through northwesterly wind climate, and as such is predicted suitable for sitting in the summer and shoulder seasons, with the exception of standing conditions at the northernmost portion of the space. A mitigation plan is recommended for the northern portion of the space in order to achieve more comfortable conditions than reported, and may include raising the height of the perimeter wind screen along the northern façade, dense coniferous vegetation, raised planter beds, trellises, porous wind screens, and/or others at the north end of the space. This will be further explored through future submissions.

The proposed Outdoor Amenity Spaces pass the pedestrian safety criteria.

5.4 Summary

The observed wind velocity and flow patterns at the proposed Development site are largely influenced by approach wind characteristics that are dictated by the surrounding areas to prevailing and less dominant wind directions. These surroundings present a suburban terrain to prevailing winds, mitigating winds from some directions, and affording wind opportunity to accelerate from others, resulting in generally comfortable conditions in the existing setting, with localised windier conditions proximate to corners of mid-rise buildings.

Once the subject site is developed, ground level wind conditions remain mostly similar to, or better than, the existing setting, with localized areas of increased pedestrian level winds noted to the immediate north and southwest of the proposed Development site. This results in wind conditions at the site and surrounds that are predicted as windy at times, but generally remain comfortable and appropriate to the areas' intended purposes throughout the year. Localised uncomfortable conditions are noted to the immediate north and southwest of the proposed Development through the winter and spring seasons, however consideration of fine design details and the proposed mitigative features in these areas will result in more comfortable conditions than reported. The relationship between surface roughness and wind is discussed in the Background and Theory of Wind Movement section and shown graphically in Figure A of the same section.

Mitigation plans are recommended for the 2nd and 3rd level Outdoor Amenity Spaces in order to improve conditions beyond those reported, and will be explored through future submissions.

The proposed Development is predicted to realise wind conditions acceptable to a typical suburban context, based on this preliminary Computational Fluid Dynamics analysis.

6. FIGURES

Figure 1: Site Aerial Photo

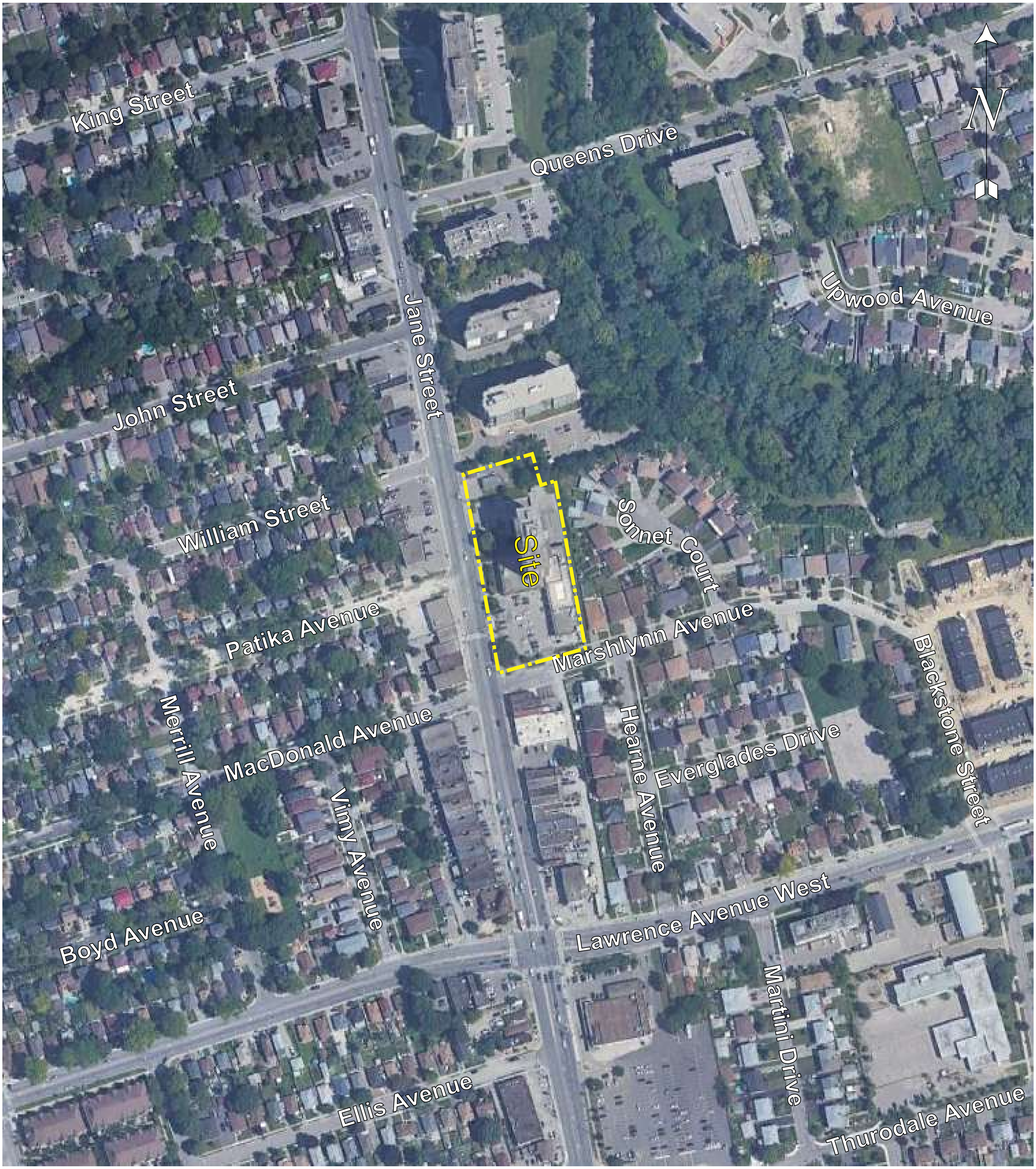


Figure 2: Site Plan

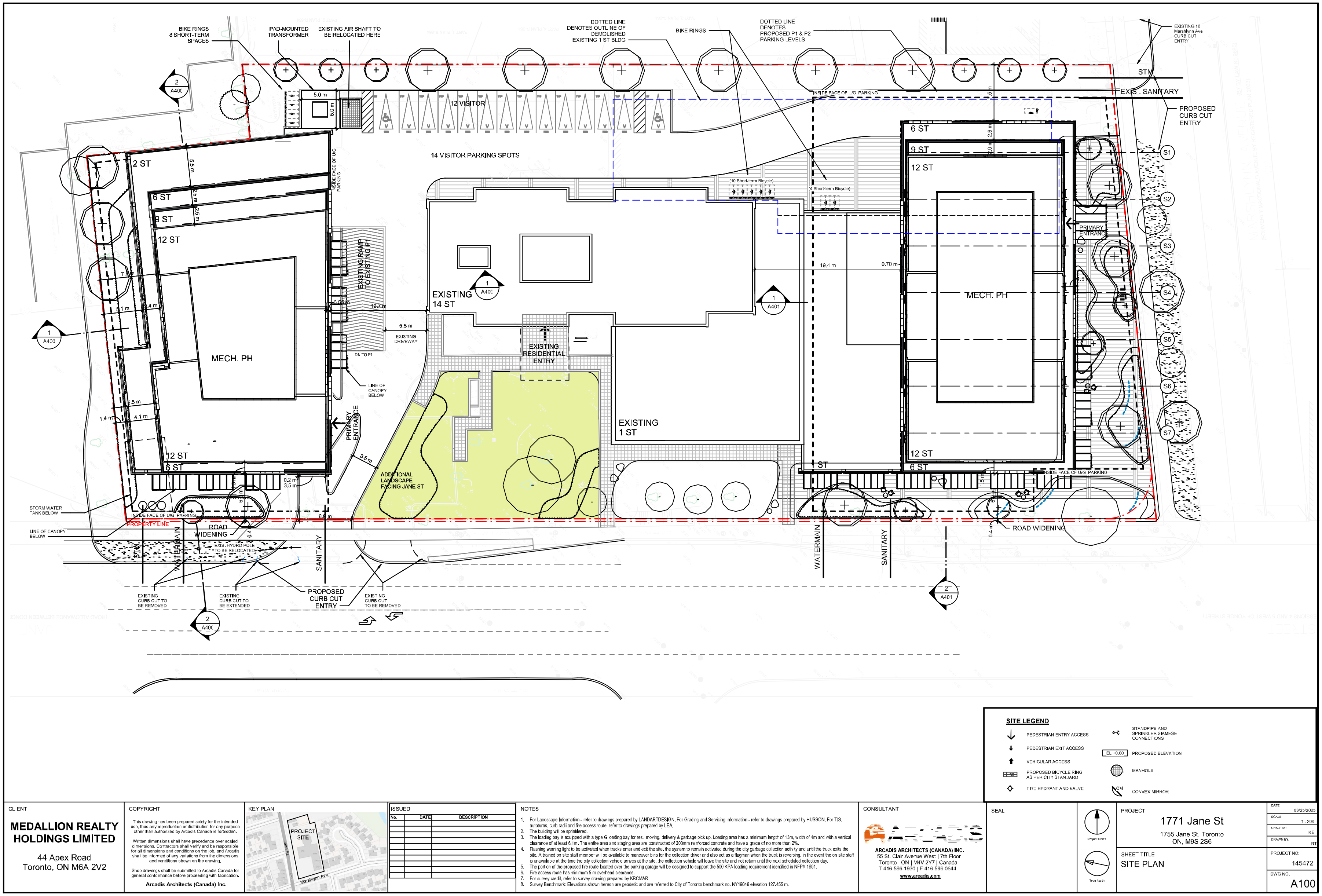
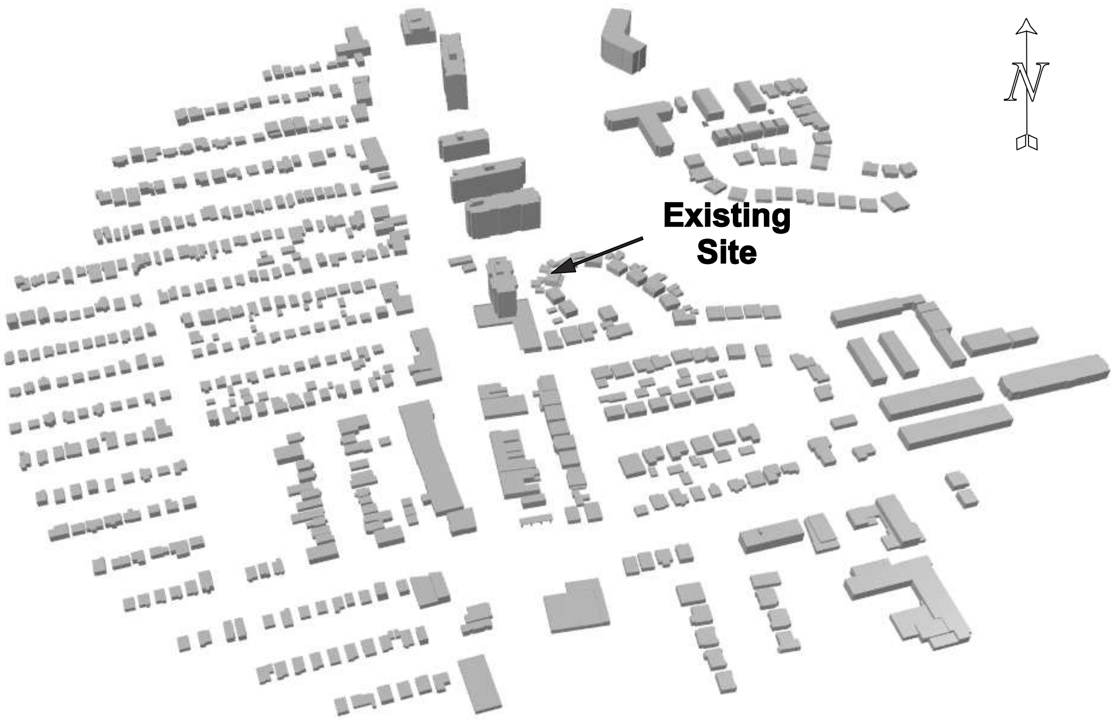
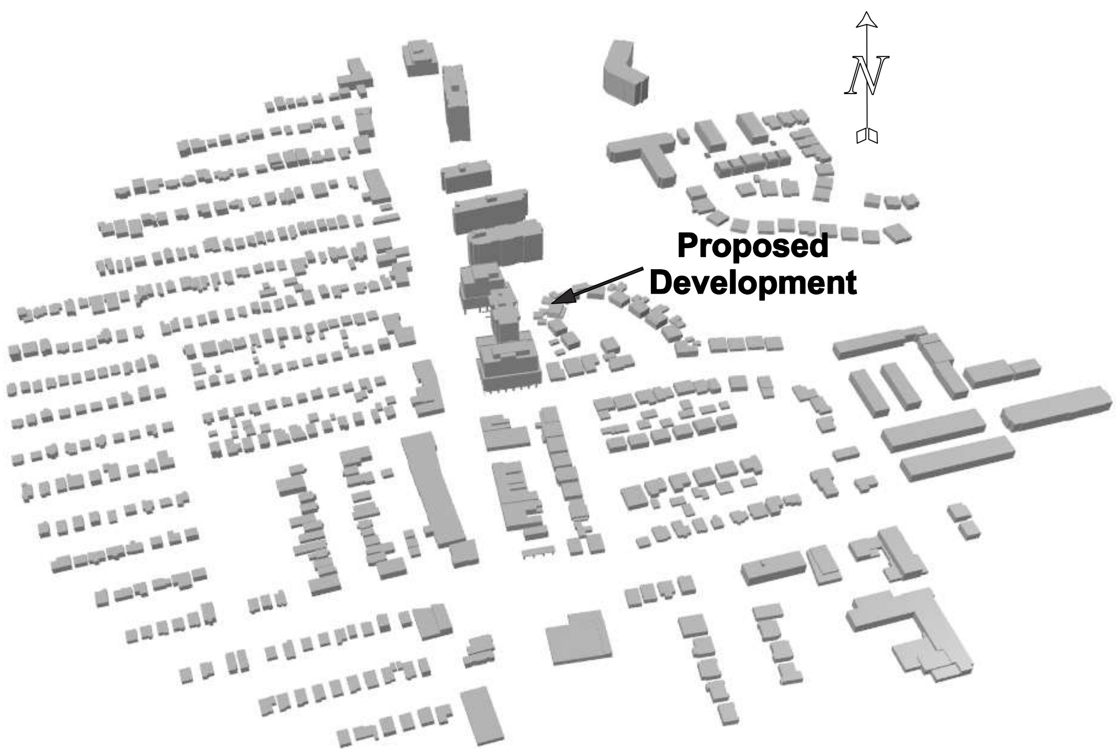


Figure 3: Computational Geometry



a) Existing Setting



b) Proposed Setting

Figure 4a: Winter Wind Rose - Pearson International Airport

Historical Directional Distribution of Winds (@ 10*m* height)
December through February (1980 - 2023)

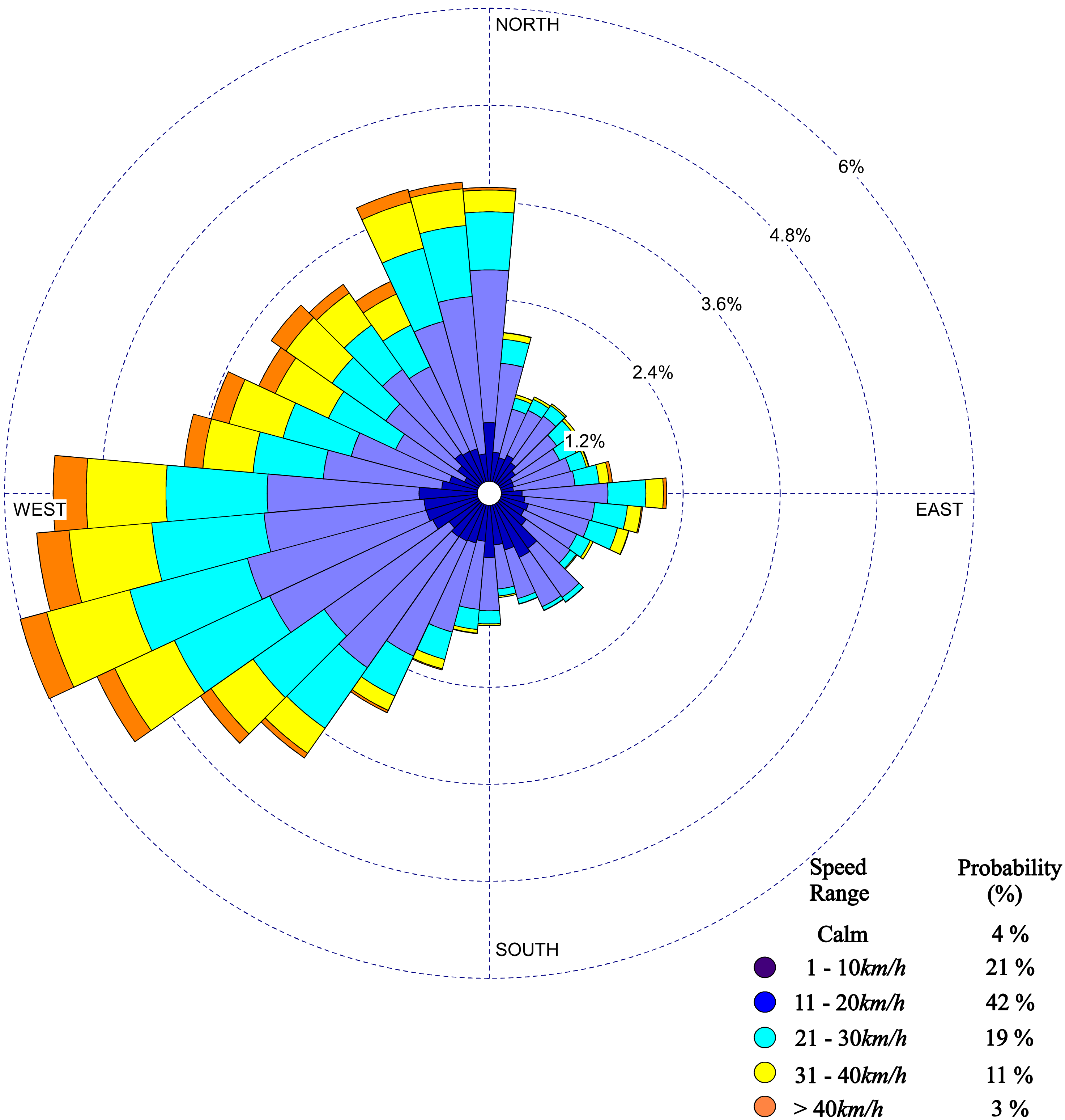


Figure 4b: Spring Wind Rose - Pearson International Airport

Historical Directional Distribution of Winds (@ 10*m* height)
March through May (1980 - 2023)

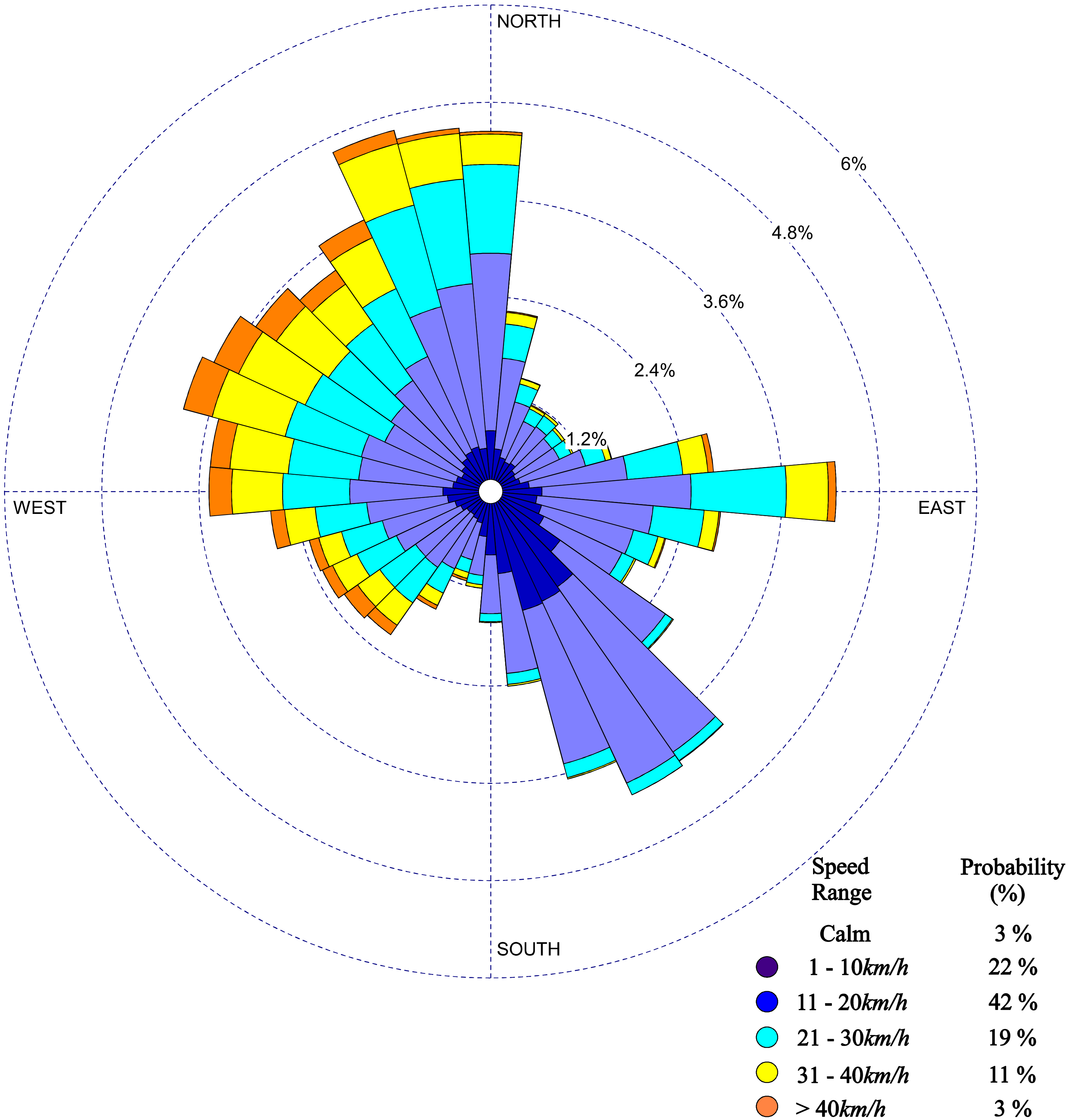
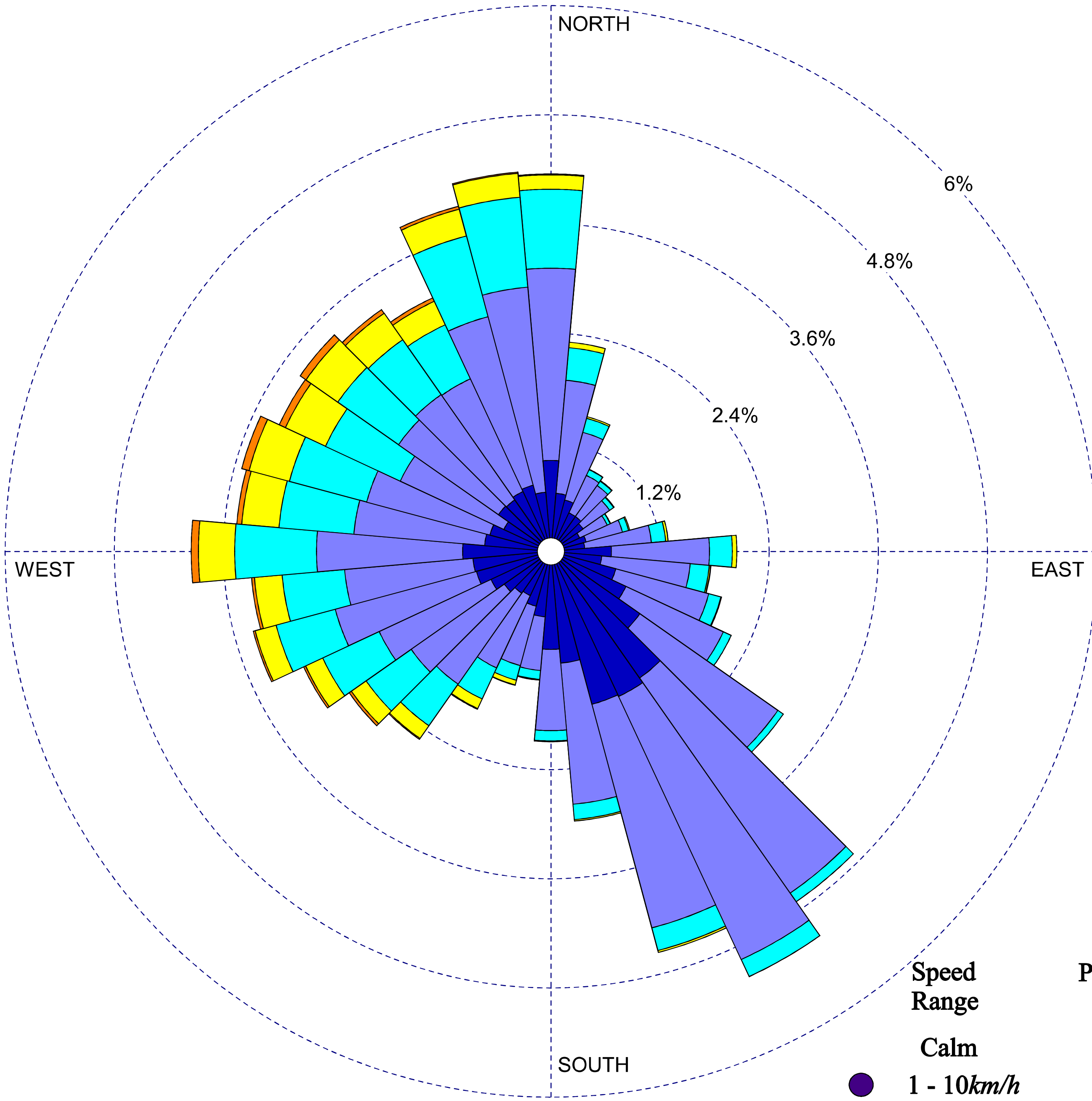


Figure 4c: Summer Wind Rose - Pearson International Airport

Historical Directional Distribution of Winds (@ 10*m* height)
June through August (1980 - 2023)



Speed Range	Probability (%)
Calm	4 %
1 - 10*km/h*	28 %
11 - 20*km/h*	47 %
21 - 30*km/h*	15 %
31 - 40*km/h*	5 %
> 40*km/h*	1%

Figure 4d: Fall Wind Rose - Pearson International Airport

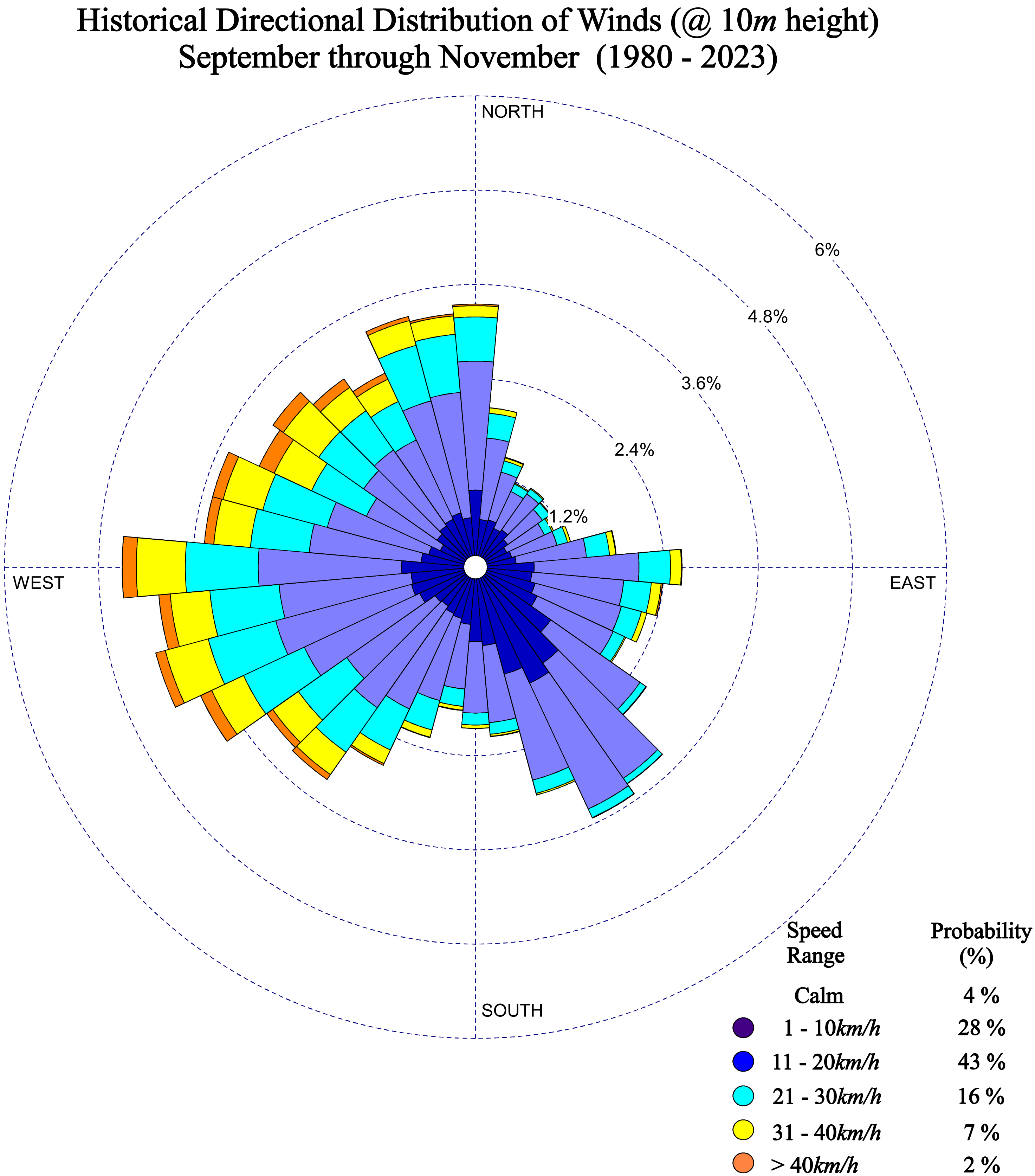
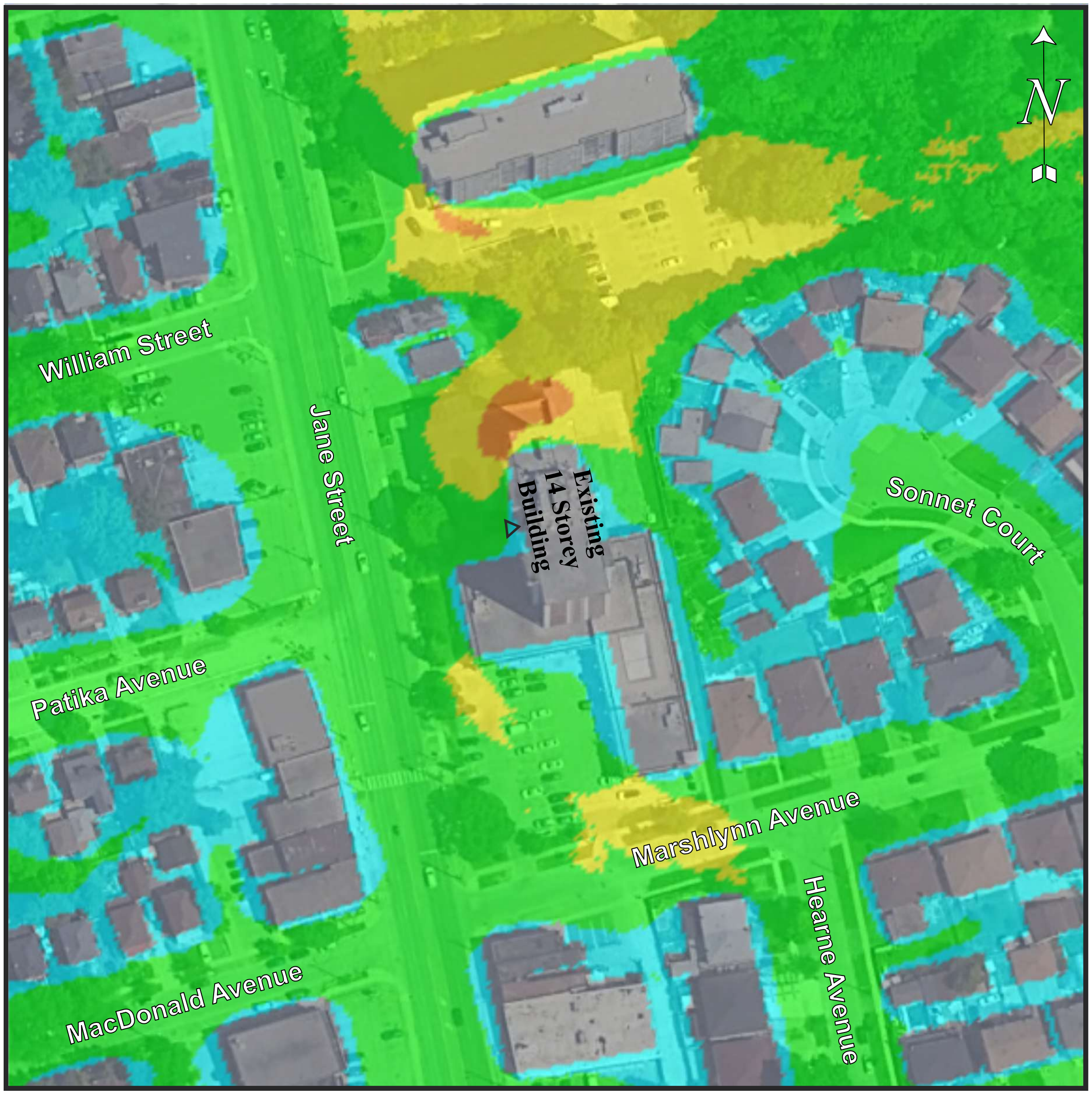


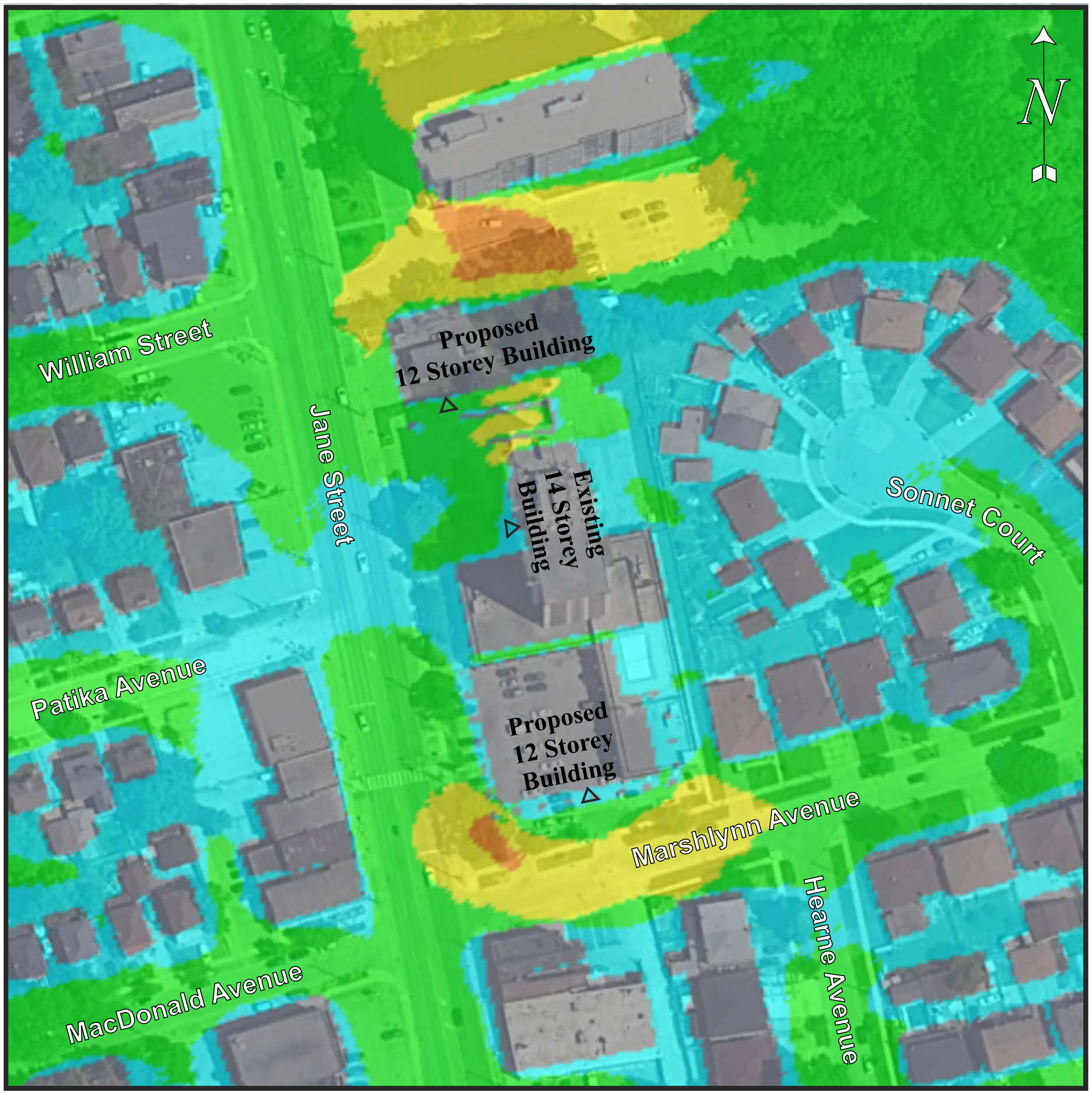
Figure 5a: Pedestrian Level Wind Velocity Comfort Categories

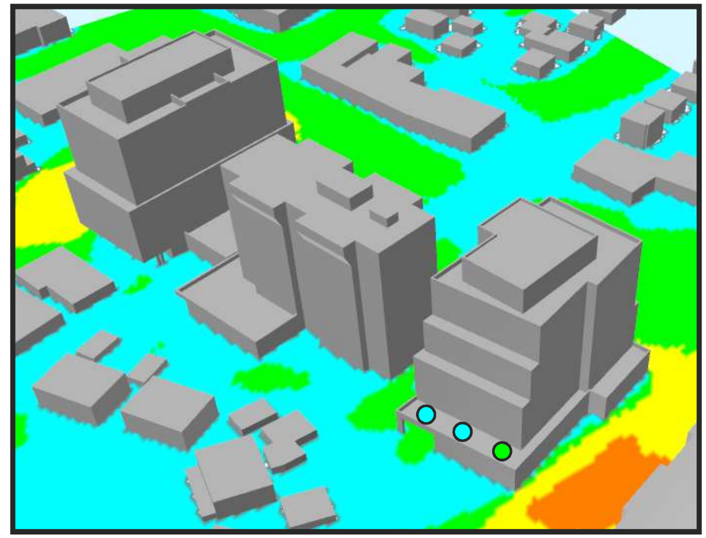


Comfort Categories - Winter - Existing

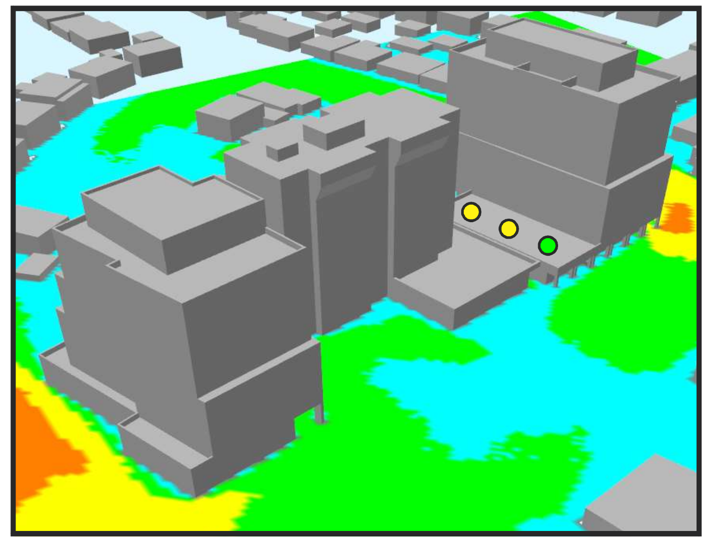
Sitting Standing Walking Uncomfortable

Figure 5b: Pedestrian Level Wind Velocity Comfort Categories





View looking Southwest

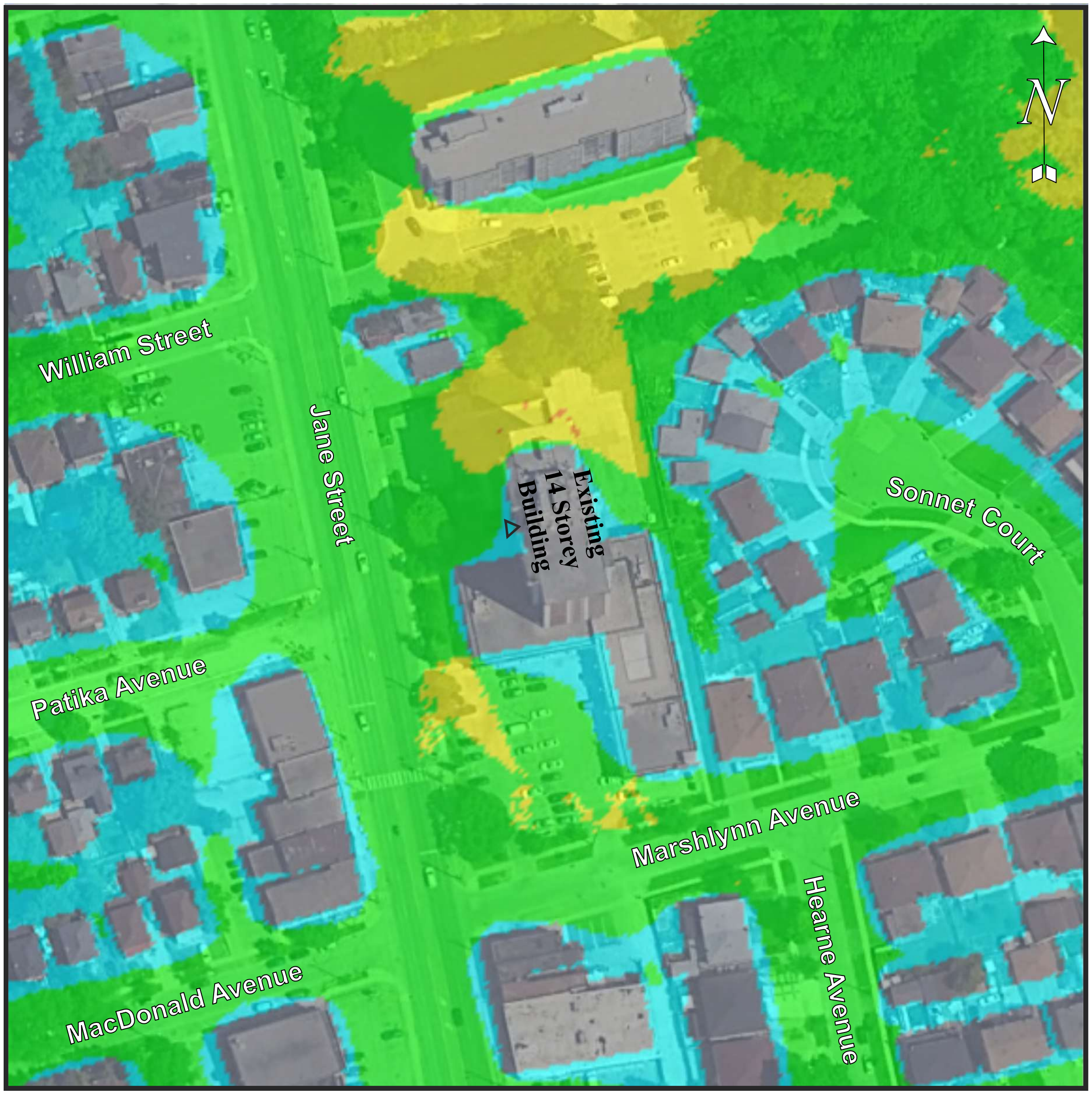


View looking Southeast

Comfort Categories - Winter - Proposed

Sitting Standing Walking Uncomfortable

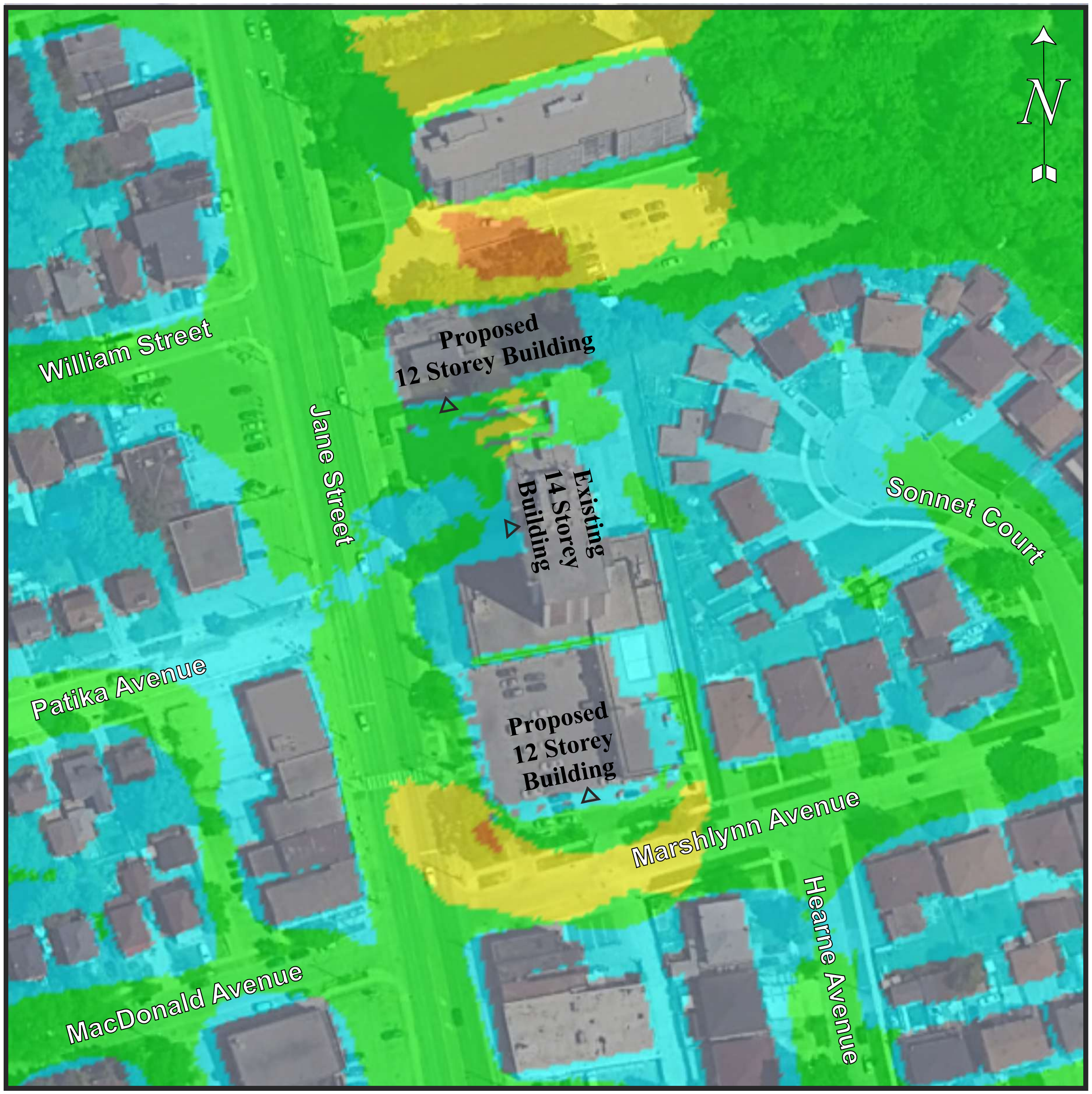
Figure 5c: Pedestrian Level Wind Velocity Comfort Categories

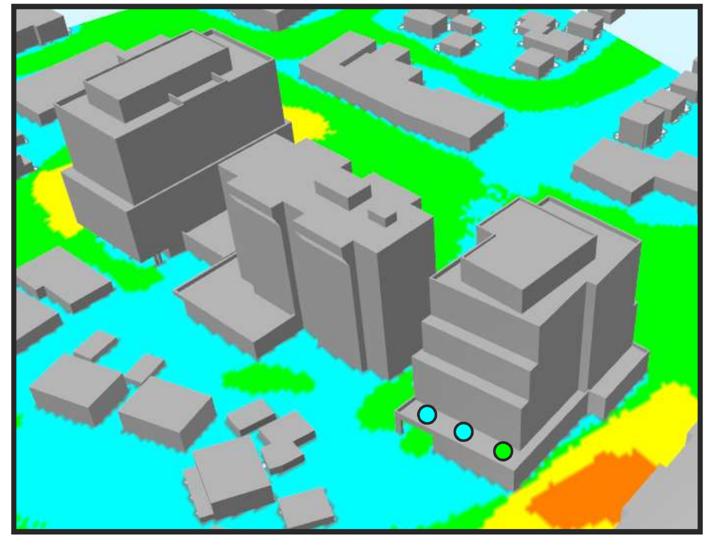


Comfort Categories - Spring - Existing

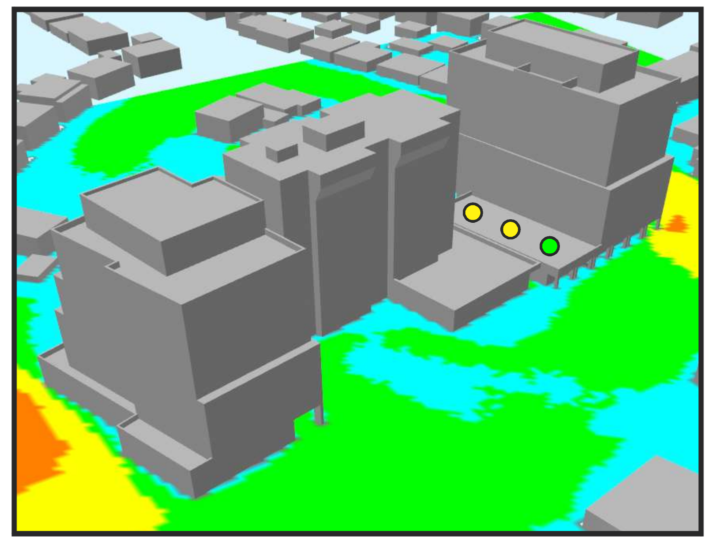
Sitting   Standing   Walking   Uncomfortable

Figure 5d: Pedestrian Level Wind Velocity Comfort Categories





View looking Southwest

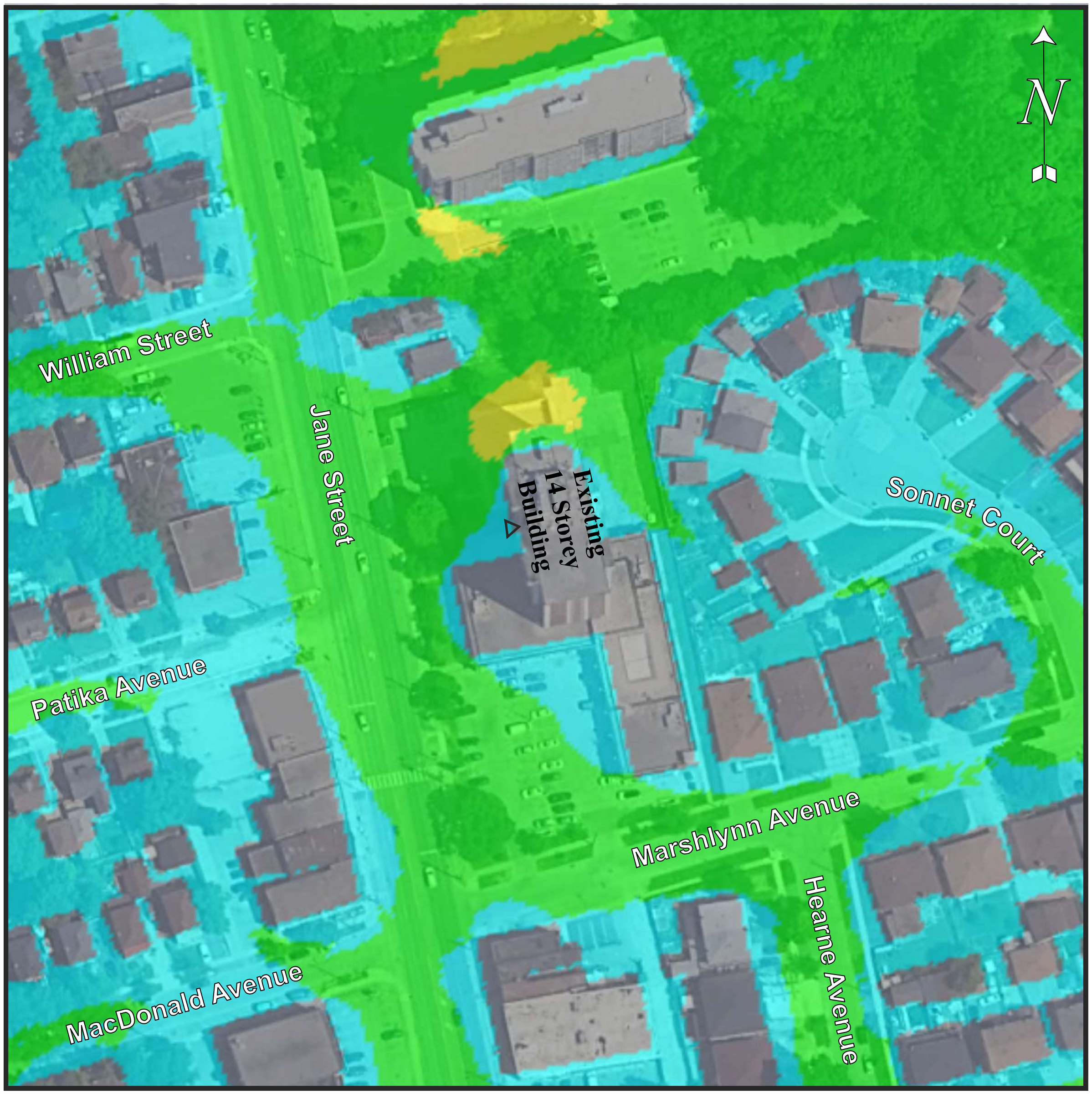


View looking Southeast

Comfort Categories - Spring - Proposed

Sitting Standing Walking Uncomfortable

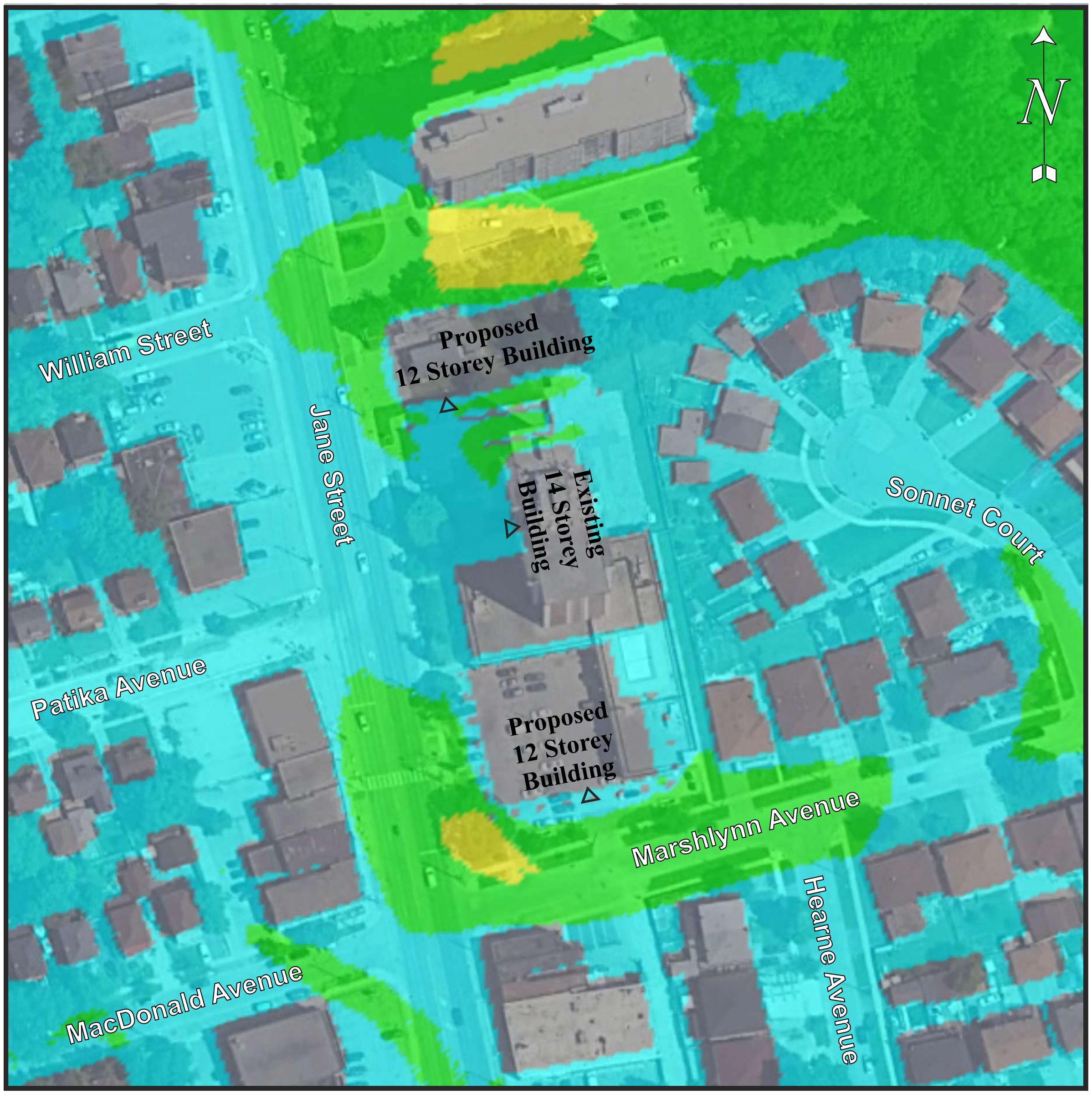
Figure 5e: Pedestrian Level Wind Velocity Comfort Categories

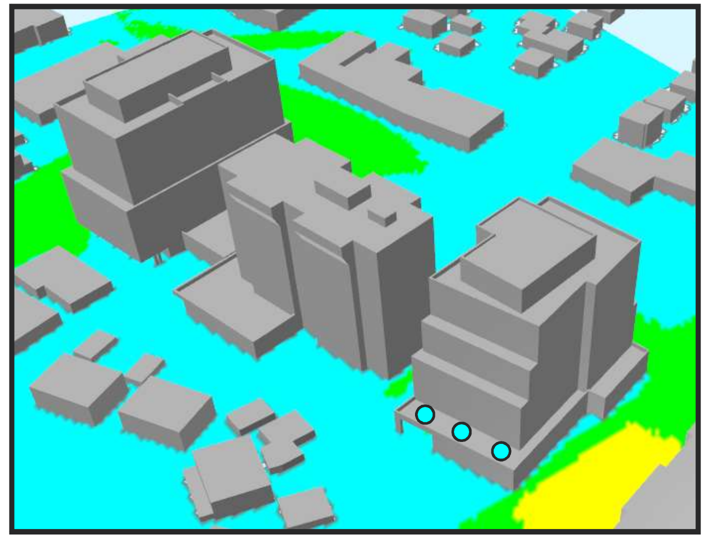


Comfort Categories - Summer - Existing

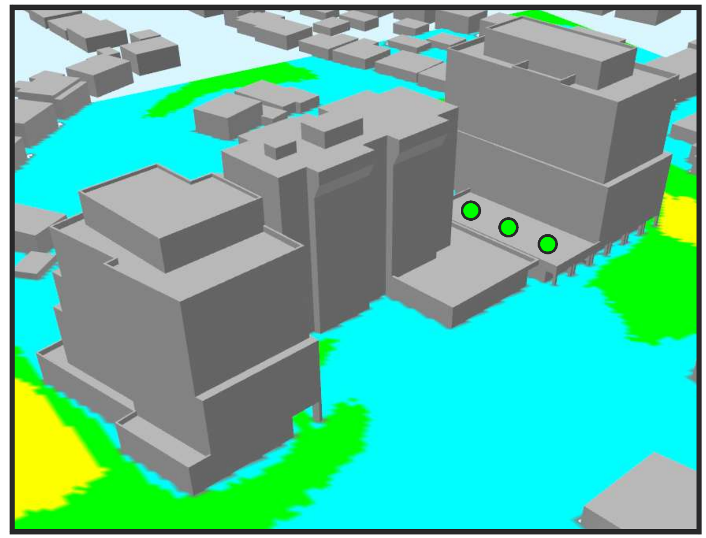
Sitting Standing Walking Uncomfortable

Figure 5f: Pedestrian Level Wind Velocity Comfort Categories





View looking Southwest

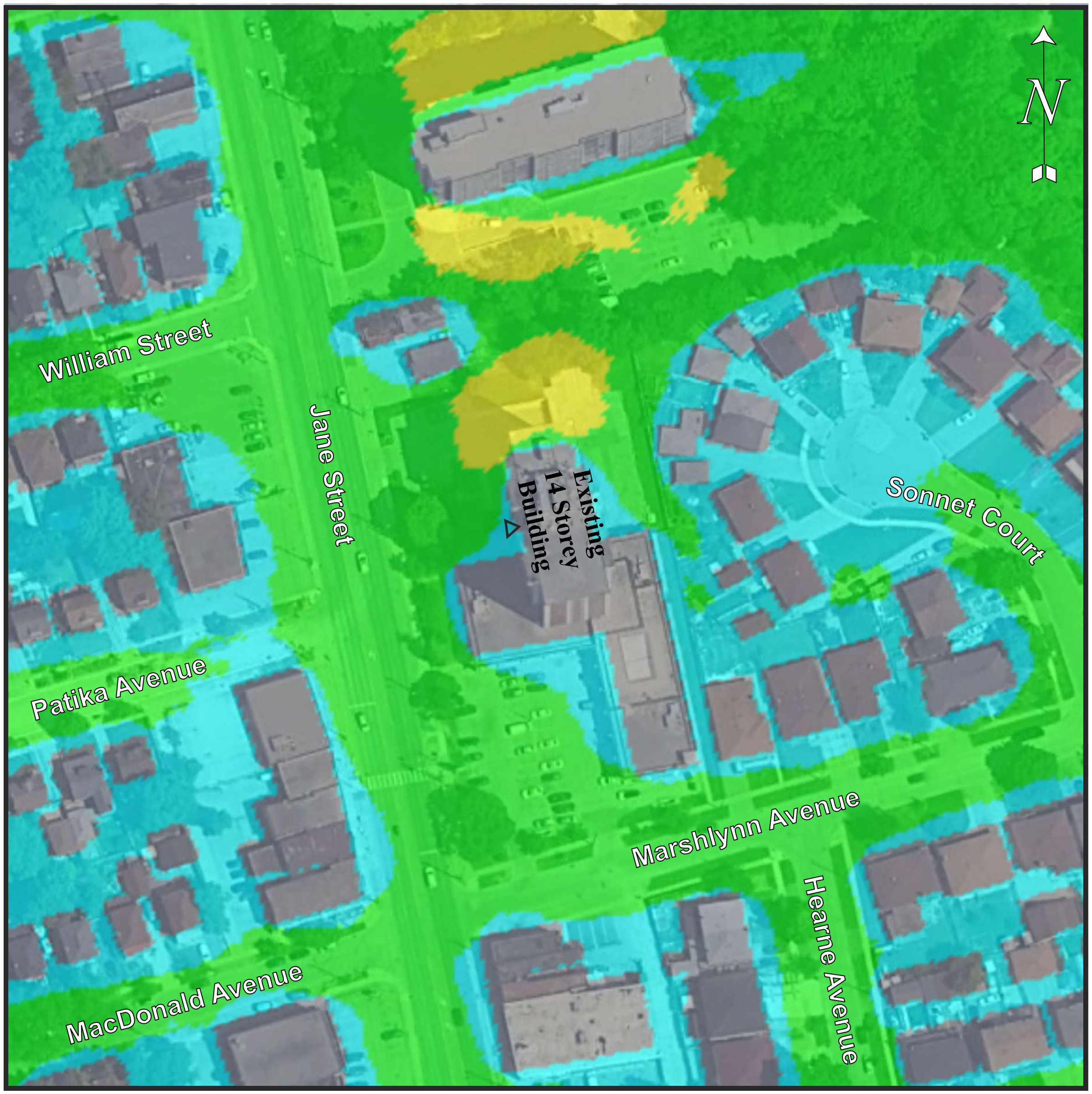


View looking Southeast

Comfort Categories - Summer - Proposed

Sitting | Standing | Walking | Uncomfortable

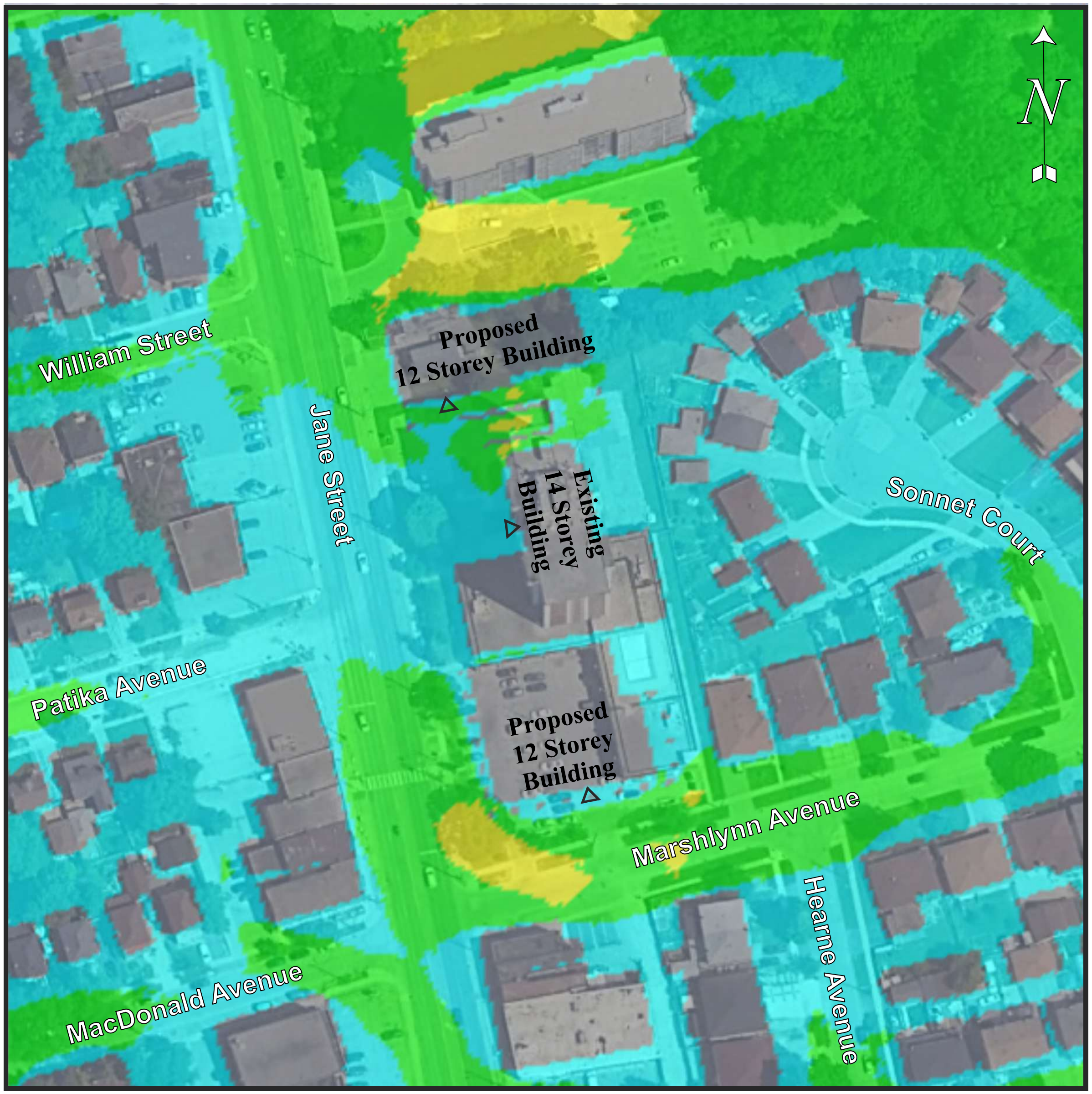
Figure 5g: Pedestrian Level Wind Velocity Comfort Categories

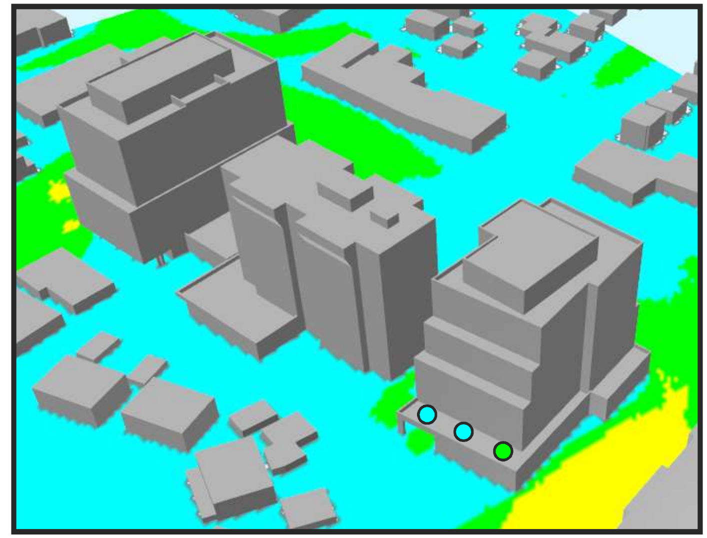


Comfort Categories - Fall - Existing

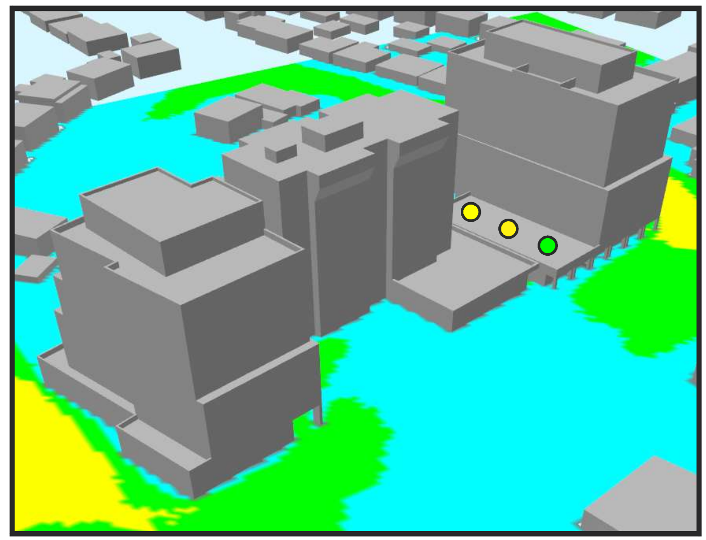
Sitting | Standing | Walking | Uncomfortable

Figure 5h: Pedestrian Level Wind Velocity Comfort Categories





View looking Southwest

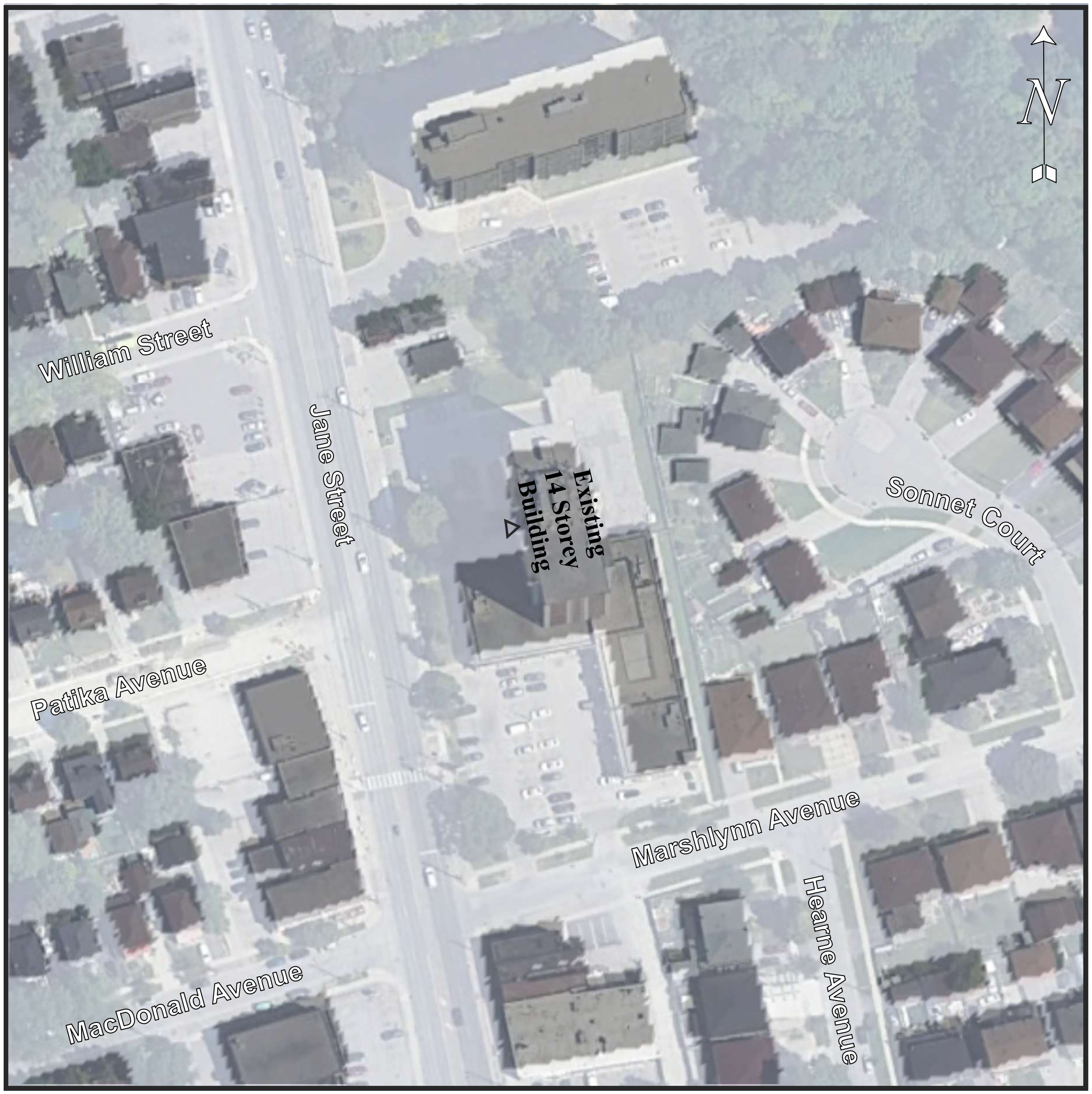


View looking Southeast

Comfort Categories - Fall - Proposed

Sitting Standing Walking Uncomfortable

Figure 6a: Pedestrian Level Wind Velocity Safety

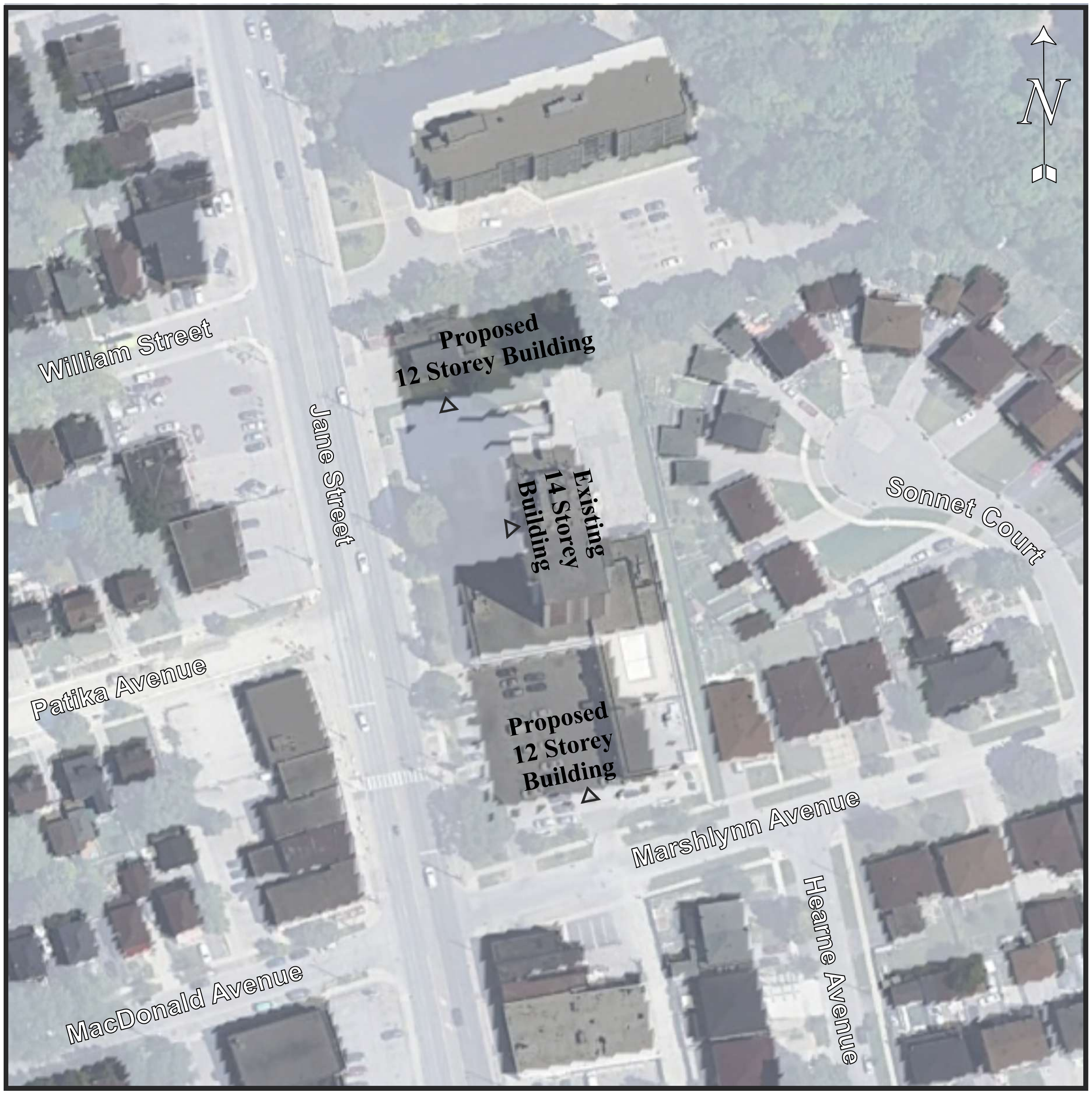


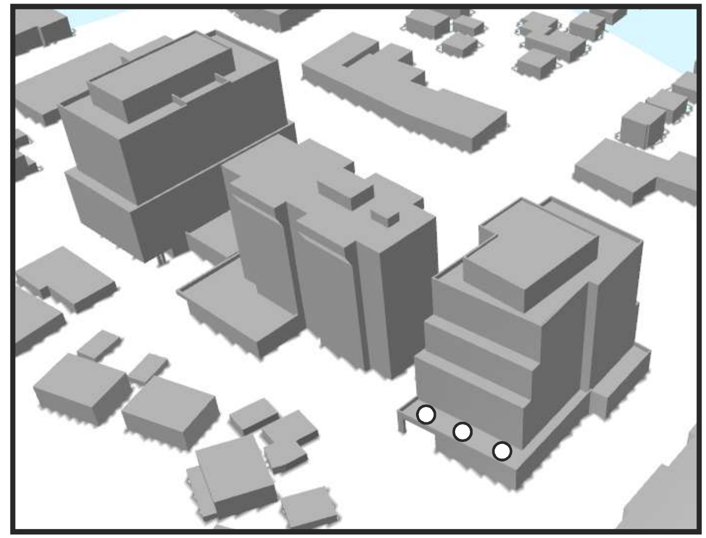
Safety Criteria - Existing

Exceeding Safety Criteria *Estimated

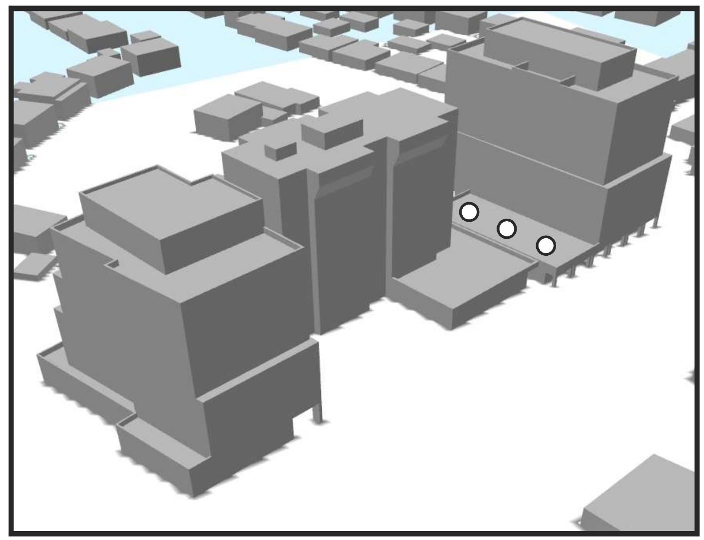
Theakston
Environmental

Figure 6b: Pedestrian Level Wind Velocity Safety





View looking Southwest



View looking Southeast

Safety Criteria - Proposed

● Exceeding Safety Criteria *Estimated

7. 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:

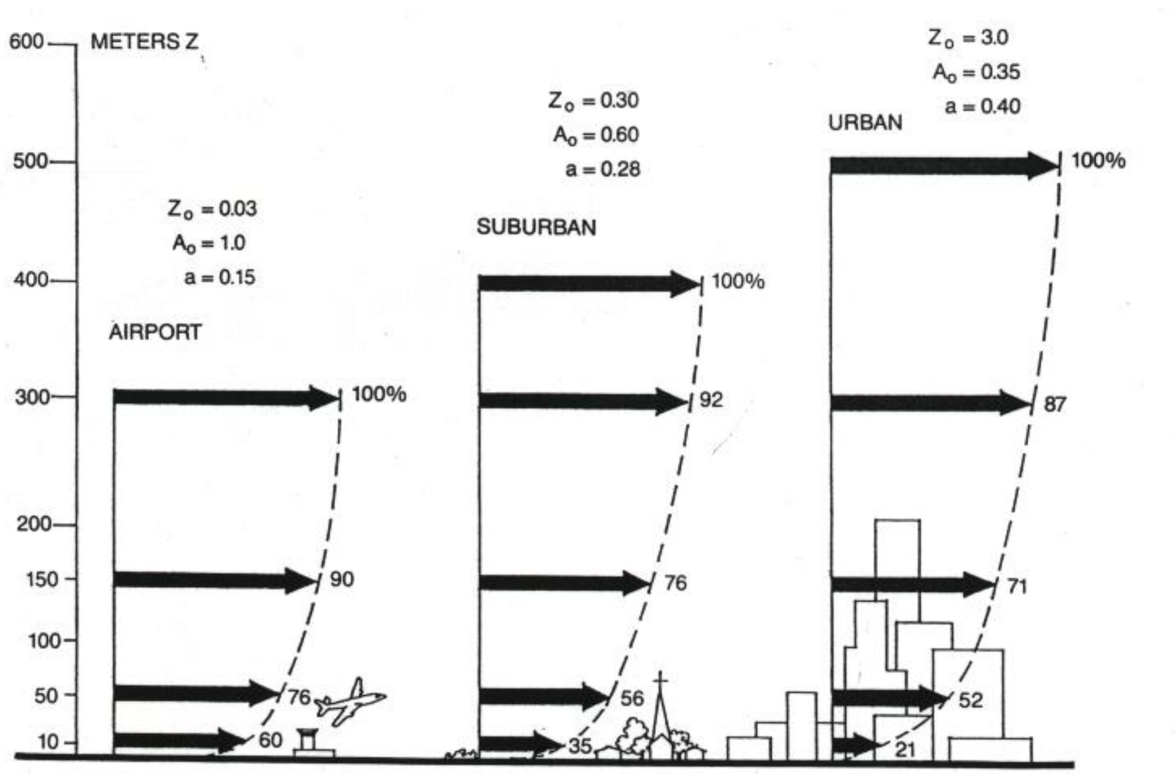


Figure A: Mean wind speed profiles for various terrain (from ASHRAE 1989).

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 section above.

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