

GRADIENTWIND

ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

267 O'Connor Street
Ottawa, Ontario

Report: 20-166-PLW-2025



January 13, 2025

PREPARED FOR

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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Official Plan Amendment and Zoning By-Law Amendment application submission requirements for the proposed mixed-use residential development located at 267 O'Connor Street in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind comfort and safety within and surrounding the subject site according to City of Ottawa wind comfort and safety criteria. The results and recommendations derived from these considerations are detailed in the main body of the report (Section 5), illustrated in Figures 3A-9, and summarized as follows:

- 1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, neighbouring existing surface parking lots, the proposed POPS, and in the vicinity of building access points, are considered acceptable.
- 2) Wind conditions within the Level 2 amenity terrace are predicted to be suitable for sitting during the typical use period (May to October, inclusive), which is considered acceptable. Conditions during this period within the common amenity terraces serving the North and South Towers at their respective MPH Levels are predicted to be suitable for a mix of sitting and standing. These terraces were modelled with 1.8-m-tall wind screens along their full perimeters to shield against direct winds.



- a. To improve comfort levels within the MPH Level terraces, mitigation inboard of the terrace perimeters targeted around designated seating areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m, measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements, with its extent dependent on the programming of the noted terraces.
- 3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Addendum: The current PLW study was completed based on architectural drawings provided Hobin Architecture Incorporated in December 2024. Updated architectural drawings were provided to the consultant team in January 2025, in which the location of the MPHs for both towers has shifted from the northeast to the southeast, shifting the MPH Level amenity terraces to the eastern elevations. The noted revision is expected minorly improve wind conditions within the MPH Level amenity terraces, with the MPHs providing modest sheltering effects from prevailing winds.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Taggart Realty Management on behalf of Taggart (O'Connor) Corporation to undertake a pedestrian level wind (PLW) study to satisfy Official Plan Amendment and Zoning By-Law Amendment application submission requirements for the proposed mixed-use residential development located at 267 O'Connor Street in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). A PLW study was conducted in September 2020¹ for the previous design of the proposed development. Our mandate within the current study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by Hobin Architecture Incorporated in December 2024, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent satellite imagery.

2. TERMS OF REFERENCE

The subject site is located at 267 O'Connor Street in Ottawa, situated on the west portion of a parcel of land bounded by O'Connor Street to the west, MacLaren Street to the north, Metcalfe Street to the east, and Gilmour Street to the south. The proposed development comprises two residential towers topped with mechanical penthouses (MPH): a 27-storey North Tower (Phase 1) and a 25-storey South Tower (Phase 2), linked by a 1-storey "C"-shaped mixed-use podium. A privately-owned publicly accessible space (POPS) is provided in the area between the two towers and to the west of the subject site at grade.

Above four levels of underground parking, the shared ground floor of the North and South Towers includes the North and South Tower main entrances along the inner south and north elevations, respectively, retail spaces to the west, indoor amenities to the north, east, and south, a loading space at the northeast corner, and shared building support spaces throughout the remainder of the level. Access to the underground

¹ Gradient Wind Engineering Inc., '267 O'Connor Street – Pedestrian Level Wind Study', [Sept 14, 2020]



parking levels is provided by a parking ramp at the northeast corner from MacLaren Street. At Level 2, the North and South Towers include indoor amenities at the southeast and northeast corners, respectively, and residential units throughout the remainder of the level. A common amenity terrace is situated between the towers, atop the shared podium. Levels 3-27 of the North Tower and Levels 3-25 of the South Tower are reserved for residential occupancy. The MPH Level of the North Tower is served by a common amenity terrace within a setback from the west elevation and includes an indoor amenity and a mechanical space to the north and south of the level, respectively. At the MPH Level of the South Tower, setbacks from the south and west elevations accommodate a common amenity terrace and the level includes mechanical space to the north and an indoor amenity at the southeast corner.

The near-field surroundings (defined as an area within 200 metres (m) of the subject site) include a mix of low-, mid-, and high-rise buildings in all directions. The far-field surroundings (defined as an area beyond the near-field but within a 2-kilometre (km) radius of the subject site) are characterized by a mix of mostly low- and mid-rise buildings from the east-northeast clockwise to the west, and by the urban exposure of the downtown Ottawa core and the open exposure of the Ottawa River from the west clockwise to the northeast. The Ottawa River flows southwest to northeast approximately 1.2 km to the northwest, and the Rideau Canal flows south to north approximately 750 m to the east of the subject site.

Site plans for the proposed and existing massing scenarios are illustrated in Figures 1A and 1B, while Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any developments which have been approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.



4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind comfort and safety criteria². The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Ottawa Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly stronger wind speeds.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 16 wind directions. The CFD simulation model was centered on the proposed development, complete with surrounding massing within a radius of 480 m. The process was performed for two context massing scenarios, as noted in Section 2.

² City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/documents/files/wind_analysis_tor_en.pdf



Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terraces serving the proposed development were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. Gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Further details of the wind flow simulation technique are presented in Appendix A.

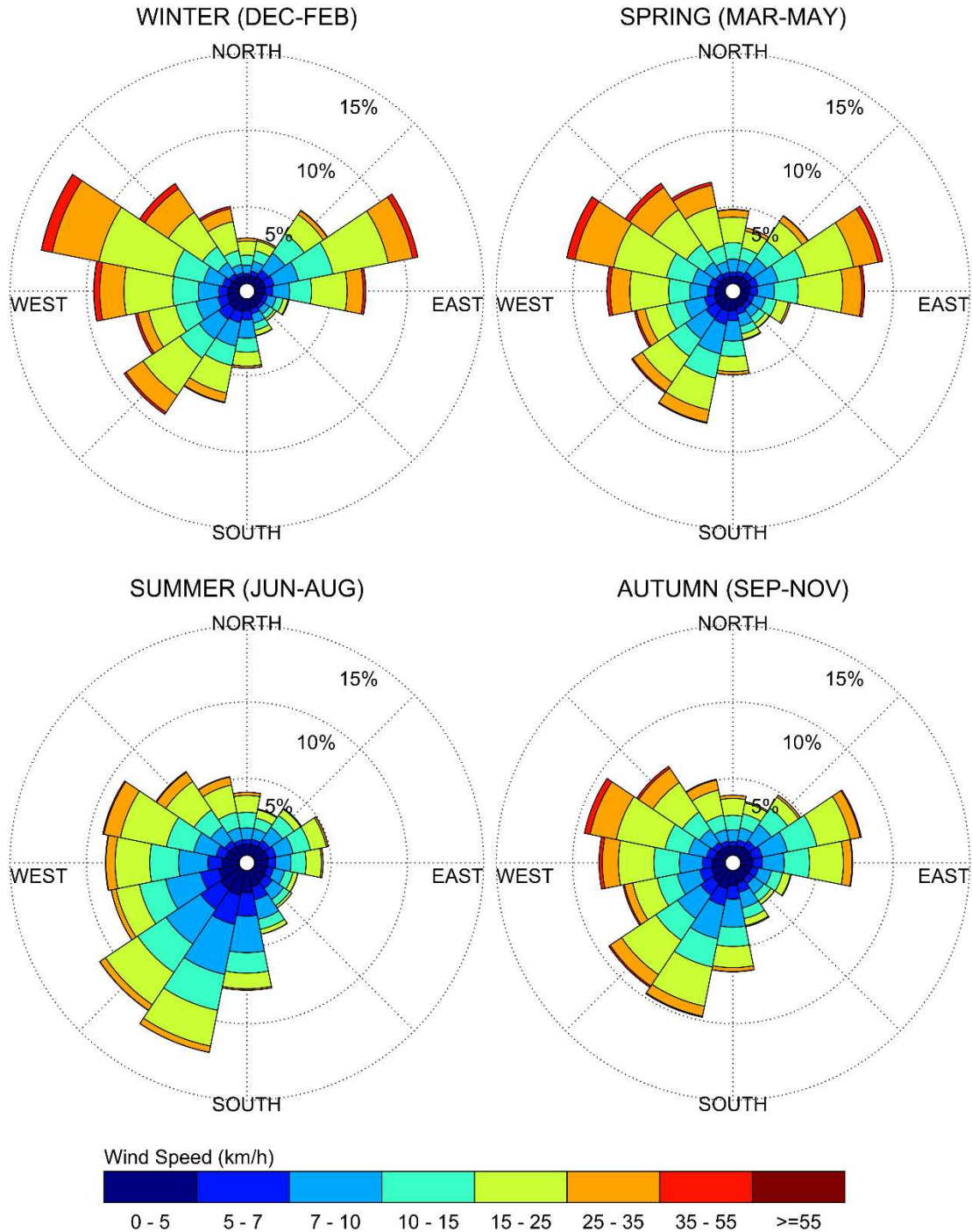
4.3 Historical Wind Speed and Direction Data

A statistical model for winds in Ottawa was developed from approximately 40 years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (that is, between 06:00 and 23:00) and divided into four distinct seasons, as stipulated in the wind criteria. Specifically, the spring season is defined as March through May, the summer season is defined as June through August, the autumn season is defined as September through November, and the winter season is defined as December through February, inclusive.

The statistical model of the Ottawa area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The prominent wind speeds and directions can be identified by the longer length of the bars. For Ottawa, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional prominence and relative magnitude of wind speed changes somewhat from season to season.



SEASONAL DISTRIBUTION OF WIND OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT



Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in km/h, measured at 10 m above the ground.



4.4 Pedestrian Wind Comfort and Safety Criteria – City of Ottawa

Pedestrian wind comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (that is, temperature and relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes based on 20% non-exceedance mean wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. The gust speeds, and equivalent mean speeds, are selected based on the Beaufort scale, which describes the effects of forces produced by varying wind speed levels on objects. Wind conditions suitable for sitting are represented by the colour blue, standing by green, strolling by yellow, and walking by orange; uncomfortable conditions are represented by the colour magenta. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	Mean Speed (km/h)	Description
SITTING	≤ 10	Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.
STANDING	≤ 14	Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.
STROLLING	≤ 17	Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.
WALKING	≤ 20	Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.
UNCOMFORTABLE	> 20	Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.



Regarding wind safety, the pedestrian safety wind speed criterion is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of 90 km/h is classified as dangerous. From calculations of stability, it can be shown that gust wind speeds of 90 km/h would be the approximate threshold wind speed that would cause an average elderly person in good health to fall. Notably, pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (equivalent gust wind speed of approximately 16 km/h) were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (equivalent gust wind speed of approximately 32 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the subject site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the target comfort classes, which are dictated by the location type for each region (that is, a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest target comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

TARGET PEDESTRIAN WIND COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Target Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting / Standing
Café / Patio / Bench / Garden	Sitting / Standing
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting / Standing
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B, which illustrate wind conditions at grade level for the proposed and existing massing scenarios and by Figures 8A-D, which illustrate wind conditions over the common amenity terraces serving the North and South Towers at Level 2 and at their respective MPH Levels. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the comfort classes presented in Section 4.4.

Wind comfort conditions are also reported for the typical use period, which is defined as May to October, inclusive. Figures 7 and 9 illustrate wind comfort conditions at grade level and over the noted common amenity terraces during this period, respectively, consistent with the comfort classes illustrated in Section 4.4.

The details of these conditions are summarized in the following pages for each area of interest.



5.1 Wind Comfort Conditions – Grade Level

Sidewalks along O’Connor Street and MacLaren Street: Following the introduction of the proposed development, wind comfort conditions over the nearby public sidewalks along O’Connor Street and MacLaren Street are predicted to be suitable for sitting during the summer and autumn, with isolated regions suitable for standing, becoming suitable for a mix of sitting and standing during the spring and winter. The noted conditions are considered acceptable.

Under the existing massing (that is, prior to the introduction of the proposed development), conditions over the sidewalks along O’Connor Street and MacLaren Street are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces slightly windier conditions in comparison to existing conditions, wind conditions are nevertheless considered acceptable.

Sidewalks along Gilmour Street: Following the introduction of the proposed development, wind comfort conditions over the nearby public sidewalks along Gilmour Street are predicted to be suitable for a mix of sitting and standing throughout the year. The noted conditions are considered acceptable.

Under the existing massing, conditions over the sidewalks along Gilmour Street are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces slightly windier conditions in comparison to existing conditions, wind comfort conditions with the proposed development are nevertheless considered acceptable.

Neighboring Existing Surface Parking Lots: Following the introduction of the proposed development, conditions over the existing surface parking lots to the northeast, southeast, and west of the subject site are predicted to be suitable for sitting throughout the year, with isolated regions suitable for standing during the spring, autumn, and winter seasons. The noted conditions are considered acceptable.

Under the existing massing, conditions over the noted surface parking lots are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces slightly windier conditions in comparison to existing conditions, conditions following the introduction of the proposed development are nevertheless considered acceptable.



POPS within the Subject Site: During the typical use period, conditions over the POPS situated between the North and South Towers and to the west of the subject site are predicted to be suitable for mostly sitting, which is considered acceptable.

Building Access Points: Conditions in the vicinity of the primary and secondary access points serving the proposed development are predicted to be suitable for standing, or better, throughout the year, which is considered acceptable.

5.2 Wind Comfort Conditions – Common Amenity Terraces

The amenity terraces serving the proposed development were modelled with 1.8-m-tall wind screens along their perimeters, which are recommended for the MPH Level terraces to provide shielding against direct winds.

Level 2 Amenity Terrace: Conditions within the common amenity terrace situated between the North and South Towers at Level 2 are predicted to be suitable for sitting throughout the year, which is considered acceptable.

North Tower – MPH Level Amenity Terrace: Conditions within the common amenity terrace serving the North Tower at the MPH Level are predicted to be suitable for mostly standing during the typical use period, with conditions predicted to be suitable for sitting closer to the tower façade and to the north and east of the terrace, as illustrated in Figure 9. Where conditions are suitable for standing, they are also predicted to be suitable for sitting at least 72% of the time, where the target is 80% to achieve the sitting comfort class.

South Tower – MPH Level Amenity Terrace: Conditions within the common amenity terrace serving the South Tower at the MPH Level are predicted to be suitable for sitting over a majority of the terrace during the typical use period, with a central region of conditions predicted to be suitable for standing, as illustrated in Figure 9. The area predicted to be suitable for standing is also predicted to be suitable for sitting for at least 74% of the time during the same period, where the target is 80% to achieve the sitting comfort criterion.



To improve comfort levels within the MPH Level amenity terraces, mitigation inboard of the terrace perimeters targeted around sensitive areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m, measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements, and its extent is dependent on the programming of the noted terraces.

5.3 Wind Safety

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas within or surrounding the subject site are expected to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.4 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (that is, construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-9. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

- 1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, neighbouring existing surface parking lots, the proposed POPS, and in the vicinity of building access points, are considered acceptable.



- 2) Wind conditions within the Level 2 amenity terrace are predicted to be suitable for sitting during the typical use period (May to October, inclusive), which is considered acceptable. Conditions during this period within the common amenity terraces serving the North and South Towers at their respective MPH Levels are predicted to be suitable for a mix of sitting and standing. These terraces were modelled with 1.8-m-tall wind screens along their full perimeters to shield against direct winds.
- a. To improve comfort levels within the MPH Level terraces, mitigation inboard of the terrace perimeters targeted around designated seating areas is recommended, in combination with tall wind screens (that is, greater than 1.8 m, measured from the local walking surface) along the perimeters of the terraces. This inboard mitigation could take the form of inboard wind screens or other common landscape elements, with its extent dependent on the programming of the noted terraces.
- 3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (for example, thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Sincerely,

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GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT 267 O'CONNOR STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:1500	DRAWING NO. 20-166-PLW-2025-1A	
	DATE JANUARY 13, 2025	DRAWN BY S.K.	



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT 267 O'CONNOR STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:1500	DRAWING NO. 20-166-PLW-2025-1B	
	DATE JANUARY 13, 2025	DRAWN BY S.K.	

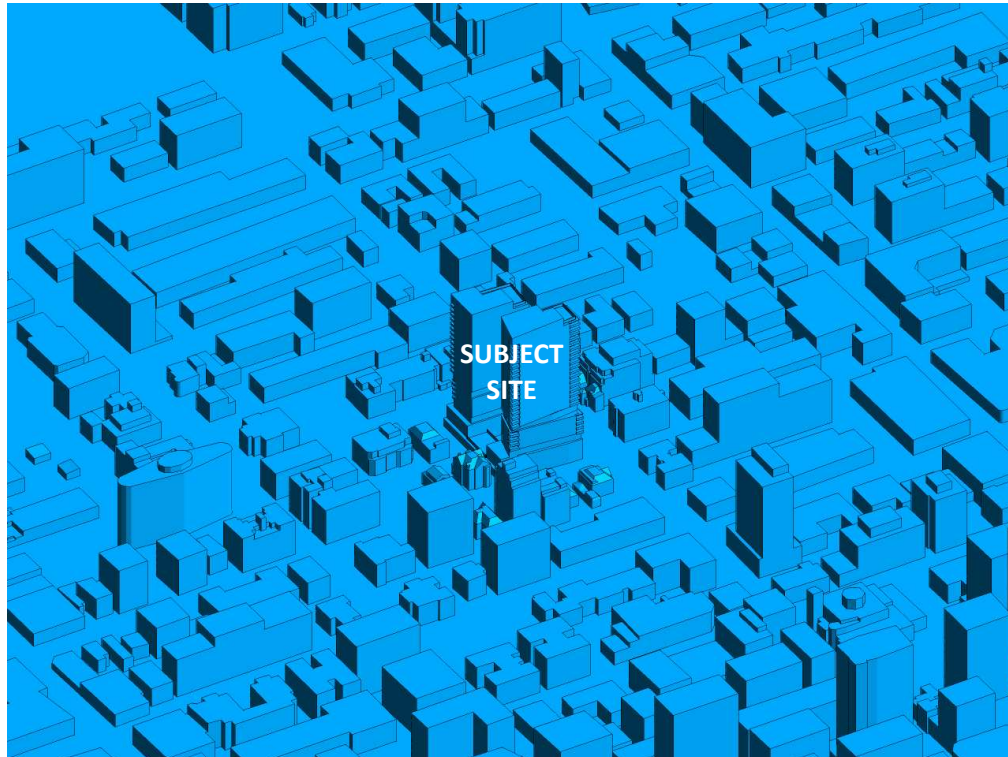


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

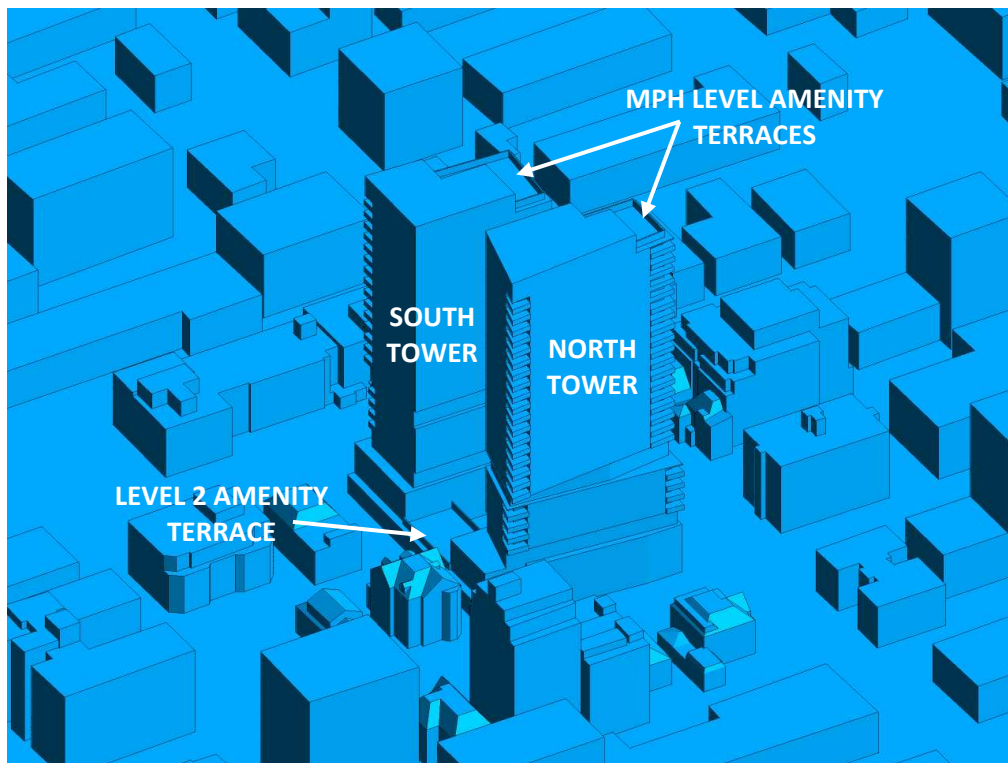


FIGURE 2B: CLOSE UP OF FIGURE 2A



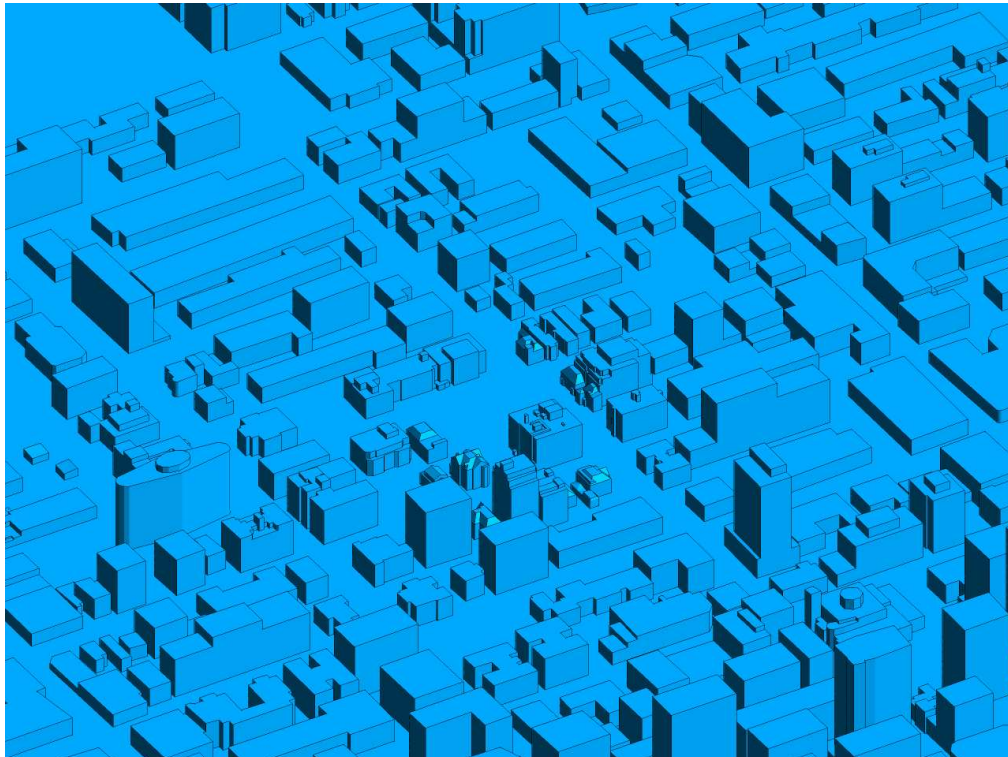


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

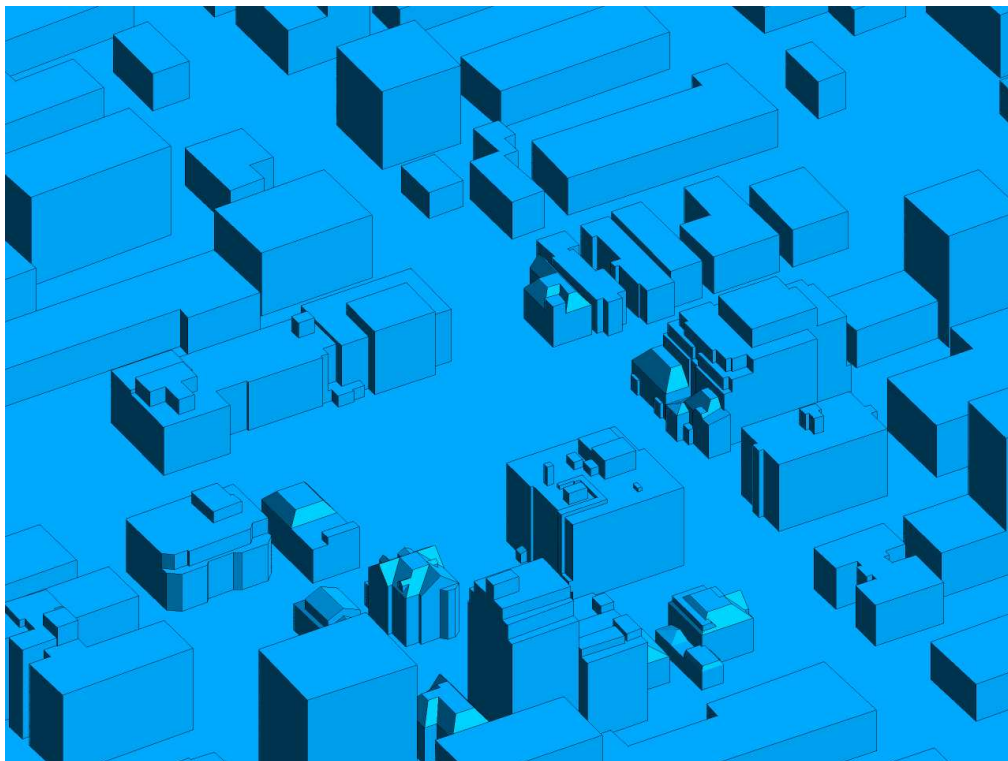


FIGURE 2D: CLOSE UP OF FIGURE 2C



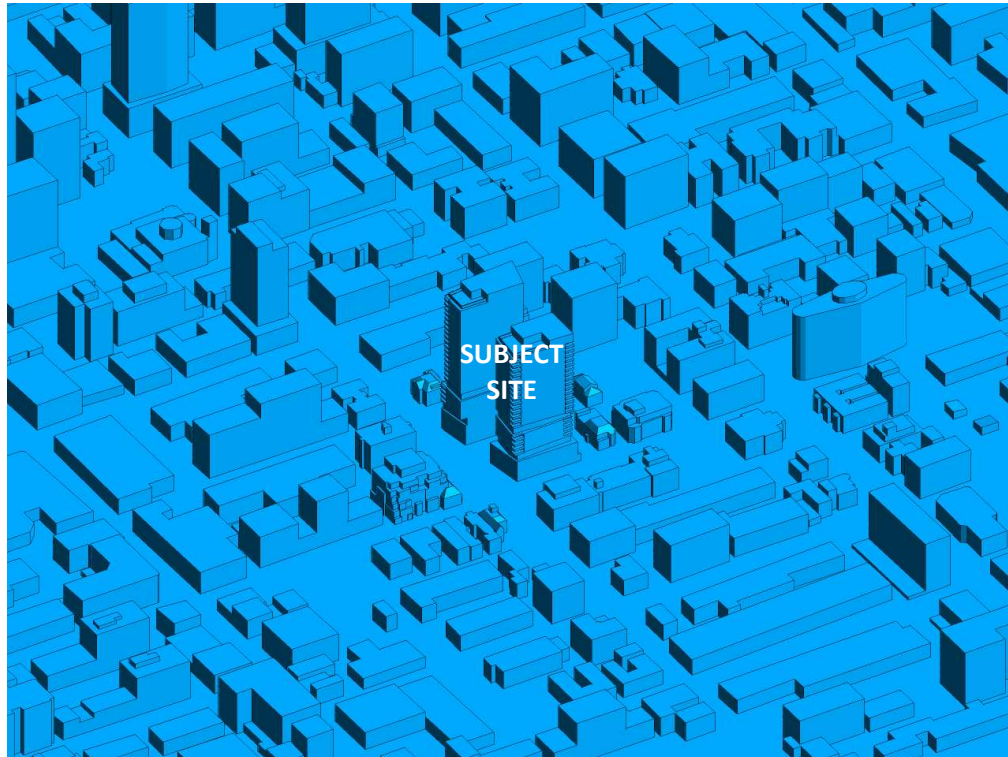


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

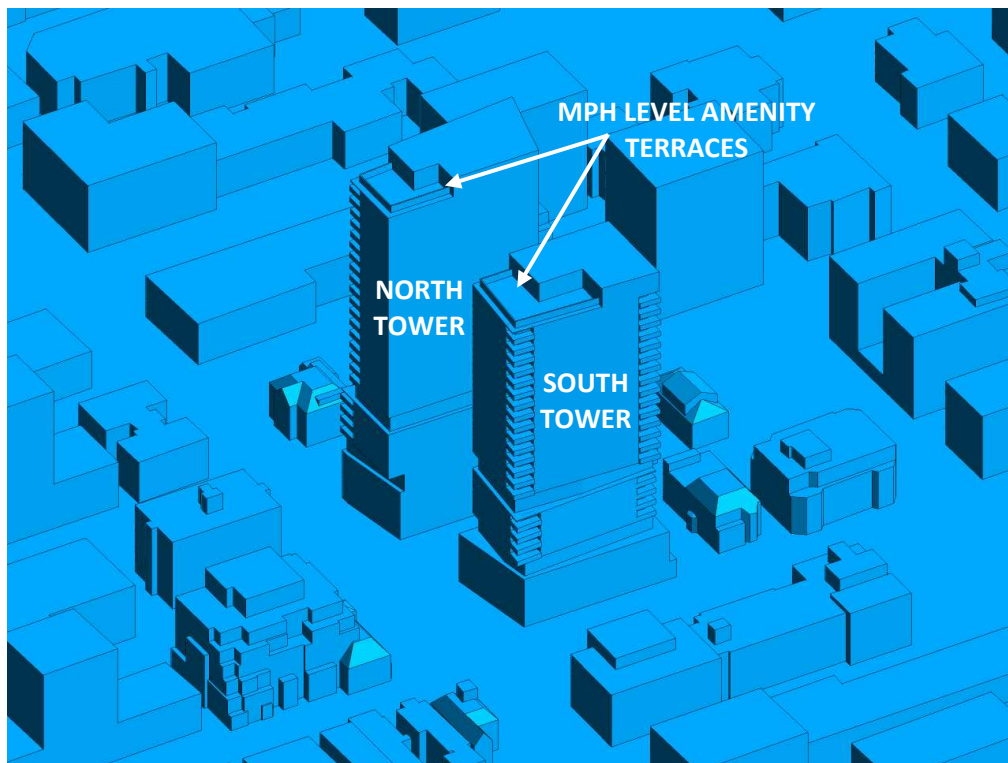


FIGURE 2F: CLOSE UP OF FIGURE 2E



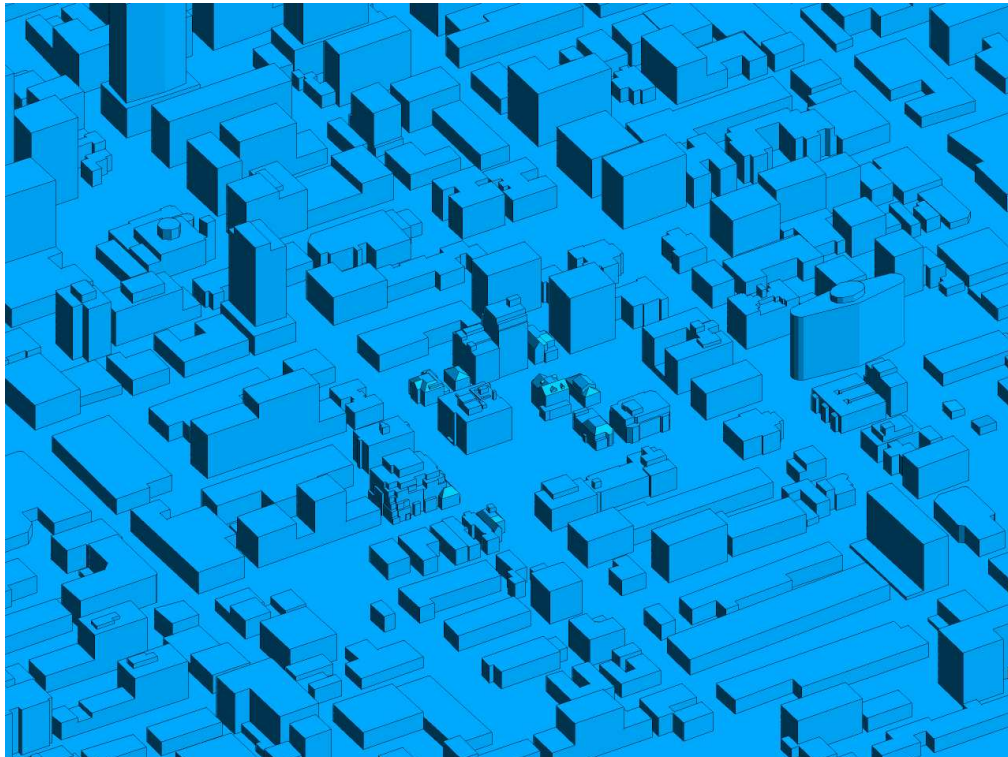


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

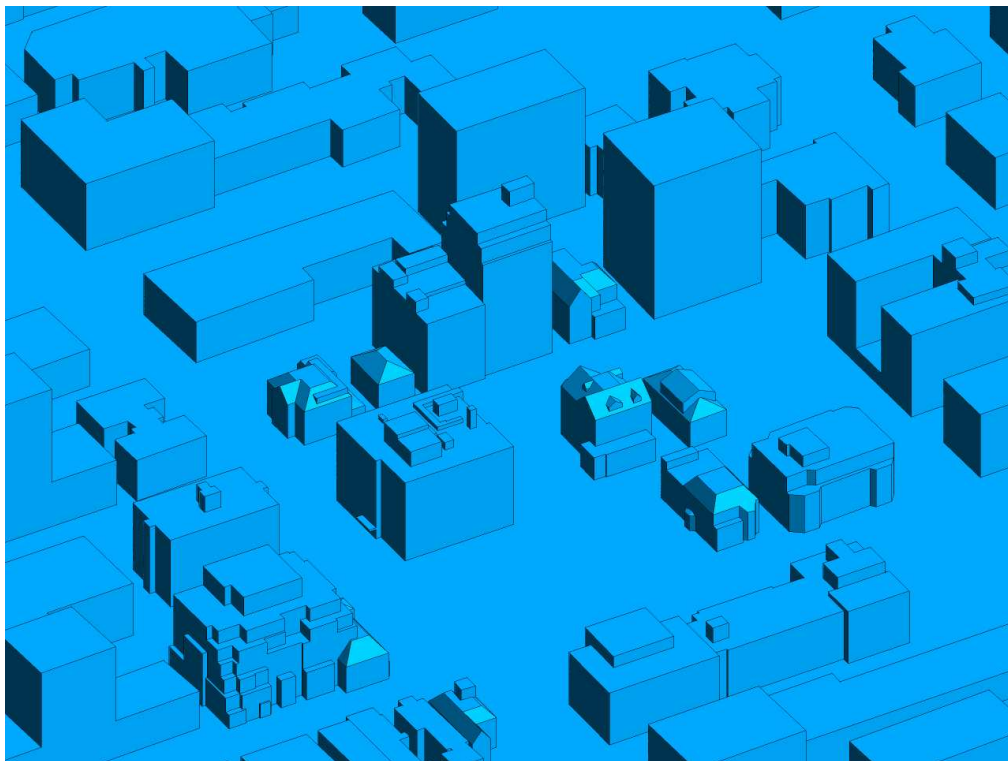


FIGURE 2H: CLOSE UP OF FIGURE 2G



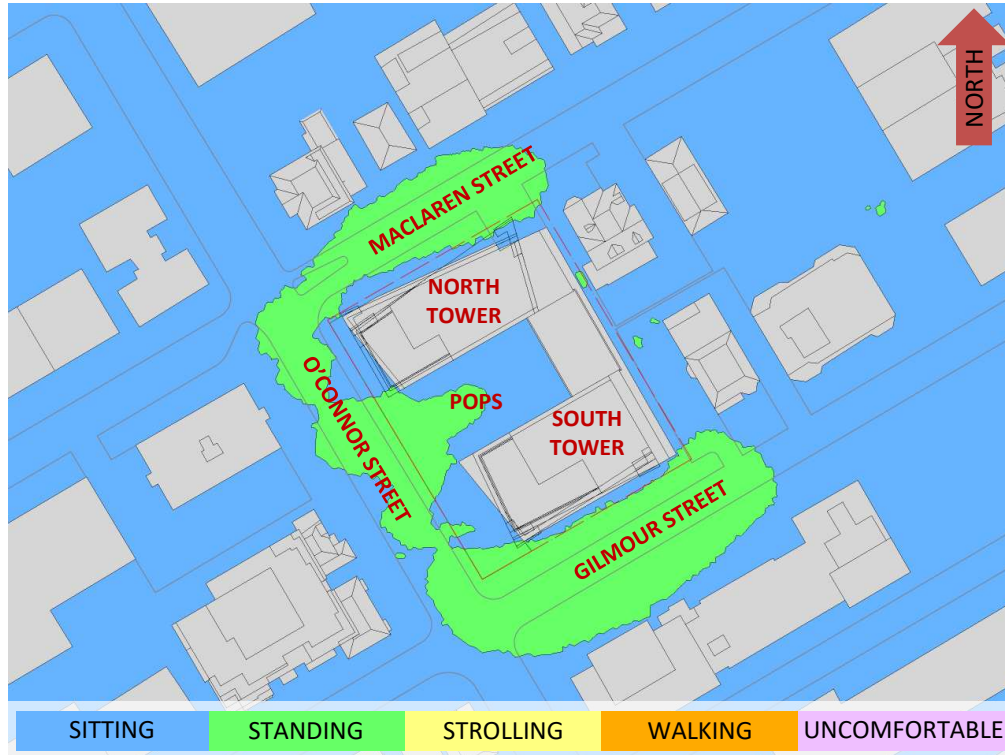


FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

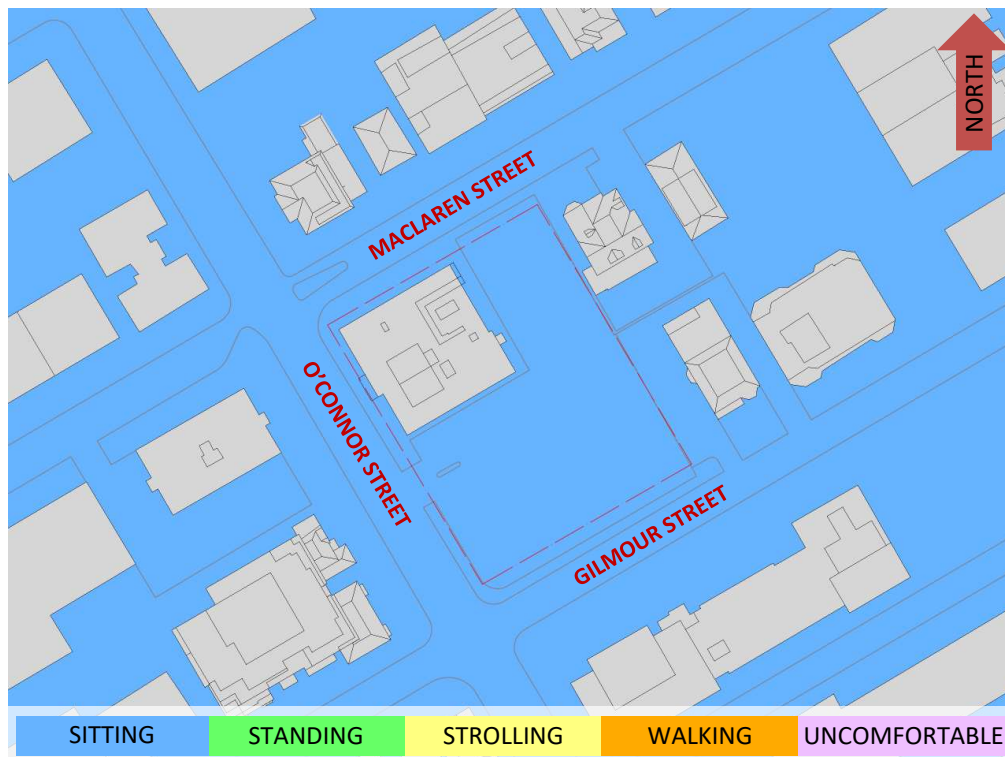


FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL– EXISTING MASSING



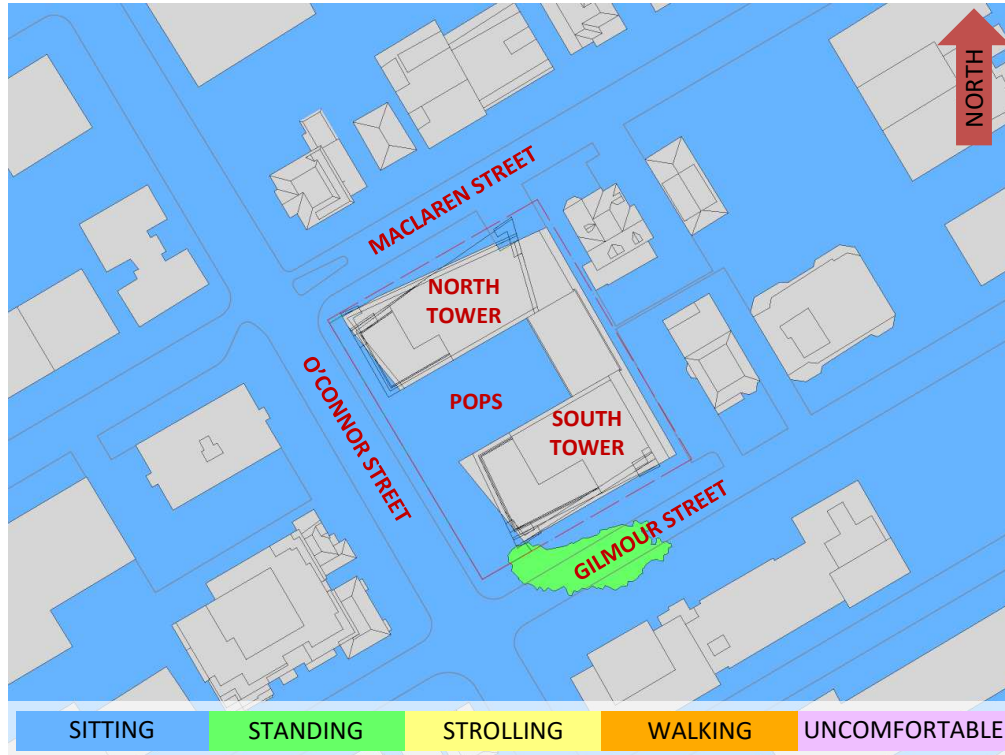


FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

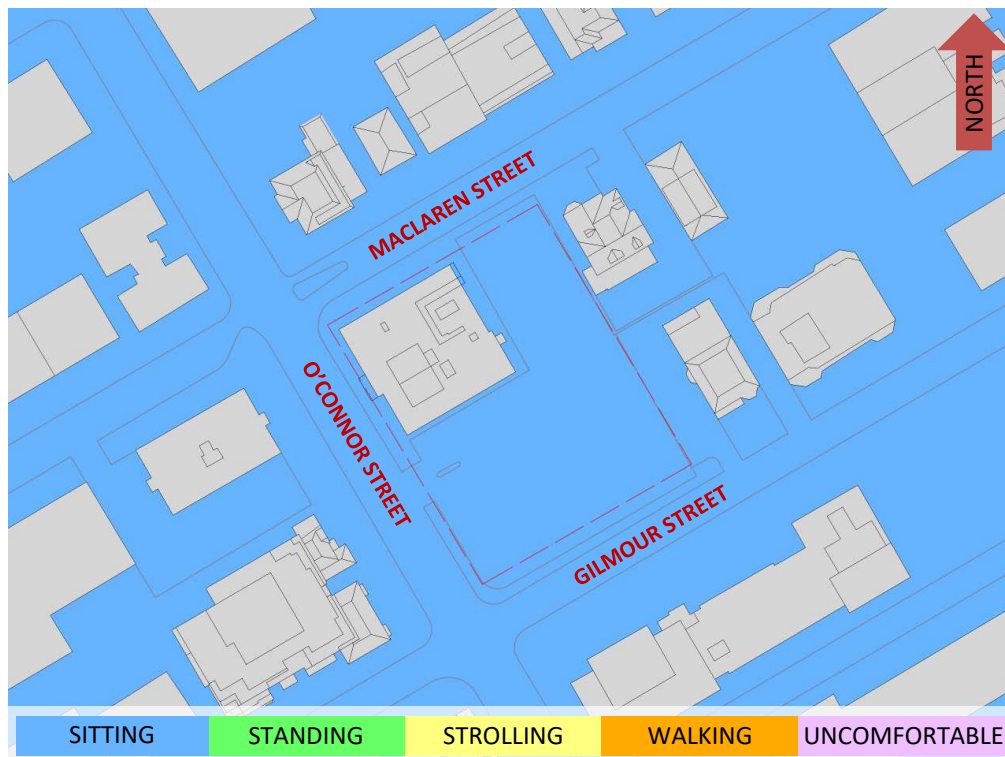


FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING



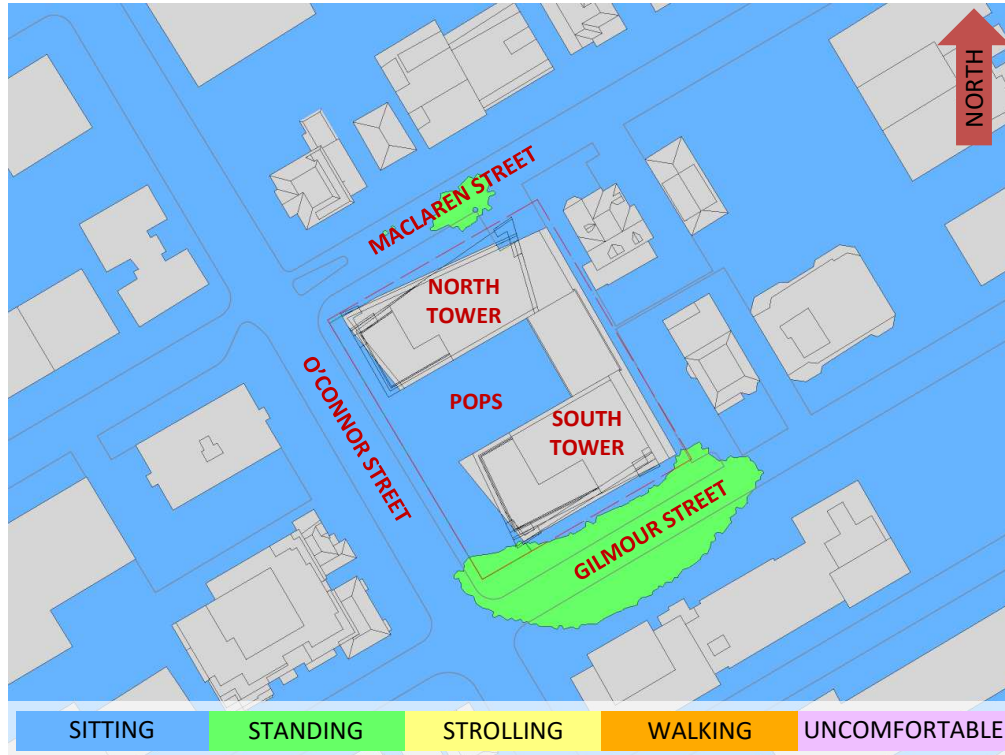


FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

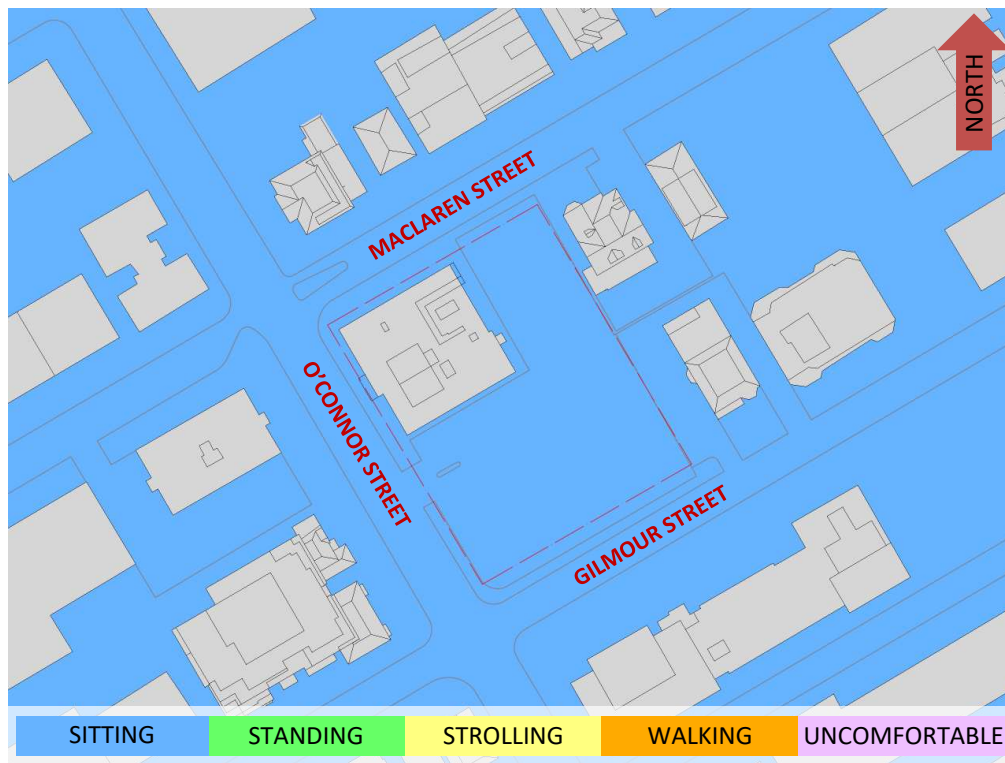


FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL– EXISTING MASSING



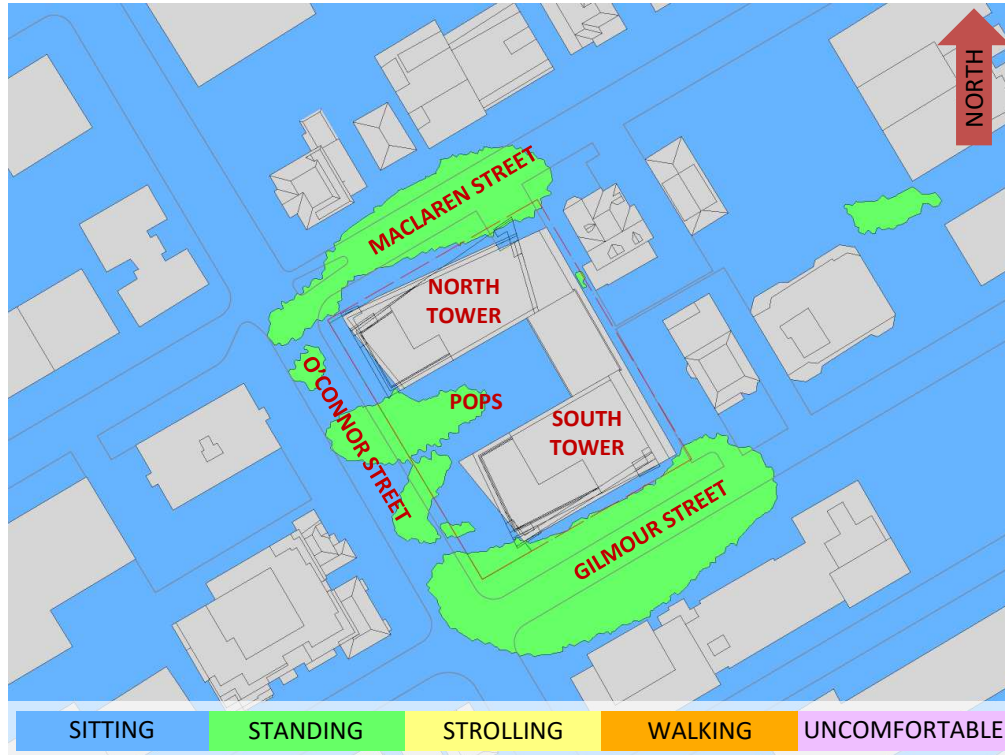


FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

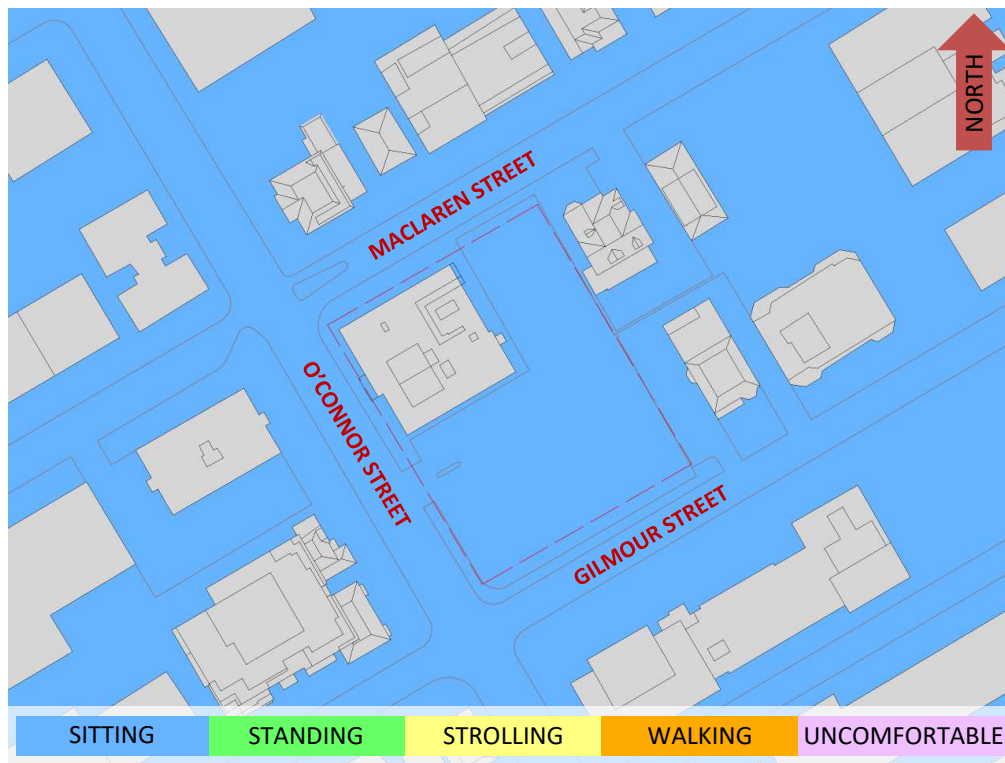


FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL- EXISTING MASSING



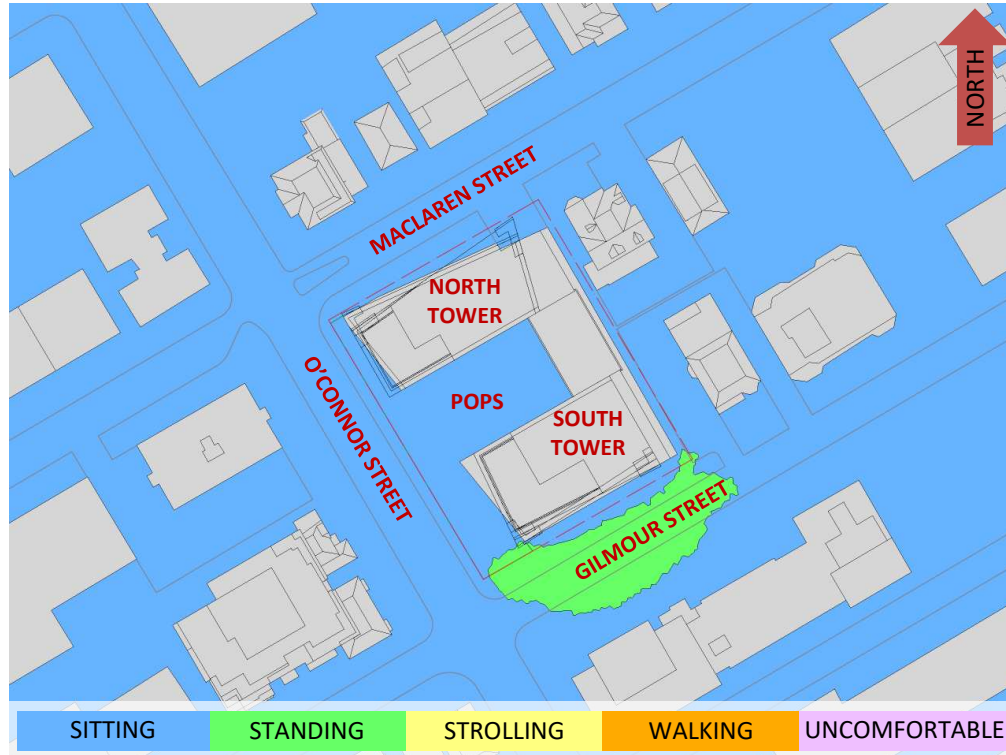


FIGURE 7: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING



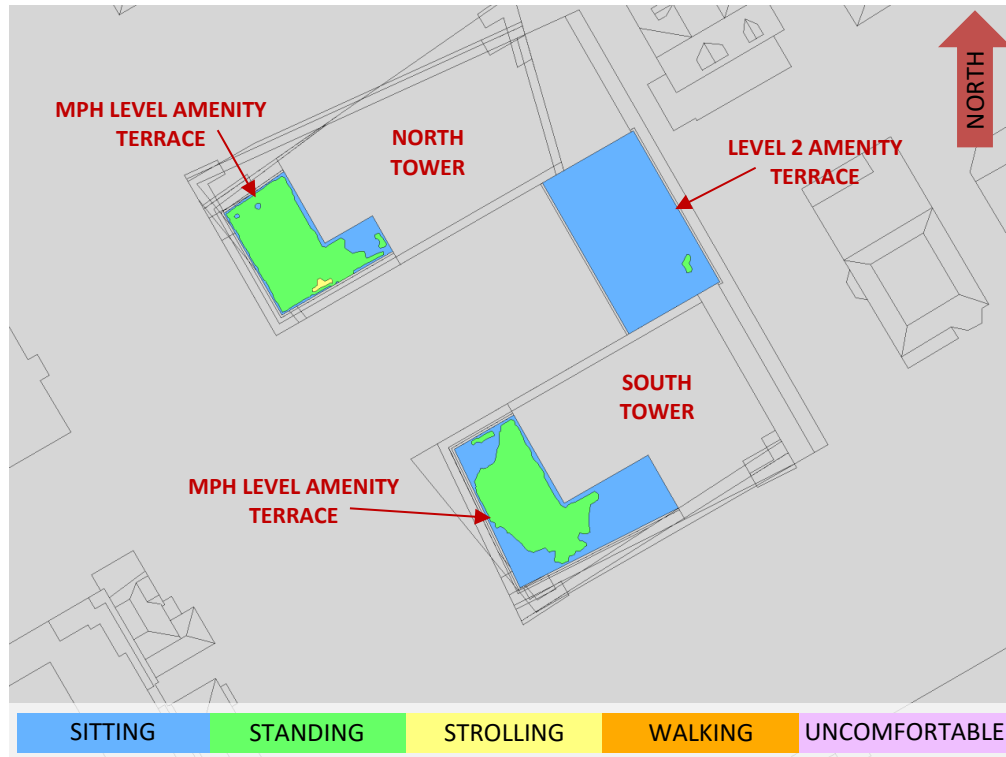


FIGURE 8A: SPRING – WIND COMFORT, COMMON AMENITY TERRACES

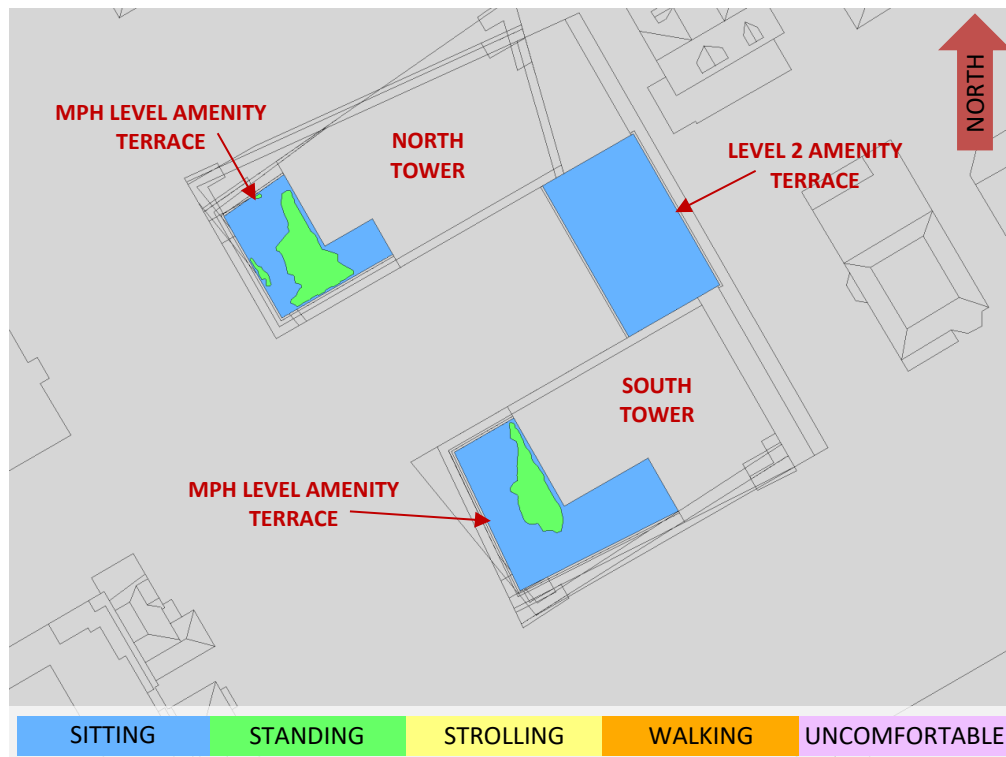


FIGURE 8B: SUMMER – WIND COMFORT, COMMON AMENITY TERRACES



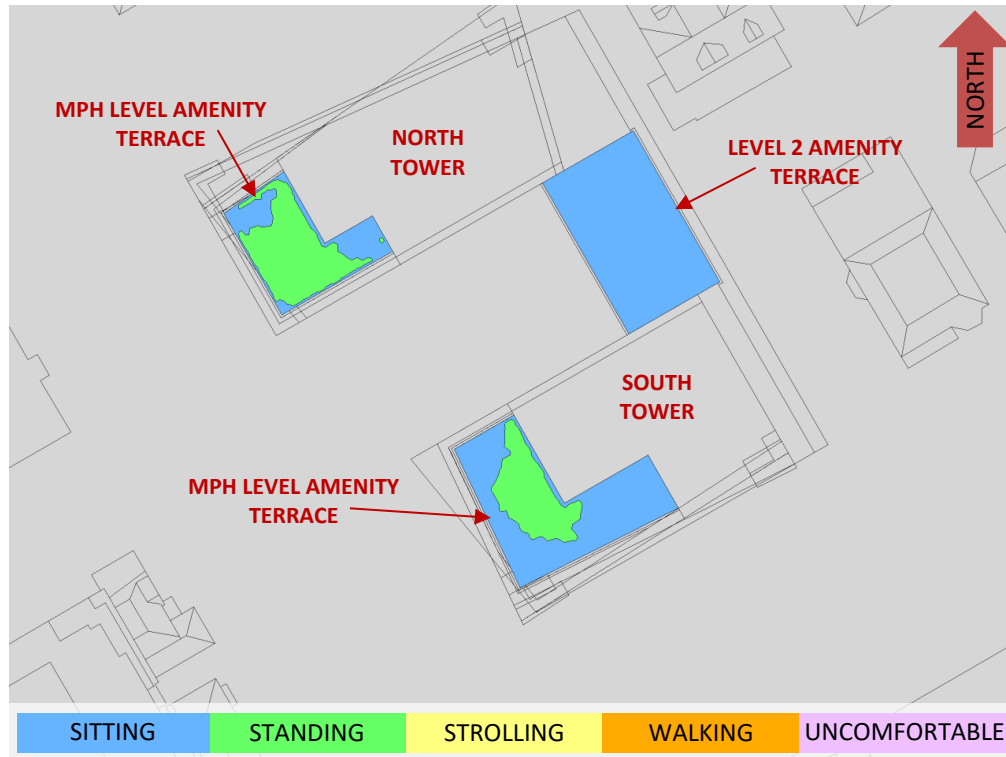


FIGURE 8C: AUTUMN – WIND COMFORT, COMMON AMENITY TERRACES

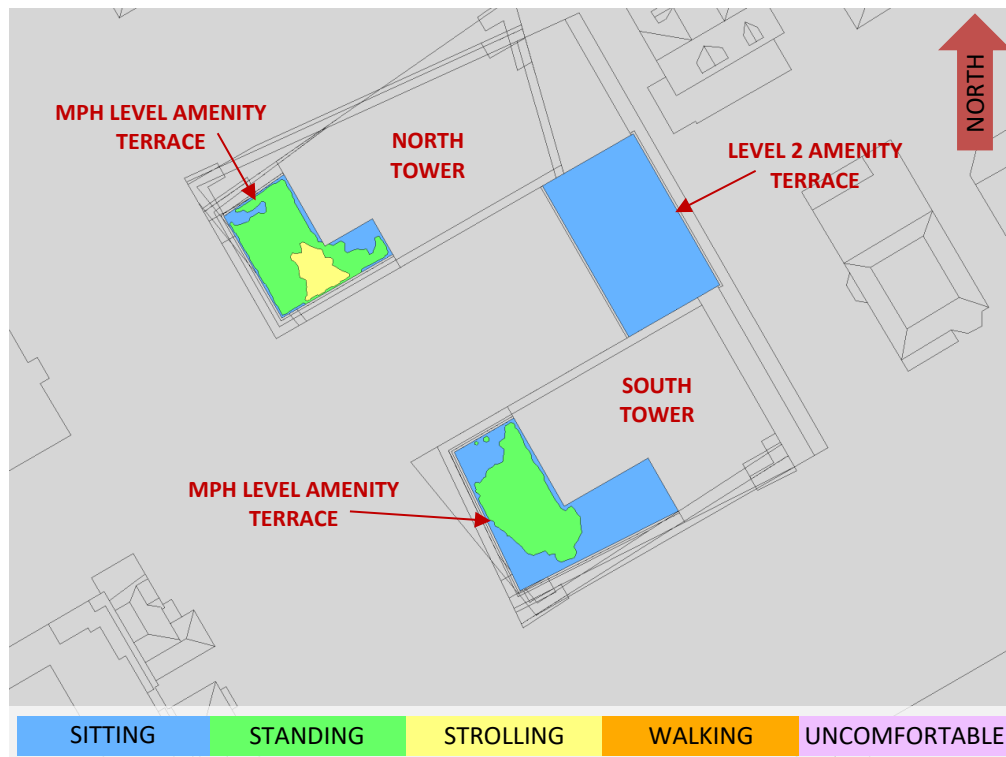


FIGURE 8D: WINTER – WIND COMFORT, COMMON AMENITY TERRACES



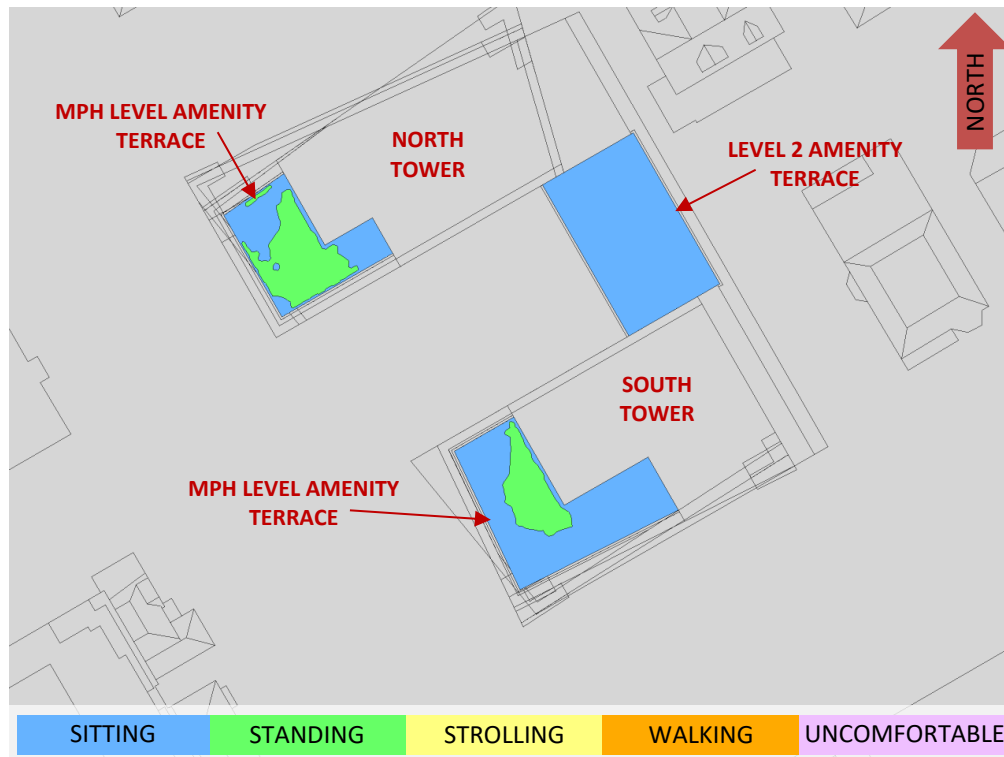


FIGURE 9: TYPICAL USE PERIOD, COMMON AMENITY TERRACES



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APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

The atmospheric boundary layer (ABL) is defined by the velocity and turbulence profiles according to industry standard practices. The mean wind profile can be represented, to a good approximation, by a power law relation, Equation (1), giving height above ground versus wind speed (1), (2).

$$U = U_g \left(\frac{Z}{Z_g} \right)^\alpha \quad \text{Equation (1)}$$

where, U = mean wind speed, U_g = gradient wind speed, Z = height above ground, Z_g = depth of the boundary layer (gradient height), and α is the power law exponent.

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 60% mean wind speed for Ottawa based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

Z_g is set to 540 m. The selection of gradient height is relatively unimportant, so long as it exceeds the building heights surrounding the subject site. The value has been selected to correspond to our physical wind tunnel reference value.

α is determined based on the upstream exposure of the far-field surroundings (that is, the area that it not captured within the simulation model).



Table 1 presents the values of α used in this study, while Table 2 presents several reference values of α . When the upstream exposure of the far-field surroundings is a mixture of multiple types of terrain, the α values are a weighted average with terrain that is closer to the subject site given greater weight.

TABLE 1: UPSTREAM EXPOSURE (ALPHA VALUE) VS TRUE WIND DIRECTION

Wind Direction (Degrees True)	Alpha Value (α)
0	0.29
22.5	0.28
45	0.27
67.5	0.26
90	0.25
112.5	0.25
135	0.25
157.5	0.25
180	0.25
202.5	0.24
225	0.25
247.5	0.25
270	0.26
292.5	0.31
315	0.30
337.5	0.30



TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

Upstream Exposure Type	Alpha Value (α)
Open Water	0.14-0.15
Open Field	0.16-0.19
Light Suburban	0.21-0.24
Heavy Suburban	0.24-0.27
Light Urban	0.28-0.30
Heavy Urban	0.31-0.33

The turbulence model in the computational fluid dynamics (CFD) simulations is a two-equation shear-stress transport (SST) model, and thus the ABL turbulence profile requires that two parameters be defined at the inlet of the domain. The turbulence profile is defined following the recommendations of the Architectural Institute of Japan for flat terrain (3).

$$I(Z) = \begin{cases} 0.1 \left(\frac{Z}{Z_g} \right)^{-\alpha-0.05}, & Z > 10 \text{ m} \\ 0.1 \left(\frac{10}{Z_g} \right)^{-\alpha-0.05}, & Z \leq 10 \text{ m} \end{cases} \quad \text{Equation (2)}$$

$$L_t(Z) = \begin{cases} 100 \text{ m} \sqrt{\frac{Z}{30}}, & Z > 30 \text{ m} \\ 100 \text{ m}, & Z \leq 30 \text{ m} \end{cases} \quad \text{Equation (3)}$$

where, I = turbulence intensity, L_t = turbulence length scale, Z = height above ground, and α is the power law exponent used for the velocity profile in Equation (1).

Boundary conditions on all other domain boundaries are defined as follows: the ground is a no-slip surface; the side walls of the domain have a symmetry boundary condition; the top of the domain has a specified shear, which maintains a constant wind speed at gradient height; and the outlet has a static pressure boundary condition.



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