

PEDESTRIAN LEVEL WIND STUDY

30 Cleary Avenue
Ottawa, Ontario

Report: 23-234-PLW



October 26, 2023

PREPARED FOR

Theia Partners

1554 Carling Avenue, Suite 55
Ottawa, ON K1Z 7M4

PREPARED BY

Sunny Kang, B.A.S., Project Coordinator
Omar Rioseco, B.Eng., Junior Wind Scientist
Justin Ferraro, P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment application requirements for the proposed multi-building development located at 30 Cleary Avenue 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 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) Most 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, existing surface parking, existing parking lots, existing walkways, laneway, surface parking, walkways, and in the vicinity of building access points, are considered acceptable. The area that is predicted to experience windy conditions is described as follows:
 - a. **Memorial Garden East of Subject Site.** During the typical use period, conditions within the above noted area are predicted to be suitable for standing, or better, following the introduction of the proposed development, while conditions are predicted to be suitable for sitting with the existing massing. The introduction of the proposed development produces windier conditions over the Memorial Garden to the east of the subject site.
- 2) Regarding the common amenity terraces serving Buildings A and B at their respective MPH Levels, wind conditions during the typical use period and recommendations regarding wind mitigation, where required, are described as follows:



- a. **Building A, MPH Level Amenity Terrace:** Conditions are predicted to be suitable mostly for sitting with regions suitable for standing near the northwest corner of the terrace and the northeast corner of the building.
 - b. **Building B, MPH Level Amenity Terrace:** Conditions are predicted to be suitable mostly for sitting with regions suitable for standing to the east and west of the terrace.
 - c. Depending on programming, the predicted wind conditions within the amenity terraces serving Buildings A and B at the MPH Level may be considered acceptable. Specifically, if the noted windier areas of the terraces will not include seating or lounging activities, the noted conditions may be considered acceptable.
 - d. If required by programming, wind comfort conditions may be improved within the MPH Level amenity terraces serving Buildings A and B by placing tall wind screens, in place of standard height guards, along their full perimeters, in combination with mitigation inboard of the terrace perimeters. This inboard mitigation could take the form of wind screens or clusters of coniferous trees located around sensitive areas, and canopies located above designated seating areas.
 - e. The extent of mitigation measures is dependent on the programming of the terraces. If necessary, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects for the future Site Plan Control application submission.
- 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.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Theia Partners to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application requirements for the proposed multi-building development located at 30 Cleary Avenue in Ottawa, Ontario (hereinafter referred to as “subject site” or “proposed development”). Our mandate within this study is to investigate wind conditions within and surrounding the subject site, and to identify areas where 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 Figurr Architects Collective in October 2023, 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 30 Cleary Avenue in Ottawa, situated approximately 180 metres (m) west of the intersection of Cleary Avenue and Richmond Road, on a nearly triangular parcel of land bounded by Cleary Avenue and the Memorial Garden to the east, a low-rise children’s centre to the south, and low-rise residential dwellings to the west. The proposed development comprises two nearly rectangular residential buildings: Building A (16 storeys) to the south and Building B (6 storeys) to the north of the subject site. Both buildings are topped with a mechanical penthouse (MPH) and share two below-grade parking levels.

The ground floor of Building A includes an indoor amenity to the north, a main entrance and shared building support spaces at the northeast corner, and residential units throughout the remainder of the level. Levels 2-16 are reserved for residential occupancy. The building steps back from all elevations at Level 5 and to the west at Level 16. The MPH Level includes an indoor amenity at the northwest corner, a fitness room at the northeast corner, and mechanical space to the south. The building steps back from the north elevation at the MPH Level to accommodate an amenity terrace.



The ground floor of Building B includes a main entrance at the southeast corner, residential units along the west elevation, an indoor amenity at the northeast corner, a bike room to the east, and shared building support spaces throughout the remainder of the level. Levels 2-6 are reserved for residential occupancy. The building extends from the east and south elevations at Level 2. The MPH Level includes an indoor amenity to the north and mechanical space to the south. The building steps back from the north and west elevations at the MPH Level to accommodate an amenity terrace.

The near-field surroundings, defined as an area within 200 m of the subject site, include low-rise residential buildings from the southeast clockwise to the northwest, a low-rise community building to the north, isolated mid-rise buildings to the east and southeast, a high-rise building to the east, a low-rise children's centre to the south, and high-rise buildings to the south-southwest. Notably, a 9-storey mixed-use residential building is approved at 797 Richmond Road, approximately 100 m to the southeast, and a 24-storey mixed-use residential building is approved at 809 Richmond Road, approximately 60 m to the south of the proposed development. The Ottawa River flows from the west to the northeast approximately 250 m to the north of the proposed development. 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 low-rise suburban massing from the northeast clockwise to the southwest with isolated mid- and high-rise buildings to the northeast and from the southeast clockwise to the southwest.

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 future developments 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 criteria¹. 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.

¹ City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/default/files/torwindanalysis_en.pdf

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 12 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.

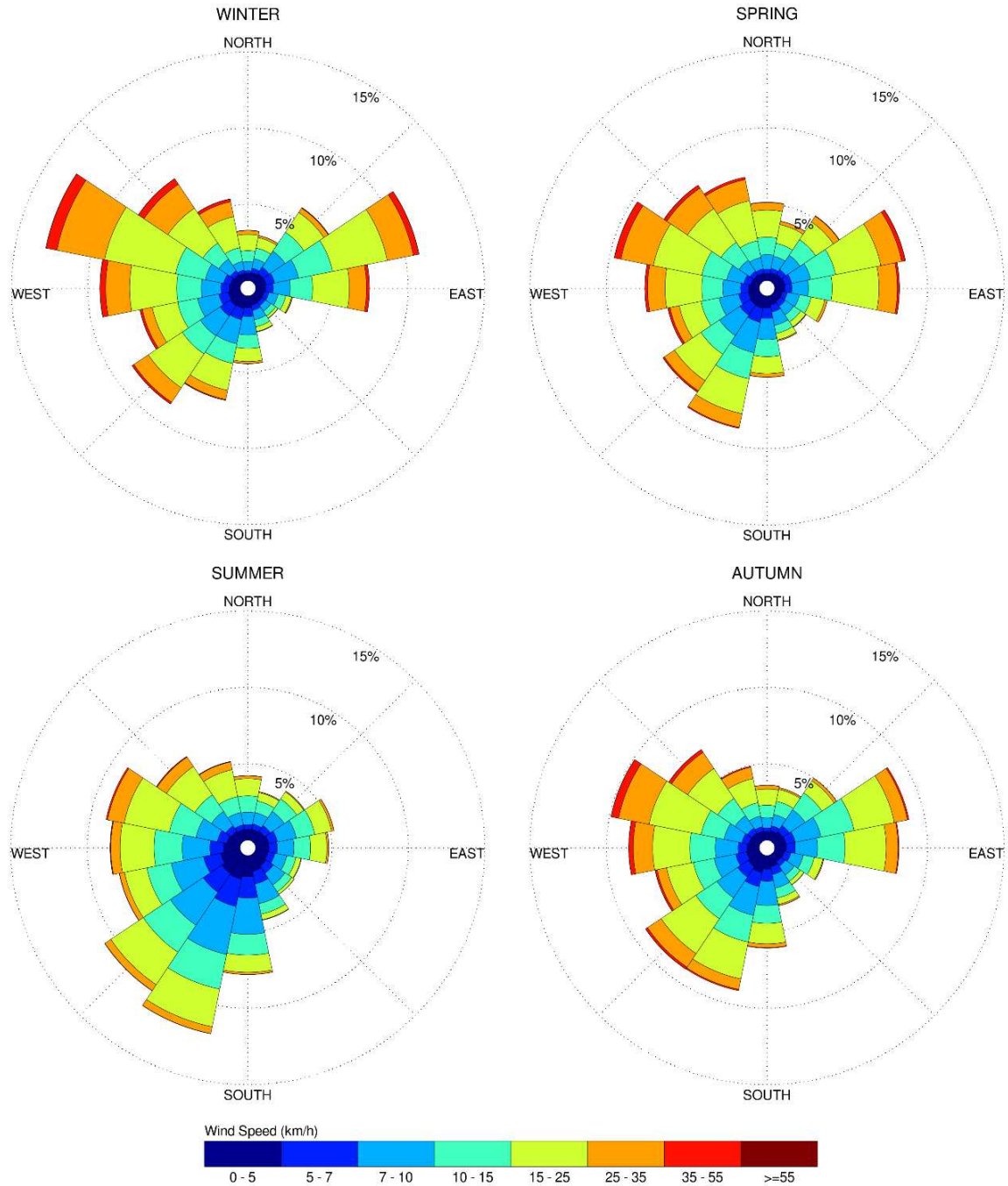
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and over the common amenities serving the proposed development 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 for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns.

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	GEM 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	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, illustrating wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 8A-8D, which illustrate conditions over the common amenity terraces serving Buildings A and B 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 7A-7B and 9 illustrate comfort conditions at grade level and over the MPH Level common amenity terraces serving Buildings A and B, respectively, consistent with the comfort classes 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 and Surface Parking along Cleary Avenue: Following the introduction of the proposed development, wind comfort conditions over the nearby public sidewalks along Cleary Avenue are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. Conditions over the surface parking along Cleary Avenue are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the sidewalks and surface parking along Cleary Avenue with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. While the introduction of the proposed development produces windier conditions along Cleary Avenue, wind conditions with the proposed development are nevertheless considered acceptable.

Memorial Garden East of Subject Site: Following the introduction of the proposed development, conditions over the Memorial Garden to the east of the subject site are predicted to be suitable for standing, or better, during the typical use period. Conditions over the Memorial Garden with the existing massing are predicted to be suitable for sitting during the typical use period. The introduction of the proposed development produces windier conditions over the Memorial Garden.

Existing Parking Lots East of Subject Site: Following the introduction of the proposed development, conditions over the existing parking lot to the east of the subject site serving the First Unitarian Congregation of Ottawa are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year, with an isolated region predicted to be suitable for strolling during the winter. Conditions over the existing parking lot to the east of the subject site serving the Unitarian House of Ottawa are predicted to be suitable for sitting during the summer and autumn, becoming suitable for standing, or better, during the winter and spring. The noted conditions are considered acceptable.

Wind conditions over the noted parking lots with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for standing, or better, during the winter and spring. While the introduction of the proposed development produces slightly windier conditions over the



existing parking lots to the east, wind conditions with the proposed development are nevertheless considered acceptable.

Existing Parking Lot Southeast of Subject Site: Following the introduction of the proposed development, conditions over the existing parking lot to the southeast of the subject site are predicted to be suitable for sitting during the summer, becoming suitable for standing throughout the remainder of the year. The noted conditions are considered acceptable.

Wind conditions over the noted parking lot with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing throughout the remainder of the year, with an isolated region suitable for strolling at the southwest corner of the parking lot. Notably, the introduction of the proposed development is predicted to improve wind comfort conditions within the parking lot during the winter season, and wind comfort conditions with the proposed development are considered acceptable.

Existing Walkways South of Subject Site: Following the introduction of the proposed development, conditions over the existing walkways serving the low-rise children's centre to the south of the subject site are predicted to be suitable for standing, or better, during the summer, becoming suitable for strolling, or better, throughout the remainder of the year, with a small, isolated region predicted to be suitable for walking during the winter. The noted conditions are considered acceptable.

Wind conditions over the noted walkways with the existing massing are predicted to be suitable for sitting during throughout the year, with small, isolated regions predicted to be suitable for standing during the spring, autumn, and winter. While the introduction of the proposed development produces windier conditions along the walkways to the south, wind conditions with the proposed development are nevertheless considered acceptable.

Proposed Laneway, Surface Parking, and Walkways within Subject Site: Conditions over the laneway extending from Cleary Avenue are predicted to be suitable for standing, or better, during the summer, becoming suitable for strolling, or better, during the autumn, and suitable for a mix of standing and strolling during the winter and spring. Conditions over the surface parking to the east of Building A are predicted to be suitable mostly for sitting during the summer, becoming suitable for standing during the autumn, suitable for a mix of standing and strolling during the spring, and suitable for strolling during the



winter. Conditions over the surface parking to the southeast of Building A are predicted to be suitable for standing, or better, during the summer, becoming suitable for standing during the autumn, and suitable for a mix of standing and strolling during the winter and spring. Conditions over the walkways within the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for strolling, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

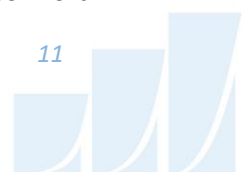
Building Access Points: Wind comfort conditions in the vicinity of all building access points serving Buildings A and B are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable.

5.2 Wind Comfort Conditions – MPH Level Common Amenity Terraces

Wind comfort conditions during the typical use period within the common amenity terraces serving Buildings A and B at their respective MPH Levels and recommendations regarding mitigation are provided as follows:

Building A, MPH Level Amenity Terrace: Conditions over the common amenity terrace serving Building A at the MPH Level are predicted to be suitable mostly for sitting with regions predicted to be suitable for standing near the northwest corner of the terrace and the northeast corner of the building, as illustrated in Figure 9. The areas that are predicted to be suitable for standing are also predicted to be suitable for sitting for at least 73% near the northwest corner of the terrace and 78% of the time to the north of the terrace and near the northeast corner of the building during the typical use period, where the target is 80% to achieve the sitting comfort criterion. Depending on programming, the predicted wind conditions within the amenity terrace serving Building A at the MPH Level may be considered acceptable. Specifically, if the noted windier areas will not include seating or lounging activities, the noted conditions may be considered acceptable.

Building B, MPH Level Amenity Terrace: Conditions over the common amenity terrace serving Building B at the MPH Level are predicted to be suitable mostly for sitting with regions suitable for standing to the east and west of the terrace, as illustrated in Figure 9. The areas that are predicted to be suitable for standing are also predicted to be suitable for sitting for at least 73% of the time to the east and 71% of the time to the west during the typical use period, where the target is 80% to achieve the sitting comfort



criterion. Depending on programming, the predicted wind conditions within the amenity terrace serving Building B at the MPH Level may be considered acceptable. Specifically, if the noted windier areas will not include seating or lounging activities, the noted conditions may be considered acceptable.

If required by programming, wind comfort conditions may be improved within the MPH Level amenity terraces serving Buildings A and B by placing tall wind screens, in place of standard height guards, along their full perimeters, in combination with mitigation inboard of the terrace perimeters. This inboard mitigation could take the form of wind screens or clusters of coniferous trees located around sensitive areas, and canopies located above designated seating areas.

The extent of mitigation measures is dependent on the programming of the terraces. If necessary, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects for the future Site Plan Control application submission.

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) Most 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, existing surface parking, existing parking lots, existing walkways, laneway, surface parking, walkways, and in the vicinity of building access points, are considered acceptable. The area that is predicted to experience windy conditions is described as follows:
 - a. **Memorial Garden East of Subject Site.** During the typical use period, conditions within the above noted area are predicted to be suitable for standing, or better, following the introduction of the proposed development, while conditions are predicted to be suitable for sitting with the existing massing. The introduction of the proposed development produces windier conditions over the Memorial Garden to the east of the subject site.
- 2) Regarding the common amenity terraces serving Buildings A and B at their respective MPH Levels, wind conditions during the typical use period and recommendations regarding wind mitigation, where required, are described as follows:
 - a. **Building A, MPH Level Amenity Terrace:** Conditions are predicted to be suitable mostly for sitting with regions suitable for standing near the northwest corner of the terrace and the northeast corner of the building.
 - b. **Building B, MPH Level Amenity Terrace:** Conditions are predicted to be suitable mostly for sitting with regions suitable for standing to the east and west of the terrace.
 - c. Depending on programming, the predicted wind conditions within the amenity terraces serving Buildings A and B at the MPH Level may be considered acceptable. Specifically, if the noted windier areas of the terraces will not include seating or lounging activities, the noted conditions may be considered acceptable.



- d. If required by programming, wind comfort conditions may be improved within the MPH Level amenity terraces serving Buildings A and B by placing tall wind screens, in place of standard height guards, along their full perimeters, in combination with mitigation inboard of the terrace perimeters. This inboard mitigation could take the form of wind screens or clusters of coniferous trees located around sensitive areas, and canopies located above designated seating areas.
 - e. The extent of mitigation measures is dependent on the programming of the terraces. If necessary, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects for the future Site Plan Control application submission.
- 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,

Gradient Wind Engineering Inc.



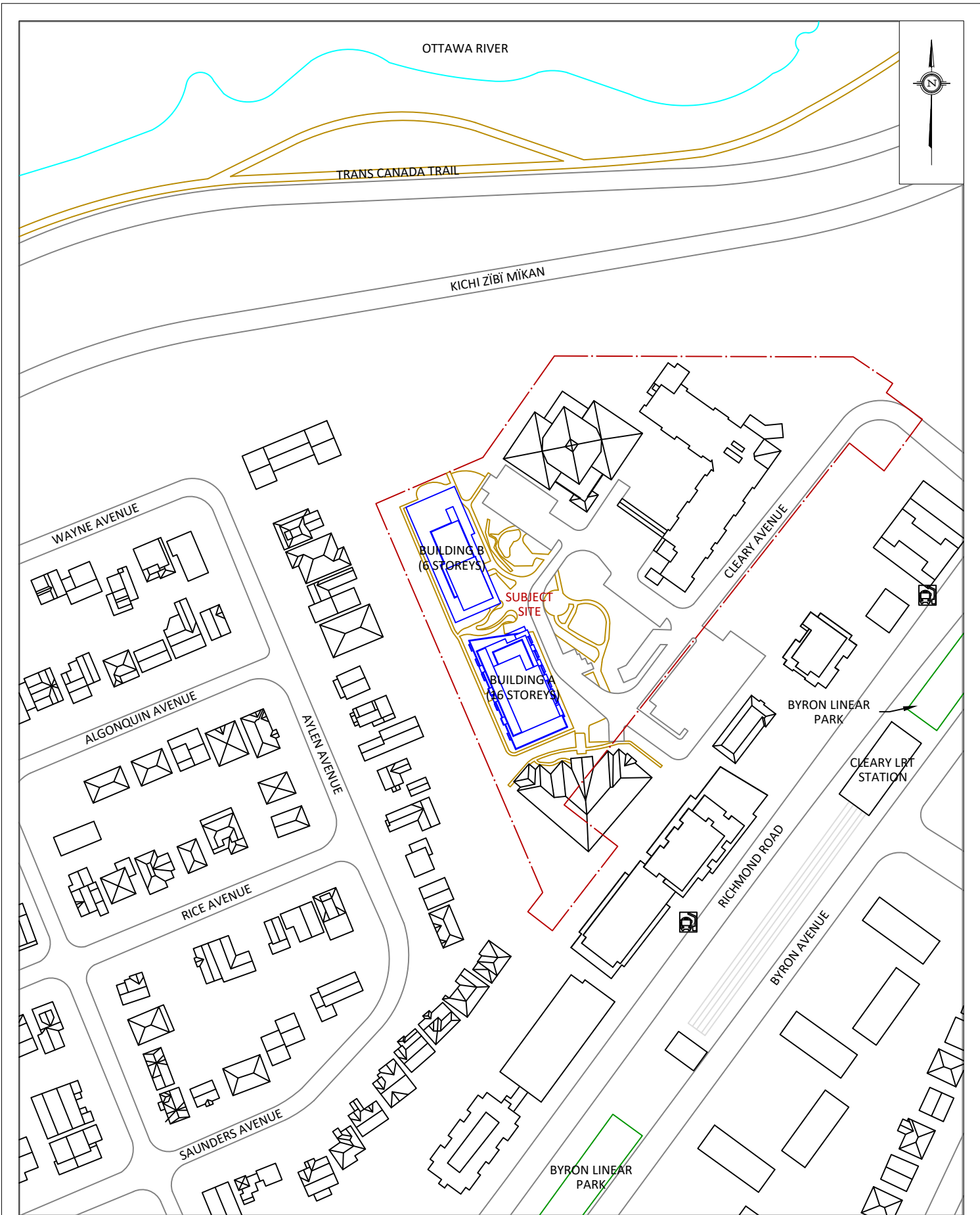
Omar Rioseco, B.Eng.
Junior Wind Scientist



Sunny Kang, B.A.S.
Project Coordinator



Justin Ferraro, P.Eng.
Principal



GRADIENTWIND

ENGINEERS & SCIENTISTS

127 WALGREEN ROAD, OTTAWA, ON
613 836 0934 • GRADIENTWIND.COM

PROJECT

30 CLEARY AVENUE, OTTAWA
PEDESTRIAN LEVEL WIND STUDY

SCALE

1:2000

DRAWING NO.

23-234-PLW-1A

DATE

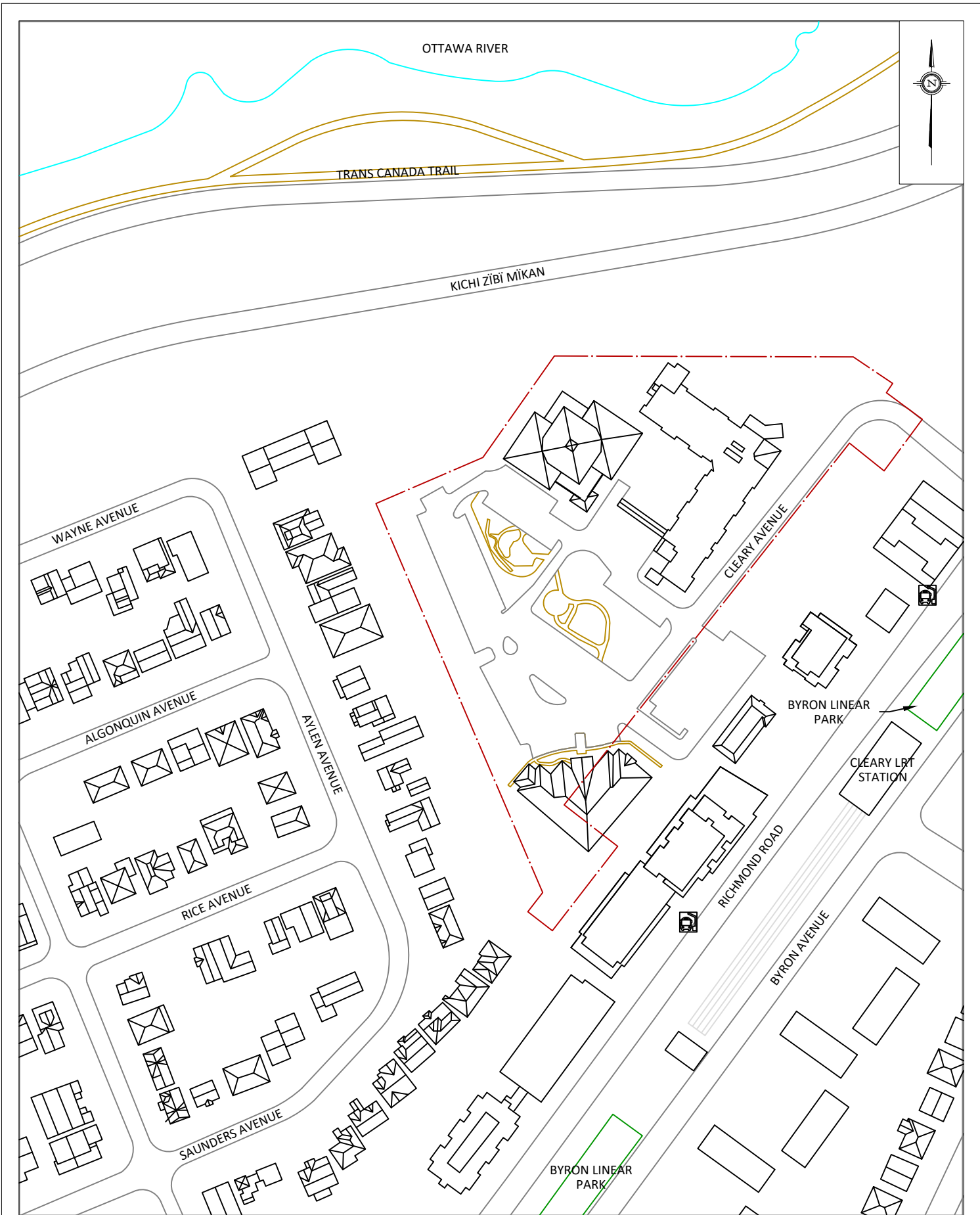
OCTOBER 23, 2023

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S.K.

DESCRIPTION

FIGURE 1A:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT



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23-234-PLW-1B

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DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT



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

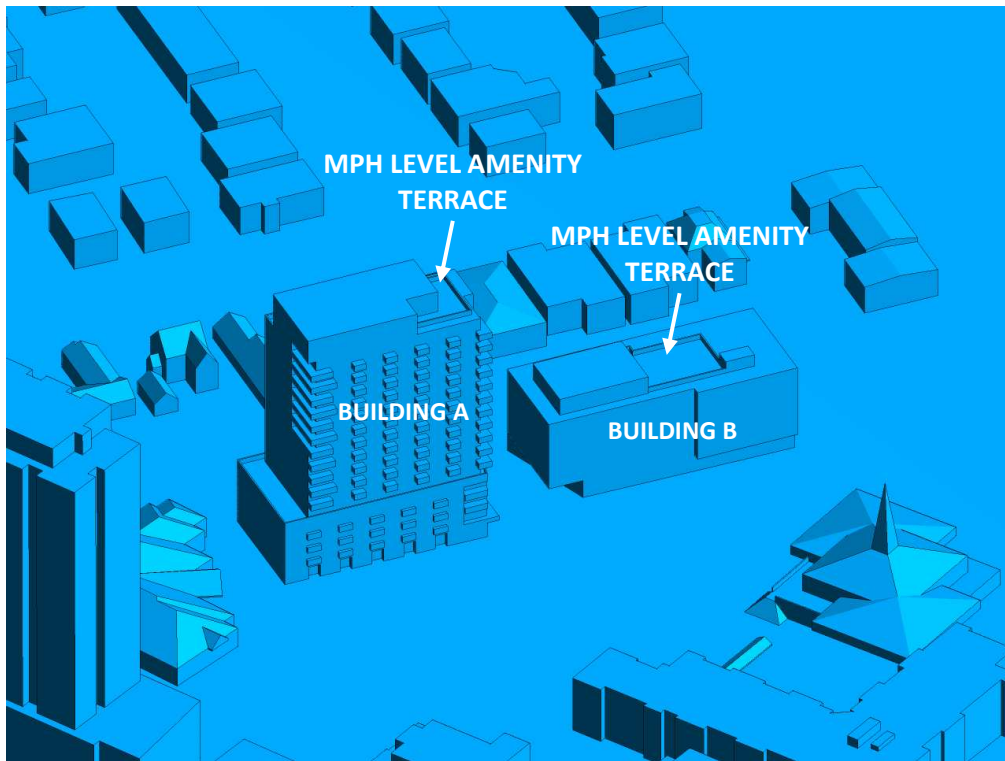


FIGURE 2B: CLOSE UP OF FIGURE 2A

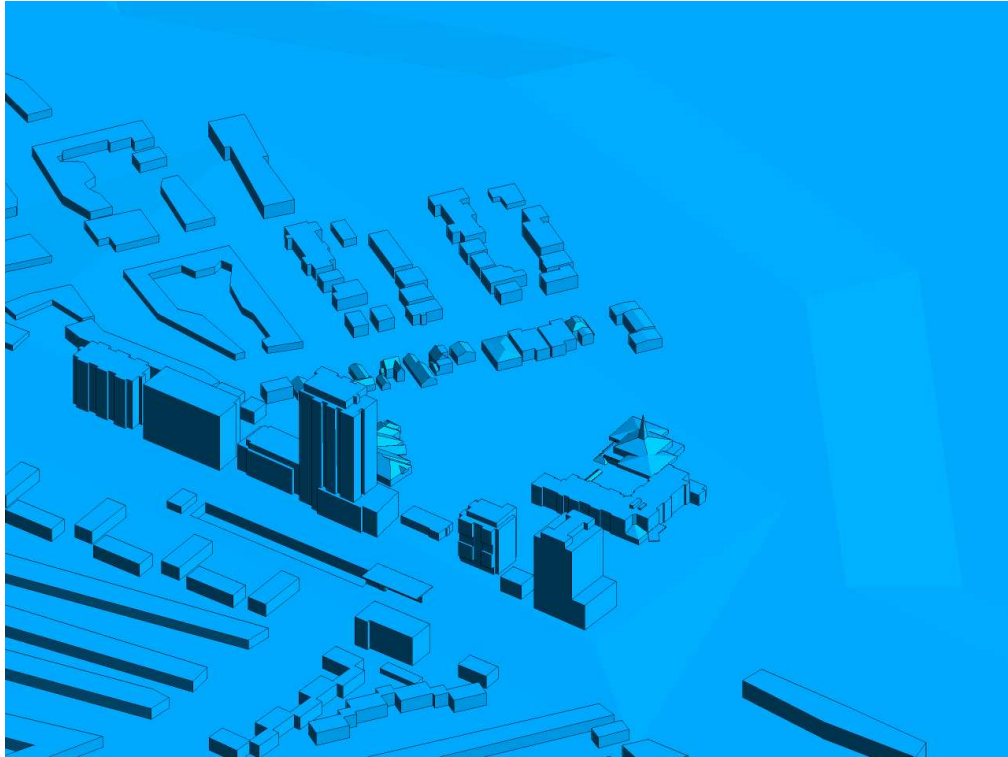


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, EAST PERSPECTIVE

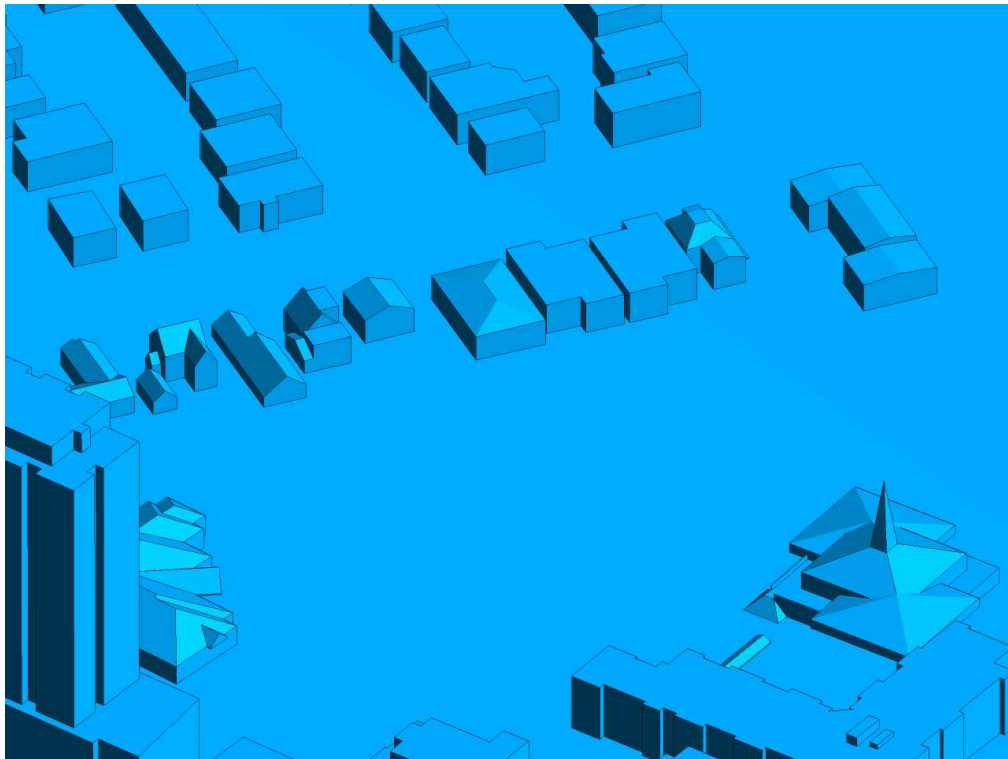


FIGURE 2D: CLOSE UP OF FIGURE 2C



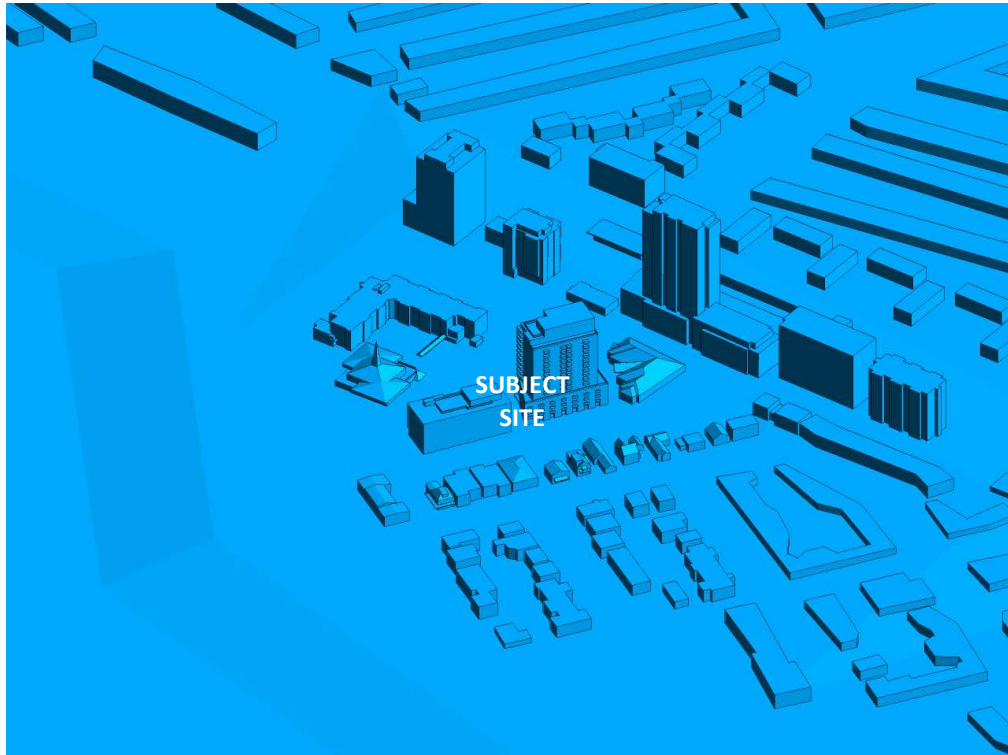


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, WEST PERSPECTIVE

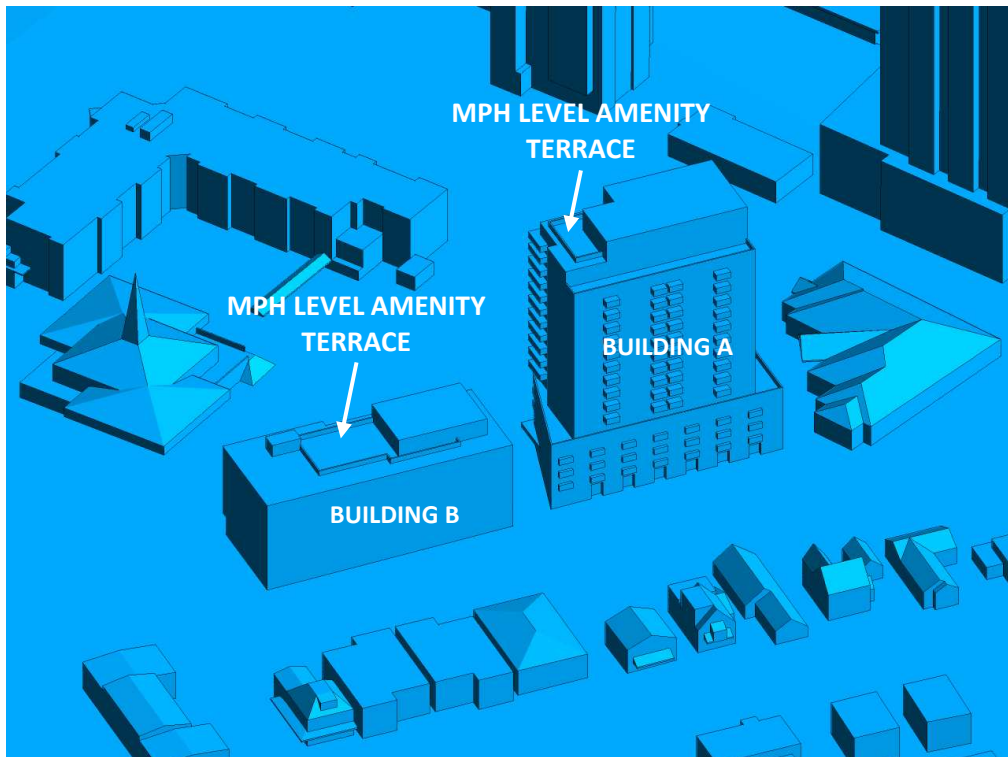


FIGURE 2F: CLOSE UP OF FIGURE 2E

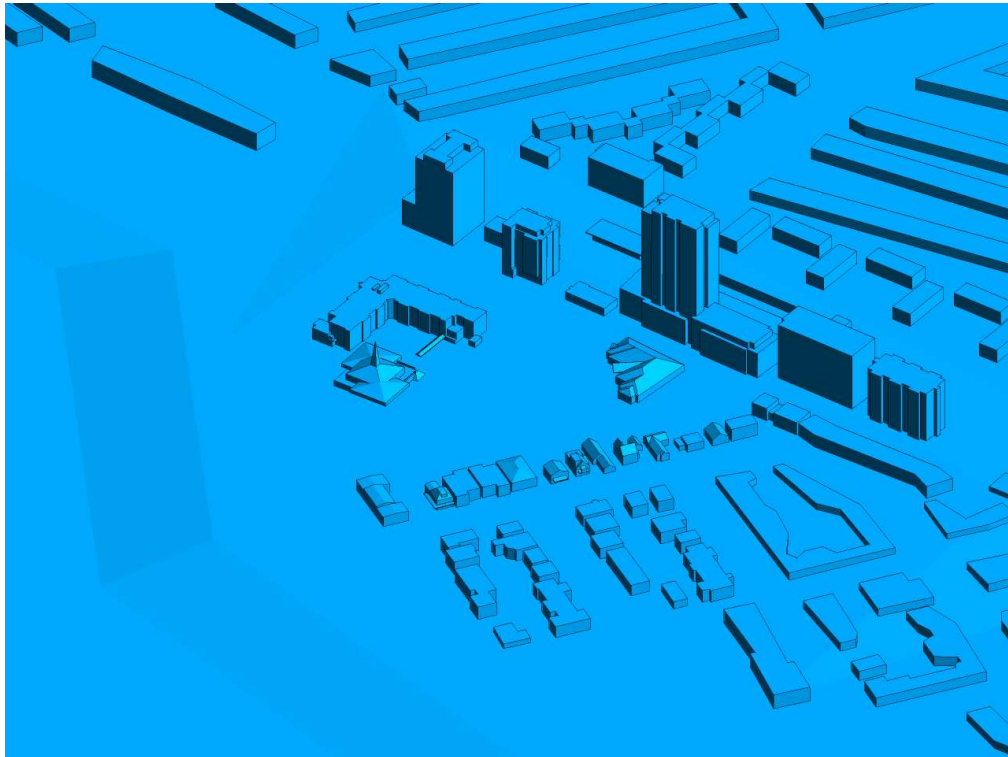


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, WEST PERSPECTIVE

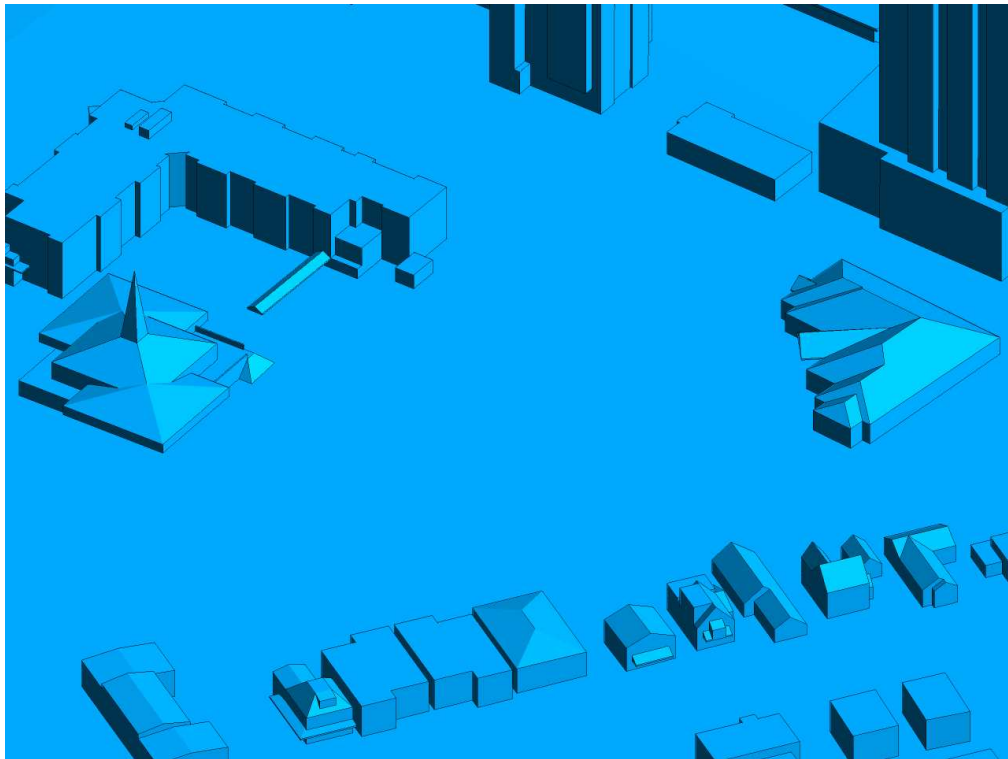


FIGURE 2H: CLOSE UP OF FIGURE 2G



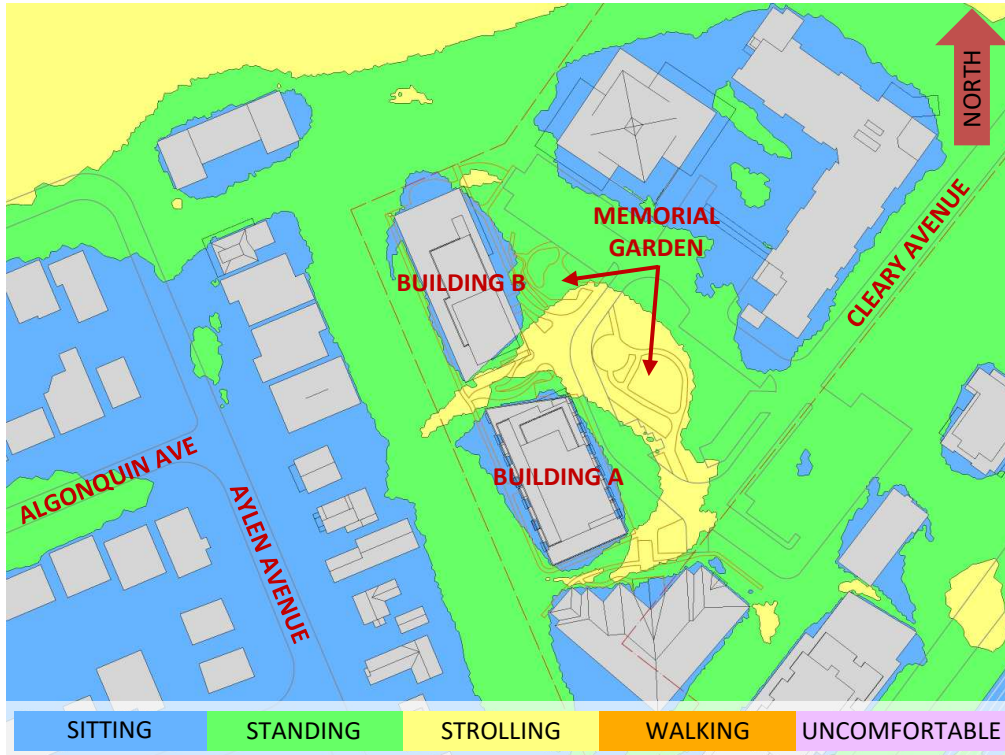


FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

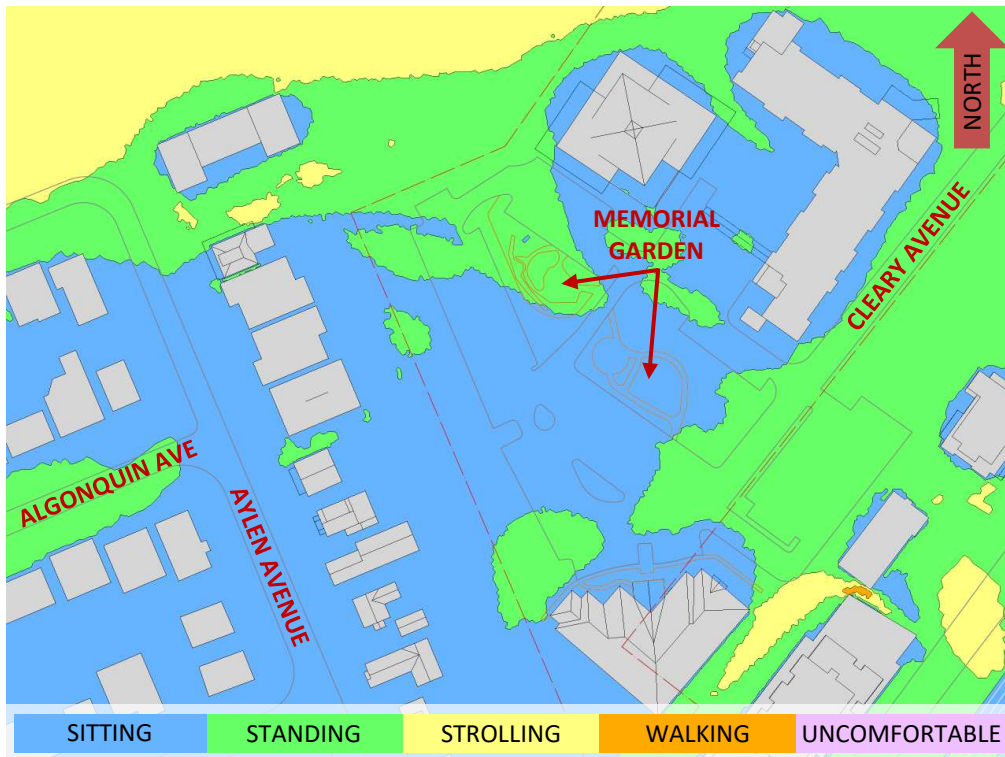


FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL – EXISTING MASSING



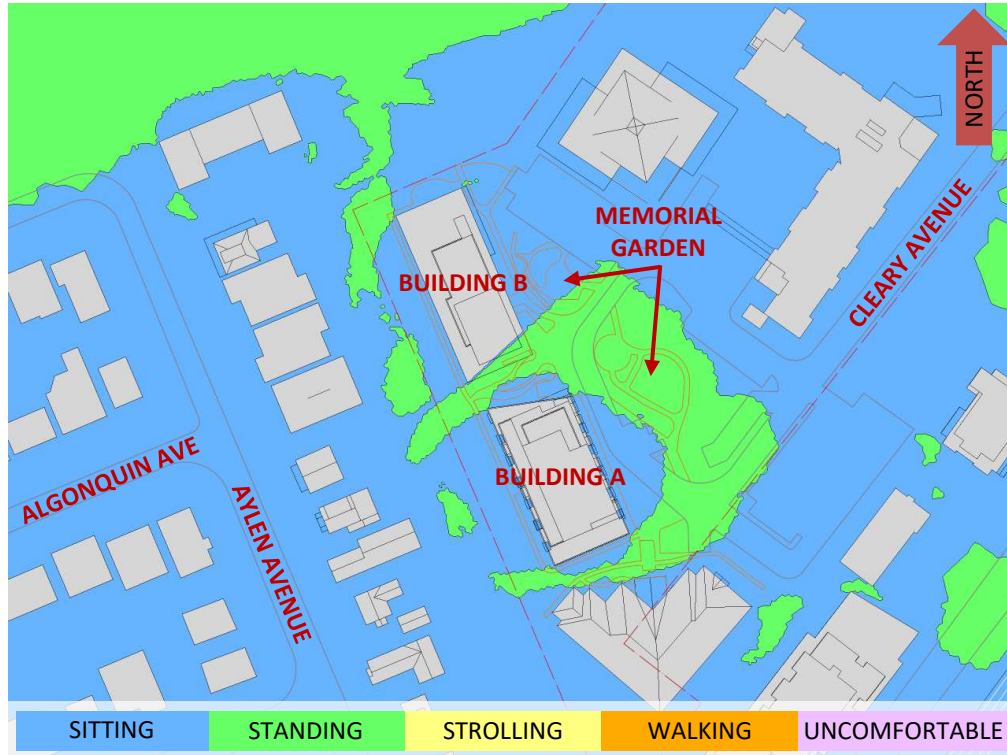


FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

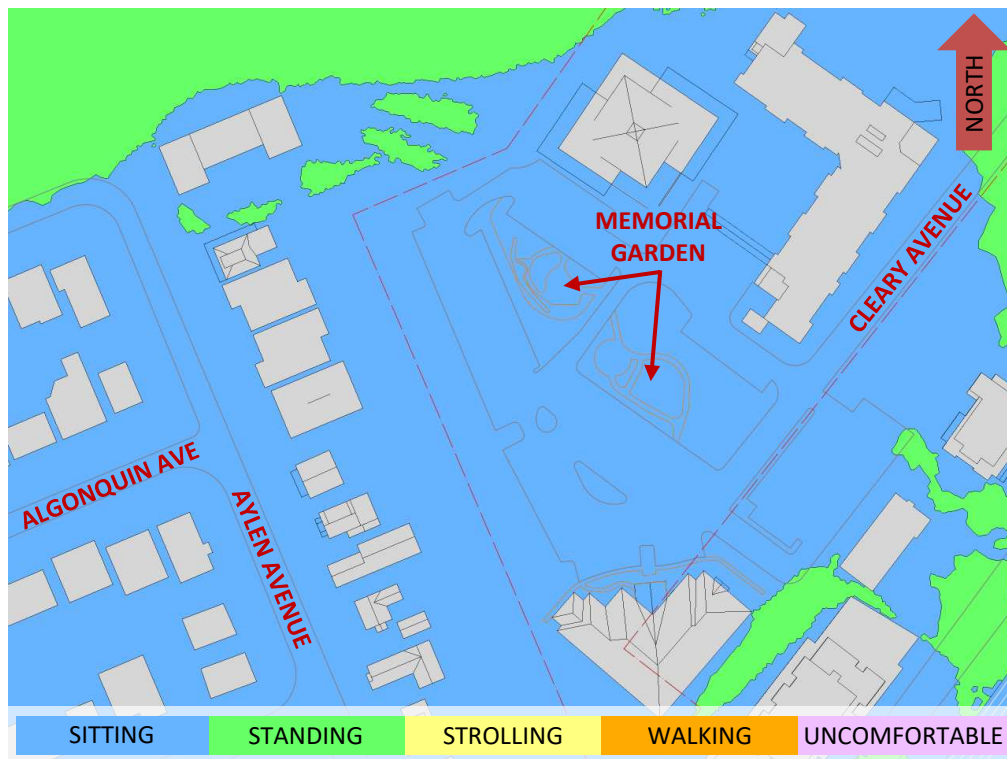


FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING



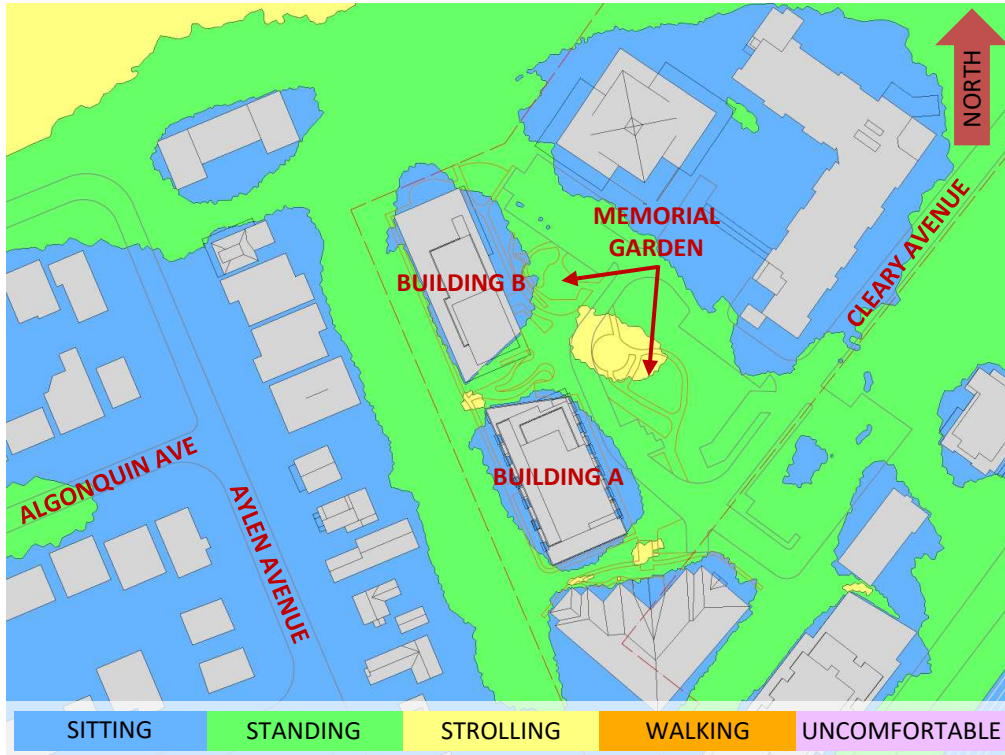


FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

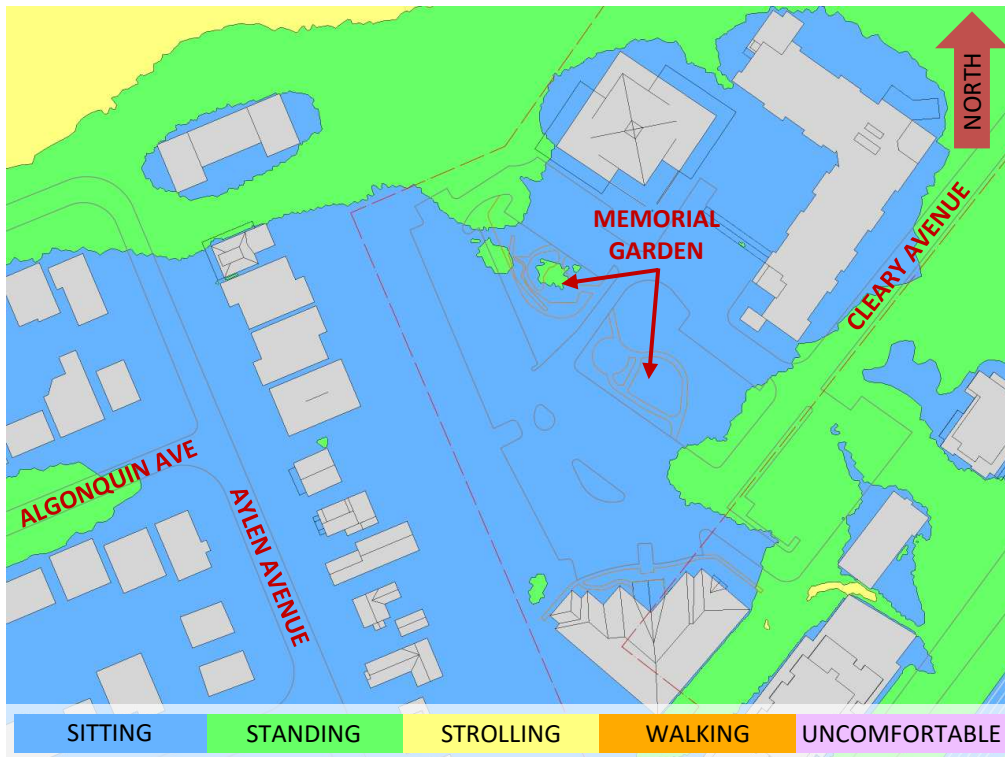


FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL – EXISTING MASSING



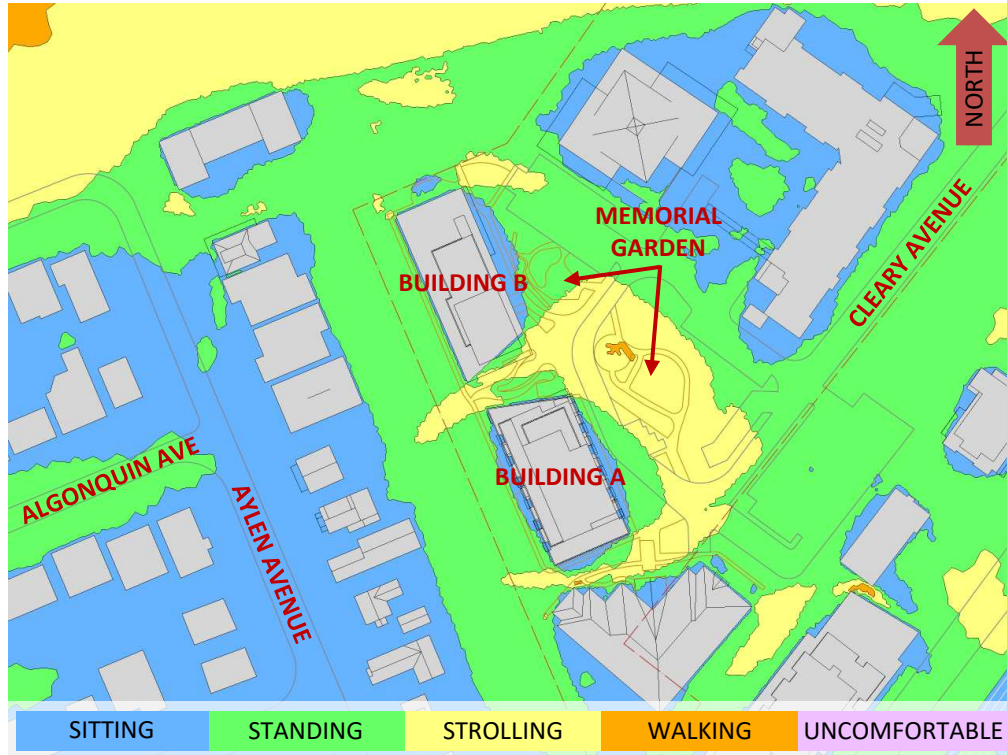


FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

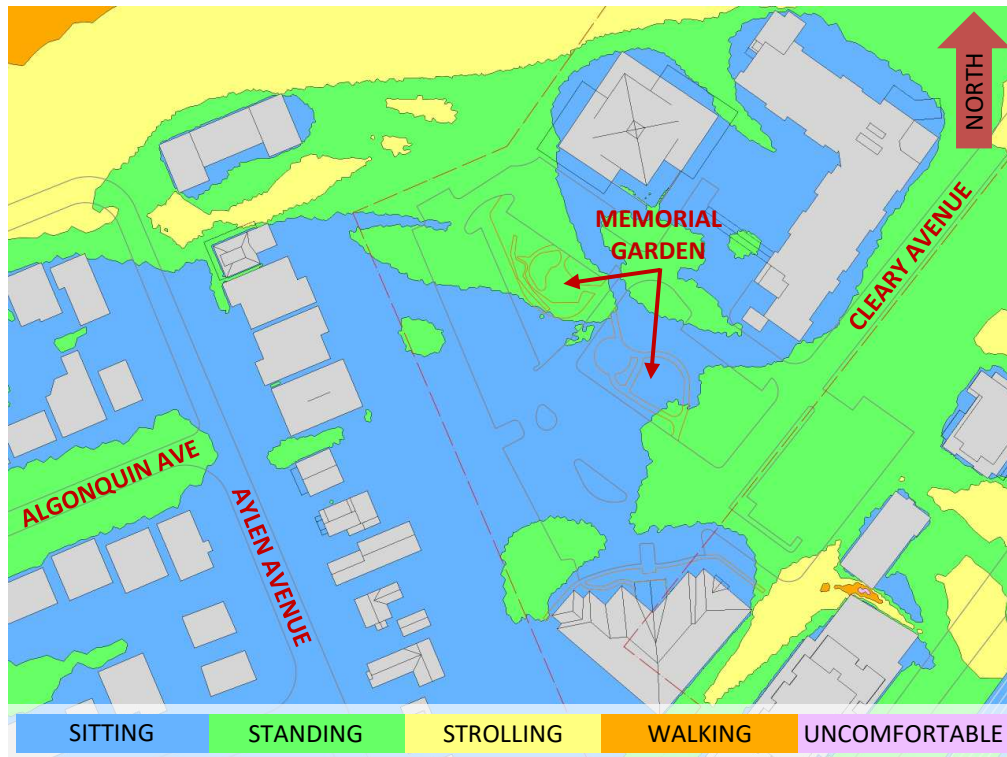


FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING



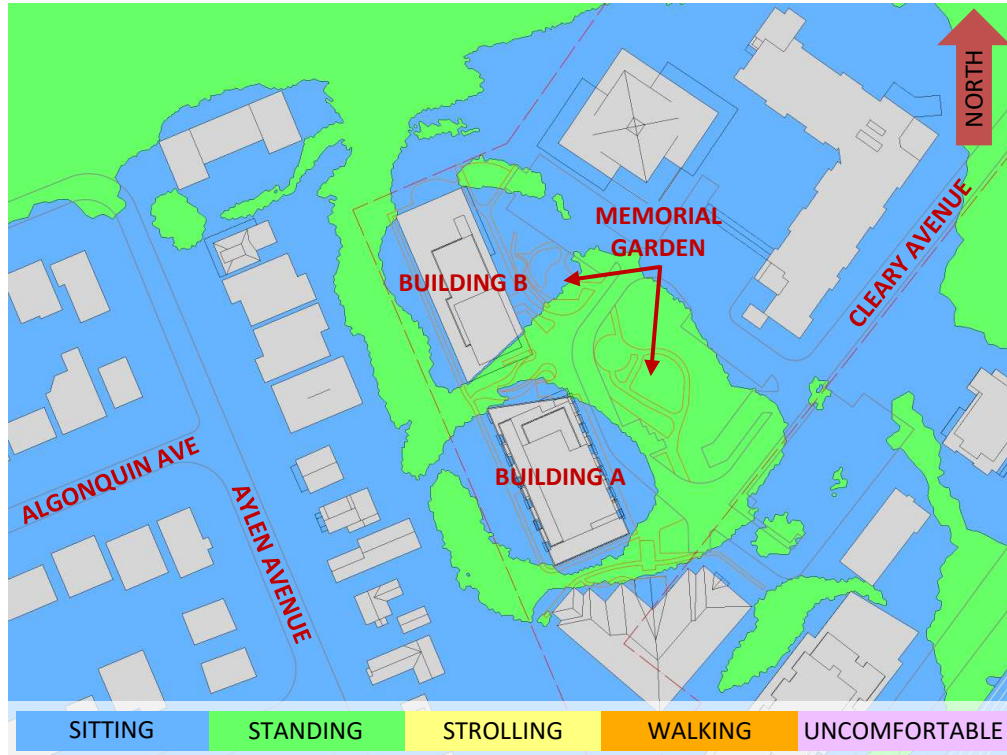


FIGURE 7A: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

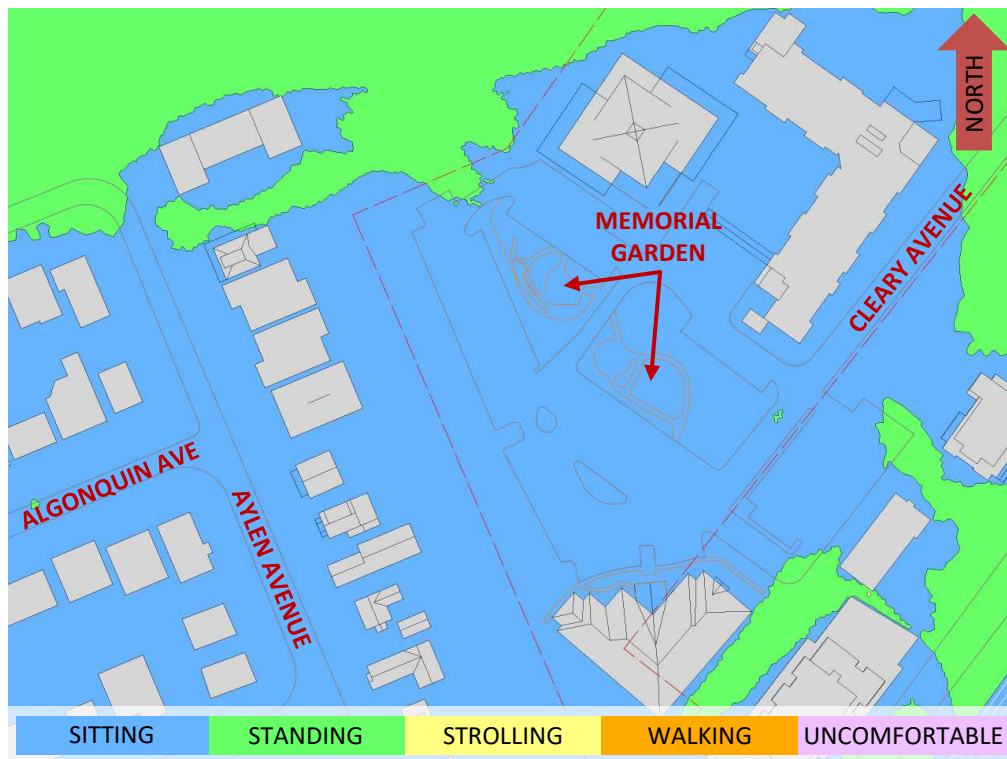


FIGURE 7B: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – EXISTING MASSING



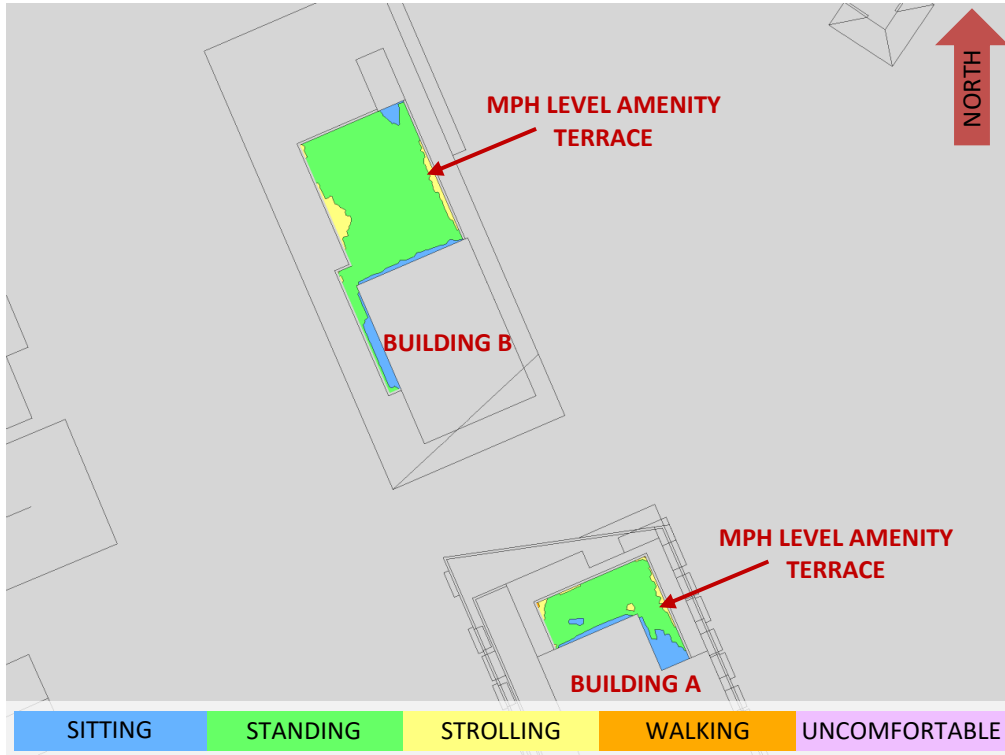


FIGURE 8A: SPRING – WIND COMFORT, MPH LEVEL AMENITY TERRACES

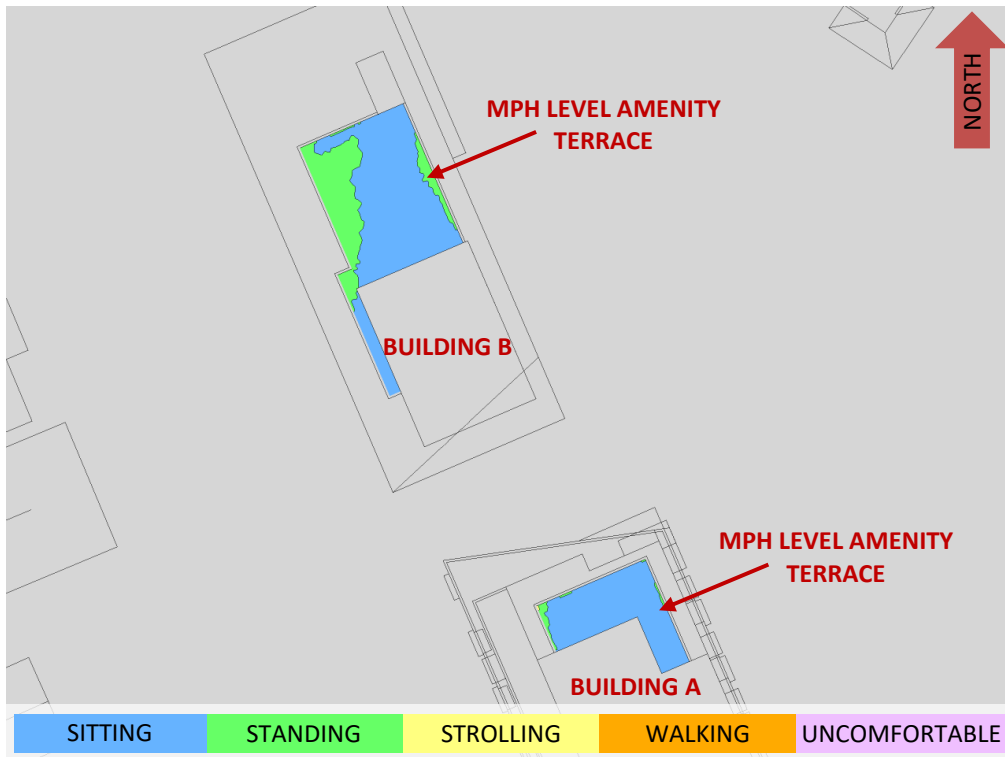


FIGURE 8B: SUMMER – WIND COMFORT, MPH LEVEL AMENITY TERRACES



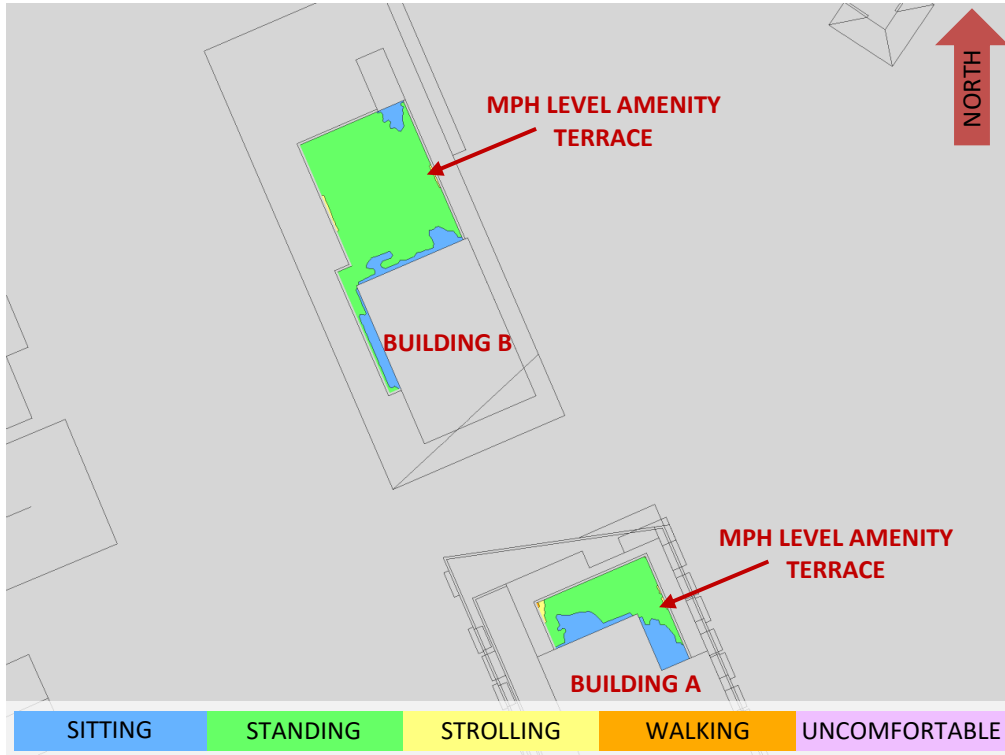


FIGURE 8C: AUTUMN – WIND COMFORT, MPH LEVEL AMENITY TERRACES

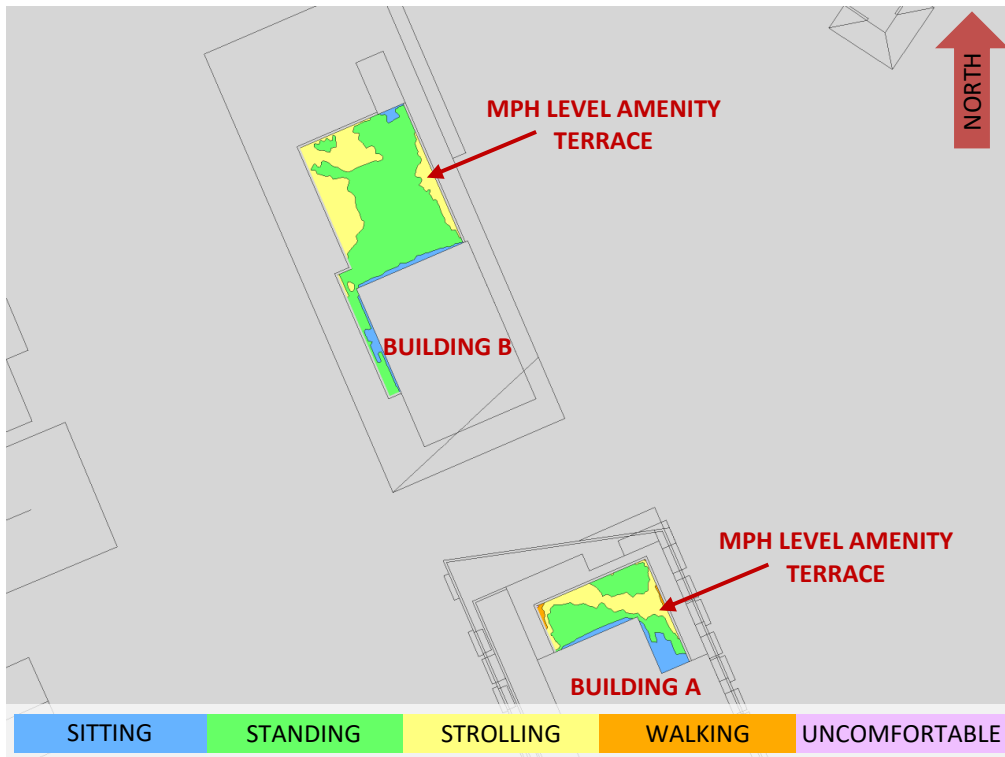


FIGURE 8D: WINTER – WIND COMFORT, MPH LEVEL AMENITY TERRACES

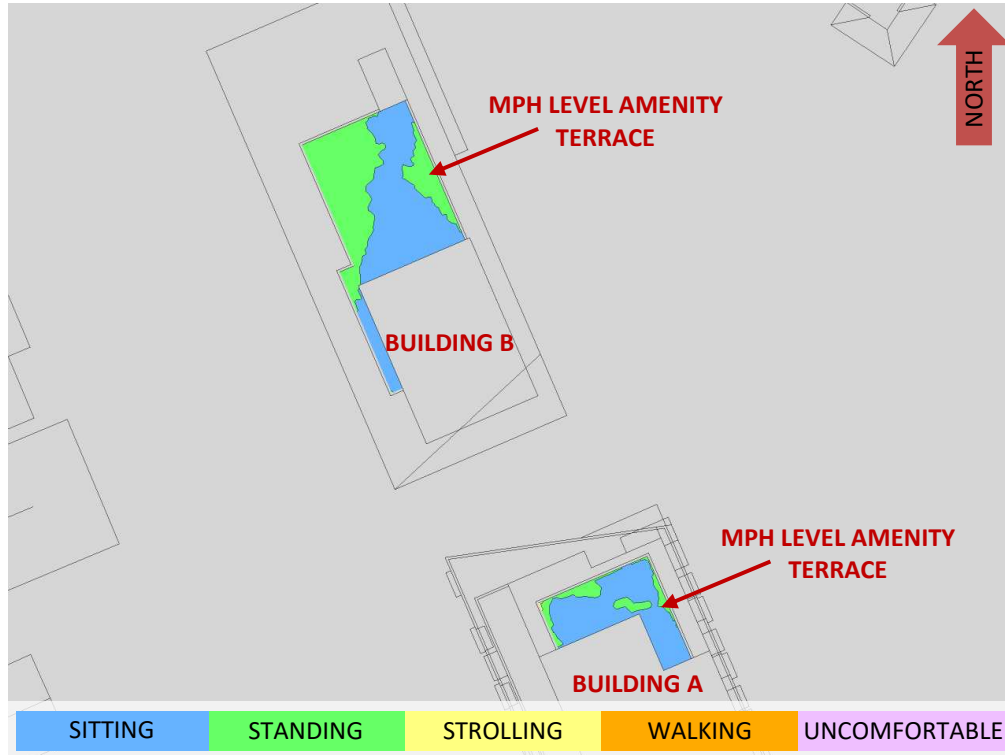


FIGURE 9: TYPICAL USE PERIOD – WIND COMFORT, MPH LEVEL AMENITY TERRACES

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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, 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	0.16
49	0.21
74	0.25
103	0.25
167	0.25
197	0.26
217	0.27
237	0.17
262	0.15
282	0.17
301	0.17
324	0.17

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.

REFERENCES

- [1] P. Arya, "Chapter 10: Near-neutral Boundary Layers," in *Introduction to Micrometeorology*, San Diego, California, Academic Press, 2001.
- [2] S. A. Hsu, E. A. Meindl and D. B. Gilhousen, "Determining the Power-Law Wind Profile Exponent under Near-neutral Stability Conditions at Sea," vol. 33, no. 6, 1994.
- [3] Y. Tamura, H. Kawai, Y. Uematsu, K. Kondo and T. Okhuma, "Revision of AIJ Recommendations for Wind Loads on Buildings," in *The International Wind Engineering Symposium, IWES 2003*, Taiwan, 2003.