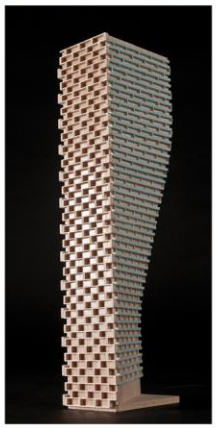
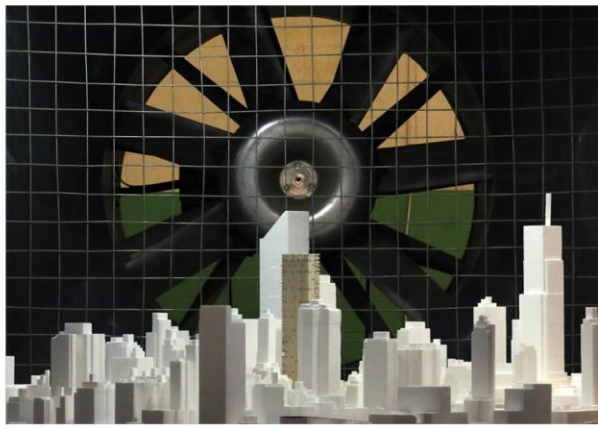
GRADIENTWIND
ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

1640-1660 Carling Avenue
Ottawa, Ontario

Report: 22-224-PLW





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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment (ZBLA) application resubmission requirements for the proposed multi-building development located at 1640-1660 Carling 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-6, 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, transit stops, neighbouring existing surface parking lots, laneways, parks, internal public streets, surface parking, walkways, and in the vicinity of building access points, are considered acceptable. The three areas of interest that are predicted to experience windier conditions are described as follows:

    a. **Transit Stop along Clyde Avenue North:** Conditions in the vicinity of the nearby transit stop along Clyde Avenue North are predicted to be suitable for standing during the summer and autumn, becoming suitable for a mix of standing and strolling during the winter and spring. It is recommended that a typical shelter be installed that provides pedestrians with protection from the elements, including during periods of strong wind activity.

    b. **Public Plaza Northwest of Subject Site and Central Public Park**. During the typical use period, conditions within the public plaza and the public park located centrally within the subject site are predicted to be suitable for a mix of sitting and standing. Depending on

the programming of the noted spaces, the noted wind conditions may be considered acceptable. Specifically, if the windier areas of these spaces that are suitable for standing will not accommodate seating or more sedentary activities, the noted wind conditions would be considered acceptable.

As required by programming, comfort levels within the noted spaces may be improved by implementing landscaping elements around sensitive areas such as tall wind screens and coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation. The extent of mitigation measures is dependent on the programming of the noted spaces.

If required by programming, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application submission.

2) Regarding the common amenity terrace serving Building 2 at Level 5, wind conditions are predicted to be suitable for mostly sitting, which is considered acceptable.

3) Regarding the common amenity terraces serving Buildings 1, 3 and 4, 5, and 6 at their respective podia rooftops, wind comfort conditions during the typical use period and recommendations regarding mitigation, where required, are described as follows:

   a. **Building 1, Level 7 Amenity Terrace**: Conditions are predicted to be mixed between sitting and standing, with conditions suitable for sitting close to the southern building façade and to the north and east of the podium roof.

   b. **Buildings 3 and 4, Level 5 Amenity Terrace**: Conditions are predicted to suitable for sitting within the majority of the area, with isolated regions of conditions suitable for standing predicted near the northeast and northwest corners of Buildings 3 and 4, respectively, and to the west of Building 3.

   c. **Building 5, Level 7 Amenity Terrace**: Conditions are predicted to suitable for standing within the majority of the area, with regions of conditions suitable for sitting predicted near the building façade and isolated regions of strolling conditions at the northwest and northeast corners of Building 5.

d. **Building 6, Level 7 Amenity Terrace**: Conditions are predicted to be mixed between sitting and standing, with conditions suitable for sitting predicted close to the building façade and to the north, east, and south of the podium roof, and conditions suitable for standing to the west and at the southwest and southeast corners of the podium.

e. Depending on the programming of the Level 5 amenity terrace serving Buildings 3 and 4, the noted conditions may be considered acceptable. Specifically, if the windier areas of the shared podium rooftop where conditions are predicted to be suitable for standing will not accommodate seating or lounging activities, the noted conditions would be considered acceptable.

f. To improve comfort levels within the remaining amenity terraces, and the Level 5 amenity terrace serving Buildings 3 and 4 if required by programming, mitigation inboard of the terrace perimeters and targeted around sensitive areas is recommended, in combination with taller perimeter wind screens. Inboard mitigation could take the form of wind screens or other common landscape elements. Canopies may also be required above sensitive areas.

g. The extent of the mitigation measures is dependent on the programming of the amenity terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application submission.

4) 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 RioCan Real Estate Investment Trust to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application resubmission requirements for the proposed multi-building development located at 1640-1660 Carling Avenue in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). A PLW study was conducted in January 2023[1] for the previous design of the 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 Hobin Architecture Incorporated in November 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 1640-1660 Carling Avenue in Ottawa, situated to the east at the intersection of Carling Avenue and Clyde Avenue North, on a parcel of land bordered by Carling Avenue to the north, low-rise buildings to the east, a proposed multi-building development and city park at 861 Clyde Avenue North to the south, and Clyde Avenue North to the west.

The subject site comprises six high-rise buildings: Buildings 1, 2, 3, 4, 5, and 6; oriented from the northeast clockwise to the north of the subject site, respectively. Two internal public streets are proposed: a north-south public street from Carling Avenue and an east-west public street from Clyde Avenue North. Surface parking spaces are situated along the two internal public streets. Access to below-grade parking (shared by all six buildings) is provided by ramps situated at the southwest corner of Building 1, along the south elevation of Building 2, and at the southeast corner of Building 5 via the internal public streets from Carling

[1] Gradient Wind Engineering Inc., '*1640-1660 Carling Avenue – Pedestrian Level Wind Study*', [Jan 19, 2023]

Avenue and Clyde Avenue North. A public plaza is situated at the northwest corner of the subject site and public parks are situated central to the subject site and at the southwest corner of the subject site.

Building 1 is a 28-storey residential rental building, inclusive of a 6-storey podium, comprising a nominally 'L'-shaped planform with its long axis-oriented along Carling Avenue. Building 2 is a 24-storey residential rental building, inclusive of a 4-storey podium. Buildings 3 and 4 are 20-storey and 18-storey residential buildings, respectively, inclusive of a shared 4-storey podium. Buildings 5 and 6 are near trapezoidal 40-storey and near rectangular 37-storey residential rental buildings, respectively, inclusive of 6-storey podia serving each building. The podium roof levels of all buildings are served by common amenity terraces.

The near-field surroundings, defined as an area within 200-metres (m) of the subject site, comprise mostly low-rise massing in all compass directions, with an isolated mid-rise building to the east-southeast. Notably, a development comprising seven mid- and high-rise buildings and a city park is approved at 861 Clyde Avenue North, to the immediate south of the subject site, a development comprising two towers (16 and 18 storeys) is approved at 1619 and 1655 Carling Avenue, to the immediate north of the subject site, and a development comprising a 22-storey residential building and a 9-storey retirement home is approved at 1705, 1707, and 1717 Carling Avenue, approximately 120 m to the west of the subject site. 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 low-rise massing in all compass directions, with isolated mid- and high-rise buildings from the west clockwise to the south, and the open exposures of the Central Experimental Farm from the east-northeast clockwise to the southeast. Notably, the Ottawa River is situated approximately 1.7 km to the west-northwest.

A site plan for the proposed massing scenario is illustrated in Figure 1, while Figures 2A-2D illustrate the computational model used to conduct the study.

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 criteria[2]. 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.

[2] 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 550 m. The process was performed for the proposed massing scenario, as noted in Section 2.

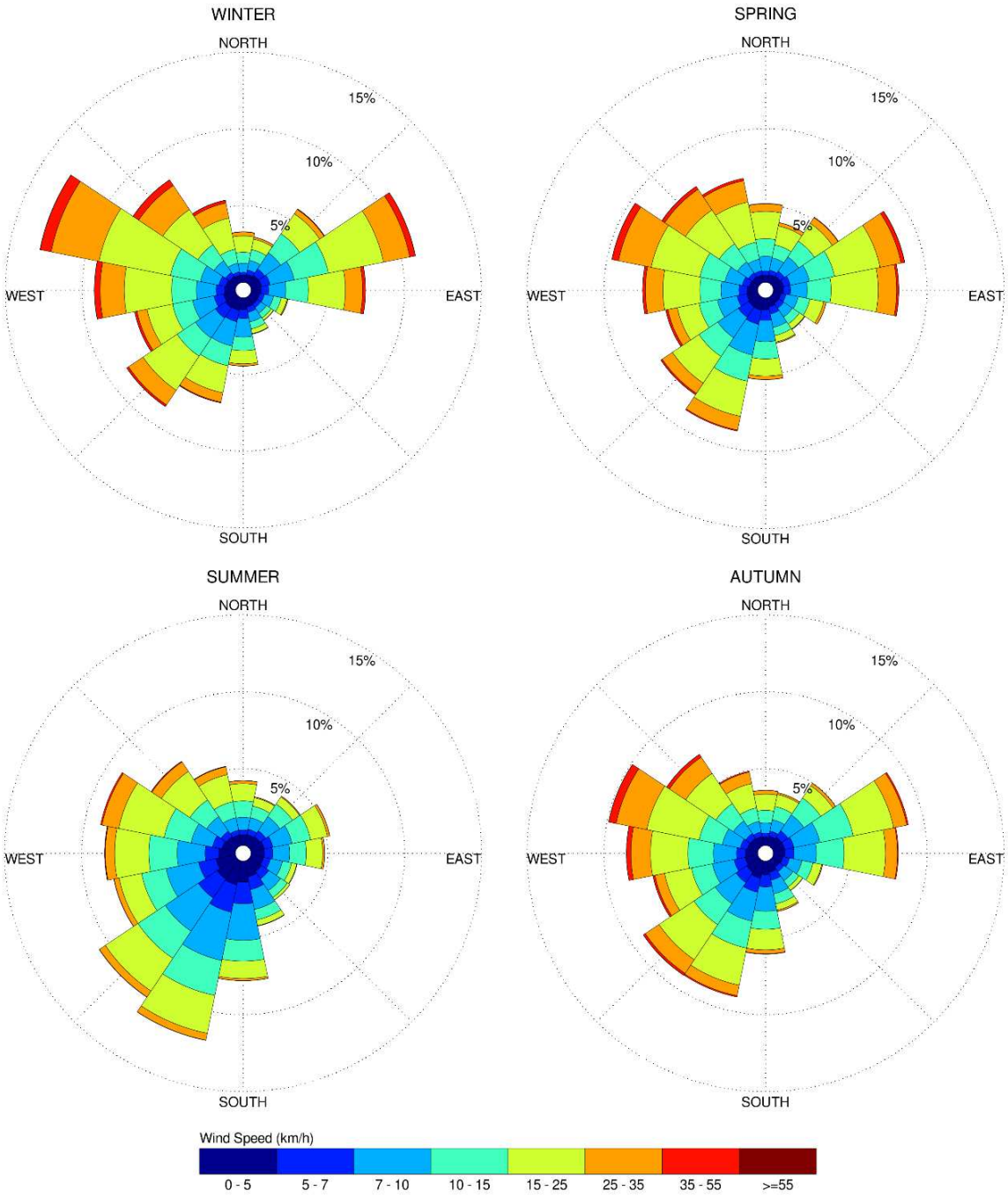
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and over the common amenity terraces serving the proposed development 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 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-3D, illustrating wind conditions at grade level for the proposed massing scenario, and by Figures 5A-5D, which illustrate conditions over the common amenity terraces serving Buildings 1-6 at their respective podium roof 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 4 and 6 illustrate comfort conditions at grade level and over the noted common amenity terraces serving the proposed development, 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.

A detailed description of the predicted wind comfort conditions for the existing massing scenario is provided in Section 5 of the noted previous PLW report described in Section 1.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks and Transit Stops along Carling Avenue: Following the introduction of the proposed development, wind comfort conditions over the nearby public sidewalks along Carling Avenue are predicted to be suitable for standing, or better during the summer, becoming suitable for strolling, or better, during the autumn, winter, and spring, with an isolated region suitable for walking during the winter. Conditions in the vicinity of the nearby westbound transit stop to the north of Carling Avenue are predicted to be suitable for sitting throughout the year, while conditions in the vicinity of the nearby eastbound transit stop to the south of Carling Avenue, which is served by a typical transit stop, are predicted to be suitable for standing during the spring, summer, and autumn, becoming suitable for a mix of standing and strolling during the winter. The noted conditions are considered acceptable.

While the introduction of the proposed development produces windier conditions over Carling Avenue in comparison to existing conditions (refer to Section 5 of the noted previous PLW report described in Section 1 for a detailed description of the predicted wind comfort conditions for the existing massing scenario), wind comfort conditions with the proposed development are nevertheless considered acceptable.

Sidewalks and Transit Stops along Clyde Avenue North: Following the introduction of the proposed development, conditions over the nearby public sidewalks along Clyde Avenue North are predicted to be suitable for standing, or better during the summer and autumn, with an isolated region suitable for strolling during the autumn, becoming suitable for strolling, or better, during the winter and spring. The noted conditions are considered acceptable.

Conditions in the vicinity of the nearby transit stop along Clyde Avenue North are predicted to be suitable for standing during the summer and autumn, becoming suitable for a mix of standing and strolling during the winter and spring. On account of the windier conditions during the colder months of the year, it is recommended that a typical shelter be installed that provides pedestrians with protection from the elements, including during periods of strong wind activity.

With the exception of the noted transit stop, while the introduction of the proposed development produces windier conditions over Clyde Avenue North in comparison to existing conditions (refer to Section 5 of the noted previous PLW report described in Section 1 for a detailed description of the

predicted wind comfort conditions for the existing massing scenario), wind comfort conditions with the proposed development are nevertheless considered acceptable.

Neighbouring Existing Surface Parking Lots: Following the introduction of the proposed development, wind conditions over the nearby neighbouring existing surface parking lot to the north of the subject site are predicted to be suitable for sitting during the summer, becoming suitable for mostly sitting throughout the remainder of the year. Conditions over the nearby neighbouring existing surface parking lot to the east of the subject site are predicted to be suitable for mostly sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year, with isolated regions suitable for strolling during the winter and spring. Conditions over the nearby neighbouring existing surface parking lots to the west of the subject site are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. The noted conditions are considered acceptable.

While the introduction of the proposed development produces windier conditions over the noted neighbouring existing surface parking lots in comparison to existing conditions (refer to Section 5 of the noted previous PLW report described in Section 1 for a detailed description of the predicted wind comfort conditions for the existing massing scenario), wind comfort conditions with the proposed development are nevertheless considered acceptable.

Laneway South of Subject Site: Following the introduction of the proposed development, wind conditions over the laneway serving 861 Clyde Avenue North to the south of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing with isolated regions suitable for strolling throughout the remainder of the year. The noted conditions are considered acceptable.

Notably, the introduction of the proposed development is predicted to result in similar comfort levels over the noted laneway, in comparison to existing conditions (refer to Section 5 of the noted previous PLW report described in Section 1 for a detailed description of the predicted wind comfort conditions for the existing massing scenario), and wind conditions with the proposed development are nevertheless considered acceptable.

City Park Southwest of Subject Site: Following the introduction of the proposed development, wind conditions within the proposed city park situated to the southwest of the subject site are predicted to be suitable for sitting during the typical use period. The noted conditions remain unchanged in comparison to existing conditions (refer to Section 5 of the noted previous PLW report described in Section 1 for a detailed description of the predicted wind comfort conditions for the existing massing scenario). The wind conditions with the proposed development are considered acceptable.

Internal Public Streets, Surface Parking, and Walkways: Conditions over the public streets, inclusive of surface parking, and the walkways within 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 isolated regions suitable for walking during the winter. The noted conditions are considered acceptable.

Public Plaza and Public Parks: During the typical use period, wind comfort conditions within the public park situated at the southwest corner of the subject site are predicted to be suitable for mostly sitting. The noted conditions are considered acceptable.

During the same period, wind conditions within the public plaza situated at the northwest corner of the subject site are predicted to be mixed between sitting and standing. Specifically, conditions suitable for sitting are predicted to the north of Building 5 and to the west of Building 6, with conditions suitable for standing predicted elsewhere within the plaza.

During the typical use period, wind comfort conditions within the public park situated at the centre of the subject site are predicted to be mixed between sitting and standing. Specifically, conditions suitable for sitting are predicted to the east and west with conditions suitable for standing predicted at the centre of the park.

Depending on the programming of the public plaza and the central public park, the noted wind conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable.

As required by programming, comfort levels within the public plaza and the central public park may be improved by implementing landscaping elements around sensitive areas such as tall wind screens and coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation. The extent of mitigation measures is dependent on the programming of the noted spaces. If required by programming, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application submission.

Building Access Points: Owing to the protection of the building façades, conditions in the vicinity of the building 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

Wind comfort conditions during the typical use period within the common amenity terraces serving Buildings 1-6 at their respective podia rooftops and recommendations regarding mitigation, where required, are described as follows:

Building 1, Level 7 Amenity Terrace: Wind conditions within the Level 7 amenity terrace serving Building 1 are predicted to be mixed between sitting and standing, as illustrated in Figure 6. Specifically, conditions suitable for sitting are predicted close to the southern building façade and to the north and east of the podium roof.

Building 2, Level 5 Amenity Terrace: Wind conditions within the Level 5 amenity terrace serving Building 2 are predicted to be suitable for mostly sitting, as illustrated in Figure 6. The noted conditions are considered acceptable.

Buildings 3 and 4, Level 5 Amenity Terrace: Wind conditions within the Level 5 amenity terrace serving Buildings 3 and 4 are predicted to suitable for sitting within the majority of the area, with isolated regions of conditions suitable for standing predicted to occur near the northeast and northwest corners of Buildings 3 and 4, respectively, and to the west of Building 3.

Building 5, Level 7 Amenity Terrace: Wind conditions within the Level 7 amenity terrace serving Building 5 are predicted to suitable for standing within the majority of the area, with regions of conditions suitable for sitting predicted to occur near the building façade and isolated regions of strolling conditions at the northwest and northeast corners of Building 5.

Building 6, Level 7 Amenity Terrace: Wind conditions within the Level 7 amenity terrace serving Building 6 are predicted to be mixed between sitting and standing. Specifically, conditions suitable for sitting are predicted close to the building façade and to the north, east, and south of the podium roof, with conditions suitable for standing to the west and at the southwest and southeast corners of the podium.

Depending on the programming of the Level 5 amenity terrace serving Buildings 3 and 4, the noted conditions may be considered acceptable. Specifically, if the windier areas of the shared podium rooftop where conditions are predicted to be suitable for standing will not accommodate seating or more sedentary activities, the noted conditions would be considered acceptable.

To improve comfort levels within the amenity terraces serving Buildings 1, 5, and 6 at the podium roof level, and the Level 5 amenity terrace serving Buildings 3 and 4 if required by programming, mitigation inboard of the terrace perimeters that is targeted around sensitive areas is recommended, in combination with taller perimeter wind screens. Inboard mitigation could take the form of wind screens or other common landscape elements. Canopies may also be required above sensitive areas.

The extent of the mitigation measures is dependent on the programming of the amenity terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support 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-6. 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, transit stops, neighbouring existing surface parking lots, laneways, parks, internal public streets, surface parking, walkways, and in the vicinity of building access points, are considered acceptable. The three areas of interest that are predicted to experience windier conditions are described as follows:

    a. **Transit Stop along Clyde Avenue North:** Conditions in the vicinity of the nearby transit stop along Clyde Avenue North are predicted to be suitable for standing during the summer and autumn, becoming suitable for a mix of standing and strolling during the winter and spring. It is recommended that a typical shelter be installed that provides pedestrians with protection from the elements, including during periods of strong wind activity.

b. **Public Plaza Northwest of Subject Site and Central Public Park**. During the typical use period, conditions within the public plaza and the public park located centrally within the subject site are predicted to be suitable for a mix of sitting and standing. Depending on the programming of the noted spaces, the noted wind conditions may be considered acceptable. Specifically, if the windier areas of these spaces that are suitable for standing will not accommodate seating or more sedentary activities, the noted wind conditions would be considered acceptable.

   As required by programming, comfort levels within the noted spaces may be improved by implementing landscaping elements around sensitive areas such as tall wind screens and coniferous plantings in dense arrangements, in combination with strategically placed seating with high-back benches and other local wind mitigation. The extent of mitigation measures is dependent on the programming of the noted spaces.

   If required by programming, an appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the development progresses. This work is expected to support the future Site Plan Control application submission.

2) Regarding the common amenity terrace serving Building 2 at Level 5, wind conditions are predicted to be suitable for mostly sitting, which is considered acceptable.

3) Regarding the common amenity terraces serving Buildings 1, 3 and 4, 5, and 6 at their respective podia rooftops, wind comfort conditions during the typical use period and recommendations regarding mitigation, where required, are described as follows:

   a. **Building 1, Level 7 Amenity Terrace**: Conditions are predicted to be mixed between sitting and standing, with conditions suitable for sitting close to the southern building façade and to the north and east of the podium roof.

   b. **Buildings 3 and 4, Level 5 Amenity Terrace**: Conditions are predicted to suitable for sitting within the majority of the area, with isolated regions of conditions suitable for standing predicted near the northeast and northwest corners of Buildings 3 and 4, respectively, and to the west of Building 3.

c. **Building 5, Level 7 Amenity Terrace**: Conditions are predicted to suitable for standing within the majority of the area, with regions of conditions suitable for sitting predicted near the building façade and isolated regions of strolling conditions at the northwest and northeast corners of Building 5.

d. **Building 6, Level 7 Amenity Terrace**: Conditions are predicted to be mixed between sitting and standing, with conditions suitable for sitting predicted close to the building façade and to the north, east, and south of the podium roof, and conditions suitable for standing to the west and at the southwest and southeast corners of the podium.

e. Depending on the programming of the Level 5 amenity terrace serving Buildings 3 and 4, the noted conditions may be considered acceptable. Specifically, if the windier areas of the shared podium rooftop where conditions are predicted to be suitable for standing will not accommodate seating or lounging activities, the noted conditions would be considered acceptable.

f. To improve comfort levels within the remaining amenity terraces, and the Level 5 amenity terrace serving Buildings 3 and 4 if required by programming, mitigation inboard of the terrace perimeters and targeted around sensitive areas is recommended, in combination with taller perimeter wind screens. Inboard mitigation could take the form of wind screens or other common landscape elements. Canopies may also be required above sensitive areas.

g. The extent of the mitigation measures is dependent on the programming of the amenity terraces. An appropriate mitigation strategy will be developed in collaboration with the building and landscape architects as the design of the proposed development progresses. This work is expected to support the future Site Plan Control application submission.

4) 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

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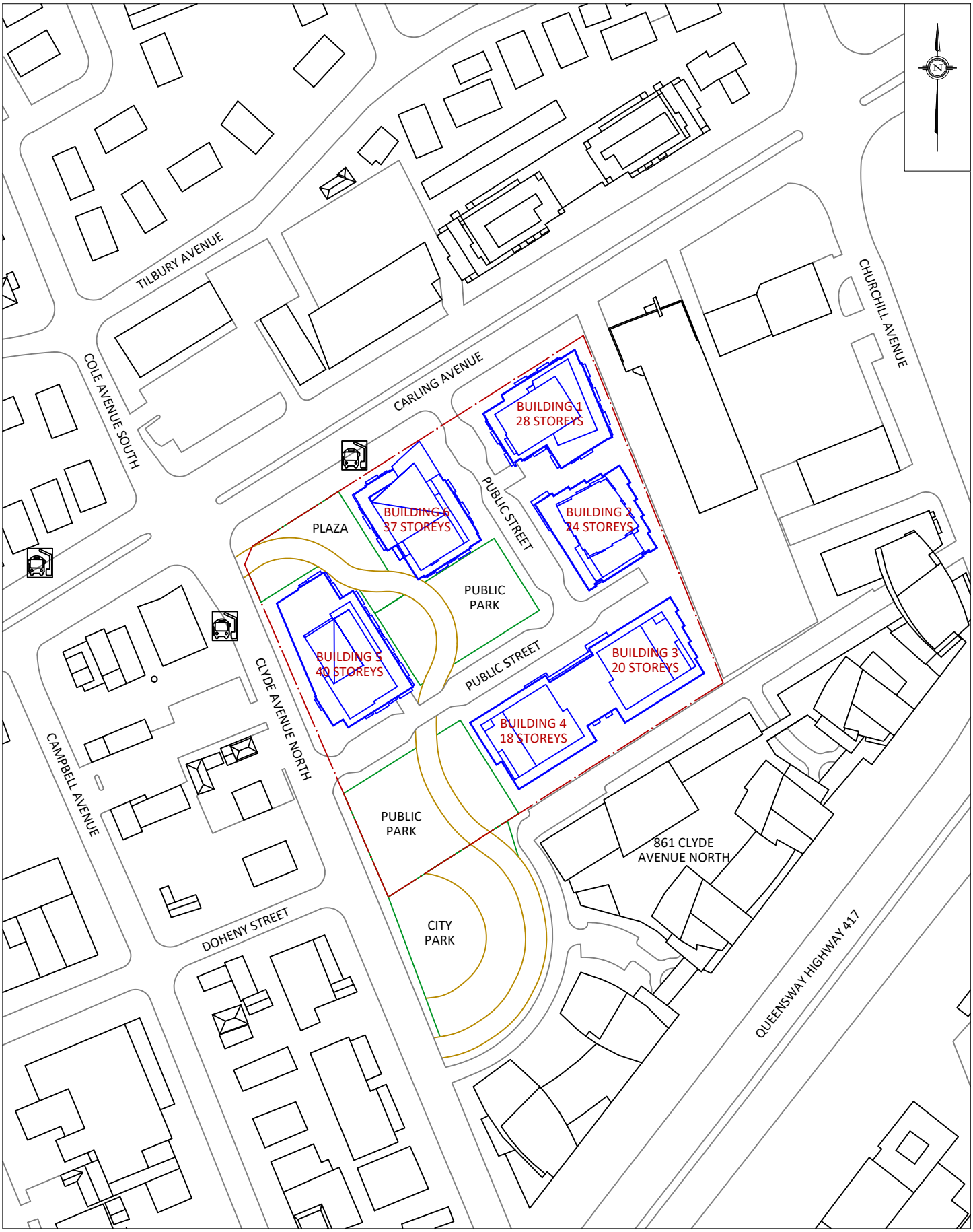

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PROJECT	1640-1660 CARLING AVENUE, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	22-224-PLW-1
DATE	DECEMBER 11, 2023
DRAWN BY	N.M.P.

DESCRIPTION

FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT

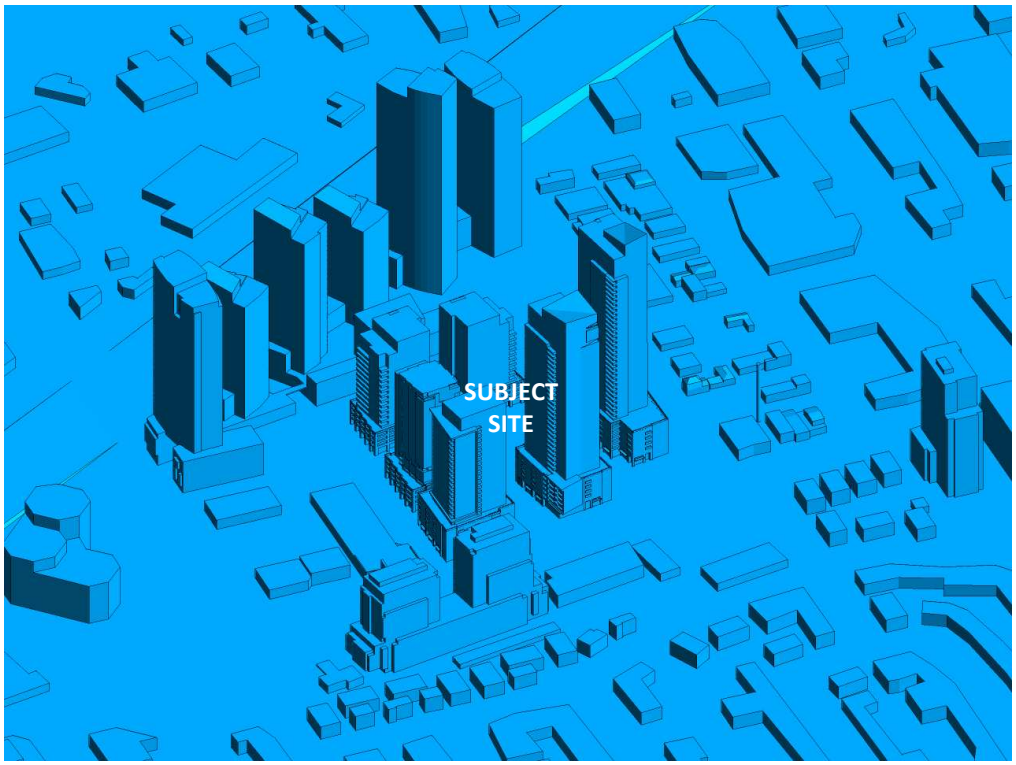

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

FIGURE 2B: CLOSE UP OF FIGURE 2A

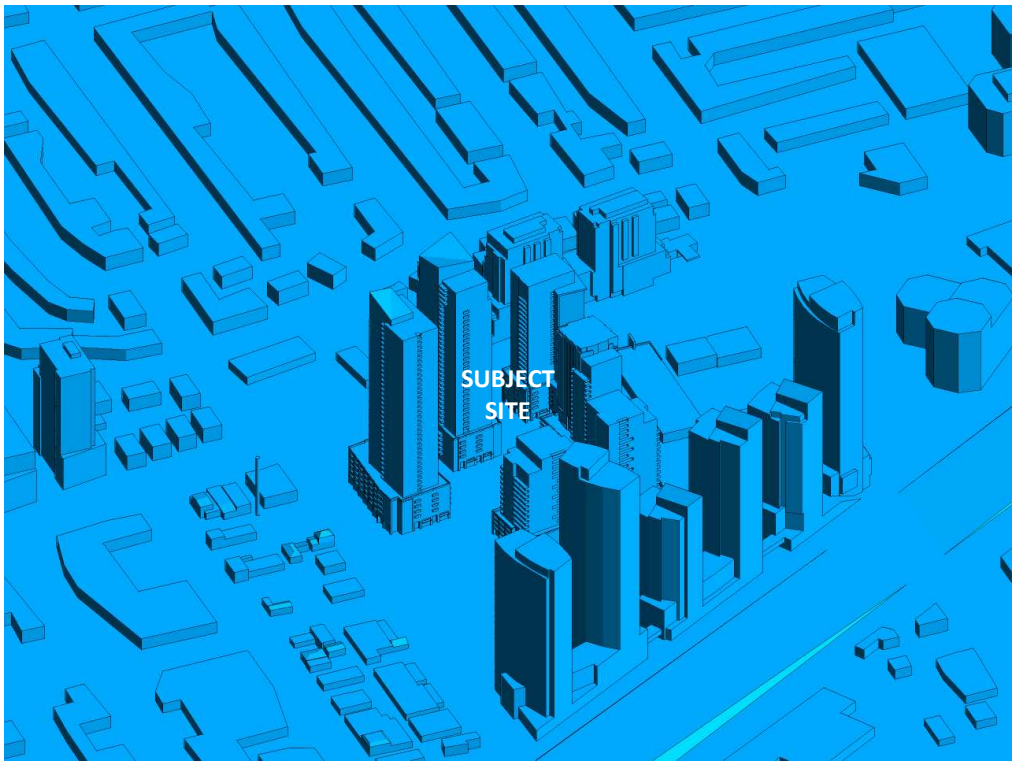

FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

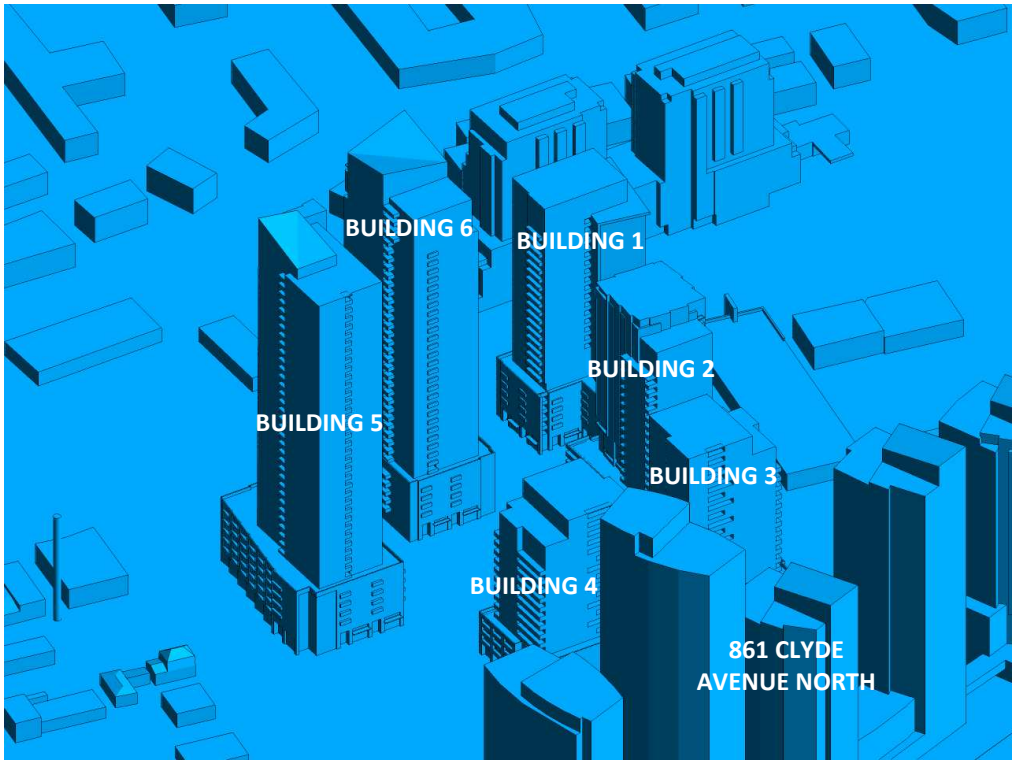

FIGURE 2D: CLOSE UP OF FIGURE 2C

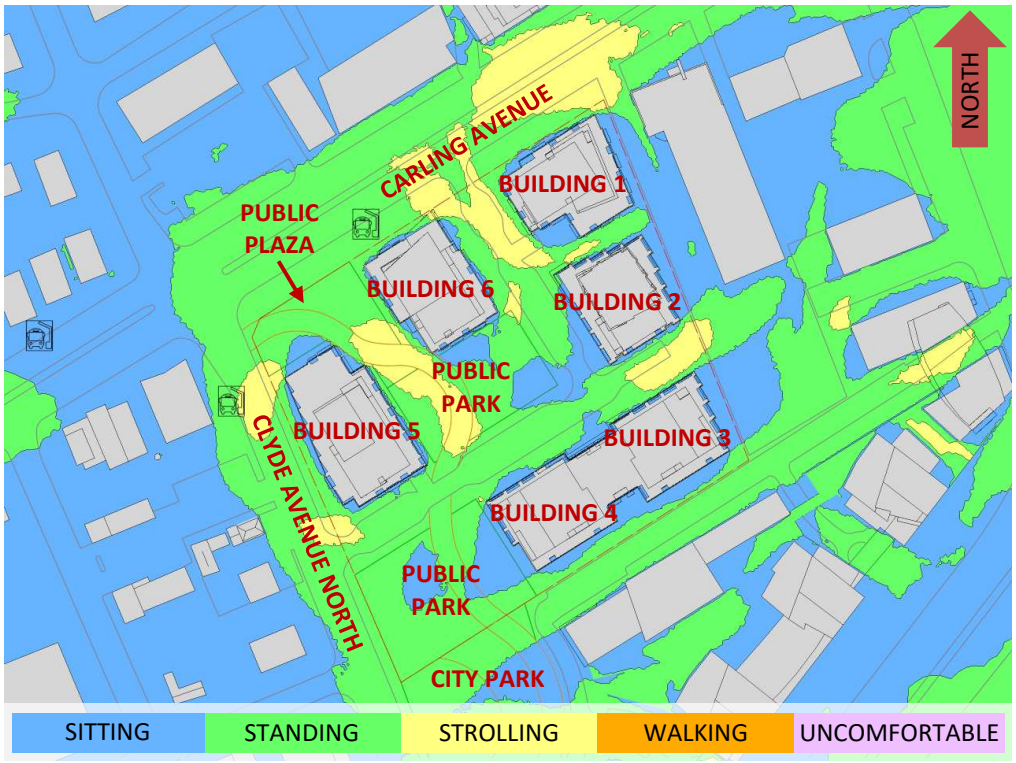

FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

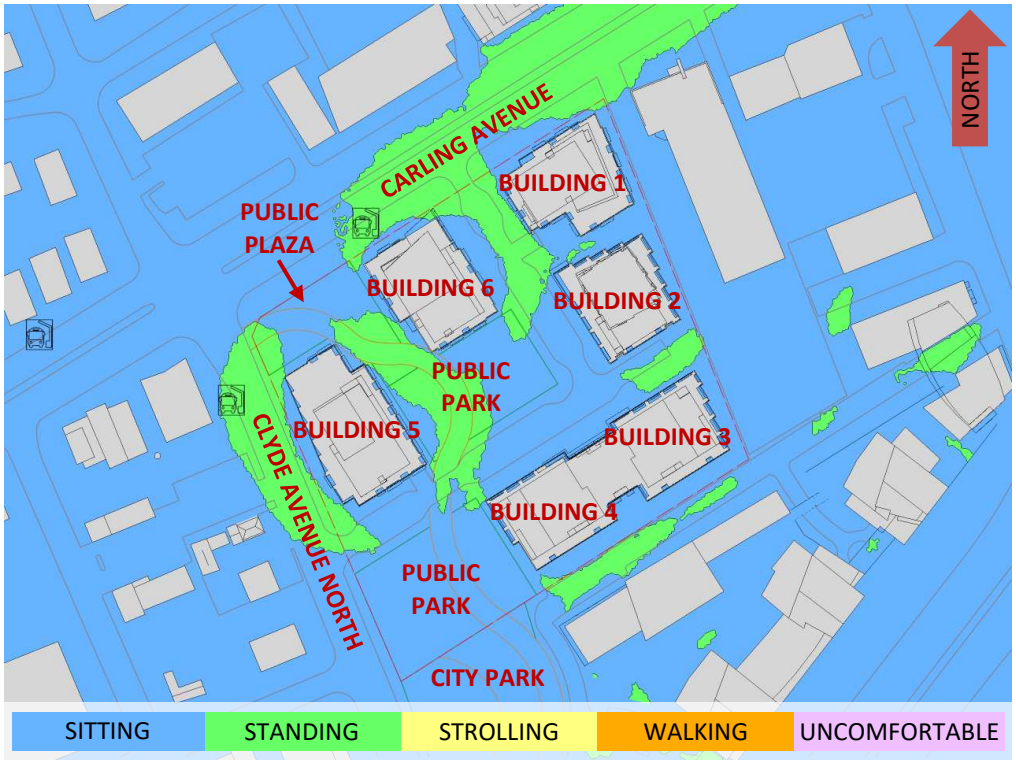

FIGURE 3B: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

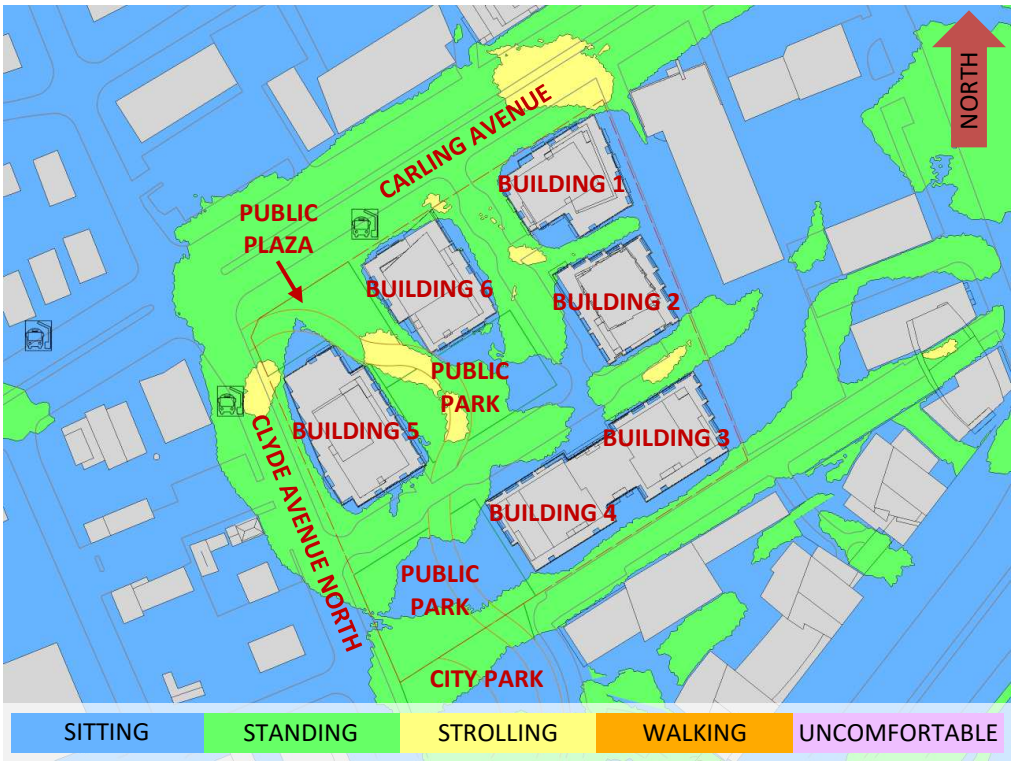

FIGURE 3C: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

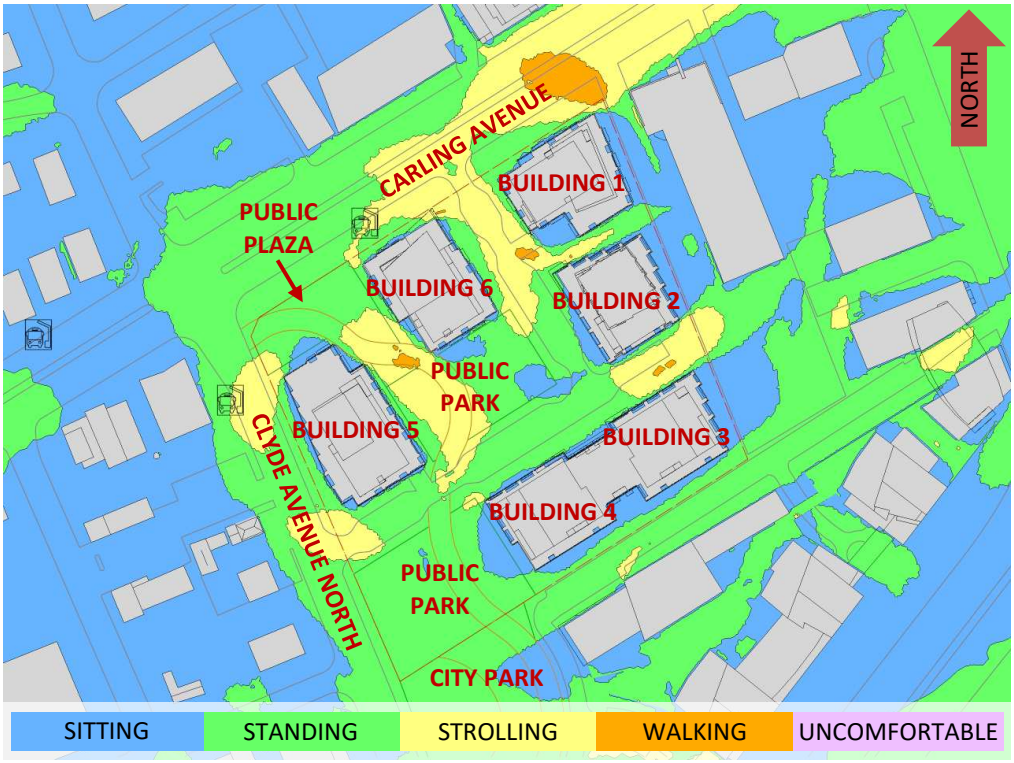

FIGURE 3D: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

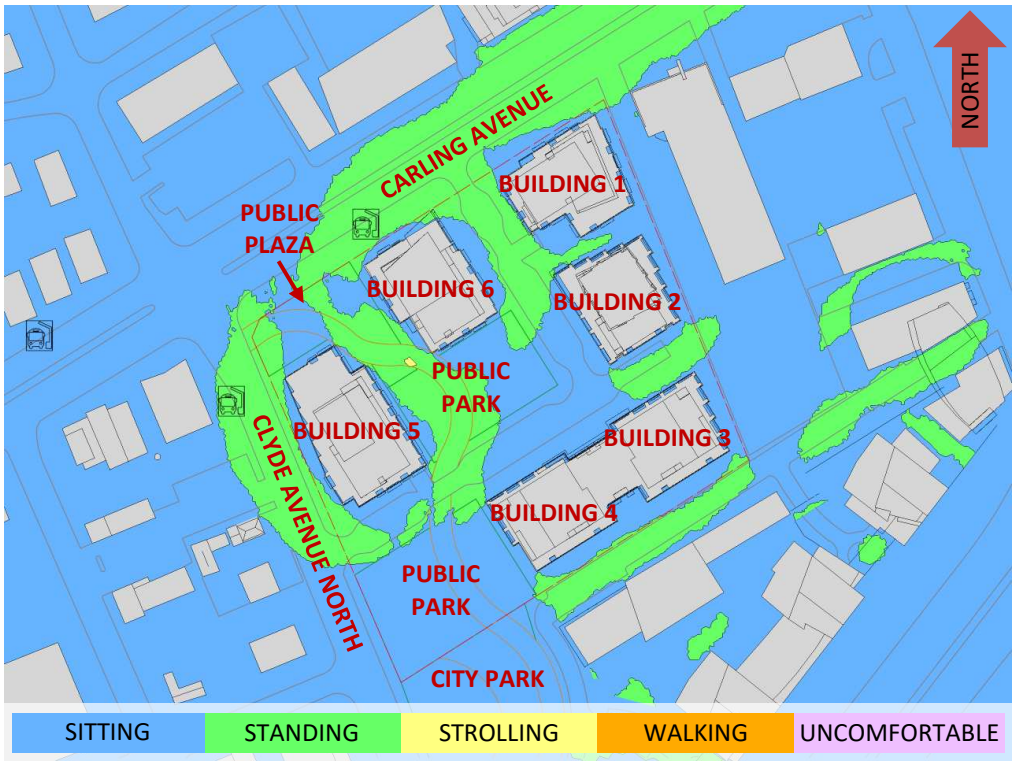

FIGURE 4: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

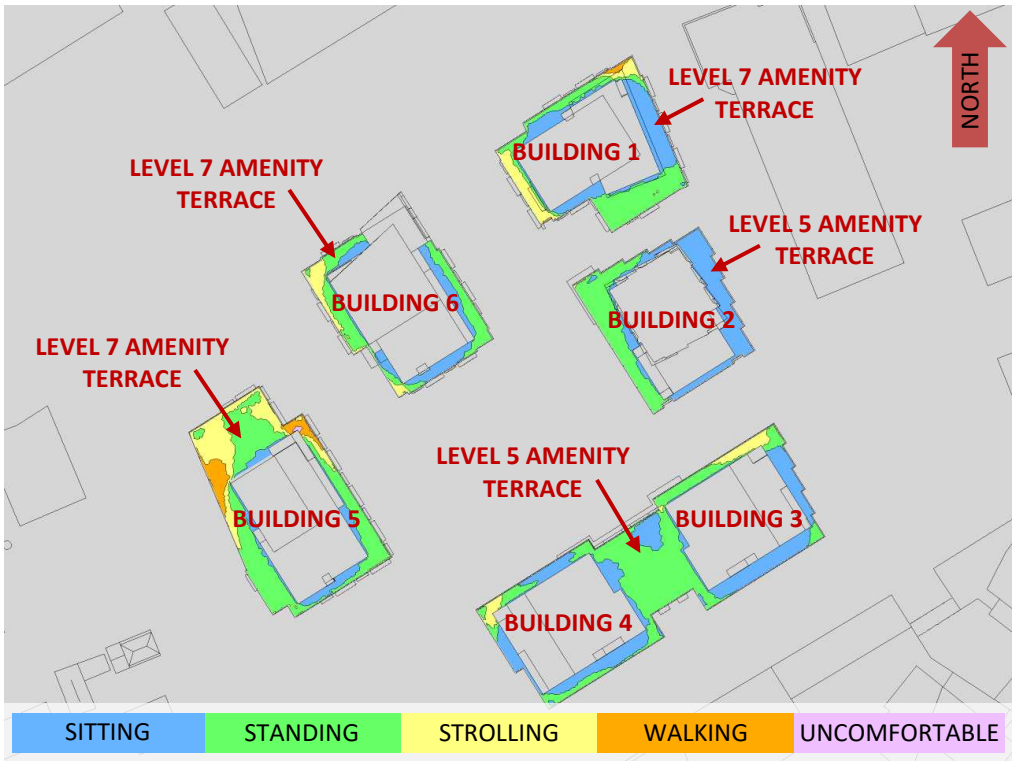

FIGURE 5A: SPRING – WIND COMFORT, COMMON AMENITY TERRACES

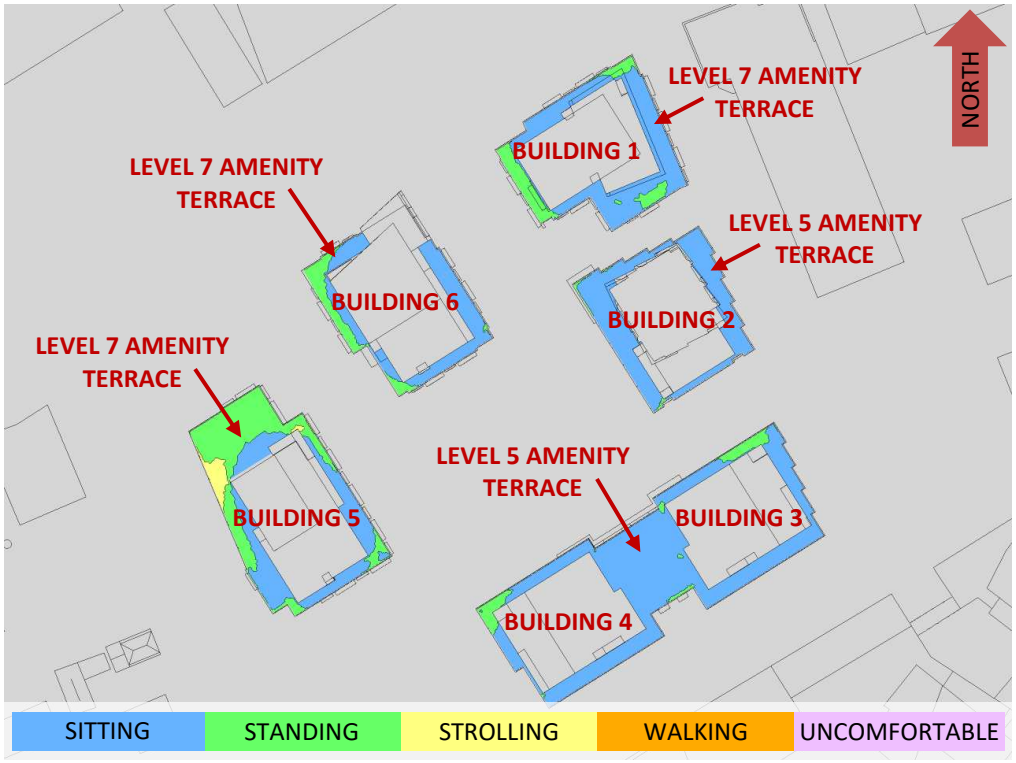

FIGURE 5B: SUMMER – WIND COMFORT, COMMON AMENITY TERRACES

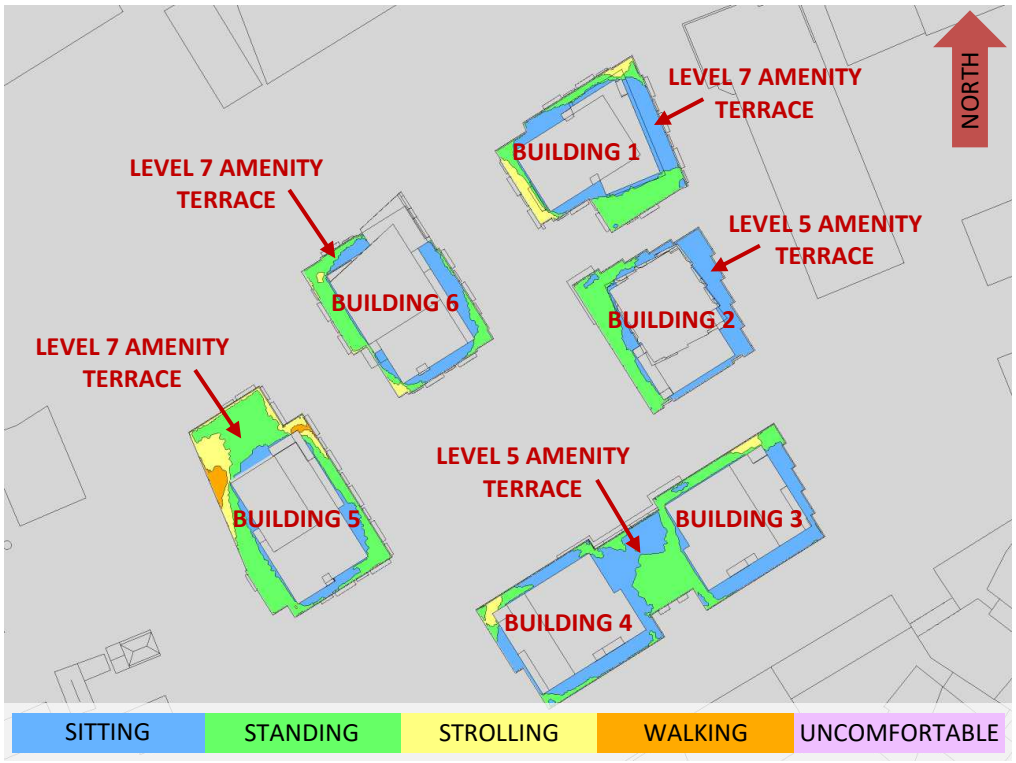

FIGURE 5C: AUTUMN – WIND COMFORT, COMMON AMENITY TERRACES

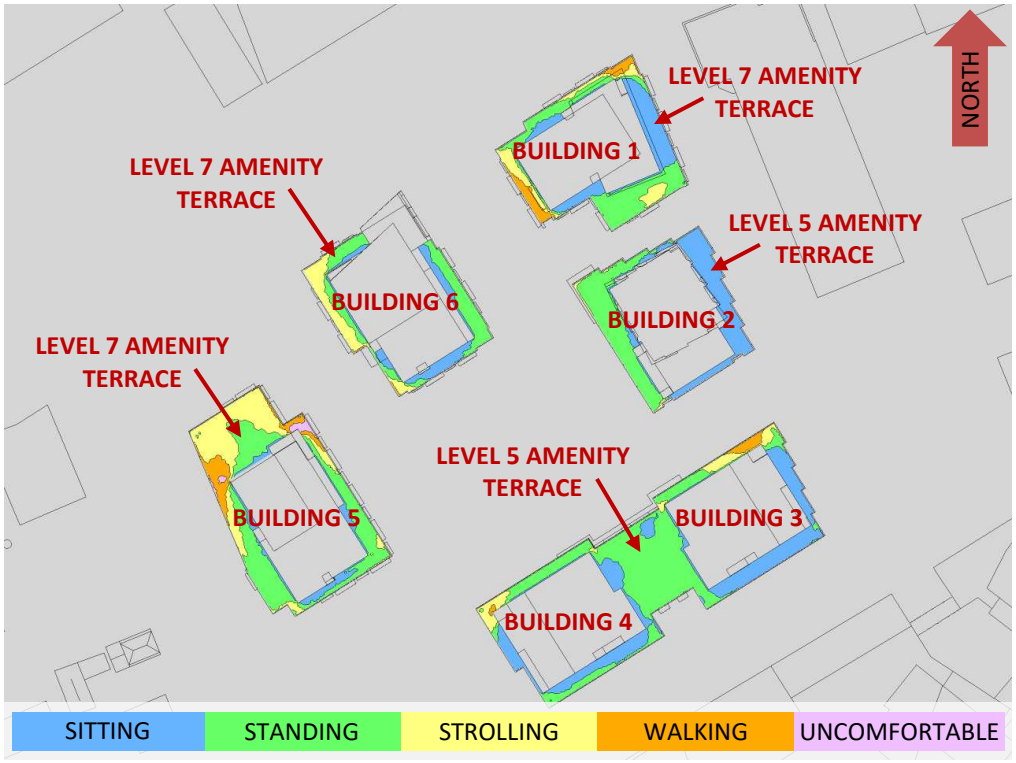

FIGURE 5D: WINTER – WIND COMFORT, COMMON AMENITY TERRACES

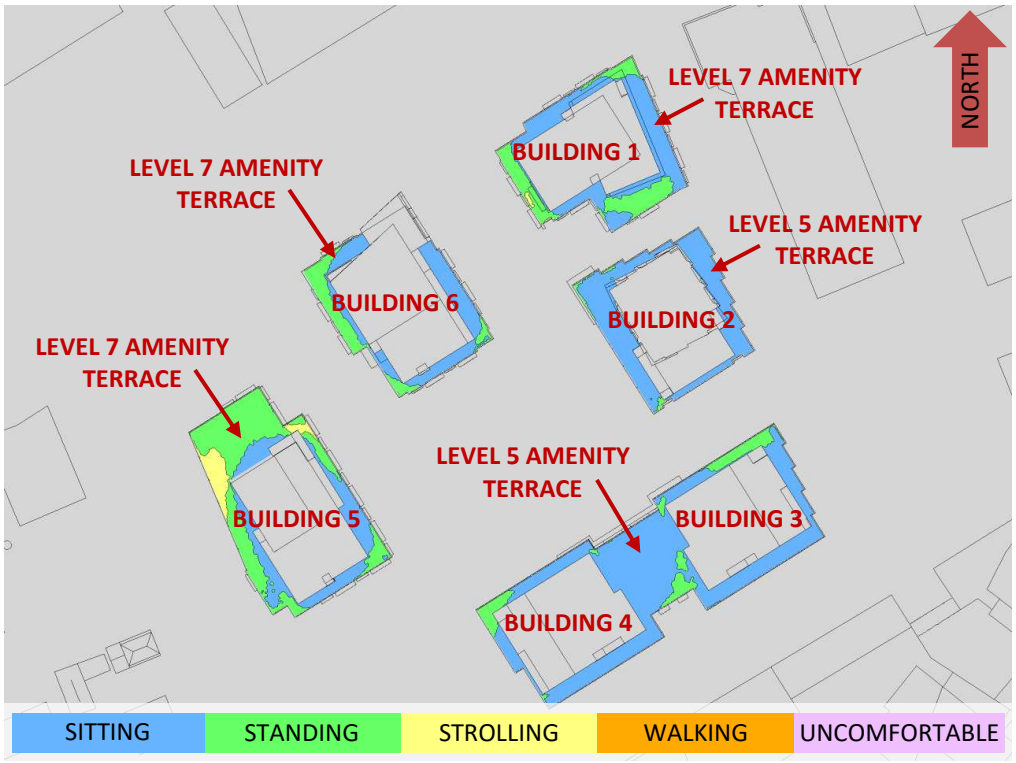

FIGURE 6: TYPICAL USE PERIOD – WIND COMFORT, COMMON AMENITY TERRACES

APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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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).

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

where, $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = 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	0.24
49	0.24
74	0.23
103	0.24
167	0.24
197	0.24
217	0.24
237	0.24
262	0.24
282	0.23
301	0.22
324	0.22

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).

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

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

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.