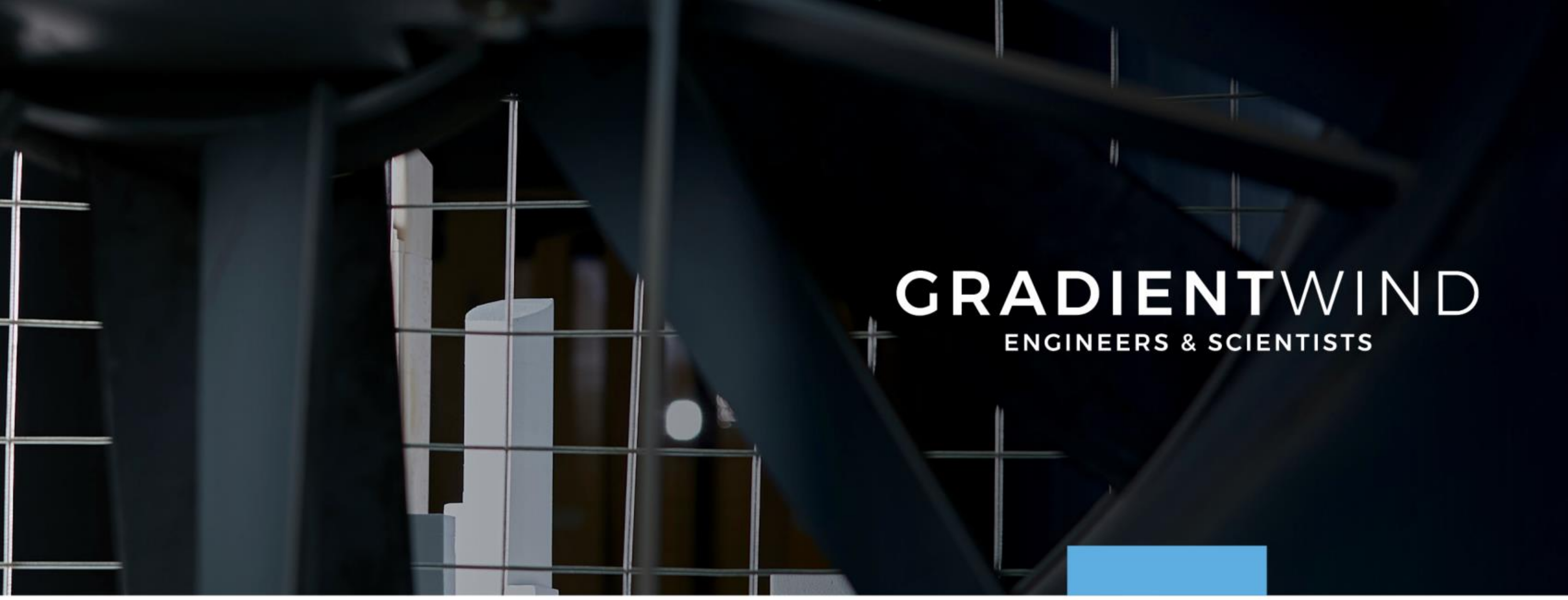
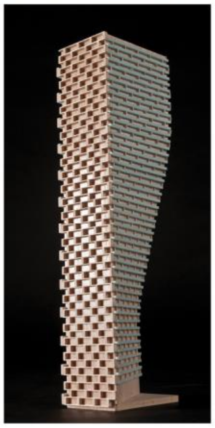
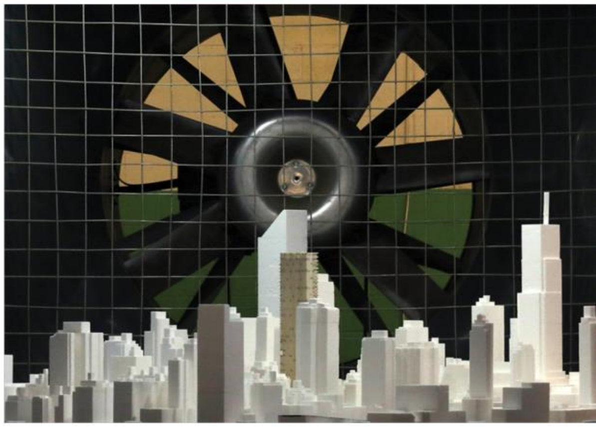



# PEDESTRIAN LEVEL WIND STUDY

1640-1660 Carling Avenue
Ottawa, Ontario

Report: 22-224-PLW





January 19, 2023

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# EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment (ZBLA) application 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-17, and summarized as follows:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, internal public streets, surface parking, walkways, the proposed laneway to the south, and in the vicinity of building access points, are considered acceptable, without mitigation. Exceptions are as follows:

    a. Public Plaza to the Northwest of the Subject Site, Public Park Central to the Subject Site, Public Park between Buildings 3 and 4:

        i. During the typical use period, wind comfort conditions within the public plaza and the public park at the centre of the subject site are mixed between sitting and standing. Wind comfort conditions during the same period within the public park between Buildings 3 and 4 are predicted to be suitable for mostly sitting, with conditions suitable for standing predicted at the southwest corner.

        ii. Depending on the programming of these spaces, the noted wind conditions may be considered acceptable. Specifically, if the noted windier areas of the public parks and plaza will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around sensitive areas. Wind barriers could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options. The extent of mitigation measures is dependent on the programming of these spaces.

b. Conditions in the vicinity of potential primary building access points along the west elevation of Building 1, the north elevation and northwest corner of Building 2, and the eastern portions of the north elevations of Buildings 3 and 4 are predicted to be suitable for standing during the summer, becoming suitable for strolling, or better, during the spring and autumn, and walking, or better, during the winter.

   i. It is recommended that primary building entrances along the noted elevations be recessed into the building façade by at least 2 m.

c. Prior to the introduction of the proposed development, 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. Following the introduction of the proposed development, wind comfort conditions within the park are predicted to be suitable for sitting within the majority of the area, with standing conditions predicted to the south and west. Where conditions are suitable for standing, they are also suitable for sitting at least 76% of the time, where the target is 80% to satisfy the sitting comfort criterion.

2) Potential common amenity terraces atop the podia roofs serving the proposed development were considered. Recommendations regarding wind mitigation are described as follows:

   a. During the typical use period, wind comfort conditions within the potential amenity terraces serving Buildings 1 and 4 at Level 5 and Building 6 at Level 7 are mixed between sitting and standing, with conditions suitable for sitting within the majority of their respective areas. Wind conditions within the Level 5 terrace serving Building 2 are mostly suitable for sitting, with limited regions of conditions suitable for standing predicted within the western portion of the terrace. Wind comfort conditions within the terrace serving Building 5 at Level 7 are predicted to be suitable for sitting within the majority of the terrace, with conditions suitable for standing to the northwest, northeast, and southwest, and strolling at the northwest and northeast corners of the terrace.

b. Depending on the programming of these terraces, these conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, then the noted wind conditions would be considered acceptable.

c. If required by programming, sitting percentages within the noted windier areas could be increased by implementing tall wind barriers around the perimeters of the terraces in combination with in-board wind barriers, which could take the form of wind screens or clusters of coniferous trees in dense arrangements, or a combination of both options, and canopies located around seating areas. The extent of mitigation measures is dependent on the programming of the terraces.

d. If mitigation in addition to perimeter wind screens is required, mitigation strategies will be developed in collaboration with the building and landscape architects. This work is expected to support the future Site Plan Control application.

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.

# TABLE OF CONTENTS

# 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 (ZBLA) application 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.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by Hobin Architecture Incorporated in December 2022, 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 one mid-rise and five 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 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 between Buildings 3 and 4.

Building 1 is a 22-storey residential rental building, inclusive of a 4-storey podium, comprising a nominally 'L'-shaped planform with its long axis-oriented along Carling Avenue. Buildings 2, 3, and 4 are near trapezoidal 30-storey, near rectangular 9-storey, and near rectangular 20-storey residential rental, seniors, and condo buildings, respectively, inclusive of 4-storey podia serving each building. Buildings 5 and 6 are trapezoidal 37-storey and nominally rectangular 40-storey mixed-use rental buildings, respectively, inclusive of 6-storey podia serving each building. The podium roof levels of Buildings 1, 2, 4, 5, and 6 were considered as potential common amenity terraces. As the setback of the tower serving Building 3 is less than 4 m at Level 5, the podium roof of Building 3 was not considered as a potential outdoor amenity terrace.

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 (ZBLA) at 861 Clyde Avenue North, to the immediate south of the subject site, a development comprising two towers (16 and 18 storeys) is approved (Site Plan Control) 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 (Site Plan Control) 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.

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 study 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[1]. 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 study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

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

## 4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of 550 m. The process was performed for two context massing scenarios, as noted in Section 2.

Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds

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

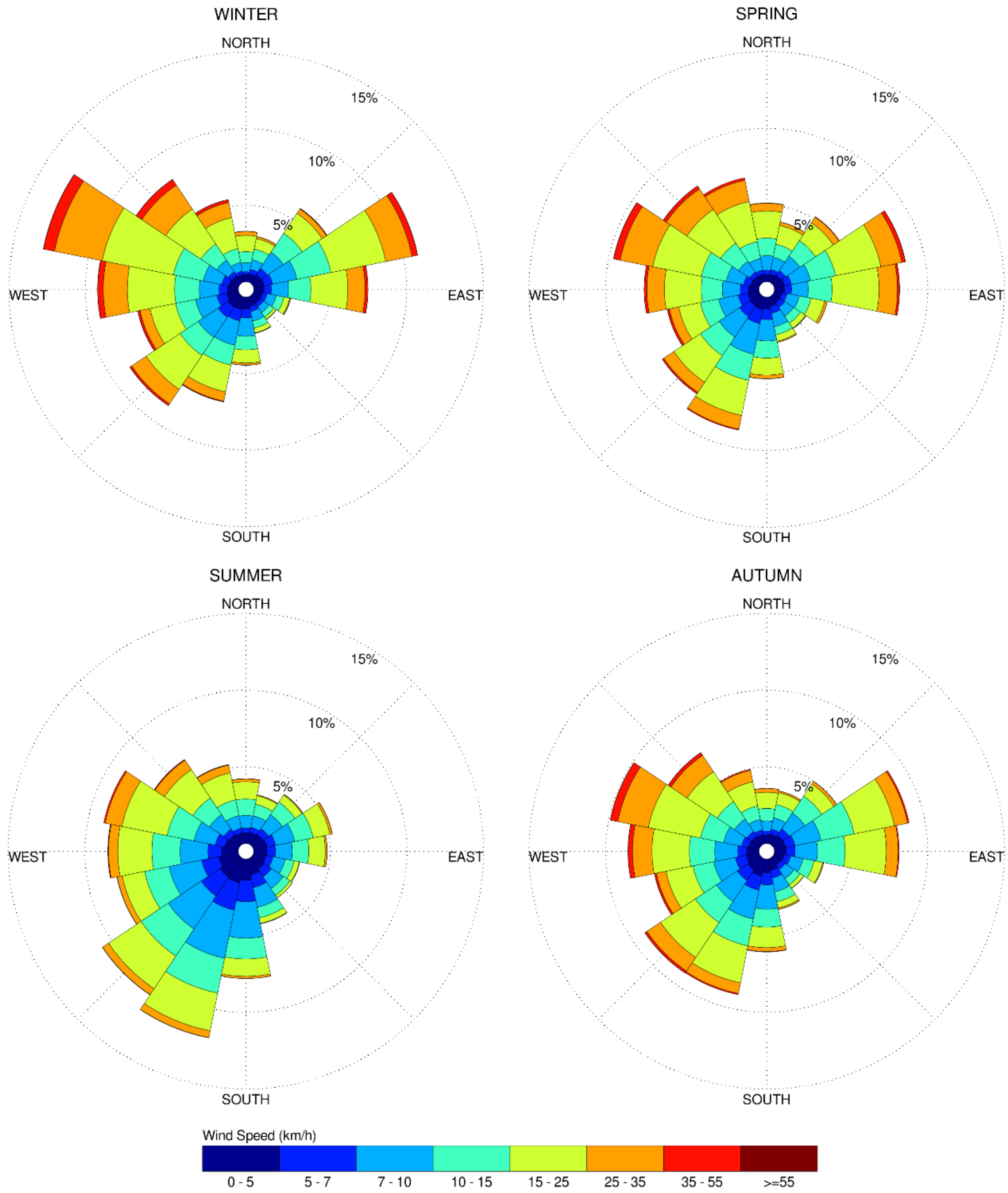
approximately 1.5 m above local grade and the potential common amenity terraces serving the proposed development were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. Gradient height represents the theoretical depth 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 preferred 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 preference 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 Comfort and Safety Criteria – City of Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (that is, temperature, relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 20% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** 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.

2) **Standing:** 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.

3) **Strolling:** 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.

4) **Walking:** 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.

5) **Uncomfortable:** 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.

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. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because 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.

### THE BEAUFORT SCALE

| Number | Description | Gust Wind Speed (km/h) | Description |
|---|---|---|---|
| 2 | Light Breeze | 9-17 | Wind felt on faces |
| 3 | Gentle Breeze | 18-29 | Leaves and small twigs in constant motion; wind extends light flags |
| 4 | Moderate Breeze | 30-42 | Wind raises dust and loose paper; small branches are moved |
| 5 | Fresh Breeze | 43-57 | Small trees in leaf begin to sway |
| 6 | Strong Breeze | 58-74 | Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty |
| 7 | Moderate Gale | 75-92 | Whole trees in motion; inconvenient walking against wind |
| 8 | Gale | 93-111 | Breaks twigs off trees; generally impedes progress |

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 speeds 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 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 desired 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 desired comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

**DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES**

| Location Types | Desired Comfort Classes |
|---|---|
| Primary Building Entrance | Standing |
| Secondary Building Access Point | Walking |
| Public Sidewalk / Bicycle Path | Walking |
| Outdoor Amenity Space | Sitting (Typical Use Period) |
| Café / Patio / Bench / Garden | Sitting (Typical Use Period) |
| Transit Stop (Without Shelter) | Standing |
| Transit Stop (With Shelter) | Walking |
| Public Park / Plaza | Sitting (Typical Use Period) |
| 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, 10A-10D, 12A-12D, 14A-14D, and 16A-16D illustrating wind conditions over the potential common amenity terraces serving Buildings 1, 2, 4, 5, and 6, respectively, 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. 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.

Wind comfort conditions at grade level, and within the noted potential amenity terraces are also reported for the typical use period, which is defined as May to October, inclusive. Figure 7 and Figures 9, 11, 13, 15, and 17 illustrate wind comfort conditions at grade and within the noted potential common amenity terraces, 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, Transit Stops, and Existing Surface Parking Along Carling Avenue and Clyde Avenue North:** Following the introduction of the proposed development, conditions over the sidewalks along Carling Avenue 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, with an isolated region suitable for walking during the winter at the northeast corner of Building 6. Conditions over the existing surface parking lots to the north of Carling Avenue are predicted to be suitable for standing, or better, throughout the year. Conditions over the sidewalks and existing parking lots along Clyde Avenue North are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing with an isolated region suitable for strolling during the spring and autumn, and suitable for a mix of standing and strolling with an isolated region suitable for walking during the winter. Conditions in the vicinity of the nearby transit stops along Carling Avenue and Clyde Avenue North are predicted to be suitable for sitting during the summer, becoming suitable standing or better throughout the remainder of the year. The noted conditions are considered acceptable.

Conditions over the sidewalks along Carling 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. Conditions in the vicinity of the nearby transit stops and existing surface parking lots along Carling Avenue and along Clyde Avenue North, and along the public sidewalks along Clyde Avenue North are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable for public sidewalks, transit stops, and surface parking lots.

**Existing Parking Lot East of Subject Site:** Following the introduction of the proposed development, conditions over the existing parking lot to the east of the subject site are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year, with an isolated region of strolling during the winter. The noted conditions are considered acceptable.

Conditions over the noted parking lot 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 in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable for parking lots.

**Proposed Laneway South of Subject Site:** Conditions over the laneway serving 861 Clyde Avenue North 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. Following the introduction of the proposed development, these conditions remain mostly similar, with conditions within the noted laneway predicted to be suitable mostly for 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.

**City Park Southwest of Subject Site:** Prior to the introduction of the proposed development, 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. Following the introduction of the proposed development, wind comfort conditions within the park are predicted to be suitable for sitting within the majority of the area, with standing conditions predicted to the south and west. Where conditions are suitable for standing, they are also suitable for sitting at least 76% of the time, where the target is 80% to satisfy the sitting comfort criterion.

**Internal Public Streets:** Conditions over the internal public streets, walkways, and surface parking spaces within the subject site are predicted to be suitable for standing, or better, during the summer, becoming suitable for mostly a mix of standing and strolling during the spring and autumn, and suitable for a mix of standing, strolling, and walking during the winter. The noted conditions are considered acceptable.

**Building Access Points:** Conditions in the vicinity of potential primary building access points along the west elevation of Building 1, the north elevation and northwest corner of Building 2, and the eastern portions of the north elevations of Buildings 3 and 4 are predicted to be suitable for standing during the summer, becoming suitable for strolling, or better, during the spring and autumn, and walking, or better, during the winter. To achieve the standing comfort class in the vicinity of primary building entrances serving Buildings 1, 2, 3, and 4 along the noted elevations, it is recommended that any primary building entrances along the noted elevations be recessed into the building façades by at least 2 m.

Conditions in the vicinity of all remaining building access points serving the proposed development are predicted to be suitable for standing, or better, throughout the year, which is considered acceptable.

**Public Plaza and Public Parks:** During the typical use period, wind comfort conditions within the public plaza situated at the northwest corner of the subject site are predicted to be suitable for sitting to the east and south, and suitable for standing throughout the remainder of the area, as illustrated in Figure 7. Where conditions are suitable for standing, they are also suitable for sitting at least 65% of the time during the same period, where the target is 80% to satisfy the sitting comfort criterion.

Wind comfort conditions during the typical use period within the public park situated central to the subject site are predicted to be mixed between sitting and standing. Specifically, conditions suitable for standing are predicted to the east, south, and northwest, as illustrated in Figure 7. During the same period, where conditions are suitable for standing, they are also suitable for sitting at least 70% of the time near the northeast and southeast corners, and at least 65% of the time at the northwest corner, where the target is 80% to satisfy the sitting comfort criterion.

During the typical use period, wind comfort conditions within the public park situated between Buildings 3 and 4 are predicted to be suitable for mostly sitting, with conditions suitable for standing predicted at the southwest corner, as illustrated in Figure 7. Where conditions are suitable for standing, they are also suitable for sitting at least 75% of the time during the same period, where the target is 80% to satisfy the sitting comfort criterion.

Depending on the programming of these spaces, the noted wind conditions may be considered acceptable. Specifically, if the noted windier areas of the public parks and plaza will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around sensitive areas. Wind barriers could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options. The extent of mitigation measures is dependent on the programming of these spaces.

## 5.2 Wind Comfort Conditions – Common Amenity Terraces

The rooftops of the podia serving Buildings 1, 2, 4, 5, and 6 were considered as potential common amenity terraces. Wind conditions for these amenity terraces are described as follows:

**Building 1, Level 5 Amenity Terrace**: During the typical use period, wind comfort conditions within the potential Level 5 amenity terrace serving Building 1 are predicted to be mixed between sitting and standing, as illustrated in Figure 9. Specifically, the east and north elevations of the podium roof are predicted to be suitable for sitting; the remaining roof areas are predicted to be suitable for standing. The areas that are predicted to be suitable for standing, according to the comfort criteria in Section 4.4, are also predicted to be suitable for sitting at least 70% of the time during the same period, where the target is 80% to achieve the sitting comfort criterion.

**Building 2, Level 5 Amenity Terrace**: During the typical use period, conditions over the potential Level 5 amenity terrace serving Building 2 are predicted to be suitable for sitting within the majority of the area, with isolated regions of conditions suitable for standing predicted to occur to the west, as illustrated in Figure 11. During the same period, where conditions are suitable standing, they are also suitable for sitting at least 79%, 78%, and 70% of the time to the west, at the northwest corner, and at the southwest corner of the terrace, respectively, where the target is 80% to meet the sitting comfort criterion.

**Building 4, Level 5 Amenity Terrace**: During the typical use period, conditions over the potential Level 5 amenity terrace serving Building 4 are predicted to be suitable for sitting within the majority of the terrace, as illustrated in Figure 13. Specifically, conditions suitable for standing are predicted along the west elevation and at the northwest corner of the podium roof; the remaining roof areas are predicted to be suitable for sitting. During the same period, where conditions are suitable standing, they are also suitable for sitting at least 75% and 70% of the time along the north perimeter and west elevation of the podium roof, respectively, where the target is 80% to meet the sitting comfort criterion.

**Building 5, Level 7 Amenity Terrace**: During the typical use period, conditions over the potential amenity terrace serving Building 5 at Level 7 are predicted to be suitable for sitting within the majority of the area, with conditions suitable for standing to the northwest, northeast, and southwest, and strolling at the northwest and northeast corners of the terrace, as illustrated in Figure 15. During the same period, where conditions are suitable standing, they are also suitable for sitting at least 70%, 65%, and 60% of the time at the southwest corner, at the northeast corner, and at the northwest corner of the terrace, respectively, where the target is 80% to meet the sitting comfort criterion.

**Building 6, Level 7 Amenity Terrace**: During the typical use period, conditions over the potential common amenity terrace serving Building 6 at Level 7 are predicted to be suitable for sitting within the majority of the terrace. Specifically, conditions suitable for standing are predicted along the west elevation and at the northeast and southeast corners of the terrace, as illustrated in Figure 17. During the same period, where conditions are suitable standing, they are also suitable for sitting at least 70% along the west elevation and at the northeast and southeast corners, and 65% of the time at the southwest corner of the terrace, where the target is 80% to meet the sitting comfort criterion.

Depending on the programming of these potential common amenity terraces serving the proposed development, these conditions may be considered acceptable. Specifically, if the noted windier areas of the terraces will not accommodate seating or lounging activities, then the noted wind conditions would be considered acceptable.

If required by the programming of the terraces, sitting percentages within the noted windier areas could be increased by implementing tall wind barriers around the perimeters of the terraces in combination with in-board wind barriers, which could take the form of wind screens or clusters of coniferous trees in dense arrangements, or a combination of both options, and canopies located around seating areas. Specifically, a 1.8-m-tall wind barrier, typically glazed, may be installed along the full perimeter of the terraces serving Buildings 1 and 6, the northwest, southwest, and west perimeters of the terrace serving Building 2, and the southwest, west, and northeast perimeters of the terrace serving Building 4, and a full perimeter wind screen, extending at least 2 m above the local walking surface, may be installed around the perimeter of the terrace serving Building 5 to extend sitting conditions. Additionally, to control wind acceleration at the corners of the tower serving Building 5, inboard wind screens may be introduced to interrupt wind flow; the wind screens should extend at least 1.8 m above the walking surface of the terrace. The extent of mitigation measures is dependent on the programming of the terraces.

If mitigation in addition to perimeter wind screens is required, mitigation strategies will be developed in collaboration with the building and landscape architects. This work is expected to support the future Site Plan Control application.

## 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-17. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, internal public streets, surface parking, walkways, the proposed laneway to the south, and in the vicinity of building access points, are considered acceptable, without mitigation. Exceptions are as follows:

    a. Public Plaza to the Northwest of the Subject Site, Public Park Central to the Subject Site, Public Park between Buildings 3 and 4:

        i. During the typical use period, wind comfort conditions within the public plaza and the public park at the centre of the subject site are mixed between sitting and standing. Wind comfort conditions during the same period within the public park between Buildings 3 and 4 are predicted to be suitable for mostly sitting, with conditions suitable for standing predicted at the southwest corner.

ii. Depending on the programming of these spaces, the noted wind conditions may be considered acceptable. Specifically, if the noted windier areas of the public parks and plaza will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around sensitive areas. Wind barriers could take the form of wind screens, clusters of coniferous trees in dense arrangements, or a combination of both options. The extent of mitigation measures is dependent on the programming of these spaces.

b. Conditions in the vicinity of potential primary building access points along the west elevation of Building 1, the north elevation and northwest corner of Building 2, and the eastern portions of the north elevations of Buildings 3 and 4 are predicted to be suitable for standing during the summer, becoming suitable for strolling, or better, during the spring and autumn, and walking, or better, during the winter.

    i. It is recommended that primary building entrances along the noted elevations be recessed into the building façade by at least 2 m.

c. Prior to the introduction of the proposed development, 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. Following the introduction of the proposed development, wind comfort conditions within the park are predicted to be suitable for sitting within the majority of the area, with standing conditions predicted to the south and west. Where conditions are suitable for standing, they are also suitable for sitting at least 76% of the time, where the target is 80% to satisfy the sitting comfort criterion.

2) Potential common amenity terraces atop the podia roofs serving the proposed development were considered. Recommendations regarding wind mitigation are described as follows:

   a. During the typical use period, wind comfort conditions within the potential amenity terraces serving Buildings 1 and 4 at Level 5 and Building 6 at Level 7 are mixed between sitting and standing, with conditions suitable for sitting within the majority of their respective areas. Wind conditions within the Level 5 terrace serving Building 2 are mostly suitable for sitting, with limited regions of conditions suitable for standing predicted within the western portion of the terrace. Wind comfort conditions within the terrace serving Building 5 at Level 7 are predicted to be suitable for sitting within the majority of the terrace, with conditions suitable for standing to the northwest, northeast, and southwest, and strolling at the northwest and northeast corners of the terrace.

   b. Depending on the programming of these terraces, these conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, then the noted wind conditions would be considered acceptable.

   c. If required by programming, sitting percentages within the noted windier areas could be increased by implementing tall wind barriers around the perimeters of the terraces in combination with in-board wind barriers, which could take the form of wind screens or clusters of coniferous trees in dense arrangements, or a combination of both options, and canopies located around seating areas. The extent of mitigation measures is dependent on the programming of the terraces.

   d. If mitigation in addition to perimeter wind screens is required, mitigation strategies will be developed in collaboration with the building and landscape architects. This work is expected to support the future Site Plan Control application.

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.***

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Jan 19, 2022
PROVINCE OF ONTARIO

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Project Coordinator


**GRADIENTWIND**
ENGINEERS & SCIENTISTS

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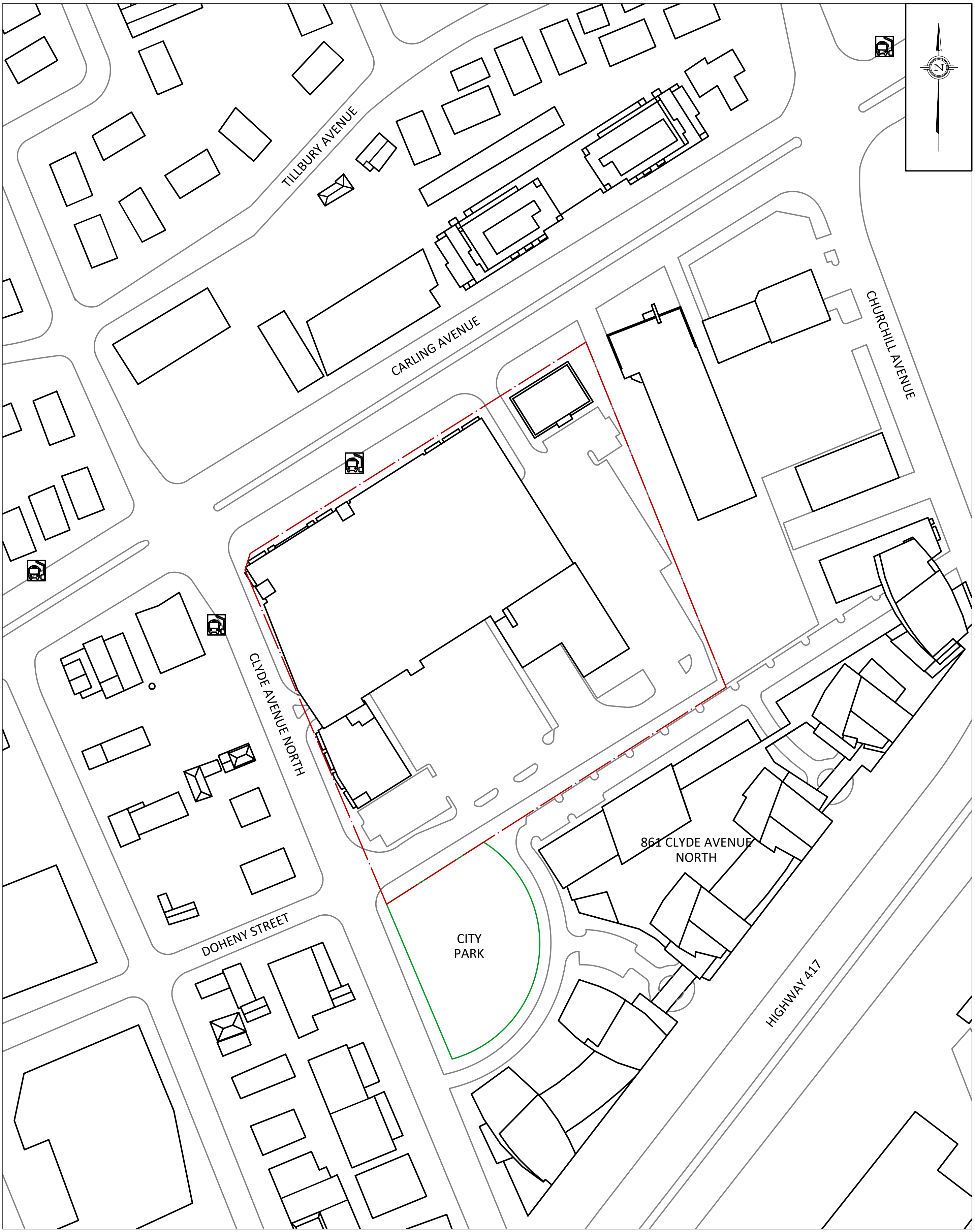
| | | | |
|---|---|---|---|
| PROJECT | 1640-1660 CARLING AVENUE, OTTAWA<br>PEDESTRIAN LEVEL WIND STUDY | | |
| SCALE | 1:2000 | DRAWING NO. | 22-224-PLW-1A |
| DATE | JANUARY 19, 2023 | DRAWN BY | S.K. |

DESCRIPTION

FIGURE 1A:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT

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| PROJECT | 1640-1660 CARLING AVENUE, OTTAWA<br>PEDESTRIAN LEVEL WIND STUDY | | |
| SCALE | 1:2000 | DRAWING NO. | 22-224-PLW-1B |
| DATE | JANUARY 19, 2023 | DRAWN BY | S.K. |

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

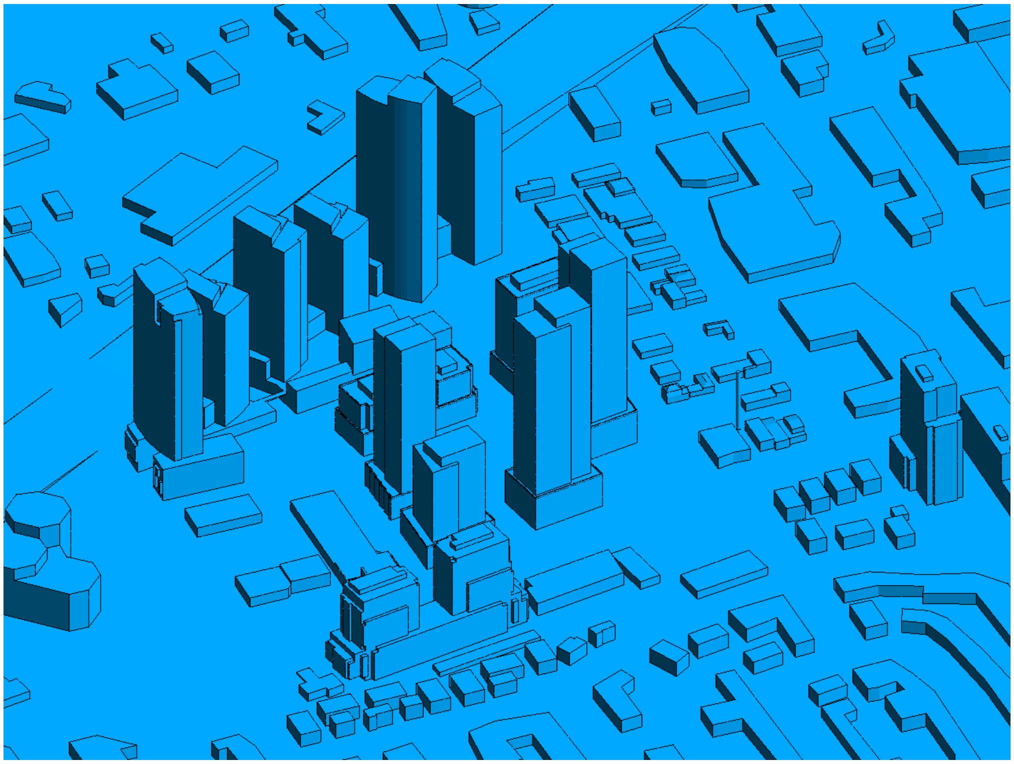


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

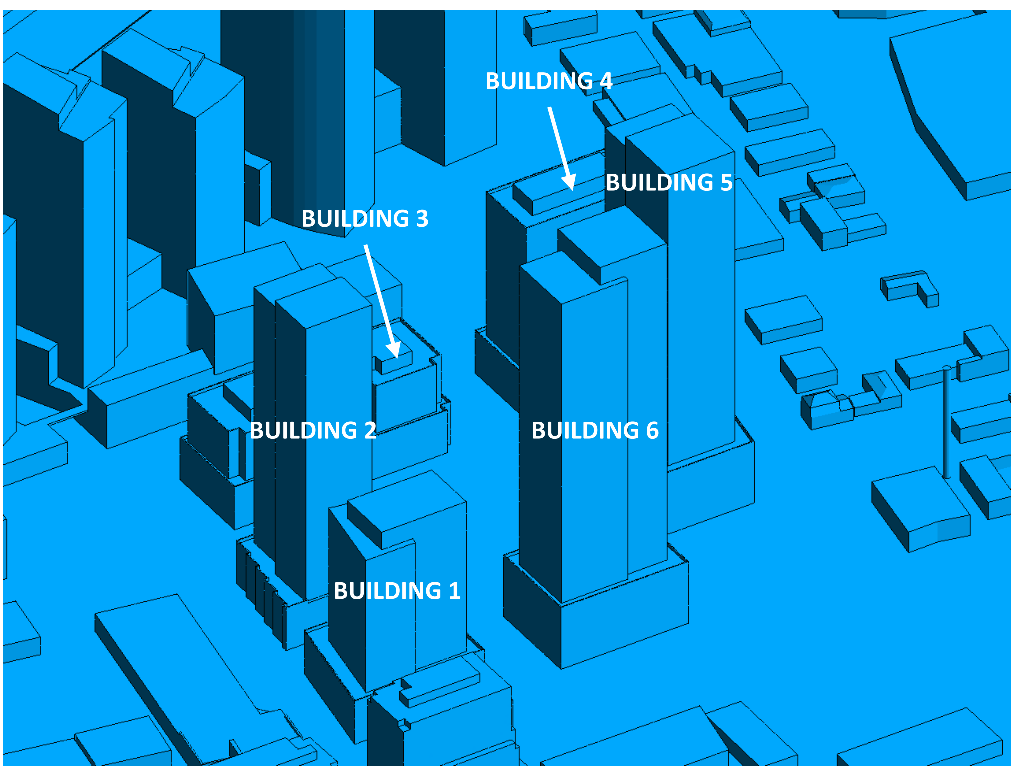



FIGURE 2B: CLOSE UP OF FIGURE 2A

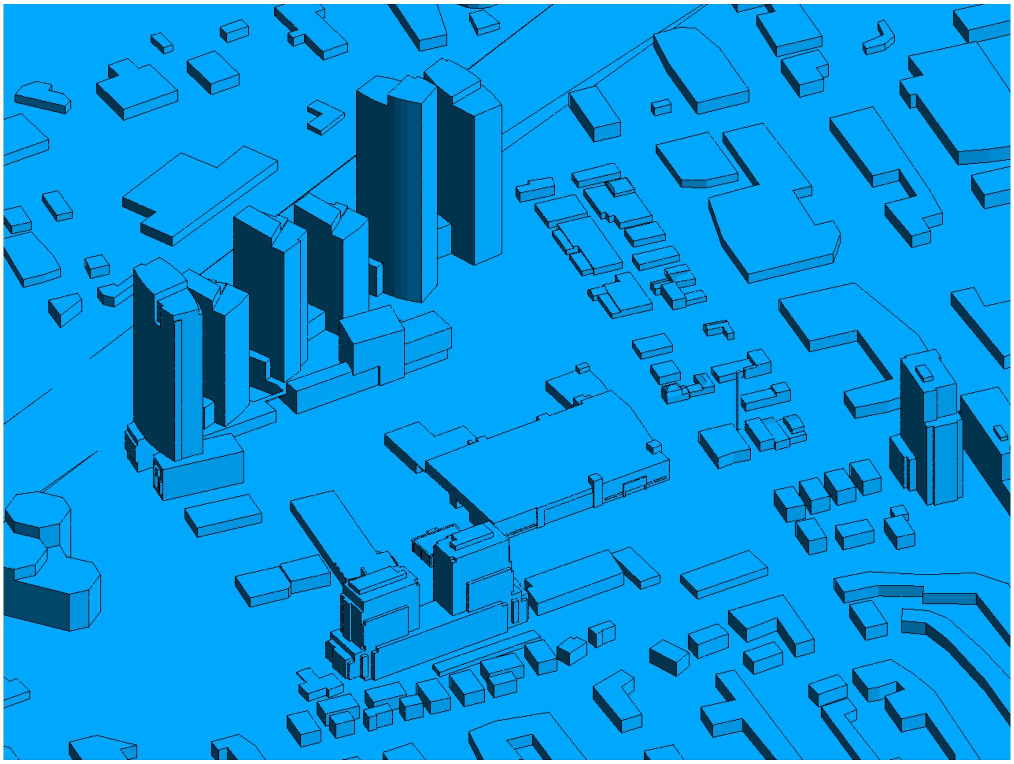


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

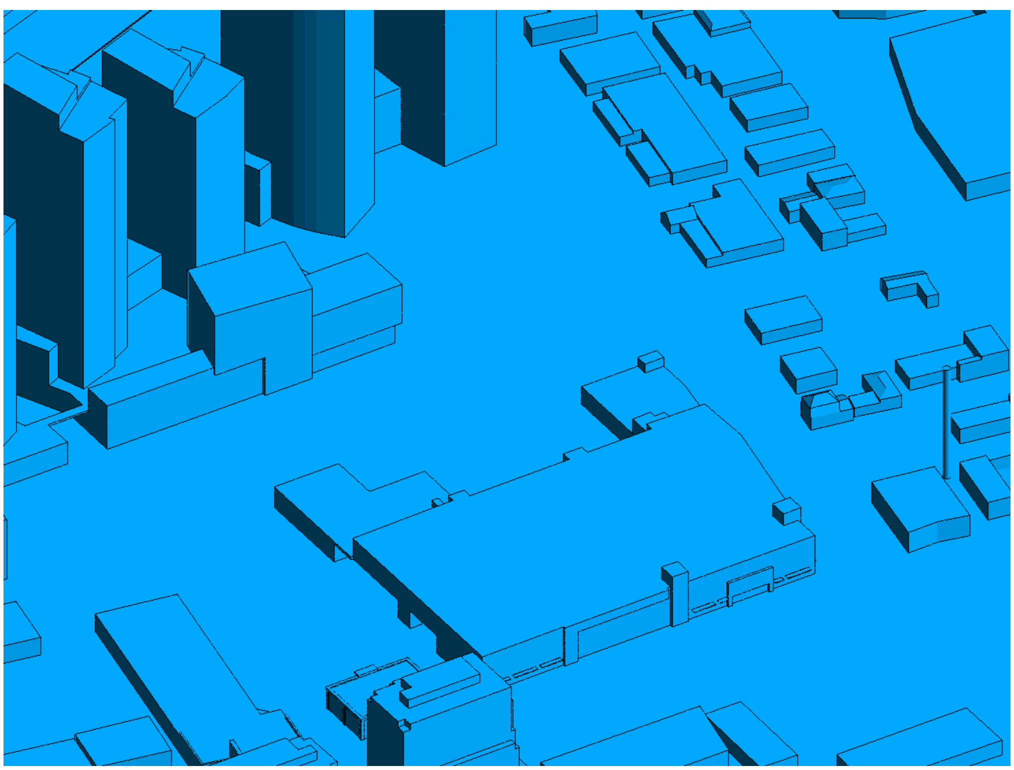


FIGURE 2D: CLOSE UP OF FIGURE 2C

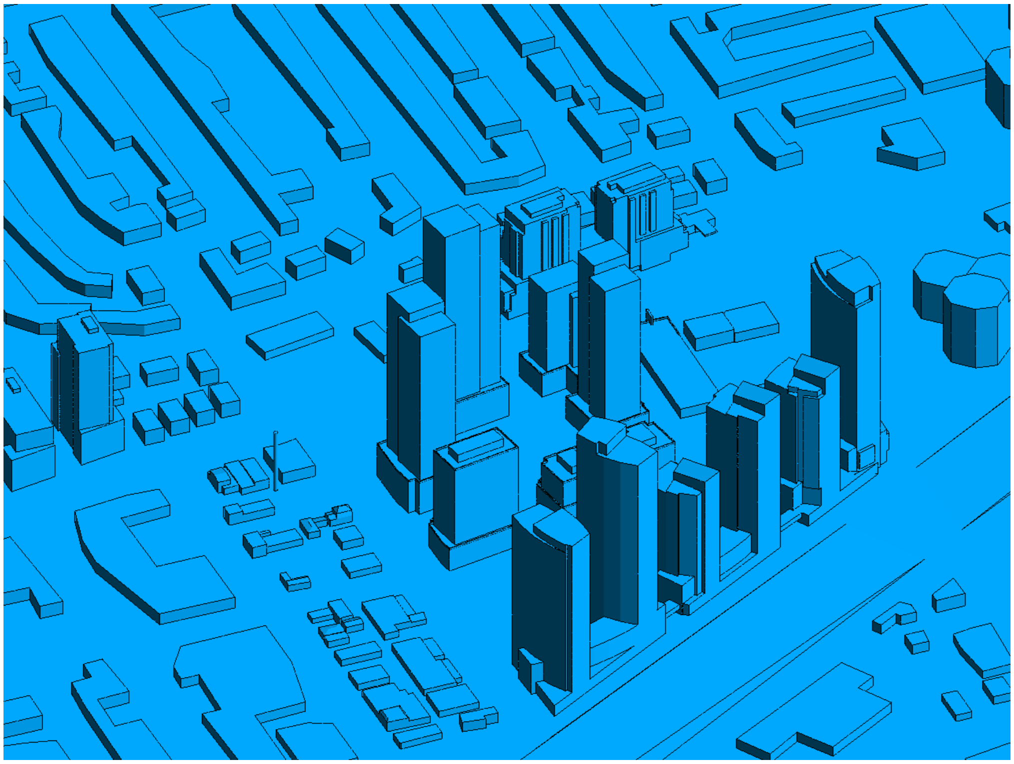


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

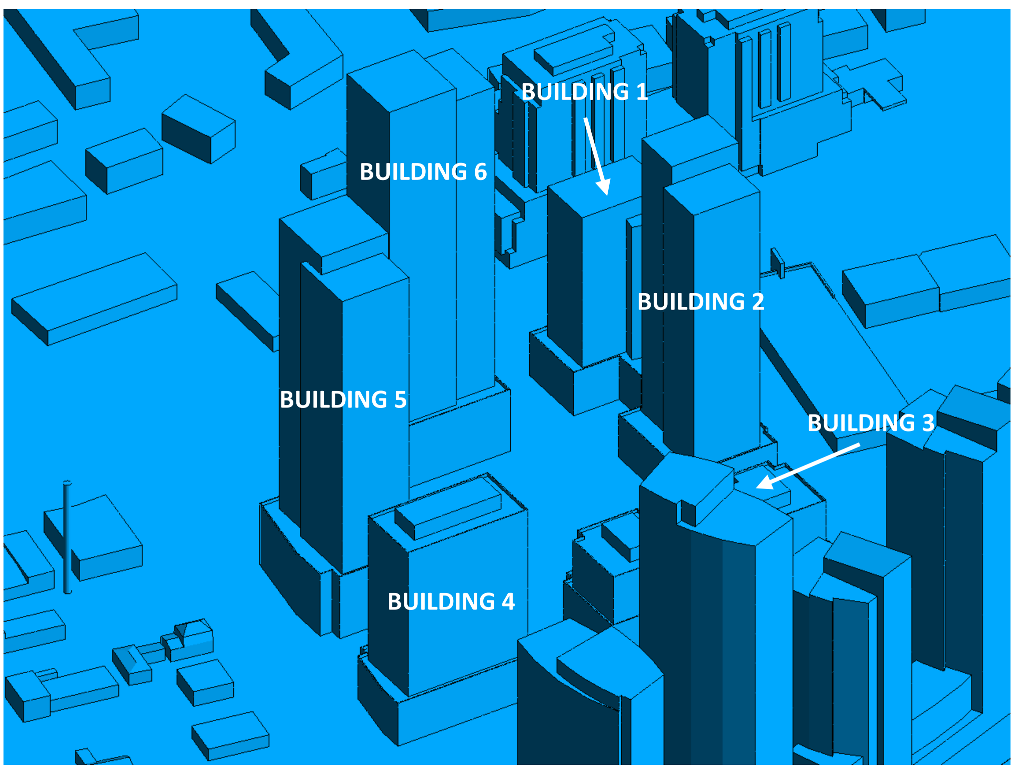



FIGURE 2F: CLOSE UP OF FIGURE 2E

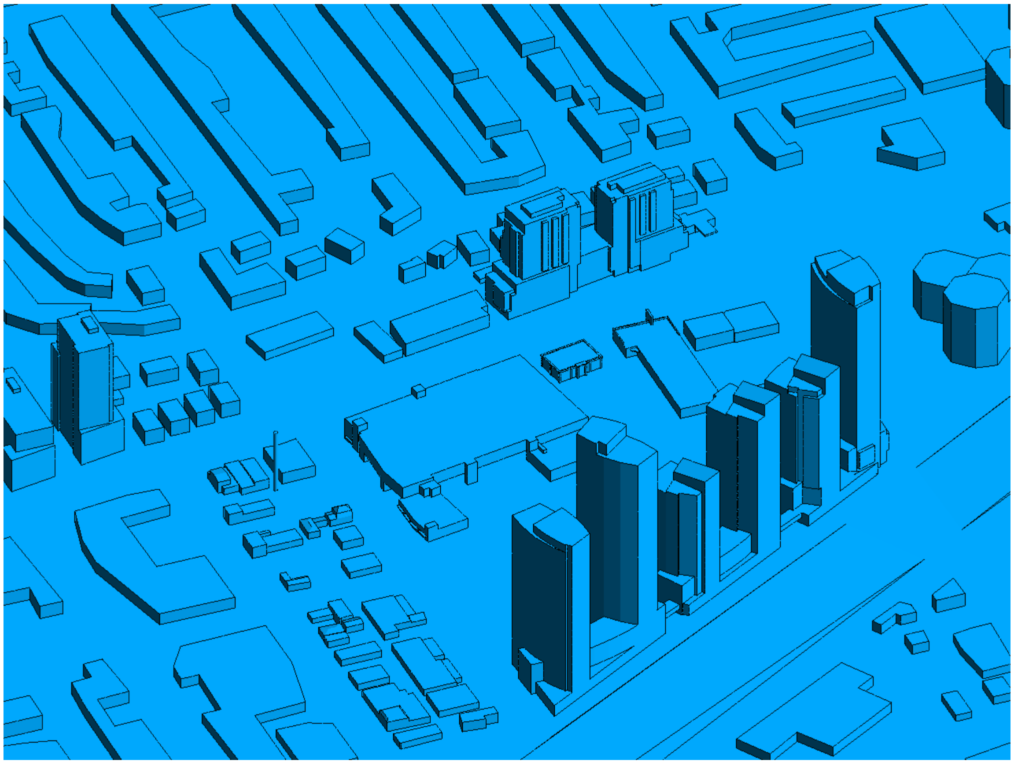


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

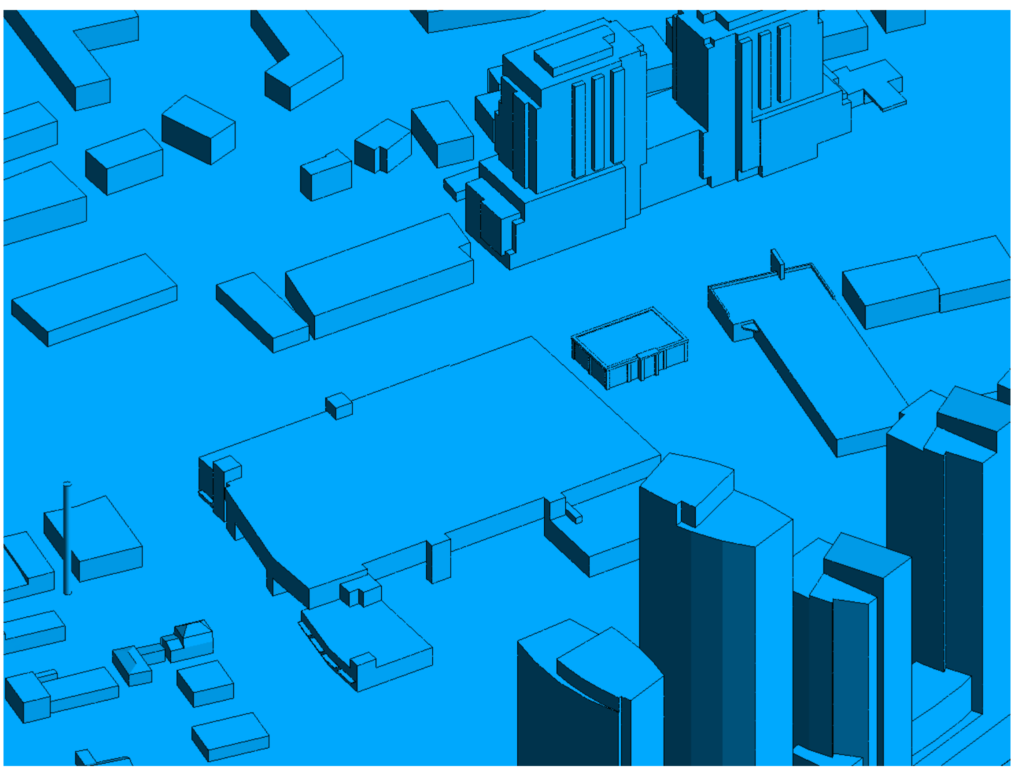


FIGURE 2H: CLOSE UP OF FIGURE 2G

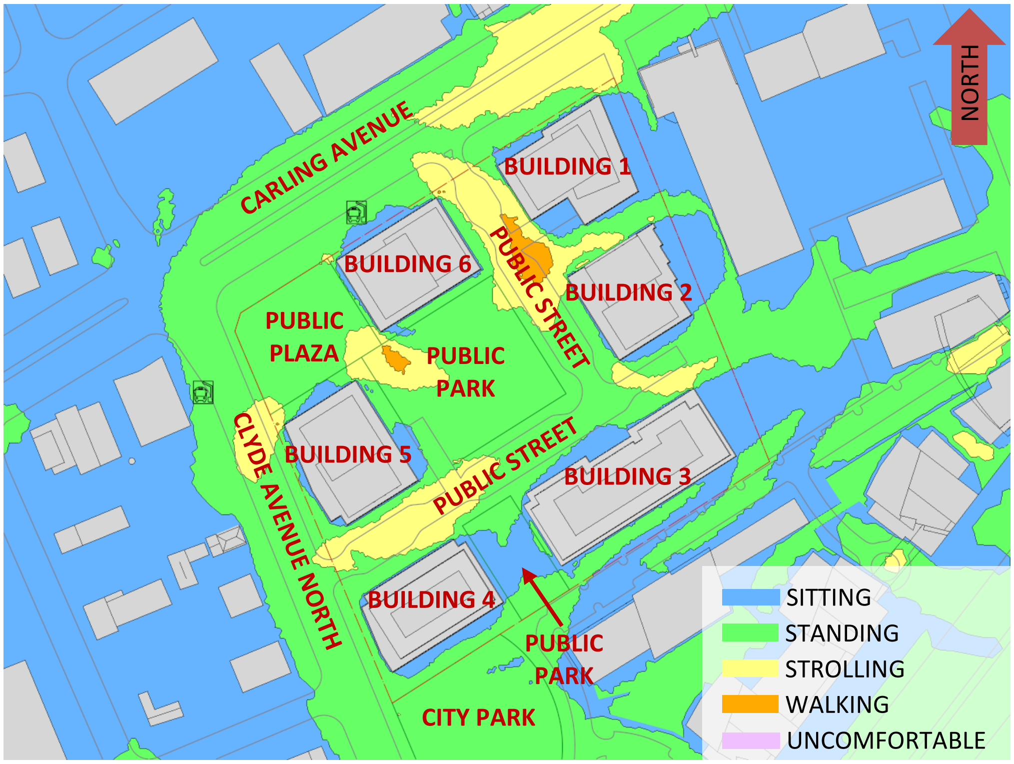



**FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**

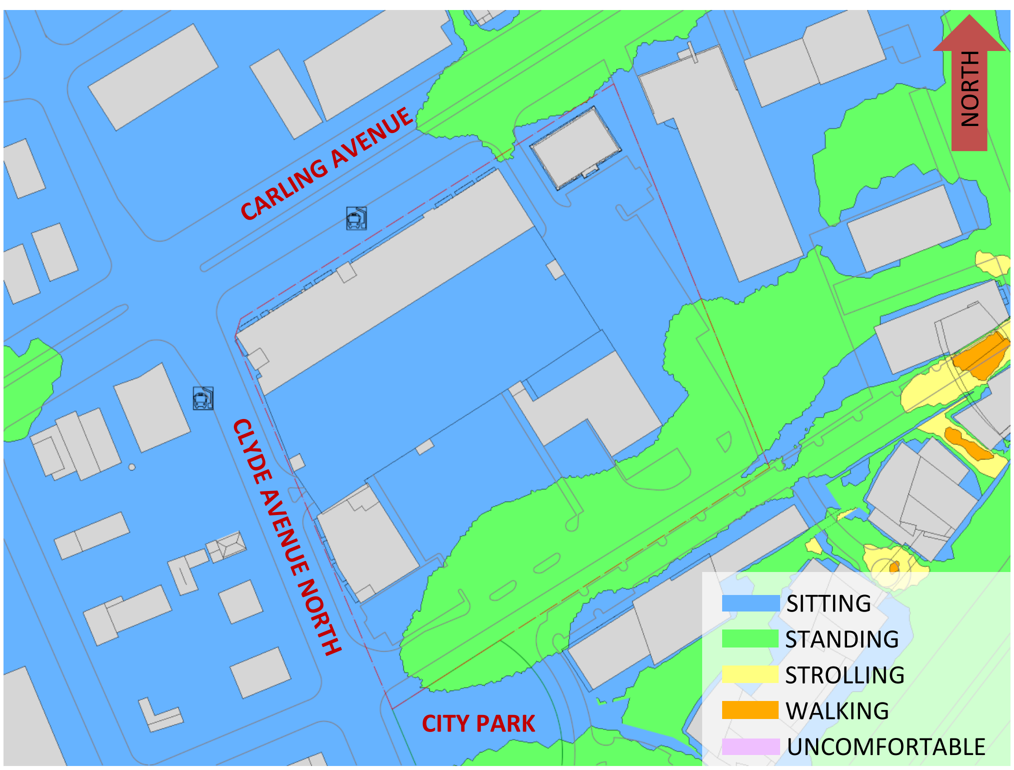



**FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL – EXISTING MASSING**

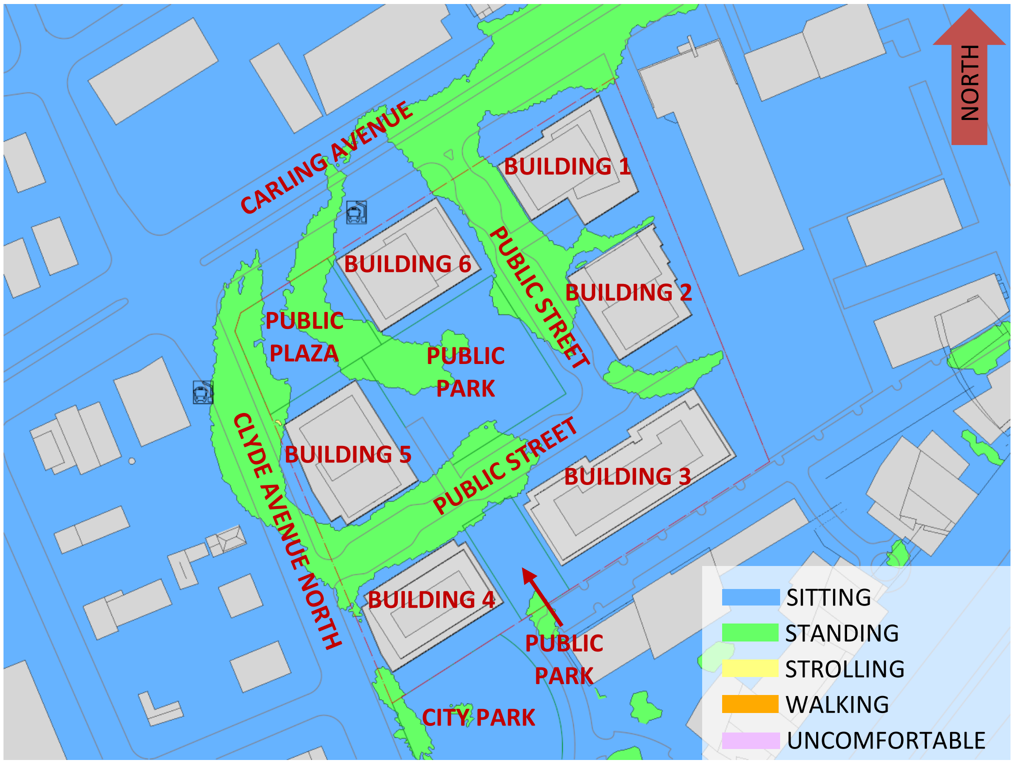



**FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**


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

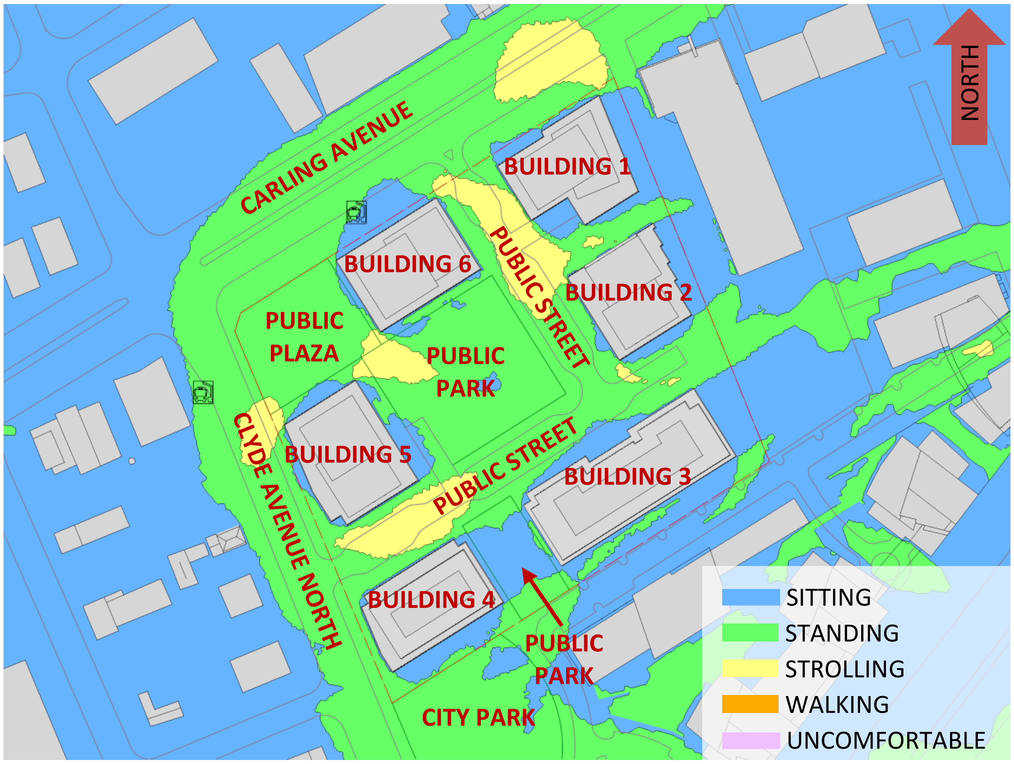



**FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**

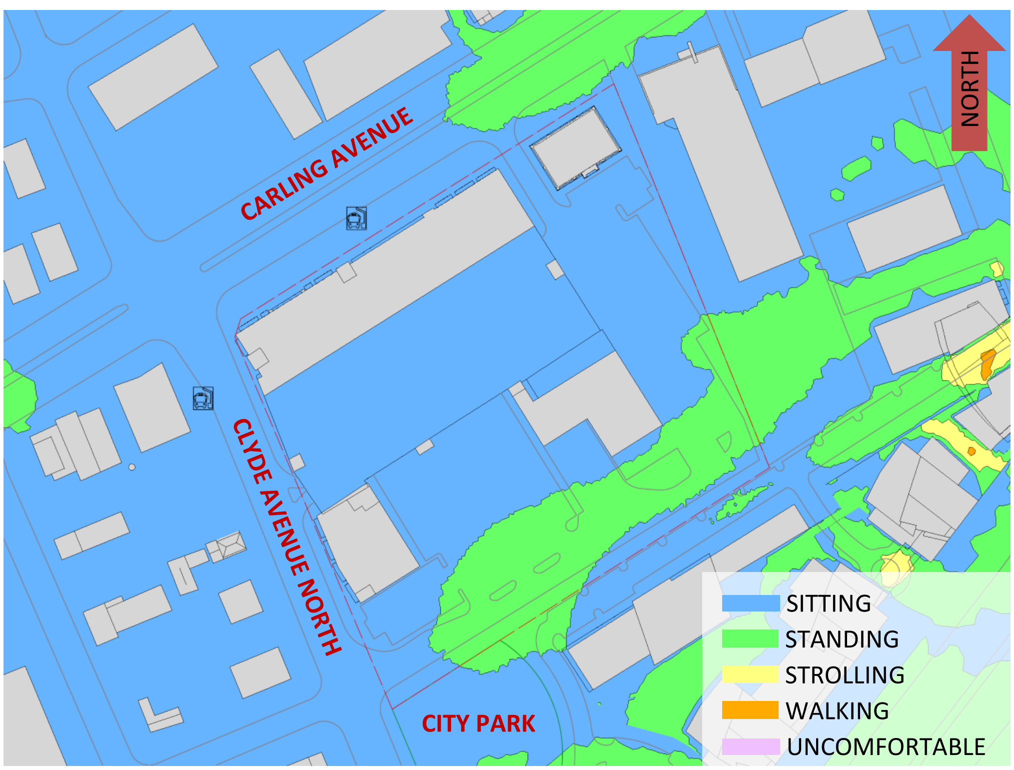



**FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL – EXISTING MASSING**

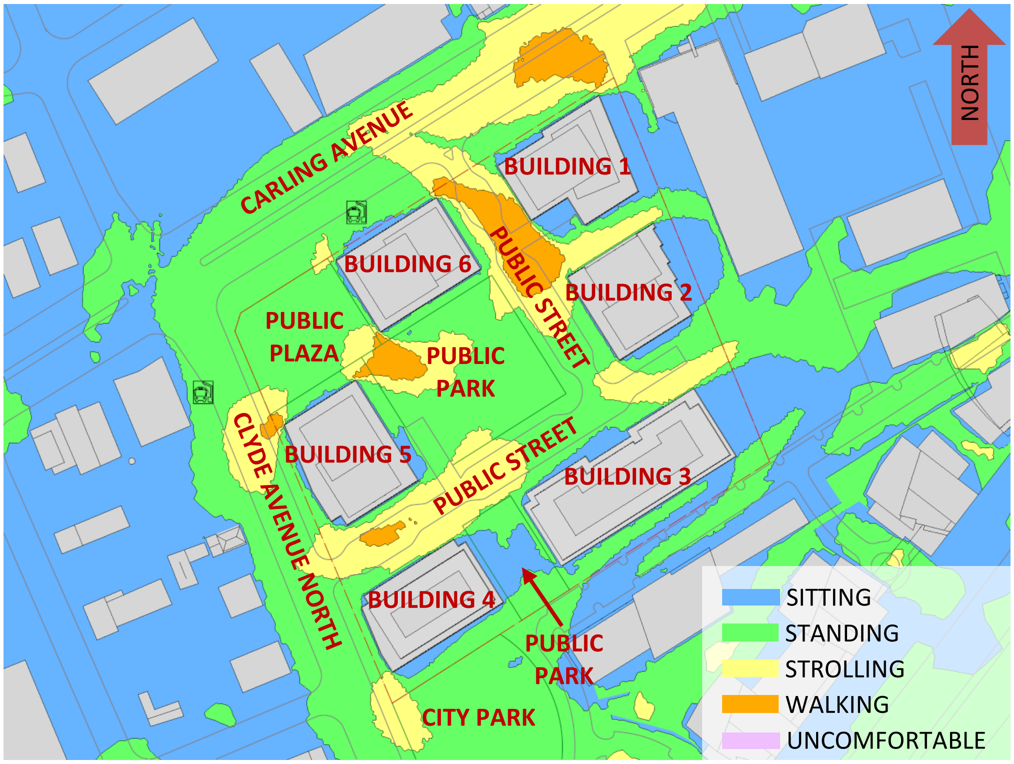



**FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**

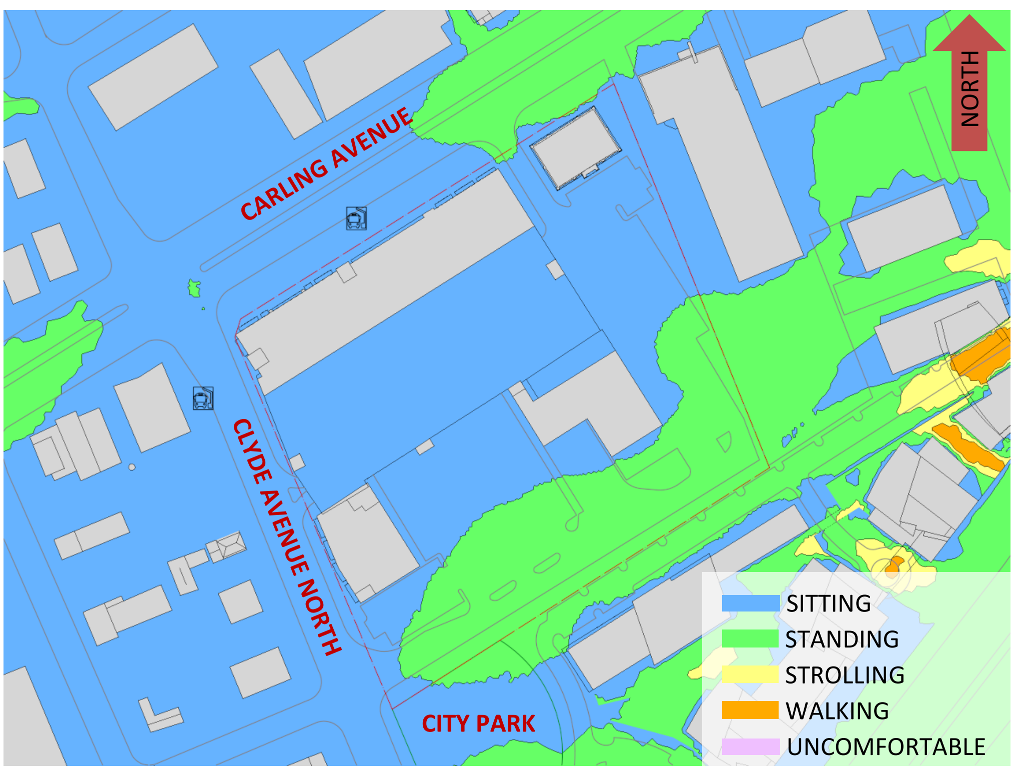



**FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING**

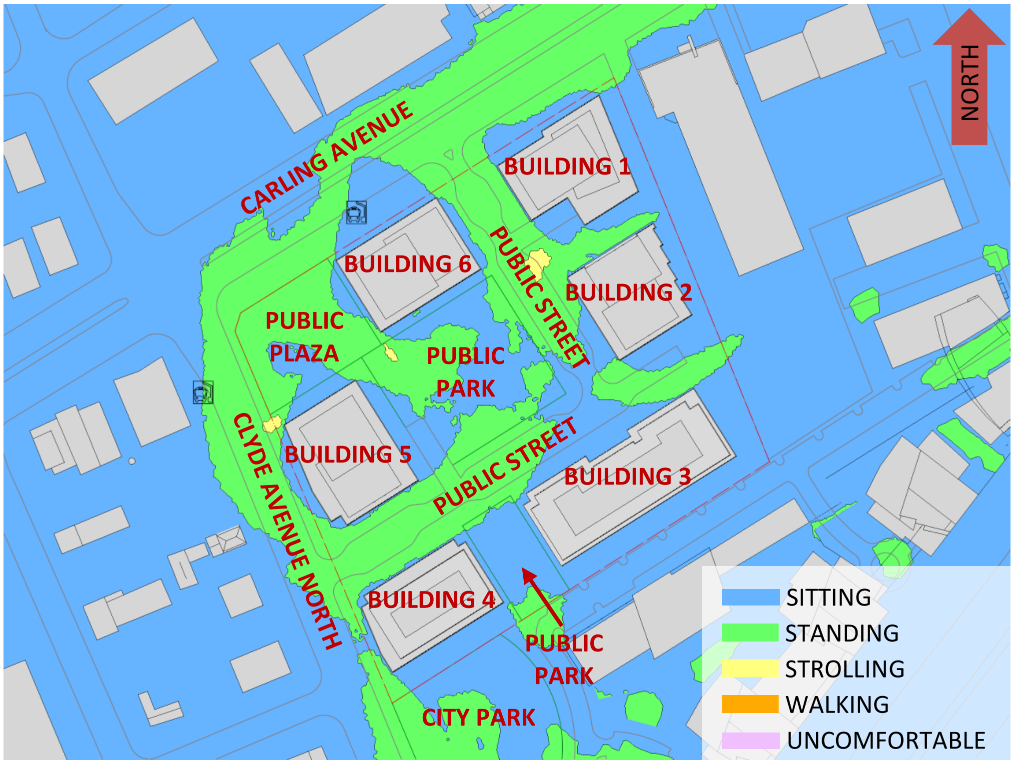



**FIGURE 7: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**

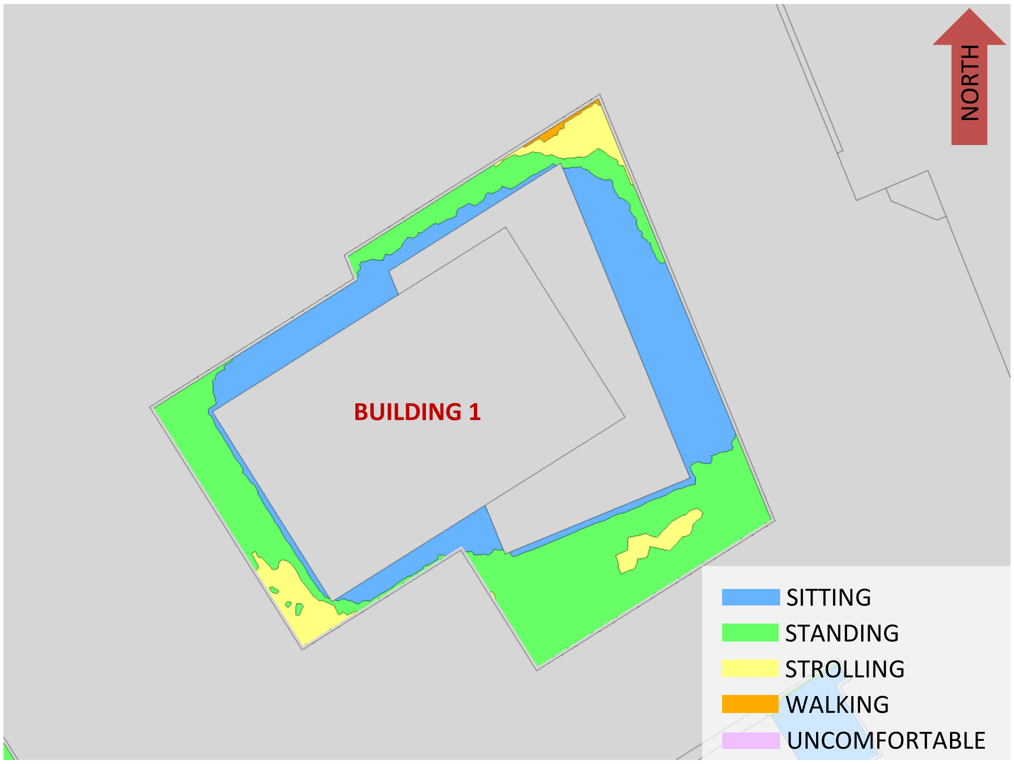



**FIGURE 8A: SPRING – WIND COMFORT, BUILDING 1 LEVEL 5 AMENITY TERRACE**

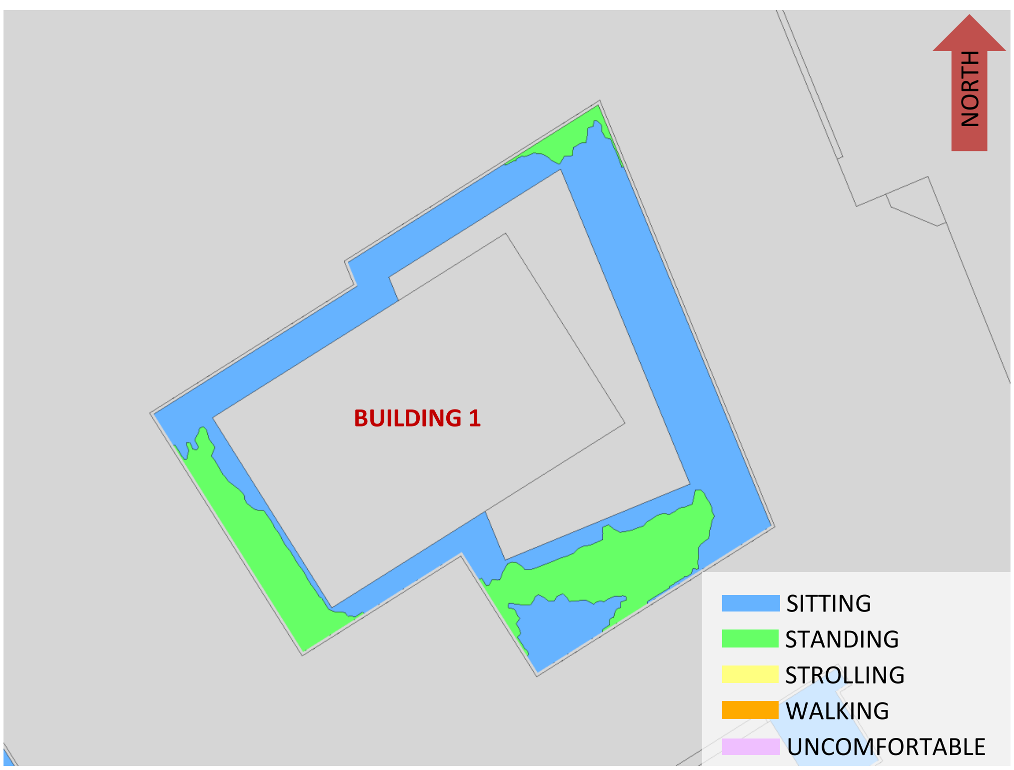



**FIGURE 8B: SUMMER – WIND COMFORT, BUILDING 1 LEVEL 5 AMENITY TERRACE**

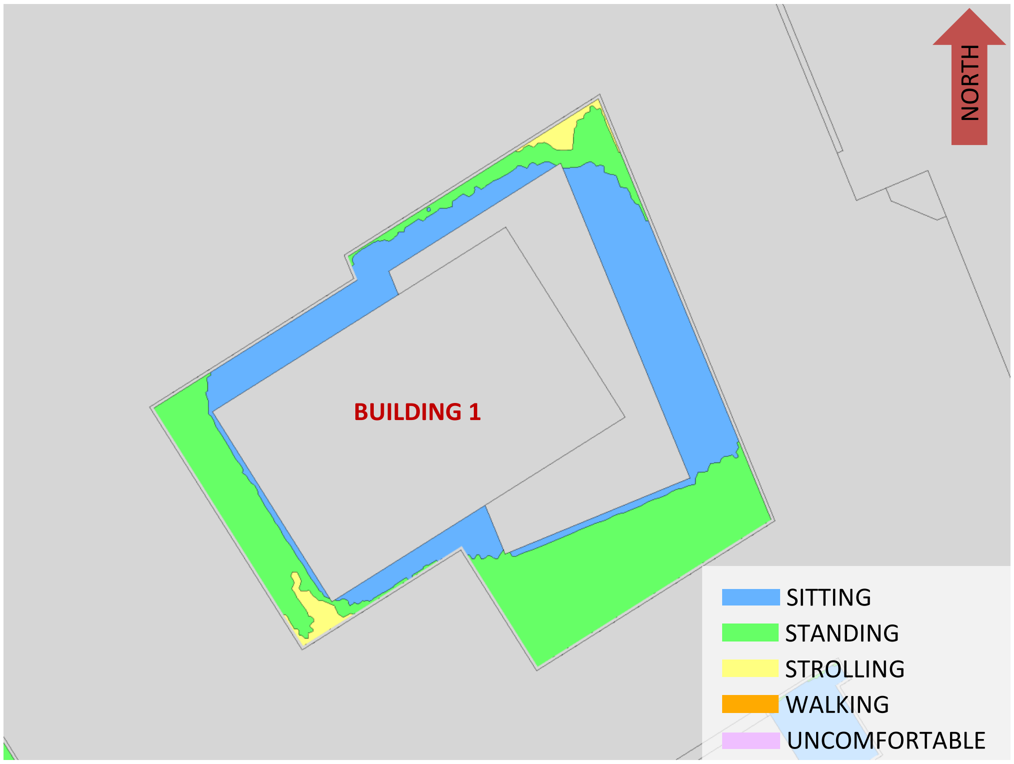



FIGURE 8C: AUTUMN – WIND COMFORT, BUILDING 1 LEVEL 5 AMENITY TERRACE

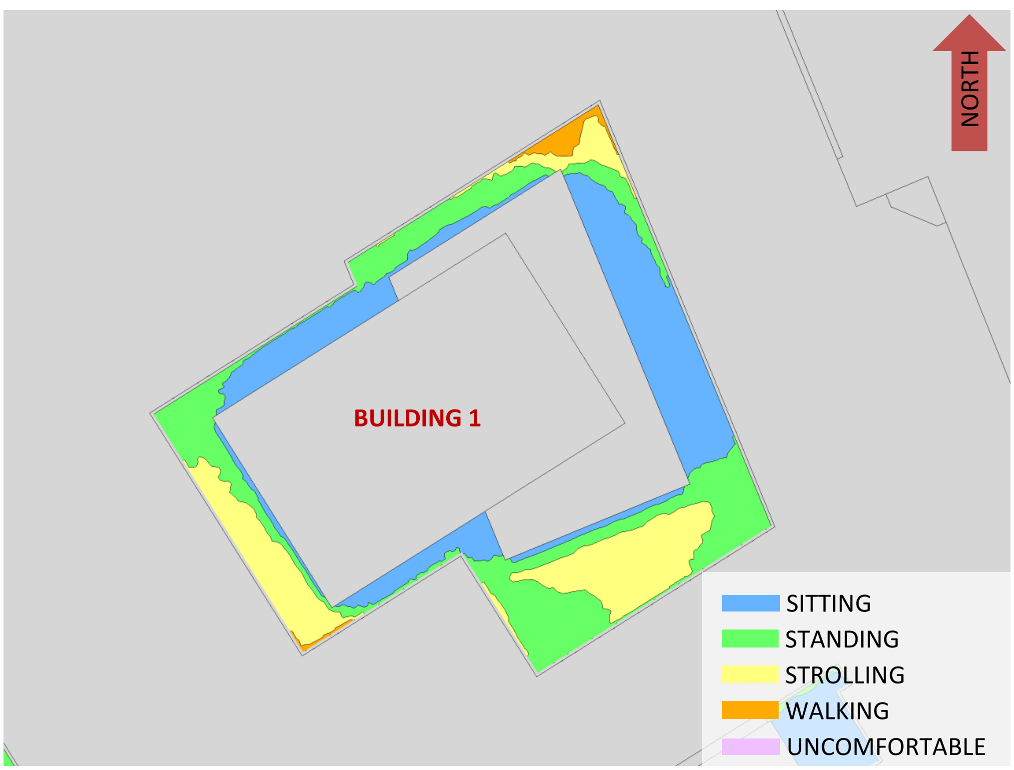



FIGURE 8D: WINTER – WIND COMFORT, BUILDING 1 LEVEL 5 AMENITY TERRACE

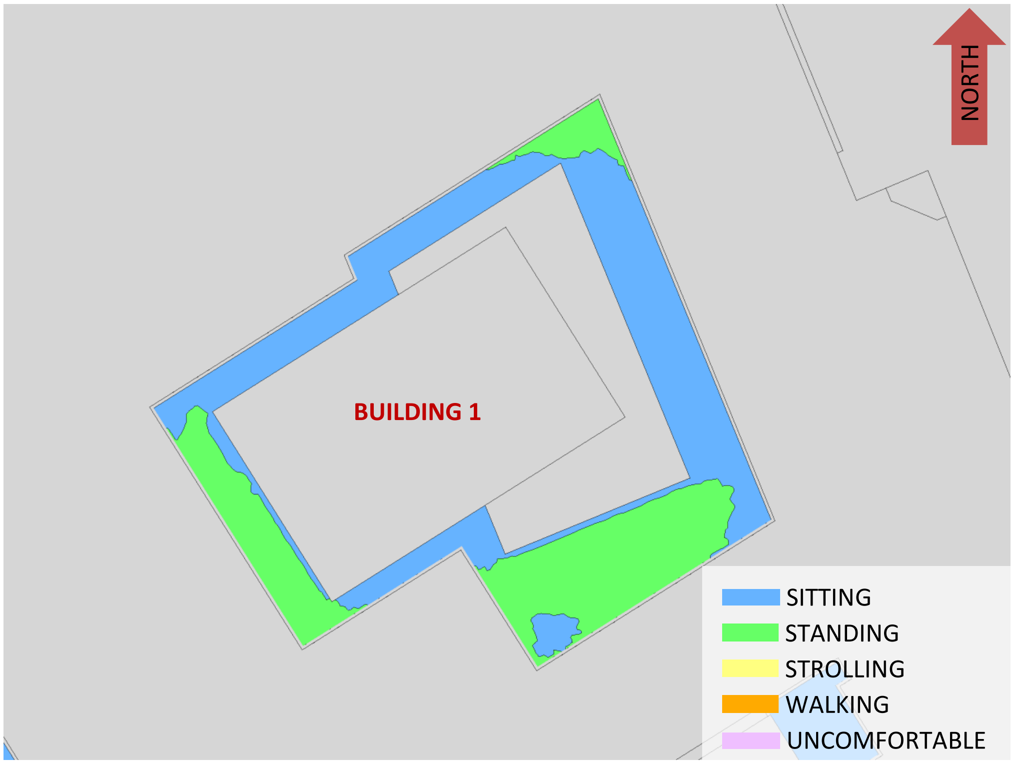



**FIGURE 9: TYPICAL USE PERIOD – BUILDING 1 LEVEL 5 AMENITY TERRACE**

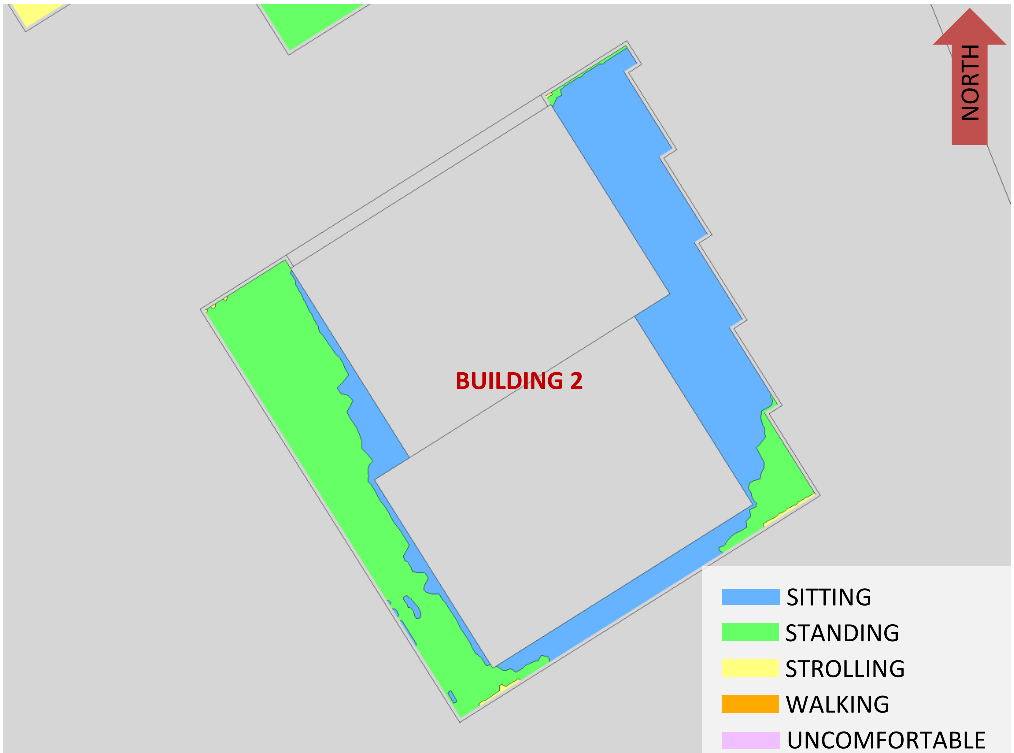



**FIGURE 10A: SPRING – WIND COMFORT, BUILDING 2 LEVEL 5 AMENITY TERRACE**


**FIGURE 10B: SUMMER – WIND COMFORT, BUILDING 2 LEVEL 5 AMENITY TERRACE**

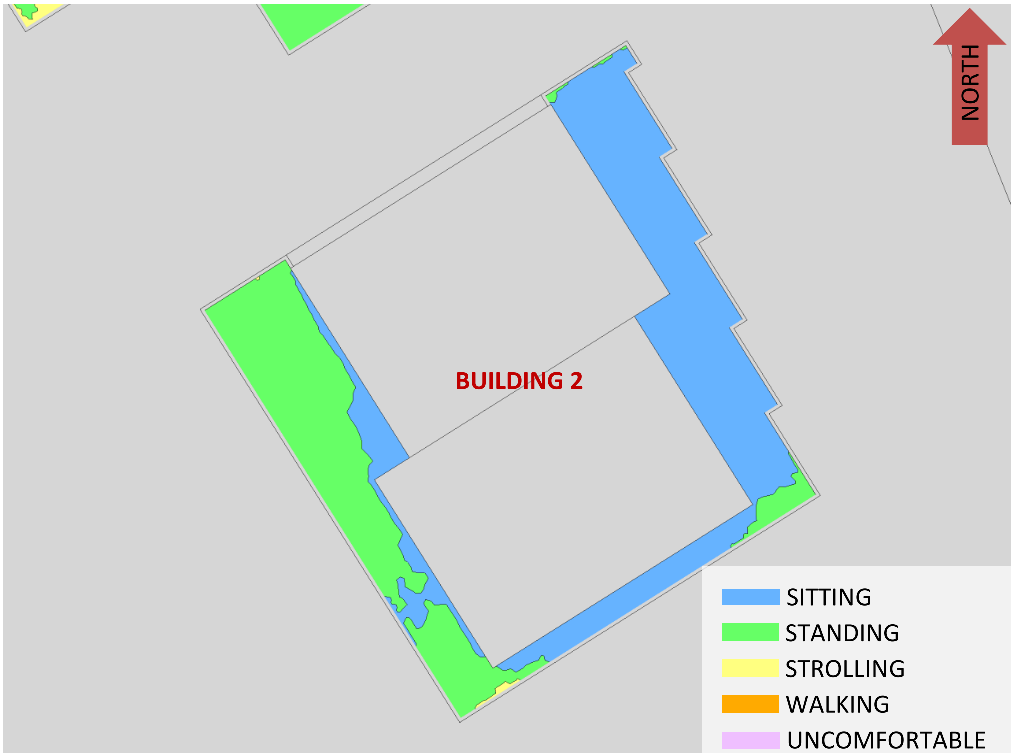



**FIGURE 10C: AUTUMN – WIND COMFORT, BUILDING 2 LEVEL 5 AMENITY TERRACE**


**FIGURE 10D: WINTER – WIND COMFORT, BUILDING 2 LEVEL 5 AMENITY TERRACE**

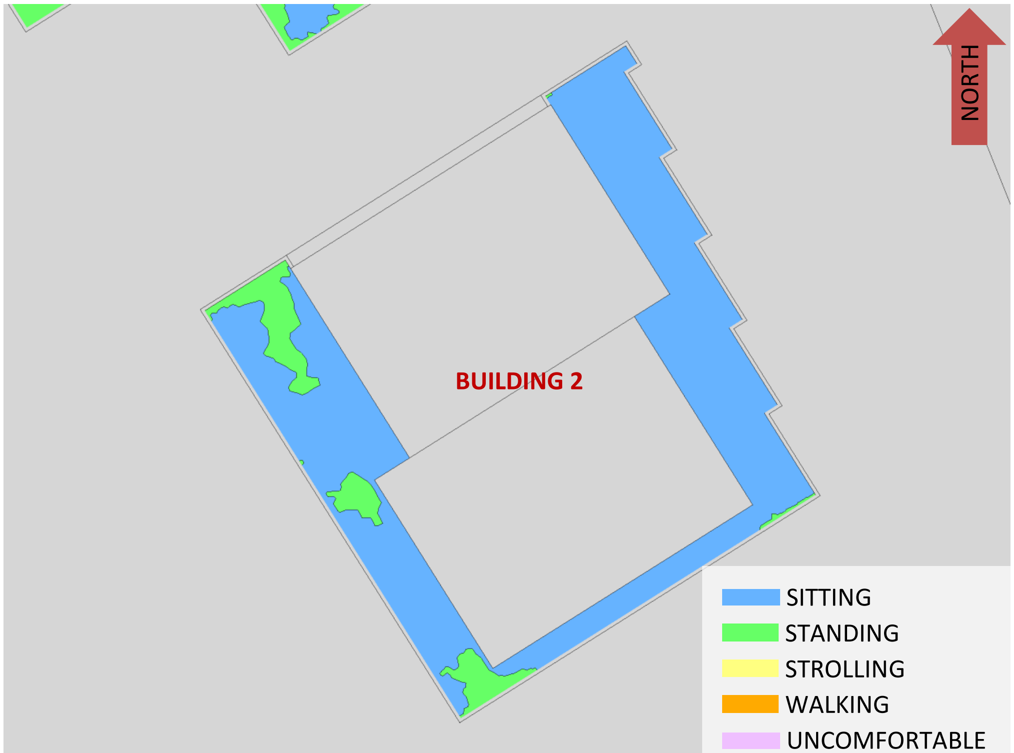



**FIGURE 11: TYPICAL USE PERIOD – BUILDING 2 LEVEL 5 AMENITY TERRACE**

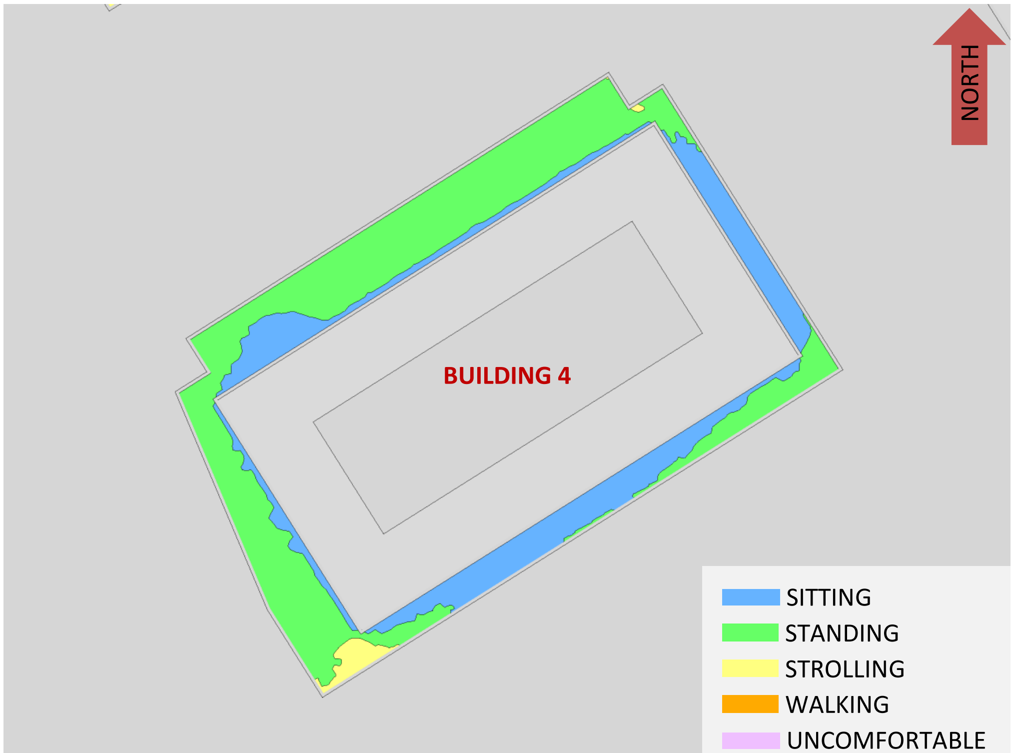



**FIGURE 12A: SPRING – WIND COMFORT, BUILDING 4 LEVEL 5 AMENITY TERRACE**

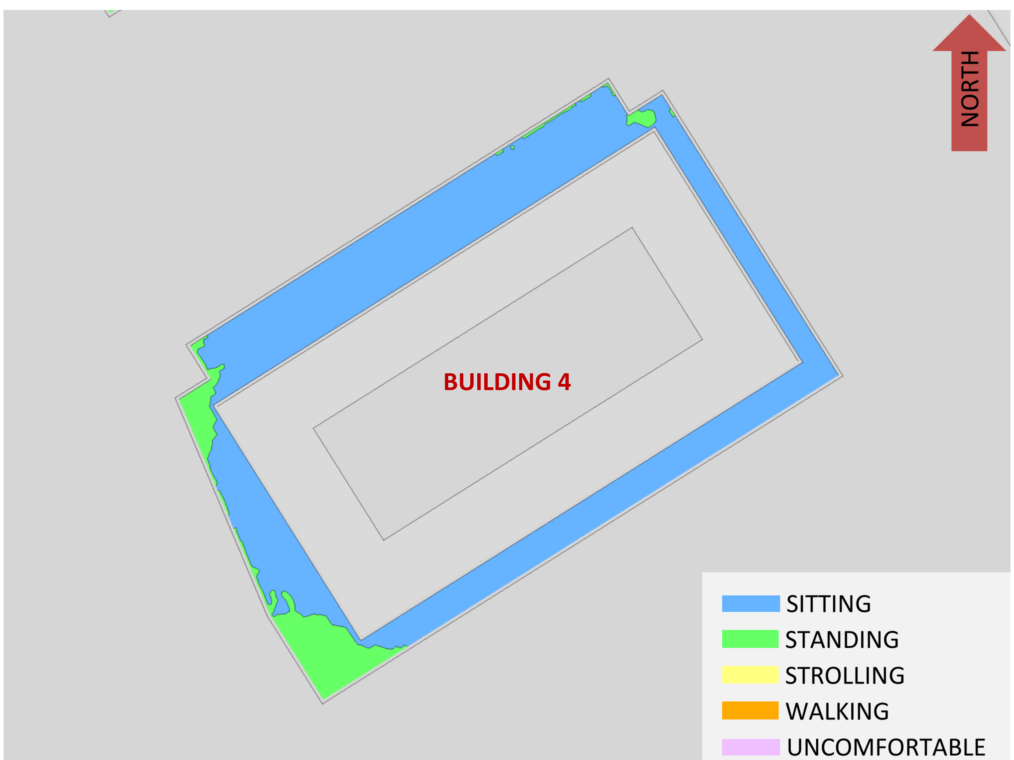



**FIGURE 12B: SUMMER – WIND COMFORT, BUILDING 4 LEVEL 5 AMENITY TERRACE**

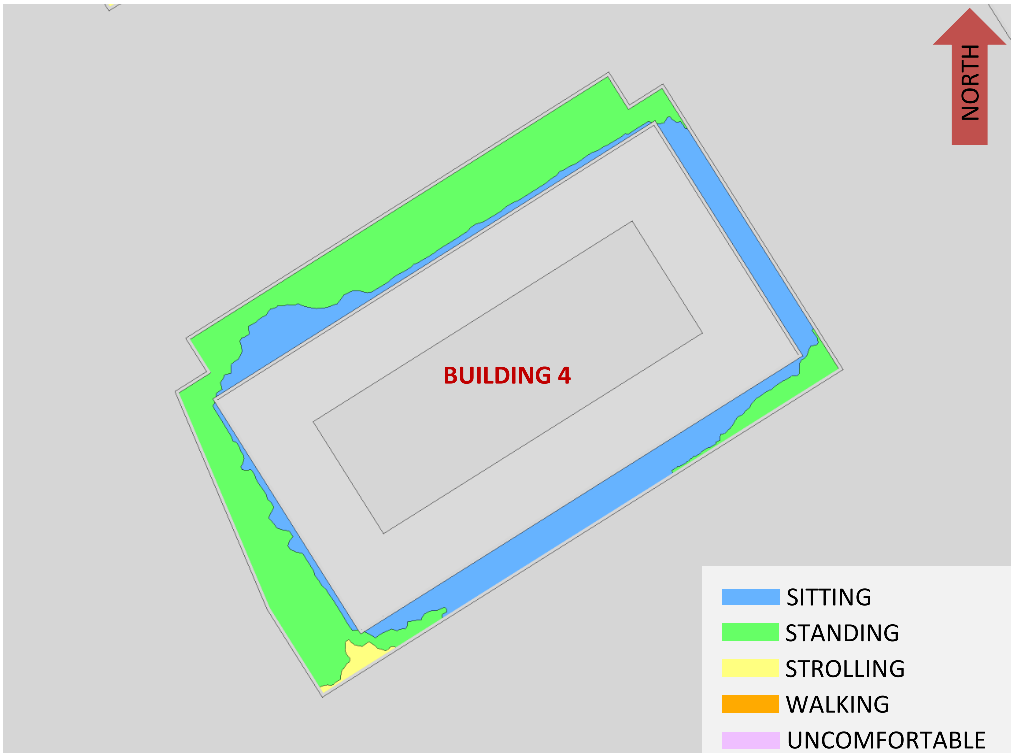



**FIGURE 12C: AUTUMN – WIND COMFORT, BUILDING 4 LEVEL 5 AMENITY TERRACE**

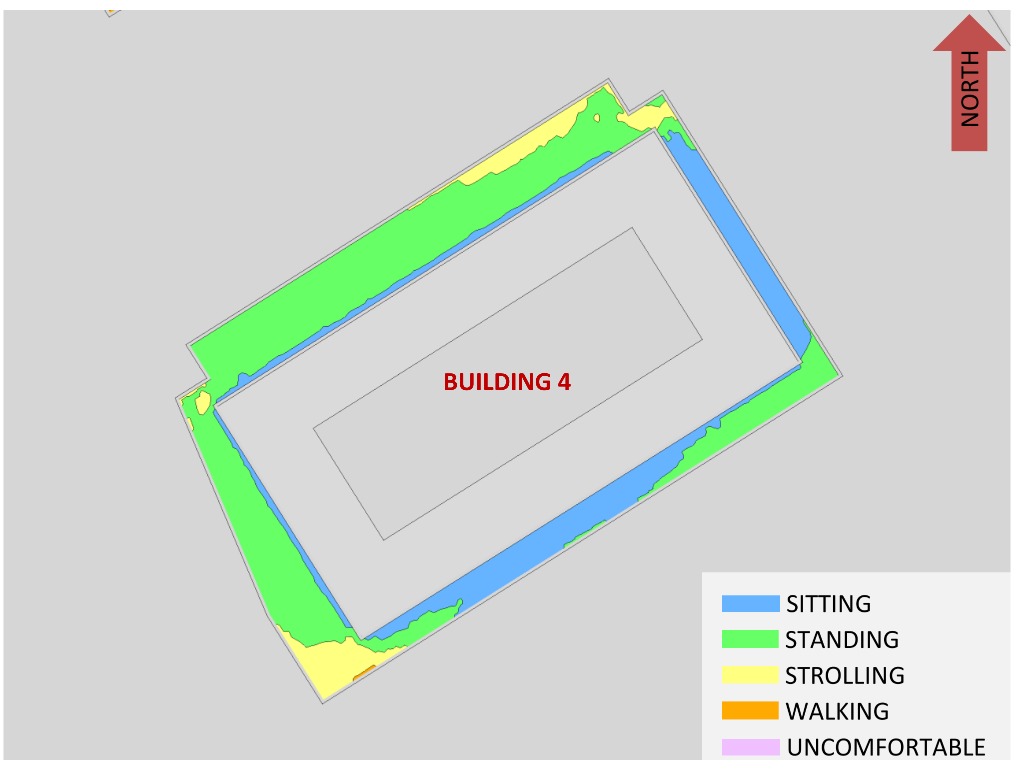



**FIGURE 12D: WINTER – WIND COMFORT, BUILDING 4 LEVEL 5 AMENITY TERRACE**

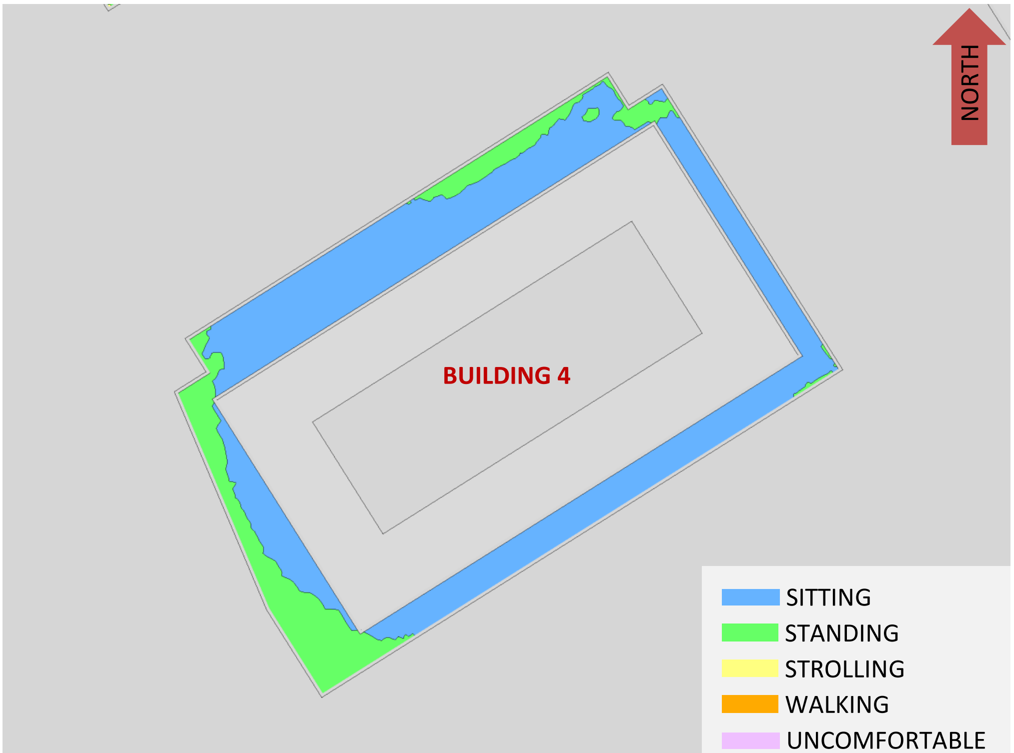



**FIGURE 13: TYPICAL USE PERIOD – BUILDING 4 LEVEL 5 AMENITY TERRACE**


**FIGURE 14A: SPRING – WIND COMFORT, BUILDING 5 LEVEL 7 AMENITY TERRACE**

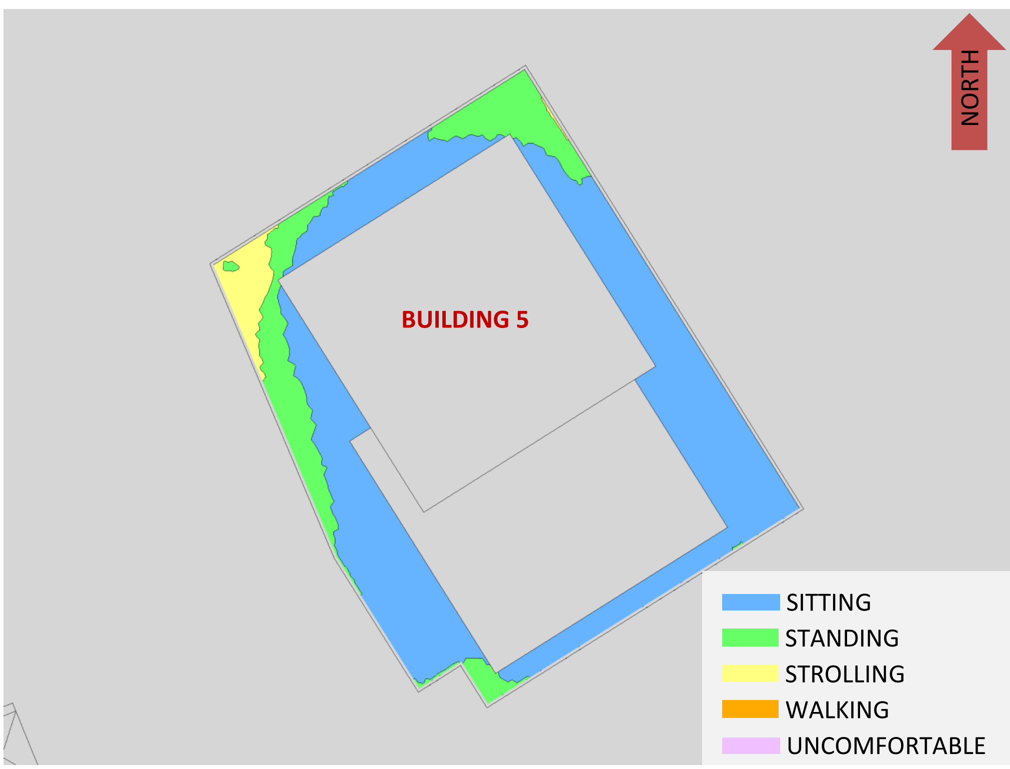



**FIGURE 14B: SUMMER – WIND COMFORT, BUILDING 5 LEVEL 7 AMENITY TERRACE**

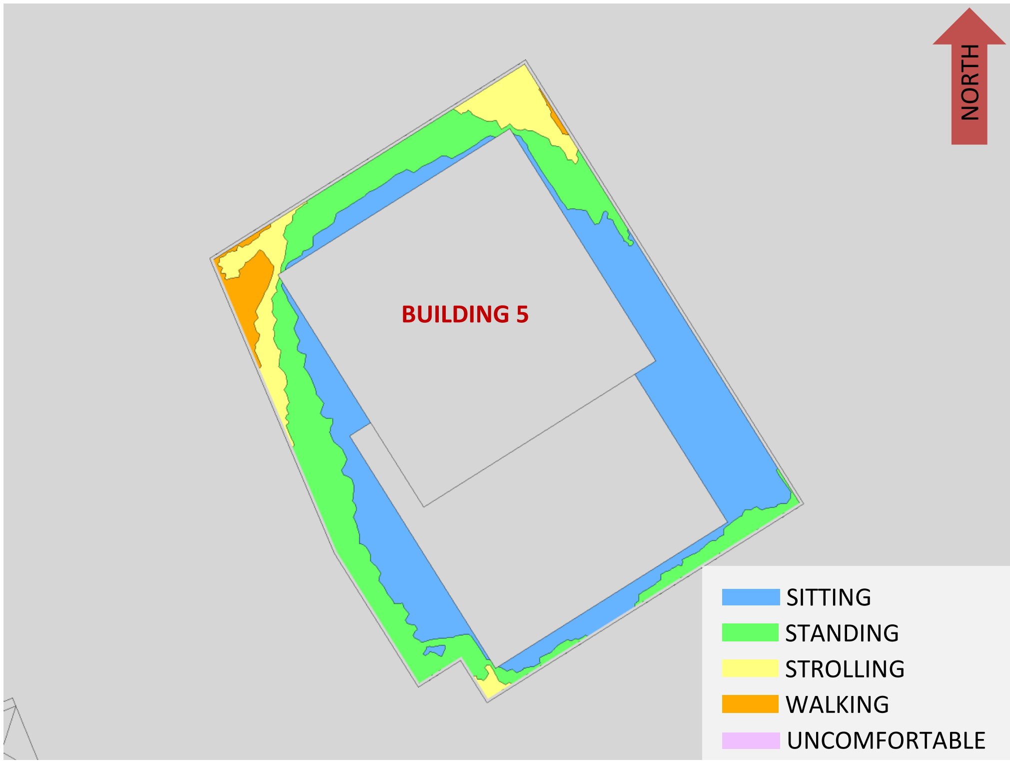



**FIGURE 14C: AUTUMN – WIND COMFORT, BUILDING 5 LEVEL 7 AMENITY TERRACE**

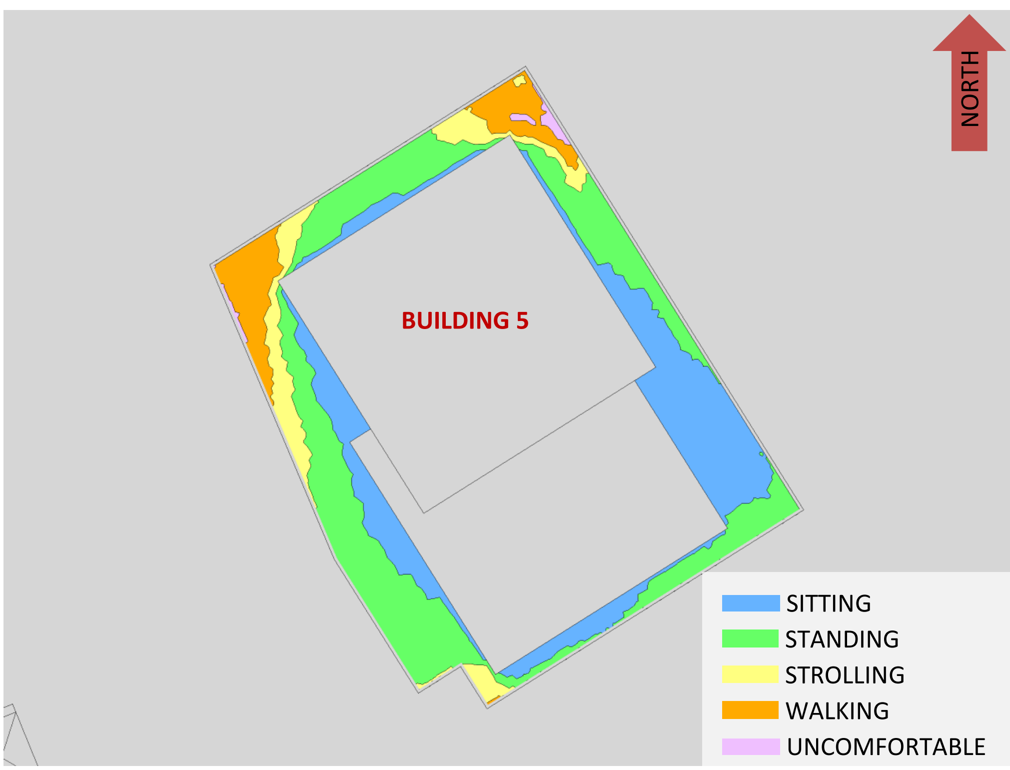



**FIGURE 14D: WINTER – WIND COMFORT, BUILDING 5 LEVEL 7 AMENITY TERRACE**

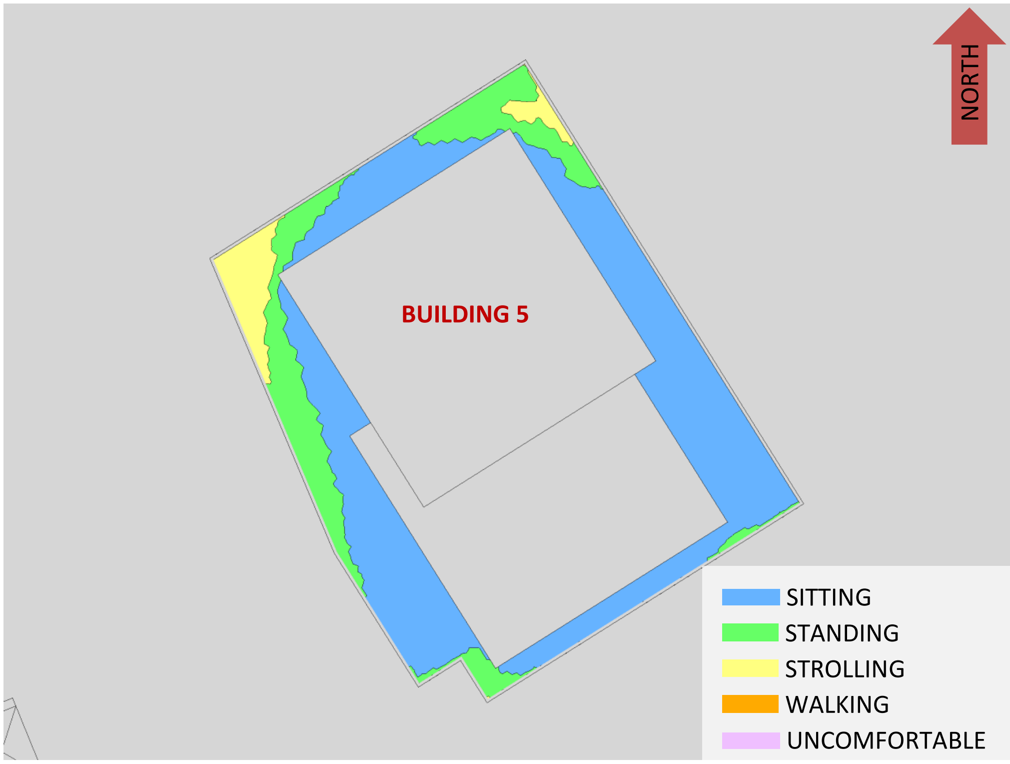



**FIGURE 15: TYPICAL USE PERIOD – BUILDING 5 LEVEL 7 AMENITY TERRACE**

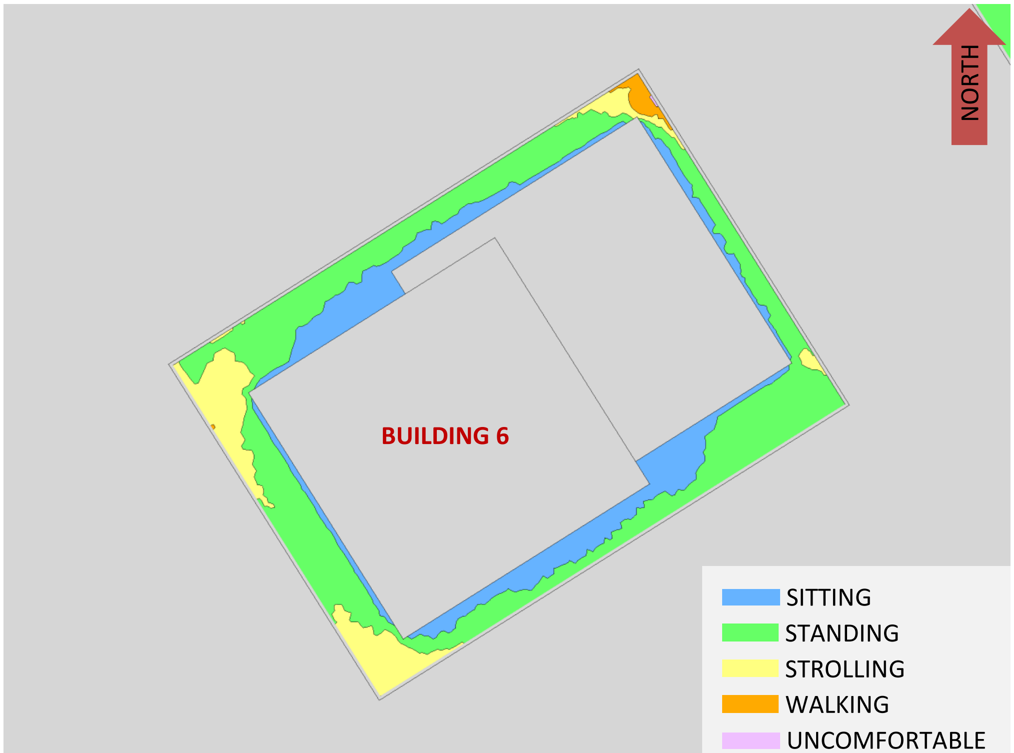



**FIGURE 16A: SPRING – WIND COMFORT, BUILDING 6 LEVEL 7 AMENITY TERRACE**


**FIGURE 16B: SUMMER – WIND COMFORT, BUILDING 6 LEVEL 7 AMENITY TERRACE**

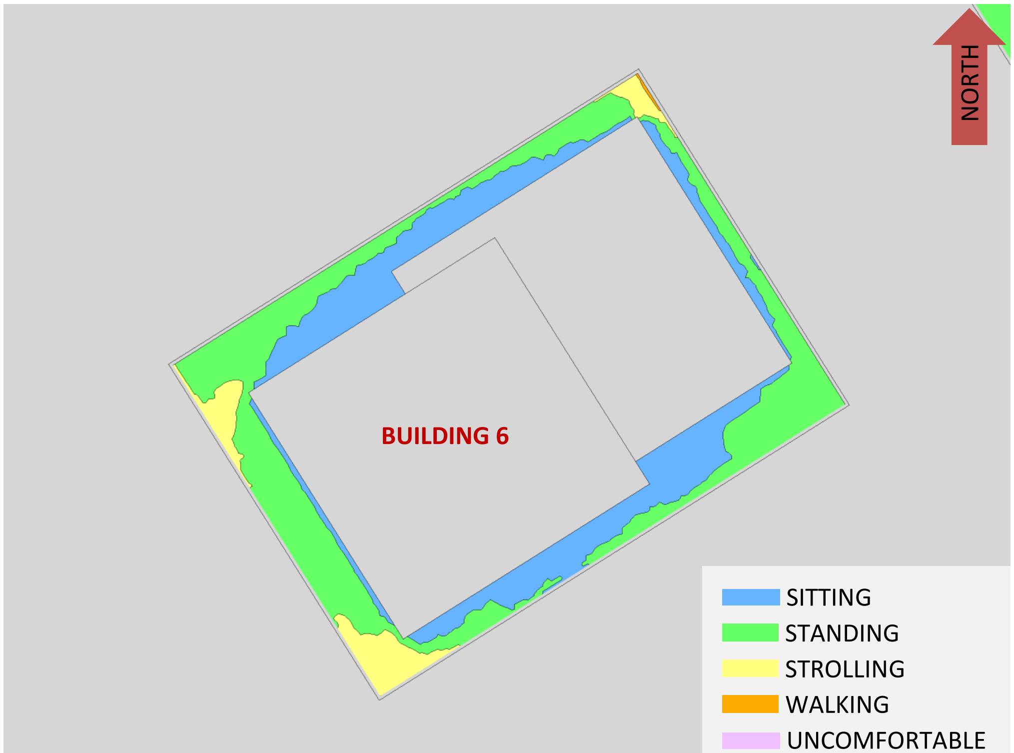



**FIGURE 16C: AUTUMN – WIND COMFORT, BUILDING 6 LEVEL 7 AMENITY TERRACE**

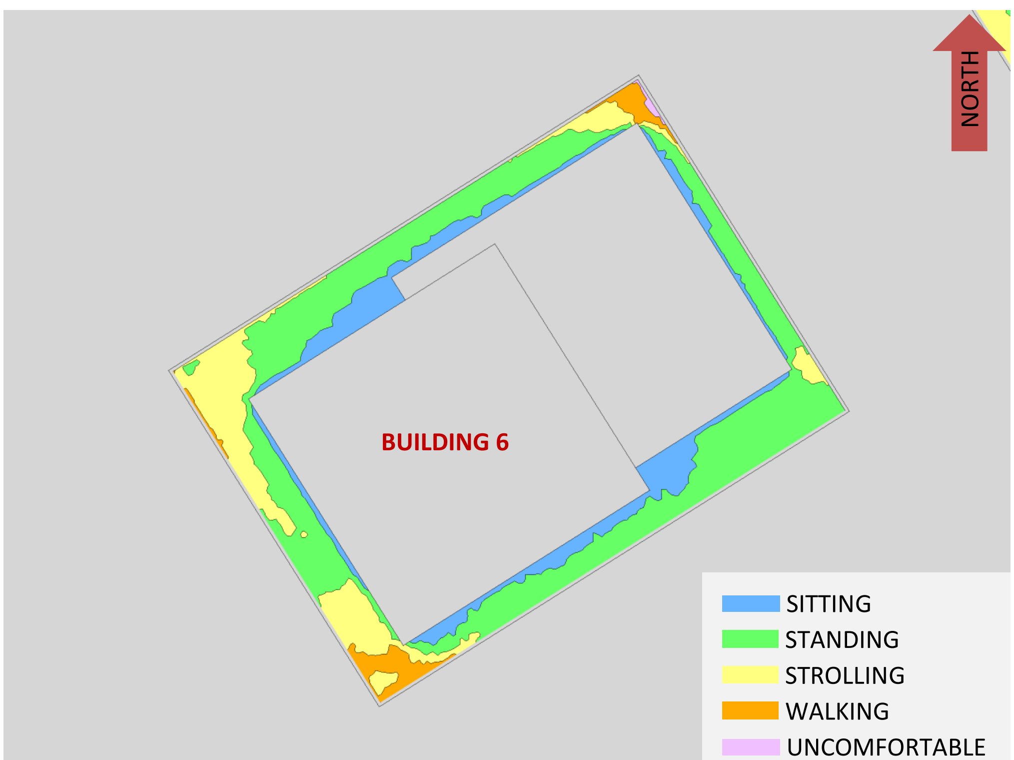



**FIGURE 16D: WINTER – WIND COMFORT, BUILDING 6 LEVEL 7 AMENITY TERRACE**

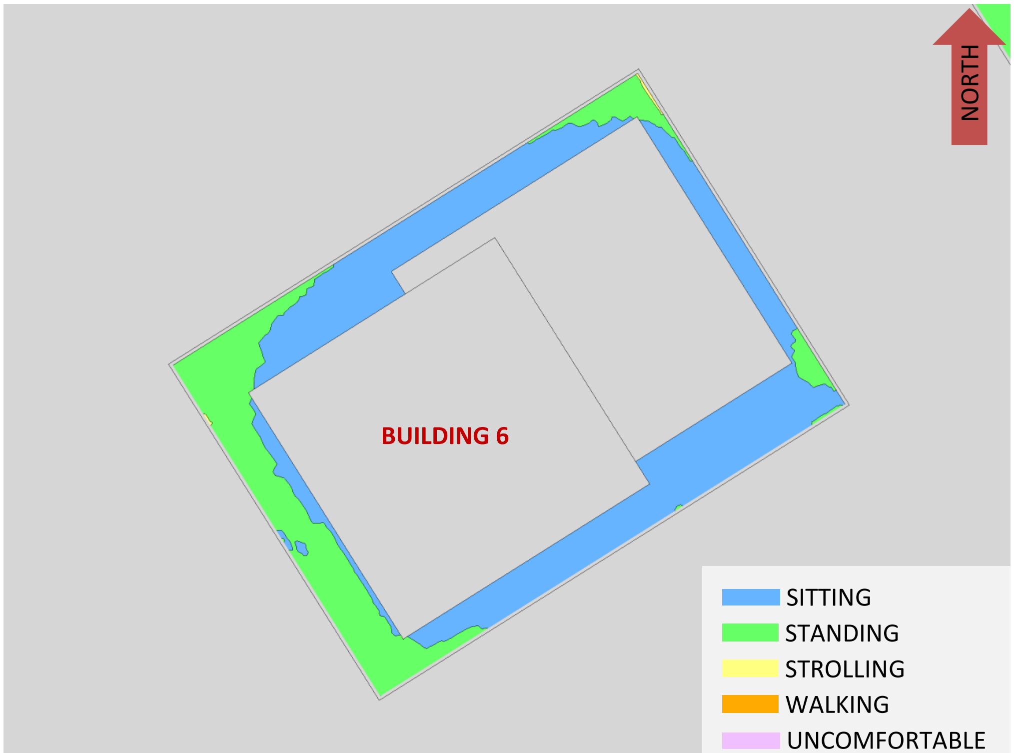
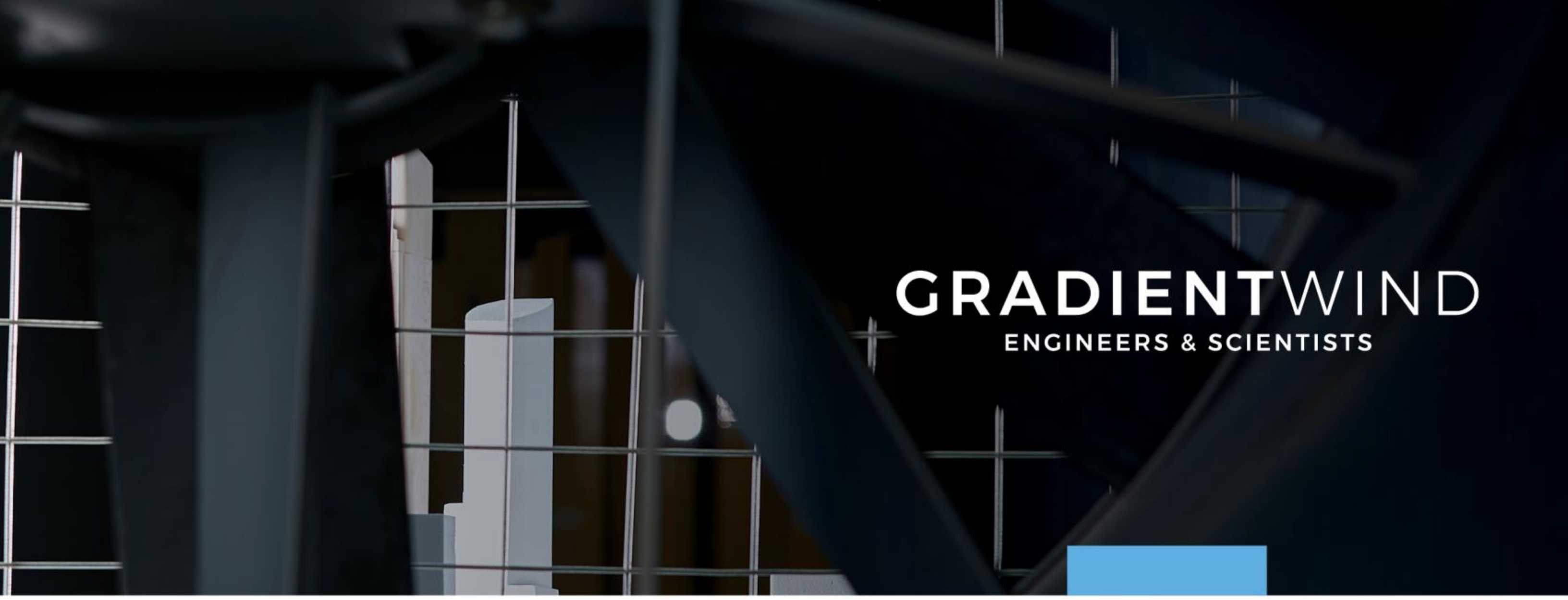



**FIGURE 17: TYPICAL USE PERIOD – BUILDING 6 LEVEL 7 AMENITY TERRACE**




# 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 $\alpha$ 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.

$\alpha$ 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).

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

Equation (2)

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

Equation (3)

where, $\boldsymbol{I}$ = turbulence intensity, $\boldsymbol{L_t}$ = turbulence length scale, $\boldsymbol{Z}$ = height above ground, and $\alpha$ 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, *"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.