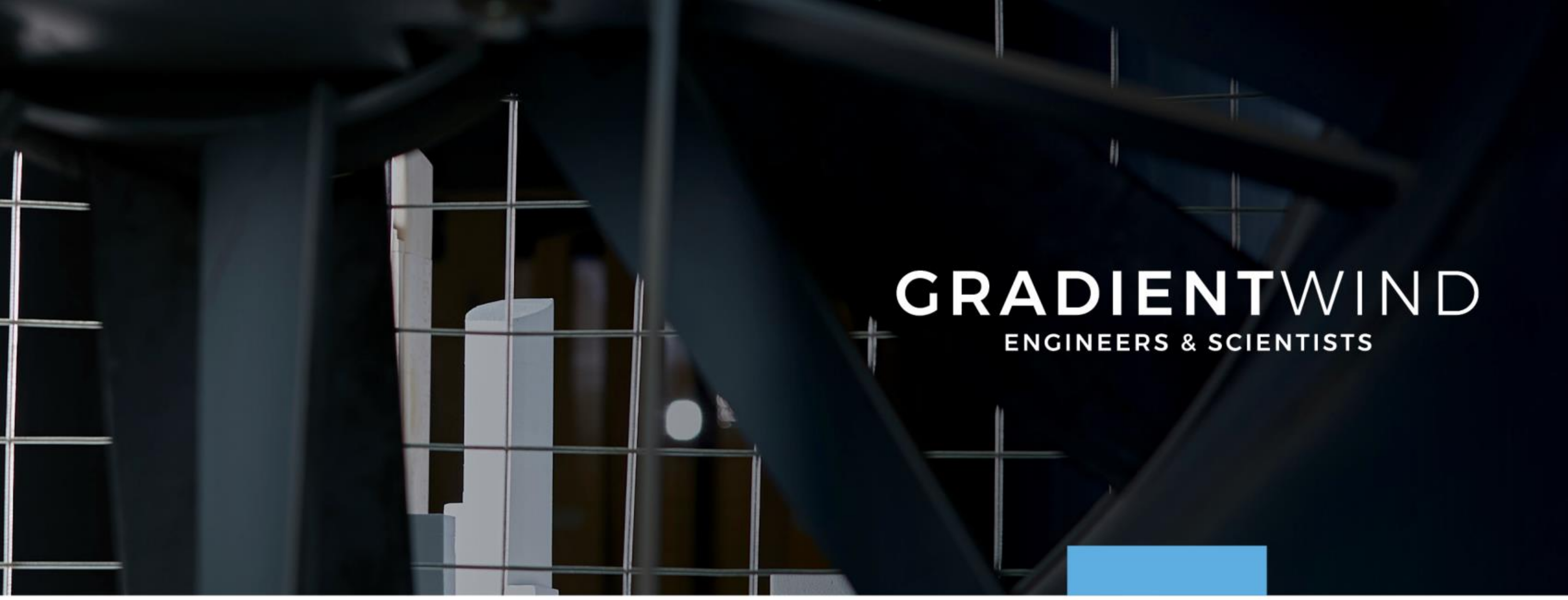
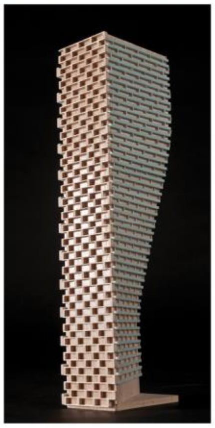
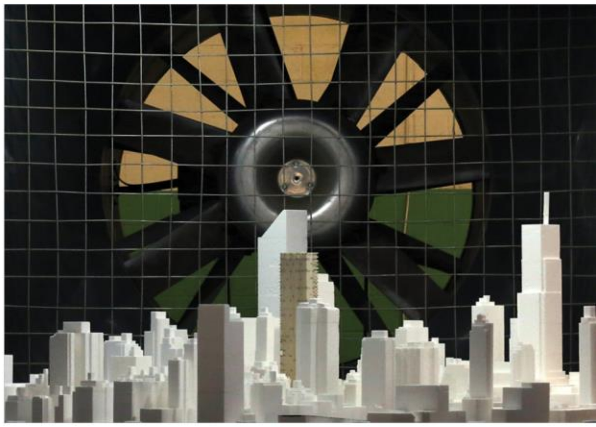


PEDESTRIAN LEVEL WIND STUDY

Zibi Block 204A
Ottawa, Ontario

Report: 22-015-PLW





March 25, 2022

PREPARED FOR

Dream Theia Ontario Block 204A LP
6 Booth Street (Albert Island)
Ottawa, ON K1R 6K8

PREPARED BY

Edward Urbanski, M.Eng., Wind Scientist
Justin Ferraro, P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Site Plan Control application requirements for the proposed mixed-use residential development, referred to as Zibi Block 204, bounded by Miwate Private on Chaudière Island in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate wind comfort and safety within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered.

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-8, and summarized as follows:

1) Following the introduction of the proposed development 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 and in the vicinity of building access points are considered acceptable.

2) Regarding the common amenity terrace serving the proposed development at Level 2, wind conditions during the typical use period are predicted to be suitable for sitting within most of the terrace, which is considered acceptable according to the comfort criteria.

    a. While the area to the northeast is predicted to be suitable for standing, according to the definitions in Section 4.4, sitting conditions are also predicted to occur for at least 70% of the time during the same period, where the target is 80%. Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the area to the northeast will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable.

3) Regarding the common amenity terrace serving the proposed development at Level 10, wind conditions during the typical use period are predicted to be suitable mostly for standing. Wind conditions are also predicted to be suitable for sitting for at least 65% of the time during the same period, where the target is 80%.

   a. To achieve the sitting comfort class in all areas during the typical use period, we recommend implementing a full perimeter wind screen, typically glazed and preferably solid (i.e., no porosity), rising at least 1.8 m above the local walking surface.

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, (e.g., 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 Dream Theia Ontario Block 204 LP to undertake a pedestrian level wind (PLW) study to satisfy Site Plan Control application requirements for the proposed residential development, referred to as Zibi Block 204, bounded by Miwate Private on Chaudière Island in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by NEUF architect(e)s, in February 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 on Chaudière Island; situated on a parcel of land bounded by Miwate Private, located at the southwest intersection of Chaudière Private and Booth Street. Throughout this report, Miwate Private is referred to as project south.

The proposed development comprises a nominally rectangular 22-storey residential building plus mechanical penthouse (MPH) above a near-triangular mixed-use nine-storey podium. Above two below-grade parking levels, shared with and accessible from the surrounding Zibi Block developments, the ground floor includes a main residential lobby, indoor amenity, and a rental office to the north, commercial spaces from the southeast clockwise to southwest, public washrooms within an inset at the south elevation of Miwate Private, and central loading, commercial waste, and residential garbage rooms. Level 2 includes indoor amenity to the east and residential units throughout the remainder of the floor. This level is also served by an outdoor amenity terrace from the north clockwise to southeast, which partially overhangs the ground floor. Levels 3-9 are reserved for residential use. Level 10 includes indoor amenity at the southwest corner and residential units throughout the remainder of the floor; a large outdoor amenity terrace is situated at the southwest corner. Levels 10-22 comprise a nominally rectangular planform and are reserved for residential use.

The near-field surroundings (defined as an area within a 200-metre (m) radius from the subject site) include Zibi Blocks 206 and 207 (under construction) and a hydro building to the north, and Zibi Block 211 (recently constructed) and Blocks 212 to 214 (planned) to the northeast. Zibi Block 208 and Head Street Square are situated to the east and Zibi Block 210 and Albert Island Courtyard are situated to the southeast. These two blocks comprise retained/retrofitted heritage buildings. Zibi Block 205A (completed) is situated to the southeast. Block 205B and 209 are located to the south, Block 202 to the southwest, and Block 201 to the west. These four blocks comprise future developments that have been zoned. Notably, the Ottawa River flows from the southwest to the north, and the Buchanan Channel, Electric Channel, and the Bronson Channel separate from the Ottawa River and flow from the southwest towards the southeast, approximately 70 m, 120 m, and 150 m to the south of the subject site, respectively. In addition, Chaudière Falls is situated to the northwest, Chaudière Bridge, which links Ottawa to Gatineau, is situated to the northeast, and Pangshimo Park is to the southwest 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 a mix of mostly low-rise residential and commercial buildings with isolated mid- and high-rise buildings in all compass directions except clusters of mid- and high-rise buildings to the north and east. Notably, Parliament Hill is located approximately 1.4 km to the east and the Canadian War Museum is approximately 250 m to the south. In addition, the Zibi developments in Gatineau, referred to as “Heritage Promenade”, “Laurier Corridor”, “Waterfront Quarter”, and “North Shore”, are situated approximately 430 m to the northwest, 440 m to the north, 420 m to the northeast, and 360 m to the north, respectively. Furthermore, the Ottawa River flows from the west toward the northeast, separating Ottawa and Gatineau.

Figure 1A illustrates the subject site and surrounding context, representing the proposed future massing scenario, while Figure 1B illustrates the existing massing. Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any changes which have been approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian wind comfort and safety conditions at key areas within and surrounding the proposed development; (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.

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

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of 480 m.

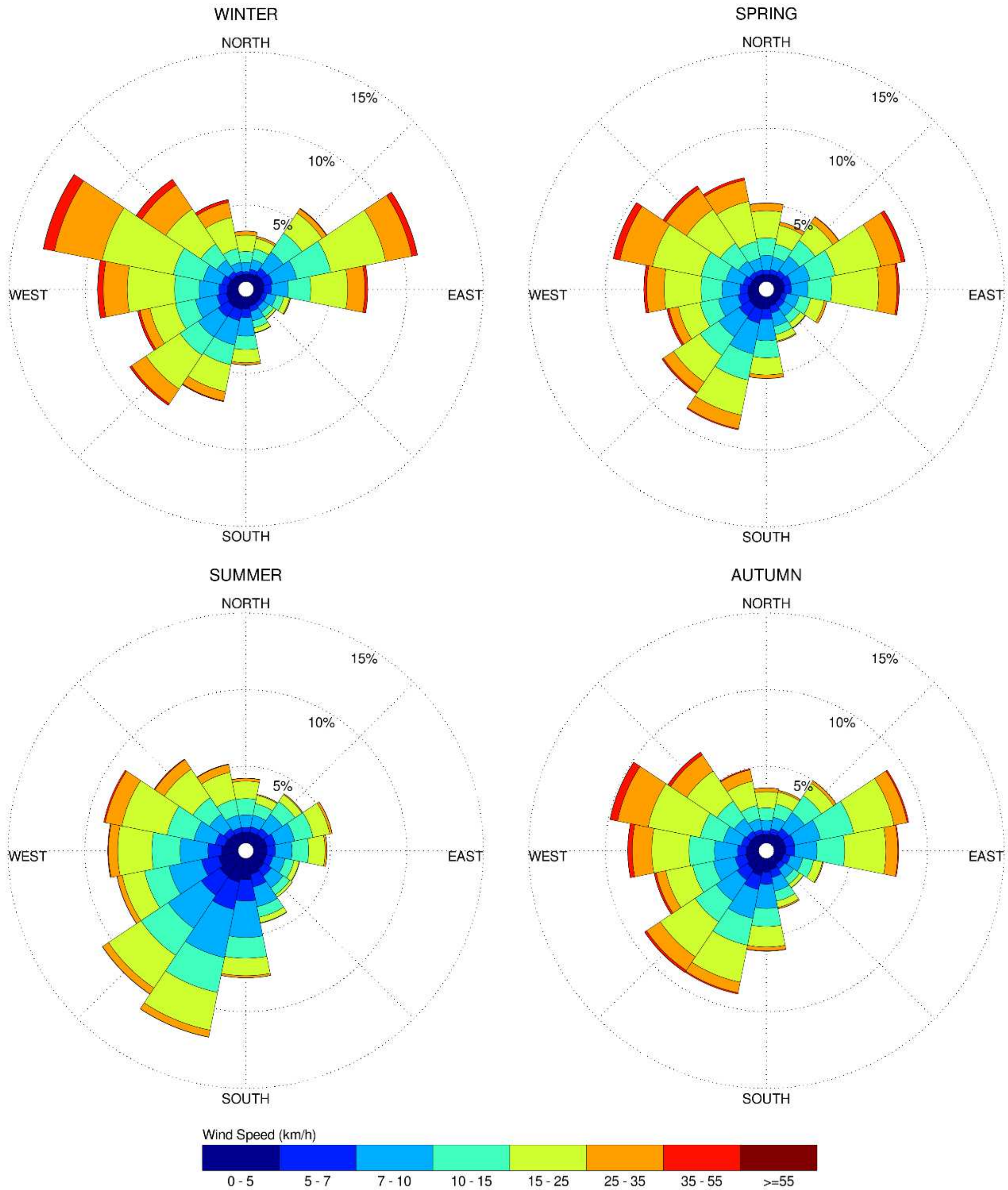
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terraces were referenced to the wind speed 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 (i.e., 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 speed of 20 km/h (equivalent gust wind speed of approximately 30 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 (i.e., 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
Café / Patio / Bench / Garden	Sitting (Summer)
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting (Summer)
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 comfort conditions at grade level for the proposed and existing massing scenarios, and Figures 7A-7D, illustrating comfort conditions over the common amenity terraces serving the proposed development at Levels 2 and 10. Conditions are presented as continuous contours of wind comfort and correspond to the comfort classes noted in Section 4.4. 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.

Conditions within the common amenity terraces serving the proposed development at Levels 2 and 10 are also reported for the typical use period, which is defined as May to October, inclusive, illustrated in Figure 8. The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Ground Floor

Sidewalks and Building Access along South Elevation of Miwate Private: Following the introduction of the proposed development, the nearby public sidewalk areas along the south elevation of Miwate Private are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the spring and autumn, and mostly suitable for standing during the winter. Conditions in the immediate vicinity of building access points are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

Conditions over the sidewalks along the south elevation of Miwate Private with the existing massing are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of sitting, standing, and strolling during autumn, and suitable for a mix of sitting, standing, strolling, and walking during the spring and winter. Notably, the introduction of the proposed development is predicted to improve wind comfort levels in the area, in comparison to existing conditions.

Sidewalks and Building Access along Northwest Elevation of Miwate Private: Following the introduction of the proposed development, the nearby public sidewalk areas along the northwest elevation of Miwate Private are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of sitting, standing, and strolling during the spring and autumn, and suitable for a mix of standing and strolling during the winter. Conditions in the immediate vicinity of building access points are predicted to be suitable for sitting during the summer, becoming suitable for standing during the remaining three seasons. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

Conditions over the sidewalks along the northwest elevation of Miwate Private with the existing massing are predicted to be suitable for a mix of sitting, standing, and strolling during the summer, becoming suitable for a mix of sitting, standing, strolling, and walking during autumn, and suitable for a mix of sitting, standing, strolling, walking during the spring and winter. Conditions during the spring and winter are also predicted to become uncomfortable within the north end of the property. Notably, the introduction of the proposed development is predicted to improve wind comfort levels in the area, in comparison to existing conditions.

Building Access North of Subject Site: Conditions in the immediate vicinity of building access point to the north of the subject site are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

Sidewalks and Building Access along Northeast Elevation of Miwate Private: Following the introduction of the proposed development, the nearby public sidewalk areas along the northeast elevation of Miwate Private are predicted to be suitable for a mix of sitting and standing during the summer and autumn, becoming suitable for a mix of sitting, standing, and strolling during the spring and winter. Conditions in the immediate vicinity of building access points are predicted to be suitable for sitting during the summer, becoming suitable for standing during the remaining three seasons. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

Conditions over the sidewalks along the northeast elevation of Miwate Private with the existing massing are predicted to be mostly suitable for a mix of sitting and standing during the summer, becoming mostly suitable for a mix of standing and strolling during the spring and autumn, and suitable for a mix of standing, strolling, and walking during winter. Notably, the introduction of the proposed development is predicted to improve wind comfort levels in the area, in comparison to existing conditions.

5.2 Wind Comfort Conditions – Common Amenity Terraces

Level 2 Common Amenity Terrace: During the typical use period, wind conditions within the common amenity terrace serving the proposed development at Level 2 are predicted to be suitable for sitting to the north and south and suitable for standing to the northeast, as illustrated in Figure 8.

Within the area that is predicted to be suitable for standing, wind conditions are also predicted to be suitable for sitting for at least 70% of the time during the same period, where the target is 80%. Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the area to the northeast will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable.

Level 10 Common Amenity Terrace: During the typical use period, conditions within the common amenity terrace serving the proposed development at Level 10 are predicted to be suitable mostly for standing, as illustrated in Figure 8. Wind conditions are also predicted to be suitable for sitting for at least 65% of the time during the same period, where the target is 80%. To achieve the sitting comfort class in all areas during the typical use period, we recommend implementing a full perimeter wind screen, typically glazed and preferably solid (i.e., no porosity), rising at least 1.8 m above the local walking surface.

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 and surrounding the subject site were found to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.4 Applicability of Results

Wind conditions over surrounding sidewalks beyond the subject site, as well as at nearby primary building entrances, will be acceptable for their intended pedestrian uses during each seasonal period upon the introduction of the subject site. Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the study site. Future changes (i.e., 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 site would alter the wind profile approaching the site; and (ii) development in proximity to the site would cause changes to local flow patterns.

Regarding primary and secondary building access points, wind conditions predicted in this study are only applicable to pedestrian comfort and safety. As such, the results should not be construed to indicate wind loading on doors and associated hardware.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-8. 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) Following the introduction of the proposed development 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 and in the vicinity of building access points are considered acceptable.

2) Regarding the common amenity terrace serving the proposed development at Level 2, wind conditions during the typical use period are predicted to be suitable for sitting within most of the terrace, which is considered acceptable according to the comfort criteria.

    a. While the area to the northeast is predicted to be suitable for standing, according to the definitions in Section 4.4, sitting conditions are also predicted to occur for at least 70% of the time during the same period, where the target is 80%. Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the area to the northeast will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable.

3) Regarding the common amenity terrace serving the proposed development at Level 10, wind conditions during the typical use period are predicted to be suitable mostly for standing. Wind conditions are also predicted to be suitable for sitting for at least 65% of the time during the same period, where the target is 80%.

    a. To achieve the sitting comfort class in all areas during the typical use period, we recommend implementing a full perimeter wind screen, typically glazed and preferably solid (i.e., no porosity), rising at least 1.8 m above the local walking surface.

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, (e.g., 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.

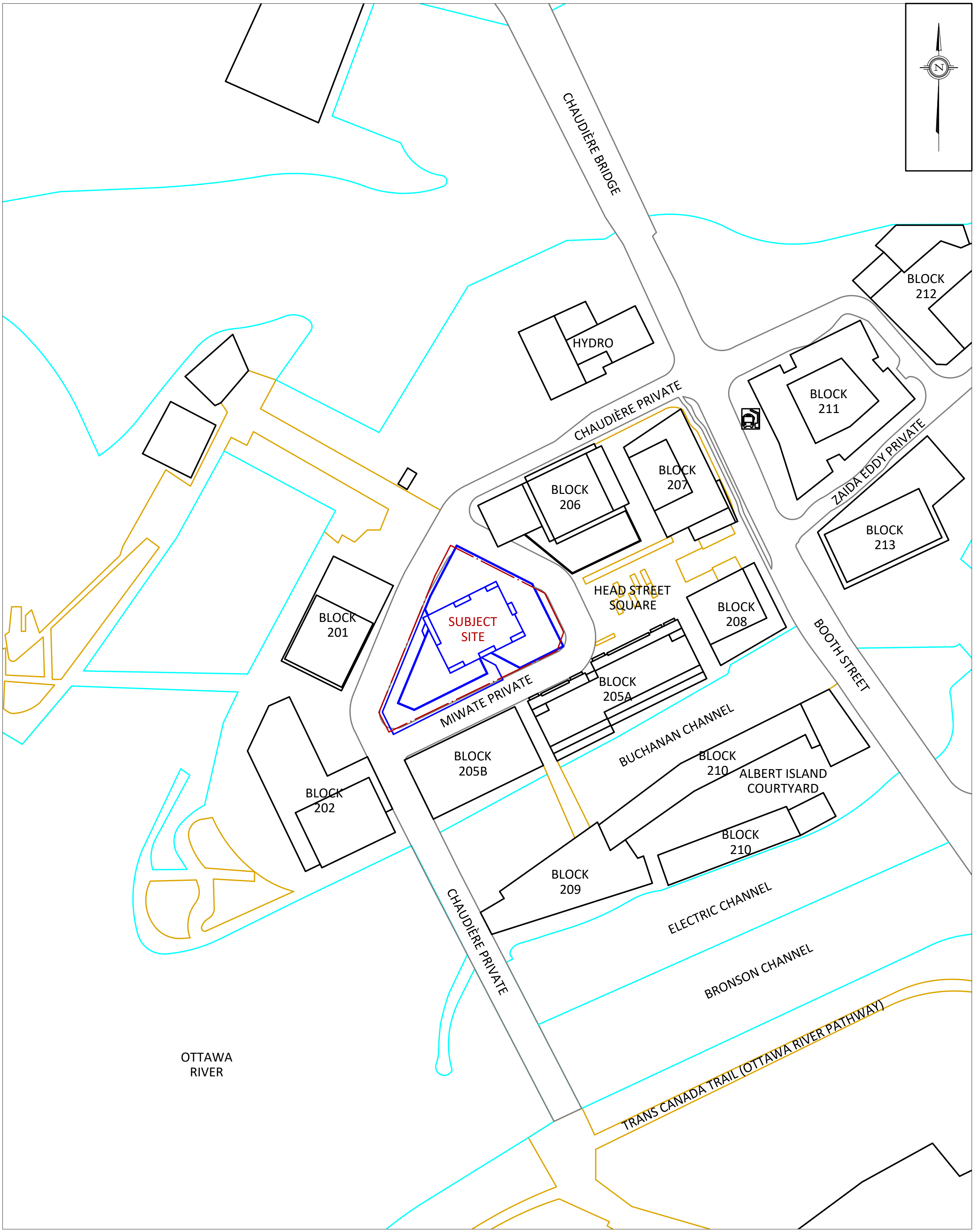
Sincerely,

Gradient Wind Engineering Inc.

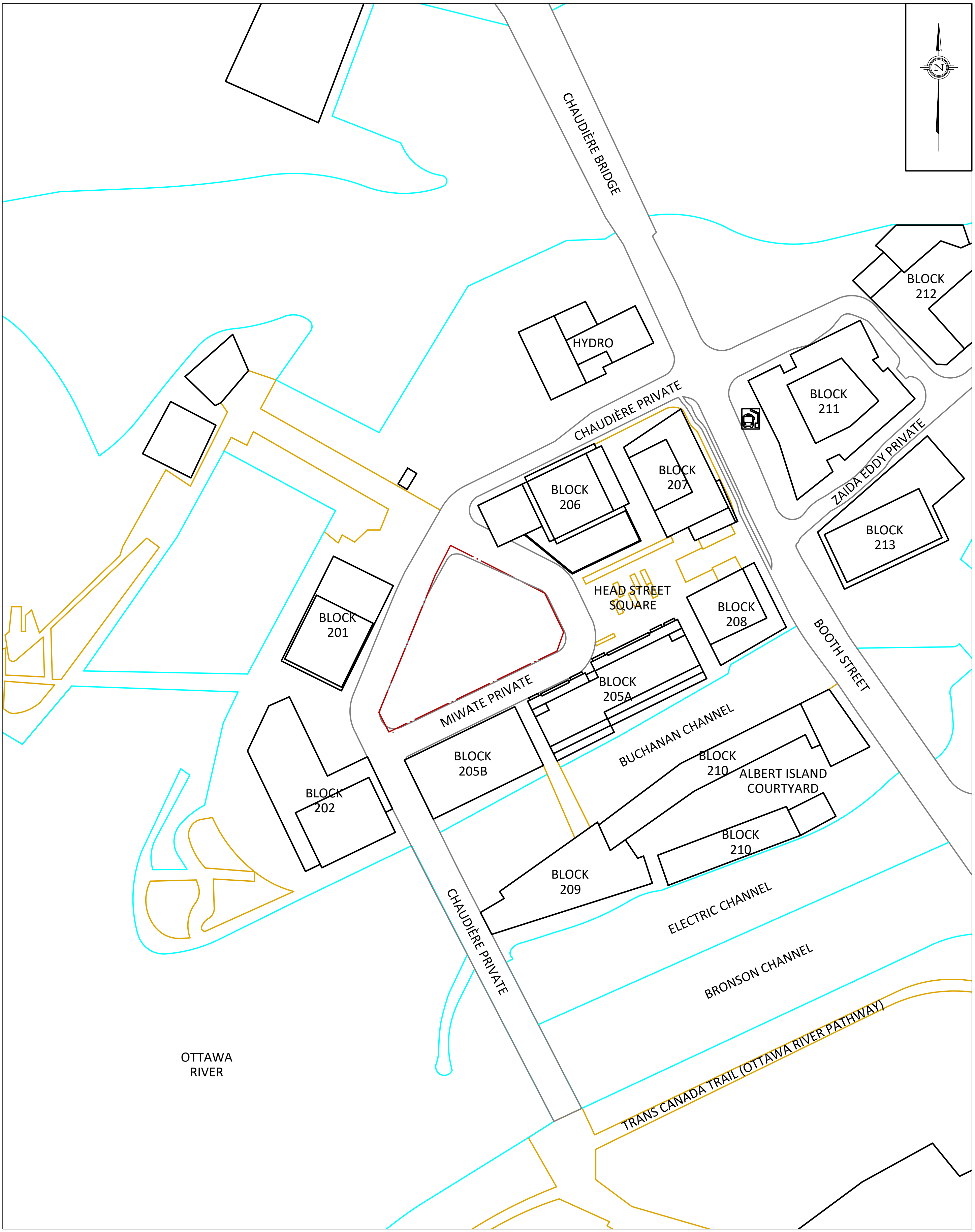
LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Mar 25, 2022
PROVINCE OF ONTARIO

Edward Urbanski, M.Eng.
Wind Scientist

Justin Ferraro, P.Eng.
Principal



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT	ZIBI BLOCK 204A, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:2000		DRAWING NO. 22-015-PLW-1A	
	DATE MARCH 25, 2022		DRAWN BY S.K.	



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PROJECT	ZIBI BLOCK 204A, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	22-015-PLW-1B
DATE	MARCH 25, 2022
DRAWN BY	S.K.
DESCRIPTION	FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT

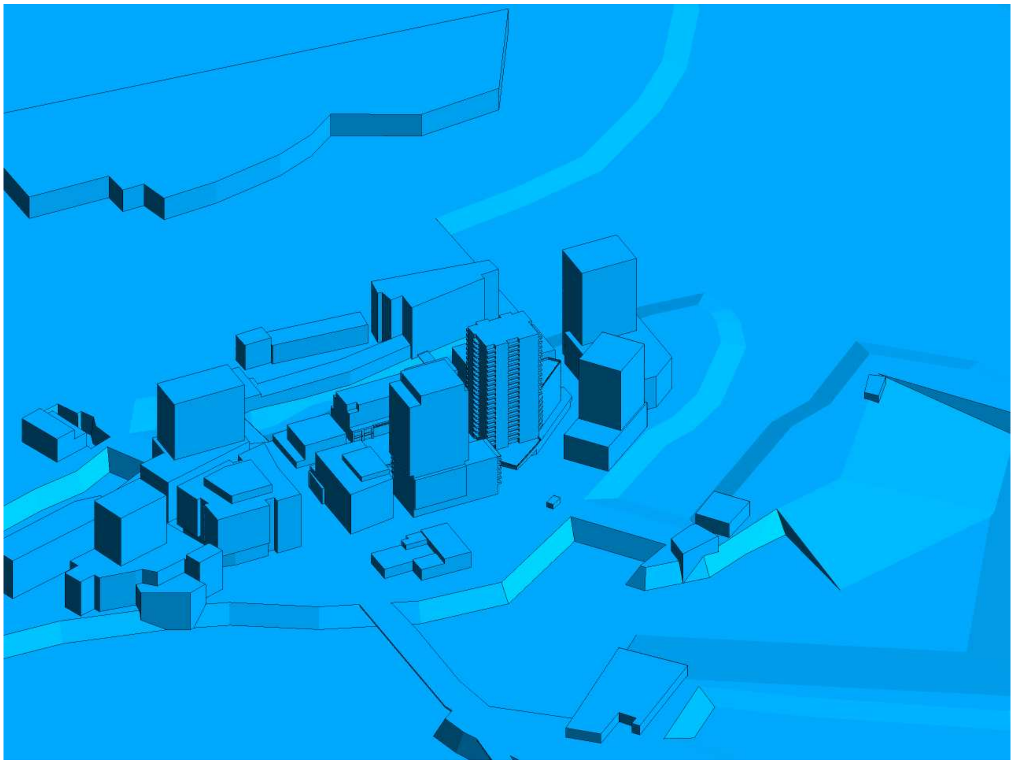

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

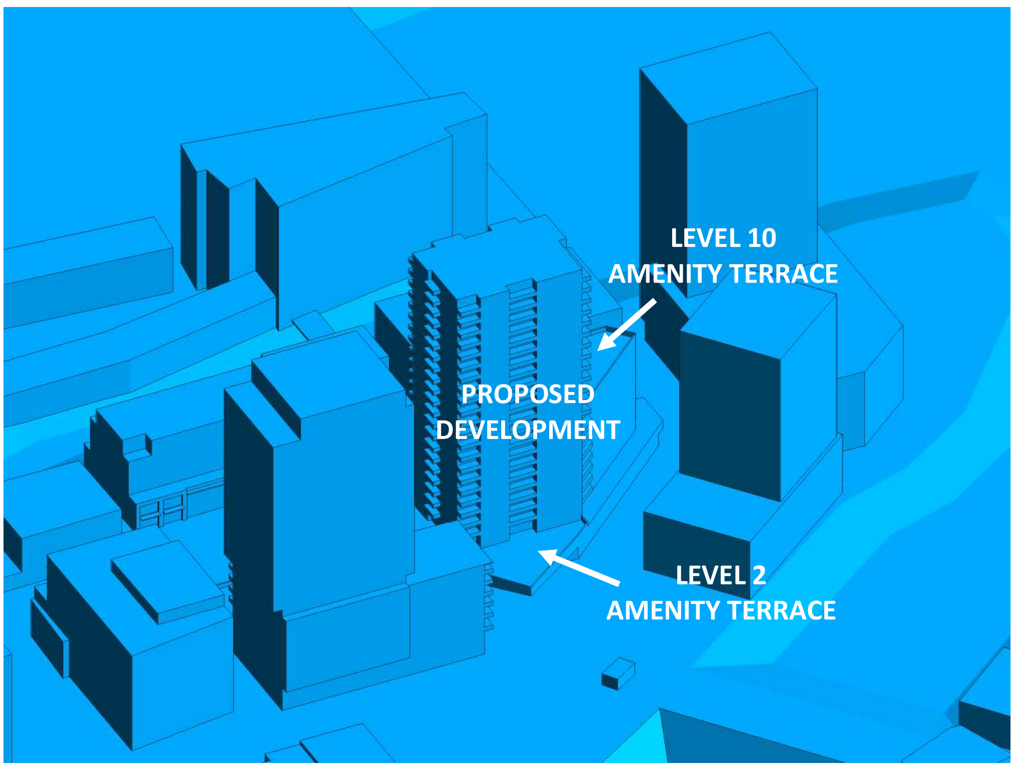

FIGURE 2B: CLOSE UP OF FIGURE 2A

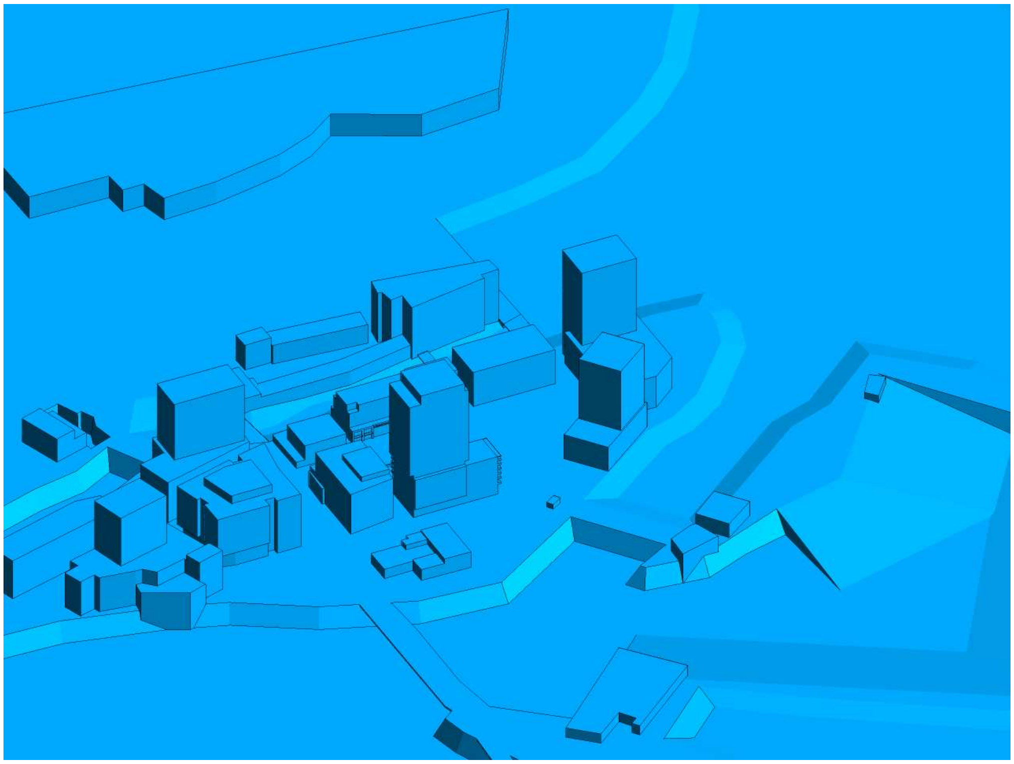

FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

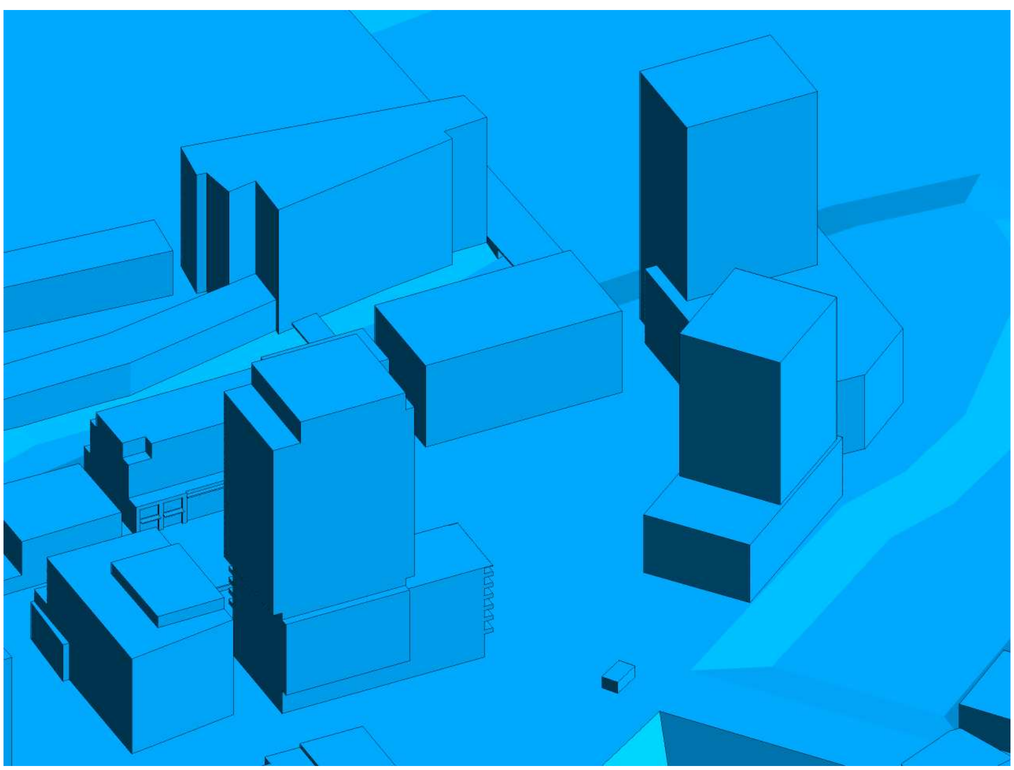

FIGURE 2D: CLOSE UP OF FIGURE 2C

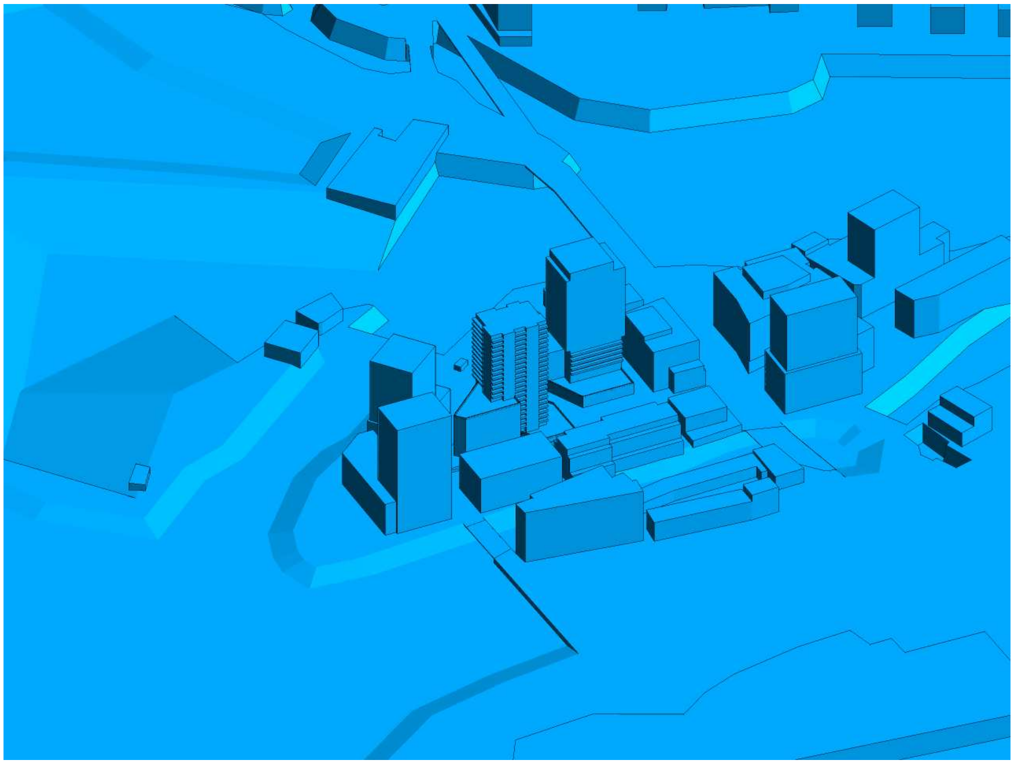

FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

FIGURE 2F: CLOSE UP OF FIGURE 2E

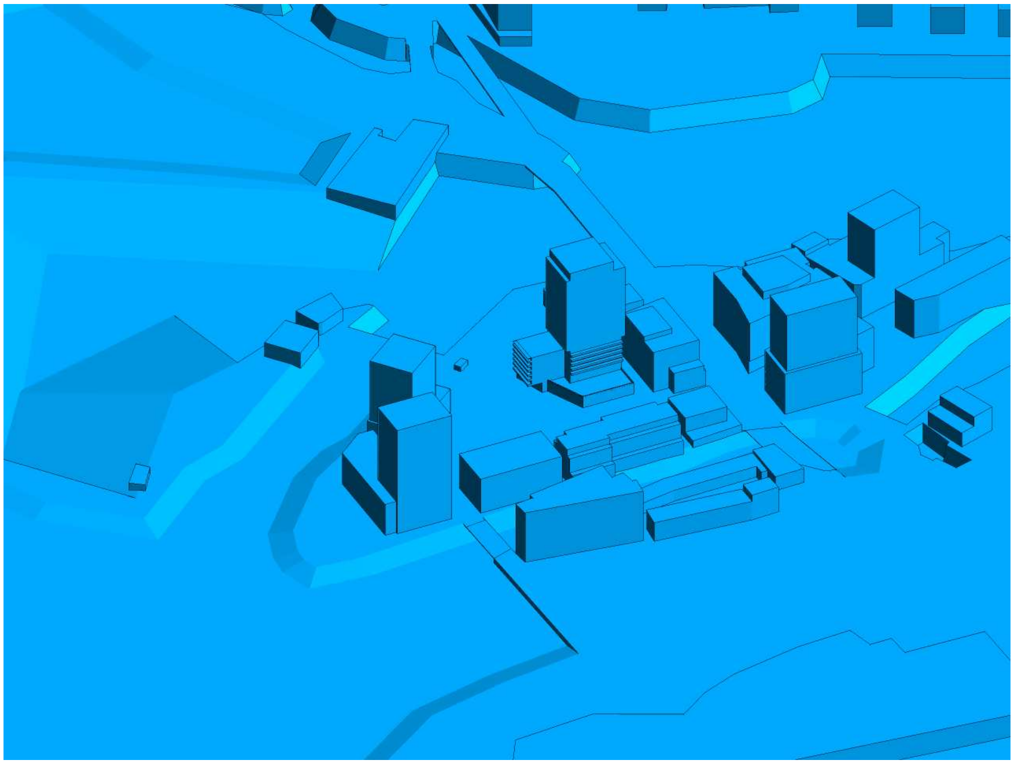

FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

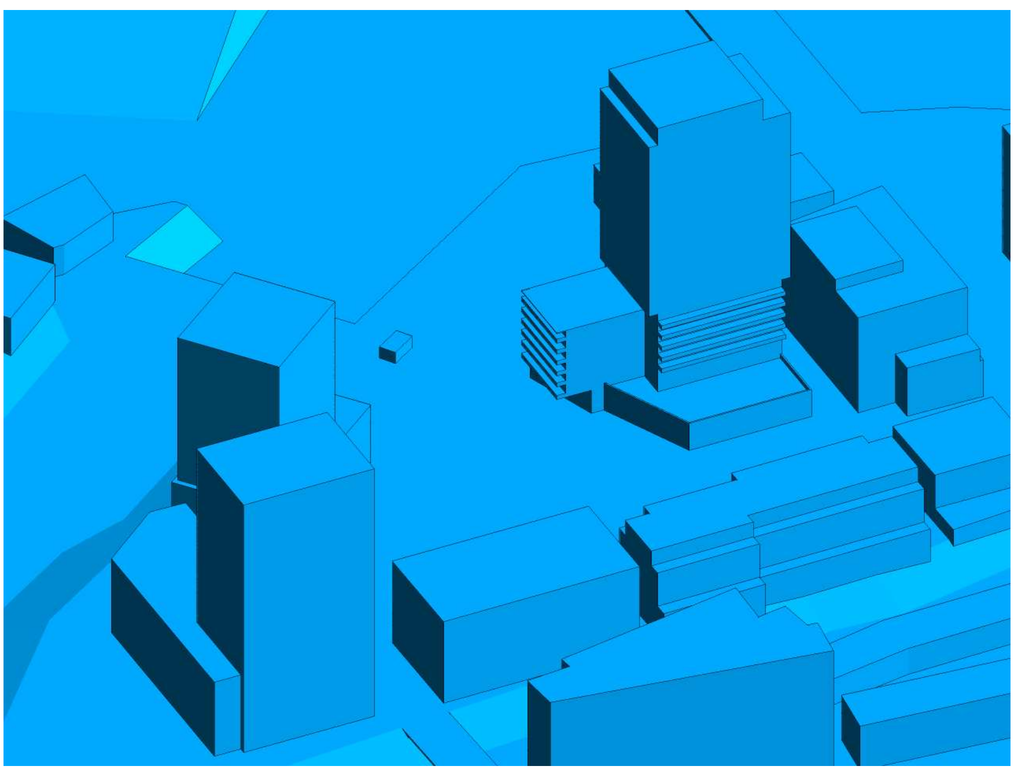

FIGURE 2H: CLOSE UP OF FIGURE 2G

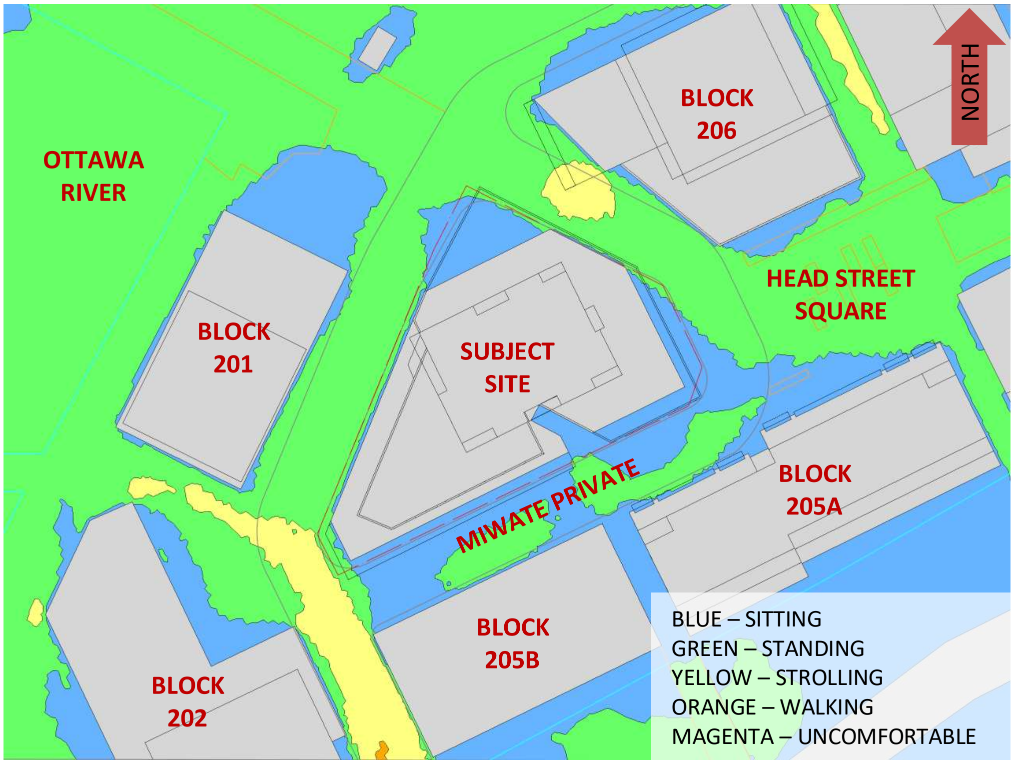

FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

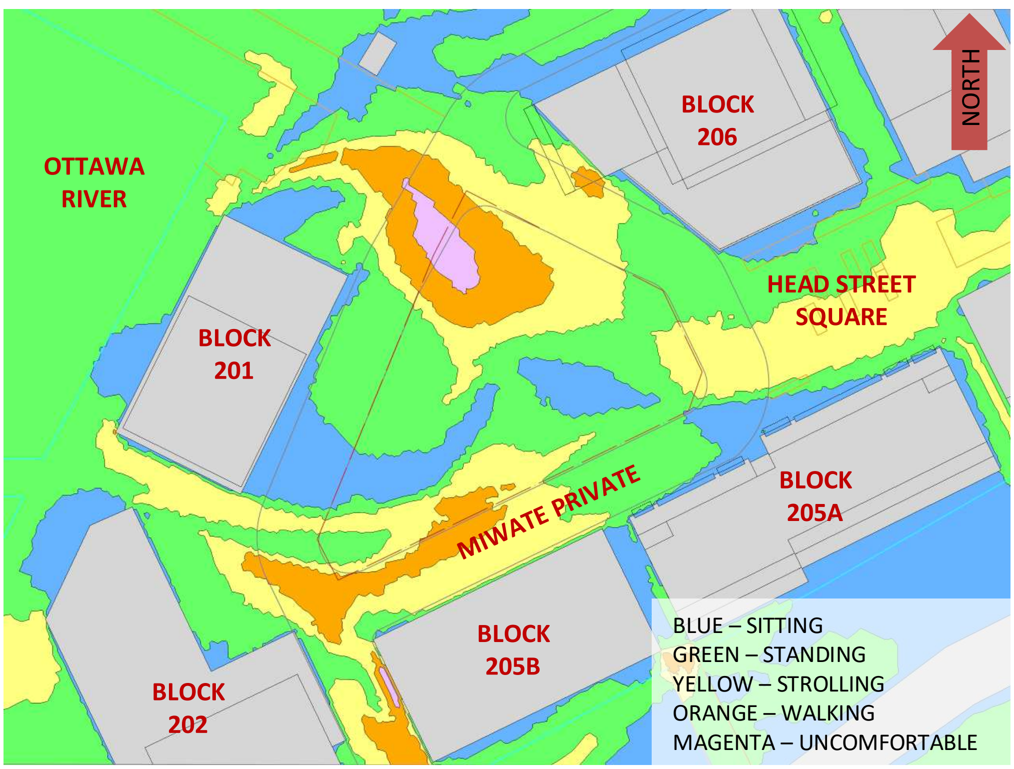

FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

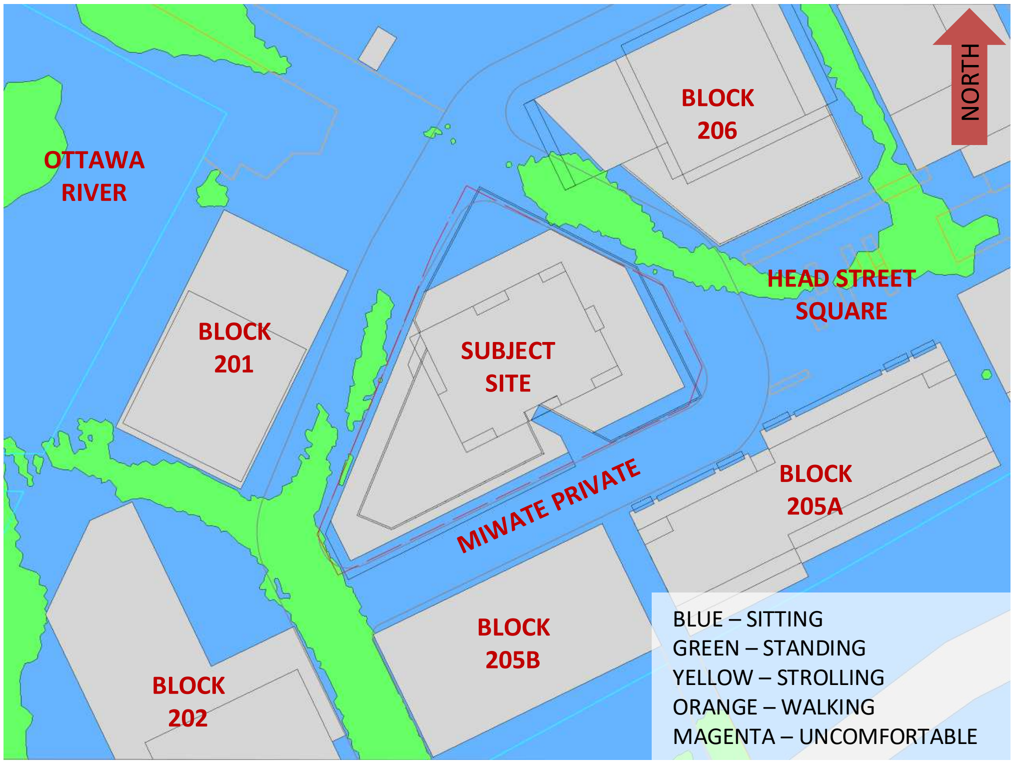

FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

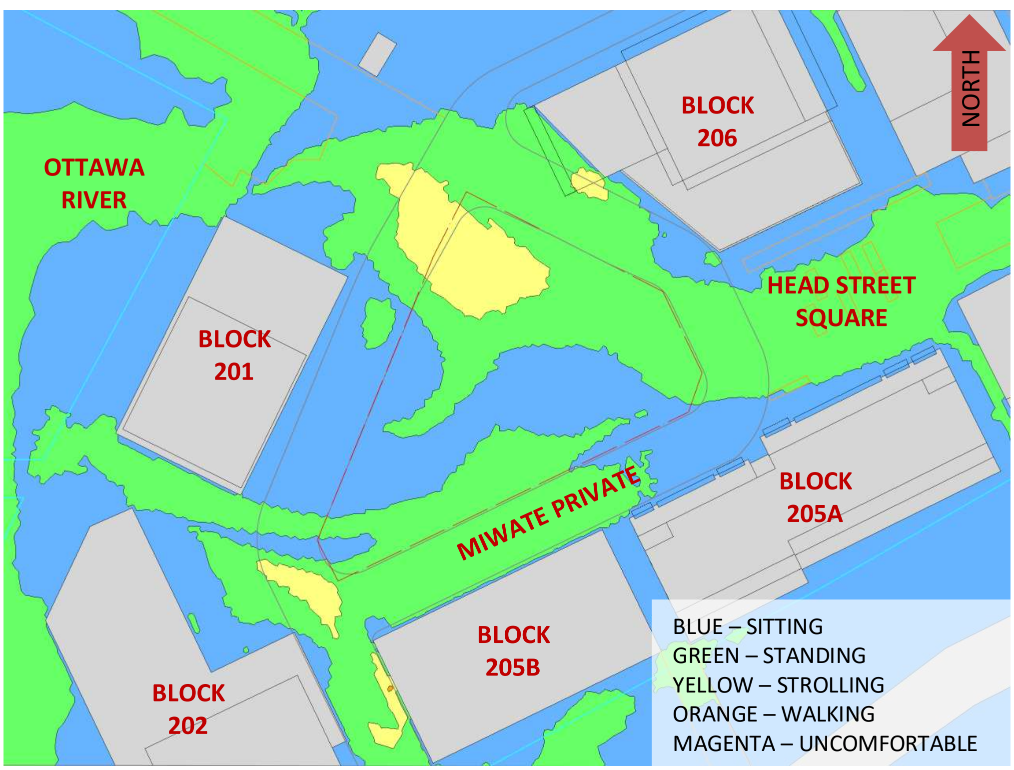

FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

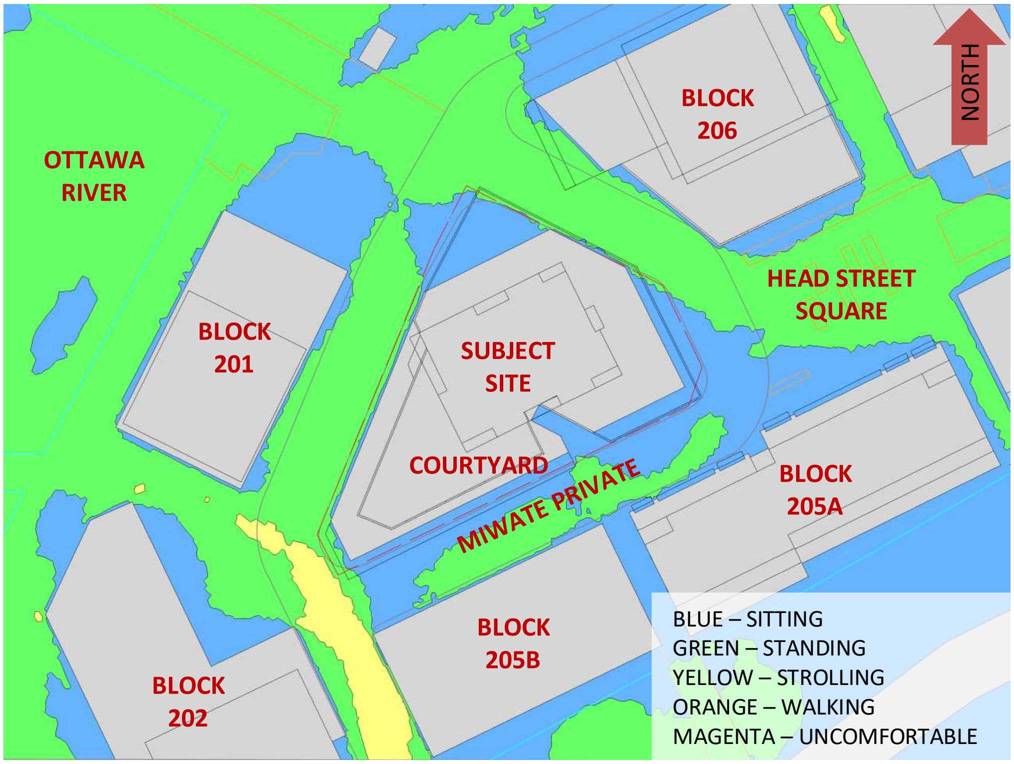

FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

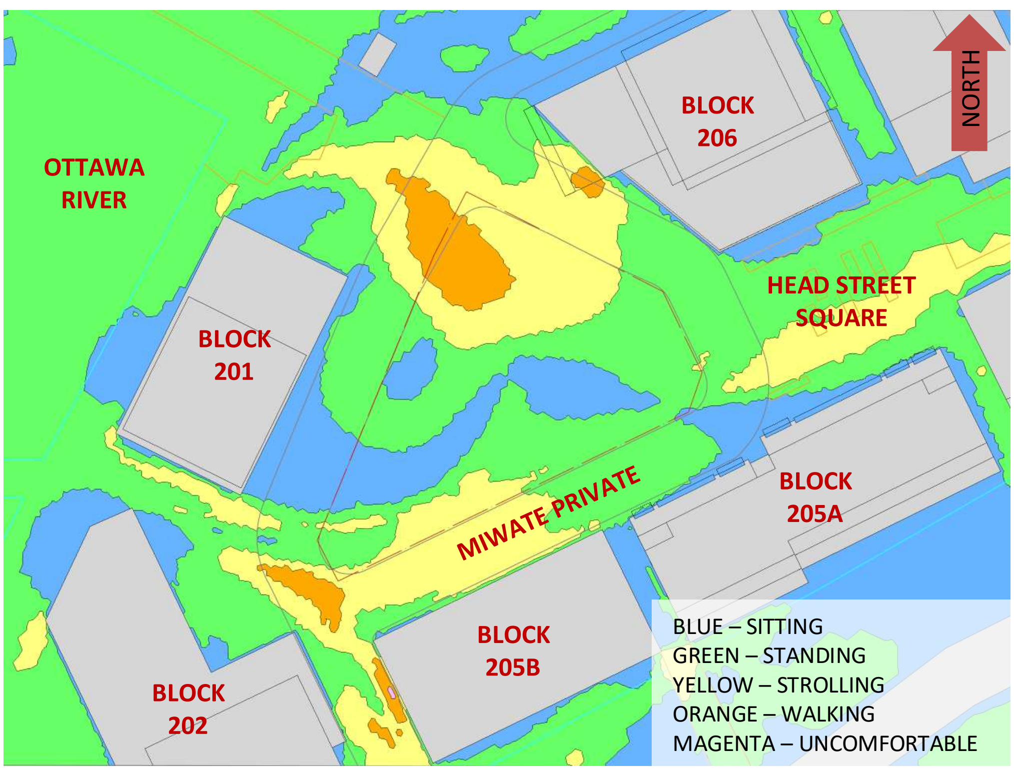

FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

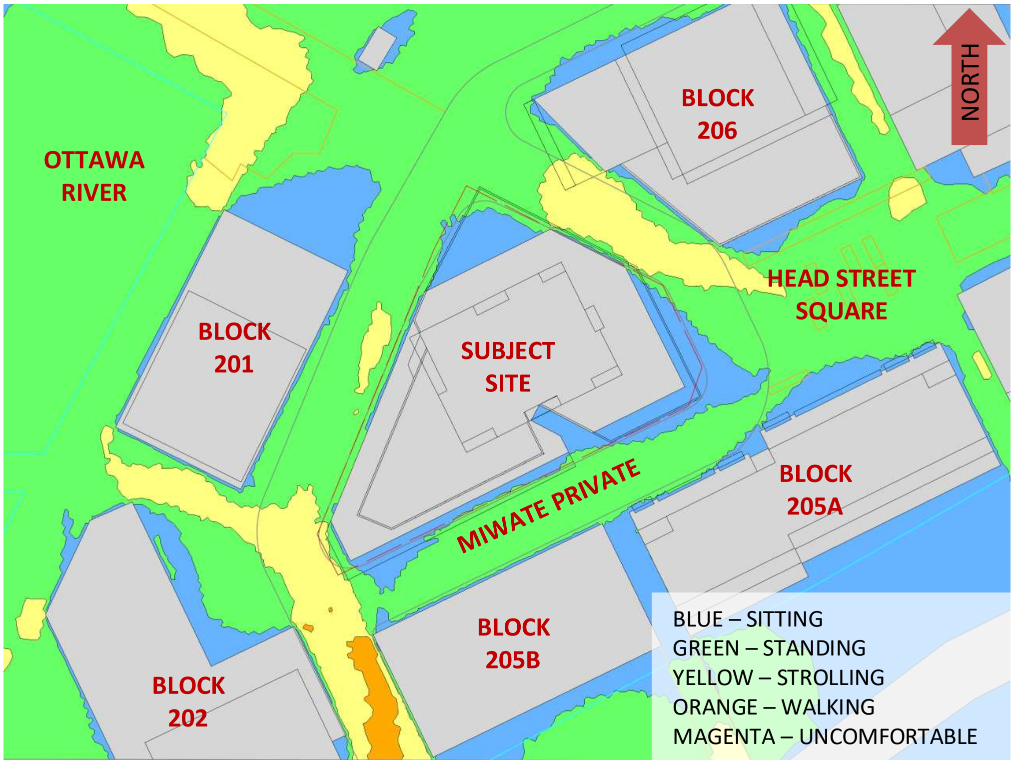

FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

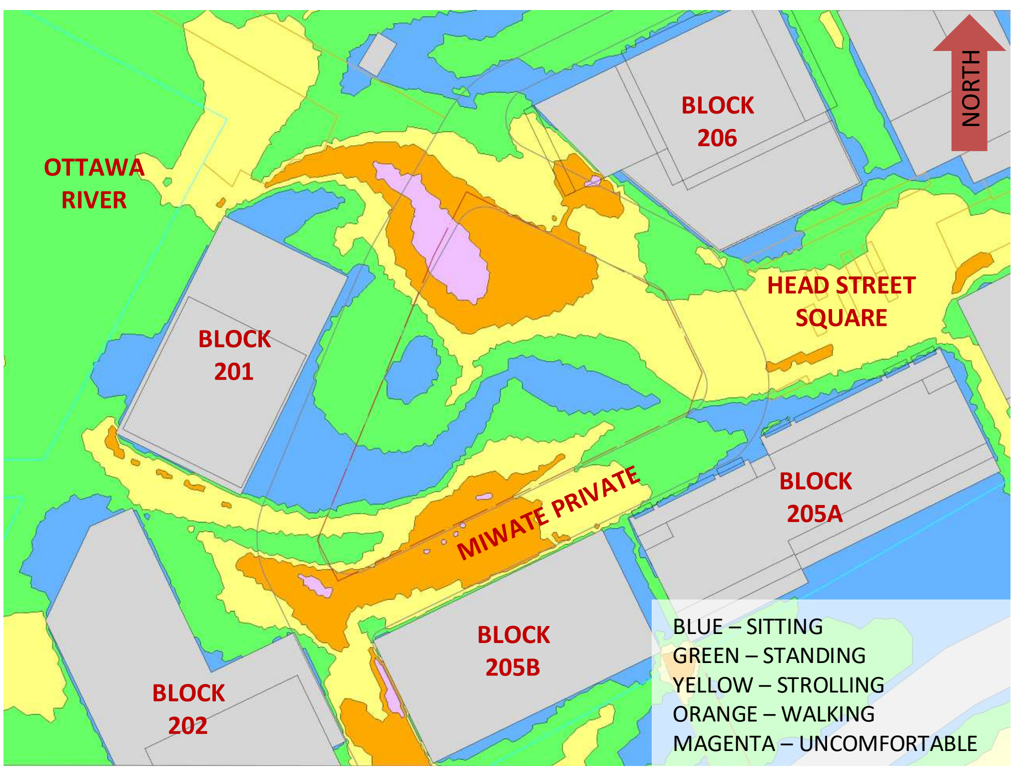

FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

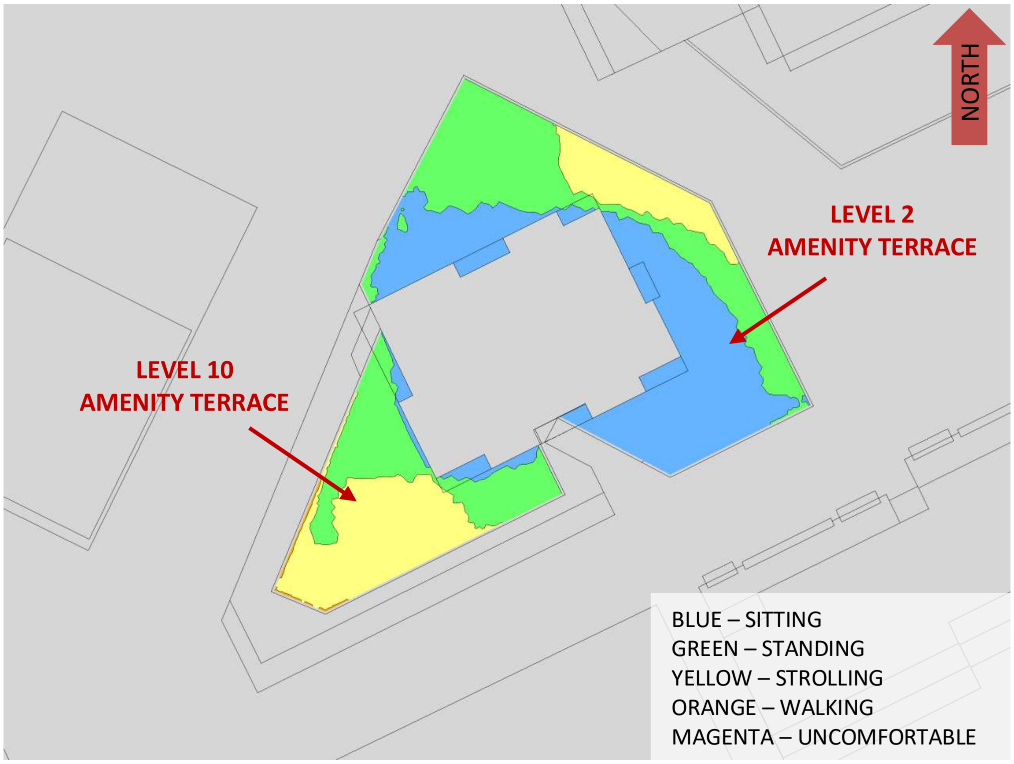

FIGURE 7A: SPRING – WIND COMFORT, COMMON AMENITY TERRACES

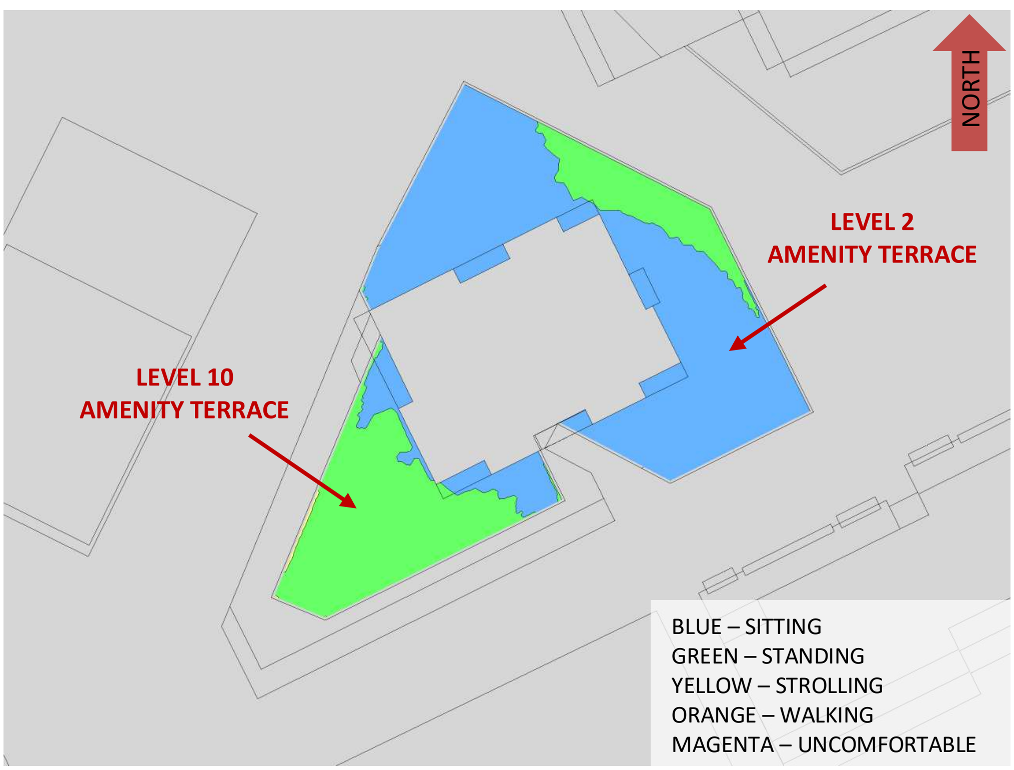

FIGURE 7B: SUMMER – WIND COMFORT, COMMON AMENITY TERRACES

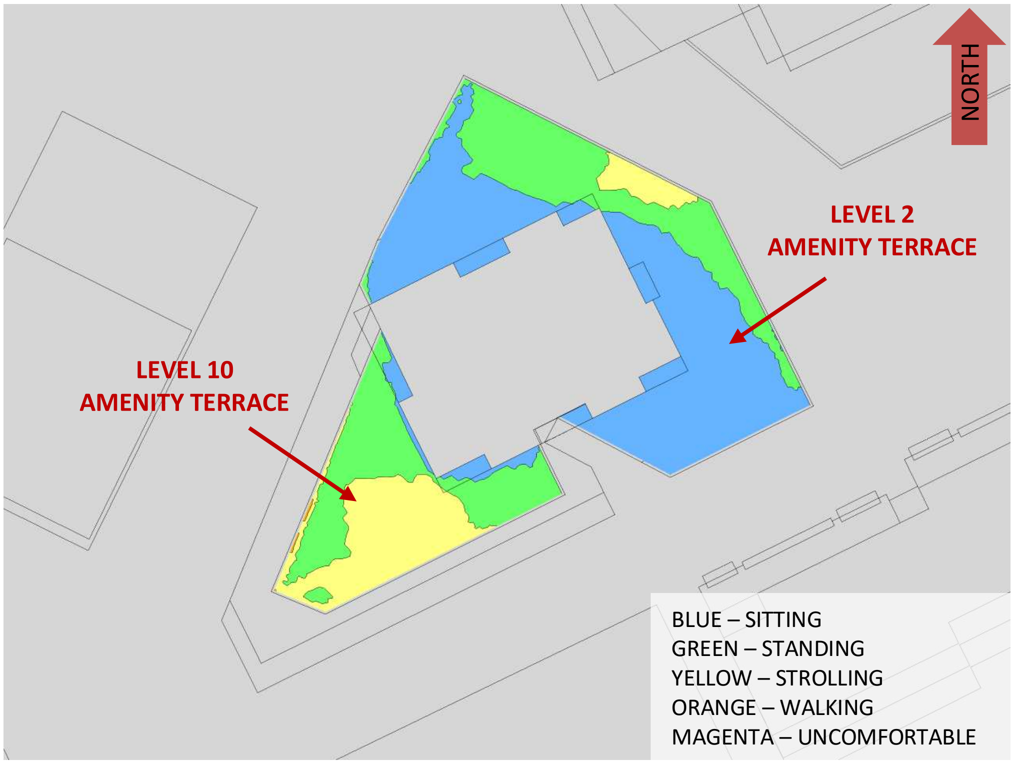

FIGURE 7C: AUTUMN – WIND COMFORT, COMMON AMENITY TERRACES

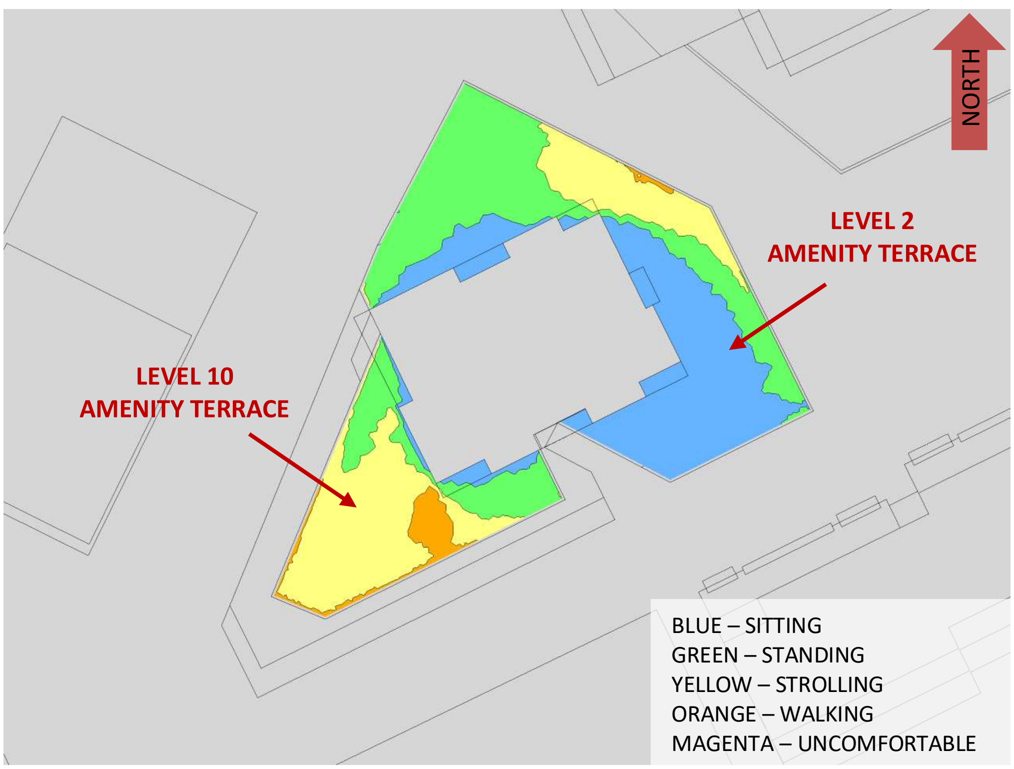

FIGURE 7D: WINTER – WIND COMFORT, COMMON AMENITY TERRACES

FIGURE 8: 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, U = mean wind speed, U_g = gradient wind speed, Z = height above ground, Z_g = depth of the boundary layer (gradient height), and α is the power law exponent.

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

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

α is determined based on the upstream exposure of the far-field surroundings (i.e., 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	0.26
49	0.21
74	0.26
103	0.26
167	0.24
197	0.22
217	0.21
237	0.18
262	0.18
282	0.20
302	0.21
324	0.24

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

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

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[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 Engieering Symposium, IWES 2003*, Taiwan, 2003.