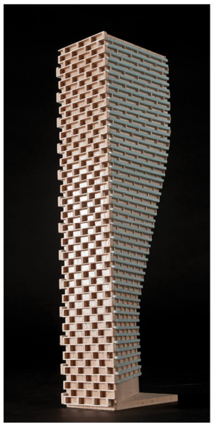
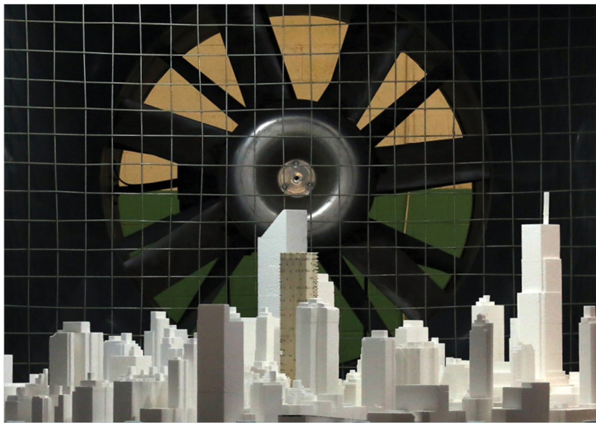
PEDESTRIAN LEVEL WIND STUDY

2046-2050 Scott Street
Ottawa, Ontario

Report: 19-246-PLW





April 24, 2020

PREPARED FOR
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PREPARED BY
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy zoning by-law amendment (ZBA) submission requirements for the proposed mixed-use development located at 2046-2050 Scott Street in Ottawa, Ontario (hereinafter referred to as “subject site”). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

A complete summary of the predicted wind comfort and safety conditions at grade level and within the elevated amenity terrace is provided in Section 5 of this report and illustrated in Figures 3A-5 (following the main text). 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 similar developments in Ottawa, we conclude the following:

1) Wind conditions around the subject site at grade level, including along Scott Street, along Ashton Avenue, at all building access points, and throughout all landscaped areas, will be acceptable for their intended uses throughout the year.

2) Wind conditions within the common amenity terraces at Level 7 will be suitable for a mix of sitting and standing during the summer. Mitigation will be required to provide sitting conditions at least 80% of the time during the typical use period, defined as late spring to early autumn. A formal wind comfort mitigation strategy will be confirmed during detailed design development, which may include raised perimeter guards and/or local wind barriers inboard of the perimeter.

3) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas surrounding the subject site at grade level were found to experience conditions that are considered dangerous.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Scott Street Developments Inc. to undertake a pedestrian level wind (PLW) study to satisfy zoning by-law amendment (ZBA) submission requirements for the proposed mixed-use development located at 2046-2050 Scott Street, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind comfort and safety within and surrounding the subject site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

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 provided by Roderick Lahey Architecture Inc. in April 2020, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent site imagery via Google Earth Pro.

2. TERMS OF REFERENCE

The subject site is located at 2046-2050 Scott Street in Ottawa, and is situated on a parcel of land bordered by Scott Street to the north, Winona Avenue to the west, Athlone Street to the east, and Ashton Avenue to the south.

Rendering, Southeast Perspective
(Courtesy of Roderick Lahey Architecture Inc.)

The proposed development comprises a 30-storey building with an irregular planform at grade. A 3-storey podium is located at the south of the building. The building steps back on all elevations at Level 7, with a common amenity space atop the 6-storey podium. The tower planform is nearly consistent up to Level 30.

The ground floor comprises commercial, amenity, lobby, and residential space, while Levels 2 and above comprise residential units. Primary residential and commercial entrances are located along the north elevation, while secondary building access points are located along the south elevation, near the centre of the west elevation, and near the south end of the east elevation.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 500-m radius of the site) are characterized primarily low-rise buildings, with several taller proposed high-rise buildings to the east and west along Scott Street, including the Minto Metropole condominium tower and the Island Park Towers to the northwest of the subject site. Additionally, the OC Transpo depressed transitway runs adjacent to, and to the north of, Scott Street. The far-field surroundings (defined as the area beyond the near field and within a five kilometer (km) radius) are characterized primarily by a mix of open and suburban wind exposures. From the northeast clockwise to east, the terrain is primarily suburban, while the presence of the Ottawa Experimental Farm contributes an open exposure from the east to southeast, resulting in a mixed open-suburban exposure. From the southeast clockwise to the southwest, the terrain is primarily suburban. The remaining compass directions produce a mix of open and suburban wind exposures as the Ottawa River produces an open exposure.

Key areas under consideration for pedestrian wind comfort and safety include surrounding sidewalks, building access points, and the amenity terrace at Level 7. Figure 1 illustrates the subject site and surrounding context, while Figures 2A-2D illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind comfort and safety conditions at key areas within and surrounding the subject 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 subject site is based on CFD simulations of wind speeds across the subject site and its surroundings 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 for Ottawa Macdonald-Cartier International Airport.

The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly more conservative (i.e., windier) wind speed values.

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 diameter of approximately 840 m.

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

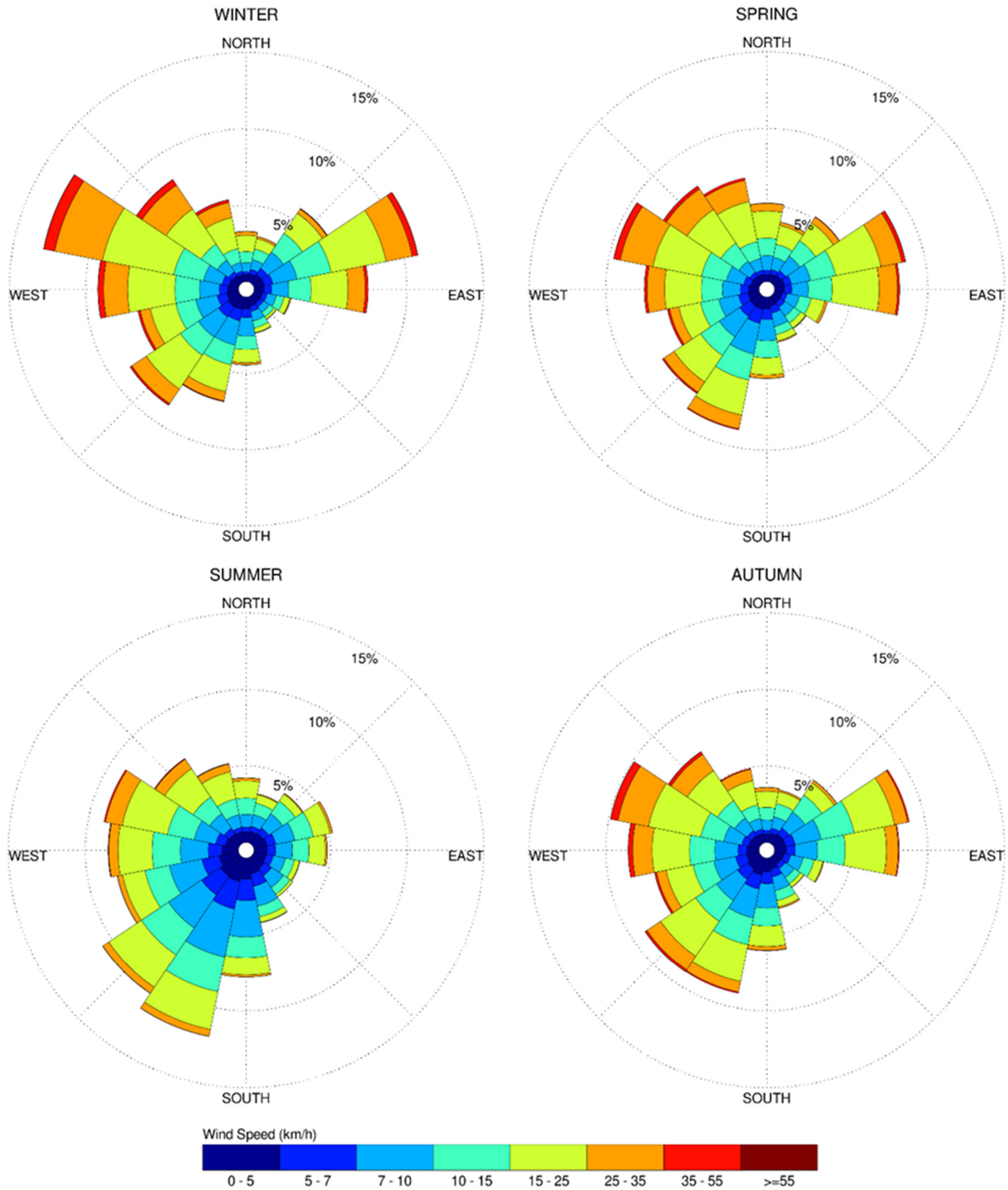
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade, and 1.5 m above the elevated common amenity terrace, were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. The gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Appendix A provides greater detail of the theory behind wind speed measurements.

4.3 Meteorological Data Analysis

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 in order to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Based on this portion of analysis, the four seasons are represented by grouping data from consecutive months based on similarity of weather patterns, and not according to the traditional calendar method. Summer is defined as June-September, autumn as October and November, winter as December-March, and spring as April and May.

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 the 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 guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 80% 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 gust equivalent mean 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 gust equivalent mean 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 gust equivalent mean 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 gust equivalent mean 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 mean gust speed ranges are selected based on 'The Beaufort Scale', which describes the effect of forces produced by varying wind speeds on levels on objects.

THE BEAUFORT SCALE

Number	Description	Wind Speed (km/h)	Description
2	Light Breeze	6-11	Wind felt on faces
3	Gentle Breeze	12-19	Leaves and small twigs in constant motion; Wind extends light flags
4	Moderate Breeze	20-28	Wind raises dust and loose paper; Small branches are moved
5	Fresh Breeze	29-38	Small trees in leaf begin to sway
6	Strong Breeze	39-49	Large branches in motion; Whistling heard in electrical wires; Umbrellas used with difficulty
7	Moderate Gale	50-61	Whole trees in motion; Inconvenient walking against wind
8	Gale	62-74	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 80% 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 (gust equivalent mean wind speed of 16 km/h) was 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 (gust equivalent mean wind speed of 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 most of 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 at tested locations, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for their associated spaces. This step involves comparing the predicted comfort class to the desired comfort class, which is dictated by the location type represented by the sensor (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrances	Standing
Secondary Building Access Points	Standing / Strolling / Walking
Primary Public Sidewalks	Strolling / Walking
Outdoor Amenity Spaces	Sitting / Standing / Strolling
Cafés / Patios / Benches / Gardens	Sitting
Transit Shelters	Sitting / Standing
Public Parks / Plazas	Sitting / Standing / Strolling
Garage / Service Entrances	Walking
Parking Lots	Strolling / Walking
Vehicular Drop-Off Zones	Standing / Strolling / Walking

5. RESULTS AND DISCUSSION

The following discussion of predicted pedestrian wind conditions is accompanied by Figures 3A-3D (following the main text) illustrating the seasonal wind conditions at grade level, and Figures 4A-4D illustrating the seasonal wind conditions within the common amenity terrace. The colour contours indicate various comfort classes predicted for certain regions. Wind conditions comfortable for sitting or more sedentary activities are represented by the colour green, standing are represented by yellow, strolling by orange, walking by blue, while uncomfortable conditions are represented by the colour magenta. Pedestrian wind comfort is summarized below for each area of interest. In addition, Figure 5 illustrates the percentage of time the amenity terrace will be suitable for sitting during the summer.

5.1 Wind Comfort Conditions – Grade Level

Scott Street: The sidewalks along Scott Street will be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of standing and strolling during the spring and autumn. Walking conditions will develop near the northeastern corner of the building during the winter. These conditions are considered acceptable.

Ashton Avenue: Conditions along Ashton Avenue, to the south of the site, will be suitable for a mix of sitting and standing during the summer and autumn, with a region becoming suitable for strolling during the remaining colder seasons. These conditions are considered acceptable.

Landscaped Areas: Conditions within the site at grade, to the west, east, and south of the building, will be suitable for a mix of sitting and standing during the summer and autumn, with areas near the building corners becoming suitable for strolling during the remaining colder seasons. These conditions are considered acceptable.

Building Entrances: Conditions at primary residential and commercial entrances at the north of the site, as well as at the building access point near the centre of the west elevation, will be suitable for sitting during the spring, summer, and autumn, becoming suitable for standing during the winter. Conditions within the immediate vicinity of all other building access points will be suitable for sitting throughout the year. All noted wind conditions are considered acceptable according to the comfort criteria in Section 4.4.

5.2 Wind Comfort Conditions – Amenity Terrace

Level 7 Amenity Terrace: Conditions within the common amenity terrace will be mostly suitable for sitting during the summer, with standing conditions developing within the areas at the southwest corner, along the east and north elevations, and within the small terrace at the northwest corner of the building. Figure 5 illustrates that, although the terrace will not achieve the sitting criterion for the required 80% of the time, most of the terrace will experience conditions suitable for sitting at least 70% of the time during the summer. Strolling conditions will develop during the autumn, and walking conditions will develop during the spring and winter.

Mitigation will be required to provide sitting conditions at least 80% of the time during the typical use period, defined as late spring to early autumn. A formal wind comfort mitigation strategy will be confirmed during detailed design development, which may include raised perimeter guards and/or local wind barriers inboard of the perimeter.

5.3 Wind Comfort Conditions – Surrounding Area Beyond the Subject Site

Wind conditions over surrounding sidewalks beyond the development 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. More specifically, development in urban centers generally creates reduction in the mean wind and localized increases in the gustiness of the wind.

6. SUMMARY

A complete summary of the predicted wind comfort and safety conditions at grade level and within the amenity terraces is provided in Section 5 of this report and illustrated in Figures 3A-4D, as well as Figure 5 (following the main text). 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 similar developments in Ottawa, we conclude the following:

1) Wind conditions around the subject site at grade level, including along Scott Street, along Ashton Avenue, at all building access points, and throughout all landscaped areas on-site, will be acceptable for their intended uses throughout the year.

2) Wind conditions within the common amenity terraces at Level 7 will be suitable for a mix of sitting and standing during the summer. Mitigation will be required to provide sitting conditions at least 80% of the time during the typical use period. A formal wind comfort mitigation strategy will be confirmed during detailed design development, which may include raised perimeter guards and/or local wind barriers inboard of the perimeter.

3) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas surrounding the subject site at grade level or within the common amenity areas were found to experience conditions that are considered dangerous.

This concludes our pedestrian level wind study and report. Please advise the undersigned of any questions or comments.

Sincerely,

Gradient Wind Engineering Inc.

Sacha Ruzzante, MASc
Junior Wind Scientist

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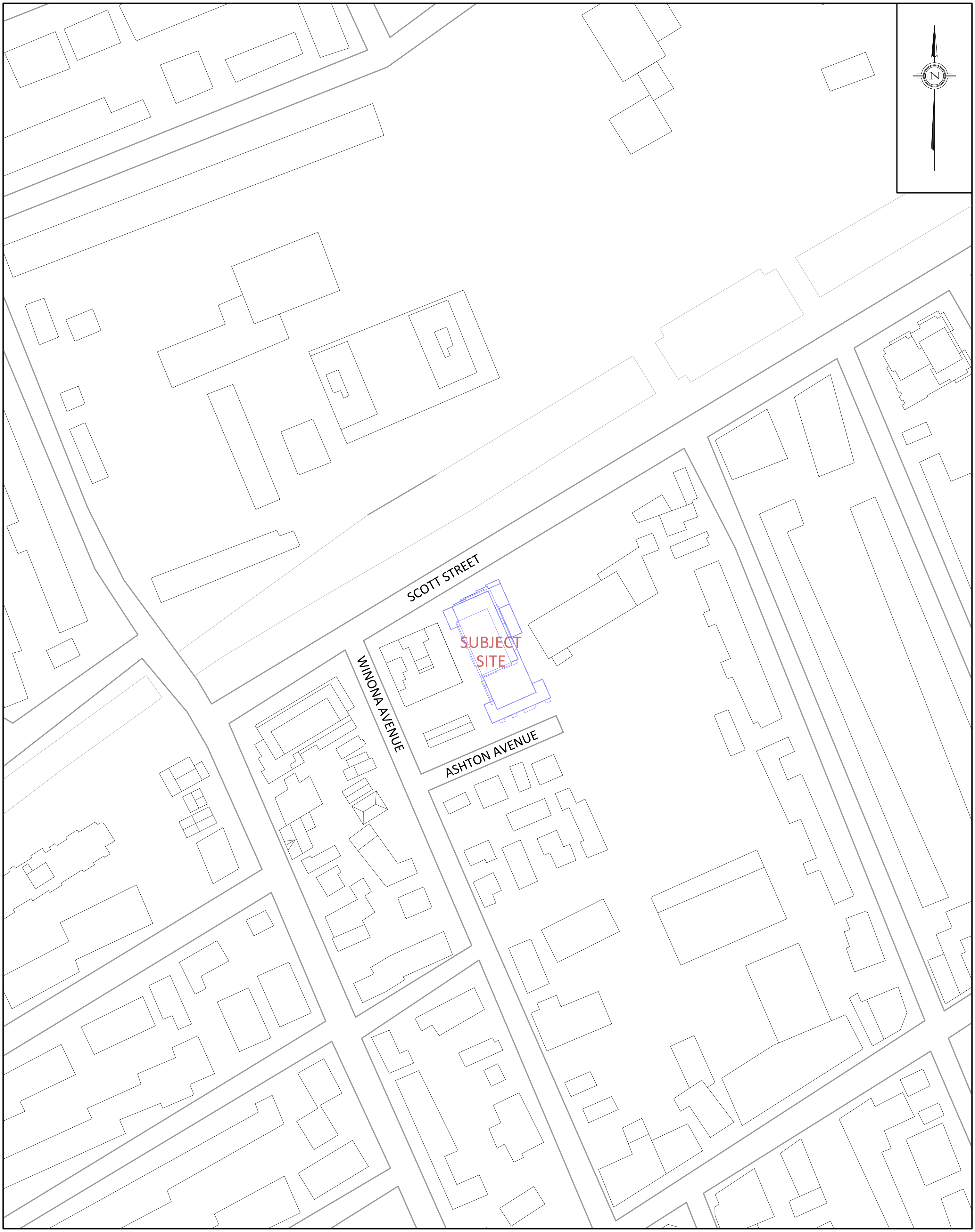
Principal

Gradient Wind File 19-246



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PROJECT	2046-2050 SCOTT STREET, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2500
DRAWING NO.	19-246-PLW-1
DATE	APRIL 16, 2020
DRAWN BY	S.R.
DESCRIPTION	FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT

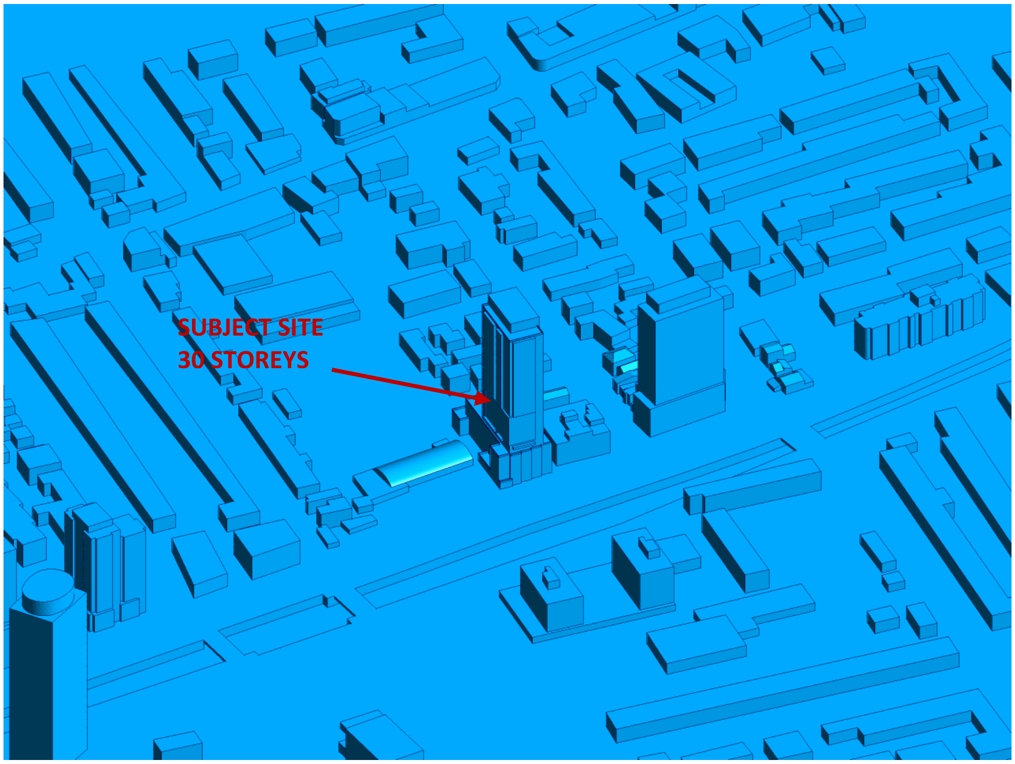

FIGURE 2A: COMPUTATIONAL MODEL, NORTH PERSPECTIVE

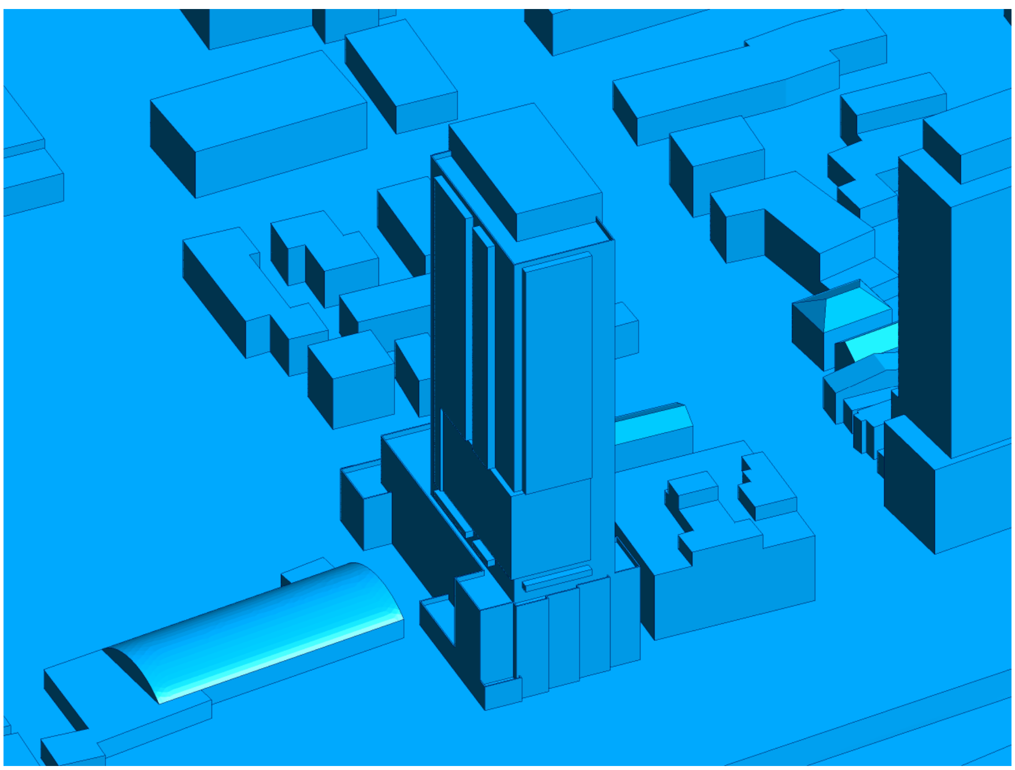

FIGURE 2B: CLOSE UP OF FIGURE 2A

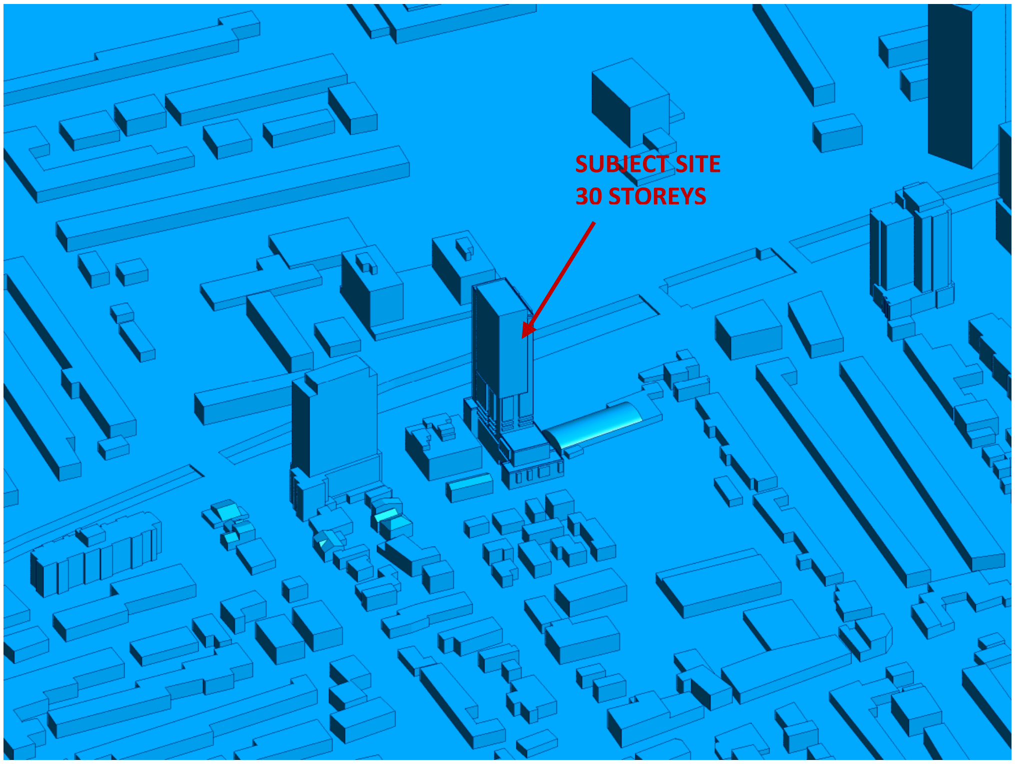

FIGURE 2C: COMPUTATIONAL MODEL, SOUTH PERSPECTIVE

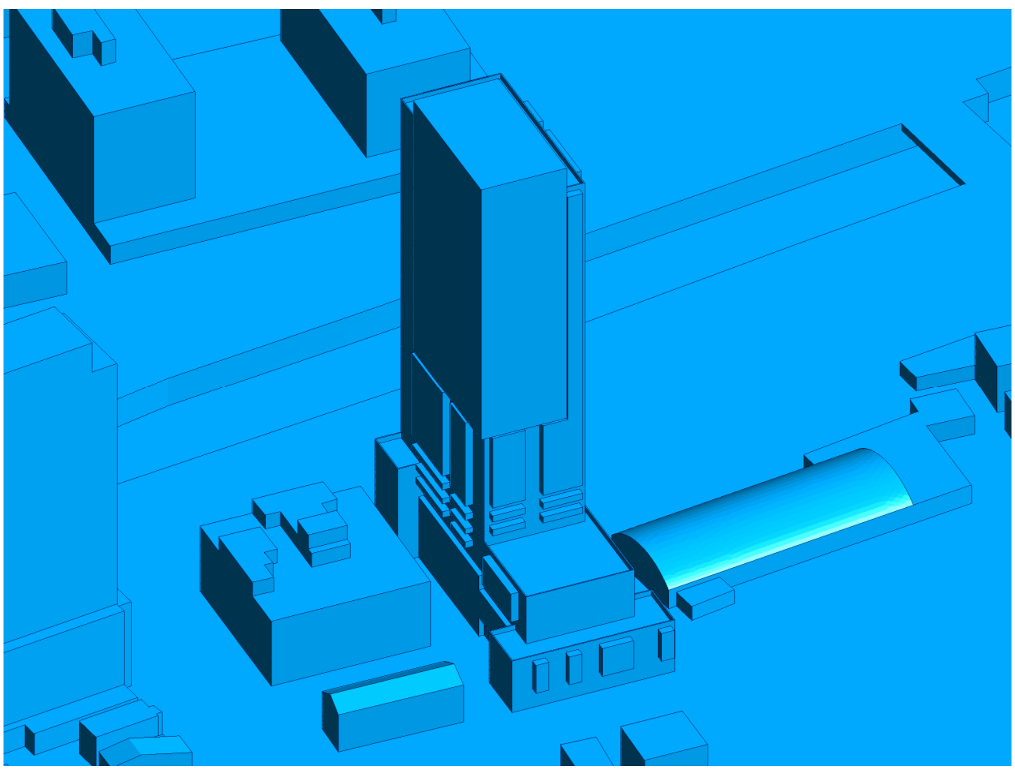

FIGURE 2D: CLOSE UP OF FIGURE 2C

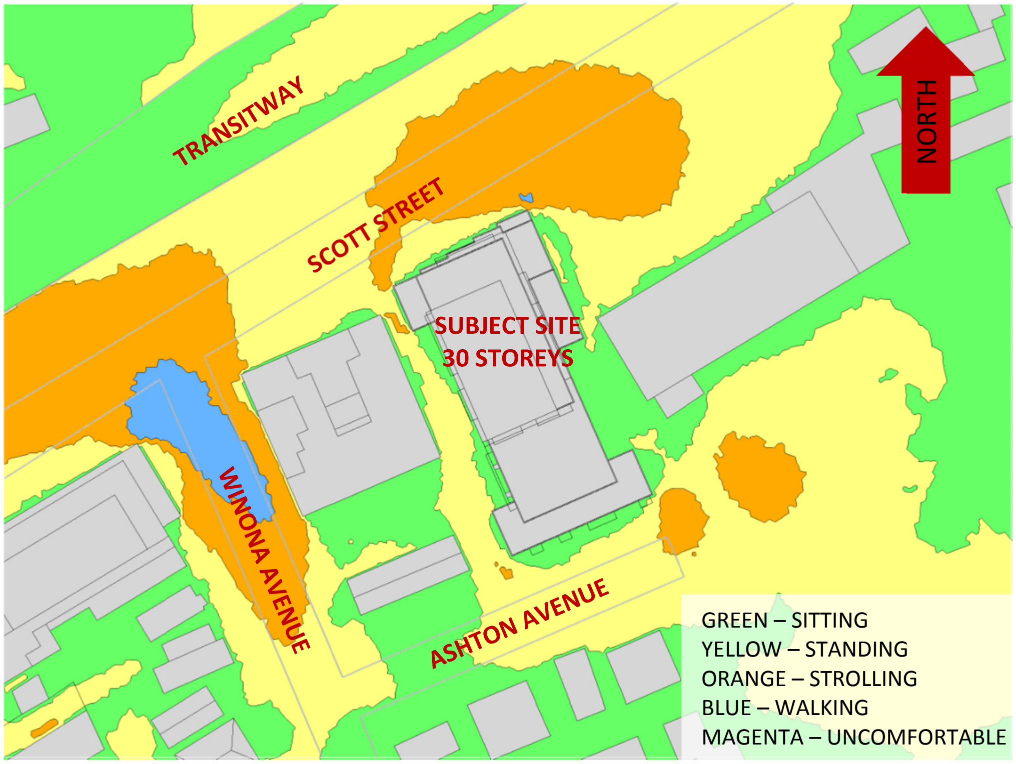

FIGURE 3A: SPRING – WIND CONDITIONS AT GRADE LEVEL

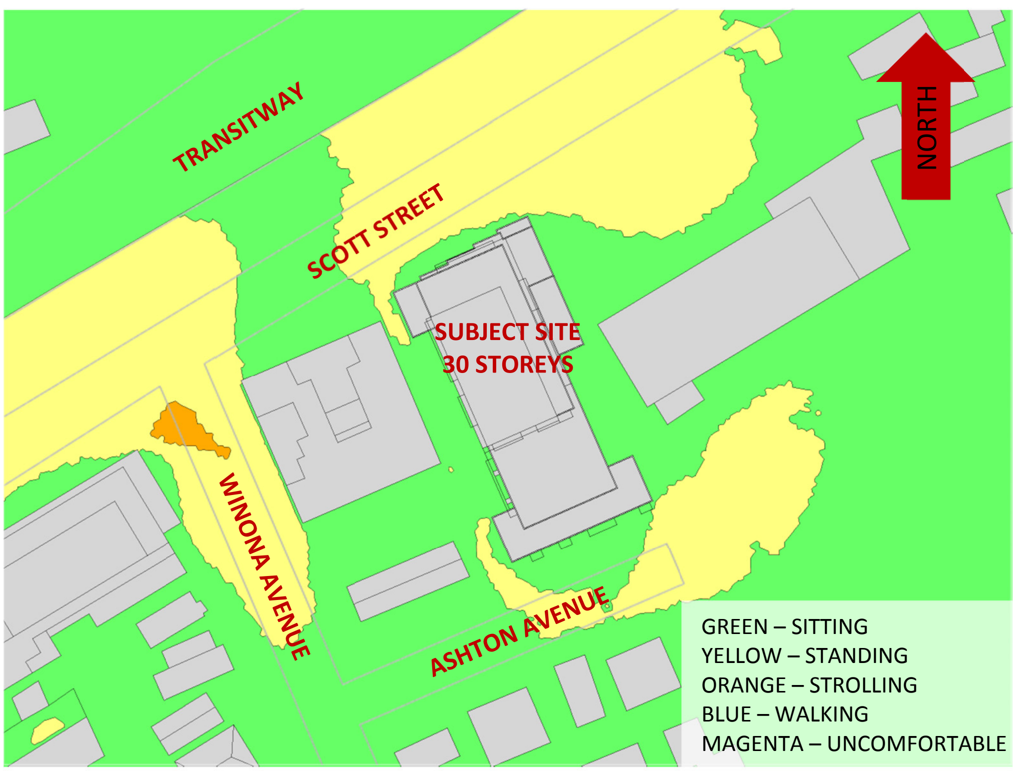

FIGURE 3B: SUMMER – WIND CONDITIONS AT GRADE LEVEL

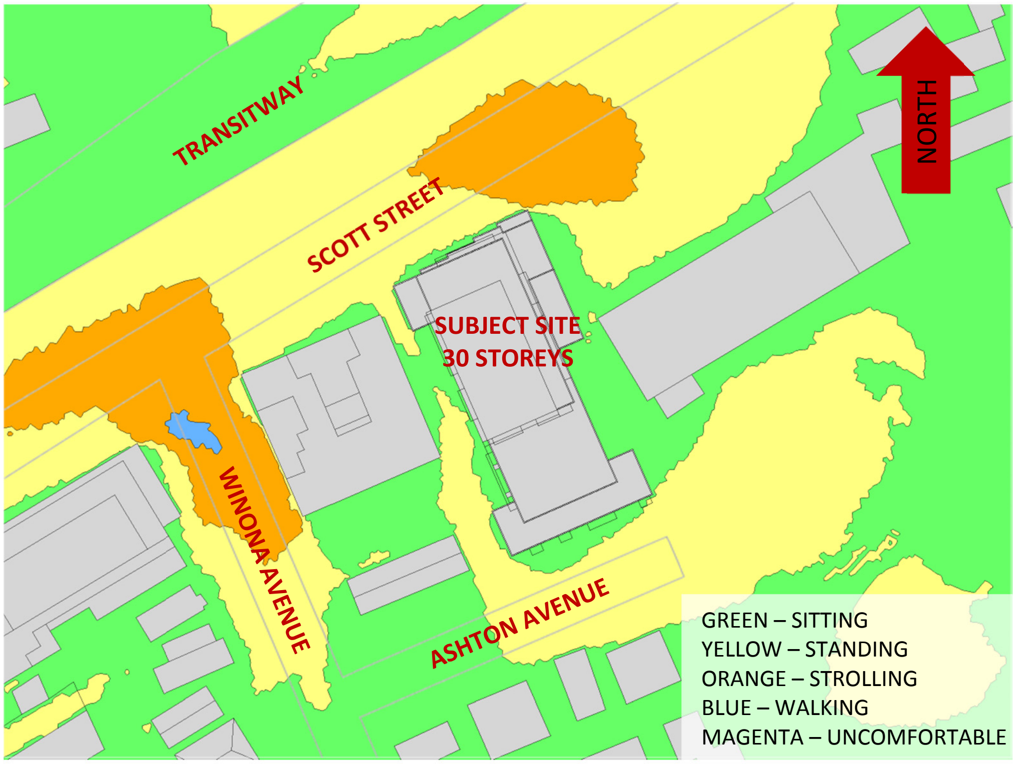

FIGURE 3C: AUTUMN – WIND CONDITIONS AT GRADE LEVEL

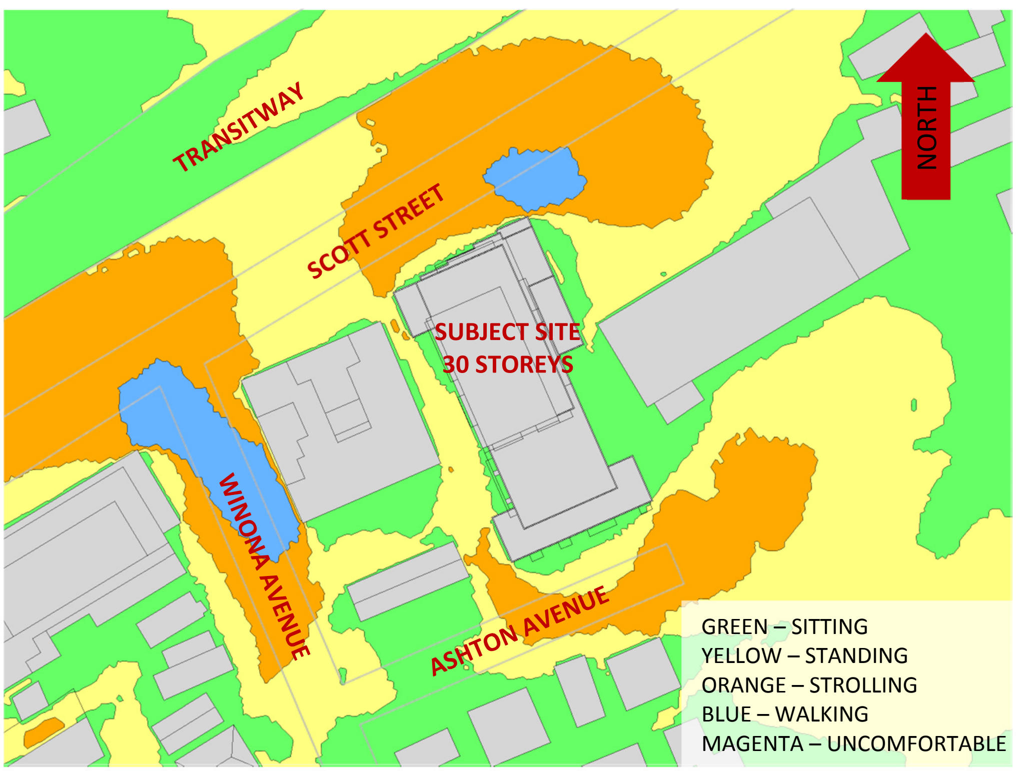

FIGURE 3D: WINTER – WIND CONDITIONS AT GRADE LEVEL

FIGURE 4A: SPRING – WIND CONDITIONS WITHIN COMMON AMENITY TERRACES

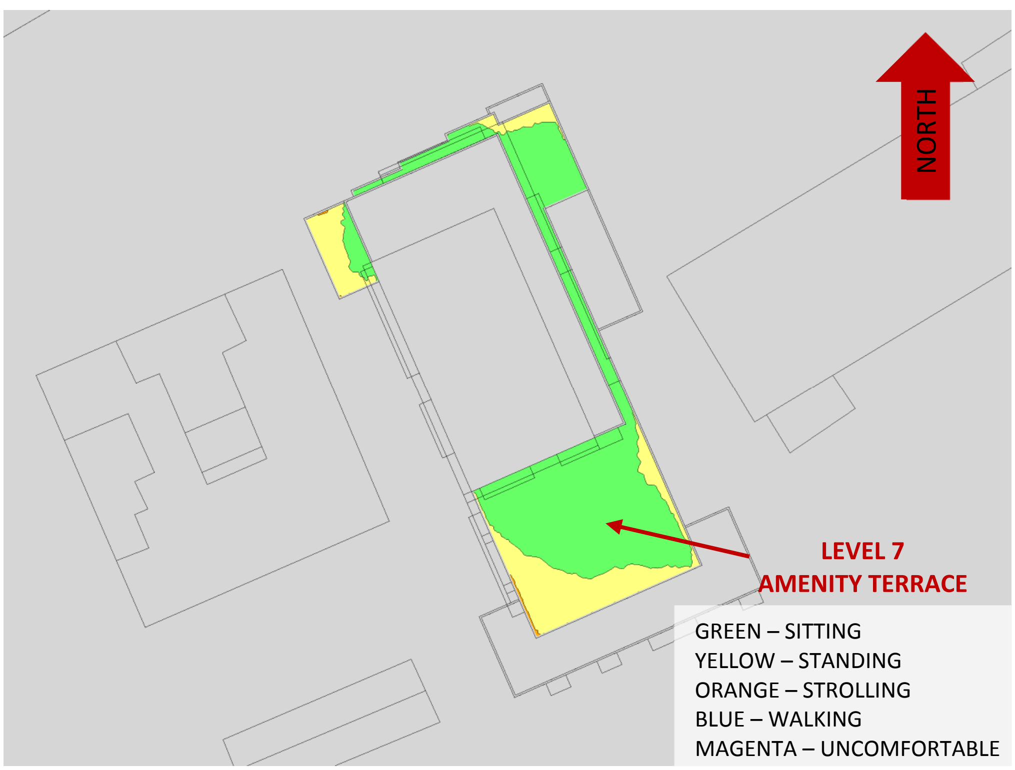

FIGURE 4B: SUMMER – WIND CONDITIONS WITHIN COMMON AMENITY TERRACES

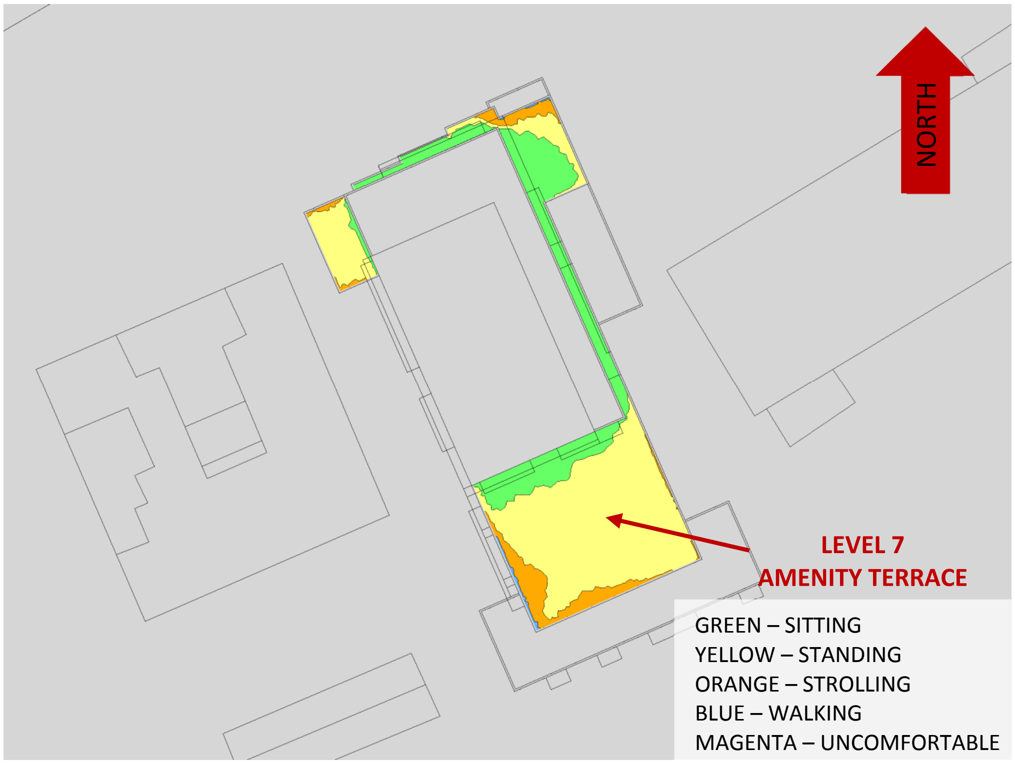

FIGURE 4C: AUTUMN – WIND CONDITIONS WITHIN COMMON AMENITY TERRACES

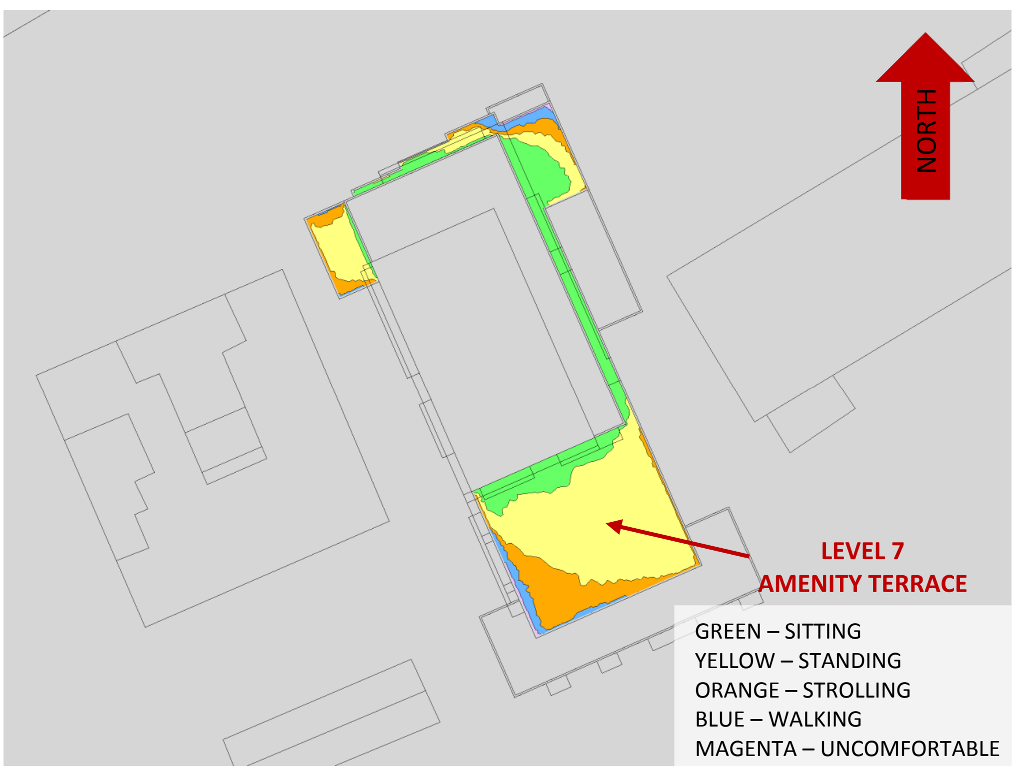

FIGURE 4D WINTER – WIND CONDITIONS WITHIN COMMON AMENITY TERRACES

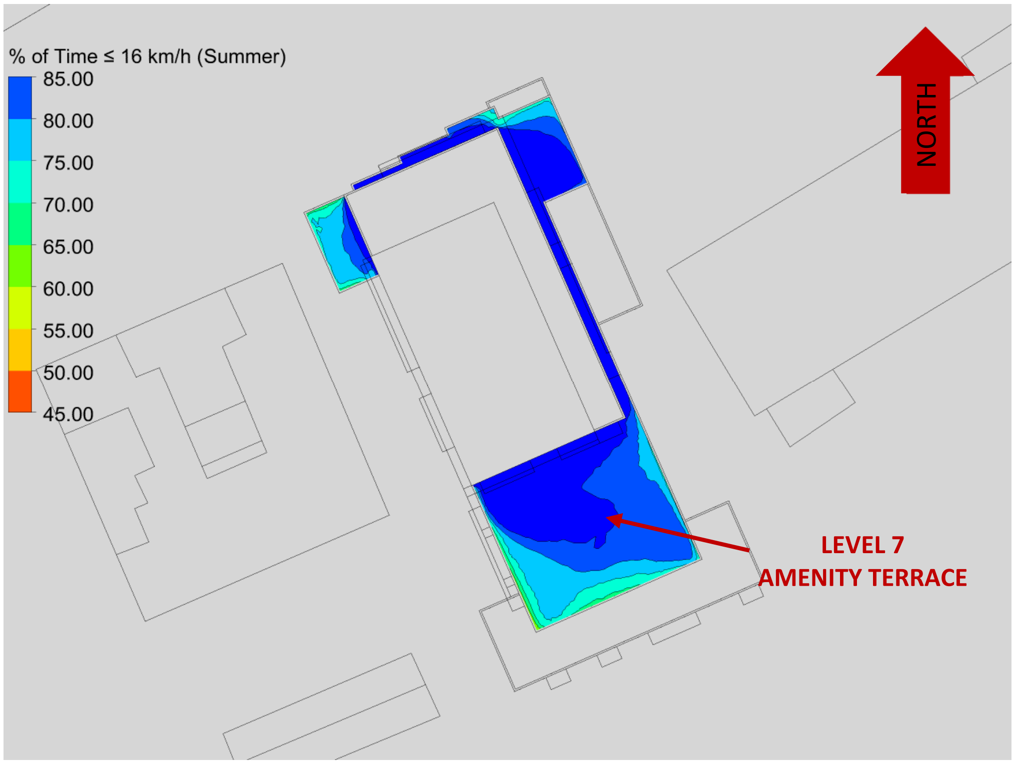

FIGURE 5: SUMMER – PERCENTAGE OF TIME SUITABLE FOR SITTING (TERRACES)

APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (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 (° True)	Alpha (α) Value
0	0.21
49	0.25
74	0.25
103	0.23
167	0.25
197	0.25
217	0.25
237	0.18
262	0.18
282	0.19
302	0.20
324	0.20

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

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

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

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

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

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

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

REFERENCES

[1] P. Arya, "Chapter 10: Near-neutral Boundary Layers," in *Introduction to Micrometeorology*, San Diego, California, Academic Press, 2001.

[2] S. A. Hsu, E. A. Meindl and D. B. Gilhousen, "Determining the Power-Law WInd Profile Exponent under Near-neutral Stability Conditions at Sea," vol. 33, no. 6, 1994.

[3] Y. Tamura, H. Kawai, Y. Uematsu, K. Kondo and T. Okhuma, "Revision of AIJ Recommendations for Wind Loads on Buildings," in *The International Wind Engieering Symposium, IWES 2003*, Taiwan, 2003.