

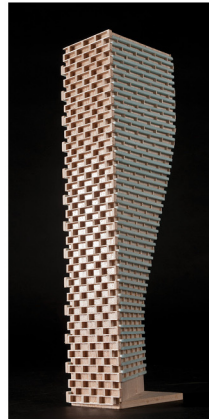
GRADIENTWIND

ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

217 Dunlop Street East
Barrie, Ontario

Report: 20-167-PLW



January 15, 2021

PREPARED FOR

Salter Pilon Architecture Inc.
151 Ferris Land, Suite 400
Barrie, ON L4M 6C1

PREPARED BY

Sacha Ruzzante, MASc, Junior Wind Scientist
Justin Ferraro, P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy zoning by-law amendment (ZBA) and site plan control application (SPA) submission requirements for the proposed residential development located at 217 Dunlop Street East in Barrie, Ontario (hereinafter referred to as the “subject site”). Our mandate within this study is to investigate pedestrian wind comfort 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, preliminary drawings prepared by Salter Pilon Architecture Inc in July 2020, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

A complete summary of the predicted wind comfort and safety conditions is provided in Section 5 of this report and illustrated in Figures 3A-3D following the main text. Based on computer simulations using the CFD technique, meteorological data analysis, and experience with similar developments in Ontario, we conclude the following:

- 1) All areas at grade level within and surrounding the subject site will be suitable for their intended uses throughout the year. Specifically, wind conditions over surrounding sidewalks, building access points, and driveways are considered acceptable for the intended pedestrian uses throughout the year.
- 2) 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.
- 3) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas surrounding the subject site at grade level were found to experience conditions that could be considered uncomfortable or dangerous.



TABLE OF CONTENTS

1. INTRODUCTION	1
2. TERMS OF REFERENCE	1
3. OBJECTIVES	2
4. METHODOLOGY.....	2
4.1 Computer-Based Context Modelling	2
4.2 Wind Speed Measurements	3
4.3 Meteorological Data Analysis.....	4
4.4 Pedestrian Comfort and Safety Guidelines	6
5. RESULTS AND DISCUSSION	8
5.1 Wind Comfort	8
5.2 Wind Safety	9
5.3 Applicability of Results.....	9
6. SUMMARY AND RECOMMENDATIONS	10

FIGURES

APPENDICES

Appendix A – Simulation of the Atmospheric Boundary Layer



1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Salter Pilon Architecture Inc to undertake a pedestrian level wind (PLW) study to satisfy zoning by-law amendment (ZBA) and site plan control application (SPA) submission requirements for the proposed residential development located at 217 Dunlop Street East in Barrie, Ontario (hereinafter referred to as the “subject site”). Our mandate within this study is to investigate pedestrian wind comfort 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, preliminary drawings prepared by Salter Pilon Architecture Inc in July 2020, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

2. TERMS OF REFERENCE

The subject site is located at 217 Dunlop Street East in Barrie, on a parcel of land bordered by Lake Simcoe to the south, Dunlop Street East to the north, and existing developments to the east and west.

The subject site comprises a 15-storey residential development. At grade, the building has a roughly rectangular planform, which remains roughly consistent to Level 10. At Level 11 the building steps back from the northeast and northwest corners. At Level 15 the building steps back from all elevations. Private balconies are provided on the south elevation, and at Level 15 the penthouse suite includes private terraces at the north and south elevations.



*Architectural Rendering, NW Perspective
(Courtesy of Salter Pilon Architecture Inc.)*



Building entrances are located along the north elevation, as well as along the south elevation. Vehicular entrances to underground parking are located from the east and west elevations. Landscaped space is provided along the north and south elevations at grade.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre (m) radius of the site) are characterized by mostly low-rise residential dwellings to the north, by some mid-rise developments to the northeast and east, by Lake Simcoe from the east clockwise to the southwest, and by an existing 7-storey development to the immediate west (215 Dunlop Street East). The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) comprise mostly low-rise residential dwellings from the northwest clockwise to northeast, the open exposure of Lake Simcoe from the east clockwise to southwest, and a mix of low-rise and high-rise developments to the west. A site plan is illustrated in Figure 1, while Figures 2A-2D illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to: (i) determine comparative pedestrian level wind comfort and safety conditions at key outdoor areas; (ii) identify areas where future wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Barrie wind climate, and synthesis of computational data with industry-accepted guidelines. The following sections describe the analysis procedures, including a discussion of the comfort guidelines.

4.1 Computer-Based Context Modelling

A computer based PLW wind 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 Lake Simcoe Regional 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.

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 on a continuous measurement plane 1.5 m above local grade 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. Further details of the CFD wind flow simulation technique are presented in Appendix A.

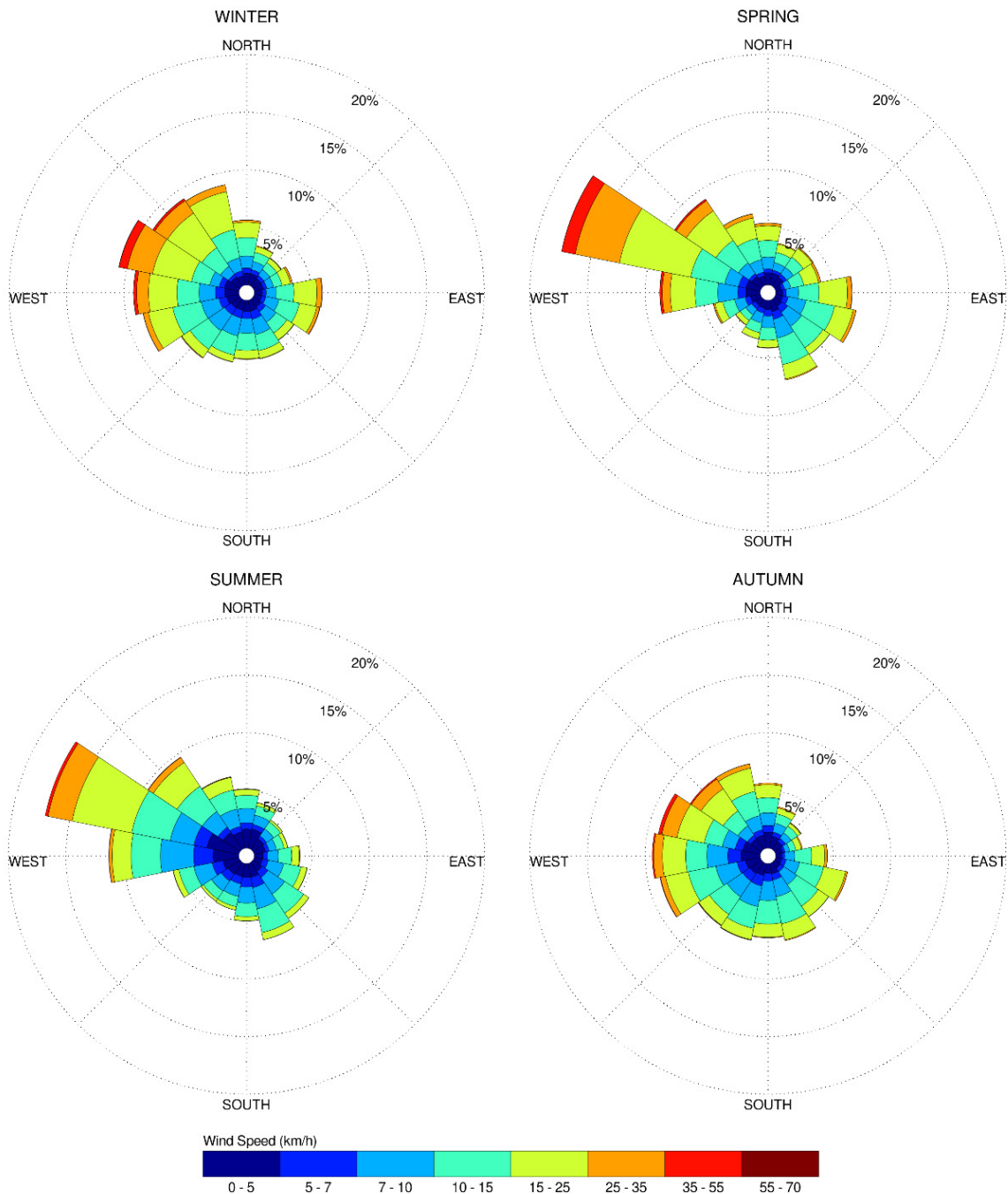


4.3 Meteorological Data Analysis

A statistical model for winds in Barrie was developed from approximately 12 years of hourly meteorological wind data recorded at Lake Simcoe Regional 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. 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; spring is defined as April-May, summer as June-September, autumn as October-November, and winter as December-March.

The statistical model of the Barrie 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 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 Barrie, the most common winds concerning pedestrian comfort occur from the west clockwise to the north. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying the calmest winds relative to the remaining seasonal periods.

SEASONAL DISTRIBUTION OF WIND LAKE SIMCOE REGIONAL AIRPORT, ORO STATION, ONTARIO



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 Guidelines

Pedestrian comfort and safety guidelines 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. Four pedestrian comfort classes are based on 80% non-exceedance gust wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. More specifically, the comfort classes and associated gust wind speed ranges are summarized as follows:

- (i) **Sitting** – A wind speed no greater than 16 km/h is considered acceptable for sedentary activities, including sitting.
- (ii) **Standing** – A wind speed greater than 16 km/h but no greater than 22 km/h is considered acceptable for activities such as standing or leisurely strolling.
- (iii) **Walking** – A wind speed greater than 22 km/h but no greater than 30 km/h is considered acceptable for walking or more vigorous activities.
- (iv) **Uncomfortable** – A wind speed greater than 30 km/h is classified as uncomfortable from a pedestrian comfort standpoint. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this comfort class.

The pedestrian safety wind speed guideline 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 greater than 90 km/h is classified as dangerous. The wind speeds associated with the above categories are gust wind speeds. 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
		Mean	Gust	
2	Light Breeze	6-11	9-17	Wind felt on faces
3	Gentle Breeze	12-19	18-29	Leaves and small twigs in constant motion; wind extends light flags
4	Moderate Breeze	20-28	30-42	Wind raises dust and loose paper; small branches are moved
5	Fresh Breeze	29-38	43-57	Small trees in leaf begin to sway
6	Strong Breeze	39-49	58-74	Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty
7	Moderate Gale	50-61	75-92	Whole trees in motion; inconvenient walking against wind
8	Gale	62-74	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 80% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if wind speeds of 16 km/h were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting or more sedentary activities. Similarly, if 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 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 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 desired comfort classes are summarized on the following page.



DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Standing / Walking
Public Sidewalks / Pedestrian Walkways	Walking
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing
Plazas	Sitting / Standing / Walking
Transit Stops	Sitting / Standing
Public Parks	Sitting / Standing / Walking
Garage / Service Entrances	Walking
Vehicular Drop-Off Zones	Standing / Walking
Laneways / Loading Zones	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-3D, which illustrate seasonal wind conditions at grade level. The wind conditions are presented as continuous contours of wind comfort within and surrounding the subject site.

The colour contours indicate predicted regions of the various comfort classes noted in Section 4.4. Wind conditions suitable for sitting are represented by the colour green, standing by yellow, and walking by blue. Uncomfortable conditions are represented by the colour magenta.

5.1 Wind Comfort

Sidewalk and Building Entrances along Dunlop Street East: Conditions over the sidewalk along Dunlop Street East 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. Owing to the protection provided by the building façade, conditions in the vicinity of the entrances are generally calmer than the adjacent sidewalk. Conditions in the vicinity of the building entrances will be suitable for sitting throughout the year. The noted conditions are considered acceptable.



Landscaped Area and Building Entrances along South Elevation: Conditions within the landscaped area to the south of the subject site are predicted to be suitable for sitting during the typical use period of late spring through early autumn, becoming suitable for a mix of sitting and standing throughout the remainder of the year. Owing to the protection provided by the building façade, conditions in the vicinity of the building entrances will be suitable for sitting throughout the year. The noted conditions are considered acceptable.

Laneway along West Elevation: Conditions over the laneway along the west elevation 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. The noted conditions are considered acceptable.

Laneway along East Elevation: Conditions over the laneway along the east elevation 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. The noted conditions are considered acceptable.

5.2 Wind Safety

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas surrounding the subject site at grade level were found to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.3 Applicability of Results

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. In general, development in urban centers creates reduction in the mean wind speeds and localized increases in the gustiness of the wind.

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. SUMMARY AND RECOMMENDATIONS

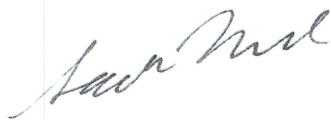
A complete summary of the predicted wind comfort and safety conditions is provided in Section 5 of this report and illustrated in Figures 3A-3D. Based on computer simulations using the CFD technique, meteorological data analysis, and experience with similar developments, we conclude the following:

- 1) All areas at grade level within and surrounding the subject site will be suitable for their intended uses throughout the year. Specifically, wind conditions over surrounding sidewalks, building access points, and driveways are considered acceptable for the intended pedestrian uses throughout the year.
- 2) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas surrounding the subject site at grade level were found to experience conditions that could be considered uncomfortable or dangerous.

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

Sincerely,

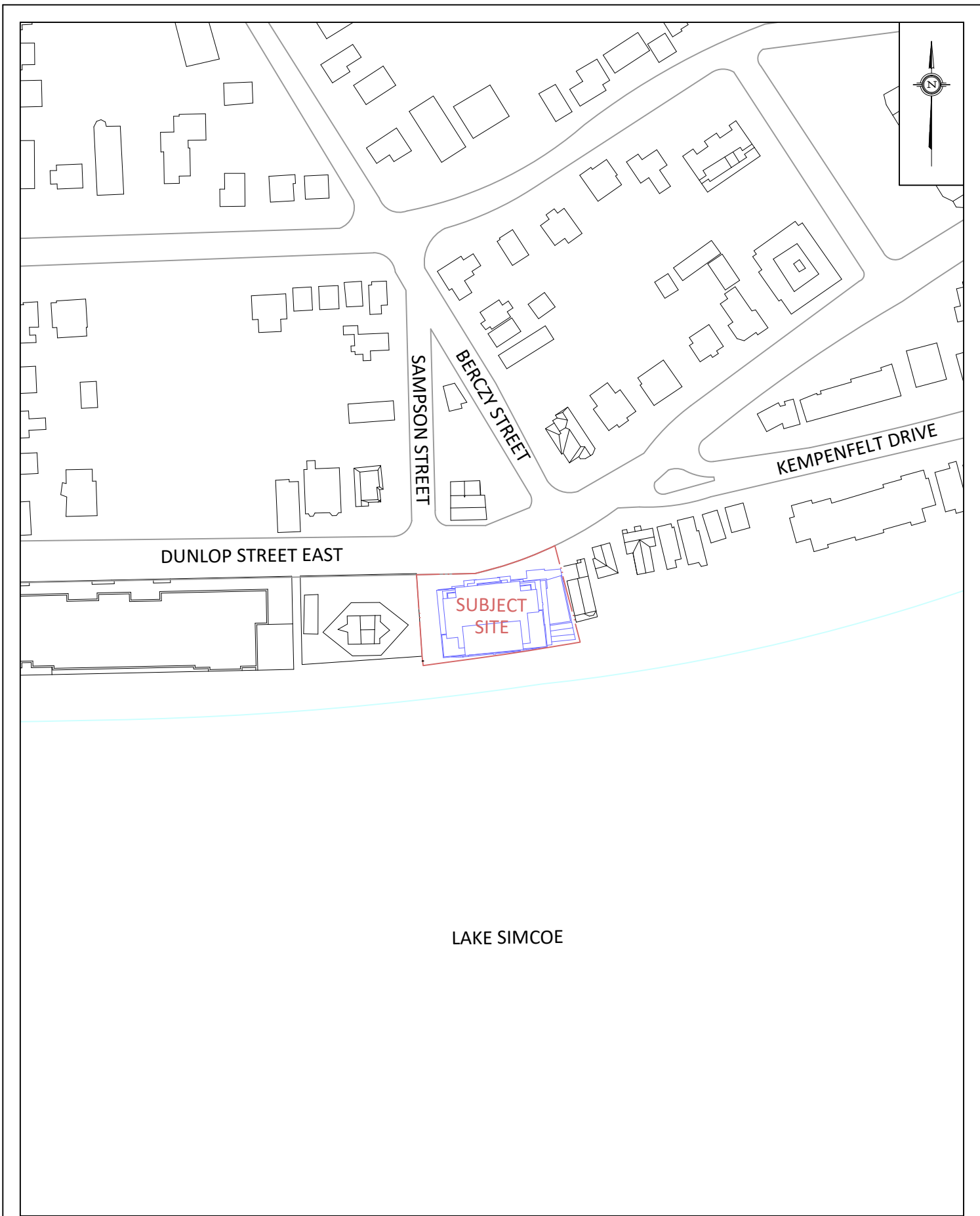
Gradient Wind Engineering Inc.



Sacha Ruzzante, MASc
Junior Wind Scientist



Justin Ferraro, P.Eng.
Principal



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT 217 DUNLOP STREET EAST, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:2000	DRAWING NO. 20-167-PLW-1	
	DATE AUGUST 18, 2020	DRAWN BY N.M.P.	

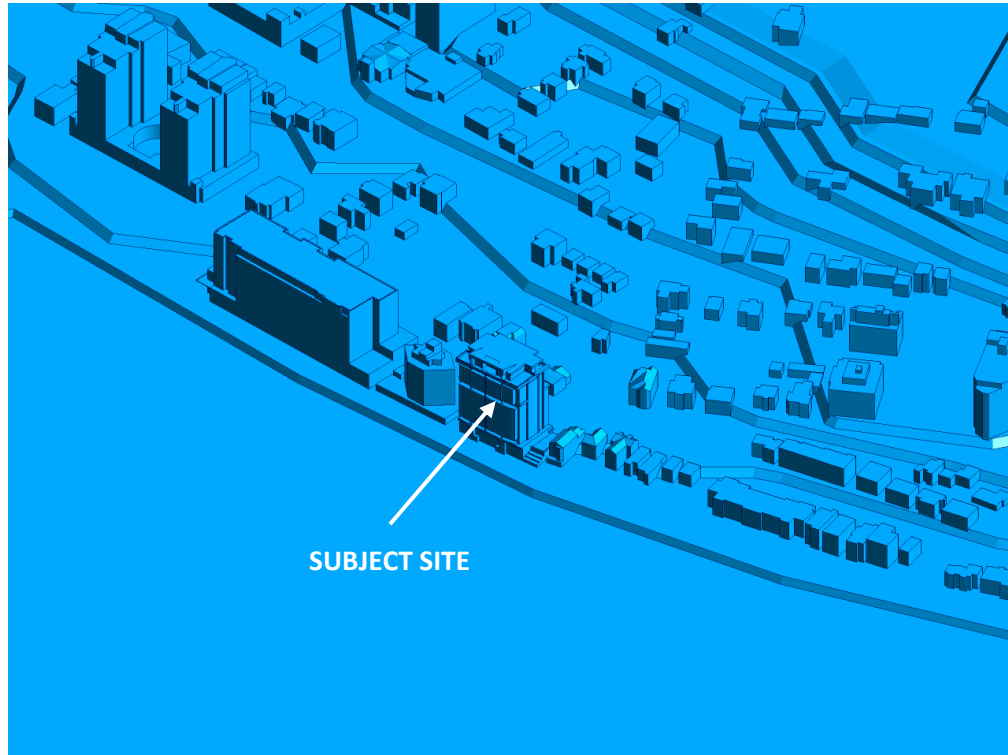


FIGURE 2A: COMPUTATIONAL MODEL, SOUTHEAST PERSPECTIVE

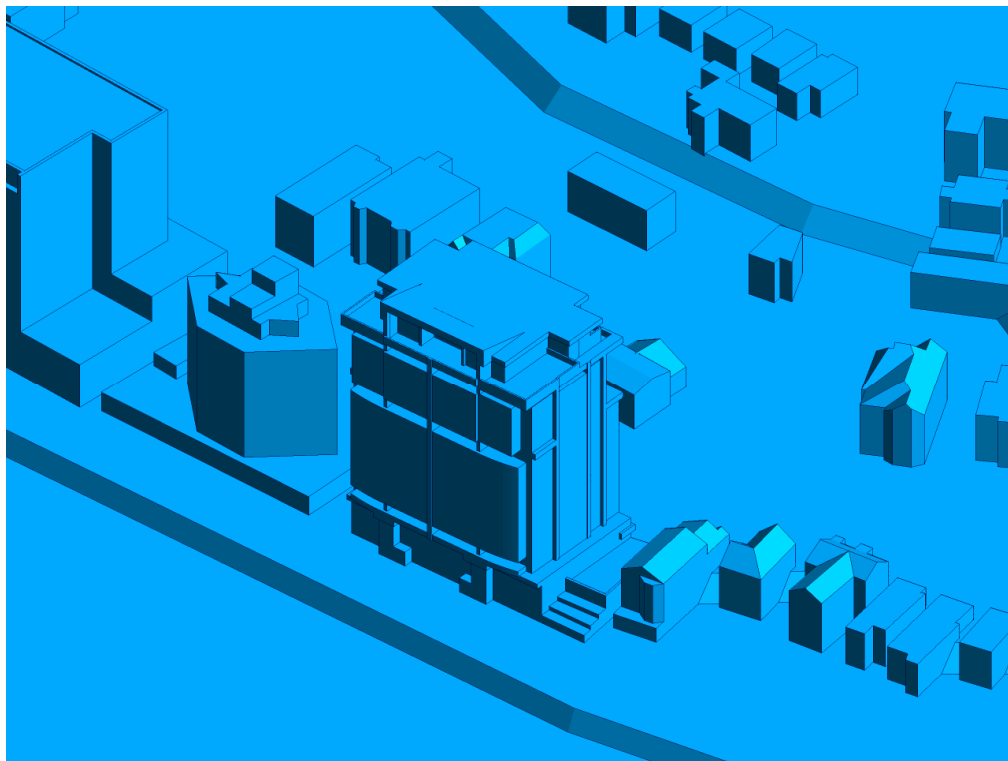


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A



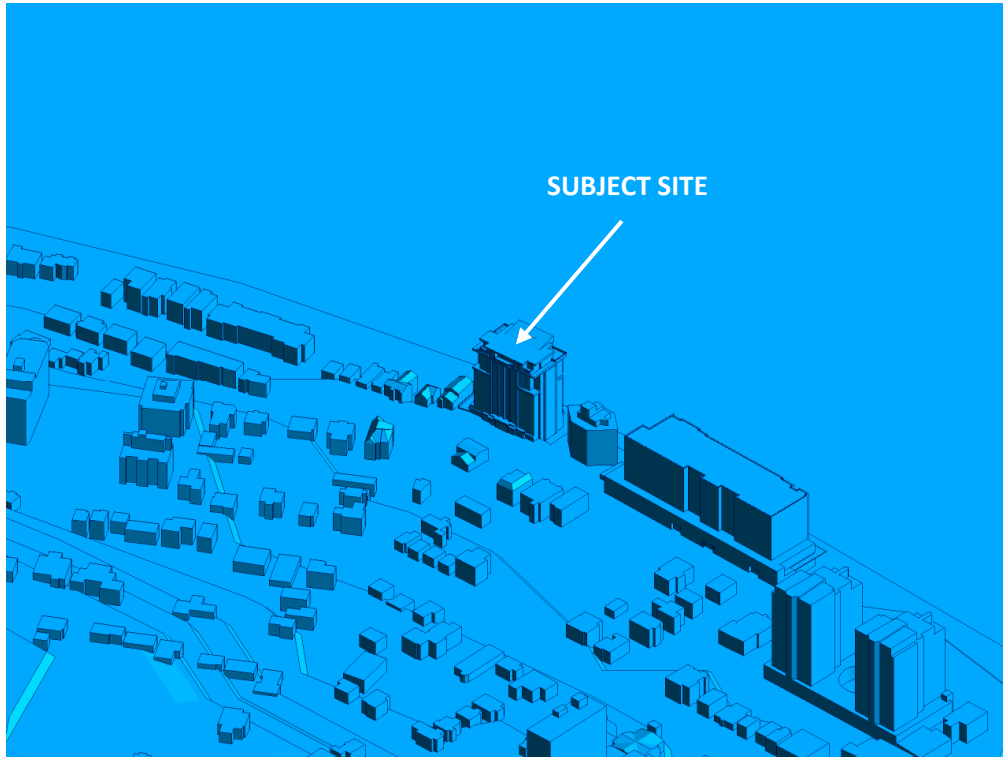


FIGURE 2C: COMPUTATIONAL MODEL, NORTHWEST PERSPECTIVE

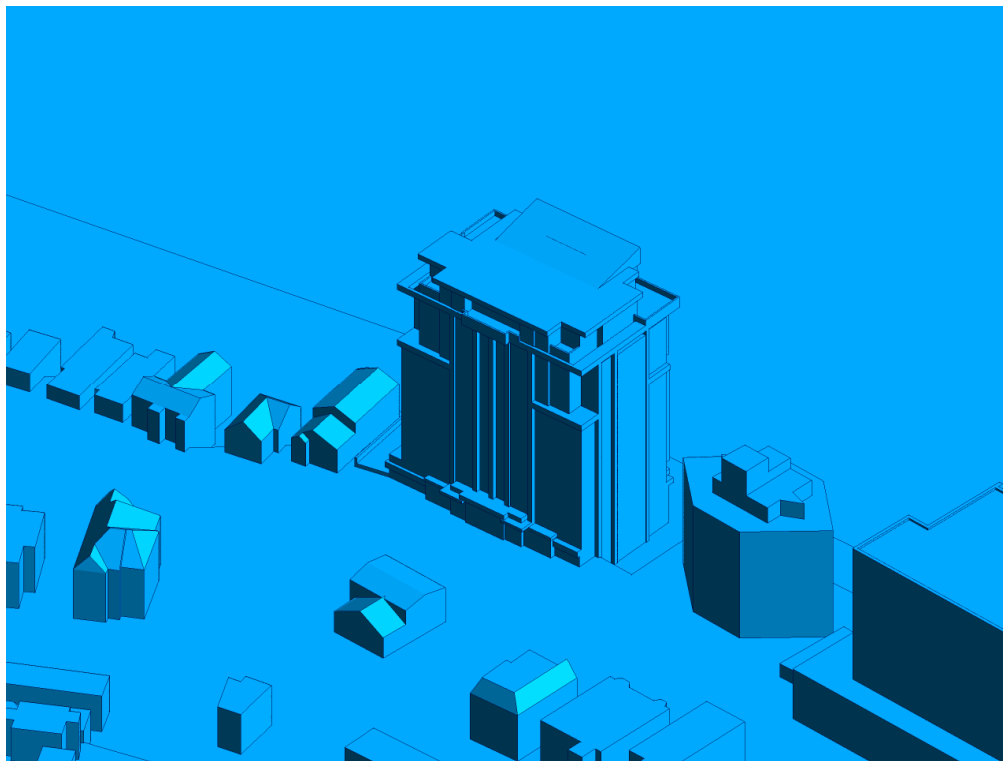
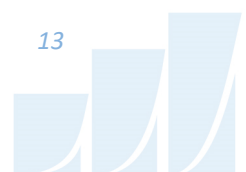


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C



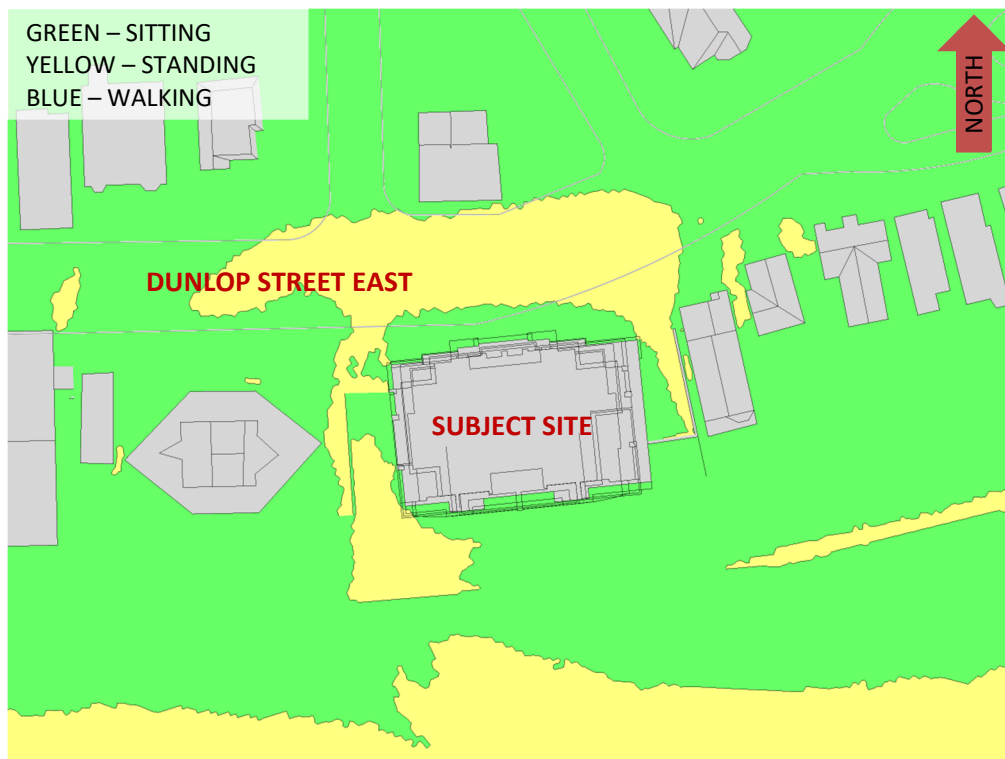


FIGURE 3A: SPRING – PEDESTRIAN WIND COMFORT CONDITIONS, GRADE LEVEL

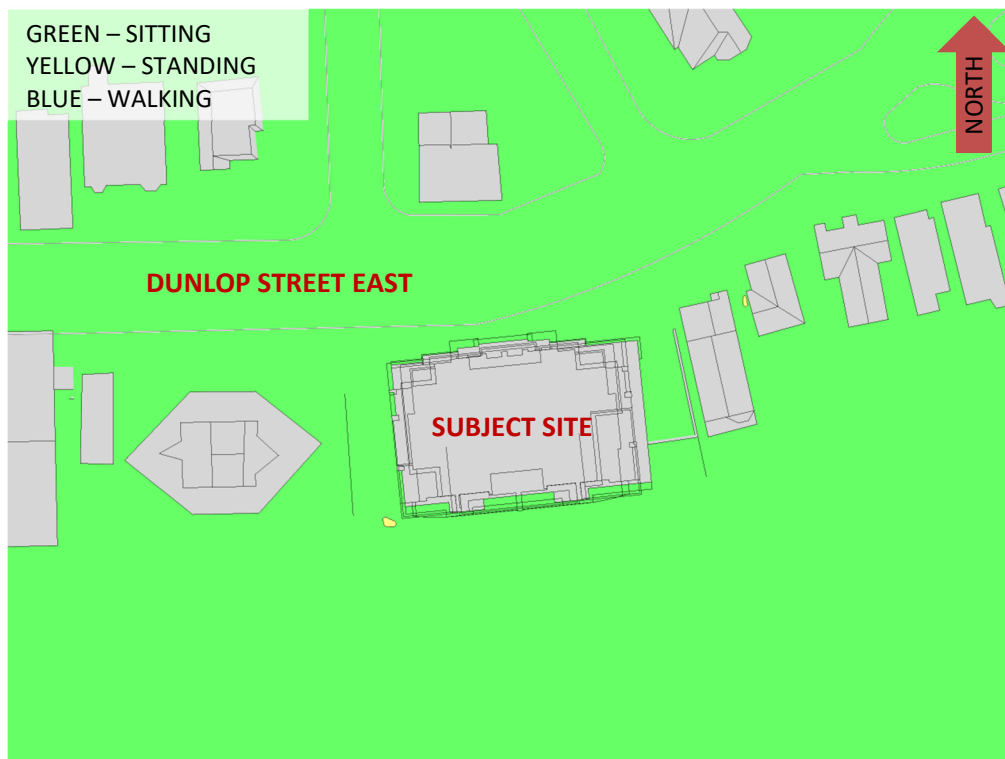
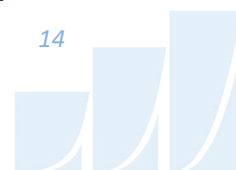


FIGURE 3B: SUMMER – PEDESTRIAN WIND COMFORT CONDITIONS, GRADE LEVEL



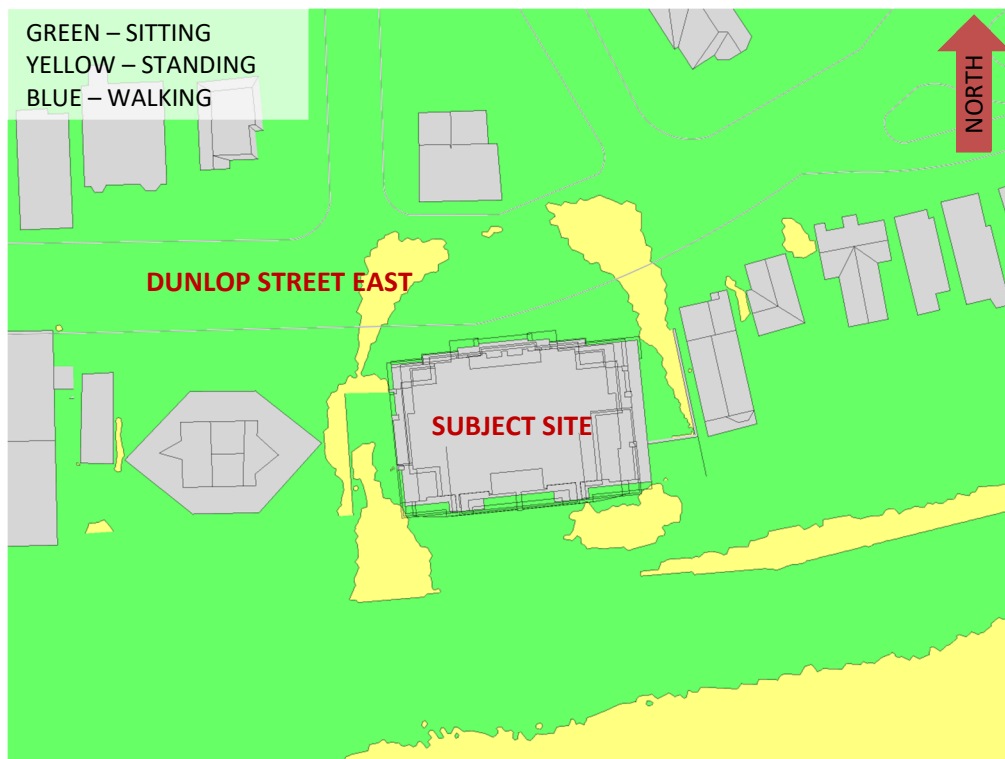


FIGURE 3C: AUTUMN – PEDESTRIAN WIND COMFORT CONDITIONS, GRADE LEVEL

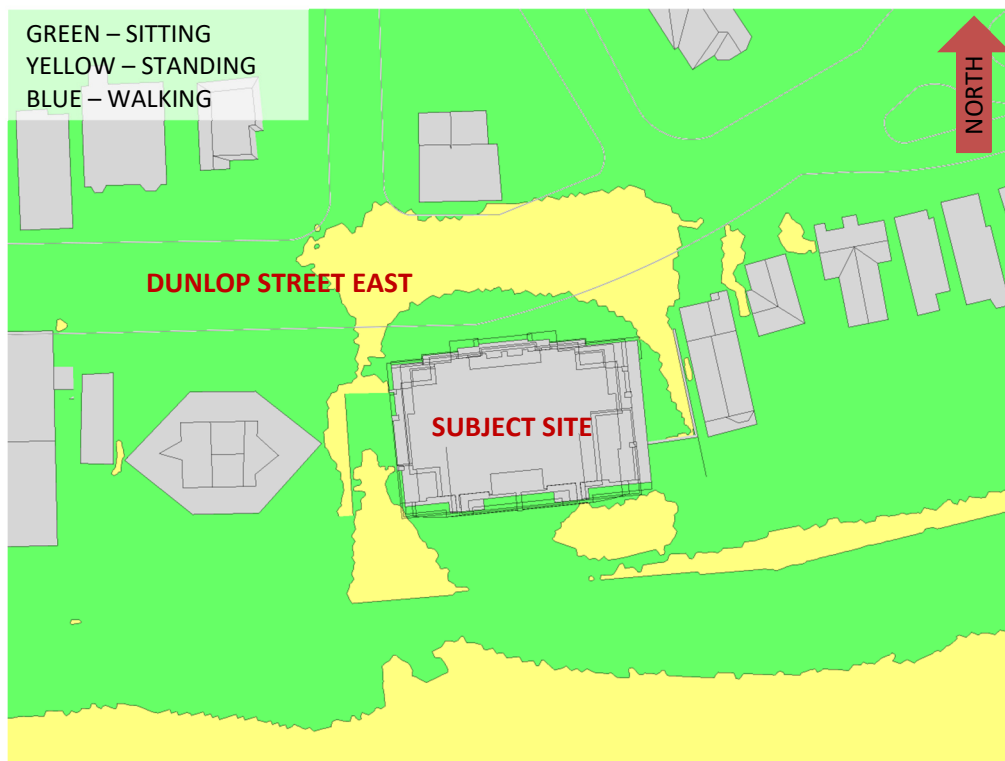
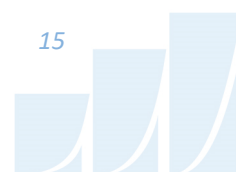
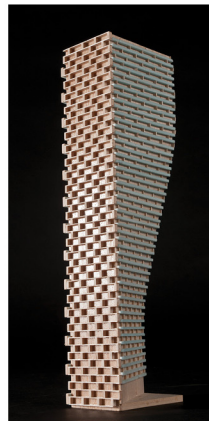


FIGURE 3D: WINTER – PEDESTRIAN WIND COMFORT CONDITIONS, GRADE LEVEL



GRADIENTWIND

ENGINEERS & SCIENTISTS



APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 50% mean wind speed for Barrie 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	0.24
40	0.25
97	0.16
136	0.18
170	0.18
210	0.20
237	0.23
258	0.24
278	0.25
300	0.24
322	0.24
341	0.24

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].

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

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

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

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



REFERENCES

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