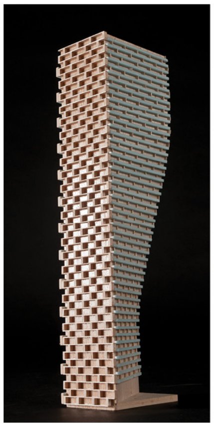
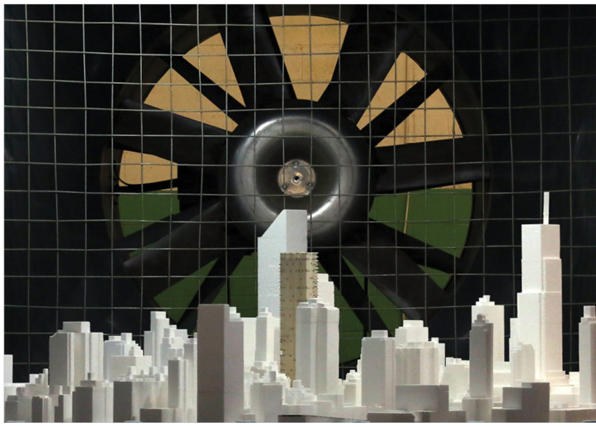
PEDESTRIAN LEVEL WIND STUDY

1 Heron's Hill Way
Toronto, Ontario

Report: 19-247-PLW R1





April 3, 2020

PREPARED FOR
Paradise Developments
1 Heron's Hill Way
Toronto, ON M2J 0G2

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

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy zoning by-law application (ZBA) requirements for a proposed development located at 1 Heron's Hill Way in Toronto, Ontario. 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 comfort and safety within and surrounding the development site. The results and recommendations derived from these considerations are summarized in the following paragraphs and detailed in the subsequent report.

A complete summary of the predicted wind comfort conditions is provided in Section 5 of this report and illustrated in Figures 3A-6B. Based on industry standard computer simulations using the CFD technique and data analysis procedures, historical wind speed and direction data provided by Environment and Climate Change Canada, architectural drawings prepared by Graziani + Corazza Architects (dated March 17, 2020), a landscape concept plan prepared by Strybos Barron King Landscape Architecture (dated April 2020), surrounding street layouts and existing and approved future building massing information obtained from the City of Toronto, and recent site imagery, we conclude the following:

1) Wind conditions over all grade-level areas within and surrounding the subject site will be acceptable throughout the year, without the need for mitigation. More specifically, wind conditions along surrounding sidewalks, as well as at all building access points, will be suitable for the intended pedestrian uses.

2) Regarding the future POPS to the immediate west of the subject site, wind comfort during the summer season is predicted to be mostly suitable for standing. The current landscape design includes a multi-tiered seating section at the south end of the POPS, which is served by a 2-m tall coniferous hedge in a planter wall. While a planter wall is expected to increase comfort levels within the POPS, as noted in Section 5.1, the general space may require mitigation in the form of architectural and landscaping elements. A detailed mitigation strategy will be provided for the future site plan control application (SPA) submission, which will be supported by quantitative mitigation testing.

3) Regarding the amenity terrace at Level 5 atop the podium roof, wind conditions are predicted to be mainly suitable for standing during the warmer seasons. The north end of the roof is designated as an inaccessible green roof and is predicted to be windy throughout the year. The landscape plan incorporates many plantings throughout the terrace, which will increase comfort levels. Similar to item (2) above, a detailed mitigation strategy will be provided for the future SPA submission, which will be supported by quantitative mitigation testing.

4) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, the introduction of the proposed development is not expected to generate wind conditions that are considered uncomfortable or unsafe within the existing grounds.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Paradise Developments to undertake a pedestrian level wind (PLW) study to satisfy zoning by-law application (ZBA) requirements for a proposed development located at 1 Heron's Hill Way in Toronto, Ontario (hereinafter referred to as "subject site"). Our mandate within this study is to investigate pedestrian wind conditions 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, historical wind speed and direction data provided by Environment and Climate Change Canada, architectural drawings prepared by Graziani + Corazza Architects (dated March 17, 2020), a landscape concept plan prepared by Strybos Barron King Landscape Architecture (dated April 2020), surrounding street layouts and existing and approved future building massing information obtained from the City of Toronto, and recent site imagery.

2. TERMS OF REFERENCE

The subject site is located at 1 Heron's Hill Way in Toronto and is situated on a rectangular-shaped parcel of land near the southwest corner of Yorkland Road and Heron's Hill Way, approximately 120 metres (m) east of the noted intersection.

The proposed development comprises a 39-storey building with a 5-storey podium, rising 126.65 m above grade to the top of the mechanical penthouse. The podium planform is rectangular with the long axis oriented along Heron's Hill Way. The main building access point is provided at the centre of the north building elevation, fronting Heron's Hill Way. A privately-owned publicly accessible space (POPS) is included at grade level at the west side of the building. A planned future municipal road is located to the east of the building, complete with a sidewalk. Lobby, parking, amenity, and office space are provided on the Level 1. Parking is also provided on one level below grade, and on podium Levels 2, 3, and 4. An internal laneway beginning from the east elevation provides access to the noted parking areas. Above the podium, the remaining levels contain residential space. At Level 5, the building is set back from all directions to create an outdoor amenity terrace and a green roof over the east and west portions, respectively. The rectangular planform of the tower shares the same orientation as the podium and is consistent until Level 39. At the mechanical penthouse level, the floorplate sets back from all directions.

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 as low-rise buildings and open space, with a building complex located north of the subject site and several other high-rise buildings dispersed around the area. The far-field surroundings (defined as the area beyond the near field and within a five kilometer (km) radius) are characterized primarily by suburban wind exposures. High-rise buildings are dispersed around the area, concentrated along Don Mills Road.

Key areas under consideration for pedestrian wind comfort and safety include surrounding sidewalks, building access points, the internal laneway, the POPS, and the amenity terrace at Level 5. 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 Toronto area wind climate, and synthesis of computational data with City of Toronto wind guidelines[1]. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort guidelines.

[1] City of Toronto Terms of Reference: Pedestrian Level Wind Study
https://www.toronto.ca/city-government/planning-development/application-forms-fees/building-toronto-together-a-development-guide/application-support-material-terms-of-reference/

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 historical wind speed and direction data obtained from Lester B. Pearson International Airport and provided by Environment and Climate Change Canada. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site, 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.

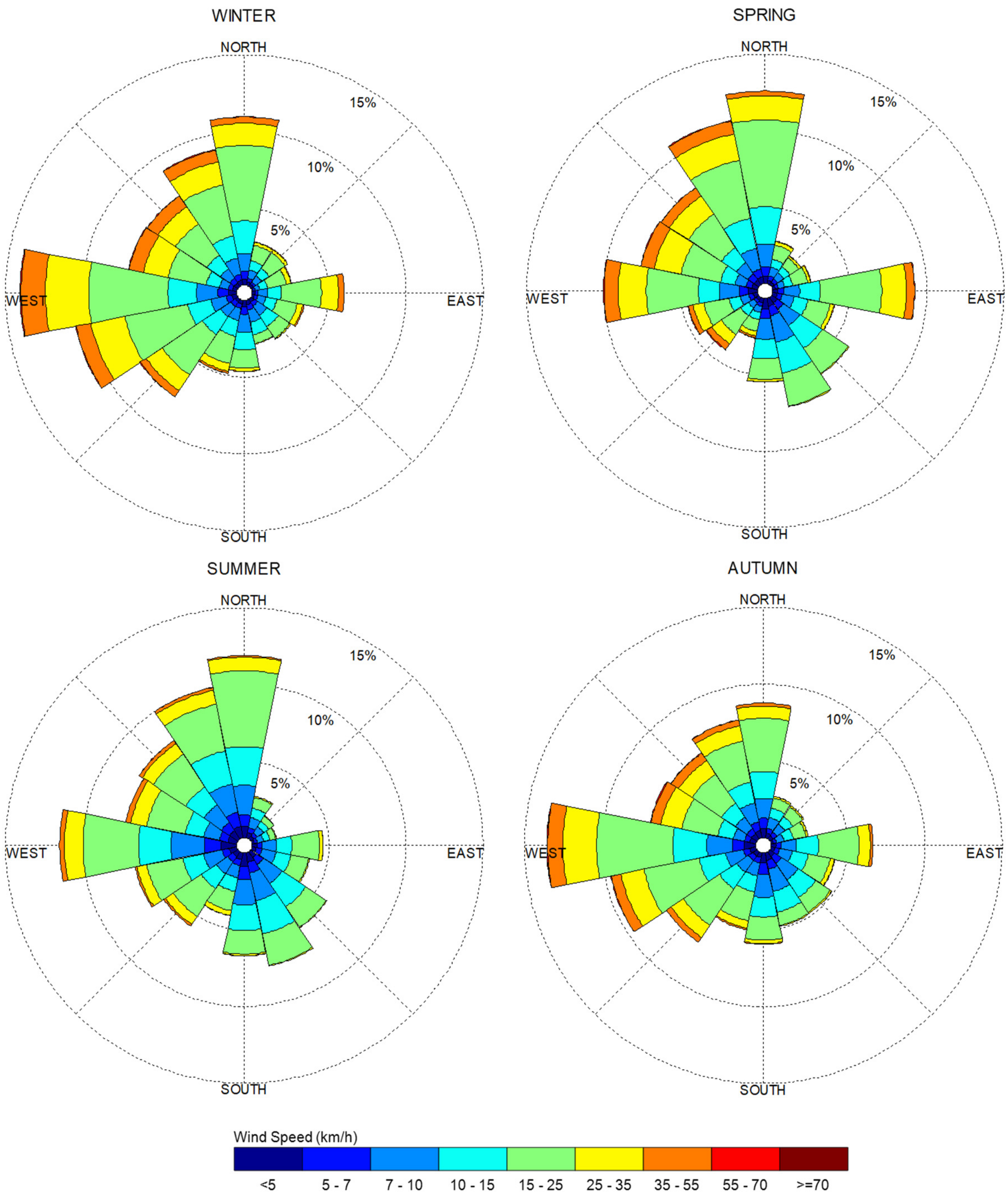
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade, as well as 1.5 m above the Level 5 amenity terrace, were referenced 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 Toronto was developed from approximately 40-years of hourly meteorological wind data recorded at Lester B. Pearson 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.

The statistical model of the Toronto 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 Toronto, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east. 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
LESTER B. PEARSON INTERNATIONAL AIRPORT, MISSISSAUGA, 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 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
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 gust 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 a gust wind speed of 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 guidelines 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 Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalks / Pedestrian Walkways	Walking
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing
Plazas	Standing / Walking
Transit Stops	Standing
Public Parks	Sitting / Walking
Garage / Service Entrances	Walking
Vehicular Drop-Off Zones	Walking
Laneways / Loading Zones	Walking

5. RESULTS AND DISCUSSION

The following discussion of predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B illustrating seasonal wind comfort conditions. 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, walking by blue, while conditions considered uncomfortable for walking are represented by the colour magenta. Pedestrian wind comfort is summarized below for each seasonal period.

5.1 Pedestrian Wind Comfort – Grade Level

- Wind conditions along the Heron's Hill Way sidewalk will be comfortable for walking or better throughout the year, which is acceptable.
- For the sidewalk along the planned municipal road to the east of the subject site, wind conditions will generally be comfortable for standing or better throughout the year, which is acceptable.
- The area south of the subject site will be suitable for standing or better throughout the year, with windier conditions near the southwest corner of the building. The noted conditions are considered acceptable.

- For the internal laneway, wind conditions will be comfortable for sitting throughout the year, which is acceptable.
- Wind conditions within the future POPS to the west of the subject site will be comfortable for standing, or better, during the summer season, a mix of standing and walking during the autumn season, becoming mostly suitable for walking during the spring and winter seasons. The current landscape design includes a multi-tiered seating section at the south end of the POPS, which is served by a 2-m tall coniferous hedge in a planter wall. While a planter wall is expected to increase comfort levels within the POPS, the general space may require mitigation in the form of architectural and landscaping elements. A detailed mitigation strategy will be provided for the future SPA submission, which will be supported by quantitative mitigation testing.

5.2 Pedestrian Wind Comfort – Level 5 Amenity Terrace

- For the amenity terrace on the podium roof, wind conditions will be mainly suitable for standing during the summer and autumn seasons, with an isolated area to the north suitable for walking. Conditions during the spring and winter seasons are predicted to be winder than those during the warmer seasons, becoming mostly suitable for a mix of standing and walking. To achieve sitting conditions consistent with the guidelines in Section 4.4, architectural and landscaping elements may be required.
- The north section of the terrace is designated as an inaccessible green roof space, while the southwest portion of the amenity terrace has an enclosed dog run park. An open lawn is planned for the central area, while the remaining area of the terrace is intended to support more sedentary activities, where planter walls are placed near seating areas. The landscape plan incorporates many plantings, which will increase comfort levels.
- Similar to the POPS area at grade level (Section 5.1), a detailed mitigation strategy will be provided for the future SPA submission, which will be supported by quantitative mitigation testing.

5.3 Influence of the Proposed Development on Existing Wind Conditions

Wind conditions over surrounding sidewalks beyond the development site, as well as at nearby 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

Based on computer simulations using the CFD technique, meteorological data analysis of the local wind climate based on historical wind speed and direction data provided by Environment and Climate Change Canada, and industry standard wind comfort and safety guidelines, we conclude the following:

1) Wind conditions over all grade-level areas within and surrounding the subject site will be acceptable throughout the year, without the need for mitigation. More specifically, wind conditions along surrounding sidewalks, as well as at all building access points, will be suitable for the intended pedestrian uses.

2) Regarding the future POPS to the immediate west of the subject site, wind comfort during the summer season is predicted to be mostly suitable for standing. The current landscape design includes a multi-tiered seating section at the south end of the POPS, which is served by a 2-m tall coniferous hedge in a planter wall. While a planter wall is expected to increase comfort levels within the POPS, as noted in Section 5.1, the general space may require mitigation in the form of architectural and landscaping elements. A detailed mitigation strategy will be provided for the future site plan control application (SPA) submission, which will be supported by quantitative mitigation testing.

3) Regarding the amenity terrace at Level 5 atop the podium roof, wind conditions are predicted to be mainly suitable for standing during the warmer seasons. The north end of the roof is designated as an inaccessible green roof and is predicted to be windy throughout the year. The landscape plan incorporates many plantings throughout the terrace, which will increase comfort levels. Similar to item (2) above, a detailed mitigation strategy will be provided for the future SPA submission, which will be supported by quantitative mitigation testing.

4) Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, the introduction of the proposed development is not expected to generate wind conditions that are considered uncomfortable or unsafe within the existing grounds.

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

Sincerely,

Gradient Wind Engineering Inc.

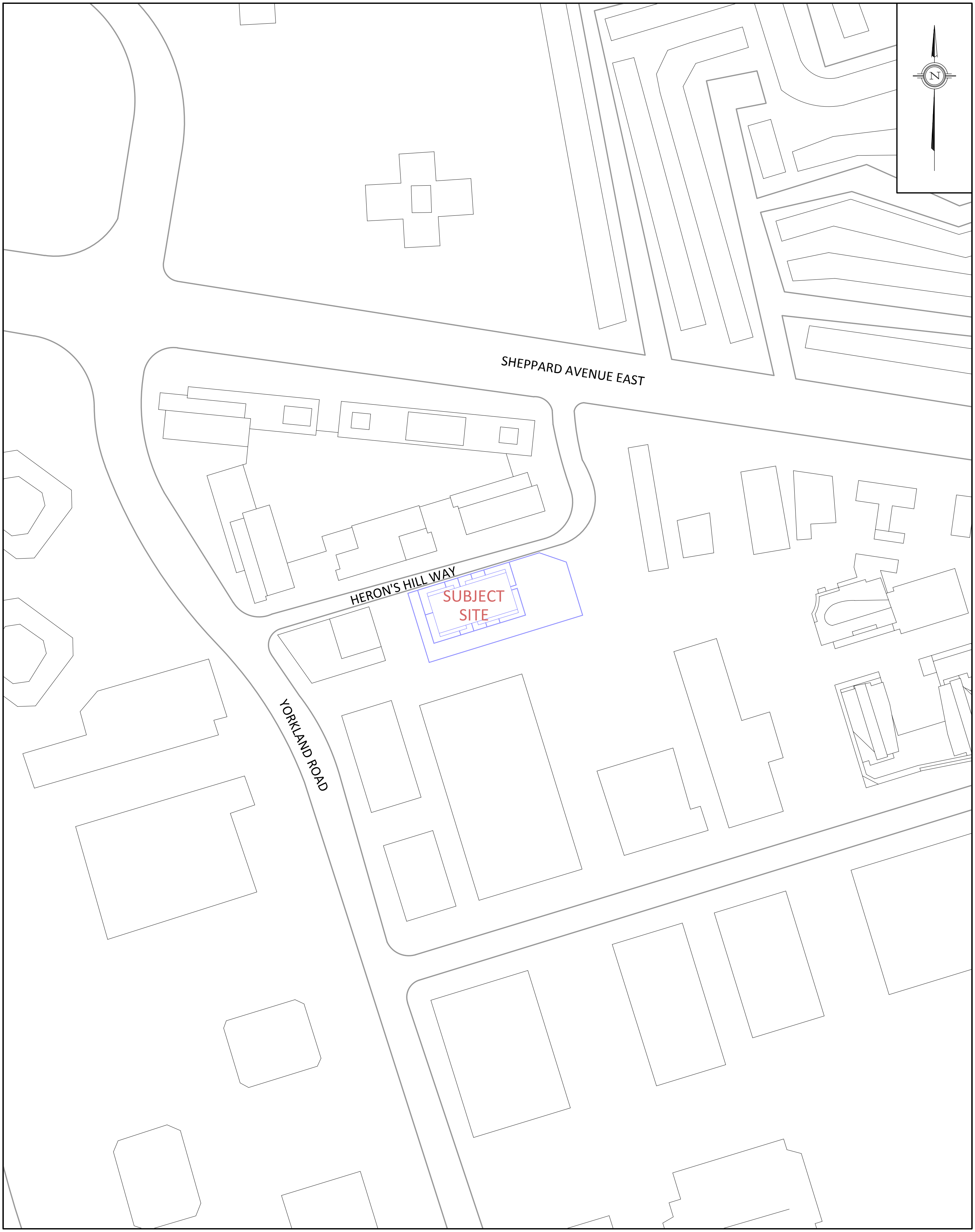
E. Urbanski

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Apr 3, 2020
PROVINCE OF ONTARIO

Edward Urbanski
Junior Wind Scientist

Justin Ferraro, P.Eng.
Principal

Gradient Wind File #19-247



GRADIENTWIND
ENGINEERS & SCIENTISTS

127 WALGREEN ROAD, OTTAWA, ON
613 836 0934 • GRADIENTWIND.COM

PROJECT	1 HERON'S HILL WAY, TORONTO PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500	DRAWING NO.	19-247-PLW-1
DATE	JANUARY 13, 2020	DRAWN BY	C.E.

DESCRIPTION

FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT

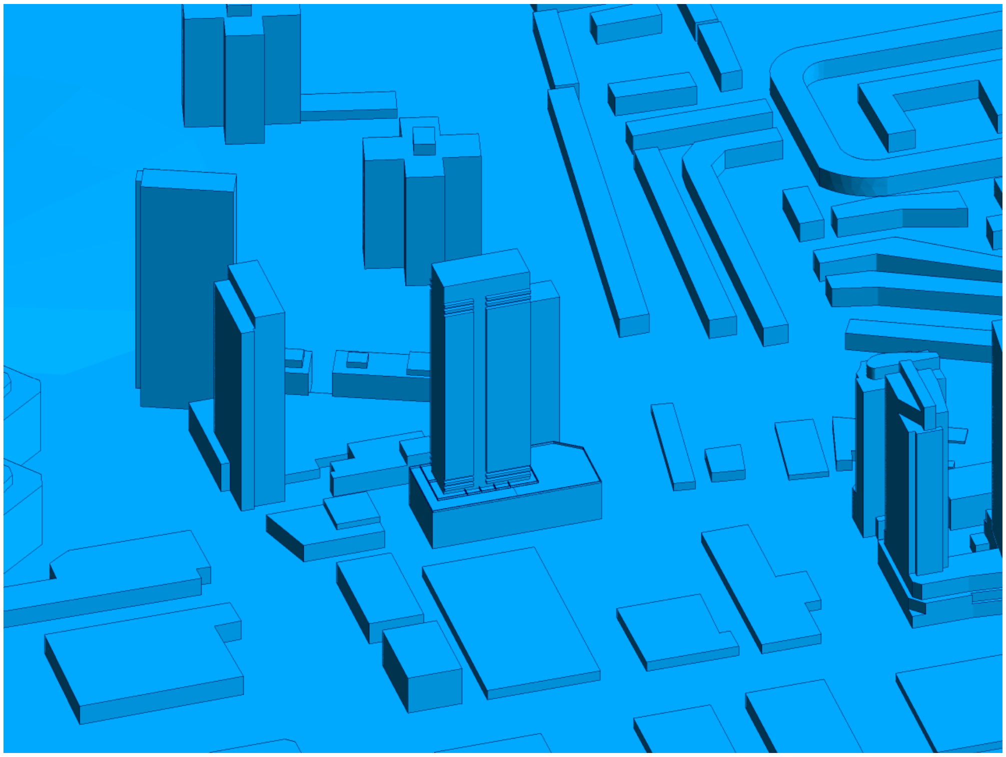


FIGURE 2A: COMPUTATIONAL MODEL, SOUTH PERSPECTIVE

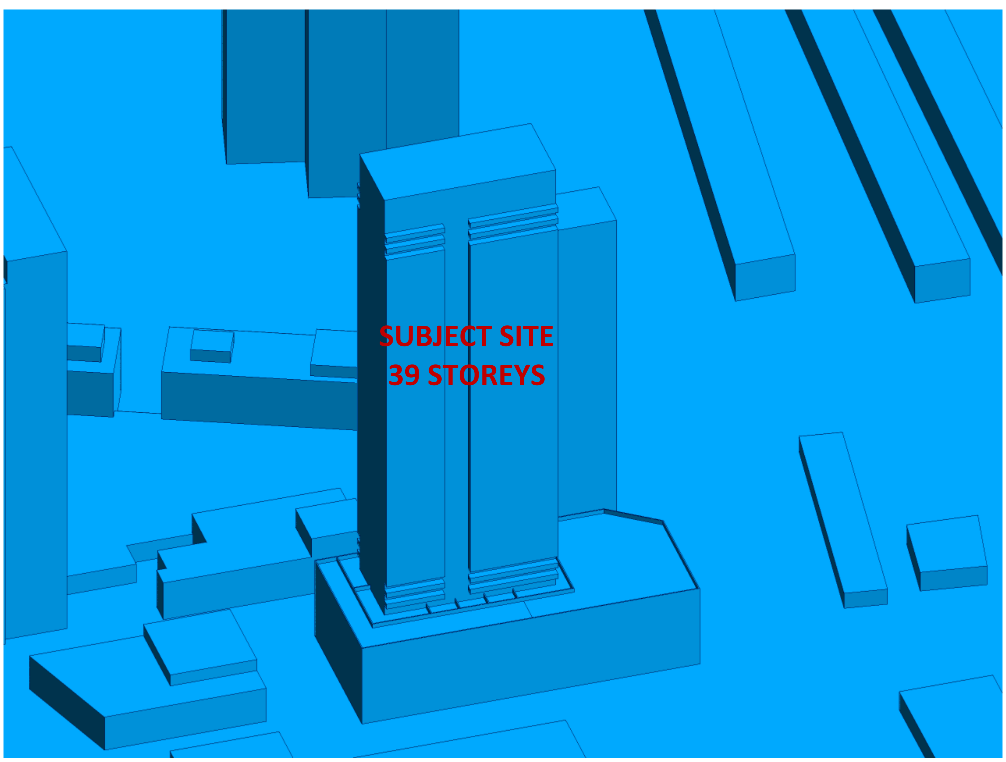


FIGURE 2B: CLOSE UP OF FIGURE 2A

FIGURE 2C: COMPUTATIONAL MODEL, SOUTHEAST PERSPECTIVE

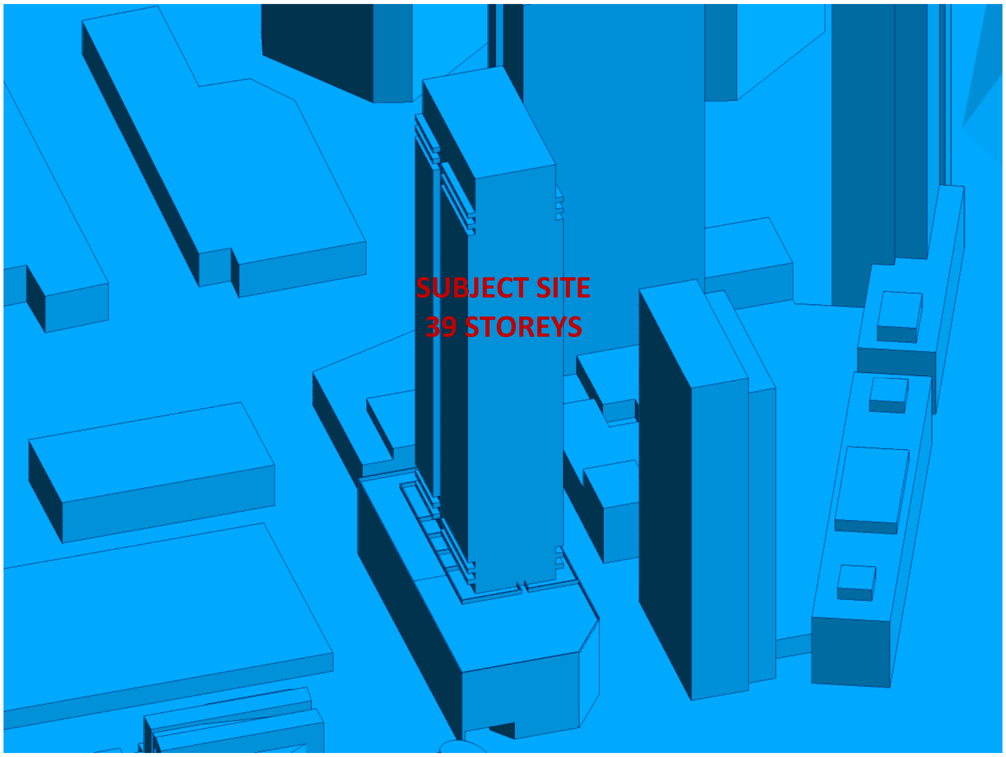


FIGURE 2D: CLOSE UP OF FIGURE 2C

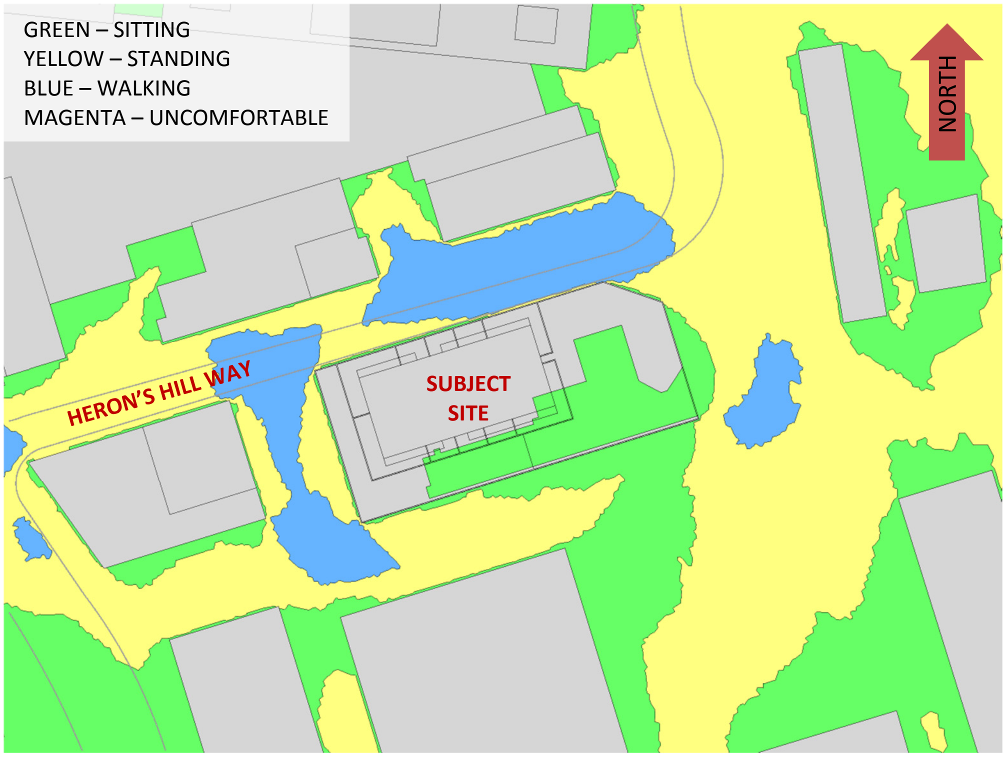


FIGURE 3A: SPRING – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

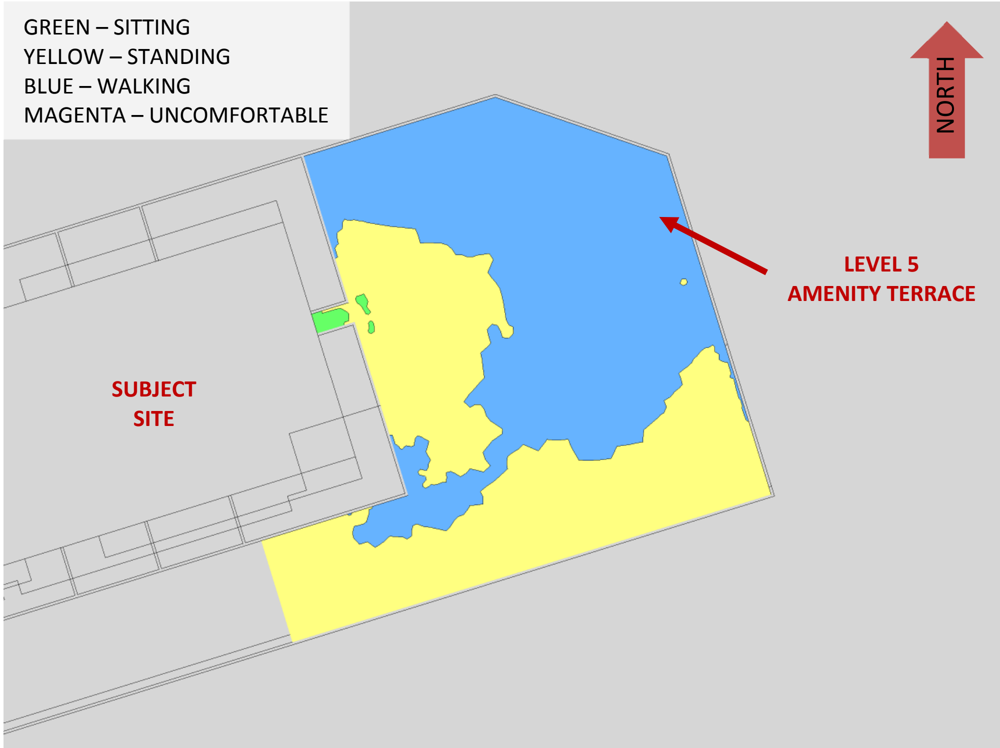


FIGURE 3B: SPRING – PEDESTRIAN WIND COMFORT, LEVEL 5 AMENITY TERRACE

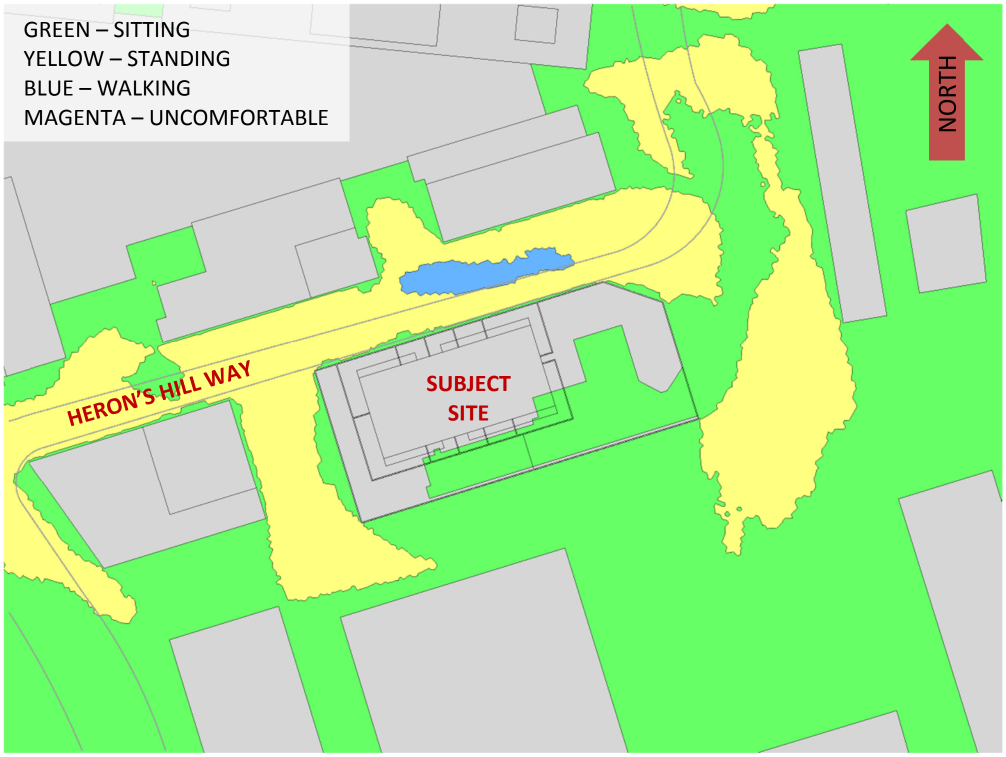


FIGURE 4A: SUMMER – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

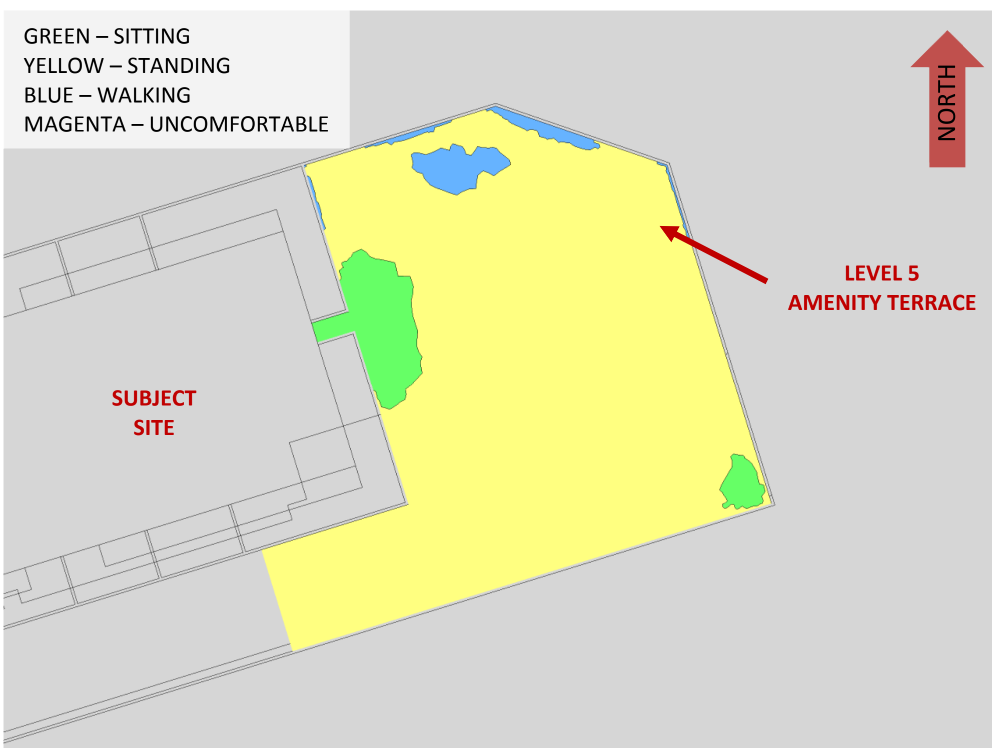


FIGURE 4B: SUMMER – PEDESTRIAN WIND COMFORT, LEVEL 5 AMENITY TERRACE

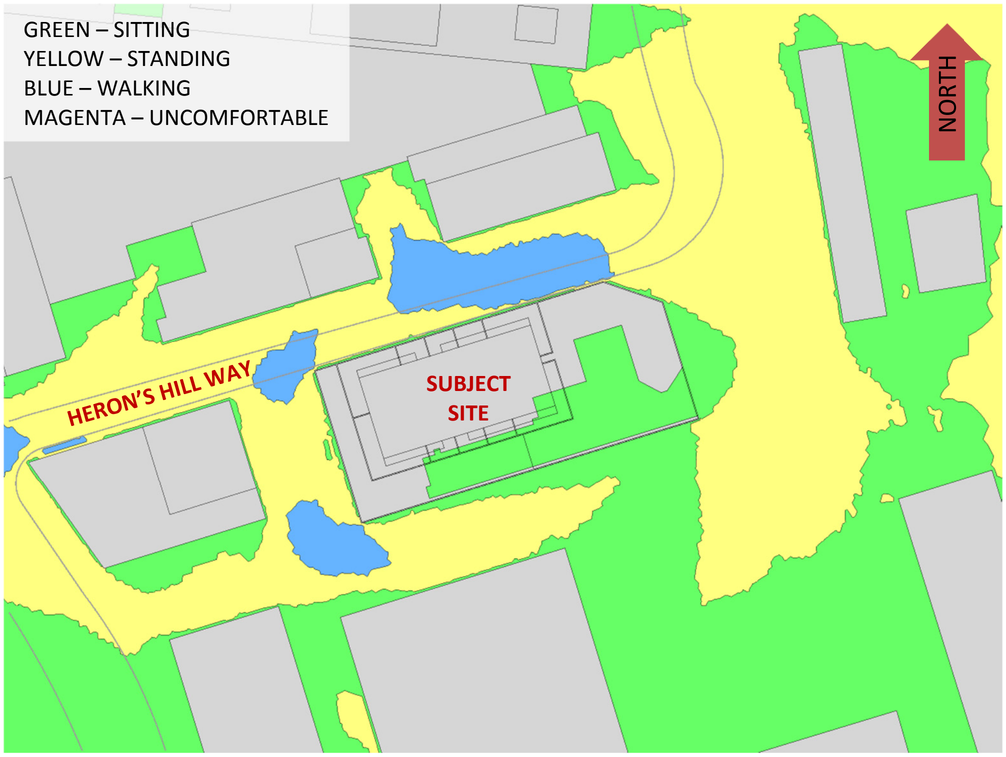


FIGURE 5A: AUTUMN – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

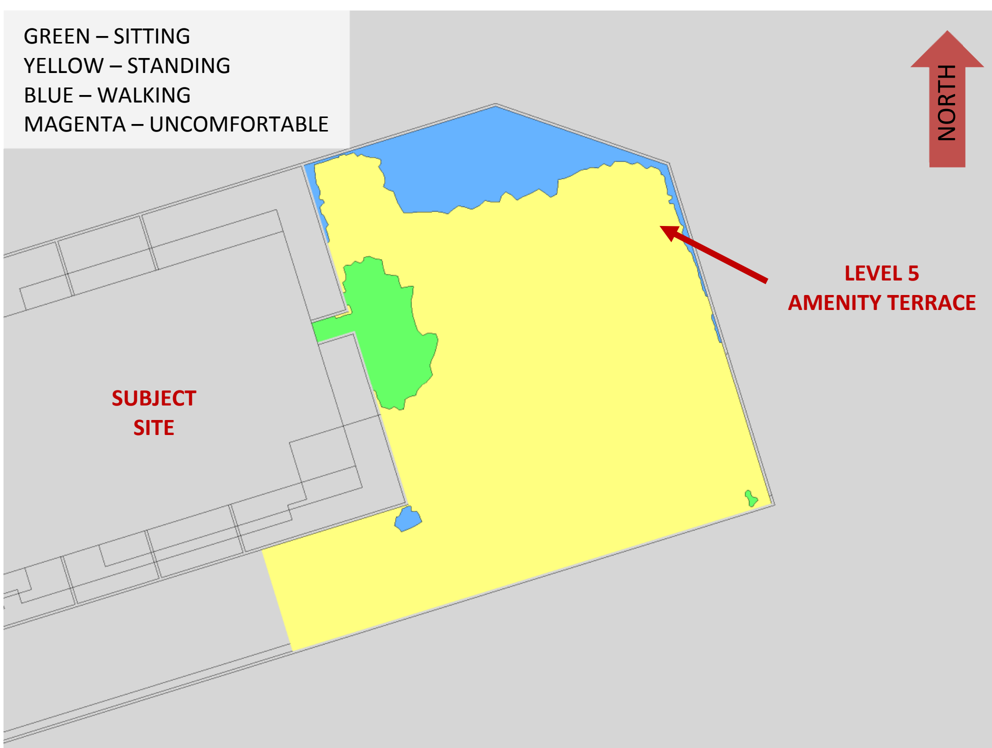


FIGURE 5B: AUTUMN – PEDESTRIAN WIND COMFORT, LEVEL 5 AMENITY TERRACE

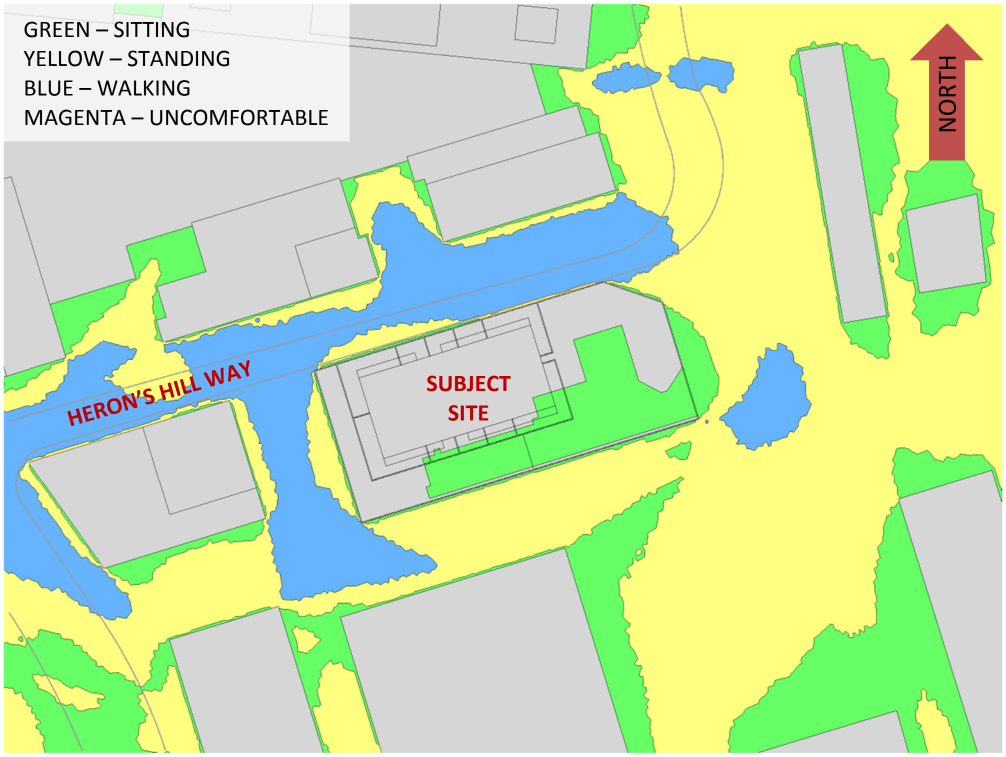


FIGURE 6A: WINTER – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

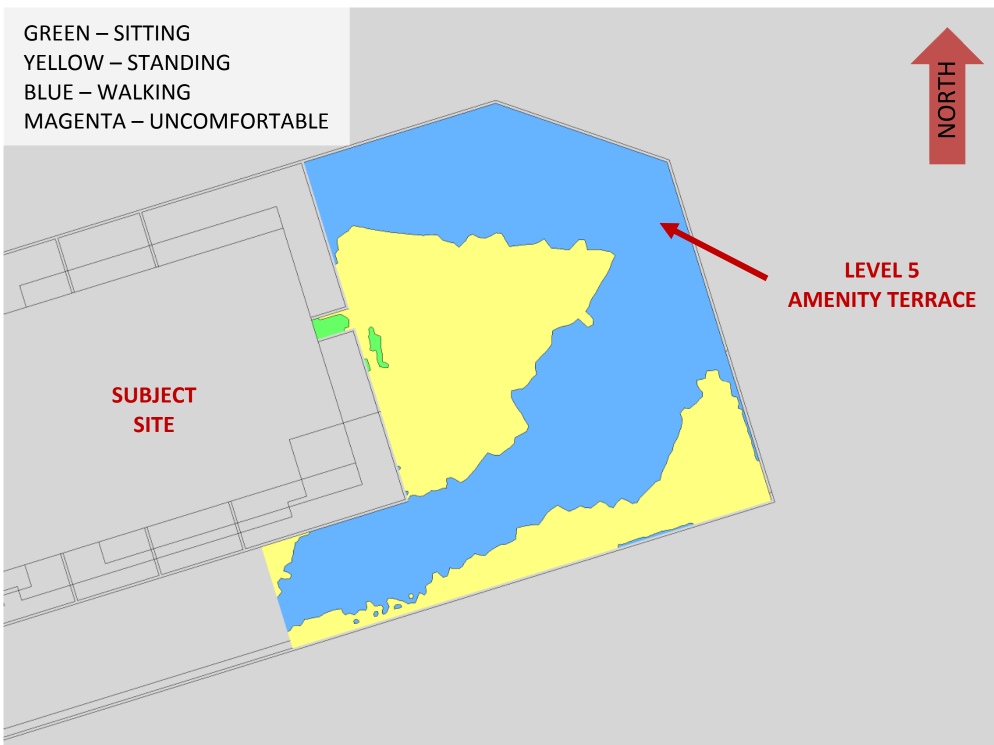


FIGURE 6B: WINTER – PEDESTRIAN WIND COMFORT, LEVEL 5 AMENITY TERRACE

APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

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 50% mean wind speed for Toronto 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	0.24
97	0.24
136	0.25
170	0.24
210	0.24
237	0.24
258	0.27
278	0.27
300	0.25
322	0.24
341	0.23

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, ***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.

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.