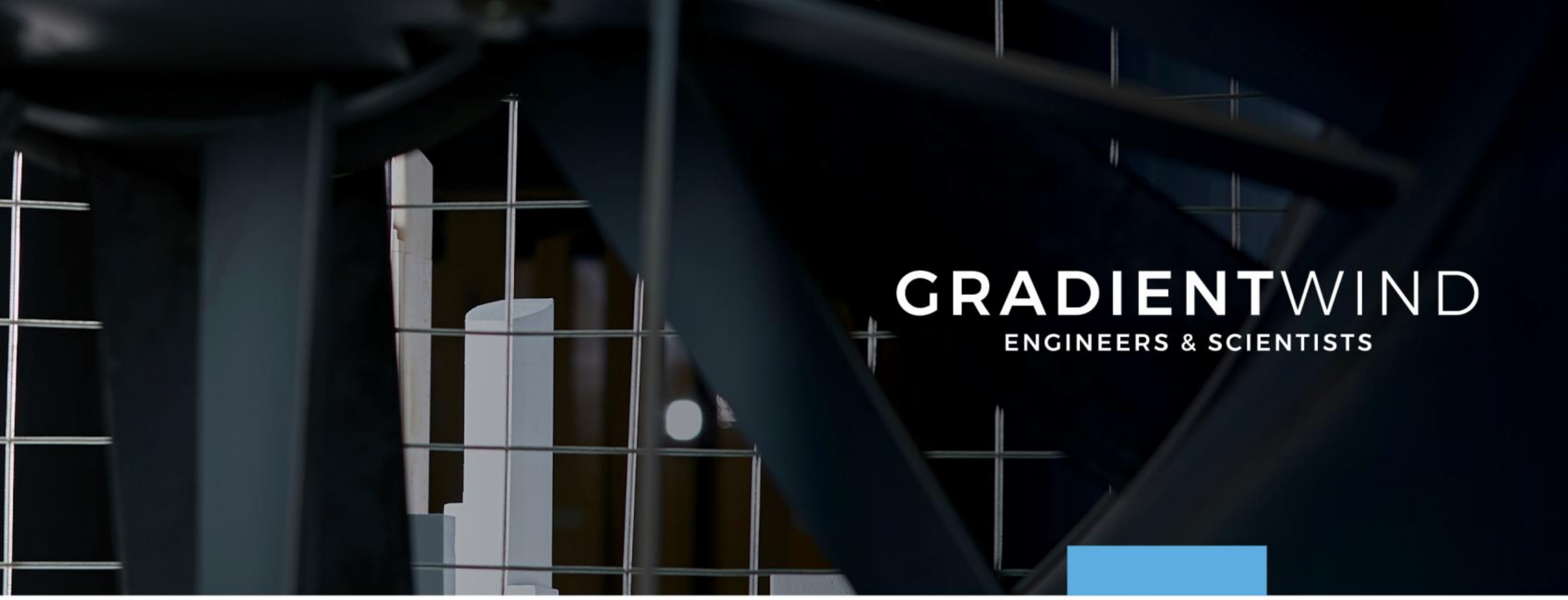
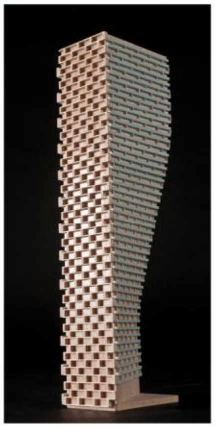
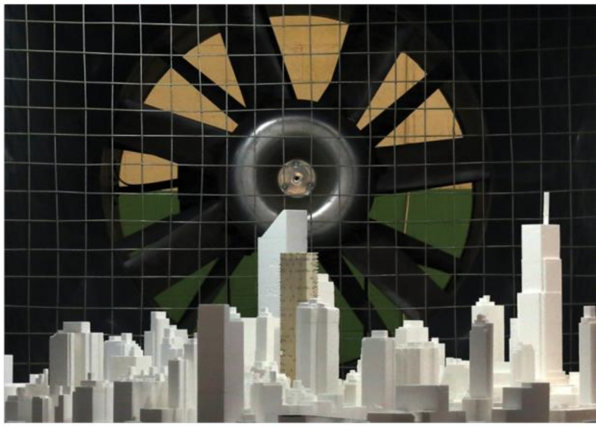


PEDESTRIAN LEVEL WIND STUDY

1041 Lakeshore Road East
Mississauga, Ontario

Report: 21-432-PLW





March 8, 2022

PREPARED FOR
1407 Lakeshore Developments Inc.
8 Steelcase Road West
Markham, ON L3R 1B2

PREPARED BY
David Huitema, 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 to satisfy concurrent Official Plan Amendment and Zoning By-law Amendment application requirements for the proposed mixed-use residential development located at 1041 Lakeshore Road East in Mississauga, 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.

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 Mississauga wind comfort and safety criteria. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-5B, and is summarized as follows:

1) All areas within and surrounding the subject site are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, transit stops, surface parking, and building access points, are considered acceptable.

2) Conditions over the Level 10 amenity terrace are predicted to be suitable for sitting during the summer, which is considered acceptable according to the comfort criteria in Section 4.4.

3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected 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 1407 Lakeshore Developments Inc. to undertake a pedestrian level wind (PLW) study to satisfy concurrent Official Plan Amendment and Zoning By-law Amendment application requirements for the proposed mixed-use residential development located at 1041 Lakeshore Road East in Mississauga, 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 Mississauga wind comfort and safety criteria, architectural drawings prepared by RAW Design Inc., in February 2022, surrounding street layouts and existing and approved future building massing information obtained from the City of Mississauga, recent satellite imagery, and experience with numerous similar developments.

2. TERMS OF REFERENCE

The subject site is located at 1041 Lakeshore Road East in Mississauga; situated on a parcel of land bounded by Lakeshore Road East to the southeast, Ogden Avenue to the southwest, Gardner Avenue to the northwest, and Strathy Avenue to the northeast. Throughout this report, the Lakeshore Road East elevation is referred to as project south.

The proposed development comprises a 10-storey mixed-use residential building, inclusive of a mechanical penthouse, with a nominally 'U'-shaped planform with its long axis-oriented along Lakeshore Road East. Above two levels of below-grade parking, the ground floor comprises retail spaces along the south elevation, residential main entrance to the west, loading access to the northwest, residential units to the northwest, north, and northeast, bicycle storage to the north, and shared building support spaces throughout the remainder of the level. Surface parking spaces are situated to the north of the subject site. Access to underground parking is provided by a ramp to the north via a laneway which runs east-west from Ogden Avenue to Strathy Avenue. From Levels 2 to 9 the building includes residential units. Setbacks from the northeast clockwise northwest at Level 5, to the northeast and northwest at Levels 6 and 7, and to the north at Levels 8 and 9 provide private terraces. Level 10 is reserved for indoor amenity and mechanical, and is served by an outdoor amenity terrace created by a setback from the northeast clockwise northwest.

Regarding wind exposures, the near-field surroundings (defined as an area falling within a 200-metre (m) radius of the subject site) include a school to the northeast, low-rise commercial buildings from the northeast clockwise southwest, and low-rise residential buildings from the southwest clockwise northeast. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) include low-rise commercial buildings and the open exposure of Lake Ontario from the northeast clockwise southwest and a mix of mostly low-rise residential buildings with isolated mid-rise residential buildings from the southwest clockwise northeast. Green spaces are situated in all compass directions with the largest spaces to the west, north, and northeast. Lake Ontario is located approximately 1.04 km to the southeast. Notably, a masterplan development referred to as "Lakeview Village" comprising predominantly mid-rise mixed-use buildings as well as townhouses, office, retail, and civic buildings is proposed at 1082 Lakeshore Road East and 800 Hydro Road, located approximately 220 m to the southwest of the subject site.

A site plan for the proposed massing scenario is illustrated in Figure 1A, while the existing scenario is illustrated in Figure 1B. 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 Mississauga.

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 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 Mississauga area wind climate, and synthesis of computational data with City of Mississauga 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 Billy Bishop Toronto City 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 proposed 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.

[1] Mississauga, Urban Design Terms of Reference, *Pedestrian Wind Comfort and Safety Studies*, June 2014 https://www.mississauga.ca/wp-content/uploads/2020/02/06113559/Pedesterian-Level-Wind-Comfort-Studies.pdf [accessed Jan 12, 2022]

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the subject site for 12 wind directions. The CFD simulation model was centered on the proposed development, complete with surrounding massing within a diameter of 1020 m.

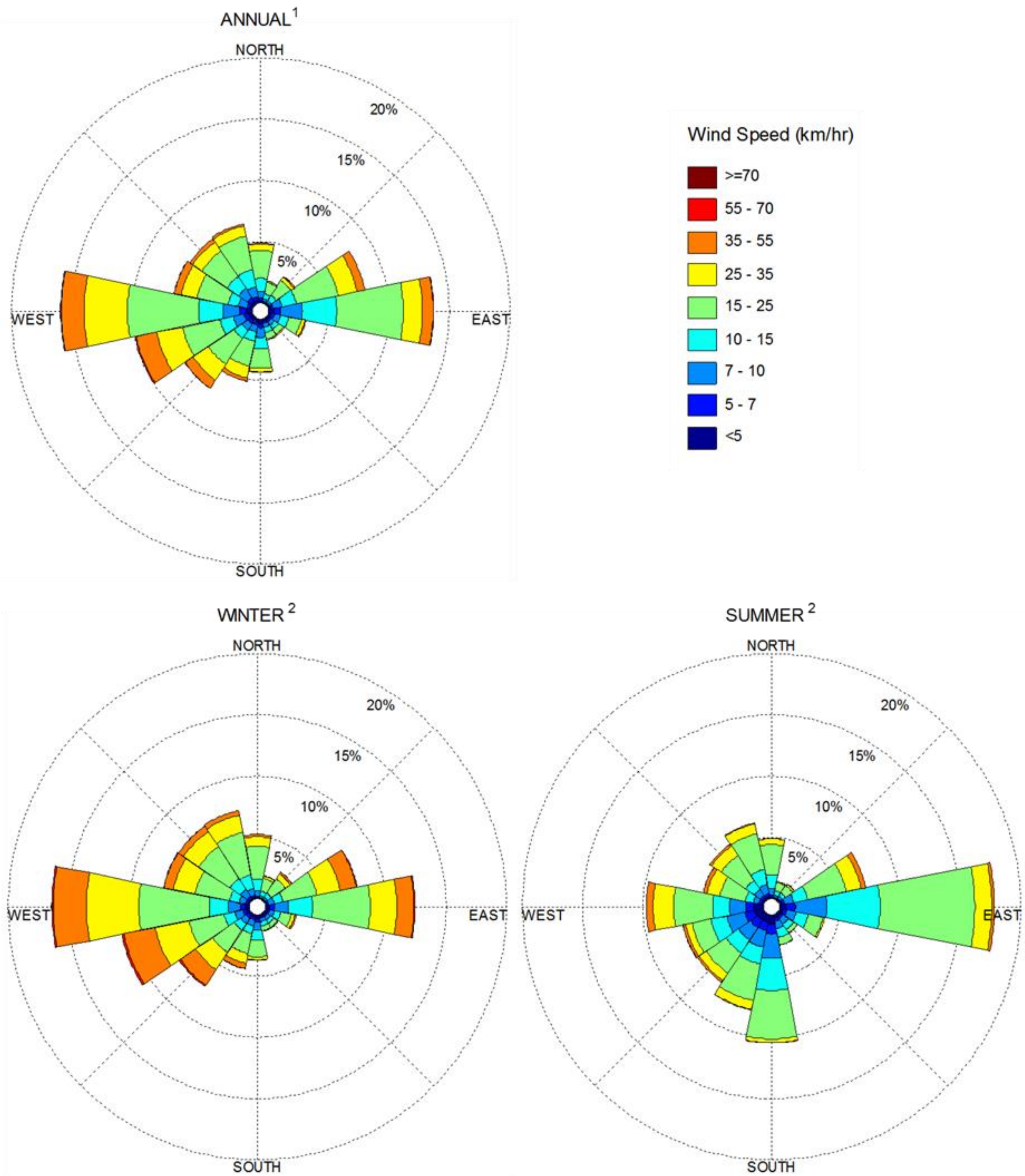
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the Level 10 common amenity terrace were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. 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 Mississauga was developed from approximately 40 years of hourly meteorological wind data recorded at Billy Bishop Toronto City Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (i.e., between 06:00 and 23:00) and divided into two distinct seasons, as stipulated in the wind criteria. Specifically, the summer season is defined as May through October, while the winter season is defined as November through April, inclusive.

The statistical model of the Mississauga 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 Mississauga (south of the Queen Elizabeth Way, or QEW), 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
BILLY BISHOP TORONTO CITY AIRPORT, TORONTO, 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 Criteria – City of Mississauga

Pedestrian wind comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature and relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Since both mean and gust wind speeds affect pedestrian comfort, their combined effect is defined in the City of Mississauga Urban Design Terms of Reference. Specifically, the criteria are defined as a Gust Equivalent Mean (GEM) wind speed, which is the greater of the mean wind speed or the gust wind speed divided by 1.85. The wind speed ranges 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. Five pedestrian comfort classes and corresponding gust wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Strolling, (4) Walking; and (5) Uncomfortable. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

1) **Sitting:** GEM wind speeds no greater than 10 km/h occurring at least 80% of the time would be considered acceptable for sedentary activities, including sitting.

2) **Standing:** GEM wind speeds no greater than 15 km/h occurring at least 80% of the time are acceptable for activities such as standing, strolling or more vigorous activities.

3) **Strolling:** GEM wind speeds no greater than 17 km/h occurring at least 80% of the time are acceptable for walking or more vigorous activities.

4) **Walking:** GEM wind speeds no greater than 20 km/h occurring at least 80% of the time are acceptable for walking or more vigorous activities.

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.

Regarding wind safety, gust wind speeds greater than 90 km/h, occurring more than 0.1% of the time on an annual basis, are classified as dangerous. From calculations of stability, it can be shown that gust wind speeds of 90 km/h would be the approximate threshold wind speed that would cause an average elderly person in good health to fall.

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 GEM wind speeds of 10 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 GEM wind speeds of 20 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 subject 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 table. 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 (During Typical Use Period)
Café / Patio / Bench / Garden	Sitting (Typical Use Period)
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting (Typical Use Period)
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-4B, which illustrate conditions at grade level for the proposed and existing massing scenarios, and by Figures 5A-5B, which illustrate conditions over the Level 10 amenity terrace serving the proposed development. Conditions are presented as continuous contours of wind comfort within and surrounding the subject site and correspond to the various 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 magenta.

Wind comfort conditions at all areas studied are considered acceptable for the intended pedestrian uses. The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks, Transit Stops, and Building Access Points along Lakeshore Road East: Conditions over the sidewalks along Lakeshore Road East are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the winter. Conditions over the nearby transit stops are predicted to be suitable for sitting during the summer. During the winter, the closest transit stop is predicted to be suitable for a mix of sitting and standing and the transit stop across the street is predicted to be suitable for standing. Near the building access points, conditions are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort criteria in Section 4.4.

Conditions over the sidewalks along Lakeshore Road East and over the nearby transit stops with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing during the winter. While the introduction of the proposed development results in slightly windier conditions in some areas, in comparison to existing conditions, wind conditions with the proposed development are considered acceptable. It is noteworthy that the introduction of the proposed development is predicted to increase comfort levels during the winter along Lakeshore Road East.

Sidewalks, Transit Stops, and Building Access Points along Ogden Avenue: Conditions over the sidewalks along Ogden Avenue are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the winter. Conditions over the nearby transit stop and in the vicinity of the building access points are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort criteria.

Conditions over the sidewalks along Ogden Avenue and over the nearby transit stops with the existing massing are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development results in windier conditions in comparison to existing conditions, wind conditions with the proposed development are considered acceptable according to the comfort criteria.

Sidewalks, Surface Parking, and Building Access Points along Laneway North of Subject Site: Conditions over the sidewalks along the laneway north of the subject site are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the winter. Conditions over the surface parking area and near the building access points are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort criteria.

Sidewalks, Transit Stops, and Building Access Points along Strathy Avenue: Conditions over the sidewalks along Strathy Avenue are predicted to be suitable for sitting during the summer, becoming mostly suitable for standing during the winter. The noted conditions are considered acceptable according to the comfort criteria in Section 4.4.

Conditions over the sidewalks along Strathy Avenue with the existing massing are predicted to be suitable for sitting during the summer, becoming mostly suitable for sitting during the winter. While the introduction of the proposed development results in windier conditions in comparison to existing conditions, wind conditions with the proposed development are considered acceptable according to the comfort criteria.

5.2 Wind Comfort Conditions – Common Amenity Terrace

Level 10 Amenity Terrace: Conditions over the Level 10 amenity terrace are predicted to be suitable for sitting during the summer, as illustrated in Figure 5A. During the winter, conditions are predicted to be windier than those during the summer, becoming mostly suitable for a mix of sitting and standing, as illustrated in Figure 5B. The noted conditions are considered acceptable according to the comfort criteria.

5.3 Wind Safety

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

5.4 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (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 subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

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 of this report and illustrated in Figures 3A-5B. Based on computer simulations using the CFD technique, meteorological data analysis of the Mississauga wind climate and wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

1) All areas within and surrounding the subject site are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, transit stops, surface parking, and building access points, are considered acceptable.

2) Conditions over the Level 10 amenity terrace are predicted to be suitable for sitting during the summer, which is considered acceptable according to the comfort criteria in Section 4.4.

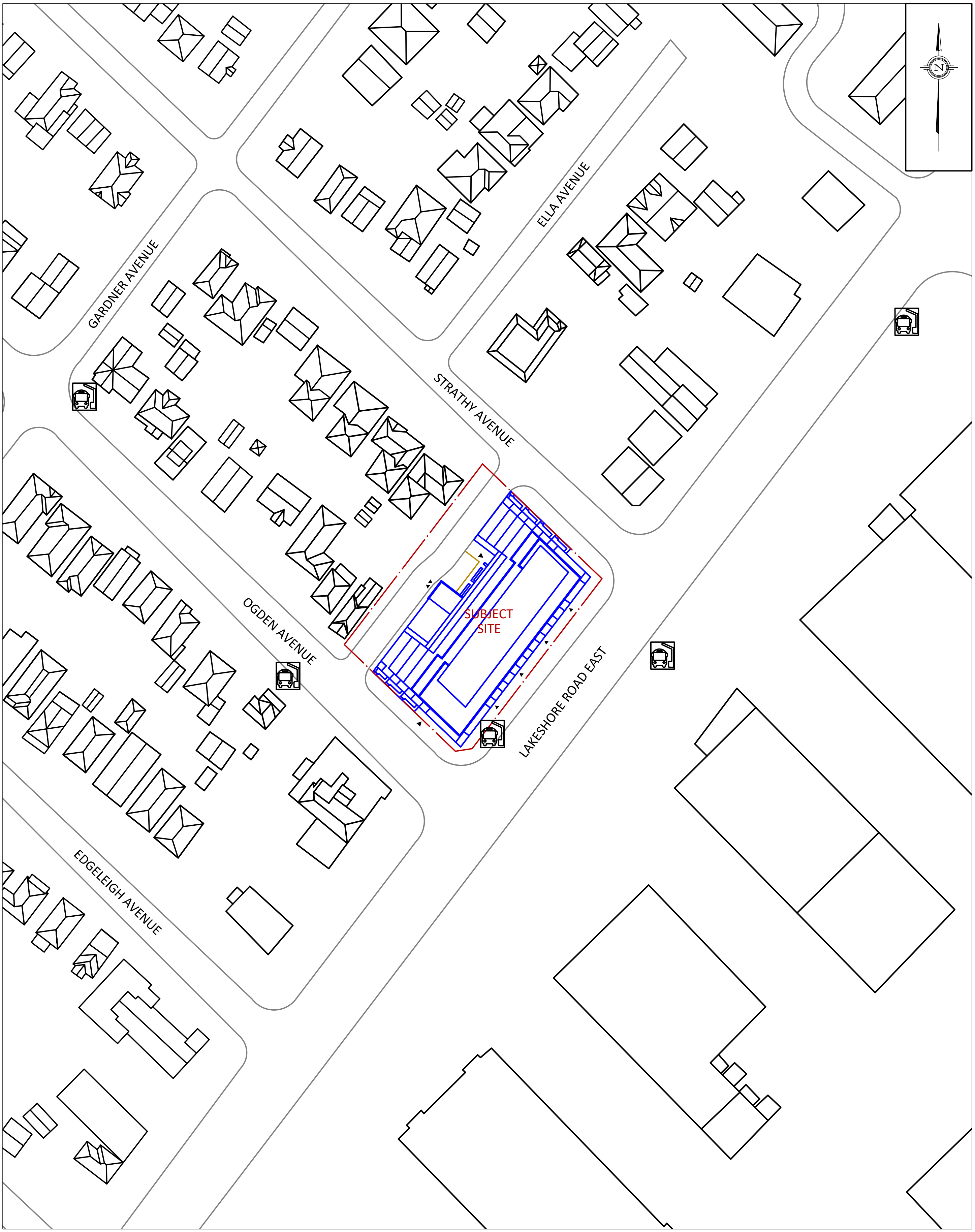
3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected over the subject site. During extreme weather events, (e.g., thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Sincerely,

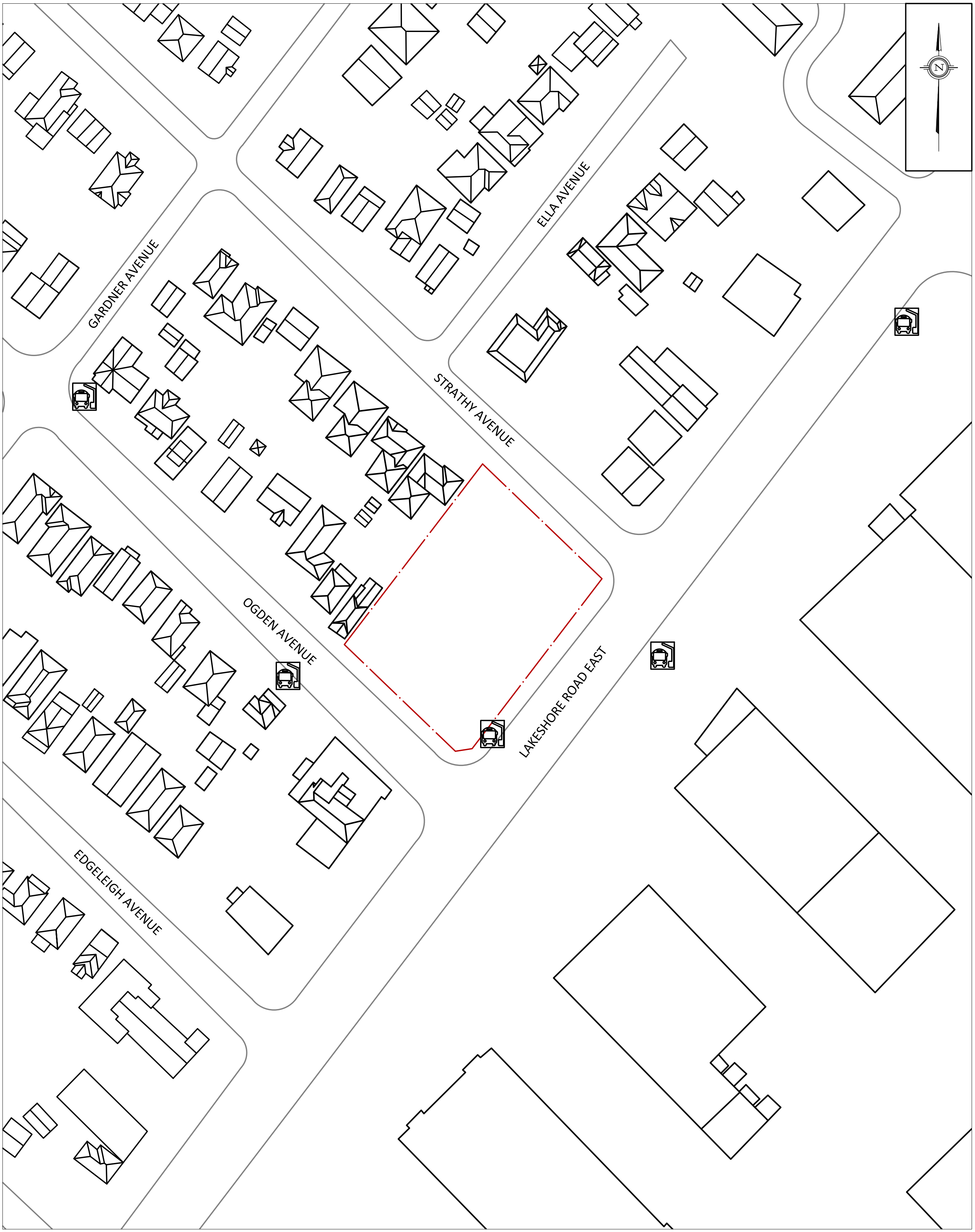
Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
Mar 8, 2022
PROVINCE OF ONTARIO

David Huitema, M.Eng.
Junior Wind Scientist



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT	1041 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE	1:1500	DRAWING NO. 21-432-PLW-1A	
	DATE	MARCH 2, 2022	DRAWN BY S.K.	



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PROJECT	1041 LAKESHORE ROAD EAST, MISSISSAUGA PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1500	DRAWING NO.	21-432-PLW-1B
DATE	MARCH 2, 2022	DRAWN BY	S.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

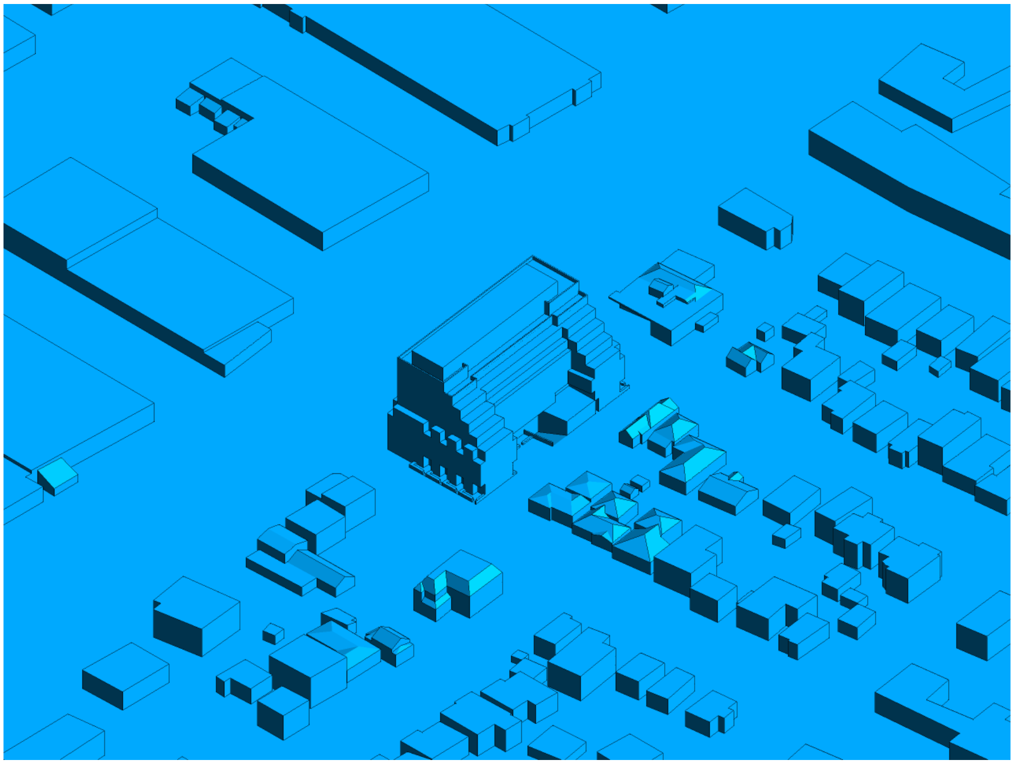

FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

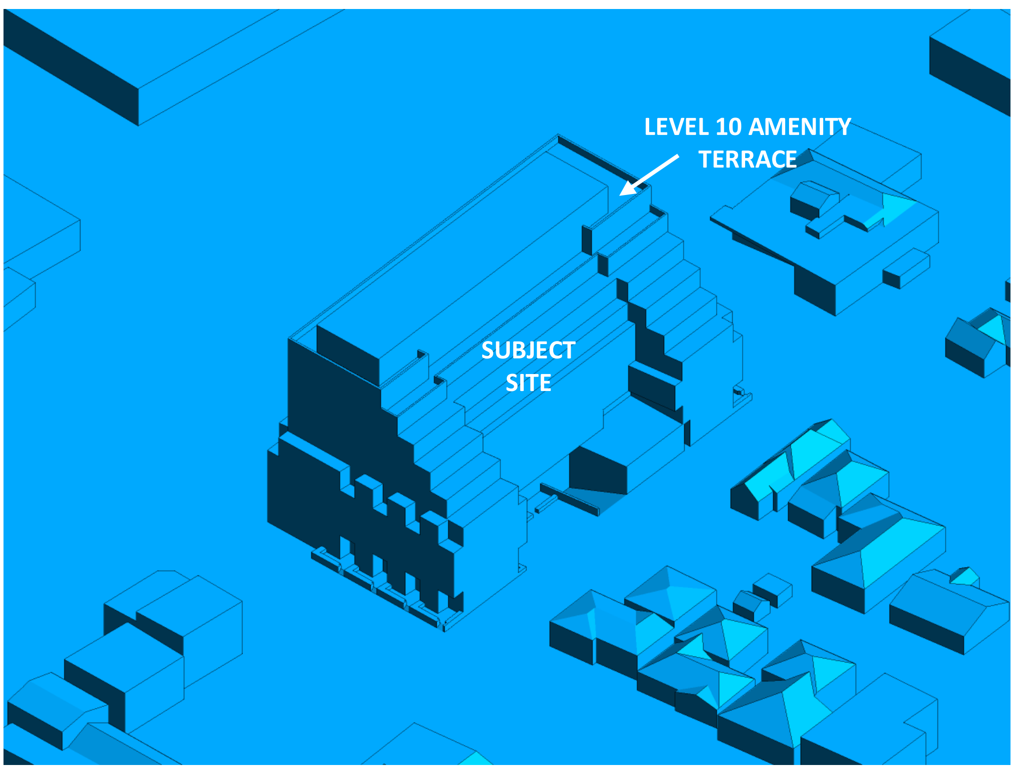

FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

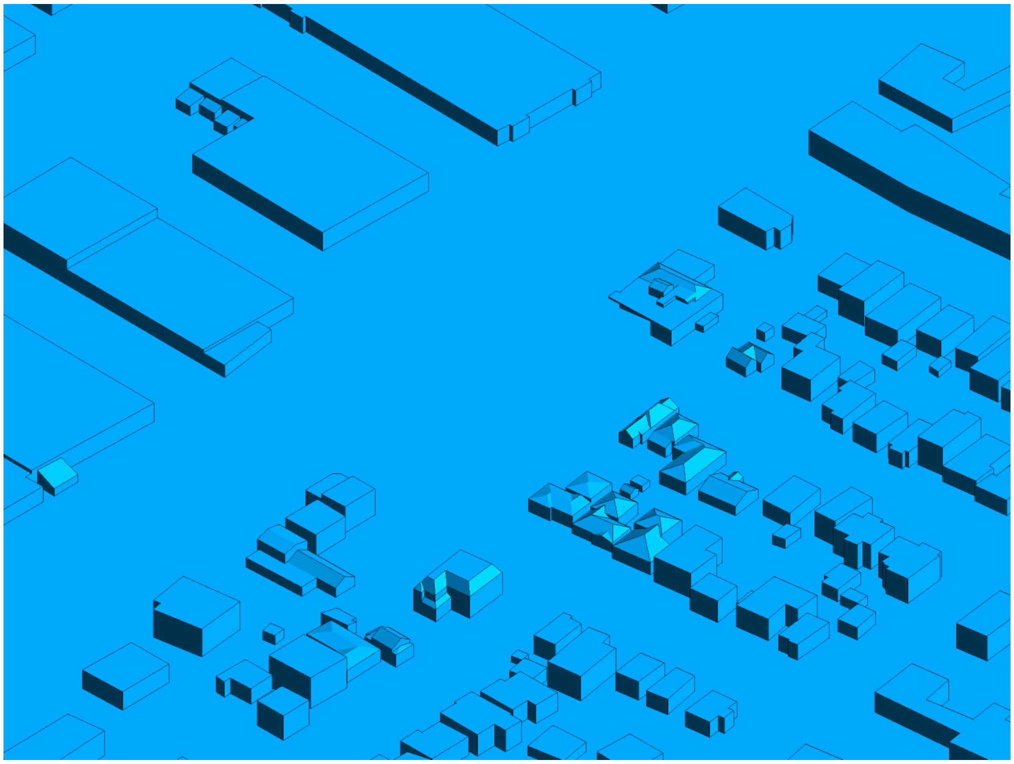

FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

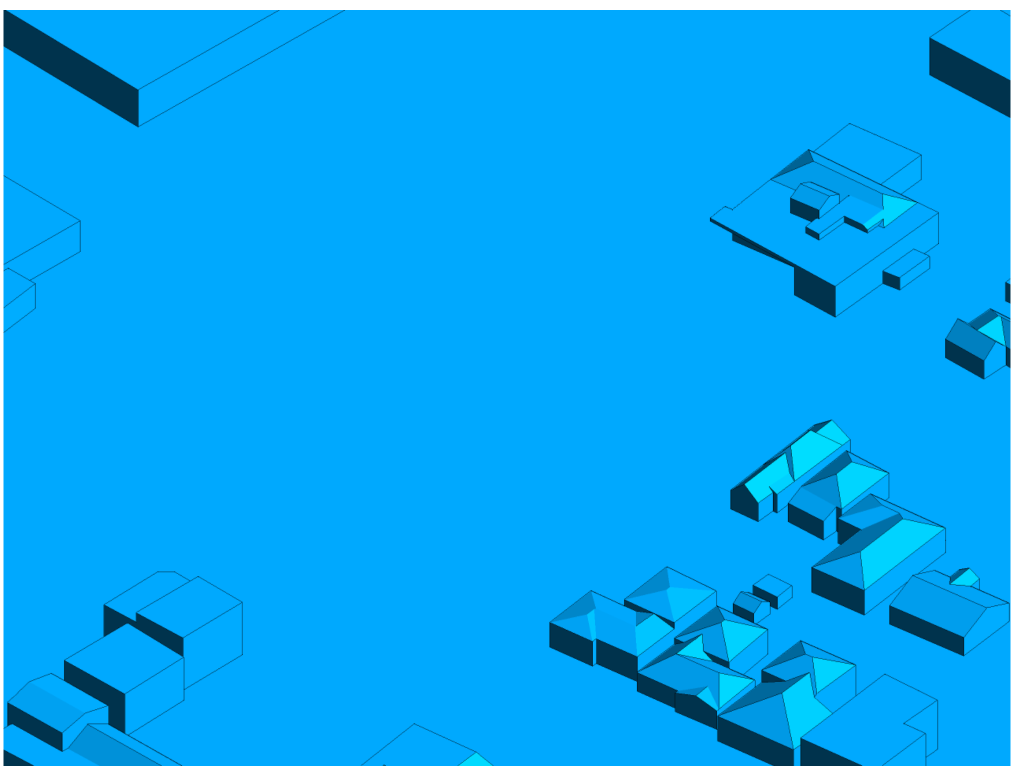

FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

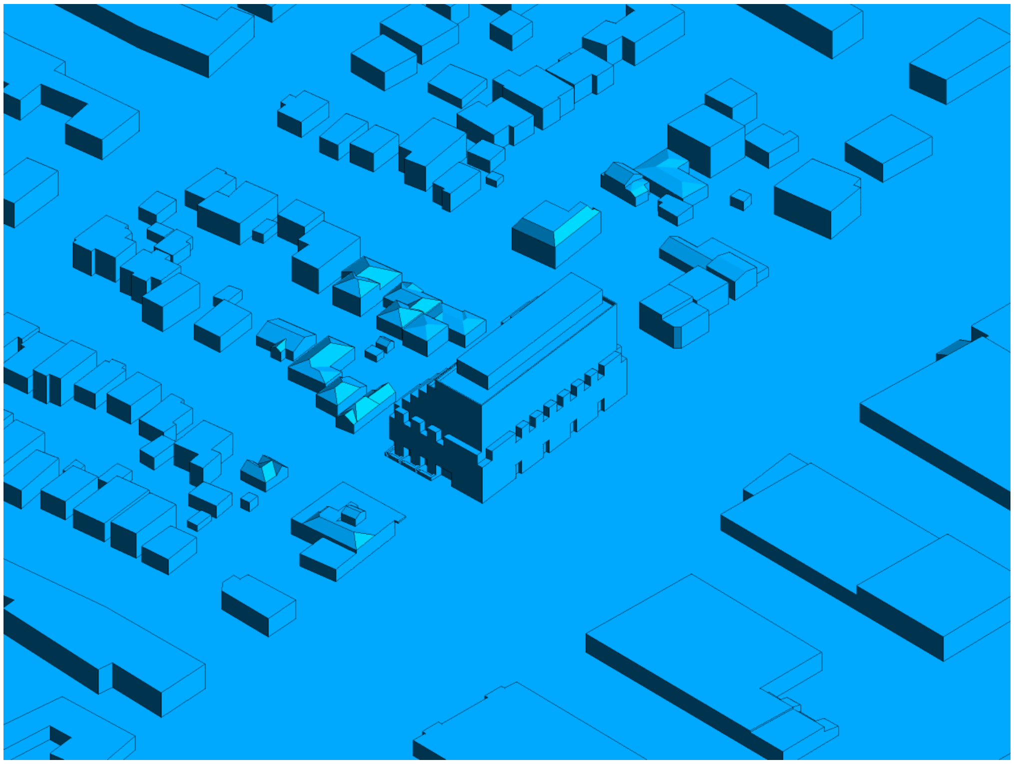

FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

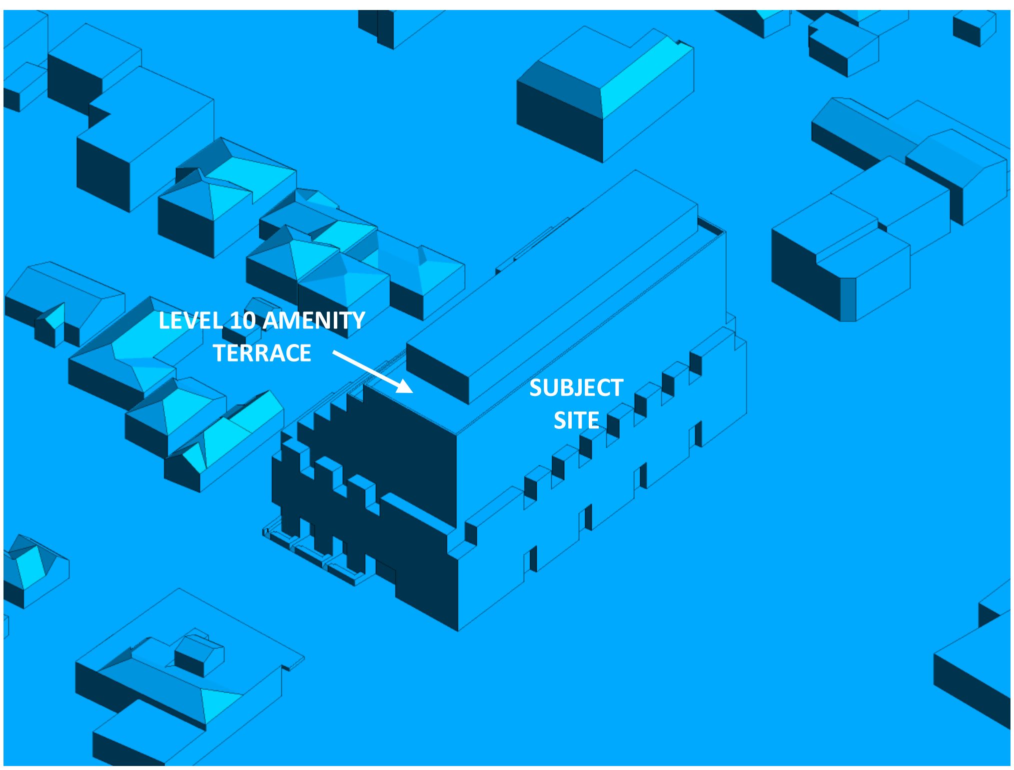

FIGURE 2F: CLOSE-UP VIEW OF FIGURE 2E

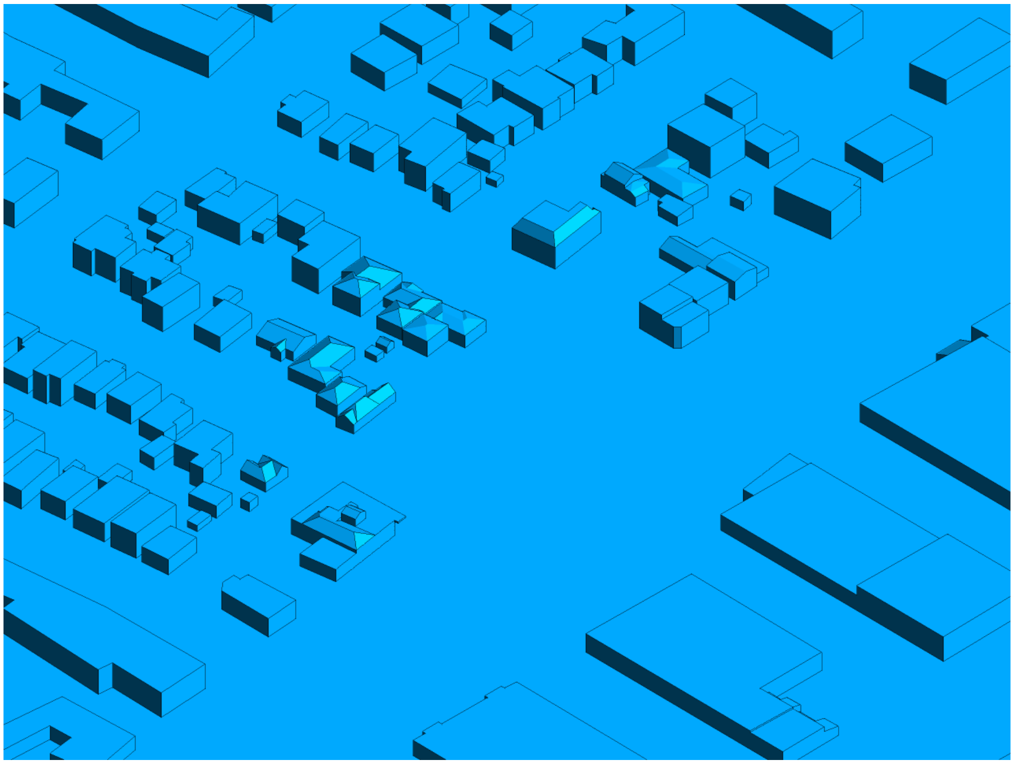

FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

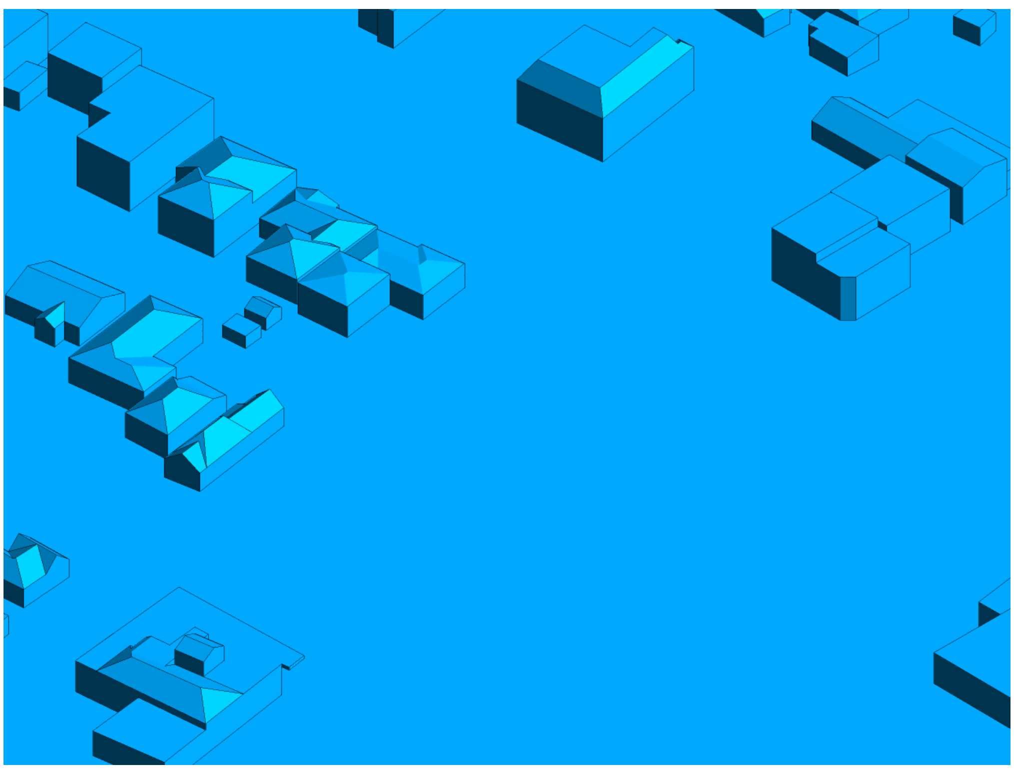

FIGURE 2H: CLOSE-UP VIEW OF FIGURE 2G

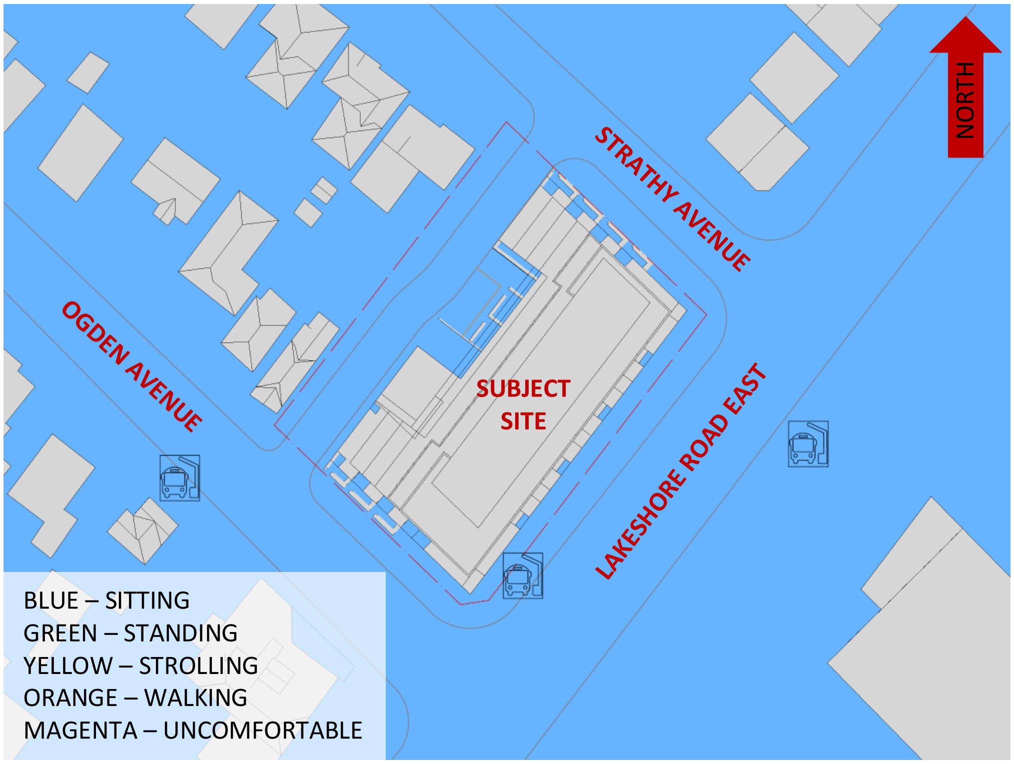

FIGURE 3A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

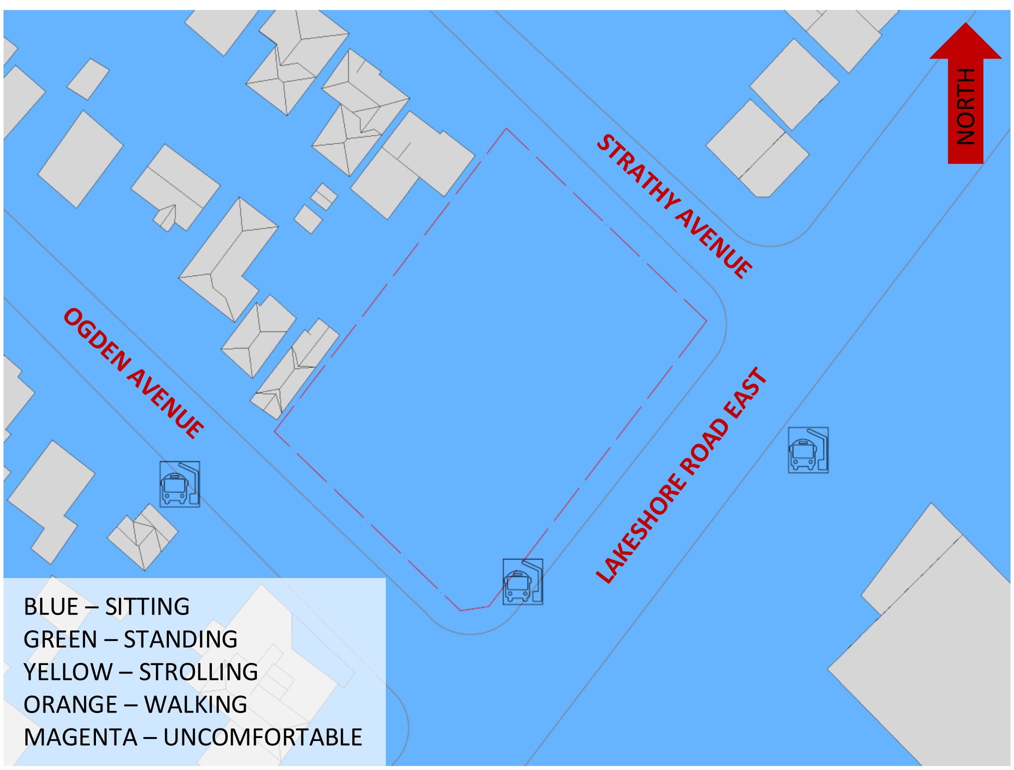

FIGURE 3B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

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

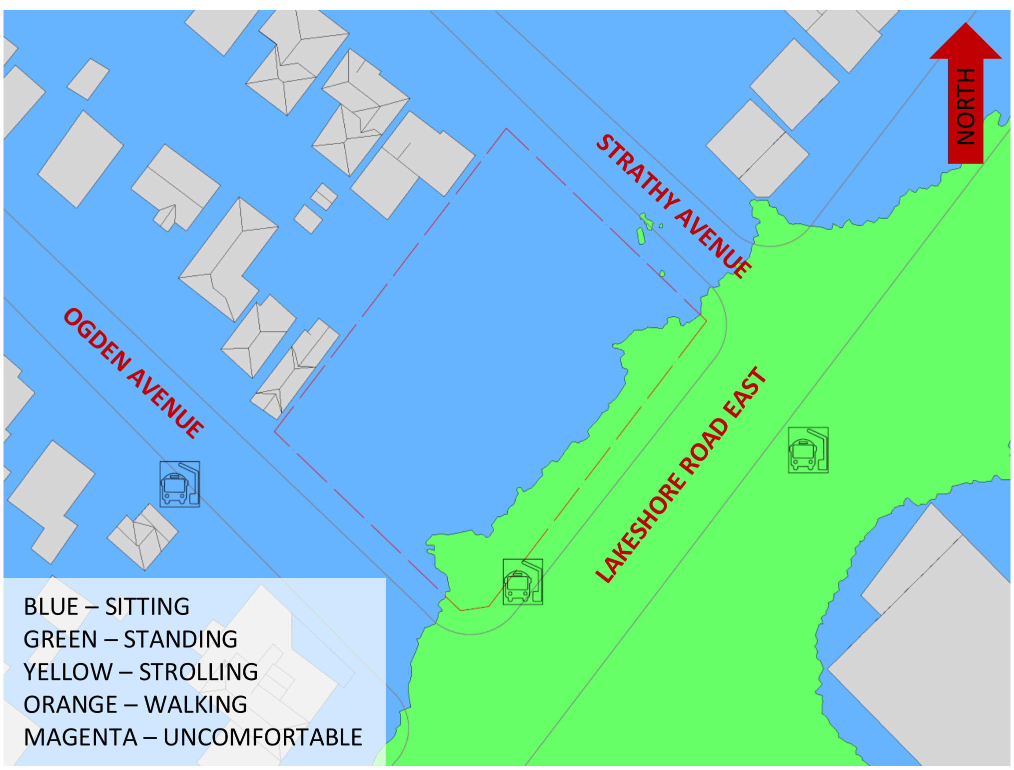

FIGURE 4B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

FIGURE 5A: SUMMER – WIND COMFORT, LEVEL 10 AMENITY TERRACE

FIGURE 5B: WINTER – WIND COMFORT, LEVEL 10 AMENITY TERRACE

APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

where, $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = depth of the boundary layer (gradient height), and 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 (Degrees True)	Alpha Value (α)
0	0.22
40	0.23
97	0.19
136	0.19
170	0.19
210	0.23
237	0.24
258	0.24
278	0.24
300	0.24
322	0.24
341	0.23

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).

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

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