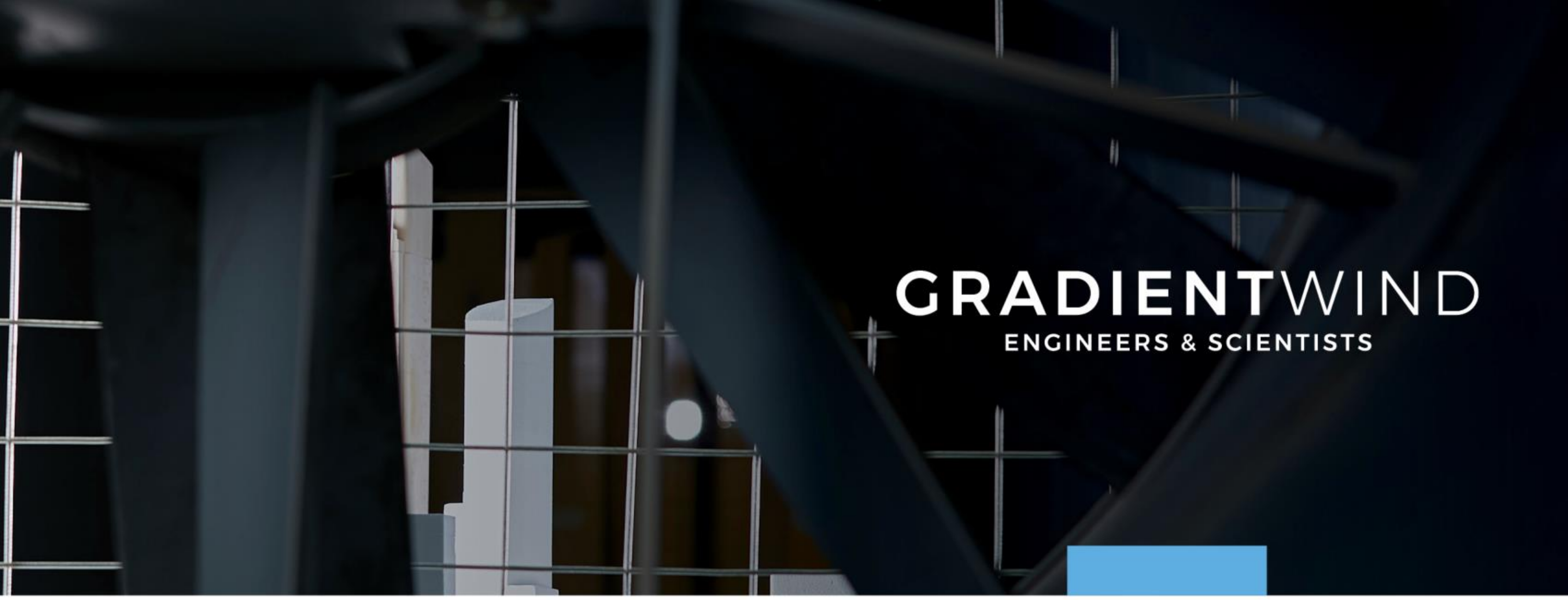
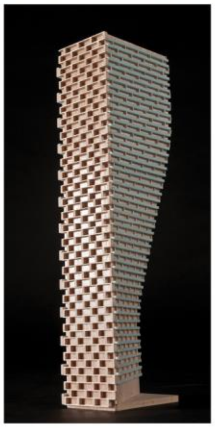
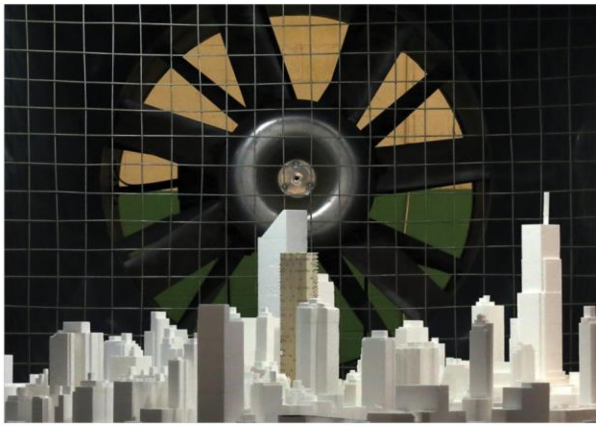


PEDESTRIAN LEVEL WIND STUDY

601 Laurier Avenue West
Ottawa, Ontario

Report: 24-134-PLW





July 15, 2024

PREPARED FOR
Heritage Investments Limited
1010 Polytek, Unit 5
Gloucester, ON K1J 9H8

PREPARED BY
Sunny Kang, B.A.S., Project Coordinator
Omar Rioseco, B.Eng., Junior Wind Scientist
David Huitema, M.Eng., P.Eng., CFD Lead Engineer

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Site Plan Control application submission requirements for the proposed residential development located at 601 Laurier Avenue West in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions 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.

The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind comfort and safety within and surrounding the subject site according to City of Ottawa wind comfort and safety criteria. The results and recommendations derived from these considerations are detailed in the main body of the report (Section 5), illustrated in Figures 3A-9, and summarized as follows:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, nearby surface parking lots, Tech Wall Dog Park, Nanny Goat Hill Community Garden, the proposed drive aisle and walkways, the grade-level outdoor amenity, and in the vicinity of building access points, are considered acceptable.

    a. Following the introduction of the proposed development, a region to the southwest of the subject site is predicted to experience conditions that may occasionally be considered uncomfortable for walking during the spring and winter seasons, exceeding the walking threshold for approximately 3% of the time during these seasons. The noted wind conditions may be considered satisfactory, as the uncomfortable conditions during the spring and winter are limited to a forested area where pedestrian access is limited.

2) Regarding the common amenity terrace serving the proposed development at Level 7, which was modelled with 1.8-m-tall wind screens along its full perimeter, conditions during the typical use period (that is, May to October, inclusive) are predicted to be suitable for sitting. The noted conditions are considered acceptable.

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 anywhere over the subject site. During extreme weather events, (for example, 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 Heritage Investments Limited to undertake a pedestrian level wind (PLW) study to satisfy Site Plan Control application submission requirements for the proposed residential development located at 601 Laurier Avenue West in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required.

Our work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by Project1 Studio in July 2024, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent satellite imagery.

2. TERMS OF REFERENCE

The subject site is located at 601 Laurier Avenue West in Ottawa, situated to the northeast of the intersection of Laurier Avenue West and Cambridge Street North. Throughout this report, Laurier Avenue West is referred to as project south. An existing 3-storey residential building to the east of the subject site is to be retained. The proposed development comprises a 28-storey residential building, inclusive of a 6-storey podium, topped by a mechanical penthouse (MPH).

Above three underground parking levels, the ground floor of the proposed development comprises a near triangular planform and includes a main entrance and indoor amenities near the southeast corner, a loading area and shared building support spaces to the east, and residential units throughout the remainder of the level. An outdoor amenity is located at the northeast corner of the subject site. Access to the underground parking levels is provided by a ramp at the southeast corner of the proposed development via a drive aisle that extends perpendicularly from Laurier Avenue West. Levels 2-6 are reserved for residential use while Level 7 includes an indoor amenity to the east and residential units throughout the remainder of the level.

The building steps back from the east and south elevations at Level 5, from all elevations at Level 7, and at the northeast corner at Level 8. A common amenity terrace is located at the southeast corner of Level 7. Levels 8-28 are reserved for residential occupancy.

Considering Laurier Avenue West as project south, the near-field surroundings, defined as an area within a 200-metre (m) radius of the subject site, includes the existing low-rise building within the subject site, the Tech Wall Dog Park, and the Nanny Goat Hill Community Garden to the east, high-rise residential buildings from the east-southeast clockwise to the southeast, a mix of low- and mid-rise buildings to the south, the Bruyère - Saint-Vincent Hospital to the southwest, low-rise buildings to the southwest and northeast, and high-rise residential buildings to the north. Notably, the Ādisōke - Ottawa Central Library is under construction at 555 Albert Street, approximately 100 m to the northwest. Furthermore, the subject site is situated atop an escarpment that runs southwest to northeast.

The far-field surroundings, defined as an area beyond the near-field but within a 2-kilometre (km) radius of the subject site, are characterized primarily by a mix of low- and mid-rise buildings with isolated high-rise buildings in all compass directions, with a cluster of mid- and high-rise buildings which define the Ottawa downtown core to the east and northeast and LeBreton Flats Park to the northwest. The Ottawa River flows from the west to the northeast, approximately 620 m to the north.

Site plans for the proposed and existing massing scenarios are illustrated in Figures 1A and 1B, while Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any changes which have been approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the development 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 site is based on CFD simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind comfort and safety criteria[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Ottawa Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the 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 stronger wind speeds.

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 proposed development, complete with surrounding massing within a radius of 480 m. The process was performed for two context massing scenarios, as noted in Section 2.

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

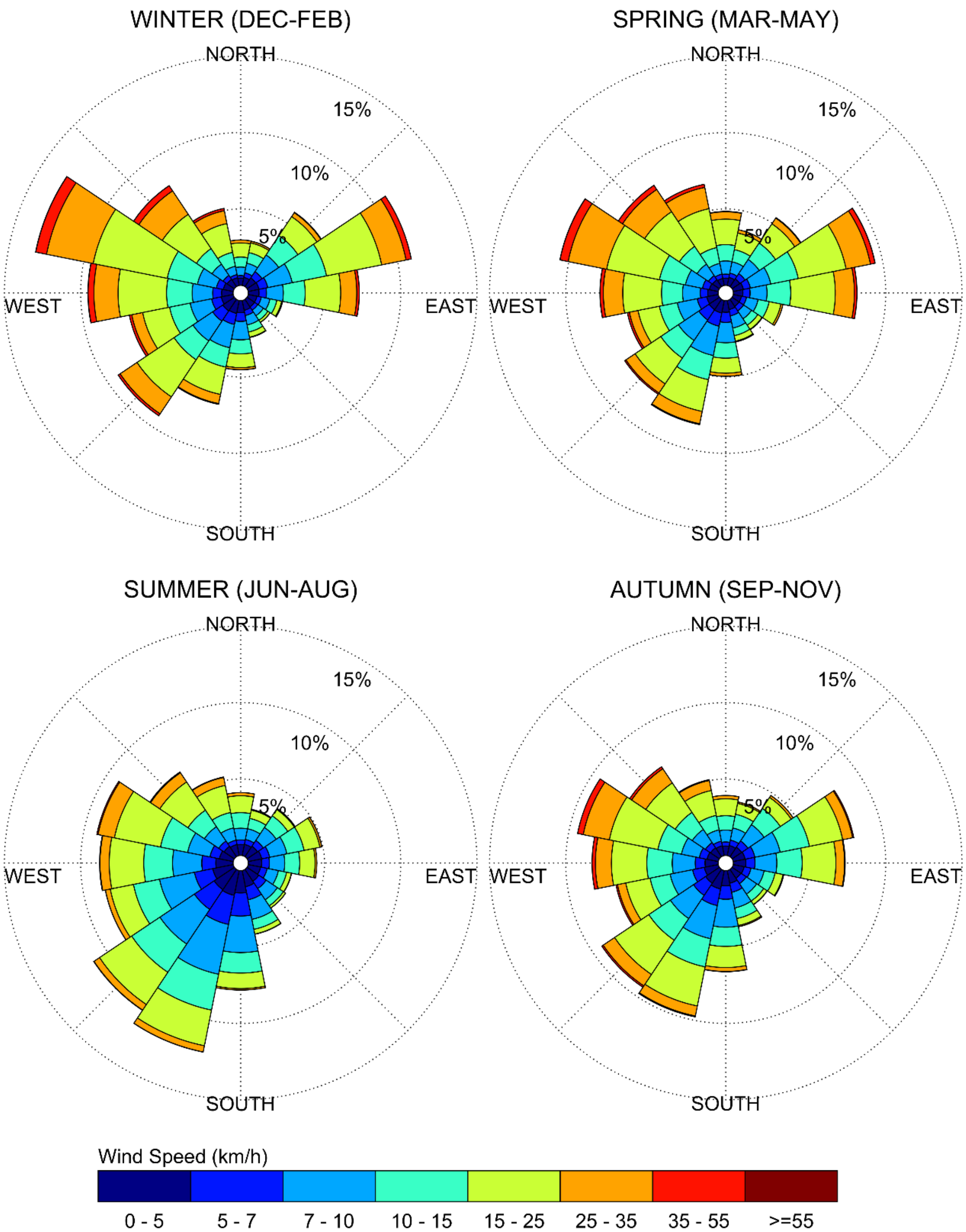
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and over the Level 7 common amenity terrace serving the proposed development were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. Gradient height represents the theoretical depth of the boundary layer of the earth's atmosphere, above which the mean wind speed remains constant. Further details of the wind flow simulation technique are presented in Appendix A.

4.3 Historical Wind Speed and Direction Data

A statistical model for winds in Ottawa was developed from approximately 40 years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed during the appropriate hours of pedestrian usage (that is, between 06:00 and 23:00) and divided into four distinct seasons, as stipulated in the wind criteria. Specifically, the spring season is defined as March through May, the summer season is defined as June through August, the autumn season is defined as September through November, and the winter season is defined as December through February, inclusive.

The statistical model of the Ottawa area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The prominent 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 prominence 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 Wind Comfort and Safety Criteria – City of Ottawa

Pedestrian wind comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (that is, temperature and relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes based on 20% non-exceedance mean wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. The gust speeds, and equivalent mean speeds, are selected based on the Beaufort scale, which describes the effects of forces produced by varying wind speed levels on objects. Wind conditions suitable for sitting are represented by the colour blue, standing by green, strolling by yellow, and walking by orange; uncomfortable conditions are represented by the colour magenta. Specifically, the comfort classes, associated wind speed ranges, and limiting criteria are summarized as follows:

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	Mean Speed (km/h)	Description
SITTING	≤ 10	Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.
STANDING	≤ 14	Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.
STROLLING	≤ 17	Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.
WALKING	≤ 20	Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.
UNCOMFORTABLE	> 20	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, 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. 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. Notably, 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.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (equivalent gust wind speed of approximately 16 km/h) were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (equivalent gust wind speed of approximately 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 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 target comfort classes, which are dictated by the location type for each region (that is, a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest target comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

TARGET PEDESTRIAN WIND COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Target Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting / Standing
Café / Patio / Bench / Garden	Sitting / Standing
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting / Standing
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B, which illustrate wind conditions at grade level for the proposed and existing massing scenarios, and by Figures 8A-D which illustrate conditions over the common amenity terrace serving the proposed development at Level 7. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the comfort classes presented in Section 4.4.

Wind conditions are also reported for the typical use period, which is defined as May to October, inclusive. Figures 7A-B and 9 illustrate wind comfort conditions at grade level and within the noted common amenity terrace, respectively, consistent with the comfort classes in Section 4.4.

The details of these conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Ground Floor

Sidewalks and Transit Stops along Bronson Avenue: Following the introduction of the proposed development, wind conditions over the public sidewalks along Bronson Avenue are predicted to be suitable for a mix of sitting and standing throughout the year. Conditions in the vicinity of the nearby transit stops along Bronson Avenue are predicted to be suitable for standing, or better, during the summer, becoming suitable for standing throughout the remainder of the year. The noted conditions are considered acceptable.

Conditions over the sidewalks along Bronson Avenue under the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the spring and winter. Under the existing massing, conditions in the vicinity of the nearby northbound transit stop are predicted to be suitable for sitting during the summer and autumn, becoming suitable for standing during the spring and winter, while conditions in the vicinity of the nearby southbound transit stop are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces slightly windier conditions over these areas in comparison to existing conditions, the predicted wind comfort conditions with the proposed development are nevertheless considered acceptable.

Sidewalks along Laurier Avenue West and Cambridge Street North: Following the introduction of the proposed development, wind conditions over the public sidewalks along Laurier Avenue West are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing, or better, throughout the remainder of the year. Conditions over the sidewalks along Cambridge Street North are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remaining seasons. The noted conditions are considered acceptable.

Conditions over the sidewalks along Laurier Avenue West and Cambridge Street North under the existing massing are predicted to be suitable for sitting throughout the year. While the introduction of the proposed development produces slightly windier conditions in comparison to existing conditions, the predicted wind comfort conditions with the proposed development are nevertheless considered acceptable.

Tech Wall Dog Park and Nanny Goat Hill Community Garden East of Subject Site: Wind comfort conditions over the Tech Wall Dog Park and Nanny Goat Hill Community Garden situated to the east of the subject site are predicted to be suitable for sitting during the typical use period prior to and following the introduction of the proposed development. The noted conditions are considered acceptable.

Neighbouring Existing Drive Aisles and Surface Parking Lots: Following the introduction of the proposed development, wind conditions over the existing surface parking lot to the northeast of the proposed development are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the autumn, and suitable for standing, or better, during the spring and winter. Conditions over the existing surface parking lots to the south are predicted to be sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. Conditions over the existing surface parking lots to the southwest are predicted to be standing, or better, during the summer, becoming suitable for walking, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

Under the existing massing, conditions over the surface parking lot to the northeast are predicted to be suitable for mostly sitting throughout the year, while conditions over the surface parking lots to the south are predicted to be suitable for sitting throughout the year. Conditions over the surface parking lots to the southwest under the existing massing are predicted to be sitting during the summer, becoming suitable for standing, or better, during the spring, autumn, and winter. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, the predicted wind comfort conditions with the proposed development are nevertheless considered acceptable.

Forested Area Southwest of Subject Site: Following the introduction of the proposed development, wind conditions over the forested area to the southwest of the subject site are predicted to be suitable for strolling, or better, during the summer, becoming suitable for a mix of standing, strolling, and walking throughout the remainder of the year. An isolated region of conditions that may occasionally be considered uncomfortable for walking during the spring and winter is predicted to the southwest of the subject site. This area is expected to be inaccessible to pedestrians. Conditions over the noted area are predicted to be suitable for walking for approximately 77% of the time during the spring and winter seasons, representing 3% exceedances of the walking threshold. As these conditions are located within a limited region where pedestrian access is restricted, the noted conditions may be considered satisfactory.

Outdoor Amenity Northeast of Subject Site: During the typical use period, wind conditions over the outdoor amenity at the northeast corner of the subject site are predicted to be suitable for mostly sitting with an isolated region suitable for standing central to the space. Where conditions are suitable for standing, they are also suitable for sitting for at least 79% of the time during the same period, where the target is 80% to achieve the sitting comfort class. As conditions are predicted to be suitable for sitting over the majority of the area and the exceedance of the sitting comfort threshold may be considered marginal, the noted conditions may be considered acceptable.

Proposed Drive Aisle and Walkways: Wind comfort conditions over the drive aisle and walkways serving the proposed development are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

Building Access Points: Owing to the protection of the building façade, wind conditions in the vicinity of the building access points serving the proposed development are predicted to be suitable for sitting throughout the year, which is considered acceptable.

5.2 Wind Comfort Conditions – Level 7 Common Amenity Terrace

As illustrated in Figure 9, wind comfort conditions within the common amenity terrace serving the proposed development at Level 7 are predicted to be suitable for sitting, which is considered acceptable. Notably, the Level 7 amenity terrace was modelled with 1.8-m-tall wind screens along its full perimeter.

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 are expected 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 (that is, 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.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-9. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, transit stops, nearby surface parking lots, Tech Wall Dog Park, Nanny Goat Hill Community Garden, the proposed drive aisle and walkways, the grade-level outdoor amenity, and in the vicinity of building access points, are considered acceptable.

    a. Following the introduction of the proposed development, a region to the southwest of the subject site is predicted to experience conditions that may occasionally be considered uncomfortable for walking during the spring and winter seasons, exceeding the walking threshold for approximately 3% of the time during these seasons. The noted wind conditions may be considered satisfactory, as the uncomfortable conditions during the spring and winter are limited to a forested area where pedestrian access is limited.

2) Regarding the common amenity terrace serving the proposed development at Level 7, which was modelled with 1.8-m-tall wind screens along its full perimeter, conditions during the typical use period (that is, May to October, inclusive) are predicted to be suitable for sitting. The noted conditions are considered acceptable.

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 anywhere over the subject site. During extreme weather events, (for example, 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,

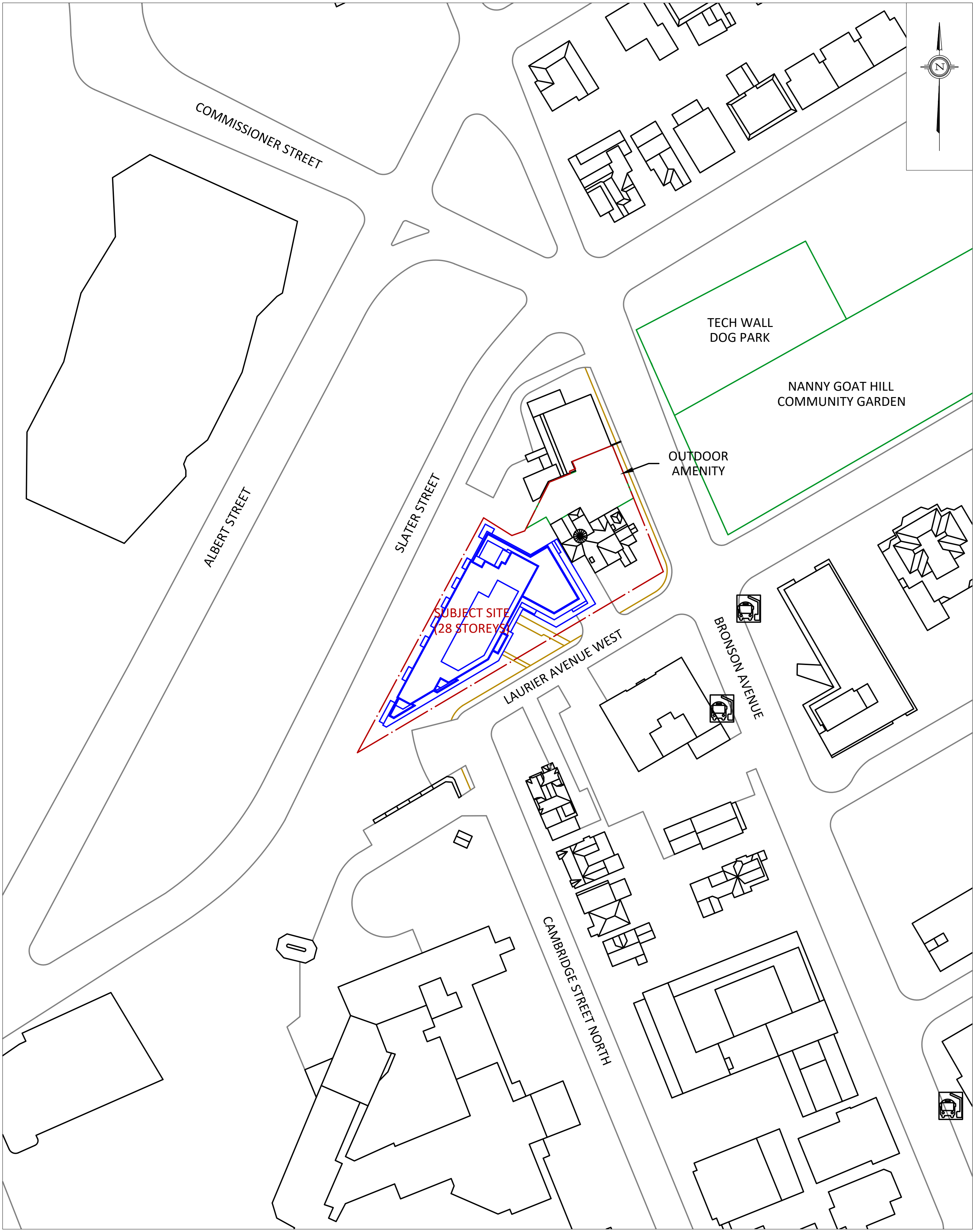
Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
D. T. HUITEMA
100561777
July 15, 2024
PROVINCE OF ONTARIO

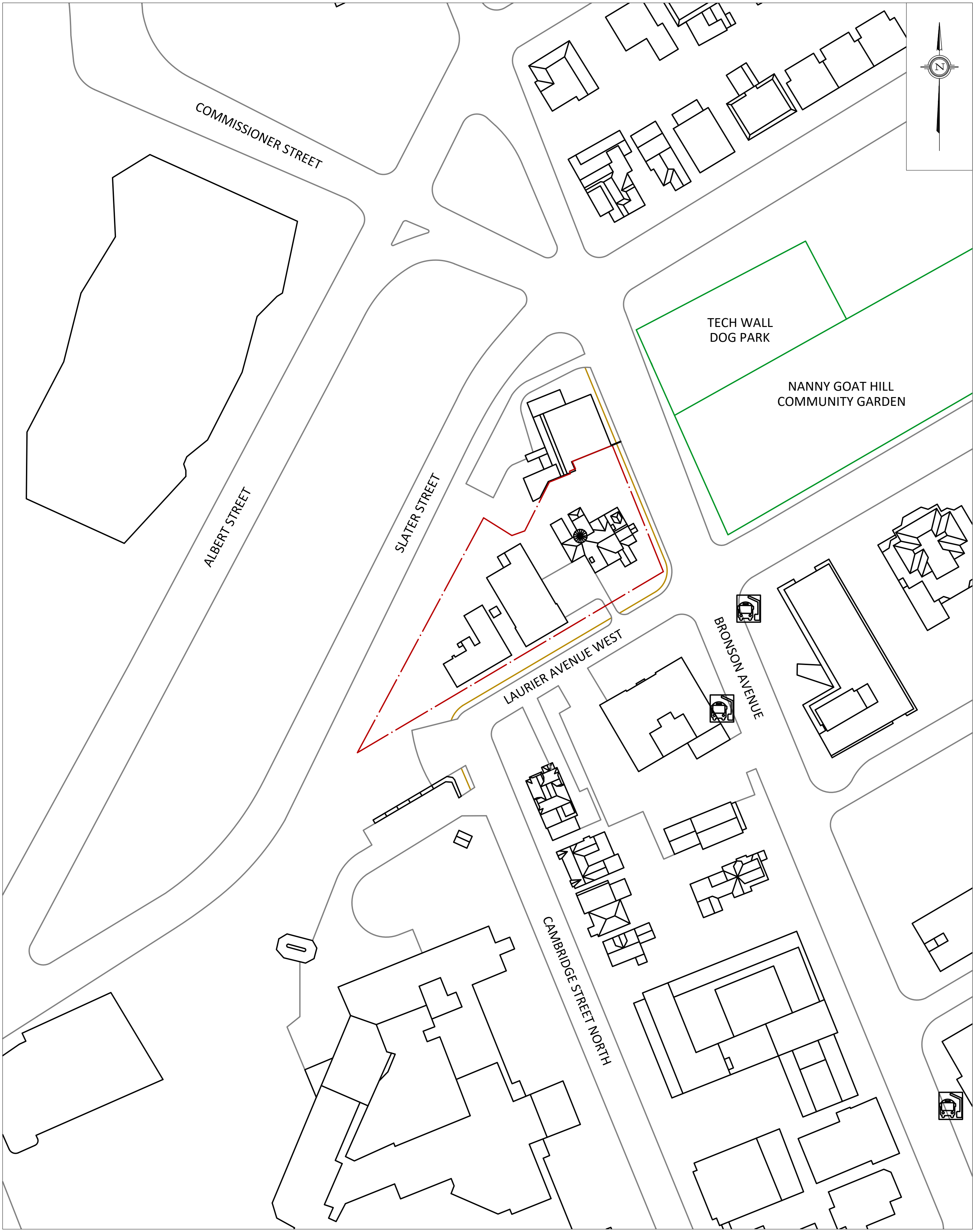
Omar Rioseco, B.Eng.
Junior Wind Scientist

David Huitema, M.Eng., P.Eng.
CFD Lead Engineer

Sunny Kang, B.A.S.
Project Coordinator



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT	601 LAURIER AVENUE WEST, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:1500	DRAWING NO. 24-134-PLW-1A		
	DATE JULY 15, 2024	DRAWN BY S.K.		



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ENGINEERS & SCIENTISTS
127 WALGREEN ROAD, OTTAWA, ON
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PROJECT		DESCRIPTION
601 LAURIER AVENUE WEST, OTTAWA PEDESTRIAN LEVEL WIND STUDY		FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:1500	DRAWING NO. 24-134-PLW-1B	
DATE JULY 15, 2024	DRAWN BY S.K.	

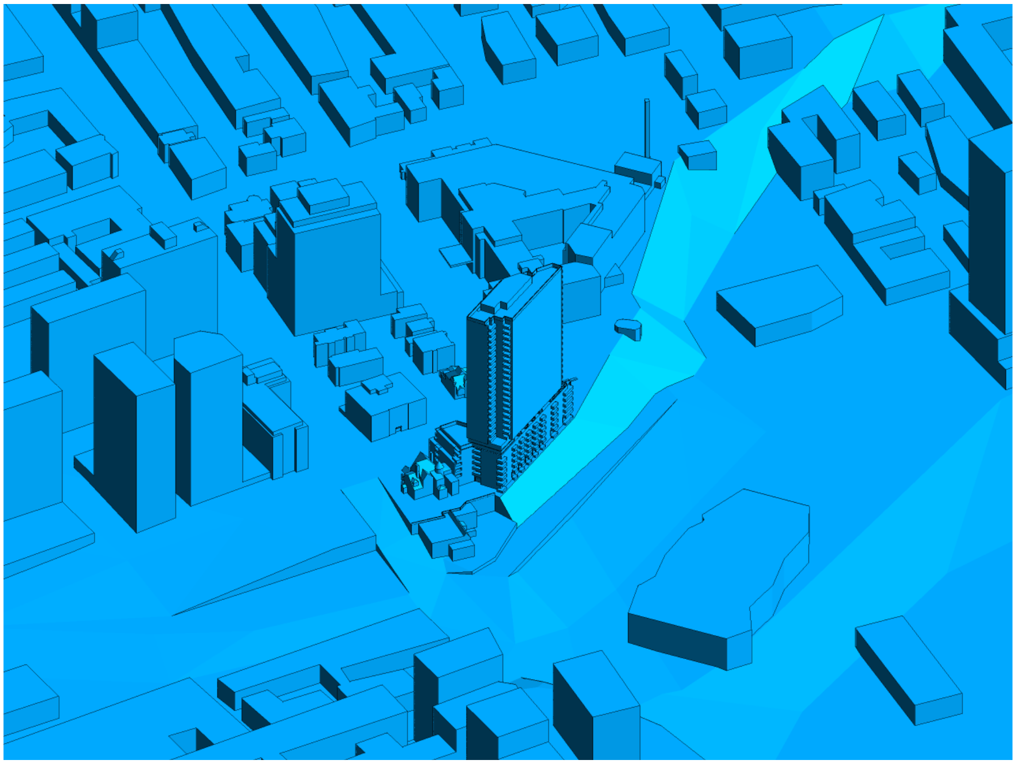


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

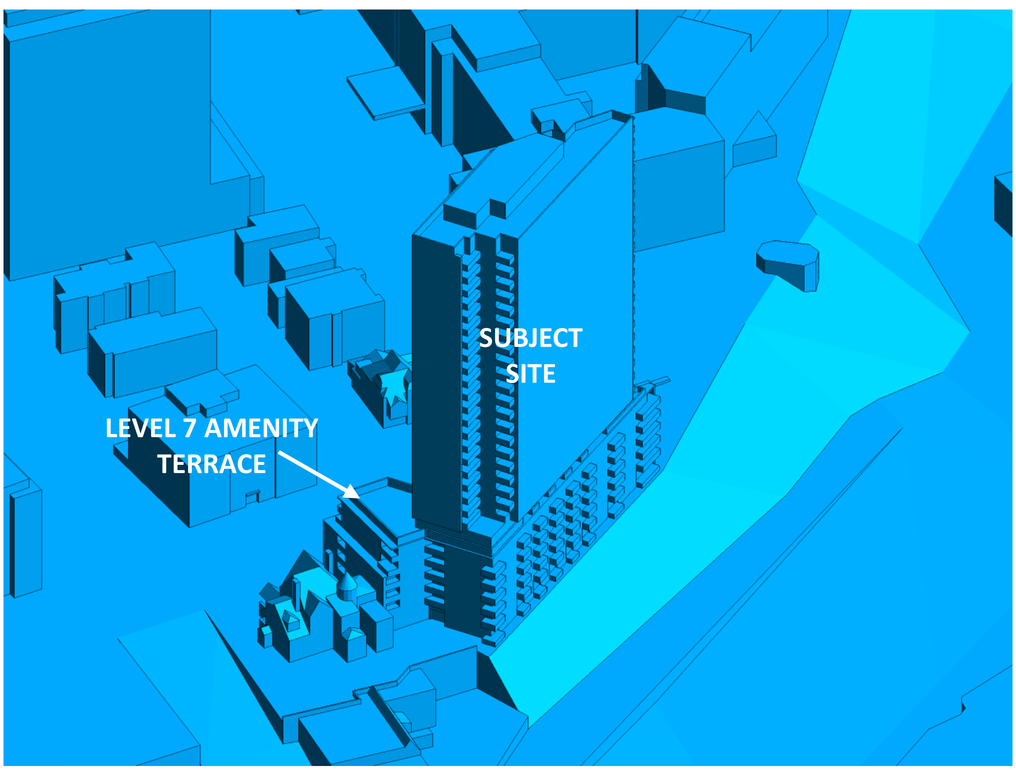


FIGURE 2B: CLOSE UP OF FIGURE 2A

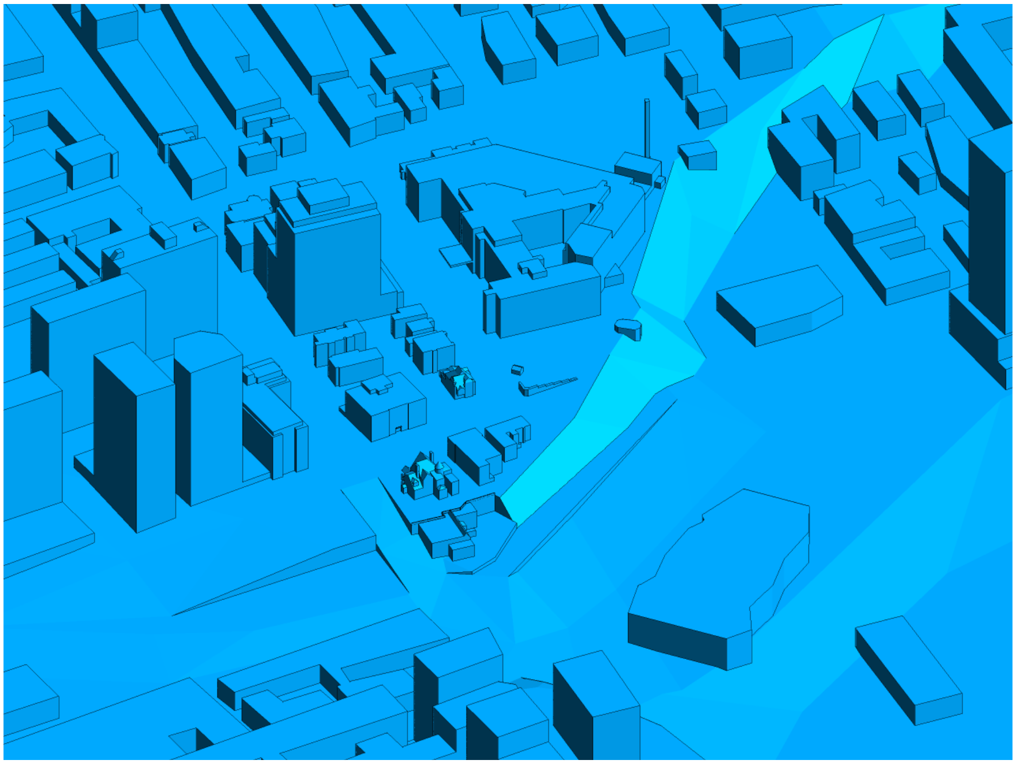


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

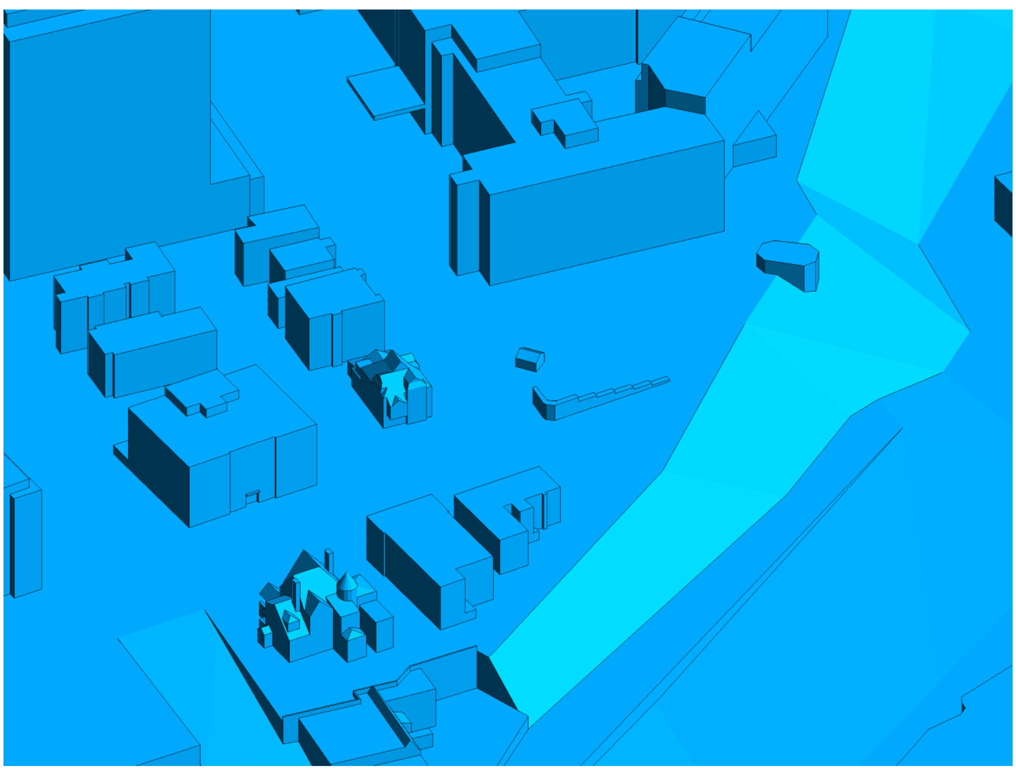


FIGURE 2D: CLOSE UP OF FIGURE 2C

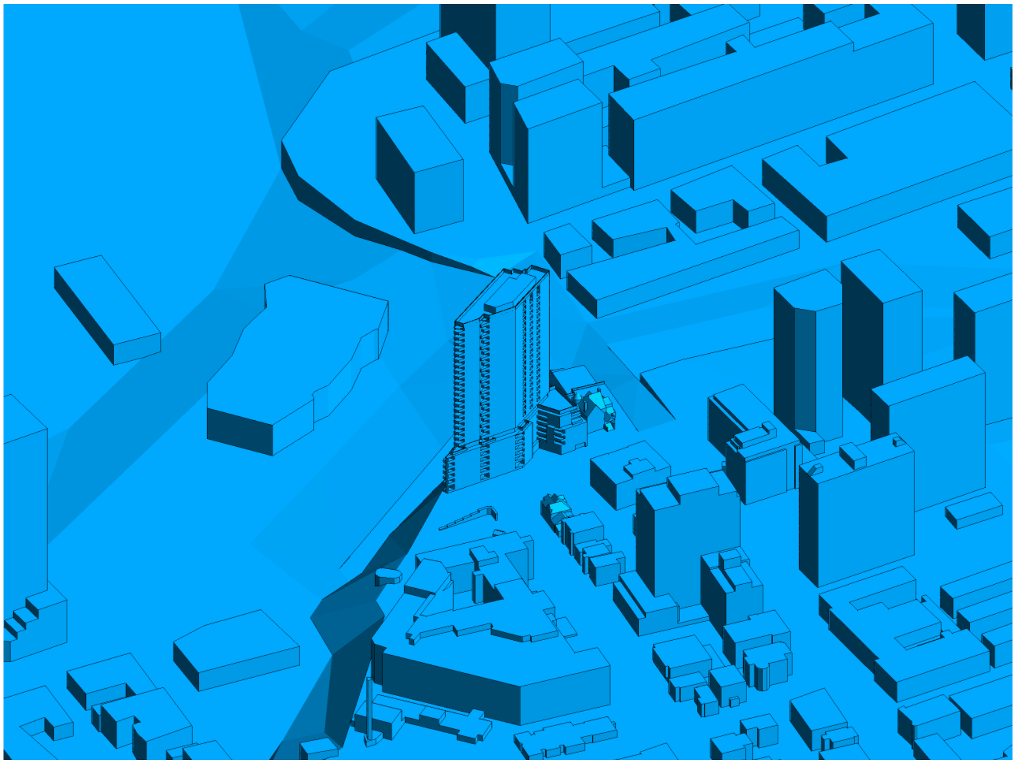


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

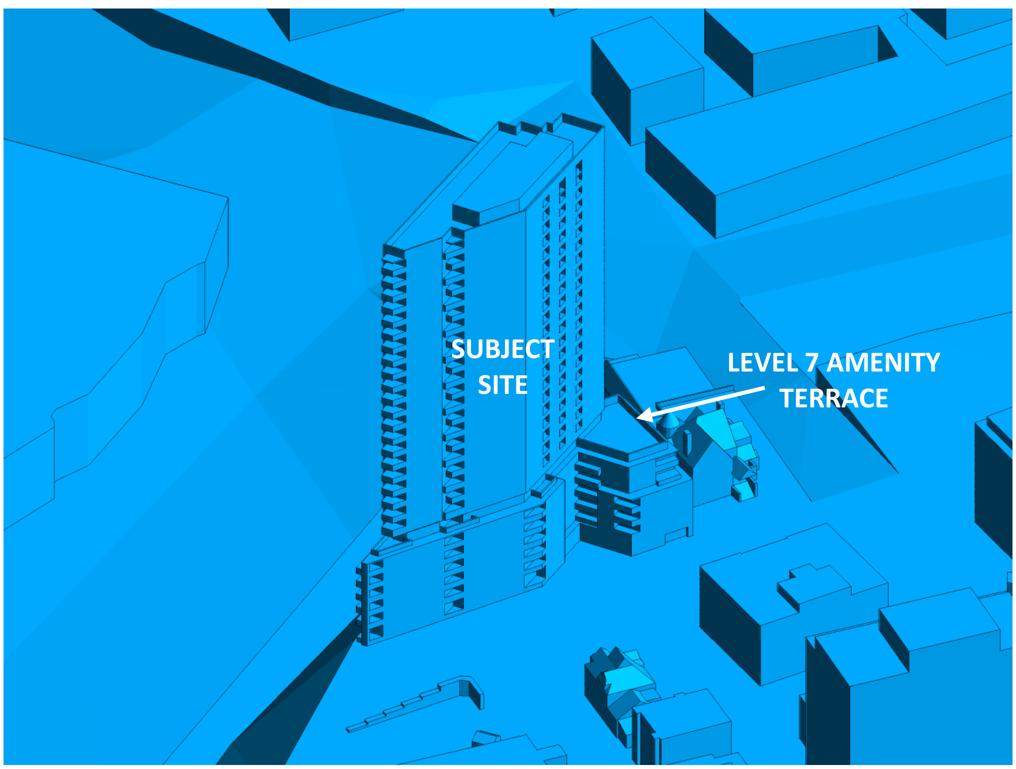


FIGURE 2F: CLOSE UP OF FIGURE 2E

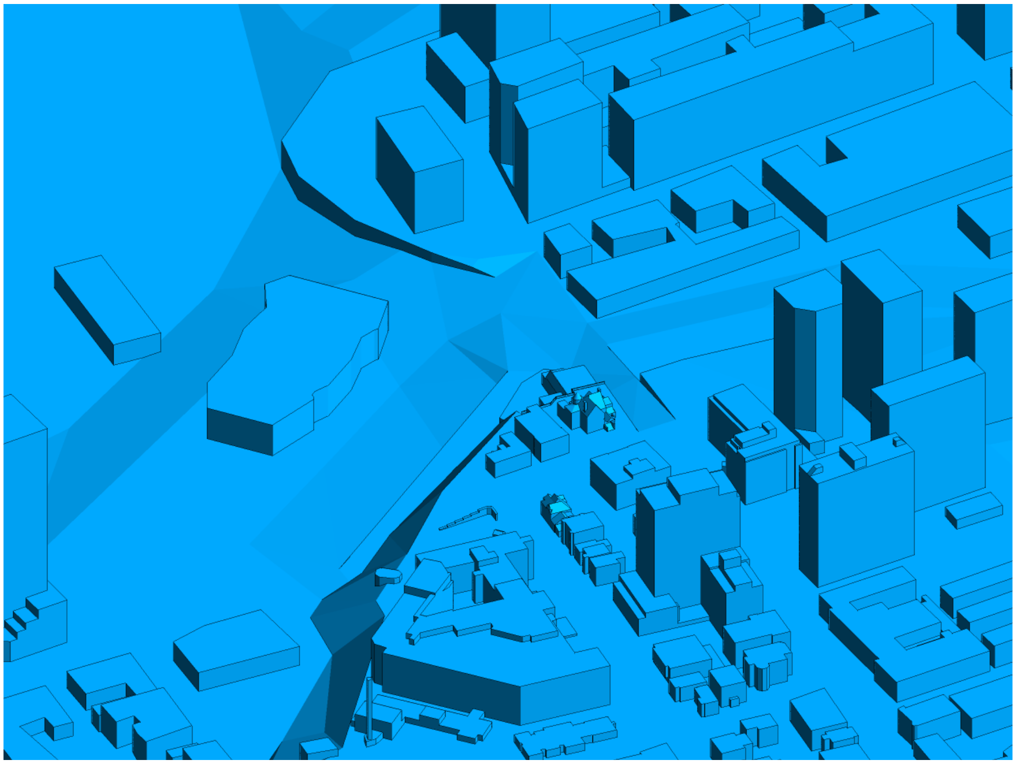


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

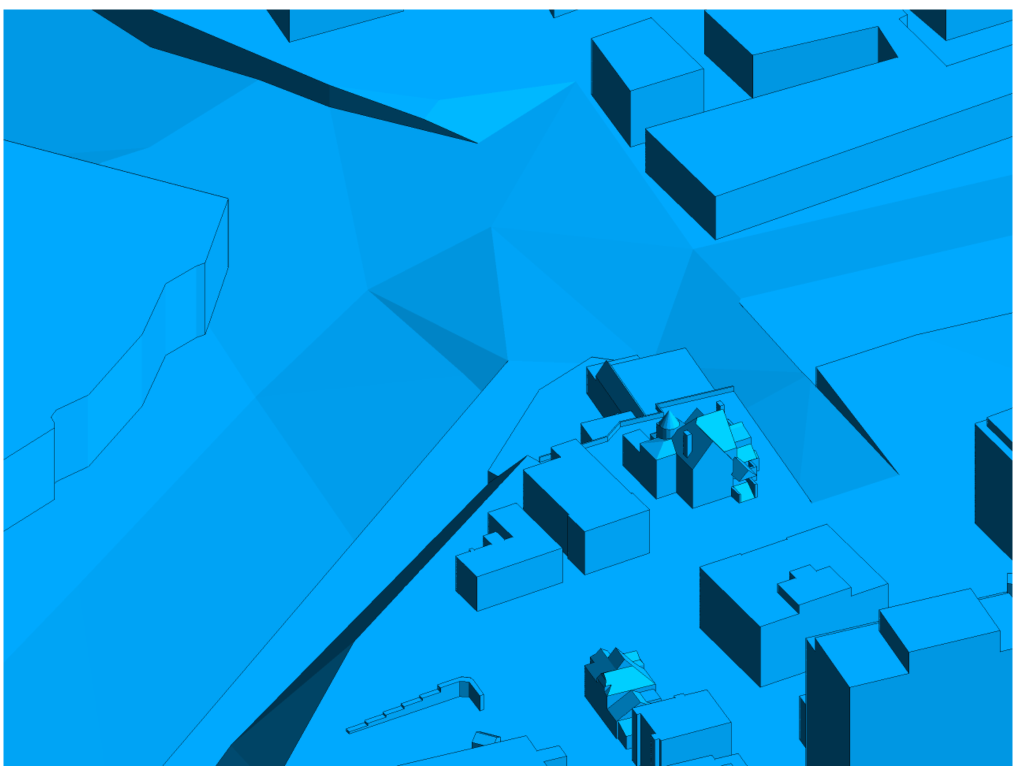


FIGURE 2H: CLOSE UP OF FIGURE 2G

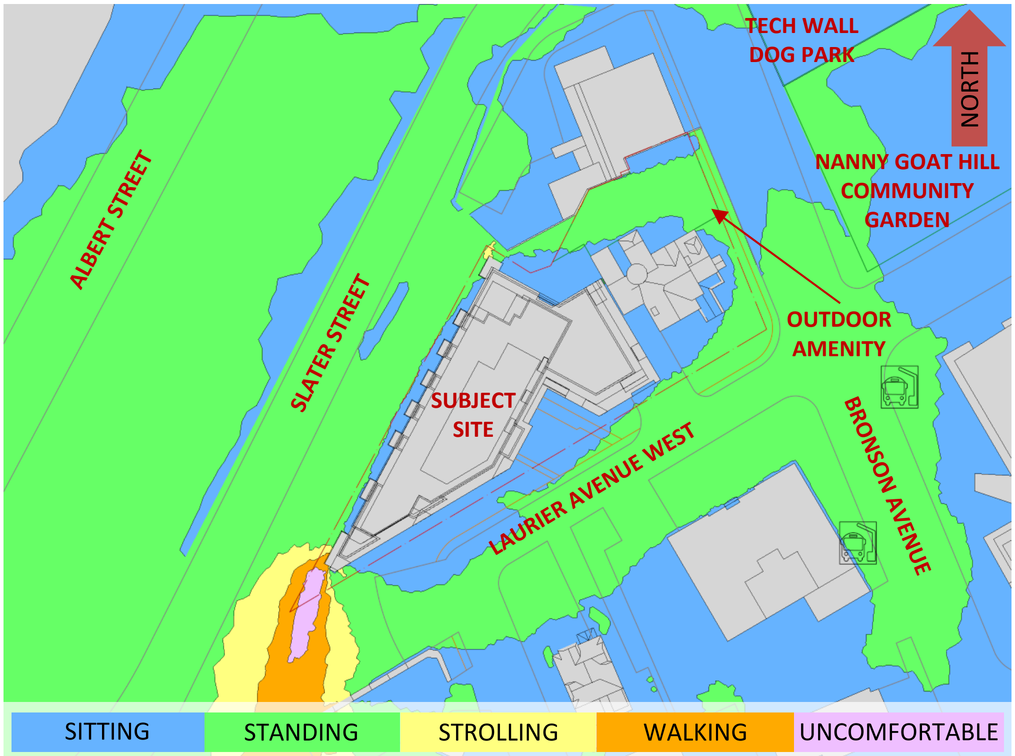


FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

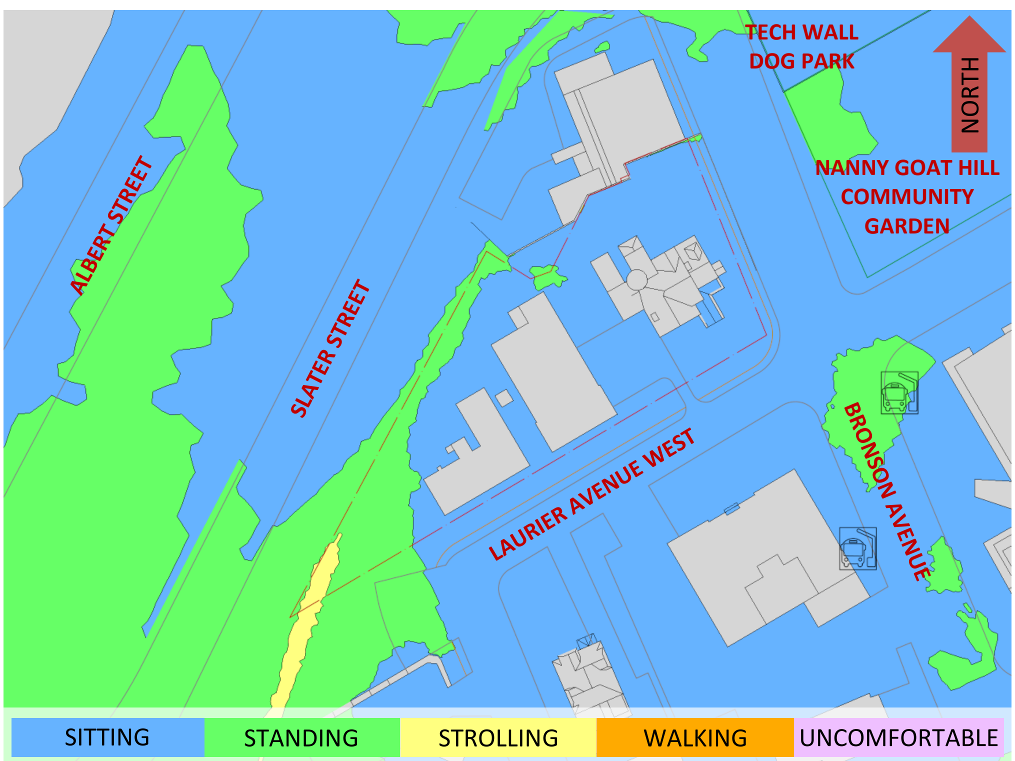


FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

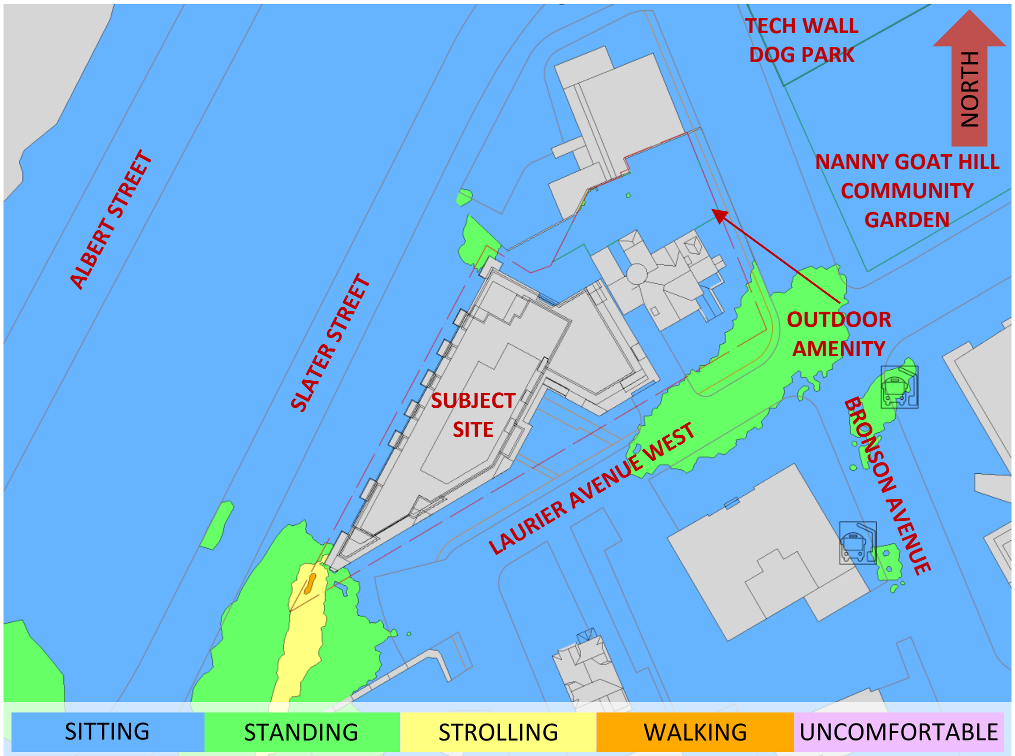


FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

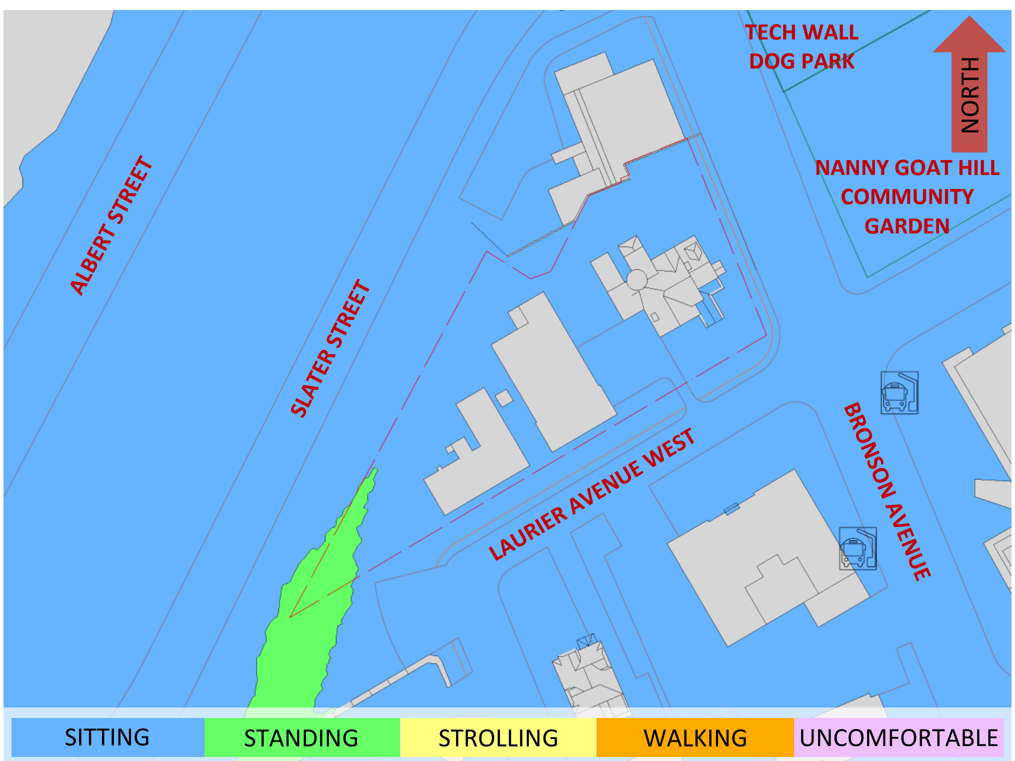


FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

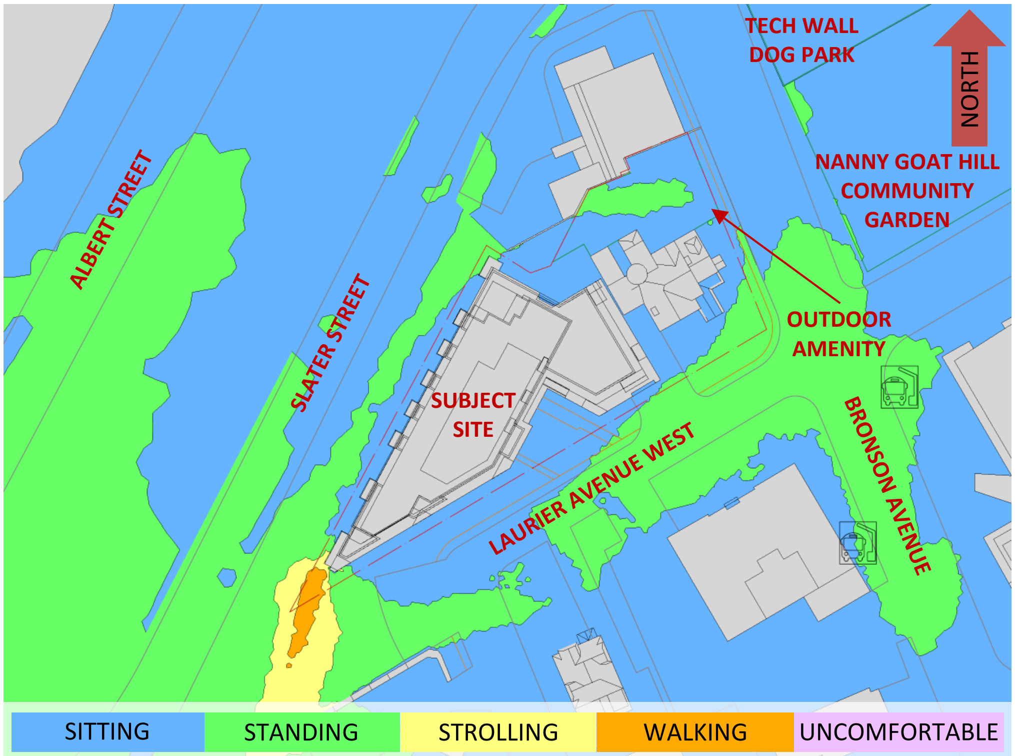


FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

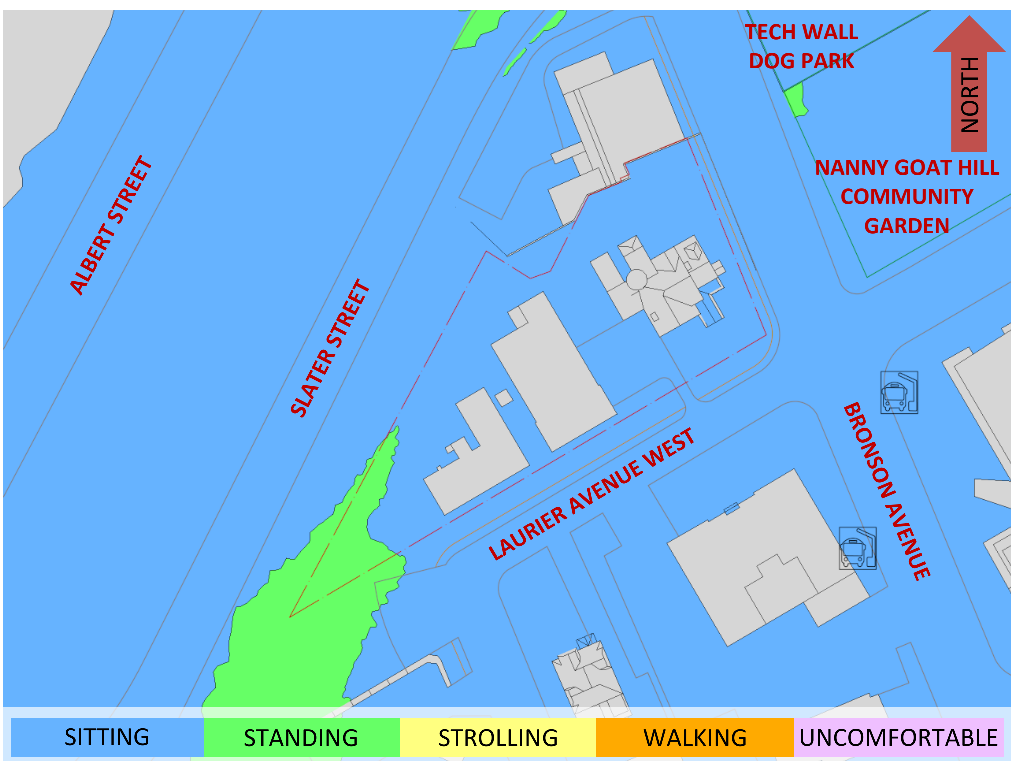


FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

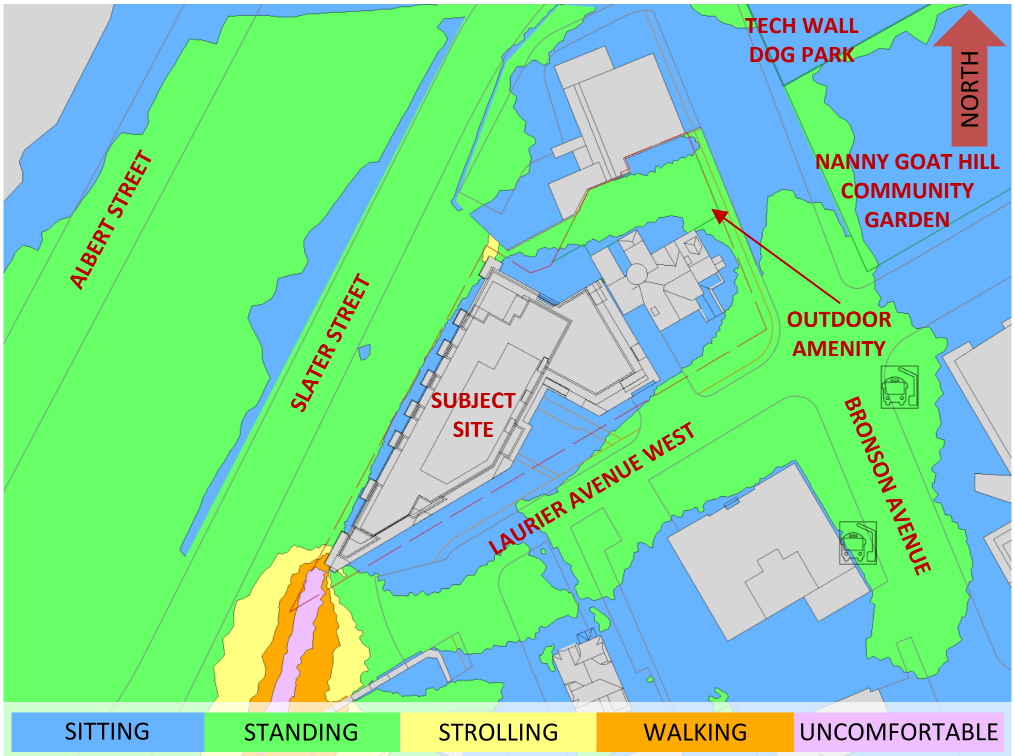


FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

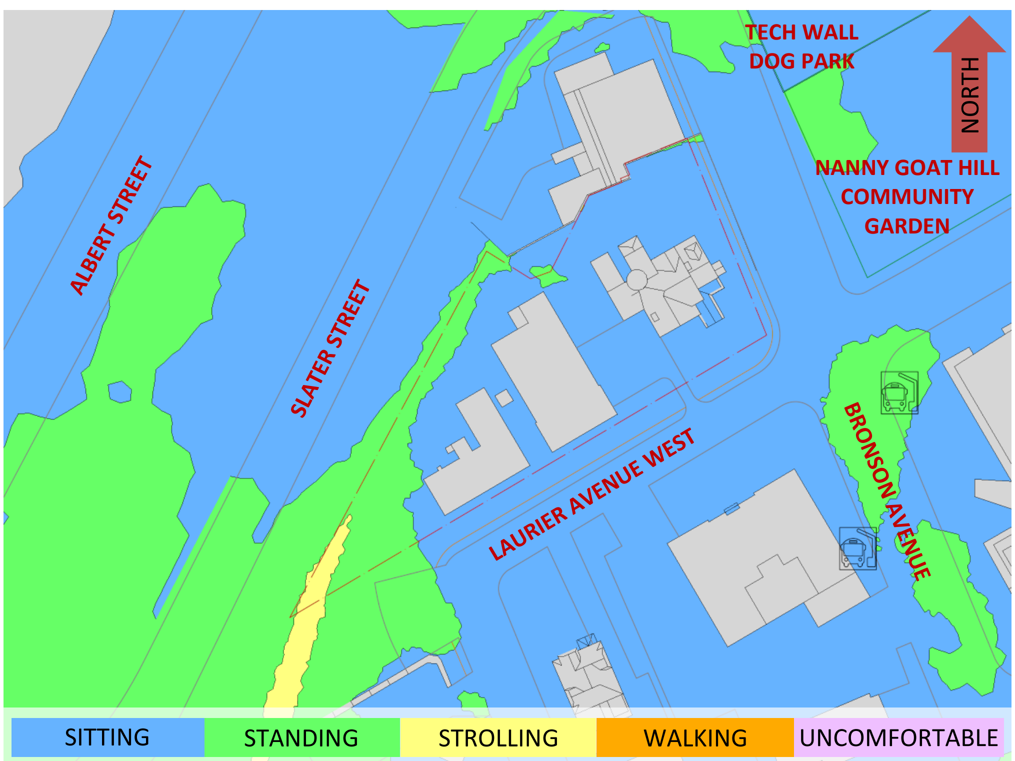


FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

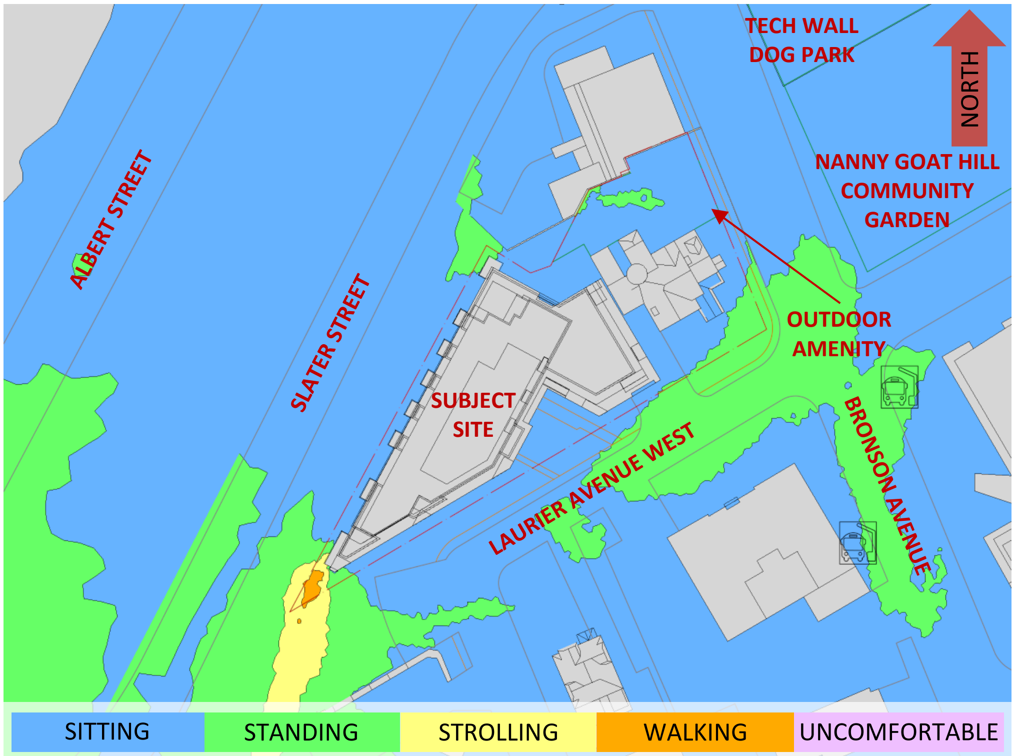


FIGURE 7A: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

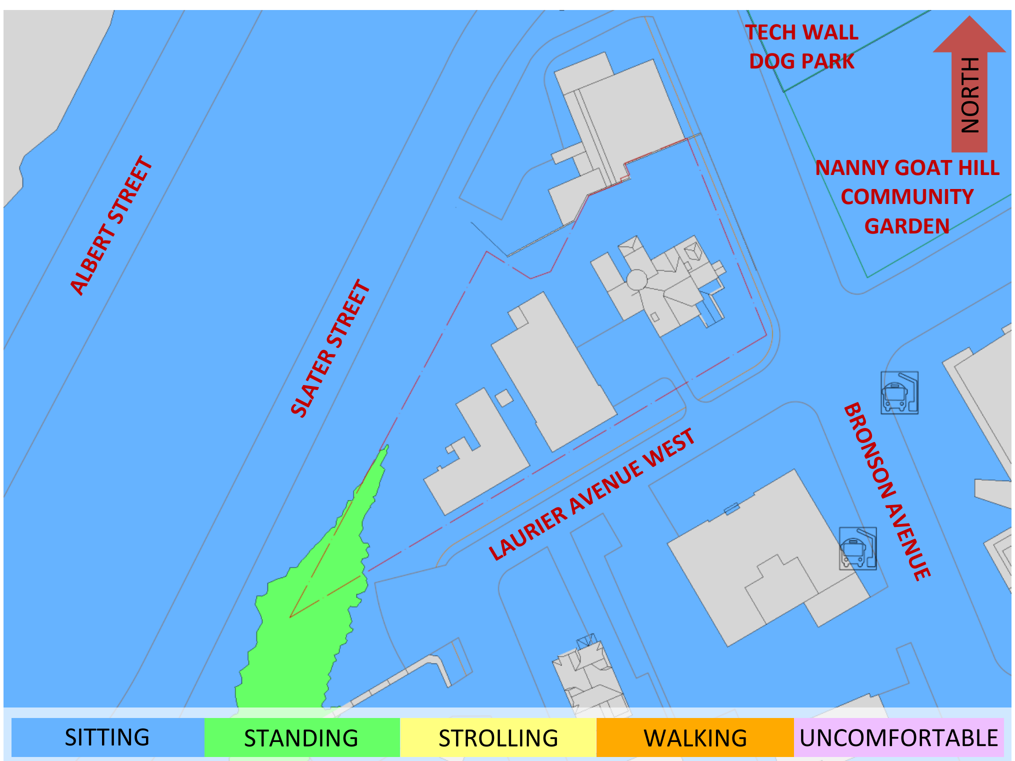


FIGURE 7B: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

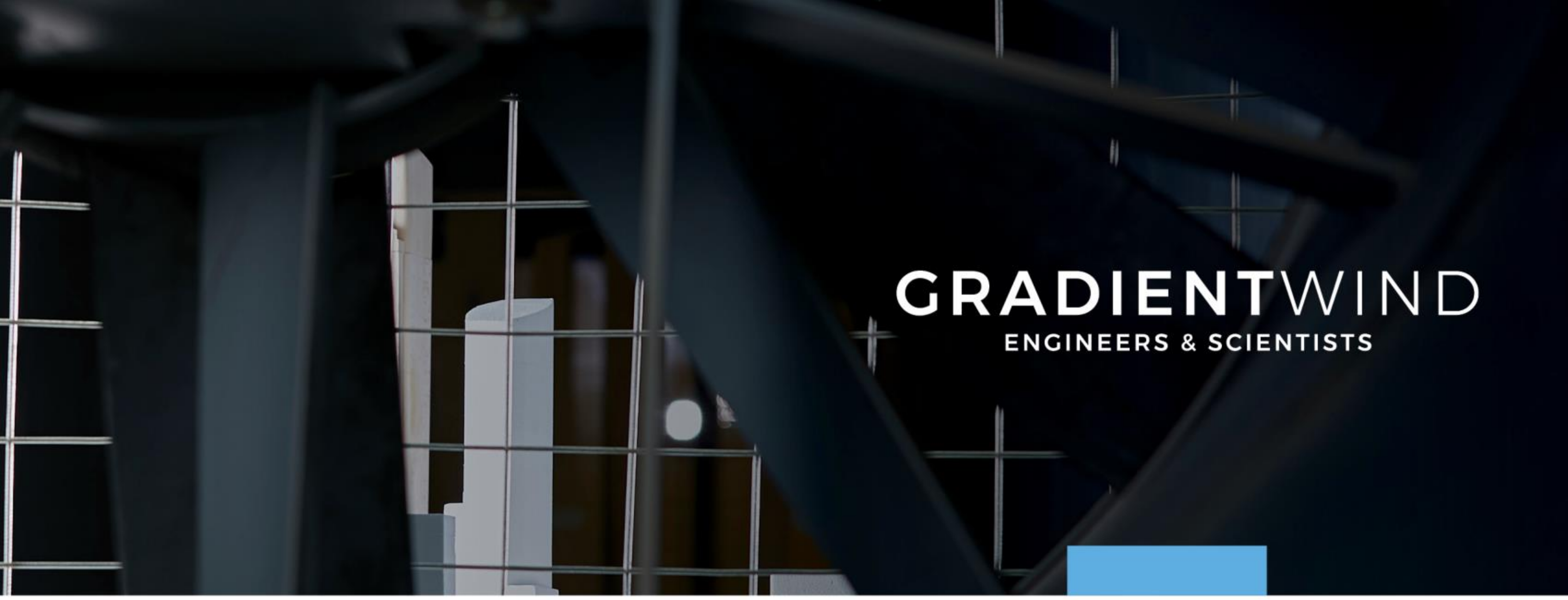
FIGURE 8A: SPRING – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

FIGURE 8B: SUMMER – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

FIGURE 8C: AUTUMN – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

FIGURE 8D: WINTER – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE

FIGURE 9: TYPICAL USE PERIOD – WIND COMFORT, LEVEL 7 COMMON AMENITY TERRACE



APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
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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 (that is, 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
22.5	0.24
45	0.30
67.5	0.30
90	0.27
112.5	0.25
135	0.25
157.5	0.25
180	0.25
202.5	0.25
225	0.25
247.5	0.23
270	0.18
292.5	0.19
315	0.23
337.5	0.24

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

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

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

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

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