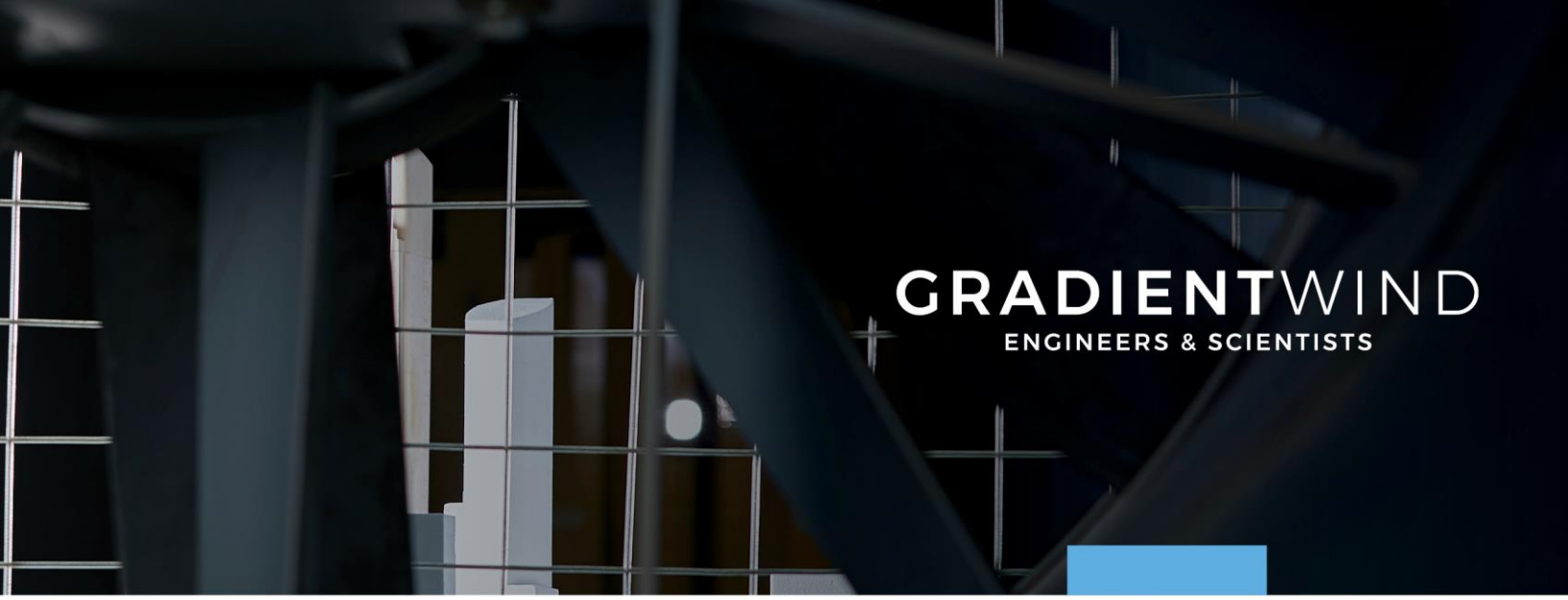
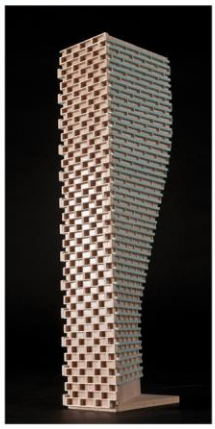


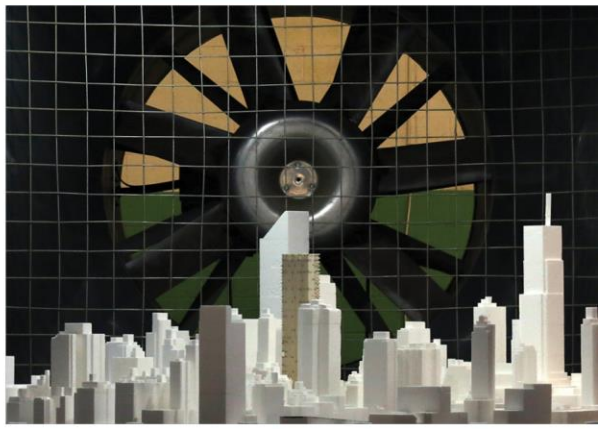
GRADIENTWIND
ENGINEERS & SCIENTISTS

# PEDESTRIAN LEVEL WIND STUDY

5640 Stanley Avenue
Niagara Falls, Ontario

Report: 22-337-PLW





June 28, 2023

PREPARED FOR
9431870 Canada Corp.
5640 Stanley Avenue
Niagara Falls, ON L2G 3X5

PREPARED BY
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# EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application requirements for the proposed mixed-use residential development located at 5640 Stanley Avenue in Niagara Falls, Ontario (hereinafter referred to as the "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. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-8D, and is summarized as follows:

1) Most 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, laneway, walkways, surface parking, drop-off zone, loading zone, existing parking lots to the southeast and southwest, and in the vicinity of building access points, are considered acceptable.

    a. During the typical use period, conditions over the patio are predicted to be suitable for sitting within the majority of the area, while standing conditions are predicted to the west. Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the noted windier area of the patio will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around the sensitive areas, or around the perimeter of the patio. Wind barriers often take the form of glazed wind screens. The extent of mitigation is dependent on the programming of the space.

b. Conditions in the vicinity of the building access point serving the residential main entrance along the west elevation of the proposed development are predicted to be suitable for strolling during the winter. The noted conditions are considered acceptable for secondary building access, but not for a primary entrance. To ensure safe operability throughout the year, we recommend recessing the entrance into the building façade by at least 1.5 m.

2) Conditions over the amenity balcony serving the proposed development at Level 2 are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable and will not require mitigation.

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 or within the neighbouring properties. 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.

**Addendum:** The PLW study was completed with the architectural drawings prepared by ACK Architects Studio Inc., in January 2023. Updated drawings were distributed to the consultant team in June 2023 with some changes to the proposed development. At Level 2, a canopy has been included at the southwest corner of the proposed development, which extends by approximately 10.5 m from the south building façade. From Levels 2 to 7, a rectangular notch has been applied at the northeast corner, and a dog walk terrace has been added at Level 3. Also, the maximum height of the building has increased by 3.05 m due to the addition of the mechanical penthouse at the northwest corner of the building.

Given the acceptable wind conditions predicted to occur within the Level 2 common amenity balcony with the original design, the new dog walk terrace is expected to experience similarly acceptable wind comfort conditions since it's well protected from the prominent westerly winds.

Regarding wind comfort conditions at grade level, the noted updates are not expected to change the main conclusions of the PLW study. The results and recommendations provided in this study are expected to be representative of the current architectural design. Additional simulations to confirm the wind conditions are not required.

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## 1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by 9431870 Canada Corp. to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application requirements for the proposed mixed-use residential development located at 5640 Stanley Avenue in Niagara Falls, Ontario (hereinafter referred to as the "subject site" or "proposed development"). Our mandate within this study is to investigate 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 is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, architectural drawings provided by ACK Architects Studio Inc., in January 2023, surrounding street layouts and existing and approved future building massing information obtained from the City of Niagara Falls, and recent site imagery.

## 2. TERMS OF REFERENCE

The subject site is located at 5640 Stanley Avenue in Niagara Falls; situated at the southeast intersection of Stanley Avenue and North Street. The proposed development comprises a nominally 'L'-shaped 14-storey mixed-use residential building, with its long axis-oriented along North Street, topped with a mechanical penthouse (MPH).

Above a below-grade parking level, the ground floor of the proposed development comprises a café/commercial space along the north elevation, residential main entrance, drop-off zone, loading zone, and shared building support spaces to the east, residential units along the south elevation and to the west, and a residential main entrance and lounge to the west. A patio serving the café/commercial space is situated at the northwest corner of the subject site, and private patios serving the residential units are situated along the south and west elevations of the proposed development. A central laneway, extending north-south from North Street and east-west along the south side of the subject site to Stanley Avenue, provides access to surface parking at the northeast corner and along the east of the subject site. The noted laneway also provides access to a ramp at the southeast corner of the proposed development leading to below-grade parking. Canopies are situated along the east elevation, extending above the central laneway,

and along the north and west elevations. At Level 2, the building extends from the east elevation at the northeast corner, above the surface parkin, to create a nominally 'L'-shaped planform. Level 2 includes a business office, community room, and fitness room to the east of the short-axis, residential units to the west of the short-axis and throughout the long-axis, and is open to below at the northwest corner. This level is served by an amenity balcony to the east. Levels 3-14 are reserved for residential use. The building steps back from the east elevation of the short-axis and from the south elevation of the long-axis at Level 3, from the north and east elevations of the long-axis and from the south and west elevations of the short-axis at Level 5, from the east elevations of the short- and long-axis at Level 8, and from the east and south elevations of the long-axis at Level 11 to accommodate for private terraces.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre (m) radius of the subject site) comprise low-rise massing in all compass directions with mid-rise hotel buildings to the north and south. The far-field surroundings (defined as the area beyond the near field and within a two-kilometre (km) radius) comprise low-rise massing and isolated mid-rise buildings in all compass directions, with isolated high-rise buildings from the east clockwise to the south. Goat Island is situated approximately 1.5 km to the southeast, east of the Niagara River, which flows from the south to the north, approximately 1.1 km to the southeast of the subject site.

Figure 1A illustrates the subject site and surrounding context, representing the proposed future massing scenario, while Figure 1B illustrates the subject site and surrounding context, representing the existing massing scenario. Figures 2A-2H illustrate the computational models used to conduct the study.

## 3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind 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 Niagara Falls area wind climate, and synthesis of computational data with industry standard wind comfort and safety guidelines. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind guidelines.

## 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 the Niagara Falls International Airport in Niagara County, New York. 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 stronger 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 subject 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.

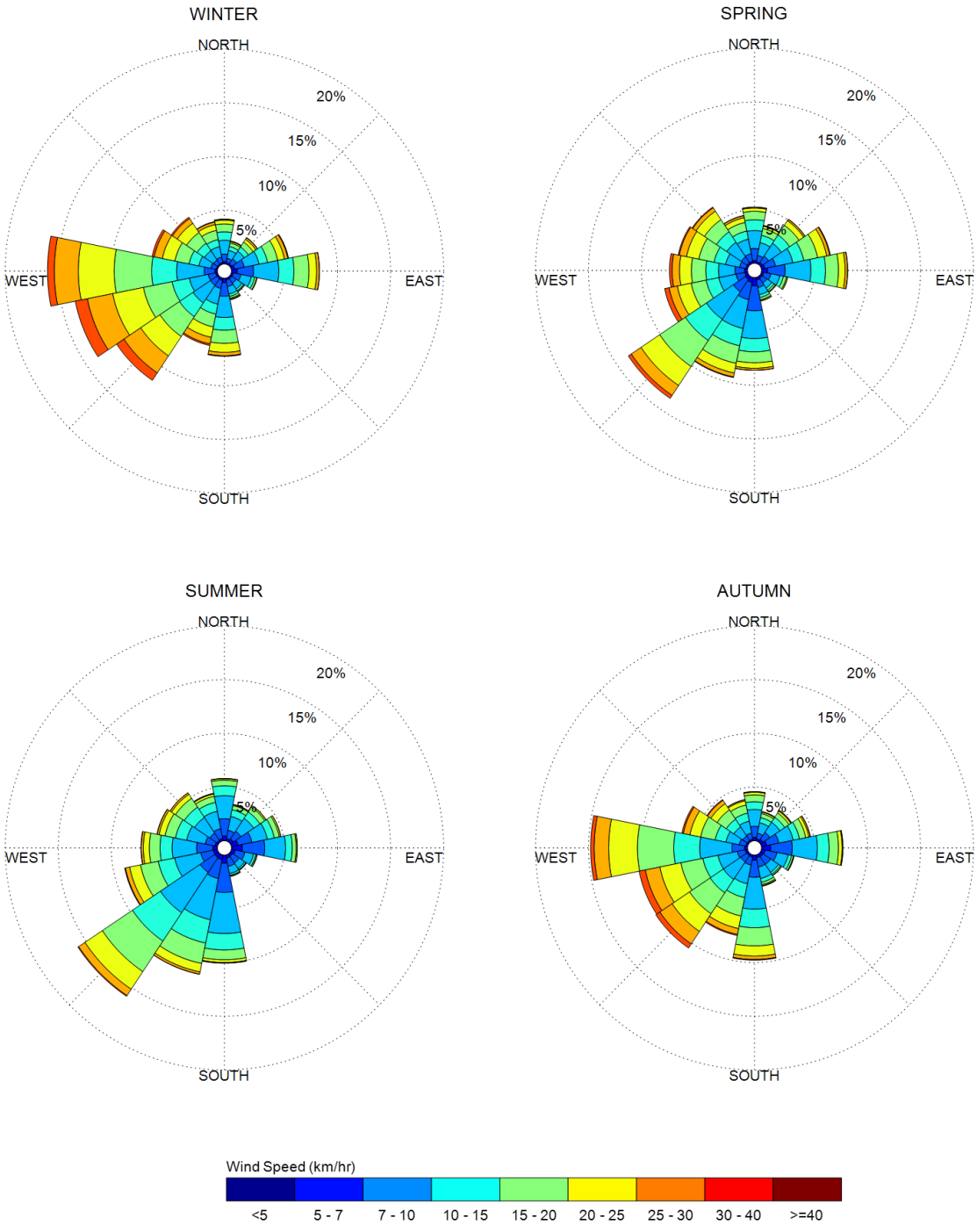
Mean and peak wind speed data obtained over the subject site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the Level 2 common amenity balcony serving the proposed 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 Niagara Falls was developed from approximately 40 years of hourly meteorological wind data recorded at Niagara Falls International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns.

The statistical model of the Niagara Falls 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 Niagara Falls, 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
## NIAGARA FALLS INTERNATIONAL AIRPORT, NIAGARA COUNTY, NEW YORK




**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 Guidelines

Pedestrian wind comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions, such as temperature and relative humidity. The comfort guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 20% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.

2) **Standing:** Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.

3) **Strolling:** Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.

4) **Walking:** Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.

5) **Uncomfortable:** Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this target.

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 90 km/h is classified as dangerous. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians.

### THE 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 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 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 throughout the site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (that is, 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 page. 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 / 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-8D, which illustrate wind conditions over the common amenity balcony serving the proposed development at Level 2. 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 the colour magenta.

Wind comfort conditions within the patio serving the proposed development at grade level are also reported for the typical use period, which is defined as May to October, inclusive. Figure 7 illustrates wind comfort conditions 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 – Grade Level

**Sidewalks and Building Access Along Stanley Avenue:** Following the introduction of the proposed development, the public sidewalk areas along Stanley Avenue are predicted to be suitable for standing, or better, during the summer, becoming suitable for strolling, or better, during the spring and autumn, and suitable for a mix of standing, strolling, and walking during the winter. The noted conditions are considered acceptable.

Conditions over the sidewalk areas along Stanley Avenue with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

Conditions in the vicinity of building access points serving the residential units along the west elevation of 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 only exception is the building access near the southwest corner of the building, which is predicted to be suitable for a mix of standing and strolling during the winter. The noted conditions are considered acceptable.

Conditions in the vicinity of the building access point serving the residential main entrance along the west elevation of the proposed development are predicted to be suitable for standing, or better, during the spring, summer, and autumn, becoming suitable for strolling during the winter. The noted conditions are considered acceptable for secondary building access, but not for a primary entrance. To ensure safe operability throughout the year, we recommend recessing the entrance into the building façade by at least 1.5 m.

**Sidewalks and Building Access Along North Street:** Following the introduction of the proposed development, the public sidewalk areas along North Street are predicted to be suitable for standing, or better, during the summer, becoming suitable for strolling, or better, during the spring and autumn, and suitable for walking, or better, during the winter. Conditions in the vicinity of all building access points along the north elevation of the proposed development are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable.

Conditions over the sidewalk areas along North Street with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

**Patio Northwest of Subject Site:** During the typical use period, conditions over the patio serving the café/commercial space at the northwest corner of the subject site are predicted to be suitable for sitting within the majority of the area, while standing conditions are predicted to the west, as illustrated in Figure 7. During the same period, the area that is predicted to be suitable for standing, according to the comfort guidelines in Section 4.4, is also predicted to be suitable for sitting for at least 77%, 72%, and 65% of the time, at the southwest corner, to the west, and at the northwest corner of the area, respectively, where the target is 80% to achieve the sitting comfort target.

Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the noted windier area of the patio will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around the sensitive areas, or around the perimeter of the patio. Wind barriers often take the form of glazed wind screens. The extent of mitigation is dependent on the programming of the space.

**Sidewalks Along Buchanan Avenue:** Following the introduction of the proposed development, the public sidewalk areas along Buchanan Avenue are predicted to be suitable for standing, or better, during the spring, summer, and autumn, with small, isolated regions suitable for strolling during the spring and autumn, becoming suitable for a mix of standing and strolling during the winter. The noted conditions are considered acceptable.

Conditions over the sidewalk areas along Buchanan Avenue with the existing massing are predicted to be suitable for sitting during the summer, suitable mostly for sitting during the spring and autumn, becoming suitable for standing, or better, during the winter. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions are nevertheless considered acceptable.

**Surface Parking Northeast of Subject Site:** Conditions over the surface parking situated at the northeast corner of the subject site are predicted to be suitable mostly for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable.

**Walkways, Surface Parking, Drop-off Zone, Loading Zone, and Building Access Along Central Laneway:** Conditions over the laneway situated central to the subject site, inclusive of the surface parking along the east side, are predicted to be suitable for standing, or better, during the summer, becoming suitable for strolling, or better, during the spring and autumn, and suitable for walking, or better, during the winter. Conditions over the walkways, drop-off zone, and loading zone along the west side of the noted laneway and in the vicinity of all building access points along the east elevation of the proposed development are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

**Walkways and Building Access Along Laneway South of Subject Site:** Conditions over the laneway situated along the south side of the subject site are predicted to be suitable for standing, or better, during the summer, becoming suitable for a mix of standing and strolling during the spring and autumn, and suitable for a mix of strolling and walking during the winter. Wind conditions over the walkway along the south elevation are predicted to be suitable for mostly sitting during the summer, becoming suitable for standing during the spring and autumn, with a region suitable for strolling on the west end of the walkway during the autumn, and suitable for a mix of standing, strolling, and walking during the winter. Conditions in the vicinity of all building access points along the south elevation of 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.

**Existing Parking Lots Southeast and Southwest of Subject Site:** Following the introduction of the proposed development, conditions over the existing parking lot situated to the southeast of the subject site are predicted to be suitable for standing, or better, during the spring, summer, and autumn, becoming suitable for strolling, or better, during the winter. Conditions over the existing parking lot situated to the southwest of the subject site are predicted to be suitable for sitting with an isolated region suitable for standing during the summer, becoming suitable for standing, or better, with an isolated region suitable for strolling during the spring and autumn, and suitable for strolling, or better, with an isolated region suitable for walking during the winter. The noted conditions are considered acceptable.

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

## 5.2 Wind Comfort Conditions – Level 2 Common Amenity Balcony

**Level 2 Common Amenity Balcony:** Wind comfort conditions over the amenity balcony serving the proposed development at Level 2 are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable.

## 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.

Regarding primary and secondary building access points, wind conditions predicted in this study are only applicable to pedestrian comfort and safety. As such, the results should not be construed to indicate wind loading on doors and associated hardware.

## 6. SUMMARY AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-8D. Based on computer simulations using the CFD technique, meteorological data analysis, and experience with numerous similar developments, the study concludes the following:

1) Most 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, laneway, walkways, surface parking, drop-off zone, loading zone, existing parking lots to the southeast and southwest, and in the vicinity of building access points, are considered acceptable.

    a. During the typical use period, conditions over the patio are predicted to be suitable for sitting within the majority of the area, while standing conditions are predicted to the west. Depending on the programming of the space, the noted wind conditions may be considered acceptable. Specifically, if the noted windier area of the patio will not accommodate seating or lounging activities, the noted wind conditions would be considered acceptable. If required by programming, sitting conditions may be extended with targeted wind barriers around the sensitive areas, or around the perimeter of the patio. Wind barriers often take the form of glazed wind screens. The extent of mitigation is dependent on the programming of the space.

    b. Conditions in the vicinity of the building access point serving the residential main entrance along the west elevation of the proposed development are predicted to be suitable for strolling during the winter. The noted conditions are considered acceptable for secondary building access, but not for a primary entrance. To ensure safe operability throughout the year, we recommend recessing the entrance into the building façade by at least 1.5 m.

2) Conditions over the amenity balcony serving the proposed development at Level 2 are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable and will not require mitigation.

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 or within the neighbouring properties. 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.

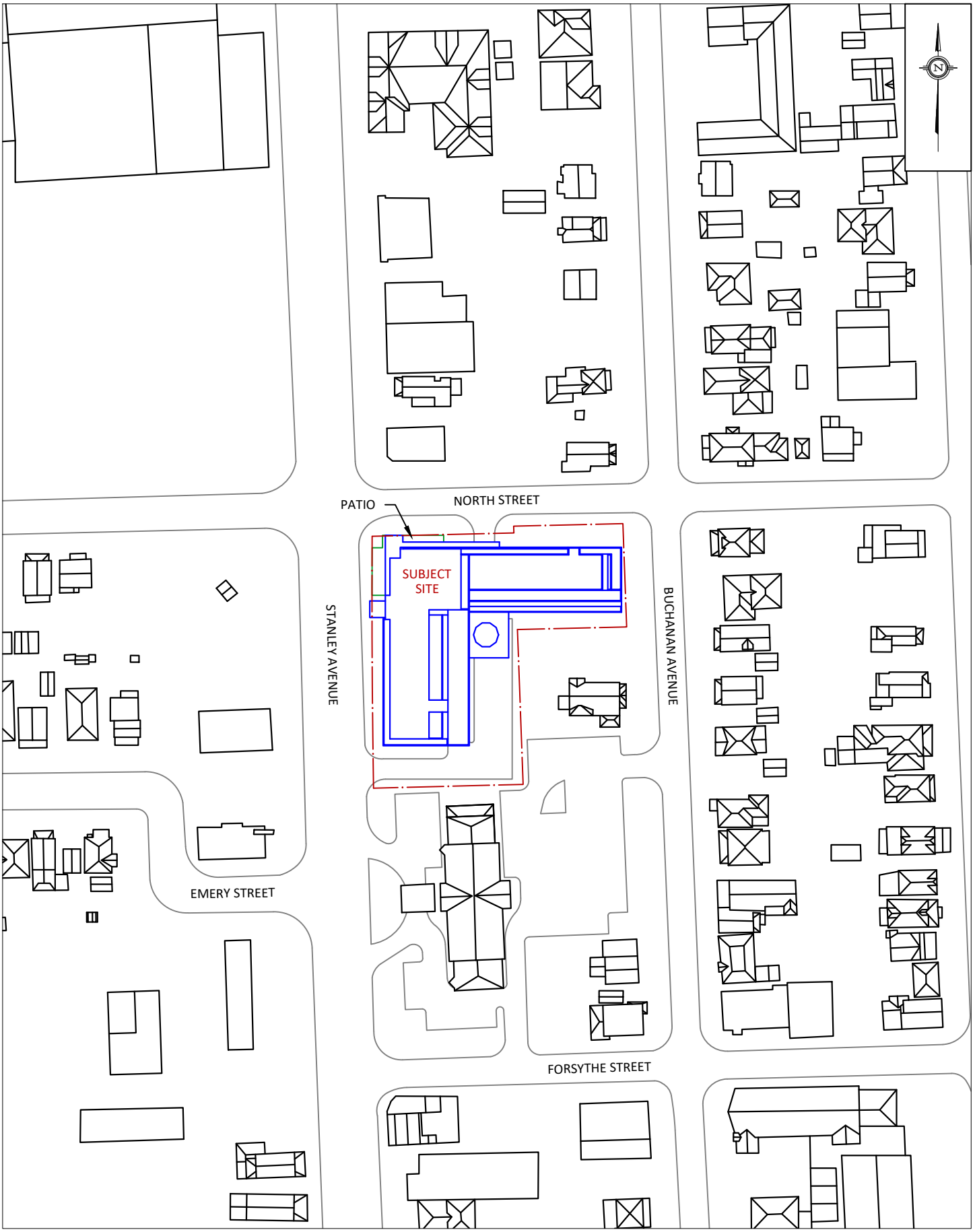
Sincerely,

***Gradient Wind Engineering Inc.***


Daniel Davalos, MESc.
Wind Scientist

Justin Ferraro, P.Eng.
Principal

Sunny Kang, B.A.S.
Project Coordinator

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| | |
|---|---|
| PROJECT | 5640 STANLEY AVENUE, NIAGARA FALLS<br>PEDESTRIAN LEVEL WIND STUDY |
| SCALE | 1:1500 |
| DRAWING NO. | 22-337-PLW-1A |
| DATE | FEBRUARY 9, 2023 |
| DRAWN BY | S.K. |

DESCRIPTION

FIGURE 1A:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT


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| PROJECT | 5640 STANLEY AVENUE, NIAGARA FALLS<br>PEDESTRIAN LEVEL WIND STUDY | | DESCRIPTION |
| SCALE | 1:1500 | DRAWING NO. | 22-337-PLW-1B |
| DATE | FEBRUARY 9, 2023 | DRAWN BY | S.K. |

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

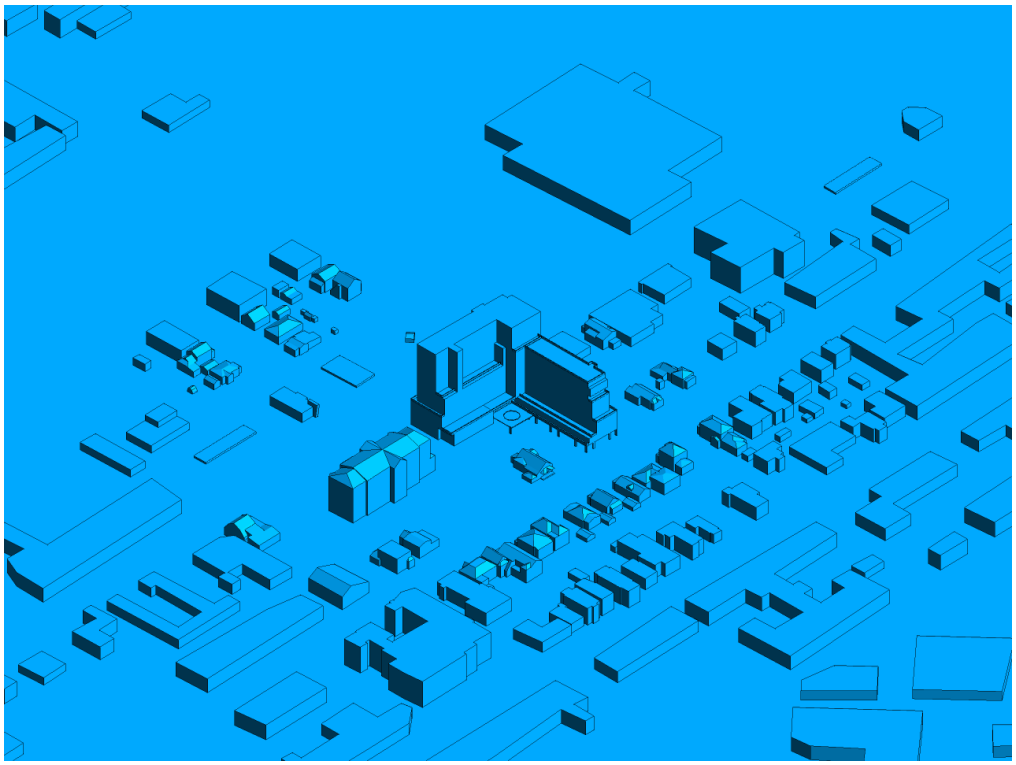

**FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTHEAST PERSPECTIVE**

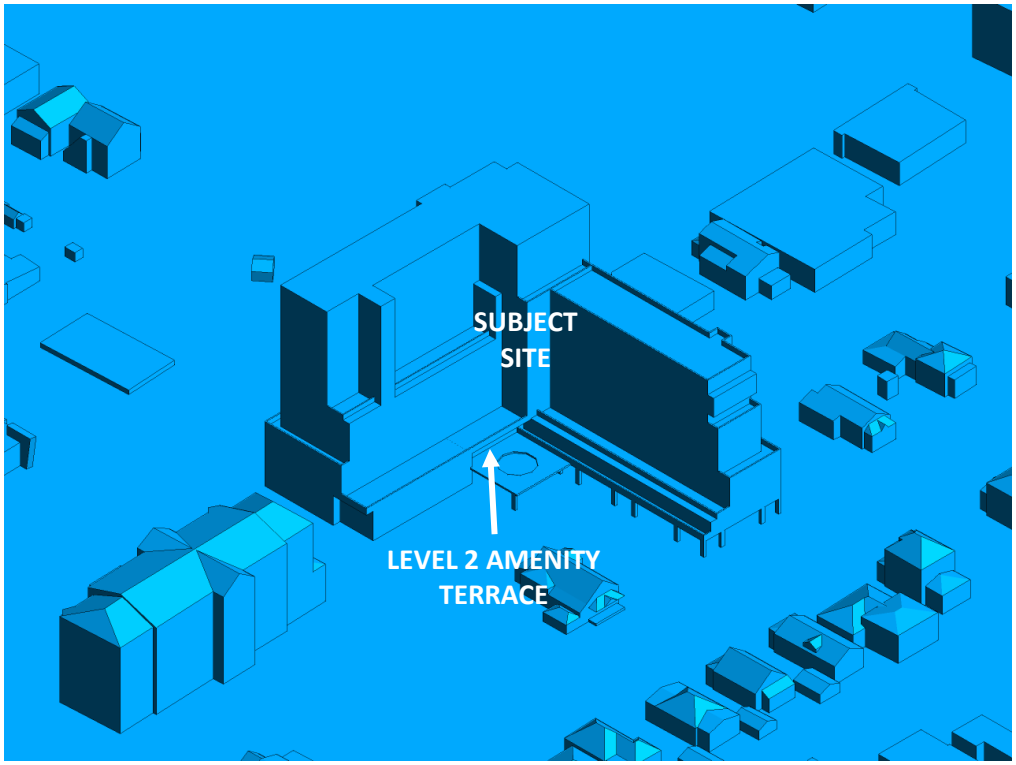


**FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A**

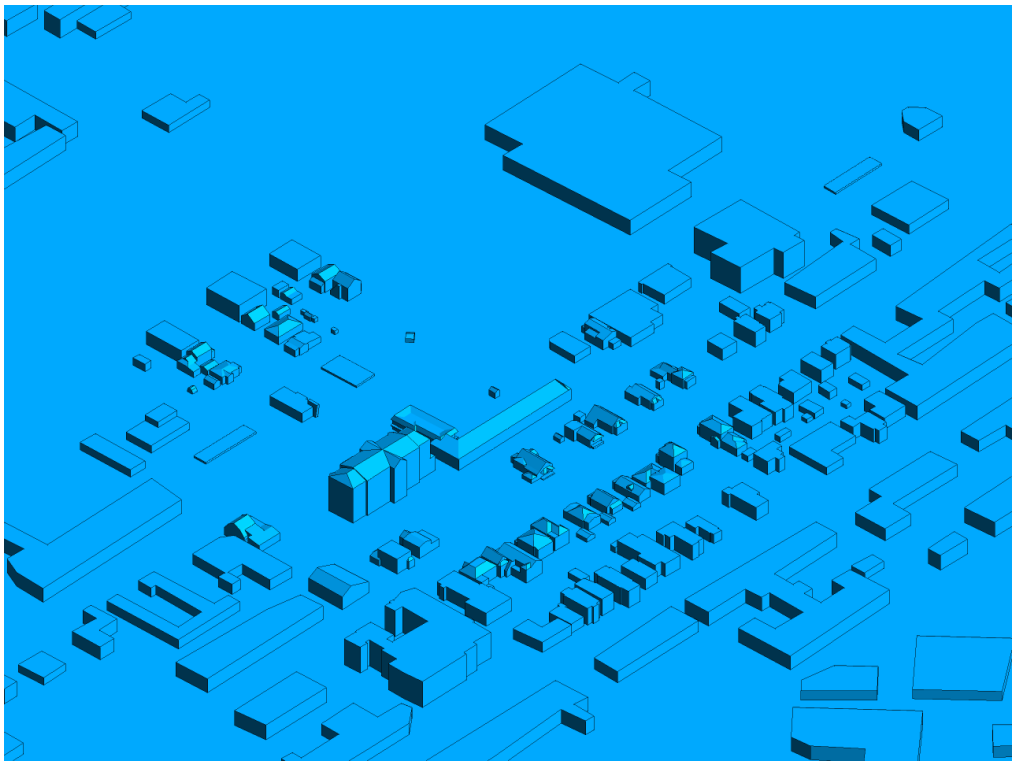

**FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTHEAST PERSPECTIVE**

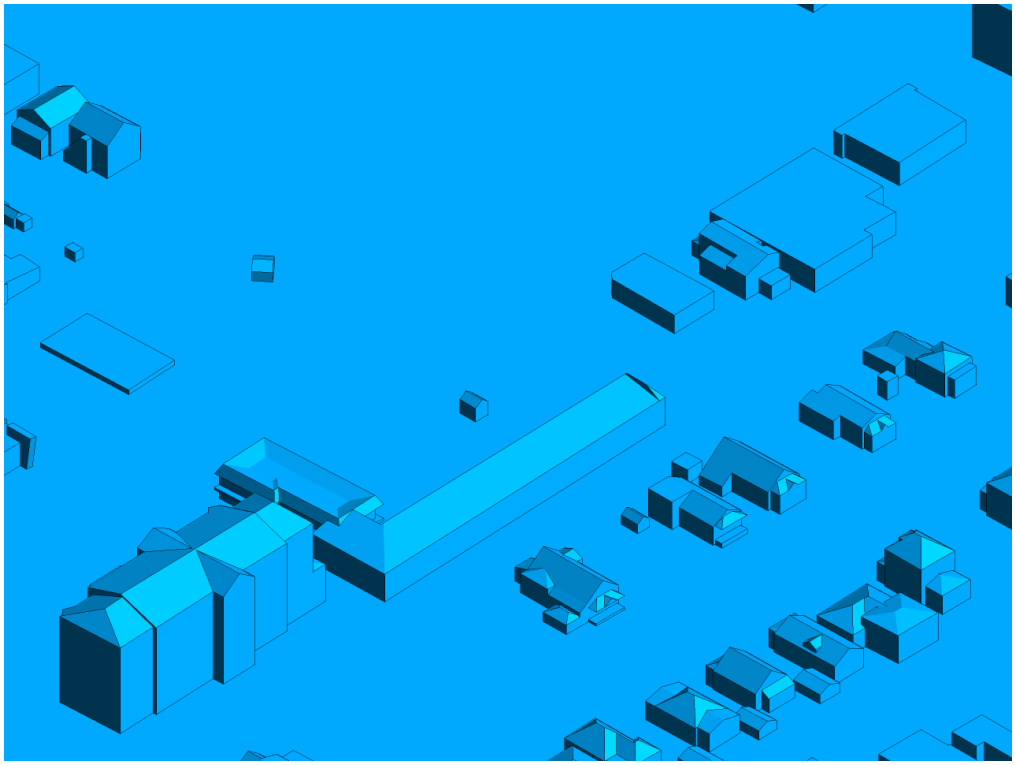

**FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C**

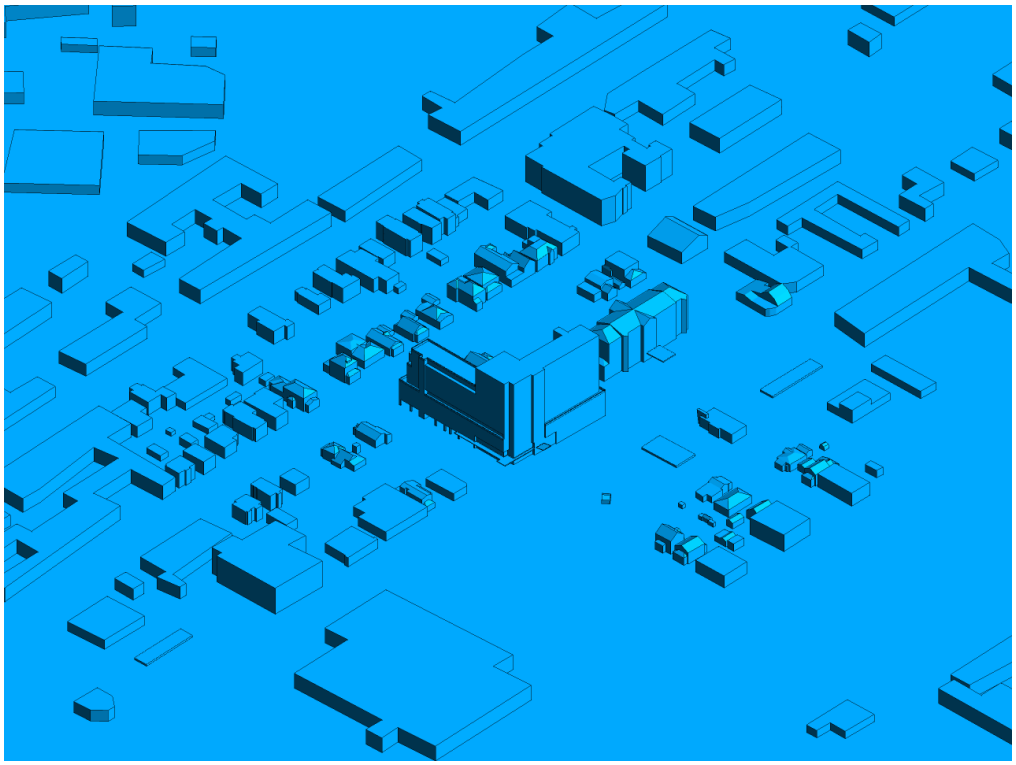

**FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTHWEST PERSPECTIVE**

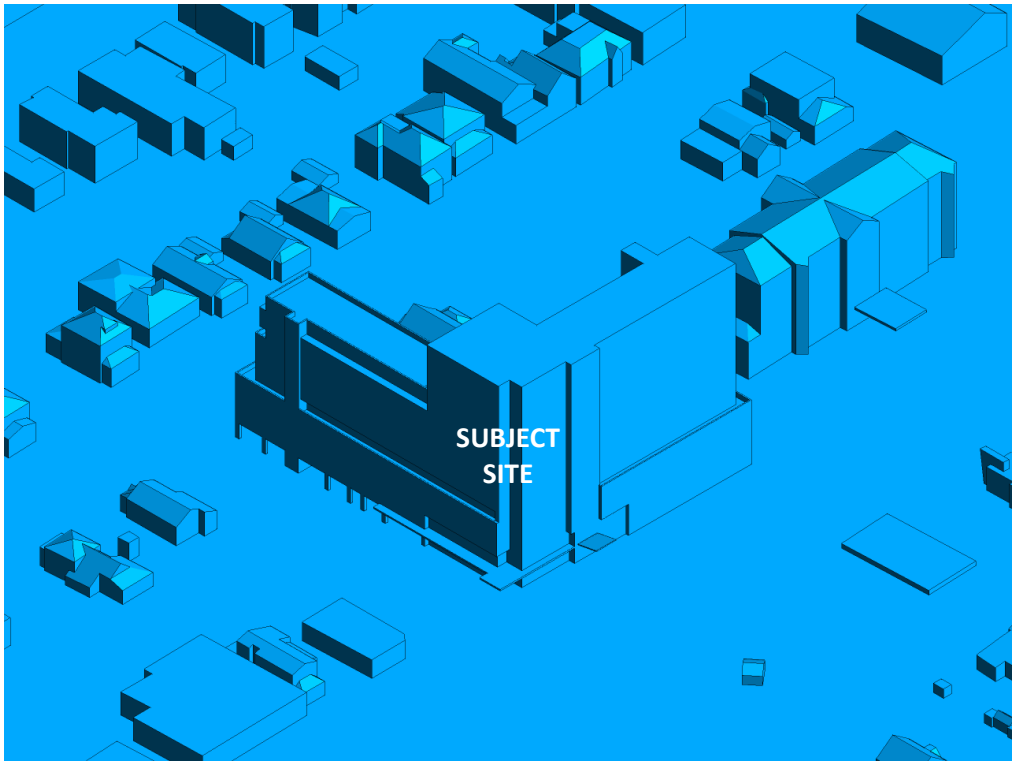


**FIGURE 2F: CLOSE-UP VIEW OF FIGURE 2E**

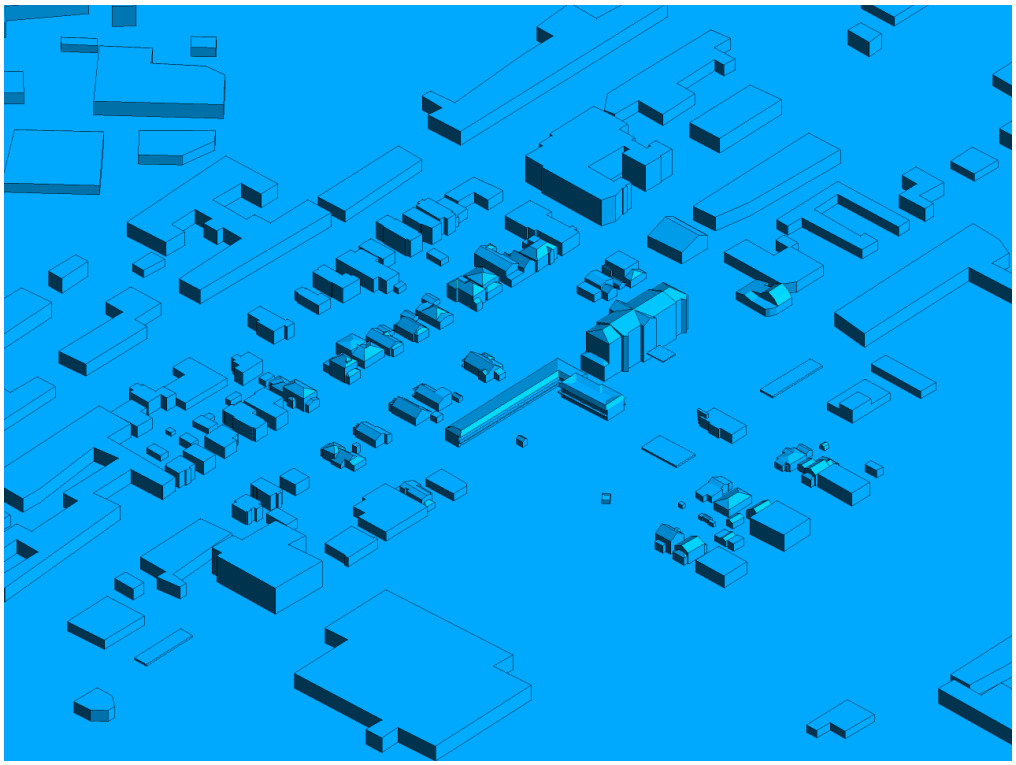

**FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, NORTHWEST PERSPECTIVE**

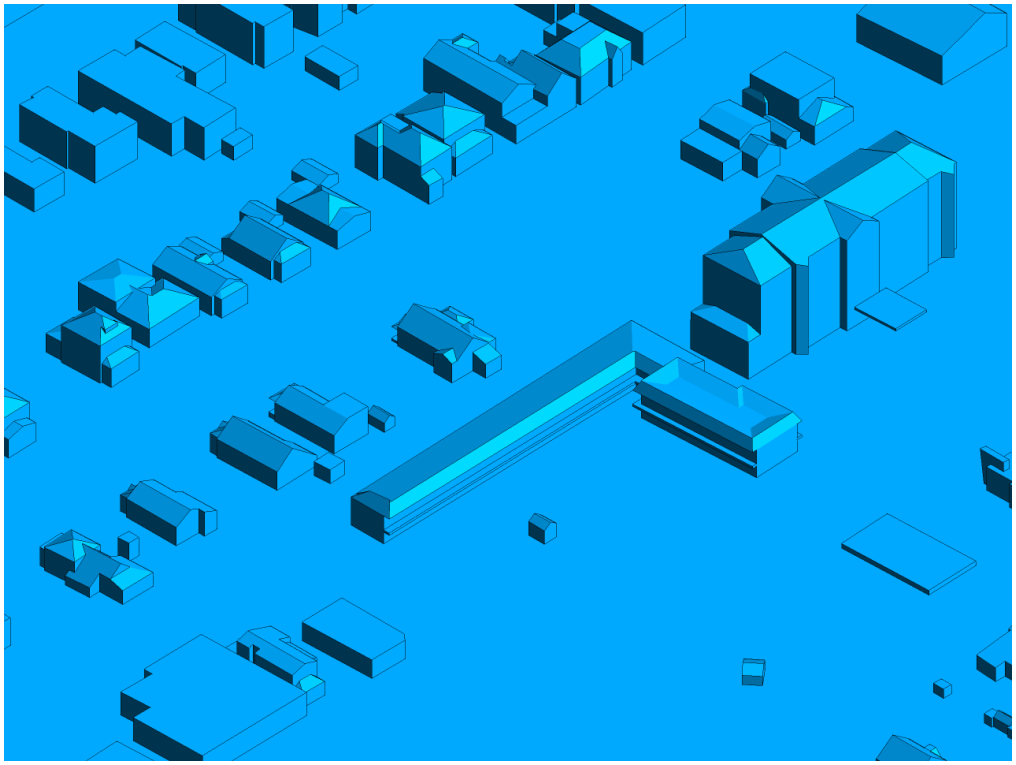

**FIGURE 2H: CLOSE-UP VIEW OF FIGURE 2G**

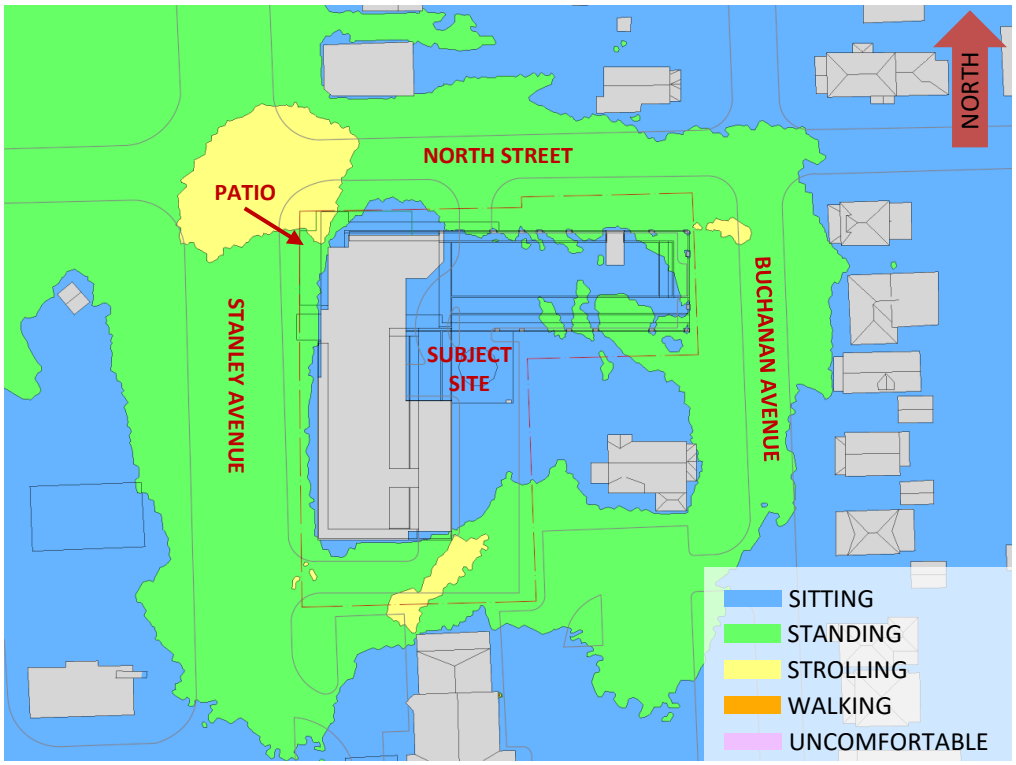


**FIGURE 3A: SPRING – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL**

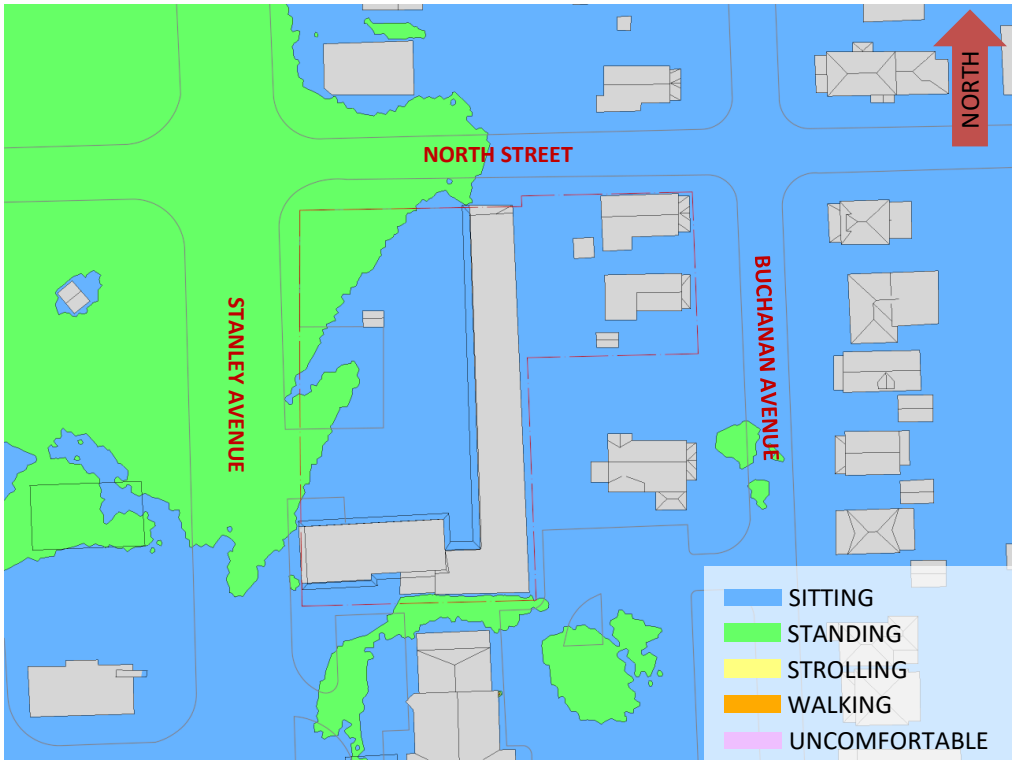


**FIGURE 3B: SPRING – EXISTING MASSING – WIND COMFORT, GRADE LEVEL**

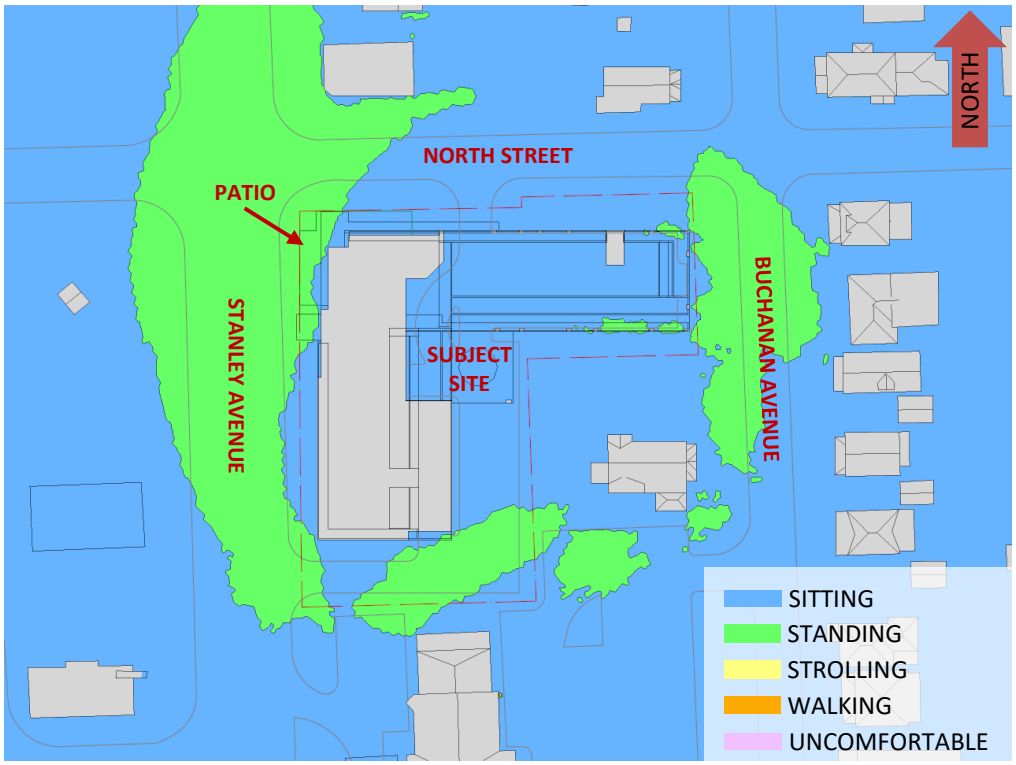


**FIGURE 4A: SUMMER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL**

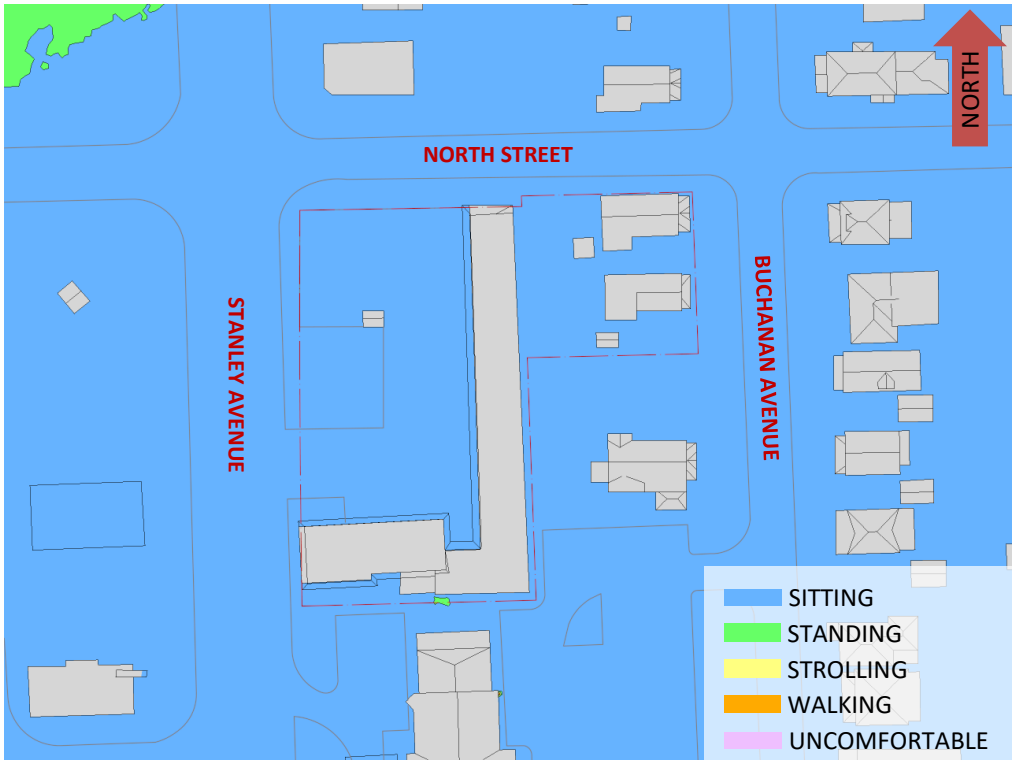


**FIGURE 4B: SUMMER – EXISTING MASSING – WIND COMFORT, GRADE LEVEL**

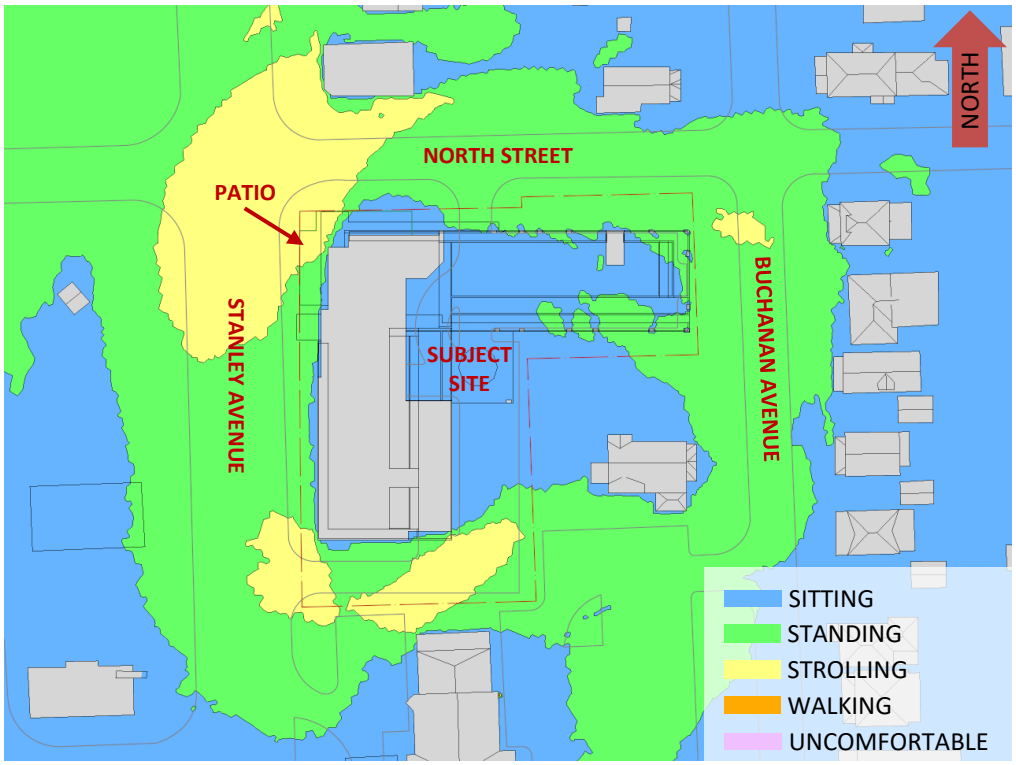


**FIGURE 5A: AUTUMN – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL**

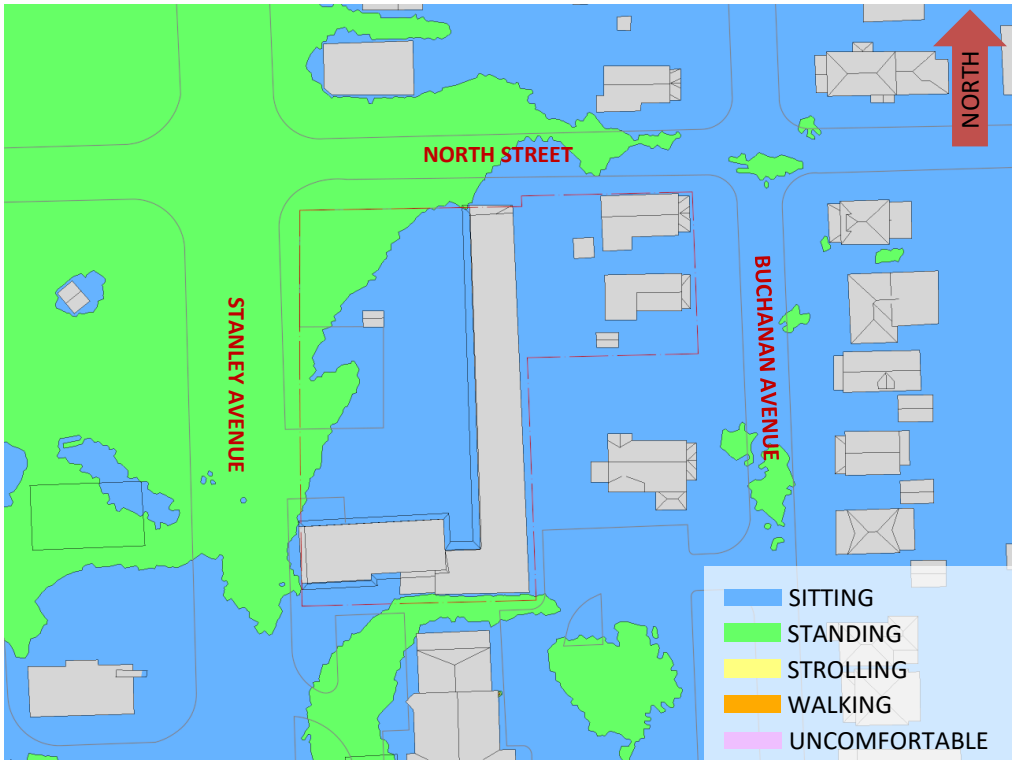


**FIGURE 5B: AUTUMN – EXISTING MASSING – WIND COMFORT, GRADE LEVEL**

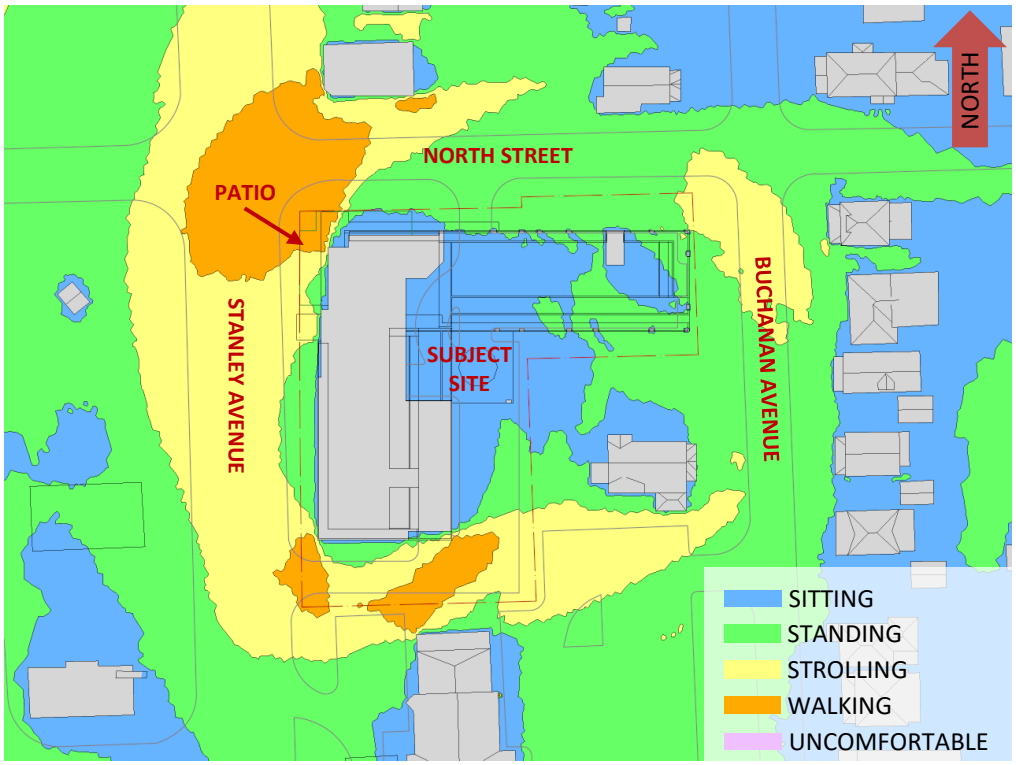


**FIGURE 6A: WINTER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL**

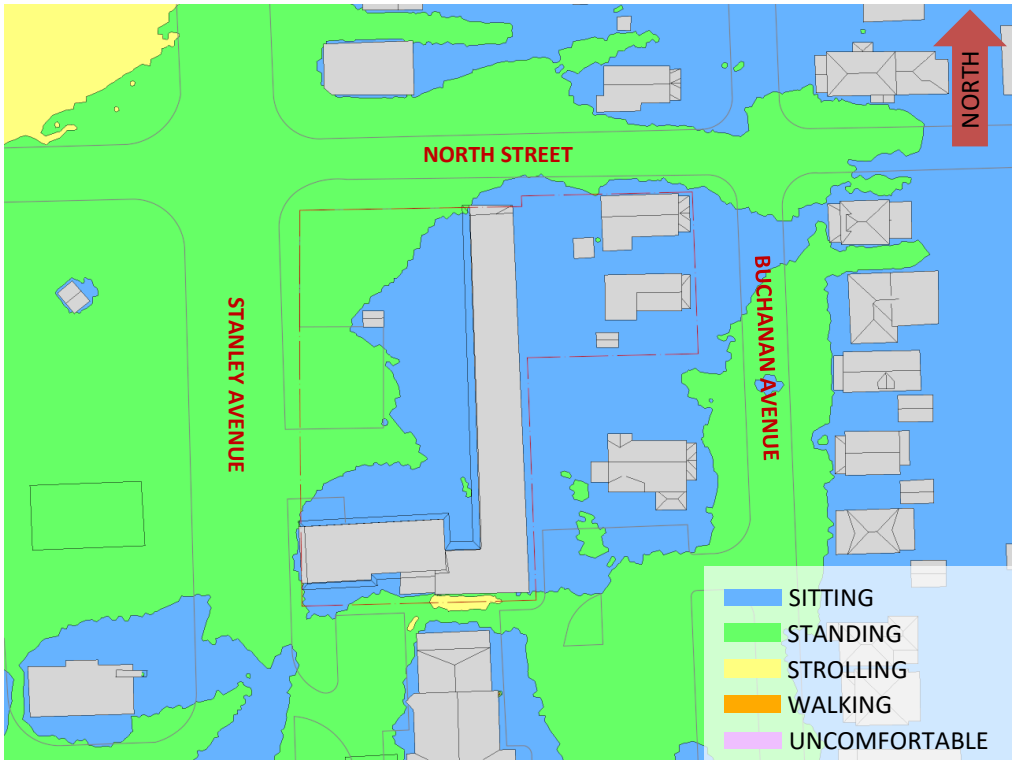


**FIGURE 6B: WINTER – EXISTING MASSING – WIND COMFORT, GRADE LEVEL**

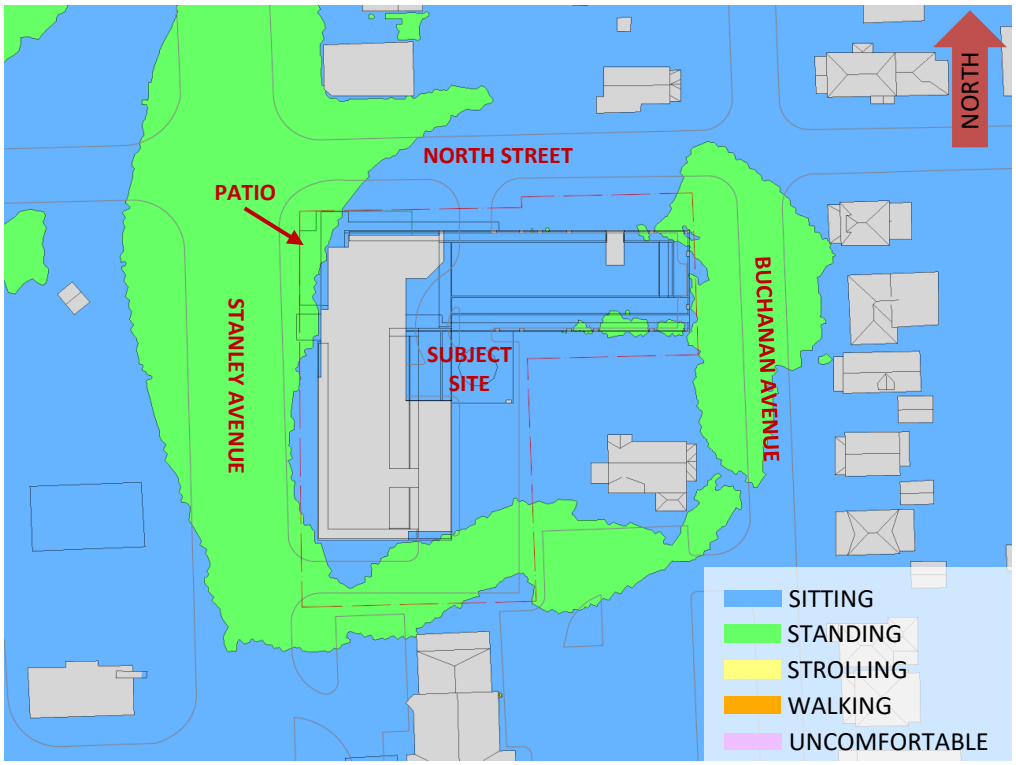


**FIGURE 7: TYPICAL USE PERIOD – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL**


**FIGURE 8A: SPRING – WIND COMFORT, LEVEL 2 COMMON AMENITY BALCONY**


**FIGURE 8B: SUMMER – WIND COMFORT, LEVEL 2 COMMON AMENITY BALCONY**


**FIGURE 8C: AUTUMN – WIND COMFORT, LEVEL 2 COMMON AMENITY BALCONY**

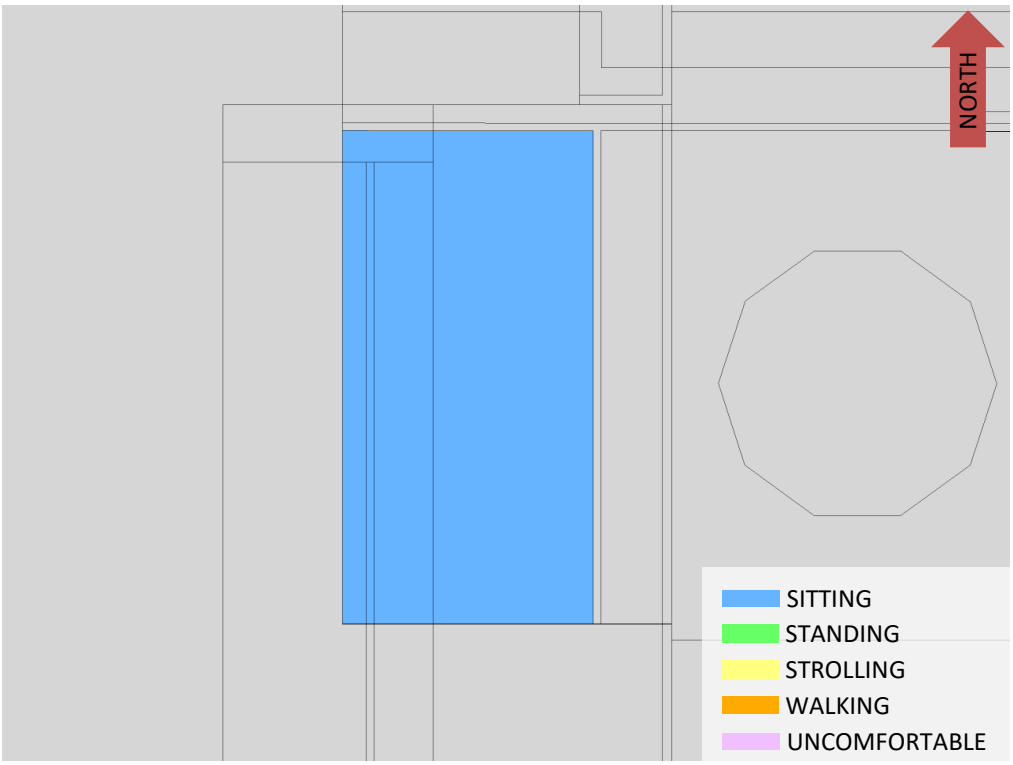


**FIGURE 8D: WINTER – WIND COMFORT, LEVEL 2 COMMON AMENITY BALCONY**


# 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 $\alpha$ 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 35% mean wind speed for Niagara Falls 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.

$\alpha$ is determined based on the upstream exposure of the far-field surroundings (that is, the area that is 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 | 0.24 |
| 38 | 0.25 |
| 70 | 0.25 |
| 123 | 0.21 |
| 190 | 0.23 |
| 210 | 0.23 |
| 224 | 0.24 |
| 236 | 0.25 |
| 250 | 0.25 |
| 270 | 0.25 |
| 294 | 0.24 |
| 322 | 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].

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

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

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

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

## REFERENCES

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

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

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