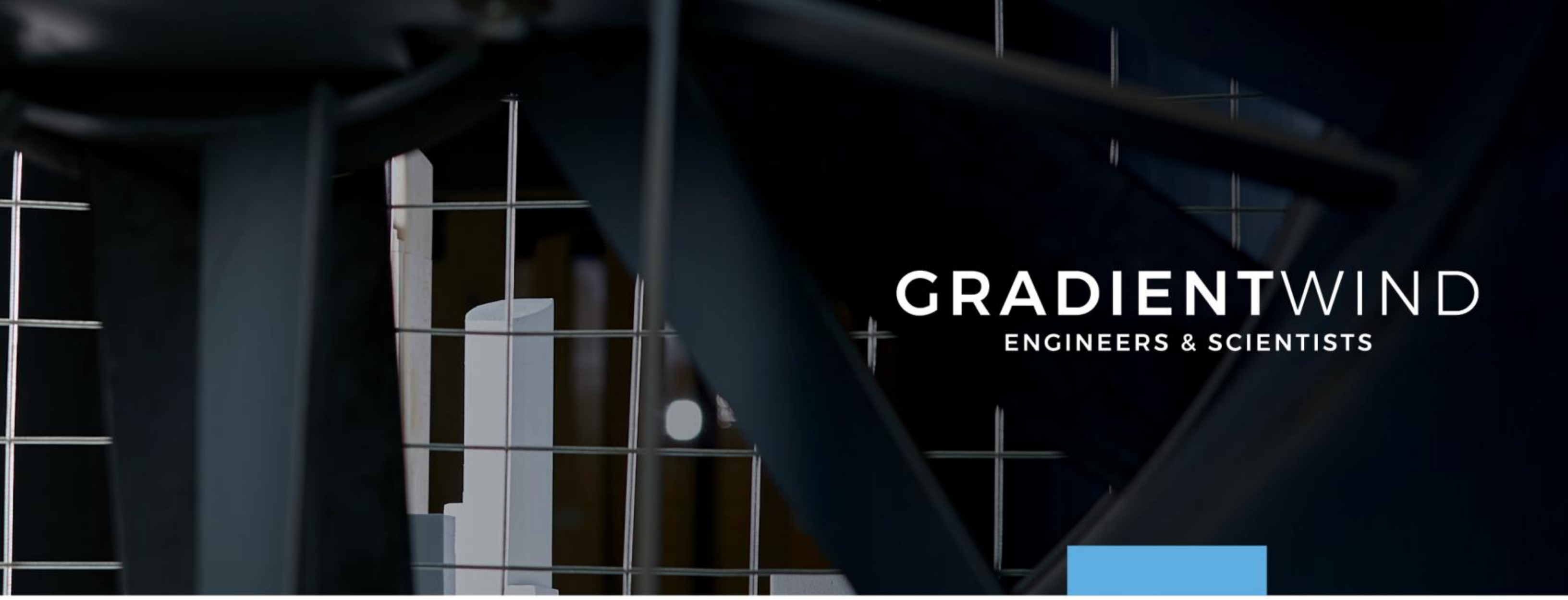
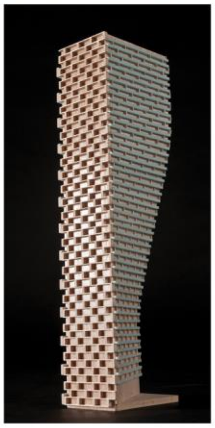
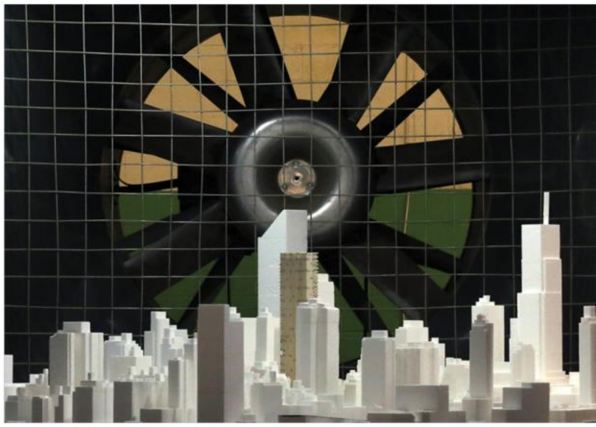



# PEDESTRIAN LEVEL WIND STUDY

780 Baseline Road
Ottawa, Ontario

Report: 22-062-PLW





May 9, 2022

PREPARED FOR
Theberge Developments Ltd.
1600 Laperriere Avenue, Suite 205
Ottawa, ON K1Z 8P5

PREPARED BY
David Huitema, M.Eng., Junior Wind Scientist
Justin Ferraro, P.Eng., Principal

# EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-law Amendment application requirements for the proposed multi-building development located 780 Baseline Road in Ottawa, 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.

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-7, 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, walkways, transit stops, and in the vicinity of building access points, are considered acceptable. An exception is described as follows:

   a. Conditions over the plaza to the east of the subject site are predicted to be suitable for a mix of standing and strolling during the typical use period.

   b. Mitigation will be required to ensure the area is suitable for a mix of sitting and standing during the typical use period. The implementation of landscape elements, such as vertical wind screen and planters with coniferous plantings in dense arrangements and strategically placed seating with high-back benches to shield the area from westerly winds would increase comfort levels. Mitigation strategies will be developed and confirmed in collaboration with the design team as the design progresses and in preparation of the future Site Plan Control application submission.

2) 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, (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.

GRADIENTWIND
ENGINEERS & SCIENTISTS

# TABLE OF CONTENTS


1. INTRODUCTION .......... 1

2. TERMS OF REFERENCE .......... 1

3. OBJECTIVES .......... 3

4. METHODOLOGY .......... 3

  4.1 Computer-Based Context Modelling .......... 3

  4.2 Wind Speed Measurements .......... 4

  4.3 Historical Wind Speed and Direction Data .......... 4

  4.4 Pedestrian Comfort and Safety Criteria – City of Ottawa .......... 6

5. RESULTS AND DISCUSSION .......... 8

  5.1 Wind Comfort Conditions – Ground Floor .......... 9

  5.2 Wind Safety .......... 11

  5.3 Applicability of Results .......... 12

6. CONCLUSIONS AND RECOMMENDATIONS .......... 12

FIGURES

APPENDICES

Appendix A – Simulation of the Atmospheric Boundary Layer

# 1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Theberge Developments Ltd. to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application requirements for the proposed multi-building development located at 780 Baseline Road in Ottawa, 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 Ottawa wind comfort and safety criteria, preliminary architectural drawings prepared by RLA Architecture, in March 2022, 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 780 Baseline Road in Ottawa; situated on a parcel of land at the southwest intersection of Baseline Road and Fisher Avenue. The proposed development comprises three buildings: "Building A", an 'L'-shaped 25-storey building situated to the southeast; "Building B", an 'L'-shaped 29-storey building situated to the northeast; and "Building C", a 'C'-shaped 25-storey building situated to the northwest of the subject site. The project will be constructed in phases with the first phase comprising Building A. All buildings include mechanical penthouse (MPH) levels. Building A is served by two below-grade parking levels, while Building B and Building C share two levels of below-grade parking. A plaza is situated to the east of the subject site, between Building A and Building B, and surface parking is provided to the south of Building C.

The ground floor of Building A includes commercial space, a residential main entrance, loading space, moving space, and elevator core at the northeast corner, an indoor amenity to the south, a loading space and shared building support spaces at the southwest corner, and residential units throughout the remainder of the level. Access to below-grade parking is provided by a ramp at the southwest corner of

Building A via a laneway from Fisher Avenue. Levels 2-25 are reserved for residential use. Floorplate setbacks are situated to the northwest at Level 4, 20, and 23 and to the south at Level 4 and 7.

The ground floor of Building B includes a residential main entrance to the southwest, retail space from the west clockwise northeast, fronting Baseline Road, indoor amenity and elevator core to the east, indoor amenity and a garbage room to the south, and central shared building support spaces. Access to below-grade parking is provided by a ramp situated in between Building B and Building C via a central laneway with vehicular entrances from Baseline Road and Fisher Avenue to the northwest and east of the subject site, respectively. Levels 2-29 are reserved for residential use. Floorplate setbacks are situated to the southeast at Level 4 and to the northwest at Level 5 and 7.

The ground floor of Building C includes a residential main entrance to the south, retail space from the southwest clockwise northeast, shared building support spaces and elevator core to the east, and indoor amenities at the southeast corner. Levels 2-25 are reserved for residential use. Floorplate setbacks are situated in all compass directions at Level 5 and to the west at Level 7.

The shortest distance between the podia serving Building A and Building B is approximately 43.6 metres (m), while the shortest distance between the two tall buildings above the podia is approximately 44.6 m. The shortest distance between the podia serving Building B and Building C is approximately 20.7 m, while the shortest distance between the two tall buildings above the podia is approximately 53.2 m.

The near-field surroundings (defined as an area within 200 m of the subject site) include low-rise residential buildings from the northeast clockwise west with open fields from the west clockwise 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 by low-rise developments in all compass directions with isolated mid- and high-rise buildings to the east, south, and from the southwest clockwise northwest, and open fields from the west to the north. Notably, green space is situated to the north of the subject site.

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 proposed developments approved by the City of Ottawa.

# 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 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 study 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 study 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.

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

## 4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of 480 m.

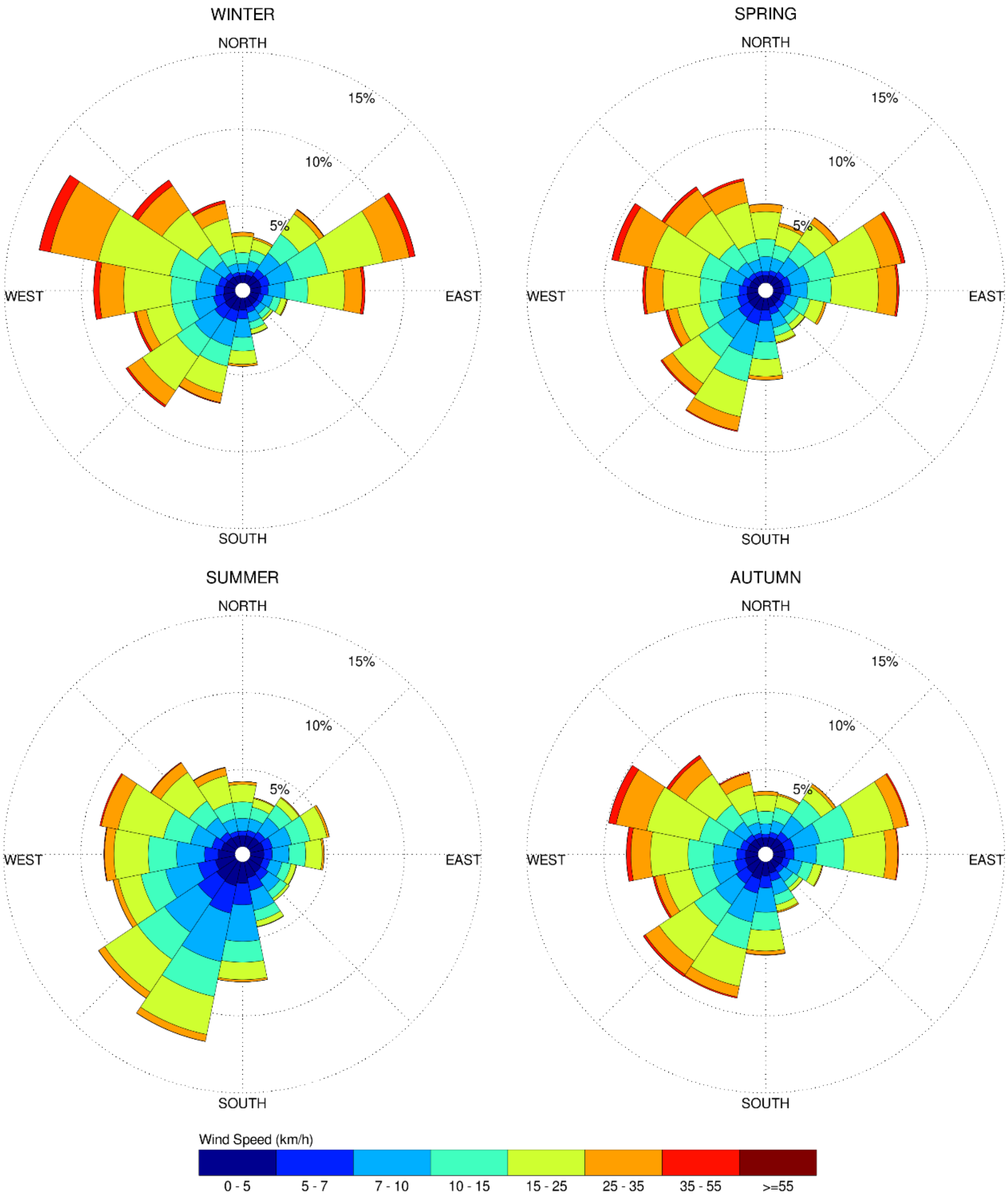
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade were referenced to the wind speed at gradient height to generate 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 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 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 preferred 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 preference 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 Comfort and Safety Criteria – City of Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The comfort criteria 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 criterion.

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. 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 criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their 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 |
| Café / Patio / Bench / Garden | Sitting (Typical Use Period) |
| Transit Stop (Without Shelter) | Standing |
| Transit Stop (With Shelter) | Walking |
| Public Park / Plaza | Sitting / Standing (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-6B, illustrating wind conditions at grade level for the proposed and existing massing scenarios. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the 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 conditions at grade 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 – Ground Floor

**Sidewalks, Building Access, and Transit Stops along Baseline Road:** Following the introduction of the proposed development, the nearby public sidewalk areas along Baseline Road are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for strolling or better during the autumn, and suitable for a mix of standing and strolling during the winter and spring with walking conditions at the southwest intersection of Baseline Road and Fisher Avenue. Conditions over the nearby transit stop along Baseline Road are predicted to be suitable for standing during the summer, becoming suitable for a mix of standing and strolling during the autumn, and suitable for strolling during the winter and spring. Conditions in the vicinity of the single building access point serving Building B along Baseline Road are predicted to be suitable for sitting during the summer, becoming suitable for standing during the remaining three seasons. The noted conditions are considered acceptable according to the City of Ottawa wind criteria in Section 4.4.

Wind conditions over the sidewalks along Baseline Road with the existing massing are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing during the autumn, and suitable for a mix of standing and strolling during the winter and spring. Conditions over the nearby transit stop along Baseline Road are predicted to be suitable for standing during the summer, becoming suitable for a mix of standing and strolling during the autumn, and suitable for strolling during the winter and spring. While the introduction of the proposed development produces slightly windier conditions in comparison to existing conditions, wind comfort conditions with the proposed development are considered acceptable.

**Sidewalks, Building Access, and Transit Stops along Fisher Avenue:** Following the introduction of the proposed development, the nearby public sidewalk areas along Fisher Avenue are predicted to be suitable for a mix of sitting and standing during the summer, suitable mostly for a mix of standing and strolling during the autumn, becoming suitable mostly for a mix of strolling and walking during the winter and spring. Conditions over the nearby transit stops along Fisher Avenue are predicted to be suitable for a mix of sitting and standing during the summer and autumn, becoming suitable for standing during the winter and spring. Conditions in the vicinity of the building access points serving Building A and Building B along Fisher Avenue are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind criteria in Section 4.4.

Wind conditions over the sidewalks along Fisher Avenue with the existing massing are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the remaining three seasons. Conditions over the nearby transit stops along Fisher Avenue are predicted to be suitable for sitting during the summer and autumn, becoming mostly suitable for standing during the winter and spring. While the introduction of the proposed development produces windier conditions in comparison to existing conditions, wind comfort conditions with the proposed development are considered acceptable.

**Plaza East of Subject Site**: Conditions over the plaza to the east of the subject site, situated between Building A and Building B, are predicted to be suitable for a mix of standing and strolling during the typical use period, as illustrated in Figure 7.

Mitigation will be required to ensure the area is suitable for a mix of sitting and standing during the typical use period. The implementation of landscape elements, such as vertical wind screen and planters with coniferous plantings in dense arrangements and strategically placed seating with high-back benches to shield the area from westerly winds would increase comfort levels. Mitigation strategies will be developed and confirmed in collaboration with the design team as the design progresses and in preparation of the future Site Plan Control application submission.

**Walkway and Building Access Along North Elevation of Building A:** Conditions over the walkway to the north of Building A are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for a mix of standing and strolling during the spring, autumn, and winter, with a small region of walking to the east during the winter. Conditions in the vicinity of the single building access point serving the north elevation of Building A are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing during the spring and autumn, and suitable for a mix of standing and strolling during the winter. The noted conditions are considered acceptable according to the City of Ottawa wind criteria in Section 4.4.

**Building Access Southwest of Building A and Building B:** Conditions in the vicinity of the building access points to the southwest of Building A and Building B are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

**Building Access Along East Elevation of Building C:** Conditions in the vicinity of the single building access point serving the east elevation of Building C are predicted to be suitable for sitting during the summer, becoming suitable for standing during the remaining three seasons. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

**Walkway, Building Access, and Surface Parking South of Building C:** Conditions over the walkway to the south of Building C are predicted to be suitable for sitting during the summer, becoming mostly suitable for sitting with standing conditions to the southeast and southwest during the remaining three seasons. Conditions in the vicinity of the single building access point along the south elevation of Building C are predicted to be suitable for sitting throughout the year. Conditions over the surface parking spaces situated to the south of Building C are predicted to be suitable for a mix of sitting and standing throughout the year with strolling conditions to the west during the spring and winter. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

**Walkway West of Building C:** Conditions over the walkway to the west of Building C are predicted to be mostly suitable for sitting during the summer, becoming suitable for a mix of sitting and standing during the spring and autumn, and suitable for standing during the winter, with small regions of strolling during the spring and winter. The noted conditions are considered acceptable according to the City of Ottawa wind criteria.

## 5.2 Wind Safety

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

### 5.3 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the 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 and illustrated in Figures 3A-7. 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, walkways, transit stops, and in the vicinity of building access points, are considered acceptable. An exception is described as follows:

    a. Conditions over the plaza to the east of the subject site are predicted to be suitable for a mix of standing and strolling during the typical use period.

    b. Mitigation will be required to ensure the area is suitable for a mix of sitting and standing during the typical use period. The implementation of landscape elements, such as vertical wind screen and planters with coniferous plantings in dense arrangements and strategically placed seating with high-back benches to shield the area from westerly winds would increase comfort levels. Mitigation strategies will be developed and confirmed in collaboration with the design team as the design progresses and in preparation of the future Site Plan Control application submission.

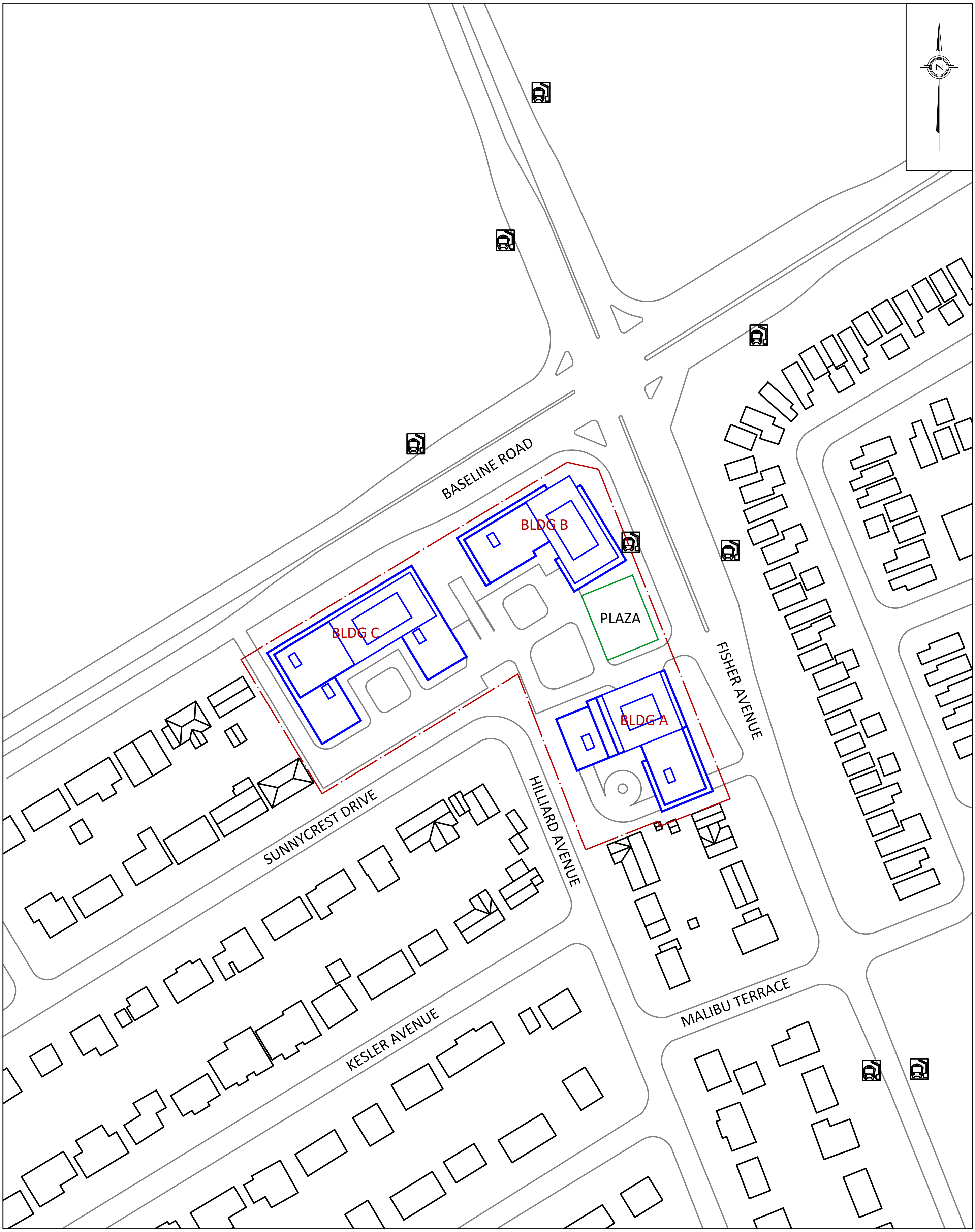
2) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (e.g., thunderstorms, tornadoes, and downbursts), pedestrian safety is the main 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.***


David Huitema, M.Eng.
Junior Wind Scientist

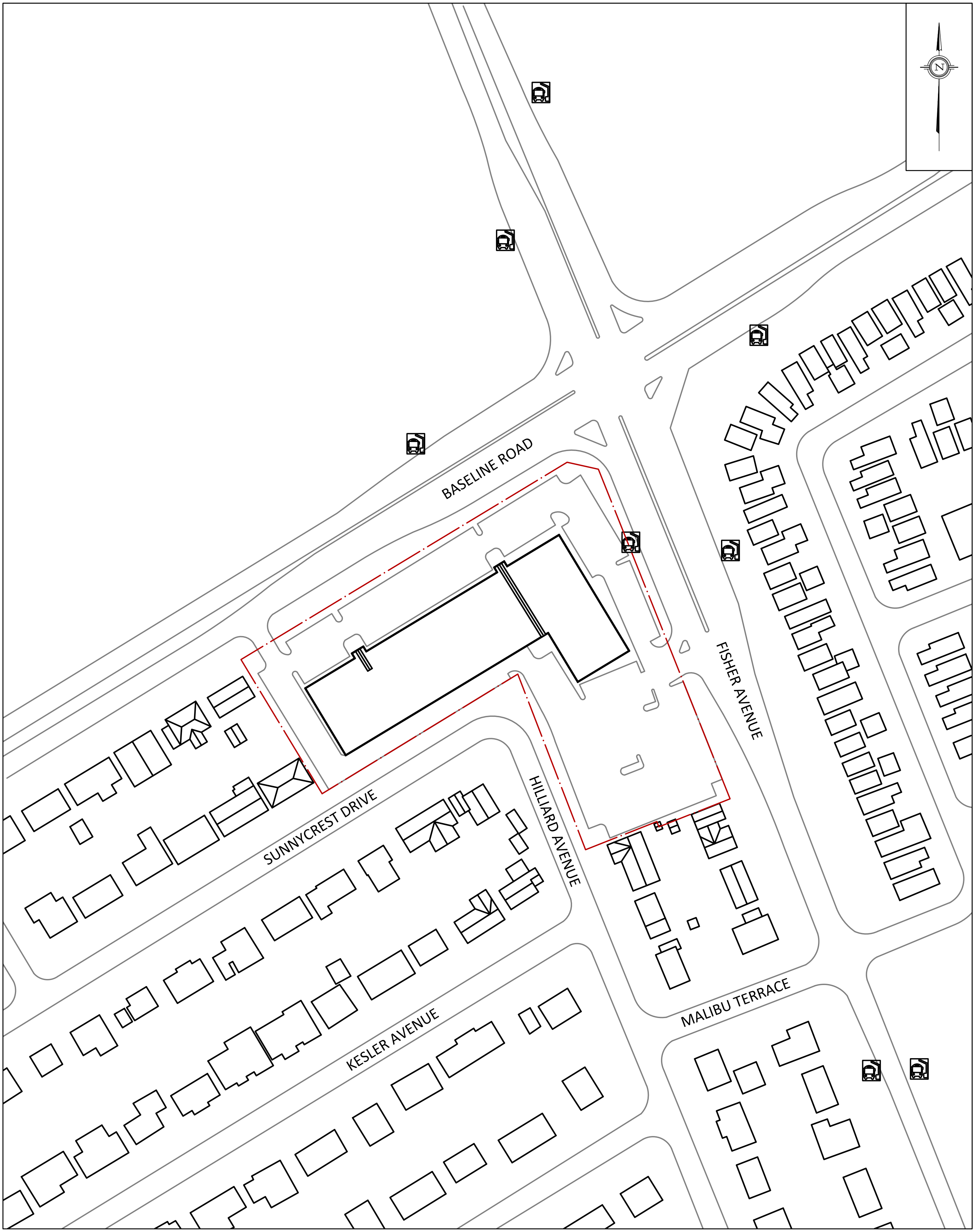
Justin Ferraro, P.Eng.
Principal




**GRADIENTWIND**
ENGINEERS & SCIENTISTS

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

| | | |
|---|---|---|
| PROJECT: 780 BASELINE ROAD, OTTAWA PEDESTRIAN LEVEL WIND STUDY | | DESCRIPTION: FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT |
| SCALE: 1:2000 | DRAWING NO.: 22-062-PLW-1A | |
| DATE: MAY 6, 2022 | DRAWN BY: S.K. | |




GRADIENTWIND
ENGINEERS & SCIENTISTS

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

| PROJECT | | DESCRIPTION |
|---|---|---|
| 780 BASELINE ROAD, OTTAWA<br>PEDESTRIAN LEVEL WIND STUDY | | FIGURE 1B:<br>EXISTING SITE PLAN AND SURROUNDING CONTEXT |
| SCALE: 1:2000 | DRAWING NO.: 22-062-PLW-1B | |
| DATE: MAY 6, 2022 | DRAWN BY: S.K. | |

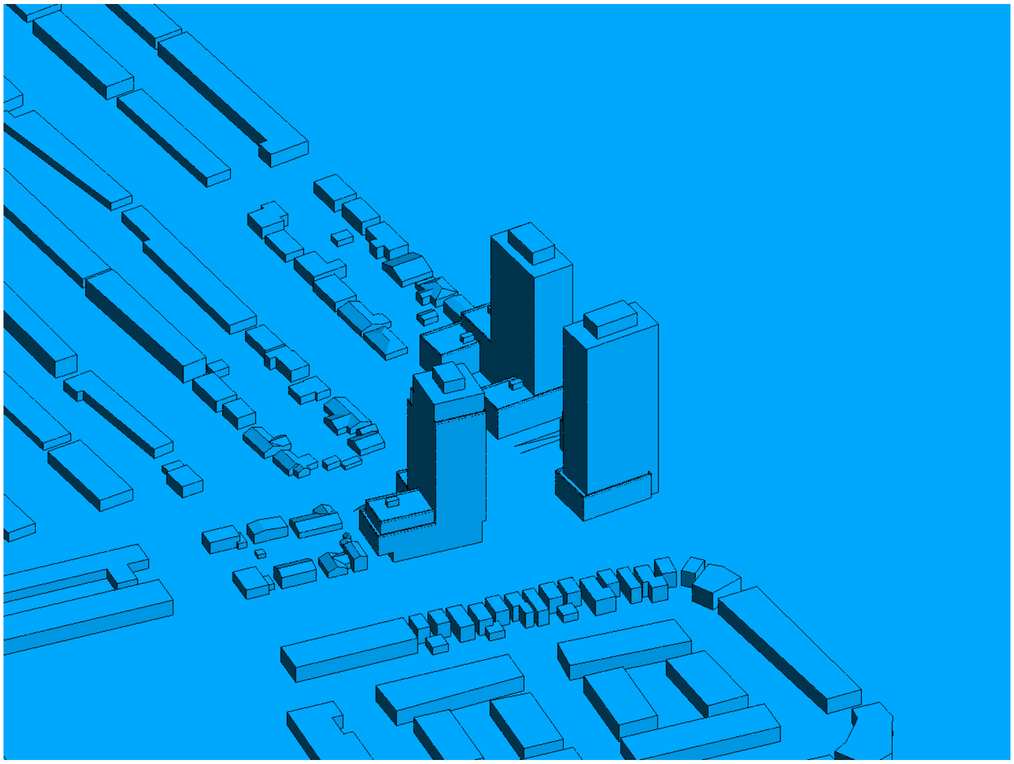


**FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, EAST PERSPECTIVE**

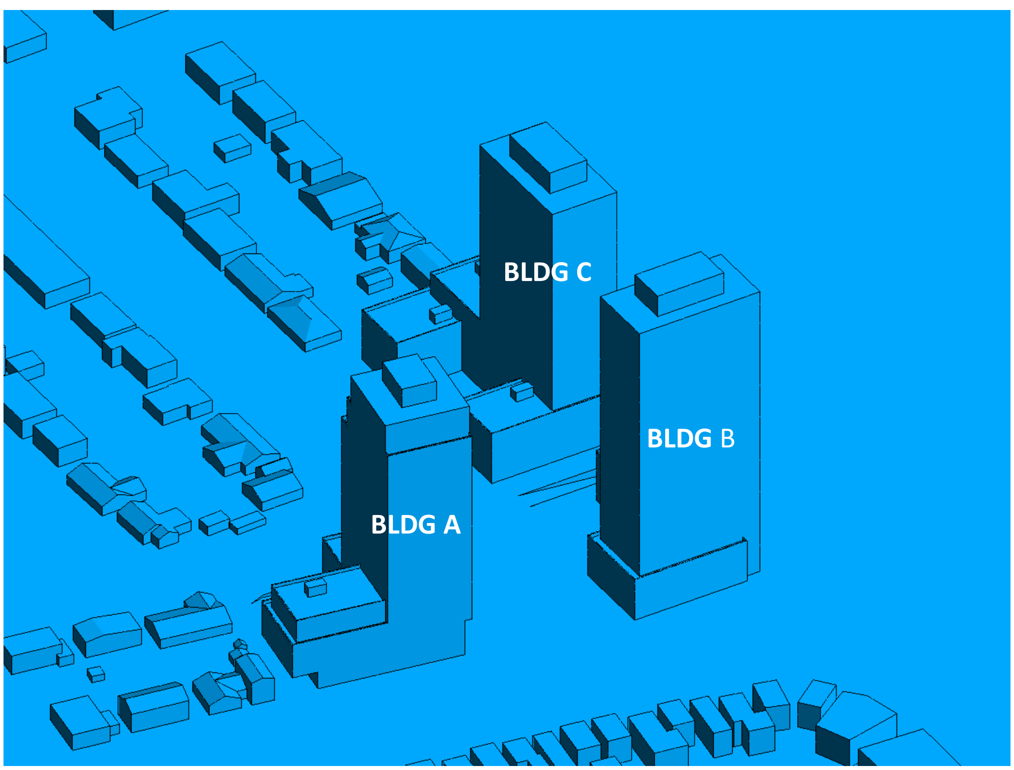



**FIGURE 2B: CLOSE UP OF FIGURE 2A**

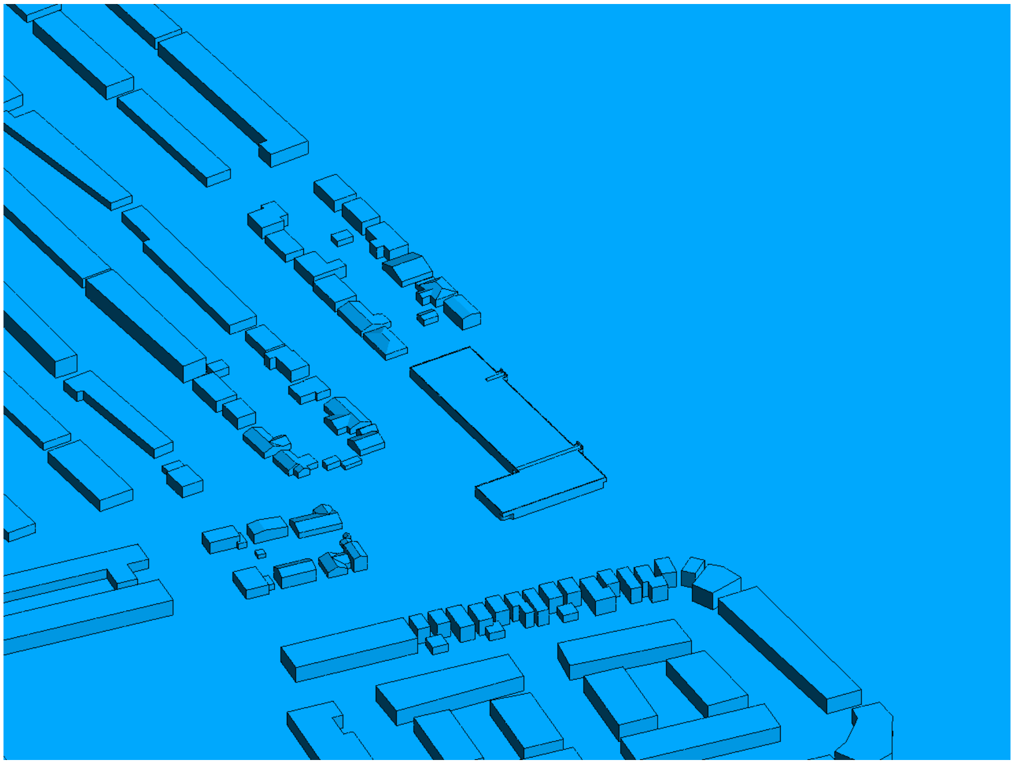


**FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, EAST PERSPECTIVE**

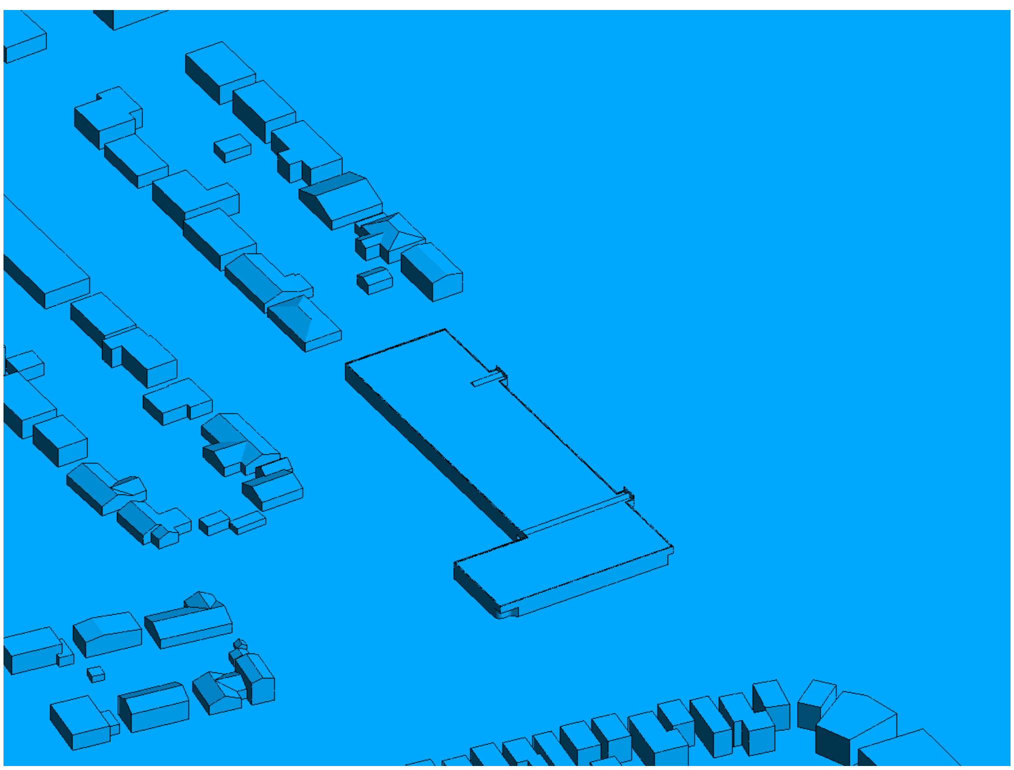


**FIGURE 2D: CLOSE UP OF FIGURE 2C**

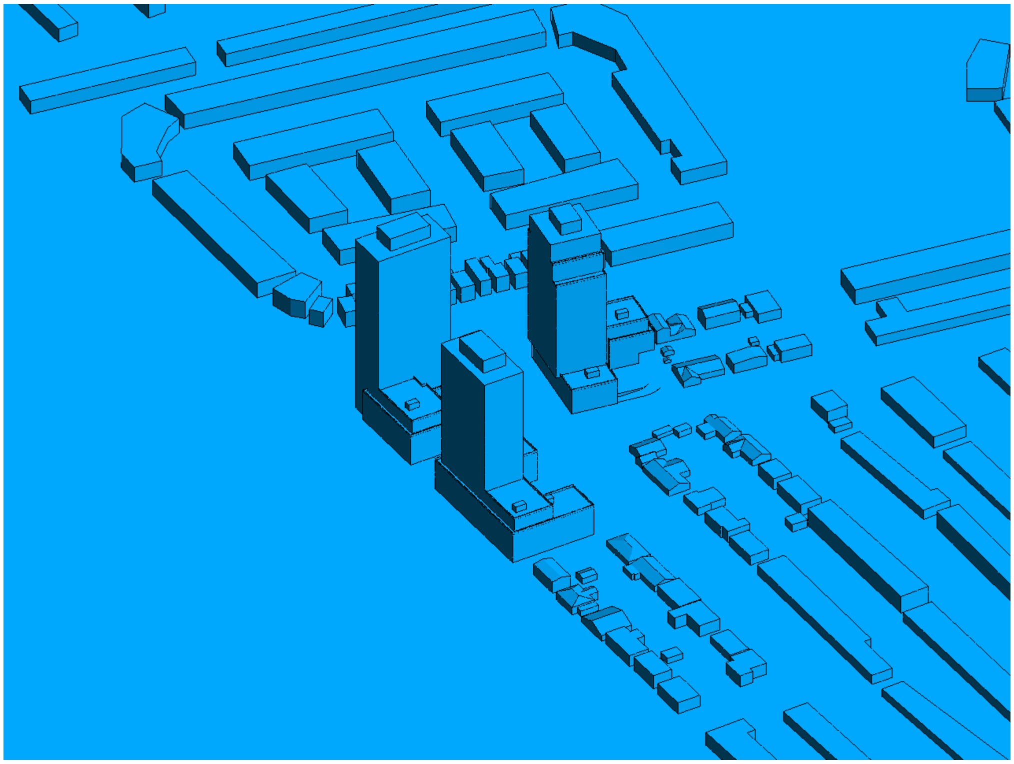


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, WEST PERSPECTIVE

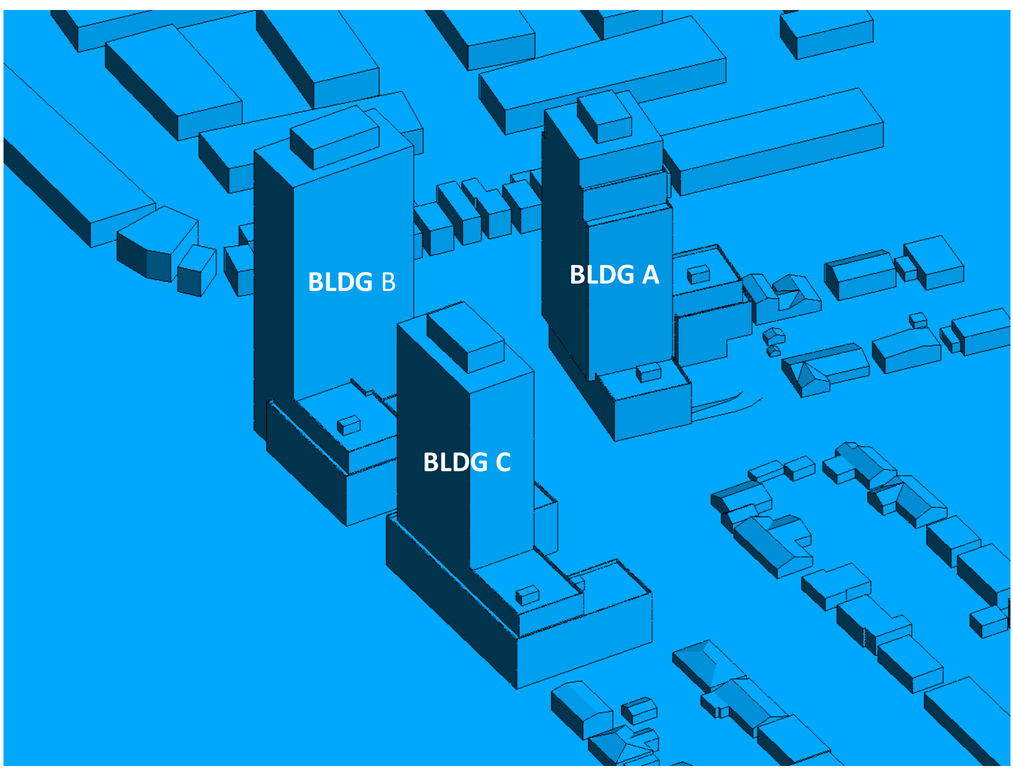



FIGURE 2F: CLOSE UP OF FIGURE 2E

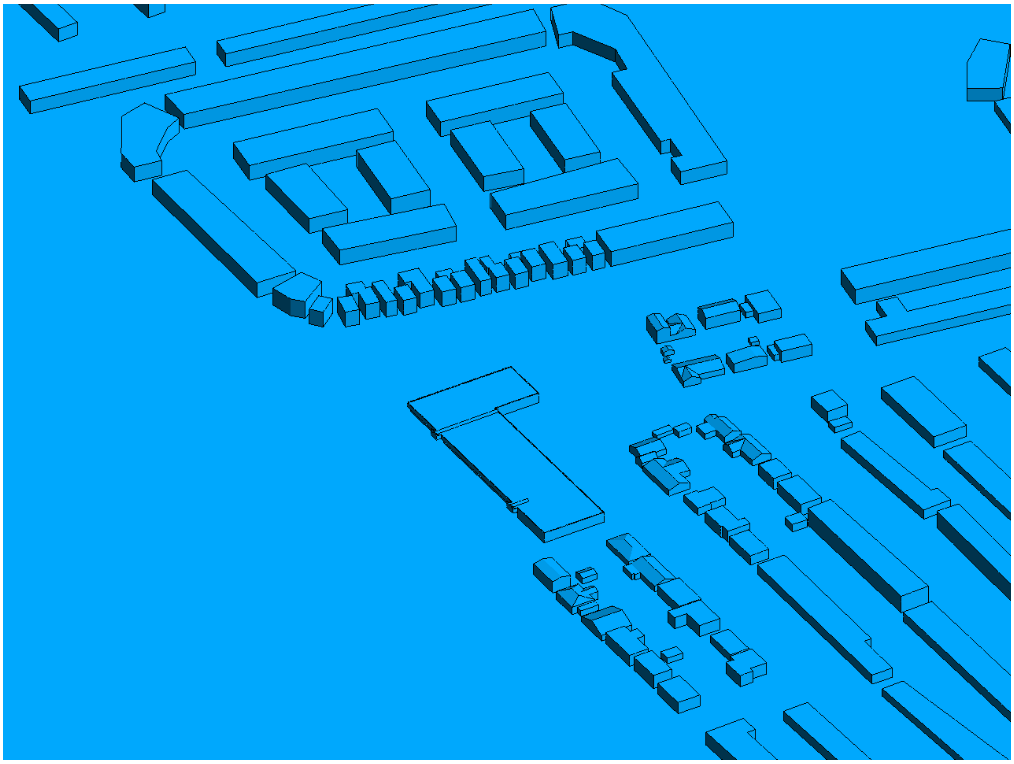


**FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, WEST PERSPECTIVE**

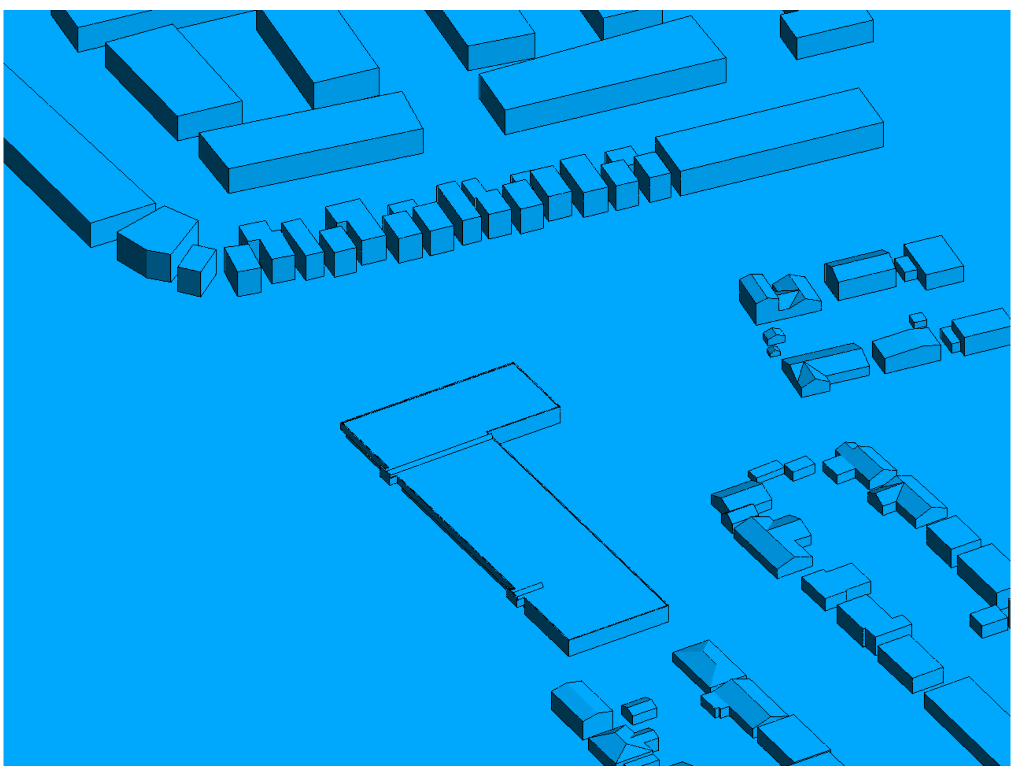


**FIGURE 2H: CLOSE UP OF FIGURE 2G**

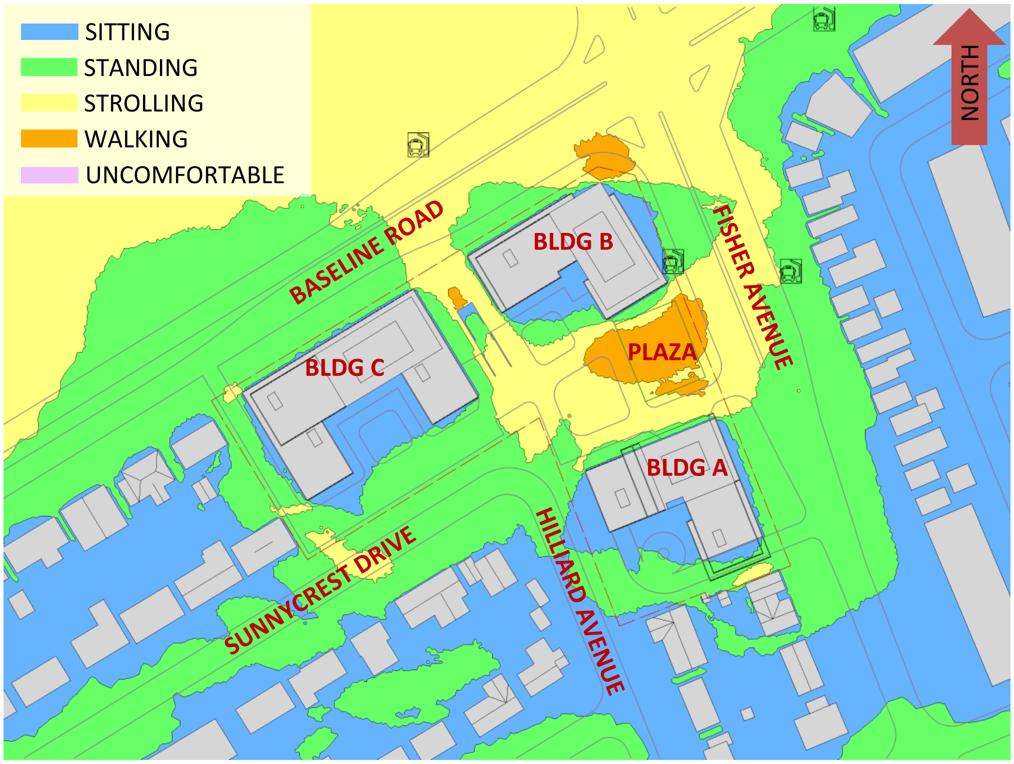



**FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**


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

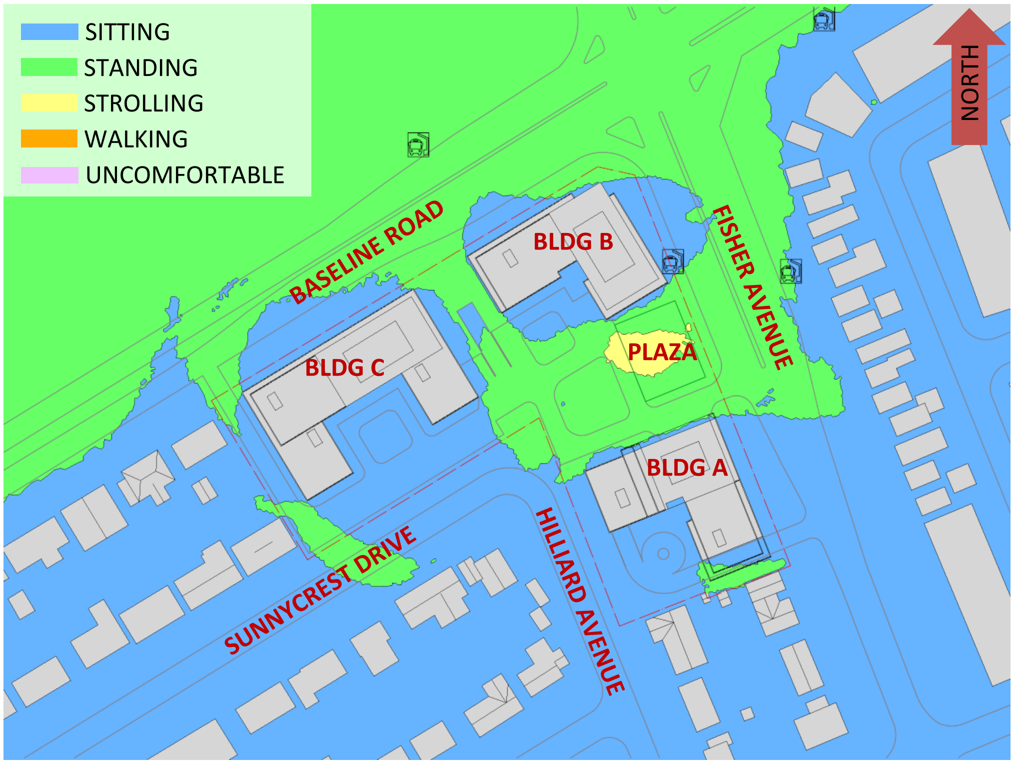



**FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**


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

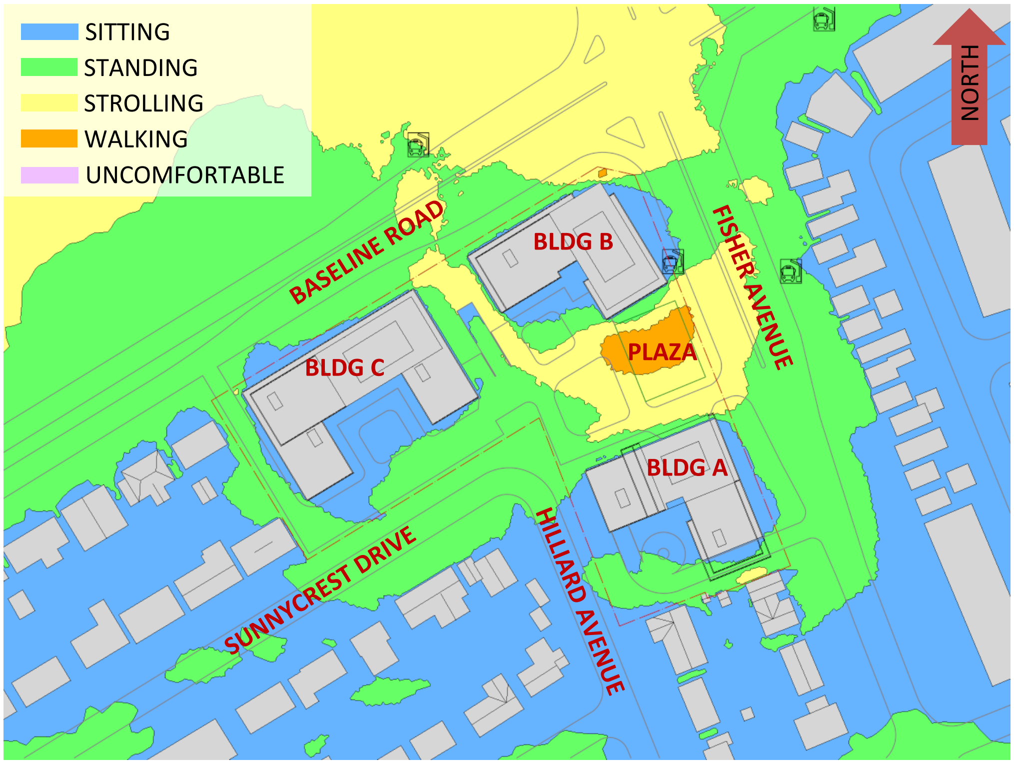



**FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**

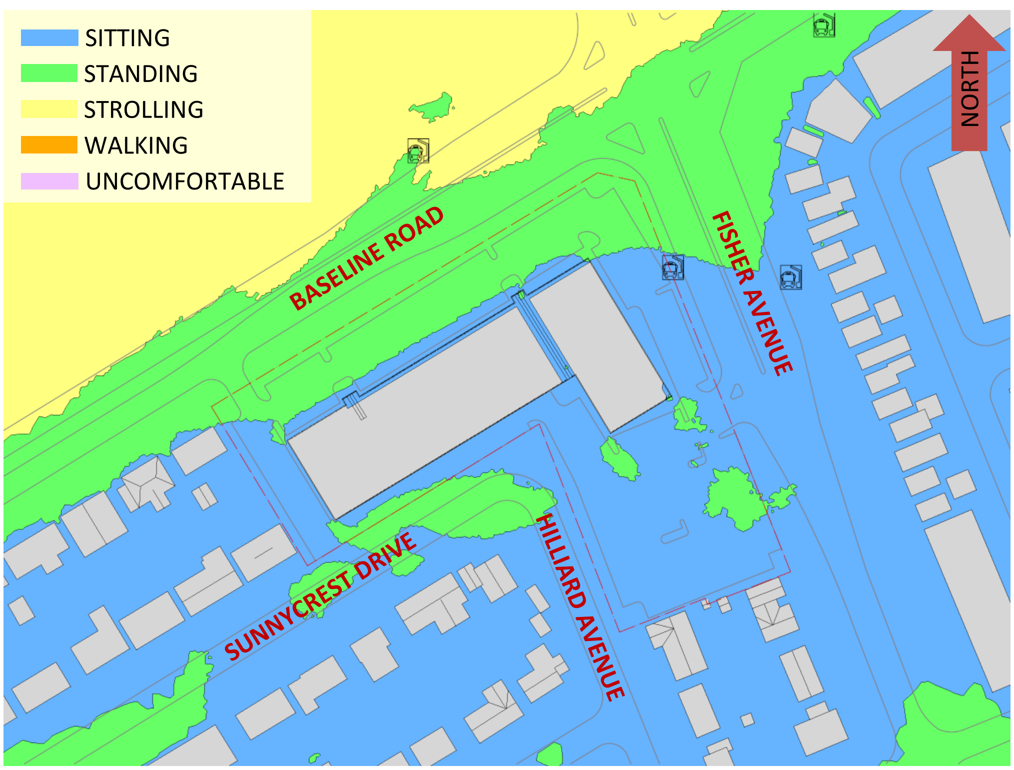



**FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL – EXISTING MASSING**

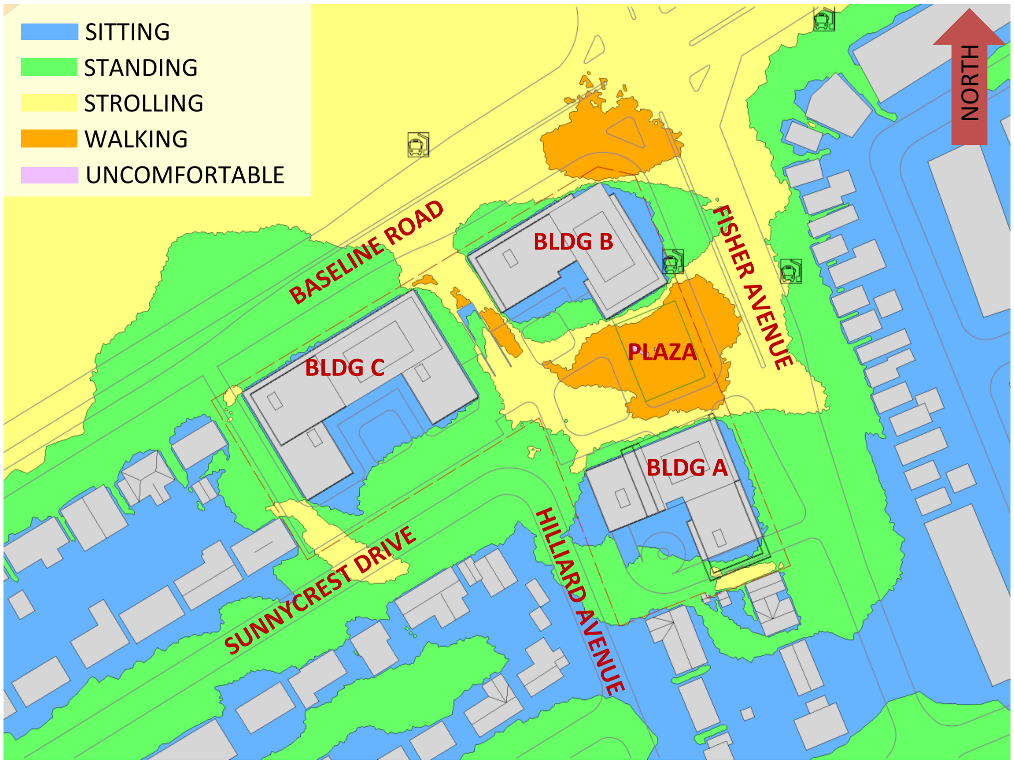



**FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**


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

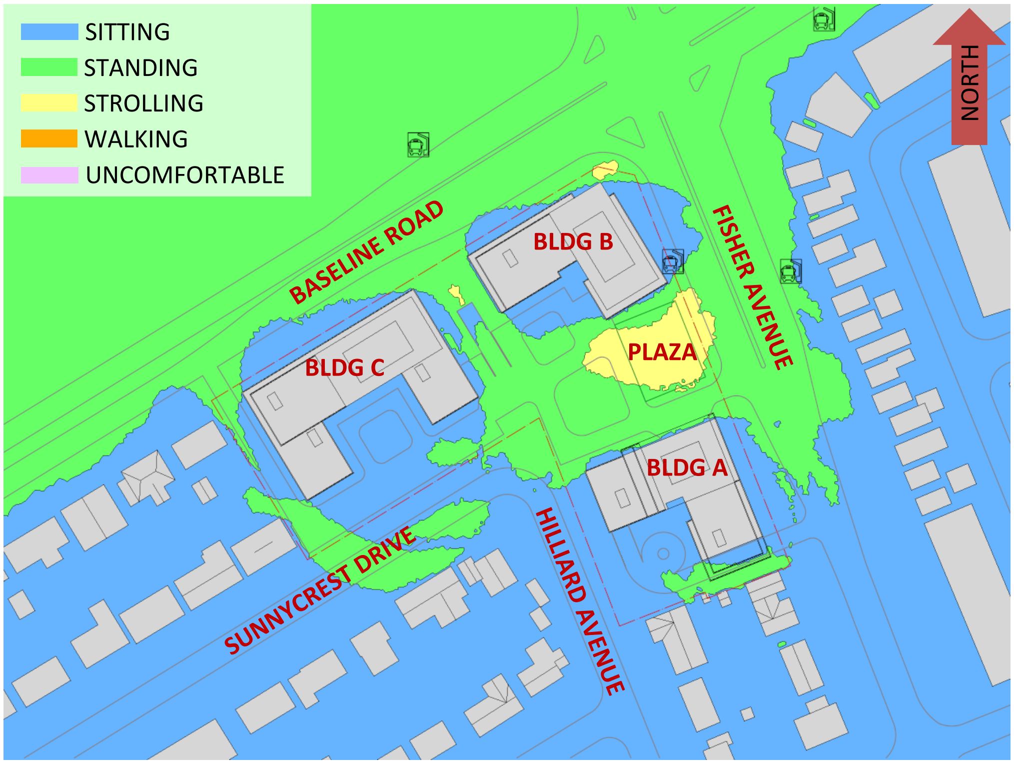
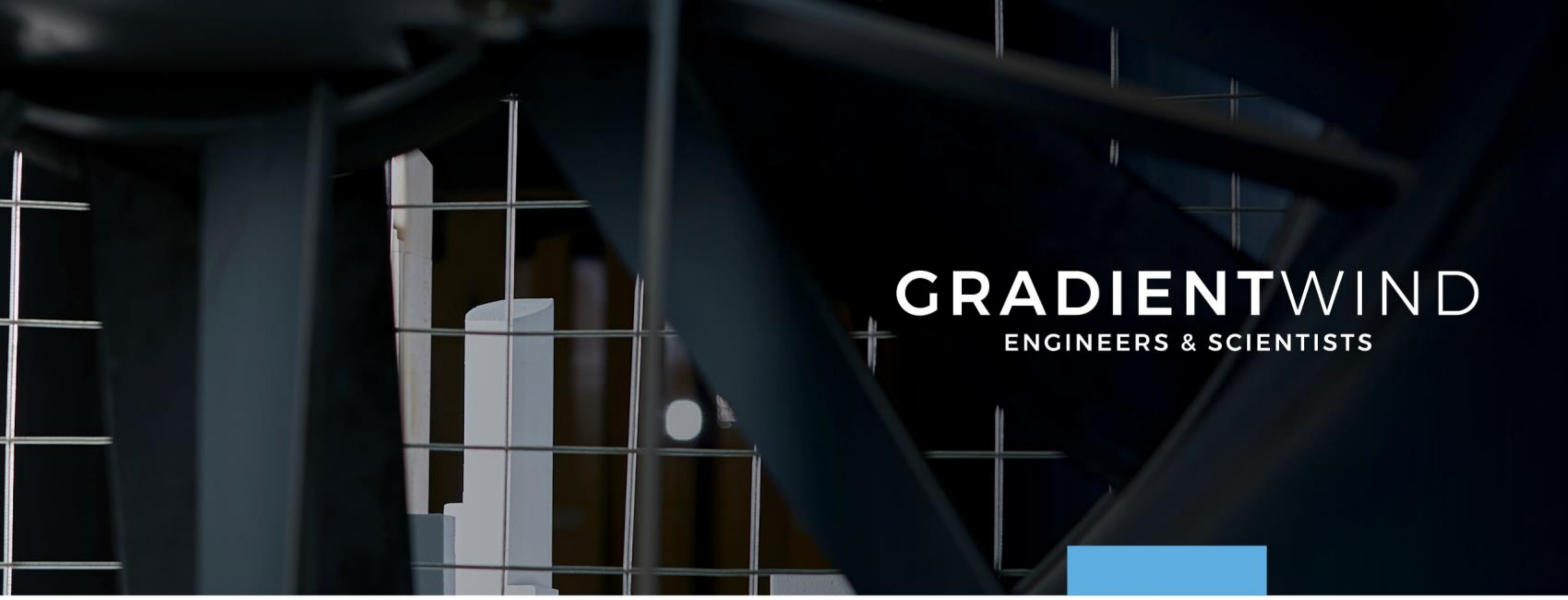
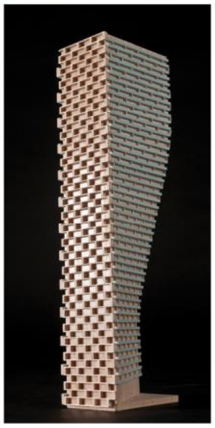
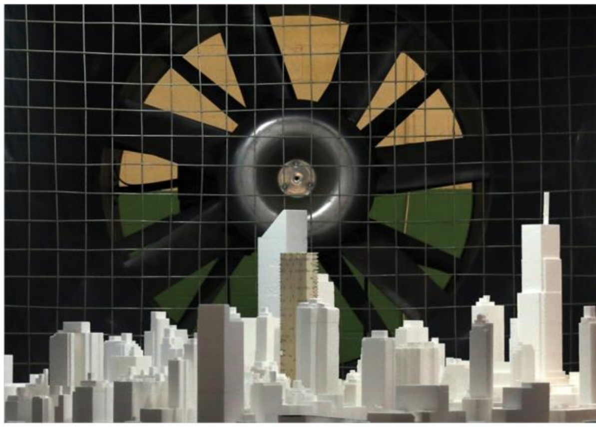



**FIGURE 7: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING**







# APPENDIX A

## SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

## SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

$$U = U_g \left(\frac{Z}{Z_g}\right)^{\alpha}$$ 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 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.

$\alpha$ 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 | 0.20 |
| 49 | 0.21 |
| 74 | 0.24 |
| 103 | 0.24 |
| 167 | 0.24 |
| 197 | 0.24 |
| 217 | 0.24 |
| 237 | 0.22 |
| 262 | 0.21 |
| 282 | 0.21 |
| 301 | 0.21 |
| 324 | 0.22 |

**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).

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

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

where, ***I*** = turbulence intensity, $\boldsymbol{L_t}$ = turbulence length scale, ***Z*** = height above ground, and $\alpha$ 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 Engieering Symposium, IWES 2003*, Taiwan, 2003.