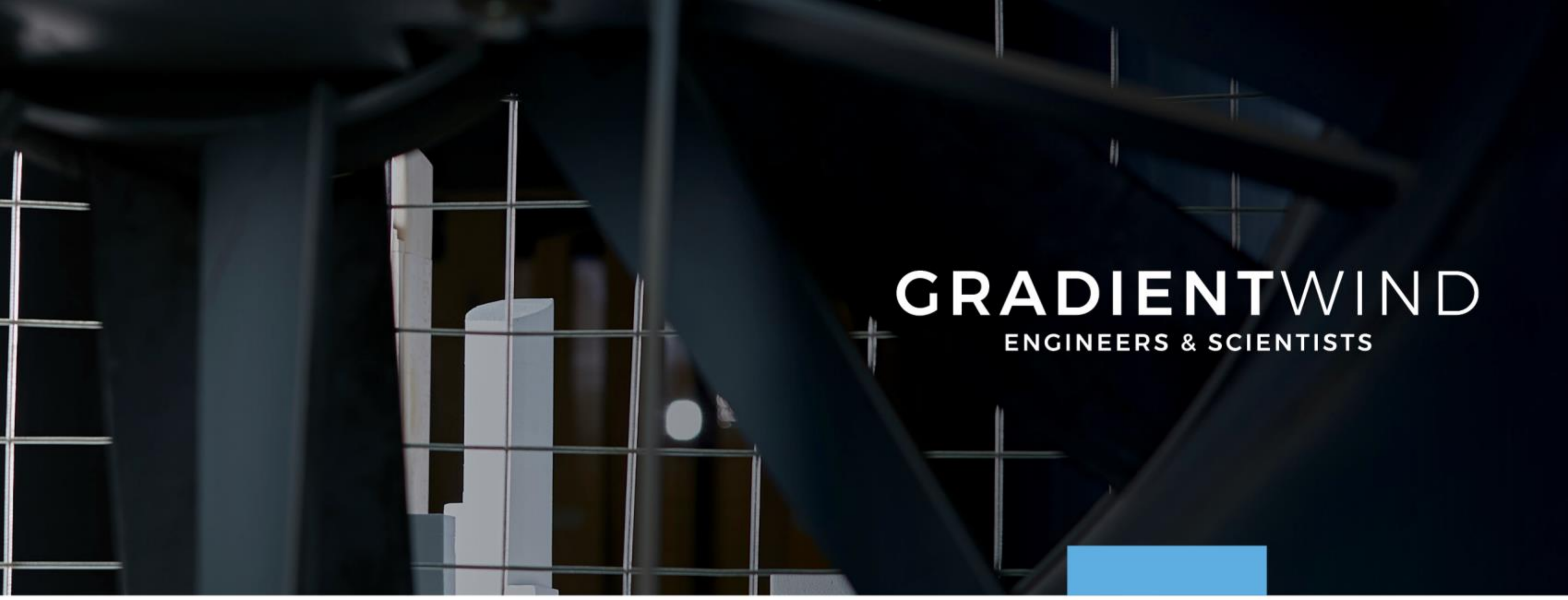
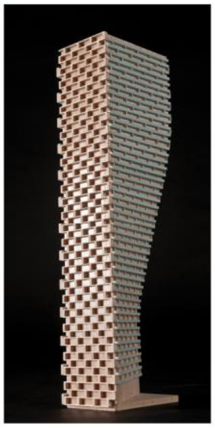
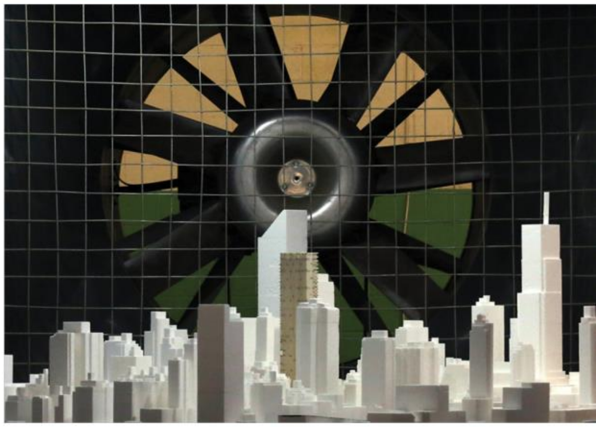


PEDESTRIAN LEVEL WIND STUDY

1166-1204 Gordon Street
Guelph, Ontario

Report: 21-378-PLW-2023





November 23, 2023

PREPARED FOR
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy Zoning By-Law Amendment (ZBLA) application resubmission requirements for the proposed multi-building development located at 1166-1204 Gordon Street in Guelph, 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 Guelph wind comfort and safety criteria. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-4B, 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, wind conditions over surrounding sidewalks, transit stops, the nearby existing surface parking lots, the proposed driveway, walkways, surface parking, grade-level outdoor amenities, and in the vicinity of building access points are considered acceptable. The areas that are predicted to experience windier conditions are described as follows:

    a. **Central Outdoor Amenity and Amenities to the North and Northeast of Apartment Building 1**. During the summer, conditions over the central outdoor amenity and the outdoor amenity to the north of Apartment Building 1 are predicted to be suitable for mostly sitting, with isolated regions of conditions suitable for standing, while conditions over the outdoor amenity to the northeast of Apartment Building 1 are predicted to be suitable for sitting over the majority of the area, with an isolated region of conditions suitable for standing to the west.

- Depending on the programming of the noted spaces, the noted conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, the predicted wind comfort conditions would be considered acceptable.

- If the programming of these spaces includes seating or lounging activities in the isolated windier areas suitable for standing, comfort levels may be improved with landscaping features such as tall wind barriers or dense coniferous plantings that are targeted around sensitive areas within these spaces.

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 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 GSD Development & Management Inc. to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-Law Amendment (ZBLA) application resubmission requirements for the proposed multi-building development located at 1166-1204 Gordon Street in Guelph, Ontario (hereinafter referred to as “subject site” or “proposed development”). A PLW study was conducted in January 2022[1] for the previous design of the 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 Guelph wind comfort and safety criteria, architectural drawings prepared by Broadview Architect Inc. in November 2023, surrounding street layouts and existing and approved future building massing information obtained from the City of Guelph, recent satellite imagery, and experience with numerous similar developments.

2. TERMS OF REFERENCE

The subject site is located at 1166-1204 Gordon Street in Guelph, situated on a parcel of land bordered by Gordon Street to the southwest, Landsdown Drive to the northeast, existing residential buildings to the northwest, and existing residential buildings and Valley Road to the southeast. Throughout this report, the Gordon Street elevation is referred to as the west elevation.

The proposed development comprises three three-storey rectangular townhouse blocks along the east of the subject site, hereinafter referred to as “Blocks 1, 2, and 3” from north to south, respectively, and two six-storey apartment buildings, each topped with a mechanical penthouse (MPH), referred to as “Apartment Building 1” and “Apartment Building 2”, at the northwest and southwest corners of the subject site, respectively. Apartment Buildings 1 and 2 share one below-grade parking level which is accessed by a ramp to the south of Apartment Building 2 via a driveway from Landsdown Drive. Central

[1] Gradient Wind Engineering Inc., ‘*1166 Gordon Street – Pedestrian Level Wind Study*’, [Jan 14, 2022]

surface parking is located between the apartment buildings and the townhouses. Outdoor amenities are provided along the north and south elevations of the subject site and between the apartment buildings.

The ground level of Apartment Building 1 includes a central lobby with entrances to the east and west, indoor amenities, a residential unit, a loading area, and shared building support spaces along the east elevation, and residential units along the west elevation. Levels 2-6 are reserved for residential occupancy. The building steps back from the north and south elevations at Level 6 to accommodate private terraces.

The ground level of Apartment Building 2 includes a central lobby with entrances to the east and west, an indoor amenity, residential units, a loading area, and shared building support spaces along the east elevation, and residential units and an office along the west elevation. Levels 2-6 are reserved for residential occupancy. The building steps back from the north and south elevations at Level 6 to accommodate private terraces.

Regarding wind exposures, the near-field surroundings (defined as an area falling within a 200-metre (m) radius of the subject site) include a mid-rise residential building to the south and low-rise residential homes in the remaining compass directions. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) are characterized by a mix of green space and low-rise massing from the north clockwise to the east-northeast and from the south-southeast clockwise to the west-southwest, and by mostly low-rise residential buildings in the remaining compass directions.

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 approved future developments.

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 Guelph area wind climate, and synthesis of computational data with City of Guelph wind comfort and safety criteria[2]. 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 the Region of Waterloo International Airport in Breslau, Ontario. 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 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 570 m. The process was performed for two context massing scenarios, as noted in Section 2.

[2] City of Guelph, *Pedestrian Level Wind Studies Terms of Reference*, May 2019

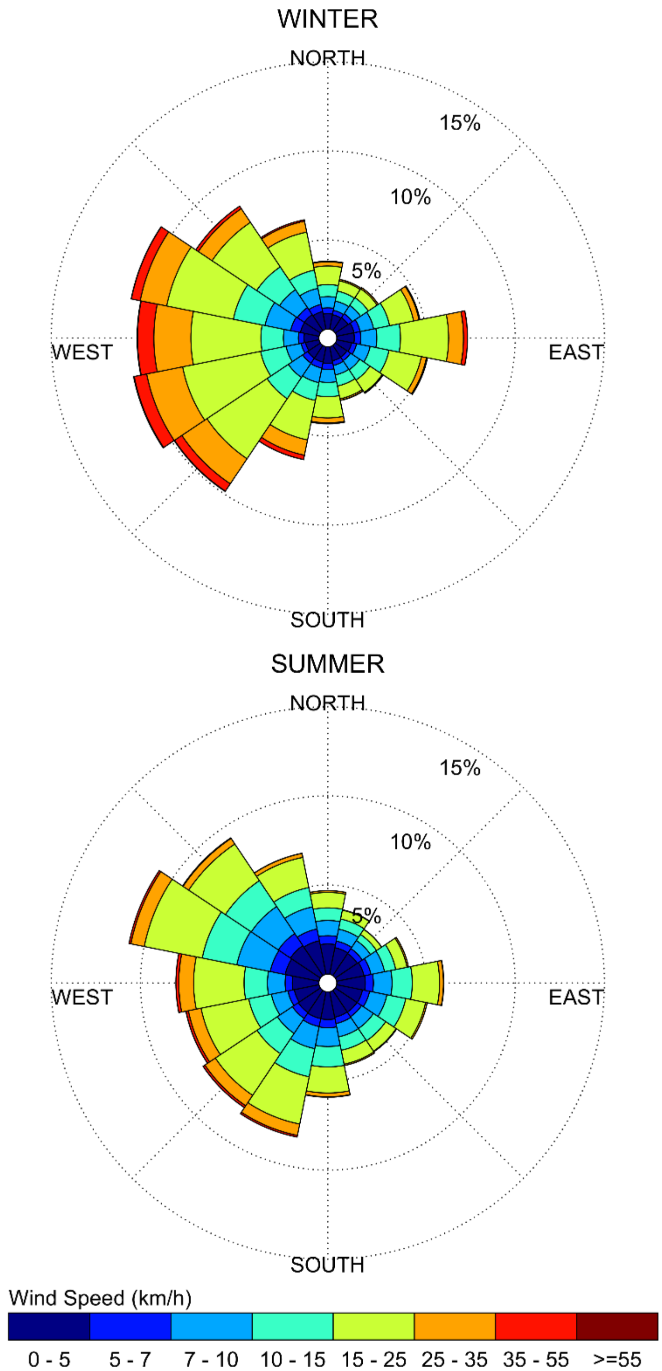
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade were referenced to the wind speed at gradient height to generate 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 Guelph was developed from 44 years (1976-2020) of hourly wind data recorded at the Region of Waterloo 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 two distinct seasons, as stipulated in the wind criteria. Specifically, summer is defined as May through October and winter is defined as November through April, inclusive.

The statistical model of the Guelph 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) between the hours of 06:00-23:00, which correspond to the appropriate hours of pedestrian use. Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction shows the frequency distribution of wind speeds for each wind direction during the measurement period. The prominent wind speeds and directions can be identified by the longer length of the bars. For the Guelph area, the common winds concerning pedestrian comfort occur from the south-southwest clockwise to north-northwest, as well as those from the east. The directional prominence and relative magnitude of the wind speed varies somewhat between summer and winter, with the summer months displaying the calmest winds relative to the winter season.

SEASONAL DISTRIBUTION OF WIND
REGION OF WATERLOO 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 Guelph

Pedestrian wind comfort and safety guidelines 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. Since both mean and gust wind speeds affect pedestrian comfort, their combined effect is defined in the City of Guelph Pedestrian Level Wind Studies Terms of Reference. Specifically, the criteria are defined as a Gust Equivalent Mean (GEM) wind speed, which is the greater of the mean wind speed or the gust wind speed divided by 1.85.

The wind speed ranges are based on the Beaufort scale, which describes the effects of forces produced by varying wind speed levels on objects. Four pedestrian comfort classes and corresponding gust wind speed ranges are used to assess pedestrian comfort: (1) Sitting; (2) Standing; (3) Walking; and (4) Uncomfortable. Specifically, the limiting criteria, associated wind speed ranges, and the colour coding for each comfort class are summarized in the following table:

PEDESTRIAN WIND COMFORT CLASS DEFINITIONS

Wind Comfort Class	GEM Speed (km/h)	Description
SITTING	≤ 10	GEM wind speeds no greater than 10 km/h occurring at least 80% of the time are considered acceptable for sedentary activities, including sitting.
STANDING	≤ 15	GEM wind speeds no greater than 15 km/h occurring at least 80% of the time are considered acceptable for activities such as standing, strolling, or more vigorous activities.
WALKING	≤ 20	GEM wind speeds no greater than 20 km/h occurring at least 80% of the time are considered acceptable for walking or more vigorous activities.
UNCOMFORTABLE	> 20	Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, are considered acceptable for moderate excesses of this criterion.

Regarding wind safety, gust wind speeds greater than 90 km/h, occurring more than 0.1% of the time on an annual basis (based on wind events recorded for 24 hours a day), are classified as dangerous. From calculations of stability, it can be shown that gust wind speeds of 90 km/h would be the approximate threshold wind speed that would cause an average elderly person in good health to fall.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if GEM wind speeds of 10 km/h were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if GEM wind speeds of 20 km/h at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established throughout the subject site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the 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 below. 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	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-4B, which illustrate wind conditions at grade level for the proposed and existing massing scenarios. 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. The details of these conditions are summarized below for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

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

Conditions over the sidewalks along Gordon Street with the existing massing are predicted to be suitable for a mix of sitting and standing throughout the year. With the existing massing, conditions in the vicinity of the nearby transit stops are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, during the winter. While the introduction of the proposed development produces slightly windier conditions along Gordon Street, conditions with the proposed development are nevertheless considered acceptable.

Existing Surface Parking Lots Across Gordon Street: Following the introduction of the proposed development, conditions over the existing surface parking lots to the west of the subject site across Gordon Street are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable.

With the existing massing, conditions over the noted surface parking lots are predicted to be suitable for standing, or better, throughout the year. While the introduction of the proposed development produces windier conditions over some areas of the noted surface parking, conditions over the parking lot to the southwest are predicted to improve in comparison to existing conditions, and conditions with the proposed development are nevertheless considered acceptable.

Sidewalks along Landsdown Drive: Prior to the introduction of the proposed development, conditions over the public sidewalks along Landsdown Drive are predicted to be suitable for mostly sitting during the summer, becoming suitable for standing, or better, during the winter. Notably, the introduction of the proposed development results in calmer conditions along Landsdown Drive in comparison to existing conditions, and the wind conditions with the proposed development are considered acceptable.

Outdoor Amenities within Subject Site: Wind conditions over the outdoor amenities situated at the northeast corner and to the south of the subject site are predicted to be suitable for sitting during the summer, as illustrated in Figure 3A. The noted conditions are considered acceptable.

Wind conditions over the central outdoor amenity situated between Apartment Buildings 1 and 2 are predicted to be suitable for mostly sitting, with isolated regions of conditions suitable for standing during the summer, as illustrated in Figure 3A. Where conditions are predicted to be suitable for standing, they are also predicted to be suitable for sitting for at least 77% of the time during the same period, where the target is 80% to achieve the sitting comfort criteria.

During the summer, conditions over the outdoor amenity to the north of Apartment Building 1 are predicted to be suitable for mostly sitting, with an isolated region of conditions suitable for standing to the east, while conditions over the outdoor amenity to the immediate northeast of Apartment Building 1 are predicted to be suitable for sitting over the majority of the space, with a region of conditions suitable for standing to the west. Where conditions are predicted to be suitable for standing, they are also predicted to be suitable for sitting for at least 76% of the time during the same period, where the target is 80% to achieve the sitting comfort criteria.

Depending on the programming of the central outdoor amenity and the outdoor amenities to the north and immediate northeast of Apartment Building 1, the noted conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, the noted conditions would be considered acceptable. If the programming of these spaces includes seating or lounging activities in the noted windier areas suitable for standing, comfort levels may be improved with landscaping features such as tall wind barriers or dense coniferous plantings that are targeted around sensitive areas within these spaces.

Driveway, Walkways, and Surface Parking within Subject Site: During the summer, wind conditions over the driveway, walkways, and surface parking within the subject site are predicted to be suitable for a mix of sitting and standing, becoming suitable for mostly standing, or better, during the winter. The noted conditions are considered acceptable.

Building Access Points: Wind comfort conditions in the vicinity of the building access points serving the proposed development are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, during the winter. The noted conditions are considered acceptable.

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 or surrounding the subject site are expected 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 (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 of this report and illustrated in Figures 3A-4B. Based on computer simulations using the CFD technique, meteorological data analysis of the Guelph area wind climate, City of Guelph wind comfort and safety criteria, 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, wind conditions over surrounding sidewalks, transit stops, the nearby existing surface parking lots, the proposed driveway, walkways, surface parking, grade-level outdoor amenities, and in the vicinity of building access points are considered acceptable. The areas that are predicted to experience windier conditions are described as follows:

    a. **Central Outdoor Amenity and Amenities to the North and Northeast of Apartment Building 1**. During the summer, conditions over the central outdoor amenity and the outdoor amenity to the north of Apartment Building 1 are predicted to be suitable for mostly sitting, with isolated regions of conditions suitable for standing, while conditions over the outdoor amenity to the northeast of Apartment Building 1 are predicted to be suitable for sitting over the majority of the area, with an isolated region of conditions suitable for standing to the west.

        - Depending on the programming of the noted spaces, the noted conditions may be considered acceptable. Specifically, if the noted windier areas will not accommodate seating or lounging activities, the predicted wind comfort conditions would be considered acceptable.

        - If the programming of these spaces includes seating or lounging activities in the isolated windier areas suitable for standing, comfort levels may be improved with landscaping features such as tall wind barriers or dense coniferous plantings that are targeted around sensitive areas within these spaces.

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 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
J. D. FERRARO
100158495
Nov 23, 2023
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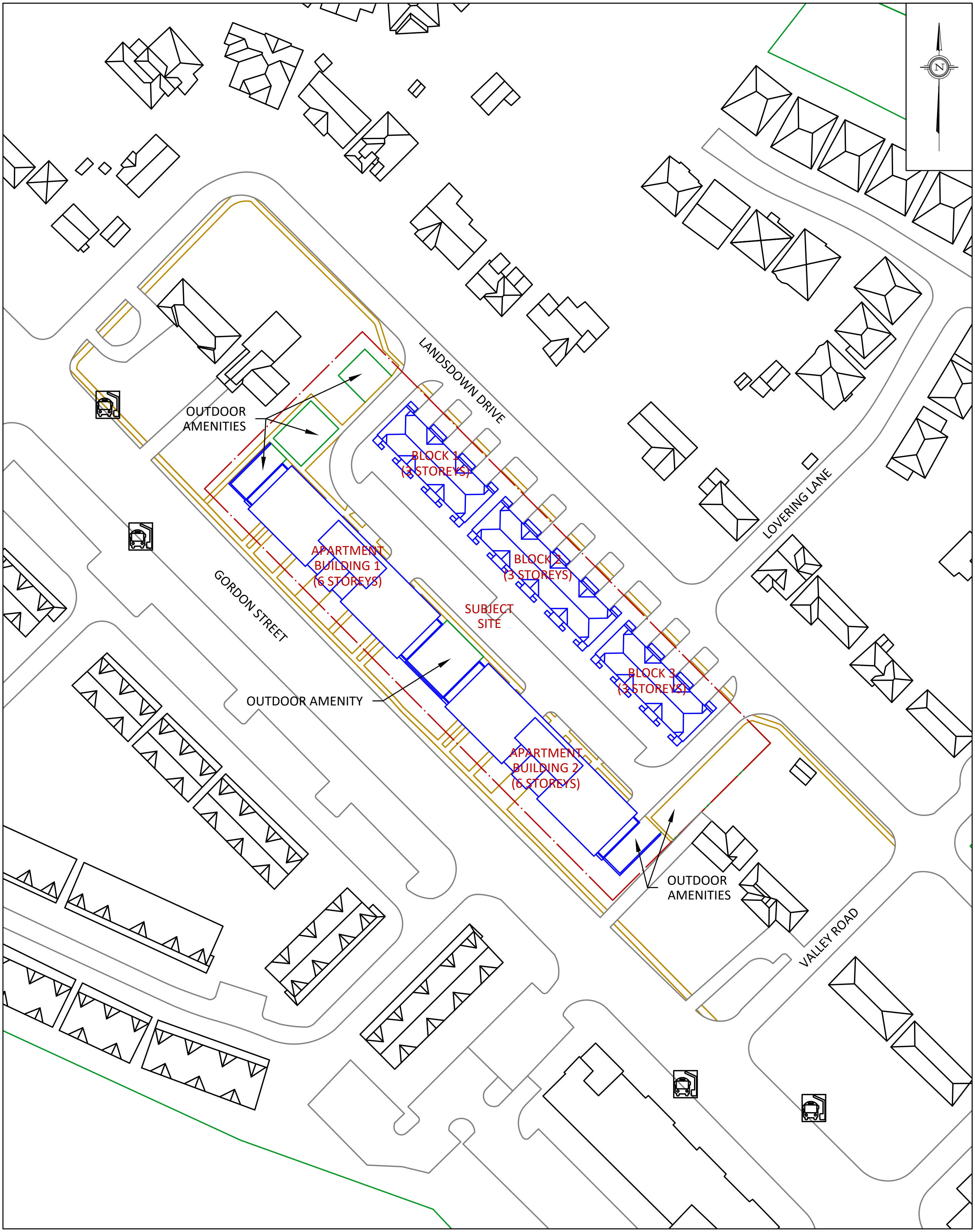

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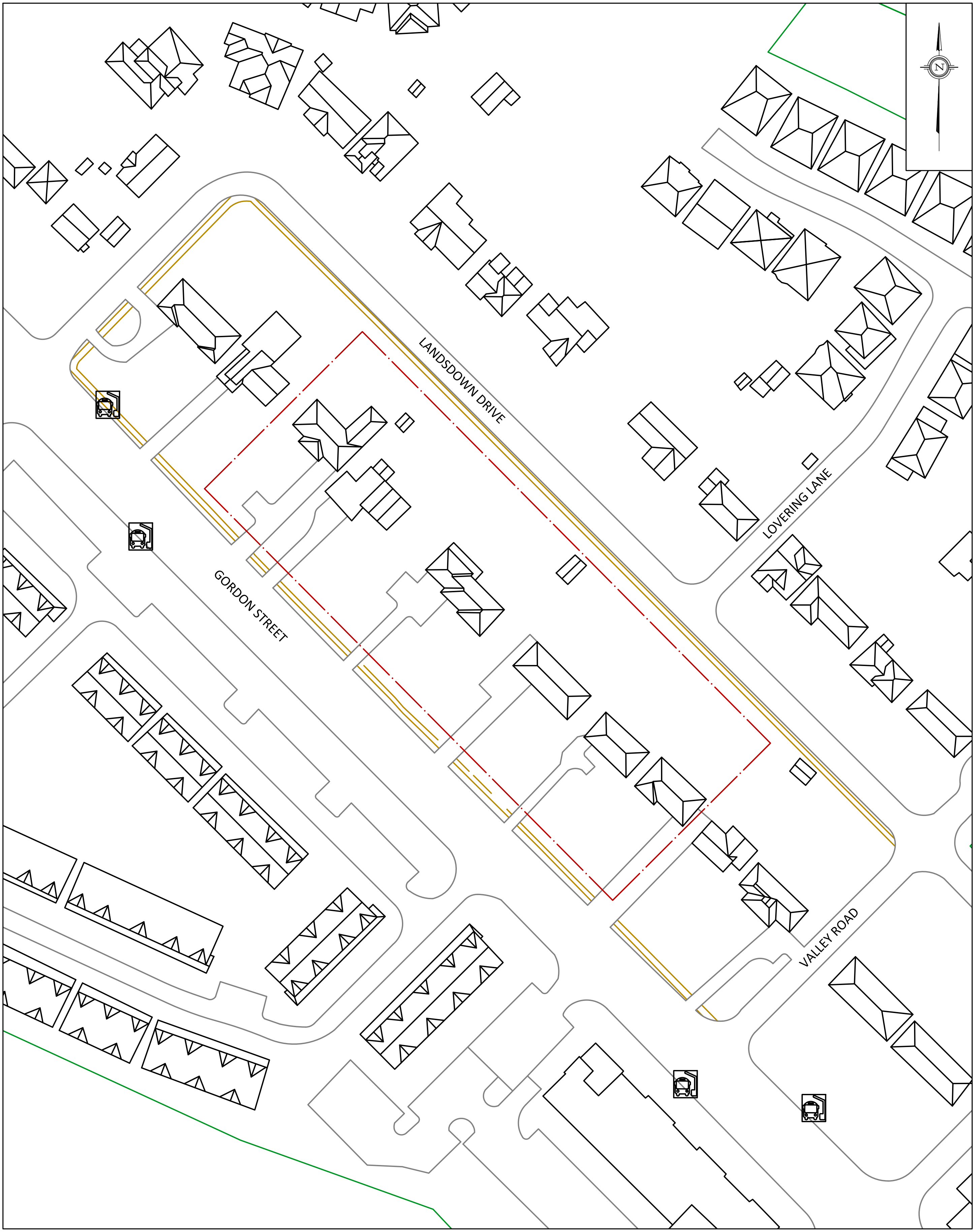
PROJECT		DESCRIPTION
1166-1204 GORDON STREET, GUELPH PEDESTRIAN LEVEL WIND STUDY		FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:1500	DRAWING NO.: 21-378-PLW-2023-1A	
DATE: NOVEMBER 22, 2022	DRAWN BY: T.K.	



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PROJECT	1166-1204 GORDON STREET, GUELPH PEDESTRIAN LEVEL WIND STUDY	
SCALE	1:1500	DRAWING NO. 21-378-PLW-2023-1B
DATE	NOVEMBER 22, 2022	DRAWN BY T.K.

DESCRIPTION
FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

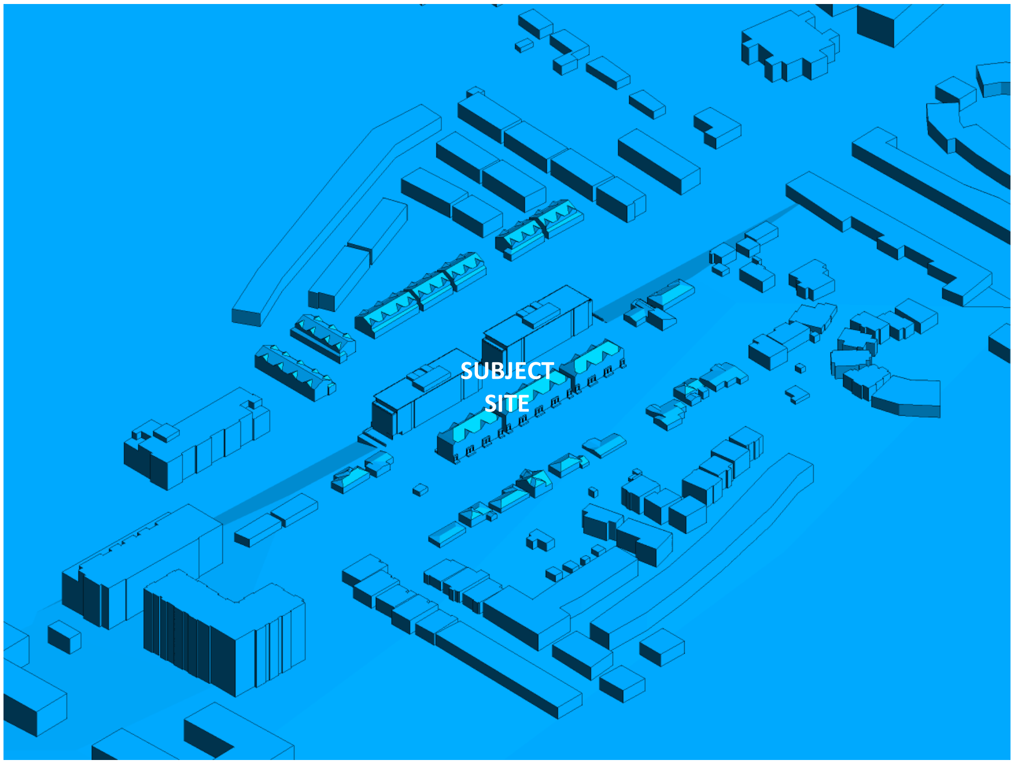


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, EAST PERSPECTIVE

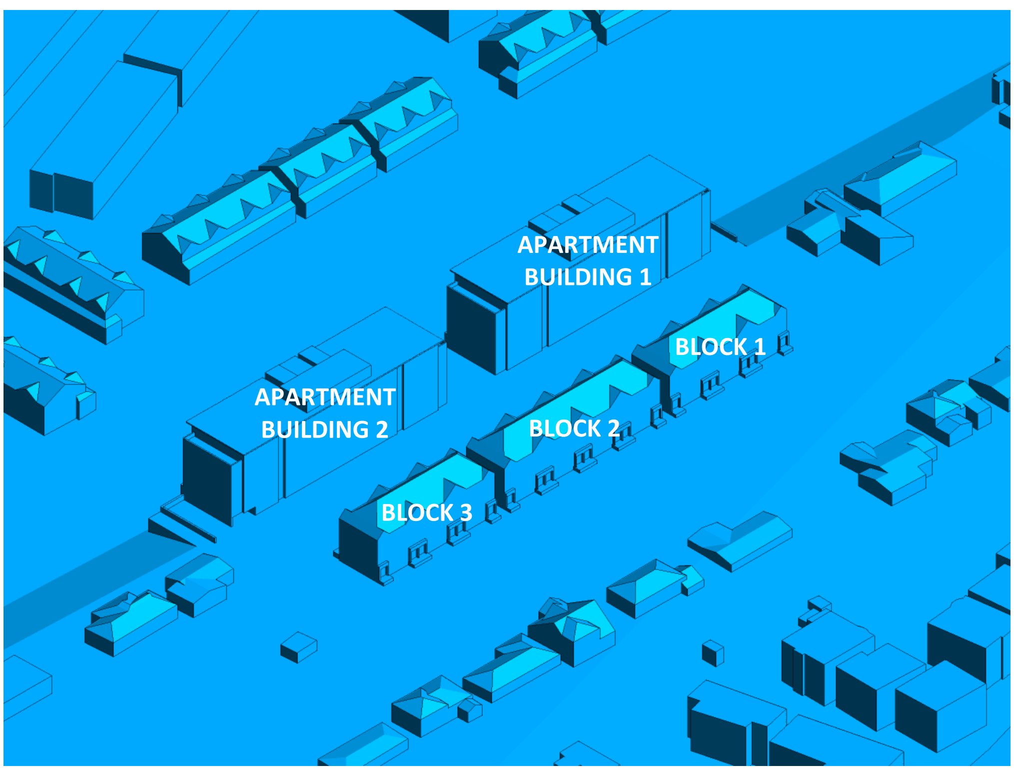


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

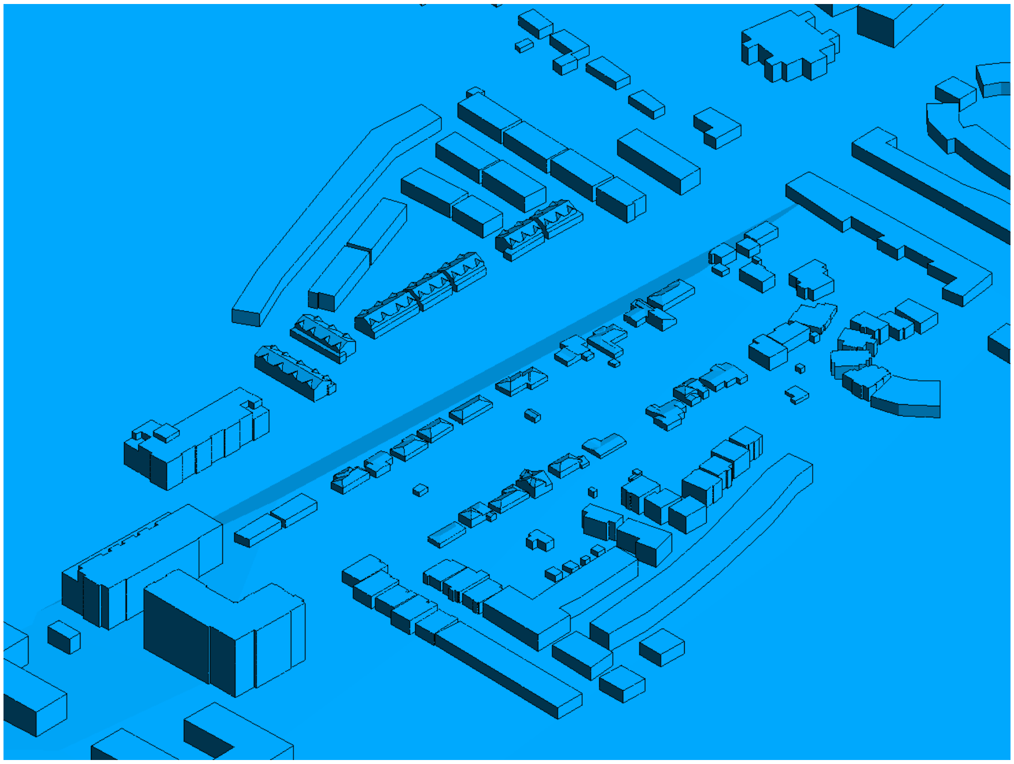


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, EAST PERSPECTIVE

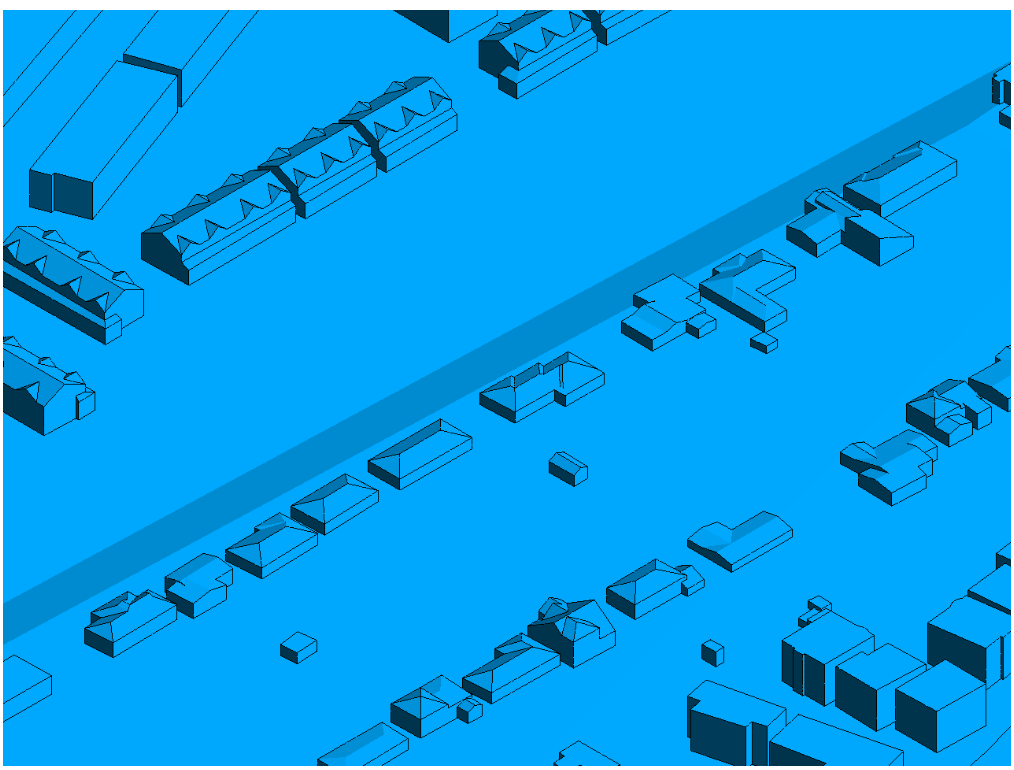


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

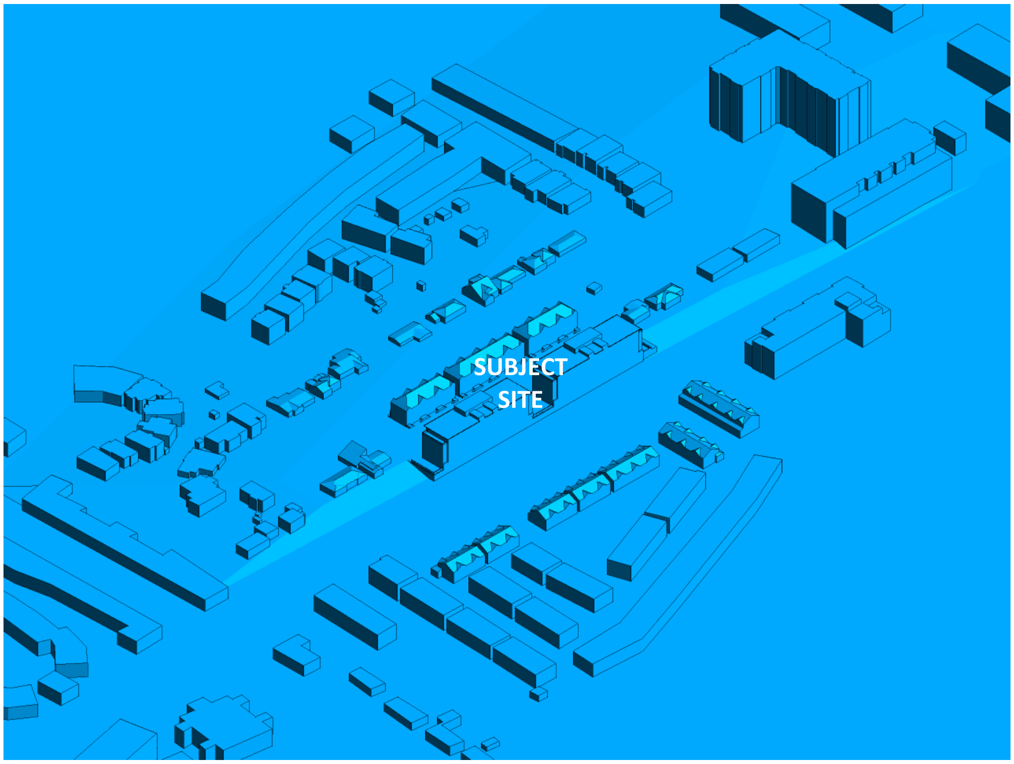


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, WEST PERSPECTIVE

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

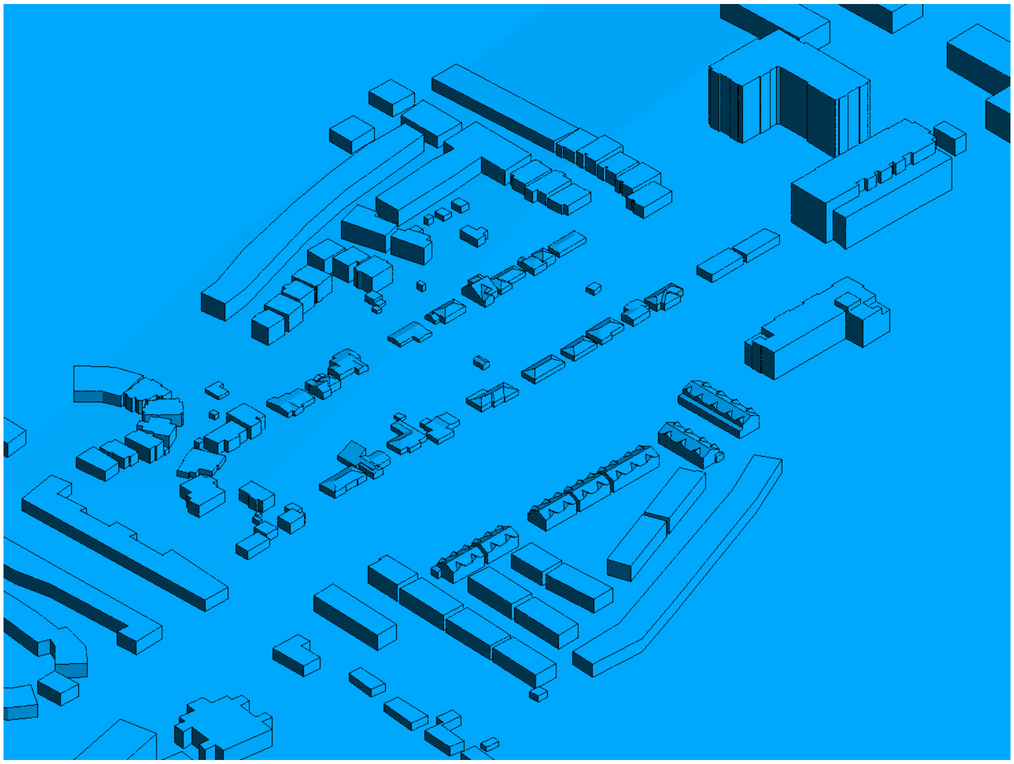


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, WEST PERSPECTIVE

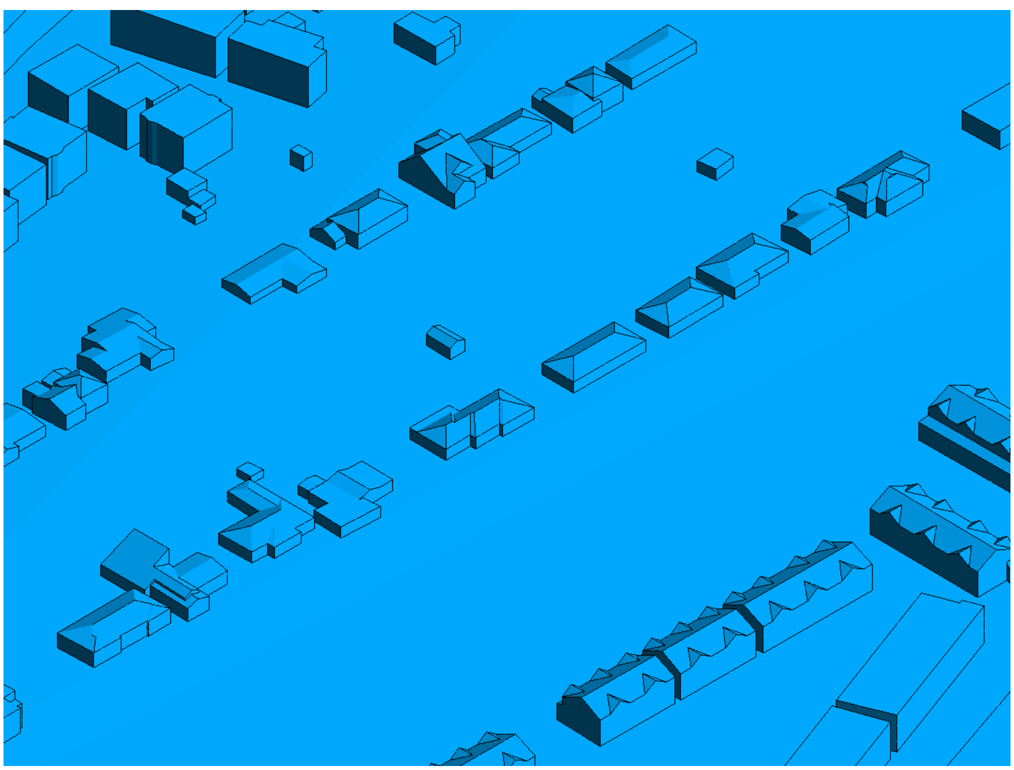


FIGURE 2H: CLOSE-UP VIEW OF FIGURE 2G

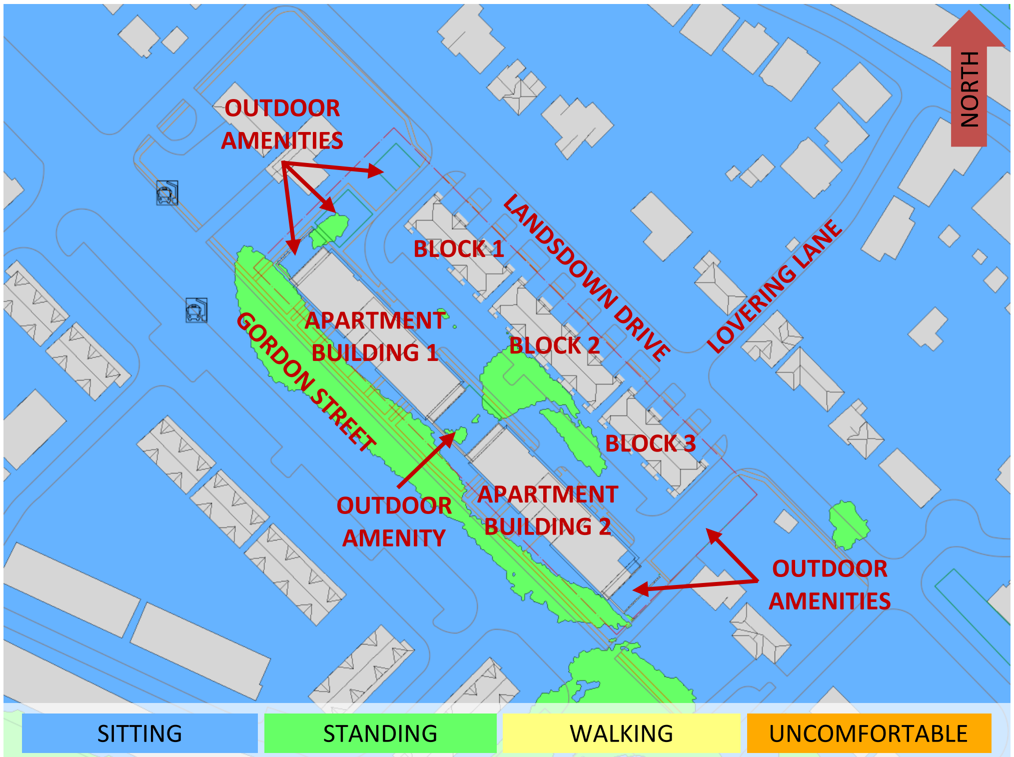


FIGURE 3A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

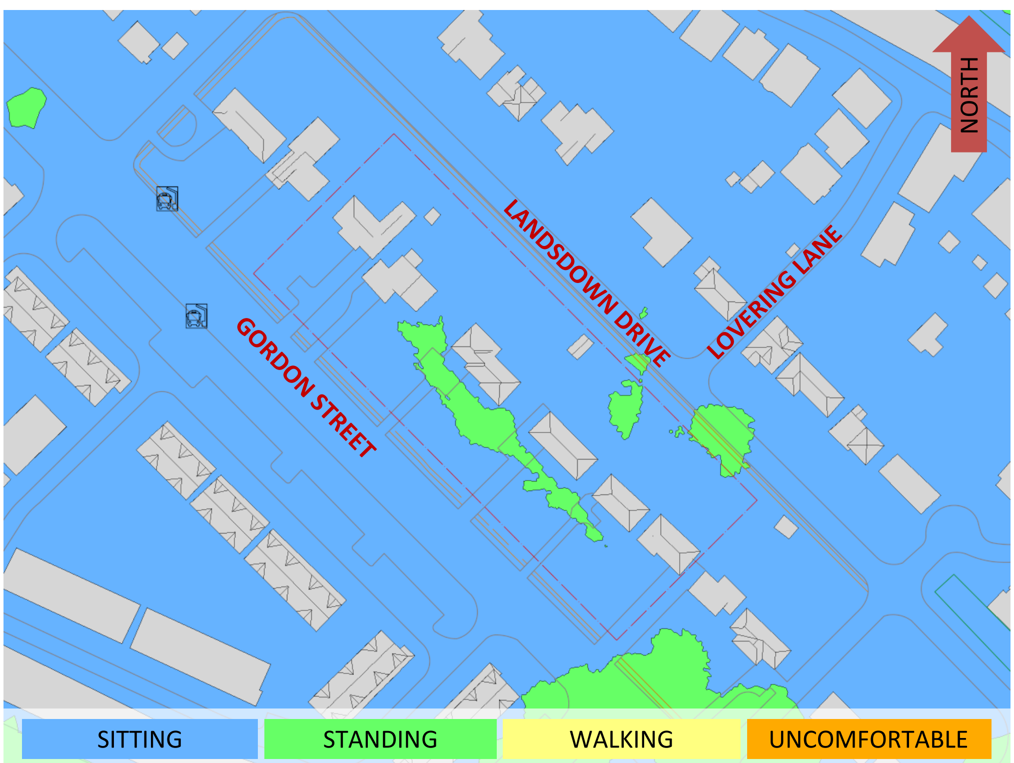


FIGURE 3B: SUMMER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING

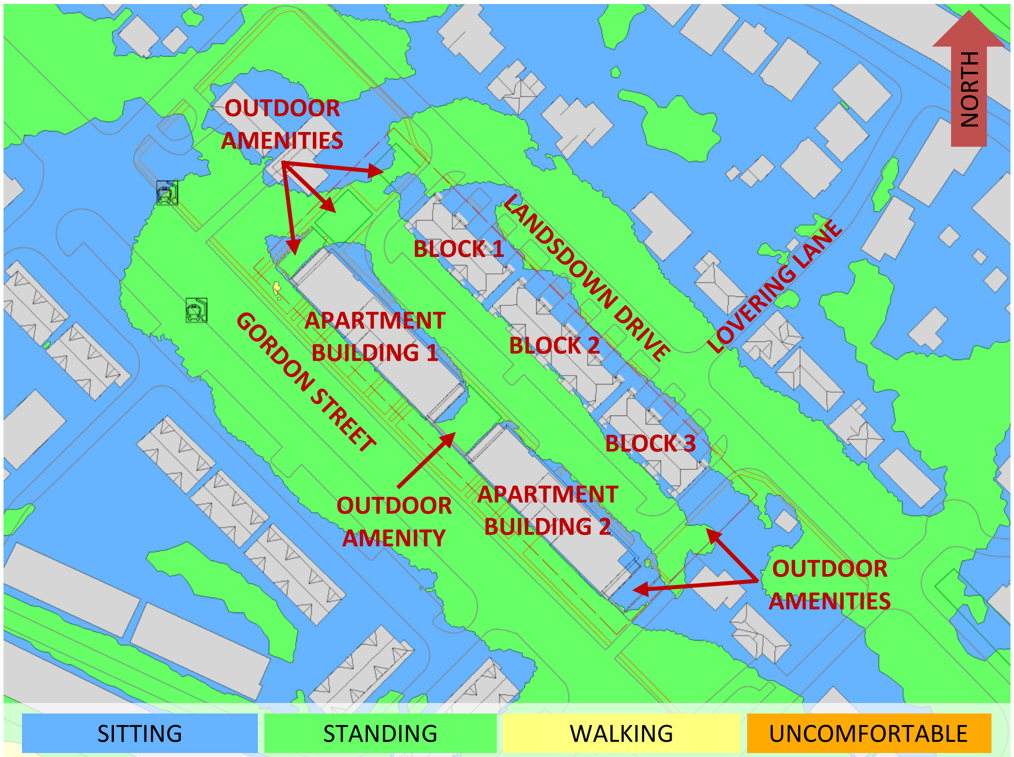


FIGURE 4A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

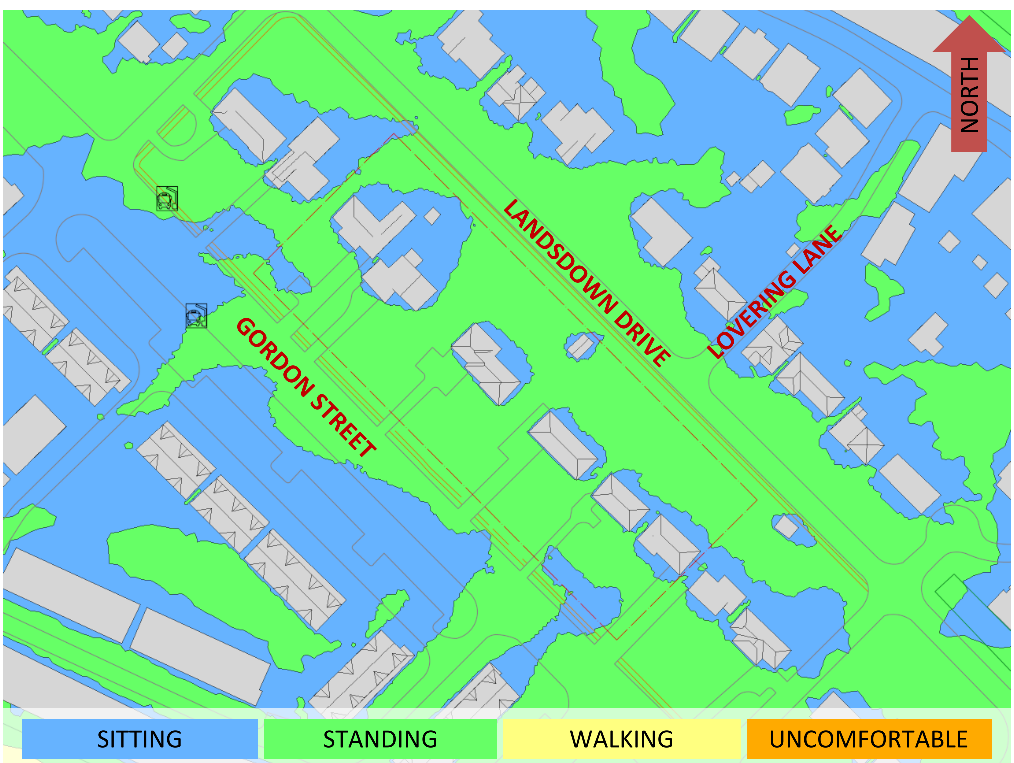
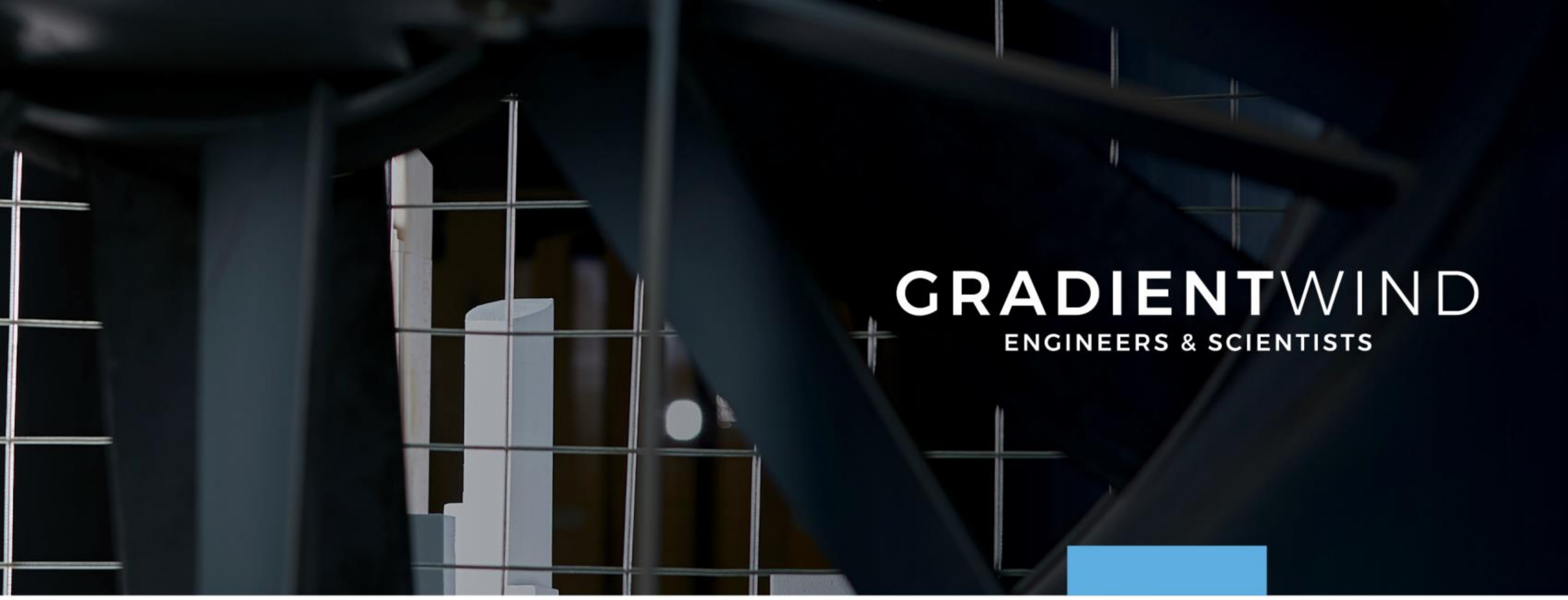
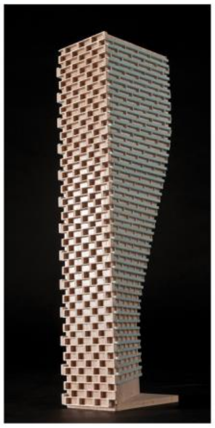
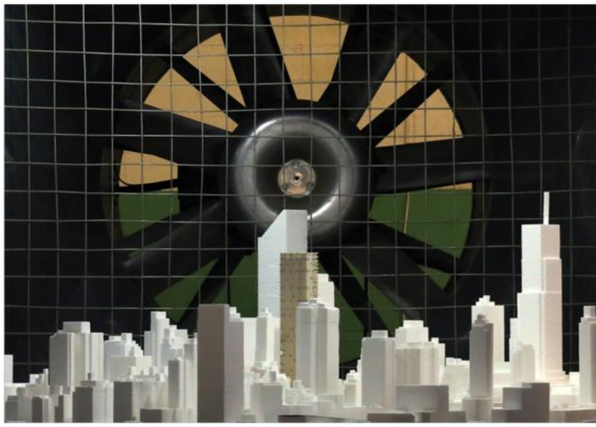


FIGURE 4B: WINTER – WIND COMFORT, GRADE LEVEL – EXISTING MASSING







APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

where, $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = depth of the boundary layer (gradient height), and α is the power law exponent.

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 85% mean wind speed for Guelph based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

Z_g is set to 540 m. The selection of gradient height is relatively unimportant, so long as it exceeds the building heights surrounding the subject site. The value has been selected to correspond to our physical wind tunnel reference value.

α is determined based on the upstream exposure of the far-field surroundings (i.e., the area that it not captured within the simulation model).

Table 1 presents the values of α used in this study, while Table 2 presents several reference values of α. When the upstream exposure of the far-field surroundings is a mixture of multiple types of terrain, the α values are a weighted average with terrain that is closer to the subject site given greater weight.

TABLE 1: UPSTREAM EXPOSURE (ALPHA VALUE) VS TRUE WIND DIRECTION

Wind Direction (Degrees True)	Alpha Value (α)
0	0.22
59	0.20
93	0.22
130	0.23
180	0.21
208	0.21
230	0.23
251	0.23
272	0.23
291	0.24
308	0.24
328	0.23

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

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

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

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

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

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

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

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.