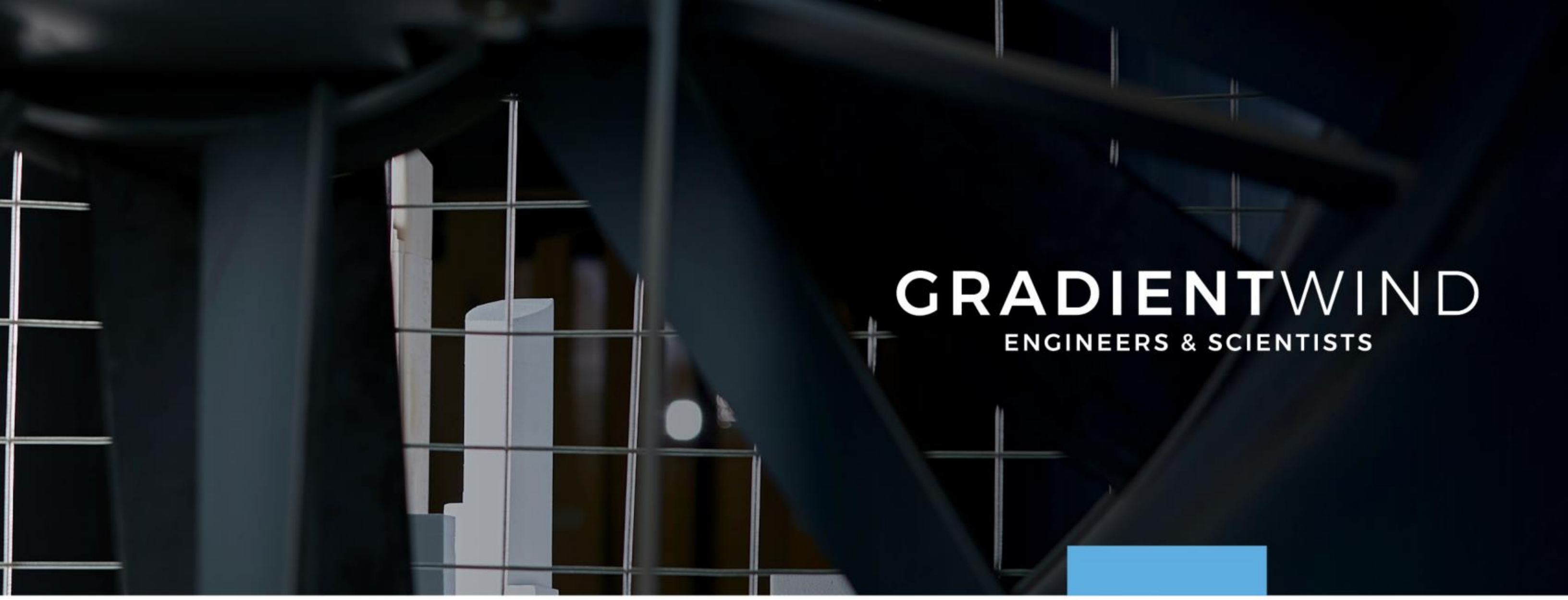
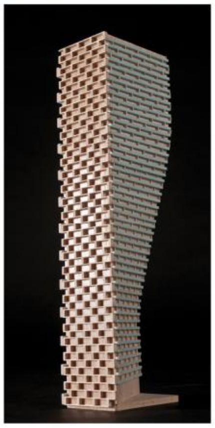
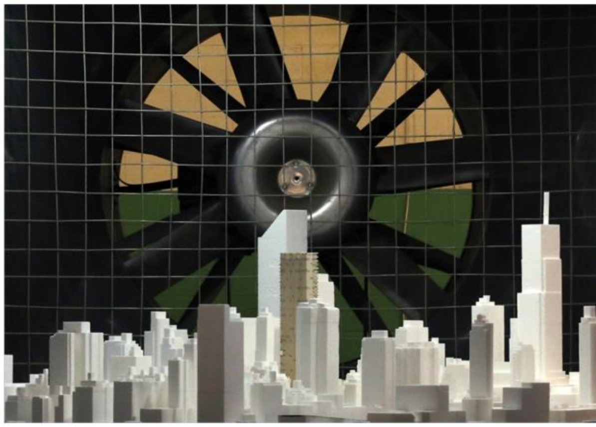


PEDESTRIAN LEVEL WIND STUDY

Park Place
Barrie, Ontario

Report: 21-417-PLW





April 21, 2022

PREPARED FOR
Park Place Co-Ownership
2851 John Street, Suite 1
Markham, ON L3R 5R7

PREPARED BY
Edward Urbanski, M.Eng., Wind Scientist
Steven Hall, M.A.Sc., P.Eng., Senior Wind Engineer

EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application submission requirements for the proposed multi-phase residential development, referred to as "Park Place", located at the intersection of Live Eight Way and South Village Way in Barrie, Ontario (hereinafter referred to as the "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. A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-8, and is summarized as follows:

1) All grade-level areas within and surrounding the subject site are predicted to receive conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, wind conditions over the surrounding sidewalks, surface parking lots, building access points, and the pocket parks are considered acceptable.

2) Conditions over the elevated amenity terraces serving the proposed development are predicted to be suitable for sitting during the typical use period of late spring through early autumn, which is considered acceptable.

3) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (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.

Addendum: The architectural drawings for the proposed development were updated following the completion of the PLW study. The current architectural drawings[1], prepared by Petroff Partnership Architects, are similar to the original architectural drawings[2] that were used to complete the PLW study. Therefore, the results and recommendations of the present study are also applicable to the current architectural design.

[1] Petroff Partnership Architects, "*Proposed Multi-Unit Residential Development Park Place Barrier – Issued for OPA & ZBA*", [Apr 15, 2022]
[2] Petroff Partnership Architects, "*Proposed Multi-Unit Residential Development Park Place Barrier – Issued for Coordination*", [Jan 27, 2022]

GRADIENTWIND
ENGINEERS & SCIENTISTS

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Park Place Co-Ownership to undertake a pedestrian level wind (PLW) study to satisfy Zoning By-law Amendment application submission requirements for the proposed multi-phase residential development, referred to as “Park Place”, located at the intersection of Live Eight Way and South Village Way in Barrie, Ontario (hereinafter referred to as the “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, industry standard wind comfort and safety guidelines, architectural drawings prepared by Petroff Partnership Architects, in January 2022, surrounding street layouts and existing and approved future building massing information obtained from the City of Barrie, recent satellite imagery, and experience with numerous similar developments.

2. TERMS OF REFERENCE

The subject site is located to the west of the intersection of Live Eight Way and South Village Way in Barrie, Ontario. The proposed residential development comprises multiple phases. South Village Way intersects east-west of the subject site, with Phase 1 located to the north and Phase 2 to the south of South Village Way. Phase 1 is further divided into Phases 1A and 1B, which are located to the northwest and northeast of the subject site, respectively.

Rendering, Southwest Perspective
(Courtesy of Petroff Partnership Architects)

Phase 1A + 1B

Phase 1 comprises two buildings, referred to as Phase 1A and 1B, rising to six and sixteen storeys, respectively, linked by a four-storey 'L'-shaped podium that begins on Level 2. Above three below-grade parking levels, the ground floors for both Phases 1A and 1B include a main residential entrance and indoor amenity to the east, shared building support spaces, and commercial spaces throughout the remainder of the level. Loading space is located at the east of Phase 1A and the north of Phase 1B. A pocket park is to the north of Phase 1A, and surface parking is to the north of Phase 1B. Access to underground parking is provided by a ramp at the east of Phase 1A via a laneway from South Village Way. Level 6 includes indoor amenity to the southeast of Phase 1A. The central outdoor amenity on this level is shared by both buildings. Phase 1B comprises a typical rectangular floorplan which begins from Level 6 and continues to upper levels. Both Phase 1A and 1B include residential units from Level 2 and above.

Phase 2

Phase 2 comprises two rectangular buildings, a Southwest Building and Southeast Building, rising to six and twelve storeys, respectively, linked by a four-storey podium that begins on Level 2. Above two below-grade parking levels, the ground floor of the Southeast Building includes a main residential entrance and lobby to the east, commercial space to the west, as well as loading space and shared building support spaces to the south, while the Southwest Building is reserved for commercial spaces with loading space at the southeast corner. Access to below-grade parking is provided by a ramp at the southeast corner of the Southeast Building via a laneway from South Village Way. A pocket park is to the south of the Southwest Building and surface parking is to the south of the Southeast Building. The central outdoor amenity on this level is shared by both buildings. The Southeast Building comprises a typical rectangular floorplan which begins from Level 6 and continues to upper levels. Both Phase 2 buildings include residential units from Level 2 and above.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within 200-metre (m) of the site) are characterized by low-rise commercial buildings and paved parking lots in all compass directions. The far-field surroundings (defined as the area beyond the near field and within a 2-kilometre (km) radius) comprise a mix of low-rise commercial buildings and green space from the north-northwest clockwise to the west, and a mix of low-rise residential buildings and green space in the remaining compass directions. Notably, the largest green spaces are located from the east clockwise to the south and from the west clockwise to the northwest. Highway 400 runs north-south approximately 350 m to the west 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 any changes which have been approved by the City of Barrie.

3. OBJECTIVES

The principal objectives of this study are to: (i) determine comparative pedestrian level wind comfort and safety conditions at key outdoor areas; (ii) identify areas where future 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 Barrie wind climate, and synthesis of computational data with industry-accepted guidelines. The following sections describe the analysis procedures, including a discussion of the comfort guidelines.

4.1 Computer-Based Context Modelling

A computer based PLW wind study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development. 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 Lake Simcoe Regional Airport.

The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly more conservative (i.e., windier) 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 site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a diameter of approximately 1.1 km.

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 on a continuous measurement plane 1.5 m above local grade and the common amenity terraces were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. The 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 CFD wind flow simulation technique are presented in Appendix A.

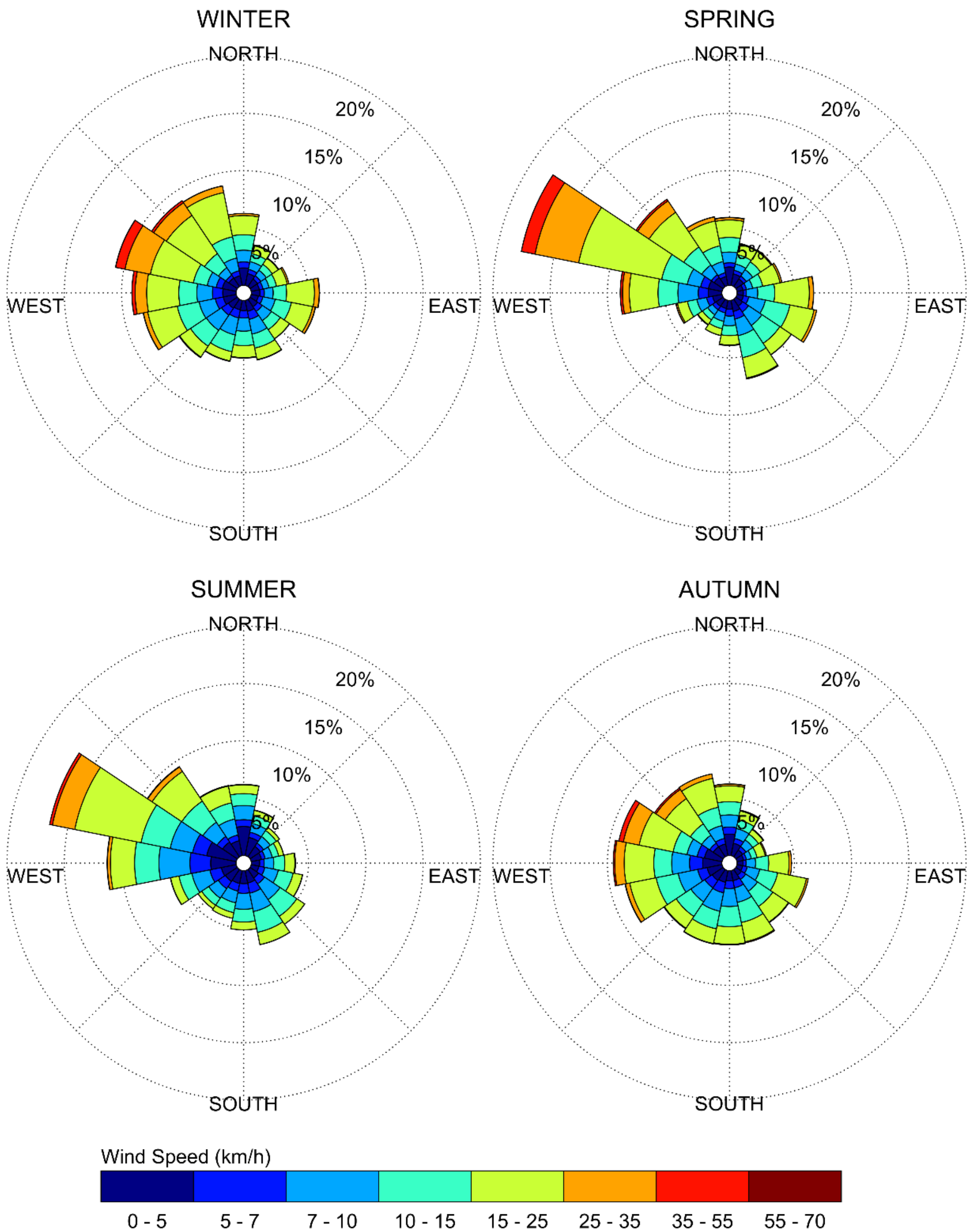
4.3 Meteorological Data Analysis

A statistical model for winds in Barrie was developed from approximately 18 years of hourly meteorological wind data recorded at Lake Simcoe Regional 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. Based on this portion of analysis, the four seasons are represented by grouping data from consecutive months based on similarity of weather patterns, and not according to the traditional calendar method; spring is defined as April-May, summer as June-September, autumn as October-November, and winter as December-March.

The statistical model of the Barrie 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 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 Barrie, the most common winds concerning pedestrian comfort occur from the west clockwise to the north. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying the calmest winds relative to the remaining seasonal periods.

Additionally, a second model was developed from approximately twenty years of similar data recorded at the Centre for Atmospheric Research Experiments in Egbert, which lies to the southwest of Barrie, whereas the Lake Simcoe Airport lies to the northeast of Barrie. The results of the second model exhibited generally lower wind speeds since the Lake Simcoe Airport is more exposed to prominent winds from Georgian Bay. Since the Lake Simcoe Airport data produce more conservative results, the results of the second model are not presented in this report.

SEASONAL DISTRIBUTION OF WIND
LAKE SIMCOE REGIONAL AIRPORT, ORO-MEDONTE, ONTARIO



Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in km/h, measured at 10 m above the ground.

4.4 Pedestrian Comfort and Safety Guidelines

Pedestrian comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, 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 80% non-exceedance gust wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated gust wind speed ranges are summarized as follows:

(i) **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.

(ii) **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.

(iii) **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.

(iv) **Walking** – Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 30 km/h.

(v) **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 comfort class.

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 greater than 90 km/h is classified as dangerous. The wind speeds associated with the above categories are gust wind speeds. 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	Wind Speed (km/h) Gust	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 80% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if wind speeds of 16 km/h were exceeded for more than 20% of the time, most pedestrians would judge that location to be too windy for sitting or more sedentary activities. Similarly, if 30 km/h at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As most of 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 (During Typical Use Period)
Café / Patio / Bench / Garden	Sitting (Typical Use Period)
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting (Typical Use Period)
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 3A-6B, illustrating wind conditions at grade level for the proposed and existing massing scenarios, and Figures 7A-7D, illustrating wind conditions over the common amenity terraces. 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 conditions are also reported for the typical use period, which is defined as May to October, inclusive. Figure 8 illustrates wind comfort conditions over the amenity terraces during this period, consistent with the comfort classes in Section 4.4.

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

5.1 Wind Comfort Conditions – Grade Level

Sidewalks along South Village Way: Following the introduction of the proposed development, conditions over the sidewalk along South Village Way are predicted to be suitable for a mix of sitting and standing during the summer, autumn, and winter, becoming suitable for a mix of sitting, standing, and strolling during the spring. The noted conditions are considered acceptable according to the comfort guidelines.

Conditions over the sidewalk with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the remaining two seasons. While the introduction of the proposed development results in windier conditions, in comparison to existing conditions, wind conditions with the proposed development are considered acceptable.

Sidewalks along Live Eight Way: Following the introduction of the proposed development, conditions over the sidewalk along Live Eight Way are predicted to be suitable for a mix of sitting and standing during the summer and autumn, becoming suitable for a mix of sitting, standing, and strolling during the spring and winter. The noted conditions are considered acceptable according to the comfort guidelines.

Conditions over the sidewalk with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the spring and winter. While the introduction of the proposed development results in windier conditions, in comparison to existing conditions, wind conditions with the proposed development are considered acceptable.

Sidewalks along West Elevation: Following the introduction of the proposed development, conditions over the sidewalk along the west elevation are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the spring and winter. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Conditions over the sidewalk with the existing massing are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the spring and winter. While the introduction of the proposed development results in slightly windier conditions, in comparison to existing conditions, wind conditions with the proposed development are considered acceptable.

Passageway beneath Phase 1: Conditions over the passageway which runs beneath the podium of Phase 1 are predicted to be suitable for a mix of sitting and standing during the summer and autumn, becoming suitable for a mix of standing and strolling during the spring and winter. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Passageway beneath Phase 2: Conditions over the passageway which runs beneath the podium of Phase 1 are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for mostly standing throughout the remainder of the year. The noted conditions are considered acceptable according to the comfort guidelines.

Pocket Park along North Elevation of Phase 1A: Conditions over the pocket park along the north elevation of Phase 1A are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the comfort guidelines.

Pocket Park along South Elevation of Phase 1A: Conditions over the pocket park along the south elevation of Phase 2 are predicted to be suitable for sitting during the typical use period of late spring through early autumn. The noted conditions are considered acceptable according to the comfort guidelines.

Surface Parking along North Elevation of Phase 1B: Conditions over the surface parking lot along the north elevation of Phase 1B are predicted to be suitable for sitting during the summer, becoming suitable for mostly standing throughout the remainder of the year. The noted conditions are considered acceptable according to the comfort guidelines.

Surface Parking along South Elevation of Phase 2: Conditions over the surface parking lot along the south elevation of Phase 2 are predicted to be suitable for sitting during the summer and autumn, becoming suitable for a mix of sitting and standing during the spring and winter. The noted conditions are considered acceptable according to the comfort guidelines.

Building Access Points: Conditions in the vicinity of building entrances serving the proposed development are predicted to be suitable for standing, or better, throughout the year. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4. Notably, while there is a region along the east façade of Phase 1A which is predicted to be suitable for strolling during the spring and winter, as illustrated in Figures 3A and 6A, there is no entrance planned in this area.

5.2 Wind Comfort Conditions – Common Amenity Terraces

Level 6 Common Amenity Terrace (Phase 1A & 1B): Conditions over the common amenity terrace serving the Phase 1A & 1B buildings at Level 6 are predicted to be suitable for sitting during the typical use period of late spring through early autumn. The noted conditions are considered acceptable according to the comfort guidelines in Section 4.4.

Level 6 Common Amenity Terrace (Phase 2): Conditions over the common amenity terrace serving the Phase 2 building at Level 6 are predicted to be suitable for sitting during the typical use period. The noted conditions are considered acceptable according to the comfort guidelines.

5.3 Wind Safety

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

5.4 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (i.e., construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

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

6. SUMMARY AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-8. Based on computer simulations using the CFD technique, meteorological data analysis of the Barrie wind climate, industry standard wind comfort and safety guidelines, 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 receive conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, wind conditions over the surrounding sidewalks, surface parking lots, building access points, and the pocket parks are considered acceptable.

2) Conditions over the elevated amenity terraces serving the proposed development are predicted to be suitable for sitting during the typical use period of late spring through early autumn, which is considered acceptable.

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

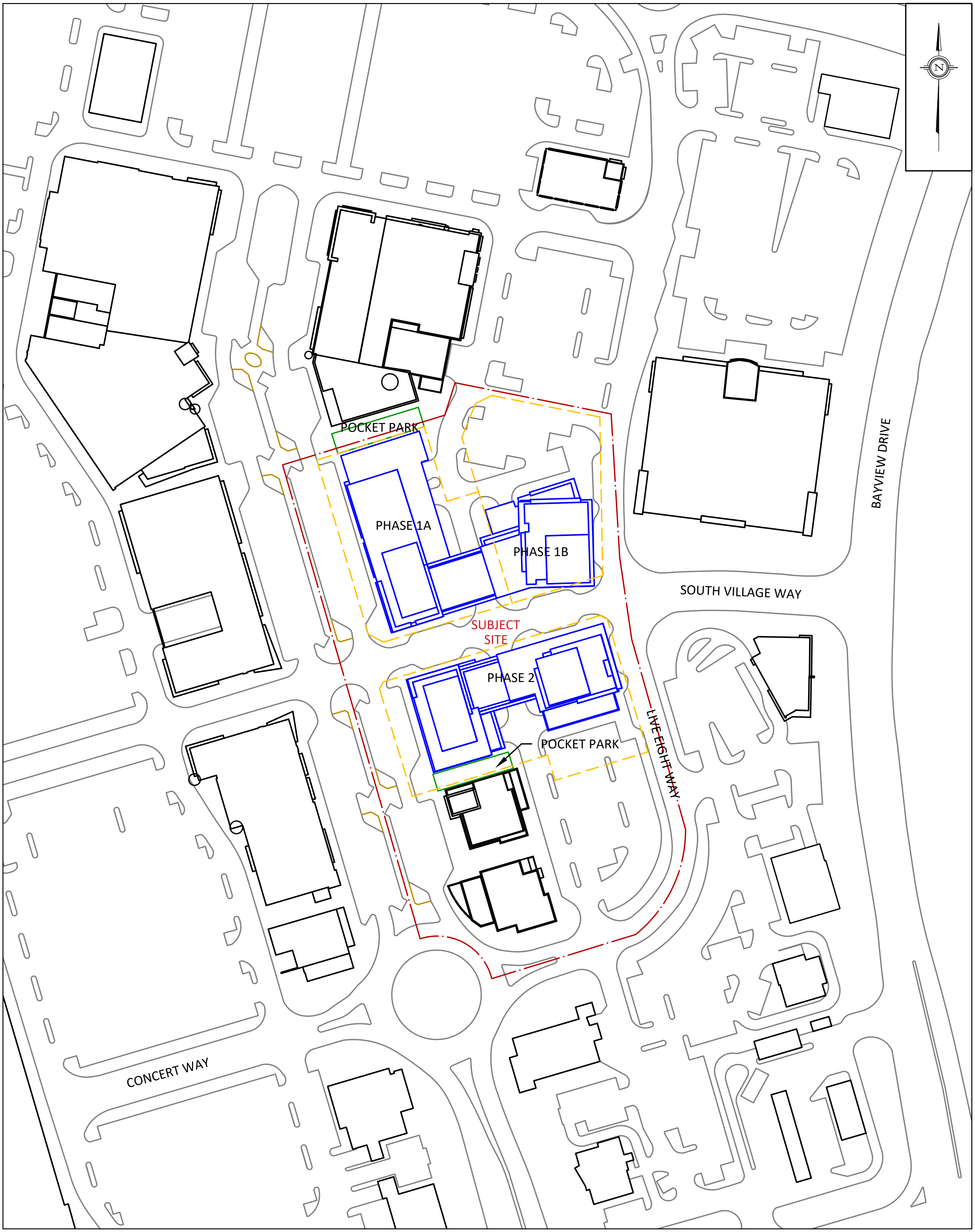
Sincerely,

Gradient Wind Engineering Inc.

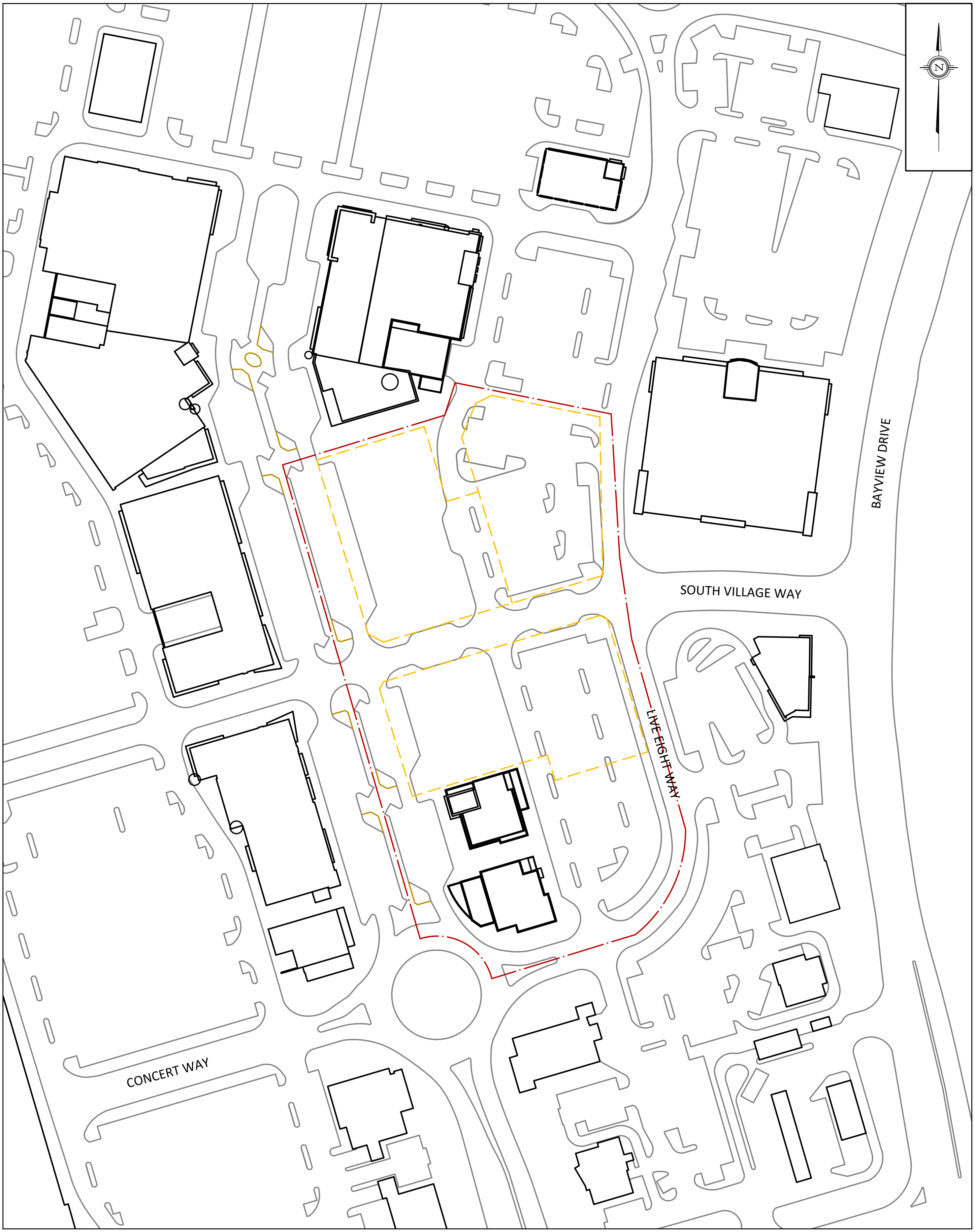
LICENSED PROFESSIONAL ENGINEER
S. R. HALL
100197168
Apr 21, 2022
PROVINCE OF ONTARIO

Edward Urbanski, M.Eng.
Wind Scientist

Steven Hall, M.A.Sc., P.Eng.
Senior Wind Engineer



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: PARK PLACE, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE: 1:2000	DRAWING NO.: 21-417-PLW-1A	
	DATE: JANUARY 31, 2022	DRAWN BY: S.K.	



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PROJECT: PARK PLACE, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT	
SCALE: 1:2000	DRAWING NO.: 21-417-PLW-1B		
DATE: JANUARY 31, 2022	DRAWN BY: S.K.		

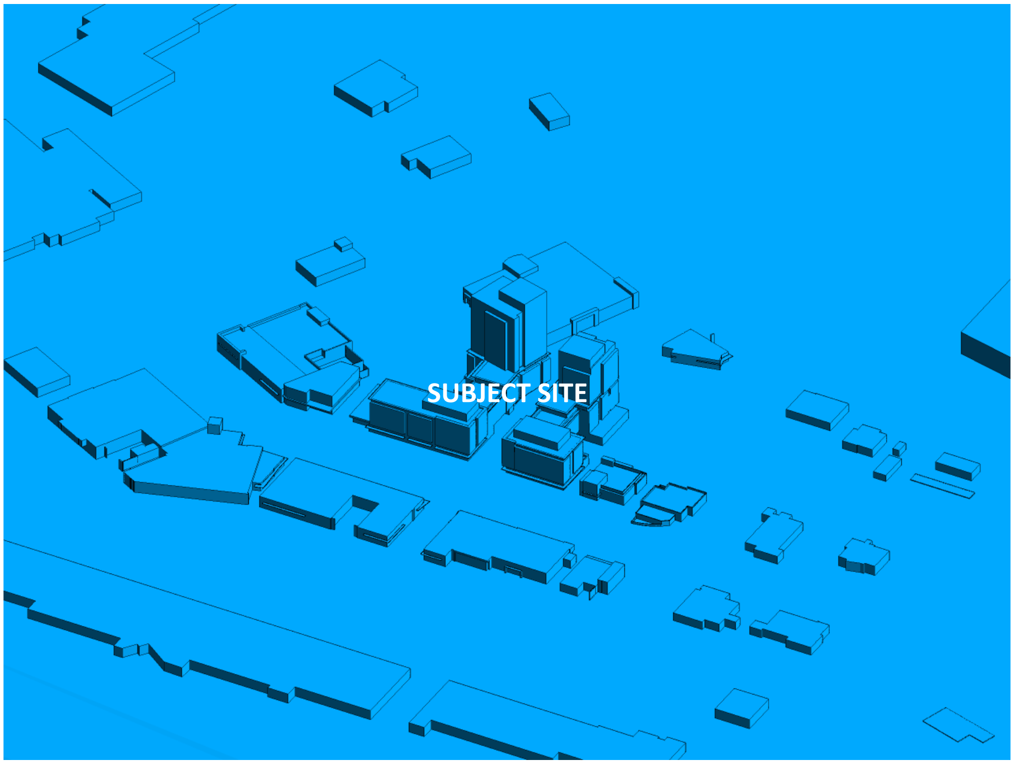


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTHWEST PERSPECTIVE

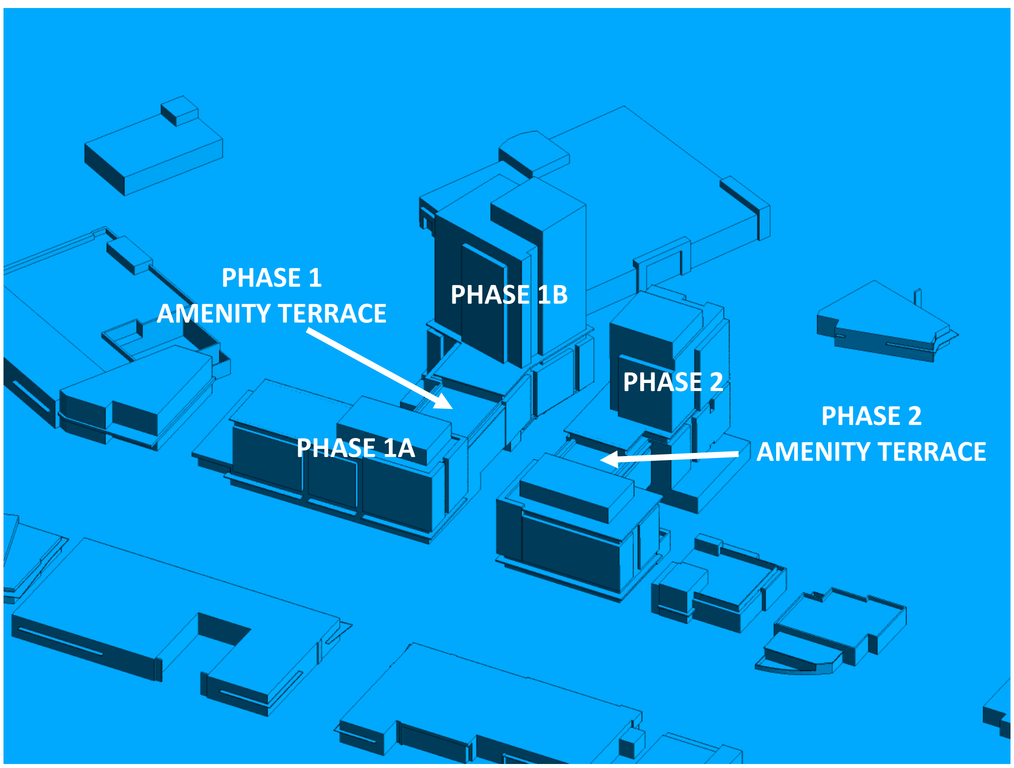


FIGURE 2B: CLOSE UP OF FIGURE 2A

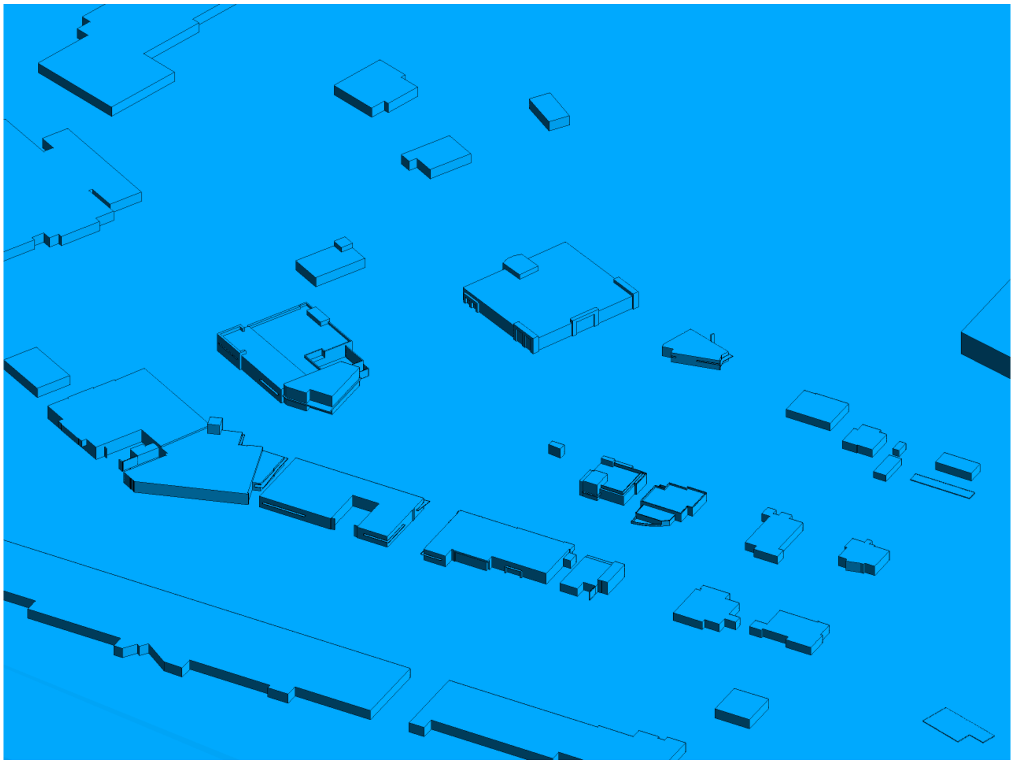


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTHWEST PERSPECTIVE

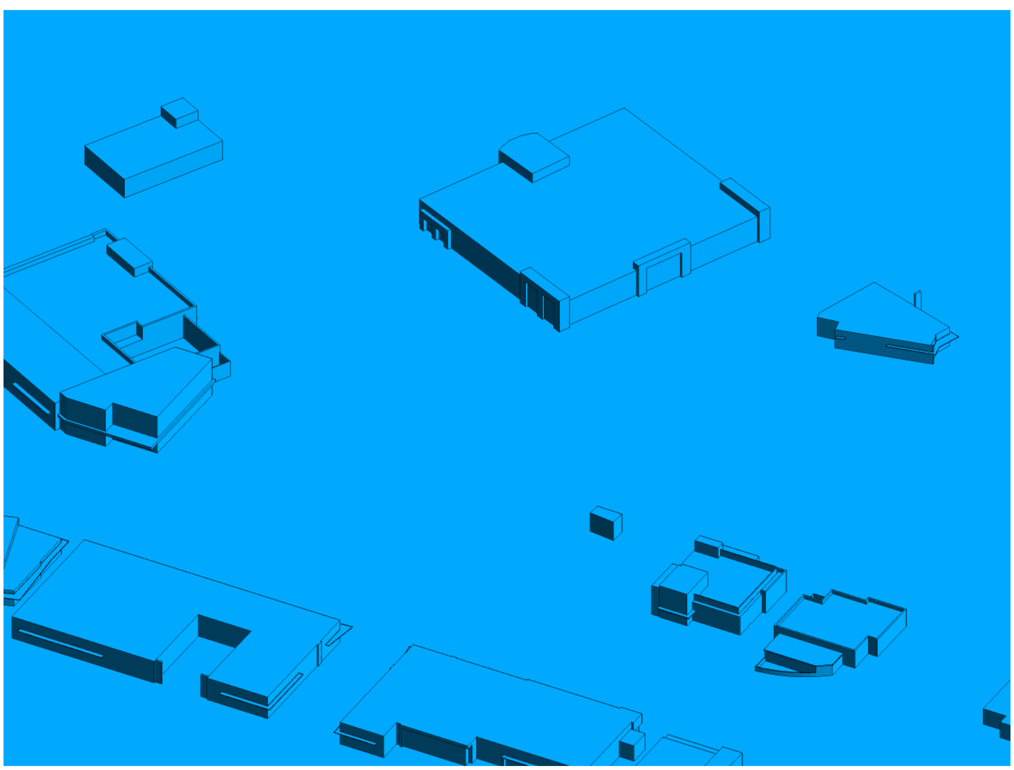


FIGURE 2D: CLOSE UP OF FIGURE 2C

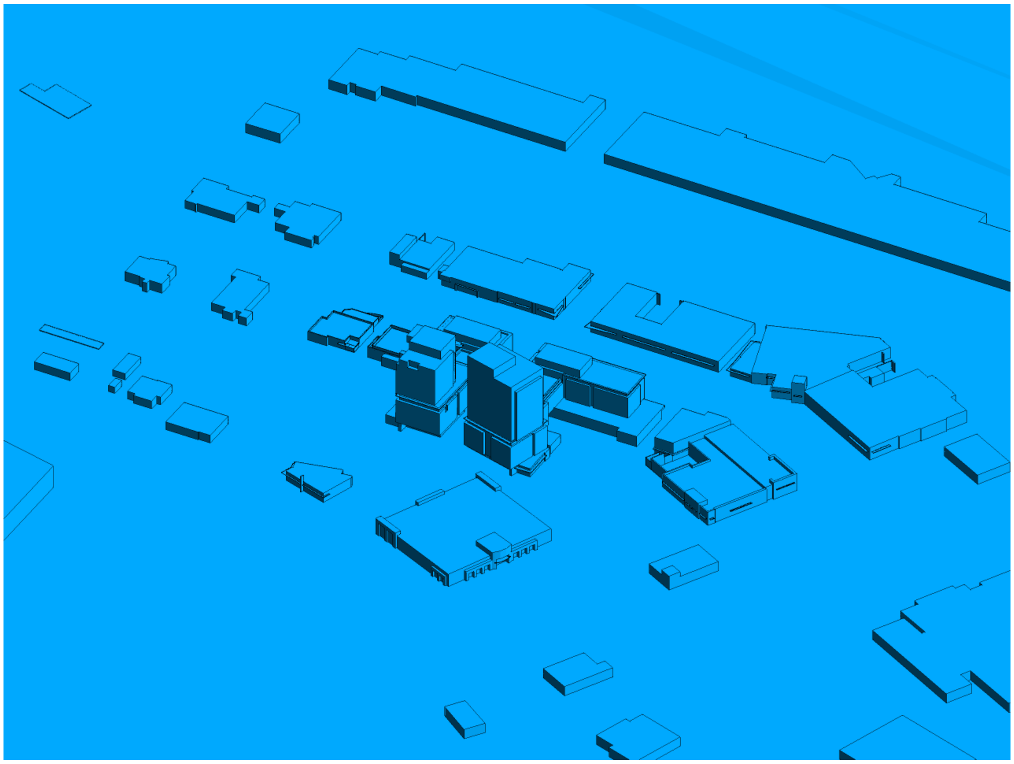


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTHEAST PERSPECTIVE

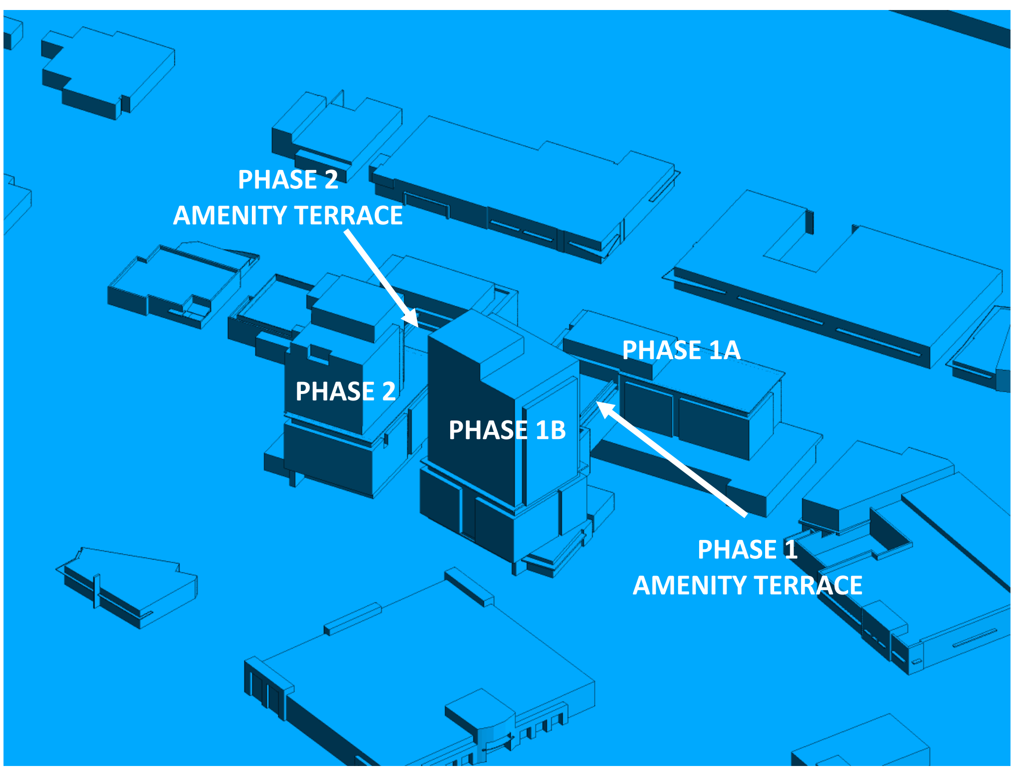


FIGURE 2F: CLOSE UP OF FIGURE 2E

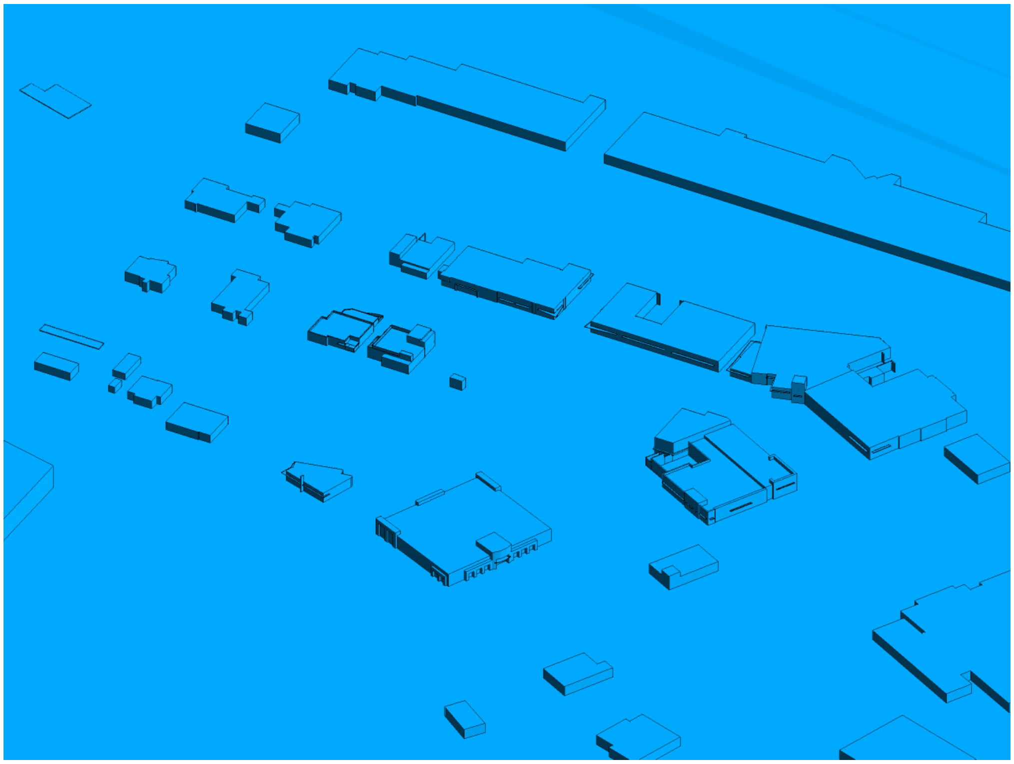


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, NORTHEAST PERSPECTIVE

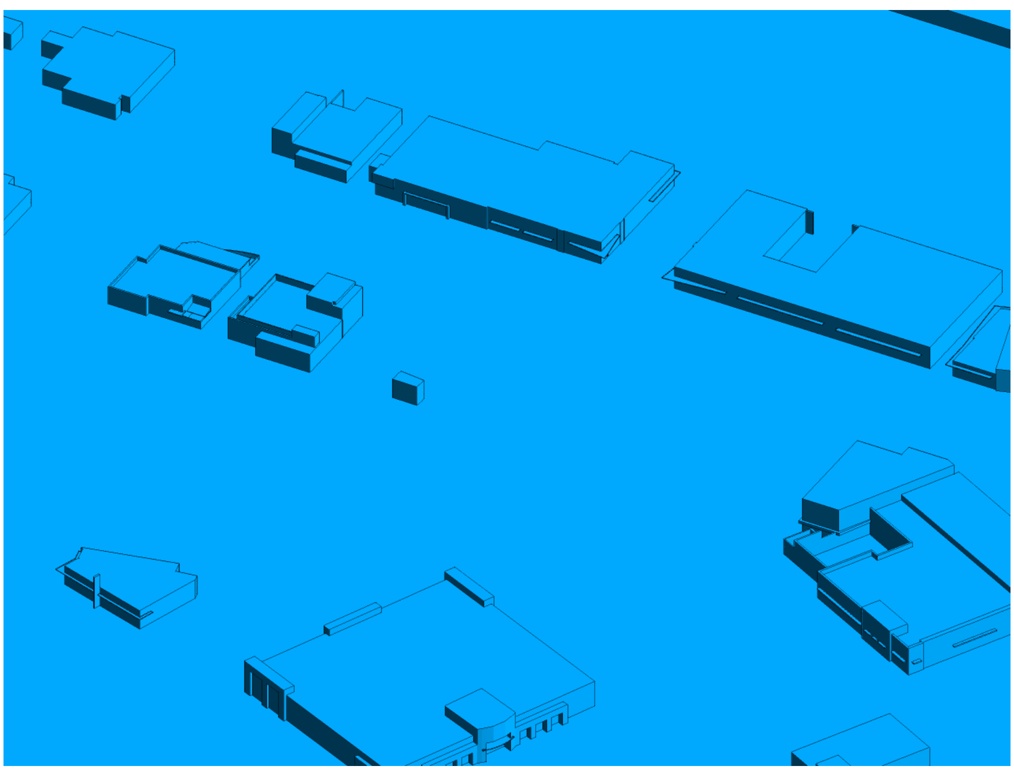


FIGURE 2H: CLOSE UP OF FIGURE 2G

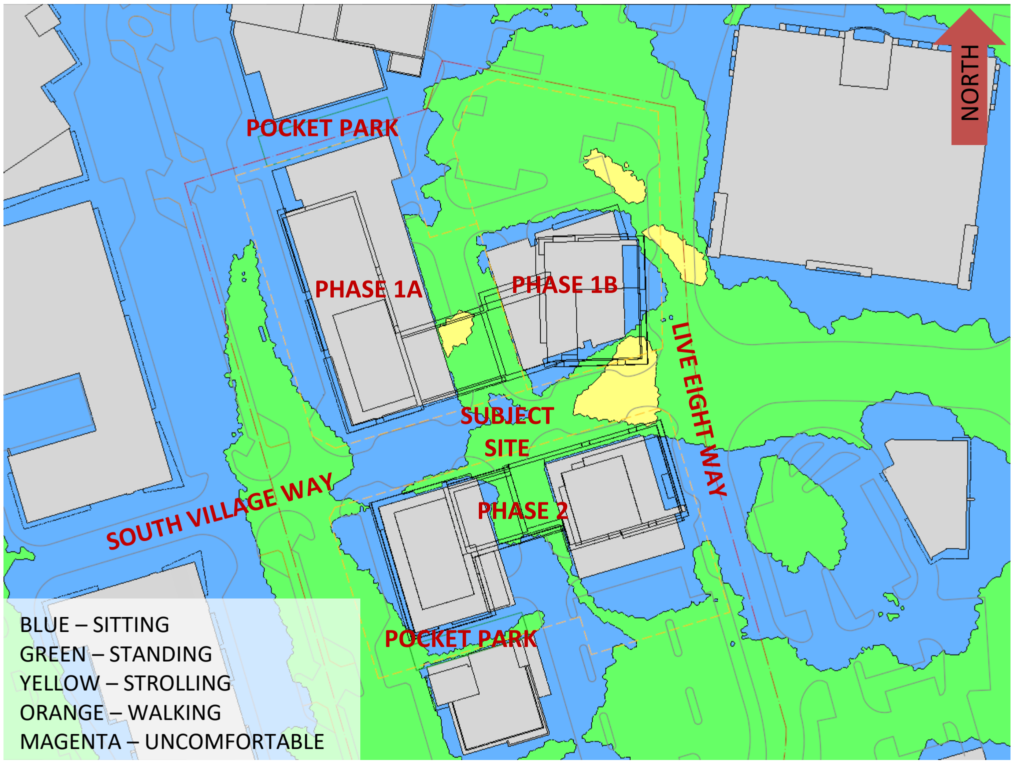


FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

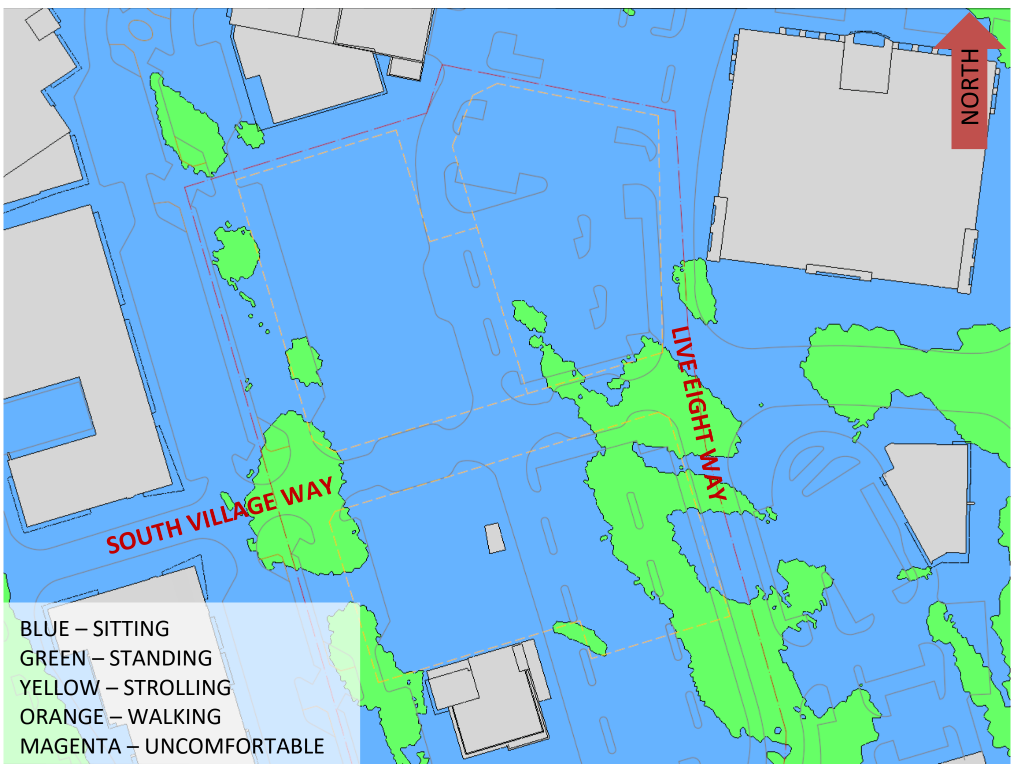


FIGURE 3B: SPRING – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

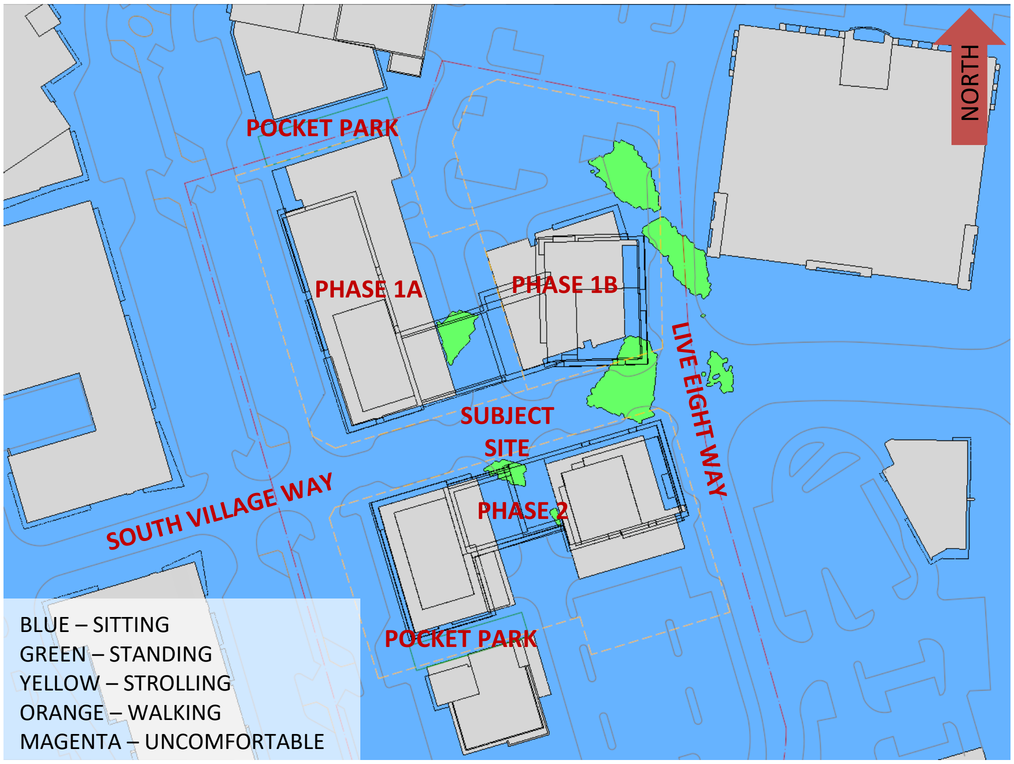


FIGURE 4A: SUMMER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

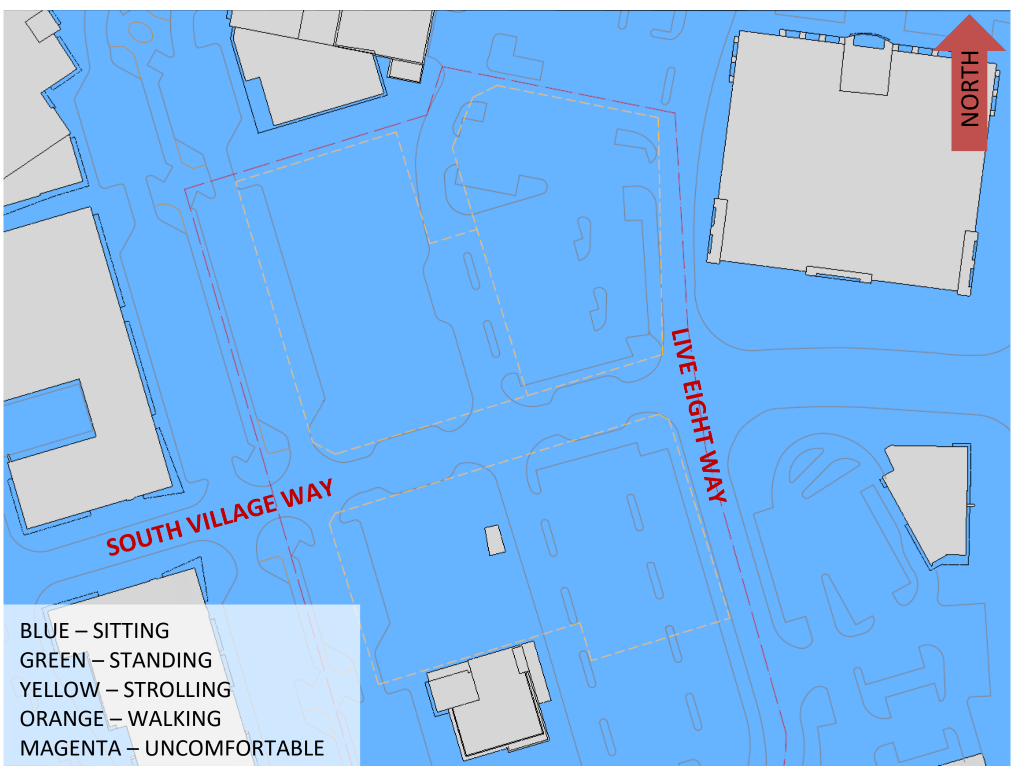


FIGURE 4B: SUMMER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

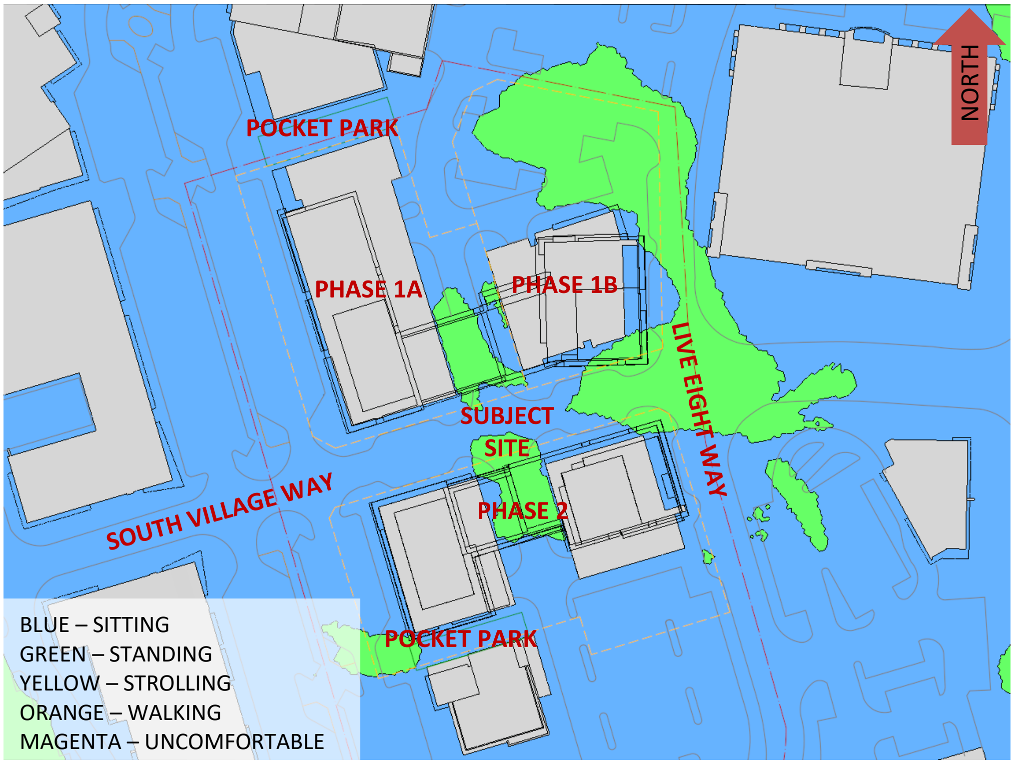


FIGURE 5A: AUTUMN – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

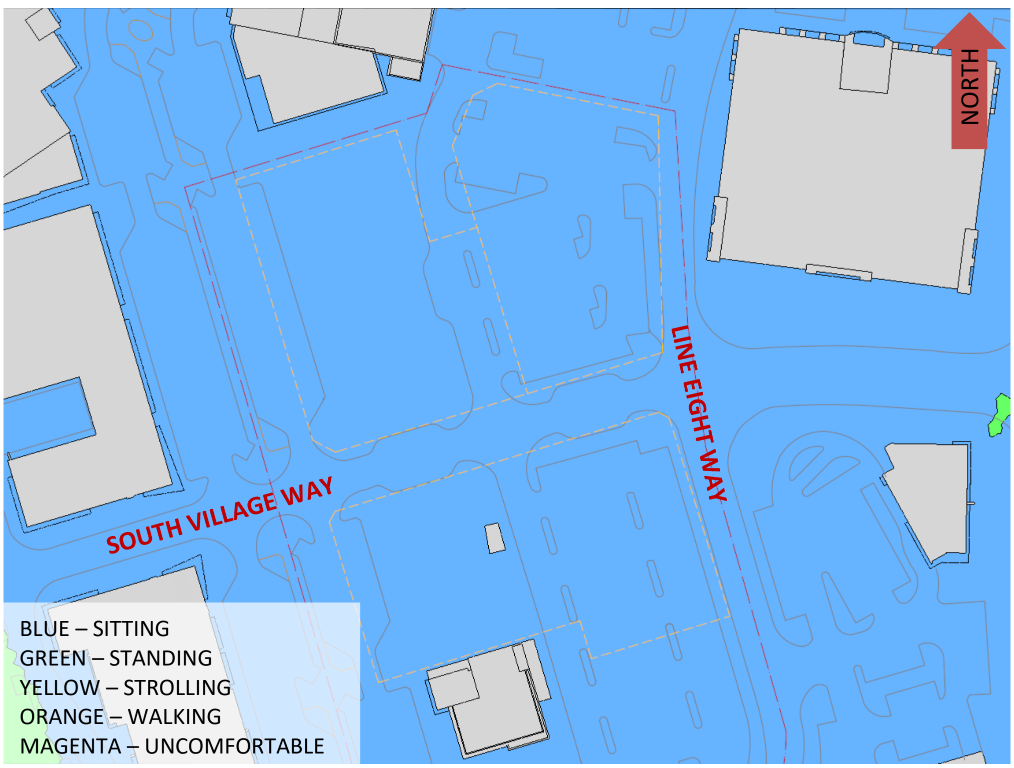


FIGURE 5B: AUTUMN – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

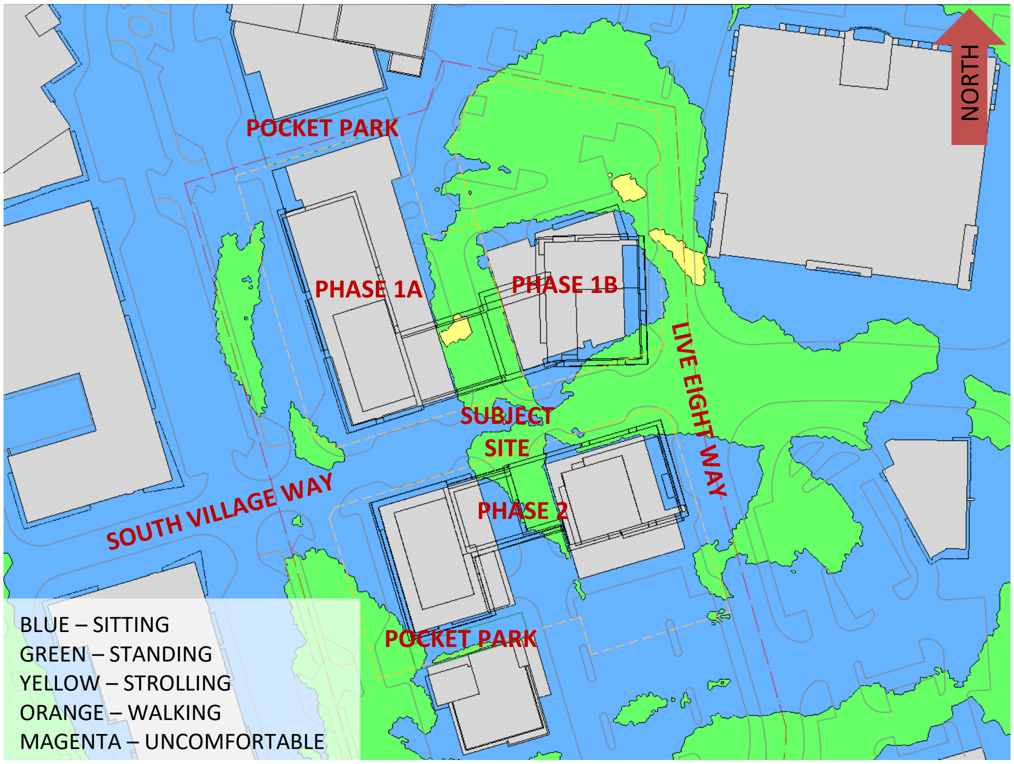


FIGURE 6A: WINTER – WIND COMFORT, GRADE LEVEL – PROPOSED MASSING

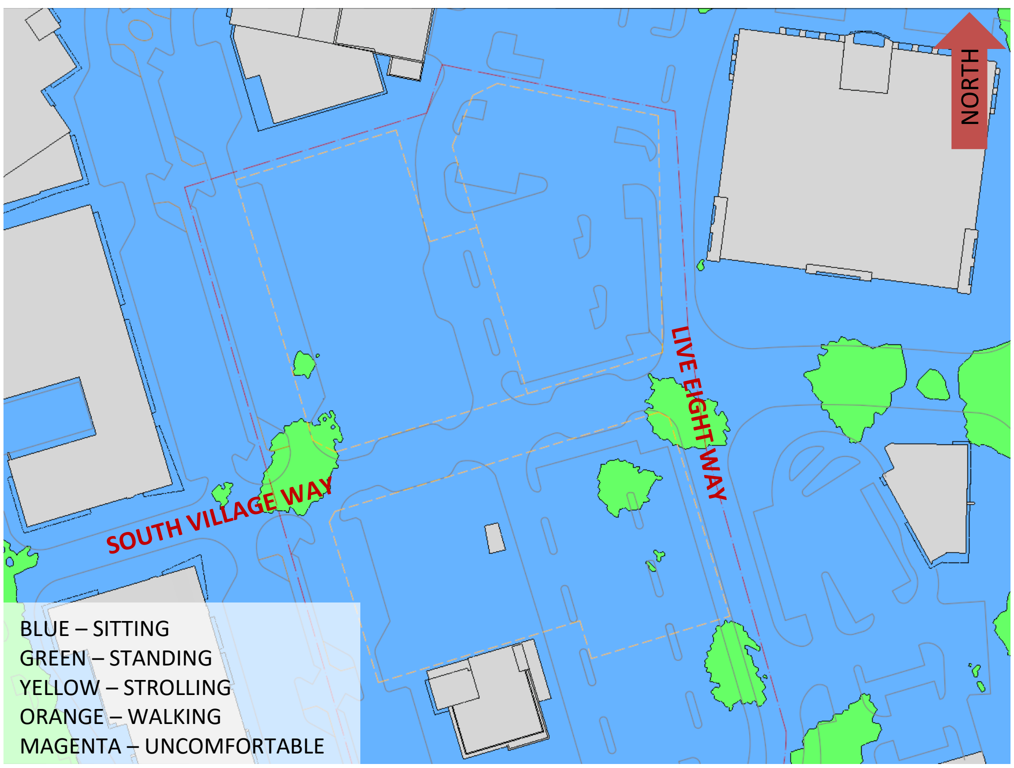


FIGURE 6B: WINTER – WIND COMFORT, GRADE LEVEL– EXISTING MASSING

FIGURE 7A: SPRING – WIND COMFORT, AMENITY TERRACES

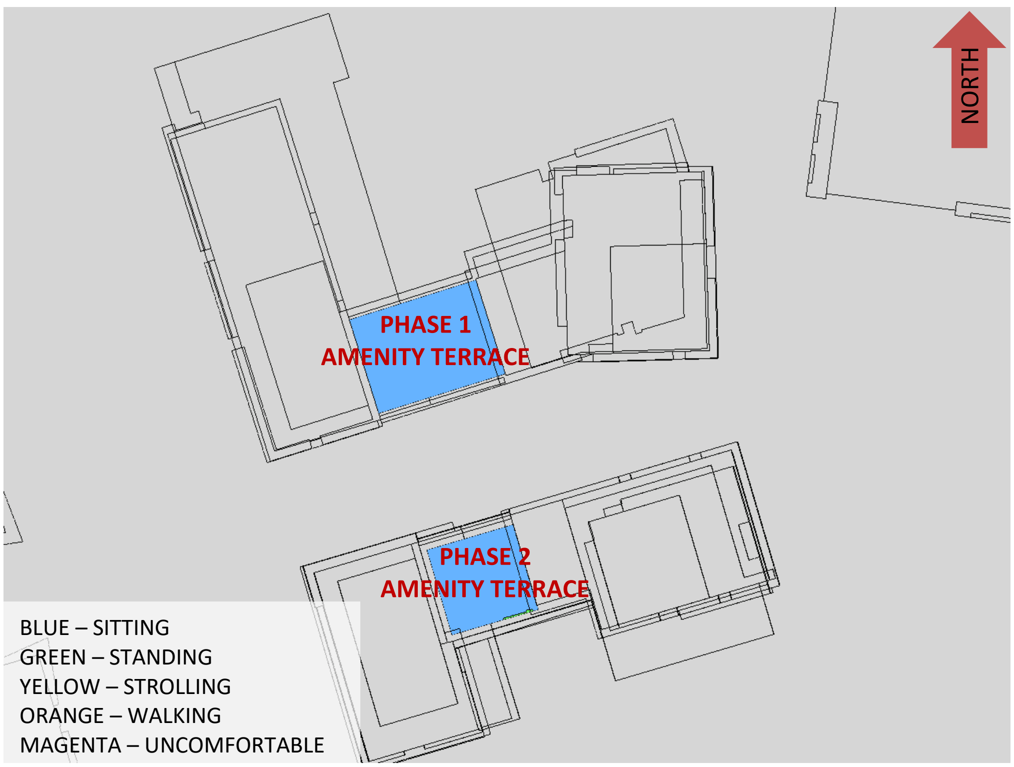


FIGURE 7B: SUMMER – WIND COMFORT, AMENITY TERRACES

FIGURE 7C: AUTUMN – WIND COMFORT, AMENITY TERRACES

FIGURE 7D: WINTER – WIND COMFORT, AMENITY TERRACES

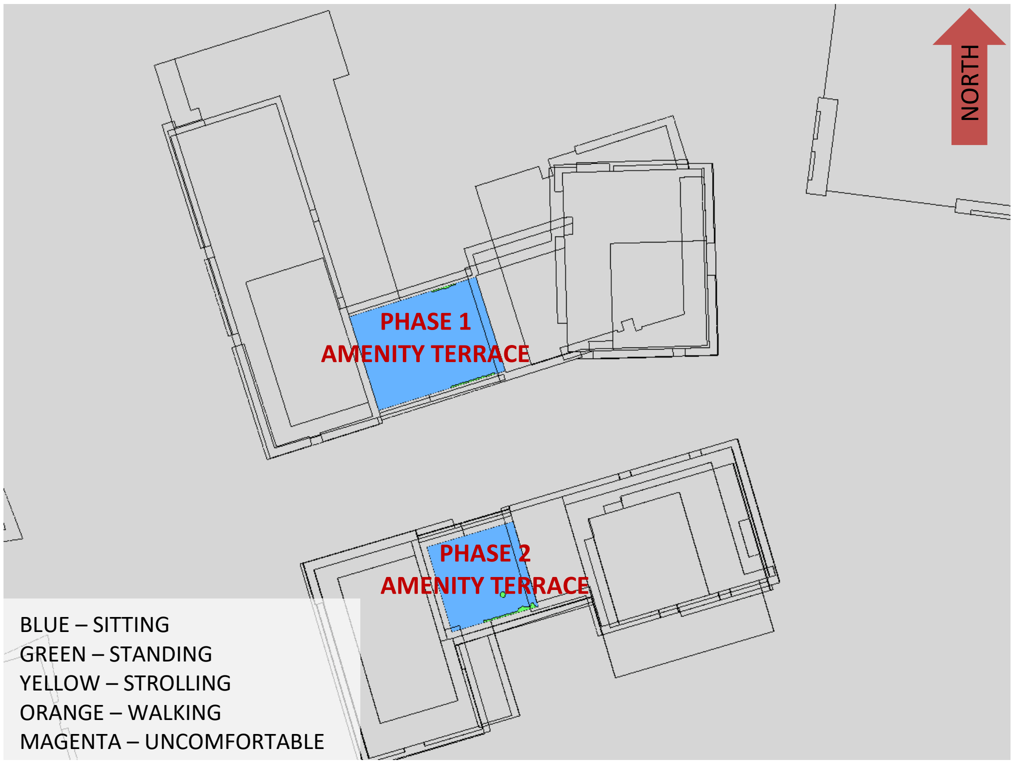
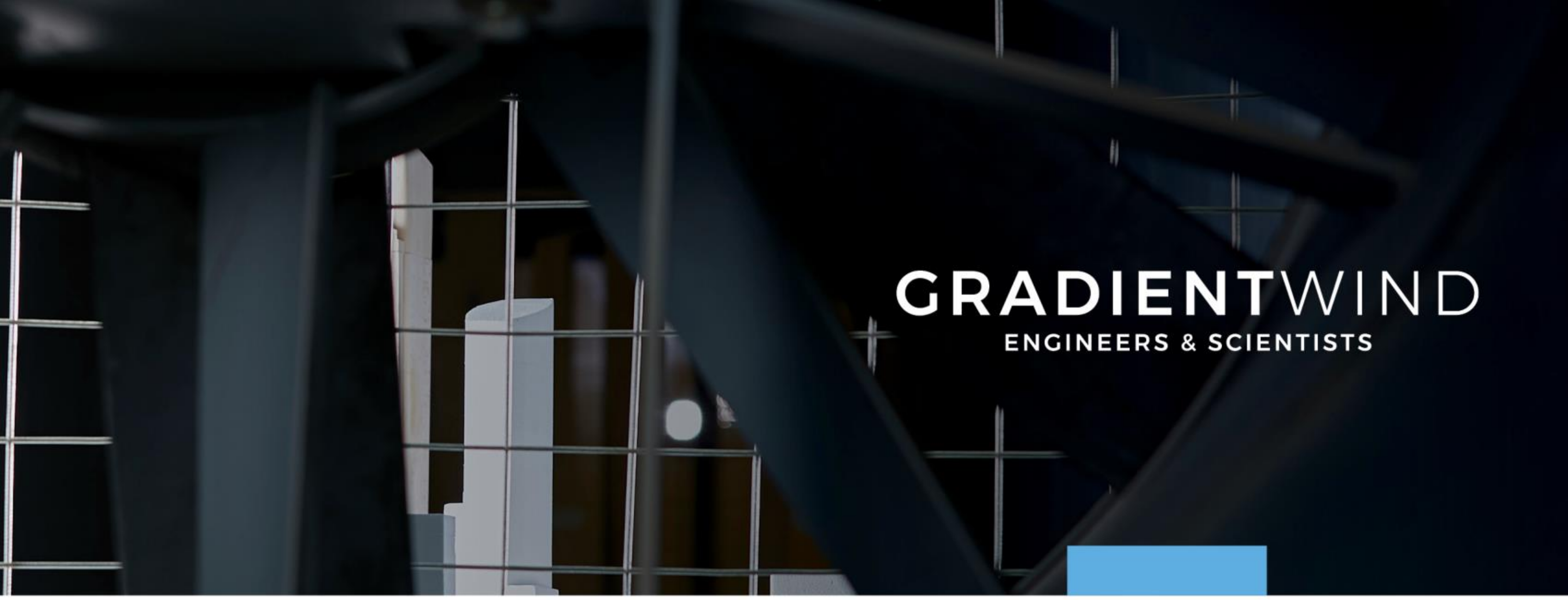
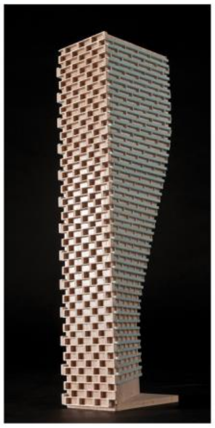
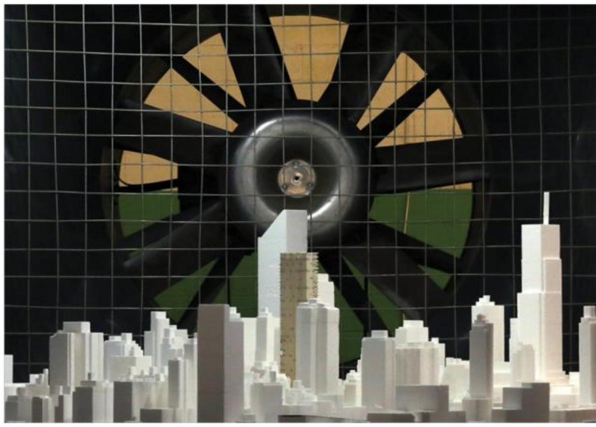


FIGURE 8: TYPICAL USE PERIOD – WIND COMFORT, AMENITY TERRACES







APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 50% mean wind speed for Barrie based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

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

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

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

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

Wind Direction (Degrees True)	Alpha Value (α)
0	0.22
40	0.22
98	0.20
132	0.20
164	0.20
200	0.20
237	0.22
263	0.22
280	0.22
295	0.22
310	0.22
331	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, 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

[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.