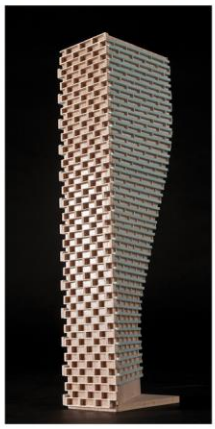
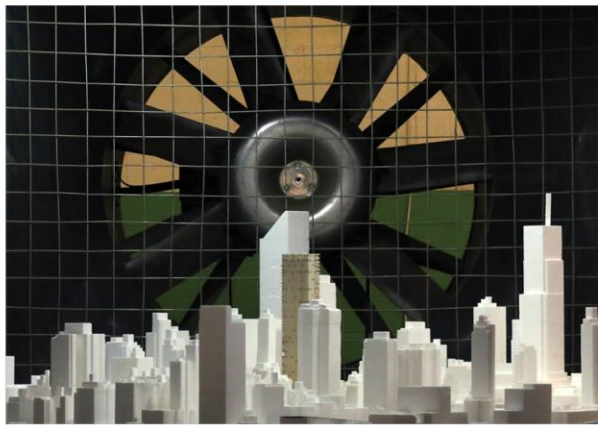
GRADIENTWIND
ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY

1047 Richmond Road
Ottawa, Ontario

Report: 21-416-PLW





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PREPARED FOR

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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to satisfy concurrent Official Plan Amendment and Zoning By-law Amendment application requirements for the proposed residential development located at 1047 Richmond Road in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate wind comfort and safety within and surrounding the subject site, and to identify any 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-6B, and summarized as follows:

1) While the introduction of the proposed development is predicted to produce generally windy conditions at grade, most 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, bus stops, and building access points, are considered acceptable for the intended pedestrian uses throughout the year. Exceptions are as follows:

    a. The pedestrian building access points serving Tower A along its east elevation and pinch point formed by the podia serving Tower A and Tower B.

    b. The pedestrian building access points serving Tower B along its north elevation.

    c. The outdoor amenity area at the ground floor, bordered by the vehicular drop-off zone to the immediate west, Tower B to the south, and Tower C to the north, and the podium connecting Tower B and Tower C.

    d. The proposed park within the south corner of the subject site, bordered by Tower A to the north, New Orchard Road to the west, and Richmond Road to the east.

e. Mitigation in the form of massing changes, such as terracing the podia serving Tower A and Tower B, would improve conditions in the general area. Regarding the outdoor amenity area and park, local mitigation in the form of landscape elements, such as a tall wind screen (typically glazed), planters with coniferous plantings in dense arrangements, and/or strategically placed seating with high-back benches, will also be required to create calm conditions during the typical use period. 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 common amenity terraces serving Tower A, Tower B, and Tower C atop their podia are predicted to be windy during the typical use period and will require mitigation to create calm wind conditions. Wind mitigation is expected to include perimeter wind screens (typically glazed) and mitigation inboard of the perimeter to protect sensitive areas. The podia serving Tower A and Tower C would also benefit from canopies extending outward from their respective towers to protect the roof areas from downwash winds incident on the north elevation of Tower A and west elevation of Tower C. Additional details of the canopy are provided in Section 5.1.

   a. 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.

3) 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 at the ground floor were found to experience conditions that could be considered dangerous, as defined in Section 4.4. The only exception is the pinch point formed by the podia serving Tower A and Tower B. The area, which is predicted to be uncomfortable during the winter, as described in Section 5.1, and is also predicted to exceed the safety threshold on an annual basis. Specifically, wind speeds greater than 90 km/h are predicted to occur for up to 0.14% of the time, where the threshold is 0.1%. Further investigation is required to determine an appropriate strategy to improve both wind comfort and safety conditions within the area.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Fengate Asset Management to undertake a pedestrian level wind (PLW) study to satisfy concurrent Official Plan Amendment and Zoning By-law Amendment application requirements for the proposed residential development located at 1047 Richmond Road in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). Our mandate within this study is to investigate 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, architectural drawings prepared by IBI Group, in December 2021, 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 1047 Richmond Road in Ottawa, situated at the intersection of Richmond Road and New Orchard Avenue North. The proposed development comprises three towers rising from two six-storey podia. The existing low-rise commercial building located at 1047 Richmond Road is to be demolished. The three towers are identified as "Tower A", "Tower B", and "Tower C", which rise 40 storeys, 38 storeys, and 36 storeys above grade counterclockwise from west to south to north, respectively. A podium serves Tower A, while a separate podium is shared by Tower B and Tower C.

Above three levels of below-grade parking, the ground floor of the podium serving Tower A includes retail space fronting a proposed park at the south corner of the subject site, a residential lobby along the east elevation, and a loading area and building services at the northwest elevation, with residential units and shared building support spaces throughout the remainder of the floor area. The ground floor of the podium serving Tower B and Tower C includes retail along the southeast elevation fronting Richmond Road, a ramp to the below-grade parking along a proposed laneway along the northwest perimeter of the subject site, loading areas and building services accessed by proposed laneways along the northwest and

northeast perimeters of the subject site, and residential lobbies and indoor amenities fronting an inner courtyard area formed by the semicircular podium, with the remainder of the floor area comprising residential units and shared building support spaces.

An outdoor amenity area is located within the centre of the inner courtyard, adjacent to a drop-off zone accessed by the laneway running along the northwest perimeter of the subject site. Levels 2-6 include indoor amenities within the inner corners of the 'U'-shaped podium serving Tower B and Tower C, with residential units throughout the remainder of the floor area. Residential units and an indoor amenity space are provided at Level 7 for Tower A, while Level 7 for Tower B and Tower C only include residential units. The podia rooftops are served by common amenity terraces. The three towers rise from the two podia with rectangular planforms, which include small setbacks from the perimeters of the podia. A portion of Tower A cantilevers its podium on the north end. All floors serving Tower A, Tower B, and Tower C above Level 7 are reserved exclusively for residential occupancy. The plan dimensions of the towers and separation distances between each tower are summarized as follow:

Tower A (40 storeys):

- The plan dimensions of a typical rectangular floorplate associated with Tower A are nominally 33 metres (m) × 23 m with the longer dimension extending parallel to New Orchard Avenue North.
- The separation distance between Tower A and Tower B is nominally 20 m.
- The separation distance between Tower A and Tower C is nominally 35 m.

Tower B (38 storeys):

- The plan dimensions of a typical rectangular floorplate associated with Tower B are nominally 43 m × 19 m with the long dimension extending parallel to Richmond Road.
- The separation distance between Tower B and Tower C is nominally 20 m.

Tower C (36 storeys):

- The plan dimensions of a typical rectangular floorplate associated with Tower C are nominally 35 m × 23 m with the long dimension extending parallel to Richmond Road.

The near-field surroundings (defined as an area within 200 m of the subject site) include the Sir John A. Macdonald Parkway and the Trans-Canada Trail from the west-southwest clockwise to the northeast, high-rise residential buildings to the east-northeast and to the west-southwest, and mostly low-rise residential buildings for the remaining compass directions. Notably, there is a 28-storey apartment building to the immediate east of the subject site at 1025 Richmond Road. Additionally, the Stage 2 Ottawa Light Rail Transit West Extension and the future New Orchard Station are currently under construction approximately 20 m to the south of the subject site. 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 the open exposure of the Ottawa River from the west-southwest clockwise to the northeast, and by mostly low-rise buildings with some isolated taller buildings for the remaining compass directions. The Britannia Conservation Area is situated approximately 1 km to the west, and Highway 417 runs southwest-northeast approximately 1.6 km to the southeast.

Key areas under consideration include the public sidewalks adjacent to the subject site, the park at the south end of the subject site, building access points serving the subject site, the outdoor amenity area at the ground floor, and the common amenity terraces serving the proposed development atop its podia. Figure 1 illustrates the subject site and surrounding context, while Figures 2A-2D illustrate the computational model used to conduct the study.

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 more conservative (i.e., windier) wind speed values.

[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 diameter of approximately 1 km.

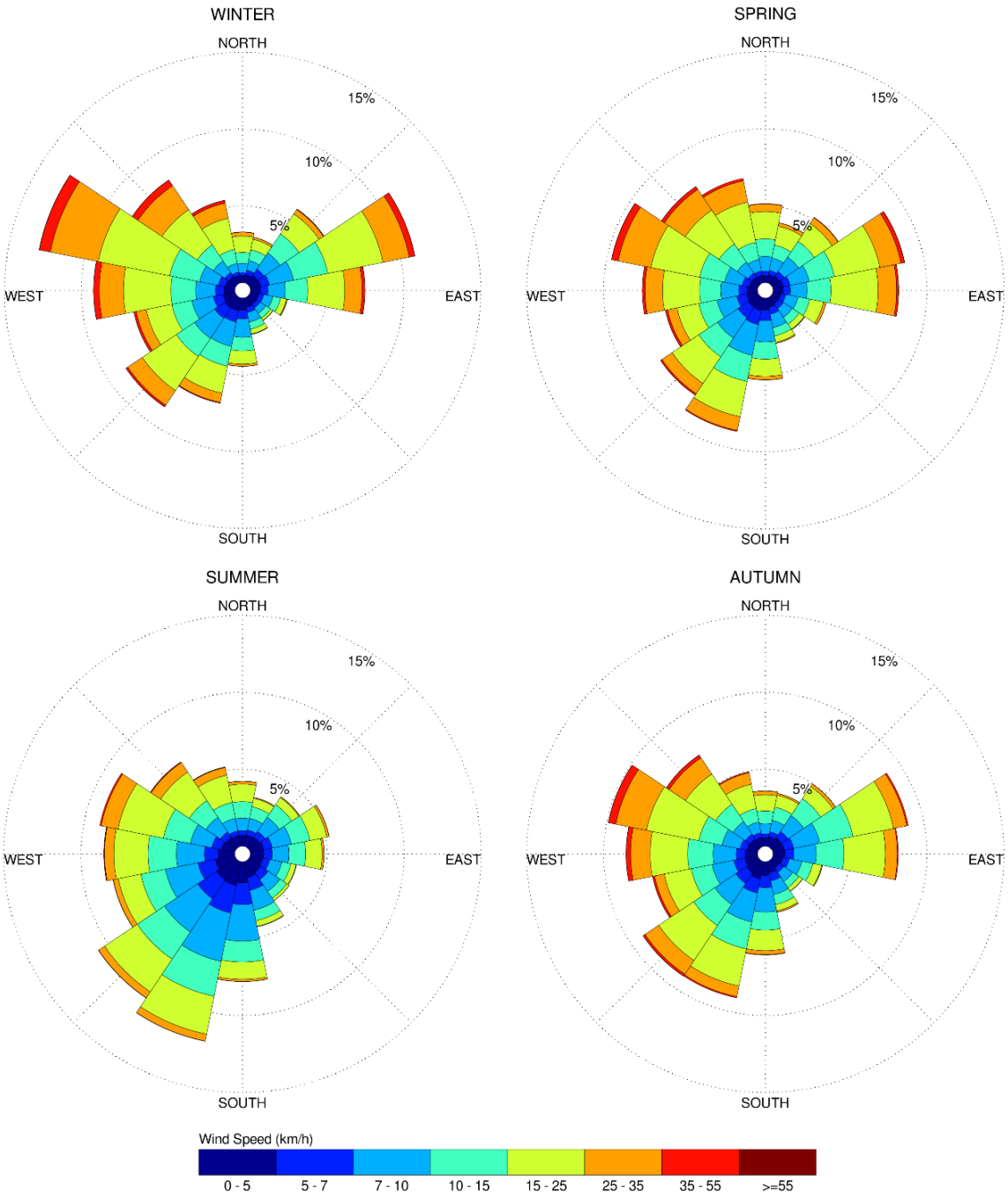
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and the common amenity terraces were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. 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 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 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	Acceptable Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Standing / Strolling / Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting
Café / Patio / Bench / Garden	Sitting
Bus/Transit Stop (Without Shelter)	Sitting / Standing
Bus/Transit Stop (With Shelter)	Strolling / Walking
Public Park / Plaza	Sitting
Garage / Service Entrance	Strolling / Walking
Parking Lot	Strolling / Walking
Vehicular Drop-Off Zone	Standing / Strolling

5. RESULTS AND DISCUSSION

The following discussion of predicted pedestrian wind conditions is accompanied by Figures 3A-3D, which illustrate seasonal wind comfort conditions at grade level, as well as by Figures 5A-5D, which illustrate seasonal wind conditions over the common amenity terraces serving the proposed development atop its podia. various common amenity terraces serving the proposed development. Conditions are presented as continuous contours of wind comfort within and surrounding the subject site. The colour contours indicate predicted regions of the various comfort classes noted in Section 4.4. 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 over the ground floor and the common amenity terraces atop the podia are also reported for the typical use period, which is defined as May to October, inclusive. Figures 4A and 6A illustrate wind comfort conditions during this period, consistent with the comfort classes in Section 4.4, while Figures 4B and 6B illustrate contours indicating the percentage of time the noted areas are predicted to be suitable for sitting during the same period. Pedestrian conditions are summarized in the following pages for each area of interest.

5.1 Wind Comfort Conditions – Grade Level

Sidewalks along New Orchard Avenue North and Bus Stop along Ambleside Drive: Following the introduction of the proposed development, conditions over the sidewalks along New Orchard Avenue North are predicted to be suitable mostly for standing during the summer with a small area suitable for strolling at the intersection with Ambleside Drive. During the autumn, conditions are predicted to be suitable for a mix of standing and strolling with a small area suitable for walking at the intersection with Ambleside Drive. During the winter and spring, conditions are predicted to be suitable mostly for walking with strolling conditions to the north of the subject site. The noted conditions are considered acceptable for public sidewalks according to the City of Ottawa wind comfort criteria in Section 4.4.

A bus stop is located near the subject site along Ambleside Drive, adjacent to the intersection with New Orchard Avenue North. Wind conditions over the bus stop are described as follows:

- Wind conditions over the bus stop located to the west of Tower A, across New Orchard Avenue North, are predicted to be suitable for standing during the summer, strolling during the autumn, a mix of strolling and walking during the spring, becoming suitable for walking during the winter.
- The bus stop is served by a typical shelter, which provides pedestrians a means to seek protection from the elements, inclusive of wind. As such, the noted wind conditions are considered acceptable according to the City of Ottawa wind comfort criteria in Section 4.4.

Sidewalks and Bus Stops along Richmond Road, New Orchard Station: Following the introduction of the proposed development, conditions over the sidewalks along Richmond Road are predicted to be suitable mostly for standing during the summer, a mix of standing and strolling during the spring and autumn, becoming suitable mostly for walking during the winter. The calmest wind conditions are predicted to occur along the north sidewalk adjacent to Tower B; the combination of Tower A and Tower B shields the noted public area from prominent westerly winds and creates sitting conditions throughout the year. The noted conditions are considered acceptable for public sidewalks according to the City of Ottawa wind comfort criteria in Section 4.4.

While two bus stops are located near the subject site along Richmond Road, they will be relocated within the construction scope of the Light Rail Transit New Orchard Station, associated with Stage 2 of the Confederation Line Extension[2]. The new bus stops are illustrated in Figure 1; one bus stop is located to the immediate south of the proposed development, while the other bus stop is included within the plaza at the west end of New Orchard Station. The new bus stops are expected to be served by a typical shelter. The CFD simulation model considered a simplified massing of New Orchard Station.

Wind conditions over the relocated bus stops are described as follows:

- Wind conditions over the bus stop at the northeast intersection of Richmond Road and New Orchard Avenue North, immediately adjacent to the proposed park, are predicted to be suitable for standing during the summer, for strolling during the spring and autumn, becoming suitable for walking during the winter. Calmer wind conditions are predicted over the bus stop within the plaza serving New Orchard Station.
- Since both bus stops are expected to be served by a typical shelter, which provides pedestrians a means to seek protection from the elements, inclusive of wind, the noted wind conditions are considered acceptable according to the City of Ottawa wind comfort criteria in Section 4.4.

Regarding New Orchard Station, wind conditions in the vicinity of the main entrance, following the introduction of the proposed development, are predicted to be suitable for a mix of sitting and standing throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria in Section 4.4.

[2] City of Ottawa, **'Overview: Stage 2 Light Rail Transit Project'**, (published Sep 29, 2020), <*https://ottawa.ca/en/planning-development-and-construction/major-projects/stage-2-light-rail-transit-project/overview*> (accessed Dec 21, 2021)

Pedestrian Building Access serving Tower A, Walkways: Conditions in the vicinity of the building access points and walkways along New Orchard Avenue North and the proposed laneway along the northwest perimeter of the subject site are predicted to be suitable for a mix of sitting and standing during the summer, suitable mostly for standing during the autumn, becoming suitable for a mix of standing and strolling during the winter season. Isolated regions at the northwest and southwest corners of Tower A are predicted to be suitable for walking during the spring and winter. The noted wind conditions are considered acceptable according to the City of Ottawa wind comfort criteria in Section 4.4.

The 'pinch point' formed by the podia serving Tower A and Tower B is predicted to be windy on account of horizontal winds that accelerate through the area from several prominent compass directions. During the summer, conditions are predicted to be suitable for strolling. Conditions during the autumn are predicted to be suitable for walking, while conditions during the spring are predicted to be suitable mostly for walking and may be uncomfortable. During the winter, conditions are predicted to be uncomfortable within the pinch point, as well as over an isolated area at the northeast corner of Tower A, represented by the colour magenta in Figure 3D. The two noted windy areas are also predicted to be suitable for walking for at least 76% of the time, where the target is at least 80%. Since the exceedance of the walking comfort class is considered small (4% of the time during the winter), the noted conditions may be considered satisfactory.

Conditions in the vicinity of building access points and the walkway adjacent to the east elevation of Tower A are predicted to be suitable mostly for standing during the summer, becoming suitable for strolling during the autumn. During the spring, conditions are predicted to be suitable for walking near the retail entrance and the exit from the podium and nearby walkways, and suitable for strolling in the vicinity of the entrance to the lobby serving Tower A. During the winter season, conditions are predicted to be suitable for a mix of strolling and walking in the vicinity of building access points and walkways. The noted conditions are considered acceptable for the secondary building access points; however, mitigation is recommended to protect the lobby entrance serving Tower A. Mitigation in the form of massing changes, such as terracing the podia serving Tower A and Tower B, would improve conditions in the general area. 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.

Pedestrian Building Access serving Tower C along North Elevation, Surface Parking serving 1025 Richmond Road: Conditions in the vicinity of the building access points and walkways serving Tower C, along its north elevation adjacent to the laneway, are predicted to be suitable for a mix of sitting and standing during the summer, for a mix of standing and strolling during the spring and autumn, becoming suitable for a mix of strolling and walking during the winter. The noted conditions are considered acceptable along the walkway, as well as in the vicinity of the secondary pedestrian building access points, according to the City of Ottawa wind comfort criteria.

The surface parking area to the east of the proposed development, which serves the existing 28-storey apartment building, is predicted to be suitable for a mix of standing and strolling during the summer, becoming suitable mostly for walking during the spring and autumn. During the winter, while conditions are predicted to be uncomfortable, the area is also predicted to be suitable for walking for at least 76% of the time. Since the exceedance of the walking comfort class is considered small (4% of the time during the winter), the noted conditions may be considered satisfactory.

Vehicular Drop-Off Zone, Outdoor Amenity, and Pedestrian Building Access serving Tower B & Tower C: Wind conditions over the central vehicular drop-off zone are predicted to be suitable for a mix of sitting and standing during the summer, for a mix of standing and strolling during the spring and autumn, becoming suitable mostly for strolling during the winter. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria in Section 4.4.

The proposed development includes an outdoor amenity area at the ground floor, bordered by the noted vehicular drop-off zone to the immediate west, Tower B to the south, Tower C to the north, and the podium connecting Tower B and Tower C. During the summer season, the amenity area is predicted to be suitable mostly for sitting. During the spring and autumn, conditions are predicted to be suitable for a mix of sitting and standing, while conditions during the winter are predicted to be suitable for a mix of sitting, standing, and strolling.

During the typical use period, conditions within the amenity area are predicted to be suitable for a mix of sitting and standing (Figure 4A). The area is also predicted to be suitable for sitting for at least 70% of the time with the majority of the area being suitable for sitting for at least 75% of the time (Figure 4B). The implementation of landscape elements, such as a 1.6-m-tall wind screen or planters with coniferous

plantings in dense arrangements, 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.

Conditions in the vicinity of the pedestrian building access points serving the podium connecting Tower B to Tower C within the courtyard are predicted to be suitable for sitting throughout the year. The only exception is the lobby entrance to Tower B where conditions are predicted to be suitable for sitting during the summer, for standing during the spring and autumn, becoming suitable for a mix of standing and strolling during the winter. Mitigation measures to address the windy conditions within the pinch point formed by Tower A and Tower B are expected to improve conditions along the Tower B elevation fronting the central courtyard. Mitigation strategies will be developed and confirmed in collaboration with the design team in preparation of the future Site Plan Control application submission.

Proposed Park within South Corner of Subject Site: Conditions over the proposed park within the south corner of the subject site, bordered by Tower A to the north, New Orchard Road to the west, and Richmond Road to the east, are predicted to be suitable for standing during the summer, a mix of standing and strolling during the autumn, for strolling during the spring, becoming suitable for a mix of mostly strolling and walking during the winter.

During the typical use period, conditions within the proposed park are predicted to be suitable mostly for standing (Figure 4A). The area is also predicted to be suitable for sitting for at least 65% of the time with the majority of the area being suitable for sitting for at least 70% of the time (Figure 4B). Mitigation is required to provide sitting conditions for at least 80% of the time during the typical use period. The implementation of landscape elements, such as a 1.6-m-tall wind screen and planters with coniferous plantings in dense arrangements, and strategically placed seating with high-back benches and other local wind mitigation, 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.

5.2 Wind Comfort Conditions – Common Amenity Terraces

Tower A, Podium Rooftop (Level 7): Wind conditions within the common amenity terrace serving Tower A atop its podium are predicted to be suitable for a mix of mostly standing and strolling during the typical use period with walking conditions isolated to the extreme east end of the terrace (Figure 6A).

The amenity terrace is also predicted to be suitable for sitting for at least 60% to 65% of the time during the same period within most areas. Mitigation is required to provide sitting conditions for at least 80% of the time during the typical use period. The implementation of a tall wind screen, typically glazed, along the perimeter of the terrace will be required to shield the area from prominent winds. Conditions could also be improved to achieve the sitting comfort class by introducing a canopy along the elevation of Tower A, extending outward from the façade by at least 3 m. The underside of the canopy should have a clear height not exceeding 5 m as measured from the walking surface of the terrace. The canopy is expected to deflect downwash winds incident on the north elevation of Tower A, including vortices that are predicted to form at the northwest corner of Tower A, away from the terrace. 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.

Podium Rooftop (Level 7) between Tower B and Tower C: Wind conditions within the common amenity terrace atop the podia (Level 7) between Towers B and C are predicted to be suitable for a mix of sitting and standing during the typical use period (Figure 6A). The calmest conditions are predicted to occur adjacent to Tower B and Tower C on account of boundary layer effects, as well as from shielding provided by Tower A from prominent westerly winds. Within the areas that are predicted to be suitable for standing, consistent with the definition in Section 4.4, sitting conditions are also predicted to occur for at least 70% of the time during the same period within most of the areas, where the target is 80%.

The implementation of a tall wind screen, typically glazed, along the west perimeter of the terrace will be required to increase sitting percentages during the typical use period. Mitigation inboard of the perimeter may also be required depending on the programming of the area. 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.

Tower C, Podium Rooftop (Level 7): Wind conditions within the common amenity terrace serving Tower C atop its podium are predicted to be suitable for a mix of mostly standing and strolling during the typical use period with sitting conditions immediately adjacent to the south elevation of Tower C (Figure 6A).

The amenity terrace is also predicted to be suitable for sitting for at least 65% to 70% of the time during the same period within most areas. Mitigation is required to provide sitting conditions for at least 80% of the time during the typical use period. The implementation of a tall wind screen, typically glazed, along the perimeter of the terrace will be required to shield the area from prominent winds. Conditions could also be improved to achieve the sitting comfort class by introducing a canopy along the south elevation of Tower C, extending outward from the façade by at least 4 m. The underside of the canopy should have a clear height not exceeding 5 m as measured from the walking surface of the terrace. The canopy is expected to deflect downwash winds incident on the south elevation of Tower C away from the terrace. 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.

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 and surrounding the subject site were found to experience conditions that could be considered dangerous, as defined in Section 4.4. The only exception is the pinch point formed by the podia serving Tower A and Tower B. The area, which is predicted to be uncomfortable during the winter, as described in Section 5.1, and is also predicted to exceed the safety threshold on an annual basis. Specifically, wind speeds greater than 90 km/h are predicted to occur for up to 0.14% of the time, where the threshold is 0.1%. Further investigation is required to determine an appropriate strategy to improve both wind comfort and safety conditions within the area.

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. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 3A-6B. 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) While the introduction of the proposed development is predicted to produce generally windy conditions at grade, most 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, bus stops, and building access points, are considered acceptable for the intended pedestrian uses throughout the year. Exceptions are as follows:

    a. The pedestrian building access points serving Tower A along its east elevation and pinch point formed by the podia serving Tower A and Tower B.

    b. The pedestrian building access points serving Tower B along its north elevation.

    c. The outdoor amenity area at the ground floor, bordered by the vehicular drop-off zone to the immediate west, Tower B to the south, and Tower C to the north, and the podium connecting Tower B and Tower C.

    d. The proposed park within the south corner of the subject site, bordered by Tower A to the north, New Orchard Road to the west, and Richmond Road to the east.

    e. Mitigation in the form of massing changes, such as terracing the podia serving Tower A and Tower B, would improve conditions in the general area. Regarding the outdoor amenity area and park, local mitigation in the form of landscape elements, such as a tall wind screen (typically glazed), planters with coniferous plantings in dense arrangements, and/or strategically placed seating with high-back benches, will also be required to create calm conditions during the typical use period. 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 common amenity terraces serving Tower A, Tower B, and Tower C atop their podia are predicted to be windy during the typical use period and will require mitigation to create calm wind conditions. Wind mitigation is expected to include perimeter wind screens (typically glazed) and mitigation inboard of the perimeter to protect sensitive areas. The podia serving Tower A and Tower C would also benefit from canopies extending outward from their respective towers to protect the roof areas from downwash winds incident on the north elevation of Tower A and west elevation of Tower C. Additional details of the canopy are provided in Section 5.1.

    a. 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.

3) 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 at the ground floor were found to experience conditions that could be considered dangerous, as defined in Section 4.4. The only exception is the pinch point formed by the podia serving Tower A and Tower B. The area, which is predicted to be uncomfortable during the winter, as described in Section 5.1, and is also predicted to exceed the safety threshold on an annual basis. Specifically, wind speeds greater than 90 km/h are predicted to occur for up to 0.14% of the time, where the threshold is 0.1%. Further investigation is required to determine an appropriate strategy to improve both wind comfort and safety conditions within the area.

Sincerely,

Gradient Wind Engineering Inc.

David Huitema, M.Eng.
Junior Wind Scientist

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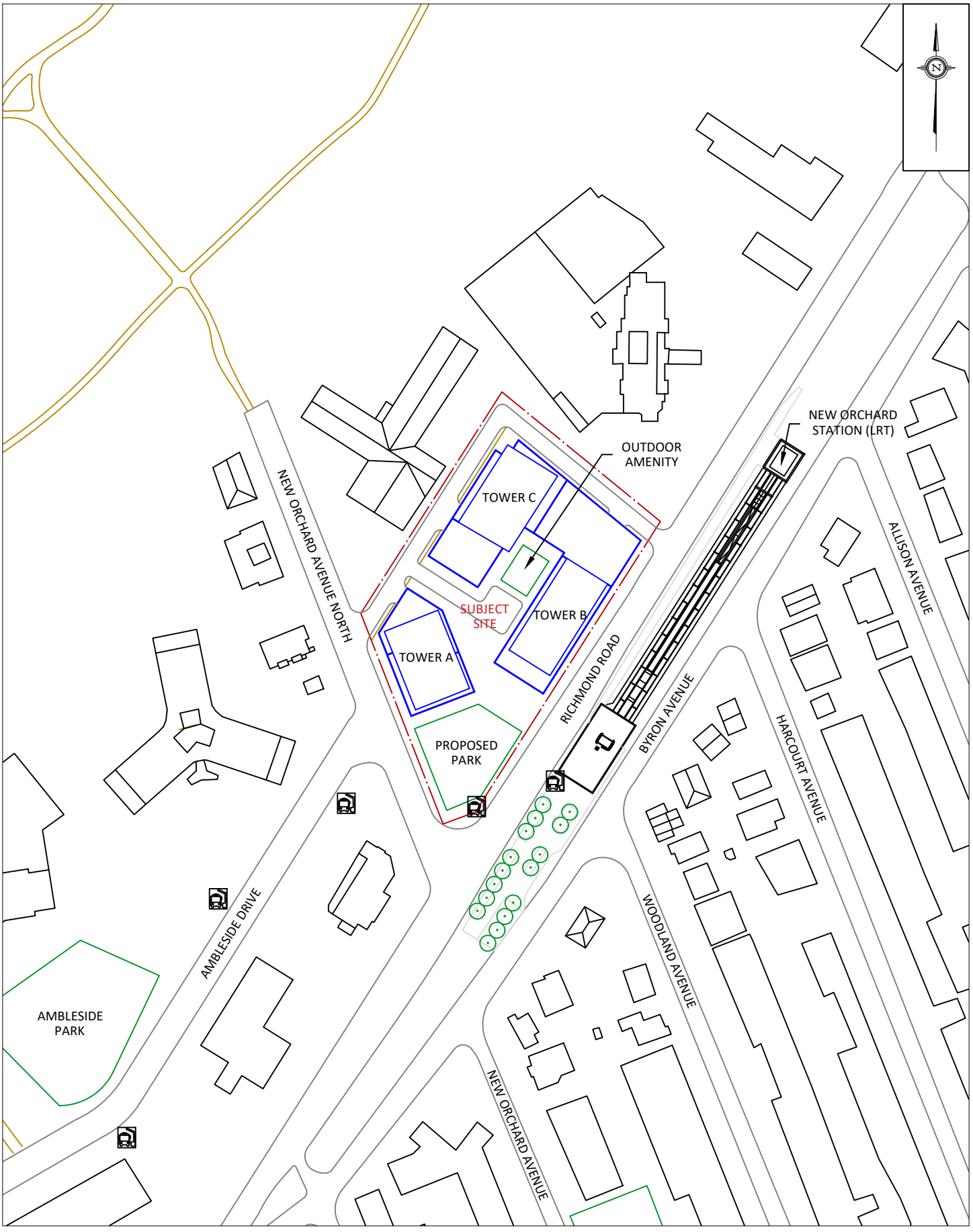
Principal



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PROJECT	1047 RICHMOND ROAD, OTTAWA PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2000
DRAWING NO.	21-416-PLW-1
DATE	DECEMBER 21, 2021
DRAWN BY	S.K.

DESCRIPTION

FIGURE 1:
PROPOSED SITE PLAN AND SURROUNDING CONTEXT

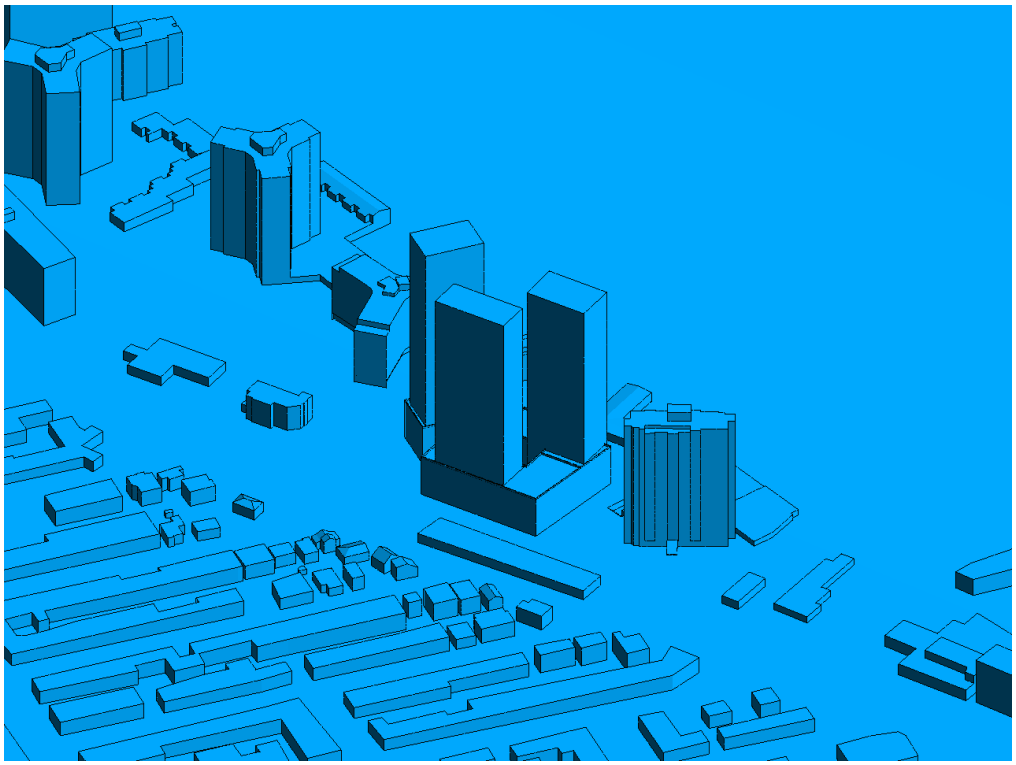

FIGURE 2A: COMPUTATIONAL MODEL, EAST PERSPECTIVE

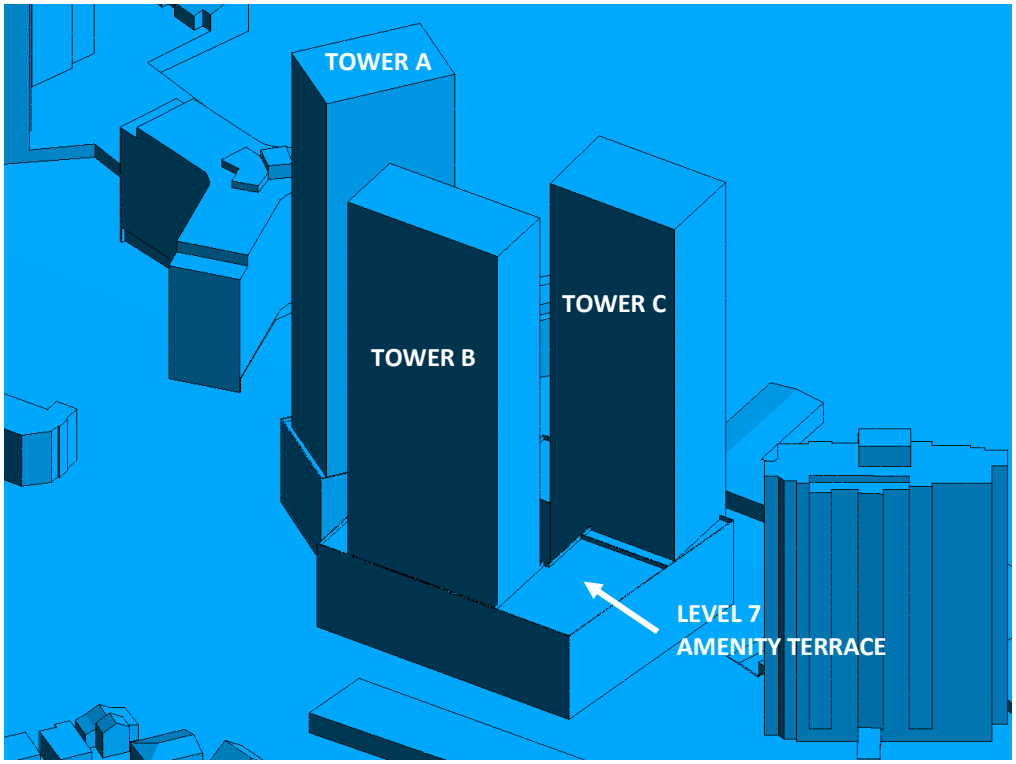

FIGURE 2B: CLOSE UP OF FIGURE 2A

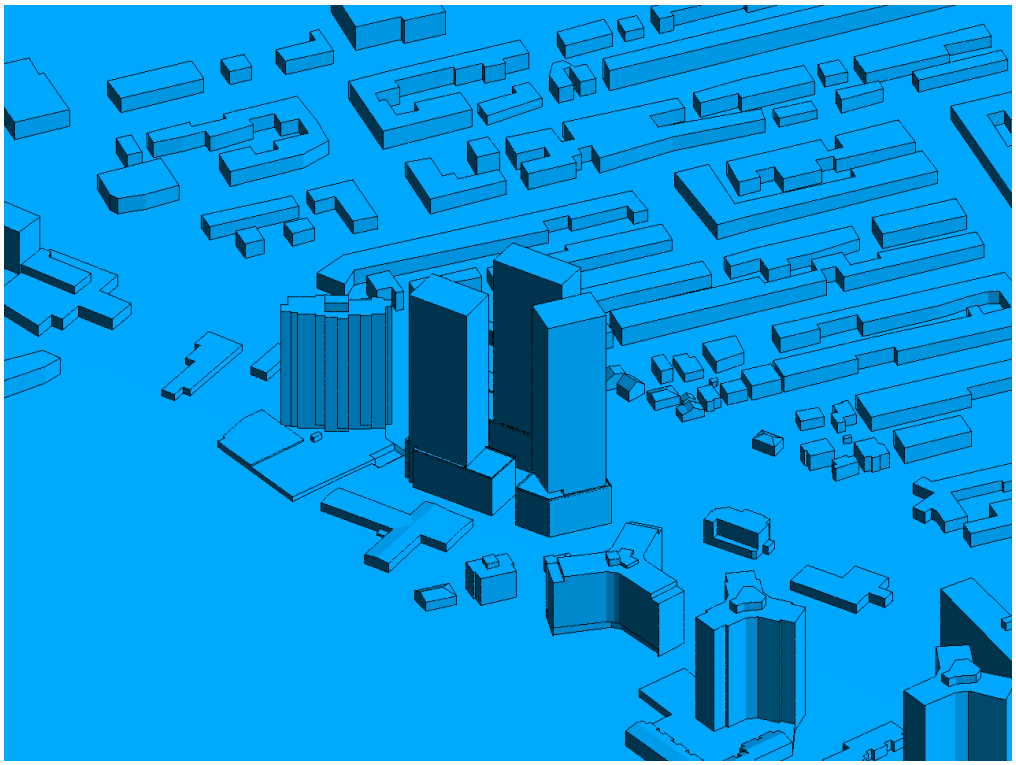

FIGURE 2C: COMPUTATIONAL MODEL, WEST PERSPECTIVE

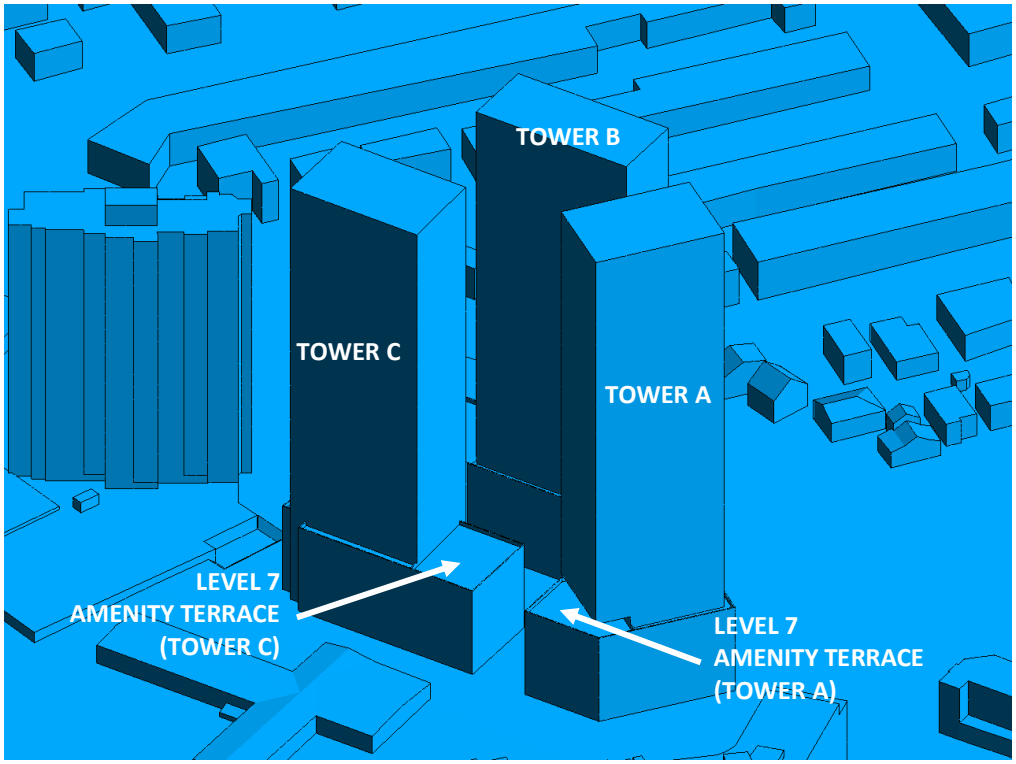

FIGURE 2D: CLOSE UP OF FIGURE 2C

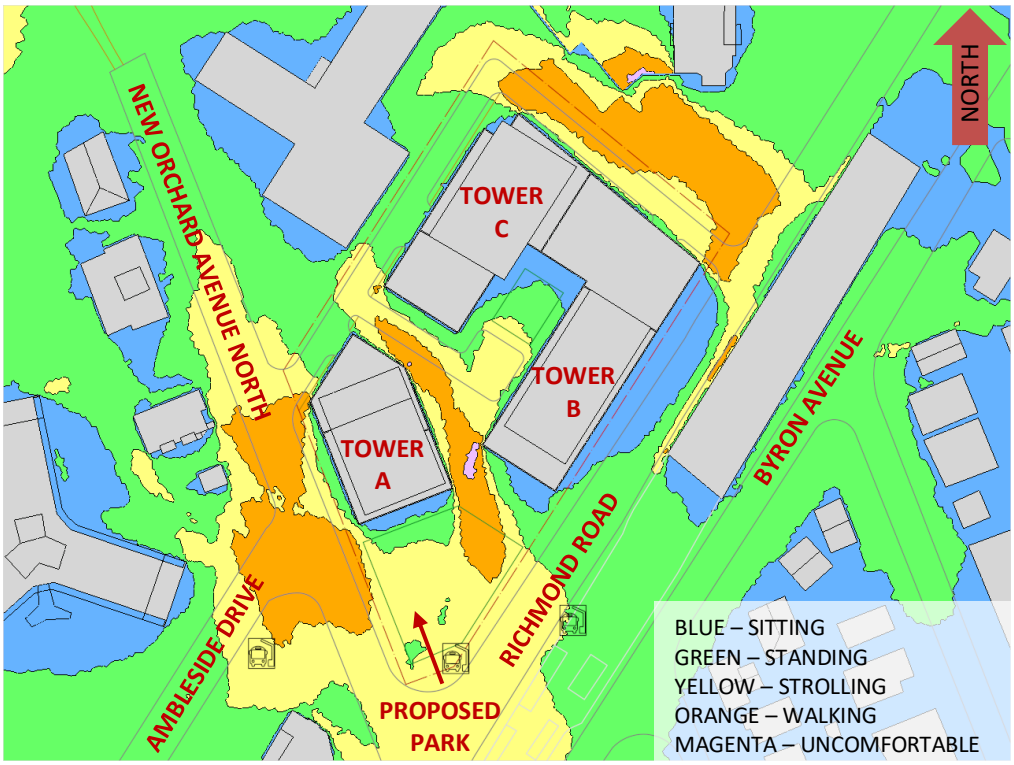

FIGURE 3A: SPRING – WIND COMFORT, GRADE LEVEL

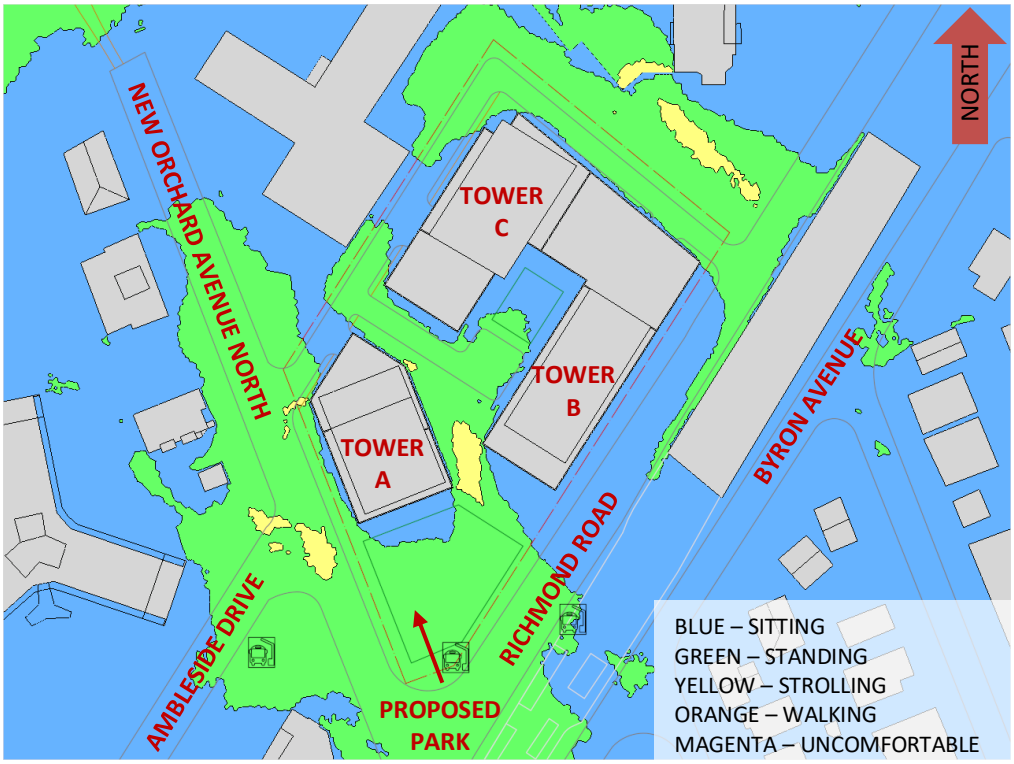

FIGURE 3B: SUMMER – WIND COMFORT, GRADE LEVEL

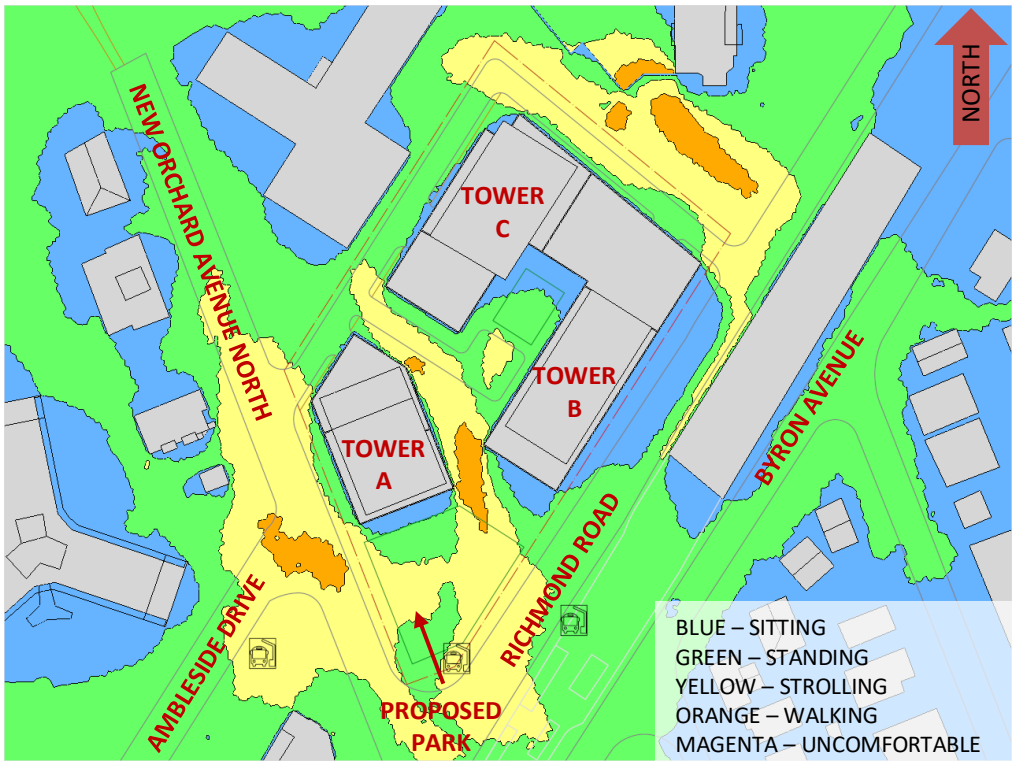

FIGURE 3C: AUTUMN – WIND COMFORT, GRADE LEVEL

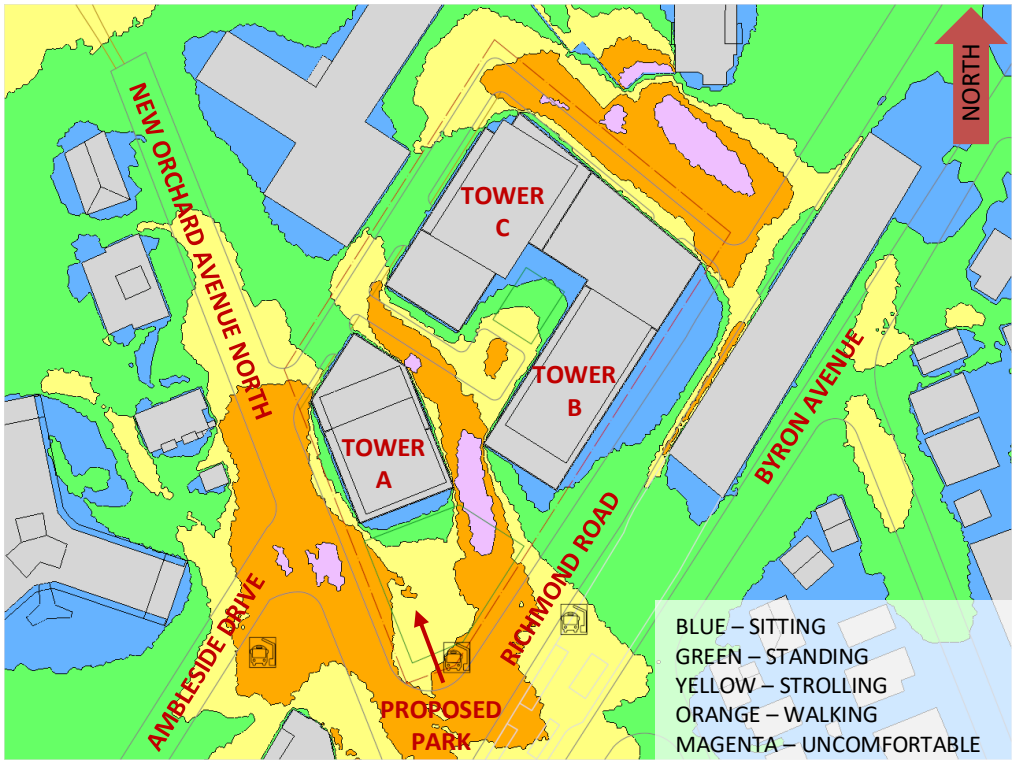

FIGURE 3D: WINTER – WIND COMFORT, GRADE LEVEL

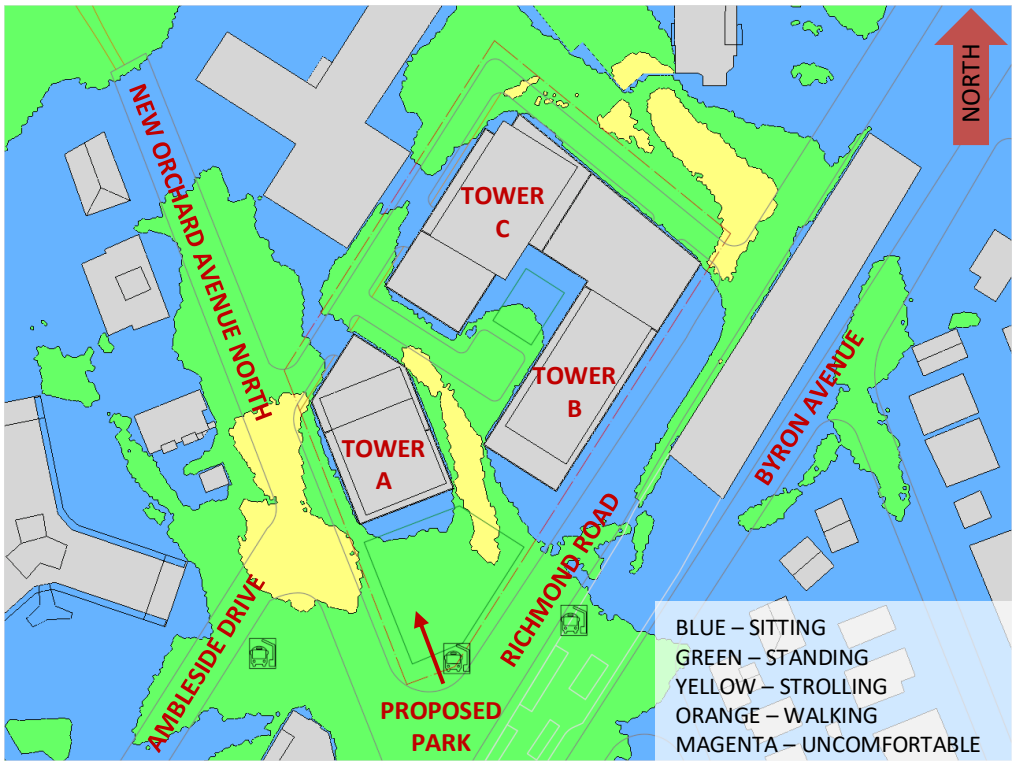

FIGURE 4A: TYPICAL USE PERIOD – WIND COMFORT, GRADE LEVEL

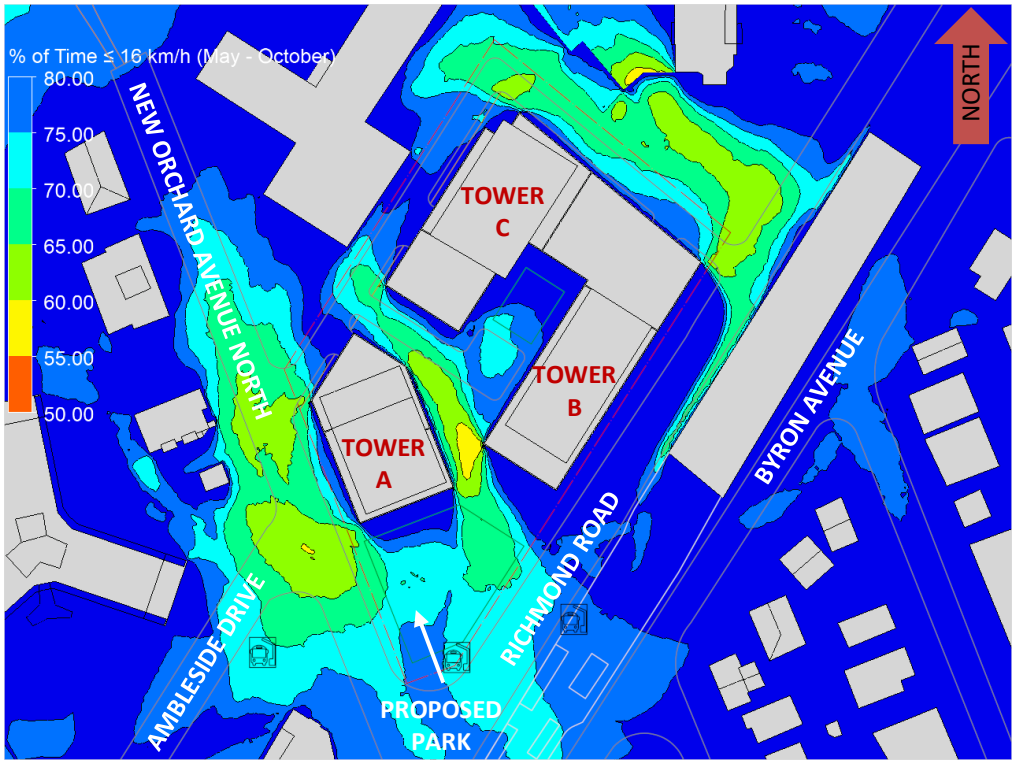

FIGURE 4B: PERCENTAGE OF TIME SUITABLE FOR SITTING IN FIGURE 4A

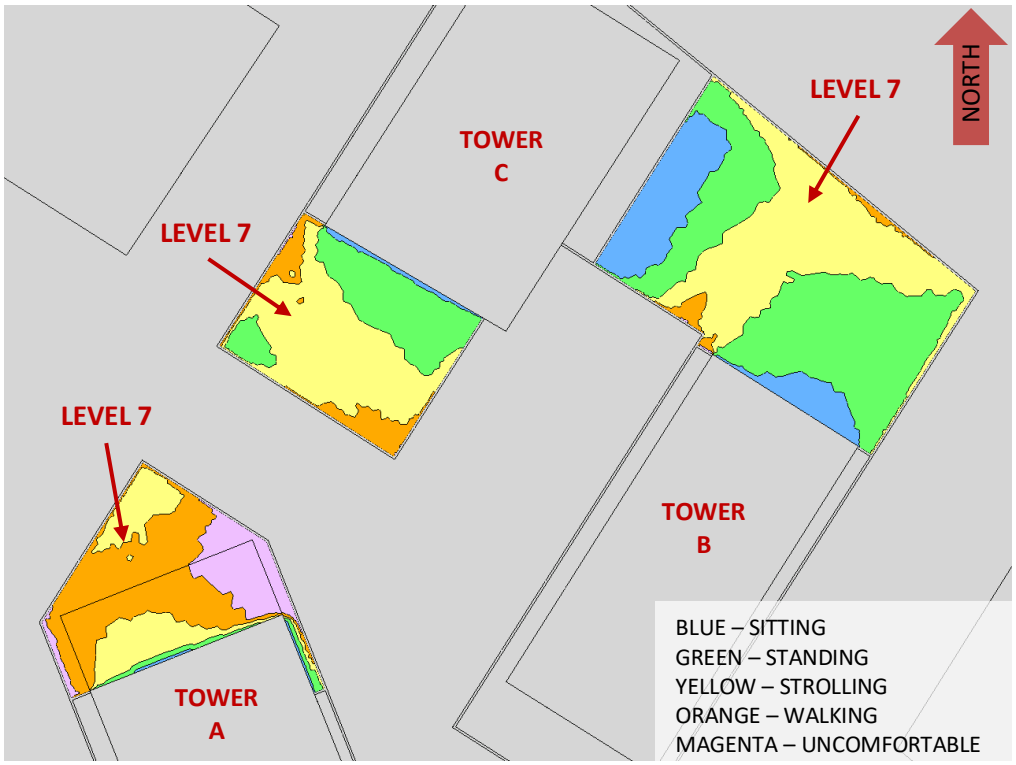

FIGURE 5A: SPRING – WIND COMFORT, COMMON AMENITY TERRACES

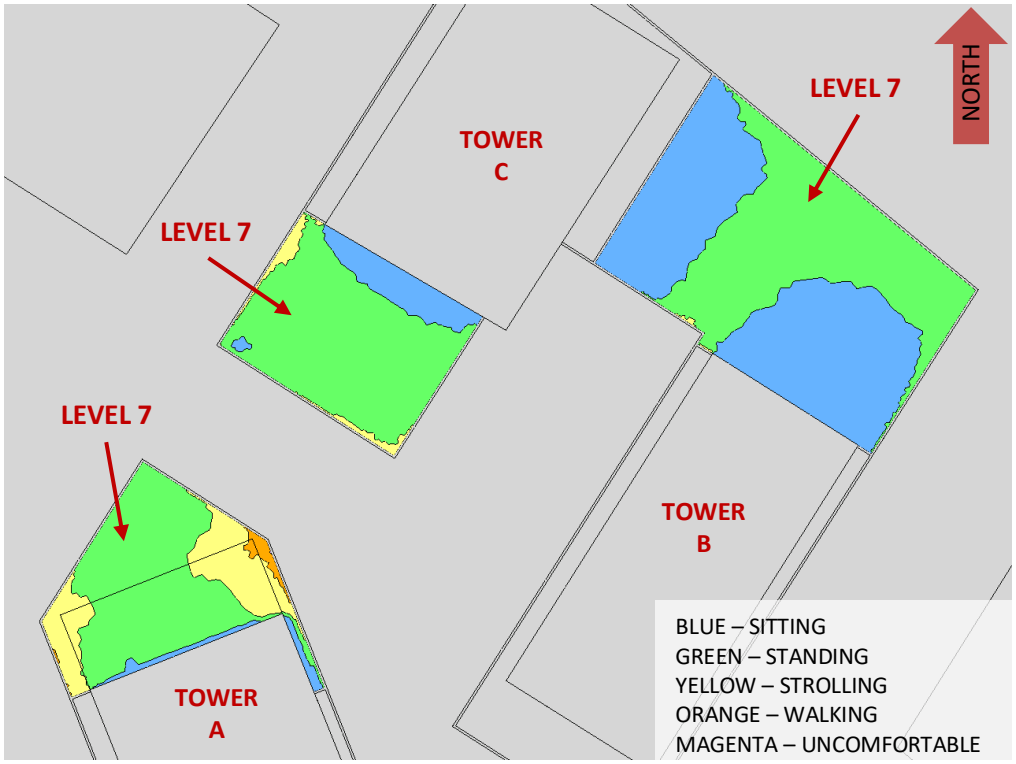

FIGURE 5B: SUMMER – WIND COMFORT, COMMON AMENITY TERRACES

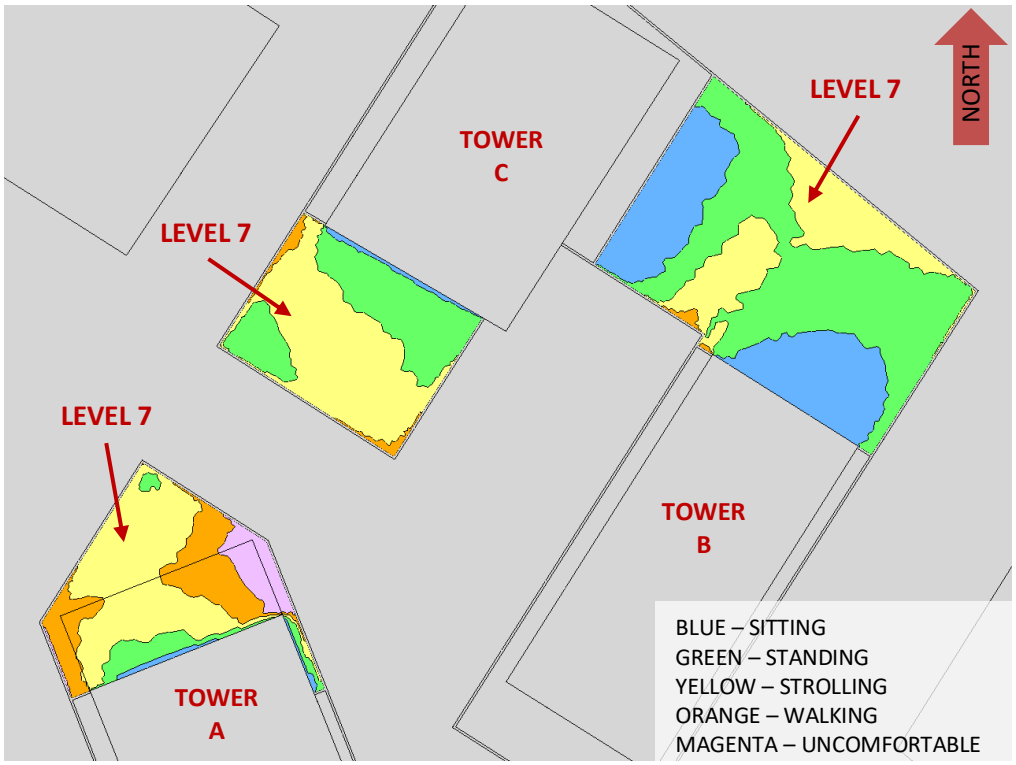

FIGURE 5C: AUTUMN – WIND COMFORT, COMMON AMENITY TERRACES

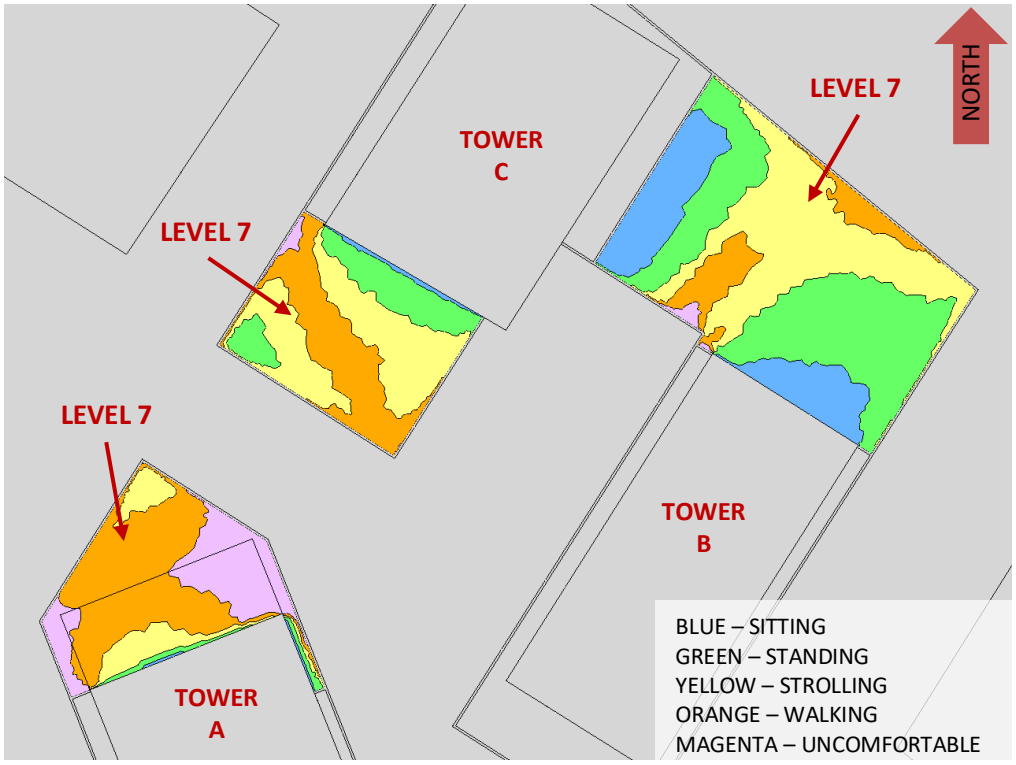

FIGURE 5D: WINTER – WIND COMFORT, COMMON AMENITY TERRACES

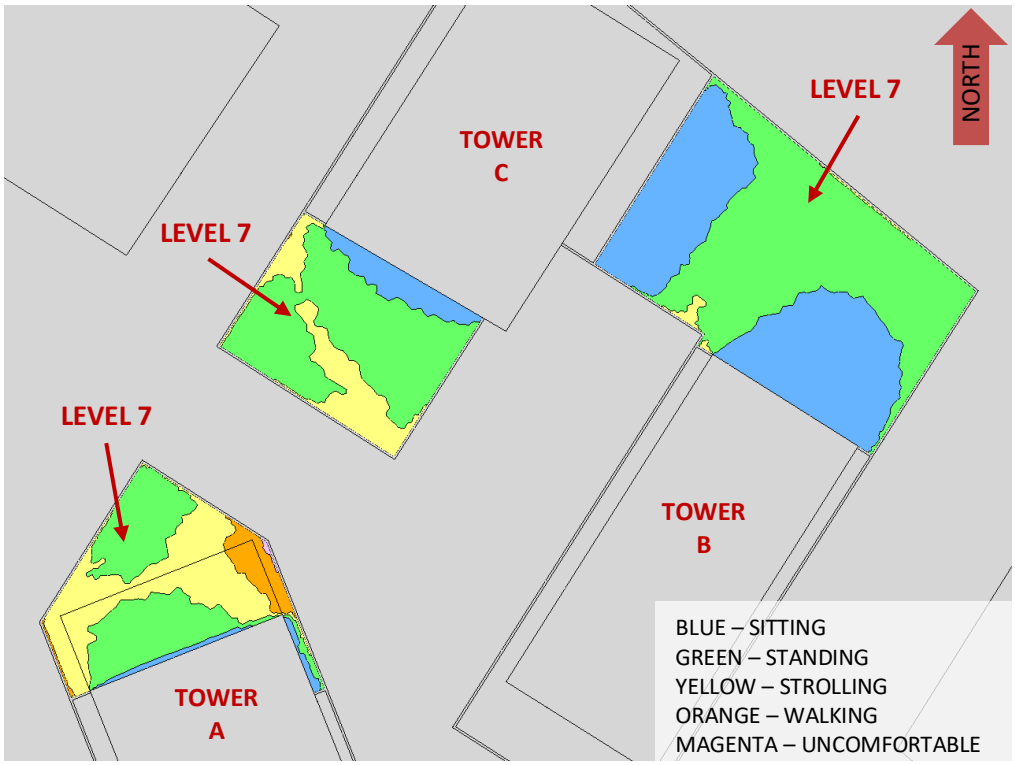

FIGURE 6A: TYPICAL USE PERIOD – WIND COMFORT, COMMON AMENITY TERRACES

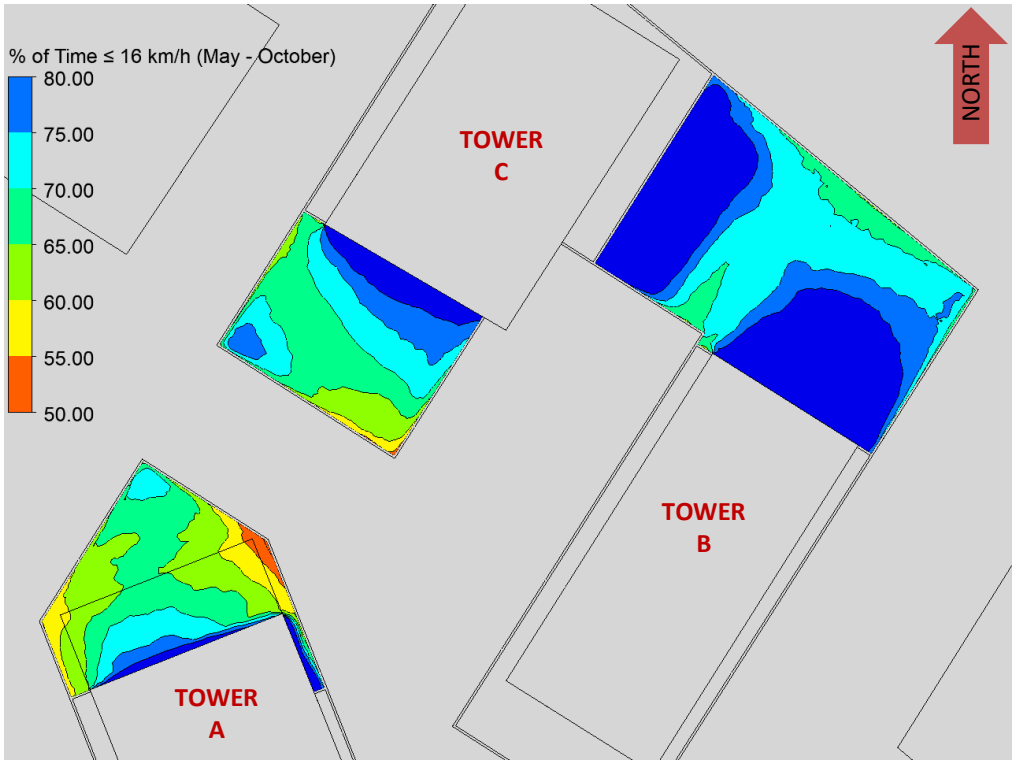

FIGURE 6B: PERCENTAGE OF TIME SUITABLE FOR SITTING IN FIGURE 6A

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 60% mean wind speed for Ottawa based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

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

α is determined based on the upstream exposure of the far-field surroundings (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	0.17
49	0.24
74	0.24
103	0.24
167	0.24
197	0.24
217	0.24
237	0.21
262	0.18
282	0.17
302	0.18
324	0.18

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

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

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

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

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

where, I = turbulence intensity, L_t = turbulence length scale, Z = height above ground, and 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.

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[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.