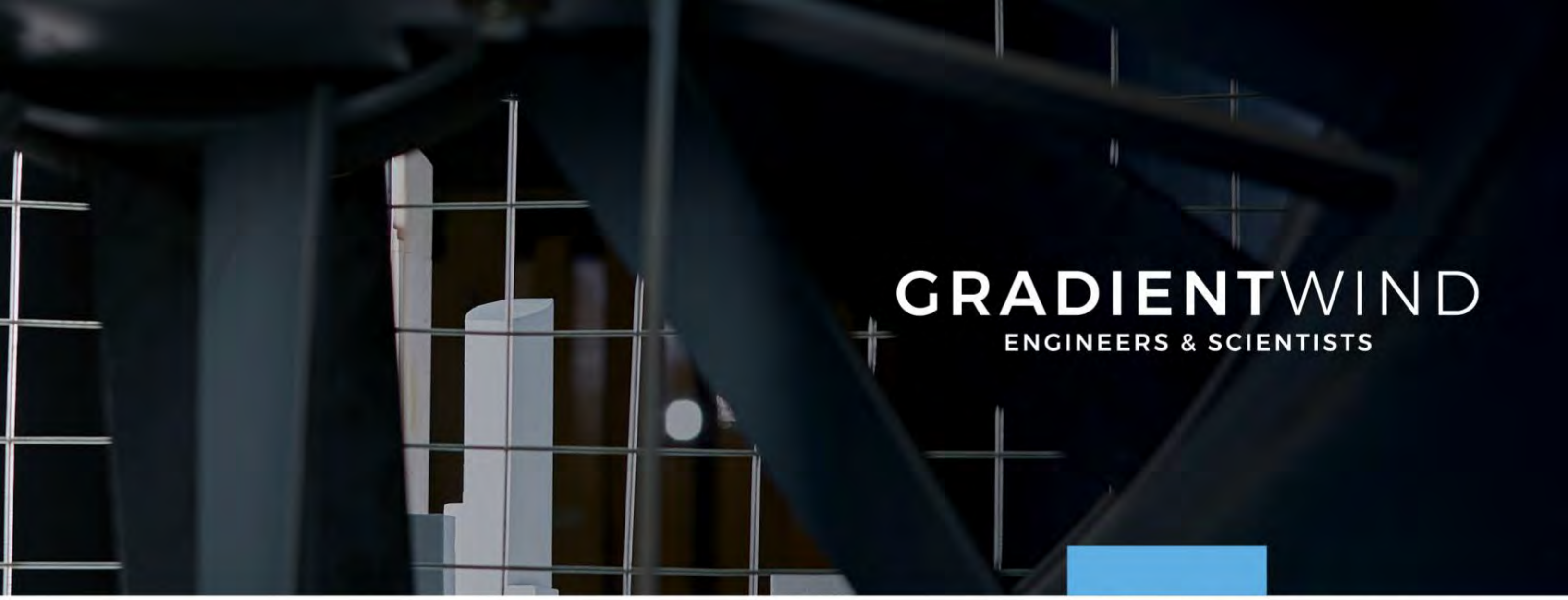
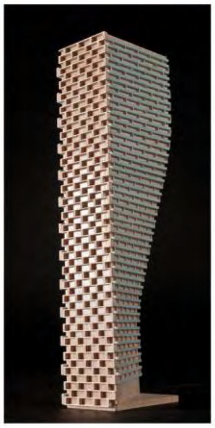
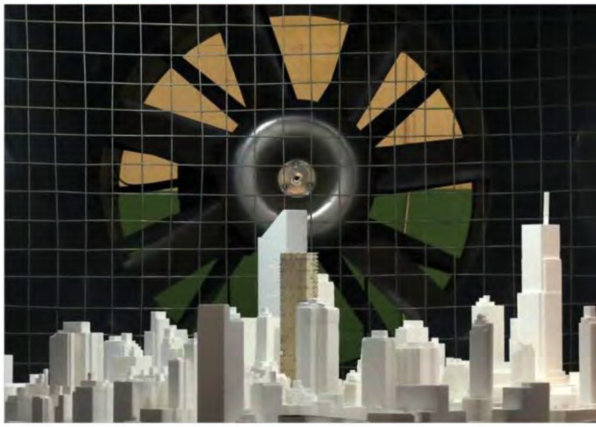


PEDESTRIAN LEVEL WIND STUDY

5800 Yonge Street
North York, Ontario

REPORT: GWE18-201-CFDPLW





July 18, 2019

PREPARED FOR
Times 5800 Inc.
3985 Highway 7 East, Suite 202
Markham, Ontario
L3R 2A2

PREPARED BY
Megan Prescott, MESc., Project Manager
Andrew Sliasas, M.A.Sc., P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed multi-building, mixed-use development located at 5800 Yonge Street in North York, Ontario. 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 comfort and safety within and surrounding the development site. The results and recommendations derived from these considerations are summarized in the following paragraphs and detailed in the subsequent report.

Our work is based on industry standard CFD simulation and data analysis procedures, architectural drawings provided by Wallman Architects in April 2019 and updated in July 2019, surrounding street layouts and existing and approved future building massing information obtained from the City of Toronto, as well as recent site imagery.

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-6B following the main text. Based on CFD test results, interpretation, and experience with similar developments, we conclude that wind conditions over many pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include north-facing primary entrances serving Towers 1 and 4, the daycare outdoor area, sections of sidewalk north of and interior to the site, and potential grade-level seating areas. To reduce wind speeds in these areas, mitigation is recommended in the form of wind barriers or recessed entrance locations as described in Section 5.

Overall, the various outdoor amenity areas serving Levels 3, 4 and 7 will not achieve sitting conditions throughout the year. To ensure comfortable conditions during the summer at these locations, mitigation is recommended in the form of wind barriers and canopies/overhead structures as described in Section 5.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience conditions that could be considered unsafe.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Times 5800 Inc. to undertake a computer-based pedestrian level wind study for a multi-building, mixed-use development to be located at 5800 Yonge Street in North York, Ontario. Our mandate within this study, as outlined in GWE proposal #18-302P R1, dated November 8, 2018, is to investigate pedestrian wind comfort within and surrounding the development site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

Our work is based on industry standard computer simulations using the Computational Fluid Dynamics (CFD) technique and data analysis procedures, architectural drawings provided by Wallman Architects in April 2019 and updated in July 2019, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

2. TERMS OF REFERENCE

The focus of this detailed pedestrian level wind study is a proposed multi-building, mixed-use development at 5800 Yonge Street in North York, Ontario. The study site is located near the southwest corner of Yonge Street and Drewry Avenue, approximately 200 metres south of the intersection.

The proposed development comprises four towers over two phases, separated west and east on the site by a private access road. Phase 1 comprises Tower 1 (38 storeys) and Tower 2 (36 storeys), respectively separated south and north by a courtyard and landscaped area. Phase 2 comprises Tower 3 (44 storeys) and Tower 4 (38 storeys), located south to north and connected by a stepped three-storey podium.

With respect to Phase 1, Towers 1 and 2 feature nearly mirrored rectangular planforms with diagonal walls and the short axis oriented along Yonge Street. Ground floor comprises residential units, lobbies facing the courtyard and drop-off area, as well as building support function spaces, and a daycare area at the west side of Tower 1. Loading areas are located near the northeast corner of either tower, accessed from Yonge Street by private access roads. A ramp to underground parking is also located near the northeast corner of Tower 2. For both towers, the floorplate sets back from all sides at Level 3 to create outdoor amenity areas over the southeast portion of Tower 1 and the over the northeast portion of Tower 2, with green roofs over the remaining areas. At Level 4, the floorplates extend to partially overhang the outdoor amenity areas below. The floorplates set back again from the west side of Level 7 to create outdoor amenity areas. Above Level 7, Tower 1 features rectangular balconies while Tower 2 balconies are curved.

Regarding Phase 2, the podium planform at grade is nearly rectangular with diagonal walls and the long axis oriented along Yonge Street. Ground floor comprises residential units along the west perimeter, lobbies near the southwest and northeast corners, retail units and a retail lobby fronting Yonge Street, as well as building support function rooms in the remaining space. A loading area and ramp to the underground parking are located near the northwest corner of the building, accessed from Yonge Street by a private access road north of the site. The floorplate sets back from all sides at Level 3, creating an outdoor amenity area at the central west and southwest section of rooftop and green roof over the remaining space. Level 3 comprises a central indoor amenity room adjacent to the outdoor amenity, and office use in the remaining space, while residential use occupies the floors above. The podium terminates at Level 4, where the podium rooftop provides an outdoor amenity area between Towers 3 and 4. Towers 3 and 4 feature nearly rectangular planforms with diagonal walls and the short axis oriented along Yonge Street. Tower 3 features curved balconies, while Tower 4 balconies are rectangular.

Following the completion of testing, changes have been made to the building form that are not reflected in the figures of this report. With respect to pedestrian wind comfort, notable changes include the following:

(i) Slight relocation of the Tower 2 lobby entrance

(ii) A slight extension and modified configuration of the outdoor daycare area at the west side of Tower 1, as well as increased overhead coverage for the area

(iii) Planform shapes of the podium and tower for Towers 1 and 4 have altered from angular to curved balconies

(iv) A relocated and slightly inset lobby location for Tower 4

(v) Phase 1 outdoor amenity areas at Level 3 have reduced somewhat in size in favour of green roof space.

(vi) Reduced size of Level 4 outdoor amenity area for Phase 2, now bounded by an extension of office spaces along the east side of Level 4

(vii) Stepped, private terraces introduced at the southwest corners of Tower 3 at Levels 42 and 43 and Tower 2 at Levels 33 and 34, the northwest corner of Towers 1 and 4 at Levels 36 and 37, as well as stepped, adjacent mechanical roofs above.

All remaining changes are considered minor from a pedestrian wind perspective.

Regarding wind exposures, the near-field surroundings of the development (defined as an area falling within a 200-metre radius of the site) are characterized by low-rise commercial buildings to the northeast, high-rise buildings to the southeast, open exposure to the southwest, and a mix of low and medium-rise buildings to the northwest, in addition to the future approved developments at 5840 Yonge Street (32 storeys) and 5915 Yonge Street (Block 1, 34 storeys), respectively located north and east of the site. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) are primarily characterized by low-rise residential suburban buildings with a moderate-density mix of low, medium and high-rise buildings south along Yonge Street.

An additional discussion follows the main assessment to consider the influence of the fully developed three-block site at 5915 Yonge Street and the proposed development at 51 Drewry Avenue, 8-28 Inez Court (32 storeys, northwest of the site) on future wind conditions within and surrounding the development site. This discussion is accompanied by Figures A1 through A6B in Appendix A.

Key areas under consideration for pedestrian wind comfort include surrounding sidewalks, walkways, building access points, nearby transit stops, the landscaped courtyard, the future park west of the site, and the various rooftop outdoor amenity areas. Figure 1 illustrates the study site and surrounding context. Figures 2A and 2B 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 Toronto area wind climate, and synthesis of computational data with industry-accepted guidelines[1]. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort guidelines.

4.1 Computer-Based Context Modelling

A computer-based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Pearson 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 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 840 metres.

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 metres above local grade were referenced to the wind speed at gradient height to

[1] Toronto Development Guide, Pedestrian Level Wind Study Terms of Reference, February 2012

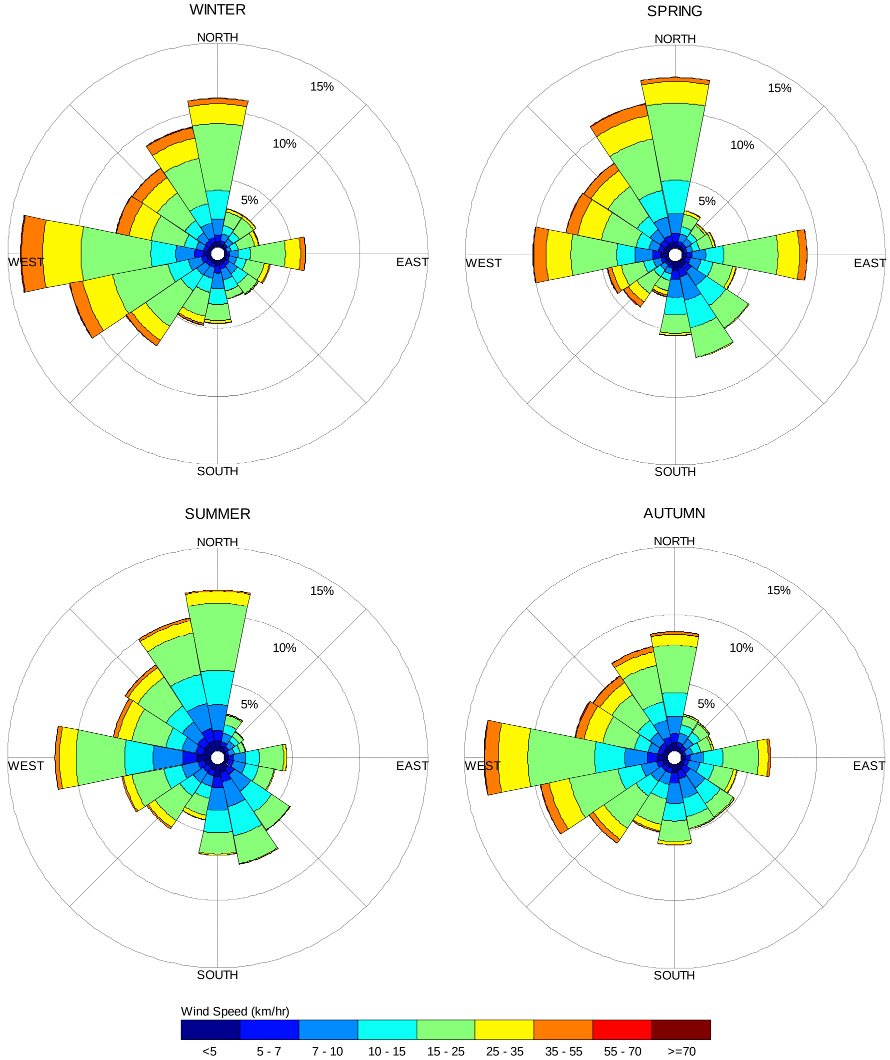
generate mean and peak velocity ratios, which were used to calculate full-scale values. The gradient height represents the theoretical depth of the boundary layer of the Earth's atmosphere, above which the mean wind speed remains constant. Appendices A and B provide greater detail of the theory behind wind speed measurements.

4.3 Meteorological Data Analysis

A statistical model for winds in Toronto, representative of North York, was developed from approximately 40-years of hourly meteorological wind data recorded at Pearson International Airport and obtained from the local branch of Atmospheric Environment Services of Environment Canada. Wind speed and direction data were analyzed for each month of the year in order 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.

The statistical model of the Toronto 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 Toronto, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east. 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.

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
PEARSON INTERNATIONAL AIRPORT, TORONTO, 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. Four pedestrian comfort classes are based on 80% non-exceedance gust wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. More specifically, the comfort classes and associated gust wind speed ranges are summarized as follows:

(i) **Sitting** – A wind speed below 16 km/h (i.e. 0 – 16 km/h) would be considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – A wind speed below 22 km/h (i.e. 16 km/h – 22 km/h) is acceptable for activities such as standing or leisurely strolling.

(iii) **Walking** – A wind speed below 30 km/h (i.e. 22 km/h– 30 km/h) is acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – A wind speed over 30 km/h is classified as uncomfortable from a pedestrian comfort standpoint. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

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. Corresponding mean wind speeds are approximately calculated as gust wind speed minus 1.5 times the root-mean-square (rms) of the wind speed measurements. Gust speeds are used in the guidelines because people 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 cause problems for pedestrians. The gust speed ranges 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.

THE BEAUFORT SCALE

NUMBER	DESCRIPTION	WIND SPEED (KM/H)	DESCRIPTION
2	Light Breeze	4-8	Wind felt on faces
3	Gentle Breeze	8-15	Leaves and small twigs in constant motion; Wind extends light flags
4	Moderate Breeze	15-22	Wind raises dust and loose paper; Small branches are moved
5	Fresh Breeze	22-30	Small trees in leaf begin to sway
6	Strong Breeze	30-40	Large branches in motion; Whistling heard in electrical wires; Umbrellas used with difficulty
7	Moderate Gale	40-50	Whole trees in motion; Inconvenient walking against wind
8	Gale	50-60	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 at tested locations, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for their associated spaces. This step involves comparing the predicted comfort class to the desired comfort class, which is dictated by the location type represented by the sensor (i.e. a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalks / Pedestrian Walkways	Walking
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing
Plazas	Standing / Walking
Transit Stops	Standing
Public Parks	Sitting / Walking
Garage / Service Entrances	Walking
Vehicular Drop-Off Zones	Walking
Laneways / Loading Zones	Walking

5. RESULTS AND DISCUSSION

The foregoing discussion of predicted pedestrian wind conditions is accompanied by Figures 3A through 6B (following the main text) illustrating the seasonal wind conditions at grade level. The colour contours indicate various comfort classes predicted for certain regions. Wind conditions comfortable for sitting or more sedentary activities are represented by the colour green, standing are represented by yellow, and conditions suitable for walking are represented by blue. The colour magenta indicates wind conditions considered uncomfortable for walking.

Yonge Street Sidewalk, Including Adjacent Retail/Lobby Entrance (Tags A & B): The Yonge Street sidewalk along the east side of the development site (Tag A) will largely be suitable for standing during the summer and standing or walking for the remainder of the year. The adjacent retail/lobby entrance serving Phase 2 (Tag B) will be suitable for sitting during the summer and standing for the remainder of the year. These conditions are acceptable.

Access Points Along North Elevation, and Adjacent Sidewalk (Tags C & D): The various primary and secondary entrances serving the north elevation of Tower 4 (Tag C) will mostly be suitable for standing during the summer and walking for the remainder of the year. While these conditions are acceptable for the stairwell and vehicular access points, the desired comfort class of standing can be achieved for the lobby entrance serving Tower 4 by either recessing the doorway at least 1.5 metres into the building façade or flanking the doorway with vertical wind barriers. For the various building entrances along the north elevation of Tower 2, conditions will be comfortable for sitting during the summer and for standing or better throughout the remaining seasons, which is acceptable.

The adjacent sidewalk serving the private access road (Tag D) will largely experience acceptable wind conditions suitable for standing or walking throughout the year, transitioning to conditions uncomfortable for walking over the east portion during the winter. These windier conditions are primarily influenced by westerly winds accelerating between the southwest corner of the adjacent, future approved development at 5840 Yonge Street and Towers 2 and 4 of the proposed development. It is noteworthy that the massing of the proposed development at 51 Drewry Avenue, 8-28 Inez Court (32 storeys, northwest of the site), and to an extent the full three-block development site at 5915 Yonge Street, will improve uncomfortable conditions at this location to conditions suitable for walking upon full build-out (illustrated in Appendix A). If calmer conditions are desired for this area in the interim, it is recommended to install a cluster of wind barriers along the sidewalk. Barriers may take the form of high-solidity wind barriers, dense coniferous plantings, or a combination thereof, and should rise no less than 2.4 metres at the time of planting. The exact placement and configuration of barriers can be confirmed at a later date as the site plan progresses.

West Side of Site (Future Beecroft Extension Sidewalk, Tag E): The west perimeter of the site will transition into an extension of the existing Beecroft Road as part of future development. This area will largely be suitable for standing during the summer and autumn and standing or walking for the remainder of the year. These conditions are acceptable for the intended future uses.

South Elevation Sidewalk and Adjacent Entrances (Tags F & G): The sidewalk serving the proposed public road south of the study site (Tag F) will generally be suitable for sitting or standing during the summer and walking or better for the remainder of the year. The adjacent access points serving the south elevation at both phases (Tag G) will be suitable for sitting or standing throughout the year. These conditions are acceptable for the intended uses.

Landscaped Area/Courtyard (Tag H): The landscaped area and courtyard between Towers 1 and 2 will be suitable for standing during the summer, standing or walking during the spring and autumn, and walking during the winter, with the windier conditions occurring over the drop-off area. If seating is desired over the landscaped, privately-owned public space (POPS) during the summer, it is recommended to install localized 2.0-metre-tall wind barriers directly west of seating areas to shield from oncoming winds channelling between Towers 1 and 2. The exact placement and configuration of barriers can be confirmed at a later date as the site plan progresses.

Outdoor Daycare Area (Tag I): The grade-level outdoor daycare area at the northwest corner of Tower 1 (Tag I) will largely be suitable for sitting during the intended use period of late spring to early autumn, with windier conditions suitable for standing occurring at the northwest corner of the building. Throughout the colder seasons, conditions become suitable for standing or walking. To provide calmer conditions suitable for sitting over the entire daycare area, it is recommended to install a high-solidity wind barrier along the full perimeter of the space, rising at least 1.8 metres above the walking surface.

Phase 1 Entrances Serving the Courtyard (Tags J & K): Regarding entrances facing the courtyard (Tag J), the lobby entrance and the daycare entrance serving Tower 1 will experience local conditions suitable for standing during the spring, summer and autumn, transitioning to walking conditions during the winter. To ensure standing conditions at these entrances, it is recommended to either recess the doorways at least 1.5 metres into the building façade or flank the doorway with vertical wind barriers.

The lobby entrance along the south side of Tower 2 will be comfortable for sitting or standing throughout the year. The secondary access points serving the east side of the north elevation of Tower 1 (Tag K) will achieve conditions suitable for walking, or better, throughout the year. These conditions are acceptable for the intended uses.

Private Access Road Intersecting Study Site, Including Adjacent Sidewalk (Tag L): The private access road intersecting the study site from north to south, as well as the adjacent sidewalk, will largely be suitable for standing or walking during the summer and autumn and walking for the remainder of the year, transitioning to conditions uncomfortable for walking near the northeast corner of Tower 1 during the winter. It is noteworthy that the massing of the proposed development at 51 Drewry Avenue, 8-28 Inez Court (32 storeys, northwest of the site), and to an extent the full three-block development site at 5915

Yonge Street, will improve uncomfortable conditions at this location to conditions suitable for walking, upon full build-out (illustrated in Appendix A). If calmer conditions are desired for this area in the interim, it is recommended to integrate a cluster of 2.4-metre-tall wind barriers near the northeast corner of Tower 1. The exact placement and configuration of barriers can be confirmed at a later date as the site plan progresses.

Nearby Transit Stop (Tag M): The transit stop southeast of the site will experience conditions suitable for standing during the summer, standing or walking during the spring and autumn and walking during the winter. This location is equipped with a three-walled transit shelter that will allow pedestrians to take cover during windy periods. Therefore, these conditions are considered acceptable.

The transit stop directly east of the study site across Yonge Street will experience wind conditions suitable for standing during the summer and walking for the remainder of the year. To achieve the desired comfort class of standing at this location, it is recommended that this stop be equipped with a three-walled transit shelter.

Future Park (Tag N): The future park west of the study site will be suitable for standing during the summer and autumn, standing or walking during the spring and walking during the winter. These conditions are acceptable provided seating or more sedentary activities are not intended for the park. If seating areas are desired for the park, it is recommended to install localized wind barriers directly north and west of seating to deflect oncoming winds. The exact placement and configuration of such barriers can be confirmed at a later date as the park design progresses.

Level 3 Outdoor Amenity Areas – Phase 1 (Tag O): The outdoor amenity areas serving Towers 1 and 2 at Level 3 will largely experience wind conditions suitable for sitting and standing throughout the year, transitioning to windier conditions suitable for walking at the northeast corner of the spaces during the three colder months. To ensure calm conditions suitable for sitting over the entire area of the terraces during the warmer months, it is recommended to raise the perimeter guard to 1.8 metres above the walking surface along the east half of the Tower 1 terrace and at the northeast corner of the Tower 2 terrace.

Level 3 Outdoor Amenity Area – Phase 2 (Tag P): The outdoor amenity area serving Phase 2 at Level 3 will generally be suitable for standing during the summer and standing or walking for the remainder of the year. To ensure conditions are comfortable for sitting over the entire space during the summer, it is recommended to raise the west perimeter guard to 1.8 metres above the walking surface and to introduce similar height localized wind barriers upwind of designated seating areas to shelter westerly and northerly wind directions. The exact placement and configuration of barriers can be confirmed at a later date as the terrace progresses.

L4 Amenity – Phase 2 (Tag Q): Under the tested building configuration, wind conditions over the outdoor amenity area serving Phase 2 at Level 4 will be suitable for sitting or standing during the summer and standing or walking for the remainder of the year. As the updated building massing creates a single-storey link between Towers 3 and 4 to the east of the amenity area, wind conditions over the terrace are expected to be somewhat improved due to the added protection from easterly winds and reduced potential of westerly winds channelling between the buildings. If seating areas will be located near the west perimeter of the terrace, it is recommended to raise the adjacent perimeter guards to 2.0 metres above the walking surface. For seating areas interior to the terrace area, 1.8-metre-tall localized wind barriers placed to the west of designated seating areas is recommended. Additionally, it is recommended to install a canopy or similar overhead structure, extending at least 2.0 metres from the plane of the balconies above, along the north elevation of Tower 3 to deflect downwash flows.

Level 7 Outdoor Amenity Area – Phase 1 (Tag R): Overall, the outdoor amenity areas serving Towers 1 and 2 at Level 7 will be suitable for standing during the summer and standing or walking for the remainder of the year. To ensure conditions are suitable for sitting during the summer, it is recommended to raise the full perimeter guard to 2.0 metres above the walking surface. As well, a canopy or similar overhead structure should be provided along the east side of the terraces to deflect downwash flows. The canopy/structure should extend at least 2.0 metres from the plane of the balconies above.

Influence of the Proposed Development on Existing Wind Conditions near the Study Site: Wind conditions over surrounding sidewalks beyond the development site and areas mentioned above will be comfortable for their intended pedestrian uses during each seasonal period upon the introduction of the proposed development.

Upon construction of the proposed development at 51 Drewry Avenue, 8-28 Inez Court (32 storeys, northwest of the site) and the full three-block development site at 5915 Yonge Street, wind speeds will tend to improve over the study site at grade-level and elevated locations. Based on additional CFD testing, illustrated in Appendix A, grade-level conditions highlighted as uncomfortable for walking in this report are predicted to improve to walking conditions following construction of these surrounding developments. Wind speeds over the outdoor amenity areas serving Tower 2 would also be improved to conditions suitable for sitting during the summer without mitigation. However, the recommended mitigation for grade-level areas, and all remaining elevated outdoor amenity areas, as outlined in this report, would remain applicable.

Wind Safety: Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience wind conditions that are considered unsafe.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for the proposed mixed-use development located at 5800 Yonge Street in North York, Ontario. The study was performed in accordance with the scope of work described in GWE proposal #18-302P R1, dated November 8, 2018, as well as industry standard CFD simulation and data analysis procedures.

A complete summary of the predicted wind conditions is provided in Section 5 of this report and illustrated in Figures 3A-6B following the main text. Based on CFD test results, meteorological data analysis, and experience with similar developments in the Greater Toronto Area, we conclude that wind conditions over many pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include north-facing primary entrances serving Towers 1 and 4, the daycare outdoor area, sections of sidewalk north of and interior to the site, and potential grade-level seating areas. To reduce wind speeds in these areas, mitigation is recommended in the form of wind barriers or recessed entrance locations as described in Section 5.

Overall, the various outdoor amenity areas serving Levels 3, 4 and 7 will not achieve sitting conditions throughout the year. To ensure comfortable conditions during the summer at these locations, mitigation is recommended in the form of wind barriers and canopies/overhead structures as described in Section 5.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site were found to experience conditions that could be considered unsafe.

This concludes our pedestrian level wind study and report. Please advise the undersigned of any questions or comments.

Sincerely,

Gradient Wind Engineering Inc.

Megan Prescott, MESc.,
Project Manager

Andrew Sliasas, M.A.Sc., P.Eng.,
Principal

GWE18-201-CFDPLW

GRADIENTWIND
ENGINEERS & SCIENTISTS

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613 836 0934 • GRADIENTWIND.COM

PROJECT 5800 YONGE STREET, NORTH YORK PEDESTRIAN LEVEL WIND STUDY			DESCRIPTION FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:2500 (APPROX.)	DRAWING NO. GWE18-201-PLW-1		
DATE MAY 16, 2019	DRAWN BY K.A.		

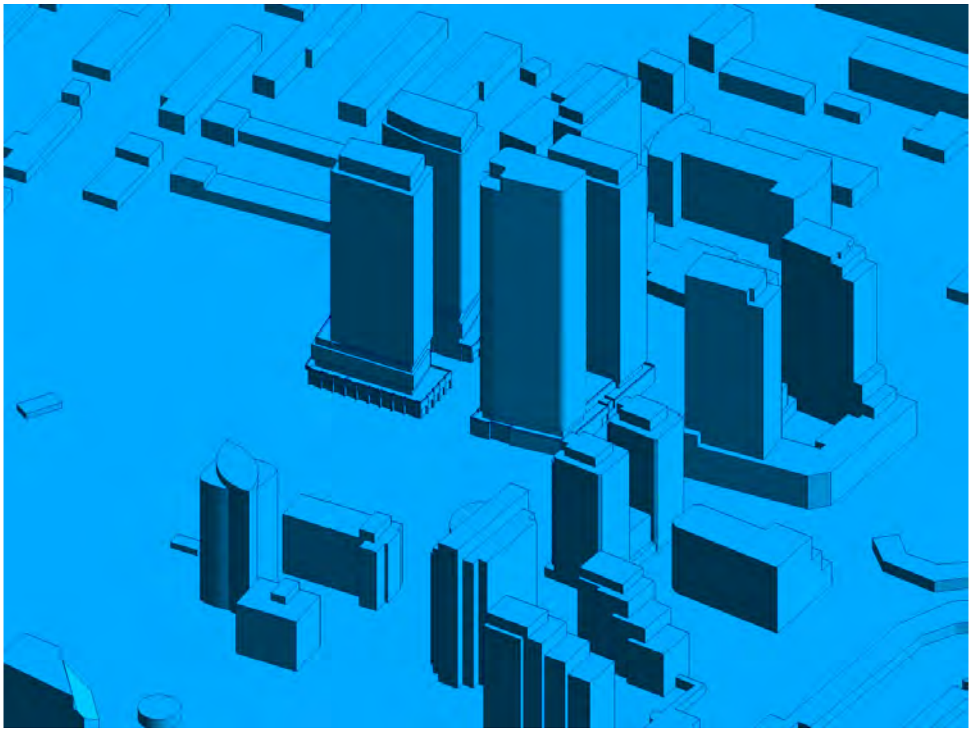


FIGURE 2A: COMPUTATIONAL MODEL, SOUTHEAST PERSPECTIVE

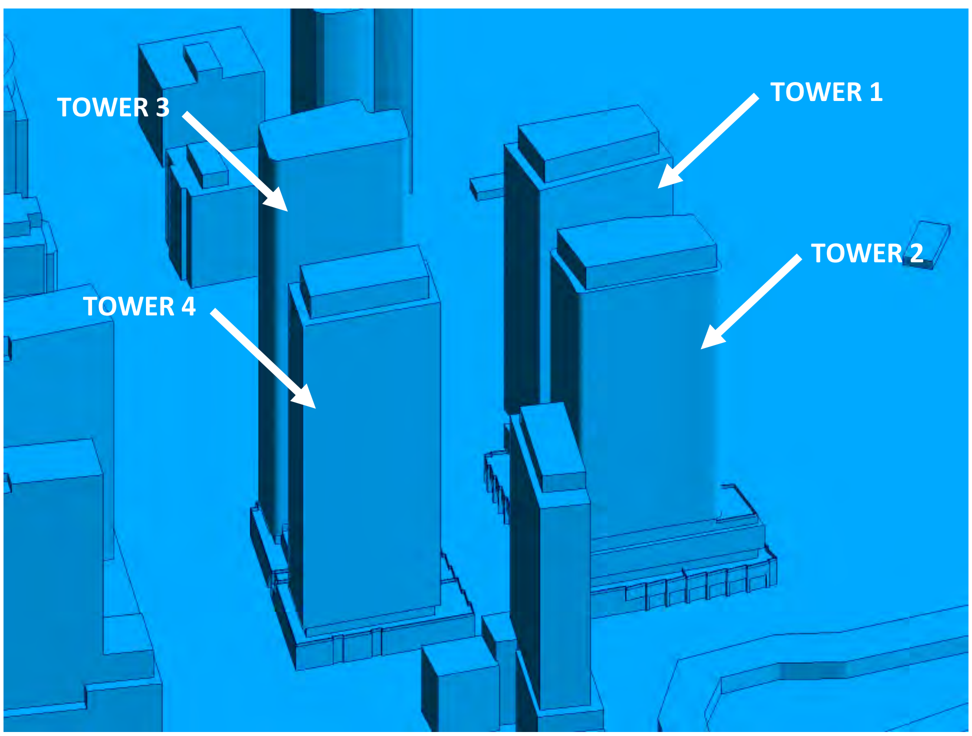


FIGURE 2B: STUDY SITE, NORTH PERSPECTIVE

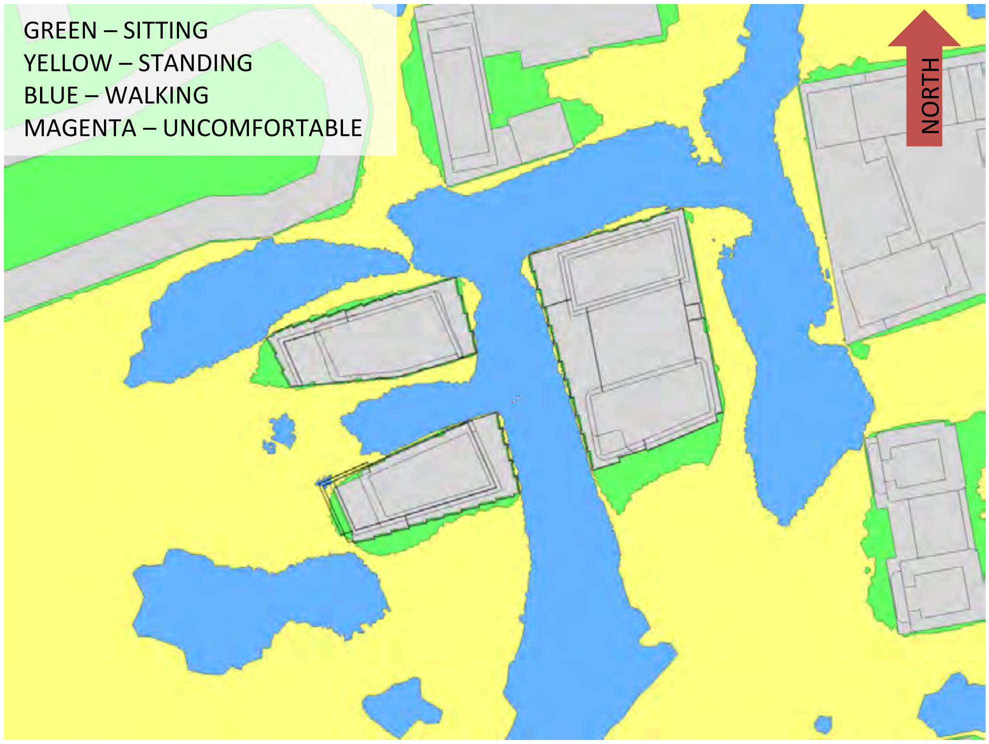
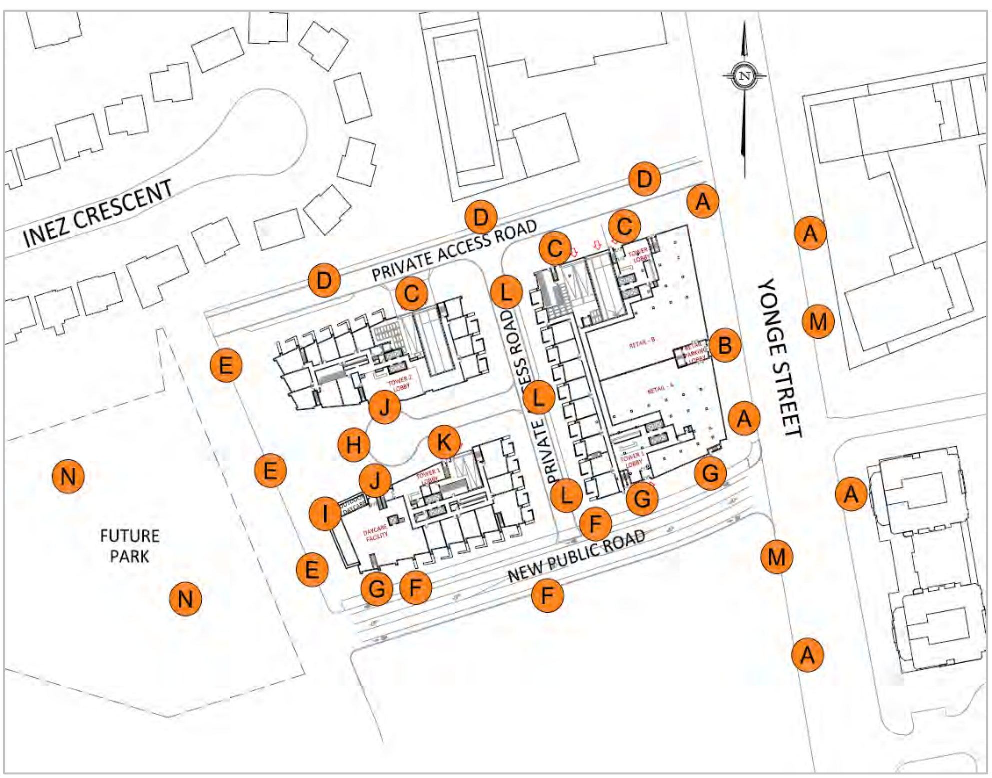


FIGURE 3A: SPRING – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

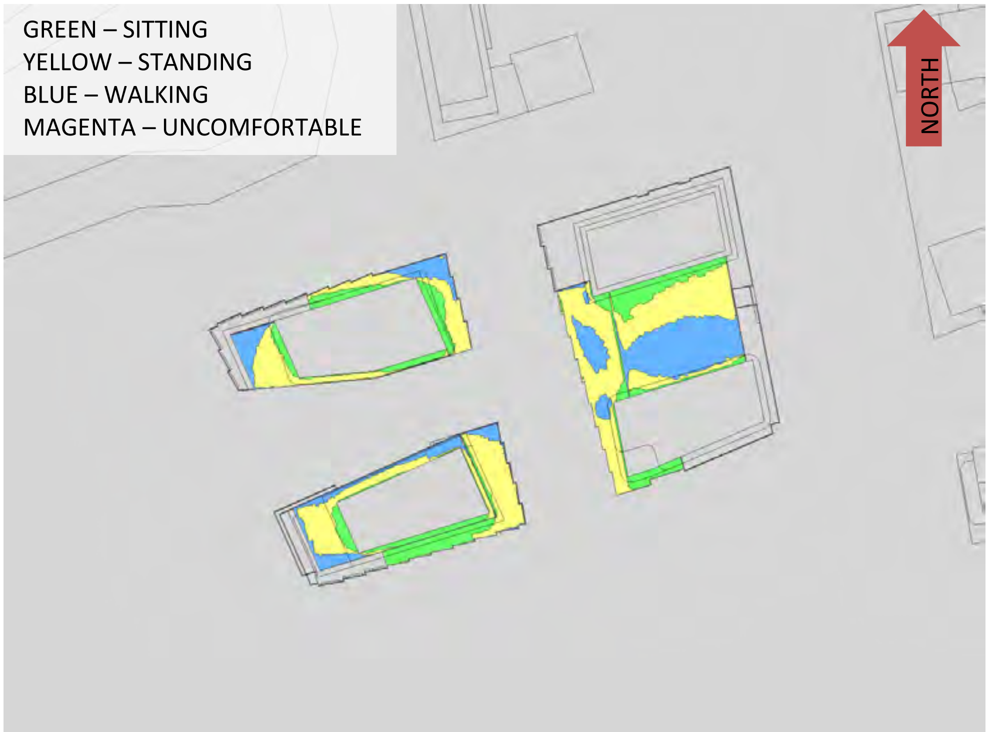
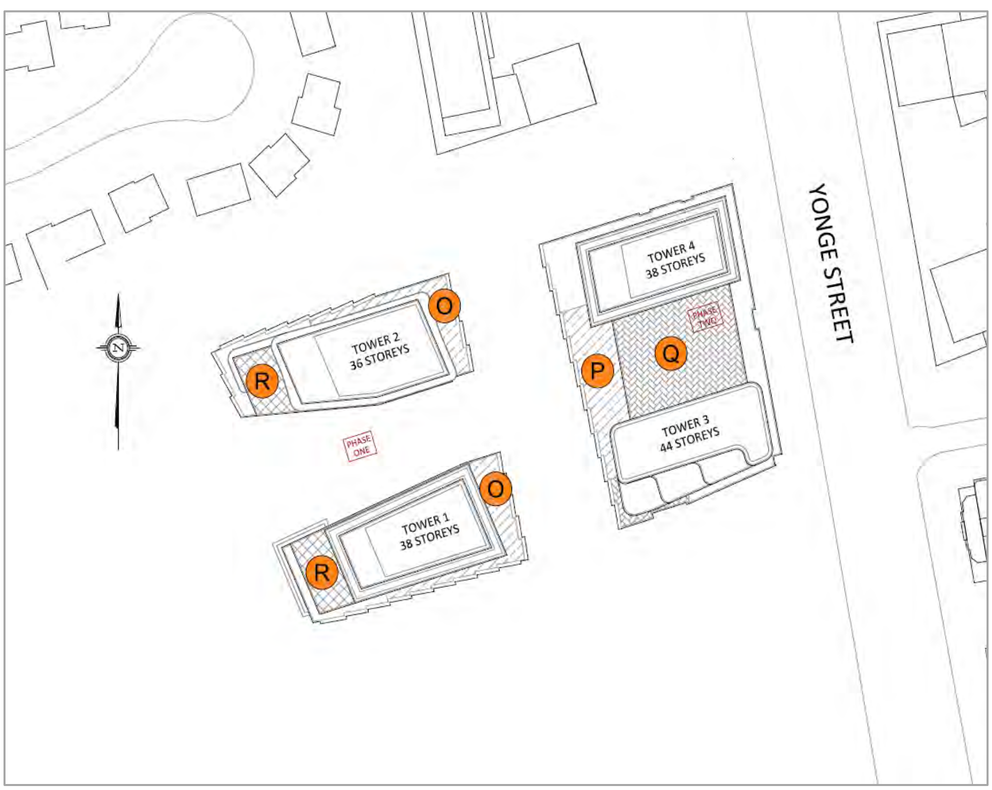


FIGURE 3B: SPRING – ELEVATED PEDESTRIAN WIND CONDITIONS



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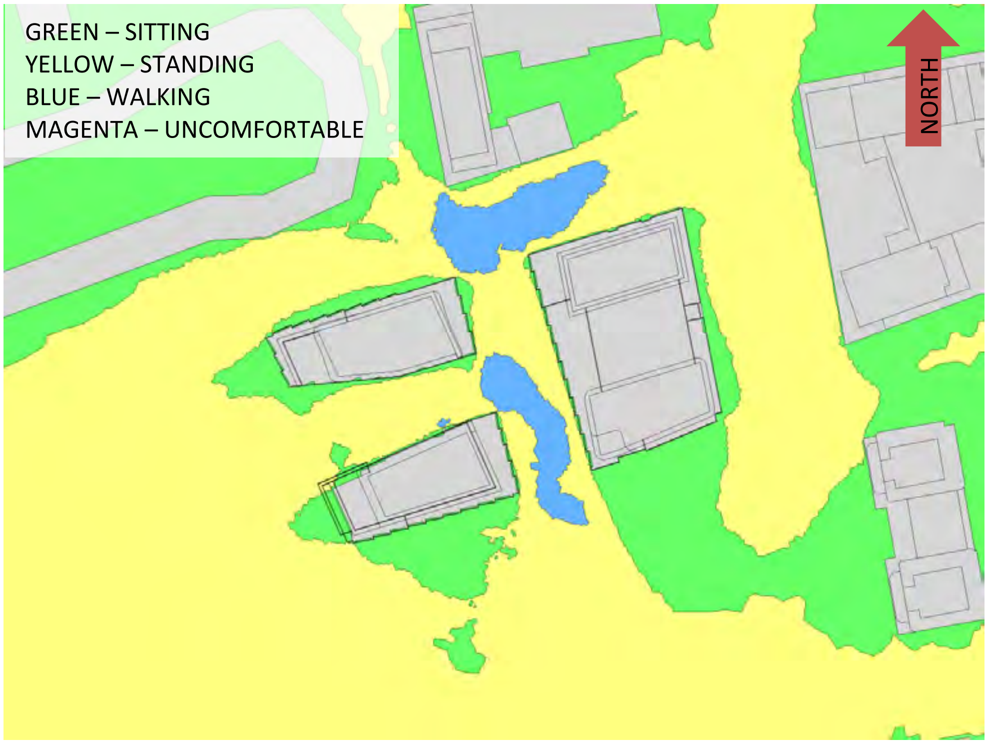
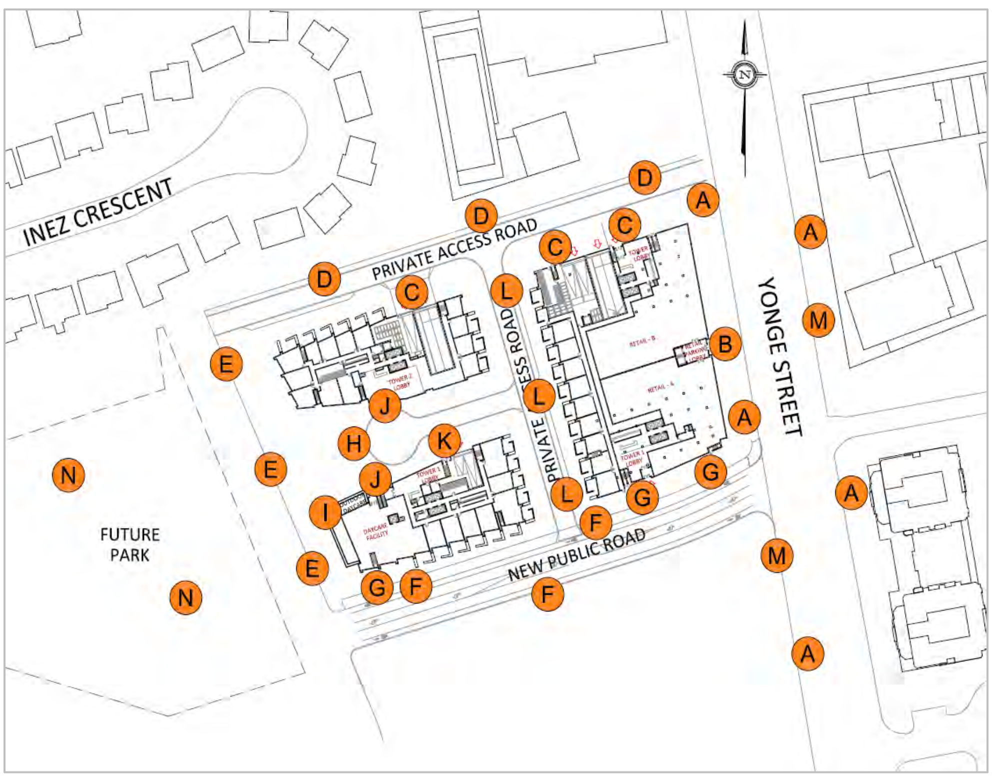


FIGURE 4A: SUMMER – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



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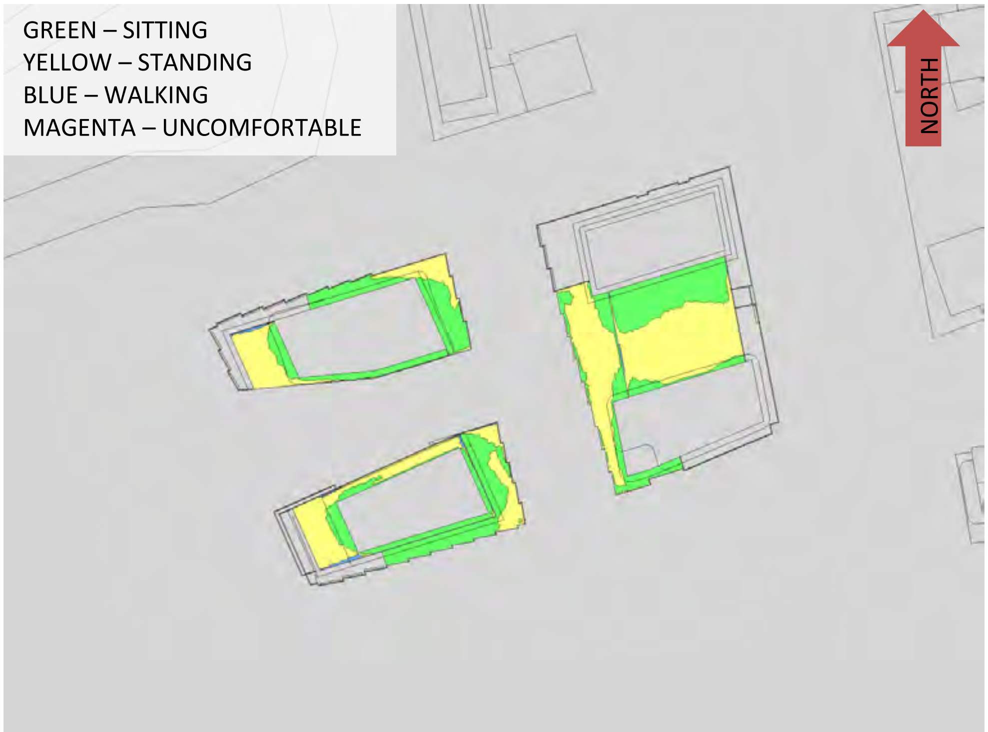
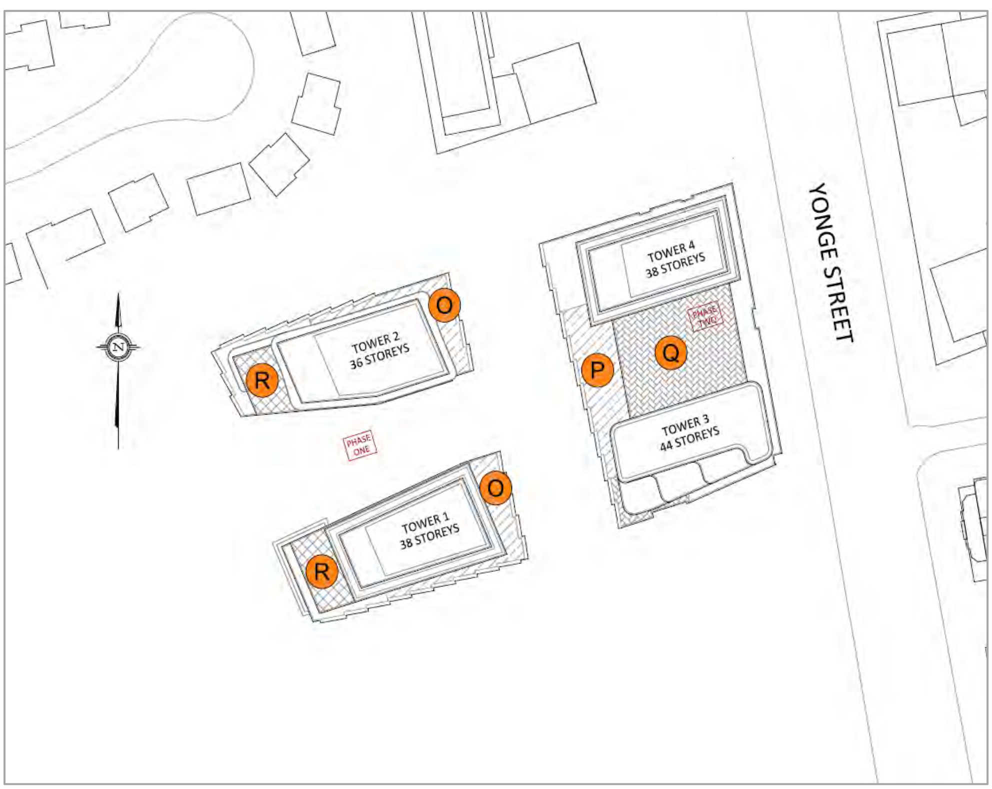


FIGURE 4B: SUMMER – ELEVATED PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

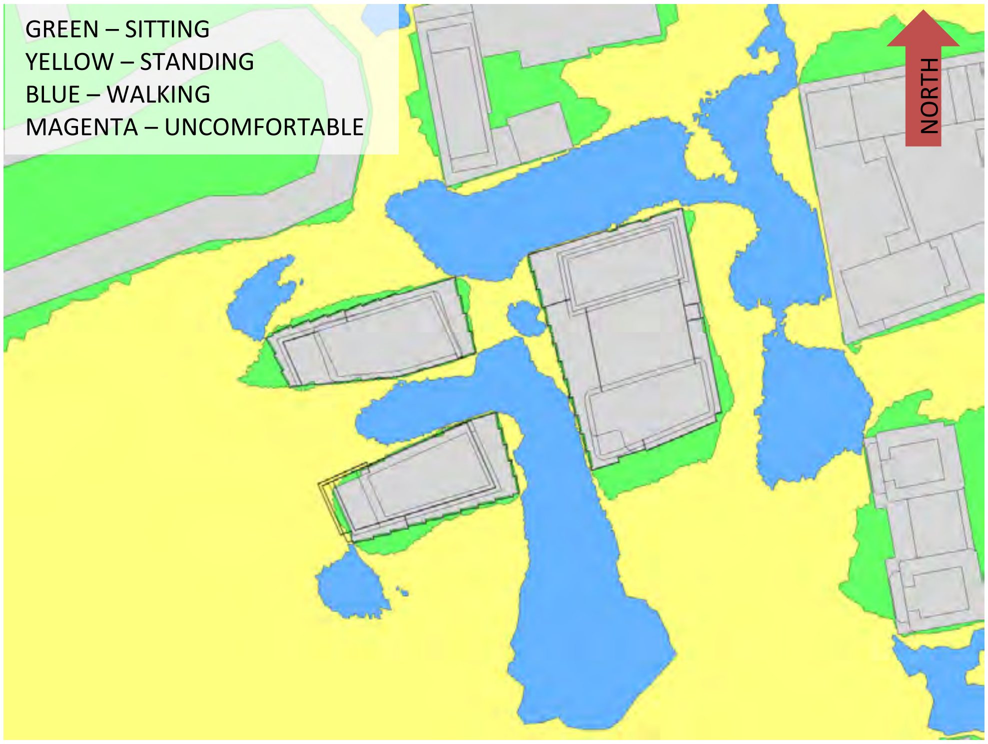
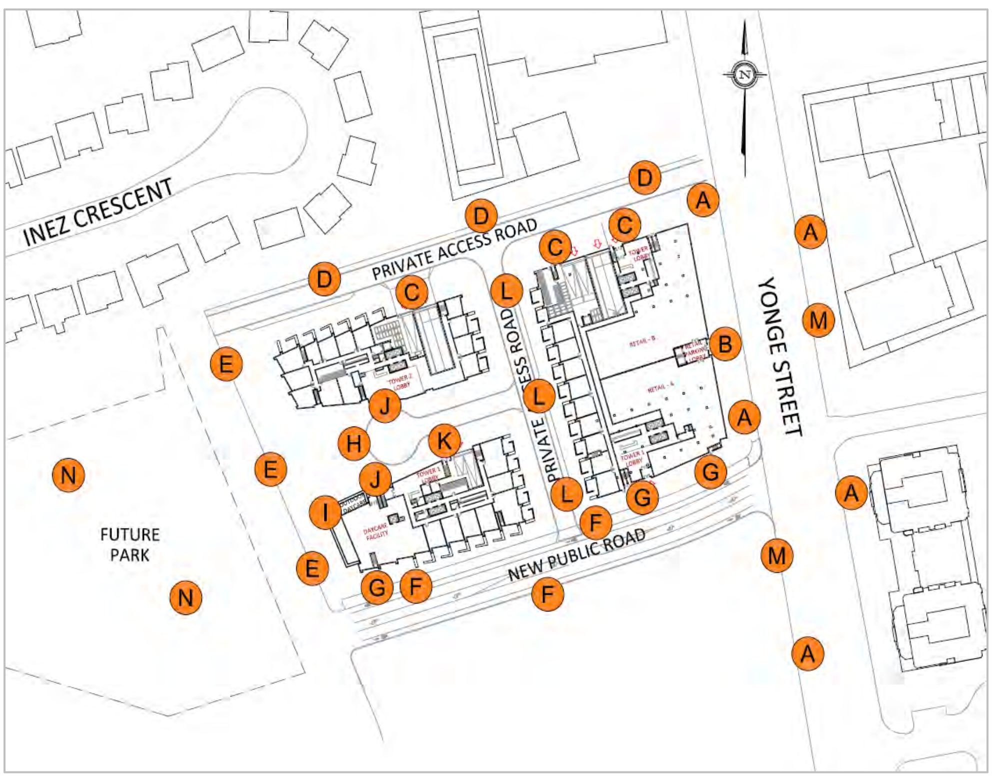


FIGURE 5A: AUTUMN – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

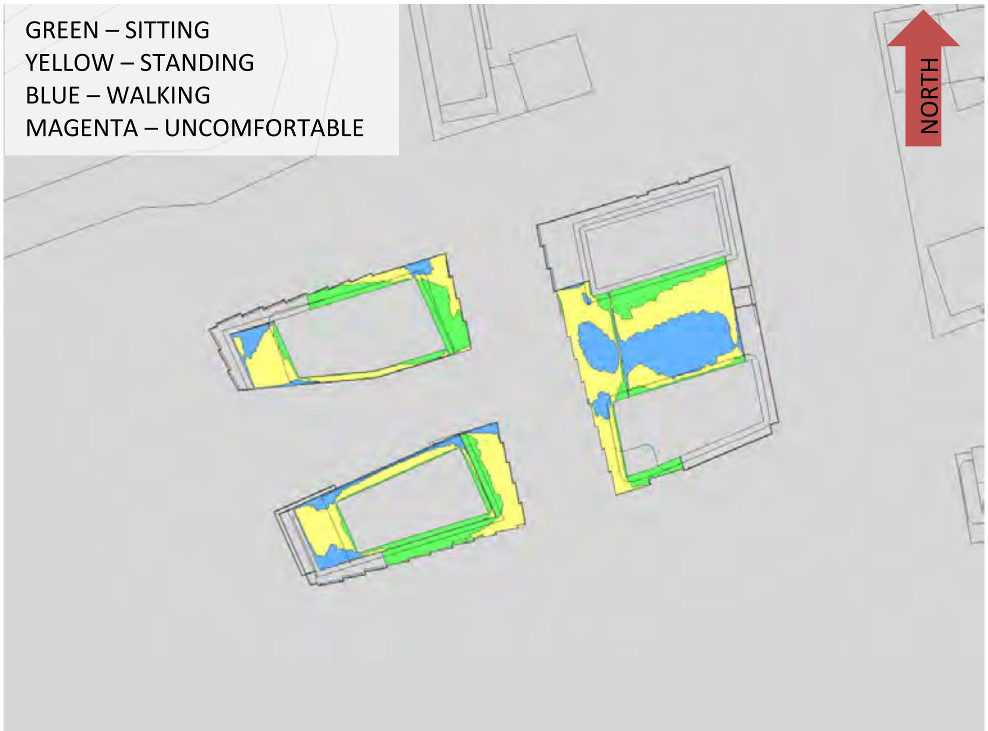
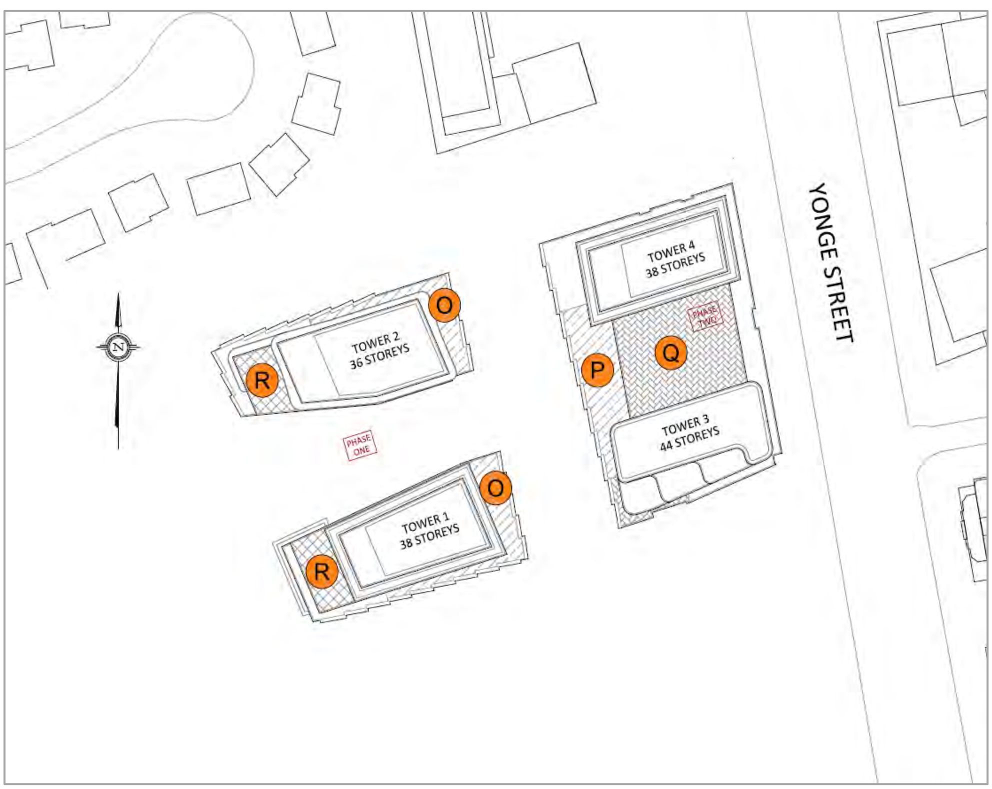


FIGURE 5B: AUTUMN – ELEVATED PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

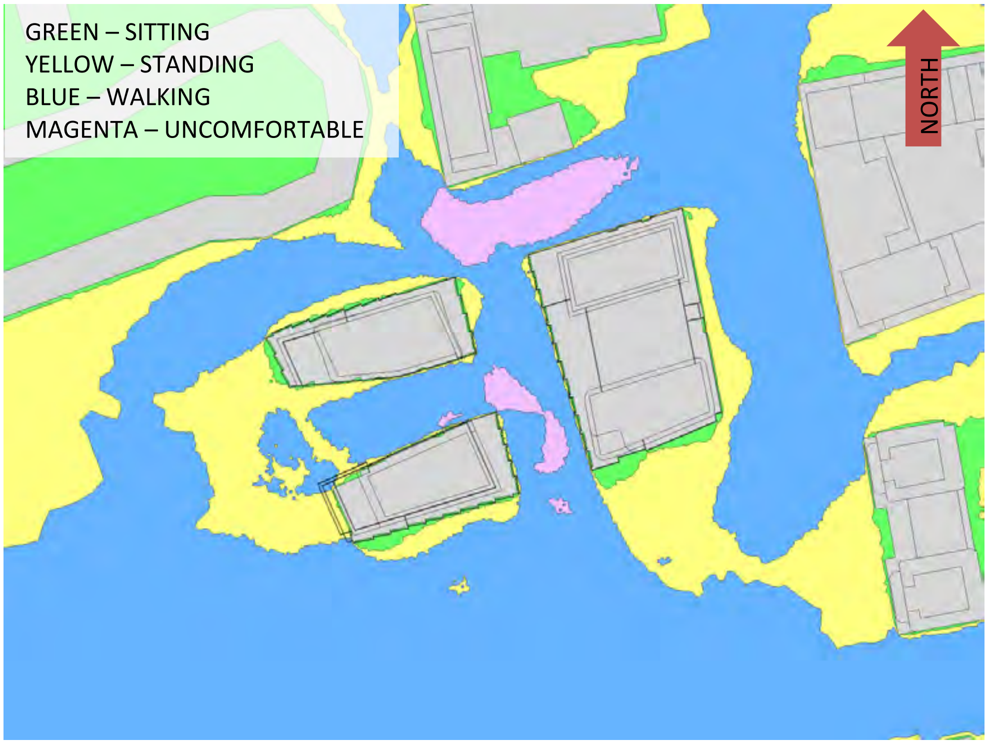
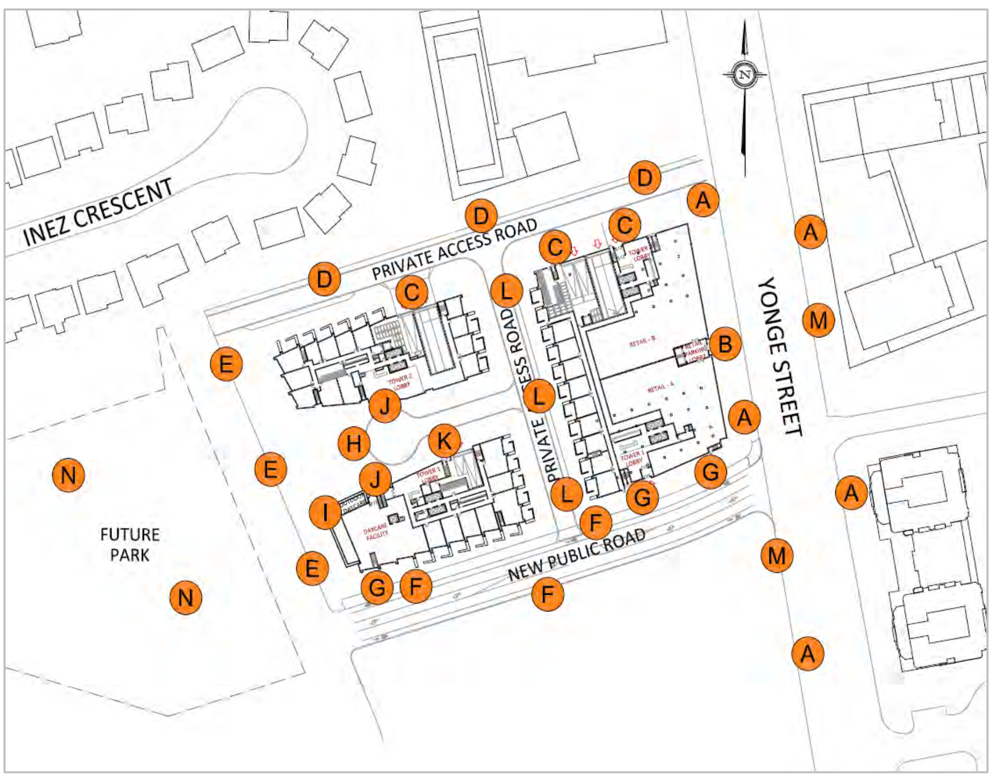


FIGURE 6A: WINTER – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

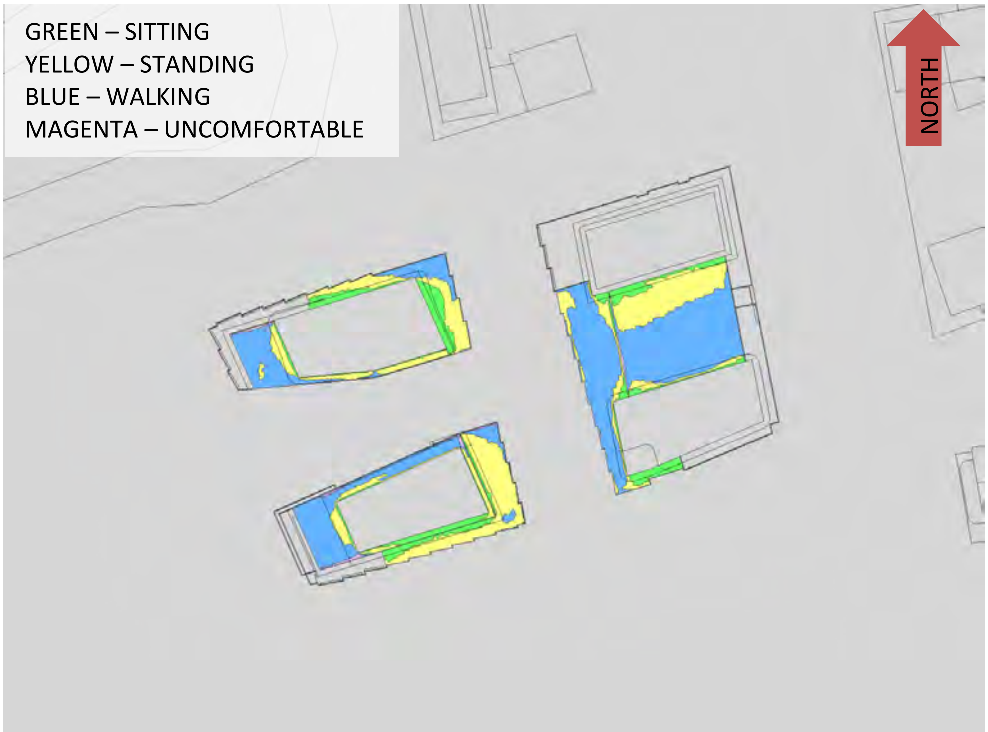
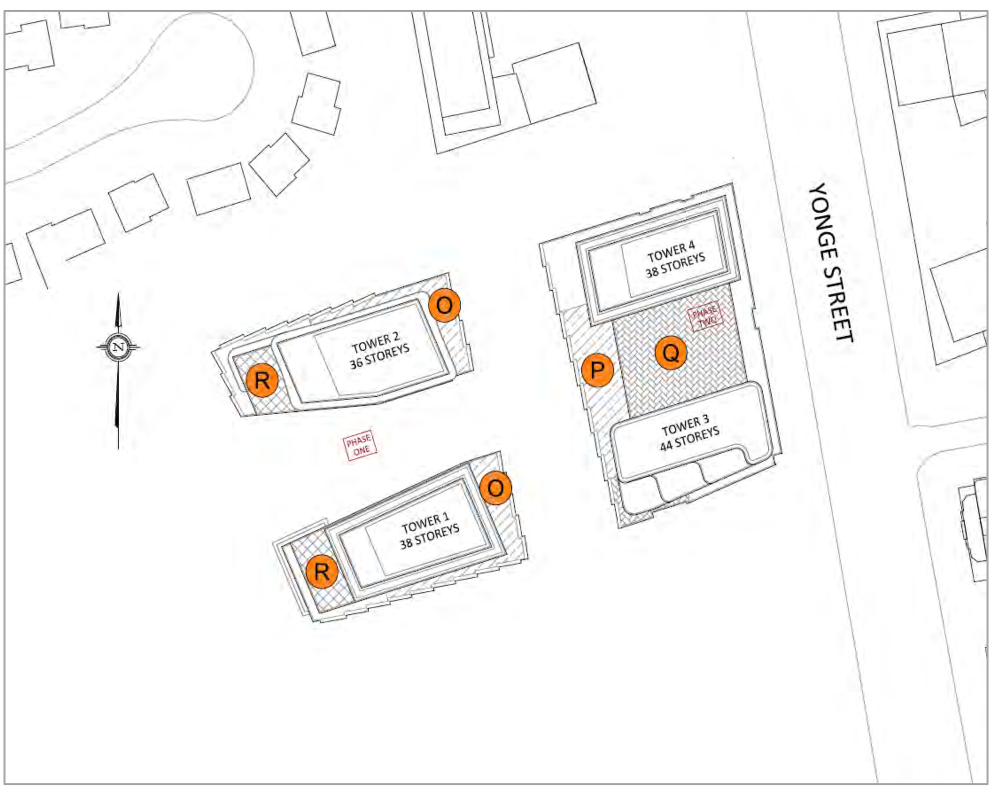


FIGURE 6B: WINTER – ELEVATED PEDESTRIAN WIND CONDITIONS



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APPENDIX A

PEDESTRIAN COMFORT CONTOURS: ALTERNATE CONTEXT SCENARIO INCLUDING 51 DREWRY AVENUE, 8-28 INEZ COURT & 3-BLOCK BUILD-OUT AT 5915 YONGE STREET

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PROJECT	5800 YONGE STREET, NORTH YORK PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500 (APPROX.)	DRAWING NO.	GWE18-201-PLW-A1
DATE	MAY 16, 2019	DRAWN BY	K.A.

DESCRIPTION

FIGURE A1:
SITE PLAN AND SURROUNDING CONTEXT
INCLUDING PROPOSED DEVELOPMENTS

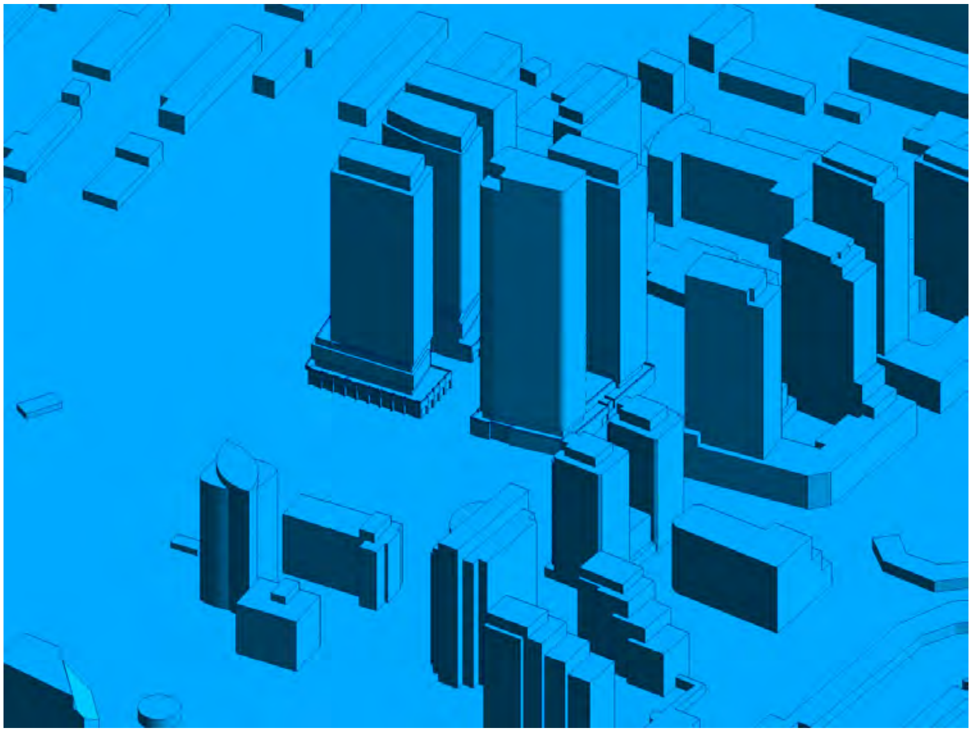

FIGURE A2A: COMPUTATIONAL MODEL, SOUTHEAST PERSPECTIVE

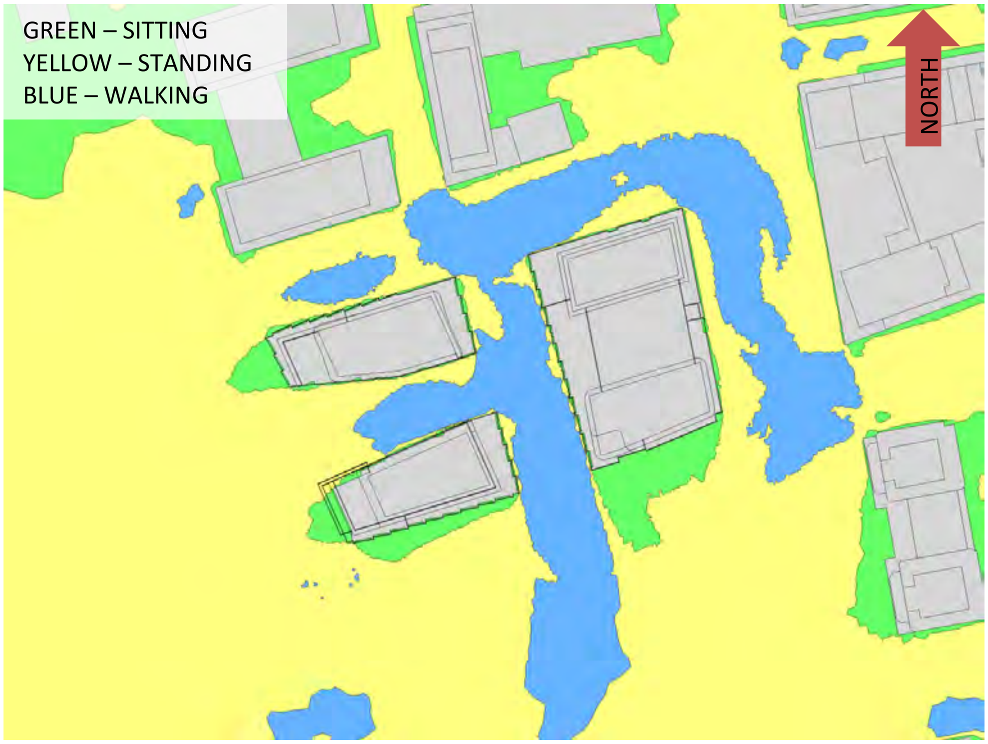

FIGURE A3A: SPRING – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS

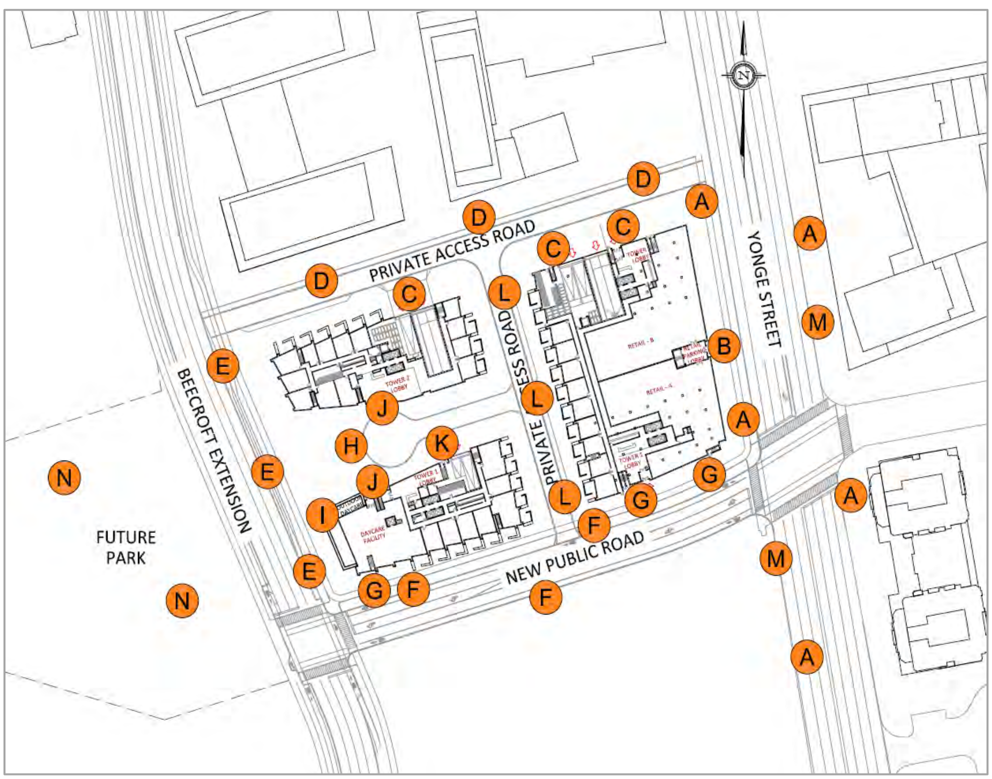

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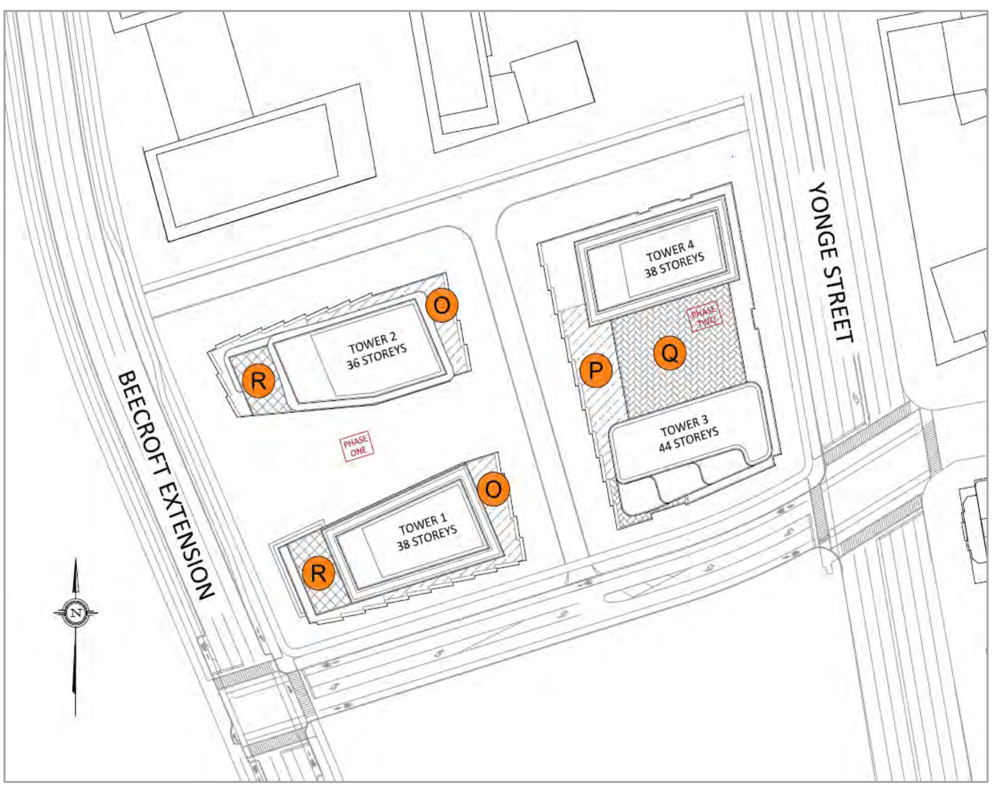
FIGURE A3B: SPRING – ELEVATED PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

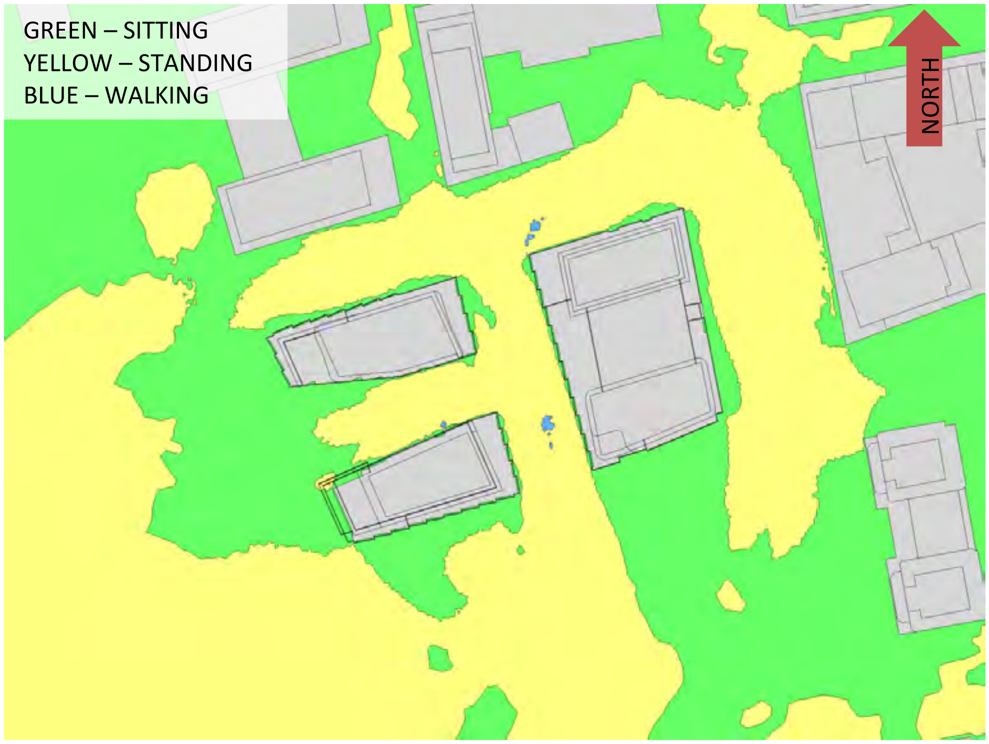
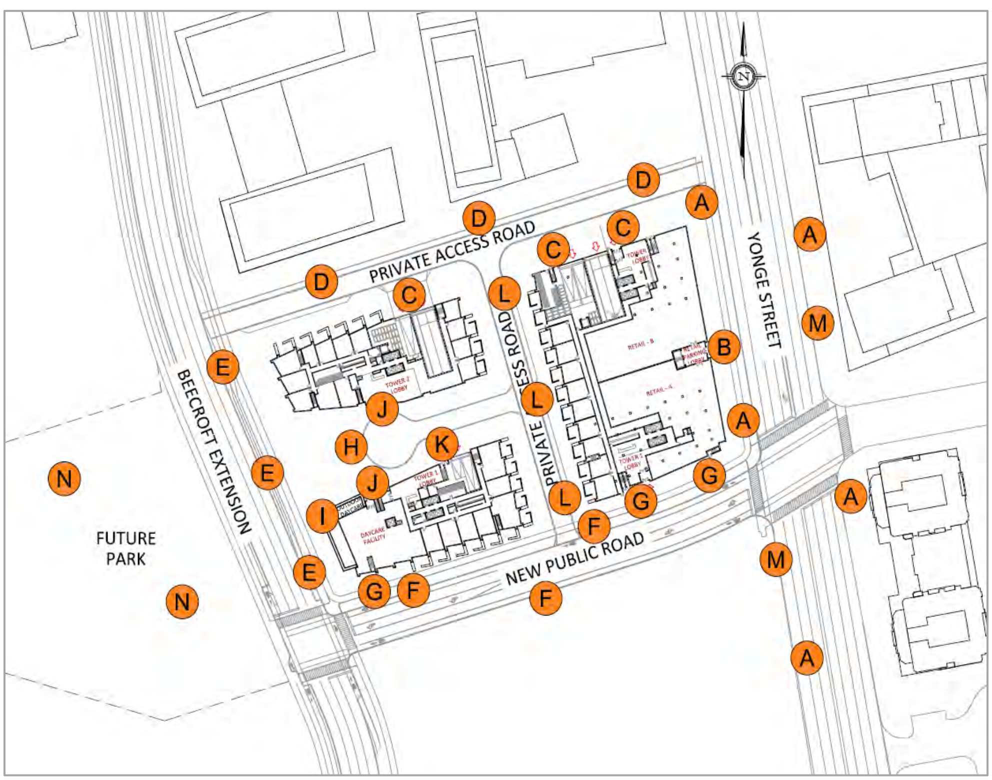


FIGURE A4A: SUMMER – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

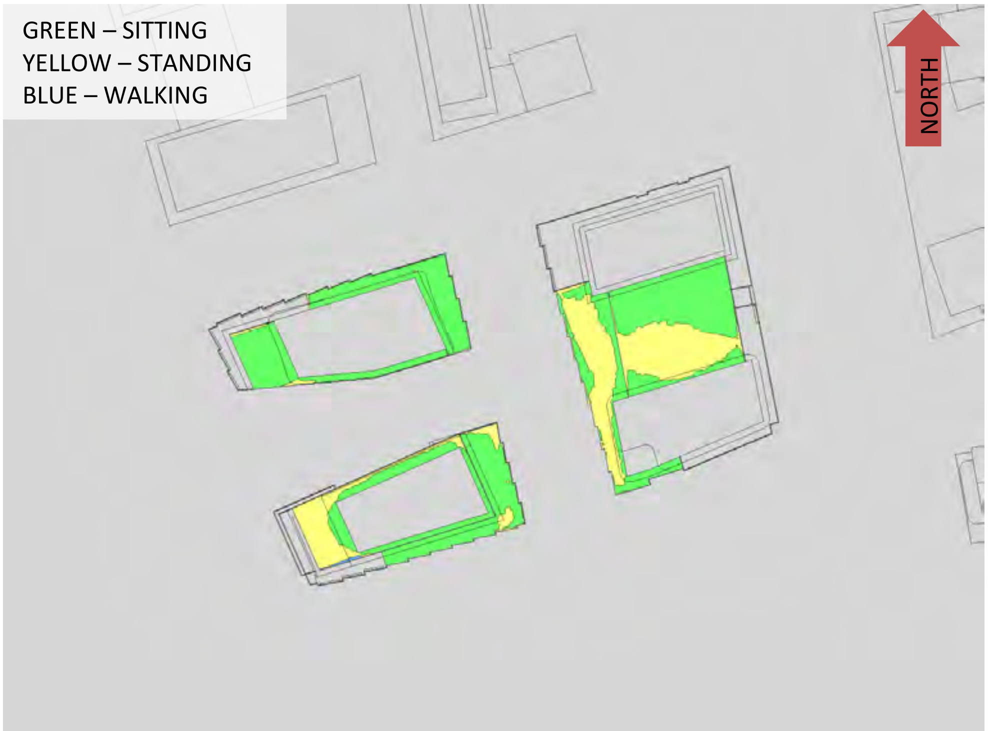
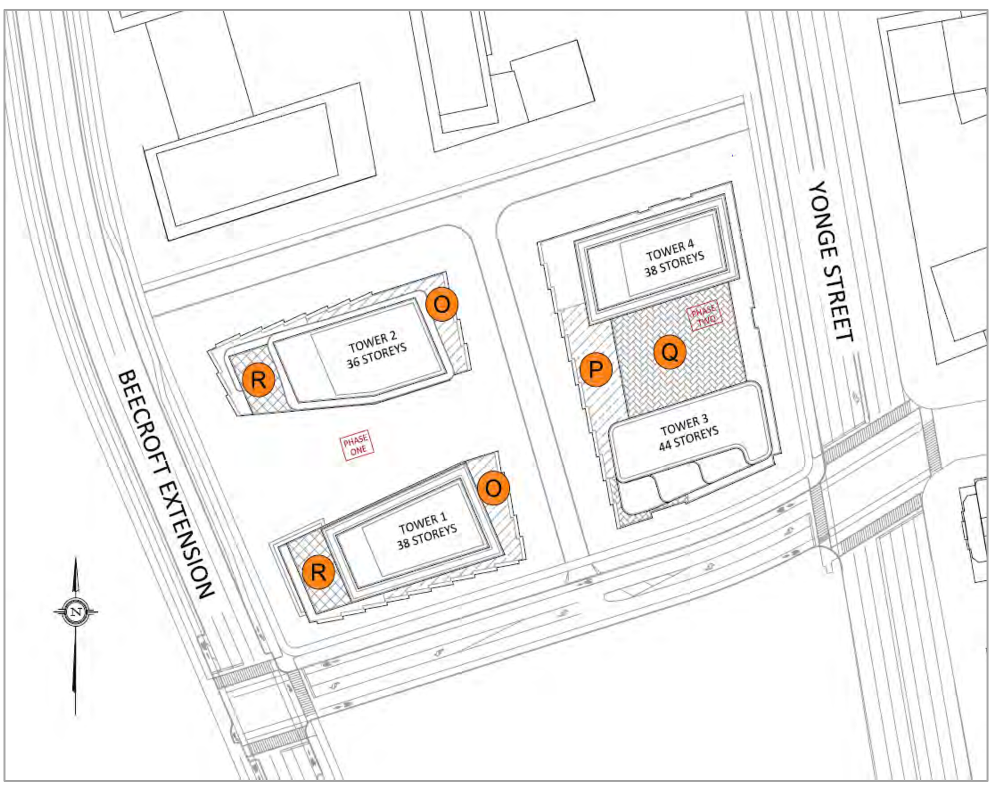


FIGURE A4B: SUMMER – ELEVATED PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

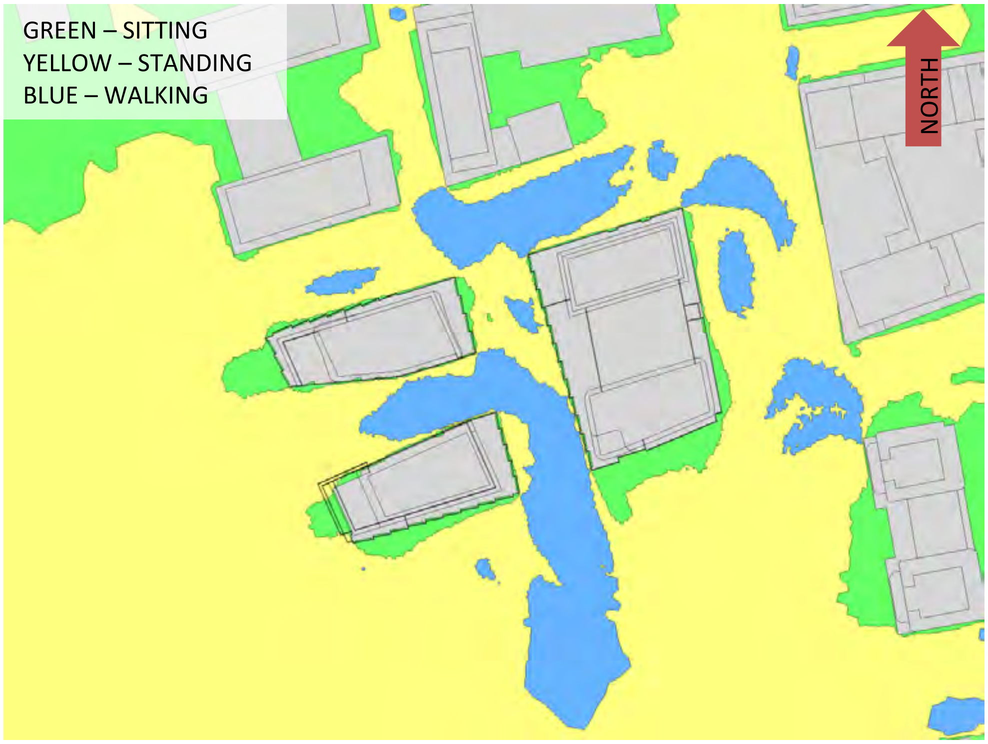
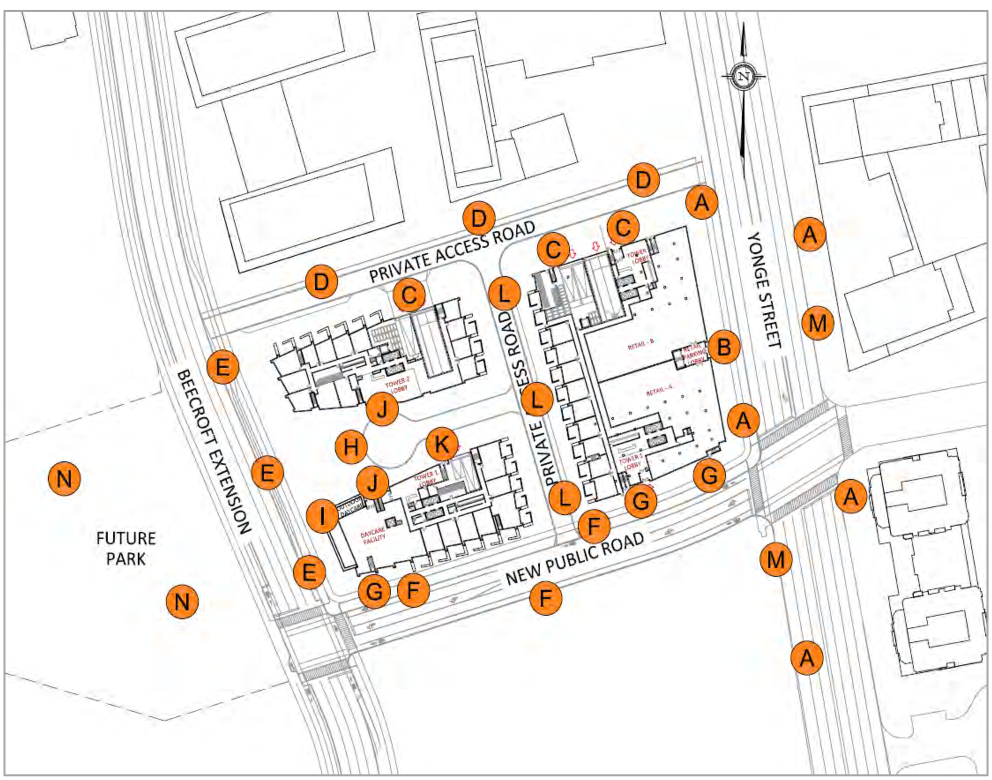


FIGURE A5A: AUTUMN – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



5800 YONGE STREET - REFERENCE LOCATIONS

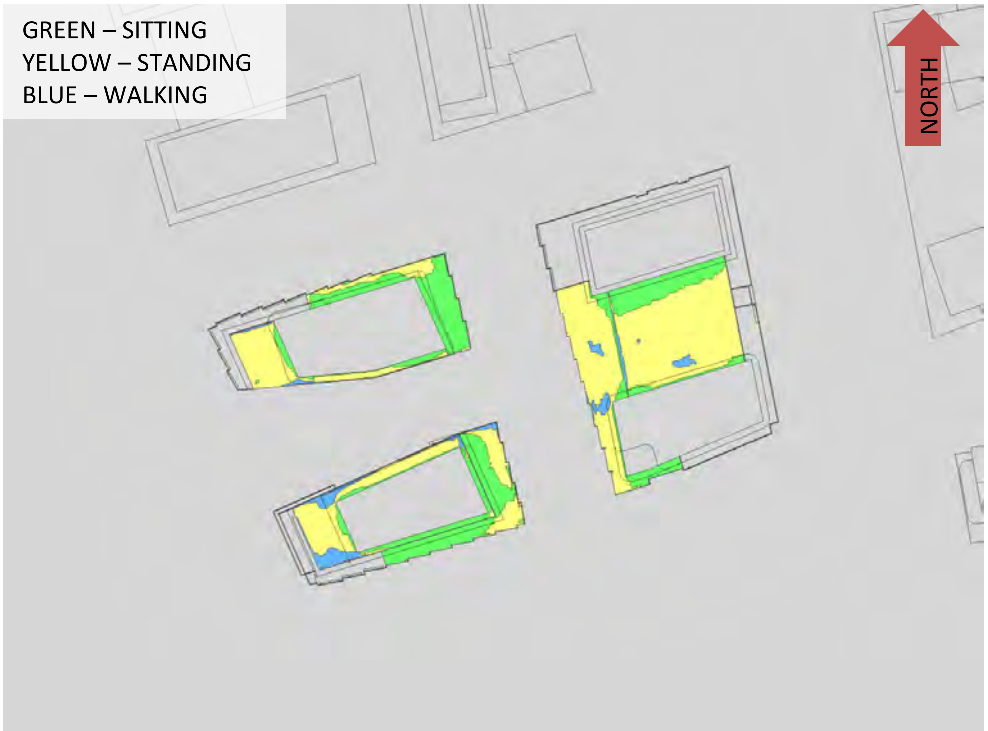


FIGURE A5B: AUTUMN – ELEVATED PEDESTRIAN WIND CONDITIONS

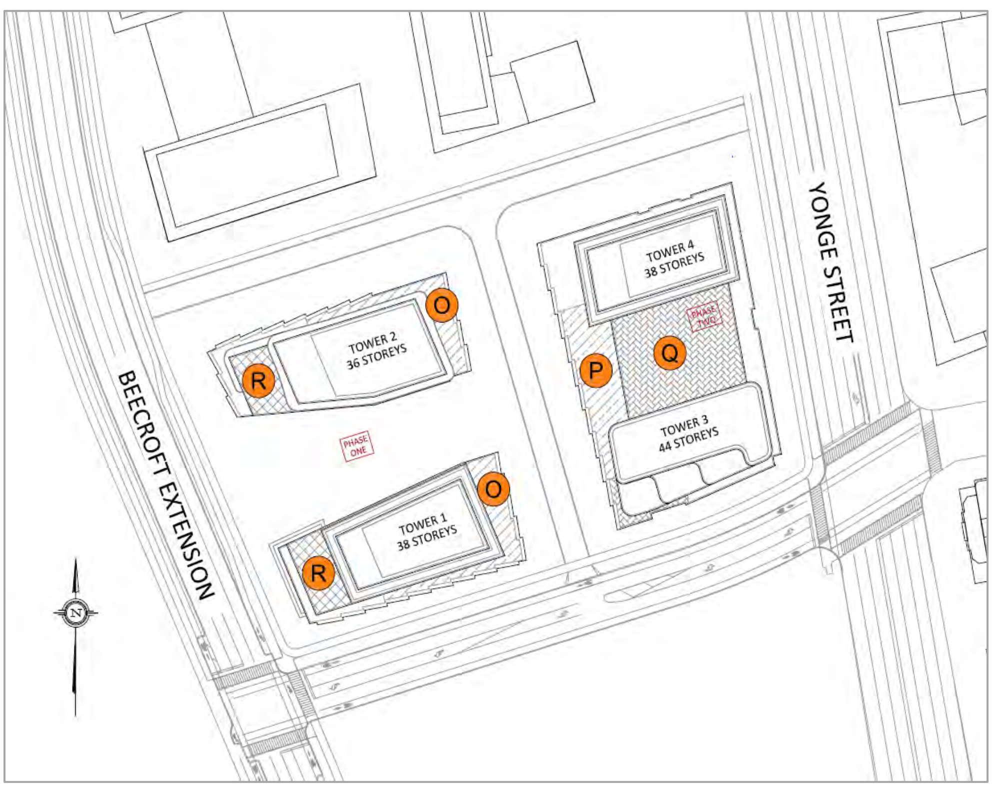


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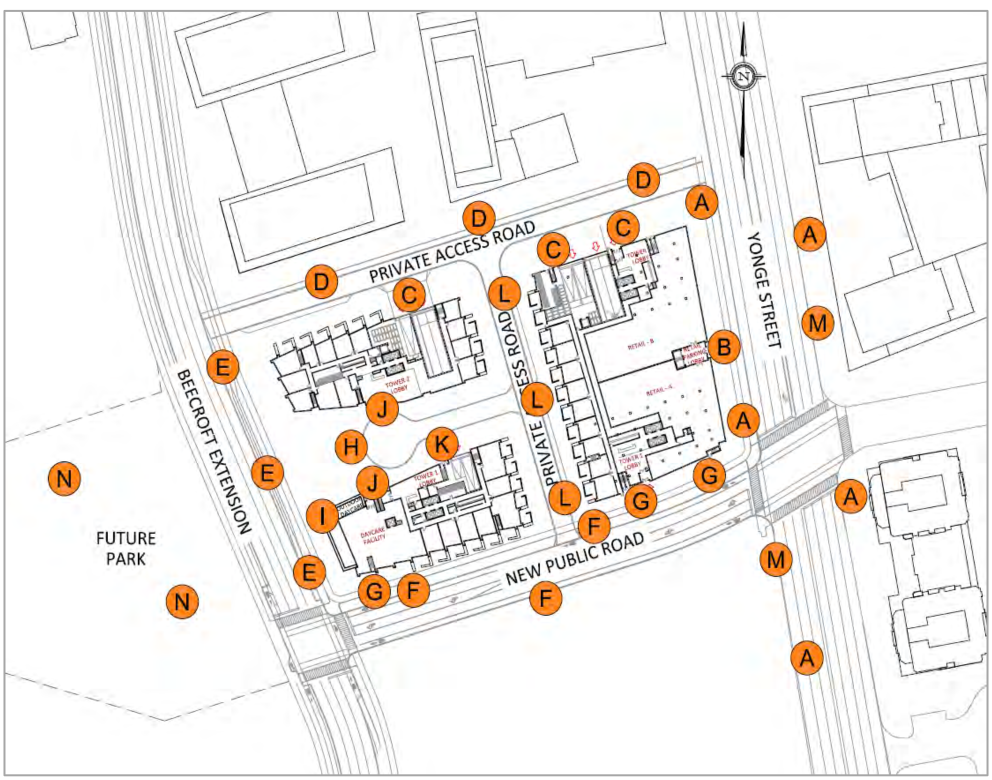
FIGURE A6A: WINTER – GRADE-LEVEL PEDESTRIAN WIND CONDITIONS



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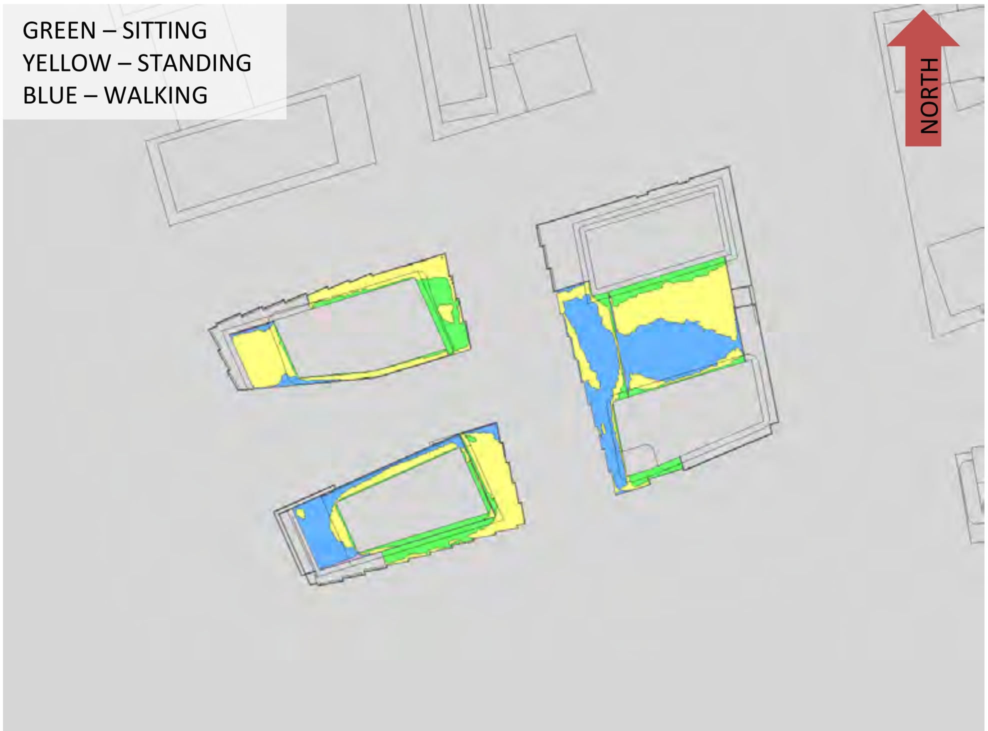
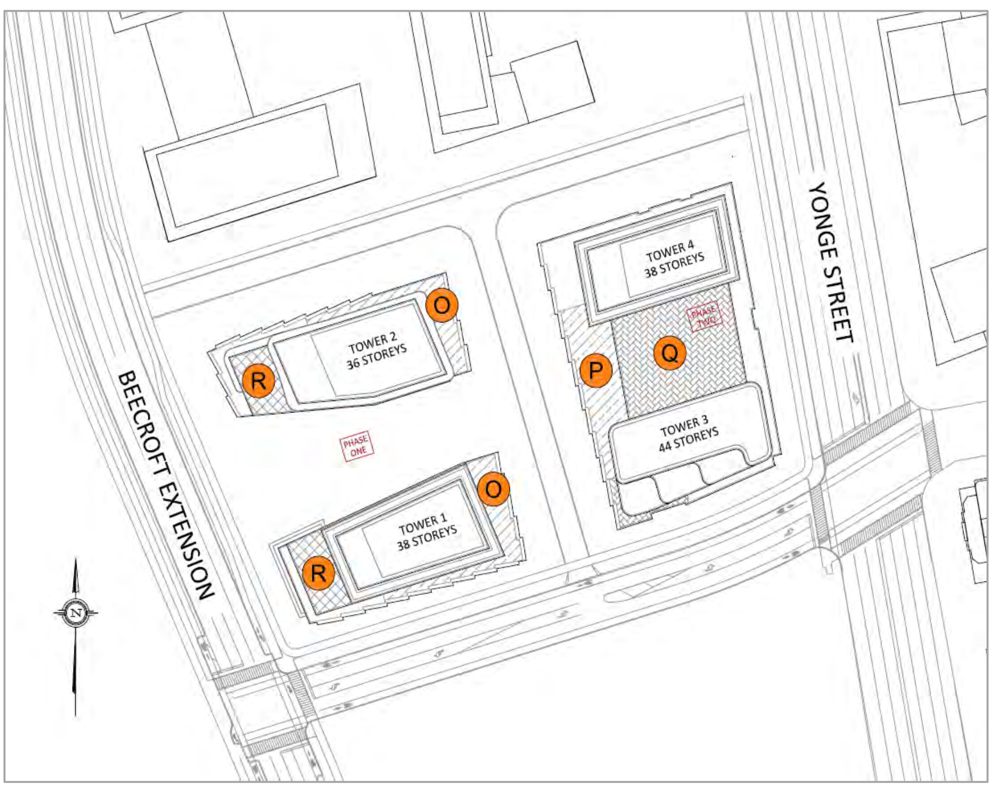


FIGURE A6B: WINTER – ELEVATED PEDESTRIAN WIND CONDITIONS



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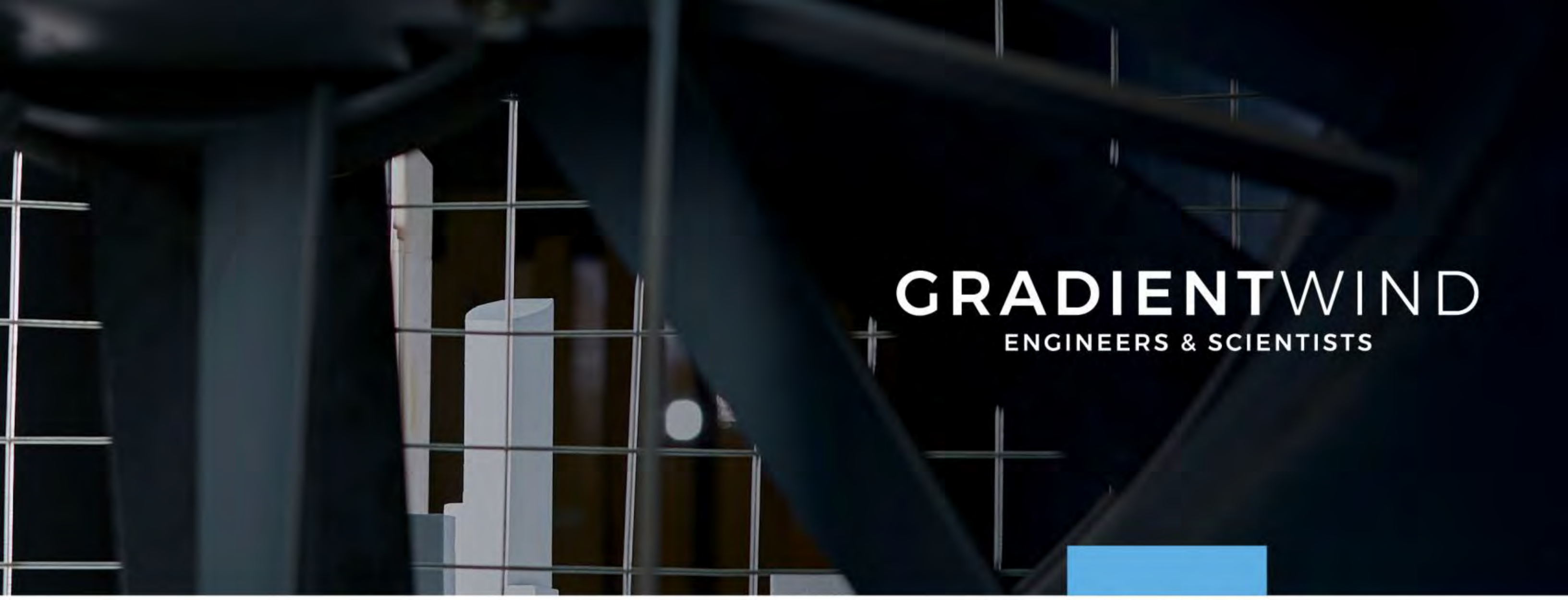

APPENDIX B

WIND TUNNEL SIMULATION OF THE NATURAL WIND

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WIND TUNNEL SIMULATION OF THE NATURAL WIND

Wind flowing over the surface of the earth develops a boundary layer due to the drag produced by surface features such as vegetation and man-made structures. Within this boundary layer, the mean wind speed varies from zero at the surface to the gradient wind speed at the top of the layer. The height of the top of the boundary layer is referred to as the gradient height, above which the velocity remains more-or-less constant for a given synoptic weather system. The mean wind speed is taken to be the average value over one hour. Superimposed on the mean wind speed are fluctuating (or turbulent) components in the longitudinal (i.e. along wind), vertical and lateral directions. Although turbulence varies according to the roughness of the surface, the turbulence level generally increases from nearly zero (smooth flow) at gradient height to maximum values near the ground. While for a calm ocean the maximum could be 20%, the maximum for a very rough surface such as the center of a city could be 100%, or equal to the local mean wind speed. The height of the boundary layer varies in time and over different terrain roughness within the range of 400 metres (m) to 600 m.

Simulating real wind behaviour in a wind tunnel requires simulating the variation of mean wind speed with height, simulating the turbulence intensity, and matching the typical length scales of turbulence. It is the ratio between wind tunnel turbulence length scales and turbulence scales in the atmosphere that determines the geometric scales that models can assume in a wind tunnel. Hence, when a 1:200 scale model is quoted, this implies that the turbulence scales in the wind tunnel and the atmosphere have the same ratios. Some flexibility in this requirement has been shown to produce reasonable wind tunnel predictions compared to full scale. In model scale the mean and turbulence characteristics of the wind are obtained with the use of spires at one end of the tunnel and roughness elements along the floor of the tunnel. The fan is located at the model end and wind is pulled over the spires, roughness elements and model. It has been found that, to a good approximation, the mean wind profile can be represented by a power law relation, shown below, giving height above ground versus wind speed.

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

Where; ***U*** = mean wind speed, U_g = gradient wind speed, ***Z*** = height above ground, Z_g = depth of the boundary layer (gradient height) and α is the power law exponent.

Figure B1 on the following page plots three velocity profiles for open country, and suburban and urban exposures.

The exponent α varies according to the type of upwind terrain; α ranges from 0.14 for open country to 0.33 for an urban exposure. Figure B2 illustrates the theoretical variation of turbulence for open country, suburban and urban exposures.

The integral length scale of turbulence can be thought of as an average size of gust in the atmosphere. Although it varies with height and ground roughness, it has been found to generally be in the range of 100 m to 200 m in the upper half of the boundary layer. Thus, for a 1:300 scale, the model value should be between 1/3 and 2/3 of a metre. Integral length scales are derived from power spectra, which describe the energy content of wind as a function of frequency. There are several ways of determining integral length scales of turbulence. One way is by comparison of a measured power spectrum in model scale to a non-dimensional theoretical spectrum such as the Davenport spectrum of longitudinal turbulence. Using the Davenport spectrum, which agrees well with full-scale spectra, one can estimate the integral scale by plotting the theoretical spectrum with varying L until it matches as closely as possible the measured spectrum:

$$f \times S(f) = \frac{\dfrac{4(Lf)^2}{U_{10}{}^2}}{\left[1 + \dfrac{4(Lf)^2}{U_{10}{}^2}\right]^{\frac{4}{3}}}$$

Where, f is frequency, S(f) is the spectrum value at frequency f, U10 is the wind speed 10 m above ground level, and L is the characteristic length of turbulence.

Once the wind simulation is correct, the model, constructed to a suitable scale, is installed at the center of the working section of the wind tunnel. Different wind directions are represented by rotating the model to align with the wind tunnel center-line axis.

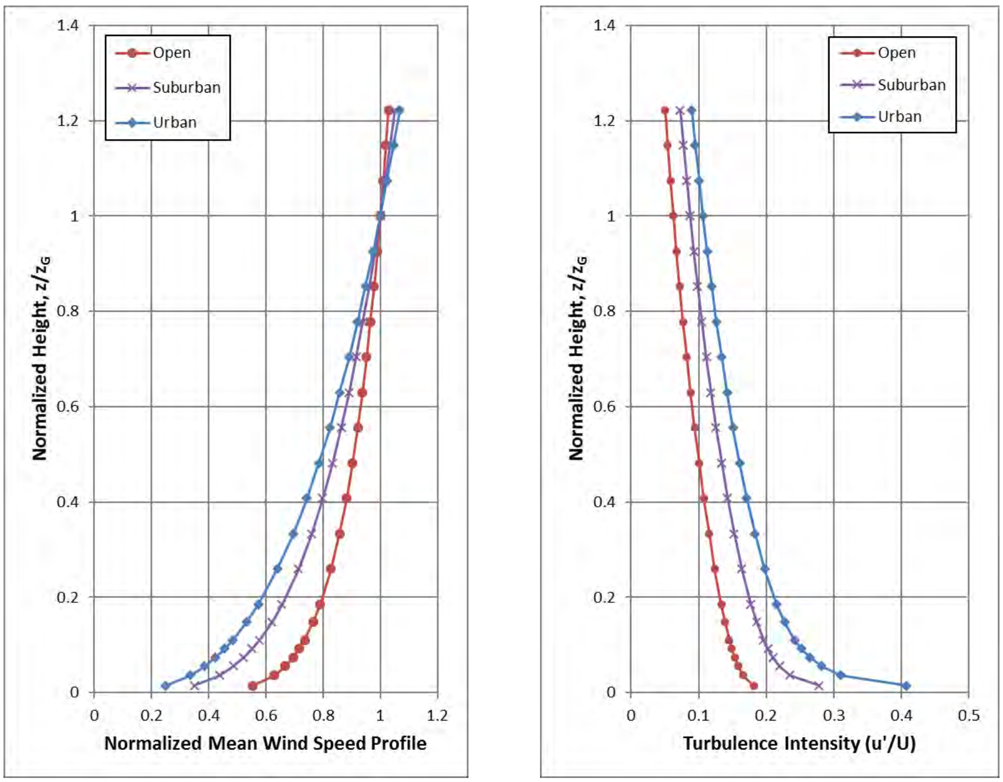

FIGURE B1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE B2 (RIGHT): TURBULENCE INTENSITY PROFILES

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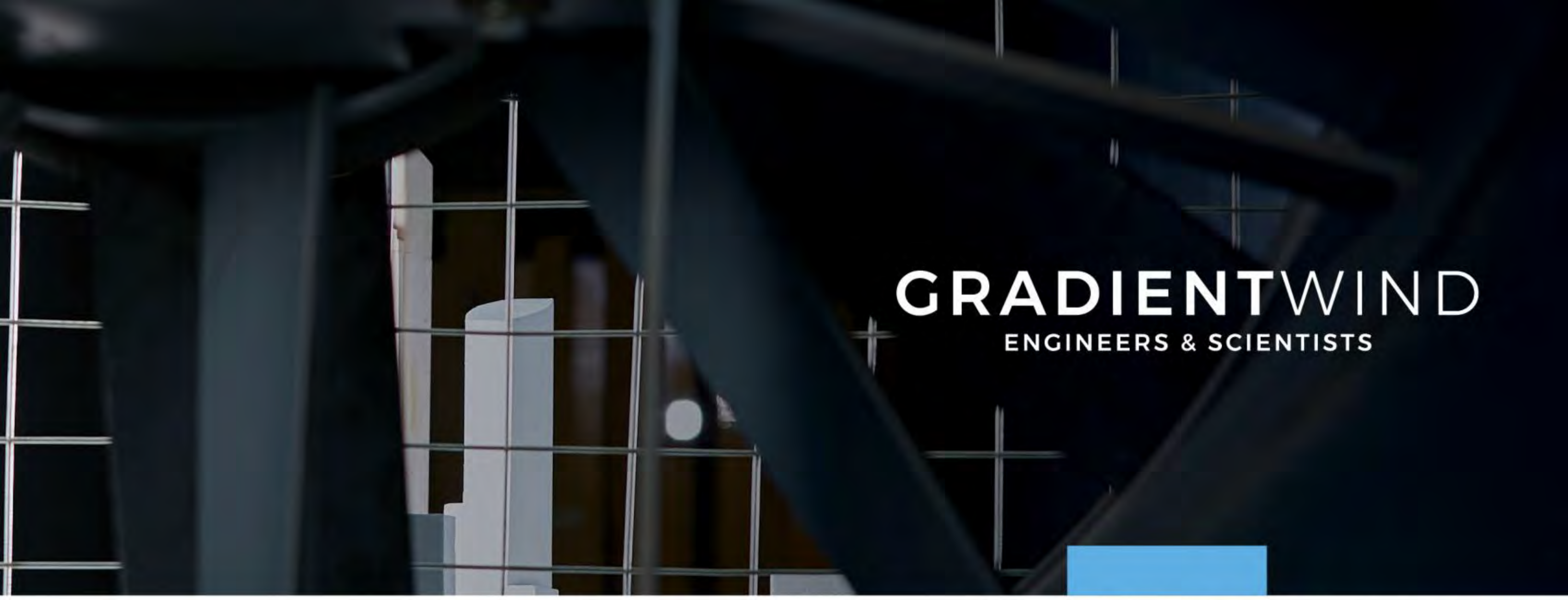
1. Teunissen, H.W., 'Characteristics of The Mean Wind And Turbulence In The Planetary Boundary Layer', Institute For Aerospace Studies, University Of Toronto, UTIAS # 32, Oct. 1970

2. Flay, R.G., Stevenson, D.C., 'Integral Length Scales in an Atmospheric Boundary Layer Near The Ground', 9th Australian Fluid Mechanics Conference, Auckland, Dec. 1966

3. ESDU, 'Characteristics of Atmospheric Turbulence Near the Ground', 74030

4. Bradley, E.F., Coppin, P.A., Katen, P.C., '*Turbulent Wind Structure Above Very Rugged Terrain*', 9th Australian Fluid Mechanics Conference, Auckland, Dec. 1966



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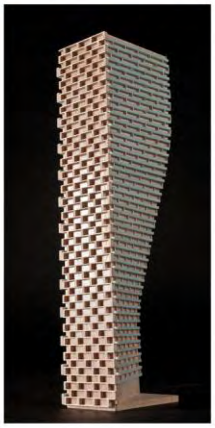

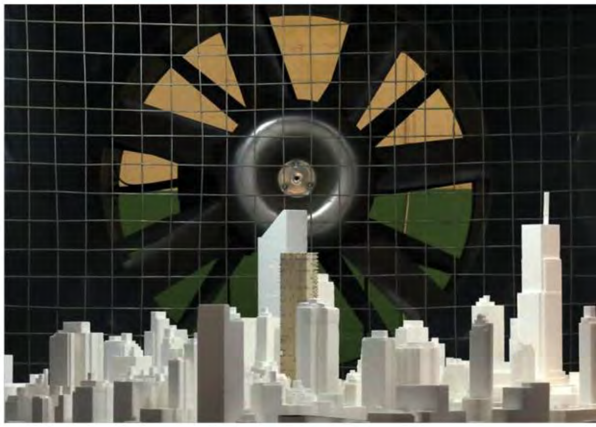

APPENDIX C

PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

The information contained within this appendix is offered to provide a greater understanding of the relationship between the physical wind tunnel testing method and virtual computer-based simulations

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PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

Pedestrian level wind studies are performed in a wind tunnel on a physical model of the study buildings at a suitable scale. Instantaneous wind speed measurements are recorded at a model height corresponding to 1.5 m full scale using either a hot wire anemometer or a pressure-based transducer. Measurements are performed at any number of locations on the model and usually for 36 wind directions. For each wind direction, the roughness of the upwind terrain is matched in the wind tunnel to generate the correct mean and turbulent wind profiles approaching the model.

The hot wire anemometer is an instrument consisting of a thin metallic wire conducting an electric current. It is an omni-directional device equally sensitive to wind approaching from any direction in the horizontal plane. By compensating for the cooling effect of wind flowing over the wire, the associated electronics produce an analog voltage signal that can be calibrated against velocity of the air stream. For all measurements, the wire is oriented vertically so as to be sensitive to wind approaching from all directions in a horizontal plane.

The pressure sensor is a small cylindrical device that measures instantaneous pressure differences over a small area. The sensor is connected via tubing to a transducer that translates the pressure to a voltage signal that is recorded by computer. With appropriately designed tubing, the sensor is sensitive to a suitable range of fluctuating velocities.

For a given wind direction and location on the model, a time history of the wind speed is recorded for a period of time equal to one hour in full-scale. The analog signal produced by the hot wire or pressure sensor is digitized at a rate of 400 samples per second. A sample recording for several seconds is illustrated in Figure B1. This data is analyzed to extract the mean, root-mean-square (rms) and the peak of the signal. The peak value, or gust wind speed, is formed by averaging a number of peaks obtained from sub-intervals of the sampling period. The mean and gust speeds are then normalized by the wind tunnel gradient wind speed, which is the speed at the top of the model boundary layer, to obtain mean and gust ratios. At each location, the measurements are repeated for 36 wind directions to produce normalized polar plots, which will be provided upon request.

In order to determine the duration of various wind speeds at full scale for a given measurement location the gust ratios are combined with a statistical (mathematical) model of the wind climate for the project site. This mathematical model is based on hourly wind data obtained from one or more meteorological stations (usually airports) close to the project location. The probability model used to represent the data is the Weibull distribution expressed as:

$$P\left(>U_g\right) = A_\theta \bullet \exp\left[\left(-\frac{U_g}{C\theta}\right)^{K\theta}\right]$$

Where,

P (> U_g) is the probability, fraction of time, that the gradient wind speed ***U_g*** is exceeded; ***θ*** is the wind direction measured clockwise from true north, ***A***, ***C***, ***K*** are the Weibull coefficients, (Units: A - dimensionless, C - wind speed units [km/h] for instance, K - dimensionless). ***A_θ*** is the fraction of time wind blows from a 10° sector centered on ***θ***.

Analysis of the hourly wind data recorded for a length of time, on the order of 10 to 30 years, yields the ***A_θ, C_θ*** and ***K_θ*** values. The probability of exceeding a chosen wind speed level, say 20 km/h, at sensor *N* is given by the following expression:

$$P_N(>20) = \Sigma_\theta P\left[\frac{(>20)}{\left(\frac{U_N}{U_g}\right)}\right]$$

$$P_N(>20) = \Sigma_\theta P\{>20/(U_N/U_g)\}$$

Where, ***U_N/U_g*** is the gust velocity ratios, where the summation is taken over all 36 wind directions at 10° intervals.

If there are significant seasonal variations in the weather data, as determined by inspection of the C_θ and K_θ values, then the analysis is performed separately for two or more times corresponding to the groupings of seasonal wind data. Wind speed levels of interest for predicting pedestrian comfort are based on the comfort guidelines chosen to represent various pedestrian activity levels as discussed in the main text.

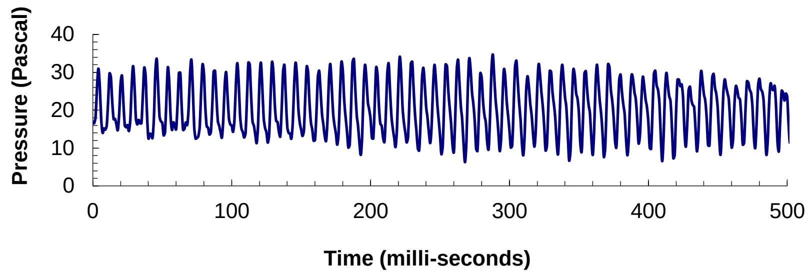

FIGURE C1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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1. Davenport, A.G., '*The Dependence of Wind Loading on Meteorological Parameters*', Proc. of Int. Res. Seminar, Wind Effects on Buildings & Structures, NRC, Toronto, 1967, University of Toronto Press.

2. Wu, S., Bose, N., 'An *Extended Power Law Model for the Calibration of Hot-wire/Hot-film Constant Temperature Probes*', Int. J. of Heat Mass Transfer, Vol.17, No.3, pp.437-442, Pergamon Press.