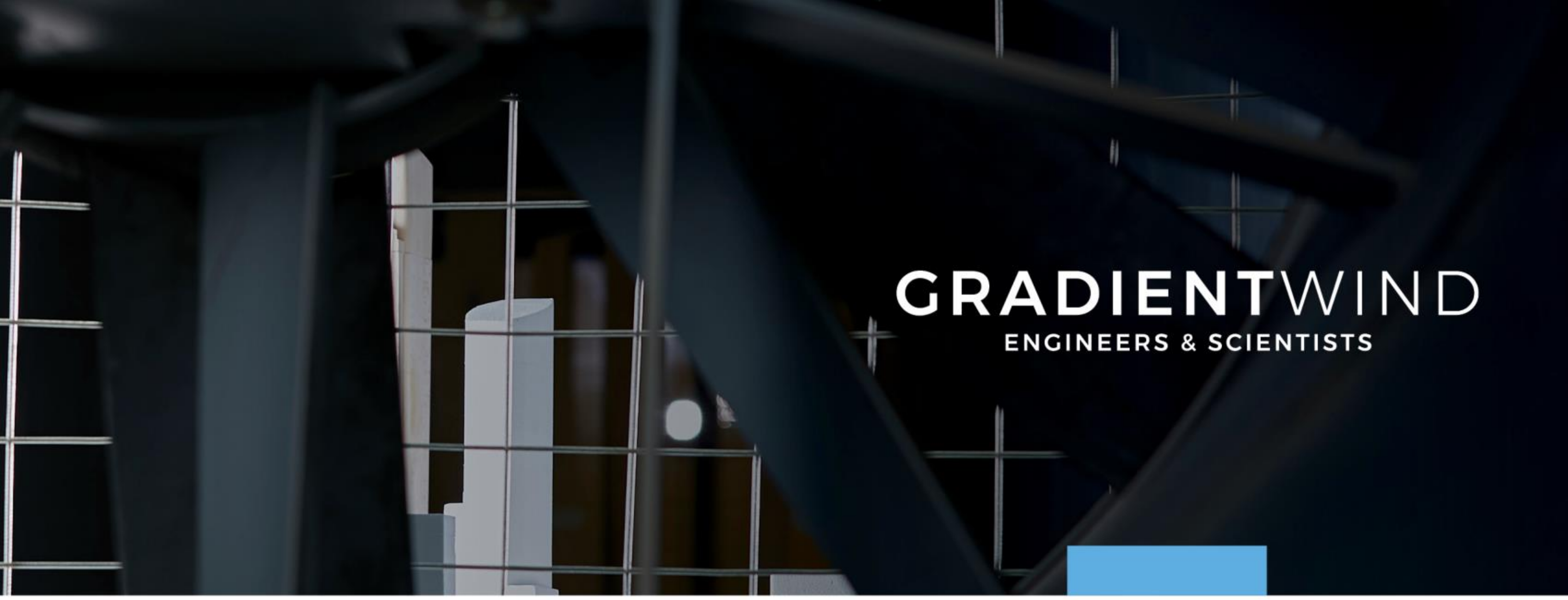
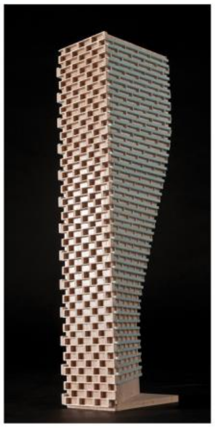
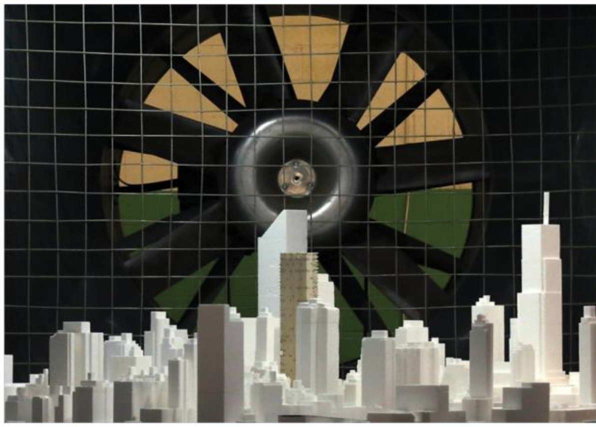


PEDESTRIAN LEVEL WIND STUDY

Barrie Waterfront
Barrie, Ontario

REPORT: GW19-214-WTPLW





December 17, 2019

PREPARED FOR
Barrie Lakeshore Developments
3200 Highway 7
Vaughan, Ontario
L4K 5Z5

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

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

EXECUTIVE SUMMARY

This report describes a comparative pedestrian level wind study undertaken to assess wind conditions for the proposed development located at 51, 53, 55 & 75 Bradford Street and 20 Checkley Street in Barrie, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study involves wind tunnel measurements of pedestrian wind speeds using a physical scale model, combined with meteorological data integration, to assess pedestrian comfort at key areas within and surrounding the study site. Grade-level areas investigated include sidewalks, walkways, parking areas, the nearby Bunkers Creek Eco-park, surrounding open spaces, and building access points. Wind comfort is also evaluated over the podia rooftops at Level 4. 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 wind tunnel testing and data analysis procedures, architectural drawings provided by Turner Fleischer Architects Inc. received in November 2019, surrounding street layouts and existing and approved future building massing information, as well as recent site imagery.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report, and is also illustrated in Figures 2A-5B, and Tables A1 through A5 in Appendix A. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments, we conclude that wind conditions over most pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions may include potential retail or residential entrances located between Towers 1 and 2, where conditions will not achieve standing criteria during the colder seasons. Depending on the proposed entrance configuration, mitigation in the form of recessed entrance locations or vertical wind barriers, as described in Section 5.2, may be required. The Level 4 podium rooftop areas, if desired for use as outdoor amenity areas, will require mitigation to ensure conditions are comfortable for sitting during the intended use period.

A comparison of the existing versus future wind comfort surrounding the study site indicates that the proposed development will have a generally neutral influence on grade-level wind conditions over surrounding areas, with a few minor exceptions. Although wind speeds marginally increase along portions of the Bradford Street sidewalk and walkways south of the site, conditions nevertheless remain acceptable for the intended uses. 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 Barrie Lakeshore Developments / Turner Fleischer Architects Inc. to undertake a comparative pedestrian level wind study for the proposed development located at 51, 53, 55 & 75 Bradford Street and 20 Checkley Street, herein referred to as the 'Barrie Waterfront' development in Barrie, Ontario. Two configurations were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) future conditions with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, architectural drawings by Turner Fleischer Architects Inc. received in November 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 the proposed Barrie Waterfront development in Barrie, Ontario. The study site is located on a parcel of land bounded by Bradford Street to the west and Lakeshore Drive to the east, approximately 70 metres south of Simcoe Street. The site is further bounded by existing developments and open space to the north, and by Bunkers Creek Eco-park to the south.

The proposed development comprises Tower 1 (38 storeys), Tower 2 (40 storeys), Tower 3 (42 storeys) and Tower 4 (22 storeys), respectively located clockwise on the study site beginning at the southwest corner. Towers 2 and 3 are connected by a rectangular podium that features an articulated rectangular extension at the northeast corner, while Towers 1 and 4 feature separate podia that are nearly rectangular in planform with diagonal or curved south walls. The podia are separated by a private road accessed from Bradford Street. Loading areas and vehicle access to indoor parking are provided for each podium at various locations along the private road, in addition to a vehicle entrance at the northeast corner of Tower 4 that is accessed from Lakeshore Drive via a driveway and roundabout along the east side of the podium. At grade, the podia serving Towers 1 through 3 feature retail units fronting Bradford Street and residential use in the remaining space, in addition to indoor parking along the east and northmost sections of the Tower 2-3 podium. The Tower 4 podium comprises a restaurant at the southwest corner, a hotel lobby at the southeast corner, a central residential lobby at the west side, and indoor parking and building support functions in the remaining space. The proposed buildings are surrounded by various open spaces, some of which integrate with the existing park to the southeast of the study site.

The typical podium plan primarily comprises indoor parking, in addition to hotel suites along the full perimeter of the Tower 4 podium, and perimeter residential units at the southeast corner of the remaining podia. At Level 4 and above, the floorplate of all four residential towers feature a similar shape that is nearly rectangular with rounded east and west building corners, and a taper at the east side accomplished by progressive insets. The towers are oriented with the long axis in the east-west direction and feature rounded balconies.

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 open space followed by low-rise buildings from the south clockwise to the north, Kempenfelt Bay to the east, and the high-rise towers at 2-6 Toronto Street and 33 Ellen Street to the northeast and southeast, respectively. A park is also located along the south perimeter of the study site, follow by further massing to the south. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) comprise predominantly low-rise buildings from the south clockwise to the north, Kempenfelt Bay to the East, and open water followed by low-rise buildings to the southeast and northeast, including a cluster of medium and high-rise buildings to the northeast beyond the near-field.

Grade-level areas investigated include sidewalks, walkways, parking areas, the nearby Bunkers Creek Eco-park, surrounding open spaces, and building access points. Wind comfort is also evaluated over the podia rooftops at Level 4. Figure 1 illustrates the study site and surrounding context, and photographs 1 through 6 depict the wind tunnel 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; (iii) recommend suitable mitigation measures, where required; and (iv) evaluate the influence of the proposed development on the existing wind conditions.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on wind tunnel measurements of wind speeds at selected locations on a reduced-scale physical model, meteorological analysis of the Barrie area wind climate and synthesis of wind tunnel data with industry-accepted guidelines. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort and safety guidelines.

4.1 Wind Tunnel Context Modelling

A detailed PLW study is performed to determine the influence of local winds at the pedestrian level for a proposed development. The physical model of the proposed development and relevant surroundings, illustrated in Photographs 1 through 4 following the main text, was constructed at a scale of 1:400. The wind tunnel model includes all existing buildings and approved future developments within a full-scale diameter of approximately 840 metres. The general concept and approach to wind tunnel modelling is to provide building and topographic detail in the immediate vicinity of the study site on the surrounding model, and to rely on a length of wind tunnel upwind of the model to develop wind properties consistent with known turbulent intensity profiles that represent the surrounding terrain.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the wind tunnel 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 study was performed by testing a total of 167 sensor locations on the scale model in Gradient Wind's wind tunnel. Of the 167 sensors, 47 were placed over the podia rooftops at Level 4. Wind speed measurements were performed for each of the sensors for 36 wind directions at 10° intervals. Figure 1 illustrates a plan of the site and relevant surrounding context, while sensor locations used to investigate wind conditions are illustrated in Figures 2A through 5B.

Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-

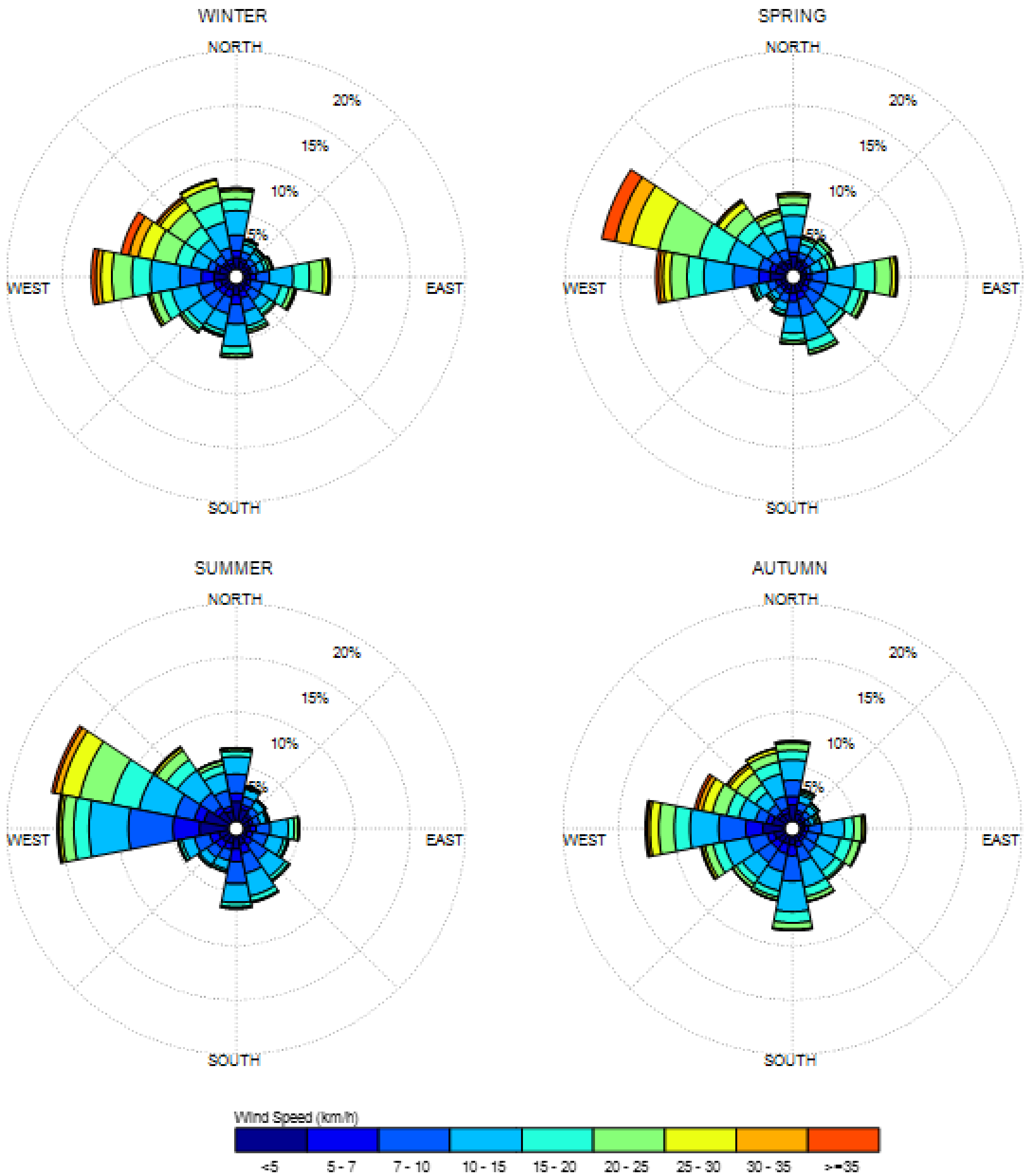
second time period. This period at model-scale corresponds approximately to one hour in full-scale, which matches the time frame of full-scale meteorological observations. Measured mean and gust wind speeds at grade were referenced to the wind speed measured near the ceiling of the wind tunnel to generate mean and peak wind speed ratios. Ceiling height in the wind tunnel represents the depth of the boundary layer of wind flowing over the earth's surface, referred to as the gradient height. Within this boundary layer, mean wind speed increases up to the gradient height and remains constant thereafter. Appendices C and D provide greater detail of the theory behind wind speed measurements. Wind tunnel measurements for this project, conducted in Gradient Wind's wind tunnel facility, meet or exceed guidelines found in the National Building Code of Canada 2010 and of 'Wind Tunnel Studies of Buildings and Structures', ASCE Manual 7 Reports on Engineering Practice No 67.

4.3 Meteorological Data Analysis

A statistical model for winds in Barrie was developed from hourly meteorological wind data recorded at Lake Simcoe Regional 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 the 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 Barrie area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in km/h. Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Barrie, the most common winds concerning pedestrian comfort occur from the northwest quadrant, 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
LAKE SIMCOE REGIONAL AIRPORT, BARRIE, 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

Following the comparison, the location is assigned a descriptor that indicates the suitability of the location for its intended use. The suitability descriptors are summarized as follows:

- **Acceptable**: The predicted wind conditions are suitable for the intended uses of the associated outdoor spaces without the need for mitigation.
- **Acceptable with Mitigation**: The predicted wind conditions are not acceptable for the intended use of a space; however, following the implementation of typical mitigation measures, the wind conditions are expected to satisfy the required comfort guidelines.
- **Mitigation Testing Recommended**: The effectiveness of typical mitigation measures is uncertain, and additional wind tunnel testing is recommended to explore other options and to ensure compliance with the comfort guidelines.
- **Incompatible**: The predicted wind conditions will interfere with the comfortable and/or safe use of a space and cannot be feasibly mitigated to acceptable levels.

5. RESULTS AND DISCUSSION

5.1 Pedestrian Comfort Suitability

Tables A1 through A5 in Appendix A provide a summary of seasonal comfort predictions for each sensor location. The tables indicate the 80% non-exceedance gust wind speeds and corresponding comfort classifications as defined in Section 4.4. In other words, a gust wind speed threshold of 19.1 for the summer season indicates that 80% of the measured data falls at or below 19.1 km/h during the summer months and conditions are therefore suitable for standing, as the 80% threshold value falls within the exceedance range of 16-22 km/h for standing. The tables include the predicted threshold values for each sensor location during each season, accompanied by the corresponding predicted comfort class (i.e. sitting, standing, walking, etc.).

The most significant findings of the PLW are summarized in the Section 5.2. To assist with understanding and interpretation, predicted conditions for the proposed development are also illustrated in colour-coded format in Figures 2A through 5B. Conditions suitable for sitting are represented by the colour green, while standing is represented by yellow, and walking by blue. Conditions uncomfortable for walking are represented by magenta. Measured mean and gust velocity ratios, which constitutes the raw data upon which the results are based, will be made available upon request.

5.2 Summary of Findings – Future Conditions

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables A1-A5 in Appendix A, this section summarizes the most significant findings of the PLW study, as follows:

1. All public sidewalks and walkways within and surrounding the development, as well as laneways and surface parking areas, will experience wind conditions suitable for standing or better during the summer and walking or better for the remainder of the year, which is acceptable.

2. Most primary building access points will be comfortable for standing or better throughout the year. Exceptions may occur within the grade-level corridor between Towers 1 and 2 (Sensors 61-65 and Sensors 116-120), which will transition to include conditions suitable for walking during the spring, autumn and winter. If primary residential or retail entrances are desired within this corridor at windy

locations, it is recommended to either recess the entrances into the building façade or flank the entrances with vertical wind barriers. All secondary and service building access points (such as stairwell exits and vehicle entrances) will be comfortable for standing or better during the summer and walking or better for the remainder of the year, which is acceptable.

3. The existing park south of the study site (Sensors 25-27, 45, and 50-53) will be comfortable for sitting during the summer and largely comfortable for standing for the remainder of the year, which is acceptable for the intended use.

4. The green space directly south of the Tower 1 podium (Sensors 54-56) will be comfortable for a mix of sitting and standing during the summer, transitioning to standing conditions for the remainder of the year. If seating or more sedentary activities are desired for areas not achieving sitting criteria during the intended use period, it is recommended to install localized wind barriers directly north and west of designated spaces. The barriers may take the form of high-solidity wind barriers, dense coniferous plantings, or a combination thereof. The exact placement and configuration of barriers, if required, can be determined at a later date as the landscape plan progresses.

5. Wind conditions over the podium roof of Tower 1 (Sensors 121-129) will range from sitting to walking during the summer and a mix of walking and standing for the remainder of the year. If windier areas of the rooftop will be intended for use as an outdoor amenity area, mitigation will be required in the form of raised perimeter guards, canopies and/or pergola structures, and localized wind barriers. The exact configuration of such mitigation be confirmed at a later date as the landscape plan progresses, in order to tailor effective and efficient mitigation measures to any designated amenity spaces.

6. The podium roof serving Towers 2 and 3 (Sensors 130-155) will be comfortable for walking or better during the summer, transitioning to include conditions uncomfortable for walking between Towers 2 and 3 (Sensors 135, 140, and 142-143) during the spring and winter. If this space is recommended for use as an outdoor amenity area, extensive mitigation will likely be required in the form of localized wind barriers, canopies and/or pergola structures, and raised perimeter guards. The exact

placement and configuration of mitigation, if required, can be confirmed at a later date as the landscape plan progresses.

7. The podium roof serving Tower 4 (Sensors 156-167) will be comfortable for a mix of sitting and standing during the summer, transitioning to conditions comfortable for walking or better for the remainder of the year. If seating or more sedentary activity areas are desired for windier locations, it is recommended to provide raised perimeter guards, as well as canopies/pergolas, and localized wind barriers. The exact placement and configuration of mitigation, if required, can be confirmed at a later date as the landscape plan progresses.

8. 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.

5.3 Summary of Findings – Existing Versus Future Conditions

To evaluate the influence of the study building on existing wind conditions at and near the study site, additional pedestrian level wind testing was performed for the existing site massing without the study building present. A comparison of wind comfort results for the existing and future configurations is provided in Tables B1 to B4 in Appendix B, which provide a summary of the comparative wind comfort predictions. The future and existing massing scenarios are shown in Photographs 1 through 6 following the main text.

Pedestrian wind comfort resulting from the construction of the study building and future surrounding developments may be described as being *unchanged*, *improved*, or *reduced* as compared to the existing conditions. These designations are not strictly determined by the predicted percentage values, rather by the change to the predicted comfort class.

A review of Tables B1 to B4 indicates that wind speeds at most grade-level areas will remain unchanged upon the introduction of the proposed study building. Although wind speeds marginally increase along portions of the Bradford Street sidewalk (Sensors 1, 3, 14, 18, 20-21, 57 and 60) and walkways south of the site (Sensors 23, 54), conditions nevertheless remain acceptable for the intended uses.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a comparative pedestrian level wind study for the proposed Barrie Waterfront development in Barrie, Ontario. The study was performed in accordance with industry standard wind tunnel testing and data analysis procedures.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report, and is also illustrated in Figures 2A-5B, and Tables A1 through A5 in Appendix A. Based on wind tunnel test results, meteorological data analysis of the Barrie wind climate, and experience with similar developments, we conclude that wind conditions over most pedestrian sensitive grade-level locations within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions may include primary retail or residential entrances located between Towers 1 and 2, where conditions will not achieve standing criteria during the colder seasons. Depending on the proposed entrance configuration, mitigation in the form of recessed entrance locations or vertical wind barriers, as described in Section 5.2, may be required. The Level 4 podium rooftop areas, if desired for use as outdoor amenity areas, will require mitigation to ensure conditions are comfortable for sitting during the intended use period.

A comparison of the existing versus future wind comfort surrounding the study site indicates that the proposed development will have a generally neutral influence on grade-level wind conditions over surrounding areas, with a few minor exceptions. Although wind speeds marginally increase along portions of the Bradford Street sidewalk and walkways south of the site, conditions nevertheless remain acceptable for the intended uses.

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.

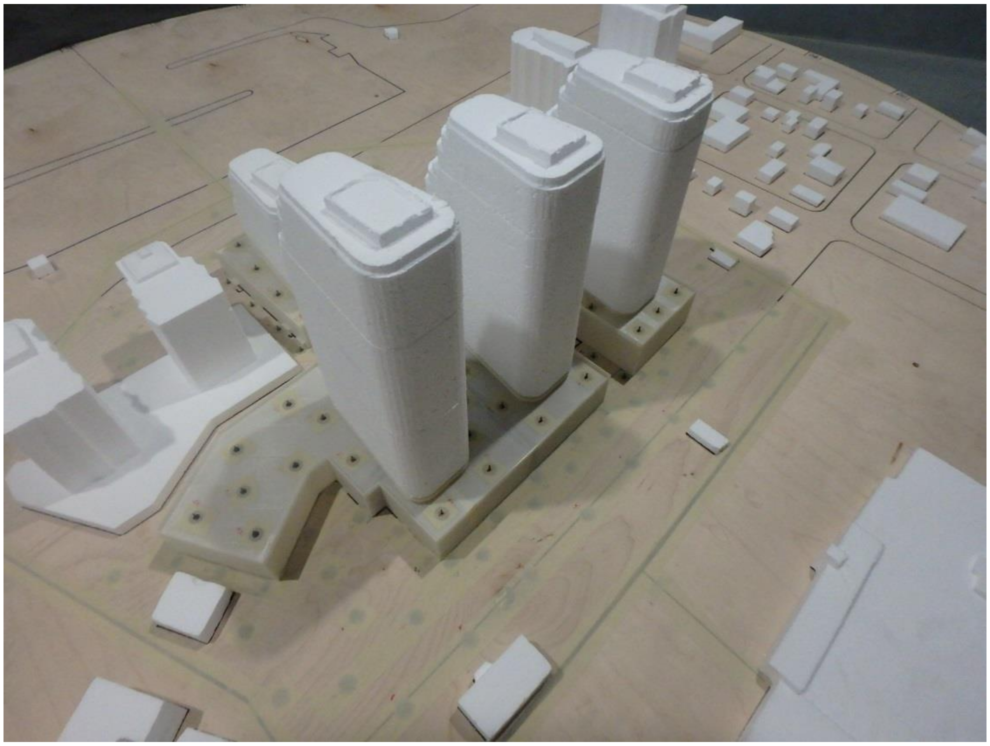
Megan Jee, MESc.,
Project Manager

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

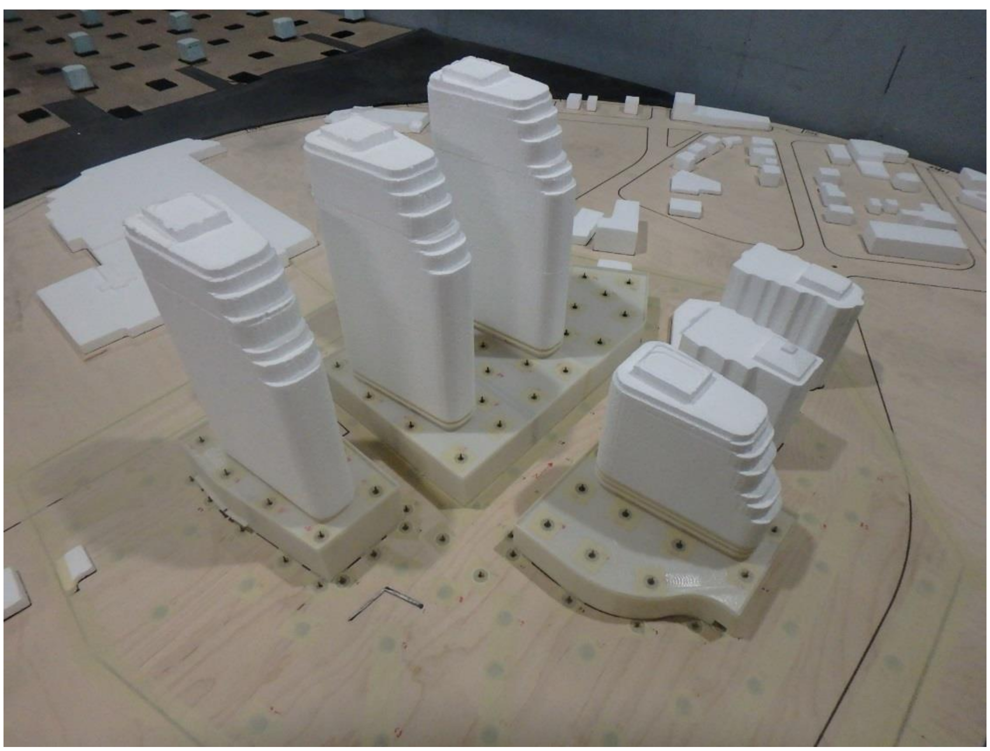
GW19-214-WTPLW

PHOTOGRAPH 1: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND

PHOTOGRAPH 2: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING UPWIND

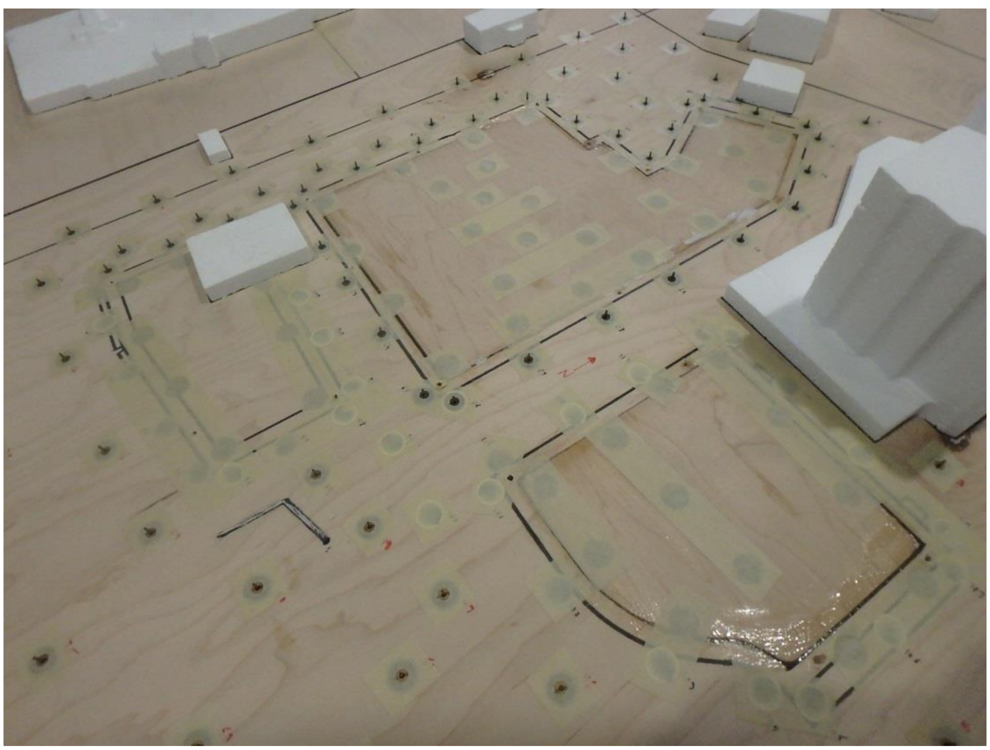


PHOTOGRAPH 3: CLOSE-UP VIEW OF STUDY MODEL LOOKING SOUTHEAST

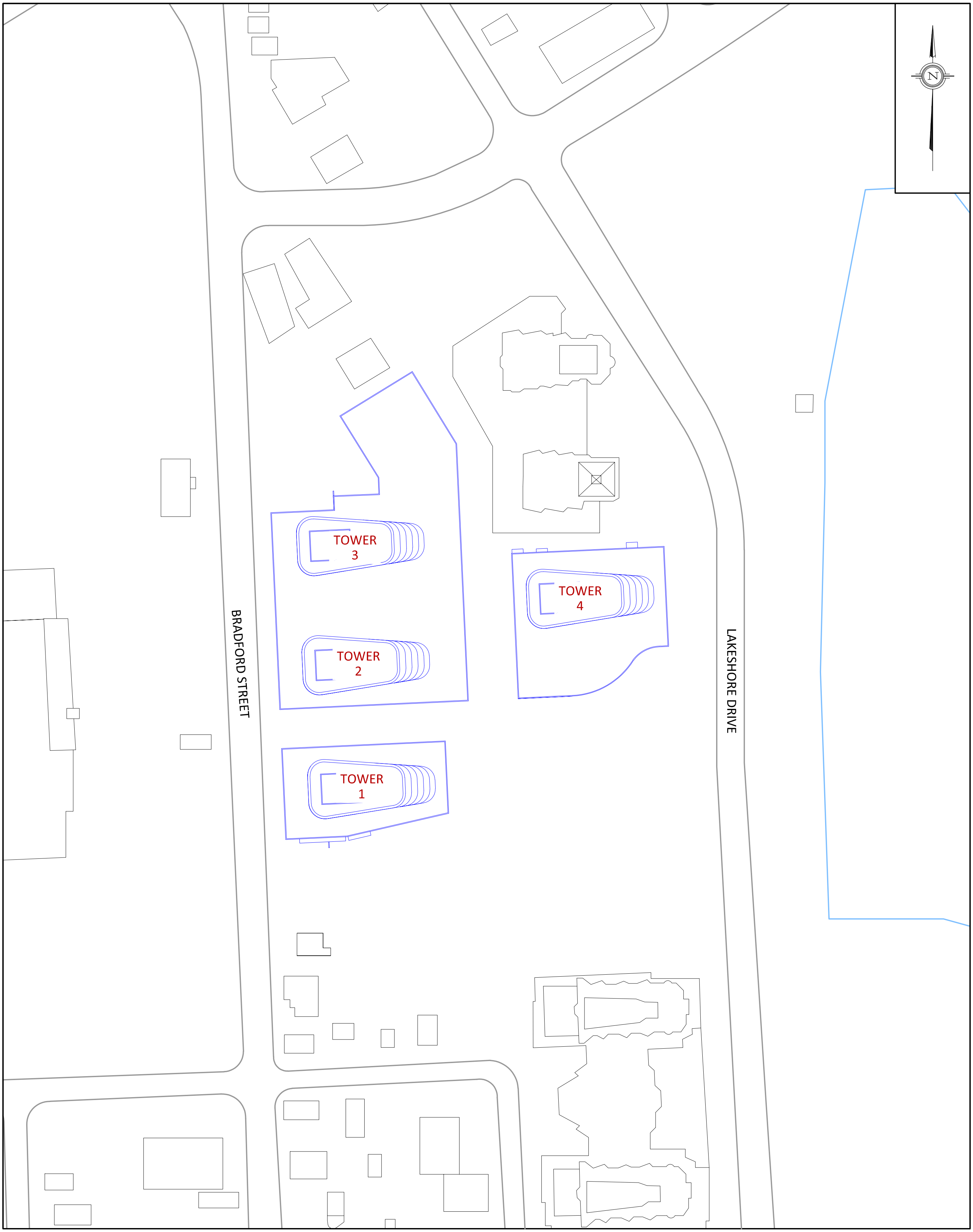


PHOTOGRAPH 4: CLOSE-UP VIEW OF STUDY MODEL LOOKING NORHTWEST

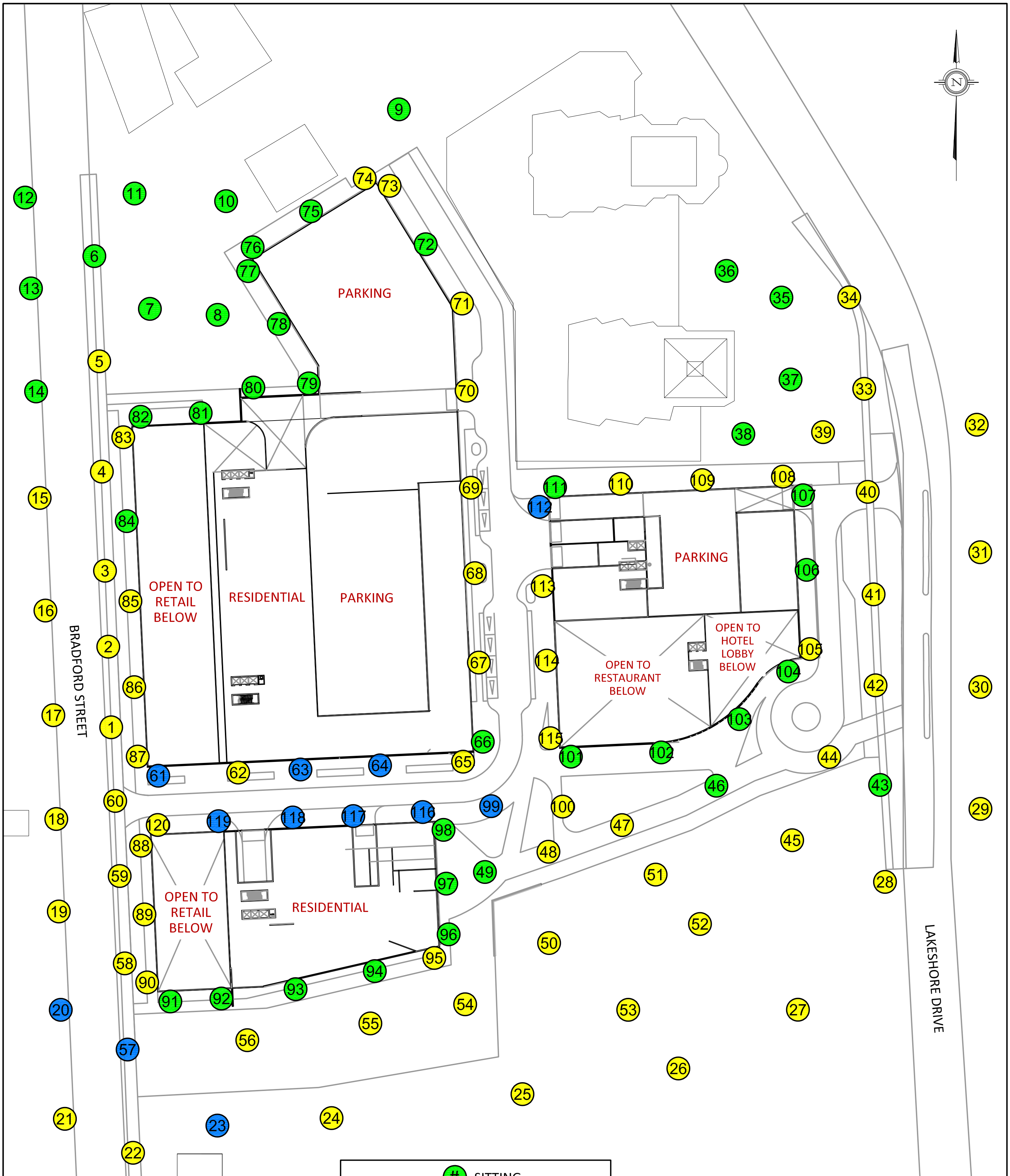
PHOTOGRAPH 5: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING SOUTHEAST



PHOTOGRAPH 6: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING NORHTWEST



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY	DESCRIPTION FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:2500 (APPROX.)	DRAWING NO. GWE19-214-PLW-1
	DATE NOVEMBER 27, 2019	DRAWN BY C.E.



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

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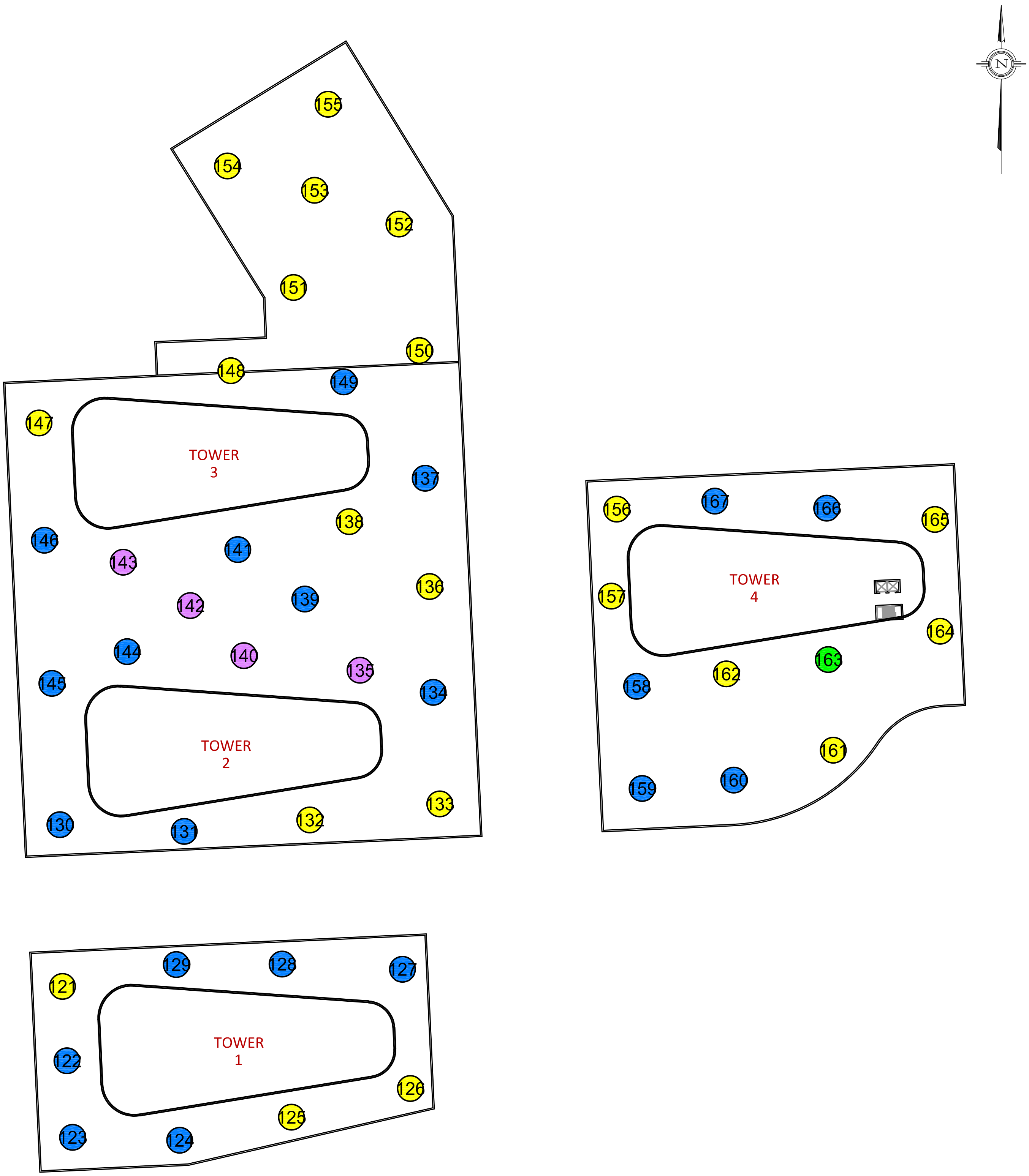
PROJECT: BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2A: SPRING - FUTURE CONDITIONS GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1500 (APPROX.)	DRAWING NO.: GWE19-214-PLW-2A	
DATE: NOVEMBER 27, 2019	DRAWN BY: C.E.	



PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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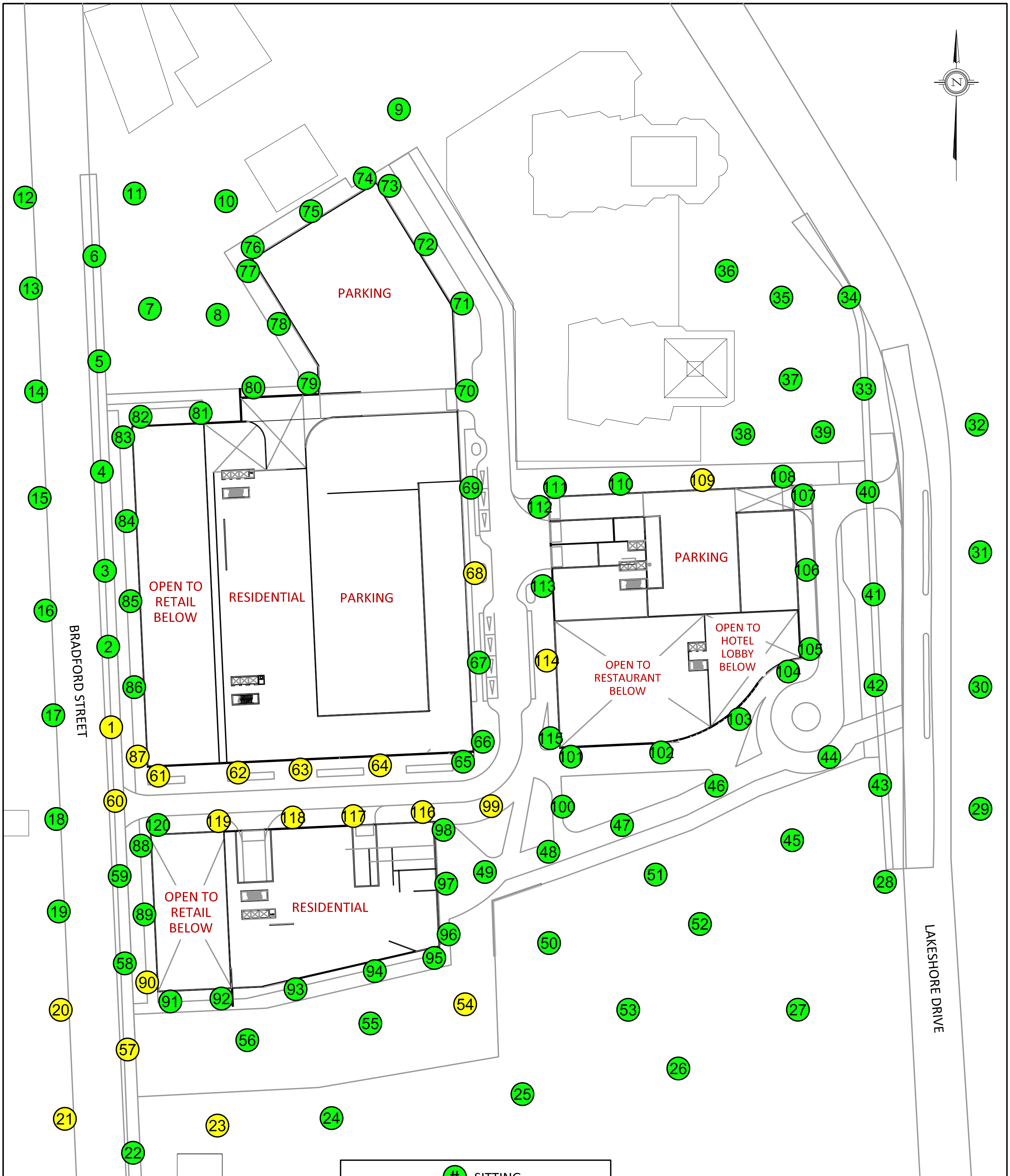
PROJECT	BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1200 (APPROX.)	DRAWING NO.	GWE19-214-PLW-2B
DATE	NOVEMBER 27, 2019	DRAWN BY	C.E.

DESCRIPTION

FIGURE 2B: SPRING
LEVEL 4 ROOF PLAN
PEDESTRIAN COMFORT PREDICTIONS



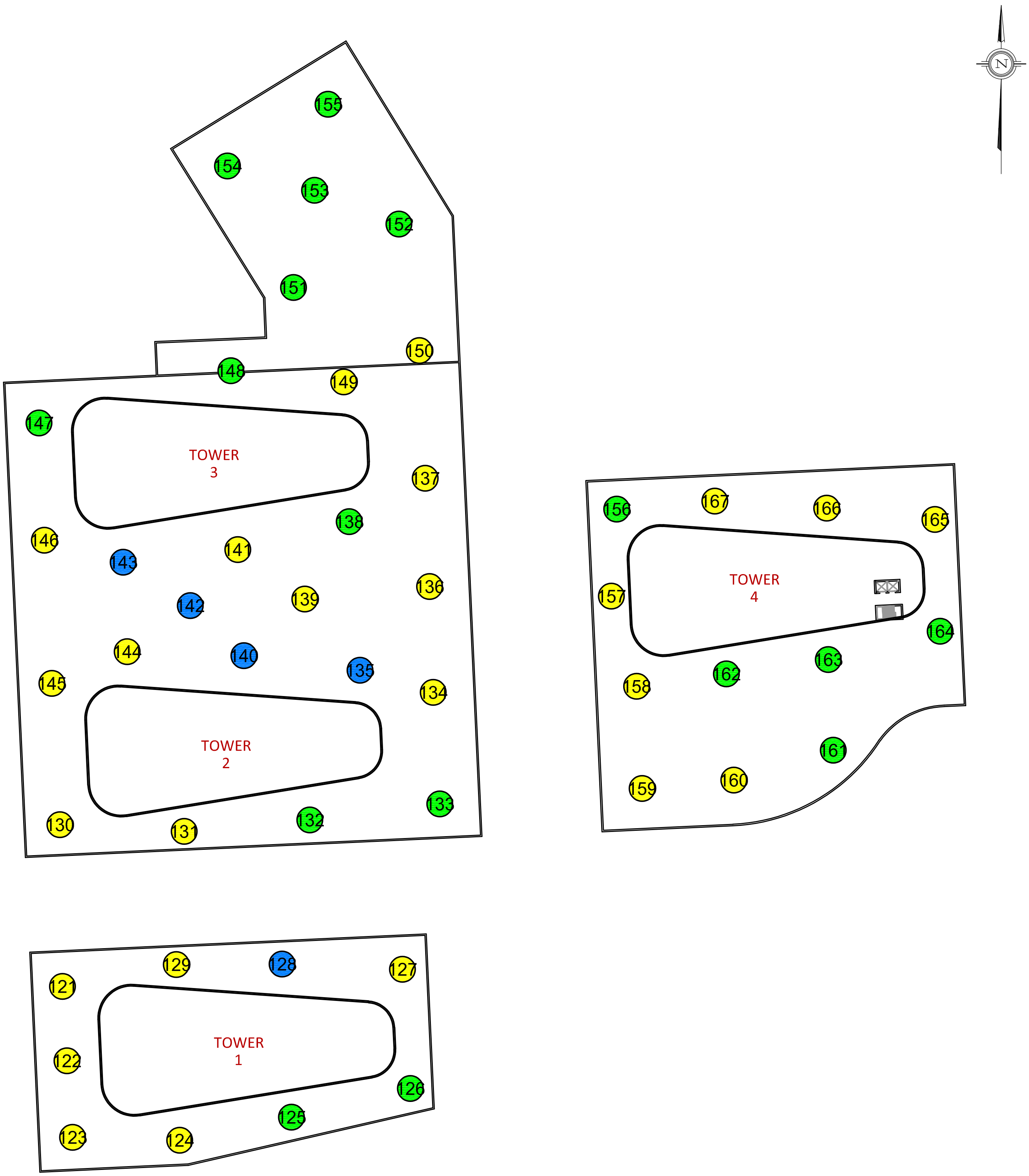
NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY SCALE: 1:1500 (APPROX.) — DRAWING NO. GWE19-214-PLW-3A DATE: NOVEMBER 27, 2019 — DRAWN BY: C.E.	DESCRIPTION: FIGURE 3A: SUMMER GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

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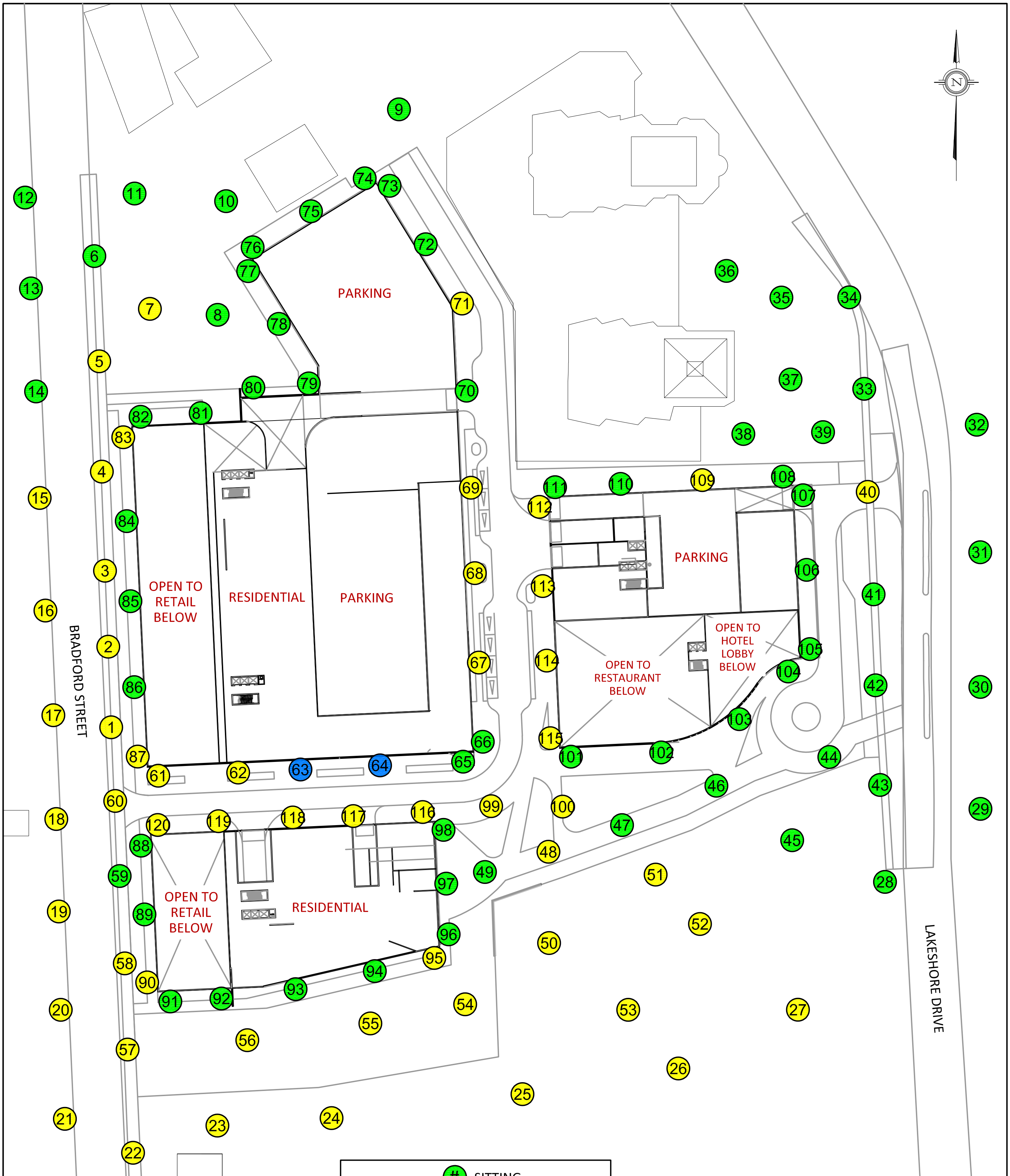
	SCALE: 1:1200 (APPROX.)	DRAWING NO.: GWE19-214-PLW-3B	
	DATE: NOVEMBER 27, 2019	DRAWN BY: C.E.	



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

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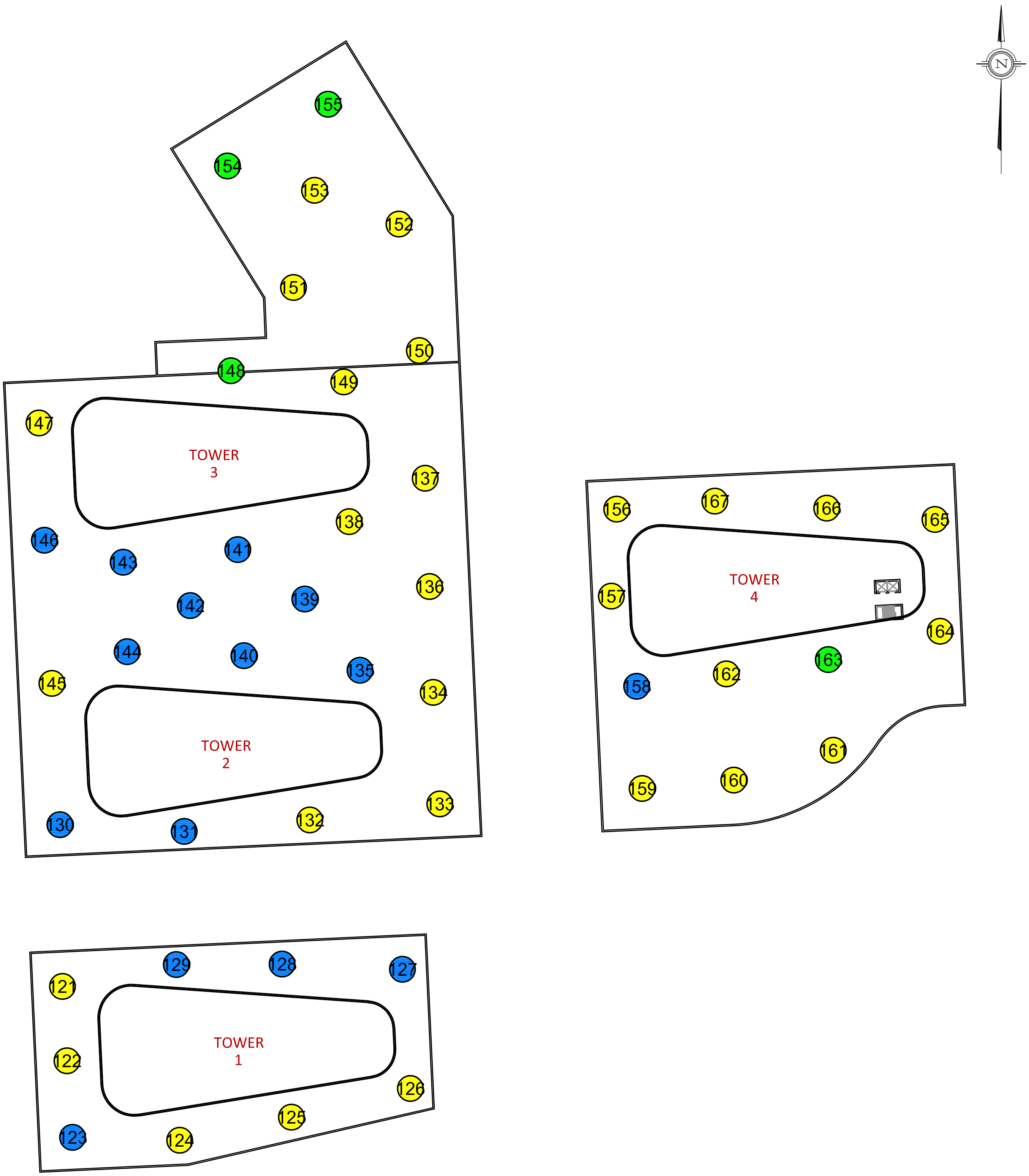
PROJECT	BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1500 (APPROX.)
DRAWING NO.	GWE19-214-PLW-4A
DATE	NOVEMBER 27, 2019
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4A: AUTUMN GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



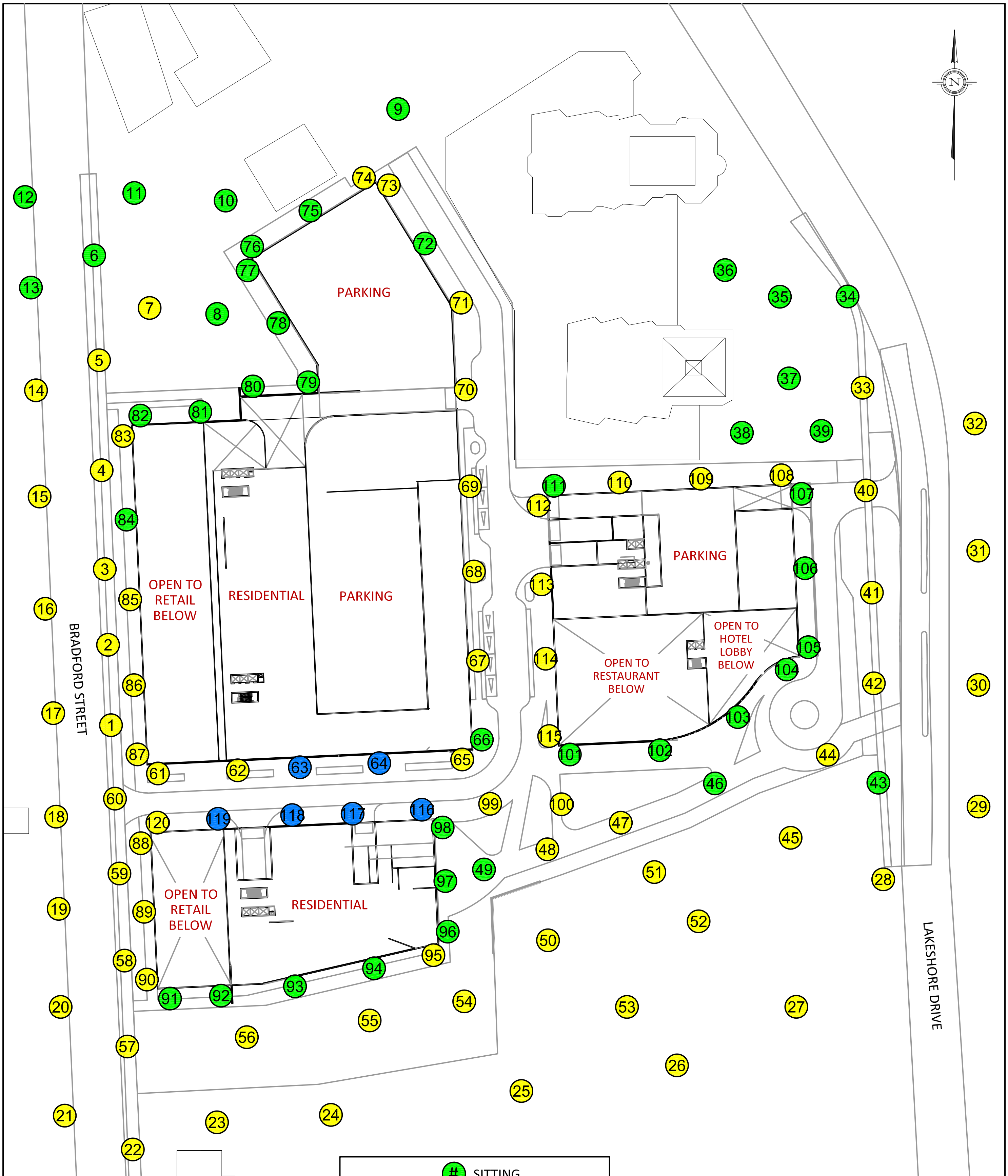
NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 4B: AUTUMN LEVEL 4 ROOF PLAN PEDESTRIAN COMFORT PREDICTIONS
	SCALE: 1:1200 (APPROX.)	DRAWING NO.: GWE19-214-PLW-4B	
	DATE: NOVEMBER 27, 2019	DRAWN BY: C.E.	



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

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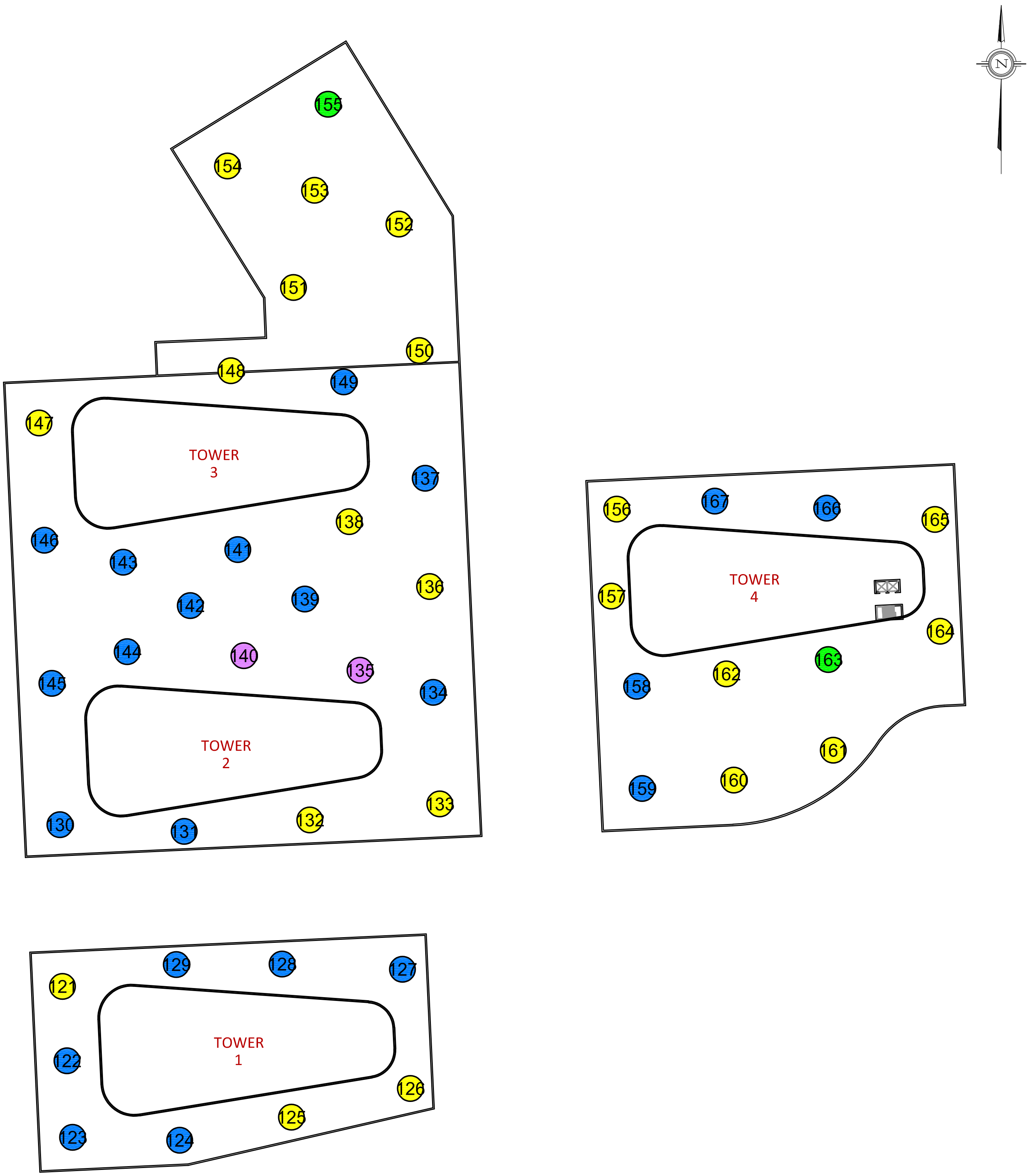
	SCALE: 1:1500 (APPROX.)	DRAWING NO.: GWE19-214-PLW-5A	
	DATE: NOVEMBER 27, 2019	DRAWN BY: C.E.	



NOTES:

1. SCALE IS APPROXIMATE.
2. # PEDESTRIAN LEVEL WIND SENSOR LOCATION.

PREDICTED COMFORT CLASSES

- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

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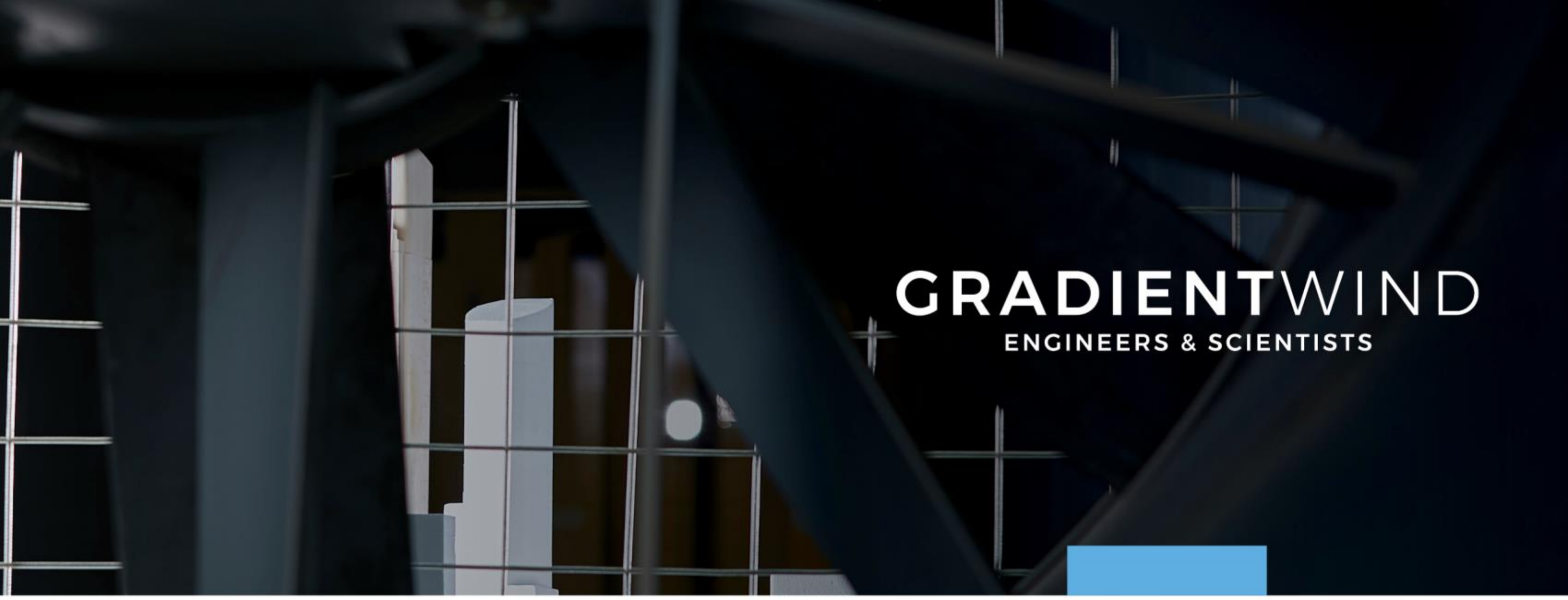
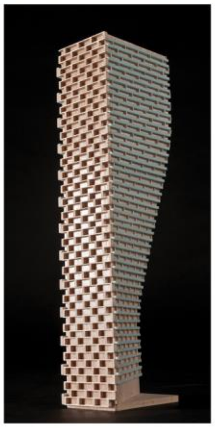
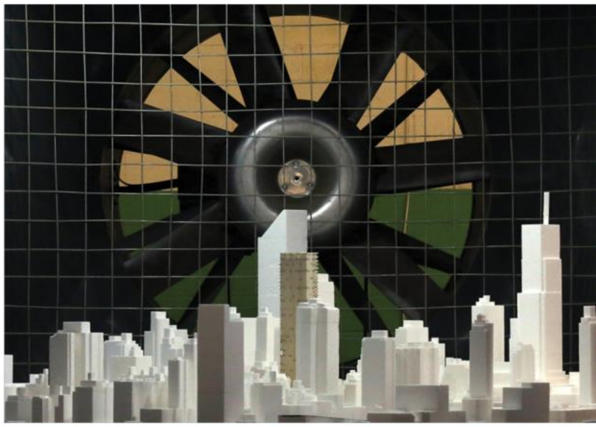
PROJECT: BARRIE WATERFRONT, BARRIE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 5B: WINTER LEVEL 4 ROOF PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1200 (APPROX.)	DRAWING NO.: GWE19-214-PLW-5B	
DATE: NOVEMBER 27, 2019	DRAWN BY: C.E.	





APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A5
(FUTURE CONDITIONS)

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h =- Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A1: SUMMARY OF PEDESTRIAN COMFORT

Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	20.7	Standing	16.2	Standing	17.5	Standing	19.6	Standing	50.0	Safe
2	18.8	Standing	15.0	Sitting	17.2	Standing	18.2	Standing	41.2	Safe
3	19.0	Standing	15.2	Sitting	17.6	Standing	18.6	Standing	40.2	Safe
4	17.0	Standing	13.6	Sitting	17.1	Standing	17.5	Standing	40.3	Safe
5	17.1	Standing	13.2	Sitting	17.1	Standing	18.2	Standing	39.6	Safe
6	15.1	Sitting	11.8	Sitting	14.9	Sitting	15.5	Sitting	33.0	Safe
7	15.3	Sitting	12.3	Sitting	16.1	Standing	17.3	Standing	37.9	Safe
8	14.9	Sitting	11.6	Sitting	14.2	Sitting	15.4	Sitting	34.0	Safe
9	15.5	Sitting	11.6	Sitting	13.7	Sitting	14.2	Sitting	33.9	Safe
10	13.2	Sitting	10.3	Sitting	12.9	Sitting	13.5	Sitting	29.3	Safe
11	15.7	Sitting	11.9	Sitting	14.7	Sitting	15.3	Sitting	35.0	Safe
12	15.4	Sitting	11.6	Sitting	14.1	Sitting	15.2	Sitting	34.9	Safe
13	14.8	Sitting	11.2	Sitting	13.4	Sitting	14.6	Sitting	30.4	Safe
14	15.7	Sitting	12.7	Sitting	16.0	Sitting	16.7	Standing	34.4	Safe
15	18.4	Standing	14.7	Sitting	17.6	Standing	18.3	Standing	40.4	Safe
16	19.5	Standing	15.2	Sitting	17.7	Standing	18.7	Standing	41.4	Safe
17	18.9	Standing	14.7	Sitting	16.7	Standing	18.4	Standing	42.1	Safe
18	19.5	Standing	14.7	Sitting	16.7	Standing	18.4	Standing	40.1	Safe
19	18.3	Standing	14.2	Sitting	16.2	Standing	18.1	Standing	39.3	Safe
20	22.7	Walking	17.0	Standing	19.6	Standing	21.9	Standing	50.2	Safe
21	21.2	Standing	16.1	Standing	17.9	Standing	20.6	Standing	49.4	Safe
22	21.2	Standing	15.8	Sitting	17.4	Standing	20.0	Standing	50.6	Safe
23	23.5	Walking	17.3	Standing	18.5	Standing	21.1	Standing	60.1	Safe
24	20.7	Standing	15.3	Sitting	17.2	Standing	18.9	Standing	55.4	Safe
25	20.4	Standing	15.4	Sitting	17.3	Standing	19.2	Standing	52.3	Safe
26	19.1	Standing	14.1	Sitting	17.2	Standing	18.1	Standing	47.4	Safe
27	17.5	Standing	13.4	Sitting	16.1	Standing	17.5	Standing	43.0	Safe
28	16.3	Standing	12.4	Sitting	15.4	Sitting	16.8	Standing	36.0	Safe
29	16.2	Standing	12.5	Sitting	15.8	Sitting	16.9	Standing	34.4	Safe
30	16.4	Standing	12.8	Sitting	15.8	Sitting	16.6	Standing	34.5	Safe
31	16.3	Standing	12.8	Sitting	15.7	Sitting	16.3	Standing	33.4	Safe
32	16.5	Standing	13.2	Sitting	15.4	Sitting	16.5	Standing	36.3	Safe
33	16.1	Standing	12.5	Sitting	15.1	Sitting	16.1	Standing	35.1	Safe
34	16.3	Standing	12.6	Sitting	15.0	Sitting	16.0	Sitting	33.7	Safe
35	15.4	Sitting	11.8	Sitting	13.9	Sitting	14.8	Sitting	32.6	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h =- Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A2: SUMMARY OF PEDESTRIAN COMFORT

Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	14.1	Sitting	10.7	Sitting	12.5	Sitting	13.4	Sitting	31.9	Safe
37	14.9	Sitting	11.7	Sitting	13.8	Sitting	14.9	Sitting	33.0	Safe
38	15.4	Sitting	11.4	Sitting	13.5	Sitting	14.4	Sitting	38.5	Safe
39	16.4	Standing	12.7	Sitting	15.1	Sitting	15.8	Sitting	35.6	Safe
40	18.5	Standing	14.9	Sitting	16.9	Standing	17.9	Standing	39.9	Safe
41	16.2	Standing	12.9	Sitting	14.8	Sitting	16.0	Standing	35.9	Safe
42	16.0	Standing	12.6	Sitting	15.2	Sitting	16.1	Standing	34.4	Safe
43	15.5	Sitting	12.1	Sitting	14.8	Sitting	15.8	Sitting	33.2	Safe
44	16.6	Standing	12.5	Sitting	14.9	Sitting	16.6	Standing	35.9	Safe
45	16.6	Standing	12.8	Sitting	16.0	Sitting	17.0	Standing	35.8	Safe
46	15.5	Sitting	11.6	Sitting	14.4	Sitting	15.5	Sitting	35.0	Safe
47	18.2	Standing	13.3	Sitting	14.9	Sitting	16.2	Standing	45.6	Safe
48	20.5	Standing	15.7	Sitting	16.4	Standing	18.8	Standing	55.5	Safe
49	15.9	Sitting	12.3	Sitting	14.8	Sitting	15.7	Sitting	33.8	Safe
50	19.3	Standing	15.5	Sitting	18.0	Standing	19.6	Standing	44.8	Safe
51	18.6	Standing	14.0	Sitting	16.2	Standing	17.4	Standing	45.7	Safe
52	17.8	Standing	13.4	Sitting	16.0	Standing	17.3	Standing	38.6	Safe
53	17.9	Standing	14.0	Sitting	16.5	Standing	17.6	Standing	45.2	Safe
54	21.0	Standing	16.1	Standing	18.7	Standing	20.2	Standing	51.8	Safe
55	19.1	Standing	14.6	Sitting	16.9	Standing	18.6	Standing	60.8	Safe
56	17.6	Standing	13.3	Sitting	16.1	Standing	17.2	Standing	46.8	Safe
57	22.6	Walking	17.0	Standing	19.2	Standing	21.4	Standing	51.7	Safe
58	20.4	Standing	16.0	Sitting	17.5	Standing	19.7	Standing	49.9	Safe
59	16.7	Standing	13.2	Sitting	15.7	Sitting	16.8	Standing	36.2	Safe
60	21.3	Standing	16.4	Standing	18.9	Standing	20.7	Standing	44.8	Safe
61	22.1	Walking	17.1	Standing	19.8	Standing	21.6	Standing	56.5	Safe
62	21.6	Standing	16.7	Standing	20.1	Standing	21.4	Standing	51.1	Safe
63	25.5	Walking	19.4	Standing	22.2	Walking	24.4	Walking	60.9	Safe
64	24.7	Walking	18.9	Standing	22.1	Walking	23.4	Walking	53.2	Safe
65	16.7	Standing	12.7	Sitting	15.5	Sitting	16.3	Standing	36.8	Safe
66	14.4	Sitting	11.5	Sitting	13.5	Sitting	14.3	Sitting	32.9	Safe
67	19.5	Standing	15.0	Sitting	16.7	Standing	18.7	Standing	43.3	Safe
68	21.4	Standing	16.1	Standing	18.4	Standing	20.2	Standing	46.3	Safe
69	20.1	Standing	15.5	Sitting	17.3	Standing	19.0	Standing	46.8	Safe
70	18.4	Standing	13.9	Sitting	15.9	Sitting	17.2	Standing	40.6	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h =- Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A3: SUMMARY OF PEDESTRIAN COMFORT

Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
71	20.2	Standing	15.4	Sitting	17.7	Standing	19.3	Standing	43.3	Safe
72	15.6	Sitting	11.7	Sitting	13.8	Sitting	15.1	Sitting	32.2	Safe
73	18.1	Standing	13.7	Sitting	15.6	Sitting	17.1	Standing	39.5	Safe
74	17.5	Standing	12.8	Sitting	14.6	Sitting	16.7	Standing	42.1	Safe
75	16.0	Sitting	12.2	Sitting	14.4	Sitting	15.9	Sitting	39.1	Safe
76	14.4	Sitting	11.1	Sitting	13.6	Sitting	15.1	Sitting	39.7	Safe
77	14.6	Sitting	11.7	Sitting	13.7	Sitting	15.4	Sitting	35.8	Safe
78	13.0	Sitting	10.3	Sitting	12.9	Sitting	14.1	Sitting	33.2	Safe
79	9.8	Sitting	7.7	Sitting	9.0	Sitting	9.8	Sitting	21.8	Safe
80	11.8	Sitting	9.1	Sitting	11.0	Sitting	12.0	Sitting	27.9	Safe
81	11.8	Sitting	9.4	Sitting	11.6	Sitting	12.7	Sitting	29.5	Safe
82	14.5	Sitting	11.4	Sitting	13.1	Sitting	15.5	Sitting	39.2	Safe
83	16.3	Standing	13.2	Sitting	16.5	Standing	17.7	Standing	40.8	Safe
84	14.9	Sitting	12.0	Sitting	14.1	Sitting	14.9	Sitting	32.4	Safe
85	16.7	Standing	13.3	Sitting	15.4	Sitting	16.4	Standing	37.5	Safe
86	17.4	Standing	13.3	Sitting	14.7	Sitting	16.5	Standing	41.9	Safe
87	20.6	Standing	16.1	Standing	16.6	Standing	19.4	Standing	55.0	Safe
88	16.5	Standing	13.1	Sitting	15.3	Sitting	16.7	Standing	39.4	Safe
89	16.7	Standing	13.1	Sitting	13.8	Sitting	16.3	Standing	43.9	Safe
90	21.7	Standing	16.6	Standing	16.0	Standing	19.8	Standing	58.3	Safe
91	14.6	Sitting	11.0	Sitting	14.3	Sitting	14.3	Sitting	37.7	Safe
92	15.4	Sitting	11.4	Sitting	14.2	Sitting	14.5	Sitting	41.3	Safe
93	15.6	Sitting	11.7	Sitting	14.1	Sitting	15.3	Sitting	41.0	Safe
94	15.7	Sitting	12.0	Sitting	14.2	Sitting	15.5	Sitting	38.5	Safe
95	19.2	Standing	14.3	Sitting	17.3	Standing	18.0	Standing	45.6	Safe
96	14.4	Sitting	10.9	Sitting	12.2	Sitting	13.2	Sitting	31.1	Safe
97	12.3	Sitting	9.9	Sitting	11.0	Sitting	11.9	Sitting	27.5	Safe
98	14.4	Sitting	10.9	Sitting	13.3	Sitting	13.3	Sitting	34.8	Safe
99	22.2	Walking	17.2	Standing	18.4	Standing	21.0	Standing	61.8	Safe
100	20.4	Standing	15.5	Sitting	16.8	Standing	18.9	Standing	55.8	Safe
101	14.6	Sitting	10.9	Sitting	13.1	Sitting	13.3	Sitting	37.2	Safe
102	14.6	Sitting	10.8	Sitting	13.7	Sitting	14.0	Sitting	36.2	Safe
103	13.1	Sitting	10.0	Sitting	12.6	Sitting	13.1	Sitting	31.3	Safe
104	11.2	Sitting	8.7	Sitting	10.3	Sitting	11.1	Sitting	23.6	Safe
105	16.5	Standing	12.5	Sitting	14.6	Sitting	15.0	Sitting	41.3	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h =- Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

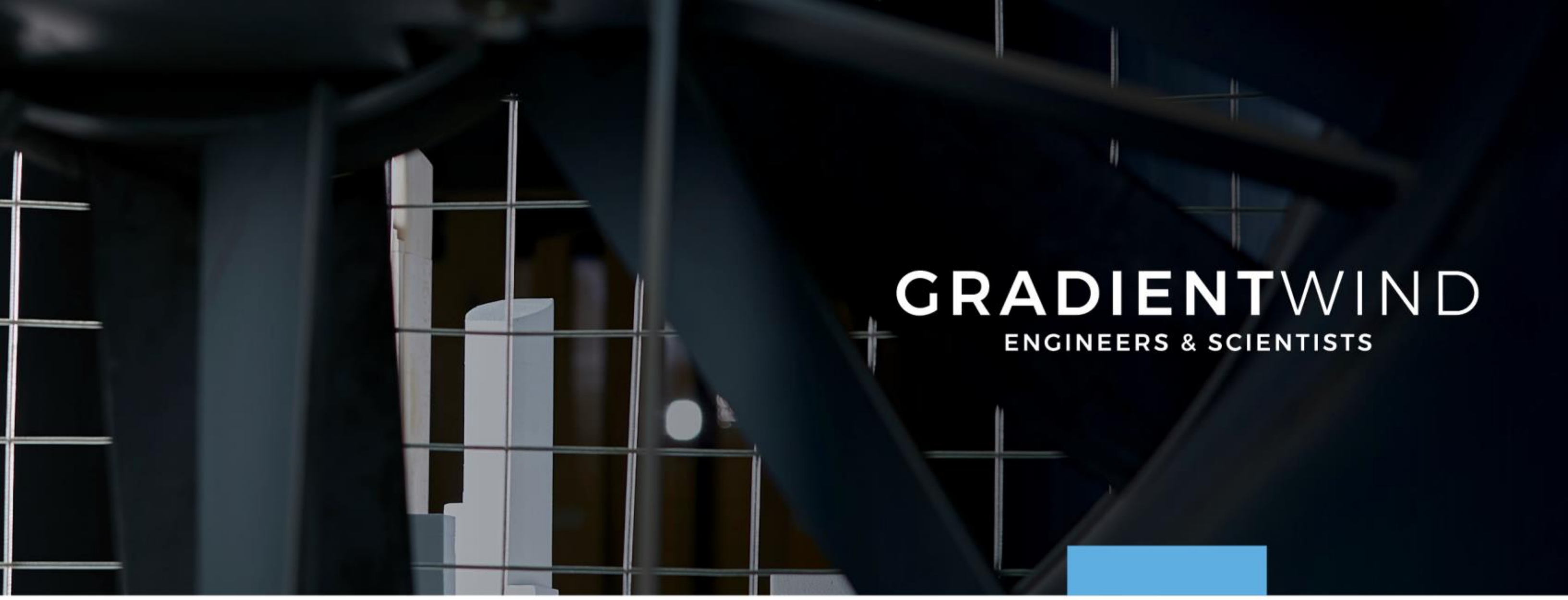
TABLE A4: SUMMARY OF PEDESTRIAN COMFORT

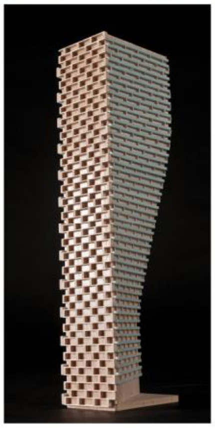
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
106	13.2	Sitting	10.1	Sitting	12.1	Sitting	12.8	Sitting	33.0	Safe
107	15.3	Sitting	10.7	Sitting	13.2	Sitting	13.4	Sitting	45.2	Safe
108	17.5	Standing	13.2	Sitting	13.8	Sitting	16.4	Standing	43.5	Safe
109	21.9	Standing	16.2	Standing	16.3	Standing	19.6	Standing	55.2	Safe
110	17.2	Standing	12.6	Sitting	14.2	Sitting	16.4	Standing	36.5	Safe
111	15.9	Sitting	12.0	Sitting	13.3	Sitting	15.1	Sitting	35.1	Safe
112	22.1	Walking	16.7	Standing	17.4	Standing	20.1	Standing	54.8	Safe
113	19.2	Standing	14.8	Sitting	17.2	Standing	18.5	Standing	40.5	Safe
114	20.4	Standing	16.1	Standing	18.4	Standing	20.2	Standing	45.8	Safe
115	19.5	Standing	15.4	Sitting	17.3	Standing	19.3	Standing	45.0	Safe
116	26.2	Walking	19.4	Standing	21.3	Standing	24.1	Walking	63.0	Safe
117	24.4	Walking	18.6	Standing	19.8	Standing	23.5	Walking	64.7	Safe
118	25.1	Walking	19.1	Standing	20.3	Standing	24.0	Walking	64.8	Safe
119	24.3	Walking	18.4	Standing	19.7	Standing	23.2	Walking	63.0	Safe
120	19.1	Standing	14.4	Sitting	16.9	Standing	18.7	Standing	46.5	Safe
121	20.9	Standing	16.3	Standing	20.3	Standing	21.1	Standing	48.2	Safe
122	22.9	Walking	18.5	Standing	21.5	Standing	22.5	Walking	52.8	Safe
123	25.6	Walking	20.1	Standing	22.8	Walking	25.2	Walking	61.8	Safe
124	23.3	Walking	17.5	Standing	20.6	Standing	23.1	Walking	59.1	Safe
125	18.5	Standing	13.3	Sitting	17.1	Standing	18.1	Standing	50.4	Safe
126	19.6	Standing	14.9	Sitting	18.3	Standing	18.4	Standing	46.4	Safe
127	25.9	Walking	19.8	Standing	22.2	Walking	24.7	Walking	59.2	Safe
128	29.6	Walking	22.7	Walking	24.4	Walking	29.2	Walking	69.8	Safe
129	29.0	Walking	21.8	Standing	24.4	Walking	28.5	Walking	71.0	Safe
130	27.0	Walking	20.5	Standing	22.4	Walking	25.9	Walking	62.3	Safe
131	27.6	Walking	21.0	Standing	24.6	Walking	26.3	Walking	68.2	Safe
132	19.4	Standing	15.0	Sitting	19.3	Standing	19.7	Standing	46.2	Safe
133	17.2	Standing	13.6	Sitting	16.9	Standing	18.2	Standing	38.0	Safe
134	25.2	Walking	19.6	Standing	21.4	Standing	24.2	Walking	58.8	Safe
135	31.4	Uncomfortable	23.5	Walking	25.4	Walking	30.0	Uncomfortable	73.4	Safe
136	21.1	Standing	16.3	Standing	19.1	Standing	21.3	Standing	49.3	Safe
137	22.9	Walking	18.2	Standing	21.2	Standing	23.4	Walking	58.5	Safe
138	19.6	Standing	15.6	Sitting	19.8	Standing	20.9	Standing	46.5	Safe
139	27.9	Walking	21.1	Standing	23.9	Walking	26.6	Walking	72.0	Safe
140	31.6	Uncomfortable	24.0	Walking	26.7	Walking	31.0	Uncomfortable	75.0	Safe

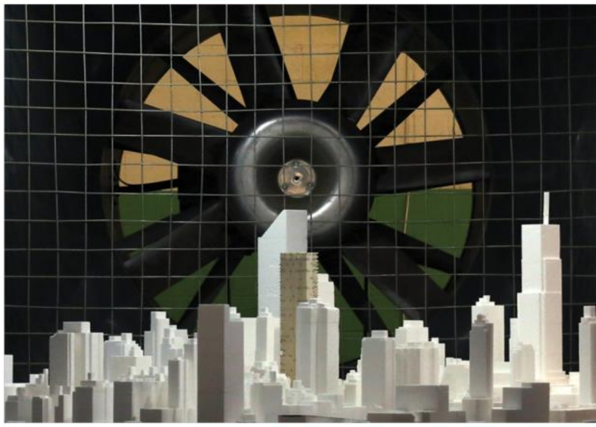
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h =- Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A5: SUMMARY OF PEDESTRIAN COMFORT

Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
141	23.5	Walking	19.0	Standing	23.1	Walking	23.7	Walking	56.3	Safe
142	30.8	Uncomfortable	23.5	Walking	26.7	Walking	29.6	Walking	76.1	Safe
143	31.6	Uncomfortable	24.3	Walking	26.7	Walking	28.9	Walking	86.0	Safe
144	28.2	Walking	21.8	Standing	25.6	Walking	28.3	Walking	65.3	Safe
145	22.4	Walking	17.2	Standing	21.3	Standing	22.9	Walking	51.6	Safe
146	28.5	Walking	22.0	Standing	24.9	Walking	28.5	Walking	66.0	Safe
147	19.3	Standing	15.2	Sitting	19.3	Standing	21.1	Standing	51.9	Safe
148	19.4	Standing	14.2	Sitting	15.8	Sitting	18.1	Standing	47.0	Safe
149	26.7	Walking	19.7	Standing	21.6	Standing	25.4	Walking	64.4	Safe
150	21.6	Standing	16.5	Standing	19.1	Standing	20.8	Standing	45.9	Safe
151	19.9	Standing	14.8	Sitting	17.3	Standing	18.3	Standing	43.4	Safe
152	19.6	Standing	15.1	Sitting	17.3	Standing	18.6	Standing	45.4	Safe
153	20.3	Standing	15.2	Sitting	17.5	Standing	18.2	Standing	44.3	Safe
154	18.1	Standing	13.6	Sitting	15.4	Sitting	16.3	Standing	40.9	Safe
155	16.6	Standing	13.0	Sitting	15.3	Sitting	16.0	Sitting	39.4	Safe
156	18.8	Standing	14.7	Sitting	17.2	Standing	18.4	Standing	40.7	Safe
157	21.3	Standing	17.2	Standing	20.2	Standing	21.2	Standing	46.9	Safe
158	26.8	Walking	20.8	Standing	22.5	Walking	26.4	Walking	67.4	Safe
159	23.2	Walking	17.3	Standing	18.8	Standing	22.3	Walking	56.7	Safe
160	22.8	Walking	17.2	Standing	18.6	Standing	21.8	Standing	57.5	Safe
161	20.5	Standing	15.7	Sitting	17.6	Standing	19.5	Standing	47.2	Safe
162	20.1	Standing	15.0	Sitting	17.4	Standing	19.2	Standing	51.3	Safe
163	15.6	Sitting	11.9	Sitting	14.5	Sitting	15.5	Sitting	38.4	Safe
164	19.6	Standing	14.7	Sitting	18.5	Standing	19.3	Standing	45.0	Safe
165	21.3	Standing	16.5	Standing	19.0	Standing	21.0	Standing	46.5	Safe
166	24.0	Walking	17.3	Standing	18.3	Standing	22.8	Walking	60.2	Safe
167	23.9	Walking	17.5	Standing	19.3	Standing	22.6	Walking	54.4	Safe





APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B4 (EXISTING VS FUTURE CONDITIONS)

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h = Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B1: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
1	Existing	13.8	Sitting	-	17.8	Standing	-
	Future	16.2	Standing	Reduced	19.6	Standing	Unchanged
2	Existing	13.7	Sitting	-	17.5	Standing	-
	Future	15.0	Sitting	Unchanged	18.2	Standing	Unchanged
3	Existing	13.6	Sitting	-	17.8	Standing	-
	Future	15.2	Sitting	Unchanged	18.6	Standing	Reduced
4	Existing	12.8	Sitting	-	16.3	Standing	-
	Future	13.6	Sitting	Unchanged	17.5	Standing	Unchanged
5	Existing	14.1	Sitting	-	17.6	Standing	-
	Future	13.2	Sitting	Unchanged	18.2	Standing	Unchanged
6	Existing	13.9	Sitting	-	16.9	Standing	-
	Future	11.8	Sitting	Unchanged	15.5	Sitting	Improved
7	Existing	13.6	Sitting	-	16.9	Standing	-
	Future	12.3	Sitting	Unchanged	17.3	Standing	Unchanged
8	Existing	13.1	Sitting	-	16.0	Sitting	-
	Future	11.6	Sitting	Unchanged	15.4	Sitting	Unchanged
9	Existing	11.8	Sitting	-	15.6	Sitting	-
	Future	11.6	Sitting	Unchanged	14.2	Sitting	Unchanged
10	Existing	10.5	Sitting	-	12.5	Sitting	-
	Future	10.3	Sitting	Unchanged	13.5	Sitting	Unchanged
11	Existing	13.3	Sitting	-	16.6	Standing	-
	Future	11.9	Sitting	Unchanged	15.3	Sitting	Improved
12	Existing	13.9	Sitting	-	17.7	Standing	-
	Future	11.6	Sitting	Unchanged	15.2	Sitting	Improved
13	Existing	13.9	Sitting	-	17.3	Standing	-
	Future	11.2	Sitting	Unchanged	14.6	Sitting	Improved
14	Existing	11.5	Sitting	-	14.3	Sitting	-
	Future	12.7	Sitting	Unchanged	16.7	Standing	Reduced
15	Existing	13.0	Sitting	-	16.7	Standing	-
	Future	14.7	Sitting	Unchanged	18.3	Standing	Unchanged

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h = Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B2: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
16	Existing	14.3	Sitting	-	18.0	Standing	-
	Future	15.2	Sitting	Unchanged	18.7	Standing	Unchanged
17	Existing	13.7	Sitting	-	17.4	Standing	-
	Future	14.7	Sitting	Unchanged	18.4	Standing	Unchanged
18	Existing	12.4	Sitting	-	15.5	Sitting	-
	Future	14.7	Sitting	Unchanged	18.4	Standing	Reduced
19	Existing	13.9	Sitting	-	17.9	Standing	-
	Future	14.2	Sitting	Unchanged	18.1	Standing	Unchanged
20	Existing	14.0	Sitting	-	18.2	Standing	-
	Future	17.0	Standing	Reduced	21.9	Standing	Unchanged
21	Existing	14.2	Sitting	-	18.3	Standing	-
	Future	16.1	Standing	Reduced	20.6	Standing	Unchanged
22	Existing	13.6	Sitting	-	17.4	Standing	-
	Future	15.8	Sitting	Unchanged	20.0	Standing	Unchanged
23	Existing	13.4	Sitting	-	17.1	Standing	-
	Future	17.3	Standing	Reduced	21.1	Standing	Unchanged
24	Existing	13.8	Sitting	-	18.5	Standing	-
	Future	15.3	Sitting	Unchanged	18.9	Standing	Unchanged
25	Existing	14.0	Sitting	-	18.1	Standing	-
	Future	15.4	Sitting	Unchanged	19.2	Standing	Unchanged
26	Existing	14.1	Sitting	-	18.8	Standing	-
	Future	14.1	Sitting	Unchanged	18.1	Standing	Unchanged
27	Existing	15.0	Sitting	-	19.2	Standing	-
	Future	13.4	Sitting	Unchanged	17.5	Standing	Unchanged
28	Existing	14.4	Sitting	-	18.3	Standing	-
	Future	12.4	Sitting	Unchanged	16.8	Standing	Unchanged
29	Existing	14.5	Sitting	-	18.6	Standing	-
	Future	12.5	Sitting	Unchanged	16.9	Standing	Unchanged
30	Existing	13.7	Sitting	-	17.5	Standing	-
	Future	12.8	Sitting	Unchanged	16.6	Standing	Unchanged

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h = Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B3: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
31	Existing	13.2	Sitting	-	17.0	Standing	-
	Future	12.8	Sitting	Unchanged	16.3	Standing	Unchanged
32	Existing	13.4	Sitting	-	17.3	Standing	-
	Future	13.2	Sitting	Unchanged	16.5	Standing	Unchanged
33	Existing	14.0	Sitting	-	17.6	Standing	-
	Future	12.5	Sitting	Unchanged	16.1	Standing	Unchanged
34	Existing	13.3	Sitting	-	17.0	Standing	-
	Future	12.6	Sitting	Unchanged	16.0	Sitting	Improved
35	Existing	13.2	Sitting	-	16.3	Standing	-
	Future	11.8	Sitting	Unchanged	14.8	Sitting	Improved
36	Existing	11.8	Sitting	-	14.5	Sitting	-
	Future	10.7	Sitting	Unchanged	13.4	Sitting	Unchanged
37	Existing	13.6	Sitting	-	16.7	Standing	-
	Future	11.7	Sitting	Unchanged	14.9	Sitting	Improved
38	Existing	12.3	Sitting	-	15.0	Sitting	-
	Future	11.4	Sitting	Unchanged	14.4	Sitting	Unchanged
39	Existing	12.7	Sitting	-	16.1	Standing	-
	Future	12.7	Sitting	Unchanged	15.8	Sitting	Improved
40	Existing	13.2	Sitting	-	16.8	Standing	-
	Future	14.9	Sitting	Unchanged	17.9	Standing	Unchanged
41	Existing	13.1	Sitting	-	16.7	Standing	-
	Future	12.9	Sitting	Unchanged	16.0	Standing	Unchanged
42	Existing	13.7	Sitting	-	17.3	Standing	-
	Future	12.6	Sitting	Unchanged	16.1	Standing	Unchanged
43	Existing	13.9	Sitting	-	17.3	Standing	-
	Future	12.1	Sitting	Unchanged	15.8	Sitting	Improved
44	Existing	14.2	Sitting	-	17.8	Standing	-
	Future	12.5	Sitting	Unchanged	16.6	Standing	Unchanged
45	Existing	14.5	Sitting	-	18.2	Standing	-
	Future	12.8	Sitting	Unchanged	17.0	Standing	Unchanged

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-16 km/h = Sitting, 16-22 km/h = Standing, 22-30 km/h = Walking, >30 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B4: COMPARATIVE SUMMARY OF PEDESTRIAN COMFORT

Sensor	Massing Scenario	Summer Pedestrian Comfort			Winter Pedestrian Comfort		
		Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing	Wind Speed (km/h) 80% data ≤	Predicted Comfort Class	Future Comfort Class Compared to Existing
46	Existing	14.8	Sitting	-	18.3	Standing	-
	Future	11.6	Sitting	Unchanged	15.5	Sitting	Improved
47	Existing	14.1	Sitting	-	17.8	Standing	-
	Future	13.3	Sitting	Unchanged	16.2	Standing	Unchanged
48	Existing	13.4	Sitting	-	17.4	Standing	-
	Future	15.7	Sitting	Unchanged	18.8	Standing	Unchanged
49	Existing	14.3	Sitting	-	18.2	Standing	-
	Future	12.3	Sitting	Unchanged	15.7	Sitting	Improved
50	Existing	13.9	Sitting	-	18.0	Standing	-
	Future	15.5	Sitting	Unchanged	19.6	Standing	Unchanged
51	Existing	14.3	Sitting	-	18.0	Standing	-
	Future	14.0	Sitting	Unchanged	17.4	Standing	Unchanged
52	Existing	13.6	Sitting	-	17.6	Standing	-
	Future	13.4	Sitting	Unchanged	17.3	Standing	Unchanged
53	Existing	14.0	Sitting	-	17.9	Standing	-
	Future	14.0	Sitting	Unchanged	17.6	Standing	Unchanged
54	Existing	13.8	Sitting	-	18.1	Standing	-
	Future	16.1	Standing	Reduced	20.2	Standing	Unchanged
55	Existing	14.0	Sitting	-	18.2	Standing	-
	Future	14.6	Sitting	Unchanged	18.6	Standing	Unchanged
56	Existing	14.2	Sitting	-	18.1	Standing	-
	Future	13.3	Sitting	Unchanged	17.2	Standing	Unchanged
57	Existing	14.0	Sitting	-	17.7	Standing	-
	Future	17.0	Standing	Reduced	21.4	Standing	Unchanged
58	Existing	13.7	Sitting	-	17.4	Standing	-
	Future	16.0	Sitting	Unchanged	19.7	Standing	Unchanged
59	Existing	11.5	Sitting	-	14.6	Sitting	-
	Future	13.2	Sitting	Unchanged	16.8	Standing	Improved
60	Existing	12.6	Sitting	-	15.9	Sitting	-
	Future	16.4	Standing	Reduced	20.7	Standing	Improved

APPENDIX C

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 C1 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 C2 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.

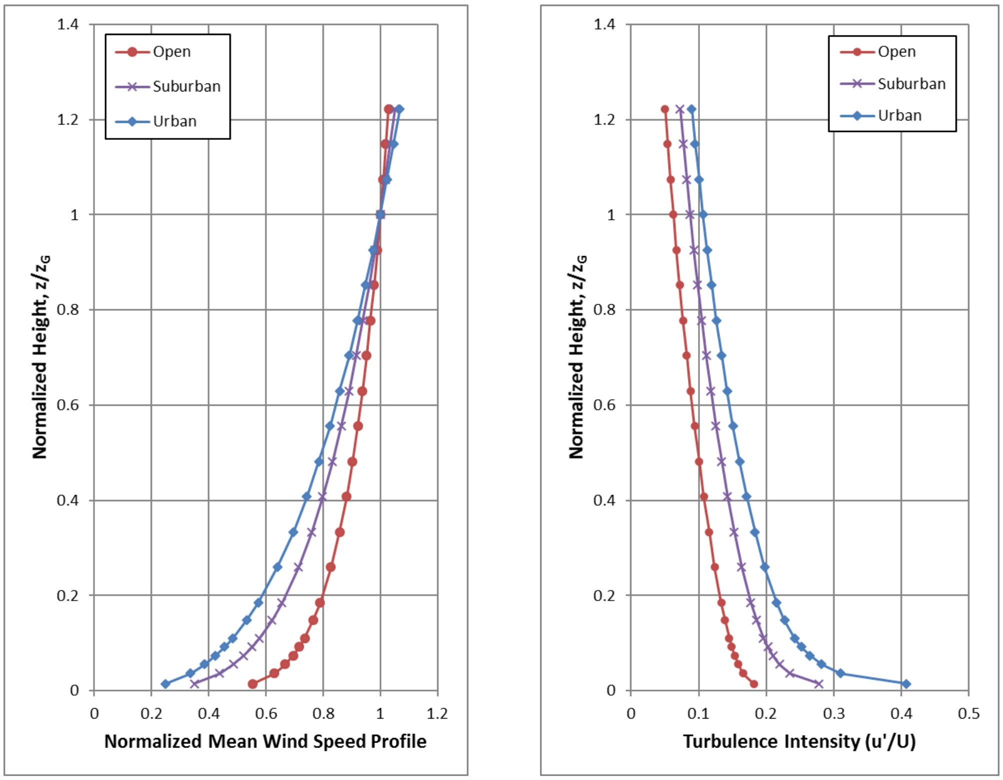

FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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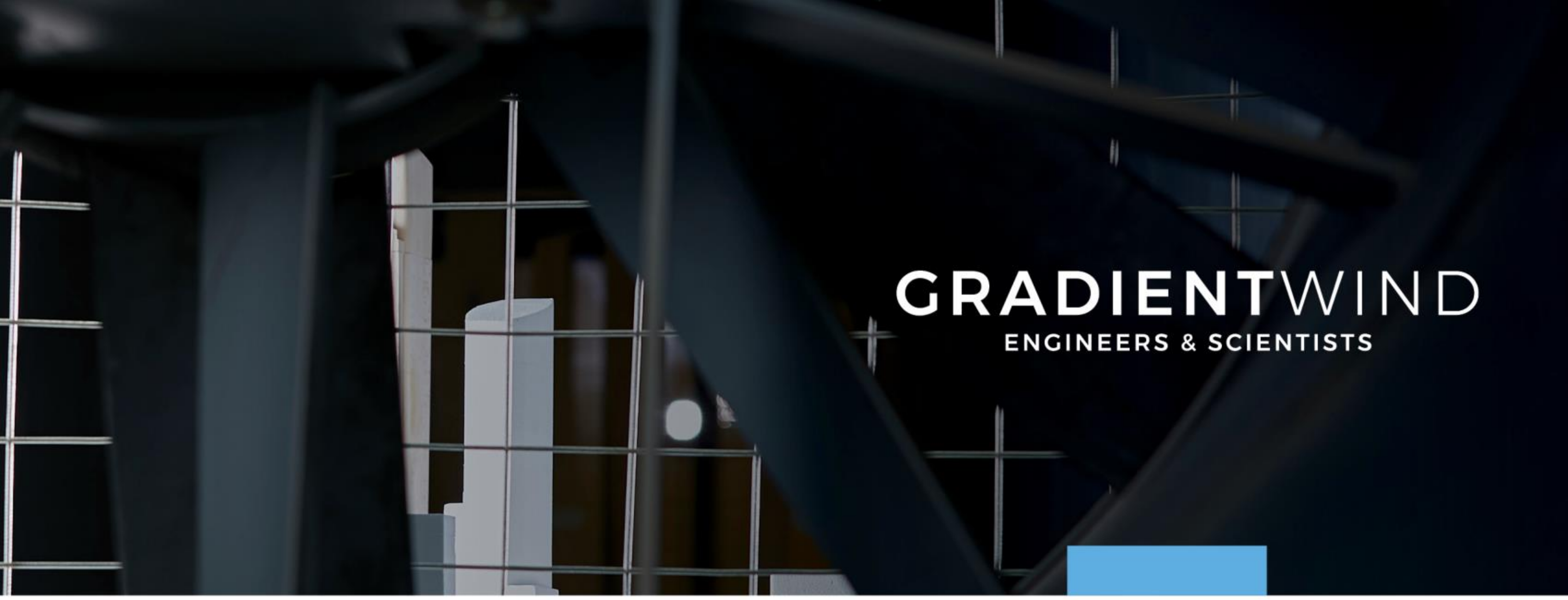

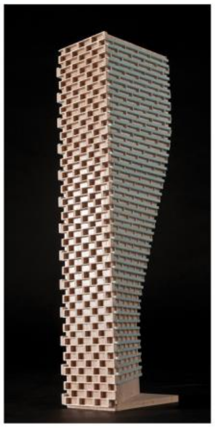

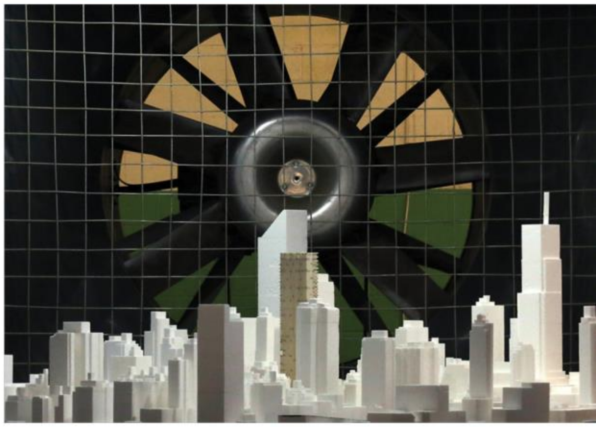

APPENDIX D

PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

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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 D1. 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:

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

$$P_N\,(>20) \quad = \quad \Sigma_\theta P\,\{>20/(U_N/Ug)\}$$

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.

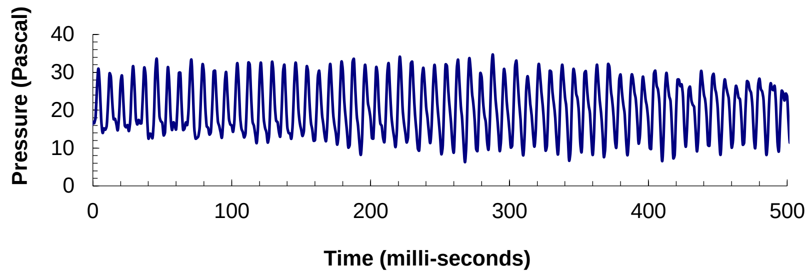

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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