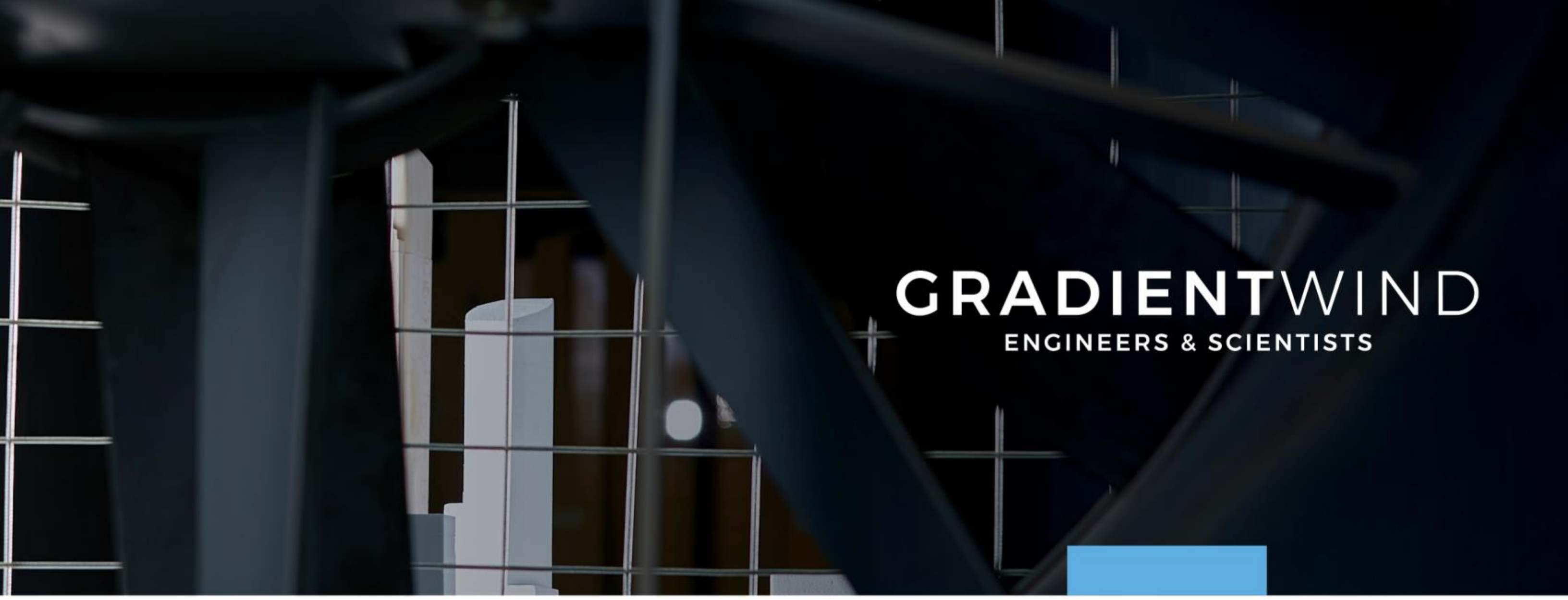
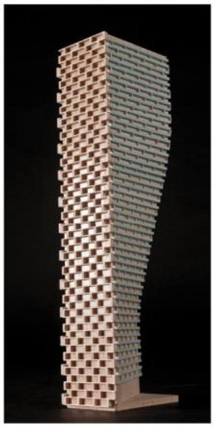
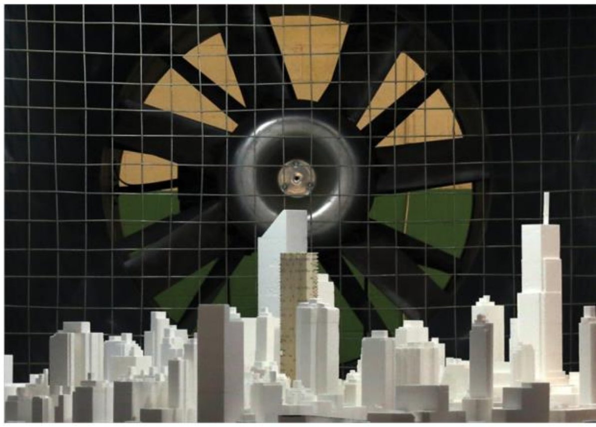


PEDESTRIAN LEVEL WIND STUDY

The Queensway &
Fordhouse Boulevard
Etobicoke, Ontario

REPORT: GW21-060-WTPLW





November 27, 2024

PREPARED FOR
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EXECUTIVE SUMMARY

This report describes a wind tunnel pedestrian level wind study undertaken to assess wind conditions for a proposed multi-building development located at 1543-1551 The Queensway and 66 & 76 Fordhouse Boulevard in Etobicoke, Ontario. Two configurations were studied: (i) *existing scenario*, including all approved, surrounding developments and without the proposed development, and (ii) *proposed scenario* 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, laneways, parking spaces, landscaped spaces, outdoor amenities, parks, and building access points. Wind comfort is also evaluated over the various elevated amenity terraces on Towers A, B, C, and D. 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 Hariri Pontarini Architects in October 2024, surrounding street layouts, as well as existing and approved future building massing information, and recent site imagery.

A complete summary of the predicted wind conditions is provided in Section 5 of this report and is also illustrated in Figures 2A through 4D, as well as Tables A1-A3 and B1-B4 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Etobicoke, we conclude that future wind conditions over many grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Mitigation is described in Section 5.2 for the proposed park to the east and for several sidewalk areas and access points between the various buildings. Additionally, mitigation is recommended, as outlined in Section 5.2, for outdoor amenity terraces across each building, to ensure wind conditions are suitable for sitting or more sedentary activities during the summer months.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site will experience wind conditions that are considered unsafe

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1. INTRODUCTION

This report describes a wind tunnel pedestrian level wind (PLW) study undertaken to assess wind conditions a proposed multi-building development located at 1543-1551 The Queensway and 66 & 76 Fordhouse Boulevard in Etobicoke, Ontario. Two configurations were studied: (i) *existing scenario*, including all approved, surrounding developments and without the proposed development, and (ii) *proposed scenario* with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, architectural drawings provided by Hariri Pontarini Architects in October 2024, 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 wind tunnel pedestrian wind study is the proposed multi-building development located at 1543-1551 The Queensway and 66 & 76 Fordhouse Boulevard in Etobicoke, Ontario. The study site is on a parcel of land bound by The Queensway to the north, Algie Avenue to the east, Fordhouse Boulevard to the south, and a new street referred to as “Street C” to the west. The study site spans the whole length of Algie Avenue and is further bound to the east by detached low-rise buildings fronting Algie Avenue.

The development comprises four buildings spanning from The Queensway to Fordhouse Boulevard, labelled Building A (30-storeys), Building B (35-storeys), Building C (40-storeys), and Building D (45-storeys) from north to south. The buildings are divided by new laneways “Street A” and “Street B”, in addition to a landscaped walkway between Buildings B and C, and a mid-block connection and park space along the east elevation of the site.

At grade, Building A comprises mixed-use space with a residential entrance along the north elevation fronting The Queensway and outdoor daycare space to the southeast. The podium includes setbacks with outdoor amenities and private terraces at Levels 4, 8, and 9 before meeting the typical tower floorplate. Buildings B, C and D comprise primarily residential space, with residential entrances along their west elevations. The nominally rectangular podiums of Buildings B and C include setbacks with outdoor amenities, green roofs, and private terraces at Levels 2, 7, and 8, while the nominally square podium of Building D includes setbacks with outdoor amenities at Level 2 and Level 6. Loading space and 2 Levels of underground parking for each building is accessed via the Street A and Street B laneways. All towers are completed with a mechanical penthouse.

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 buildings and surface parking in each direction, with the Gardiner Expressway running east-west approximately 20 metres to the south. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) comprise low-rise suburban and commercial exposure in all directions, with isolated clusters of high-rise buildings to the far north, east, and southwest.

Grade-level areas investigated include sidewalks, laneways, parking spaces, landscaped spaces, outdoor amenities, parks, and building access points. Wind comfort is also evaluated over the various elevated amenity terraces on Towers A, B, C, and D. Figures 1A and 1B illustrates the *existing* and *proposed* study sites and surrounding context, respectively, 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 Toronto wind climate and synthesis of wind tunnel data with industry-accepted guidelines[1]. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort and safety guidelines.

[1] Pedestrian Level Wind Study Terms of Reference Guide, 2022

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 6 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 136 sensor locations on the scale model in Gradient Wind's wind tunnel. Of these 136 sensors, 116 were located at grade and the remaining 20 sensors were located over various outdoor amenity terraces. Wind speed measurements were performed for each of the 136 sensors for 36 wind directions at 10° intervals. Figures 1A and 1B illustrates the *existing* and *proposed* study sites and surrounding context, respectively, while sensor locations used to investigate wind conditions are illustrated in Figures 2A through 4D.

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

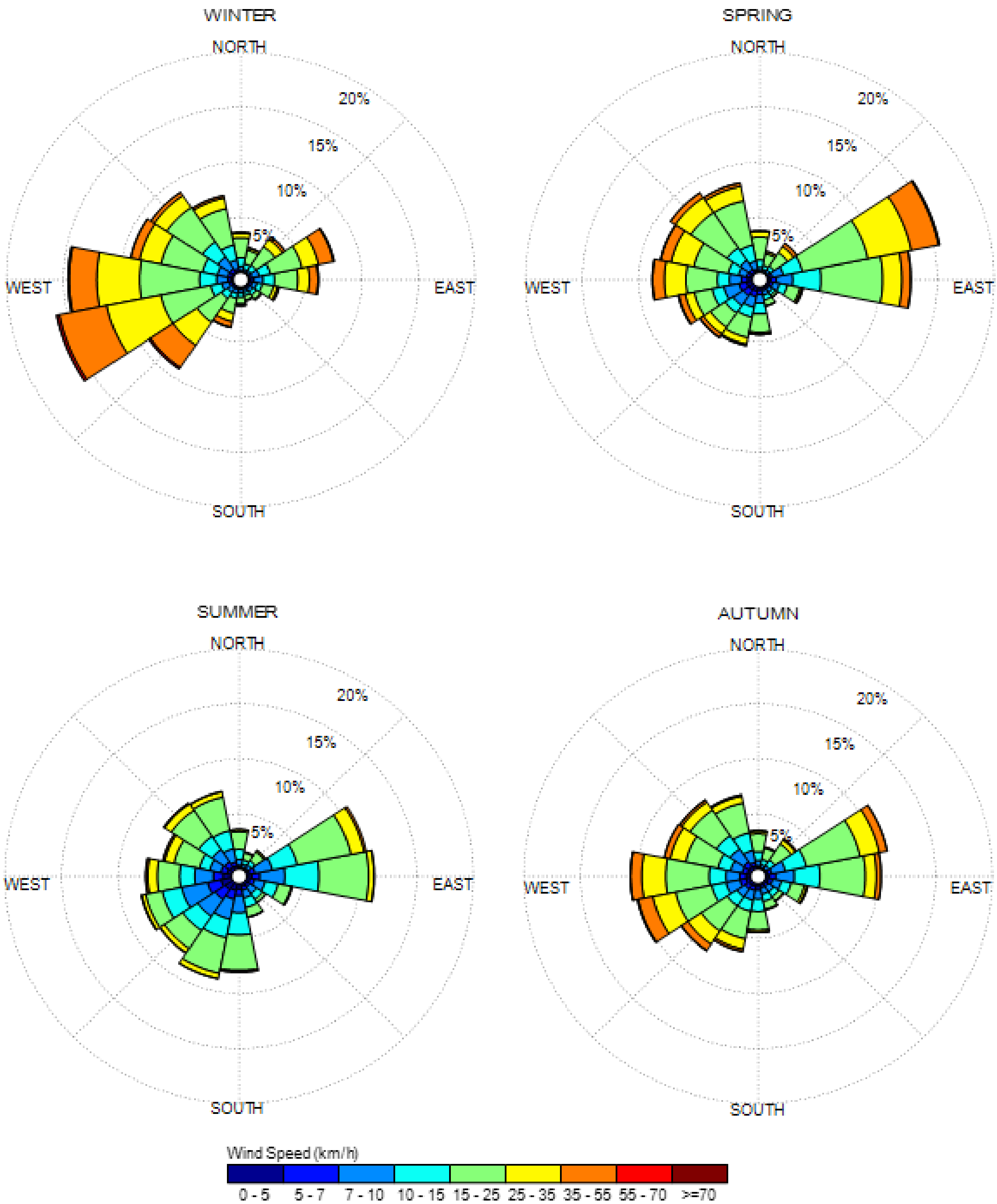
C and D provide greater detail of the theory behind wind speed measurements. Wind tunnel measurements for this project, conducted in Gradient Wind's wind tunnel facility, meet or exceed guidelines found in the National Building Code of Canada 2015 and of 'Wind Tunnel Studies of Buildings and Structures', ASCE Manual 7 Reports on Engineering Practice No 67.

4.3 Meteorological Data Analysis – Billy Bishop Toronto City Airport

A statistical model for winds in Toronto was developed from over 50 years of hourly meteorological wind data recorded at Billy Bishop Toronto City Airport. 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 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 Billy Bishop Toronto City Airport, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east-northeast. 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
BILLY BISHOP TORONTO CITY 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 Guest Equivalent Mean (GEM) wind speed ranges, which include (i) Sitting; (ii) Standing; (iii) Walking; and (iv) Uncomfortable. More specifically, the comfort classes and associated GEM wind speed ranges are summarized as follows:

(i) **Sitting** – A wind speed below 10 km/h (i.e. 0 – 10 km/h) would be considered acceptable for sedentary activities, including sitting.

(ii) **Standing** – A wind speed below 15 km/h (i.e. 10 km/h – 15 km/h) is acceptable for activities such as standing or leisurely strolling.

(iii) **Walking** – A wind speed below 20 km/h (i.e. 15 km/h – 20 km/h) is acceptable for walking or more vigorous activities.

(iv) **Uncomfortable** – A wind speed over 20 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.

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if wind speeds of 10 km/h were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting or more sedentary activities. Similarly, if 20 km/h at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As 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 below.

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

Tables A1 through A3 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the *existing* massing scenario. Similarly, Tables B1 through B4 in Appendix B provide the seasonal comfort predictions for under the *proposed* massing scenario. The tables indicate the 80% non-exceedance GEM wind speeds and corresponding comfort classifications as defined in Section 4.4. In other words, a 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 walking, as the 80% threshold value falls within the exceedance range of 15-20 km/h for walking. 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 study are summarized in Sections 5.1 and 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 4D. Conditions suitable for sitting are represented by the colour blue, while standing is represented by green, and walking by yellow. Conditions considered uncomfortable for walking are represented by the colour orange. For locations where the wind safety criterion is exceeded, the sensor is highlighted in red.

5.1 Pedestrian Comfort Suitability – *Existing Scenario*

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables A1-A3 in Appendix A and illustrated in Figures 2A through 2D, this section summarizes the significant findings of the PLW study with respect to the *existing scenario*, as follows:

1. All sidewalks, laneways, parking areas, and landscaped spaces within and surrounding the proposed development currently experience wind conditions suitable for walking or better throughout the year, with largely standing or better conditions present.
2. The nearby outdoor patio serving 1557 The Queensway (Sensor 24) is currently comfortable for sitting or more sedentary conditions throughout the warmer months.
3. All existing building entrances surrounding the proposed development are currently comfortable for standing or better throughout the year.
4. 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 are considered unsafe or too windy for walking.

5.2 Pedestrian Comfort Suitability – *Proposed Scenario*

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables B1-B4 in Appendix B and illustrated in Figures 3A through 4D, this section summarizes the significant findings of the PLW study with respect to the *proposed scenario*, as follows:

1. Most existing sidewalks, laneways, parking areas, and landscaped spaces within and surrounding the proposed development will continue to experience wind conditions suitable for walking or better throughout each seasonal period, which is acceptable for the intended uses of the spaces.

Exceptions include the sidewalk area at the northwest corner of Building A along The Queensway (Sensor 30), and along portions of Fordhouse Boulevard (Sensors 13, 14, 81, and 86).

Future internal sidewalks and pathways will also exceed the walking comfort threshold, specifically:

- along Street A between Building A and Building B (Sensors 43, 47-49, 62, 63, and 112);
- along the landscaped walkway between Building B and Building C (Sensors 54-57 and 69-76);
- along Street B between Building C and Building D (Sensors 64, 65, 88-92, 102, and 106-108); and
- at the southwest corner of Building D (Sensor 87);

The noted areas will intermittently experience conditions uncomfortable for walking during the three colder seasons.

Regarding the sidewalk along The Queensway at the northwest corner of Building A (Sensor 30), the walking exceedance is limited to the winter when pedestrian usage is reduced, therefore the noted conditions are considered acceptable without the need for mitigation.

For the uncomfortable conditions along Fordhouse Boulevard south of the study site (Sensors 13, 14, and 81) and at the southwest corner of Building D (Sensor 86 and 87) proposed plantings at the intersection of Street C and Fordhouse Boulevard are expected to improve conditions within any walkable areas. However, it is recommended that these plantings be largely coniferous or that wind screens be integrated within the landscape, to buffer west winds accelerating around the building corner.

To improve conditions along Street A between Building A and Building B (Sensors 43, 47-49, 62, 63, and 112), it is recommended to introduce a series of wind barriers staggered along the north elevation of Building B and offset from the southeast corner of Building A, towards the midblock connection, to buffer salient westerly winds. These barriers may take the form of wind screens or dense coniferous planters and should rise at least 2.0 metres at the time of installation.

For conditions in the region between Building B and Building C (Sensors 54-57 and 69-76), proposed plantings scattered throughout the landscaped area are expected to provide some relief, especially if the plantings will be coniferous, but further mitigation is recommended at the base of the Building B and Building C podiums. This mitigation could take the form of wind barriers staggered along the façades or an overhead canopy along the eastern portion of the south building B façade and north Building C façade.

Lastly, for the uncomfortable conditions along Street B between Building C and Building D (Sensors 64, 65, 88-92, 102, and 106-108), it is recommended to implement wind barriers scattered along potential walking areas, particularly towards the west. Alternatively, densification of the proposed plantings along the southwest corner of Building C and the northwest corner of Building D would be beneficial, especially if coniferous plantings are included.

The exact composition and configuration of recommended mitigation can be coordinated with the design team at a later date as the landscape plan progresses.

2. Most primary entrances serving the site will experience wind conditions suitable for standing throughout the year, which is appropriate. Limited exceptions include:

    - the northeast entrance to the daycare space in Building A (Sensor 34);
    - the northwest residential entrance to Building A (Sensor 46);
    - the southwest entrance to the indoor amenity space in Building C (Sensor 65); and
    - various townhouse entrances throughout (Sensors 49, 54-56, 63, 71, 73, and 75).

    The noted areas will intermittently experience walking or uncomfortable conditions during the three colder seasons. The townhouse entrances are currently recessed within the building façade, therefore additional mitigation is not necessary to achieve standing conditions. Additionally, the built-in recession at the daycare entrance (Sensor 34) is expected to improve the isolated walking conditions in the winter months to acceptable levels.

    The mitigation recommended for the areas between the buildings in Section 5.2.1 is expected to also improve conditions at the noted amenity entrance (Sensor 65), but it is further recommended to either install flanking vertical wind barriers and a canopy overhead or to recess the entrance within the façade. Alternatively, sliding or revolving doors may be considered. Similar mitigation provided for the Building A residential entrance is recommended to remove the standing exceedance in the winter.

3. Most secondary building access points (including stairwell exits and vehicle access points) will experience wind conditions suitable for walking or better throughout the year, which is appropriate. Exceptions include:

   - the loading and below-grade parking entrances to Building A (Sensor 43), Building B (Sensor 62), Building C (Sensor 64), and Building D (Sensor 88);
   - the pet wash entrance at the northwest corner of Building C (Sensor 70);
   - the stairwell, pet wash, and bicycle parking access to Building B (Sensors 56, 57 & 63);
   - the bicycle parking access to Building C (Sensor 108);
   - the Canada Post access to Building D (Sensor 88); and
   - The bicycle parking access to Building D (Sensor 90).

   The noted access points intermittently experience uncomfortable for walking conditions throughout the three colder seasons. However, the mitigation recommended for the adjacent sidewalks in Section 5.2.1 above is expected to improve wind speeds at these access points to within acceptable walking levels, with no additional mitigation needed.

4. The proposed outdoor daycare area at the southeast corner of Building A (Sensors 40-42) is expected to be comfortable for a mix of sitting and standing throughout each seasonal period, with largely sitting conditions during the summer and autumn, which is acceptable.

5. The grade-level outdoor amenity at the southwest corner of Building C (Sensor 104 and 105) will be comfortable for a mix of sitting and standing throughout the spring, summer and autumn, which is acceptable.

6. The park dedication at the southeast corner of the site (Sensors 79, 80, and 91-94) will experience conditions ranging from sitting to walking throughout the warmer months, with windier conditions measured towards the north and south extents. Notably, conditions at the north edge (Sensors 91 and 92) become uncomfortable for walking during the winter. It is recommended to add clusters of

vertical wind screens or coniferous plantings offset from the northwest and southwest corners of Building D in addition to wind barriers directly west of any seating areas to improve conditions to acceptable levels. It may also be necessary to provide pergolas or canopies overhead of designated seating areas.

7. The nearby outdoor patio serving 1557 The Queensway (Sensor 24) will remain comfortable for sitting or more sedentary conditions throughout the warmer months, which is acceptable.

8. All existing building entrances surrounding the proposed development will remain comfortable for standing or better throughout the year.

9. Concerning Building A terrace amenities, the Level 4 terrace (Sensor 121) will be comfortable for sitting throughout the year, with no mitigation needed.

   The Level 8 terrace (Sensors 117-120) will be suitable for primarily standing throughout the summer, with walking and uncomfortable conditions present towards the east end (Sensors 118-120) during the shoulder seasons. To improve conditions, it is recommended to raise the perimeter guard 1.8 metres above the walking surface and install a canopy or pergola above seating areas to deflect downwash flows.

10. For Building B, the Level 2 terrace (Sensors 122 and 123) will be comfortable for sitting during the summer, without the need for mitigation.

    The Level 7 terrace (Sensors 124-126) will be suitable for standing or walking during the summer, transitioning to include uncomfortable conditions during the spring and autumn. To ensure conditions are comfortable for sitting or more sedentary activities across the terrace, it is recommended to increase the west terrace perimeter guard to 2.0-metres above the walking surface, and install a canopy along the south elevation of the tower, to deflect downwash flows.

11. The Level 7 terrace of Building C (Sensors 127-129) will be suitable for largely standing throughout the summer, with sitting conditions towards the west end (Sensor 127), and standing, walking, and marginally uncomfortable conditions towards the east end (Sensors 128 and 129). To ensure sitting conditions, it is recommended to provide staggered vertical wind barriers along the terrace, particularly east and west of designated seating areas.

It is notable that the Building C Level 2 terrace was not tested during this study, as it was not indicated as an amenity on the plans used for modeling. However, it is expected to experience a mix of standing or walking conditions during the summer, with the potential for uncomfortable conditions during the spring and autumn. It is recommended to raise the west perimeter guard to 2.0 metre above the walking surface and provide canopies or pergolas overhead of designated seating areas, particularly along the base of the tower.

12. For Building D, the Level 2 terrace (Sensor 132-134) will be comfortable for sitting or standing during the summer, with the windier conditions occurring along the north portion. To improve conditions, it is recommended to raise the north perimeter guard to 1.8 metres above the walking surface and provide canopies or pergolas overhead of designated seating areas.

    Concerning the Level 7 terrace, the northwest portion (Sensors 130 and 131) will be suitable for standing during the summer, and the southeast portion (Sensors 135 and 136) will experience a mix of sitting and walking conditions during the summer. To improve conditions, it is recommended to raise the north perimeter guard of the northwest portion, and the east perimeter guard of the southeast portion, to 2.0 metres above the walking surface. It is further recommended to provide canopies or pergolas along the base of the tower over the northwest portion.

13. Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site will 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 multi-building development located at 1543-1551 The Queensway and 66 & 76 Fordhouse Boulevard in Etobicoke, 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 of this report and is also illustrated in Figures 2A through 4D, as well as Tables A1-A3 and B1-B4 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Etobicoke, we conclude that the future wind conditions over many grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis, with mitigation recommended in Section 5.2 for the proposed park to the east and for several sidewalk areas and building access points between the various buildings. Additionally, mitigation is recommended, as outlined in Section 5.2, for outdoor amenity terraces across each building, to ensure wind conditions are suitable for sitting or more sedentary activities during the summer months.

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no areas over the study site will experience wind conditions that are 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.

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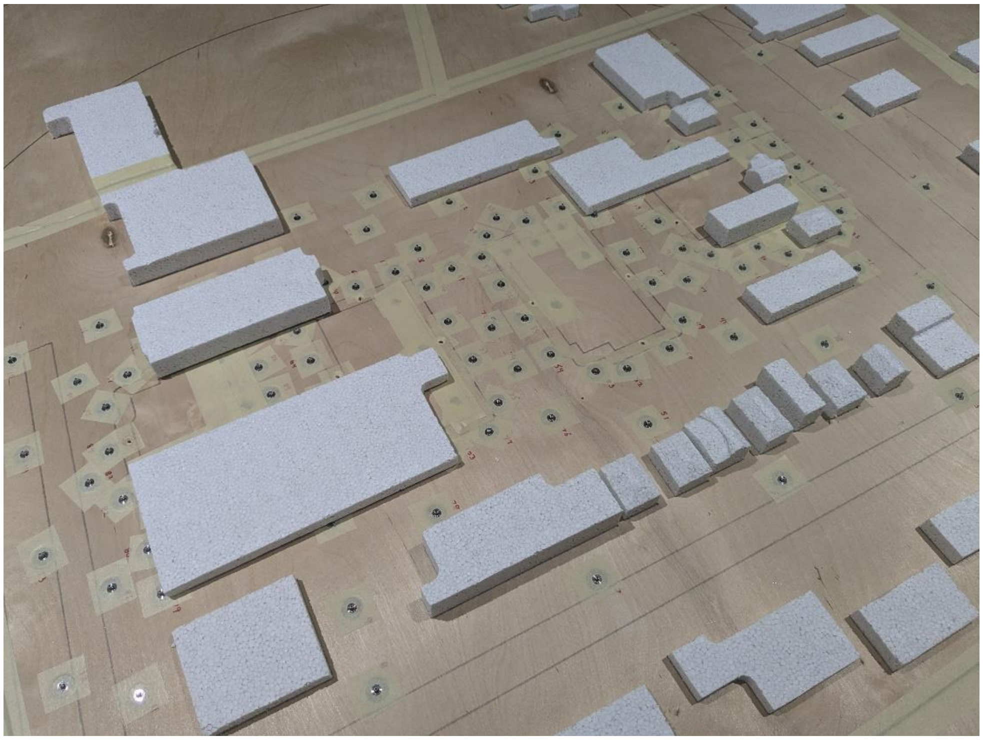
Junior Wind Scientist

Angelina Gomes, B.Eng., EIT,
Wind Scientist

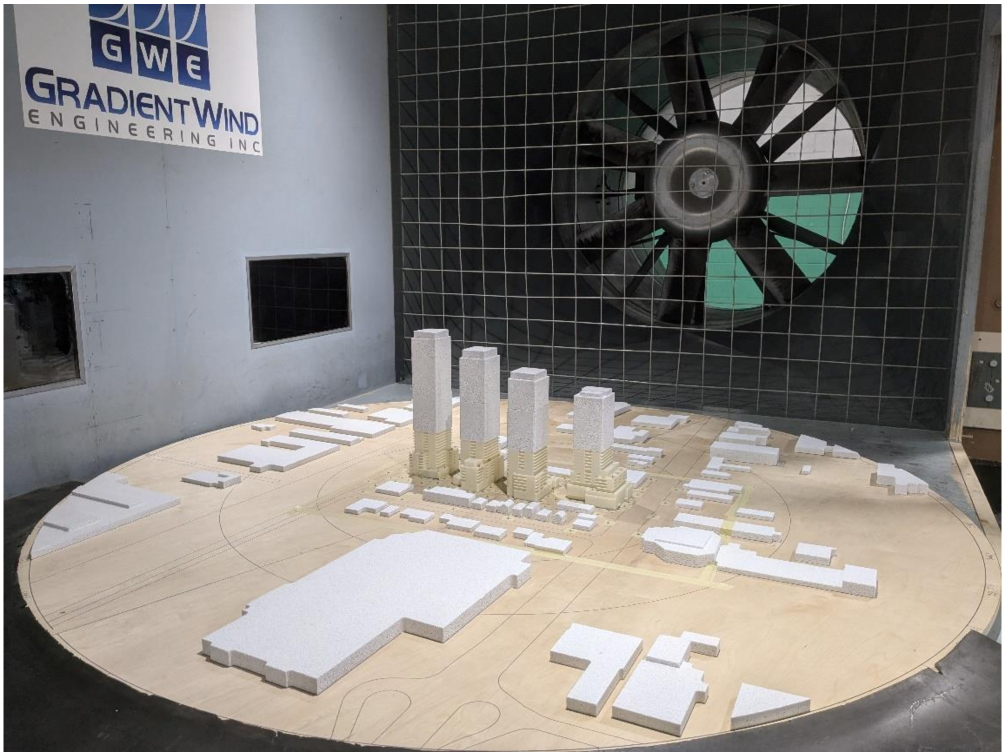
Andrew Sliasas, M.A.Sc., P.Eng.,
Principal

GW21-060-WTPLW

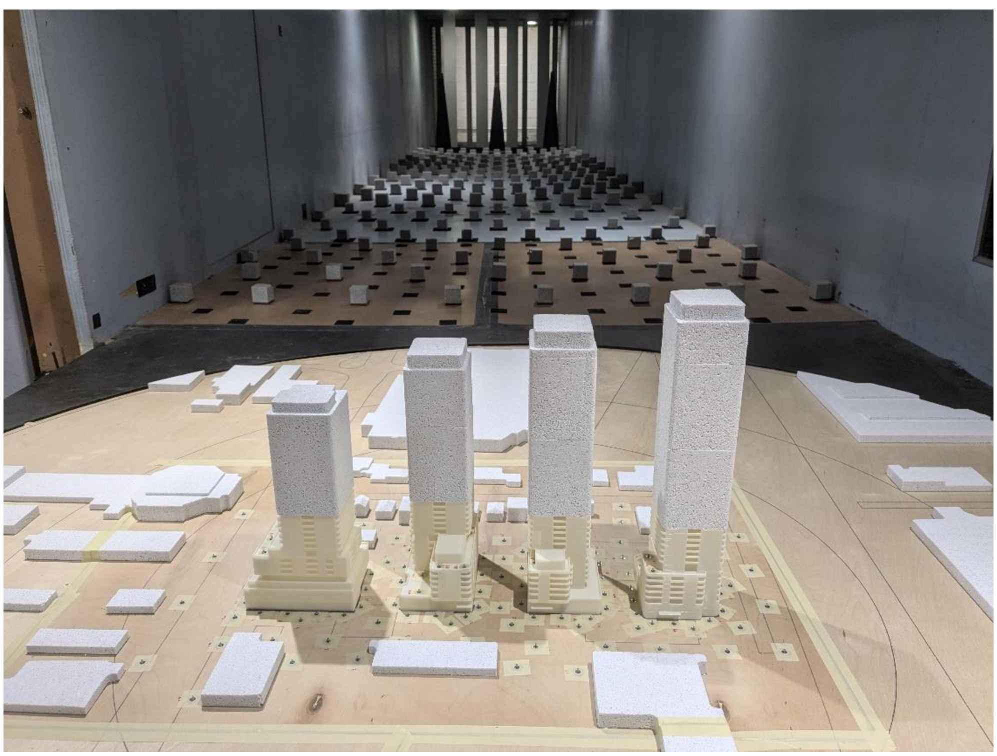


PHOTOGRAPH 1: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING NORTHWEST

PHOTOGRAPH 2: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING SOUTHEAST

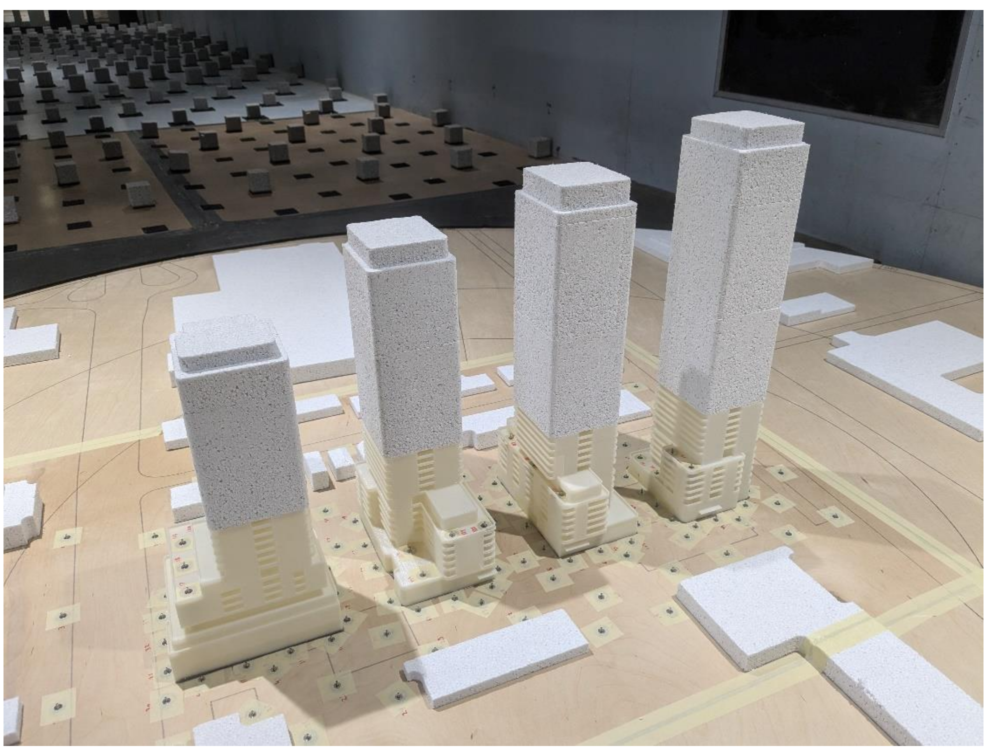


PHOTOGRAPH 3: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND



PHOTOGRAPH 4: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING UPWIND

PHOTOGRAPH 5: CLOSE-UP VIEW OF PROPOSED STUDY MODEL LOOKING NORTHWEST



PHOTOGRAPH 6: CLOSE-UP VIEW OF PROPOSED STUDY MODEL LOOKING SOUTHEAST

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ENGINEERS & SCIENTISTS

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PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2500 (APPROX.)
DRAWING NO.	GW21-060-PLW-1A
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 1A: EXISTING SITE PLAN AND SURROUNDING CONTEXT

GRADIENTWIND ENGINEERS & SCIENTISTS	PROJECT THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1B: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	SCALE 1:2500 (APPROX.)	DRAWING NO. GW21-060-PLW-1B	
	DATE NOVEMBER 18, 2024	DRAWN BY C.E.	

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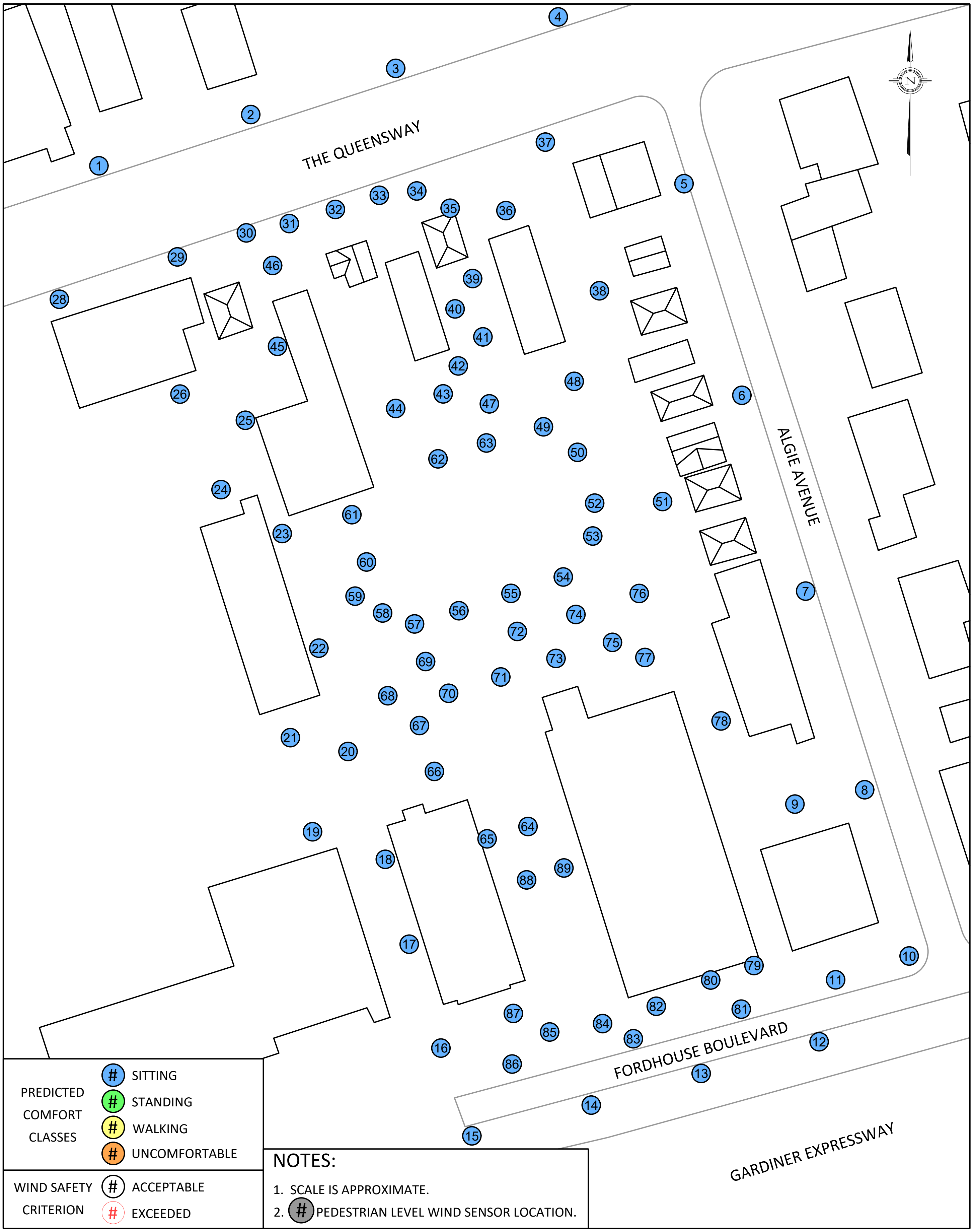
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2A: SPRING EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE	1:1400 (APPROX.)	DRAWING NO. GW21-060-PLW-2A	
DATE	NOVEMBER 18, 2024	DRAWN BY C.E.	



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PROJECT: THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 2B: SUMMER EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS	
SCALE: 1:1400 (APPROX.)	DRAWING NO.: GW21-060-PLW-2B		
DATE: NOVEMBER 18, 2024	DRAWN BY: C.E.		

PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

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

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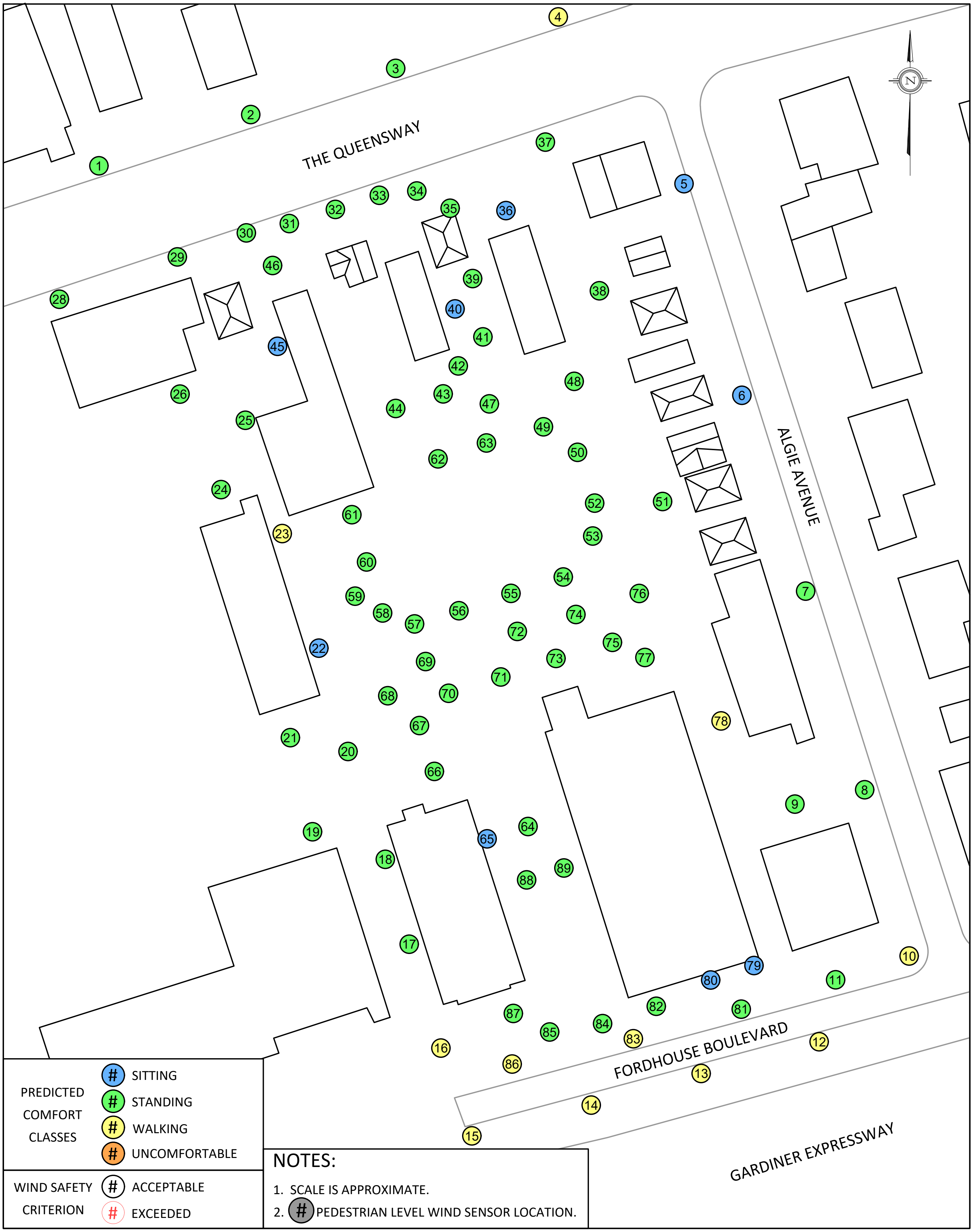
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1400 (APPROX.)
DRAWING NO.	GW21-060-PLW-2C
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 2C: AUTUMN EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



NOTES:

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

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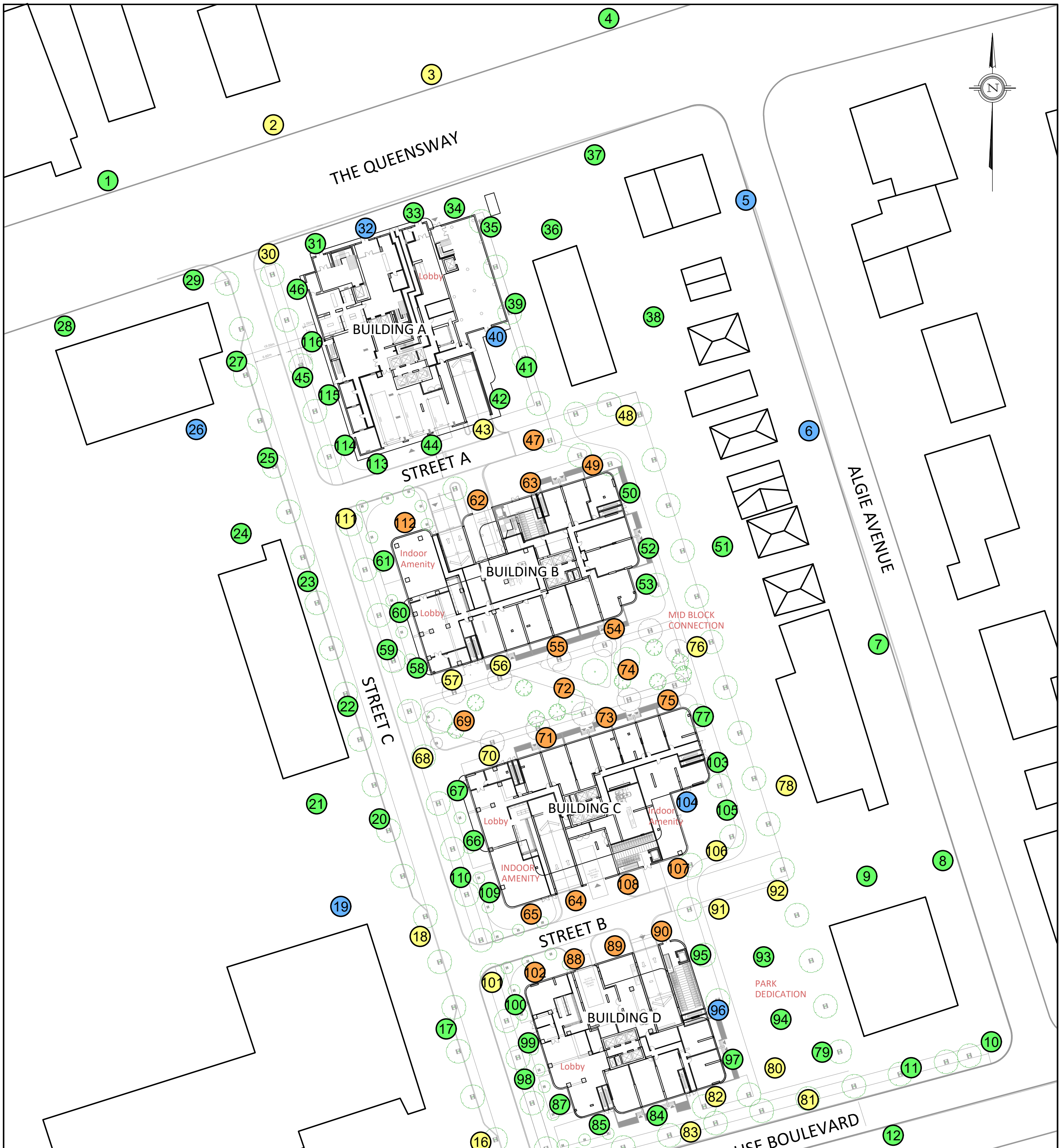
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1400 (APPROX.)
DRAWING NO.	GW21-060-PLW-2D
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 2D: WINTER EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES

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

WIND SAFETY CRITERION

- \# ACCEPTABLE
- \# EXCEEDED

NOTES:

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

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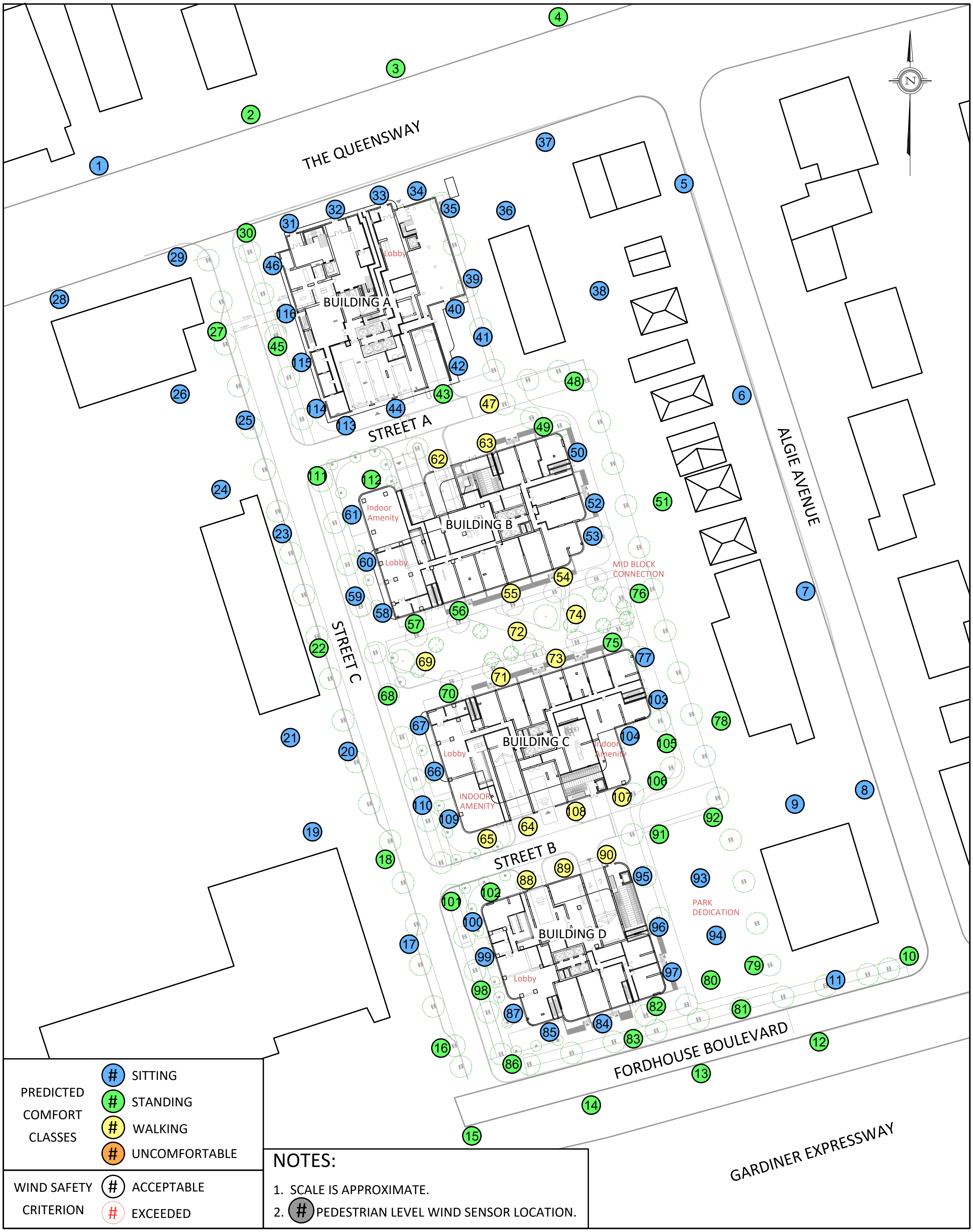
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1400 (APPROX.)
DRAWING NO.	GW21-060-PLW-3A
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3A: SPRING PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



NOTES:

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

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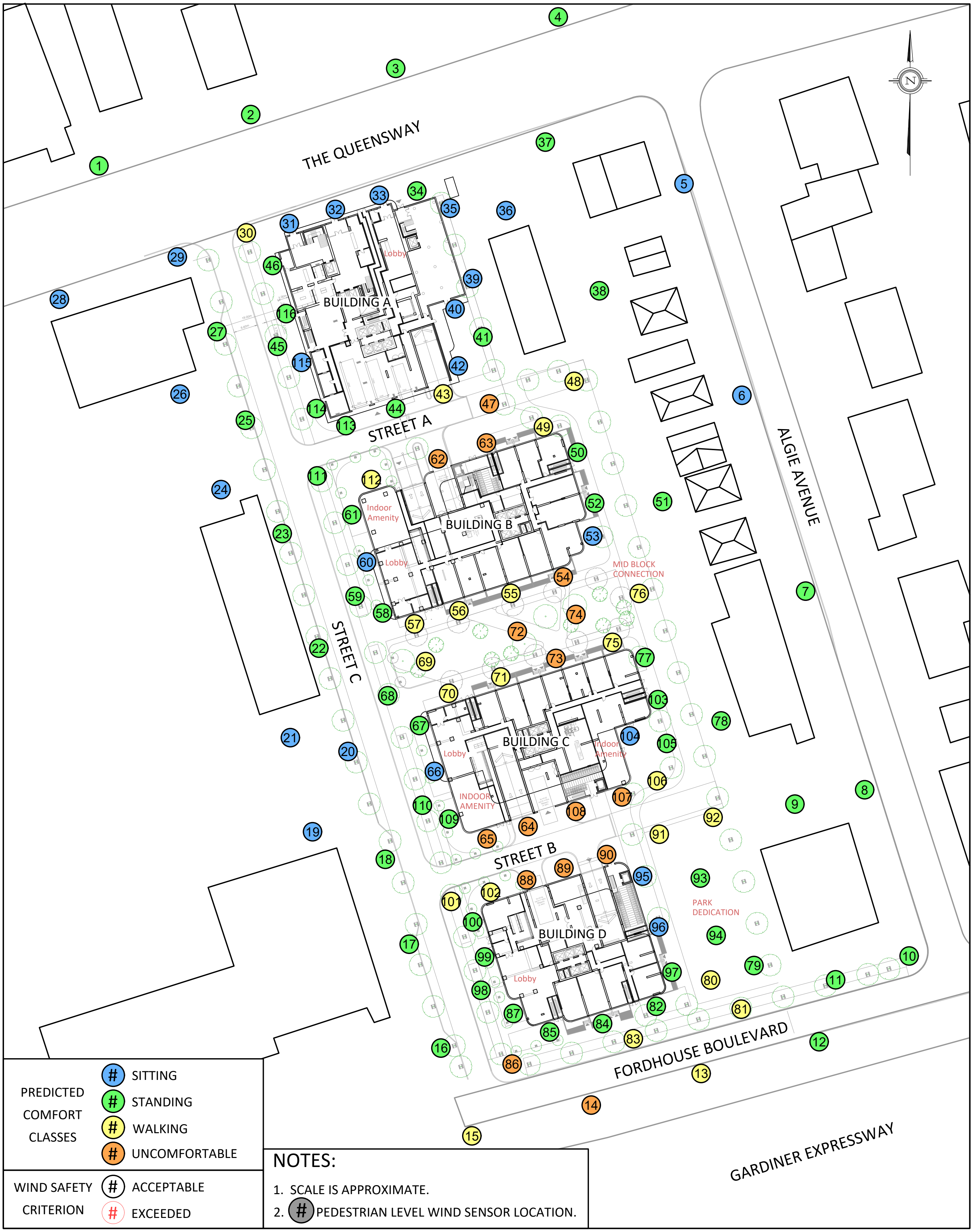
PROJECT: THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 3B: SUMMER PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1400 (APPROX.)	DRAWING NO.: GW21-060-PLW-3B	
DATE: NOVEMBER 18, 2024	DRAWN BY: C.E.	



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

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

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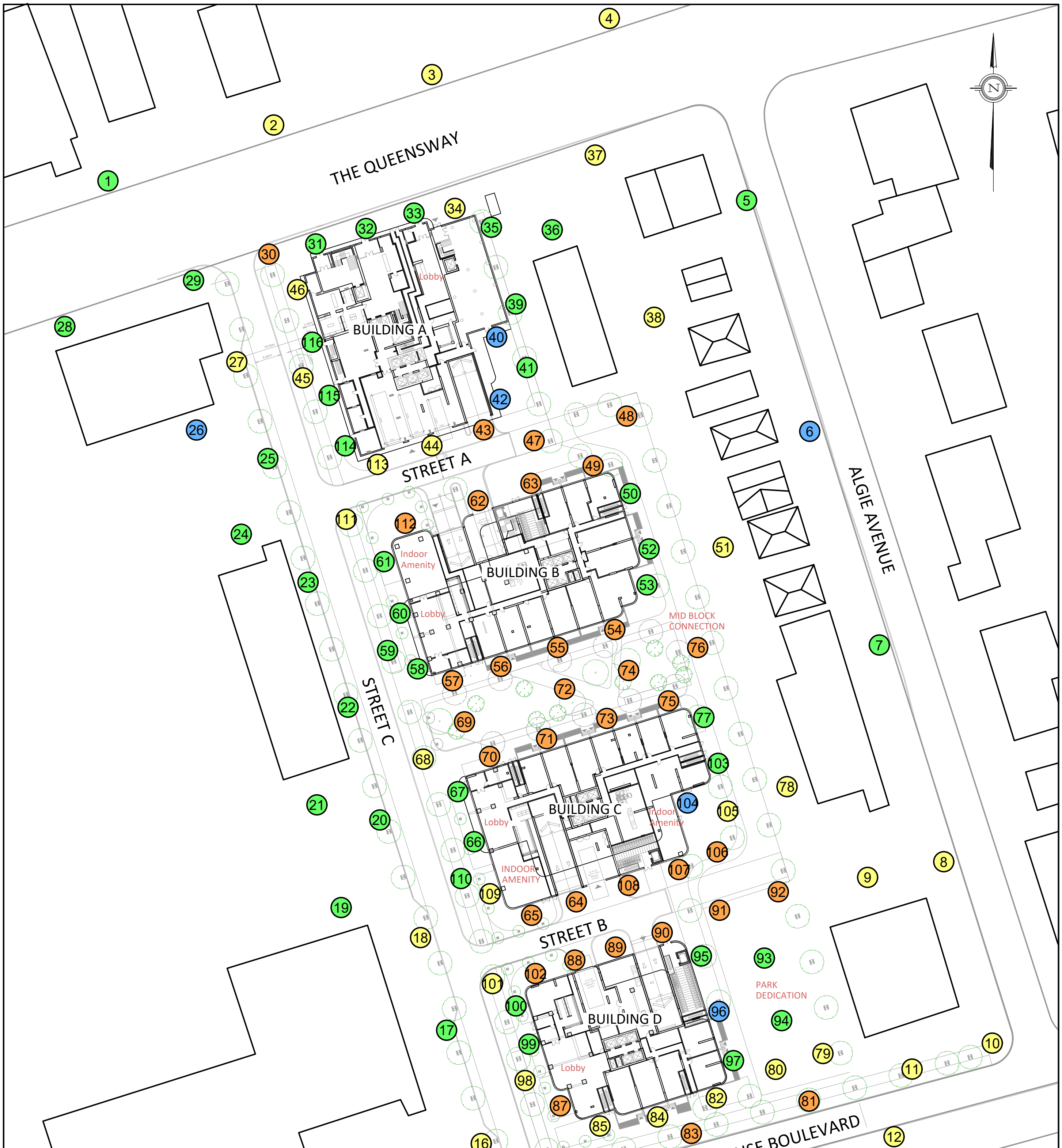
PROJECT: THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 3C: AUTUMN PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:1400 (APPROX.)	DRAWING NO.: GW21-060-PLW-3C	
DATE: NOVEMBER 18, 2024	DRAWN BY: C.E.	



PREDICTED COMFORT CLASSES
- # SITTING
- # STANDING
- # WALKING
- # UNCOMFORTABLE

WIND SAFETY CRITERION
- # ACCEPTABLE
- # EXCEEDED

NOTES:

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

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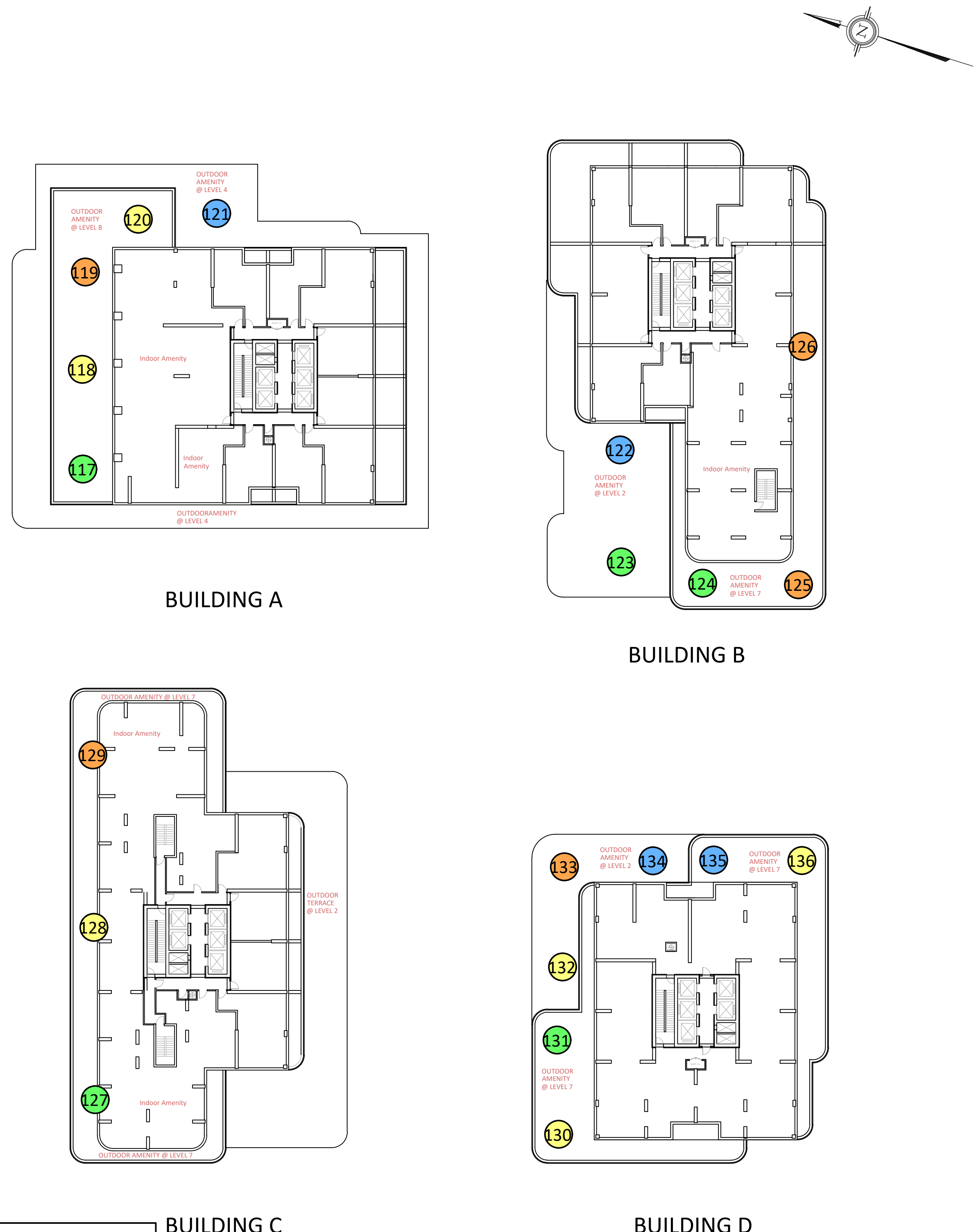
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1400 (APPROX.)
DRAWING NO.	GW21-060-PLW-3D
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3D: WINTER PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES	#	SITTING
	#	STANDING
	#	WALKING
	#	UNCOMFORTABLE
WIND SAFETY CRITERION	#	ACCEPTABLE
	#	EXCEEDED

NOTES:

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

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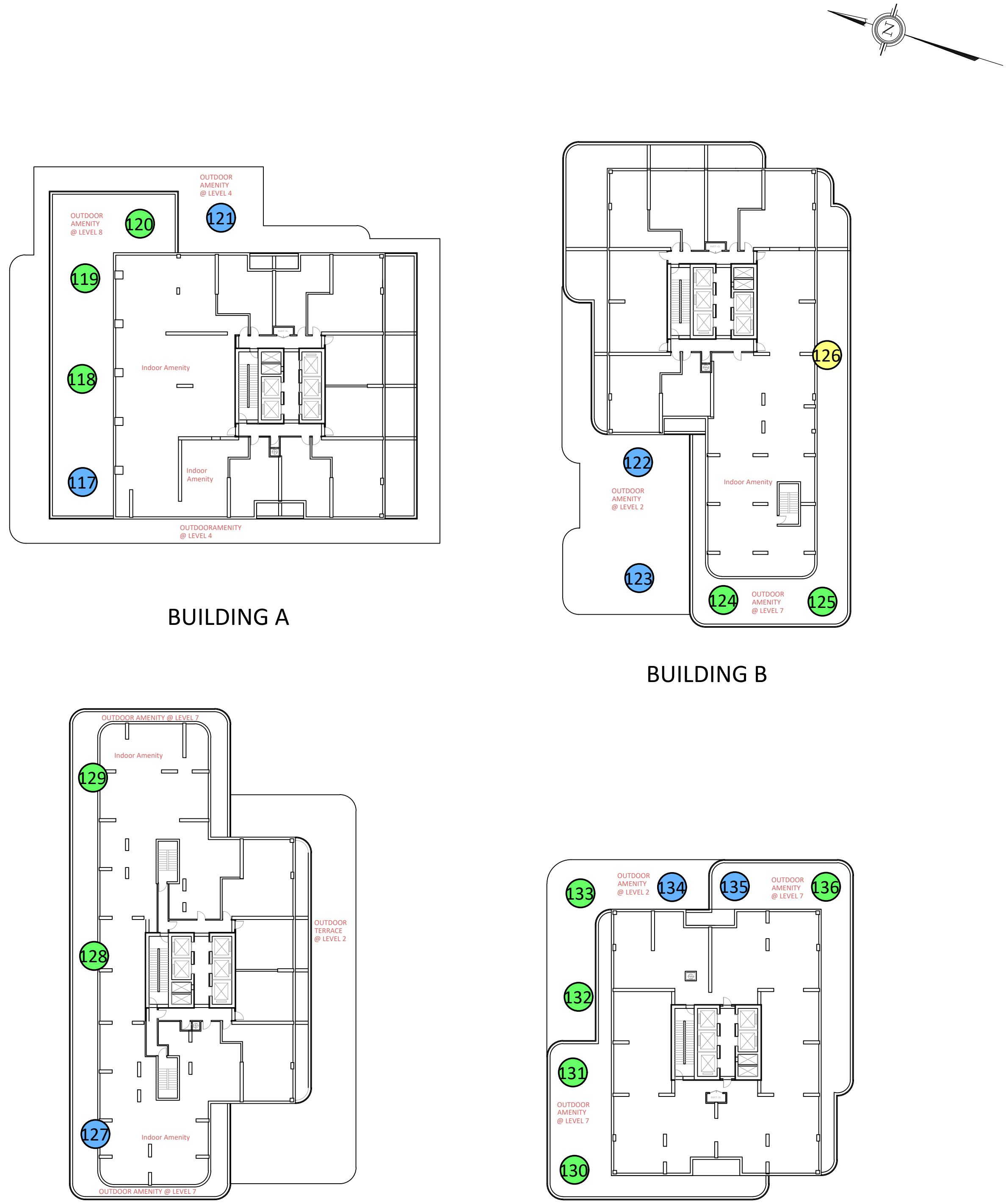
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:800 (APPROX.)
DRAWING NO.	GW21-060-PLW-4A
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4A: SPRING OUTDOOR AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS



BUILDING C

BUILDING D

PREDICTED COMFORT CLASSES	
#	SITTING
#	STANDING
#	WALKING
#	UNCOMFORTABLE

WIND SAFETY CRITERION	
#	ACCEPTABLE
#	EXCEEDED

NOTES:

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

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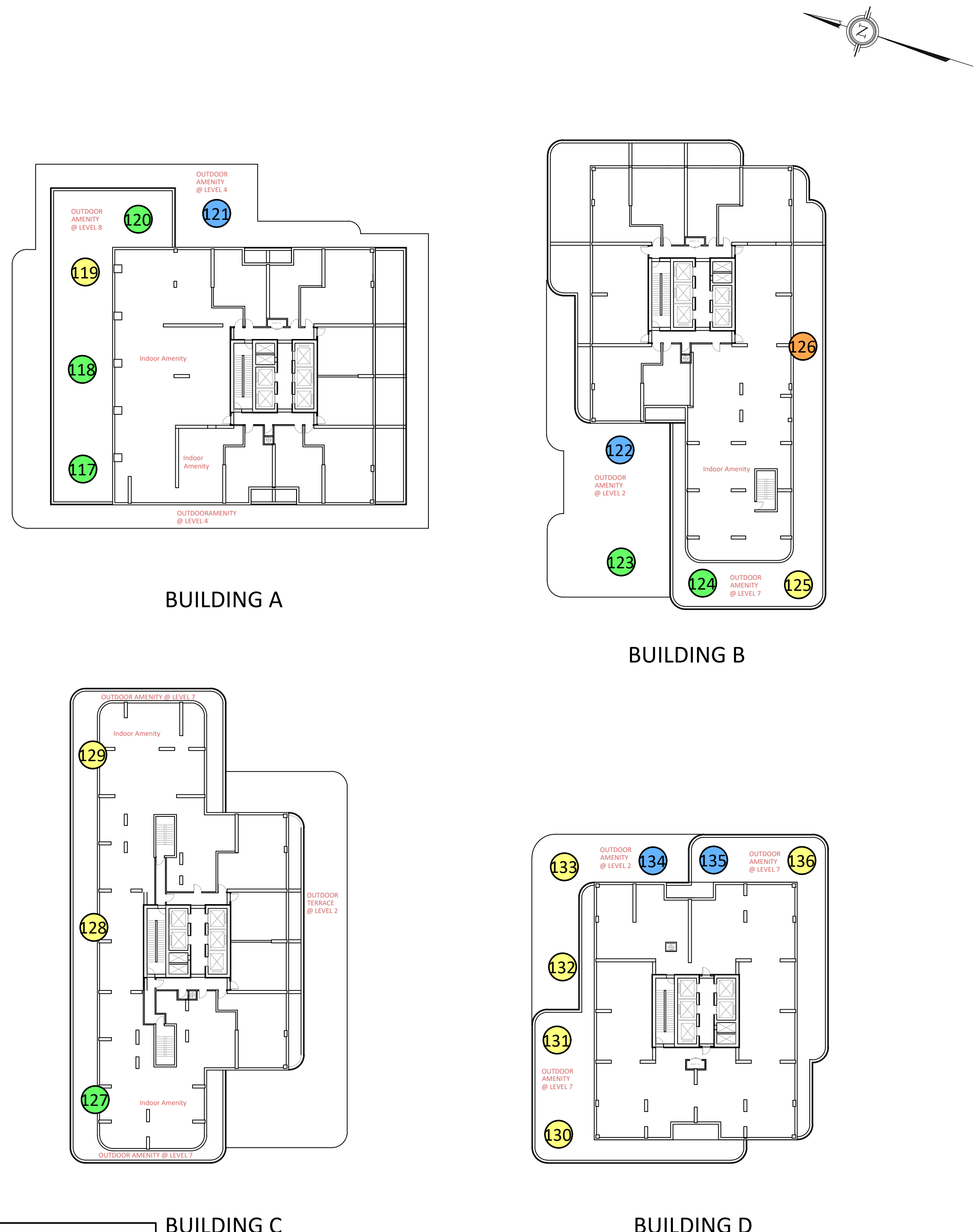
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:800 (APPROX.)
DRAWING NO.	GW21-060-PLW-4B
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4B: SUMMER OUTDOOR AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES	
#	SITTING
#	STANDING
#	WALKING
#	UNCOMFORTABLE

WIND SAFETY CRITERION	
#	ACCEPTABLE
#	EXCEEDED

NOTES:

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

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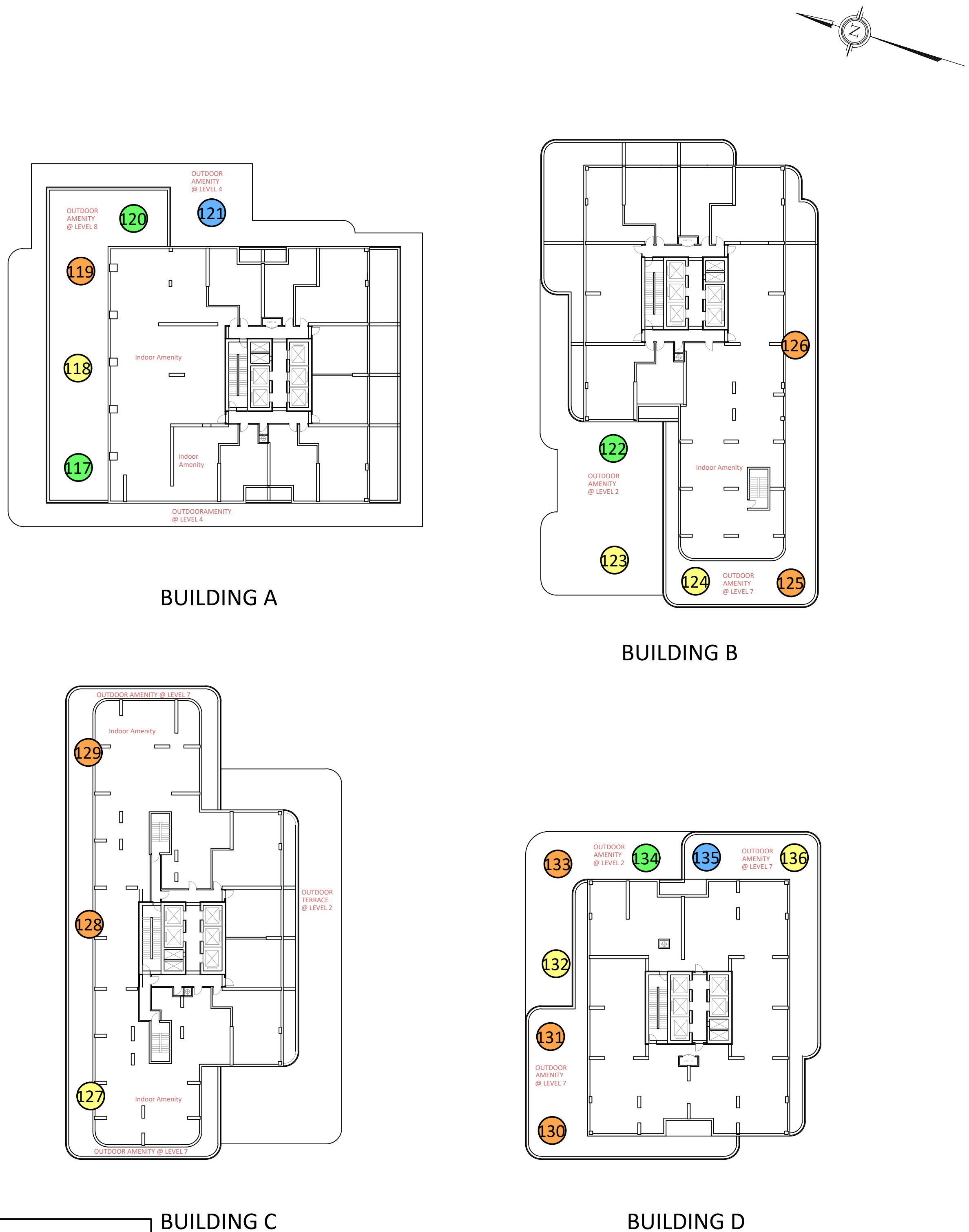
PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY	
SCALE	1:800 (APPROX.)	DRAWING NO. GW21-060-PLW-4C
DATE	NOVEMBER 18, 2024	DRAWN BY C.E.

DESCRIPTION
FIGURE 4C: AUTUMN
OUTDOOR AMENITY PLAN
PEDESTRIAN COMFORT PREDICTIONS



PREDICTED COMFORT CLASSES	#	SITTING
	#	STANDING
	#	WALKING
	#	UNCOMFORTABLE
WIND SAFETY CRITERION	#	ACCEPTABLE
	#	EXCEEDED

NOTES:

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

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PROJECT	THE QUEENSWAY & FORDHOUSE BLVD, ETOBICOKE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:800 (APPROX.)
DRAWING NO.	GW21-060-PLW-4D
DATE	NOVEMBER 18, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4D: WINTER OUTDOOR AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS

APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A3 (EXISTING SCENARIO)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A1: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

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	10.5	Standing	7.9	Sitting	9.6	Sitting	12.0	Standing	37.7	Safe
2	10.3	Standing	7.5	Sitting	9.8	Sitting	12.9	Standing	40.3	Safe
3	11.6	Standing	8.1	Sitting	10.5	Standing	13.7	Standing	42.2	Safe
4	12.5	Standing	8.5	Sitting	11.3	Standing	15.3	Walking	46.0	Safe
5	9.2	Sitting	6.8	Sitting	8.1	Sitting	9.7	Sitting	34.2	Safe
6	8.5	Sitting	6.5	Sitting	7.5	Sitting	8.9	Sitting	32.0	Safe
7	10.5	Standing	8.1	Sitting	9.5	Sitting	11.5	Standing	39.8	Safe
8	11.0	Standing	7.7	Sitting	9.9	Sitting	12.8	Standing	39.5	Safe
9	10.3	Standing	6.8	Sitting	9.3	Sitting	12.4	Standing	41.4	Safe
10	13.0	Standing	9.6	Sitting	12.1	Standing	15.7	Walking	45.7	Safe
11	11.1	Standing	8.1	Sitting	10.7	Standing	14.5	Standing	44.6	Safe
12	14.1	Standing	9.9	Sitting	13.0	Standing	17.5	Walking	49.2	Safe
13	13.4	Standing	9.6	Sitting	12.5	Standing	16.8	Walking	47.8	Safe
14	13.7	Standing	10.0	Sitting	12.7	Standing	17.0	Walking	48.8	Safe
15	13.5	Standing	9.6	Sitting	12.5	Standing	16.6	Walking	47.8	Safe
16	12.2	Standing	8.9	Sitting	11.5	Standing	15.6	Walking	45.3	Safe
17	11.6	Standing	9.0	Sitting	10.7	Standing	13.3	Standing	43.6	Safe
18	11.9	Standing	8.7	Sitting	10.6	Standing	13.1	Standing	43.1	Safe
19	10.8	Standing	7.2	Sitting	10.2	Standing	13.8	Standing	42.3	Safe
20	11.5	Standing	8.2	Sitting	10.8	Standing	14.5	Standing	43.5	Safe
21	11.0	Standing	7.9	Sitting	10.6	Standing	14.7	Standing	44.8	Safe
22	8.7	Sitting	6.4	Sitting	7.3	Sitting	8.7	Sitting	30.4	Safe
23	11.1	Standing	7.6	Sitting	10.7	Standing	15.1	Walking	49.3	Safe
24	8.8	Sitting	6.1	Sitting	8.2	Sitting	11.5	Standing	36.2	Safe
25	8.5	Sitting	6.4	Sitting	8.4	Sitting	11.1	Standing	35.4	Safe
26	8.8	Sitting	6.3	Sitting	8.2	Sitting	10.8	Standing	35.1	Safe
28	10.1	Standing	7.0	Sitting	9.3	Sitting	12.7	Standing	40.3	Safe
29	10.2	Standing	6.9	Sitting	9.4	Sitting	12.7	Standing	39.4	Safe
30	11.7	Standing	7.7	Sitting	10.3	Standing	13.3	Standing	39.8	Safe
31	11.1	Standing	7.7	Sitting	9.8	Sitting	12.4	Standing	37.5	Safe
32	10.5	Standing	7.1	Sitting	9.6	Sitting	12.9	Standing	39.1	Safe
33	11.8	Standing	7.9	Sitting	10.5	Standing	13.9	Standing	40.6	Safe
34	9.6	Sitting	6.3	Sitting	8.6	Sitting	11.5	Standing	37.2	Safe
35	11.3	Standing	7.0	Sitting	9.7	Sitting	12.8	Standing	46.2	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

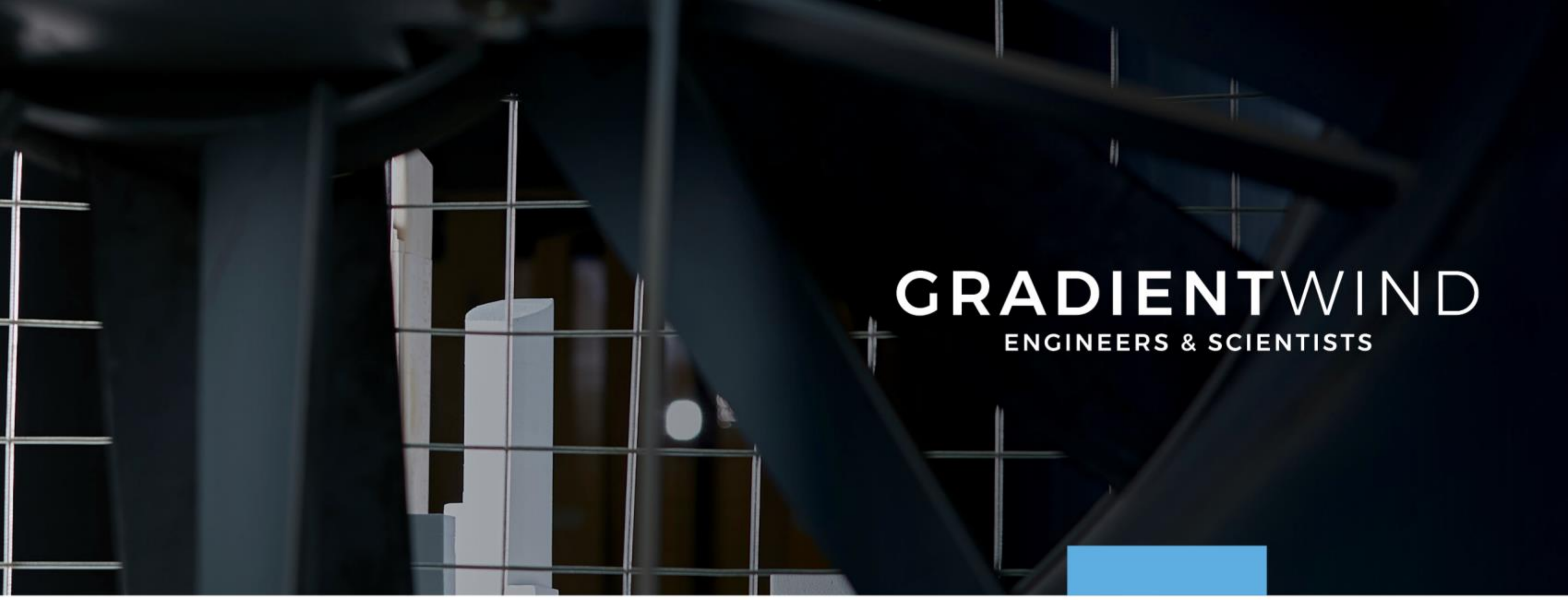
TABLE A2: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

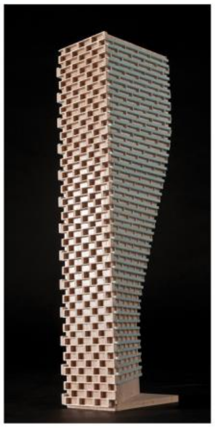
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	8.9	Sitting	6.1	Sitting	7.8	Sitting	9.6	Sitting	32.8	Safe
37	11.3	Standing	8.3	Sitting	10.6	Standing	13.4	Standing	40.6	Safe
38	9.3	Sitting	7.3	Sitting	8.4	Sitting	10.1	Standing	33.1	Safe
39	9.4	Sitting	6.8	Sitting	8.5	Sitting	10.7	Standing	34.8	Safe
40	8.3	Sitting	6.1	Sitting	7.3	Sitting	8.6	Sitting	31.3	Safe
41	9.6	Sitting	7.5	Sitting	8.8	Sitting	10.5	Standing	35.0	Safe
42	9.3	Sitting	7.1	Sitting	8.6	Sitting	10.5	Standing	34.8	Safe
43	9.2	Sitting	6.8	Sitting	8.9	Sitting	12.0	Standing	39.8	Safe
44	10.1	Standing	7.1	Sitting	8.7	Sitting	10.9	Standing	36.5	Safe
45	8.4	Sitting	5.9	Sitting	7.6	Sitting	9.8	Sitting	31.0	Safe
46	9.8	Sitting	6.7	Sitting	8.5	Sitting	10.7	Standing	35.8	Safe
47	9.5	Sitting	7.3	Sitting	8.9	Sitting	11.1	Standing	35.1	Safe
48	9.0	Sitting	7.1	Sitting	8.8	Sitting	11.1	Standing	35.7	Safe
49	9.5	Sitting	7.3	Sitting	8.9	Sitting	11.1	Standing	34.9	Safe
50	9.1	Sitting	6.8	Sitting	8.6	Sitting	11.2	Standing	35.4	Safe
51	8.5	Sitting	6.3	Sitting	8.0	Sitting	10.3	Standing	33.3	Safe
52	10.0	Sitting	7.4	Sitting	9.6	Sitting	13.0	Standing	39.2	Safe
53	10.2	Standing	7.5	Sitting	9.8	Sitting	13.2	Standing	40.0	Safe
54	11.2	Standing	7.9	Sitting	10.7	Standing	14.3	Standing	43.3	Safe
55	11.2	Standing	8.5	Sitting	10.7	Standing	13.8	Standing	42.8	Safe
56	11.8	Standing	8.7	Sitting	11.1	Standing	14.2	Standing	43.8	Safe
57	12.0	Standing	8.9	Sitting	10.9	Standing	13.3	Standing	41.9	Safe
58	10.9	Standing	8.0	Sitting	9.9	Sitting	12.1	Standing	39.4	Safe
59	10.5	Standing	7.7	Sitting	9.2	Sitting	11.0	Standing	38.5	Safe
60	9.9	Sitting	7.4	Sitting	9.1	Sitting	11.4	Standing	39.8	Safe
61	8.9	Sitting	6.4	Sitting	8.2	Sitting	10.7	Standing	34.7	Safe
62	10.1	Standing	7.8	Sitting	9.3	Sitting	11.1	Standing	36.1	Safe
63	9.7	Sitting	7.5	Sitting	9.4	Sitting	12.0	Standing	37.8	Safe
64	12.6	Standing	9.1	Sitting	11.0	Standing	13.5	Standing	43.8	Safe
65	9.0	Sitting	6.4	Sitting	7.6	Sitting	9.2	Sitting	32.7	Safe
66	11.3	Standing	7.5	Sitting	10.2	Standing	14.0	Standing	43.8	Safe
67	12.2	Standing	8.4	Sitting	11.2	Standing	14.8	Standing	43.5	Safe
68	11.8	Standing	8.4	Sitting	10.9	Standing	14.0	Standing	42.7	Safe
69	12.2	Standing	8.7	Sitting	11.1	Standing	14.4	Standing	43.3	Safe
70	11.9	Standing	8.4	Sitting	10.8	Standing	14.0	Standing	42.6	Safe

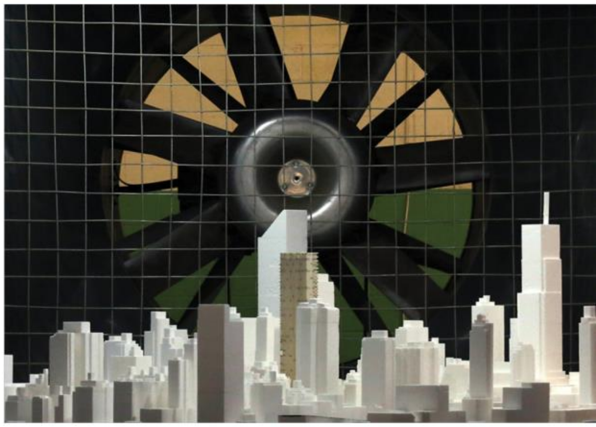
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A3: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

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	12.1	Standing	8.8	Sitting	11.3	Standing	14.8	Standing	44.0	Safe
72	10.5	Standing	7.8	Sitting	9.6	Sitting	12.1	Standing	40.1	Safe
73	11.5	Standing	7.9	Sitting	10.7	Standing	14.4	Standing	43.6	Safe
74	10.7	Standing	7.6	Sitting	10.0	Sitting	13.4	Standing	41.9	Safe
75	10.4	Standing	7.1	Sitting	9.5	Sitting	12.7	Standing	40.3	Safe
76	9.4	Sitting	6.7	Sitting	8.8	Sitting	11.5	Standing	37.8	Safe
77	10.3	Standing	7.0	Sitting	9.0	Sitting	11.4	Standing	38.0	Safe
78	13.7	Standing	9.5	Sitting	12.3	Standing	15.9	Walking	47.1	Safe
79	7.8	Sitting	6.2	Sitting	7.5	Sitting	9.3	Sitting	35.2	Safe
80	7.6	Sitting	5.7	Sitting	7.1	Sitting	8.7	Sitting	32.3	Safe
81	11.7	Standing	8.4	Sitting	11.0	Standing	14.8	Standing	45.4	Safe
82	9.4	Sitting	6.8	Sitting	8.9	Sitting	12.4	Standing	42.0	Safe
83	14.4	Standing	10.0	Sitting	13.3	Standing	17.9	Walking	49.1	Safe
84	12.8	Standing	9.4	Sitting	11.5	Standing	14.7	Standing	43.8	Safe
85	11.6	Standing	8.6	Sitting	10.9	Standing	14.3	Standing	43.7	Safe
86	12.1	Standing	8.6	Sitting	11.4	Standing	15.4	Walking	46.3	Safe
87	9.6	Sitting	7.3	Sitting	9.2	Sitting	12.1	Standing	40.7	Safe
88	11.1	Standing	7.9	Sitting	10.0	Sitting	12.6	Standing	43.7	Safe
89	11.5	Standing	8.6	Sitting	10.8	Standing	14.0	Standing	42.4	Safe







APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B4 (PROPOSED SCENARIO)

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B1: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

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	12.7	Standing	9.4	Sitting	11.7	Standing	14.6	Standing	55.1	Safe
2	15.8	Walking	11.5	Standing	15.0	Standing	20.0	Walking	60.1	Safe
3	16.1	Walking	10.7	Standing	14.8	Standing	19.8	Walking	60.9	Safe
4	14.5	Standing	10.1	Standing	13.4	Standing	18.6	Walking	56.0	Safe
5	9.6	Sitting	7.5	Sitting	8.8	Sitting	10.6	Standing	35.1	Safe
6	8.8	Sitting	6.8	Sitting	8.1	Sitting	9.7	Sitting	33.9	Safe
7	11.2	Standing	8.6	Sitting	10.4	Standing	12.6	Standing	43.4	Safe
8	12.8	Standing	8.6	Sitting	12.1	Standing	16.3	Walking	61.5	Safe
9	11.4	Standing	7.9	Sitting	12.4	Standing	18.9	Walking	68.6	Safe
10	13.9	Standing	10.6	Standing	13.2	Standing	16.5	Walking	53.0	Safe
11	11.0	Standing	8.4	Sitting	11.2	Standing	15.4	Walking	56.0	Safe
12	14.5	Standing	10.7	Standing	14.2	Standing	19.6	Walking	65.1	Safe
13	18.8	Walking	12.9	Standing	18.2	Walking	26.2	Uncomfortable	81.5	Safe
14	22.8	Uncomfortable	14.1	Standing	21.0	Uncomfortable	29.5	Uncomfortable	77.6	Safe
15	18.9	Walking	12.2	Standing	16.1	Walking	20.3	Uncomfortable	62.7	Safe
16	16.7	Walking	11.5	Standing	14.6	Standing	17.7	Walking	57.8	Safe
17	11.8	Standing	9.3	Sitting	10.7	Standing	12.8	Standing	43.3	Safe
18	16.7	Walking	11.6	Standing	13.6	Standing	15.2	Walking	54.7	Safe
19	10.0	Sitting	7.0	Sitting	8.6	Sitting	10.3	Standing	39.4	Safe
20	11.7	Standing	8.4	Sitting	9.8	Sitting	11.5	Standing	43.0	Safe
21	10.9	Standing	7.9	Sitting	9.4	Sitting	10.9	Standing	46.5	Safe
22	14.4	Standing	10.1	Standing	11.7	Standing	13.1	Standing	52.8	Safe
23	13.1	Standing	8.9	Sitting	10.6	Standing	12.4	Standing	46.9	Safe
24	12.3	Standing	8.5	Sitting	10.0	Sitting	11.1	Standing	51.4	Safe
25	12.9	Standing	8.8	Sitting	10.8	Standing	13.5	Standing	47.5	Safe
26	8.8	Sitting	6.2	Sitting	7.4	Sitting	8.8	Sitting	36.3	Safe
27	14.5	Standing	10.6	Standing	13.1	Standing	16.1	Walking	53.4	Safe
28	10.9	Standing	7.3	Sitting	9.4	Sitting	11.6	Standing	44.6	Safe
29	10.7	Standing	7.1	Sitting	8.8	Sitting	10.5	Standing	49.6	Safe
30	19.5	Walking	14.7	Standing	18.9	Walking	25.5	Uncomfortable	73.4	Safe
31	10.7	Standing	6.9	Sitting	9.6	Sitting	12.7	Standing	45.8	Safe
32	9.6	Sitting	6.1	Sitting	9.0	Sitting	13.0	Standing	47.3	Safe
33	10.3	Standing	6.5	Sitting	10.0	Sitting	15.0	Standing	52.9	Safe
34	13.1	Standing	7.6	Sitting	11.6	Standing	16.5	Walking	55.2	Safe
35	11.3	Standing	8.0	Sitting	9.3	Sitting	10.1	Standing	47.0	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B2: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

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	11.6	Standing	7.6	Sitting	9.8	Sitting	12.6	Standing	45.7	Safe
37	14.5	Standing	10.0	Sitting	13.4	Standing	18.3	Walking	57.6	Safe
38	12.8	Standing	9.8	Sitting	12.3	Standing	15.6	Walking	53.3	Safe
39	10.1	Standing	7.3	Sitting	8.8	Sitting	10.7	Standing	49.4	Safe
40	6.6	Sitting	4.7	Sitting	5.9	Sitting	7.5	Sitting	23.5	Safe
41	12.9	Standing	9.2	Sitting	10.1	Standing	11.5	Standing	51.3	Safe
42	11.6	Standing	7.9	Sitting	9.3	Sitting	9.9	Sitting	48.8	Safe
43	19.5	Walking	14.4	Standing	19.6	Walking	27.2	Uncomfortable	74.4	Safe
44	12.6	Standing	9.1	Sitting	12.5	Standing	17.7	Walking	53.6	Safe
45	13.0	Standing	10.2	Standing	12.1	Standing	15.1	Walking	51.1	Safe
46	10.7	Standing	9.3	Sitting	11.4	Standing	15.7	Walking	56.9	Safe
47	22.1	Uncomfortable	16.1	Walking	21.4	Uncomfortable	29.1	Uncomfortable	76.6	Safe
48	16.6	Walking	13.0	Standing	17.2	Walking	24.3	Uncomfortable	69.1	Safe
49	21.3	Uncomfortable	14.6	Standing	19.6	Walking	25.4	Uncomfortable	79.8	Safe
50	11.7	Standing	8.4	Sitting	10.1	Standing	11.9	Standing	58.0	Safe
51	13.8	Standing	10.5	Standing	13.5	Standing	17.6	Walking	57.2	Safe
52	11.6	Standing	7.9	Sitting	10.6	Standing	13.3	Standing	55.2	Safe
53	11.2	Standing	7.2	Sitting	9.3	Sitting	11.4	Standing	50.3	Safe
54	23.6	Uncomfortable	16.9	Walking	22.2	Uncomfortable	29.0	Uncomfortable	75.3	Safe
55	20.8	Uncomfortable	15.6	Walking	19.6	Walking	24.7	Uncomfortable	67.7	Safe
56	18.8	Walking	14.2	Standing	17.4	Walking	20.7	Uncomfortable	65.1	Safe
57	18.5	Walking	13.0	Standing	16.6	Walking	20.9	Uncomfortable	69.2	Safe
58	11.8	Standing	7.7	Sitting	10.6	Standing	14.2	Standing	56.7	Safe
59	12.2	Standing	8.4	Sitting	10.4	Standing	13.0	Standing	53.4	Safe
60	11.0	Standing	8.4	Sitting	9.5	Sitting	11.7	Standing	50.9	Safe
61	11.3	Standing	8.9	Sitting	11.0	Standing	14.0	Standing	47.6	Safe
62	26.4	Uncomfortable	17.7	Walking	23.5	Uncomfortable	30.2	Uncomfortable	77.8	Safe
63	22.0	Uncomfortable	15.5	Walking	20.4	Uncomfortable	27.5	Uncomfortable	72.6	Safe
64	23.9	Uncomfortable	17.6	Walking	22.3	Uncomfortable	29.4	Uncomfortable	72.2	Safe
65	22.1	Uncomfortable	15.9	Walking	20.9	Uncomfortable	28.2	Uncomfortable	75.0	Safe
66	10.7	Standing	7.9	Sitting	9.5	Sitting	11.5	Standing	50.1	Safe
67	10.8	Standing	8.9	Sitting	10.2	Standing	12.2	Standing	47.4	Safe
68	17.5	Walking	12.6	Standing	14.9	Standing	17.3	Walking	59.4	Safe
69	21.5	Uncomfortable	15.5	Walking	19.7	Walking	24.7	Uncomfortable	68.0	Safe
70	19.9	Walking	13.6	Standing	17.5	Walking	21.4	Uncomfortable	64.8	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

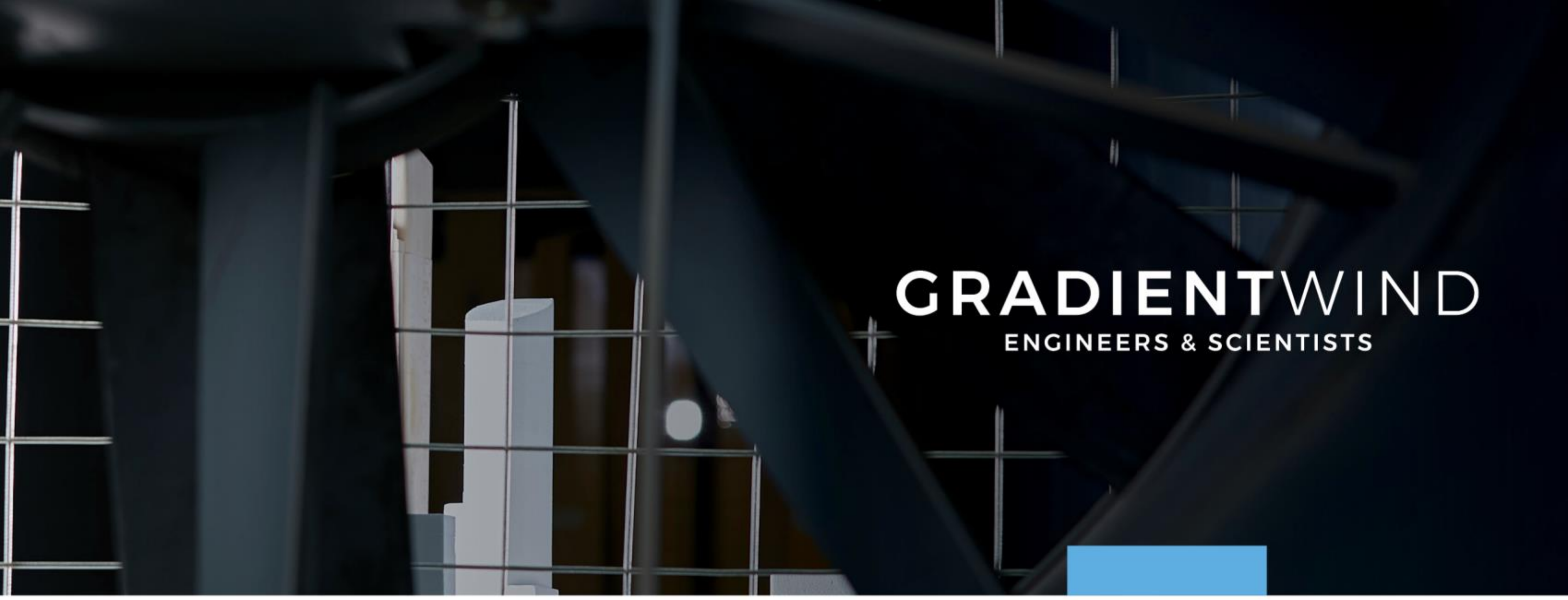
TABLE B3: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

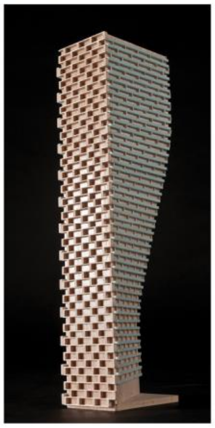
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
71	22.7	Uncomfortable	15.0	Standing	19.8	Walking	24.9	Uncomfortable	68.3	Safe
72	23.9	Uncomfortable	17.1	Walking	22.0	Uncomfortable	27.9	Uncomfortable	71.3	Safe
73	23.9	Uncomfortable	15.8	Walking	21.3	Uncomfortable	28.1	Uncomfortable	72.9	Safe
74	24.4	Uncomfortable	17.1	Walking	22.6	Uncomfortable	29.9	Uncomfortable	75.6	Safe
75	22.3	Uncomfortable	14.0	Standing	19.9	Walking	27.2	Uncomfortable	76.6	Safe
76	17.1	Walking	11.7	Standing	16.7	Walking	23.1	Uncomfortable	68.7	Safe
77	11.2	Standing	8.6	Sitting	10.1	Standing	11.7	Standing	52.2	Safe
78	15.4	Walking	11.1	Standing	14.7	Standing	19.0	Walking	67.5	Safe
79	13.5	Standing	10.7	Standing	12.9	Standing	16.1	Walking	59.7	Safe
80	16.3	Walking	12.7	Standing	15.2	Walking	18.4	Walking	65.1	Safe
81	15.6	Walking	12.1	Standing	15.3	Walking	20.4	Uncomfortable	70.1	Safe
82	16.3	Walking	12.3	Standing	15.0	Standing	18.9	Walking	76.4	Safe
83	18.3	Walking	12.7	Standing	17.8	Walking	25.0	Uncomfortable	82.8	Safe
84	14.5	Standing	9.9	Sitting	13.6	Standing	18.0	Walking	72.1	Safe
85	12.7	Standing	8.9	Sitting	11.9	Standing	16.1	Walking	74.5	Safe
86	23.1	Uncomfortable	14.6	Standing	20.6	Uncomfortable	27.6	Uncomfortable	73.6	Safe
87	14.2	Standing	9.0	Sitting	14.2	Standing	20.9	Uncomfortable	70.2	Safe
88	24.0	Uncomfortable	16.5	Walking	22.2	Uncomfortable	29.5	Uncomfortable	75.2	Safe
89	25.5	Uncomfortable	17.4	Walking	23.6	Uncomfortable	31.5	Uncomfortable	77.8	Safe
90	25.4	Uncomfortable	17.1	Walking	23.7	Uncomfortable	31.9	Uncomfortable	80.9	Safe
91	18.7	Walking	12.7	Standing	19.8	Walking	28.9	Uncomfortable	81.1	Safe
92	16.2	Walking	11.5	Standing	16.2	Walking	23.6	Uncomfortable	73.2	Safe
93	12.4	Standing	9.8	Sitting	11.8	Standing	14.6	Standing	50.9	Safe
94	12.0	Standing	9.7	Sitting	11.1	Standing	13.3	Standing	52.6	Safe
95	11.1	Standing	8.4	Sitting	10.0	Sitting	11.7	Standing	44.2	Safe
96	9.0	Sitting	6.9	Sitting	8.2	Sitting	10.0	Sitting	44.3	Safe
97	12.4	Standing	8.2	Sitting	10.3	Standing	12.3	Standing	51.5	Safe
98	14.7	Standing	10.7	Standing	13.9	Standing	18.2	Walking	60.5	Safe
99	12.7	Standing	9.7	Sitting	11.6	Standing	14.5	Standing	56.7	Safe
100	11.6	Standing	9.8	Sitting	11.2	Standing	13.1	Standing	49.4	Safe
101	17.6	Walking	12.8	Standing	15.1	Walking	17.3	Walking	61.6	Safe
102	20.8	Uncomfortable	14.8	Standing	19.8	Walking	26.7	Uncomfortable	89.5	Safe
103	10.9	Standing	8.7	Sitting	10.2	Standing	12.2	Standing	52.6	Safe
104	8.5	Sitting	6.2	Sitting	7.7	Sitting	9.7	Sitting	34.4	Safe
105	14.1	Standing	10.2	Standing	12.5	Standing	15.6	Walking	53.8	Safe

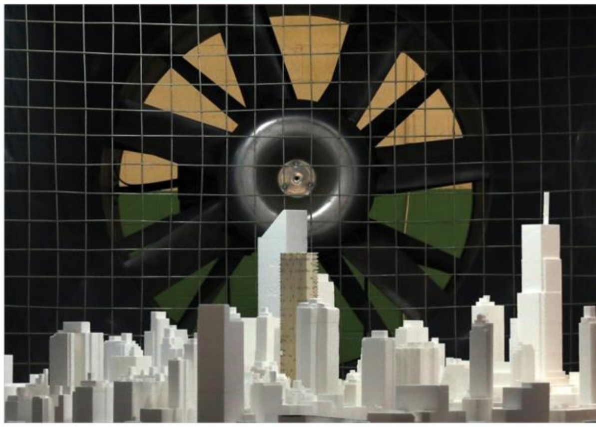
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE B4: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

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	18.2	Walking	12.9	Standing	17.9	Walking	23.8	Uncomfortable	73.4	Safe
107	22.7	Uncomfortable	15.4	Walking	21.3	Uncomfortable	28.4	Uncomfortable	75.2	Safe
108	23.1	Uncomfortable	16.6	Walking	22.1	Uncomfortable	29.8	Uncomfortable	76.3	Safe
109	12.6	Standing	8.5	Sitting	12.9	Standing	18.8	Walking	59.3	Safe
110	11.7	Standing	8.5	Sitting	11.0	Standing	14.7	Standing	50.4	Safe
111	17.8	Walking	12.1	Standing	14.6	Standing	17.0	Walking	58.9	Safe
112	20.9	Uncomfortable	14.3	Standing	18.6	Walking	23.1	Uncomfortable	64.2	Safe
113	13.5	Standing	8.7	Sitting	12.3	Standing	16.0	Walking	57.5	Safe
114	11.8	Standing	8.6	Sitting	10.4	Standing	13.2	Standing	50.9	Safe
115	10.7	Standing	7.9	Sitting	9.2	Sitting	11.2	Standing	45.7	Safe
116	11.9	Standing	9.4	Sitting	10.8	Standing	13.0	Standing	46.5	Safe
117	13.4	Standing	8.5	Sitting	11.2	Standing	14.3	Standing	59.0	Safe
118	16.5	Walking	10.8	Standing	14.4	Standing	18.2	Walking	62.8	Safe
119	22.7	Uncomfortable	14.8	Standing	19.1	Walking	23.4	Uncomfortable	76.8	Safe
120	16.6	Walking	10.9	Standing	12.7	Standing	14.5	Standing	60.2	Safe
121	7.8	Sitting	5.6	Sitting	6.9	Sitting	8.5	Sitting	33.0	Safe
122	9.3	Sitting	6.5	Sitting	8.7	Sitting	12.1	Standing	40.4	Safe
123	14.0	Standing	9.3	Sitting	12.2	Standing	15.3	Walking	53.6	Safe
124	13.4	Standing	10.4	Standing	13.9	Standing	19.0	Walking	61.8	Safe
125	21.0	Uncomfortable	14.2	Standing	18.5	Walking	23.9	Uncomfortable	71.4	Safe
126	21.4	Uncomfortable	16.6	Walking	22.6	Uncomfortable	31.7	Uncomfortable	89.3	Safe
127	10.3	Standing	7.9	Sitting	11.0	Standing	16.1	Walking	71.2	Safe
128	18.2	Walking	11.6	Standing	15.8	Walking	20.5	Uncomfortable	62.4	Safe
129	20.3	Uncomfortable	12.8	Standing	17.7	Walking	23.1	Uncomfortable	78.7	Safe
130	15.5	Walking	12.8	Standing	16.5	Walking	23.3	Uncomfortable	84.9	Safe
131	14.6	Standing	10.2	Standing	15.3	Walking	24.3	Uncomfortable	79.6	Safe
132	18.2	Walking	11.3	Standing	15.4	Walking	20.0	Walking	70.7	Safe
133	22.0	Uncomfortable	14.1	Standing	18.8	Walking	24.6	Uncomfortable	72.9	Safe
134	9.6	Sitting	7.4	Sitting	9.0	Sitting	11.0	Standing	36.7	Safe
135	8.4	Sitting	6.1	Sitting	7.4	Sitting	9.0	Sitting	31.8	Safe
136	19.1	Walking	15.0	Standing	16.7	Walking	17.8	Walking	68.6	Safe







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

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.

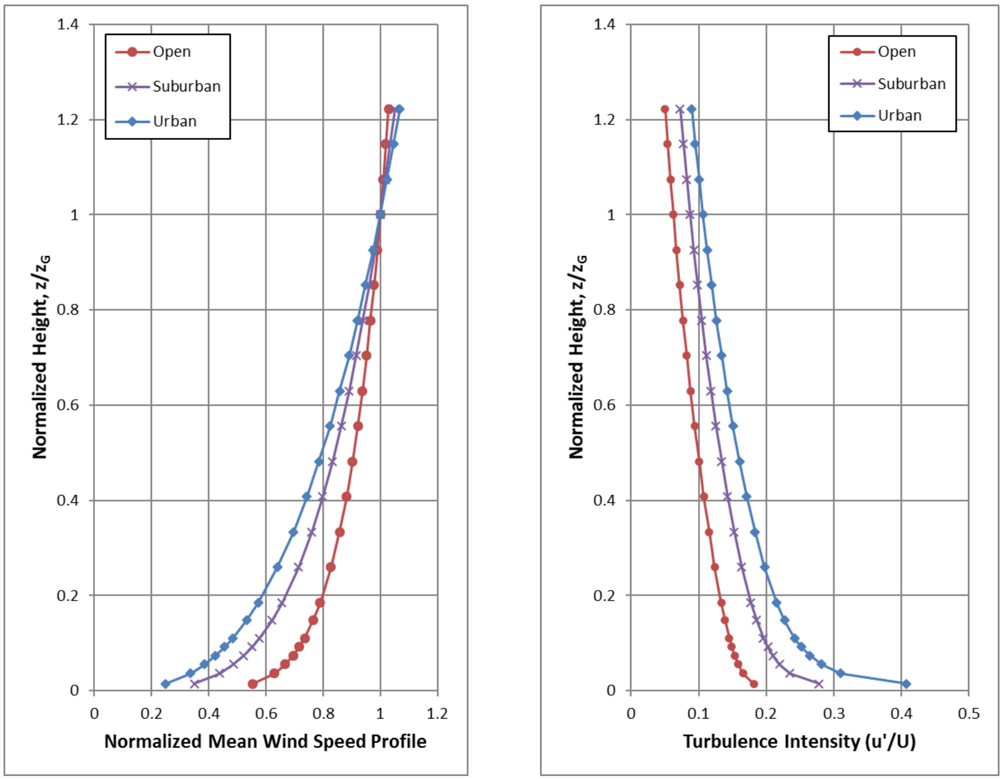

FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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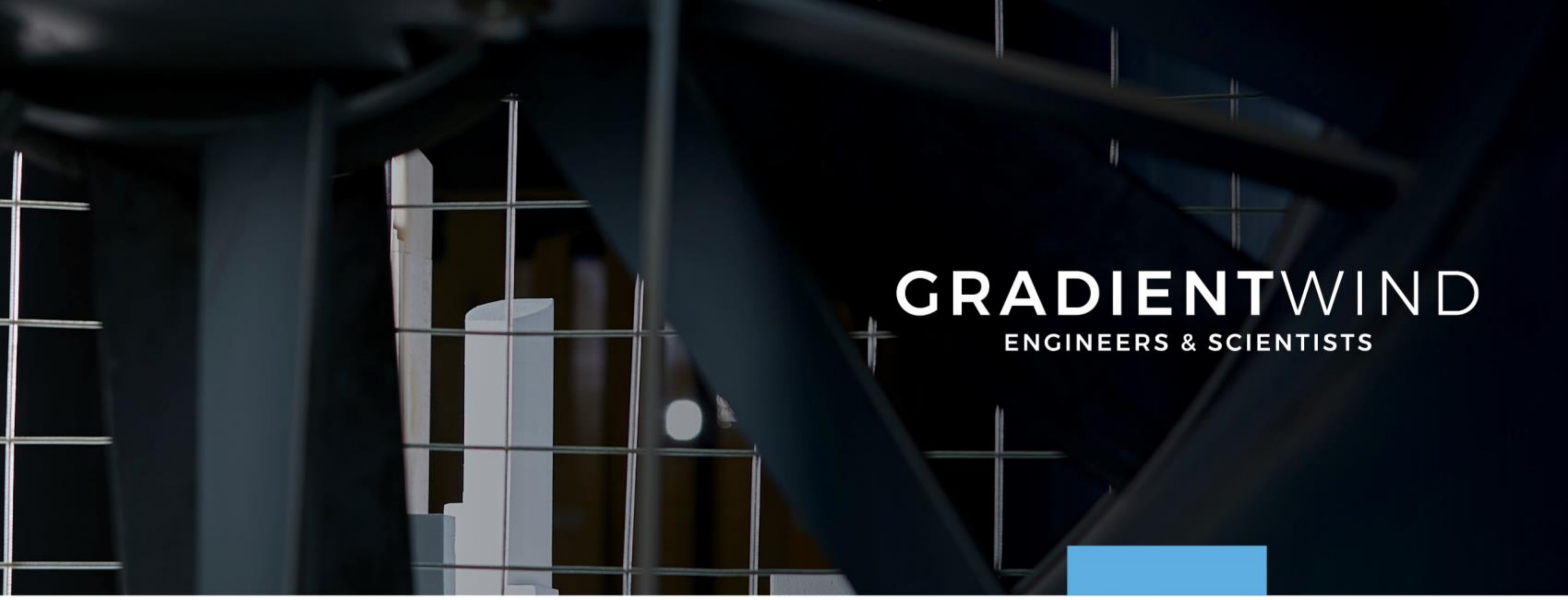

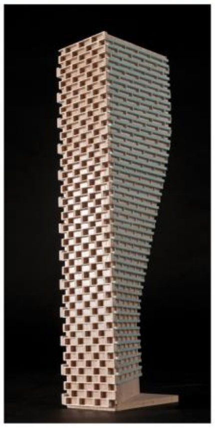

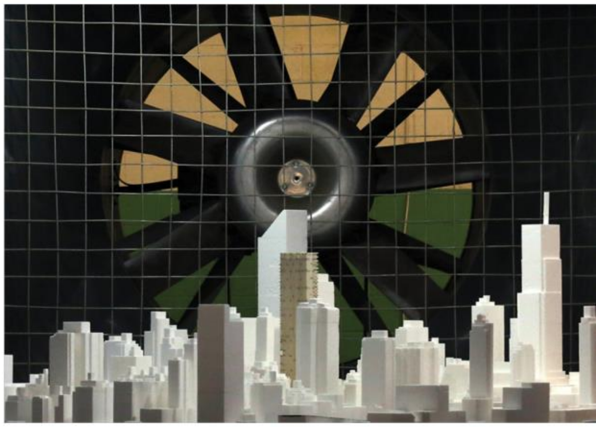

APPENDIX D

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:

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

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

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.

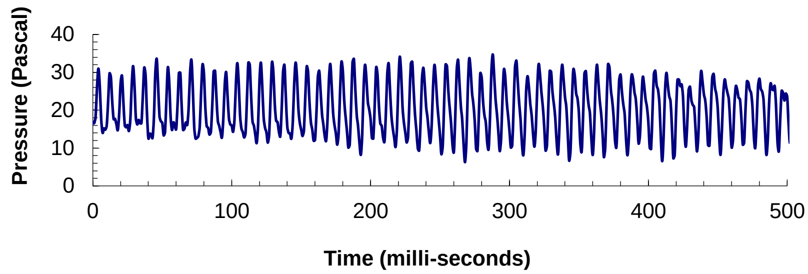

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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