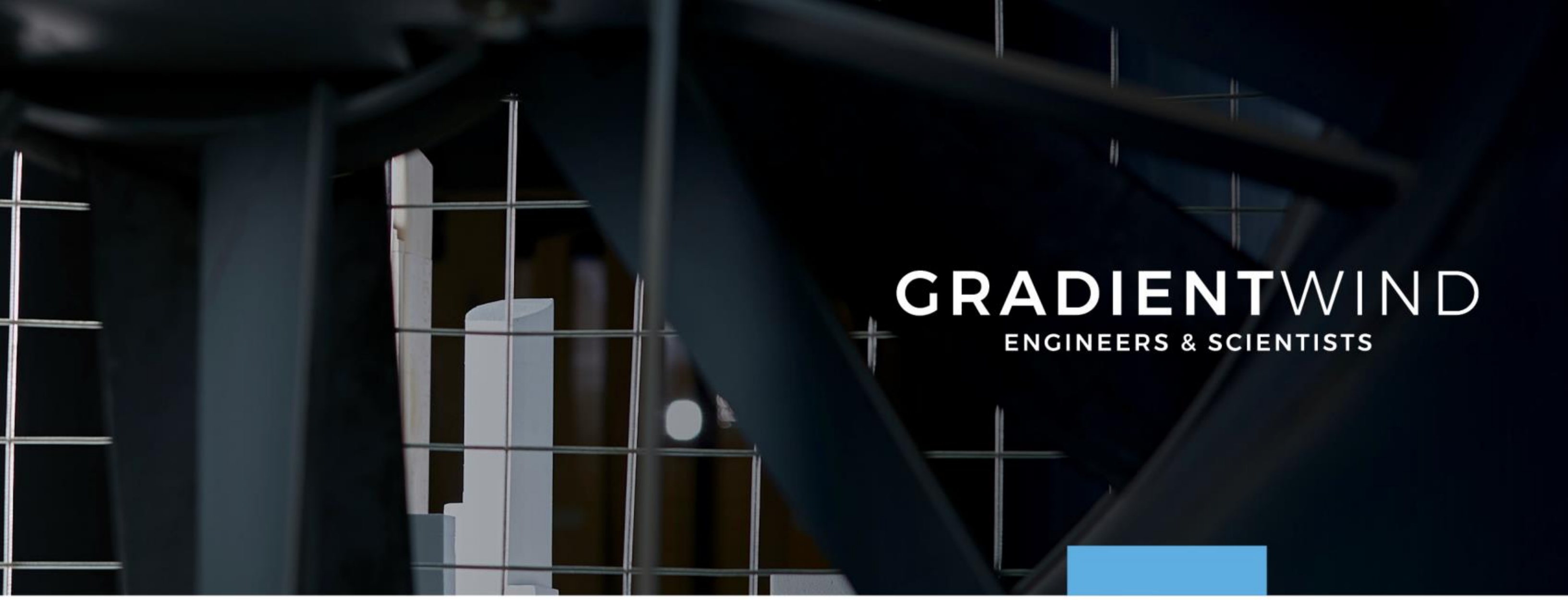
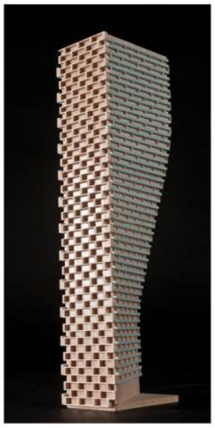
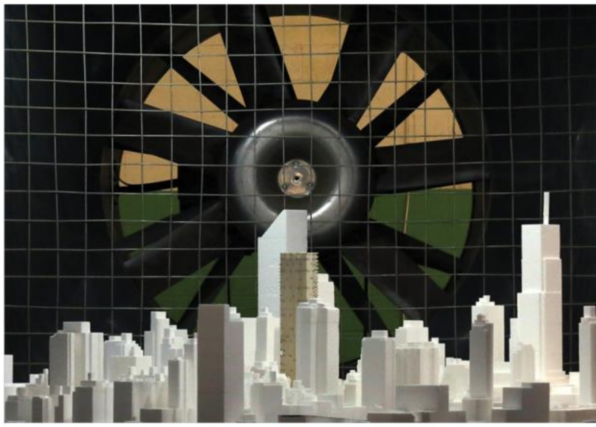


PEDESTRIAN LEVEL WIND STUDY

1050 Markham Road
Scarborough, Ontario

REPORT: GW24-059-WTPLW





May 29, 2024

PREPARED FOR
CAPREIT Limited Partnership
11 Church Street, Suite 401
Toronto, Ontario
M5E 1W1

PREPARED BY
Sam Woolsey, M.E.Sc., Junior Wind Scientist
Nick Petersen, P.Eng., Wind Engineer

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

EXECUTIVE SUMMARY

This report describes a wind tunnel pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development located at 1050 Markham Road in Scarborough, 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 areas, landscaped spaces, transit stops, outdoor amenity areas, and building access points. Wind comfort is also evaluated over the Level 2 outdoor amenity terraces. 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 Wallman Architects in April and May 2024, surrounding street layouts, as well as existing and approved future building massing information obtained from the City of Toronto, 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-4D, and Tables A1-A3 and B1-B3 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Scarborough, we conclude that the future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include several primary lobby entrances, for which mitigation is recommended as detailed in Section 5.2. Additionally, the Level 2 outdoor amenity terraces will experience wind conditions comfortable for sitting or more sedentary activities throughout the year, without the need for mitigation.

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.

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1. INTRODUCTION

This report describes a wind tunnel pedestrian level wind (PLW) study undertaken to assess wind conditions for a proposed mixed-use development located at 1050 Markham Road in Scarborough, 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 Wallman Architects in April and May 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 mixed-use high-rise development located at 1050 Markham Road in Scarborough, Ontario. The study site is situated at the northwest corner of the intersection of Markham Road and Brimorton Drive.

The study site comprises a 15-storey residential tower to the west and a 37-storey residential tower to the east both rising from stepped six-storey mixed-use podia. Loading zones, residential lobby entrances, and three levels of below-grade parking for each building are accessed from a central north-south driveway from Brimorton Drive bisecting the site. At grade, both buildings feature indoor/outdoor amenity spaces to the north, with residential units, retail space, and building support services elsewhere. The floorplates of both buildings set back at Level 2 to accommodate outdoor amenity spaces, with indoor amenities and residential units within. At Level 3, the west tower sets back from the east elevation to accommodate private terraces. Level 4 rises uniformly, above which the floorplate sets back along the south and west elevations to accommodate private terraces. Level 6 rises uniformly, above which the floorplate sets back along the east elevation to accommodate additional private terraces. The typical tower floorplate rises uniformly from Level 7 through its full height, upon which a mechanical penthouse completes the tower.

At Level 3, the east tower sets back from the north elevation to accommodate private terraces. Levels 4 through 6 rise uniformly. At Level 7, the floorplate sets back along the north, east, and south elevations featuring private terraces, above which the typical tower floorplate rises uniformly to full height, upon which a mechanical penthouse completes the tower and the development.

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 suburban buildings in all directions, with the existing (19-storey) 1050 Markham Road tower directly to the north, and the proposed group of 5 towers (14, 16, 28, 28, and 34-storeys) across Markham Road to the east of the site, and 555 Brimorton Drive (15-storeys) to the south across Brimorton Drive. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) are composed primarily of low-rise suburban buildings in all directions primarily constituting a continuation of the near-field, with the Gatineau Hydro Corridor open space approximately 350 meters south of the study site, and additional high-rise massing proposed approximately 350 meters northeast of the study site along Markham Road (18, 37, 33, and 8-storeys).

Grade-level areas investigated include sidewalks, laneways, parking areas, landscaped spaces, transit stops, outdoor amenity areas, and building access points. Wind comfort is also evaluated over the Level 2 outdoor amenity spaces. 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 Scarborough area 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.

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 76 sensor locations on the scale model in Gradient Wind's wind tunnel. Of these 76 sensors, 74 were located at grade and the remaining two sensors were located over the Level 2 amenity terraces. Wind speed measurements were performed for each of the 76 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

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

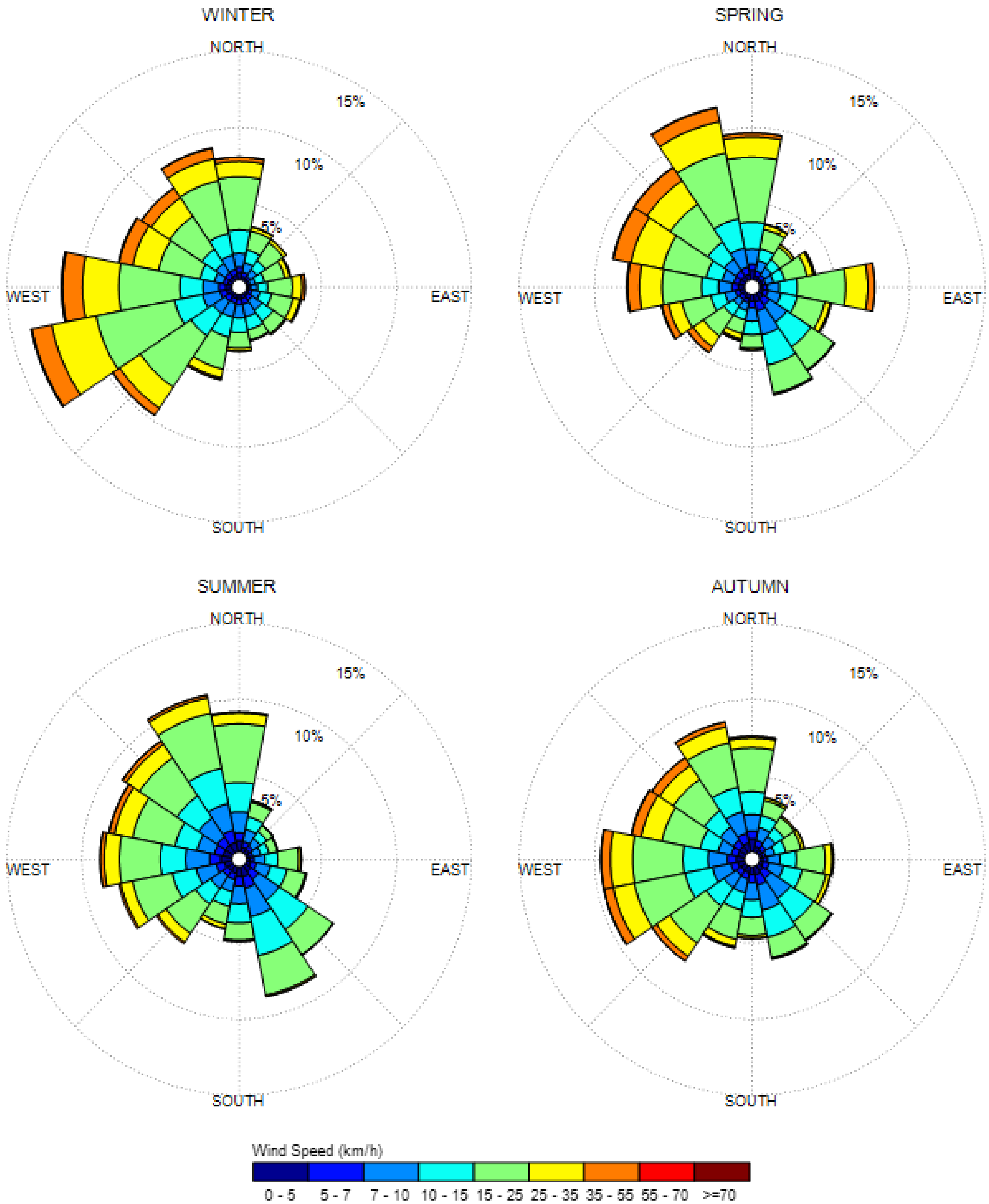
at grade were referenced to the wind speed measured near the ceiling of the wind tunnel to generate mean and peak wind speed ratios. Ceiling height in the wind tunnel represents the depth of the boundary layer of wind flowing over the earth's surface, referred to as the gradient height. Within this boundary 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 - Pearson International Airport

A statistical model for winds in Scarborough was developed from over 50 years of hourly meteorological wind data recorded at Pearson International 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 Scarborough 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 Pearson International Airport, the most common winds concerning pedestrian comfort occur from the southwest clockwise to the north, as well as those from the east. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying the calmest winds relative to the remaining seasonal periods.

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
PEARSON INTERNATIONAL AIRPORT, TORONTO, ONTARIO



Notes:

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

4.4 Pedestrian Comfort and Safety Guidelines

Pedestrian comfort and safety guidelines are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e. temperature, relative humidity). The comfort guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Four pedestrian comfort classes are based on 80% non-exceedance 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 B3 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. Most public sidewalks, laneways, parking areas, and landscaped spaces within and surrounding the proposed development site currently experience wind conditions suitable for walking or better throughout each seasonal period. Exceptions include sections of sidewalk and landscaping at the northeast and southwest corners of the intersection of Markham Road and Brimorton Drive (Sensor 9 and 13, respectively), which both experience uncomfortable wind conditions during the winter and spring.

2. The public transit stops along Markham Road (Sensors 11 & 46) are currently comfortable for standing or better during the summer and autumn, and walking throughout the rest of the year. It is notable that both stops are equipped with pedestrian shelters.

3. The main entrance to the existing tower at 1050 Markham Road to the north of the study site (Sensor 1) currently experiences wind conditions comfortable for standing during the summer, autumn, and winter, with walking conditions during the spring.

4. The main entrance to the existing 555 Brimorton Drive to the south of the study site (Sensor 17) currently experiences wind conditions suitable for standing or better throughout the year.

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

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-B3 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 public sidewalks, laneways, parking areas, and landscaped spaces within and surrounding the proposed development will experience acceptable wind conditions suitable for walking or better during each seasonal period, with a few isolated exceptions. Specifically, walkways and landscaped spaces along Markham Road (Sensors 7, 9, & 42), along Brimorton Drive (Sensors 14 & 15), and the laneway bisecting the site (Sensors 56, 57, & 59) will become intermittently uncomfortable for walking during the colder months. Considering that the exceedances of the walking criterion in all instances is marginal (generally <1km/h, see Appendix B), windspeeds are improved for the *existing* uncomfortable cases (Sensors 9 & 14), and no locations exceed the annual wind speed safety criterion, the noted conditions are considered acceptable without the need for mitigation.

2. The public transit stops along Markham Road (Sensors 11 & 46) will continue to be comfortable for standing or better during the summer and autumn, and walking throughout the rest of the year, which is acceptable considering both stops are equipped with pedestrian transit shelters.

3. Most primary residential, retail, and amenity building access points serving the study site, will be suitable for standing or better throughout the year, which is acceptable. The residential lobby entrances along the central driveway (Sensors 54 & 60), exceed this criterion during colder seasons. It is recommended to either recess the entrances within the façade, provide flanking wind barriers and/or overhead canopies, or substitute swing doors with sliding options. If an external retail entrance will be present at the southeast corner of the site it is recommended it be located along the calmer southeast edge (Sensor 47).

   Most secondary building access points will be comfortable for walking or better throughout the year, which is appropriate, with the exception of the parking entrances along the laneway bisecting the study site (Sensors 56 & 57), which will experience uncomfortable wind conditions during the winter. As these exceedances are marginal (<1 km/h see Appendix B), and limited pedestrian use is expected, the noted conditions are considered acceptable without the need for mitigation.

4. The main entrance to the existing tower at 1050 Markham Road to the north of the study site (Sensor 1) and the existing 555 Brimorton Drive development to the south of the study site (Sensor 17), will experiences wind conditions comfortable for standing or better throughout the year, which is appropriate and an improvement on *existing* conditions.

5. The grade-level outdoor amenity spaces along the north elevations (Sensors 38-41 & 70-74) will generally be comfortable for sitting throughout the summer months, which is acceptable.

6. The Level 2 outdoor amenities (Sensors 75 & 76) will be suitable for sitting or more sedentary activities throughout the year, which is favourable and does not require mitigation. In the latest architectural drawings a portion of the west tower Level 2 terrace has moved to the east elevation. This space is likewise expected to be sheltered, calm, and suitable for sitting throughout the warmer months.

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

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for the proposed residential development located at 1050 Markham Road in Scarborough, 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-B3 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in Scarborough, we conclude that the future wind conditions over most grade-level pedestrian wind-sensitive areas within and surrounding the study site will be acceptable for the intended uses on a seasonal basis. Exceptions include several primary lobby entrances, for which mitigation is recommended as detailed in Section 5.2. Additionally, the Level 2 outdoor amenity terraces will experience wind conditions comfortable for sitting or more sedentary activities throughout the year, without the need for mitigation.

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,

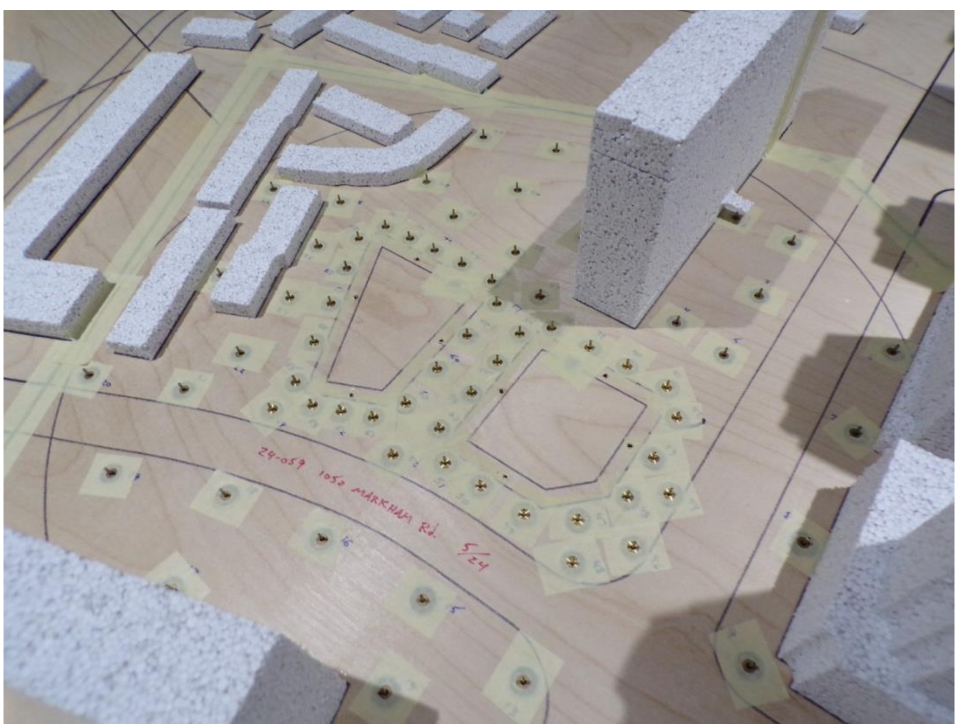
Gradient Wind Engineering Inc.

Sam Woolsey, M.E.Sc.,
Junior Wind Scientist

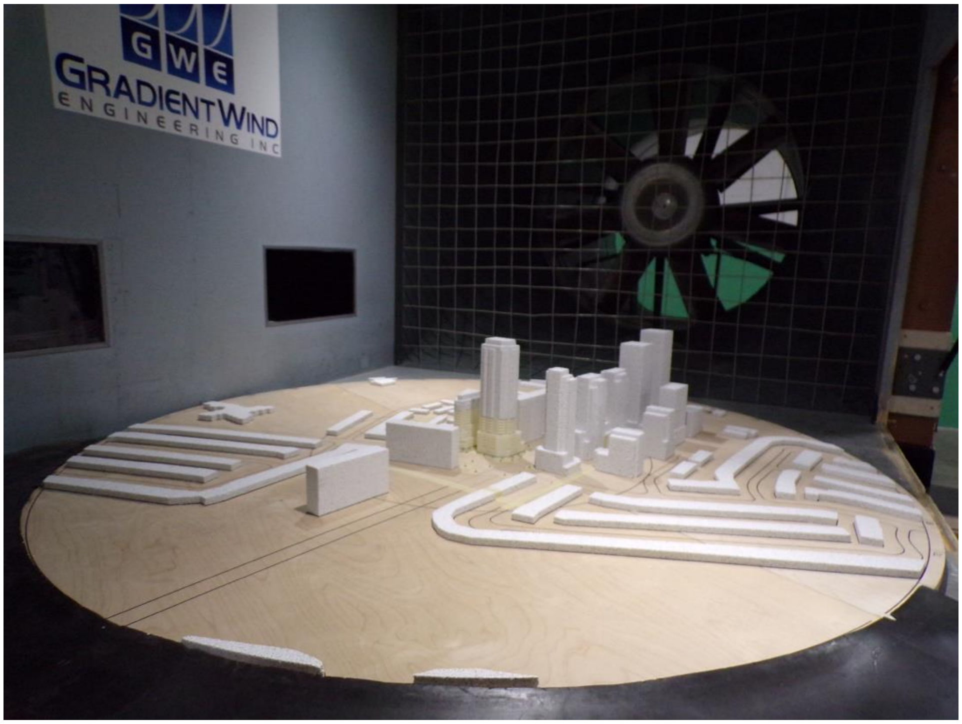
Nick Petersen, P.Eng.,
Wind Engineer

GW24-059-WTPLW

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



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

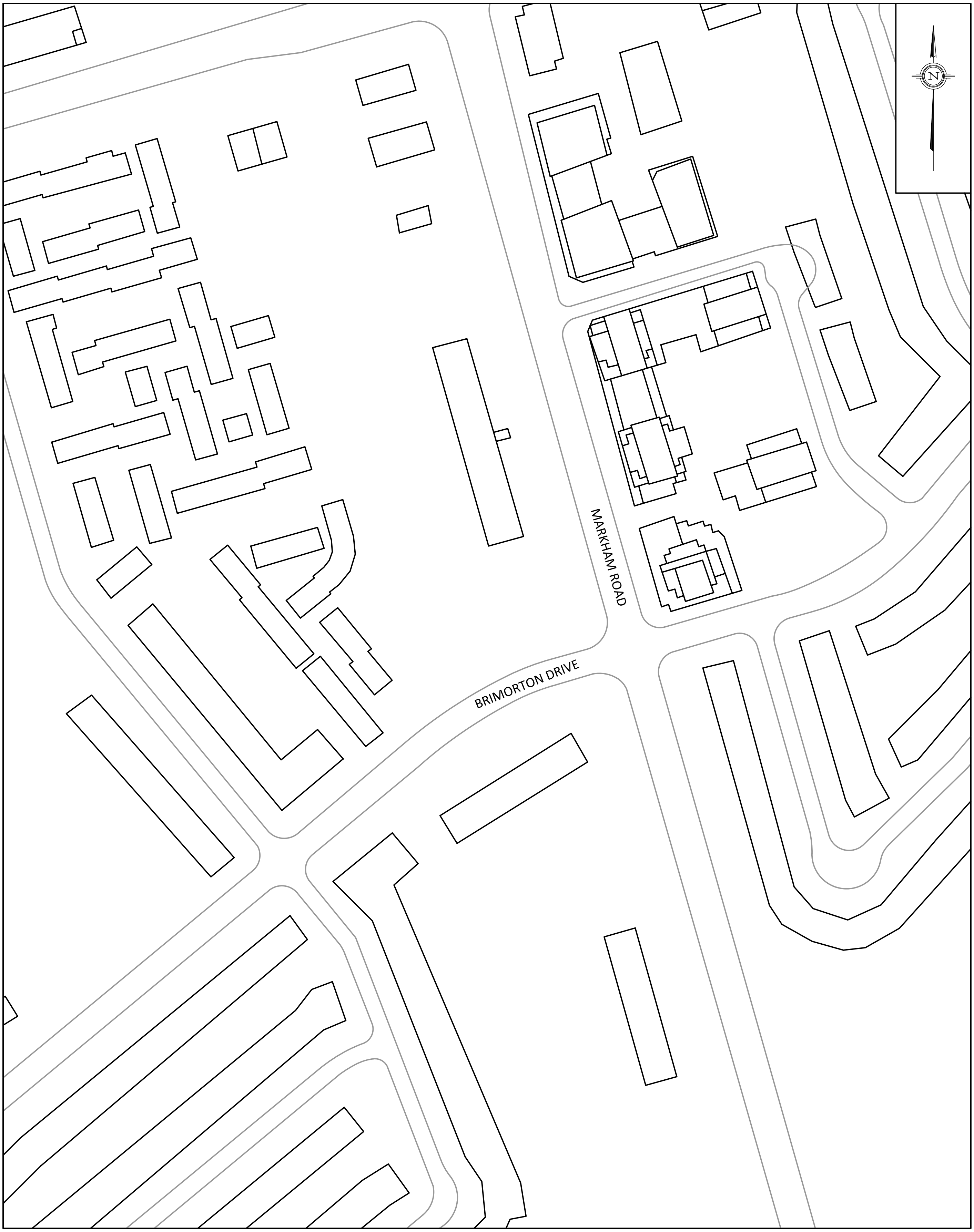


PHOTOGRAPH 3: STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND

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

PHOTOGRAPH 5: CLOSE-UP VIEW OF STUDY MODEL LOOKING NORTH

PHOTOGRAPH 6: CLOSE-UP VIEW OF STUDY MODEL LOOKING SOUTH



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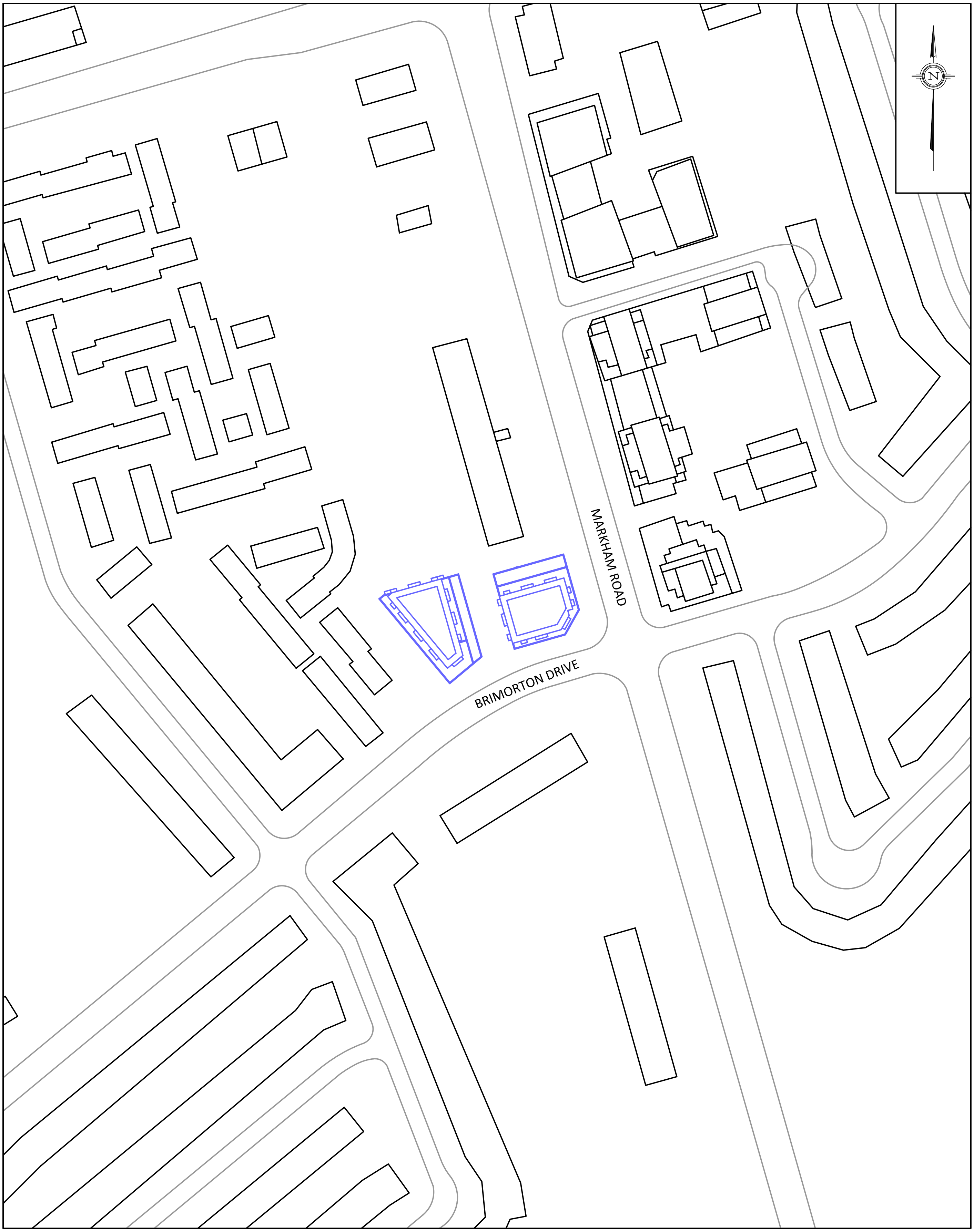
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:2500 (APPROX.)	DRAWING NO.	GW24-059-PLW-1A
DATE	MAY 29, 2024	DRAWN BY	C.E.

DESCRIPTION

FIGURE 1A:
EXISTING SITE PLAN
AND SURROUNDING CONTEXT



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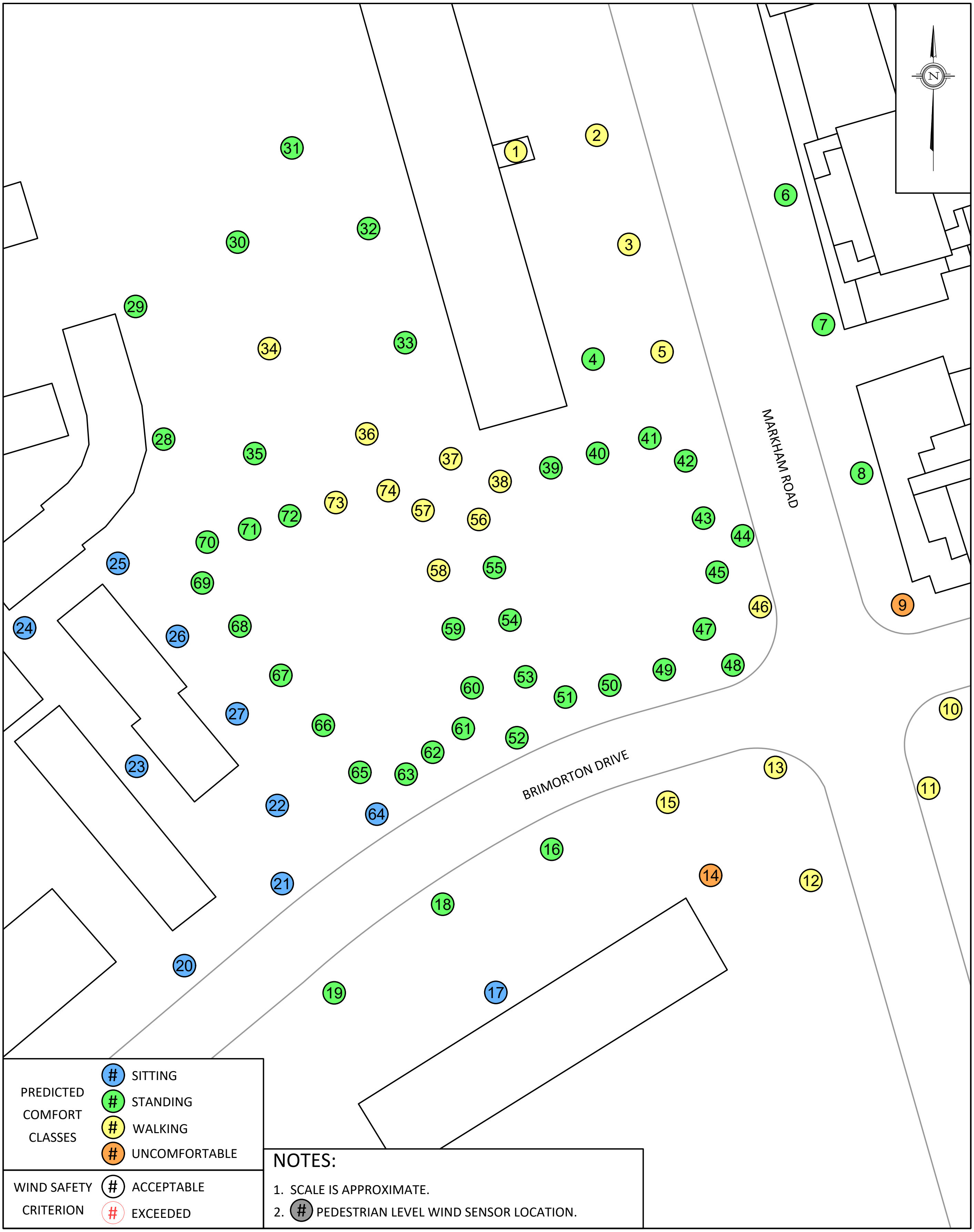
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1B: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE	1:2500 (APPROX.)	DRAWING NO. GW24-059-PLW-1B	
DATE	MAY 29, 2024	DRAWN BY C.E.	



NOTES:

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

GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY SCALE: 1:1000 (APPROX.) — DRAWING NO. GW24-059-PLW-2A DATE: MAY 29, 2024 — DRAWN BY: C.E.	DESCRIPTION: FIGURE 2A: SPRING EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS

NOTES:

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

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PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW24-059-PLW-2B
DATE	MAY 29, 2024	DRAWN BY	C.E.

DESCRIPTION

FIGURE 2B: SUMMER
EXISTING GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS

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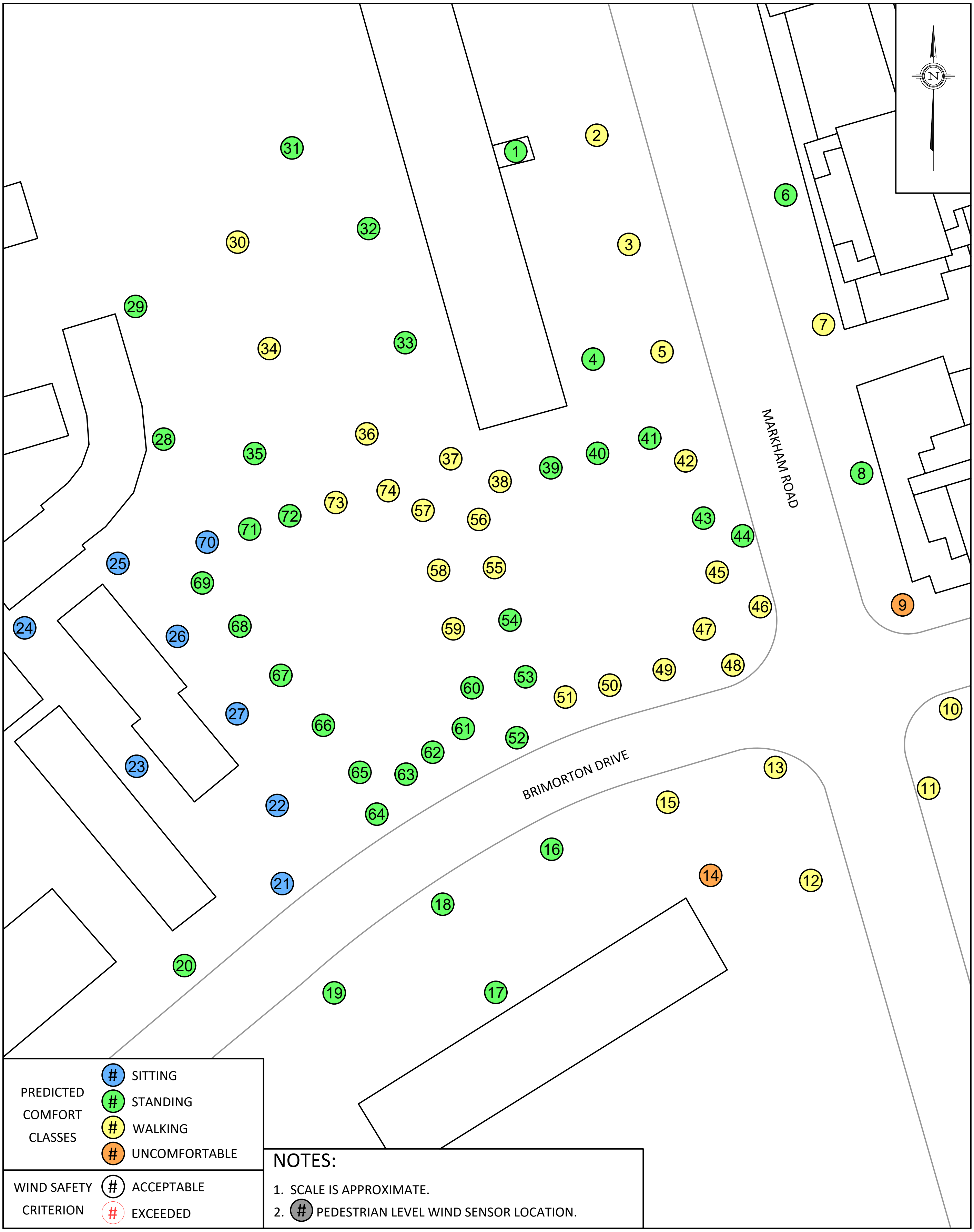
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-059-PLW-2C
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 2C: AUTUMN EXISTING GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



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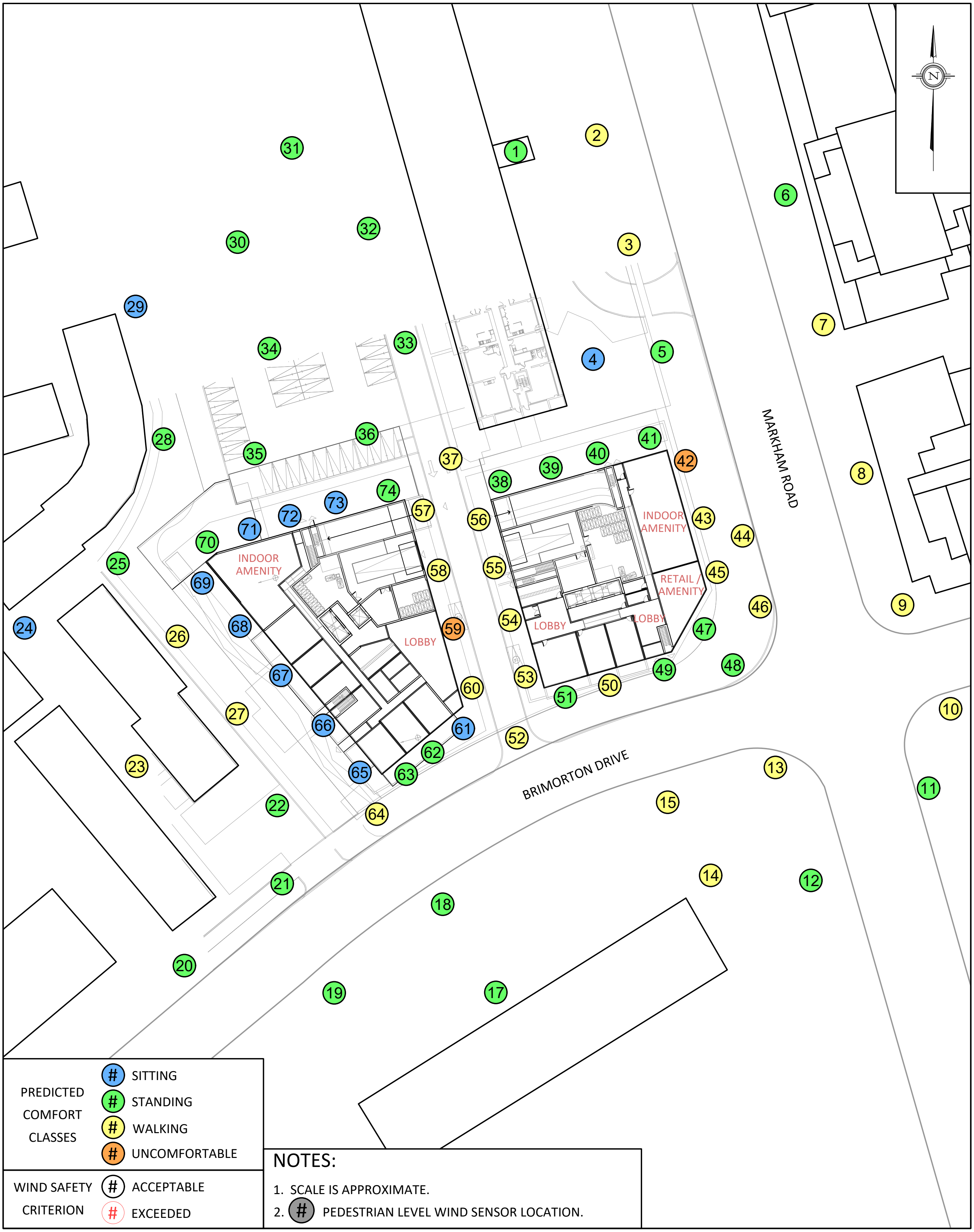
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW24-059-PLW-2D
DATE	MAY 29, 2024	DRAWN BY	C.E.

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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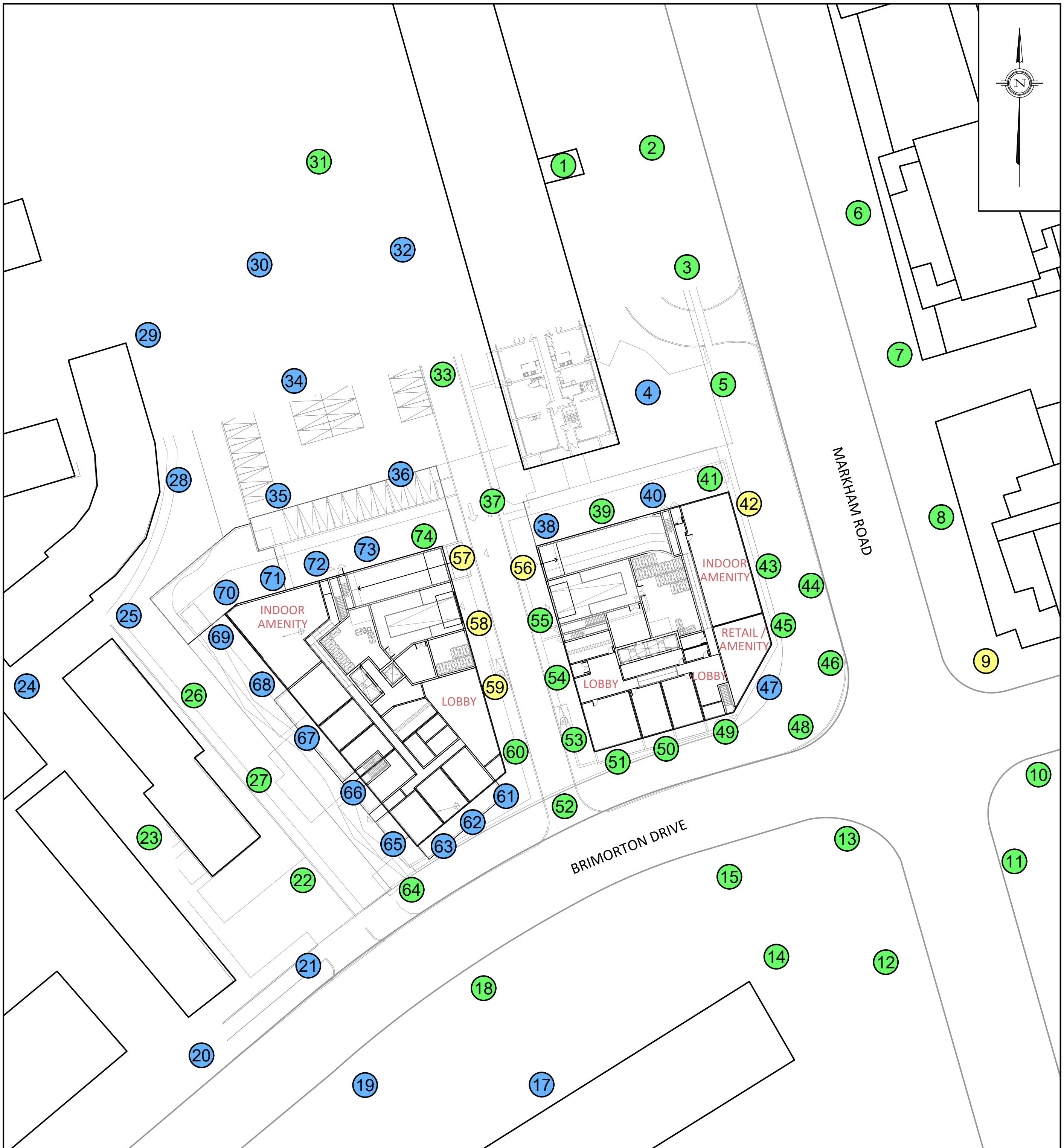
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY	
SCALE 1:1000 (APPROX.)	DRAWING NO. GW24-059-PLW-3A	
DATE MAY 29, 2024	DRAWN BY C.E.	

DESCRIPTION

FIGURE 3A: SPRING
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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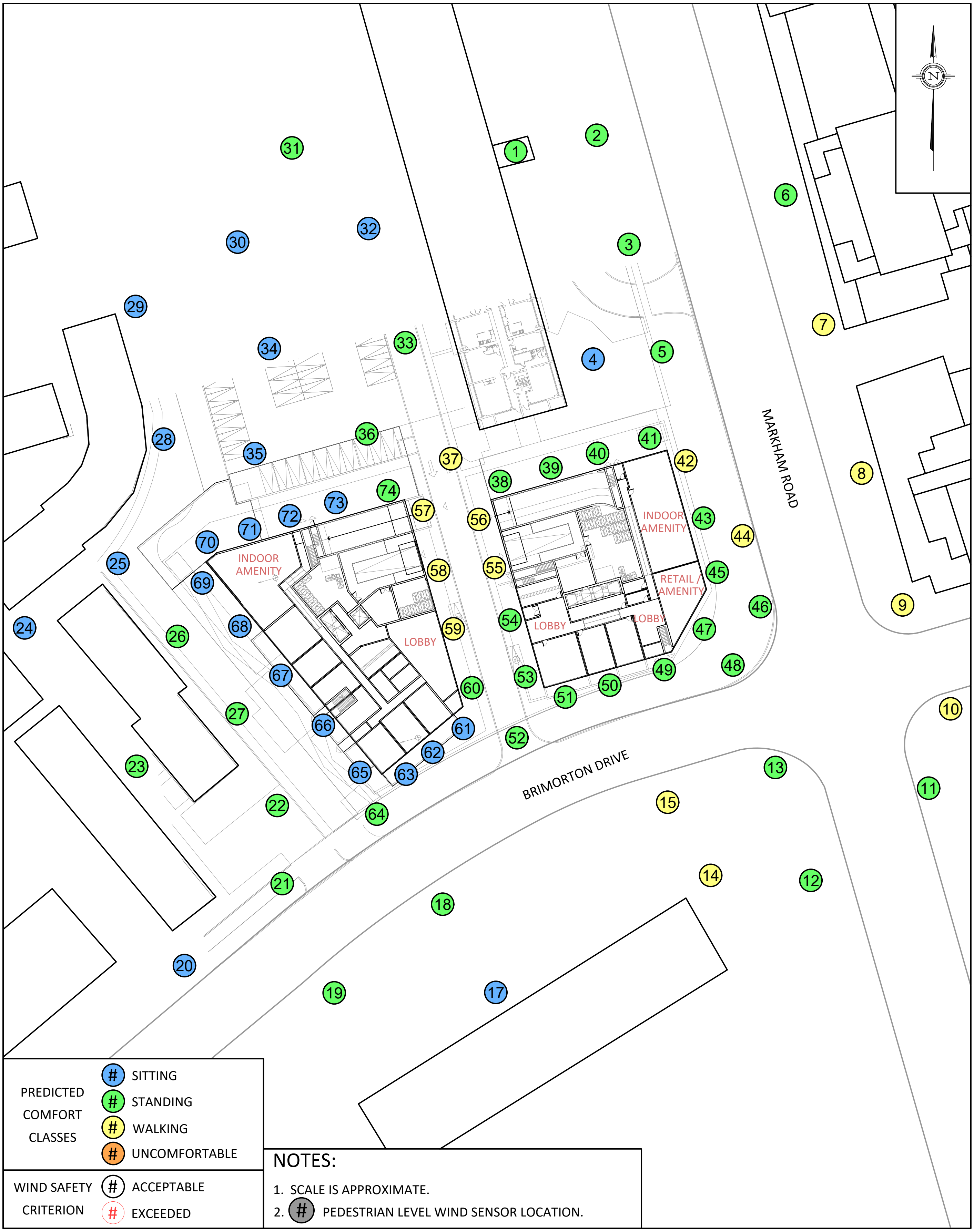
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-059-PLW-3B
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3B: SUMMER PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



NOTES:

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

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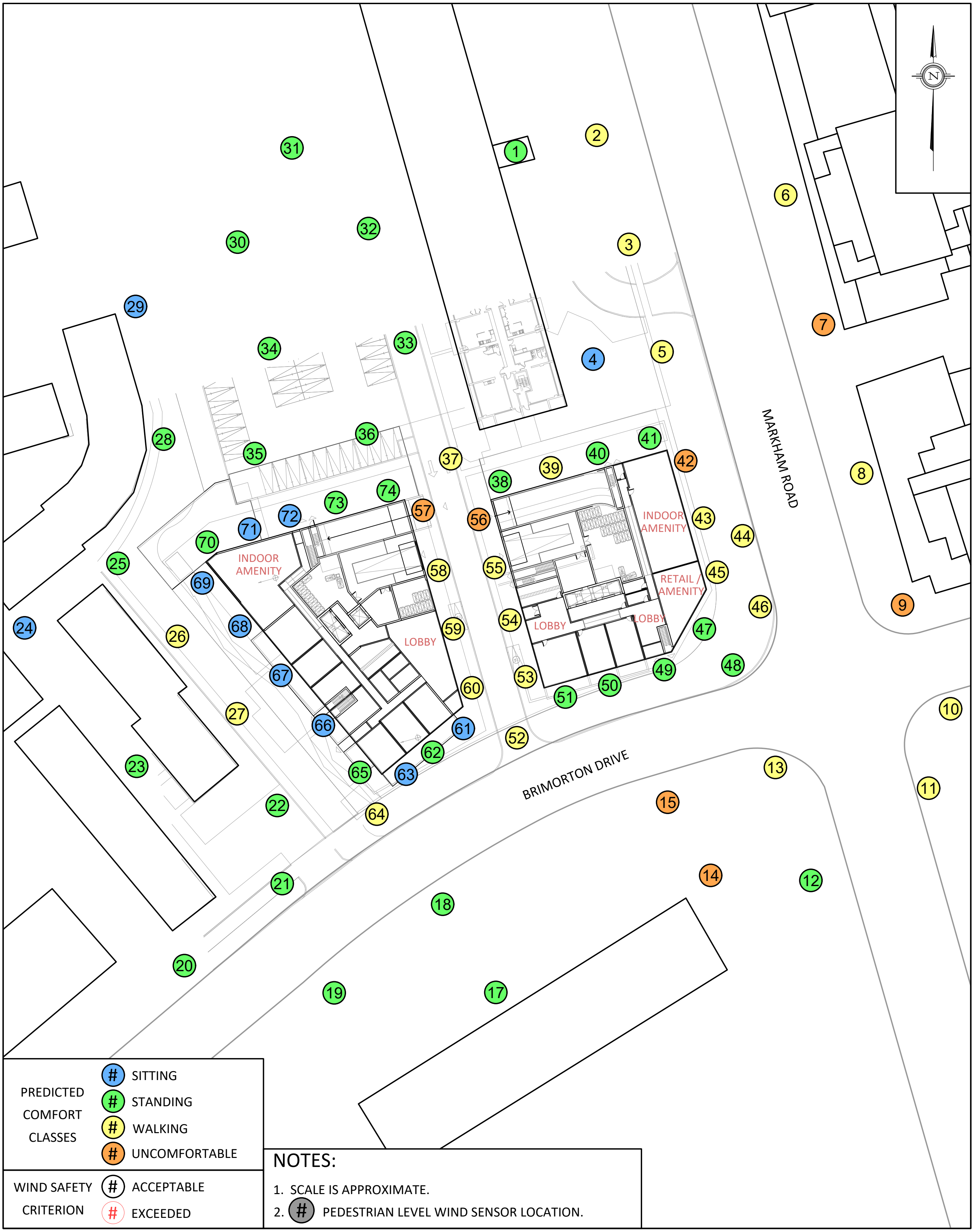
PROJECT	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-059-PLW-3C
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3C: AUTUMN PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS



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	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-059-PLW-3D
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 3D: WINTER PROPOSED GROUND FLOOR PLAN PEDESTRIAN COMFORT PREDICTIONS

LEVEL 2

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	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:600 (APPROX.)
DRAWING NO.	GW24-059-PLW-4A
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4A: SPRING LEVEL 2 AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS

LEVEL 2

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	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:600 (APPROX.)	DRAWING NO.	GW24-059-PLW-4B
DATE	MAY 29, 2024	DRAWN BY	C.E.

DESCRIPTION

FIGURE 4B: SUMMER
LEVEL 2 AMENITY PLAN
PEDESTRIAN COMFORT PREDICTIONS

LEVEL 2

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	1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY
SCALE	1:600 (APPROX.)
DRAWING NO.	GW24-059-PLW-4C
DATE	MAY 29, 2024
DRAWN BY	C.E.
DESCRIPTION	FIGURE 4C: AUTUMN LEVEL 2 AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS

LEVEL 2

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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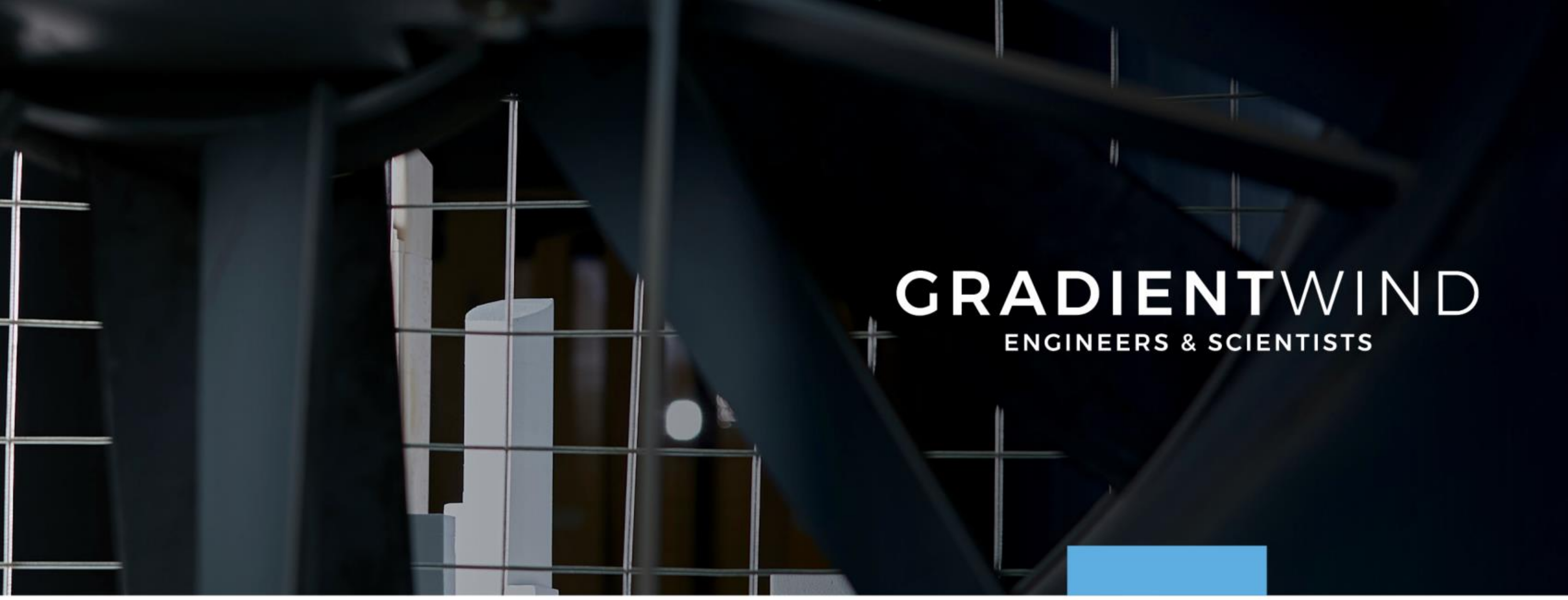
PROJECT: 1050 MARKHAM ROAD, SCARBOROUGH PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION: FIGURE 4D: WINTER LEVEL 2 AMENITY PLAN PEDESTRIAN COMFORT PREDICTIONS
SCALE: 1:600 (APPROX.)	DRAWING NO. GW24-059-PLW-4D	
DATE: MAY 29, 2024	DRAWN BY: C.E.	



APPENDIX A

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

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	15.9	Walking	12.4	Standing	13.1	Standing	14.5	Standing	55.7	Safe
2	17.6	Walking	13.6	Standing	15.2	Walking	18.1	Walking	63.1	Safe
3	17.0	Walking	12.9	Standing	14.6	Standing	17.7	Walking	64.6	Safe
4	12.5	Standing	10.0	Sitting	10.8	Standing	12.6	Standing	46.4	Safe
5	16.0	Walking	12.7	Standing	14.7	Standing	17.8	Walking	67.3	Safe
6	12.3	Standing	9.9	Sitting	11.6	Standing	14.5	Standing	57.1	Safe
7	13.6	Standing	10.9	Standing	12.6	Standing	16.7	Walking	67.0	Safe
8	12.3	Standing	9.5	Sitting	10.9	Standing	14.5	Standing	68.4	Safe
9	21.1	Uncomfortable	16.7	Walking	18.9	Walking	23.2	Uncomfortable	78.7	Safe
10	18.0	Walking	13.4	Standing	15.9	Walking	20.0	Walking	71.8	Safe
11	15.7	Walking	12.1	Standing	14.0	Standing	17.6	Walking	66.7	Safe
12	17.9	Walking	14.1	Standing	14.8	Standing	17.7	Walking	70.2	Safe
13	16.3	Walking	12.9	Standing	14.2	Standing	17.2	Walking	59.2	Safe
14	20.8	Uncomfortable	15.5	Walking	17.5	Walking	21.6	Uncomfortable	74.7	Safe
15	17.6	Walking	12.9	Standing	14.6	Standing	17.7	Walking	58.4	Safe
16	13.6	Standing	10.0	Sitting	11.6	Standing	13.8	Standing	55.8	Safe
17	9.1	Sitting	7.0	Sitting	8.4	Sitting	10.3	Standing	43.3	Safe
18	10.5	Standing	8.0	Sitting	8.9	Sitting	10.6	Standing	45.1	Safe
19	13.4	Standing	10.2	Standing	11.4	Standing	13.3	Standing	55.2	Safe
20	10.0	Sitting	8.1	Sitting	8.8	Sitting	10.2	Standing	37.7	Safe
21	9.2	Sitting	7.5	Sitting	8.2	Sitting	8.9	Sitting	37.3	Safe
22	9.8	Sitting	7.6	Sitting	8.1	Sitting	9.1	Sitting	37.3	Safe
23	9.3	Sitting	7.0	Sitting	7.9	Sitting	9.3	Sitting	36.2	Safe
24	6.6	Sitting	5.1	Sitting	5.6	Sitting	6.4	Sitting	25.2	Safe
25	8.0	Sitting	6.0	Sitting	6.6	Sitting	7.7	Sitting	29.7	Safe
26	9.4	Sitting	6.8	Sitting	7.6	Sitting	9.0	Sitting	35.4	Safe
27	10.0	Sitting	7.5	Sitting	8.2	Sitting	9.8	Sitting	36.4	Safe
28	12.6	Standing	9.3	Sitting	9.9	Sitting	11.4	Standing	45.0	Safe
29	13.5	Standing	10.4	Standing	10.7	Standing	12.1	Standing	46.0	Safe
30	14.8	Standing	12.0	Standing	13.0	Standing	15.9	Walking	58.7	Safe
31	13.7	Standing	11.2	Standing	12.2	Standing	14.8	Standing	55.9	Safe
32	11.3	Standing	9.0	Sitting	9.9	Sitting	11.7	Standing	49.6	Safe
33	11.8	Standing	9.4	Sitting	10.1	Standing	12.4	Standing	56.4	Safe
34	15.3	Walking	12.3	Standing	13.2	Standing	15.8	Walking	58.5	Safe
35	14.3	Standing	10.8	Standing	11.7	Standing	13.8	Standing	51.2	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	16.7	Walking	13.0	Standing	14.6	Standing	17.5	Walking	64.0	Safe
37	17.1	Walking	13.7	Standing	15.4	Walking	18.5	Walking	65.2	Safe
38	15.7	Walking	12.2	Standing	14.2	Standing	17.5	Walking	66.3	Safe
39	11.0	Standing	9.0	Sitting	10.8	Standing	13.5	Standing	60.7	Safe
40	11.1	Standing	8.9	Sitting	10.3	Standing	12.6	Standing	52.8	Safe
41	12.9	Standing	10.4	Standing	11.8	Standing	14.3	Standing	56.7	Safe
42	13.5	Standing	11.0	Standing	12.3	Standing	15.1	Walking	59.7	Safe
43	13.5	Standing	10.8	Standing	12.2	Standing	14.9	Standing	59.3	Safe
44	14.1	Standing	11.5	Standing	12.6	Standing	15.0	Standing	60.2	Safe
45	14.6	Standing	11.6	Standing	13.0	Standing	15.5	Walking	59.1	Safe
46	16.2	Walking	12.7	Standing	14.1	Standing	16.8	Walking	62.9	Safe
47	14.8	Standing	11.5	Standing	13.1	Standing	15.8	Walking	59.6	Safe
48	15.0	Standing	11.7	Standing	13.3	Standing	15.9	Walking	58.7	Safe
49	14.5	Standing	11.0	Standing	13.1	Standing	16.1	Walking	61.4	Safe
50	14.4	Standing	10.7	Standing	12.7	Standing	15.6	Walking	58.3	Safe
51	14.6	Standing	10.7	Standing	12.8	Standing	15.4	Walking	57.0	Safe
52	12.9	Standing	9.6	Sitting	11.3	Standing	13.7	Standing	53.0	Safe
53	13.6	Standing	10.0	Sitting	11.9	Standing	14.5	Standing	55.7	Safe
54	13.6	Standing	10.1	Standing	12.0	Standing	14.6	Standing	54.7	Safe
55	14.8	Standing	11.1	Standing	13.5	Standing	16.3	Walking	60.4	Safe
56	15.4	Walking	11.7	Standing	13.8	Standing	16.9	Walking	61.5	Safe
57	16.1	Walking	12.2	Standing	14.2	Standing	17.6	Walking	64.9	Safe
58	15.4	Walking	11.4	Standing	13.6	Standing	16.6	Walking	63.4	Safe
59	14.7	Standing	11.0	Standing	12.9	Standing	15.9	Walking	58.8	Safe
60	13.5	Standing	9.8	Sitting	11.6	Standing	14.0	Standing	54.2	Safe
61	12.4	Standing	9.1	Sitting	10.7	Standing	13.0	Standing	50.9	Safe
62	12.0	Standing	8.9	Sitting	10.3	Standing	12.3	Standing	50.0	Safe
63	11.0	Standing	8.2	Sitting	9.5	Sitting	11.2	Standing	47.8	Safe
64	9.9	Sitting	7.7	Sitting	8.7	Sitting	10.2	Standing	45.3	Safe
65	11.2	Standing	8.4	Sitting	9.5	Sitting	11.3	Standing	43.6	Safe
66	11.4	Standing	8.5	Sitting	9.4	Sitting	11.3	Standing	41.8	Safe
67	11.9	Standing	8.6	Sitting	9.5	Sitting	11.4	Standing	43.2	Safe
68	11.6	Standing	8.5	Sitting	9.3	Sitting	11.2	Standing	42.8	Safe
69	11.2	Standing	8.2	Sitting	9.0	Sitting	10.6	Standing	40.6	Safe
70	10.6	Standing	7.8	Sitting	8.4	Sitting	9.8	Sitting	41.1	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	13.3	Standing	9.9	Sitting	10.7	Standing	12.6	Standing	47.5	Safe
72	13.1	Standing	9.6	Sitting	10.6	Standing	12.7	Standing	50.2	Safe
73	15.3	Walking	11.5	Standing	13.1	Standing	15.7	Walking	59.2	Safe
74	16.2	Walking	12.2	Standing	14.1	Standing	17.4	Walking	65.2	Safe

APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B3
(PROPOSED 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 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	14.8	Standing	11.0	Standing	12.0	Standing	13.4	Standing	60.0	Safe
2	16.9	Walking	12.7	Standing	14.7	Standing	17.9	Walking	62.9	Safe
3	15.7	Walking	11.9	Standing	13.8	Standing	17.0	Walking	62.5	Safe
4	9.7	Sitting	7.7	Sitting	8.5	Sitting	9.8	Sitting	40.7	Safe
5	14.8	Standing	11.9	Standing	13.2	Standing	15.4	Walking	58.7	Safe
6	12.6	Standing	10.4	Standing	12.5	Standing	15.6	Walking	63.5	Safe
7	17.2	Walking	14.2	Standing	16.3	Walking	20.1	Uncomfortable	71.5	Safe
8	16.7	Walking	13.3	Standing	15.4	Walking	19.4	Walking	73.1	Safe
9	19.8	Walking	15.2	Walking	17.0	Walking	20.5	Uncomfortable	74.2	Safe
10	16.8	Walking	12.6	Standing	15.1	Walking	18.8	Walking	67.6	Safe
11	15.0	Standing	11.8	Standing	13.6	Standing	17.1	Walking	66.5	Safe
12	14.1	Standing	11.4	Standing	12.2	Standing	14.5	Standing	65.1	Safe
13	16.0	Walking	12.5	Standing	14.3	Standing	17.5	Walking	66.1	Safe
14	18.3	Walking	13.9	Standing	16.8	Walking	21.3	Uncomfortable	78.2	Safe
15	19.3	Walking	14.8	Standing	17.4	Walking	22.1	Uncomfortable	76.7	Safe
17	10.3	Standing	8.0	Sitting	9.2	Sitting	11.1	Standing	44.4	Safe
18	14.2	Standing	11.2	Standing	12.3	Standing	13.8	Standing	53.5	Safe
19	11.6	Standing	9.0	Sitting	10.1	Standing	11.5	Standing	46.3	Safe
20	11.8	Standing	8.8	Sitting	9.6	Sitting	10.8	Standing	47.2	Safe
21	12.0	Standing	9.5	Sitting	10.2	Standing	11.2	Standing	51.1	Safe
22	12.4	Standing	10.3	Standing	11.2	Standing	13.0	Standing	49.2	Safe
23	15.9	Walking	11.9	Standing	12.3	Standing	14.4	Standing	61.6	Safe
24	9.3	Sitting	7.5	Sitting	7.9	Sitting	8.8	Sitting	36.0	Safe
25	11.5	Standing	9.4	Sitting	9.9	Sitting	11.4	Standing	44.8	Safe
26	15.8	Walking	12.7	Standing	13.6	Standing	15.8	Walking	60.7	Safe
27	15.4	Walking	12.4	Standing	13.2	Standing	15.7	Walking	59.8	Safe
28	10.5	Standing	9.4	Sitting	9.7	Sitting	10.6	Standing	47.7	Safe
29	9.8	Sitting	7.9	Sitting	8.4	Sitting	9.7	Sitting	38.3	Safe
30	11.2	Standing	9.0	Sitting	9.8	Sitting	12.0	Standing	48.4	Safe
31	12.0	Standing	10.1	Standing	11.0	Standing	13.4	Standing	52.3	Safe
32	10.1	Standing	8.9	Sitting	9.5	Sitting	10.8	Standing	43.7	Safe
33	11.3	Standing	10.1	Standing	11.0	Standing	12.8	Standing	50.6	Safe
34	10.2	Standing	8.2	Sitting	9.2	Sitting	10.9	Standing	44.9	Safe
35	10.3	Standing	8.1	Sitting	9.1	Sitting	10.7	Standing	46.4	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

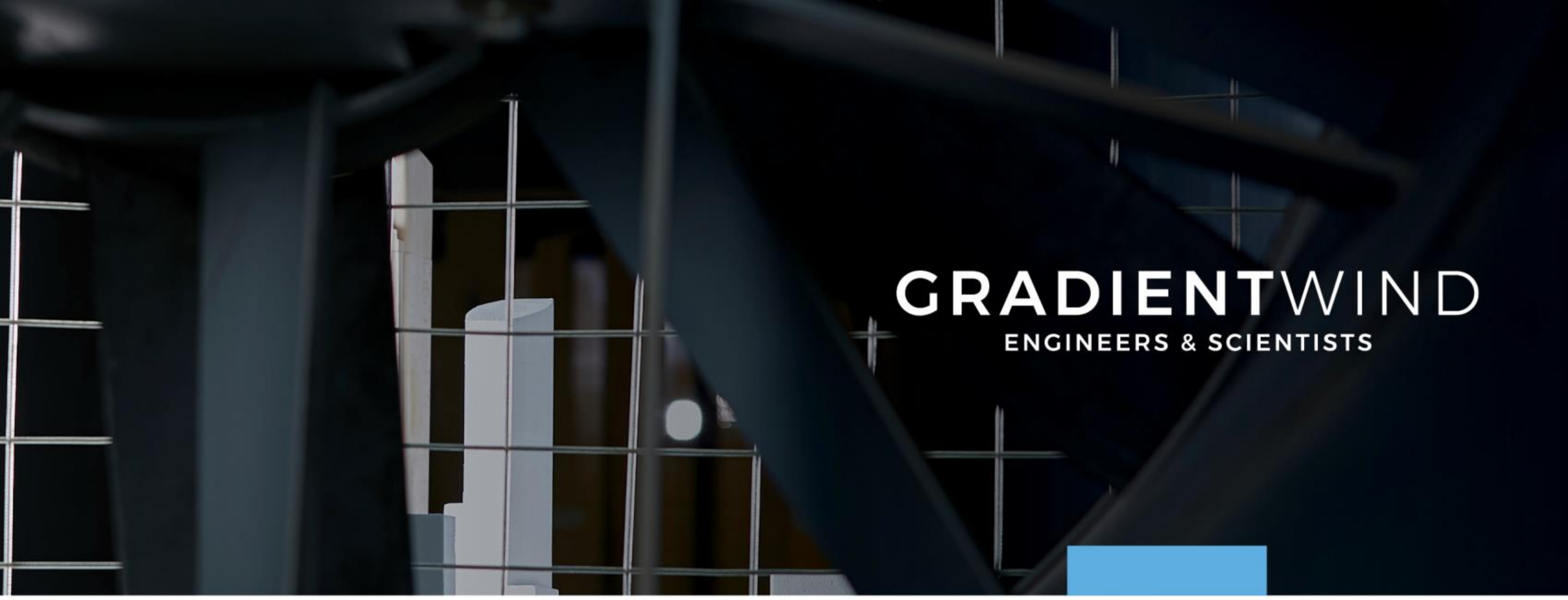
TABLE B2: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

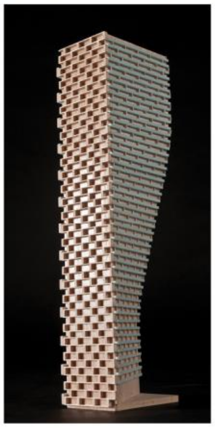
Sensor	Pedestrian Comfort								Pedestrian Safety	
	Spring		Summer		Autumn		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	11.3	Standing	9.0	Sitting	10.2	Standing	12.1	Standing	48.8	Safe
37	16.3	Walking	13.9	Standing	15.4	Walking	18.2	Walking	63.3	Safe
38	11.5	Standing	8.7	Sitting	10.3	Standing	12.4	Standing	49.0	Safe
39	13.7	Standing	10.8	Standing	12.9	Standing	16.1	Walking	68.0	Safe
40	12.2	Standing	9.6	Sitting	11.4	Standing	13.6	Standing	56.1	Safe
41	13.5	Standing	10.6	Standing	12.1	Standing	15.0	Standing	58.3	Safe
42	20.3	Uncomfortable	15.4	Walking	17.0	Walking	20.4	Uncomfortable	74.4	Safe
43	16.6	Walking	12.9	Standing	14.3	Standing	16.8	Walking	63.3	Safe
44	18.6	Walking	14.8	Standing	16.2	Walking	19.1	Walking	67.3	Safe
45	16.4	Walking	13.1	Standing	13.9	Standing	16.3	Walking	64.4	Safe
46	15.8	Walking	12.5	Standing	13.5	Standing	16.1	Walking	63.5	Safe
47	12.4	Standing	9.9	Sitting	11.2	Standing	13.2	Standing	58.0	Safe
48	14.3	Standing	11.0	Standing	12.5	Standing	14.8	Standing	59.2	Safe
49	14.4	Standing	10.7	Standing	12.6	Standing	14.7	Standing	57.4	Safe
50	15.4	Walking	10.8	Standing	12.6	Standing	14.8	Standing	62.1	Safe
51	14.0	Standing	10.9	Standing	11.9	Standing	13.6	Standing	56.1	Safe
52	16.6	Walking	12.6	Standing	14.0	Standing	16.4	Walking	57.3	Safe
53	16.7	Walking	13.2	Standing	14.0	Standing	17.0	Walking	63.5	Safe
54	15.4	Walking	12.5	Standing	13.6	Standing	16.1	Walking	57.4	Safe
55	18.1	Walking	14.6	Standing	15.9	Walking	19.4	Walking	66.5	Safe
56	19.2	Walking	16.3	Walking	17.5	Walking	20.9	Uncomfortable	69.6	Safe
57	18.3	Walking	15.6	Walking	16.8	Walking	20.2	Uncomfortable	73.5	Safe
58	18.6	Walking	15.1	Walking	16.2	Walking	18.6	Walking	62.5	Safe
59	20.2	Uncomfortable	15.9	Walking	16.9	Walking	19.3	Walking	65.5	Safe
60	15.6	Walking	12.3	Standing	13.4	Standing	15.3	Walking	53.9	Safe
61	8.9	Sitting	7.0	Sitting	8.0	Sitting	9.0	Sitting	37.8	Safe
62	11.3	Standing	8.9	Sitting	9.7	Sitting	10.4	Standing	47.4	Safe
63	10.9	Standing	8.3	Sitting	9.0	Sitting	9.0	Sitting	53.1	Safe
64	15.9	Walking	12.9	Standing	14.8	Standing	17.0	Walking	60.0	Safe
65	9.7	Sitting	8.1	Sitting	9.7	Sitting	12.4	Standing	52.2	Safe
66	8.3	Sitting	6.9	Sitting	7.5	Sitting	9.0	Sitting	38.9	Safe
67	8.0	Sitting	6.7	Sitting	6.9	Sitting	8.0	Sitting	34.1	Safe
68	7.4	Sitting	6.1	Sitting	6.6	Sitting	7.5	Sitting	32.2	Safe
69	9.7	Sitting	8.4	Sitting	9.0	Sitting	10.0	Sitting	44.9	Safe
70	11.7	Standing	8.9	Sitting	9.5	Sitting	11.9	Standing	52.0	Safe

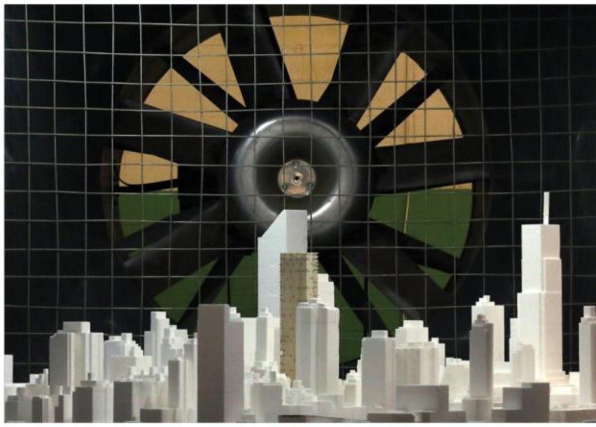
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-15 km/h = Standing, 15-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE 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	9.2	Sitting	7.1	Sitting	8.0	Sitting	9.6	Sitting	39.5	Safe
72	8.1	Sitting	6.3	Sitting	7.2	Sitting	8.6	Sitting	36.8	Safe
73	9.7	Sitting	7.4	Sitting	8.4	Sitting	10.1	Standing	40.2	Safe
74	14.0	Standing	10.4	Standing	11.5	Standing	14.0	Standing	53.6	Safe
75	7.7	Sitting	6.2	Sitting	7.0	Sitting	8.4	Sitting	33.3	Safe
76	7.5	Sitting	5.8	Sitting	6.5	Sitting	8.0	Sitting	30.2	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 B1 on the following page plots three velocity profiles for open country, and suburban and urban exposures.

The exponent α varies according to the type of upwind terrain; α ranges from 0.14 for open country to 0.33 for an urban exposure. Figure 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.

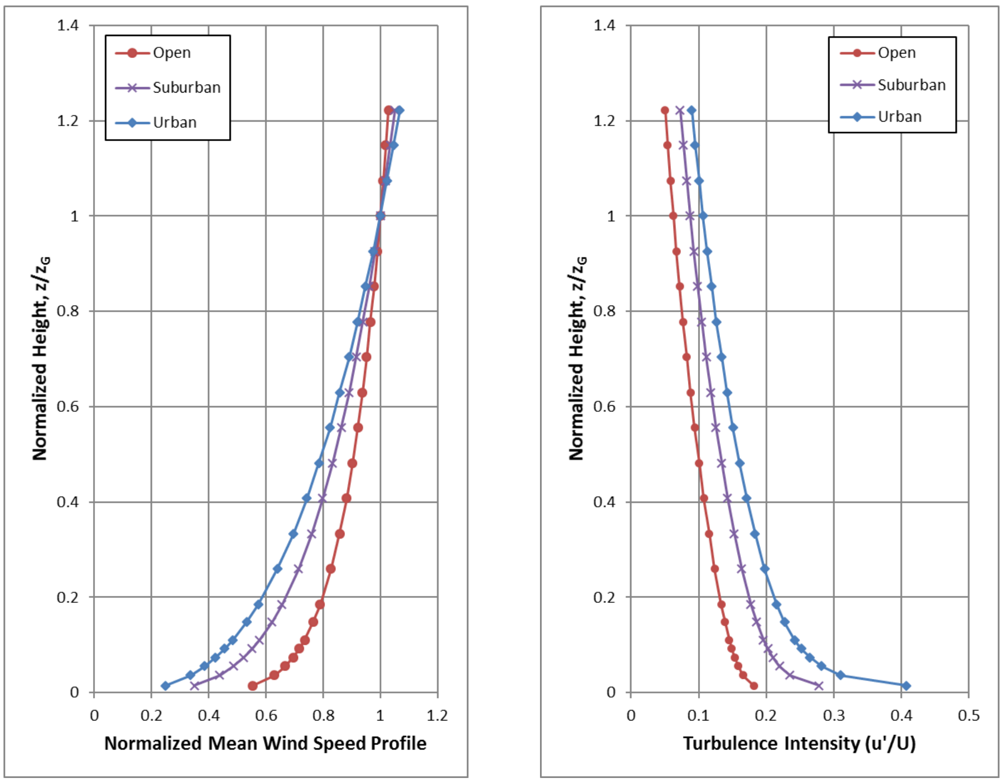

FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

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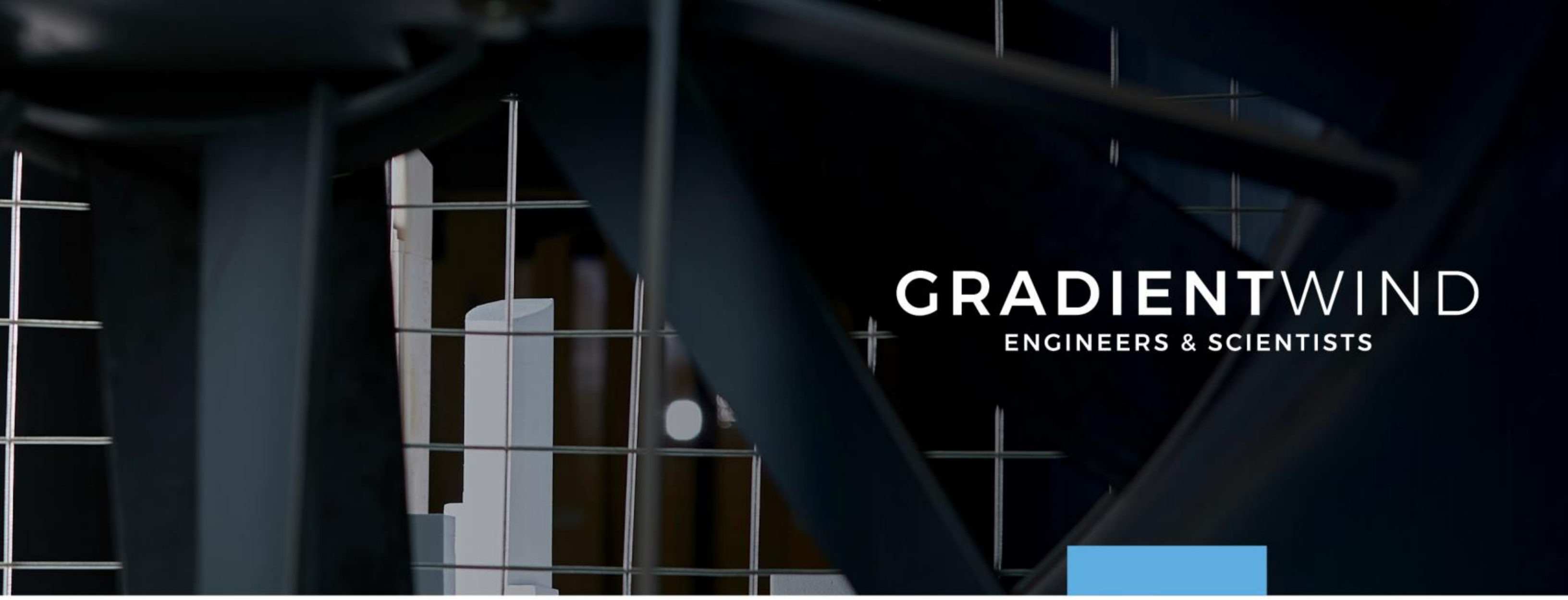

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APPENDIX D

PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

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.

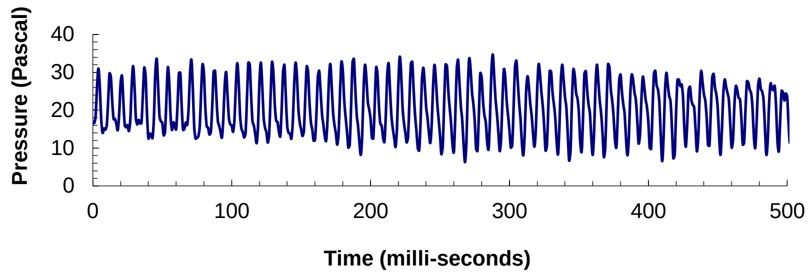

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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