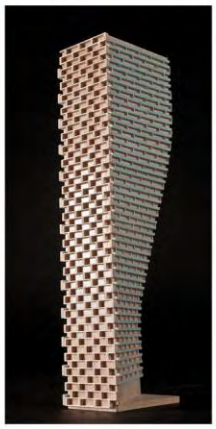
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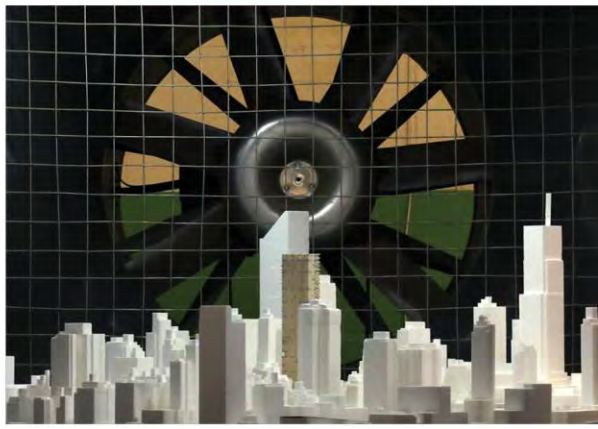
PEDESTRIAN LEVEL WIND STUDY

35 Plains Road East
Burlington, Ontario

REPORT: GW24-102-WTPLW







July 4, 2024

PREPARED FOR

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EXECUTIVE SUMMARY

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development located at 35 Plains Road East in Burlington, Ontario. 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. To evaluate the influence of the proposed development on the existing wind conditions surrounding the site, two massing configurations were studied: (i) *existing* scenario, including all approved, surrounding developments and without the proposed development, and (ii) *future* scenario with the proposed development in place. Grade-level areas investigated include sidewalks, walkways, driveways, landscaped spaces, patios, transit stops, outdoor amenities, parking areas, and building access points. Wind comfort is also evaluated over the rooftop outdoor amenity terrace. 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, City of Burlington wind criteria, architectural drawings provided by KFA Architects + Planners Inc. in May 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-4B, as well as Tables A1-A2 and B1-B2 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in the area, we conclude that wind conditions, with respect to the *future* scenario over most grade level pedestrian-sensitive areas within and surrounding the development site, will be acceptable for the intended pedestrian uses on an annual and seasonal basis. Exceptions include walkways and secondary access points near the northwest corner of the building, for which mitigation is recommended as described in Section 5.2. Additionally, to ensure the entire rooftop outdoor amenity terrace is suitable for sitting during the warmer months, mitigation is recommended as described in Section 5.2.

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 could be considered unsafe.

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1. INTRODUCTION

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed mixed-use development located at 35 Plains Road East in Burlington, Ontario, in support of an OPA/ZBA submission. Two conditions were studied: (i) *existing* scenario, including all approved, surrounding developments and without the proposed development, and (ii) *future* scenario with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, City of Burlington wind criteria, architectural drawings provided by KFA Architects + Planners Inc. in 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 pedestrian wind study is the proposed development located at 35 Plains Road East in Burlington, Ontario. The study site is located at the west corner of the intersection of Plains Road East and Cooke Boulevard.

The development comprises a 12-storey building with an "L"-shaped planform aligned longitudinally with Cooke Boulevard. A proposed driveway runs west-east along the north perimeter (relative to project north), perpendicular to Cooke Boulevard, providing access to a loading area, surface parking, and ramp to two levels of underground parking. The ground floor comprises a residential lobby to the east fronting Cooke Boulevard, retail spaces along the south and east elevations, and building support services in the remaining spaces. The upper levels are reserved for residential occupancy. At Level 2, the northern portion of the floorplate extends to the west and north to cover the driveway and loading area below. The building rises to full height, with setbacks from the west and north at Level 7, from the east and south at Level 8, and from all elevations at roof level, where a mechanical penthouse, a green roof, and a rooftop outdoor amenity complete 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 low- and mid-rise residential and commercial buildings in all directions, with future high-rise buildings approved directly west (1026 Cooke Boulevard, 29 storeys), to the north (53-71 Plains Road East & 1025 Cooke Boulevard, 10 and 12 storeys), and to the

east (40-70 Plains Road East, 12 storeys). The far-field surroundings (defined as the area beyond the near field and within a two-kilometre radius) include low-rise massing from the north-northeast clockwise to the southwest, the open exposure of Lake Ontario, which is situated approximately 900 m to the southeast, from the east clockwise to the south-southwest, and a mix of low-rise massing and green space in the remaining directions. Isolated clusters of mid-rise buildings are situated to the south-southwest along Plains Road West.

Grade-level areas investigated include sidewalks, walkways, driveways, landscaped spaces, patios, transit stops, outdoor amenities, parking areas, and building access points. Wind comfort is also evaluated over the rooftop outdoor amenity terrace. Figures 1A and 1B illustrate the study site and surrounding context for the existing and future test scenarios, 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 surrounding the site.

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 Burlington area wind climate and synthesis of wind tunnel data with industry-accepted guidelines. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort and safety guidelines.

4.1 Wind Tunnel Context Modelling

A detailed PLW study is performed to determine the influence of local winds at the pedestrian level for a proposed development. The physical model of the proposed development and relevant surroundings, illustrated in Photographs 1 through 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 60 sensor locations on the scale model in Gradient Wind's wind tunnel. Of these 60 sensors, 56 were located at grade and the remaining four sensors were located on the rooftop outdoor amenity terrace. Wind speed measurements were performed for each of the 60 sensors for 36 wind directions at 10° intervals. Figures 1A and 1B illustrate a plan of the site and relevant surrounding context for the existing and future test scenarios, respectively, while sensor locations used to investigate wind conditions are illustrated in Figures 2A through 4B.

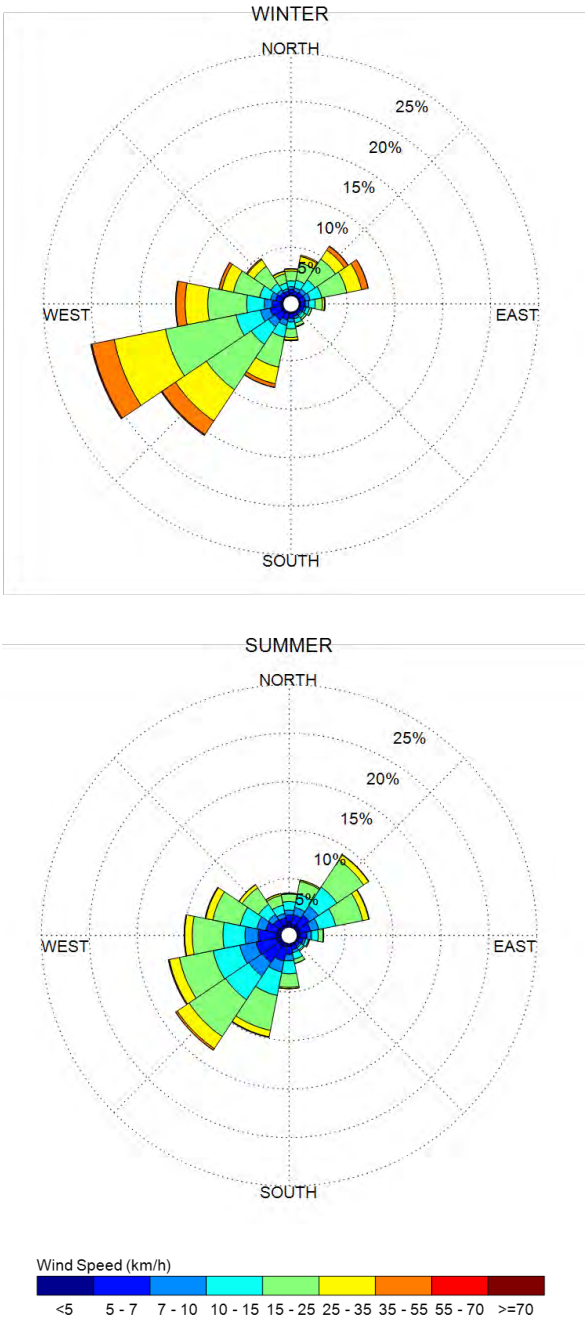
Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-second time period. This period at model-scale corresponds approximately to one hour in full-scale, which 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

A statistical model for winds in Burlington was developed from approximately 40-years of hourly meteorological wind data recorded at John C. Munro Hamilton International Airport, and obtained from the local branch of Atmospheric Environment Services of Environment Canada. Wind speed and direction data were analyzed for each month of the year in order to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Following the Pedestrian Level Wind Study Guidelines and Terms of Reference for Burlington, the year is represented by a two-season model, and not according to the traditional calendar method.

The statistical model of the Burlington 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 Burlington, the most common winds concerning pedestrian comfort occur from the southwest, followed by those from the northeast. The directional preference and relative magnitude of the wind speed varies somewhat from season to season, with the summer months displaying calmer winds relative to the winter.

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
JOHN C. MUNRO HAMILTON INTERNATIONAL AIRPORT, HAMILTON, 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) Strolling, (iv) Walking; and (v) 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 14 km/h (i.e. 10 km/h – 14 km/h) is acceptable for activities such as standing.

(iii) **Leisurely Walking (Strolling)** – A wind speed below 17 km/h (i.e. 14 km/h – 17 km/h) is acceptable for activities such as strolling.

(iv) **Fast Walking (Walking)**– A wind speed below 20 km/h (i.e. 17 km/h – 20 km/h) is acceptable for walking or more vigorous activities.

(v) **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 / Strolling
Outdoor Amenity Spaces	Sitting / Standing
Cafés / Patios / Benches / Gardens	Sitting / Standing / Strolling
Plazas	Strolling
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-A2 in Appendix A provide a summary of seasonal comfort predictions for each sensor location under the *existing* massing scenario. Similarly, Tables B1-B2 in Appendix B provide the seasonal comfort predictions for under the *future* 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 17-20 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, strolling, 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 4B. Conditions suitable for sitting are represented by the colour blue, while standing is represented by green, strolling by yellow, and walking by orange. Conditions considered uncomfortable for walking are represented by the colour magenta.

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-A2 in Appendix A and illustrated in Figures 2A through 2B, this section summarizes the significant findings of the PLW study with respect to the *existing scenario*, as follows:

1. Most public sidewalks, walkways, driveways, landscaped spaces, and parking areas within and surrounding the proposed development currently experience wind conditions suitable for walking or better throughout the year. Exceptions include portions of the driveway and walkway at the future 1026 Cooke Boulevard to the north (Sensors 2 and 4 & 5, respectively) and an isolated sidewalk portion along Cooke Boulevard to the northeast of the site (Sensor 38), which become uncomfortable for walking during the winter months.
2. The existing dog daycare backyard area at 1017 Waterdown Road to the southwest of the site (Sensor 21) is currently suitable for sitting during the summer months and standing during the winter months.
3. The nearby transit stop along Plains Road East to the east of the site (Sensor 34) currently experiences standing conditions during the summer months and walking conditions during the winter months.
4. The retail patio to the south of the site at 20 Plains Road East (Sensor 27) is currently suitable for sitting during the summer months and standing during the winter months.

5. The grade-level outdoor amenity at the future 1026 Cooke Boulevard (Sensor 9) is currently suitable for sitting during the summer months and standing during the winter months.
6. 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 – *Future Scenario*

Based on the analysis of the measured data, consideration of local climate data, and the suitability descriptors provided in Tables B1-B2 in Appendix B and illustrated in Figures 3A through 4B, this section summarizes the significant findings of the PLW study with respect to the *future scenario*, as follows:

1. Most public sidewalks, walkways, driveways, landscaped spaces, and parking areas within and surrounding the proposed development will experience wind conditions suitable for walking or better throughout the year, which is acceptable for the intended uses of spaces. Exceptions include an isolated sidewalk portion along Plains Road East (Sensor 16), driveway and walkway portions at the future 1026 Cooke Boulevard (Sensors 2, 4, 5, & 7), and on the north side of the study site (Sensors 7, 43, 44, & 54), which exceed the walking criterion during the winter months.

   It is noteworthy that exceedances of the walking criterion are generally marginal (< 2km/h), restricted to the colder months, and all wind speeds remain safe. The uncomfortable conditions at the future 1026 Cooke Boulevard (Sensors 2, 4, 5, & 7) are largely pre-existing. Therefore, the noted wind conditions are considered acceptable. Similarly, considering the marginality of the exceedances, the noted conditions at the sidewalk portion along Plains Road East (Sensor 16) and surface parking internal to the development (Sensor 43) are considered acceptable without mitigation.

   For the covered northwest corner of the study building (Sensor 44 & 54), it is recommended to provide staggered windscreens along the walkway to buffer winds accelerating around the building corner. Barriers may take the form of high-solidity wind screens and should rise at least 1.8 metres at the time of installation. The exact composition and configuration of these and other mitigations in the following paragraphs can be coordinated with the design team as the landscape plans develop.

2. The residential lobby and all retail entrances (Sensors 45-49) will be suitable for standing or better throughout the year, which is appropriate.

   All secondary building access points (including vehicular entrances, building exits, and loading areas) will generally be suitable for walking or better on a seasonal basis, which is acceptable. Exceptions include the stairwell exit and portion of loading area near the northwest corner of the building (Sensors 44 and 54) where wind conditions will be uncomfortable during the winter. The mitigation recommended in Item 1, above, will ensure suitable conditions at these access points.

3. The existing dog daycare backyard area at 1017 Waterdown Road to the southwest of the site (Sensor 21) will experience sitting conditions on a seasonal basis, which is an improvement from *existing* conditions and acceptable for the intended use of space.

4. The nearby transit stop along Plains Road East to the east of the site (Sensor 34) will be suitable for standing or better throughout the year, which is ideal and represents an improvement from the *existing* conditions.

5. The existing retail patio to the south at 20 Plains Road East (Sensor 27) will remain suitable for sitting during the summer months and standing during the winter months, which is acceptable.

6. The grade-level outdoor amenity at the future 1026 Cooke Boulevard (Sensor 9) will remain suitable for sitting during the summer months and standing during the winter, which is appropriate for the intended use of space.

7. The rooftop outdoor amenity (Sensors 57-60) will experience a mix of sitting and standing wind conditions during the summer months, with standing conditions at the central portion to the east (Sensors 58 & 59). If sitting conditions are desired in these areas, it is recommended to raise the proposed amenity fencing, as delineated in the architectural plan, to at least 2.0 metres above the walking surface along the east perimeter of the amenity.

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

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind study for a proposed development located at 35 Plains Road East in Burlington, 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-4B, as well as Tables A1-A2 and B1-B2 in the appendices. Based on wind tunnel test results, meteorological data analysis, and experience with similar developments in the area, we conclude that wind conditions, with respect to the *future* scenario over most grade level pedestrian-sensitive areas within and surrounding the development site, will be acceptable for the intended pedestrian uses on an annual and seasonal basis. Exceptions include walkways and secondary access points near the northwest corner of the building, for which mitigation is recommended as described in Section 5.2. Additionally, to ensure the entire rooftop outdoor amenity terrace is suitable for sitting during the warmer months, mitigation is recommended as described in Section 5.2.

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 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.



Cristiano Kondo, MESc.,
Junior Wind Scientist

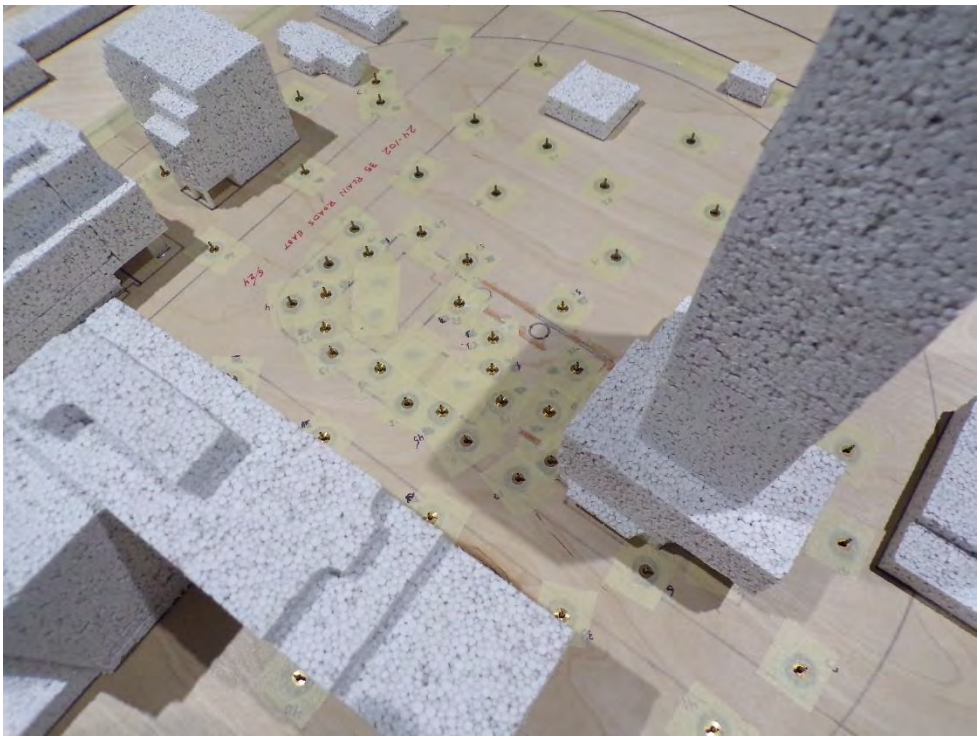


Nick Petersen, P.Eng.,
Wind Engineer



Angelina Gomes, B.Eng.,
Wind Scientist

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



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



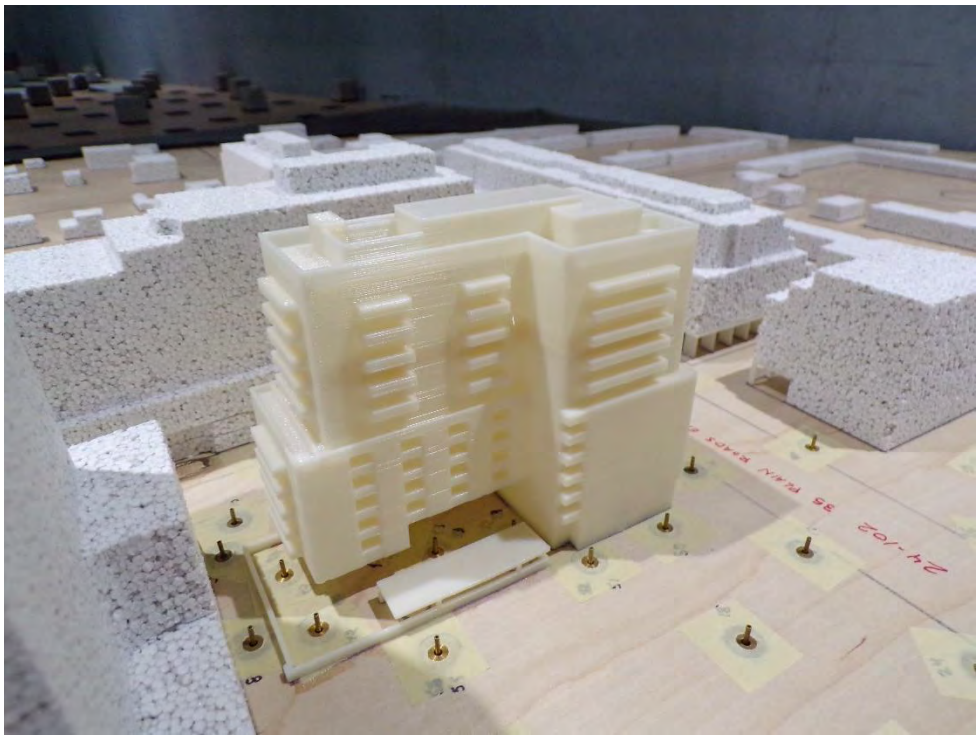
PHOTOGRAPH 3: FUTURE STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING DOWNWIND



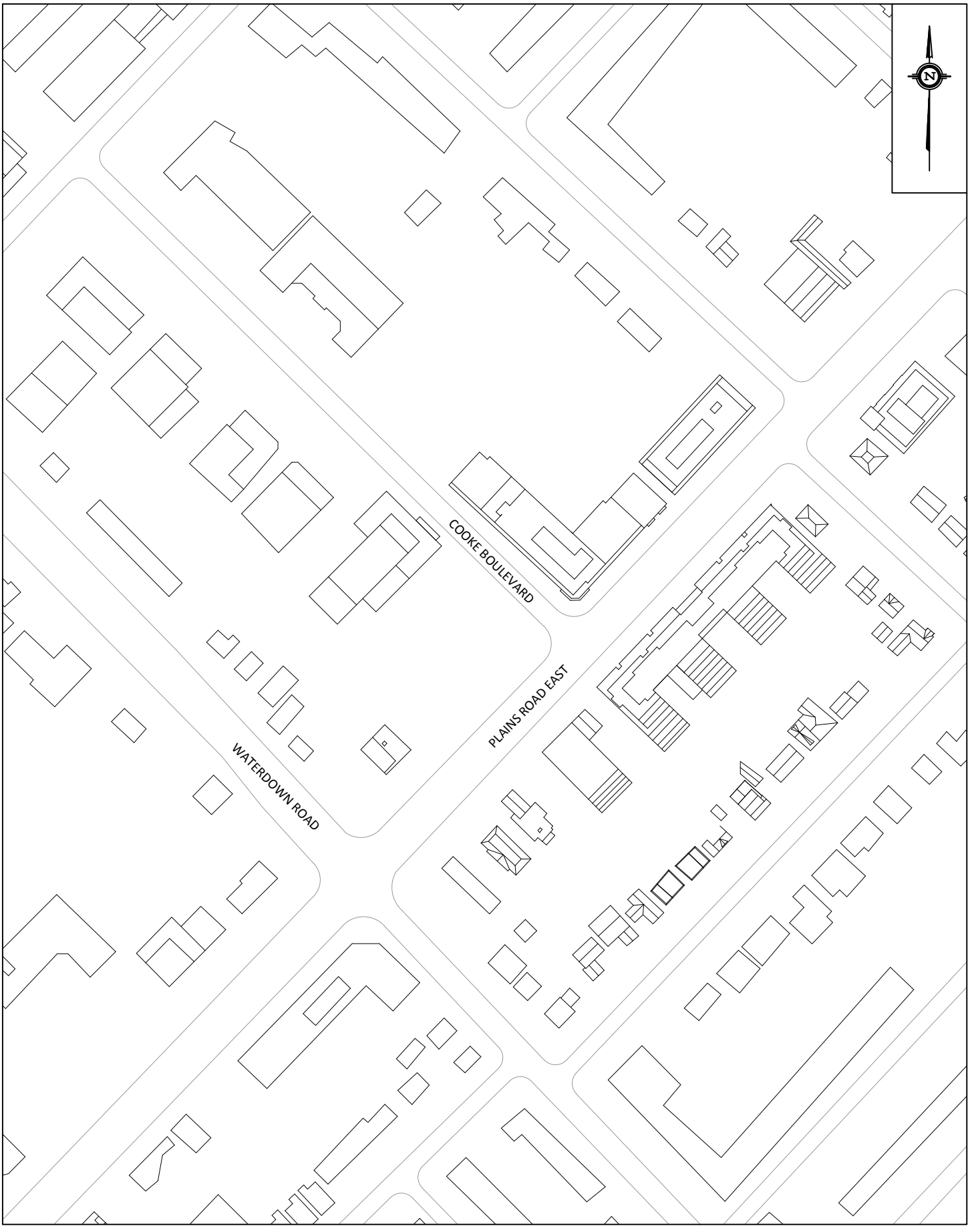
PHOTOGRAPH 4: FUTURE STUDY MODEL INSIDE THE GWE WIND TUNNEL LOOKING UPWIND



PHOTOGRAPH 5: CLOSE-UP VIEW OF FUTURE STUDY MODEL LOOKING SOUTHWEST



PHOTOGRAPH 6: CLOSE-UP VIEW OF FUTURE STUDY MODEL LOOKING NORTHEAST

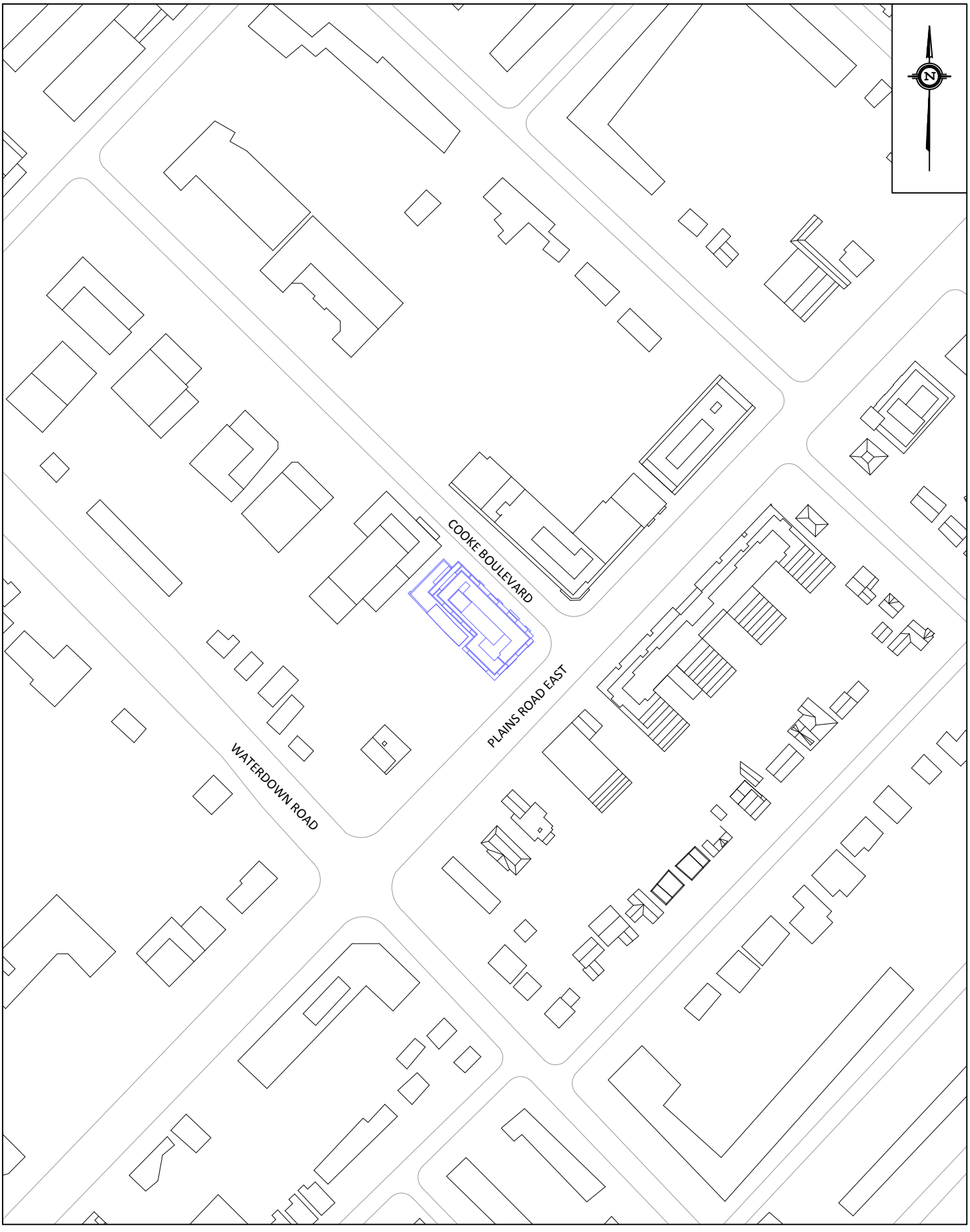


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SCALE	1:2500 (APPROX.)
DRAWING NO.	GW24-102-PLW-1A
DATE	JUNE 17, 2024
DRAWN BY	K.A.

DESCRIPTION

FIGURE 1A:
EXISTING SCENARIO
AND SURROUNDING CONTEXT



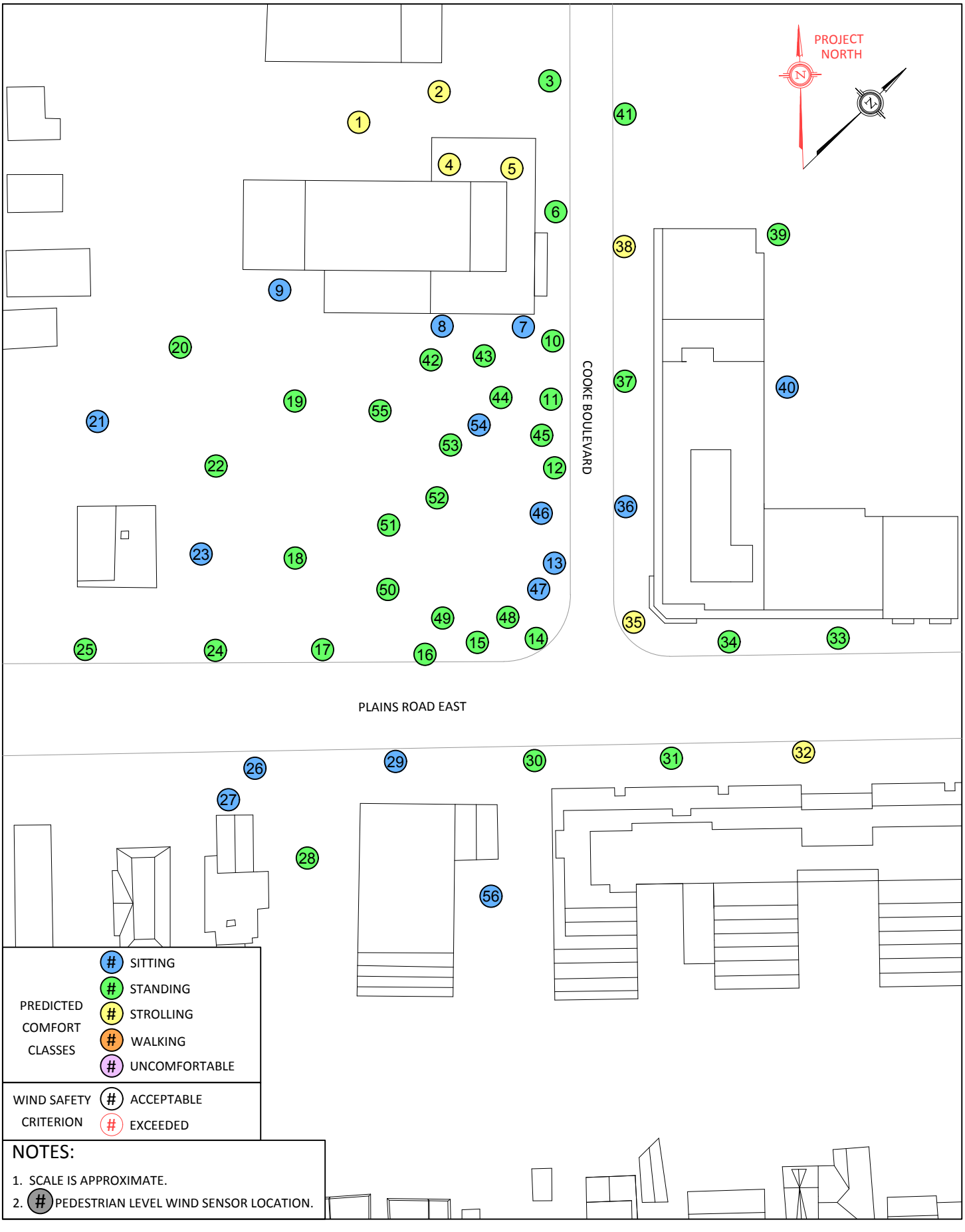
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DESCRIPTION

FIGURE 1B:
FUTURE SCENARIO
AND SURROUNDING CONTEXT



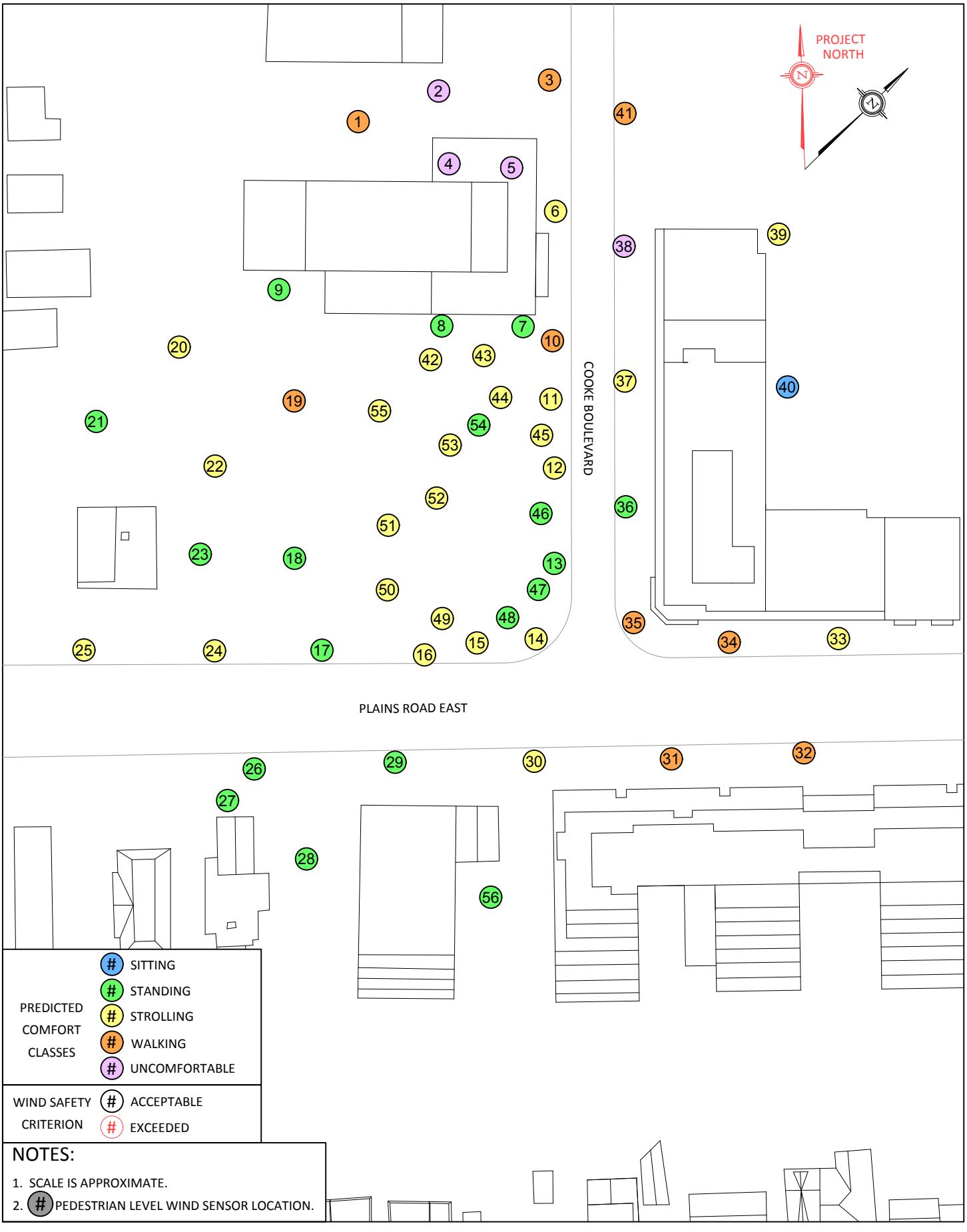
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DESCRIPTION

FIGURE 2A: SUMMER
EXISTING GRADE LEVEL PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



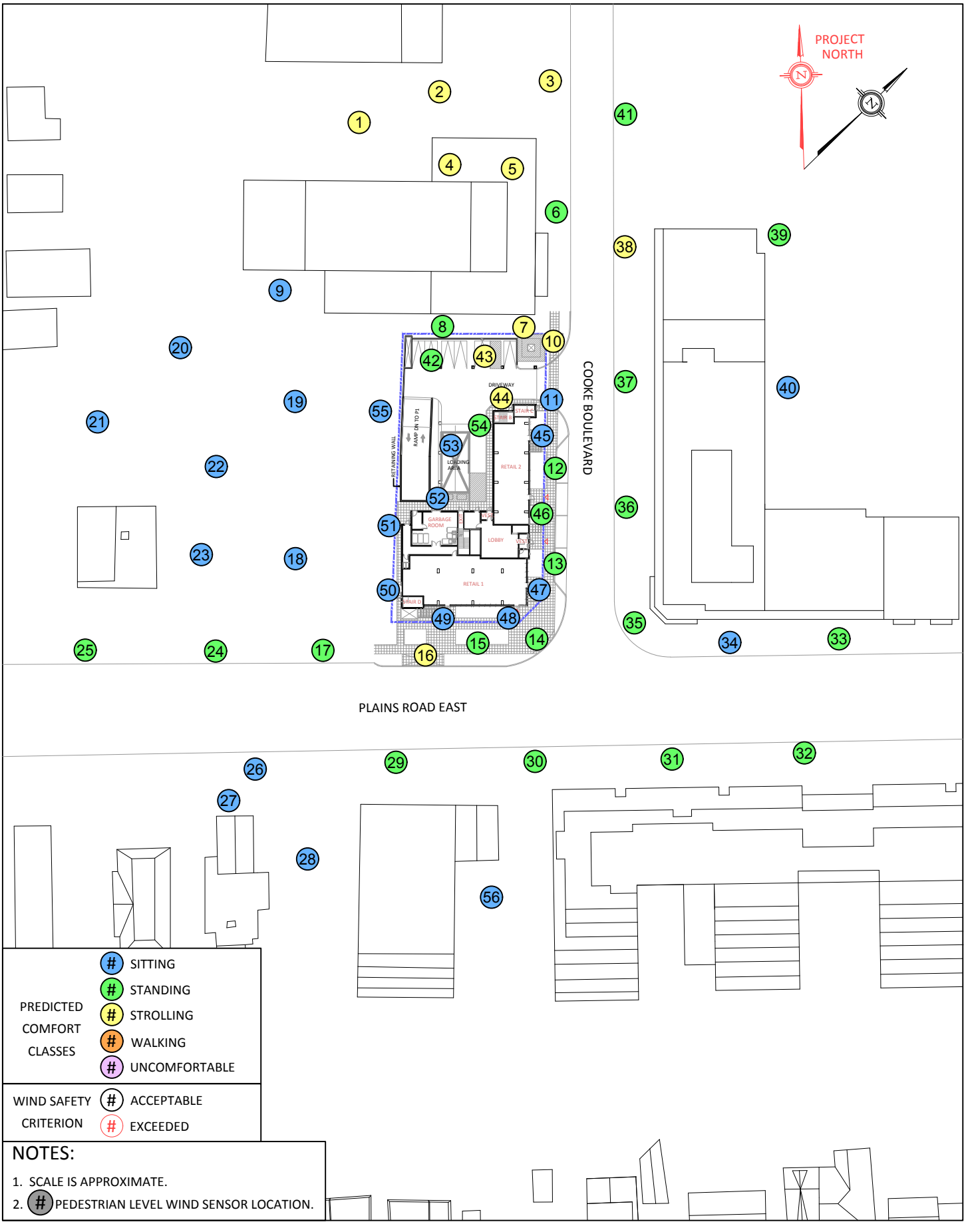
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DESCRIPTION

FIGURE 2B: WINTER
EXISTING GRADE LEVEL PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS

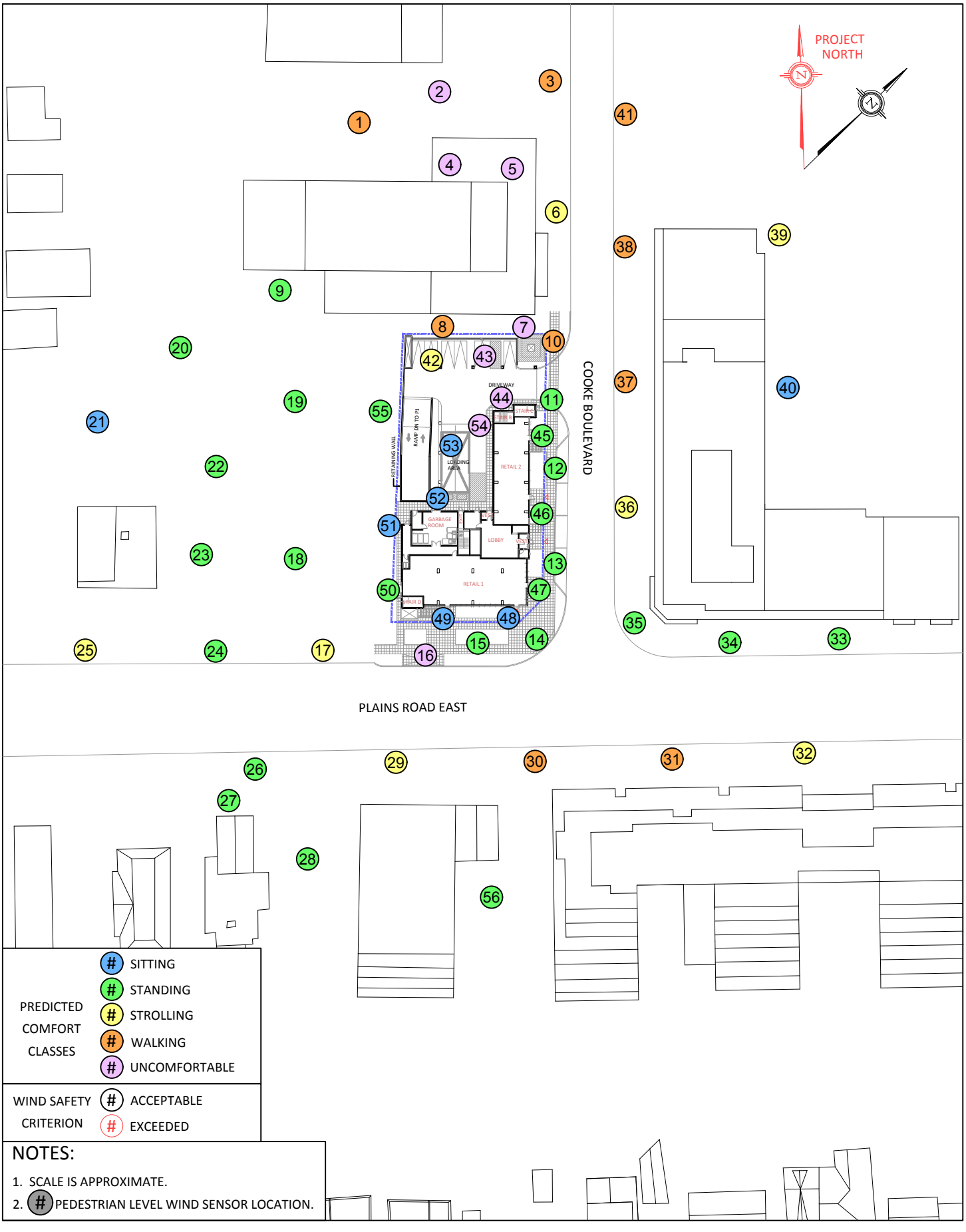


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FIGURE 3A: SUMMER
FUTURE GRADE LEVEL PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



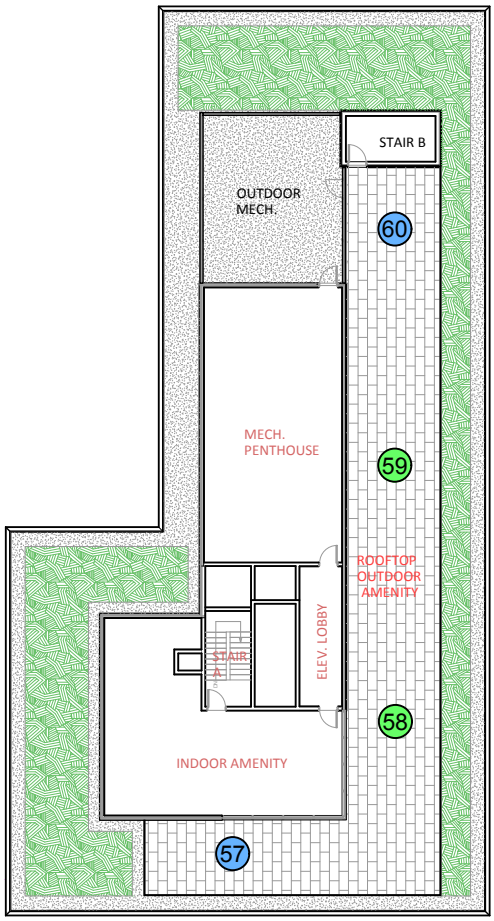
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DESCRIPTION

FIGURE 3B: WINTER
FUTURE GRADE LEVEL PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



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

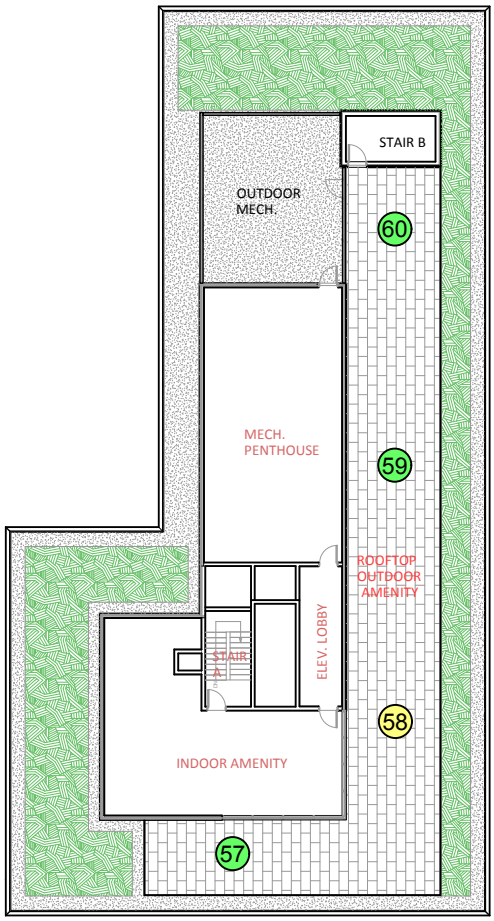
NOTES:

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

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PROJECT	35 PLAINS ROAD EAST, BURLINGTON PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION
SCALE	1:400 (APPROX.)	DRAWING NO.	GW24-102-PLW-4A
DATE	JUNE 17, 2024	DRAWN BY	K.A.

FIGURE 4A: SUMMER
FUTURE TERRACE PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



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

NOTES:

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

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PROJECT	35 PLAINS ROAD EAST, BURLINGTON PEDESTRIAN LEVEL WIND STUDY
SCALE	1:400 (APPROX.)
DRAWING NO.	GW24-102-PLW-4B
DATE	JUNE 17, 2024
DRAWN BY	K.A.

DESCRIPTION

FIGURE 4B: WINTER
FUTURE TERRACE PLW SENSOR LAYOUT
PEDESTRIAN COMFORT PREDICTIONS



APPENDIX A

PEDESTRIAN COMFORT SUITABILITY, TABLES A1-A2 (EXISTING SCENARIO)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

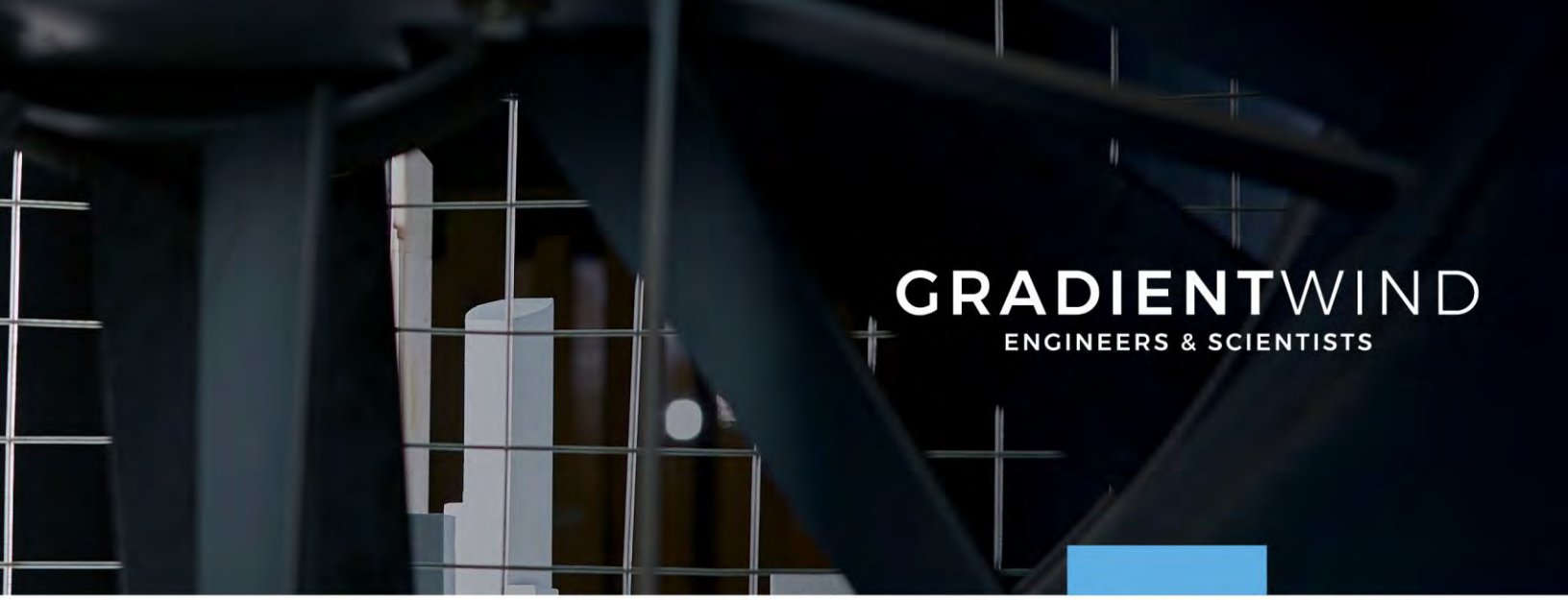
TABLE A1: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	14.2	Strolling	17.8	Walking	59.6	Safe
2	15.6	Strolling	20.2	Uncomfortable	62.3	Safe
3	13.0	Standing	18.0	Walking	61.5	Safe
4	15.1	Strolling	21.4	Uncomfortable	72.7	Safe
5	16.8	Strolling	23.7	Uncomfortable	80.7	Safe
6	12.4	Standing	15.9	Strolling	60.8	Safe
7	8.7	Sitting	11.9	Standing	49.0	Safe
8	9.6	Sitting	13.2	Standing	54.2	Safe
9	7.8	Sitting	11.0	Standing	57.1	Safe
10	13.5	Standing	17.6	Walking	59.1	Safe
11	11.9	Standing	15.7	Strolling	56.5	Safe
12	10.8	Standing	14.1	Strolling	52.5	Safe
13	9.3	Sitting	12.4	Standing	47.2	Safe
14	10.9	Standing	14.3	Strolling	54.4	Safe
15	11.5	Standing	15.4	Strolling	56.0	Safe
16	11.8	Standing	15.7	Strolling	54.7	Safe
17	10.5	Standing	13.8	Standing	51.8	Safe
18	10.3	Standing	14.0	Standing	51.2	Safe
19	13.3	Standing	19.6	Walking	69.2	Safe
20	11.5	Standing	15.9	Strolling	55.0	Safe
21	8.7	Sitting	11.6	Standing	48.8	Safe
22	11.5	Standing	15.9	Strolling	54.2	Safe
23	8.2	Sitting	10.8	Standing	42.9	Safe
24	10.6	Standing	14.2	Strolling	49.3	Safe
25	11.7	Standing	16.5	Strolling	55.0	Safe
26	9.0	Sitting	12.2	Standing	44.8	Safe
27	8.1	Sitting	11.4	Standing	46.4	Safe
28	10.2	Standing	13.9	Standing	53.4	Safe
29	9.4	Sitting	12.7	Standing	48.5	Safe
30	11.1	Standing	15.2	Strolling	51.6	Safe
31	12.7	Standing	17.3	Walking	59.2	Safe
32	14.4	Strolling	19.7	Walking	67.7	Safe
33	12.0	Standing	15.1	Strolling	56.5	Safe
34	13.4	Standing	18.2	Walking	73.5	Safe
35	14.2	Strolling	19.7	Walking	68.1	Safe

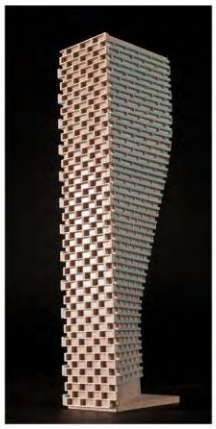
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

TABLE A2: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

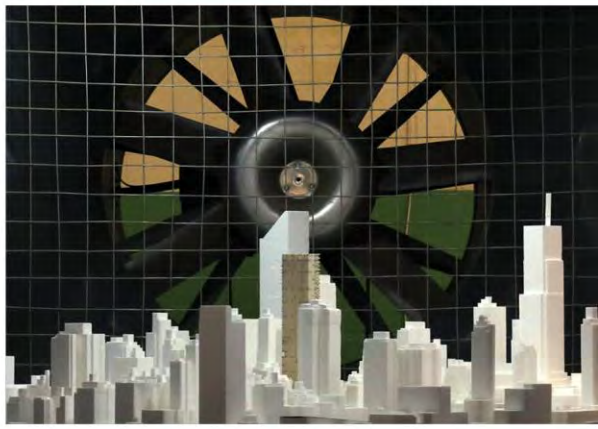
Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	9.2	Sitting	12.3	Standing	53.2	Safe
37	11.5	Standing	15.9	Strolling	68.9	Safe
38	16.8	Strolling	22.2	Uncomfortable	74.5	Safe
39	11.5	Standing	15.3	Strolling	59.8	Safe
40	7.1	Sitting	9.7	Sitting	39.5	Safe
41	13.8	Standing	18.5	Walking	64.0	Safe
42	10.9	Standing	15.8	Strolling	67.5	Safe
43	10.3	Standing	14.3	Strolling	57.2	Safe
44	10.6	Standing	14.7	Strolling	59.6	Safe
45	11.0	Standing	14.5	Strolling	56.3	Safe
46	9.6	Sitting	12.6	Standing	51.1	Safe
47	10.0	Sitting	13.3	Standing	51.5	Safe
48	10.6	Standing	13.9	Standing	54.8	Safe
49	11.3	Standing	15.0	Strolling	54.1	Safe
50	11.4	Standing	15.1	Strolling	53.9	Safe
51	10.4	Standing	14.6	Strolling	55.4	Safe
52	10.4	Standing	14.7	Strolling	59.7	Safe
53	10.9	Standing	15.5	Strolling	62.3	Safe
54	9.7	Sitting	13.6	Standing	59.6	Safe
55	11.4	Standing	16.8	Strolling	66.3	Safe
56	9.3	Sitting	11.9	Standing	51.5	Safe











APPENDIX B

PEDESTRIAN COMFORT SUITABILITY, TABLES B1-B2 (FUTURE SCENARIO)

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Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 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 (FUTURE SCENARIO)

Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	14.2	Strolling	17.8	Walking	61.7	Safe
2	15.9	Strolling	21.1	Uncomfortable	64.1	Safe
3	14.2	Strolling	19.4	Walking	62.2	Safe
4	14.6	Strolling	21.2	Uncomfortable	76.1	Safe
5	16.8	Strolling	23.9	Uncomfortable	77.3	Safe
6	11.1	Standing	14.2	Strolling	60.7	Safe
7	15.5	Strolling	21.7	Uncomfortable	70.5	Safe
8	13.8	Standing	19.2	Walking	62.6	Safe
9	7.6	Sitting	11.9	Standing	64.5	Safe
10	14.7	Strolling	20.0	Walking	65.5	Safe
11	9.6	Sitting	12.2	Standing	47.0	Safe
12	10.3	Standing	13.3	Standing	50.3	Safe
13	10.3	Standing	13.2	Standing	54.8	Safe
14	10.7	Standing	13.3	Standing	51.2	Safe
15	11.0	Standing	13.9	Standing	60.4	Safe
16	15.5	Strolling	21.5	Uncomfortable	78.7	Safe
17	12.5	Standing	16.7	Strolling	59.9	Safe
18	9.0	Sitting	12.4	Standing	48.8	Safe
19	9.8	Sitting	13.1	Standing	55.1	Safe
20	9.7	Sitting	13.2	Standing	52.9	Safe
21	7.4	Sitting	9.6	Sitting	52.8	Safe
22	8.6	Sitting	11.6	Standing	51.7	Safe
23	8.7	Sitting	11.6	Standing	43.2	Safe
24	10.2	Standing	13.6	Standing	51.1	Safe
25	11.0	Standing	15.1	Strolling	51.4	Safe
26	8.6	Sitting	11.7	Standing	44.5	Safe
27	7.6	Sitting	10.3	Standing	41.3	Safe
28	9.7	Sitting	13.5	Standing	51.5	Safe
29	10.9	Standing	14.8	Strolling	53.6	Safe
30	13.7	Standing	19.5	Walking	72.0	Safe
31	12.7	Standing	18.3	Walking	72.9	Safe
32	12.0	Standing	16.1	Strolling	60.6	Safe
33	10.7	Standing	12.8	Standing	53.4	Safe
34	9.8	Sitting	12.0	Standing	51.0	Safe
35	10.2	Standing	13.1	Standing	51.5	Safe

Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 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 (FUTURE SCENARIO)

Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	12.2	Standing	16.7	Strolling	62.8	Safe
37	12.6	Standing	17.6	Walking	69.0	Safe
38	14.3	Strolling	19.4	Walking	70.6	Safe
39	11.0	Standing	15.7	Strolling	60.6	Safe
40	6.7	Sitting	8.9	Sitting	38.8	Safe
41	13.3	Standing	18.8	Walking	65.4	Safe
42	11.5	Standing	16.2	Strolling	55.8	Safe
43	14.6	Strolling	21.0	Uncomfortable	68.6	Safe
44	15.5	Strolling	21.9	Uncomfortable	86.2	Safe
45	9.7	Sitting	12.6	Standing	47.1	Safe
46	10.3	Standing	12.9	Standing	54.4	Safe
47	8.8	Sitting	11.0	Standing	46.1	Safe
48	8.1	Sitting	10.0	Sitting	52.8	Safe
49	7.6	Sitting	9.5	Sitting	52.5	Safe
50	9.4	Sitting	13.9	Standing	59.2	Safe
51	7.1	Sitting	9.7	Sitting	41.2	Safe
52	5.5	Sitting	7.4	Sitting	27.5	Safe
53	6.0	Sitting	8.3	Sitting	32.2	Safe
54	13.7	Standing	20.4	Uncomfortable	70.2	Safe
55	8.5	Sitting	11.5	Standing	46.8	Safe
56	9.4	Sitting	12.1	Standing	50.0	Safe
57	8.4	Sitting	10.8	Standing	47.1	Safe
58	12.0	Standing	15.2	Strolling	58.0	Safe
59	10.3	Standing	13.2	Standing	56.6	Safe
60	8.2	Sitting	10.5	Standing	48.8	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; U = mean wind speed, U_g = gradient wind speed, Z = height above ground, Z_g = depth of the boundary layer (gradient height) and α is the power law exponent.

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

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

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

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.

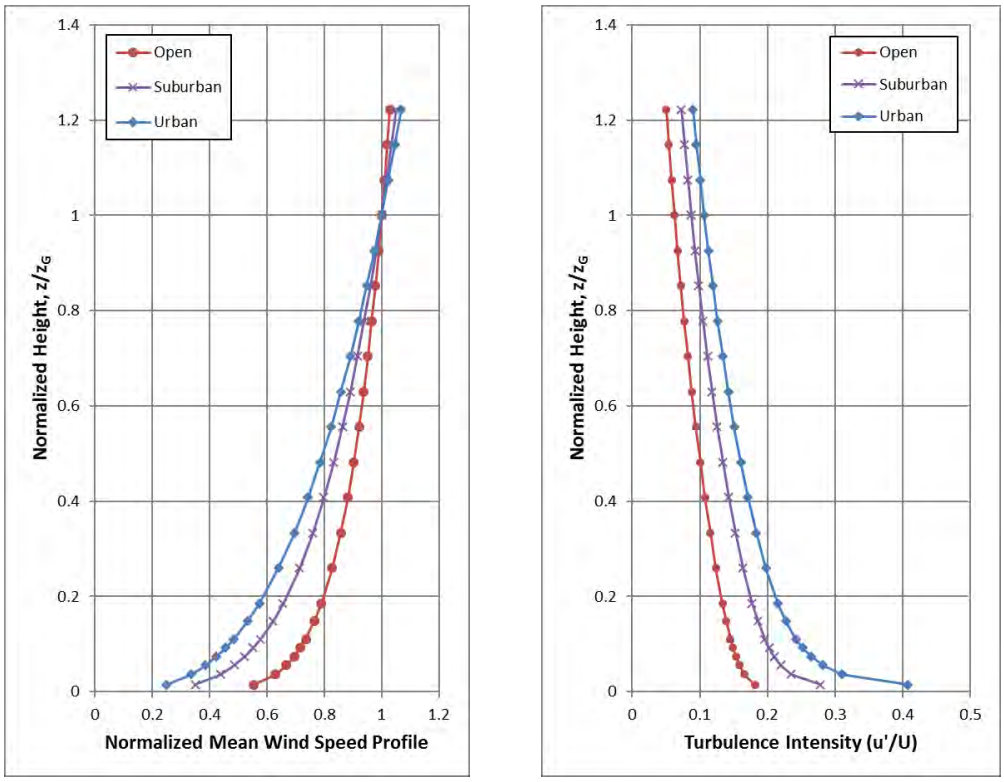


FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES

REFERENCES

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

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

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

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



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:

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

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

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.

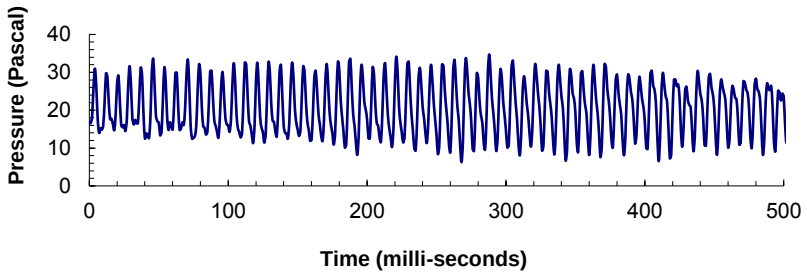


FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

REFERENCES

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

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