GRADIENTWIND
ENGINEERS & SCIENTISTS

March 1, 2024

Hamilton 188 GP Inc. c/o Vantage Developments Inc.
9 Kintyre Avenue,
Toronto, ON M4M 1M2

Re: Pedestrian Level Wind Opinion Letter
188 Cannon Street East, Hamilton, ON
GWE File No.: 24-021 PLW OL

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Hamilton 188 GP Inc. c/o Vantage Developments Inc. to undertake a preliminary pedestrian wind assessment for the proposed residential development located at 188 Cannon Street East in Hamilton, Ontario. This letter intends to provide a professional opinion regarding anticipated pedestrian wind conditions for the site based on drawings provided by Arcadis Architects Inc. in February 2024, consideration of existing and approved surrounding developments, statistical knowledge of the Hamilton wind climate, and experience with similar projects in Hamilton.

The development site is located on the southeast corner of the intersection of Cannon Street East and Ferguson Ave North. In the near-field, the site is surrounded primarily by low-rise residential buildings in all directions, with a 12-storey building at 80 Cathcart Street to the southeast and an 18-storey building to the south at 125 Wellington Street North. The far-field surroundings (beyond the near-field and within a two-kilometre radius) are mostly characterized by low-rise suburban exposure in all directions, with Lake Ontario located at approximately 2.0 kilometres distant in the north quadrant, the Hamilton escarpment at less than 1.5 kilometres in the south quadrant, and the denser Hamilton downtown core n the southwest quadrant. The site wind conditions are also influenced by the local wind climate, defined statistically in a figure following the main text.

The proposed development comprises a 32-storey tower building with an approximate rectangular planform. Two existing 2-storey retail spaces are retained at the southwest corner of the site. A loading area, surface parking, and four levels of above-ground parking are accessed via the alleyway along the east elevation. The ground floor comprises a lobby to the northwest fronting Cannon Street East, an indoor amenity to the north, and building support services in the remaining spaces. Levels 2-5 comprise residential units along the west elevation, in addition to the internal parking. The floorplate sets back from all elevations at Level 6, accommodating outdoor and indoor amenities to the southeast, and residential units with private terraces elsewhere. The residential floorplate rises to the full height, with a setback from the south at Level 13, and is completed with a mechanical penthouse.

Pedestrian wind comfort is determined by three main factors, including (i) the geometry and orientation of the study building, (ii) shielding and channeling effects created by the massing and relative spacing of surrounding buildings, and (iii) the alignment of the study building with respect to statistically prominent wind directions. For Hamilton, the most common winds occur from the southwest, followed by those from the northeast. The directional preference and relative magnitude of wind speed change somewhat from season to season.

Prominent southwesterly and northeasterly winds will approach the site with minimal obstruction due to the low-rise surrounding massing in these directions, notably to the immediate west with the adjacent open park and parking space, however, the more distant downtown core and escarpment will also serve to buffer these winds. The proposed development will rise significantly above the surrounding massing, resulting in the capture and redirection of higher-level wind flows toward the grade, although this will be somewhat mitigated by the tower setback from the podium façade along all elevations at Level 6.

Overall, the various sidewalk and parking areas along Cannon Street East and Ferguson Avenue North (Tags A & B) are generally expected to be comfortable for standing or better during the summer and strolling or walking during the winter, with the windiest conditions occurring at the intersection where prevailing winds will accelerate around the northwest corner of the building. The noted conditions are acceptable. Closer to the building façade and including the building access points (Tags B & C) conditions are expected to be slightly calmer with added protection provided by the study building, generally being comfortable for standing or strolling on a seasonal basis, with modestly windier conditions possible at the building corners. Should the primary lobby entrance at the northwest building corner exceed the standing criterion, a wraparound canopy would be recommended. The alleyway to the east and private yards to the south of the building (Tags E & F) are somewhat more sheltered from prevailing winds and expected to be suitable primarily for sitting during the summer and standing or better during the winter, which is acceptable.

Concerning the Level 6 outdoor amenity (Tag G), the terrace is exposed to prominent southwesterly and northeasterly wind, hence, it is expected to experience a mix of sitting and standing conditions during the summer. To ensure conditions suitable for sitting or more sedentary activities over the full terrace, it will likely be necessary to provide mitigation, such as raised perimeter guards and overhead pergolas near seating areas, particularly in the southeast corner area, where windier conditions are likely to occur.

Overall, the site is expected to experience minor exceedances of the wind comfort criteria with conventional mitigatory solutions being applicable. The foregoing opinions are based on knowledge and experience of wind flow patterns around buildings. While these statements are expected to be reliable for the site as a whole. This concludes our preliminary assessment. Please advise the undersigned of any questions or comments.

Sincerely,

Gradient Wind Engineering Inc.

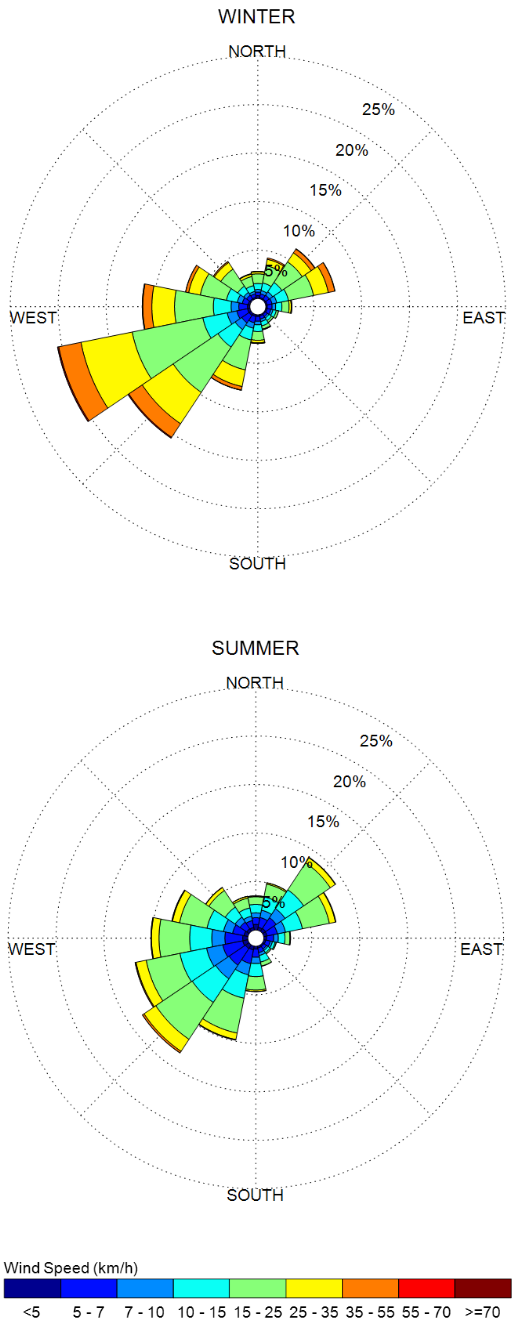
Cristiano Kondo

Cristiano Kondo, MESc.,
Junior Wind Scientist

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

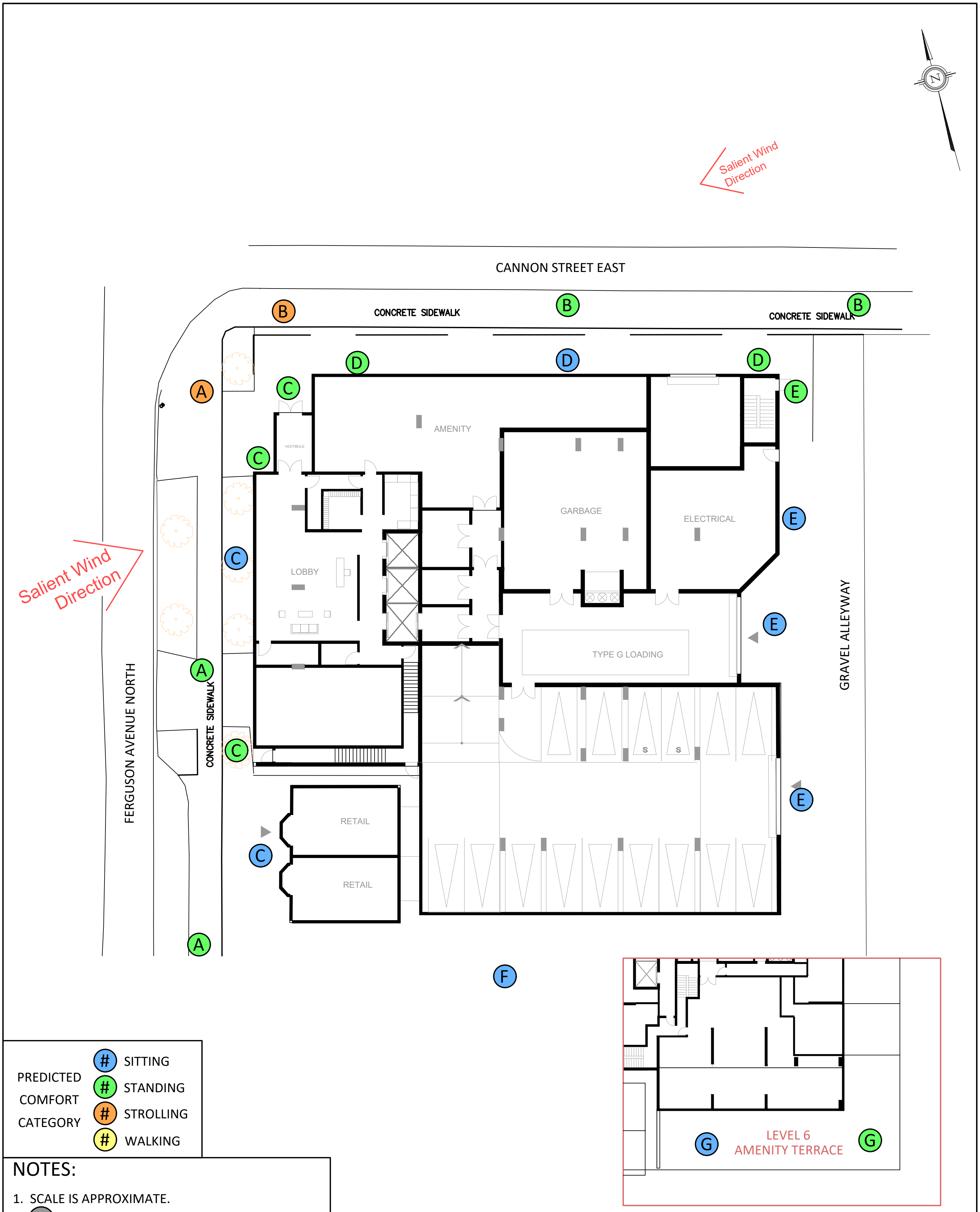
24-021 PLW OL

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
HAMILTON INTERNATIONAL AIRPORT, HAMILTON, ONTARIO



Notes:

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



PREDICTED COMFORT CATEGORY

- 🔵 # SITTING
- 🟢 # STANDING
- 🟠 # STROLLING
- 🟡 # WALKING

NOTES:

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

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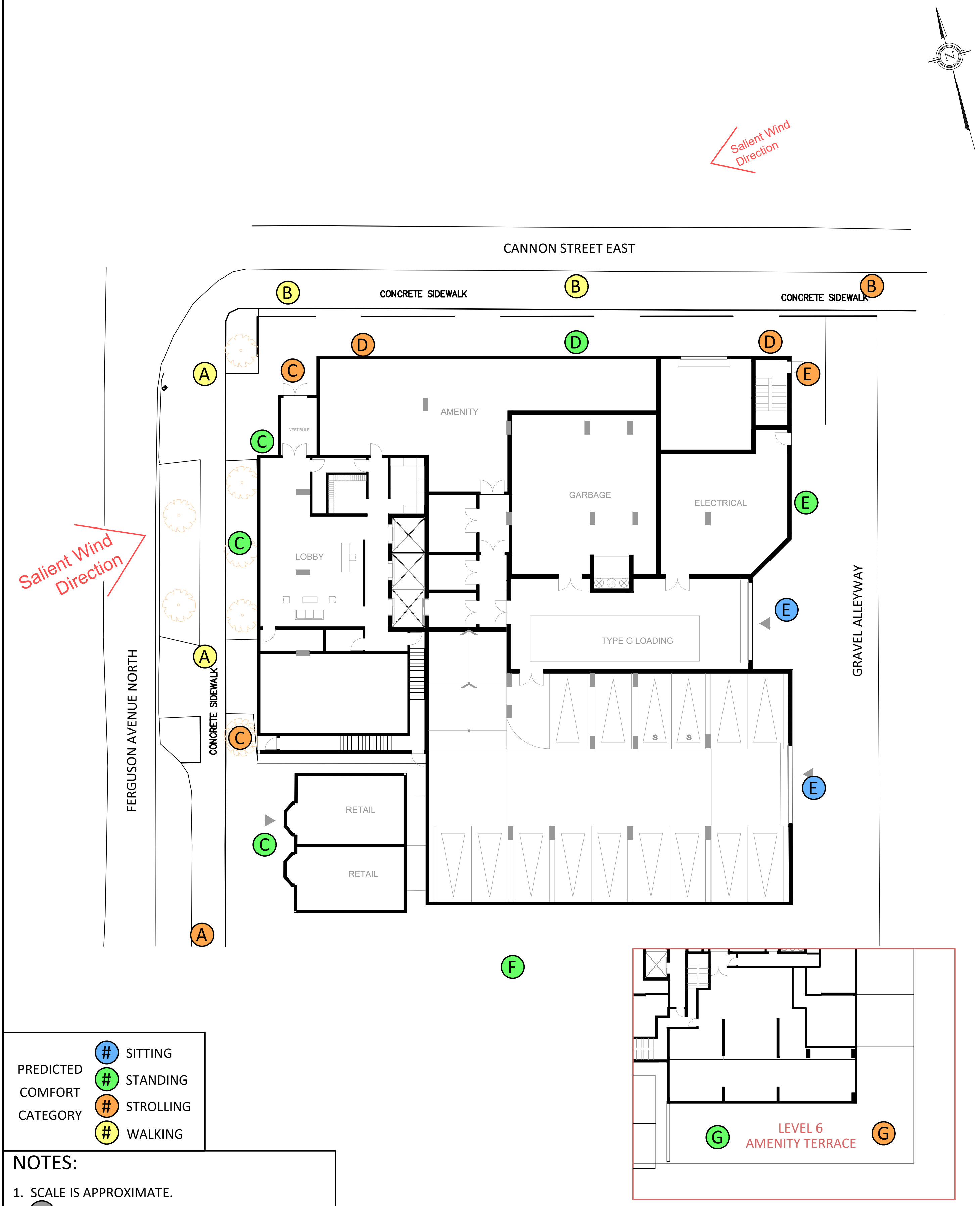
PROJECT 188 CANNON STREET EAST, HAMILTON PEDESTRIAN LEVEL WIND ASSESSMENT		DESCRIPTION FIGURE 1: SITE PLAN SUMMER - PEDESTRIAN COMFORT PREDICTIONS
SCALE N.A.	DRAWING NO. GW24-021-PLWOL-1	
DATE MARCH 1, 2024	DRAWN BY C.K.	



PREDICTED COMFORT CATEGORY

- 🔵 # SITTING
- 🟢 # STANDING
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NOTES:

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PROJECT
188 CANNON STREET EAST, HAMILTON
PEDESTRIAN LEVEL WIND ASSESSMENT

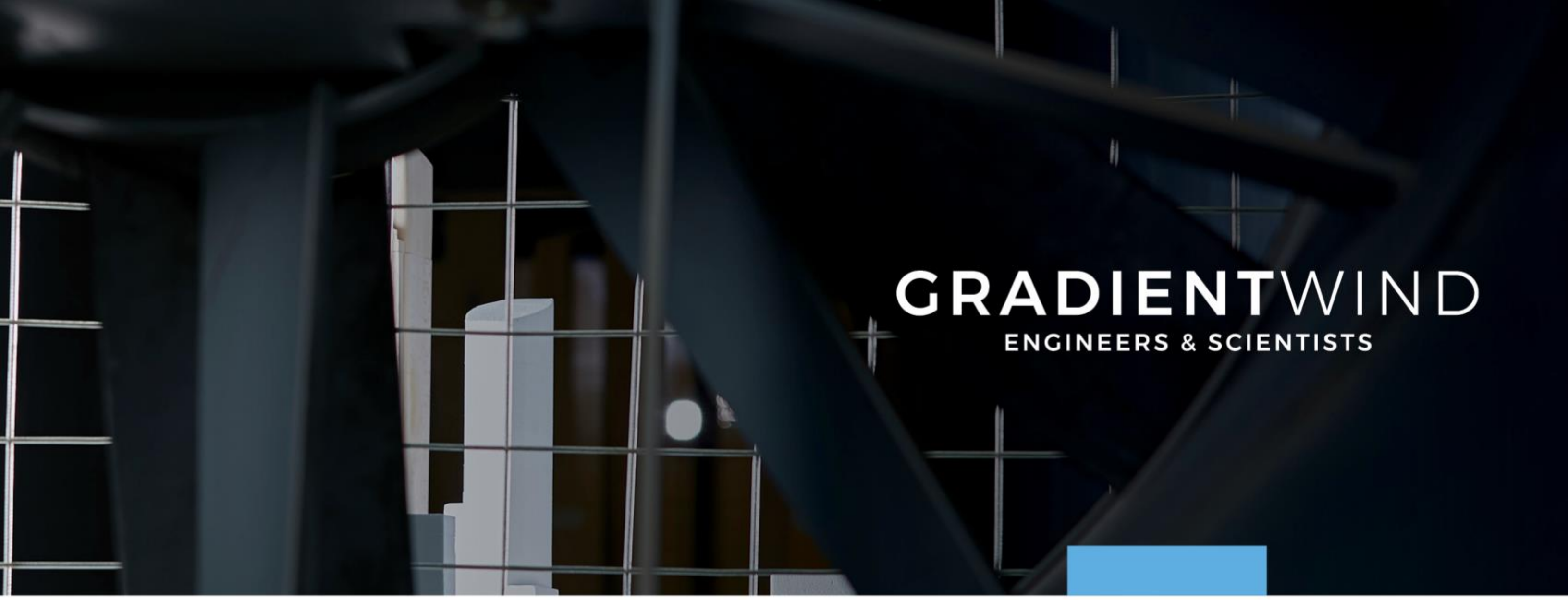
SCALE
N.A.

DRAWING NO.
GW24-021-PLWOL-2

DATE
MARCH 1, 2024

DRAWN BY
C.K.

DESCRIPTION
FIGURE 2:
SITE PLAN
WINTER - PEDESTRIAN COMFORT PREDICTIONS



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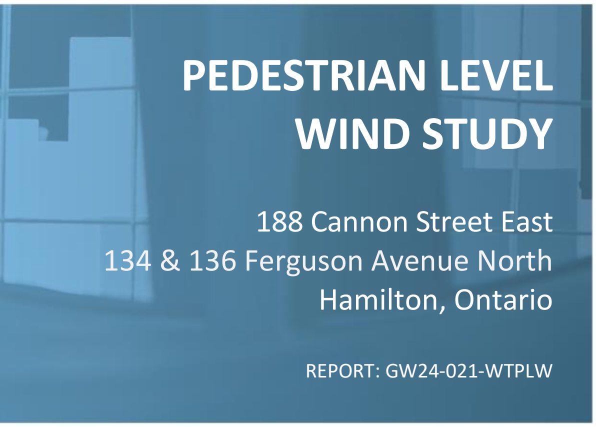
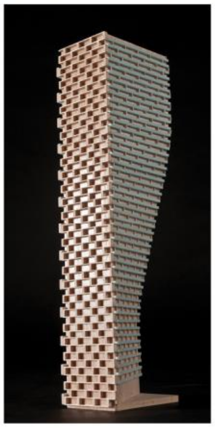
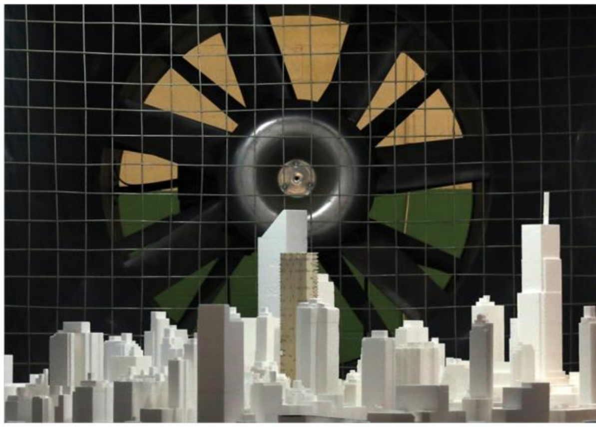


PEDESTRIAN LEVEL WIND STUDY

188 Cannon Street East
134 & 136 Ferguson Avenue North
Hamilton, Ontario

REPORT: GW24-021-WTPLW





April 12, 2024

PREPARED FOR
Hamilton 188 GP Inc.
c/o Vantage Developments
9 Kintyre Avenue
Toronto, Ontario
M4M 1M2

PREPARED BY
Cristiano Kondo, MESc., Junior Wind Scientist
Nick Petersen, P.Eng., Wind Engineer

EXECUTIVE SUMMARY

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed residential development located at 188 Cannon Street E and 134 & 136 Ferguson Avenue N in Hamilton, 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. Grade-level areas investigated include sidewalks, walkways, laneways, landscaped areas, parking spaces, transit stops, and building access points. Wind comfort is also evaluated over the Level 6 and 13 terraces. To evaluate the influence of the proposed development on the existing wind conditions surrounding the site, two massing configurations were studied: (i) existing conditions without the proposed development, and (ii) conditions with the proposed development in place. 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 Hamilton wind criteria, architectural drawings provided by Arcadis in March 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 5.2 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 conditions 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 portions of the sidewalks/walkways at the northwest corner of the development and the adjacent lobby access point, for which mitigation is recommended as described in Section 5.2. To ensure the entire Level 6 outdoor amenity will be suitable for sitting or more sedentary activities during the summer 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, apart from the noted southeast corner of the study building, were found to experience wind conditions that are considered unsafe.

TABLE OF CONTENTS

1. INTRODUCTION

This report describes a pedestrian level wind study undertaken to assess wind conditions for a proposed residential development located at 188 Cannon Street E and 134 & 136 Ferguson Avenue N in Hamilton, Ontario, in support of a site plan application. Two conditions were studied: (i) existing conditions, including all approved, surrounding developments and without the proposed development, and (ii) conditions with the proposed development in place. The study was performed in accordance with industry standard wind tunnel testing techniques, City of Hamilton wind criteria, architectural drawings provided by Arcadis in March 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 188 Cannon Street East in Hamilton, Ontario. The study site is located on the southeast corner of the intersection of Cannon Street East and Ferguson Ave North. Two existing 2-storey retail spaces are retained at the southwest corner of the site.

The proposed development comprises a 32-storey tower building with an approximately rectangular planform. A loading area, surface parking, and four levels of above-ground parking are accessed via the alleyway along the east elevation. The ground floor comprises a lobby to the northwest fronting Cannon Street East, an indoor amenity to the north, and building support services in the remaining spaces. Levels 2-5 comprise residential units along the west elevation, in addition to the internal parking. The floorplate sets back from all elevations at Level 6, accommodating outdoor and indoor amenities to the southeast, and residential units with private terraces elsewhere. The floorplate rises to Level 13, where it sets back from the south featuring a private terrace. Above, the residential floorplate rises to the full height, where a mechanical penthouse completes the tower.

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 primarily by low-rise residential buildings in all directions, with a 12-storey building at 80 Cathcart Street to the southeast and an 18-storey building to the south at 125 Wellington Street North. The far-field surroundings (defined as the area beyond the near field and within a two-kilometer radius) are generally characterized by low-rise suburban exposure in all directions, with Lake Ontario located at approximately 2.0 kilometres distant in the north quadrant, the Hamilton escarpment at less than 1.5 kilometres in the south quadrant, and the denser Hamilton downtown core in the southwest quadrant.

Grade-level areas investigated include sidewalks, walkways, laneways, landscaped areas, parking spaces, transit stops, and building access points. Wind comfort is also evaluated over the Level 6 and 13 terraces. 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 Hamilton 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 58 sensor locations on the scale model in Gradient Wind's wind tunnel. Of these 58 sensors, 53 were located at grade and the remaining five sensors were located over the rooftop terraces. Wind speed measurements were performed for each of the 58 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.

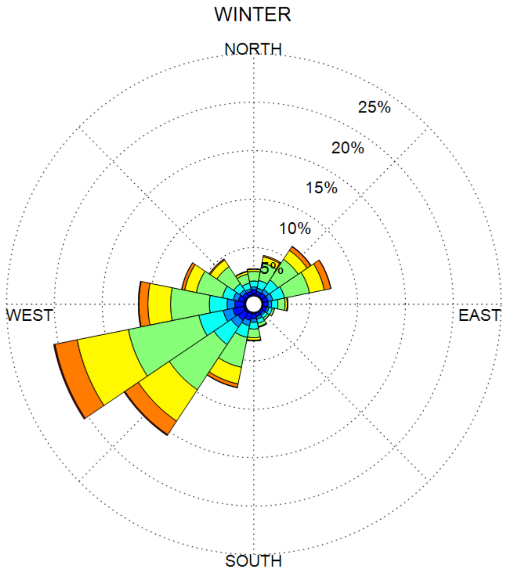
Mean and peak wind speed values for each location and wind direction were calculated from real-time pressure measurements, recorded at a sample rate of 500 samples per second, and taken over a 60-second time period. This period at model-scale corresponds approximately to one hour in full-scale, which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

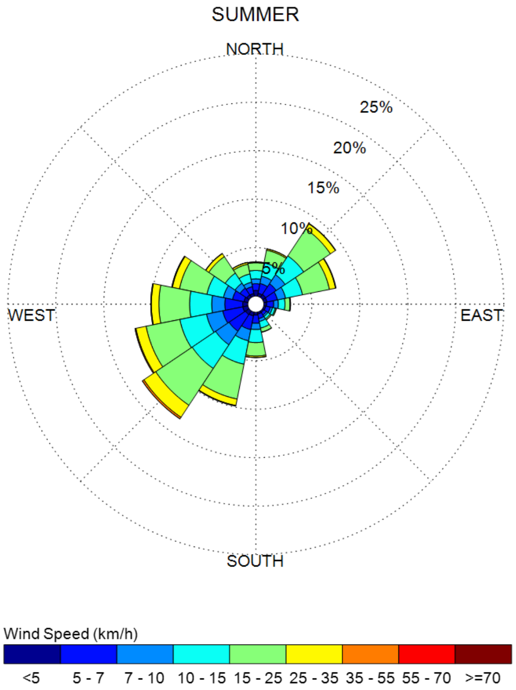
4.3 Meteorological Data Analysis

A statistical model for winds in Hamilton 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 Terms of Reference: Pedestrian Level Wind Study for Downtown Hamilton, the year is represented by a two-season model, and not according to the traditional calendar method.

The statistical model of the Hamilton 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 Hamilton, 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) **Strolling** – A wind speed below 17 km/h (i.e. 14 km/h – 17 km/h) is acceptable for activities such as strolling.

(iv) **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 *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 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. All public sidewalks, walkways, laneways, parking areas, and landscaped spaces within and surrounding the proposed development currently experience wind conditions suitable for strolling or better during each seasonal period.
2. The nearby existing backyard areas around the site (Sensors 34-36) are currently suitable for sitting throughout the year.
3. The primary entrance to the existing commercial building to the north at 181 Cannon Street East (Sensor 7) currently experiences sitting wind conditions during each seasonal period.
4. The nearby transit stop along Cannon Street East to the northwest (Sensor 1) currently experiences standing conditions during the summer and walking conditions during the winter months.
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-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 *proposed scenario*, as follows:

1. Most public sidewalks, walkways, laneways, landscaped spaces, and parking areas within and surrounding the proposed development will experience wind conditions suitable for walking or better during each seasonal period, which is acceptable for the intended uses of space. Exceptions include isolated portions of the sidewalk along Cannon Street East and Ferguson Avenue North (Sensors 6, 8, 26, & 41-43), and the laneway at the southeast corner of the study building (Sensor 50). Additionally, this southeast corner (Sensor 50) will marginally exceed the annual safety criterion.

   For the majority of the sidewalk portions (6, 8, 26, & 43), it is noteworthy that in all instances the exceedance of the walking comfort threshold is generally marginal (<2km/h, See Appendix B), limited to colder months, and wind speeds remain safe, as defined in Section 4.4. Additionally, existing and proposed landscaping is expected to further buffer salient winds and reduce wind speeds in these spaces. Regarding the marginally "unsafe" southeast corner (Sensor 50), pedestrian access is limited in this area, so mitigation is not considered necessary, however, clustered wind barriers, an overhead canopy, or cordoning off the space, are viable mitigatory options if desired. Regarding the walkway at the northwest corner (Sensors 42 & 43), it is recommended to provide a 1.8-metre-deep wraparound canopy at this corner and/or vertical wind barriers to the east and south. Such barriers may comprise high-solidity windscreens, coniferous/marcescent plantings, or a combination thereof, the exact composition and configuration of which can be coordinated with the design team as the landscaping plans develop.

2. The residential lobby entrance (Sensor 42) will exceed the standing criterion throughout the year. It is recommended to flank the doorway with vertical wind barriers and provide a 2.0-metre-deep canopy overhead or recess the entrance within the façade. Alternatively, sliding or revolving doors may be substituted for swinging options or the entrance could be moved further south (Sensor 44) where conditions are calmer. All retail entrances 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 be suitable for walking or better on a seasonal basis, which is appropriate.

3. The primary entrance to the existing commercial building to the north at 181 Cannon Street East (Sensor 7) will be suitable for standing during the summer months and exceed the standing criterion during the colder months. It is noteworthy that this entrance is currently sheltered with a canopy. Therefore, much calmer conditions are expected at the entrance in practice.
4. The nearby existing backyard areas around the site (Sensors 34-36) will be suitable for standing or better during the summer months, transitioning to walking or better during winter. It is notable that these results do not account for the solid fences and tall plantings present around each of the yards. Overall, the noted conditions are considered acceptable.
5. The nearby transit stop along Cannon Street East to the northwest (Sensor 1) will experience standing conditions during the summer and strolling conditions during the winter months. The noted conditions represent a marginal improvement from the existing wind conditions and are therefore acceptable.
6. The Level 6 private and amenity terrace (Sensors 54-57) will generally be suitable for sitting during the summer months, with winder conditions measured near/at the southeast corner (Sensor 55). It is recommended to provide a 2.0-metre-deep wraparound canopy at the corner or pergola/trellis structures, and raise the nearby corner perimeter guards to at least 2.0 metres above the walking surface.
7. The Level 13 terrace (Sensor 58) will be suitable for sitting or more sedentary activities during the summer months and standing during the winter, without mitigation.
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, apart from the noted southeast corner of the study building, 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 a proposed residential development located at 188 Cannon Street East in Hamilton, Ontario. The study was performed in accordance with industry standard wind tunnel testing and data analysis procedures.

A complete summary of the predicted wind conditions is provided in Section 5.2 of this report and is also illustrated in Figures 2A-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 conditions 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 portions of the sidewalks/walkways at the northwest corner of the development and the adjacent lobby access point, for which mitigation is recommended as described in Section 5.2. To ensure the entire Level 6 outdoor amenity will be suitable for sitting or more sedentary activities during the summer 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, apart from the noted southeast corner of the study building, were found to experience wind conditions that are considered unsafe.

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

Sincerely,

Gradient Wind Engineering Inc.

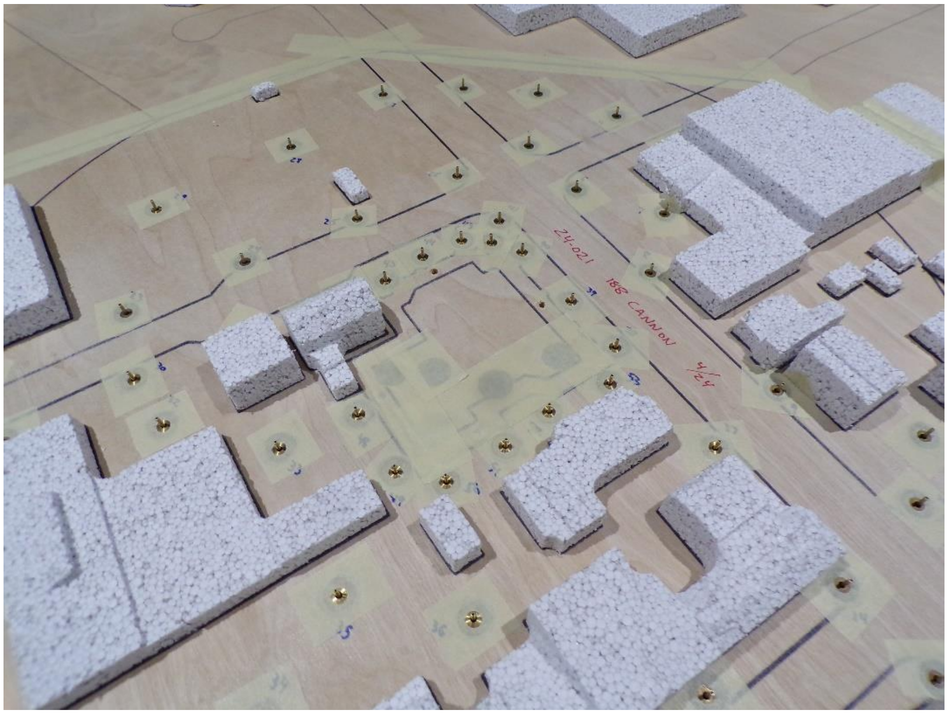
Cristiano Kondo

Cristiano Kondo, MESc.,
Junior Wind Scientist

Nick Peterson

Nick Petersen, P.Eng.,
Wind Engineer

GW24-021-WTPLW



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

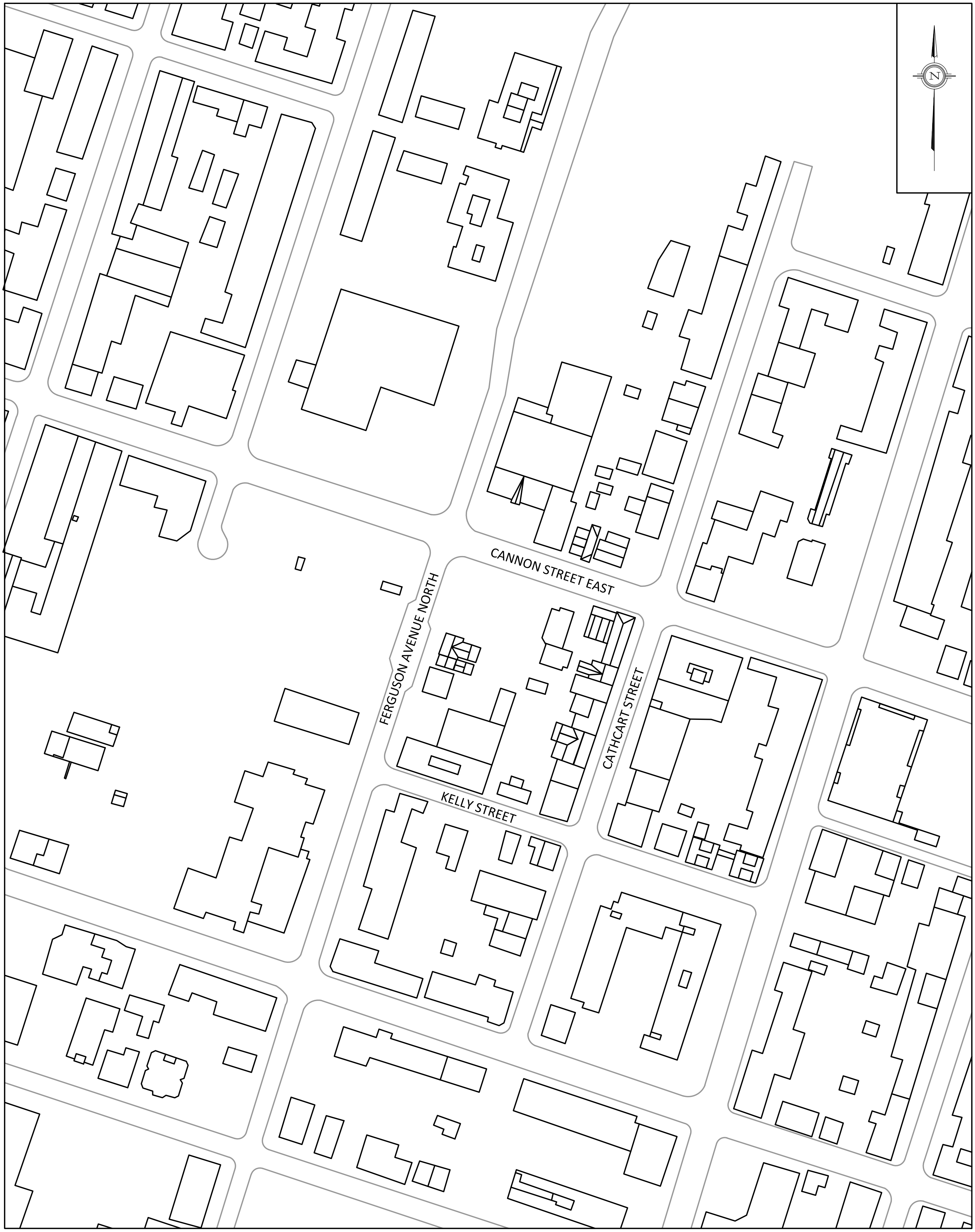
PHOTOGRAPH 2: CLOSE-UP VIEW OF EXISTING CONTEXT MODEL LOOKING SOUTHEAST

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

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

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

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



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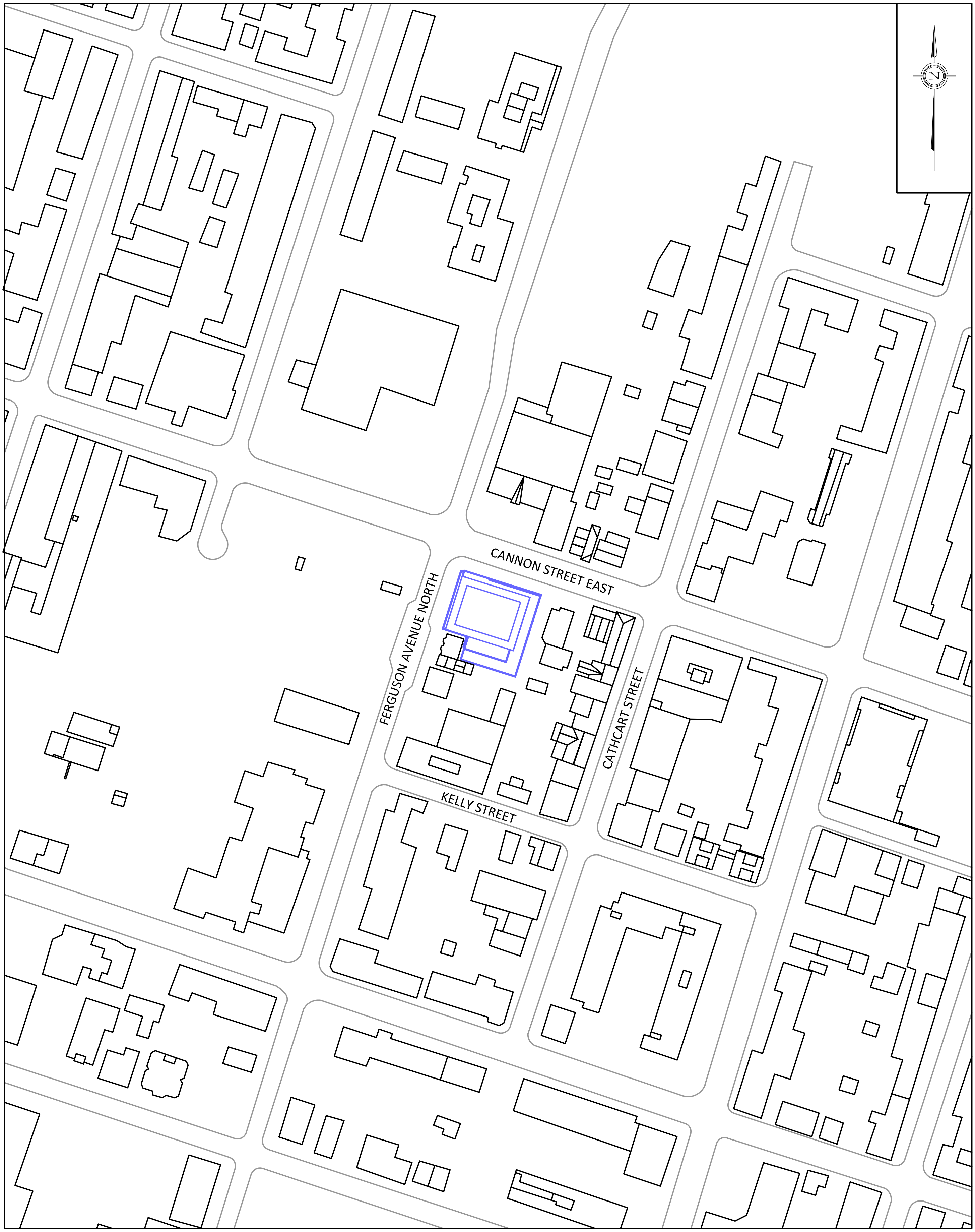
PROJECT 188 CANNON STREET EAST, HAMILTON PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: EXISTING SCENARIO AND SURROUNDING CONTEXT
SCALE 1:2500 (APPROX.)	DRAWING NO. GW24-021-PLW-1A	
DATE APRIL 12, 2024	DRAWN BY K.A.	



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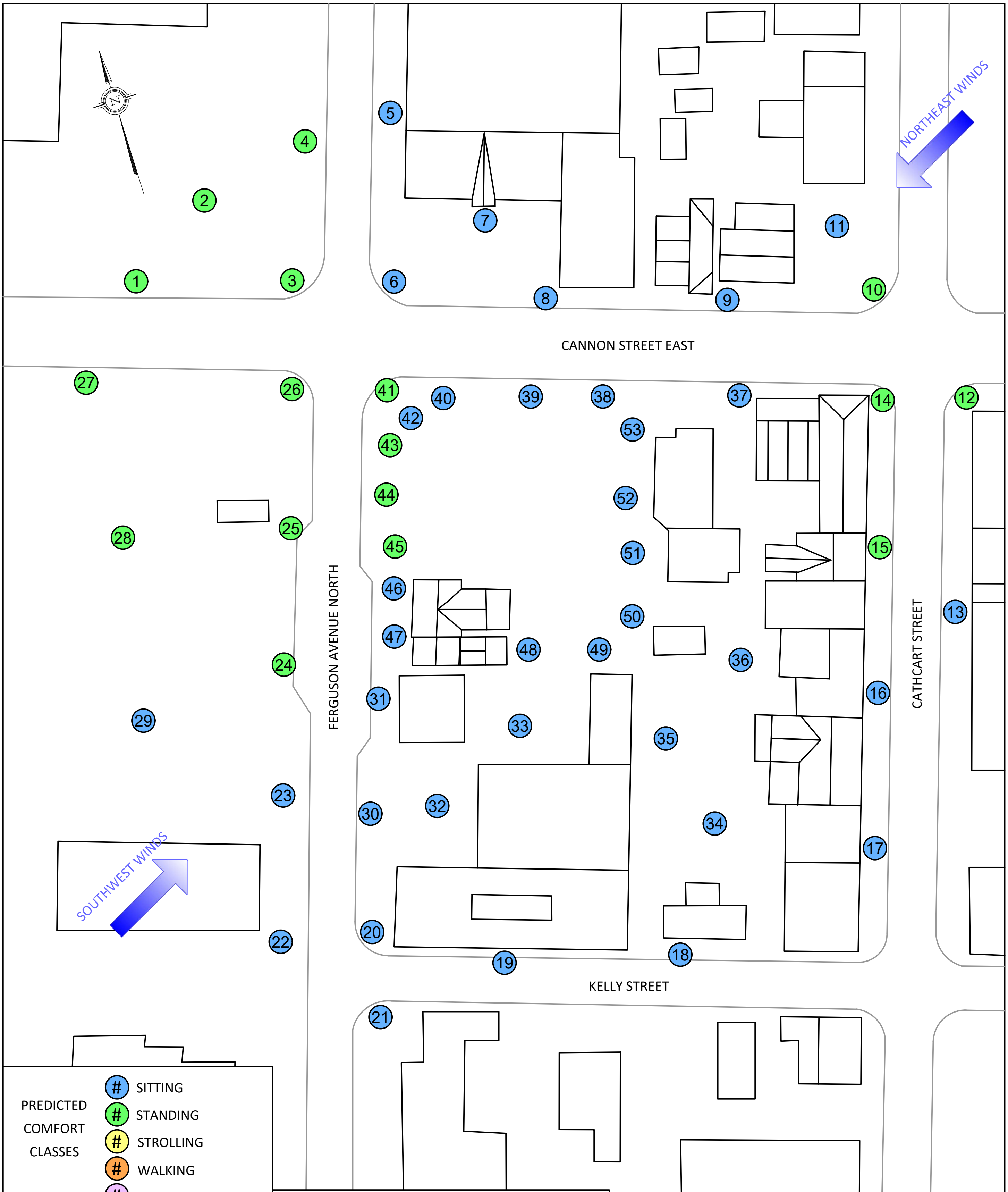
SCALE	1:2500 (APPROX.)
DRAWING NO.	GW24-021-PLW-1B
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 1B: FUTURE SCENARIO SITE PLAN AND SURROUNDING CONTEXT



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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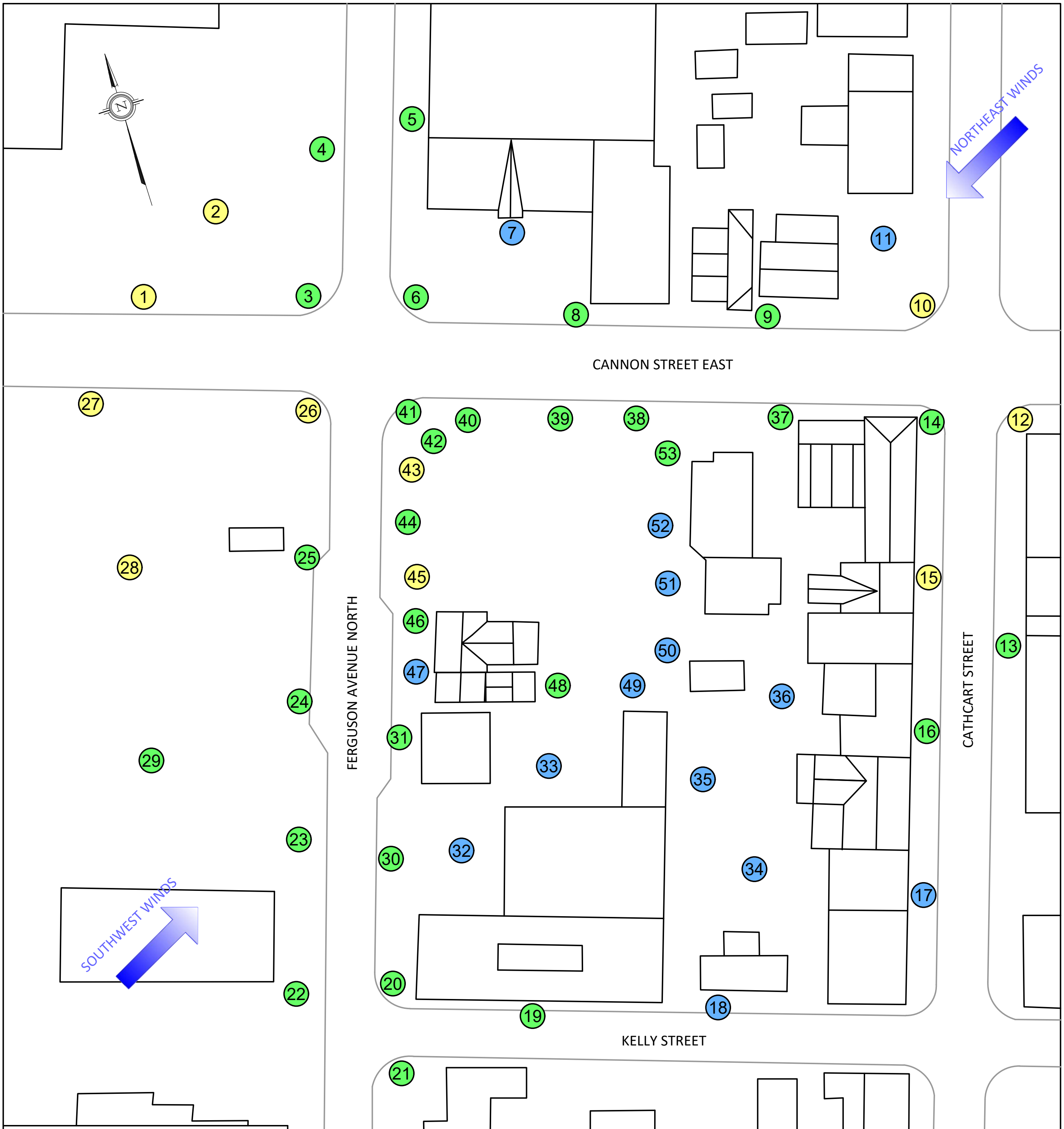
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-021-PLW-2A
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 2A: SUMMER EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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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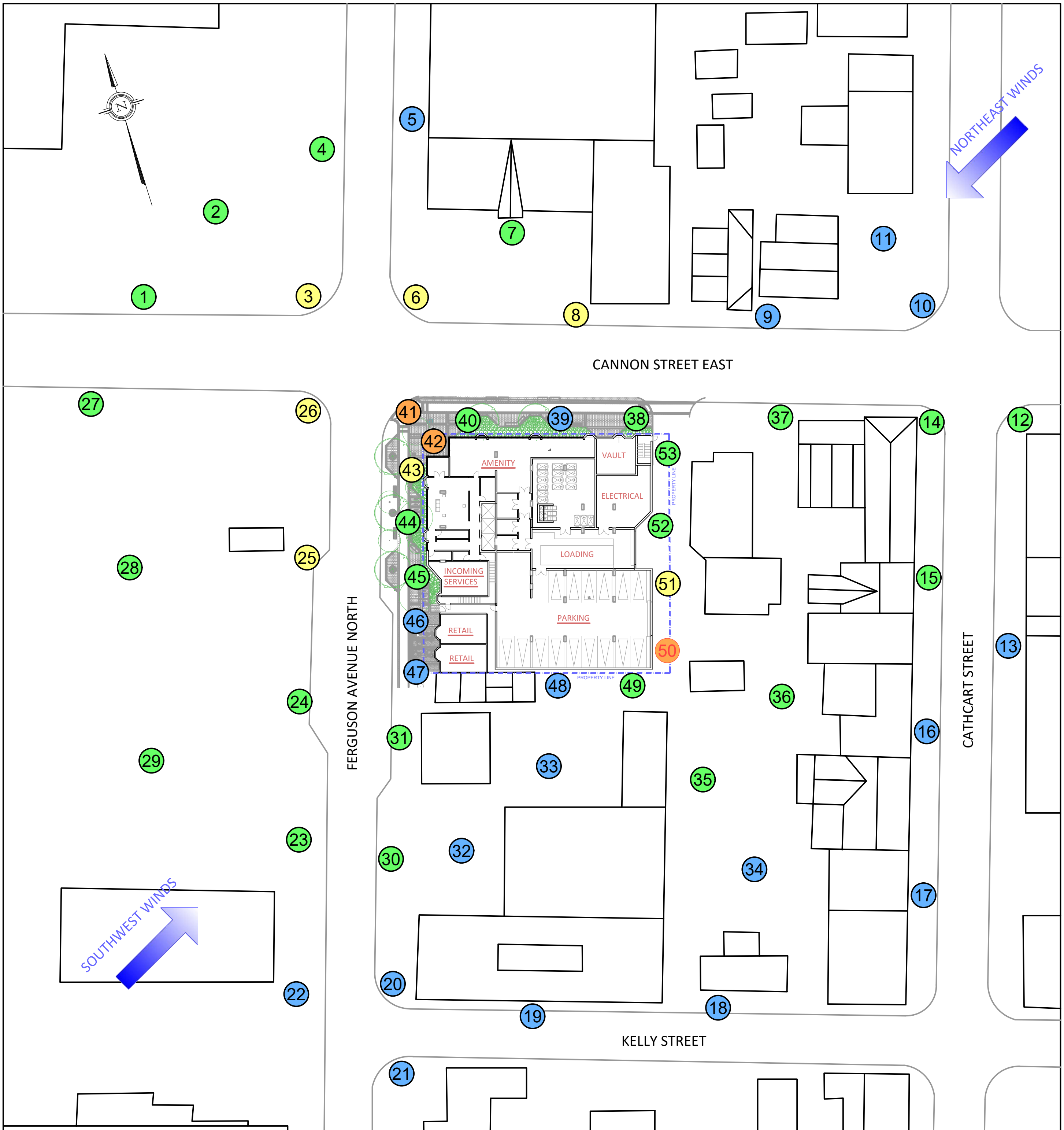
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-021-PLW-2B
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 2B: WINTER EXISTING GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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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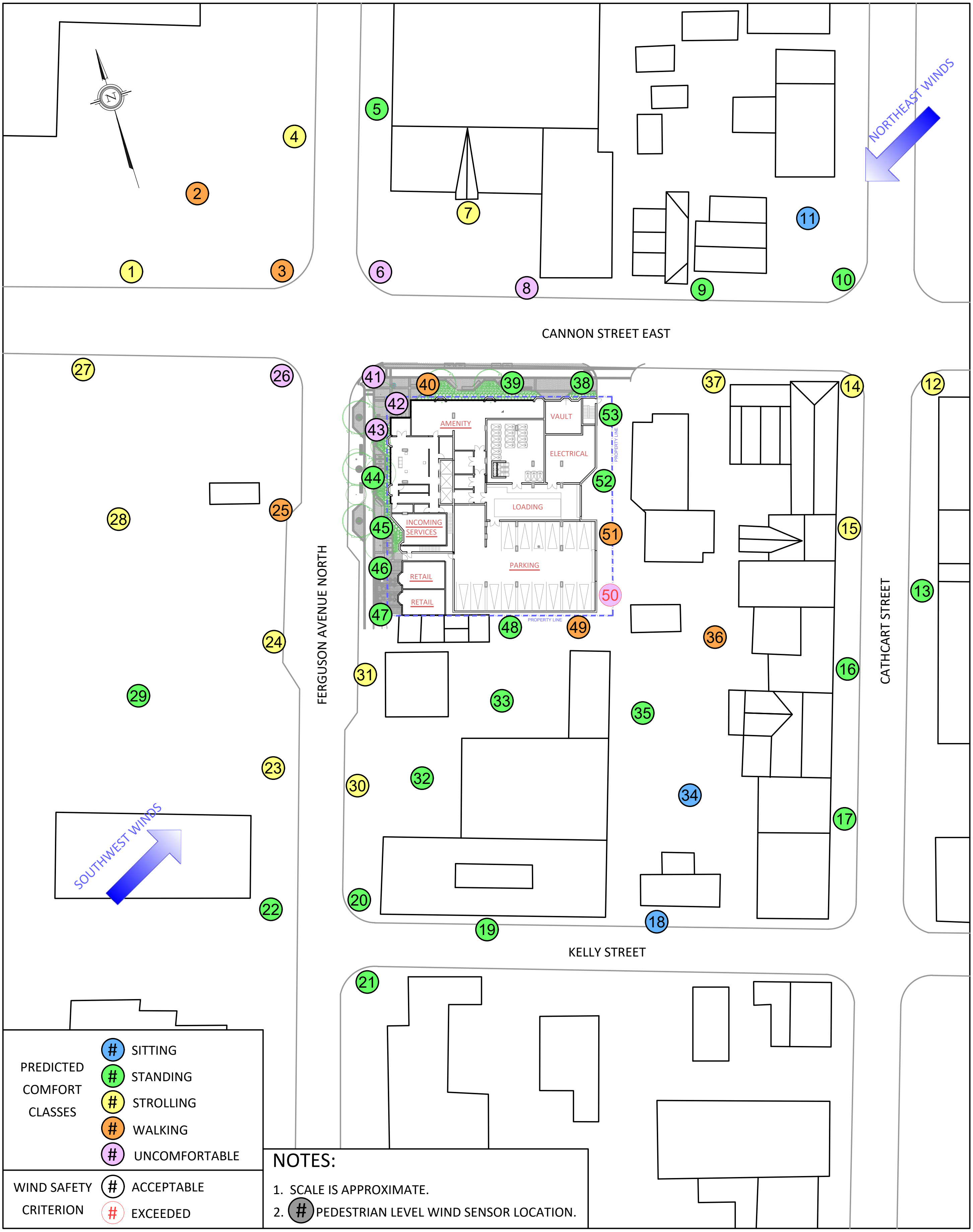
PROJECT	188 CANNON STREET EAST, HAMILTON PEDESTRIAN LEVEL WIND STUDY
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-021-PLW-3A
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 3A: SUMMER FUTURE GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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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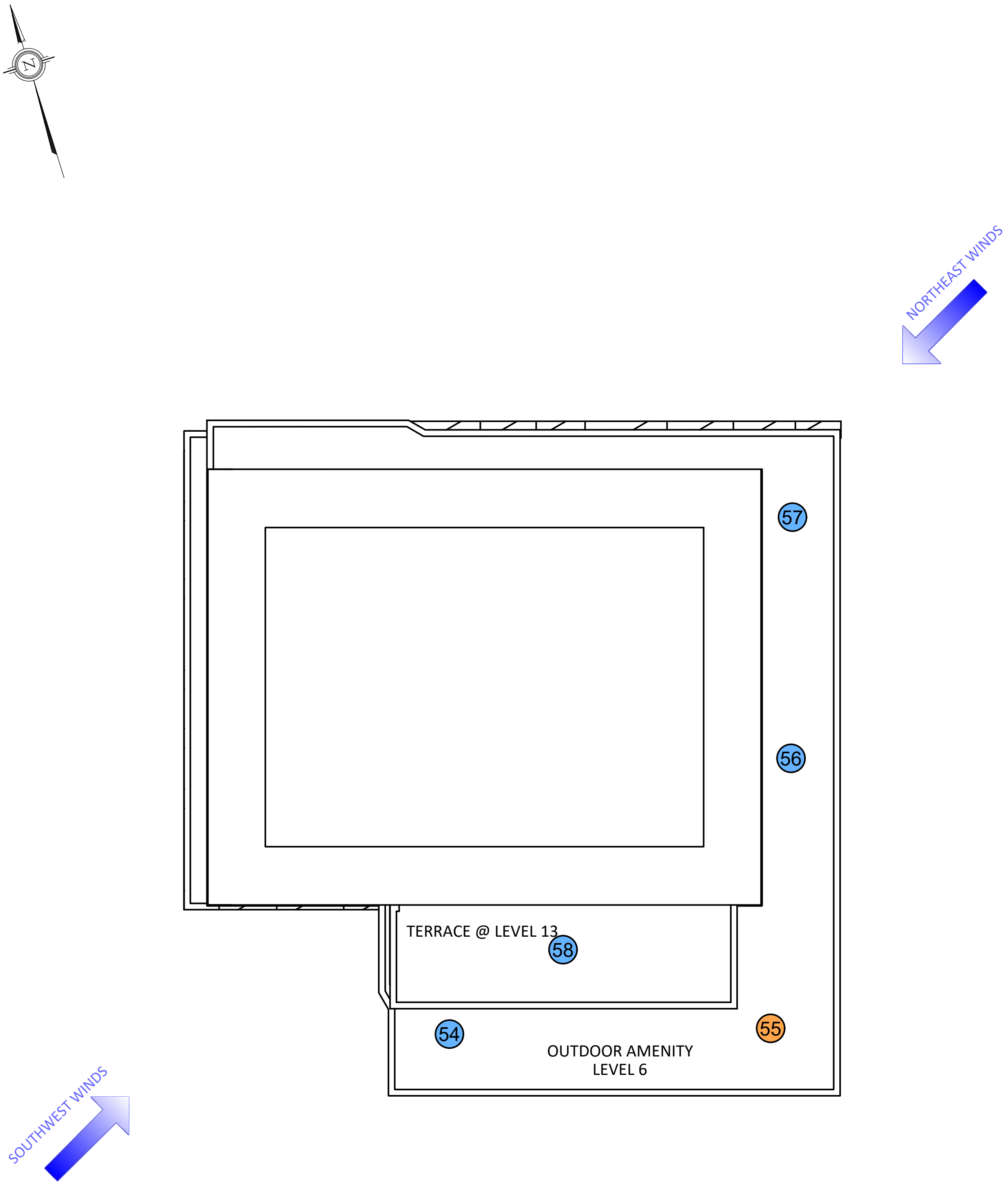
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW24-021-PLW-3B
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 3B: WINTER FUTURE GRADE LEVEL PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



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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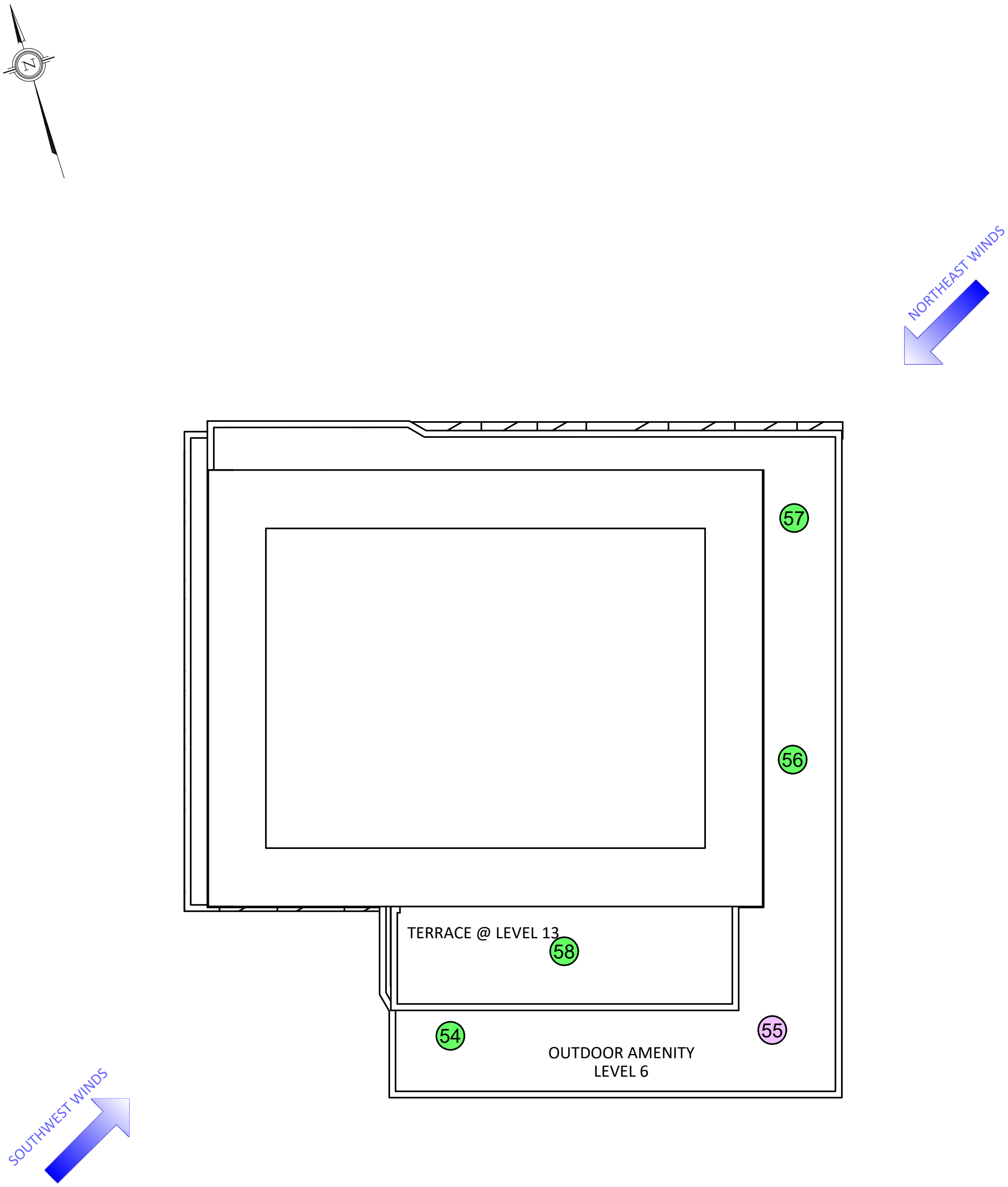
PROJECT	188 CANNON STREET EAST, HAMILTON PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:400 (APPROX.)	DRAWING NO.	GW24-021-PLW-4A
DATE	APRIL 12, 2024	DRAWN BY	K.A.

DESCRIPTION

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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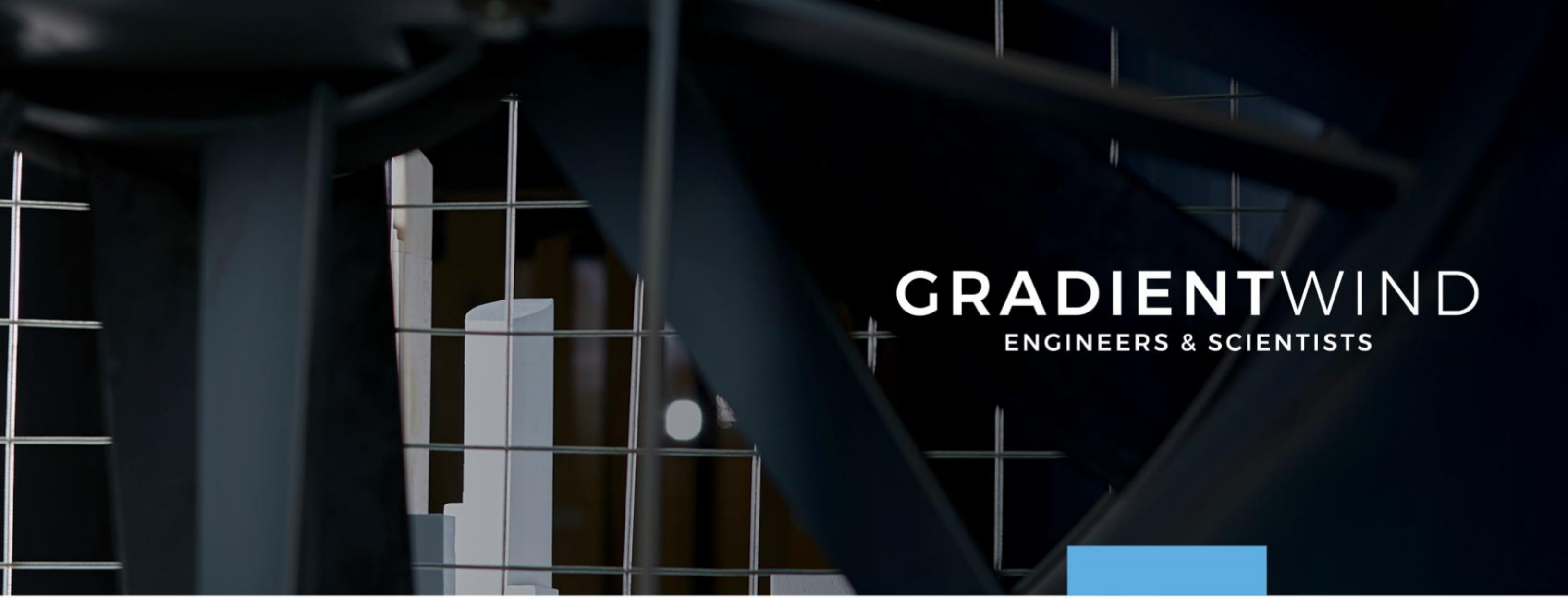
PROJECT	188 CANNON STREET EAST, HAMILTON PEDESTRIAN LEVEL WIND STUDY
SCALE	1:400 (APPROX.)
DRAWING NO.	GW24-021-PLW-4B
DATE	APRIL 12, 2024
DRAWN BY	K.A.
DESCRIPTION	FIGURE 4B: WINTER FUTURE TERRACE PLW SENSOR LAYOUT PEDESTRIAN COMFORT PREDICTIONS



APPENDIX A

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

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

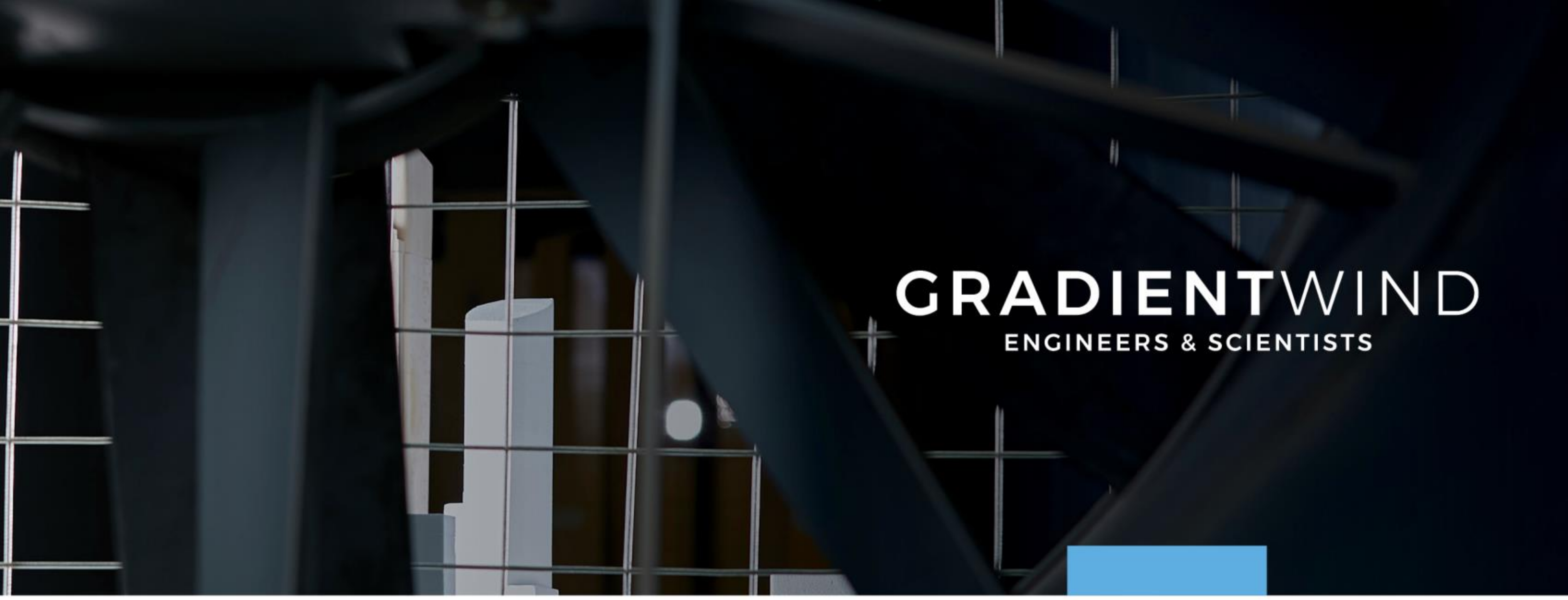
TABLE A1: SUMMARY OF PEDESTRIAN COMFORT (EXISTING SCENARIO)

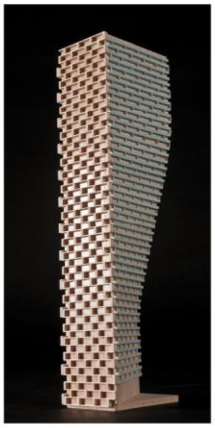
Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	10.8	Standing	14.4	Strolling	49.9	Safe
2	11.4	Standing	15.0	Strolling	51.1	Safe
3	10.3	Standing	13.8	Standing	46.4	Safe
4	10.6	Standing	13.6	Standing	45.9	Safe
5	9.2	Sitting	11.6	Standing	40.7	Safe
6	9.7	Sitting	13.0	Standing	44.1	Safe
7	6.4	Sitting	8.9	Sitting	36.6	Safe
8	7.9	Sitting	10.7	Standing	39.3	Safe
9	7.6	Sitting	10.9	Standing	43.9	Safe
10	10.5	Standing	14.3	Strolling	47.0	Safe
11	7.0	Sitting	9.3	Sitting	36.4	Safe
12	12.4	Standing	16.3	Strolling	57.1	Safe
13	8.2	Sitting	11.1	Standing	47.1	Safe
14	10.2	Standing	13.8	Standing	47.7	Safe
15	11.4	Standing	14.3	Strolling	63.8	Safe
16	7.9	Sitting	10.3	Standing	41.2	Safe
17	6.9	Sitting	9.1	Sitting	33.8	Safe
18	5.7	Sitting	7.6	Sitting	29.7	Safe
19	7.9	Sitting	10.4	Standing	37.6	Safe
20	8.1	Sitting	10.5	Standing	41.8	Safe
21	8.5	Sitting	11.5	Standing	47.3	Safe
22	9.9	Sitting	13.3	Standing	45.2	Safe
23	9.3	Sitting	12.0	Standing	40.0	Safe
24	10.3	Standing	13.5	Standing	44.2	Safe
25	10.5	Standing	14.0	Standing	47.2	Safe
26	10.9	Standing	14.5	Strolling	48.5	Safe
27	11.0	Standing	14.5	Strolling	50.4	Safe
28	11.3	Standing	14.8	Strolling	50.3	Safe
29	8.9	Sitting	12.1	Standing	43.9	Safe
30	8.8	Sitting	11.5	Standing	39.8	Safe
31	8.0	Sitting	10.5	Standing	37.7	Safe
32	6.5	Sitting	8.9	Sitting	32.7	Safe
33	7.4	Sitting	9.9	Sitting	35.6	Safe
34	5.7	Sitting	7.6	Sitting	28.8	Safe
35	6.0	Sitting	7.7	Sitting	28.3	Safe

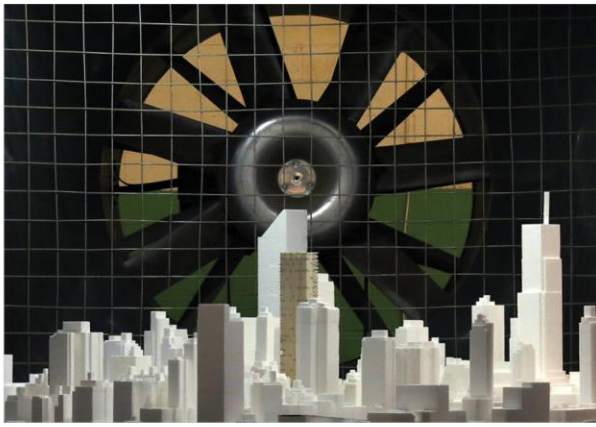
Guidelines	
Pedestrian Comfort	**20% exceedance wind speed** 0-10 km/h = Sitting, 10-14 km/h = Standing, 14-17 km/h = Strolling, 17-20 km/h = Walking, >20 km/h = Uncomfortable
Pedestrian Safety	**0.1% exceedance wind speed** 0-90 km/h = Safe

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	6.0	Sitting	7.9	Sitting	31.6	Safe
37	10.0	Sitting	13.4	Standing	47.1	Safe
38	8.9	Sitting	12.0	Standing	43.0	Safe
39	9.3	Sitting	12.6	Standing	44.6	Safe
40	9.9	Sitting	13.4	Standing	46.9	Safe
41	10.3	Standing	14.0	Standing	47.5	Safe
42	9.7	Sitting	13.1	Standing	44.6	Safe
43	10.7	Standing	14.4	Strolling	48.3	Safe
44	10.2	Standing	13.6	Standing	46.9	Safe
45	10.5	Standing	14.3	Strolling	48.4	Safe
46	9.9	Sitting	13.3	Standing	48.0	Safe
47	6.9	Sitting	9.3	Sitting	35.2	Safe
48	8.5	Sitting	11.2	Standing	39.8	Safe
49	6.4	Sitting	8.5	Sitting	32.2	Safe
50	7.5	Sitting	9.6	Sitting	33.1	Safe
51	7.1	Sitting	9.2	Sitting	33.6	Safe
52	6.8	Sitting	9.0	Sitting	35.0	Safe
53	9.8	Sitting	13.1	Standing	45.2	Safe







APPENDIX B

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

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

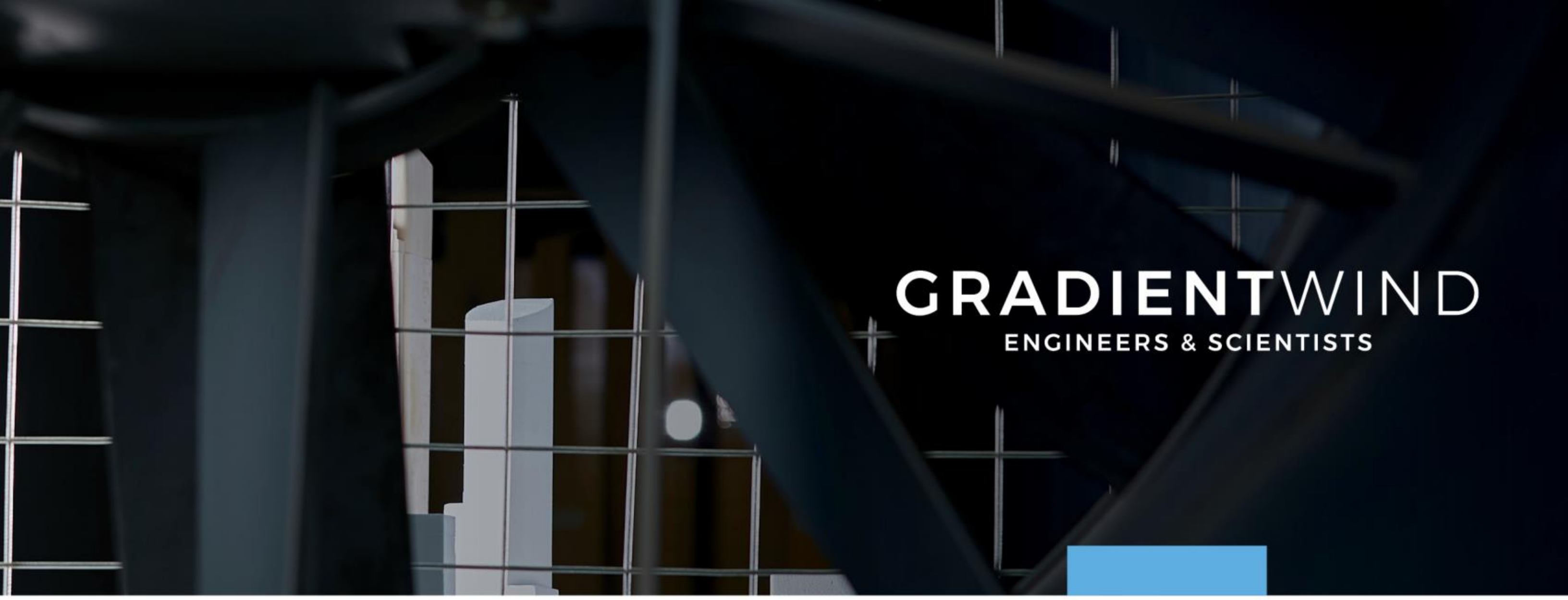
TABLE B1: SUMMARY OF PEDESTRIAN COMFORT (PROPOSED SCENARIO)

Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
1	12.1	Standing	15.9	Strolling	52.7	Safe
2	13.3	Standing	17.5	Walking	55.9	Safe
3	14.1	Strolling	18.9	Walking	61.8	Safe
4	11.3	Standing	15.3	Strolling	54.2	Safe
5	9.0	Sitting	12.6	Standing	54.9	Safe
6	15.5	Strolling	21.3	Uncomfortable	70.9	Safe
7	11.6	Standing	16.1	Strolling	59.5	Safe
8	15.1	Strolling	21.5	Uncomfortable	74.4	Safe
9	9.2	Sitting	12.2	Standing	45.9	Safe
10	9.9	Sitting	13.9	Standing	60.8	Safe
11	7.1	Sitting	9.4	Sitting	38.1	Safe
12	12.0	Standing	15.8	Strolling	57.6	Safe
13	9.0	Sitting	12.1	Standing	50.6	Safe
14	12.8	Standing	17.0	Strolling	64.0	Safe
15	12.6	Standing	15.8	Strolling	65.3	Safe
16	9.1	Sitting	11.8	Standing	45.6	Safe
17	8.0	Sitting	10.9	Standing	39.2	Safe
18	6.4	Sitting	8.5	Sitting	31.3	Safe
19	9.0	Sitting	11.9	Standing	43.4	Safe
20	8.0	Sitting	10.3	Standing	40.5	Safe
21	8.7	Sitting	11.3	Standing	46.3	Safe
22	9.1	Sitting	12.0	Standing	43.0	Safe
23	12.0	Standing	15.2	Strolling	59.7	Safe
24	12.1	Standing	14.8	Strolling	60.7	Safe
25	15.5	Strolling	19.0	Walking	75.5	Safe
26	16.8	Strolling	21.5	Uncomfortable	69.3	Safe
27	12.0	Standing	15.5	Strolling	55.3	Safe
28	13.3	Standing	16.5	Strolling	70.5	Safe
29	10.4	Standing	12.8	Standing	61.9	Safe
30	11.6	Standing	15.3	Strolling	58.5	Safe
31	10.6	Standing	14.1	Strolling	58.9	Safe
32	8.6	Sitting	11.5	Standing	41.0	Safe
33	10.0	Sitting	13.1	Standing	48.0	Safe
34	7.4	Sitting	9.8	Sitting	38.1	Safe
35	10.3	Standing	13.7	Standing	49.8	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 (PROPOSED SCENARIO)

Sensor	Pedestrian Comfort				Pedestrian Safety	
	Summer		Winter		Annual	
	Wind Speed	Comfort Class	Wind Speed	Comfort Class	Wind Speed	Safety Class
36	12.8	Standing	17.4	Walking	58.9	Safe
37	11.5	Standing	14.8	Strolling	57.0	Safe
38	10.2	Standing	13.8	Standing	56.3	Safe
39	9.3	Sitting	12.7	Standing	52.0	Safe
40	12.9	Standing	18.5	Walking	78.6	Safe
41	18.9	Walking	25.7	Uncomfortable	77.3	Safe
42	18.4	Walking	25.2	Uncomfortable	88.8	Safe
43	15.9	Strolling	21.2	Uncomfortable	73.8	Safe
44	10.3	Standing	12.5	Standing	58.4	Safe
45	11.1	Standing	13.3	Standing	61.2	Safe
46	9.3	Sitting	11.8	Standing	46.8	Safe
47	9.4	Sitting	12.7	Standing	55.1	Safe
48	8.2	Sitting	11.1	Standing	49.9	Safe
49	12.6	Standing	18.2	Walking	65.7	Safe
50	17.4	Walking	23.6	Uncomfortable	90.4	Dangerous
51	14.6	Strolling	19.2	Walking	77.0	Safe
52	11.1	Standing	13.8	Standing	57.1	Safe
53	10.5	Standing	12.8	Standing	63.7	Safe
54	7.8	Sitting	11.1	Standing	49.1	Safe
55	18.7	Walking	25.4	Uncomfortable	80.9	Safe
56	9.1	Sitting	11.1	Standing	58.7	Safe
57	8.8	Sitting	10.4	Standing	70.4	Safe
58	8.2	Sitting	12.0	Standing	54.5	Safe



APPENDIX C

WIND TUNNEL SIMULATION OF THE NATURAL WIND

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:

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

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.

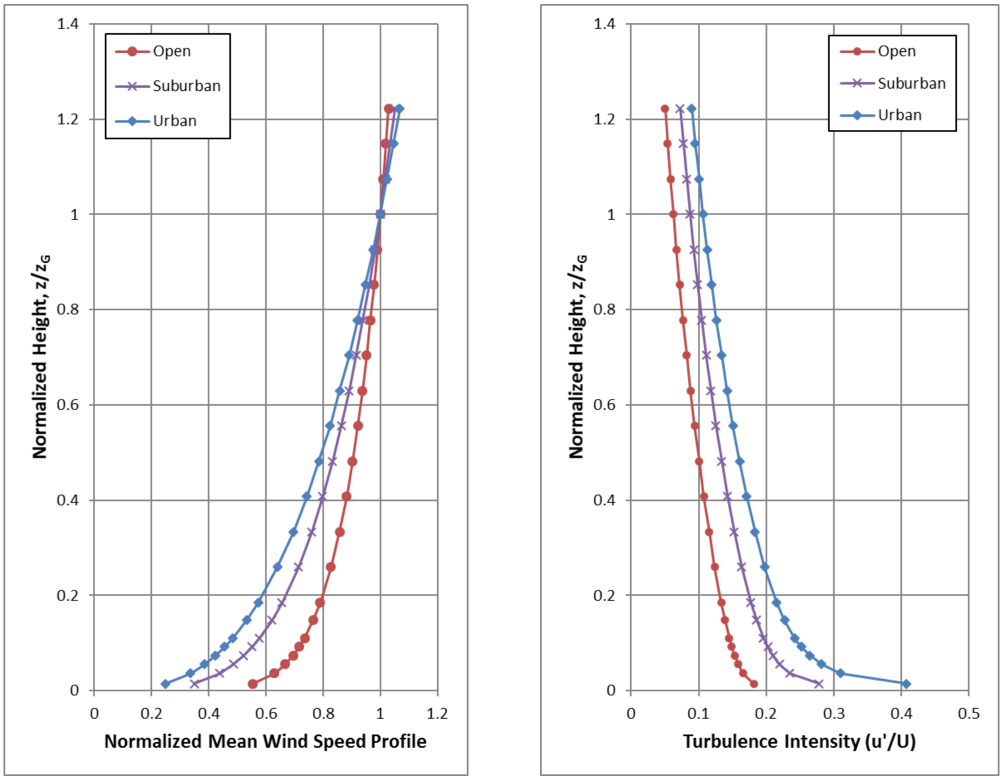


**FIGURE C1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE C2 (RIGHT): TURBULENCE INTENSITY PROFILES**

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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

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.

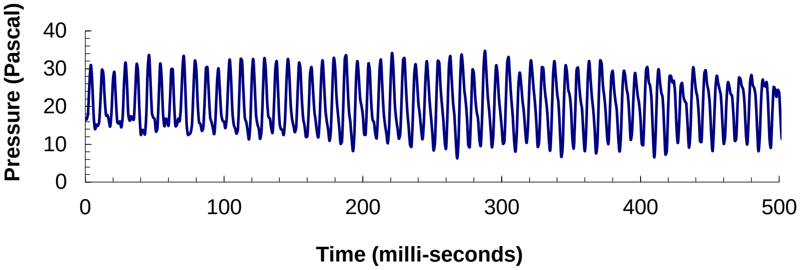

FIGURE D1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

REFERENCES

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