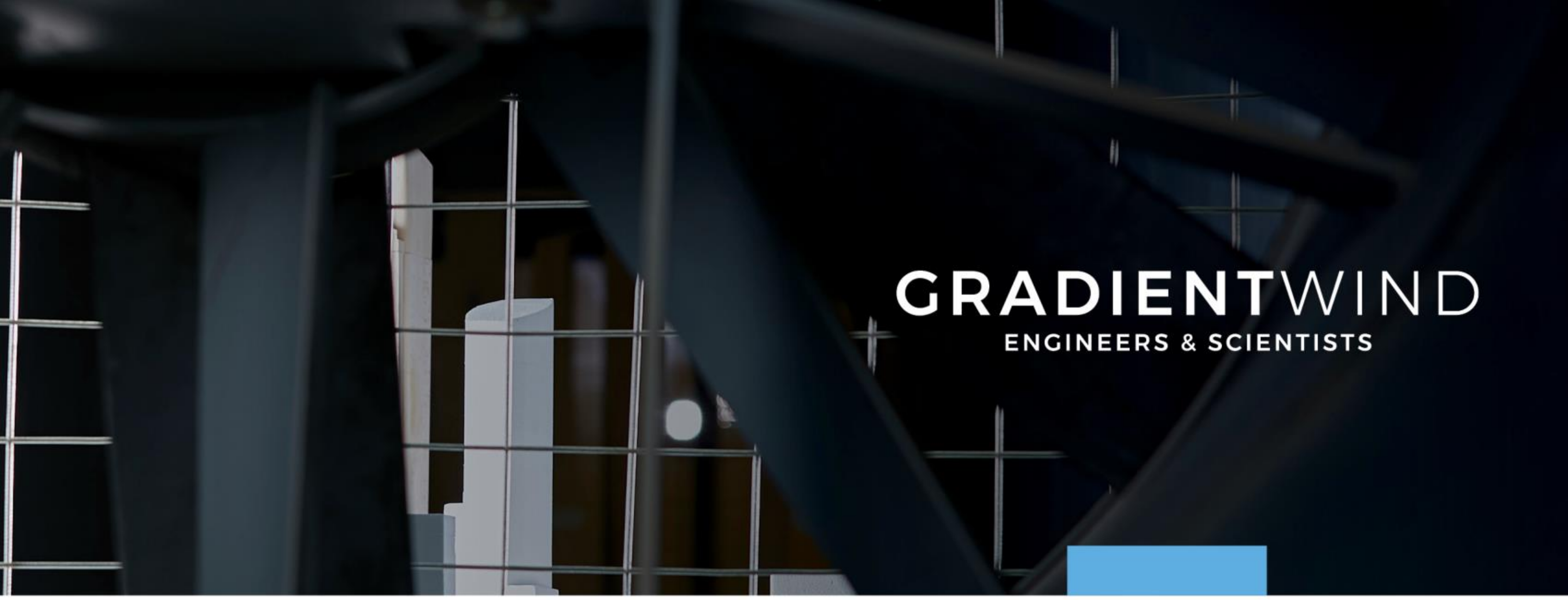
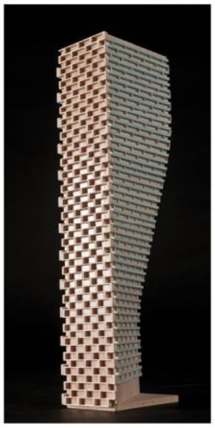


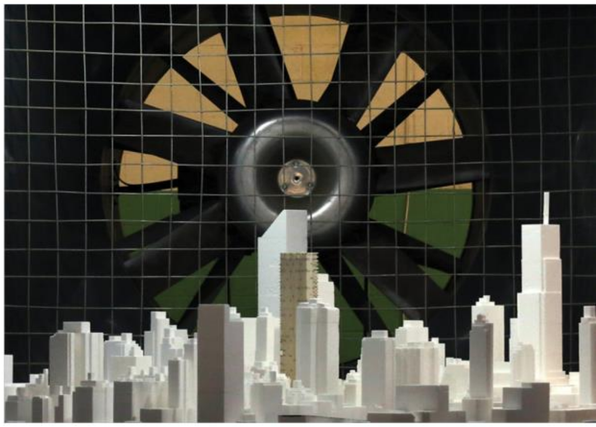
GRADIENTWIND
ENGINEERS & SCIENTISTS

PEDESTRIAN LEVEL WIND STUDY AND SNOW DRIFT ASSESSMENT

930 Carling Avenue & 520 Preston Street
New Campus Development of
The Ottawa Hospital, Ottawa, Ontario

Report: 20-049-PLW-2022





October 4, 2022

PREPARED FOR
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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study and grade-level snow drift and accumulation assessment undertaken to satisfy Site Plan Control and Federal Land Use and Design Approval application requirements for the proposed Phases 3 and 4 (Hospital and Central Utility Plant) of the New Campus Development for The Ottawa Hospital (TOH) in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). The mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where required. Additionally, the study will estimate snow drifting patterns at key building access points, such as loading docks, emergency vehicle access, and other pedestrian accessed areas, that may cause operational issues and unusual snow removal considerations.

The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian wind comfort and safety within and surrounding the subject site according to City of Ottawa wind comfort and safety criteria. The results and recommendations derived from these considerations are detailed in the main body of the report (Section 5), illustrated in Figures 5A-10, and summarized as follows:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, surface parking, loading zones, and in the vicinity of building access points, are considered acceptable.

2) The terraces, gardens, and courtyards serving the main hospital building are predicted to be suitable for sitting during the typical use period. Specifically, conditions over the Emergency Level courtyard, the Level 1 wellness garden, and the Level 5 and 6 terraces serving the Tower A are predicted to be acceptable.

3) Regarding grade-level snow drifting, we have the following conclusions:

    a. Many of the locations considered, which are illustrated in Figure 11, are likely to experience regular drift accumulations during the winter period. Of particular importance, moderate snow drift accumulations are expected to occur in the vicinity of the main entrance of the main hospital building and the loading area at the northeast corner of the CUP. Although frequent, the amount of accumulation is not expected to be problematic beyond typical local conditions.

    b. Provided a regular snow removal program is followed for the noted areas, snow drift accumulations are not anticipated to hinder the day-to-day operations of the proposed development. The snow removal program is anticipated to be similar to other snow removal programs in Ottawa.

4) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (e.g., thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Addendum: The detailed PLW study and snow drift assessment was performed based on architectural drawings received in July 2022. An updated set of drawings from HDR Architecture Associates Inc. was received in September 2022. The changes to the updated drawings are considered minor for the purposes of this study. Notably, the north elevations of both Towers A and B have been set back approximately 9 m, and the northeast corner of the CUP has been set back by approximately 7 m, relative to the previous drawings. Overall, the noted changes are not expected to change the main conclusions of the study.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Parsons Inc. to undertake a pedestrian level wind (PLW) study and snow drifting assessment to satisfy Site Plan Control and Federal Land Use and Design Approval application requirements for Phases 3 and 4 (Hospital and Central Utility Plant) of the proposed New Campus Development for The Ottawa Hospital (TOH), located between 930 Carling Avenue and 520 Preston Street in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). The mandate within this study is to investigate pedestrian wind conditions within and surrounding the subject site, and to identify areas where conditions may interfere with certain pedestrian activities so that mitigation measures may be considered. Additionally, the study will estimate snow drifting patterns at key building access points, such as loading docks, emergency vehicle access, and other pedestrian accessed areas, that may cause operational issues and unusual snow removal considerations.

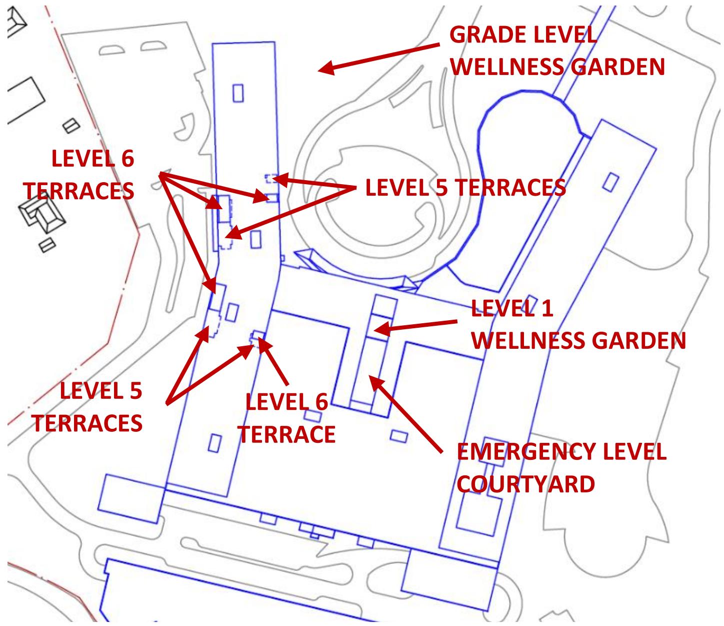
The work is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, City of Ottawa wind comfort and safety criteria, architectural drawings prepared by HDR Architecture Associates Inc., in July 2022, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent satellite imagery.

2. TERMS OF REFERENCE

Architectural Rendering, North Perspective
(Courtesy of HDR Architecture Associates Inc.)

The New Campus Development for TOH is located between 930 Carling Avenue and 520 Preston Street in Ottawa; situated on a parcel of land bounded by Carling Avenue to the north, Preston Street to the east, Prince of Wales Drive to the southeast, Birch Drive to the southwest, and Maple Drive to the west. The New Campus Development Master Site Plan includes a main hospital building and a Central Utility Plant (CUP) as Phases 4 and 3, respectively, both of which form the focus of the present study. The New Campus Development also includes the Phase 2 Parking Garage to the east, future research building to the north, and three future towers at the northeast corner along Carling Avenue.

The main hospital building comprises two nearly rectangular building components connected by a common podium. The building to the northwest is an eight-storey building, hereinafter referred to as "Tower A", and the building to the ssoutheast is a 12-storey building, hereinafter referred to as "Tower B". Tower A includes terraces along the east and west elevations at Levels 5 and 6 and Tower B includes a helicopter pad on the roof. Entrances to the main hospital building are provided below-grade on the east elevation (public access to the emergency room) and west elevation (ambulance access), and grade-level access on the south (loading area) and north. Above the Emergency Level, entrances are provided at Level 1 on the north elevation. Additionally, a pedestrian bridge at the northeast corner provides access between Level 1 and the parking garage to the northeast. Within the Emergency Level, there is a courtyard provided at the centre, and at Level 1, there is a wellness garden which overlooks the Emergency Level courtyard.



Location of Terraces, Gardens, and Courtyards

The CUP is a one-storey triangular building located at the southwest corner of the subject site aligned with Maple Drive to the southwest. There is a fuelling and loading area located at the northeast corner, and a main entrance located at the northwest corner. The CUP is located below the level of Maple Drive and includes open areas and covered areas that will include surface parking.

The near-field surroundings (defined as an area within 200 metres (m) of the subject site) include a mix of low- to high-rise massing to the north of Carling Avenue, and a mix of open space and the low-rise massing serving the Central Experimental Farm to the southwest of the subject site. The far-field surroundings (defined as an area beyond the near-field but within a 2-kilometre (km) radius of the subject site) include a mix of mostly low- to high-rise buildings from the south-southwest clockwise to the northeast, a mix of low-rise massing and the open exposure of Dow's Lake and the Rideau Canal from the northeast clockwise to the east-southeast, a mix of the open exposure of the Dominion Arboretum and the mostly mid- and high-rise buildings of Carleton University from the east-southeast clockwise to the south-southeast, the open exposures of the Central Experimental Farm from the south-southeast clockwise to the south-southwest, and a mix of suburban massing and the open exposures of the Central Experimental Farm for the remaining compass directions.

Figure 1A illustrates the subject site and surrounding context, representing the proposed future massing scenario. Figure 1B illustrates the subject site and surrounding context, representing the existing massing scenario. These scenarios are hereinafter referred to as the "Proposed Massing", and "Existing Massing" scenarios, respectively. Figures 2A-2H illustrate the computational models used to conduct the study. The existing massing scenario includes the existing massing and any future developments approved by the City of Ottawa.

3. OBJECTIVES

The principal objectives of the PLW study are to (i) determine pedestrian level wind conditions at key areas within and surrounding the proposed development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

The principal objectives of the grade-level snow drift and accumulation study are to (i) estimate snow drifting patterns around key building access points serving the proposed development site; and (ii) recommend suitable maintenance considerations, where required.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on computational fluid dynamics (CFD) simulations of wind speeds across the subject site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind comfort and safety criteria[1]. The following sections describe the analysis procedures, including a discussion of the noted pedestrian wind criteria.

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[1] City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/default/files/torwindanalysis_en.pdf

4.1 Computer-Based Context Modelling

A computer based PLW study was performed to determine the influence of the wind environment on pedestrian comfort over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Ottawa Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly stronger wind speeds.

4.2 Wind Speed Measurements

The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a radius of 625 m. The process was performed for two context massing scenarios, as noted in Section 2.

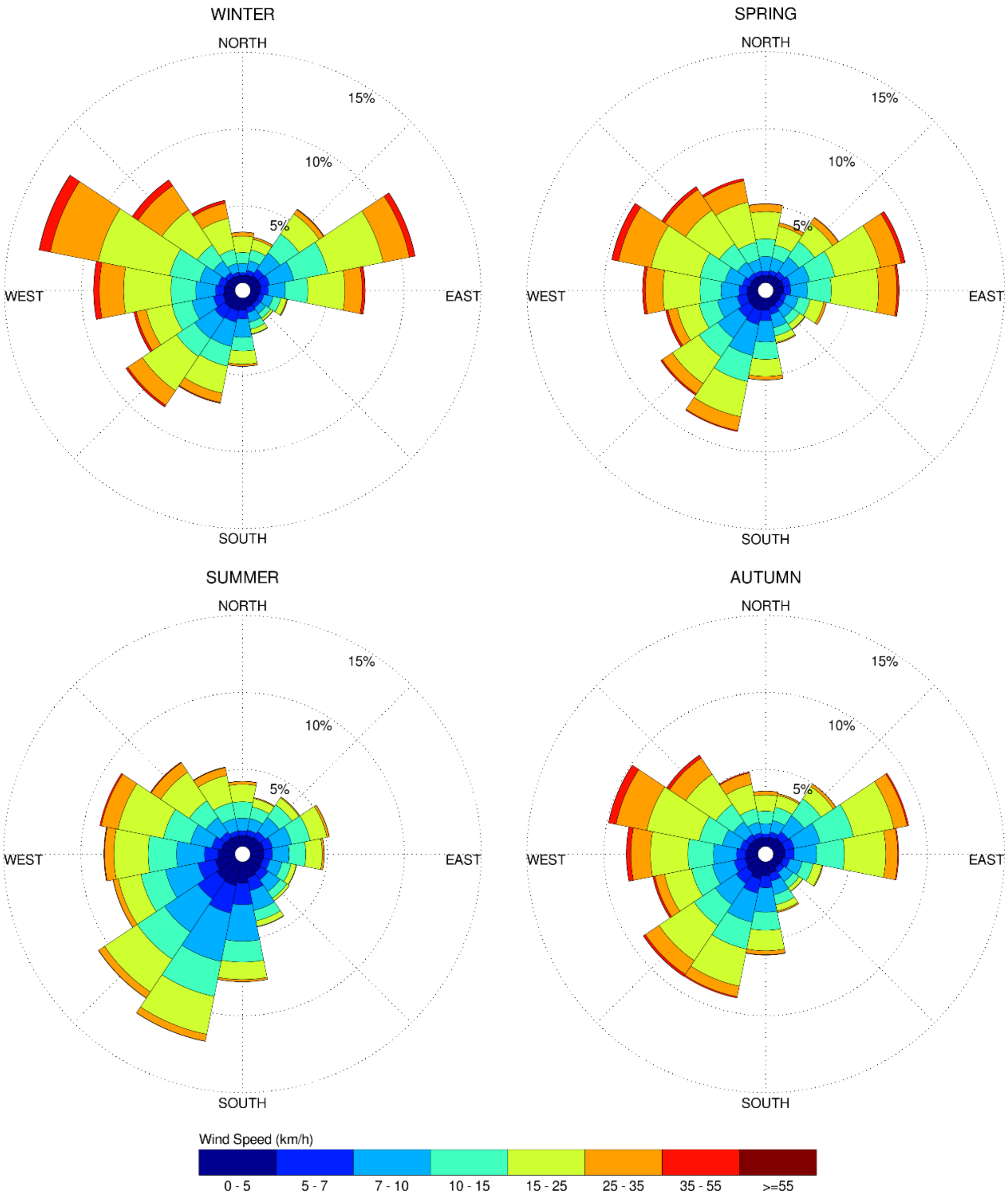
Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade and above the terraces, gardens, and plazas serving the proposed development were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. Gradient height represents the theoretical depth of the boundary layer of the earth’s atmosphere, above which the mean wind speed remains constant. Further details of the wind flow simulation technique are presented in Appendix A.

4.3 Historical Wind Speed and Direction Data

A statistical model for winds in Ottawa was developed from approximately 60 years of hourly meteorological wind data recorded at Ottawa Macdonald-Cartier International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were analyzed for each month of the year to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns.

The statistical model of the Ottawa 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 kilometers per hour (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 Ottawa, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional preference and relative magnitude of wind speed changes somewhat from season to season. During periods of snowfall, the prominent wind directions are northeast clockwise to east while the most prominent winds for higher wind speeds originate from the northeast clockwise to the east, as illustrated in Figure 3 (bottom).

SEASONAL DISTRIBUTION OF WIND
OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT



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 Daily Snowfall Data

Table 1 summarizes the 10 winter seasons with the largest total cumulative snowfall amounts. The snowfall amounts, reported in centimeters (cm), represent the arithmetic sum of all snowfalls during a given winter season. Climate statistics for the 1970-1971 winter season, which represents the greatest cumulative snowfall within the available data, are provided in Figure 4.

TABLE 1: SUMMARY OF LARGEST CUMULATIVE SEASONAL SNOWFALL AMOUNTS & TOTAL SNOWFALL DAYS MEASURED AT OTTAWA INTERNATIONAL AIRPORT

Year	Snowfall Amount (cm)	Total Snowfall Days
1970-1971	444.6	75
2007-2008	432.7	79
1992-1993	347.3	80
1971-1972	312.6	74
2018-2019	311.9	65
2016-2017	309.8	64
1996-1997	301.8	87
1993-1994	284.6	70
1995-1996	283.2	78
1959-1960	280.4	71

Table 2, on the following page, provides further details regarding monthly snowfall amounts and the corresponding number of snowfall days over the noted measurement. Of note are snowfall events with greater than 10 cm in any one given day, which are most common during the months of December, January, February, and March. Additionally, since storms can span consecutive days, cumulative snowfall data over a period of three days are also reported as a measure of the storms that occur during the winter months.

TABLE 2: NUMBER OF SNOWFALL DAYS AND MAXIMUM 3-DAY CUMULATIVE SNOWFALL AMOUNTS FOR OTTAWA (1953-2021)

Month	Number of Snowfall Days					Maximum 3-Day Cumulative Snowfall Amounts (cm)
	≤ 2.5 cm	>2.5 cm ≤5.0 cm	> 5.0 cm ≤ 10 cm	> 10 cm ≤ 20 cm	> 20 cm	
November	4.0	1.3	0.9	0.4	0.0	35.4
December	8.6	2.4	2.1	1.1	0.3	47.4
January	8.9	2.8	2.7	0.7	0.2	53.1
February	7.0	2.3	1.9	0.9	0.3	54.2
March	4.9	1.4	1.3	0.8	0.2	48.0
April	2.1	0.6	0.3	0.1	0.0	31.4
Annual	36.4	11.0	9.3	4.2	1.0	

4.5 Pedestrian Comfort and Safety Criteria – City of Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The comfort criteria assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 20% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 16 km/h.

2) **Standing:** Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 22 km/h.

3) **Strolling:** Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 27 km/h.

4) **Walking:** Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The equivalent gust wind speed is approximately 32 km/h.

5) **Uncomfortable:** Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

The pedestrian safety wind speed criterion 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 90 km/h is classified as dangerous. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians.

THE BEAUFORT SCALE

Number	Description	Gust Wind Speed (km/h)	Description
2	Light Breeze	9-17	Wind felt on faces
3	Gentle Breeze	18-29	Leaves and small twigs in constant motion; wind extends light flags
4	Moderate Breeze	30-42	Wind raises dust and loose paper; small branches are moved
5	Fresh Breeze	43-57	Small trees in leaf begin to sway
6	Strong Breeze	58-74	Large branches in motion; Whistling heard in electrical wires; umbrellas used with difficulty
7	Moderate Gale	75-92	Whole trees in motion; inconvenient walking against wind
8	Gale	93-111	Breaks twigs off trees; generally impedes progress

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 20% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (equivalent gust wind speed of approximately 16 km/h) were exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (equivalent gust wind speed of approximately 32 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As 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 throughout the site, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for discrete regions within and surrounding the subject site. This step involves comparing the predicted comfort classes to the desired comfort classes, which are dictated by the location type for each region (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their typical windiest desired comfort classes are summarized on the following page. Depending on the programming of a space, the desired comfort class may differ from this table.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

Location Types	Desired Comfort Classes
Primary Building Entrance	Standing
Secondary Building Access Point	Walking
Public Sidewalk / Bicycle Path	Walking
Outdoor Amenity Space	Sitting (Typical Use Period)
Café / Patio / Bench / Garden	Sitting (Typical Use Period)
Transit Stop (Without Shelter)	Standing
Transit Stop (With Shelter)	Walking
Public Park / Plaza	Sitting (Typical Use Period)
Garage / Service Entrance	Walking
Parking Lot	Walking
Vehicular Drop-Off Zone	Walking

5. RESULTS AND DISCUSSION

5.1 Pedestrian Wind Comfort Conditions

The following discussion of the predicted pedestrian wind conditions for the subject site is accompanied by Figures 5A-8B, illustrating wind conditions at grade level for both massing scenarios, and by Figures 9A-9D, illustrating wind conditions over the terraces, gardens, and courtyards serving the proposed development. Conditions are presented as continuous contours of wind comfort throughout the subject site and correspond to the comfort classes presented in Section 4.4. Conditions suitable for sitting are represented by the colour blue, standing by green, strolling by yellow, and walking by orange; uncomfortable conditions are represented by the colour magenta.

Wind comfort conditions within the noted terraces, gardens, and courtyards serving the proposed development are also reported for the typical use period, which is defined as May to October, inclusive. Figure 10 illustrates wind comfort conditions consistent with the comfort classes in Section 4.4. The details of these conditions are summarized in the following pages for each area of interest.

5.1.1 Wind Comfort Conditions – Grade Level

Walkways and Building Access Points Along North Elevation of Main Hospital Building: Conditions over the walkways along the north elevation of the main hospital building are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. Owing to the protection of the building façade, conditions in the vicinity of building entrances along the north elevation are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Parking Lot Along North Elevation of Main Hospital Building: Conditions over the parking lot along the north elevation of the main hospital building are predicted to be suitable for sitting during the summer, becoming suitable for mostly standing during the spring and autumn, and suitable for a mix of standing and strolling during the winter. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Walkways and Building Access Points Along East Elevation of Main Hospital Building: Conditions over the walkways along the east elevation of the main hospital building are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. In the vicinity of building entrances along the east elevation, conditions are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Walkways and Building Access Points Along South Elevation of Main Hospital Building: Conditions over the walkways along the south elevation of the main hospital building are predicted to be suitable for a mix of sitting and standing throughout the year. In the vicinity of building entrances along the south elevation conditions are predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Walkways and Building Access Points Along West Elevation of Main Hospital Building: Conditions over the walkways along the west elevation of the main hospital building are predicted to be suitable for mostly sitting during the summer, becoming suitable for a mix of sitting and standing during the autumn, and suitable for standing during the spring and winter. In the vicinity of building entrances along the west elevation, conditions are predicted to be suitable for sitting during the spring, summer, and autumn, becoming suitable for standing, or better, during the winter. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Walkways, Loading Zone, and Building Access Points at Northeast Corner of CUP: Conditions over the walkways and loading zone at the northeast corner of the CUP are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. In the vicinity of building entrances at the northeast corner of the CUP, conditions are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Walkways and Building Access Points at Northwest Corner of CUP: Conditions over the walkways at the northwest corner of the CUP are predicted to be suitable for sitting during the summer, becoming suitable for a mix of sitting and standing throughout the remainder of the year. In the vicinity of building entrances at the northwest corner of the CUP, conditions are predicted to be suitable for sitting during the summer, becoming suitable for standing, or better, throughout the remainder of the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Sidewalks along Maple Drive: Following the introduction of the proposed development, conditions over the sidewalks along Maple Drive are predicted to be suitable for sitting during the summer, becoming suitable for standing throughout the remainder of the year. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria.

Conditions over the sidewalks along Maple Drive with the existing massing are predicted to be suitable for a mix of sitting and standing during the summer, becoming suitable for standing during the autumn, and suitable for a mix of standing and strolling during the spring and winter. Notably, the introduction of the proposed development produces calmer conditions in comparison to existing conditions and are considered acceptable.

5.1.2 Wind Comfort Conditions – Terraces, Gardens, and Courtyards

Grade Level Wellness Garden: The grade level wellness garden near the northeast corner of Tower A is predicted to be suitable for sitting during the typical use period. The noted conditions are considered acceptable according to the City of Ottawa criteria.

Emergency Level Courtyard: The courtyard on the Emergency Level serving the proposed development is predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa criteria.

Level 1 Wellness Garden: The stone garden on Level 1 serving the proposed development is predicted to be suitable for sitting throughout the year. The noted conditions are considered acceptable according to the City of Ottawa criteria.

Level 5 and 6 Terraces, Tower A: The Level 5 and 6 terraces serving Tower A of the main hospital building are predicted to be suitable for sitting during the typical use period, becoming suitable for standing, or better, during the colder months. The noted conditions are considered acceptable according to the City of Ottawa criteria.

5.2 Wind Safety

Within the context of typical weather patterns, which exclude anomalous localized storm events such as tornadoes and downbursts, no pedestrian areas within or surrounding the subject site are expected to experience conditions that could be considered dangerous, as defined in Section 4.4.

5.3 Snow Drifting at Grade

A total of 7 drift zones ("zones"), illustrated in Figure 11, have been considered in this assessment. Based on our experience with numerous similar past projects, our predictions are summarized below.

1. **Main Entrance of Main Hospital Building**: Snow is expected to accumulate in this zone for several wind directions. Importantly, snow is expected to accumulate during northeasterly winds, which are common during snowfall events.
2. **Parking Lot North of Main Hospital Building**: Snow is expected to scour from the parking lot for most wind conditions.
3. **Loading Area East of Main Hospital Building**: While snow is expected to scour from this zone during northeasterly winds, which are common during snowfall events, snow may accumulate in this area during northwesterly winds, which are also common.
4. **Loading Area at Northeast Corner of CUP**: Snow in this zone is expected to accumulate during northeasterly winds, which are common during snowfall events.
5. **Entrances and Walkways South of Main Hospital Building**: Snow is expected to accumulate in this zone for several wind directions.
6. **Entrances at Northwest Corner of CUP**: Snow in this zone is only expected to scour for higher wind speeds.
7. **Entrances and Walkways West of Main Hospital Building**: While snow in this zone is expected to scour for most wind directions, some accumulation is expected for southeasterly winds. Southeasterly winds are less common in Ottawa than other directions.

Given the frequency of snowfall events, combined with significant drift conditions associated with prominent wind directions, many of the locations considered are likely to experience regular drift accumulations during the winter period. Of particular importance, the main entrance of the main hospital building and the loading area at the northeast corner of the CUP (zones 1 and 4) are estimated to accumulate moderate amounts of snow. Although frequent, the amount of accumulation is not expected to be problematic beyond typical local conditions. On this basis, we advise that a snow and ice control program be created to address regular snow accumulations in the noted areas. These areas can be managed with regular snow clearing and heated slabs (where desired) to prevent ice buildup on walkways, near building entrances, on service ramps, and on outdoor staircases. While heated slabs can assist with snow and ice clearing, they may need to be cleared following power outages or large storms that exceed the melting capacity of the slabs to prevent ice formation. Additionally, heated slabs should be accompanied with a drainage system to prevent ice formation at the edge of the slabs. The use of vestibules at main entrances is helpful to provide a transition area where residual water and snow from footwear can be discharged. Furthermore, for areas where snow will accumulate, adequate drainage will be required to deal with simultaneous rapid snow melting and heavy precipitation that is likely to occur during the late winter and spring periods. Providing that a regular snow removal and/or melting program is followed, we do not anticipate that grade level drift accumulations will hinder the day-to-day operations of the facility during the winter period.

5.4 Applicability of Results

Pedestrian wind comfort and safety have been quantified for the specific configuration of existing and foreseeable construction around the subject site. Future changes (i.e., construction or demolition) of these surroundings may cause changes to the wind effects in two ways, namely: (i) changes beyond the immediate vicinity of the subject site would alter the wind profile approaching the subject site; and (ii) development in proximity to the subject site would cause changes to local flow patterns.

Regarding primary and secondary building access points, wind conditions predicted in this study are only applicable to pedestrian comfort and safety. As such, the results should not be construed to indicate wind loading on doors and associated hardware.

6. CONCLUSIONS AND RECOMMENDATIONS

A complete summary of the predicted wind conditions is provided in Section 5 and illustrated in Figures 5A-10. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with numerous similar developments, the study concludes the following:

1) All grade-level areas within and surrounding the subject site are predicted to experience conditions that are considered acceptable for the intended pedestrian uses throughout the year. Specifically, conditions over surrounding sidewalks, walkways, surface parking, loading zones, and in the vicinity of building access points, are considered acceptable.

2) The terraces, gardens, and courtyards serving the main hospital building are predicted to be suitable for sitting during the typical use period. Specifically, conditions over the Emergency Level courtyard, the Level 1 wellness garden, and the Level 5 and 6 terraces serving Tower A are predicted to be acceptable.

3) Regarding grade-level snow drifting, we have the following conclusions:

    a. Many of the locations considered, which are illustrated in Figure 11, are likely to experience regular drift accumulations during the winter period. Of particular importance, moderate snow drift accumulations are expected to occur in the vicinity of the main entrance of the main hospital building and the loading area at the northeast corner of the CUP. Although frequent, the amount of accumulation is not expected to be problematic beyond typical local conditions.

    b. Provided a regular snow removal program is followed for the noted areas, snow drift accumulations are not anticipated to hinder the day-to-day operations of the proposed development. The snow removal program is anticipated to be similar to other snow removal programs in Ottawa.

4) The foregoing statements and conclusions apply to common weather systems, during which no dangerous wind conditions, as defined in Section 4.4, are expected anywhere over the subject site. During extreme weather events, (e.g., thunderstorms, tornadoes, and downbursts), pedestrian safety is the main concern. However, these events are generally short-lived and infrequent and there is often sufficient warning for pedestrians to take appropriate cover.

Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
S. R. HALL
100197168
Oct. 4, 2022
PROVINCE OF ONTARIO

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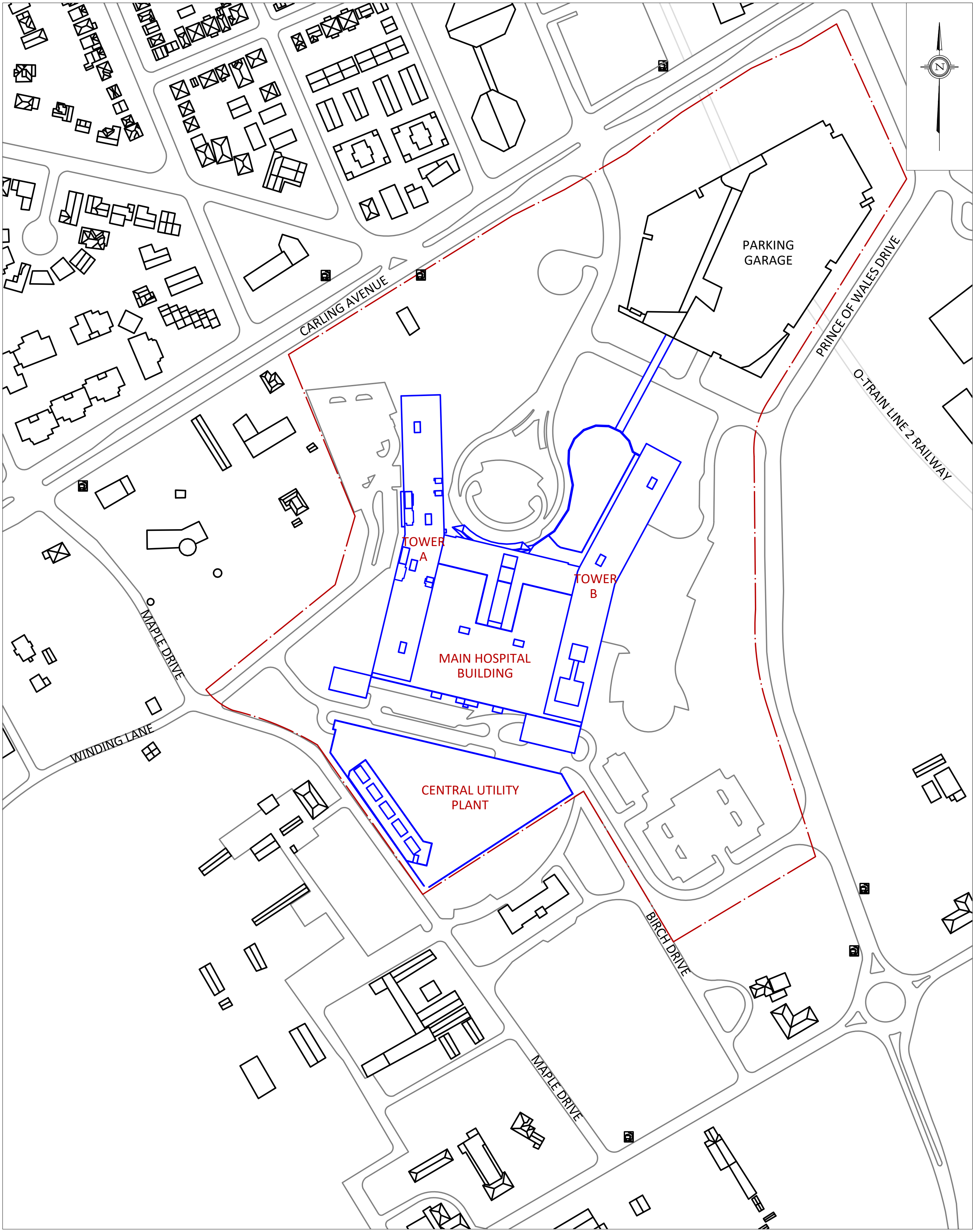
Steven Hall, M.A.Sc., P.Eng.
Senior Wind Engineer



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PROJECT NEW CAMPUS DEVELOPMENT, THE OTTAWA HOSPITAL, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:4000	DRAWING NO. 20-049-PLW-2022-1A	
DATE SEPTEMBER 30, 2022	DRAWN BY S.K.	

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PROJECT NEW CAMPUS DEVELOPMENT, THE OTTAWA HOSPITAL, OTTAWA PEDESTRIAN LEVEL WIND STUDY		DESCRIPTION FIGURE 1B: EXISTING SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:4000	DRAWING NO. 20-049-PLW-2022-1B	
DATE SEPTEMBER 30, 2022	DRAWN BY S.K.	

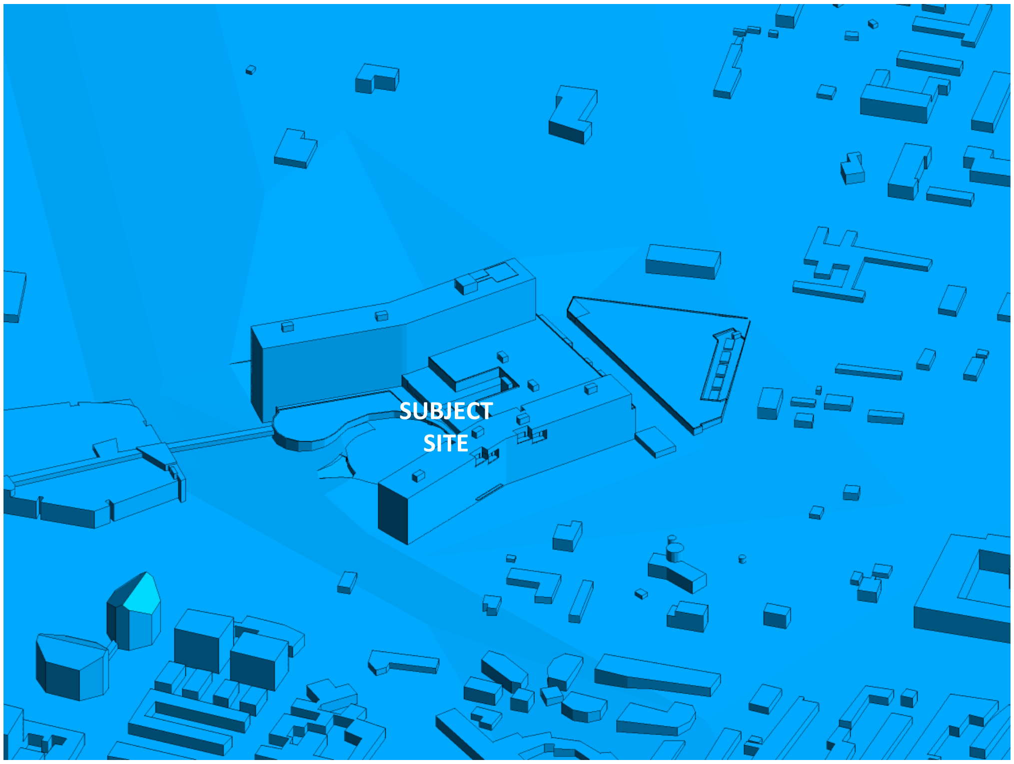


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTHWEST PERSPECTIVE

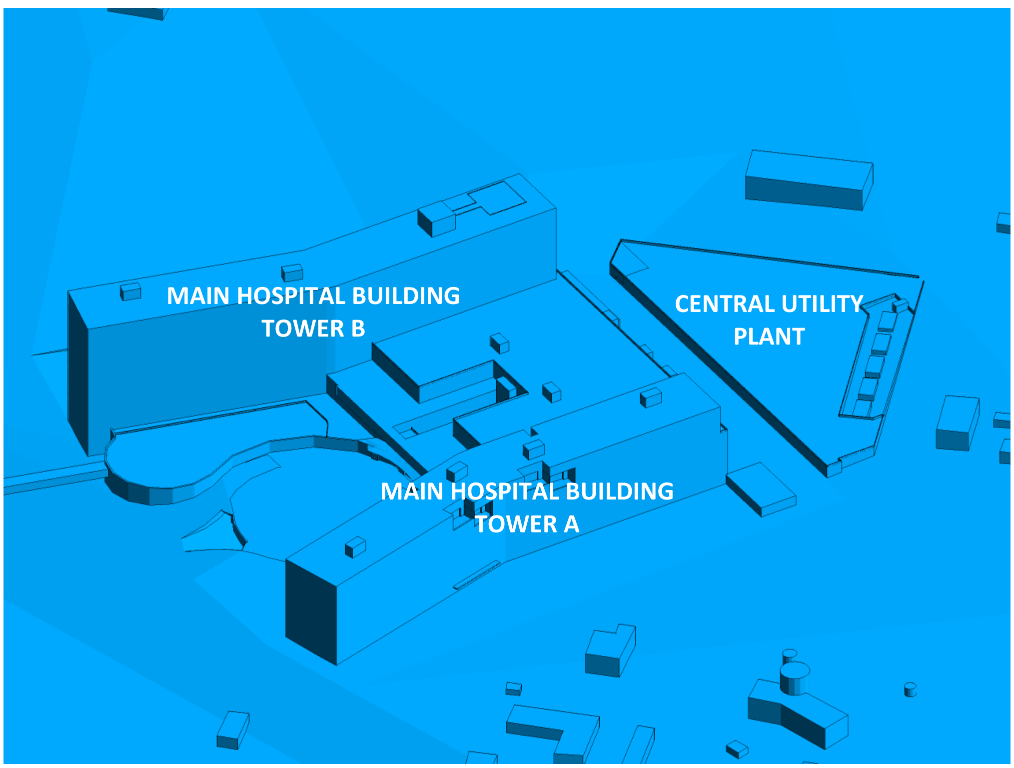


FIGURE 2B: CLOSE UP OF FIGURE 2A

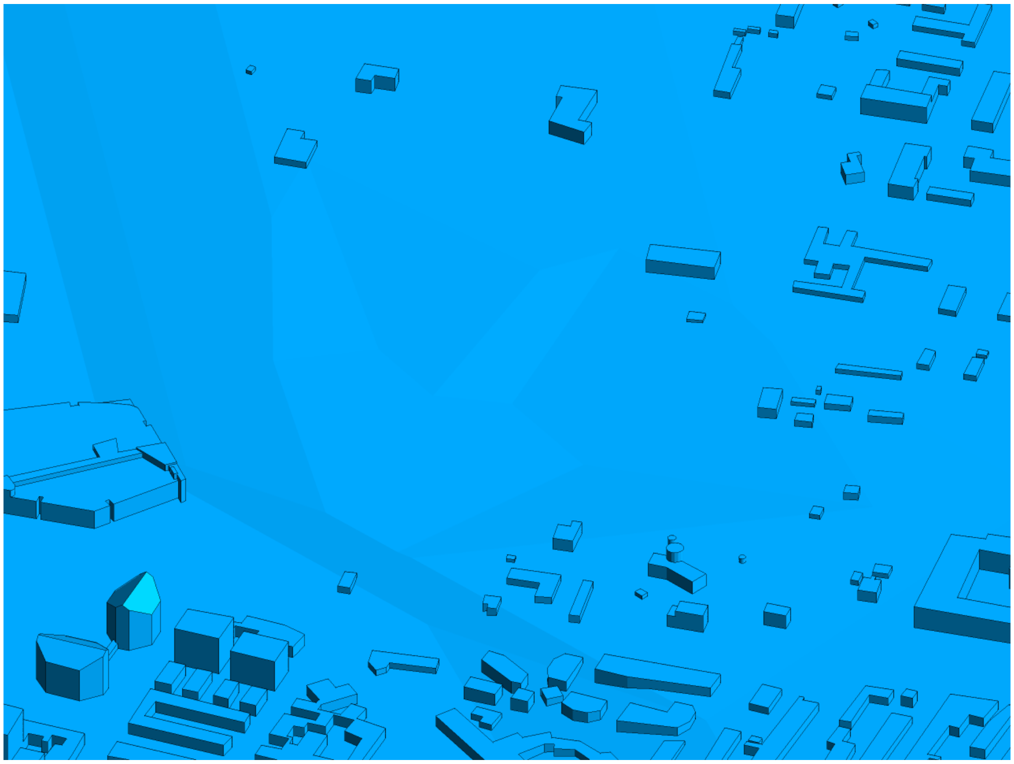


FIGURE 2C: COMPUTATIONAL MODEL, EXISTING MASSING, NORTHWEST PERSPECTIVE

FIGURE 2D: CLOSE UP OF FIGURE 2C

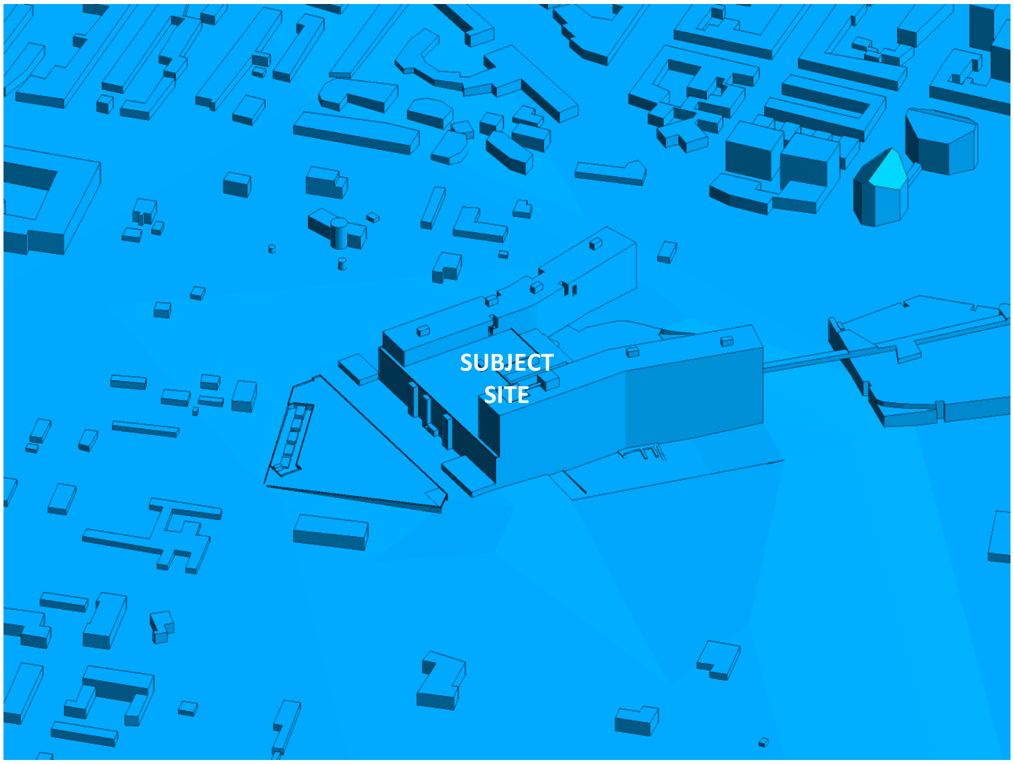


FIGURE 2E: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTHEAST PERSPECTIVE

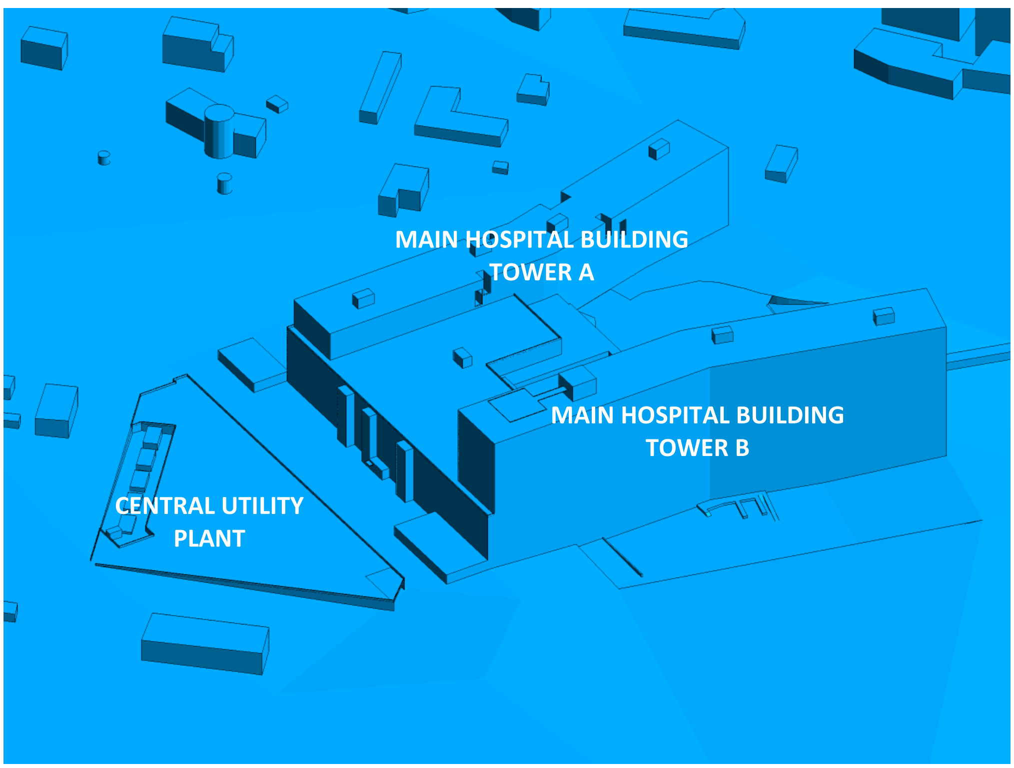


FIGURE 2F: CLOSE UP OF FIGURE 2E

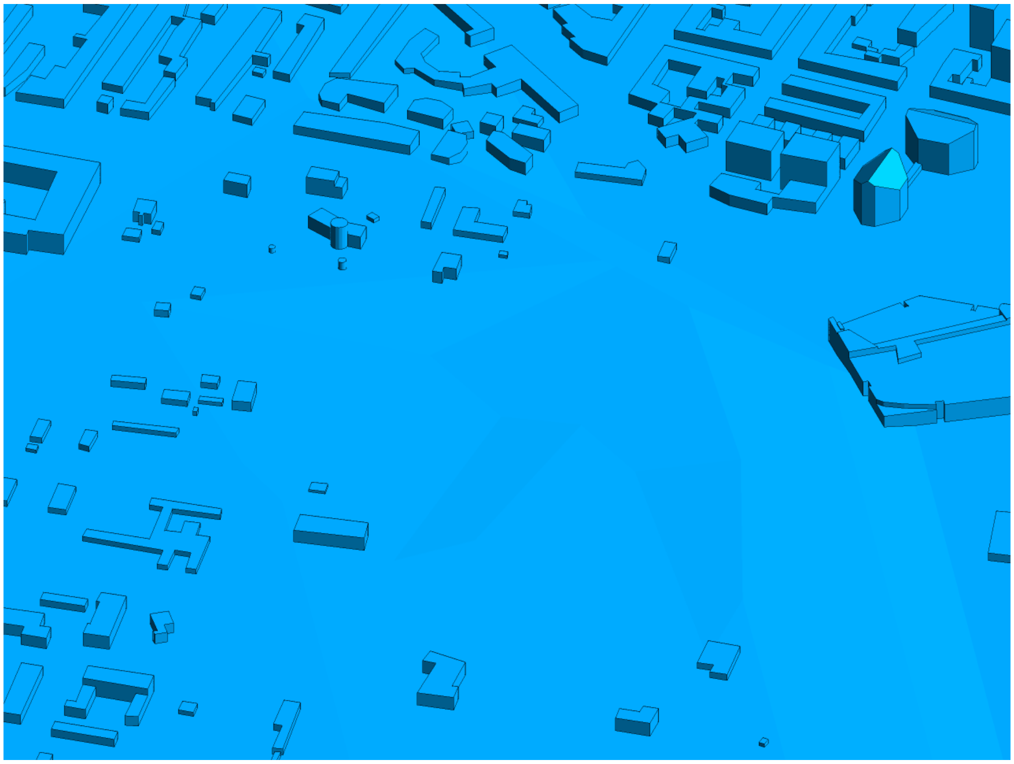


FIGURE 2G: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTHEAST PERSPECTIVE

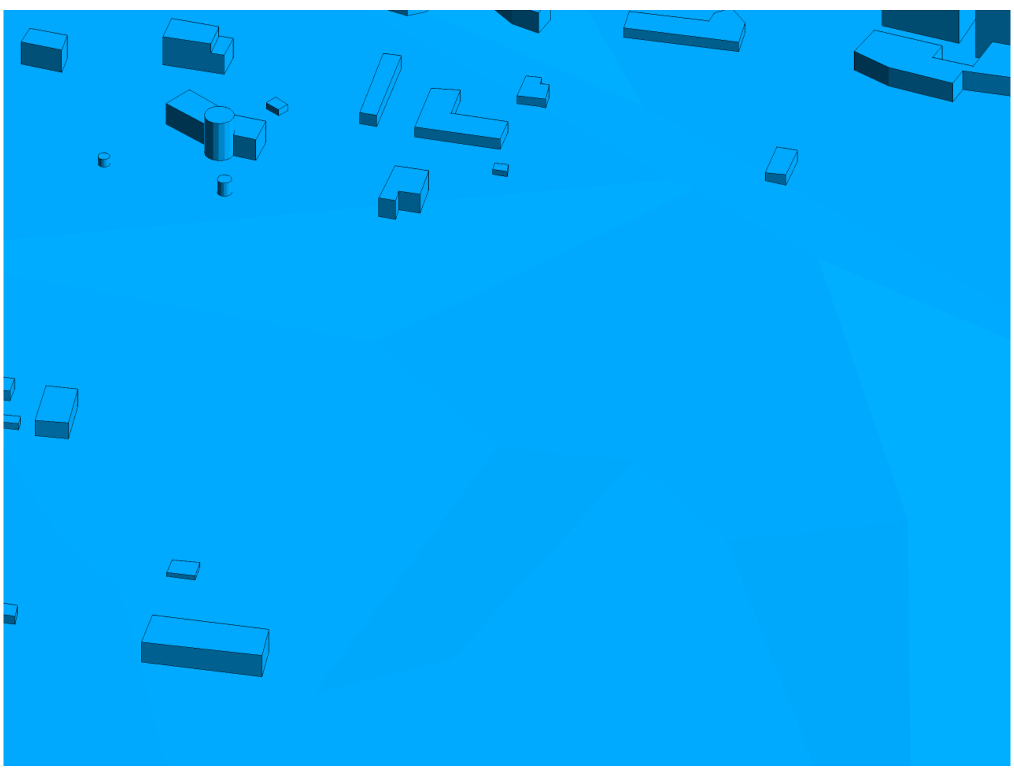
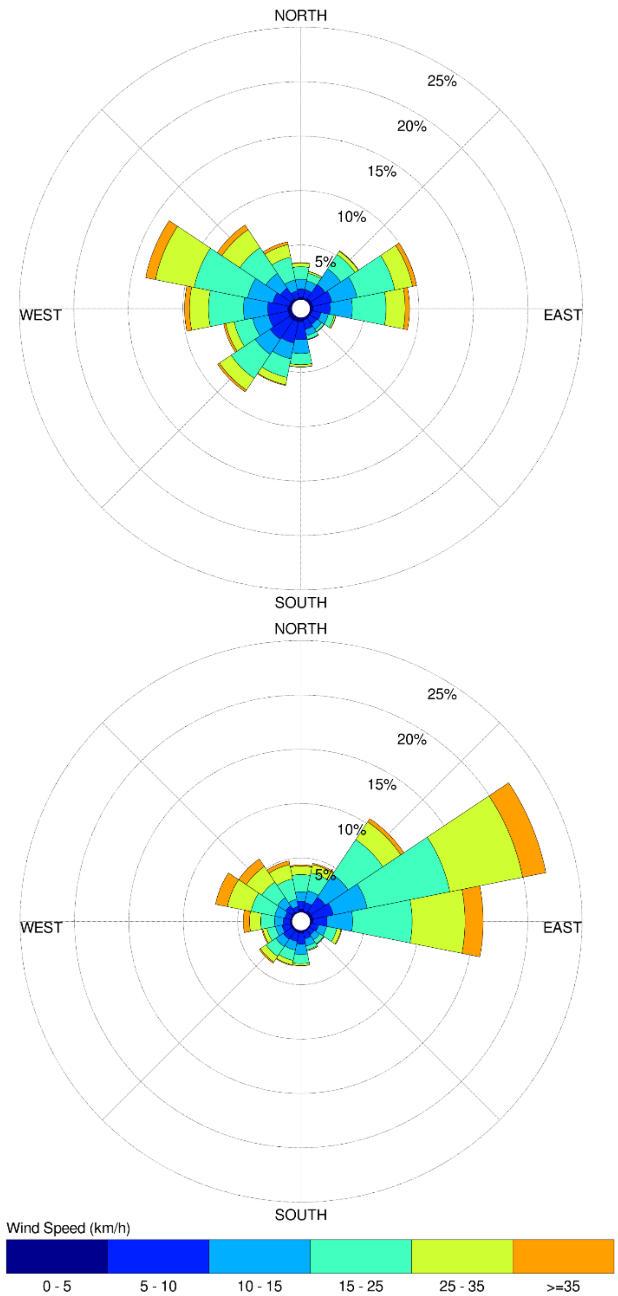


FIGURE 2H: CLOSE UP OF FIGURE 2G



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.

FIGURE 3: DISTRIBUTION OF WIND DURING THE WINTER SEASON (TOP) AND DISTRIBUTION OF WIND DURING SNOWFALL EVENTS (BOTTOM) OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT (1953-2017)

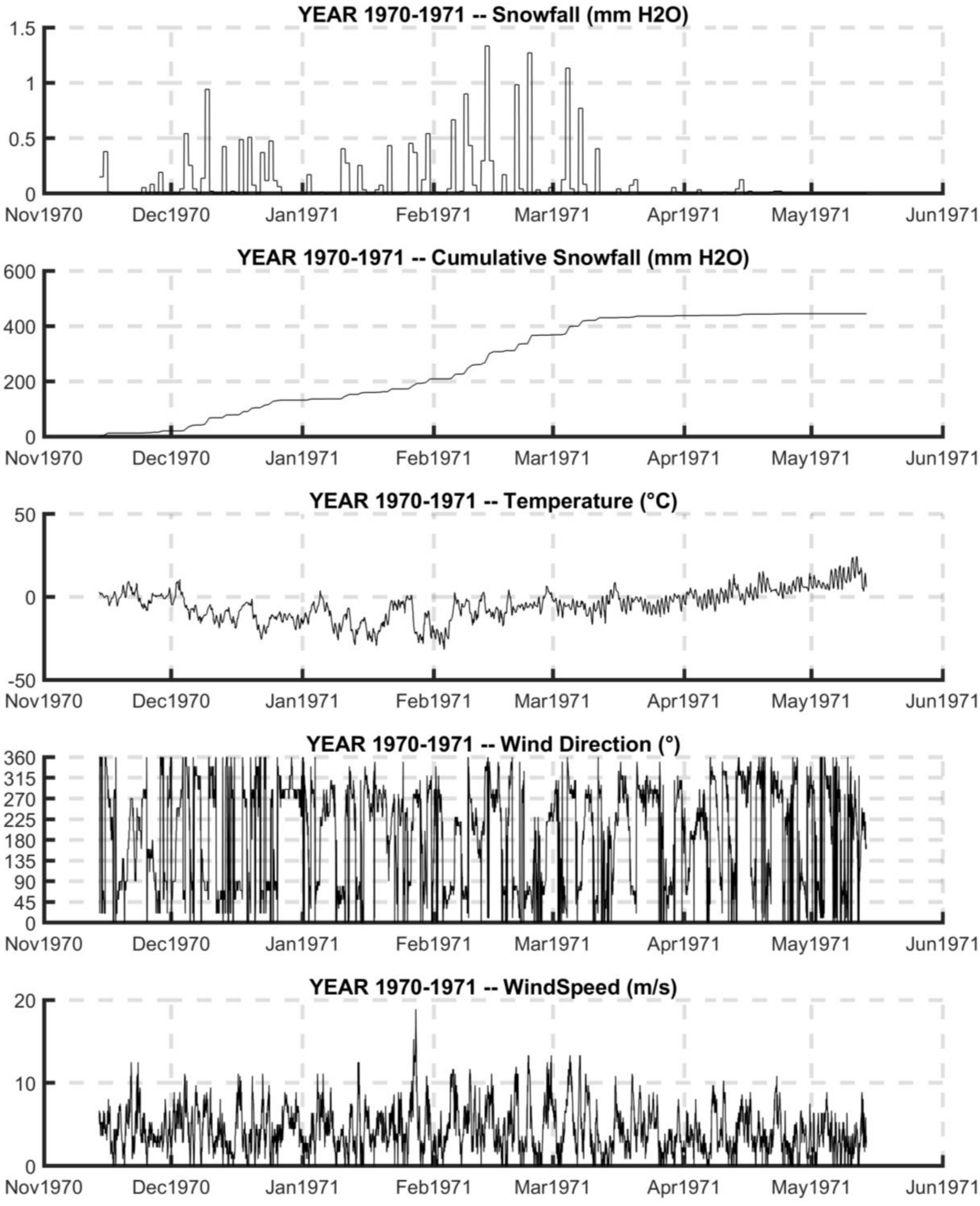


FIGURE 4: RAW CLIMATE STATISTICS (WINTER SEASON, 1970-1971)
OTTAWA MACDONALD-CARTIER INTERNATIONAL AIRPORT

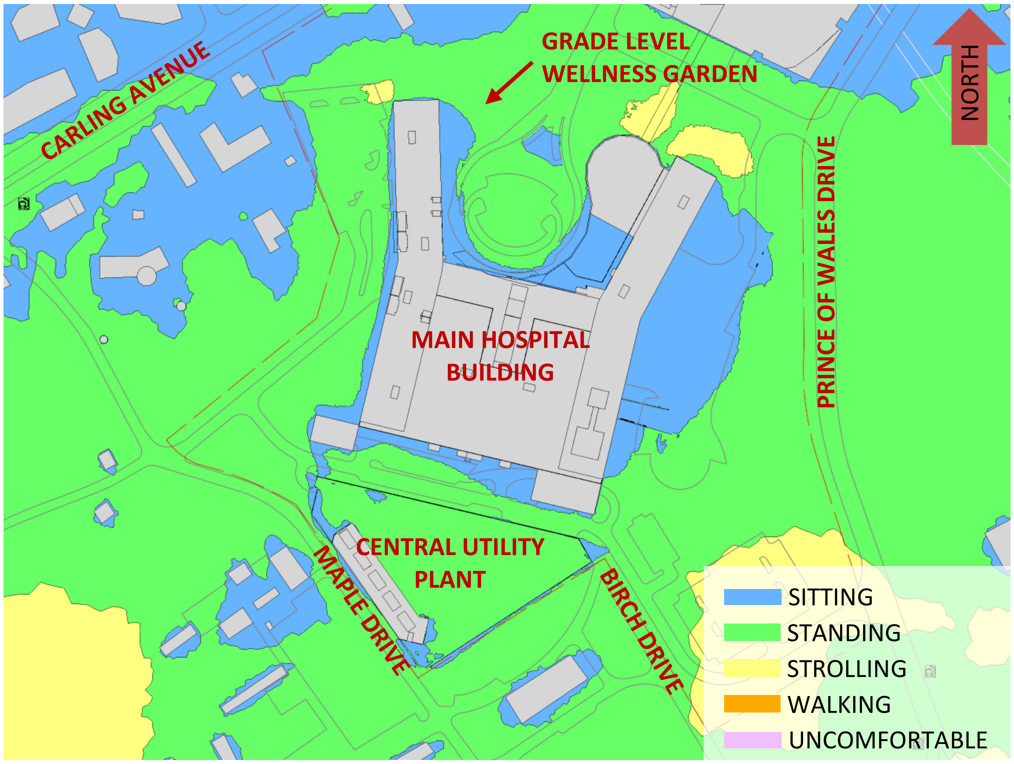


FIGURE 5A: SPRING – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

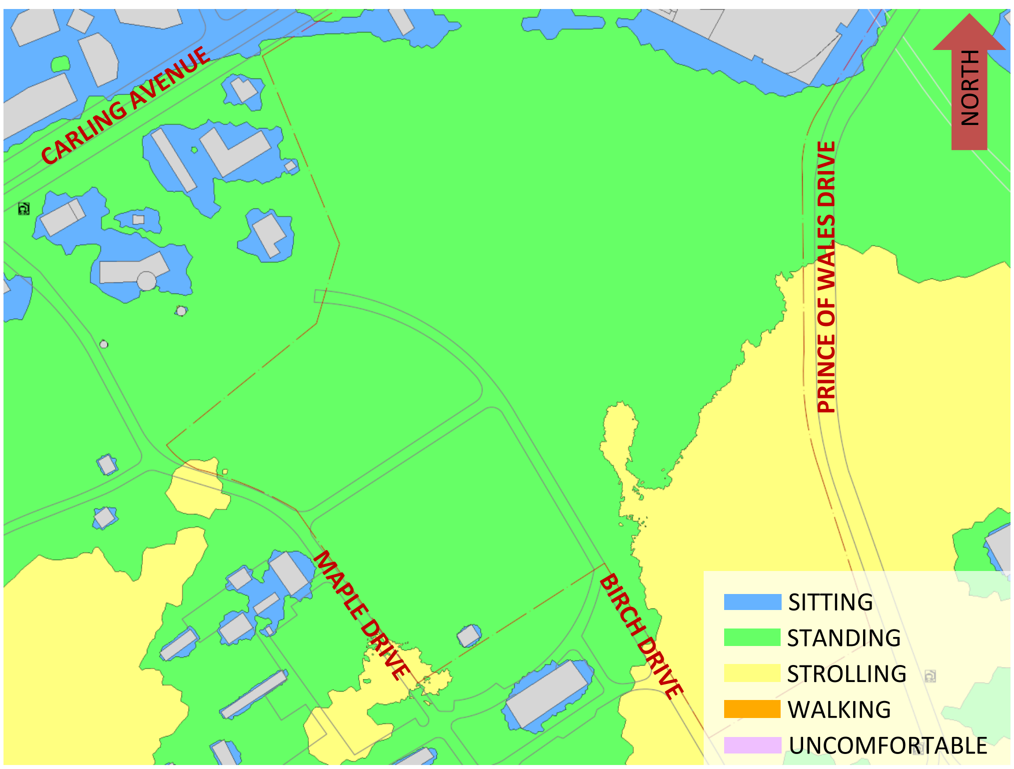


FIGURE 5B: SPRING – EXISTING MASSING – WIND COMFORT, GRADE LEVEL

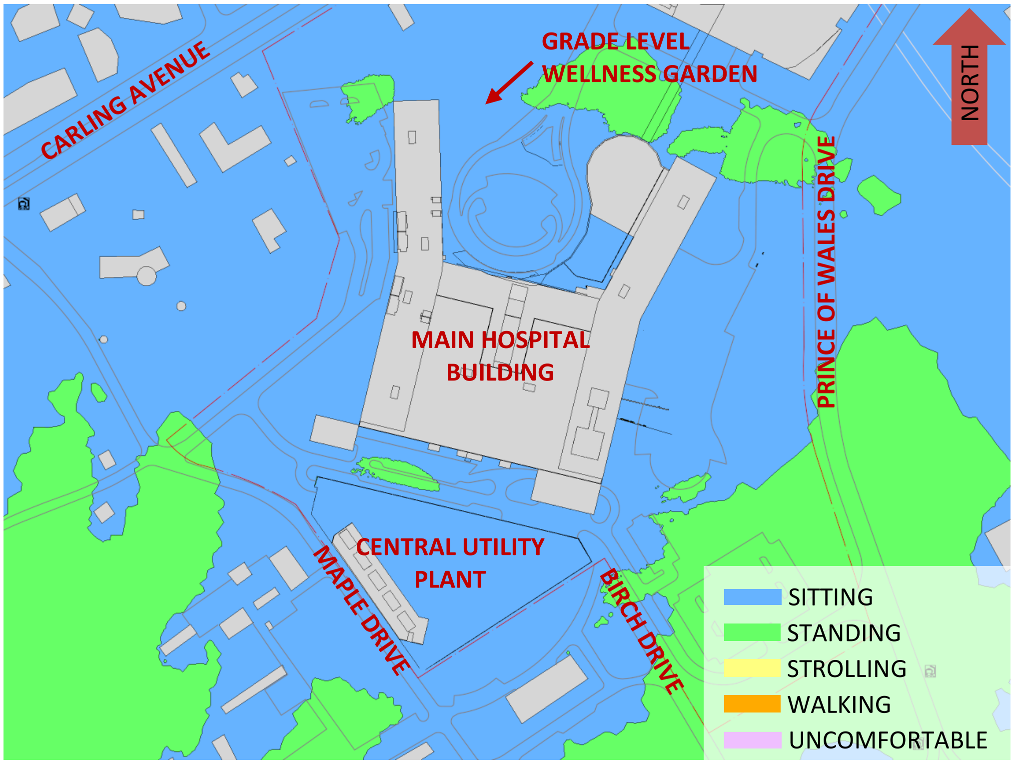


FIGURE 6A: SUMMER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

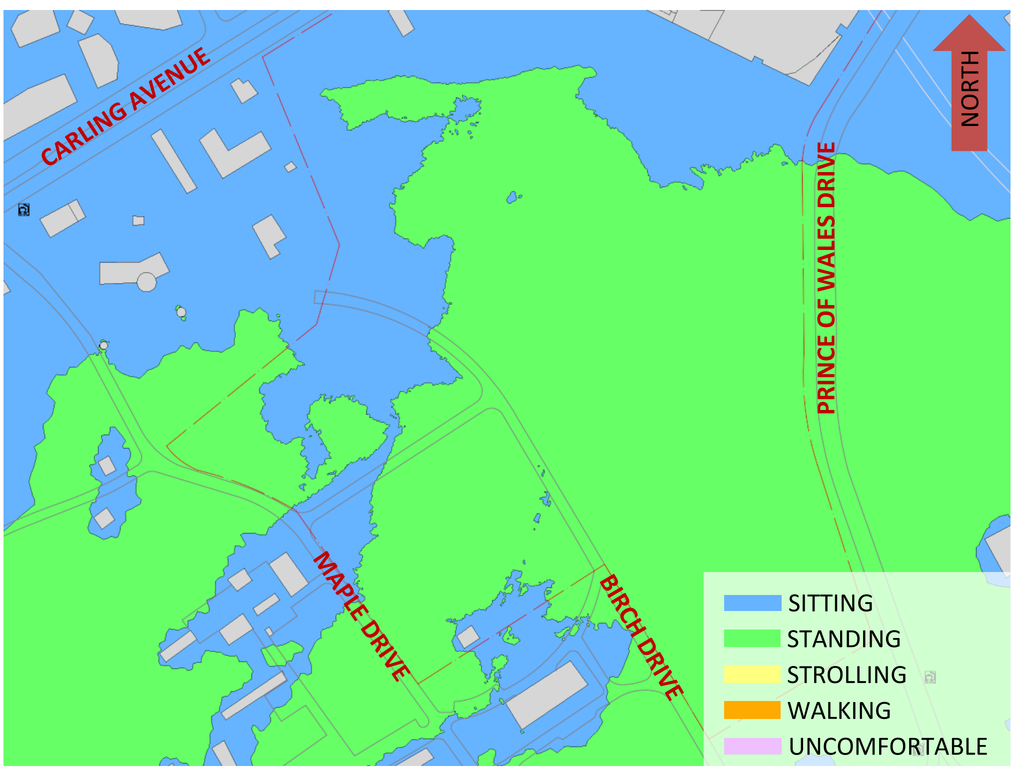


FIGURE 6B: SUMMER – EXISTING MASSING – WIND COMFORT, GRADE LEVEL

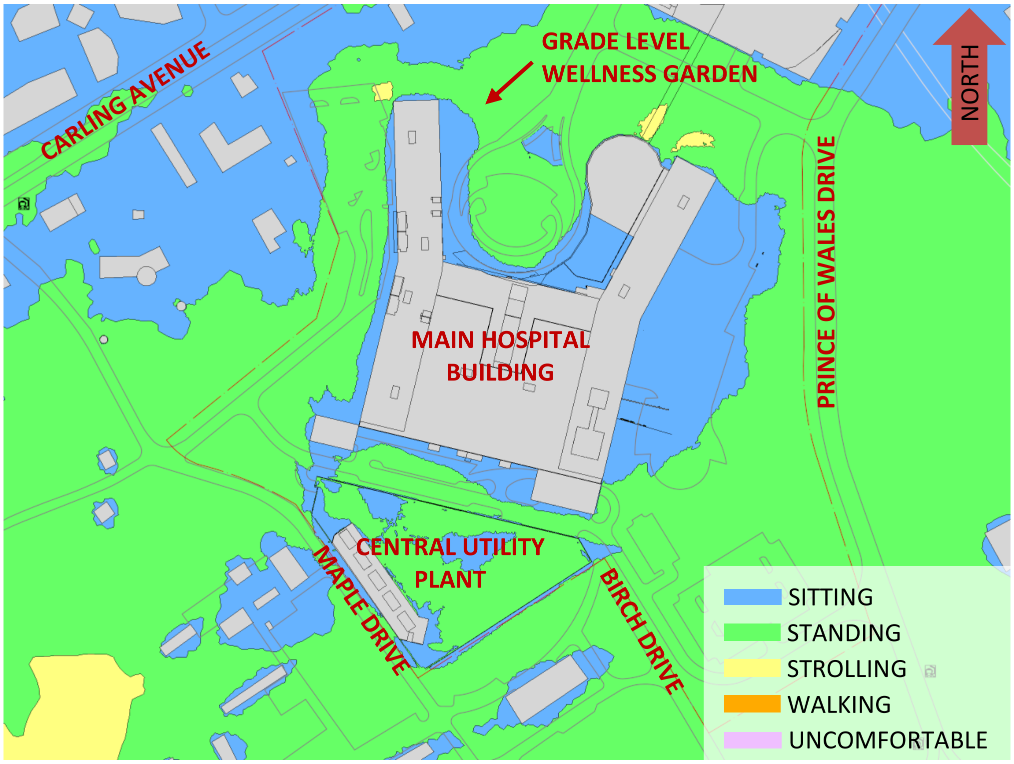


FIGURE 7A: AUTUMN – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

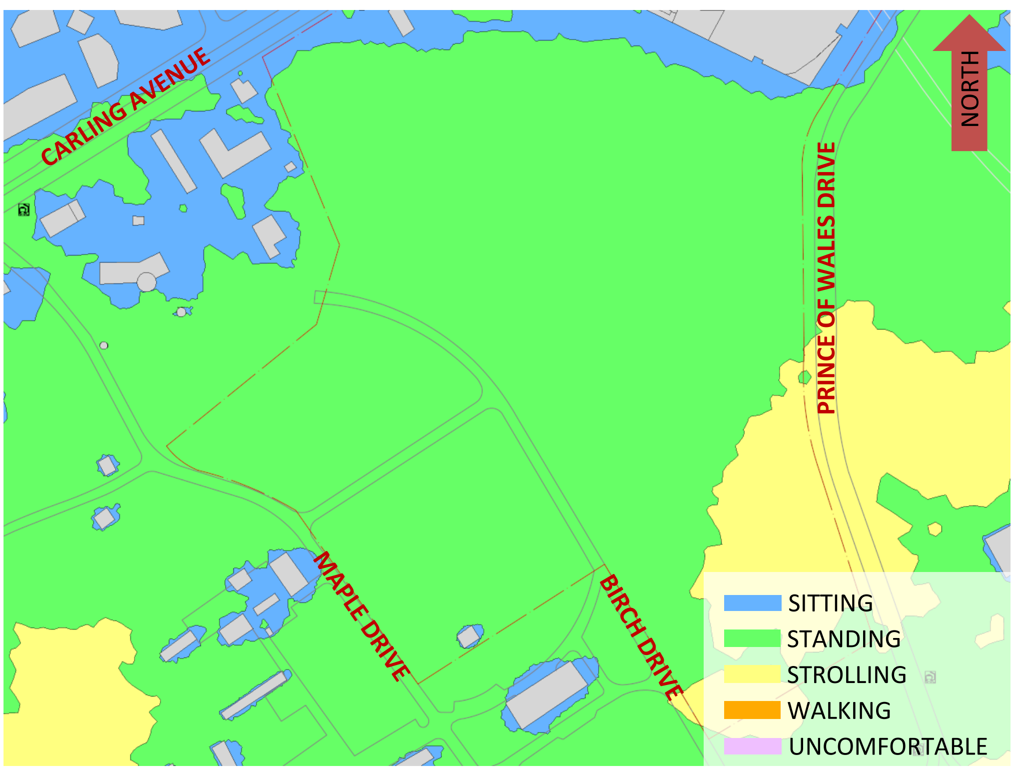


FIGURE 7B: AUTUMN – EXISTING MASSING – WIND COMFORT, GRADE LEVEL

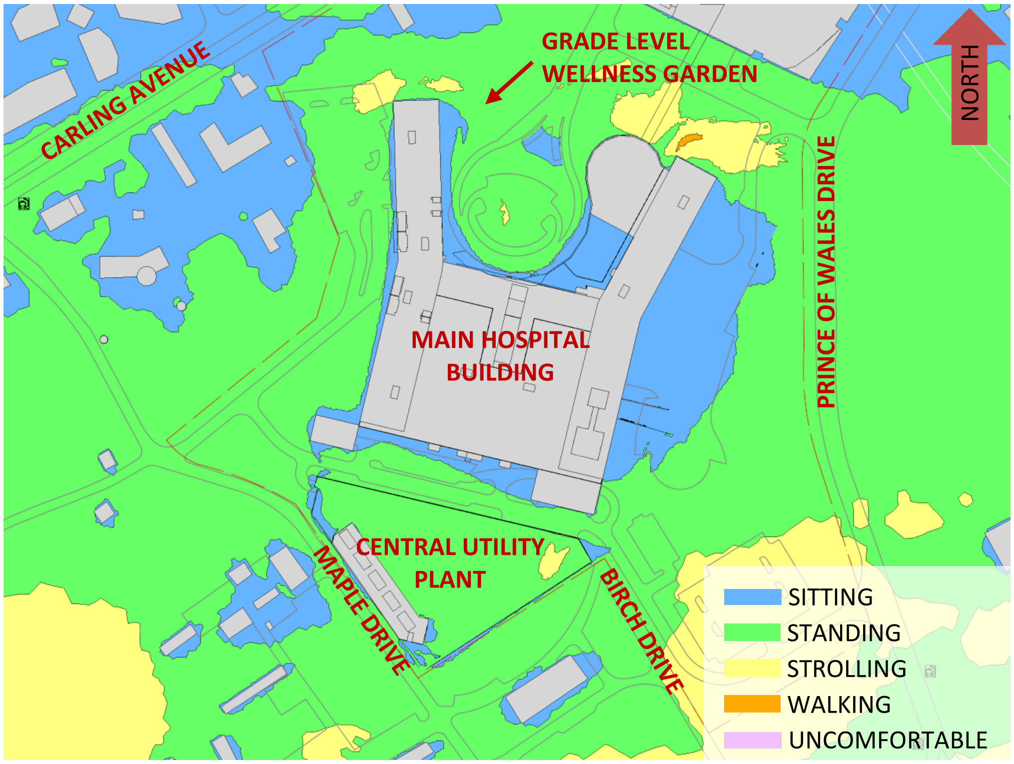


FIGURE 8A: WINTER – PROPOSED MASSING – WIND COMFORT, GRADE LEVEL

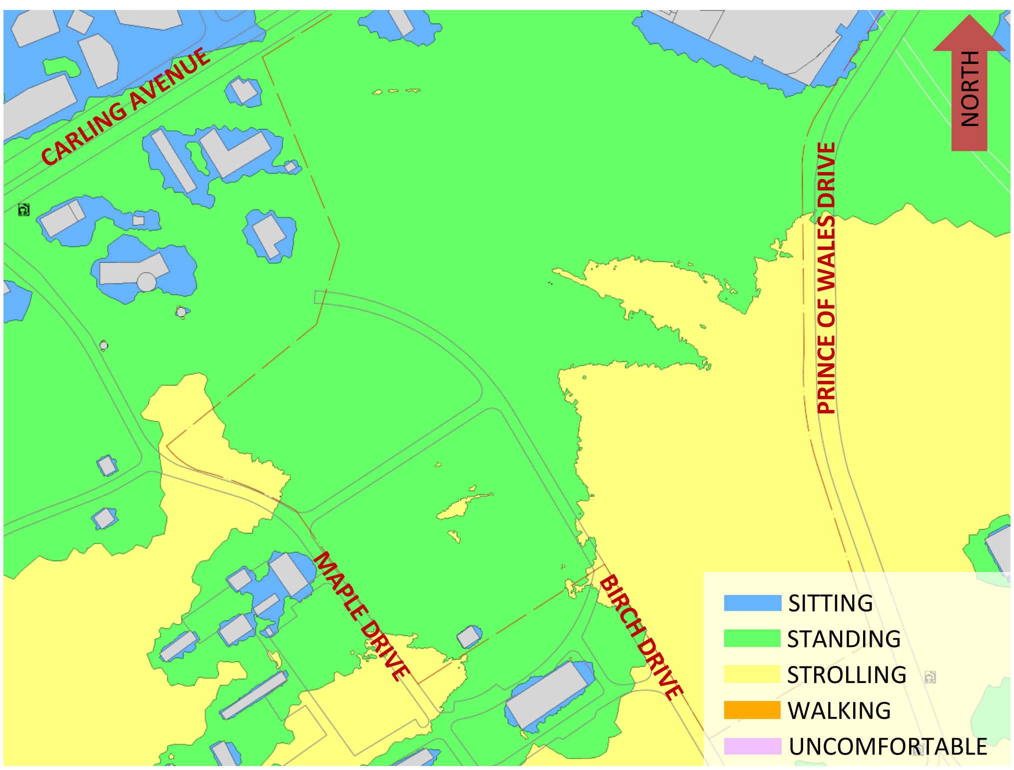


FIGURE 8B: WINTER – EXISTING MASSING – WIND COMFORT, GRADE LEVEL

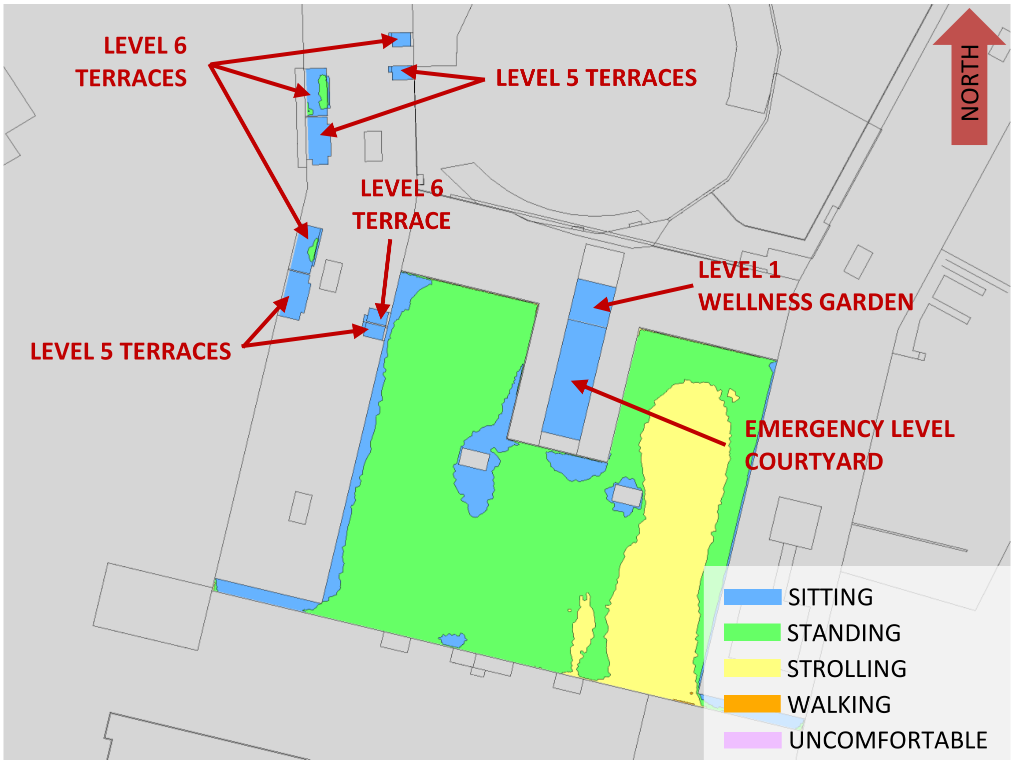


FIGURE 9A: SPRING – TERRACES, GARDENS, AND COURTYARDS

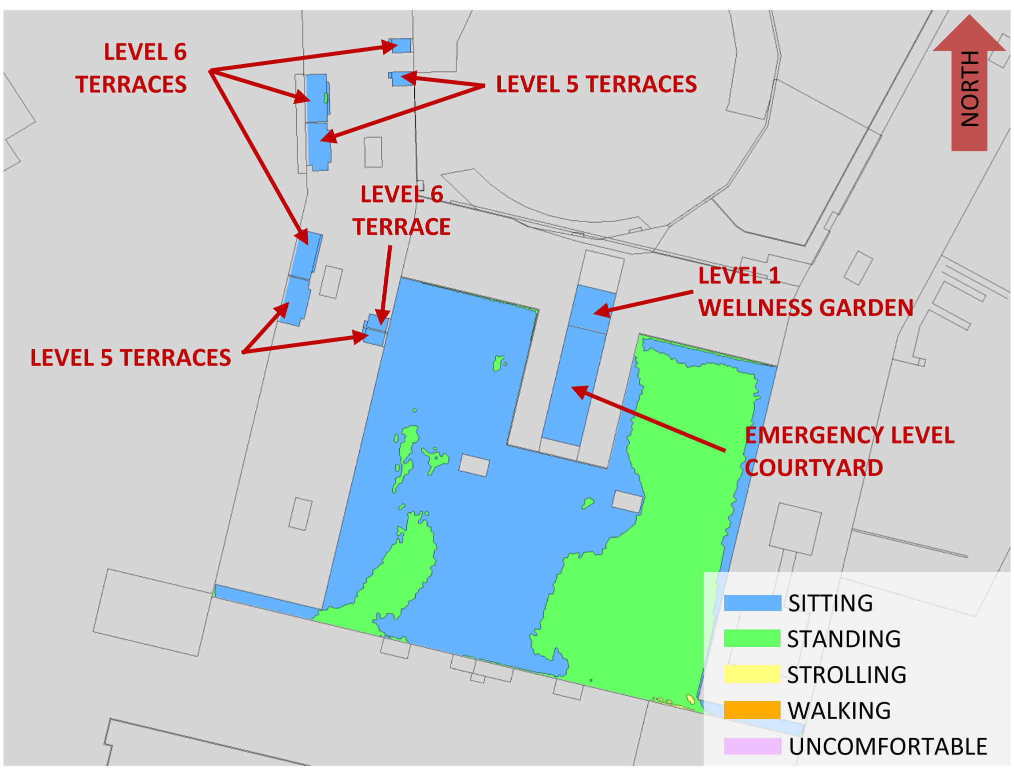


FIGURE 9B: SUMMER – TERRACES, GARDENS, AND COURTYARDS

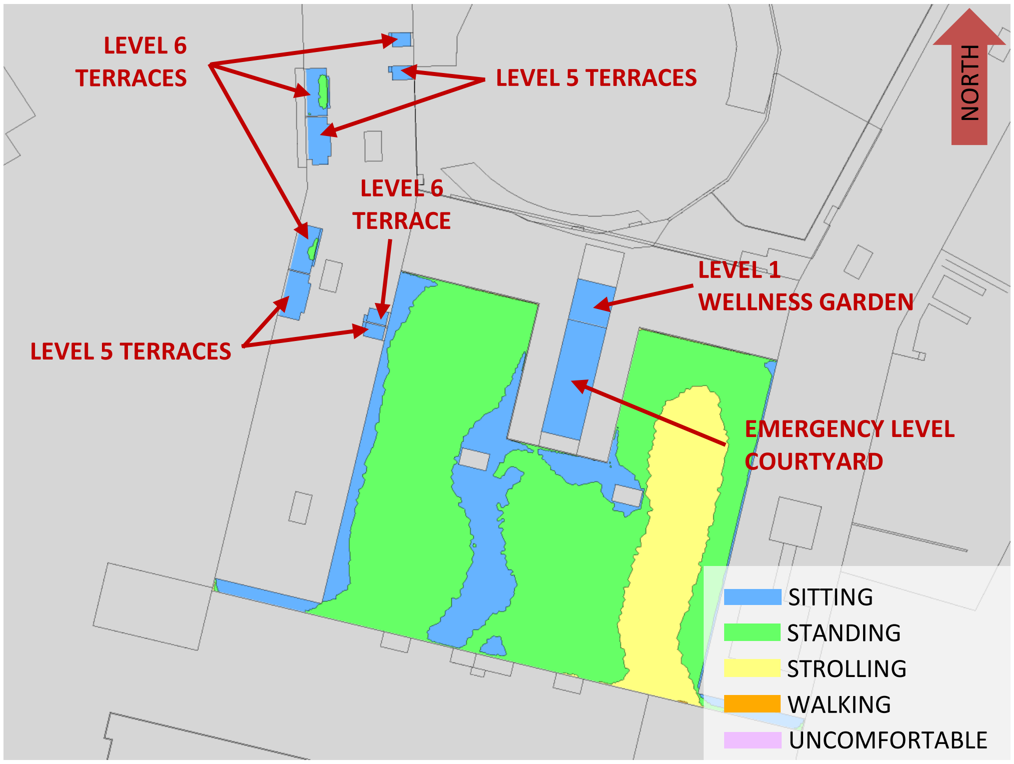


FIGURE 9C: AUTUMN – TERRACES, GARDENS, AND COURTYARDS

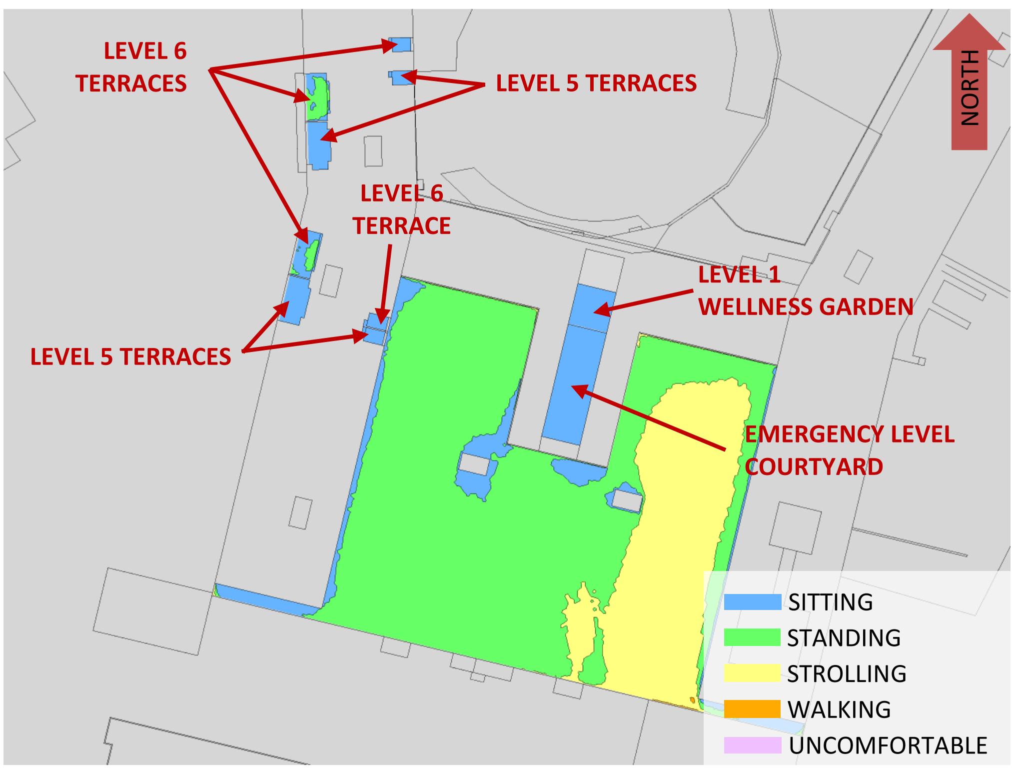


FIGURE 9D: WINTER – TERRACES, GARDENS, AND COURTYARDS

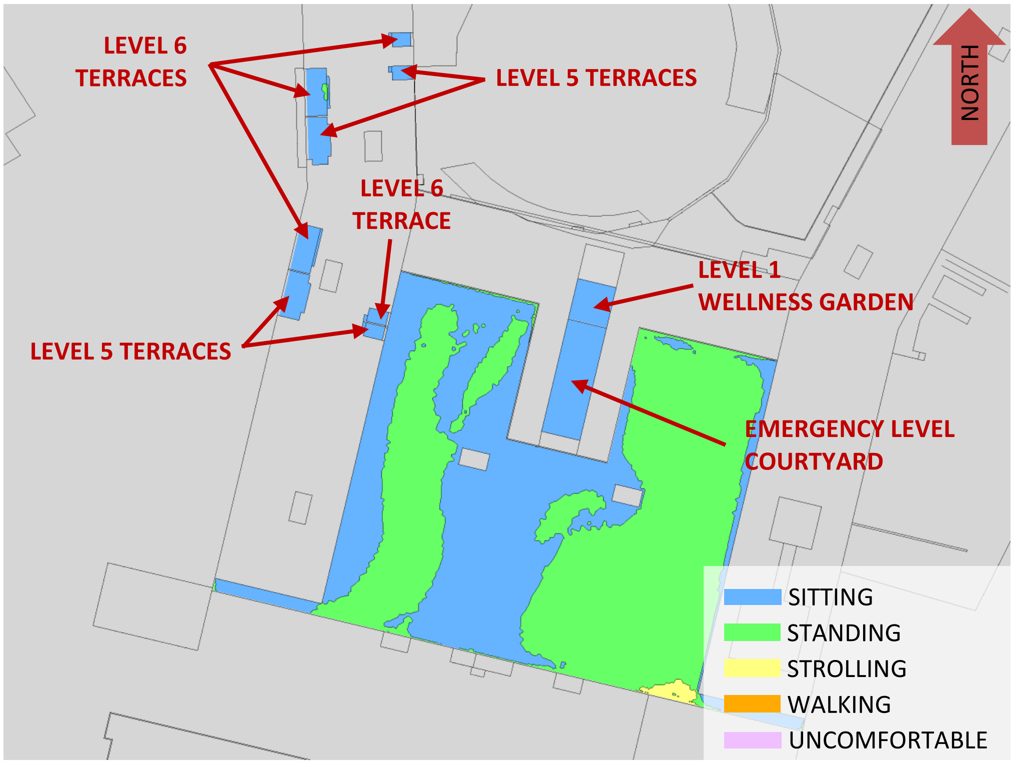


FIGURE 10: TYPICAL USE PERIOD – TERRACES, GARDENS, AND COURTYARDS

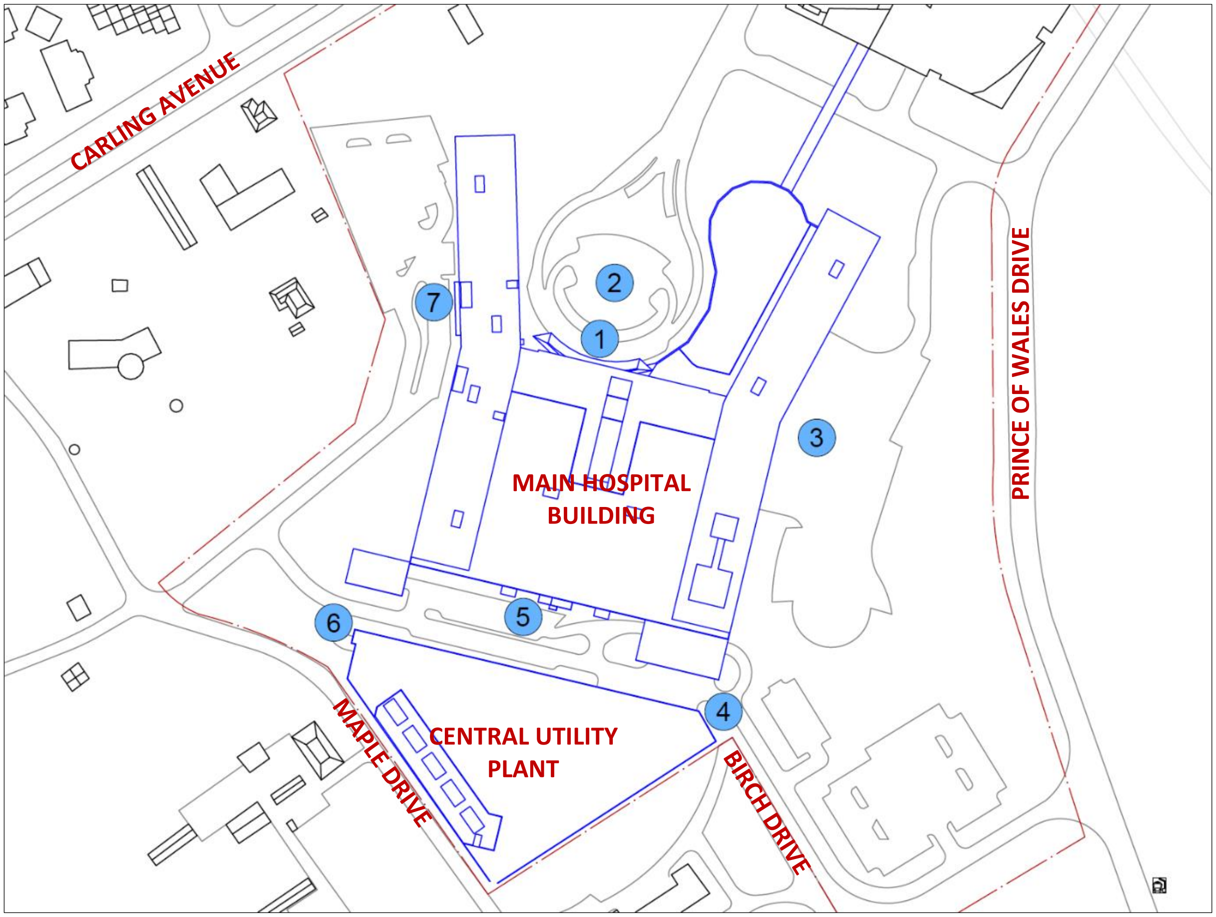
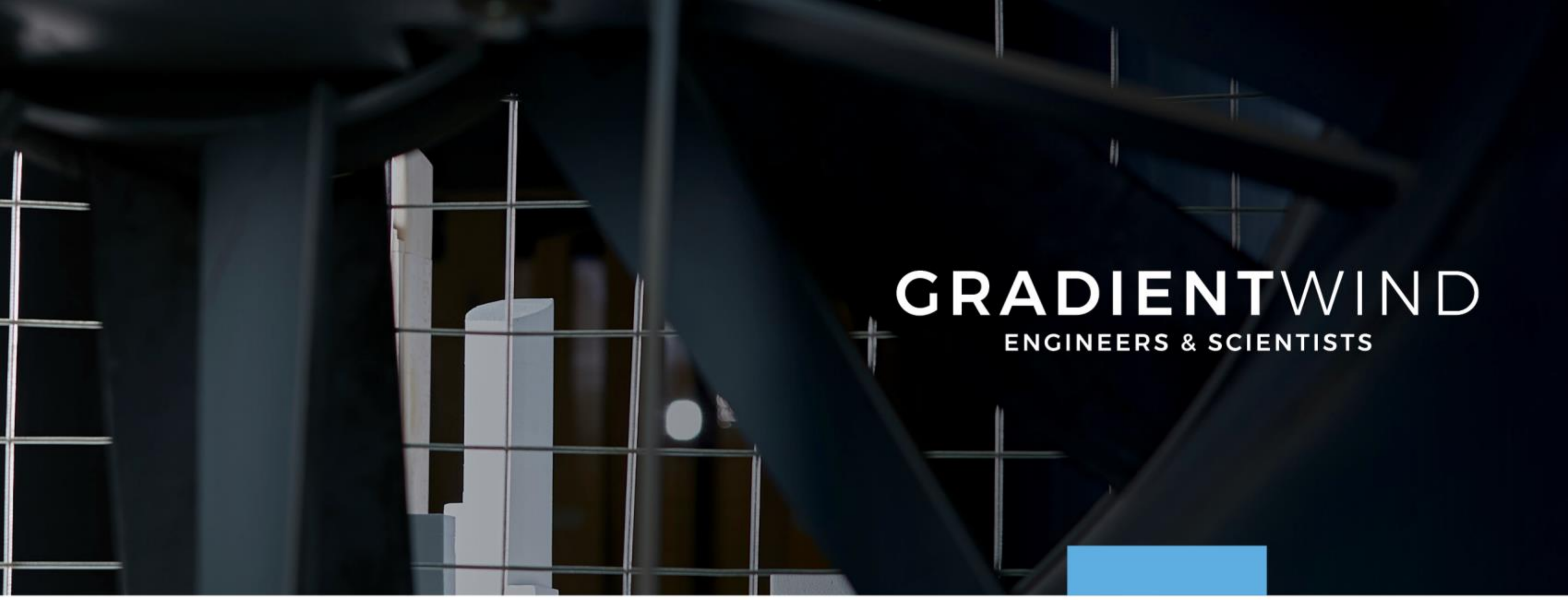
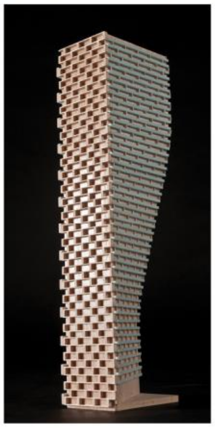
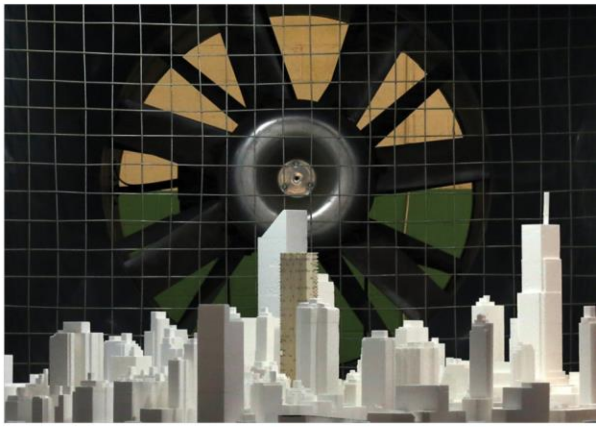


FIGURE 11: SNOW DRIFT ZONES AROUND MAIN HOSPITAL BUILDING AND CUP







APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

The atmospheric boundary layer (ABL) is defined by the velocity and turbulence profiles according to industry standard practices. The mean wind profile can be represented, to a good approximation, by a power law relation, Equation (1), giving height above ground versus wind speed (1), (2).

$$U = U_g \left(\frac{Z}{Z_g}\right)^{\alpha} \qquad \text{Equation (1)}$$

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 60% mean wind speed for Ottawa based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

Z_g is set to 540 m. The selection of gradient height is relatively unimportant, so long as it exceeds the building heights surrounding the subject site. The value has been selected to correspond to our physical wind tunnel reference value.

α is determined based on the upstream exposure of the far-field surroundings (i.e., the area that it not captured within the simulation model).

Table 1 presents the values of α used in this study, while Table 2 presents several reference values of α. When the upstream exposure of the far-field surroundings is a mixture of multiple types of terrain, the α values are a weighted average with terrain that is closer to the subject site given greater weight.

TABLE 1: UPSTREAM EXPOSURE (ALPHA VALUE) VS TRUE WIND DIRECTION

Wind Direction (Degrees True)	Alpha Value (α)
0	0.26
49	0.25
74	0.25
103	0.24
167	0.20
197	0.19
217	0.22
237	0.22
262	0.25
282	0.25
301	0.25
324	0.25

TABLE 2: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

Upstream Exposure Type	Alpha Value (α)
Open Water	0.14-0.15
Open Field	0.16-0.19
Light Suburban	0.21-0.24
Heavy Suburban	0.24-0.27
Light Urban	0.28-0.30
Heavy Urban	0.31-0.33

The turbulence model in the computational fluid dynamics (CFD) simulations is a two-equation shear-stress transport (SST) model, and thus the ABL turbulence profile requires that two parameters be defined at the inlet of the domain. The turbulence profile is defined following the recommendations of the Architectural Institute of Japan for flat terrain (3).

$$I(Z) = \begin{cases} 0.1\left(\frac{Z}{Z_g}\right)^{-\alpha-0.05}, & Z > 10\ \text{m} \\ 0.1\left(\frac{10}{Z_g}\right)^{-\alpha-0.05}, & Z \leq 10\ \text{m} \end{cases}$$ Equation (2)

$$L_t(Z) = \begin{cases} 100\ \text{m}\sqrt{\frac{Z}{30}}, & Z > 30\ \text{m} \\ 100\ \text{m}, & Z \leq 30\ \text{m} \end{cases}$$ Equation (3)

where, ***I*** = turbulence intensity, $\boldsymbol{L_t}$ = turbulence length scale, ***Z*** = height above ground, and α is the power law exponent used for the velocity profile in Equation (1).

Boundary conditions on all other domain boundaries are defined as follows: the ground is a no-slip surface; the side walls of the domain have a symmetry boundary condition; the top of the domain has a specified shear, which maintains a constant wind speed at gradient height; and the outlet has a static pressure boundary condition.

REFERENCES

[1] P. Arya, "Chapter 10: Near-neutral Boundary Layers," in *Introduction to Micrometeorology*, San Diego, California, Academic Press, 2001.

[2] S. A. Hsu, E. A. Meindl and D. B. Gilhousen, "Determining the Power-Law WInd Profile Exponent under Near-neutral Stability Conditions at Sea," vol. 33, no. 6, 1994.

[3] Y. Tamura, H. Kawai, Y. Uematsu, K. Kondo and T. Okhuma, "Revision of AIJ Recommendations for Wind Loads on Buildings," in *The International Wind Engineering Symposium, IWES 2003*, Taiwan, 2003.