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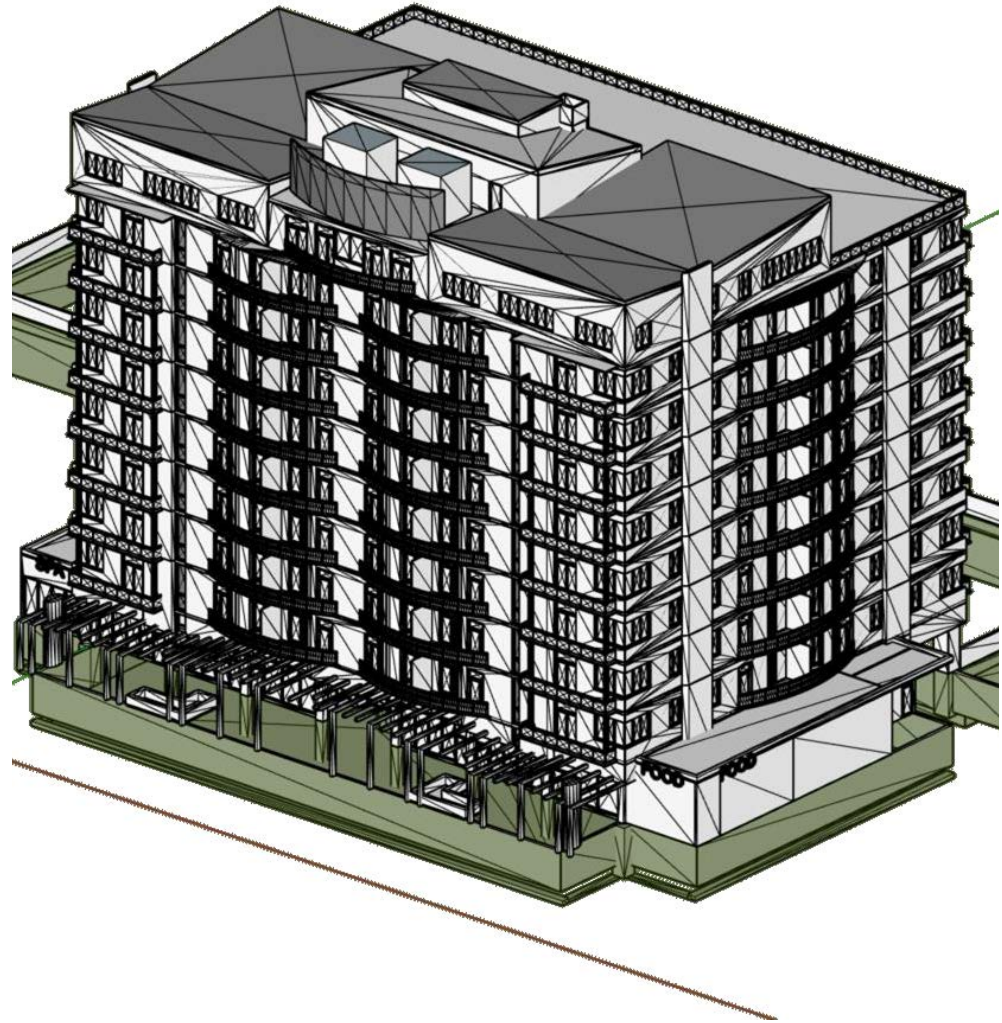
Date: April 24, 2023

Re: Pedestrian Wind Assessment

180 King Street South

Waterloo, Ontario

SLR Project #241.030886.00001



John MacDonald Architect

**Prepared by:**

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For:

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c/o AXIA GeoCapital Inc.
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Principal Engineer, Microclimate

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1.0 INTRODUCTION

SLR Consulting (Canada) Ltd. (SLR) was retained by 1000237993 Ontario Inc. to conduct a pedestrian wind assessment for the proposed 180 King Street South project in Waterloo, Ontario. This report is provided in support of the development's upcoming Zoning Bylaw Amendment (ZBA) application with the City of Waterloo.

1.1 Existing Development

The proposed development is located at the north corner of King Street South and Allen Street East in Waterloo, Ontario. The site is currently occupied by a seven-storey commercial building and parking lot.

Figure 1 provides an aerial view of the immediate study area. A virtual site visit was conducted by SLR using Google Earth images dated March 28, 2022, and an in-person site visit was conducted on March 21, 2023. Several images of the site and surroundings are included in **Figures 2a** through **2d**.

Immediately surrounding the site are high-rise residential developments to the southwest and south, and low-rise commercial and residential buildings in all other directions. Beyond the immediate surroundings, low-rise and mid-rise commercial and residential developments continue in all directions.



Figure 1: Aerial view of existing site & surroundings
Credit: Google Earth Pro, dated 3/28/2022

1.2 Surrounding Developments

Typically, known nearby developments with Site Plan Approval (SPA) approval and/or those currently under construction within the context extents are included as existing surroundings. Additionally, nearby developments that are currently undergoing the approvals process can be included as future surroundings.

For this assessment, the in-construction development at 168 King Street South (shown in **Figures 5a, 5b, and 5c**) was included as an existing surrounding in the Existing, Proposed, and Future Configurations.

Furthermore, the following proposed developments (shown in **Figure 5c**) were included as future surroundings only in the Future Configuration:

1. 185 King Street South (under review); and,
2. 215 King Street South (approved).



Figure 2a: Looking northwest along King Street South

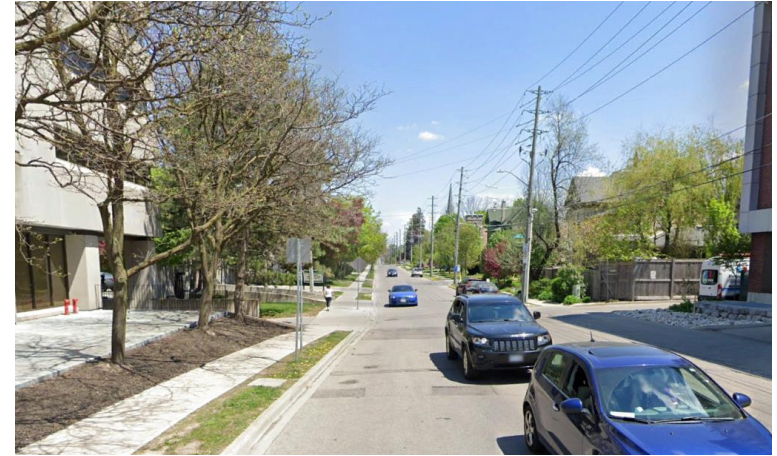


Figure 2c: Looking northeast along Allen Street East

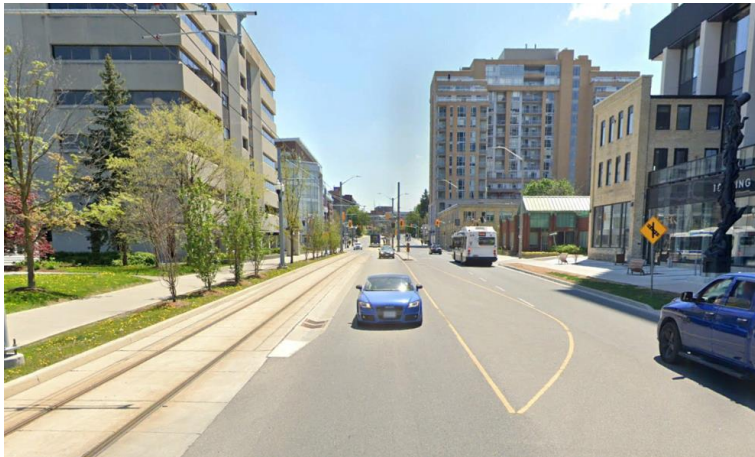


Figure 2b: Looking southeast along King Street South

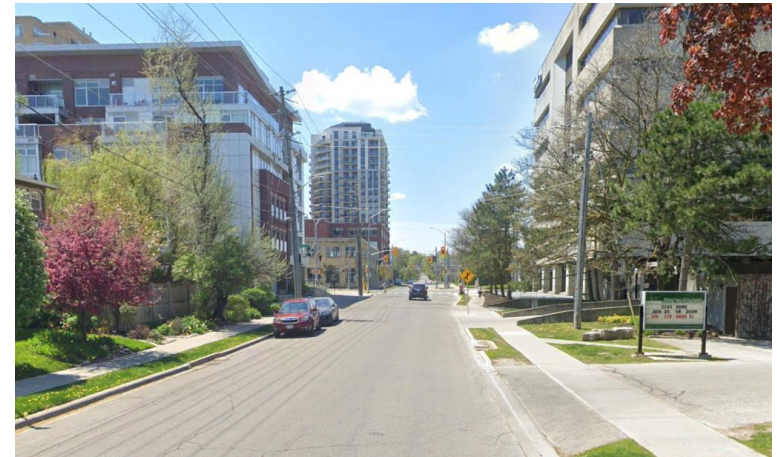


Figure 2d: Looking southwest along Allen Street East

1.3 Proposed Development

The proposed redevelopment is located at the northeast corner of King Street South and Allen Street East in Waterloo, Ontario, and includes the adaptive re-use of the existing seven-storey building to a ten-storey mixed-use building (**Figure 3**). Two grade-level outdoor patios and a grade-level outdoor common area are proposed along King Street South.

1.4 Areas of Interest

Areas of interest for pedestrian wind conditions include those areas which pedestrians are expected to use on a frequent basis. Typically, these include sidewalks, main entrances, transit stops, plazas and parks. On-site areas of interest are shown in **Figure 4**.

Note, Project North is approximately 46° counter-clockwise from True North. When referring to the building, Project North (i.e., parallel to King Street South) is used; when referring to wind directions, True North is used.

The main entrance is situated in the centre of the west facade, along King Street South. Secondary entrances are situated along King Street South (near the northwest and southwest corners), as well as near the northeast corner, and along the east facade.

Within the project vicinity, two transit stops are located on the east and west corners of the intersection of King Street South and Allen Street, directly south of the site. A Light Rail Transit (LRT) station is also located in the centre of King Street South, to the southeast of the site.



Figure 3: Rendering of proposed redevelopment
Credit: John MacDonald Architect

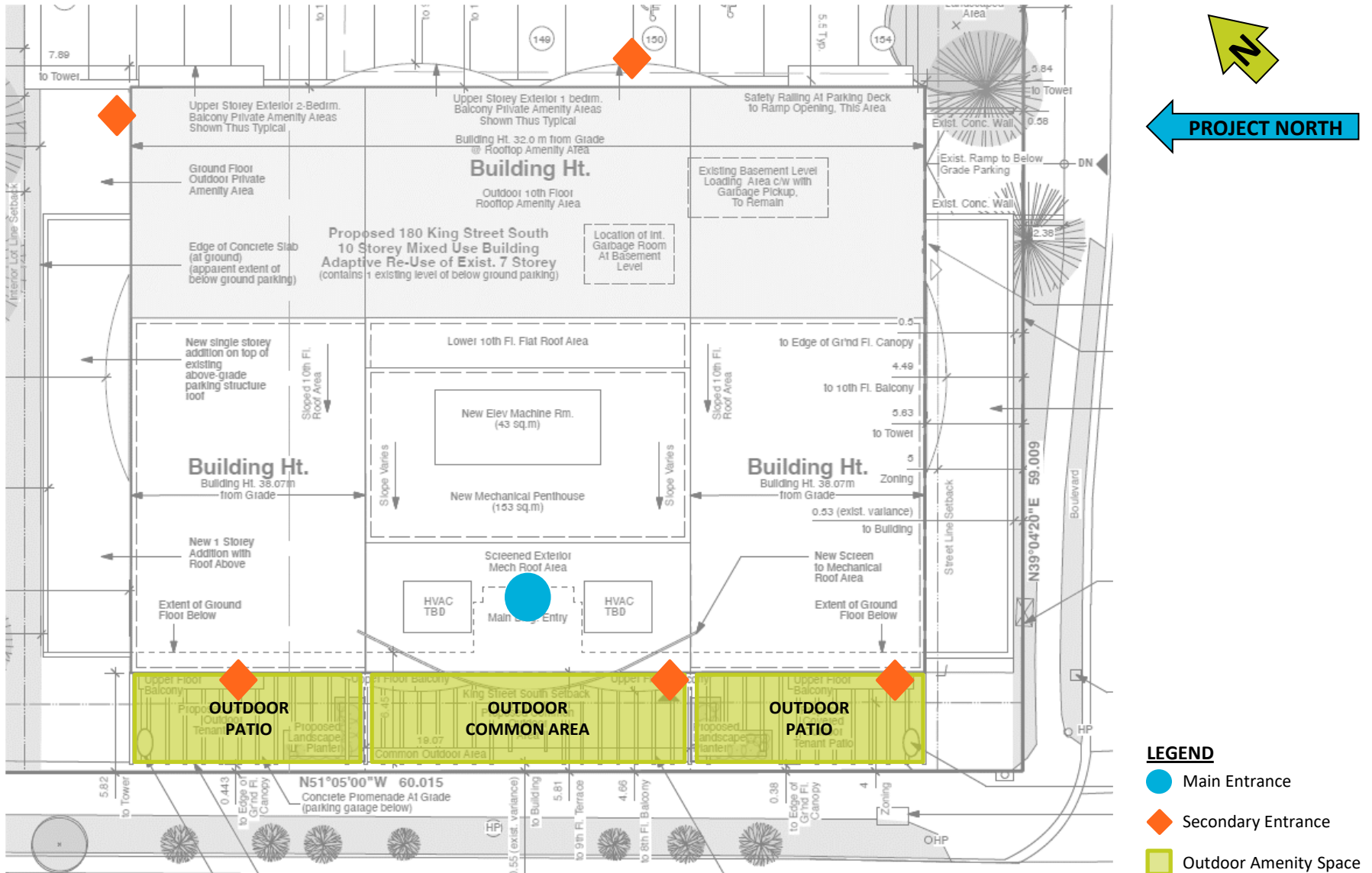


Figure 4: Areas of interest – Grade level

2.0 APPROACH

A screening-level assessment was conducted using computational fluid dynamics (CFD). As with any simulation, there are some limitations with this modeling technique, specifically in the ability to simulate the turbulence, or gustiness, of the wind. Nonetheless, CFD analysis remains a useful tool to identify potential wind issues, especially when assessing mean wind speeds. This CFD-based mean wind speed assessment employs a comparable analysis methodology to that used in wind tunnel testing. The results of CFD modeling are also an excellent means of readily identifying relative changes in wind conditions associated with different site configurations.

2.1 Methodology

Wind comfort conditions for areas of interest were predicted on and around the development site to identify potentially problematic windy areas. A 3D model and site plan of the proposed redevelopment were provided by John MacDonald Architect on March 16, 2023, and an updated image of the preliminary project massing was provided on April 24, 2023. A view of the 3D model used in the computer wind comfort analysis are shown in **Figures 5a** and **5c**. This model included surrounding buildings within 500 m from the study site centre.

The simulations were performed using CFD software by Meteodyn Inc. The entire 3D space throughout the modeled area is filled with a three-dimensional grid. The CFD virtual wind tunnel calculates wind speed at each one of the 3D grid points. The upstream “roughness” for each test direction is adjusted to reflect the various upwind conditions and wind characteristics encountered around the actual site. Wind flows for a total of 16 compass directions were simulated. Although wind speeds are calculated throughout the entire modeled area, wind comfort conditions were only plotted for a smaller area immediately surrounding the proposed development.

SLR assessed three configurations for comparison purposes:

- **Existing Configuration:** Existing site with existing surroundings, including nearby developments that are currently under construction.
- **Proposed Configuration:** Proposed development with existing surroundings, including nearby developments that are currently under construction.
- **Future Configuration:** Proposed development with existing and future surroundings, including nearby developments that are currently under construction.

The three configurations are shown in **Figures 5a, 5b, and 5c**.

Wind flows were predicted for the existing site, with the proposed development, and with future developments for comparison purposes. The CFD-predicted wind speeds for all test directions and grid points were then combined with historical wind climate data for the region to predict the occurrence of wind speeds in the pedestrian realm, and to compare against wind criteria for comfort and safety; these results are shown in the various wind flow images. The analysis of wind conditions is undertaken for four seasons: winter (January to March), spring (April to June), summer (July to September), and autumn (October to December). However, only the seasonal extremes of summer and winter are discussed in the report. The results of the analysis for spring and autumn can be found in **Appendix A**.

Results are presented through discussion of the wind conditions along major streets and the areas of interest. The comfort criteria are based on predictions of localized wind forces combined with frequency of occurrence. Climate issues that influence a person’s overall “thermal” comfort, (e.g., temperature, humidity, wind chill, exposure to sun or shade, etc.) are not considered in the comfort rating.



Figure 5a: Massing Model – Existing Configuration

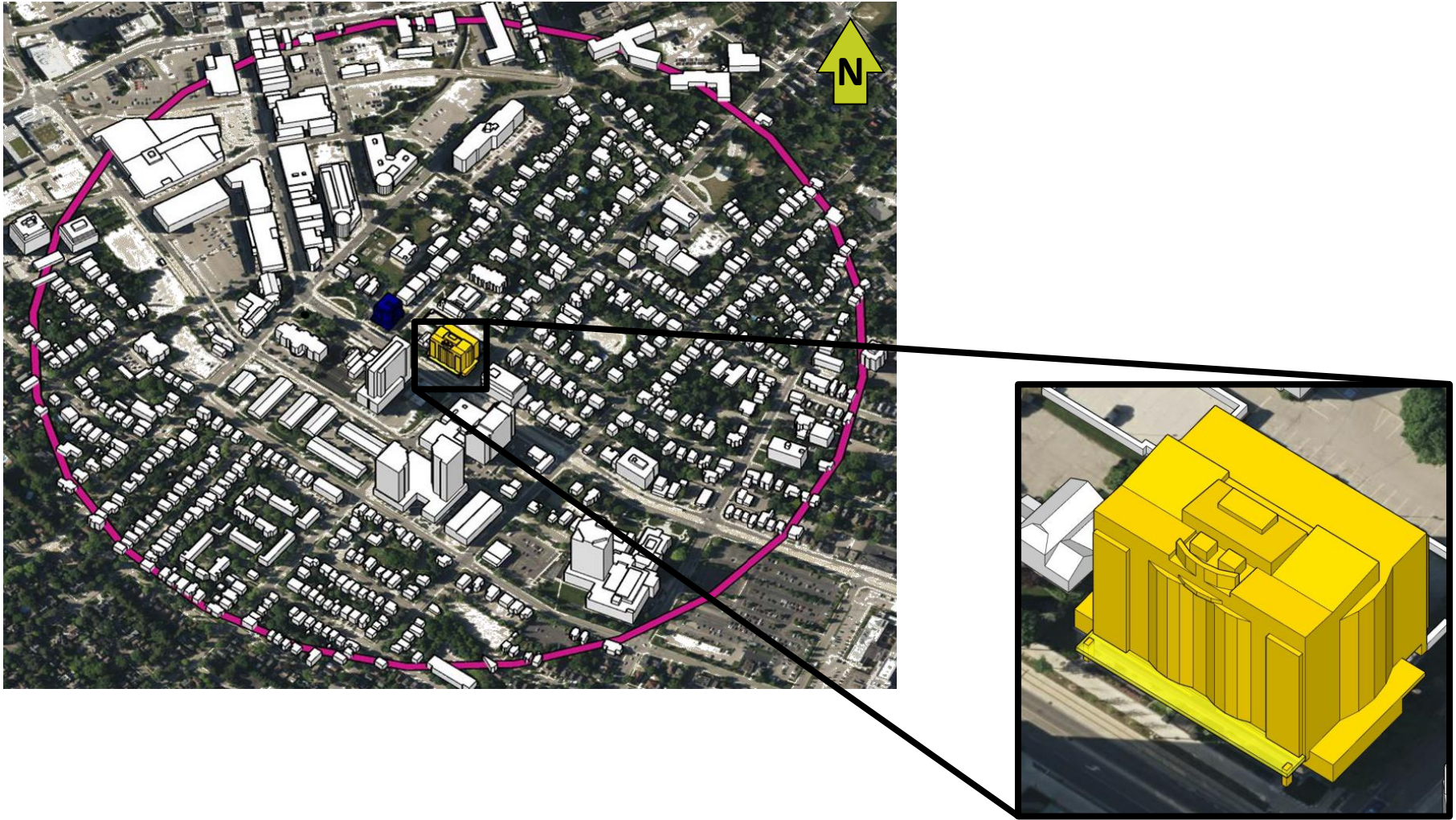


Figure 5b: Massing Model – Proposed Configuration

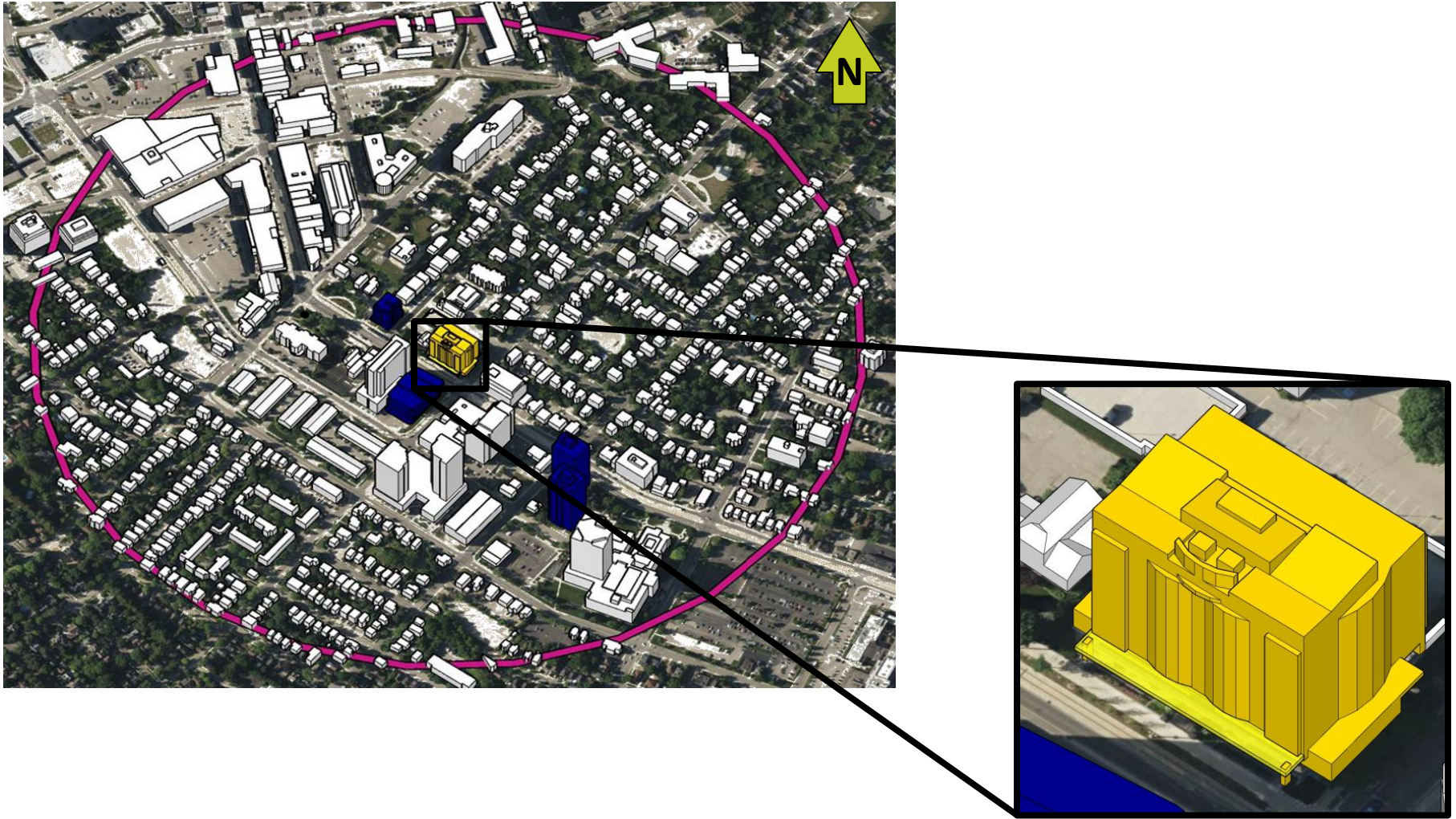


Figure 5c: Massing Model – Future Configuration

2.2 Wind Climate

Wind data recorded at Waterloo Regional Airport in Breslau, Ontario, for the period of 1993 to 2020 were obtained and analysed to create a wind climate model for the region. Annual and seasonal wind distribution diagrams (“wind roses”) are shown in **Figure 6**. These diagrams illustrate the percentage of time wind blows from the 16 main compass directions. Of main interest are the longest peaks that identify the most frequently occurring wind directions. The annual wind rose indicates that wind approaching from the southwest through northwest and east directions are most prevalent. The seasonal wind roses readily show how the prevalent winds shift throughout the year.

The directions from which stronger winds (e.g., > 30 km/h) approach are also of interest as they have the highest potential of creating problematic wind conditions, depending upon site exposure and the building configurations. The wind roses in **Figure 6** also identify the directional frequency of these stronger winds, as indicated in the figure’s legend colour key. On an annual basis, strong winds occur from the northwesterly, southwesterly sectors and from the east. All wind speeds and directions were included in the wind climate model.

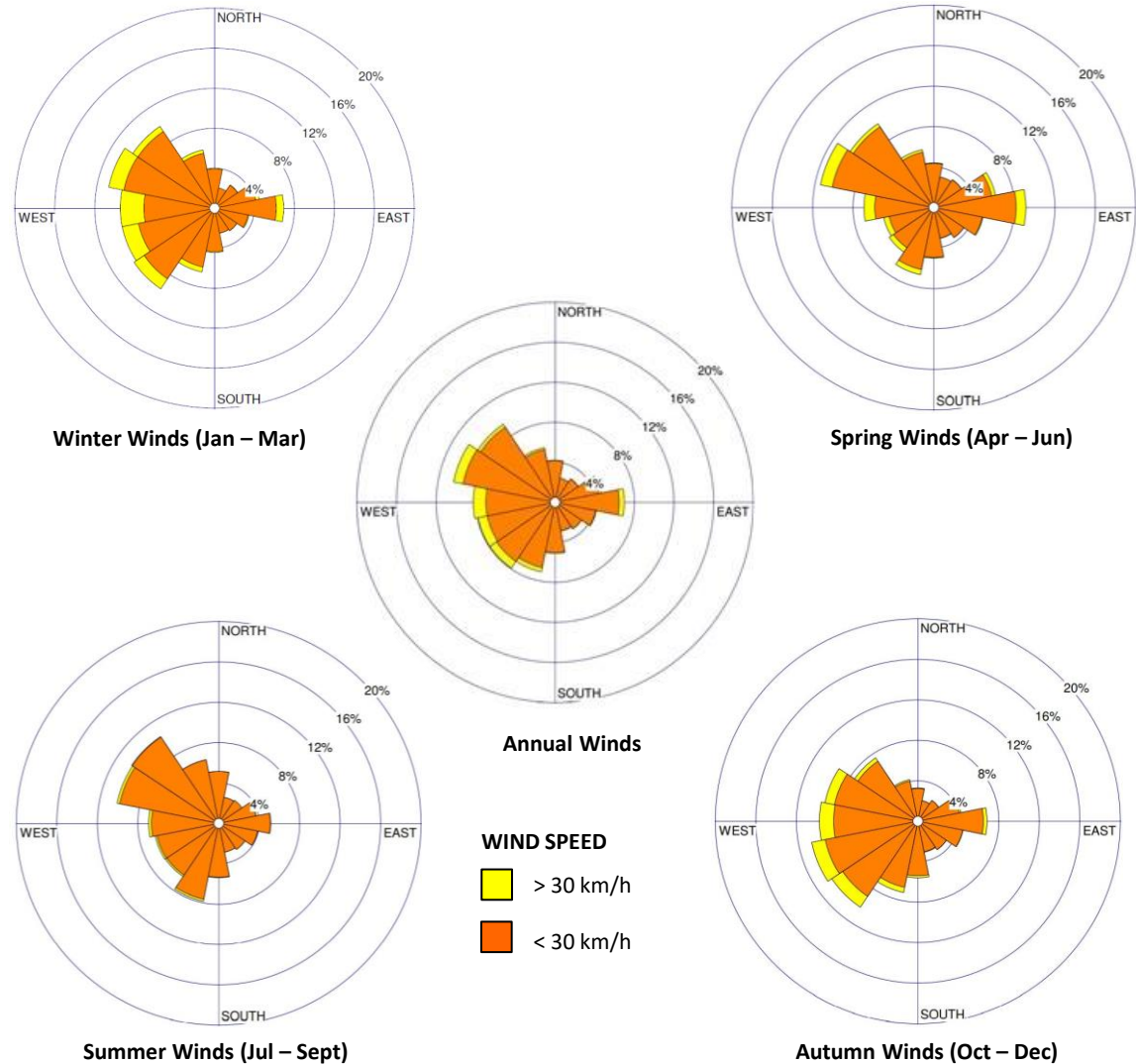


Figure 6: Wind Roses for Waterloo Regional Airport (1993 – 2020)

3.0 PEDESTRIAN WIND CRITERIA

Wind comfort conditions are discussed in terms of being acceptable for certain pedestrian activities and are based on predicted wind force and the expected frequency of occurrence. Wind chill, clothing, humidity and exposure to direct sun, for example, all affect a person's thermal comfort; however, these influences are not considered in the wind comfort criteria.

The comfort criteria, which are based on certain predicted hourly mean wind speeds being exceeded 5% of the time, are summarized in **Table 1**. Generally, this is equivalent to a wind event of several hours duration occurring about once per week.

The criterion for wind safety in the table is based on hourly mean wind speeds that are exceeded once per year (approximately 0.01% of the time). When more than one event is predicted annually, wind mitigation measures are then advised. The wind safety criterion is shown in **Table 2**.

The criteria for wind comfort and safety used in this assessment are similar to those developed at the Boundary Layer Wind Tunnel Lab of Western University, together with building officials in London, England. They are broadly based on the Beaufort Scale and on previous criteria that were originally developed by Davenport. Similar criteria are used by the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory for pedestrian wind study projects located around the globe. For a list of references, describing the criteria and history of its development see **Section 7.0**.

Table 1: Wind Comfort Criteria

Activity	Comfort Ranges for Mean Wind Speed Exceeded 5% of the Time		Description of Wind Comfort
Sitting	0 to 14 km/h	0 to 4 m/s	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper comfortably.
Standing	0 to 22 km/h	0 to 6 m/s	Gentle breezes suitable for main building entrances and transit stops.
Leisurely Walking	0 to 29 km/h	0 to 8 m/s	Moderate breezes suitable for walking along pedestrian thorough fares.
Fast Walking	0 to 36 km/h	0 to 10 m/s	Strong breezes that can be tolerated if one's objective is to walk, run or cycle without lingering.
Uncomfortable	> 36 km/h	> 10 m/s	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended.

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded Once Per Year (0.01%)		Description of Wind Effects
Any	72 km/h	20 m/s	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

4.0 RESULTS

Figures 7a through 11b present graphical images of the wind comfort conditions for the summer and winter months on and around the proposed development. These typically represent the seasonal extremes of best and worst case. The “comfort zones” shown are based on an integration of wind speed and frequency for all 16 wind directions tested with the seasonal wind climate model. The presence of mature trees can lead to wind comfort levels that are marginally more comfortable than shown, during seasons when foliage is present. **Appendix A** presents the wind comfort conditions for spring and autumn and **Appendix B** presents the wind safety conditions on an annual basis.

There are generally accepted wind comfort levels that are desired for various pedestrian uses. However, in some climates these may be difficult to achieve in the winter due to the overall climate. For sidewalks, walkways and pathways, wind comfort suitable for leisurely walking are desirable year-round but may not be feasible in the winter. The presence of benches on a sidewalk, which are an optional use, does not change the overall wind comfort requirement for sidewalk. Wind conditions of fast walking are satisfactory for loading areas, laneways, and a limited portion of a sidewalk, considering exposure is brief for pedestrians. For main entrances, transit stops, and public amenity spaces such as parks and playgrounds, wind conditions conducive to standing are preferred throughout the year. For on-site amenity areas, wind conditions suitable for sitting or standing are desirable during the summer, with stronger wind flows, conducive to leisurely walking, tolerated in the winter. The most stringent category of sitting is desirable during the summer for dedicated seating areas, such as patios, where calmer wind is expected for the comfort of patrons.

4.1 Building Entrances & Walkways

Existing on-site wind conditions are expected to be comfortable for sitting in the summer (**Figure 7a**) and sitting or standing in the winter (**Figure 7b**).

In the Proposed Configuration, with the addition of the proposed development, on-site wind conditions are generally expected to be comfortable for sitting or standing year-round (**Figures 8a and 8b**) with a localized area near the west corner of the building comfortable for leisurely walking in the winter (**Figure 8b**). Similar wind conditions are predicted in the Future Configuration with the addition of the future developments (**Figures 9a and 9b**), albeit with slightly calmer wind conditions when compared with the Proposed Configuration. These wind conditions are considered appropriate for the on-site walkways.

In the summer, wind conditions comfortable for sitting are anticipated at all entrances in both the Proposed and Future Configurations (**Figures 10a and 11a**). In the winter for the Proposed Configuration (**Figure 10b**), wind conditions at most entrances are predicted to be comfortable for sitting and both tenant patio entrances are expected to be comfortable for standing. In the Future Configuration (**Figure 11b**), wind conditions at both tenant patio entrances are anticipated to improve to be comfortable for sitting. These wind conditions are suitable for entrances.

Note that the main entrance is recessed deep into the west building facade, which is a positive design feature for sheltering the entrance from prevailing winds. This recessed entrance orientation should be retained in the final building design. It should also be noted that the proposed canopy along the west building facade is too porous to be impactful for disrupting wind flows in that area and does not affect the presented wind conditions.

4.2 Grade-Level Common Area & Tenant Patios

In both the Proposed and Future Configurations, wind conditions at the grade-level common area and tenant patios are anticipated to be comfortable for sitting in the summer (**Figures 10a and 11a**) and sitting or standing in the winter (**Figures 10b and 11b**). These wind conditions are considered appropriate for outdoor amenity areas intended for passive uses.

It should be noted that slightly calmer wind conditions are expected in these outdoor amenity spaces throughout the year in the Future Configuration, when compared to the Proposed Configuration (i.e., when comparing **Figure 10a** to **Figure 11a** and **Figure 10b** to **Figure 11b**).

4.3 Surrounding Sidewalks & Transit Stops

In all three configurations, wind conditions on the sidewalks surrounding the site are expected to be comfortable for leisurely walking or better throughout the year (**Figures 7a through 9b**). These wind conditions are considered suitable for sidewalks.

In both the Existing and Proposed Configurations, wind conditions at the two bus stops to the south of the site are predicted to be comfortable for sitting in the summer (**Figures 7a and 8a**) and sitting or standing in the winter (**Figures 7b and 8b**), which is appropriate. At the LRT station to the southeast, wind conditions are expected to be comfortable for standing in the summer (**Figures 7a and 8a**), which is suitable for a transit stop, and leisurely walking in the winter (**Figures 7b and 8b**). Note, the stronger wind flows in the winter are an existing wind condition.

In the Future Configuration, an improvement in wind conditions is anticipated with the addition of future developments to the surroundings. In this configuration, wind conditions at all three transit stops are predicted to be comfortable for sitting in the summer (**Figure 9a**) and sitting or standing in the winter (**Figure 9b**).

4.4 Wind Safety

The wind safety criterion is expected to be met in all areas for all three of the Existing, Proposed, and Future Configurations, including on the grade-level common area and tenant patios and on the surrounding sidewalks, on an annual basis (**Appendix B**).

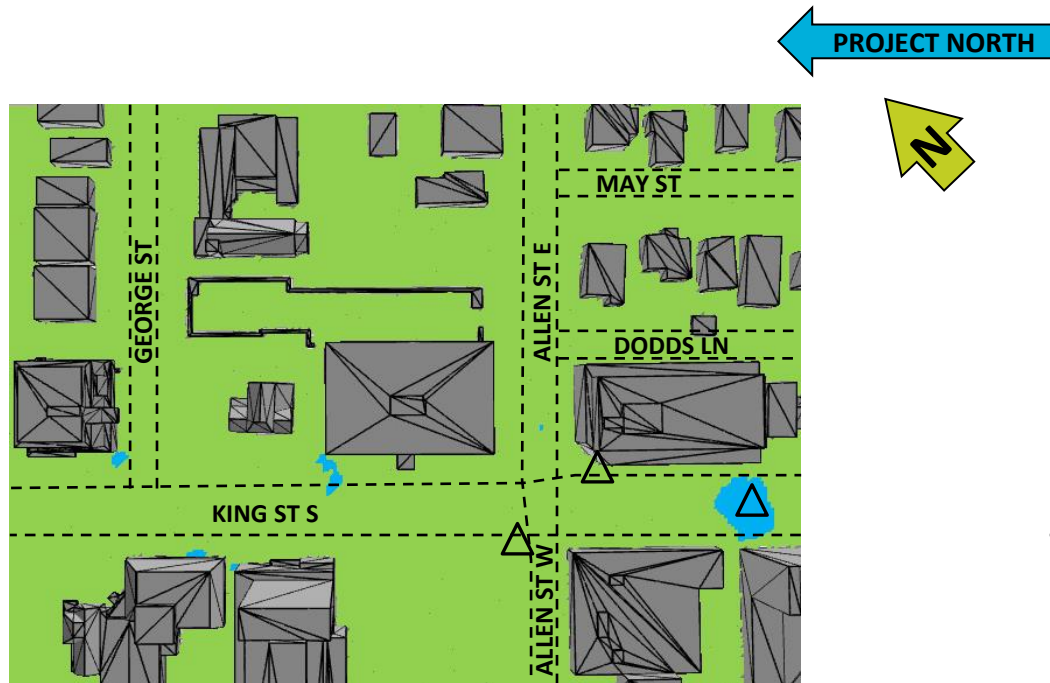


Figure 7a: Existing Configuration – Pedestrian Wind Comfort
Summer – On-site & Surrounding Areas

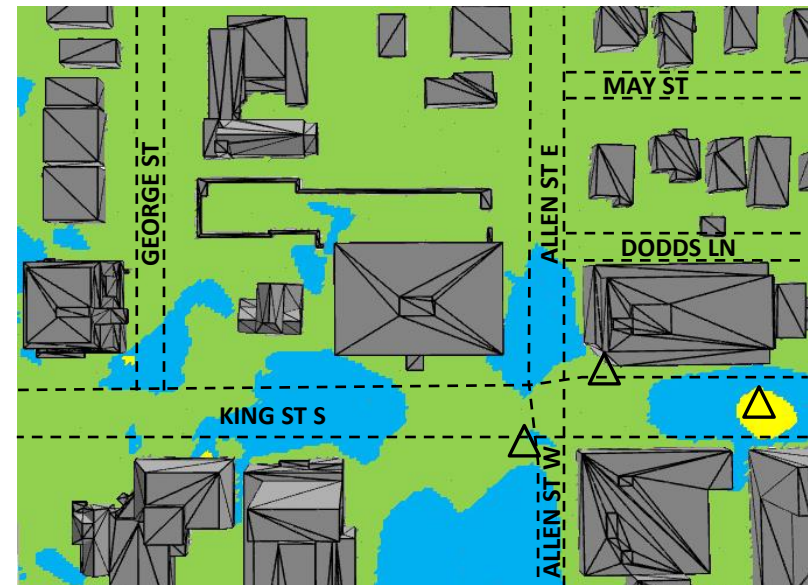


Figure 7b: Existing Configuration – Pedestrian Wind Comfort
Winter – On-site & Surrounding Areas

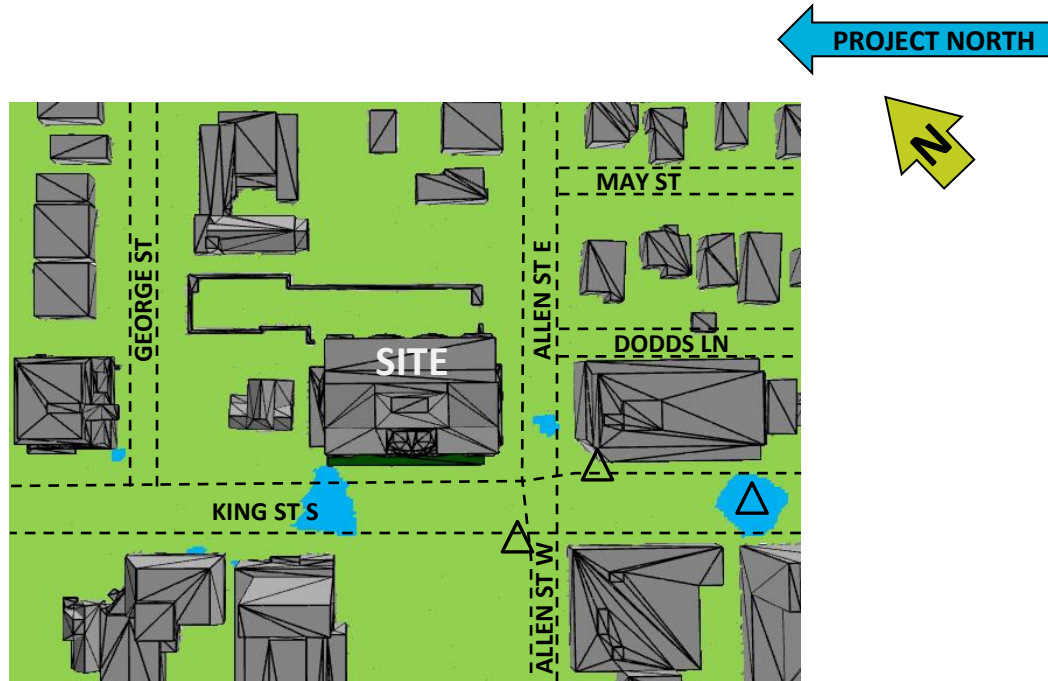


Figure 8a: Proposed Configuration – Pedestrian Wind Comfort
Summer – On-site & Surrounding Areas

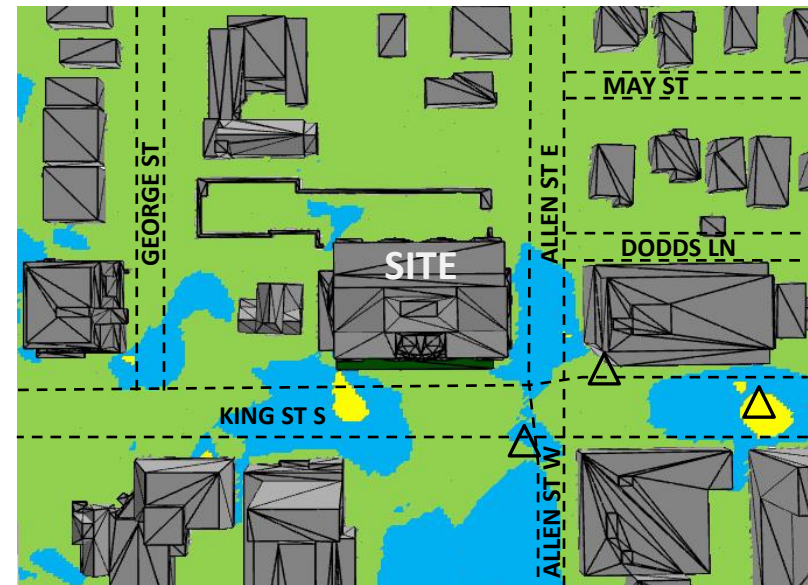


Figure 8b: Proposed Configuration – Pedestrian Wind Comfort
Winter – On-site & Surrounding Areas

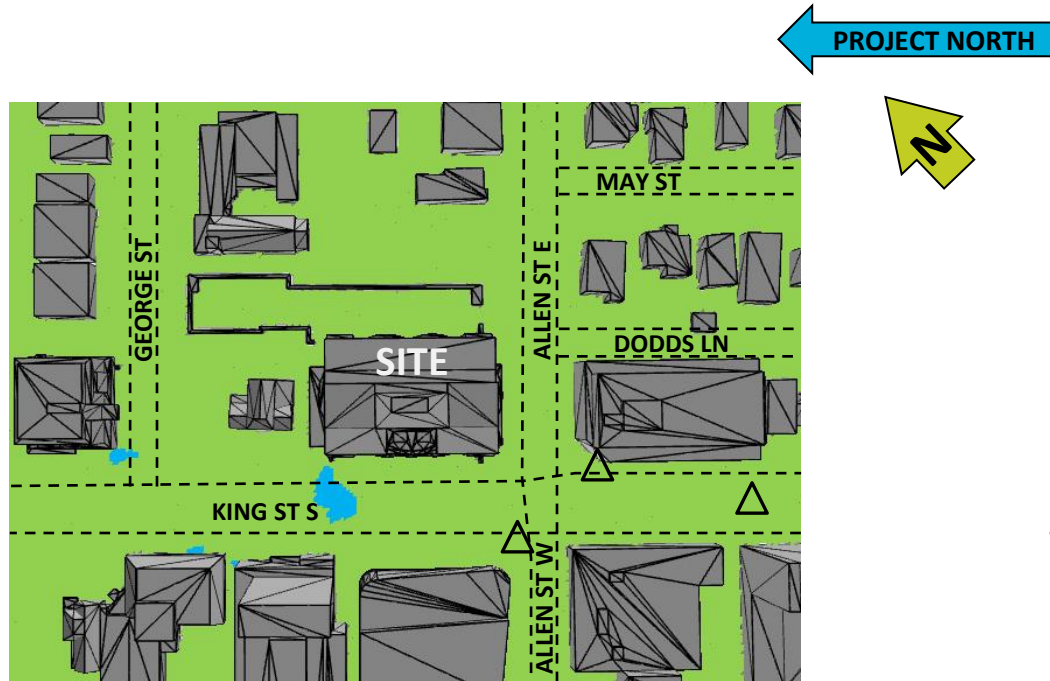


Figure 9a: Future Configuration – Pedestrian Wind Comfort
Summer – On-site & Surrounding Areas

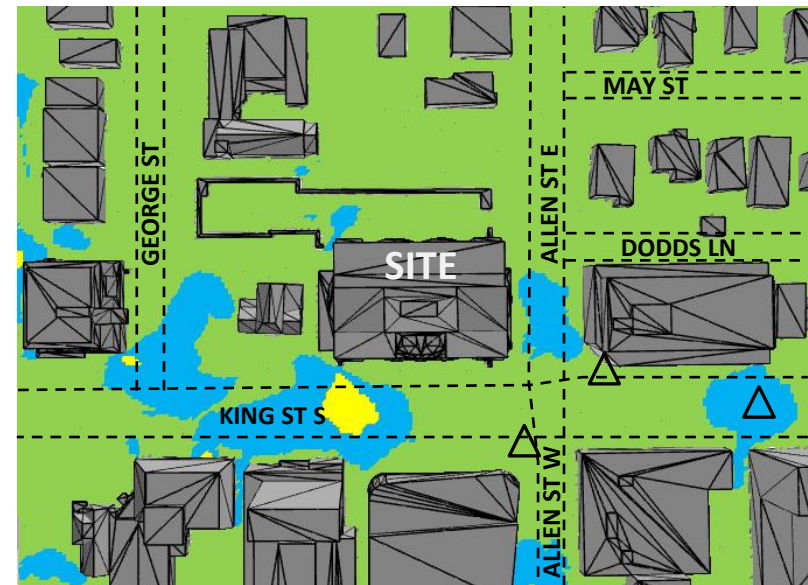


Figure 9b: Future Configuration – Pedestrian Wind Comfort
Winter – On-site & Surrounding Areas



**Figure 10a: Proposed Configuration – Pedestrian Wind Comfort
Summer – Building Entrances & Walkways**

**Figure 10b: Proposed Configuration – Pedestrian Wind Comfort
Winter – Building Entrances & Walkways**



**Figure 11a: Future Configuration – Pedestrian Wind Comfort
Summer – Building Entrances & Walkways**

**Figure 11b: Future Configuration – Pedestrian Wind Comfort
Winter – Building Entrances & Walkways**

5.0 CONCLUSIONS & RECOMMENDATIONS

The pedestrian wind conditions predicted for the proposed development at 180 King Street South in Waterloo have been assessed through computational fluid dynamics modeling techniques. Based on the results of our assessment, the following conclusions have been reached:

- The wind safety criterion is anticipated to be met at all areas on and surrounding the development in all configurations.
- Wind conditions on the site, including all entrances and the grade-level common area and tenant patios, are expected to be suitable for the intended use year-round for both the Proposed and Future Configurations. Note that the current recessed orientation for the main entrance is positive and should be retained in the final building design. It should also be noted that the proposed canopy along the west building façade does not affect wind conditions.
- On the sidewalks surrounding the proposed development, including nearby bus stops and LRT station, wind conditions are predicted to be suitable for the intended use in both the Proposed and Future Configurations.

6.0 LIMITATIONS OF LIABILITY

This report has been prepared and the work referred to in this report has been undertaken by SLR Consulting (Canada) Ltd. (SLR) for 1000237993 Ontario Inc., hereafter referred to as the “Client”. It is intended for the sole and exclusive use of the Client. The report has been prepared in accordance with the Scope of Work and agreement between SLR and the Client. Other than by the Client and the City of Waterloo in their role as land use planning approval authorities, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted unless payment for the work has been made in full and express written permission has been obtained from SLR.

This report has been prepared in a manner generally accepted by professional consulting principles and practices for the same locality and under similar conditions. No other representations or warranties, expressed or implied, are made.

Opinions and recommendations contained in this report are based on conditions that existed at the time the services were performed and are intended only for the Client, purposes, locations, time frames and project parameters as outlined in the Scope of Work and agreement between SLR and the Client. The data reported, findings, observations and conclusions expressed are limited by the Scope of Work. SLR is not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. SLR does not warranty the accuracy of information provided by third party sources.

7.0 REFERENCES

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Appendix A

Pedestrian Wind Comfort Analysis

Spring (April – June) & Autumn (October – December)

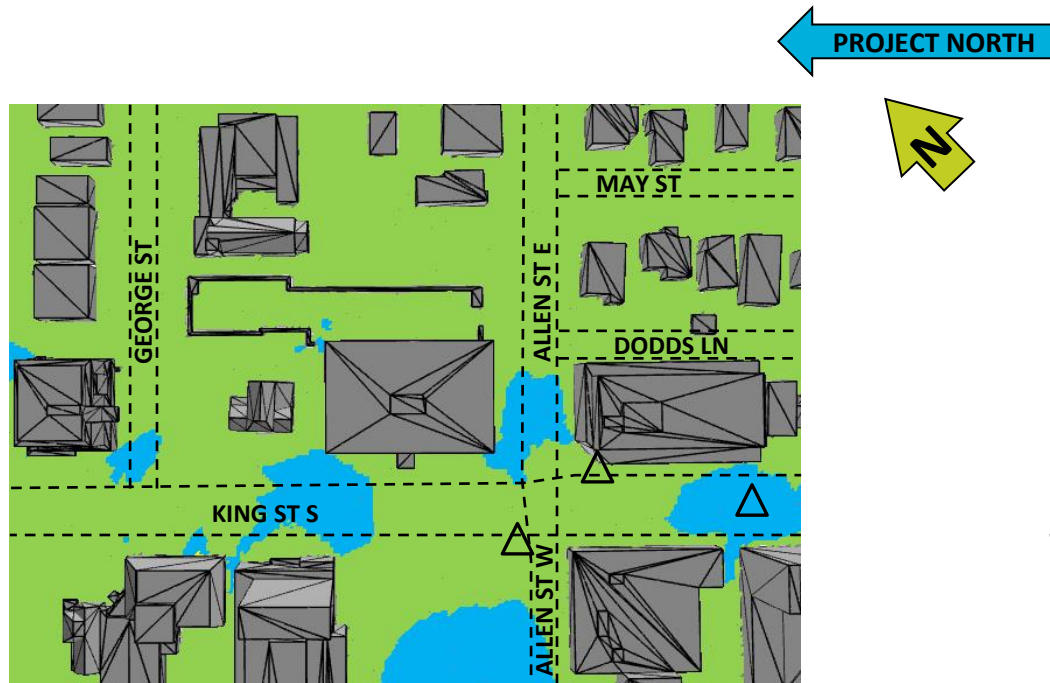


Figure A1a: Existing Configuration – Pedestrian Wind Comfort
Spring – On-site & Surrounding Areas

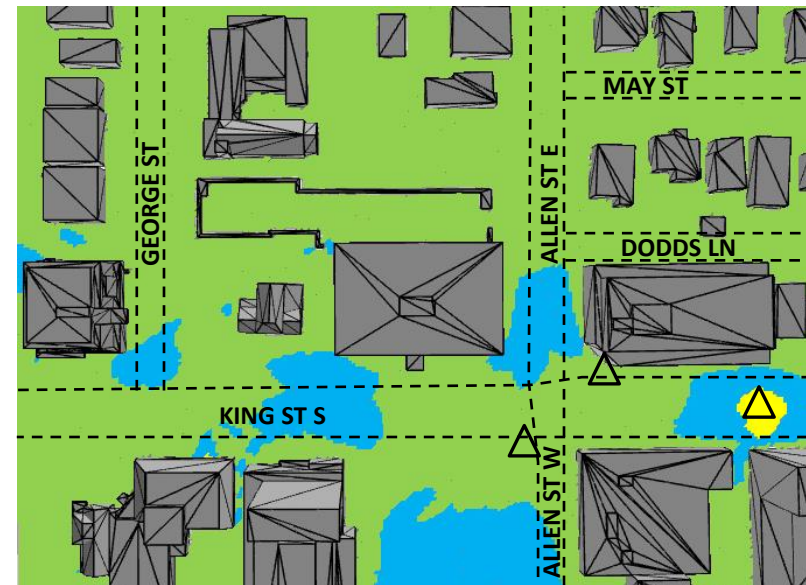


Figure A1b: Existing Configuration – Pedestrian Wind Comfort
Autumn – On-site & Surrounding Areas

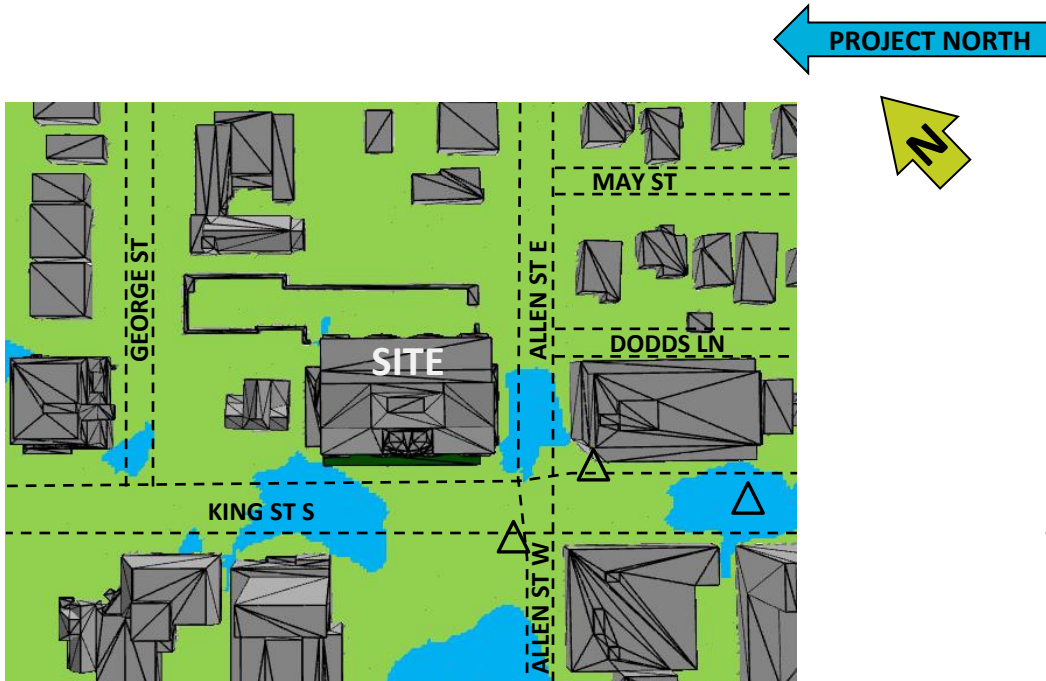


Figure A2a: Proposed Configuration – Pedestrian Wind Comfort
Spring – On-site & Surrounding Areas

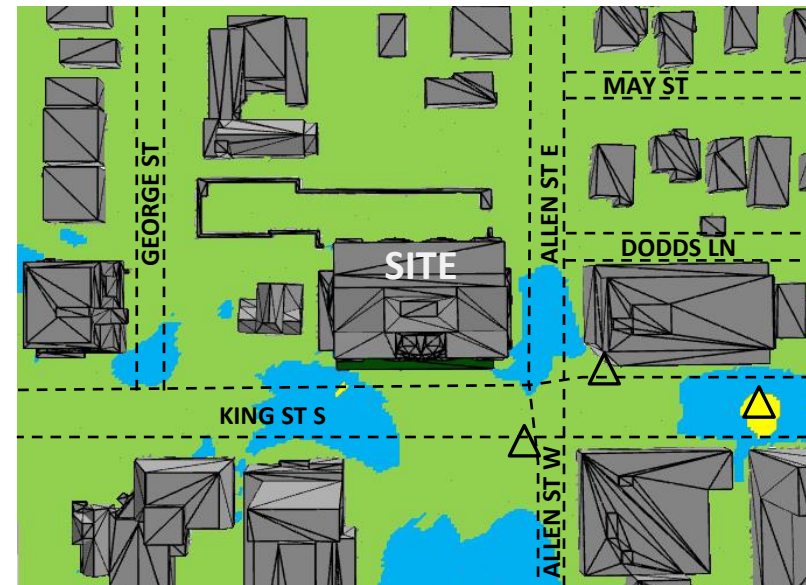
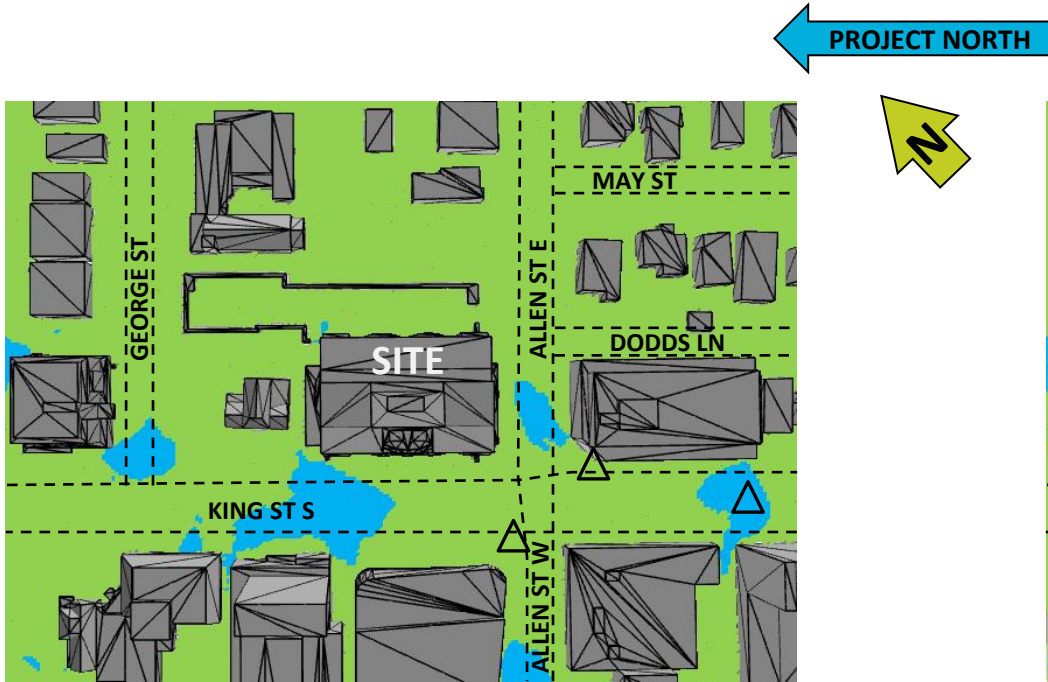
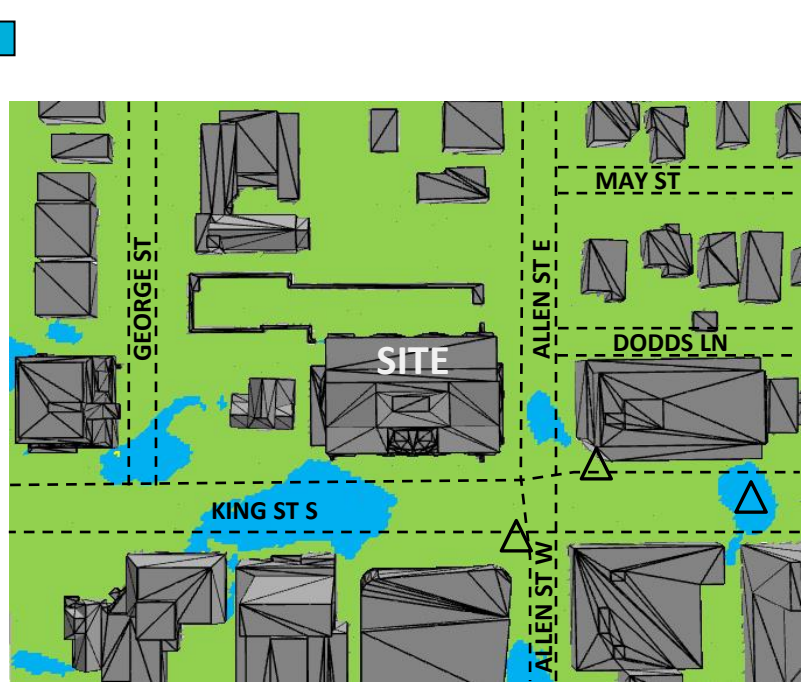


Figure A2b: Proposed Configuration – Pedestrian Wind Comfort
Autumn – On-site & Surrounding Areas



- Sitting
- Standing
- Leisurely Walking
- Fast Walking
- Uncomfortable
- Transit Stop

**Figure A3a: Future Configuration – Pedestrian Wind Comfort
Spring – On-site & Surrounding Areas**



- Sitting
- Standing
- Leisurely Walking
- Fast Walking
- Uncomfortable
- Transit Stop

**Figure A3b: Future Configuration – Pedestrian Wind Comfort
Autumn – On-site & Surrounding Areas**

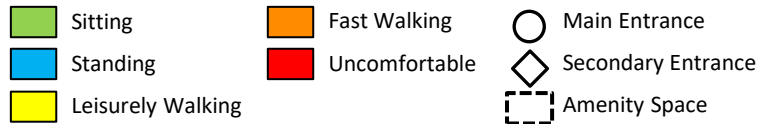
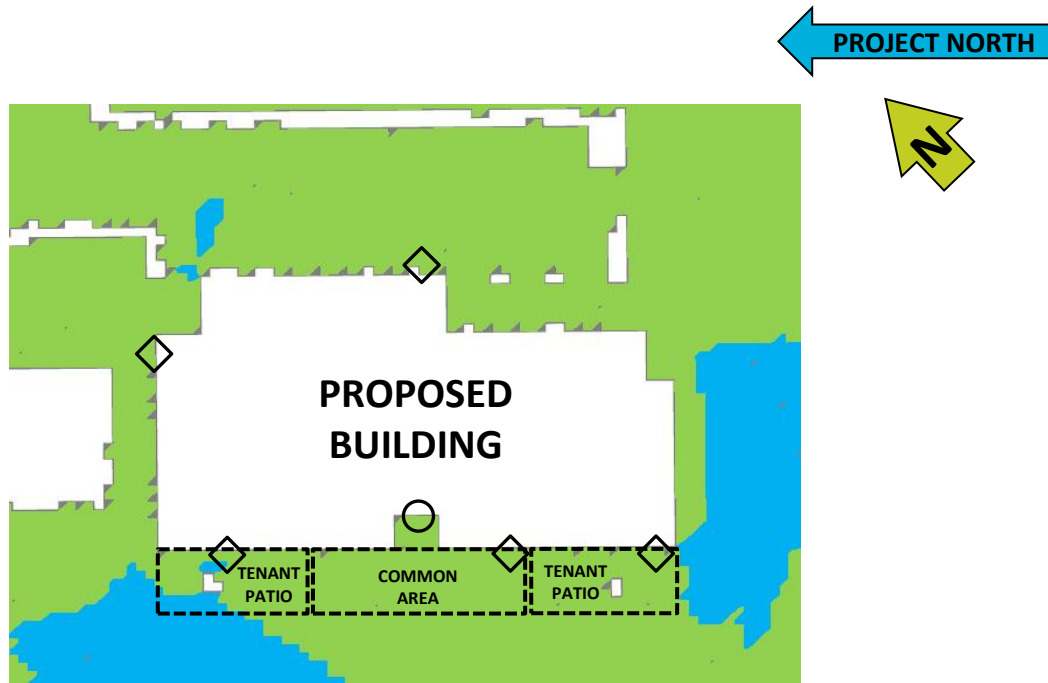


Figure A4a: Proposed Configuration – Pedestrian Wind Comfort
Spring – Building Entrances & Walkways

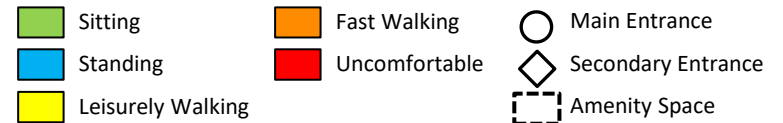


Figure A4b: Proposed Configuration – Pedestrian Wind Comfort
Autumn – Building Entrances & Walkways



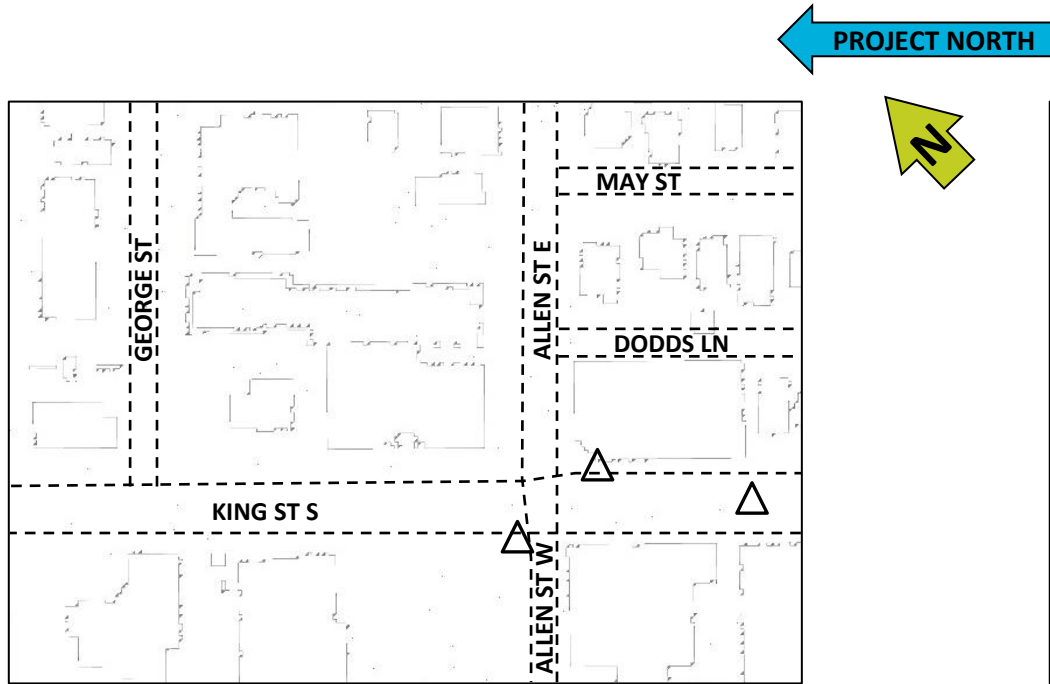
Figure A5a: Future Configuration – Pedestrian Wind Comfort
Spring – Building Entrances & Walkways

Figure A5b: Future Configuration – Pedestrian Wind Comfort
Autumn – Building Entrances & Walkways

Appendix B

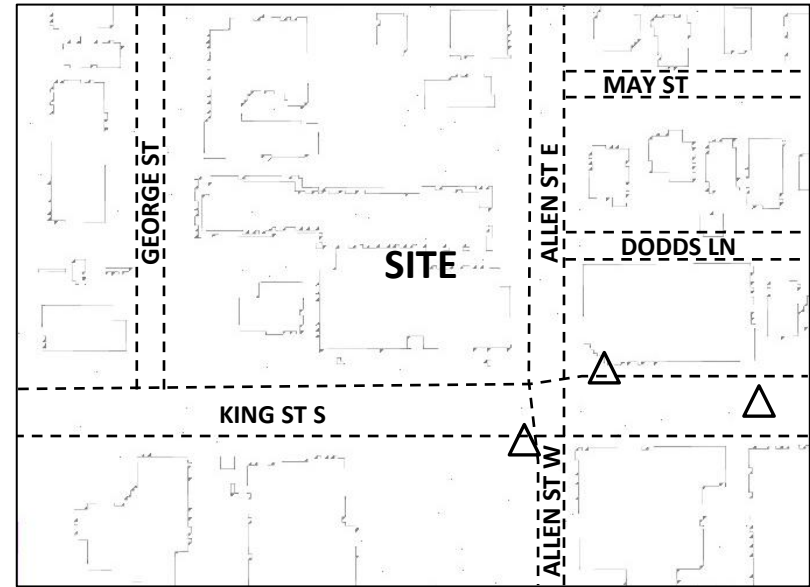
Pedestrian Wind Safety Analysis

Annual



Exceeded Safety Criterion Transit Stop

**Figure B1a: Existing Configuration – Wind Safety
Annual – On-site & Surrounding Areas**



Exceeded Safety Criterion Transit Stop

**Figure B1b: Proposed Configuration – Wind Safety
Annual – On-site & Surrounding Areas**

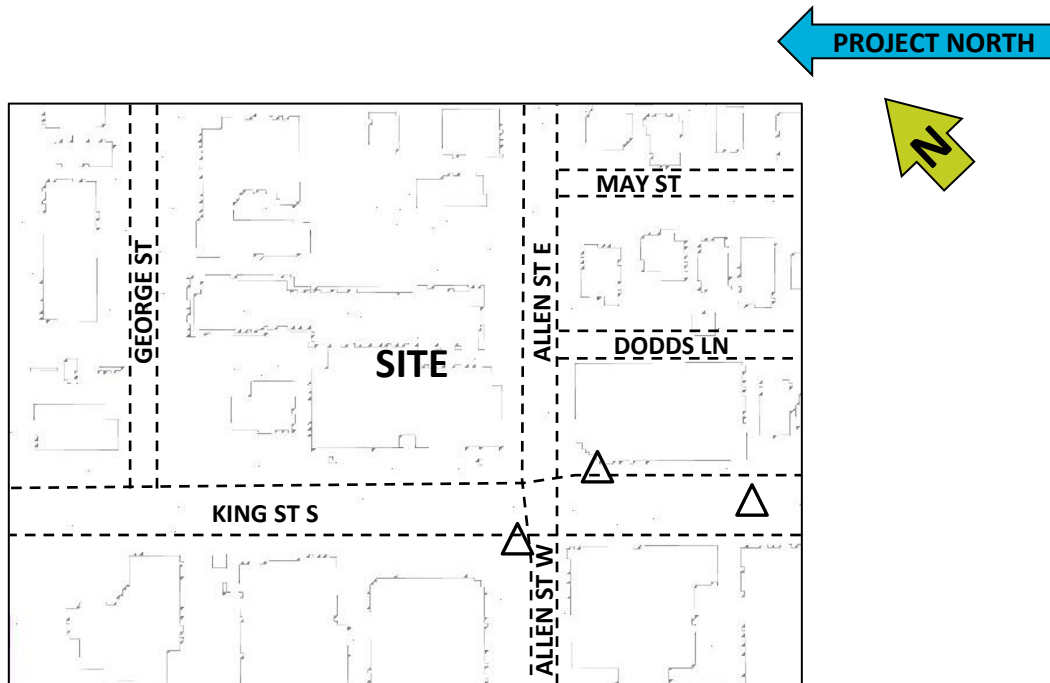


**Figure B1c: Future Configuration – Wind Safety
Annual – On-site & Surrounding Areas**