Pedestrian Level Wind Study
Template A for Complete Application Evaluation

1. General	
A. Name of the Project: 2451-2455 Danforth Avenue	
B. Date: November 6, 2024	C. Address of Application: 2451-2455 Danforth Ave, Toronto, Ontario
D. Name of Consultant: RWDI	
E. Phone number and email of the Consultant: 647-474-1048 x2031 kathryn.kim@rwdi.com	

2. Description	
A. Short Description of the Project: Project site is at SE corner of Danforth Ave and Westlake Ave. The project is a 35-stry and a 13-stry building with a common low podium	
B. Programme of the Application: Zoning	C. Number of buildings for this Application: 2

3. (When required) Triggers	
A. Location (Map 1): ○ Area 1 ⦿ Area 2	B1. Height in Metres: B2. Height Triggers Classification (Table 1): ○ Low ○ Moderate ⦿ High
C. Additional triggers: n/a	
D. Final Classification: ○ Low ○ Moderate ⦿ High	

4. Application Process	
A. Application type: ○ OPA ○ ZBLA ⦿ Combined OPA/ZBLA ○ SPA	B. Method of Wind Study for this Application: ○ CFD Phase 1 ⦿ CFD Phase 2 ○ WTS *CFD: Computational Fluid Dynamics Software. WTS: Wind Tunnel Study.
C. Was a CFD Phase 1 submitted at Pre-Application consultation? ○ Yes ⦿ No	
D. Were there any previous applications for this project? ○ Yes ⦿ No	

If Yes:

D.1 Date:	D.2 Type of previous application process: ○ Low ○ Moderate ○ High
D.3 Method of Wind Study for the previous Application: ○ CFD Phase 1 ○ CFD Phase 2 ○ WTS	
D.4 Important findings in the previous Study:	

UD-WS-2021-001

4. Application Process – Continued

E. If this application is for a SPA, are there any design changes between the previous and current Application? ○ Yes ○ No ◉ Not Applicable

If Yes:

E.1 Describe the design changes between the previous and current application:

E.2 Do those changes qualify as significant: ○ Yes ○ No

If yes, is this a submission for a revised study? ○ Yes ○ No ○ Not Applicable

F. Did the urban designer approve the type of wind study assessment method/ the location of the sensors/vulnerable areas: ◉ Yes ○ No

G. If a CFD is used for the study, did you provide a 3D model: ○ Yes ◉ No

H. Please attach a diagram with heights of the buildings that were used for the context of the scenarios that were tested

5. Required Contents

A. Which scenarios have been tested:

☑ Existing ☑ Proposed ☐ Mitigation ☐ Phases

B. Is this a large project? ◉ Yes ○ No

C. Is this project with different stages? ○ Yes ◉ No

D. Main Areas of Interest:

Public sidewalks, residential and retail entrances, a POPS on the east side of Building A and amenity terraces on the podium roof

E. Data Station Used:

Billy Bishop Toronto City Airport

6. Technical Information

A. Are you fully compliant with all of the technical specifications in the Terms of Reference and Guide:

◉ Yes ○ No

B. Are you fully compliant with the City criteria for comfort and safety? ◉ Yes ○ No

If not, please explain:

C. Is the consultant acknowledging that this method is appropriate for this study: ◉ Yes ○ No

6. Technical Information Continued

D. Is the consultant recommending a different method of study? ◉ Yes ○ No

If Yes:

D.1 Please explain:

Wind tunnel testing should be conducted at the SPA stage to quantify the wind conditions and, if needed, to refine mitigation solutions.

7. General Comments

Declaration of Consultant

I Kathryn Kim

(Print name)

certify that I have examined the contents of the application, certify that the information submitted with it is accurate and concur with the submission of the application.

Date: November 6, 2024

Signature of Consultant: [signature]

2451-2495 DANFORTH AVENUE

TORONTO, ONTARIO

PEDESTRIAN WIND ASSESSMENT

PROJECT #2406343
NOVEMBER 6, 2024

SUBMITTED TO

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained to conduct a pedestrian wind assessment for the proposed development at 2451-2495 Danforth Avenue in Toronto, Ontario. The objective of this assessment is to provide an evaluation of the potential wind impact of the proposed development in support of the Official Plan Amendment (OPA) and Zoning By-law Amendment (ZBA) application.

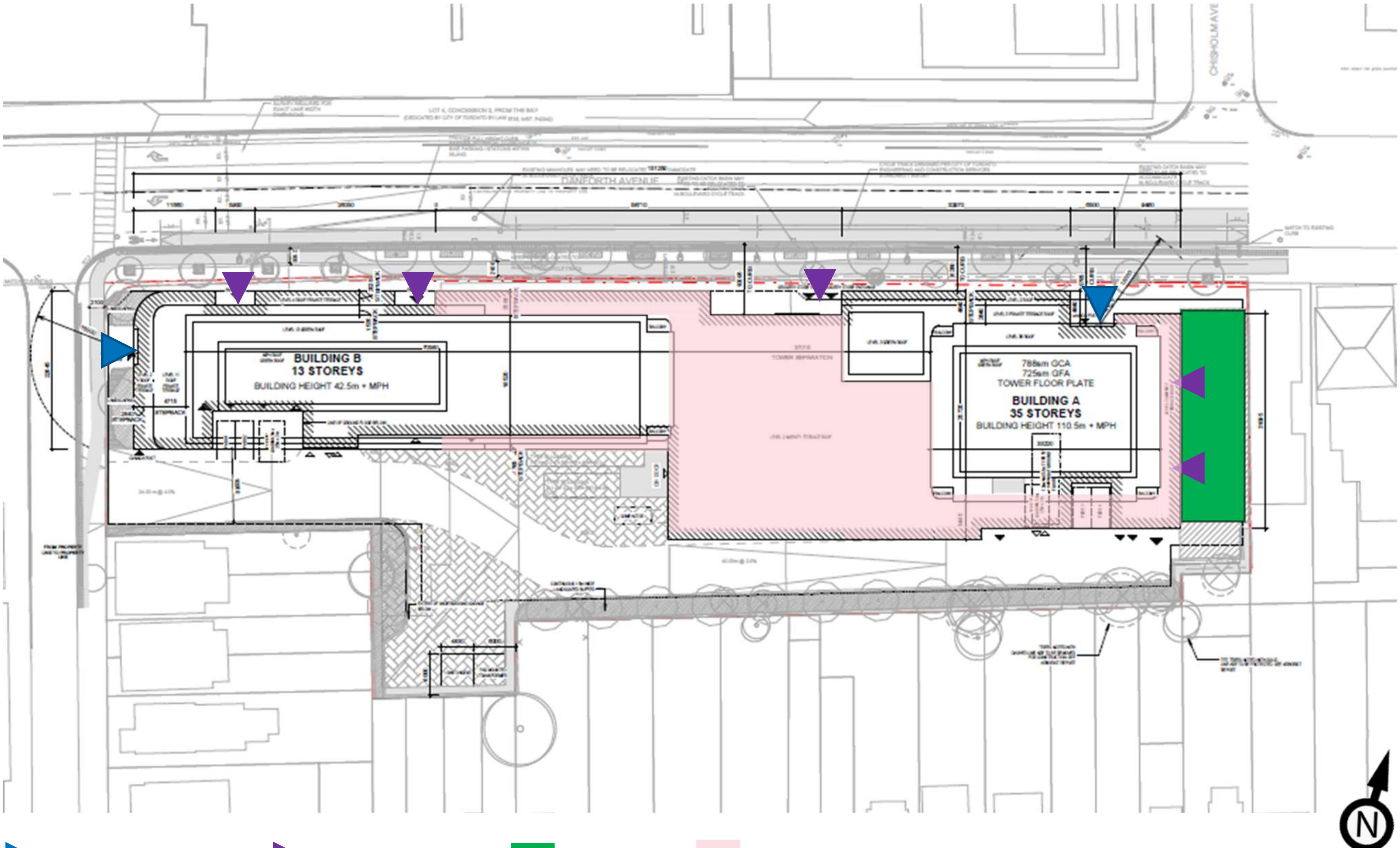
The project site is located at the southeast corner of the intersection of Danforth Avenue and Westlake Avenue. It is surrounded primarily by low-rise suburban neighbourhoods and commercial buildings (Image 1). There are existing and future tall buildings along Danforth Avenue to the east and west of the project site.

The project consists of Building A at 35-storeys and Building B at 13-storeys on a common low podium (Images 2 and 3). Key areas of interest for this wind assessment include public sidewalks, residential and retail entrances, a POPS on the east side of Building A and amenity terraces on the podium roof (Image 3).

Image 1: Aerial view of the existing site and surroundings (Credit: Google Maps)


Image 2: Northwest view of the proposed development

1. INTRODUCTION



Residential Entrance | Retail Entrance | POPS | Podium Terrace

Image 3: Site plan of the proposed building

2. METHODOLOGY

2.1 Objective

The objective of this assessment is to provide an evaluation of the potential impact of the proposed development on wind conditions in pedestrian areas on and around it based on Computational Fluid Dynamics (CFD) modelling. The assessment is based on the following:

- A review of the regional long-term meteorological data from Billy Bishop Toronto City Airport;
- 3D model and drawings of the proposed project received by RWDI on October 10, 2024;
- The use of *Orbital Stack*, an in-house CFD tool;
- Wind tunnel studies completed by RWDI for similar projects in Toronto;
- RWDI's engineering judgment, experience, and expert knowledge of wind flows around buildings; and,
- The City of Toronto wind comfort and safety criteria as specified by the *Pedestrian Level Wind Study Terms of Reference Guide* (June 2022).

Note that other microclimate issues such as those relating to cladding and structural wind loads, door operability, air quality, snow impact, etc. are not part of the scope of this assessment

2.2 CFD for Wind Simulation

CFD is a numerical technique that can be used for simulating wind flows in complex environments. For this analysis, CFD techniques were used to generate a virtual wind tunnel where flows around the site and its surroundings were simulated in full scale. The computational domain that covered the site and its surroundings was divided into millions of small cells where calculations were performed, yielding a prediction of wind conditions across the entire study domain. CFD excels as a tool for wind modelling, presenting early design advice, comparing different design and site scenarios, resolving complex flow physics, and helping diagnose problematic wind conditions.

While the computational modelling method used in the current assessment does not explicitly simulate the transient behaviour of turbulent wind, its effects were estimated based on other calculated quantities. RWDI has found this approach to be appropriate for the assessment of typical wind comfort conditions. Wind safety issues, which relate to transient, higher-speed gusts, are discussed qualitatively, based on the CFD predictions and our extensive wind-tunnel experience for similar projects.

In order to quantify the transient behaviour of wind and refine any conceptual mitigation measures, a more detailed assessment would be required using either boundary-layer wind tunnel or transient computational modelling.

2. METHODOLOGY

2.3 Simulation Model

Wind flows were simulated using *Orbital Stack*, an in-house computational fluid dynamics (CFD) tool, for the Existing and Proposed site configurations with the existing surroundings.

The computer model of the proposed buildings is shown in Image 4, and the Existing and Proposed configurations with the proximity model are shown in Images 5a and 5b, respectively. For the purposes of this computational study, the 3D model was simplified to include only the necessary building and terrain details that would affect the local wind flows in the area and around the site. Landscaping and other smaller architectural and accessory features were not included in the computer model in order to provide more conservative wind conditions (as is the norm for this level of assessment).

The wind speed profiles in the atmospheric boundary, approaching the modelled area were simulated for 16 directions (starting at 0°, at 22.5° increments around the compass). Wind data in the form of ratios of wind speeds at approximately 1.5 m above concerned levels, to the mean wind speed at a reference height were obtained. The data was then combined with meteorological records obtained from Billy Bishop Toronto City Airport to determine the wind speeds and frequencies in the simulated areas.

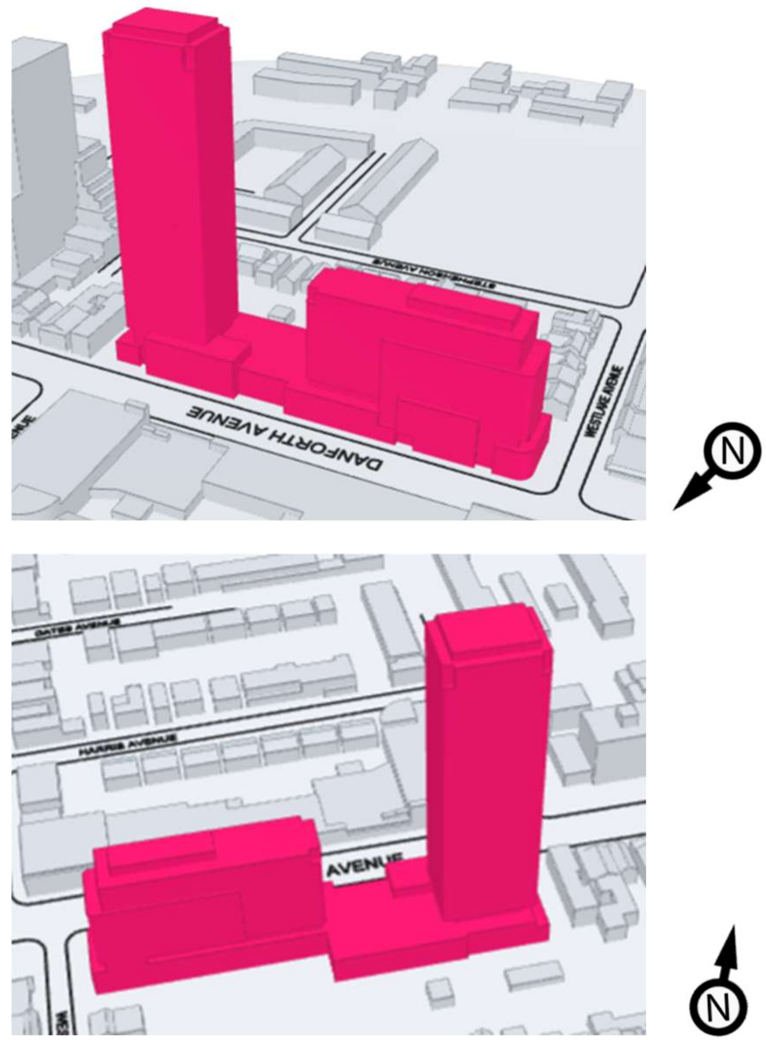


Image 4: Computer model of the proposed project

2. METHODOLOGY

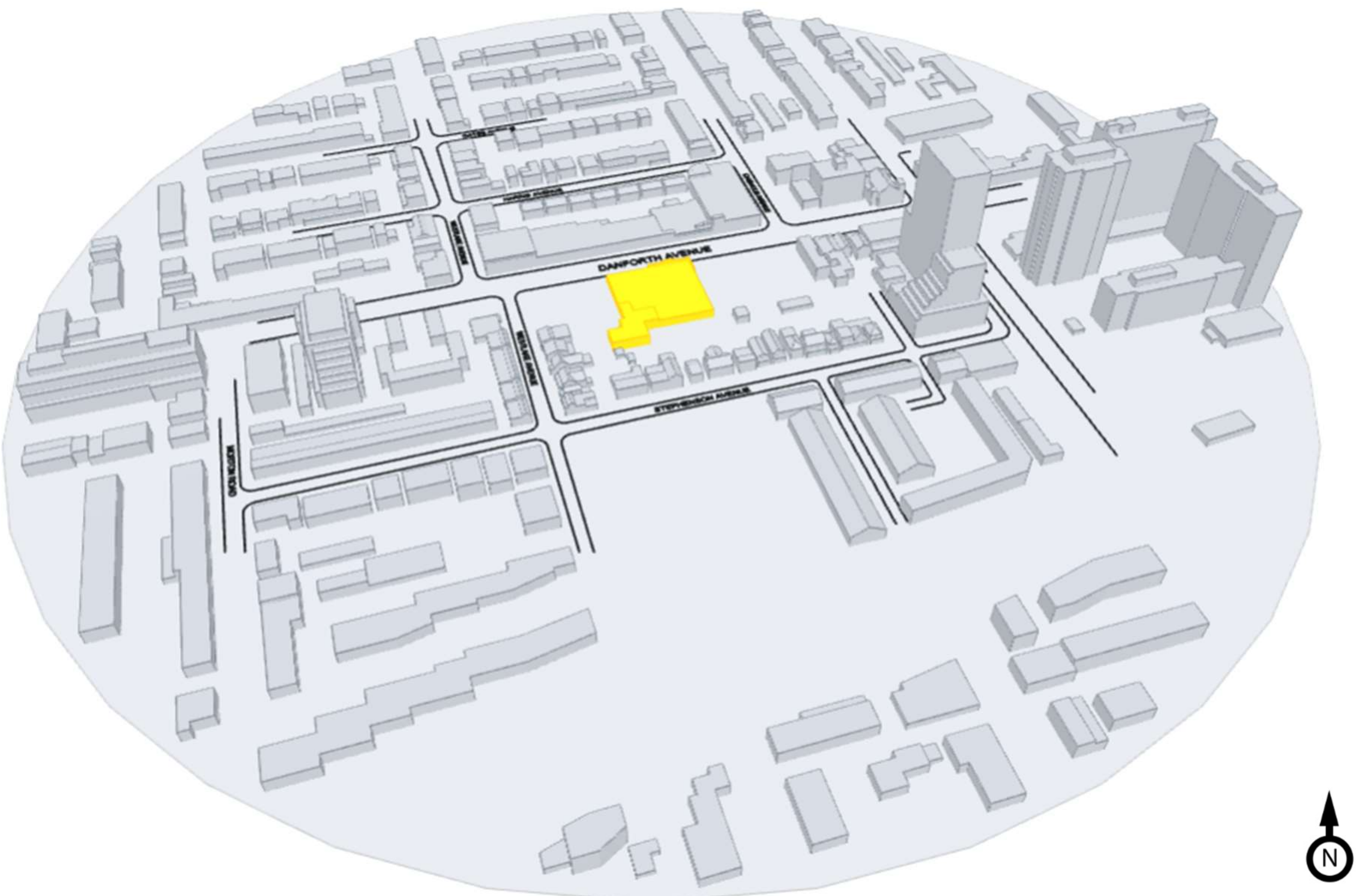


Image 5a: Computer model of the existing site and extended surroundings

2. METHODOLOGY

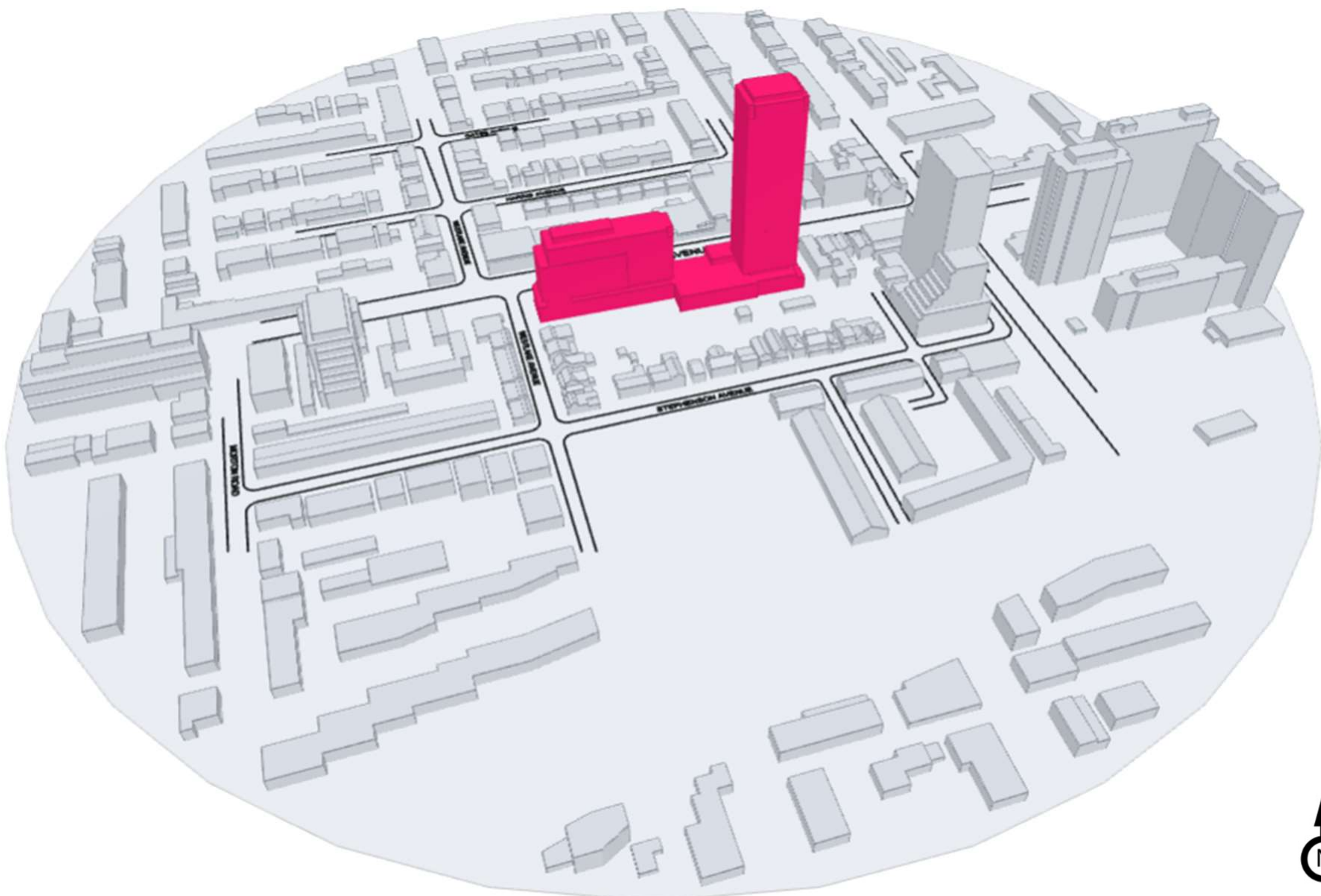


Image 5b: Computer model of the proposed buildings and extended surroundings

3. METEOROLOGICAL DATA

Meteorological data from Billy Bishop Toronto City Airport for the period from 1994 to 2023 were used as a reference for wind conditions in the area as this is the nearest station to the site with long-term, hourly wind data. The distributions of wind frequency and directionality for four seasonal periods (as required by the City of Toronto) are presented in the wind roses in Image 6.

Winds from the east-northeast are predominant throughout the year. During spring, summer and fall, secondary winds occur from the southwest through northwest directions, with the frequency of those winds being lowest in the summer. During winter, strong winds are frequent from east-northeasterly and southwesterly to northwesterly directions. Strong winds of a speed greater than 30 km/h measured at the airport (red and yellow bands) occur most often in the winter, followed by spring, fall, and summer. Winds from the west-southwest through north-northwest and east directions potentially could be the source of uncomfortable or severe wind conditions, depending upon the site exposure and development design.

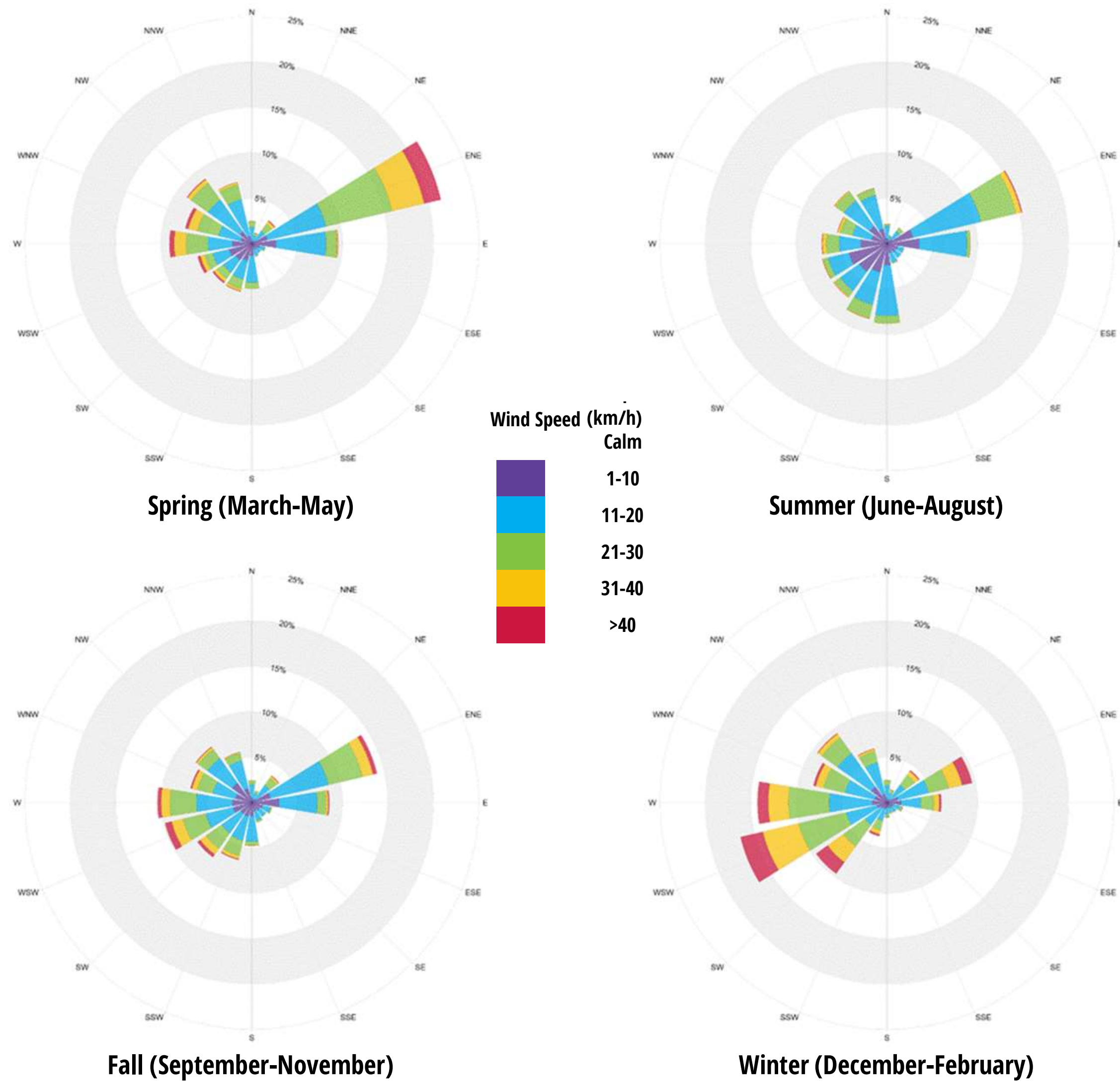


Image 6: Directional distribution of winds approaching Billy Bishop Toronto City Airport (1994-2023)

4. WIND CRITERIA

The criteria specified in the *Pedestrian Level Wind Study Terms of Reference Guide (June 2022)* prepared by the City of Toronto are used in the current study and presented below. The criteria consider pedestrian comfort (pertaining to common wind speeds conducive to different levels of human activity) and safety (pertaining to infrequent but strong gusts that could affect a person's footing).

For the current development, wind speeds comfortable for walking are appropriate for sidewalks and walkways, lower wind speeds comfortable for standing are required at entrances and bus-stops. Calm wind speeds suitable for sitting are desired on the amenity terraces in the seasons that the area will be used frequently. In our opinion, higher wind speeds may be considered appropriate in the winter, when such areas will get little to no use in the severe cold climate in Toronto.

Comfort Category	Speed (km/h)	Description	Area of Application
Sitting	**≤ 10** at least 80% of the time	Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.	Park benches, restaurant and café seating, balconies, amenity terraces, children's areas, etc. intended for relaxed, and usually seated activities.
Standing	**≤ 15** at least 80% of the time	Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated	Areas where seated activities are not expected but would be used for passive activities such as bus-stops, dog areas and main entrances.
Walking	**≤ 20** at least 80% of the time	Relatively high speeds that can be tolerated during intentional walking, running and other active movements.	Sidewalks, parking lots, alleyways and areas where pedestrian activity is primarily for walking.
Uncomfortable	**> 20** more than 20% of the time	Strong winds, considered a nuisance for most activities.	Not acceptable in areas with pedestrian access
Safety Criterion	**Gust (km/h)**	**Description**	**Area of Application**
Exceeded	**> 90** At least 0.1 % of the time (9 hours) in a year)	Excessive gusts that can adversely affect one's balance and footing. Wind mitigation is typically required.	Not acceptable in any area of interest

5. RESULTS AND DISCUSSION

5.1 Wind Flow Around the Project

Wind generally tends to flow over buildings of uniform height, without disruption. Buildings that are taller than their surroundings tend to intercept and redirect winds around them. The mechanism in which winds are directed down the height of a building is called *Downwashing*. These flows subsequently move around exposed building corners, causing a localized increase in wind activity due to *Corner Acceleration*. When two buildings are situated side by side, wind flow tends to accelerate through the space between the buildings due to C*hannelling Effect* caused by the narrow gap. *Podium* massing, low roofs and canopies diffuse downwash and reduce the potential wind impact on the ground level. These flow patterns are illustrated in Image 7.

The project, up to 35 storeys, will be taller than the buildings that exist in the immediate surroundings and is expected to redirect winds down and cause increased wind activity. The potential wind impact would be reduced by several positive design features such as the large low podium as well as the location and orientation of the lower Building B.

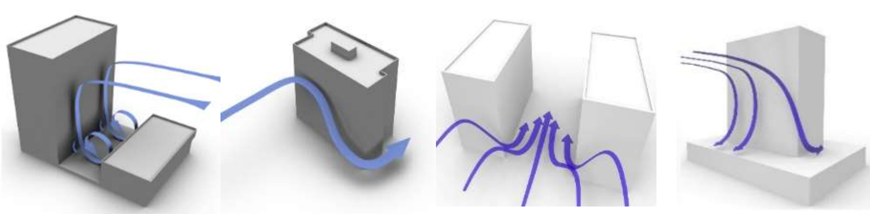


Image 7: General wind flow patterns

5.2 Simulation Results

The predicted wind comfort conditions for the Existing and Proposed configurations are presented in Images 8 through 11 for four seasons, respectively. The seasonal wind conditions on the podium terraces are presented in Image 13. These results are presented as colour contours of wind speeds calculated based on the wind criteria (Section 4). The contours represent wind speeds at a horizontal plane approximately 1.5 m above the concerned level.

The assessment against the safety criterion (Section 4) was conducted qualitatively based on the predicted wind conditions and our wind tunnel experience with similar developments.

A detailed discussion of the expected wind conditions with respect to the prescribed criteria and applicability of the results follows in Sections 5.3. and 5.4. The discussion includes recommendations for wind control to reduce the potential of high wind speeds for the design team's consideration (Section 5.5).

5. RESULTS AND DISCUSSION

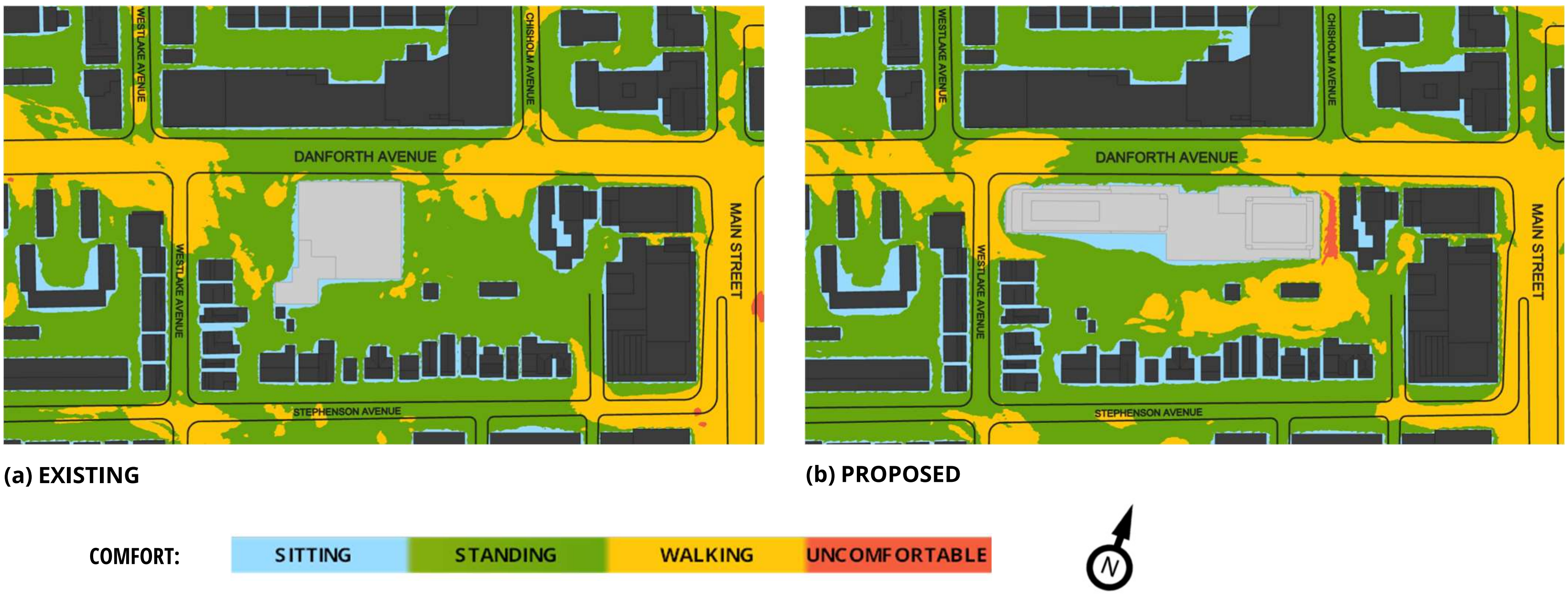


Image 8: Predicted wind conditions – GROUND LEVEL – SPRING

5. RESULTS AND DISCUSSION

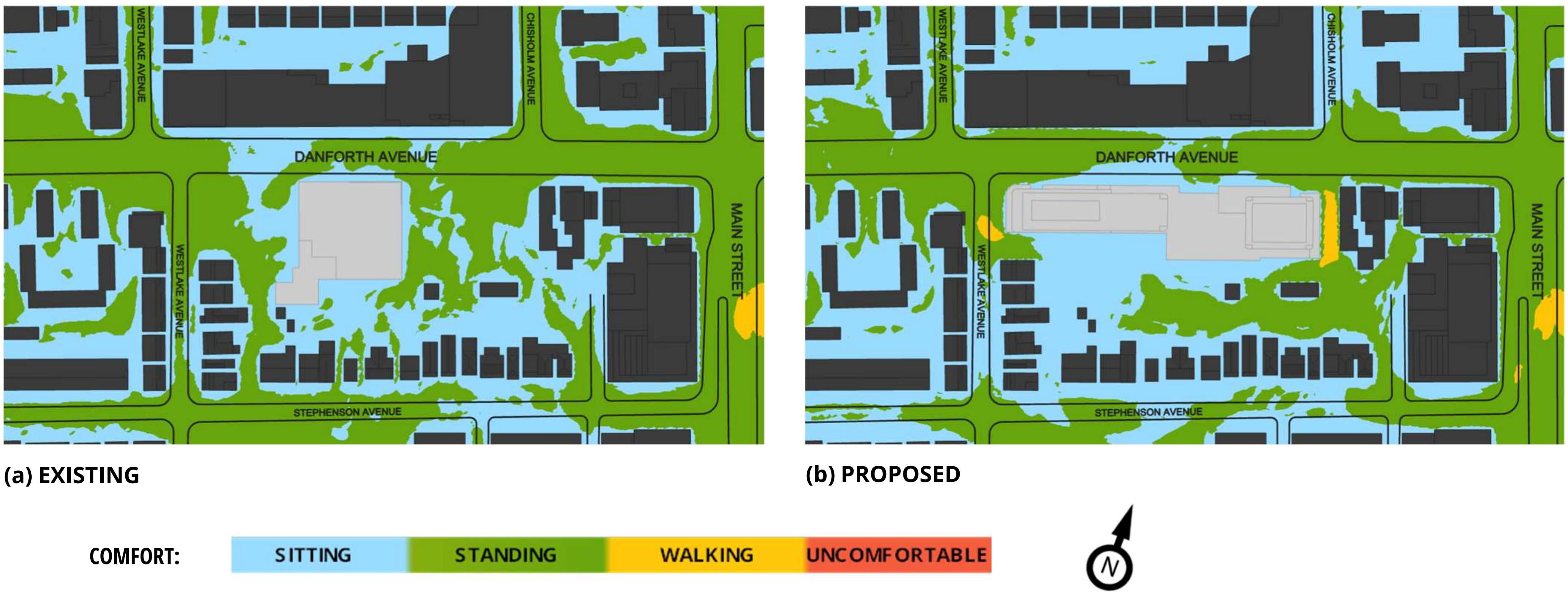


Image 9: Predicted wind conditions – GROUND LEVEL – SUMMER

5. RESULTS AND DISCUSSION

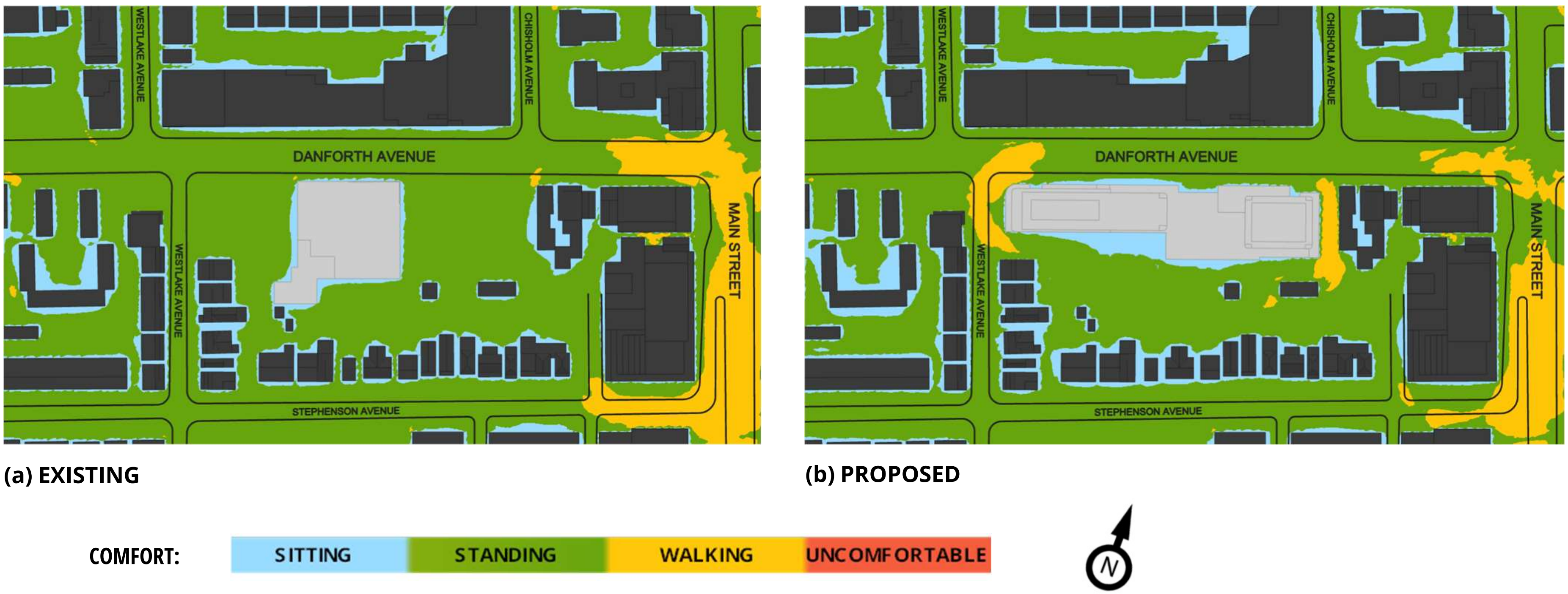


Image 10: Predicted wind conditions – GROUND LEVEL – FALL

5. RESULTS AND DISCUSSION

Image 11: Predicted wind conditions – GROUND LEVEL – WINTER

5.3 Existing Scenario

The existing site is occupied by a large low-rise building and parking lots. Wind conditions on and immediately around the site are comfortable for sitting or standing in the summer (Image 9a), for standing in the fall (Image 10a) and for walking or better in the spring and winter (see Images 8a and 11a).

The prevailing easterly and westerly winds may accelerate around the existing tall building to the east of the site, causing uncomfortable wind conditions along Danforth Avenue, Stephenson Avenue and Main Street in the winter (red areas in Image 11a), where wind speeds may also exceed the safety criterion.

5.4 Proposed Scenario

With the proposed project in place, wind conditions in the surrounding areas are predicted to be similar or slightly improved from the existing conditions (Images 8 through 11). In the winter, for example, the uncomfortable (red) areas along Danforth Avenue, Stephenson Avenue and Main Street in the proposed configuration (Image 11b) are considerably smaller than those in the existing configuration (11a). This can be attributed to the sheltering provided by the proposed project from the prevailing west and northwest winds.

Wind conditions on the project site are also predicted to be similar to those that currently exist, due to the proposed large low podium. Other positive wind control features include the arrangement of the two proposed towers as well as the position and orientation of the lower Building B with respect to the prevailing west and east winds.

At the east and west ends of the proposed project, however, increased wind activity is anticipated, and it may result in uncomfortable wind conditions in the winter and spring seasons (red areas in Images 11b and 8b).

5.4.1 Sidewalks

As shown in Image 3, public sidewalks are located along Danforth Avenue and Westlake Avenue, to the north and west of the project, respectively. South of the project will be used primarily for driving and a POPS is located on the east side of Building A.

Suitable wind conditions are predicted on the sidewalks throughout the year (Images 8b through 11b), except around the western corners of Building B, where uncomfortable wind conditions may occur in the winter (Image 11b). The potential wind mitigation concepts are provided in Section 5.5.

Given the moderate height of Building B, the resultant wind speeds are expected to meet the wind safety criterion. Wind tunnel testing should be conducted at the SPA stage to quantify the wind conditions and, if needed, to refine mitigation solutions.

5. RESULTS AND DISCUSSION

5.4.2 Main Entrances

Image 3 shows all entrances along Danforth Avenue are in recessed areas and suitable wind conditions comfortable for sitting or standing are expected throughout the year. Image 12 provides enlarged 3D views of wind conditions around the residential and retail entrances at the base of the project in the winter season, which are the worst-case conditions. The retail entrances on the east façade of Building A and the residential entrance on the west façade of Building B are more exposed and they are close to uncomfortable (red) zones in the winter, as shown in Image 12.

5.4.3 POPS

On the POPS on the east side of Building A, wind speeds are predicted to be comfortable for walking in the summer and fall and uncomfortable in the winter and spring (Images 8b – 11b). Winds are channelled between the proposed Building A and the existing buildings to the east, and they may exceed the safety limit from time to time in the winter and spring seasons. It should be noted that this assessment does not include programming or any wind mitigation elements in the POPS space. RWDI will work with the design team to select wind control features in the POPS space, which will be demonstrated at the SPA stage.

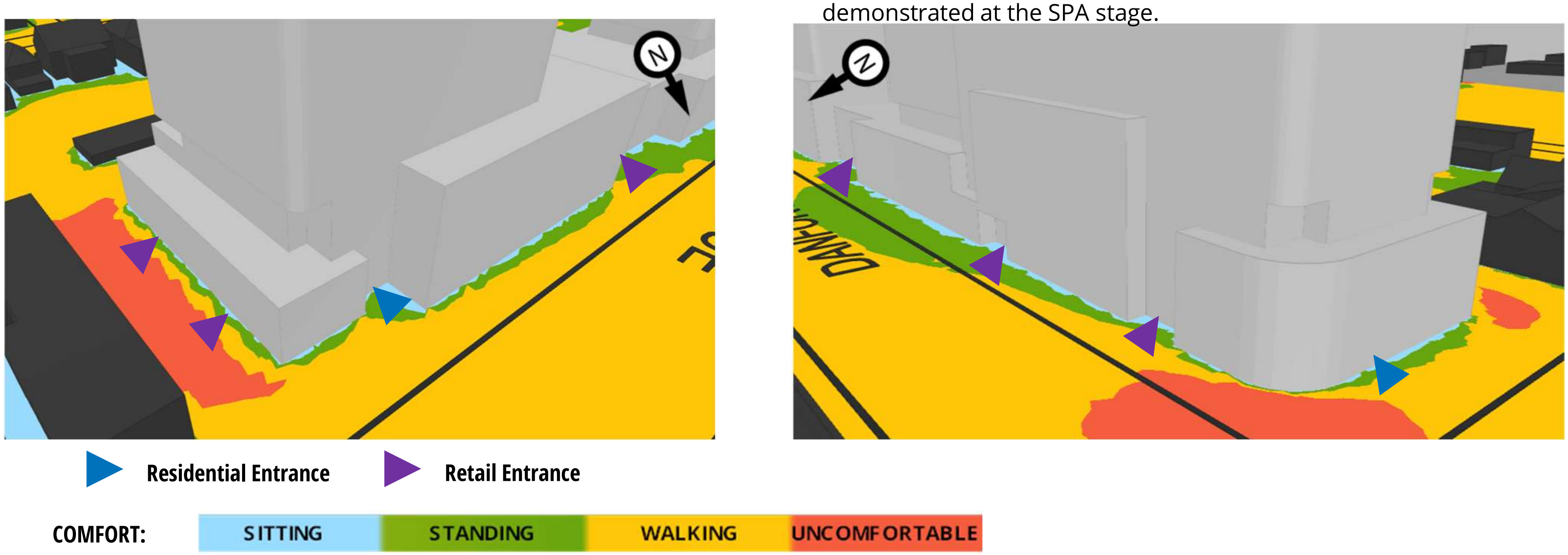


Image 12: Predicted wind conditions around entrances – WINTER (worst case)

5.4.4 Podium Terraces

Wind conditions on the podium terraces are shown in Image 13 for all four seasons. In the summer (13b) when these areas are typically in use, wind conditions are generally comfortable for standing or walking. Higher wind speeds comfortable for walking or uncomfortable are expected during other seasons (13a, 13c and 13d).

Lower wind speeds comfortable for sitting or standing are typically required for outdoor terraces. Note that guardrails, wind screens, or landscaping, which were not included in the CFD simulations, would reduce the wind speeds on the terraces.

5.5 Conceptual Mitigation Measures

As discussed in Section 5.4, several pedestrian areas on and around the proposed project site are predicted to have windy conditions. Potential wind mitigation measures are provided below with photo examples for the design team's consideration.

The uncomfortable wind conditions around the northwest corner and, to a lesser extent, the southwest corner of Building B are caused by the corner accelerations of winds being deflected down by the building. Potential wind controls measures could include massing changes (i.e., building corner articulations), architectural additions (canopies, wind screens), or landscaping (sidewalk trees) – see photos in Image 14a for examples.

Where entrances cannot be recessed, added protection is recommended. Specifically, the entrances at the west and east end of the project can be protected by canopies above and wind screens or planters on both sides of the doorways (Image 14b).

The wind conditions in the POPS on the east side of Building A were tested without any programming but can be improved by landscaping, including screens or rows of dense trees at both the north and south ends and canopy-type trees over the space, plus planters, screens and trellises around any seating areas – see Image 14c.

Elevated wind speeds on the podium terraces are caused by both horizontal winds approaching the podium and vertical winds deflected down by the proposed towers. Therefore, wind mitigation measures should include tall guardrails along the perimeter and trellises/canopies at the base of the towers. Additional landscaping elements are recommended for seating areas, and they may take the form of planters, local screens and trellises (Image 14c). This will be demonstrated at the SPA stage.

RWDI can help guide the placement of wind control features, including landscaping, to achieve appropriate levels of wind comfort based on the programming of the various outdoor spaces.

5. RESULTS AND DISCUSSION

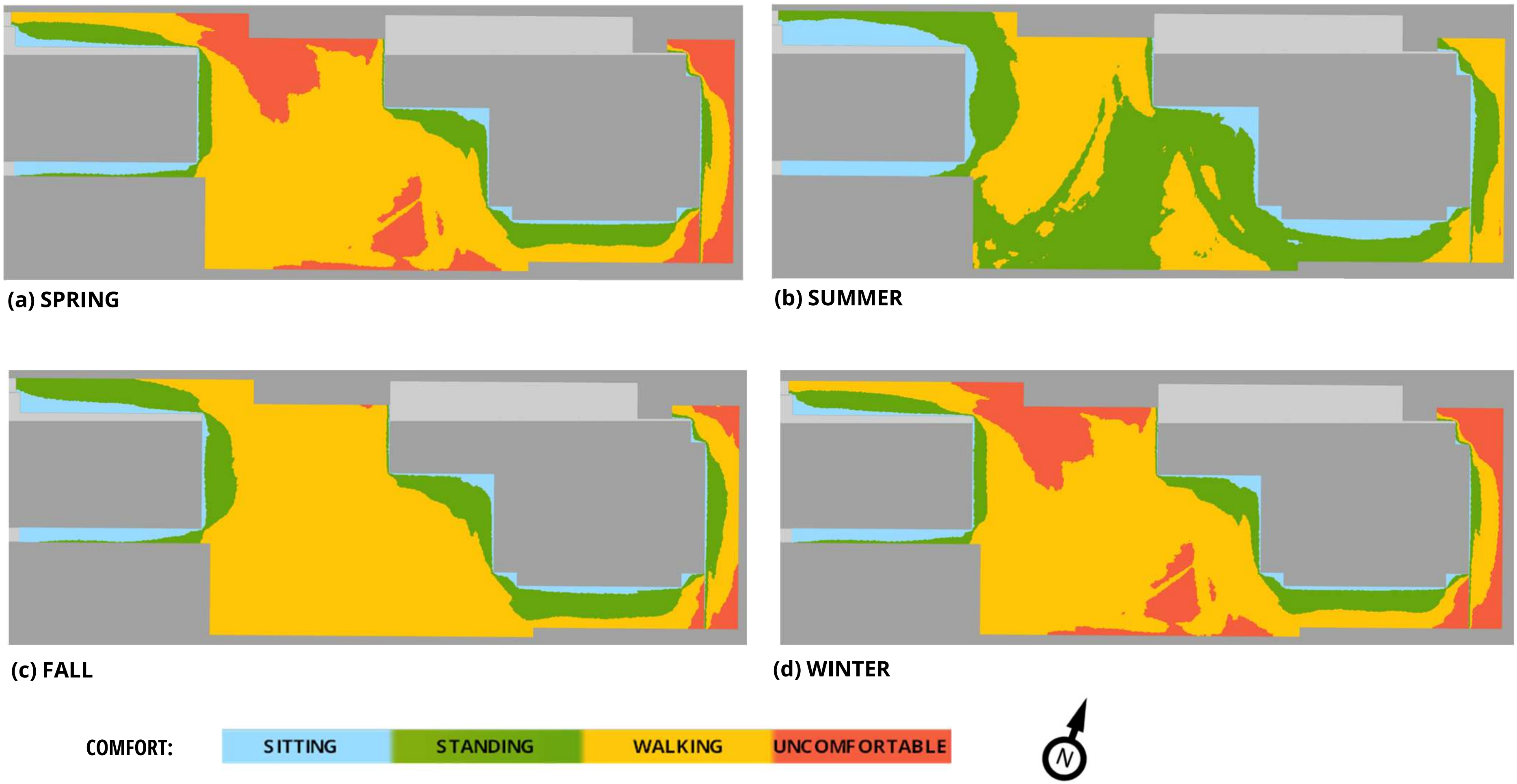


Image 13: Predicted wind conditions – PODIUM TERRACES

5. RESULTS AND DISCUSSION

Image 14a: Wind mitigation for the western corners of Building B

Image 14b: Wind mitigation for the west and east entrances

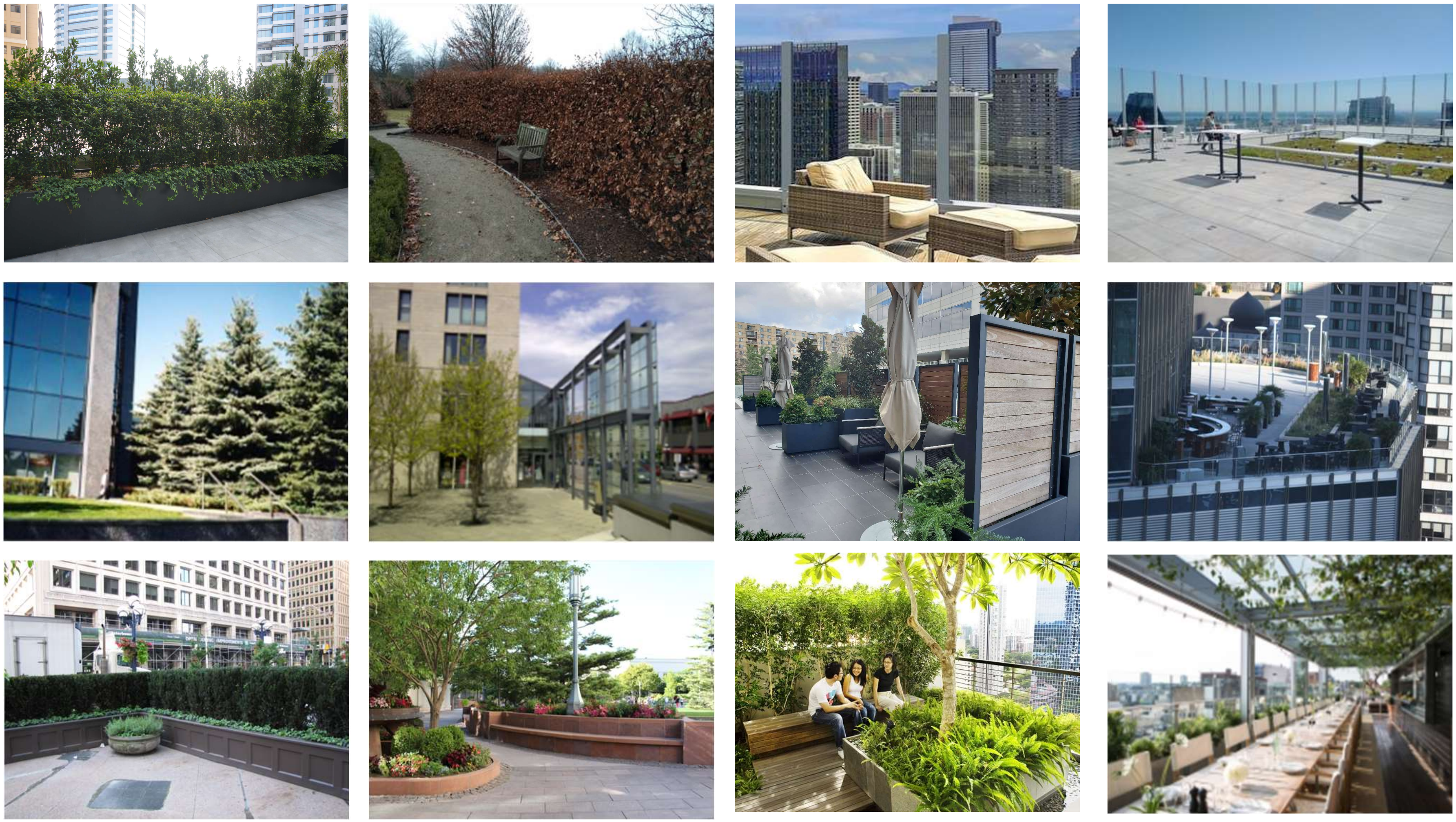


Image 14c: Wind mitigation for the POPS and podium terraces

6. SUMMARY

RWDI was retained to provide an assessment of the potential pedestrian level wind impact of the proposed residential development at 2451-2495 Danforth Avenue in Toronto, Ontario. Our assessment was based on the local wind climate, the current design of the proposed development, the existing surrounding buildings, and computational modelling and simulation of wind conditions. Our findings are summarized as follows:

- The existing wind conditions on and around the project site are suitable for intended pedestrian uses throughout the year. The area to the east of the site is an exception, where uncomfortable wind conditions are expected along sidewalks in the winter.
- The addition of the proposed project is expected to improve the existing uncomfortable conditions to the east.
- On the project site, wind conditions are predicted to be appropriate for most pedestrian areas, including sidewalks and entrances.
- Elevated wind speeds and uncomfortable wind conditions are expected in the winter around the western corners of Building B, and near the residential and retail entrances on the west and east building façades. Higher-than-desired wind speeds are also predicted at the proposed POPS and on the podium terraces.
- Conceptual wind control measures for windy areas have been discussed in section 5.5.
- Wind-tunnel testing should be conducted at the SPA stage to quantify the predicted wind conditions and refine the recommended mitigation measures.

7. STATEMENT OF LIMITATIONS

Design Assumptions

The findings/recommendations in this report are based on the building geometry and architectural drawings communicated to RWDI on October 10, 2024. Should the details of the proposed design and/or geometry of the building change significantly, results may vary.

File Name	File Type	Date Received (mm/dd/yyyy)
241010_2216_Danforth_3D	dwg	10/10/2024
241009_2216 Danforth and Westlake Draft Set	pdf	10/10/2024

Changes to the Design or Environment

It should be noted that wind comfort is subjective and can be sensitive to changes in building design and operation that are possible during the life of a building. In the event of changes to the design, construction, or operation of the building in the future, RWDI could provide an assessment of their impact on the discussions included in this report. It is the responsibility of Others to contact RWDI to initiate this process.

Limitations

This report was prepared by Rowan Williams Davies & Irwin Inc. for First Capital ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein and authorized scope. The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared. Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.

8. REFERENCES

1. H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004), “Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions”, *ASCE Structure Congress 2004,* Nashville, Tennessee.

2. H. Wu and F. Kriksic (2012). “Designing for Pedestrian Comfort in Response to Local Climate”, *Journal of Wind Engineering and Industrial Aerodynamics*, vol.104-106, pp.397-407.

3. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), “Experience with Remedial Solutions to Control Pedestrian Wind Problems”, *10th International Conference on Wind Engineering*, Copenhagen, Denmark.