REPORT

NIAGARA FALLS CONDO (6285 & 6289 MAIN STREET)

NIAGARA FALLS, ONTARIO

PEDESTRIAN WIND COMFORT ASSESSMENT

PROJECT #2102430
December 7, 2023

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 Niagara Falls Condo project at 6285 & 6289 Main Street in Niagara Falls, Ontario. The objective of this assessment is to provide an evaluation of the potential wind conditions around the proposed project in support of an OPA/Rezoning application.

The project (Image 1) is located at the northwest corner of the intersection of Main Street and Murray Street and is primarily surrounding by low-rise suburban and commercial buildings. A few tall buildings exist further out to the east and southeast.

The project consists of a 20-storey residential tower with a low podium on the east and south sides (Image 2). Outdoor amenities are proposed on the podium roof (Level 2) and the tower rooftop.

In In addition to the amenity spaces, key areas of interest for this assessment include the main building entrances, drop-off area and the sidewalks and properties near the site (Image 3).

Image 1: Aerial view of the existing site and surroundings
Source: Google Maps

Image 2: 3D-model of the proposed project

1. INTRODUCTION

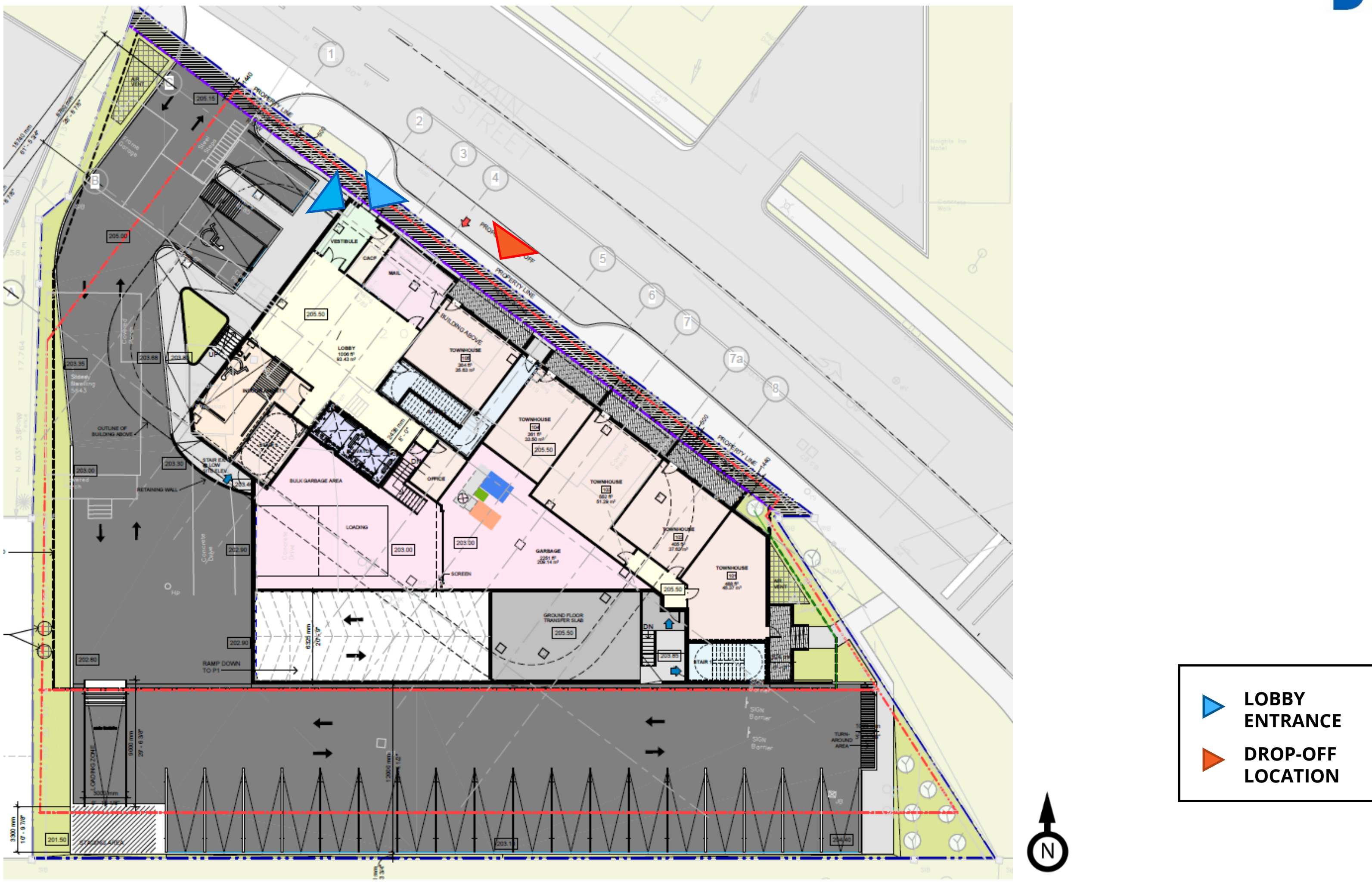


Image 3: Ground floor plan identifying building entrances and drop-off area

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 Niagara Falls International Airport;
- 3D model of the proposed project received on October 5, 2023;
- The use of *Orbital Stack*, an in-house CFD tool;
- RWDI's engineering judgment, experience, and expert knowledge of wind flows around buildings[1-3]; and,
- The wind comfort and safety criteria for Niagara Region.

Note that other wind related issues such as cladding and structural wind loads, door operability, air quality, snow impact, noise, vibration, 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

CFD simulations were completed for two scenarios:

Existing: Existing site and surroundings, and

Proposed: Proposed development with the existing surroundings.

The computer model of the proposed building is shown in Image 4, and the Existing and Proposed configurations with the proximity model are shown in Images 5a and 5b. The 3D models were 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 approaching the modelled area were simulated for 16 directions (starting at 0°, at 22.5° increments around the compass), accounting for the effects of the atmospheric boundary layer and terrain impacts. Wind data were obtained 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. The data was then combined with meteorological records obtained from Niagara Falls International Airport to determine the wind speeds and frequencies in the simulated areas.

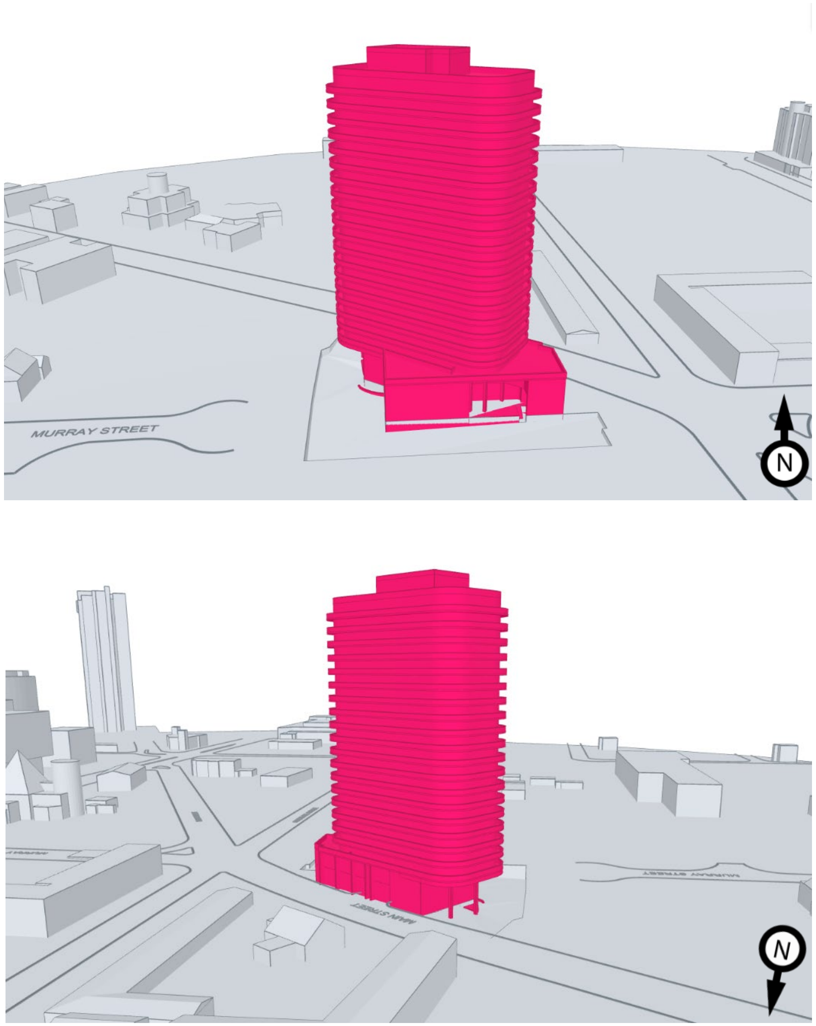


Image 4: Computer model of the proposed project

2. METHODOLOGY

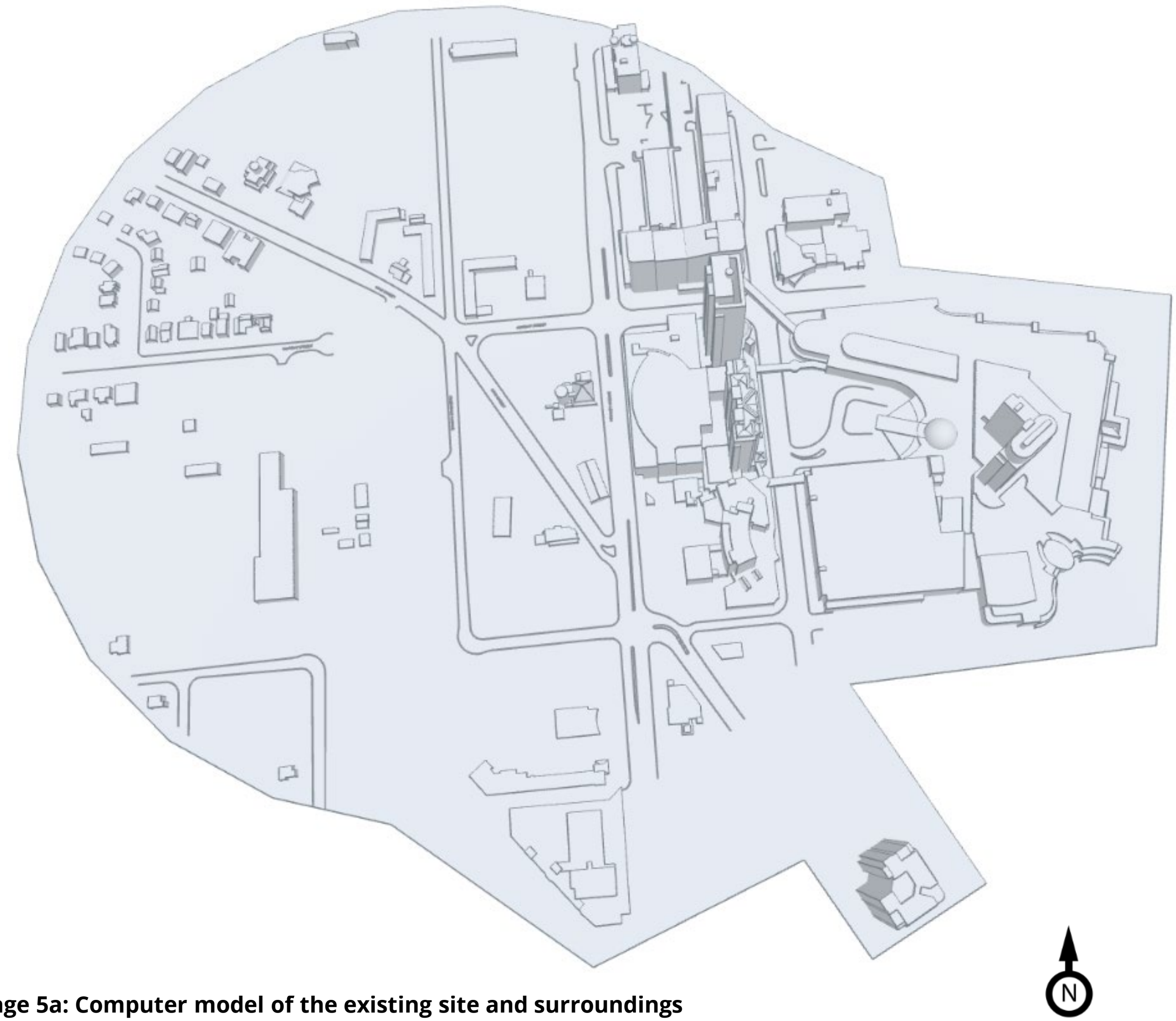


Image 5a: Computer model of the existing site and surroundings

2. METHODOLOGY

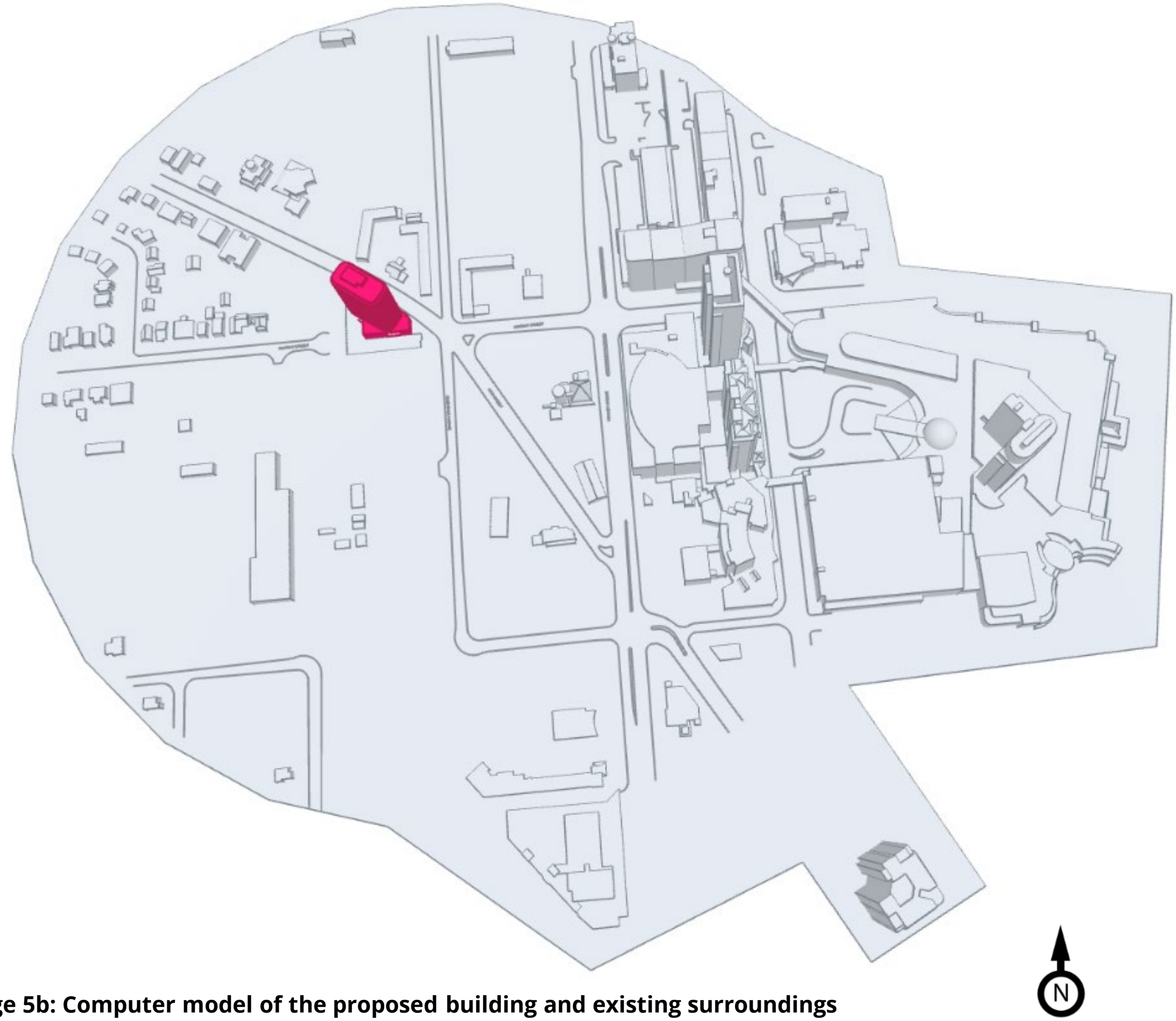


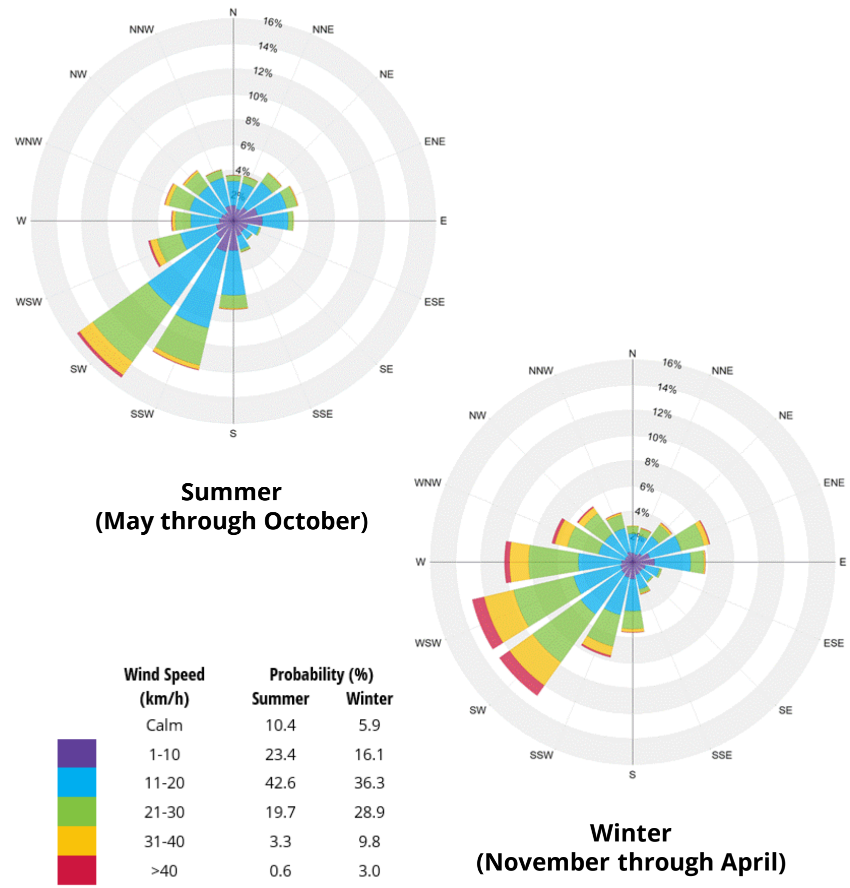
Image 5b: Computer model of the proposed building and existing surroundings

3. METEOROLOGICAL DATA

Long-term wind data recorded at Niagara Falls International Airport between 1991 and 2021, inclusive, were analyzed for the summer (May to October) and winter (November to April) months. Image 6 graphically depicts the directional distributions of wind frequencies and speeds for these periods.

Winds from the southwest quadrant are predominant throughout the year as indicated by the wind roses, with secondary winds from the northeast and northwest quadrants. Strong winds of a mean speed greater than 30 km/h measured at the airport (at an anemometer height of 10 m) occur for 3.9% and 12.8% of the time during the summer and winter seasons, respectively, and they are primarily from the southwesterly directions.

Wind statistics were combined with the simulated data to predict the wind conditions at the project site and assessed against the wind criteria for pedestrian comfort.



Wind Speed (km/h)	Probability (%) Summer	Winter
Calm	10.4	5.9
1-10	23.4	16.1
11-20	42.6	36.3
21-30	19.7	28.9
31-40	3.3	9.8
>40	0.6	3.0

Image 6: Directional distribution of winds approaching Niagara Falls International Airport between 1991 and 2021

4. WIND CRITERIA

Based on pedestrian level wind study terms of reference guide for Niagara Region (dated July 2022), the public realm, streetscapes and public/private outdoor open spaces related to the existing and proposed buildings are to be comfortable for their intended use. The table below describes the minimum criteria for specific locations. The criteria deal with comfort and safety of pedestrians:

Comfort: Commonly experienced wind speeds have been categorized into ranges based on the activity level of a person that the winds would be conducive to. Lower wind speeds are desirable for passive activities and active pedestrians would be tolerant of higher wind speeds.

Safety: It is important to assess wind conditions in the pedestrian realm from a safety perspective as strong wind gusts can deter safe pedestrian use of outdoor spaces. Wind speeds associated with wind gusts are infrequent but deserve special attention due to their potential impact on pedestrian safety.

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	Main entrances, bus-stops, dog areas, and other outdoor areas where seated activities are not expected.
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 Buildings

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*. 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 at 20 storeys, will be taller than the buildings that exist in the immediate surrounding areas and therefore will redirect winds to ground level (Image 8). The proposed low podium is a positive design feature which will help moderate wind impacts at ground level to some extent, but the podium roof will be windy as a result.

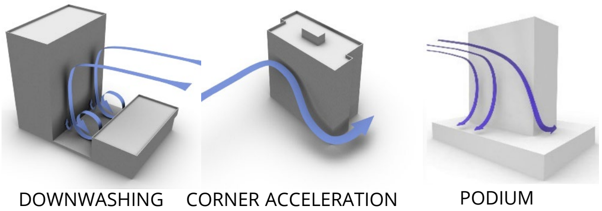


Image 7: General wind flow patterns

5.2 Simulation Results

The predicted seasonal wind comfort conditions for the Existing and Proposed configurations are presented in Images 9 and 10. The 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 extensive experience with wind tunnel assessments in the Niagara region.

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.

5. RESULTS AND DISCUSSION

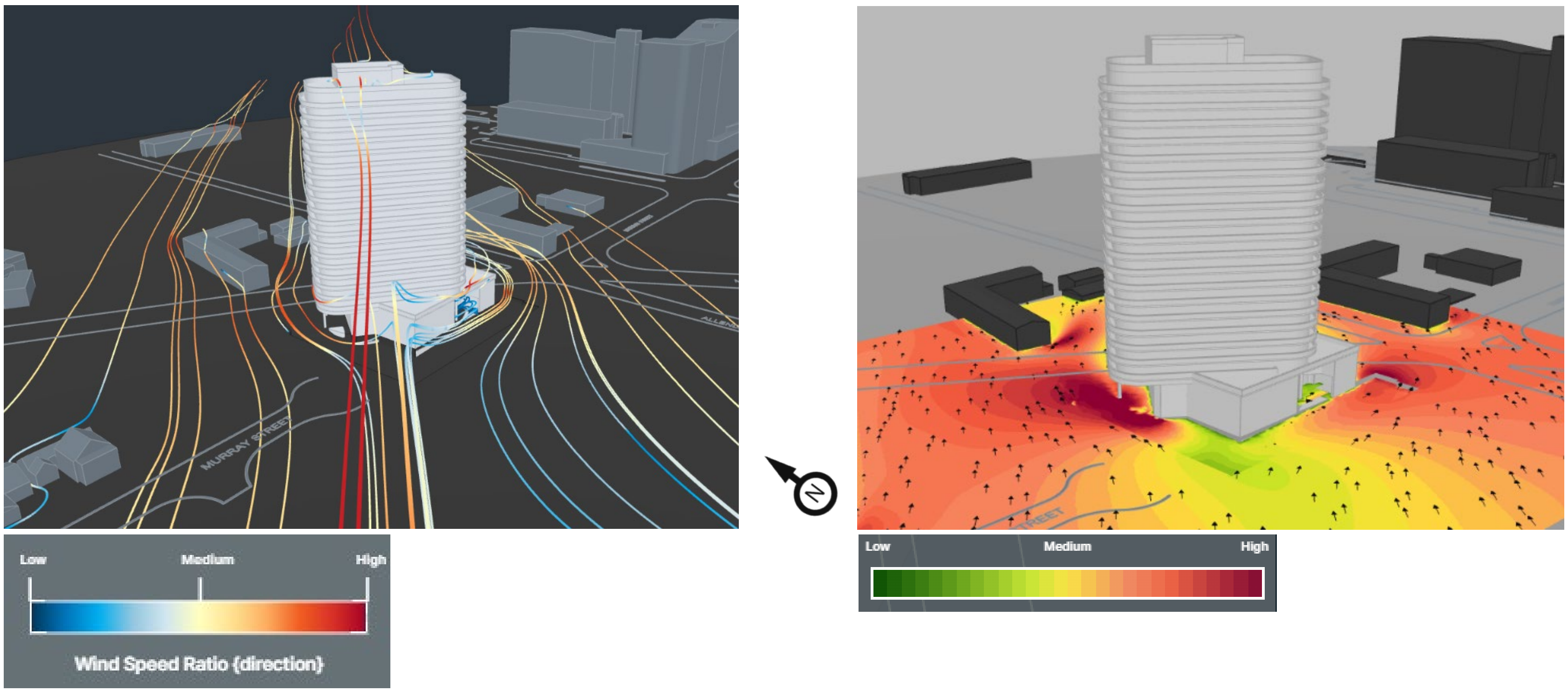
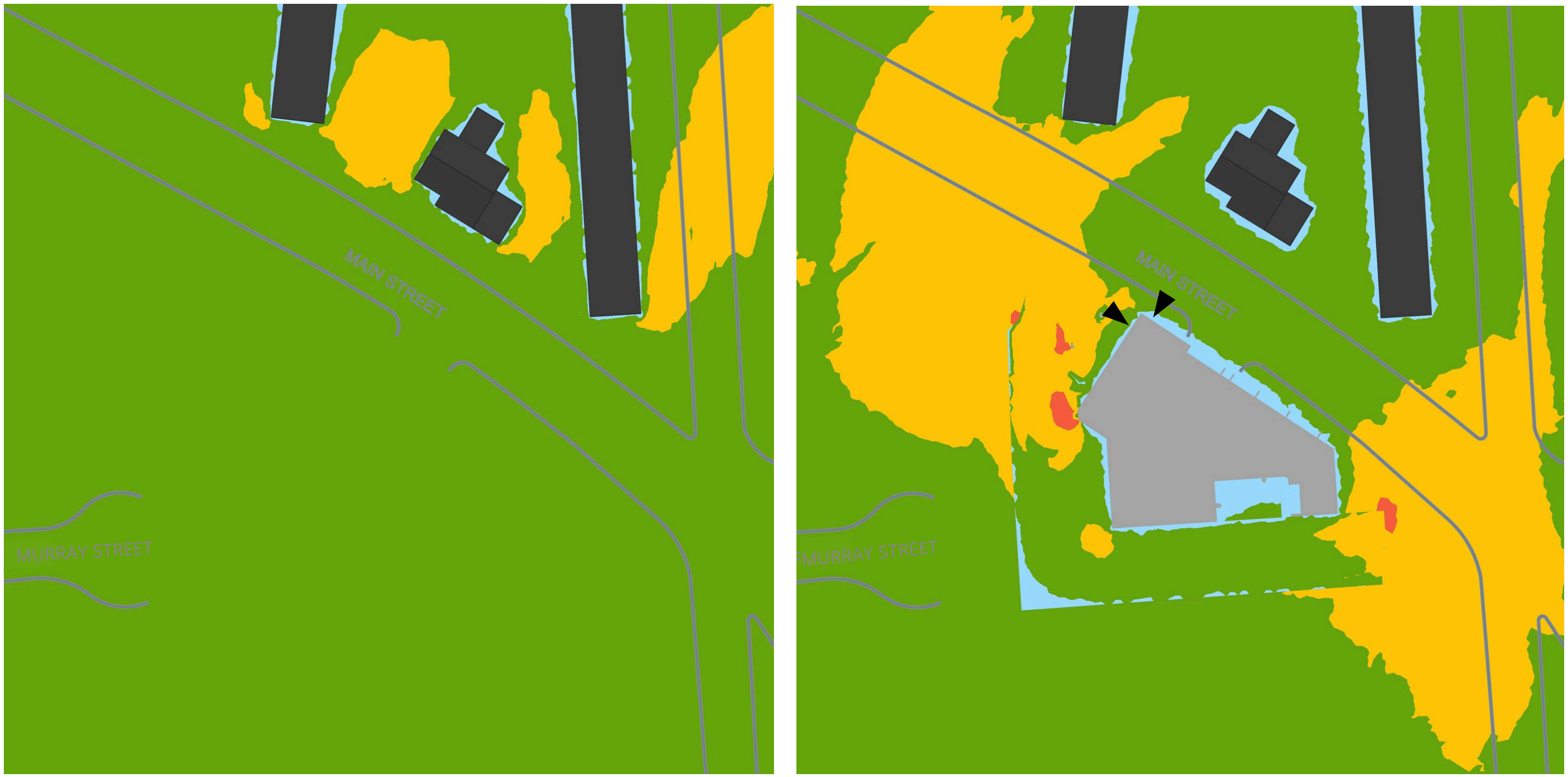


Image 8: Flow patterns around the proposed building for the predominant southwesterly winds

5. RESULTS AND DISCUSSION

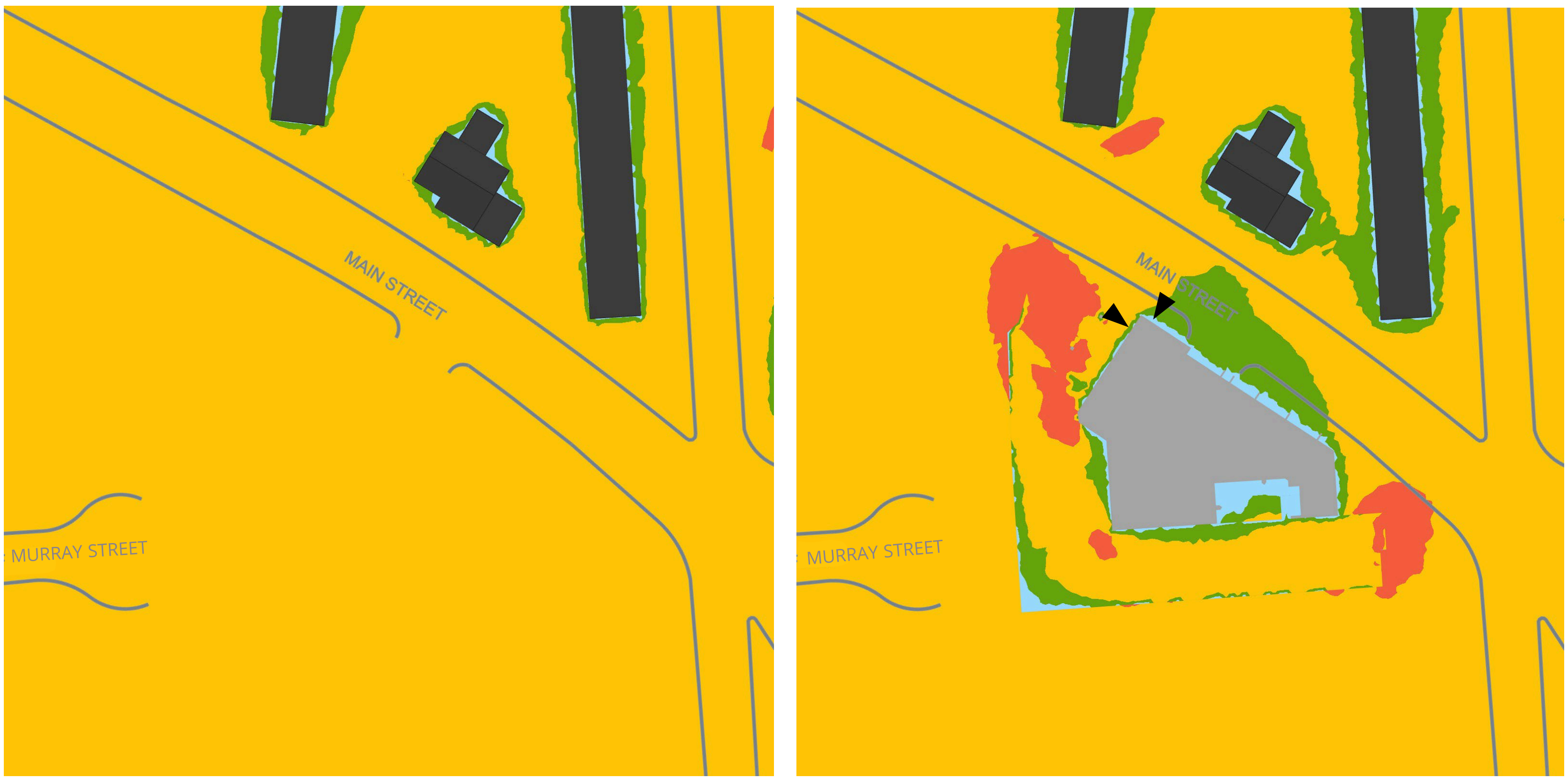


(a) EXISTING

(b) PROPOSED

Image 9: Predicted wind conditions – GROUND LEVEL – SUMMER

5. RESULTS AND DISCUSSION



(a) EXISTING

(b) PROPOSED

COMFORT: SITTING | STANDING | WALKING | UNCOMFORTABLE

N

►: Entrance

Image 10: Predicted wind conditions – GROUND LEVEL – WINTER

5.3 Existing Scenario

The existing site is undeveloped and surrounded by low-rise commercial and residential buildings, and therefore will not redirect winds to create any notable impact. Results for the Existing scenario are presented in Images 9a and 10a. Wind conditions at most areas on and around the site are considered comfortable for standing in the summer and for walking in the winter.

Wind conditions at all areas near the project site meet the pedestrian safety criterion.

5.4 Proposed Scenario

The proposed building is taller than the buildings that currently exist in the vicinity and is expected to increase wind activity around the site (Images 9b and 10b). The low podium on the east and south sides will help in reducing the wind impact of the building at grade level.

5.4.1 Sidewalks and Neighbouring Properties

Wind speeds on most sidewalks and walkways around the proposed building are expected to be comfortable for standing or walking throughout the year (Images 9b and 10b). These conditions are appropriate for the intended active pedestrian use. However, areas to the northwest, southwest and southeast of site are expected to see increased wind speeds due to the downwashing of the prevailing southwesterly winds off the tall building facades and their subsequent acceleration near the corners. Higher wind speeds at these corner areas are expected to be mostly comfortable for walking during the summer, and uncomfortable during the winter.

Reduced wind speeds are predicted at pedestrian areas to the northeast of the site due to the protection from southwesterly winds afforded by the tall tower. For example, enhanced wind comfort conditions are expected in the pool area of the neighboring building to the north, across Main Street, during the summer with the proposed building in place.

Wind safety criterion is expected to be met at all grade-level areas around the site, except for localized areas near the southeast and northwest building corners.

5.4.2 Main Entrances and Drop-off Area

Wind conditions near the Lobby entrance to the north are expected to be comfortable for sitting or standing throughout the year which is suitable for the intended use. Wind speeds near the western lobby entrance are expected to be comfortable for standing in summer and for walking during the winter. The winter wind conditions are considered higher than desired for an entrance location.

Wind speeds in the drop-off area on the north side are expected to be comfortable for sitting or standing throughout the year which is ideal for the intended use.

5.4.3 Wind Mitigation Strategies at Grade

It is worth noting that that proposed landscaping was not included in the computer model of the project to obtain baseline wind conditions. Landscaping features like tall trees will help reduce wind speeds around them. Coniferous trees afford wind control benefits in the winter and shoulder seasons as well. In addition to trees, vertical wind control features such as porous wind screens, planters and art features can be used to diffuse the wind energy and improve local conditions on pedestrian areas. For these elements to be effective a minimum height of 2 m and a porosity of 20-30% are recommended (see examples in image 11).

Ideally, we would recommend relocating main lobby entrances away from the building corner. To reduce wind speeds at the entrances, a recessed design can be considered to create a sheltered doorway. Alternatively, wind screens/landscaping can be placed on both sides of the doors to reduce wind speeds. Examples are shown Image 12.

The effectiveness of all mitigation features can be quantified using physical scale model tests in the wind tunnel.

5. RESULTS AND DISCUSSION

Image 11: Examples of wind control solutions for the sidewalks/walkways

Image 12: Design strategies for wind control at entrances

5. RESULTS AND DISCUSSION

5.4.4 Level 2 Amenity Terrace

Wind speeds increase with elevation. The Level 2 amenity terrace would be directly exposed to the southwesterly winds as well as the winds that are redirected by the tower. As a result, wind conditions at most areas on the Level 2 terrace are expected to be higher than desired for passive patron use throughout the year and potentially exceed the safety criterion (Image 13).

To improve the wind conditions, minimum 6-8 ft tall guardrails around the perimeter of the terrace can be considered. Overhead features like wide canopies and trellises can be added at the tower base to deflect the wind downdrafts away from the terrace. Additionally, wind screens, partitions and planters may be interspersed throughout the terrace and particularly around designated gathering or seating areas. Some examples of wind control features are shown in Image 14.

5.4.5 Rooftop Amenity Terrace

The roof-top amenity space would be exposed to stronger winds at a higher elevation. As such, wind speeds are expected to be too high and uncomfortable for passive use throughout the year and exceed the safety criterion in the absence of any wind protection (Image 13).

We recommend tall guardrails or screens around the perimeter of the rooftop terrace in order to disrupt the strong winds approaching horizontally at this elevation. Tall landscaping features, wind screens or trellises may be used locally to help lower wind speeds in patron areas. Some examples of wind control features are shown in Image 14.

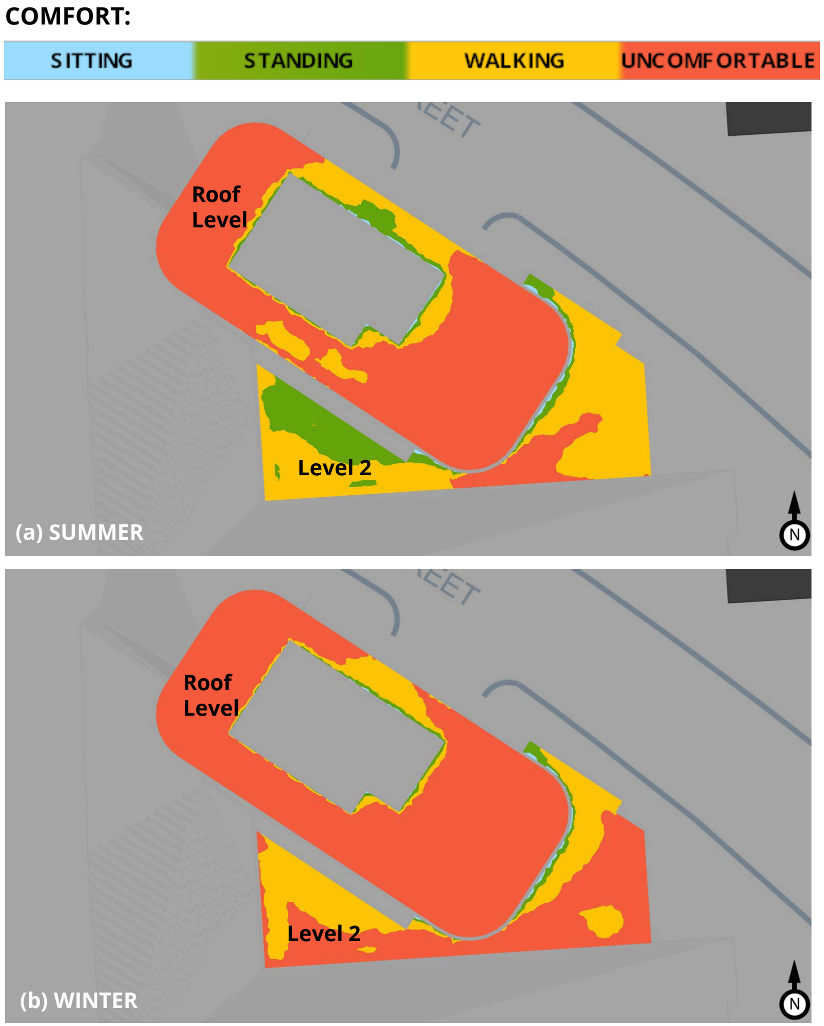


Image 13: Predicted wind conditions – LEVEL 2 and ROOFTOP AMENITY TERRACES

5. RESULTS AND DISCUSSION

Image 14: Design strategies for wind control on the amenity terraces

6. SUMMARY

RWDI was retained to provide an assessment of the potential pedestrian level wind impact of the proposed Niagara Falls Condo project in Niagara Falls, Ontario. Our assessment was based on computational modelling, simulation and analysis of wind conditions for the proposed development design, in conjunction with the local wind climate data and the Niagara Falls wind criteria for pedestrian comfort and safety. Our findings are summarized as follows:

- Wind conditions on and around the existing site are generally comfortable for standing during the summer and for walking during the winter. These wind speeds meet the pedestrian wind safety criterion.
- The proposed building is taller than surroundings, therefore redirecting wind to ground level. The low podium structure will help in reducing the wind impact of the building.
- Wind conditions at most ground-level areas are expected to be appropriate for the intended pedestrian usage around the site, including sidewalks, walkways, lobby entrances and the drop-off area.
- Higher wind speeds and uncomfortable conditions are expected near the northwest, southwest and southeast building corners during the winter. Higher-than-desired wind speeds are also predicted at the west lobby entrance in the winter.
- Throughout the year, wind speeds on the Level 2 and the Roof-top amenity spaces are expected to be for the most part higher than desired for passive patron use.
- The pedestrian wind safety criterion is anticipated to be met at most grade-level areas, apart from the localized zones near the northwest and southeast building corners. This criterion may also be exceeded on the exposed regions of the above-grade amenity areas.
- Conceptual wind control strategies applicable to each windy area are discussed in the report. 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. The performance of the proposed wind control features can be assessed through wind tunnel testing.

7. DESIGN ASSUMPTIONS

The findings/recommendations in this report are based on the building geometry and architectural drawings communicated to RWDI, listed below. 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)
3DView-WORKINGMODEL	AutoCAD	10/05/2023
119051 - Niagara Falls Condo - Schematic Package - 2023.09.25	PDF	09/29/2023

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. These could be, for example: outdoor programming, operation of doors, elevators, and shafts pressurizing the tower, changes in furniture layout, etc.. 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.

8. STATEMENT OF LIMITATIONS

This report was prepared by Rowan Williams Davies & Irwin Inc. for Zeljko Holdings Limited (“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.

9. 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.