ATTACHMENT D

REPORT

937 VIEW STREET

VICTORIA, BC

PEDESTRIAN WIND COMFORT ASSESSMENT

PROJECT #2302982
April 12, 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 project at 937 View Street in Victoria, BC. The objective of this assessment is to provide an evaluation of the potential pedestrian-level wind conditions around the proposed development.

The project site is located on the south side of View Street, between Vancouver Street and Quadra Street (Image 1). The site is surrounded by mid to high-rise buildings in all but the southeastern directions, where buildings are primarily low to mid-rise.

The project will consist of a 23-storey tower with a 5-storey podium structure, at an approximate height of 75 m. In addition to sidewalks and properties near the project site, important areas of interest for this assessment include the amenity terraces on levels 2, 6, and 23 (Image 2) and the building entrances / drop-off area on View Street (Image 3).

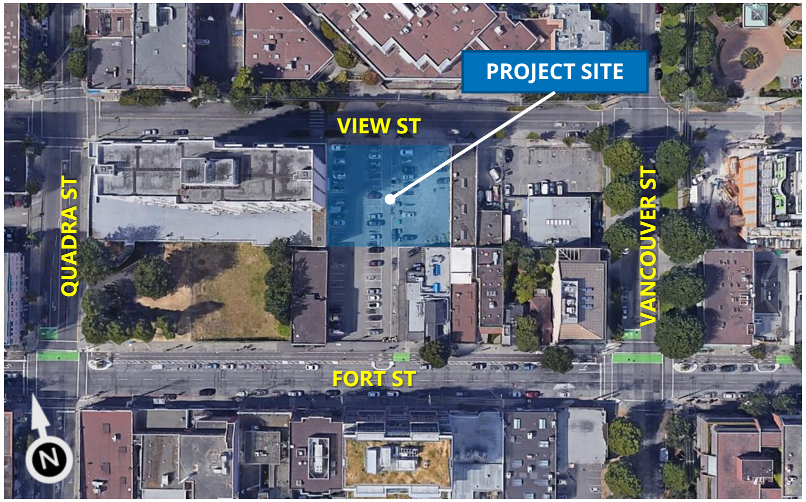

Image 1: Aerial view of the existing site and surroundings
Source: Google Maps

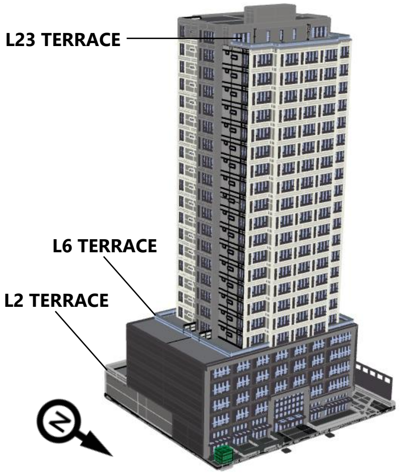

Image 2: 3D model of the proposed project

1. INTRODUCTION

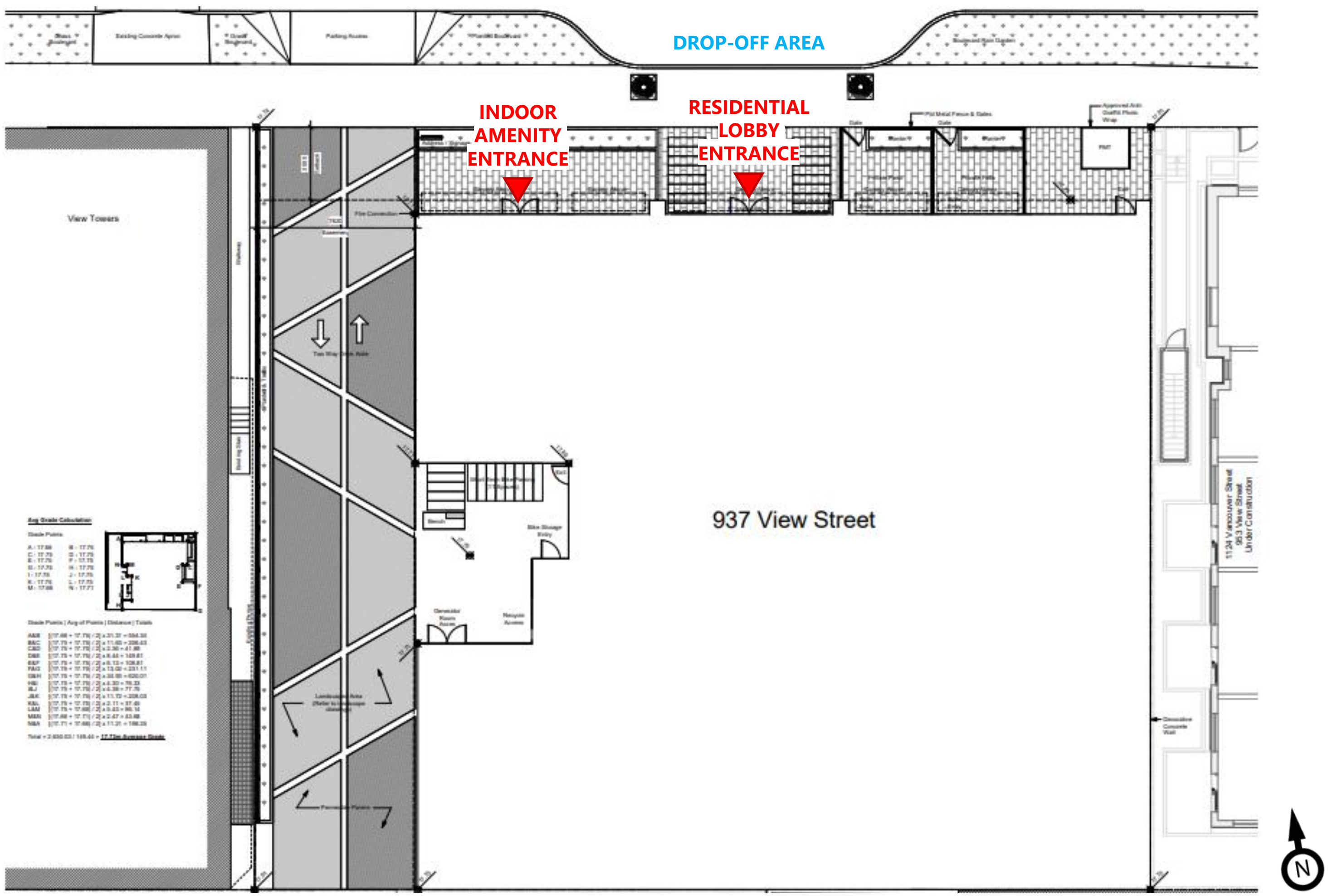

Image 3: Site plan highlighting the location of building entrances and drop-off area on View Street

2. METHODOLOGY

2.1 Objective

The objective of this study is to assess the wind environment in pedestrian areas on and around the proposed project based on Computational Fluid Dynamics (CFD) modelling. The assessment is based on the following:

- A review of the regional long-term meteorological data from Victoria Harbour Seaplane Airport;
- 3D e-model of the proposed project and architectural drawings received on Mar 17, 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 RWDI wind comfort and safety criteria.

Note that other microclimate issues such as those relating to cladding and structural wind loads, door operability, air quality, 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 flow in complex environments. For modelling winds around buildings, CFD techniques are used to generate a virtual wind tunnel where flows around the site, surroundings and the study building are simulated at full scale. The computational domain that covers the site and surroundings are divided into millions of small cells where calculations are performed, which allows for the "mapping" of wind conditions across the entire study domain. CFD excels as a tool for wind modelling and presentation for providing early design advice, comparing different design and site scenarios, resolving complex flow physics, and helping diagnose problematic wind conditions.

Gust conditions are infrequent but deserve special attention due to their potential impact on pedestrian safety. The computational modelling method used in the current assessment does not quantify the transient behavior of the wind, including wind gusts. The effect of gust, i.e., wind safety, is predicted qualitatively in this assessment using analytical methods and wind-tunnel-based empirical models[1]. The assessment has been conducted by experienced microclimate specialists in order to provide an accurate prediction of wind conditions.

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

2.3 Simulation Model

CFD simulations were completed for the proposed project with existing and approved future surroundings.

The computer model of the proposed building is shown in Image 4, and the extended surroundings around the project are shown in Image 5. 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 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 Victoria Harbour Seaplane Airport to determine the wind speeds and frequencies in the simulated areas.

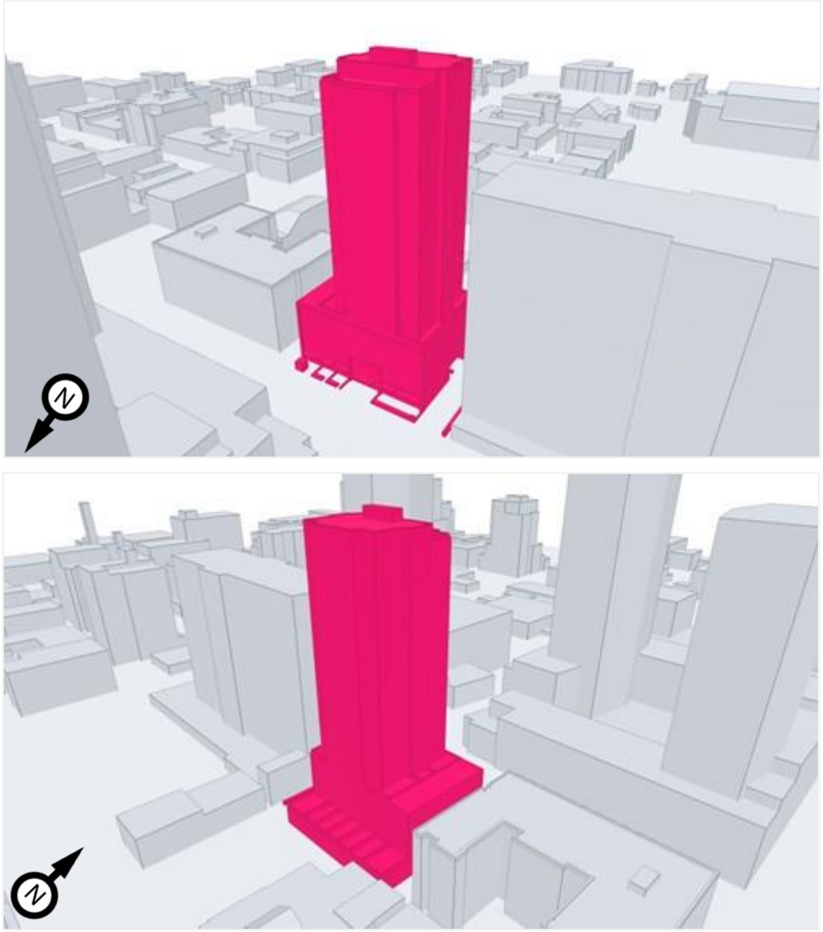

Image 4: Computer model of the proposed project

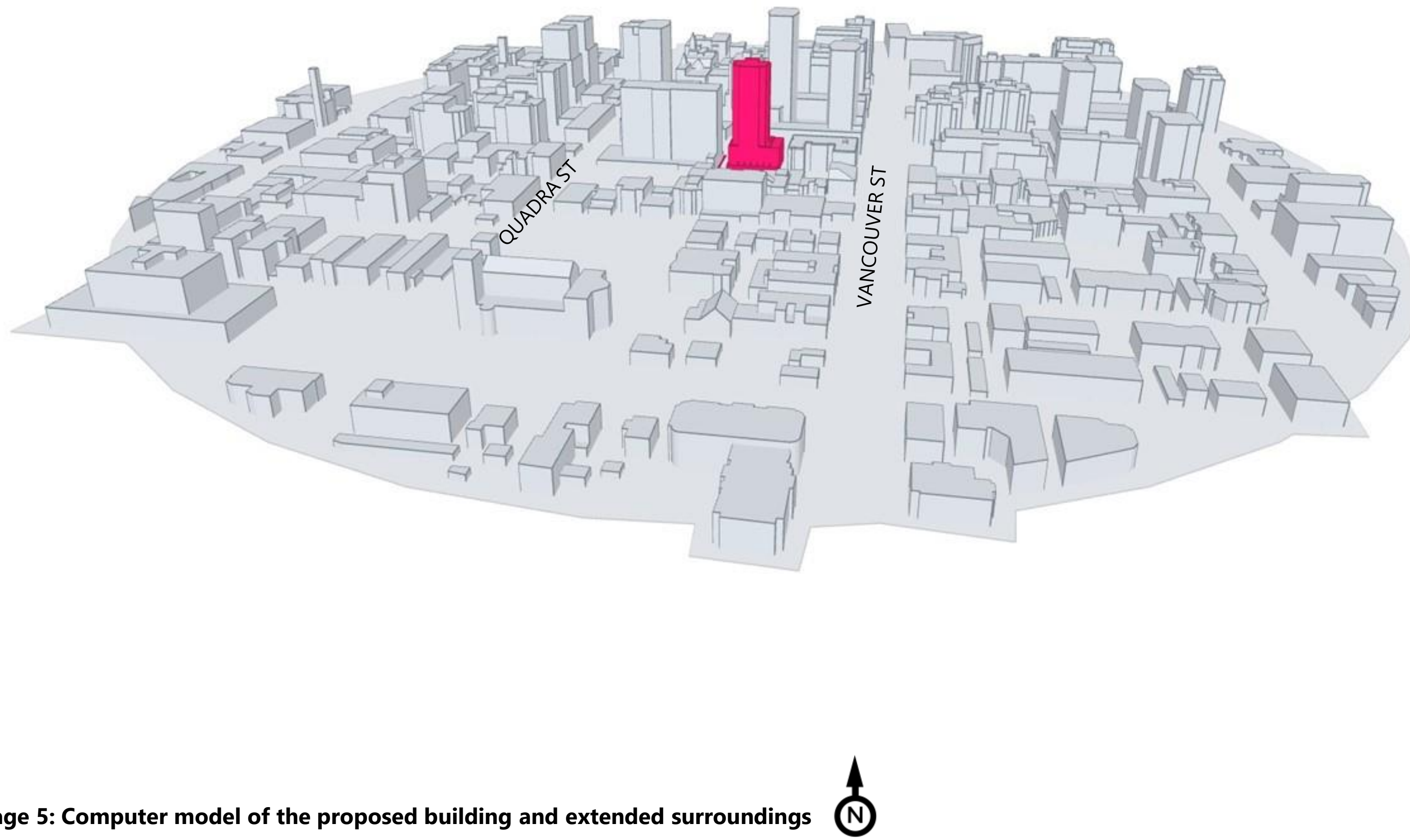

Image 5: Computer model of the proposed building and extended surroundings

3. METEOROLOGICAL DATA

Long-term wind data recorded at Victoria Harbour Seaplane Airport between 1995 and 2020, 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.

As indicated by the wind roses, winds from the southwesterly to westerly directions are predominant throughout the year with secondary winds from the northerly and southeasterly directions during the winter season. Strong winds of a mean speed greater than 30 km/h (measured at the airport at an anemometer height of 10 m) are generally infrequent in the area (red and yellow bands in Image 6).

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 and safety.

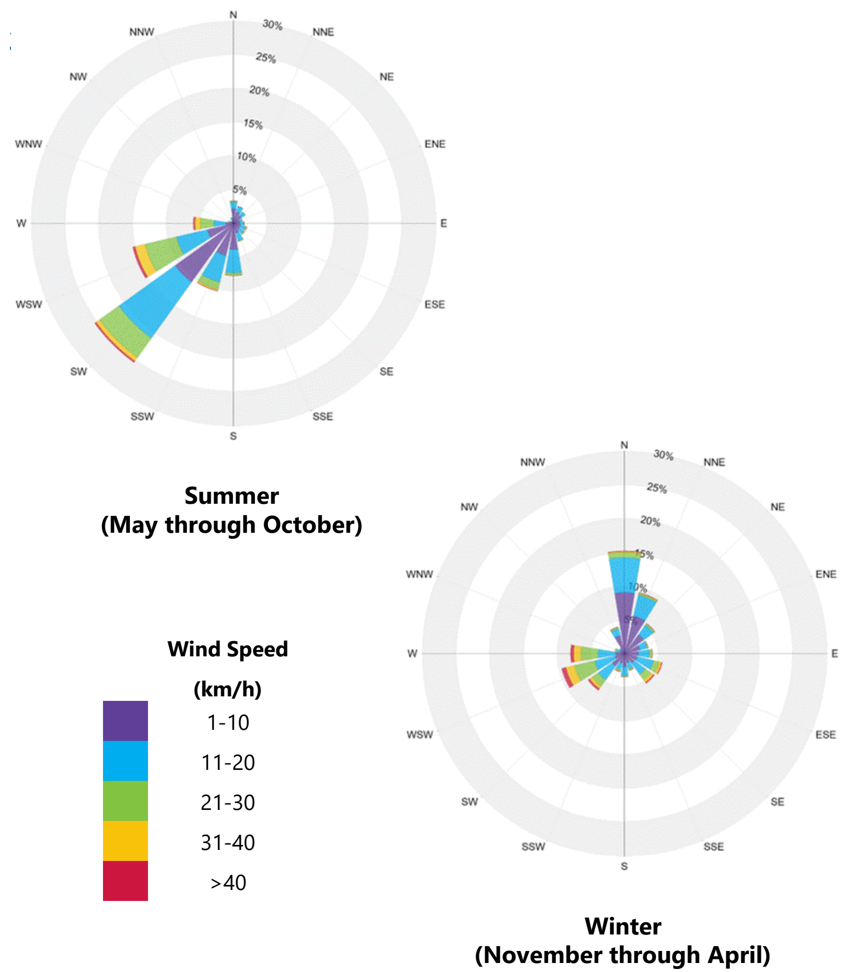

Image 6: Directional distribution of wind approaching Victoria Harbour Seaplane Airport (1995 to 2020)

4. WIND CRITERIA

The RWDI pedestrian wind criteria are used in the current study; the criteria presented in the table below, addresses pedestrian safety and comfort. These criteria have been developed by RWDI through research and consulting practice since 1974. They have also been widely accepted by municipal authorities, building designers and the city planning community.

4.1 Pedestrian Comfort

Pedestrian comfort is associated with common wind speeds conducive to different levels of human activity. Wind conditions are considered suitable for sitting, standing, strolling or walking if the associated mean wind speeds (see table) are expected for at least four out of five days (80% of the time). The assessment considers winds occurring between 6 AM and midnight. Limited usage of outdoor spaces is anticipated in the excluded period. Speeds that exceed the criterion for Walking are categorized Uncomfortable. These criteria for wind forces represent average wind tolerance. They are sometimes subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can also affect people's perception of the wind climate.

Comfort Category	GEM Speed (km/h)	Description (Based on seasonal compliance of 80%)
Sitting	≤ 10	Calm or light breezes desired for outdoor seating areas where one can read a paper without having it blown away
Standing	≤ 14	Gentle breezes suitable for main building entrances, bus stops, and other places where pedestrians may linger
Strolling	≤ 17	Moderate winds appropriate for window shopping and strolling along a downtown street, plaza or park
Walking	≤ 20	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
Uncomfortable	> 20	Strong winds considered a nuisance for all pedestrian activities. Wind mitigation is typically recommended

4.2 Pedestrian Safety

Pedestrian safety is associated with excessive Gust Speeds that can adversely affect a person's balance and footing. These are usually infrequent events but deserve special attention due to the potential impact on pedestrian safety.

Safety Criterion	Gust Speed (km/h)	Description (Based on annual exceedance of 9 hrs or 0.1% of time)
Exceeded	> 90	Excessive gusts that can adversely affect one's balance and footing. Wind mitigation is typically required.

5. RESULTS AND DISCUSSION

5.1 Presentation of Results

The results of the assessment are presented and discussed in detail in Section 5.3. The graphical presentation is in the form of color contours of wind speeds calculated based on the wind comfort criteria described in Section 4.1, at 1.5m above the levels of interest (Images 8 and 9).

The assessment against the safety criterion (Section 4.2) was conducted qualitatively based on the predicted wind conditions and our extensive experience with wind tunnel assessments. **Wind conditions at all areas in the proximity of the site and at above-grade areas are expected to meet the safety criterion.**

<u>**Target Conditions**</u>

Wind speeds comfortable for walking or strolling are appropriate for sidewalks and walkways where pedestrians are likely to be active and moving intentionally. Lower wind speeds comfortable for standing are required for entrances and areas where people are expected to be engaged in passive activities. Calm wind speeds suitable for sitting are desired in areas where prolonged periods of passive activities are anticipated, such as outdoor amenity areas, seating areas, etc.

5.2 General Wind Flow Mechanisms

Wind 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 and in the gaps between buildings (Corner Acceleration and *Channelling Effect*). Podiums, canopies, and large trees/screens can help reduce the impact of these wind effects at ground level. These flow patterns are illustrated in Image 7.

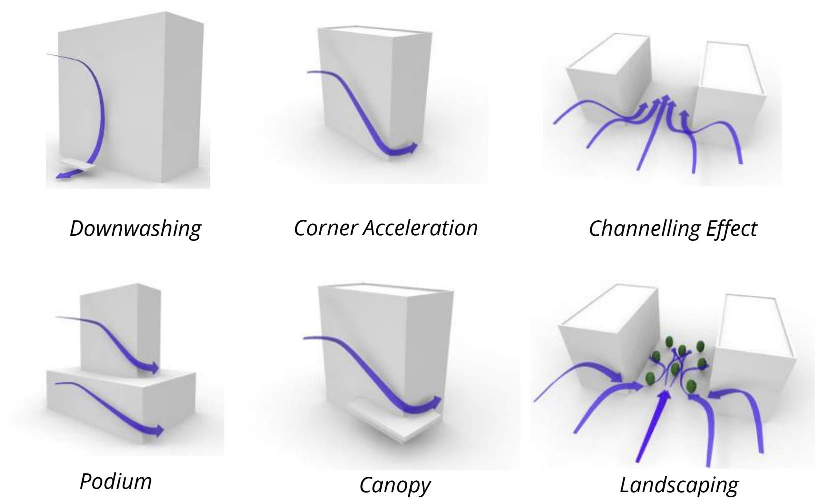

Image 7: General wind flow patterns

5. RESULTS AND DISCUSSION

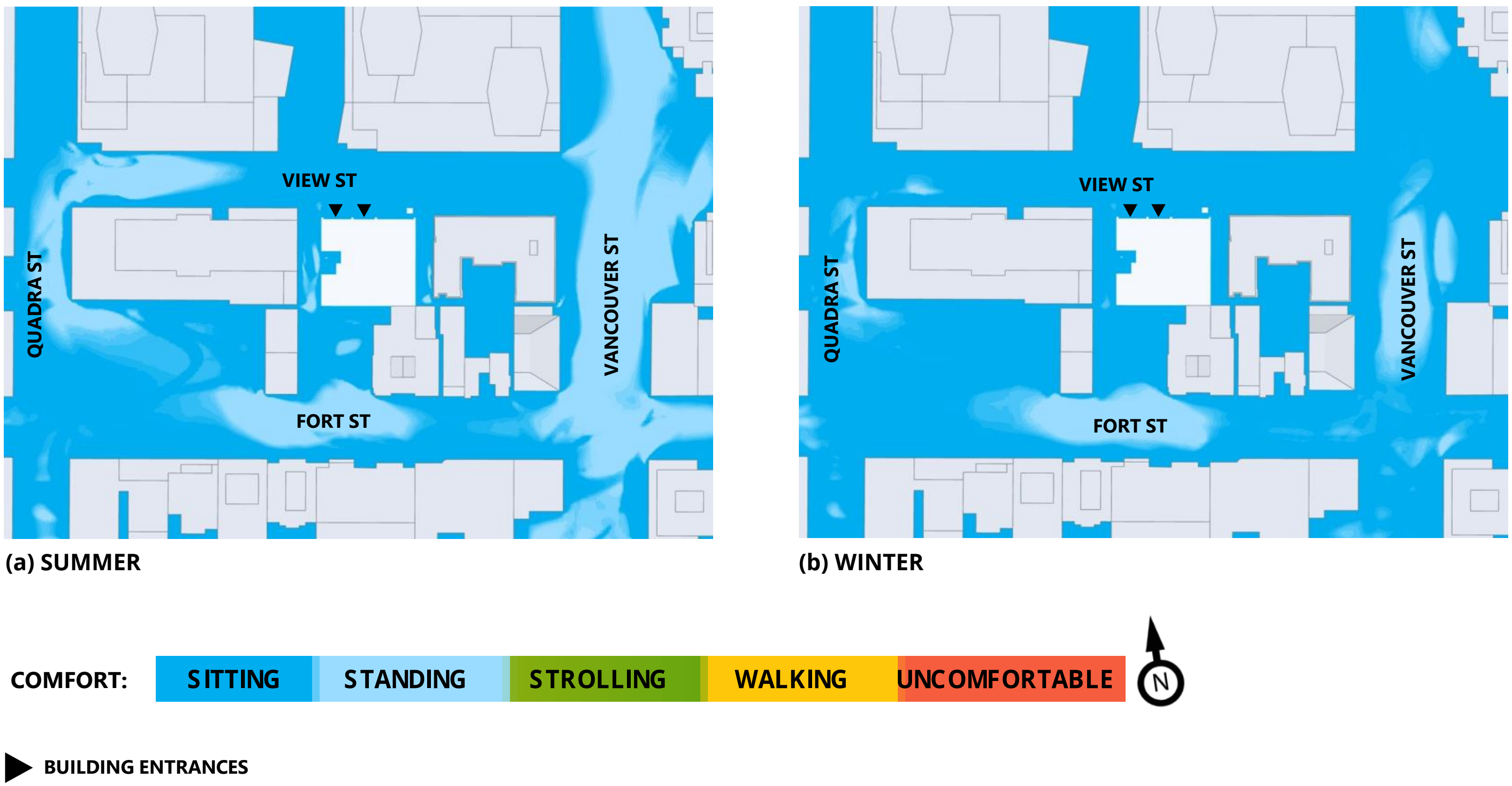

Image 8: Predicted wind conditions at grade level

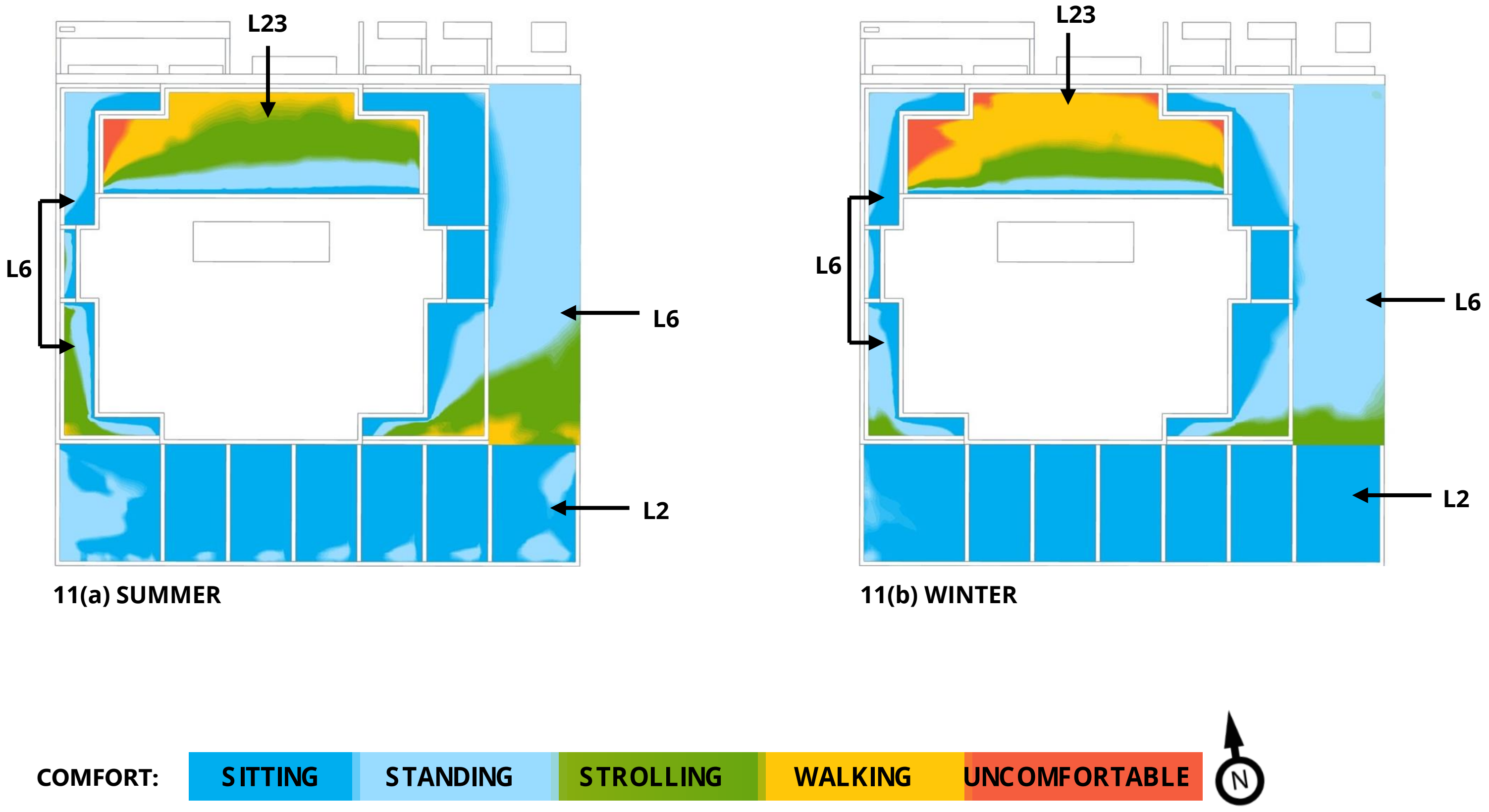

Image 9: Predicted wind conditions at above-grade levels

5.3 Predicted Wind Comfort Conditions

Strong winds are infrequent in Victoria, BC when compared to more severe wind climates found across Canada. Therefore, even though the proposed tower is taller than the existing buildings on the site and most surroundings to the south, wind speeds around the project site are expected to be generally low. Sheltering afforded by the tall surrounding buildings on the west through north to east also contribute to the calm wind speeds around the project site.

5.3.1 Grade Level

Wind speeds at grade are expected to be mostly comfortable for sitting during the summer (Image 8a). Slightly higher wind speeds, comfortable for standing, are anticipated on the west side of the building due to the downwashing and channelling of the seasonally frequent southwesterly winds between the proposed project and the adjacent building to the west. In the winter, wind speeds comfortable for sitting are anticipated at all locations immediately around the project site (Image 8b). These conditions are appropriate for the intended use of sidewalks, building entrances, and drop-off areas.

5.3.2 Above-Grade Levels

Wind speeds on the Level 2 terraces are expected to be mostly comfortable for sitting throughout the year, with speeds near the edges being slightly higher during the summer, especially on the southwest part (Image 9a). If desired, lower wind speeds can be achieved on these areas by positioning rows of planters/screens along the east, south and west perimeters. If the plants/screens are sufficiently tall (minimum 1.5m) and have a dense foliage, they will help slow winds down near targeted seating areas.

On the Level 6 terrace, wind conditions in areas near the building façade are expected to be comfortable for sitting, while further away, most areas are anticipated to have conditions suitable for standing (Images 9a and 9b). Increased wind speeds comfortable for strolling or walking are predicted on the southwest and southeast parts of the Level 6 terrace, especially during the summer (Images 9a and 9b). Wind speeds above the comfort threshold for standing are generally higher than ideal for outdoor amenities. Conditions on these areas can be improved by increasing the height of the railings along the southeast and southwest edges of the terrace to at least 2m and by adding overhead features wrapping around the southeast and southwest tower corners. The taller railings will address the direct exposure of the targeted areas to southwesterly and southeasterly winds, while overhead features such as trellises/canopies will help deflect the downwashing winds away from the terrace.

Wind conditions on the Level 23 terrace are anticipated to be comfortable for standing near the building façade and for strolling or walking on the northern areas (Images 9a and 9b). Uncomfortable conditions are expected on the far west portion of the terrace. These higher wind speeds on the rooftop terrace, caused by the exposure to stronger winds at higher elevations, are not suitable for passive activities.

5. RESULTS AND DISCUSSION

5.3 Predicted Wind Comfort Conditions

Improved conditions can be achieved by increasing the height of the guardrails to at least 2m and using landscaping elements in the form of planters/screens/trellises throughout the terrace to break the wind flows and diffuse their energy. Such elements can be strategically placed around designated seating and passive-use areas to create low-wind zones for patrons. These recommendations are summarized in Image 9, and examples of the recommended wind control features are shown in Image 10. RWDI can help guide the placement of local wind control features such as wind screens and landscaping as the programming of the terraces evolves.

Image 9: Recommended wind control features for above-grade levels

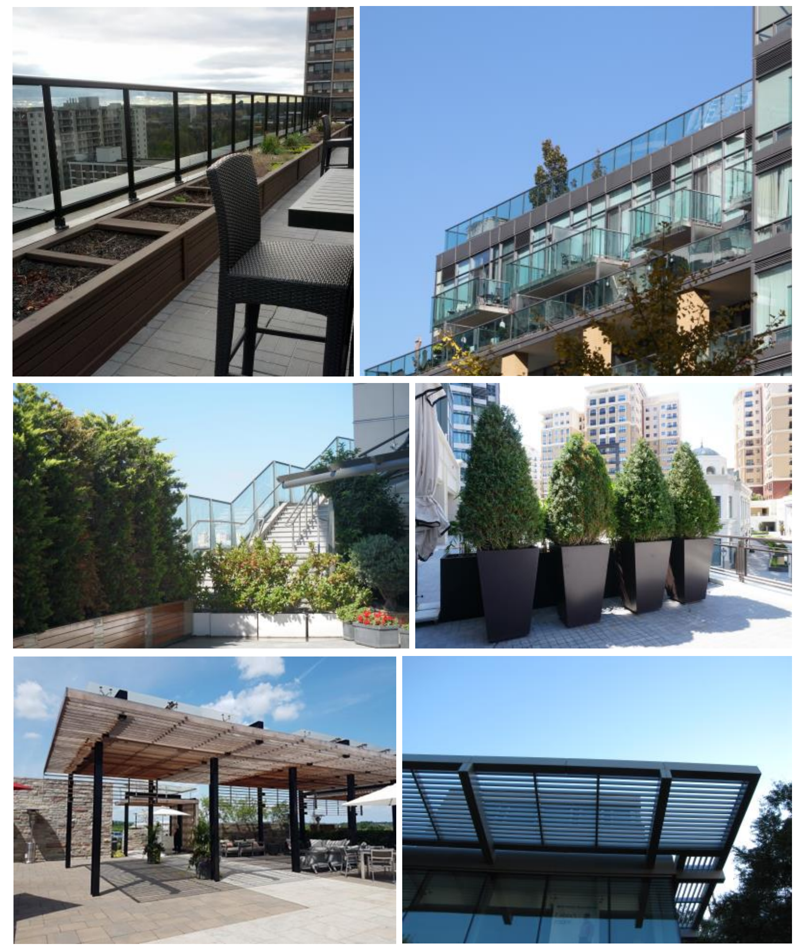

Image 10: Examples of wind control features

6. SUMMARY

RWDI was retained to provide an assessment of the wind environment around the proposed project at 937 View Street in Victoria, BC. 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 RWDI wind criteria for pedestrian comfort and safety. Our findings are summarized as follows:

- The wind safety criterion is expected to be met at all areas assessed at and above grade.
- Wind speeds at grade are expected to be appropriate for pedestrian use yearlong – this includes nearby sidewalks, building entrances, and the drop-off area on view street.
- The wind environment on the Level 2 terraces is anticipated to be calm and suitable for most outdoor uses.
- Wind conditions on most of the Level 6 terrace are expected to be adequate for outdoor activities, however, higher-than-ideal wind speeds are predicted on the southwest and southeast parts of the terrace, especially during the summer.
- Calm wind conditions are anticipated near the façade of the tower on the Level 23 terrace; however, elevated wind speeds are expected away from the façade, especially on the west part of the terrace, where speeds are predicted to be uncomfortable.
- Conceptual wind control measures are presented to improve wind conditions on the terraces.

RWDI can help guide the placement of local wind control features such as wind screens and landscaping elements as the programming of the outdoor spaces evolves.

7. DESIGN ASSUMPTIONS

The findings/recommendations in this report are based on the building geometry and architectural drawings communicated to RWDI on March 17, 2023, 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)
23-03-17_937 View Street_Wind Study Model	.DWG	03/17/2023
937 View Street -DRAFT DP Revisions 230317	.PDF	03/17/2023

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 RWDI AIR Inc. (“RWDI”) for dHKarchitects (“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.