GRADIENTWIND
ENGINEERS & SCIENTISTS

June 6, 2023

Hennepin's View Inc.
6361 Fallsview Boulevard
Niagara Falls, ON L2G 3V9

Attn: Sean Finlay, CFA
sfinlay@broadviewadvisors.ca

Dear Mr. Finlay:

Re: Mist Study
Oakes Hotel, Niagara Falls
Gradient Wind File 22-366-MIST

1. INTRODUCTION

This report describes a mist study to satisfy Zoning By-law Amendment (ZBLA) application requirements for the proposed hotel redevelopment, referred to as "Oakes Hotel", located at 6546 Fallsview Boulevard and 6503-6519 Stanley Avenue in Niagara Falls, Ontario (hereinafter referred to as the "subject site" or "proposed development"). Our mandate within this study is to investigate the wind impact of the proposed development on the misting conditions from the plume rising from the Horseshoe Falls in the City of Niagara Falls.

The focus of this study is the proposed hotel redevelopment at 6546 Fallsview Boulevard, comprised of two 58-storey towers with a shared 7-storey podium. The study is based on industry standard computer simulations using the computational fluid dynamics (CFD) technique and data analysis procedures, architectural drawings provided by architects-Alliance in January 2022, surrounding street layouts and existing and approved future building massing information obtained from the City of Niagara Falls, and recent site imagery.

2. METHODOLOGY

2.1 Computer-Based Context Modelling

The approach followed to quantify misting conditions from the Horseshoe Falls is based on CFD simulations of wind speeds across the subject site and the Horseshoe Falls within a virtual environment and meteorological analysis of the Niagara Falls area wind climate.

The general concept and approach to CFD modelling is to represent building and topographic details in the immediate vicinity of the subject site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

The analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the subject site and the Horseshoe Falls. The process was performed for the proposed and existing context massing scenarios, respectfully illustrated in Figures 1A and 1B, while Figures 2A-3B illustrate the computational models used for the analysis. Per industry standard practice, trees, vegetation, and other existing and proposed landscape elements were omitted from the model due to the difficulty of providing accurate seasonal representation of vegetation. Additionally, water and mist were not included in the simulations. Further details of the wind flow simulation technique are presented in Appendix A.

2.2 Historical Wind Speed and Direction Data

A statistical model for winds in Niagara Falls was developed from approximately 40 years of hourly meteorological wind data recorded at Niagara Falls International Airport and obtained from Environment and Climate Change Canada. Wind speed and direction data were separated into two distinct seasons. Specifically, the summer season is defined as May though October, and the winter season is defined as November through April, inclusive.

The statistical model of the Niagara Falls area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated in Figure 4. The plots illustrate seasonal distribution of measured wind speeds and directions in kilometers per hour (km/h). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Niagara Falls, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 36 km/h. The directional preference and relative magnitude of wind speed changes somewhat from season to season.

The proposed development is situated approximately 550 m to the west-northwest of the Horseshoe Falls. Considering the location of the proposed development relative to the Horseshoe Falls, and the prevailing wind directions from the southwest followed by the northwest, winds from the west-northwest direction (297°) were selected for the CFD simulation, which is the direction between the proposed development and the Horseshoe Falls. The maximum increase in misting conditions on the Canadian side of the Horseshoe Falls following the introduction of the proposed development is expected for this direction, due to the redirection of mist from the Horseshoe Falls back towards the Canadian side of the Falls from the wake generated by the proposed development.

3. RESULTS AND DISCUSSION

Figures 5A-6C present contours of the gust wind speed and direction on vertical slice planes for the proposed and existing massing scenarios. Specifically, the results for three vertical slice planes are presented, representing planes intersecting the Horseshoe Falls and the centres of the south tower, north tower, and between the two towers of the proposed development. The gust wind speed is normalized by the gradient wind speed, which represents the theoretical depth of the boundary layer of the earth’s atmosphere, above which the mean wind speed remains constant.

Following the introduction of the proposed development, the building wake generated by the proposed development is increased in comparison to the wake generated by the existing hotel. The increase is illustrated in the noted figures (that is, there is an increase in low and moderate wind speeds, represented by the blue to green coloured contours in Figures 5A-6C). The extent of the wake generated by the proposed development is greater than that of the existing hotel massing, extending beyond Table Rock Centre and over the Horseshoe Falls.

Furthermore, in the wake of the existing hotel massing is a reversed flow, which can be identified from the velocity vectors that are orientated back towards the existing hotel massing, in the opposing direction of the west-northwesterly wind. The extent of this recirculating reversed flow is predicted to increase following the introduction of the proposed development, extending over the Horseshoe Falls and into the mist plume. This recirculating flow is predicted to extract mist and direct it towards the Canadian side of the Horseshoe Falls, resulting in a predicted increase in misting conditions over the shelf adjacent to the Horseshoe Falls, inclusive of the Table Rock Centre, the Niagara River Parkway, and the adjacent pedestrian walkways and areas on the Canadian side of the Falls.

Due to the complex wind flows around the proposed development, no increase in the entrainment of the mist plume over the escarpment to the west of the Table Rock Centre is predicted to occur. That is, no significant increase in misting conditions is predicted over the subject site, the neighbouring hotels and Fallsview Casino Resort atop the escarpment, and the Falls Incline Railway following the introduction of the proposed development in comparison to conditions with the existing hotel massing.

The reversed flow in the wake of the high-rise hotel towers in the Fallsview area atop the escarpment along the Niagara River entrains mist from the Horseshoe Falls and pulls the mist back towards the Canadian side of the Falls; in the absence of these high-rise towers, prevailing winds would instead push the mist plume towards the American side of the Falls. Specifically, the increased wake and reversed flow behind the proposed development that are predicted to increase misting conditions is expected following the introduction of a taller building in the mostly suburban massing of Niagara Falls. However, prevailing winds in the Niagara Falls area are predominantly from the southwest, while the proposed development is situated to the north-northwest of the Horseshoe Falls. For southwesterly winds, it is expected that the introduction of the proposed development will have a lesser impact on misting conditions in comparison to other tall developments to the south along the escarpment, which are expected to create large wakes with reversed flows that counter the prevailing wind to redirect the mist plume towards the Canadian side of the Falls.

4. SUMMARY

Based on computer simulations using the CFD technique, meteorological data analysis of the Niagara Falls wind climate, and experience with numerous similar developments in Niagara Falls and elsewhere, the study concludes the following:

1. The proposed development is situated approximately 550 m to the west-northwest of the Horseshoe Falls. Under winds from this direction, reversed wind flows within the wake of the proposed development are predicted to extend into the mist plume rising from the Horseshoe Falls.

2. The increased extent of the wake and reversed flow generated by the proposed development is predicted to result in an incremental redirection of the existing mist plume towards the Canadian side of the Falls, increasing misting conditions over Table Rock Centre, the Niagara Parkway, and the nearby pedestrian walkways, in comparison to existing conditions.

3. The increase in misting conditions is not predicted to extend over the escarpment towards the proposed development and the nearby high-rise hotels, inclusive of the Fallsview Casino Resort and the Falls Incline Railway.

4. The increased misting conditions in the wake of the proposed development are predicted to occur for relatively infrequent north-northwesterly winds. For the predominantly southwesterly winds in the Niagara Falls area, the introduction of the proposed development is expected to have a lesser impact on misting conditions on the Canadian side of the Falls in comparison to other tall developments to the south along the escarpment.

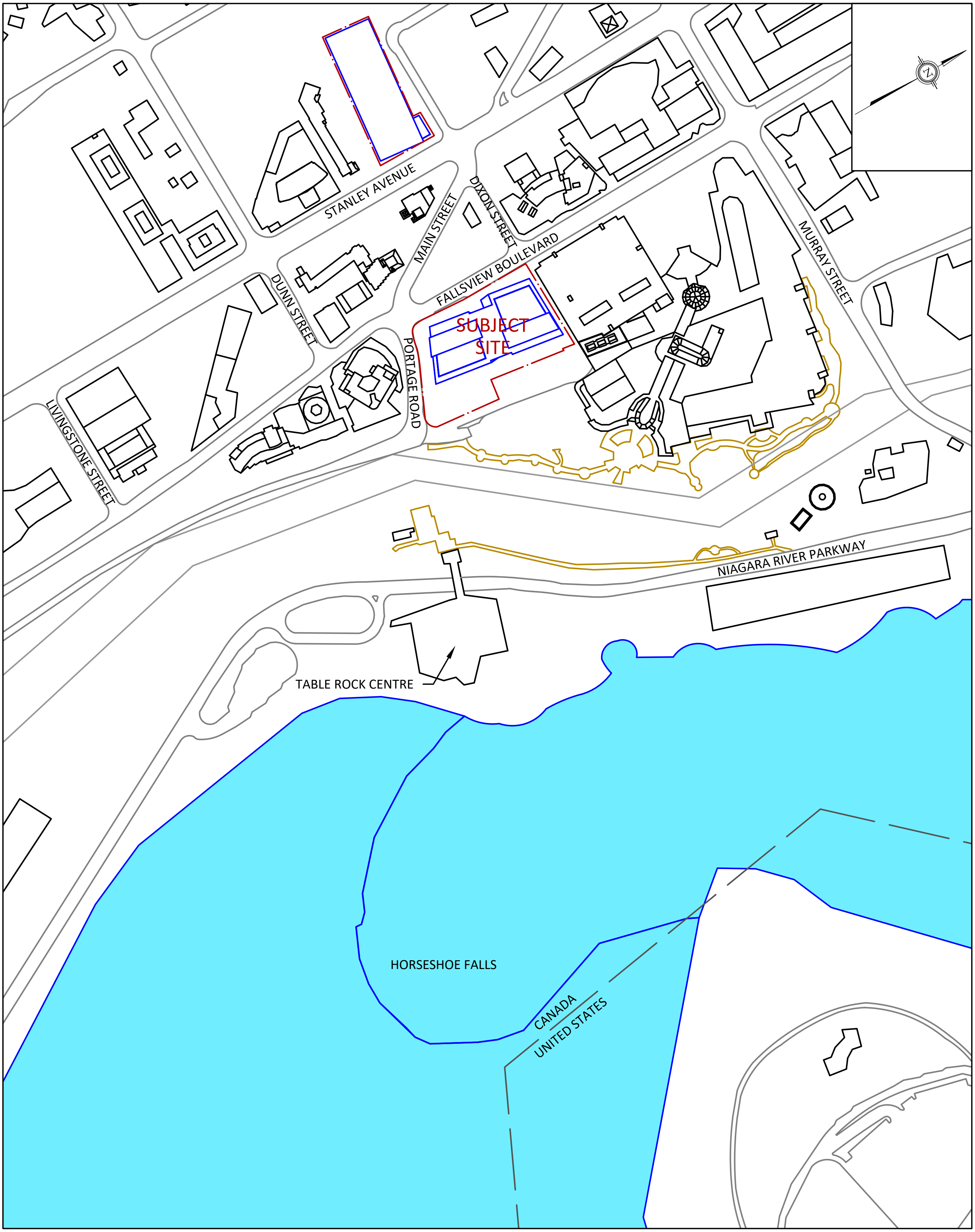
Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. D. FERRARO
100158495
June 6, 2023
PROVINCE OF ONTARIO

David Huitema, M.Eng.
Junior Wind Scientist

Justin Ferraro, P.Eng.
Principal



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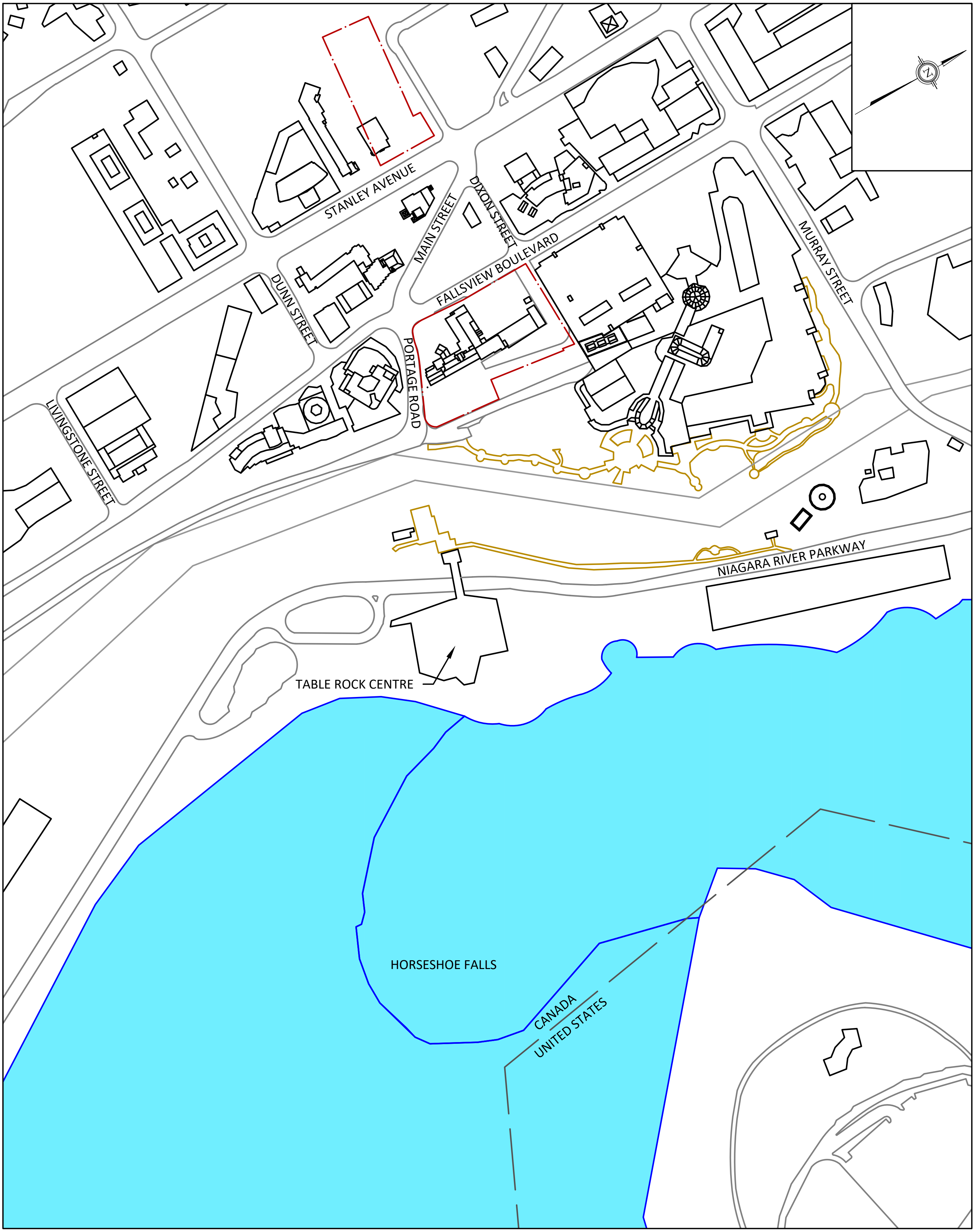
PROJECT OAKES HOTEL, NIAGARA FALLS MIST STUDY		DESCRIPTION FIGURE 1A: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
SCALE 1:5000	DRAWING NO. 22-366-MIST-1A	
DATE MARCH 16, 2023	DRAWN BY T.K.	



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PROJECT	OAKES HOTEL, NIAGARA FALLS MIST STUDY		
SCALE	1:5000	DRAWING NO.	22-366-MIST-1B
DATE	MARCH 16, 2023	DRAWN BY	T.K.

DESCRIPTION

FIGURE 1B:
EXISTING SITE PLAN AND SURROUNDING CONTEXT

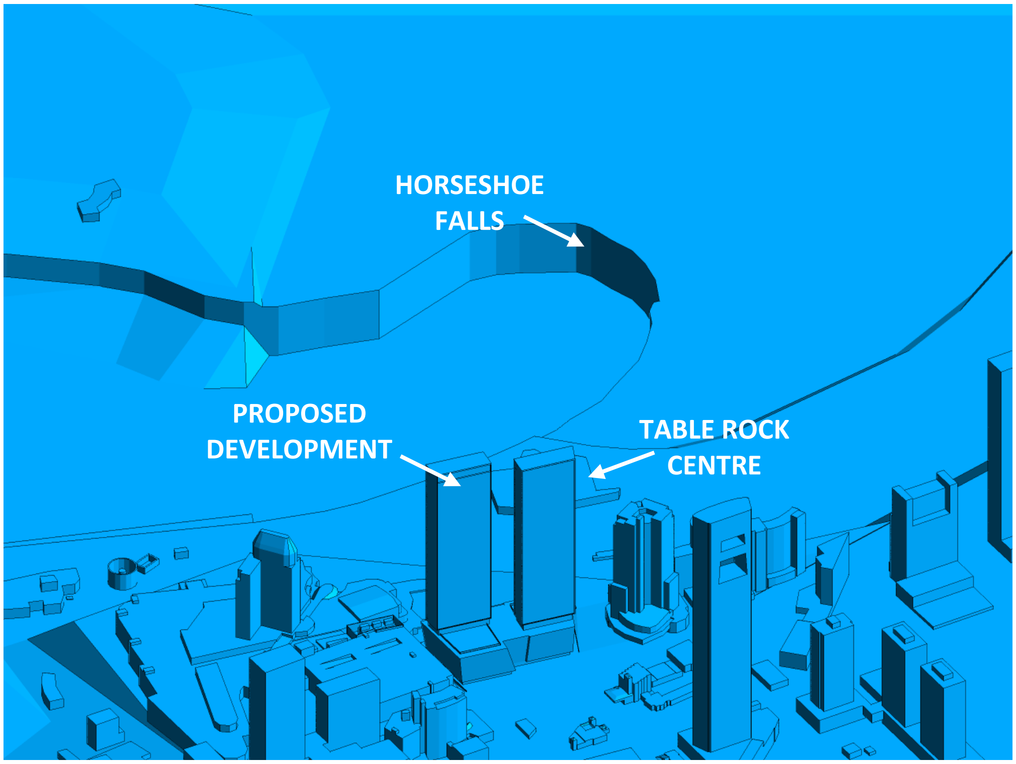


FIGURE 2A: COMPUTATIONAL MODEL, PROPOSED MASSING, NORTH PERSPECTIVE

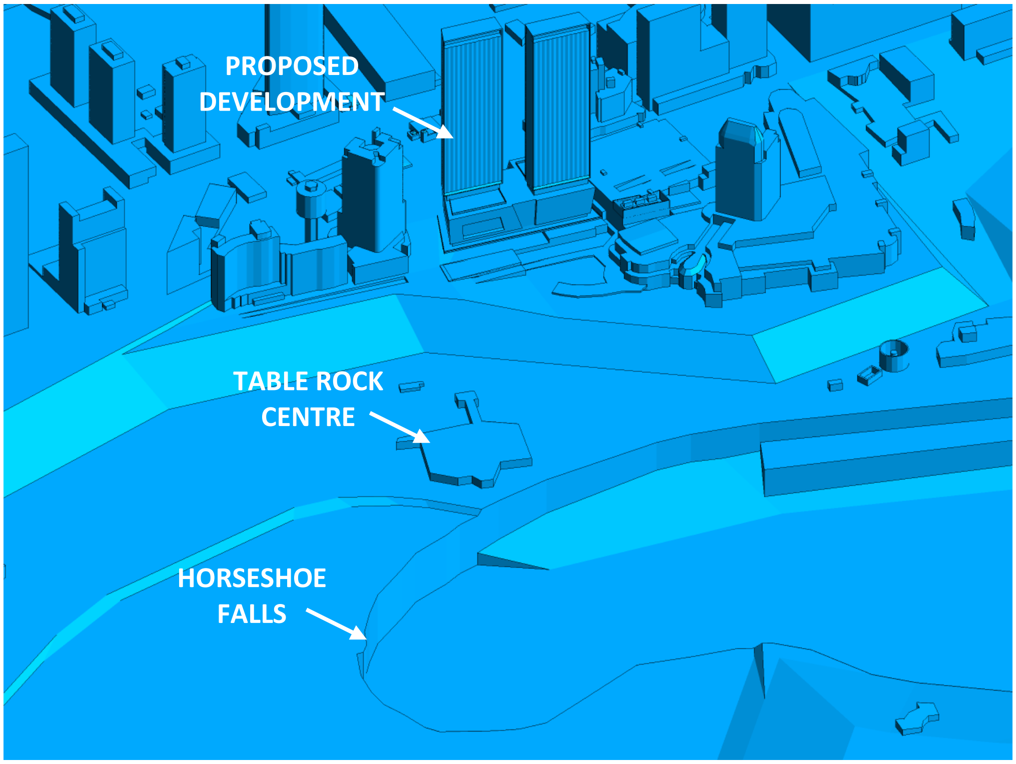


FIGURE 2B: COMPUTATIONAL MODEL, PROPOSED MASSING, SOUTH PERSPECTIVE

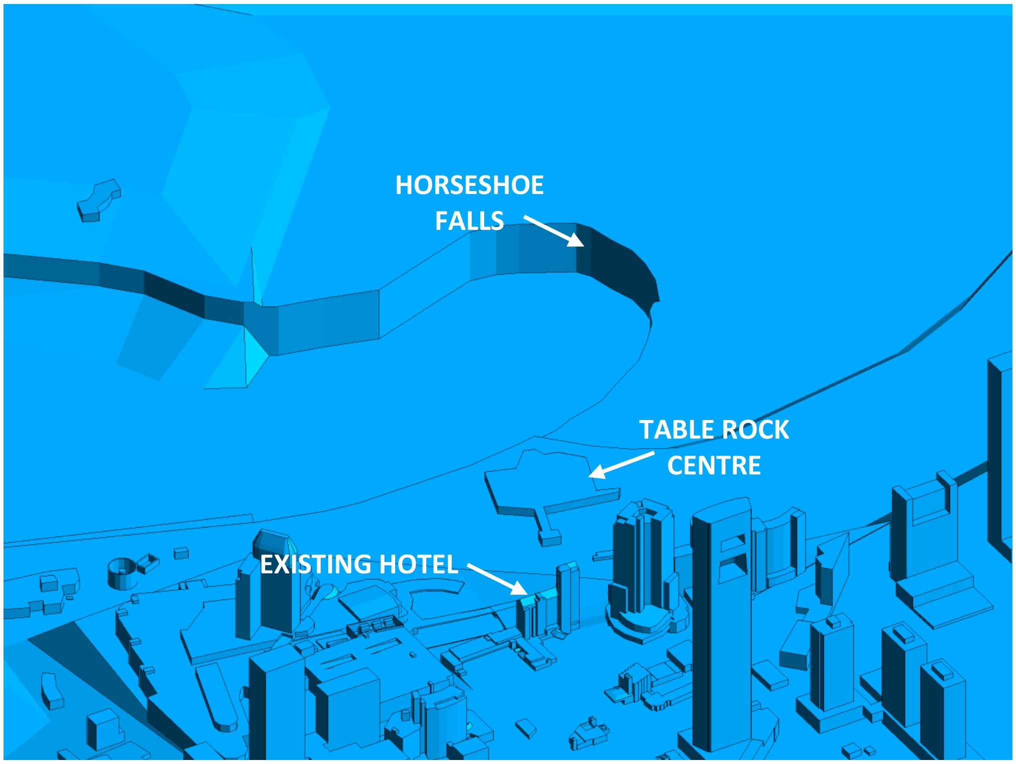


FIGURE 3A: COMPUTATIONAL MODEL, EXISTING MASSING, NORTH PERSPECTIVE

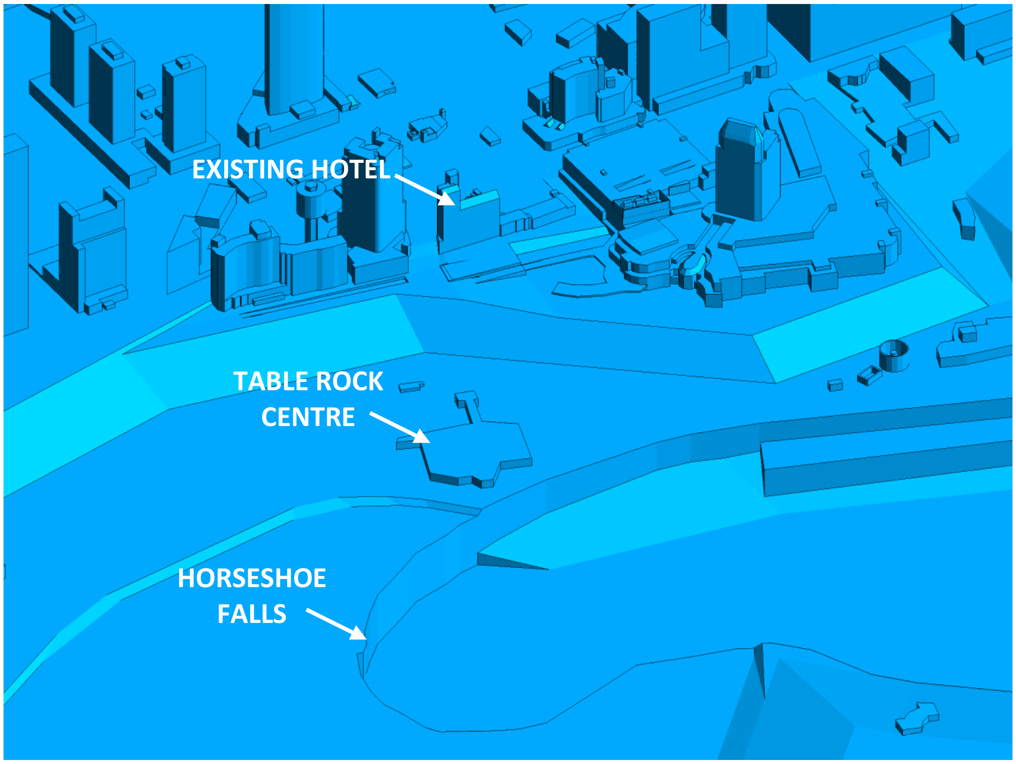


FIGURE 3B: COMPUTATIONAL MODEL, EXISTING MASSING, SOUTH PERSPECTIVE

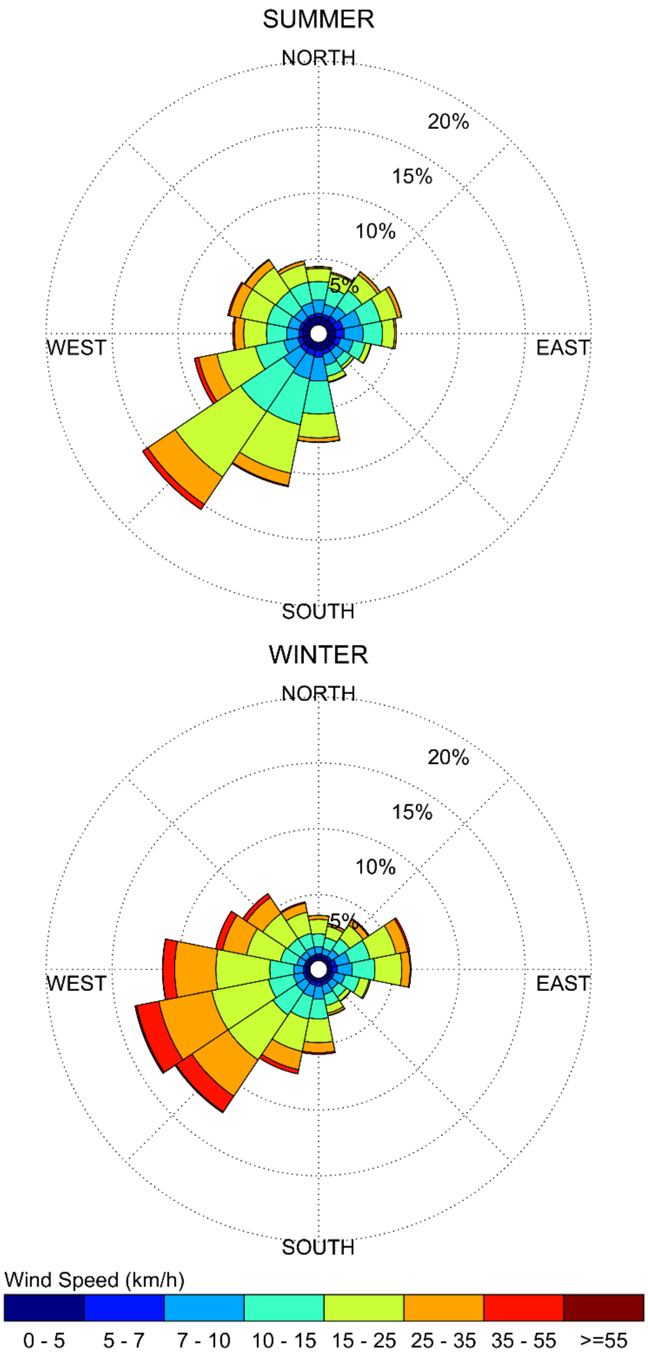


FIGURE 4: SEASONAL DISTRIBUTION OF WIND
NIAGARA FALLS INTERNATIONAL AIRPORT, NIAGARA COUNTY, NEW YORK

Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in km/h, measured at 10 m above the ground.

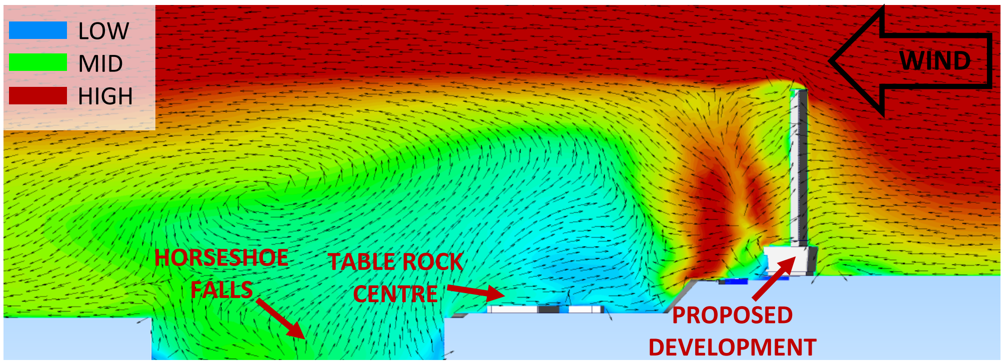


FIGURE 5A: WIND FLOW PATTERN THROUGH SOUTH TOWER PLANE – PROPOSED MASSING

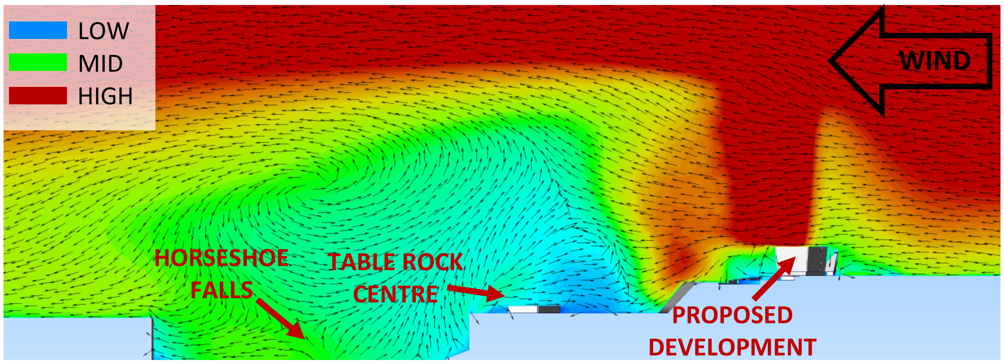


FIGURE 5B: WIND FLOW PATTERN THROUGH CENTRE TOWER PLANE – PROPOSED MASSING

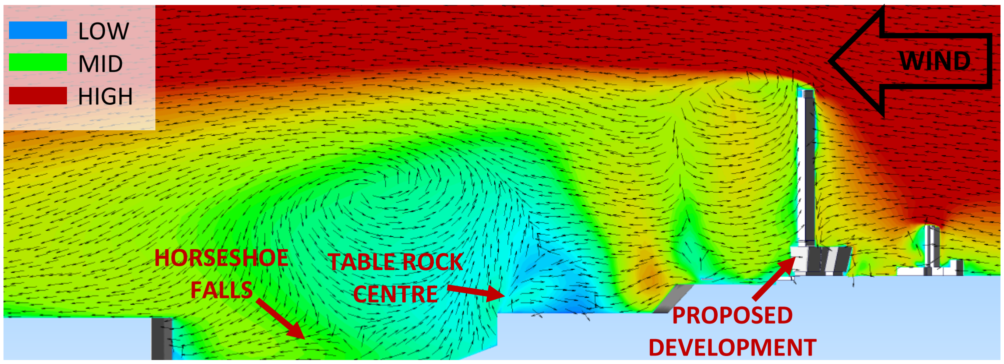


FIGURE 5C: WIND FLOW PATTERN THROUGH NORTH TOWER PLANE – PROPOSED MASSING

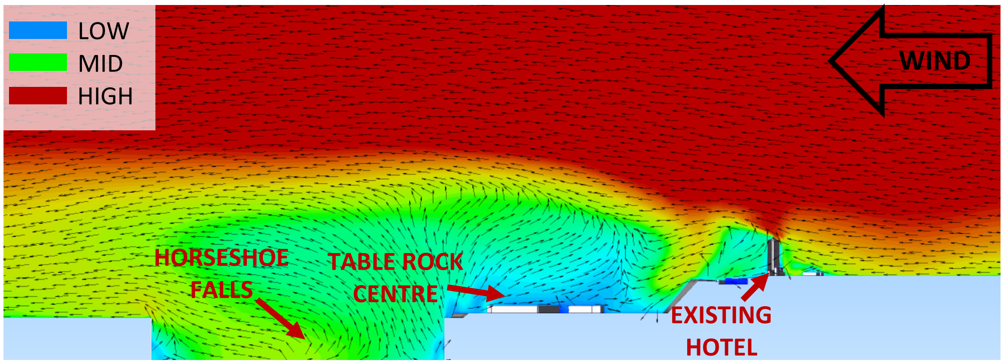


FIGURE 6A: WIND FLOW PATTERN THROUGH SOUTH TOWER PLANE – EXISTING MASSING

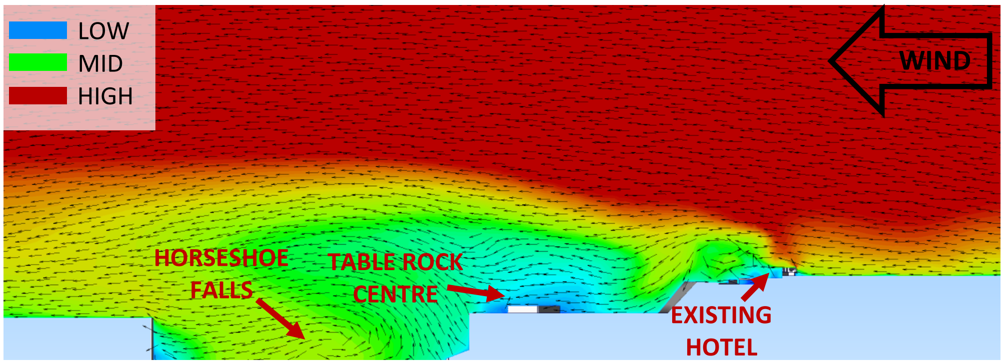


FIGURE 6B: WIND FLOW PATTERN THROUGH CENTRE TOWER PLANE – EXISTING MASSING

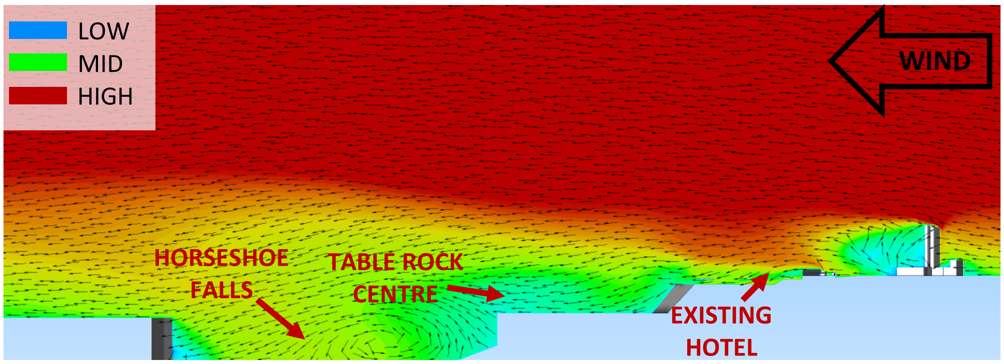
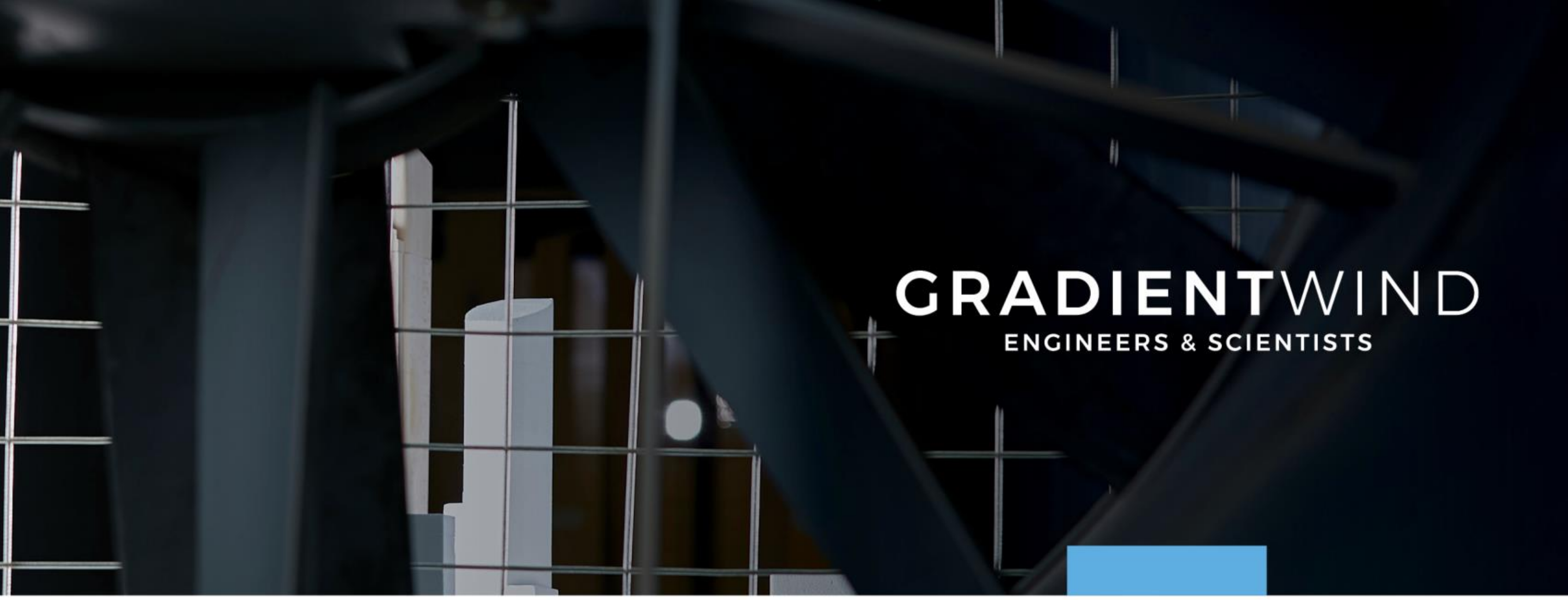
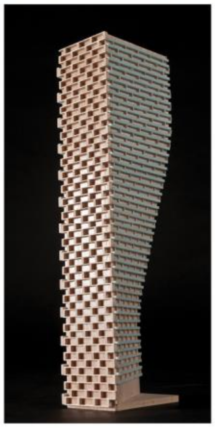
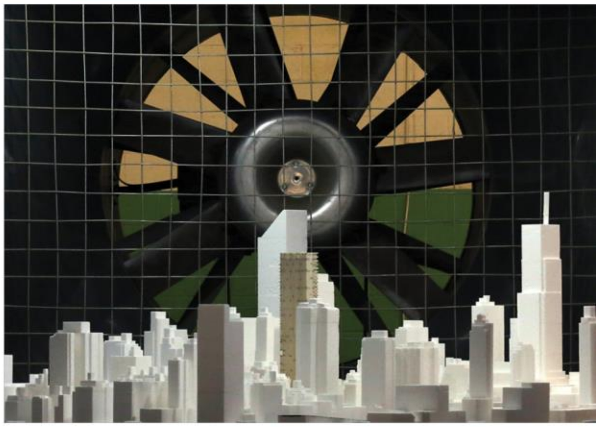


FIGURE 6C: WIND FLOW PATTERN THROUGH NORTH TOWER PLANE – EXISTING MASSING







APPENDIX A

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

SIMULATION OF THE ATMOSPHERIC BOUNDARY LAYER

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

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

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

For the model, U_g is set to 6.5 metres per second (m/s), which approximately corresponds to the 35% mean wind speed for Niagara Falls based on historical climate data and statistical analyses. When the results are normalized by this velocity, they are relatively insensitive to the selection of gradient wind speed.

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

α is determined based on the upstream exposure of the far-field surroundings (that is, the area that is not captured within the simulation model). For the west-northwest wind direction, a value of 0.24 for α was used for the suburban exposure of the subject site for winds from this direction.

Table 1 presents several reference values of α.

TABLE 1: DEFINITION OF UPSTREAM EXPOSURE (ALPHA VALUE)

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

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

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

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

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

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

REFERENCES

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

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

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