Appendix D:
Pedestrian Wind Assessment

REPORT

HUDSON YARDS WRY

NEW YORK, NY

PEDESTRIAN WIND COMFORT ASSESSMENT

PROJECT #2401834
September 18, 2024

SUBMITTED TO

Mark Townsend
Vice President,
Design Hudson Yards
mark.townsend@related.com

The Related Companies
30 Hudson Yards, Floor 73
New York, NY 10001

SUBMITTED BY

Jennifer Shoniker
Technical Coordinator / Associate
Jennifer.shoniker@rwdi.com

Neetha Vasan, M.A.Sc., LEED A.P.
Senior Specialist / Associate
Neetha.Vasen@rwdi.com

Jordan Gilmour, P.Eng.
Project Delivery Manager
Jordan.Gilmour@rwdi.com

RWDI
600 Southgate Drive
Guelph, ON, Canada, N1G 4P6
T: 519.823.1311

1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained to conduct a pedestrian wind assessment for the proposed Western Rail Yards project in New York, NY. The objective of this assessment is to provide an evaluation of the potential wind conditions in outdoor pedestrian/patron areas on and around the proposed development.

The Development Site consists of Manhattan Block 676, Lots 1 and 5, and occupies the entire area bounded by West 30th and West 33rd Streets and Eleventh and Twelfth Avenues (see Image 1). The Development Site is a superblock zoning lot with an area of approximately 571,592 square feet.

Three scenarios were assessed in this study. These include 1) the existing condition, 2) the Proposed Project, and 3) the "No Action" scenario. The Proposed Project scenario includes three buildings: a proposed hotel with gaming, a residential building and an office building, while the No Action scenario consists of five towers of various heights atop three, low-rise podium structures (Image 2). Building A in the Proposed Project scenario has a stepped form, and the proposed Building C tower will be atop a large podium , which are favorable massing features for reducing wind impacts. In addition to sidewalks and properties near the project site, key areas of interest for this assessment include the podium roof levels and the Hudson Green public open space between the buildings, which include walkways, gardens and parks (Image 3).

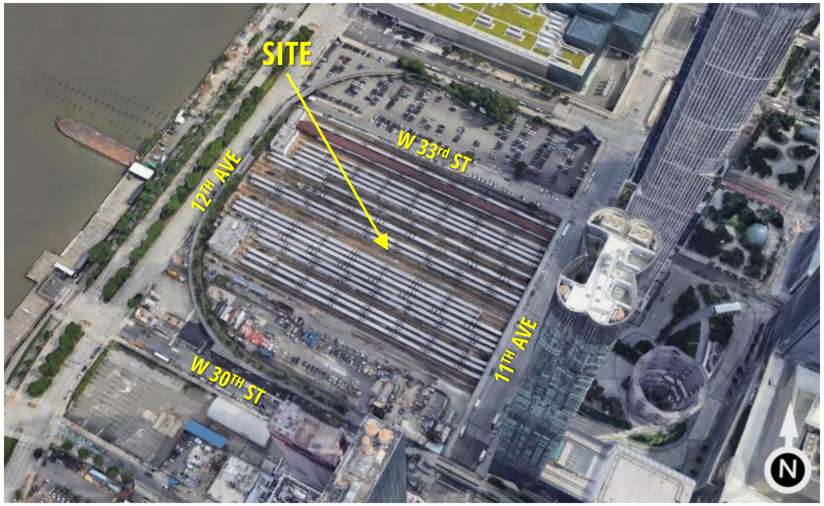
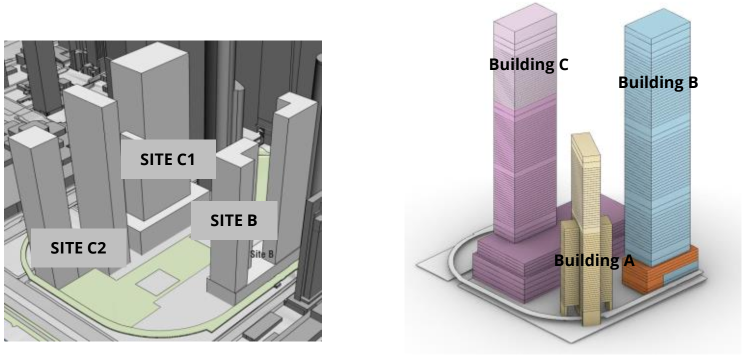


Image 1: Aerial view of the existing site and surroundings
Source: Google Maps



No Action Scenario **Proposed Project Scenario**

Image 2: Conceptual massing/renderings of the No Action scenario and the Proposed Project scenario

1. INTRODUCTION

Image 3: Key outdoor areas of interest at grade level – identified on an illustrative site plan of the Proposed Project scenario

2. METHODOLOGY

2.1 Objective

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

- A review of the regional long-term meteorological data from Newark Liberty International Airport;
- 3D e-models of the proposed project received on August 8, 2024;
- 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, 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 modeling, presenting early design advice, comparing different design and site scenarios, resolving complex flow physics, and helping diagnose problematic wind conditions.

While the computational modeling method used in the current assessment does not explicitly simulate the transient behavior 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 behavior of wind and refine any conceptual mitigation measures, a more detailed assessment would be required using either boundary-layer wind tunnel or transient computational modeling.

2. METHODOLOGY

2.3 Simulation Model

CFD simulations were completed for three (3) scenarios:

- Existing site and surroundings;
- No Action scenario with the existing surroundings; and,
- Proposed Project scenario with the existing surroundings.

The computer models and proximity models of the three scenarios are shown in Images 4 and 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. The proposed trees (assumed to be deciduous) were included in the Proposed Project scenario, but the other scenarios did not include landscaping. In order to ensure a conservative analysis, the study analyzed the maximum bulk envelopes for Sites A, B, and C in the Proposed Project scenario. In reality, the buildings to be developed on these sites would be shorter and/or narrower than the maximum envelopes, because there would not be enough allowable floor area available to occupy all the space in the maximum bulk envelopes. Therefore, the analysis provides a worst-case 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 5 ft above concerned levels, to the mean wind speed at a reference height. The data was then combined with meteorological records obtained from Newark Liberty International Airport to determine the wind speeds and frequencies in the simulated areas.

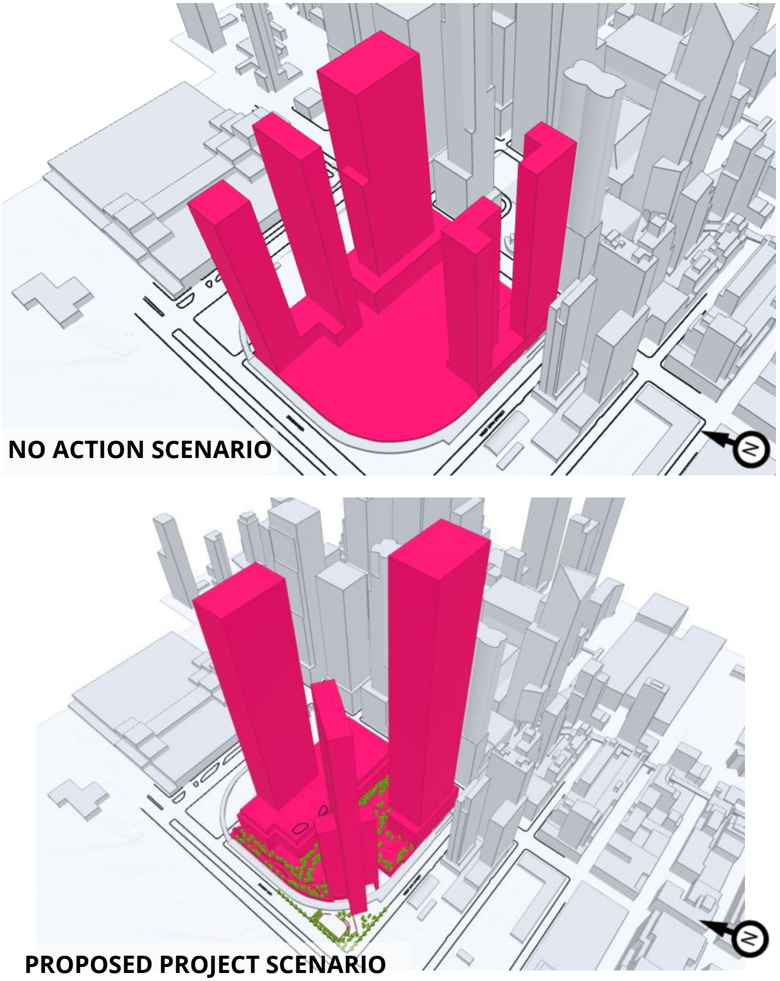


Image 4: Computer models of the proposed scenarios

2. METHODOLOGY

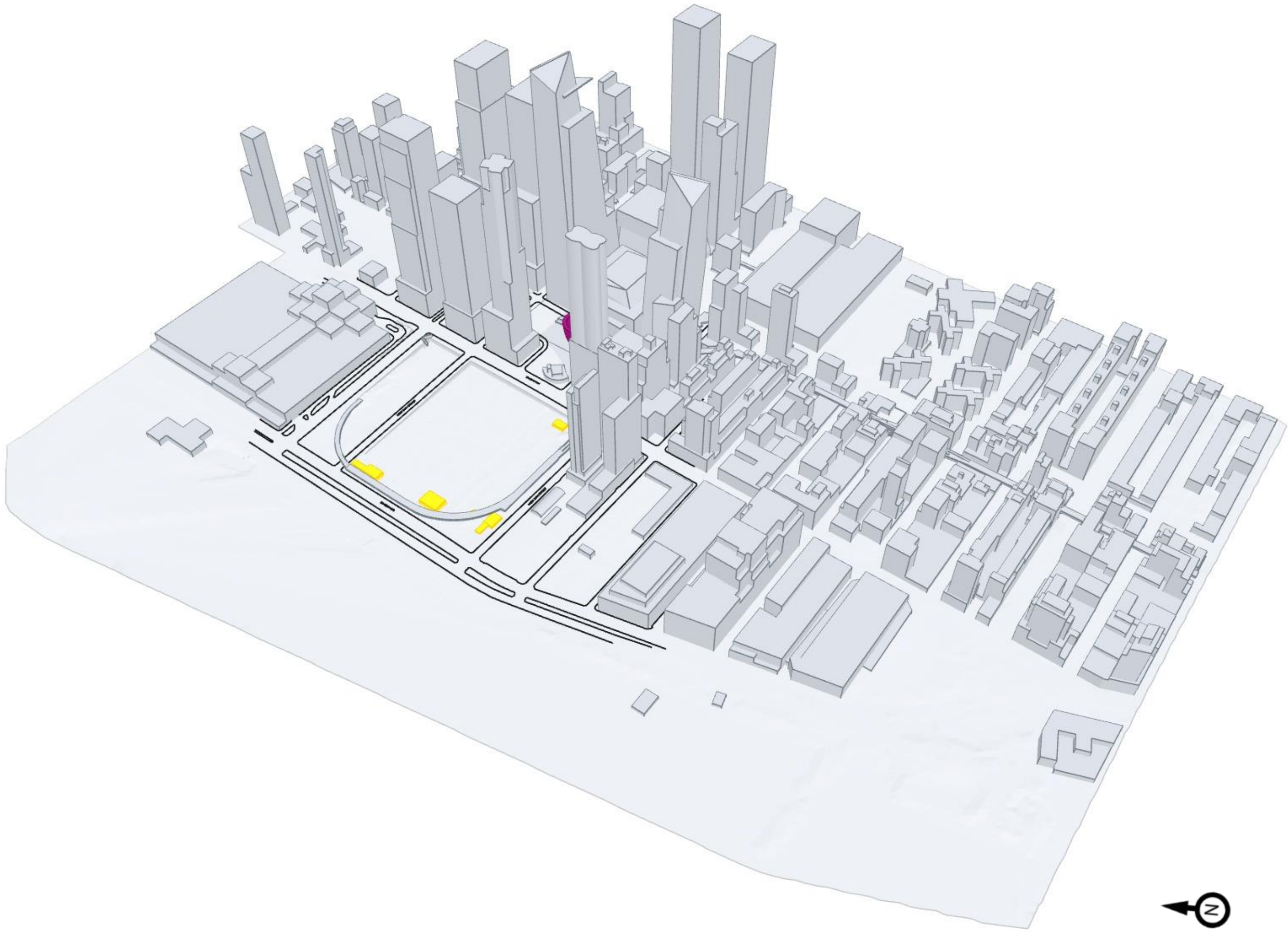


Image 5: Computer model of the existing site and extended surroundings

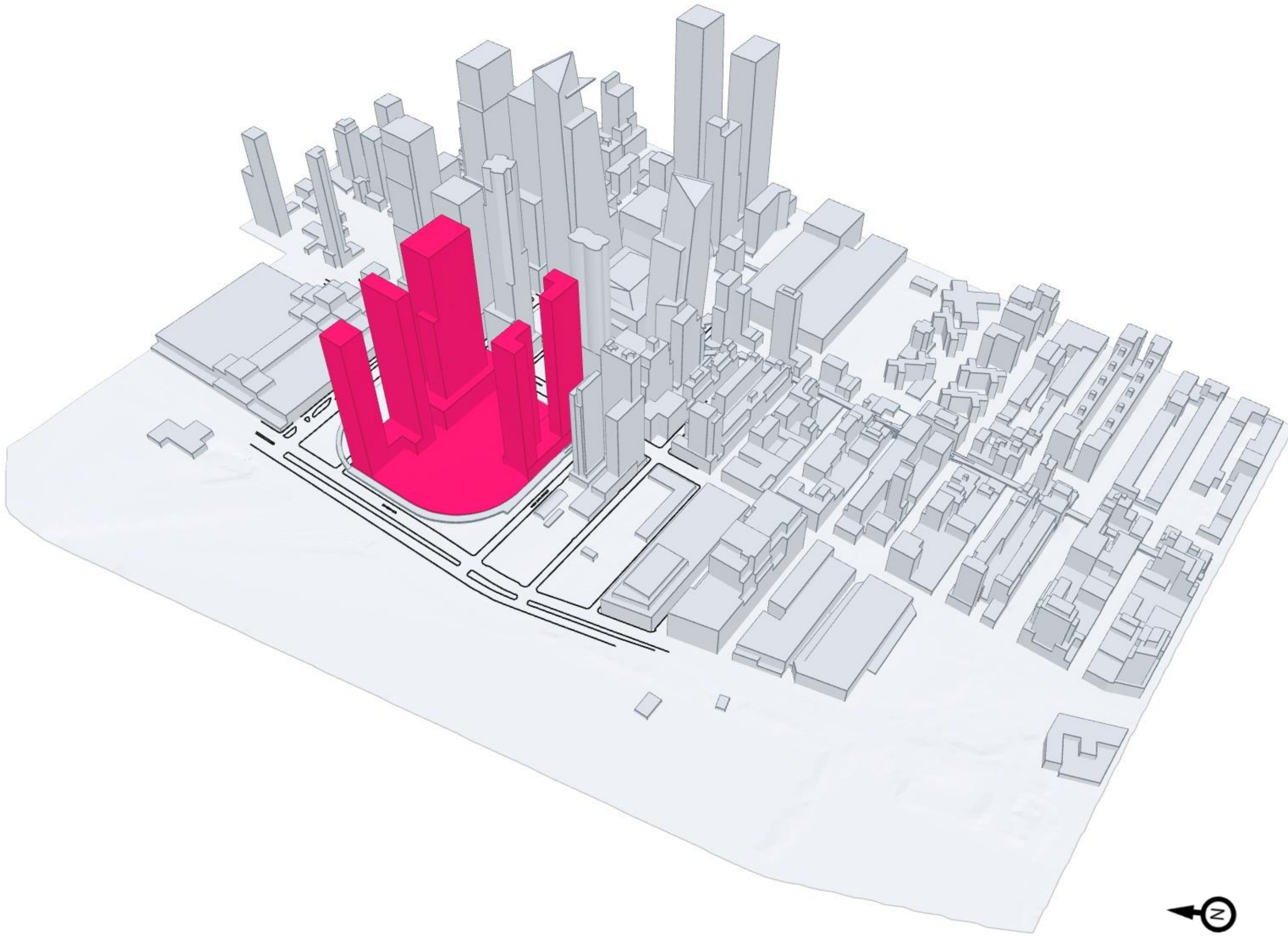


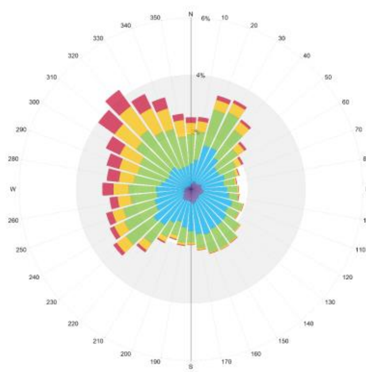
Image 6: Computer model of the no action scenario and extended surroundings

2. METHODOLOGY

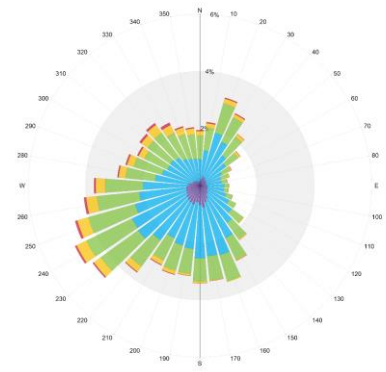
Image 7: Computer model of the Proposed Project scenario (with landscaping) and extended surroundings

3. METEOROLOGICAL DATA

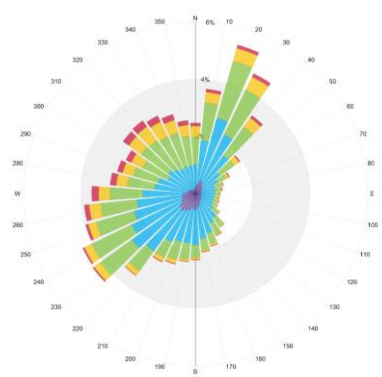
Long-term wind data recorded at Newark Liberty International Airport between 1993 and 2023, inclusive, were analyzed for the spring (March to May), summer (June to August), fall (September to November), and Winter (December to February) seasons. Image 8 graphically depicts the directional distributions of wind frequencies and speeds for these periods. Winds from the southwest through northwest and north-northeast are predominate throughout the year as indicated by the wind roses. Strong winds of a mean speed greater than 20 mph measured at the airport (at an anemometer height of 30 ft) are more frequent in the winter and approach predominantly from the north, northwest and west (red and yellow bands in Image 8). These winds potentially could be the source of uncomfortable or severe wind conditions, depending on the site exposure and development design. 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.



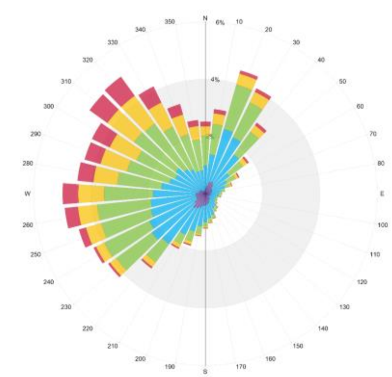
Spring (March – May)



Summer (June – August)



Fall (September – November)



Winter (December – February)

Image 8: Directional distribution of wind approaching Newark Liberty International Airport (1993 to 2023)

Table 1: Probabilities of Occurrence

	Wind Speed (mph)	Probability (%)			
		Spring	Summer	Fall	Winter
	Calm	5.3	5.4	6.5	5.9
	1-5	10.8	13.4	12.8	10.5
	6-10	34.5	43.9	38.7	32.4
	11-15	31.2	30.6	29.9	31.2
	16-20	12.0	5.7	8.8	12.9
	>20	6.3	1.1	3.2	7.0

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 (mph)	Description (Based on seasonal compliance of 80%)
Sitting	**≤ 6**	Calm or light breezes desired for outdoor seating areas where one can read a paper without having it blown away
Standing	**≤ 8**	Gentle breezes suitable for main building entrances, bus stops, and other places where pedestrians may linger
Strolling	**≤ 10**	Moderate winds appropriate for window shopping and strolling along a downtown street, plaza or park
Walking	**≤ 12**	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
Uncomfortable	**> 12**	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 (mph)	Description (Based on annual exceedance of 9 hrs or 0.1% of time)
Exceeded	**> 56**	Excessive gusts that can adversely affect one's balance and footing. Wind mitigation is typically required

5. RESULTS AND DISCUSSION

5.1 Wind Flow around Buildings

Wind approaching over open areas and water are typically very strong and can cause notable impacts on tall buildings exposed to the flow. These impacts are often intensified when the subject buildings are substantially taller than those in the surroundings. When wind is intercepted by a building, 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*. Wind also tends to accelerate through the space between buildings aligned with the predominant wind direction due to *channeling effect*. Low p*odium* and building roofs and canopies disrupt downwash and reduce the potential wind impact on the ground level. These flow patterns are illustrated in Image 9.

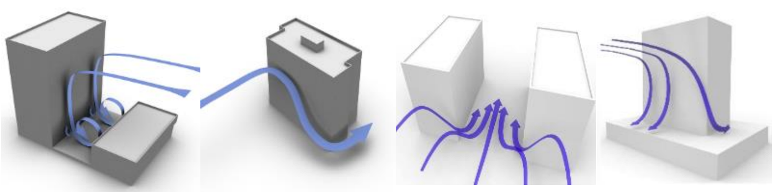


Image 9: General wind flow patterns

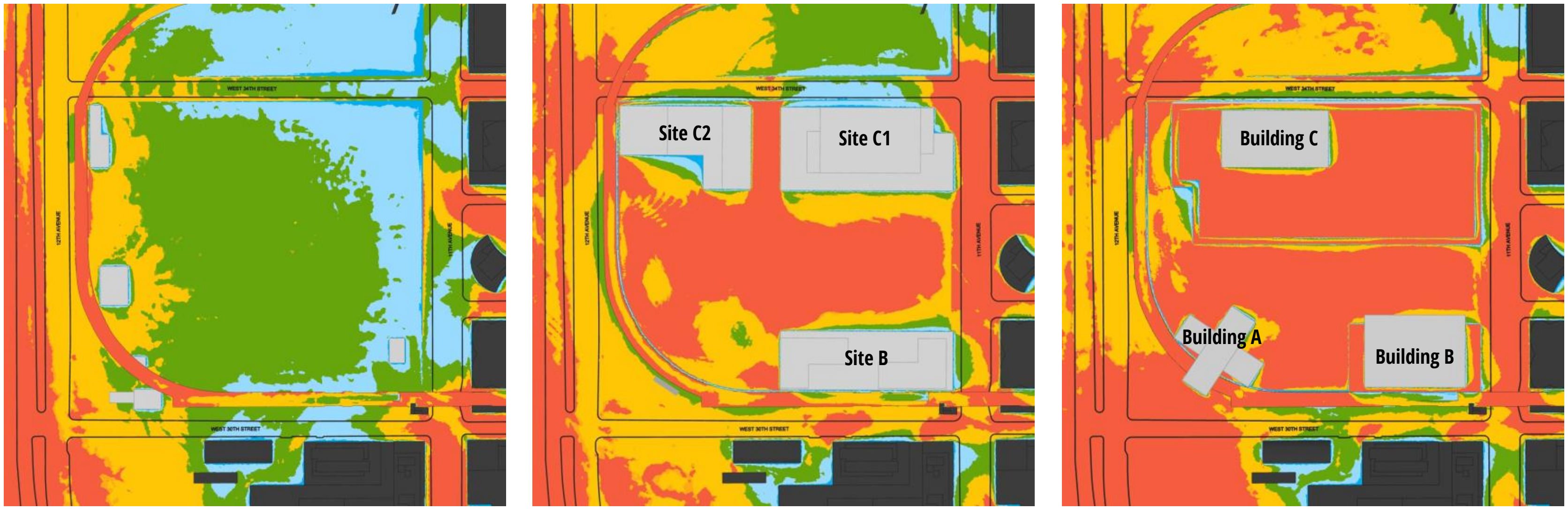
5.2 Presentation of Results

The predicted seasonal wind comfort conditions for the Existing, No-Action and Proposed Project scenarios are presented in Images 10 through 13. The results are presented as color contours of wind speeds calculated based on the wind comfort criteria (Section 4.1). The contours represent wind speeds at a horizontal plane approximately 5 ft above the concerned levels.

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 in New York.

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

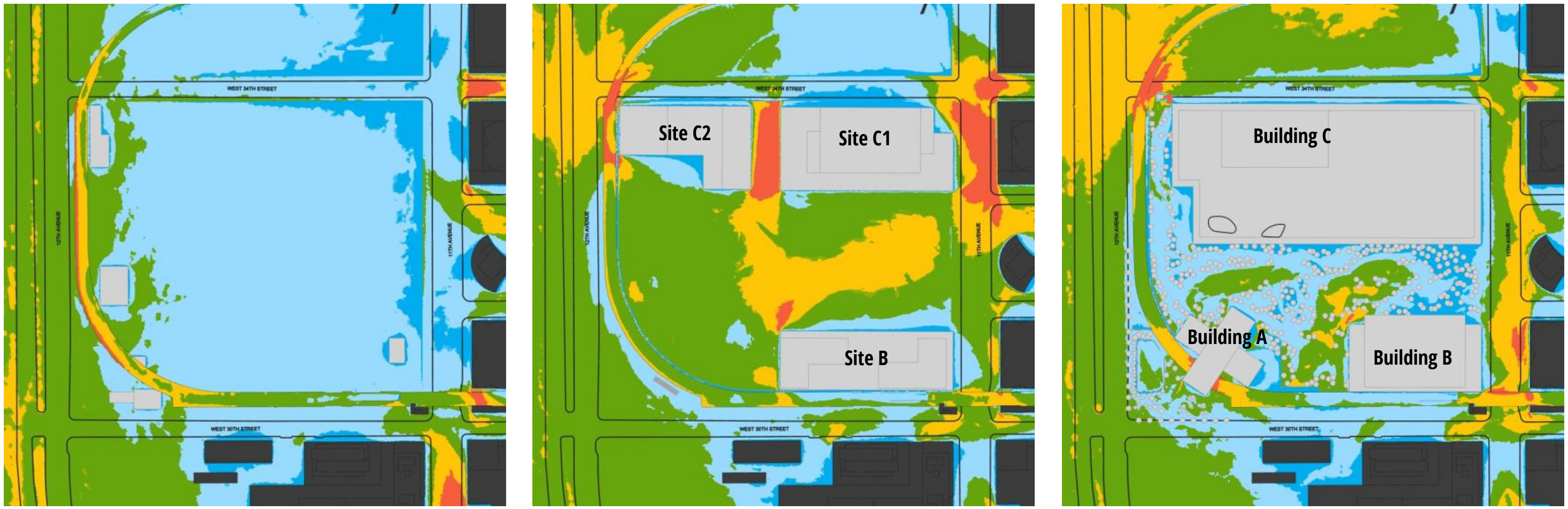
5. RESULTS AND DISCUSSION



(a) EXISTING **(b) NO ACTION SCENARIO** **(C) PROPOSED PROJECT SCENARIO WITH LANDSCAPING**

COMFORT: SITTING STANDING STROLLING WALKING UNCOMFORTABLE

Image 10: Predicted wind conditions – Ground level – Spring



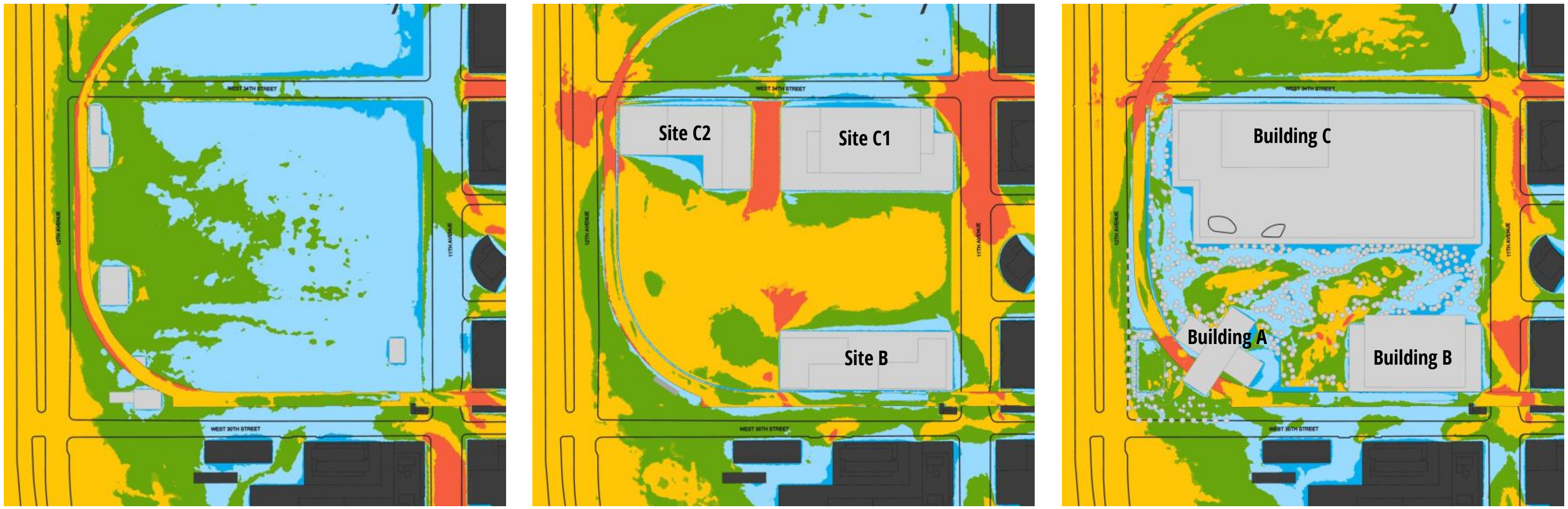
(a) EXISTING

(b) NO ACTION SCENARIO

(C) PROPOSED PROJECT SCENARIO WITH LANDSCAPING

COMFORT: SITTING STANDING STROLLING WALKING UNCOMFORTABLE

Image 11: Predicted wind conditions – Ground level – Summer



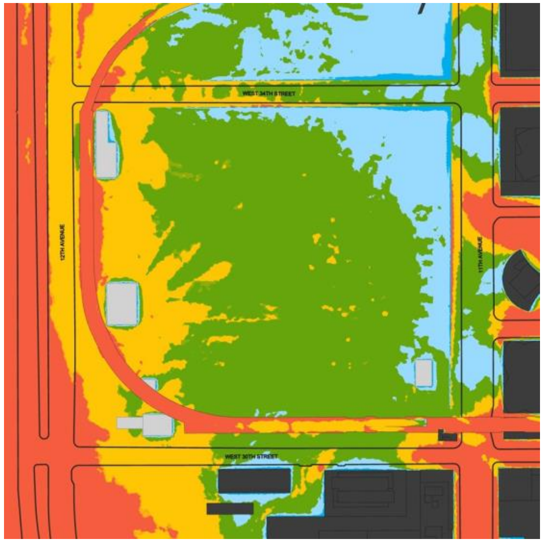
(a) EXISTING

(b) NO ACTION SCENARIO

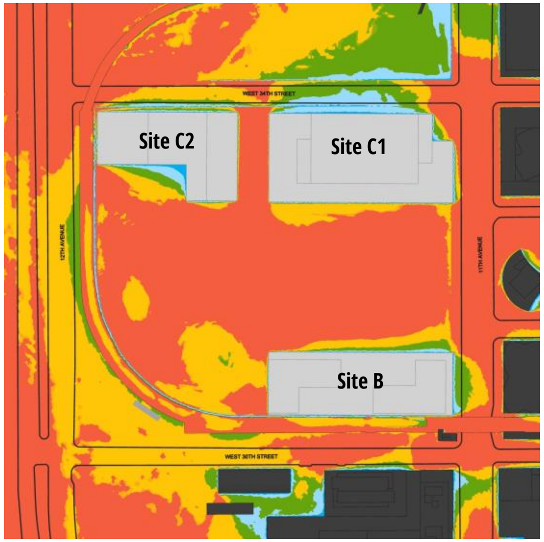
(c) PROPOSED PROJECT SCENARIO WITH LANDSCAPING

COMFORT: SITTING | STANDING | STROLLING | WALKING | UNCOMFORTABLE

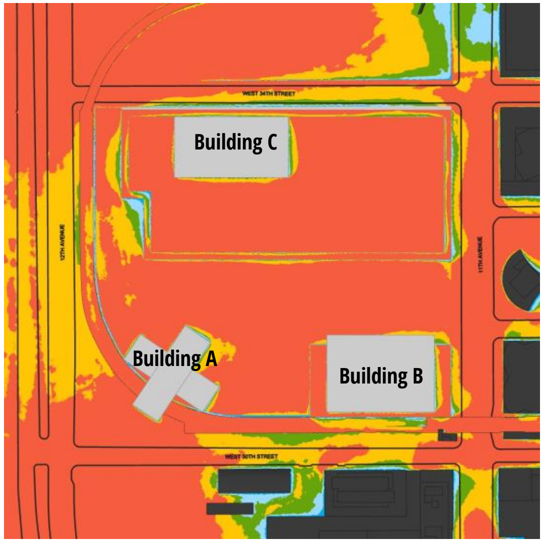
Image 12: Predicted wind conditions – Ground level – Fall



(a) EXISTING



(b) NO ACTION SCENARIO



(c) PROPOSED PROJECT SCENARIO WITH LANDSCAPING

COMFORT: SITTING STANDING STROLLING WALKING UNCOMFORTABLE

N

Image 13: Predicted wind conditions – Ground level – Winter

5.3 Existing

The existing site consists of an old rail yard and parking lots and therefore will not redirect winds to create any notable impact. Parts of the site would be affected by the direct exposure to wind approaching from the northwest and southwest over the Hudson river, and by wind redirected toward the site by the existing tall buildings around it. The site does, however, benefit from the wind protection afforded by the high-rise buildings to the east/northeast from the prevailing northeasterly easterly winds. Results for the Existing scenario are presented in Images 10a, 11a, 12a, and 13a for the four seasons. Wind conditions at most areas on and around the proposed site in the existing scenario are considered comfortable for standing in the summer, standing or strolling in the fall, and generally strolling or walking in the spring and winter. Lower speeds occur at the east end of the site, however high wind activity that is considered uncomfortable in the spring and winter occur immediately around the existing tall buildings on 11th Avenue.

5.4 No-Action Scenario

The No-Action scenario proposes five high-rise towers. These tall towers are expected to deflect wind downward and promote wind accelerations between the buildings and around windward building corners (See Section 5.2). The low podiums of the towers will act as a horizontal break for downwashing flows and provide some wind control.

Wind conditions at most areas on the project site are expected to be comfortable for strolling during the summer and walking during the fall (Images 11b and 11c). In both seasons uncomfortable conditions are predicted between Building C1 and C2, Building C1 and 35 Hudson Yards to the east, and around most building corners. During the spring and winter, wind conditions are predicted to be comfortable for walking in some areas close to the building perimeters and areas along the sidewalks of 12th Avenue, West 30th Street and West 33rd Street (Image 10a and 13a). Relatively higher wind speeds are expected around all other areas of the site, where conditions are predicted to be uncomfortable. Uncomfortable conditions are also expected in several areas between the proposed buildings and along the sidewalks of 11th Avenue to the east.

5.5 Proposed Project Scenario

The Proposed Project scenario will comprise three towers that are taller than most of the surrounding buildings. Building C will have a low podium, the roof of which would act as a horizontal break for downwashing flows, and thereby reduce the wind impact of the tower on grade level areas. The proposed deciduous trees/shrubs are expected to help reduce wind speeds around the site during the summer and fall when the trees are in full foliage (Images 11c and 12c). Increased wind speeds are expected, however, at the western building corners as well as high elevation areas between the buildings even in the presence of the trees (Image 10c, 11c, 12c, and 13c).

5.5.1 Sidewalks

Wind conditions are expected to be comfortable for standing or strolling at most areas around the site in the summer and fall in the No Action and Proposed Project scenarios (Image 11b and 11c). Higher winds speeds, comfortable for walking are expected in the green space between the buildings on site and between the buildings along 11th Avenue. Uncomfortable conditions are predicted near the northwest corner of the Building A.

During the spring and winter, wind speeds are predicted to be similar to the No-Action scenario with conditions comfortable for walking or uncomfortable around the site.

5.5.2 Public Green Space

In the Proposed Project scenario, the Hudson Green public open space outdoor amenity areas at grade, which include walkways, gardens and parks are detailed in Image 3. During the summer and fall when the outdoor spaces are frequented and the proposed large trees are in full foliage, wind speeds, at some areas are anticipated to be comfortable for passive use. Wind conditions are expected to be generally comfortable for standing in the public green space areas which is suitable for passive use. Higher winds predicted to be comfortable for strolling or waking are observed in some areas between the proposed buildings and around the northwest corners of Building A and the Building B. (Image 11c and 12c).

During the spring and winter when the trees have lost their leaves and therefore would provide little to no wind control benefit, wind conditions at most areas of the Public Green Space are expected to be uncomfortable for pedestrian use (Image 10c and 13c). For areas where higher wind speeds than desired are expected, RWDI can help guide the development of wind control features to achieve appropriate levels of wind comfort (Section 5.6.1).

5.5.3 Podium Roof Levels

Wind speed increases with elevation; the podium roofs are exposed to the stronger winds at higher elevations as well as winds that are redirected by the tall towers. Therefore, conditions on most podium roofs, throughout the year, are expected be windier than desired (Images 9a and 9b). Mitigation strategies for above grade levels are discussed in section 5.6.2.

5. RESULTS AND DISCUSSION

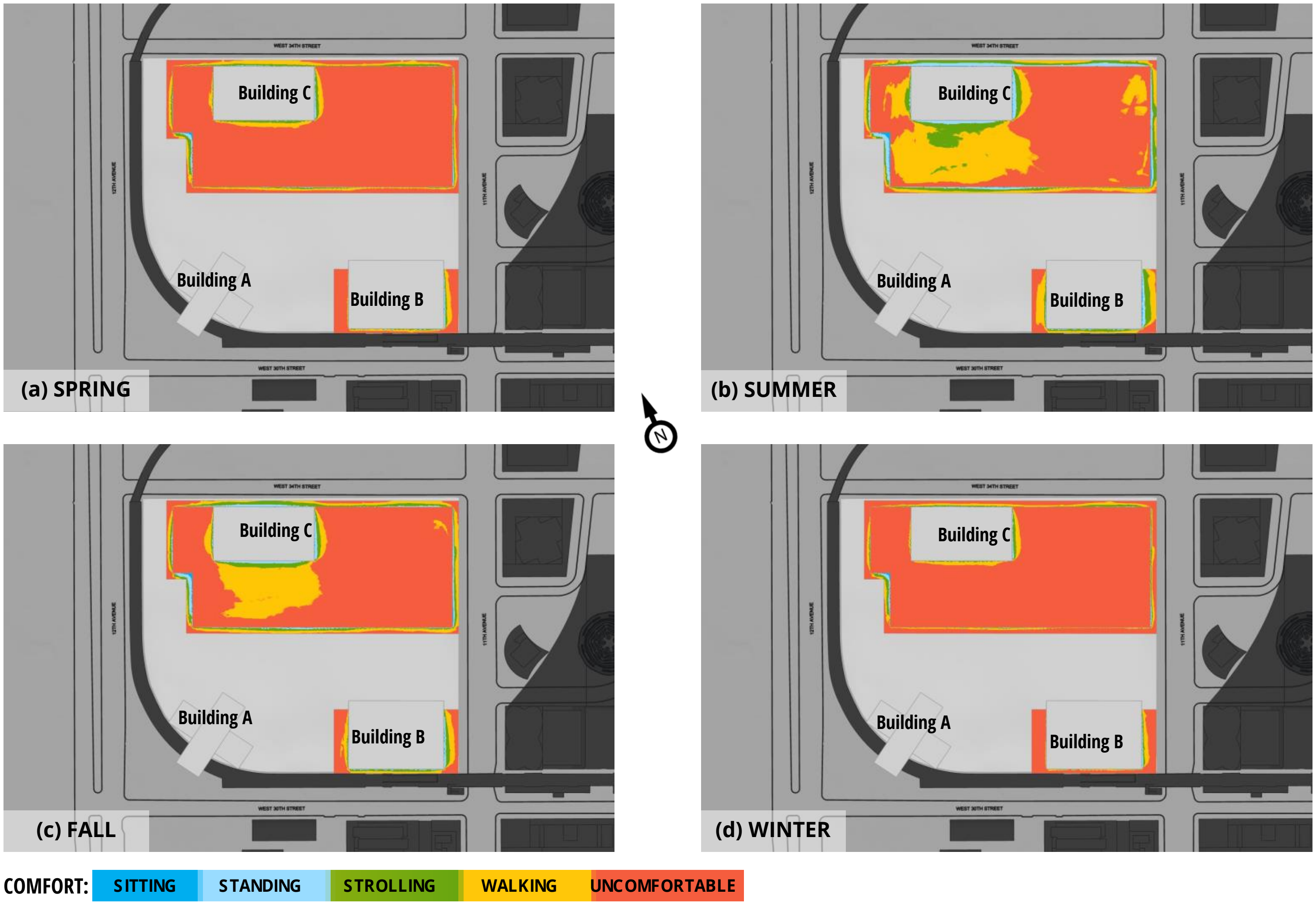
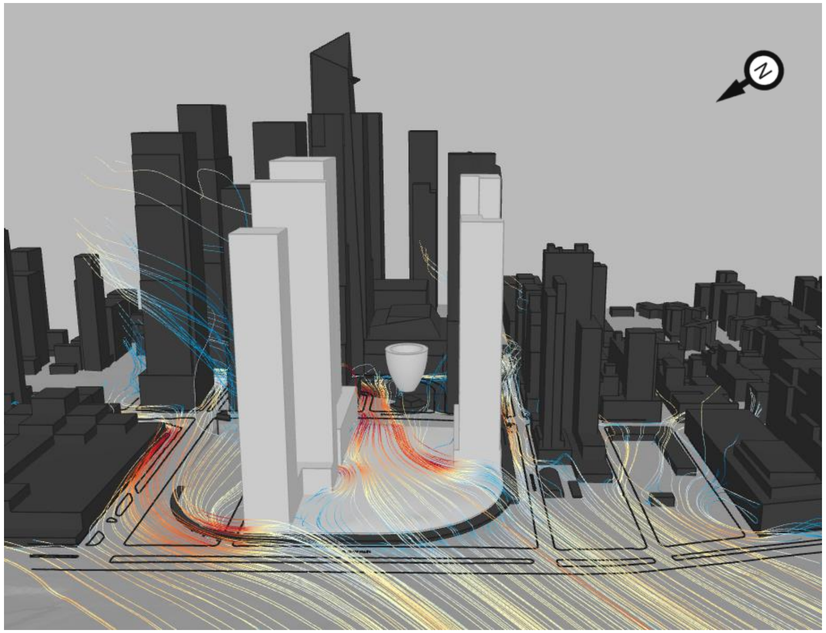
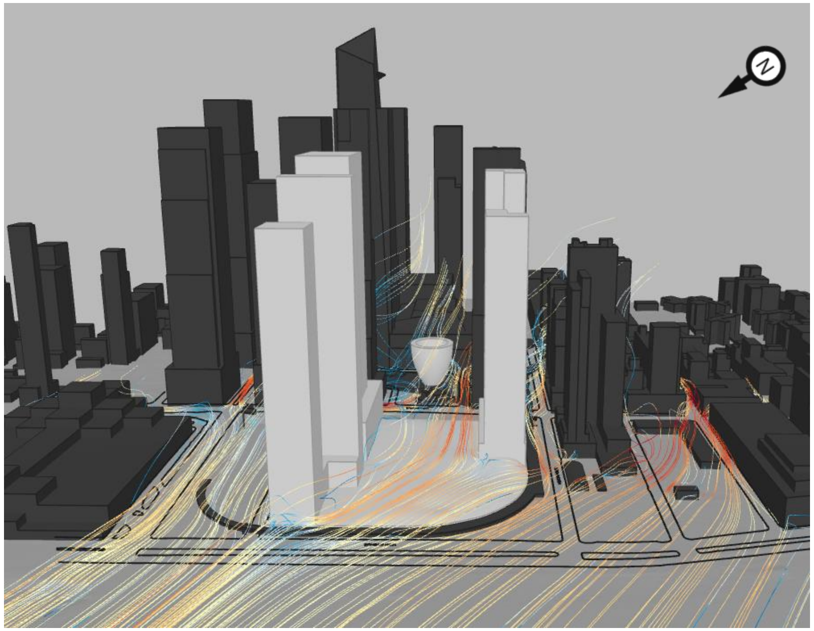


Image 14: Predicted wind conditions – Above-grade – Proposed Project scenario

5. RESULTS AND DISCUSSION



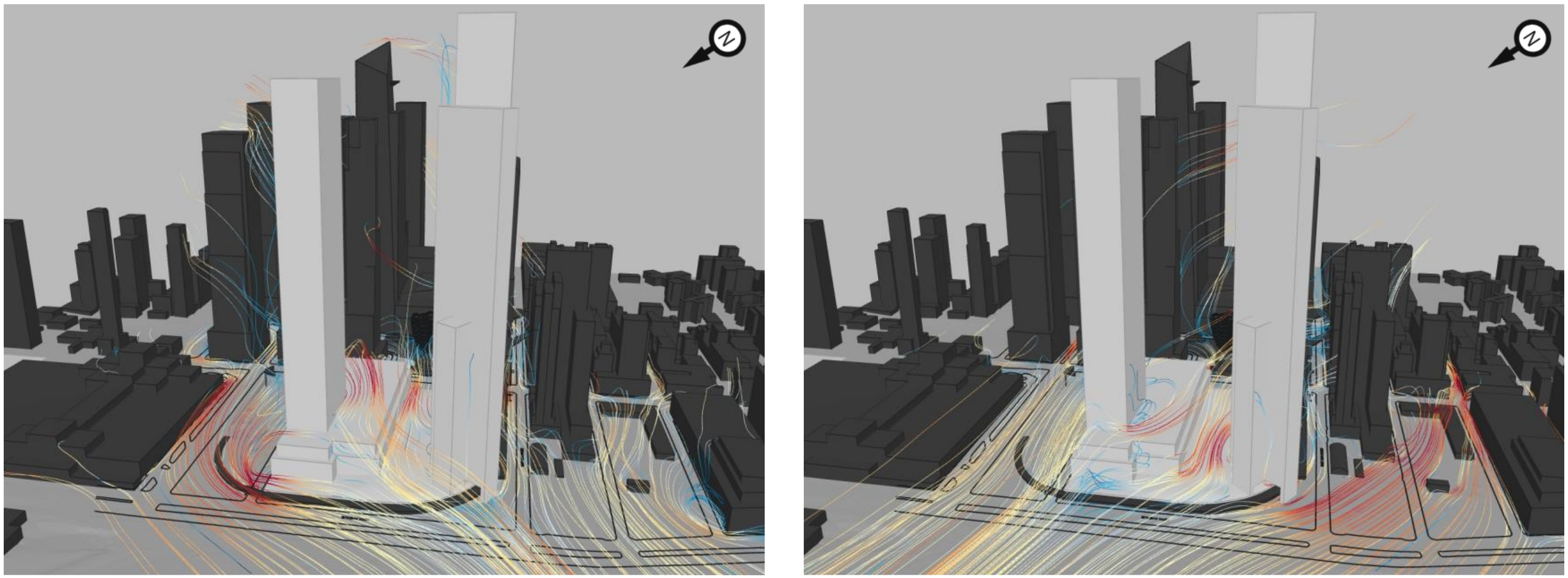
(a) Winds from the westerly direction



(b) Winds from the northwesterly direction

Image 15a: Anticipated wind flow patterns around the proposed buildings and on the podium levels for the predominant winds – NO-ACTION Scenario

5. RESULTS AND DISCUSSION



(a) Winds from the westerly direction

(b) Winds from the northwesterly direction

Image 15b: Anticipated wind flow patterns around the proposed buildings and on the podium levels for the predominant winds – Proposed Project Scenario

5. RESULTS AND DISCUSSION

5.6 Wind Mitigation Strategies

5.6.1 Wind Mitigation Strategies at Grade

To address downwashing winds and winds accelerating around corners, building massing changes, in the form of additional setbacks of the towers from the podium edges and façade articulation (including modified corner massing for the podiums and at lower levels of the towers to streamline wind flows) are advised. Large canopies wrapping around the podium corners may be strategically placed to address downwashing flows near corners, and vertical wind control elements in the form of coniferous trees or tall screens (perforated to a porosity of approximately 30%) can be added near the windy corners to address corner acceleration flows.

The proposed landscaping detailed in Image 3 is positive and will help reduce wind speeds locally around them, especially during the summer and fall. Dense, evergreen trees afford wind control benefits in the winter and shoulder seasons and would be beneficial in the areas between buildings and around building corners. Additionally, overhead trellises and vertical wind control features such as windscreens, planters and art features can be used to improve local wind conditions between buildings, on sidewalks and within the outdoor amenity spaces, and park areas (See examples in image 16).

5.6.2 Wind Mitigation Strategies Above Grade

We encourage the design team to consider minimum 6 ft tall guardrails around the podium roof perimeters to reduce the exposure of the amenity areas to the prevailing winds. Additionally, we recommend the consideration of overhead features like canopies and trellises at the tower bases to deflect the wind downdrafts away from the terraces. Wind screens, partitions, and planters may be interspersed throughout the terraces or used to surround designated gathering or seating areas. Some examples of these wind control features are shown in Image 17.

RWDI can work with the design team to refine the location and size of appropriate wind control solutions as the design progresses.

5. RESULTS AND DISCUSSION

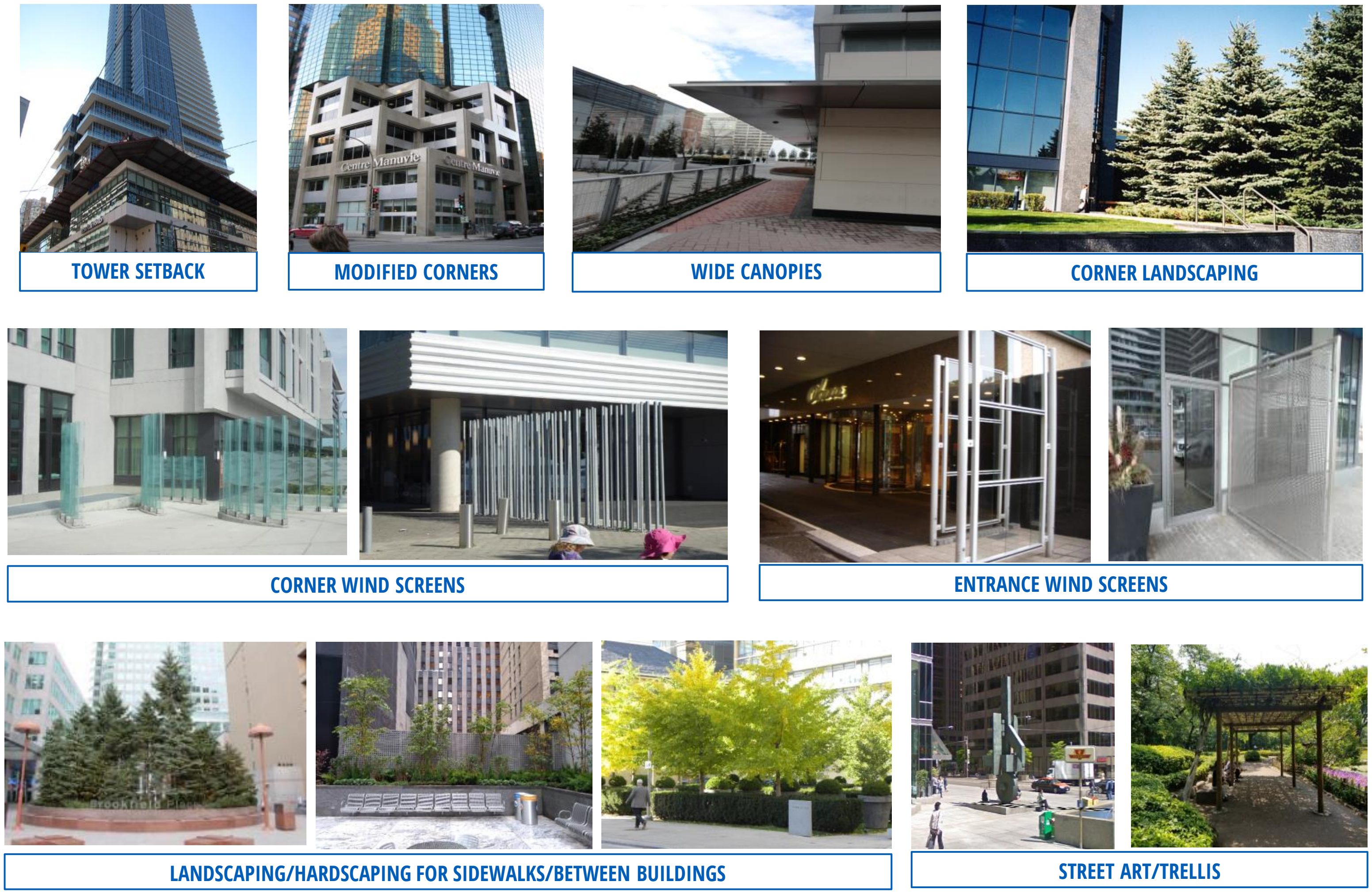


Image 16: Design strategies for grade level areas

5. RESULTS AND DISCUSSION

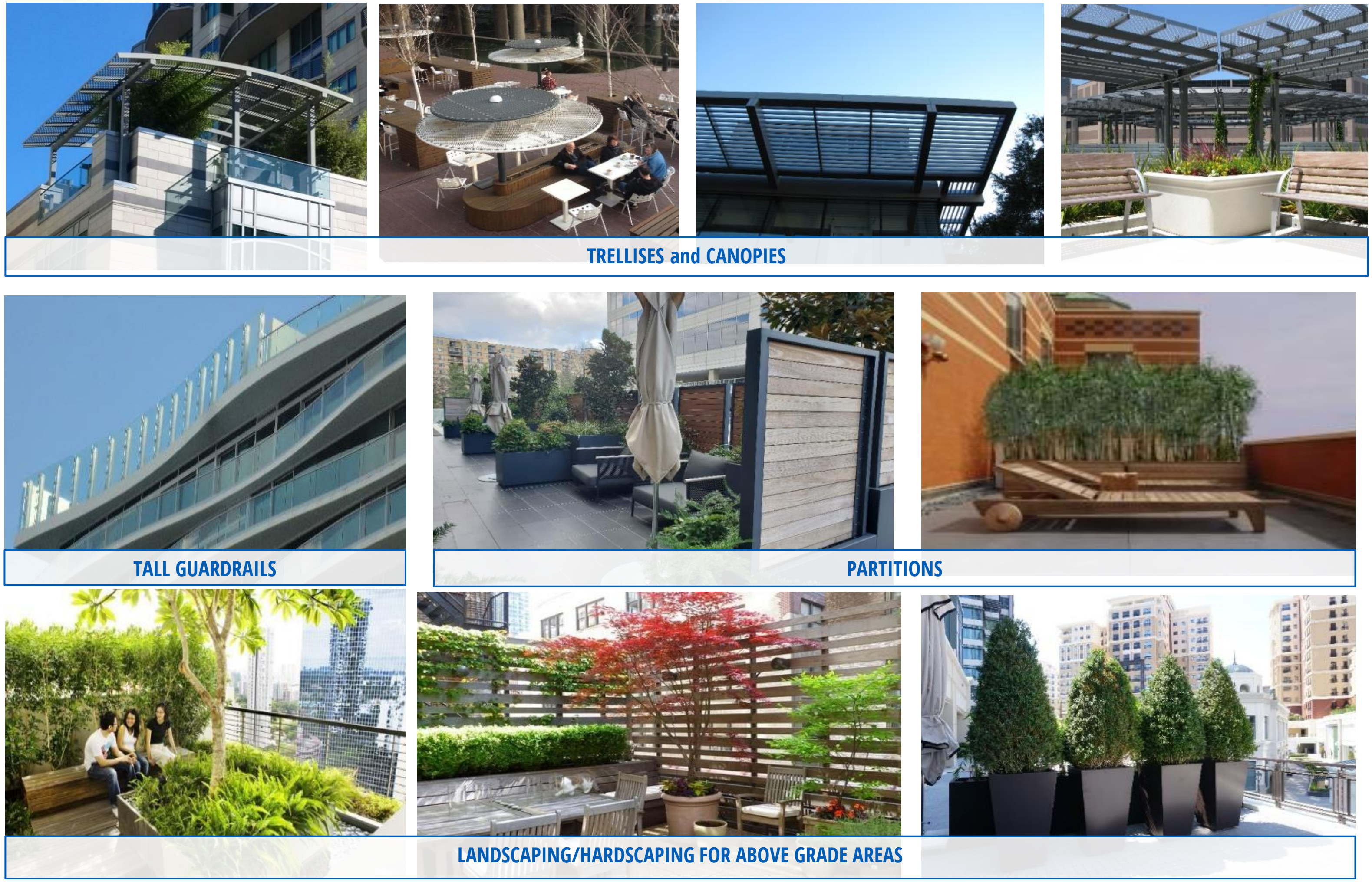


Image 17: Design strategies for above grade levels

6. SUMMARY

RWDI was retained to provide an assessment of the potential pedestrian level wind impact of the proposed Western Rail Yard project in New York, NY. Our assessment was based on computational modeling, simulation and analysis of wind conditions, in conjunction with the local wind climate data and the RWDI wind criteria for pedestrian comfort and safety. Our findings are summarized as follows:

- Wind conditions at most areas on the existing site are suitable for the intended pedestrian use throughout the year. Uncomfortable conditions in the spring and winter occur around the existing tall buildings on 11th Avenue.
- The No-Action scenario is similar or taller in height than its surroundings and exposed to the prevailing westerly winds and therefore will redirect wind to ground level. Wind conditions are expected to be comfortable for pedestrian use at most areas on site in the summer and fall with uncomfortable conditions predicted at most areas during the spring and winter.
- Similar to the No-Action scenario, the Proposed Project scenario is expected to redirect wind to ground level. However, the proposed landscaping and several positive features in the massing design will help moderate wind impacts in some localized areas around the development.
- In the Proposed Project scenario, wind conditions at most areas at the ground level, are expected to be appropriate for pedestrian usage during the summer and fall when the proposed trees are in full foliage. Higher wind speeds are expected in a few areas between the proposed buildings and around the northwest building corners of the Building A and Building B.
- During the spring and winter uncomfortable wind speeds are expected at most areas on the site.
- In the Proposed Project scenario, wind speeds at most areas of the podium roof levels are predicted to be higher than desired for passive use.

Strategies for wind control at the ground and upper-level areas are provided for the design team's consideration. 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.

7. DESIGN ASSUMPTIONS

The findings/recommendations in this report are based on the drawings communicated to RWDI in August 2024 and 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)
20240710_WRY_NR Scenario	Rhino	08/08/2024
20240710_WRY_Proposed project Scenario	Rhino	08/08/2024
20240710_WRY_Proposed project Scenario_Illustrative Building	Rhino	08/08/2024
WRY No Action scenario for ped wind	AutoCad	08/08/2024

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. 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 The Related Companies ("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.