APPENDIX E

PEDESTRIAN WIND

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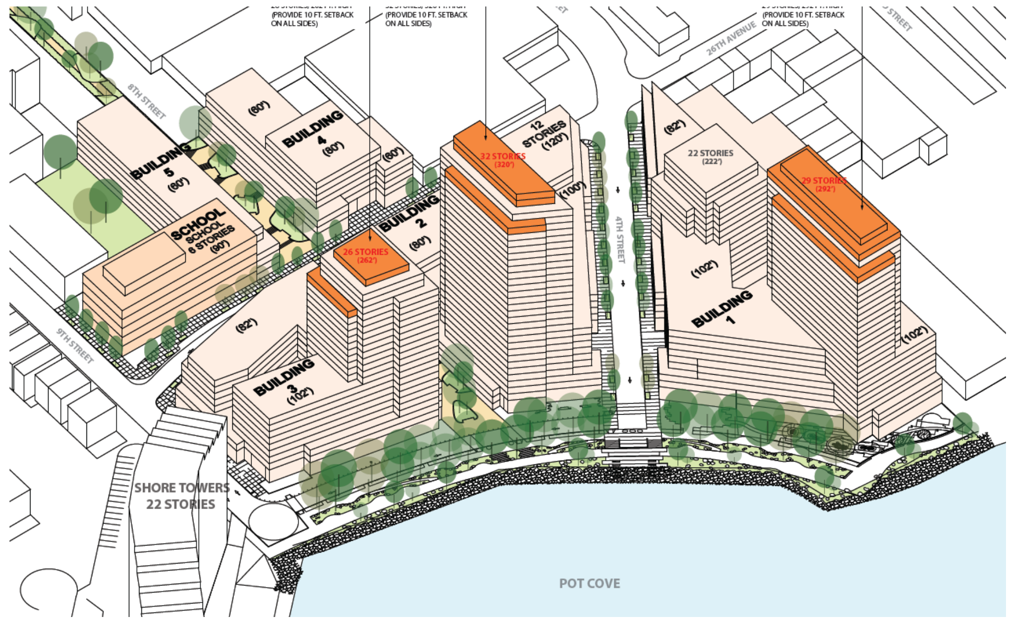

Date: February 26, 2014

To: 2030 Astoria Developers, LLC
c/o Davidoff Hutcher & Citron LLP
605 Third Avenue, 34th Floor
New York, NY 10158

Re: **Pedestrian Wind Assessment**
Astoria Cove Development
Astoria, Queens, New York
Novus Project # 13-0282

Novus Team:

Scientist:	Jenny Vesely, B.Eng., EIT
Specialist:	Tahrana Lovlin, MAES, P.Eng.
Senior Specialist:	Bill Waechter, C.E.T.

1.0 INTRODUCTION

Novus Environmental Inc. (Novus) was retained by 2030 Astoria Developers, LLC to conduct a pedestrian wind assessment for the Astoria Cove Development in Astoria, Queens, New York. This report is in support of a planning submission to the City of New York.

1.1 Existing Development

The proposed development is located in Pot Cove just west of the Robert F. Kennedy Bridge in Queens, NY. **Figure 1** provides an aerial view of the immediate study area.

Directly surrounding the proposed development there are mainly low-rise commercial properties, with some mid-rise residential properties further south, and low-rise residential properties to the east. There is also a high-rise development immediately adjacent to the east.

Both existing and approved developments in the surrounding area were considered, as provided in the 3-D Sketch-Up model. The portions of the approved Hallets Point development most proximate to the project site, to the west, were also included in this assessment.

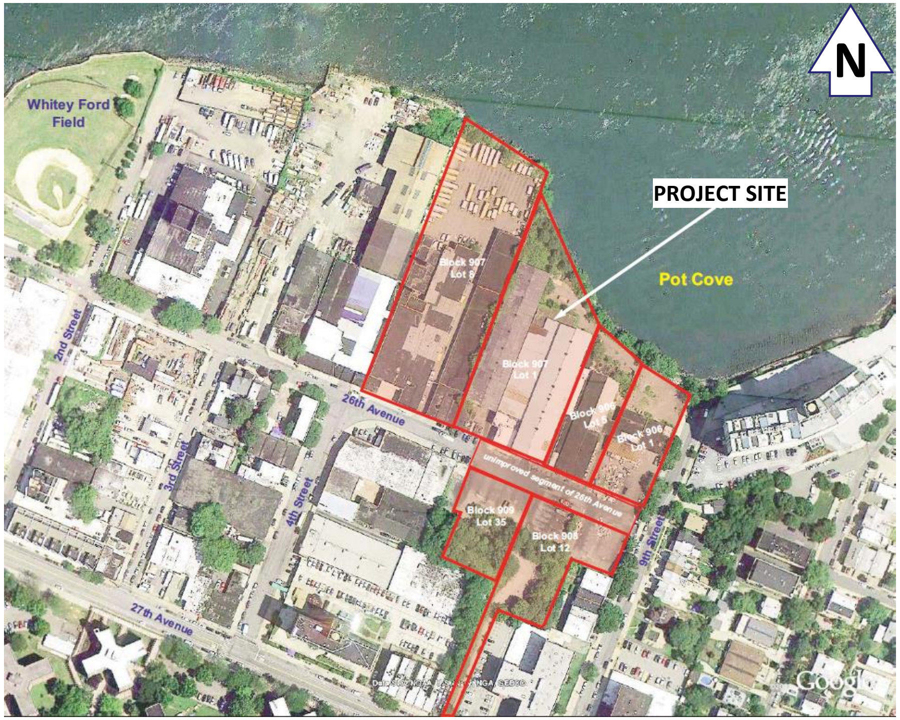

Figure 1: Context Plan
(Provided by Philip Habib & Associates, January 20, 2014)

1.2 Proposed Development

The proposed development includes five buildings, ranging in height from six to 32-storeys, with the taller buildings being located along the waterfront. The development will be mixed-use, including both commercial and residential spaces, as well as a school.

1.3 Areas of Interest

Areas of interest for pedestrian wind conditions include those areas which pedestrians are expected to use on a frequent basis. Typically these include sidewalks, main entrances, transit stops, plazas and parks. While there are several transit stops along 27th Avenue, they are sufficiently far enough from the proposed development that any potential wind influences will be insignificant at best.

Figure 2 shows the ground floor plan of the proposed development. Highlighted in pink are the commercial areas; in orange are the residential areas; and, the school is shown in blue. Residential entrances for Building 1 are located on 4th Street. Building 2 has residential entrances on 4th Street and 26th Avenue, and entrances to townhouses on 8th Street. Building 3 also has townhouse entrances on 8th and 9th Streets, with a residential entrance on 26th Avenue. The residential entrance for Building 4 is on 26th Avenue and there are townhouse entrances on 8th Street. A school is located in Building 5, with an entrance on 26th Avenue, and the building's townhouse entrances are on 8th Street; all other residential units would be accessed via 26th Avenue. There are also several retail entrances associated with each of the buildings (pink sections), located on all streets as well as along the shoreline.

A pedestrian walkway and park space is located along the shoreline.

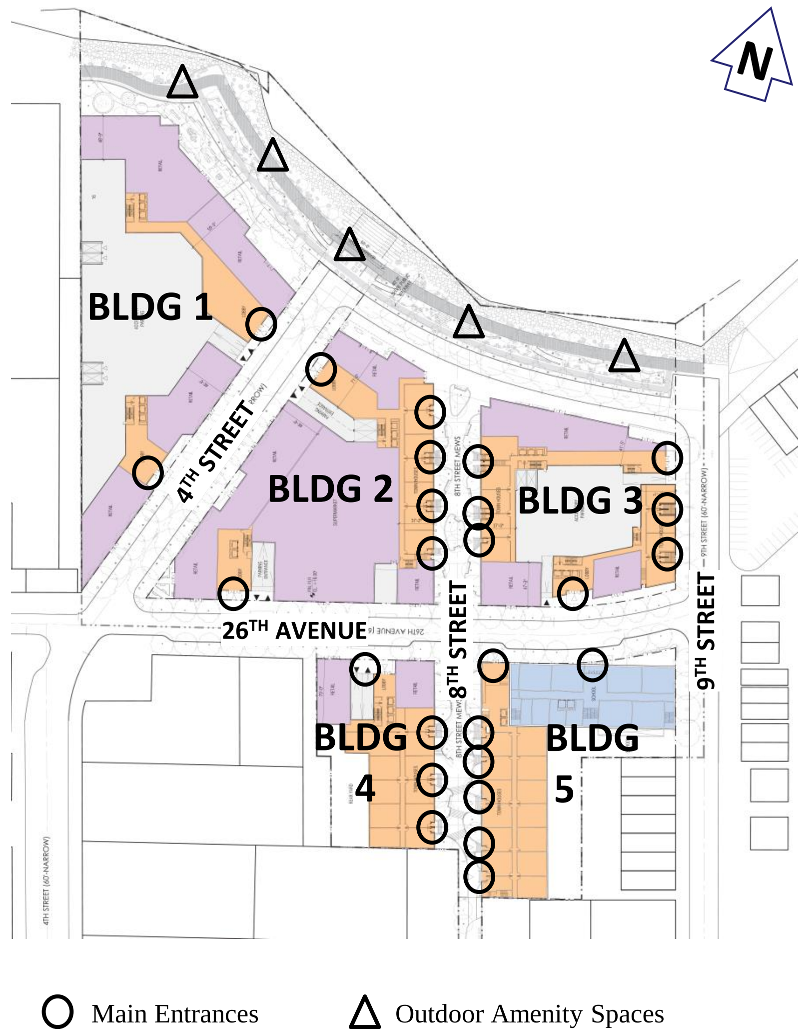

Figure 2: Areas of Interest

2.0 APPROACH

A screening-level assessment was conducted using computational fluid dynamics (CFD). As with any simulation, there are some limitations with this modeling technique, specifically in the ability to simulate the turbulence, or gustiness, of the wind. Nonetheless, CFD analysis remains a useful tool to identify potential wind issues. This CFD-based wind assessment employs a comparable analysis methodology to that used in wind tunnel testing. The results of CFD modelling are an excellent means of readily identifying relative changes in wind conditions associated with different site configurations or with alternative built forms.

2.1 Methodology

Wind comfort conditions for areas of interest were predicted on and around the development site to identify potentially problematic windy areas. A 3-D model of the proposed development and surroundings was provided by Philip Habib & Associates on January 23, 2014. A view of the 3D massing model used in the computer wind comfort analysis is shown in **Figure 3**. The model included buildings within approximately 1500 ft from the study site. The simulations were performed using "UrbaWind" software, a commercial CFD package produced by Metodyn Inc.

The entire 3D space throughout the modeled area is filled with a three-dimensional grid. The CFD virtual wind tunnel calculates wind speed at each one of the 3D grid points. The upstream "roughness" for each test direction is adjusted to reflect the various upwind conditions (e.g., water, urban buildings, city core, etc.) and wind characteristics encountered around the actual site. Wind speeds for a total of 16 compass directions were assessed. Although wind speeds are calculated throughout the entire modeled area, wind comfort conditions were plotted for a smaller area within approximately one block of the development site to reduce computational run time. In addition, these areas most proximate to the development site are expected to be most affected by the proposed project.

Wind flows were predicted with the proposed development in place to understand wind conditions at the site. The CFD-predicted wind speeds for all test directions and grid points were then combined with historical wind climate data for the region to predict the occurrence of wind speeds in the pedestrian realm, and to compare against wind criteria for comfort and safety; these results are shown in the various wind flow images that follow. The analysis of wind conditions was undertaken for the seasonal extremes of summer and winter.

Results are presented through discussion of the wind conditions surrounding each of the proposed buildings. The comfort criteria are based on predictions of localized wind forces combined with frequency of occurrence. Climate issues that influence a person's overall "thermal" comfort, (e.g., temperature, humidity, wind chill, exposure to sun or shade, etc.) are not considered in the comfort rating. Also note that the assessment does not account for the presence of mature trees, thus wind comfort conditions for months when foliage is present could be better than those predicted.

Figure 3: 3D Massing Model

2.2 Wind Climate

Wind data recorded at LaGuardia International Airport for the period of 1981 to 2011 were obtained and analysed to create a wind climate model for the seasonal extremes. Annual and seasonal wind distribution diagrams ("wind roses") are shown in **Figure 4**. These diagrams illustrate the percentage of time wind blows from the 16 main compass directions. Of main interest are the longest peaks that identify the most frequently occurring wind directions. The annual wind rose indicates that wind approaching from northwesterly, northeasterly and southerly directions are most prevalent. The seasonal wind roses readily show how the prevalent winds shift throughout the year.

The directions from which stronger winds (e.g., > 19 mph) approach are also of interest as they have the highest potential of creating problematic wind conditions, depending upon site exposure and the building configurations. The wind roses in **Figure 4** also identify the directional frequency of these stronger winds, as indicated in the figure's legend colour key. On an annual basis, strong winds occur from northwest sectors.

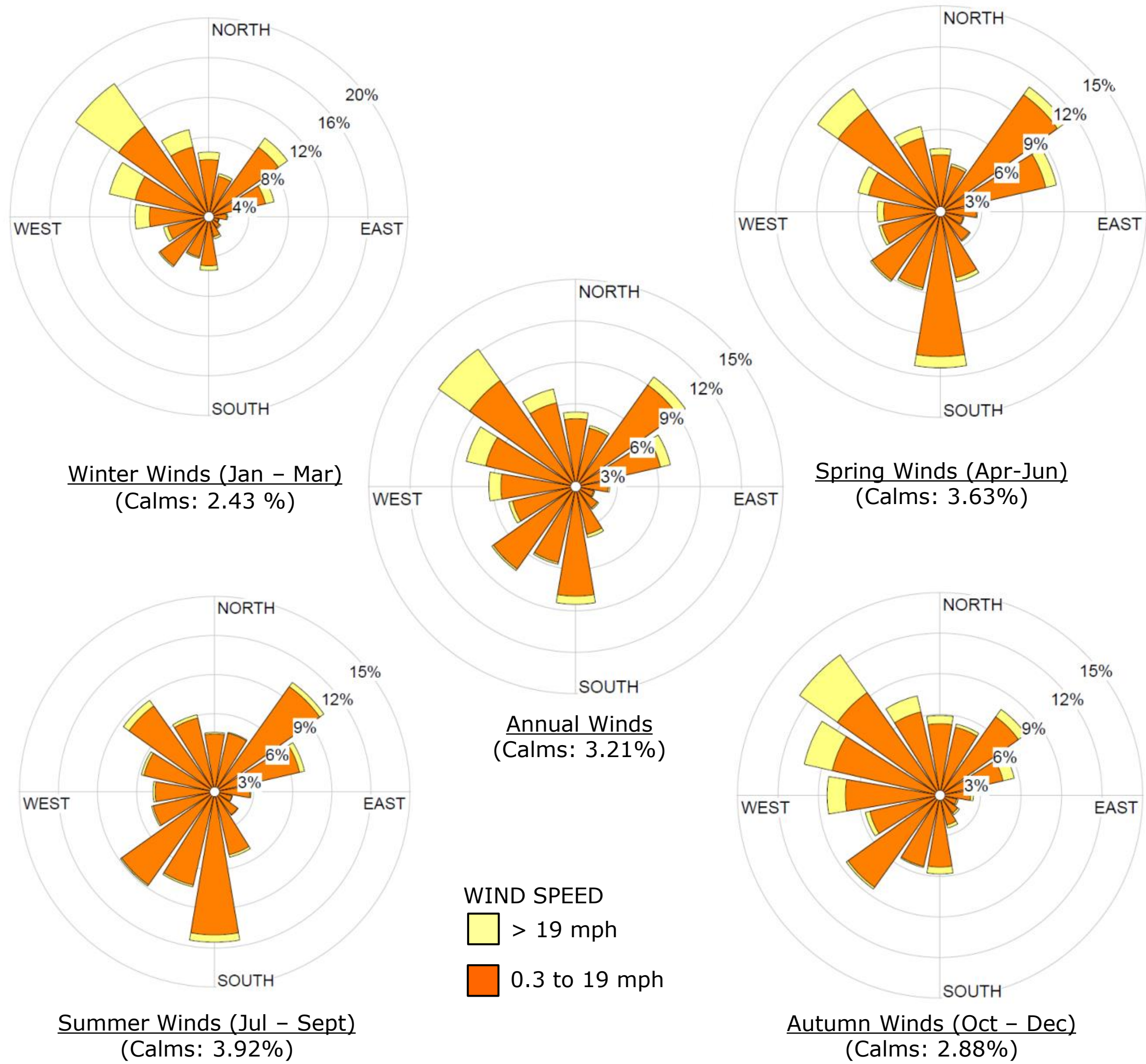

Figure 4: Wind Roses for LaGuardia International Airport (1981-2011)

3.0 PEDESTRIAN WIND CRITERIA

Wind comfort conditions are discussed in terms of being acceptable for certain pedestrian activities and are based on predicted wind force and the expected frequency of occurrence. Wind chill, clothing, humidity and exposure to direct sun, for example, all affect a person's thermal comfort; however, these influences are not considered in the wind comfort criteria.

The comfort criteria, which are based on certain predicted hourly mean wind speeds being exceeded 5% of the time, are summarized in **Table 1**. Very roughly, this is equivalent to a wind event of several hours duration occurring about once per week.

The criterion for wind safety in the table is based on hourly mean wind speeds that are exceeded 0.1% of the time (approximately nine hours per year). When more than three, 3-hour events are predicted to exceed the Fair-Weather Area criterion on an annual basis, the inclusion of wind control measures is then advised, especially for frequently accessed areas. The wind safety criterion is shown in **Table 2**.

The criteria for wind comfort and safety used in this assessment are based on those developed at the Boundary Layer Wind Tunnel Lab of the University of Western Ontario, together with building officials in London England. They are based broadly on the Beaufort Scale and on previous criteria that were originally developed by Davenport. The criteria are used by the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory for pedestrian wind study projects located around the globe. A detailed description of the criteria and history of its development is contained in the references.

Table 1: Wind Comfort Criteria

Activity	Comfort Ranges for Mean Wind Speed Exceeded 5% of the Time		Description of Wind Effects
Sitting	0 to 9 mph	0 to 4 m/s	• Light wind felt on face • Leaves rustle
Standing	0 to 14 mph	0 to 6 m/s	• Hair is disturbed, clothing flaps • Light leaves and twigs in motion • Wind extends lightweight flag
Leisurely Walking	0 to 18 mph	0 to 8 m/s	• Moderate, raises dust, loose paper • Hair disarranged • Small branches move
Fast Walking	0 to 22 mph	0 to 10 m/s	• Force of wind felt on body • Trees in leaf begin to move • Limit of agreeable wind on land
Uncomfortable	> 22 mph	> 10 m/s	• Small trees sway • Wind considered a nuisance

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded 3 Times per Year (3x3hr)		Description of Wind Effects
Any [1]	45 mph	20 m/s	• Difficult to walk straight • Wind noise on ears unpleasant

[1] Equivalent to the "Fair Weather Location" criterion of UWO's Criteria, which applies to frequently accessed areas.

4.0 RESULTS

Figures 5a through **8b** present graphical images of the predicted wind comfort conditions for the summer and winter months around the proposed development. Wind conditions suitable for leisurely walking are preferred along sidewalks during the summer and winter months, but can be difficult to achieve in the winter. At main entrances, winds rated suitable for standing are preferred on a year-round basis. Wind comfort levels suitable for sitting and standing are preferred in outdoor amenity spaces.

4.1 Building 1

Building 1, at the northwest corner of the site, is 29 storeys tall. There are two residential entrances and several retail entrances located on 4th Street, where wind conditions are predicted to be comfortable for sitting in summer and winter (**Figures 5a and 5b**). Along the shoreline, the retail entrances are expected to be comfortable for sitting throughout the year. During the winter, channeling along 4th Street of the predominant northeasterly winds results in wind conditions suitable for leisurely walking in the summer and fast walking in the winter at the northeast corner of Building 1.

The shoreline walkway and park space are predicted to be comfortable for sitting or standing during the summer and standing or leisurely walking during the winter, with the potential for increased wind activity (red and orange color, left image of **Figure 5b**) at the northwest corner of the building. Also at the northwest corner, the mean wind speed is predicted to exceed the safety criterion (black area in left image of **Figure 5b**). Although this area will not be frequented by pedestrians, as there are no entrances or other amenity spaces, we recommend including wind reduction features such as canopies, vertical wind screens, and/or

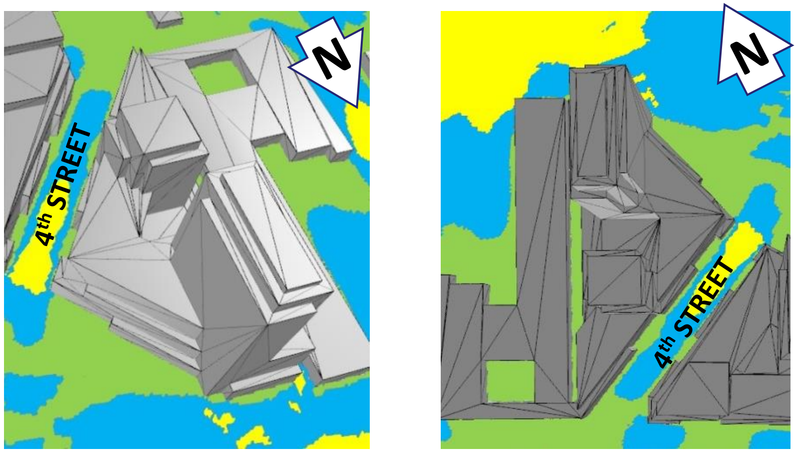

Figure 5a: Predicted Wind Comfort At Building 1 – Summer

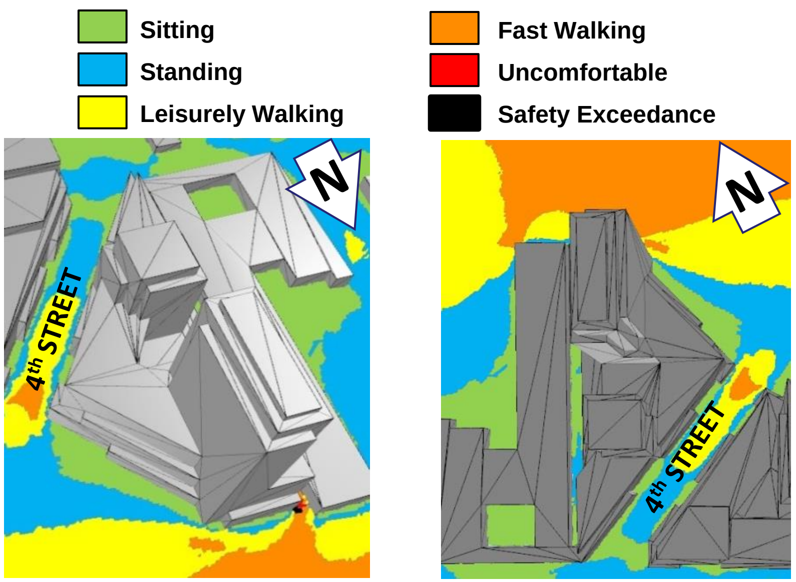

Figure 5b: Predicted Wind Comfort At Building 1 – Winter

extensive landscaping in the area, to disrupt the strong wind flows. Further testing, at a later stage in the planning process, is recommended to determine the necessity and effectiveness of such features.

4.2 Building 2

Building 2, the tallest building at 32-storeys, is located along the shore, in the middle of the development. Along 4th Street, there is a residential entrance and several retail entrances. There are also several townhouse entrances along 8th Street.

As discussed previously, predominant winds are channelled between the buildings, creating winds comfortable for leisurely or fast walking in the summer and winter, respectively, along the north half of 4th and 8th Streets (left images in **Figures 6a and 6b**). At most of the entrances to Building 2, wind conditions are expected to be comfortable for standing throughout the year. Near the northwest and northeast corners, there is the potential for higher wind speeds creating less comfortable conditions, particularly in the winter (**Figure 6b**). In these areas, the design team should consider wind reduction features in the vicinity to enhance the local wind conditions; this could be completed with further testing.

On the south side of the building, along 26th Avenue, wind conditions are generally predicted to be comfortable for sitting in the summer time and standing in the winter, which is suitable for the anticipated usage. The shoreline walkway is mainly comfortable for sitting or standing throughout the year, with the potential for areas of leisurely walking in the winter.

The safety criterion is met in the areas surrounding Building 2.

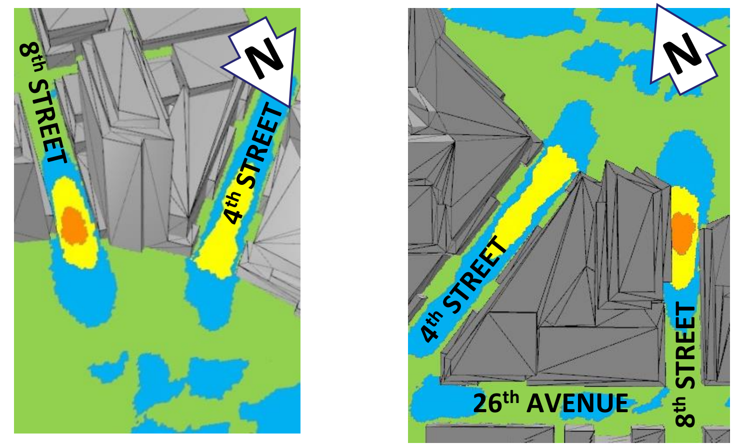

Figure 6a: Predicted Wind Comfort At Building 2 – Summer

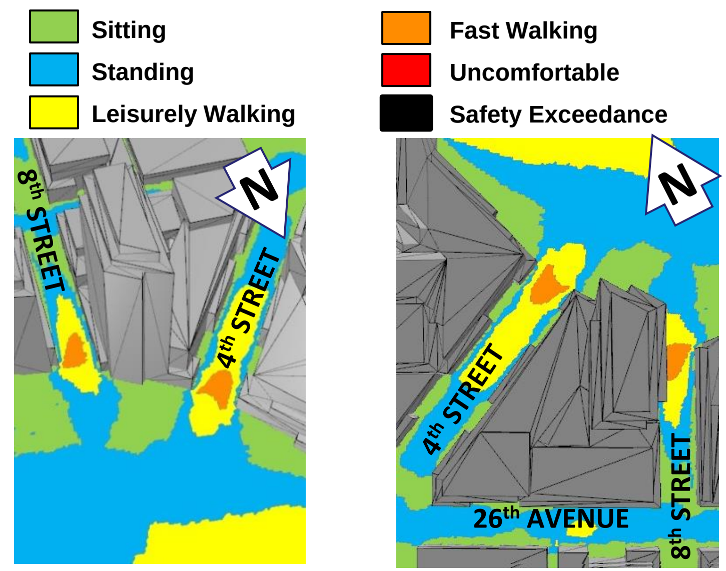

Figure 6b: Predicted Wind Comfort At Building 2 – Winter

4.3 Building 3

Building 3 is located at the northeast corner of the site and is 26-storeys tall. There are several townhouse entrances along 8th and 9th Streets, along with the main residential entrance on 9th Street.

Wind conditions at most of the entrances are anticipated to be comfortable for standing throughout the year. Again, the exception being at the northwest corner of the building, along 8th Street, where higher wind speeds conducive to leisurely or fast walking are anticipated (right images, **Figures 7a and 7b**).

At the northeast corner of the building, along 9th Street, the acceleration of the predominant northeasterly and northwesterly winds between the proposed building and the adjacent existing high-rise create an area where uncomfortable wind speeds are predicted. In addition, the safety criterion was exceeded near the northeast corner of Building 3 (black area in left images of **Figures 7a and 7b**). We recommend the inclusion of wind reduction features such as canopies, wind screens and/or landscaping in these areas. Further testing is recommended to determine the necessity, and effectiveness, of such features.

Along the north and south sides of Building 3, winds are predicted to be comfortable for sitting or standing, which is suitable for entrances and sidewalks. The shoreline walkway is predicted to be comfortable for sitting near the west corner of building, but uncomfortable towards the east corner throughout the year.

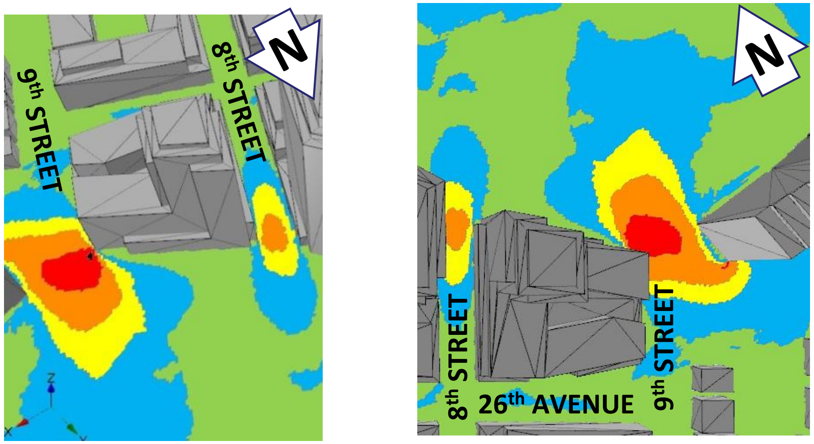

Figure 7a: Predicted Wind Comfort At Building 3 – Summer

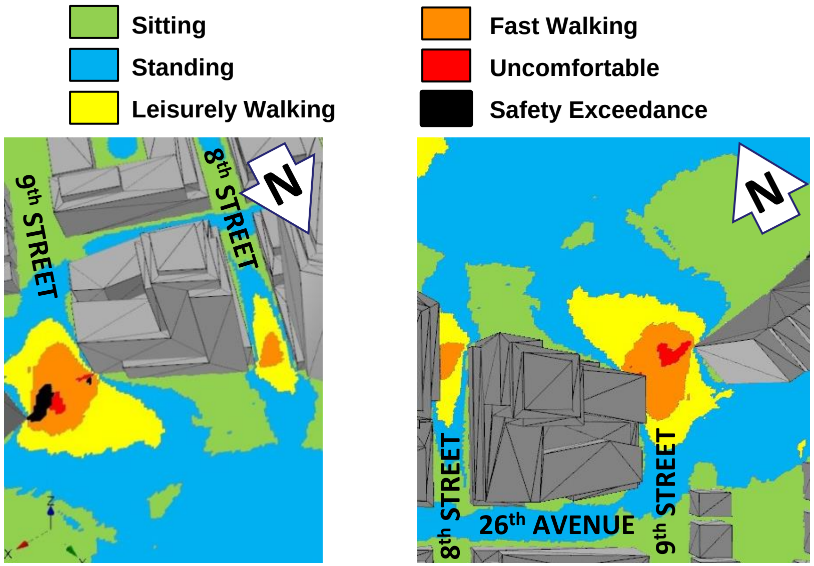

Figure 7b: Predicted Wind Comfort At Building 3 – Winter

4.4 Building 4

Building 4 is located south of Building 2 and is eight storeys tall. There are residential and retail entrances located along 26th Avenue and townhouse entrances on 8th Street. Here, the taller buildings along the shoreline provide protection from winds coming off the water; hence, wind conditions suitable for sitting are predicted around the building in the summer, with conditions suitable for sitting or standing in the winter (**Figures 8a and 8b**). These wind conditions are considered suitable for the anticipated usage.

4.5 Building 5

Building 5, six-storeys in height, is located south of Building 3 and includes a school in the east wing. Entrances to the townhouses are located on 8th Street, while the residential entrance and the entrance to the school are located on 26th Avenue.

Similar to Building 4, Building 5 is protected from the predominant winds by the buildings to the north. Wind conditions are mainly predicted to be comfortable for sitting in the summer and winter, with wind conditions conducive to standing or leisurely walking anticipated at the southeast corner of the building in the winter (**Figure 8b**). These wind conditions are considered suitable for the anticipated usage.

Figure 8a: Predicted Wind Comfort At Buildings 4 & 5 – Summer

- Sitting
- Standing
- Leisurely Walking
- Fast Walking
- Uncomfortable
- Safety Exceedance

Figure 8b: Predicted Wind Comfort At Buildings 4 & 5 – Winter

5.0 CONCLUSIONS AND RECOMMENDATIONS

The pedestrian wind conditions predicted for the proposed Astoria Cove Development in Queens, New York have been assessed through numerical modelling techniques. Based on the results of our assessment, the following conclusions and recommendations have been reached:

- Throughout the development, wind conditions at entrances are generally expected to be comfortable for sitting or standing throughout the year. Higher wind speeds from the northwest and northeast sectors created less comfortable conditions at the northwest and northeast corners of Buildings 1 through 3, due to the local acceleration of the wind flows. In these areas, we suggest the design team consider wind reduction features to enhance local wind conditions.
- The safety criterion is predicted to be exceeded near the northwest corner of Building 1 in the winter, and at the northeast corner of Building 3, both seasonally and annually. Further testing is recommended in the future at a more advanced design stage to explore the most appropriate wind reduction features.
- Buildings 4 and 5 are sheltered from the predominant winds by the taller buildings to the north; hence, wind conditions are generally predicted to be comfortable for sitting or standing year-round.
- Along the shoreline walkway and park space, wind conditions are generally expected to be suitable for the intended usage throughout the year. Higher wind speeds, suitable for fast walking or considered uncomfortable are predicted near the north corner of Building 1 and the northeast corner of Building 3. We suggest the design team consider wind reduction features in these areas, to enhance local wind conditions.

Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Sincerely,
Novus Environmental Inc.

Jenny Vesely, B.Eng., EIT
Scientist

Tahrana Lovlin, MAES, P.Eng.
Specialist – Microclimate

Bill F. Waechter, C.E.T.
Senior Specialist - Microclimate

6.0 REFERENCES

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April 4, 2014

2030 Astoria Developers, LLC
C/o Davidoff Hutcher & Citron LLP
605 Third Avenue, 34th Floor
New York, NY 10158

Attn: Mr. Ron Mandel RM@dhclegal.com

Re: Pedestrian Wind Assessment
Astoria Cove Development
Novus File No. 13-0282

Dear Mr. Mandel,

Novus Environmental Inc. (Novus) was retained by 2030 Astoria Developers, LLC to conduct a pedestrian wind assessment for the Astoria Cove Development in Astoria, Queens, New York.

A report was issued on February 21, 2014 using computational fluid dynamics, a numerical modelling technique, describing problematic wind conditions, and potentially unsafe, at the northeast corner of Building 3, along 9th Street and the esplanade.

The Department of City Planning requested the following additional information:

(1) Determine if the projected high wind condition adjacent to Shore Towers (at its northwest corner) would be as the result of the No-Action condition; and

(2) Information regarding the incorporation of a canopy or another measure to forestall a projected high wind condition adjacent to the northeast corner of Building 3.

This addendum will provide additional detail regarding these issues and the potential conceptual design changes necessary to improve wind conditions in this area.

As stated in our previous report (dated February 21, 2014), the acceleration of the prevailing northwesterly and northeasterly winds between the proposed Building 3 and the adjacent, existing high-rise (Shore Towers) creates an area of uncomfortable and exceedance of wind safety criterion. Although a No-Action (existing) site condition was not examined, our experience and knowledge of building aerodynamics suggest that accelerated winds already exist near the adjacent Shore Towers. We do not have a measure of the magnitude of the No-Action wind activity in this area. However, the massing and orientation of Shore Towers plus its exposure to the prevailing northwest winds, are conditions commonly associated with accelerated corner wind flows. In our opinion, any building form on the site of Building 3 would be faced with a similar pre-existing wind condition and would require special design considerations. This has in part been addressed in a positive way in the Astoria Cove Development, as the Building 3 tower is situated to the northeast, away from the accelerated existing winds near Shore Towers. Had the Building 3 tower been placed in this existing windy area, the local wind conditions would have been made significantly more intense.

Recommendations

In order to minimize the potential for exceedance of safety criterion, there are numerous mitigative features which could be considered by the team. We have included a broad range of architectural design features to provide the design team with examples of conceptual ideas that can be considered:

- The inclusion of a large (minimum 15 ft. wide) wrap-around canopy at the northeast corner of Building 3 (Figure 1). In addition, vertical wind screens may be necessary beneath the canopy, to disrupt horizontal wind flows off the water. The inclusion of a canopy and possibly wind screens are conceptually the type of architectural features typically used in similar situations to reduce wind levels to a point below safety criterion thresholds.
- Another concept is Chamfering the northeast corner of Building 3. This would enlarge the space between it and the adjacent existing building (Figure 2), thus minimizing the acceleration of wind flows;
- In addition, a possibility is the inclusion of setbacks or terraces at the northeast corner of Building 3. These horizontal elements would deflect and disrupt the wind flows. These elements would need to be a minimum of 20 ft. wide in order to be effective (Figure 3). The idea is to “open” up the space between Building 3 and the nearby existing building;

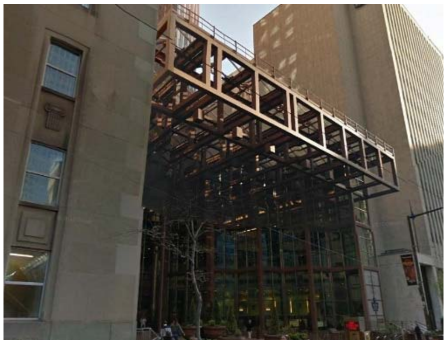

Figure 1: Large Canopy in Toronto

Figure 2: Chamfered Corner in Toronto

Figure 3: Terraced Facade in Toronto

Along the north and south sides of Building 3, winds are predicted to be comfortable for sitting or standing, which is suitable for entrances and sidewalks. The shoreline walkway is predicted to be comfortable for sitting near the west corner of building, but uncomfortable towards the east corner throughout the year. We suggest the design team consider wind reduction features in these areas, to enhance local wind conditions. In order to determine the necessity and effectiveness of these potential mitigation features, wind tunnel testing would be required. Due to the potential severity of the wind conditions, as well as the influence of the adjacent existing building, a combination of mitigation features may be necessary. And while a significant change to the massing of Building 3 may be the most effective method of improving the wind climate, it may not be feasible within the current design constraints.

Should you have any questions or comments, please feel free to contact me.

Sincerely,
Novus Environmental Inc.

Tahrana Lovlin, MAES, P.Eng.
Specialist – Microclimate

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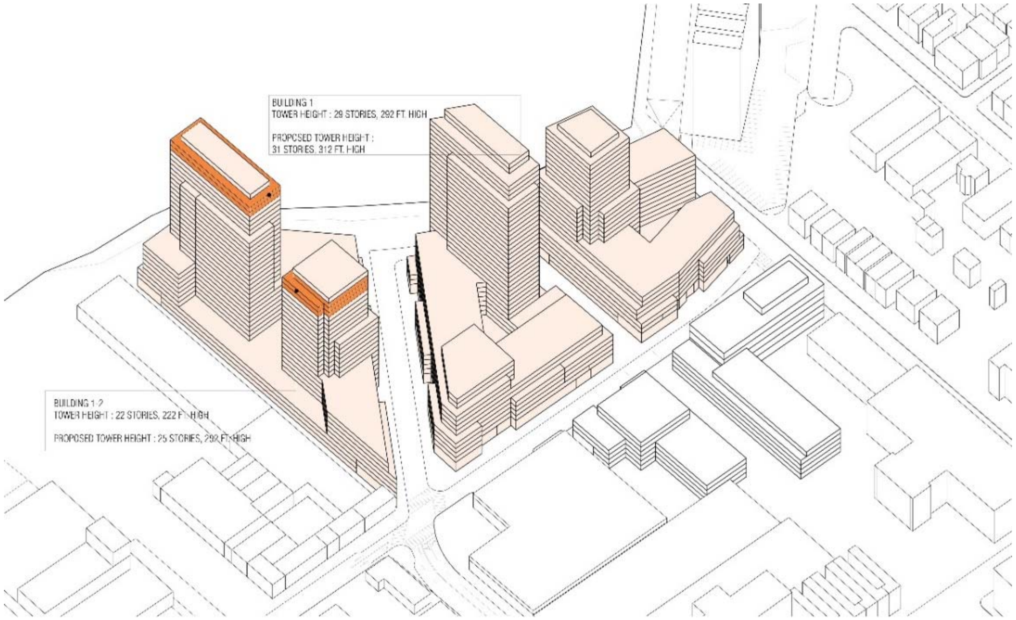
Guelph, ON, N1G 4T2
226.706.8080 | www.novusenv.com

Date: July 24, 2014

To: 2030 Astoria Developers, LLC
c/o Davidoff Hutcher & Citron LLP
605 Third Avenue, 34th Floor
New York, NY 10158

Re: **Pedestrian Wind Study**
Astoria Cove Development
Astoria, Queens, New York
Novus Project # 13-0282



Credit: Studio V Architecture

Novus Team:
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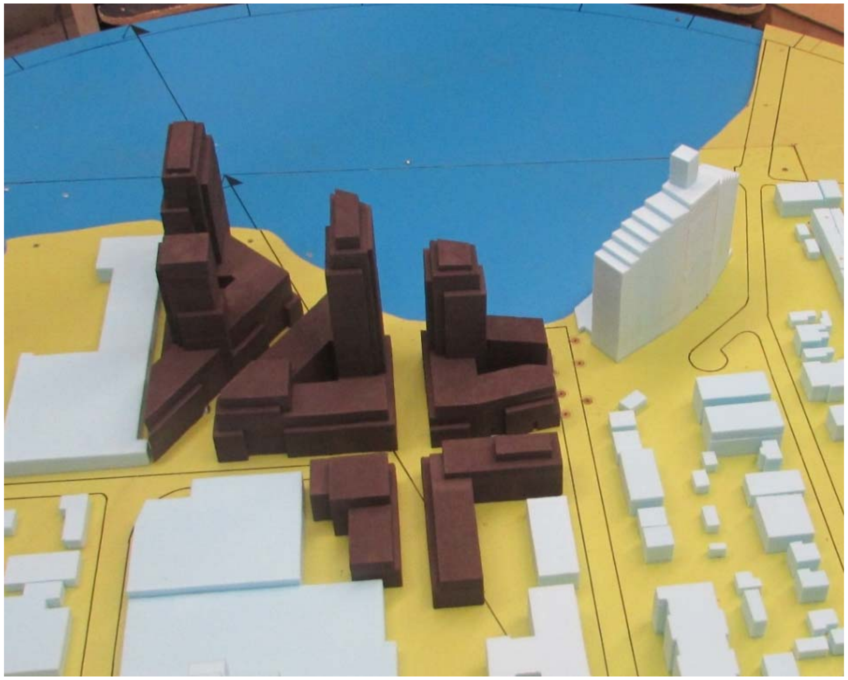
Specialist: Tahrana Lovlin, MAES, P.Eng.

TABLE OF CONTENTS



1.0 INTRODUCTION

Novus Environmental Inc. (Novus) was retained by 2030 Astoria Developers, LLC to conduct a wind tunnel study of pedestrian wind comfort and safety for the Astoria Cove Development in Astoria, Queens, New York. Previous CFD analysis, during the pedestrian wind assessment, had illustrated the potential for high wind speeds in the vicinity of the northeast corner of Building 3. Therefore, a wind tunnel study was undertaken to accurately determine the wind conditions in the area, with and without the proposed development in place. Note, the emphasis of this study is on potential safety concerns in the area; the discussion of wind comfort is included for completeness.

This report summarizing the wind tunnel study is submitted as part of an Environmental Impact Statement, prepared in connection with the land use application filed with the City of New York for the Astoria Cove Development, in accordance with the City Environmental Quality Review (CEQR procedures).

1.1 Existing Development

The proposed development is located in Pot Cove just west of the Robert F. Kennedy Bridge in Queens, NY. **Figure 1** provides an aerial view of the immediate study area.

Directly surrounding the proposed development there are mainly low-rise commercial properties, with some mid-rise residential properties further south, and low-rise residential properties to the east. There is also a mid-rise development immediately adjacent to the east.

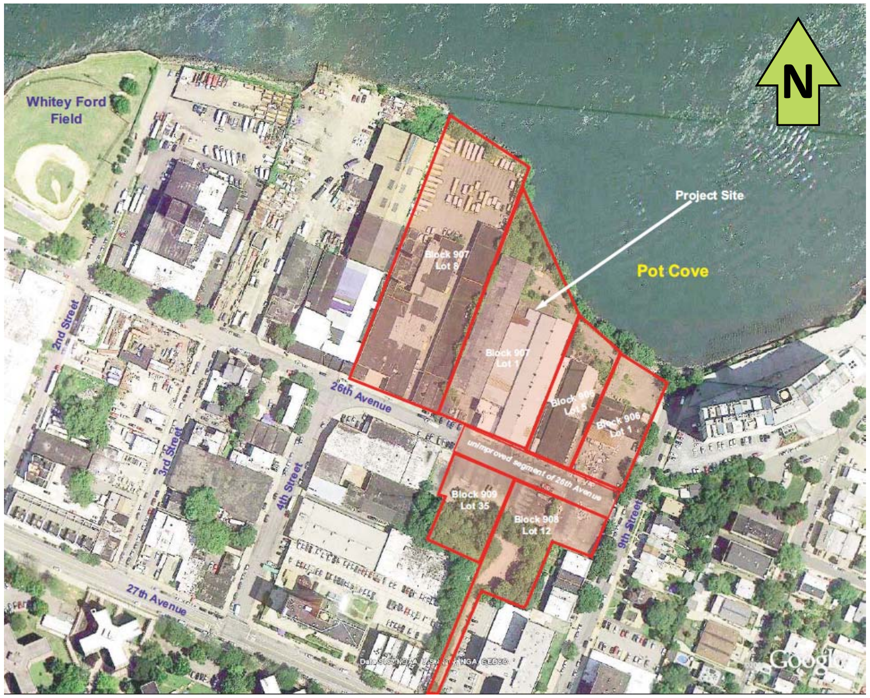


Figure 1: Context Plan
Credit: Philip Habib & Associates, January 20, 2014

Both existing and approved developments in the surrounding area were considered in the wind tunnel model, as provided in the 3-D Sketch-Up model. The approved Hallets Point development, to the west, was also included in this assessment.

1.2 Proposed Development

The proposed development includes five buildings, ranging in height from six to 32-storeys, with the taller buildings being located along the waterfront. The development will be mixed-use, including both commercial and residential spaces. The focus of this study is at the northeast corner of Building 3. A site plan for the entire proposed development is shown in **Figure 2**.

1.3 Areas of Interest

Areas of interest for pedestrian wind conditions include those areas which pedestrians are expected to use on a frequent basis. Typically these include sidewalks, main entrances, transit stops, plazas and parks. However, for this particular project, the emphasis was the wind conditions at the northeast corner of Building 3. In this area there are several building entrances, including retail entrances, the residential lobby entrance, and the townhouse entrances. In addition, there are the sidewalks along 9th Street, and the pedestrian walkway and park along the shore. Locations of interest surrounding Building 3 are identified in **Figure 3**.

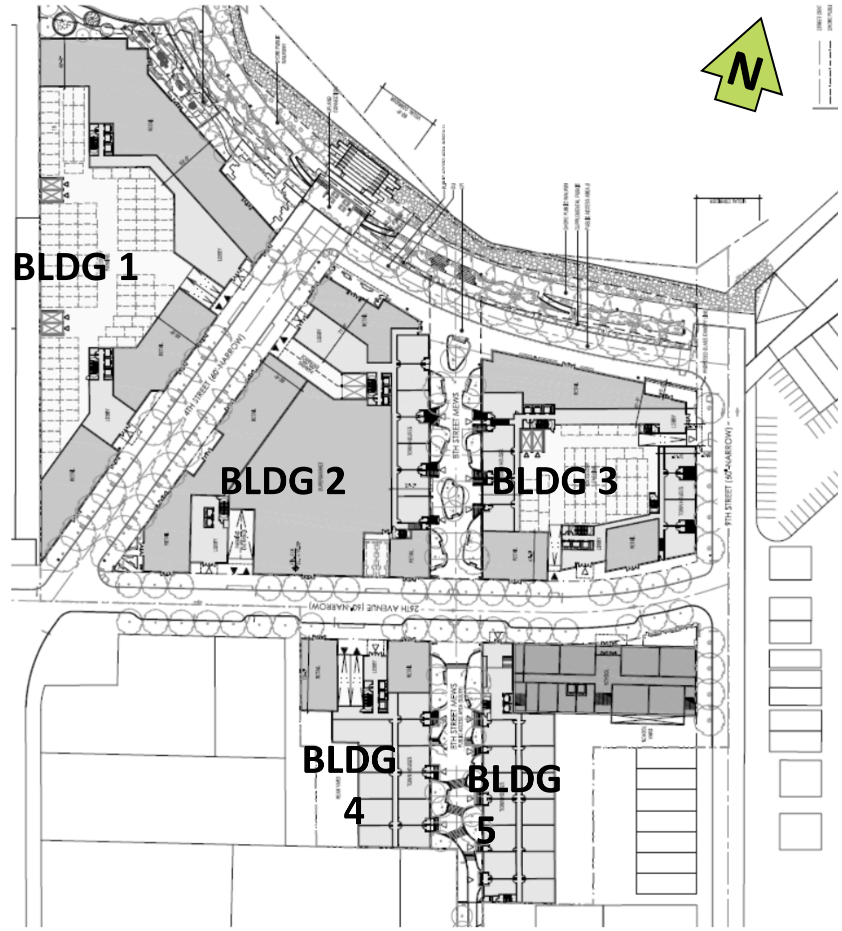
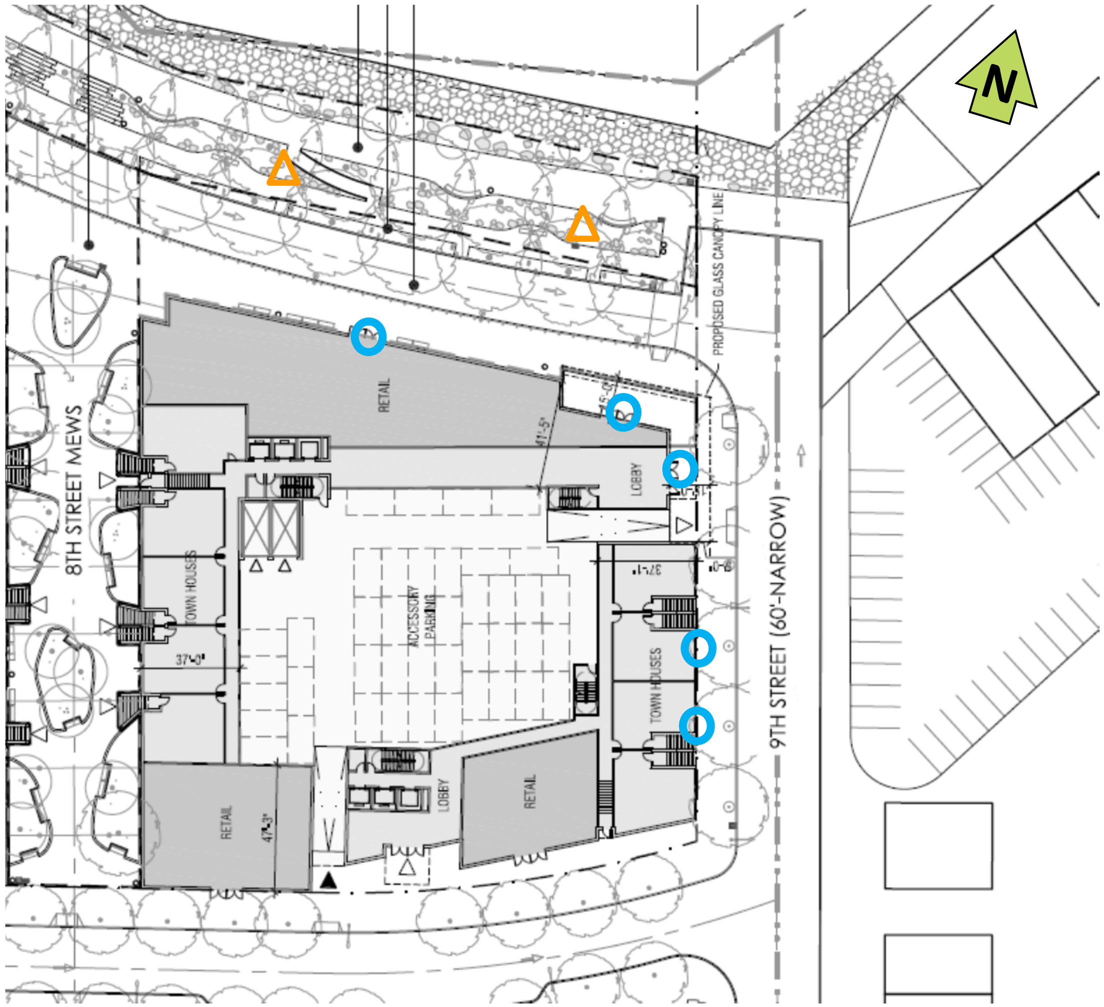


Figure 2: Site Plan of Proposed Development
Credit: Studio V Architecture



Building Entrances   Outdoor Amenity Spaces

Figure 3: Areas of Interest

2.0 APPROACH

The objective of the wind tunnel study is to assist the design team and City Planning officials in making informed decisions about the building form considered and its influence on pedestrian comfort. This quantitative analysis involves the construction of a physical model of the development and surrounding features that influence wind flow. The physical model is instrumented with probes and tested in a wind tunnel. Afterwards, the wind tunnel data are combined with regional meteorological data; this analysis is then compared to the relevant wind criteria and standards in order to determine how appropriate the wind conditions on site are for the intended pedestrian usage.

2.1 Scale Model Construction

A 1:400 scale model of the Astoria Development was constructed based on up-to-date drawing information received by Novus on June 24, 2014.

The proximity model of the surrounding area was built in block form for a radius of approximately 1600 ft from the site centre. As existing buildings surrounding the site will influence wind characteristics, existing buildings, those under construction and approved buildings (i.e., developments having an approved Land Use & Environment Review) were included in the model for both the Existing and Proposed Configurations. Information regarding which approved developments to include within the existing surrounds was based on the 3-D model provided by Philip Habib & Associates on January 23, 2014, which included the Hallets Point development to the west. Grade differences between the development site and water were included in the model.

Photographs of the wind tunnel model showing both the Existing and Proposed Configurations are included in **Figures 4a and 4b**.

2.2 Wind Tunnel

Wind tunnel tests were conducted in the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory at the University of Western Ontario. The upstream test section of the wind tunnel included generic roughness blocks and turbulence-generating spires to modify the wind flow approaching the model. These features develop characteristics of the wind flow that are similar to the actual site. The test model is rotated on a turn-table to simulate different wind directions with the upstream terrain being changed as appropriate to reflect the various upwind conditions encountered around the site.

The test model was equipped with 12 omni-directional probes to record wind speed at the pedestrian-level (approximately 5-6 ft above grade). The orientation of the model was rotated in 10° intervals on the turn-table to permit measurement of wind speed at each probe location for 36 wind directions. The wind tunnel data were then combined with the wind climate model for this region to predict the occurrence of wind speeds in the pedestrian realm and compare against wind criteria for comfort and safety.

Figure 4a: Existing Configuration

Figure 4b: Proposed Configuration

2.2 Wind Climate

Wind data recorded at LaGuardia International Airport for the period of 1996 to 2011 were obtained and analysed to create a wind climate model for the seasonal extremes. Annual and seasonal wind distribution diagrams ("wind roses") are shown in **Figure 5**. These diagrams illustrate the percentage of time wind blows from the 16 main compass directions. Of main interest are the longest peaks that identify the most frequently occurring wind directions. The annual wind rose indicates that wind approaching from northwesterly, northeasterly and southerly directions are most prevalent. The seasonal wind roses readily show how the prevalent winds shift throughout the year.

The directions from which stronger winds (e.g., > 19 mph) approach are also of interest as they have the highest potential of creating problematic wind conditions, depending upon site exposure and the building configurations. The wind roses in **Figure 5** also identify the directional frequency of these stronger winds, as indicated in the figure's legend colour key. On an annual basis, strong winds occur from northwest sectors.

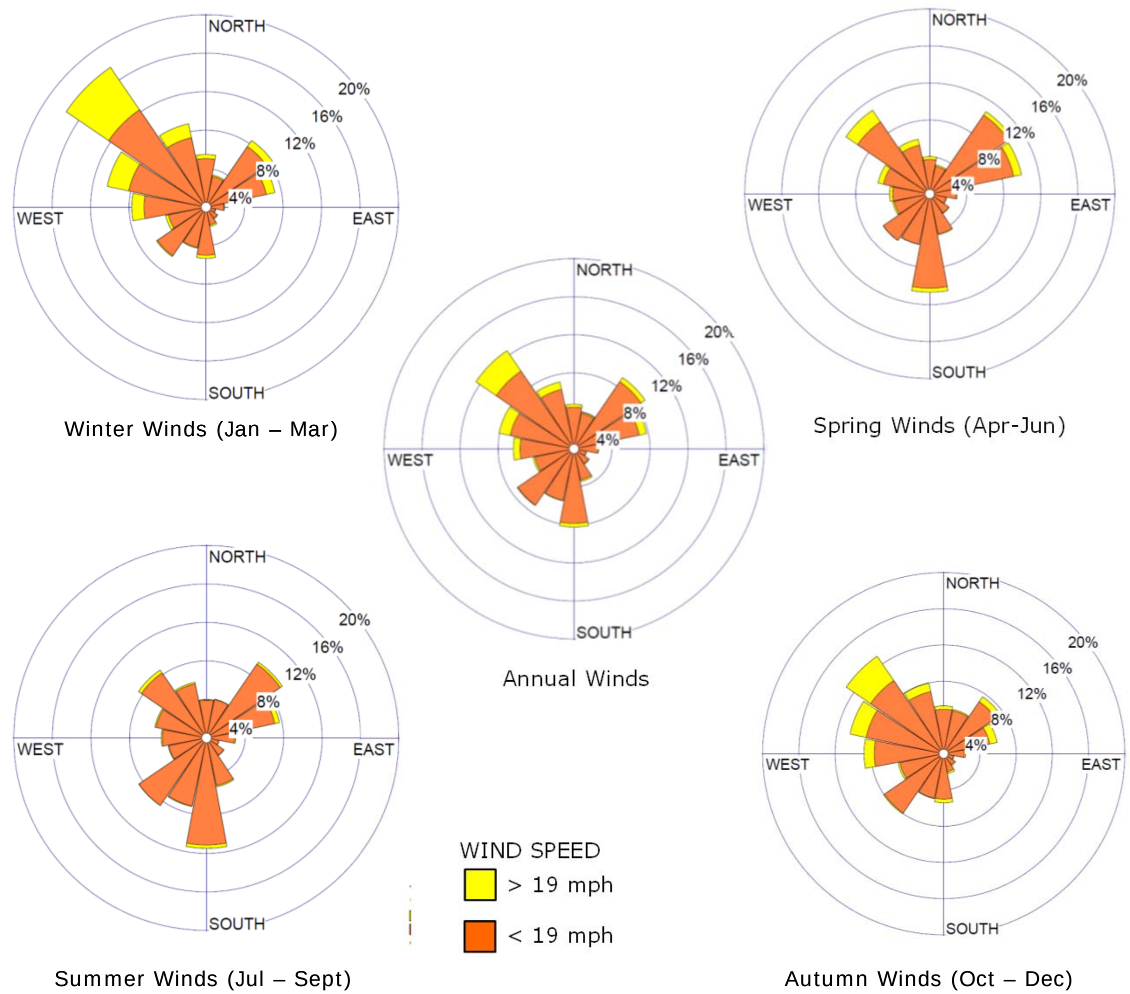


Figure 5: Wind Roses for LaGuardia International Airport (1996-2011)

3.0 PEDESTRIAN WIND CRITERIA

Wind comfort conditions are discussed in terms of being acceptable for certain pedestrian activities and are based on predicted wind force and the expected frequency of occurrence. Wind chill, clothing, humidity and exposure to direct sun, for example, all affect a person's thermal comfort; however, these influences are not considered in the wind comfort criteria.

The comfort criteria, which are based on certain predicted hourly mean wind speeds being exceeded 5% of the time, are summarized in **Table 1**. Very roughly, this is equivalent to a wind event of several hours duration occurring about once per week.

Two criteria for wind safety are shown in **Table 2**, and are based on hourly mean wind speeds that are exceeded 0.1% of the time (approximately nine hours per year). The lower value was used in the assessment of a nearby development, and relates to areas typically used by elderly and the infirm and on bicycle paths. The higher value, typically used by Novus, is more applicable to the general population. When more than three, 3-hour events (nine hours a year) are predicted to exceed the criterion on an annual basis, wind mitigation measures are then advised, especially for frequently accessed areas.

The criteria for wind comfort and safety used in this assessment are based on those developed at the Boundary Layer Wind Tunnel Lab of the University of Western Ontario, together with building officials in London England. They are based broadly on the Beaufort scale and on previous criteria that were originally developed by Davenport. The criteria are used by the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory for pedestrian wind study projects located around the globe. For a list of references, describing the criteria and history of its development see Section 7.0.

Table 1: Wind Comfort Criteria

Activity	Comfort Ranges for Mean Wind Speed Exceeded 5% of the Time		Description of Wind Effects
Sitting	0 to 9 mph	0 to 4 m/s	• Light wind felt on face • Leaves rustle
Standing	0 to 14 mph	0 to 6 m/s	• Hair is disturbed, clothing flaps • Light leaves and twigs in motion • Wind extends lightweight flag
Leisurely Walking	0 to 18 mph	0 to 8 m/s	• Moderate, raises dust, loose paper • Hair disarranged • Small branches move
Fast Walking	0 to 22 mph	0 to 10 m/s	• Force of wind felt on body • Trees in leaf begin to move • Limit of agreeable wind on land
Uncomfortable	> 22 mph	> 10 m/s	• Small trees sway • Umbrella use becomes difficult

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded 3 Times per Year (3x3hr)		Description of Wind Effects
Any [1]	34 mph	15 m/s	• Difficult to walk straight • Wind noise on ears unpleasant
	45 mph	20 m/s	

[1] The lower safety threshold of 34 mph relates to areas typically used by elderly and the infirm and on bicycle paths, while the higher value is more applicable to the general population.

4.0 RESULTS

4.1 Interpretation of Results

The analysis of wind comfort was undertaken for all four seasons in this study. The results for the summer and winter seasons are the focus of the discussion within this report and are displayed on plans and in graph form, as per the following examples. Full detailed results for the spring and autumn seasons can be found in **Appendix A**.

In the graphs, the vertical bars represent the mean wind speed (in mph) exceeded 5% of the time for the test configurations at each location. The dashed horizontal lines represent wind speed thresholds for the wind comfort criteria (**Figure 6a**). At the right side of each graph are white bars that represent ambient wind conditions for typical suburban and rural areas of this region. The blue bars represent wind conditions in the Existing Configuration, while the green bars represent the Proposed Configuration. For example, wind conditions at Sensor #4 were suitable for leisurely walking in the Existing Configuration and standing in the Proposed Configuration. **Figure 6b** illustrates the safety criteria.

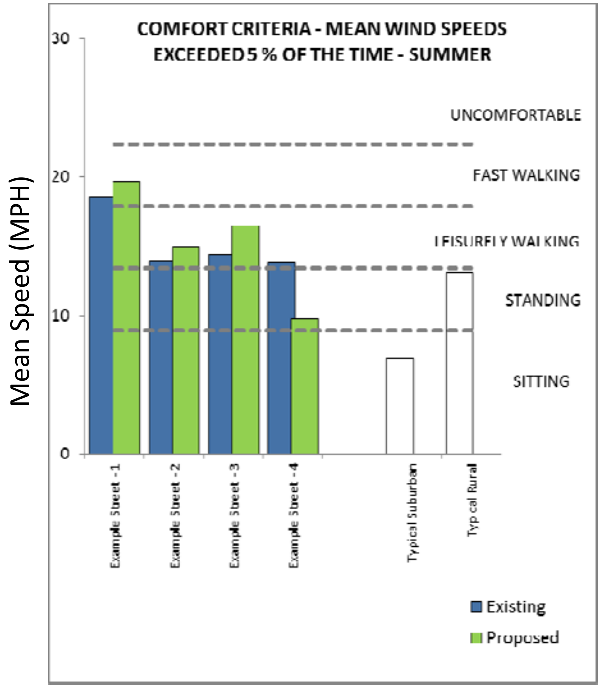


Figure 6a: Example Results – Comfort Criteria (5% Mean Wind Speeds)

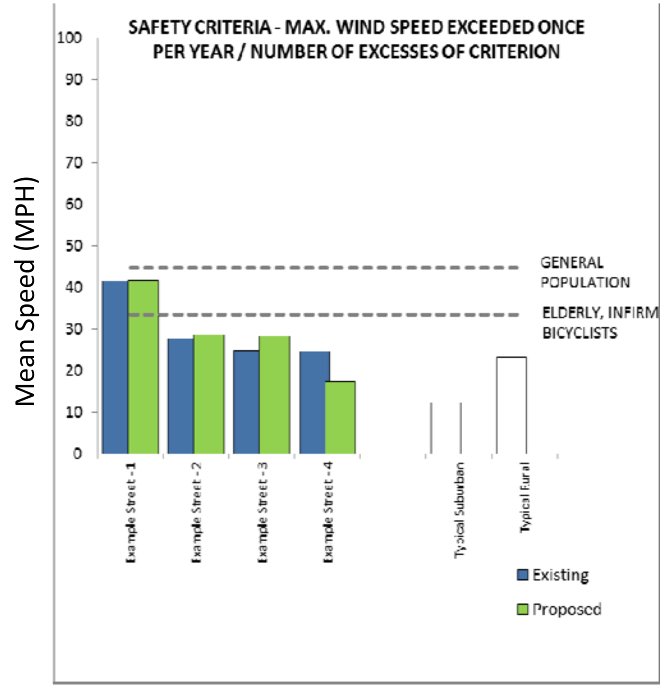


Figure 6b: Example Results – Safety Criteria (Annual 0.1% Mean Wind Speeds)

4.2 Discussion of Results

Generally, conditions surrounding the northeast corner of Building 3 were similar or improved from the Existing Configuration with the proposed development in place.

Results are presented through discussion of the wind conditions on the site, and along nearby major streets, all of which were previously outlined in Section 1.3. Note the comfort criterion are based on wind force alone, thus climate issues that influence a person's overall "thermal" comfort (e.g., temperature, humidity, wind chill, shade, etc.) are not considered in this analysis.

There are generally accepted wind comfort levels that are desired for various pedestrian uses. For example, for public sidewalks, wind comfort suitable for **leisurely walking** would be desirable year-round. For main entrances and transit stops, wind conditions conducive to **standing** would be preferred throughout the year, but can be difficult to achieve in regions where winter winds are inherently harsh. For amenity spaces, wind conditions suitable for **sitting** and/or **standing** are generally desirable during the summer months. The most stringent category of **sitting** is considered appropriate for cafes and public parks during the summer.

Figure 7: Proposed Configuration

4.2.1 Building Entrances & Walkways (Locations 1 – 12)

For the Existing Configuration, wind conditions were generally suitable for leisurely walking or better in the summer (see **Figure 9a**). In the winter, wind conditions were generally conducive to fast walking or better (see **Figure 9b**). The exception, in both seasons, was near the adjacent existing building (Location 9), where wind conditions were suitable for fast walking in the summer and were uncomfortable in the winter.

With the proposed development in place, wind conditions were generally similar (see **Figure 8**). In the summer, wind conditions were suitable for sitting or standing at the various entrances (Locations 1 to 3 and 5 to 7). Further away from the building, along the east sidewalk of 9th Street, as well as along the shoreline walkway, wind conditions were conducive to fast walking or better in the summer. At the corner of Building 3, wind conditions were suitable for leisurely walking in the summer.

During the winter, wind conditions along the north facade (Locations 1 to 3) were suitable for standing in the winter time (see **Figure 8**). At the residential lobby and some of the townhouse entrances (Locations 5 and 6), conditions were suitable for leisurely walking in the winter. Along the east side of 9th street, as well as along the shoreline walkway wind conditions were generally suitable for leisurely walking or better in the winter. Wind conditions near the adjacent building (Location 9) were uncomfortable in the winter. However, these wind conditions are similar to existing conditions (see **Figures 9a** and **9b**). The high wind speeds along 9th Street are an existing issue, and are due to the orientation of the existing building in conjunction with the predominant northwesterly and northeasterly winds.

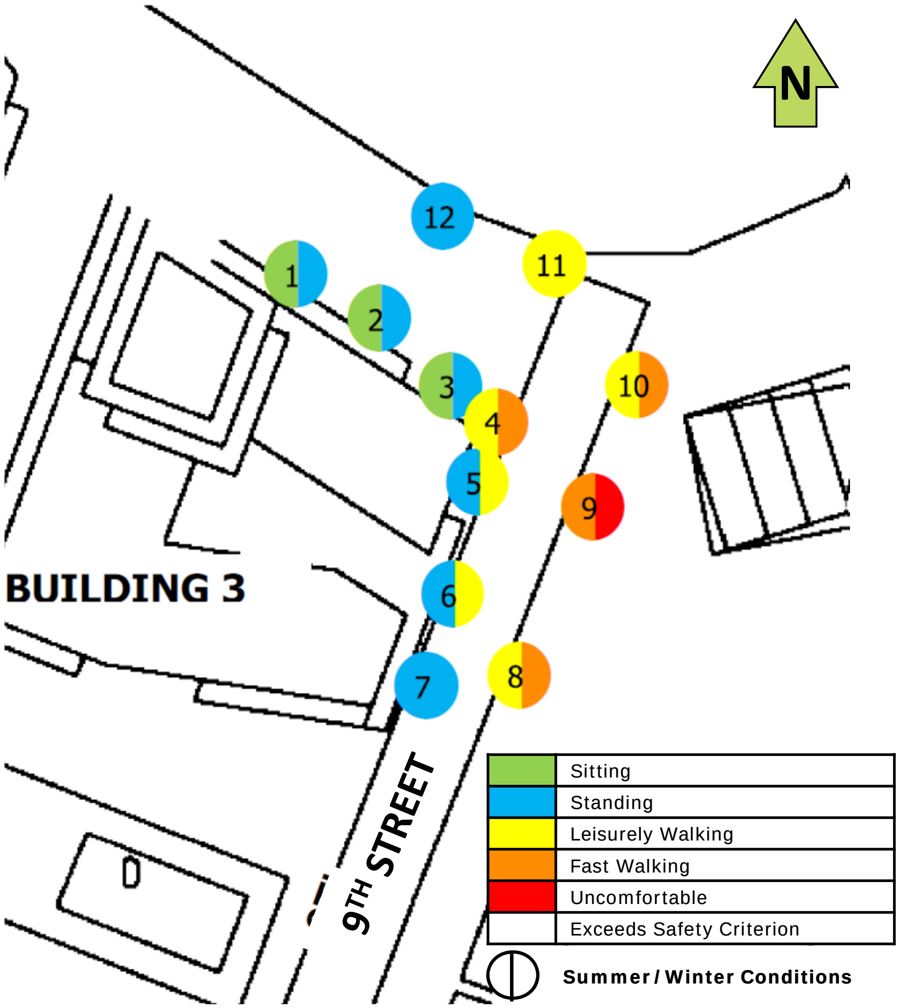


Figure 8: Proposed Configuration

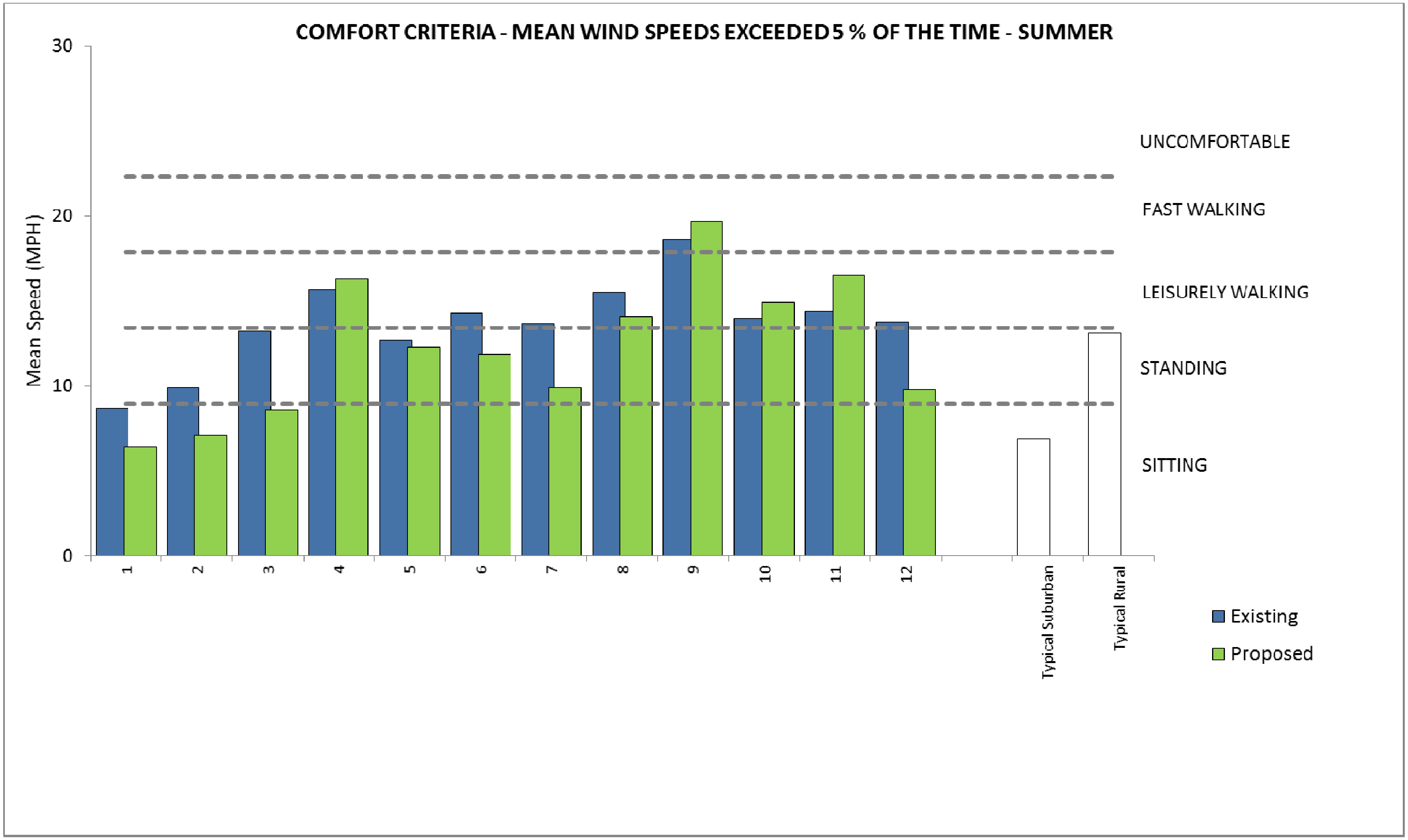


Figure 9a: Wind Comfort Results – Summer

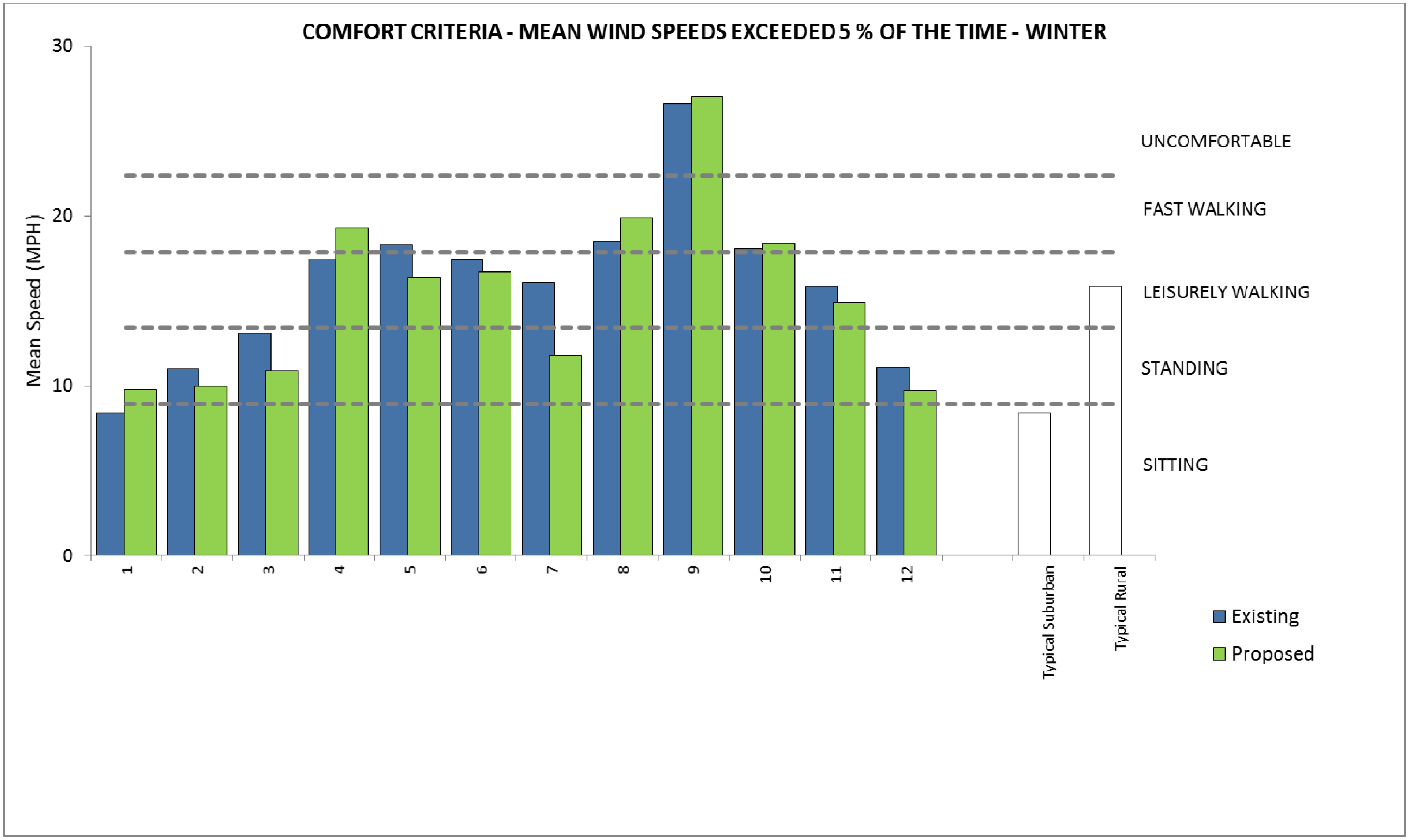


Figure 9b: Wind Comfort Results – Winter

4.3 Wind Safety

The wind safety results are presented for two criteria: the criterion typically used by Novus (45 mph) and the one previously used by CPP (34 mph) for a nearby development. Both wind speed values are based on the “Lawson Criteria”. The lower value relates to vulnerable populations and cyclists, while the higher value is applicable for the general population.

The safety criterion was met at all location in both the Existing and Proposed Configurations, if the higher value of 45 mph is used. If the lower value of 34 mph is used, the area adjacent the existing building (Location 9) does not meet the safety criterion on an annual basis (see Figure 10). However, this occurs in both the Existing and Proposed Configurations, which confirms these wind conditions as an existing issue. The wind safety conditions did not change with the Astoria Cove Development present.

As stated in the CEQR Technical manual, in the event that studies indicate the potential for exacerbation of pedestrian wind conditions that could affect pedestrian safety, modifications to the urban design features of the projects, including changes to the building massing, landscaping and other measures, should be considered. While this wind tunnel study indicates that the proposed development would increase wind speeds in some areas along the Building 3 facade, these wind conditions are not considered uncomfortable nor do they exceed the safety criterion. Thus no changes to the urban design of the Astoria Cove Development are warranted pursuant to CEQR.

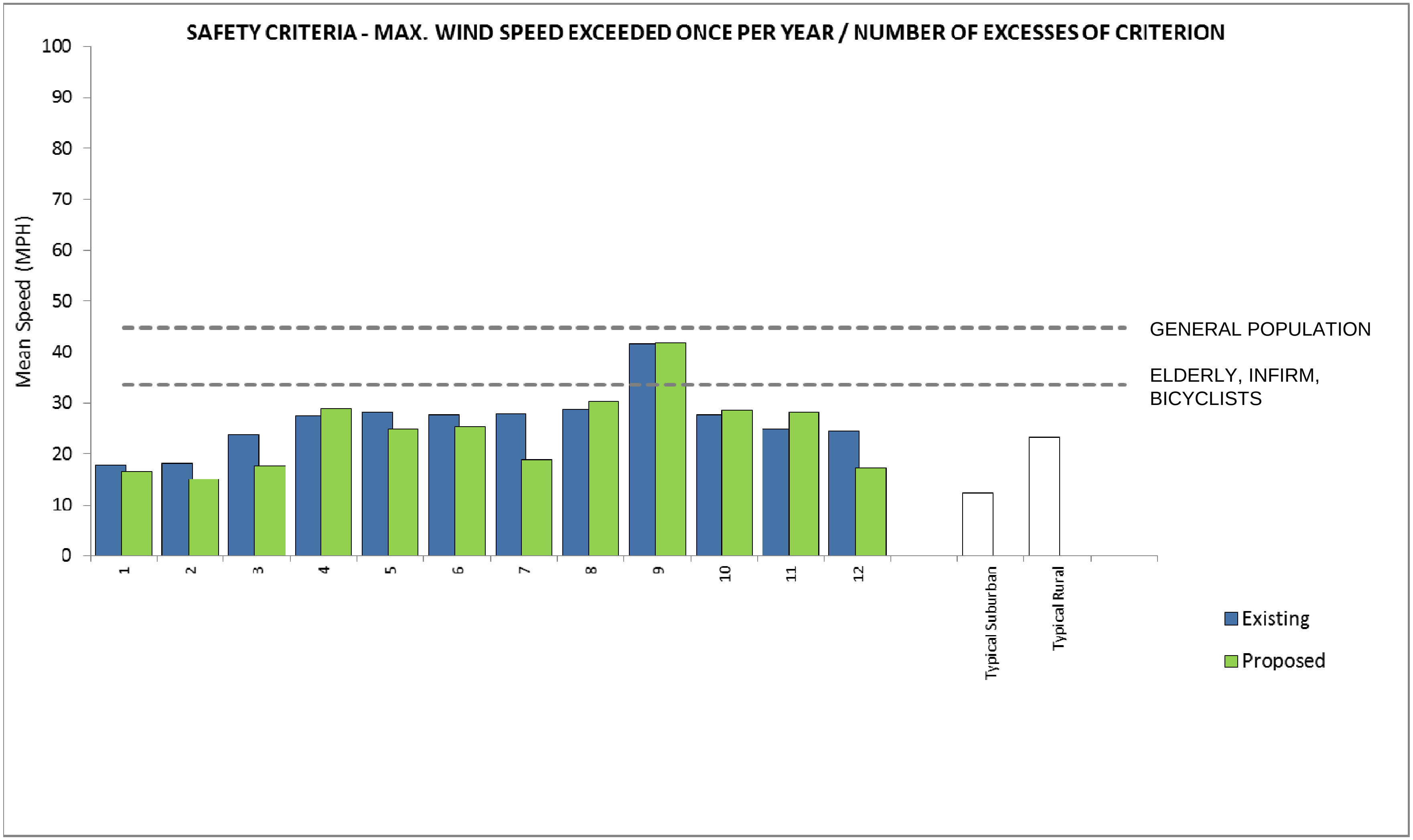


Figure 10: Wind Safety Results – Annual

5.0 CONCLUSIONS

The pedestrian wind conditions around Building 3 of the proposed development in Astoria Cove have been assessed through wind tunnel modelling techniques. Based on the results of our study, the following conclusions and recommendations have been reached:

- Wind conditions around Building 3 of the proposed development were generally unchanged from the Existing Configuration.
- The entrances on the north facade of Building 3 were suitable for the intended use.
- The fast walking and uncomfortable wind conditions occurring on 9th Street are an existing issue.
- The wind safety conditions did not change with the Astoria Cove development in place.

6.0 STUDY APPLICABILITY

This study is based on wind tunnel testing and provides a qualitative analysis of the pedestrian wind comfort conditions on and around the proposed development. Any subsequent alterations to the design may influence these findings. Novus should be contacted to provide additional comments and/or recommendations for additional analysis of the design revisions.

Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Sincerely,
Novus Environmental Inc.

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Scientist – Microclimate

Tahrana Lovlin, MAES, P.Eng.
Specialist- Microclimate

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Appendix A

Pedestrian Wind Comfort Results

Spring (April – June) and Autumn (October – December)

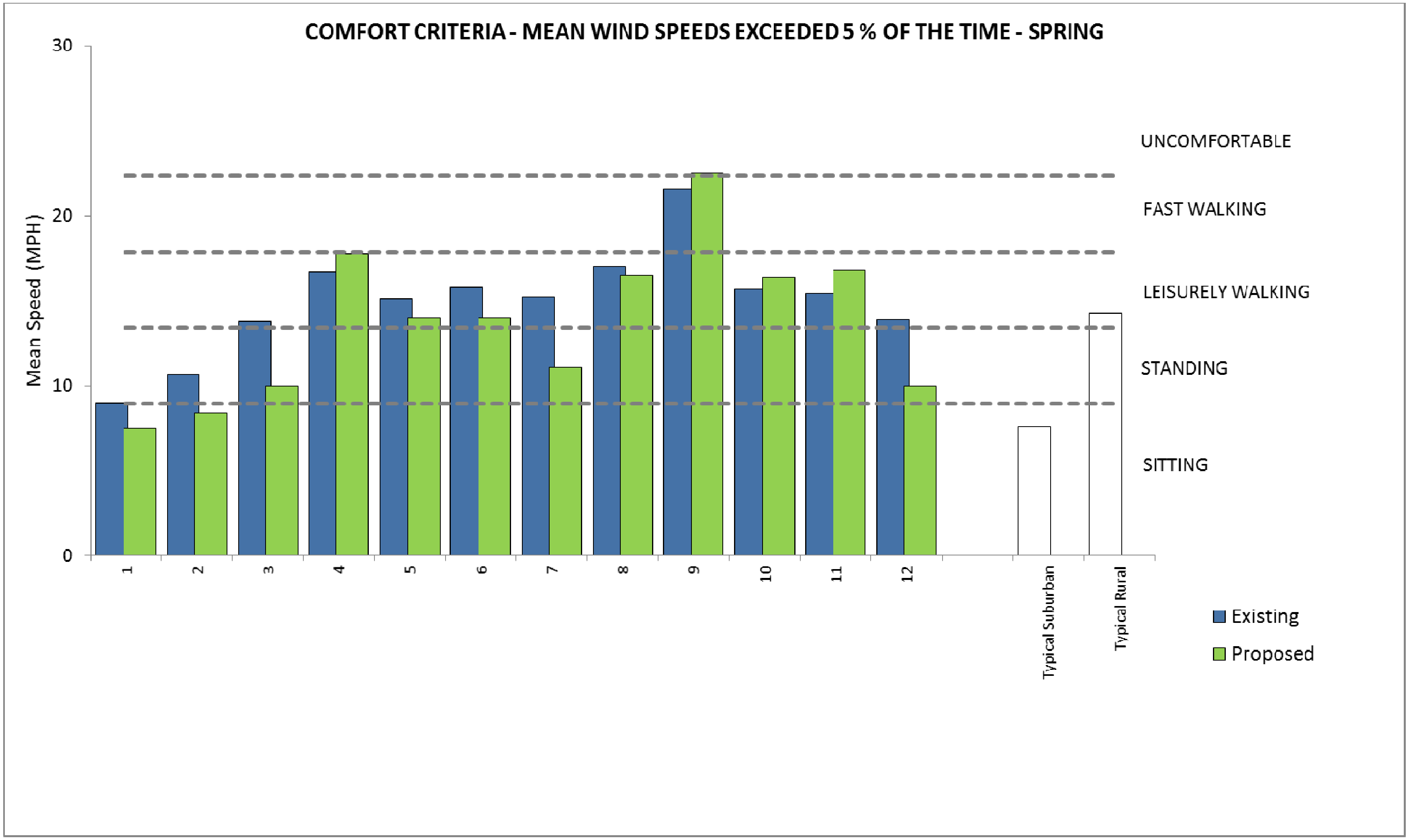

Figure A1: Pedestrian Wind Conditions – Spring Season

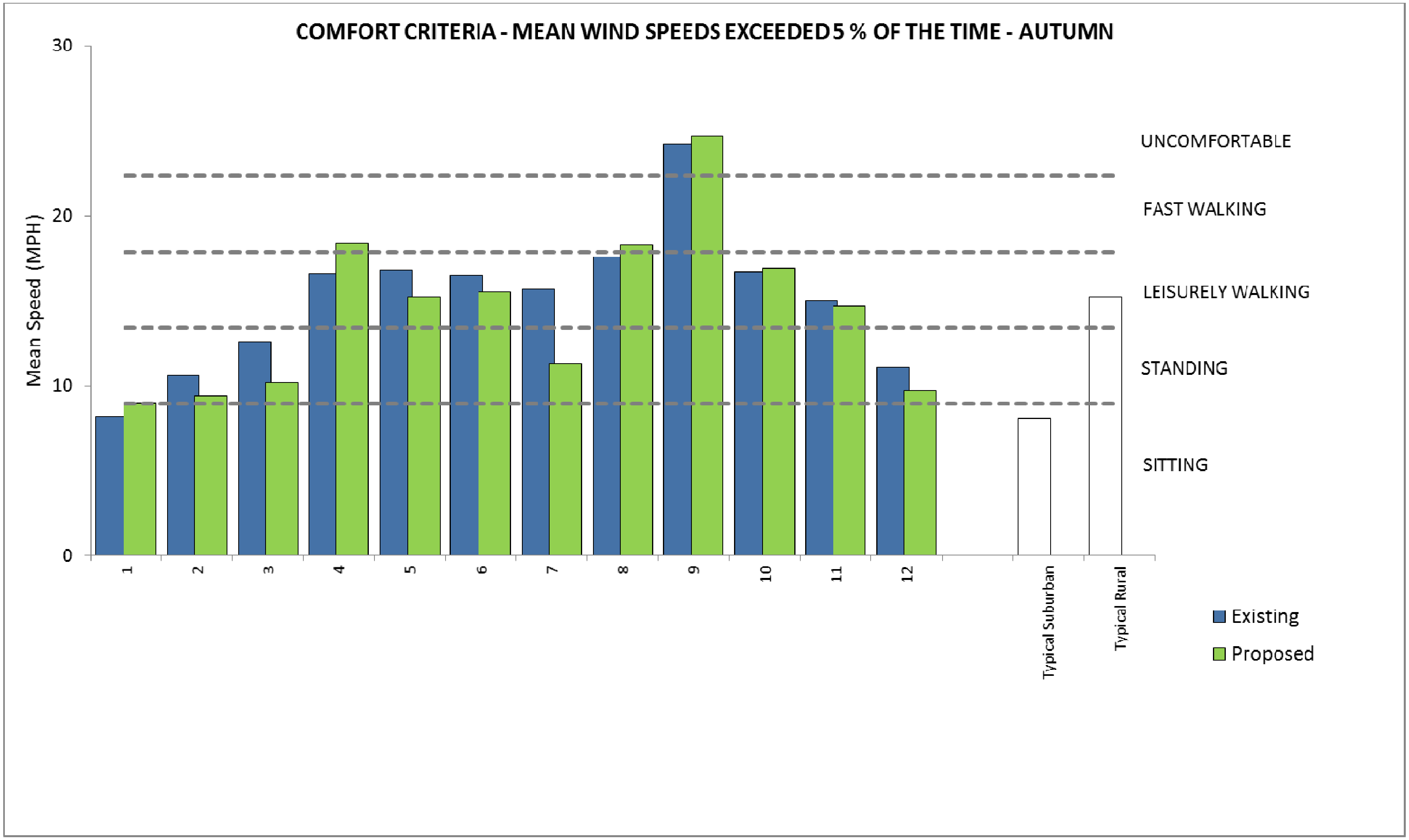

Figure A2: Pedestrian Wind Conditions – Autumn Season