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23/02/18
PROVINCE OF ONTARIO

Date: February 23, 2018

To: 2526574 Ontario Limited
4800 Dufferin Street
Toronto, Ontario M3H 5S9

Re: **Pedestrian Wind Assessment**
Ladies Golf Club of Toronto
Markham, Ontario
Novus Project #17-0386

Kirkor Architects + Planners

Novus Team:

Senior Engineer:	Jenny Vesely, P.Eng
Specialist:	Tahrana Lovlin, MAES, P.Eng.

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1.0 INTRODUCTION

Novus Environmental Inc. (Novus) was retained by 2526574 Ontario Limited to conduct a pedestrian wind assessment for the proposed Ladies Golf Club of Toronto development on a small portion of the golf course site located on Royal Orchard Boulevard in Markham, Ontario. This report is in support of the Official Plan Amendment (OPA) and Zoning By-law Amendment (ZBA) application for the development.

1.1 Existing Development

The proposed development is located on Royal Orchard Boulevard, just west of Bayview Avenue. The site is currently occupied by a golf course. **Figure 1** provides an aerial view of the immediate study area. A virtual site visit was conducted by Novus using Google Earth images dated August and September 2017; these images are included in **Figures 2a** through **2d**.

Immediately surrounding the site is the golf course to the south through west, low-rise residential buildings to the northwest and north, and Bayview Avenue to the northeast through southeast. Beyond the immediate surroundings there are low-rise residential buildings to the south through west to northeast, with mid to high-rise residential buildings immediately east of Bayview Avenue, and low-rise commercial beyond to the east and southeast.

Approved developments and developments under construction in the surrounding area are typically included as existing surroundings for the analysis. However, no such developments were identified in a 500m radius of the proposed development.

Figure 1: Aerial view of existing site and surroundings
Credit: Google Earth Pro™, dated October 9, 2016

Figure 2a: Looking south along Royal Orchard Boulevard at site

Figure 2b: Looking west along Royal Orchard Boulevard

Figure 2c: Looking north along Bayview Avenue (Royal Orchard Blvd. access on left)

Figure 2d: Looking east along Green Lane

1.2 Proposed Development

The proposed residential development consists of two buildings, connected by a single storey podium. Building A, on the north half of the site, is 12-storeys tall for a total height of approximately 42m. Building B, on the south half of the site, is 14-storeys tall for a total height of approximately 49m. The building is oriented with the long axis aligned in a northwest/southeast direction. The existing grade of the site generally falls from north to south and from east to west. The west edge of the site drops approximately 3m, thus allowing a "walkout basement" condition on the west side of the building. A rendering of Building A is shown in **Figure 3**.

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. There is a transit stop on the north side of Royal Orchard Boulevard (north of the proposed site). There is also a proposed public park immediately north of the proposed development.

There is outdoor amenity space on Level P1 along the west facade of Building A, in addition to the amenity space at grade level along the west side of the podium connecting Buildings A and B. These areas are all shown in **Figure 4**.

Figure 3: Rendering of Proposed Development (Building A)
Credit: Kirkor Architects + Planners

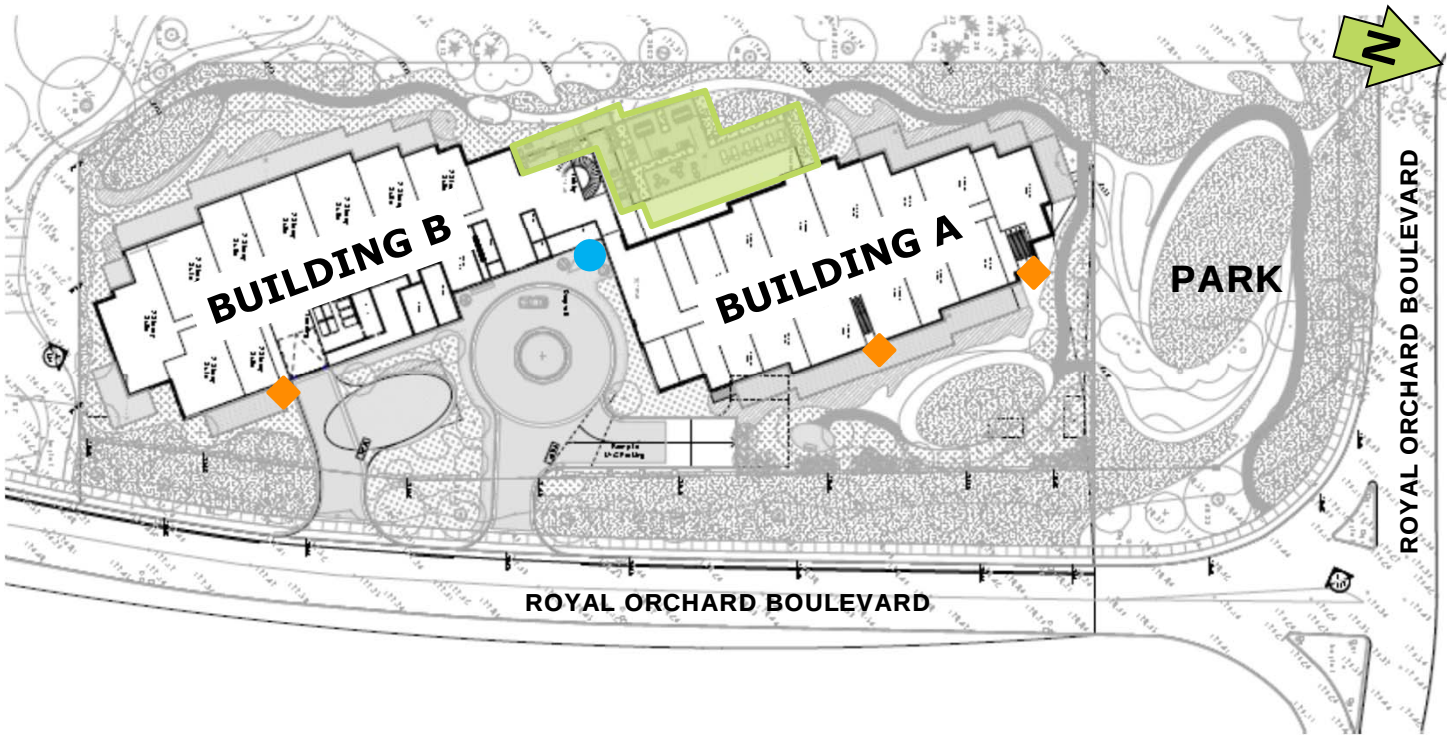


Figure 4: Areas of interest on grade level plan

LEGEND

- Main Entrance (at grade level, east side)
- Secondary Entrance (at grade level, east side)
- Outdoor Amenity Space – Level P1 (at grade level, west side)

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, especially when assessing mean wind speeds. This CFD-based mean wind speed assessment employs a comparable analysis methodology to that used in wind tunnel testing. The results of CFD modeling are also 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 3D model of the proposed development as well as floor plans and elevations were provided by Kirkor Architects + Planners on January 19, 2018. A view of the 3D model used in the computer wind comfort analysis is shown in **Figure 5**. This model included surrounding buildings within approximately 480m from the study site. The simulations were performed using CFD software by Meteodyn 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 and wind characteristics encountered around the actual site. Wind flows for a total of 16 compass directions were simulated. Although wind speeds are calculated throughout the entire modeled area, wind comfort conditions were only plotted for a smaller area immediately surrounding the proposed development.

Wind flows were predicted for both the existing site, as well as with the proposed development for comparison purposes. 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. The analysis of wind conditions is undertaken for four seasons: Winter (January to March), Spring (April to June), Summer (July to September), and Autumn (October to December). However, only the seasonal extremes of summer and winter are discussed within the report. The results of the analysis for spring and autumn can be found in **Appendix A**.

Results are presented through discussion of the wind conditions along major streets and the areas of interest. 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.

Figure 5: Massing Model

2.3 Wind Climate

Wind data recorded at Pearson International Airport in Toronto for the period of 1986 to 2015 were obtained and analysed to create a wind climate model for the region. Annual and seasonal wind distribution diagrams ("wind roses") are shown in **Figure 6**. 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 the westerly through northerly 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., > 30 km/h) 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 6** 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 the northwesterly and westerly sectors. All wind speeds and directions were included in the wind climate model.

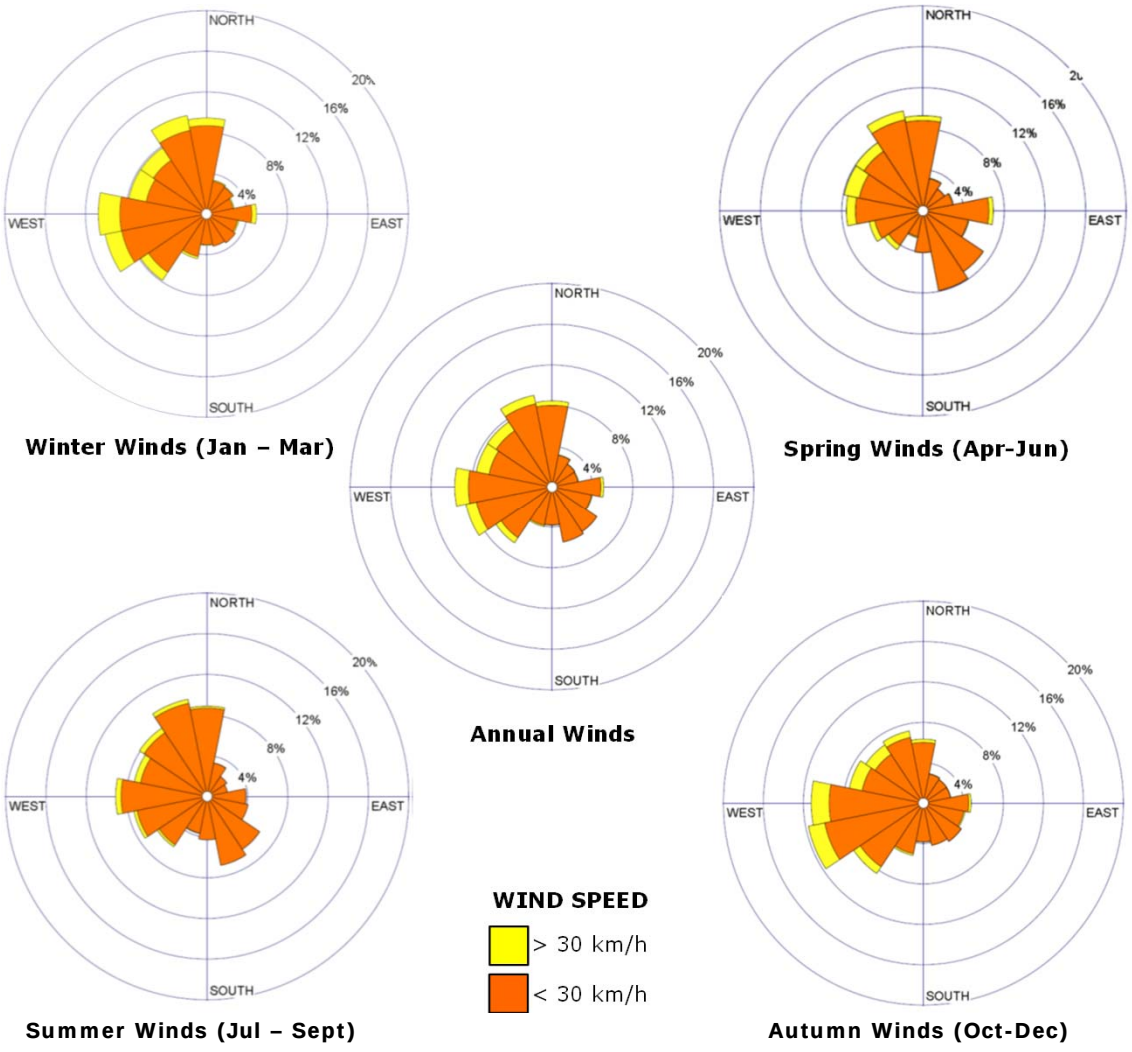


Figure 6: Wind Roses for Pearson International Airport (1986-2015)

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 once per year (approximately 0.01% of the time). When more than one event is predicted annually, wind mitigation measures are then advised. 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 broadly based 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.

Table 1: Wind Comfort Criteria

Activity	Comfort Ranges for Mean Wind Speed Exceeded 5% of the Time		Description of Wind Effects
Sitting	0 to 14 km/h	0 to 4 m/s	• Light wind felt on face • Leaves rustle
Standing	0 to 22 km/h	0 to 6 m/s	• Hair is disturbed, clothing flaps • Light leaves and twigs in motion • Wind extends lightweight flag
Leisurely Walking	0 to 29 km/h	0 to 8 m/s	• Moderate, raises dust, loose paper • Hair disarranged • Small branches move
Fast Walking	0 to 36 km/h	0 to 10 m/s	• Force of wind felt on body • Trees in leaf begin to move • Limit of agreeable wind on land
Uncomfortable	> 36 km/h	> 10 m/s	• Small trees sway • Umbrella use becomes difficult

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded Once Per Year (0.01%)		Description of Wind Effects
Any [1]	72 km/h	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 7a through **9b** present graphical images of the wind comfort conditions for the summer and winter months around the proposed development. These represent the seasonal extremes of best and worst case. **Appendix A** presents the wind comfort conditions for spring and autumn. The "comfort zones" shown are based on an integration of wind speed and frequency for all 16 wind directions tested with the seasonal wind climate model. 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.

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 dedicated seating areas, while for public parks **sitting** and/or **standing** would be appropriate in the summer.

4.1 Existing Wind Conditions

In the Existing Configuration, wind conditions around the proposed site (which is currently a par-3 hole on the golf course) are comfortable for standing in the summer, with wind conditions conducive to leisurely walking in the winter (**Figures 7a a**nd **8a**).

Wind conditions along Royal Orchard Boulevard are suitable for leisurely walking or better throughout the year. At the transit stop north of the proposed site, wind conditions are comfortable for sitting in the summer and standing in the winter (**Figures 7a** and **8a**). In the proposed park, wind conditions are conducive to standing in the summer and leisurely walking in the winter.

4.2 Building Entrances & Walkways

At the main entrance to the proposed building, in the middle of the east facade, wind conditions are comfortable for sitting in both the summer and winter seasons (**Figure 9a** and **9b**). These wind conditions are considered ideal for the intended usage.

At the three exits along the east facades of Buildings A and B, wind conditions are also calm, and hence comfortable for sitting throughout the year (**Figures 9a** and **9b**). These wind conditions are considered appropriate for the intended usage. At the north exit on Building A, we recommend keeping the exit door on the east facade, in an interior corner, where the door will be sheltered from the prevailing westerly winds that accelerate around the north side of the building.

On the walkways surrounding the proposed development, wind conditions are comfortable for leisurely walking or better in the summer (**Figures 7b** and **9a**). In the winter, wind conditions along the east and west sides of the proposed development are conducive to leisurely walking or better. Along the north and south facades, however, wind conditions are suitable for fast walking or are uncomfortable in the winter (**Figures 8b** and **9b**). These local wind accelerations are due to the downwashing of the prevailing westerly winds around the corners of the building. Recommendations for mitigation will be described in **Section 4.5**.

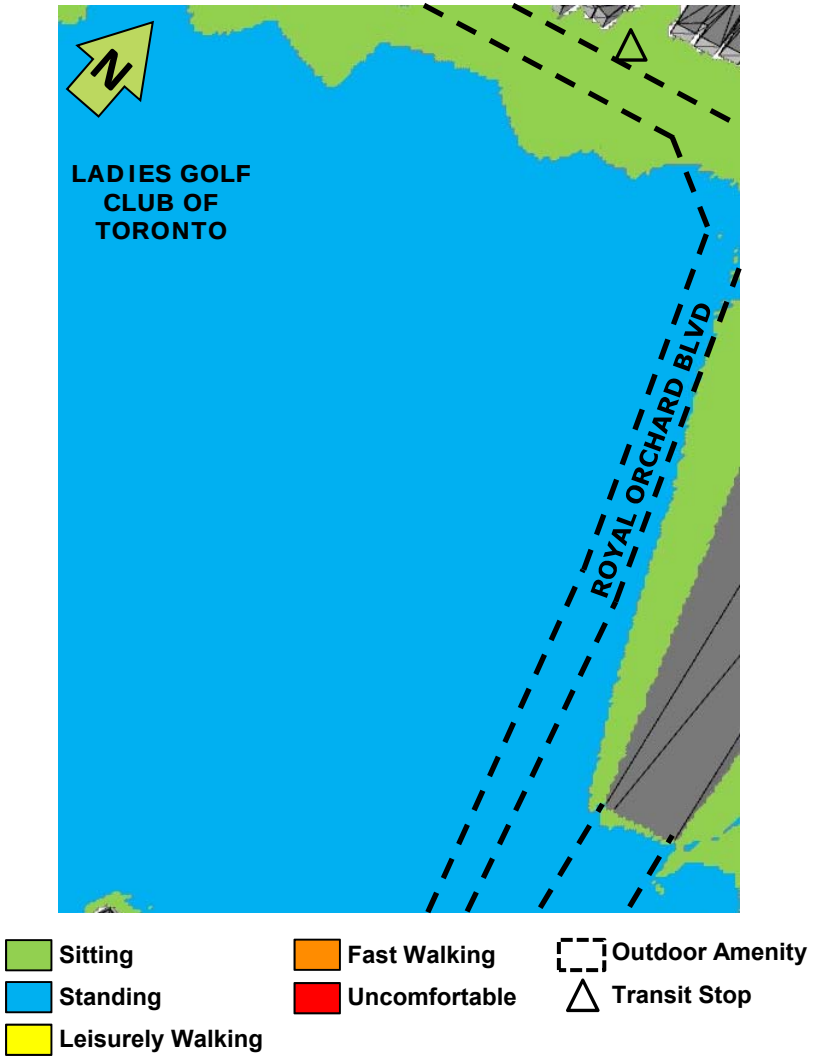


Figure 7a: Existing Conditions – Grade Level – Summer

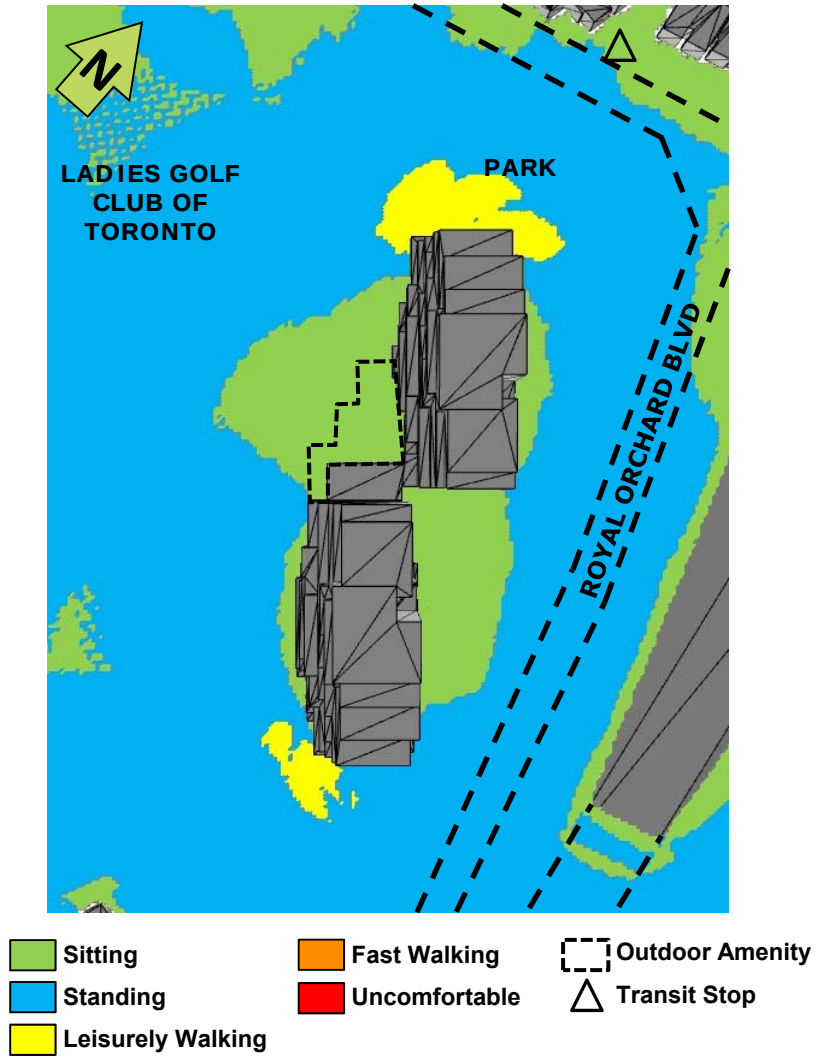


Figure 7b: Proposed Conditions – Grade Level – Summer

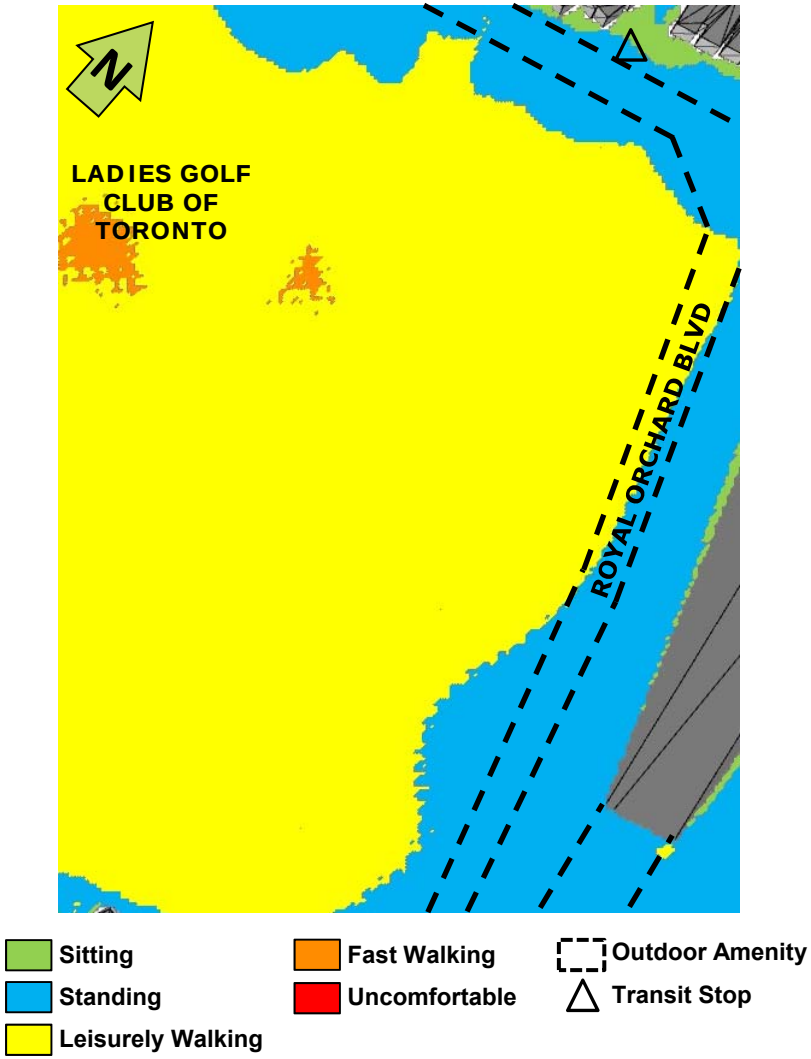


Figure 8a: Existing Conditions – Grade Level – Winter

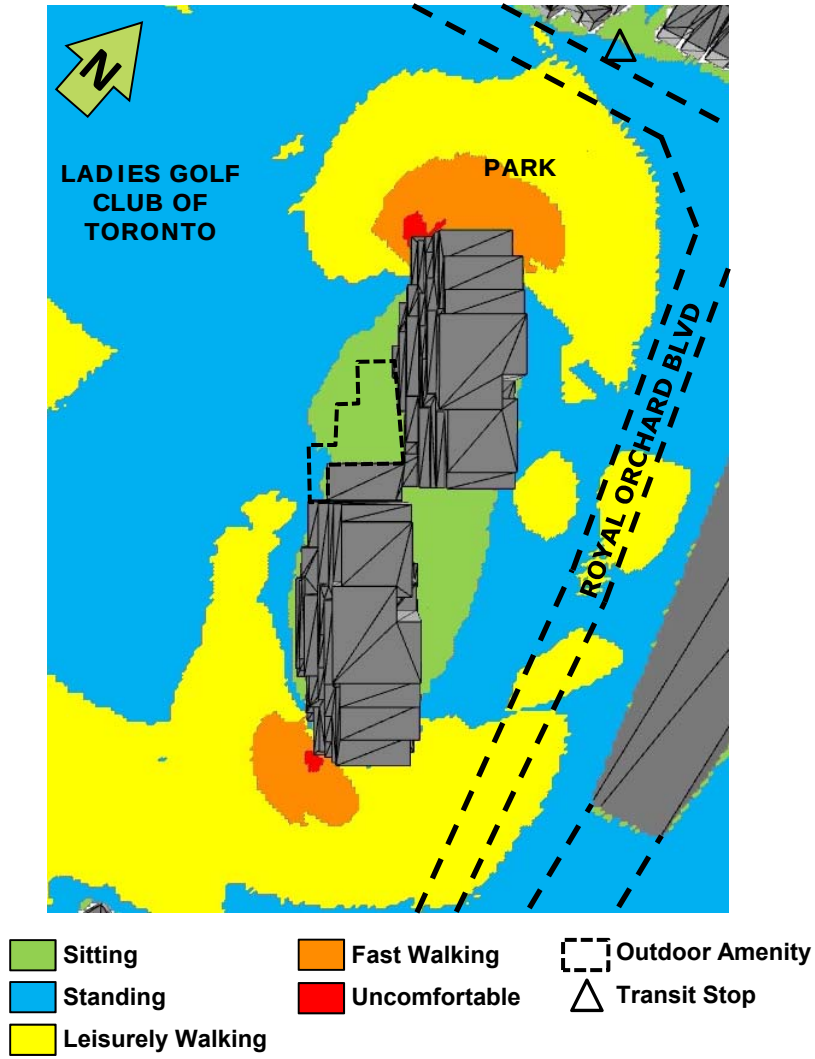


Figure 8b: Proposed Conditions – Grade Level – Winter

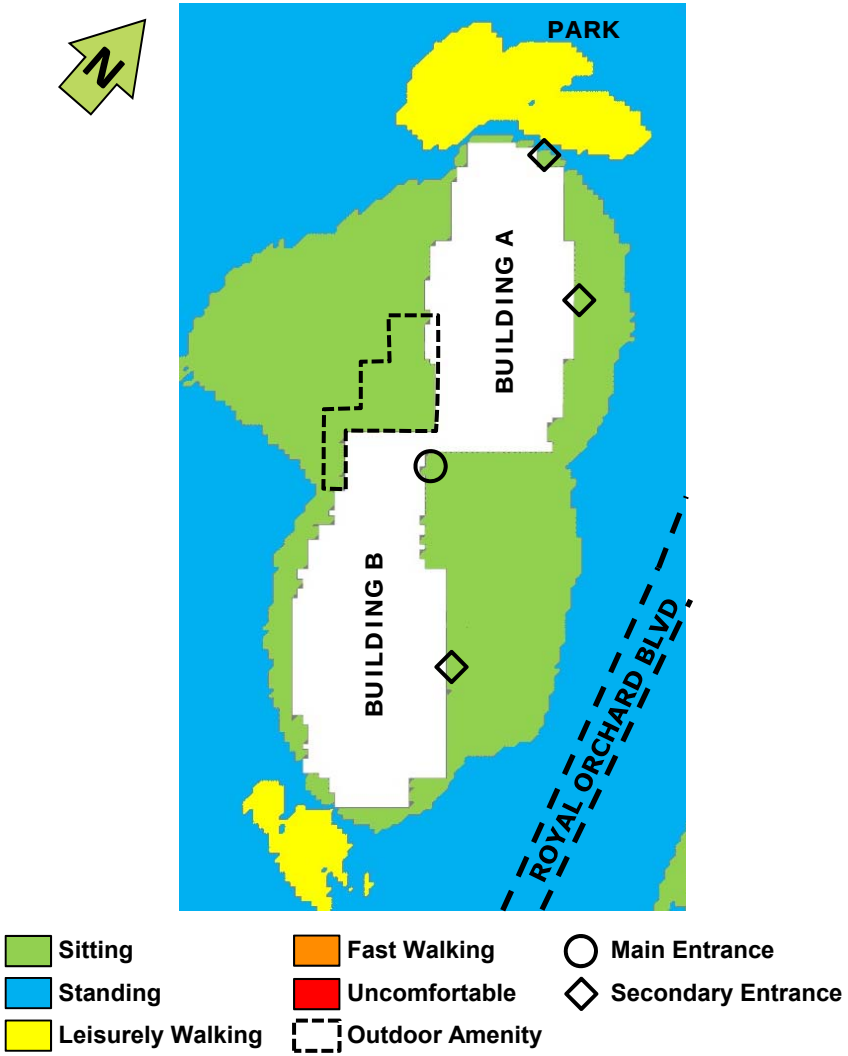


Figure 9a: Proposed Conditions – Summer – Building Footprint at Grade

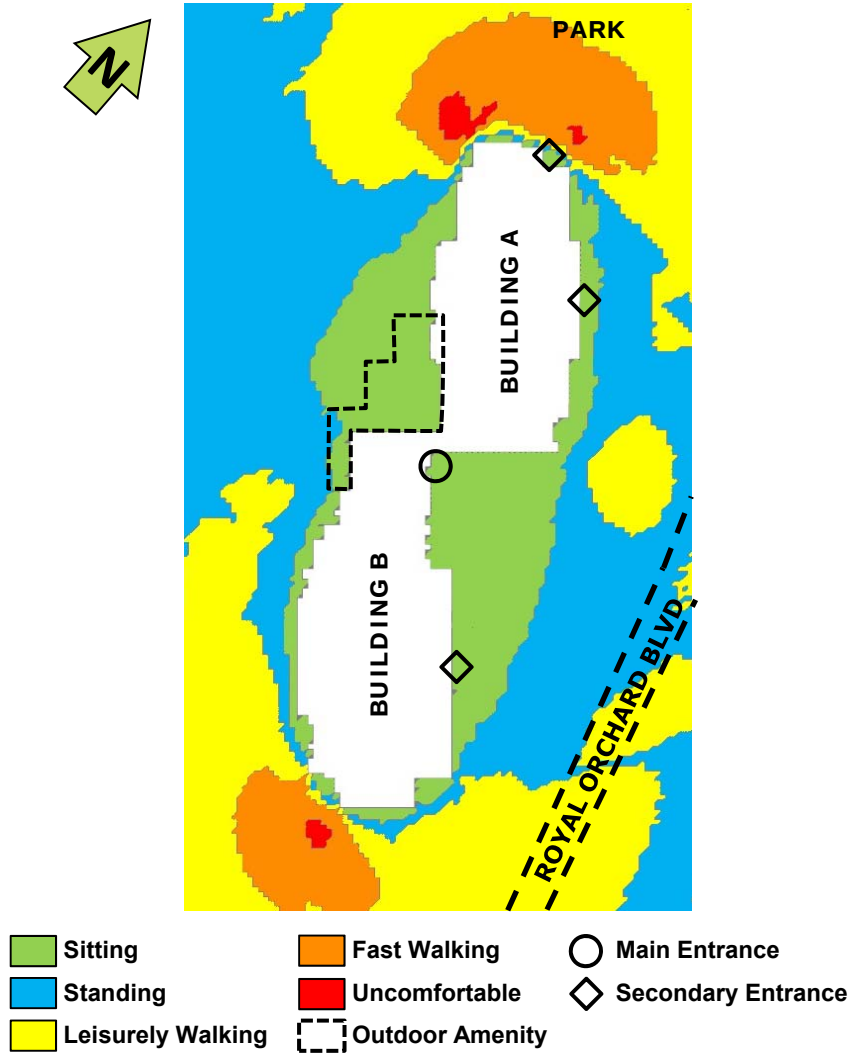


Figure 9b: Proposed Conditions – Winter – Building Footprint at Grade

4.3 Amenity Terraces

On the west side of the development there are amenity terraces at grade (**Figure 4**). In both the summer and winter seasons, wind conditions on these terraces are suitable for sitting or standing (**Figures 9a** and **9b**). Similar wind conditions occur in the spring and autumn (**Appendix A**). These wind conditions are considered appropriate for the expected usage. Due to the exposure of these terraces to the afternoon sun in the summer and the overall calmness of the wind conditions, the design team should consider shading features for the area (architectural and/or landscaping) in order to optimize thermal comfort.

4.4 Surrounding Sidewalks & Park

Wind conditions along Royal Orchard Boulevard remain suitable for leisurely walking or better throughout the year (**Figures 7b** and **8b**). At the transit stop to the north of the proposed development, wind conditions remain comfortable for sitting or standing throughout the year. These wind conditions are considered appropriate for the expected usage.

Wind conditions in the proposed park (north of the proposed development) are suitable for leisurely walking or better in the summer (**Figures 7b** and **9a**). In the winter, wind conditions are comfortable for leisurely or fast walking (**Figures 8b** and **9b**). Note, the analysis does not take into account the significant number of trees planned for the park, as well as the existing trees within the golf course. Nor does this assessment take into account the intended programming in the park. Hence wind conditions in the proposed park are anticipated to be slightly calmer than what is discussed here.

4.5 Wind Safety

In the Existing Configuration, the wind safety criterion is met in all areas surrounding the existing site. In the Proposed Configuration, the wind safety criterion is met in all areas except two small isolated areas at the northwest and southwest corners of the proposed development (**Figure 10**). These gust events are due to the prevailing winds from the southwest and northwest quadrants interacting with the proposed development.

Note, the analysis does not take into account the significant number of trees planned for the park, as well as the existing trees within the golf course. **These mature trees provide a disruption to the wind flows, hence wind conditions on the site may be slightly better than those described.**

It is our opinion that through this process and once a model is created which accounts for existing and proposed trees, landscaping, etc. along with minor design revisions, wind safety should not be an issue. Given the above, in the unlikely event that landscaping and minor design changes do not address this matter, we have outlined several other mitigation measures to rectify this isolated situation, including increasing the size of the horizontal steps along the north and south facades. By including large horizontal elements at multiple heights on the north and south facades, the downwashing flows will be intercepted and dissipated before reaching grade. Alternatively, architectural features such as vertical screens, canopies, etc. could be included at grade-level. We will work with the design team to incorporate appropriate mitigation measures and conduct further analysis (wind tunnel study) to confirm the efficacy of such features prior to Site Plan Approval (SPA).

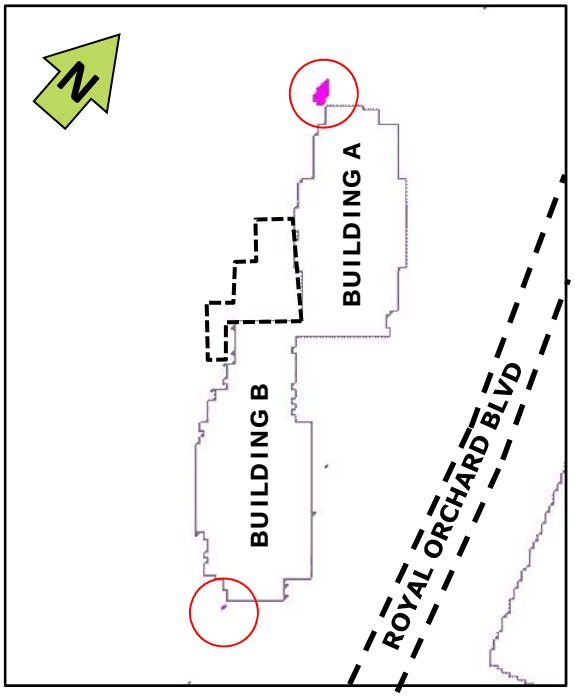


Figure 10: Wind Safety – Proposed Configuration – Grade Level - Annual

5.0 CONCLUSIONS & RECOMMENDATIONS

The pedestrian wind conditions predicted for the proposed development at the Ladies Golf Club of Toronto in Markham have been assessed through numerical modeling techniques. Based on the results of our assessment, the following conclusions have been reached:

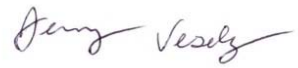
- The wind safety criterion is met at all locations surrounding the development in the Existing Configuration. The criteria is not met in small isolated areas in the Proposed Configuration. Novus will work with the design team to conduct further analysis incorporating recommended mitigation measures prior to SPA.
- Wind conditions at the main entrance, the secondary entrances, and on the amenity terraces are suitable for sitting or standing throughout the year, which is appropriate for the intended usage.
- On the walkways immediately surrounding the development, wind conditions are generally suitable for the intended usage. Uncomfortable wind conditions occur along the north and south facades in the winter. Recommendations are described.
- On the sidewalks surrounding the proposed development, wind conditions generally remain unchanged. Wind conditions are suitable for leisurely walking or better year-round in both the Existing and Proposed Configurations.
- In order to determine the efficacy of the recommended mitigation for the north and south facades, additional analysis is required. Novus will work with the design team to develop and confirm the inclusion of appropriate mitigation features.

6.0 ASSESSMENT APPLICABILITY

This assessment is based on computer modeling techniques and provides a qualitative overview of the pedestrian wind comfort conditions on and surrounding the proposed development site. Any subsequent alterations to the design may influence these findings, possibly requiring further review by Novus.

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

Sincerely,
Novus Environmental Inc.



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Appendix A

Pedestrian Wind Comfort Analysis

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

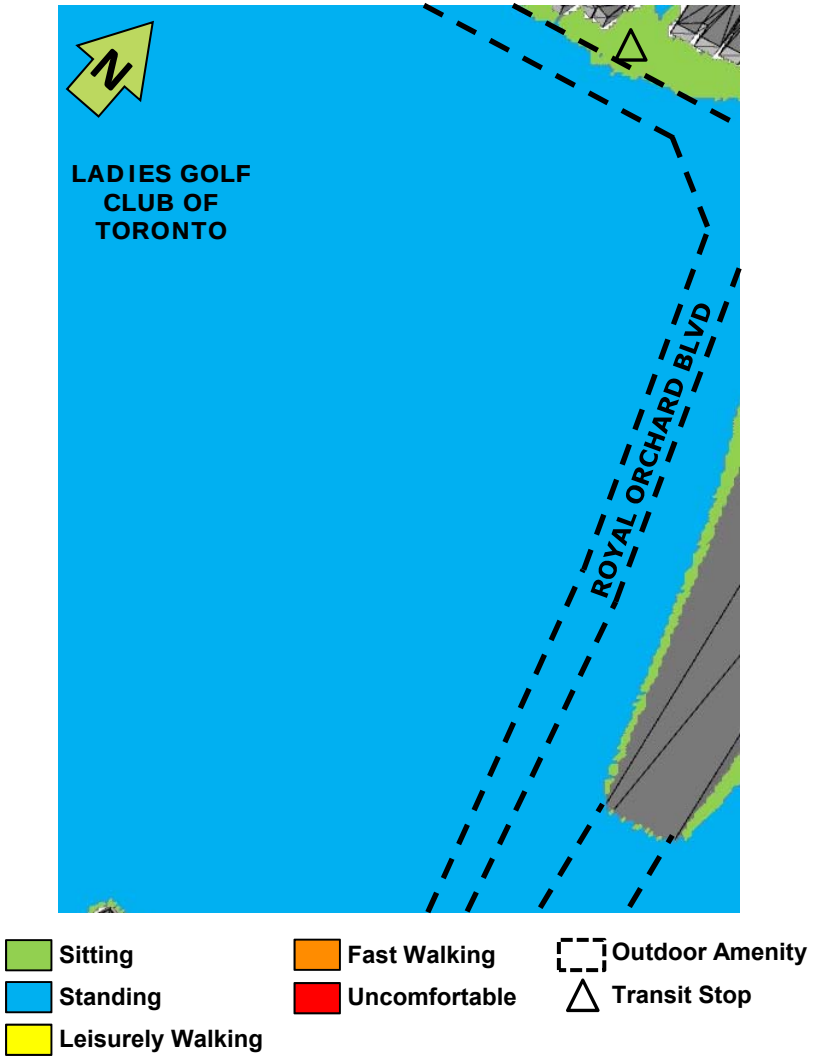

Figure A1a: Existing Configuration – Grade – Spring

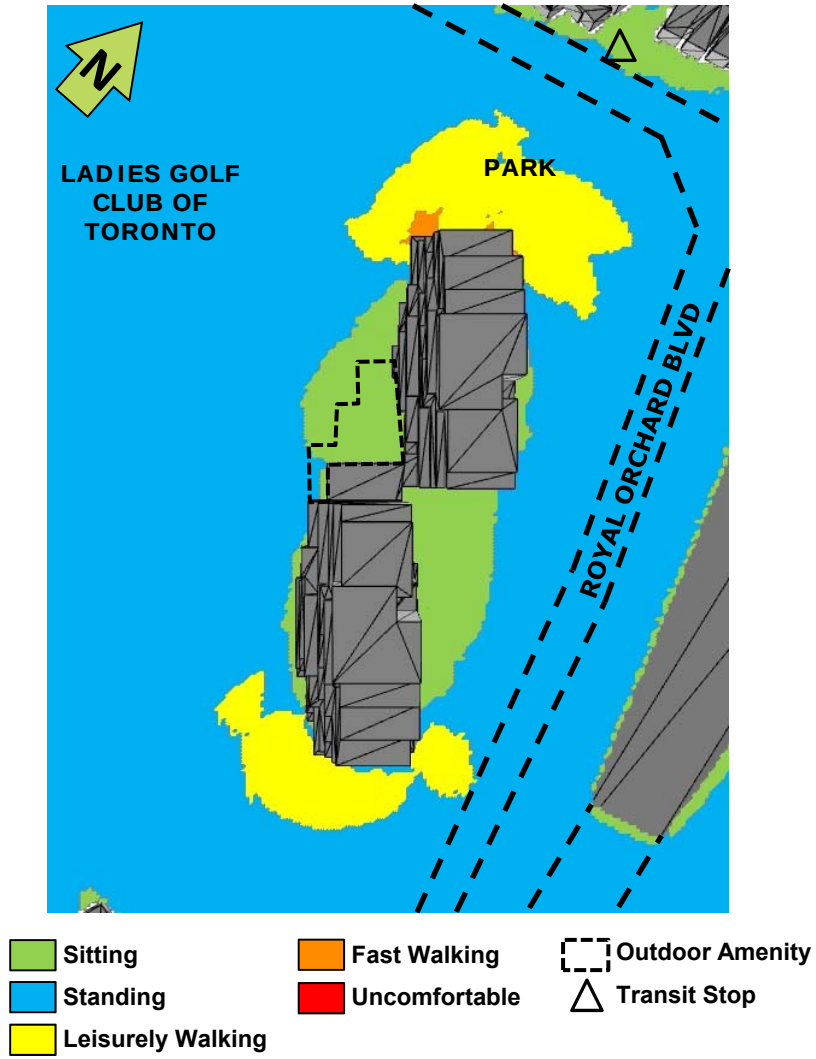

Figure A1b: Proposed Configuration – Grade – Spring

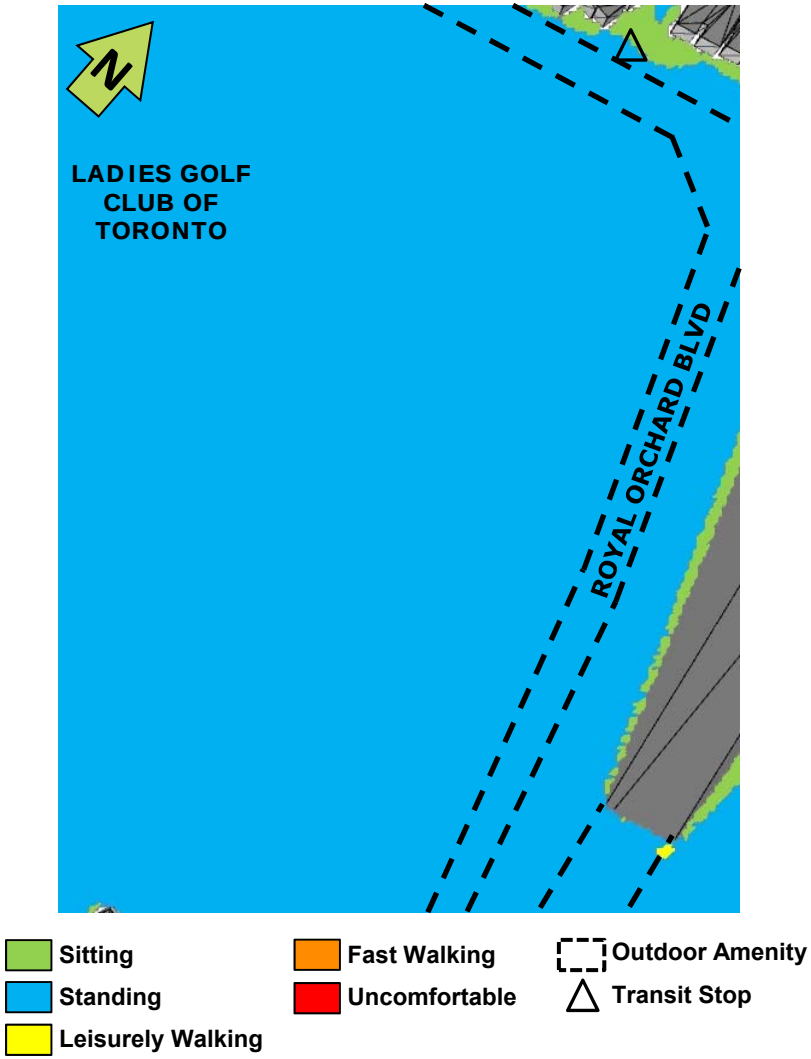

Figure A2a: Existing Configuration – Grade – Autumn

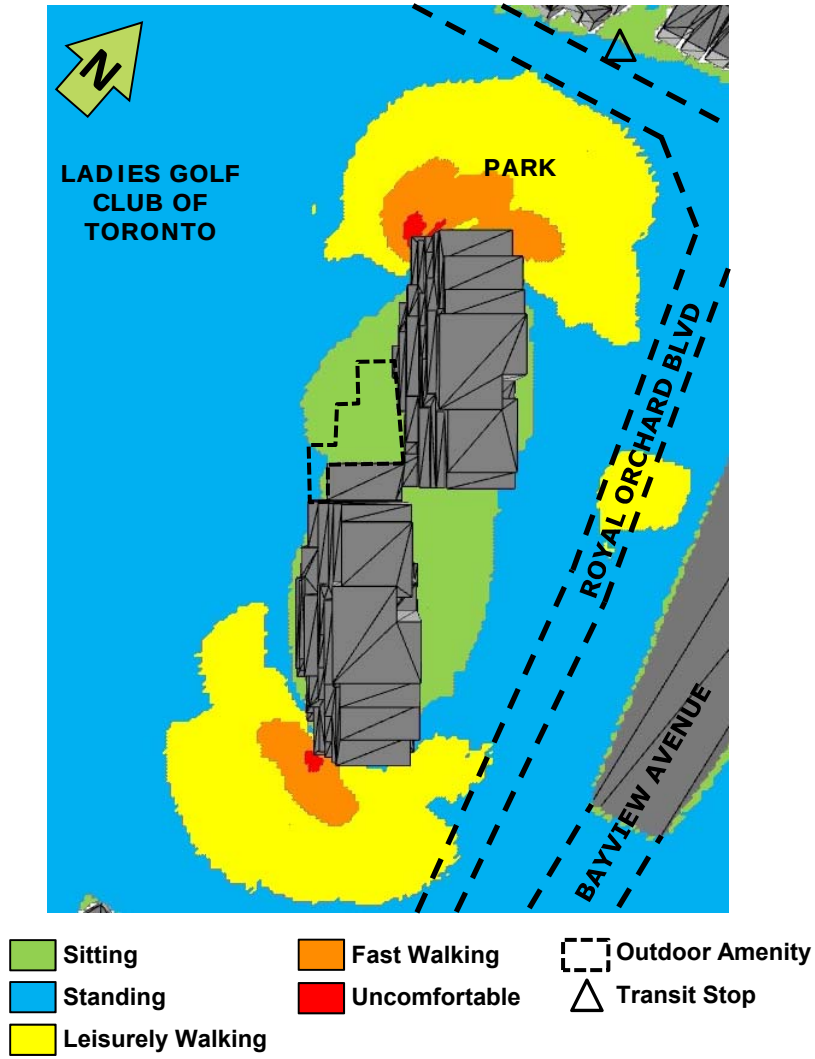

Figure A2b: Proposed Configuration – Grade – Autumn