REPORT

WILLOW TREE TOWER

HALIFAX, NS

PEDESTRIAN WIND STUDY

RWDI #1804408

May 13, 2019

SUBMITTED TO

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EXECUTIVE SUMMARY

Wind conditions around the proposed Willow Tree Tower are discussed in detail within the content of this report and can be summarized as follows:

- Wind conditions meet the recommended wind safety criterion at all locations in the existing and proposed configurations.
- At grade level, conditions are comfortable for their intended use at all locations in the summer, and most locations during the winter. Exceptions are one location in the existing configuration and two locations in the proposed configuration along Quinpool Road where uncomfortable wind conditions are detected in the winter. Conceptual wind control measures are discussed for these locations.
- Above grade, most locations are comfortable for the intended use in the summer. Recommendations for wind control are made to improve conditions at three locations on Levels 5 and 6 during the summer.

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1 INTRODUCTION

RWDI was retained by Geiger Huot Architectes to assess and consult on the pedestrian wind conditions on and around the proposed Willow Tree Tower project in Halifax, Nova Scotia. The project site, as shown in **Image 1**, is located on the north side of Quinpool Road, between Parker Street and Robie Street. The proposed building is approximately 80 m tall, consisting of a 25-storey tower with multilevel above-grade terraces.

The purpose of the study is to assess the wind environment around the project in terms of pedestrian comfort and safety. The quantitative assessment was based on wind speed measurements on a scale model of the project and its surroundings in a boundary-layer wind tunnel. The assessment focused on critical pedestrian areas and amenity spaces including the main and secondary entrances, outdoor terraces and sidewalks along adjacent streets.

This report summarizes the methodology of wind tunnel studies for pedestrian wind conditions, describes the RWDI pedestrian wind comfort and safety criteria, presents the local wind conditions and their effects on pedestrians and provides conceptual wind control measures, where necessary.

Image 1: Aerial view of site and surroundings (courtesy of Google™ Earth)

2 METHODOLOGY

2.1 Wind Tunnel Study Model

In order to assess the wind environment around the proposed project, a 1:400 scale model of the project site and surroundings was constructed for the wind tunnel tests and the following configurations were tested:

A - Existing Configuration: Existing building on site with existing surroundings (**Image 2A**); and,

B - Proposed Configuration: Proposed project with existing surroundings (**Image 2B**).

The scale model of the proposed project was constructed using the design information and drawings listed in **Appendix A**. The wind tunnel model included all relevant surrounding buildings and topography within approximately 480 m radius of the study site. The boundary-layer wind conditions beyond the modelled area were also simulated in RWDI's wind tunnel. The wind tunnel model was instrumented with 55 wind speed sensors to measure mean and gust wind speeds at a full-scale height of approximately 1.5 m. The placement of wind measurement locations was based on our experience and understanding of the pedestrian usage for this site, and it was reviewed by Geiger Huot Architectes. These measurements were recorded for 36 equally incremented wind directions.

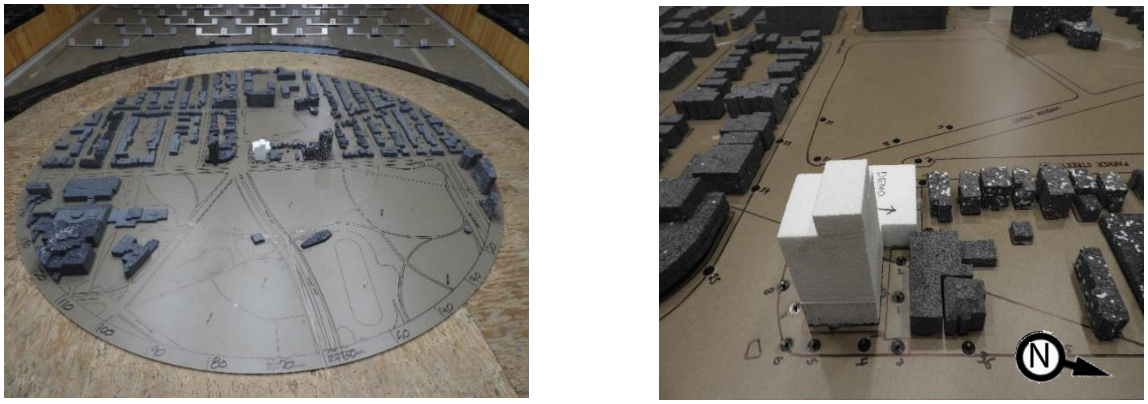


Image 2A: Wind tunnel study model - Existing configuration

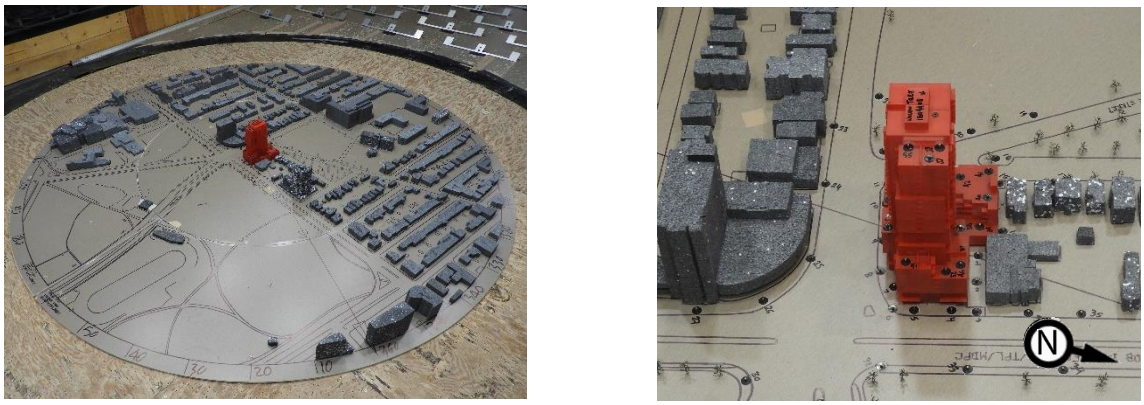
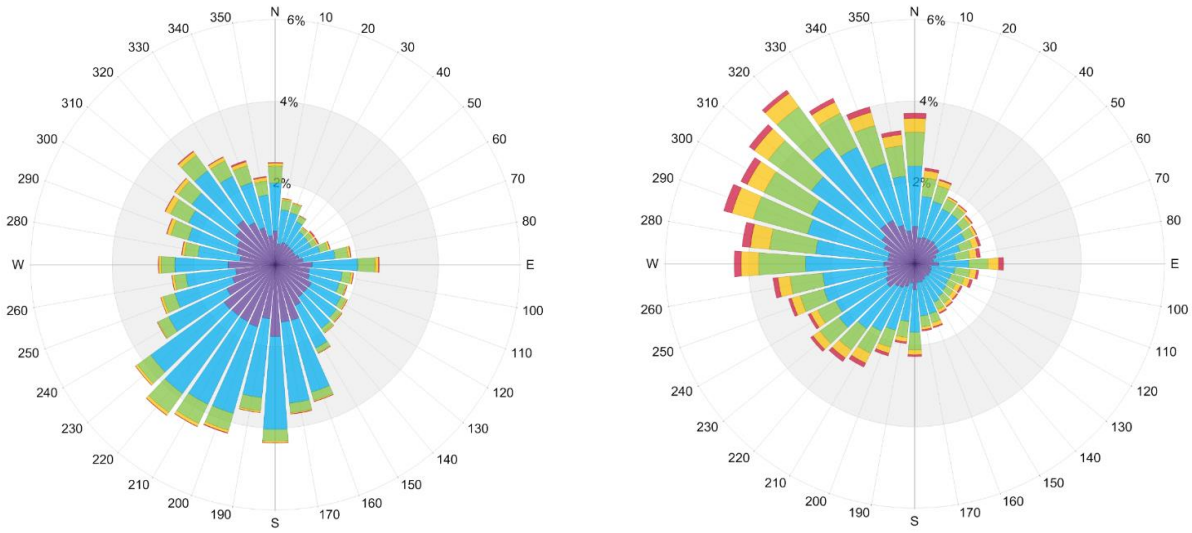


Image 2B: Wind tunnel study model - Proposed configuration

2.2 Meteorological Data

Wind statistics recorded at Shearwater Airport between 1985 and 2015 were analysed for the Summer (May through October) and Winter (November through April) seasons. **Image 3** graphically depicts the directional distributions of wind frequencies and speeds for the two seasons. Winds are frequently from the south through west-southwest directions in the summer. During the winter, the prevailing winds are from the west through north directions, as indicated by the wind roses. Strong winds of a mean speed greater than 30 km/h measured at the airport (at an anemometer height of 10m) occur more often in the winter (10.6%) than in the summer (2.5%). Winds from the west through north and east directions could potentially be the source of uncomfortable or even severe wind conditions, depending upon the site exposure or development design. The analysis methods have accounted for these and all winds directions.

Wind statistics from the Shearwater Airport were combined with the wind tunnel data in order to predict the frequency of occurrence of full-scale wind speeds. The full-scale wind predictions were then compared with the RWDI criteria for pedestrian comfort and safety.



Summer (May – October) **Winter (November – April)**

Wind Speed (km/h)	Probability (%) Summer	Winter
Calm	4.8	3.1
1-10	37.0	24.0
11-20	45.0	41.6
21-30	10.8	20.7
31-40	2.1	7.7
>40	0.4	2.9

Image 3: Directional distribution of winds approaching Shearwater Airport from 1985 to 2015

2.3 Wind Criteria

The RWDI pedestrian wind criteria, which have been developed by RWDI through research and consulting practice since 1974, are used in the current study. These criteria have been widely accepted by municipal authorities as well as by the building design and city planning community. They are sometimes subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can affect a person's perception of the wind climate. Therefore, comparisons of wind speeds for the existing and proposed building configurations are the most objective way in assessing local pedestrian wind conditions. In general, the combined effect of mean and gust speeds on pedestrian comfort can be quantified by a Gust Equivalent Mean (GEM).

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

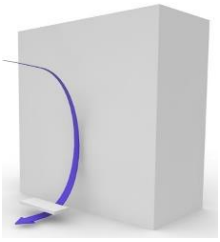
Notes:
(1) GEM speed = max (mean speed, gust speed/1.85);
(2) GEM speeds listed above are based on a seasonal exceedance of 20% of the time between 6:00 and 23:00. Nightly hours between 0:00 and 5:00 are excluded from the wind analysis for comfort since limited usage of outdoor spaces is anticipated; and,
(3) Instead of standard four seasons, two periods of summer (May to October) and winter (November to April) are adopted in the wind analysis, because in a colder climate such as that found in Halifax, there are distinct differences in pedestrian outdoor behaviours between these two-time periods.

Safety Criterion	Gust Speed (km/h)	Description
Exceeded	> 90	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

Notes:
(1) Based on an annual exceedance of 9 hours or 0.1% of the time for 24 hours a day; and,
(2) Only gust speeds need to be considered in the wind safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential safety impact on pedestrians.

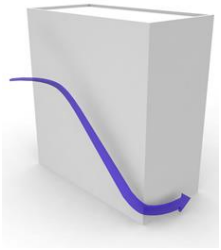
2.4 Generalized Wind Flows

In our discussion of wind conditions, reference may be made to the following generalized wind flows (**Image 4**). If these building/wind combinations occur for prevailing winds, there is a greater potential for increased wind activity.



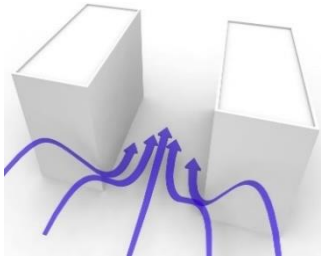
DOWNWASHING

Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. This is often the main cause for wind accelerations around large buildings at the pedestrian level.



CORNER ACCELERATION

When winds approach at an oblique angle to a tall façade and are deflected down, a localized increase in the wind activity or corner acceleration can be expected around the exposed building corners at pedestrian level.



CHANNELLING EFFECT

When two buildings are situated side by side, wind flow tends to accelerate through the space between the buildings due to channeling effect caused by the narrow gap.

Image 4: Generalized wind flows

3 RESULTS AND DISCUSSION

The predicted wind comfort and safety conditions pertaining to the two configurations assessed are graphically depicted on site plans in **Figures 1A through 2B**. These conditions and the associated wind speeds are presented in **Table 1**, located in the Tables section of this report. The following is a detailed discussion of the suitability of the predicted wind comfort conditions for the anticipated pedestrian use of each area of interest.

Wind conditions that meet the safety criterion are predicted at all locations for both the existing and proposed configurations.

3.1 Grade Level (Locations 1 through 36)

Wind conditions comfortable for walking or strolling are appropriate for walkways as pedestrians will be active and less likely to remain in one area for prolonged periods of time. Lower wind speeds conducive to standing are preferred at main entrances where pedestrians are apt to linger. The main entrance of the proposed building is situated at Location 9 in **Figures 1B** and **2B**. Retail entrances are planned along Parker Street, Quinpool Road, and Robie Street, near Locations 4, 5, 10, 12, 13 and 14.

3.1.1 Existing Configuration

Summer wind conditions are suitable for strolling or better around the existing project site (**Figure 1A**), which is appropriate. During the winter, wind conditions are mostly suitable for walking and strolling, except one location with uncomfortable conditions (Location 26 in **Figure 2A**).

3.1.2 Proposed Configuration

The addition of the proposed building causes local changes in wind speeds during both summer and winter. However, when considering all locations, the average wind speeds for both the existing and proposed configurations are similar.

During the summer, all grade level locations are predicted to remain suitable for the intended use (Figure 1B). Conditions at the entrances are all comfortable for sitting or standing.

During the winter, conditions at most locations are predicted to be suitable for the intended pedestrian use (**Figure 2B)**. Uncomfortable wind conditions, slightly above the 20 km/h threshold, are predicted at Locations 11 and 25 (**Figure 2B, Table 1**). However, overall conditions on Robie Street south of Quinpool Road are improved with the addition of the proposed building; strong winds shift from Location 26 (**Figure 2A**) to Location 25 (**Figure 2B**). These wind conditions are typical during the winter around high-rise buildings in Halifax.

3.2 Above-Grade Levels (Locations 37 through 55)

It is generally desirable for wind conditions on terraces intended for passive activities to be comfortable for sitting or standing in the summer. During the winter, these areas are not frequently used; therefore, increased wind activity is considered appropriate.

During the summer, most areas are suitable for their intended use. However, the wind speeds at Locations 40, 41, and 43 are predicted to be comfortable for strolling, higher than desirable for passive activities (**Figure 1B**). The winds at Locations 40 and 41 are predominantly from the southwest, which the 5th floor terrace is exposed to. Winds at Location 43 are likely from downwashing effects (**Image 4**) from the tower. As shown in Table 1, the wind speeds are marginally over the 'standing' threshold of 14 km/h. Additional landscaping features (**Image 5**) interspersed on the 5th and 6th floor terraces are expected to bring about calmer conditions, if desired. Taller guardrails would also be a positive design feature for wind control.

Image 5: Examples of Landscaping Options for Wind Control on Elevated Outdoor Terraces

4 APPLICABILITY

The wind conditions presented in this report pertain to the proposed Willow Tree Tower as detailed in the architectural design drawings listed in **Appendix A**. Should there be any design changes that deviate from this list of drawings, the wind condition predictions presented may change. Therefore, if changes in the design are made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

5 REFERENCES

1) ASCE Task Committee on Outdoor Human Comfort (2004). *Outdoor Human Comfort and Its Assessment*, 68 pages, American Society of Civil Engineers, Reston, Virginia, USA.

2) Williams, C.J., Hunter, M.A. and Waechter, W.F. (1990). "Criteria for Assessing the Pedestrian Wind Environment," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.36, pp.811-815.

3) Williams, C.J., Soligo M.J. and Cote, J. (1992). "A Discussion of the Components for a Comprehensive Pedestrian Level Comfort Criteria," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.41-44, pp.2389-2390.

4) Soligo, M.J., Irwin, P.A., and Williams, C.J. (1993). "Pedestrian Comfort Including Wind and Thermal Effects," *Third Asia-Pacific Symposium on Wind Engineering*, Hong Kong.

5) Soligo, M.J., Irwin, P.A., Williams, C.J. and Schuyler, G.D. (1998). "A Comprehensive Assessment of Pedestrian Comfort Including Thermal Effects," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.77&78, pp.753-766.

6) Williams, C.J., Wu, H., Waechter, W.F. and Baker, H.A. (1999). "Experiences with Remedial Solutions to Control Pedestrian Wind Problems," *Tenth International Conference on Wind Engineering*, Copenhagen, Denmark.

7) Lawson, T.V. (1973). "Wind Environment of Buildings: A Logical Approach to the Establishment of Criteria", *Report No. TVL 7321*, Department of Aeronautic Engineering, University of Bristol, Bristol, England.

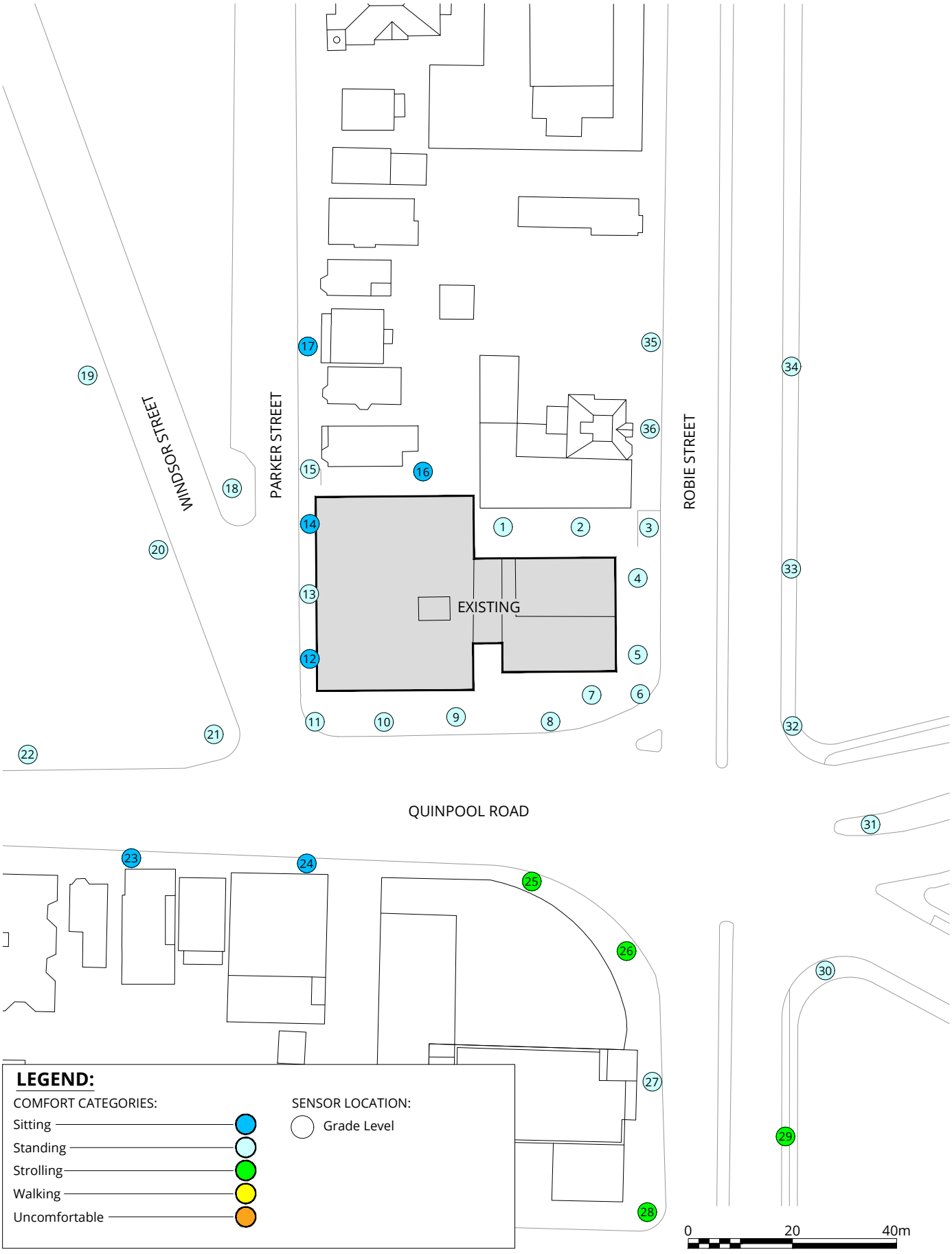
8) Durgin, F. H. (1997). "Pedestrian Level Wind Criteria Using the Equivalent average", *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 66, pp. 215-226.

9) Wu, H. and Kriksic, F. (2012). "Designing for Pedestrian Comfort in Response to Local Climate", *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.104-106, pp.397-407.

10) Wu, H., Williams, C.J., Baker, H.A. and Waechter, W.F. (2004), "Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions", *ASCE Structure Congress 2004,* Nashville, Tennessee.

11) Williams, C.J., Wu, H., Waechter, W.F. and Baker, H.A. (1999). "Experiences with Remedial Solutions to Control Pedestrian Wind Problems," *Tenth International Conference on Wind Engineering*, Copenhagen, Denmark.

FIGURES



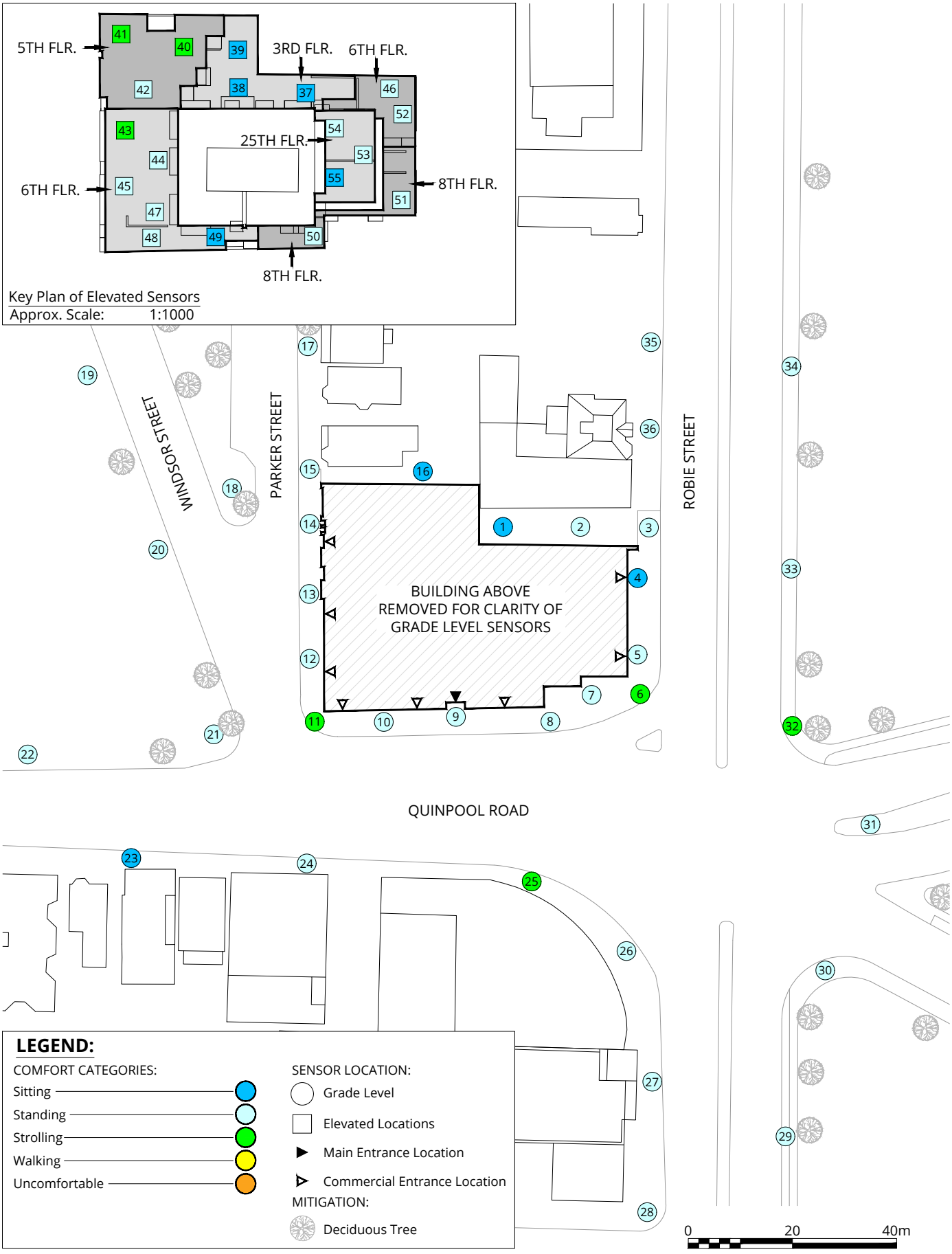
Pedestrian Wind Comfort Conditions
Existing Configuration
Summer (May to October, 6:00 to 23:00)

Willow Tree Tower - Halifax, NS

Project #1804408

True North

Drawn by: MDN	Figure: 1A
Approx. Scale:	1:1000
Date Revised:	May 8, 2019



Pedestrian Wind Comfort Conditions
Proposed Configuration
Summer (May to October, 6:00 to 23:00)

Willow Tree Tower - Halifax, NS

Project #1804408

True North

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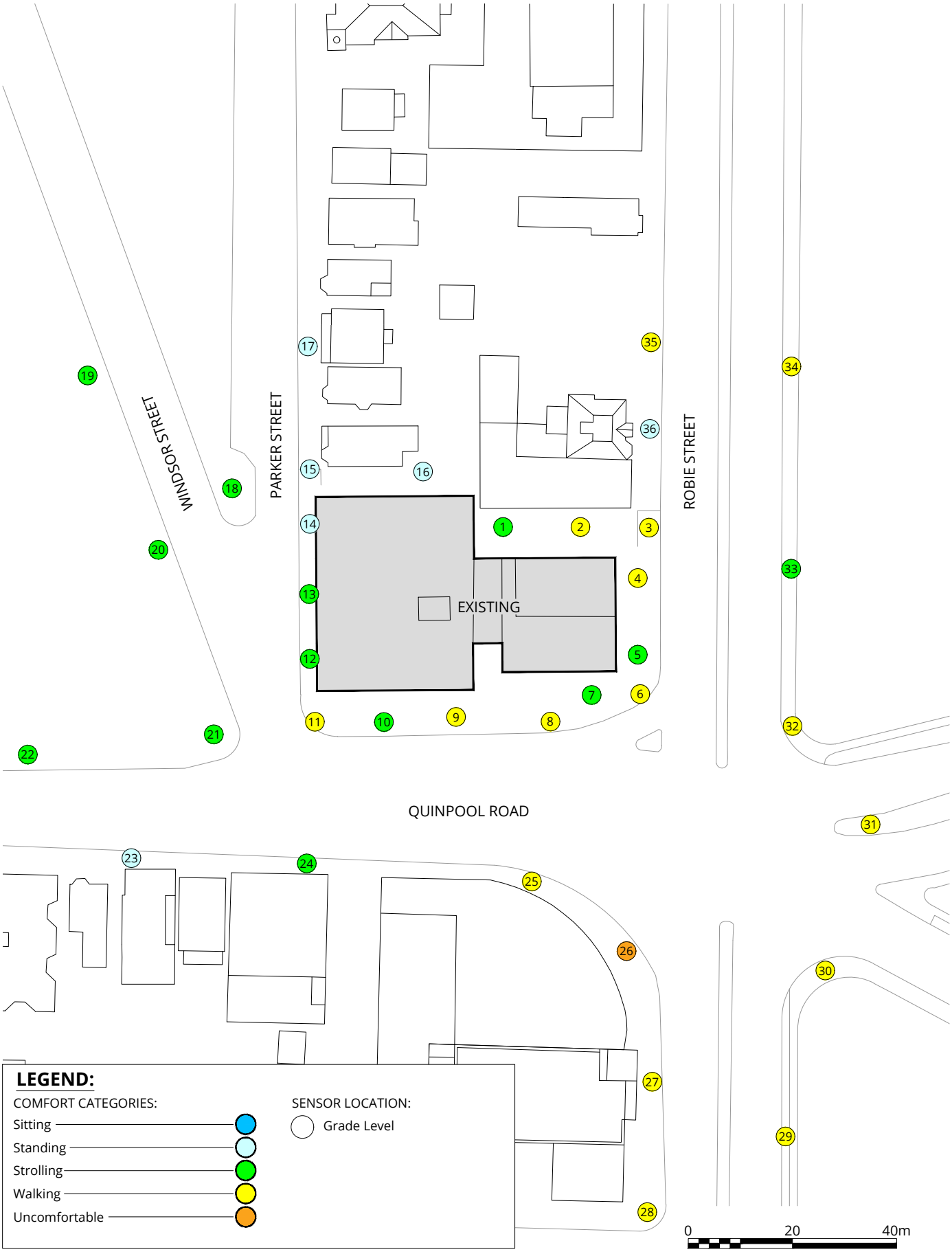


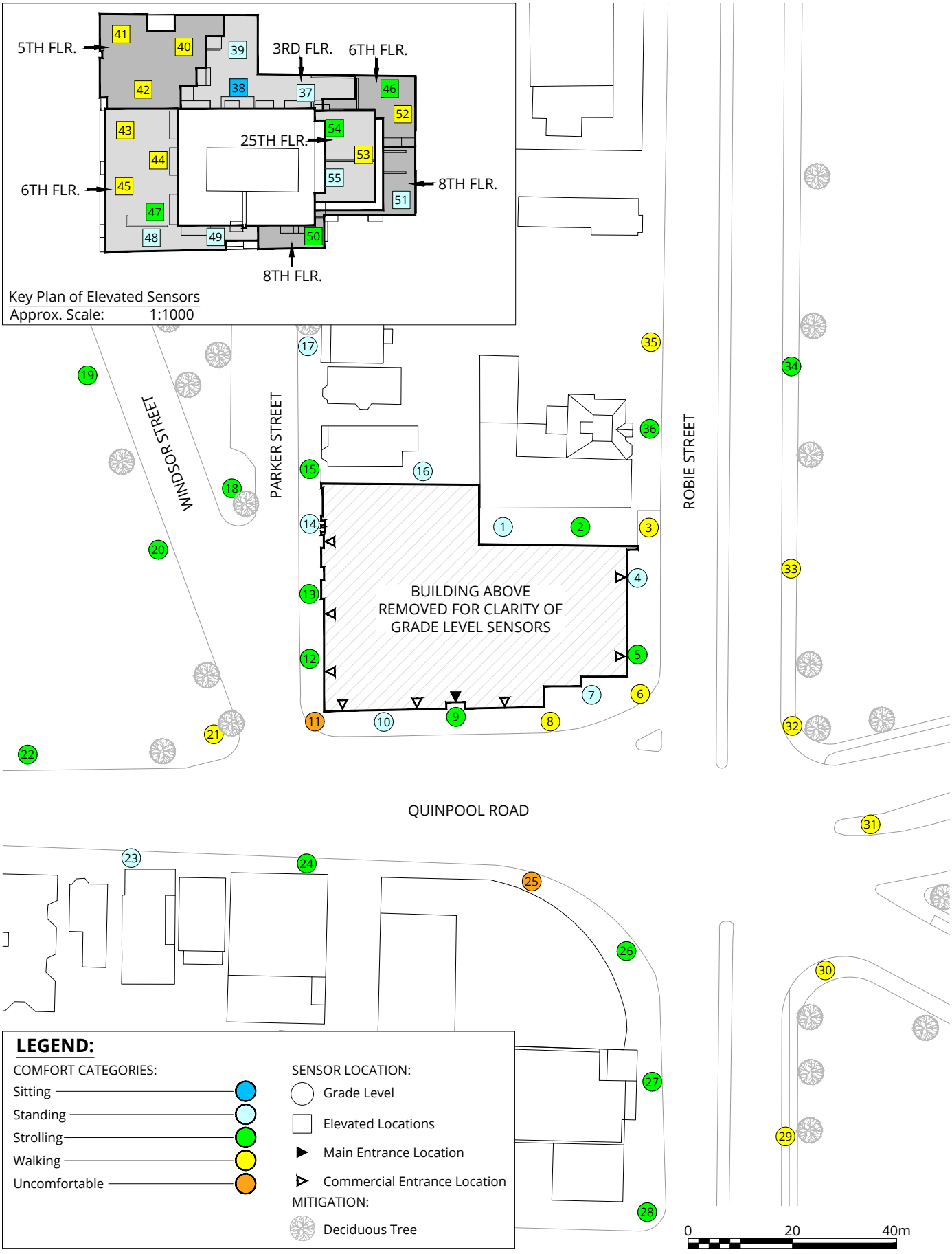
Pedestrian Wind Comfort Conditions
Existing Configuration
Winter (November to April, 6:00 to 23:00)

Willow Tree Tower - Halifax, NS

Project #1804408

True North

Drawn by: MDN	Figure: 2A
Approx. Scale:	1:1000
Date Revised:	May 8, 2019



Pedestrian Wind Comfort Conditions
Proposed Configuration
Winter (November to April, 6:00 to 23:00)

Willow Tree Tower - Halifax, NS

Project #1804408

True North

Drawn by: MDN	Figure: 2B
Approx. Scale:	1:1000
Date Revised:	May 8, 2019

TABLES

Table 1: Pedestrian Wind Comfort and Safety Conditions

Location	Configuration	Wind Comfort				Wind Safety	
		Summer		Winter		Annual	
		Speed (km/h)	Rating	Speed (km/h)	Rating	Speed (km/h)	Rating
1	Existing	12	Standing	15	Strolling	67	Pass
	Proposed	9	Sitting	13	Standing	57	Pass
2	Existing	14	Standing	19	Walking	86	Pass
	Proposed	11	Standing	16	Strolling	68	Pass
3	Existing	14	Standing	20	Walking	79	Pass
	Proposed	14	Standing	20	Walking	76	Pass
4	Existing	13	Standing	18	Walking	75	Pass
	Proposed	10	Sitting	13	Standing	63	Pass
5	Existing	13	Standing	17	Strolling	72	Pass
	Proposed	11	Standing	15	Strolling	70	Pass
6	Existing	14	Standing	18	Walking	72	Pass
	Proposed	16	Strolling	20	Walking	81	Pass
7	Existing	13	Standing	17	Strolling	72	Pass
	Proposed	12	Standing	14	Standing	62	Pass
8	Existing	14	Standing	19	Walking	79	Pass
	Proposed	14	Standing	18	Walking	75	Pass
9	Existing	14	Standing	18	Walking	75	Pass
	Proposed	12	Standing	16	Strolling	66	Pass
10	Existing	12	Standing	15	Strolling	70	Pass
	Proposed	11	Standing	13	Standing	70	Pass
11	Existing	13	Standing	18	Walking	75	Pass
	Proposed	16	Strolling	22	Uncomfortable	84	Pass
12	Existing	10	Sitting	15	Strolling	67	Pass
	Proposed	12	Standing	17	Strolling	69	Pass
13	Existing	11	Standing	15	Strolling	63	Pass
	Proposed	11	Standing	15	Strolling	68	Pass
14	Existing	10	Sitting	13	Standing	56	Pass
	Proposed	12	Standing	14	Standing	63	Pass
15	Existing	11	Standing	14	Standing	56	Pass
	Proposed	13	Standing	16	Strolling	67	Pass
16	Existing	9	Sitting	13	Standing	49	Pass
	Proposed	9	Sitting	13	Standing	56	Pass
17	Existing	10	Sitting	14	Standing	56	Pass
	Proposed	11	Standing	13	Standing	57	Pass

Table 1: Pedestrian Wind Comfort and Safety Conditions

Location	Configuration	Wind Comfort				Wind Safety	
		Summer		Winter		Annual	
		Speed (km/h)	Rating	Speed (km/h)	Rating	Speed (km/h)	Rating
18	Existing	11	Standing	15	Strolling	63	Pass
	Proposed	12	Standing	15	Strolling	67	Pass
19	Existing	12	Standing	16	Strolling	64	Pass
	Proposed	11	Standing	15	Strolling	62	Pass
20	Existing	12	Standing	16	Strolling	65	Pass
	Proposed	12	Standing	15	Strolling	67	Pass
21	Existing	12	Standing	16	Strolling	66	Pass
	Proposed	13	Standing	18	Walking	80	Pass
22	Existing	11	Standing	15	Strolling	60	Pass
	Proposed	11	Standing	15	Strolling	66	Pass
23	Existing	9	Sitting	13	Standing	59	Pass
	Proposed	9	Sitting	13	Standing	56	Pass
24	Existing	10	Sitting	15	Strolling	65	Pass
	Proposed	12	Standing	17	Strolling	72	Pass
25	Existing	15	Strolling	20	Walking	77	Pass
	Proposed	16	Strolling	23	Uncomfortable	85	Pass
26	Existing	15	Strolling	21	Uncomfortable	81	Pass
	Proposed	14	Standing	17	Strolling	73	Pass
27	Existing	13	Standing	19	Walking	82	Pass
	Proposed	11	Standing	15	Strolling	70	Pass
28	Existing	15	Strolling	19	Walking	77	Pass
	Proposed	14	Standing	17	Strolling	70	Pass
29	Existing	15	Strolling	20	Walking	77	Pass
	Proposed	14	Standing	18	Walking	73	Pass
30	Existing	14	Standing	19	Walking	73	Pass
	Proposed	14	Standing	19	Walking	75	Pass
31	Existing	14	Standing	18	Walking	70	Pass
	Proposed	14	Standing	19	Walking	74	Pass
32	Existing	14	Standing	19	Walking	75	Pass
	Proposed	15	Strolling	20	Walking	80	Pass
33	Existing	13	Standing	17	Strolling	70	Pass
	Proposed	14	Standing	19	Walking	75	Pass
34	Existing	13	Standing	18	Walking	68	Pass
	Proposed	13	Standing	17	Strolling	68	Pass

Table 1: Pedestrian Wind Comfort and Safety Conditions

Location	Configuration	Wind Comfort				Wind Safety	
		Summer		Winter		Annual	
		Speed (km/h)	Rating	Speed (km/h)	Rating	Speed (km/h)	Rating
35	Existing	13	Standing	18	Walking	67	Pass
	Proposed	14	Standing	18	Walking	70	Pass
36	Existing	11	Standing	14	Standing	71	Pass
	Proposed	13	Standing	16	Strolling	74	Pass
37	Existing	-	-	-	-	-	-
	Proposed	8	Sitting	11	Standing	50	Pass
38	Existing	-	-	-	-	-	-
	Proposed	8	Sitting	10	Sitting	44	Pass
39	Existing	-	-	-	-	-	-
	Proposed	10	Sitting	14	Standing	59	Pass
40	Existing	-	-	-	-	-	-
	Proposed	15	Strolling	18	Walking	75	Pass
41	Existing	-	-	-	-	-	-
	Proposed	16	Strolling	19	Walking	80	Pass
42	Existing	-	-	-	-	-	-
	Proposed	13	Standing	18	Walking	76	Pass
43	Existing	-	-	-	-	-	-
	Proposed	15	Strolling	20	Walking	84	Pass
44	Existing	-	-	-	-	-	-
	Proposed	13	Standing	19	Walking	88	Pass
45	Existing	-	-	-	-	-	-
	Proposed	14	Standing	20	Walking	88	Pass
46	Existing	-	-	-	-	-	-
	Proposed	12	Standing	16	Strolling	75	Pass
47	Existing	-	-	-	-	-	-
	Proposed	13	Standing	17	Strolling	70	Pass
48	Existing	-	-	-	-	-	-
	Proposed	12	Standing	14	Standing	78	Pass
49	Existing	-	-	-	-	-	-
	Proposed	10	Sitting	12	Standing	62	Pass
50	Existing	-	-	-	-	-	-
	Proposed	14	Standing	16	Strolling	83	Pass
51	Existing	-	-	-	-	-	-
	Proposed	12	Standing	14	Standing	74	Pass

Table 1: Pedestrian Wind Comfort and Safety Conditions

Location	Configuration	Wind Comfort				Wind Safety	
		Summer		Winter		Annual	
		Speed (km/h)	Rating	Speed (km/h)	Rating	Speed (km/h)	Rating
52	Existing	-	-	-	-	-	-
	Proposed	12	Standing	18	Walking	80	Pass
53	Existing	-	-	-	-	-	-
	Proposed	12	Standing	18	Walking	77	Pass
54	Existing	-	-	-	-	-	-
	Proposed	12	Standing	17	Strolling	81	Pass
55	Existing	-	-	-	-	-	-
	Proposed	10	Sitting	13	Standing	63	Pass

Seasons		Hours
Summer	May - October	6:00 - 23:00 for comfort
Winter	November - April	0:00 - 23:00 for safety

Configurations	
Existing	Without the proposed development
Proposed	With the proposed Willow Tree Tower

Comfort Speed (km/h)	
(20% Seasonal Exceedance)	
≤ 10	Sitting
11 - 14	Standing
15 - 17	Strolling
18 - 20	Walking
> 20	Uncomfortable

Safety Speed (km/h)	
(> 0.1% Annual Exceedance)	
≤ 90	Pass
> 90	Exceeded

APPENDIX A

APPENDIX A:
DRAWING LIST FOR MODEL CONSTRUCTION

The drawings and information listed below were received from Geiger Huot Architectes and were used to construct the scale model of the proposed Willow Tree Tower. Should there be any design changes that deviate from this list of drawings, the results may change. Therefore, if changes in the design are made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

File Name	File Type	Date Received (dd/mm/yyyy)
revised WTT Halifax Central Arch R16-With new height - 3D 2019-04-10.dwg	AutoCAD	10/04/19
WTT 3d 20190501.dwg	AutoCAD	02/05/19
image004.jpg	JPEG Bitmap	02/05/19