The Boundary Layer Wind Tunnel Laboratory

Pedestrian Level Wind Study

4050 Yonge Street, Toronto, Ontario

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Submitted To:

Mr. Mario Angelucci
Easton's Group/Gupta Group
3100 Steeles Avenue E, Suite 601
Markham, ON L3R 8T3

Submitted By:

The Boundary Layer Wind Tunnel Laboratory
The University of Western Ontario
Faculty of Engineering
London, Ontario
N6A 5B9

D. Garnham, Project Manager
P. Case, Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

MAIN FINDINGS

This report describes the pedestrian-level wind study performed at the Boundary Layer Wind Tunnel Laboratory for the development at 4050 Yonge Street in Toronto. The project site is located on the northwest corner of the intersection of Yonge St. and York Mills Road. A detailed discussion of the results is contained in Section 3.5. A description of the criteria used can be found in Section 3.4.

Tests were carried out for three configurations described as follows:

- Existing Site - the existing site is presently a bare surface parking lot with a single storey York Mills Subway entrance structure at the eastern edge. The site is surrounded by dense groves of mature trees to the southwest and north. As these are largely deciduous trees, their protective influence is largely felt during late spring through early fall. To the east and south of the site are, amongst mature treed areas, are buildings of height similar to the proposed development.

- Proposed Site – the proposed site consists of a two tower development. The western tower is 28 storeys and primarily residential, while the eastern tower is 14 storeys and will house retail, office, and commercial space on the first 3 floors with residential use above. The west and east towers are connected through an extensive 3-9 storey podium and have a total height of about 107.2m and 59.7m, respectively. Figure 1 shows a plan view of the proposed development. Eight porous wind-screens were installed in a staggered pattern to the west of the podium near the southwest corner of the podium in order to mitigate to wind conditions in the vicinity. Likewise, four porous windscreens were also installed to the north of the podium near the northeast corner. The porous wind screens can be seen in the photographs in Figure 5C.

Both configurations are described in more detail at the beginning of Section 3.5. An image of each tested configuration is shown in Figure 5.

Figure 9 indicates the 52 locations at which wind speeds were measured. Location 1 is located on the Level 4 Outdoor Amenity space, location 2 is located on the Level 2 Outdoor Amenity space while locations 3 and 4 are located on the Level 9 Outdoor Amenity space; these locations were only tested for the proposed configuration.

The evaluation for safety is summarized schematically in Figure 10. Comfort results for each season are summarized schematically in Figures 11 through 14. These summarize the suitability of each measurement location with respect to pedestrian-level safety or comfort. The comfort and safety categories used correspond to those summarized in section 3.4.

Colour-coded diagrams further summarize the suitability of each measurement location with respect to pedestrian-level safety and pedestrian comfort for each tested configuration. Figures 15 and 16 present these for safety considerations for each of the existing and proposed configurations, respectively. For comfort considerations these are presented in Figures 17a to 17d for the spring, summer, autumn, and winter seasons for the existing configuration, respectively. Similarly, the seasonal comfort diagrams for the proposed configuration can be found in Figures 18a to 18h. The comfort and safety categories used in these figures correspond to those summarized in section 3.4.

The introduction of a high-rise building development in a relatively open environment will invariably create local wind speed-ups for some wind directions. With that expectation, the focus is to identify and develop strategies to make wind conditions suitable for the intended usage for negatively affected area. For example, entry areas should have a comfort category consistent with standing activities, while sidewalks should meet the condition of being comfortable for walking.

Existing Site

The immediate site surroundings are comprised of a suburban environment for the majority of wind directions, the exception being the northwesterly directions which are dominated by parkland / golf course. Directly to the north and east sides of the development are 14-15 storey residential buildings.

Beyond the immediate site, the region is largely characterized by typical suburban exposure for many directions. An aerial view of the existing site can be seen in Figure 2.

Given the mixture of open and suburban surroundings, it is not surprising that the measured wind speeds for the existing site are, in general, consistent with a typical suburban environment or marginally greater, while not quite achieving wind speeds expected in open environments.

For the existing configuration, all tested locations meet the recommended safety criterion. With respect to comfort, the results indicate that all tested locations are suitable for standing or sitting.

Influence of Proposed Development

The proposed development was tested without any immediate on-site landscaping. As a result, these results can be expected to provide somewhat conservative estimates of full-scale wind speeds.

In general, the influence on wind speeds for measurement locations away from the proposed development is minimal. The comfort categorizations at most offsite measurement locations remain largely unchanged from those of the existing condition. In any case, these off-sire locations remain suited for the intended sidewalk usages of the respective areas.

Closer to the proposed development there are observed areas of increased winds. These can be particularly pronounced from late autumn through to early spring. In spring, autumn, and winter Locations 5, 8, and 12 are classified as suitable for leisurely walking. The summertime conditions at these locations are suitable for short-term standing or sitting.

Numerous locations are classified as suitable for leisurely walking in the spring and wintertime. This reflects a variation from the existing configuration where these locations were suitable for short-term sitting or standing. These areas however are still suitable for the intended usage year-round, with the summertime season at these locations marginally better and generally suitable for short term standing or sitting.

Measurements at remaining ground level locations around the site are generally suited for standing or sitting activities during the summer months. These locations are moderately windier during winter and typically suited for standing activities or better.

With respect to pedestrian safety, most locations meet the recommended safety criterion. The exception to this is Locations 1, 3 and 4. These locations on upper amenity spaces exceed the criteria for an all-weather area and fall into the fair-weather criteria category; this carries the recommendation that access to this area by pedestrian traffic during extreme wind conditions be restricted where possible. Since these areas are understood to be controlled amenity spaces, restricting access during a wind event should be considered. Taller perimeter glass screens and/or large planters with evergreen plantings can also be effective for enhancing seasonal usage.

Table 2 summarizes the number of times per year the measurement location exceeds the safety criteria for all-weather and/or fair-weather areas. Please refer to the footnotes in the table for how these criteria categories apply specifically to the tabulated exceedances.

Mitigation Strategies

Preliminary tests identified Locations 5 and 12 as having wind conditions that were expected to exceed desired comfort levels and be unsuited for their intended usage. For these areas, windscreens were incorporated into the main test program. Specifically, a series of 8 porous windscreens were installed onsite to the west of the development and in the vicinity of measurement Location 6, and 4 porous windscreens were installed onsite in the area north of the development near Location 11. The wind screens can be seen in the photographs found in Figure 5b and were arranged in a staggered pattern. The wind screens were found to be effective in mitigating the high wind speeds. These remedial screens

are to be installed along the west and north border of the development and may be in the form of porous wind screens or evergreen plantings.

The wind speeds at upper amenity spaces in the area of Locations 1, 3 and 4 are comfortable for sitting and leisurely walking in the summer months. Should it be desired to improve summer conditions or extend the usage of these areas into other seasons mitigation measures will be required. Suggested mitigative measures to improve comfort could include taller perimeter glass screens and large planters with evergreen plantings. Controlled access during wind events can also be considered given the location.

1 THE WIND CLIMATE FOR TORONTO

1.1 Meteorological Data

An analysis of historical wind data from both the Lester B. Pearson International Airport (ISH Station No. 716240) and the Billy Bishop Toronto City Airport (ISH Station No. 712650) was carried out to develop a wind climate model for Toronto. Lester B. Pearson International Airport is herein referred to as Pearson, while Billy Bishop Toronto City Airport is herein referred to as Island. The historical data consists of time periods 1982 – 2014 for Pearson and 1980 – 2014 for Island. Although earlier records are available for Pearson (1950 – 1966), during these years the anemometer was located atop a building and therefore the data cannot be reliably interpreted. Additional years absent from the data record include 1967 – 1972 and 1978 – 1981.

Based on the analysis of the hourly wind records, a probability distribution of wind speed and direction is developed, referred to as the Parent Wind Climate. The corresponding predicted hourly mean wind speeds at 10 m corrected for standard open exposure are 22.6 m/s and 24.9 m/s for return periods of 10 years and 50 years, respectively. These wind speeds correspond to hourly mean wind pressures of approximately 0.33 kPa and 0.40 kPa.

The annual maxima were extracted from the historical data and fit by a Type I extreme value distribution (Gumbel) for Pearson and Island. The analysis of these extremes predict a 50 year wind speed of approximately 26 m/s for each station with a greater increase in the wind speed with return period compared to the Parent Wind Climate. This probability distribution of wind speed and direction is referred to as the Unscaled BLWTL Wind Climate model.

1.2 Statistical Wind Climate Model

The specified dynamic wind pressures in the National Building Code of Canada (NBCC) 2010 are 0.34 kPa and 0.44 kPa for return periods of 10 years and 50 years, respectively. Based on the specified air density in the NBCC of about 1.29 kg/m^3, the corresponding wind speeds are 23 m/s and 26 m/s for return periods of 10 years and 50 years, respectively. For design purposes, the Unscaled BLWTL Wind Climate model is scaled to match the 50-year return period wind speed. This adjusted climate model is referred to as the Scaled BLWTL Wind Climate model.

The predicted wind speeds at surface level (10m) for the Parent Wind Climate model, the Unscaled BLWTL Wind Climate model, and the Scaled Wind Climate model are plotted for various return periods in Figure 3a. For the analysis of wind tunnel data, the climate models are converted to a reference height of 500 m using a standard open exposure wind profile. The converted climate models are shown in Figure 3b.

The Parent Wind Climate is considered the more representative of 'everyday winds' (return periods of 1 week to 1 year) and is used for the calculation of pedestrian level wind speeds. Table 1 summarizes the predicted wind speeds for return periods typically associated with evaluating the pedestrian level environment.

The directional characteristics of winds associated with various return periods are indicated by the relative importance factors shown in Figure 4. The wind climate model indicates that for strong winds, westerly directions are the most important.

The design probability distribution of hourly mean wind speed (at 10 m height) and wind direction is shown in Appendix A. Both annual and seasonal distributions are shown.

2 THE MODELLING OF THE SITE AND THE WIND

2.1 Overall Approach

The basic tool used is the Laboratory's boundary layer wind tunnel. The tunnel is designed with a very long test section, which allows extended models of upwind terrain to be placed in front of the model of the building under test. The modelling is done in more detail close to the site. The wind flow then develops characteristics which are similar to the wind over the terrain approaching the actual site. This methodology has been highly developed (see References 2 and 3) and is detailed below.

2.2 Model Design

Close-up views of the 1:400 scale model are shown in Figure 5.

Aerodynamic model components:

The model of the 4050 Yonge Street development model built in detail from foam.

1. A detailed proximity model of the surrounding city built in block outline, including the local topography, from Styrofoam for a radius of approximately 500m.
2. Generic models of upstream terrain, modelled by setting appropriate heights of generic roughness blocks and by turbulence-generating spires to produce wind characteristics representative of those at the project site.

The building model and the proximity model are rotated to simulate different wind directions with the upstream terrain being changed as appropriate. Testing was carried out for 2 configurations of the surroundings, namely the existing, and proposed (with windscreens):

- The existing configuration included a bare parking lot and the single storey York Mills Subway entrance structure at the eastern edge;
- the proposed configuration includes the two towers along with the associated podium structure. The proposed configuration further included 8 porous wind screens staggered along the west side of the development near the southwest corner of the podium, and 4 porous windscreens installed on north side of the development toward the northeast corner of the development. Inclusion of these windscreens in the proposed configuration was based on preliminary measurements that identified Locations 5 and 12 as exceeding desired comfort levels.

Photographs of the configurations are shown in Figure 5. Two different terrain models were used, these are shown in Figure 6 and the azimuth ranges over which they were used are shown in Figure 7.

2.3 Characteristics of the Modelled Wind

Figure 8 presents vertical profiles of the mean speed and of the intensity of the longitudinal component of turbulence, measured just upstream of the centre of the turntable, for each upstream terrain exposure.

The model profiles are good representations of the expected variation of full-scale wind speed and turbulence over the building height. The reference wind speed measured in the wind tunnel has been scaled such that the expected full-scale wind speeds at roof height are achieved.

3 THE DETERMINATION OF PEDESTRIAN-LEVEL WIND SPEEDS

3.1 Overall Approach

Detailed measurements were made of pedestrian-level wind speeds at locations of interest around the project. Views of the model in the wind tunnel are shown in Figure 5 for each of the tested configurations. These wind-tunnel findings were then combined with the extratropical wind climate to provide statistical predictions of expected pedestrian-level wind speeds around the site.

Assessment for pedestrian safety is based on the mean wind speed predicted to be exceeded once a year. Assessment for pedestrian comfort is based on the mean wind speed predicted to be exceeded 5% of the time.

General descriptions of the testing and analysis procedure are given in Reference 1.

3.2 Model Instrumentation

Figure 9 indicates the 52 locations at which wind speeds were measured. Location 1 is on the Level 4 Outdoor Amenity space, Location 2 is on the Level 2 Outdoor Amenity space and Locations 3 and 4 are on the Level 9 Outdoor Amenity space; these locations were only tested for the proposed configuration.

Locations were placed systematically along the sidewalk areas around the proposed development and on existing neighbouring pedestrian traffic routes.

Measurements were made using omni-directional pressure sensors which measure both mean and fluctuating components of the wind speed parallel to the ground at a height of about 1.5 to 2m in full scale.

3.3 Aerodynamic Data

Measurements were taken at 10° intervals for the full range of azimuths.

The polar plots in Appendix B show the wind speed at each of the sensors, expressed as a ratio of the mean wind speed at reference height. The angular coordinate gives the direction of the approach wind, relative to true North.

The radial magnitudes and the shapes of the polar plots in Appendix B provide valuable indications of the relative magnitudes of wind speeds at different locations and their sensitivity to the direction of the approach wind.

These plots can be useful to identify important wind directions that can influence conditions at a particular location. In turn, this information can be used to inform and develop mitigation strategies.

3.4 Statistical Prediction of Pedestrian-Level Winds

The directional characteristics of the extratropical wind climate are shown in Figure 4.

The predicted wind speeds are obtained by combining the statistical wind climate model of wind speed and direction with the aerodynamic data measured in the wind tunnel. Two types of prediction are provided:

1. Wind speeds exceeded during 5% of the time on an annual basis.
2. Wind speeds exceeded once per year.

Criteria for pedestrian comfort and safety, for temperate climates are as follows:

CRITERIA	DESCRIPTION	MEAN WIND SPEED EXCEEDED 5% OF THE TIME
Comfort level 4	**Standing, Sitting - long exposure**	**14 km/h**
Comfort level 3	**Standing, Sitting - short exposure**	**22 km/h**
Comfort level 2	**Leisurely Walking**	**29 km/h**
Comfort level 1	**Fast Walking**	**36 km/h**

CRITERIA	DESCRIPTION	MEAN WIND SPEED EXCEEDED ONCE PER YEAR
Safety level 2	**All-Weather Areas**	**54 km/h**
Safety level 1	**Fair-Weather Areas**	**72 km/h**

The comfort categories can be basically described as follows:

- **Comfort Level 4 (C4) - Standing, Sitting for long exposure:** Wind felt on faces, leaves rustle slightly. Suitable for promenades, outdoor restaurants, or park benches where people may linger for long periods to eat, relax, or read a newspaper.
- **Comfort Level 3 (C3) - Standing, Sitting for short exposure:** Leaves and small twigs in constant motion; wind extends light flags. These winds are comfortable for building entrances or bus stops where people are likely to linger for a short time.
- **Comfort Level 2 (C2) - Leisurely Walking:** Raises dust and loose paper; small branches are moved. Wind speeds experienced are appropriate for activities which involve slow walking such as a leisurely stroll or window shopping.
- **Comfort Level 1 (C1) - Fast Walking:** Small trees in leaf begin to sway; can cause movement to hair and loose clothing. Areas experiencing these winds would be appropriate for sidewalks, parks, or playing fields where people are active with little notice of moderate wind activity and unlikely to be in one location very long.
- **Areas which exceed Comfort Level 1 wind speeds (C1+)** could experience winds that are felt as a force on the body, cause large branches or whole trees to sway, or perhaps be an inconvenience to walking.

The safety categories are established to recognize that strong winds may cause a loss of balance or the toppling of an infirm or elderly person. More stringent safety requirements are recommended for essential areas which are expected to be used in all weather conditions. The following gives a description of the levels for evaluating safety:

- **All-weather areas (S2):** areas that need to be used in all weather conditions, such as building entrances, sidewalks, etc.
- **Fair-weather areas (S1):** areas that are not used or can be closed in severe weather, such as park benches, lookout points, etc.
- **Areas which exceed Safety Level 1 (S1+)** are considered to pose a serious hazard and are undesirable regardless of activity.

These criteria reflect the findings of many pedestrian wind studies at The Boundary Layer Wind Tunnel Laboratory. These criteria were first published by Kapoor et al (Reference 6).

3.5 Tests Results and Discussion

The tested configurations are as follows:

1. Existing Site - the existing site is presently a bare surface parking lot with a single storey York Mills Subway entrance structure at the eastern edge. Figure 2 shows an aerial view of the existing site.
2. Proposed Site – the proposed site consists of a two tower development with an extensive podium. Figure 1 shows a plan view of the proposed development. Eight porous wind screens staggered along the west side of the development near the southwest corner of the podium, and 4 porous windscreens near the northeast corner of the development were also included in this configuration.

Note that preliminary measurements identified Locations 5 and 12 as having wind conditions that were expected to exceed desired comfort levels and be unsuited for their intended usage. For these areas, windscreens were incorporated into the main test program for the proposed site configuration.

On-site landscaping was not included for these tested configurations. Results can therefore be expected to reflect a somewhat conservative representation of expected wind conditions and allow an understanding of flow patterns around the development.

Figure 10 compares the predicted wind speeds at the various locations for these configurations along with the criteria for pedestrian safety. Similar plots of predicted wind speeds compared to the criteria for pedestrian comfort can be found in Figures 11, 12, 13, and 14 for spring, summer, autumn, and winter seasons, respectively.

Colour-coded diagrams are also used to summarize the suitability of each measurement location with respect to pedestrian-level safety and pedestrian comfort for each of the tested configurations. Figures 15 and 16 present these for safety considerations for the Existing and Proposed configurations, respectively. For comfort considerations these are presented in Figures 17 and 18 for the Existing and Proposed configurations, respectively, with results provided separately for each season.

Results are discussed below for each of the tested configurations.

3.5.1 Existing Site Configuration

Results for the existing configuration reflect current expected wind conditions at the existing 4050 Yonge Street site. This configuration is referred to as the ‘Existing Site’.

With respect to pedestrian safety:

1. All tested locations meet the recommendations for pedestrian safety.

With respect to pedestrian comfort:

1. All tested locations are generally suited for standing or sitting activities in the summer months.
2. Most tested locations remain suitable for standing and sitting activities in the winter months with the exception being the northeast corner of Yonge St. and York Mills Rd. which is suitable for leisurely walking during the winter; this is considered suitable for sidewalk usage.

As expected, and given the sites combination of suburban surroundings with some nearby open areas, the measured wind speeds for the existing site are consistent with or marginally greater than a typical suburban environment, while typically less windy than a typical open country exposure.

3.5.2 Proposed Development Configuration

Tests of the proposed development were carried out with the existing York Mills Subway entrance structure replaced by the proposed towers and associated podium structure; all other details of the surroundings are consistent with the existing configuration.

With respect to pedestrian safety:

1. All tested ground-level locations meet the recommendations for pedestrian safety.
2. Locations 1, 3 and 4 (located in raised amenity spaces at Levels 2, 4, or 9) exceed the safety criteria for an all-weather area and fall into the fair-weather criteria category; this carries the recommendation that access to this area by pedestrian traffic during extreme wind conditions be restricted where possible. Since these areas are understood to be controlled outdoor amenity spaces, restricting access during a wind event should be considered. Taller perimeter glass screens and/or large planters with evergreen plantings can also be effective for enhancing seasonal usage.
3. Table 2 summarizes the number of times per year the wind speed exceeds the safety criteria. The magnitudes of wind speed exceedances are summarized in Figure 10.
4. All other areas meet the criteria for all-weather areas which are discussed in detail above.

With respect to pedestrian comfort:

1. In summertime, the comfort categorization at most measurement locations remains unchanged from the existing condition. Summertime exceptions to this are Locations 5, 8, and 12 around the perimeter of the development; with the presence of the proposed towers, these locations are rated suitable for standing/short sitting, which remains consistent with the sidewalk usage. Locations 1 to 4 on the amenity decks are suitable for short sitting or leisurely walking. Inclusion of higher perimeter rails and planters throughout the amenity spaces can also be effective for enhancing or extending seasonal usage.
2. In the wintertime, numerous locations see their comfort classification increase to leisurely walking; this remains suitable for the intended sidewalk usage.
3. Locations 1 and 4 are suitable for fast walking in spring and wintertime. Some mitigation around these areas would be beneficial to improve the comfort category to sitting or standing, which is more suited to amenity space short term usage. Controlling access during wind events is also an effective strategy.
4. All other Locations either see minimal change or an improvement in comfort class.
5. With respect to all other tested locations, these are expected to be suitable for the intended usage.

3.6 Seasonal Differences

The amount and type of activity for a given location can vary by season. For example, a terrace or outdoor amenity area may have limited or restricted usage during the winter season. Thus, in some cases it is valuable to look at the wind speeds and the corresponding classification of pedestrian comfort on a more detailed season-by-season basis. Table 3 (existing configuration) and Table 4 (proposed configuration) present wind comfort class for each tested location for each of the four seasons, as well as on an annual basis

In general, compared to the annual wind speeds presented above, wind speeds during the winter months are about 10% higher, in the summer they are about 20% lower, and in the spring and autumn they are about the same.

3.7 Summary Remarks

General Overview

The proposed development in general is expected to increase winds locally around the development. This is typical with the introduction of a tall building development in a typically low-rise dominated area. This is most noticeable on the sidewalks around the perimeter of the development, particularly near the perimeter corners. The local speedups are observed to be largely influenced by the frequent westerly winds.

With the expectation of increased local winds, the focus should not be to return wind conditions to an 'as-it-was' state, but rather identify and develop strategies to make wind conditions suitable for the intended usage. For example, entry areas should have a comfort category consistent with standing activities or better, while sidewalks should meet the condition of being comfortable for walking.

Influence of Proposed Development

While the effects of local wind acceleration around the buildings demonstrate a modest influence to winds at adjacent properties, the comfort category at these locations remain acceptable for the intended usages.

Mitigation Strategies

Preliminary tests identified Locations 5 and 12 as having wind conditions that were expected to exceed desired comfort levels and be unsuited for their intended usage. For these areas, windscreens were incorporated into the main test program. Specifically, a series of 8 porous windscreens were installed onsite to the west of the development and in the vicinity of measurement Location 6, and 4 porous windscreens were installed onsite in the area north of the development near Location 11. The wind screens can be seen in the photographs found in Figure 5b and were arranged in a staggered pattern. The wind screens were found to be effective in mitigating the high wind speeds. These actual remedial screens to be installed along the west and north border of the development may be in the form of porous wind screens or evergreen plantings.

The wind speeds at the upper amenity spaces in the area of Locations 1, 3 and 4 are comfortable for sitting and leisurely walking in the summer months. Should it be desired to improve summer conditions or extend the usage of these areas into other seasons mitigation measures will be required. Suggested mitigative measures could be in the form of taller perimeter glass screens and large planters with evergreen plantings which would improve comfort levels. In addition, controlled access during wind events can be considered given the location.

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TABLES

TABLE 1 TABLE OF PREDICTED WIND SPEEDS

	Hourly Mean Wind Speeds (m/s)	
Return Period	Ht = 10 m	Ht = 500 m
1 Week	11.5	21.0
1 Month	14.6	26.6
1 Year	19.0	34.6

Notes:

1. The wind speeds shown are representative of open country exposure.

TABLE 2 NUMBER OF EXCEEDANCES OF SAFETY LEVELS PER YEAR – PROPOSED CONFIGURATION

Probe No.	All-Weather Areas Exceeded 54 km/h (1)	Fair-Weather Areas Exceeded 72 km/h (2)
1	1.8	< 1
3	1.0	< 1
4	3.6	< 1

Note:

1. To assure public safety in all-weather areas, it is recommended that an hourly mean wind speed of 54 km/h is not be exceeded once per year.
2. To assure public safety in fair-weather areas, it is recommended that an hourly mean wind speed of 72 km/h is not be exceeded once per year.
3. For Probe Numbers not listed, the number of exceedances is < 1 for both All-weather and fair-weather categories.

TABLE 3 PEDESTRIAN WIND COMFORT CLASSES FOR EXISTING SITE – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
5	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
6	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
7	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
8	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
9	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
10	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)

Probe Location	Season	Comfort Class	Suitable Usage
11	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
12	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
13	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
14	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
15	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
16	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
17	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
18	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
19	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
20	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 17a-17d.

TABLE 3 (CONT) PEDESTRIAN WIND COMFORT CLASSES FOR EXISTING SITE – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
21	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
22	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
23	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
24	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
25	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
26	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
27	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
28	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
29	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
30	Annual	C3	Sitting (Short)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)

Probe Location	Season	Comfort Class	Suitable Usage
31	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
32	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
33	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
34	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
35	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
36	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
37	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
38	Annual	C3	Sitting (Short)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
39	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
40	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 17a-17d.

TABLE 3 (CONT) PEDESTRIAN WIND COMFORT CLASSES FOR EXISTING SITE – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
41	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
42	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
43	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
44	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
45	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
46	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
47	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
48	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
49	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
50	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)

Probe Location	Season	Comfort Class	Suitable Usage
51	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Short)
	Winter	C3	Sitting (Short)
52	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Long)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 17a-17d.

TABLE 4 PEDESTRIAN WIND COMFORT CLASSES WITH PROPOSED DEVELOPMENT – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
1	Annual	C2	Leisurely Walking
	Spring	C1	Fast Walking
	Summer	C2	Leisurely Walking
	Autumn	C2	Leisurely Walking
	Winter	C1	Fast Walking
2	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
3	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C2	Leisurely Walking
	Winter	C2	Leisurely Walking
4	Annual	C1	Fast Walking
	Spring	C1	Fast Walking
	Summer	C2	Leisurely Walking
	Autumn	C1	Fast Walking
	Winter	C1	Fast Walking
5	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
6	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
7	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
8	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C2	Leisurely Walking
	Winter	C2	Leisurely Walking
9	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
10	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)

Probe Location	Season	Comfort Class	Suitable Usage
11	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
12	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C2	Leisurely Walking
	Winter	C2	Leisurely Walking
13	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
14	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
15	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
16	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
17	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
18	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
19	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
20	Annual	C4	Sitting (Long)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 18a-18h.

TABLE 4 (CONT) PEDESTRIAN WIND COMFORT CLASSES WITH PROPOSED DEVELOPMENT – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
21	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
22	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
23	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
24	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
25	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
26	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
27	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
28	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
29	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
30	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)

Probe Location	Season	Comfort Class	Suitable Usage
31	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
32	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
33	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C2	Leisurely Walking
	Winter	C2	Leisurely Walking
34	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C2	Leisurely Walking
35	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
36	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
37	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
38	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
39	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
40	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C3	Sitting (Short)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 18a-18h.

TABLE 4 (CONT) PEDESTRIAN WIND COMFORT CLASSES WITH PROPOSED DEVELOPMENT – SEASONAL

Probe Location	Season	Comfort Class	Suitable Usage
41	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
42	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
43	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
44	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
45	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C4	Sitting (Long)
46	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
47	Annual	C4	Sitting (Long)
	Spring	C4	Sitting (Long)
	Summer	C4	Sitting (Long)
	Autumn	C4	Sitting (Long)
	Winter	C3	Sitting (Short)
48	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
49	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C3	Sitting (Short)
	Winter	C3	Sitting (Short)
50	Annual	C2	Leisurely Walking
	Spring	C2	Leisurely Walking
	Summer	C3	Sitting (Short)
	Autumn	C2	Leisurely Walking
	Winter	C2	Leisurely Walking

Probe Location	Season	Comfort Class	Suitable Usage
51	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C2	Sitting (Short)
	Winter	C2	Sitting (Short)
52	Annual	C3	Sitting (Short)
	Spring	C3	Sitting (Short)
	Summer	C4	Sitting (Long)
	Autumn	C2	Sitting (Short)
	Winter	C2	Sitting (Short)

Note:

Comfort Classes and their description can be found in Section 3.4. Results are also shown in Figures 11-14, and Figures 18a-18h.

FIGURES

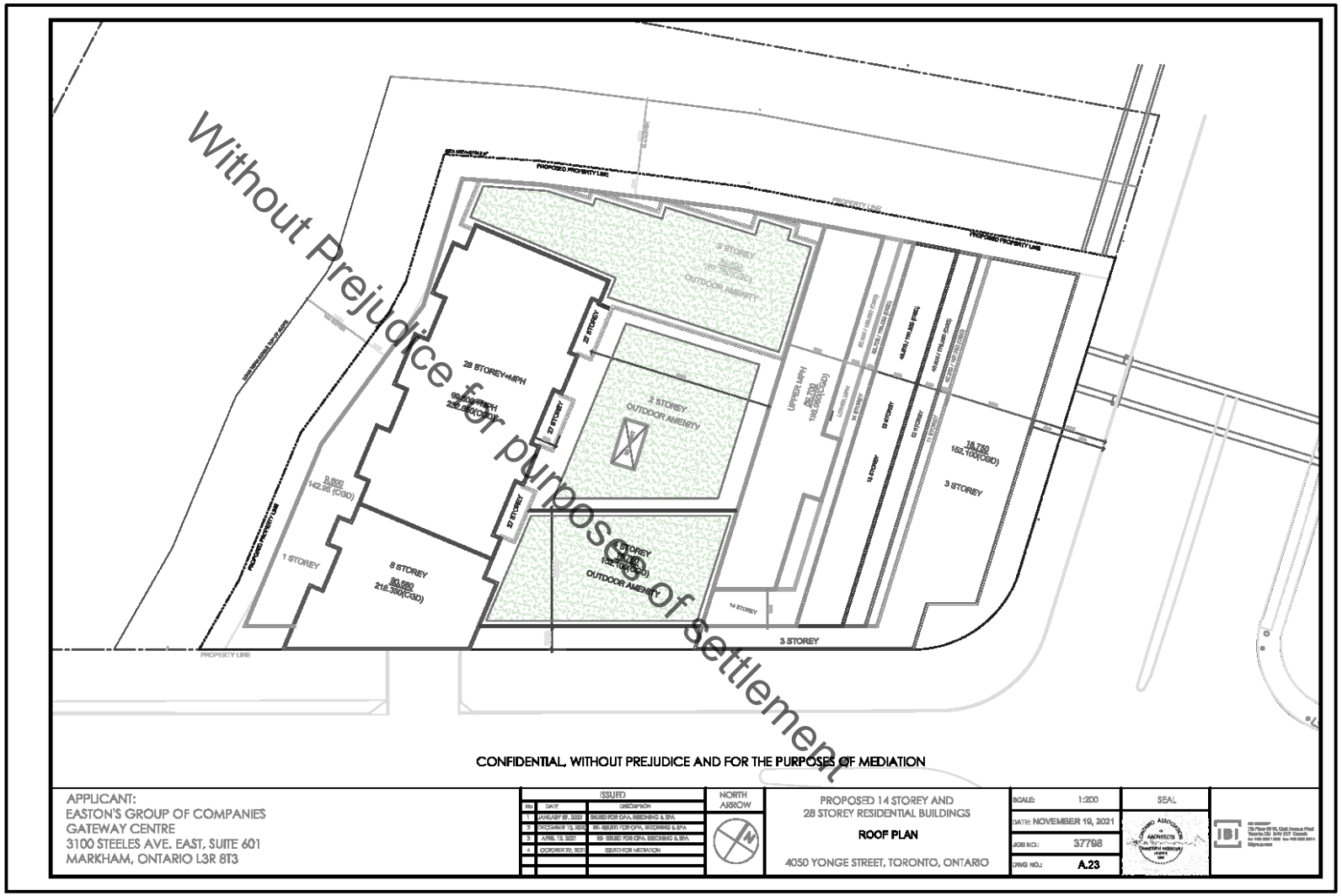


FIGURE 1 PLAN VIEW OF THE DEVELOPMENT

FIGURE 2 AERIAL VIEW OF EXISTING SITE LOCATION

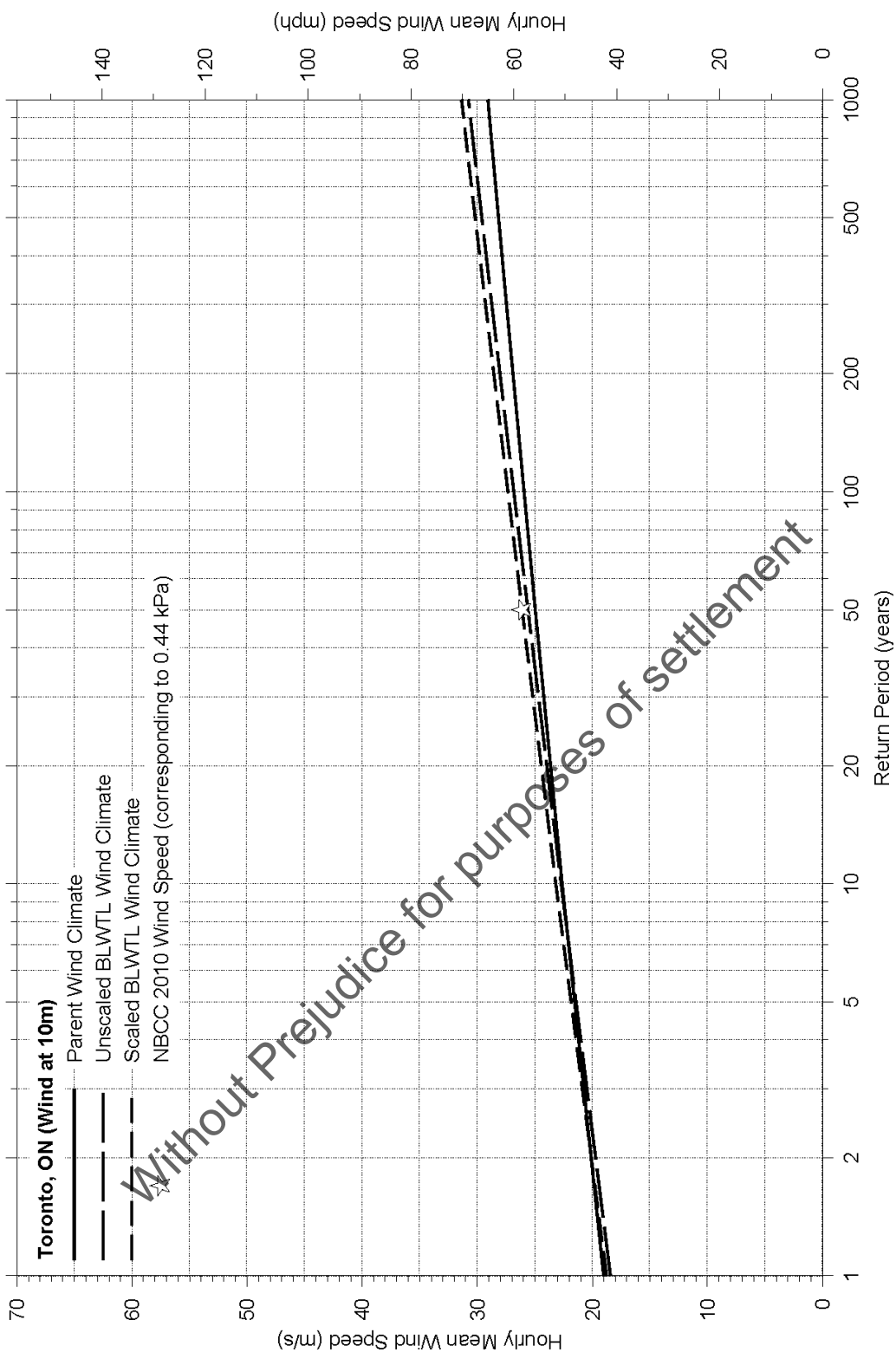


FIGURE 3a PREDICTED ANNUAL EXTREME REFERENCE WIND SPEEDS AT 10 m HEIGHT FOR VARIOUS RETURN PERIODS

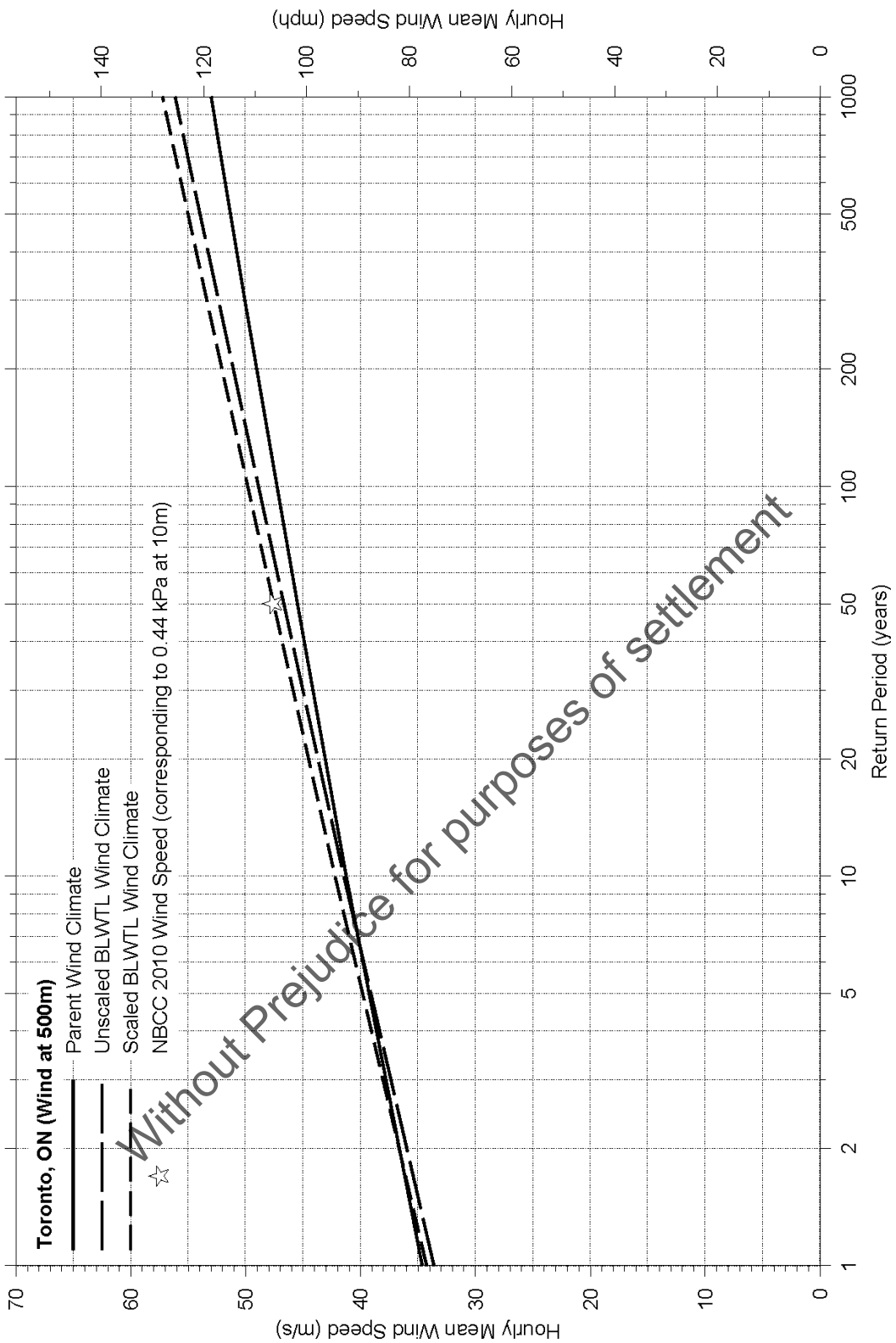


FIGURE 3b PREDICTED ANNUAL EXTREME REFERENCE WIND SPEEDS AT 500m HEIGHT FOR VARIOUS RETURN PERIODS

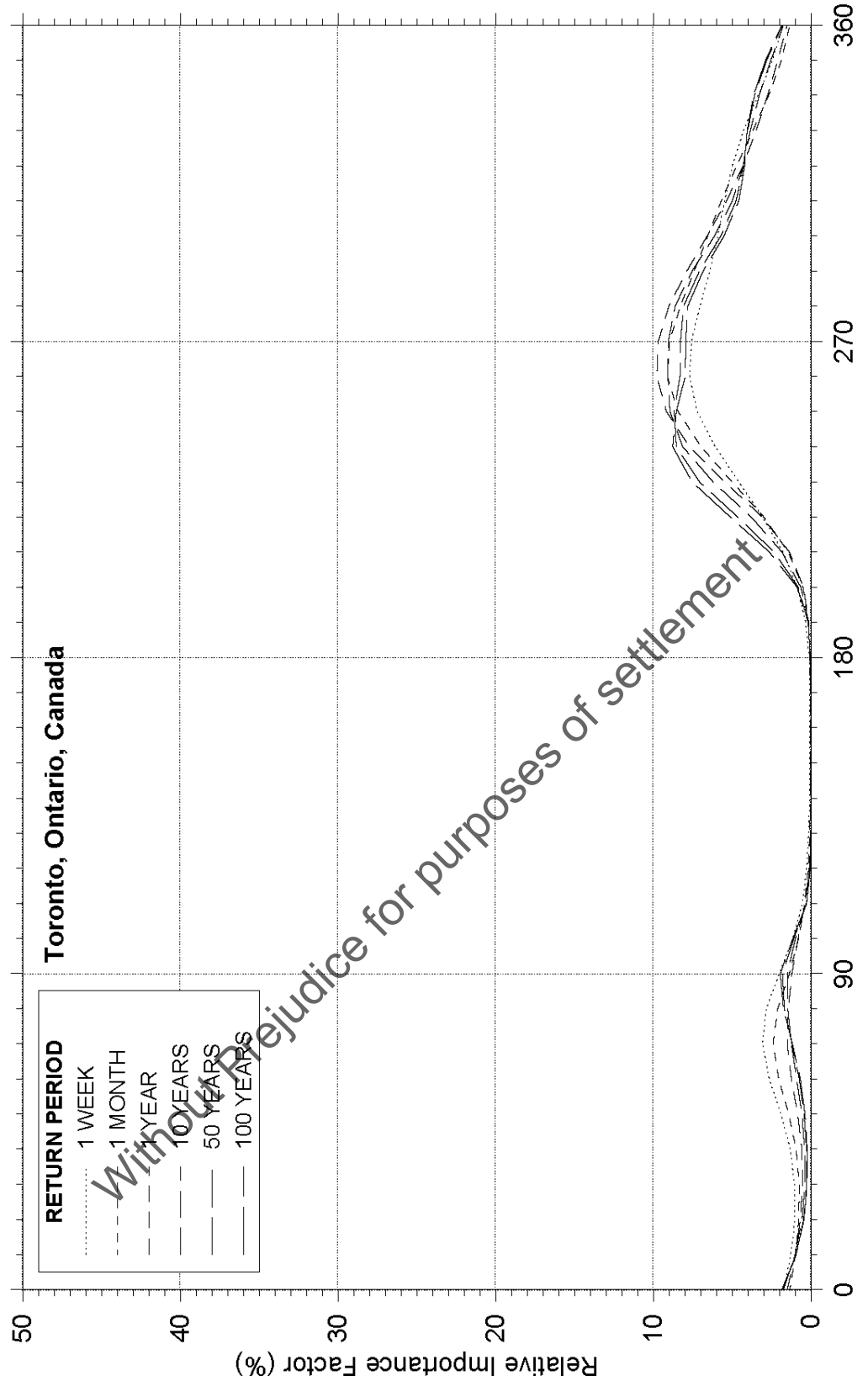


FIGURE 4a RELATIVE IMPORTANCE OF AZIMUTHAL SECTOR TO THE PROBABILITY OF EXCEEDING VARIOUS RETURN-PERIOD WIND SPEEDS - ANNUAL

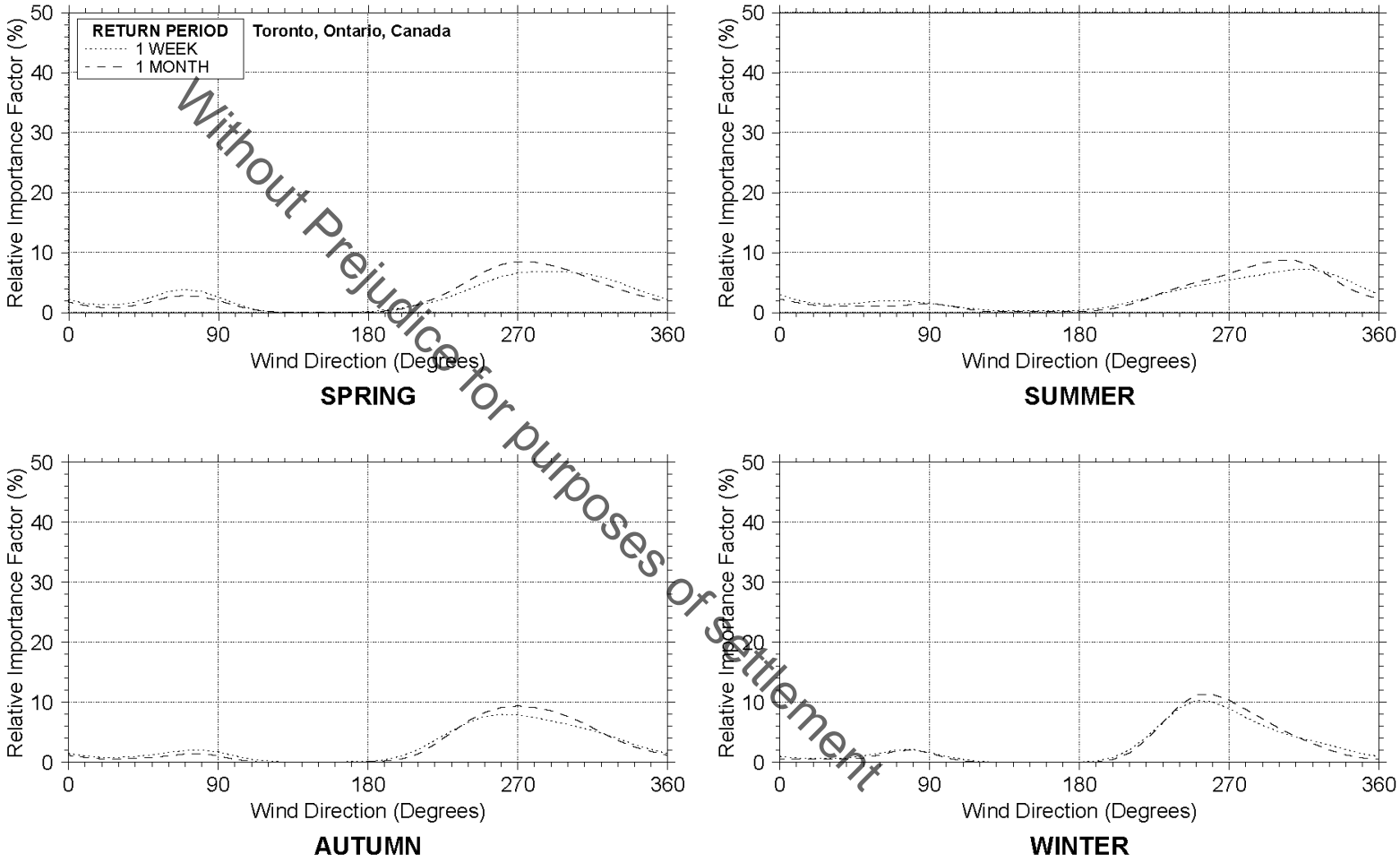


FIGURE 4b RELATIVE IMPORTANCE OF AZIMUTHAL SECTOR TO THE PROBABILITY OF EXCEEDING VARIOUS RETURN-PERIOD WIND SPEEDS - SEASONAL

EXISTING CONFIGURATION

PROPOSED CONFIGURATION – WITH WINDSCREENS

FIGURE 5a CLOSE UP VIEWS OF THE PEDESTRIAN LEVEL WIND SPEED MODELS AND CONFIGURATIONS TESTED

PROPOSED CONFIGURATION – WITH WINDSCREENS CONT'D

FIGURE 5b CLOSE UP VIEWS OF THE PEDESTRIAN LEVEL WIND SPEED MODELS AND CONFIGURATIONS TESTED

EXPOSURE 1 - EXISTING

EXPOSURE 2 - PROPOSED

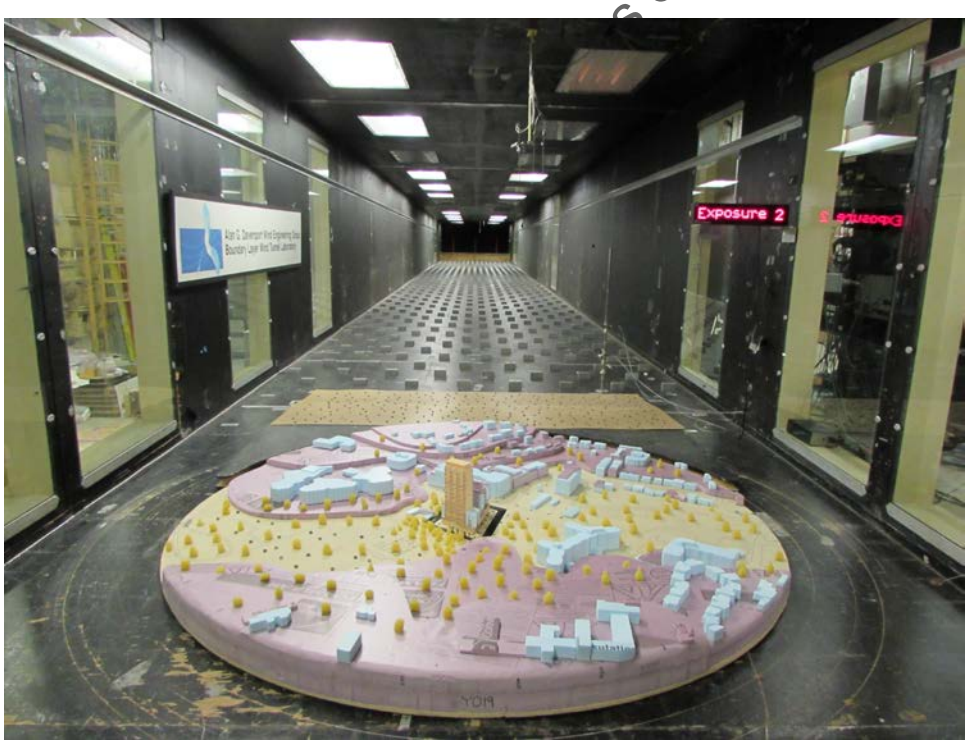


FIGURE 6 PHOTOGRAPHS OF THE MODEL IN THE WIND TUNNEL SHOWING THE UPSTREAM TERRAIN MODELS (EXPOSURES) USED

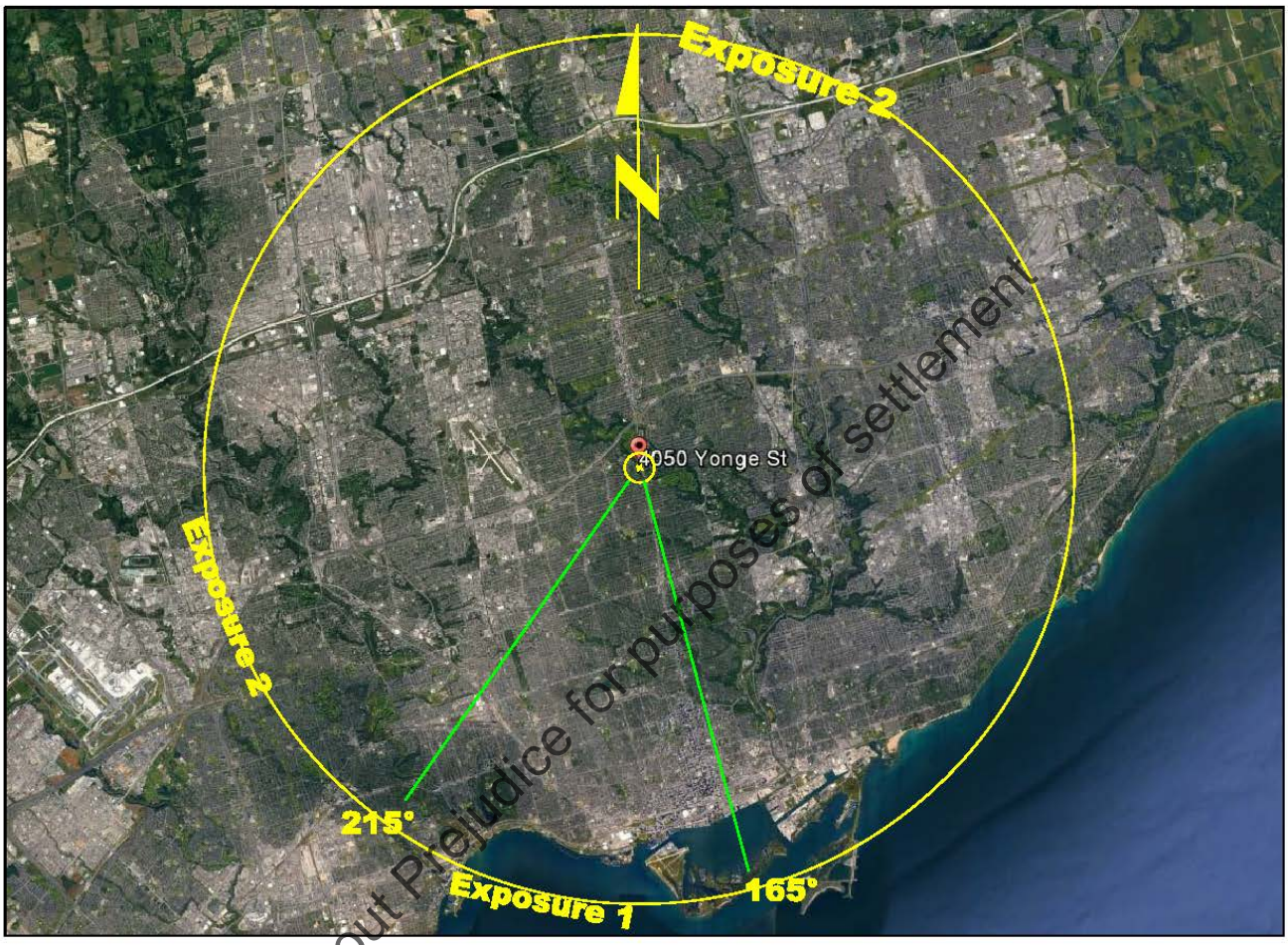


FIGURE 7 AZIMUTH RANGES OVER WHICH THE UPSTREAM TERRAIN MODELS WERE USED

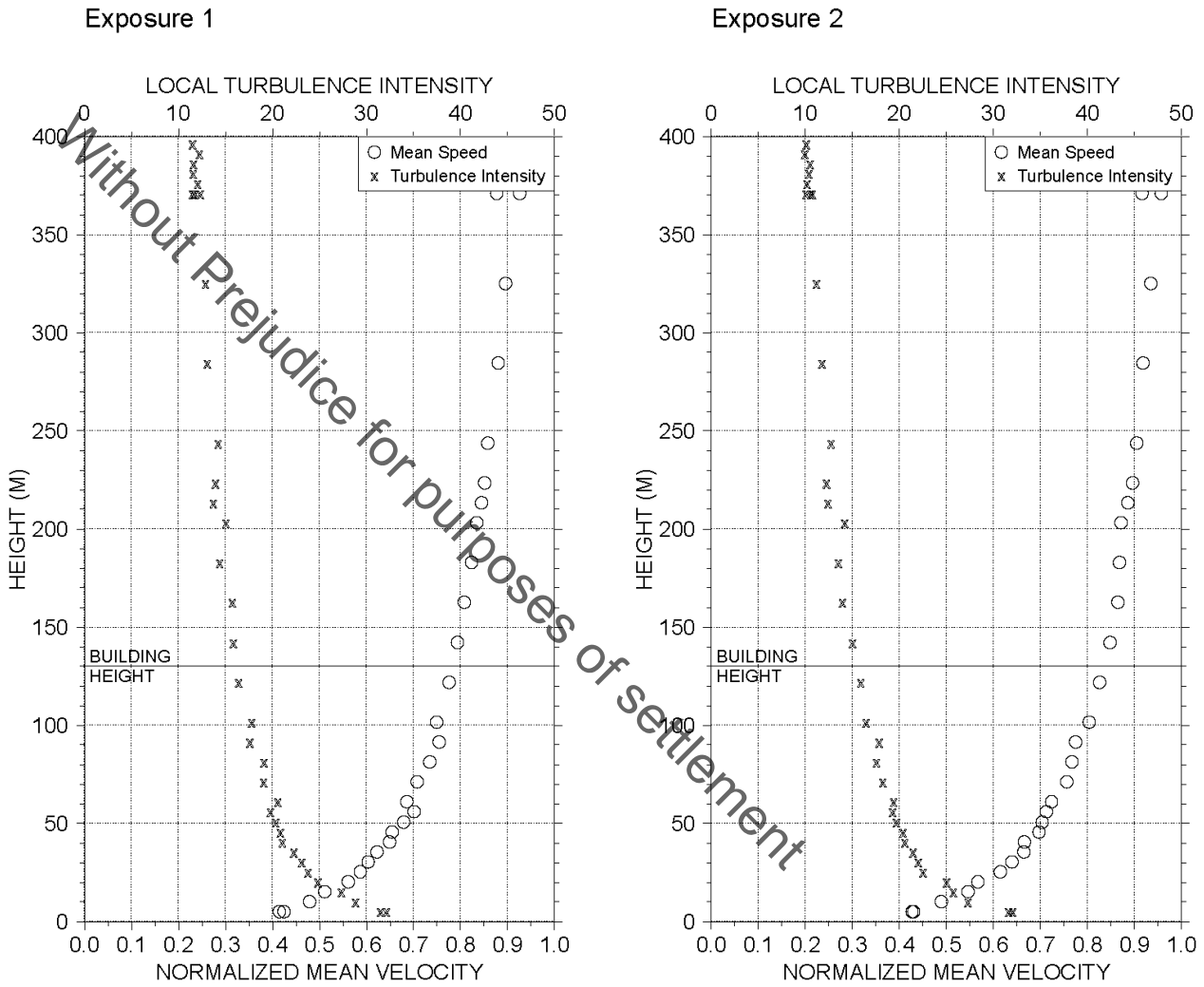


FIGURE 8 VERTICAL PROFILES OF MEAN WIND SPEED AND LONGITUDINAL TURBULENCE INTENSITY MEASURED JUST UPSTREAM OF THE PROXIMITY MODEL.

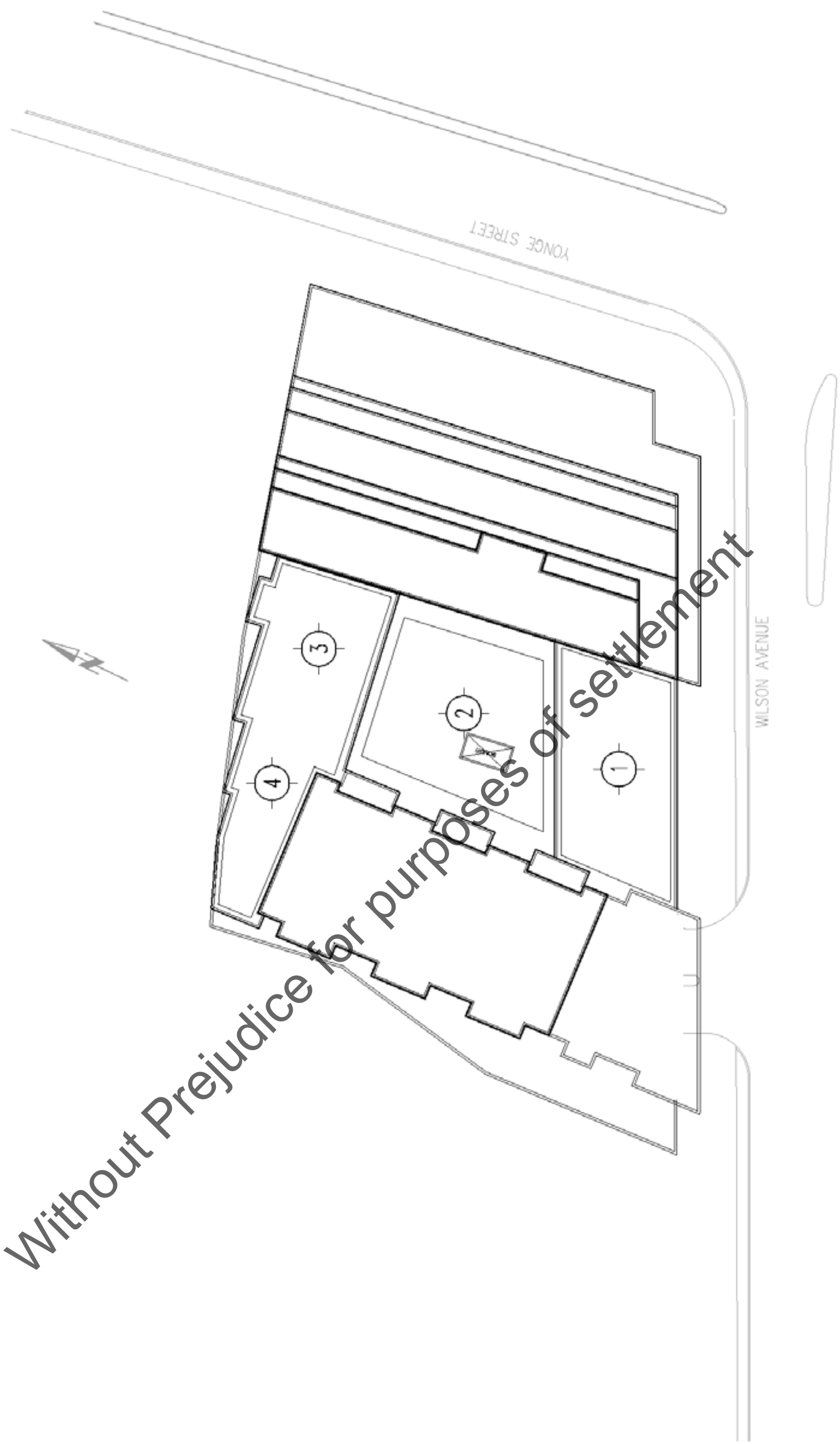


FIGURE 9a MEASUREMENT LOCATIONS FOR PEDESTRIAN-LEVEL WIND SPEEDS – TERRACE LEVEL

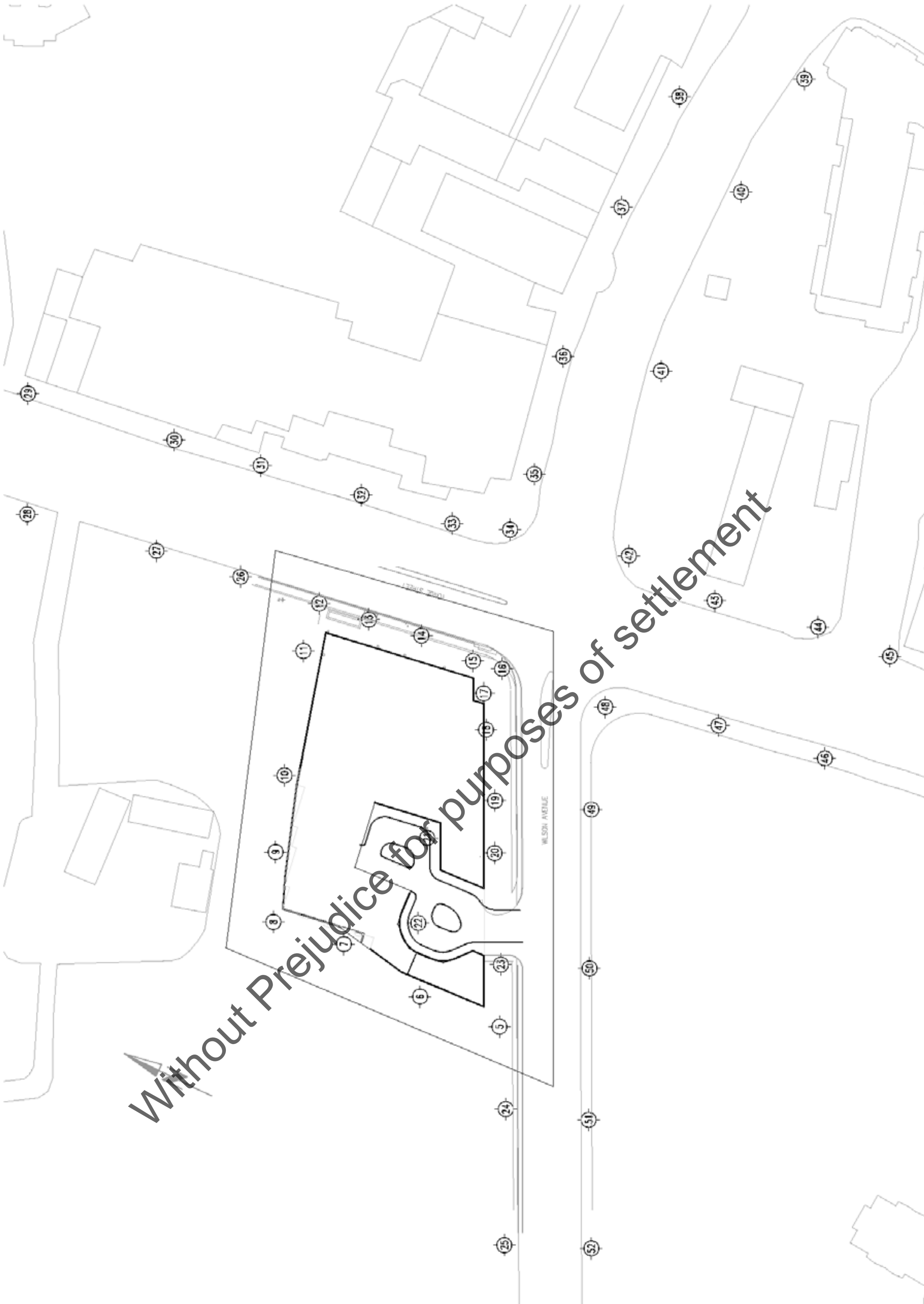


FIGURE 9b MEASUREMENT LOCATIONS FOR PEDESTRIAN-LEVEL WIND SPEEDS – GROUND LEVEL

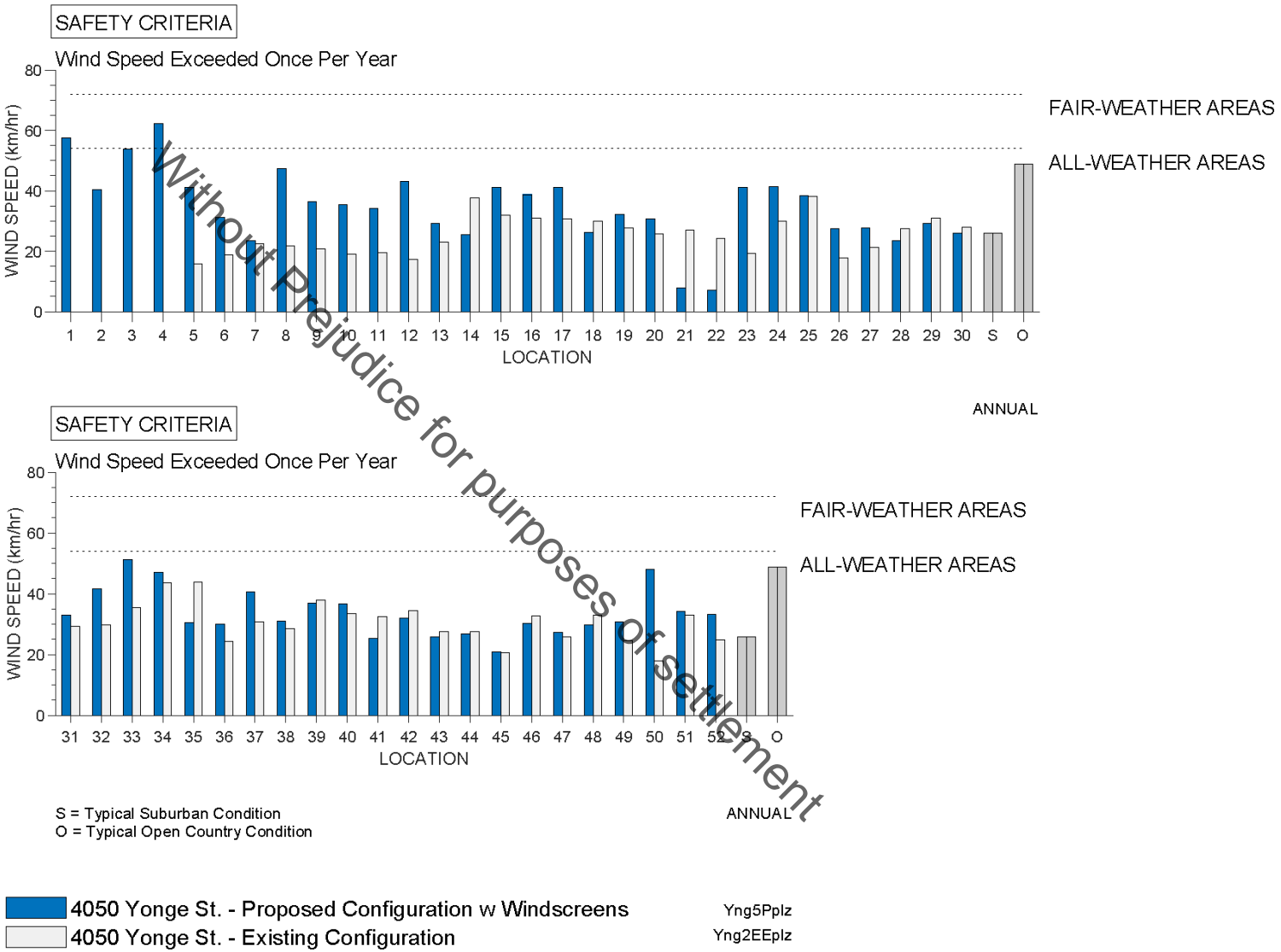


FIGURE 10 PREDICTED WIND SPEEDS COMPARED WITH CRITERIA FOR PEDESTRIAN SAFETY

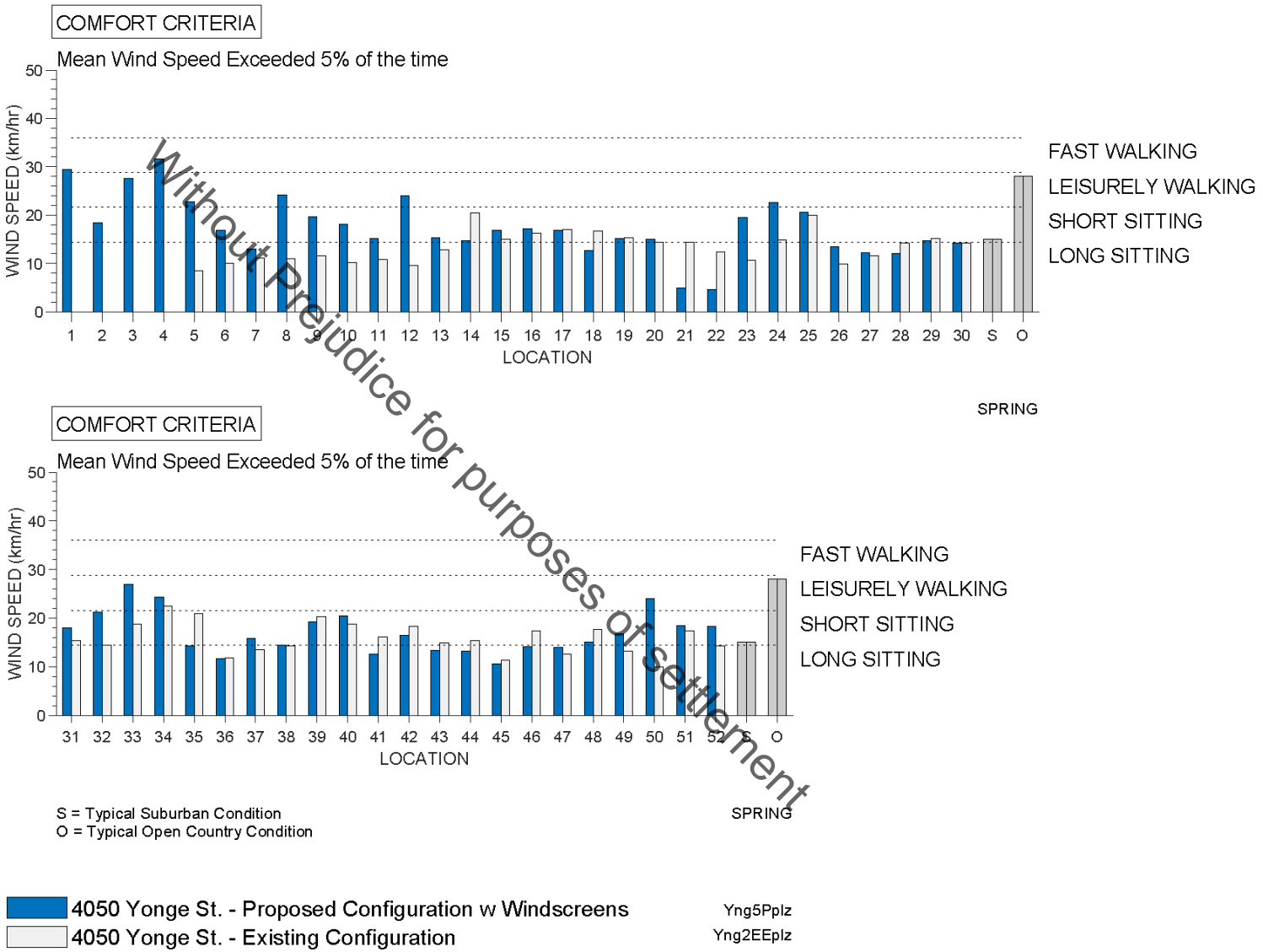


FIGURE 11 PREDICTED WIND SPEEDS COMPARED WITH CRITERIA FOR PEDESTRIAN COMFORT – SPRING

FIGURE 12 PREDICTED WIND SPEEDS COMPARED WITH CRITERIA FOR PEDESTRIAN COMFORT – SUMMER

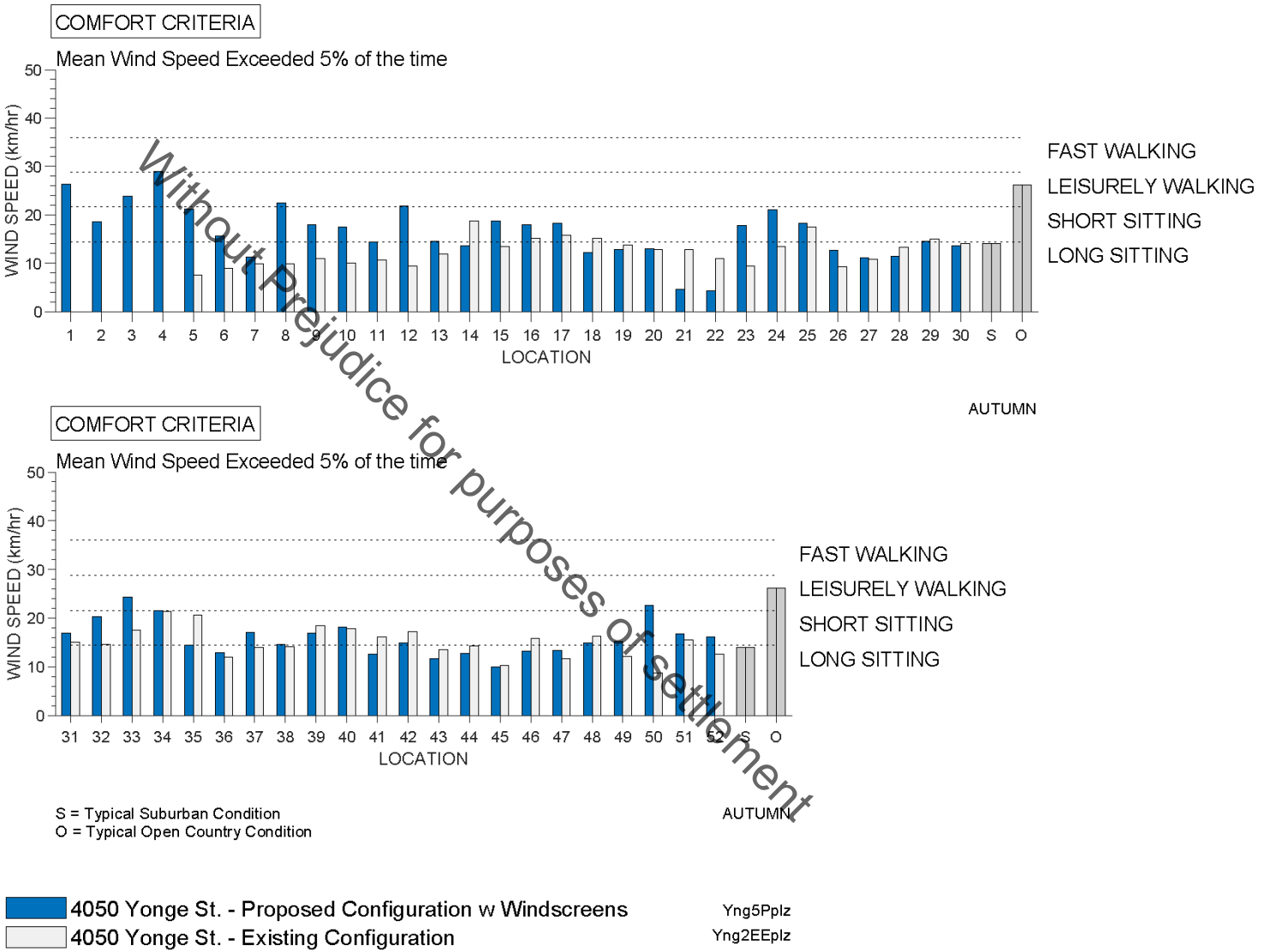


FIGURE 13 PREDICTED WIND SPEEDS COMPARED WITH CRITERIA FOR PEDESTRIAN COMFORT – AUTUMN

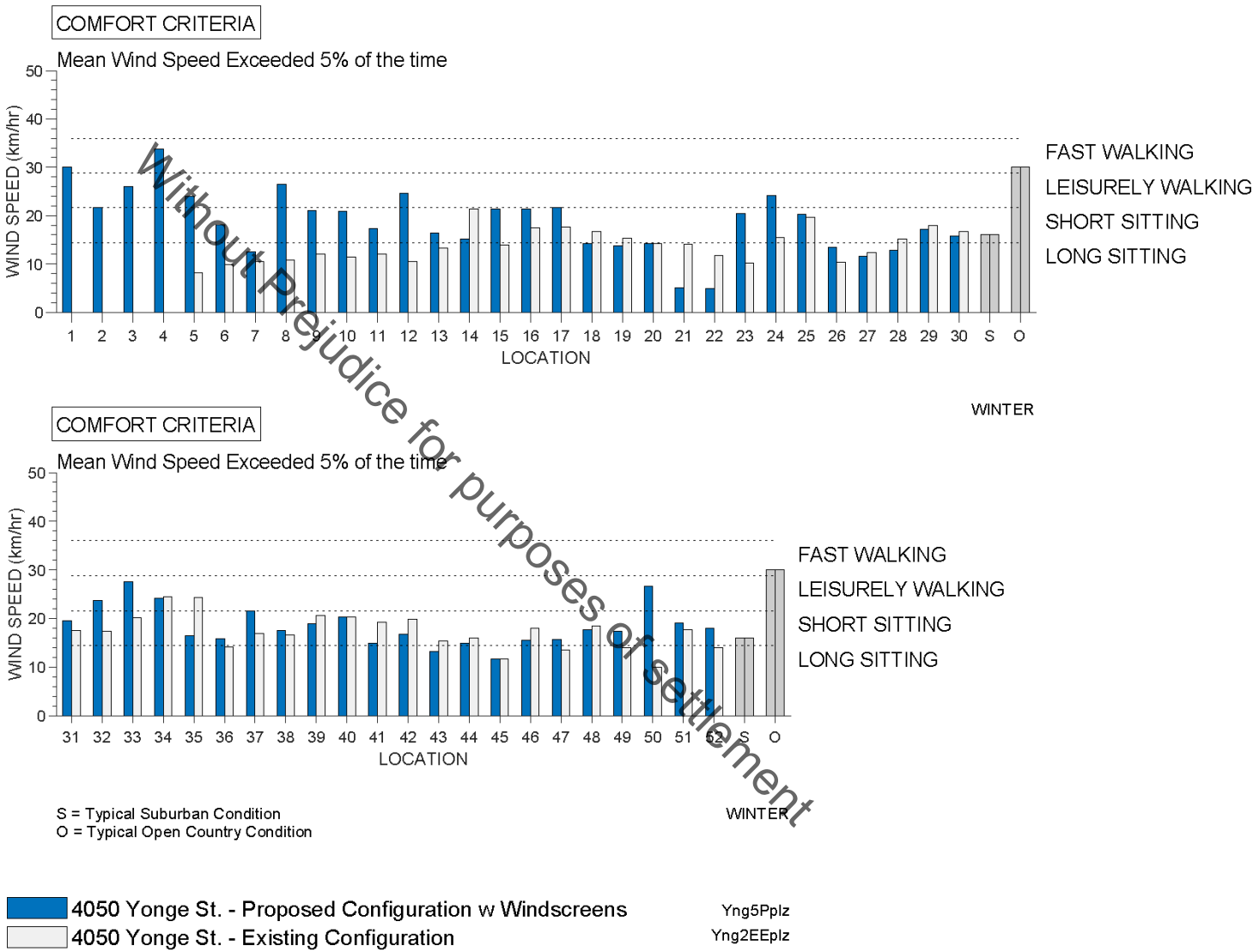


FIGURE 14 PREDICTED WIND SPEEDS COMPARED WITH CRITERIA FOR PEDESTRIAN COMFORT – WINTER

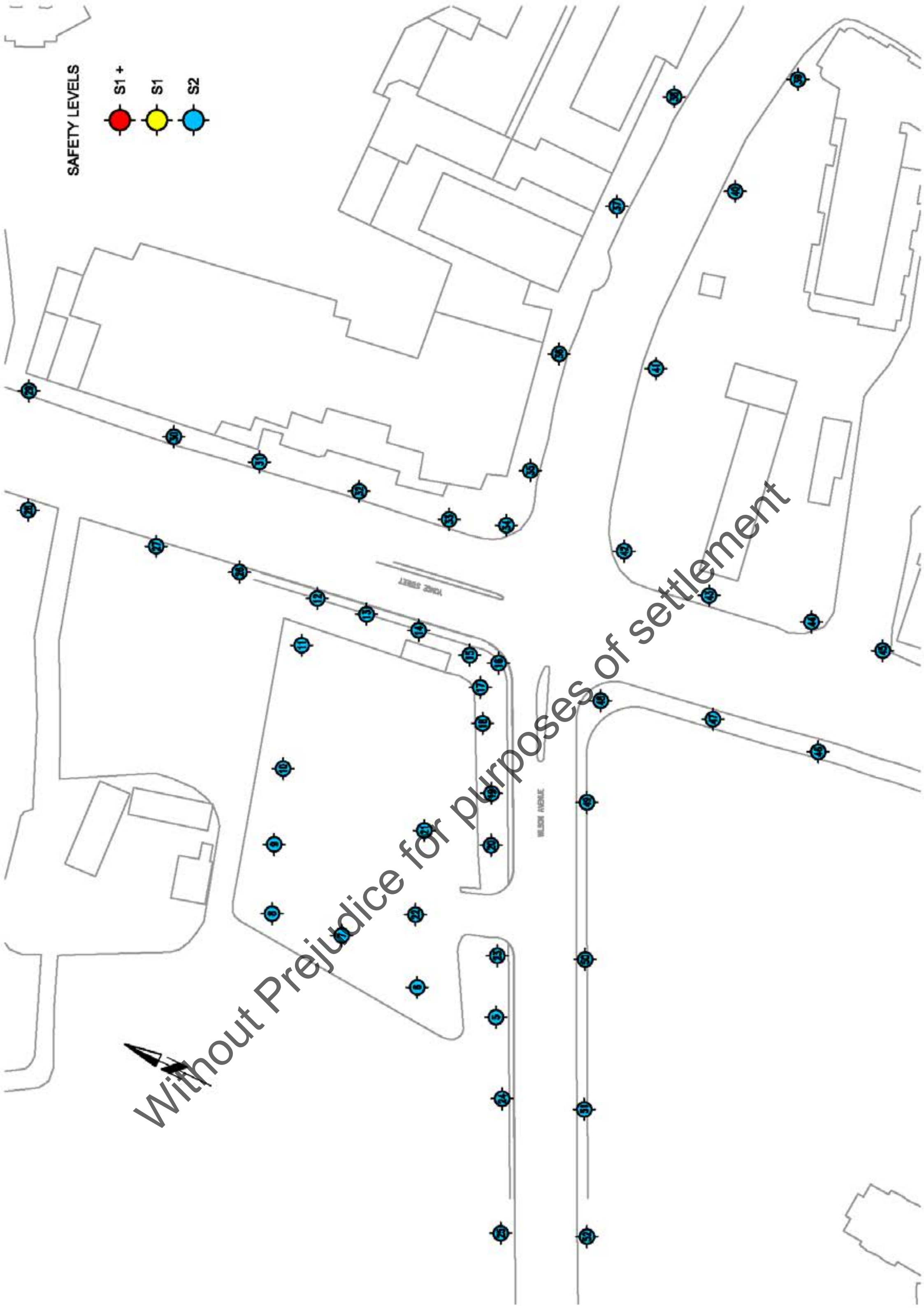


FIGURE 15 SUMMARY OF PREDICTED SAFETY LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE CONFIGURATION; GROUND LEVEL

FIGURE 16a SUMMARY OF PREDICTED SAFETY LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; TERRACE LEVEL

FIGURE 16b SUMMARY OF PREDICTED SAFETY LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; GROUND LEVEL

FIGURE 17a SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE; GROUND LEVEL - SPRING

FIGURE 17b SUMMARY OF PREDICTED <u>COMFORT</u> LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE; GROUND LEVEL - SUMMER

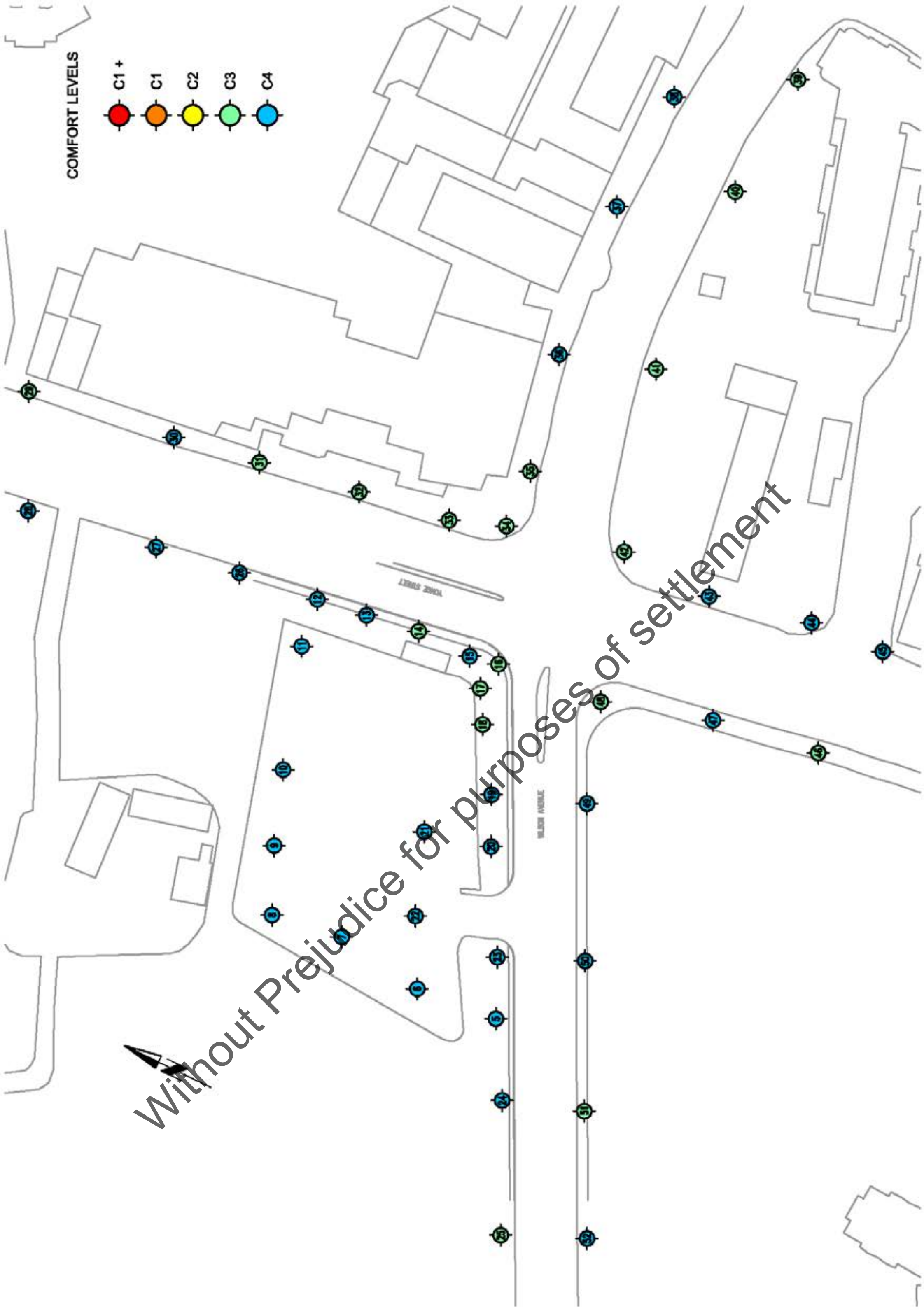


FIGURE 17c SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE; GROUND LEVEL - AUTUMN

FIGURE 17d SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – EXISTING SITE; GROUND LEVEL - WINTER

FIGURE 18a **SUMMARY OF PREDICTED <u>COMFORT</u> LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; TERRACE LEVEL – SPRING**

FIGURE 18b SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; GROUND LEVEL - SPRING

FIGURE 18c SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; TERRACE LEVEL - SUMMER

FIGURE 18d **SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; GROUND LEVEL - SUMMER**

FIGURE 18e SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; TERRACE LEVEL - AUTUMN

FIGURE 18f SUMMARY OF PREDICTED <u>COMFORT</u> LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; GROUND LEVEL - AUTUMN

FIGURE 18g SUMMARY OF PREDICTED COMFORT LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; TERRACE LEVEL - WINTER

FIGURE 18h SUMMARY OF PREDICTED <u>COMFORT</u> LEVELS FOR PEDESTRIAN-LEVEL WIND SPEEDS – PROPOSED DEVELOPMENT WITH WINDSCREENS INSTALLED; GROUND LEVEL - WINTER

APPENDIX A

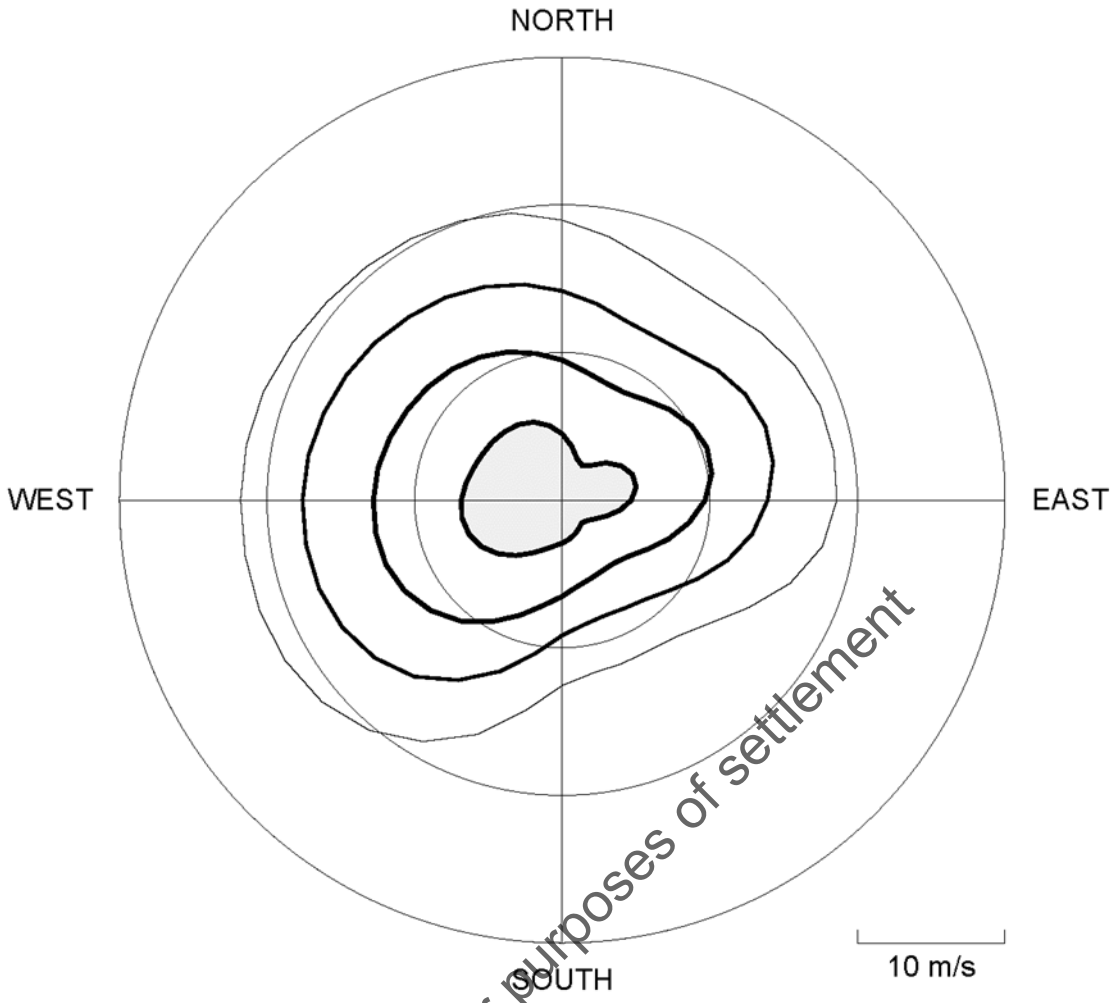
PROBABILITY DISTRIBUTIONS OF WIND SPEED AND DIRECTION

In the plots, the radial distance represents the wind speed at a reference height of 500 m in standard open country exposure. Contours are plotted for four probability levels: the innermost contour is for a probability level of 0.01 or 1% of the time. The other contours represent 0.1%, 0.01% and 0.001% of the time. Thus, the more-common winds are represented by the inner contours and the more-rare winds by the outer contours.

These plots have been derived using data at 16 compass directions, which were interpolated to every 10°. Thus, a point on the innermost contour would represent the wind speed that is exceeded 1% of the time within a 10° sector centred on that wind direction.

To determine the probability of exceeding a particular wind speed at a particular direction, interpolate between the contour levels. For example, to determine the probability of exceeding 20 m/s from the west, find the point on the plot corresponding to this speed and direction. In this case (for 20 m/s at 270°), the probability of exceeding 20 m/s from the west falls between the 1% and 0.1% contours, and is approximately 0.35%.

The probability of a particular wind speed being exceeded regardless of direction can be obtained by summing the probabilities of exceeding that wind speed at every 10° over the full 360° azimuth range.



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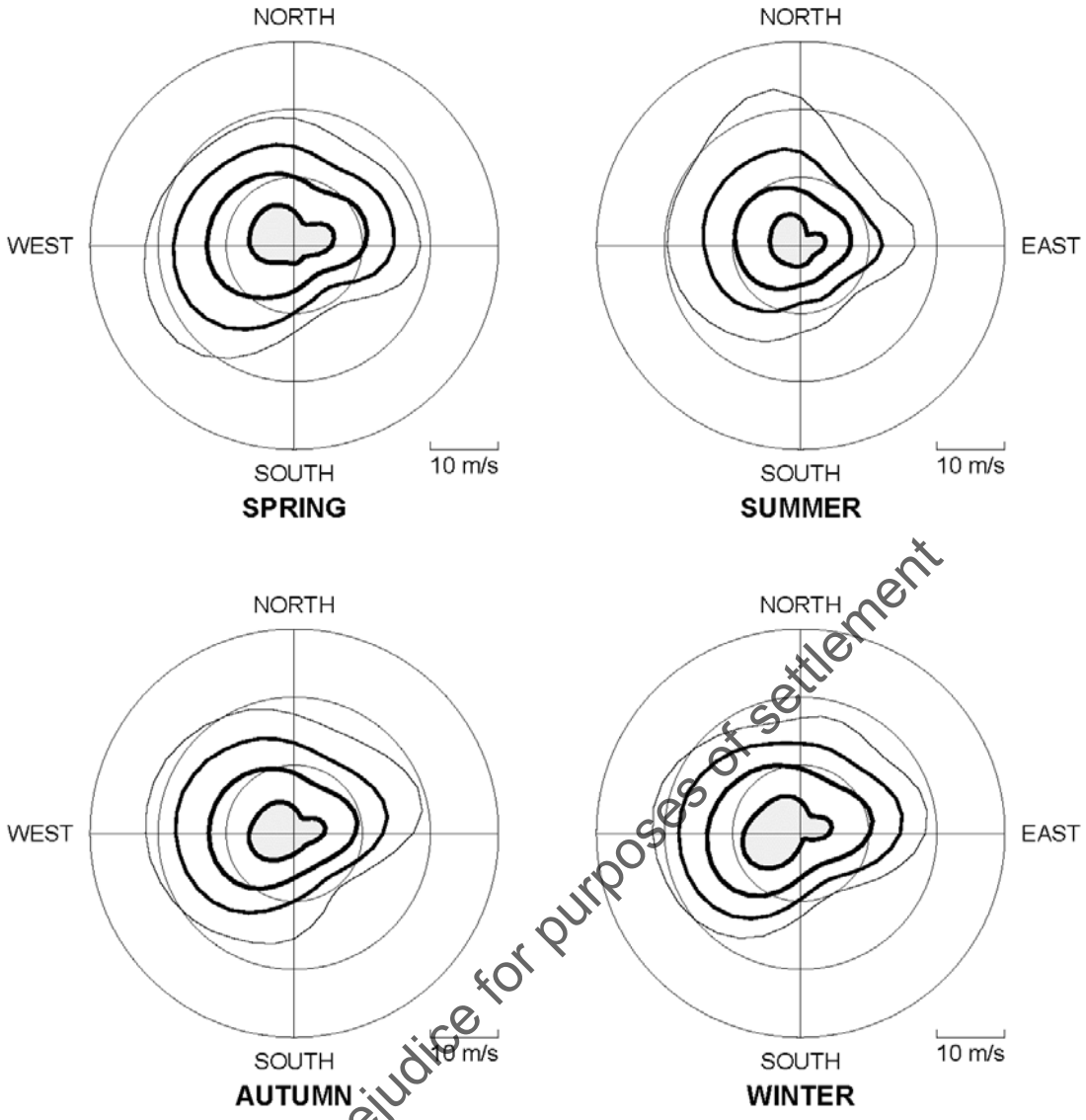
A point on the innermost contour represents the wind speed exceeded 1% of the time within a 10 degree sector centred on that direction.
Other contours represent probability levels of:
0.1%, 0.01% and 0.001% respectively.

Toronto, Ontario, Canada



A point on the innermost contour represents the wind speed exceeded 1% of the time within a 10 degree sector centred on that direction. Other contours represent probability levels of: 0.1%, 0.01% and 0.001% respectively.

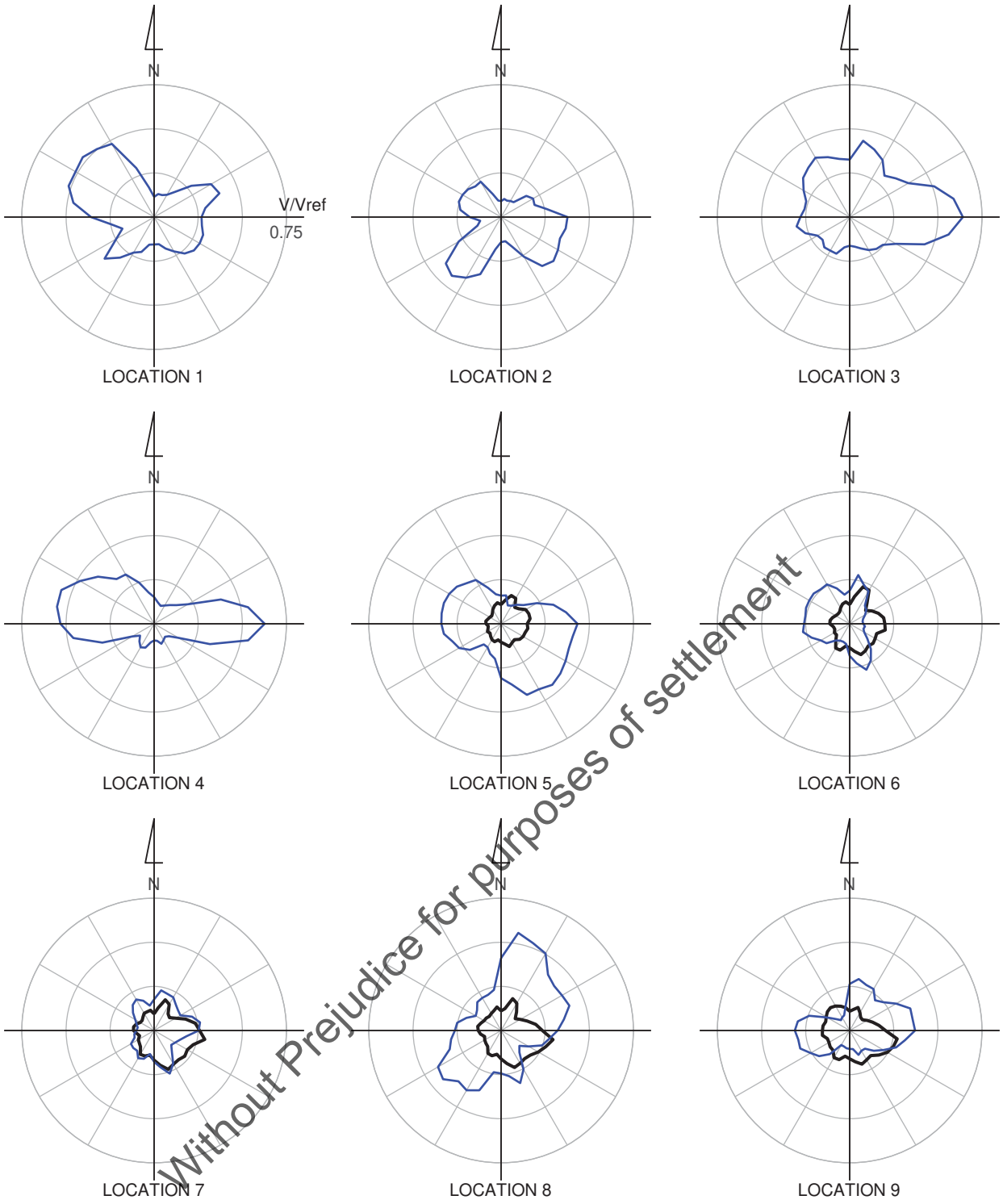
Toronto, Ontario, Canada

APPENDIX B

POLAR PLOTS OF SPEED COEFFICIENTS

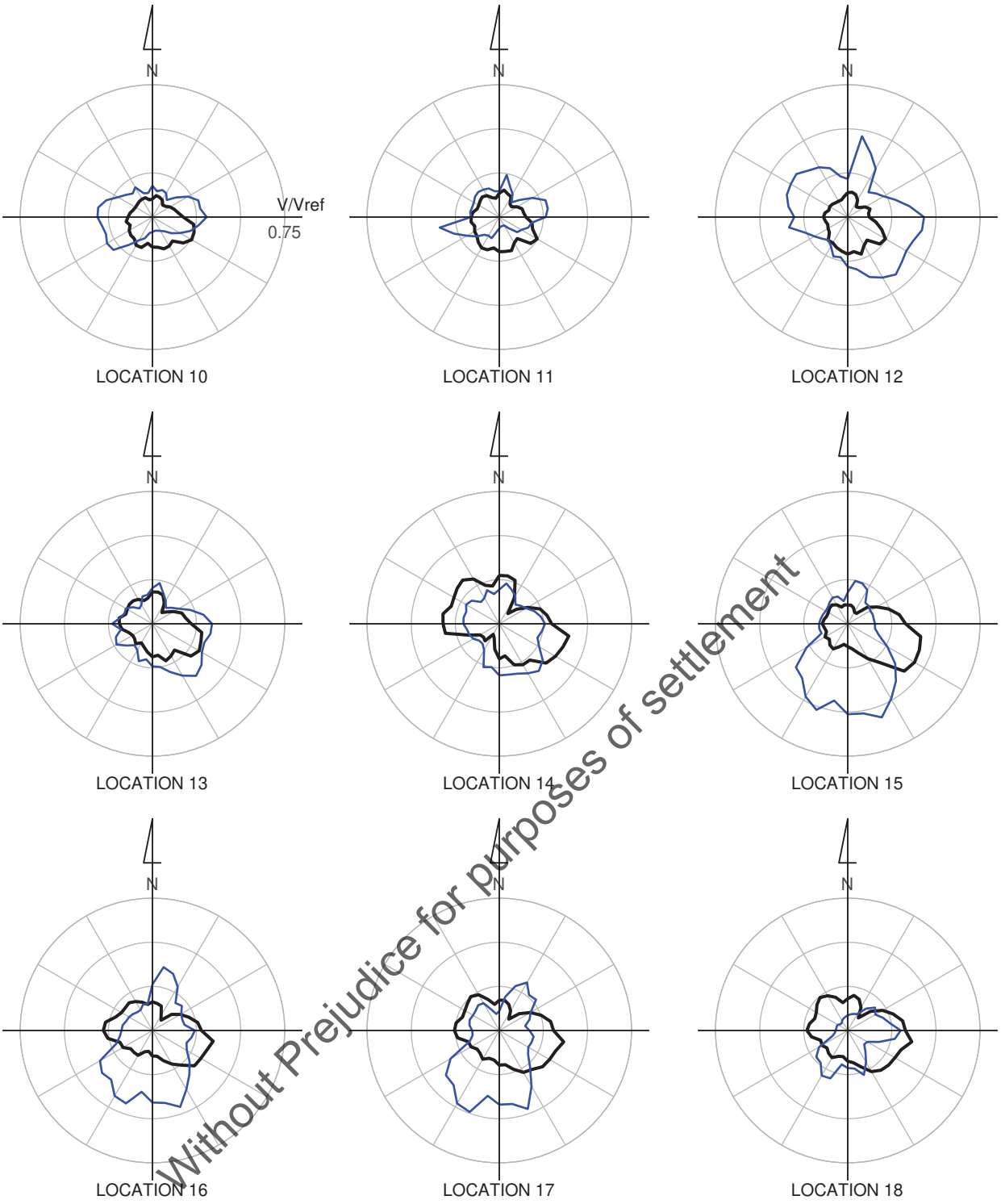
Speed ratios are the speed at the probe height divided by the speed at reference height (see Figure 3b).

The azimuth indicated refers to the direction of the oncoming reference-height wind flow, measured from true North. Surface wind directions may vary considerably from these.



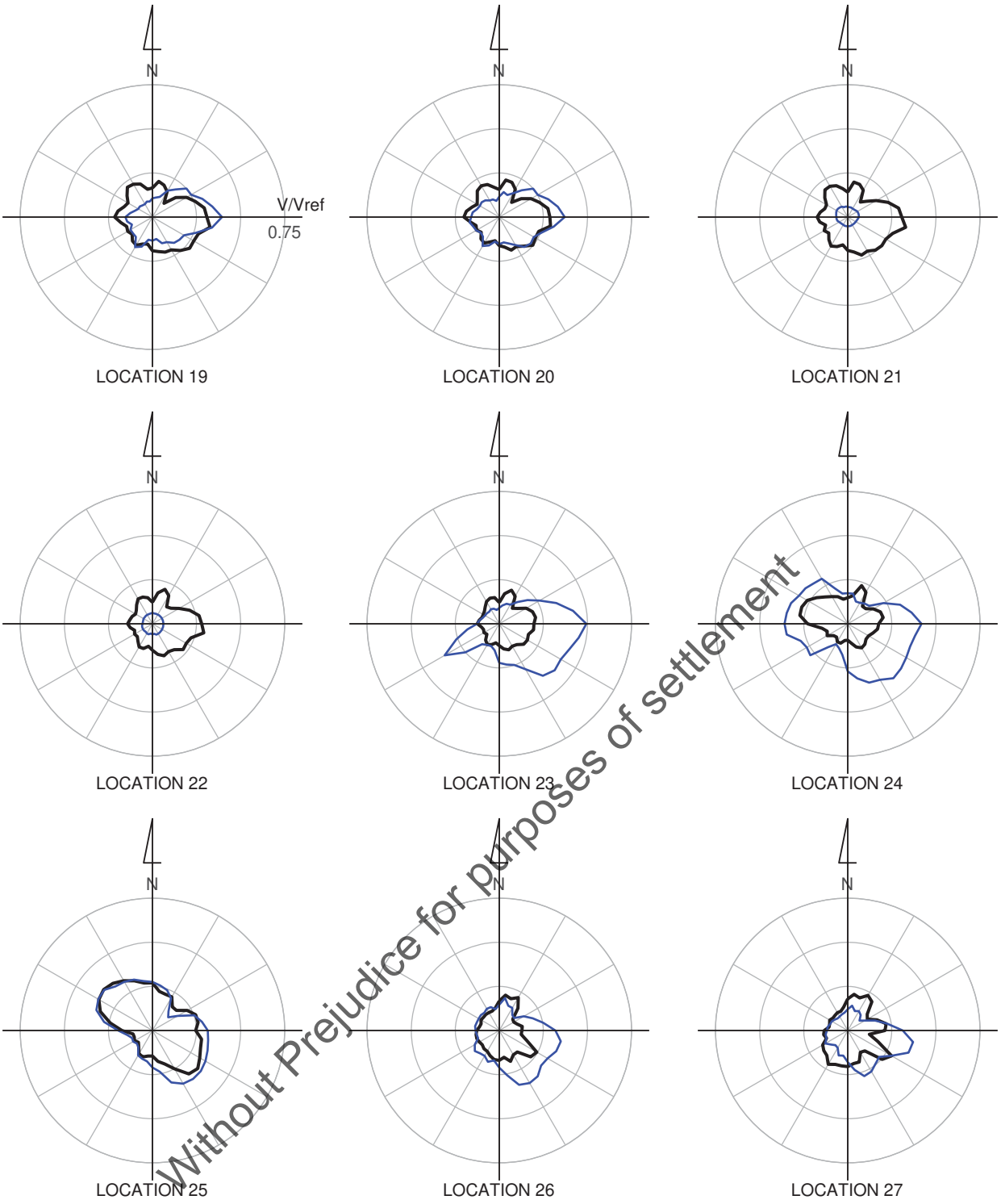
4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean



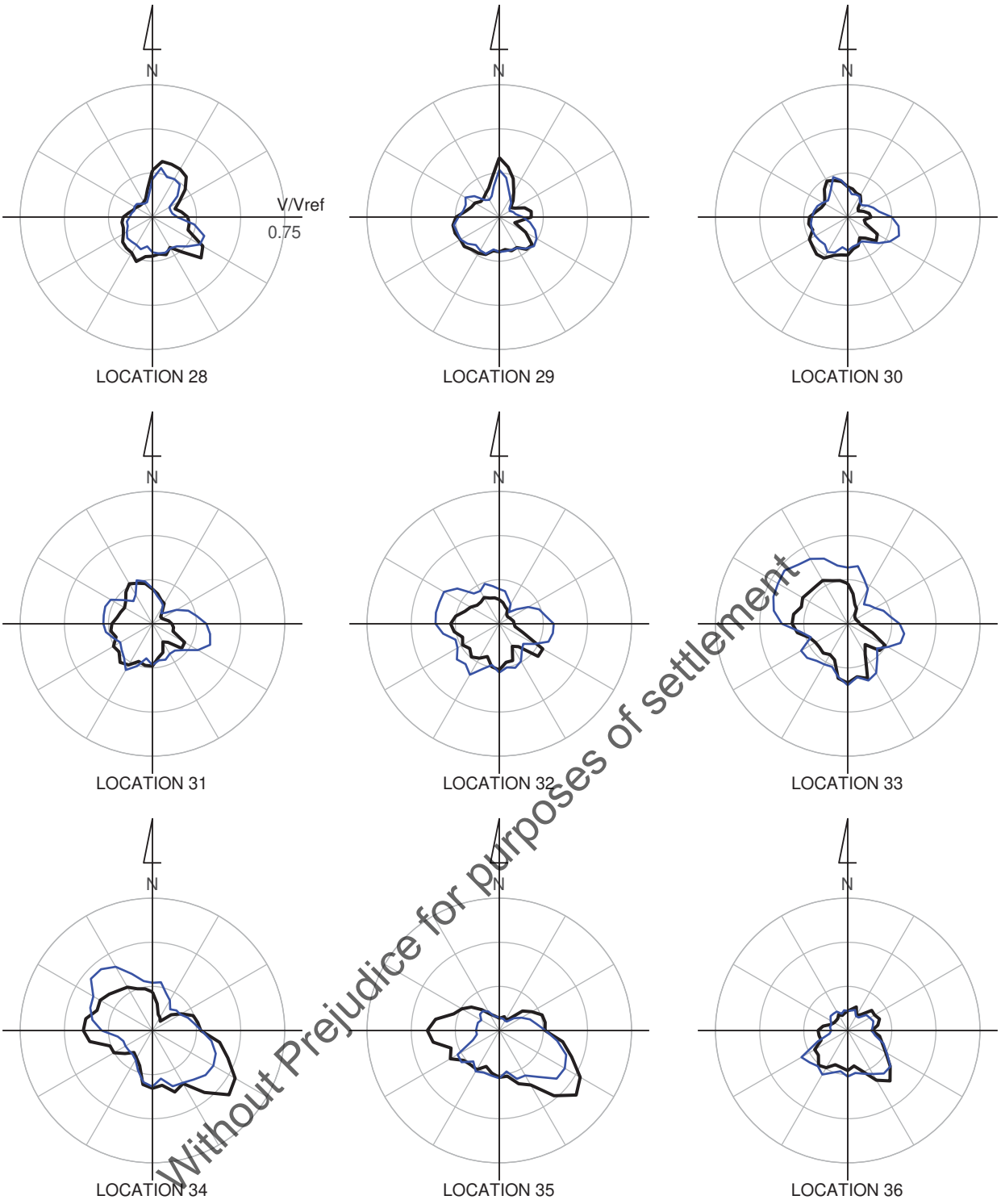
4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean



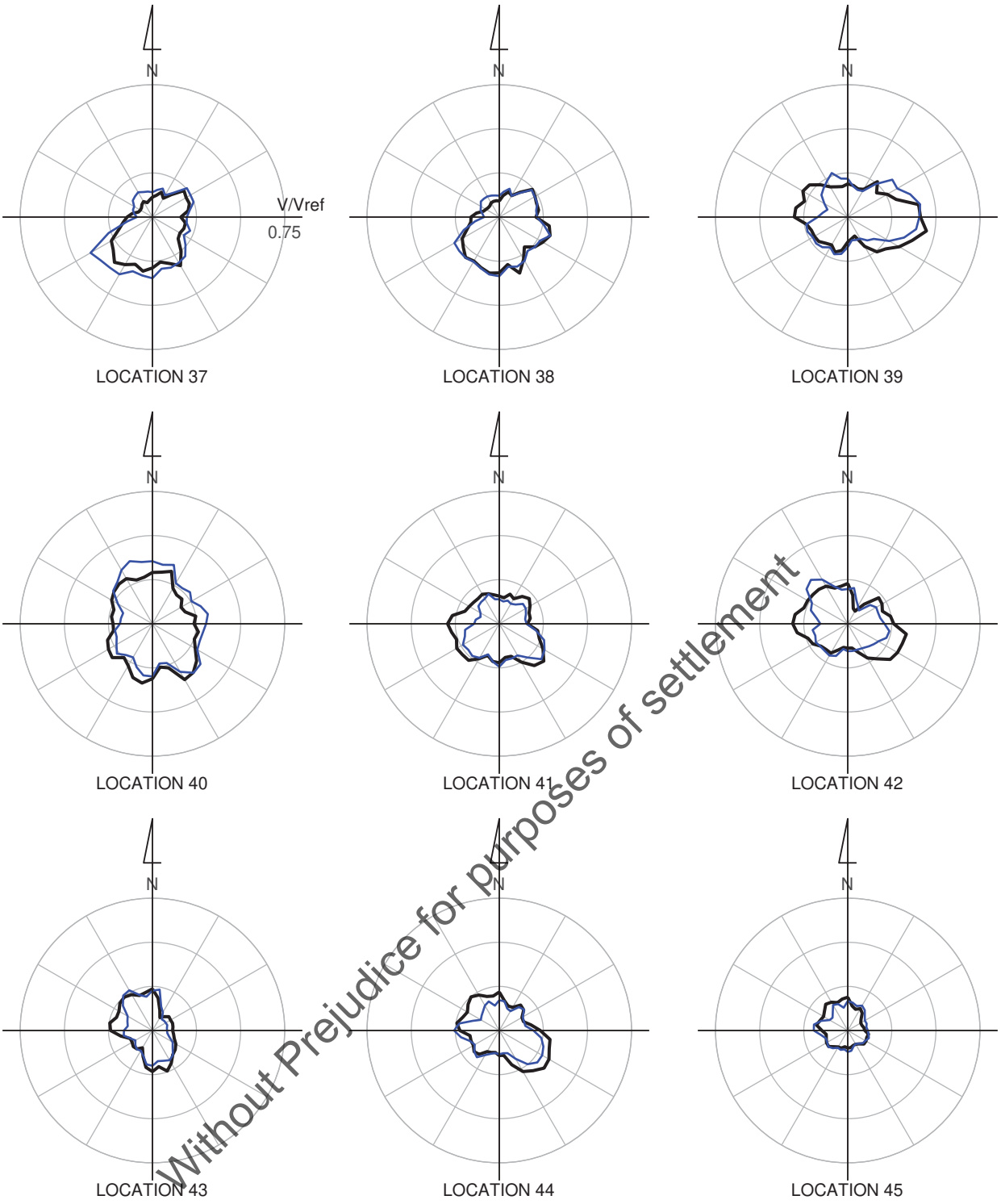
4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean



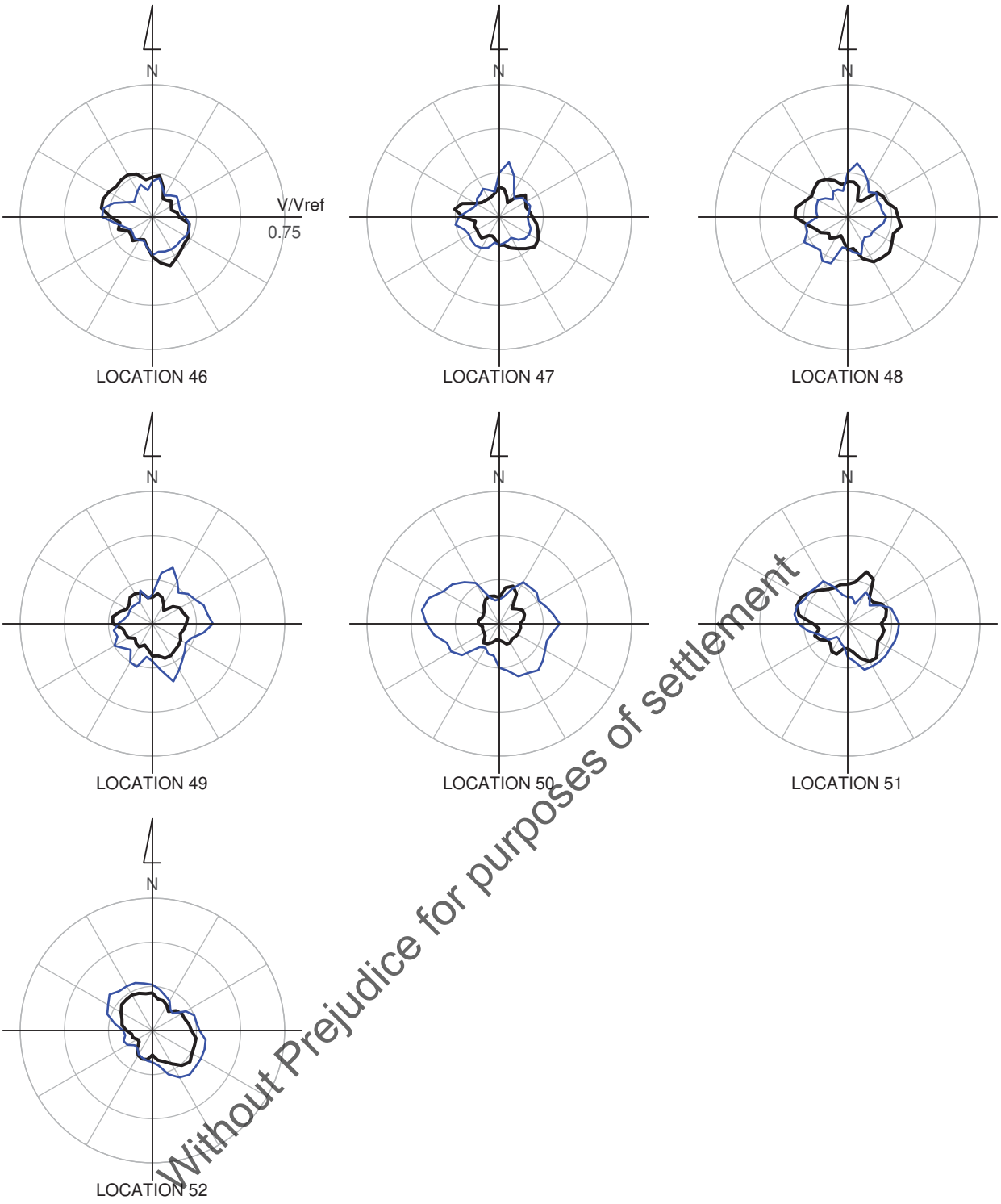
4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean



4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean



4050 Yonge St. - Existing Configuration — Yng2EEplz/Mean

4050 Yonge St. 2021 Massing - Proposed Configuration w Windscreens — Yng5Pplz/Mean