



Highways Department
Major Works Project Management Office

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Agreement No. CE 43/2010 (HY)
Central Kowloon Route
- Design and Construction

Air Ventilation Assessment -
Volume 2: Gascoigne Road Flyover

(Ref: REP-286-02)



September 2016

ARUP 
Mott MacDonald

Arup-Mott MacDonald Joint Venture

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Appendix A

Directional Velocity Ratios for Individual Study Points

1 Introduction

This report is in relation to the Detailed Study for the Air Ventilation Assessment Study of the development known as the Central Kowloon Route (CKR) Project, Kowloon, Hong Kong.

A detailed study of air ventilation characteristics for the proposed noise enclosures at the Gascoigne Road Flyover site in Yau Ma Tei was carried out. The study was undertaken in accordance with the current best international practice requirements stipulated in “Manuals and Reports on Engineering Practice No. 67 : Wind Tunnel Studies of Buildings and Structures, Virginia 1999 issued by American Society of Civil Engineers”, “Wind Engineering Studies of Buildings, Quality Assurance Manual on Environment Wind Studies AWES-QAM-1-2001 issued by Australasian Wind Engineering Society” and “Hong Kong Environment Transport and Works Bureau, 2006, Technical Circular No. 1/06 for Air Ventilation Assessments”.

The location of the proposed site for this study is given in Figure 1. The site is located in Yau Ma Tei, to the east of Victoria Harbour and bordering an area that is highly developed. The project consists of three proposed zones as depicted in Figure 2:

- Zone 1: Re-provisioned Gascoigne Road Flyover, including semi and full noise enclosures.
- Zone 2: Semi-enclosed noise structure near the centre of the development site.
- Zone 3: Large noise enclosure at the western end of the development site.

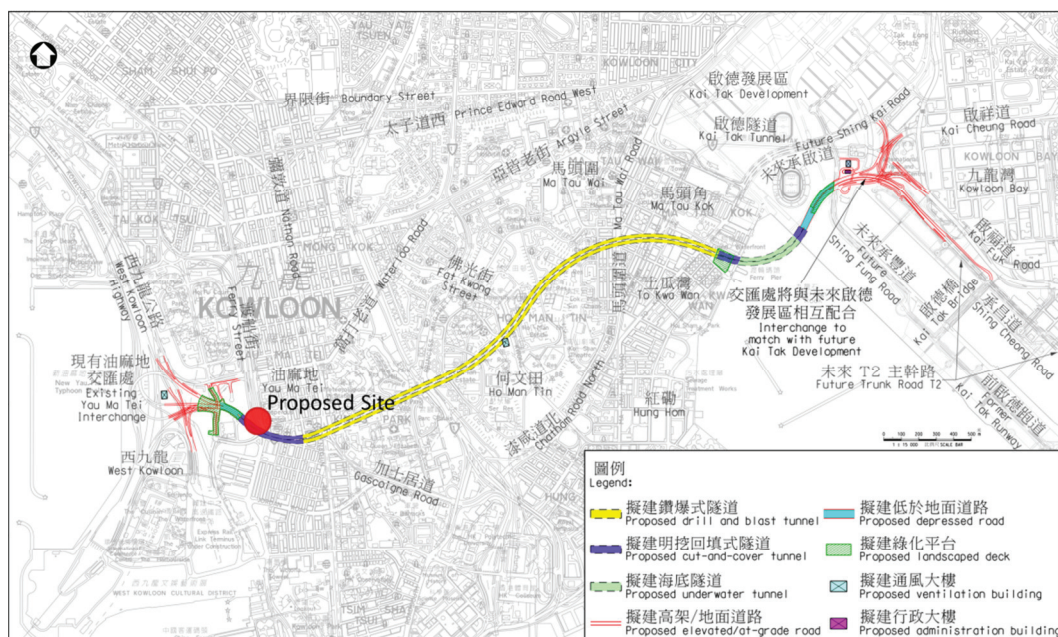


Figure 1: Proposed Site for the Study

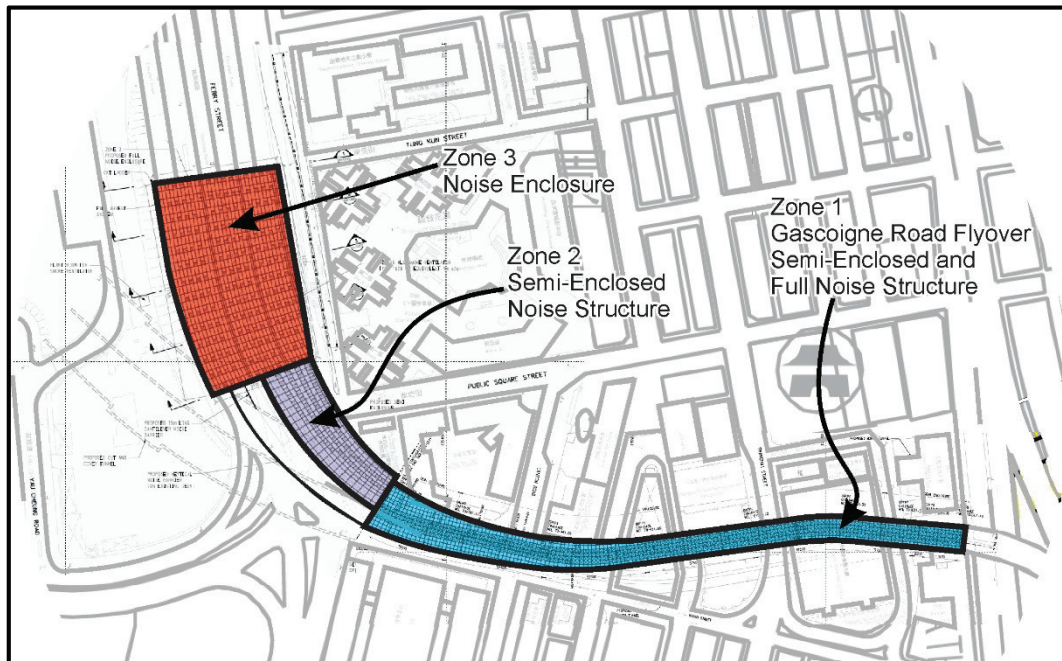


Figure 2: Study Development Zones

2 The Wind Tunnel Model

Wind tunnel testing was undertaken to obtain accurate wind velocity ratio measurements using a 1:300 scale model. The study model incorporates all necessary features on the development to ensure an accurate wind flow is achieved around the model. A proximity model was also constructed and represents the surrounding buildings and significant topographical effects within a radius of 375m. Testing was performed for two configurations as follows:

- Existing site conditions. Photographs of the wind tunnel model are shown in Figures 3a to 3f.
- With the inclusion of the proposed Gascoigne Road Flyover development and associated building demolition. Photographs of the wind tunnel model are shown in Figures 3g to 3l.

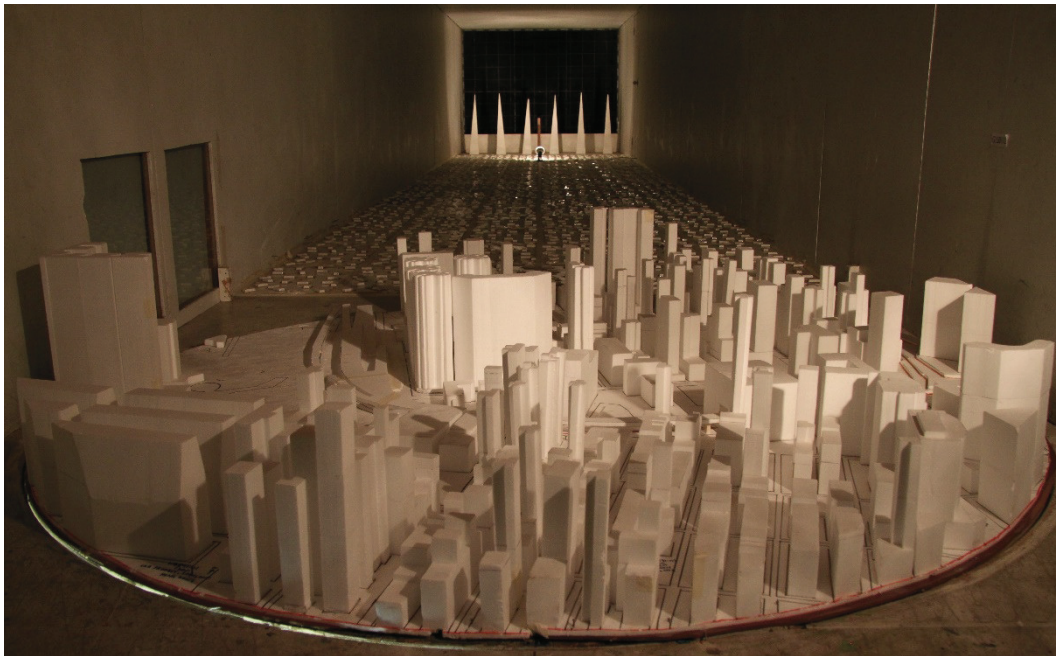


Figure 3a: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the south)

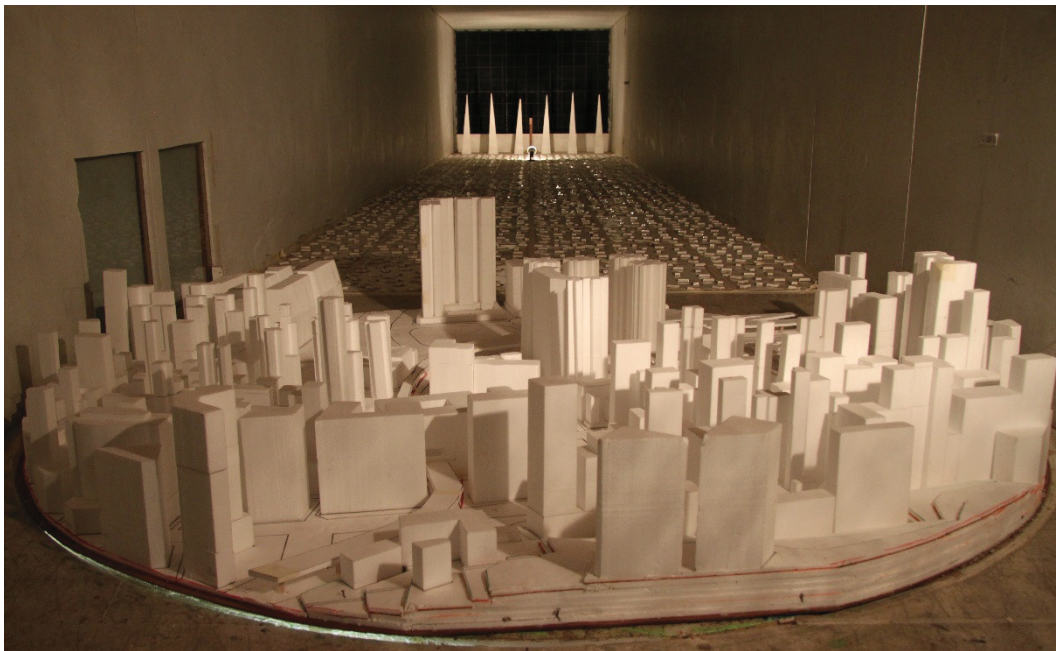


Figure 3b: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the south-east)

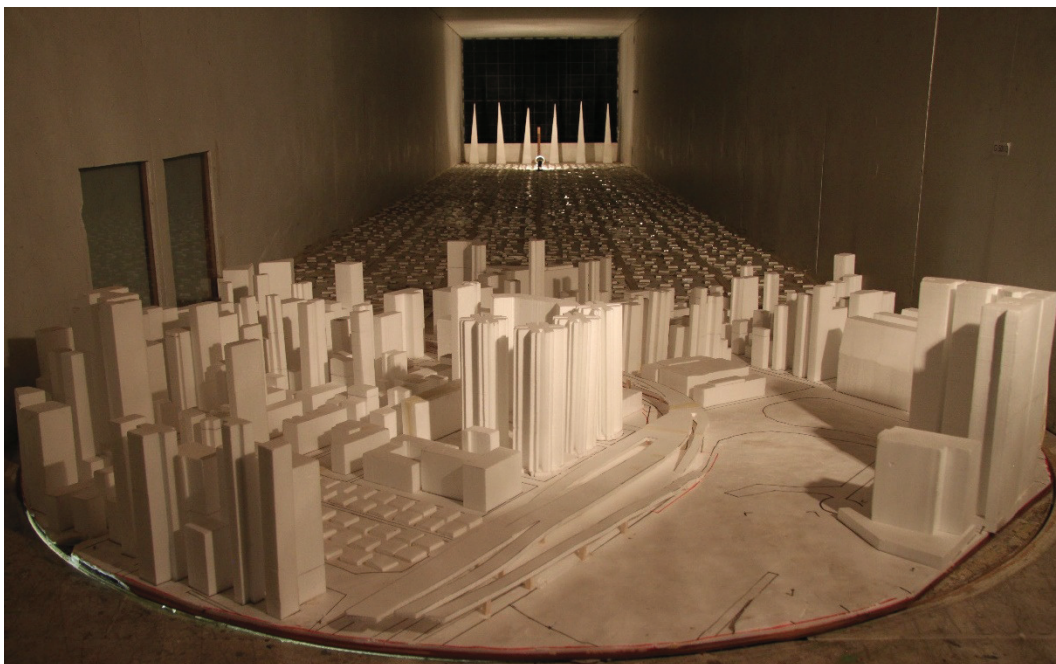


Figure 3c: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the north-west)

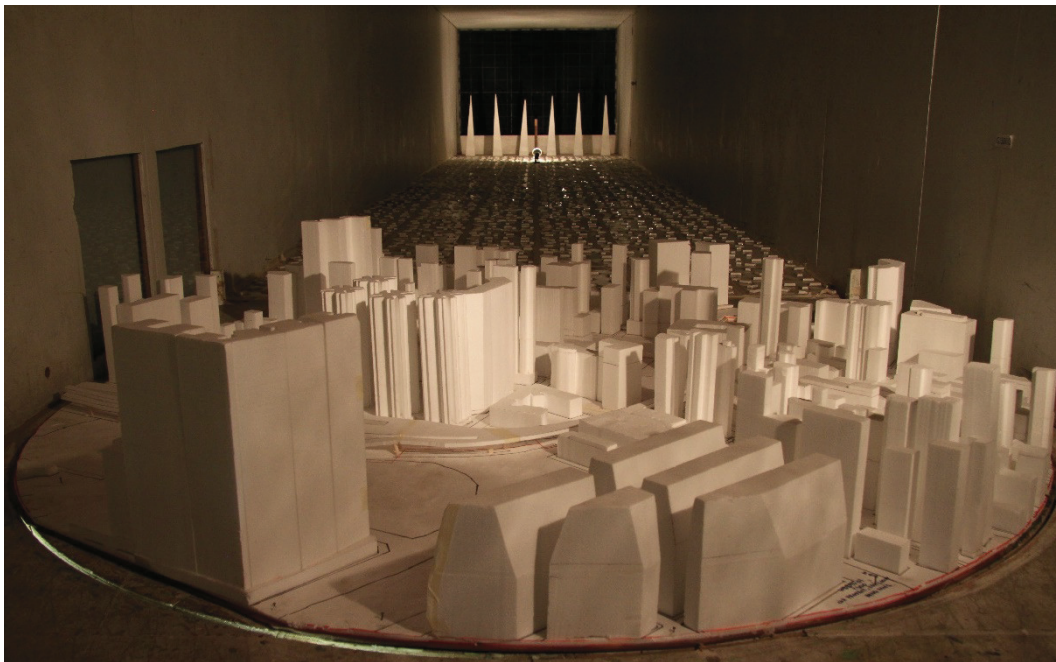


Figure 3d: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the south-west)

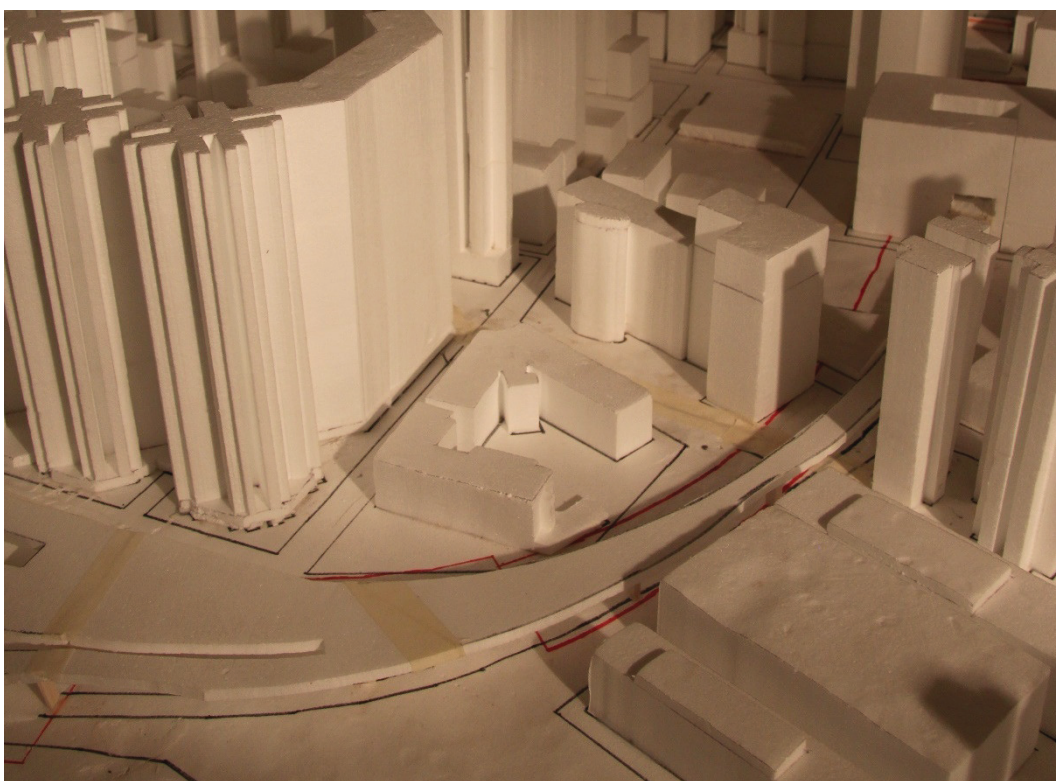


Figure 3e: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the south-west)

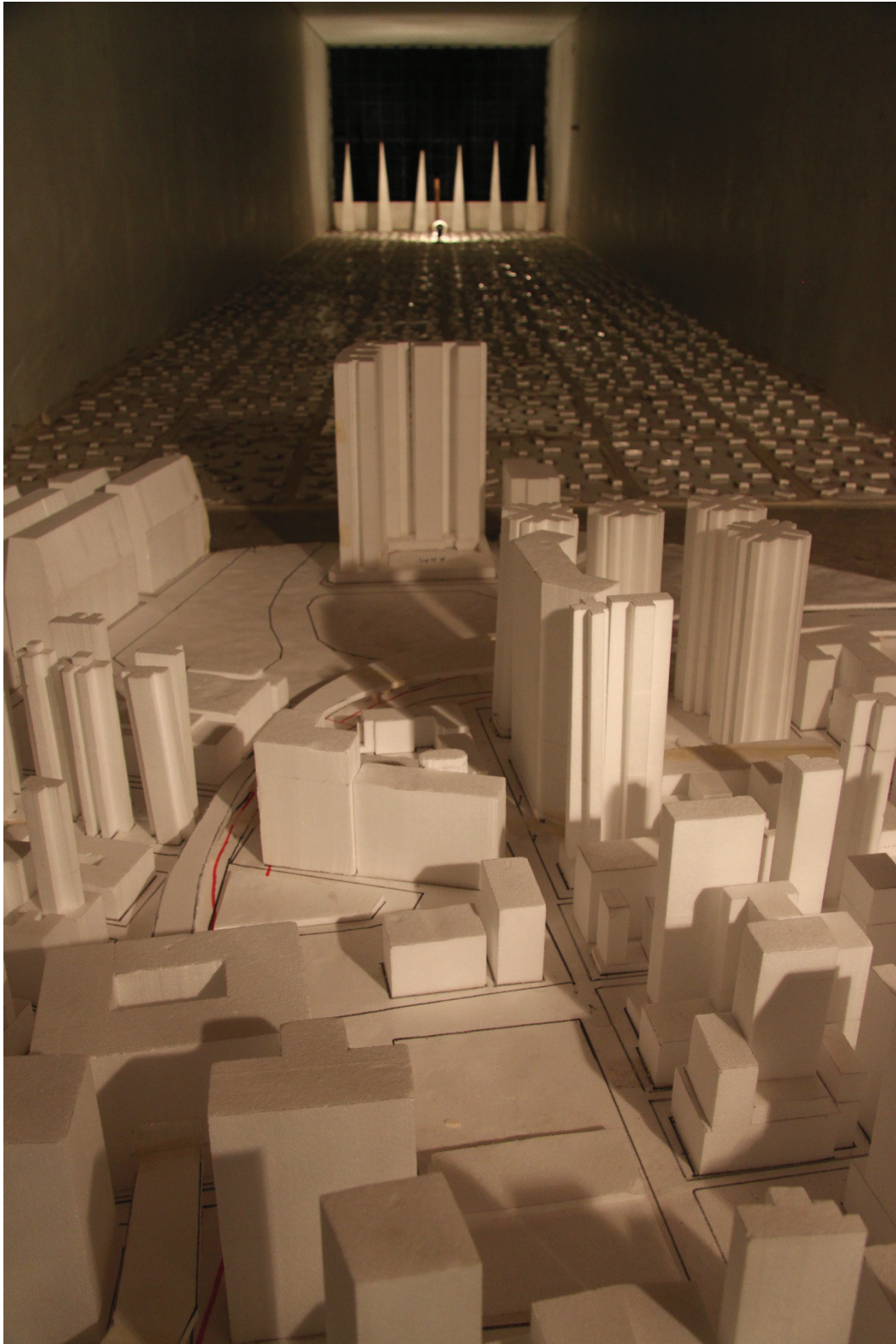


Figure 3f: Photograph of the Wind Tunnel Model – Existing Site Conditions
(view from the east)

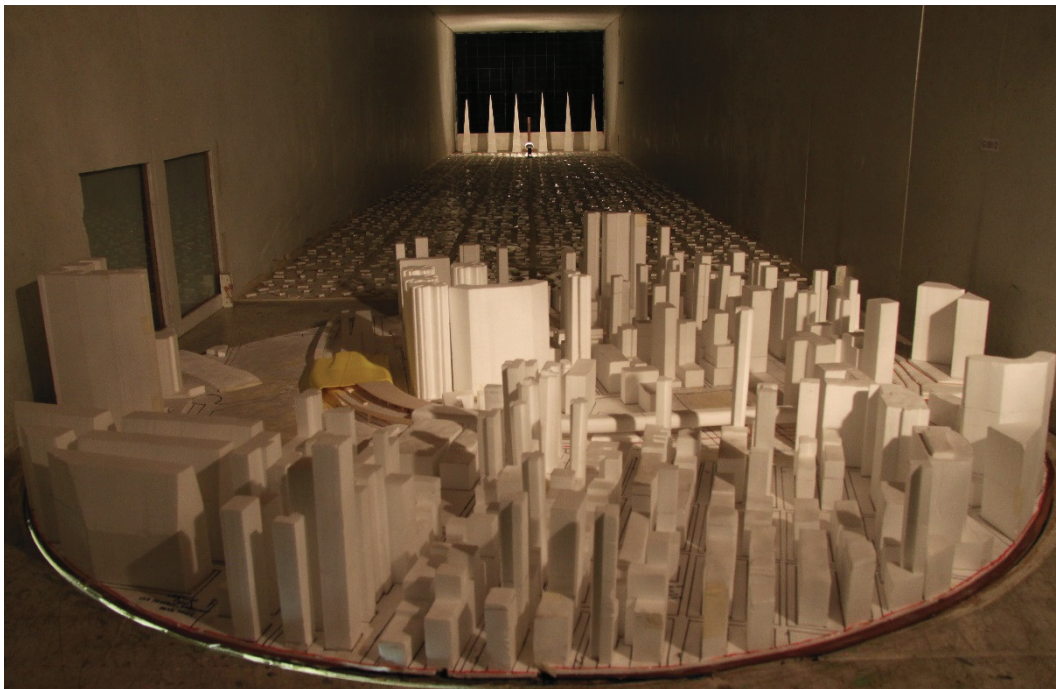


Figure 3g: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the south)



Figure 3h: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the east)

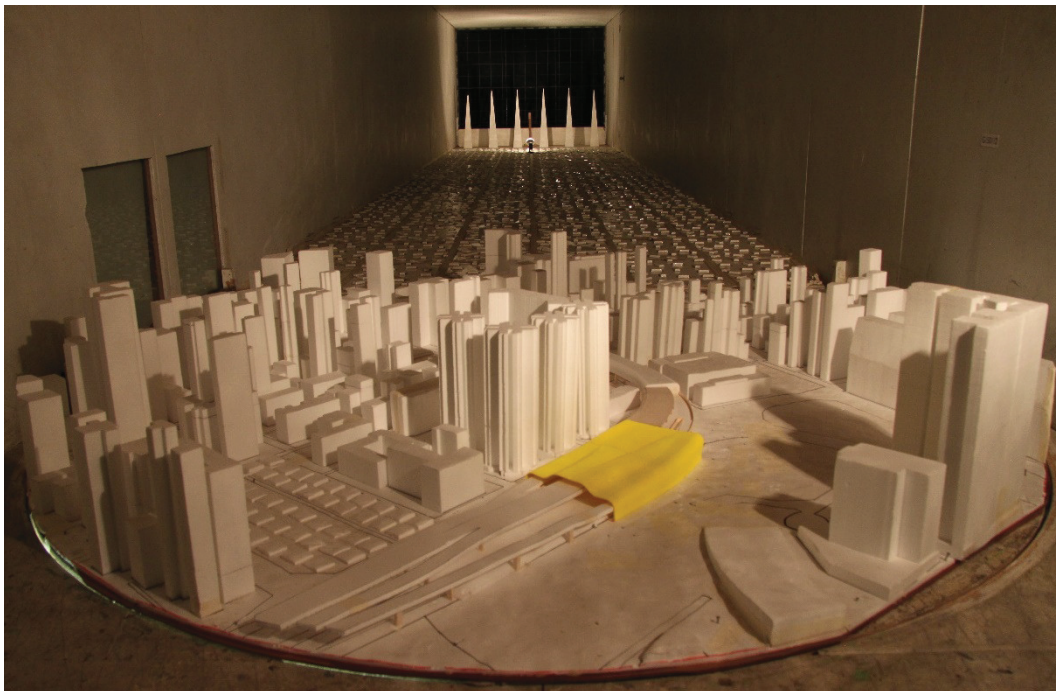


Figure 3i: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the north-west)

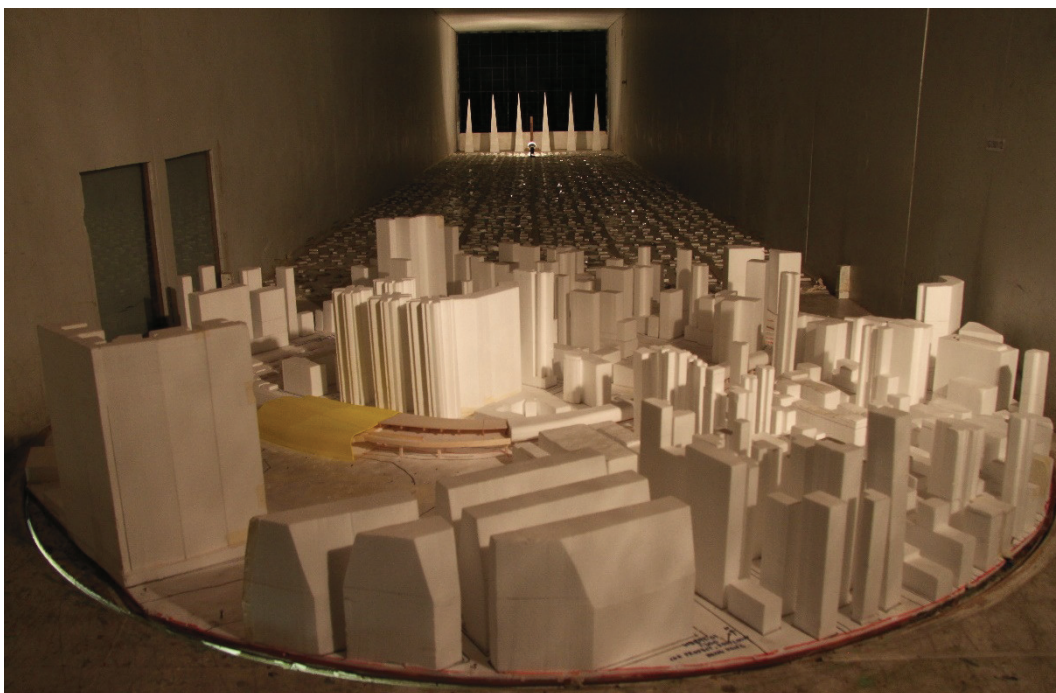


Figure 3j: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the south-west)



Figure 3k: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the south-west)



Figure 3m: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the east)

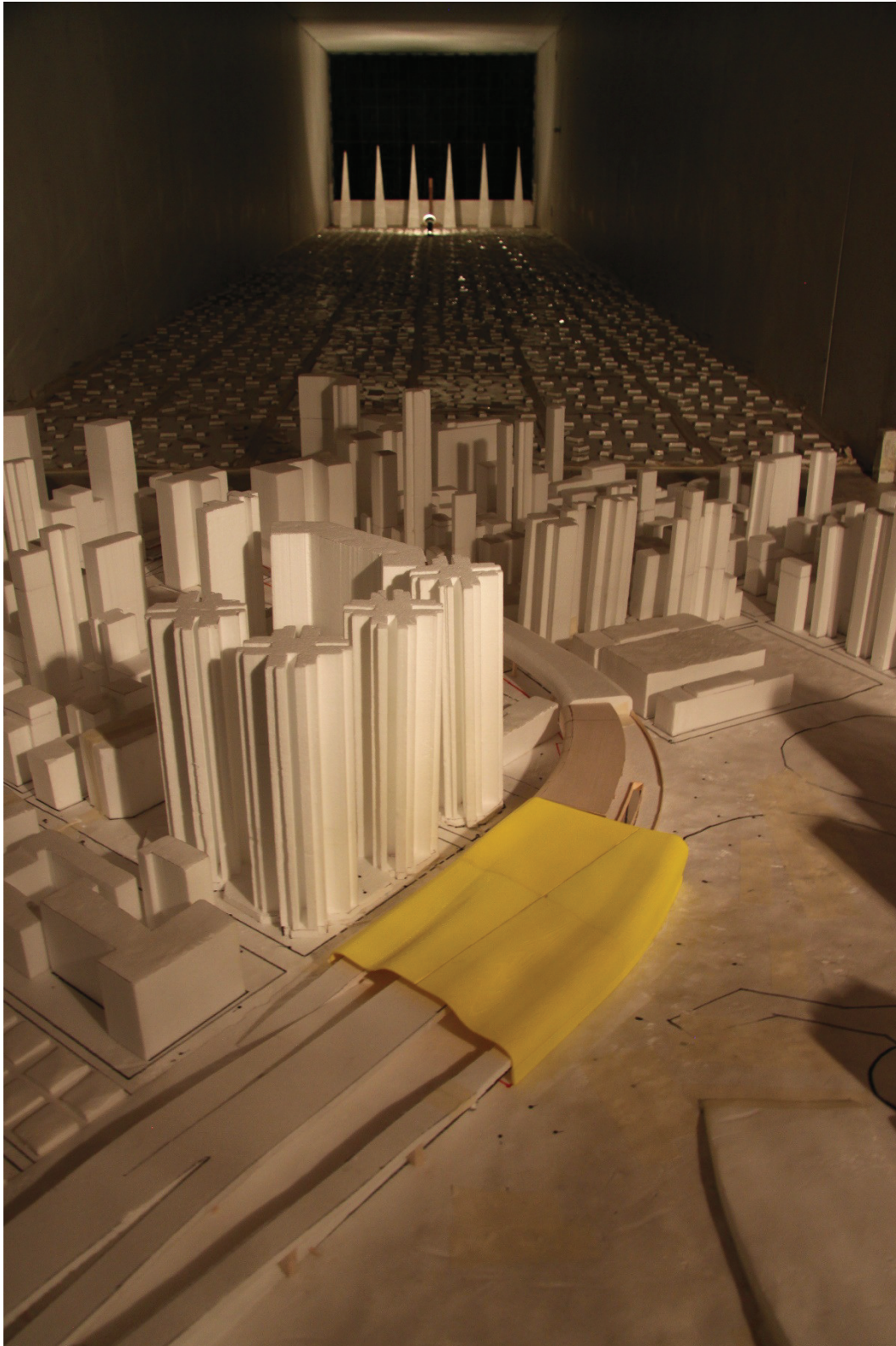


Figure 31: Photograph of the Wind Tunnel Model – With Proposed Development
(view from the north-west)

3 The Wind Model

Testing was performed using the blockage-tolerant boundary layer wind tunnel facility, which has a 2.6m wide working section with a fetch length of 14m and a maximum mean free-stream wind speed of approximately 15m/s, shown in Figure 4. No correction is required for blockage effects. The facility is set up to model atmospheric boundary layer flows at length scales ranging from 1:4000 to 1:50. The wind flow regime can be modified through the use of different surface roughness, spires and fences to model different scale atmospheric boundary layer flows and for different terrains.

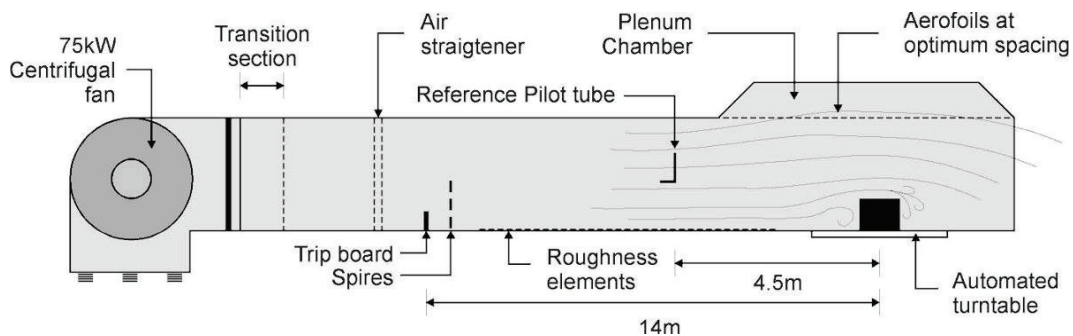


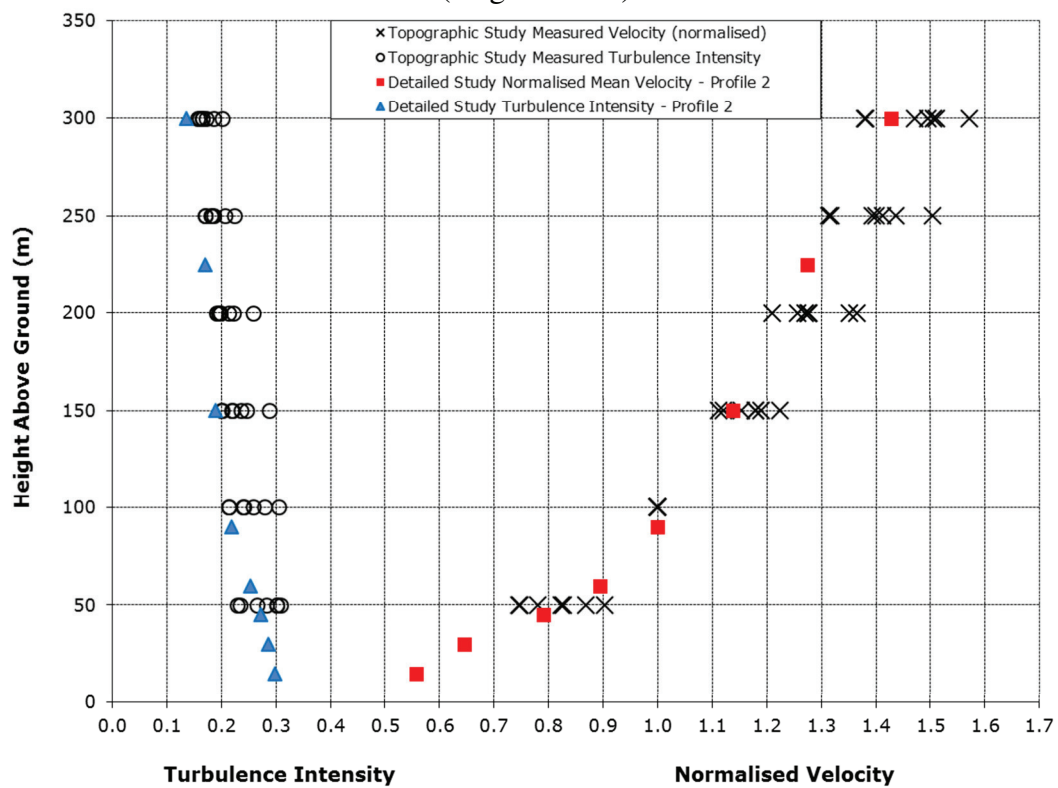
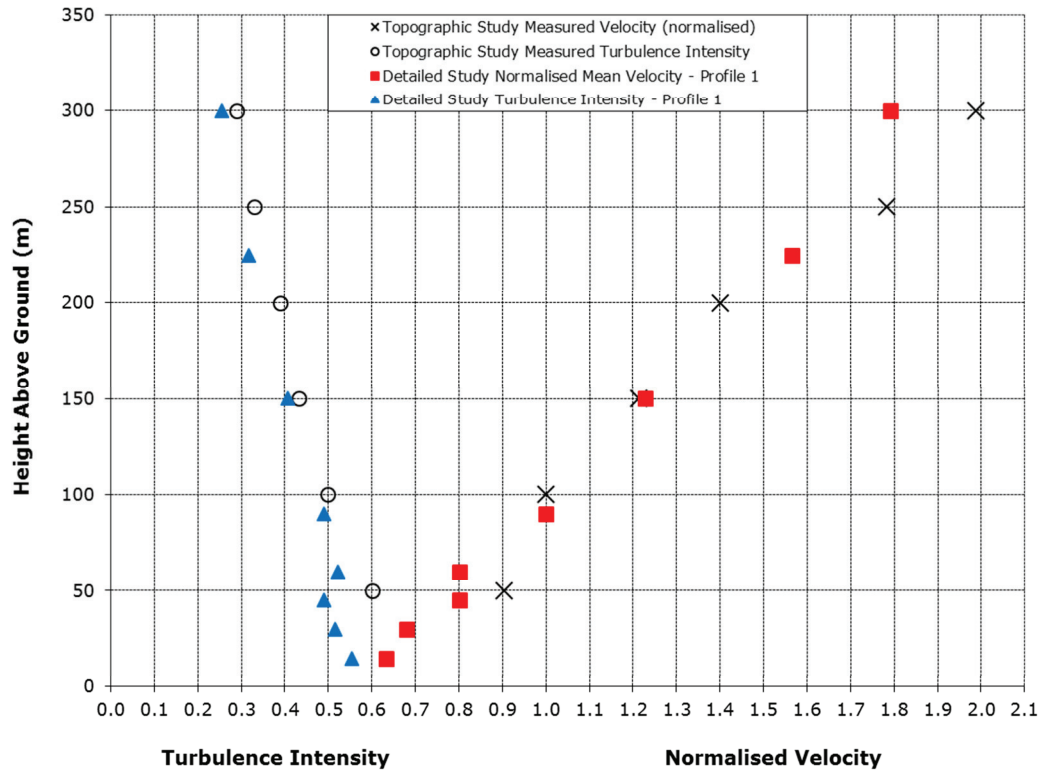
Figure 4: Boundary Layer Wind Tunnel Facility

The model of the subject development was setup in the wind tunnel, and mean wind speeds were measured in the form of velocity coefficients. Wind speed measurements are made in the wind tunnel for 16 wind directions, at 22.5 degree increments for the full 360 degree azimuth.

The free-stream wind speeds at the reference height, measured upstream of the test model and the local wind speeds at the test locations were monitored using a set of Dantec hot-wire anemometers. In addition, care was taken in the alignment of the probe wire and in avoiding wall-heating effects. This procedure provides comprehensive information about the wind environment to be expected at each of the study locations for the various wind directions.

The output from the hot-wire probes is obtained using a National Instruments 12-bit data acquisition card. The signal was low pass filtered at 32 Hz to simulate a 3-second gust in full-scale time. A sample rate of 1000 samples per second was used, which is more than adequate for the given frequency band.

Profiles for velocity and turbulence intensity were obtained for each of the 16 wind directions as part of the Site Wind Availability Study carried out at the 1:4000 scale. These profiles were classified into 5 test configurations and recreated at the 1:300 scale using an appropriate combination of roughness elements and fences in the wind tunnel fetch. Figures 5a to 5e show plots of the velocity and turbulence intensity profiles used for each test configuration, along with the angles tested for each configuration.



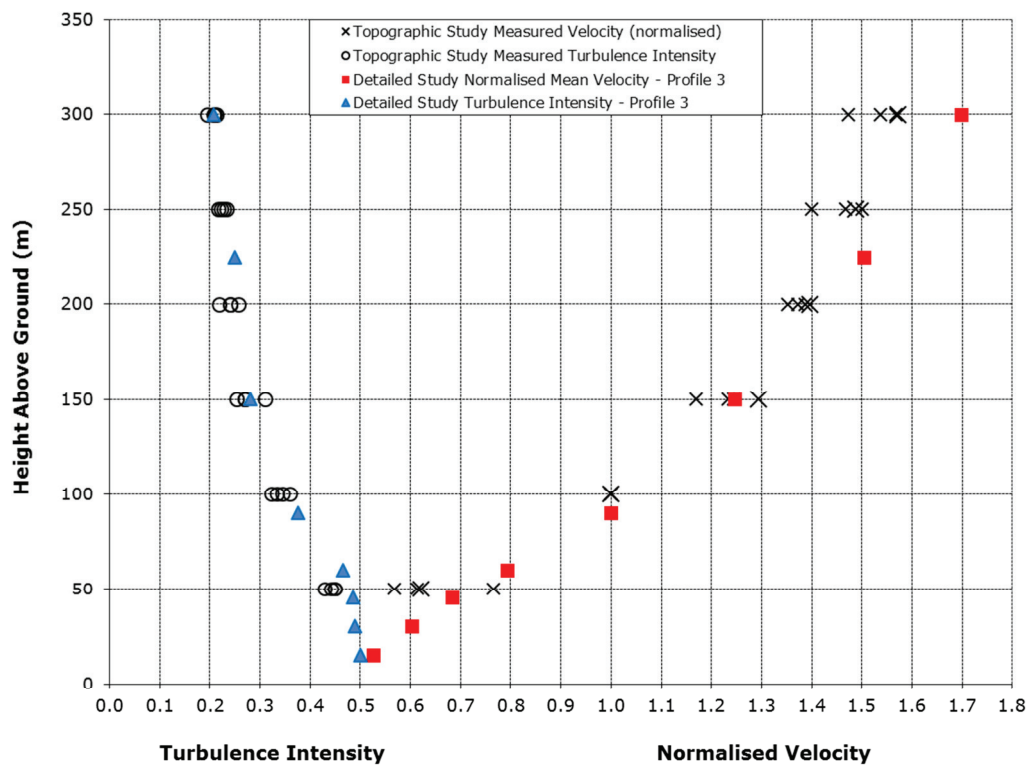


Figure 5c: Wind Profile 3
(Angles 0°, 22.5°, 45° and 180°)

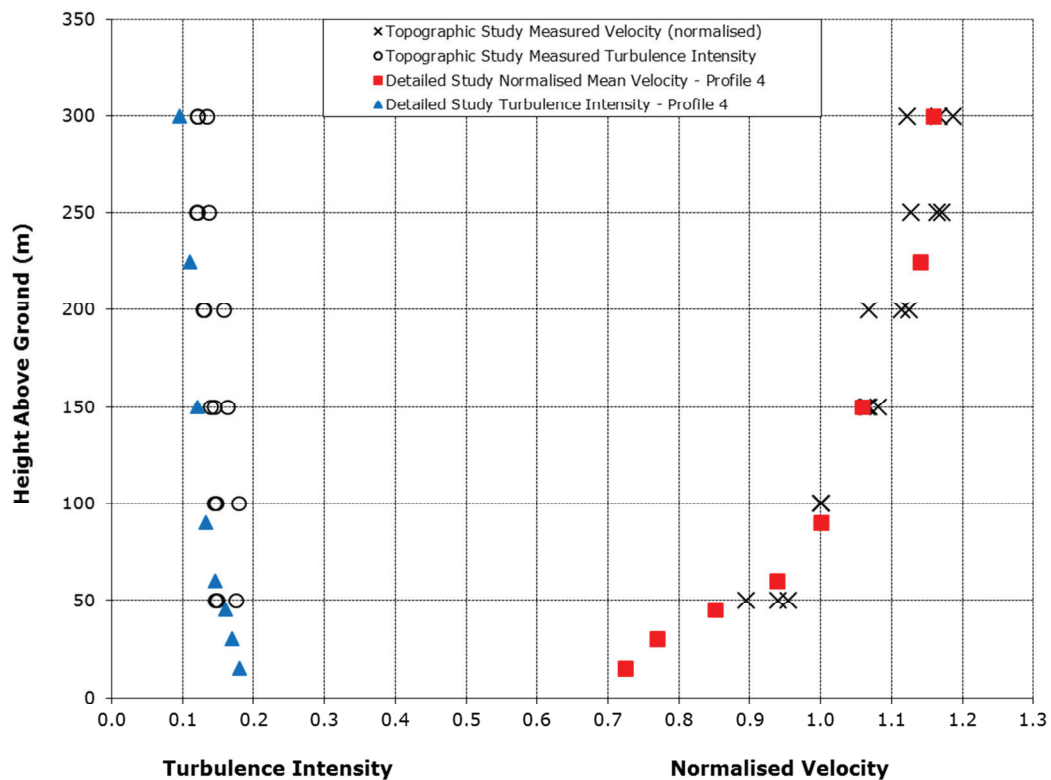


Figure 5d: Wind Profile 4
(Angles 247.5°, 270° and 292.5°)

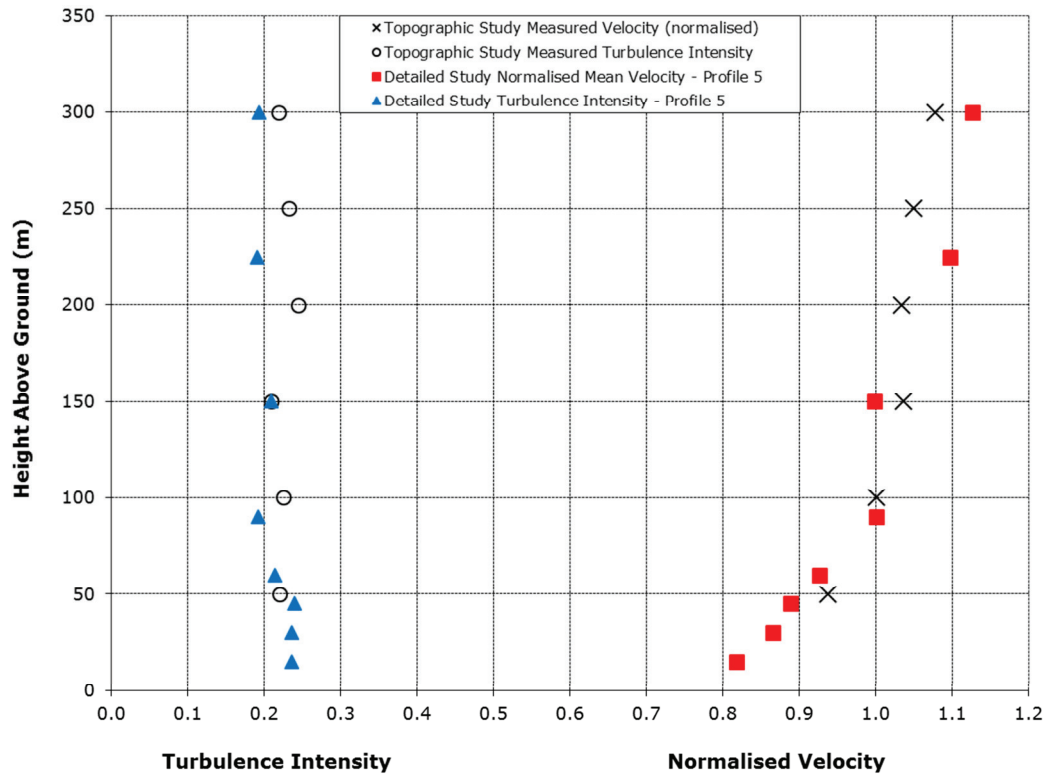


Figure 5e: Wind Profile 5
(Angle 225°)

The assessment area which houses the test points for the detailed study extend to a distance H from the perimeter of the proposed noise enclosures, where H is the height of the tallest proposed structure, as defined in the Hong Kong Environment Transport and Works Bureau, Technical Circular No. 1/06 for Air Ventilation Assessments (2006). Test points were evenly spaced within the assessment area for each of the sites selected for analysis. The test points were placed both outside of and within the project site boundary.

The test point layout was devised to adequately track the flow of air towards and around the development site. A total of 94 study points were located and grouped into the following parent groups:

- 43 Perimeter test points: Positioned at a distance of H/2 from the perimeter of the base of the proposed structure. These “Perimeter” study points are to indicate the localised impacts on wind conditions for the immediate surrounding areas.
- 51 Overall Test Points: Evenly distributed throughout the open spaces, roads and pedestrian trafficable areas located within a distance of H from the perimeter of the base of the proposed structure. These points indicate the impact of the subject development on wind conditions in the overall surrounding area.

The layout of study points for the detailed study is presented in Figure 6.

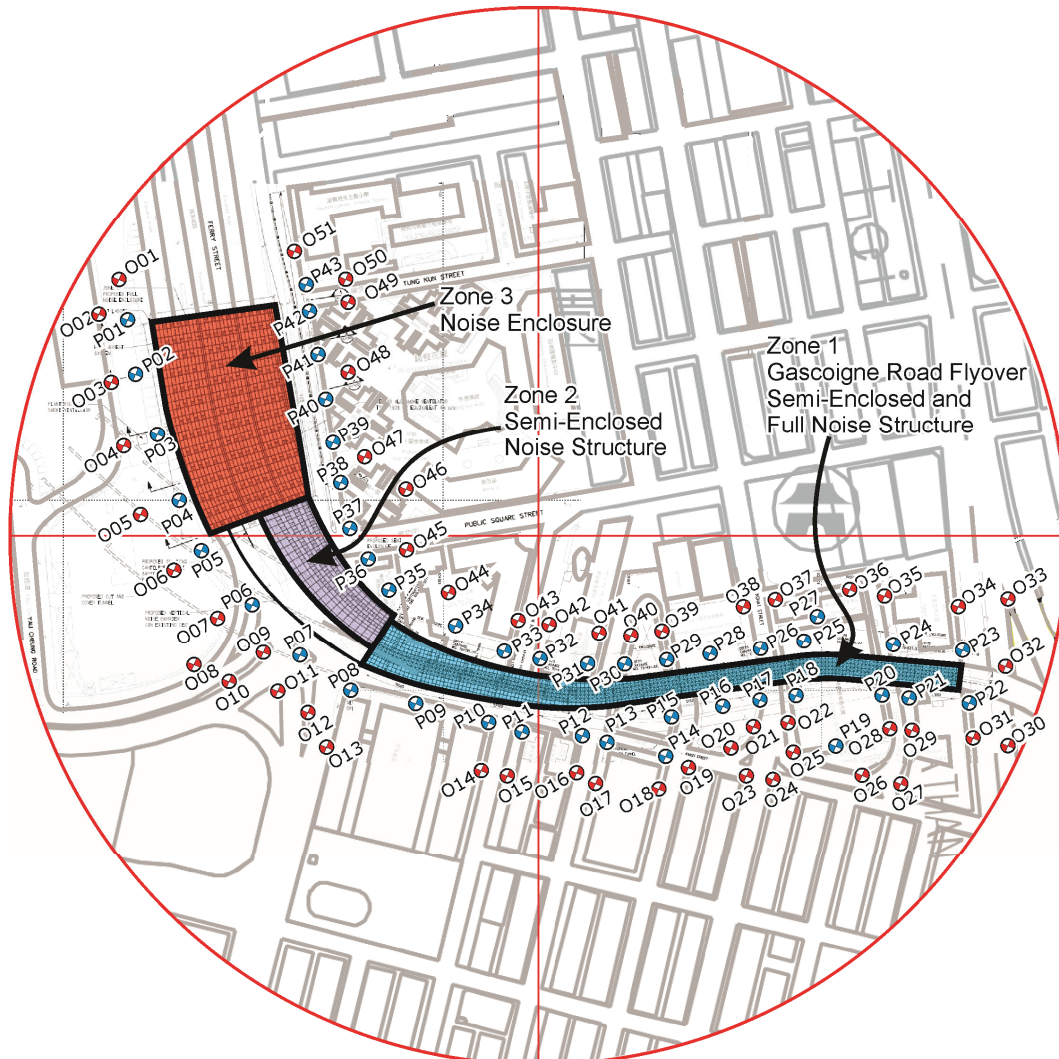


Figure 6: Layout of Perimeter and Overall Study Points

4 Results

The local mean velocity ratios referenced to the mean upstream wind speed measured at 500m height were obtained for each of the 16 wind directions for both the existing site conditions and with the inclusion of the proposed development. The directional results were weighted based on the frequency of occurrence of wind from each direction under the annual and summer climate models, presented in the Site Wind Availability Report (**Appendix B** in Volume 1 of this Report). The site velocity ratio (SVR) is the average of all perimeter test points, while the local velocity ratio (LVR) is the average of all perimeter and overall test points together. The velocity ratios for each point are given in Figures 7a and 7b for the annual wind conditions and Figures 8a and 8b for the summer wind conditions. Table 1 and 2 show the average SVR and LVR for the entire development for the annual and summer wind climates respectively.

The SVR and LVR experience negligible change with the inclusion of the proposed development for the annual wind conditions. This indicates that the air ventilation performance will not be impacted in the immediate vicinity of the development, or in the local area surrounding the development.

Table 1: Summary of the Site and Local Average Annual Velocity Ratios

Test Configuration	SVR	LVR
Existing Site Conditions	0.151	0.161
With the Inclusion of the Gascoigne Road Flyover Development	0.153	0.159

For summer wind conditions, the SVR increases from 0.191 to 0.194 with the inclusion of the proposed development, indicating that overall air ventilation performance will be marginally improved in the immediate vicinity of the site. Similarly, the LVR increases from 0.193 to 0.195 with the inclusion of the proposed development. This indicates that the overall air ventilation performance will be marginally improved in the local area surrounding the development.

Table 2: Summary of the Site and Local Average Summer Velocity Ratios

Test Configuration	SVR	LVR
Existing Site Conditions	0.191	0.193
With the Inclusion of the Gascoigne Road Flyover Development	0.194	0.195

As shown in Figures 7a and 7b, the velocity ratios of the most stagnant points are increased with the inclusion of the proposed development under the annual wind conditions. This is partly due to the proposed removal of buildings along the roadway. Many areas that currently experience high air ventilation underwent a slight reduction in velocity ratio, which implies improved level of pedestrian comfort in the event of strong winds for these areas. The benefit for both of the areas highlighted above is not visible from simply observing the SVR and LVR

alone due to the averaging process. Figures 8a and 8b demonstrate that the same benefit is also observable for the summer wind conditions.

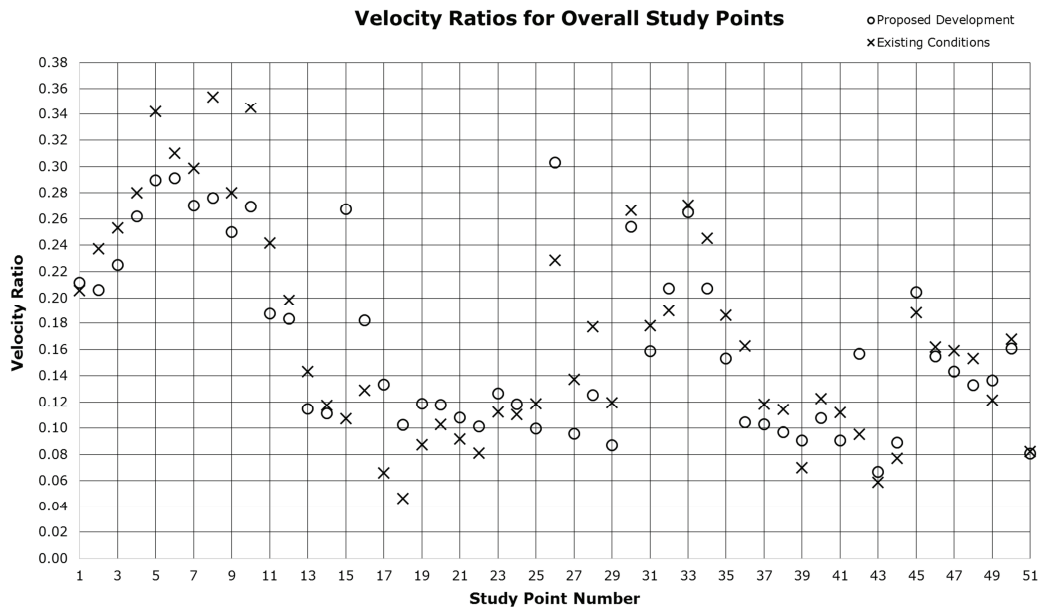


Figure 7a: Velocity Ratios for Overall Study Points: Annual Winds

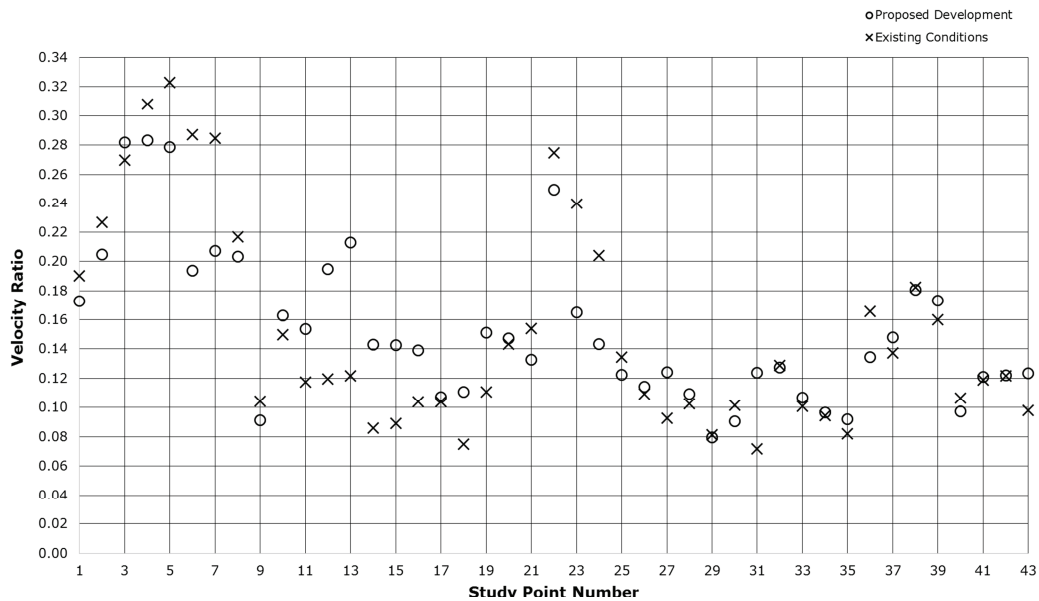


Figure 7b: Velocity Ratios for Perimeter Study Points: Annual Winds

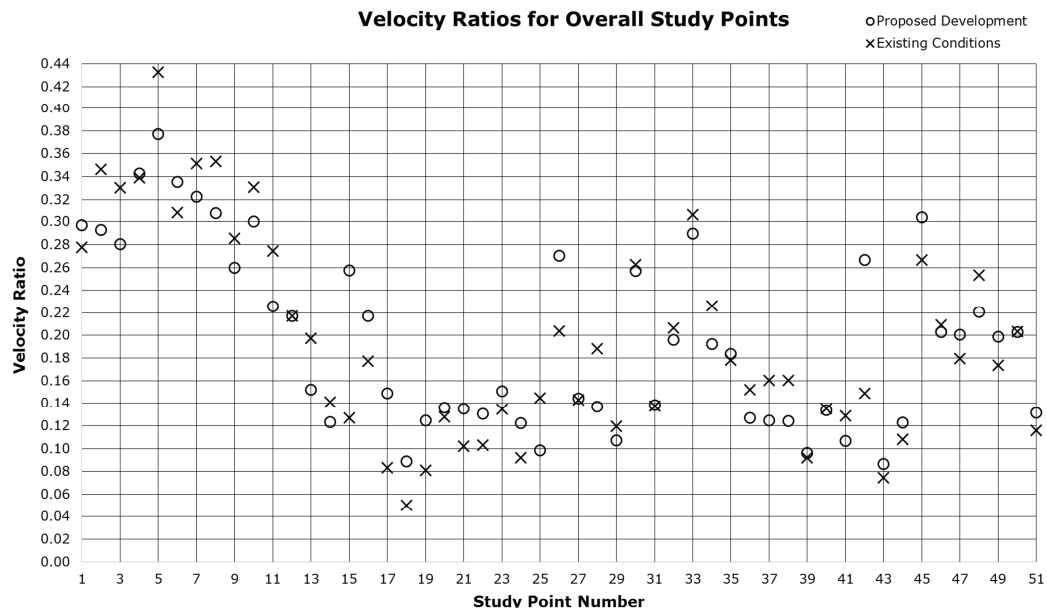


Figure 8a: Velocity Ratios for Overall Study Points: Summer Winds

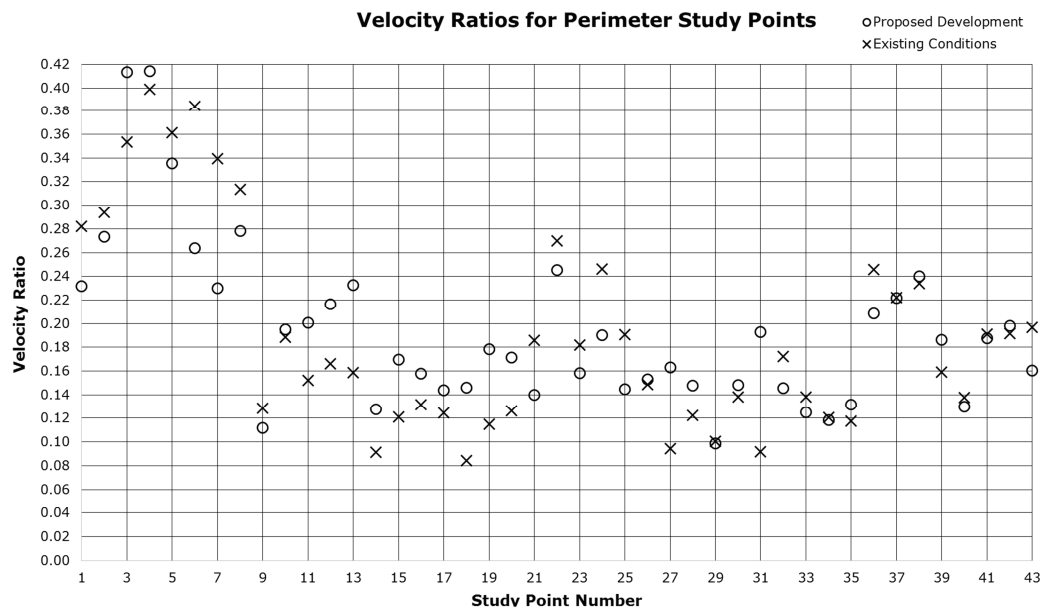


Figure 8b: Velocity Ratios for Perimeter Study Points: Summer Winds

5 Conclusion

A Detailed Study was carried out as part of the Air Ventilation Assessment (AVA) for the CKR Project. This report relates to the Gascoigne Road Flyover site, located in Yau Ma Tei at the western end of the CKR Project. Wind tunnel testing was performed using a boundary layer wind tunnel, which has a 2.6m wide working section and has a fetch length of 14m. The study was undertaken in accordance with the current best international practice requirements stipulated in “Manuals and Reports on Engineering Practice No. 67 : Wind Tunnel Studies of Buildings and Structures, Virginia 1999 issued by American Society of Civil Engineers”, “Wind Engineering Studies of Buildings, Quality Assurance Manual on Environment Wind Studies AWES-QAM-1-2001 issued by Australasian Wind Engineering Society” and “Hong Kong Environment Transport and Works Bureau, 2006, Technical Circular No. 1/06 for Air Ventilation Assessments”.

Measurements for the Detailed Study were carried out using a 1:300 scale model of the development. The effects of nearby buildings and land topography were accounted for through the use of a proximity model, which represents an area with a radius of 375m. The wind velocity and turbulence measurements obtained from the Site Wind Availability Study were categorised into five wind profiles and replicated at a scale of 1:300 for use in the this study. Velocity ratios referenced to a height of 500m were measured for the 16 compass wind directions and combined with the annual and summer wind directional frequencies presented in the Site Wind Availability Study. The SVR and LVR for the site were determined. Testing was performed for two scenarios; one with the existing site conditions, the other with the inclusion of the proposed development.

The results of this study indicate that the inclusion of the proposed development will not affect the air ventilation performance of the immediate vicinity or the surrounding local area for the annual wind conditions. For the summer wind conditions, a marginal overall improvement in the air ventilation performance was demonstrated for both the immediate vicinity and the surrounding local area.

With the inclusion of the proposed development, the most stagnant areas around the development experienced the most improvement in air ventilation performance. This is partly due to the proposed removal of buildings along the roadway. Many areas that currently experience high air ventilation underwent a slight reduction in velocity ratio, which implies improved level of pedestrian comfort in the event of strong winds for these areas. The benefit for both of the areas highlighted above is not visible from simply observing the SVR and LVR alone due to the averaging process.

6 References

“Manuals and Reports on Engineering Practice No. 67 : Wind Tunnel Studies of Buildings and Structures, Virginia 1999 issued by American Society of Civil Engineers”

"Wind Engineering Studies of Buildings, Quality Assurance Manual on Environment Wind Studies AWES-QAM-1-2001 issued by Australasian Wind Engineering Society”

“Hong Kong Environment Transport and Works Bureau, 2006, Technical Circular No. 1/06 for Air Ventilation Assessments”

Appendix A

Directional Velocity Ratios for Individual Study Points

A1 Existing Site Conditions

	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
Probability of Occurrence: Annual	0.121	0.083	0.088	0.151	0.234	0.049	0.031	0.030	0.043	0.031	0.049	0.032	0.025	0.010	0.006	0.015
Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point O01	0.17	0.14	0.11	0.12	0.22	0.18	0.12	0.16	0.37	0.28	0.40	0.52	0.28	0.22	0.25	0.33
Point O02	0.24	0.16	0.12	0.13	0.18	0.21	0.21	0.24	0.30	0.59	0.42	0.71	0.47	0.47	0.37	0.40
Point O03	0.25	0.17	0.15	0.16	0.26	0.18	0.19	0.18	0.24	0.30	0.47	0.64	0.58	0.50	0.36	0.36
Point O04	0.36	0.18	0.20	0.21	0.23	0.22	0.22	0.27	0.40	0.39	0.48	0.27	0.59	0.58	0.48	0.44
Point O05	0.39	0.28	0.31	0.30	0.20	0.19	0.26	0.32	0.40	0.68	0.66	0.43	0.73	0.95	0.61	0.55
Point O06	0.43	0.35	0.39	0.38	0.16	0.12	0.19	0.20	0.27	0.44	0.39	0.41	0.33	0.55	0.52	0.55
Point O07	0.43	0.38	0.30	0.23	0.15	0.14	0.22	0.28	0.26	0.35	0.67	0.57	0.28	0.49	0.55	0.59
Point O08	0.48	0.44	0.37	0.47	0.19	0.13	0.24	0.23	0.24	0.31	0.66	0.53	0.24	0.42	0.52	0.64
Point O09	0.40	0.40	0.33	0.26	0.15	0.12	0.23	0.33	0.19	0.30	0.48	0.33	0.20	0.43	0.50	0.55
Point O10	0.49	0.45	0.39	0.45	0.17	0.15	0.25	0.37	0.23	0.55	0.46	0.34	0.21	0.39	0.50	0.61
Point O11	0.33	0.27	0.24	0.20	0.14	0.15	0.33	0.39	0.15	0.25	0.44	0.39	0.20	0.30	0.40	0.41
Point O12	0.26	0.27	0.23	0.15	0.12	0.10	0.18	0.44	0.16	0.20	0.32	0.26	0.18	0.18	0.26	0.33
Point O13	0.13	0.11	0.11	0.12	0.08	0.15	0.12	0.23	0.11	0.18	0.24	0.33	0.53	0.27	0.17	0.18
Point O14	0.14	0.06	0.05	0.10	0.11	0.15	0.14	0.13	0.07	0.06	0.08	0.19	0.47	0.40	0.27	0.26
Point O15	0.10	0.06	0.07	0.15	0.07	0.10	0.08	0.08	0.07	0.07	0.14	0.19	0.30	0.36	0.33	0.34
Point O16	0.09	0.07	0.07	0.11	0.09	0.24	0.28	0.15	0.04	0.07	0.10	0.28	0.55	0.55	0.45	0.28
Point O17	0.05	0.03	0.04	0.05	0.07	0.10	0.10	0.08	0.04	0.04	0.06	0.12	0.20	0.20	0.15	0.11
Point O18	0.07	0.05	0.04	0.04	0.02	0.05	0.03	0.04	0.02	0.04	0.03	0.05	0.14	0.29	0.19	0.10
Point O19	0.12	0.07	0.12	0.13	0.05	0.06	0.05	0.05	0.03	0.07	0.07	0.14	0.15	0.21	0.13	0.08
Point O20	0.10	0.08	0.06	0.09	0.08	0.21	0.19	0.14	0.08	0.09	0.09	0.20	0.19	0.28	0.16	0.09
Point O21	0.08	0.08	0.05	0.07	0.11	0.09	0.10	0.08	0.07	0.10	0.16	0.09	0.12	0.12	0.09	0.07
Point O22	0.07	0.07	0.05	0.05	0.08	0.09	0.07	0.07	0.08	0.09	0.15	0.12	0.18	0.30	0.07	0.06
Point O23	0.13	0.10	0.07	0.11	0.08	0.11	0.16	0.14	0.10	0.13	0.14	0.18	0.23	0.27	0.20	0.13
Point O24	0.10	0.05	0.08	0.23	0.11	0.04	0.05	0.04	0.04	0.09	0.08	0.11	0.17	0.18	0.14	0.09
Point O25	0.10	0.08	0.06	0.09	0.14	0.13	0.09	0.15	0.12	0.13	0.15	0.21	0.23	0.26	0.17	0.11
Point O26	0.08	0.11	0.22	0.32	0.38	0.32	0.09	0.07	0.13	0.19	0.29	0.08	0.11	0.15	0.07	0.05
Point O27	0.09	0.11	0.10	0.14	0.19	0.13	0.08	0.10	0.09	0.17	0.27	0.10	0.09	0.10	0.08	0.08
Point O28	0.09	0.14	0.16	0.19	0.22	0.21	0.24	0.24	0.18	0.18	0.27	0.06	0.14	0.16	0.14	0.08
Point O29	0.05	0.08	0.09	0.14	0.19	0.10	0.09	0.10	0.08	0.07	0.16	0.13	0.12	0.13	0.06	0.04
Point O30	0.09	0.07	0.16	0.34	0.47	0.31	0.21	0.22	0.15	0.14	0.25	0.33	0.31	0.16	0.10	0.16
Point O31	0.10	0.08	0.23	0.31	0.24	0.20	0.16	0.08	0.08	0.10	0.11	0.08	0.07	0.12	0.08	0.07
Point O32	0.05	0.05	0.11	0.28	0.28	0.23	0.16	0.17	0.10	0.11	0.19	0.39	0.33	0.16	0.04	0.07
Point O33	0.07	0.08	0.15	0.35	0.40	0.43	0.34	0.24	0.14	0.17	0.44	0.41	0.28	0.13	0.08	0.10
Point O34	0.09	0.09	0.14	0.34	0.41	0.39	0.38	0.23	0.09	0.09	0.18	0.21	0.14	0.06	0.06	0.14
Point O35	0.19	0.20	0.13	0.11	0.27	0.37	0.26	0.08	0.05	0.09	0.16	0.19	0.19	0.11	0.21	0.11
Point O36	0.10	0.08	0.10	0.18	0.27	0.27	0.14	0.06	0.05	0.10	0.17	0.12	0.15	0.11	0.20	0.09
Point O37	0.09	0.07	0.10	0.08	0.11	0.12	0.14	0.10	0.12	0.18	0.33	0.16	0.16	0.36	0.13	0.05
Point O38	0.08	0.06	0.08	0.09	0.10	0.14	0.19	0.12	0.13	0.16	0.34	0.13	0.16	0.27	0.10	0.05

	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
Probability of Occurrence: Annual	0.121	0.083	0.088	0.151	0.234	0.049	0.031	0.030	0.043	0.031	0.049	0.032	0.025	0.010	0.006	0.015
Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point O39	0.05	0.01	0.00	0.06	0.11	0.05	0.05	0.04	0.00	0.09	0.14	0.20	0.20	0.12	0.06	0.05
Point O40	0.09	0.07	0.08	0.14	0.13	0.19	0.26	0.21	0.10	0.07	0.10	0.12	0.20	0.08	0.07	0.07
Point O41	0.07	0.06	0.07	0.12	0.12	0.22	0.28	0.23	0.08	0.06	0.11	0.10	0.14	0.06	0.09	0.08
Point O42	0.12	0.07	0.05	0.04	0.04	0.07	0.09	0.13	0.10	0.19	0.32	0.18	0.22	0.28	0.29	0.17
Point O43	0.08	0.07	0.03	0.04	0.03	0.05	0.07	0.08	0.05	0.07	0.09	0.08	0.15	0.38	0.11	0.07
Point O44	0.05	0.04	0.04	0.05	0.08	0.10	0.12	0.12	0.11	0.12	0.21	0.07	0.09	0.12	0.07	0.04
Point O45	0.09	0.08	0.09	0.11	0.21	0.29	0.43	0.44	0.33	0.27	0.26	0.27	0.27	0.31	0.29	0.14
Point O46	0.29	0.20	0.13	0.06	0.06	0.07	0.12	0.18	0.22	0.25	0.27	0.15	0.64	0.71	0.43	0.12
Point O47	0.34	0.24	0.15	0.04	0.07	0.05	0.09	0.08	0.21	0.21	0.25	0.09	0.50	0.57	0.48	0.10
Point O48	0.15	0.14	0.11	0.04	0.07	0.04	0.05	0.07	0.14	0.49	0.53	0.39	0.49	0.52	0.35	0.40
Point O49	0.14	0.15	0.10	0.07	0.05	0.07	0.04	0.06	0.09	0.25	0.31	0.28	0.42	0.38	0.26	0.22
Point O50	0.20	0.30	0.16	0.09	0.09	0.17	0.07	0.10	0.12	0.26	0.35	0.23	0.39	0.33	0.31	0.30
Point O51	0.06	0.07	0.08	0.06	0.06	0.05	0.05	0.05	0.06	0.16	0.16	0.26	0.22	0.15	0.20	0.16
Point P01	0.18	0.13	0.10	0.12	0.14	0.12	0.13	0.15	0.21	0.30	0.44	0.68	0.42	0.42	0.31	0.34
Point P02	0.26	0.14	0.13	0.15	0.20	0.19	0.21	0.22	0.25	0.30	0.44	0.38	0.53	0.46	0.37	0.39
Point P03	0.29	0.17	0.16	0.15	0.25	0.26	0.21	0.27	0.40	0.66	0.45	0.31	0.52	0.53	0.39	0.43
Point P04	0.37	0.25	0.23	0.24	0.20	0.17	0.23	0.30	0.38	0.65	0.77	0.28	0.56	0.61	0.56	0.53
Point P05	0.44	0.40	0.34	0.31	0.14	0.19	0.36	0.35	0.24	0.33	0.70	0.33	0.40	0.63	0.61	0.58
Point P06	0.34	0.32	0.25	0.18	0.14	0.19	0.34	0.37	0.22	0.55	0.73	0.53	0.45	0.48	0.48	0.47
Point P07	0.38	0.34	0.31	0.22	0.14	0.13	0.28	0.36	0.21	0.71	0.65	0.29	0.19	0.38	0.47	0.47
Point P08	0.28	0.26	0.20	0.13	0.07	0.09	0.22	0.15	0.16	0.29	0.54	0.67	0.81	0.39	0.26	0.18
Point P09	0.15	0.09	0.08	0.09	0.04	0.06	0.16	0.15	0.08	0.14	0.14	0.18	0.24	0.34	0.25	0.27
Point P10	0.14	0.10	0.09	0.14	0.12	0.22	0.18	0.16	0.14	0.15	0.22	0.23	0.41	0.34	0.19	0.19
Point P11	0.11	0.09	0.07	0.10	0.09	0.11	0.10	0.10	0.09	0.10	0.17	0.20	0.52	0.31	0.24	0.21
Point P12	0.09	0.06	0.07	0.11	0.09	0.16	0.13	0.07	0.04	0.10	0.22	0.33	0.38	0.52	0.32	0.16
Point P13	0.09	0.06	0.08	0.10	0.11	0.23	0.20	0.09	0.05	0.08	0.21	0.21	0.32	0.43	0.29	0.15
Point P14	0.10	0.07	0.09	0.12	0.05	0.05	0.05	0.05	0.04	0.08	0.11	0.17	0.15	0.30	0.16	0.09
Point P15	0.07	0.07	0.06	0.08	0.06	0.12	0.09	0.06	0.04	0.10	0.14	0.26	0.27	0.29	0.19	0.10
Point P16	0.08	0.07	0.06	0.07	0.13	0.09	0.09	0.09	0.06	0.08	0.11	0.30	0.33	0.30	0.09	0.08
Point P17	0.08	0.07	0.07	0.09	0.12	0.13	0.11	0.08	0.05	0.09	0.12	0.26	0.24	0.18	0.15	0.09
Point P18	0.09	0.07	0.08	0.05	0.07	0.09	0.08	0.06	0.05	0.07	0.09	0.15	0.14	0.09	0.08	0.07
Point P19	0.08	0.06	0.05	0.08	0.19	0.12	0.08	0.12	0.07	0.08	0.11	0.09	0.16	0.34	0.11	0.07
Point P20	0.05	0.08	0.09	0.16	0.27	0.23	0.10	0.09	0.05	0.09	0.11	0.07	0.08	0.22	0.06	0.03
Point P21	0.10	0.17	0.13	0.13	0.16	0.13	0.20	0.23	0.15	0.17	0.25	0.19	0.29	0.29	0.08	0.06
Point P22	0.10	0.08	0.13	0.47	0.40	0.38	0.19	0.16	0.12	0.13	0.35	0.33	0.27	0.18	0.12	0.16
Point P23	0.09	0.08	0.32	0.44	0.36	0.28	0.17	0.11	0.06	0.10	0.15	0.11	0.15	0.13	0.07	0.07
Point P24	0.10	0.11	0.08	0.16	0.30	0.37	0.33	0.18	0.11	0.17	0.35	0.27	0.30	0.14	0.16	0.07
Point P25	0.13	0.15	0.12	0.07	0.09	0.08	0.10	0.11	0.11	0.18	0.37	0.41	0.24	0.35	0.15	0.07
Point P26	0.10	0.09	0.08	0.07	0.10	0.09	0.10	0.06	0.07	0.14	0.33	0.18	0.23	0.30	0.17	0.07
Point P27	0.10	0.13	0.11	0.07	0.09	0.06	0.05	0.05	0.06	0.10	0.16	0.10	0.12	0.10	0.13	0.08

	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
Probability of Occurrence: Annual	0.121	0.083	0.088	0.151	0.234	0.049	0.031	0.030	0.043	0.031	0.049	0.032	0.025	0.010	0.006	0.015
Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point P28	0.10	0.10	0.08	0.07	0.10	0.10	0.12	0.07	0.06	0.12	0.22	0.13	0.17	0.18	0.16	0.09
Point P29	0.09	0.07	0.07	0.06	0.07	0.05	0.05	0.04	0.05	0.09	0.21	0.15	0.15	0.12	0.09	0.07
Point P30	0.04	0.04	0.05	0.09	0.12	0.20	0.21	0.13	0.07	0.08	0.22	0.19	0.16	0.12	0.08	0.06
Point P31	0.03	0.03	0.04	0.06	0.08	0.17	0.18	0.12	0.05	0.06	0.14	0.07	0.06	0.06	0.06	0.04
Point P32	0.08	0.08	0.07	0.09	0.12	0.24	0.34	0.25	0.09	0.10	0.24	0.16	0.18	0.22	0.19	0.16
Point P33	0.08	0.06	0.05	0.07	0.07	0.19	0.30	0.18	0.08	0.11	0.20	0.12	0.11	0.17	0.23	0.15
Point P34	0.12	0.09	0.07	0.07	0.05	0.10	0.16	0.10	0.11	0.16	0.22	0.07	0.12	0.23	0.16	0.08
Point P35	0.06	0.08	0.06	0.05	0.05	0.07	0.13	0.11	0.07	0.17	0.17	0.08	0.30	0.29	0.21	0.11
Point P36	0.07	0.06	0.07	0.11	0.14	0.39	0.46	0.57	0.22	0.25	0.18	0.17	0.41	0.22	0.16	0.15
Point P37	0.12	0.08	0.08	0.05	0.07	0.15	0.24	0.28	0.24	0.19	0.43	0.20	0.33	0.41	0.25	0.17
Point P38	0.30	0.20	0.22	0.07	0.07	0.08	0.20	0.27	0.27	0.27	0.50	0.16	0.28	0.26	0.24	0.23
Point P39	0.47	0.19	0.27	0.02	0.04	0.04	0.07	0.09	0.10	0.18	0.30	0.14	0.35	0.34	0.18	0.17
Point P40	0.16	0.15	0.07	0.04	0.06	0.03	0.07	0.10	0.09	0.16	0.28	0.15	0.24	0.25	0.37	0.29
Point P41	0.09	0.09	0.09	0.05	0.06	0.03	0.06	0.08	0.14	0.31	0.39	0.24	0.38	0.45	0.34	0.46
Point P42	0.11	0.12	0.09	0.07	0.05	0.11	0.07	0.11	0.15	0.28	0.41	0.22	0.38	0.27	0.24	0.22
Point P43	0.05	0.04	0.06	0.06	0.03	0.04	0.04	0.08	0.09	0.42	0.62	0.23	0.20	0.19	0.14	0.12

A2 With Proposed Development

	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
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Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point O01	0.15	0.10	0.10	0.11	0.24	0.24	0.16	0.21	0.34	0.57	0.38	0.37	0.36	0.27	0.24	0.27
Point O02	0.22	0.16	0.13	0.12	0.15	0.16	0.14	0.17	0.30	0.58	0.35	0.55	0.39	0.40	0.29	0.33
Point O03	0.24	0.21	0.14	0.14	0.21	0.19	0.17	0.18	0.23	0.49	0.41	0.34	0.31	0.39	0.31	0.35
Point O04	0.29	0.22	0.18	0.18	0.20	0.22	0.22	0.24	0.36	0.64	0.43	0.46	0.45	0.46	0.33	0.35
Point O05	0.34	0.25	0.28	0.20	0.17	0.20	0.22	0.30	0.36	0.59	0.74	0.27	0.51	0.61	0.45	0.43
Point O06	0.40	0.34	0.33	0.27	0.14	0.14	0.18	0.22	0.20	0.27	0.81	0.32	0.43	0.58	0.45	0.50
Point O07	0.38	0.36	0.29	0.21	0.12	0.13	0.14	0.24	0.16	0.32	0.63	0.58	0.32	0.65	0.46	0.51
Point O08	0.40	0.36	0.32	0.22	0.14	0.12	0.14	0.18	0.20	0.30	0.65	0.39	0.32	0.61	0.45	0.52
Point O09	0.40	0.35	0.29	0.21	0.13	0.10	0.14	0.28	0.17	0.27	0.43	0.37	0.22	0.47	0.46	0.49
Point O10	0.39	0.36	0.33	0.20	0.14	0.10	0.16	0.21	0.39	0.33	0.50	0.38	0.25	0.59	0.43	0.51
Point O11	0.25	0.22	0.19	0.15	0.10	0.08	0.13	0.34	0.16	0.24	0.38	0.38	0.24	0.20	0.26	0.24
Point O12	0.25	0.22	0.18	0.15	0.09	0.09	0.12	0.32	0.14	0.23	0.31	0.33	0.40	0.22	0.26	0.29
Point O13	0.11	0.10	0.10	0.11	0.06	0.11	0.09	0.16	0.11	0.13	0.25	0.24	0.26	0.17	0.13	0.12
Point O14	0.10	0.07	0.08	0.13	0.10	0.12	0.11	0.11	0.06	0.05	0.09	0.13	0.37	0.33	0.30	0.26
Point O15	0.10	0.07	0.08	0.48	0.37	0.42	0.39	0.36	0.06	0.07	0.17	0.18	0.37	0.37	0.47	0.44
Point O16	0.09	0.07	0.07	0.19	0.20	0.33	0.34	0.21	0.05	0.08	0.12	0.27	0.53	0.51	0.68	0.55
Point O17	0.04	0.04	0.05	0.16	0.19	0.27	0.25	0.19	0.03	0.07	0.08	0.13	0.28	0.22	0.28	0.23
Point O18	0.07	0.06	0.06	0.22	0.08	0.15	0.14	0.15	0.02	0.04	0.04	0.03	0.11	0.25	0.33	0.16
Point O19	0.11	0.07	0.12	0.12	0.10	0.29	0.27	0.19	0.03	0.07	0.09	0.08	0.12	0.15	0.20	0.09
Point O20	0.09	0.06	0.07	0.12	0.12	0.31	0.25	0.20	0.08	0.09	0.09	0.11	0.12	0.26	0.20	0.09
Point O21	0.08	0.08	0.07	0.10	0.10	0.14	0.16	0.09	0.06	0.10	0.13	0.23	0.25	0.46	0.17	0.08
Point O22	0.08	0.07	0.06	0.09	0.10	0.10	0.14	0.10	0.07	0.10	0.13	0.26	0.24	0.27	0.17	0.08
Point O23	0.09	0.09	0.07	0.15	0.11	0.19	0.24	0.21	0.13	0.13	0.15	0.11	0.19	0.33	0.22	0.11
Point O24	0.08	0.07	0.10	0.21	0.09	0.13	0.16	0.12	0.07	0.09	0.15	0.10	0.16	0.23	0.18	0.08
Point O25	0.08	0.07	0.09	0.12	0.12	0.05	0.08	0.06	0.05	0.07	0.09	0.16	0.15	0.27	0.18	0.09
Point O26	0.07	0.10	0.24	0.47	0.51	0.41	0.27	0.13	0.13	0.18	0.24	0.18	0.31	0.29	0.18	0.09
Point O27	0.05	0.04	0.03	0.05	0.11	0.11	0.08	0.13	0.13	0.13	0.23	0.22	0.26	0.18	0.16	0.07
Point O28	0.07	0.05	0.06	0.16	0.17	0.17	0.14	0.11	0.06	0.08	0.12	0.17	0.26	0.26	0.15	0.15
Point O29	0.05	0.05	0.04	0.07	0.11	0.19	0.10	0.06	0.05	0.07	0.11	0.17	0.15	0.22	0.08	0.05
Point O30	0.12	0.09	0.16	0.36	0.36	0.48	0.19	0.19	0.11	0.13	0.29	0.26	0.32	0.23	0.13	0.14
Point O31	0.09	0.07	0.19	0.26	0.20	0.18	0.13	0.09	0.07	0.11	0.15	0.09	0.13	0.17	0.09	0.07
Point O32	0.05	0.06	0.13	0.37	0.31	0.27	0.19	0.18	0.11	0.10	0.18	0.23	0.19	0.12	0.08	0.09
Point O33	0.08	0.09	0.17	0.34	0.40	0.41	0.31	0.23	0.11	0.16	0.32	0.49	0.28	0.19	0.12	0.13
Point O34	0.09	0.08	0.10	0.27	0.36	0.36	0.32	0.15	0.05	0.08	0.14	0.19	0.15	0.08	0.07	0.14
Point O35	0.16	0.19	0.11	0.11	0.10	0.33	0.26	0.20	0.06	0.10	0.29	0.18	0.24	0.25	0.12	0.15
Point O36	0.06	0.06	0.08	0.10	0.11	0.18	0.13	0.09	0.06	0.11	0.21	0.14	0.14	0.15	0.08	0.07
Point O37	0.05	0.05	0.06	0.10	0.14	0.11	0.14	0.09	0.07	0.11	0.23	0.12	0.11	0.15	0.13	0.06
Point O38	0.05	0.04	0.04	0.11	0.11	0.09	0.14	0.10	0.06	0.13	0.25	0.15	0.09	0.10	0.09	0.07

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Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point O39	0.08	0.07	0.09	0.09	0.11	0.06	0.06	0.05	0.05	0.11	0.12	0.17	0.12	0.10	0.08	0.07
Point O40	0.11	0.08	0.08	0.07	0.11	0.15	0.15	0.12	0.06	0.09	0.22	0.21	0.15	0.08	0.09	0.08
Point O41	0.08	0.06	0.08	0.08	0.09	0.11	0.14	0.10	0.05	0.09	0.14	0.17	0.12	0.11	0.12	0.08
Point O42	0.10	0.08	0.07	0.10	0.09	0.17	0.15	0.15	0.10	0.19	0.71	0.41	0.49	0.32	0.18	0.12
Point O43	0.08	0.05	0.04	0.06	0.04	0.06	0.06	0.06	0.04	0.09	0.16	0.16	0.12	0.08	0.10	0.11
Point O44	0.07	0.06	0.05	0.07	0.08	0.09	0.13	0.11	0.12	0.12	0.20	0.15	0.15	0.19	0.07	0.04
Point O45	0.11	0.09	0.10	0.09	0.22	0.24	0.40	0.34	0.41	0.47	0.35	0.27	0.34	0.45	0.32	0.19
Point O46	0.27	0.19	0.13	0.05	0.06	0.08	0.17	0.21	0.19	0.22	0.28	0.11	0.59	0.64	0.54	0.13
Point O47	0.15	0.15	0.15	0.06	0.09	0.07	0.12	0.11	0.07	0.45	0.29	0.19	0.50	0.56	0.45	0.10
Point O48	0.13	0.12	0.09	0.04	0.06	0.04	0.05	0.07	0.09	0.28	0.54	0.24	0.59	0.63	0.37	0.24
Point O49	0.12	0.17	0.09	0.10	0.06	0.07	0.05	0.07	0.08	0.47	0.35	0.22	0.47	0.40	0.29	0.22
Point O50	0.18	0.28	0.14	0.06	0.09	0.22	0.08	0.09	0.10	0.24	0.34	0.27	0.38	0.34	0.34	0.39
Point O51	0.06	0.07	0.08	0.05	0.03	0.04	0.05	0.06	0.06	0.16	0.22	0.36	0.26	0.13	0.17	0.14
Point P01	0.18	0.14	0.10	0.10	0.15	0.17	0.14	0.18	0.15	0.28	0.29	0.48	0.32	0.36	0.27	0.29
Point P02	0.21	0.18	0.14	0.14	0.15	0.17	0.15	0.20	0.21	0.58	0.37	0.38	0.36	0.36	0.31	0.33
Point P03	0.27	0.21	0.17	0.15	0.21	0.27	0.24	0.27	0.38	0.65	0.82	0.53	0.42	0.46	0.33	0.39
Point P04	0.35	0.28	0.22	0.14	0.13	0.21	0.15	0.22	0.34	0.73	0.95	0.35	0.61	0.62	0.44	0.46
Point P05	0.37	0.33	0.28	0.22	0.14	0.18	0.29	0.33	0.20	0.27	0.61	0.44	0.46	0.63	0.52	0.54
Point P06	0.18	0.16	0.17	0.16	0.12	0.13	0.19	0.30	0.18	0.26	0.61	0.36	0.18	0.30	0.24	0.27
Point P07	0.31	0.28	0.25	0.16	0.10	0.09	0.16	0.30	0.16	0.31	0.37	0.33	0.19	0.22	0.28	0.27
Point P08	0.29	0.24	0.15	0.14	0.07	0.10	0.19	0.17	0.15	0.26	0.45	0.56	0.70	0.29	0.28	0.26
Point P09	0.09	0.08	0.08	0.11	0.05	0.05	0.11	0.09	0.07	0.13	0.20	0.15	0.16	0.13	0.11	0.12
Point P10	0.14	0.11	0.08	0.15	0.16	0.24	0.26	0.24	0.12	0.12	0.18	0.18	0.41	0.43	0.27	0.23
Point P11	0.07	0.09	0.09	0.15	0.14	0.27	0.26	0.34	0.09	0.11	0.18	0.17	0.50	0.49	0.27	0.24
Point P12	0.07	0.10	0.08	0.26	0.24	0.41	0.37	0.20	0.06	0.15	0.21	0.17	0.28	0.27	0.34	0.20
Point P13	0.08	0.08	0.08	0.37	0.21	0.51	0.36	0.24	0.06	0.10	0.24	0.19	0.32	0.29	0.38	0.20
Point P14	0.10	0.07	0.11	0.32	0.12	0.14	0.11	0.13	0.05	0.08	0.16	0.10	0.13	0.20	0.30	0.17
Point P15	0.09	0.08	0.06	0.18	0.13	0.31	0.22	0.19	0.08	0.10	0.19	0.16	0.24	0.32	0.33	0.15
Point P16	0.08	0.07	0.08	0.17	0.15	0.23	0.18	0.18	0.07	0.10	0.17	0.16	0.21	0.29	0.46	0.16
Point P17	0.09	0.08	0.05	0.09	0.09	0.17	0.14	0.07	0.06	0.11	0.18	0.28	0.29	0.27	0.16	0.09
Point P18	0.08	0.08	0.07	0.09	0.10	0.14	0.16	0.08	0.05	0.09	0.17	0.31	0.30	0.30	0.16	0.07
Point P19	0.08	0.08	0.06	0.15	0.19	0.25	0.17	0.19	0.08	0.13	0.16	0.17	0.39	0.48	0.17	0.14
Point P20	0.09	0.14	0.08	0.12	0.19	0.15	0.16	0.21	0.05	0.10	0.17	0.20	0.42	0.46	0.19	0.11
Point P21	0.10	0.17	0.10	0.13	0.14	0.12	0.10	0.10	0.06	0.10	0.16	0.17	0.29	0.42	0.14	0.08
Point P22	0.12	0.09	0.13	0.41	0.35	0.33	0.19	0.16	0.09	0.13	0.27	0.29	0.37	0.31	0.19	0.14
Point P23	0.11	0.11	0.13	0.24	0.20	0.20	0.15	0.12	0.07	0.10	0.15	0.16	0.27	0.25	0.13	0.12
Point P24	0.06	0.08	0.07	0.10	0.17	0.38	0.27	0.18	0.11	0.17	0.26	0.18	0.19	0.21	0.10	0.05
Point P25	0.07	0.06	0.06	0.11	0.18	0.10	0.13	0.07	0.06	0.11	0.19	0.25	0.21	0.27	0.11	0.06
Point P26	0.06	0.06	0.06	0.10	0.13	0.13	0.13	0.08	0.06	0.12	0.22	0.30	0.26	0.29	0.10	0.07
Point P27	0.07	0.06	0.07	0.09	0.17	0.12	0.10	0.09	0.06	0.12	0.18	0.44	0.24	0.29	0.12	0.07

	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°
Probability of Occurrence: Annual	0.121	0.083	0.088	0.151	0.234	0.049	0.031	0.030	0.043	0.031	0.049	0.032	0.025	0.010	0.006	0.015
Probability of Occurrence: Summer	0.025	0.022	0.025	0.048	0.138	0.079	0.065	0.064	0.101	0.083	0.145	0.097	0.065	0.020	0.011	0.012
Point P28	0.07	0.08	0.07	0.11	0.09	0.14	0.11	0.08	0.06	0.09	0.21	0.32	0.28	0.30	0.10	0.09
Point P29	0.08	0.07	0.06	0.08	0.06	0.09	0.06	0.06	0.05	0.11	0.11	0.21	0.20	0.11	0.06	0.06
Point P30	0.06	0.07	0.04	0.04	0.07	0.09	0.13	0.16	0.08	0.11	0.27	0.27	0.27	0.28	0.14	0.05
Point P31	0.11	0.10	0.07	0.07	0.08	0.11	0.16	0.18	0.08	0.13	0.30	0.47	0.35	0.36	0.16	0.07
Point P32	0.10	0.11	0.11	0.14	0.10	0.16	0.16	0.08	0.06	0.14	0.17	0.17	0.28	0.35	0.28	0.17
Point P33	0.10	0.10	0.07	0.11	0.09	0.11	0.13	0.07	0.05	0.12	0.19	0.12	0.20	0.35	0.21	0.12
Point P34	0.12	0.10	0.07	0.09	0.06	0.09	0.14	0.12	0.10	0.15	0.17	0.10	0.16	0.26	0.16	0.08
Point P35	0.06	0.06	0.06	0.05	0.08	0.07	0.14	0.10	0.08	0.23	0.18	0.17	0.18	0.40	0.18	0.10
Point P36	0.10	0.09	0.08	0.08	0.08	0.10	0.13	0.40	0.45	0.23	0.24	0.26	0.17	0.37	0.15	0.17
Point P37	0.10	0.07	0.08	0.06	0.13	0.22	0.32	0.34	0.19	0.17	0.31	0.18	0.38	0.44	0.24	0.19
Point P38	0.27	0.19	0.18	0.07	0.07	0.17	0.28	0.34	0.28	0.24	0.45	0.14	0.31	0.29	0.21	0.22
Point P39	0.41	0.17	0.20	0.06	0.08	0.09	0.16	0.15	0.18	0.20	0.29	0.12	0.38	0.37	0.31	0.25
Point P40	0.13	0.12	0.07	0.05	0.05	0.04	0.10	0.10	0.07	0.15	0.21	0.16	0.28	0.31	0.24	0.19
Point P41	0.08	0.07	0.10	0.04	0.08	0.06	0.10	0.14	0.13	0.25	0.35	0.17	0.42	0.53	0.39	0.43
Point P42	0.09	0.11	0.06	0.06	0.08	0.09	0.08	0.10	0.11	0.29	0.43	0.25	0.40	0.33	0.22	0.18
Point P43	0.19	0.29	0.13	0.05	0.02	0.03	0.04	0.11	0.11	0.16	0.30	0.40	0.22	0.22	0.13	0.10