Hong Kong Housing Authority

Public Housing Development at Wang Chau, Yuen Long

Air Ventilation Assessment (Expert Evaluation)

REP-035-00

Issue 2 | 14 August 2014

Job number 226464

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Document Verification

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Job title		Public Housing Development at Wang Chau, Yuen Long			**Job number** 226464
Document title		Air Ventilation Assessment (Expert Evaluation)			**File reference** 035
Document ref		REP-035-00			
Revision	**Date**	**Filename**	REP-035-00 AVA - rev6.docx		
Issue 1	22 Jul 2014	**Description**	First issue		
			Prepared by	Checked by	Approved by
		Name	[redacted]	[redacted]	[redacted]
		Signature	[redacted]	[redacted]	[redacted]
Issue 2	14 Aug 2014	**Filename**	REP-035-00 AVA - rev6.docx		
		Description	Second issue		
			Prepared by	Checked by	Approved by
		Name	[redacted]	[redacted]	[redacted]
		Signature	[redacted]	[redacted]	[redacted]
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
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Contents

1 Introduction

1.1 Project Background

Ove Arup & Partners Hong Kong Limited (Arup) was appointed by Hong Kong Housing Authority (HKHA) to conduct an air ventilation assessment (AVA) for the proposed public housing (PH) development at a potential site at Wang Chau, Yuen Long. The location of the project site and its environs in the vicinity are shown in **Figure 1.1**.

The project site is bounded by Long Ping Road and Long Ping Estate to the east, Chun Hing San Tsuen, Shui Tin Tsuen and Fung Chi Tsuen to the south, Wing Ning Tsuen and Long Tin Road to the west, as well as a hilly terrain to the north. The site area is about 5.6ha.

The site currently falls within an area zoned "Green Belt" (GB) according to the Approved Ping Shan Outline Zoning Plan (OZP) No. S/YL-PS/14. Rezoning is required for the proposed PH site.

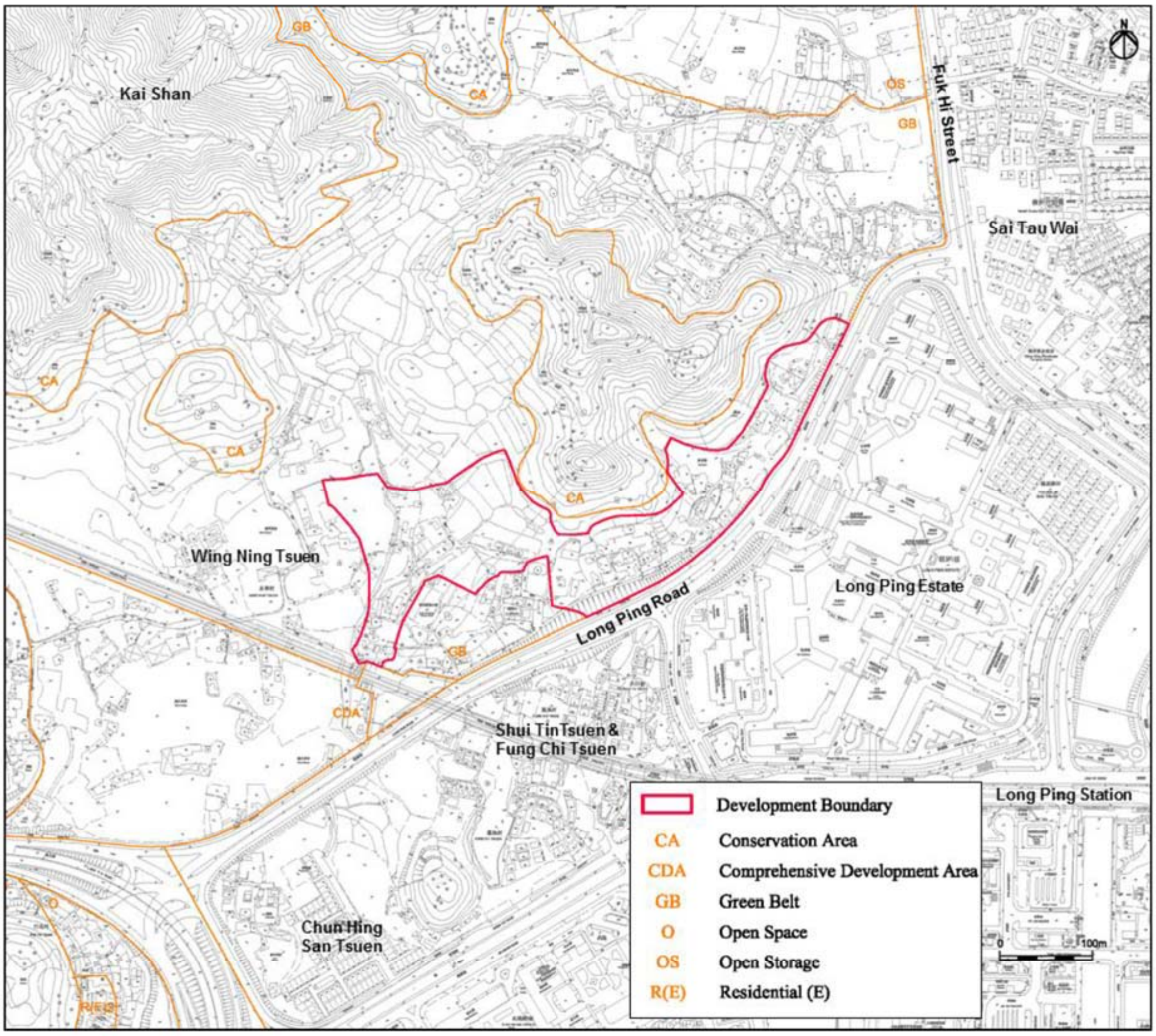


Figure 1.1 Location of project site

1.2 Purpose of the Report

The purposes of this report are:

(1) Identify the site wind availability;

(2) Evaluate the site wind characteristics on the proposed development;

(3) Evaluate the effect of proposed development on the air ventilation; and

(4) Identify problem areas and recommend improvements to the proposed development.

2 Study Area

The site is currently occupied by farmland, fallow land, rural residential dwellings, temporary structures and few open storages. The surrounding areas of the Project site are characterized by a mixture of various land uses. These include high-rise residential developments, villages and low-rise residential developments, natural landscapes, burial grounds and graves, open storage uses, major roads and railway tracks. **Figure 2.1a** shows the location of the project site and its environs in the vicinity and **Figure 2.1b** shows the photos of different land use surroundings.

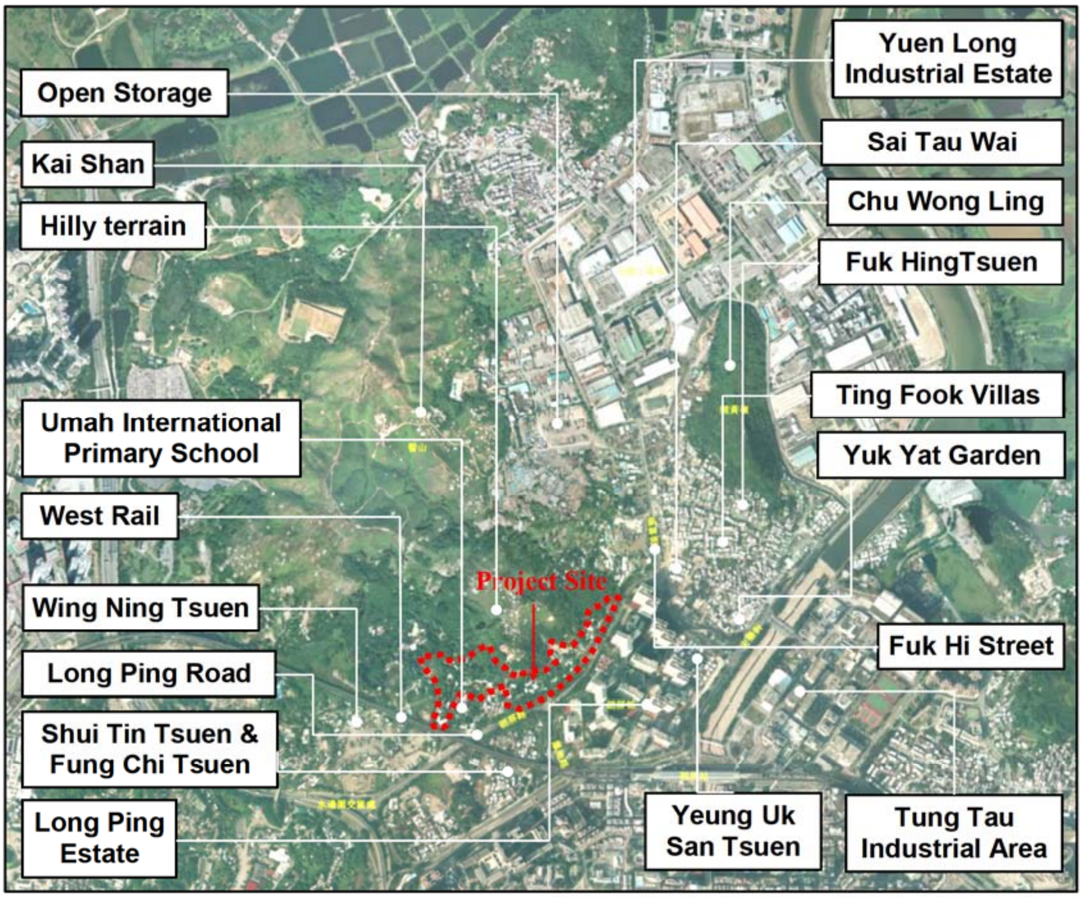


Figure 2.1a Location of project site and its environs in the vicinity

Long Ping Estate

Shui Tin Tsuen

Yuk Yat Garden

Sai Tau Wai

Kai Shan

Open Storage

Long Ping Road

West Rail

Yuen Long Industrial Estate	Tung Tau Industrial Area

Figure 2.1b Photos of different land use surroundings

3 Proposed development

Development Proposal

The proposed development site consists of 10 residential building blocks for Home Ownership Scheme (HOS) and Public Rental Housing (PRH), car parks, retails, one social welfare block, one 24-classroom primary school, and complementary recreational facilities.

Based on the tentative implementation programme, the planned population intake would be in year 2025. **Figure 3.1** shows the conceptual layout plan of the proposed PH development

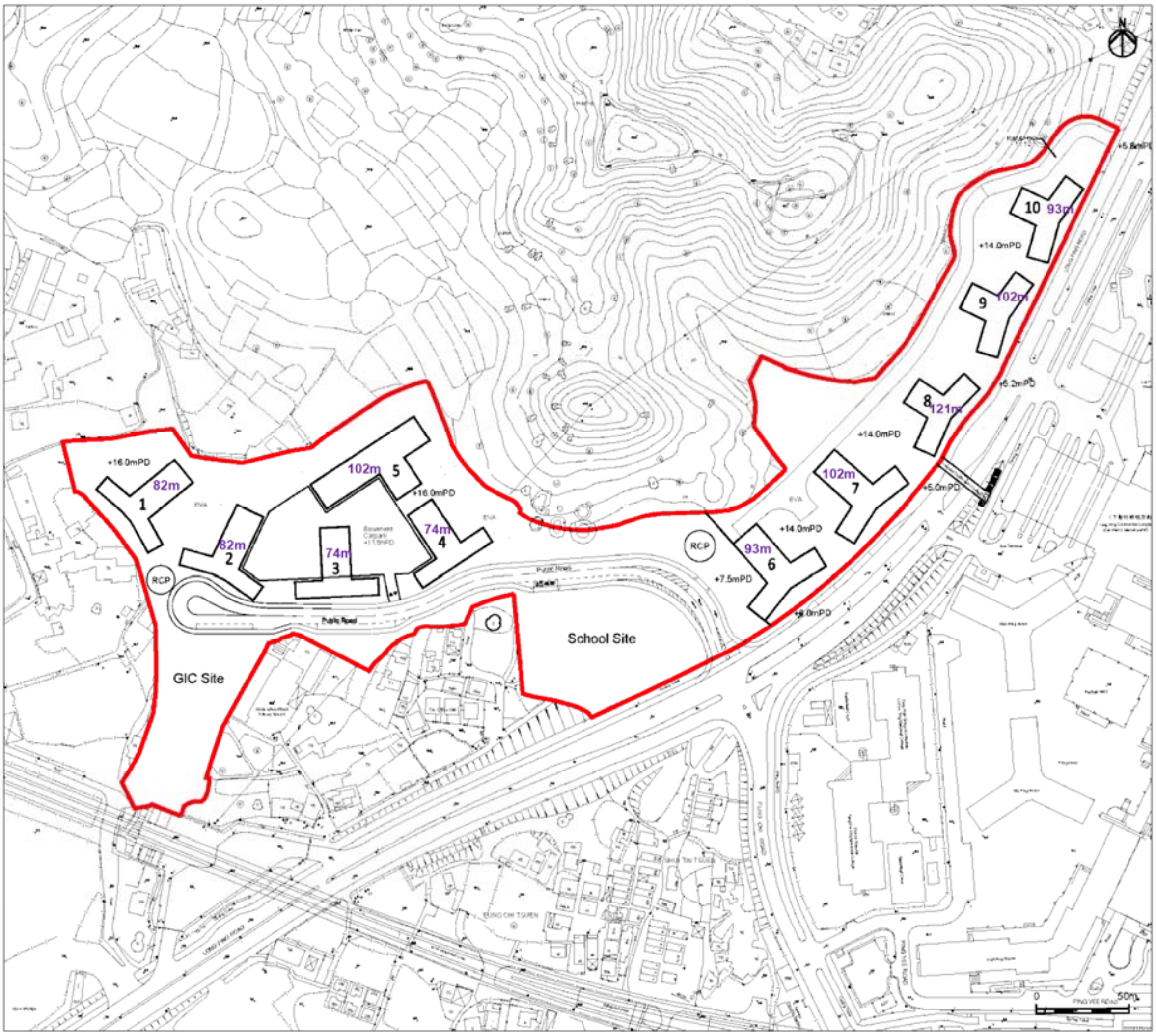


Figure 3.1 Conceptual layout plan of proposed PH development

Development Parameters

The planning parameters are yet to be confirmed at the stage of the study. For the purpose of this AVA, the expert evaluation is based on the tentative planning parameters as summarized in **Table 3.1** below.

Table 3.1: Summary of development parameters

Development	Parameter
Maximum Plot Ratio	6.0
Total number of flats	About 4,000 flats (subject to detailed design)
Design population	About 12,300 persons (subject to flat number)
Total Gross Floor Area	About 246,000m^2 (subject to detailed design)
Primary School	One 24 Classroom Primary School (subject to detailed design and EDB's funding)
Social Welfare Facilities	Subject to detailed design and SWD's funding

Height Profile

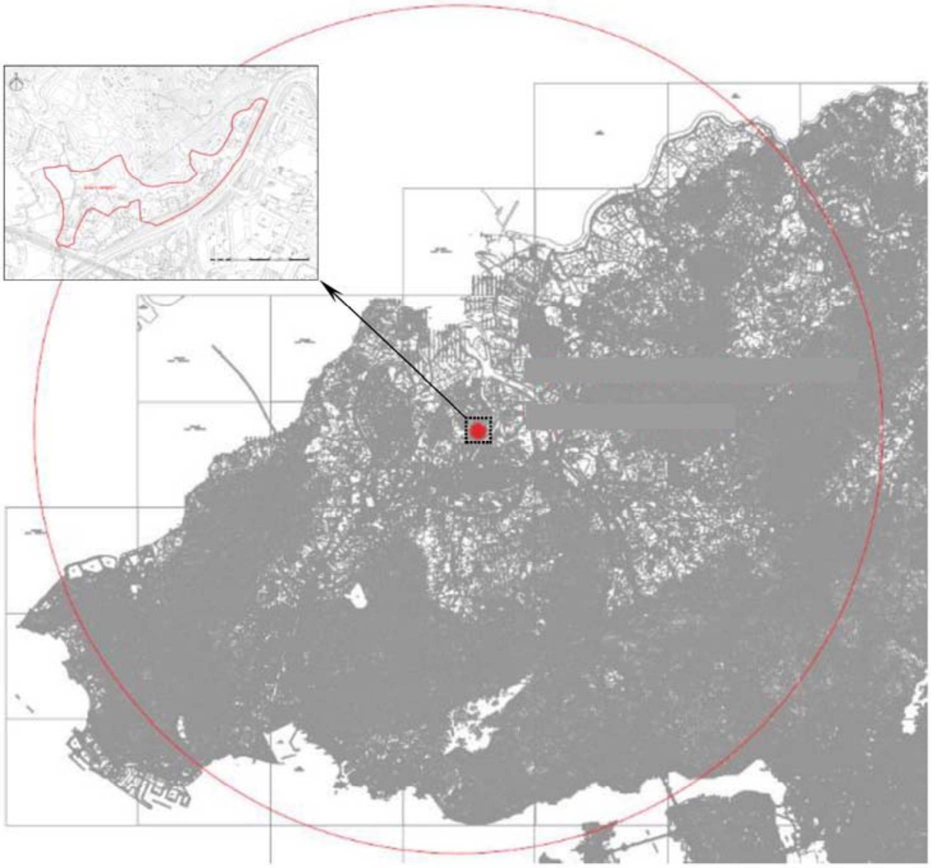
The conceptual layout of the proposed buildings within the development site is shown in **Figure 3.1** and tentative height profile of the proposed buildings is presented in **Table 3.2**. The platform level of the western site is 16mPD and that of eastern site is 14mPD. The heights of the western residential building blocks range from 74m to 102m above ground (i.e. about 90mPD to 118mPD); while that of the eastern residential building blocks range from 93m to 121m above ground (i.e. about 107 mPD to 135mPD). The Social Welfare Block is of 18m above ground (i.e. about 35mPD). The primary school is of 28m above ground (i.e. about 45mPD).

Table 3.2: Height Profile of Development

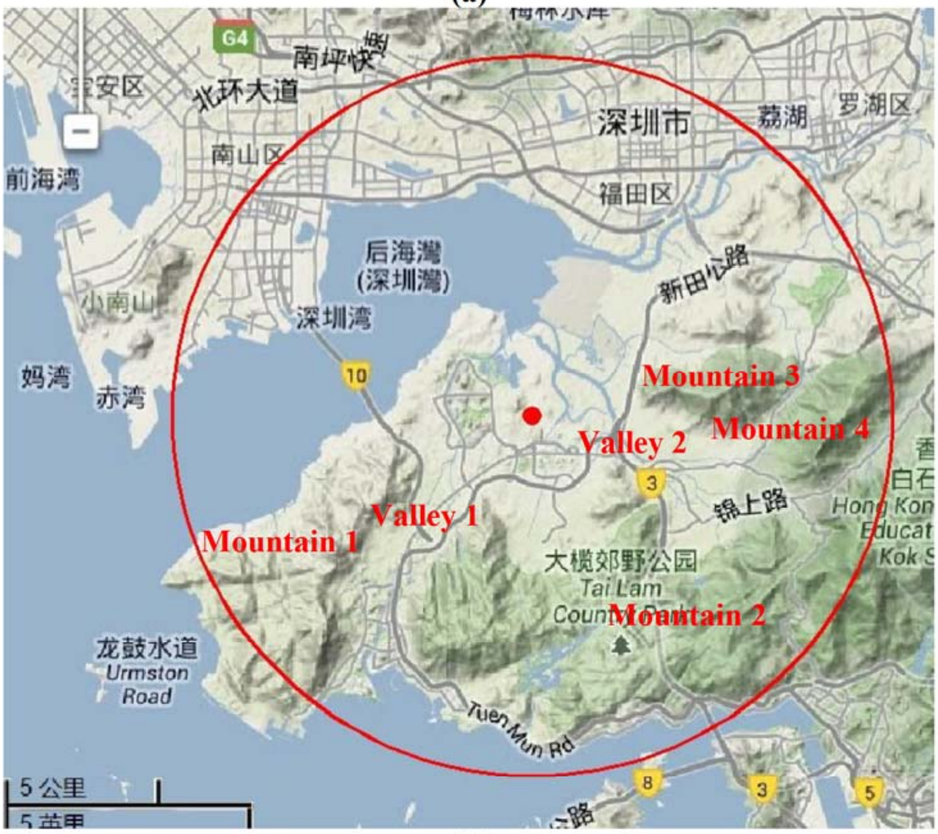
	Building Height (m above ground)	Building Height (mPD)
Residential Buildings		
Block 1 (HOS)	82	98
Block 2 (HOS)	82	98
Block 3 (HOS)	74	90
Block 4 (HOS)	74	90
Block 5 (HOS)	102	118
Block 6 (PRH)	93	107
Block 7 (PRH)	102	116
Block 8 (PRH)	121	135
Block 9 (PRH)	102	116
Block 10 (PRH)	93	107
Social Welfare Block	18	35
Primary School	28	45

4 Site Wind Availability Assessment

A 1:4,000 scale topographical model with 3 m in radius (equivalent to 12 km in radius in actual scale) was established. It covered the surrounding area up to a distance not less than 10 km from the proposed development site. A B5000 Digital Topographic Map was used for the model construction. The modelling area is shown in **Figure 4.1**.



(a)



(b)

Figure 4.1 SWAS modelling area: (a) digital map; (b) topographic map.

The approach wind field (mean wind profile, turbulence intensity profile and longitudinal turbulence spectrum) in the wind tunnel was adjusted according to the Japanese wind load code of AIJ-2004.

The mean wind speed profile was adjusted to follow the power law:

$$U(z) = U_{ref}(z / z_{ref})^{\alpha}. \quad (1)$$

where α is the power exponent and U_{ref} is the reference mean wind speed at the reference height of z_{ref}.

The turbulence profile was adjusted according to the AIJ-2004 wind code:

$$I(z) = 0.1(z / z_G)^{-\alpha-0.05}. \quad (2)$$

where z_G stands for the gradient height, and α is the power exponent.

The von Karman model was adopted for the wind turbulence spectrum.

The wind tunnel measurements were taken at 22.5° intervals for the full 360° azimuth (i.e., 16 wind directions) at the geometric centre of the physical model. The wind directions were defined as positive travelling clockwise from the north.

For each wind direction, the mean wind speeds, turbulence intensities and yaw angles were determined at 10 different height levels, equivalent to 25, 50, 75, 100, 150, 200, 250, 300, 400 and 500m in actual scale.

The wind roses at WGL for both the annual and summer winds are shown in **Figure 4.2**, based on records during 2000-2013 (speed unit: m/s) and measured by the cup anemometer installed at a height of 82.7m above the mean sea level, or 28 m atop the Waglan Island zenith. There are three prevailing wind directions for the annual wind: east, with a wind occurrence frequency of 19%; east-northeast, with an occurrence frequency of 18%; and north, with an occurrence frequency of 12%. For the summer wind, there are two dominant wind directions: southwest, with an occurrence frequency of 20%, and east, with an occurrence frequency of 13%.

The details of the site wind availability shall refer to Final Technical Report No. 3H (TR-3H) Preferred Option and Technical Assessment – Air Ventilation Assessment submitted in June 2014.

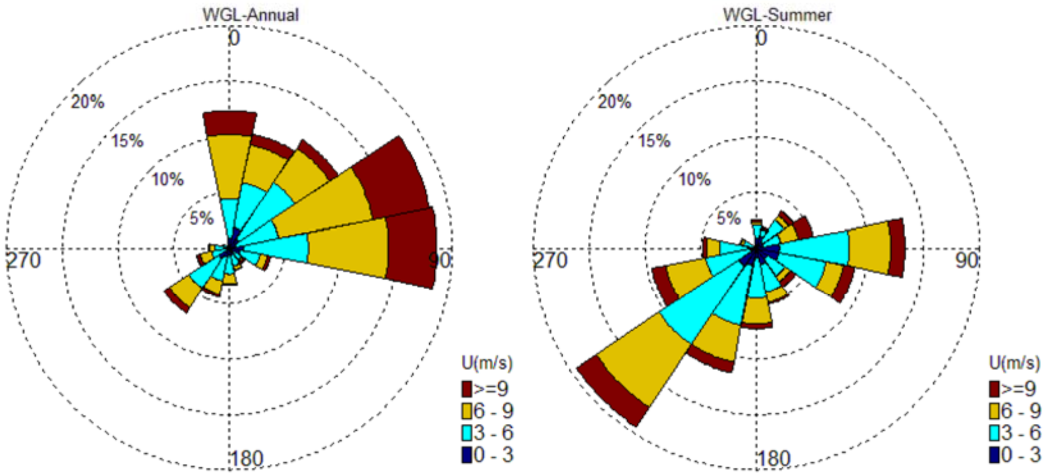


Figure 4.2 Wind roses of daily mean wind at the WGL station (13 years' data)

The estimated wind roses of the annual winds and summer winds at different height levels are shown in **Figure 4.3** and **Figure 4.4** respectively. **Tables 4.1** and **4.2** summarize the probability of 16 wind directions at 25m, 150m and 500m.

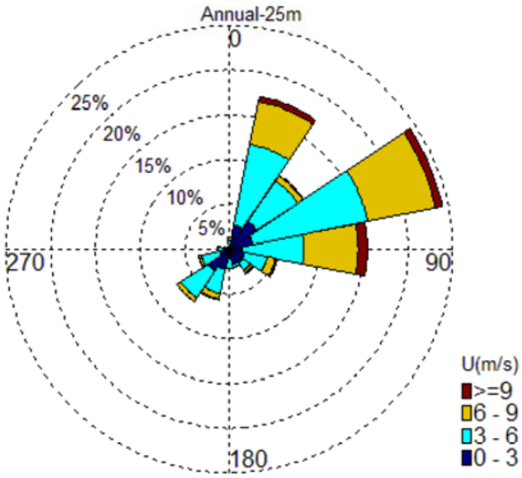
According to the wind rose plots shown in **Figures 4.3 – 4.4**, there are three prevailing directions for the annual winds at the lower and middle atmospheric boundary layers: north-northeast (NNE), east-northeast (ENE) and east (E). Northeast (NE) is another dominant direction at the upper height levels above 200 m. Similarly, as shown in **Figure 4.4**, there are also three prevailing directions for the summer winds at the lower and middle atmospheric boundary layers: southwest (SW), south-southwest (SSW) and west-southwest (WSW). East-southeast (ESE) is another prevailing azimuth at the upper height levels.

Table 4.1: Directional occurrence frequency of annual wind (%)

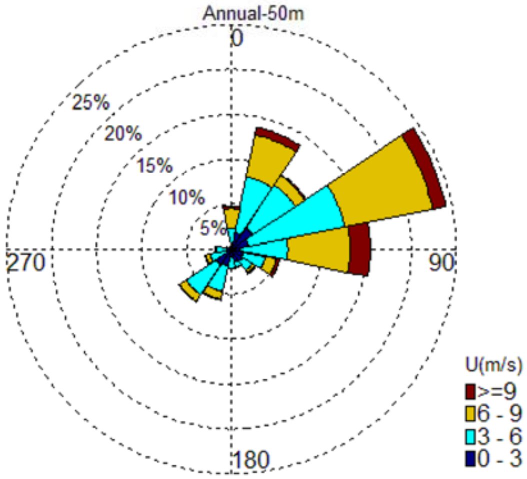
Height	N	NNE	NE	ENE	E	ESE	SE	SSE
25m	1.31	17.34	9.93	24.28	15.45	5.43	3.25	2.06
150m	4.81	13.86	9.93	24.31	15.45	5.45	3.25	2.06
500m	4.81	13.86	15.93	18.31	15.45	6.97	1.72	2.06
Height	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**
25m	2.10	5.79	7.04	3.55	1.30	0.61	0.16	0.32
150m	2.11	5.79	7.03	3.01	1.27	1.22	0.16	0.31
500m	2.11	3.51	9.31	3.01	1.25	1.21	0.16	0.30

Table 4.2: Directional occurrence frequency of summer wind (%)

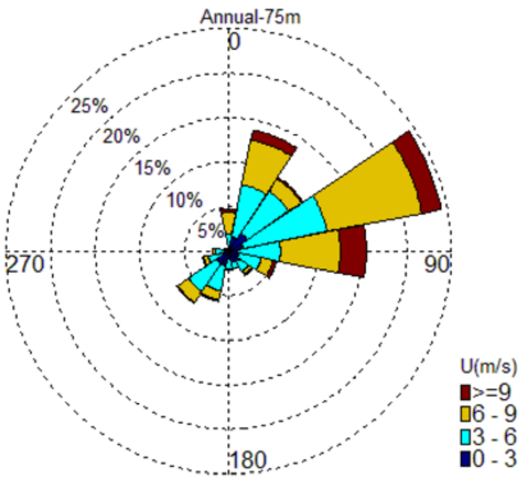
Height	N	NNE	NE	ENE	E	ESE	SE	SSE
25m	0.24	3.22	2.62	7.53	8.98	9.30	8.21	5.16
150m	1.08	2.37	2.62	7.55	8.97	9.32	8.21	5.17
500m	1.07	2.36	4.98	5.16	8.96	13.29	4.23	5.18
Height	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**
25m	4.75	13.97	19.40	10.93	3.46	1.51	0.25	0.33
150m	4.75	13.97	19.40	9.57	3.04	3.30	0.25	0.33
500m	4.74	7.88	25.51	9.57	3.05	3.30	0.25	0.32


Annual-25m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(a)


Annual-50m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(b)


Annual-75m
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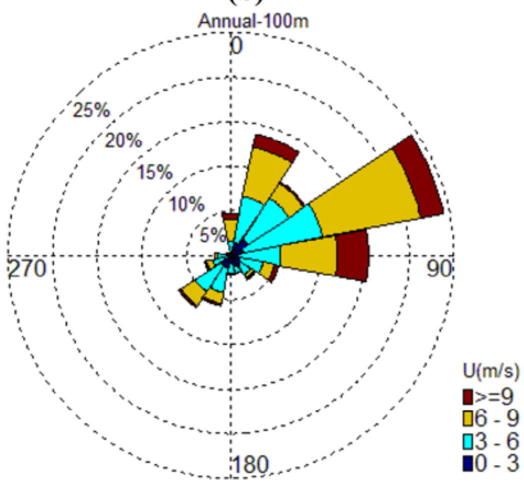
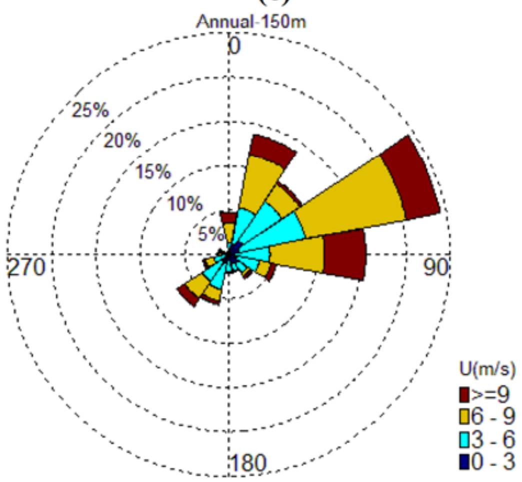
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

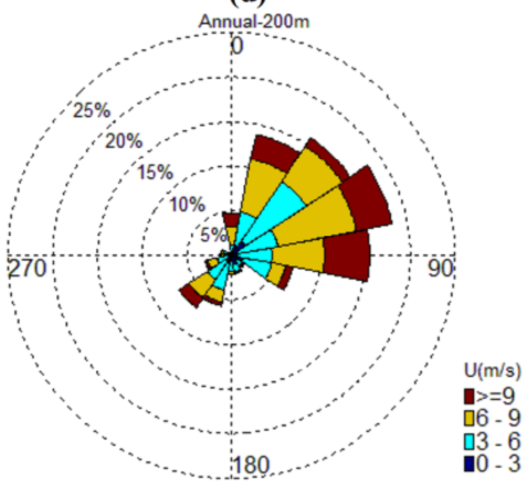
(c)


Annual-100m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(d)


Annual-150m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(e)


Annual-200m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(f)

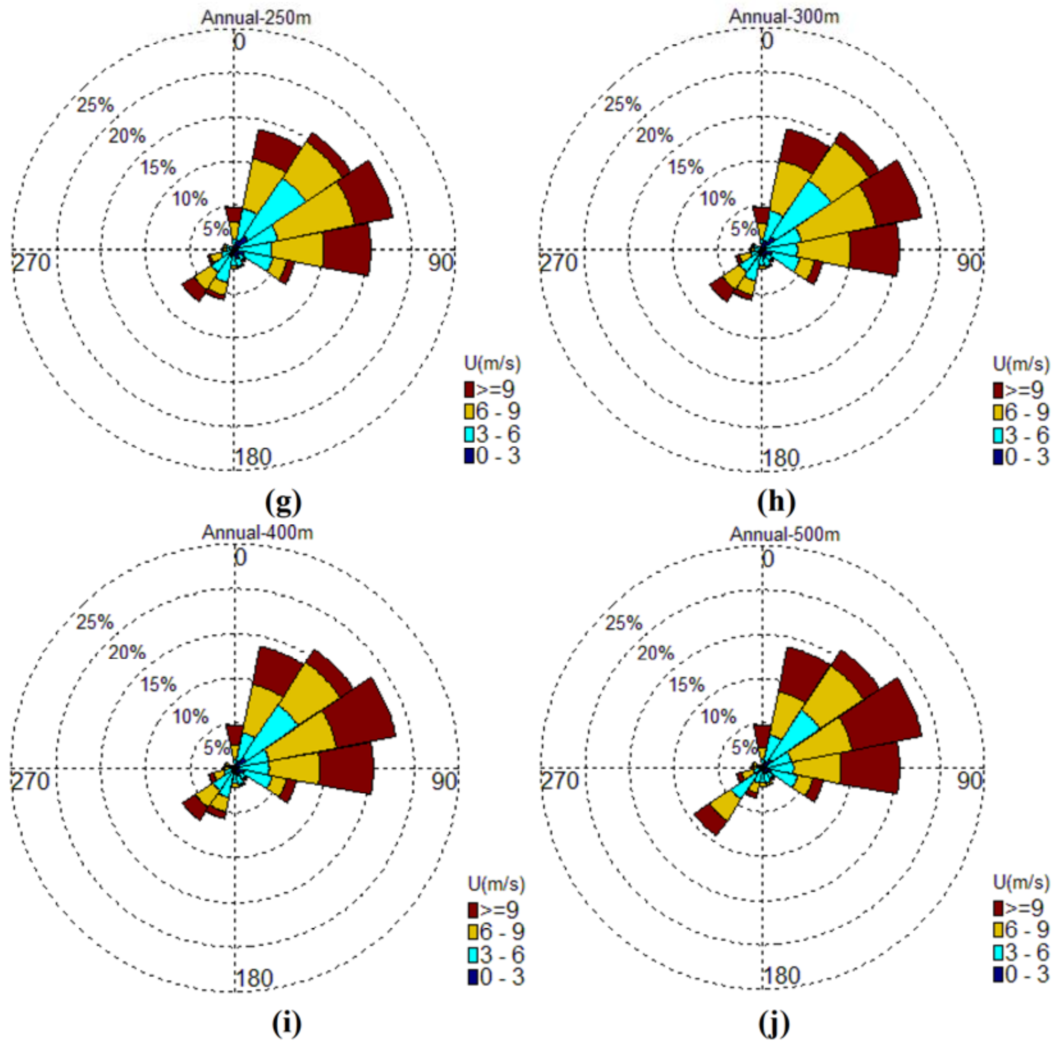
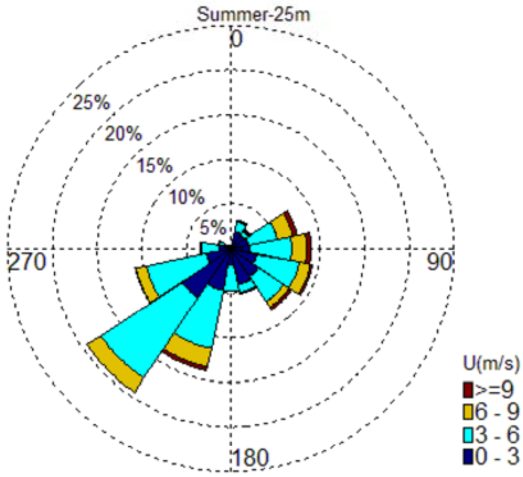
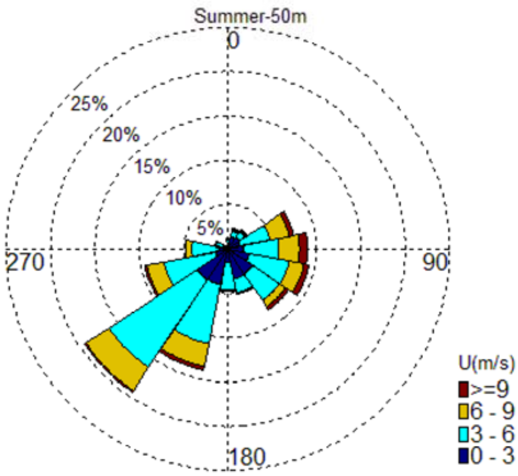


Figure 4.3 Wind roses at different height levels above the proposed development site under annual wind condition

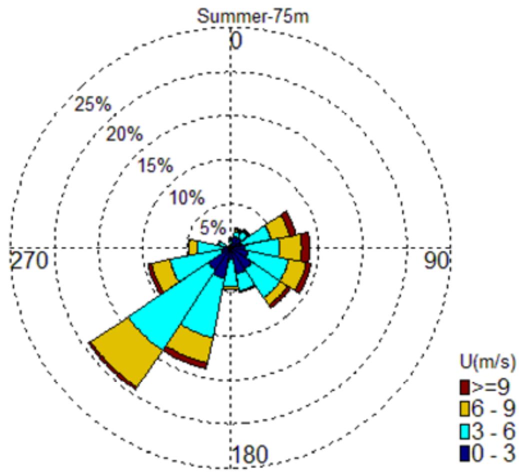
(a) 25 m; (b) 50 m; (c) 75 m; (d) 100 m; (e) 150 m; (f) 200 m; (g) 250 m; (h) 300 m; (i) 400 m; (j) 500 m.


Summer-25m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

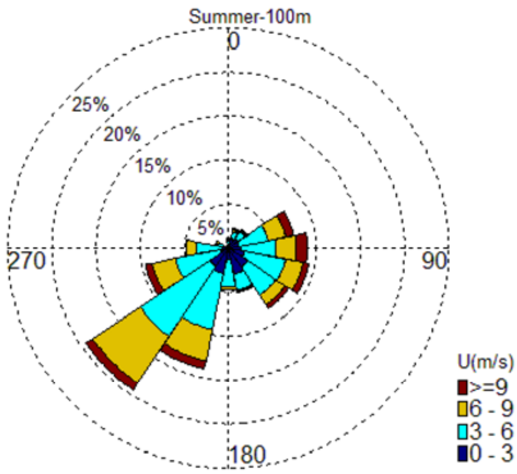
(a)


Summer-50m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

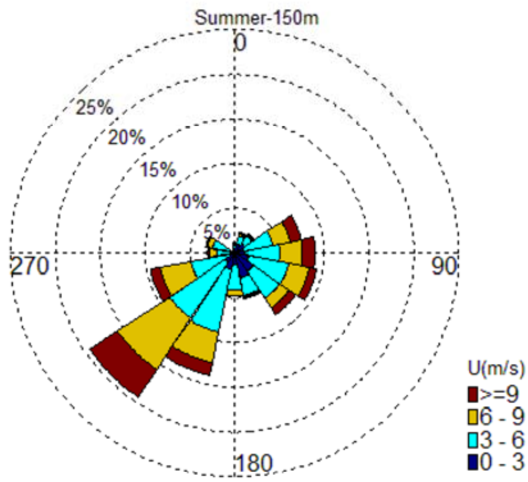
(b)


Summer-75m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

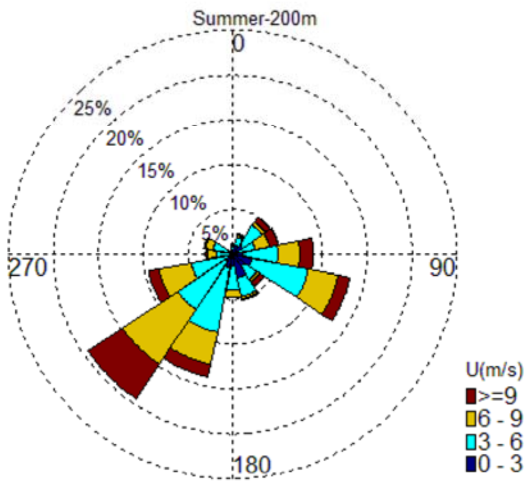
(c)


Summer-100m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(d)


Summer-150m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(e)


Summer-200m
0
90
180
270
5%
10%
15%
20%
25%
U(m/s)
>=9
6 - 9
3 - 6
0 - 3

(f)

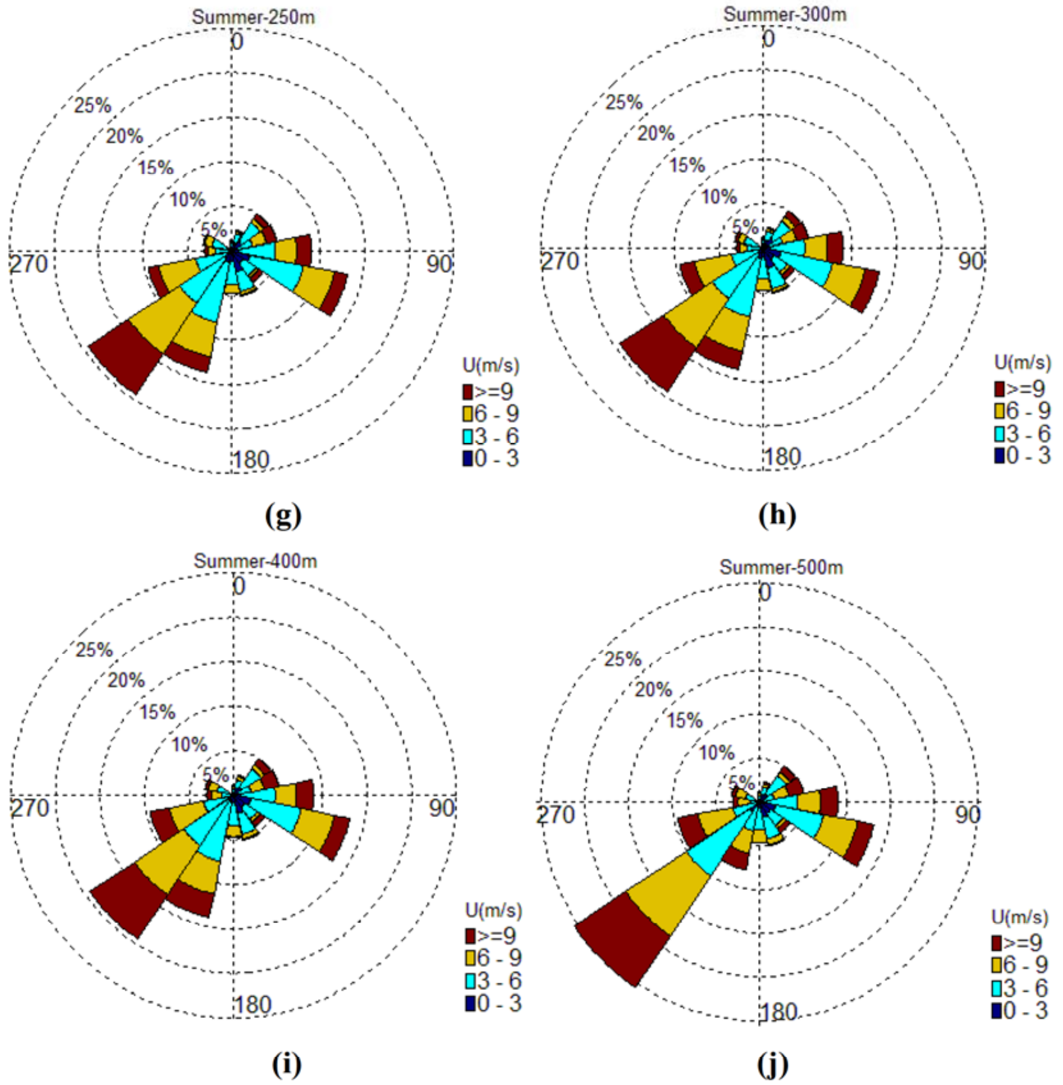


Figure 4.4 Wind roses at different height levels above the proposed development site under summer wind condition
(a) 25 m; (b) 50 m; (c) 75 m; (d) 100 m; (e) 150 m; (f) 200 m;
(g) 250 m; (h) 300 m; (i) 400 m; (j) 500 m.

5 Existing Conditions

The existing building height in the vicinity of the development site is shown in **Figure 5.1**. The existing site characteristics include the followings:

Road pattern within the district: The Fuk Hi Street is oriented in N-S direction whilst the Long Ping road is oriented in NE – SW direction. These two roads are considered as the major wind pathways. In addition, several minor roads in the vicinity also act as potential air pathways.

Distribution of building height: The built area generally exhibits a low to medium height profile with 3-storey village houses to the south, southwest and northeast of the project site, and open storage, temporary structures and scattered low rise buildings to the north of the project site. They are not expected to block the wind from northeastern and southwestern directions. Long Ping Estate is the tallest development in the vicinity of the project site with Double H blocks of approx. 28 storeys, New Slab blocks of approx. 23 storeys, and Trident (i.e. Y-shape) blocks of approx. 35 storeys. Open spaces are identified in between the buildings.

Hilly Terrain: To the north and northwest, the project site is surrounded by a hilly terrain with a ridgeline of about 50mPD. Chu Wong Ling is located to the northeast side further away from the project site with a ridgeline of 40-50mPD.

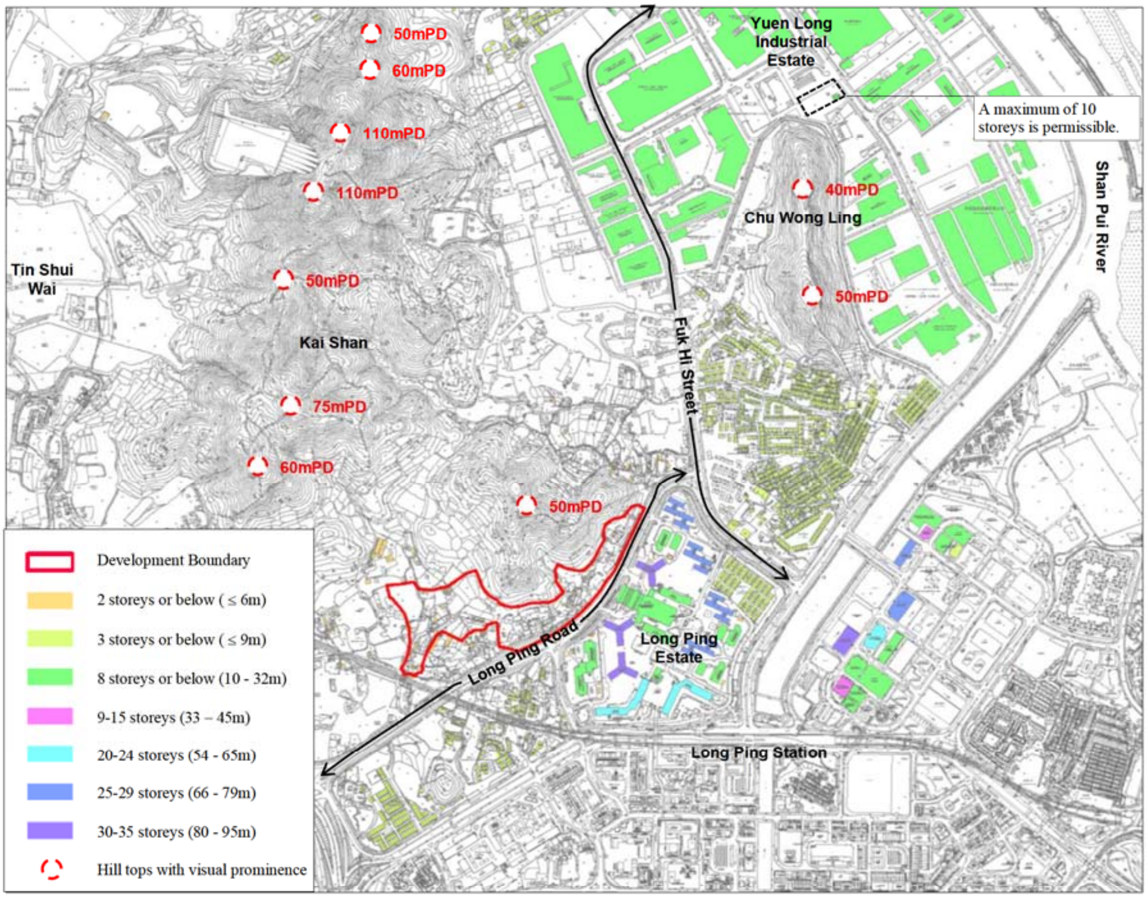


Figure 5.1 Existing building height in the vicinity

5.1 Annual Wind Conditions

Section 4 has identified the annual prevailing wind directions as north-northeast (NNE), east-northeast (ENE) and east (E) wind. **Figure 5.2** shows the prevailing winds for the existing scenario under the annual conditions. The major breezeways are marked by blue arrows.

To the NNE direction of the proposed development, it comprises mainly low rise residential buildings (~3 storeys), Chu Wong Ling (with ridgeline of about 50 mPD) and low rise industrial buildings (~ 8 storeys) inside the Yuen Long Industrial Estate. Given the low rise nature of the buildings, it would not block the wind flow. Besides, the length in N-S direction of Chu Wong Ling is around 580m and the length in the E-W direction of Chu Wong Ling is around 180m. Given the elliptical shape of Chu Wong Ling, it is anticipated that it would also not block the NNE wind. The NNE wind will flow along the two sides of Chu Wong Ling, and will penetrate into the site through Long Ping Road. Another pathway will flow over the hill and pass over the proposed site towards Hang Tau Tsuen.

To the ENE direction and E direction of the proposed development, it comprises some low rise residential building (~ 3 storeys), Long Ping Estate and Tung Tau Industrial Area. Although there are several high rise buildings (~ 29 – 35 storeys) inside Long Ping Estate and Tung Tau Industrial Area, the ENE and E wind can still penetrate into the site from the open spaces in between the buildings. After the wind passes through the proposed site, it will flow uphill towards Tin Shui Wai.

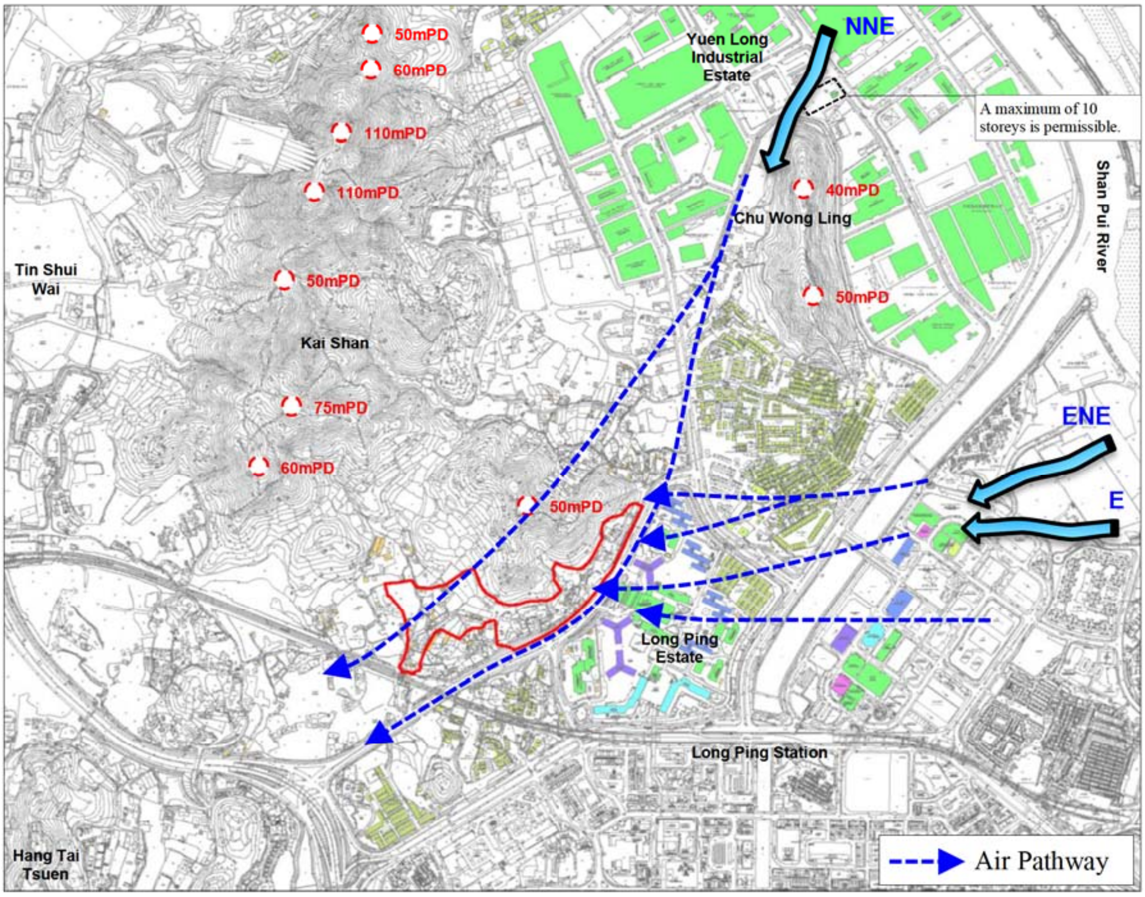


Figure 5.2 Existing wind environment under NNE / ENE /E direction (annual conditions)

5.2 Summer Wind Conditions

Section 4 has identified the summer prevailing wind directions as southwest (SW), south-southwest (SSW) and west-southwest (WSW). **Figure 5.3** shows the prevailing winds for the existing condition under the summer wind conditions. The major breezeways are marked by orange arrows.

To the SW, SSW and WSW direction of the proposed development, it comprises mainly low rise buildings such as Hang Tau Tsuen, Chun Hing San Tsuen, Shui

Tin Tsuen, etc. These low-rise buildings would not block the wind flow. The SW / SSW / WSW winds will penetrate into the site through Long Ping Road. Another pathway will pass over the proposed development, uphill and then downhill towards the Yuen Long Industrial Estate.

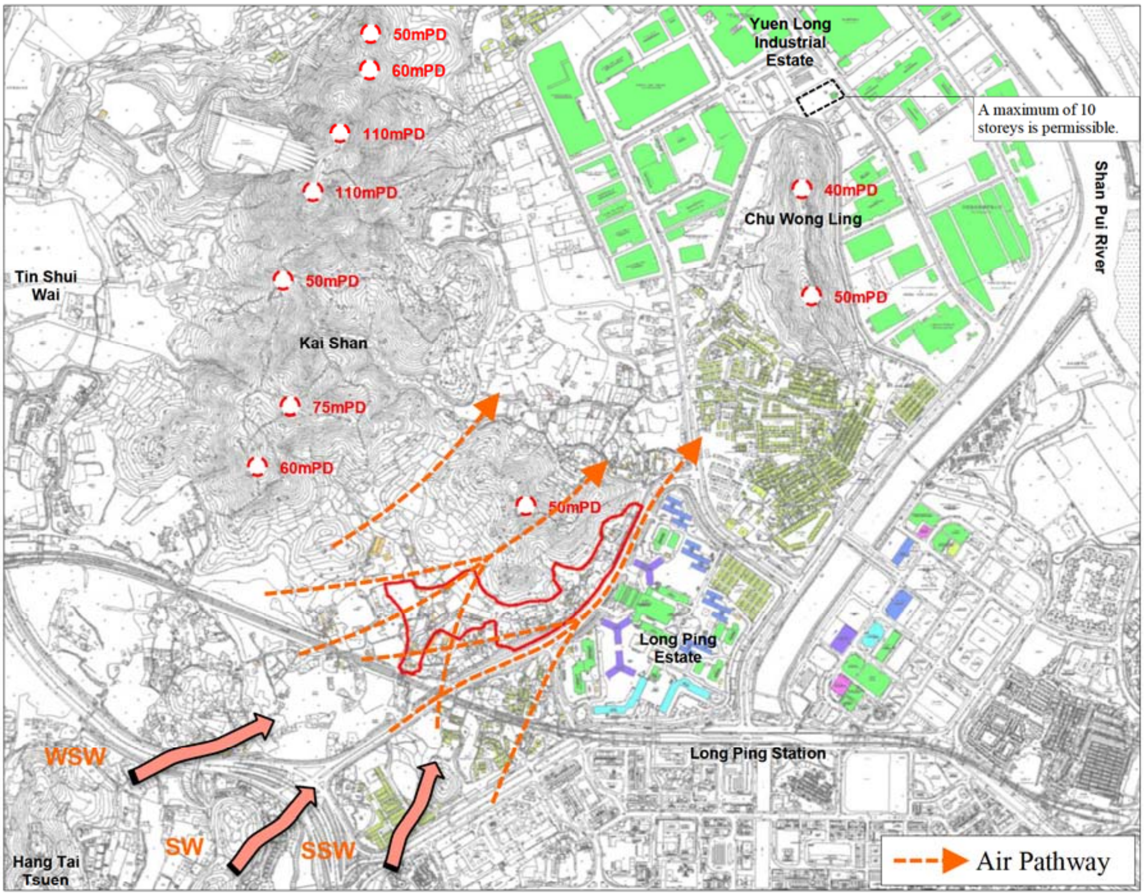


Figure 5.3 Existing wind environment under SW, SSW and WSW direction (summer conditions)

6 Air Ventilation Assessment for the Proposed Development

6.1 Annual Wind Conditions

Under the annual prevailing winds, the air flows are indicated by blue arrows and light blue arrows shown in **Figure 6.1**. During the NNE wind, main breezeway will follow the hill profile and road orientation. Hence, wind will flow along Long Ping Road and the perimeter of the hill (together with the EVA running along the site platform of blocks 6 to 10). It is anticipated that it changes direction a little bit. In between the two wind breezeways, some weaker air pathways may exist between the buildings to allow wind penetration into building blocks 6 – 10 and the school site.

Another air pathway will flow over the hill slope of around 50m high and penetrate into the building blocks 1 – 5. To increase the permeability of the wind to the site and social welfare block and reduce the formation of the wake area affecting the Fung Chi Tsuen and Shui Tin Tsuen, building separations of 10m to >15m amongst the buildings (shown in **Figure 6.1**) have been allowed. For Umah International Primary School, which is located to the south of the development, the wind can penetrate to the site through the building gap of the development. Hence the development's influence to the ventilation of the school is expected to be minor.

Nevertheless, two weaker air pathways between building blocks 4 and 5, and between building blocks 1 and 2 are identified.

To allow a better penetration of wind to the pedestrian level, stepping building height for the building blocks 6 -10 (varying from about 107 mPD to max. 135 mPD) have been designed to optimise the wind capturing potential of the development itself. Hence, the variation in building height profile would enhance air movements, allow wind deflection and avoid air stagnation at pedestrian level. The effectiveness of the stepping building height will be studied in separate initial AVA study.

During the ENE and E wind, the air pathways will penetrate into the proposed development through the building gaps (shown as light blue arrows in **Figure 6.1**) and the proposed road in front of building blocks 1 – 4. In the downstream of building blocks 6-10, it is the hill. Hence, the wake effect of the wind will have no impact on it. To increase the permeability of the wind, building separations of 10m to >15m amongst the buildings (shown in **Figure 6.1**) have been allowed. Nevertheless, weaker air pathways between building blocks 4 and 5 and between building blocks 9 and 10 have been identified. For the Wing Ning Tsuen, it is at about 100m from the proposed buildings (i.e. block 1) of the development. It is anticipated that the wake effect of the buildings will have less impact on it under the E/ENE wind.

To allow the better penetration of wind to the pedestrian level, stepping building height for the building blocks 1 -5 (varying from about 90 mPD to about 118 mPD) have been adopted to optimise the wind capturing potential of the development itself. The effectiveness of the stepping building height will be studied in separate initial AVA study.

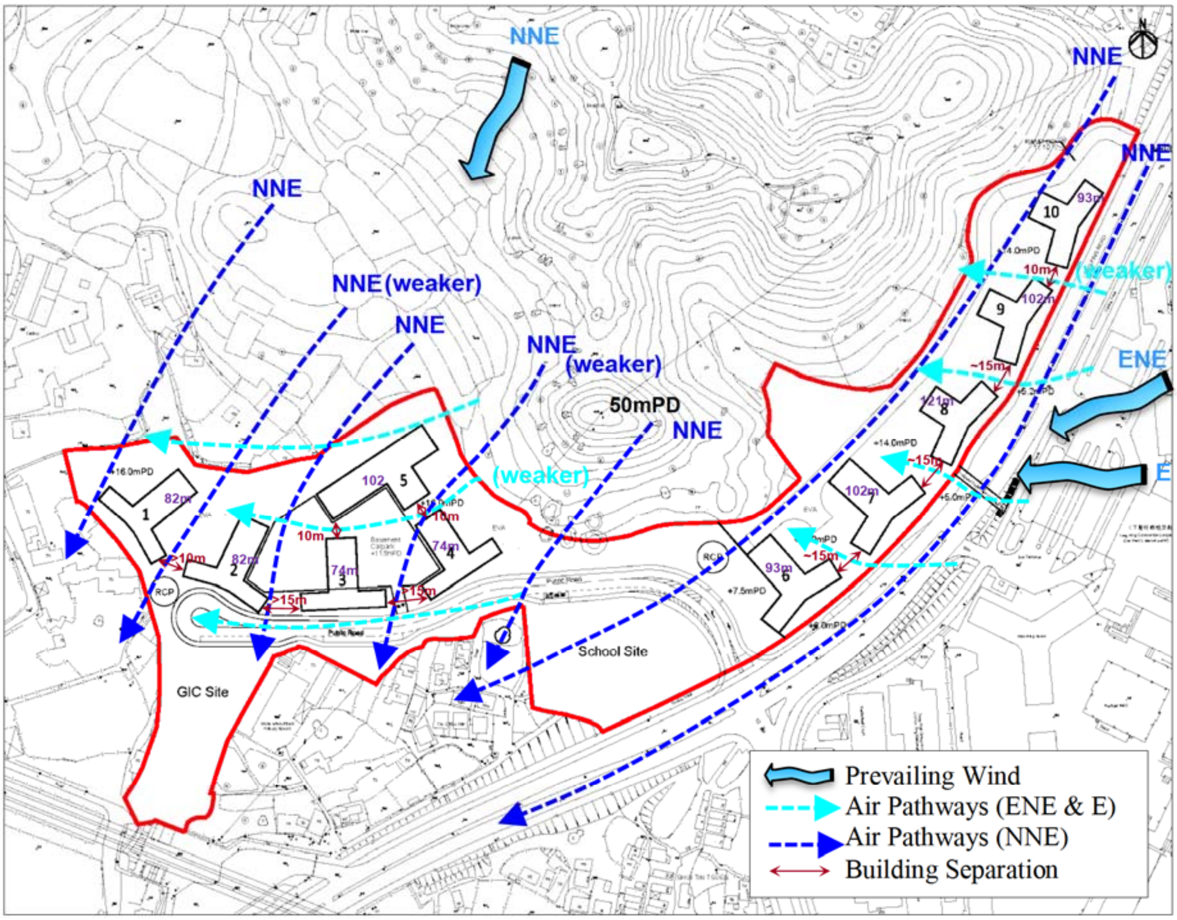


Figure 6.1 Local air paths of proposed development under NNE, ENE and E directions

6.2 Summer Wind Conditions

Under the summer prevailing winds, the air flows are indicated by orange arrows in **Figure 6.2**. During the SW, SSW and WSW winds, the air will flow along Long Ping Road and the perimeter of the hill (together with the EVA running along the site platform of block 6 to 10) to penetrate into the school site and building blocks 6 - 10. The stepping building height for the building blocks 6 -10 (varying from about 107 mPD to max. 135 mPD) would increase wind capturing potential of the development itself. Under summer wind, the proposed buildings do not block the main wind corridor. The development's influence to the downstream area is expected to be minor.

For the social welfare block and blocks 1 – 5, the air pathways will penetrate into the site through the proposed road and the building gaps of 10m to >15m amongst the buildings (shown in **Figure 6.2**). A weaker air pathway is identified between building blocks 1 and 2. The stepping building height for the building blocks 1 -5 (varying from about 90 mPD to about 118 mPD) would increase the wind capturing potential of the development itself. The effectiveness of the stepping building height will be studied in separate initial AVA study.

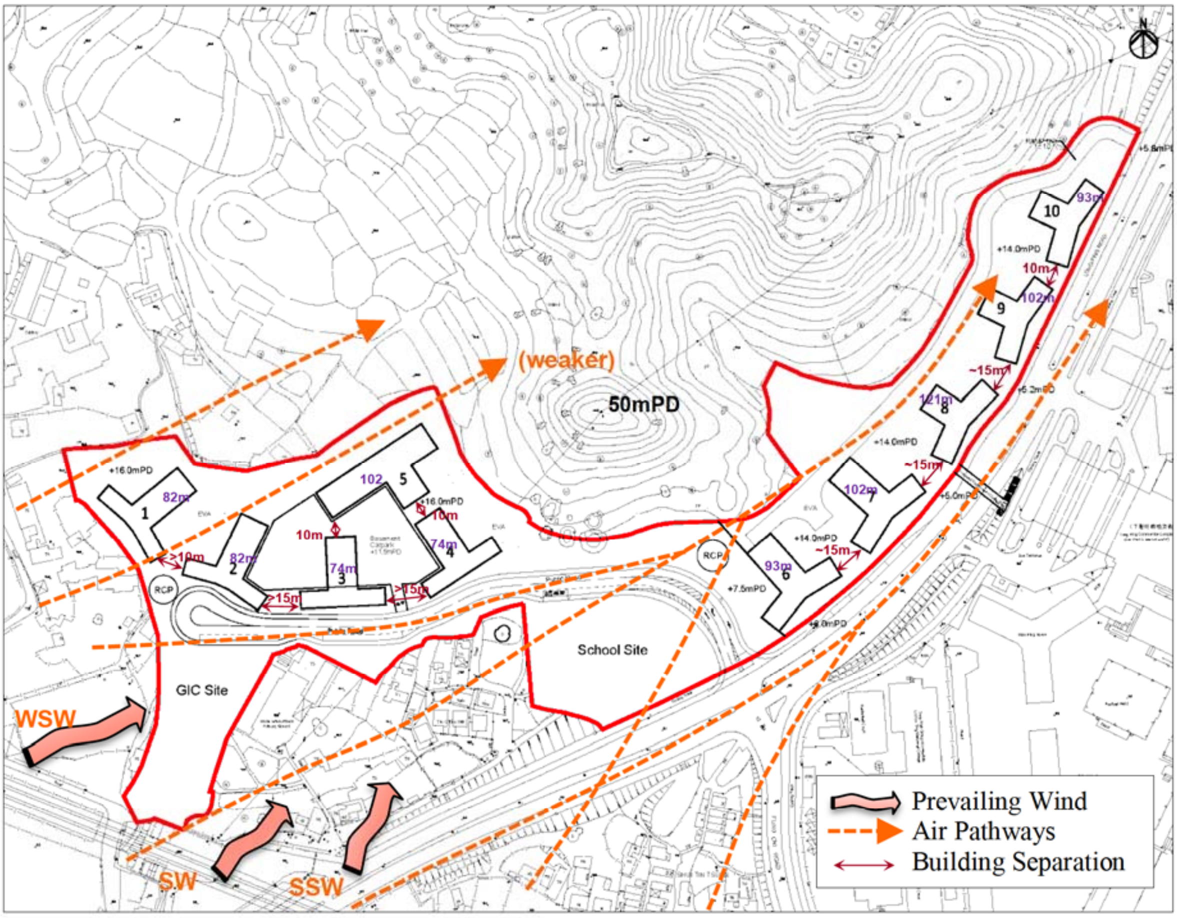


Figure 6.2 Local air paths of proposed development under SSW, SW and WSW directions

7 Recommendations

Two possible measures are recommended for the proposed development to further enhance the air ventilation:

1. Widen the separations between the residential blocks 1 and 2, blocks 4 and 5, blocks 3 and 5 and blocks 9 and 10 by re-orientating and/or re-positioning of the buildings to allow more or wider local air paths as far as possible;
2. Shorten the northern wing of the block 3 and block 4 as far as possible to allow a wider passageway and hence more smooth air flow.

8 Conclusion

The expert evaluation aims at providing qualitative analysis of wind performance of the project site based on the planning of the proposed development and assessing the effects of the proposed development on the surrounding areas. An AVA Initial Study is still required after the rezoning process in order to quantitatively estimate the wind performance at the pedestrian level on and around the site, to derive the airflow patterns and to provide better illustrations of the ventilation performance of the proposed development.