AECOM

Planning Department

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Category A1 - Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment

An Instructed Project at Ap Lei Chau

Expert Evaluation – Final Report

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1 INTRODUCTION

Background

1.1 The Hong Kong Special Administrative Region (HKSAR) Government Planning Department (PlanD) has identified a site at Ap Lei Chau for development. It is considered necessary to conduct an expert evaluation to assess the preliminary air ventilation impacts of the proposed development proposal and development parameters which include the imposition of appropriate development restrictions to guide future development of the area. This site, namely Project Area hereafter, is located at the southwest portion of Ap Lei Chau Island, west to the Ap Lei Chau Industrial Estate.

1.2 In January 2015, AECOM Asia Company Ltd. (the Consultant) was commissioned by the PlanD to undertake an Expert Evaluation Study for the Project Area located on Ap Lei Chau Island as shown in **Figure 1.1** below to examine the air ventilation performance of the potential development within the Study Area. The Study Area is defined to cover the whole Ap Lei Chau Island which included regions that may likely to be affected by the proposed development in Project Area in terms of wind environment.

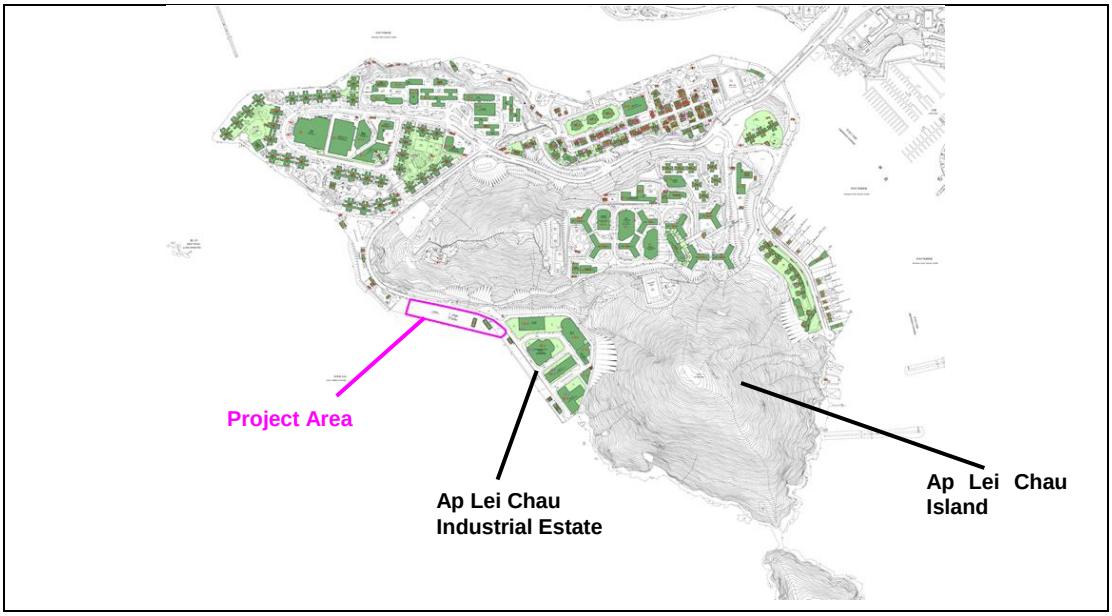


Figure 1.1 Extent of Ap Lei Chau Island

1.3 The developments outside the Study Area have a relatively far distance away from the Project Area and are unlikely to give rise to air ventilation to the Project Area. In this Expert Evaluation Report, focus will be on the wind environment within the Study Area.

1.4 This expert evaluation report is based on the following materials given by the PlanD to the Consultant:

- Location Map of the Project Area
- Development Parameters of the Project Area
- Existing Spot Heights of Ap Lei Chau Island
- Existing Building Height Profiles for Ap Lei Chau Island
- Data on Building Polygons
- Experimental Site Wind Availability Study for Wong Chuk Hang, Hong Kong
- Term Consultancy for air ventilation assessment services Cat. A1– Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment (PLNQ 37/2007)

1.5 In the preparation stage of the expert evaluation report, the Consultant has studied the given materials listed in paragraph 1.4 and carried out site visit and inspection.

Objectives of the Expert Evaluation Study

1.6 The objective of this study is to assess the air ventilation impacts of the development proposal for incorporation into the Outline Zoning Plan (OZP). The Expert Evaluation Study has made reference to the "Housing, Planning and Lands Bureau Technical Circular No.1/06, Air Ventilation Assessment" which recommended that it is important to allow adequate air ventilation through the built environment for pedestrian comfort.

1.7 The key purposes of the Expert Evaluation are to identify the major wind breezeways, air paths good wind performance areas, locate obvious problematic areas and propose appropriate mitigation measures if necessary. Based on the findings of the Expert Evaluation, it is required to determine whether further study is required.

1.8 This Expert Evaluation Report presents the following findings:

- Analyse relevant wind data to understand the wind environment of the Project Area and its surroundings;
- Identify and analyse major topographical features of the Project Area and its immediate vicinity. In addition, greeneries/landscape characteristics of the Project Areas as well as its surroundings are identified;
- Identify and analyse the land use of the Project Area as well as its immediate surrounding areas including existing developments, committed developments and planned developments. It is observed that there are currently no planned / committed developments with significant size / height within the Study Area.
- Based on the analyses of the baseline conditions, identify good features that shall be retained/strengthened while spotting problematic wind regions that may warrant attention; and
- Recommend appropriate technical methodologies if further initial study/detailed study for Project Areas is required.

1.9 This Expert Evaluation Report is written and arranged as follows:

- The "Wind Environment" section analyses relevant wind data to ascertain the wind environment of the Project Area and neighbouring region.
- After the prevailing wind directions are identified, the topographical features of the Project Areas and its immediate vicinity are analysed in the section "Topographical Features and Wind Flow" where **the impact of the topographies within the Study Area on the wind environment within Project Area** is discussed.
- Following the section of "Topographical Features and Wind Flow" is a section of "Existing land use and Building Morphology within Study Area". Land use of the Project Area as well as its immediate surrounding areas including existing developments are discussed in this section. Investigation of the impact of existing developments on **the wind environment within Project Area** is carried out. Existing good features and problematic areas are also identified.
- Following discussion of the impact of the existing developments on wind performance of the Project Area, the investigation of **the potential impact on the existing wind environment induced by the proposed developments within the Project Area** is documented in the section "Expert Evaluation on the Project Area". Existing good features that should be retained is identified while problematic regions that may warrant attention be spotted.
- Propose mitigation measures if any problematic areas are identified.
- A conclusion and summary section on the major findings of this study and a recommendation on whether further AVA study on the Project Areas is required are presented in the end.

2 WIND ENVIRONMENT

2.1 Natural wind availability is crucial to the investigation of wind ventilation performance. In this section, relevant measured wind data obtained from the Hong Kong Observatory (HKO) weather station and computed wind data from the MM5 model at the Study Area are analysed and compared in order to identify the prevailing wind directions.

Wind Direction Analysis based on HKO Weather Stations' Data

2.2 There are a total of 46 weather stations (See **Figure 2.1**) operated by Hong Kong Observatory (HKO) which provide reliable data on the wind environment in Hong Kong. The wind information and weather data from these stations provide reference to aid a general understanding of the surface wind environment.

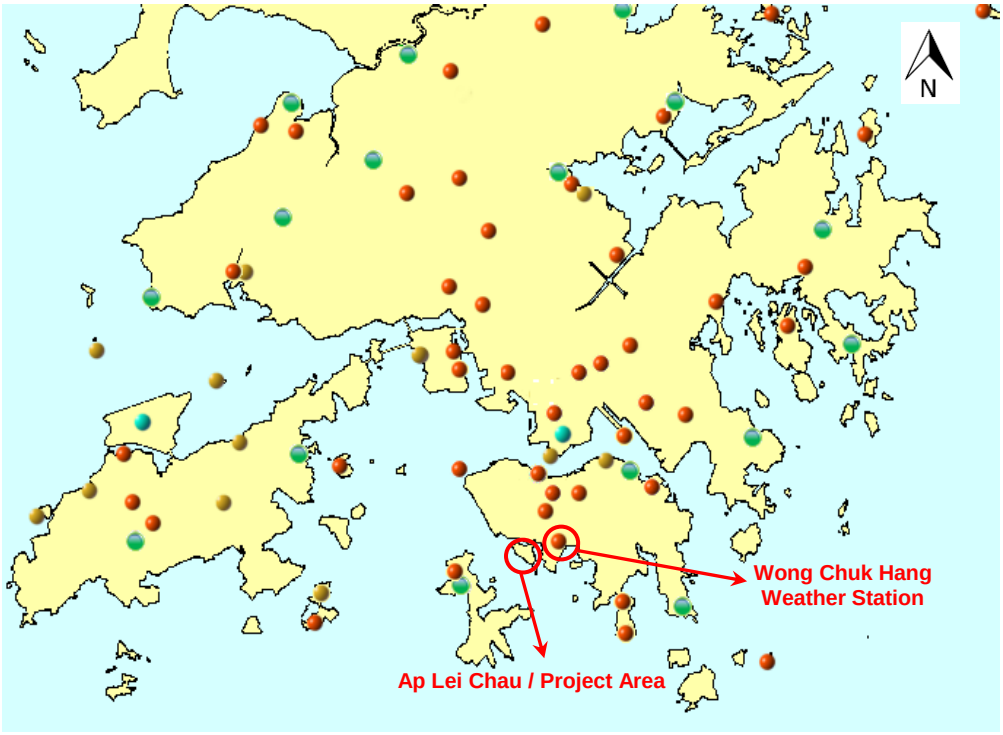


Figure 2.1 Locations of HKO Weather Stations in Hong Kong

2.3 The Wong Chuk Hang Automatic Weather Station is the closest station to the Project Area (with the distance of 2.7km from the boundary of the Project Area). The wind data from Wong Chuk Hang Weather Station is therefore used for identification of the prevailing wind directions and in assessing the site wind availability.

Wind Direction Analysis based on Wong Chuk Hang Station Data

2.4 Wind Rose from Wong Chuk Hang Weather Station are extracted from the HKO website (http://www.hko.gov.hk/cis/region_climat/HKS/HKS_windrose_year_e.htm), the wind rose are divided into 12 wind directions (i.e. N, NNE, ENE, E, ESE, SSE, S, SSW, WSW, W, WNW and NNW).

2.5 The Wong Chuk Hang Weather Station is 5mPD in height, located between Nam Long Shan and Bennet's Hill. The prevailing winds will be redirected and channelled by local terrain features near the Weather Station. This explains the wind data collected by the weather station are mainly concentrated in easterly and westerly winds.

2.6 Referring to the average annual wind rose at Wong Chuk Hang Weather Station from 1990 to 2013 as shown in **Figure 2.2**; it is observed that the winds from E and ESE directions have high probabilities of occurrence (each over 20% of annual percentage frequency occurrence). Furthermore, wind from ENE direction has an annual percentage occurrence frequency of approximately 10%, which is relatively less compared to the annual winds from the E and ESE.

2.7 Apart from the mentioned three wind directions in paragraph 2.5, annual winds from other directions all have percentage occurrence frequencies of less than 10%. As a result, annual winds from the E, ESE and ENE are considered as annual prevailing winds.

2.8 Wind data from June to August are able to reflect the wind environment during summer seasons and are used to identify the prevailing summer wind directions. According to the average monthly wind roses (averaged from 1990 to 2013) of the summer months at Wong Chuk Hang Automatic Weather Station in **Figure 2.3**, the winds from E and ESE have percentage frequency occurrences of more than 10% for all the three summer months. Furthermore, wind from WSW direction has obtained a percentage frequency occurrence of nearly 10% in June and with more than 10% of percentage frequency occurrence in July and August.

2.9 From the discussion in paragraph 2.7, winds from E, ESE and, WSW are considered to be prevailing summer prevailing wind directions.

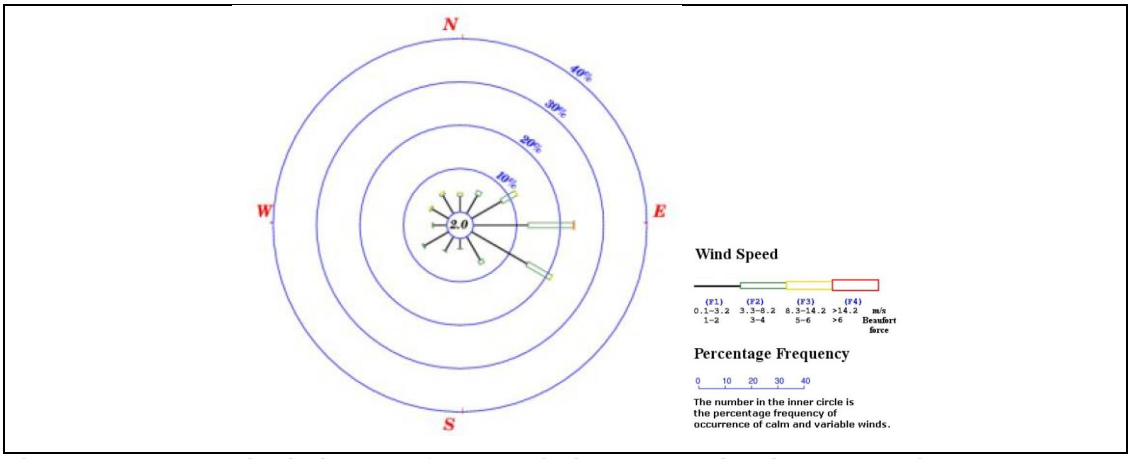


Figure 2.2 Annual Wind Rose of Wong Chuk Hang Station (1990 - 2013)

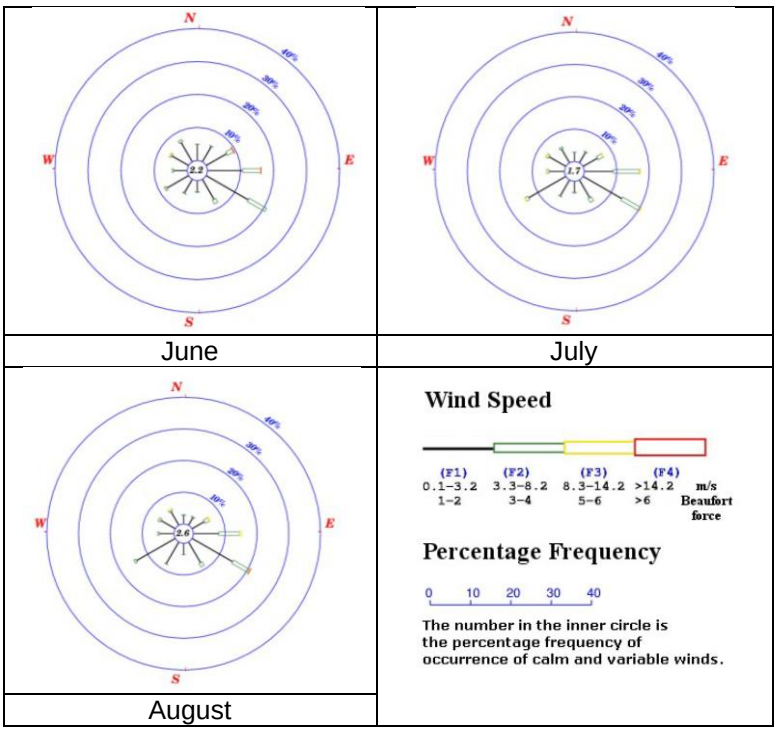


Figure 2.3 Wind Roses in summer months from Wong Chuk Hang Station (1990 - 2013)

2.10 According to the analysis in paragraphs 2.4 to 2.8 and based on the Wong Chuk Hang Weather Station wind roses, the winds from E, ENE and ESE are considered to be the prevailing annual winds, while the winds from E, ESE, and WSW are considered to be summer prevailing winds.

Wind Direction Analysis based on MM5 model

2.11 Apart from the wind data from the HKO automatic weather stations mentioned above, the researchers from Hong Kong University of Science and Technology (HKUST) have also simulated a set of wind data using MM5 model which is documented in the "Term Consultancy for AVA Services - Expert Evaluation on Air Ventilation Assessment of Aberdeen and Ap Lei Chau Area". Based on the dataset obtained from HKUST, the annual and summer wind roses (60m, 120m and 450m above ground) are presented in **Figure 2.4** below. These wind data are extracted at the vicinity of HK Electric Operational HQ which is approximately 435m northwest to the Development Site, and its location is marked in **Figure 2.5**.

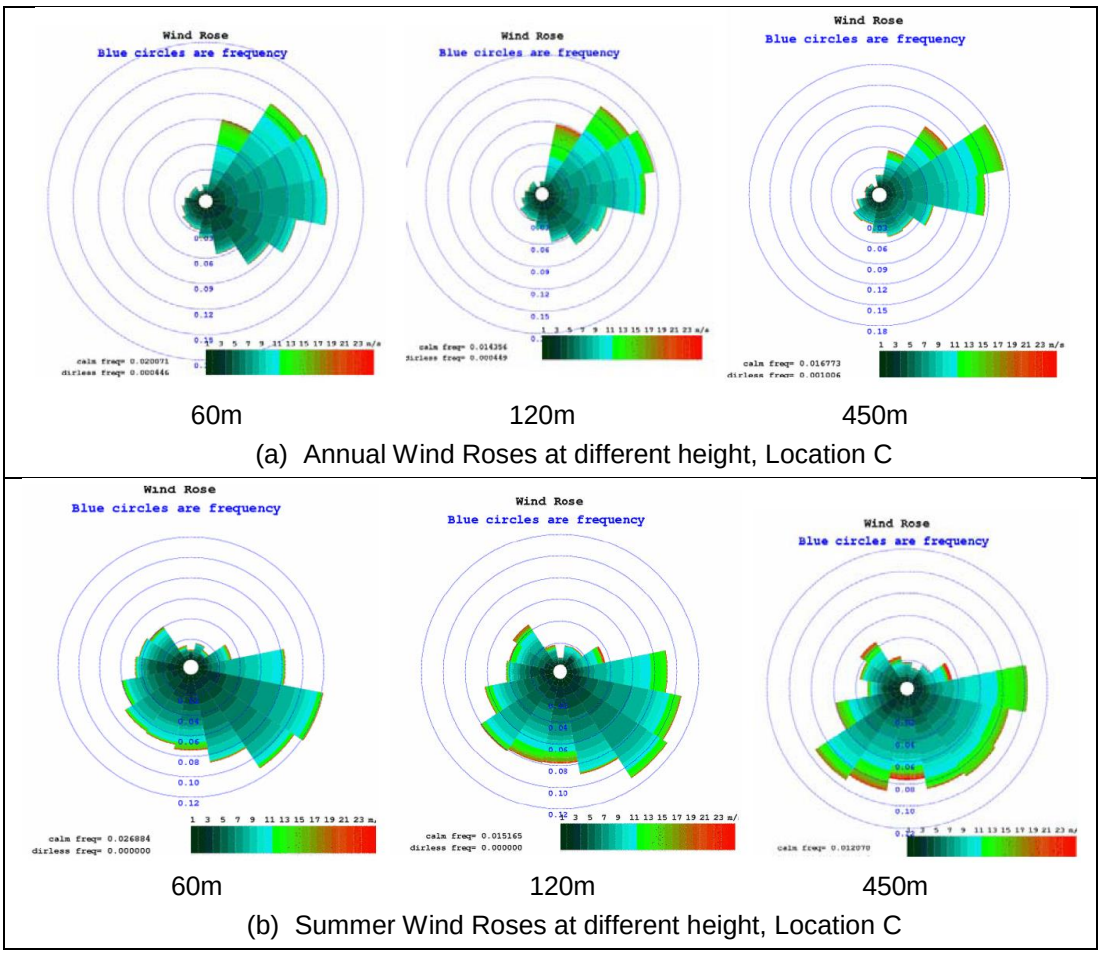


Figure 2.4 Annual and Summer Wind Roses at Location C (near HK Electric Operational HQ) obtained from MM5 model

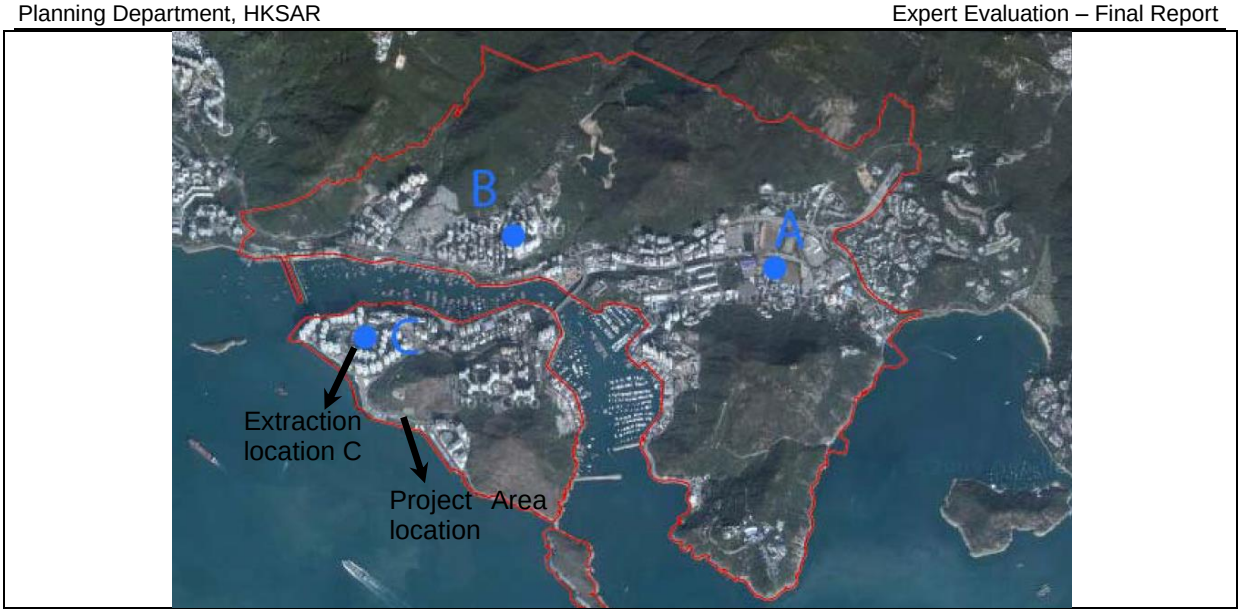


Figure 2.5 Illustration of the extraction location of MM5 wind data

2.12 Based on the MM5 wind data at 450mPD height, the annual wind towards the Study Area is mainly from **NE, ENE** and **E** directions. The north easterly quadrant winds have contributed around 40% of the annual wind towards the Study Area.

2.13 According to the summer wind roses obtained at the same location and height, the summer prevailing winds affecting the Ap Lei Chau area mainly comprised by south eastern quadrant winds (i.e. **E**, **ESE**, **SE**, and **SSE**) and south western quadrant winds (i.e. **SSW** and **SW**). Generally speaking, the south eastern quadrant summer winds obtained a slightly higher overall occurrence than the summer winds from south western quadrant.

Wind Direction Analysis based on Wind Tunnel Experiment

2.14 In the "Experimental Site Wind Availability Data for Wong Chuk Hang", wind characteristics in Wong Chuk Hang area which is near Ap Lei Chau have been analysed by wind tunnel experiments. Owing to the close proximity of the Wind Tunnel Study Area and the Project Area for this Expert Evaluation, the wind data of this experiment is also a valuable reference in determining wind availability of Ap Lei Chau. The wind tunnel experiment study area is marked in **Figure 2.6**.

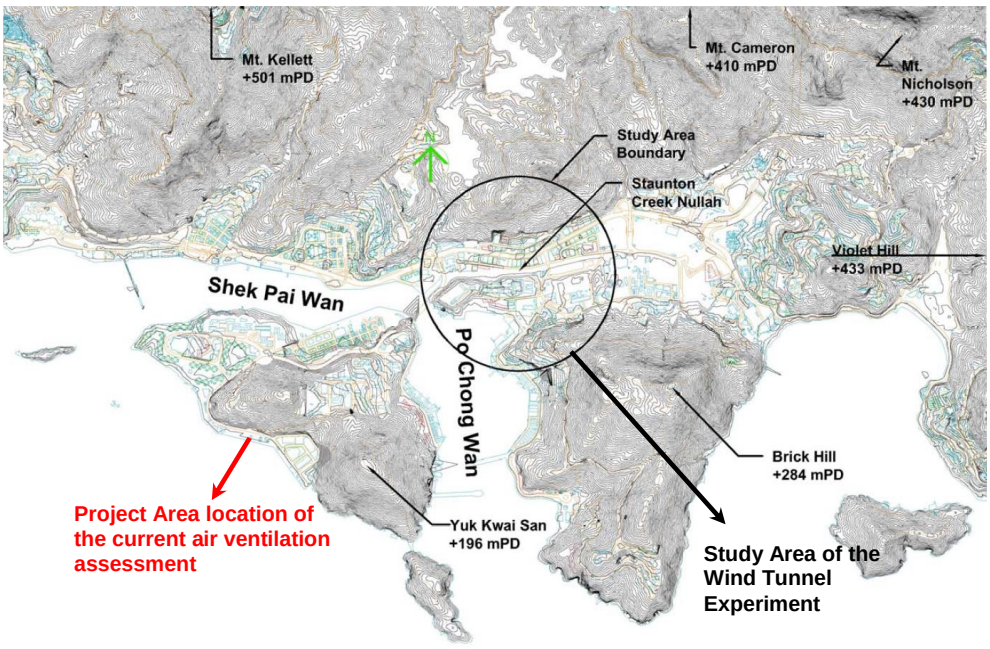


Figure 2.6 Location of the Wind Tunnel Experiment study area

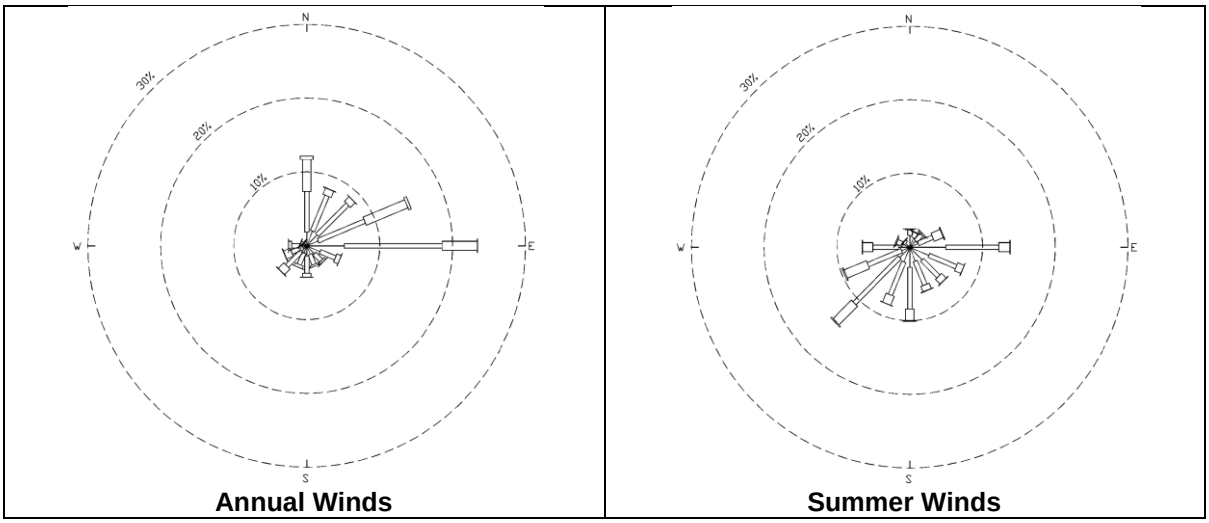


Figure 2.7 Annual and Summer Wind Roses extracted at 500mPD

2.15 By referring to the wind tunnel data, the region near Ap Lei Chau relies heavily on northeast quadrant winds (i.e. N, ENE and E), as these winds obtained a total occurrence of around 52% in a year. On the other hand, summer winds are mainly comprised by WSW, SW, S and E winds, which maintained overall occurrence of over 40% within summer seasons.

Summary and Identification of prevailing wind directions

2.16 By reviewing the wind data from HKO Wong Chuk Hang weather station, the MM5 model and Wind Tunnel Experiment study, it can be concluded that the annual prevailing winds mainly come from **N**, **NE, ENE, E** and **ESE** directions.

2.17 During the summer season, wind mainly comes from the south eastern quadrant (i.e. **E**, **ESE**, **SE, SSE**) and south westerly quadrant (i.e. **S**, **SSW**, **SW**, **WSW**).

2.18 **Table 2.1** summarized the annual and summer prevailing winds from difference sources, while **Figure 2.5** is an illustrational diagram showing the prevailing wind directions towards the Study Area and Project Area during the annual and summer season.

Table 2.1 Summary of annual and summer prevailing winds from different sources

	Annual	Summer
Wong Chuk Hang Weather Station	ENE, E, ESE	ESE, WSW, E
MM5 Model	E, NE, ENE	E, ESE, SE, SSE, SSW, SW
Wind Tunnel Experiment	E, ENE, N	E, WSW, SW, S

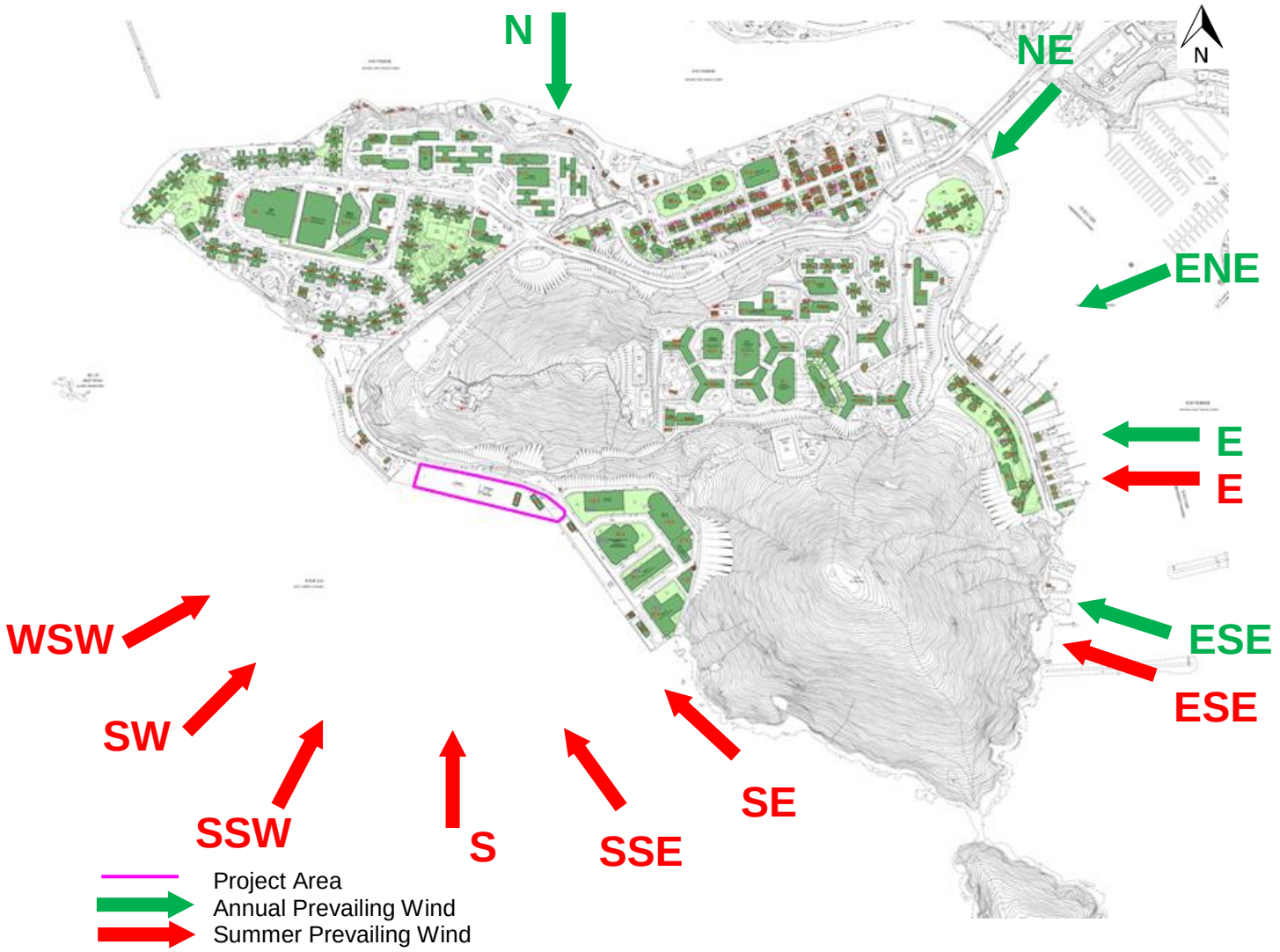


Figure 2.8 Summary of Prevailing Winds towards the Project Area

3 TOPOGRAPHICAL FEATURES AND WIND FLOW

3.1 The topographical features within the Study Area will affect the wind flows and the general wind environment of the Ap Lei Chau Island.

3.2 The flow of wind around and over hilly terrains is very complex and depends greatly on the shape of the topographies, atmospheric stability conditions and the strength of the prevailing wind etc. **Figure 3.1** below illustrates typical wind flow over hills under moderate wind speed conditions. As shown in the figure, wind either flows over the hill or bends around it and creates eddy flows with opposite direction to the upper wind flow in the lee side. **Appendix A** further explains this complex physical phenomenon.

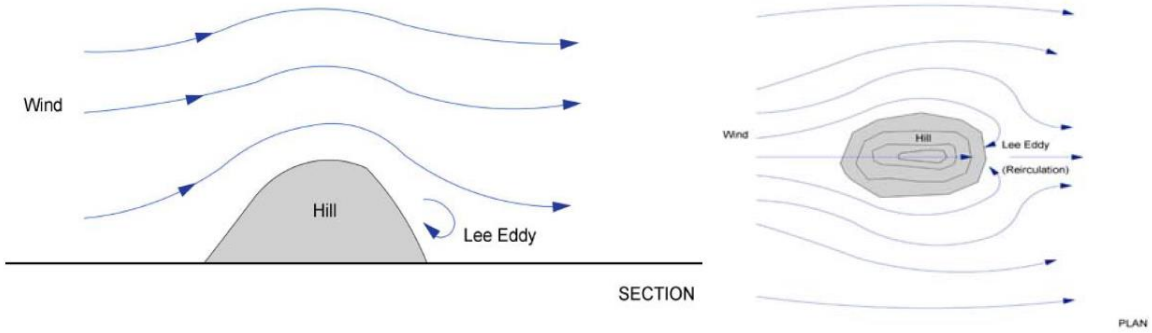


Figure 3.1 Illustration of Wind Flow over Hills under Moderate Wind

(Source: Cat. A1– Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment (PLNQ 35/2009), Revised Final Report, Chai Wan Area)

3.3 This section describes the major topographical features within Ap Lei Chau and their impacts on the wind environment of the Project Area during annual and summer seasons.

Major Topographical Features

3.4 Ap Lei Chau is an island of approximately 1.4km × 1.2km in size. It fronts the open sea to its south, southwest and west, with Aberdeen and Wong Chuk Hang areas located to its north and east respectively separated by the water channel namely Shek Pai Wan and Aberdeen Channel. The southern and central portions of the island are covered by hilly topographies of Yuk Kwai Shan, with two relatively high points (terrain height at around 190mPD and 142mPD) and a valley in between them (see **Figure 3.2**). The topography at the north western and north eastern areas of Ap Lei Chau island are relatively flat as the terrain height at these areas range from 20mPD to 25mPD.

Under the Annual Prevailing Winds

3.5 As mentioned in Section 2 above, the prevailing annual wind directions are from N, NE, ENE, E and ESE. A portion of annual winds from the E and ESE directions will be forced to flow over / around Yuk Kwai Shan (Right Peak) before reaching the Project Area, while part of the N wind will have to flow over / around the Yuk Kwai Shan (Left Peak) and reach the Project Area. However, a portion of NE and ENE wind will pass through the relatively lower ground where Lei Tung Estate is situated and then flow through the air path between the two peaks of Yuk Kwai Shan to reach the Project Area.

3.6 The Project Area is located to the western direction of Yuk Kwai Shan (Right Peak) with maximum height at 196mPD. This hilly terrain may weaken the air flows towards the Project Area from the E and ESE directions, meanwhile Yuk Kwai Shan (Left Peak) may weaken the N annual prevailing wind towards the Project Area. The presence of the valley located between the two high grounds (as mentioned in Paragraph 3.4) will redirect the local winds which speed up when passing through it under ENE and NE wind conditions. However, as partially

sheltered by Lei Tung Estate, the NE wind passing through the valley may be slightly reduced; hence the effectiveness of this wind corridor may be weakened.

Under the Summer Prevailing Winds

3.7 The prevailing summer wind directions are from the E, ESE, SE, SSE, S, SSW, SW and WSW. Similar to the discussion of annual winds above, the summer winds from E and ESE would be shielded by the highest land of Yuk Kwai Shan (Right Peak) before reaching the Project Area as this peak is around 190mPD in height. On the other hand, the SE and SSE winds are able to reach the Project Area from the open sea without terrain blockage.

3.8 Due to the geographical location of the Project Area facing the open sea, the S, SSW, SW and WSW winds are able to flow to the Project Area from the open sea directly, and would not experience any blockage by the hilly terrains before reaching the Project Area.

3.9 Since the Project Area is located on the coast of south western Ap Lei Chau Island, sea breeze is expected to occur in summer season, which may further facilitate pedestrian wind environment.

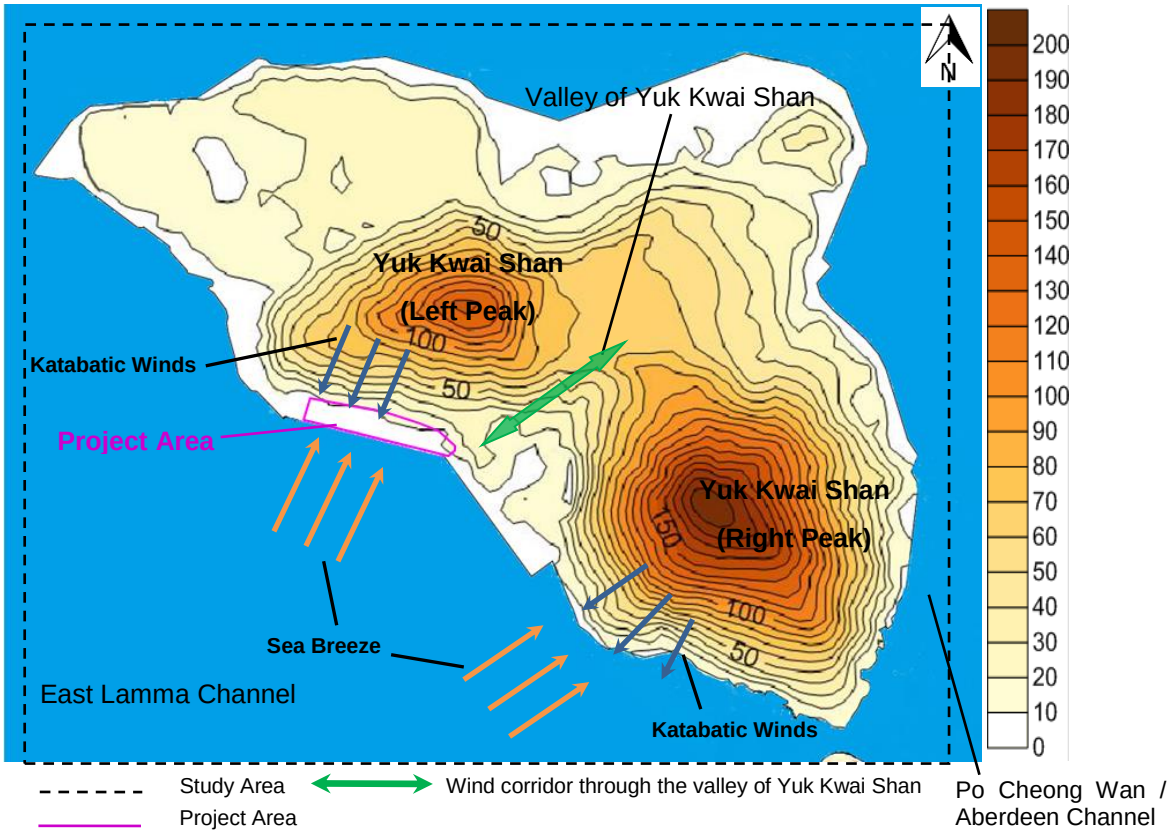


Figure 3.2 Digital Elevation Map of the Study Area

4 EXISTING LAND USE AND BUILDING MORPHOLOGY WITHIN STUDY AREA

4.1 Following the investigation of the effect of topographical features on the wind environment of the Project Area in Section 3 above, this section investigates the potential impact of the building morphology of Ap Lei Chau on the air ventilation performance of the Project Area.

Land Use

4.2 The land use on Ap Lei Chau Island is guided by the Aberdeen and Ap Lei Chau Outline Zoning Plan (OZP) No. S/H15/29. The land use types are shown in **Figure 4.1** below:

- The areas highlighted in light blue are zoned “Government, Institution or Community”.

- The areas in orange are zoned "Other Specified Uses". The area to the immediate southeast of the Project Area will be rezoned to "Open Space".
- The areas in reddish brown and medium brown are designated as Residential Type land uses.
- The area in grass green, light green and green are zoned as "Green Belt", Costal Protection Area" and "Open Space", respectively.
- The areas in pink are zoned as "Commercial", while the regions in purple are "Industrial" land uses, there are two major "Industrial" land uses areas, the first one is occupied by shipyards, the other one is the "Ap Lei Chau West Industrial Area" which will be rezoned to "OU(B)" with the same height restriction.
- The Project Area falls within areas zoned "Government, Institution or Community", "Other Specified Uses" annotated 'Cargo Handling Area" and "Industrial".

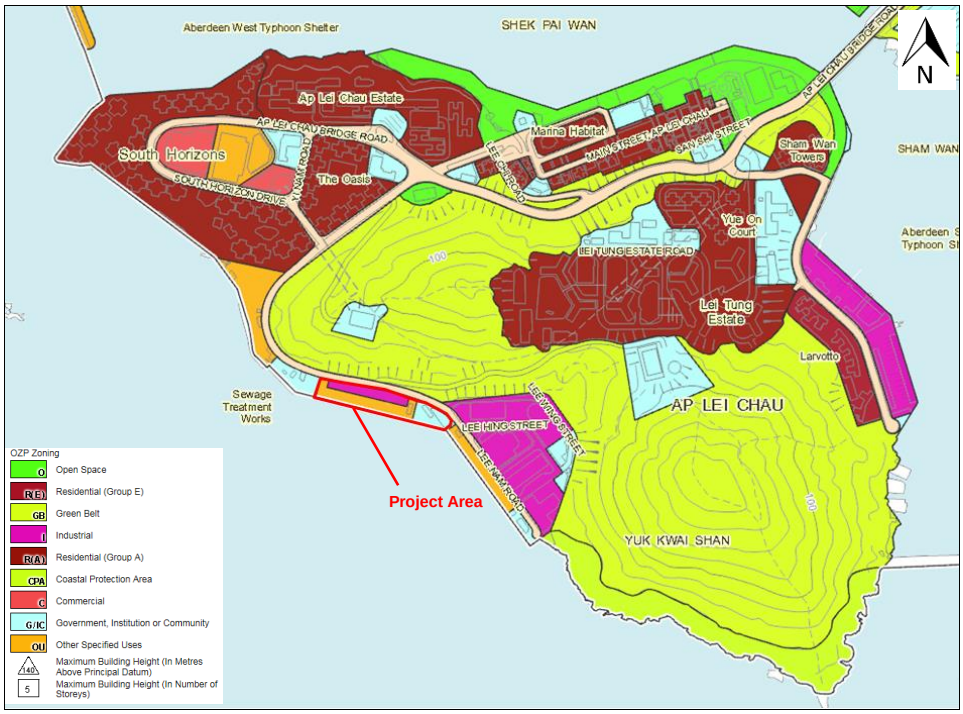


Figure 4.1 Land Uses of Ap Lei Chau Island

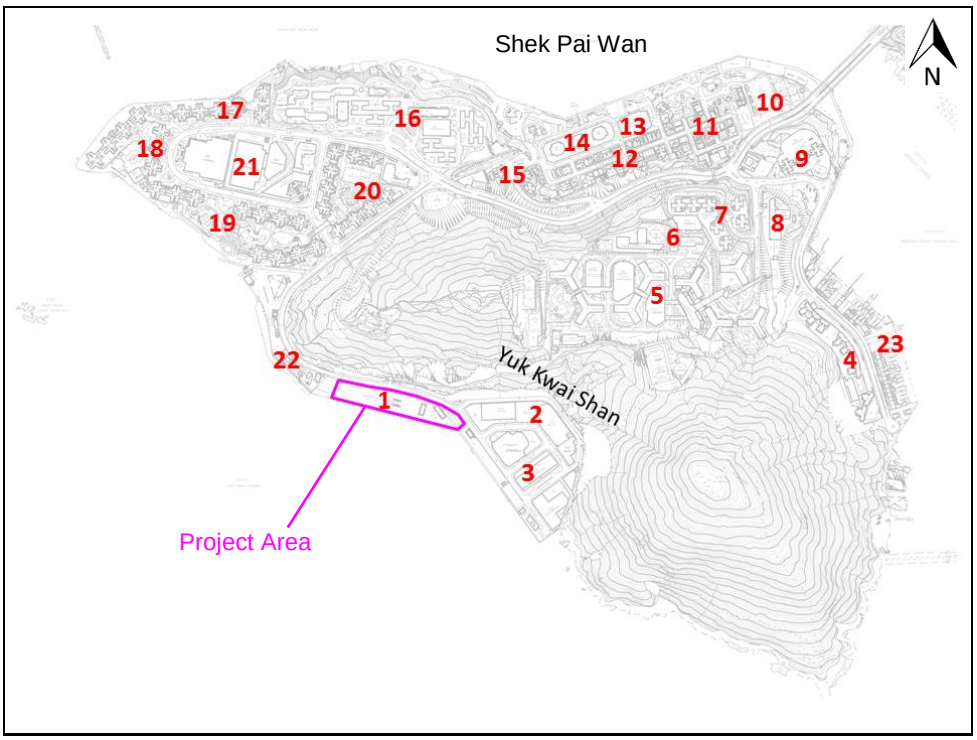
4.3 Proposed residential buildings (with height restriction of 110mPD) are proposed within the Project Area. The parameters of the proposed developments at the Project Area are listed in **Table 4.1** below.

Table 4.1 Proposed Parameters of the Developments in the Project Area

Site area	Approximately 1.18 hectares
Proposed Plot Ratio	About 6
Building Height Restriction	110mPD

Existing Building Morphology within the Study Area

4.4 **Figure 4.2** below shows the major existing developments at the surroundings of the Project Area within the Study Area. The heights (in mPD) of the developments are also listed.



1. Project Area (proposed 110mPD), currently Hong Kong School of Motoring (~9.6mPD)	2. Horizon Plaza (110.5mPD), Electric Tower (118.3mPD) Ap Lei Chau Industrial Estate Station Building (27.6mPD)
3. Dah Chong Hong (Motor Service Centre) Ltd. Ap Lei Chau Service Centre (68.4mPD), Harbour Industrial centre (98.4mPD) Oceanic Industrial Centre (95.3mPD)	4. Larvotto (136.2mPD in maximum height)
5. Lei Tung Estate (163.3mPD in maximum height)	6. Aberdeen Baptist Lui Ming Choi College (87.6mPD) St. Peter's Catholic Primary School (78.2mPD)
7. Yue On Court (139.5mPD)	8. HK True Light College (51.5mPD)
9. Sham Wan Towers (167.1mPD)	10. Ap Lei Chau Park (8.8mPD)
11. Multiple residential buildings near Ping Lan Street (80.6mPD in maximum height)	12. Multiple residential buildings along Main Street Ap Lei Chau (75.5mPD in maximum height)
13. Ap Lei Chau Municipal Services Building (39.5mPD)	14. Marina Habitat (141.9mPD)
15. Ap Lei Chau Centre (86.3mPD), Kam Fat Building (93.2mPD) and Ap Lei Chau Fire Station (40mPD)	16. Ap Lei Chau Estate (93.4mPD in maximum height)
17. South Horizons Phase I (131mPD)	18. South Horizons Phase II (133mPD)
19. South Horizons Phase III (129mPD)	20. The Oasis (121.8mPD)
21. Marina Square (37.7mPD), HK Electric Co Ltd.(20mPD), Car park Building (51.2mPD), and Precious Blood Primary School (South Horizons) (44.2mPD)	22. New Shell Depot
23. Shipyard	

Figure 4.2 Existing Developments within Ap Lei Chau Island

4.5 The northern portion of Ap Lei Chau Island is mainly occupied by mid to high rise residential developments while the southern portion is mainly occupied by hilly terrains of Yuk Kwai Shan as shown in **Figure 4.1**. The major existing residential developments are divided into three groups as marked as number 1 to 3 as shown in **Figure 4.3**, while there are also two areas which major consist of industrial developments within Ap Lei Chau Island marked as 4 and 5. The purpose for division of groups as in **Figure 4.3** is for ease of discussion in the following paragraphs.

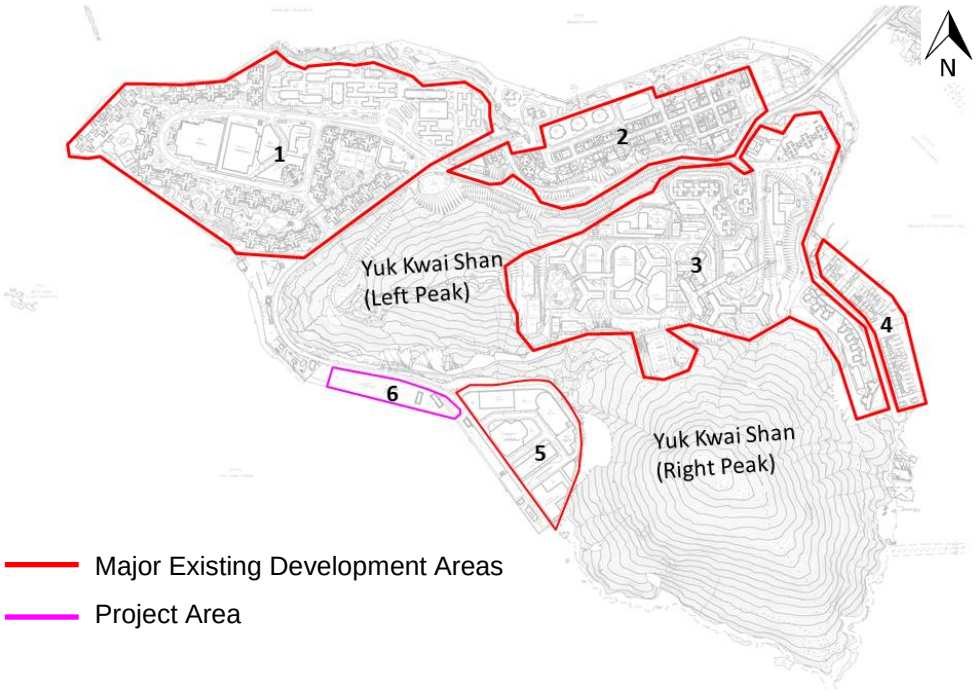


Figure 4.3 Major Groups of Existing Developments

4.6 Region 1 is located in the north western portion of Ap Lei Chau Island. Within Region 1 are high rise residential developments of Ap Lei Chau Estate, South Horizons and The Oasis with maximum height of approximately 133mPD. Centre of Region 1 are some low to medium-rise commercial and G/IC developments (Marina Square, HK Electric Co Ltd, Car Park Building, Precious Blood Primary School) with maximum height of approximately 51mPD.

4.7 The residential developments nearest to the boundary of the Project Area within Region 1 are the residential developments of South Horizons Phase III and The Oasis marked as number 19 and 20 in **Figure 4.2**. These developments are located at a distance of approximately 280m from the boundary of the Project Area.

4.8 Region 2 is located in the northern portion of Ap Lei Chau Island. It mainly consists of medium to high rise residential developments. The highest residential developments within this region are Marina Habitat, which is approximately 142mPD in height.

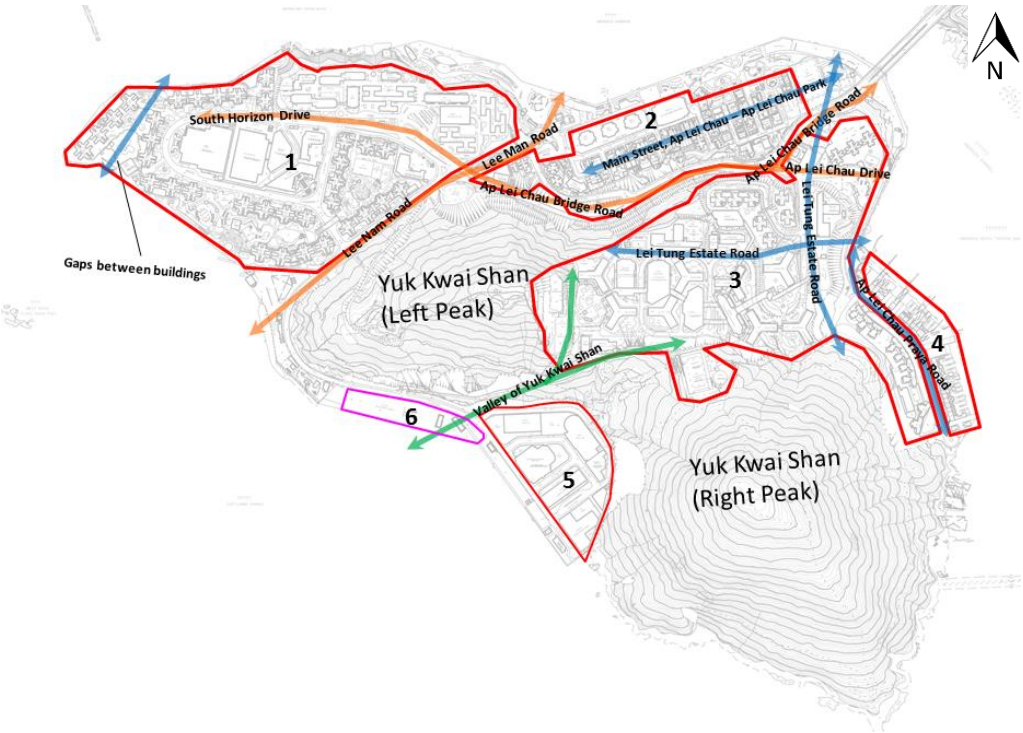
4.9 Region 3 is located in the north eastern to eastern portion of Ap Lei Chau Island. The tallest buildings in the area are the residential clusters of Sham Wan Tower. Meanwhile, the existing residential development within this region nearest to the Project Area is Lei Tung Estate (~160mPD in height). Other major developments within Region 3 include the Larvotto which is approximately 136mPD in height and Yue On Court which is approximately 140mPD in height. There are also some medium-rise institutional developments within Region 3 including the Aberdeen Baptist Lui Ming Choi College (87.6mPD), St. Peter's Catholic Primary School and the HK True Light College.

4.10 Region 4 is located on the eastern shore of Ap Lei Chau Island. This region contains mainly low-rise ship maintenance industrial developments and various ship docks for ship parking.

4.11 Region 5 is located to the immediate east of the Project Area. Within this region are high-rise industrial developments (with most developments are more than 90mPD in height) including the Horizon Plaza, Electric Tower, Dah Chong Hong (Motor Service Centre) Ltd., Ap Lei Chau Service Centre, Harbour Industrial Centre and the Oceanic Industrial Centre.

Air Paths within Ap Lei Chau

4.12 By understanding the prevailing winds direction, the local topography and building morphology, the air paths within Ap Lei Chau are identified and illustrated in **Figure 4.4** below:



Air paths of the whole Study Area

Air paths within Region 1 to Region 4

Air paths within / near Region 5 and Project Area

Figure 4.4 Illustration of air paths within Ap Lei Chau area

Air Paths within the Whole Study area

4.13 There are two major air paths facilitating air ventilation on Ap Lei Chau Island. They basically follow two road alignments. The first one is Lee Man Road - Lee Nam Road aligning in NE-SW direction, located between Region 1 and Region 2 / Yuk Kwai Shan Left Peak hill slope. The second one is South Horizon Drive – Ap Lei Chau Bridge Road – Ap Lei Chau Drive / Ap Lei Chau Bridge Road, which aligns in approximately East – West direction located at the northern portion of the island. These wind corridors would allow better wind penetration at the northern and western part of the Study Area under the annual NE, E winds and the summer SW wind.

Air paths within Region 1

4.14 The section of Lee Nam Road near The Oasis and Ap Lei Chau Estate in the NE-SW alignment serves as a potential air path in Region 1 under the NE / ENE winds. Meanwhile, the gap between buildings of South Horizons Phase II is considered air path which facilitates NE and NNE annual winds. The air paths under the E / ESE winds are Ap Lei Chau Bridge Road between The Oasis and Ap Lei Chau Estate as well as South Horizon Drive. These air paths are essential to the wind environments within Region 1.

4.15 Under the ESE summer wind, the air paths within Region 1 are the same as those mentioned in Paragraph 4.14, while under S / SSW and SW summer winds, the air paths within Region 1 are the gaps between building clusters in South Horizons Phases II, and Lee Nam Road respectively.

Air paths within Region 2

4.16 Under the annual ENE wind, the air path within Region 2 is Main Street Ap Lei Chau, while Ap Lei Chau Bridge Road (near Yu On Court, Sham Wan Towers and Ap Lei Chau Park) serves as an air path under both ENE and E winds.

Air paths within Region 3

4.17 The air paths identified within Region 3 under the E wind are the section of Lei Tung Estate Road between Lei Tung Estate and the two schools (Aberdeen Baptist Lui Ming Choi College and St. Peter's Catholic Primary School), as well as Ap Lei Chau Drive between HK True Light College and Sham Wan Tower. Under N wind, the section of Lei Tung Estate Road to the immediate east of Lei Tung Estate and Yu On Court serves as an air path.

Air paths within Region 4

4.18 The SSE-NNW and SE-NW aligned Ap Lei Chau Praya Road would serve as a major air path within Region 4 under SSE and SE summer winds.

Air paths within / near Region 5

4.19 Under the annual NE / ENE winds, the valley of Yuk Kwai Shan would serve as air path near Region 5, as mentioned in Paragraph 3.5, and facilitates air flows there. It is also noticed that the valley of Yuk Kwai Shan serves as an air path in the vicinity of Region 5 under the WSW and SW summer winds. However, the valley is located at the downwind side of or is parallel to Region 5 under summer winds, it is not expected that the valley would enhance the wind environment within Region 5 during summer.

Impact of Existing Developments on the Wind Environment within Project Area

Under the Annual Prevailing Winds

It is understood that a building of height H is generally possible to induce a wind wake of approximately H from the building. Inside the wake region, there exists weaker and more turbulent wind which is collectively referred to as a "wind shadow region" behind the building.

Impact of developments within Regions 1, 2 and 4

4.20 It is noticed that the developments within Regions 1, 2, and 4 are more than 250m away from the Project Area boundary and have building height of less than 160mPD, while the hilly terrain of Yuk Kwai Shan lies in between these existing developments and the Project Area. It is expected that the developments in Regions 1, 2, and 4 would not cause significant influence in wind environment within the Project Area under any annual prevailing winds.

Impact of developments within Region 3

4.21 Under the NE and ENE wind directions, the residential clusters of Lei Tung Estate within Region 3 are located at the upwind side of Project Area. The nearest existing developments to the Project Area are the residential developments of Lei Tung Estates which are approximately 160mPD in height. It is noticed that these bulky buildings of Lei Tung Estate

may partially block the NE prevailing winds towards the valley of Yuk Kwai Shan and weaken the valley wind. However, the ENE wind and NNE wind can still flow around the Lee Tung Estate and enter the valley. It is also observed that there are other high-rise developments located to the north/north eastern directions of Lei Tung Estate (i.e. Yue On Court, Larvotto, Sham Wan Tower, Marina Estate, etc.). Given the fact that these developments are further away from the valley, the weakening effect from these developments on the airflows towards Lei Tung Estate and the valley is considered insignificant.

4.22 Under the E annual wind, the downwind location of Region 3 developments is the hill of Yuk Kwai Shan, while under the annual prevailing ESE and N wind directions, the downwind area of Region 3 is the existing developments of Region 2 and Region 5 respectively. The Project Area is not likely to be affected by development in Region 3 under these annual prevailing wind directions.

Impact of developments within Region 5

4.23 Under the annual N and NE direction, the downwind side of Region 5 is the open sea. The Project Area is located to the west of Region 5. It is not expected that the wind environment within the Project Area will be affected by the developments in Region 5 under these annual prevailing winds.

4.24 Under the annual prevailing winds from ENE, E and ESE directions, it is observed that wind will be sheltered and weakened by Yuk Kwai Shan before reaching the Project Area. Also, the Project Area is located at the downwind side of Region 5 under these annual prevailing winds. Provided that the tallest building heights in Region 5 is around 120mPD which may induce wind influence zone of around 120m to the downwind side, the wind influence region induced by Region 5 buildings is expected to cover the eastern portion of the Project Area and reduce the air ventilation performance in the region.

Under the Summer Prevailing Winds

Impact of developments within Region 1, 2, and 4

4.25 Similar to the discussion in Paragraph 4.22 above, the existing developments would not inflict significant air ventilation impact upon the Project Area, owing to the far distances and the hilly terrain in-between the Regions and Project Area.

Impact of developments within Region 3

4.26 Under the E, ESE, SE and SSE summer prevailing winds, the Region 3 developments will not cause negative impacts on the wind environment at the Project Area, as Region 3 is located at downwind side of or is parallel to the Project Area under these wind directions. While under the S / SSW winds and SW / WSW winds, the downwind side of Region 3 is Region 2 and Region 4 areas respectively. Thus, the wind environment in Project Area will not be affected by these developments.

Impact of developments within Region 5

4.27 Under the E, ESE summer winds, similar to the discussion in Paragraph 4.26, the wind environment within Project Area will be affected by the existing developments in Region 5. Meanwhile, under the SE, SSE, S, SSW, SW and WSW winds, the Project Area is located to the west of Region 5 developments, and no impacts on the wind environment at Project Area is expected.

5 EXPERT EVALUATION ON THE PROJECT AREA

5.1 Following the investigation of the potential impact of the existing developments on the Project Area in terms of air ventilation performance in Section 4, this section presents the influence of the proposed developments within the Project Area on the existing developments.

Planning Parameters of the Project Area

5.2 The Project Area is situated at the seafront southwest to the Yuk Kwai Shan. The Ap Lei Chau Industrial Estate which comprised of multiple medium to high-rise industrial developments with building heights ranging from approximately 27mPD to 118mPD is situated at the immediate east of the Project Area.

5.3 The Project Area is proposed to be developed into high-rise residential buildings with a height restriction of around 110mPD and a plot ratio of 6.

The prevailing winds in the vicinity of Project Area

5.4 As mentioned in Section 2, the annual prevailing wind comes from N, NE, ENE, E and ESE winds while the summer prevailing winds comes from the E, ESE, SE, SSE, S, SSW and WSW directions.

Impact of existing developments on the wind environment in Project Area

5.5 The major existing developments within the Study Area have been discussed in Section 4. The industrial buildings of Ap Lei Chau Industrial Estate to the immediate east of the Project Area which may weaken the incoming E, ENE and ESE wind, and Lei Tung Estate in Region 3 that may partially block the NE prevailing winds from entering the valley. All other major existing developments situated within Regions 1, 2 and 4 including South Horizons Phase III and Oasis, etc., are not likely to affect the wind environment at the Project Area.

Under the Annual Prevailing Winds

5.6 Under the annual prevailing winds (i.e. N, NE, ENE, E and ESE), the proposed buildings within the Project Area are expected to induce wind wakes that are likely to reach 110m to the corresponding downwind area.

5.7 Under all the identified annual prevailing wind directions (i.e. N, NE, ENE, E and ESE), the downwind region of the Project Area is the open sea. There will be no air ventilation issue.

5.8 All of the existing developments within Region 1 to Region 4 are located far away (over 240m) from the boundary of Project Area. Considering such far distances and that the Project Area is located at the foot of Yuk Kwai Shan, as well as that these developments are on the upwind of the Project Area under all annual prevailing winds, it is not expected that the wind influence region induced by the proposed developments will give rise to negative air ventilation impacts to these existing developments under all annual prevailing winds.

5.9 The industrial buildings within Ap Lei Chau Industrial Estate in Region 5 are the only high-rise industrial developments situated in the immediate vicinity of the Project Area. Since these industrial buildings are all located on the upwind or on the side of the Project Area under the annual prevailing winds, the wind environment within the Ap Lei Chau Industrial Estate Area will not be affected by the proposed developments.

Under the Summer Prevailing Winds

5.10 Under the E and ESE summer prevailing winds, the air ventilation impacts induced by the proposed developments within Project Area are similar to E and ESE annual winds and can be referred to the above discussions in Paragraph 5.6 and 5.7.

5.11 Under the SE, SSE and S summer prevailing wind, the proposed developments in the Project Area would shelter the incoming winds towards Lee Nam Road to the immediate north of the Project Area. On the other hand, owing to the local terrain feature (Yuk Kwai Shan) and the relatively far distance between the Project Area and the nearby existing development (i.e. South Horizon Phase III), the proposed developments within the Project Area will not cause significant air ventilation impacts to existing developments further inland.

5.12 Under the SSW, SW and WSW summer wind directions, wind environment at Lee Nam Road (aligning in ESE-WNW direction near Region 5) is likely to be affected after the construction of the proposed developments at Project Area, yet the portion of Lee Nam Road aligning in SW-NE direction allows penetration of the sea wind to the inland areas. The wind wakes induced from the proposed developments are not likely to reach Lei Tung Estate, which is around 260m from the boundary of Project Area. However, the proposed developments within the Project Area may create wind shelter against the valley of Yuk Kwai Shan, thus partially reducing wind penetration to the inland areas through this air path (the valley) under SSW, SW and WSW summer winds.

5.13 Under the WSW wind, the eastern-most section of the proposed developments in the Project Area would possibly be located at the immediate upwind side of Ap Lei Chau Industrial Estate (the west portion of Horizon Plaza) and may cause slight influence to the wind environment in this small portion of industrial area. However, due to the small frontage length of the Project Area facing the industrial area, the blockages induced by the proposed buildings under this specific wind are not expected to be significant and the incoming winds are still able to reach Ap Lei Chau Industrial Area via the open sea and Lee Nam Road. Hence, the impacts on wind environment by the proposed developments within the Project Area at Ap Lei Chau Industrial Estate are expected to be minimal.

6 SUMMARY OF THE OBSERVATIONS AND RECOMMENDATIONS PROPOSED FOR THE PROJECT AREA

6.1 Based on the above paragraphs 5.5 to 5.12, it can be concluded that due to the geographical location of the Project Area, the development of the proposed buildings within the Project Area may not cause significant air ventilation impact to most of the areas frequently accessed by pedestrian, under all annual and summer prevailing winds. Nevertheless, to enhance the penetration of SW, S and SE winds through the Project Area at the pedestrian level at portion of Lee Nam Road to the north of the proposed development, the following building design of the proposed residential development at the Project Area are recommended.

Major design principles recommended for the future development in Project Area

6.2 As there is no development layout at current stage, it is thus recommended that future development should avoid long building frontage along the seafront with adequate separation distances between building blocks in minimizing the wind impact against Lee Nam Road under SE, SSE, S, SSW and SW winds (such design merit features can be referred to building clusters at South Horizons located to the northwest of Project Area). The building separation would also facilitate penetration of the prevailing wind through Project Area, enter the valley and reach the downstream areas. **Figure 6.1** demonstrates the principle of such arrangement. The provision of building permeability could be referenced to the Buildings Department's Sustainable Building Design Guidelines APP-152.

6.3 In addition to the measures mentioned in Paragraph 6.2, the design with reduced site coverage and a minimized podium / podium free design, as well as gaps between the podiums and the building towers above are also recommended for the proposed buildings within Project Area. In general, these design features would generally further enhance wind permeability through the Project Area at pedestrian level, alleviating the influence in air ventilation, if any, caused by the high-rise buildings. These design features are illustrated in **Figure 6.2** below.

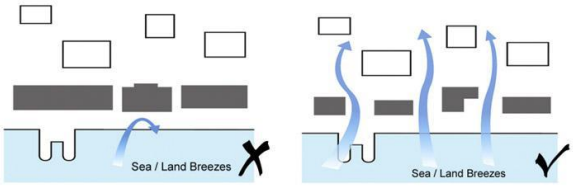
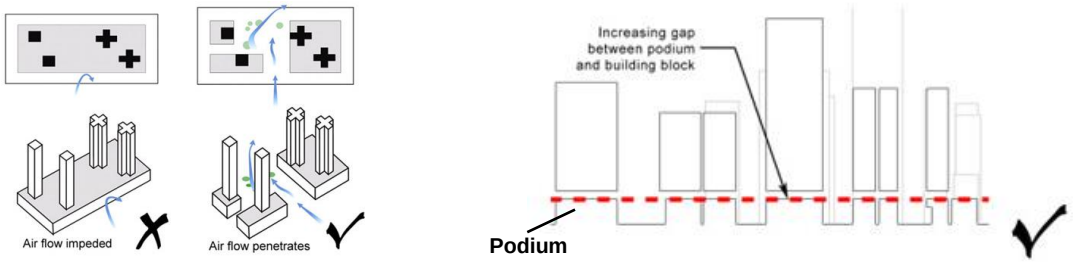


Figure 6.1 Guideline on water front building design and arrangement



(a) Reduced site coverage podium design (b) increase gap between podium and building block

Figure 6.2 Merit design features of podium

7 SUMMARY AND CONCLUSION

7.1 The Project Area of this study is situated on the south-western portion of Ap Lei Chau Island facing the open sea. There are hilly terrains to the north and east of the Project Area with maximum height of 142mPD and 190mPD respectively, namely Yuk Kwai Shan, with a valley between the high grounds.

7.2 There are several regions with high-rise high-density residential developments on Ap Lei Chau Island but such urban areas are far away from the Project Area. The only existing developments that may affect the wind environment of the Project Area are those within the Ap Lei Chau Industrial Estate, located to the immediate east of the Project Area, as well as Lei Tung Estate, which would create partial blockage against the air path of the valley.

7.3 Based on the wind data from the HKO, the MM5 Model and the wind tunnel experiment, the annual prevailing winds of Ap Lei Chau are from the N, NE, ENE, E and ESE, whereas the summer prevailing winds are winds from E, ESE, SE, SSE, S, WSW, SW and SSW directions.

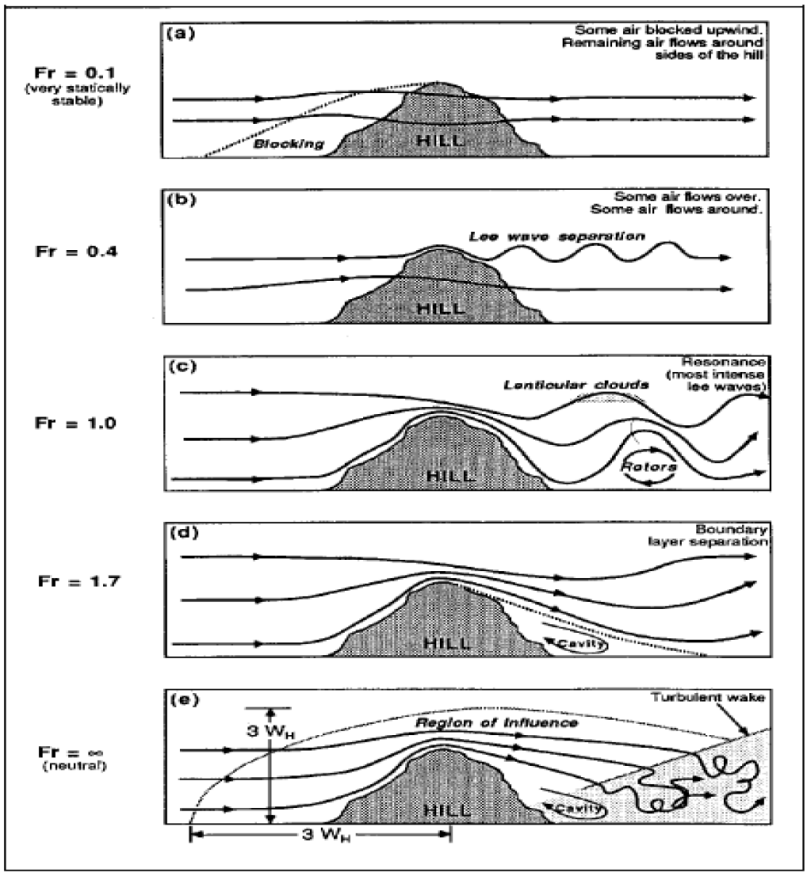
7.4 Under the annual and summer prevailing wind directions, the valley between the high grounds of Yuk Kwai Shan acts as an effective air path to maintain the wind environment within the nearby area.

7.5 The location of the Project Area is far from most existing developments and is sheltered by one of the high grounds of Yuk Kwai Shan. In addition, it fronts the open sea and benefits from the sea wind. Therefore, despite the high-rise nature of the proposed buildings in the Project Area at 110mPD, these proposed buildings are not likely to give rise to air ventilation issues to the most of existing developments located in the far inland under most of the annual and summer winds.

7.6 With regard to the possible blockage of wind against the valley of Yuk Kwai Shan and the possible influences against Ap Lei Chau Industrial Area and Lee Nam Road, improvement measures, including proper arrangement of buildings to avoid blockage of winds against the valley, reduced site coverage and minimization of podium / podium free design, are recommendation.

7.7 By taking into account the geographical location of the Project Area, topographical features and existing building morphologies within Ap Lei Chau Island, together with the analysis in this report, the proposed developments of 110mPD height residential developments are unlikely to impose significant air ventilation impacts within the Project Area and its surroundings after the incorporation of the proposed improvement measures. Further Air Ventilation Assessment is not recommended.

Appendix A: Wind over a small hill.



For a strongly stable environments, i.e. where the buoyancy affects are strong, and Fr ≈ 1, the air flows around the hill ((a)) and a stagnant mass of air builds up before the hill. **At a slightly faster wind** (Fr ≈ 0.4) some of the air flows over the hill ((b)) while the air at lower altitudes separate to flow around the hill. The natural wavelength of the air that flows over the top is much smaller than the hill size and the flow is perturbed by the hill to form lee waves. A lee wave separation occurs from the top and flows above the air that flows around the hill. A column of air with the same height as the hill approaches the hill and a fraction of it flows above the hill. **At higher wind speeds** and Fr ≈ 1.0, the stability is weaker and the wavelength of the gravity waves (lee waves) approaches the size of the hill ((c)). A natural resonance forms the large amplitude lee waves or mountain waves. If there is sufficient moisture, lenticular clouds can form along the crests of the waves downstream of the hill. **For stronger winds** with Fr ≈ 1.7 ((d)) the natural wavelength is longer than the hill dimensions, thus causing a boundary layer separation at the lee of the hill. **Neutral stratification** ((e)) occurs for strong winds with neutral stability (no convection) and Froude number approaching infinity. The streamlines are disturbed upwind and above the hill out to a distance of about 3 times the hill length WH. Near the top of the hill the streamlines are packed closer together, causing a speed-up of the wind. Immediately downwind of the hill is often a cavity associated with boundary layer separation. This is the start of a turbulent wake behind the hill. The height of the turbulent wake is initially the same order as the size of the hill and grows in size and diminishes in turbulent intensity downwind. Eventually the turbulence decays and the wind flow returns to its undisturbed state.

Froude number (Fr)

$$F_r^2 = \frac{\text{Inertial forces}}{\text{Bouyant forces}} \qquad F_r^2 = \frac{\bar{u}_0^2/W_h}{g\Delta\theta/\theta_0}$$

The inertial forces (order $\bar{u}_0^2/W_h$) act in the horizontal direction along the wind flow, and the buoyant forces (order $g\frac{\Delta\theta}{\theta_0}$ where $\Delta\theta$ is a typical temperature disturbance, g is gravitational acceleration, θ_0 is potential temperature) act in the vertical. The Froude number can be more elaborately defined as

[courtesy Sykes, R.I., 1980, "An asymptotic theory of incompressible turbulent boundary-layer flow over a small hump", J. Fluid Mech.101: 647-670.]