Planning Department

Agreement No. PLNQ 56/2012

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

An Instructed Project at Stanley

Expert Evaluation – Final Report

November 2014

	Name	Signature
Prepared & Checked:	Karl An / Simon Wong	
Reviewed & Approved:	Anna Chung	

Version: Final Date: 25th November 2014

Disclaimer

AECOM Asia Co. Ltd.
11/F, Grand Central Plaza, Tower 2, 138 Shatin Rural Committee Road, Shatin, NT, Hong Kong
Tel: (852) 3105 8686 Fax: (852) 2317 7609 www.aecom.com

Table of Contents

Page

List of Figures

List of Tables

List of Appendix

1 INTRODUCTION

Background

1.1 The Hong Kong Special Administrative Region (HKSAR) Government Planning Department (PlanD) has identified two sites at Stanley with rezoning potential for low-rise, low-density residential development and considered that it is necessary to conduct an expert evaluation to assess qualitatively the potential air ventilation impacts of the proposed development proposal which includes the imposition of appropriate development restrictions to guide future development or redevelopment of the area.

1.2 In January 2014, AECOM Asia Company Ltd. (the Consultant) was commissioned by the Hong Kong Planning Department (PlanD) to undertake an Expert Evaluation Study for the two Project Areas on Stanley Peninsula as shown in **Figure 1.1** below to examine the air ventilation performance of the potential development within the Study Area.

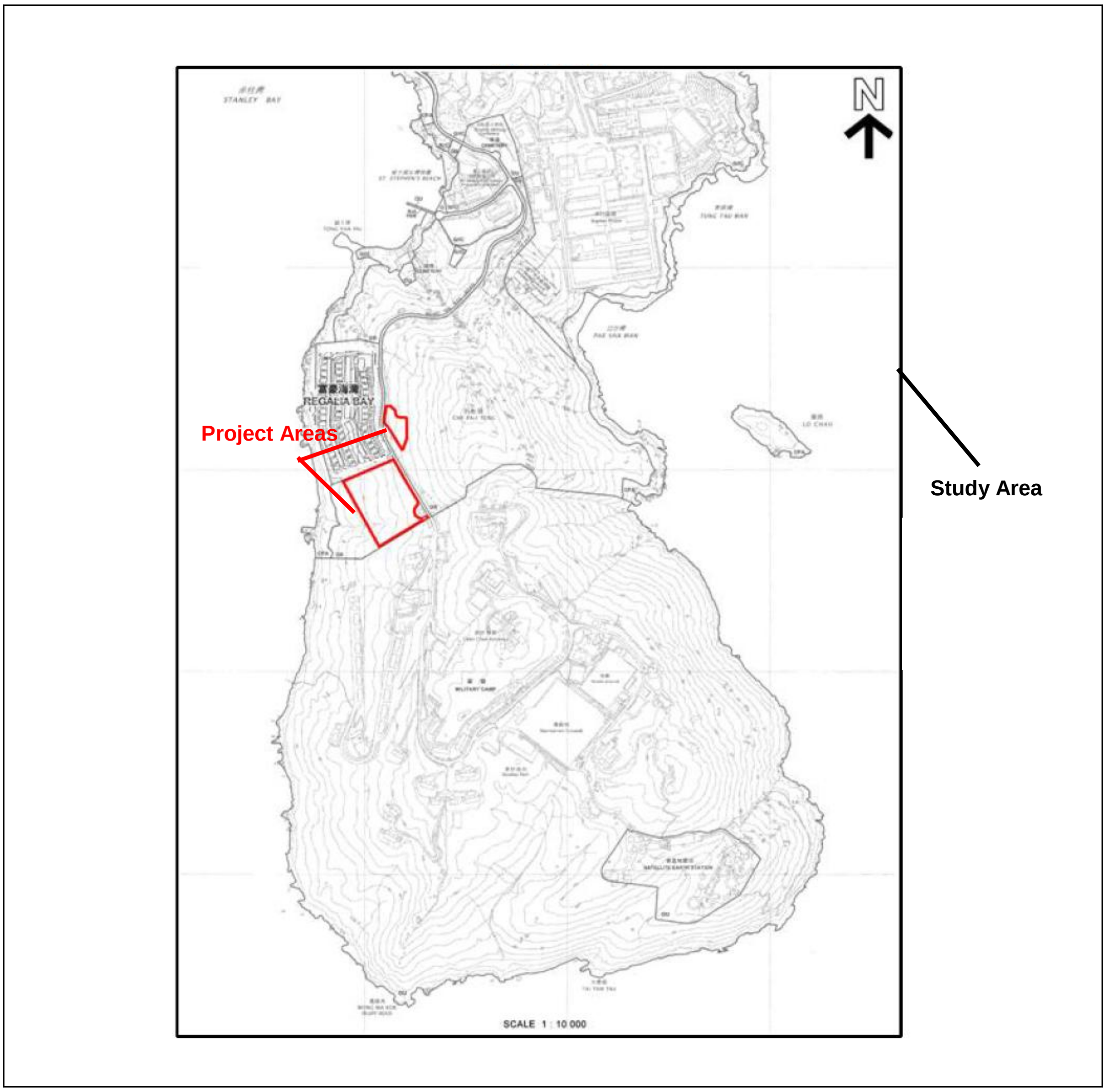


Figure 1.1 Extent of Stanley Peninsula Area

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

- Location Map of the Study Area and Project Areas
- Aerial Photo of the Study Area
- Existing Spot Heights of Stanley Peninsula
- Existing Building Height Profiles for Stanley Peninsula
- Data on Building Polygons and Digital Elevation Model for Stanley Peninsula

1.4 In the preparation stage of the expert evaluation report, the Consultant has studied the given materials listed in paragraph 1.3 and carried out site visit and inspection.

Objectives of the Expert Evaluation Study

1.5 The objective of this study is to assess the air ventilation impacts of the proposed rezoning proposal for incorporation into the Stanley Outline Zoning Plan. The Expert Evaluation Study has made reference to PlanD's study: "Feasibility Study for Establishment of Air Ventilation Assessment System" which recommended that it is important to allow adequate air ventilation through the built environment for pedestrian comfort.

1.6 The key purposes of the Expert Evaluation are to identify the 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 initial study or detailed study is required.

1.7 This Expert Evaluation Report will present the following findings:

- Analyse relevant wind data to understand the wind environment of the Project Areas and its surroundings;
- Identify and analyse major topographical features of the Project Areas and its immediate vicinity. In addition, greeneries/landscape characteristics of the Project Areas as well as its surroundings will be identified;
- Identify and analyse the land use of the Project Areas as well as its immediate surrounding areas including existing developments and planned developments. It is observed that there are currently no planned developments 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.

1.8 This Expert Evaluation Report will be written and arranged as follows:

- The "Wind Environment" section will analyse relevant wind data to ascertain the wind environment of the Project Areas and neighbouring region.
- After the prevailing wind directions are identified, the topographical features of the Project Areas and its immediate vicinity will be 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 Areas** will be discussed.

- Following the section of "Topographical Features and Wind Flow" will be a section of "Existing land use and Building Morphology within Study Area". Land use of the Project Areas as well as its immediate surrounding areas including existing developments will be discussed in this section. Investigation of the impact on **the wind environment within Project Areas due to the existing developments in the vicinity** will be carried out. Existing good features and problematic areas will also be identified.

- Following discussion of the impact of the existing developments on wind performance of the Project Areas, the investigation of the potential impact in terms of wind environment on **the existing buildings due to the proposed developments within the Project Areas** will be documented in the section "Expert Evaluation on the Project Area". Existing good features that should be retained will be identified while problematic regions that may warrant attention will be spotted.

- 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 will be 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 stations and computed wind data from the MM5 model at the Study Area will be analysed and compared in order to identify the prevailing wind directions.

<u>Wind Direction Analysis based on HKO Weather Stations' Data</u>

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 valuable insights to aid a general understanding of the surface wind environment especially near pedestrian level.

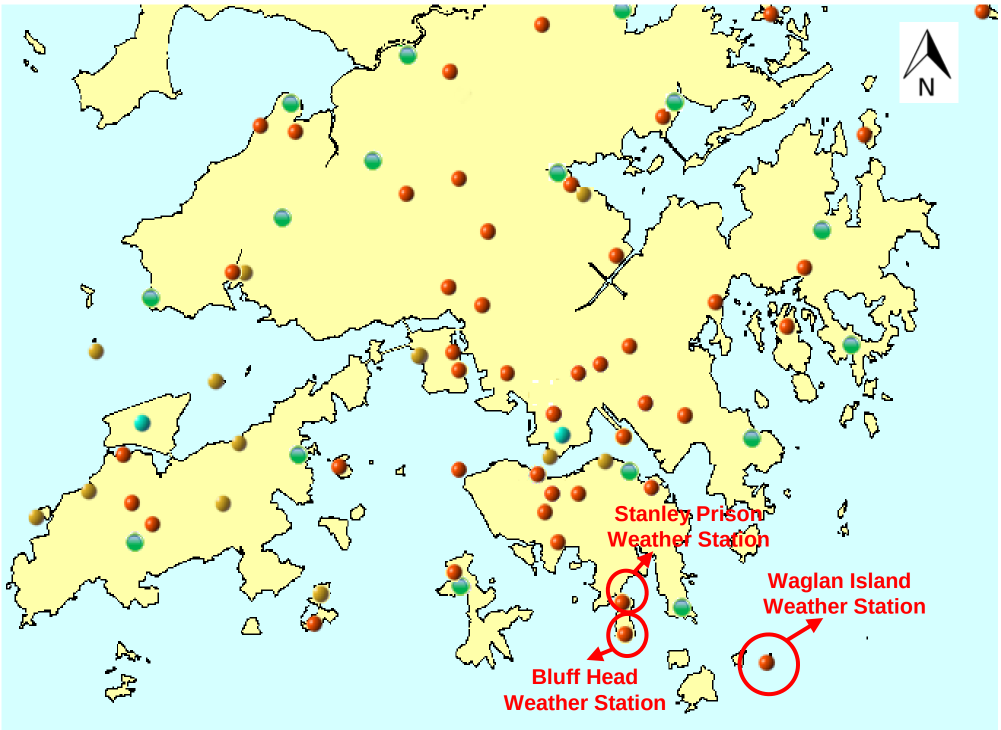


Figure 2.1 Locations of HKO Weather Stations in Hong Kong

2.3 The automatic wind station at Waglan Island (WGL) has a very long measurement record (in operation since 1989 and its measured wind data is relatively unaffected by Hong Kong's complex topography. Therefore, the wind data from this station are generally adopted to estimate the site wind availability in wind related studies prior to taking into account the local topographical features for the assessment of most development sites.

2.4 Apart from Waglan Island Weather Station, the Bluff Head (Stanley) Weather Station which is located at the south of the Project Areas is the closest station to the Project Areas. There is also a station at Stanley Prison which is located at the north-east of the Project Area, but this station provides temperature data only. As a result, the Bluff Head (Stanley) Weather Station is used in assessing the site wind availability, in addition to the Waglan Island Weather Station.

Wind Direction Analysis based on Waglan Island Weather Station Data

2.5 By referring to the annual wind rose at WGL station from the years 2008 to 2012 shown in **Figure 2.2** below, it is observed that winds from the north eastern quadrant have a relatively high probability of occurrence compared to other wind directions.

2.6 All the wind directions in the north eastern quadrant (i.e. N, NNE, NE, ENE and E) have percentage occurrence of over 8% as shown in **Figure 2.2**. Among the wind directions from the north eastern quadrant, the easterly and east north easterly winds each with percentage of frequency occurrence of approximately 16%. Apart from the easterly wind (which is the wind with the highest percentage of occurrence), a major component of wind also comes from the northerly, north easterly and north-north easterly directions (each with percentage of frequency occurrence of approximately 12%). In addition, the north eastern winds have a relatively high occurrences compared to winds from the south eastern, south western and north western quadrants. As a result, winds from the north eastern quadrant are considered as the dominant annual wind directions based on the wind rose data from the WGL station.

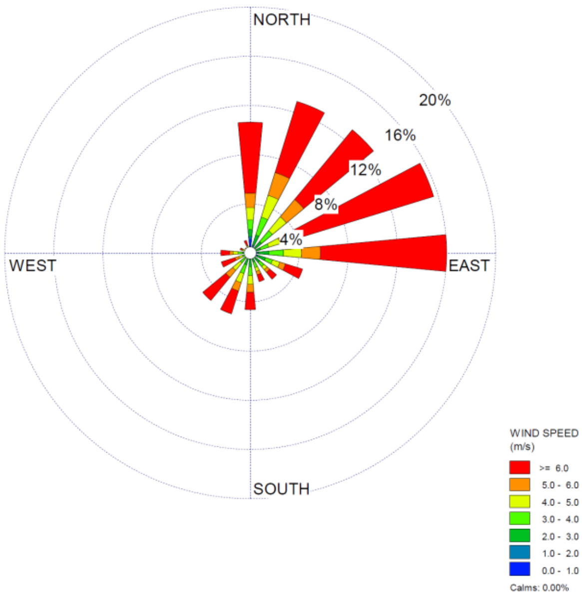
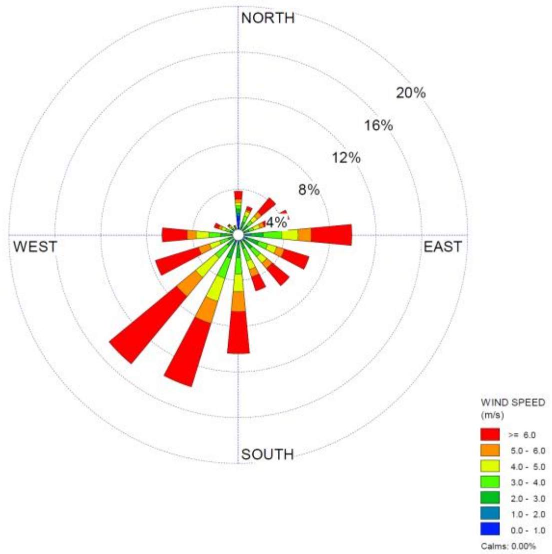


Figure 2.2 Wind Rose of WGL Weather Station (2008 – 2012)

* Note that wind data in 2012 is the latest available wind data at the time of the Expert Evaluation.

2.7 In Hong Kong, summer wind is very important and beneficial for thermal comfort; and identification of the summer wind characteristics is crucial. By referring to the June to August wind rose at WGL station from 2008 to 2012 as shown in **Figure 2.3**, during summer season, the summer prevailing winds generally come from the south-westerly directions (i.e. SSW, SW and S, each with frequency occurrence exceeding 8%), except the westerly and the west south-westerly winds, which have a frequency occurrence below 8%. In addition, the easterly wind also has an occurrence frequency of more than 8%.



June to August

Figure 2.3 Summer Month Wind Roses of WGL (2008 – 2012)

2.8 From the discussion in paragraphs 2.5 to 2.7 and based on the Waglan Island weather station wind data, winds from the north eastern quadrant (i.e. N, NNE, NE, ENE and E) are considered to be the annual prevailing winds and the SSW, SW and S winds together with the easterly wind are the summer prevailing winds.

Wind Direction Analysis based on Bluff Head Weather Station Data

2.9 By referring to the averaged annual wind rose at Bluff Head (Stanley) Weather Station from 2008 to 2012 shown in **Figure 2.4** below, it is observed that the winds from the east and east-northeast directions have high probabilities of occurrence (each over 15%). Furthermore, winds from the north eastern direction and the east-south easterly directions each possess an occurrence frequency of approximately 10%. These two winds are also dominant winds in addition to the winds from the east and east- north easterly directions.

2.10 By comparing with the annual wind rose from the Waglan Island weather station and the Bluff Head weather station, it is observed that the easterly and the east-north easterly winds are the two dominant wind directions but with certain differences in magnitude and frequency of occurrence. The reason of this discrepancy is due to the difference in location and measurement height of the two weather stations and the fact that the measured wind data at the Waglan Island is not affected by Hong Kong's complex topography while the wind data measured at the Bluff Head weather station is more affected by local topography and existing building developments in its vicinity. However, considering the Bluff Head weather station is less than 500m away from the Project Area while Waglan Island is around 5000m from Stanley, the wind data of Bluff Head Weather Station is more applicable in determining the local wind availability within the regions of the Project Area in this specific study.

2.11 Owing to the differences in location and measurement height of the Waglan Island weather station and the Bluff Head weather station, the summer wind rose of the Bluff Head station in **Figure 2.5** differs from the summer wind rose of the Waglan Island in **Figure 2.3**. The summer wind rose from the Bluff Head weather station shows that the summer wind mainly comes from the east and the west directions, each with an occurrence frequency of approximately 12%, while winds from S, ESE, WSW, WNW, NW, SW and SE each has an occurrence frequency of approximately 8%.

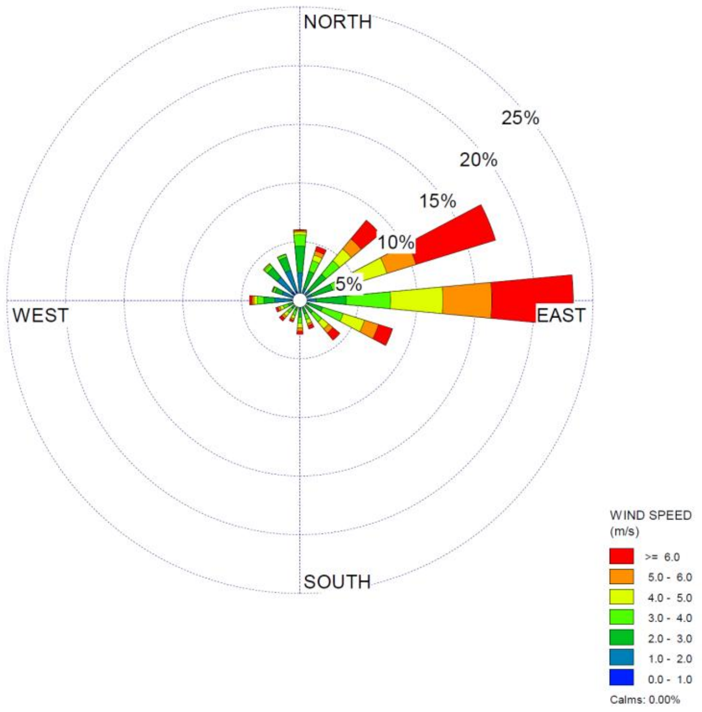
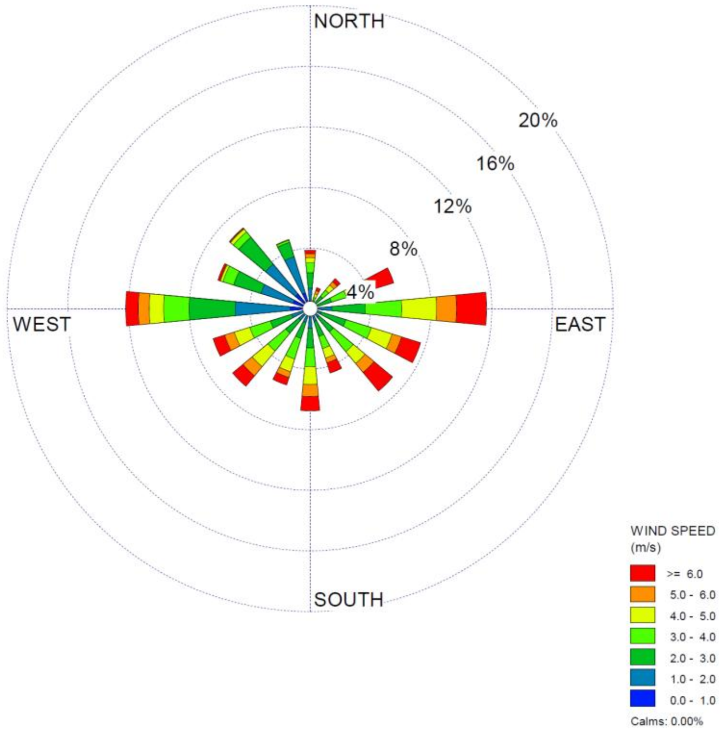


Figure 2.4 Annual Wind Rose of Bluff Head Weather Station (2008 - 2012)



June to August

Figure 2.5 Summer Month Wind Roses of Bluff Head Weather Station (2008 - 2012)

2.12 According to the analysis in paragraphs 2.9 to 2.11 and based on the Bluff Head weather station wind roses, the winds from the easterly and the east-north easterly winds together with the north easterly and east south-easterly winds are considered to be dominant annual winds.

Wind Direction Analysis based on MM5 model

2.13 Apart from the wind data from the HKO automatic weather stations mentioned above, the simulation data obtained from the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5) can also be adopted to study the general wind pattern within the Study Area that is induced by nearby topographical features.

2.14 Annual wind rose at the grid (30, 18) at 596m height generated from the MM5 model at the Study Area is extracted from the Website of PlanD "Site Wind Availability in Hong Kong" (http://www.pland.gov.hk/pland_en/misc/MM5/index.html) and shown in **Figure 2.6** below.

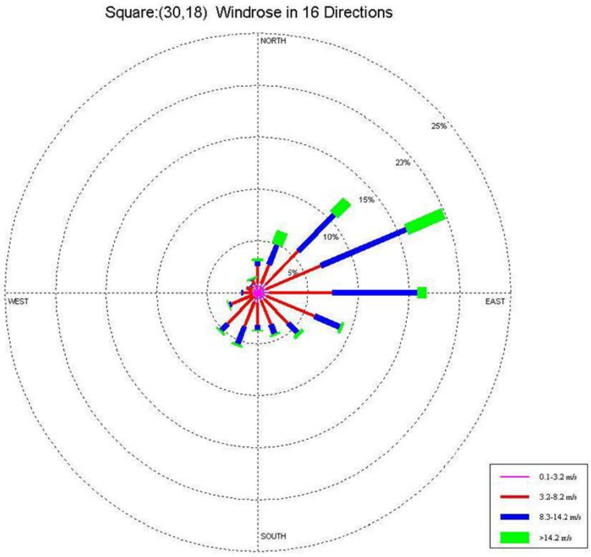


Figure 2.6 Annual Wind Roses at 596m obtained from MM5 model

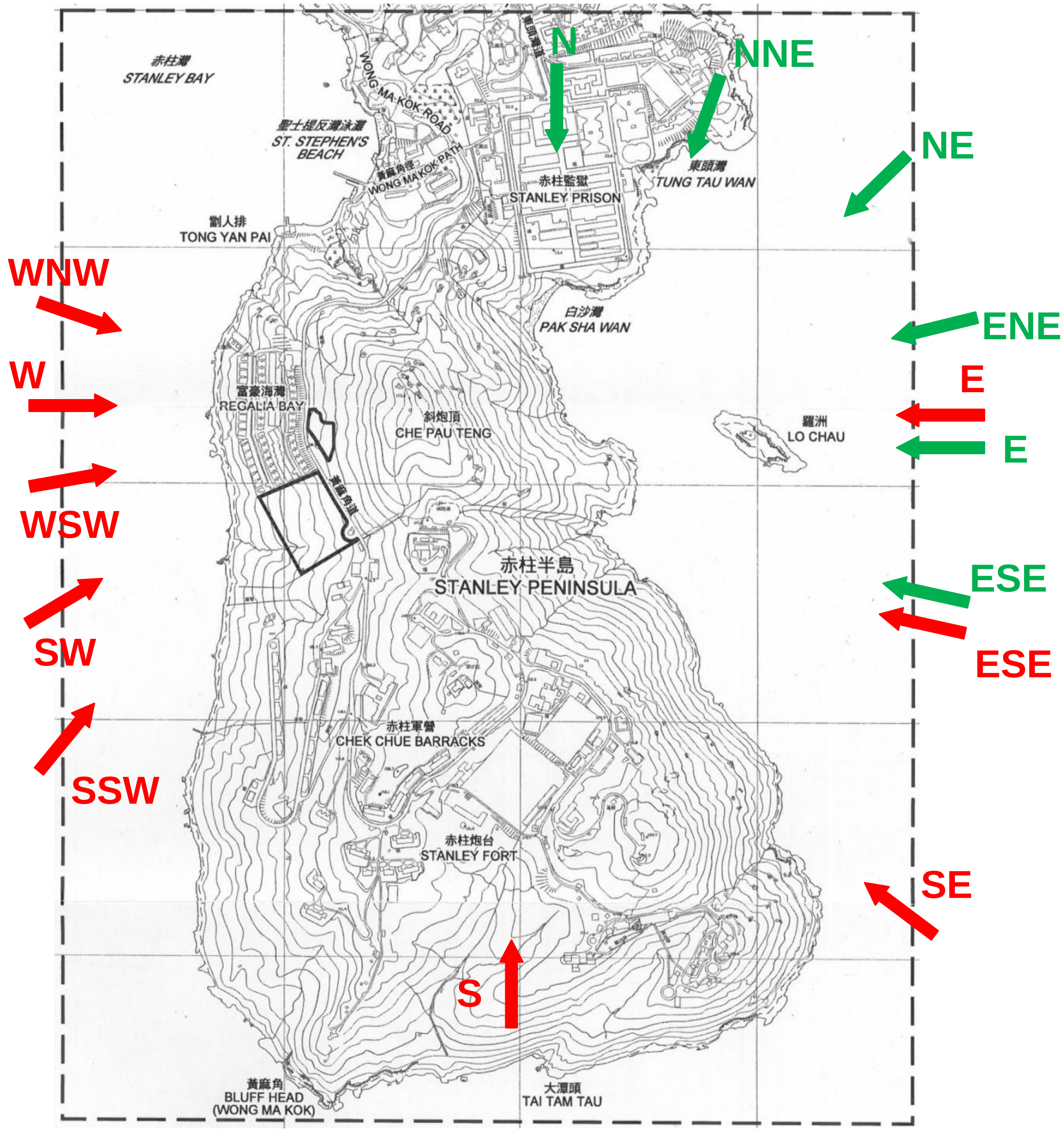
2.15 Based on the MM5 wind data, the annual wind of the Study Area is mainly from the northeast and east directions. The north easterly quadrant winds have contributed nearly 60% of the annual wind towards the Study Area.

Summary and Identification of prevailing wind directions

2.16 By reviewing the wind data from both the HKO stations and the MM5 model, it can be concluded that the annual wind mainly comes from the **north-easterly quadrant (E, ENE, NE, NNE and N)** and also **east-south easterly** direction annually.

2.17 During the summer season, wind mainly comes from the **east** and **west**. In addition, winds from **ESE, WSW, WNW, S, SW, SSW** and **SE** are also considered to be major winds during summer season.

2.18 **Figure 2.7** below is an illustration diagram showing the prevailing wind directions towards the Project Areas during the annual and summer seasons.



Project Area
Study Area
Annual Prevailing Wind
Summer Prevailing Wind

Figure 2.7 Summary of Prevailing Winds towards the Project Areas

3 TOPOGRAPHICAL FEATURES AND WIND FLOW

3.1 The topographical features within the Study Area affect wind flows and the general wind environment of the Stanley Peninsula.

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.

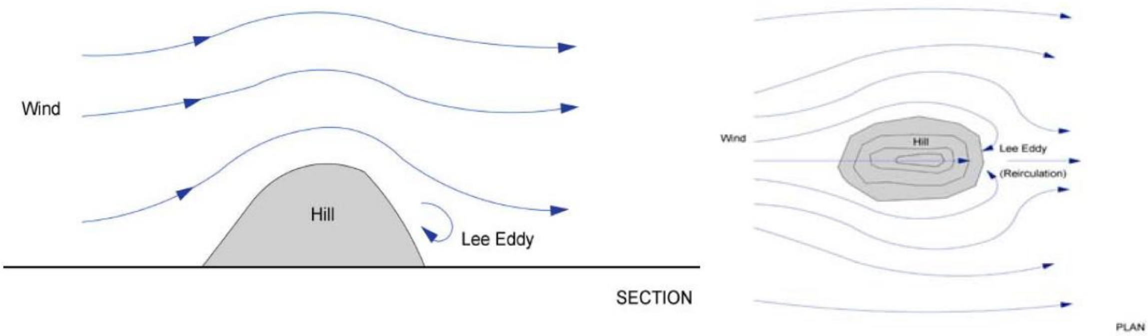
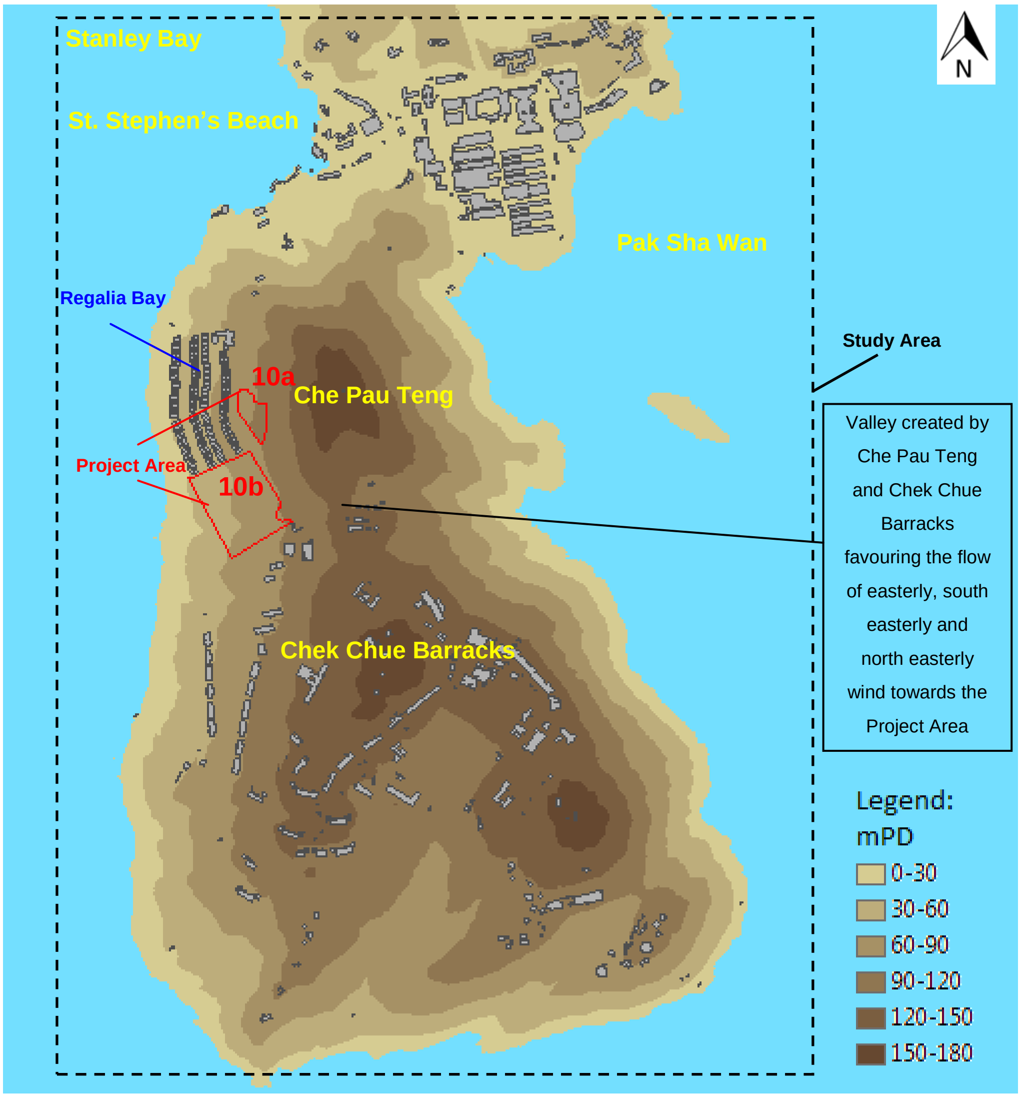


Figure 3.1 Illustration of Wind Flow over Hills under Moderate Wind

3.3 This section describes the major topographical features within the Study Area and their impacts on the Project Areas annually and during summer seasons.

Major Topographical Features

3.4 The Stanley Peninsula is like a pear shape and covered by hilly topographies with significant local high points namely Che Pau Teng (terrain height at 176.7mPD) and Chek Chue Barrack (terrain height at 155mPD, with maximum building height at 167.5mPD) as shown in **Figure 3.2** below. There is a valley in between the two high grounds (Che Pau Teng and Chek Chue Barracks) (see **Figure 3.2**). The Stanley Peninsula is surrounded by sea to its east, south and west and occupied by mostly low-rise and low-density developments. The absence of high rise developments on the peninsula results in generally good wind ventilation performance at most times of the year.



- - - - - - Study Area

Figure 3.2 Digital Elevation Map of the Study Area

Under the Annual Prevailing Winds

3.5 As mentioned in paragraph 2.16 above, the prevailing annual wind directions are E, ENE, NE, NNE and N and ESE. A portion of annual winds from the E, ENE, NE, and NNE directions will flow over the hill of Che Pau Teng before reaching Project Areas 10a and 10b, while a portion of the ESE wind will flow over the high grounds of Che Pau Teng and Chek Chue Barracks prior to reaching both Project Areas.

3.6 The Project Area 10a is located to the west of Che Pau Teng (maximum height at 176.7mPD) which may weaken the approach flows from the north easterly, north-north easterly and the east-north easterly directions whereas the mountain where the buildings of the Chek Chue Barracks are located may weaken the east south-easterly wind towards Project Area 10a. However, there are no obstacles located to the north of Project Area 10a. It is expected that northern wind can reach Project Area 10a without any significant local obstruction. Furthermore, a portion of annual winds from the north eastern quadrant and also the ESE wind is expected to flow around the hills of Che Pau Teng and reach Project Area 10a. As a result, after the development of the proposed buildings, similar wind environment is expected compared with the current situation.

3.7 The valley created by the two high grounds (Che Pau Teng and Chek Chue Barracks) as mentioned in paragraph 3.2 will create channelling effect and is effective in redirecting the easterly, east-north easterly and east-south easterly annual winds towards the Project Area 10b. In particular, easterly wind can reach Project Area 10b without obstruction through this valley. The presence of this valley will alter local wind directions and speed up wind flows while passing through it. The northerly and north north easterly annual winds are expected to reach Project Area 10b without any significant topographical obstructions.

<u>Under the Summer Prevailing Winds</u>

3.8 The prevailing summer wind directions are from the **E, W, ESE, WSW, WNW, S, SW, SSW** and **SE** as mentioned in paragraph 2.21 above. The Project Area 10a has a higher topographical elevation than the Regalia Bay (located to its west) and Project Area 10b (to its southwest) and also there are no topographical blockage for the Project Area 10b to its western and south-western directions, hence summer prevailing winds including W, WSW, WNW, SW and SSW can reach the Project Area without any signicant local obstruction.

3.9 In addition to the observations in paragraph 3.9, there does not exist any topographical blockages to the southern wind on Project Area 10b. Furthermore Project Area 10a has a slightly higher topographical elevation than Project Area 10b. Therefore, it is expected that there will be no significant air ventilation issues due to topography under the southerly wind condition. For the easterly wind, it can reach Project Area 10b without obstruction through this valley as mentioned in paragraph 3.6. However for Project Area 10a, the easterly wind towards it will be weakened by Che Pau Teng.

3.10 As the Project Areas 10a and 10b are located close to the hilly terrains of Che Pau Teng, minor katabatic (downhill) air movement can be expected from the vegetated hill slopes surrounding them. These downhill air movements are expected to be more significant during the summer season which favours the wind performance of the Project Areas during those times.

3.11 By the above assessment of topographical features and wind flow, there is one major air path existed in the Study Area (i.e. the valley between Che Pau Teng and Chek Chue Barracks). Meanwhile, there are no significant problematic areas observed.

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 Areas in Section 3 above, this section will investigate the potential impact of the existing developments within the Study Area on the air ventilation performance of the Project Areas.

Land Use

4.2 The statutory Outline Zoning Plan (OZP) of Stanley No. S/H19/10 is shown in **Figure 4.1** below and the land use types are stated below:

- The areas coloured in light blue are zoned “Government, Institution or Community”. The area hatched orange colour is zoned “Other Specified Uses”.
- The areas coloured in dark brown and light brown are zoned “Residential (Group A)” and “Residential (Group C)”, respectively.
- The area coloured in light green and dark green are zoned “Green Belt” and “Open Space”, respectively.
- The Project Areas are currently zoned as “Green Belt”.

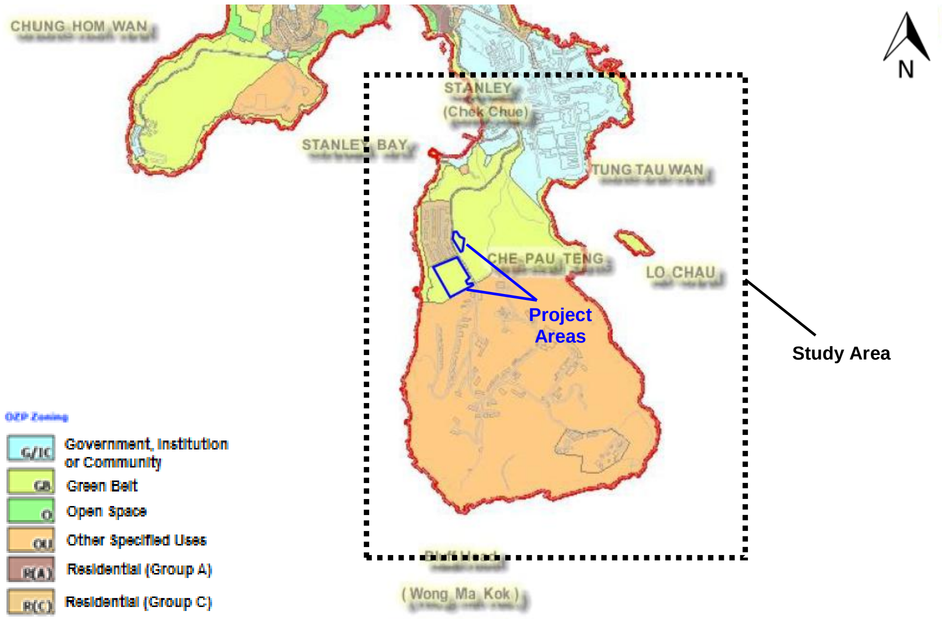


Figure 4.1 Land Uses in Stanley Peninsula Area

4.3 Low-rise (4 domestic storeys above 1 storey carport) and low-density (maximum site coverage of 22.5%) residential buildings are proposed within the Project Areas. The proposed parameters of the developments in the Project Areas are listed in **Table 4.1** below.

Table 4.1 Proposed Parameters of the Developments in the Project Areas

Site area (about):	About 3 hectares
Maximum Plot Ratio:	0.9
Maximum Site Coverage:	22.5%
Maximum No. of storeys:	4-storey in addition to 1 storey of carport

Existing Building Morphology within the Study Area

4.4 **Figure 4.2** below shows the major existing and committed developments in the vicinity of the Project Areas. Site photographs of these developments are shown in **Figure 4.3**.

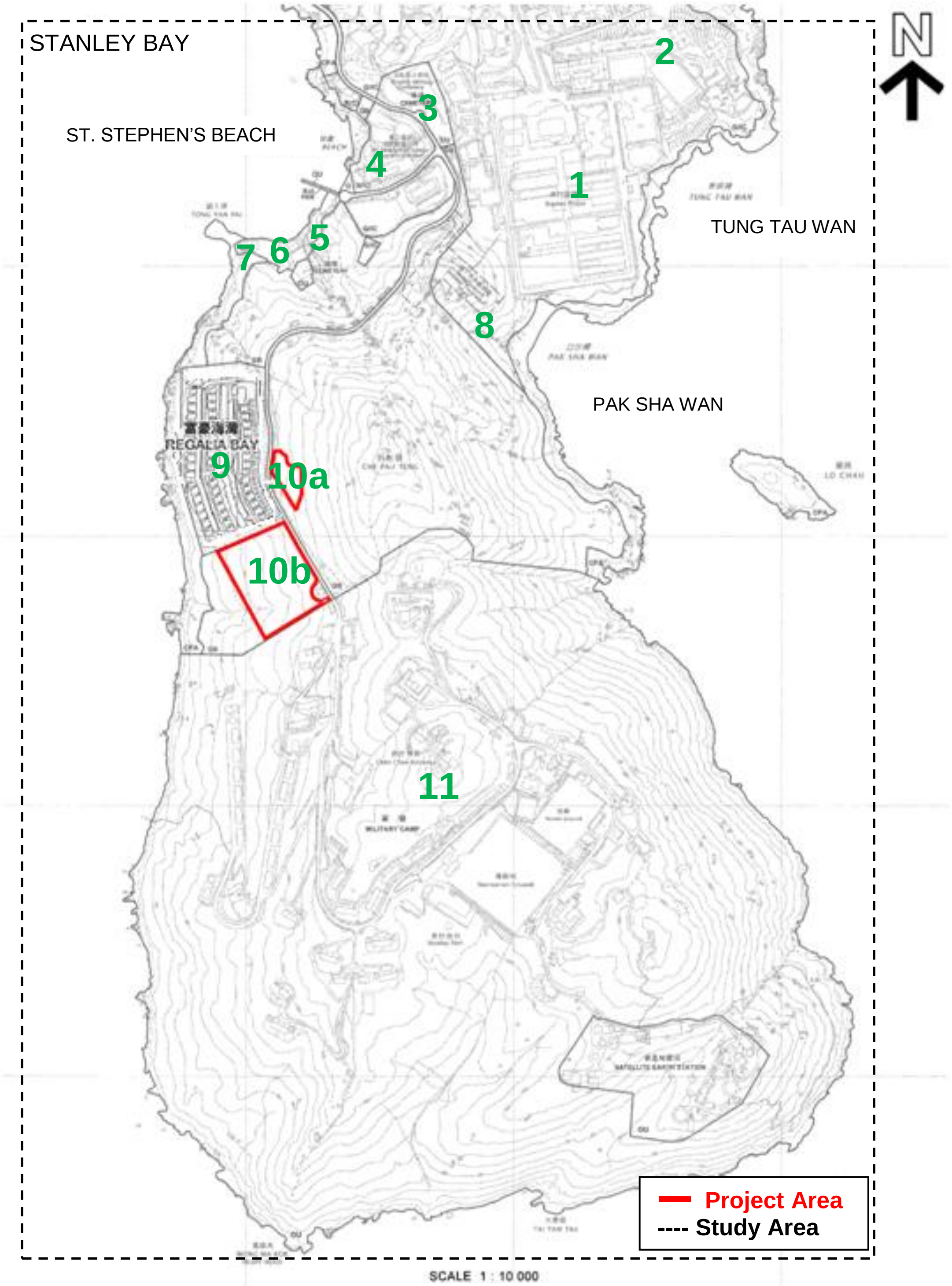


Figure 4.2 **Existing and Committed Developments in Stanley Peninsula Area**

1. Stanley Prison

2. Stanley Prison Staff Quarters

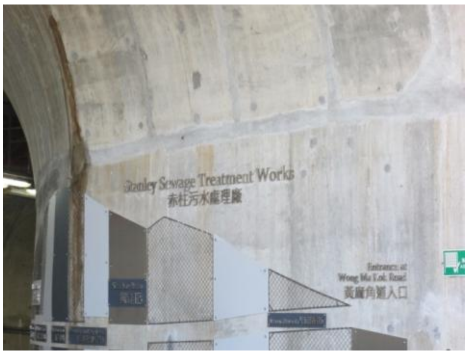
3. Stanley Military Cemetery

4. St. Stephen's College Preparatory School

5. St. Stephen's Beach Water Sports Center

6. The Hong Kong Federation of Youth Groups - Stanley Outdoor Activities Centre

7. Hong Kong Sea Cadet Corp. Jubilee Centre



8. Stanley Sewage Treatment Works

	
9. Regalia Bay Houses	10. (a,b) Project Area
	
11. Chek Chue Barracks	

Figure 4.3 Photos of Existing and Committed Developments in Stanley Peninsula Area

4.5 The Stanley Peninsula area is generally occupied by low to medium density developments. Most of the developments possess a building height of less than 6 storeys, and only a couple of buildings in this area possess building height up to 12 storeys. The building heights of the existing development are shown in **Figure 4.4**. To the further north east of the Project Areas are Stanley Prison and its Staff Quarters which are marked as number 1 to 2 in **Figure 4.2**. There are some outdoor sports centre and schools as marked as number 3 to 7 in **Figure 4.2** above, and shown in the photos in **Figure 4.3**.

4.6 The tallest buildings in the area can be found at the Chek Chue Barracks which is marked as number 11 in **Figure 4.2**. The Barrack developments are located to the south and south east at approximately 150m away from the Project Areas. The military camps of the Chek Chue Barracks are located on the high ground to the south of Che Pau Teng with mostly low-rise buildings of 1 to 3 storeys high.

4.7 To the immediate adjacency of the Project Areas are existing lower residential developments, the Regalia Bay with maximum building height of no more than 4 storeys which are marked as number 9 in **Figure 4.2** and the corresponding photo shown in **Figure 4.3**.

<u>Under the Annual Prevailing Winds</u>

4.8 These clusters of developments of the Stanley Prison are located far away (more than 400m) from the boundary of the Project Areas, separated by the hilly terrain of Che Pau Teng in between, therefore, the Stanley Prison are not expected to give rise to any adverse air ventilation impact to both the Project Areas 10a and 10b under the annual prevailing winds (i.e. N, NE, NNE, ENE, E and ESE).

4.9 The developments of the Chek Chue Barracks are also located at a distance far away (more than150m), under annual wind directions, the developments of the Chek Chue Barracks are unlikely to affect both Project Areas in terms of air ventilation performance.

4.10 Under the annual prevailing wind directions from the NNE, NE, ENE, E and ESE, the Regalia Bay would not generate any potential air ventilation problems to both Project Areas 10a and 10b as the sites are not located at the downwind side of Regalia Bay. While under the prevailing wind from N, the Project Area 10b is located at the downwind side of Regalia Bay. However, due to the low-rise low-density nature of the developments at Regalia Bay, the northerly wind can reach Project Area 10b and is expected to maintain the wind environment there.

Under the Summer Prevailing Winds

4.11 The Stanley Prison developments and the Chek Chue Barrack developments would not affect the Project Areas 10a and 10b in terms of wind environment as they are located at a distance far away from the Project Areas.

4.12 Project Area 10a is located east of Regalia Bay but with its level higher than the Regalia Bay. Therefore, during summer, winds from W, WNW, WSW, SW and SSW directions can reach Project Area 10a without any significant local obstruction and hence no air ventilation problem is expected. Due to the natural gradient of the terrain (with increasing gradient from the west to east), a natural stepping height profile of the houses of Regalia Bay is formed, resulting in a diversion of wind to the pedestrian level. Given the topography and its downhill location, the Regalia Bay will not affect Project Area 10b under the summer winds from W, WNW, WSW, SW and SSW directions.

4.13 For summer winds from E, ESE, S and SE, there are no residential buildings upwind of the Project Areas and the Project Areas are not located to the immediate downwind location of the Regalia Bay. As a result, the Regalia Bay will not give rise to any adverse air ventilation issues to both the Project Areas 10a and 10b under these wind conditions.

4.14 By summarizing paragraphs 4.11 to 4.13, no significant air ventilation impact is expected to arise for Project Areas 10a and 10b due to the existing developments within the Study Area during the summer season.

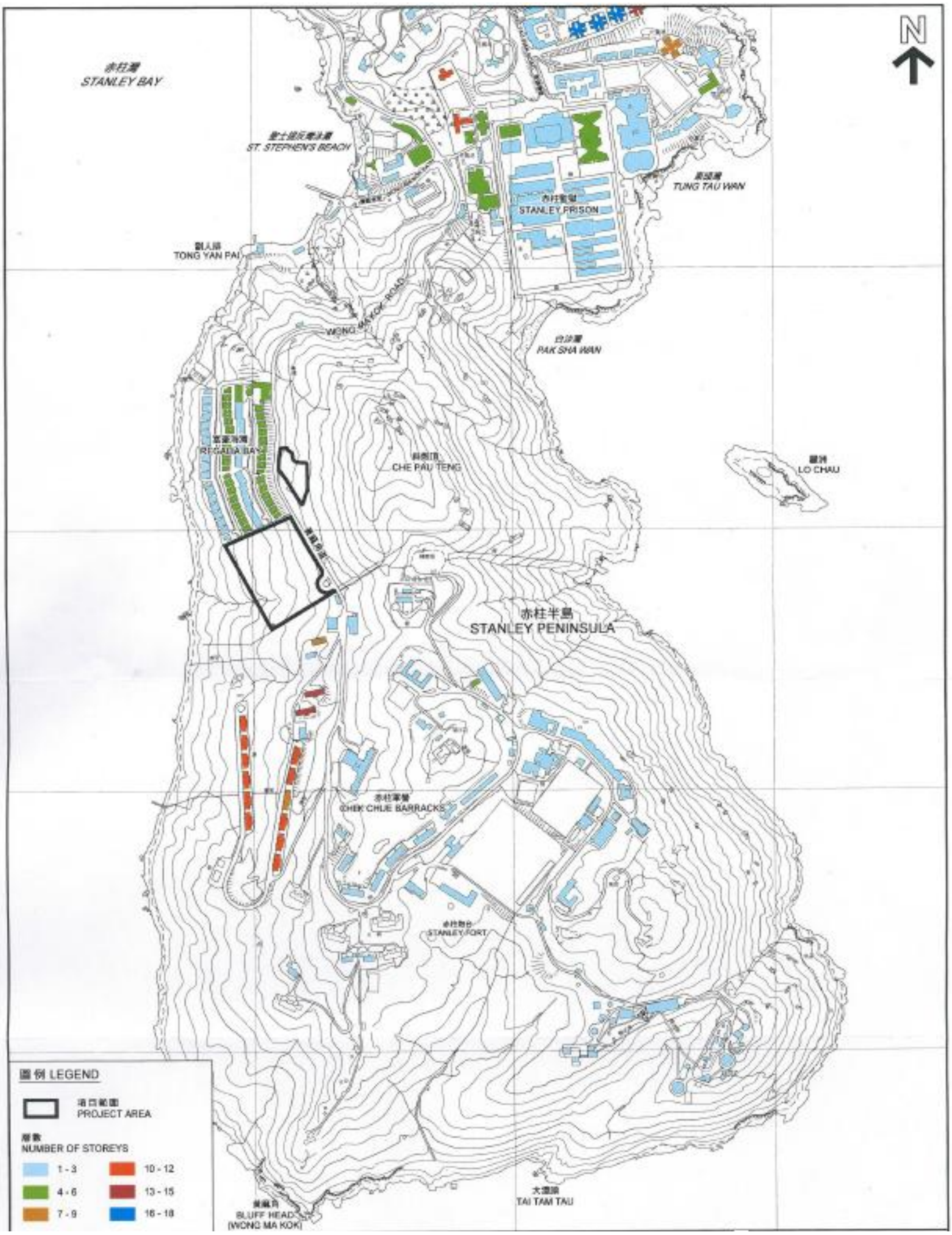


Figure 4.4 Height of the Existing Buildings in the vicinity of the Project Areas

5 EXPERT EVALUATION ON THE PROJECT AREAS

5.1 Following the investigation of the potential impact of the existing developments on the Project Areas 10a and 10b in terms of air ventilation performance in Section 4, this section presents the influence of the proposed developments within the Project Areas 10a and 10b on the existing developments.

Recap of some major information about the Project Areas

5.2 The Project Areas (marked as 10a and 10b in **Figure 4.2**) are situated in the immediate vicinity to the east and south of Regalia Bay which are low-rise developments as shown in **Figures 4.3** and **4.4** with building heights ranging from approximately 40mPD to 90mPD with the developments of at most 4-storeys in height with a stepped terraced building profile. The Project Areas are situated on the hilly terrain west of the Che Pau Teng, Stanley Peninsula, and fronting Stanley Bay, rising from approximately 30mPD to the west to approximately 80mPD to the east.

5.3 The Project Areas are proposed to be developed into low-rise residential buildings of around 5-storey (4-storeys in addition to 1 storey carport) in height with site coverage of 22.5%, i.e. low-density development. As mentioned in Section 2, the annual prevailing wind comes from the north eastern quadrant including N, NNE, NE, ENE, E wind directions and also the ESE wind while the summer wind comes from the S, ESE, SE, SW, SSW, WSW, WNW, W and E directions.

5.4 The major existing developments within the Study Area are listed in Section 3. Except for the Regalia Bay, the developments including the Chek Chue Barracks developments and the Stanley Prison developments are located far away from the boundary of the Project Areas.

Under the Annual Prevailing Winds

5.5 The Chek Chue Barrack developments are located on the higher ground far away from the Project Areas (over 150m) and another major existing development which is the Stanley Prison/Stanley Prison Staff Quarters are located at the far north eastern direction from the Project Areas. Under annual prevailing winds, the proposed developments in both Project Areas 10a and 10b would not give rise to adverse ventilation impact to the aforementioned existing developments within the Stanley Peninsula area.

5.6 The outdoor sports and recreation centres near St. Stephen’s beach, which are located far north of the Project Areas 10a and 10b, would also not be affected by the proposed developments within the Project Areas under the annual winds as they are not located downstream of the Project Areas. The Project Areas 10a and 10b situated at both sides of Wong Ma Kok Road are expected not to narrow this road in the Study Area after the developments. Thus, comparable wind environment is expected after proposed developments.

5.7 Given the Regalia Bay is located at the downwind location of Project Area 10a under the E, ENE, NE, NNE and ESE annual prevailing winds, both Project Area 10a and Regalia Bay are situated at the leeward side of Che Pau Teng; hence downhill air flow are expected to reach Regalia Bay from the hill top of Che Pau Teng, and the developments of Project Area 10a are not expected to cause adverse impact upon Regalia Bay under the aforementioned wind directions due to its low profile. Apart from that, the downstream area of the Project Area 10b under the NNE, NE, ENE, E and ESE annual prevailing wind directions is the open sea. Developments within the Project Area 10b will not cause adverse air ventilation issues under these annual wind directions to the Regalia Bay.

5.8 Under the northern annual wind, the location of the Project Areas 10a and 10b will not result in any ventilation issues to the existing developments as there are no existing developments to the immediate downstream area of the Project Areas 10a and 10b.

5.9 The proposed developments within the Project Areas are low-rise low-density developments; significant wind ventilation issue is therefore not expected.

5.10 Due to the fact that the proposed developments within Project Areas 10a and 10b are all low-rise low-density, and the two Project Areas have a separation distance of no less than 15m. It is not expected that the two Project Areas would cause adverse impact upon each other in terms of air ventilation performance.

Under the Summer Prevailing Winds

5.11 The summer winds from the W, WNW, SSW, SW and WSW directions can reach the Project Areas from the sea without any obstruction. In addition to the low site coverage and low-rise proposed developments within the Project Areas 10a and 10b, summer winds from the sea can penetrate easily through these proposed developments and maintain wind penetration to the vicinity of the Project Areas 10a and 10b.

5.12 There is an increase in terrain height within both Project Areas 10a and 10b from the west to east. The terrain formation will naturally create stepping building height profile with lower buildings located to the west and higher buildings to the east, provided that every building possesses the same height in terms of number of storeys. This natural stepping height profile will assist the flow of summer winds (W, WNW, WSW, SSW, and SW) and enhance pedestrian comfort within both Project Areas 10a and 10b during the summer season.

5.13 The proposed development is 5 storeys and of low-density with plot ratio of 0.9 and site coverage capped at 22.5%. Wind is expected to pass through the non built up area, within the Project Area 10b and penetrate to the residential houses at Regalia Bay. The existing wind environment would be maintained though the Regalia Bay is located at the immediate downwind side of Project Area 10b. Project Area 10b would not give rise to air ventilation issues to the existing developments under the southerly summer winds. In addition, as there are no existing developments to the downwind side of the Project Area 10a under the southerly wind, this Project Area is not expected to give rise to air ventilation issues to the existing developments under the southerly summer winds.

5.14 Similar to the annual E and ESE winds, the summer E and ESE winds would possess the same wind flow characteristics, therefore the observations stated in paragraph 5.7 on the air ventilation impact by the Project Areas 10a and 10b on existing nearby developments are valid under the summer E and ESE prevailing winds.

5.15 Under the SE summer wind direction, although the Regalia Bay is located at the downwind location of Project Area 10a under this summer prevailing wind, both Project Area 10a and Regalia Bay are situated at the leeward side of Che Pau Teng; downhill air flow are expected to reach Regalia Bay from the hill top of Che Pau Teng, and the developments of Project Area 10a are not expected to cause impact upon Regalia Bay under SE wind direction. Furthermore, under the SE summer wind, the downstream area of Project Area 10b is mainly the open sea, with a small portion covering the southern portion of Regalia Bay developments. However, the downhill air movement from Che Pau Teng will reach these Regalia Bay developments and benefit the wind environment there. Therefore, developments within the Project Area 10b will not cause adverse air ventilation issues under the summer SE wind direction to the Regalia Bay.

5.16 In addition, similar to the reasons in paragraph 5.10, it is not expected that the two Project Areas would cause adverse impact upon each other in terms of air ventilation performance during summer seasons.

Summary of the Observations

5.17 Based on the above paragraphs 5.5 to 5.16, it can be concluded that the low-rise proposed developments of around 4 storeys above carport with site coverage of 22.5% are not expected to create adverse air ventilation impact within the Project Areas 10a and 10b and on the existing developments in the Study Area during the annual and summer times.

6 SUMMARY AND CONCLUSION

6.1 The two Project Areas are situated on the western slopes of the Stanley Peninsula facing the open water of Stanley Bay. Next to the sites are the existing 3 to 4-storeyed houses of Regalia Bay located to the immediate northwest of the sites. The Chek Chue Barracks in the south is located about 150m to its south. The proposed developments at the sites are subject to maximum plot ratio of 0.9, maximum building height of 4 storeys in addition to 1 storey of carport, and maximum site coverage of 22.5%.

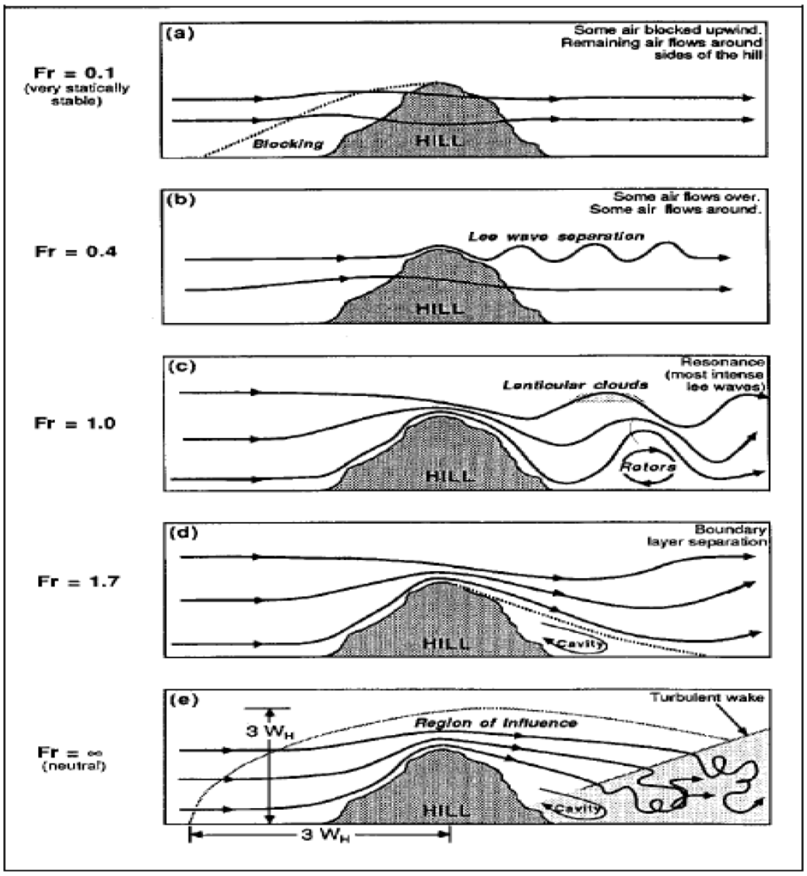
6.2 Based on the wind data from the HKO and MM5 Model, the annual prevailing winds of the Stanley Peninsula are from the north eastern quadrants and from the ESE, whereas the summer prevailing winds are easterly and westerly winds together with winds from ESE, WSW, WNW, S, SW, SSW and SE directions.

6.3 Under the easterly annual and summer prevailing wind direction to Project Areas 10a and 10b, the valley created by the Che Pau Teng and the terrain of Chek Chue Barracks is an effective channel to enhance wind ventilation to the Project Areas.

6.4 Since the proposed development is restricted to a maximum of 5 storeys and of low-density with plot ratio of 0.9 and site coverage of 22.5%, it is not expected to have adverse air ventilation impact to the existing developments under annual prevailing winds and summer prevailing winds.

6.5 In view of the proposed low development density and sparsely developed site context, adverse ventilation impacts are not anticipated from the proposed developments and the decline in pedestrian wind environment within the Study Area are not expected when compared to the current situation. Thus, further Air Ventilation Assessment is not required.

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.]