TERM CONSULTANCY FOR AIR VENTILATION ASSESSMENT SERVICES

Cat. A1– Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment (PLNQ 37/2007)

Final Report
Sai Ying Pun & Sheung Wan Area

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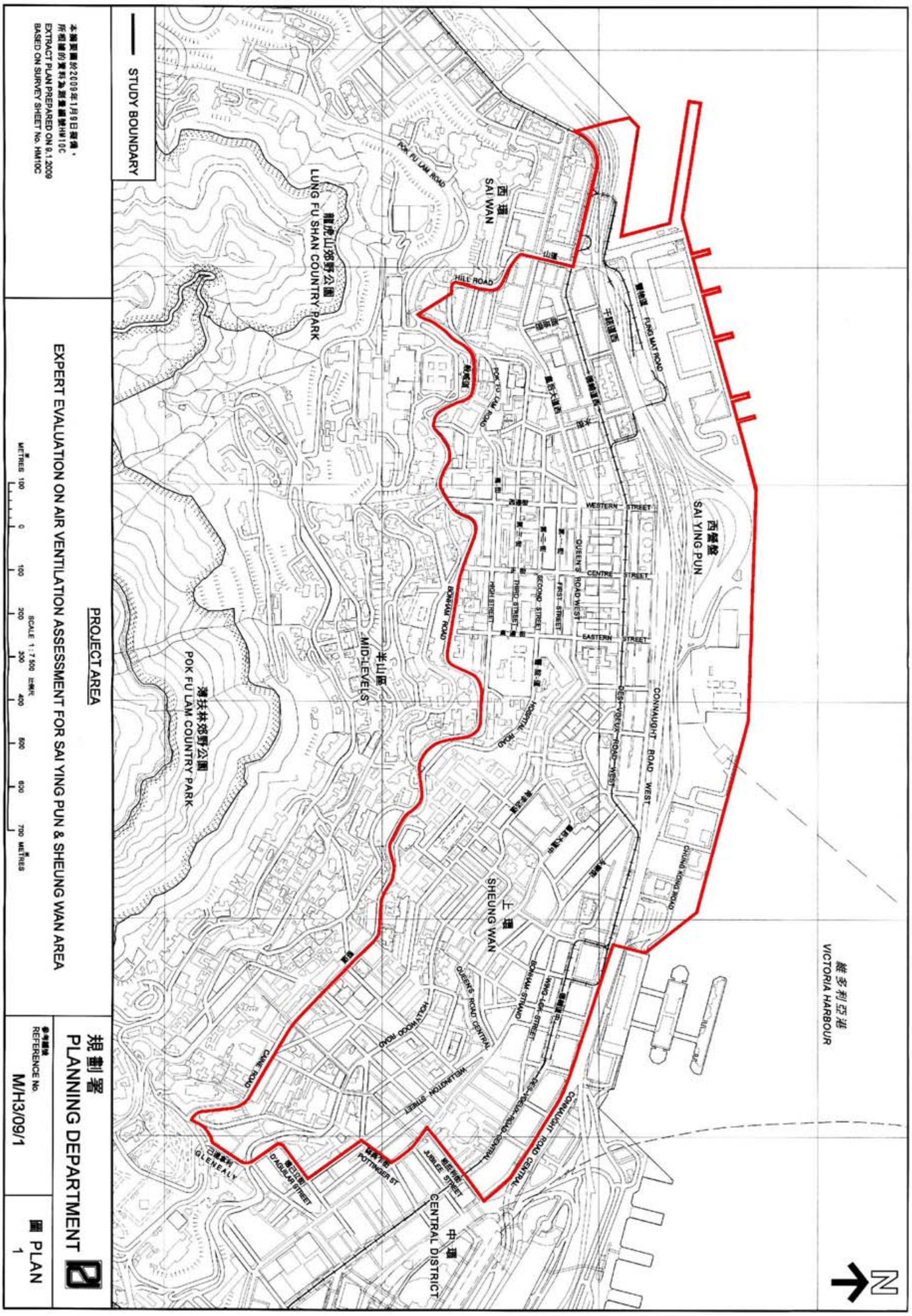
by Professor Edward Ng
School of Architecture, CUHK, Shatin, NT, Hong Kong
T: 26096515 F:26035267
E: edwardng@cuhk.edu.hk W: www.edwardng.com

The Study Area



Expert Evaluation Report
of Sai Ying Pun and Sheung Wan Area

Executive Summary

0.1 Wind Availability

(a) The annual prevailing wind of the Sai Ying Pun and Sheung Wan Area (the Area) is mainly from the East and North-East. The summer wind is mainly coming from the East and the Southerly quarters.

0.2 Existing Conditions

(a) The Area has high building volume and building site coverage is high. There is a few large open spaces acting as "air spaces" and streets are narrow. The air ventilation on the whole is poor.

(b) Tall buildings occupying full frontage along waterfront obstruct winds from the Harbour coming into the inland area. There are few direct north-south air paths of the Area meaning that it is difficult for winds from the waterfront to reach the inland areas.

(c) Tall and closely packed buildings of the Central District obstruct winds from the east. The main streets and roads that are parallel to the easterly wind flow, such as, Des Voeux Road West, Queen's Road West, Second Street and High Street are air paths of the Area. However, they are not straight in alignment and rather narrow their efficacy, as air paths, is not high.

(d) Summer winds from the south and the south-west are weakened over the developments in the adjacent district in the Mid-levels West, and the weakened air paths are unable to direct the useful southerly summer winds from reaching the Area effectively.

(e) "Air spaces" like the former Central Police Station Compound; former Police Married Quarters site in Hollywood Road; the collection of Caine Road Garden, Caine Land Garden and Blake Garden; Hollywood Road Park; and King George V Memorial Park are very useful to the Area and should be kept and enhanced with greenery.

(f) The Area is under great redevelopment pressure. Care must be exercised with further potential re-development so as not to worsen air ventilation in the area. Mitigation measures must be considered and implemented for all new developments.

0.3 The Initial Planned Scenario

(a) Further re-development will increase the building volume with tall and bulky buildings occupying the entire area. This will result in higher building height to street width ratio (H/W) and will further worsen the air ventilation of the Area. This is not recommended without suitable mitigation measures.

(b) The stepped height concept of the Initial Planned Scenario would result in very deep and extensive street canyons – in the order of 10:1. Without corresponding mitigation measures to alleviate the situation, the air ventilation would be further deteriorated.

(c) Buildings along the waterfront must not occupy the entire site frontage. A 20-30% non-building area (NBA) / permeability is recommended.

(d) All north-south streets and lanes from Connaught Road West southwards must be widened.

(e) For better air ventilation in the east-west directions, it is suggested that Queen's Road West and Queen's Road Central be widened, if feasible. In addition, Bonham Strand and Hollywood Road in Sheung Wan are suggested to be similarly widened, if feasible.

(f) North-south air paths (red lines in Figure 6.6) that extend southwards from the waterfront to form a north-south through route and connect with major "air spaces" are useful for better ventilation.

(g) The "Government, Institution and Community" ("G/IC") and "Open Space" ("O") zones along the air paths are important providing air spaces to the study area and enhance the efficacy of the air paths. They must be maintained and enhanced with greenery. Further greening and tree planting is necessary and strongly recommended.

(h) Major "Air spaces" like the former Central Police Station Compound; former Police Married Quarters site in Hollywood Road; the collection of Caine Road Garden, Caine Land Garden and Blake Garden; Hollywood Road Park; and King George V Memorial Park should be kept and enhanced. Further greening and tree planting is necessary.

(i) Consider pedestrianisation to provide a few green corridors for pedestrian traversing the area.

0.4 The Revised Scenario

In response to the expert evaluations of the initial planned scenario, a revised scenario is proposed by the Planning Department. A number of suggested improvement measures illustrated and listed below have been incorporated in formulating the BH restrictions and to address the air ventilation issues earlier identified. The revised scenario is further evaluated below:

(1) Where there are already development restrictions (GFA, plot ratio and building height restrictions), they are not relaxed.

Evaluation: The existing allowable permissible GFA and plot ratio for "C" and "R(A)" developments are already high, (Figure 5.11 and 6.4). Not further relaxing them is only alternative practical compromise.

(2) All open spaces/green areas are maintained and majority of G/IC facilities is restricted to the existing height.

Evaluation: This improvement is in accordance with section 5.6.6 (i): The "GIC" and "O" zones in the Area should be respected. They provide useful "lungs" of air spaces in the Area. They should not be further developed with tall buildings or re-zoned for bulky development. This would ensure that the existing useful air spaces "lungs" are kept intact.

(3) Important "Air Spaces" including the former Central Police Station Compound, former Police Married Quarters site at Hollywood Road, Caine Road Garden and Caine Lane Garden; Blake Garden; Hollywood Road Park; and King George V Memorial Park have been kept.

Evaluation: This improvement is in accordance with the section 5.1.1: The study area has a few large open spaces acting as "air spaces" where air ventilation can be relieved given the dense urban morphology (Figure 5.1). They are very useful air spaces to the Area. Wake interference and isolated roughness flows (Figure 5.3) are possible bringing air into the pedestrian level.

(4) A stepped height concept with progressive increase towards uphill directions has been adopted taken the topography into consideration.

Evaluation: As mentioned in section 5.3.7, given that the buildings in many of the study areas are already tall, the street canyons are already deep, changing building heights a little bit one way or another would not matter ground level air ventilation that much. In this case, the most effective way to improve air ventilation is to introduce gaps. A variation of 20m in height would make little difference for the air ventilation issues.

(5) All existing north-south streets/lanes have been maintained. All new developments/redevelopments abutting major north-south roads/streets/lanes will be imposed with a 2m wide set-back requirement from the lot boundary above 15m measured from mean street level to create wider north-south air paths for better ventilation and visual permeability.

Evaluation: This improvement is in line with the recommendation in sections 6.3.1(b) & (d). It is suggested that they be widened 30-50% to rough compensate the ill-effects of future taller buildings. Should this be not practically feasible, a "second best" alternative is to impose "NBA" or building setback/gap/separation

on top of the 15m podium level. The introduction of set-back above podium level by a minimum of 2m abutting major north-south streets is useful in enhancing the north-south air paths for better air ventilation.

(6) Future developments are encouraged to adopt suitable design measures to minimize any possible adverse impacts. These include greater permeability of podium, wider gap between buildings, non-building area to create air/wind path, perforate building towers and podium designs, positioning of building towers to align with the prevailing wind directions, as appropriate.

Evaluation: This improvement is in line with the recommendations in section 5.6.6(iii). Should the encouraged design measures be implemented, it will help to improve the air ventilation of the Area.

(7) Individual development in the northern part near the waterfront when redeveloped is encouraged not to occupy the entire site frontage for better penetration of sea breeze into the urban core especially during calm background wind conditions when the sea breezes are useful.

Evaluation: This improvement is in line with the recommendations in section 6.3.1(a). The NBA should ideally start from the ground level. Should this be not practically feasible, a "second best" alternative is to provide the "NBA" or "building gap/separation" above 15m podium level (measured from the mean function level) and upwards. Should the encouraged design measures be implemented, it will help to improve the air ventilation of the area.

(8) Existing narrow roads/streets and foot paths in the SOHO and immediate adjoining area subject to traffic constraints will be widened to enhance the pedestrian/traffic movements as well as air ventilation.

Evaluation: This measure, if implemented, is useful for air ventilation.

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Expert Evaluation Report of **Sai Ying Pun and Sheung Wan Area**

1.0 The Assignment

1.1 In order to provide better planning control on the building height upon development/redevelopment, the draft Sai Ying Pun & Sheung Wan Outline Zoning plan (OZP) (the Plan) is being reviewed with a view to incorporating appropriate development restrictions in the Notes for various development zones of the OZP to guide future development/redevelopment. It is considered necessary to conduct an expert evaluation to assess the preliminary air ventilation impacts of the proposed building height restrictions.

1.2 This expert evaluation report is based on the materials given by Planning Department to the Consultant including:

- existing building height (in mPD & absolute height) for Sai Ying Pun & Sheung Wan Area
- proposed building height restrictions (in mPD) for Sai Ying Pun & Sheung Wan Area
- committed projects and planned projects
- aerial photos of Sai Ying Pun & Sheung Wan Area
- spot heights in Sai Ying Pun & Sheung Wan Area
- OZPs covering H3 (Sai Ying Pun & Sheung Wan) and H11 (Mid-levels West)

1.3 The consultant has studied the above mentioned materials, and has conducted site inspection. During the writing of the report, the consultant has working sessions with colleagues at Planning Department.

2.0 Background

2.1 Planning Department's study: "Feasibility Study for Establishment of Air Ventilation Assessment System" has recommended that it is important to allow adequate air ventilation through the built environment for pedestrian comfort.

2.2 Given Hong Kong's high density urban development, the study opines that: "more air ventilation, the better" is the useful design guideline.

2.3 The study summarizes 10 qualitative guidelines for planners and designers. For the OZP level of consideration, breezeways/air paths, street grids and orientations, open spaces, non-building areas, waterfront sites, scales of podium, building heights, building dispositions, and greeneries are all important strategic considerations.

2.4 The study also suggests that Air Ventilation Assessment (AVA) be conducted in 3 stages: Expert Evaluation, Initial Studies, and Detailed Studies. The suggestion have been adopted and incorporated into HPLB and ETWB Technical Circular no. 1/06. The key purposes of Expert Evaluation are to:

(a) Identify good design features.
(b) Identify obvious problem areas and propose some mitigation measures.
(c) Define "focuses" and methodologies of the Initial and/or Detailed studies.
(d) Determine if further study should be staged into Initial Study and Detailed Study, or Detailed Study alone.

2.5 To conduct the Expert Evaluation systematically and methodologically, it is necessary to undertake the following information analyses:

(a) Analyse relevant wind data as the input conditions to understand the wind environment of the Area.
(b) Analyse the topographical features of the Area, as well as the surrounding areas.
(c) Analyse the greenery/landscape characteristics of the Area, as well as the surrounding areas.
(d) Analyse the land use and built form of the Area, as well as the surrounding areas.

Based on the analyses:

(e) Estimate the characteristics of the input wind conditions of the Area.
(f) Identify the wind paths and wind flow characteristics of the Area through slopes, open spaces, streets, gaps and non-building areas between buildings, and low-rise buildings; also identify stagnant/problem areas, if any.
(g) Estimate the need of wind for pedestrian comfort.

Based on the analyses of the EXISTING urban conditions:

(h) Evaluate the strategic role of the Area in air ventilation term.
(i) Identify problematic areas which warrant attention.
(j) Identify existing "good features" that needs to be kept or strengthened.

Based on an understanding of the EXISTING urban conditions:

(k) Compare the prima facie impact, merits or demerits of the building height restrictions as proposed by Planning Department on Air Ventilation.
(l) Highlight problem areas, if any. Recommend improvements and mitigation measures if possible.
(m) Identify focus areas or issues that may need further studies. Recommend appropriate technical methodologies for the study if needed.

3.0 The Wind Environment

3.1 Hong Kong Observatory (HKO) stations provide useful and reliable data of the wind environment in Hong Kong (Figure 3.1). There are some 46 stations operated by HKO in Hong Kong. Together, they allow a very good general understanding of the wind environment especially close to ground level.

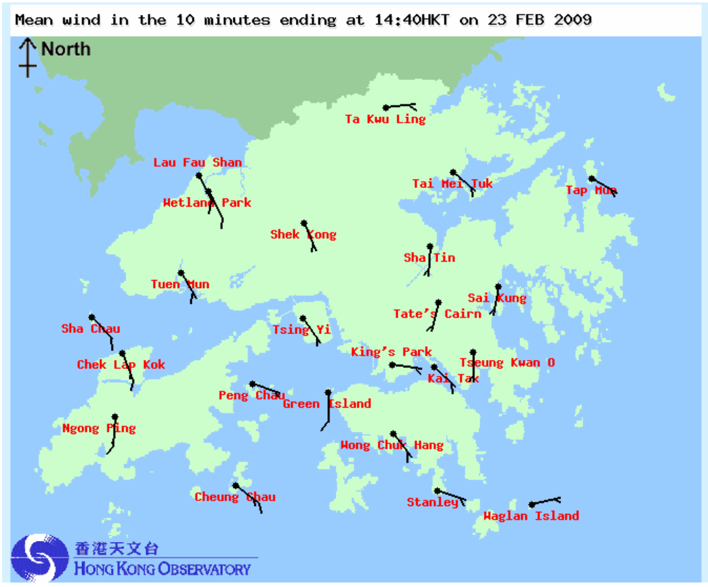

Figure 3.1 Some of the HKO stations in Hong Kong. This is a screen captured at 2:40pm on 23 Feb 2009 from the HKO website. The arrows show the wind directions and speeds of the time.

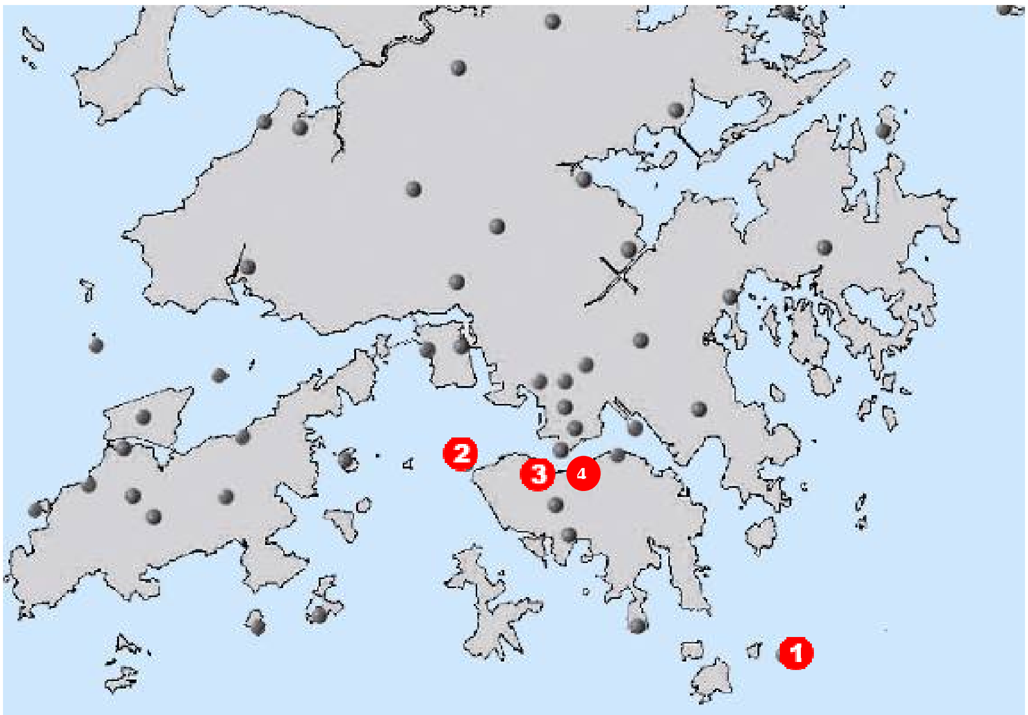

Figure 3.2 The HKO stations at 1: Waglan Island (WGL), 2: Green Island (GI), 3: Central (Star Ferry Pier) and 4: Central Plaza.

3.2 The HKO station at Waglan Island (WGL) is normally regarded by wind engineers as the reference station for wind related studies (Figure 3.3). The station has a very long measuring record, and it is unaffected by Hong Kong's complex topography [unfortunately, it is known not to be able to capture the thermally induced local wind circulation like sea breezes too well]. Based on WGL wind data, studies are typically employed to estimate the site wind availability taking into account the topographical features around the site.

3.3 Examining the annual wind rose of WGL, it is apparent that the annual prevailing wind in Hong Kong is from the East. There is also a major component of wind coming from the North-East; and there is a minor, but nonetheless observable component from the South-West. Around 70% of the time, WGL has weak to moderate wind (0.1m/s to 8.2 m/s).

3.4 For the study, it is important to understand the wind environment seasonally or monthly (Figure 3.4 and 3.5). In the winter months of Hong Kong, the prevailing wind comes from the North-East. In the summer months, they come from the South-West. As far as AVA is concerned, in Hong Kong, the summer wind is very important and beneficial to thermal comfort. Hence, based on WGL data, it is very important to plan our city, on the one hand, to capture the annual wind characteristics, and on the other hand, to maximize the penetration of the summer winds (mainly from the South-West) into the urban fabric.

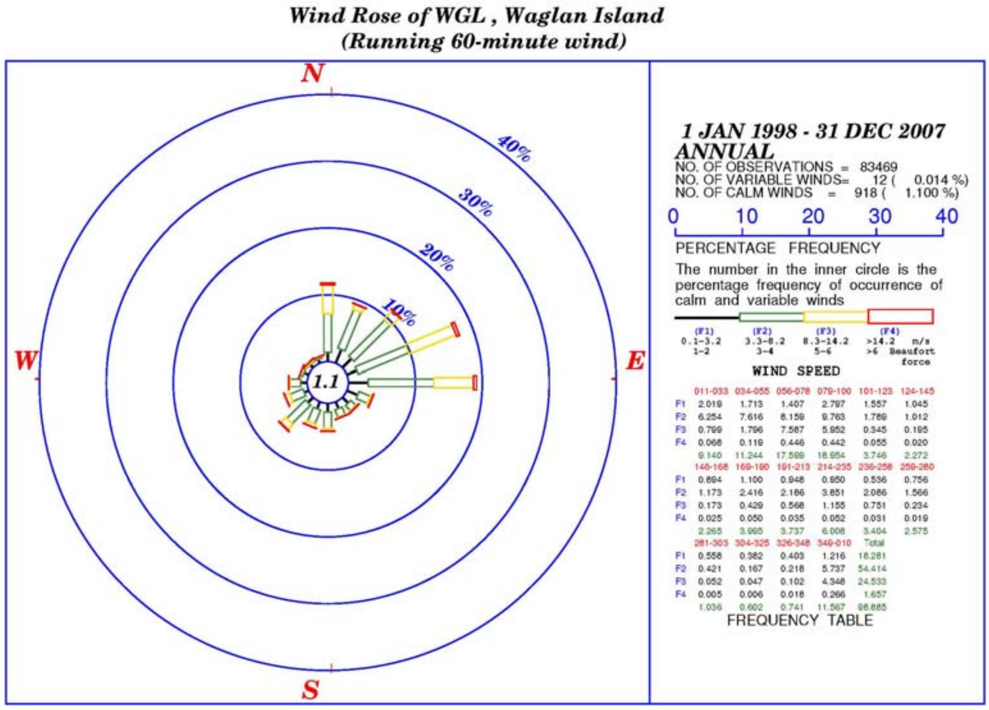

Figure 3.3 Wind rose of WGL 1998 – 2007[1] (annual)

[1] Wind data in 1998 – 2007 are the latest available 10-year data from HKO to the consultant.

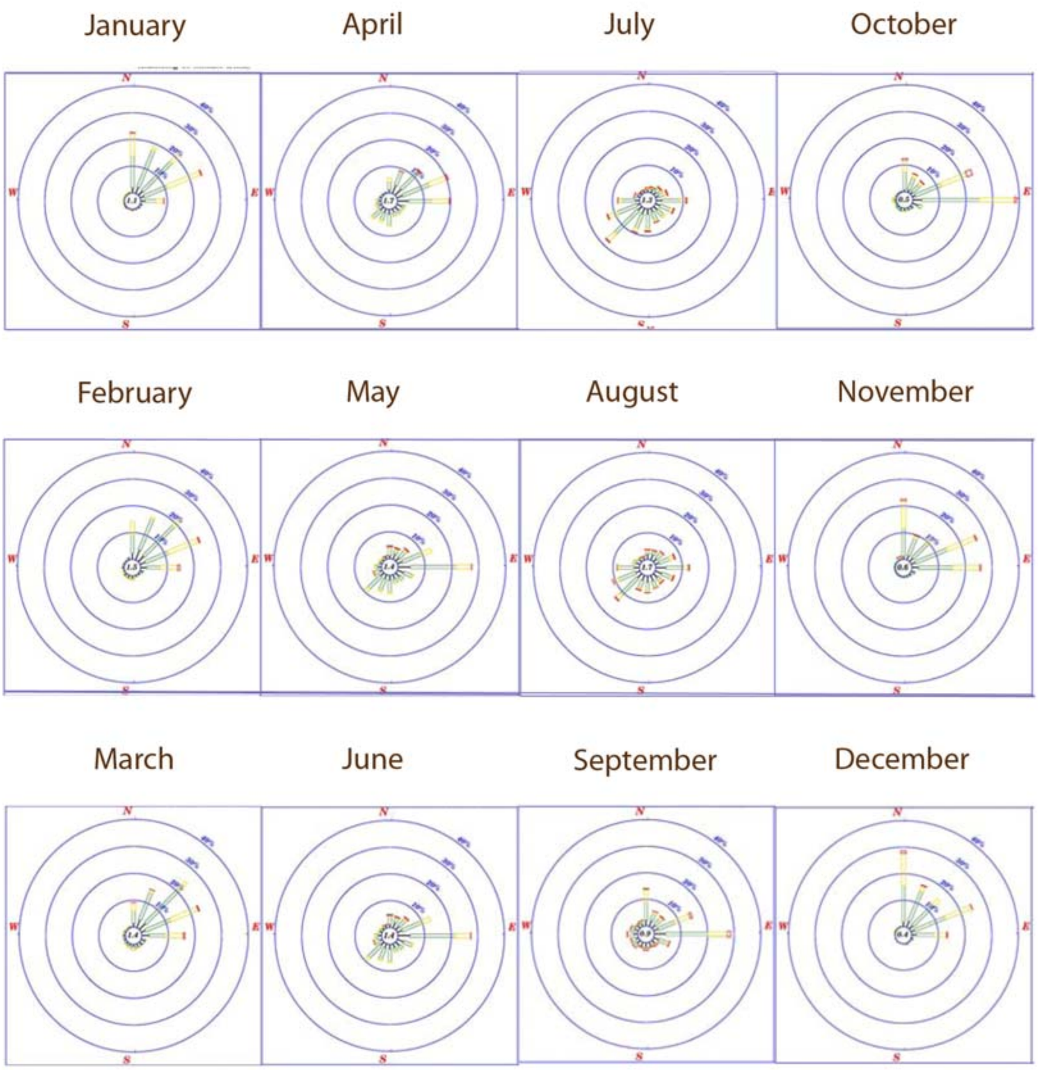

Figure 3.4 Monthly wind roses of WGL 1998 – 2007

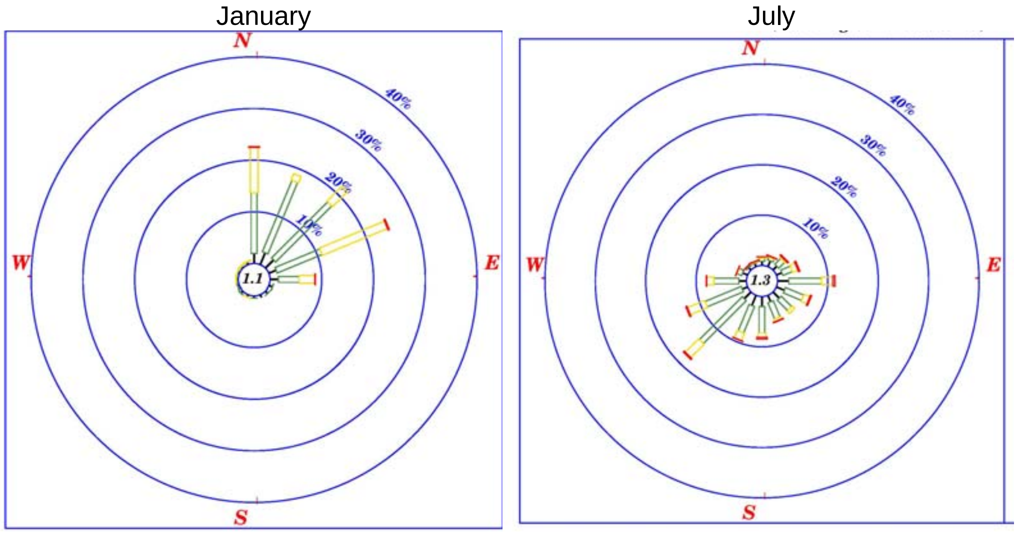

Figure 3.5 Wind roses of WGL 1998 – 2007 (Jan and July)

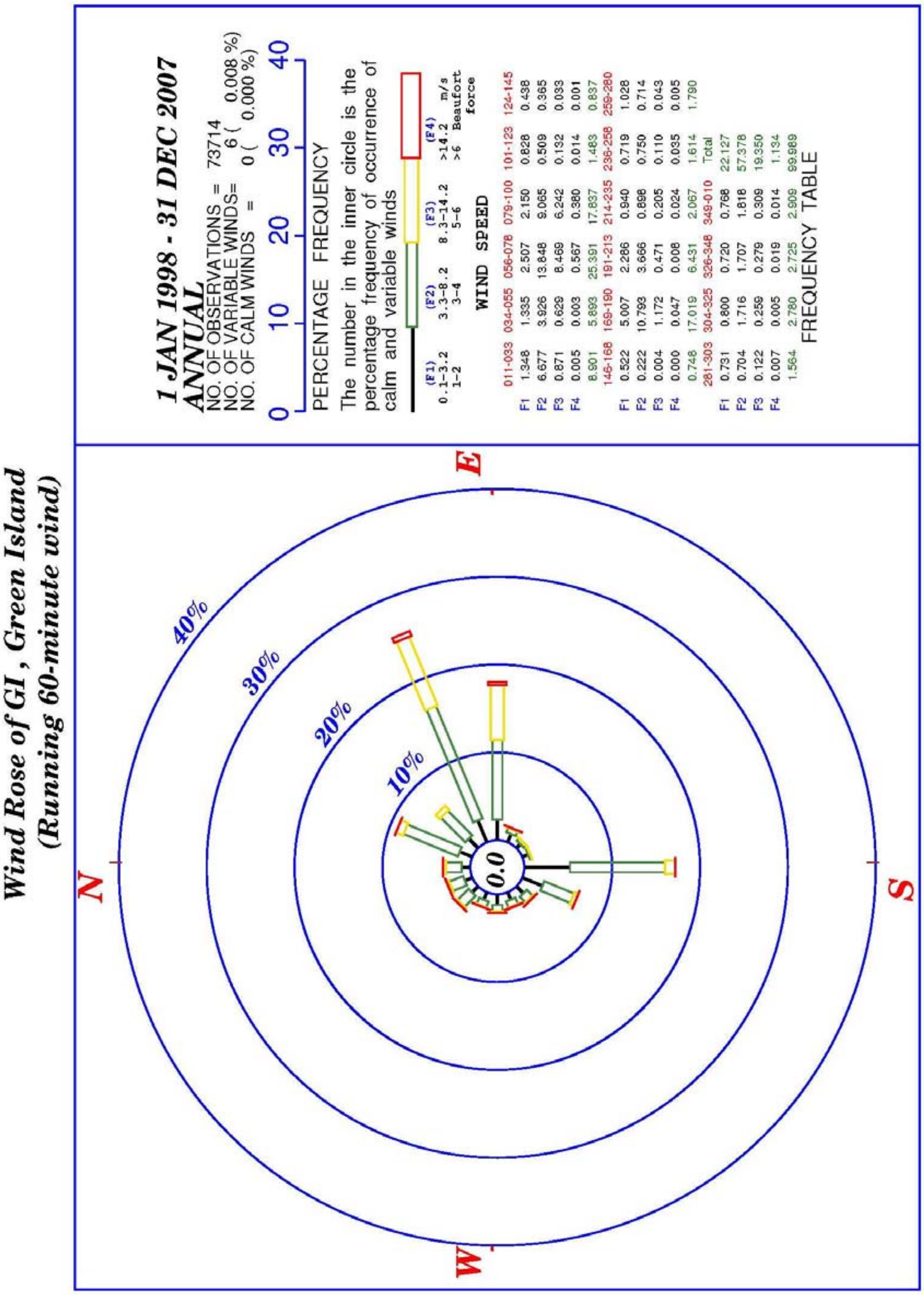

Figure 3.6 Wind rose of Green Island 1998-2007 (annual)

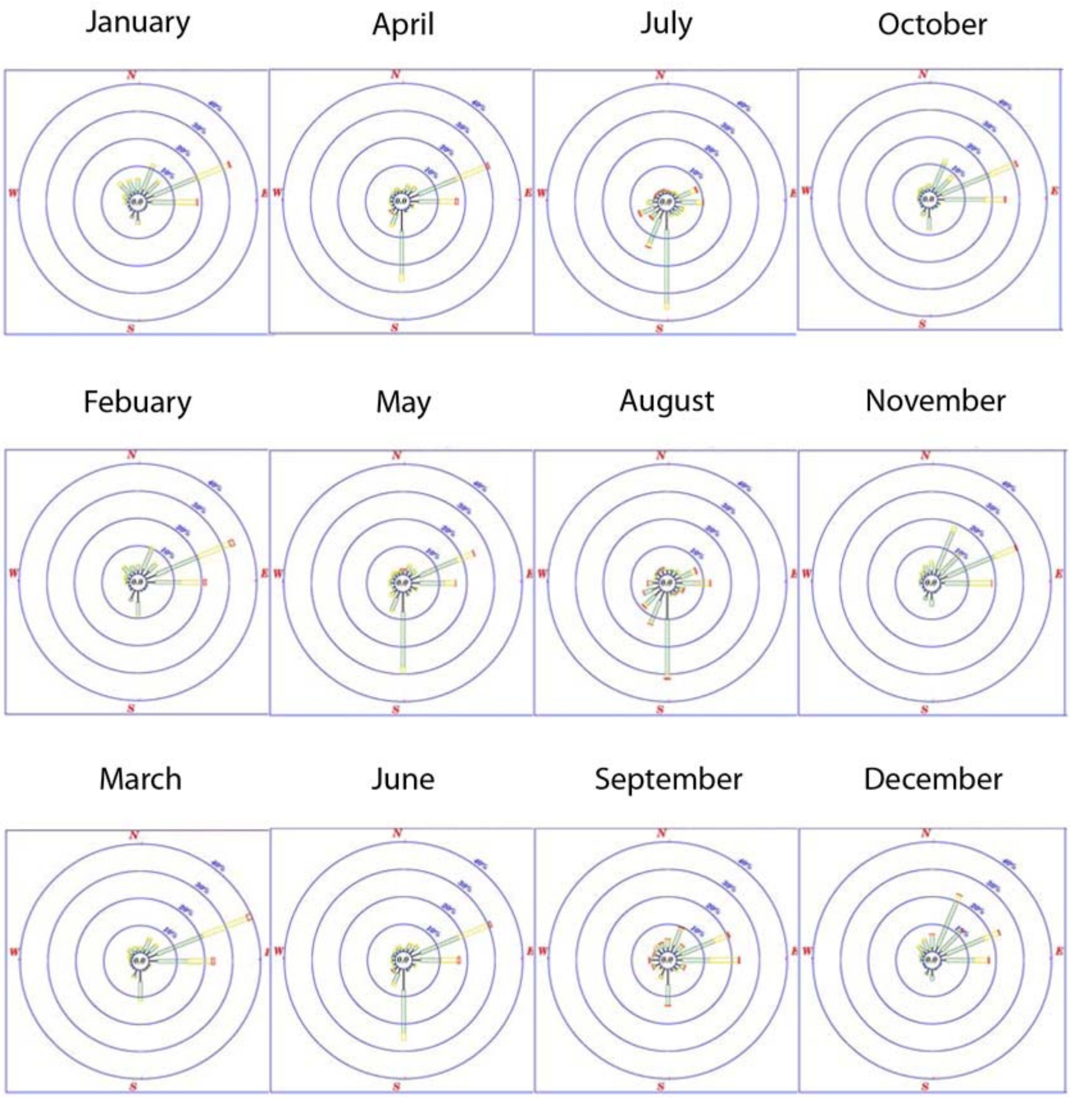

Figure 3.7 Monthly wind roses of Green Island 1998 – 2007

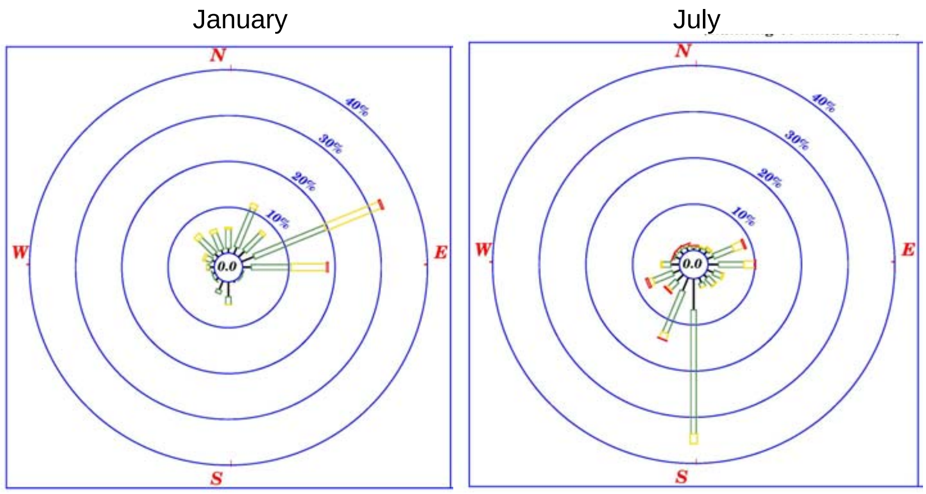

Figure 3.8 Wind roses of Green Island 1998 – 2007 (Jan and July)

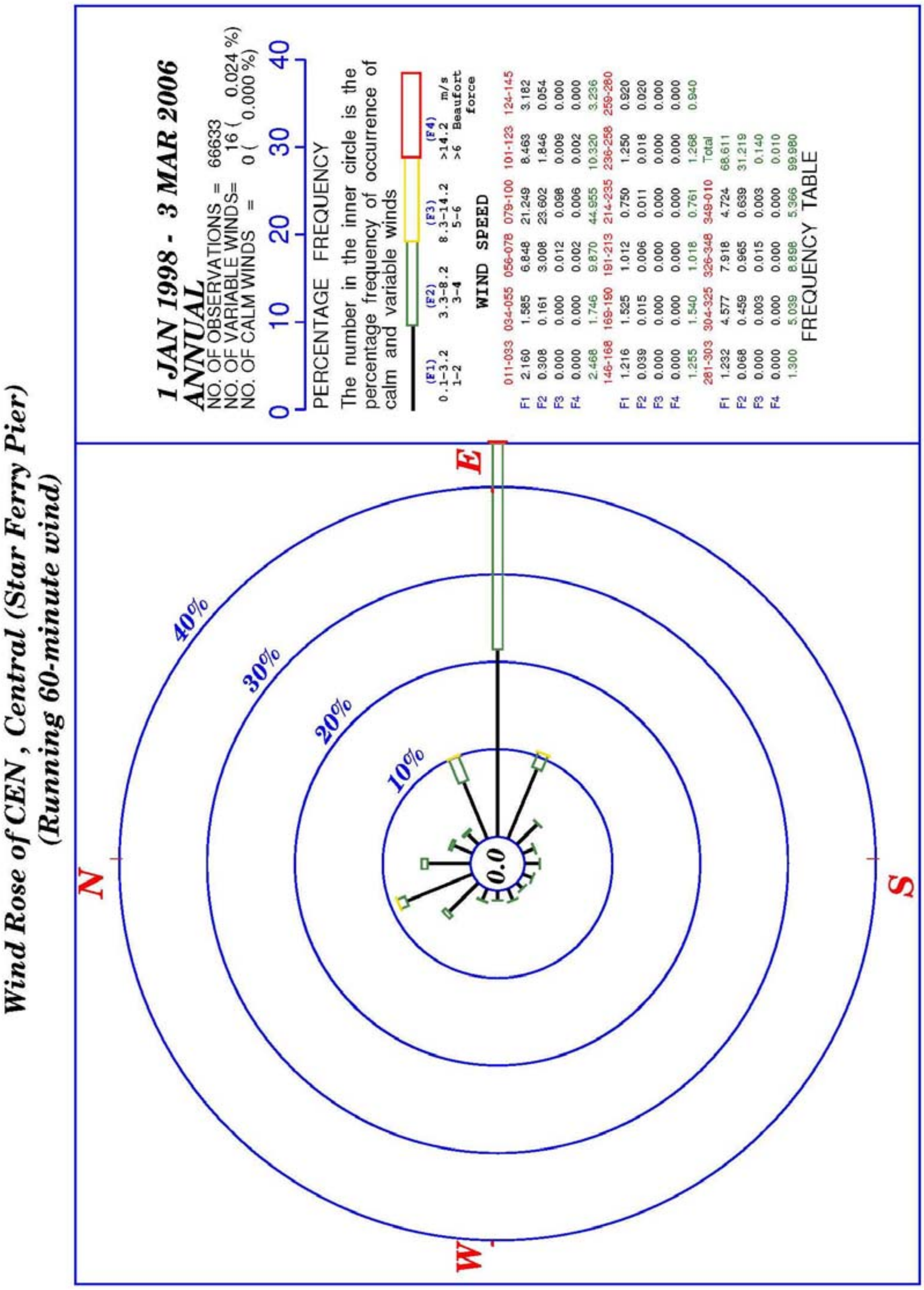

Figure 3.9 Wind rose of Central (Star Ferry Pier) 1998-2007 (annual)

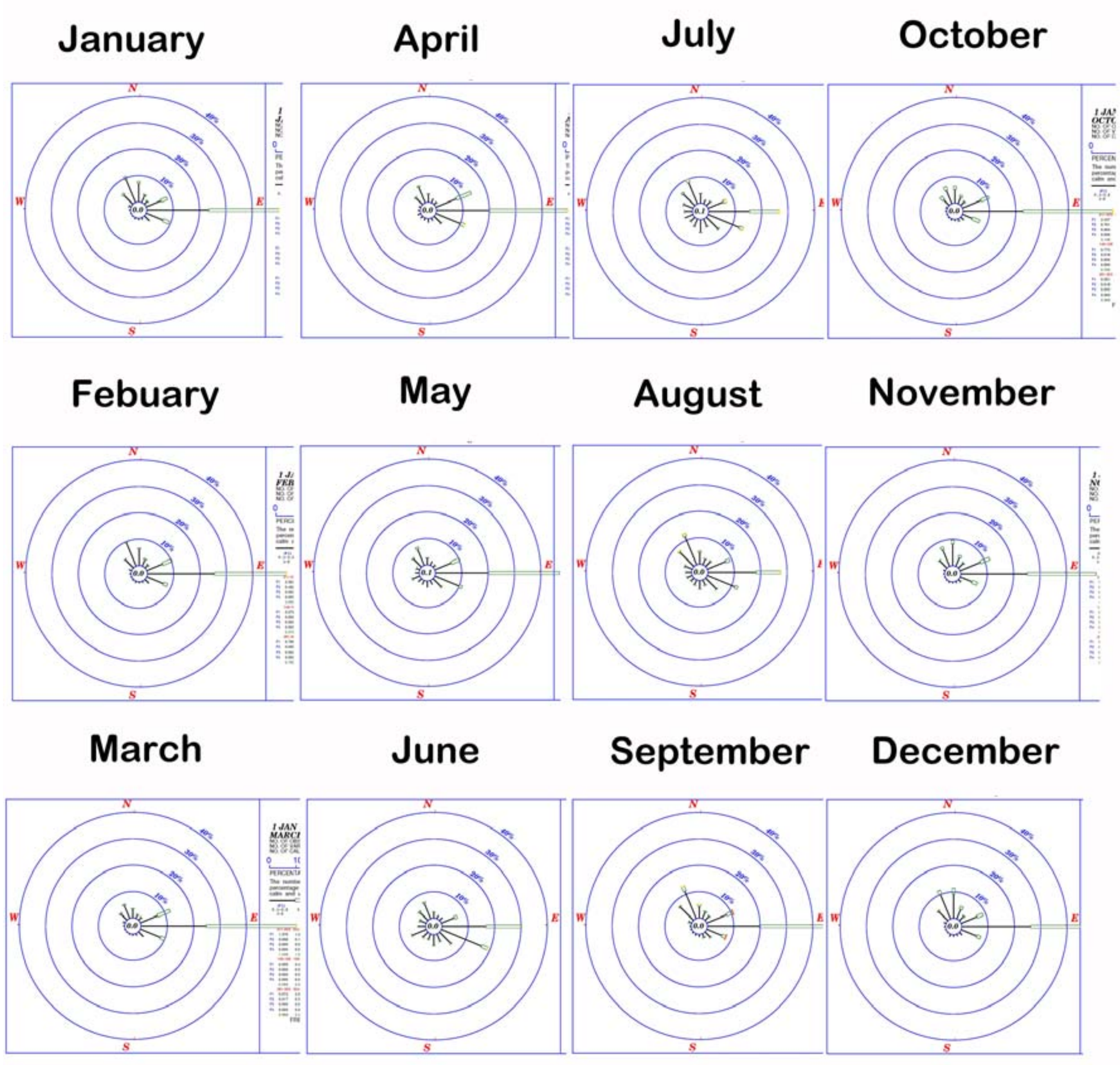

Figure 3.10 Monthly wind roses of Central (Star Ferry Pier) 1998 – 2007

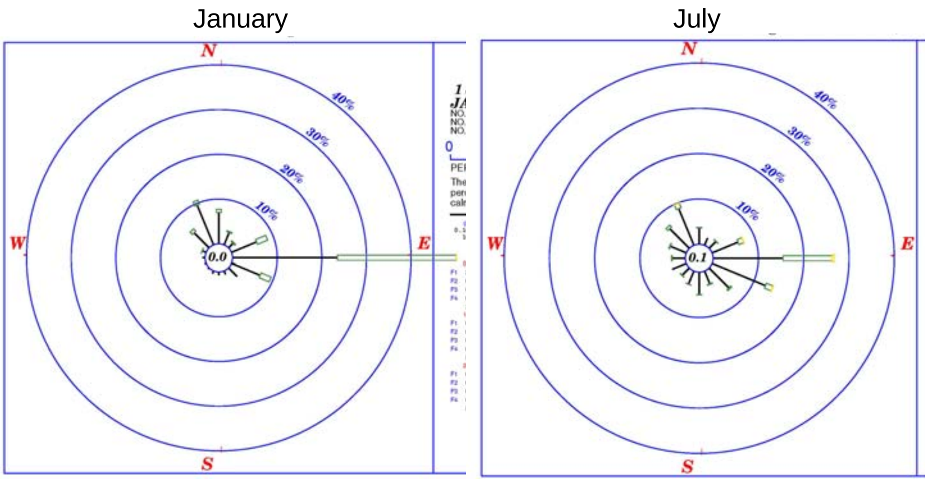

Figure 3.11 Wind roses of Central (Star Ferry Pier) 1998 – 2007 (Jan and July)

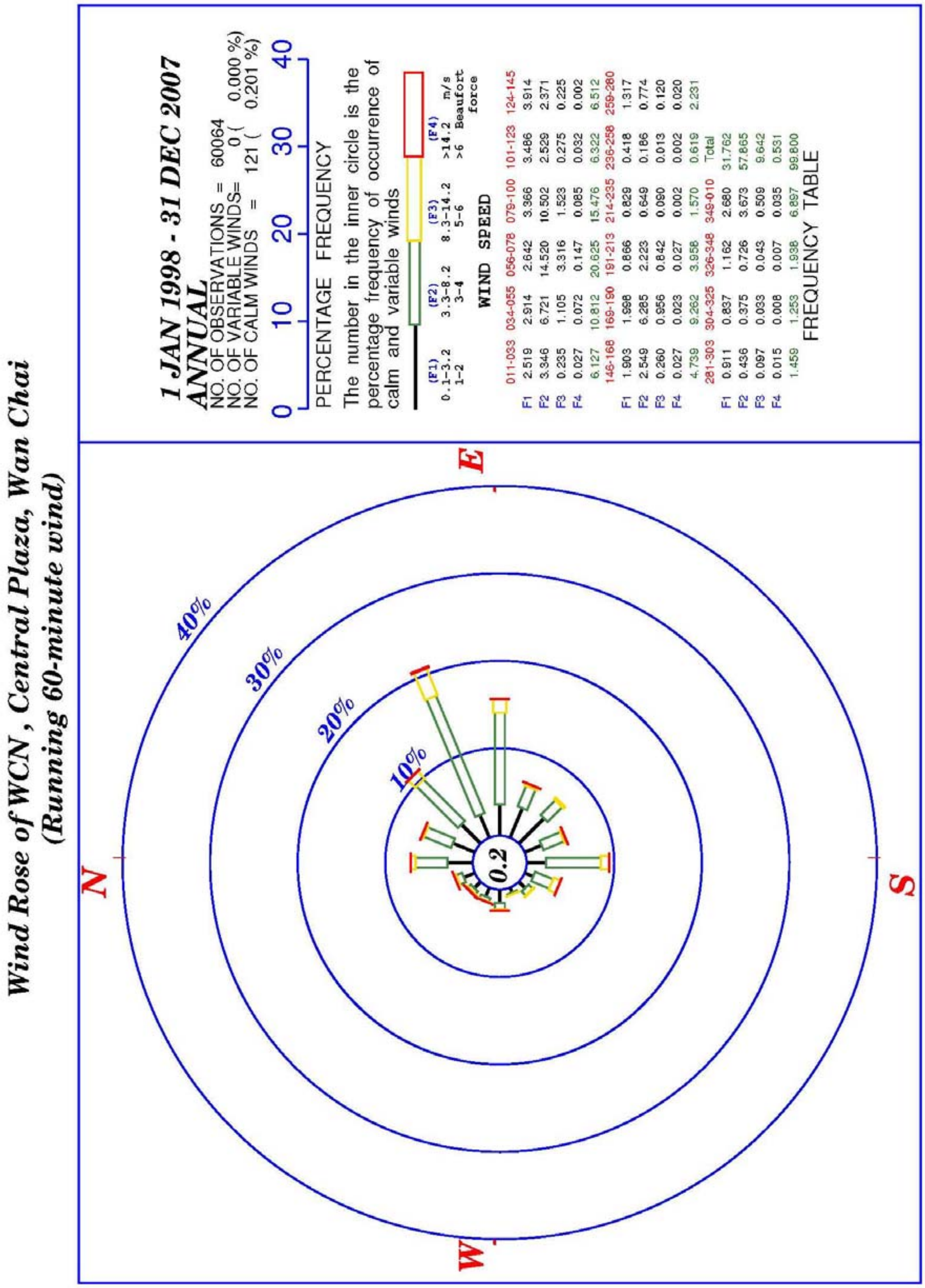

Figure 3.12 Wind rose of Central Plaza 1998-2007 (annual)

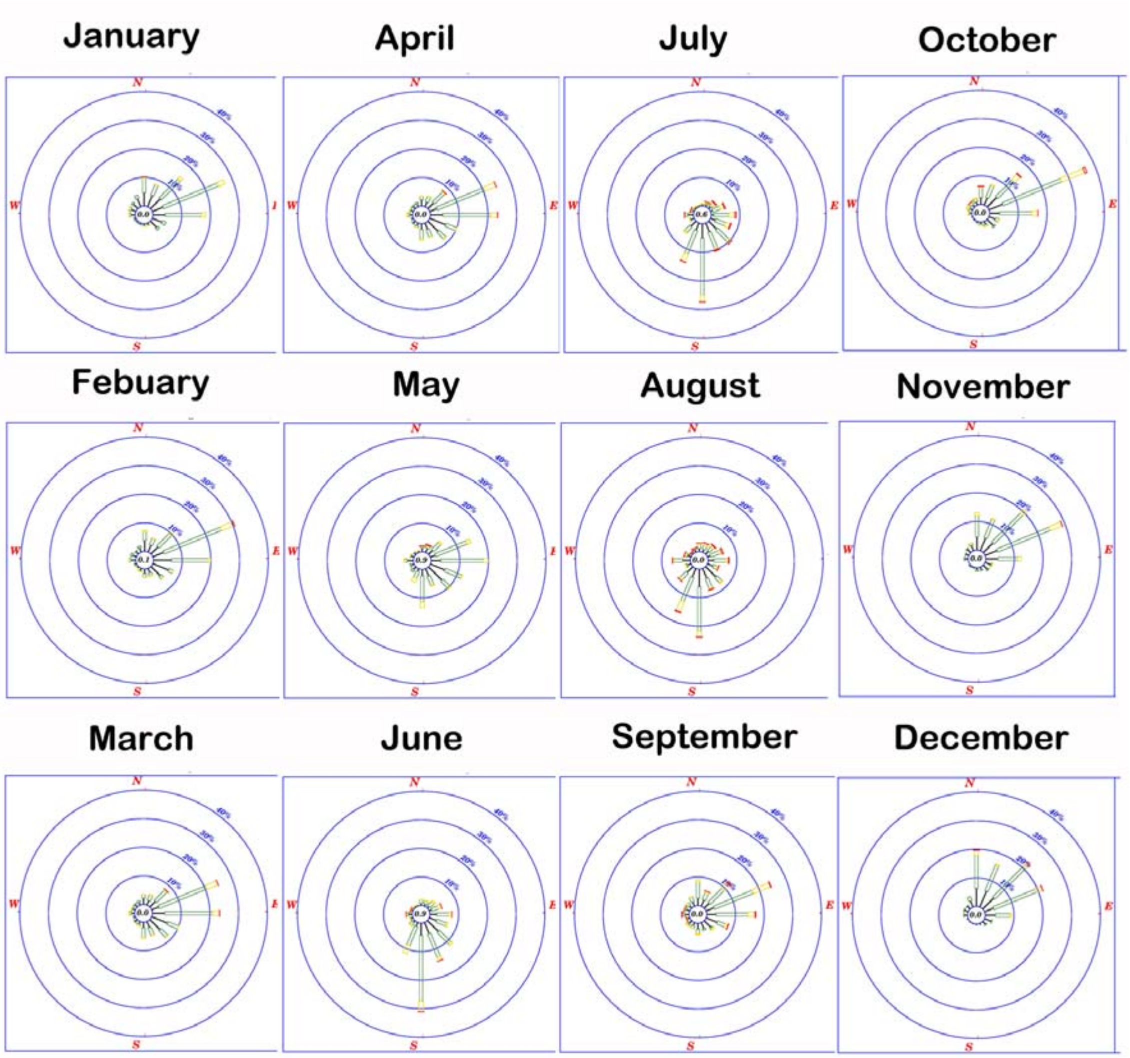

Figure 3.13 Monthly wind roses of Central Plaza 1998 – 2007

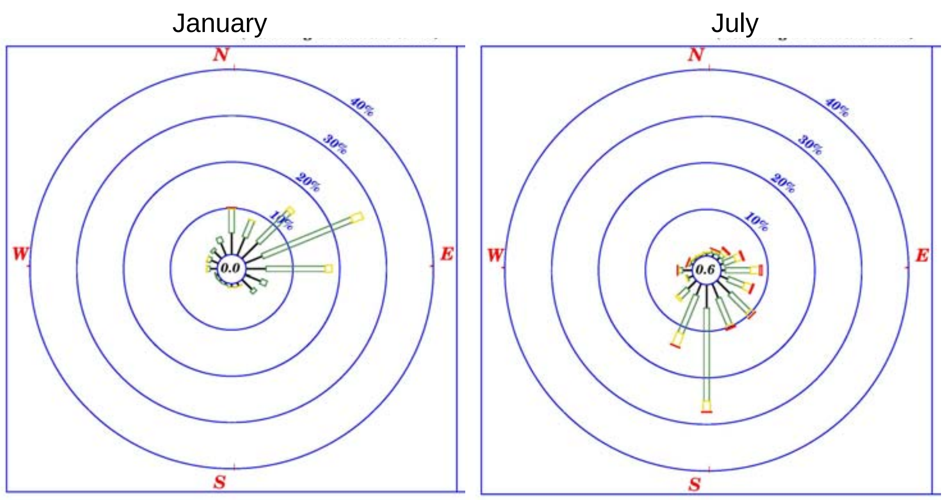

Figure 3.14 Wind roses of Central Plaza 1998 – 2007 (Jan and July)

3.5 Hong Kong University of Science and Technology (HKUST) have simulated a set of wind data using MM5. The data period covers the whole year of 2004. Based on this dataset, 4 locations of the Area are extracted at 120m and 450m above ground (Figures 3.15 to 3.23). These 4 locations, according to the theories of MM5, are selected to reflect the general wind pattern within the study area induced by topography. The altitude of 450m can be assumed to represent the atmospheric boundary layer (ABL) wind characteristics which gives good indication of the free wind of the area. The 120m height can represent urban canopy layer (UCL) wind characteristics and the UCL data is useful to account for topographical effects.

Figure 3.15 The 4 locations of MM5 extracted data

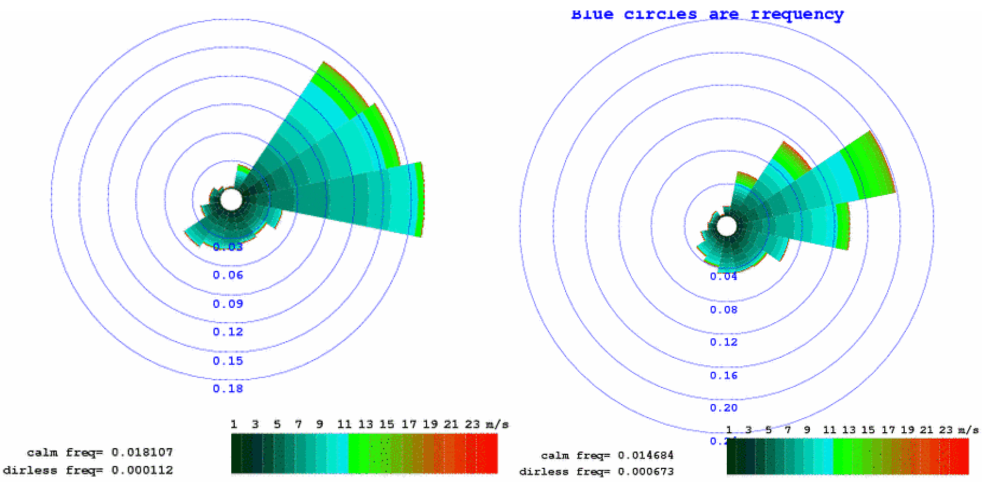

Figure 3.16 Wind roses (annual) at A (left:120m) (right:450m)

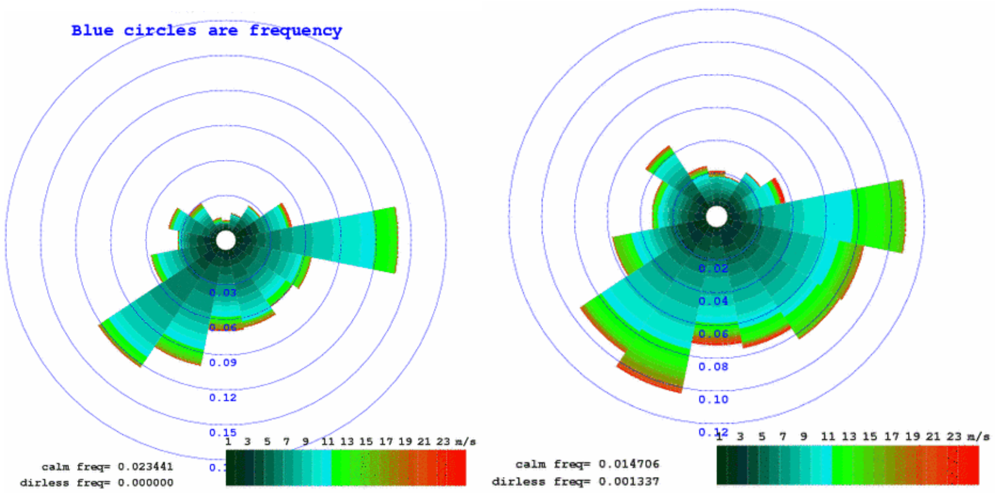

Figure 3.17 Wind roses (summer) at A (left:120m) (right:450m)

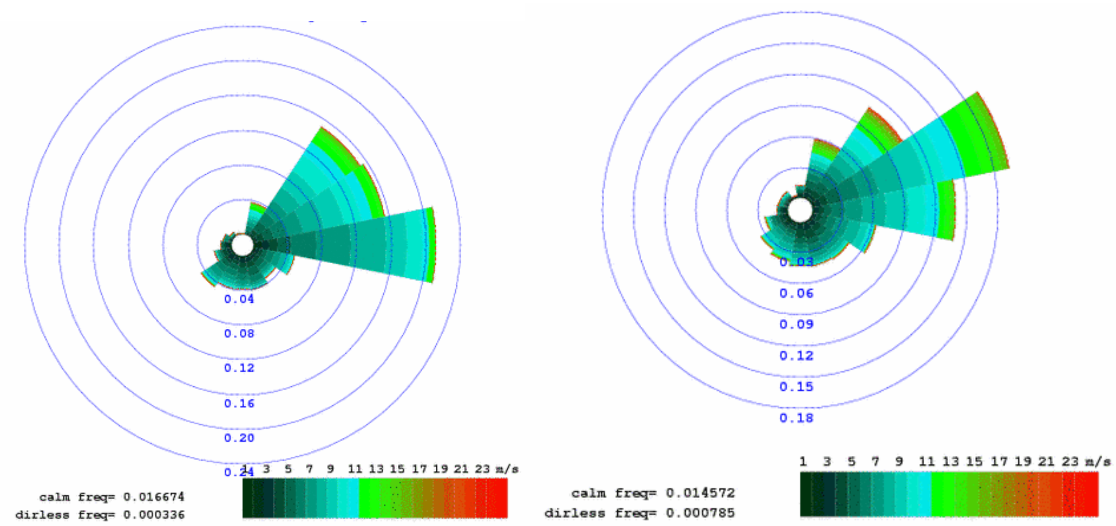

Figure 3.18 Wind roses (annual) at B (left:120m) (right:450m)

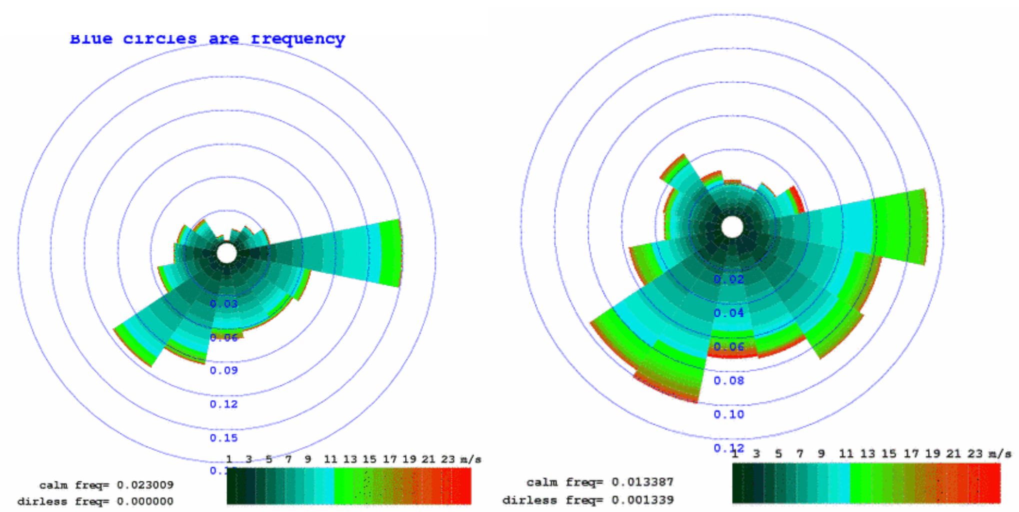

Figure 3.19 Wind roses (summer) at B (left:120m) (right:450m)

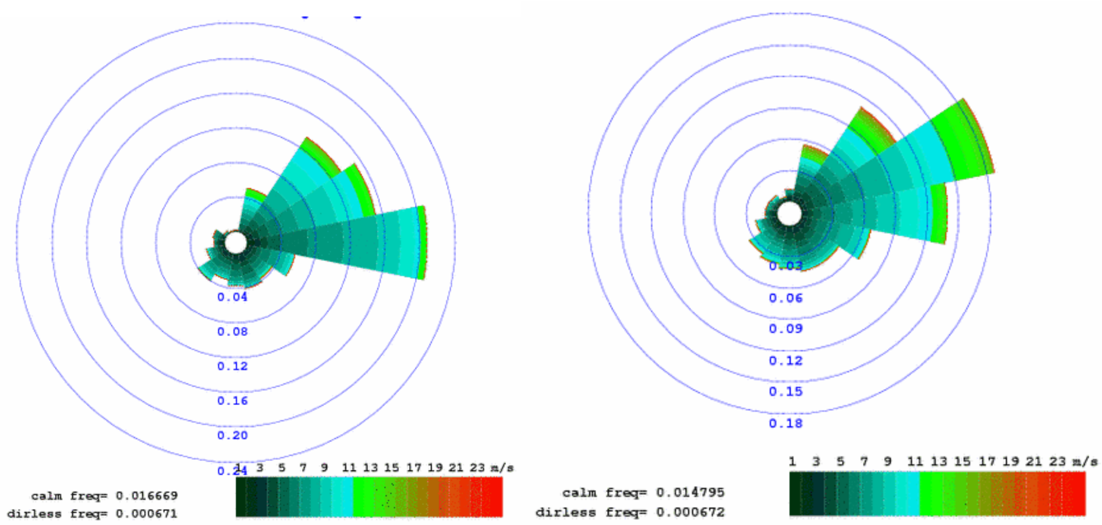

Figure 3.20 Wind roses (annual) at C (left:120m) (right:450m)

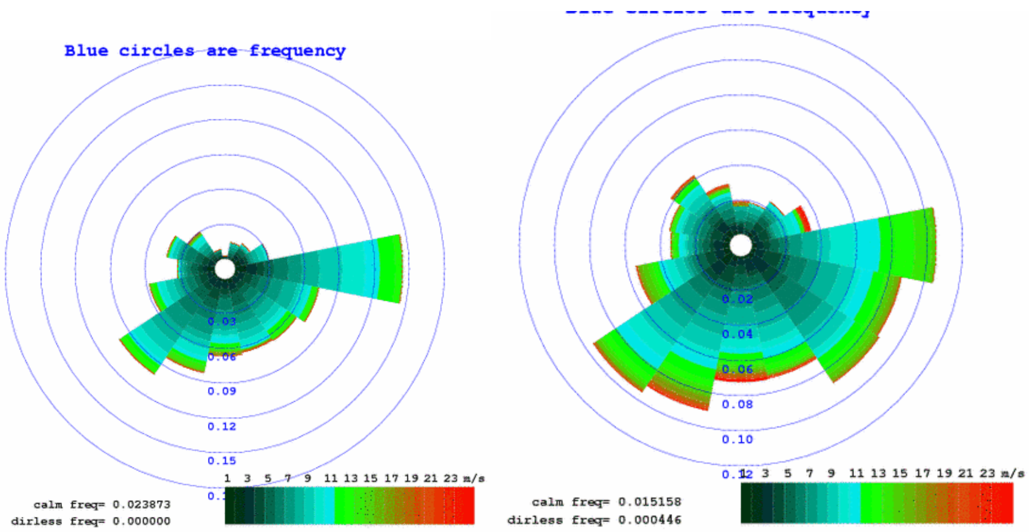

Figure 3.21 Wind roses (summer) at C (left:120m) (right:450m)

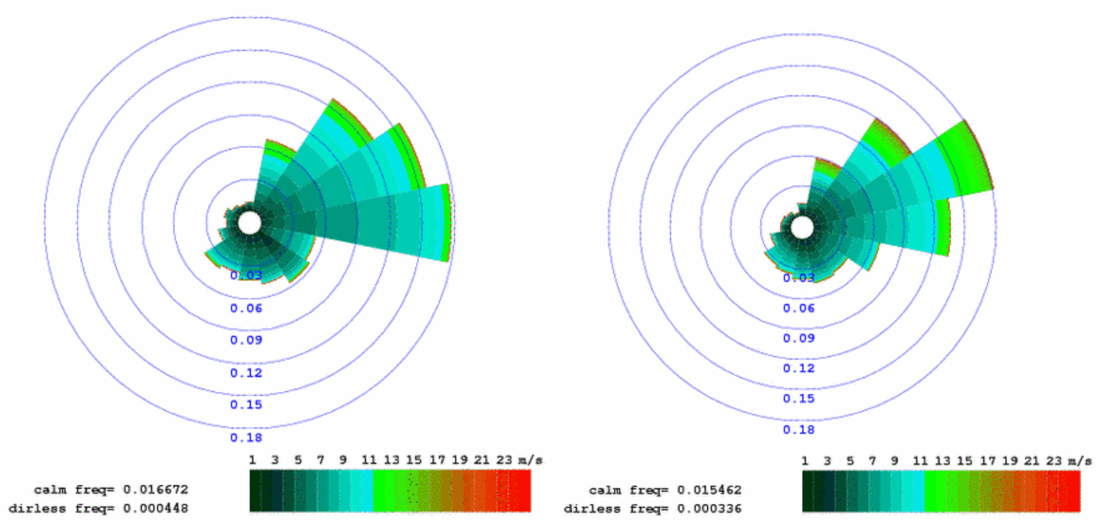

Figure 3.22 Wind roses (annual) at D (left:120m) (right:450m)

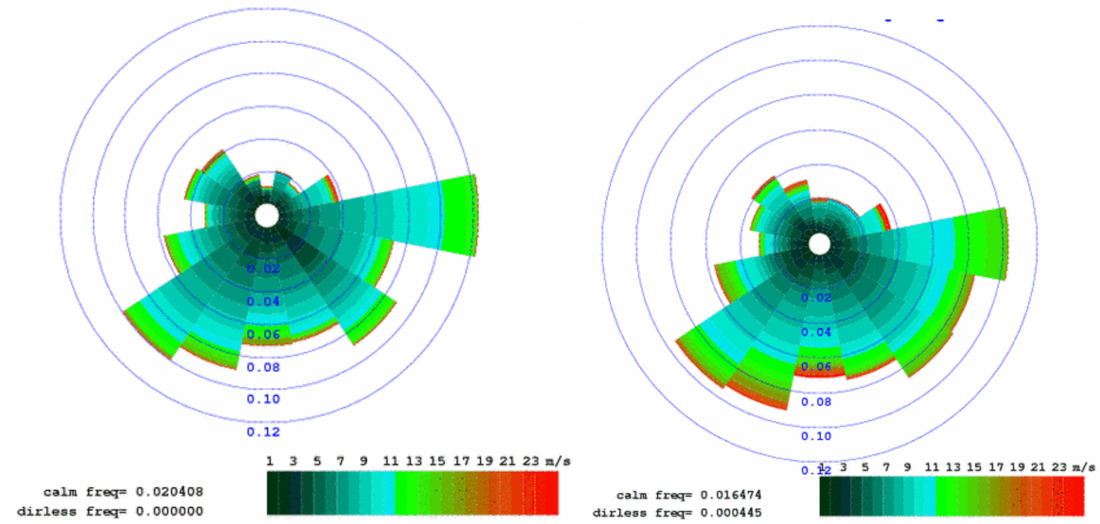

Figure 3.23 Wind roses (summer) at D (left:120m) (right:450m)

3.6 Extracted from the simulated MM5 data, a general understanding of the summer and the annual prevailing wind directions of the Study Area and the surroundings are indicated in Figure 3.24 and 3.25.

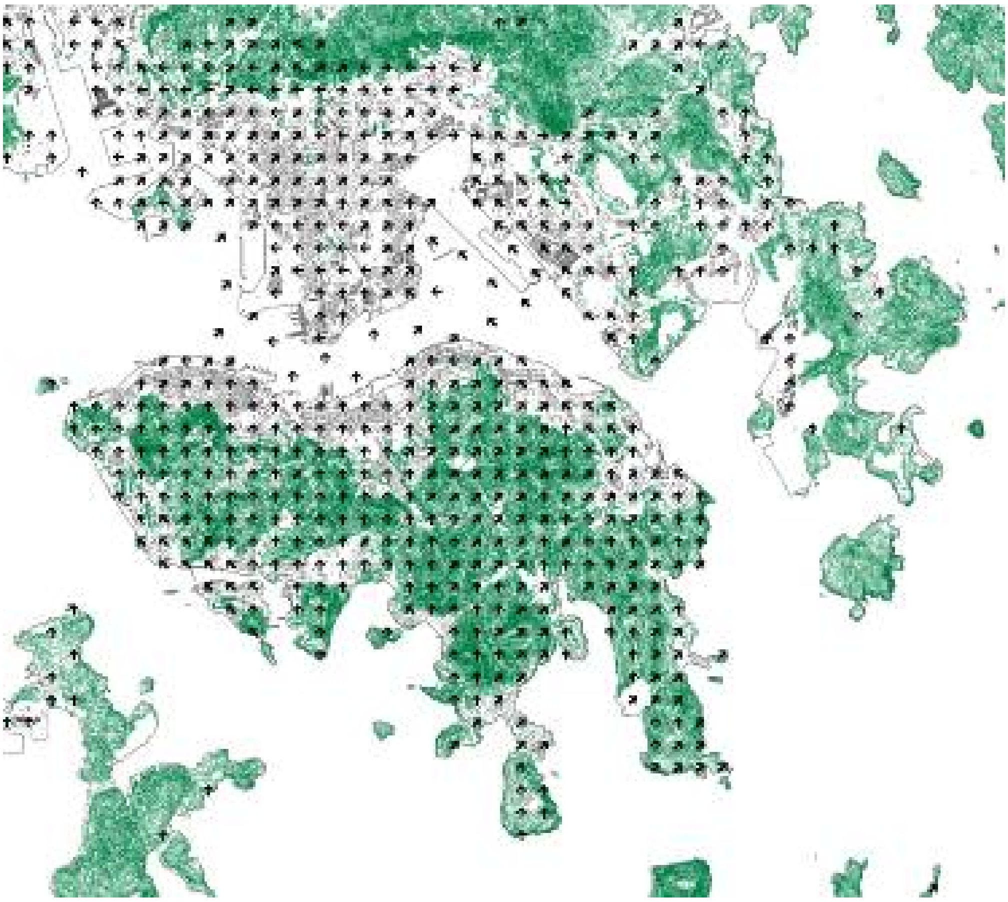

Figure 3.24 Prevailing wind directions of the summer months (Jun-Aug) based on MM5.

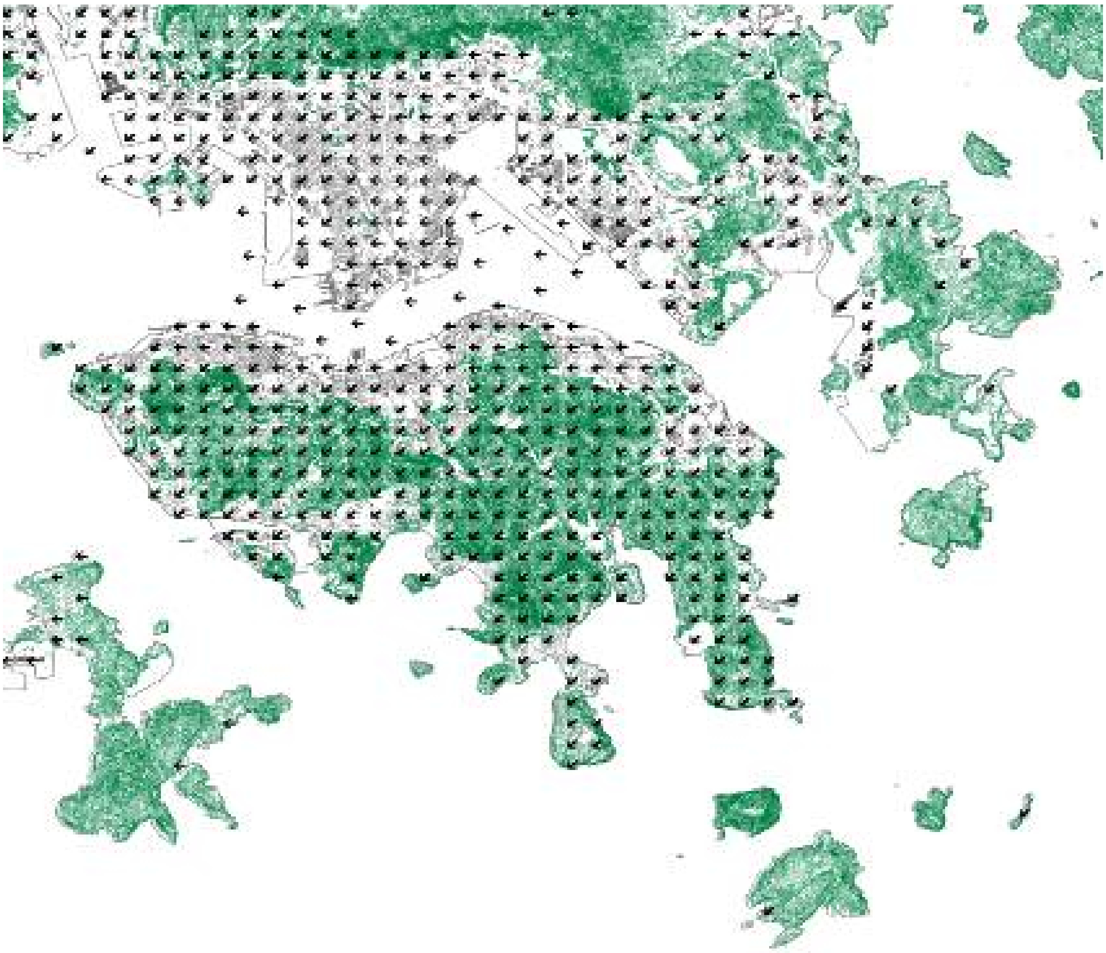

Figure 3.25 Prevailing wind directions (annual) based on MM5

3.7 Based on the MM5 simulated wind roses of the 4 locations extracted, one can evaluate that there are little differences among them (Table 1) in terms of prevailing wind directions.

Table 1 Evaluated prevailing directions of the 4 locations

	Annual	Summer
A	E, NE	E, SW
B	E, NE	E, SW
C	E, NE	E, SW
D	E, NE	E, SW

3.8 With the kind assistance of Urban Renewal Authority (URA), from Oct 2005 – Oct 2006, Chinese University of Hong Kong (CUHK) researchers had mounted a wind mast on top of Millennium Plaza on Queen's Road Central (Figure 3.26). The anemometer is at 125 mPD. It captures the Urban Canopy Layer (UCL) wind very well. At UCL, the wind characteristics allow one to have useful information of the air mass that moves through the city fabric.

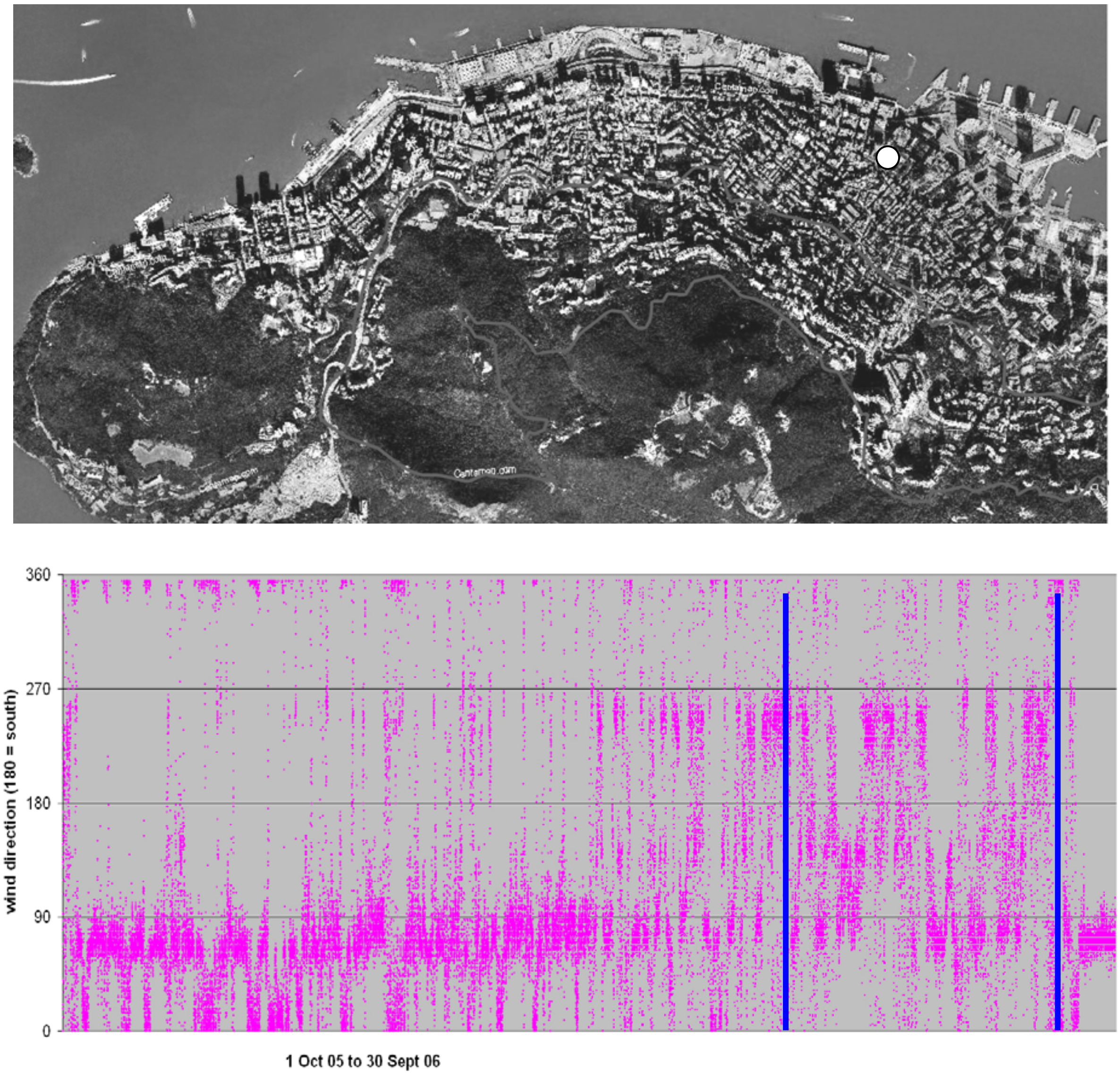

Figure 3.26 (Top) Location of CUHK's wind mast on Millennium Plaza (1 Oct 2005 – 30 Sept 2006); (Bottom) Wind directions [Y axis, 0 or 360 is north, 180 is south, 90 is east,]; the period of interest is between 1 June to 31 August – between the two blue lines.

3.9 CUHK's limited measurement indicates that the mean wind speed at this height is around 3 m/s – which is weak. The annual prevailing direction is east (as indicated by the heavily pinked areas in Figure 3.26). However, in the summer months of June, July and August (between the two blue lines), the prevailing wind directions oscillate between south-east and south-west. The study findings coincide well with HKUST's MM5 simulations.

3.10 Based on the available wind data shown in Figure 3.3 – 3.26, it is concluded that <u>the annual wind of the study area is mainly from the East and North-East. The</u>

<u>summer wind is mainly coming from the East and the Southerly quarters (Figure 3.27).</u>

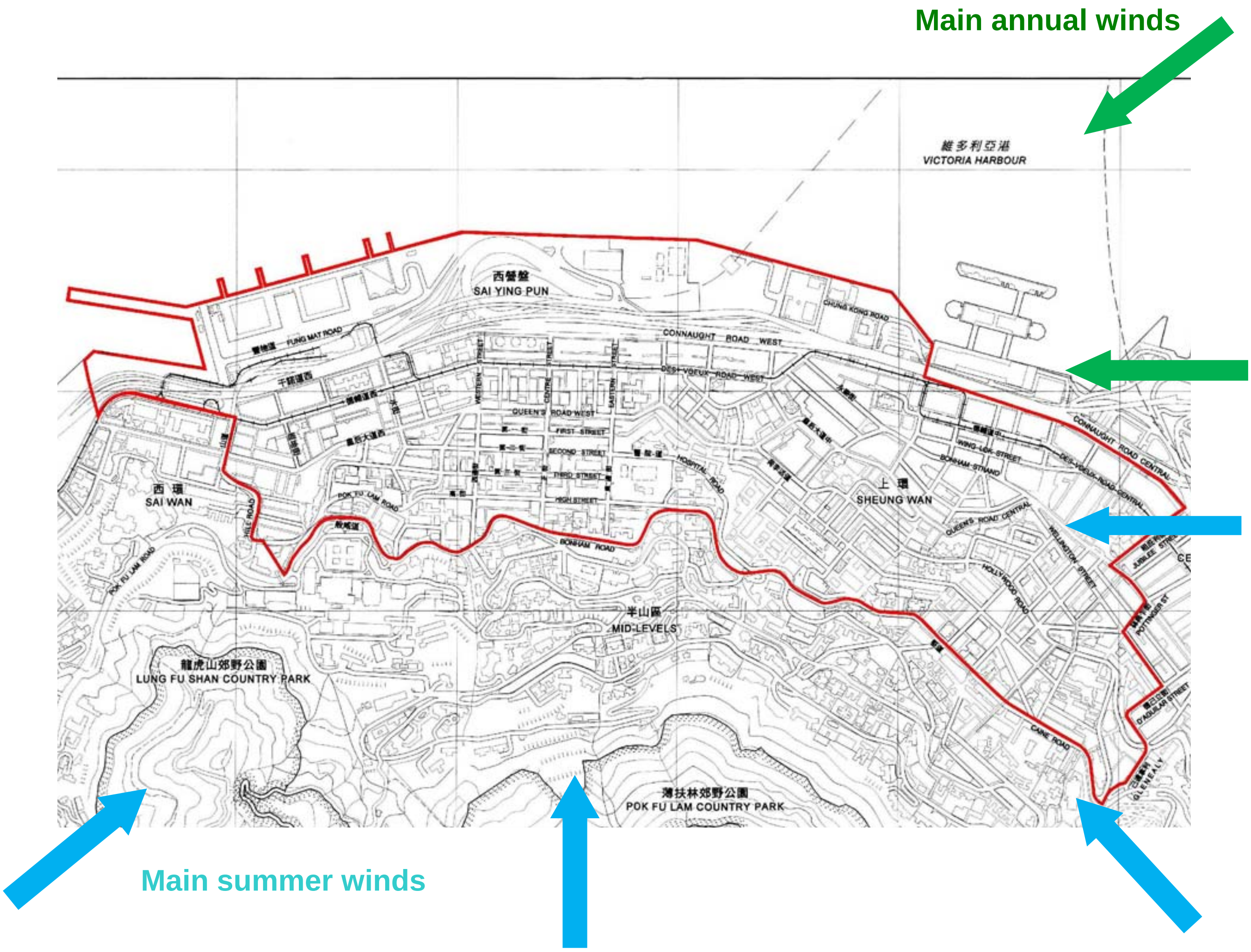

Figure 3.27 A summary of the prevailing winds of the Area

4.0 Topography, Land-Sea Breezes and the Urban Wind Environment

4.1 The Area is fronting the Victoria Habour. It rises from the sea level to 50 to 80 mPD, at Mid-levels West with the Peak of about 550 mPD lies further south (Figure 4.1).

4.2 Wind coming from the south will shield by the hills and developments at Mid-levels West (Figure 4.2). A key section showing the wind flow pattern across the Area from the Peak is shown in Figure 4.3.

4.3 Appendix A shows the 3 dimensional flow patterns. It can be very complicated depending on a number of factors, e.g. the speed of the incoming wind. In moderate wind conditions, it is predicted that a lee-wave will be generated and a number of eddies will form, and some re-circulation will be expected when the southerly wind arrives at Mid-levels West. However, the dense urban structure dampens the flow of this wind. By the time it reaches the southern boundary of the Area, it is already very weak.

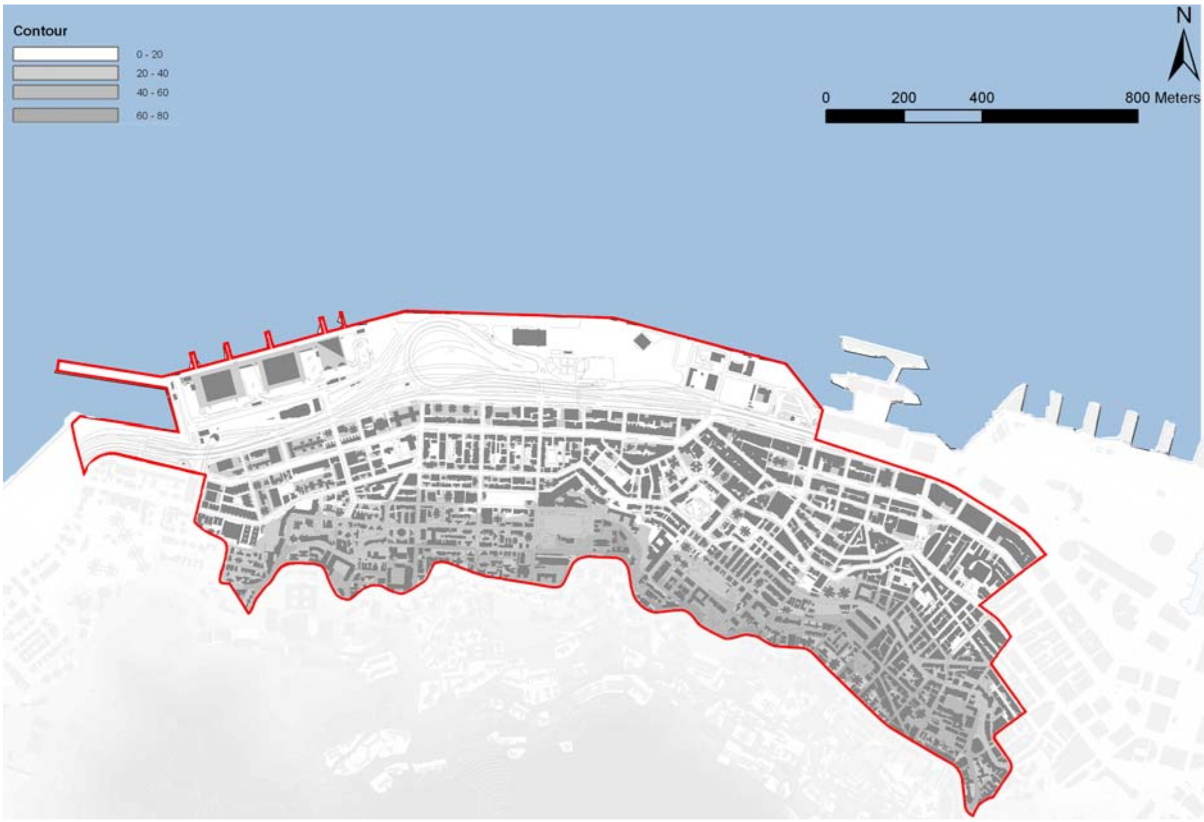

Figure 4.1 A digital elevation map of the Area

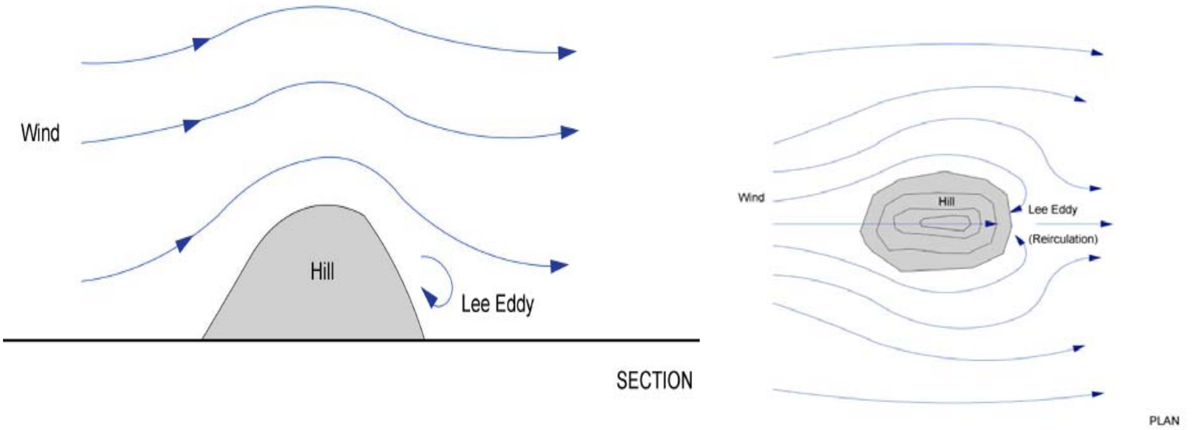

Figure 4.2 An example of wind flow across hills under moderate wind.

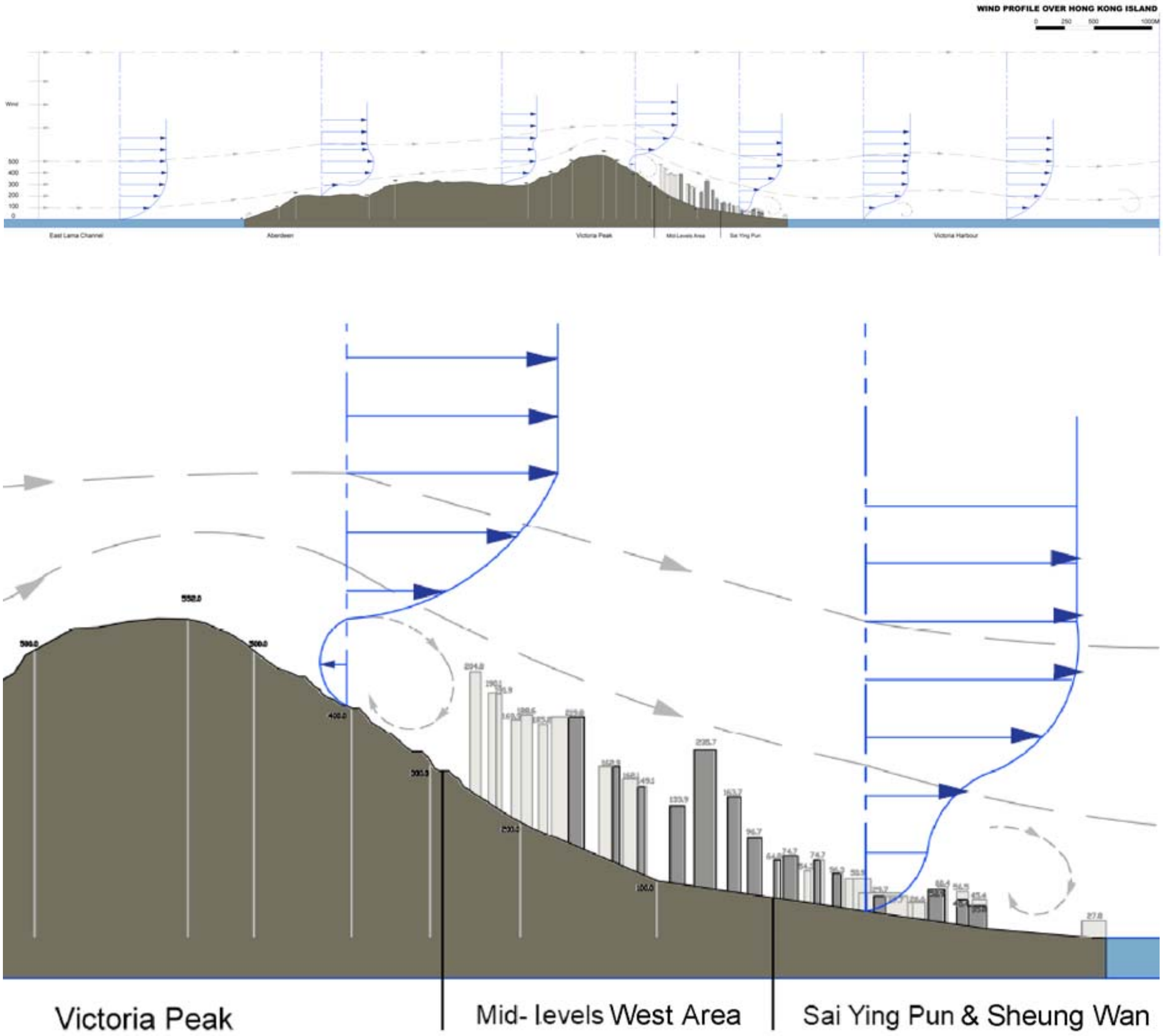

Figure 4.3 (Top) A possible (simplified) wind flow pattern across the site when the incoming "moderate wind" is from the south (left). The Area can experience eddies, re-circulations and fluctuations. (Bottom) a zoom in of the top figure focusing on the Study Area.

4.4 Bear in mind section 4.3 above, the strategic importance of Mid-levels West to the air ventilation environment of the Area has already elaborated in the Expert Evaluation Report for the Mid-levels West [available on Planning Department website]. According to the report, layers of east-west orientated buildings of 170 mPD to 250 mPD occupy full frontage to capture full sea view, will weaken the north-south air paths from the hills, It is unlikely that the Area could enjoy too much of the summer prevailing winds from the southerly quarters.

4.5 The summer winds come from the south and the south-west. Some of the air flows will be diverted by the Peak and arrive at the Area from the south-west along the Pok Fu Lam Road valley, and over the service reservoir / staff quarters of Hong Kong University. Shek Tong Tsui is at the direct down stream of this valley wind system, could benefit from this southerly winds. Unfortunately, the bulky towers and also podia of The Belcher's to the west, beyond the Area, blocks and diminishes the effectiveness of the southern valley winds.

4.6 For wind coming from the North-East and East over the Victoria Harbor, it is expected that wind from the waterfront can penetrate via the north-south streets between Connaught Road Central and Des Voeux Road Central as well as Connaught Road West and Des Voeux Road West into the urban fabric. These streets are important air paths for the Area. Due to the high ground coverage and limited air space of the built-up urban morphology, it is expected that this wind from the waterfront may only penetrate one block, up to Des Voeux Road West of the Area.

4.7 Wind from the East will flow over the land mass and the Central District. It is expected that it will flow along main streets and roads that are parallel to the wind flow, for example, Des Voeux Road West, Queen's Road West, Second Street and High Street. However, due to the fact that none of these streets are "straight", and they are rather narrow, their efficacy as air path is not high.

5.0 The Existing Conditions

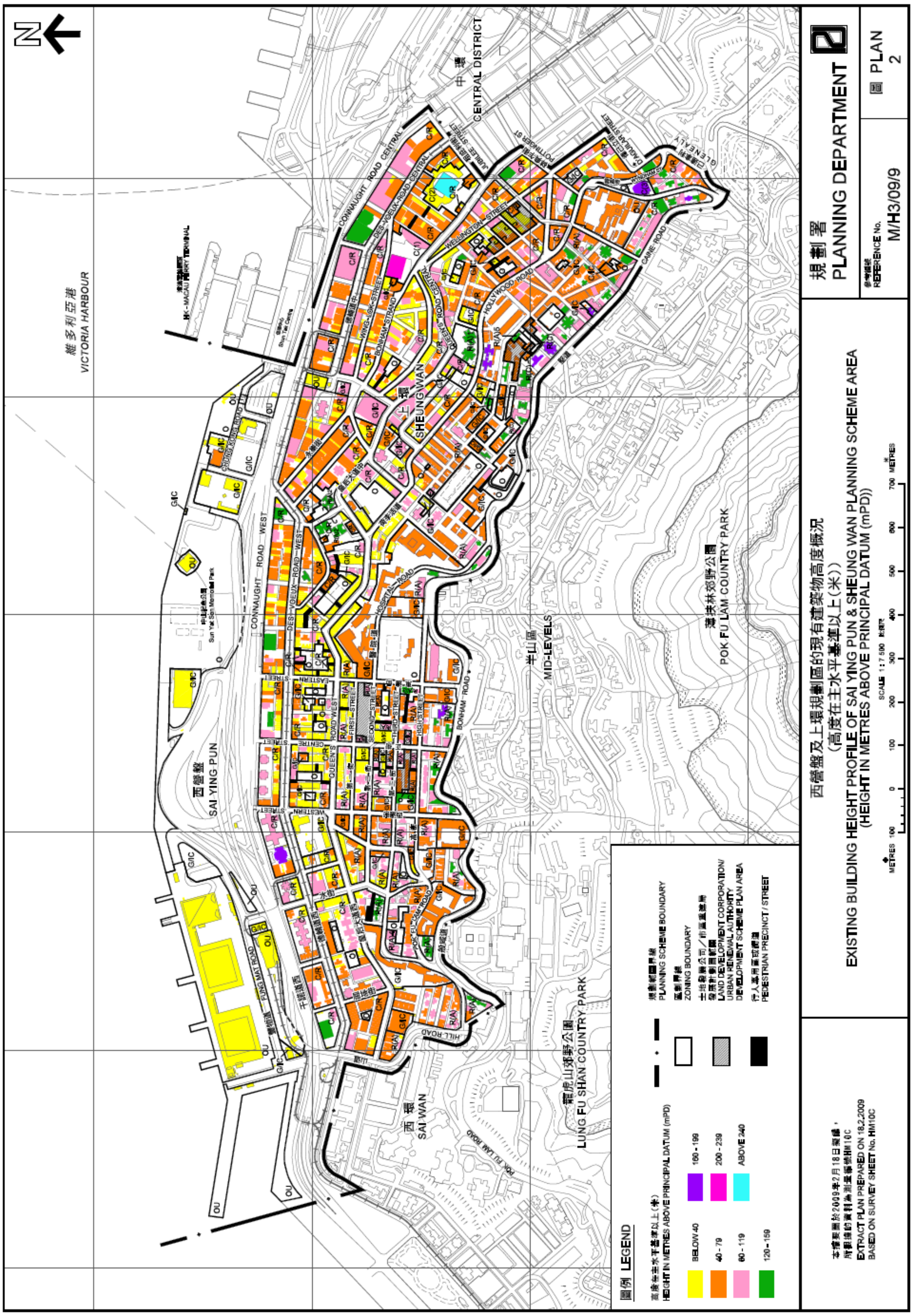

Figure 5.1 The existing building height profile of the study area in meters above principal datum (mPD)

5.1 Greenery, Open Spaces and Landscaping

Figure 5.2 A greenery map of the Area based on land use data provided by Planning Department.

5.1.1 The study area has a few large open spaces acting as "air spaces" where air ventilation can be relieved given the dense urban morphology (Figure 5.1). They include the former Central Police Station Compound; the former Police Married Quarters site at Hollywood Road; the collection of Caine Road Garden and Caine Lane Garden; Blake Garden; Hollywood Road Park; and King George V Memorial Park (Figure 5.2). They are very useful air spaces to the Area. Wake interference and isolated roughness flows (Figure 5.3) is possible bringing air into the pedestrian.

5.1.2 Apart from the 6 "air spaces", there are also a host of smaller green open spaces (Figure 5.4). Some of these green open spaces are in the form of backyard and courtyard spaces to the immediate neighbourhood. Sai Wo Lane Playground and Li Sing Street Playground are two of the many examples. However, due to their smaller size and the tall buildings around them, they are not too important for air ventilation except of course that they still provide some porosity and reliefs to the immediate surrounding buildings.

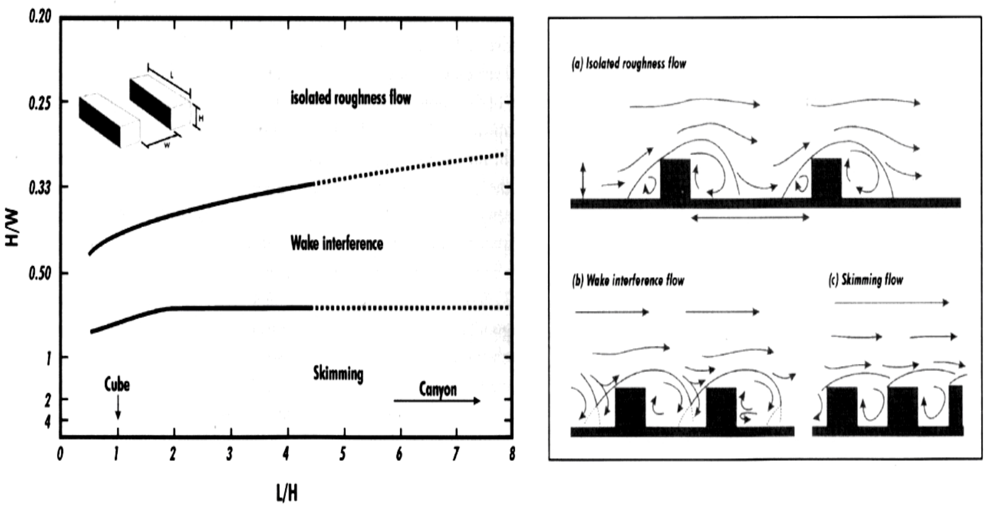

Figure 5.3 The relationship between building height and street width ratio and the possible flow regimes.

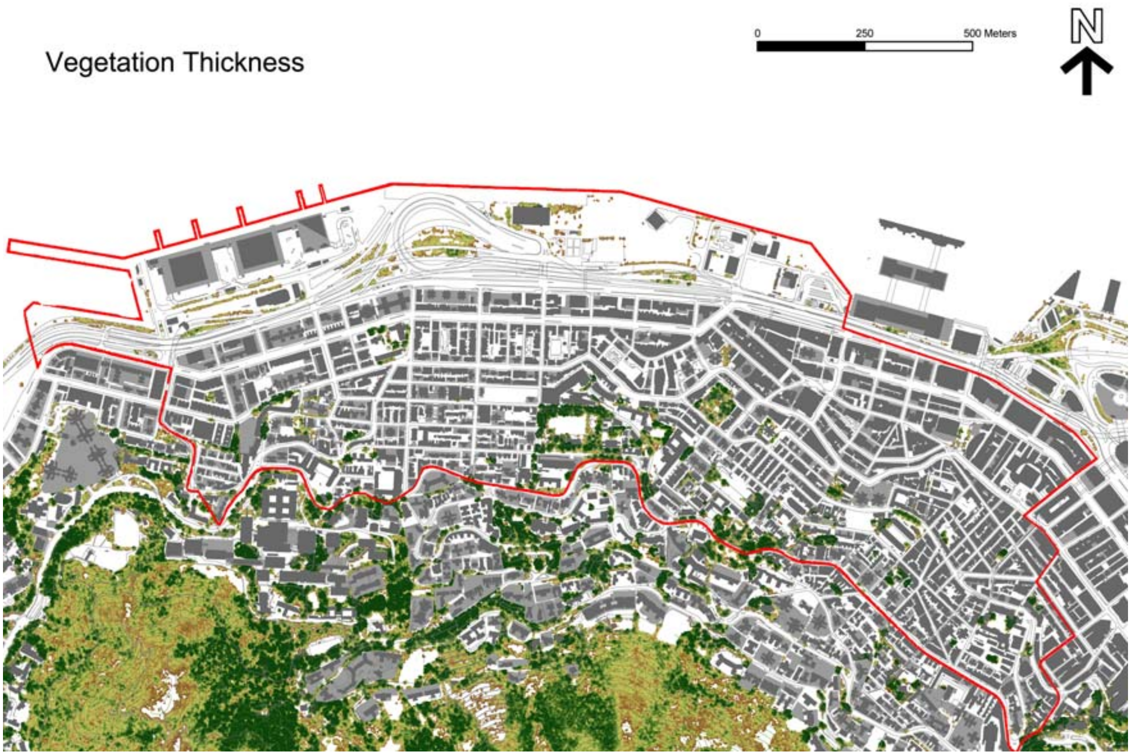

Figure 5.4 Vegetation of the study area based on LiDAR data provided by PlanD.

<u>5.2 Land Use and Urban Morphology</u>

5.2.1 Figure 5.2 and 5.4 above show that the greenery coverage of the Area is small and the corresponding Ground Coverage (GC) is high.

5.2.2 The Area has a mixture of different zones – mostly "Residential (Group A)" ("R(A)") and "Commercial/Residential" ("C/R"), and with a number of residential developments. It also has a good number of scattered “G/IC” and “O” zones, with low-rise structures or no buildings act as air spaces and providing spatial reliefs.

5.2.3 On the whole the building volume density of the Area is high. Higher building volume increases the urban thermal capability. This creates higher thermal stress in the summer months and the need for higher air ventilation to mitigate the negative thermal effects. Researchers at CUHK have earlier resolved a set of Building Volume Density (BVD) understanding of Hong Kong. A relevant area is as shown in Figure 5.5.

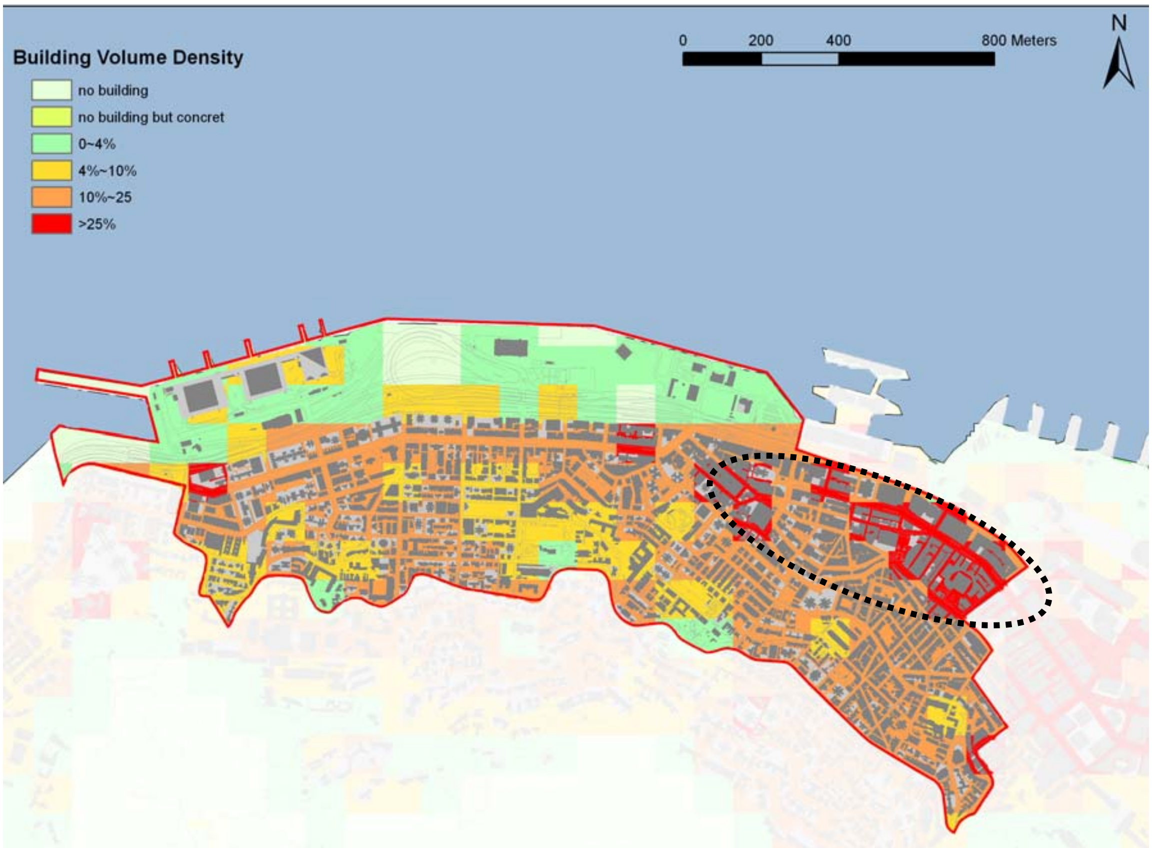

Figure 5.5 Building Volume Ratio map of the Area resolved to 100m x 100m grid. [For a site that occupies 100m x 100m, with a plot ratio of say 5, the building volume of the site will be about 150,000m^3. Building Volume Density in % (BVD) is building volume in m^3 of a 100m x 100m grid of land divided by a datum value of 1,200,000 m^3]

5.2.4 A very high BVD can be found around Des Voeux Road Central near The Centre (Figure 5.5 dotted circle) and very high thermal capacity is expected. Apart from a few open spaces, BVD is also high in the other part of the Area. More importantly, it should be noted that areas with high and very high BVD cover a very large area and are not, like some other parts of metro Hong Kong, grouped in smaller clusters with air paths around them.

5.2.5 Researchers at CUHK have earlier resolved a set of Ground Coverage Ratio [1] (GC) understanding of Hong Kong. A relevant area is marked in circle as shown in Figure 5.6. High ground coverage reduces urban porosity at the pedestrian level and thus reduces the potentials of air ventilation. On the whole the GC of the study area is "mid" to "high". High GC can be found around Des Voeux Road Central near The Centre (Figure 5.6 dotted circle). Clusters of grids with high GC can also be found elsewhere in the Area.

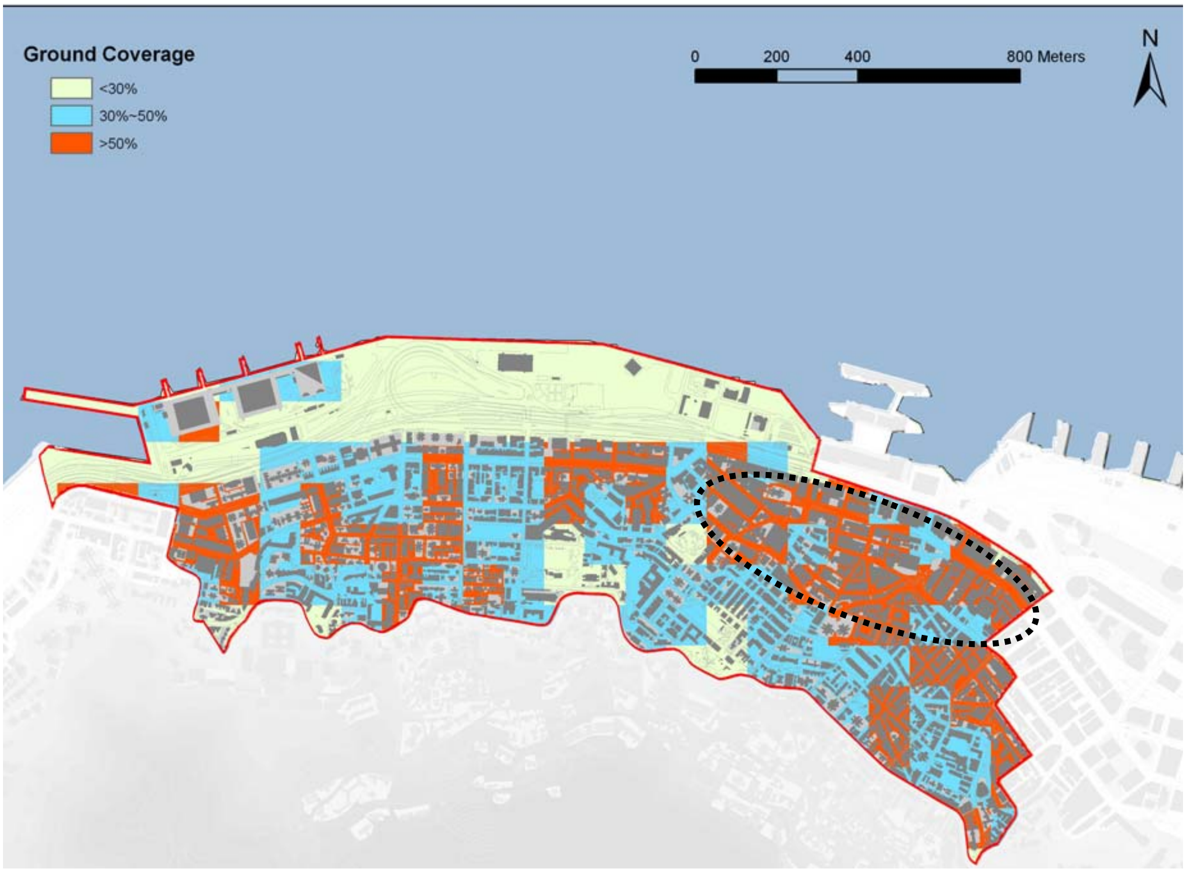

Figure 5.6 Ground Coverage Ratio map of the Area resolved to 100mx100m cell area (include roads, open spaces and ground area covered by buildings and podiums)

5.2.6 The research team led by Professor Jimmy Fung of HKUST has also calculated the Frontal Area Density (FAD) [2] for the Area at different height bands. Results in Figure 5.7a and 5.7b largely coincide with the BVD understanding in 5.2.3 and the GC analysis in 5.2.5. The connected blue grids (lesser FAD) of Figure 5.7b-15-60m (indicated by the three arrows) show that, currently, with the variant building heights and many lower buildings, there are potentials for air paths over buildings,

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[1] Ground Coverage Ratio (GC) is the ratio of total ground area (include roads and open spaces) and ground area covered by buildings and podiums in a 100m x 100m grid.

[2] Frontal Area Density (FAD) is a measure of the frontal area per unit horizontal area per unit height increment, has been used by researchers in urban canopy communities to help quantify the drag force as a function of height. Detailed explanation and calculation is illustrated in Appendix B.

and thus potentials for air ventilation. It is unfortunate that these potentials are diminished due to the higher FAD grids along the waterfront.

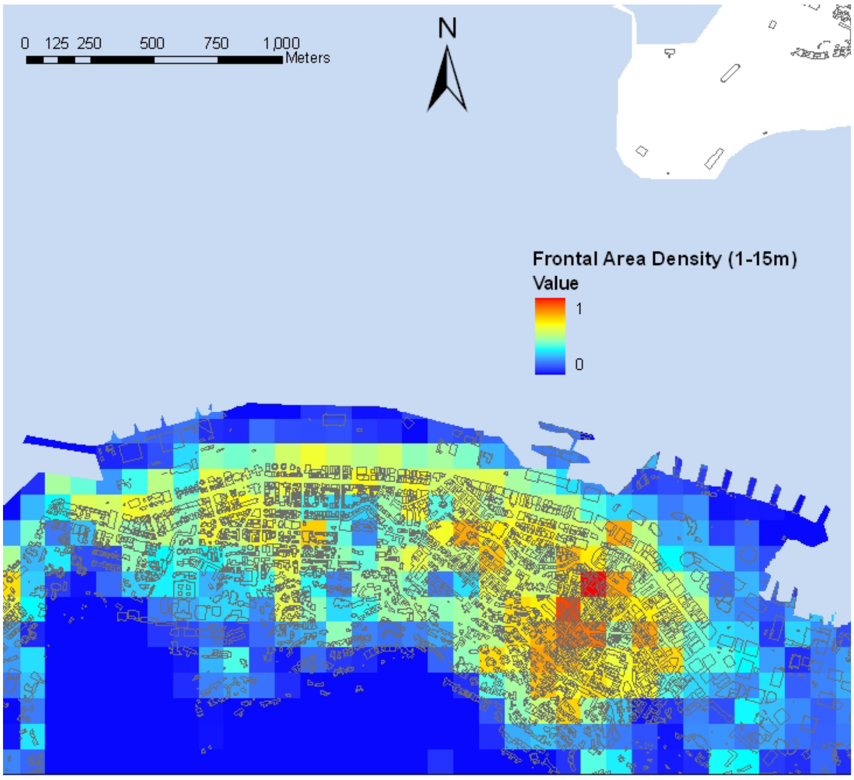


Figure 5.7a Frontal Area Density of the Study Area at height level of 1 – 15m (podium level)

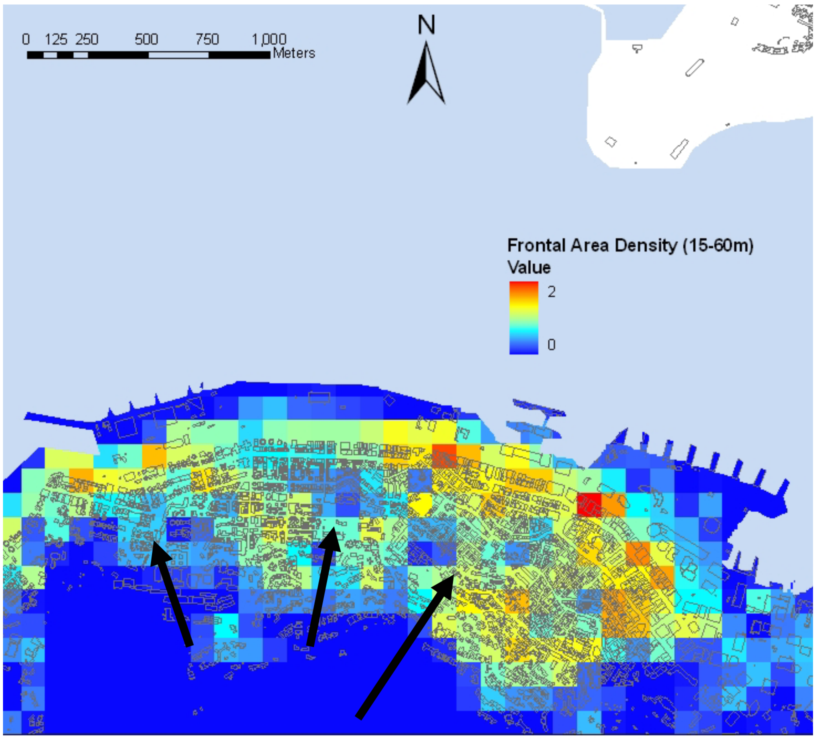


Figure 5.7b Frontal Area Density of the Study Area at height level of 15 – 60m (building tower level)

5.2.7 Sections across the Area are shown in Figure 5.8 – 5.11. The deep canyons of buildings with narrow streets are shown, with H/W ratios being in the order of 2:1 to occasionally 10:1. Figure 5.11 shows a scenario of the Initial Planned Scenario.

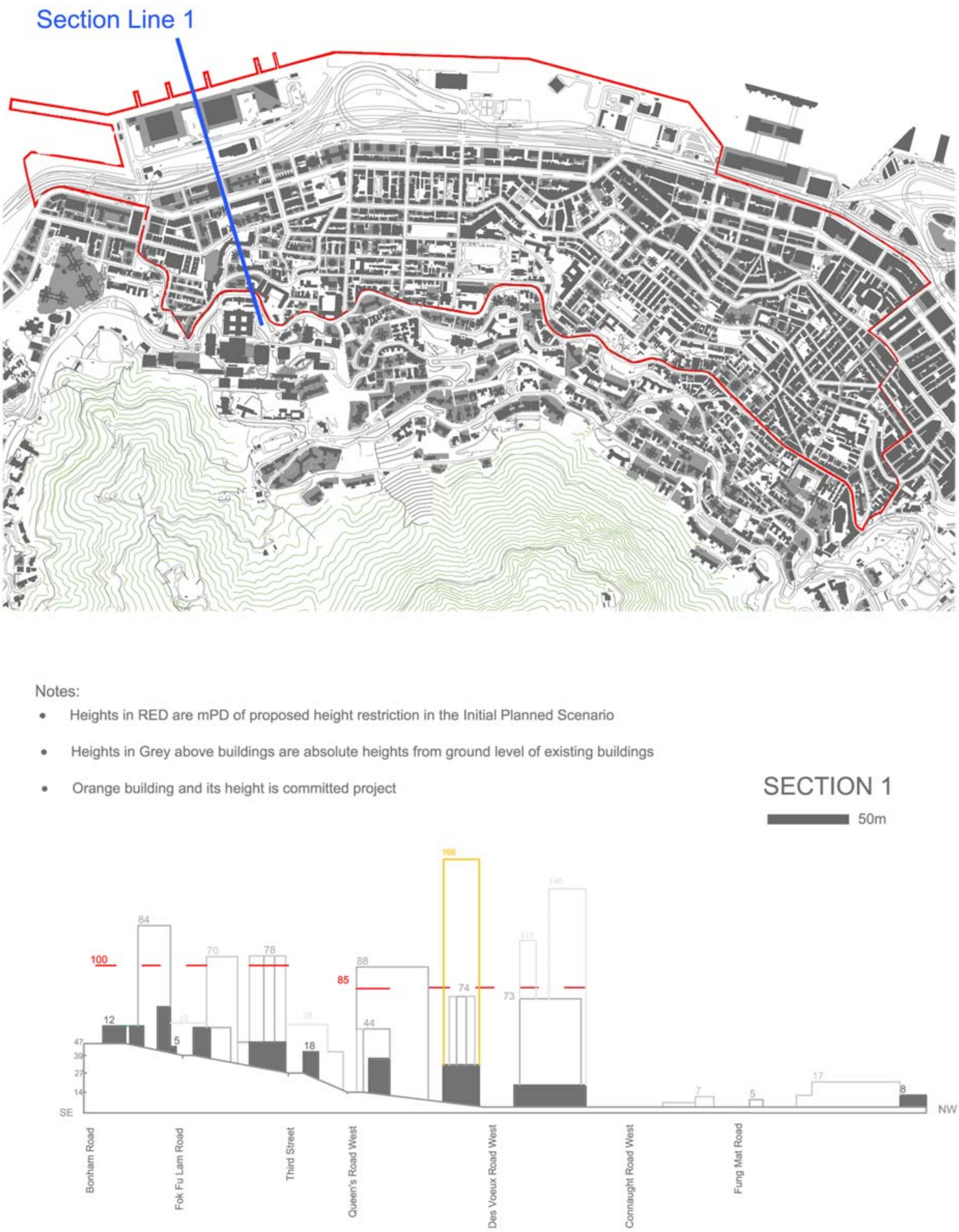
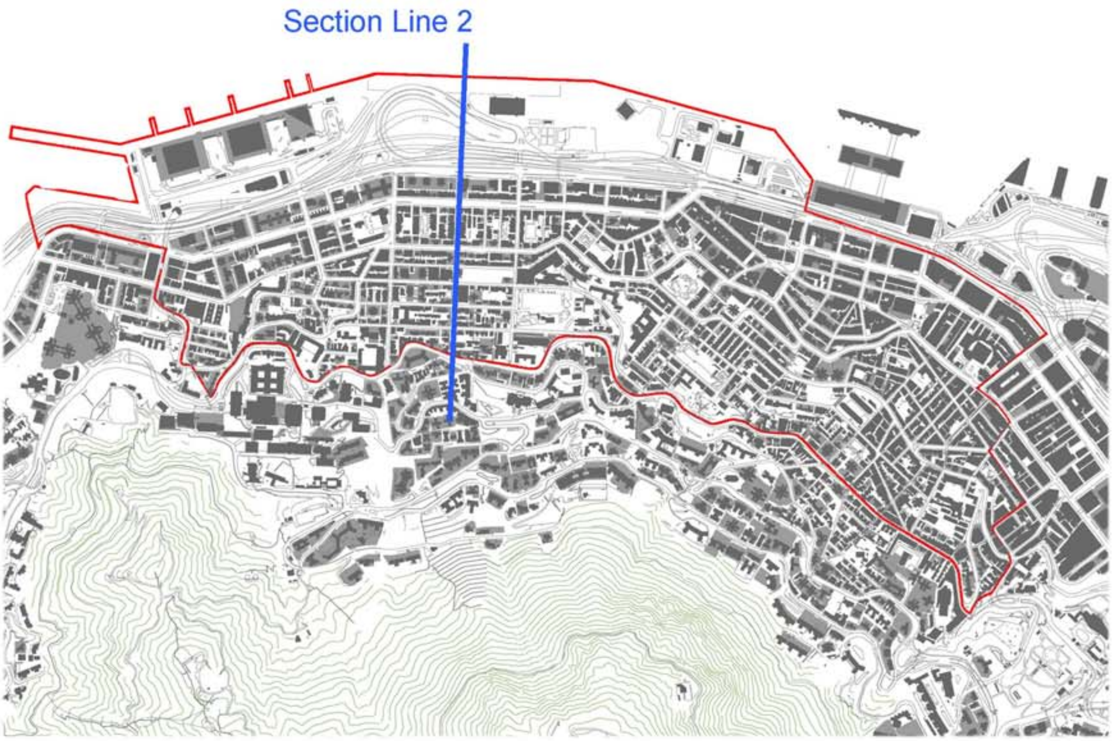


Figure 5.8 Example 1 of Section across the Area. Also refer to section 5.2.6 and 5.4.2 for an understanding of Frontal Area Density and air path over buildings.



Notes:

- Heights in RED are mPD of proposed height restriction in the Initial Planned Scenario
- Heights in Grey above buildings are absolute heights from ground level of existing buildings
- Orange buildings and their heights are committed projects

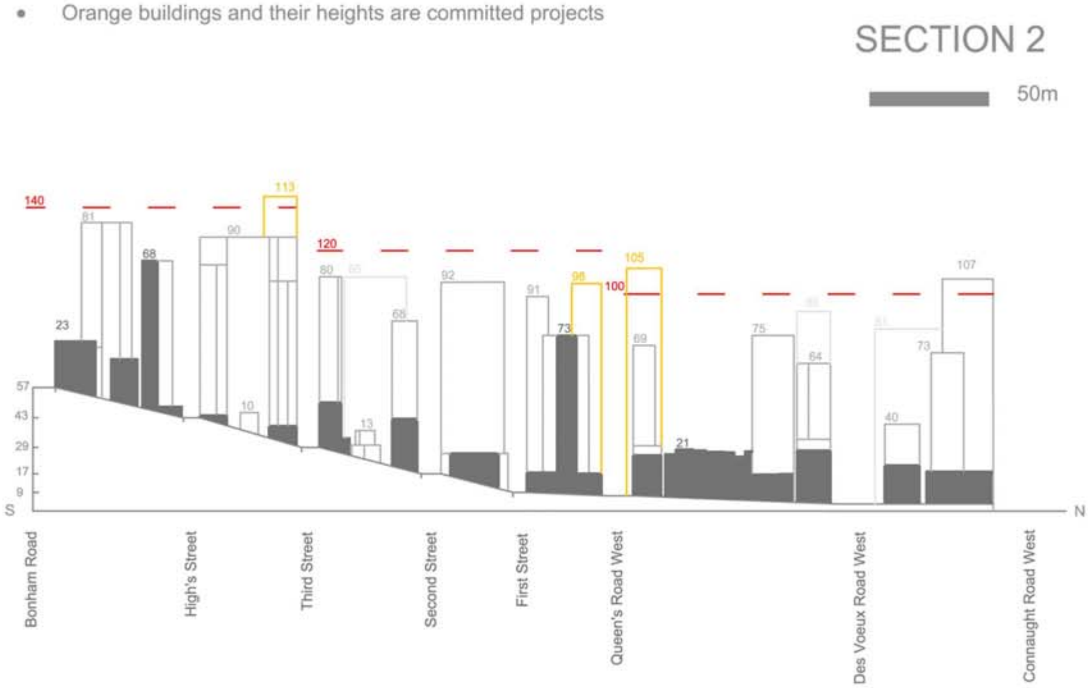


Figure 5.9 Example 2 of Section across the Area

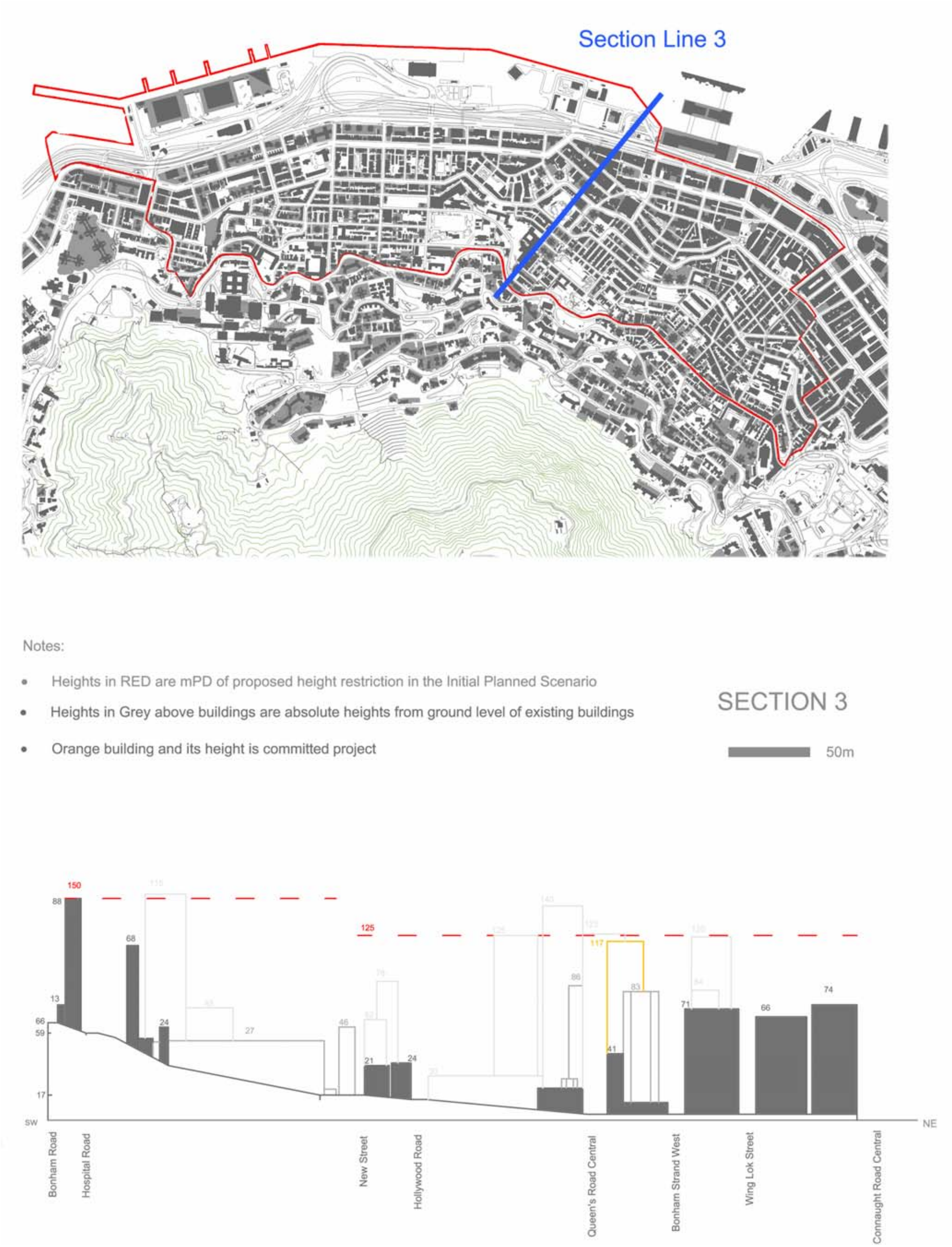


Figure 5.10 Example 3 of Section across the Area

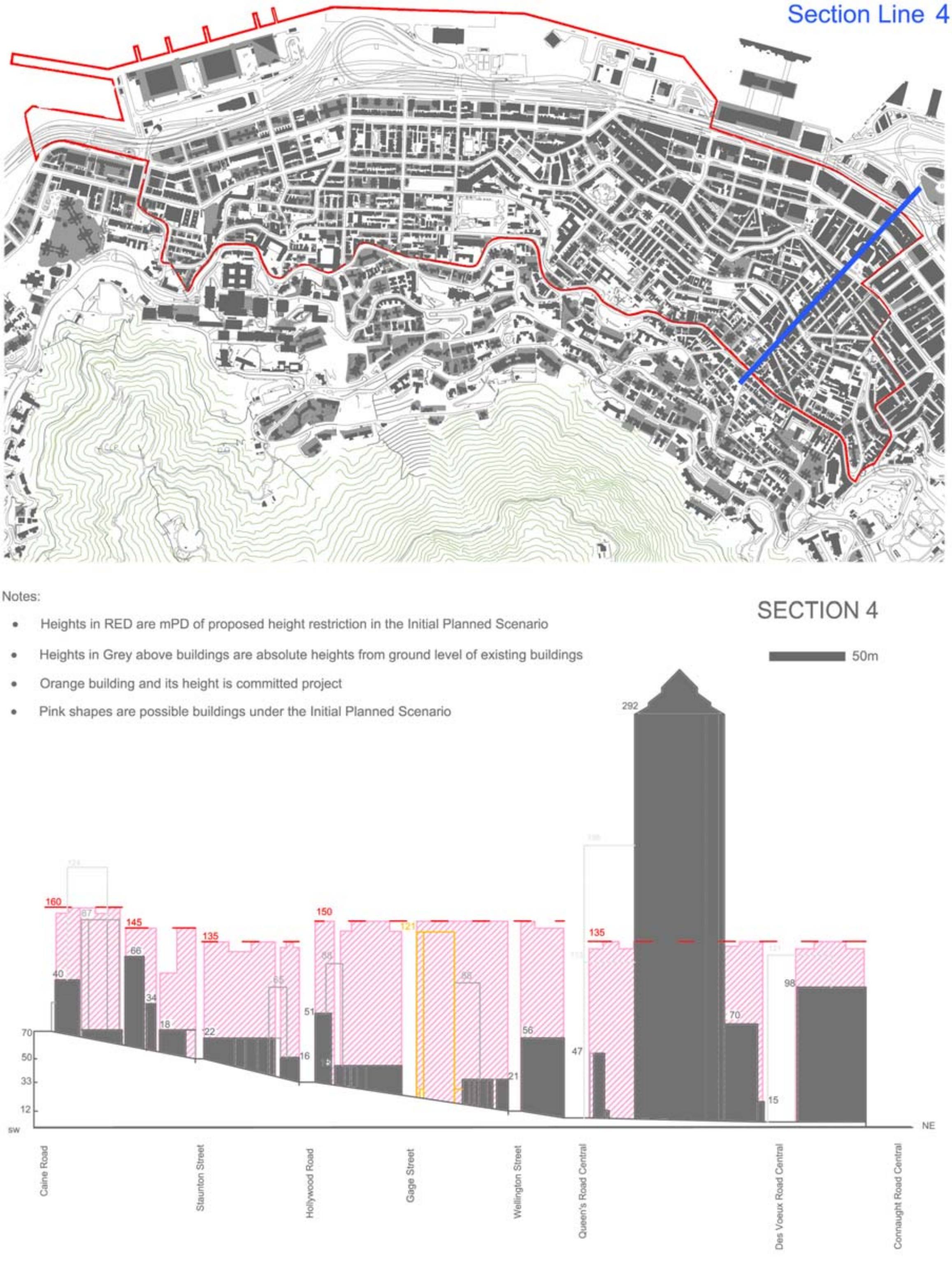


Figure 5.11 Example 4 of Section across the Area. For an explanation of the "pink" shapes, see section 6.2.5.

5.3 Street Grid and Canyon Air Flow

5.3.1 The land fill north of Connaught Road West is largely empty and flat. Winds from the Victoria Habour can flow almost unobstructed over it and Connaught Road West. The north-south streets between Connaught Road West and Des Voeux Road West along the waterfront are useful and important air paths for wind coming from the North-East over the Victoria Harbor. Due to the high ground coverage and limited air space of the built-up urban morphology, it is expected that this wind from the waterfront may only penetrate one block, up to Des Voeux Road Central and Des Voeux Road West of the Area.

5.3.2 Streets parallel to the wind are effective air paths (Figure 5.12). The street grid of the Area ranges from irregular in Sheung Wan area to regular and orthogonal in Sai Ying Pun area.

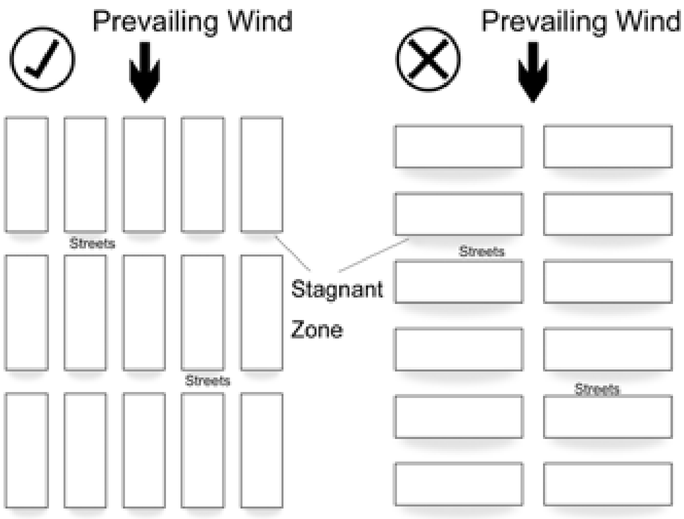


Figure 5.12 Streets parallel to the wind flow are effective air paths. VR in the order of 0.1 or slightly higher can be expected. Streets perpendicular to the incoming wind have stagnant zones within its canyons. VR in the order of 0.05 or less can be expected.

5.3.3 The main east-west arteries in Sheung Wan area, like Des Voeux Road Central, Bonham Strand, Hollywood Road and Caine Road, are its main air paths. In Sai Ying Pun area, arteries, like Des Voeux Road West, Queen's Road West and Bonham Road, are its main air paths. First Street, Second Street, Third Street and High Street are also its east-west air paths. However, as most of these arteries are not "straight" and "wide" enough, their efficacy as air path is not really that high.

5.3.4 On the whole, the streets and roads in the Area are narrow. In Sheung Wan area between Connaught Road Central and Queen's Raod Central, buildings are tall. The Building Height to Street Width Ratio (H/W) is high, and is largely in the order of 3 to 5.

5.3.5 Elsewhere in the southern areas of Sheung Wan and in Sai Ying Pun, with older and lower buildings, the H/W ratio is largely in the order of 2 to 3. There are a few taller towers of 30 to 40 storeys, but they are mostly isolated.

5.3.6 With wind from directions perpendicular to the canyons, downwashes due to the differentials in building heights is occasionally likely when building heights are very different. Otherwise, with smaller building height differences, this is unlikely. It is known that for long and deep canyons with an H/W ratio of 2 and above, a double vortex phenomenon will be observed (see Figure 5.13). For long and deep canyons with an H/W ratio of 5 and above, there will be little or no air ventilation at the pedestrian level due to winds moving above the urban canopy. In these cases, air ventilation will only pass through building gaps, streets parallel to the wind, and open spaces. Otherwise, air mass exchange will only be due to the local thermal differentials and diffusions, and buoyancy effects; they provide weak air ventilation to the otherwise stagnant zones near the ground.

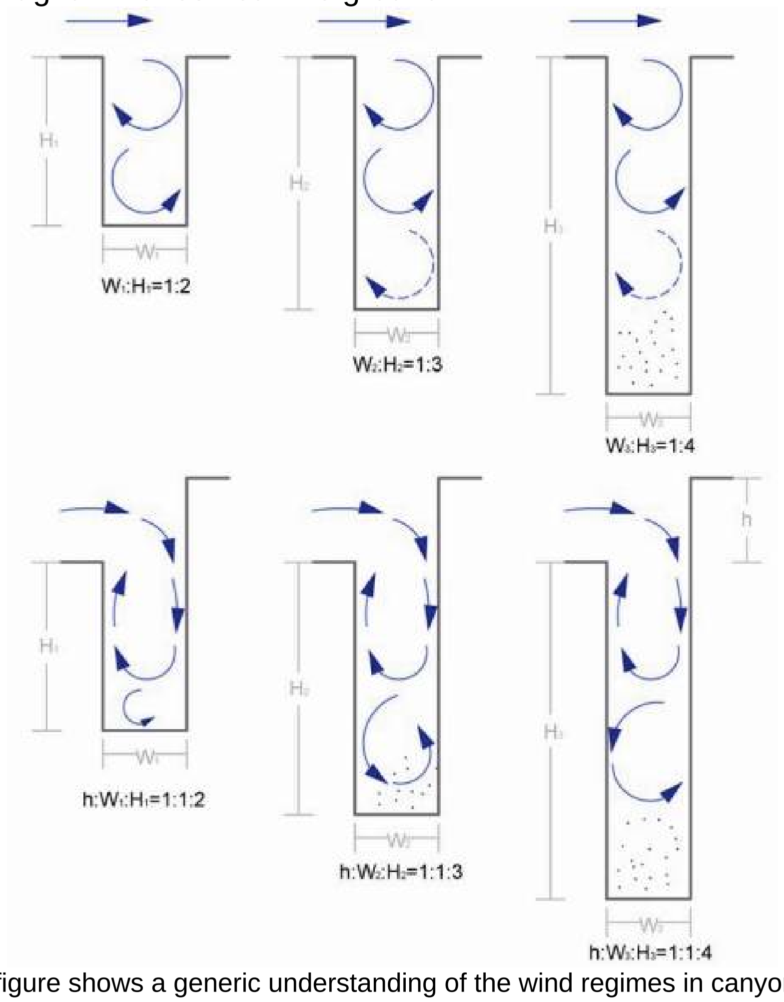


Figure 5.13 The figure shows a generic understanding of the wind regimes in canyons, and canyons with downwashes. Beyond a H/W ratio of 2:1, the ground level of canyons, even with the so call downwash effects, will have very weak eddies and air ventilation.

[Reference: A. KOVAR-PANSKUS, P. LOUKA, J.-F. SINI, E. SAVORY, M. CZECH, A. ABDELQARI, P. G. MESTAYER and N. TOY, INFLUENCE OF GEOMETRY ON THE MEAN FLOWWITHIN URBAN STREET CANYONS – A COMPARISON OF WIND TUNNEL EXPERIMENTS AND NUMERICAL SIMULATIONS, Water, Air, and Soil Pollution: Focus 2: 365–380, 2002, Kluwer Academic Publishers.]

5.3.7 Given that the buildings in many of the study areas are already tall, the street canyons are already deep, changing building heights a little bit one way or another would not matter ground level air ventilation that much. For example, all else being equal, a street canyon of H/W of 4:1 or 5:1 would have very similar air ventilation performance at ground level. In this case, the most effective way to improve air ventilation is to introduce gaps.

5.4 An Evaluation of Air Paths

5.4.1 On the whole, the streets and roads are narrow in the Area. And buildings are tall in Sheung Wan area between Connaught Road Central and Queen's Road Central. The Building Height to Street Width Ratio (H/W) is high, and is largely in the order of 3 to 5. The area has medium to high ground coverage (refer to Figure 5.6), wind from the harbor is largely blocked by buildings along the waterfront. Some weakened air ventilation find its way through narrows roads and streets perpendicular to the waterfront; but this weakened air flow would not penetrate too far into the inner area – up to Des Voeux Road.

5.4.2 For the summer winds come from the south and the south-west, they are largely blocked and weakened by tall buildings occupying full frontage at Mid-levels West. The north-south air path is weakened and ineffective. Based on the FAD analysis as in section 5.2.6 and Figure 5.7a and 5.7b of this report, currently there are potentials for air paths over buildings, namely from Eliot Hall of Hong Kong University southwards over St Paul College and Water Street (see Figure 5.8); from West End Park, King George V Memorial Park to Li Sing Street; and from Wing Wa Girl's School, Blake Garden to Lok Ku Road. It is unfortunate that these potentials are diminished due to the higher FAD grids along Des Voeux Road on the waterfront.

5.4.3 For wind coming from the East over the land mass and the Central District, it is expected that it will flow along main streets and roads that are parallel to the wind flow, for example, Des Voeux Road West, Queen's Road West Second Street and High Street. However, due to the fact that none of these roads or streets is "straight", and they are rather narrow with high H/W ratio, their efficacy as air path is not high.

5.5 Key Evaluations

5.5.1 All in all, currently, the Area presents a high Building Volume Density and high Ground Coverage, but narrow and ineffective air paths. Due to the tall and dense buildings in the Area, it is already very difficult for wind to flow into the Area. Any planning decision has to pay due respect to this issue, and find ways to mitigate the existing situation. However, some parts of the Area have already "over-developed" as far as air ventilation is concerned.

5.5.2 Based on the evaluation as in section 5.4.1 above, allowing further developments in this area in the form of larger, taller and bulkier buildings must be carefully considered. In a nutshell, the narrow streets laid down a century ago were not designed for tall buildings of 20 storeys or taller on both sides. They are originally designed to accommodate buildings with a H/W of 1:1 to 1:1.5.

5.5.3 Given the tall building morphology that already exists, finding ways to create air paths and porosity with non-building areas, building set backs, and open and green spaces would be the planning strategy to aim for.

5.6 An Evaluation with Potential Re-development

5.6.1 A detailed AV assessment requires information beyond density, building heights and plot ratios. The information on building heights can provide only some general indications. That is to say, high density city and tall buildings obviously will increase the roughness and reduce AV, but designing and positioning the buildings one way or another could either reduce the impact or worsen it – and the difference could be great. As such, building shapes, building disposition and position, gaps and permeability, are more important design parameters to optimize the AV performance.

5.6.2 Nonetheless, as an illustration, considering that there would be three to four long rows of tall buildings of 30-40 storeys (or higher) with large podia form a continuous wall like barrier from Sheung Wan to Sai Ying Pun along narrow east-west existing streets, which are perpendicular to the summer winds. These long rows of buildings would form “very deep” street canyons, even wind parallel to these deep canyons would find it difficult to pass. Furthermore, the buildings add to the roughness, increase the thermal capacity, and block the wind. The probability of such a scenario should be avoided.

5.6.3 Based on the information provided by Planning Department, it is anticipated that many sites in the Area will be re-developed up to the permitted intensity in the next 10 years or so with taller, larger and bulkier buildings, and with big podia. The Building Volume Density (BVD) as well as the Ground Coverage (GC) will be increased. There is no precise project information as mentioned in section 5.5.1 above, hence the exact AV impact is difficult to predict.

5.6.4 As a result, many “high” BVD areas would be increased to “very high” (Figure 5.5). And area of “mid” ground coverage would also be increased to “high” (Figure 5.6). Furthermore, due to taller buildings, the Sky View will be reduced, the street canyons will be increased and existing gaps between buildings may be closed. All these changes would have an effect on pedestrian level thermal comfort and air ventilation permeability.

5.6.5 Based on the understanding above, it is expected that with the potential re-development fully executed, the “to be air ventilation environment” of the Area could be worsen. As the Area is already over-developed, adding further bulky buildings is not recommended. Other than air ventilation, proper planning and design control is extremely important considerations.

5.6.6 The following should be taken into consideration in future development / redevelopment as far as possible for better air ventilation.

(i) The “G/IC” and “O” zones in the Area should be respected. They provide useful “lungs” of air spaces in the Area. They should not be further developed with tall buildings or re-zoned for bulky development.

(ii) Air paths should be provided by designating non-building areas. It is recommended that air paths be strategically incorporated in the Area as a whole, and for each development site as far as possible.

(iii) The scale and size of the podium should be restricted. Specific design to incorporate permeable podium from ground to say 30m should be encouraged. Properly perforated podium provides air paths for air ventilation.

(iv) Towers must not be designed to occupy the full frontage of the site. Appropriate gaps between the towers, and within the towers (illustration can be found in Figure 5.14), must be provided as far as practicable to allow air ventilation through them.

(v) Greeneries and landscaping should be encouraged and enhanced. Existing trees must not be disturbed.

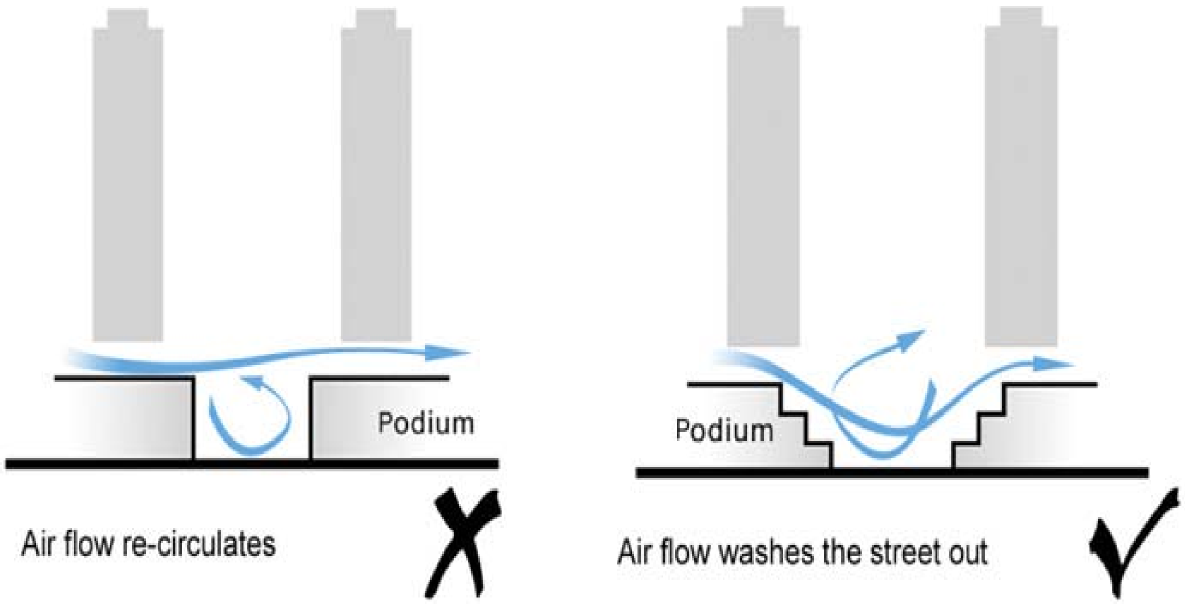


Figure 5.14 An illustration of gaps within the towers (Source: HKPSG)

6.0 The Initial Planned Scenario

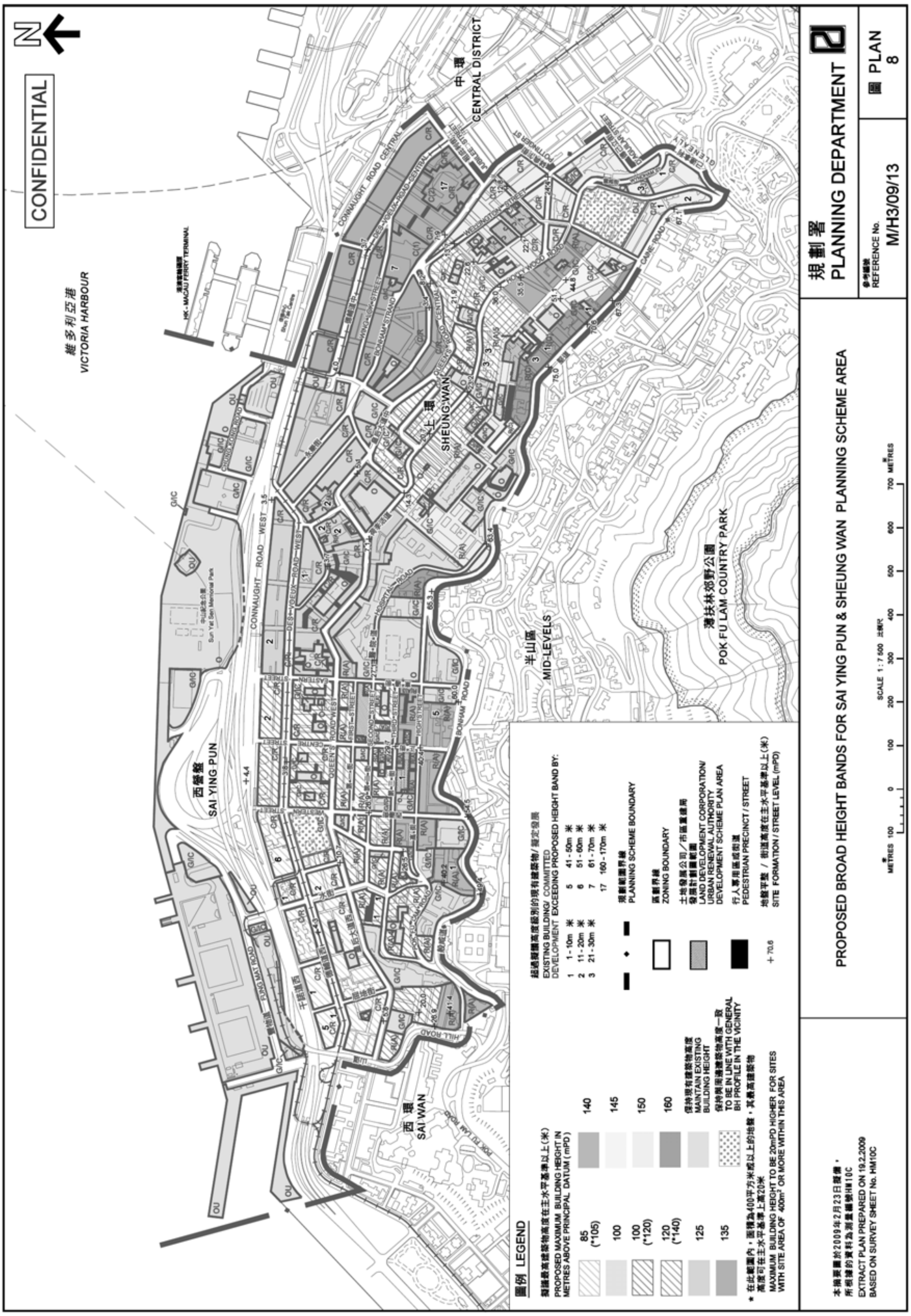


Figure 6.1 The Initial Planned Scenario of the Area.

6.1 Basic Principles

6.1.1 As a principle, for air ventilation, a tall building has a longer wind-wake (area behind the building that has lower air ventilation). The length of the wind-wake is normally taken as a few times (generally regarded to be around 1 to 4 times. Some researchers put it at 15 times) the height of the building. That is to say, a tall building affects more and further of its neighbours. On the other hand, a long and slab like building has a shorter but wider wind-wake. It affects very much its immediate neighbours. All else remains the same, the worst case scenario for air ventilation is therefore a tall and wide building. Building height control has a basis given this context.

6.1.2 However, given the existing conditions of tall buildings, and the possibility of more taller and bulkier buildings of the Area, height restrictions with minor height differences may not be the most important consideration for air ventilation. The air ventilation in some denser part of the Area is already poor and will worsen further due to the potential re-development, height restrictions itself is NOT the most effective measure to improve the air ventilation of the Area.

6.1.3 As a principle, for air ventilation, a variation of building heights in close proximity is preferred as it can create pressure differences and urban roughness; and they can encourage some downwashes, diffusions and mixing of air. The proposed height restrictions could take the above into consideration. Careful mixing of buildings with different heights in close proximity would allow that. See also Figure 5.13 and Appendix B for the understanding of building heights. Hong Kong Planning Standards and Guidelines (HKPSG) show an example of varying height profile, as in Figure 6.2.

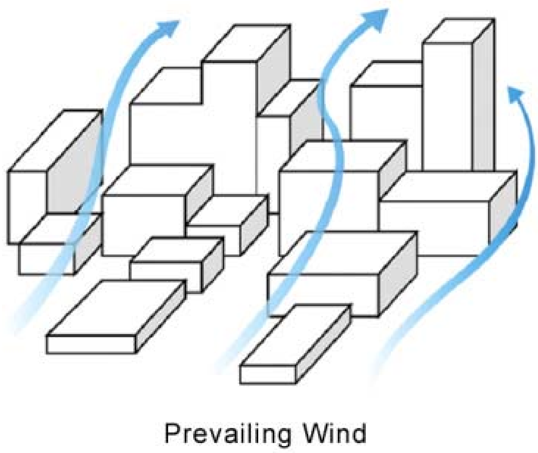


Figure 6.2 An illustrated example of varying height profile

6.1.4 In general, given that there are developments of a certain density and building volume, for air ventilation, it is strategically advisable:

(a) to allow as much air space as possible for the development to maneuver flexibly. The result may be that some buildings will be taller, and others will be shorter and fatter;

(b) to designate non-building areas parallel to the incoming prevailing winds, thus forming air paths. In general, setting aside 20 to 30% of the site width for non-building area is a good starting point;

(c) to perforate the building towers and the podium, especially at the lower level (say ground to 30m), so that useful AV could be optimized at the pedestrian level; and

(d) to maximize greeneries.

6.1.5 With and without the building height control, it is anticipated that developers will still build their podiums. The lower portion of the development typically impacts more on the pedestrian level AV performance – it is actually more important to control this.

6.1.6 It is important that a proposal of height restrictions do not adversely impact the air ventilation performance. Stringent height control could adversely result in lower but fatter slab like building. More of the ground floor space would be occupied hence increasing the site coverage, which is an important indicator of air ventilation performance. It is generally agreed that when building heights are controlled, developers may need to build buildings that occupy more of the ground increasing the very important site coverage. However, in practice, the understanding stated above may not be entirely correct as developers typically would position their buildings to maximize the site frontage anyway. A shorter and larger building will only add to the depth of the buildings (Figure 6.3). When the summer wind comes from the south, the frontages of buildings are perpendicular to the wind. Adding further depth to the buildings does not impact too much the air ventilation. This understanding taking the common practice must be borne in mind.

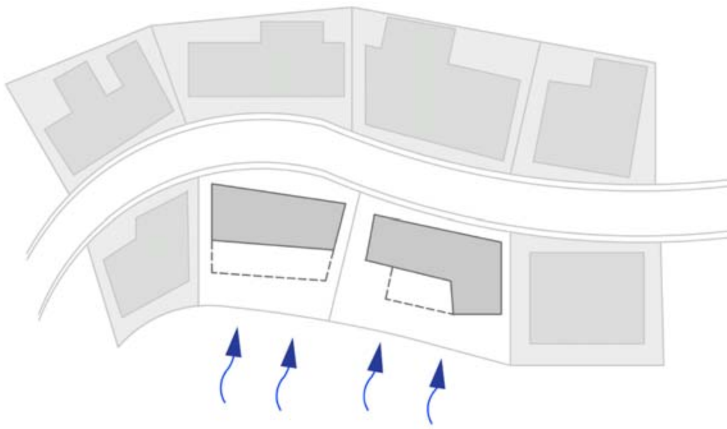


Figure 6.3 *With wind coming perpendicular to the street, adding further depth (dotted lines) to a building occupying the full frontage of the street does not impact too much the AV performance.*

6.1.7 Due to the high building height to street width ratio (H/W) of 3:1 or more in the Area, in general, building height control is NOT the most effective planning strategy for securing good city air ventilation at pedestrian level. [For it to be effective, the

H/W ratio of less than 2:1 is a pre-requisite.] Designing air ventilation not from above the buildings, but from their sides is a useful strategy. The provision of connected air paths, open spaces, green areas, non-building areas, building setbacks, and so on are far more effective strategy to improve air ventilation at the pedestrian levels.

6.2 An Evaluation of the Initial Planned Scenario

6.2.1 All the "G/IC" sites in the Area have been kept to maintain existing building height. For air ventilation, this would largely result in a "status quo" condition. As evaluated earlier, "G/IC" and "O" zones provide useful reliefs and it is useful to keep and if possible enhance them through further greening and tree planting.

6.2.2 The former Central Police Station Compound and former Police Married Quarters site in Hollywood Road have been identified as important "air spaces" to the Area. It is recommended that they should be kept and enhanced as in section 6.2.1 above.

6.2.3 In general, a stepped building height concept has been adopted. This ranges from 160 mPD along Caine Road in Sheung Wan to 85 mPD along Des Voeux Road West in Sai Ying Pun. This roughly equal to an absolute building height of about 90m on Caine Road in Sheung Wan and about 80m in Sai Ying Pun. That is to say, given the same street width, the high H/W ratios in both cases would be similar.

6.2.4 Taller buildings can be expected in some areas of Sheung Wan; for example an area along the waterfront has been restricted to 135 mPD. This would result in building heights of around 130 m tall. An area west of it has been restricted to 125 mPD. This would result in building heights of around 120 m tall. High H/W ratios would result.

6.2.5 Based on the initial Planned Scenario, given the narrow streets and roads in the Area, the H/W ratio at Wing Lok Street or Bonham Strand in Sheung Wan, would be in excess of 12:1. When fully developed, this would be VERY DEEP street canyons indeed (Figure 5.11). It is anticipated that when that happens, critically poor urban air ventilation would results.

6.2.6 Elsewhere, for example at First Street, Second Street and Third Street in Sai Ying Pun, currently, the H/W ratios are in the order 2:1 or 3:1. Occasionally, over very narrow street frontages, this can increase to 6:1 or 7:1. However, when fully developed, the H/W ratio would be increased to around 10:1. And this would be VERY EXTENSIVE of over 300m long from Eastern Street to Western Street with only the narrow Centre Street in between.

6.2.7 It must be stressed that when the streets were laid out in the area at the turn of the century, they were designed with an H/W ratio of 1:1 in mind. This was controlled under the building regulations of 1903. The streets are never designed for the 10:1 ratio anticipated.

6.2.8 Apart from a street width to building height (street canyon) understanding, it is possible to evaluate the Initial Planned Scenario based on the inevitable increase of building volume in the Area. A pseudo but realistic hypothesis has been tested using the existing building foot print as the basis [no increase in ground (site) coverage]. They are extruded to the maximum allowed given the restricted building height. The BVD has been re-computed. The results are shown in Figure 6.4. Comparing this with Figure 5.4, it is apparent that most areas would have an increase of BVD from "high" to "very high". An increase in urban thermal heat stress in the summer months of Hong Kong is expected.

6.2.9 Apart from the BVD understanding, it is anticipated that re-developments would be larger and bulkier with extensive podia that occupy the entire site area. This would increase the Ground Cover (GC) of the Area, reduce the pedestrian level air volume and further restrict air ventilation.

6.2.10 Based on the BVD and GC understanding of the Initial Planned Scenario, urban thermal stress would increase, and urban air ventilation would decrease. The combined effect adds to human thermal stress and reduces urban thermal comfort.

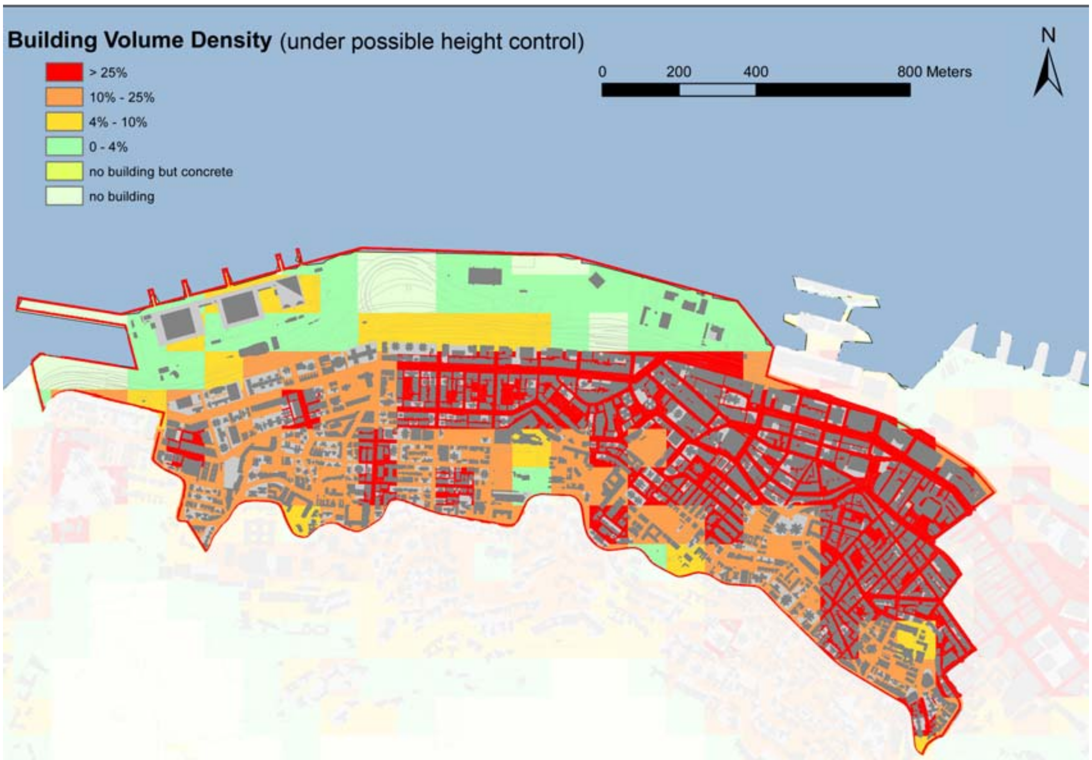


Figure 6.4 Building Volume Ratio map of the Area resolved to 100m x 100m grid based on the Initial Planned Scenario.

6.2.11 All in all, there seems to be no mitigation measure (i.e. reduction of ground coverage and increased greeneries) in the initial Planned Scenario to off set the adverse effects of higher building volume, larger and bulkier buildings and the increase of street canyons.

6.3 Some suggestions to improve the Initial Planned Scenario

6.3.1 The following suggestions, based on a sketch drawing (Appendix C) and have been discussed with Planning Department colleagues, is recommended for consideration when formulating the Recommended Scenario (Figure 6.5):

(a) According to section 11.2.9 of Hong Kong Planning Standards and Guidelines (Figure 6.5), buildings along the waterfront (shaded green in Figure 6.6), when re-developed, must not occupy the entire site frontage. When background prevailing wind is weak, sea breeze from the waterfront will be highly beneficial to the area. A 20-30% non-building area is recommended. [e.g. If the site frontage is 50m, then the building can only occupy 35-40m of its frontage. The NBA should ideally start from the ground level. Should this be not practically feasible, a "second best" alternative to start the "NBA" or "building gap/separation" from the top of the 15m podium level is acceptable.

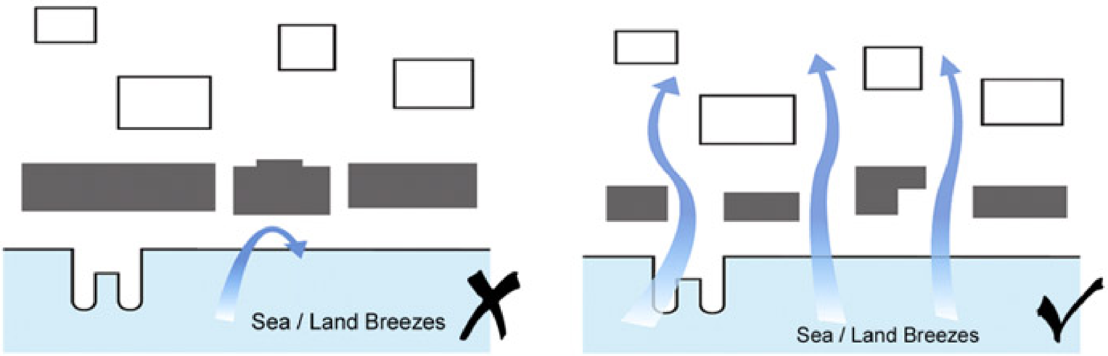


Figure 6.5 Waterfront buildings should avoid wind blockage (Source: HKPSG)

(b) All north-south streets and lanes from Connaught Road Central southwards must be widened. They include Jubilee Street, Gilman Street – Gilman Bazar, Wing Wo Street, and so on, as marked "red lines" on Figure 6.6. It is suggested that they be widened 30-50% to rough compensate the ill-effects of future taller buildings.

(c) For east-west air ventilation, it is suggested that Queen's Road West and Queen's Road Central be widened. This will serve as the main east-west air path to the heart of the study area. In addition, in Sheung Wan, Bonham Strand and Hollywood Road are suggested to be similarly widened. Refer to Figure 6.6 brown dotted lines. It is recommended that buildings along the abovementioned roads and strand be required to setback upon redevelopment. Ideally, refer to Figure 5.11, the setback would have to be in the order of 10m either side to roughly maintain the existing H/W ratio. This may not be practically feasible. If other planning considerations need to be taken into account, then “a set back” is better than “no setback”. A suggestion may be in the order of 2-3m. The widened streets must be landscaped with tree planting.

(d) North-south air paths (red lines in Figure 6.6) that extend southward from the Connaught Road West are useful. Similar to (b) above, it is suggested that they be widened 30-50% to rough compensate the ill-effects of future taller buildings. Should this be not practically feasible, a “second best” alternative is to impose “NBA” or building setback/gap/separation on top of the 15m podium level.

(e) The “G/IC” and “O” sites (shaded blue in Figure 6.6) along the air paths (red lines) are important air spaces to the Area which would enhance the efficacy of the air paths. They must be maintained and enhanced. No further increase of building volume, tall and bulky buildings should be allowed. Further greening and tree planting is necessary.

(f) Major “Air spaces” like the former Central Police Station Compound; the former Police Married Quarters site in Hollywood Road; the collection of Caine Road Garden, Caine Lane Garden and Blake Garden; Hollywood Road Park; and King George V Memorial Park are very useful to the Area and should be kept and enhanced. No further development is recommended. Further greening and tree planting is also necessary.

(g) The Area has a maze of minor lanes and streets. Most of them are stepped and are narrow. But together, they provide useful air ventilation connections and perforations at the pedestrian level. They must ALL be identified, preserved and enhanced. Opportunities should be taken to further widen and connect these lanes and streets as far as practicable.

(h) Historically, there are narrow scavenging lanes typically 6 feet in width. They have ceased to be functional and are now beginning to be sandwiched between tall buildings, it is suggested that they can be utilized by allowing redevelopment to occupy it and at the same time requiring the building to setback the same amount from the main street (Figure 6.7).

(i) Plaza and open spaces like that between Cosco Tower and Grand Millennium Plaza, and the space around The Center, provide some relieves and improved air spaces at the pedestrian level. They are useful design features, and selectively in congested areas, they can be encouraged.

(j) The re-development around Peel Street, Graham Street seems to be tall buildings but with reduced ground (site) coverage. For air ventilation, this can be a design strategy for improving the urban air ventilation. This should be selectively allowed when appropriate.

(k) In line with the suggestion in (a) above. NBA for each of the individual site to reduce the frontal area is also recommended (Figure 6.8).

(l) However, all in all, it must be stressed that the suggestions here can only partially offset the ill-effects of tall and bulky buildings that are going to happen given the need to accommodate the "development potentials" of the sites to the allowable plot ratio in the Area.

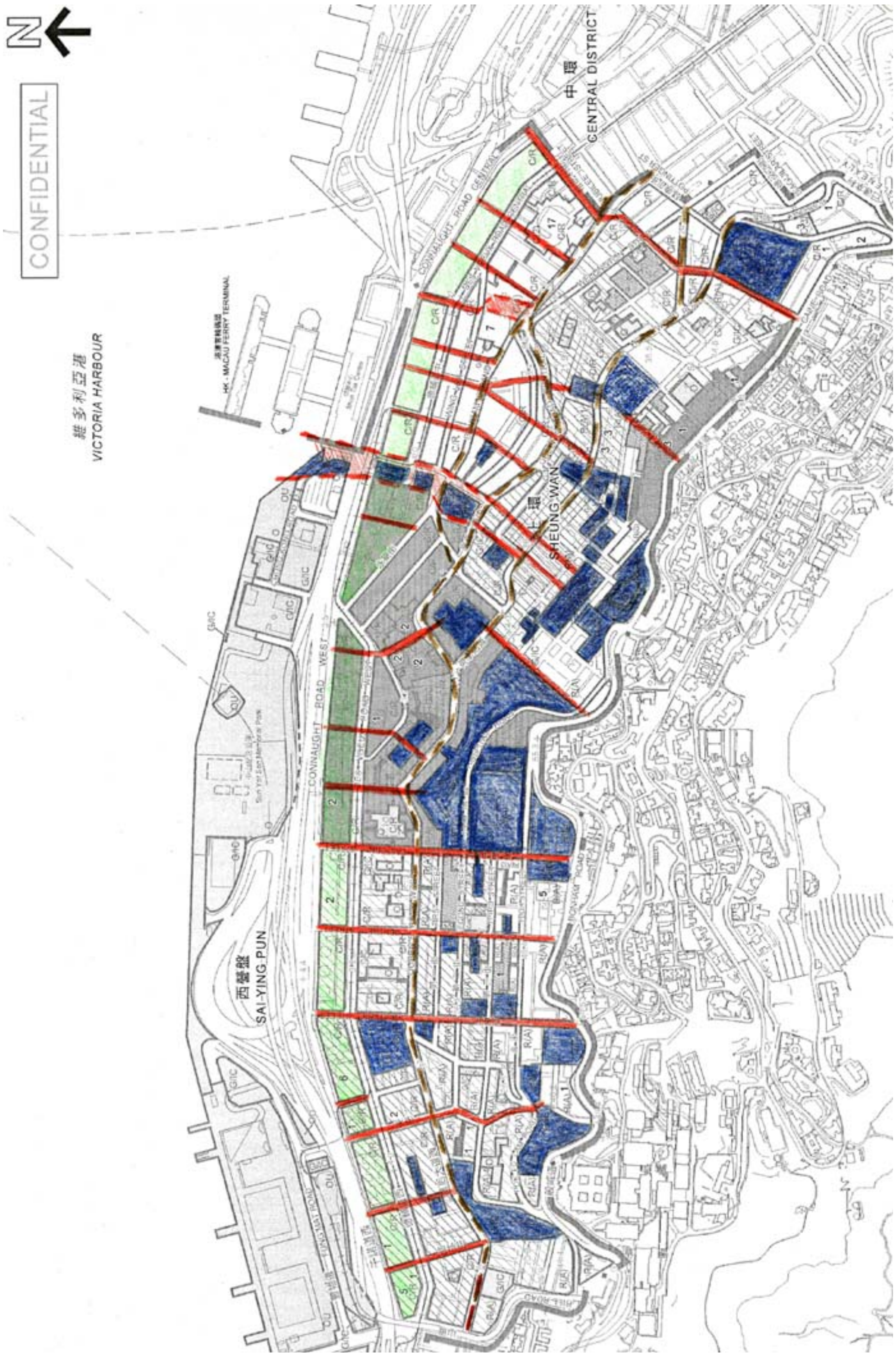


Figure 6.6 Some suggestions to improve the Initial Planned Scenario with air paths and air spaces. .

(existing) (suggested)

Figure 6.7 Building setback utilizing the scavenging lane. Wider streets can result.

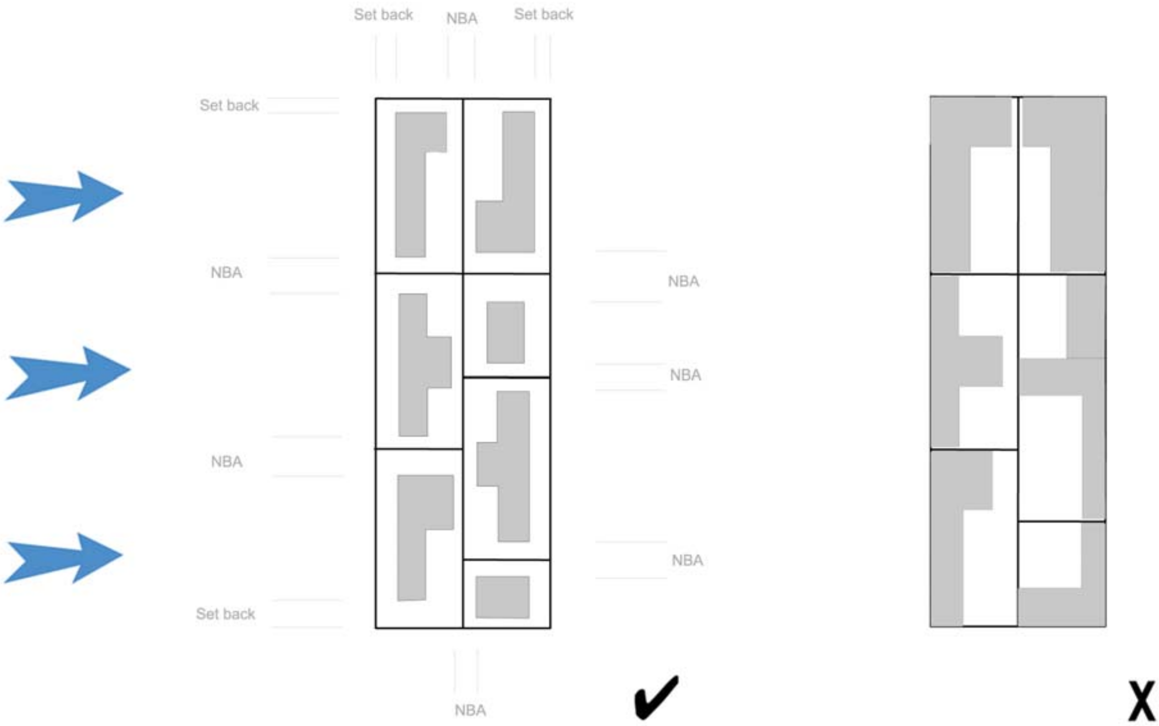


Figure 6.8 Within a street block, NBA between site lots and setback from the street of each individual site could result in a more perforated urban morphology on the whole. This is beneficial to urban air ventilation.

7.0 The Revised Scenario

7.1 In response to the expert evaluations of the initial planned scenario in section 6.0, a revised scenario (Figure 7.1) is proposed by the Planning Department. A number of suggested improvement measures as illustrated in Figures 7.1&7.2 and listed below have been incorporated in formulating the BH restrictions and to address the air ventilation issues earlier identified. The revised scenario is further evaluated below:

(1) Where there are already development restrictions (GFA, plot ratio and building height restrictions), they are not relaxed.

Evaluation: The existing allowable permissible GFA and plot ratio for "C" and "R(A)" developments are already high, (Figure 5.11 and 6.4). Not further relaxing them is only alternative practical compromise.

(2) All open spaces/green areas are maintained and majority of G/IC facilities is restricted to the existing height.

Evaluation: This improvement is in accordance with section 5.6.6 (i): The "GIC" and "O" zones in the Area should be respected. They provide useful "lungs" of air spaces in the Area. They should not be further developed with tall buildings or re-zoned for bulky development. This would ensure that the existing useful air spaces "lungs" are kept intact.

(3) Important "Air Spaces" including the former Central Police Station Compound, former Police Married Quarters site at Hollywood Road, Caine Road Garden and Caine Lane Garden; Blake Garden; Hollywood Road Park; and King George V Memorial Park have been kept.

Evaluation: This improvement is in accordance with the section 5.1.1: The study area has a few large open spaces acting as "air spaces" where air ventilation can be relieved given the dense urban morphology (Figure 5.1). They include the former Central Police Station Compound; former Police Married Quarters site at Hollywood Road; the collection of Caine Road Garden and Caine Lane Garden; Blake Garden; Hollywood Road Park; and King George V Memorial Park (Figure 5.2). They are very useful air spaces to the Area. Wake interference and isolated roughness flows (Figure 5.3) are possible bringing air into the pedestrian level.

(4) A stepped height concept with progressive increase towards uphill directions has been adopted taken the topography into consideration.

Evaluation: As mentioned in section 5.3.7, given that the buildings in many of the study areas are already tall, the street canyons are already deep, changing building heights a little bit one way or another would not matter ground level air ventilation that much. For example, all else being equal, a street canyon of H/W of 4:1 or 5:1 would have very similar air ventilation performance at ground level. In this case, the most effective way to improve air ventilation is to introduce gaps. A variation of 20m in height would make little difference for the air ventilation issues.

(5) All existing north-south streets/lanes have been maintained. All new developments/redevelopments abutting major north-south roads/streets/lanes will be imposed with a 2m wide set-back requirement from lot boundary above 15m measured from mean street level to create wider north-south air paths for better ventilation and visual permeability.

Evaluation: This improvement is in line with the recommendation in sections 6.3.1(b) & (d). It is suggested that they be widened 30-50% to rough compensate the ill-effects of future taller buildings. Should this be not practically feasible, a "second best" alternative is to impose "NBA" or building setback/gap/separation on top of the 15m podium level. The introduction of set-back above podium level by a minimum of 2m abutting major north-south streets is useful in enhancing the north-south air paths for better air ventilation.

(6) Future developments are encouraged to adopt suitable design measures to minimize any possible adverse impacts. These include greater permeability of podium, wider gap between buildings, non-building area to create air/wind path, perforate building towers and podium design, positioning of building towers to align with the prevailing wind directions, as appropriate.

Evaluation: This improvement is in line with the recommendations in section 5.6.6(iii). Should the encouraged design measures be implemented, it will help to improve the air ventilation of the Area.

(7) Individual development in the northern part near the waterfront when redeveloped is encouraged not to occupy the entire site frontage for better penetration of sea breeze into the urban core especially during calm background wind conditions when the sea breezes are useful.

Evaluation: This improvement is in line with the recommendations in section 6.3.1(a). The NBA should ideally start from the ground level. Should this be not practically feasible, a "second best" alternative is to provide the "NBA" or "building gap/separation" above 15m podium level (measured from the mean formation level) and upwards. Should the encouraged design measures be implemented, it will help to improve the air ventilation of the area.

(8) Existing narrow roads/streets and foot paths in the SOHO and immediate adjoining area subject to traffic constraints will be widened to enhance the pedestrian/traffic movements as well as air ventilation.

Evaluation: This measure, if implemented, is useful for air ventilation.

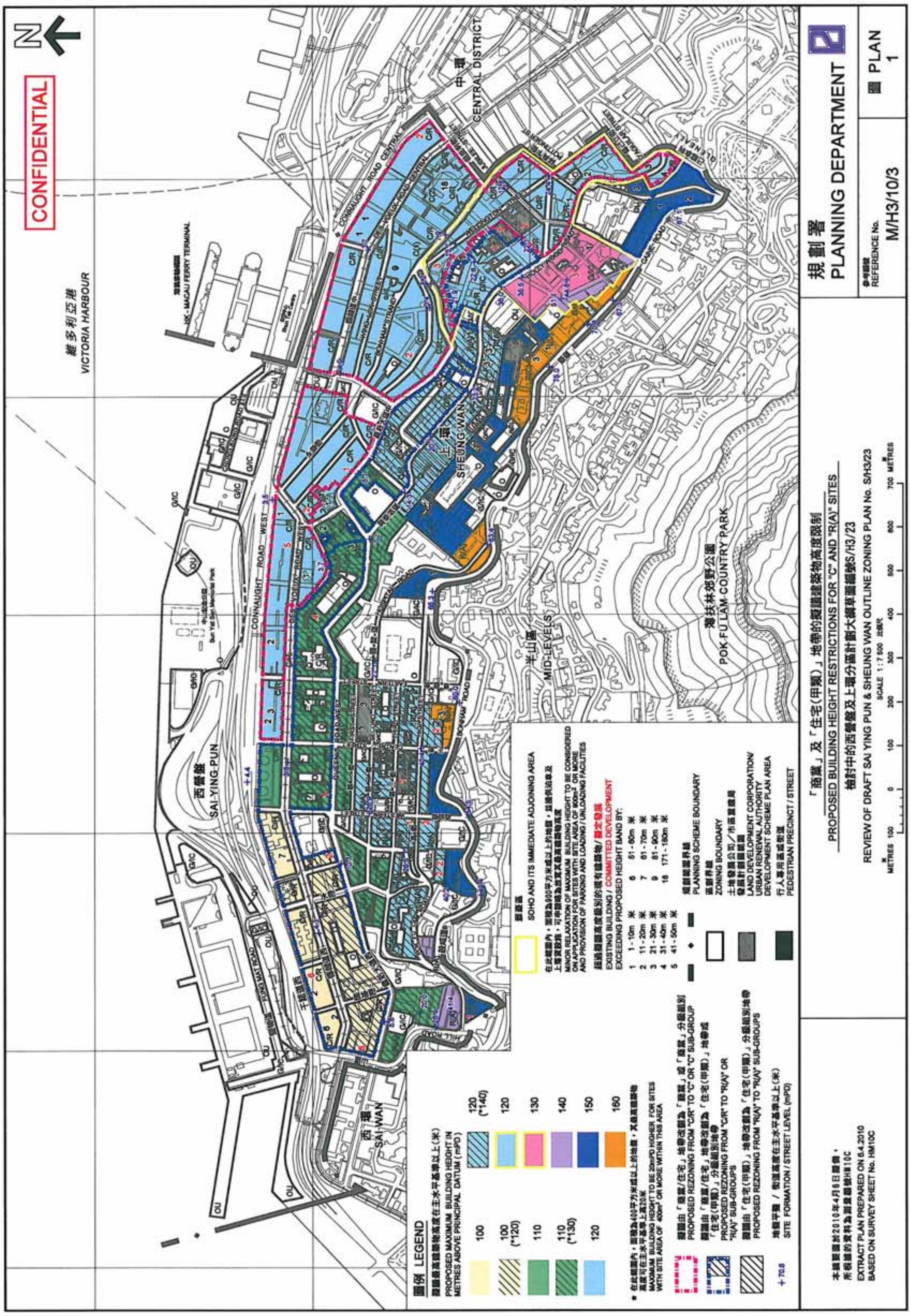


Figure 7.1 Revised scenario of proposed height bands for the Area

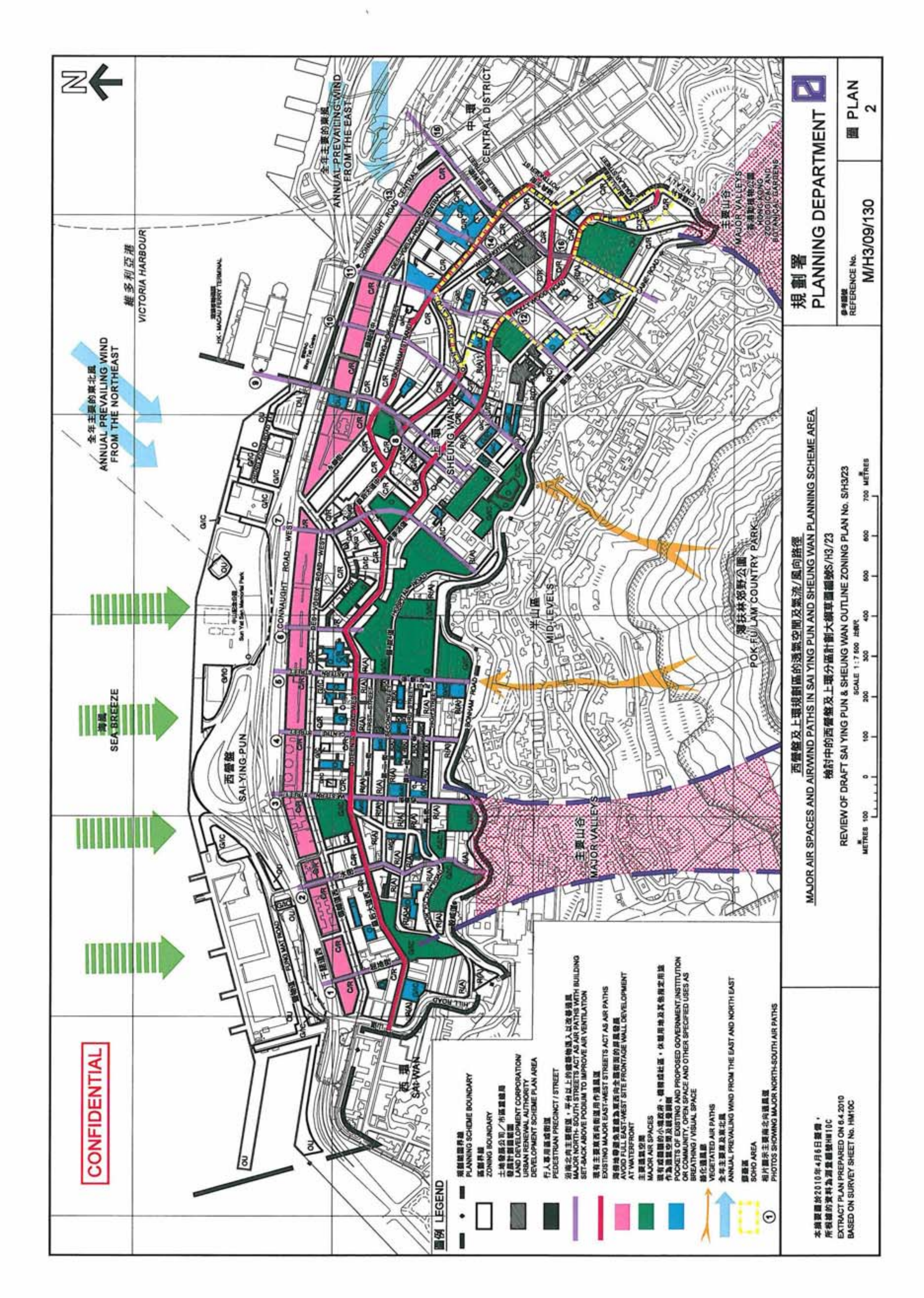


Figure 7.2 Revised scenario of major air spaces and air paths in the Area

Date: 19 April 2010

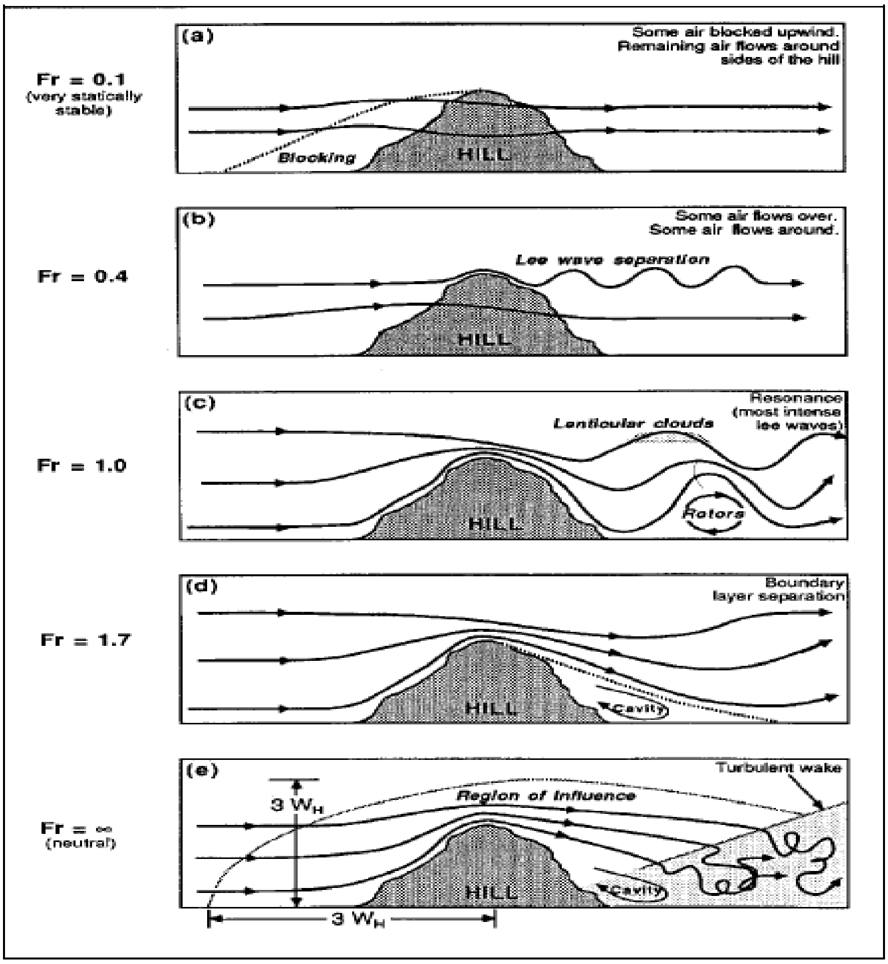
Professor Edward Ng
On behalf of technical experts in the term consultant term

School of Architecture, CUHK,
Shatin, NT, Hong Kong
T: 26096515 F:26035267
E: edwardng@cuhk.edu.hk

Consultant team

	Expertise
Professor Edward Ng (Coordinator) CUHK, Hong Kong	Architect, Environmental and sustainable studies
Miss Betty Ho	Planner,
Mr K S Wong	Architect,
Professor Jimmy Chi-Hung Fung HKUST, Hong Kong	Mathematician, Meso-scale wind field modeling, CFD
Dr S C Kot, (retired) HKUST, Hong Kong	Mechanical Engineer, Aerodynamicist, Computational Fluid Dynamics (CFD), Wind tunnel engineer

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)

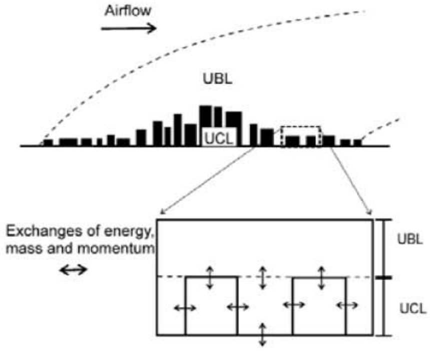
$$F_r^2 = \frac{\text{Inertial forces}}{\text{Bouyant forces}} \qquad F_r^2 = \frac{\bar{u}_0^2/W_h}{g\Delta\theta/\theta_0}$$

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.]

Appendix B:

A scientific understanding of building heights for City Planning



The air mass exchange of an urban area can be understood based on the Urban Boundary Layer (UBL) and the Urban Canopy Layer (UCL) interaction.

To optimize air ventilation of the UCL, which is the layer of human occupation including pedestrian at ground level, it is useful to maximize the energy, mass and momentum exchange between UBL and UCL. The vertical exchange is denoted by U_E and can be expressed with the following equations:

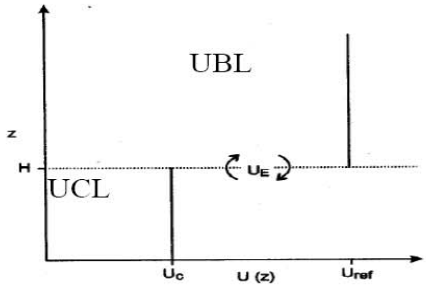
$$\frac{U_C}{u^*} = \left[\frac{\lambda_f}{2}\right]^{-0.5} \quad \text{for } \lambda_f > 0.2$$

$$\frac{U_E}{u^*} = \left[\frac{1}{k}\ln\left(\frac{z_{ref} - d}{z_o}\right) - \frac{U_C}{u^*}\right]^{-1}$$

where

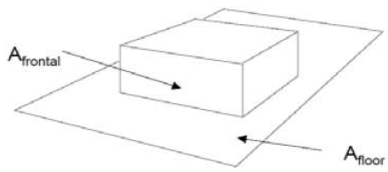
$$\frac{U_C}{u^*} = \left[\frac{z_o}{2H}\right]^{-0.5} \quad \text{for } \lambda_f < 0.2$$

Uc	the average flow within the canopy
U*	friction velocity
Zo	roughness length
d	displacement height
λf	frontal area density
H	average building height
K	von Karman constant = 0.4



λf frontal area density :-

$$\lambda_f = \left(\frac{\sum_{obstacles} A_{frontal}}{A_{floor}}\right)$$



Hence, to increase U_E , it is important to lower the displacement height (which is normally taken as 0.7*UCL, and UCL is commonly taken as 1.2*H). It is also important to increase the roughness length (Zo) by optimizing λf to around 0.1 to 0.3.

All else being equal, this means a collection of <u>tall buildings</u> in an urban area resulting in high UCL and high λf, and therefore higher displacement height, can lead to lower U_E. Lowering building heights can be a solution.

Furthermore, this also means that closely packed buildings of <u>uniform building height</u> (or small building height variation) can result in lower Zo and can lead to lower U_E. Creating large building height variations can be a solution. Having a building height to street width (H/W) ratio of less than 1.5 to 2 in order to avoid a skimming flow regime developing can also be a solution.

Professor Edward Ng, CUHK, 2009.

Appendix C: A working sketch towards air paths and air spaces for air ventilation of the study area for the Initial Planned Scenario