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

Wan Chai Area

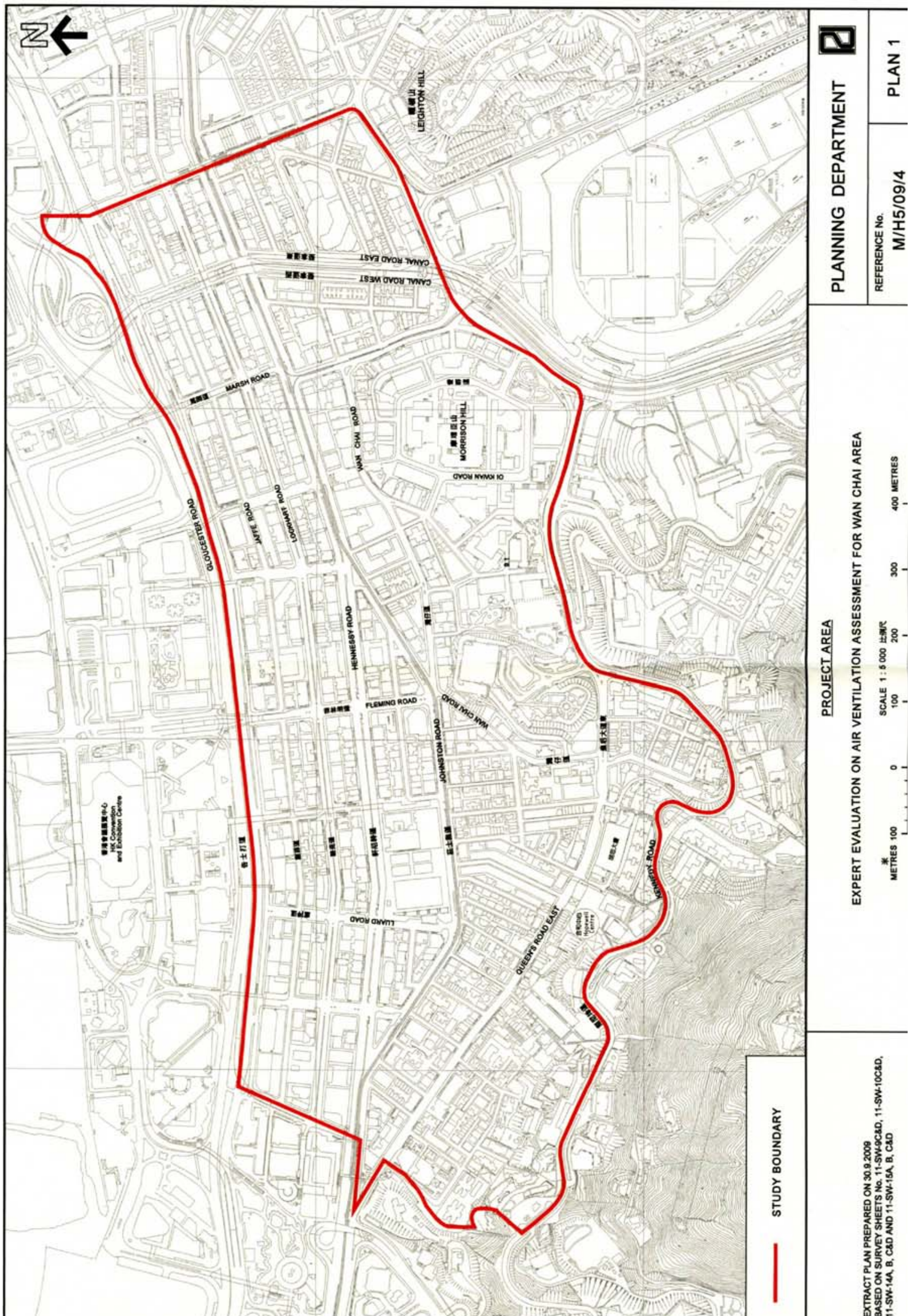
September 2010

建築 中大

……………………………………….

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 Wan Chai Area - **Executive Summary**

0.1 Wind Availability

(a) Based on the available wind data, the annual wind of the study area (the Area) is mainly from the East and North-East. The summer wind is mainly coming from the Southerly quarters over the hills and from the East due to the channeling effects of Victoria Harbour.

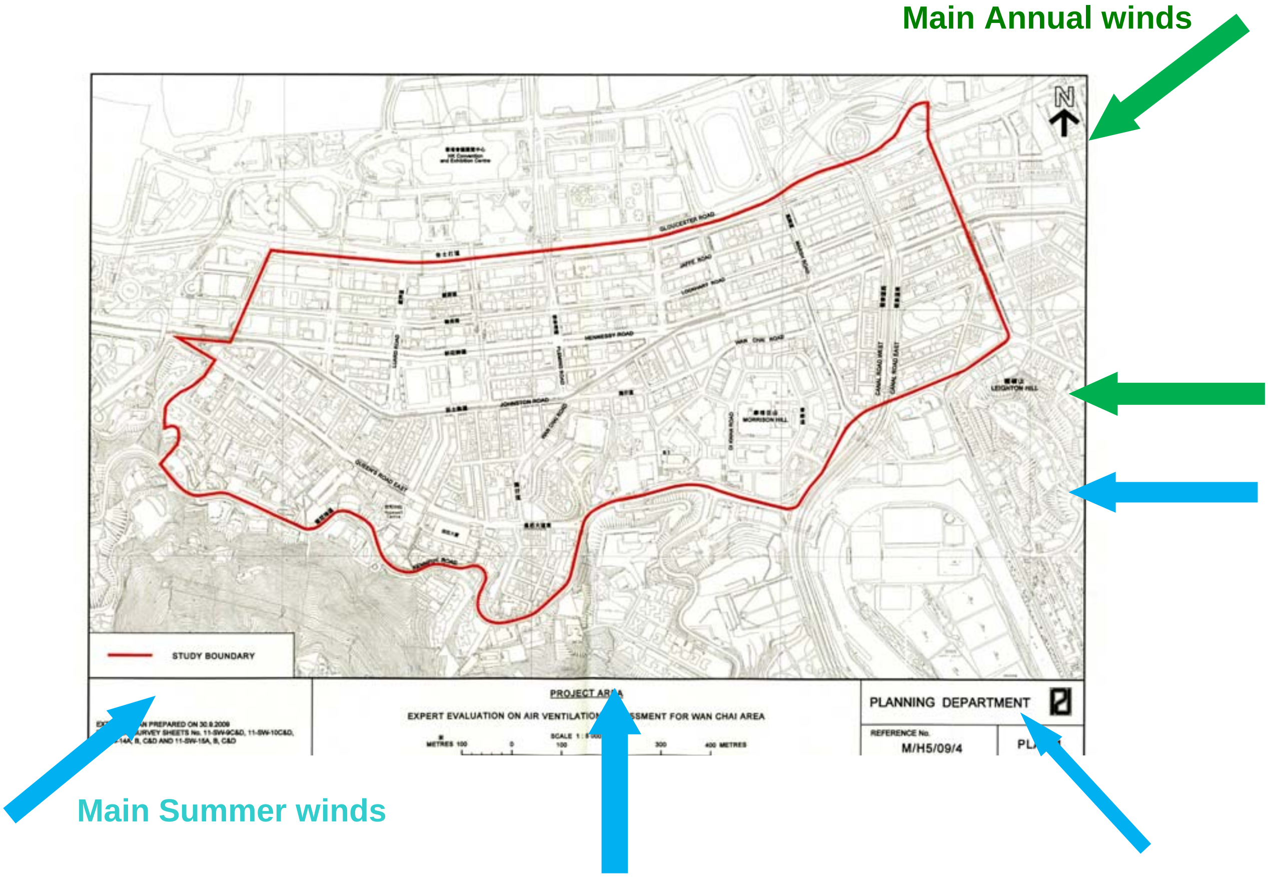


Figure 0.1 A summary of the prevailing winds of the Area

0.2 Existing conditions

(a) North-south streets between Gloucester Road and Johnston Road are about 25m wide. East-west streets in the study area are 15-30m wide. Buildings on both sides of streets are 40-120mPD. So the height to width ratio (H/W) is in the order of 3 or higher. Skimming flow into the street canyon will occur when H/W is larger than 2 and when wind is flowing perpendicular to the streets.

(b) The Area has a few larger open spaces as "air spaces" where air ventilation can be relieved within the dense urban morphology. There are: Southorn Playground, HK Jockey Club Garden, Wan Chai Park (together with Wah Yan College HK and Tung Wah Centenary Square Garden), and green area west of Hopewell Centre. They can be useful reliefs to the Area.

(c) Due to the fact that the greenery coverage of the Area is small to medium; the corresponding Ground Coverage (GC) is medium to high. The building volume density (BVD) of the Area is medium to high. Very high BVD can be found around the intersection of Spring Garden Lane and Queen's Road East, Hennessy Road in the middle and east near Causeway Bay. Very high thermal capacity is expected. Elsewhere, apart from a few open spaces, BVD is also high.

(d) For wind coming from the East over Victoria Harbour and Causeway Bay, it is expected that wind will flow along the major east-west roads such as Gloucester Road, Jaffe Road, Lockhart Road, Hennessy Road, Johnston Road, Queen's Road East and Kennedy Road. These streets are important air paths for the Area.

(e) For wind coming from the North-East over Victoria Harbour, it will penetrate into the study area through the Wan Chai Sports Ground and the greenery area immediately outside the Cross Harbour Tunnel. It is also expected to penetrate via the north-south streets between Gloucester Road and Hennessy Road into the urban fabric.

(f) For wind coming from the south over the hills and the Mid-levels East area, the small valley wind system identified along Wan Chai Gap Road can assist locally. However, there is no air path possibility for this wind system to penetrate further into the Area. It will more or less terminate at Queen's Road East. There are some existing north-south aligned roads on both sides of Queen's Road East, which also functions as local/minor air paths. To facilitate better air ventilation, these roads should not be built-over. Opportunities should be taken to widen these roads and/or to align them in such a way that north-south air paths can be formed to provide air passages for wind coming from the south to Wan Chai North through the western part of Wan Chai.

(g) Due to the low rise buildings of Morrison Hill, southerly wind in the summer months can flow over Morrison Hill Swimming Pool and surrounding GIC buildings. It is important to maintain the efficacy of the existing air path along Tonnochy Road and the open space to its immediate south. Opportunity should be taken to extend the air path southward to connect with that over the low-rise G/IC sites at Morrison Hill.

(h) West of Tonnochy Road, there is no street or road that connects all the way from the south of the Area to the north. Hence there is no direct air path parallel to the incoming southerly wind. It is vitally important to find ways to create south-north air paths.

0.3 The Existing Conditions with Committed Projects

(a) The committed projects are mostly single tower development on their own podium. Although they are tall buildings, at the moment they do not form wall like structures that would adversely affect the prevailing wind movement and air ventilation.

(b) The extensive (100%) site coverage podia of the newer developments replace the more porous older buildings at or near ground level. This has the impact of increasing ground coverage and reducing near ground level air volume which is not conducive to urban air ventilation.

(c) Potential developments are expected to be developed to their respective maximum plot ratio, maximum podium coverage and maximum height allowed. On the whole, from an urban district based perspective, they will increase the thermal load of the area; they will increase urban roughness, diminish air ventilation potentials; and they may form deep street canyons and eventually wall like barriers.

0.4 The Initial Planned Scenario

(a) The 4 G/IC sites between Fleming Road and Stewart Road are aligned with each other along the north-south direction. Since one G/IC site in the middle is tentatively proposed to be developed up to 110mPD, the connected air path will be disturbed in the middle and some incoming wind will be weakened. It is therefore recommended that appropriate land sale conditions should be included for this site requiring the developer to adopt air ventilation improvement/mitigation measures, e.g. non-building areas, to facilitate the north-south air movement over these G/IC sites. A design that incorporates features that allows high permeability is desirable. It is also suggested that the maximum building height of the site be reduced to 80mPD to be compatible with the height of the existing building to the south to allow low level air ventilation in the Area.

(b) On the whole, the inevitable increase of building volume and thus thermal load should be mitigated with a reduction of ground coverage and increased greenery. It is highly recommended to be incorporated.

(c) Building disposition affects air ventilation, how buildings should be designed with air ventilation permeability in mind should be stated. Building gaps and separations are very important (refer to SDU's Building Design to Foster a Quality and Sustainable Built Environment is a good start). It is recommended that appropriate building design to improve air permeability at podium level should be encouraged. Building set back above podium level from the side boundaries are encouraged so as to provide wider building separations to improve air ventilation.

(d) Building permeability as mentioned in (c) above is particularly important for the "R(A)" belts of sites on the southern side of Wan Chai Road.

(e) It is important to respect all existing roads within the "R(A)" and "C/R" zones. They should not be developed over with the amalgamation of sites. These roads are air spaces. Air spaces allow air movement and circulation by mixing and turbulent flow while air paths allow more directional air mass exchange by advection.

(f) Based on the views expressed under the previous section on Initial Planned Scenario, Planning Department has proposed to incorporate some of the mitigation measures mentioned.

(g) All in all, given practical constraints and the need to respect 'development rights' of the land owner, the proposed mitigation measures seem to have noted some of the more important concerns we have expressed with the Initial Planned Scenario. We regard this represents a small but important step towards creating a quality urban environment for the general public of Hong Kong.

0.5 The Revised Planned Scenario

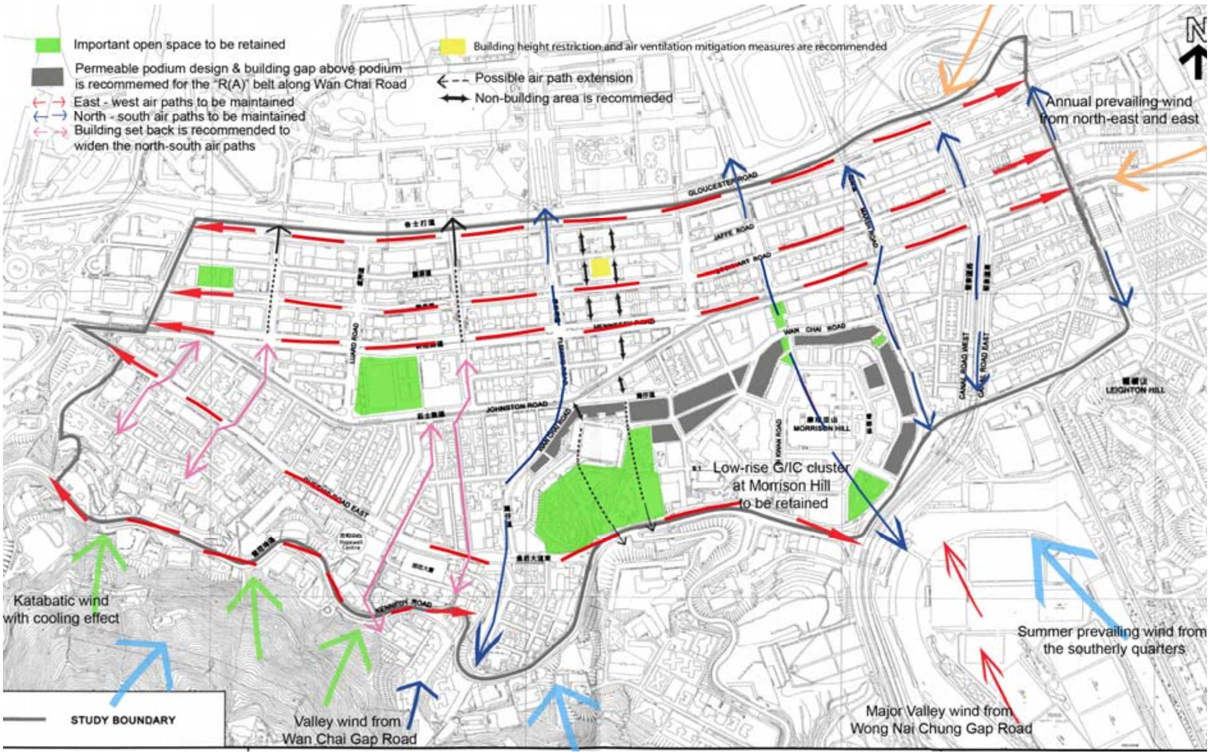


Figure 0.2 Some mitigation measures incorporated into the Initial Planning Scenario

(a) Based on the views expressed under the previous sections on Initial Planned Scenario, Planning Department has proposed to incorporate some of the mitigation measures mentioned and provided a Revised Planned Scenario (Figure 0.2)

(b) All in all, given practical constraints and the need to respect 'development rights' of the land owners, the proposed mitigation measures have noted and responded to some of the more important concerns we expressed on the Initial Planned Scenario. However, the overall need to reduce the Ground Coverage, Building Volume Density and building height has not been addressed. Besides, more non-building areas and greeneries are still highly encouraged to include. We regard this represents a small but important step towards creating a quality urban environment for the general public of Hong Kong.

Expert Evaluation Report of
Wan Chai Area

1.0 The Assignment

1.1 In order to provide better planning control on the building height upon development/redevelopment, the approved Wan Chai Outline Zoning Plan (OZP) No. S/H5/25 (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 & number of storeys) for Wan Chai Area
-	existing building height restriction for “R(C)” under Wan Chai OZP
-	proposed building height restrictions for “C”, “R(A)”,”R(B)”, “G/IC”, “OU” in Wan Chai Area
-	committed projects and potential development sites
-	aerial photo of Wan Chai Area
-	spot heights in Wan Chai Area

1.3 The consultant has studied the above mentioned materials, and has conducted site inspection on 18th and 25th November 09. During the writing of the report, the consultant has working sessions with colleagues of Planning Department on 29th October 2009, 20th January 2010 and 19th March 2010.

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 has 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.

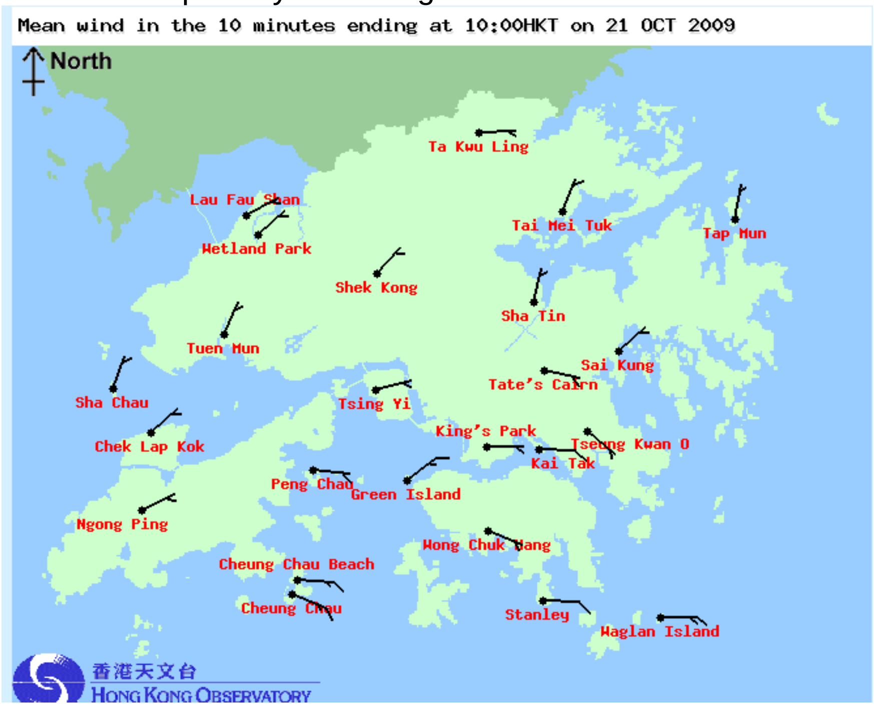


Figure 3.1 Some of the HKO stations in Hong Kong. This is a screen capture at 10am on 21 Oct 2009 from the HKO website. The arrows show the wind directions and speeds of the time.

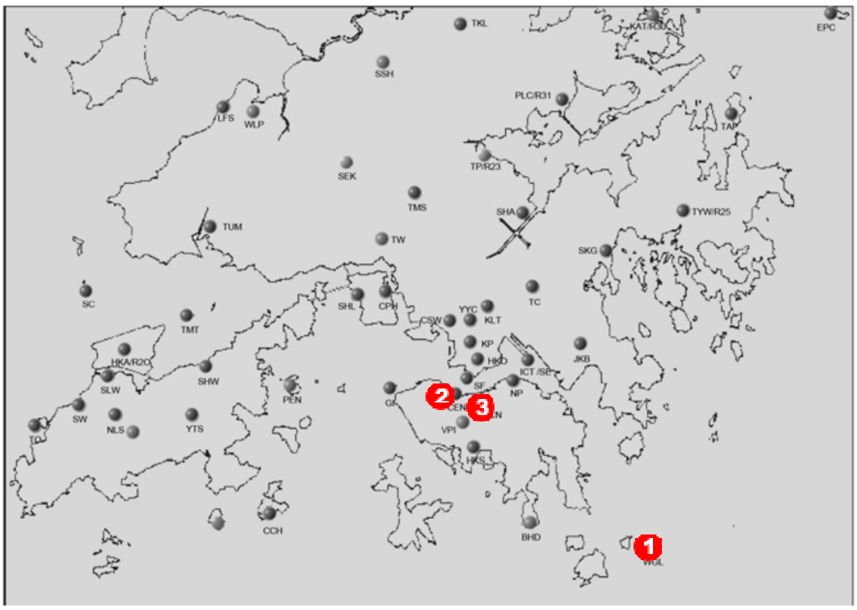


Figure 3.2 The HKO stations at 1: Waglan Island (WGL), 2: Central Star Ferry Pier (CEN), 3: Central Plaza (WCN)

3.2 The HKO station at Waglan Island (WGL) is normally regarded by wind engineers as the reference station for wind related studies (Location 1 in Figure 3.2). 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 (Figure 3.3), 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 (Figures 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.

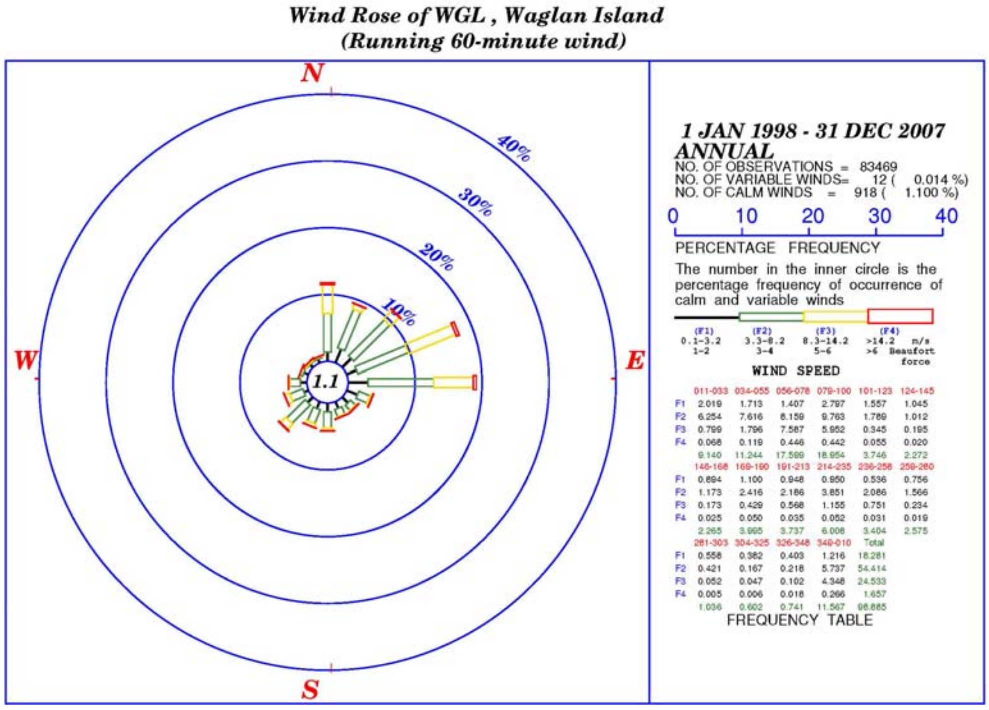


Figure 3.3 Wind rose of WGL 1998 – 2007[1] (annual)

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

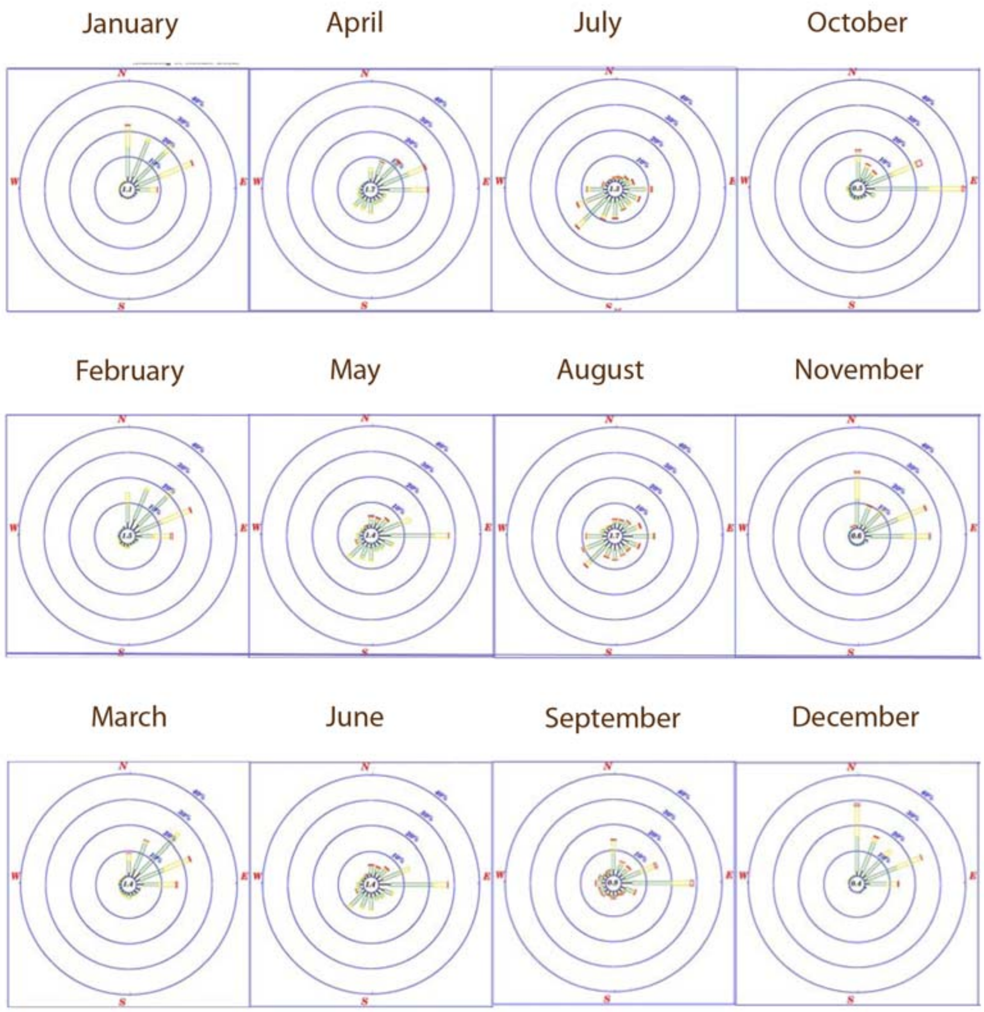


Figure 3.4 Monthly wind roses of WGL 1998 – 2007

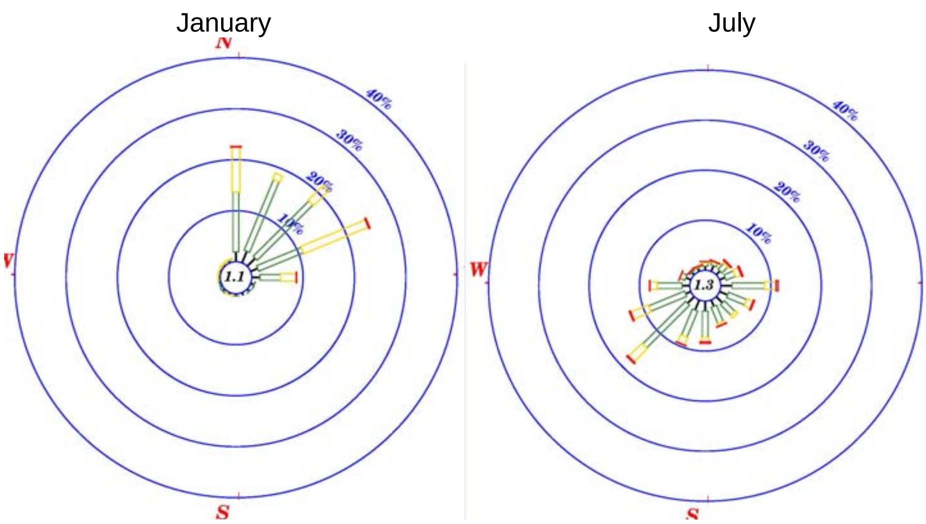


Figure 3.5 Wind roses of WGL 1998 – 2007 (Jan and July)

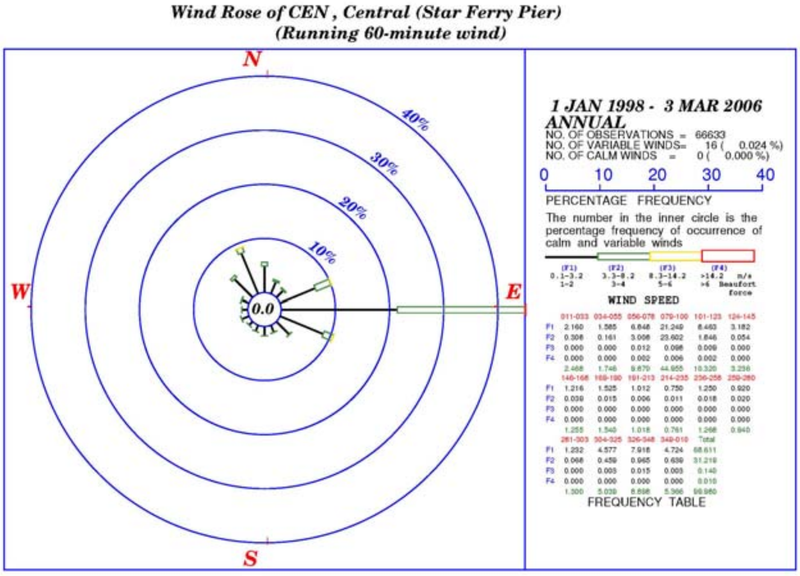


Figure 3.6 Wind rose of Central Star Ferry Pier 1998-2007 (annual)

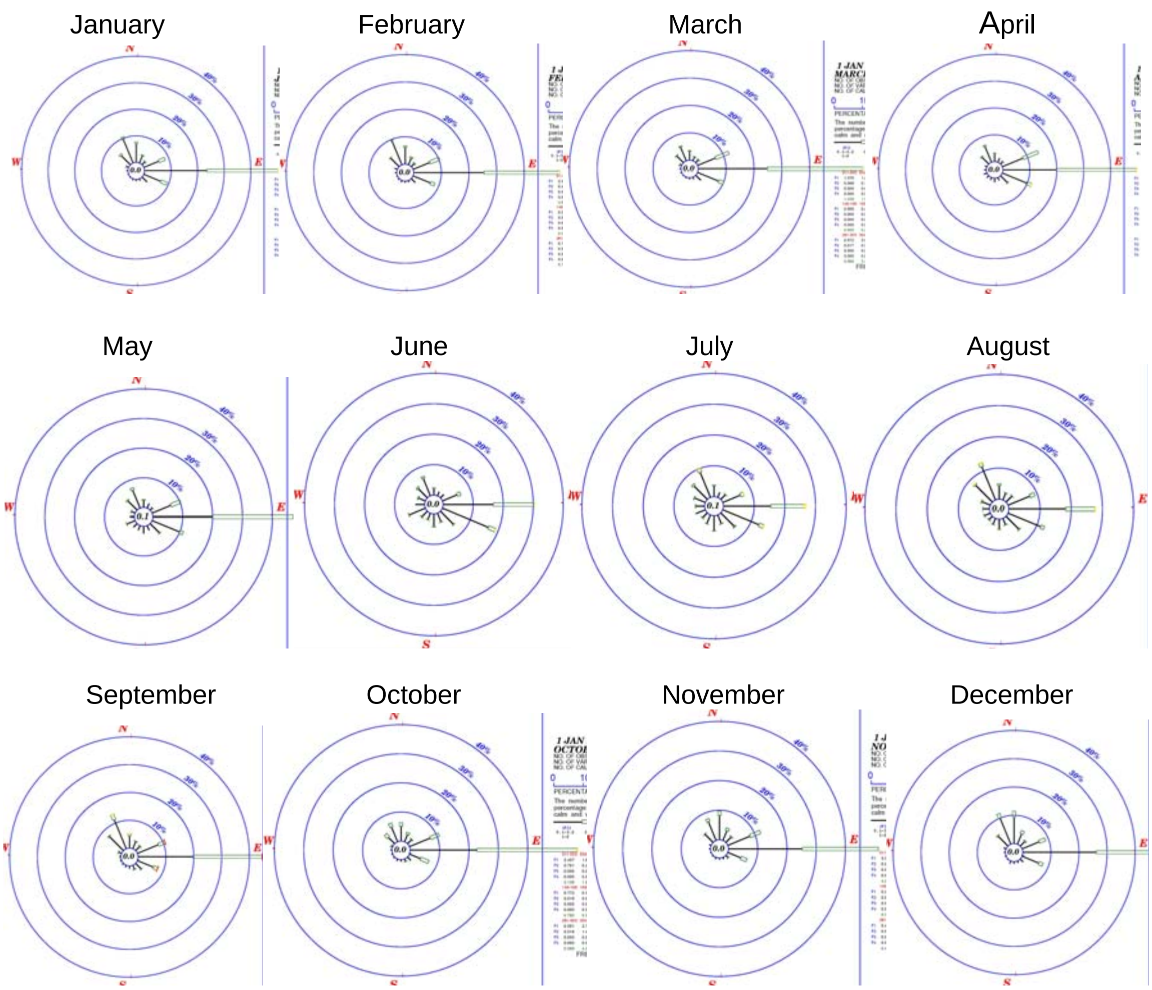


Figure 3.7 Monthly wind roses of Central Star Ferry Pier 1998 – 2007

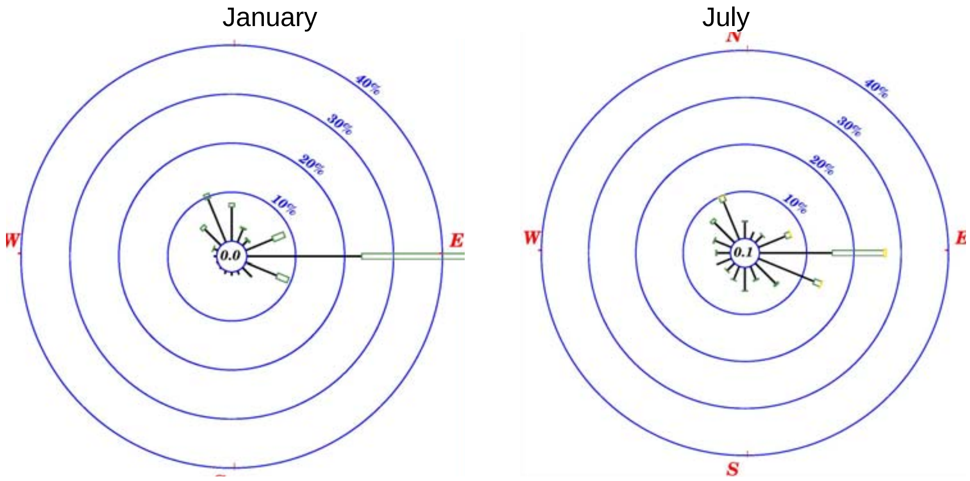


Figure 3.8 Wind roses of Central Star Ferry Pier 1998 – 2007 (Jan and July)

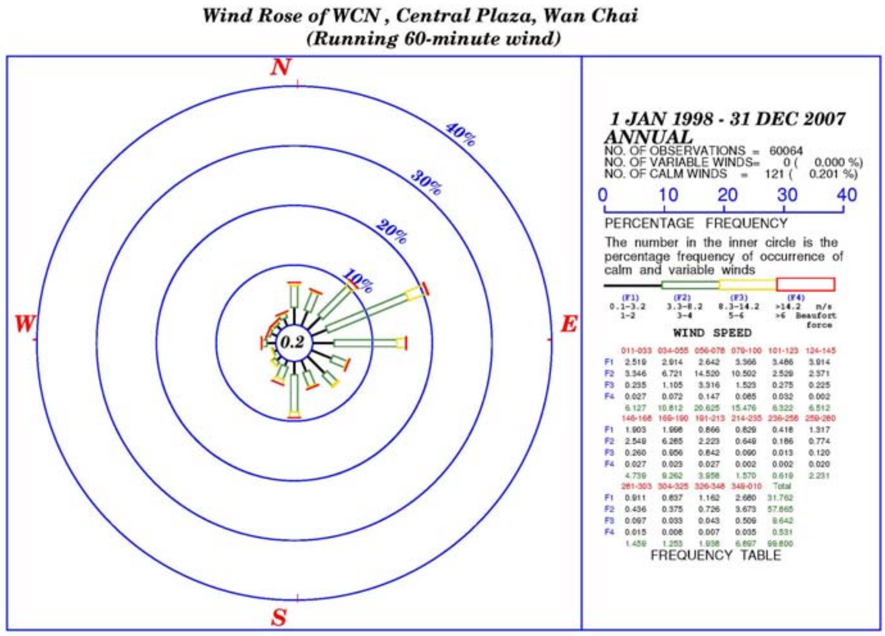


Figure 3.9 Wind rose of Central Plaza 1998-2007 (annual)

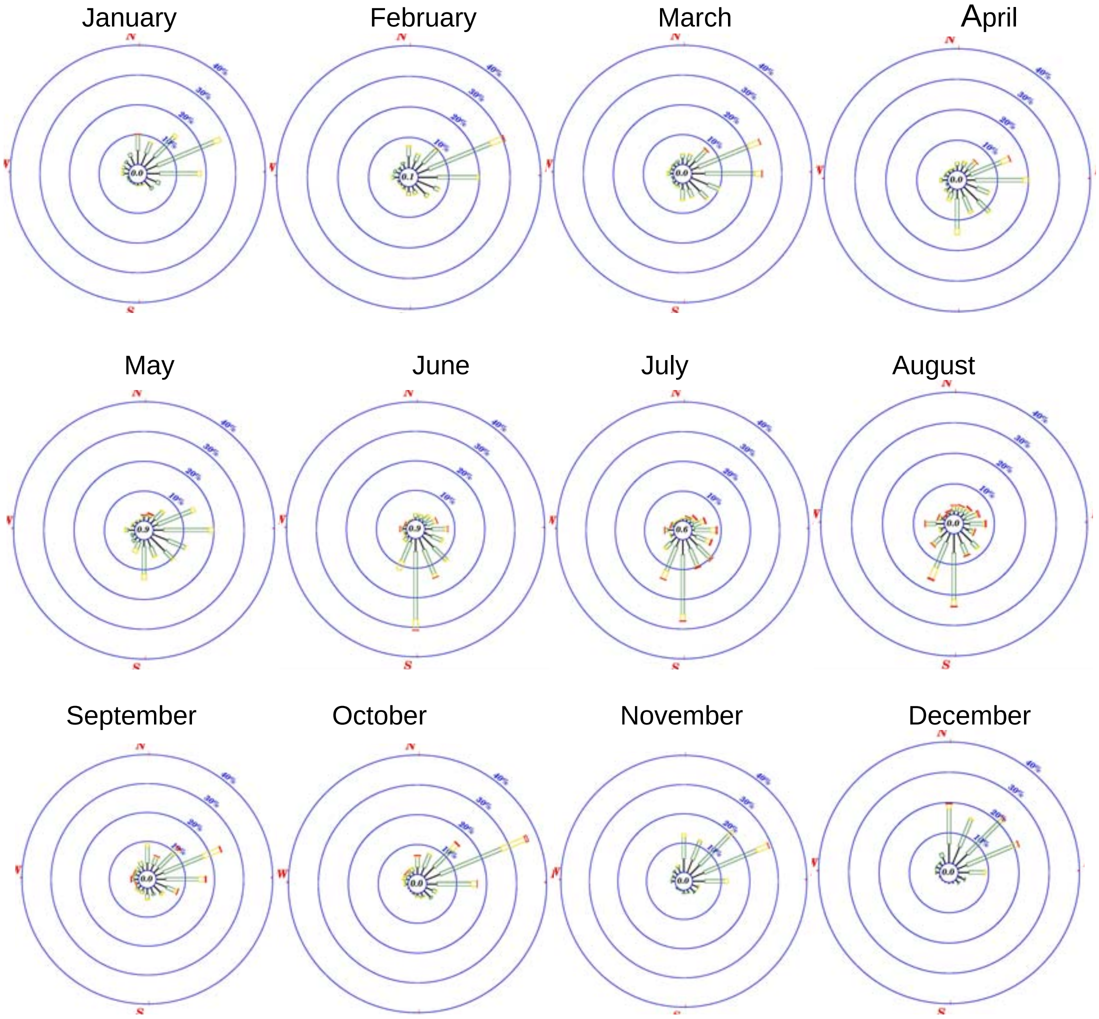


Figure 3.10 Monthly wind roses of Central Plaza 1998 – 2007

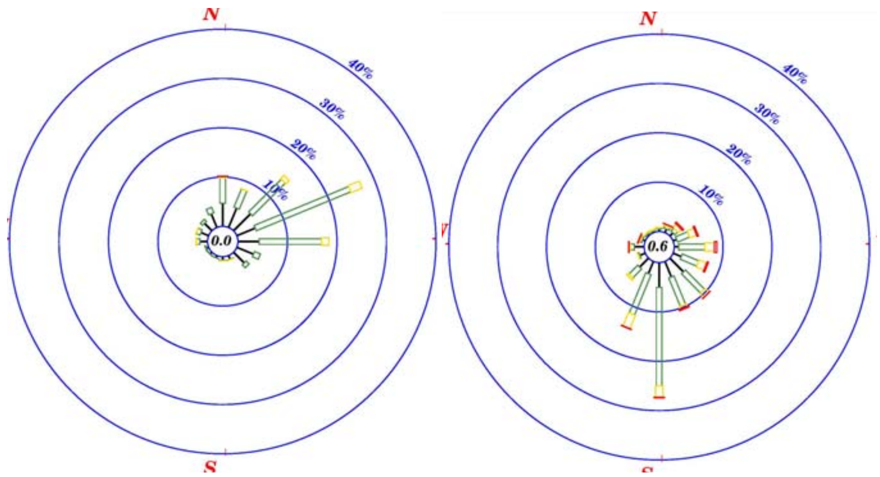


Figure 3.11 Wind roses of Central Plaza 1998 – 2007 (Jan and July)

3.5 Besides Waglan Island, wind data from two other nearby stations are also analyzed, namely Central Star Ferry Pier and Central Plaza (Figures 3.6 – 3.11). Both annual and summer data at Central Star Ferry show a strongly dominant component of East wind. Data at Central Plaza record wind ranging from northeast, east wind, and southeast to south. However, Central Star Ferry Pier is widely open to the sea and the measurement is dominated by the channeling effect. Wind at Central Plaza is measured at a height of 378mPD and the data is less affected by topography in the south or channeling effect of Victoria Harbour.

3.6 Researchers at Hong Kong University of Science and Technology (HKUST), Prof Alexis Lau and Prof Jimmy Fung, have simulated a set of wind data using MM5. The data period cover the whole year of 2004. Based on this dataset, 3 locations of the Area are extracted at 120m and 450m above ground (Figures 3.12 – 3.18). These 3 locations, according to the theories of MM5, are selected to representatively reflect the general wind pattern within the study area induced by topography. The altitude of 450m can be assumed to represent the gradient height under atmospheric boundary layer (ABL) wind characteristic 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 3.12 The 3 locations of MM5 extracted data

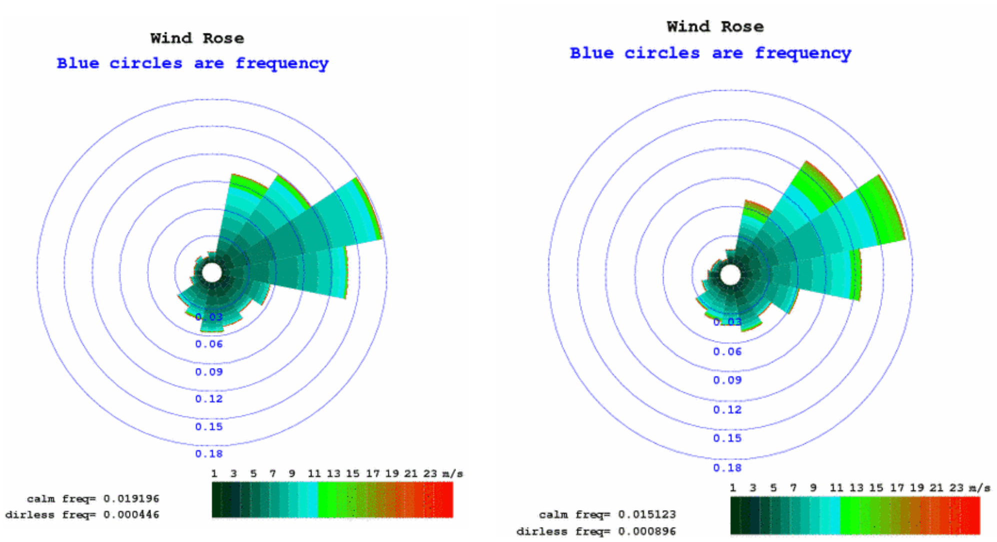


Figure 3.13 Wind roses (annual) at A (left:120m) (right:450m)

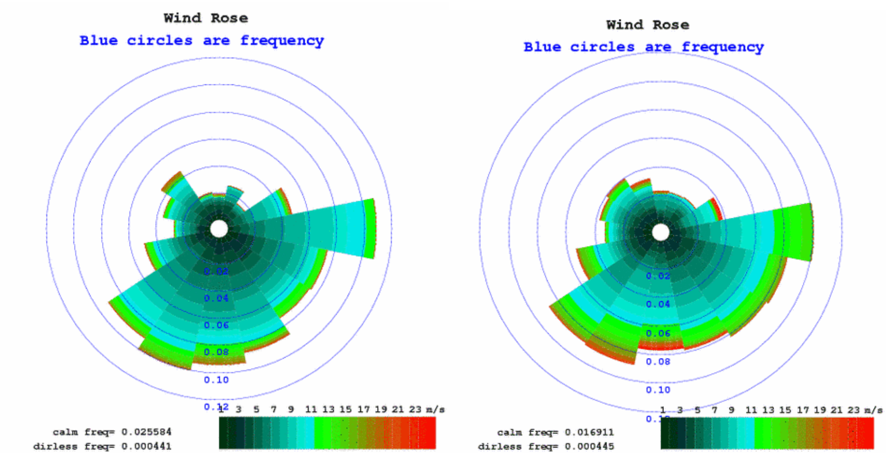


Figure 3.14 Wind roses (summer) at A (left:120m) (right:450m)

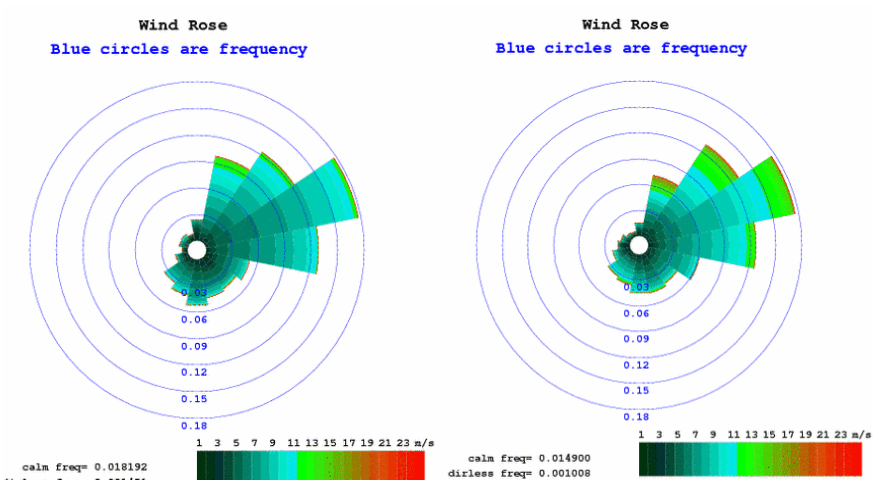


Figure 3.15 Wind roses (annual) at B (left:120m) (right:450m)

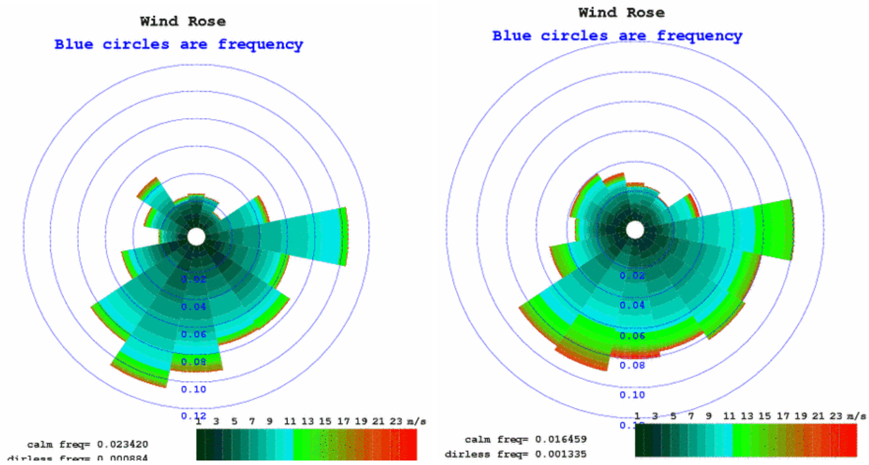


Figure 3.16 Wind roses (summer) at B (left:120m) (right:450m)

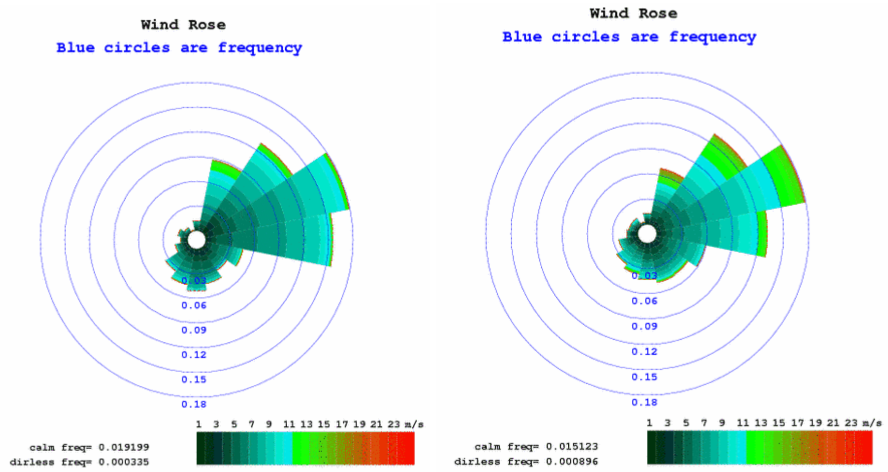


Figure 3.17 Wind roses (annual) at C (left:120m) (right:450m)

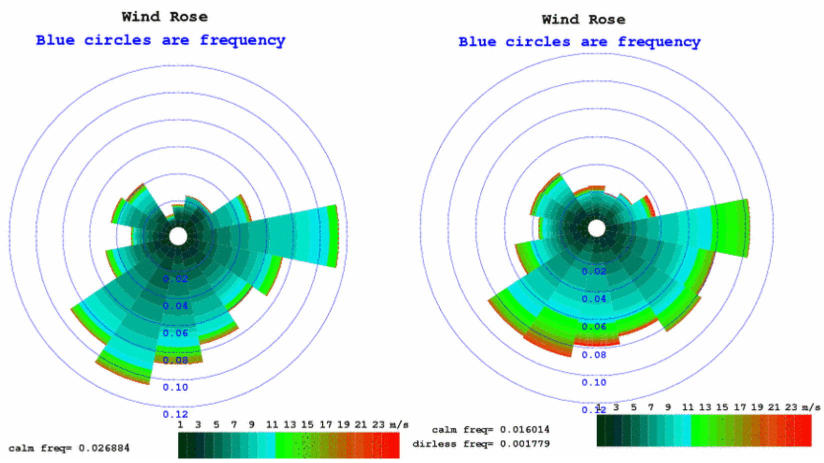


Figure 3.18 Wind roses (summer) at C (left:120m) (right:450m)

3.7 Extracted from the simulated MM5 data, a general understanding of the summer and the annual prevailing wind directions of the Area and the surroundings are indicated in Figures 3.19 and 3.20. This general (urban canopy height) understanding should not be confused with illustrations in Figures 4.1, 5.7 and 5.8. Although together contributing to air ventilation assessment, they belong to different steps of analysis. In Figures 3.19-3.20, 60mPD is selected to account for the local typological effect. Parameterized ground cover has been taken into account in this stage of evaluation. Detailed analysis of this area-average understanding to take into account local valley and channeling effects, as well as street layouts & building morphology of the area is then further evaluated at the street level as in Figure 4.1 and Figures 5.7-5.8 respectively.

Figure 3.19 Prevailing wind directions (annual) based on MM5 (60mPD).

Figure 3.20 Prevailing wind directions of the summer months (Jun-Aug) based on MM5 (60mPD).

3.8 Based on the MM5 simulated wind roses of the 3 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 3locations

	Annual	Summer
A	E, NE	S, E, SW, SE
B	E, NE	S, E, SW
C	E, NE	S, E, SW

3.9 In summary, based on the available wind data shown in Figures 3.3 – 3.20, one may conclude that <u>the annual wind of the study area is mainly from the East and North-East. The summer wind is mainly coming from the Southerly quarters over the hills and from the East due to the channeling effects of Victoria Harbour (Figure 3.21).</u>

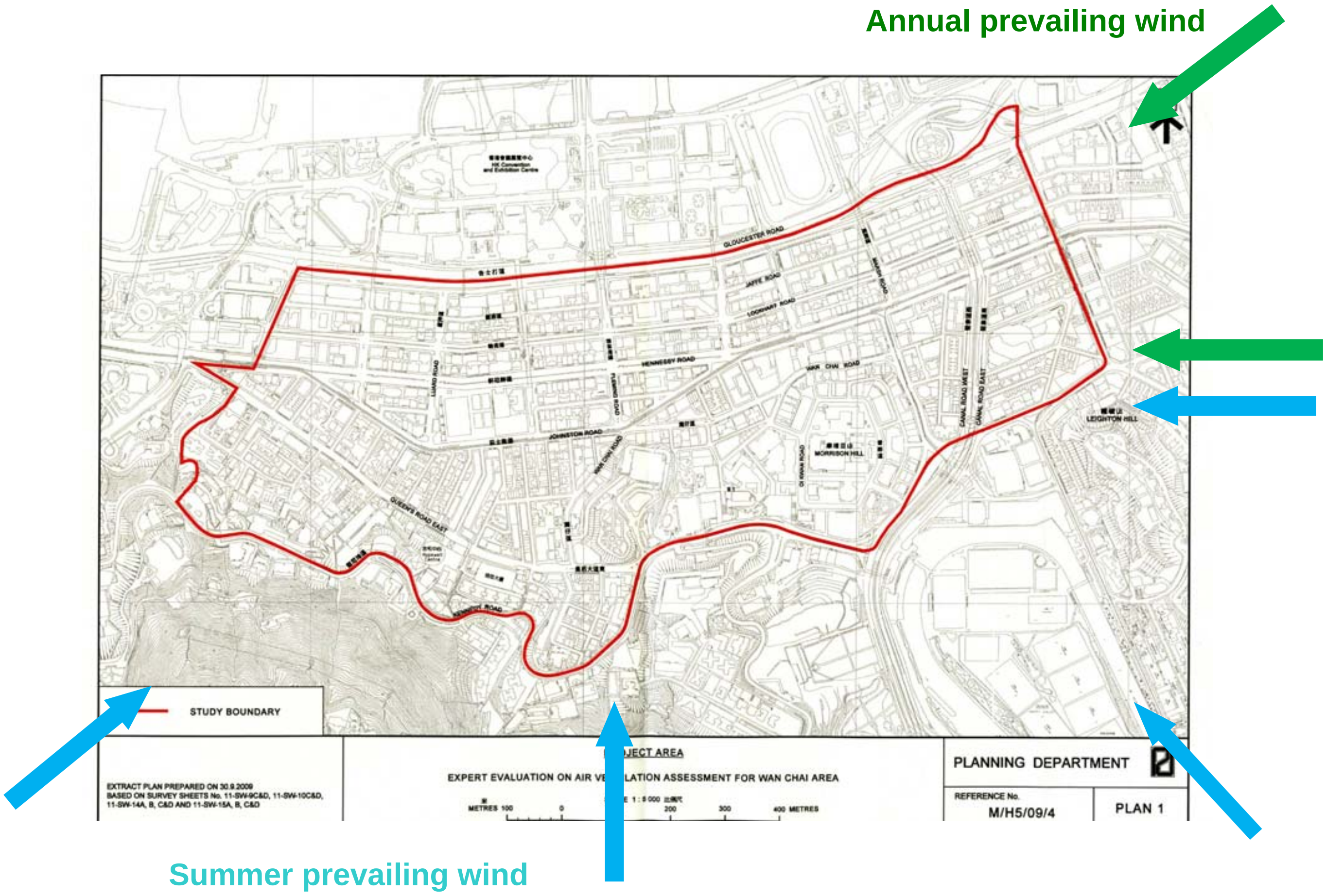


Figure 3.21 A summary of the prevailing winds of the Area

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

4.1 The Area is along Victoria Harbour. It rises from about the 4mPD along Gloucester Road in the north to about 40mPD at Kennedy Road near Wan Chai Gap Road and about 65mPD near Monmouth Path in the south. Beyond the southern boundary of the study area, Mount Cameron and Mount Nicholson of about 400mPD lies on the south (Figure 4.1).

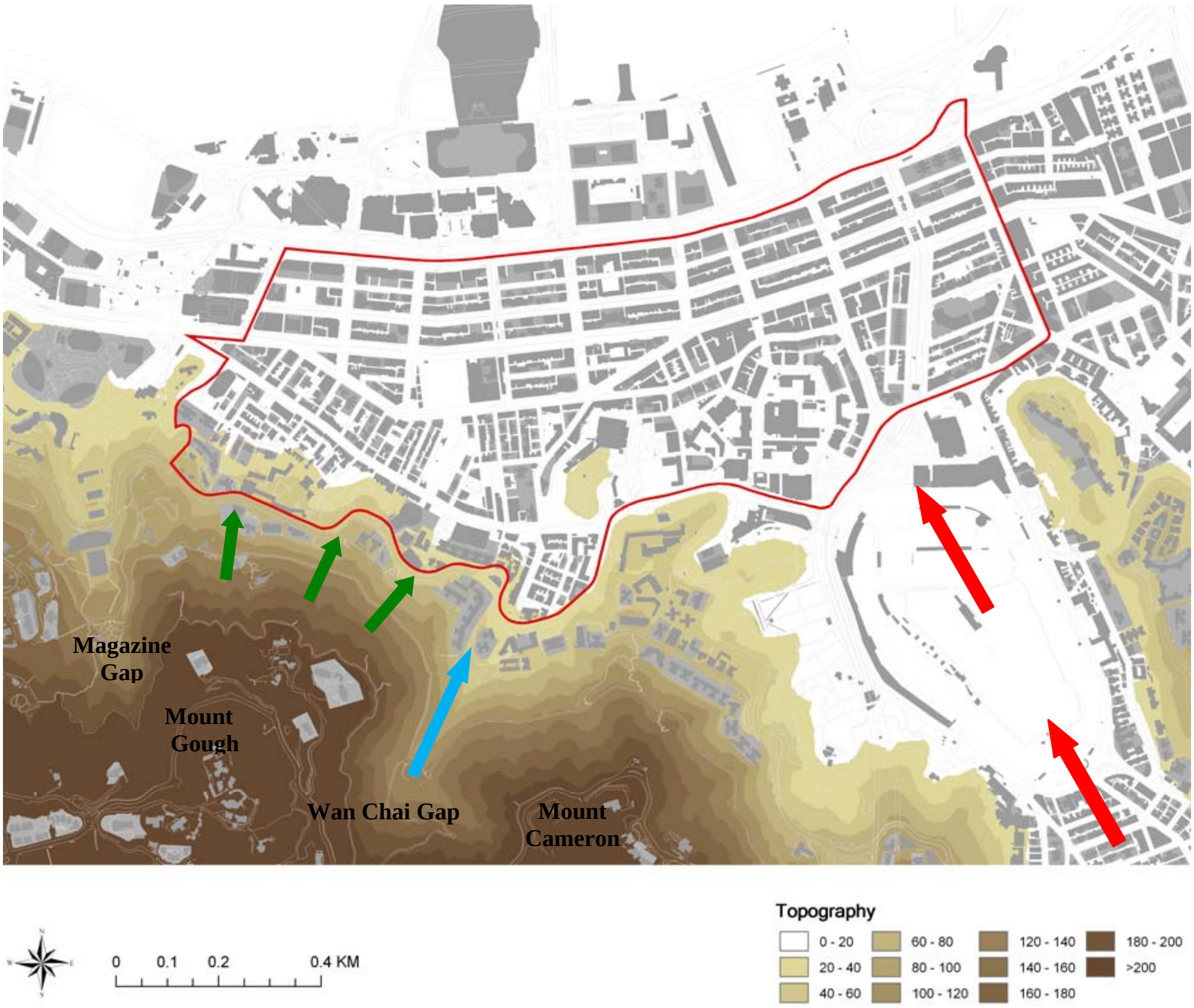


Figure 4.1 A digital elevation map of the Area

4.2 For wind coming from the East over Victoria Harbour and Causeway Bay, it is expected that wind will flow along the major east-west roads. Further understanding will be provided in the section titled "Air Paths" in 5.4 later in the report.

4.3 For wind coming from the North-East over Victoria Harbour, it will penetrate into the study area through the Wan Chai Sports Ground and the greenery area immediately outside the Cross Harbour Tunnel. Illustrations on map are shown in Figure 5.7. It is also expected to penetrate via the north-south streets between Gloucester Road and Hennessy Road into the urban fabric.

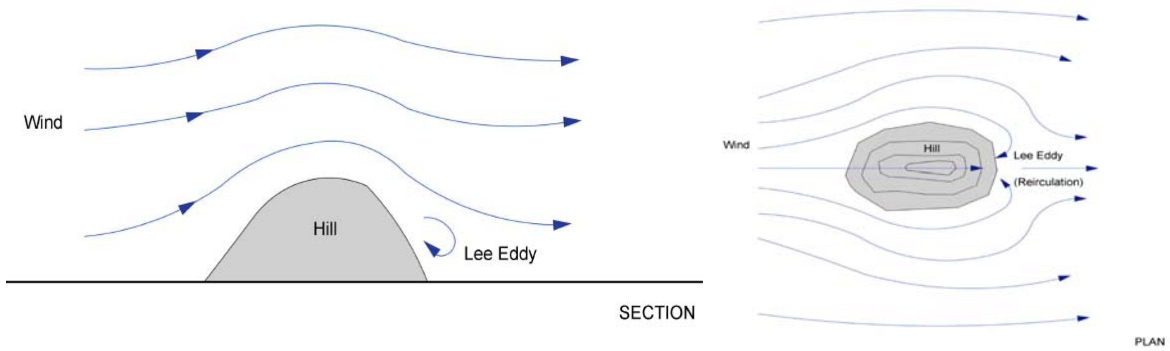


Figure 4.2 An example of wind flow across hills under moderate wind.

4.4 For wind coming from the South over the hills and Mid-levels East, taking the topography into account, the hills south of the Area weaken and shield the incoming wind (Figure 4.2).

4.5 For wind coming from the South over the hills, the 3 dimensional flow patterns can be very complicated depending on a number of factors, e.g. the speed of the incoming wind [Appendix A]. 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 the study area.

4.6 There is one valley wind system along Wan Chai Gap Road identified as the blue arrow in Figure 4.1. It is important to respect and utilize this valley wind. The valley wind from the south is assisted by the prevailing southerly summer winds.

4.7 There is another more major valley wind system along Wong Nai Chung Gap Road identified as the red arrows in Figure 4.1. This valley wind flows over the open ground of Happy Valley. It is important to respect and utilize this valley wind. This valley wind from the south is assisted by the prevailing southerly summer winds. The southerly wind system is very important for the Area.

4.8 Some downhill air movement (katabatic wind) over the vegetated hill slopes, green arrows, can be expected arriving at the south western boundaries of the Area between Wan Chai Gap and Magazine Gap. This can provide some useful cool and fresh air ventilation to the areas south of Queen's Road East. Vegetation west of Hopewell Centre extends from Kennedy Road to Queen's Road East allows this downhill air movement to go further and may benefit buildings north of Queen's Road East. The same can be evaluated for the vegetated area of Wah Yan College, Wan Chai Park and HK Jockey Club Garden.

5.0 The Existing Conditions

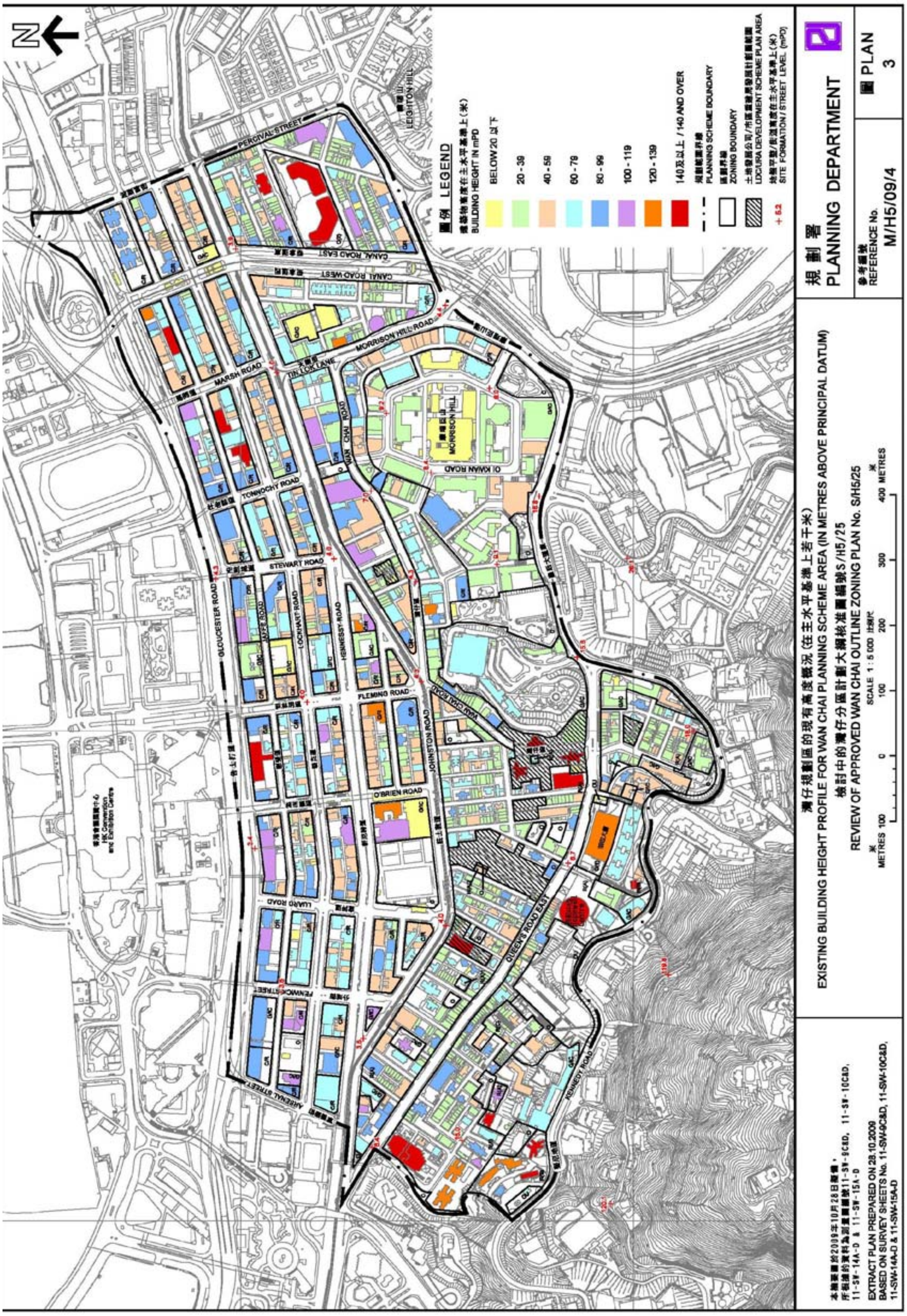


Figure 5.1 The existing building height profile of the Area in meters above principal datum (mPD)

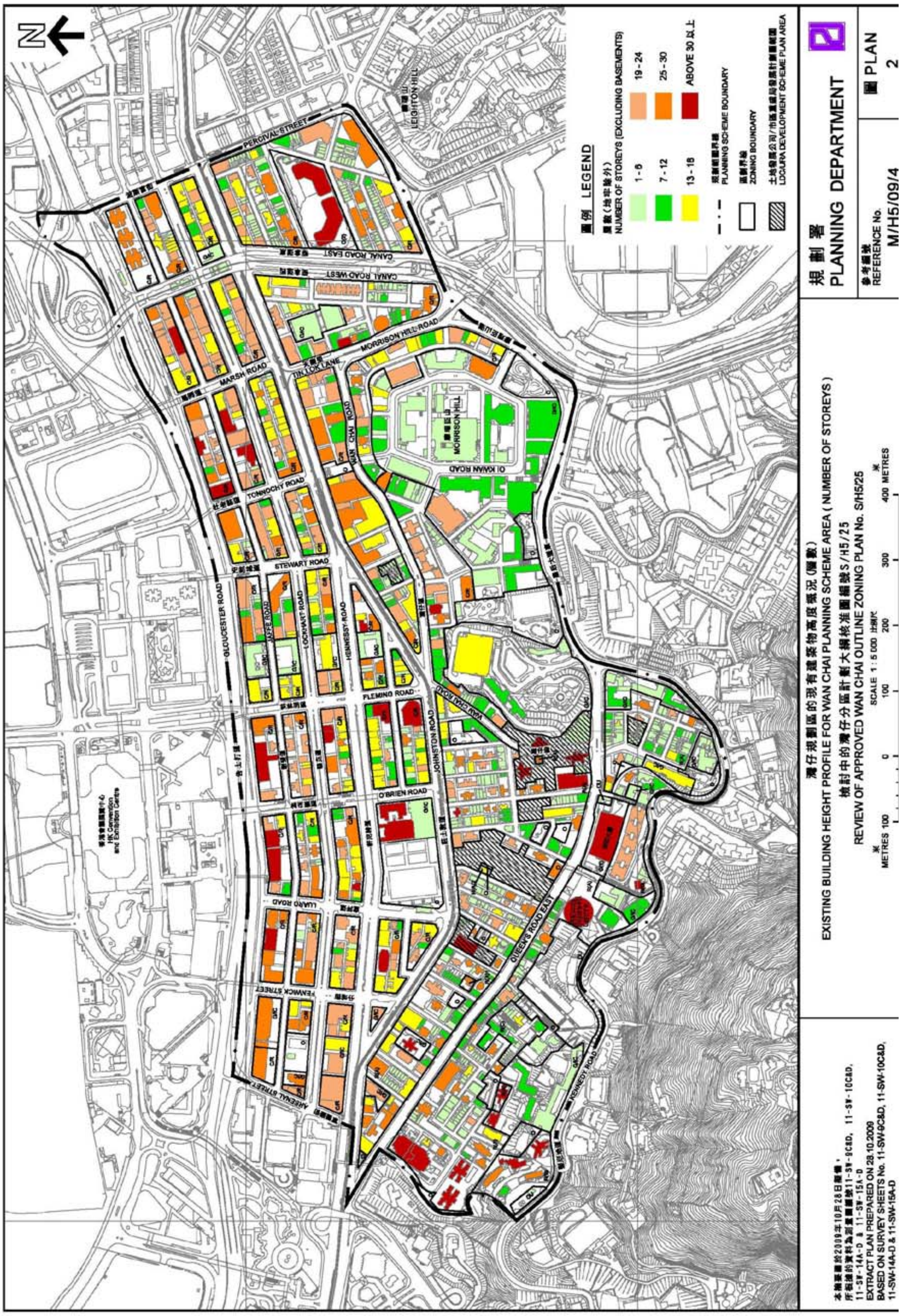


Figure 5.2 The existing building height profile of the Area in number of storeys

5.0.1 The existing building heights in mPD and in number of storeys are as shown in Figure 5.1 and Figure 5.2 respectively. Overall, most buildings range from 13 storeys to 30 storeys, or 40 mPD to 120mPD.

5.0.2 North-south streets between Gloucester Road and Johnston Road are about 25m wide. East-west streets in the Area are 15-30m wide. Buildings on both sides of streets are 40-120mPD. So the height to width ratio (H/W) is in the order of 3 or higher. Refer to Figure 5.3, skimming flow into the street canyon will occur when H/W is larger than 2 and when wind is flowing perpendicular to the streets.

5.0.3 Narrow north-south streets are about 10m wide in a long strip of areas between Johnston Road, Queen's Road East and Wan Chai Road. With a building height profile of 20-100mPD, the height to width ratio is in the order of 2 or more. Again, refer to Figure 5.3, skimming flow into the street canyon will occur when H/W is larger than 2 and when wind is flowing perpendicular to the streets.

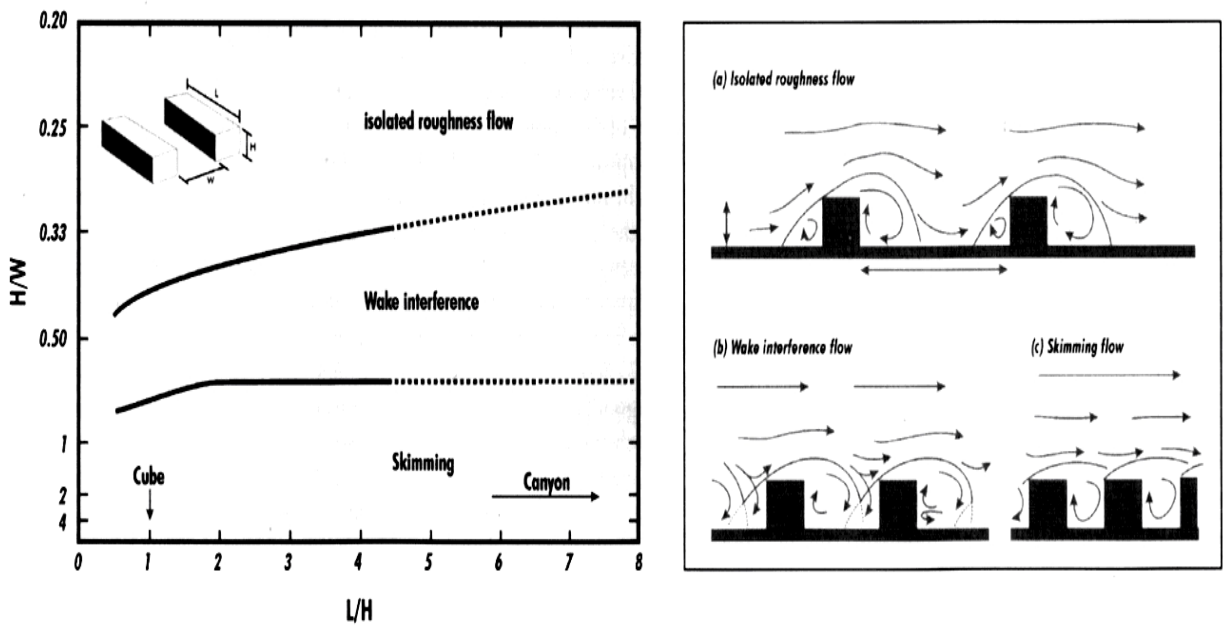


Figure 5.3 The relationship between building height and street width ratio and the possible flow regimes.

5.1 Greenery, Open Spaces and Landscaping

5.1.1 The Area has a few larger existing open spaces as "air spaces" where air ventilation can be relieved within the dense urban morphology (blue circles in Figure 5.4). They are Southorn Playground, HK Jockey Club Garden, Wan Chai Park (together with Wah Yan College HK and Tung Wah Centenary Square Garden), and green area west of Hopewell Centre. They can be useful reliefs to the Area. Influences of committed projects on the existing greenery will be discussed in section 5.5.3.

5.1.2 Apart from the above-mentioned "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. For example, there are Lockhart Road Playground, Tai Wo Street Playground, Kwong Ming Street Children's Playground and Monmouth Terrace Playground. 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 5.4 A greenery map of the Area based on land use data provided by Planning Department.

5.2 Land Use and Urban Morphology

5.2.1 Refer to section 5.1 above, due to the fact that the greenery coverage of the Area is small to medium; the corresponding Ground Coverage (GC) is medium to high (blue to red grids in Figure 5.5).

5.2.2 Researchers at CUHK have earlier resolved a set of Ground Coverage Ratio [1](GC) understanding of Hong Kong. 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" ((blue to red grids in Figure 5.5). High GC can be found distributed in the study area (See the red grids in Figure 5.5).

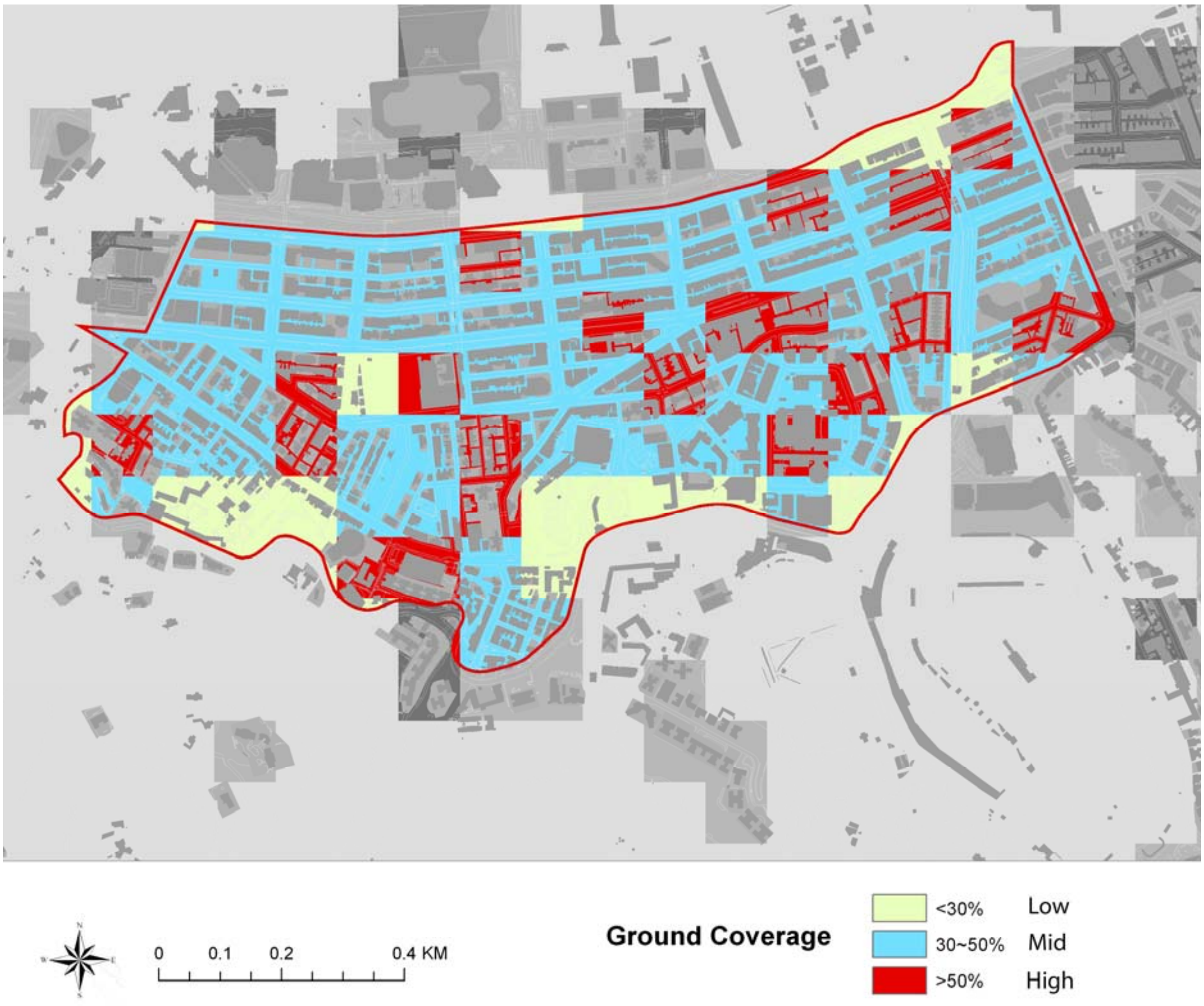


Figure 5.5 Ground Coverage Ratio map of the Area resolved to 100mx100m cell area (include roads, open spaces and ground area covered by buildings and podia)

5.2.3 The Area has a mixture of different zones – mostly C/R and R(A), and with a number of R(A) zones. It also has a good number of scattered GIC and O zones, with low or no buildings, providing some air space reliefs.

[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. The classification can be referred to Working Paper 1A of the Study "Urban Climatic Map and Standards for Wind Environment – Feasibility Study".

5.2.4 On the whole the building volume density of the Area is medium to high. Higher building volume increases the urban thermal capability. This creates higher thermal heat load and possible 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. The relevant areas with high BVD within the Area are circled in Figure 5.6. High BVD pixels not in cluster are not included in the evaluation. An area-average understanding works best at the OZP design and planning decision-making level.

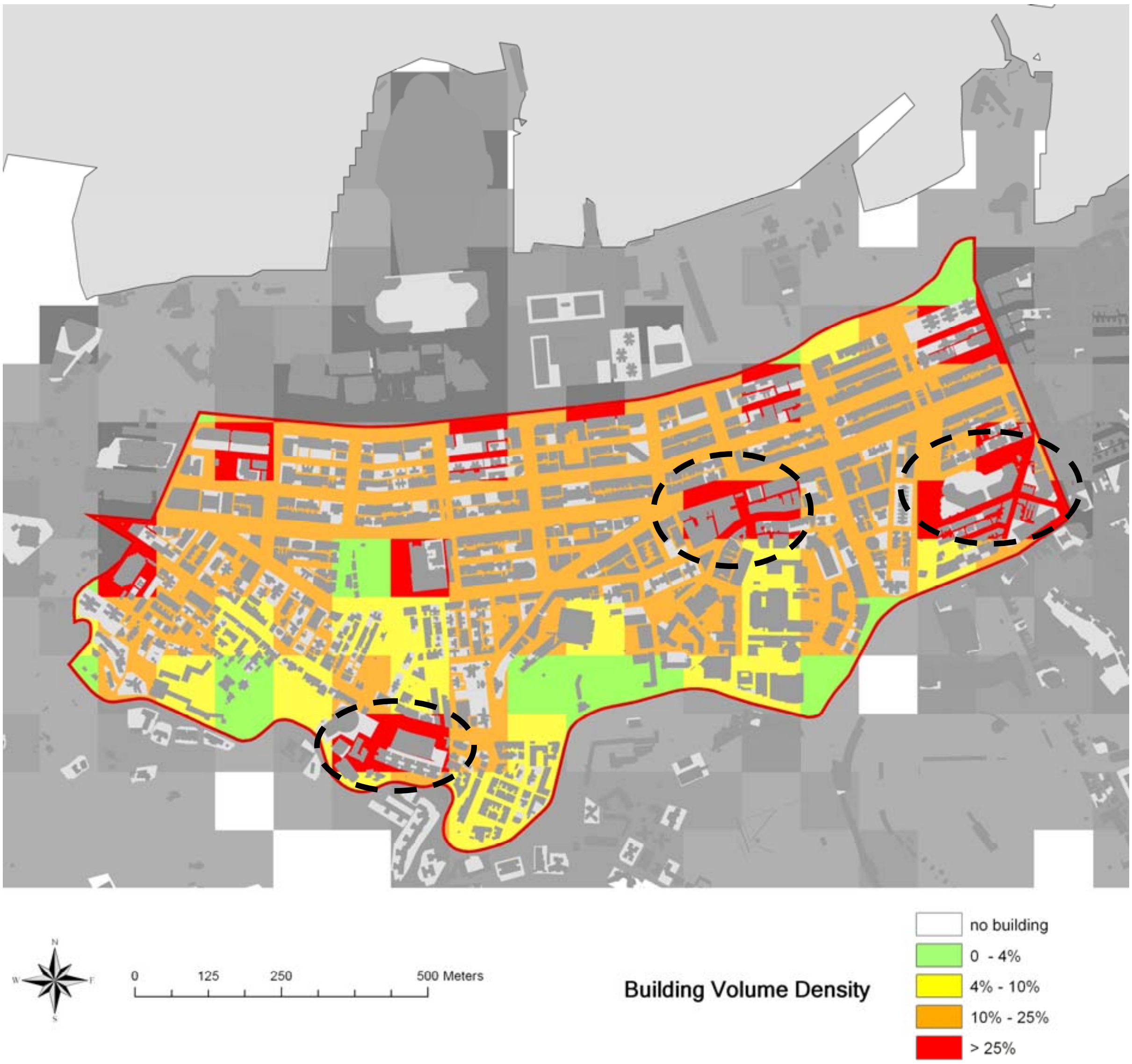


Figure 5.6 Building Volume Ratio map of the Area resolved to 100m x 100m grid. [For a site that occupies 100m x 100m, with a plot ratio of say 5, the building volume of the site will be about 150,000m^3. Building Volume Density in % (BVD) is building volume in m^3 of a 100m x 100m grid of land divided by a datum value of 1,200,000 m^3]

5.2.5 Very high BVD can be found around the intersection of Spring Garden Lane and Queen's Road East, Hennessy Road in the middle and east near Causeway Bay

(Figure 5.6 dotted circles). Very high thermal capacity is expected. Elsewhere, apart from a few open spaces, BVD is also high. More importantly, it should be noted that the high and very high BVD areas cover very large areas and are not, like some other parts of metro Hong Kong, grouped in smaller clusters with air paths around them.

5.3 G/IC, O and GB sites

5.3.1 The Area has some G/IC sites and open spaces. Open spaces have been discussed in section 5.1.

5.3.2 Morrison Hill Swimming Pool and surrounding institutional buildings, Jockey Club Garden, and schools on Kennedy Road to the west are large GIC sites in the study area. They are located at the southern boundaries of study area and can be important to the urban area when wind arrives from the south. Buildings on them should be kept very low and the ground should be enhanced with greenery and tree planting.

5.3.3 There is a series of four GIC sites east of Fleming Road between Johnston Road and Gloucester Road. If redeveloped properly, they can be a very useful north-south air path to their immediate areas. Proper strategies include decrease/no increase of building volume, more greenery, decrease of ground coverage and properly positioned buildings for air paths should be incorporated.

5.3.4 The “precious” O zones in areas between Johnston Road and Queen’s Road East should be kept and vegetated. Upon development, further open spaces are needed and encouraged.

5.4 Air Paths

5.4.1 For wind coming from the East over Victoria Harbour and Causeway Bay, it is expected that wind will flow along the major east-west roads such as Gloucester Road, Jaffe Road, Lockhart Road, Hennessy Road, Johnston Road, Queen’s Road East and Kennedy Road. These streets are important air paths for the Area (Figure 5.7).

5.4.2 For wind coming from the North-East over Victoria Harbour, it will penetrate into the study area through the Wan Chai Sports Ground and the greenery area immediately outside the Cross Harbour Tunnel. It is also expected to penetrate via the north-south streets between Gloucester Road and Hennessy Road into the urban fabric.

Figure 5.7 Air paths of the Area when wind comes from the east and north east over Victoria Harbour.

Figure 5.8 Air paths of the Area when wind comes from the south and over the valleys.

5.4.3 For wind coming from the South over the hills and Mid-levels East, the small valley wind system identified along Wan Chai Gap Road (blue arrow in Figure 4.1) can assist locally. However, there is no air path possibility for this wind system to penetrate further into the Area. It will more or less terminate at Queen's Road East. The existing north-south aligned roads on both sides of Queen's Road East should not be built over. Opportunities should be taken to widen these roads and to align them in such a way that north-south air paths can be formed.

5.4.4 Due to the low rise buildings of Morrison Hill, southerly wind in the summer months can flow over Morrison Hill Swimming Pool and surrounding GIC buildings. It is encouraged to at least maintain Tonnochy Road so as to maintain this air path's efficacy. Opportunities should be taken to widen Tonnochy Road and extend the air path over Tonnochy Road southward to connect with that over the low-rise "G/IC" sites at Morrison Hill. Based on parametric researches done by The Chinese University of Hong Kong, a building height to street width ratio of no more then 3:1 can be suggested for parallel wind movement.

5.4.5 The open space south of Tonnochy Road is very important to remain as it connects directly to the waterfront.

5.4.6 West of Tonnochy Road, there is no street or road that connects all the way from the south of the Area to the north. Hence there is no direct air path parallel to the incoming southerly wind. It is vitally important to find ways to create south-north air paths. There are some existing north-south aligned roads on both sides of Queen's Road East, which functions as local/minor air paths. To facilitate better air ventilation, these roads should not be built-over. Opportunities should be taken to widen these roads and/or to align them in such a way that north-south air paths can be formed to provide air passages for wind coming from the south to Wan Chai North through the western part of Wan Chai.

5.5 The Existing Conditions with Committed Projects

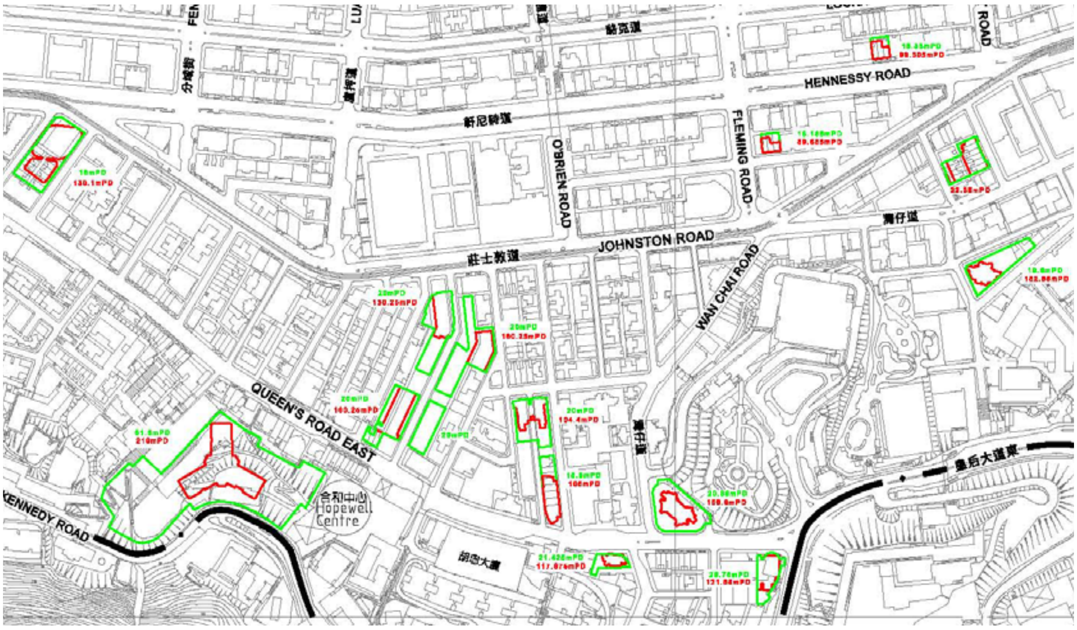


Figure 5.9 Committed Developments in the Area

5.5.1 There are some scattered committed developments in the Area (Figures 5.9 & 5.10). They are mostly single tower development on their own podium. Although they are tall buildings, at the moment they do not form wall like structures that would adversely affect the prevailing wind movement and air ventilation.

5.5.2 The extensive (100%) site coverage podia of the newer developments replace the more porous older buildings at near ground level. This has the impact of increasing ground coverage and reducing near ground level air volume not conducive to urban air ventilation.

5.5.3 The building and its podium west of Hopewell Centre will likely remove the vegetated slope. This will diminish the downhill air movement from the vegetated hills to its south.

5.5.4 Not far away, another two slots of long podium with some high-rise building are committed at both sides of Lee Tung Street. The disposition of top buildings will not adversely affect the air ventilation too much. The extensive podium has been commented in 5.5.2 above.

5.5.5 Potential developments are expected in the Area (Figure 5.11). They are expected to be developed to their respective maximum plot ratio, maximum podium coverage and maximum height allowed. On the whole, from an urban district based perspective, they will increase the thermal load of the area; they will increase urban roughness, diminish air ventilation potentials; and they may form deep street canyons and eventually wall like barriers.

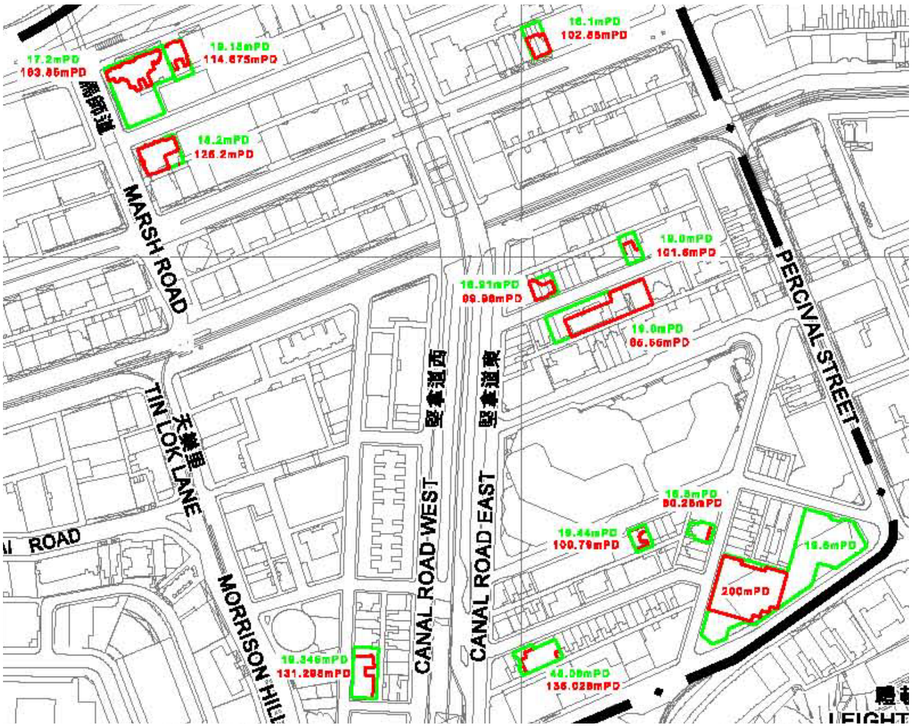


Figure 5.10 Committed Developments in the Area

5.5.6 Without further details or information of the building and podium form, size, shape and disposition, it is difficult to evaluate or expect fully their impact.

5.5.7 The area between Johnston Road and Queen's Road East is of particular concern. It receives no or little wind from the south due to the long line of tall buildings on the south side of Queen's Road East. The north-south orientated roads are extremely narrow. Eventually, it is possible that buildings of 110m tall will line both sides of the narrow streets forming deep canyons. It is recommended that appropriate building design to improve air permeability at podium level should be encouraged. Building set back above podium level from the side boundaries are encouraged so as to provide wider building separations to improve air ventilation.

5.5.8 Figure 5.11 shows it happening. The strip of "C/R" zoned land north of Jockey Club Garden, Wan Chai Park and Morrison Hill is expected to be fully re-developed. This has the possibility of forming a tall and wall like structure that could continue in excess of half a kilometer potentially blocking all the southerly wind to a large extent of the Area. Building permeability as mentioned in section 5.5.7 above is particularly important for this area.

5.5.9 Tang Lung Street to the north of Times Square is L shaped. With tall buildings going to appear along it, it will become a "dead-end" especially at its eastern tip from an air ventilation perspective. Figure 5.12 shows it happening.

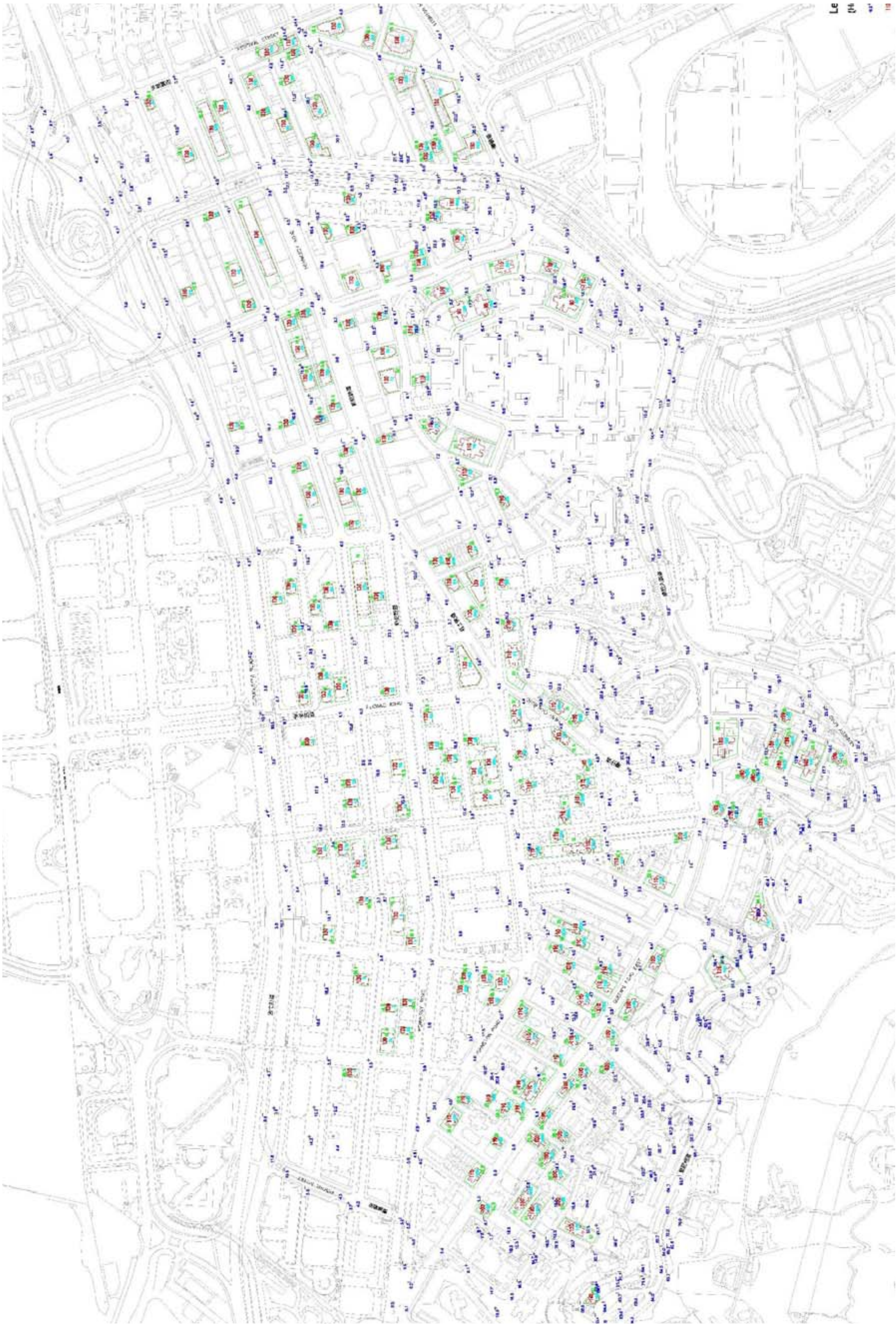


Figure 5.11 Potential Development Sites in the Area

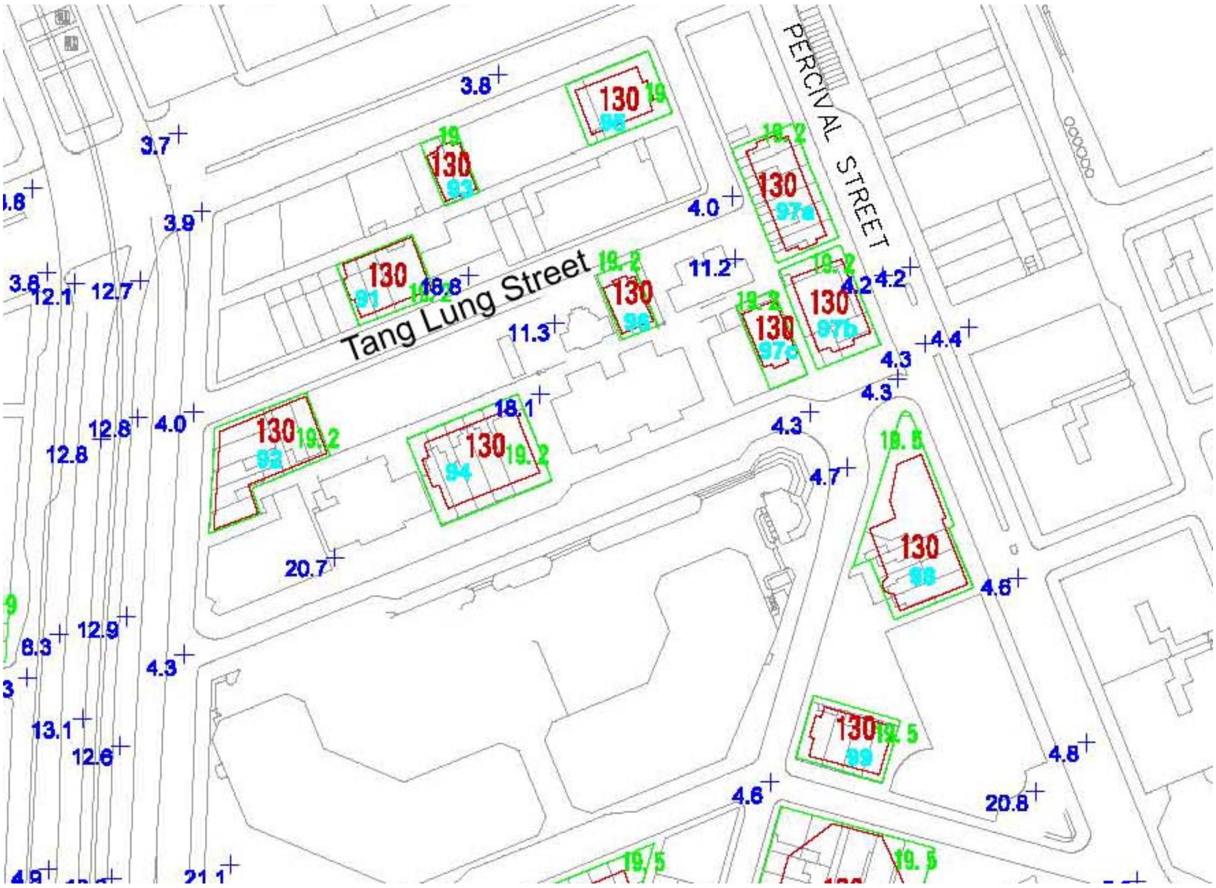


Figure 5.12 Potential Developments around Tang Lung Street

6.0 Expert Evaluation and Recommendations of the Initial Planned Scenario

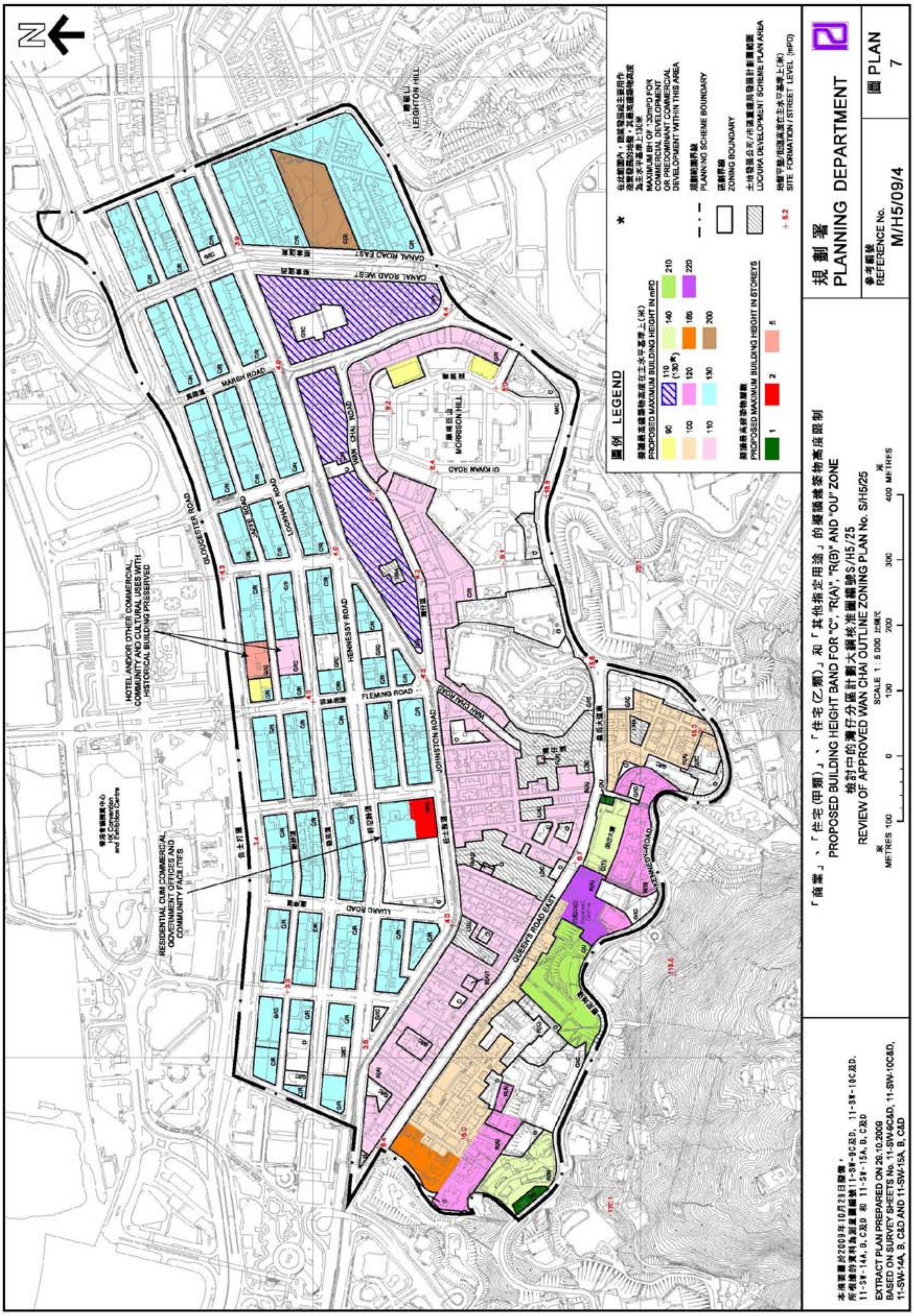


Figure 6.1 The Initial Planned Scenario of the Area (proposed building height band for "C", "R(A)", "R(B)" and "OU" Zones).

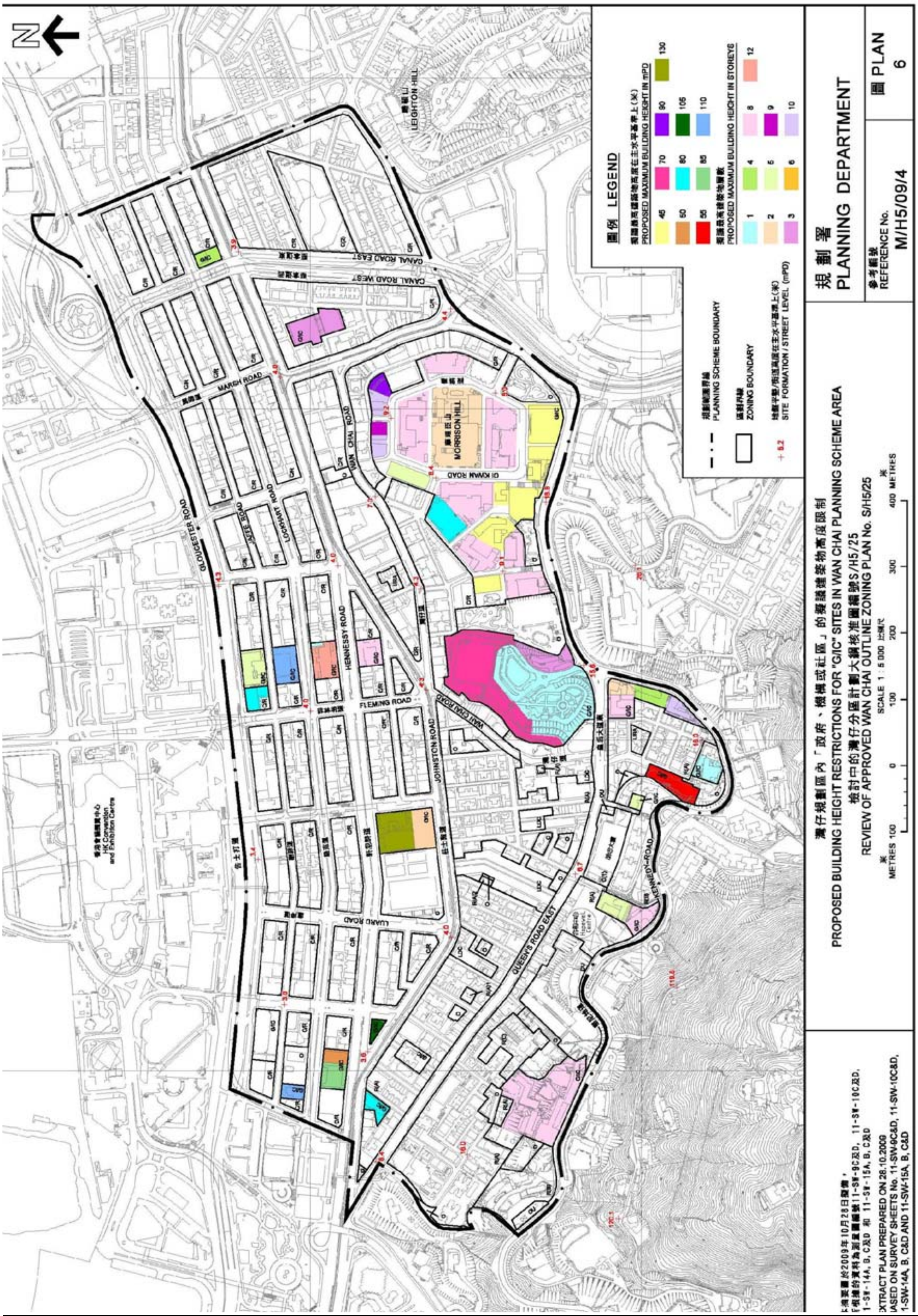


Figure 6.2 The Initial Planned Scenario of the Area (proposed building height restriction for "G/IC" sites)

6.1.1 Figures 6.1 and 6.2 represent the initial planned scenario of the Area. Basically a number of height bands have been proposed. The area between Gloucester Road and Johnston Road has mostly been limited to a uniform height band of 130mPD. The area south of Johnston Road has been limited to another uniform height band of 120 mPD. A mixture of height bands of 90mPD to 220 mPD have been proposed south of Queen's Road East.

6.1.2 On the whole, based on Figure 6.1, the proposed height restrictions are higher than the height of the existing majority of buildings. Based on Figure 6.2, the proposed height restrictions for G/IC sites, more or less reflect the existing conditions.

6.1.3 A detailed AV assessment requires information beyond density, building heights and plot ratios. The information on building heights can provide only some general feeling. 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. For example, 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 the height of the building. That is to say, a tall building affects more and further of its neighbors. On the other hand, a long and slab like building has a shorter but wider wind-wake. It affects more its immediate neighbours. The worst case scenario for air ventilation is therefore a tall and wide building.

6.1.4 A number of air ventilation principles must firstly be explained. Firstly, given Hong Kong's tall building urban morphology, beyond a certain absolute building height (as related to the building height to street ratio (H/W), or in the order of say 80m+ high even a street width of say 25m), the heights of building cease to be the key consideration factor for air ventilation at pedestrian level. There is small material difference between building heights of 110mPD and 130mPD from air ventilation point of view, taking into consideration the width of the same street.

6.1.5 Secondly, given that buildings are tall, the street canyons are deep, changing building heights a little bit one way or another would not matter air ventilation that much. For example, all else being equal, a street canyon of H/W of 3:1, 4:1 or 5:1 would have very similar air ventilation performance at ground level (Figure 6.3). In this case, the most effective way to improve air ventilation is to introduce building gaps. In addition, 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 (refer to Figure 7.1) are far more effective strategy to improve air ventilation at the pedestrian levels.

6.1.6 Thirdly, as a principle, for air ventilation, a variation of building heights in close proximity is preferred as it can create pressure differences (See appendix B); and they can also 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.

6.1.7 Fourthly, given that there are tall 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, based on research by the Chinese University of Hong Kong, setting aside 30% of the site for non-building area (no podium) 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.

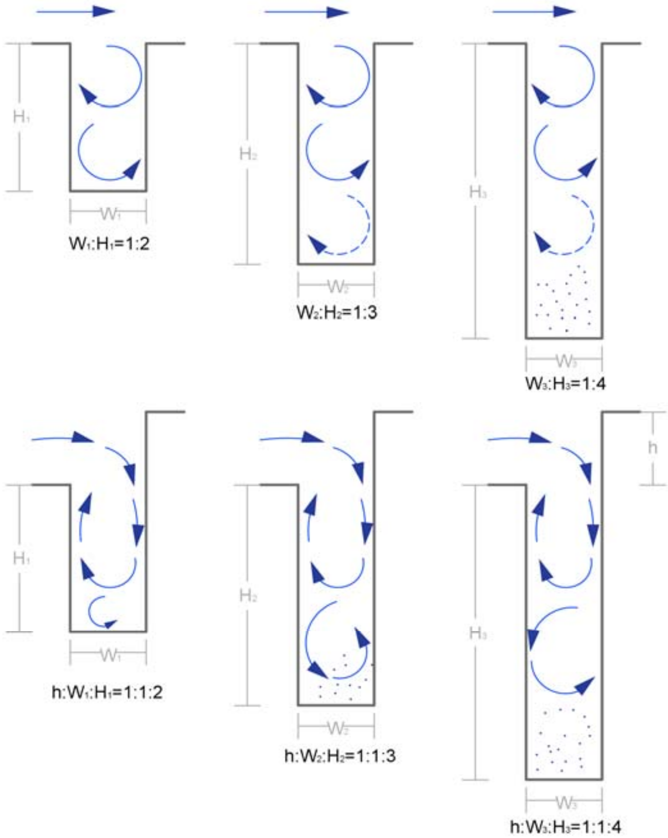


Figure 6.3 Wind regimes in canyons, and canyons with downwashes. Beyond a H/W ratio of 2:1, the ground level of canyons, even with the so call downwash effects, will have very weak eddies and air ventilation. *[Reference: A. KOVAR-PANSKUS, P. LOUKA, J.-F. SINI, E. SAVORY, M. CZECH, A. ABDELQARI, P. G. MESTAYER and N. TOY, INFLUENCE OF GEOMETRY ON THE MEAN FLOWWITHIN URBAN STREET CANYONS – A COMPARISON OFWIND TUNNEL EXPERIMENTS AND NUMERICAL SIMULATIONS, Water, Air, and Soil Pollution: Focus 2: 365–380, 2002, Kluwer Academic Publishers.]*

6.1.8 Fifthly, it is important to ensure that, given the context of tall buildings in Hong Kong, air paths and urban permeability in the form of open space, non-building area (NBA), low buildings and structures, and building set back, can be more important considerations.

6.1.9 Based on the principles above, the overall evaluation is that the initial planned scenario does NOT seem to incorporate any air ventilation best practice and principles. No air path, NBA, building setback, open space and therefore air ventilation connectivity strategy has been incorporated.

6.1.10 A few detail comments are provided below:

(a) Refer to section 5.3.3, The 4 G/IC sites between Fleming Road and Stewart Road (Figure 6.2) are aligned with each other along the north-south direction. Since one G/IC site in the middle is tentatively proposed to be developed up to 110mPD, the connected air path will be disturbed in the middle and some incoming wind will be weakened. It is therefore recommended that appropriate land sales condition should be included for this site to adopt air ventilation improvement/mitigation measures, e.g. non-building areas, to facilitate the north-south air movement over these G/IC sites. A design that incorporates features that allows high permeability is desirable. It is also suggested that the maximum building height of the site be reduced to 80mPD to be compatible with the height of the existing building to the south to allow low level air ventilation in the Area.

(b) There is no provision to respect the katabatic downhill air movement as identified in sections 4.6 and 4.8 above. This should be addressed for areas north of Kennedy Road.

(c) The inevitable increase of building volume and thus thermal load should be mitigated with a reduction of ground coverage and more greenery. It is highly recommended to be incorporated.

(d) Building disposition affects air ventilation, how buildings should be designed with air ventilation permeability in mind needs to be stated[1]. Building gaps and separation are very important.

(e) The strip of "C/R" zoned land north of Jockey Club Garden, Wan Chai Park and Morrison Hill is expected to be fully re-developed, to 110 mPD. This would form a tall and wall like structure that could continue in excess of half a kilometer blocking all the southerly wind to a large

[1] Please refer to the guidelines on required Building Separation Distance, indicated in the section of 5.2.5, of the published "Building Design to Foster a Quality and Sustainable Built Environment" by the Council for Sustainable Development in early 2009. In the guideline, it is proposed that for site areas greater than two hectares or with continuous building width of greater than 60 metres, an intervening space equivalent to 20% - 33% of the total frontage area of the building or buildings would be required.

extent of the Area. It is important to specify gaps and NBA. Note in particular the lot south of the “O” zone extended south of Fleming Road.

(f) It is important to respect all existing roads within the “R(A)” and “C/R” zones. They should not be developed over with the amalgamation of sites. These roads are air spaces. Air spaces allow air movement and circulation by mixing and turbulent flow while air paths allow more directional air mass exchange by advection.

(g) Find ways to deal with the dead end of Tang Lung Street as identified in section 5.5.9.

(h) Find ways to deal with the lack of north-south air path as identified in section 5.4.6.

7.0 Expert Evaluation of the Revised Planned Scenario

7.1 In general, existing open spaces will be maintained as breathing space and to provide more greenery to facilitate air ventilation. Also, it is stated in the Explanatory Statement of the OZP that building setback and more permeable podium design are encouraged for better air ventilation. In particular, based on the views expressed under the previous sections on Initial Planned Scenario, Planning Department has proposed to incorporate the following mitigation measures under the Revised Planned Scenario (Figure 7.1 – Figure 7.3):

i. Taking into consideration the open amenity area near the Cross Harbour Tunnel portal, Wan Chai Sports Ground and the low-rise G/IC facilities to the northeast of the Area, the building height restriction for the area to the north of Hennessy Road and east of Tonnochy Road is reduced to 110mPD to facilitate the incoming north-east prevailing wind (Figure 7.1).

ii. The building heights of the G/IC cluster at Morrison Hill are revised to reflect the existing height of the buildings in order to maintain the existing low-rise character as well as facilitating the penetration of the southerly wind coming from Happy Valley over the Area (Figure 7.2).

iii. In view of the recommendations to improve the north-south air ventilation condition in areas on both sides of Queen’s Road East, it is proposed to impose NBAs along (see the pink arrows in Figure 7.3):

(a) Wing Fung Street/Anton Street;
(b) St. Francis Street/Greeson Street;
(c) Spring Garden Lane; and
(d) Tai Yuen Street.

iv. Moreover, in order to maintain the existing air path over the row of G/IC sites between Fleming Road and Stewart Road, it is proposed to impose NBAs at ground or above podium along the side boundaries of these sites.

v. It is also proposed to impose NBAs above podium of building sites near the junction of Johnston Road/Wan Chai Road to extend the air paths along these G/IC sites and Fleming Road southward through Ruttonjee Hospital towards Kennedy Road. The imposition of NBAs above podium will break up the strip of buildings within the proposed "R(A)" zone to the south of Wan Chai Road to improve air ventilation.

7.2 This has been evaluated as follows:

(a) Response to 7.1 (i): While maintaining the width of the existing roads in this area, the reduction in building height restriction will slightly improve the building height to street ratio. This will facilitate the penetration of the incoming north-east prevailing wind into the Area to some extent.

(b) Response to 7.2 (ii) : The building height restriction for the G/IC cluster at Morrison Hill will generally facilitate wind coming from the open ground of Happy Valley over this low-rise G/IC cluster.

(c) Response to 7.1(iii): There are some existing north-south aligned roads on both sides of Queen's Road East, which also functions as local/minor air paths. To facilitate better air ventilation, these roads should not be built-over and widened in such a way that north-south air paths can be formed to provide air passages for wind coming from the south to Wan Chai North through the western part of Wan Chai. It is good to consider non-building areas or setback than nothing.

(d) Response to 7.1 (iv): Refer to the 4 "G/IC" sites between Fleming Road and Stewart Road, it is recommended that the buildings should be set back at ground level to allow the formation of north-south air paths along both the eastern and western sides of these sites to facilitate air ventilation. Also the redevelopment at the Wan Chai Police Married Quarters site should be restricted to a maximum building height of 80mPD to be compatible with the existing building to the south for air ventilation purpose.

(e) Response to 7.1 (v): If significant non-building areas at ground level or above podium for developments north to Ruttonjee Hospital can be imposed to connect Fleming Road, through Ruttonjee Hospital, Jockey Club Garden and to Kennedy Road, the air ventilation in the north-south direction will be improved. It also suggested other north-south air paths in the Area be improved by introducing non-building areas.

(f) Appropriate building design to improve air permeability at podium level should always be encouraged. Also, building set back above podium level from the side boundaries are encouraged to provide wider building separations to improve air ventilation. This is particularly important for the "R(A)" belt on the south of Wan Chai Road. See Figure 7.1. In addition, Tak Yan Street Children's Playground is proposed to be rezoned to "O" and a non-building area at the Lady Trench Training Centre be designated to improve the air path.

(g) The low-rise G/IC cluster at Morrison Hill should be maintained as major visual and spatial relief for penetration of the southerly wind from the valley wind system along Wong Nai Chung Gap Road, particularly along the air path aligning with Tonnochy Road. The major north-south air paths are indicated by blue lines in Figure 7.3.

(h) Major open spaces and other low-rise G/IC facilities should be maintained as visual and spatial relief for better air ventilation. See Figure 7.3 for the major open spaces.

(i) The main east-west and north-south air paths of the area have been noted and indicated.

7.3 All in all, given practical constraints and the need to respect 'development rights' of the land owner, the proposed mitigation measures have noted and responded to some of the major concerns we expressed on the Initial Planned Scenario. However, the overall need to reduce the Ground Coverage, Building Volume Density and building height has not been addressed. Besides, more non-building areas and greeneries are still highly encouraged to include. We regard this represents a small but important step towards creating a quality urban environment for the general public of Hong Kong.

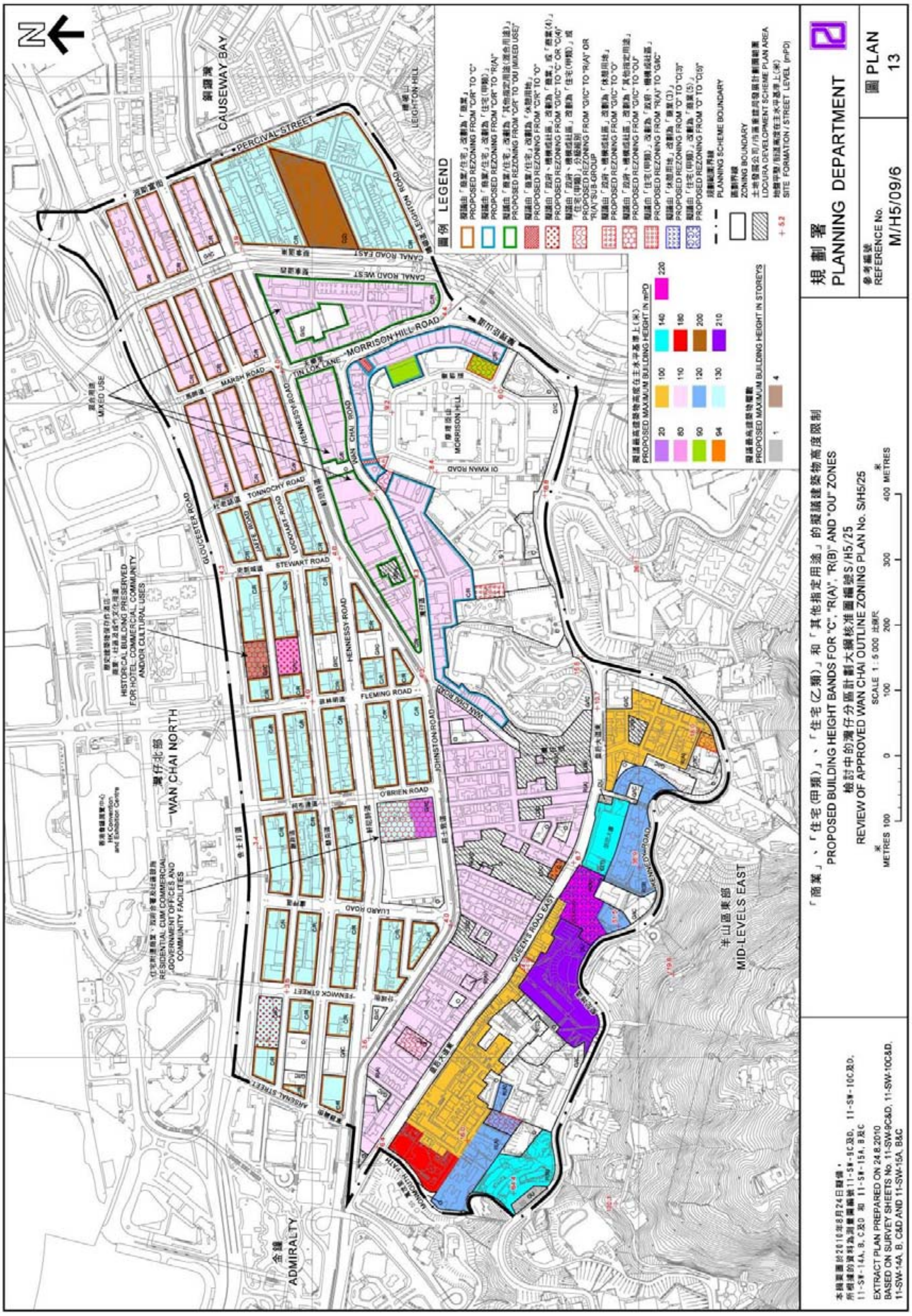


Figure 7.1 the Revised Planning Scenario

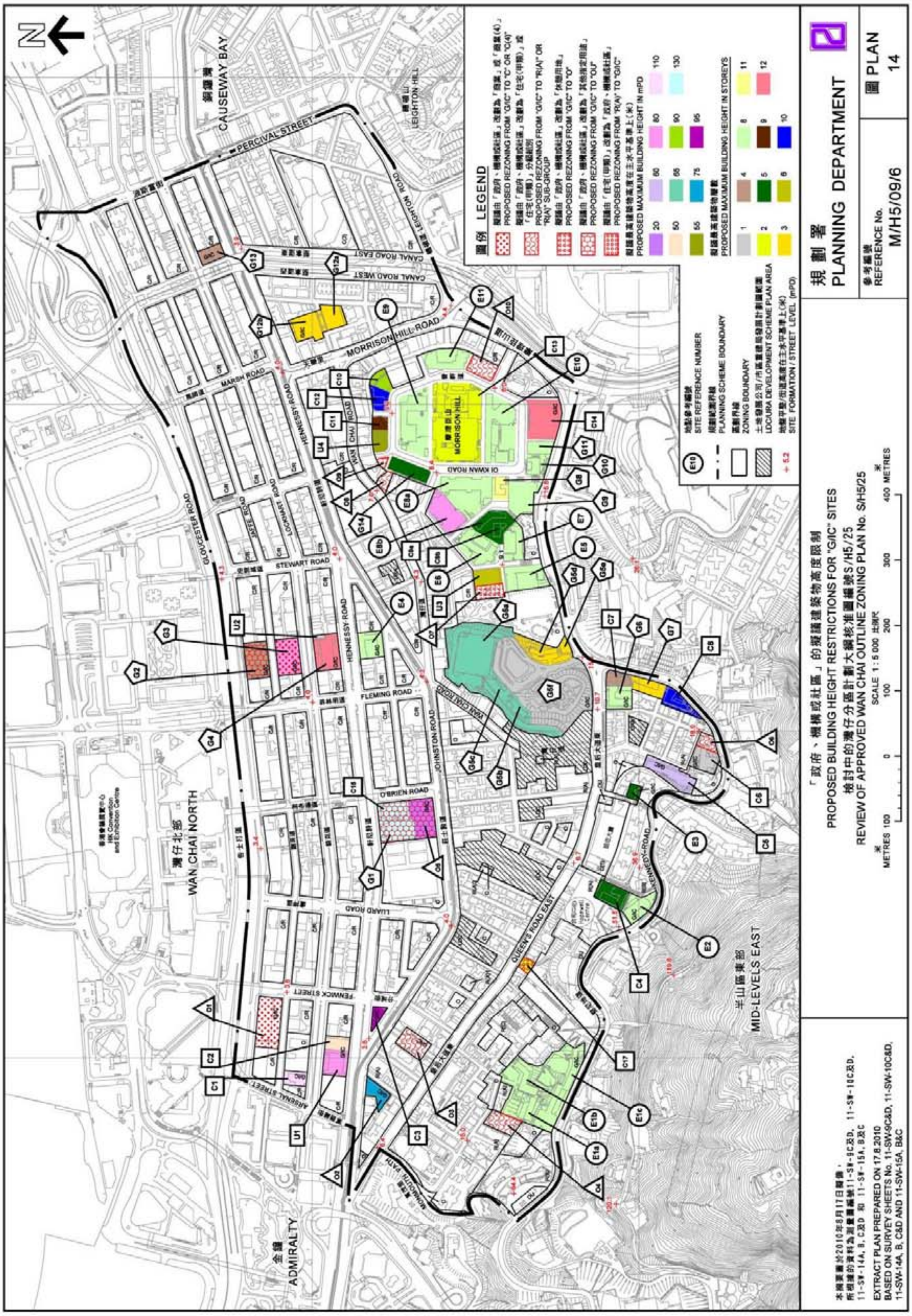


Figure 7.2 the Revised Planning Scenario

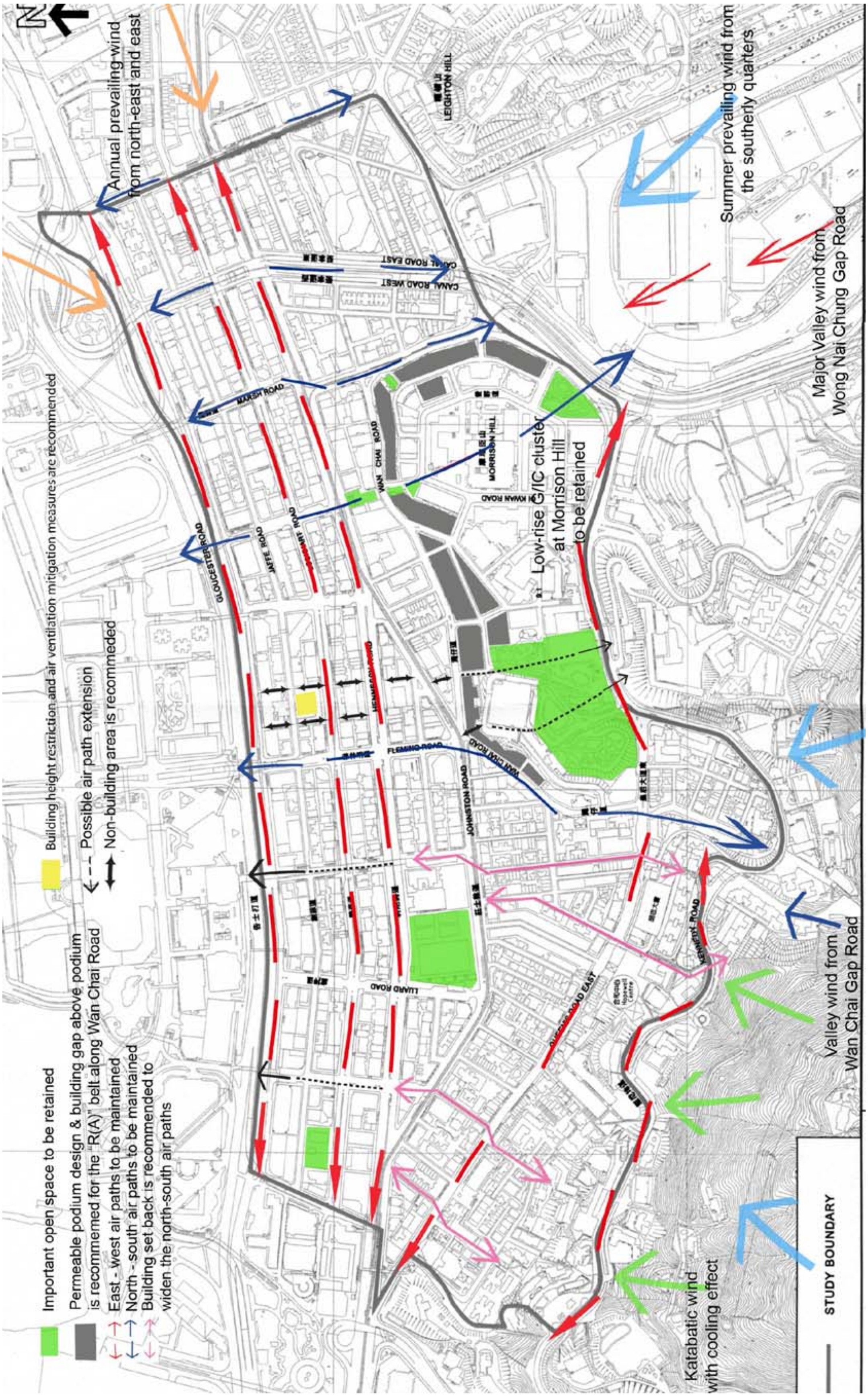


Figure 7.3 the Revised Planning Scenario

Date: 01 September 2010

Professor Edward Ng

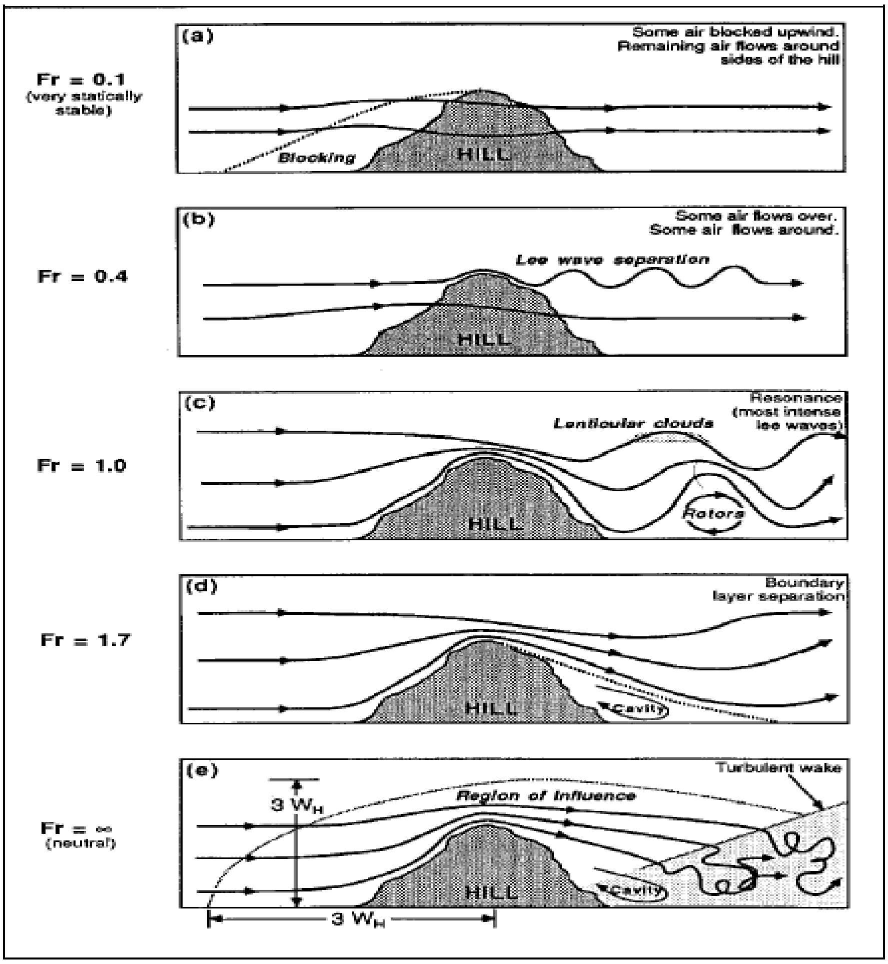
On behalf of technical experts in the term consultant term

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)

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

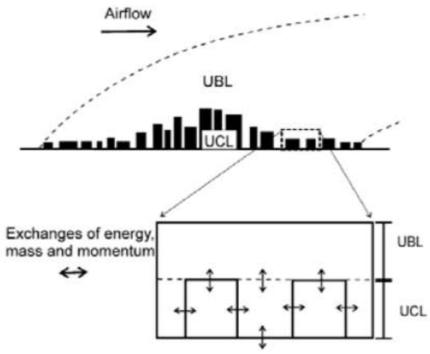
The inertial forces (order $\bar{u}_0^2/W_h$) act in the horizontal direction along the wind flow, and the buoyant forces (order $g\frac{\Delta\theta}{\theta_0}$ where $\Delta\theta$ is a typical temperature disturbance, g is gravitational acceleration, θ_0 is potential temperature) act in the vertical.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

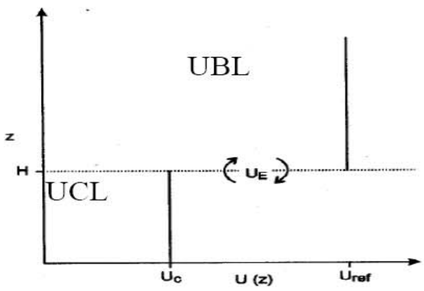
$$\frac{U_E}{u^*} = \left[\frac{1}{k} \ln\left(\frac{z_{ref} - d}{z_o} \right) - \frac{U_C}{u^*} \right]^{-1}$$

where

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

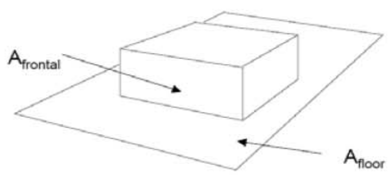
$$\frac{U_C}{u^*} = \left[\frac{z_o}{2H} \right]^{-0.5} \quad \text{for } \lambda_f < 0.2$$

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.