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Prepared by	WH Leung/Jimmy Yam/Rumin Yin	Date	7 April 2008
Subject	Executive Summary for Air Ventilation Assessment (AVA) - Initial Study		

1. INTRODUCTION

Ove Arup & Partner Hong Kong Ltd (Arup) was commissioned by the Hong Kong Housing Authority (HKHA) to carry out an Air Ventilation Assessment (AVA) – Initial Study for the Redevelopment at Lower Ngau Tau Kok (The Development) using the methodology as stipulated in the "Technical Circular No. 1/06 – Air Ventilation Assessments" (Technical Circular) jointly issued by Housing, Planning and Lands Bureau and Environmental, Transport and Works Bureau on 19th July 2006.

The purpose of this study is to assess and compare the ventilation performance of the two design schemes which are the Baseline Scheme and the Proposed Scheme.

This file note summarizes the preliminary results of the air ventilation performance of the Baseline and Proposed Scheme.

2. BACKGROUND

The Development is located in Kwun Tong District adjacent to the Kowloon Bay MTR Station and a number of private and public housing developments. The Upper Ngau Tau Kok Estate is located to its south Telford Gardens is located to its west and Amoy Gardens to its north. These locations would be deliberately considered during the wind performance analysis.

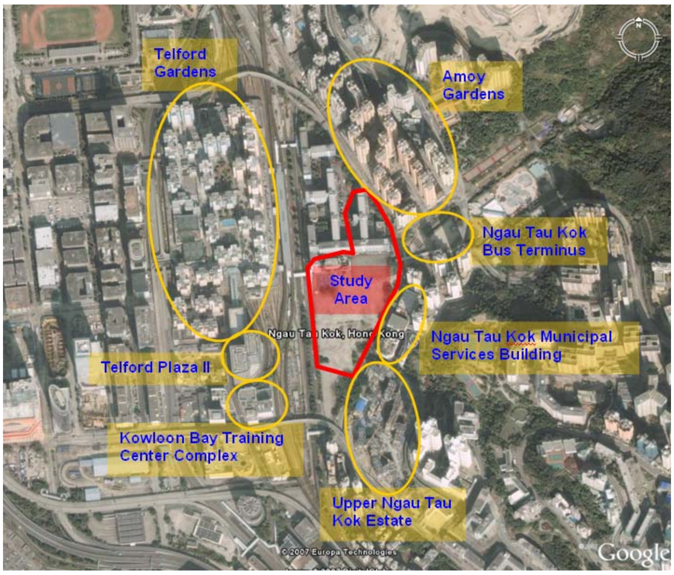


Figure 1 Extent of the Study Area and surrounding sites in Lower Ngau Tau Kok *(extracted from GoogleEarth)*

3. STUDY SCENARIOS

Totally two scenarios were investigated in the AVA study which includes

1. ***Baseline Scheme*** *– This is the control scheme with the same development as the proposed redevelopment, using old building footprint and new CFA massing*
2. ***Proposed Scheme*** *– Newly proposed development scheme consist of 6 public housing blocks, a 3-storey car park, District Open Space (DOS) and a Cross District Community Cultural Centre (CDC)*

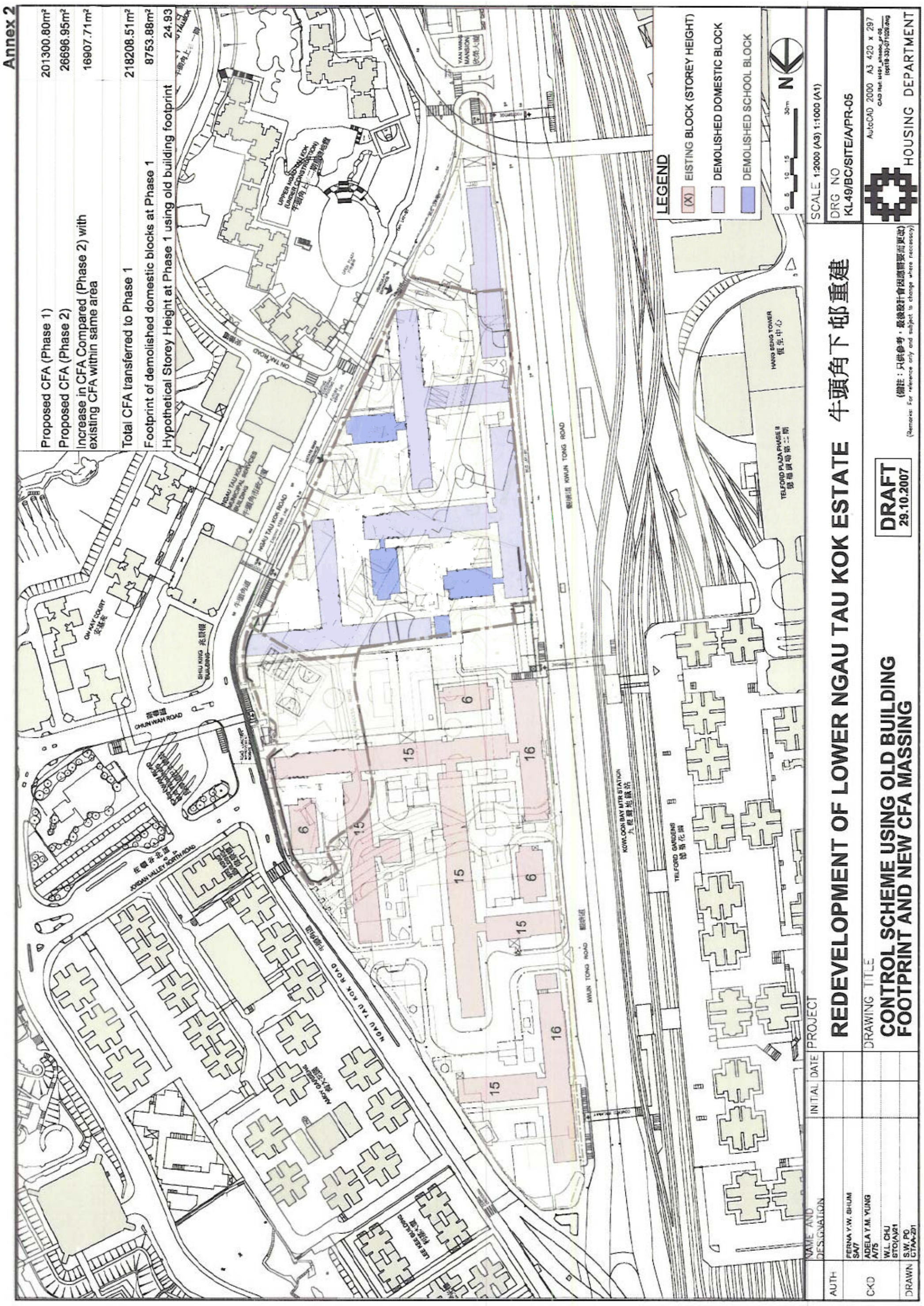


Figure 2 Master layout plan for the Baseline Scheme

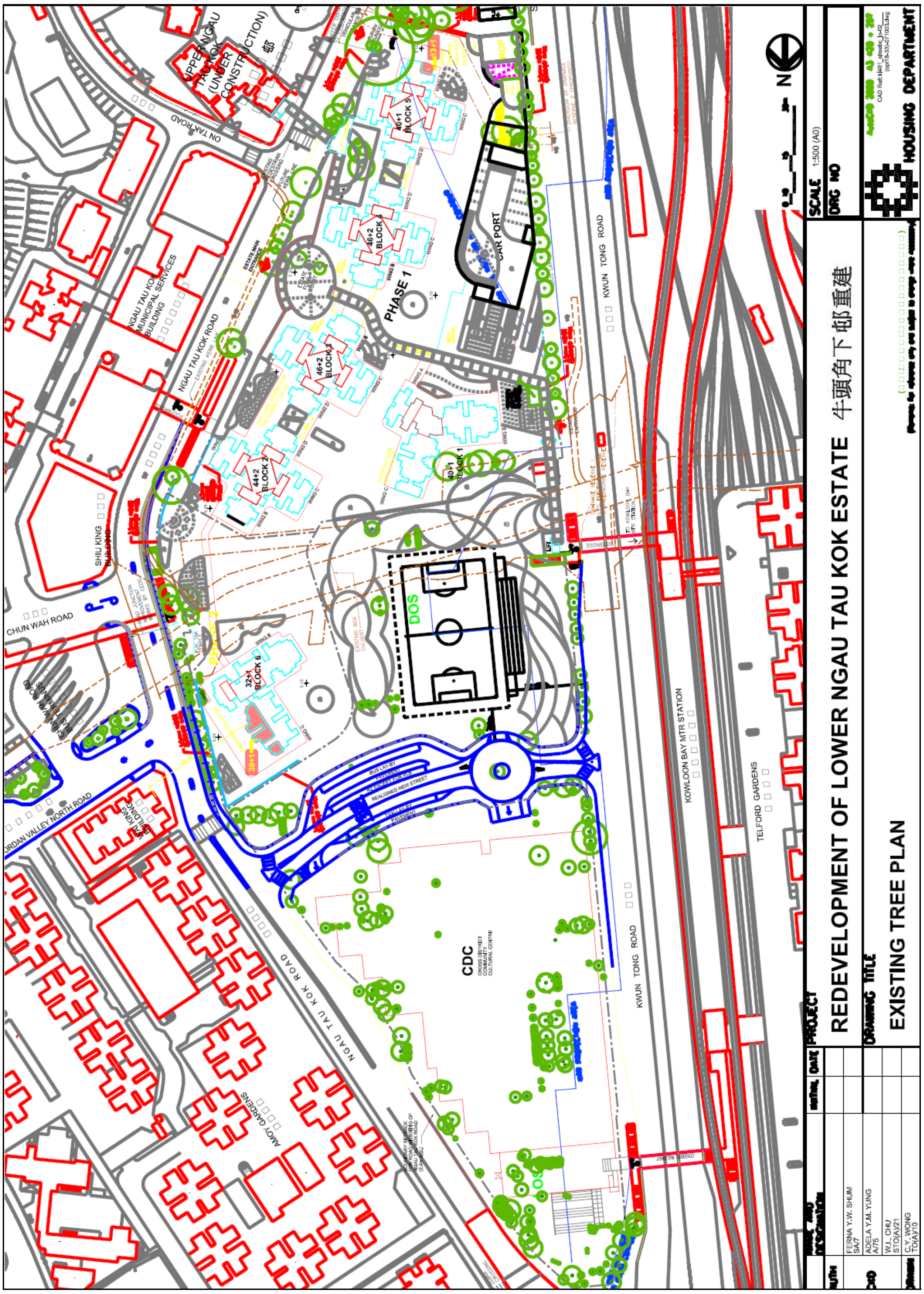


Figure 3 Master layout plan for the Proposed Scheme

4. METHODOLOGY OF THE STUDY

This ventilation study utilized the Air Ventilation Assessment (AVA) methodology for initial study as stipulated in Annex A to the Technical Circular "Technical Guide for Air Ventilation Assessment for Developments in Hong Kong" (Technical Guide).

4.1 Site Wind Availability

The site wind availability data was obtained from MM5 model, which is calculated by mesoscale model (MM5) at the height of around 596 m above the ground. The most frequent wind directions covering 79.7% of the wind are NNE, NE, ENE, E, ESE, SE, SSW and SW. A wind rose showing the frequency of occurrence of different wind directions as well as a summary of the frequency for the eight chosen wind directions considered for the study are attached below.

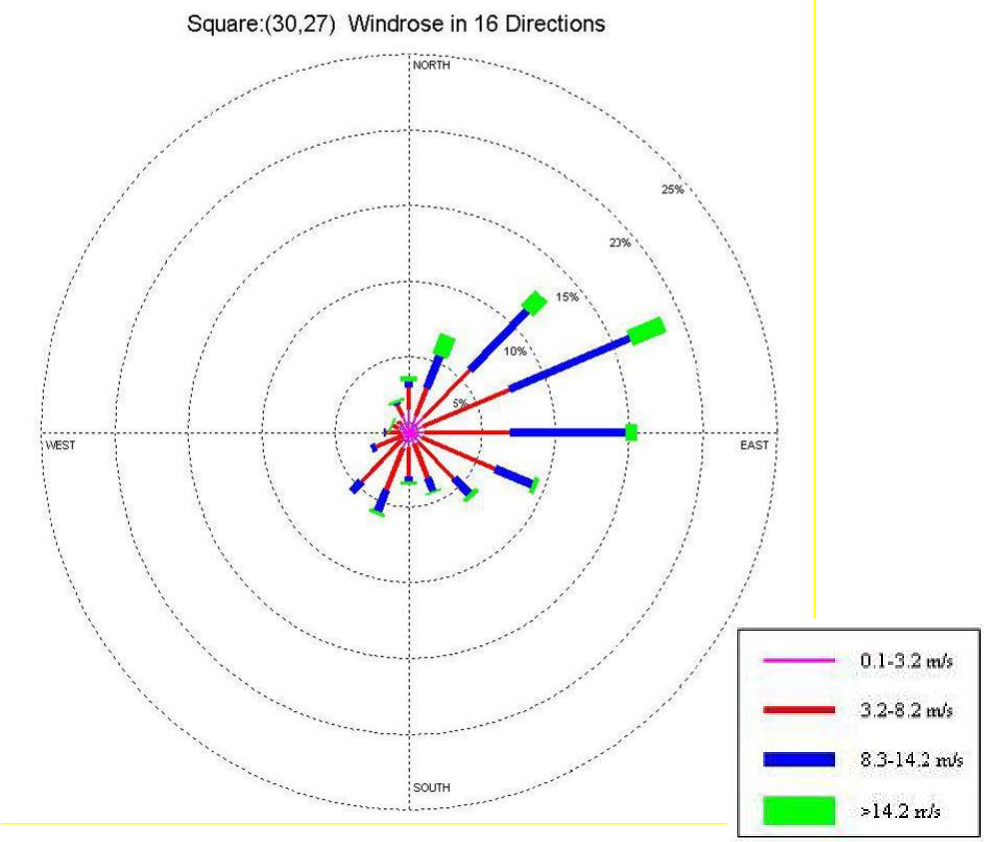


Figure 4 Wind rose based on MM5 simulation

Wind Direction	Percentage of Occurrence (%)	Wind Direction	Percentage of Occurrence (%)	Wind Direction	Percentage of Occurrence (%)	Wind Direction	Percentage of Occurrence (%)
N	*3.6*	E	***15.3***	S	*3.4*	W	*1.7*
NNE	***6.8***	ESE	***9.2***	SSW	***5.8***	WNW	*1.3*
NE	***12.6***	SE	***6.0***	SW	***5.5***	NW	*1.0*
ENE	***18.5***	SSE	*4.2*	WSW	*2.7*	NNW	*2.2*

- *Numbers in green represent the selected prevailing wind directions for simulation*

Table 1 Annual frequency of the approaching wind for the site

4.2 Wind Profile

The vertical discretization of the velocity profile is being approximated using an exponential law, which is a function of ground roughness and height:

$$U_z = U_G\left(\frac{z}{z_G}\right)^n \qquad (1)$$

Where

U_G = reference velocity at height $\mathbf{z_G}$

$\mathbf{z_G}$ = reference height

$\mathbf{z}$ = height above ground

U_z = velocity at height $\mathbf{z}$

The power **n** is related to the ground roughness, which is determined by terrain types. For this study, this factor is assumed to be 0.35 for all wind direction.

4.3 Project Assessment Area and Surrounding Area

With reference to the Technical Guide, the area of evaluation and assessment includes all areas within the Development sites, as well as a belt up to 1H (H being the height of the tallest building within the Development which is equivalent to 160m) from the site boundary ***(Assessment Area)***. Further, the model area was built to include another 160m meters (2H) beyond the Assessment Area ***(Surrounding Area)***. Nearby prominent topographical features beyond the Surrounding Area were also included in the model to take into account the topographic effect.

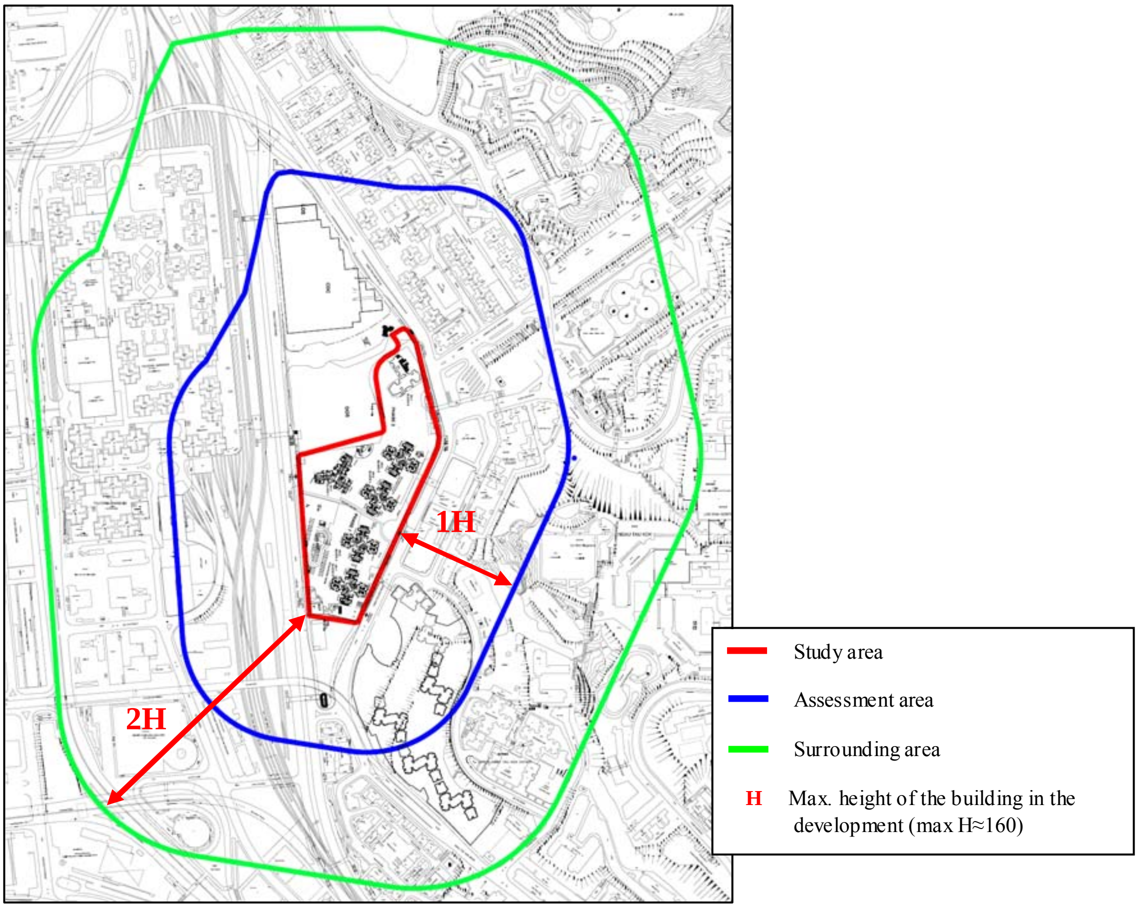


Figure 5 Site boundary (red), Assessment Area (blue) and Surrounding Area (green) for the study

4.4 Assessment Parameter

The Velocity Ratio (VR) as proposed by the Technical Circular was employed to assess the ventilation performance of the Proposed Development and its impact to the surroundings. High VR across the development implies less impact associated with the Proposed Development. The calculation of VR is given by the following formula:

$$VR = \frac{V_p}{V_\infty}$$

V_∞ = the wind velocity at the top of the wind boundary layer (typically assumed to be around 596m above the centre of the site of concern, or at a height where wind is unaffected by the urban roughness below).

V_p = the wind velocity at the pedestrian level (2m above ground) after taking into account the effects of buildings.

The higher the value of VR, the less is the impact due to buildings on wind availability.

The average VR is defined as the weighted average VR with respect to the percentage of occurrence of the considered wind direction. This gives a general idea of the ventilation performance at the considered location on an annual basis.

4.5 Test Points for Local and Site Ventilation Assessment

Monitoring test points are placed within the Development site to determine the ventilation performance. There are three types of test points:

(i) Perimeter test point

Perimeter test points are the points positioned on the project site boundary. According to the Technical Circular for AVA, 39 perimeter points *(red spots)* are positioned on the project site boundary and each point is around 10-50m in between.

(ii) Overall test points

Overall test points are those points evenly positioned within the Assessment Area in the open space on the streets and places where pedestrian frequently access. According to the Technical Circular for AVA, 105 overall test points *(blue spots)* are selected and shown in Figure 6.

(iii) Special test points

Special test points are positioned in areas that the air ventilation performance are especially concerned. 11 special test points *(green spots)*, which is located at the podium level of the existing developments surrounding the project site, are selected and shown in Figure 6.

These test points are located within the site assessment area and are 1H from the study site boundary.

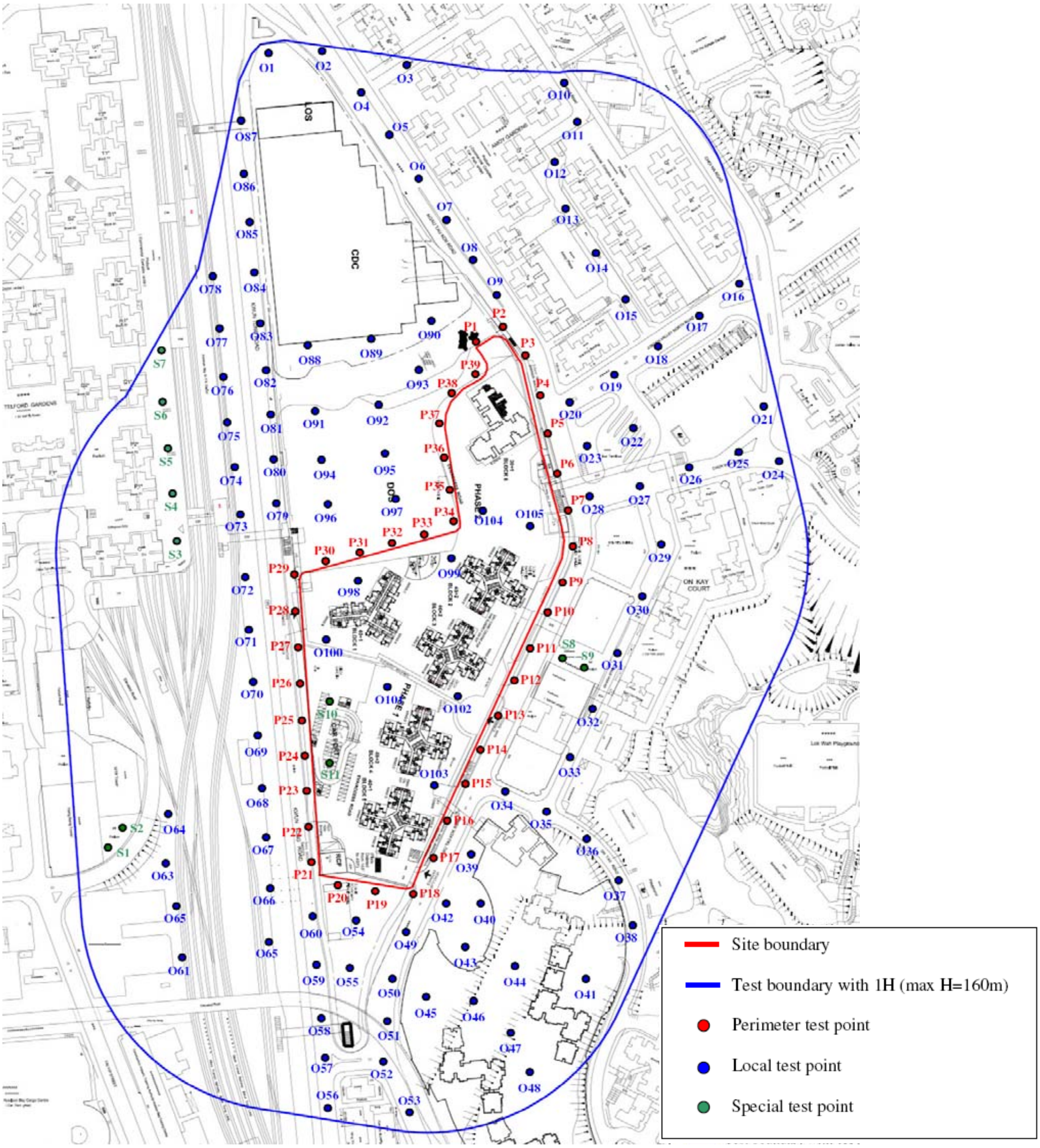


Figure 6 Demarcation of the test locations for site air ventilation assessment

4.6 Assessment Tool

Computational Fluid Dynamics (CFD) technique was utilized for this Study. With the use of three-dimensional CFD method, the local airflow distribution can be visualized in details. The velocity distribution within the flow domain, being affected by the site-specific design and the nearby topography, was simulated under the prevailing wind conditions considered.

4.6.1 CFD Model

The CFD models of the two studied scenarios are approximately 2500m(L) x 2000m(W) x 930m(H) and contain more than 3,600,000 cells. It covers the entire development and provides sufficient consideration on surrounding topography. The model contains information of the surrounding buildings and site topography from Geographic Information System (GIS) platform. Body-fitted unstructured grid technique is used to fit the geometry to reflect the complexity of the development geometry.

By referring to the CAD drawings of the two studied scenarios, the CFD models were constructed as shown below.

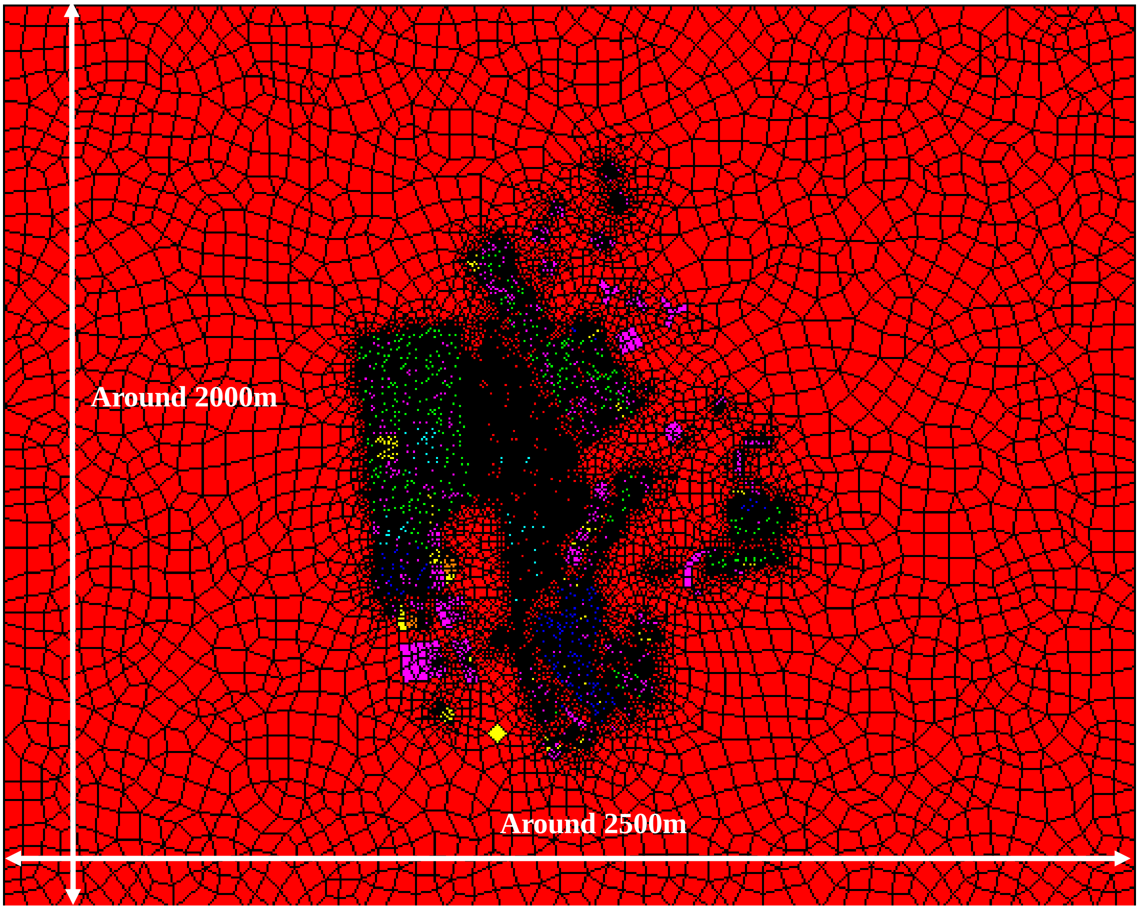
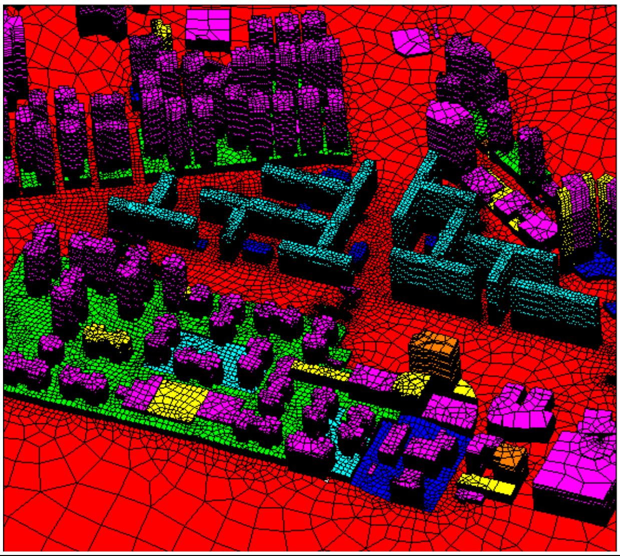
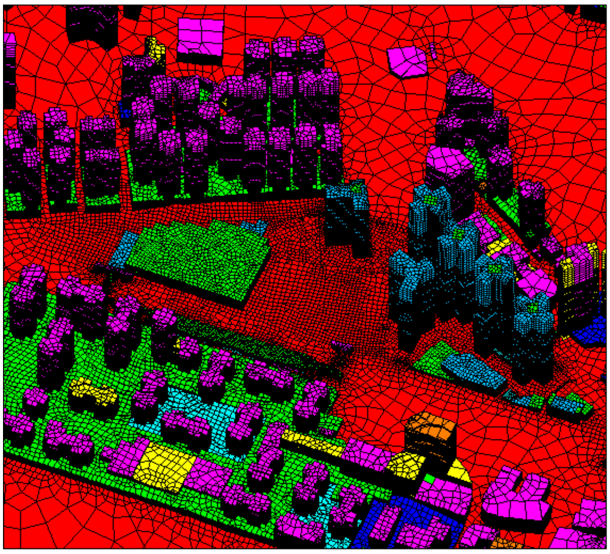


Figure 7 Domain of the CFD model





(a) Baseline scheme	(b) Proposed scheme

Figure 8 CFD model for the two schemes

4.6.2 Turbulence Model

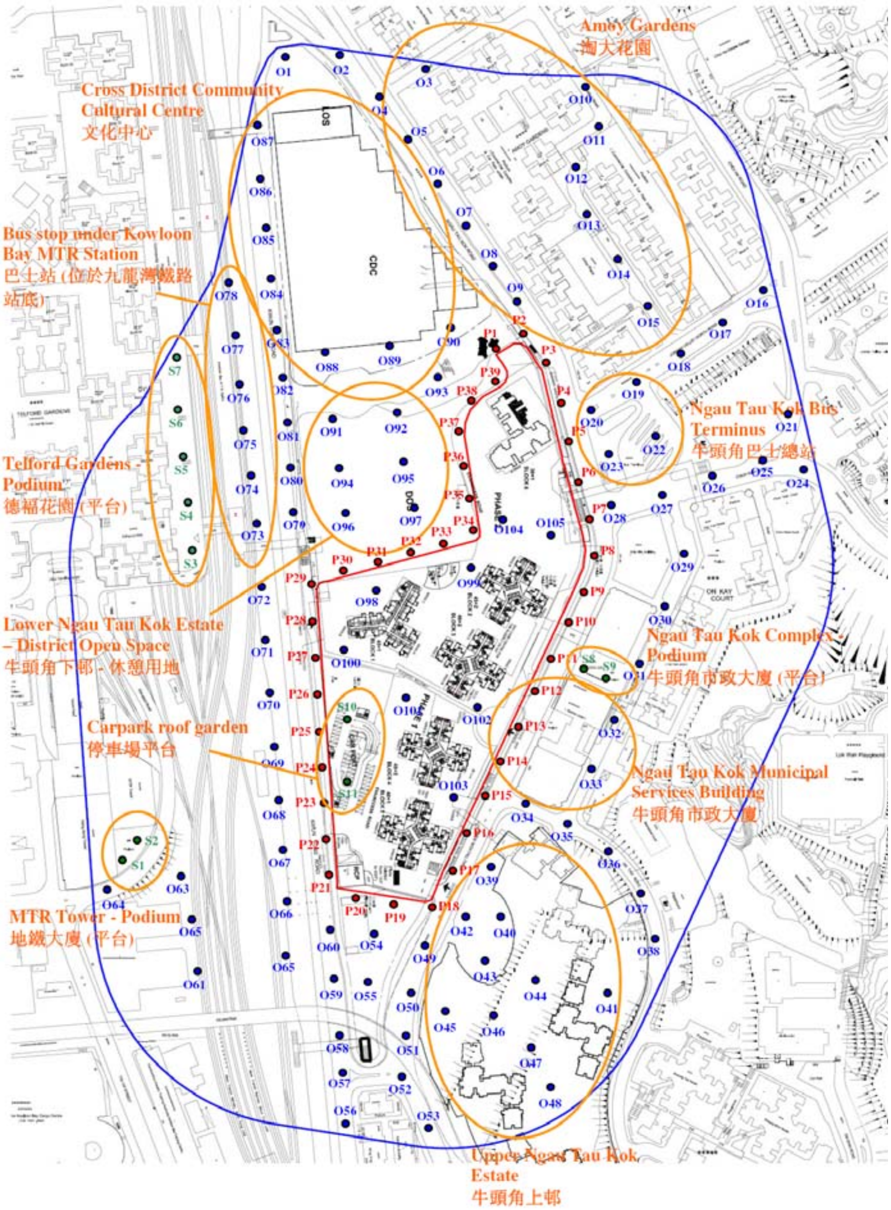
Arup has developed expertise in the state-of-the-art of advanced CFD technique - **Detached Eddy Simulation (DES)** running on parallel computers. The technique provides a more accurate representation of the levels of turbulence that can be expected in an urban environment. These are also very useful for presentation purposes, providing a detailed understanding of the flow characteristics throughout the flow domain.

5. MEASURING PARAMETERS

With reference to the Technical Guide, two ratios were determined to give a simple quantity to summarize the ventilation performance:

- **Site spatial average Velocity Ratio (SVR)** - This gives a hint of how the development proposal impacts the wind environment of its immediate vicinity. This is the average of VR values of all perimeter test points.
- **Local spatial average Velocity Ratio (LVR)** - This gives a hint of how the development proposal impacts the wind environment of the local area. This is the average of VR values of all overall and perimeter test points.

The following figure indicated the list of the focus areas and the relevant test points.



Focuses area	Test point
Amoy Gardens 淘大花園	O3-15
Ngau Tau Kok Bus Terminus 牛頭角巴士總站	O19-20, O22-23
Ngau Tau Kok Municipal Services Building 牛頭角市政大廈	P12-14, O32-33
Upper Ngau Tau Kok Estate 牛頭角上邨	O39-O48
Bus stop under Kowloon Bay MTR Station 巴士站 (位於九龍灣鐵路站底)	O73-O78
Lower Ngau Tau Kok Estate – District Open Space 牛頭角下邨 - 休憩用地	O91,O92,O94-O97
Cross District Community Cultural Centre (CDC) 文化中心	O83-O90
Lower Ngau Tau Kok Estate (The site) 牛頭角下邨	O98-O105
MTR Tower - Podium 地鐵大廈 (平台)	S1-S2
Telford Gardens - Podium 德福花園 (平台)	S3-S7
Ngau Tau Kok Complex - Podium 牛頭角市政大廈 (平台)	S8-S9
Carpark roof garden 停車場平台	S10-S11

Figure 9 Test point location and the focuses area

6. SUMMARY OF FINDINGS

The contour maps of the average VR for the two studied schemes are shown in Figure 10 and Figure 11 respectively.

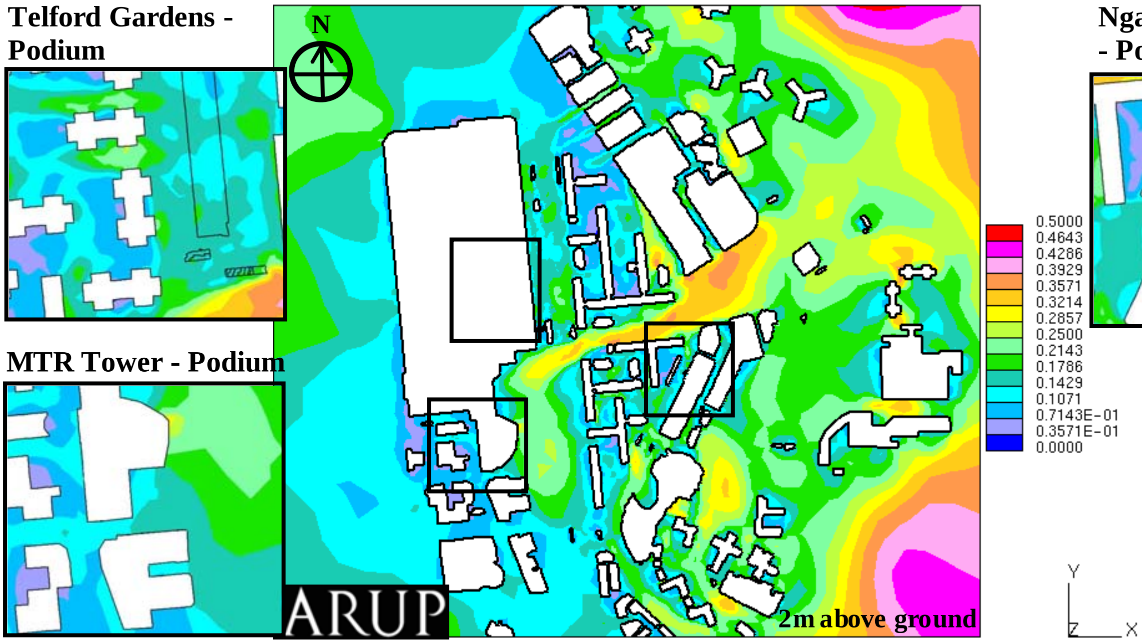


Figure 10 Contour maps of the average VR for the Baseline Scheme

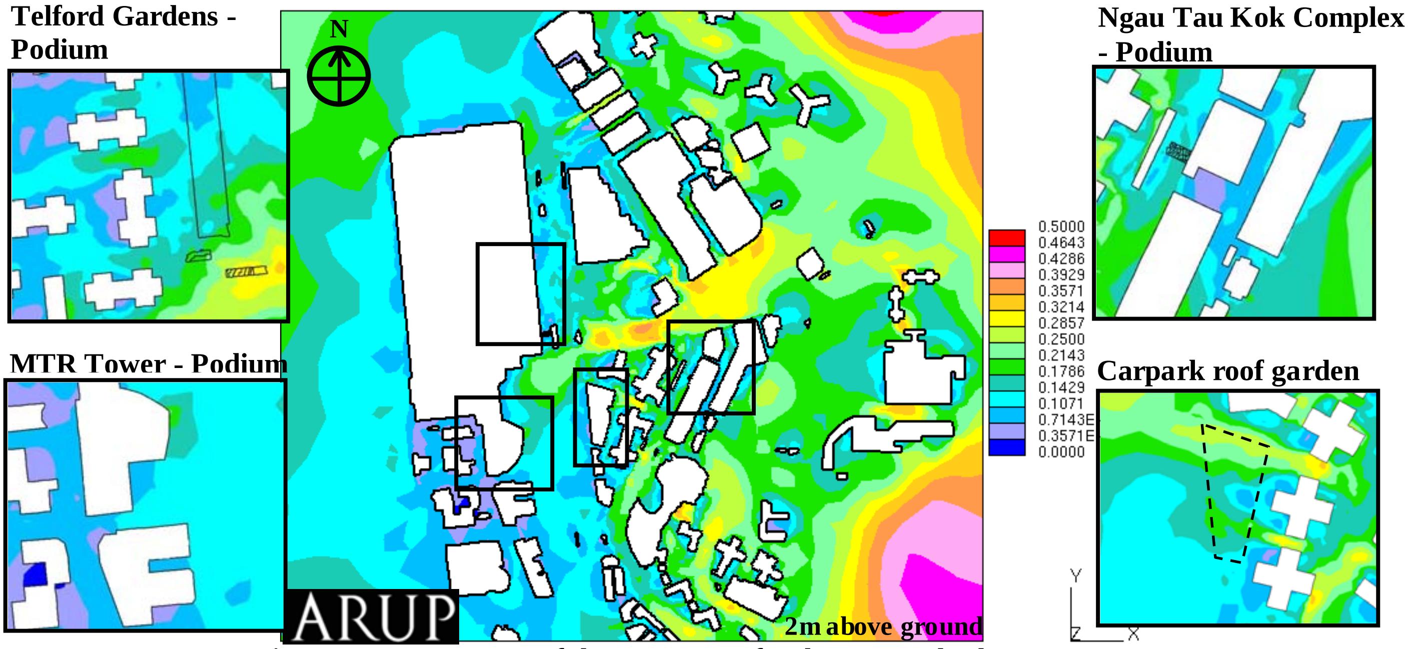


Figure 11 Contour maps of the average VR for the Proposed Scheme

The following table summarizes the values of SVR and LVR for the two studied schemes. Results show that both SVR and LVR are the same for both schemes.

	Baseline Scheme	Proposed Scheme
SVR	0.20	0.20
LVR	0.19	0.19

Table 2 Average VR of the Baseline Scheme and Proposed Scheme

The table below shows the average velocity ratios of the focus areas for the two schemes.

Focus Areas	Average Velocity Ratio	
	Baseline scheme	Proposed scheme
Amoy Gardens 淘大花園	**0.16**	**0.17**
Ngau Tau Kok Bus Terminus 牛頭角巴士總站	**0.34**	**0.31**
Ngau Tau Kok Municipal Services Building 牛頭角市政大廈	**0.14**	**0.15**
Upper Ngau Tau Kok Estate 牛頭角上邨	**0.17**	**0.19**
Bus stop under Kowloon Bay MTR Station 巴士站 (位於九龍灣鐵路站底)	**0.14**	**0.13**
Lower Ngau Tau Kok Estate – District Open Space 牛頭角下邨 - 休憩用地	**0.11**	**0.24**
Cross District Community Cultural Centre (CDC) 文化中心	**0.14**	**0.17**
Lower Ngau Tau Kok Estate (The site) 牛頭角下邨	**0.24**	**0.23**
MTR Tower - Podium 地鐵大廈 (平台)	**0.10**	**0.09**
Telford Gardens - Podium 德福花園 (平台)	**0.16**	**0.13**
Ngau Tau Kok Municipal Services Building - Podium 牛頭角市政大廈 (平台)	**0.06**	**0.07**
Carpark roof garden 停車場平台	**-**	**0.14**

Table 3 Average VR of the focus areas

Results show that the Proposed Scheme achieves higher value of the average velocity ratio in most focus areas e.g. **Cross District Community Cultural Centre (CDC), Lower Ngau Tau Kok Estate – District Open Space (DOS), Ngau Tau Kok Municipal Services Building, Upper Ngau Tau Kok Estate and Amoy Gardens** compared to the Baseline Scheme, especially for the DOS where the VR has been increased by 118%. The reason of such improvement is that the DOS is situated along the ventilation corridor of the Proposed Scheme, whilst the area is somehow enclosed for the Baseline Scheme.

There are some focus areas with relatively lower VR for the Proposed Scheme as compared to the Baseline case. For the **bus stop under Kowloon Bay MTR Station** and **Podium of MTR Tower**, the decrements of VR are small such that there would not be significant impact on air ventilation. For the **Ngau Tau Kok Bus Terminus**, the VR for the Proposed Scheme is still relatively high although there is a decrement. On the other hand, the studied area at the **Podium of Telford Gardens** is mainly for loading / unloading which is not a major pedestrian circulation area. Therefore, the air ventilation impact on the occupants would be minor.