BMT Asia Pacific

Establishment of Centre of Excellence in Paediatrics in Kai Tak Development (Programme Nos.: 76MM)

Air Ventilation Assessment Report

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Air Ventilation Assessment Report

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Keyword

Assessment Area	Generally including the projects surrounding up to a perpendicular distance H from the project boundary, H being the height of the tallest building on site.
Assessment Points	Selected locations where Velocity Ratios are reported.
Boundary of buildings included in the model	The boundary of buildings applied to the Computational Modelling (In the study, the inner area of up to a perpendicular distance of 3H from the project boundary is included).
Boundary of terrain included in the model	The boundary of terrain applied to the Computational Modelling (In the study, the inner area of up to a perpendicular distance of 10H from the project boundary is included).
CFD	Computational Fluid Dynamics
Expert Evaluation	A qualitative assessment of the design and/ or design options and to facilitate the identification of problems and issues.
Initial Study	A quantitative assessment and comparison of design options to facilitate option selection.
Local spatial average Velocity Ratio (LVR)	The average Velocity Ratio of the Overall Test Points and the Perimeter Test Points to give a hint of how the development proposal impacts the wind environment of the local area. $LVR = \sum_{i=1}^{n} \frac{VR_{i,j}}{n}$ where N is the total number of test points.
Overall Test Points	Test Points evenly distributed and positioned in the open spaces, on the streets and places of the Project and Assessment Areas where pedestrians frequently access.
Perimeter Test Points	Test Points positioned on the project site boundary.
Project Area	Defined by the project site boundaries including all open areas that pedestrians are likely to access.
Site Wind Availability Data	Wind characteristics of the natural wind availability of the Site
Site spatial average Velocity Ratio (SVR)	The average Velocity Ratio of the Perimeter Test Points to give a hint of how the development proposal impacts the wind environment of its immediate vicinity. $SVR = \sum_{i=1}^{n} \frac{VR_{i,j}}{n}$ where N is the total number of test points.
Spatial Average Velocity Ratio (SAVR)	The average Wind Velocity Ratio of the Test Points to give a hint of how the development proposal impacts the wind environment of the area of interest. $SAVR = \sum_{i=1}^{n} \frac{VR_{i,j}}{n}$ where N is the total number of test points.

Surrounding Area	The area that conditions the approaching wind profiles appropriately. The Surrounding Area of up to a perpendicular distance of 2H from the project boundary should be included in the AVA study. Sometimes it may be necessary to enlarge the Surrounding Area if there are prominent features (e.g. tall buildings or large and bulky obstructions) immediately outside the 2H zone.
Wind Velocity Ratio (VR)	An indicator of wind availability, which is defined as Vp/V∞ (V pedestrian/Vinfinity). V∞ captures the wind velocity at the top of the wind boundary layer (assumed to be 600 m above ground in this study). V∞ is taken as the wind availability of the Site. Vp captures the wind velocity at the pedestrian level (2m above ground) after taking into account the effects of buildings and urban features. $VR = \frac{V_p}{V_\infty}$
Weighted Wind Velocity Ratio (VRw)	The Weighted Wind Velocity Ratio is the sum of the Wind Velocity Ratio of wind from direction i (VRi) multiply by the probability (Fi) of wind coming from that direction as expressed by the formulae. $VRw = \sum_{i=1}^{8} F_i \times VR_i$ It is a common practice in initial study of air ventilation assessment to account for wind coming from the most 8 probable directions.

1 Introduction

1.1 Background

1.1.1.1 The proposed development is to establish new hospitals (hereafter as "the Project") in the South Apron of the Kai Tak Development.

1.1.1.2 BMT Asia Pacific Limited (BMT) has been commissioned by Architectural Service Department (ArchSD) to conduct an Air Ventilation Assessment (AVA) of the Proposed Hospitals in the South Apron of the Kai Tak Development. The Project will comprise the proposed development of Centre of Excellence in Paediatrics (CEP).

1.1.1.3 This report covered the AVA study for the Centre of Excellence in Paediatrics (hereafter as "the proposed development") at Site C (hereafter as "the Site"). Figure 1.1 shows the location of the Site and its environs.

1.1.1.4 The AVA study aims to assess the air ventilation impacts of the proposed development on the Site and its adjacent areas. Different design schemes were studied in order to optimise the block layout for the proposed development. The optimised block layout and further improvement of the proposed development will be incorporated in design stage of the project under a design and build contract at later stage.

1.1.1.5 The scope of the AVA study is summarized as follows:

- To obtain precise approaching Site Wind Availability Data and characteristic information at atmospheric boundary layer for various wind directions accounting for not less than 75% of the annual probable winds.
- To assess the wind velocity ratios at the assessment points on the street level.
- To compare and analyse the assessment results of the proposed development schemes and to recommend improvement measures with respect to poor air ventilation performance.
- To prepare a report documenting the comparison of the assessment results and findings of all proposed development schemes.
- To determine the Preferred Scheme among different schemes in consideration of air ventilation performance

1.2 Development Schemes

1.2.1.1 The initial planning intent of the subject site will consist of multi-storey buildings with plot ratio of 5.0. Such plot ratio was recommended by Planning Department during the initial stage, which tally with the density control parameters imposed for the most of the development sites intended for non-domestic uses. However, due to the special functional needs and operational requirements of the hospital, a plot ratio 5.5 is adopted in the proposed development. It is anticipated that such increase shall not impose significant impact on air ventilation.

1.2.1.2 Basically, the two schemes provide under the study the same building footprint with the same building height of approximately 60 m above ground at roof level. The first scheme is one single multi-storey building while the second scheme are two multi-storey buildings. The former design scheme is named as Single Tower while the latter is named as Twin Tower design scheme.

1.2.1.3 Appendix A shows the section views of the two schemes for the proposed development.

1.3 Broad Approach of AVA Study

1.3.1.1 The methodology of the AVA study strictly follows the guidelines that being set out in the Technical Circular for Air Ventilation Assessments issued by the Government of HKSAR in 2006 [1].

1.3.1.2 Wind Velocity Ratio (VR) has been adopted as an indicator of wind performance for the proposed development to show the amount of wind available on ground level by taking into account the surrounding buildings and topography and the proposed development. It is defined as V_p/V_∞ (V pedestrian/V infinity). V_∞ captures the wind velocity at the top of the wind boundary layer and is taken as the wind availability of the Site. V_p captures the wind velocity at the pedestrian level.

1.3.1.3 The general rule is that the higher the Wind VR, the less likely would be the impact of the proposed development on the wind availability. The reported Wind VRs provide a basis for the air ventilation characteristics of the proposed design schemes as well as identifying any air ventilation problems for further improvement.

1.3.1.4 The qualitative Expert Evaluation (in Section 2) provides an insight on the likely interaction between the topography and the buildings on the wind environment and determines the potential problem areas.

1.3.1.5 In this AVA study, an Initial Study has also been conducted which includes a Site Wind Availability Data study using the best available meteorological data and the relevant standards to determine the wind availability and characteristics.

1.3.1.6 Details for the assessment approach of the Site Wind Availability Data Study and Initial Study are presented in Section 3 as well.

2 Expert Evaluation

2.1 Wind Environment

2.1.1.1 With reference to the AVA Study Report for Kai Tak Planning Review dated March 2007, the prevailing winds of the study area mainly come from the north-northeast, east and east-southeast directions. [2]

2.1.1.2 Regarding to the report of Expert Evaluation and Advisory Report for Proposed Amendments to Ngau Tau Kok and Kowloon Bay Outline Zoning Plan dated November 2010, it was concluded that the annual prevailing wind directions for the Ngau Tau Kok and Kowloon Bay area are north-easterlies, easterlies and south-easterlies while the summer prevailing winds are easterlies, south-easterlies, southerlies and south-westerlies. [3]

2.1.1.3 With reference to the Summary of Meteorological and Tidal Observations in Hong Kong 2009 issued by Hong Kong Observatory, it is apparent that the annual prevailing winds in Kai Tak Station are from east and southeast quarter. [4]

2.1.1.4 According to the wind data from the above references, it is concluded that the prevailing wind in the area mainly come from the north-northeast and east directions in non-summer period, and east and east-southeast directions in summer period.

2.2 Key Wind Characteristic and Site Environs

2.2.1.1 The proposed development is located in the South Apron of Kai Tak Development. The Site is situated on the south-western side of the planned Road D4, which is a planned district distributor connecting the future Runway Precinct with the Kowloon Bay waterfront. The Site is currently a vacant government land with no ground structure.

2.2.1.2 To the immediate southeast, the development is a low-rise building, namely Public Works Central Laboratory Building which will be planned as a gas pigging station. To the east, the building blocks are mid- to high-rise commercial buildings. To the northwest, they are planned to be low- to mid-rise buildings for Government/ Institution or Community (G/IC) use according to Kai Tak Outline Zoning Plan (S/K22/2) gazetted on 26 August 2011. To the immediate northeast, it will be the planned Centre of Excellence in Neuroscience (CEN) and New Acute Hospital (NAH).

2.2.1.3 In consideration of the topographical feature surrounding the Kai Tak Development Area, it is surrounded by mountains at the outer areas (i.e. Fei Ngo Shan, Lion Rock, Golden Hill, Victoria Peak, Jardine's Lookout and Mount Parker) and high-

rise developments at different directions. The densely populated urban area, i.e. Kwun Tong, Ngau Tau Kok and Kowloon Bay is relatively a flat land and the ground level gradually increases uphill towards Northeast. Wind flows through the mountains and high-rise buildings before reaching the Kai Tak Development Area. Less wind obstruction is anticipated from SE as Kai Tak Development Area aligns with Lei Yue Mun at the SE direction.

2.2.1.4 In general, better air ventilation performance would be experienced at the Kai Tak Development Area under SE wind direction as it is relatively open at south and southeast sides and where is close to waterfront. On the other hand, the worst scenario will take place under NE wind direction as its outer north and northeast side consists of densely populated mid- to high-rise commercial, industrial and residential buildings.

2.2.1.5 Figure 1.1 shows the location of the Site and its environs.

2.2.1.6 Some south-easterly winds are likely deflected by the existing and planned developments, i.e. Pacific Trade Centre, OCTA Tower and planned residential developments at ex-Kowloon Godown and Kerry Godown, to the east of the subject development. On the other hand, some south-easterly winds generally flow over the low-rise building, i.e. Public Works Central Laboratory Building, to the southeast as well as the non-building area (NBA) and reach the Site without much obstruction. The winds will then likely flow to the inner area of Kai Tak Development via Road D4.

2.2.1.7 Wang Chiu Road is straight and aligned along the north-south direction which could allow the wind flow from north towards the site. However there will be obstruction of northerlies due to the future CEN and NAH.

2.2.1.8 Wai Yip Street likely channels some northerly wind, then the winds flow over the low-rise buildings, i.e. New Kowloon Bay Vehicle Examination Centre and Kowloon Bay Motor Vehicle Examination Centre and reach the Site. However, Wai Yip Street does not connect all the way from north to south, which air path does not fully parallel to the incoming northerly wind. Such its efficacy is reduced before reaching the Site.

2.2.1.9 Albeit other north-south orientated Wang Tai Road, Wang Mau Street and Wang Hoi Road are relatively narrow and buildings of high ground coverage are located along them, some northerlies could still penetrate along the roads with slight obstruction of the low-rise Refuse Transfer Centre at the south. Some northerly winds could flow towards the site after passing through the building gap of the future CEN and NAH. However it will be relatively weak wind flow and low ventilation rate might be experienced at the north and northeast side of the Site.

2.3 Good Design Features

2.3.1.1 Single Tower is recognized as the initial design. It fully complies with the relevant building requirements and recommendations in Sustainable Building Design Guideline. This design scheme allows efficient use of floor spaces which is a benefit to the operation of CEP. As the single tower with long facade will likely impose wind and view blockage and improper from the urban design point of view, it is proposed to separate into two individual towers connecting by link bridges at various levels to reduce the building bulk, which are known as Twin Tower design scheme in order to increase the building permeability. In Twin Tower design scheme, the building separation was maximised in consideration of the length of the site.

2.3.1.2 As aforementioned it is anticipated that better air ventilation performance will be achieved under winds from SE quarter as it is relatively open on south and southeast side and where is close to waterfront. Due to the shape and orientation of the Site and efficient use of available space, the building blocks are aligned along Road D4 and thus the building gap does not align with the prevailing wind direction. However it aligns with the NE wind and the building gap of future CEN and NAH to form a visual and air ventilation corridor of low zone across the two sites. Moreover wider building separation between two towers could help effective air flows around buildings in desirable directions.

2.4 Problem/ Focus Areas

2.4.1.1 As aforementioned, the winds from northeast quarter is likely sheltered by the densely populated buildings at upwind direction which might result in relatively low ventilation rate on north and northeast side of the Site. On the other hand, as the proposed development is located near to the waterfront, its potential impact on wind penetration and wind impediment at inland areas will be a concern. It is required to pay attention on its building orientation, building bulk and permeability.

2.4.1.2 In summary, significant impacts on air ventilation imposed by the proposed development is not anticipated although it is located near waterfront. It is because the building height is relatively low and the building permeability has been considered as far as practicable. However, relatively low ventilation might be experienced on the north and northeast side of the Site while potential impact on wind penetration throughout the area might be occurred. Hence, an Initial Study was conducted to study the ventilation performance of the schemes.

3 Initial Study

3.1 Site Wind Availability Data

3.1.1.1 For the Site Wind Availability Data study, precise wind availability and characteristic information in terms of wind rose (directions, magnitudes and frequencies), wind profiles are compiled using information obtained from the AVA Study Report for Kai Tak Planning Review as well as the international standards. [2], [6]

3.1.1.2 The wind rose data in the AVA Study Report for Kai Tak Planning Review was used for this AVA study, which was calculated by mesoscale model (MM5) at height of 500 m above the ground. [2]

3.1.1.3 According to the wind rose, 23.0% of the site approaching wind at 500 m above the ground would be from ESE which is considered as dominant prevailing wind. On the other hand, about 16.2% and 15% of wind will be from E and NE quarter (i.e. NNE and NE), respectively.

3.1.1.4 In order to comply with the Technical Circular for Air Ventilation Assessments [1], not less than 75% of the annual probable winds have been accounted which includes the total of eight wind directions (i.e. N, NNE, NE, ENE, E, ESE, SE, WSW winds). The considered wind directions and their annual probabilities are shown in Table 3.1 below.

Table 3.1 Wind Boundary Conditions Applied in the Initial Study

No.	Wind Boundary Condition	Annual Probability
1	ESE	23.0 %
2	E	16.2 %
3	NNE	9.9 %
4	SE	6.8 %
5	ENE	5.6 %
6	N	5.2 %
7	NE	5.1 %
8	WSW	4.8 %
	Total:	**76.6 %**

3.1.1.5 The wind boundary profiles are also in line with the AVA study for Kai Tak Planning Review. [2] The reference velocity is taken as 7.5 m/s at 500 m above ground. The wind boundary profiles are generated with the exponential power law. Table 3.2 presents the terrain coefficient crossed by approaching wind conditions.

Table 3.2 Directional Approach Wind Conditions

No.	Wind Direction	Terrain Coefficient
1	ESE	0.39
2	E	0.29
3	NNE	0.17
4	SE	0.28
5	ENE	0.10
6	N	0.36
7	NE	0.19
8	WSW	0.21

3.2 Methodology of Initial Study

3.2.1 Computational Fluid Dynamics (CFD) Approach

3.2.1.1 With reference to the Technical Circular for Air Ventilation Assessments [1], CFD method is used as "fit for the purpose".

3.2.1.2 The optimum CFD Model is created based on "the Quality Assurance Manual on Environment Wind Studies (AWES-QAM-1-2001)" [3] and the "Guide for the Verification and Validation of Computational Fluid Dynamics Simulations (American Institute of Aeronautics and Astronautics 1998) [7]". The CFD models are shown in Figure 3.2. The details of CFD modelling verification are described in the following section.

3.2.2 Domain of CFD Model

3.2.2.1 A computational model with 2 km wide terrain and 500 m height boundary covering the Site, the assessment area and the surrounding area including all existing buildings, planned buildings and topographical features has been

constructed. The highest building within the domain is 170 m. Figure 3.2 presents different views for the CFD model of bounding surfaces for Scheme 2.

3.2.2.2 As shown in Figure 3.2, the CFD model was built with a domain of 3000 m (L) x 3000 m (W) x 500 m (H).

3.2.3 Validity of CFD Modelling

3.2.3.1 Reference [7] recommends benchmark tests of the partial differential equations and their finite volume representation to investigate any CFD coding errors. However, for this project, one of the most reliable and fully verified commercial 3D CFD tools in Fluent 6.3, which is widely used in Hong Kong & Asia Pacific, has been adopted. Therefore, verification of the code is not required for the present analysis. For an extensive description of the Fluent code verification and benchmark tests, refer to reference [8].

3.2.4 General Settings of CFD Model

3.2.4.1 The CFD model was generated with the combination of tetrahedral and prism cells. Four layers of equally spaced prism cells are generated from the ground level up to 2 m above the ground level for the entire computational model. This was intended to predict the steep velocity gradient close to the ground level. The rest of the computational volume was filled with high quality un-skewed tetrahedral cells. The grid size on the proposed development was the smallest with a minimum size of 0.5 m. The mesh size was expanded out from the proposed development buildings with expansion ratio of 1.2. Also a multiple small length scale was applied for the neighbouring building surfaces and narrow streets. The smallest grid applied is about 2 m. Based on these, the mesh size was expanded out away from the surrounding building surfaces and narrow streets to the rest of the computational volume. As a result, approximately 7.62 million-cell hybrid CFD model was created for the study.

3.2.4.2 The Realizable k-ε turbulence model and a 2^{nd}-order discretization scheme were used in the simulations. The convergence criterion used was the requirement that the sum of the absolute normalised residuals be less than $1x10^{-3}$.

3.2.4.3 Figure 3.3 shows the grid arrangement for the CFD model.

3.3 Assessment Points

3.3.1 Perimeter and Overall Test Points

3.3.1.1 The assessment area is approximately 100 m from the site boundary. Figure 3.4 shows the selected assessment point locations for the AVA study. The assessment points (ID# C_P01 – C_P30) at the site boundary are finely positioned to provide enough wind characteristic information around the Site, which are known as perimeter test point. These points are used to assess Site spatial

average Velocity Ratio (SVR) and give a hint of how the development proposal impacts the wind environment of its immediate vicinity.

3.3.1.2 The assessment area covers neighboring streets and roads; and adjacent pedestrian access. These are overall test points (ID# O01 – O33) and used to assess Local spatial average Velocity Ratio (LVR). This gives a hint of how the development proposal impacts the wind environment of the local area.

3.3.1.3 The locations of assessment points are identical for the schemes which are summarized in Table 3.3 below.

Table 3.3 Air Ventilation Assessment Points

Assessment Location	Assessment Point ID
Zone 1 Footpath to the North	O01 – O06
Zone 2 Cheung Yip Street	C_P12 – C_P16, O07 – O10
Zone 3 Section of Road D4	C_P01 – CP12, O08, O11 – O16
Zone 4 Waterfront Promenade	O17 – O24
Zone 5 Section of Road D4 connecting to Runway	C_P01, C_P27 – C_P30, O25 – O30
Zone 6 GIC site at NW	O31 – O33
Proposed Development (i.e. SVR)	C_P01 – C_P30

3.4 Results and Key Findings

Site Air Ventilation Assessment

3.4.1 Site Spatial Average Velocity Ratios (SVRs)

3.4.1.1 Site spatial average Velocity Ratios (SVRs) were determined for the Site Area in order to quantify the air ventilation effects of the proposed development on its immediate surrounding areas. The annual SVR for Single Tower design scheme is 0.15 while the directional SVRs range from 0.11 to 0.32. For Twin Tower design scheme, the annual SVR is 0.13 with the range of directional SVRs from 0.09 to 0.29.

3.4.1.2 The directional SVRs of N, (0.11_{Single} / 0.11_{Twin}), NNE (0.13_{Single} / 0.12_{Twin}), NE (0.13_{Single}), E (0.12_{Single} / 0.09_{Twin}) and ESE (0.13_{Single} / 0.12_{Twin}) are relatively lower

than the corresponding annual SVR (0.15_{Single} / 0.13_{Twin}) because of its leeward position, wind impediment caused by windward building and the irregular road alignment with the prevailing wind directions reducing the wind penetration through the area. For example the planned gas pigging station likely deflects some of ESE wind. E wind could reach the proposed development via Cheung Yip Street, however the wind along Cheung Yip Street subsequently encounter the building facade downwash from Tower B of the proposed development and the flows are then diverted.

3.4.1.3 Most of the directional SVRs are generally of similar magnitude in both schemes, except under ENE and SE wind conditions with decrease in the magnitude of VRs in Scheme 2. Such reductions are due to two reasons. First, in Twin Tower design scheme under ENE wind direction, the wind flow through the gap between CEN and NAH buildings encounter the building facade downwash from Tower A of the proposed development, the interaction of these flows then leads to lower wind velocity in comparing with Single Tower design scheme. Second, more streamlined flow along the building of the proposed development is observed in the Single Tower design scheme under SE wind direction.

3.4.1.4 In the Twin Tower design scheme, the building separation between two towers provides some ventilation improvement under certain wind directions (e.g. ESE and E). Under WSW wind condition, excellent wind penetration is observed while some wind amplification is also observed, especially at or near the edge of towers and building gap. Such amplification occurs because of the corner-streams and flow channelization while passing through the building gap. Significant impact on this phenomenon is not expected as these areas will be a landscaped garden, trees can then help alleviate the windy condition.

3.4.1.5 Some wind penetrations through the building separation in Twin Tower scheme design were also observed under N, NNE and E wind directions. The building separation helps deliver some wind flows to the proposed development and its surrounding areas and reduce the potential effect of long facade along the waterfront in consideration of urban design.

3.4.1.6 In addition, significant wind obstruction caused by the footbridges at various levels connecting the towers of the proposed development was not observed. There is also no adverse impact being observed on the footbridges connecting the proposed development, CEN and NAH buildings.

3.4.1.7 The Wind VRs of the perimeter test points under the wind boundary conditions are summarized in Table B1 and B2 of Appendix B.

Local Ventilation Assessment

3.4.2 Local Spatial Average Velocity Ratios (LVRs)

3.4.2.1 Local spatial average Velocity Ratios (LVRs) were determined from all perimeter and overall test points in order to quantify the air ventilation effects of the proposed

development on the assessment area. The annual LVR for Single Tower design scheme is 0.17 whilst the directional LVRs for Scheme 2 range from 0.13 to 0.30. For Twin Tower design scheme, the annual LVR is 0.16 with the directional LVRs from 0.13 to 0.30.

3.4.2.2 The annual LVR is of similar magnitude in both schemes. Most of the directional LVRs are also of similar magnitude, except SE wind conditions with reduced VR in Scheme 2. Reduction was observed under SE wind condition, which is due to more streamlined flows along Road D4 and Waterfront Promenade.

3.4.2.3 The study area will experience slightly lower LVRs under N (0.13_{Single} / 0.13_{Twin}), NNE (0.14_{Single} / 0.14_{Twin}) and E (0.14_{Single} / 0.13_{Twin}) wind conditions with comparing to their annual LVRs (0.17_{Single} / 0.16_{Twin}). Most of areas will receive less wind penetration especially wind coming from E due to wind obstruction caused by the upwind buildings located to the East near the waterfront and weak wind flow through the roads. The wind flow is diverted upon encountering those upwind buildings, subsequently the building corners separate the flow and create stagnant zone at the leeward side causing low air movement. Albeit that, desirable wind penetration is observed under some wind conditions. Some directional LVRs, i.e. ENE (0.24_{Single} / 0.20_{Twin}), ESE (0.17_{Single} / 0.16_{Twin}), SE (0.23_{Single} / 0.17_{Twin}) and WSW (0.30_{Single} / 0.30_{Twin}) wind directions, are of similar or higher magnitude to its annual LVR (0.17_{Single} / 0.16_{Twin}) in both schemes whilst LVR of NE wind with slightly higher magnitude then its annual LVR was also observed in Twin Tower design scheme, however the change is not significant.

3.4.2.4 The Wind VRs of the overall test points under the wind boundary conditions are summarized in Table B1 and B2 of Appendix B.

3.4.3 Spatial Average Velocity Ratios (SAVRs) for the Area of Interest

3.4.3.1 Spatial Average Velocity Ratios (SAVRs) for each representative area and street that were determined for Scheme 2. The annual SAVRs for each area and street are presented in Table 3.4.

Table 3.4 Spatial Average Velocity Ratios for the Area of Interest

Area of Interest	Design Scheme	
	Single Tower	Twin Tower
Zone 1 Footpath to the North	0.26	0.28
Zone 2 Cheung Yip Street	0.19	0.18
Zone 3 Section of Road D4	0.14	0.15
Zone 4 Waterfront Promenade	0.19	0.15
Zone 5 Section of Road D4 connecting to Runway	0.17	0.17
Zone 6 GIC site at NW	0.20	0.18
Proposed Development (i.e. SVR)	0.15	0.13

3.4.3.2 The detailed SAVRs for the areas of interest are presented in Table B3 and B4 of Appendix B. The annual SAVRs at Footpath to North (0.26_{Single}/ 0.28_{Twin}), Cheung Yip Street (0.19_{Single} / 0.18_{Twin}) and Section of Road D4 connecting to Runway (0.17_{Single} / 0.17_{Twin}) are similar to or relatively higher than the other annual SAVRs and their annual LVRs (0.17_{Single} / 0.16_{Twin}). The results indicate that those areas act as the major air paths in the vicinity of proposed development.

3.4.3.3 The annual SAVRs at the areas of interest in Twin Tower design scheme are of similar magnitude to the Single Tower design scheme. This implies that the ventilation performance at the areas of interest is generally maintained, except the proposed development, Zone 4 - Waterfront Promenade and Zone 6 – GIC site at NW are slightly reduced in SAVR. The building separation of Twin Tower design scheme provides a wind pathway under E, NNE, N and WSW as shown in Appendix C. On the other hand, the plots in Appendix C also illustrates that the existing and planned high-rise developments along Kai Hing Road to the east near waterfront, i.e. Pacific Trade Centre, OCTA Tower and planned residential developments at ex-Kowloon Godown and Kerry Godown, will deflect the winds coming from E and ESE. Such some wind obstruction under E and ESE directions will likely be experienced at the subject development and inner area.

3.4.3.4 Zone 1 – Footpath to North: The annual SAVR for Single Tower and Twin Tower design scheme are 0.26 and 0.28 respectively, which is significantly higher than SVR and LVR. Evidently Zone 1 is affected by the differences between schemes under some wind directions and some increases were observed in Twin Tower design scheme. Open walkway at ground connecting the future CEN and NAH buildings with similar alignment/ permeable area of the building gap between towers can optimize the ventilation performance of area. Such can be observed under WSW wind condition, where the building separation in Twin Tower design scheme allows wind penetration and delivers wind flow to inner area. Under ENE and ESE, the aforesaid open walkway allows streamlined flow throughout the area. In general, excellent ventilation performance shall be achieved in this area.

3.4.3.5 Zone 2 – Cheung Yip Street: The annual SAVR for Single Tower design scheme is 0.19 and for Twin Tower design scheme is 0.18. The annual SAVR is of similar magnitude between schemes. Some changes were found in Twin Tower design scheme comparing to Single Tower design scheme. The changes under NNE, ENE and NE winds are due to the street width slightly narrowed down and downwash from Tower B of the proposed development. Besides that, the rest of directional SAVR are fairly similar in both schemes. The ventilation condition between two schemes is similar.

3.4.3.6 Zone 3 – Section of Road D4: The annual SAVR for Single Tower design scheme is 0.14 while the annual SAVR for Twin Tower design scheme is 0.15. Most of the directional SAVRs are of similar magnitude, except ENE and ESE. Decrease observed under ENE wind is due to downwash from Tower A of the proposed development encounters the flow from the gap at grade between CEN and NAH buildings, then less wind flow along this road was resulted. Under ESE wind, increase is because of more wind flowing through open walkway connecting CEN and NAH buildings. Overall the decreased VRs are offset by the increased VRs, such the ventilation is fairly similar between schemes.

3.4.3.7 Zone 4 – Waterfront Promenade: The annual SAVR for Single Tower and Twin Tower design scheme are 0.19 and 0.15 respectively. In general, the wind ventilation of Zone 4 in Single Tower design scheme is better than the Twin Tower design scheme. It is due to the smaller wake zone and more streamline flow in Single Tower design scheme. There is a potential gust impact for wind coming from WSW.

3.4.3.8 Zone 5 – Section of Road D4 connecting to Runway: The annual SAVR is 0.17 for both Single Tower and Twin Tower design schemes. Most of the directional SVARs are of similar magnitude except ENE and WSW wind directions. Positive change for wind coming ENE and negative change for wind coming from WSW were observed. Both changes are due to the Single Tower allowing slightly wider road and facilitating wind ventilation.

3.4.3.9 Zone 6 – GIC site at NW: The annual SAVR for Single Tower design scheme is 0.20 while the annual SAVR for Twin Tower design scheme is 0.18. Most of the directional SAVRs are of similar magnitude. Decrease and increase were also

observed. Decrease under SE wind direction is due to more streamlined flow in Single Tower design scheme allowing more flow to further area while under ENE wind direction, increase is because of deflected wind from CEN facilitated downwash at Tower A of the proposed development.

3.4.3.10 In summary, significant air ventilation problem due to the proposed development is not anticipated with reference to the assessment results. The annual SAVR are of similar magnitude between schemes. In general, the ventilation is fairly similar. The building separation in Twin Tower design scheme provides ventilation improvement at certain wind directions. The Twin Tower design scheme is desirable under some wind directions and the separation between towers brings some advantages to the stagnate area, meanwhile in consideration of the potential obstruction of long facade along waterfront, the ease of access to the landscaped garden by patients and wind comfort of landscaped garden, and the alignment with future development of CEN and NAH buildings, the Twin Tower design scheme is more preferable.

3.4.3.11 According to the assessment findings, it is clear that the permeable area (i.e. the headroom under link bridges) at Site A buildings and Site C should be well aligned in order to maximise the wind penetration of the area. At this stage, this scheme is a conceptual design. In future design stage of the proposed development, further design improvement on air ventilation performance and optimum design regarding the building separation and building setback will be reviewed by the design and build contractor and an Air Ventilation Assessment will be required to demonstrate the design performance.

4 Conclusion

4.1.1.1 This AVA study investigated the pedestrian wind environment and provided the necessary information for a balanced decision on the overall planning and design process. It also identifies the ventilation corridors/ air paths and wind availability in the assessment area.

4.1.1.2 The proposed development is located in the South Apron of Kai Tak Development. The Site is situated on the south-western side of the planned Road D4, which is a planned district distributor connecting the future Runway Precinct with the Kowloon Bay waterfront. The Site is currently a vacant government land with no ground structure.

4.1.1.3 There are two conceptual design schemes being reviewed in this study. All schemes complied with statutory requirements. From the urban planning point of view, the long facade of Single Tower design facing the harbour front is not desirable. It is proposed to be two individual towers with building separation of about 40m apart between towers. An Initial Study was carried out to study the air ventilation performance in both schemes.

4.1.1.4 According to the wind rose data in the AVA Study Report for Kai Tak Planning Review, 23.0% of the site approaching wind would be from ESE. On the other hand, about 16.2% and 15% of wind will be from E and NE quarter (i.e. NNE and NE), respectively.

4.1.1.5 In the Single Tower design scheme, the annual SVR is 0.15 while the annual LVR is 0.17. In the Twin Tower design scheme, the annual SVR and LVR are 0.13 and 0.16 respectively. The annual directional SAVRs at the areas of interest are of similar magnitude. Although there is a building separation in the Twin Tower design scheme, there seems no major change in the VRs. This is because the building separation of Twin Tower design scheme does not align with the major wind directions due to the site constraint. Significant increase in VR was not observed. However the building separation demonstrates its role as a wind pathway under E, NNE, N and WSW as shown in Appendix C.

4.1.1.6 With reference to the assessment findings, no significant air ventilation problem due to the proposed development is anticipated. Substantial differences between schemes are also not anticipated in terms of ventilation performance. In consideration of the potential obstruction of long facade along waterfront in Single Tower design scheme, the ease of access to the landscaped garden by patients and wind comfort of landscaped garden and the alignment with future development of CEN and NAH buildings, the Twin Tower design scheme is more preferable.

4.1.1.7 The current scheme is only a conceptual design. In future design stage of the proposed development, further design improvement on air ventilation performance optimum design regarding the building separation and building setback will be

reviewed by the design and build contractor and subsequently an Air Ventilation Assessment will be required.

5 References

1. Housing, Planning and Lands Bureau Technical Circular No. 1/06, Environment, Transport and Work Bureau Technical Circular No. 1/06 for Air Ventilation Assessments

2. Technical Note 4 of Kai Tak Development Comprehensive Planning and Engineering - Stage 1 Planning Review, 2007

3. Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment Services (PLNQ 35/2009) for the Proposed Amendments to Ngau Tau Kok and Kowloon Bay Outline Zoning Plan – Final, Planning Department, November 2010

4. Summary of Meteorological and Tidal Observations in Hong Kong, Hong Kong Observatory, 2009

5. AWES-QAM-1-2001, Wind Engineering Studies of Buildings

6. AS/NZS 1170.2-2000, Australian New Zealand Standard, SAA Loading Code Part 2: Wind loads

7. American Institute of Aeronautics and Astronautics, Guide for the Verification and Validation of Computational Fluid Dynamics Simulations. G-077-1998, 1998

8. Fluent, Biography of Fluent User Guide 6.1, 2003

Figures

Establishment of Centre of Excellence in Paediatrics in Kai Tak Developmemt (Programme Nos.: 76MM)

Air Ventilation Assessment Report

Site Location and Its Environs

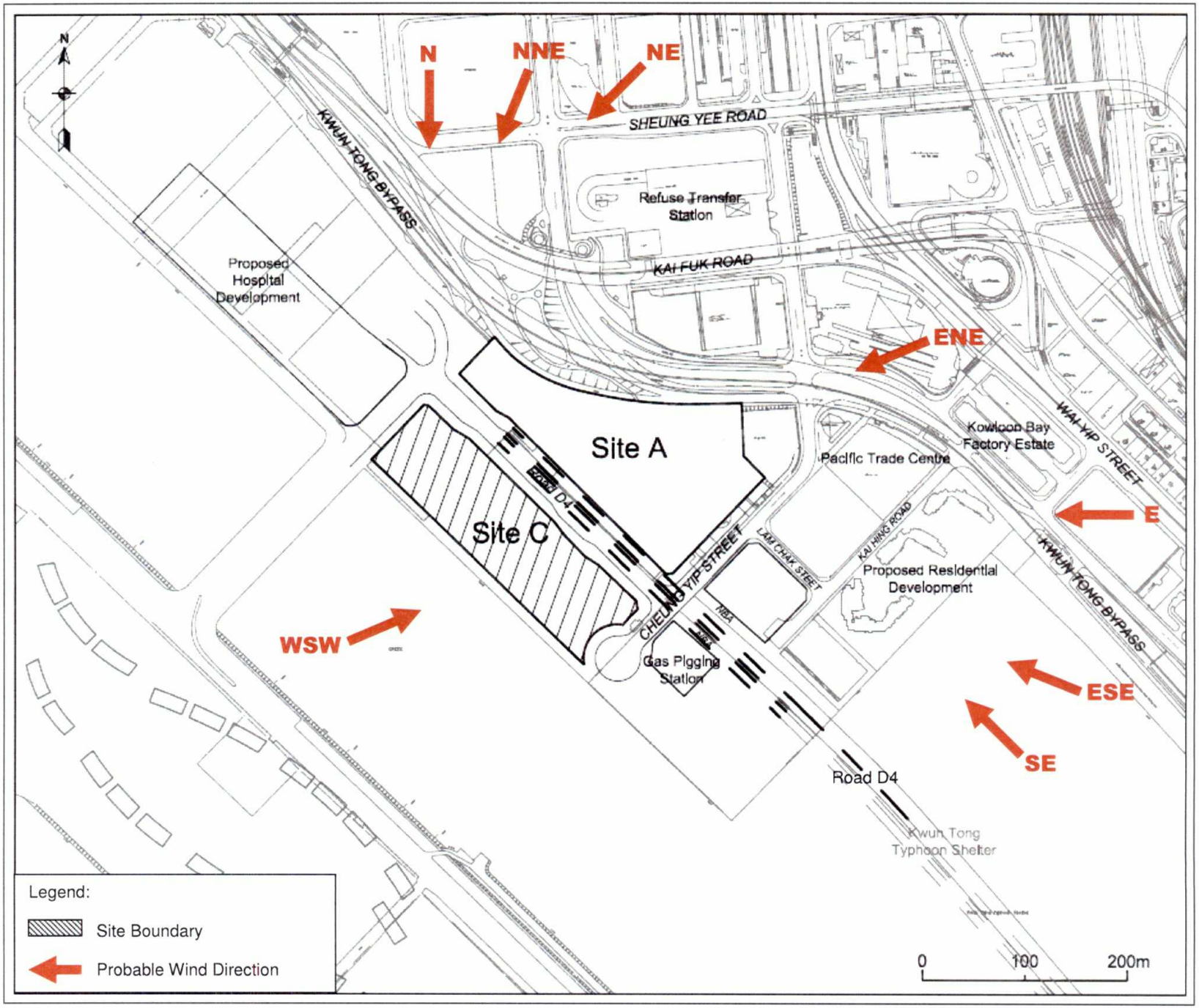
Figure 1.1

Scale: NTS

Date: February 2012

Rev.: 1

BMT Asia Pacific

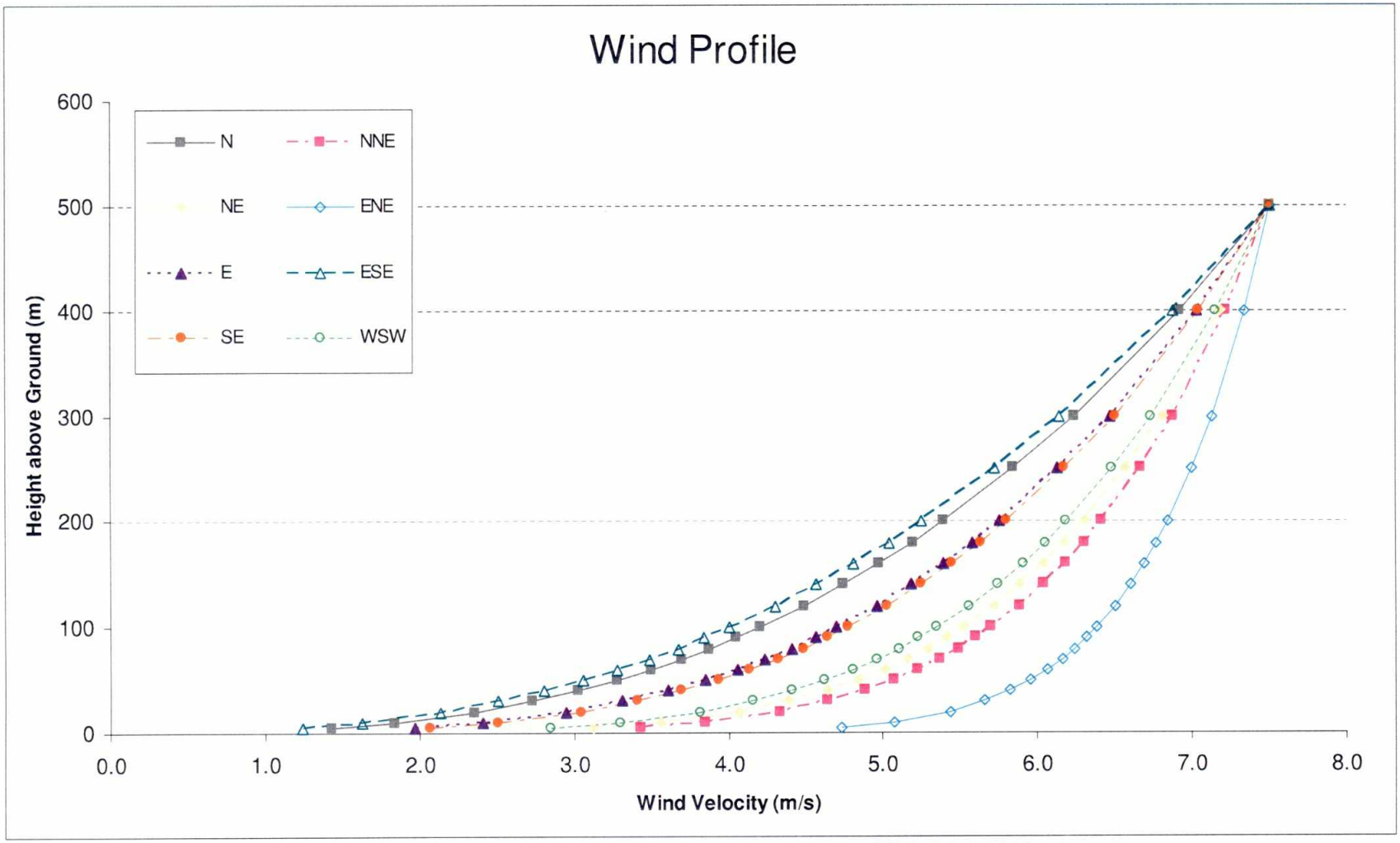


Establishment of Centre of Excellence in Paediatrics in Kai Tak Developmemt (Programme Nos.: 76MM)

Air Ventilation Assessment Report

Wind Profile for Initial Study

Figure 3.1



Reference: Technical Note 4 of Kai Tak Development Comprehensive Planning and Engineering - Stage 1 Planning Review, 2007 (AVA Study for Kai Tak Development)

Scale: NTS

Date: February 2012

Rev.: 1

BMT Asia Pacific

Establishment of Centre of Excellence in Paediatrics in Kai Tak Developmemt (Programme Nos.: 76MM)

Air Ventilation Assessment Report

CFD Model of Bounding Surfaces

Figure 3.2

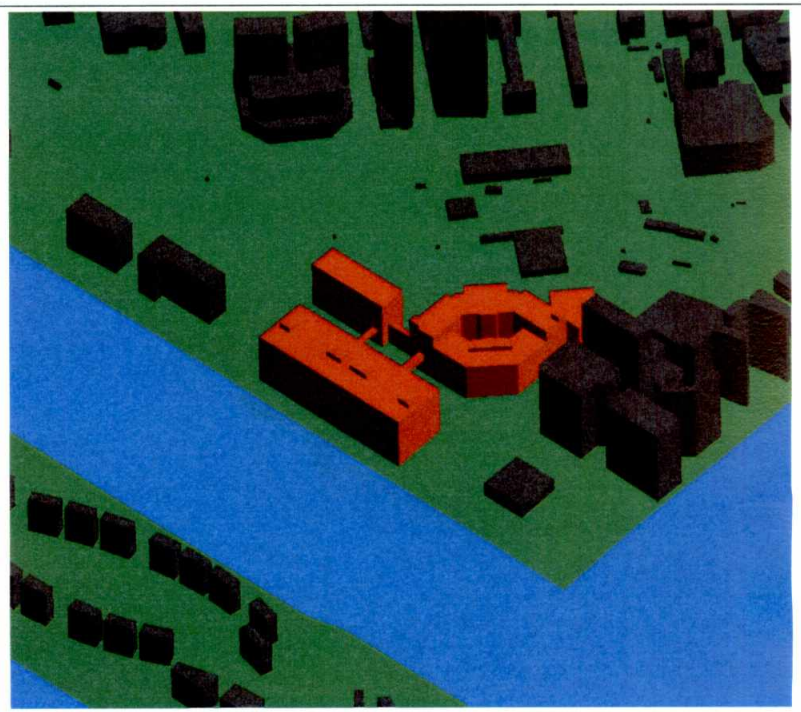
Scale: NTS

Date: February 2012

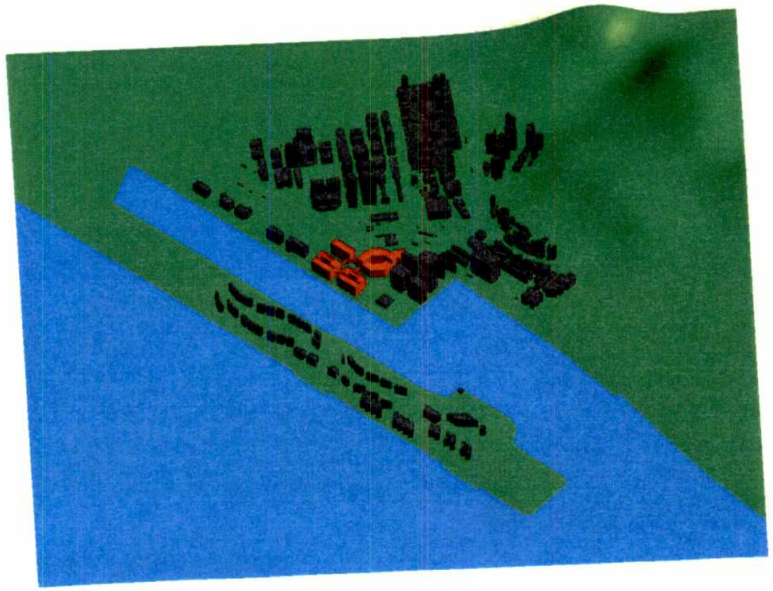
Rev.: 1

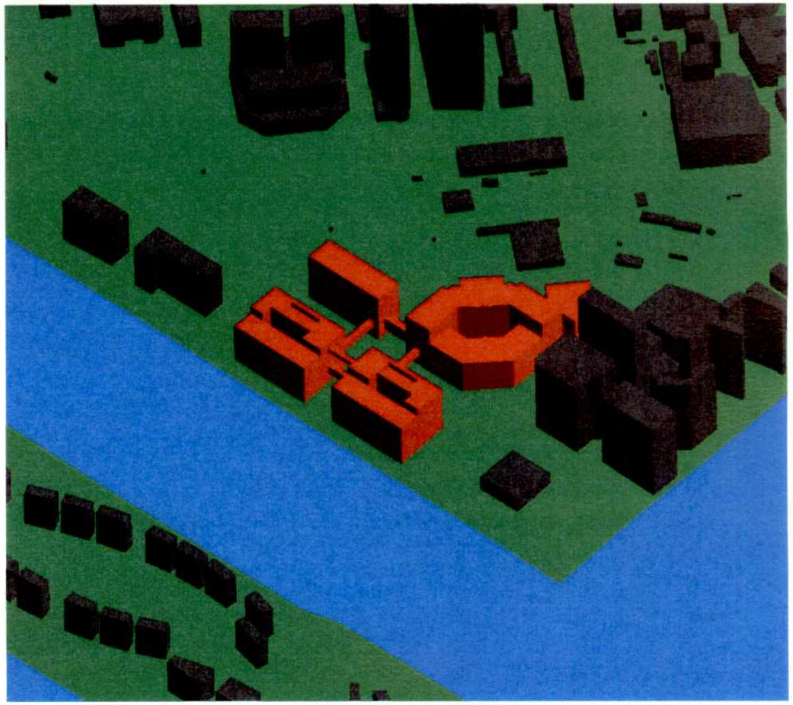
BMT Asia Pacific

Single Tower Scheme



Twin Tower Scheme





Establishment of Centre of Excellence in Paediatrics in Kai Tak Development (Programme Nos.: 76MM)

Air Ventilation Assessment Report

Grid Arrangement for the CFD Model

Figure 3.3

Scale: NTS

Date: February 2012

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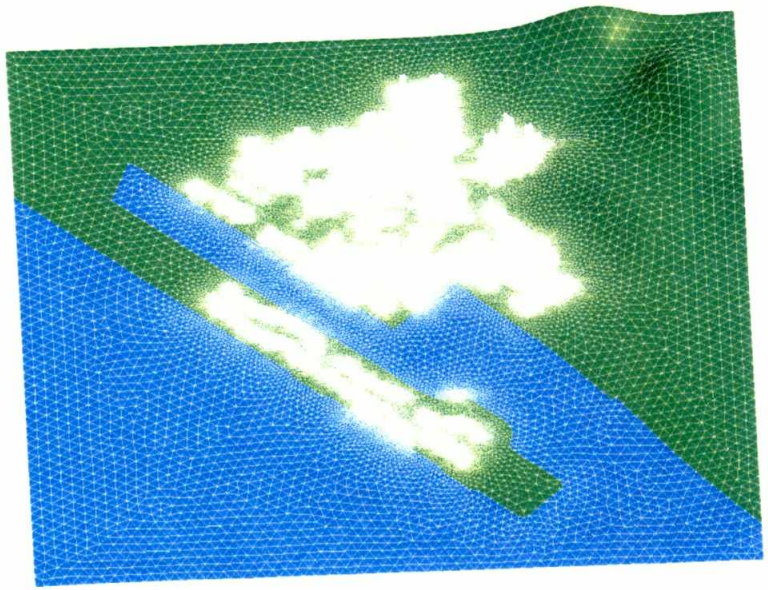
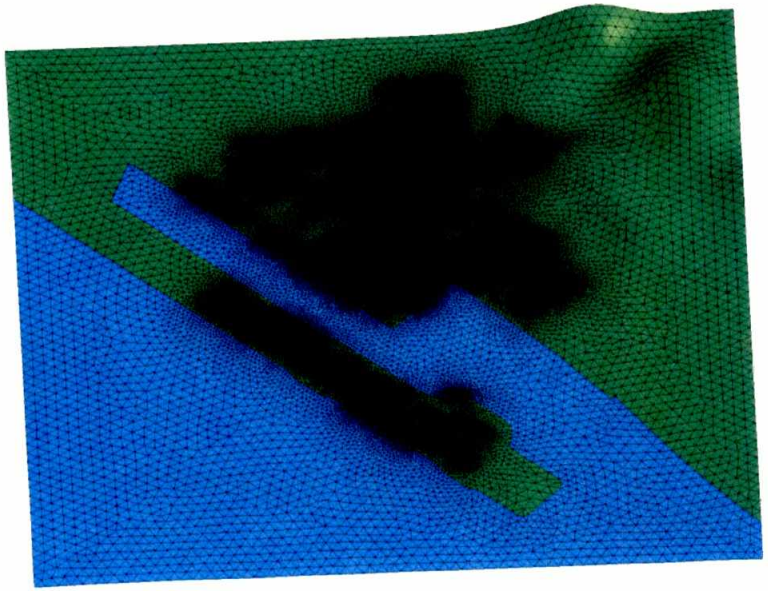
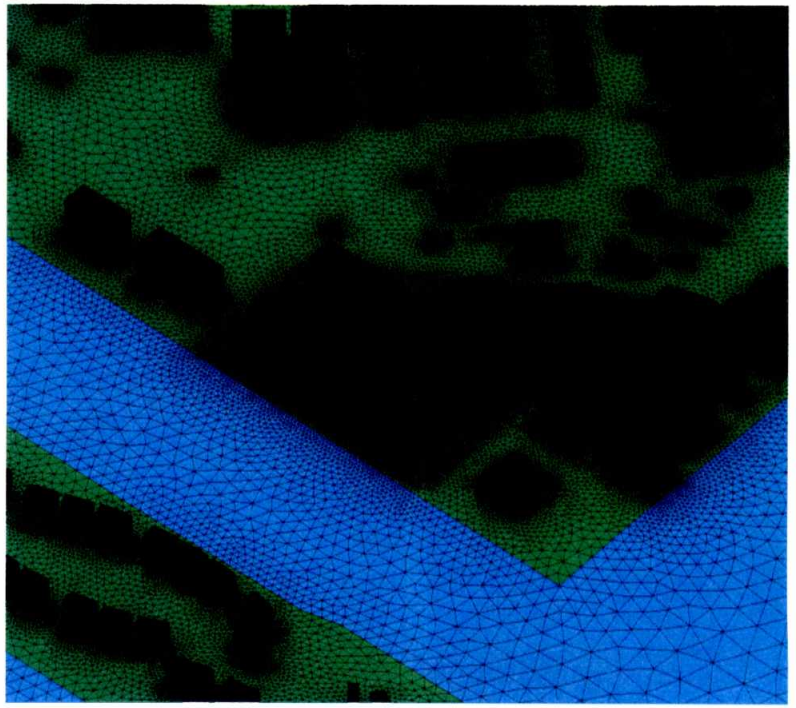
Single Tower Scheme



Twin Tower Scheme





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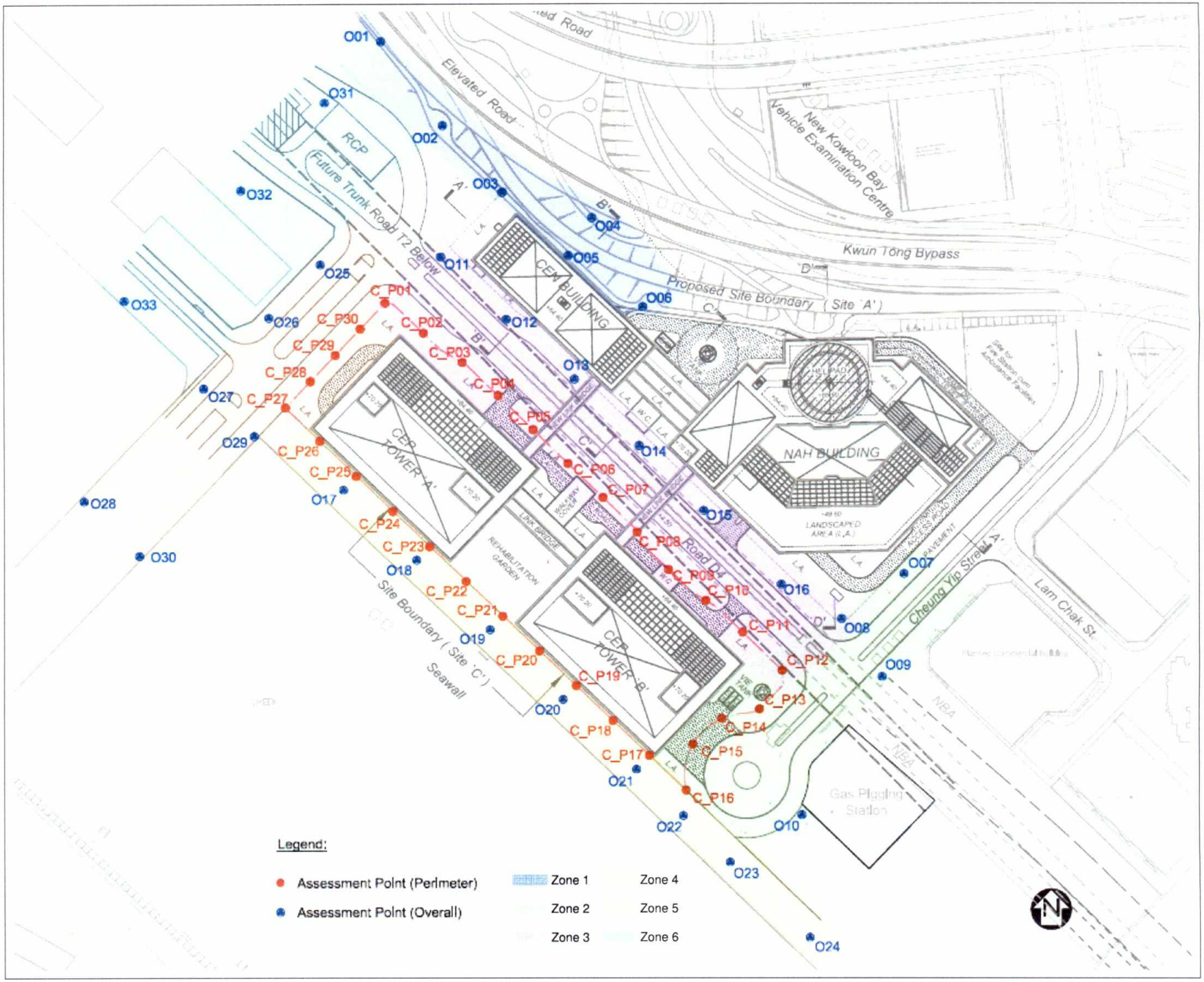
Air Ventilation Assessment Report

Location of Assessment Points

Figure 3.4



Scale: NTS

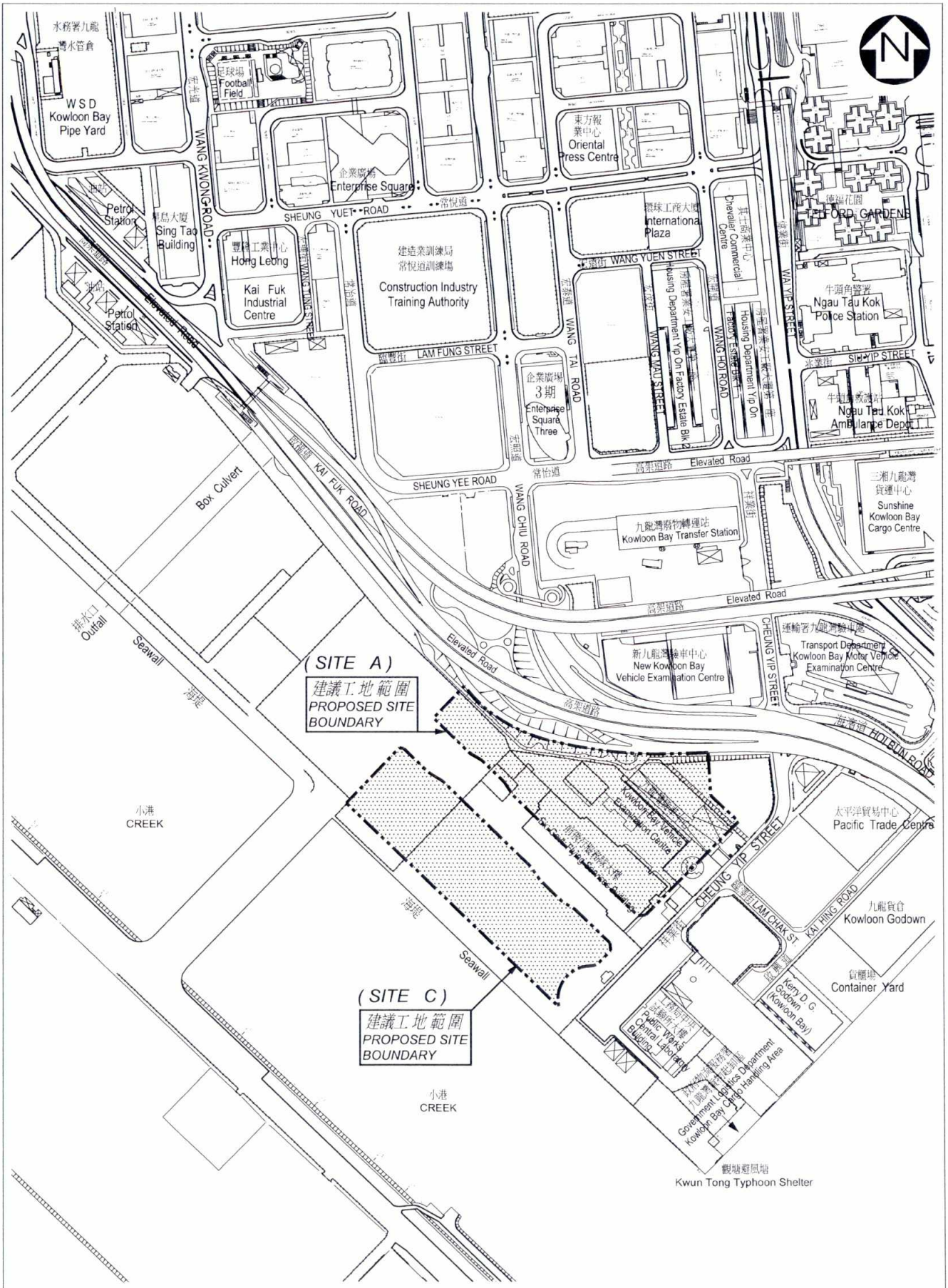
Date: February 2012

Rev.: 1

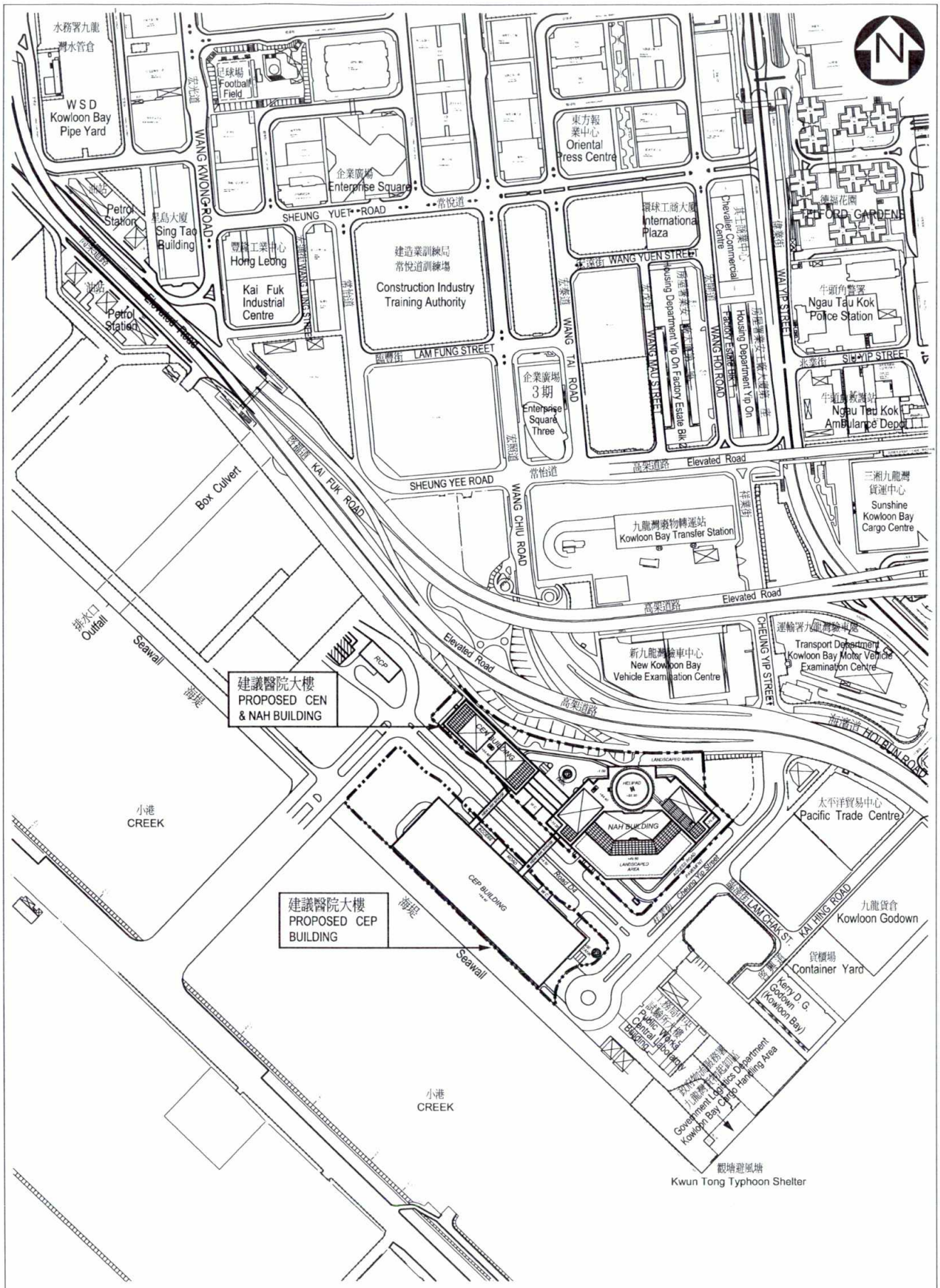
BMT Asia Pacific

Appendix A

Development Scheme



PWP NO. 076MM & 077MM ESTABLISHMENT OF CENTRE OF EXCELLENCE IN PAEDIATRICS & NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT SITE LOCATION PLAN	drawn by 繪圖	date 日期 2/2012	drawing no. 圖則編號 AVA/SK-001	scale 比例 1:5 000
	approved 覆核	date 日期 2/2012		
	office 辦事處 PROJECT MANAGEMENT BRANCH 工程策劃管理處		ARCHITECTURAL SERVICES DEPARTMENT 建築署	



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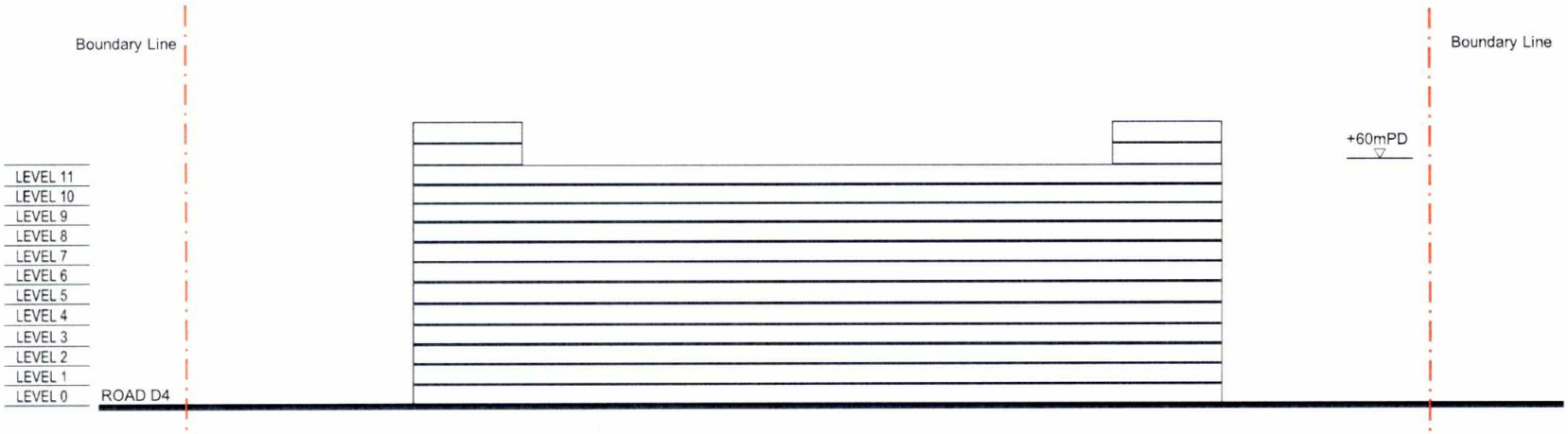
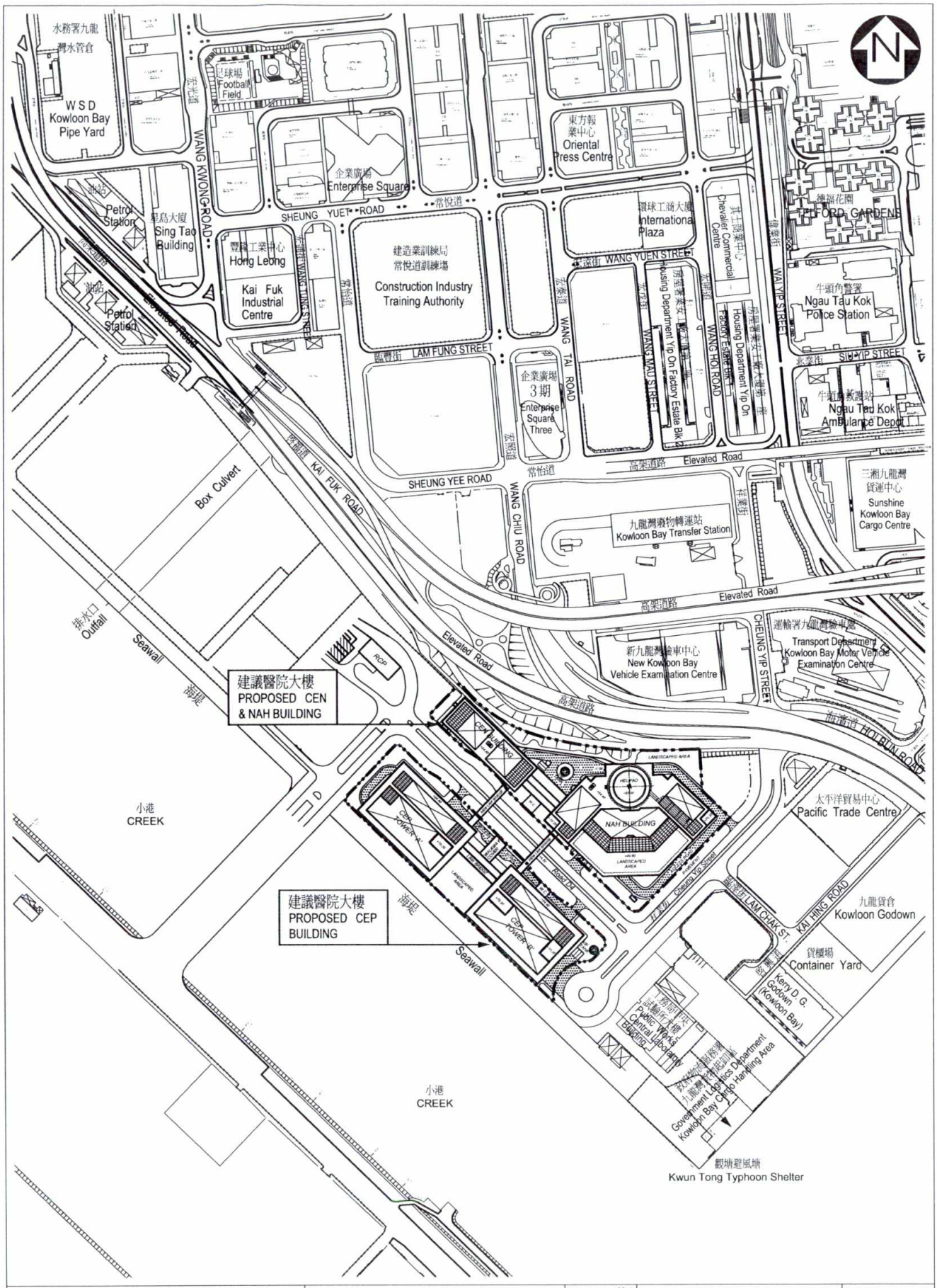
	approved 覆核	date 日期 9/2011	ARCHITECTURAL SERVICES DEPARTMENT 建築署	
	office 辦事處 PROJECT MANAGEMENT BRANCH 工程策劃管理處			


Boundary Line
Boundary Line
+60mPD
LEVEL 11
LEVEL 10
LEVEL 9
LEVEL 8
LEVEL 7
LEVEL 6
LEVEL 5
LEVEL 4
LEVEL 3
LEVEL 2
LEVEL 1
LEVEL 0
ROAD D4



PWP NO. *077MM* *ESTABLISHMENT OF CENTRE OF EXCELLENCE IN NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT* *BLOCK PLAN*	drawn by 繪圖	date 日期 *9/2011*	drawing no. 圖則編號 *8010/Xa002*	scale 比例 *1:5 000*
	approved 覆核	date 日期 *9/2011*		
	office 辦事處 PROJECT MANAGEMENT BRANCH 工程策劃管理處		ARCHITECTURAL SERVICES DEPARTMENT 建築署	

PWP NO. 076MM & 077MM

ESTABLISHMENT OF CENTRE OF EXCELLENCE IN PAEDIATRICS & NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT

SITE PLAN

drawn by 繪圖

approved 覆核

office 辦事處

PROJECT MANAGEMENT BRANCH 工程策劃管理處

date 日期 2/2012

date 日期 2/2012

drawing no. 圖則編號 AVA/SK-002

scale 比例 1:2000

ARCHITECTURAL SERVICES DEPARTMENT 建築署

宏照道

高架道路

新九龍灣驗車中心
New Kowloon Bay Vehicle Examination Centre

Kwun Tong Bypass

Elevated Road

高架道路

Elevated Road

Site for Fire Station cum Ambulance Facilities

RAMP ON TO LEV -1

+70.20

+64.40

HELIPAD +65.90

NAH BUILDING

+49.60 LANDSCAPED AREA (L.A.)

ACCESS ROAD

PAVEMENT

Cheung Yip Street 祥業街

`A' 臨澤街 Lam Chak St.

`D'

`A'

`B'

`C'

Proposed Site Boundary (Site `A')

E/O

VIE TANK

CEN BUILDING

+64.40

L.A.

W.C.

+70.20

RCP

Future Trunk Road T2 Below

NEW LINK BRIDGE

+4.50

Road D4

ACCESS ROAD

WALKWAY COVER

LINK BRIDGE

CEP TOWER `A'

CEP TOWER `B'

LANDSCAPE GARDEN

`E'

Site Boundary (Site `C')

海堤 Seawall

`B'

`C'

N

PWP NO. 076MM & 077MM

ESTABLISHMENT OF CENTRE OF EXCELLENCE IN PAEDIATRICS & NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT

SECTION `A'-`A' & `B'-`B'

drawn by 繪圖

approved 覆核

office 辦事處

PROJECT MANAGEMENT BRANCH 工程策劃管理處

date 日期 2/2012

date 日期 2/2012

drawing no. 圖則編號 AVA/SK-003

scale 比例 1:1500

ARCHITECTURAL SERVICES DEPARTMENT 建築署

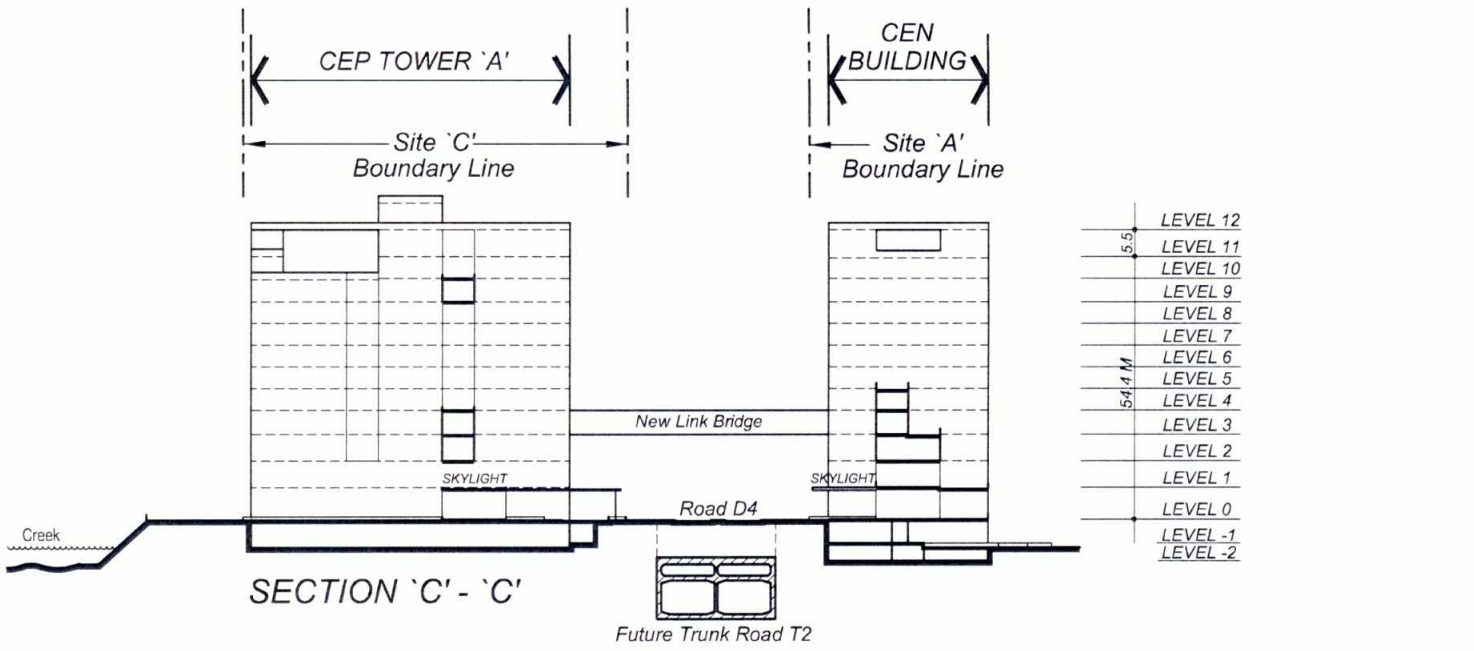
SECTION `A' - `A'

SECTION `B' - `B'

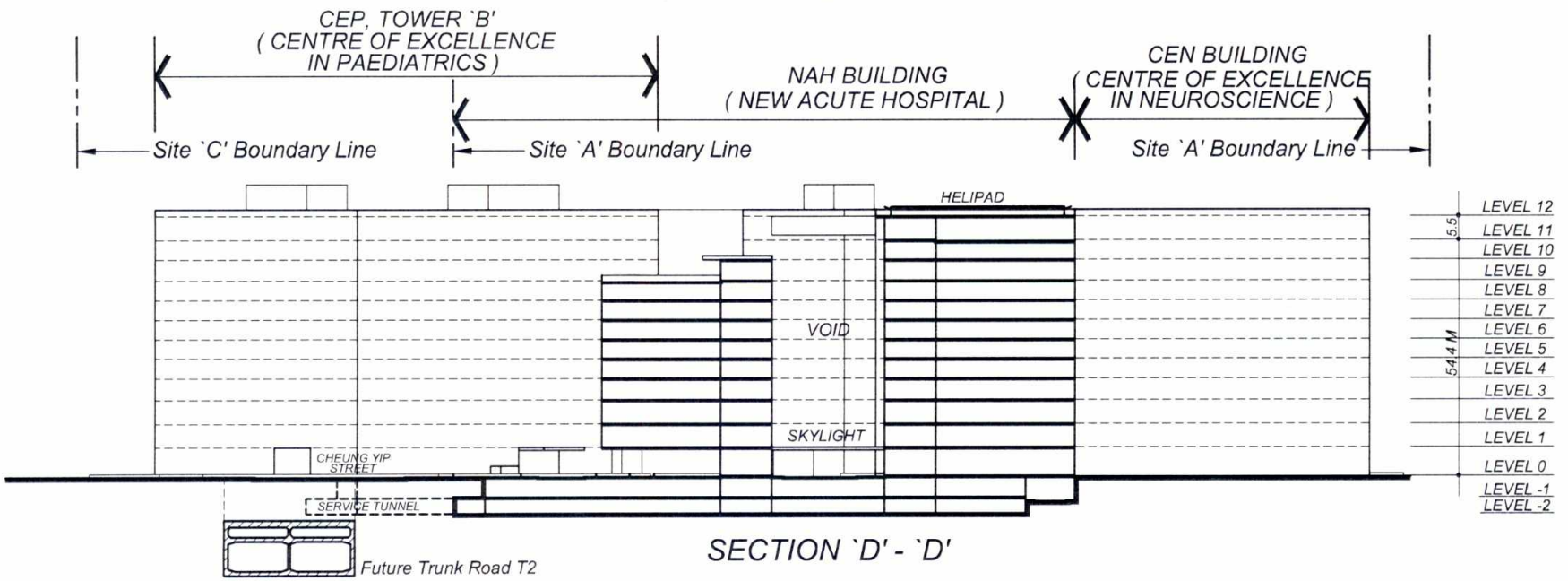
PWP NO. 076MM & 077MM

ESTABLISHMENT OF CENTRE OF EXCELLENCE IN PAEDIATRICS & NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT

SECTION `C'-`C' & `D'-`D'



SECTION `C' - `C'



SECTION `D' - `D'

drawn by 繪圖

approved 覆核

office 辦事處

PROJECT MANAGEMENT BRANCH 工程策劃管理處

date 日期 2/2012

date 日期 2/2012

drawing no. 圖則編號 AVASK-004

scale 比例 1:1500

ARCHITECTURAL SERVICES DEPARTMENT 建築署

SECTION `E' - `E'

PWP NO. 076MM & 077MM

ESTABLISHMENT OF CENTRE OF EXCELLENCE IN PAEDIATRICS & NEUROSCIENCE AND A NEW ACUTE HOSPITAL IN KAI TAK DEVELOPMENT

SECTION `E' - `E'

drawn by 繪圖

approved 覆核

office 辦事處 PROJECT MANAGEMENT BRANCH 工程策劃管理處

date 日期 2/2012

date 日期 2/2012

drawing no. 圖則編號 AVA/SK-005

scale 比例 1:1500

ARCHITECTURAL SERVICES DEPARTMENT 建築署

Appendix B

Velocity Ratios

APPENDIX B: Velocity Ratios

Table B1 Single Tower: Velocity Ratios at the Assessment Points

Assessment Points	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
LVR									
O01	0.18	0.19	0.24	0.27	0.23	0.39	0.33	0.27	0.28
O02	0.22	0.27	0.39	0.42	0.31	0.43	0.24	0.10	0.33
O03	0.30	0.42	0.45	0.47	0.33	0.42	0.23	0.08	0.36
O04	0.20	0.23	0.25	0.06	0.24	0.30	0.12	0.08	0.22
O05	0.22	0.29	0.24	0.14	0.24	0.24	0.15	0.17	0.22
O06	0.11	0.07	0.03	0.33	0.13	0.12	0.08	0.14	0.12
O07	0.20	0.45	0.16	0.39	0.24	0.10	0.11	0.36	0.22
O08	0.07	0.21	0.23	0.39	0.14	0.09	0.35	0.42	0.19
O09	0.20	0.37	0.28	0.44	0.15	0.07	0.42	0.31	0.22
O10	0.15	0.17	0.06	0.26	0.04	0.07	0.10	0.20	0.11
O11	0.17	0.12	0.11	0.13	0.17	0.08	0.12	0.52	0.15
O12	0.09	0.10	0.03	0.16	0.14	0.04	0.17	0.46	0.12
O13	0.08	0.01	0.19	0.25	0.10	0.02	0.21	0.20	0.10
O14	0.13	0.17	0.28	0.23	0.19	0.07	0.24	0.02	0.15
O15	0.18	0.15	0.30	0.31	0.17	0.06	0.19	0.17	0.16
O16	0.15	0.09	0.10	0.15	0.20	0.09	0.19	0.34	0.15
O17	0.01	0.03	0.01	0.15	0.14	0.21	0.30	0.11	0.14
O18	0.02	0.09	0.05	0.13	0.09	0.19	0.27	0.26	0.14
O19	0.03	0.05	0.05	0.15	0.09	0.20	0.27	0.34	0.15
O20	0.07	0.04	0.05	0.10	0.12	0.26	0.29	0.42	0.17
O21	0.08	0.14	0.34	0.27	0.17	0.28	0.42	0.53	0.26
O22	0.06	0.33	0.23	0.37	0.12	0.25	0.29	0.50	0.25
O23	0.08	0.29	0.07	0.18	0.06	0.19	0.01	0.45	0.16
O24	0.09	0.09	0.33	0.38	0.09	0.37	0.35	0.44	0.26
O25	0.38	0.26	0.25	0.46	0.04	0.13	0.07	0.21	0.18
O26	0.13	0.10	0.17	0.06	0.07	0.10	0.08	0.63	0.13
O27	0.20	0.08	0.07	0.17	0.18	0.22	0.35	0.31	0.19
O28	0.08	0.08	0.23	0.25	0.21	0.33	0.32	0.32	0.24
O29	0.16	0.04	0.10	0.20	0.18	0.23	0.36	0.27	0.19
O30	0.09	0.06	0.28	0.31	0.16	0.35	0.30	0.28	0.24

Assessment Points	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
O31	0.14	0.19	0.37	0.29	0.21	0.36	0.23	0.22	0.27
O32	0.34	0.08	0.09	0.36	0.12	0.10	0.11	0.19	0.14
O33	0.15	0.06	0.17	0.24	0.19	0.19	0.33	0.23	0.19
SVR									
C_P01	0.36	0.17	0.22	0.14	0.14	0.12	0.17	0.62	0.19
C_P02	0.28	0.14	0.13	0.19	0.17	0.10	0.15	0.49	0.17
C_P03	0.29	0.13	0.14	0.16	0.13	0.07	0.16	0.39	0.15
C_P04	0.06	0.04	0.07	0.21	0.06	0.04	0.19	0.19	0.08
C_P05	0.18	0.02	0.12	0.30	0.16	0.03	0.21	0.22	0.12
C_P06	0.10	0.06	0.19	0.23	0.11	0.05	0.20	0.21	0.11
C_P07	0.13	0.18	0.25	0.14	0.15	0.06	0.24	0.15	0.14
C_P08	0.15	0.17	0.28	0.19	0.14	0.02	0.12	0.07	0.11
C_P09	0.15	0.17	0.27	0.24	0.11	0.05	0.12	0.07	0.12
C_P10	0.13	0.12	0.11	0.19	0.17	0.07	0.12	0.24	0.13
C_P11	0.16	0.06	0.08	0.26	0.19	0.13	0.36	0.09	0.16
C_P12	0.16	0.22	0.19	0.38	0.17	0.04	0.29	0.31	0.17
C_P13	0.14	0.37	0.19	0.42	0.08	0.05	0.31	0.33	0.18
C_P14	0.02	0.21	0.26	0.37	0.09	0.09	0.33	0.05	0.15
C_P15	0.05	0.26	0.29	0.38	0.16	0.17	0.35	0.51	0.23
C_P16	0.05	0.33	0.24	0.37	0.12	0.25	0.29	0.51	0.25
C_P17	0.07	0.15	0.34	0.31	0.17	0.26	0.39	0.54	0.25
C_P18	0.08	0.03	0.02	0.07	0.15	0.31	0.40	0.50	0.21
C_P19	0.07	0.03	0.05	0.08	0.12	0.22	0.26	0.43	0.16
C_P20	0.06	0.03	0.06	0.10	0.09	0.18	0.25	0.39	0.14
C_P21	0.03	0.05	0.04	0.12	0.08	0.17	0.24	0.35	0.13
C_P22	0.02	0.09	0.04	0.12	0.07	0.16	0.25	0.31	0.13
C_P23	0.01	0.10	0.04	0.12	0.08	0.17	0.26	0.27	0.13
C_P24	0.01	0.10	0.03	0.12	0.08	0.16	0.26	0.21	0.13
C_P25	0.02	0.01	0.03	0.14	0.11	0.18	0.27	0.12	0.12
C_P26	0.04	0.09	0.04	0.16	0.17	0.21	0.29	0.16	0.16
C_P27	0.19	0.02	0.04	0.28	0.14	0.18	0.14	0.34	0.16
C_P28	0.15	0.04	0.02	0.28	0.10	0.11	0.06	0.35	0.12
C_P29	0.14	0.18	0.03	0.21	0.06	0.09	0.13	0.51	0.14
C_P30	0.13	0.21	0.05	0.06	0.10	0.11	0.07	0.52	0.14

Table B2 Twin Tower: Velocity Ratios at the Assessment Points

Assessment Points	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
LVR									
O01	0.23	0.16	0.30	0.40	0.23	0.45	0.32	0.25	0.31
O02	0.27	0.25	0.39	0.50	0.29	0.48	0.23	0.28	0.36
O03	0.26	0.38	0.42	0.45	0.34	0.47	0.16	0.59	0.39
O04	0.17	0.22	0.26	0.14	0.23	0.36	0.07	0.11	0.24
O05	0.21	0.26	0.27	0.17	0.24	0.26	0.12	0.02	0.22
O06	0.09	0.07	0.10	0.35	0.14	0.17	0.07	0.02	0.14
O07	0.21	0.44	0.24	0.39	0.31	0.06	0.14	0.39	0.24
O08	0.07	0.19	0.15	0.20	0.08	0.12	0.37	0.40	0.17
O09	0.24	0.38	0.14	0.38	0.31	0.12	0.46	0.30	0.26
O10	0.28	0.11	0.06	0.25	0.18	0.09	0.11	0.17	0.14
O11	0.18	0.14	0.11	0.13	0.28	0.16	0.02	0.56	0.19
O12	0.12	0.08	0.08	0.08	0.20	0.08	0.09	0.17	0.11
O13	0.09	0.09	0.06	0.04	0.05	0.12	0.12	0.36	0.11
O14	0.12	0.25	0.21	0.06	0.21	0.16	0.23	0.12	0.18
O15	0.04	0.16	0.33	0.33	0.12	0.06	0.12	0.15	0.13
O16	0.08	0.12	0.23	0.29	0.12	0.07	0.15	0.40	0.14
O17	0.06	0.02	0.13	0.09	0.08	0.09	0.13	0.26	0.09
O18	0.06	0.04	0.21	0.11	0.04	0.05	0.14	0.40	0.09
O19	0.14	0.04	0.26	0.08	0.13	0.12	0.09	0.32	0.13
O20	0.02	0.07	0.15	0.08	0.05	0.14	0.14	0.38	0.12
O21	0.04	0.12	0.34	0.11	0.07	0.21	0.40	0.50	0.19
O22	0.03	0.28	0.14	0.18	0.08	0.23	0.27	0.47	0.20
O23	0.17	0.27	0.01	0.16	0.09	0.20	0.08	0.42	0.17
O24	0.12	0.08	0.28	0.27	0.09	0.33	0.34	0.41	0.23
O25	0.39	0.27	0.07	0.59	0.23	0.10	0.04	0.22	0.21
O26	0.06	0.07	0.15	0.31	0.07	0.06	0.07	0.58	0.12
O27	0.11	0.07	0.10	0.34	0.15	0.17	0.22	0.28	0.17
O28	0.03	0.12	0.19	0.27	0.13	0.25	0.30	0.29	0.20
O29	0.15	0.18	0.11	0.18	0.14	0.16	0.22	0.23	0.17
O30	0.13	0.10	0.24	0.31	0.12	0.25	0.30	0.30	0.21

Assessment Points	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
O31	0.07	0.17	0.40	0.41	0.16	0.28	0.21	0.23	0.24
O32	0.37	0.10	0.08	0.36	0.11	0.10	0.00	0.15	0.13
O33	0.16	0.06	0.11	0.32	0.17	0.18	0.16	0.21	0.17
SVR									
C_P01	0.29	0.11	0.10	0.11	0.30	0.32	0.16	0.59	0.26
C_P02	0.01	0.01	0.06	0.09	0.19	0.34	0.16	0.02	0.17
C_P03	0.20	0.06	0.14	0.16	0.18	0.13	0.15	0.13	0.14
C_P04	0.12	0.03	0.24	0.21	0.09	0.12	0.17	0.18	0.12
C_P05	0.20	0.03	0.25	0.16	0.16	0.06	0.18	0.06	0.12
C_P06	0.20	0.33	0.23	0.22	0.04	0.17	0.19	0.45	0.19
C_P07	0.19	0.13	0.28	0.19	0.13	0.09	0.23	0.44	0.16
C_P08	0.17	0.17	0.29	0.19	0.04	0.05	0.12	0.08	0.11
C_P09	0.13	0.17	0.26	0.24	0.07	0.04	0.11	0.13	0.11
C_P10	0.11	0.12	0.10	0.21	0.11	0.06	0.12	0.11	0.10
C_P11	0.10	0.09	0.20	0.27	0.11	0.05	0.27	0.12	0.12
C_P12	0.11	0.17	0.09	0.24	0.08	0.13	0.25	0.39	0.16
C_P13	0.09	0.34	0.18	0.12	0.09	0.13	0.28	0.30	0.17
C_P14	0.01	0.15	0.20	0.05	0.08	0.13	0.28	0.11	0.13
C_P15	0.04	0.16	0.22	0.04	0.10	0.14	0.33	0.21	0.15
C_P16	0.03	0.27	0.15	0.16	0.08	0.22	0.29	0.48	0.20
C_P17	0.03	0.14	0.30	0.11	0.08	0.20	0.39	0.51	0.19
C_P18	0.03	0.03	0.08	0.10	0.05	0.12	0.18	0.44	0.11
C_P19	0.02	0.05	0.11	0.07	0.04	0.12	0.13	0.39	0.10
C_P20	0.02	0.08	0.19	0.06	0.04	0.13	0.09	0.35	0.10
C_P21	0.03	0.04	0.24	0.06	0.01	0.10	0.07	0.31	0.09
C_P22	0.04	0.20	0.25	0.08	0.08	0.05	0.07	0.40	0.11
C_P23	0.05	0.04	0.21	0.10	0.03	0.05	0.13	0.42	0.09
C_P24	0.05	0.03	0.17	0.09	0.05	0.06	0.12	0.35	0.09
C_P25	0.06	0.03	0.09	0.09	0.06	0.09	0.11	0.29	0.09
C_P26	0.04	0.02	0.04	0.10	0.08	0.11	0.10	0.19	0.09
C_P27	0.14	0.20	0.00	0.27	0.11	0.15	0.07	0.21	0.14
C_P28	0.31	0.21	0.03	0.23	0.10	0.09	0.07	0.19	0.13
C_P29	0.17	0.18	0.06	0.39	0.04	0.10	0.07	0.42	0.14
C_P30	0.23	0.08	0.06	0.08	0.04	0.08	0.06	0.46	0.10

Table B3 Single Tower: Velocity Ratios at the Areas of Interest

Assessment Areas	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
Zone 1	0.21	0.24	0.27	0.28	0.25	0.32	0.19	0.14	0.26
Zone 2	0.12	0.29	0.21	0.38	0.13	0.10	0.28	0.33	0.19
Zone 3	0.16	0.12	0.17	0.22	0.15	0.06	0.20	0.27	0.14
Zone 4	0.06	0.13	0.14	0.22	0.11	0.24	0.27	0.38	0.19
Zone 5	0.18	0.11	0.13	0.22	0.13	0.18	0.19	0.40	0.17
Zone 6	0.21	0.11	0.21	0.30	0.17	0.22	0.22	0.21	0.20
LVR	0.13	0.14	0.16	0.24	0.14	0.17	0.23	0.30	0.17
SVR	0.11	0.13	0.13	0.21	0.12	0.13	0.23	0.32	0.15

Table B4 Twin Tower: Velocity Ratios at the Areas of Interest

Assessment Areas	Directional Velocity Ratio (VR)								Weighted Velocity Ratio (VRw)
	5.2%	9.9%	5.1%	5.6%	16.2%	23.0%	6.8%	4.8%	
	N	NNE	NE	ENE	E	ESE	SE	WSW	
Zone 1	0.21	0.23	0.29	0.34	0.25	0.37	0.16	0.21	0.28
Zone 2	0.12	0.25	0.16	0.20	0.15	0.13	0.28	0.31	0.18
Zone 3	0.13	0.13	0.18	0.18	0.13	0.12	0.17	0.26	0.15
Zone 4	0.08	0.12	0.19	0.14	0.08	0.17	0.20	0.40	0.15
Zone 5	0.18	0.14	0.10	0.28	0.13	0.16	0.14	0.34	0.17
Zone 6	0.20	0.11	0.20	0.36	0.15	0.19	0.13	0.20	0.18
LVR	0.13	0.14	0.18	0.20	0.13	0.16	0.17	0.30	0.16
SVR	0.11	0.12	0.16	0.15	0.09	0.12	0.16	0.29	0.13

Notes:

Zone 1 - Footpath to North

Zone 2 - Cheung Yip Street

Zone 3 - Section of Road D4

Zone 4 - Waterfront Promenade

Zone 5 - Section of Road D4 connecting to Runway

Zone 6 - GIC site to NW

Appendix C

Velocity Contour/ Vector Plots

APPENDIX C: Velocity Contour/ Vector Plots

Figure C1-1. Single Tower: Velocity Ratio Contour and Vector Plot under ESE Prevailing Wind

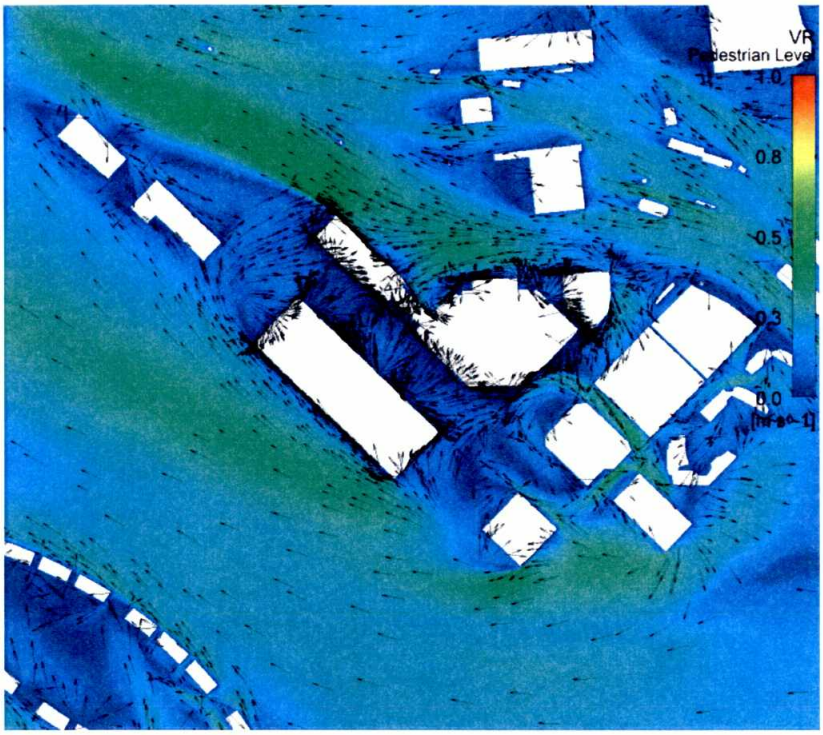


Figure C1-2. Twin Tower: Velocity Ratio Contour and Vector Plot under ESE Prevailing Wind

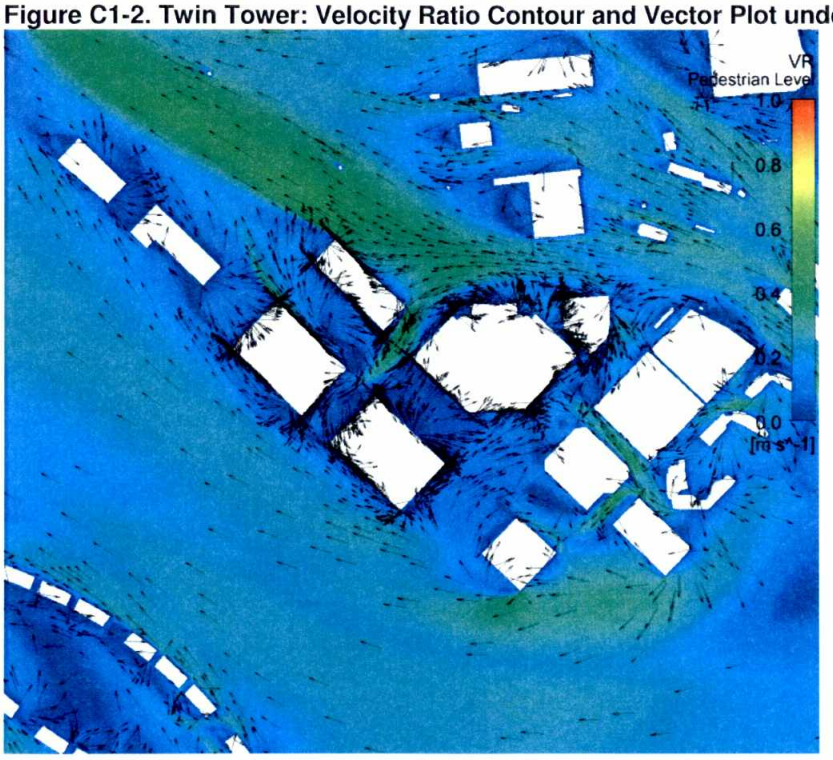


Figure C2-1. Single Tower: Velocity Ratio Contour and Vector Plot under E Prevailing Wind

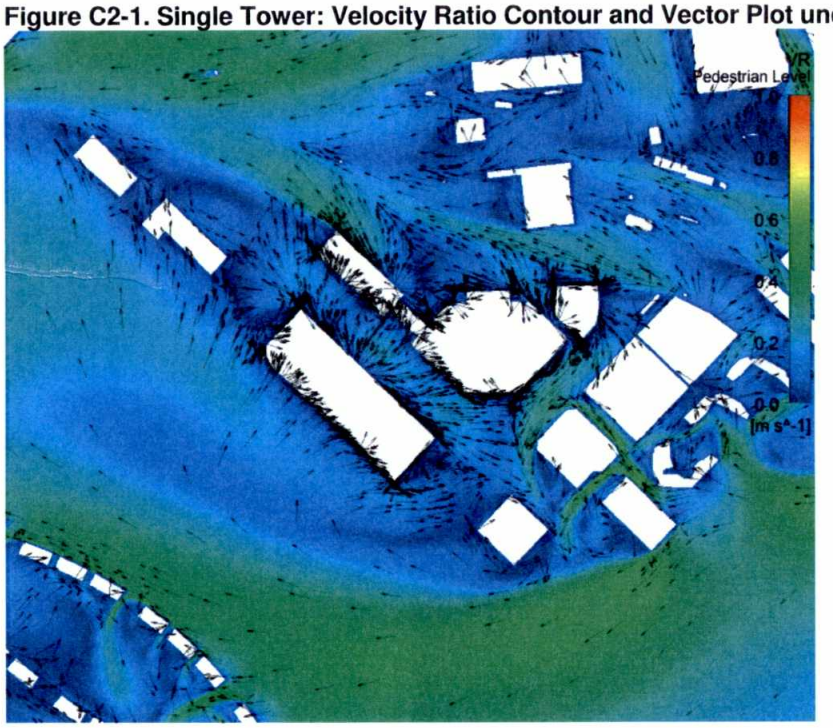


Figure C2-2. Twin Tower: Velocity Ratio Contour and Vector Plot under E Prevailing Wind

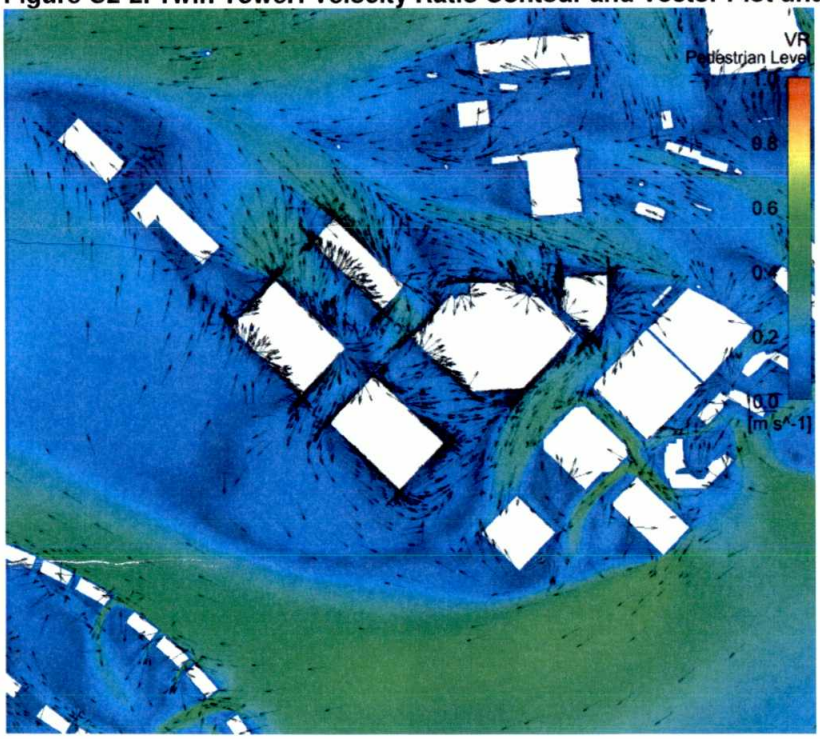


Figure C3-1. Single Tower: Velocity Ratio Contour and Vector Plot under NNE Prevailing Wind

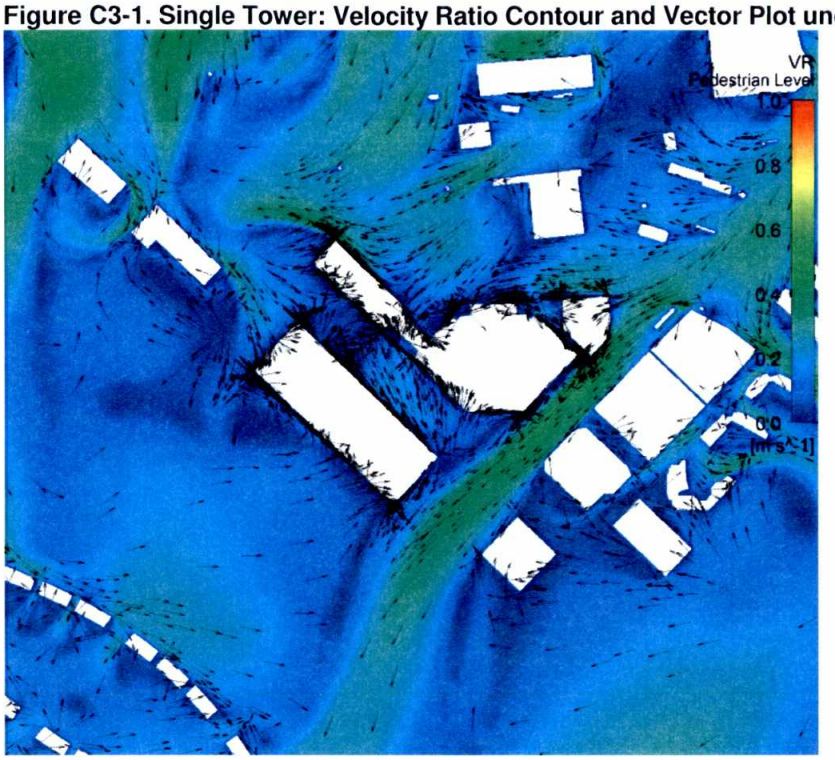


Figure C3-2. Twin Tower: Velocity Ratio Contour and Vector Plot under NNE Prevailing Wind

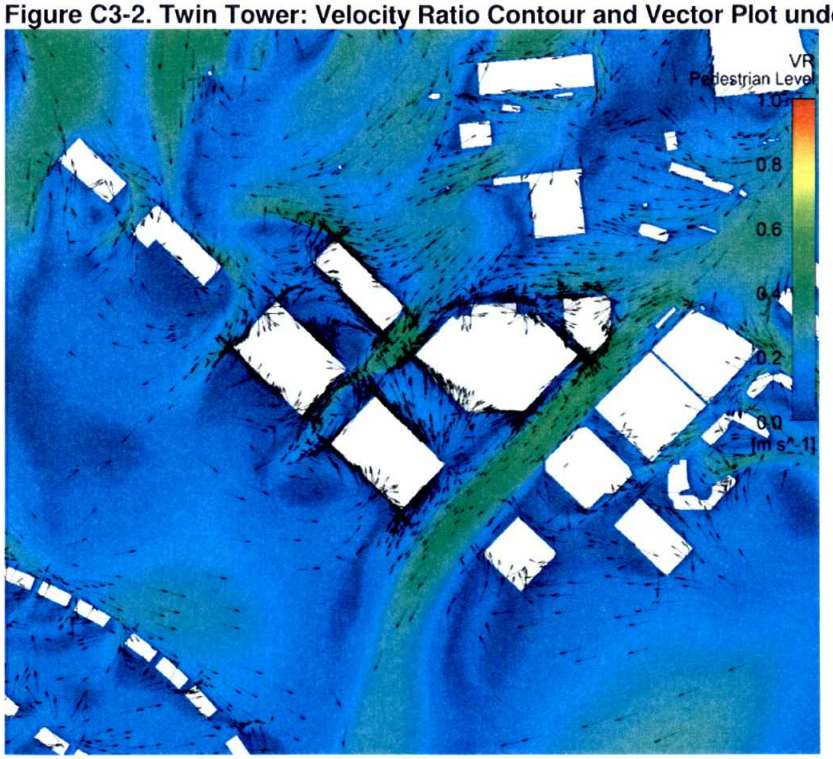


Figure C4-1. Single Tower: Velocity Ratio Contour and Vector Plot under SE Prevailing Wind

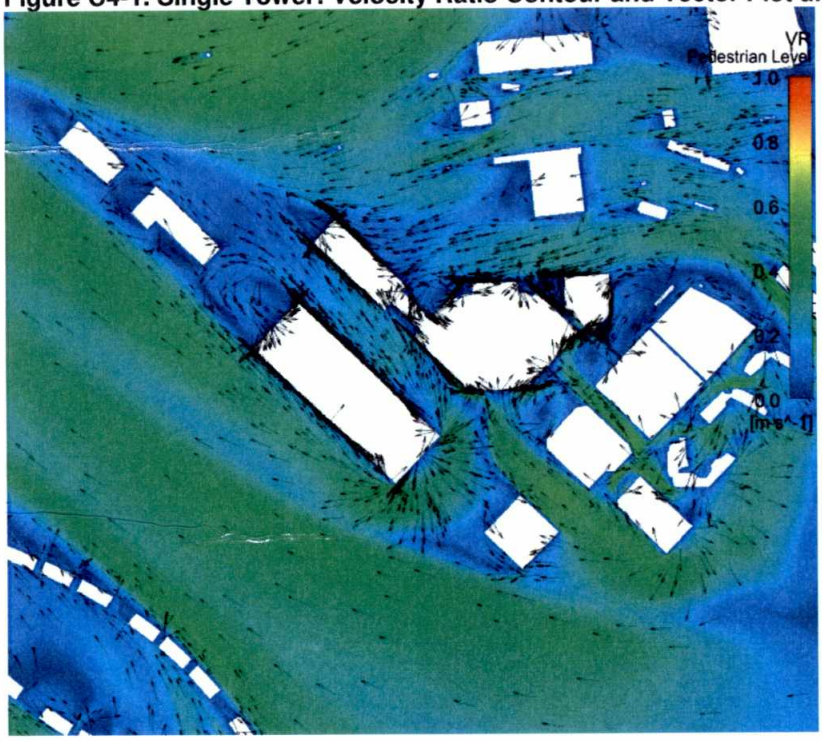


Figure C4-2. Twin Tower: Velocity Ratio Contour and Vector Plot under SE Prevailing Wind

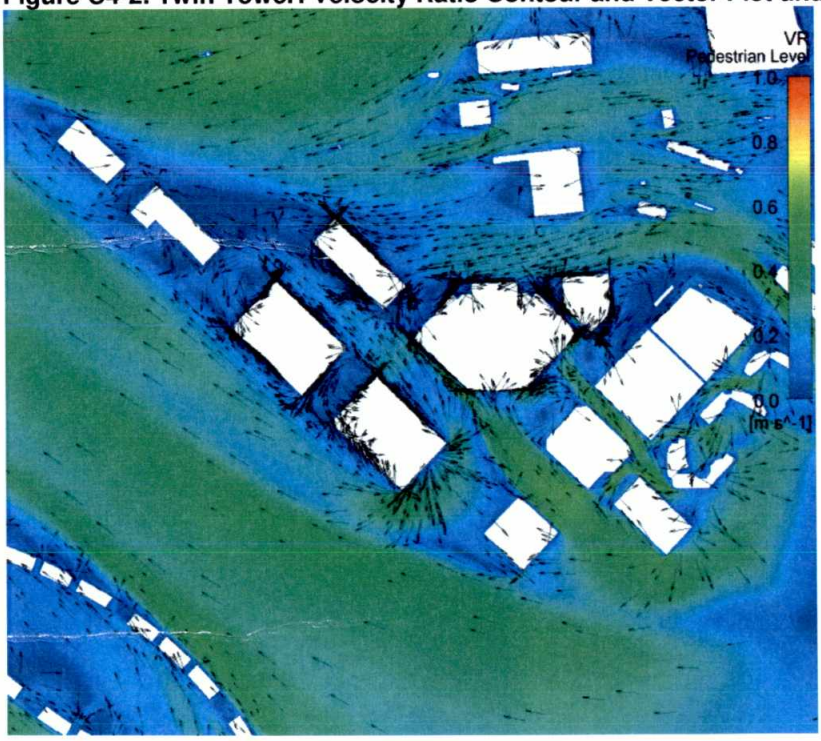


Figure C5-1. Single Tower: Velocity Ratio Contour and Vector Plot under ENE Prevailing Wind

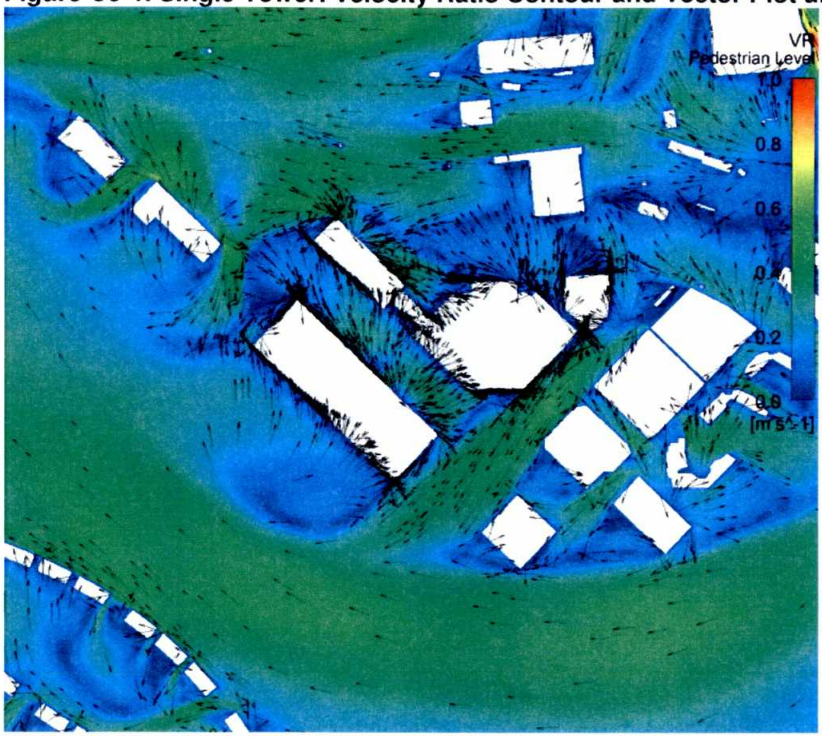


Figure C5-2. Twin Tower: Velocity Ratio Contour and Vector Plot under ENE Prevailing Wind

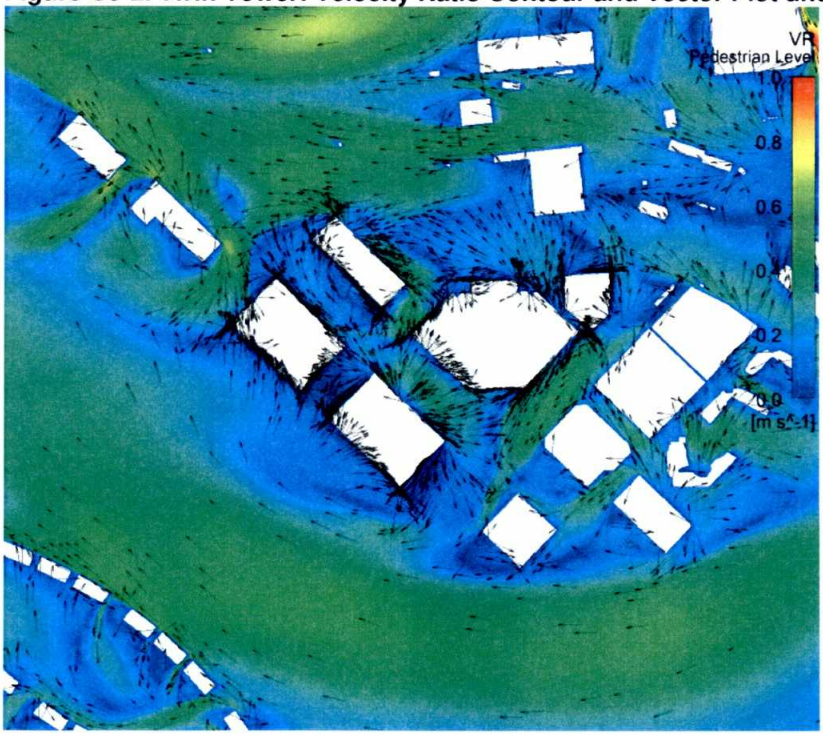


Figure C6-1. Single Tower: Velocity Ratio Contour and Vector Plot under N Prevailing Wind

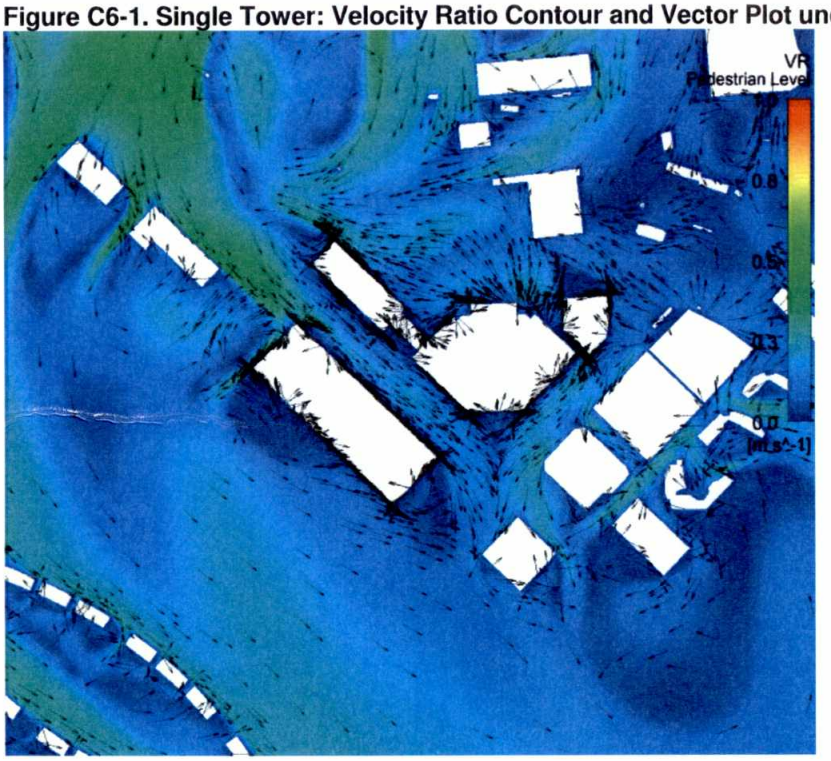


Figure C6-2. Twin Tower: Velocity Ratio Contour and Vector Plot under N Prevailing Wind

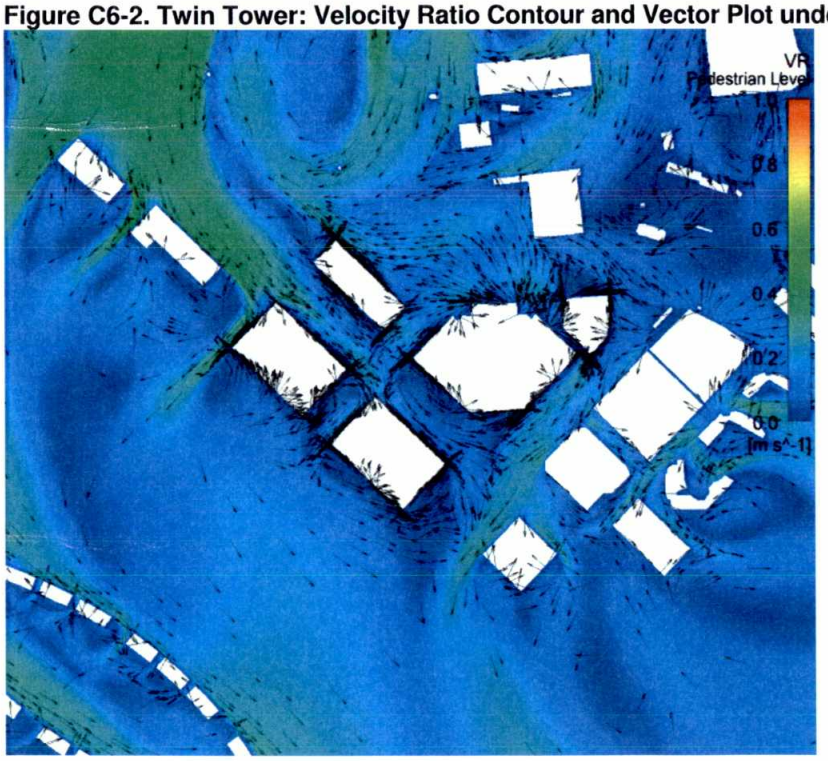


Figure C7-1. Single Tower: Velocity Ratio Contour and Vector Plot under NE Prevailing Wind

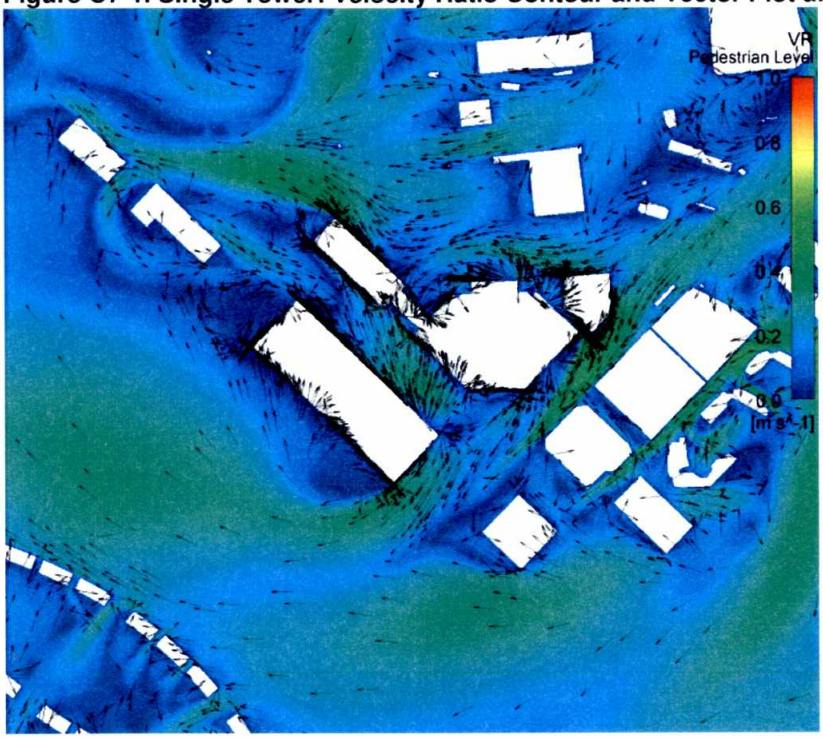


Figure C7-2. Twin Tower: Velocity Ratio Contour and Vector Plot under NE Prevailing Wind

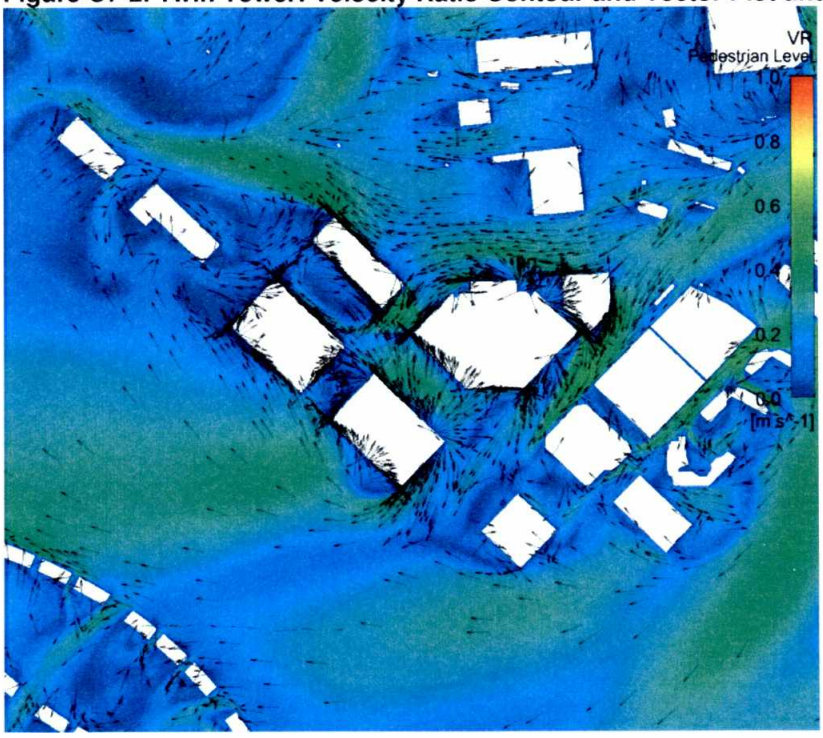


Figure C8-1. Single Tower: Velocity Ratio Contour and Vector Plot under WSW Prevailing Wind

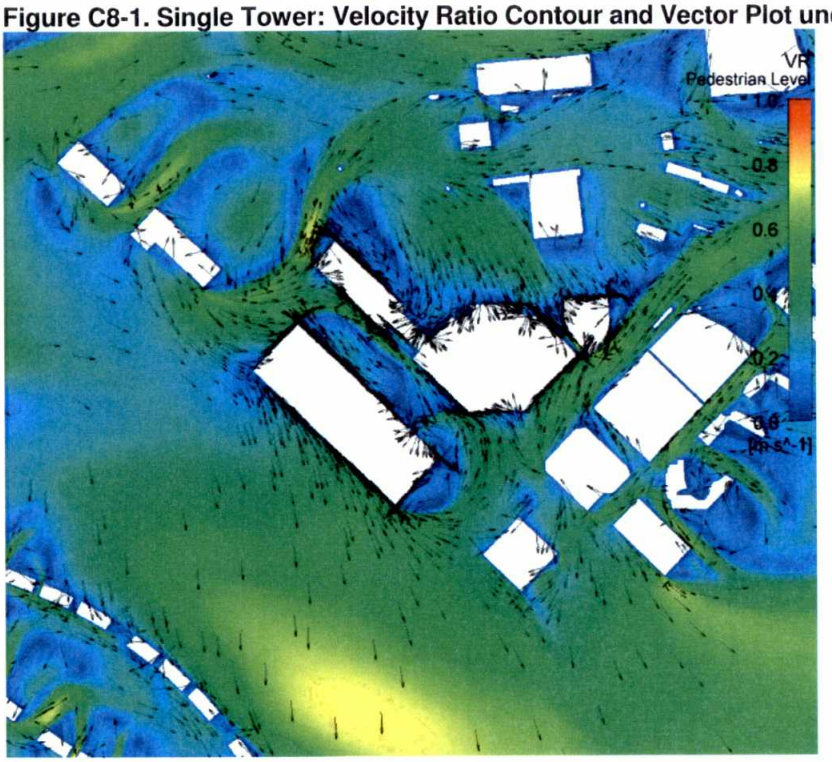
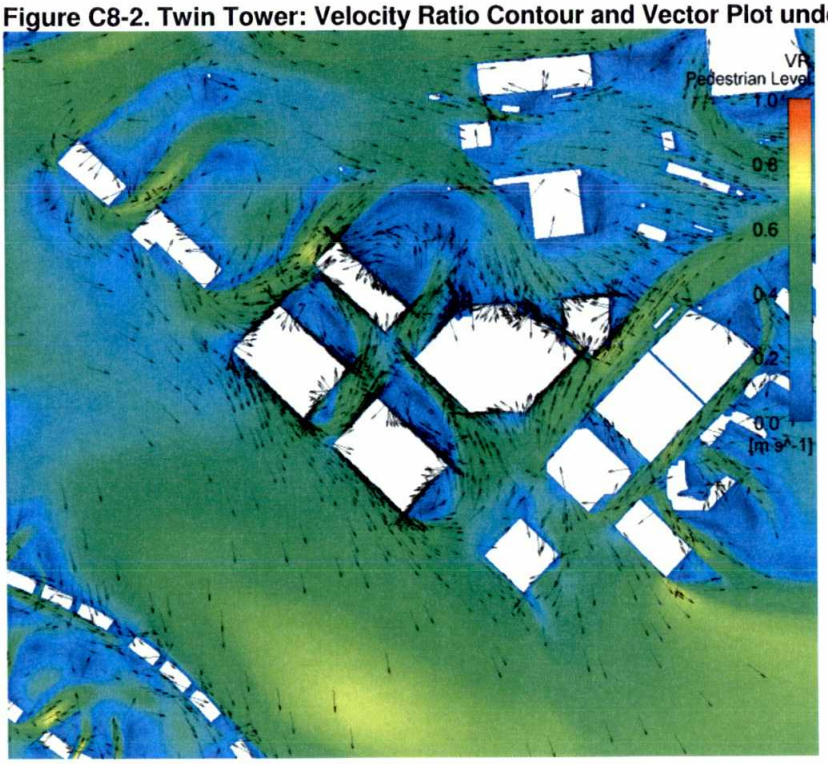



Figure C8-2. Twin Tower: Velocity Ratio Contour and Vector Plot under WSW Prevailing Wind