CONSULTANCY STUDY FOR AIR VENTILATION ASSESSMENT SERVICES

Cat. A1– Term Consultancy for Expert Evaluation on Air Ventilation Assessment (PLN AVA 2018)

Final Report

For an Instructed Project for Sheung Shui Areas 4 & 30

November 2021

INSTITUTE OF Future Cities

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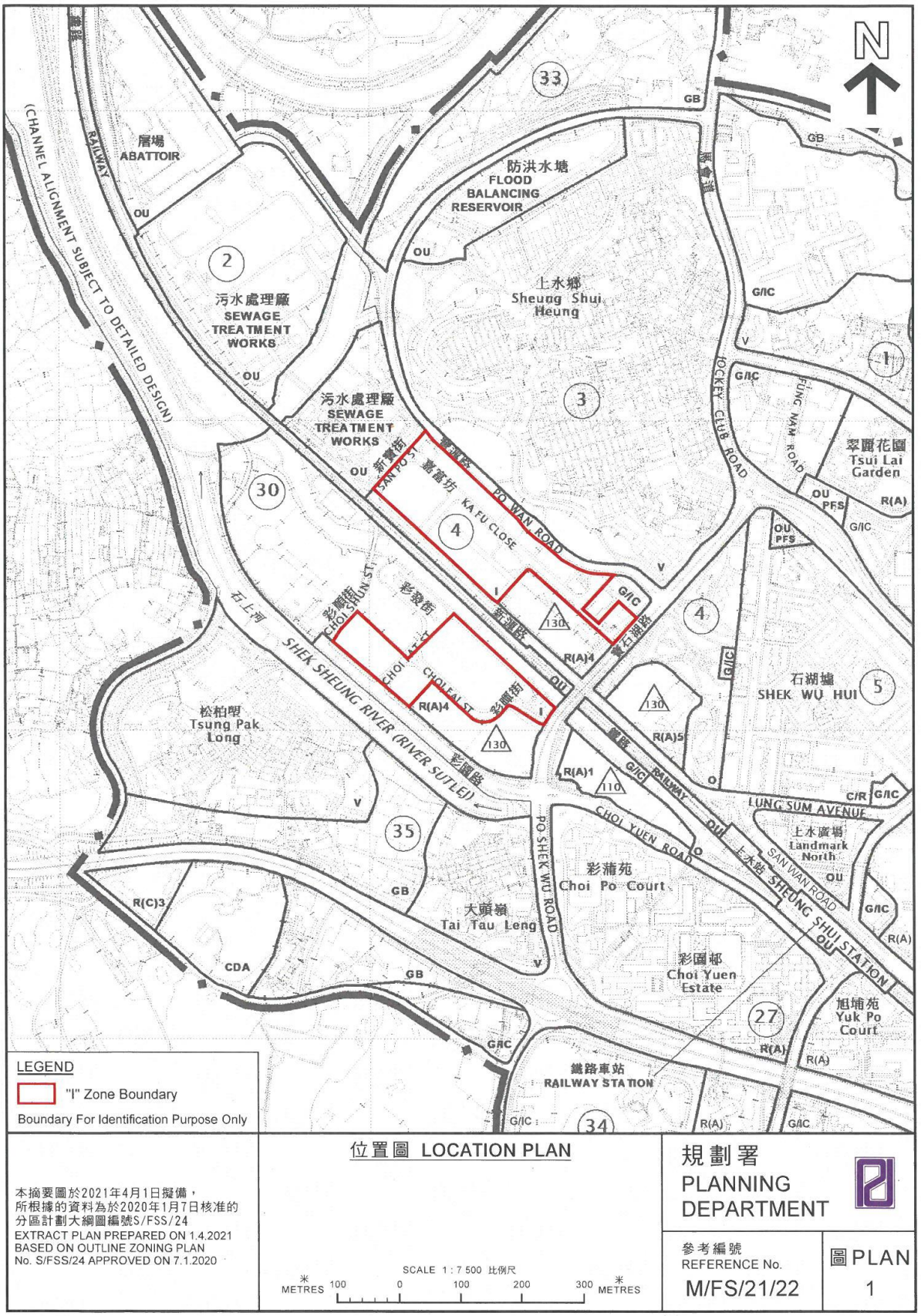
The Project Sites



Expert Evaluation Report
for an Instructed Project for Sheung Shui Areas 4 & 30

Executive summary

0.1 Wind Availability
(a) The annual prevailing winds of the Project Sites are mainly from the north-northeast (NNE), east (E), east-southeast (ESE) and southeast (SE). The summer winds of the Project Sites mainly come from the east (E), east-southeast (ESE), southeast (SE), south-southeast (SSE), south-southwest (SSW) and southeast (SW).

0.2 Existing Conditions

(a) The buildings in the Project Sites are low-rise developments with building heights around 30mPD to 45mPD. To the north-east, south and south-west of the Project Sites, there are a number of low-rise villages (~15 to 20mPD). To the south-east of the Projects Sites, some middle-rise to high-rise residential buildings up to ~120mPD could be observed. There are some proposed public housing developments and proposed primary school next to the Project Sites.

(b) The low-rise village type developments to the north-east, south and south-east of the Project Sites would not affect the prevailing winds flowing into the Project Sites. The open spaces and building gaps of some middle-rise to high-rise residential buildings to the south-east direction of the Projects Sites would allow the prevailing winds reaching the Project Sites. Separate Air Ventilation Assessment (AVA) Studies of proposed public housing developments and proposed primary school have been conducted. Some mitigation measures (such as building gaps) of the development sites have been proposed to minimize any negative impacts and maintain the existing wind environment.

0.3 Expert Evaluation of the Project Sites

(a) The AVA Study has assessed the wind performance for Project Sites in Sheung Shui Areas 4 & 30 and its surrounding for the proposed relaxation on building height restriction from 25m to 75mPD (equivalent to about 65m with site formation level at about 10mPD). Under the AVA Study, the worst-case scenario has been assumed.

(b) In general, air ventilation can achieve better performance if measures, such as breezeways, air paths, open spaces, gaps between buildings and building permeability especially near ground level, are applied. Considering the current air paths in the Project Sites, proposing some air paths in the Project Sites would be effective to enhance the air ventilation performance for the Project Sites and surrounding areas.

(c) Under the prevailing winds, the future developments in this Project Sites will create some wake areas on the leeward side of developments. The depths of

possible wake areas depend on the building height (around 75mPD) or the width of the buildings.

(d) With the building height increasing up to 75mPD, it is possible that the Project Sites will form some deep and long canyons with an H/W (Height / Width) ratio above 4:1 and an L/W (Length / Width) ratio above 15:1 especially perpendicular to the prevailing NNE, SSW and SW winds. For a deep canyon 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. Furthermore, for longer street canyons, corner vortices fade with increasing street length and the wind at the ground level is weak in the depth of the street canyon. It is recommended to incorporate the air paths indicated in Figure 7.5 in the building design stage upon redevelopment to avoid long street canyons.

(e) With major wind corridors/air paths and relatively narrow frontal width, the prevailing E, ESE, SE and SSE winds can be dispersed through the area at pedestrian level with less adverse wind effect to the Project Sites and their vicinity. NW-SE orientated Choi Fat Street can allow urban air flow inside the Project Site under prevailing easterly and south-easterly winds. It is recommended that air movements can be extended along NW-SE orientated Choi Fat Street flowing through the Proposed Primary School Site and Proposed Public Housing Site northwest of the Project Site. The area in the black dotted circle in Figure 7.5 is the entrance for the easterly and south-easterly winds flowing into Ka Fu Close. It is recommended the future developments in this area should not block the easterly and south-easterly winds flowing into Ka Fu Close. At building design stage, the project proponents in this area should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow the building separation requirement (20-33.3%) in the "Sustainable Building Design Guidelines".

(f) Under prevailing NNE, SSW and SW winds, the Project Sites will form deep and long canyons and cause adverse wind effect. To mitigate the impacts mentioned in (c) and (d) and consider insufficient air paths in the Project Sites under prevailing NNE, SSW and SW winds, it is recommended to incorporate two 15m wide air paths in the Project Sites. These two air paths can break down the long street canyon to aid the lateral flow induced by corner eddies entering into the street canyon. Moreover, with the existing grid pattern of streets aligning with the prevailing wind directions, these air paths allow the prevailing north-easterly and south-westerly winds flowing through the Project Sites and further into the surrounding areas including the Proposed Primary School Site.

(g) The Proposed Primary School is a sensitive receiver in the vicinity of the Project Sites. Under prevailing winds, especially summer SW and SSW winds, Hi Tech Centre will create some wake areas on the leeward side to the Proposed Primary School site, and form some deep and long canyons between the Hi Tech Centre (up to 75mPD) and the buildings on the school site. If the future developments on the school site are close to Hi Tech Centre side, it is recommended that the project proponent, at building design stage, should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability

in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow the building separation requirement (20-33.3%) in the "Sustainable Building Design Guidelines".

(f) However, even with the proposed air paths, some development will possibly have large frontal areas with frontal width up to around 120m (such as Jumbo Plaza) under norther-easterly and south-westerly winds respectively. These developments with possible large frontal areas will cause some local air ventilation issues. To enhance the air ventilation performance in the Project Sites, it is recommended, at building design stage, that project proponents in these areas should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow the building separation requirement (20-33.3%) in the "Sustainable Building Design Guidelines".

0.4 Further Work

(a) Given that both designated air paths and requirement of building separation requirements under the Sustainable Building Design Guidelines as set out in paragraph 0.3(f) would be fulfilled as recommended, the Project Sites would have no major air ventilation issues. If the requirements of air paths and building separations cannot be met, further quantitative assessments should be conducted to demonstrate that the performance of any future development be no worse off than the scenario with these measures.

Expert Evaluation Report

for an Instructed Project for Sheung Shui Areas 4 & 30

1.0 The Assignment

1.1 The Planning Department (PlanD) is currently reviewing the land use and building height (BH) restriction of the industrial area in Sheung Shui Areas 4 & 30 (the Areas), subject to technical feasibility. Consideration may be given to relaxing the existing BH restriction of the Areas on the Outline Zoning Plan (OZP) to help optimize the utilization of the Areas and also encourage industrial transformation. Taking into account the requirements of the Sustainable Building Design Guidelines (SBDG), the building height restriction (BHR) for the Areas is reviewed while keeping the permissible development intensity. It is considered that an expert evaluation on air ventilation assessment (AVA EE) is necessary to assess the possible air ventilation impacts of the proposal from air ventilation viewpoint. The assessment will make reference to the possible alternative ventilation measures under the SBDG.

1.2 The study aims to assess the potential air ventilation impacts of the proposal, to identify possible wind potential and problem areas, to examine whether the proposed building height restriction is appropriate, and to explore and recommend air ventilation improvement or mitigation measures where appropriate to enhance or address the possible wind potential or problems identified or improve the wind environment.

1.3 This AVA EE report is based on all previous AVA studies relating to the concerned areas and the materials given by PlanD to the Consultant.

1.4 In this particular AVA EE, the focus is put to assess the air ventilation performance of the Initial Scenario, which refers to the general building profile of an Initial Scenario assuming redevelopment up to the maximum permissible extent of the proposal together with any developments approved or committed by the Town Planning Board or the Administration.

1.5 The consultant has studied the foregoing materials. During the preparation of the report, the consultant has visited the site and conducted working sessions with PlanD.

2.0 Background

2.1 PlanD's study "Feasibility Study for Establishment of Air Ventilation Assessment System" (Feasibility Study) 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 Feasibility Study opines that: "more air ventilation, the better" is the useful design guideline.

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

2.4 The Feasibility Study also suggests that AVA could be conducted in three stages: Expert Evaluation, Initial Study, and Detailed Study. The suggestion has been adopted and incorporated into Housing Planning and Lands Bureau (HPLB) and Environment, Transport and Works Bureau (ETWB) Technical Circular no. 1/06. The key purposes of Expert Evaluation are to the following:

(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; and
(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 analysis:

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

Based on the analysis of site context and topography:

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

Based on the analysis of the EXISTING urban conditions:

(h) evaluate the strategic role of the study area in air ventilation term;
(i) identify problematic areas which warrant attention; and
(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 different development restrictions as proposed by PlanD on air ventilation;

(l) highlight problem areas, if any. Recommend improvements and mitigation measures if possible; and
(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) weather stations provide useful and reliable measurement data on the wind environment in Hong Kong (Figure 3.1). There are some 46 weather stations operated by HKO in Hong Kong. Together, these stations allow for a good general understanding of the wind environment.

Figure 3.1 Some of the HKO weather stations in Hong Kong (a screen capture at 18:30 on 11 Jul 2021 from the HKO website)

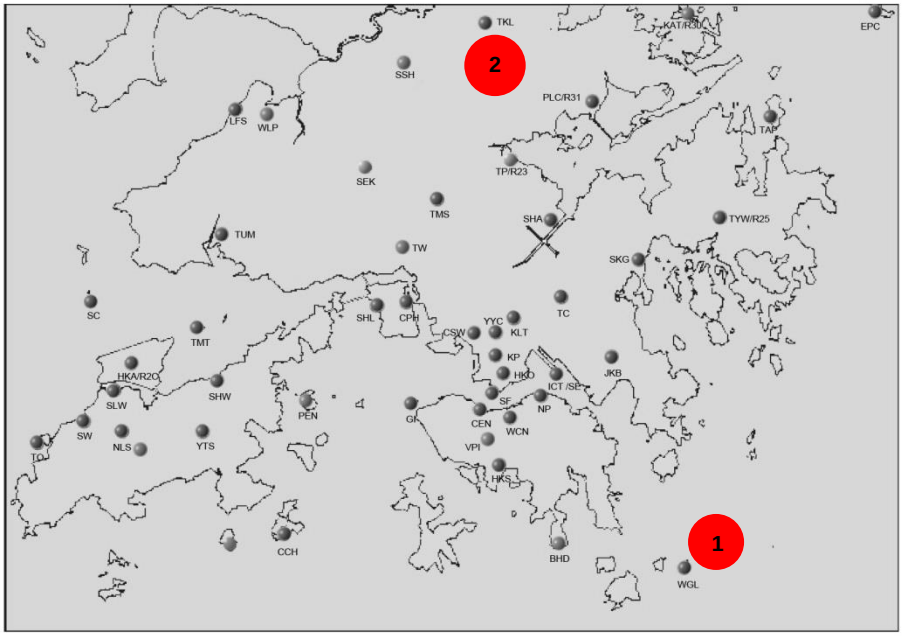


Figure 3.2 The HKO weather stations at 1: Waglan Island (WGL), 2: Ta Kwu Ling (TKL)

3.2 The HKO weather 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 measurement record, and is unaffected by Hong Kong's complex topography. However, it is known not to be able to capture the thermally induced local wind circulation like sea breezes very well. Based on WGL wind data, AVA studies are typically employed to estimate the site wind availability taking into account the topographical features around the site.

3.3 Based on the annual wind rose of WGL weather station (Figure 3.3), it is apparent that the annual prevailing wind in Hong Kong is from the east (E). A major component of wind also comes from the north-east (NE); and there is a minor, but nonetheless observable component from the south-west (SW). WGL has weak to moderate wind (0.1m/s to 8.2 m/s) approximately 70% of the time.

3.4 For the AVA study, seasonally or monthly wind environment should be understood (Figures 3.4 and 3.5). During winter, the prevailing wind comes from the NE, whereas it comes from the SW during summer. As far as AVA is concerned in Hong Kong, the summer wind is very important and beneficial for 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 SW) into the urban fabric.

3.5 Apart from WGL, the wind data of Ta Kwu Ling (TKL) weather station[1] (Figure 3.2) have also been extracted from HKO for reference (Figure 3.6 to Figure 3.8) as the nearest station measuring wind environment for the Project Sites. It can be observed that the annual prevailing winds are mainly from the north (N), east (E) and

[1] https://www.hko.gov.hk/en/cis/region_climat/windrose.htm?&std=TKL

east-southeast (ESE). The summer prevailing winds are mainly from the east (E), east-southeast (ESE) and south-southwest (SSW).

3.6 Noting the limitation of the wind data of WGL weather station mentioned in paragraph 3.2, wind characteristic from the web-based database system available on PlanD's website[1] (i.e. RAMS wind data) has also been referred. Data from four locations (i.e. x:069, y:083; x:069, y:084; x:070, y:083; x:070, y:084), which cover the Project Sites (Figure 3.9), were simulated at 200m, 300m and 500m above the ground (Figures A-1 to A-4 in Appendix A). These locations, according to the application of Regional Atmospheric Modeling System (RAMS), were selected to reflect the general wind patterns of the Project Sites induced by topography. Prevailing wind directions are summarised in Table 1. As the HKO weather station at Ta Kwu Ling is not within the Project Sites and the surroundings of Ta Kwu Ling are different from those of Project Sites, the RAMS wind data extracted from PlanD's website is more representative to reflect the wind availability of the Project Sites. In the present study, the height level of 200m is adopted in determine the prevailing annual/summer winds. It can be observed that the annual prevailing winds of the Project Sites are mainly from north-northeast (NNE), east (E), east-southeast (ESE) and southeast (SE) in accordance with the RAMS wind data extracted from PlanD's website. The summer prevailing winds of Project Sites are mainly from the east (E), east-southeast (ESE), southeast (SE), south-southeast (SSE), south-southwest (SSW) and southeast (SW). In general, the wind data from RAMS are consistent with those of Ta Kwu Ling and WGL.

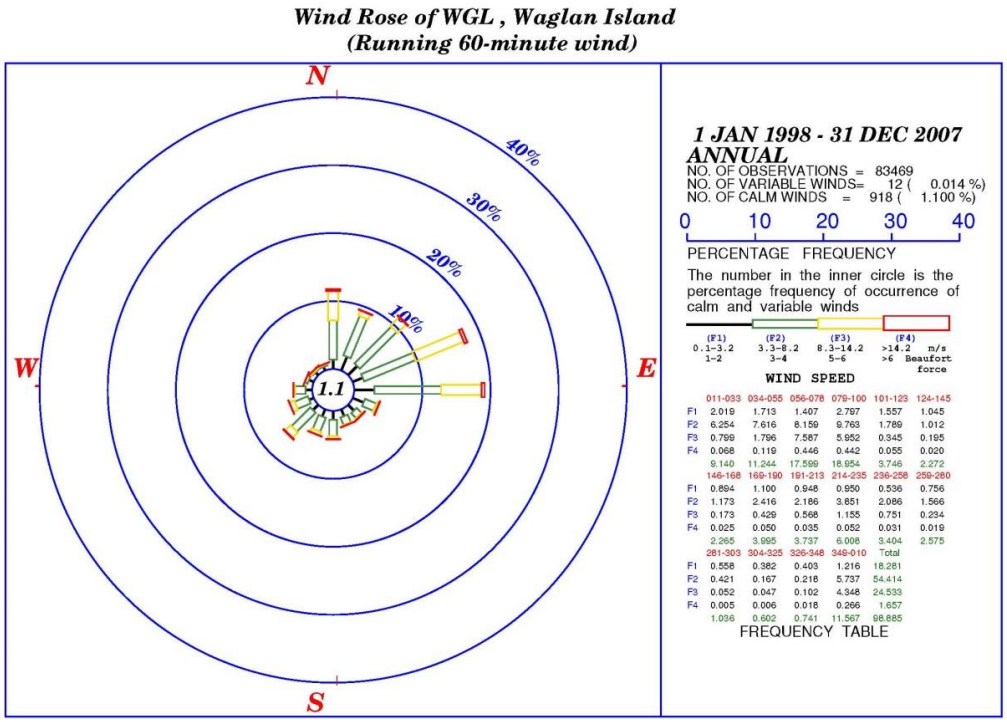


Figure 3.3 Wind rose of WGL weather station from 1998 to 2007[2] (annual)

[1] http://www.pland.gov.hk/pland_en/info_serv/site_wind/site_wind/index.html

[2] Wind data of WGL from 1998 to 2007 are the latest available 10-year data from HKO to the consultant.

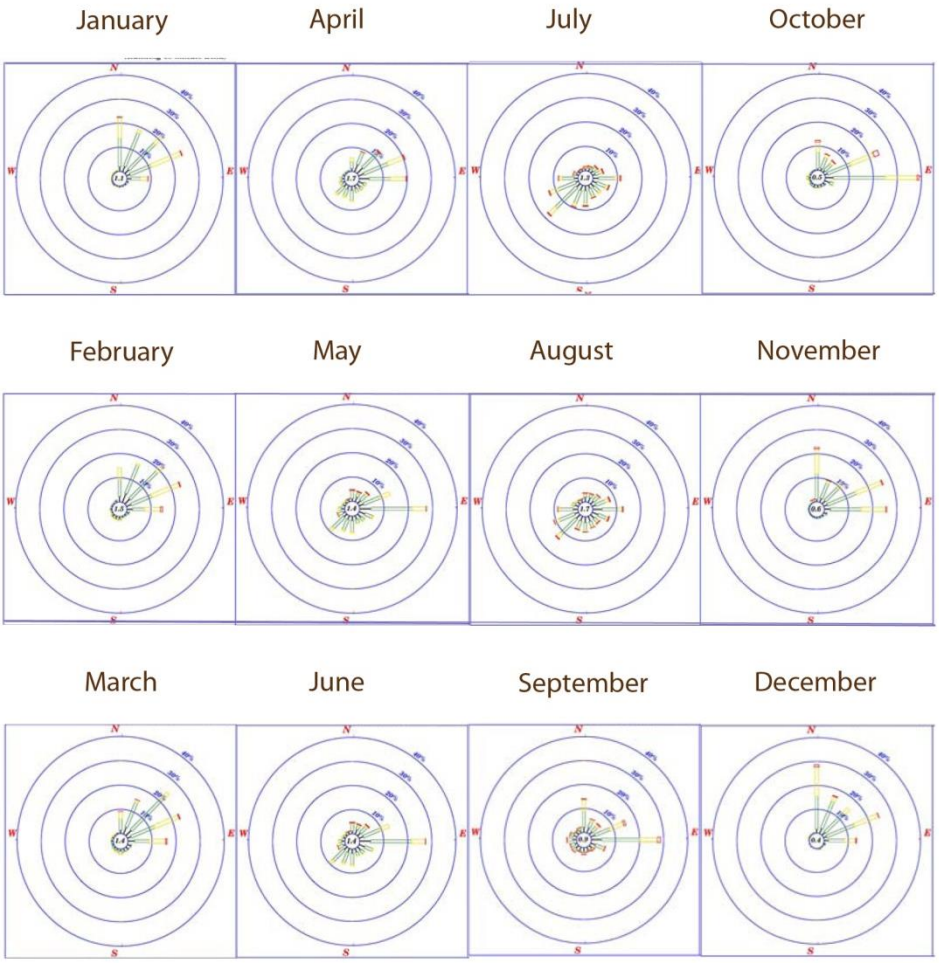


Figure 3.4 Monthly wind roses of WGL weather station from 1998 to 2007

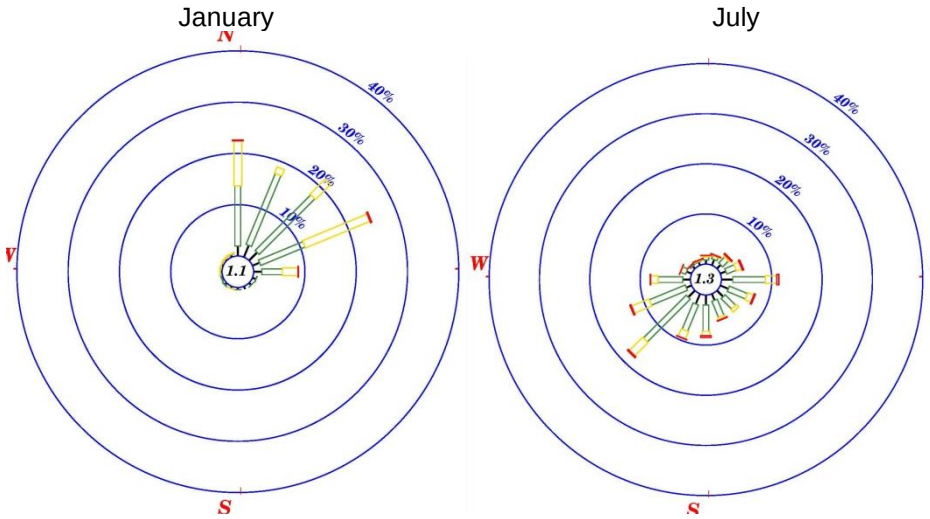


Figure 3.5 Wind roses of WGL weather station from 1998 to 2007 (Jan and July)

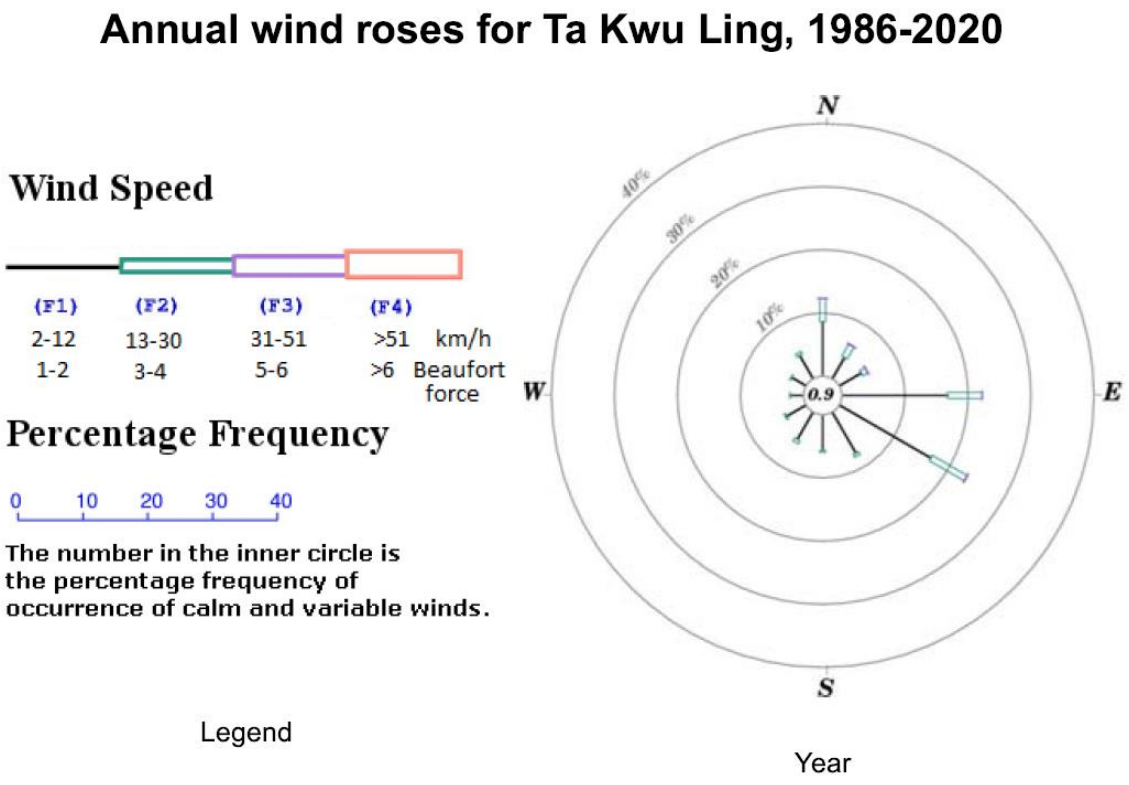


Figure 3.6 Wind rose of Ta Kwu Ling weather station from 1986 to 2020 (annual)

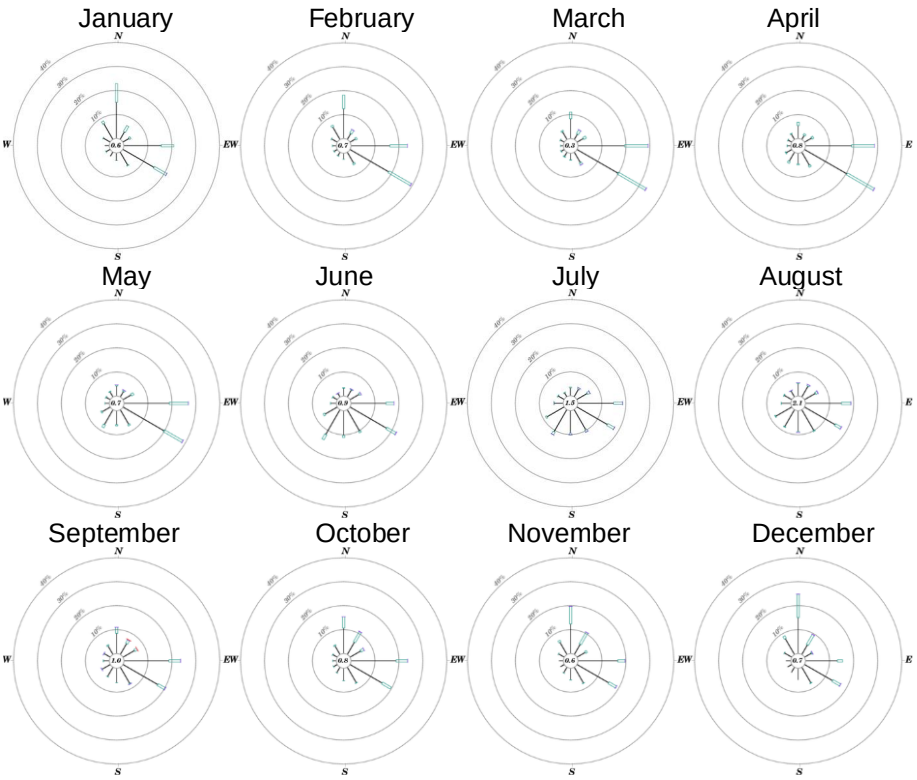


Figure 3.7 (as an example) monthly wind roses of Ta Kwu Ling weather station from 1986 to 2020

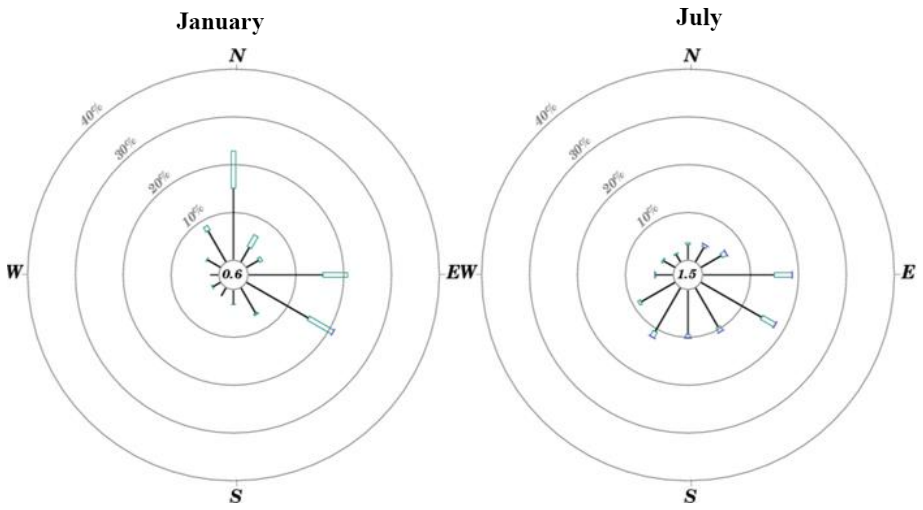


Figure 3.8 (as an example) Wind roses of Ta Kwu Ling weather station from 1986 to 2020 (Jan and July)

Figure 3.9 RAMS Grid and the Project Sites

3.8 In summary, based on the available wind data (Table 1) by considering that wind data from RAMS is likely to be more representative to reflect the wind availability of the Project Sites elaborated in paragraph 3.6, it can be concluded the annual prevailing winds of the Project Sites are mainly from the north-northeast (NNE), east (E), east-southeast (ESE) and southeast (SE). The summer winds of the Project Sites mainly come from the east (E), east-southeast (ESE), southeast (SE), south-southeast (SSE), south-southwest (SSW) and southeast (SW) (Figure 3.10). The prevailing winds are compatible with other AVA EE studies[1] [2](refer to Figures B-1 and B-2 in Appendix B).

Table 1 Summary of Prevailing Wind Directions

			Period	
			Annual (Percentage)	Summer (Percentage)
HKO weather station	Ta Kwu Ling weather station		N, E, ESE	E, ESE, SSW
RAMS Wind data on the Project Sites	x:069; y:083	200m	ESE (0.186), E (0.168), NNE (0.121), SE (0.105)	SE (0.156), SSW (0.130), ESE (0.099), E (0.093), SW (0.093)
	x:069; y:084	200m	E (0.179), ESE (0.173), NNE (0.128), SE (0.103)	SE (0.143), SSW (0.131), E (0.098), SW (0.097)
	x:070; y:083	200m	ESE (0.180), E (0.169), NNE (0.112), SE (0.109)	SE (0.153), SSW (0.124), SSE (0.102), E (0.092)
	x:070; y:084	200m	E (0.181), ESE (0.169), NNE (0.123), SE (0.104)	SE (0.140), SSW (0.126), SSE (0.106), E (0.097), SW (0.095)
Summary of wind directions			**NNE, E, ESE, SE**	**E, ESE, SE, SSE, SSW, SW**

[1] Civil Engineering and Development Department: Site Formation and Infrastructure Works for Housing Developments at Pak Tin Extension and Chak On Road South, Sham Shui Po and Choi Shun Street, Sheung Shui - Feasibility Study (2020)
[2] Hong Kong Housing Authority: Air Ventilation Assessment of Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site - Expert Evaluation Report (2019)

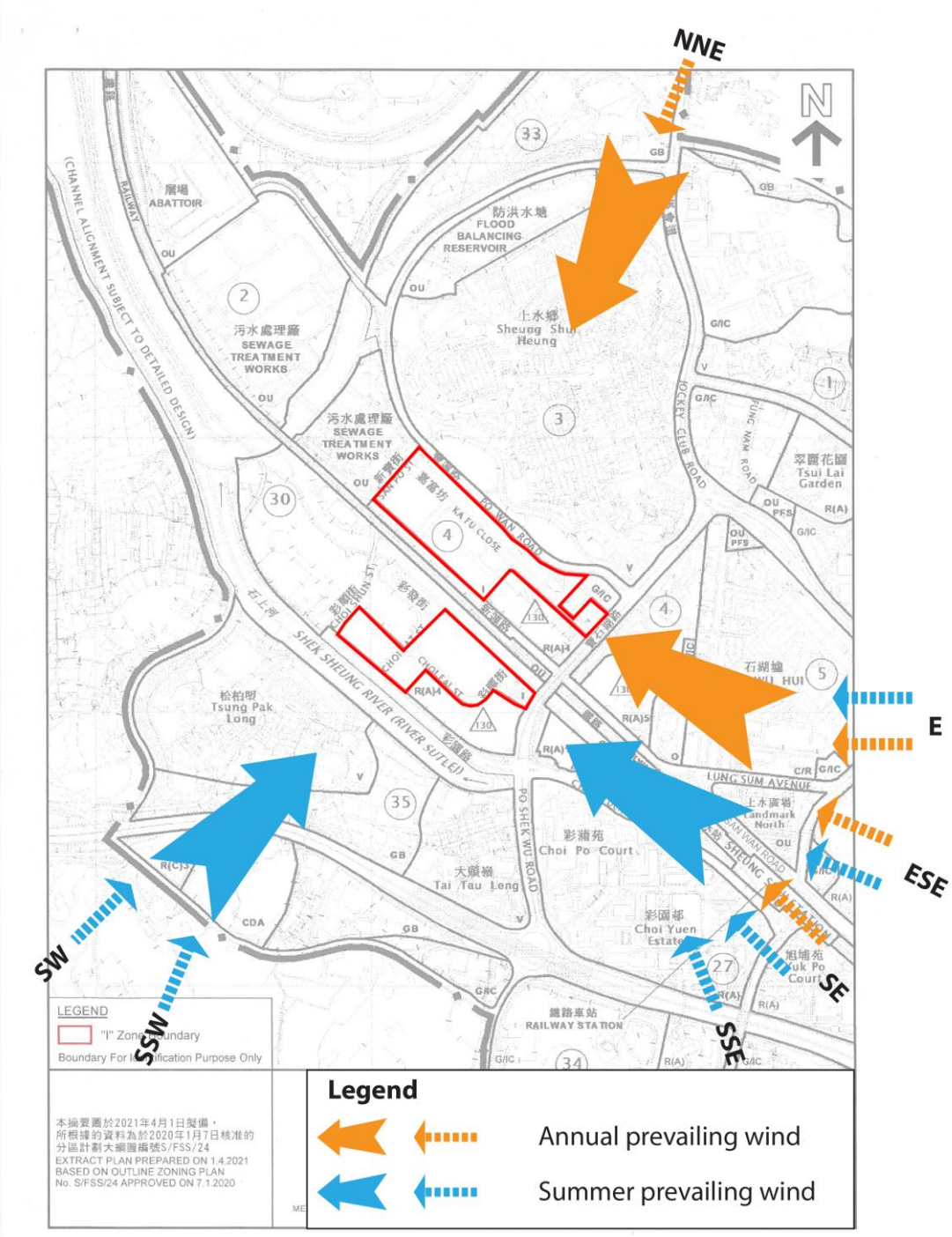


Figure 3.10 A summary of the prevailing winds of the Project Sites

4.0 Topography and the Wind Environment

4.1 The Project Sites are located at the north-western periphery of the Sheung Shui New Town. As shown on Figure 4.1, the Project Sites are located on a flat land with Long Valley and Fanling Golf Course lie in its west and south respectively. Two local hills, namely, Tai Shek Mo about 180m high and Wa Shan about 170m high are located relatively far from the Project Sites in the northwest and northeast directions respectively. The prevailing winds from all directions including the NNE, E, ESE, SE, SSE, SSW and SW are unlikely to be affected by the topography but immediate surroundings as discussed in section 5.0.

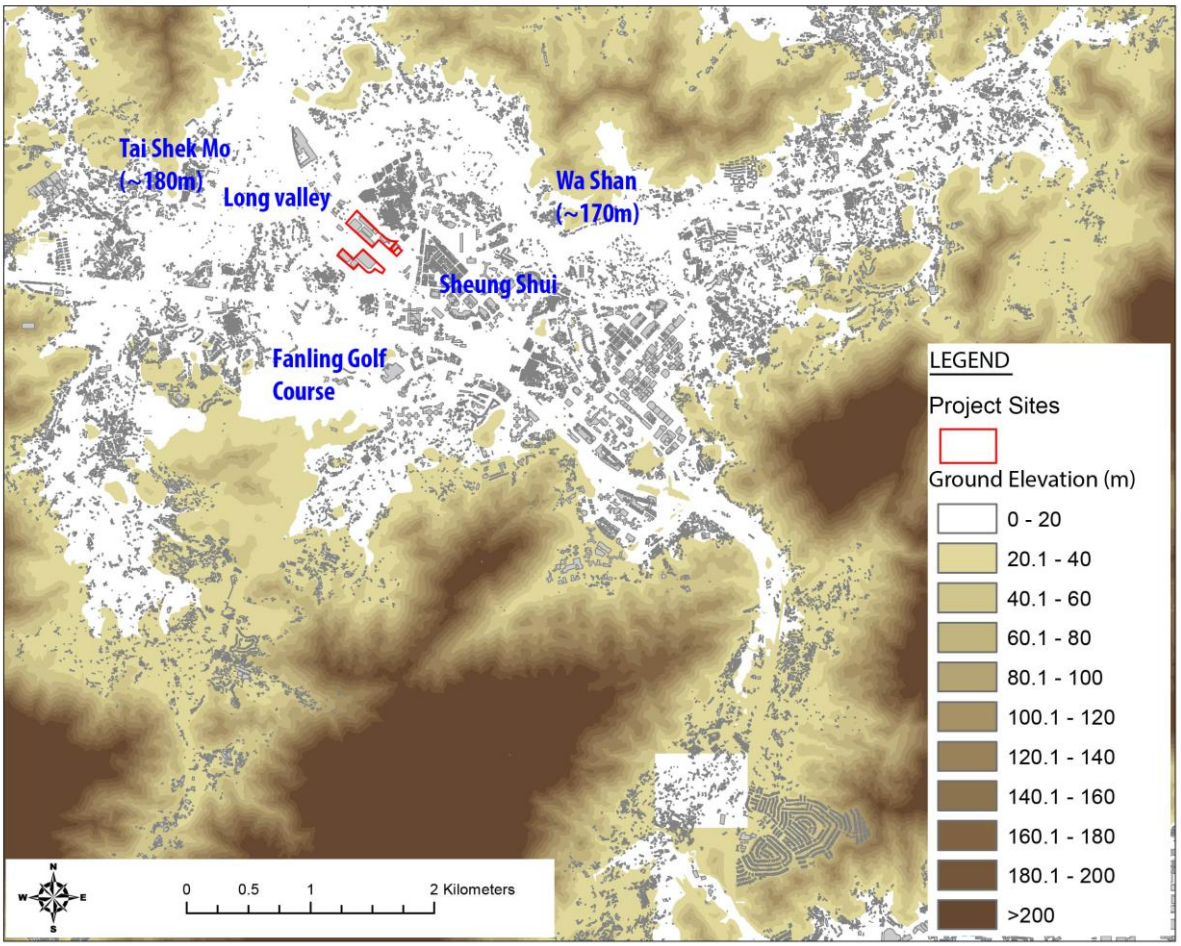


Figure 4.1 Topography and wind environment surrounding the Project Sites.

5.0 Existing Conditions

5.1 As shown in Figure 5.1, the buildings in the Project Sites are low-rise developments with building heights around 30mPD to 45mPD. To the north-east direction of the Project Sites, a number of villages such as Po Sheung Tsuen, Hing Yan Tsuen (~15 to 20mPD) etc. could be observed. Similarly, some other villages, namely Hak Ka Wai and Tsung Pak Long (~15mPD) could also be observed to the south and south-west of the Sites. To the south-east direction of the Projects Sites, some middle-rise to high-rise residential buildings such as Po Shek Wu Estate (up to ~120mPD), Choi Po Court Estate (up to ~100mPD) etc. could be observed. There are some proposed public housing developments from 130mPD to 149mPD (Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site) at the immediate south-east of the Project Sites. Moreover, there are proposed Public Housing (160mPD) and Proposed Primary School at the immediate north-west of the Project Site at Area 30. (Figure 5.2)

5.2 The urban morphology of the city determines the characteristics of the in-urban canyon air flow. As mentioned above, the Project Sites are surrounded by different environments. Based on the Power Law, the power law exponent (a) could be 0.3 to 0.4[1] for east wind due to the built-up area to the E and SE of the sites, and 0.2 to 0.3[1] due for sub-urban low-rise built-up area NNE and SW of the site. (Refer to Figure A-5 in Appendix A)

5.3 Therefore, under the prevailing winds from the NNE, SSW and SW, the low-rise village type developments to the north-east, south and south-east of the Project Site would not affect the prevailing winds flowing into the Project Sites. The wind speed at gradient height from the north and south could be higher than other directions (refer to Figure A-5 in Appendix A). However, the proposed Public Housing and Proposed Primary School at the immediate north-west of the Project Site at Area 30 may create weak ventilation environment in the immediate leeward region. An AVA EE[2] of this site has been conducted. Some mitigation measures (such as building gaps) of the development site have been proposed to minimize any negative impacts and maintain the existing wind environment.

5.4 Under the prevailing winds from the E, ESE, SE and SSE, the open spaces and building gaps in Shek Wu Hui Jockey Club Playground, Po Shek Wu Estate and Choi Po Court etc. would allow the prevailing winds reaching the Project Sites. The wind speed at gradient height from the E and SE could be moderately affected by the built-up areas (refer to Figure A-5 in Appendix A). Furthermore, the Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site at the immediate south-east of the Project Sites may create weak ventilation

[1] Hong Kong Planning Department: Feasibility Study on Establishment of Air Ventilation Assessment – final report (2005)

[2] Civil Engineering and Development Department: Site Formation and Infrastructure Works for Housing Developments at Pak Tin Extension and Chak On Road South, Sham Shui Po and Choi Shun Street, Sheung Shui - Feasibility Study (2020)

environment in the immediate leeward region. An AVA EE[1] of these sites has been conducted. Some mitigation measures (such as building gaps) of the development sites have been proposed to minimize any negative impacts and maintain the existing wind environment.

[1] Hong Kong Housing Authority: Air Ventilation Assessment of Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site - Expert Evaluation Report (2019)

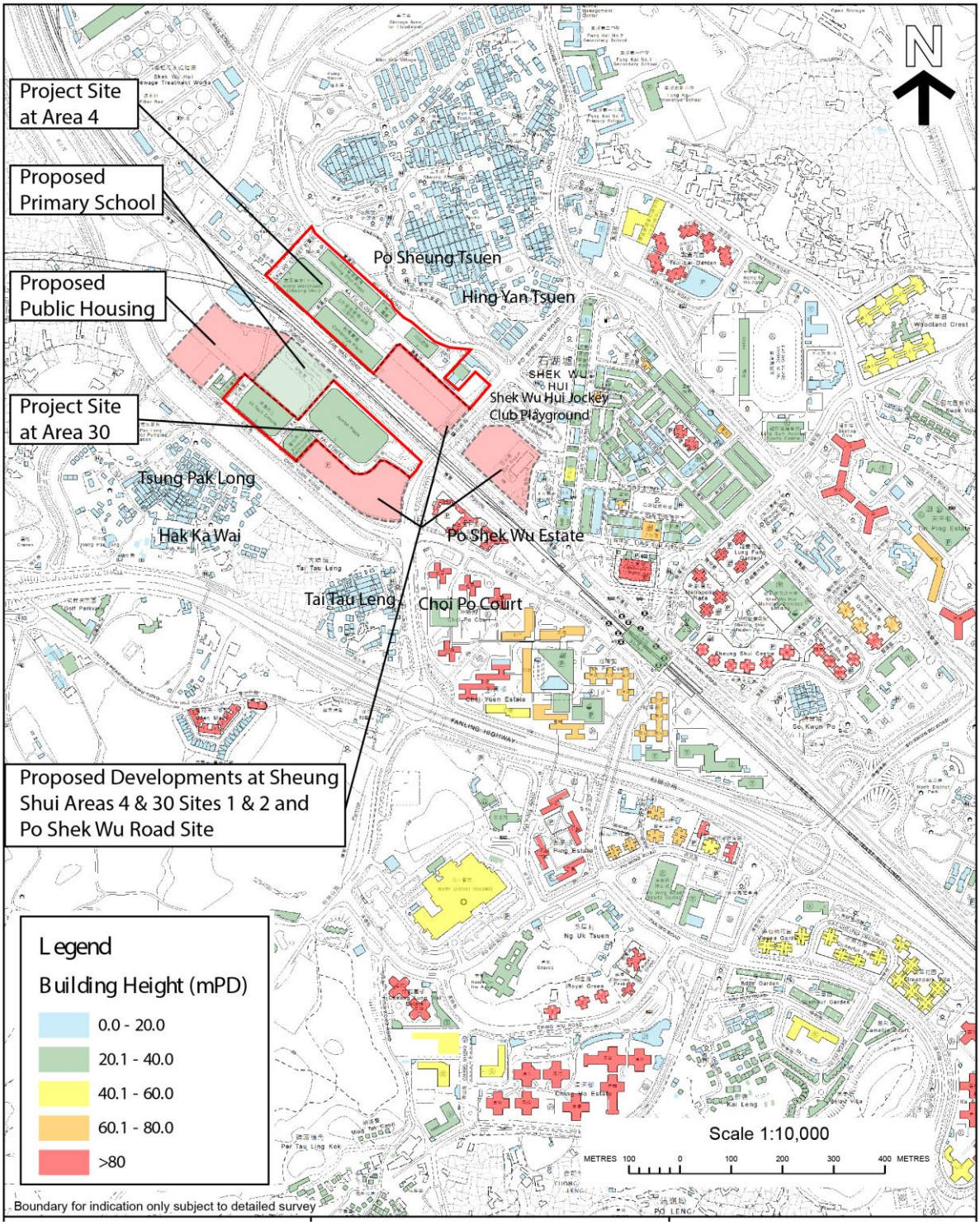


Figure 5.1 Height of the existing buildings in mPD.

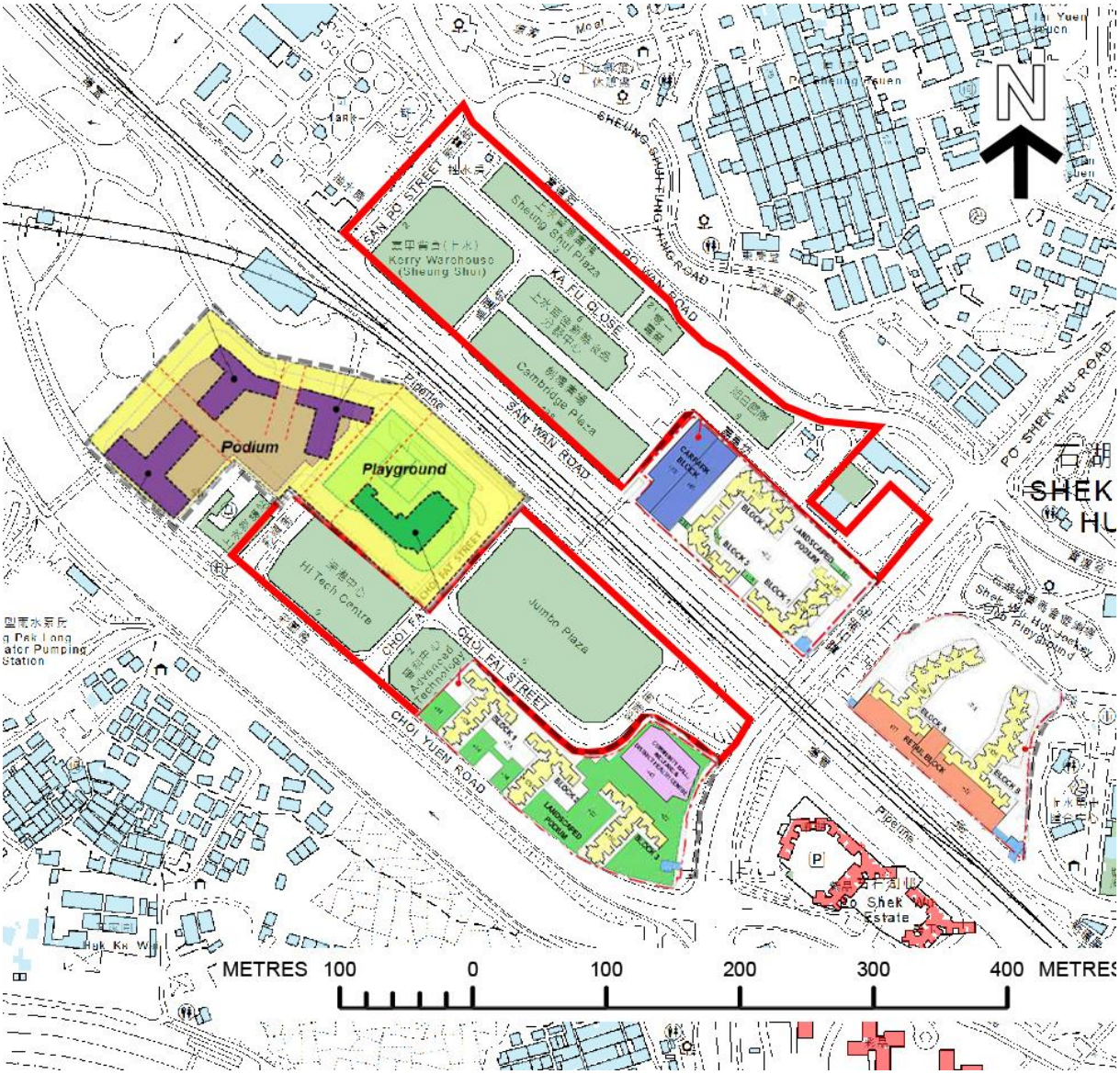


Figure 5.2 Existing buildings and proposed layouts of nearby developments[1][2].

[1] Hong Kong Housing Authority: Air Ventilation Assessment of Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site - Expert Evaluation Report (2019)

[2] Civil Engineering and Development Department: Site Formation and Infrastructure Works for Housing Developments at Pak Tin Extension and Chak On Road South, Sham Shui Po and Choi Shun Street, Sheung Shui - Feasibility Study (2020)

6.0 Urban Air Movements

6.1 Major roads/streets in parallel with or less than 30 degrees to the prevailing wind directions together with open spaces and low-rise buildings can form urban air paths (Figures 6.1 and 6.3). The existing wind condition in the Project Area mainly relies on the existing road network and open spaces.

6.2 Under prevailing winds from the E, ESE, SE and SSE, Po Wan Road, East Rail Line, San Wan Road, Choi Yuan Road, Shek Sheung River together with adjacent open areas can form some major wind corridors. Ka Fu Close and Choi Fat Street, which are oriented in the similar direction of prevailing south-easterly winds, together with some open spaces and gaps between buildings can allow air movements inside the Project Sites. With major wind corridors and air paths, the prevailing E, ESE, SE and SSE winds can be dispersed through the area at pedestrian level with less adverse wind effect to the Project Sites and their vicinity. (Figure 6.1)

6.3 Under prevailing NNE, SSW and SW winds, some major roads and streets such as San Po Street, Choi Shun Street, Choi Fat Street, Po Shek Wu Road, which are oriented in the similar direction of prevailing winds, together with some open spaces and gaps between buildings can allow the penetration of the NNE, SSW and SW winds into the Project Sites and surrounding areas (Figures 6.2 and 6.3). However, there is a lack of major roads/streets and open spaces in other parts of the Project Sites as highlighted in the dotted circle of Figures 6.2 and 6.3. Air movements can hardly be identified under prevailing NNE, SSW and SW winds through this part of the Project Sites.

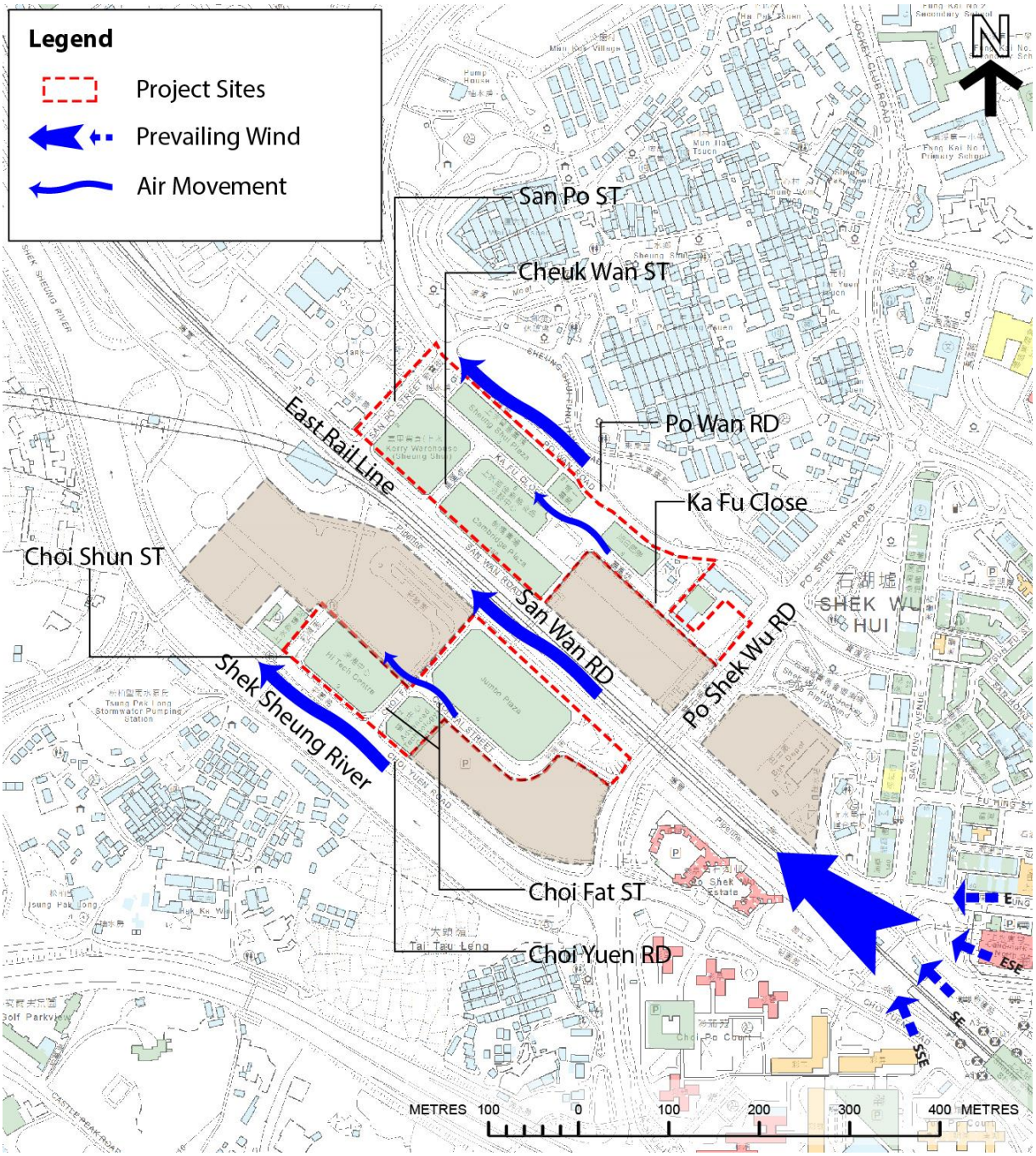


Figure 6.1 Air Movement of the Project Sites and surrounding areas under prevailing E, ESE, SE and SSE wind.

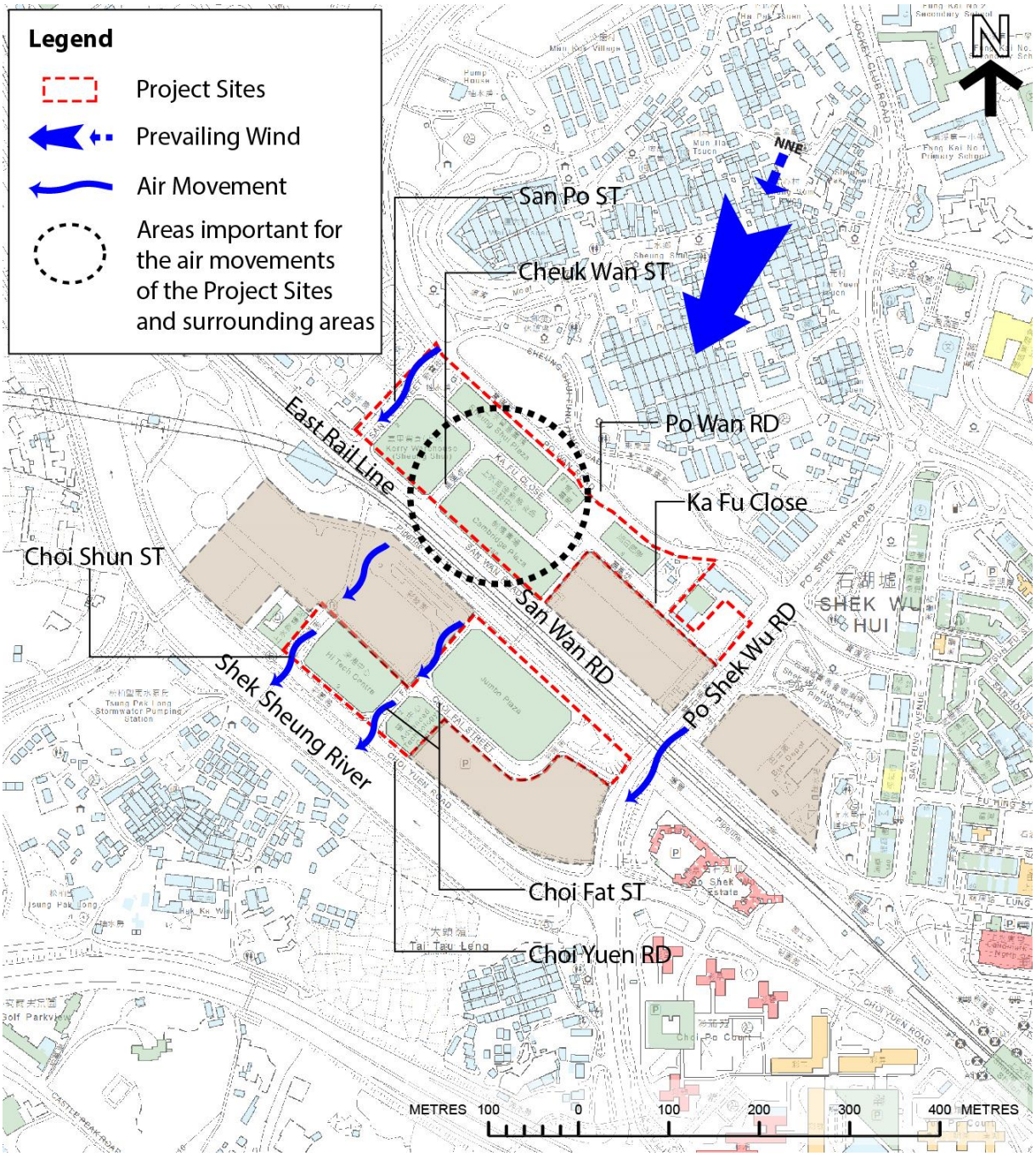


Figure 6.2 Air Movement of the Project Sites and surrounding areas under prevailing NNE wind.

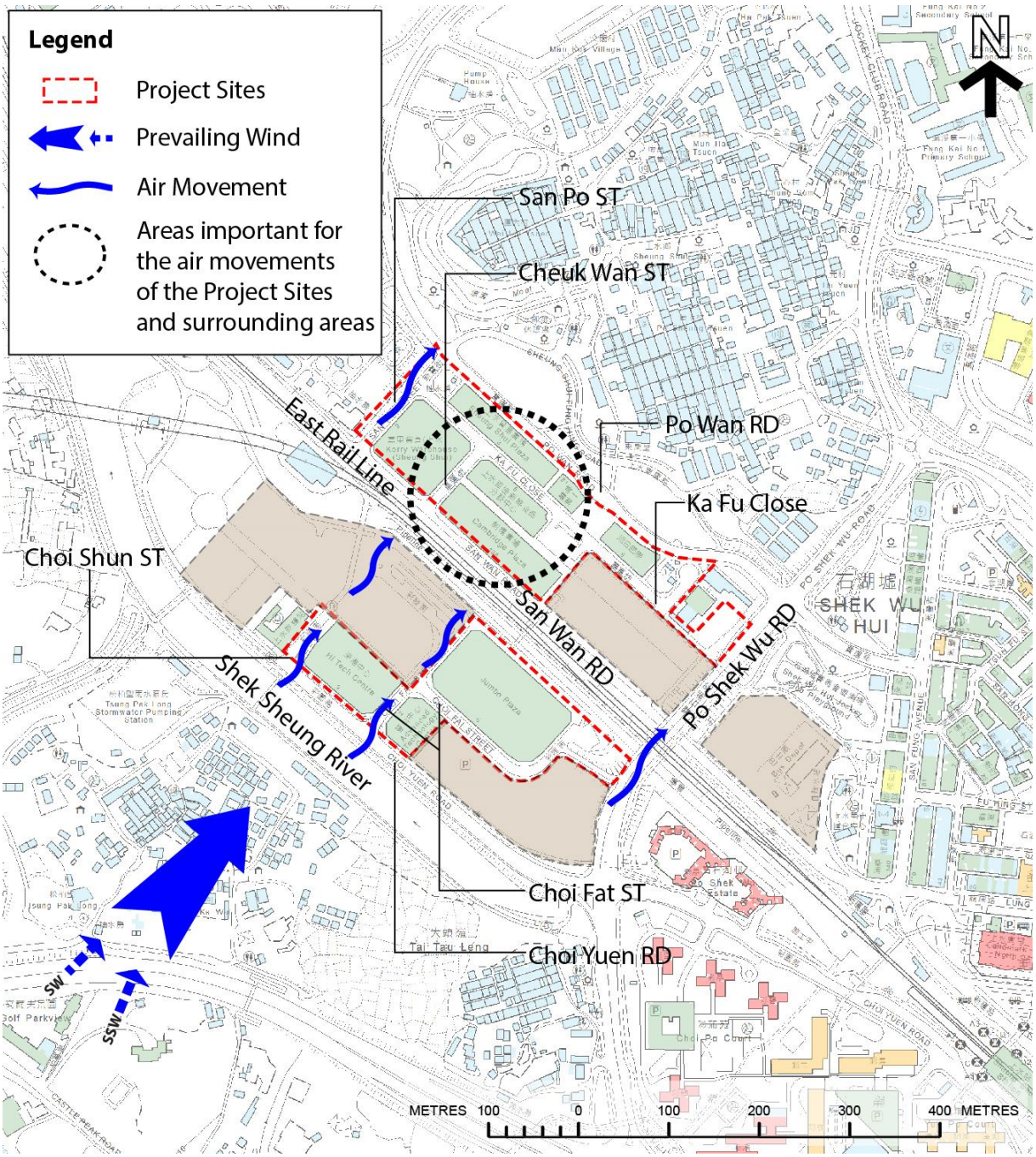


Figure 6.3 Air Movement of the Project Sites and surrounding areas under prevailing SSW and SW wind.

7.0 Expert Evaluation of the Project Sites

7.1 The AVA Study has assessed the wind performance for the Project Sites in Sheung Shui Areas 4 & 30 and its surrounding for the proposed relaxation on building height restriction from 25m to 75mPD (equivalent to about 65m with site formation level at about 10mPD) (Figure 7.1). Under the AVA Study, the worst-case scenario has been assumed.

7.2 In general, air ventilation can achieve better performance if measures, such as breezeways, air paths, open spaces, gaps between buildings and building permeability especially near ground level, are applied. Considering the current air paths and potential problematic areas discussed in section 6, proposing some air paths in the Project Sites would be effective to enhance the air ventilation performance for the Project Sites and surrounding areas.

7.3 Under the prevailing winds, the future developments in the Project Sites will create some wake areas on the leeward side of the developments (Figures 7.2 to 7.4). The depths of possible wake areas depend on the building height (around 75mPD) or the width of the buildings (refer to Figure A-6 in the Appendix A). The wake areas under E, ESE, SE and SSE winds will extend to some NE-SW orientated streets, some open spaces in the Project Sites and some surrounding areas northwest of the Project Sites including Cheuk Wan Street, San Po Street, Sewage Treatment Works, Proposed Primary School Site, Choi Fat Street and Choi Shun Street (Figure 7.2). The wake areas under NNE, SSW and SW winds will extend to some NW-SE orientated streets, some open spaces in the Project Sites and some surrounding areas southwest and northeast of the Project Sites respectively including Shek Sheung River, Choi Yuen Road, Choi Fat Street, East Rail Line, San Wan Road, Ka Fu Close and Po Wan Road (Figures 7.3 and 7.4).

7.4 With the building height increasing up to 75mPD, it is possible that the Project Sites will form some deep and long canyons[1] with an H/W (Height / Width) ratio above 4:1 and an L/W (Length / Width) ratio above 15:1 especially perpendicular to the prevailing NNE, SSW and SW winds (indicated in the dotted circle in Figures 7.3 and 7.4). Refer to Figure A-7 in the Appendix A; for a deep canyon 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. Furthermore, for longer street canyons, corner vortices (Figure A-8 in the Appendix A) fade with increasing street length[2] and the wind at the ground level is weak in the depth of the street canyon (Figure A-9 in the Appendix A). It is recommended to incorporate the air paths indicated in Figure 7.5 in the building design stage upon redevelopment to avoid long street canyons.

7.5 As discussed in Para. 6.2, with major wind corridors/air paths and relatively narrow frontal width, the prevailing E, ESE, SE and SSE winds can be dispersed

[1] Refer to Sustainable Building Design Guidelines (APP-152); it will be regarded as continuous façade if a building or a group of buildings has separation less than 15m.
[2] Theurer, W. (1999). Typical building arrangements for urban air pollution modelling. Atmospheric Environment, 33(24), 4057-4066.

through the area at pedestrian level with less adverse wind effect (wake areas) to the Project Sites and their vicinity (Figure 7.2). As shown in Figure 6.1, NW-SE orientated Choi Fat Street can allow urban air flow inside the Project Site under prevailing easterly and south-easterly winds. It is recommended that air movements can be extended along NW-SE orientated Choi Fat Street flowing through the Proposed Primary School Site and Proposed Public Housing Site northwest of the Project Site. The area in the black dotted circle in Figure 7.5 is the entrance for the easterly and south-easterly winds flowing into Ka Fu Close. It is recommended the future developments in this area should not block the easterly and south-easterly winds flowing into Ka Fu Close. At building design stage, the project proponents in this area should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow the building separation requirement (20-33.3%) in the "Sustainable Building Design Guidelines".

7.6 Under prevailing NNE, SSW and SW winds, the Project Sites will form deep and long canyons and cause adverse wind effect (Figures 7.3 and 7.4). To mitigate the impacts mentioned in Para. 7.3 and 7.4, and consider insufficient air movements in the Project Sites under prevailing NNE, SSW and SW winds discussed in section 6, it is recommended to incorporate two 15m wide air paths in the Project Sites (Figure 7.5). These two air paths can break down the long street canyon to aid the lateral flow induced by corner eddies entering into the street canyon. Moreover, with the existing grid pattern of streets aligning with the prevailing wind directions, these air paths allow the prevailing north-easterly and south-westerly winds flowing through the Project Sites and further into the surrounding areas including the Proposed Primary School Site.

7.7 The Proposed Primary School is a sensitive receiver in the vicinity of the Project Sites. Under prevailing winds, especially summer SW and SSW winds, Hi Tech Centre will create some wake areas on the leeward side to the Proposed Primary School site (Figure 7.4). It could form some deep and long canyons between the Hi Tech Centre (up to 75mPD) and the buildings on the school site, and then cause adverse wind effect. If the future developments on the school site are close to Hi Tech Centre side, it is recommended that the project proponent, at building design stage, should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow the building separation requirement (20-33.3%) in the "Sustainable Building Design Guidelines".

7.8 However, even with the proposed air paths, some development will possibly have large frontal areas with frontal width up to around 120m (such as Jumbo Plaza) under norther-easterly and south-westerly winds respectively. These developments with possible large frontal areas will cause some local air ventilation issues. To enhance the air ventilation performance in the Project Sites, it is recommended, at building design stage, that project proponents in these areas should make reference to the design guidelines of Building Setback, Building Disposition and Building Permeability in "Hong Kong Planning Standard and Guidelines" (HKPSG) and follow

the building separation requirement (20-33.3%) in the “Sustainable Building Design Guidelines”[1].

[1] Hong Kong Buildings Department. Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers: Sustainable Building Design Guidelines (APP-152). 2016.

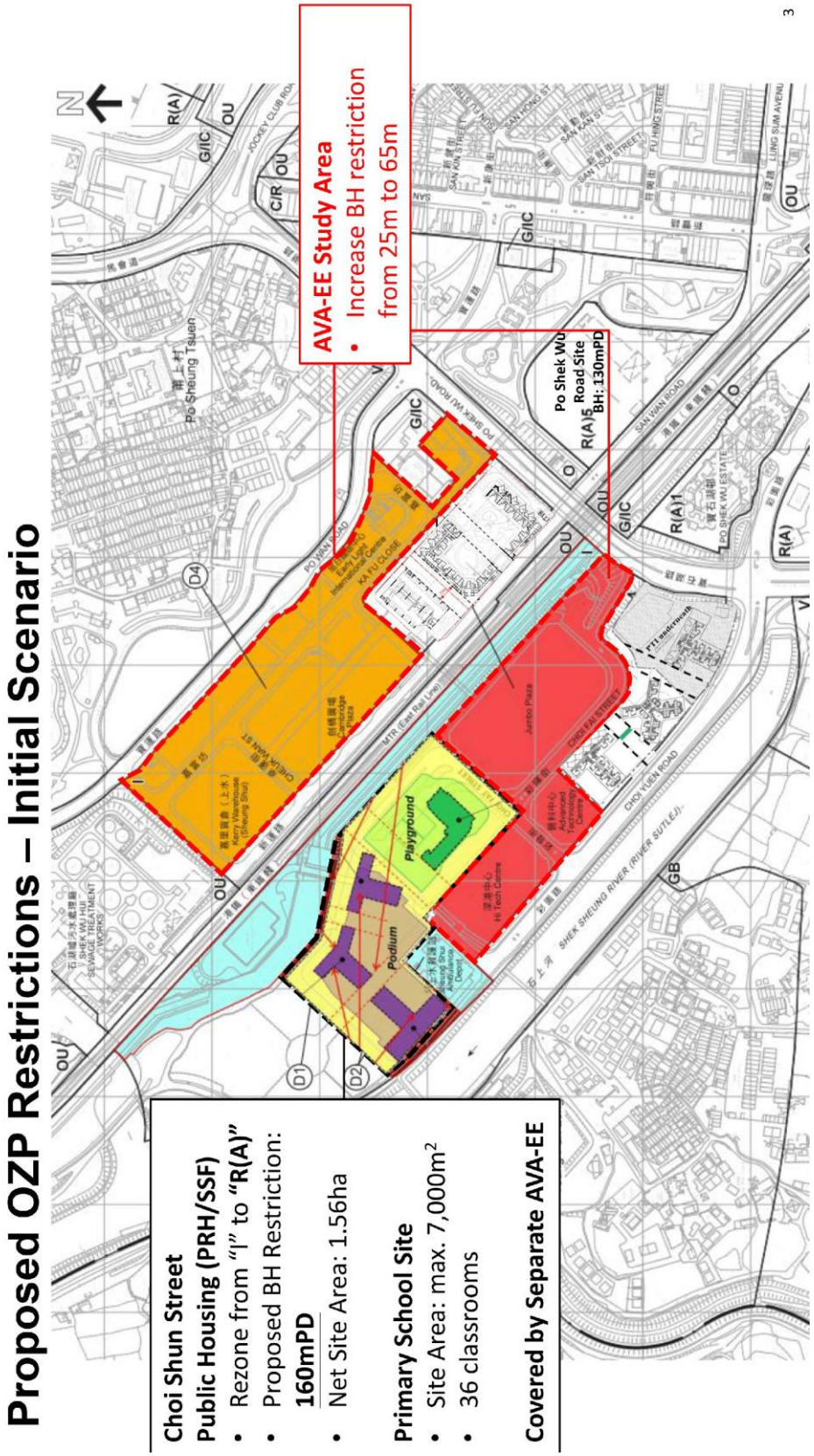


Figure 7.1 Initial Scenario of the Project Sites.

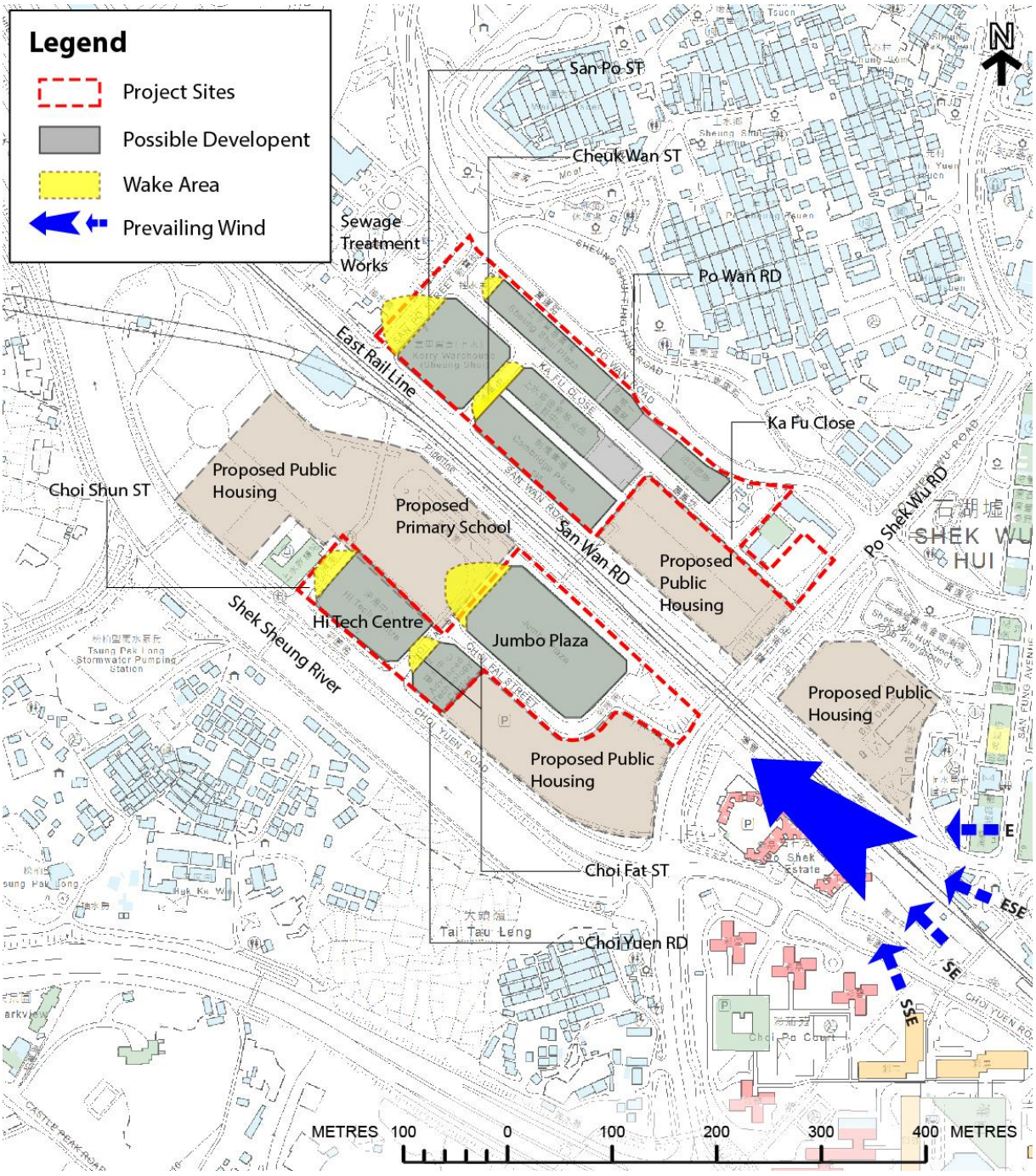


Figure 7.2 Possible wake areas under prevailing E, ESE, SE and SSE winds.

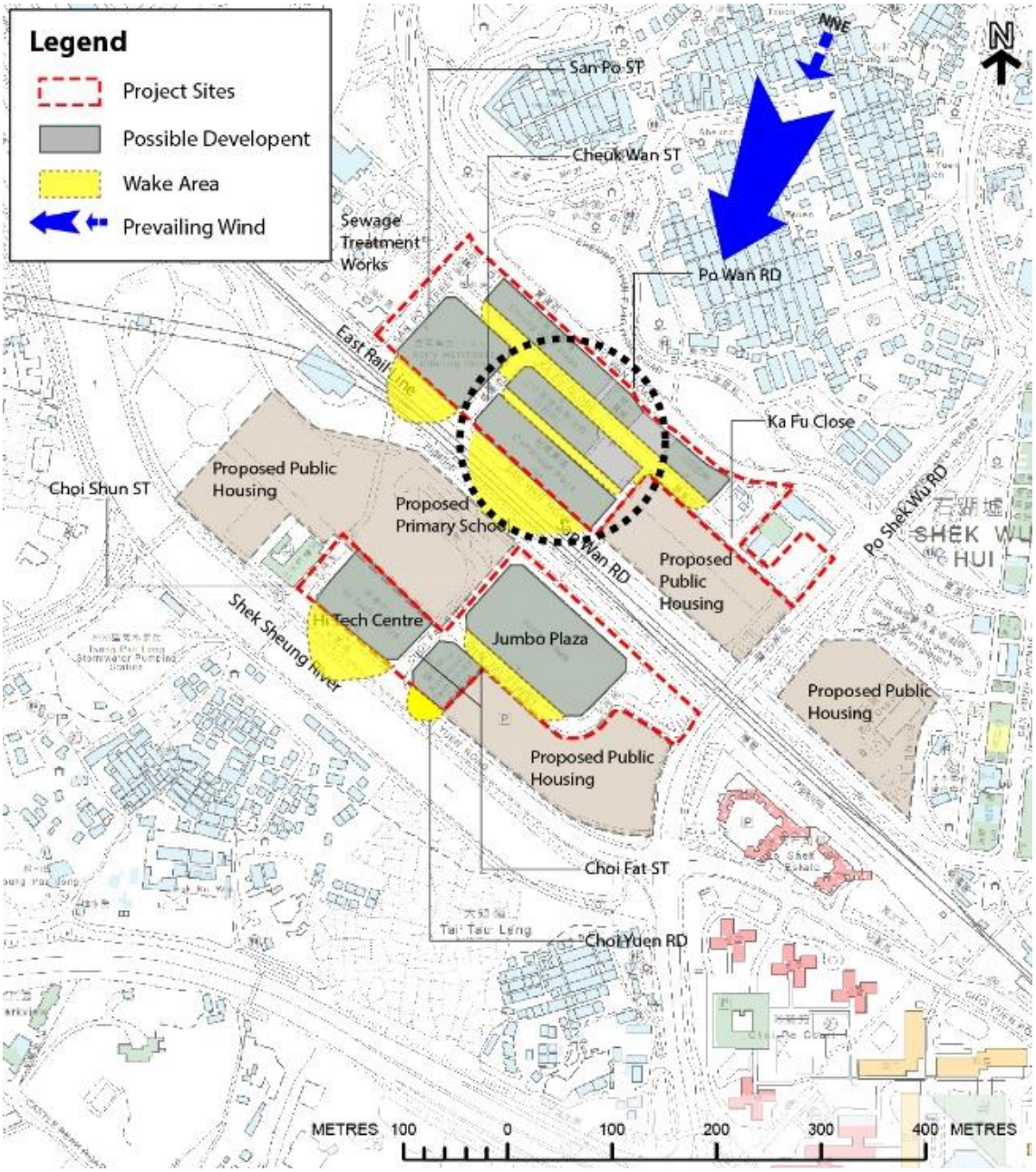


Figure 7.3 Possible wake areas under prevailing NNE wind.

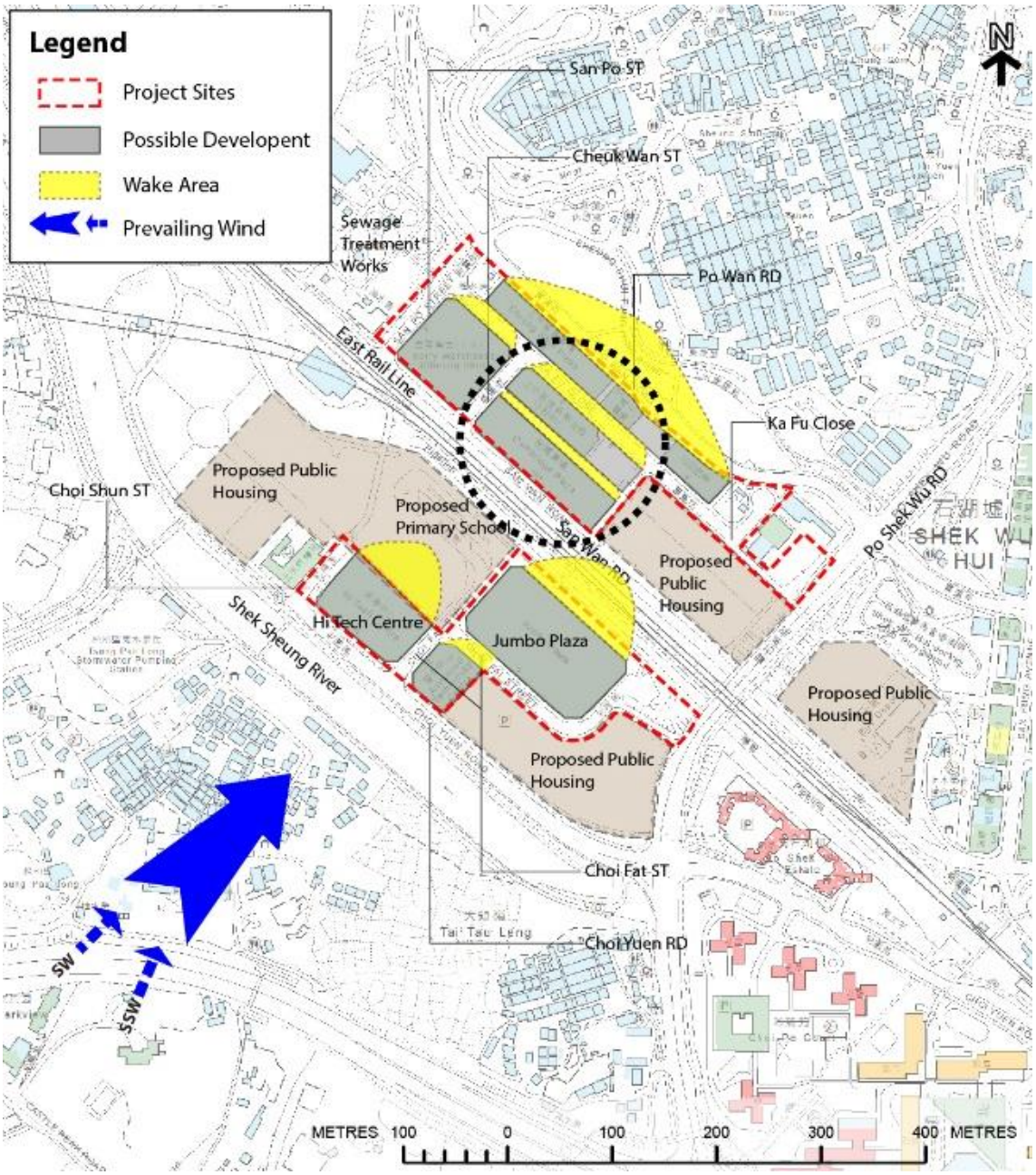


Figure 7.4 Possible wake areas under prevailing SSW and SW winds.

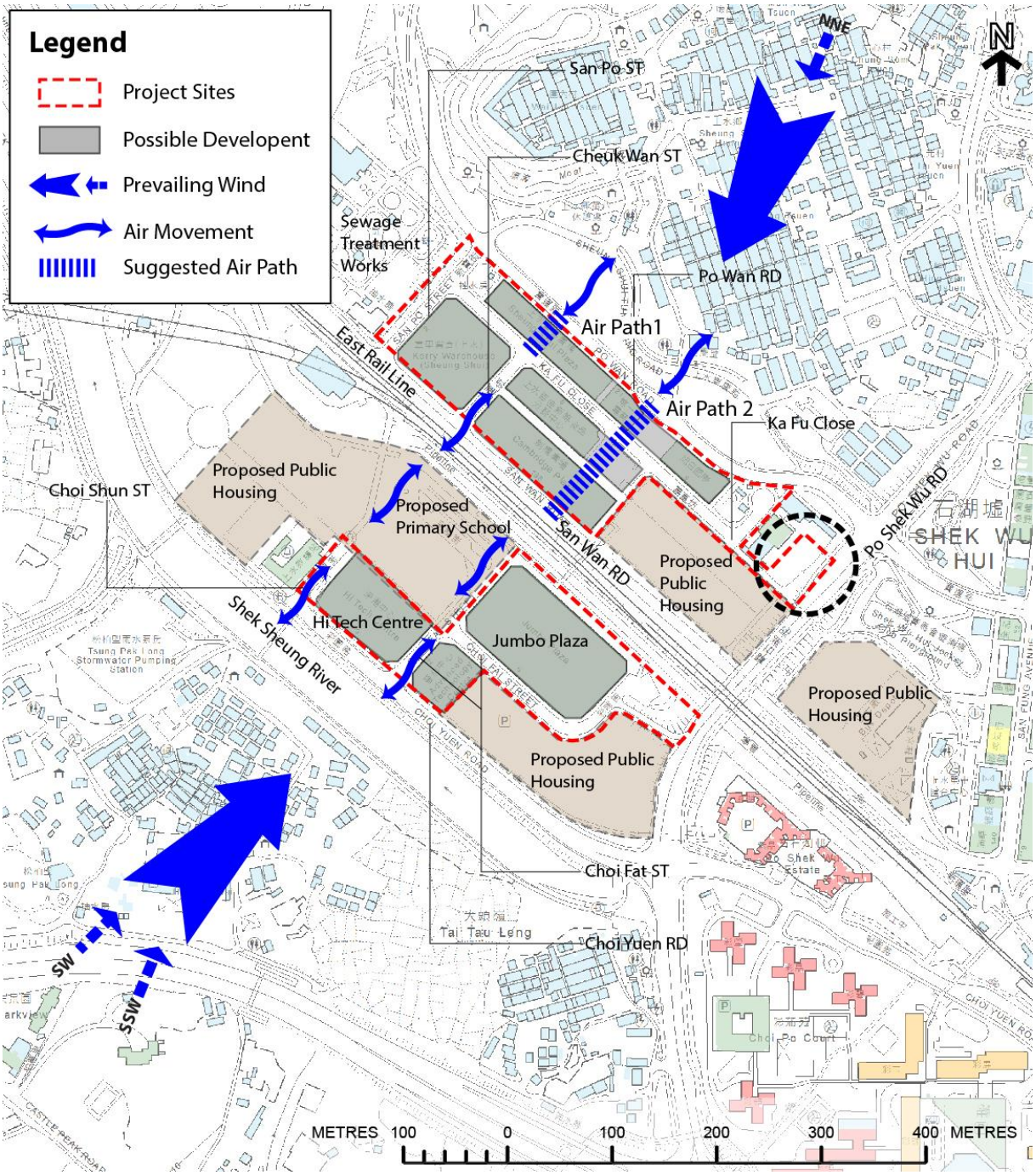


Figure 7.5 Suggested Air Paths under prevailing winds.

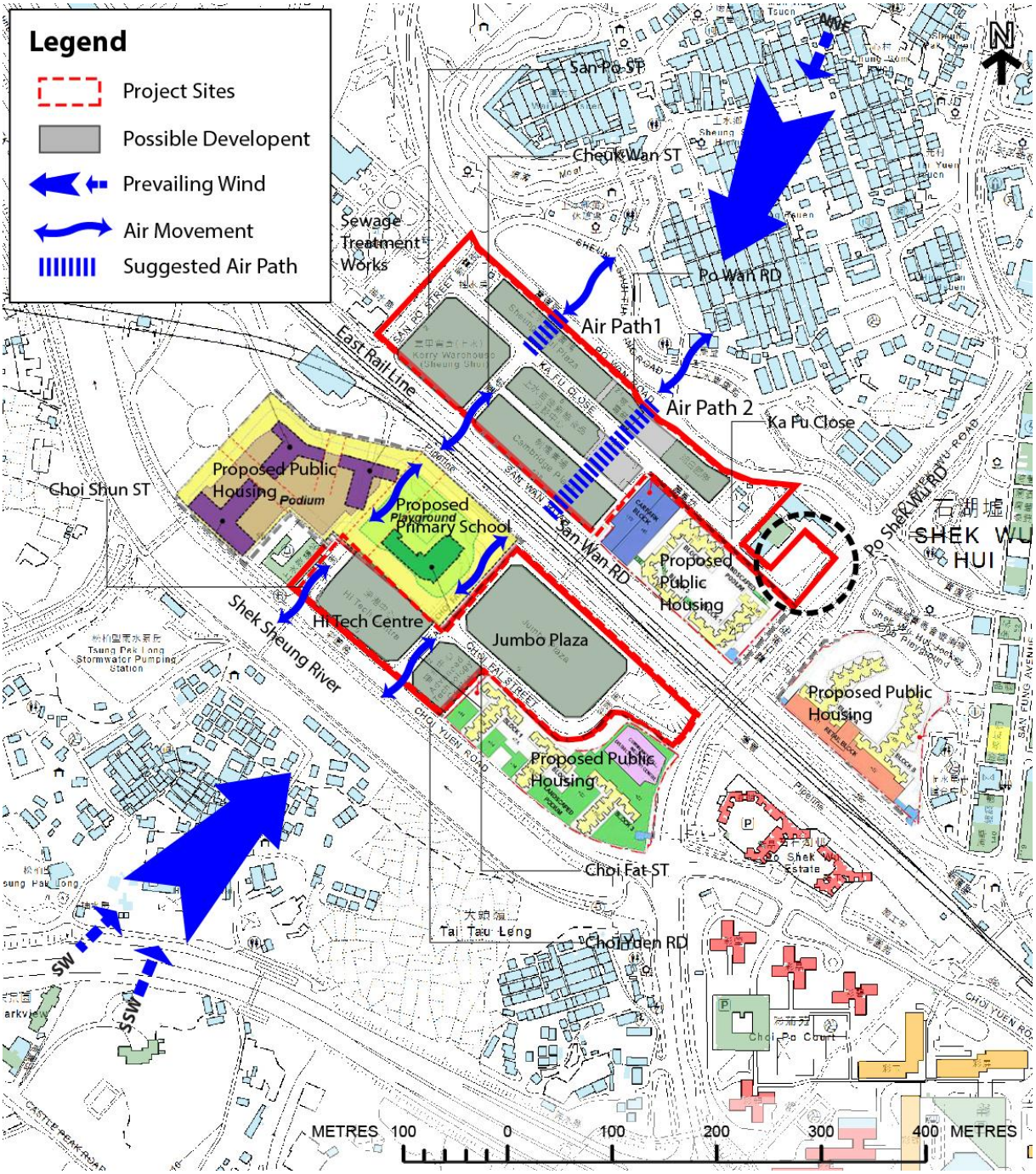


Figure 7.6 Suggested Air Paths with the layouts of nearby proposed developments.

8.0 Further Work

8.1 Given that both designated air paths and requirement of building separation requirements under the Sustainable Building Design Guidelines as set out in paragraph 7.6 would be fulfilled as recommended, the Project Sites would have no major air ventilation issues. If the requirements of air paths and building separations cannot be met, further quantitative assessments should be conducted to demonstrate that the performance of any future development be no worse off than the scenario with these measures.

Prepared by

_____ Date: 16 November 2021

Justin Ho

Endorsed by

_____ Date: 16 November 2021

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Appendix A

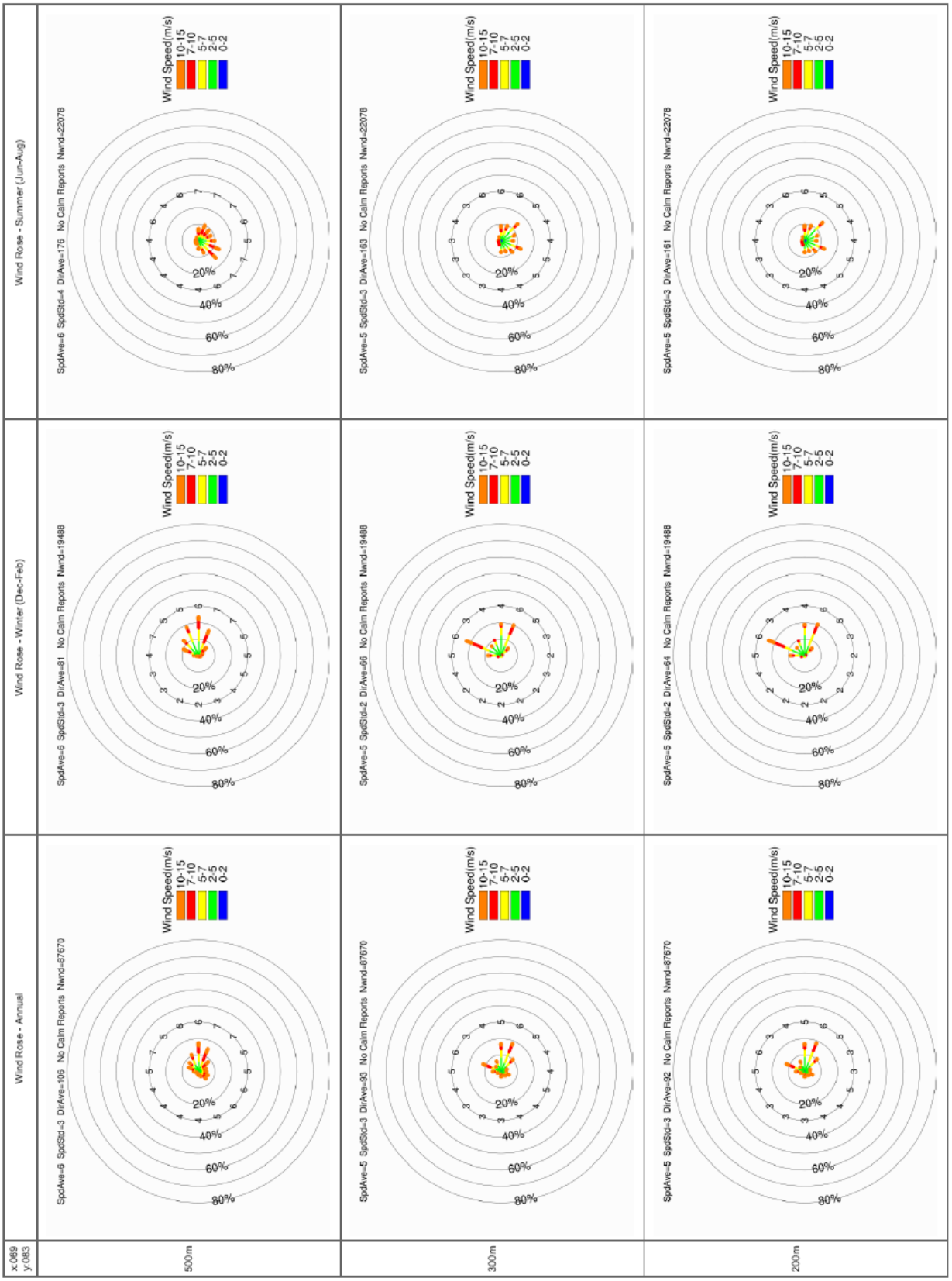


Figure A-1 The RAMS wind rose extracted from PlanD's website at grid x:069; y:083

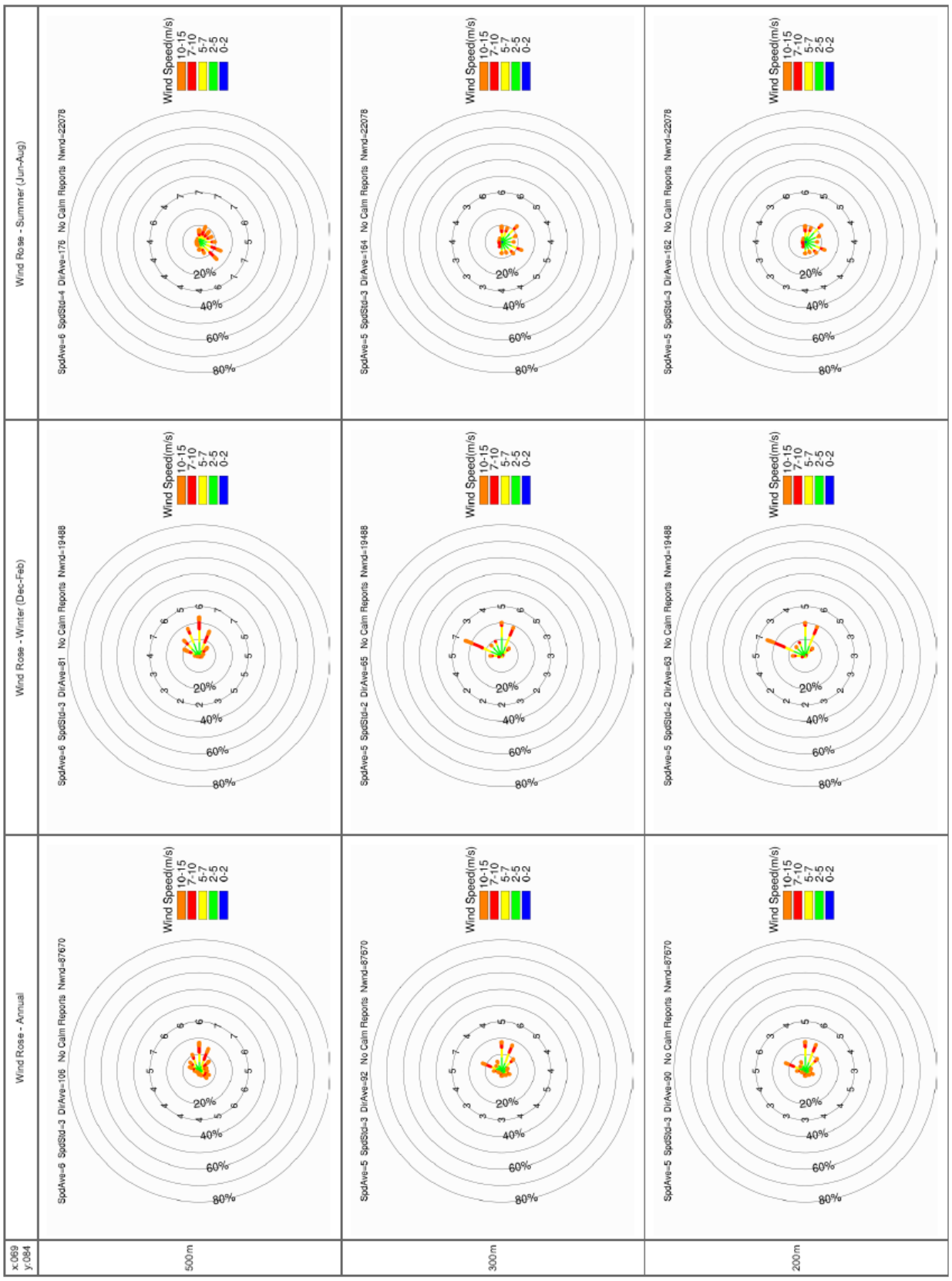


Figure A-2 The RAMS wind rose extracted from PlanD's website at grid x:069; y:084

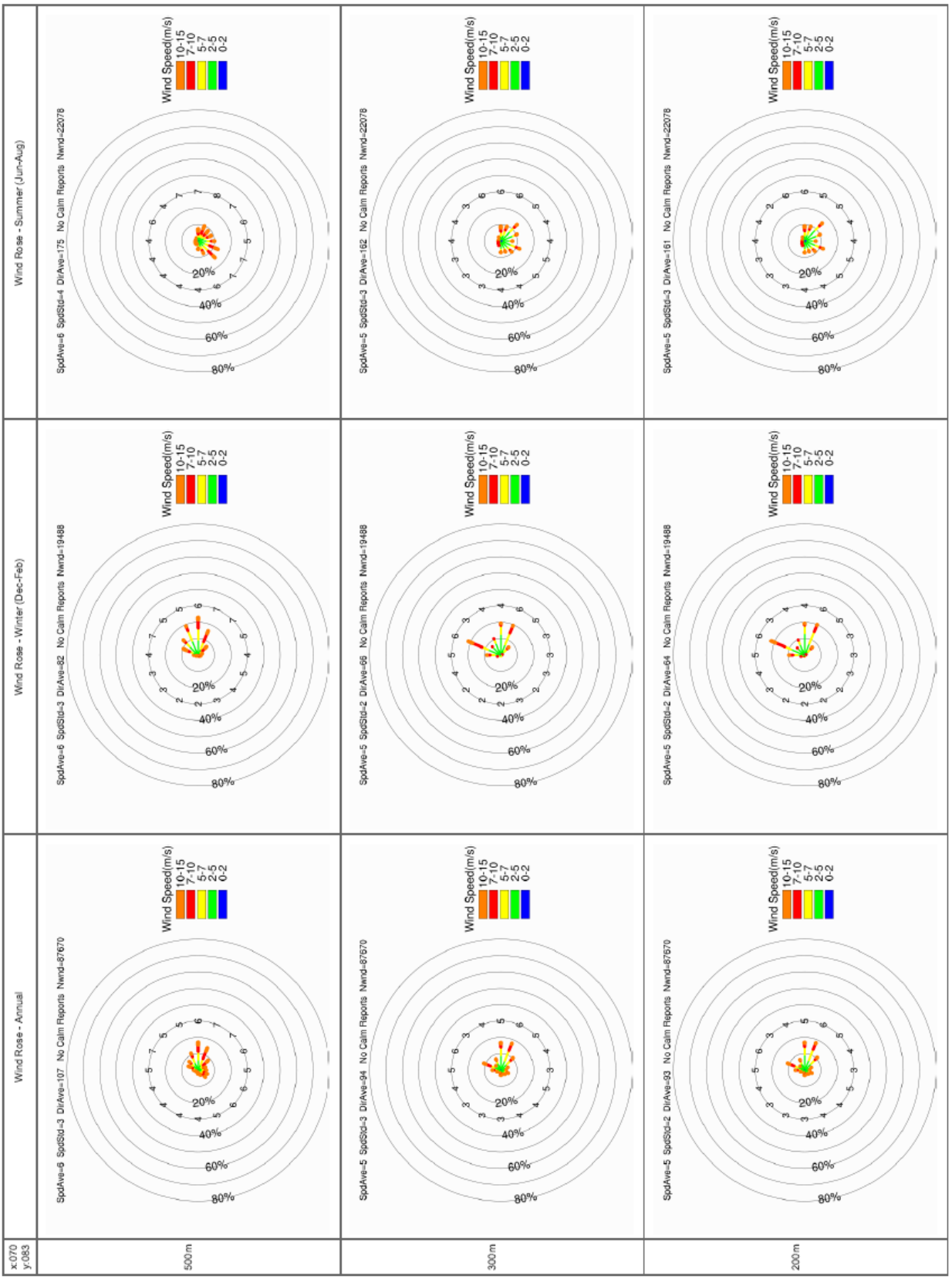


Figure A-3 The RAMS wind rose extracted from PlanD's website at grid x:070; y:083

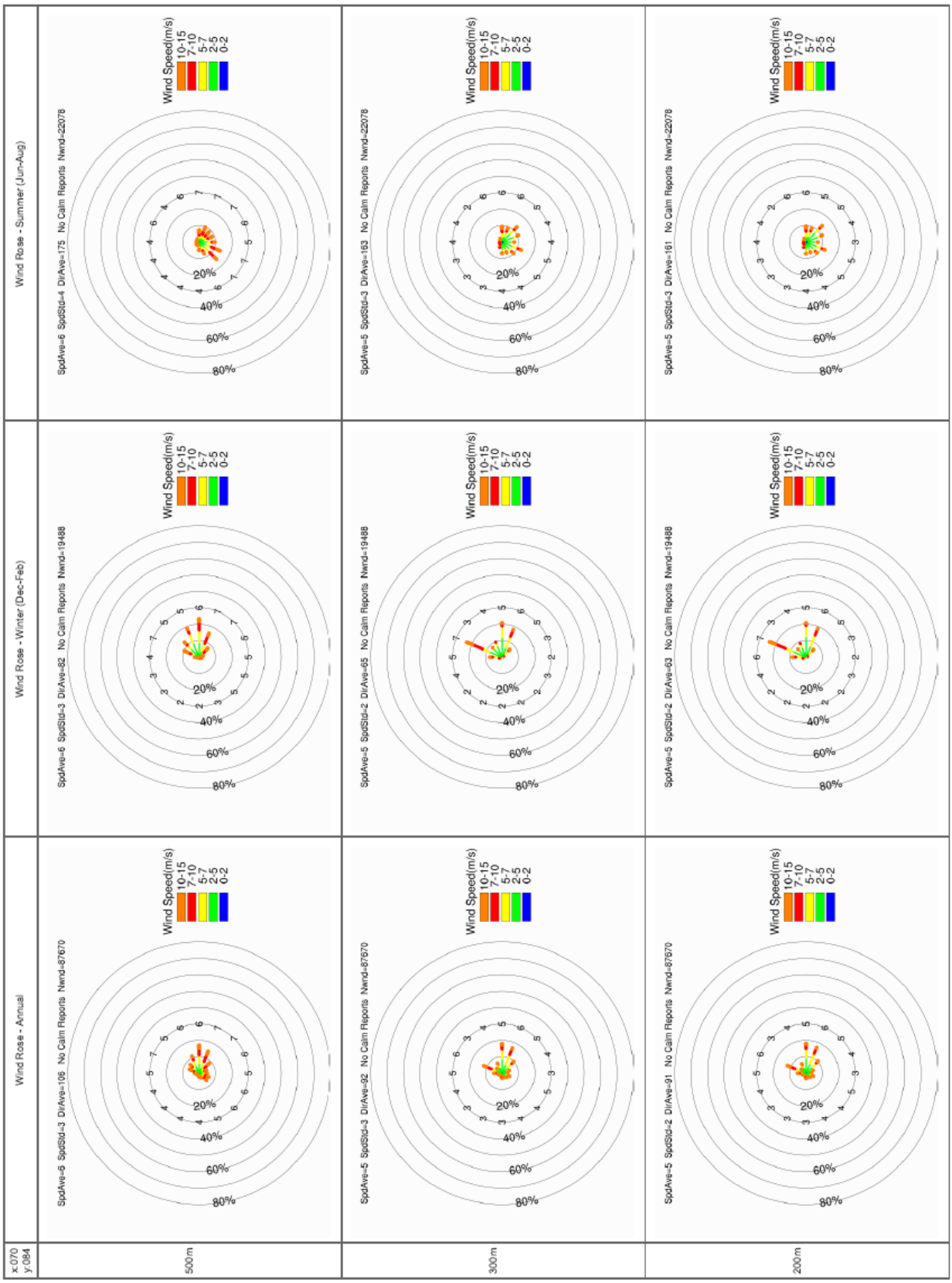
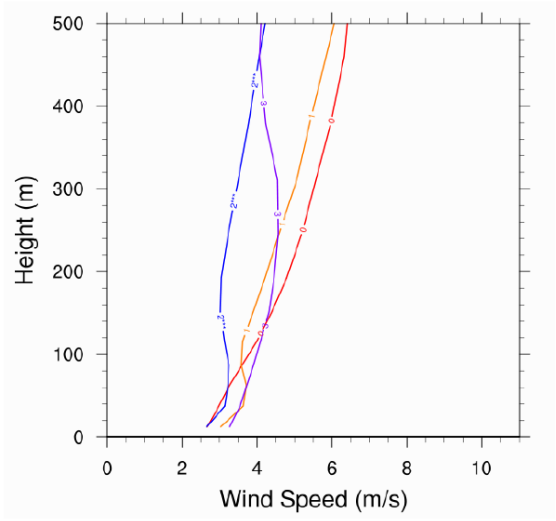
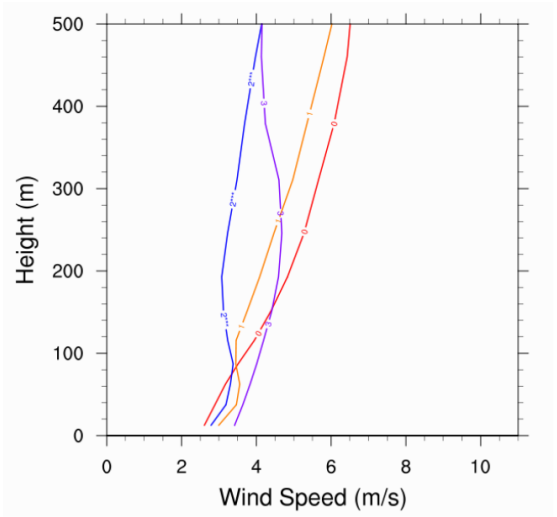


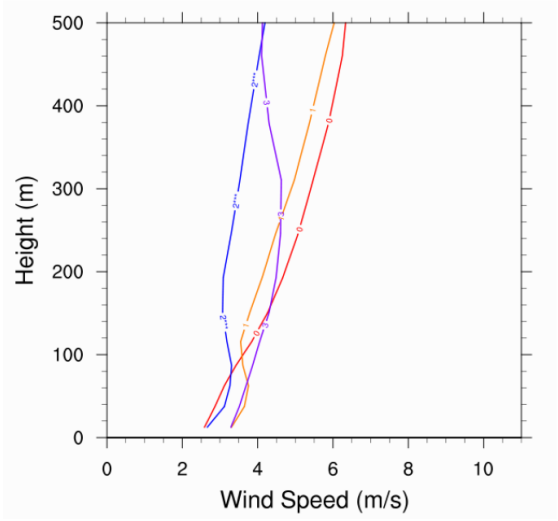
Figure A-4 The RAMS wind rose extracted from PlanD's website at grid x:070; y:084



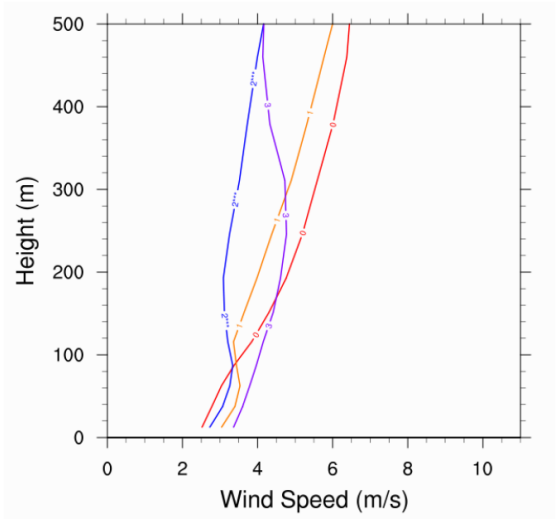
at grid x:069; y:083



at grid x:069; y:084



at grid x:070; y:083



at grid x:070; y:084

Figure A-5 The vertical wind speed profile of RAMS wind data extracted from PlanD's website

3.3.2.1 The pattern of air flow around isolated buildings is well known. (Figure 3.3.2.1) (Figure 3.3.2.2) (Figure 3.3.2.3)

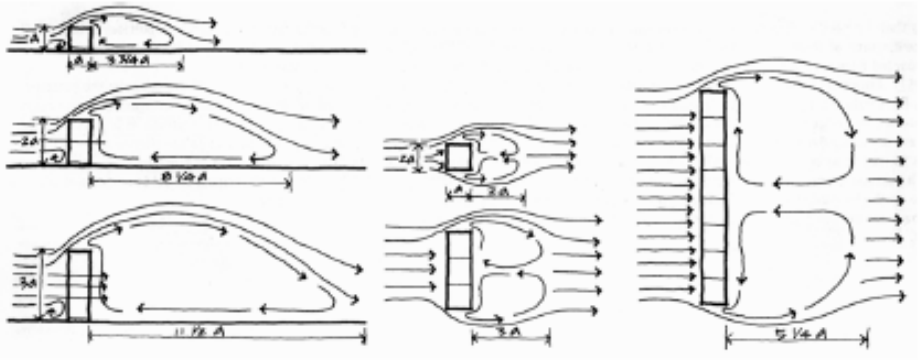


Figure 3.3.2.1: Wind flow around a simple building. Note that the wind 'shadow' behind the building depends on the "bulk" of the building represented by the height and width (permeability not shown here) is known as the wake area. Wind speed in this area is lower than the free wind. It could be highly turbulent. (Evan 1057) (Courtesy G Z. Brown 2001)

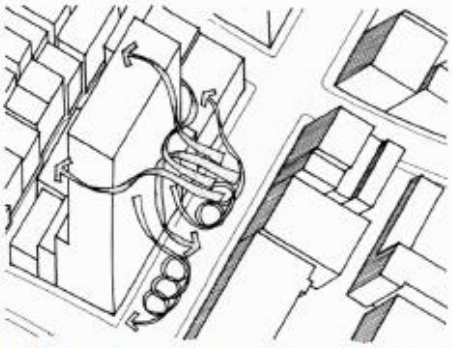


Figure 3.3.2.2: Wind flow on the windward face of a simple slab building. Note the downward vortex it generates. This phenomenon could cause uncomfortable wind gust at ground level under some conditions. Or it could be used beneficially to bring fresh air down to the street level. (Gandemer 1978) (Thurow 1983) (Courtesy G Z. Brown 2001)

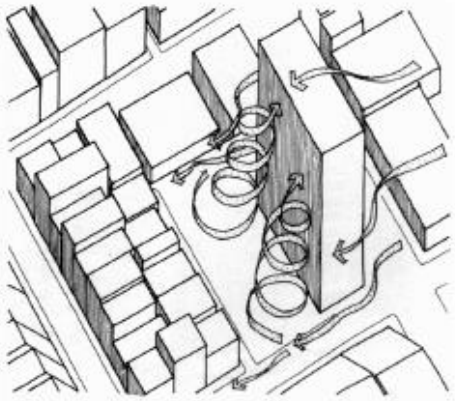


Figure 3.3.2.3: Wind over a slab building in the city and the "wake" effect it generates at its back. This zone could be considered the wind shadow of the building in front and may cause undesirable effects if not carefully handled. ((Courtesy G Z. Brown 2001)

Figure A-6 Pattern of air flow around buildings in "Planning Department: Feasibility Study for Establishment of Air Ventilation Assessment System, FINAL REPORT (2005)"

With wind from directions perpendicular to the canyons, downwashes due to the differentials in building heights is occasionally likely when building heights are very different. Otherwise, with smaller building height differences, this is unlikely. It is known that for long and deep canyons with an H/W ratio of 2 and above, a double vortex phenomenon will be observed (see Figure A-2). However, 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.

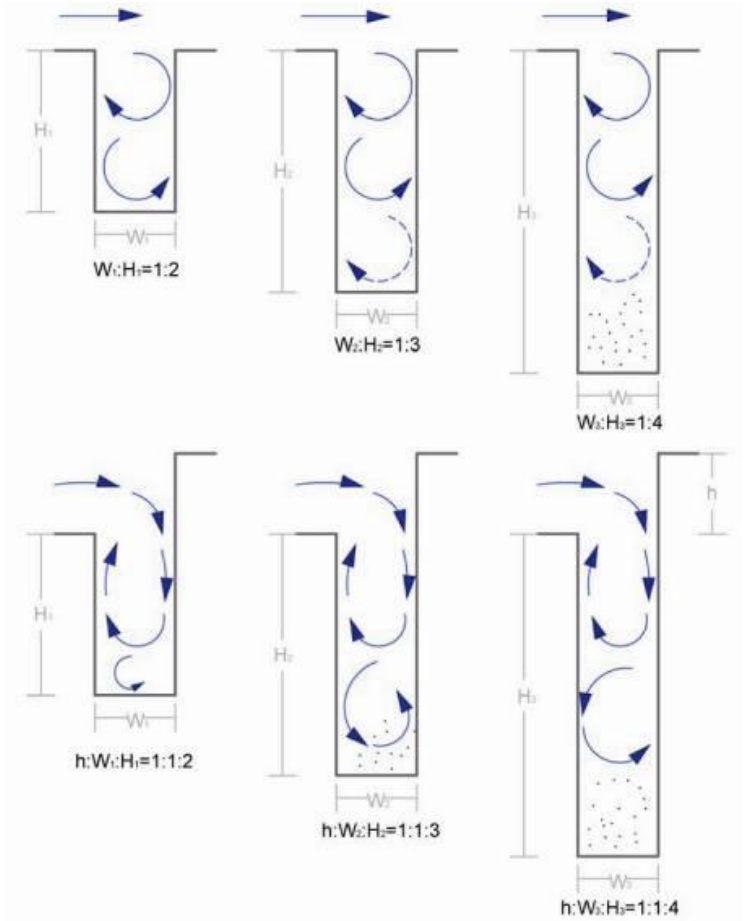


Figure A-7 The figure shows a generic understanding of the wind regimes in canyons, and canyons with downwashes.

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

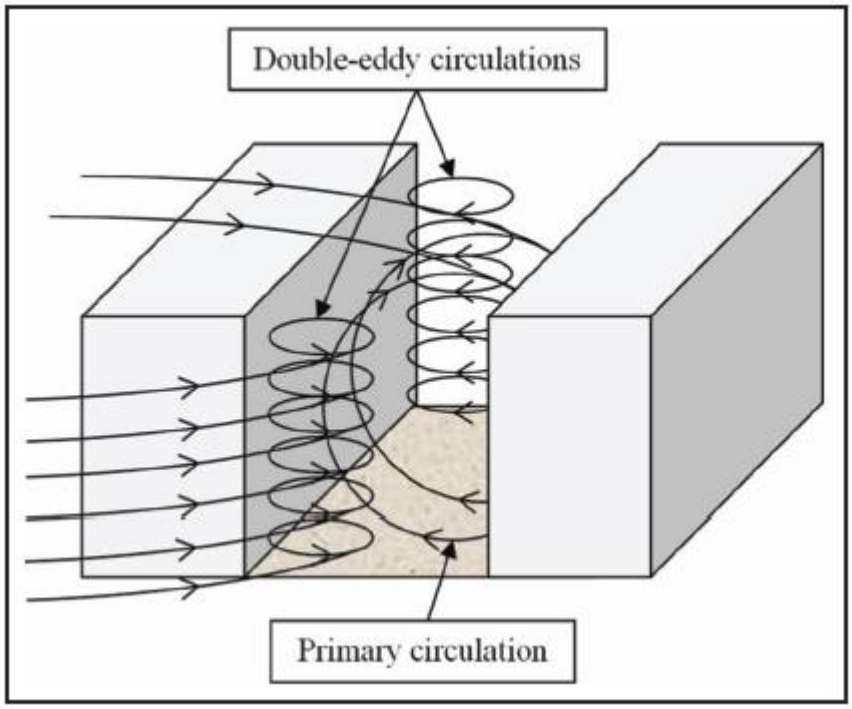

Figure A-8 Flow structures in an isolated street canyon with perpendicular air flow.

[Reference: Yazid, A. W. M., Sidik, N. A. C., Salim, S. M., & Saqr, K. M. (2014). A review on the flow structure and pollutant dispersion in urban street canyons for urban planning strategies. *Simulation*, 0037549714528046.]

CFD study on street canyon

Studies in Hong Kong show that with the increase of the H/W, the air flow will go up along the long street canyon. The wind at the ground level is weak in the depth of the street canyon.

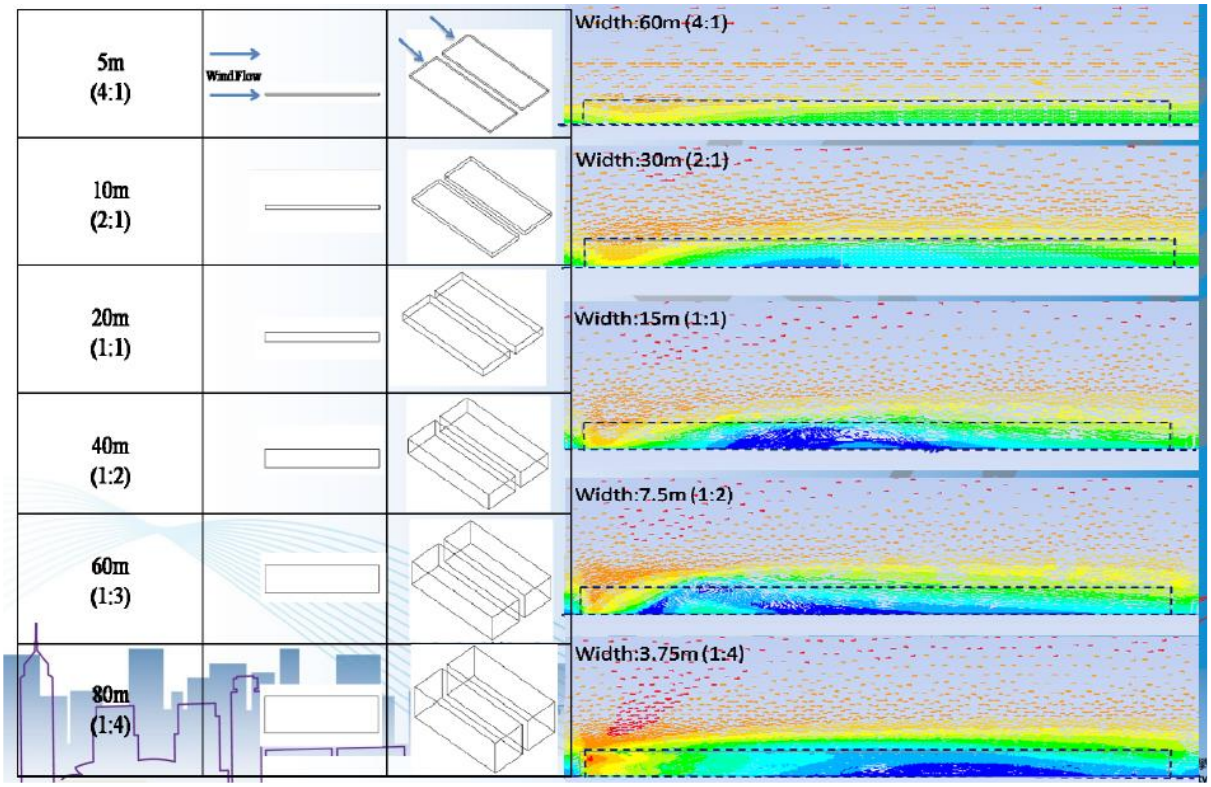

Figure A-9 CFD study on street canyon with varying width/height

[Reference: Choi, E. Air ventilation studies.
https://www.housingauthority.gov.hk/hdw/content/static/file/en/aboutus/events/qualityhousing/seminar/07CityUProfEdmundChoi.pdf]

Appendix B

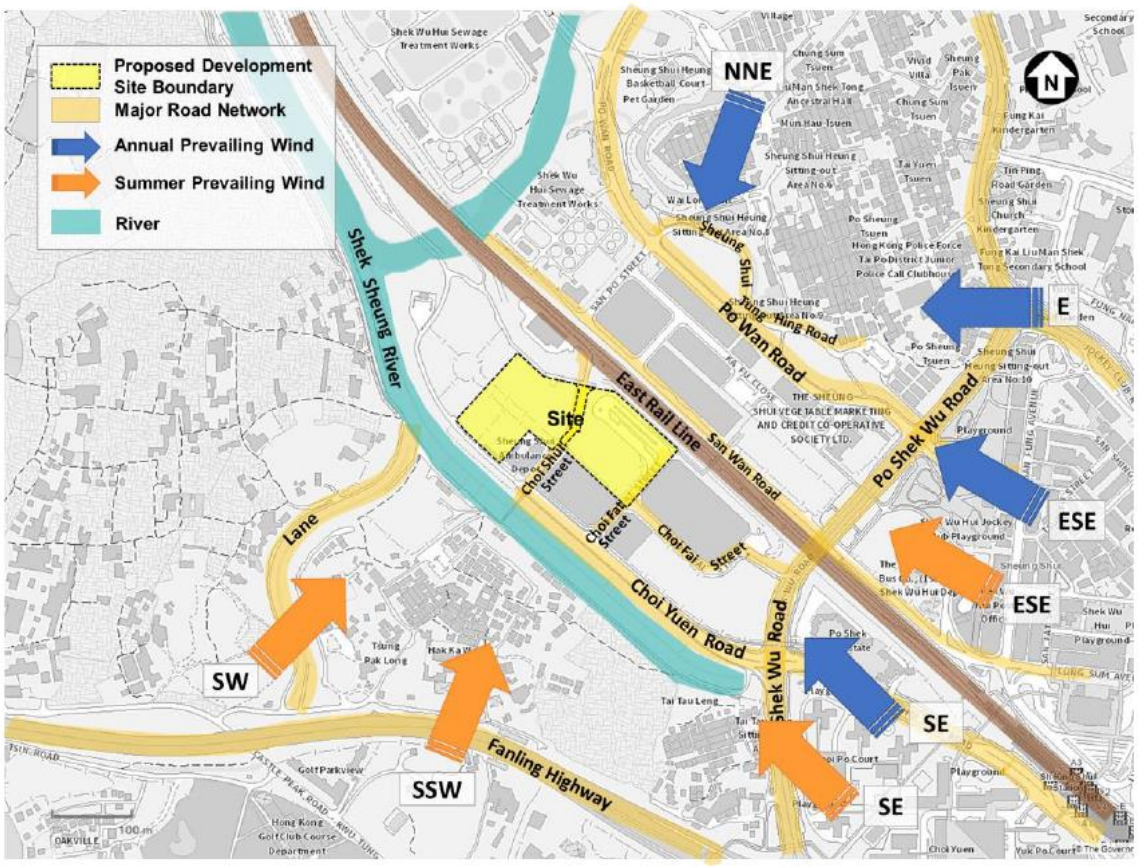

Figure B-1 Summary of Prevailing Annual and Summer Winds of the Site for Housing Developments at Pak Tin Extension and Chak On Road South, Sham Shui Po and Choi Shun Street

[Reference: Civil Engineering and Development Department: Site Formation and Infrastructure Works for Housing Developments at Pak Tin Extension and Chak On Road South, Sham Shui Po and Choi Shun Street, Sheung Shui - Feasibility Study (2020)]

3.3 Summary of Site Wind Availability

The wind data from RAMS published by PlanD and Ta Kwu Ling Weather Station have been studied and summarized in Table 3.

Table 3 Prevailing Wind Directions for the Project Sites

Prevailing Wind	Annual	Summer
RAMS	NNE/E/ESE	ESE/SE/SSE/SSW
HKO (Ta Kwu Ling Weather Station)	E	E/SSW

It could be concluded that the annual prevailing wind is from north-northeast (NNE), east (E) and east-southeast (ESE) directions, whereas the summer prevailing wind comes from east (E), east-southeast (ESE), southeast (SE), south-southeast (SSE) and south-southwest (SSW). The evaluation of site wind performance would consider both site wind availability data and site characteristics.

Prevailing Wind	Annual	Summer
Studied Wind Directions	NNE/E/ESE	E/ESE/SE/SSE/SSW

Figure B-2 Summary of Prevailing Annual and Summer Winds of the Site for Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site

[Reference: Hong Kong Housing Authority: Air Ventilation Assessment of Proposed Developments at Sheung Shui Areas 4 & 30 Sites 1 & 2 and Po Shek Wu Road Site - Expert Evaluation Report (2019)]