AECOM Asia Company Limited

Air Ventilation Assessment Report for Expansion of Hong Kong Science Museum and Hong Kong Museum of History

June 2022

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Glossary List

LCSD	Leisure and Cultural Services Department
PlanD	Planning Department
OZP	Outline Zoning Plan
HKScM	Hong Kong Science Museum
HKMH	Hong Kong Museum of History
AVA	Air Ventilation Assessment
CFD	Computational Fluid Dynamics
VR	Wind Velocity Ratio
V_∞	Wind availability of the Site
V_P	Wind velocity at the 2m pedestrian level
VR_W	Frequency weighted wind velocity ratio calculated
SVR_W	Site Spatial Average Wind Velocity Ratio
LVR_W	Local Spatial Average Wind Velocity Ratio

1 INTRODUCTION

1.1 Background

1.1.1 The Air Ventilation Assessment (AVA) Study is prepared on behalf of the Leisure and Cultural Services Department (i.e. the Applicant) to seek the permission of the Town Planning Board for proposed minor relaxation of building height and site coverage restrictions for the Expansion of Hong Kong Science Museum and Hong Kong Museum of History – located in Tsim Sha Tsui, bounded by Chatham Road South, Granville Road, Science Museum Road and Cheong Wan Road ("the Subject Site") to examine the air ventilation performance of its building design quantitatively and formulate effective and practicable measures enhancing the air ventilation as part of the continuous design improvement process.

1.1.2 The Application Site falls within an area zoned "Other Specified Uses" ("OU") annotated "Museums" ("OU(Museum)") and the area shown as 'Road' on the Approved Tsim Sha Tsui Outline Zoning Plan ("OZP") No. S/K1/28 gazetted on 13.12.2013. It is noted that this site is subject to a maximum building height restriction of 30mPD, a maximum site coverage of 60% and a minimum building setback of 7m from the site boundary along Chatham Road South to ensure the availability of land for open space provision and to facilitate air ventilation respectively.

1.2 Objectives

1.2.1 The air ventilation assessment for the proposed development is conducted in accordance with the methodology outlined in the Technical Guide for AVA for Developments in Hong Kong (the Technical Guide) annexed in Housing, Planning and Lands Bureau (HPLB) and the Environment, Transport and Works Bureau (ETWB) TC No. 1/06.

1.2.2 The main purposes of the AVA study include:

- To assess the characteristics of the wind availability (V_∞) of the site;
- To depict the general wind flow pattern and a quantitative estimation of wind performance at the pedestrian level reported using Wind Velocity Ratio (VR);
- To quantitatively assess the air ventilation performance in the neighborhood of the proposed development; and;
- To compare the difference of air ventilation performance between the proposed design scheme and the baseline scheme.

2 PROJECT DESCRIPTION

2.1 Site Characteristics

2.1.1 The Subject Site, Expansion of Hong Kong Science Museum (HKScM) and Hong Kong Museum of History (HKMH), is located in the Tsim Sha Tsui region, it currently consists of multiple commercial building blocks situated to the north and earth of the Tsim Sha Tsui MTR station. The Hong Kong Polytechnic University is located on North of the Subject Site, Chatham Road South to the west and north and Cheong Wan Road to the north of the Subject Site in which it is bounded by the Granville Road to the east and south and Science Museum Road to the east of the Subject Site as shown in Figure 1. The detailed building height data of the existing buildings within the Surrounding Area are demonstrated in Appendix A.

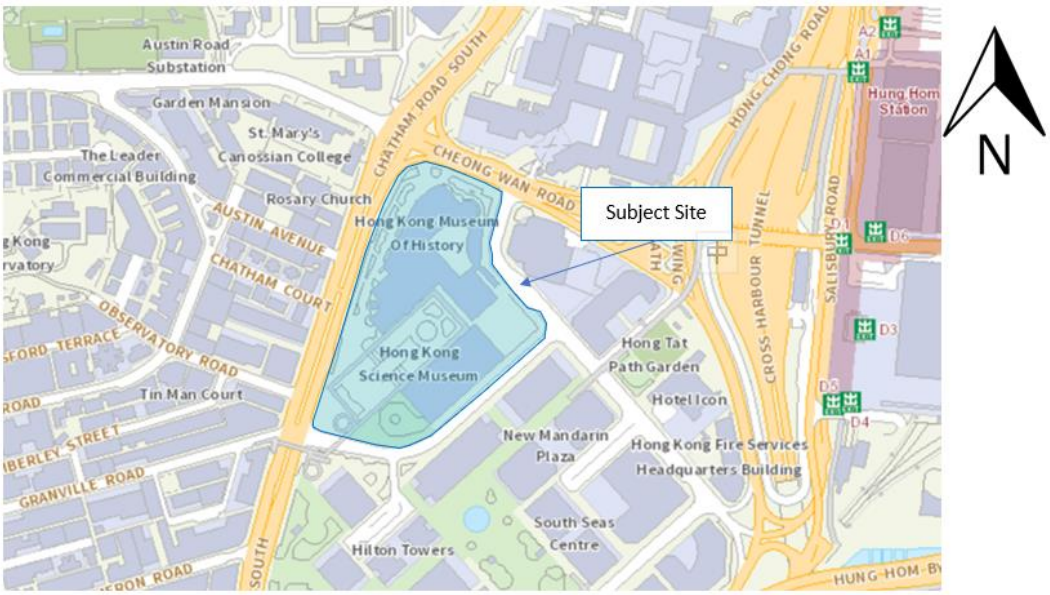


Figure 1 Overview of the Project Area and its Surroundings (Source: GeoInfo Map)

2.2 Baseline Scheme and Proposed Scheme

2.2.1 The proposed development includes the existing Hong Kong Science Museum (HKScM) and Hong Kong Museum of History (HKMH) as shown in Figure 2 and the proposed expansion consisting of two parts, i.e. Annex 1 with site area of about 1,860m^2 and Annex 2A & 2B with site area of about 7,981m^2. The total GFA increase from the expansion is about 33,280m^2.

2.2.2 In addition, relaxation of maximum building height restriction from 30mPD to 38mPD is proposed while the implication on air ventilation performance would be analyzed by CFD simulation in the current study.

Figure 2 The Existing Buildings in the Subject Site

2.2.3 There are two design schemes studied in this report. The baseline scheme is the existing condition with only two building blocks, i.e. HKScM and HKMH as shown in Figure 3 whereas the proposed scheme includes the existing blocks as well as the proposed expansions as shown in Figure 4.

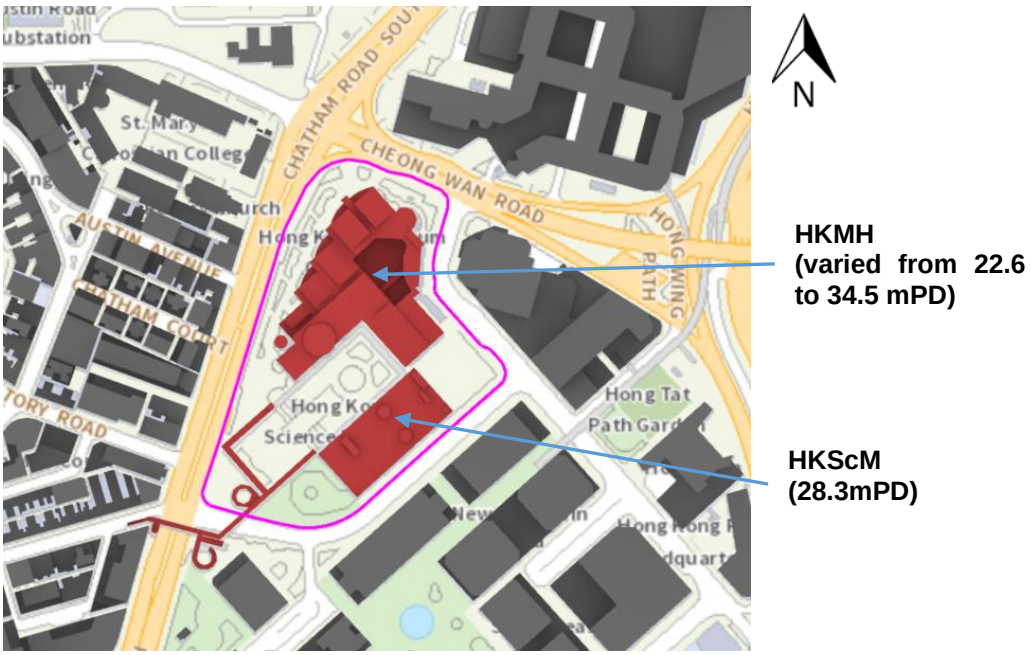


Figure 3 Top View of the Baseline Scheme

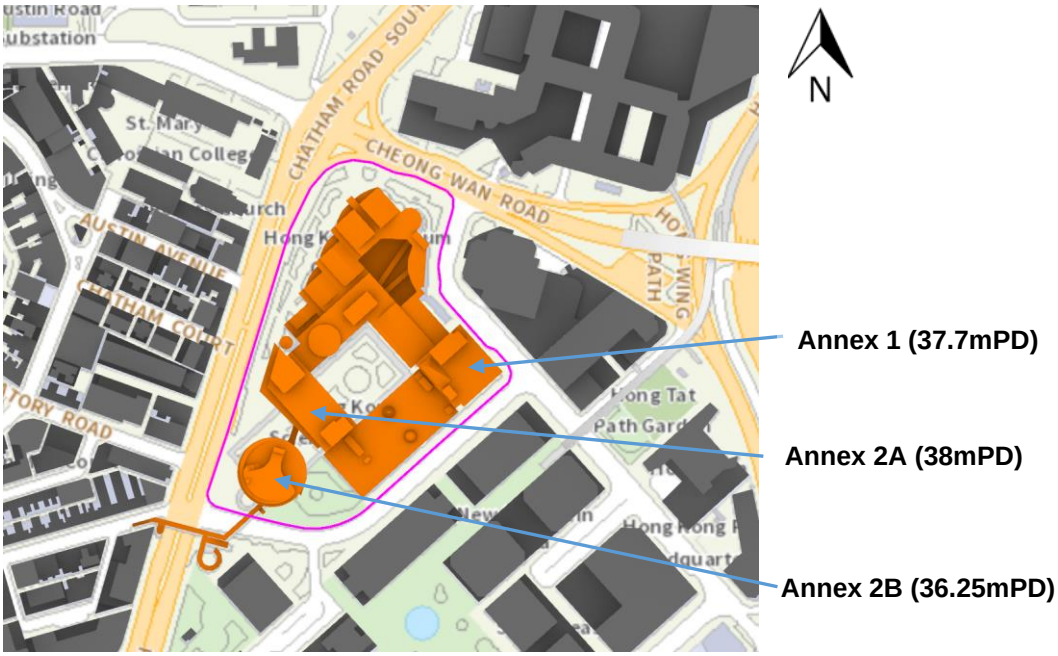


Figure 4 Top View of the Proposed Scheme

2.2.4 Figure 5 to Figure 8 show the 3D physical model of the Baseline Scheme and the Proposed Scheme.

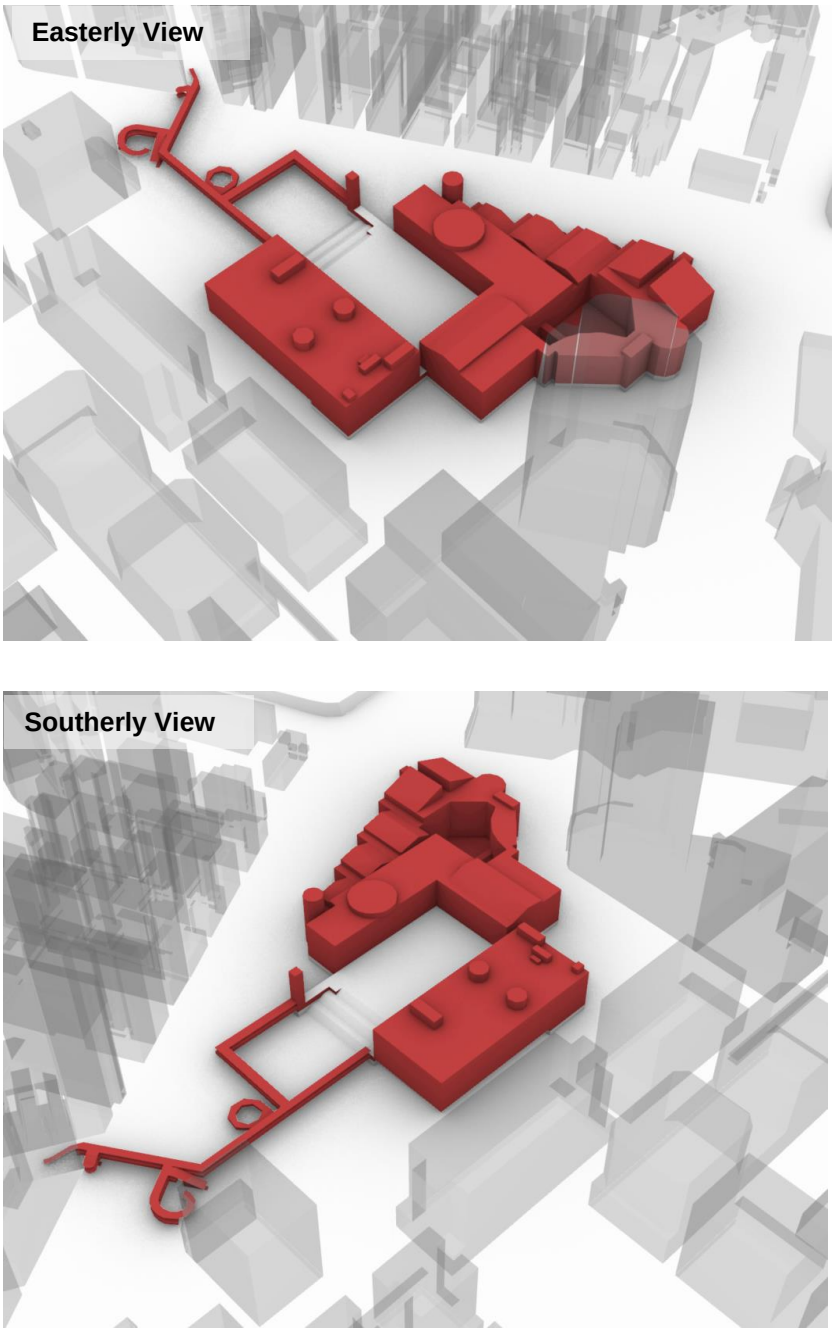


Figure 5 3D Model of the Baseline Development

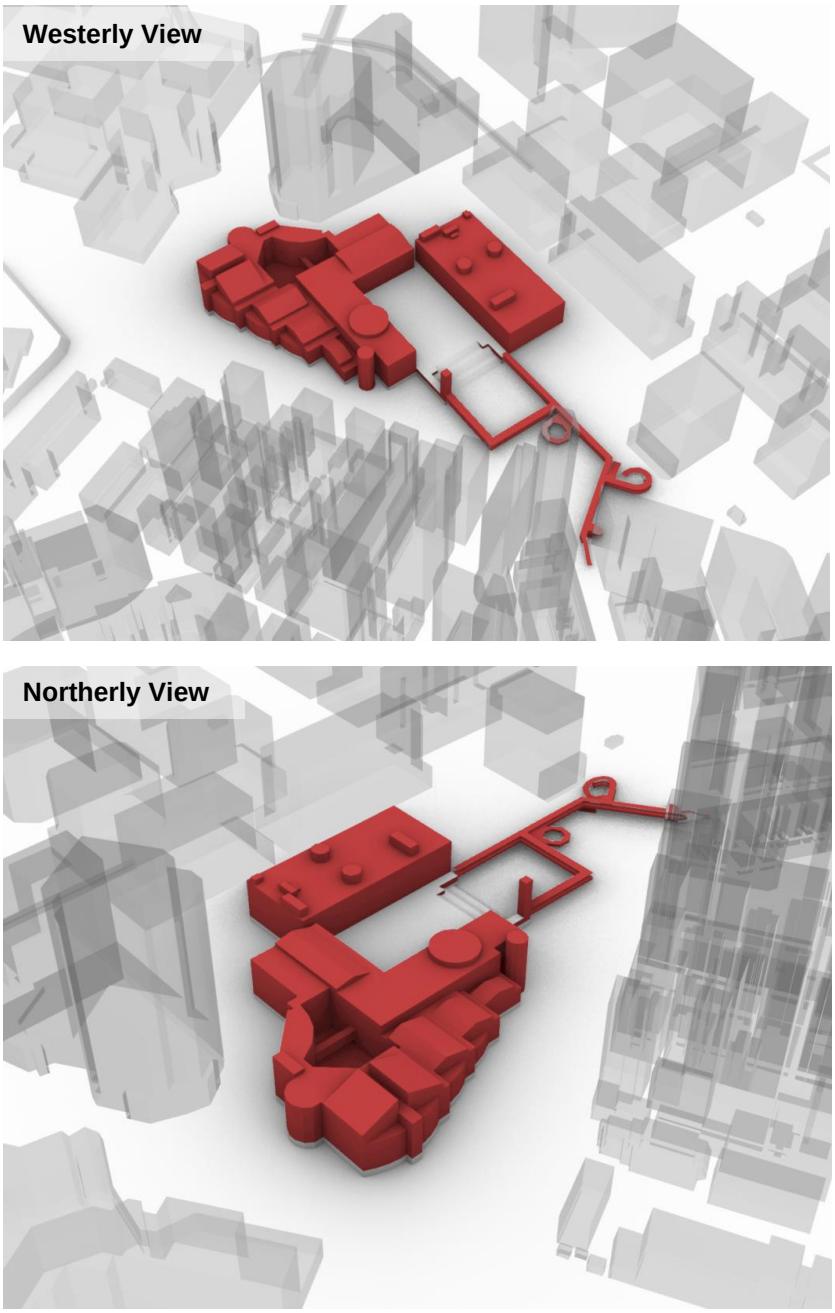


Figure 6 3D Model of the Baseline Development

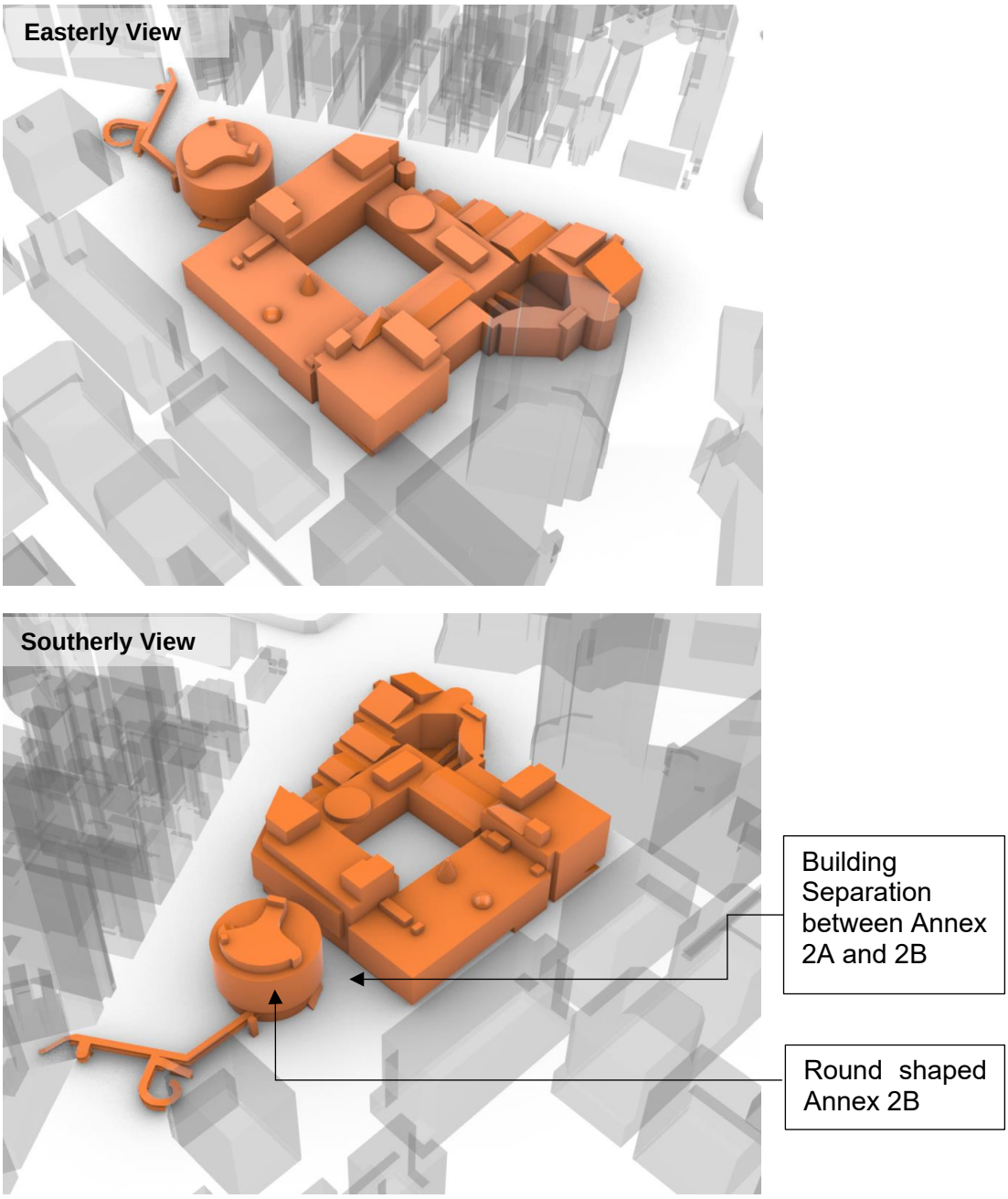


Figure 7 3D Model of the Proposed Development

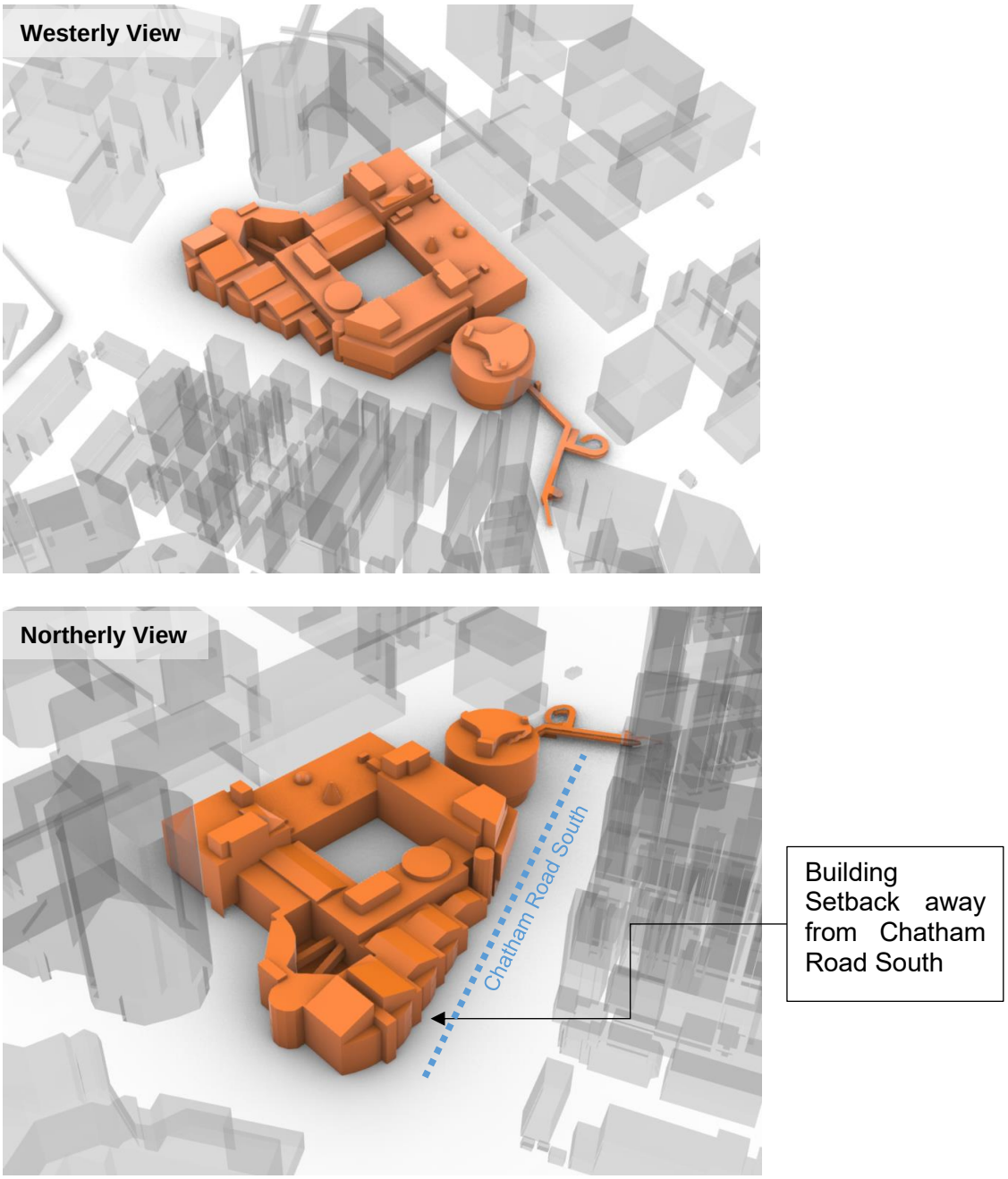


Figure 8 3D Model of the Proposed Development

2.2.5 Figure 9 illustrates a section through the proposed development.

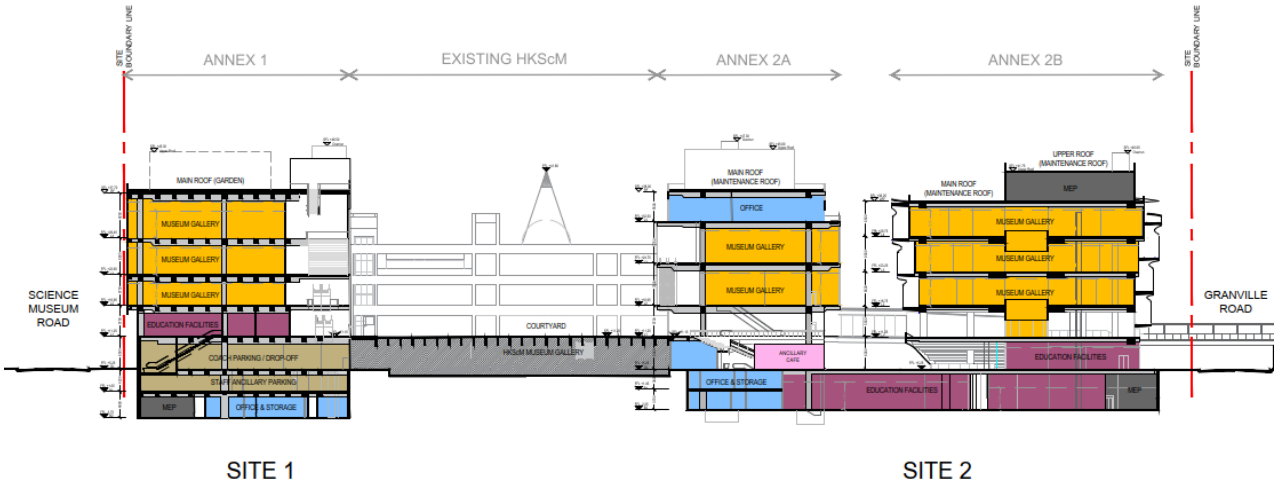


Figure 9 Section of Proposed Annex Buildings

2.3 Good Wind Feature in the Baseline and Proposed Schemes

2.3.1 With reference to the Tsim Sha Tsui Outline Zoning Plan No. S/K1/28, a minimum building setback of 7m from the site boundary along Chatham Road South to facilitate air ventilation should be applied in the design scheme.

2.3.2 It is noted that the Baseline Scheme, i.e. the existing condition, has adopted the building setback of at least 7m from the site boundary along Chatham Road South while this good wind feature is carefully remained as well during developing the proposed extension Annex 2A and 2B in the Proposed Scheme as shown in Figure 10.

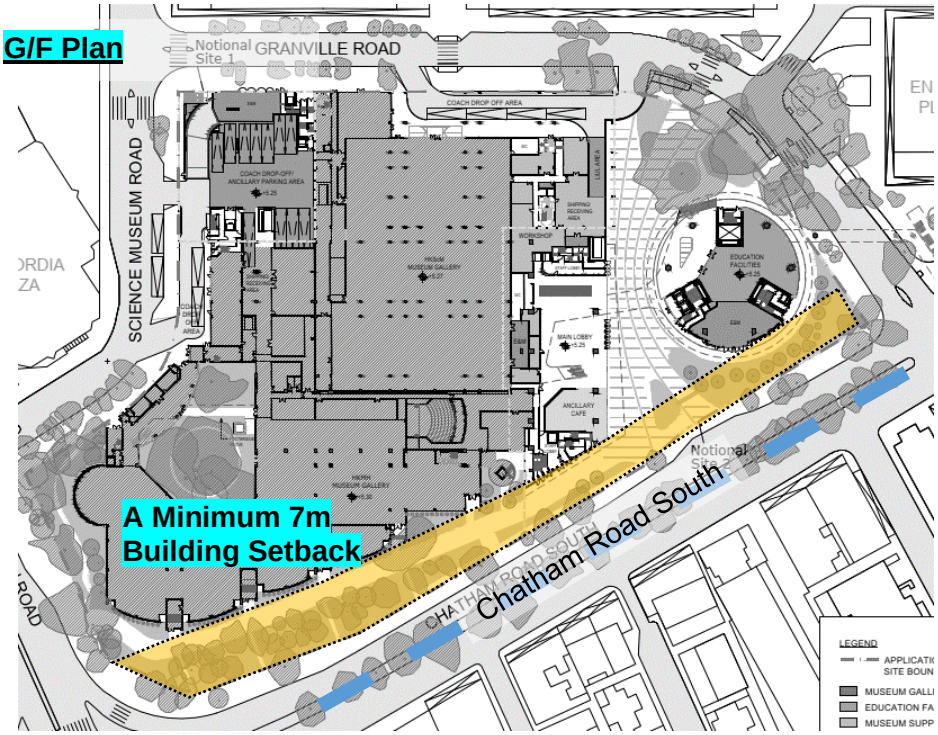


Figure 10 Ground Floor Plan of the Proposed Scheme

2.3.3 As the location of Annex 2A and 2B is an open space under the Baseline Scheme, wind performance at the vicinity of Annex 2A and 2B might be affected adversely under the Proposed Scheme. To mitigate the implication, building separation between the Annex 2A and 2B is adopted in the design scheme. Detailed dimensions on the building separation is illustrated from Figure 11 to Figure 13. It is anticipated that the building separation would provide a wind passage to improve the wind performance at the site perimeter area.

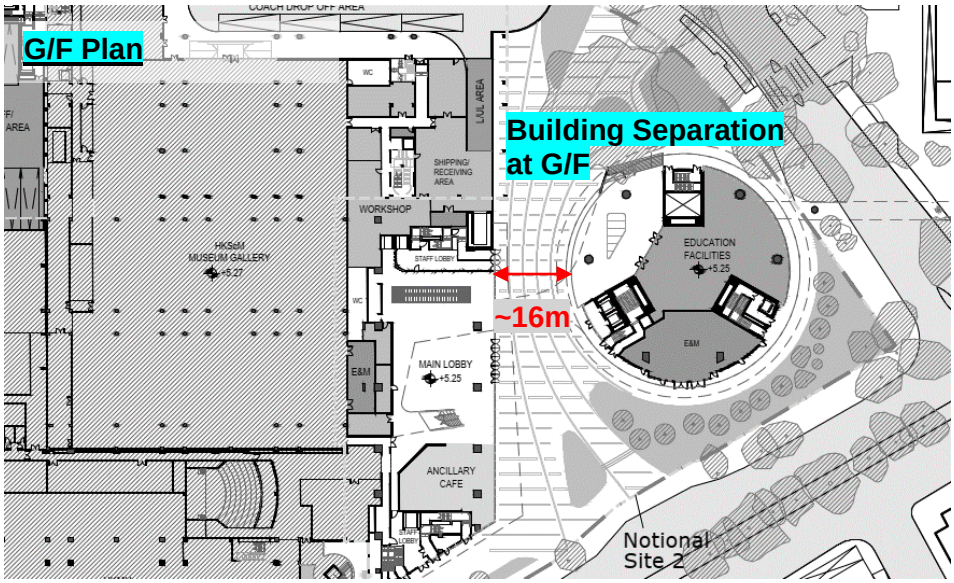


Figure 11 Ground Floor Plan of Annex 2A and 2B

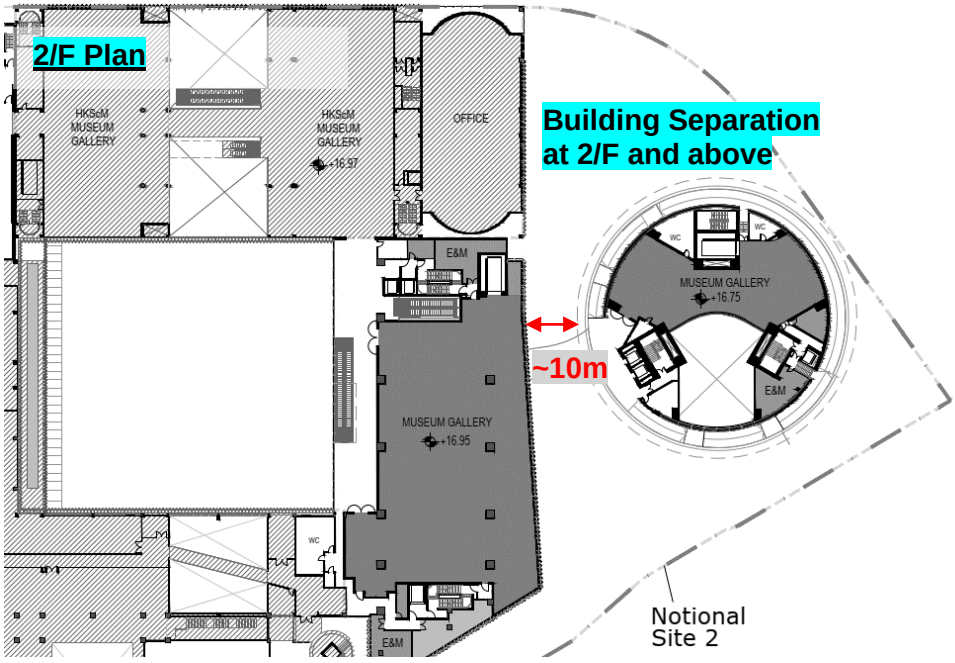


Figure 12 Second Floor Plan of Annex 2A and 2B

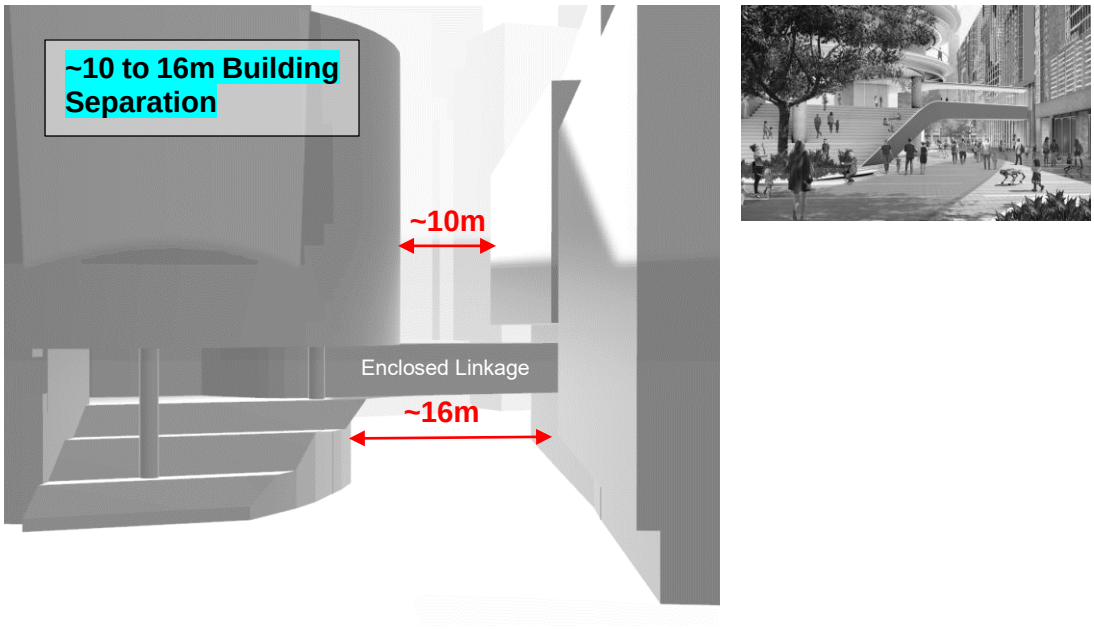
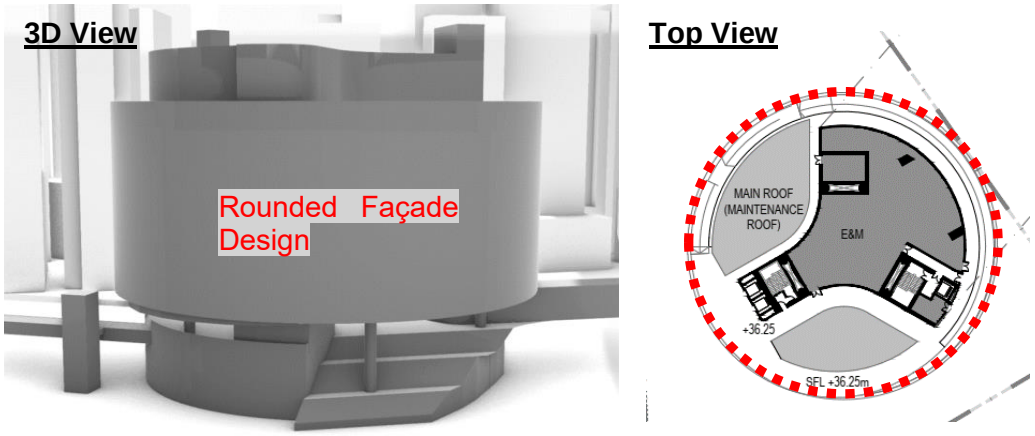


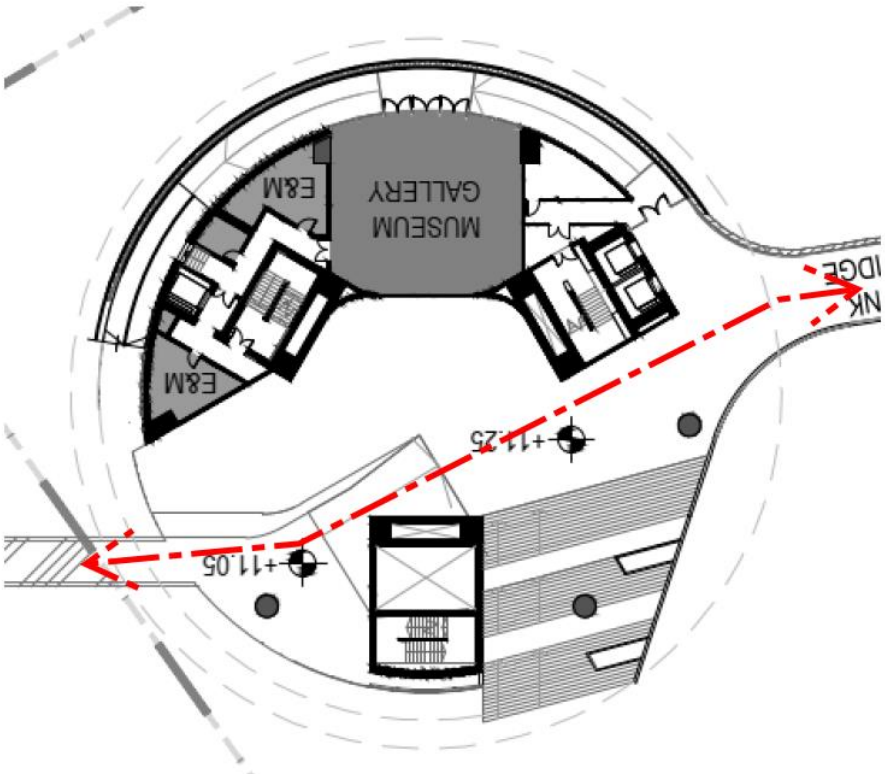
Figure 13 Building Separation between the Annex 2A and 2B

2.3.4 In addition, to further reduce the wind resistance, Annex 2B adopts a round shaped façade design which would streamline wind penetration and improve the wind performance.



2.3.5 Moreover, to facilitate wind penetration at lower level, empty bay and grand staircase design at 1/F is incorporated in the Annex 2B. With the increased permeability at 1/F of the Annex 2B, it is expected that extra airflow would be introduced and thus benefit the wind environment under the Proposed Scheme.

1/F Plan



3D Sectional View

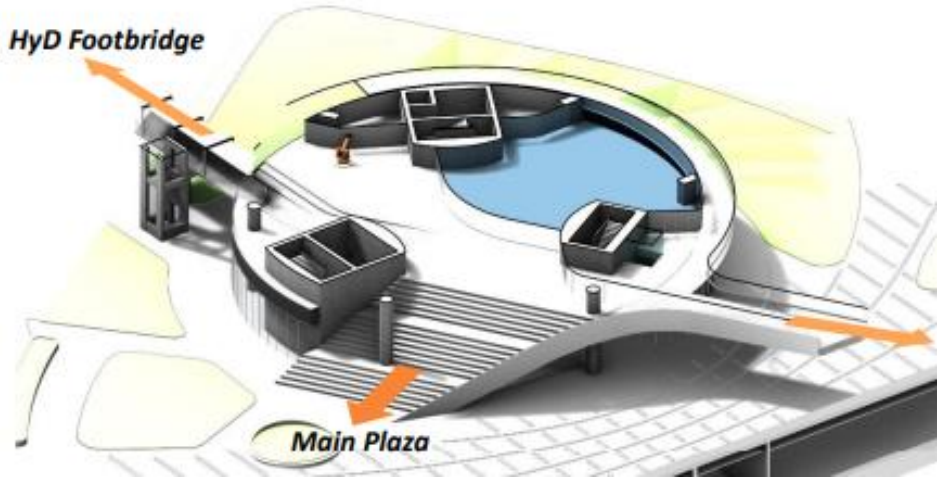


Figure 14 The Permeable Design at 1/F of the Annex 2B

3 ASSESSMENT METHODOLOGY

3.1 General

3.1.1 The AVA study was carried out with reference to the following guidelines:

- Technical Guide for AVA for Developments in Hong Kong, and
- Recommendations on the use of CFD in Predicting Pedestrian Wind Environment

3.1.2 The latter guideline is issued by a working group C14 “Impact of Wind and Storms on City Life and Built Environment” of the European Cooperation in the field of Scientific and Technical Research (COST) led by internationally leading European laboratories and institutes.

3.2 Site Wind Availability

3.2.1 The natural wind availability data is the basis for the investigation of air ventilation performance of the Subject Site. The RAMS site wind availability data released at the website of the Hong Kong Planning Department is adopted in the current study.

3.2.2 For the Subject Site in this study, the site wind availability data from PlanD at grid (081, 038) is adopted. The annual and summer prevailing wind rose diagram (at 500m above ground) of the site is shown in Figure 16 and Figure 17. The wind rose diagram indicates the dominance of each of the 8 wind directions and the respective wind speed distribution.

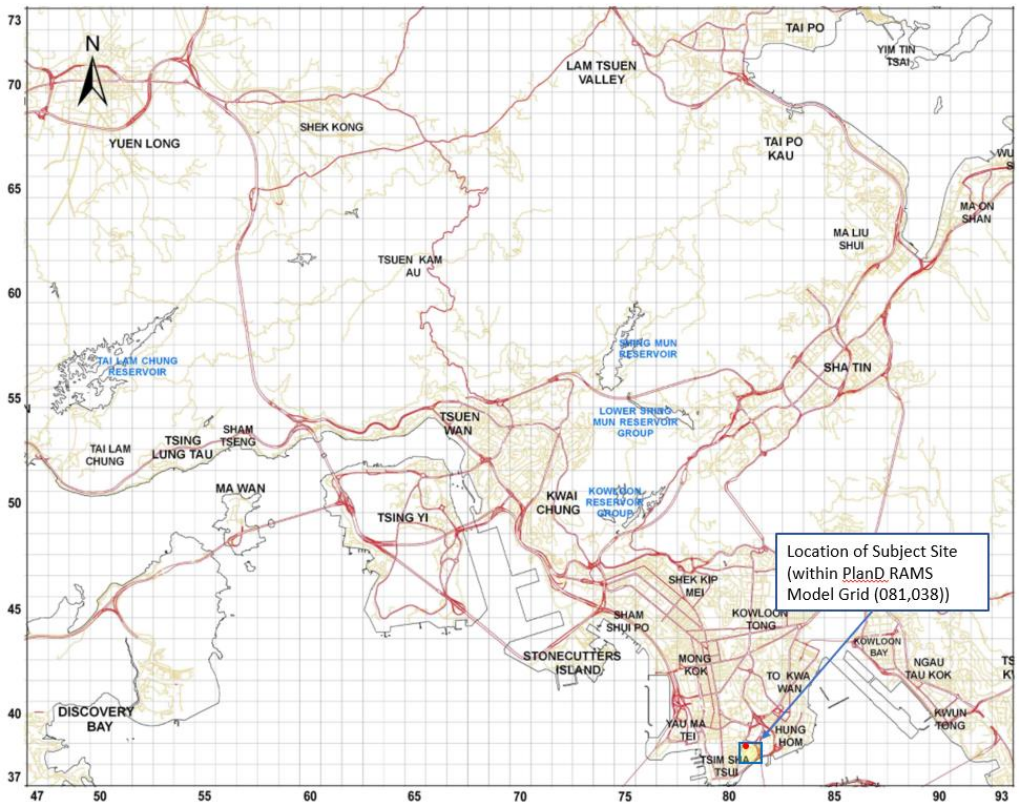


Figure 15 Location of data extraction in RAMS model

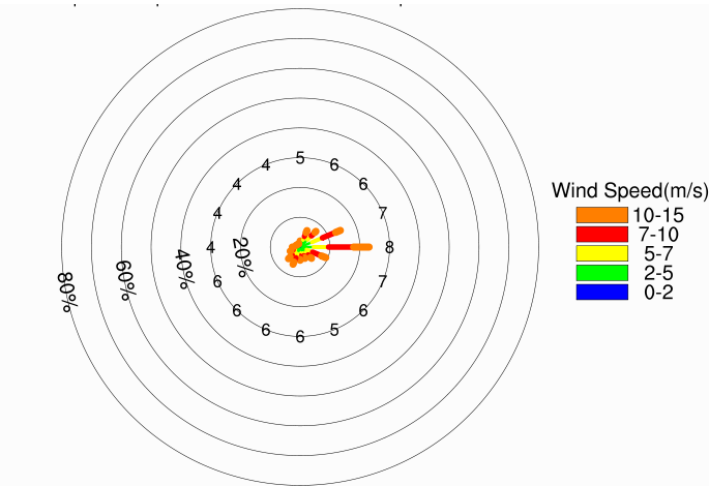


Figure 16 Annual Wind Rose at Grid (081, 038) at 500m

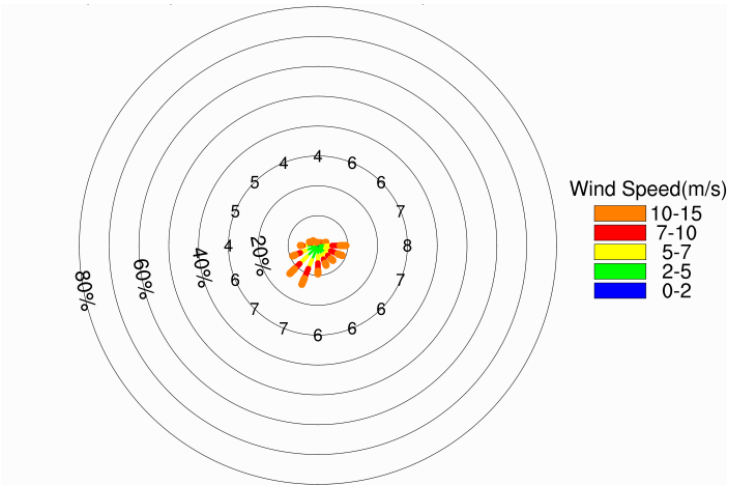


Figure 17 Summer Wind Rose at Grid (081, 038) at 500m

3.3 Modelling Tool and Model Setup

3.3.1 Assessment is conducted by means of three dimensional CFD model. The well-recognized commercial CFD package ICEM and Fluent 19.0 is used in this exercise. FLUENT model has been widely applied for various wind environment research and studies worldwide. The accuracy level of the FLUENT model is widely accepted by the industry for air ventilation application.

Wind directions

3.3.2 In the CFD model, wind environment surrounding the Subject Site will be simulated under at least 8 most prevailing wind directions (which would represent occurrence of more than 75% of time) under both annual and summer condition to illustrate the change in local wind condition due to the proposed development. These prevailing wind directions are determined based on the wind availability simulation result of RAMS model published by Planning Department (PlanD from hereafter).

3.3.3 According to the wind probability table from PlanD together with the wind rose analysis results, the percentage of occurrence of a particular wind direction is

calculated and tabulated in Table 1. More details of the original wind probability data can be found in Appendix B.

3.3.4 From the wind rose obtained from the Planning Department's website, it is noted that the occurrence of wind from NNE, NE, ENE, E, ESE, SE, SSW and SW, which aggregately account for over 75% of the time throughout the year, E wind is the most predominant wind and contributes for 23.5% of time in a year.

3.3.5 While in summer, the wind environment is dominated by E, ESE, SE, SSE, S, SSW, SW and WSW incoming winds, as the total occurrence of these winds being over 75%. SSW wind is the most predominant wind and contributes for 14.3% of time in a year.

Table 1 Frequency of occurrence of individual wind direction

Wind Direction (081, 038)	Wind Direction % of Annual Occurrence [1]	Wind Direction % of Summer Occurrence [1]
N	2.1%	0.9%
NNE	**6.1%**	1.1%
NE	**7.6%**	1.4%
ENE	**14.9%**	3.2%
E	**23.5%**	**9.9%**
ESE	**9.4%**	**9.1%**
SE	**5.4%**	**7.3%**
SSE	4.1%	**7.3%**
S	4.5%	**9.8%**
SSW	**6.3%**	**14.3%**
SW	**5.6%**	**13.7%**
WSW	3.7%	**9.3%**
W	2.7%	5.9%
WNW	1.5%	3.1%
NW	1.3%	2.3%
NNW	1.2%	1.2%
	78.8% Annual Total	**80.7% Summer Total**

Note

[1] Data for percentage of wind occurrence is directly extracted from the PlanD's wind probability table

[2] Average wind speed is calculated based on the percentage of wind occurrence of individual range of wind speed from wind probability table.

Vertical wind profiles

3.3.6 The wind profile calculated from RAMS is adopted in this AVA study. It is recommended to extract the RAMS wind profile data from 10 – 500m directly as it can reflect the exact wind data. For the near ground wind speed, the power law equation is used to approximate near ground wind profile. Figure 18 indicates the data points calculated by power law for 0-10m and extracted from RAMS data for 10-500m height. For wind data above 500m height, the velocity is assumed the same as the data at 500m. These wind data will be the input parameters in the CFD simulation.

The vertical discretization of the velocity profile between 0 to 10m is approximated by using a power law, which is a function of ground roughness and height:

$$U_Z = U_G \left(\frac{Z}{Z_G}\right)^n$$

where U_G = reference velocity at height Z_G

Z_G = reference height

Z = height above ground

U_Z = velocity at height z

n = power law exponent

The power n is related to the ground roughness. A larger value of the power n represents the higher roughness of the ground e.g. n value of the dense city is larger than that of the rural area as shown in the table below. The n-value used in the current study is 0.5.

Terrain type	n-value
Sea and open space	~0.15
Suburban or mid-rise	~0.35
City center or high-rise	~0.5

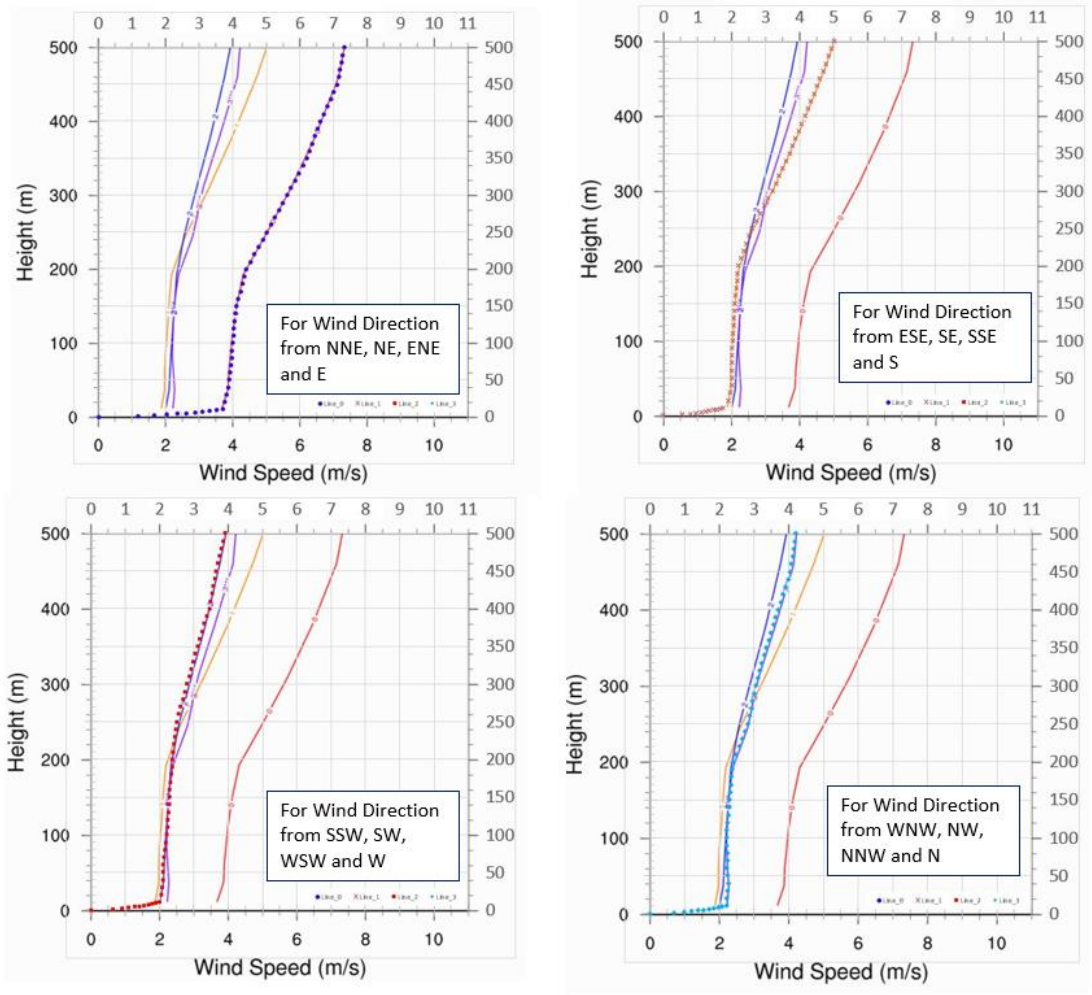


Figure 18 Wind profile from RAMS (Grid X:081 Y: 038)

Turbulence model

3.3.7 With reference to the recommendation stated in COST action C14, realizable K-epsilon turbulence model is adopted in this study to evaluate the wind performance of the Subject Site. Figure 19 illustrates the setup for turbulence model selection in the FLUENT software.

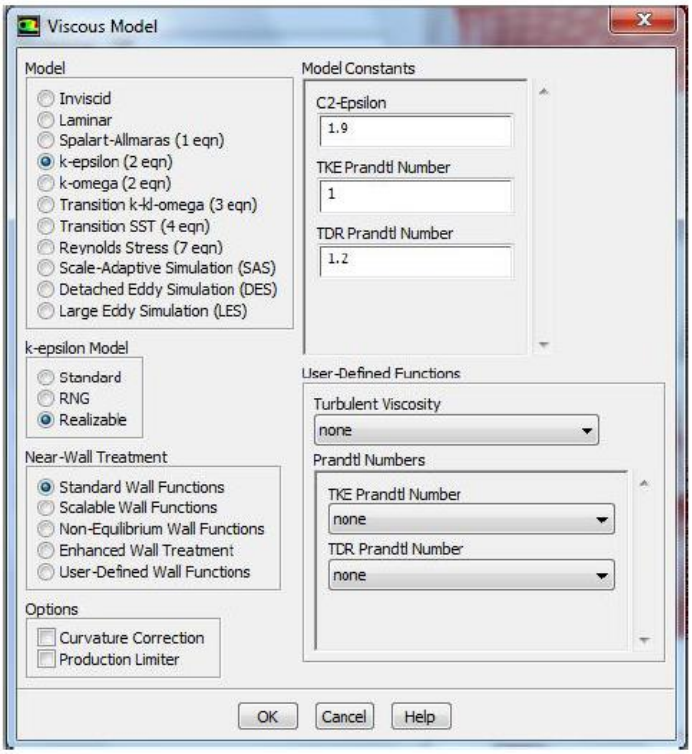


Figure 19 Viscous Model Setup of Fluent

3.3.8 Variables including fluid velocities and fluid static pressure are calculated through the computational domain. The CFD code captures, simulates and determines the air flow inside the domain under study based on viscous fluid turbulence model. Solutions are obtained by iterations.

Computational domain

3.3.9 A three dimensional CFD model is constructed to capture all major components such as topographical features and buildings within and in the vicinity of the Subject Site that would likely to affect the wind flow. According to the Technical Guide, the Assessment Area and the Surrounding Area should include the project's surrounding up to a perpendicular distance of 1H and 2H respectively from the project boundary, H being the height of the tallest building in the project site.

3.3.10 The tallest structure in this case would be the proposed development, which has a height of around +38mPD. Therefore, a Study Area covering not less than 80m from the Subject Site Boundary should be included in the formulation of CFD model. Considering the impact from the nearby large prominent building structures, e.g. the Concordia Plaza, a much larger computational domain is also created as shown in Figure 20 and Figure 21.

3.3.11 The coverage of the Assessment and Surrounding Areas are enlarged to 100m (1H) and 200m (2H) respectively measured from the tall building (Concordia Plaza, +98.3mPD) in assessment area of the Project Area. In view the site circumstance, the Assessment and Surrounding Areas have been extended to include the areas where pedestrians frequently access.

3.3.12 The model takes information on the surrounding buildings and site topography via the Geographical Information System (GIS) platform. The computational domain of the CFD model for the Study is approximately 2,500m (L) x 2,500m (W) x 600m (H). The computational model is shown in Figure 20.

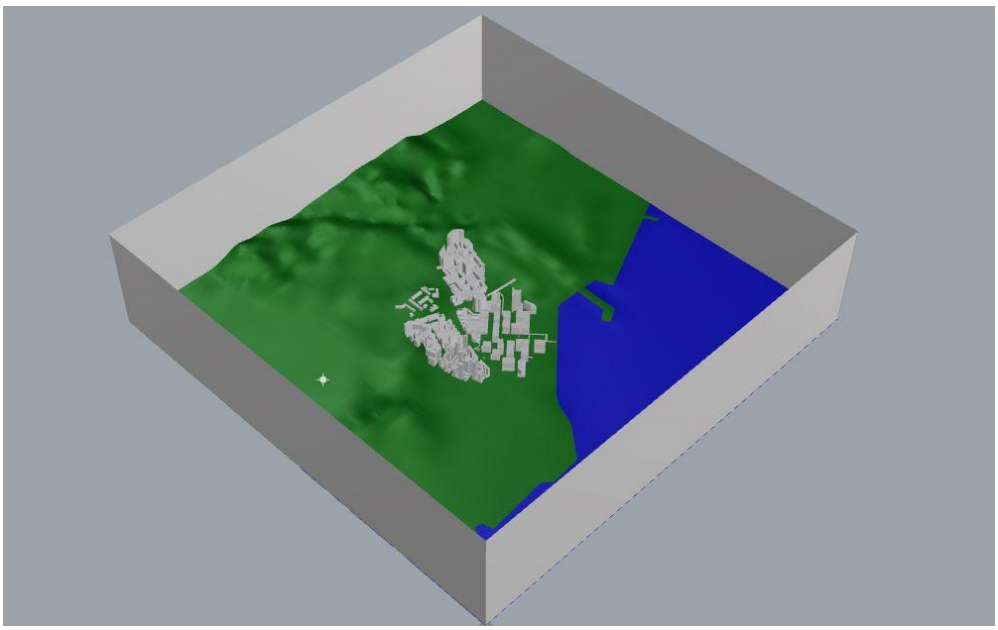


Figure 20 Extent of Computational Domain for CFD Model

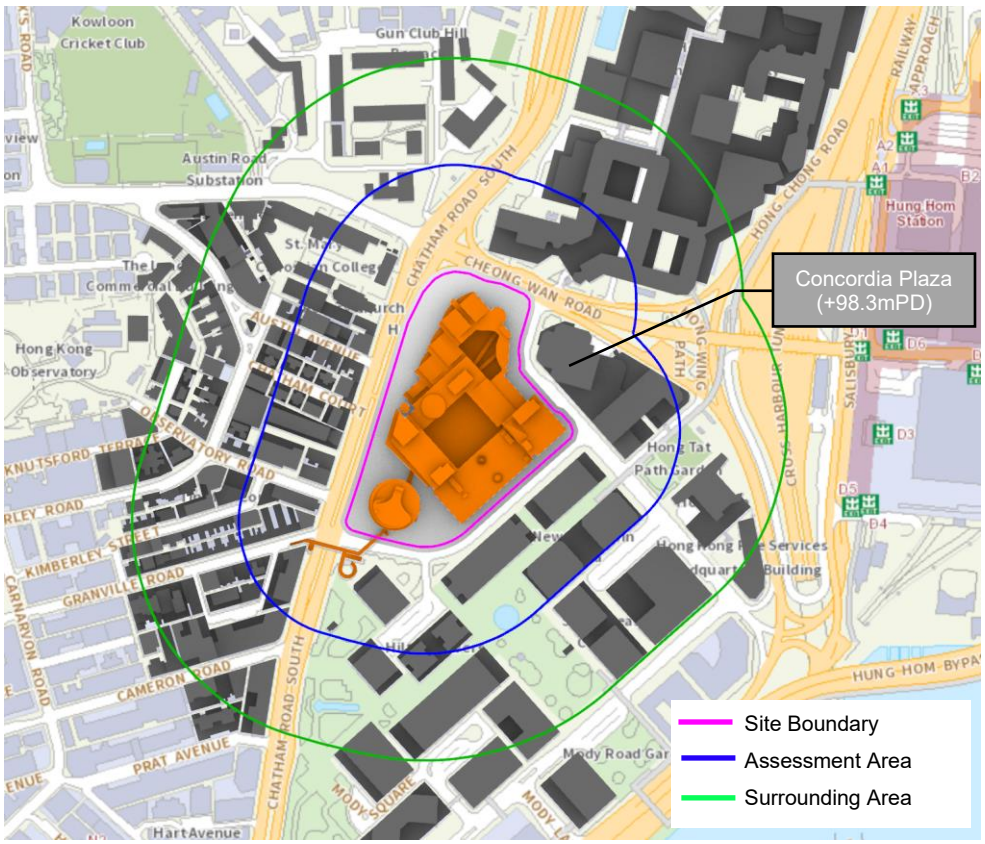


Figure 21 Boundaries of Subject Site, Assessment Area and Surrounding Area

Boundary condition

3.3.13 The inflow face of the computational domain is set as the velocity inlet condition and the outflow face is set as the pressure outlet. The wind profile as stated in Section 3.3.6 is applied to the inlet boundary with User Defined Function (UDF) coded in FLUENT. For top faces and the sides of the bounding box, symmetric boundary condition is applied. Non-slip wall condition is employed for the ground and building walls.

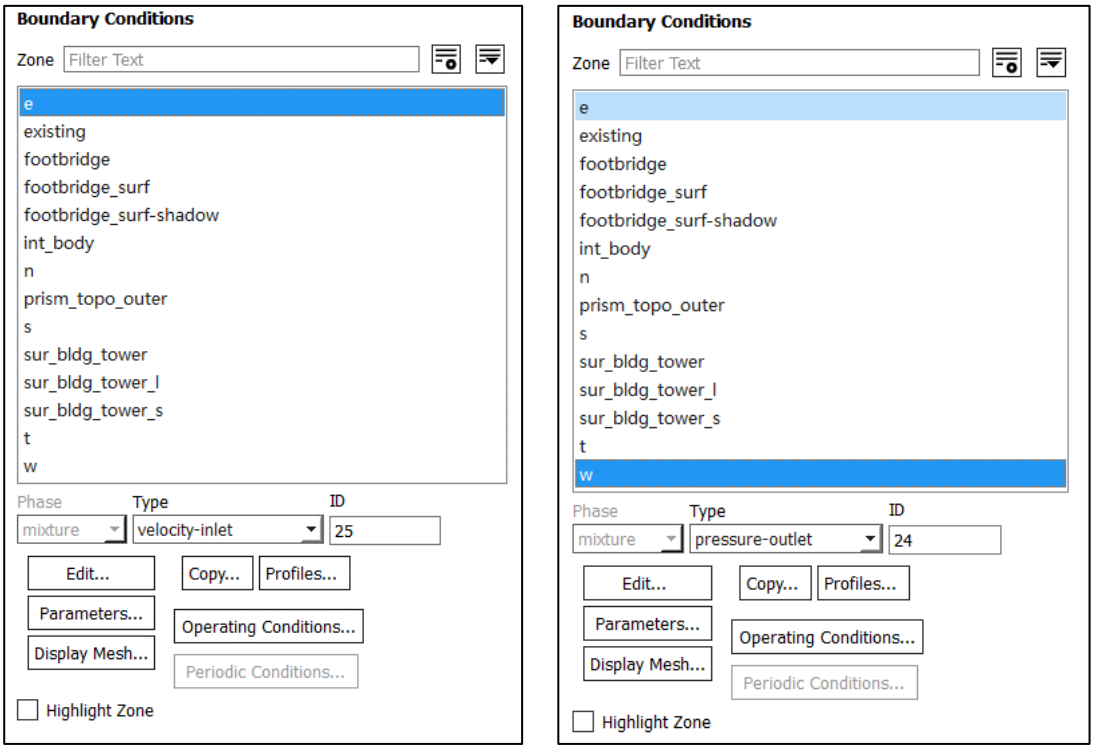


Figure 22 Setup of Boundary Conditions in Fluent

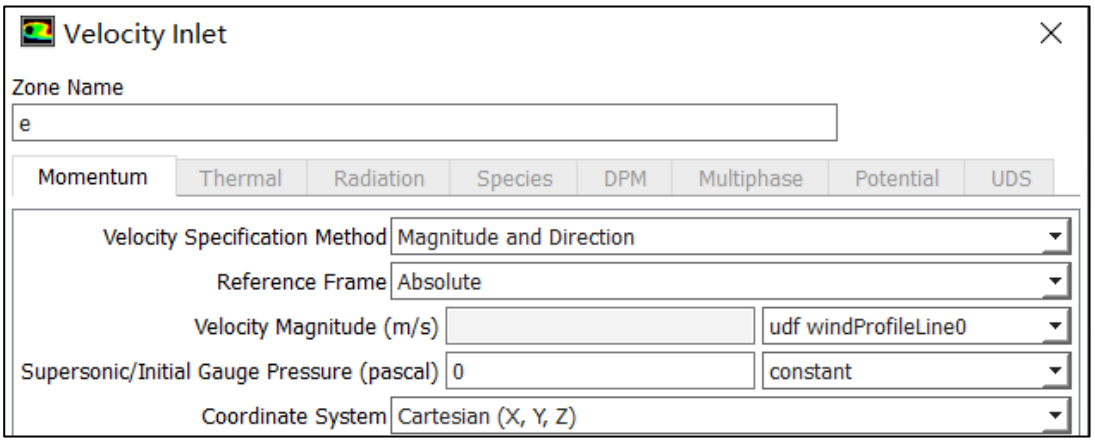


Figure 23 Velocity Setup for Inlet in Fluent

Mesh setting

3.3.14 Given the large computational domain adopted in this assessment and the physical limitation on the computational resources of the CFD model, the global maximum size of cells is 64m. Smaller cells are applied in the vicinity of the Subject Site with a global minimum size of 1m and global maximum size of 16. Tetra size ratio of 1:4 is applied to the building structures so as to better capture the wind flow around buildings. Five layers of prism cells (each layer of 0.5m thick) are also employed above the terrain. In the CFD model, the pedestrian level points are all located at 2m above ground level at the fourth cell away from the terrain to ensure the obtainment of a higher resolution of wind flow near the ground as per the recommendation from COST action C14. The total number of cells for this study would be anticipated to be in the range of about 8,000,000 cells in tetrahedral mesh.

3.3.15 The general model layout and the grid cell of the computational model are shown in Figure 24.

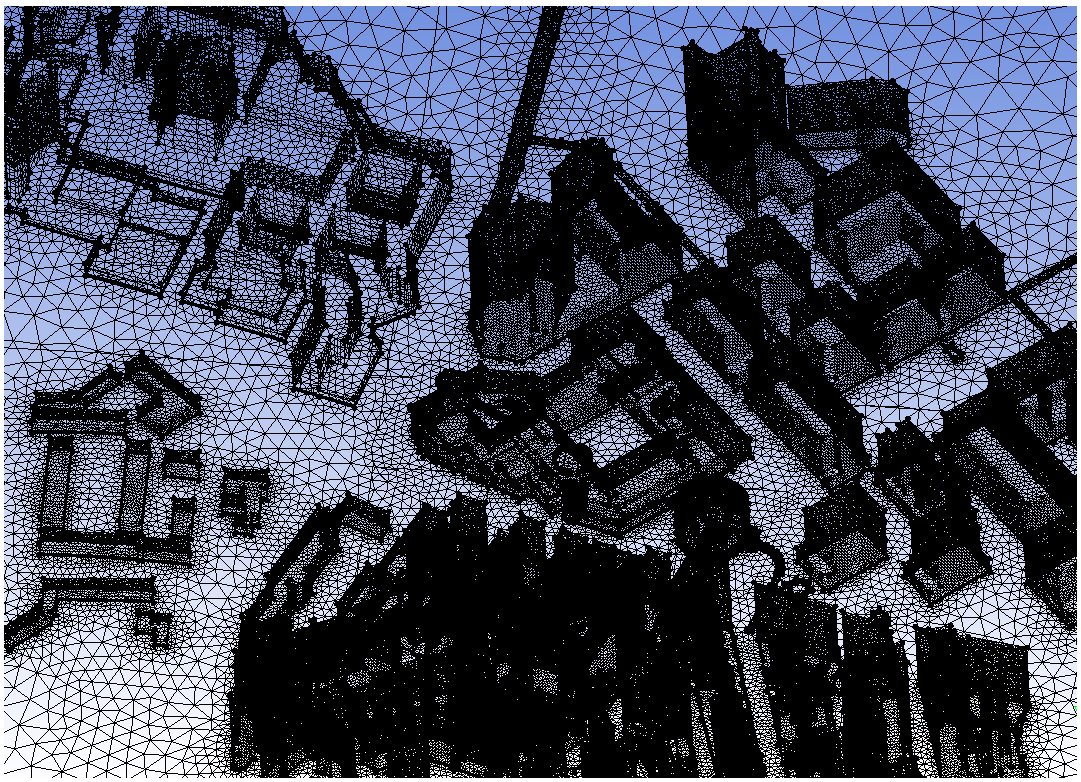


Figure 24 Images of Mesh Cells Setup in the CFD Model (Proposed Scheme)

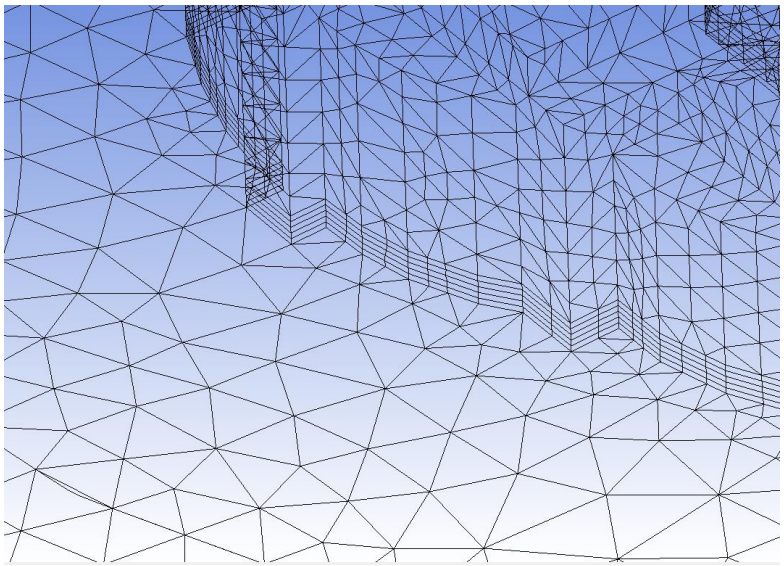


Figure 25 5 Layers of Prism Mesh Cells Setup in the CFD Model

3.4 Test points

3.4.1 Wind velocity ratio (VR) indicates how much of the wind availability is experienced by pedestrians on the ground which is a relatively simple indicator to reflect the wind environment of the study site. VR is defined as VR = V_P /V_∞ where,

V_P is the wind velocity at the 2m pedestrian level;

V_∞ is the wind velocity at the top of the wind boundary layer (greater than 500m in height) would not be affected by the ground roughness and local site features.

3.4.2 VR_W is the frequency weighted wind velocity ratio calculated based on the frequency of occurrence of all the 17 wind directions for the purpose of comparison.

3.4.3 For Site Air Ventilation Assessment, the Site Spatial Average Wind Velocity Ratio (SVR_W) and individual VR_W of all perimeter test points are reported. SVR_W is the average of VR_W of all perimeter test points.

3.4.4 For Local Air Ventilation Assessment, the Local Spatial Average Wind Velocity Ratio (LVR_W) of all overall test points and perimeter test points, and individual VR_W of the overall test points are reported. LVR_W is the average of all overall test points and perimeter test points.

3.4.5 The SVR_W and LVR_W are worked out so as to understand the overall impact of air ventilation on the immediate and further surroundings of the Project Area due to the proposed development.

3.4.6 The wind environment assessment is analyzed by comparing the weighted-average wind velocity of the test points, which was taken into account the probability of different wind directions. Both perimeter test points and overall test points will be selected within the Assessment Area in order to assess the impact on the immediate surroundings and local areas respectively. Overall test points will be evenly distributed over surrounding open spaces, streets and other parts of the Assessment Area where pedestrian can or will mostly access.

3.4.7 The site spatial average velocity are evaluated based on 30 Perimeter Test Points (P Points) while the Local spatial average Velocity are calculated based on 108 Overall Test Points (O Points). Additionally, 46 Special Test Points (S Points) for Baseline Scheme and 35 Special Test Points for Proposed Scheme are added within the site boundary to further assess the wind performance of the localized key spaces in the site.

3.4.8 The test points are distributed evenly within the assessment area, covering the routes which are likely to be accessed by pedestrians. All test points are elevated at 2m above ground level. The details about the test point location are illustrated in Figure 26.

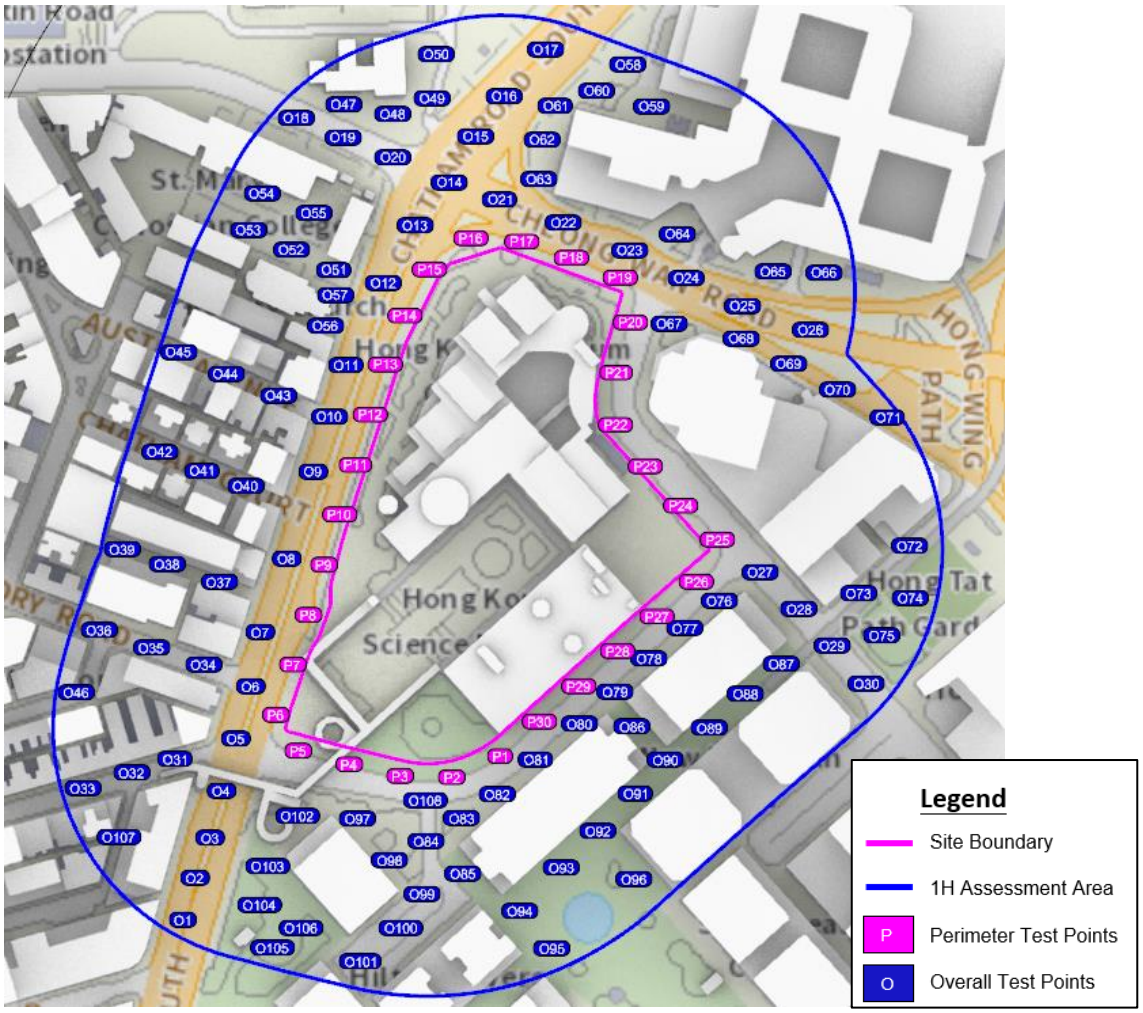
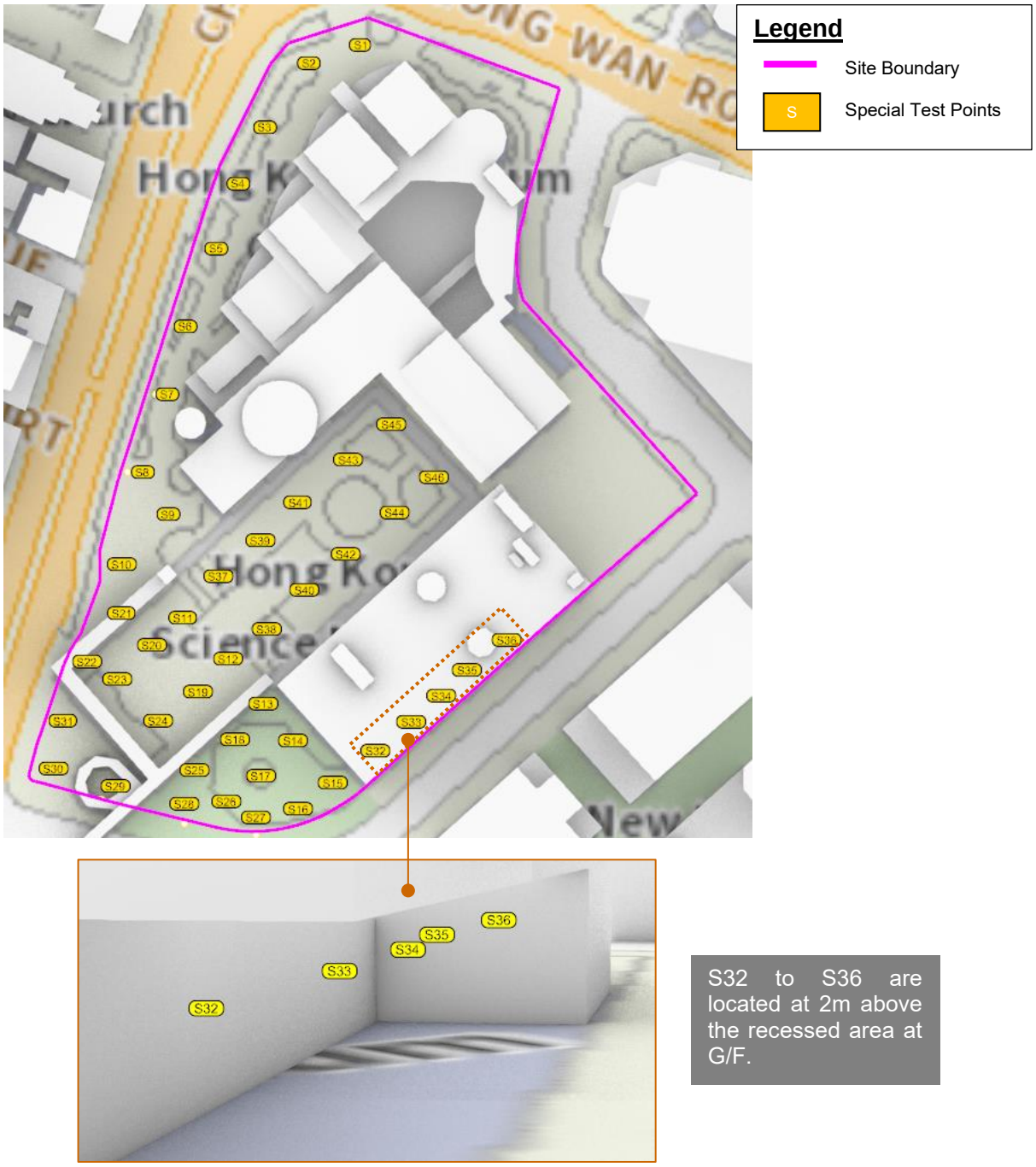


Figure 26 Test point Location for Overall Test Points and Perimeter Test Points



S32 to S36 are located at 2m above the recessed area at G/F.

Figure 27 Location of Special Test Points (Baseline Scheme)

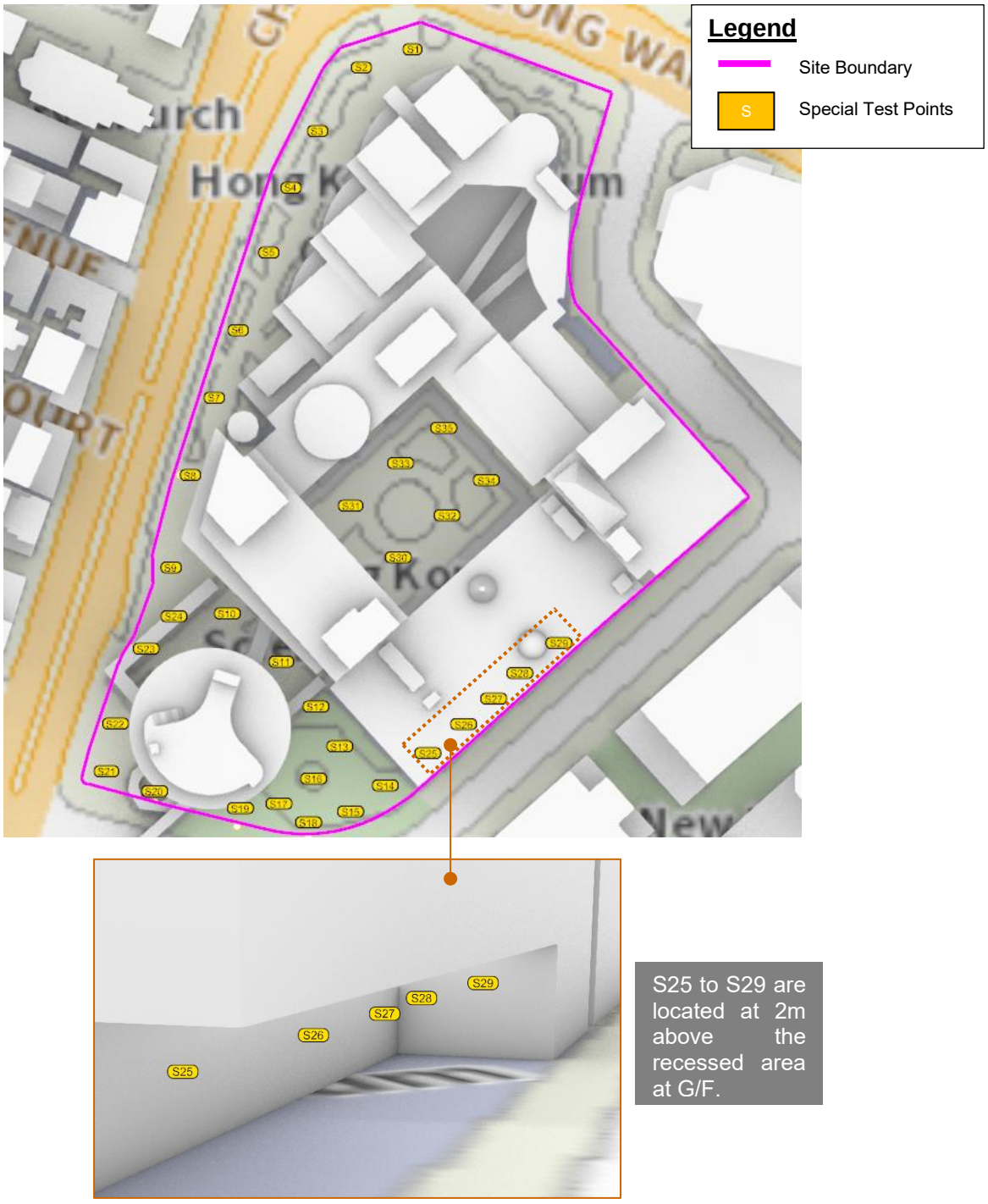


Figure 28 Location of Special Test Points (Proposed Scheme)

3.4.9 The Test Points are consolidated into 27 groups of focus area for discussion on the wind influences in different specific regions.

Table 2 Focus Areas outside the Project Site

Group	Focus Areas	Test Points
G1	The Hong Kong Polytechnic University	O58-66
G2	Concordia Plaza & New East Ocean Centre	P21-25, O27-28, O67-73
G3	Harbour Crystal Centre	O27 -28, O76-79, O86-90
G4	East Ocean Centre	O80-85, O90-94
G5	New Mandarin Plaza	O29-30, O87-92, O96
G6	Urban Council Centenary Garden	O92-96, O103-106
G7	Hilton Towers/ Granville Square	O99-101
G8	Energy Plaza	O97-103
G9	Building Cluster 1	O5-6, O31-36, O46
G10	Building Cluster 2	O7-8, O34-42
G11	Building Cluster 3	O9-10, O41-45
G12	Building Cluster 4	O10-11, O43-O45
G13	Rosary Church	O56-57
G14	St. Mary's Canossian College	O12-13, O18-20, O51-55
G15	Gun Club Hill Barracks-Block 13	O47-50
G16	Austin Road & Cheong Wan Road	O18-26
G17	Chatham Road South	O1-17
G18	Granville Road	P1-5, P26-30, O5, O31-33
G19	Science Museum Road	P20-25, O27-30
G20	Hong Tat Path Garden	O74-75
G21	Austin Avenue	O43-45
G22	Chatham Court	O40-42
G23	Observatory Road	O34-36

Table 3 Focus Areas inside the Project Site

Group	Focus Areas	Special Test Points for Baseline Scheme	Special Test Points for Proposed Scheme
G24	Setback Area	S1-9	S1-8
G25	Open Space around Annex 2B	S10-31	S9-24
G26	Recessed Area	S32-36	S25-29
G27	Podium Courtyard	S37-46	S30-35

Figure 29 Focus Area Location

4 RESULTS AND DISCUSSIONS

4.1 Wind Directional Analysis

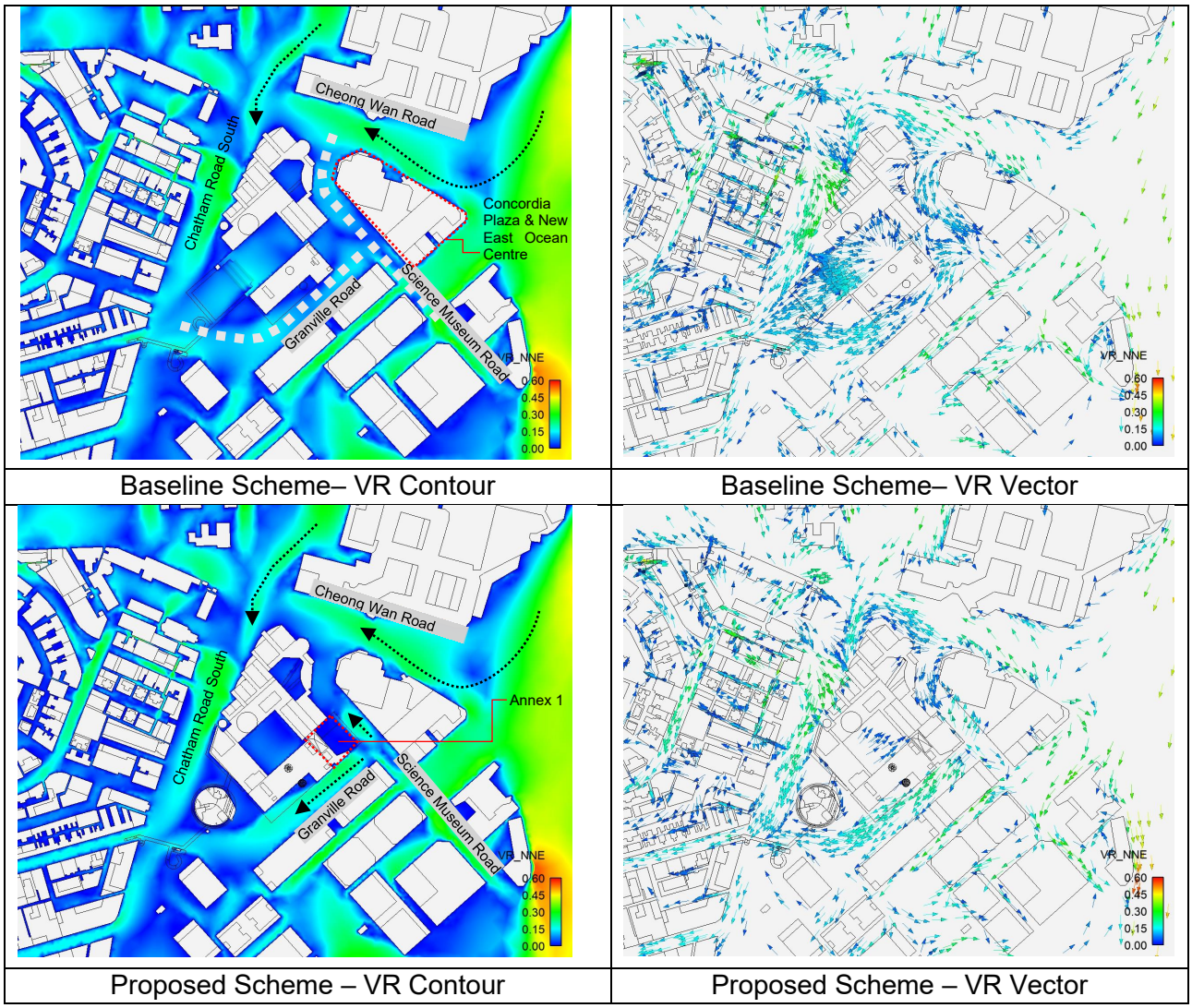


Figure 30 NNE Wind (Annual: 6.1%) at 2m above Ground

The Chatham Road South serves as one of the main breezeways under the NNE winds. Another portion of NNE wind is diverted into the Cheong Wan Road due to the large building massings of Concordia Plaza & New East Ocean Centre.

The proposed expansion Annex 1 in the Proposed Scheme would allow separation of the incoming wind into two branches entering the Granville Road and the Science Museum Road respectively. Thus, a wind enhancement is occurred at the Granville Road and the Science Museum Road under the Proposed Scheme when compared with the Baseline Scheme.

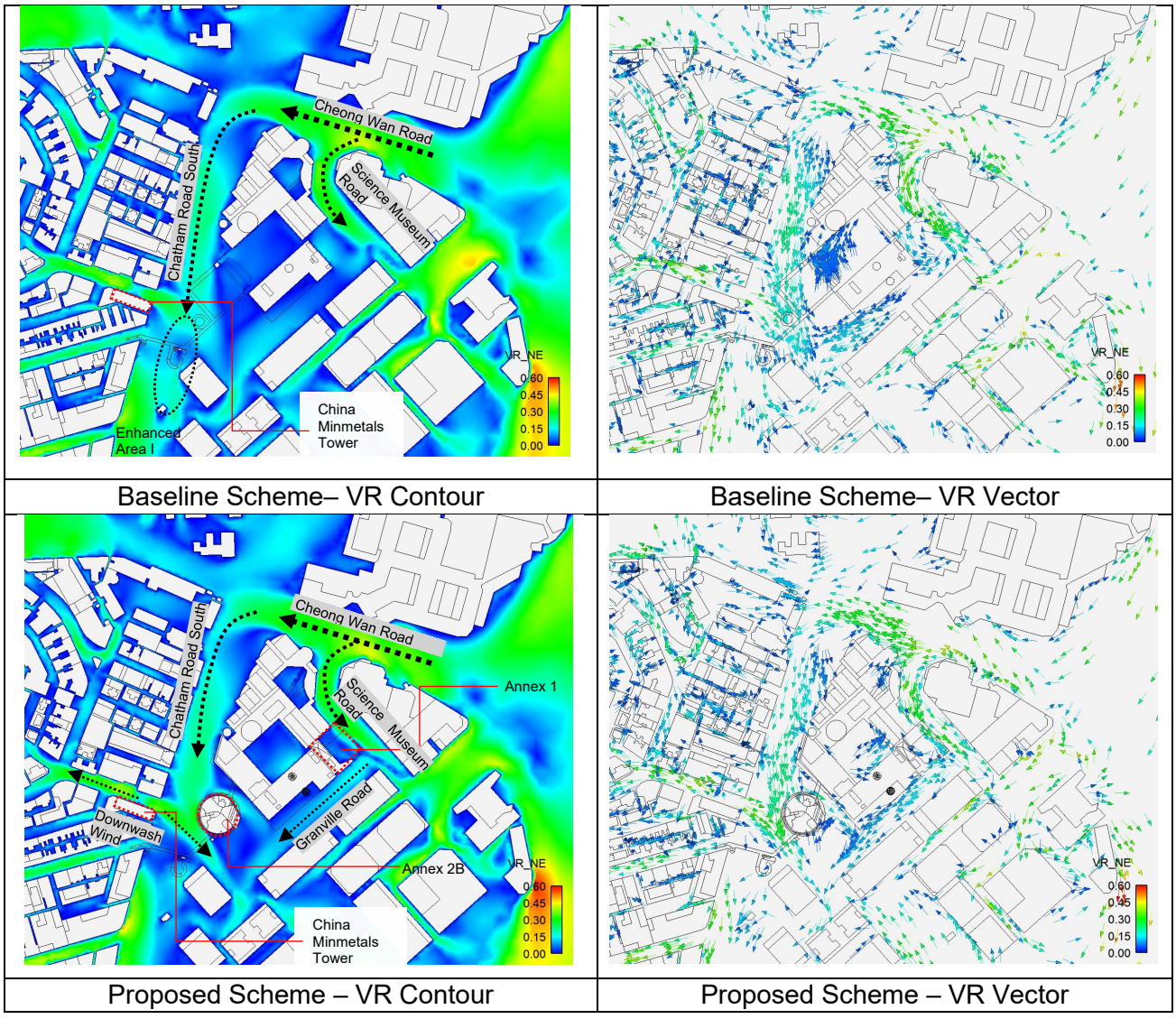


Figure 31 NE Wind (Annual: 7.6%) at 2m above Ground

The NE wind approaches the project site through the Cheong Wan Road and then a portion of wind deflect into the Science Museum Road while another portion of wind shift into the Chatham Road South.

It is observed that the wind performance is enhanced at the souther part of the Chatham Road South under the Baseline Scheme as marked in Figure 31. However, under the Proposed Scheme, the proposed Annex 2B would reduce wind dynamics along the Chatham Road South resulting in the downwash airflow caused by the China Minmetals Tower entering the Granville Road. On the other hand, the proposed Annex 1 would help to channel more air into the Granville Road as well.

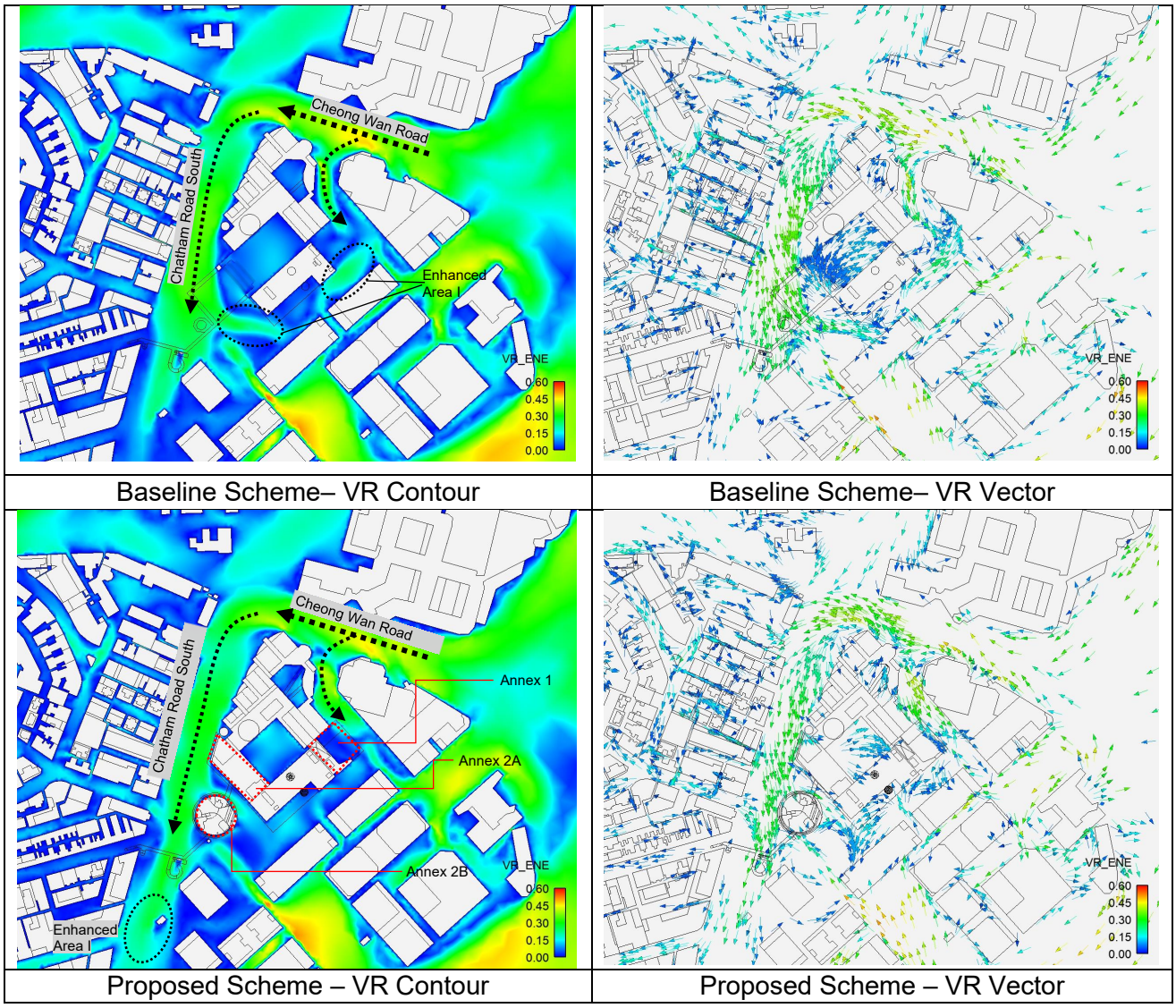


Figure 32 ENE Wind (Annual: 14.9%) at 2m above Ground

Similar to the NE wind, ENE wind approaches the project site through the Cheong Wan Road and then a portion of wind deflect into the Science Museum Road while another portion of wind turn into the Chatham Road South.

Comparing to the Proposed Scheme, the higher wind velocity ratio would be achieved at the southern and eastern area of the project site under the Baseline Scheme as marked in Figure 32 while the proposed Annex 2A & 2B would be able to guide the wind along the Chatham Road South going farther such that local enhancement would be obtained at the bottom part of the Chatham Road South.

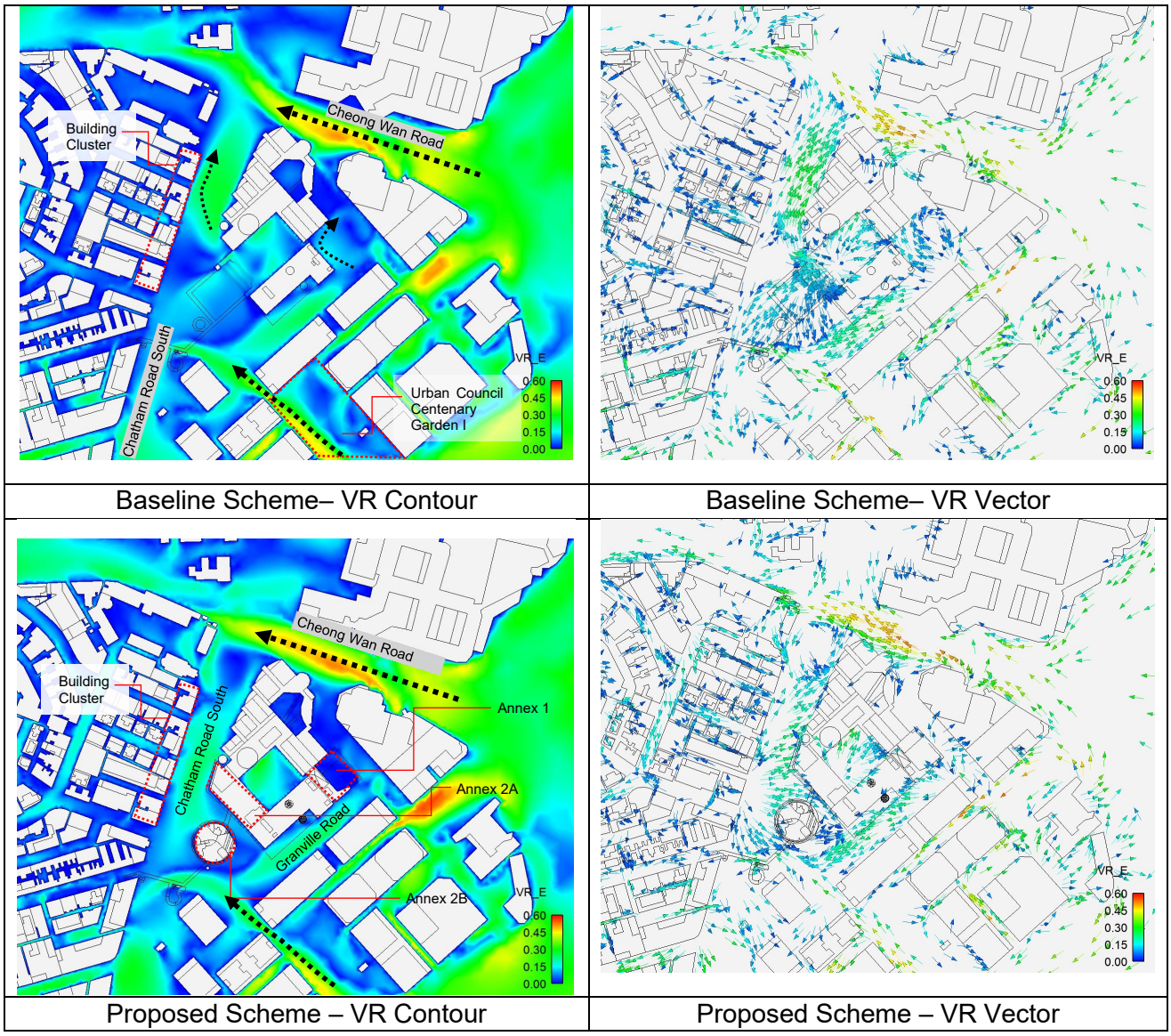


Figure 33 E Wind (Annual: 23.5% & Summer: 9.9%) at 2m above Ground

The E wind occupies 23.5% wind occurrence, which makes it the most dominant prevailing wind under annual condition. The overall wind performance of the Baseline Scheme and the Proposed Scheme is similar. The wind approaches the project site through the Cheong Wan Road and the Urban Council Centenary Garden.

The high level wind could skim over the project development and then shielded by the high-rise building cluster along the Chatham Road South. With comparison to the Baseline Scheme, the proposed Annex 1 with ~38mPD height would affect the flow pattern at high level and shift the wind toward south slightly at the Chatham Road South.

In addition, the presence of the proposed Annex 1 under Proposed Scheme would guide a portion of E wind at pedestrian level to Granville Road leading to slightly higher VRs at Granville Road.

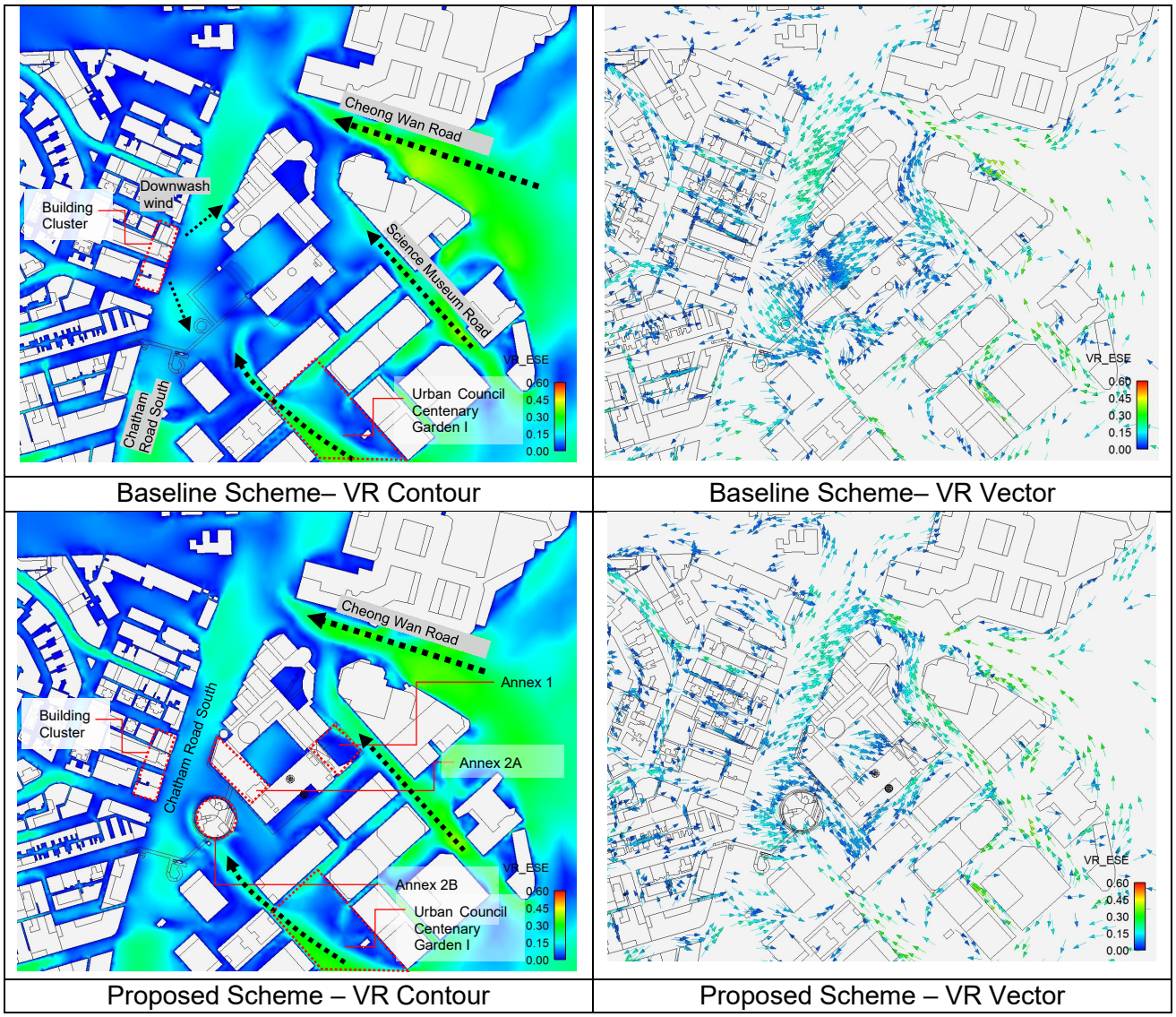


Figure 34 ESE Wind (Annual: 9.4% & Summer: 9.1%) at 2m above Ground

Different from the E wind, three branches of winds together generate a wind environment under the ESE wind, and the airflow along the Science Museum Road is enhanced.

To be specific, the proposed Annex 1 would be able to divert a branch of wind into the Granville Road in the mean while help to keep the wind flowing further along the Science Museum Road as comparing to the Baseline Scheme.

On the other hand, the high-rise building cluster along the Chatham Road South could formulate downwash wind under both the Baseline Scheme and the Proposed Scheme. But the proposed Annex 2A and 2B would cause resistance to the downwash airflow such that more winds would be maintained along the Chatham Road South.

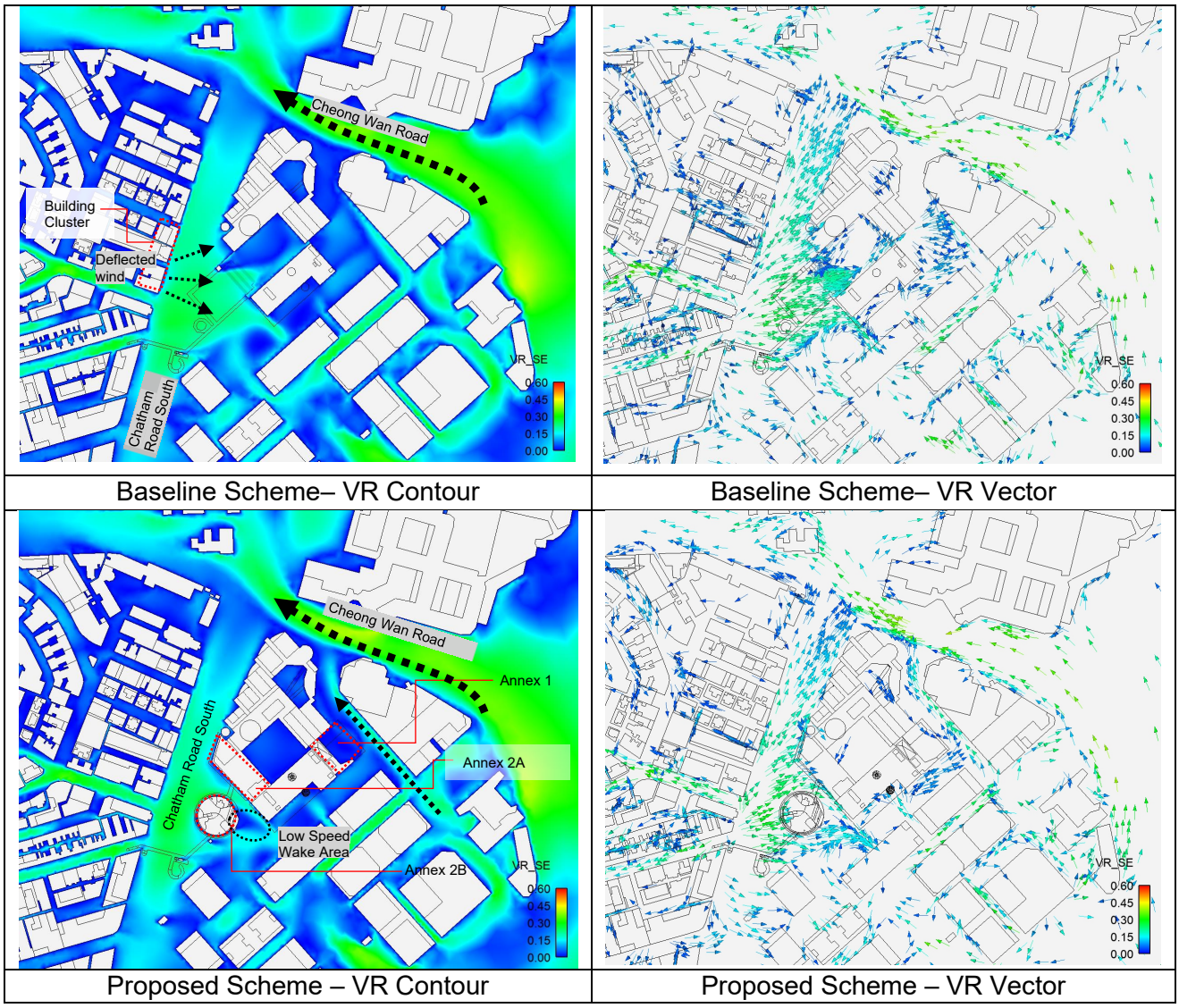


Figure 35 SE Wind (Annual: 5.4% & Summer: 7.3%) at 2m above Ground

Similar to ESE wind, the proposed Annex 1 would slightly enhance the wind performance at the Science Museum Road as well under SE wind when comparing to the Baseline Scheme. However, the location of the proposed Annex 2A & 2B would block the wind from the Chatham Road South noticeably resulting in a low speed area at the southern side of the project site as marked in Figure 35.

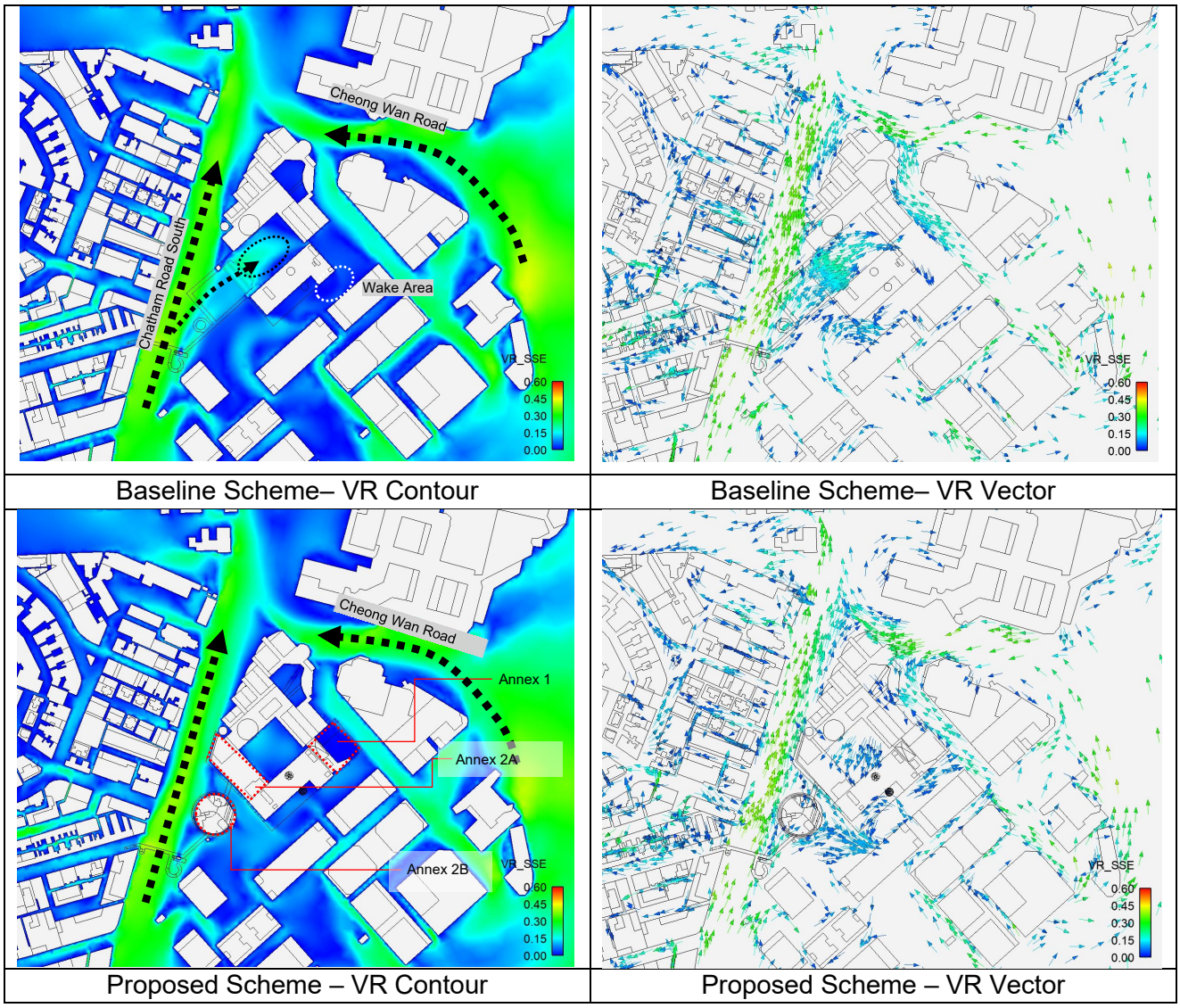


Figure 36 SSE Wind (Summer: 7.3%) at 2m above Ground

The wind along the Chatham Road South becomes the major wind source for the project site under SSE wind direction, apart from the diverted wind along the Cheong Wan Road.

It can be observed that the presence of Annex 2A & 2B would enhance the wind performance along the Chatham Road South while a portion of wind separate from the mainstream entering the project site under the Baseline Scheme as shown in Figure 36. Hence, the VR value of the Proposed Scheme is higher than that of the Baseline Scheme at the western site perimeter.

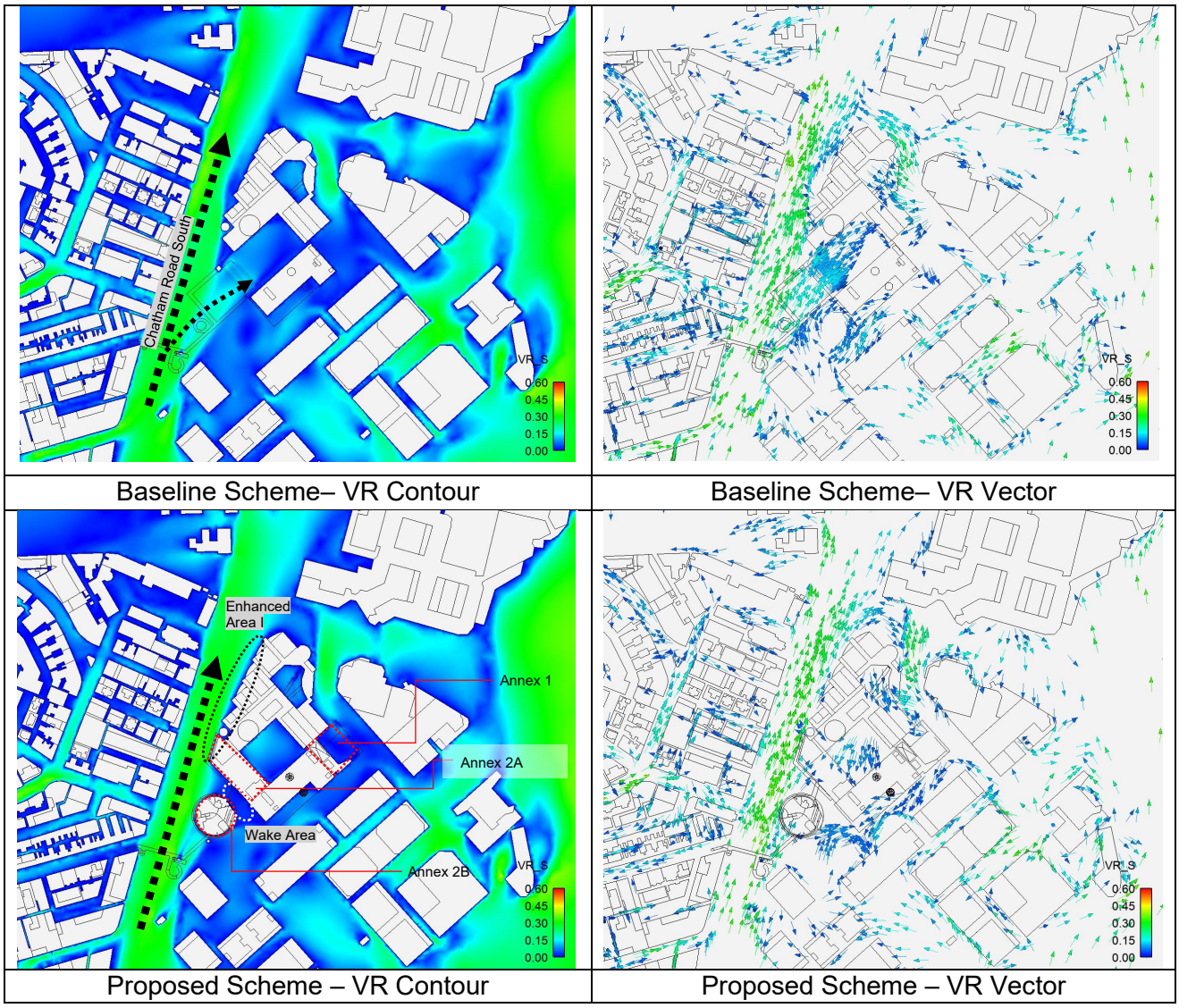


Figure 37 S Wind (Summer: 9.8%) at 2m above Ground

Similar to SSE wind, the S wind would approach the project site through the Chatham Road South and the wind performance at the Chatham Road South would be enhanced especially along the western façade of the project building under the Proposed Scheme whereas a branch of airstream entering the project site would reduce the flow rate along the Chatham Road South under the Baseline Scheme. As a result, the VR value of the Proposed Scheme is higher than that of the Baseline Scheme at the western site perimeter.

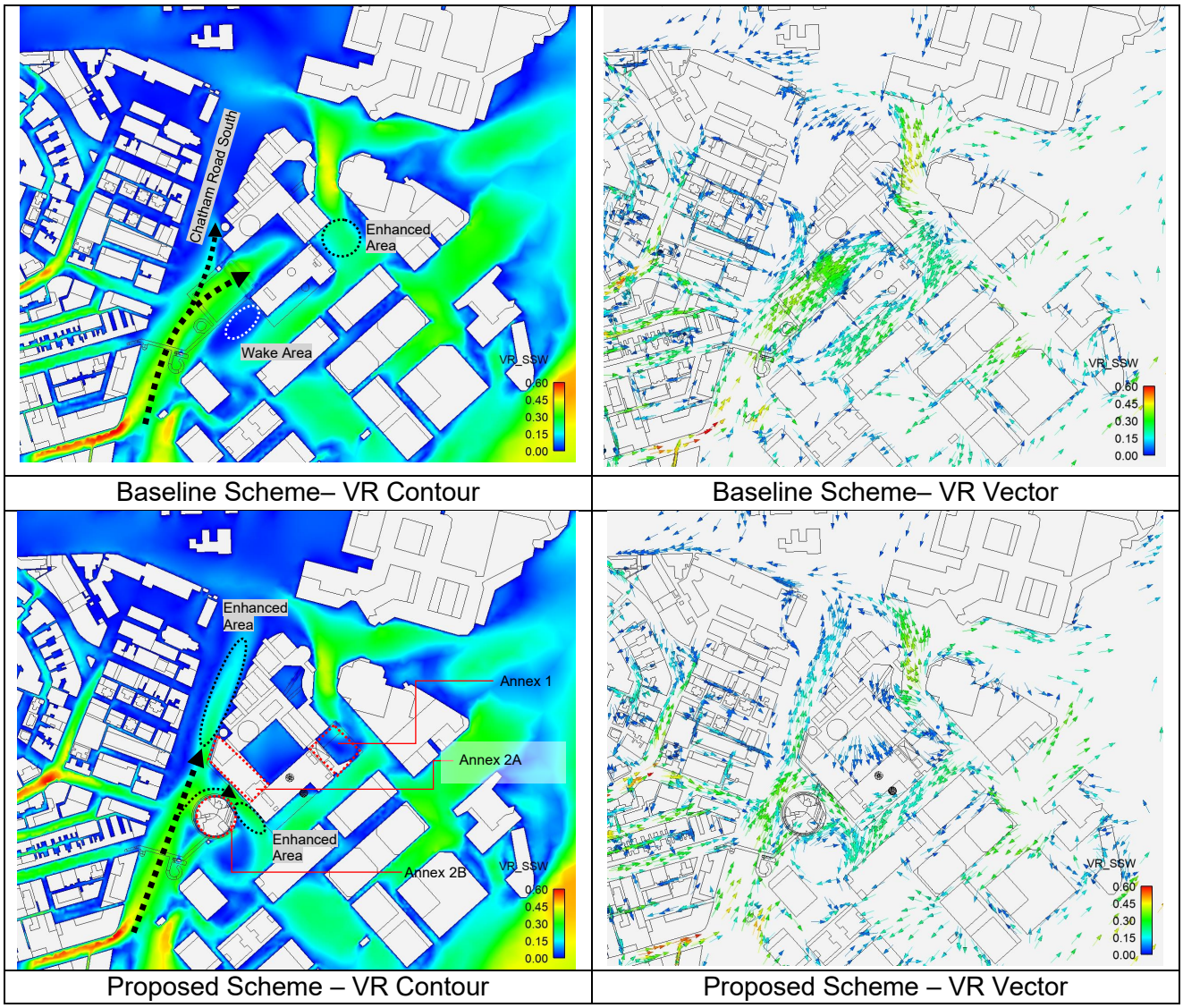


Figure 38 SSW Wind (Annual: 6.3% & Summer: 14.3%) at 2m above Ground

The SSW wind flows along the Chatham Road South like S wind but the 22.5 degree westward wind incident angle makes the main airstream penetrating into the project site under the Baseline Scheme.

Under the Proposed Scheme, the airstream would encounter the southwestern façade of the Annex 2A and then turn east along the project building. Unlike the Baseline Scheme, Annex 2A would also guide a portion of airstream along the Chatham Road South. Although Annex 1 would affect wind turning direction and cause lower VR along the Science Museum Road locally, the round shaped Rotunda would facilitate wind penetration at the perimeter of the project site.

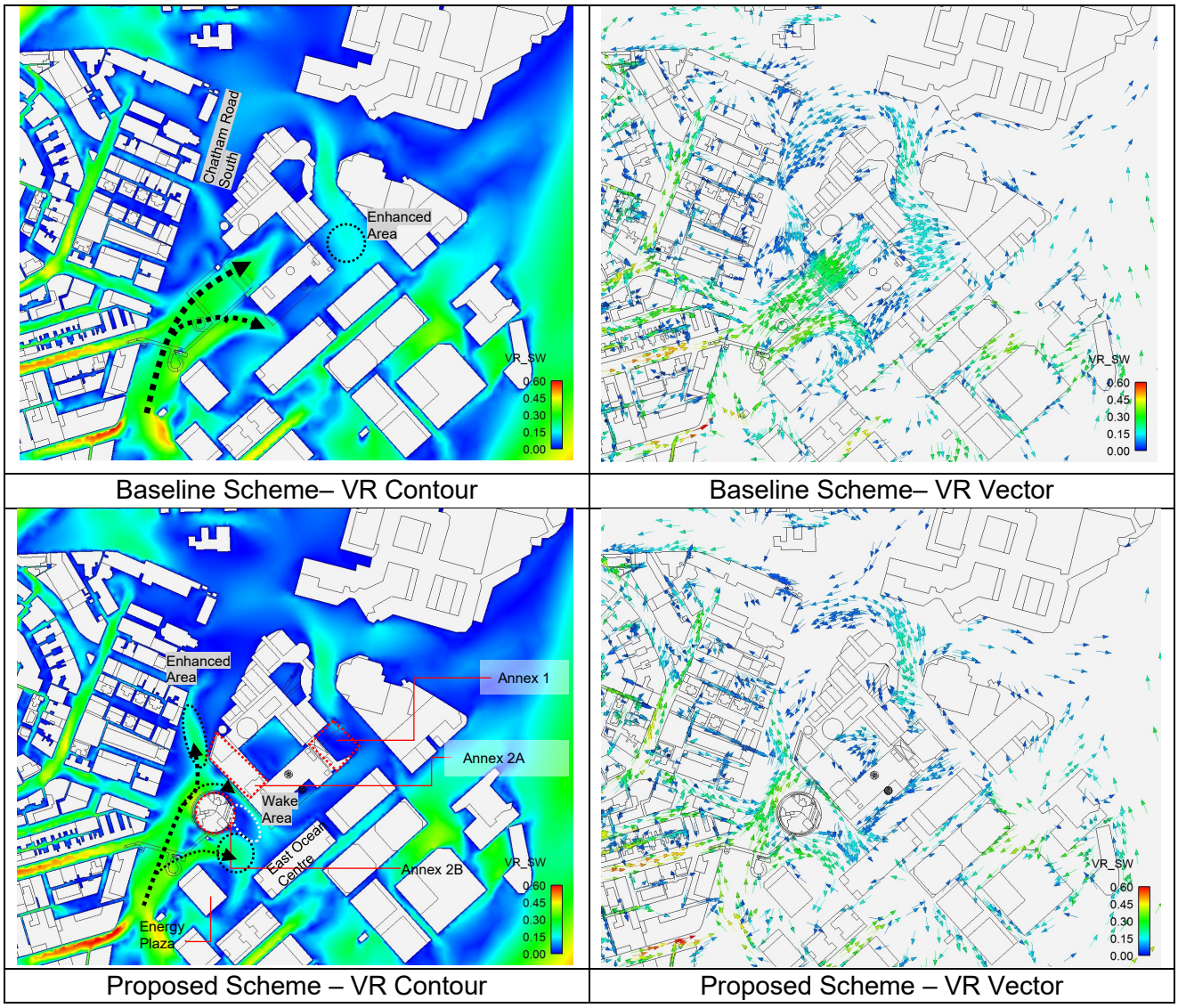
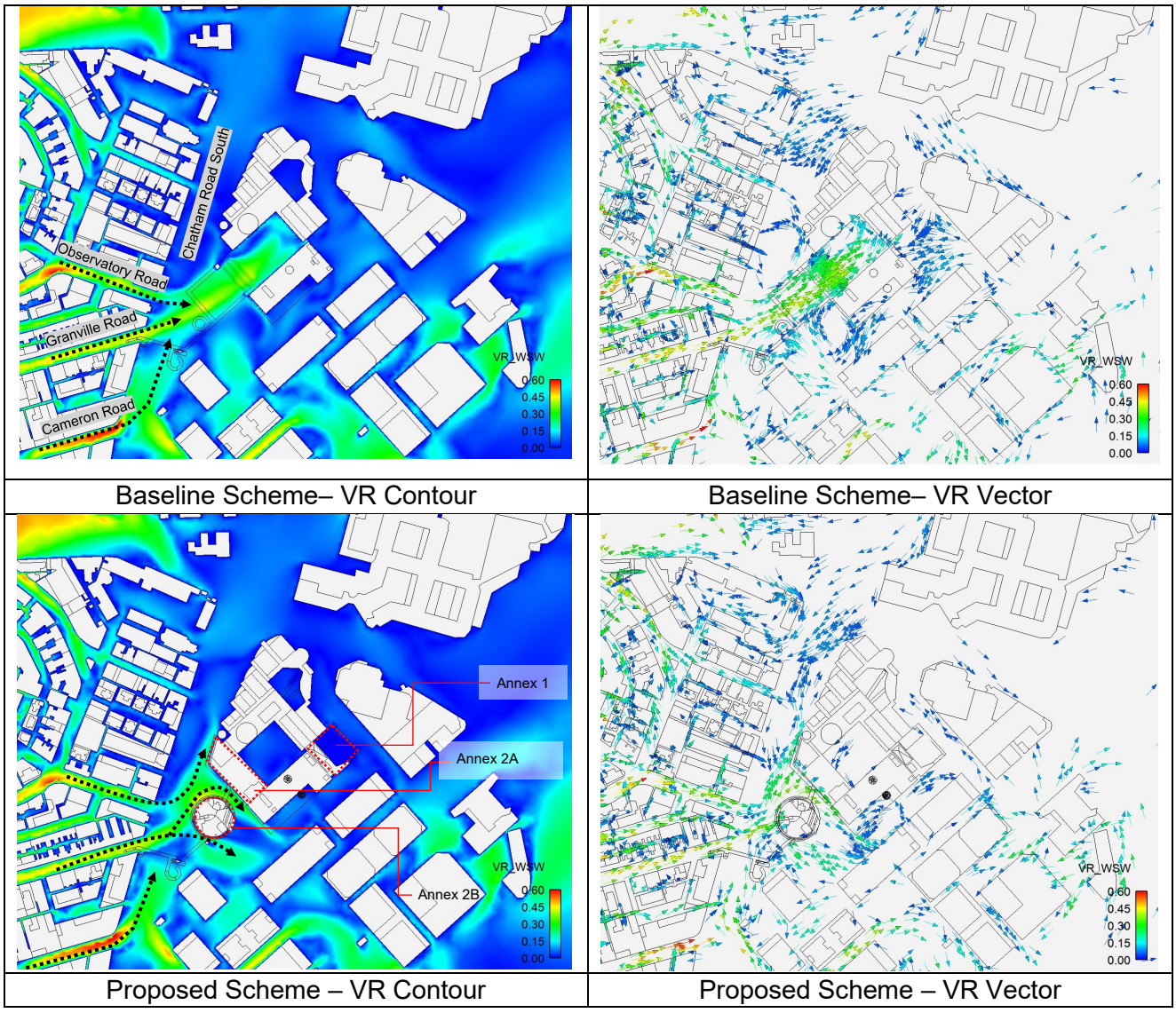


Figure 39 SW Wind (Annual: 5.6% & Summer: 13.7%) at 2m above Ground

Like SSW wind, similar phenomena also appeared under SW wind that the airstream from Chatham Road South would be divided into two branches by Annex 2A under the Proposed Scheme. Likewise, low speed area would be formulated close to Annex 1.

It is noticed that the Rotunda would divert incoming wind towards the East Ocean Centre such that the higher VR is achieved at the space between Annex 2B and Energy Plaza under the Proposed Scheme.

Overall, the wind performance at the site perimeter becomes better under the Proposed Scheme.



Baseline Scheme– VR Contour | Baseline Scheme– VR Vector

Proposed Scheme – VR Contour | Proposed Scheme – VR Vector

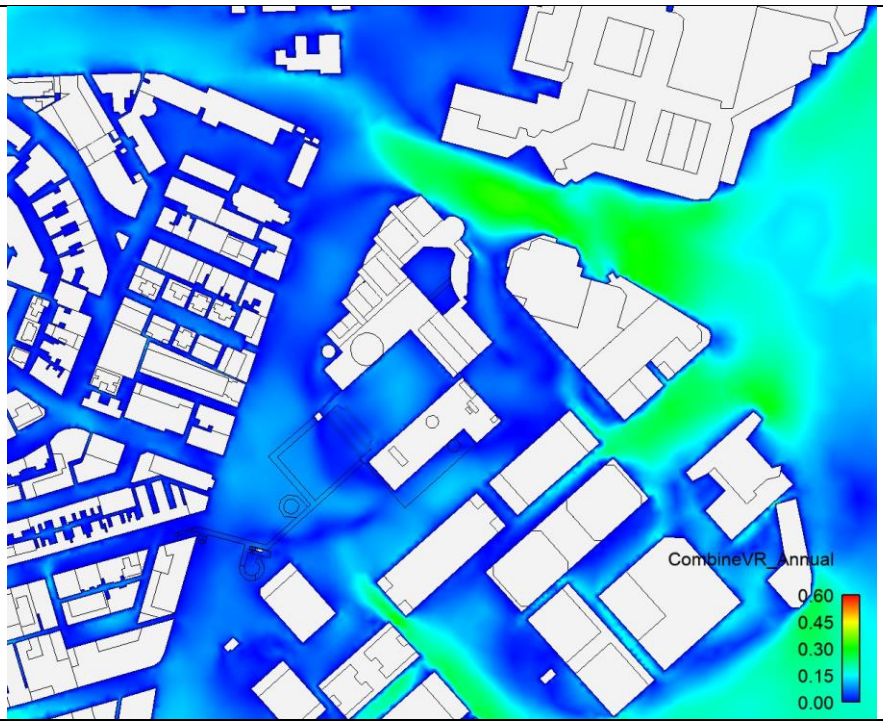
Figure 40 WSW Wind (Summer: 9.3%) at 2m above Ground

The WSW wind would approach the project site through the Observatory Road, the Granville Road and the Cameron Road and eventually gather at the Chatham Road South.

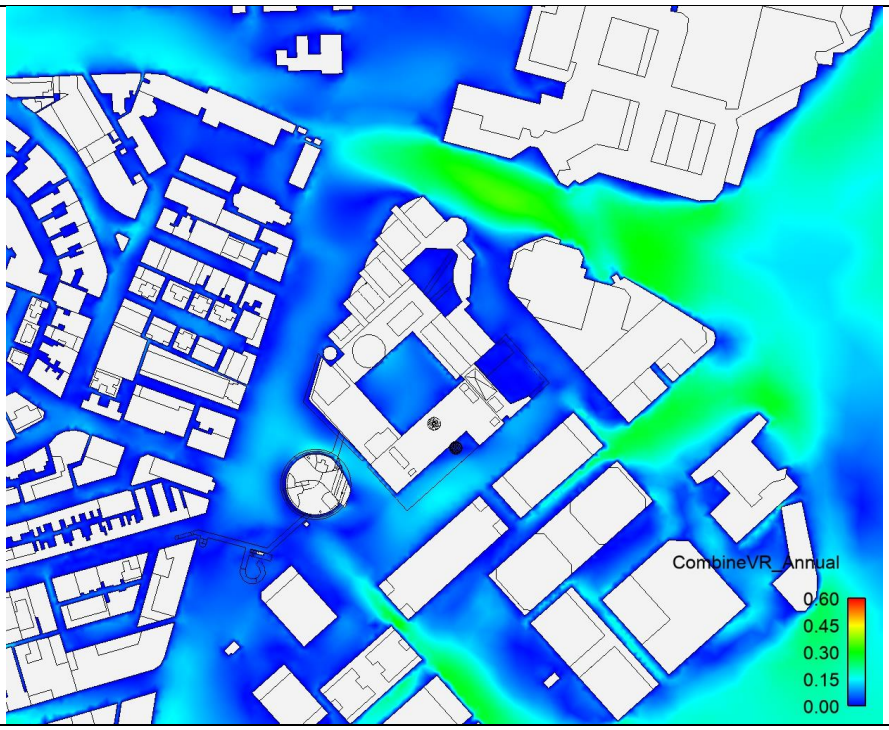
Under the Baseline Scheme, the gathered wind flow towards the courtyard within the project site whereas the airstream would separate into three branches along the Chatham Road South, southeastern façade of Annex 2A and southern side of Annex 2B, which is similar to the scenarios for SSW and SW winds under the Proposed Scheme.

4.2 Summary of the Wind Velocity Ratio Results

4.2.1 The annual wind frequency weighted average VR_W plot for the subject site is present in Figure 41 and Figure 42.

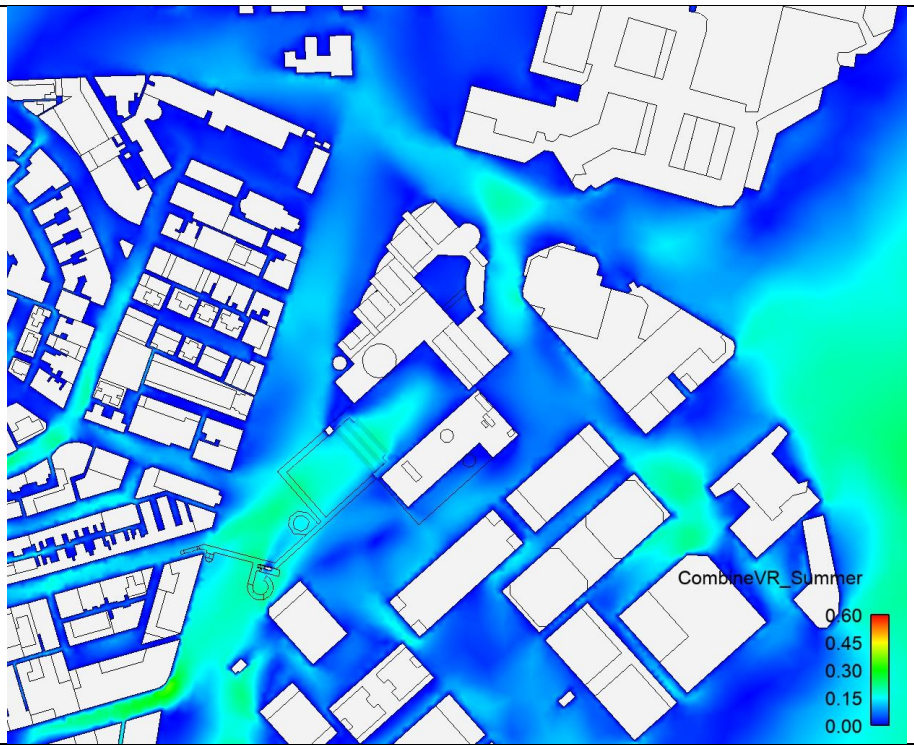


Baseline Scheme – Annual Wind

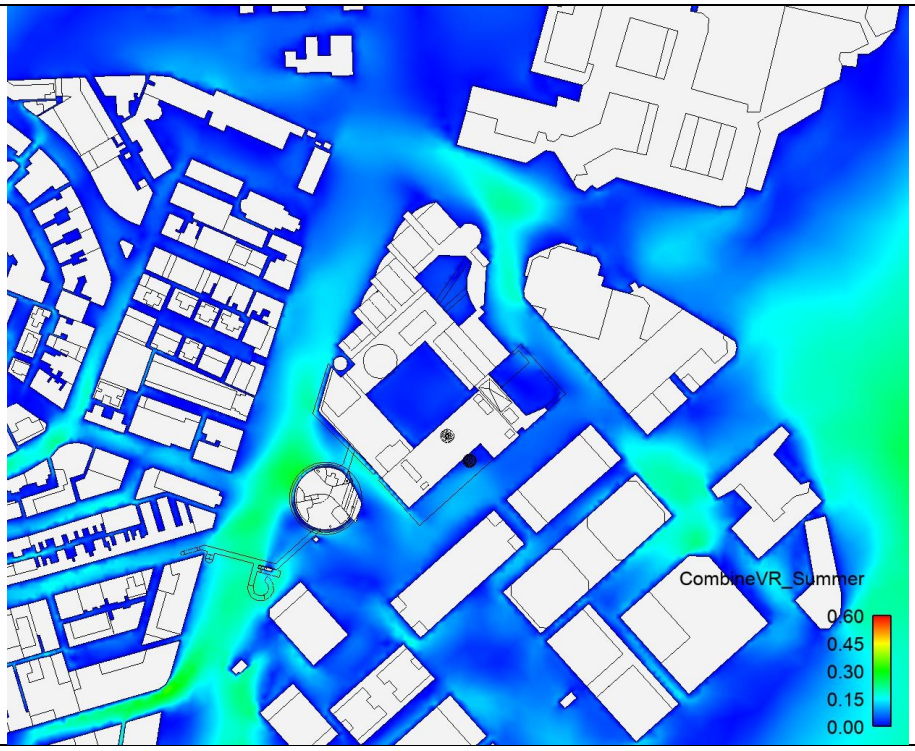


Proposed Scheme – Annual Wind

Figure 41 Frequency Weighted Wind Velocity Ratio Contour Plot (Annual Wind) at 2m above Ground



Baseline Scheme – Summer Wind



Proposed Scheme – Summer Wind

Figure 42 Frequency Weighted Wind Velocity Ratio Contour Plot (Summer Wind) at 2m above Ground

4.2.2 In general, similar wind environment is achieved at the neighborhood area of the project site for the Baseline and Proposed Schemes under both annual and summer conditions.

4.2.3 Specifically, the Annex 1 in the Proposed Scheme would generate slightly better wind performance along the Science Museum Road and the Granville Road under most of the annual winds but it would become slightly worse under most of the summer winds. The Annex 2A would be able to facilitate the airflow keeping along the Chatham Road South under both annual and summer winds. The location of the Annex 2B would separate the summer prevailing winds, e.g. SSW, SW and WSW winds, diverting the airstream along the southern façade of Annex 2A and towards the East Ocean Centre.

4.2.4 The results of VR_W for different focus areas of test points are summarized in Table 4. It is noted that the VR values of the Baseline Scheme at the identified focus areas are quite close to those of the Proposed Scheme, representing almost equal wind performance is achieved under the two schemes.

Table 4 Summary of Wind Velocity Ratio for Different Focus Areas

Group	Focus Areas	Test Points	Average VR_W (Annual Winds)		Average VR_W (Summer Winds)	
			Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
G1	The Hong Kong Polytechnic University	O58-66	0.13	0.13	0.10	0.10
G2	Concordia Plaza & New East Ocean Centre	P21-25, O27-28, O67-73	0.21	0.21	0.15	0.14
G3	Harbour Crystal Centre	O27 -28, O76-79, O86-90	0.16	0.16	0.14	0.14
G4	East Ocean Centre	O80-85, O90-94	0.18	0.18	0.14	0.14
G5	New Mandarin Plaza	O29-30, O87-92, O96	0.23	0.23	0.18	0.18
G6	Urban Council Centenary Garden	O92-96, O103-106	0.17	0.17	0.16	0.16
G7	Hilton Towers/ Granville Square	O99-101	0.12	0.10	0.12	0.12
G8	Energy Plaza	O97-103	0.13	0.12	0.13	0.13
G9	Building Cluster 1	O5-6, O31-36, O46	0.13	0.13	0.20	0.20
G10	Building Cluster 2	O7-8, O34-42	0.11	0.10	0.11	0.10
G11	Building Cluster 3	O9-10, O41-45	0.11	0.12	0.10	0.10

Group	Focus Areas	Test Points	Average VR_w (Annual Winds)		Average VR_w (Summer Winds)	
			Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
G12	Building Cluster 4	O10-11, O43-O45	0.13	0.12	0.12	0.11
G13	Rosary Church	O56-57	0.09	0.10	0.05	0.05
G14	St. Mary's Canossian College	O12-13, O18-20, O51-55	0.10	0.10	0.09	0.09
G15	Gun Club Hill Barracks-Block 13	O47-50	0.14	0.13	0.12	0.11
G16	Austin Road & Cheong Wan Road	O18-26	0.24	0.25	0.16	0.17
G17	Chatham Road South	O1-17	0.16	0.16	0.17	0.17
G18	Granville Road	P1-5, P26-30, O5, O31-33	0.13	0.14	0.15	0.16
G19	Science Museum Road	P20-25, O27-30	0.18	0.17	0.16	0.16
G20	Hong Tat Path Garden	O74-75	0.34	0.34	0.23	0.23
G21	Austin Avenue	O43-45	0.09	0.09	0.08	0.09
G22	Chatham Court	O40-42	0.09	0.09	0.06	0.06
G23	Observatory Road	O34-36	0.14	0.13	0.18	0.18
G24	Setback Area	Baseline S1-9 Proposed S1-8	0.16	0.16	0.11	0.14
G25	Open Space around Annex 2B	Baseline S10-31 Proposed S9-24	0.14	0.13	0.16	0.15
G26	Recessed Area	Baseline S32-36 Proposed S25-29	0.08	0.08	0.07	0.07
G27	Podium Courtyard	Baseline S37-46 Proposed S30-35	0.11	0.10	0.13	0.08

4.2.5 A summary of the predicted wind velocity ratios for the Perimeter Test Points and the Overall Test Points i.e. SVR_W and LVR_W under both annual and summer prevailing winds are presented in Table 5 below to compare the overall wind performance of the Baseline Scheme and the Proposed Scheme.

4.2.6 Details of the wind velocity ratio at each test point location are presented in Appendix C.

Table 5 Summary of Wind Velocity Ratio of Two Schemes

Wind Condition	Annual Winds		Summer Winds	
Scheme	Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
SVR_W	0.18	0.18	0.14	0.15
LVR_W	0.16	0.16	0.14	0.14

4.2.7 The result shows that the SVR_W and LVR_W of the proposed scheme is comparable to those of the baseline scheme under annual winds while only the SVR_W is slightly higher than the Baseline Scheme under summer winds.

4.2.8 Hence, it can be concluded that no adverse air ventilation implication would be caused under the Proposed Scheme with comparison to the Baseline Scheme.

5 CONCLUSIONS

5.1.1 This AVA Study Report aims at assessing the characteristics of the wind availability of the site, providing a general airflow pattern and a quantitative estimation of wind performance at the pedestrian level under the annual and summer wind directions with the highest occurrence and investigating the effectiveness of ventilation for Baseline Scheme and Proposed Scheme.

5.1.2 From the finding of this AVA Initial Study, the SVRw for Baseline Scheme is at 0.18 under the annual prevailing wind from NNE, NE, ENE, E, ESE, SE, SSW and SW directions which amount to about 78.8% of the whole time in a year, while that of the Proposed Scheme is at 0.18 as well.

5.1.3 The LVRw for the Baseline Scheme is 0.16 under the annual wind directions stated above, and that of the Proposed Scheme is at 0.16 as well.

5.1.4 Thus, the Proposed Scheme is considered comparable to the Baseline Scheme in terms of air ventilation performance in the vicinity of the Study Area under annual prevailing winds.

5.1.5 The SVRw for Baseline Scheme is maintained at 0.14 under the summer prevailing wind from E, ESE, SE, SSE, S, SSW, SW and WSW directions which amount to about 80.7% of the whole time in a year, while that of the Proposed Scheme is at 0.15. Thus, the Proposed Scheme is considered slightly better than the Baseline Scheme in terms of air ventilation performance in the vicinity of the Study Area under summer prevailing winds.

5.1.6 The LVRw for the Base Scheme is 0.14 under the annual wind directions stated above, and that of the Proposed Scheme is maintained at 0.14. It can be concluded that the Proposed Scheme maintains a similar air ventilation performance compared to the Baseline Scheme under the summer prevailing winds.

5.1.7 Therefore, it can be concluded that no adverse air ventilation implication would be caused under the Proposed Scheme with comparison to the Baseline Scheme.

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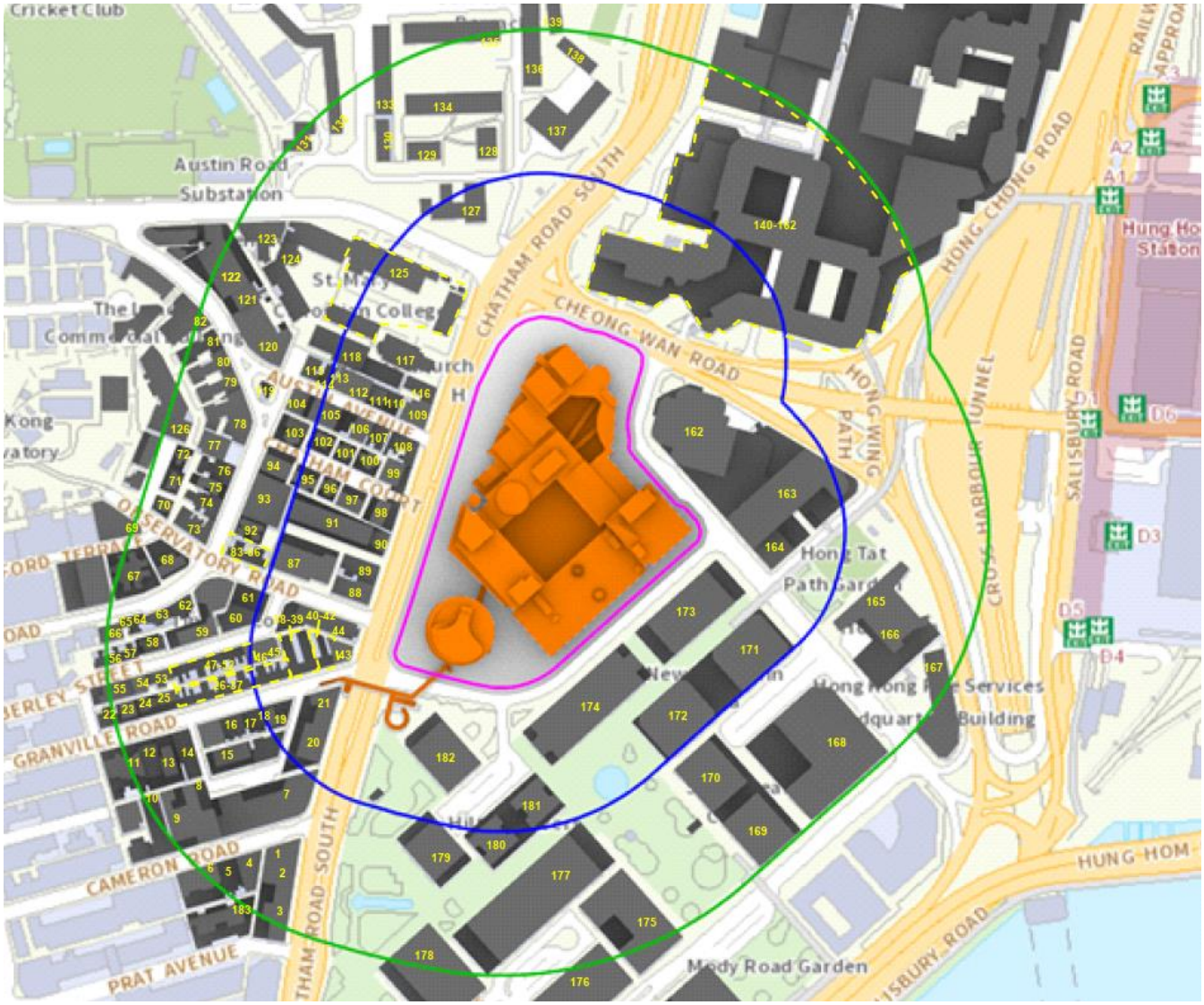
APPENDIX A

Building Height of Surrounding Buildings


Cricket Club
Austin Road Substation
CHATHAM ROAD SOUTH
CHEONG WAN ROAD
HONG CHONG ROAD
HONG WING PATH
CROSS HARBOUR TUNNEL
SALISBURY ROAD
HUNG HOM
Hung Ho Station
Hong Tat Path Garden
Mody Road Garden
OBSERVATORY ROAD
GRANVILLE ROAD
CAMERON ROAD
PRAT AVENUE
D1
D3
D4
D5
D6
A1
A2
A3
140-162

ID	Building	Estimated Building Height (m)
1	Cameron Center	52.73
2	Katherine House	56.62
3	Chevalier House	56.59
4	Kok Pah Mansion	52.98
5	Long Kee Mansion	27.96
6	China Insurance Building	112.11
7	Park Hotel	52.66
8	Wing Hing Mansion	106.01
9	The Cameron	93.20
10	Tsim Sha Tsui Baptist Church	31.23
11	Wan Fai Mansion	42.80
12	Hang Wan Building	31.19
13	Hang Lung Building	43.20
14	Grand Building	28.72
15	Rise Commercial Building	40.80
16	Fortune House	27.33
17	62 Granville Road	18.60
18	64 Granville Road	18.60
19	Wai Wah Building	40.50
20	Oriental Centre	56.67
21	Best Western Plus	56.42
22	37 Granville Road	19.77
23	Tern Commercial Bilding	41.00
24	Hing Ming Building	32.60
25	Granville House	38.60
26-37	43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65 Granville Road	16.64 - 17.88
38-39	65, 67, 69 Granville Road	17.55
40-42	71, 73, 75 Granville Road	17.88
43	Kolling Centre	105.64
44	China Minmetals Tower	68.05
45	1A Kimberley Street	15.41
46	Everglory Centre	105.19
47-52	1D, 1E, 1F, 1G, 1H, 1J Kimberley Street	15.87-17.02
53	Kimley Building	42.81
54	Philip House	103.92
55	On Luen Building	54.73
56	16 Kimberly Street	13.44
57	14 Kimberly Street	15.86
58	8 Kimberly Street	25.29
59	The Empire Hotel Kowloon	79.10
60	Tin Man Court	55.30
61	Church Assembly Hall (Christian Stewards)	46.90

ID	Building	Estimated Building Height (m)
62	Kimbry Court	36.21
63	Kimlai Court	31.33
64	52 Kimberley Road	24.81
65	50 Kimberley Road	24.81
66	Tung Wui Building	58.61
67	Luna Court	44.00
68	Carsion Mansion	44.20
69	Stanford Hillview Hotel	47.57
70	Green View Court	63.57
71	Knutsford Hotel	26.20
72	Observatory Mansion	35.30
73	Pacific Building	34.03
74	Beauty Mansion	30.64
75	New Landwide Commercial Building	37.20
76	South East Mansion	28.75
77	Passkon Court	50.41
78	Kimberley Mansion	42.55
79	Austin Mansion	34.68
80	Carnival Mansion	31.97
81	Companion Court	22.87
82	Windsor Mansion	38.12
83-86	14, 16, 18, 20 Observatory Road	19.41-21.61
87	8 Observatory Road	85.44
88	South Sea Apartment	57.05
89	Golden Mansion	45.77
90	Oriental Crystal Finance Centre	32.60
91	Beverley Commercial Centre	41.51
92	Shun Fai Building	92.87
93	68 Kimberley Road	51.74
94	Kee Shing Centre	40.30
95	King's Commercial Building	53.98
96	Creative Mansion	42.70
97	Yi Serviced Apartment	55.70
98	May Wah Court	46.00
99	Popway Hotel	60.51
100	Kency Tower	48.40
101	Wang Fu Building	39.40
102	Dolford Mansion	43.00
103	Kee Shing Commercial Building	42.90
104	Kam Kok Mansion	47.79
105	Woon Lee Commercial Building	56.44
106	Foo Hoo Centre	58.21

ID	Building	Estimated Building Height (m)
107	Golden House	37.34
108	Grandview Mansion	31.31
109	Winston Mansion	50.46
110	Residence G (2 Austin Avenue)	20.19
111	Austin Commercial Centre	45.90
112	Somptueux Austin	86.54
113	10 Austin Avenue	14.44
114	10A Austin Avenue	14.29
115	86-96 KIMBERLEY ROAD 12-12A AUSTIN AVENUE	33.20
116	Catholic Centre	11.09
117	Rosary Church	13.20
118	St. Mary's Canossian College Hall	16.68
119	Kimberley Road Substation	3.21
120	Kiu Fung Mansion	52.08
121	Perfect Commercial Building	40.00
122	Austin Tower	43.70
123	Garden Mansion	67.43
124	St. Mary's Canossian School (162 AUSTIN ROAD)	24.04
125	St. Mary's Canossian College (158-162 AUSTIN ROAD)	23.25
126	Universal Mansion	29.26
127	Gun Club Hill Barracks Block 13	12.10
128	Gun Club Hill Barracks Block 10	13.70
129	Gun Club Hill Barracks Block 11	11.81
130	Gun Club Hill Barracks Block 12	14.90
131	Gun Club Hill Barracks Block 14	5.77
132	Gun Club Hill Barracks Block C	13.27
133	Gun Club Hill Barracks Block 3	11.49
134	Gun Club Hill Barracks Block 2	14.00
135	Gun Club Hill Barracks Block 1	12.87
136	Gun Club Hill Barracks Block 8	9.35
137	Gun Club Hill Barracks A	14.42
138	Gun Club Hill Barracks Block K1	9.23
139	Gun Club Hill Barracks Block K2	8.39
140-161	The Hong Kong Polytechnic University	13.16-35.32
162	Concordia Plaza	76.50
163	New East Ocean Centre	61.22
164	Woodcliffe	43.27
165	University House	113.16
166	Hotel Icon	93.70
167	Hong Kong Fire Services Headquarters Building	46.58
168	Chinachem Golden Plaza	47.09
169	South Seas Centre Tower 1	51.31

ID	Building	Estimated Building Height (m)
170	South Seas Centre Tower 2	51.31
171	New Mandarin Plaza Block B	30.90
172	New Mandarin Plaza Block A	30.90
173	Harbour Crystal Centre	30.30
174	East Ocean Centre	33.20
175	Regal Kowloon Hotel	47.61
176	The Royal Garden	49.02
177	Peninsula Centre	47.13
178	Auto Plaza	45.73
179	Inter-continental Plaza	33.90
180	Hilton Tower Block A	30.30
181	Hilton Tower Block B	30.30
182	Energy Plaza	47.04
183	Prat Mansions	129.53

APPENDIX B

Site Wind Availability Data

Wind Probability Table (Annual Wind)

Grid (081, 038)	Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
V_infinity(m/s)	Sum	0.021	0.061	0.076	0.149	0.235	0.094	0.054	0.041	0.045	0.063	0.056	0.037	0.027	0.015	0.013	0.012
00_to_01	0.021	0.001	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001
01_to_02	0.053	0.002	0.004	0.005	0.004	0.007	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.001	0.001	0.002
02_to_03	0.082	0.004	0.006	0.008	0.008	0.009	0.005	0.005	0.005	0.004	0.006	0.006	0.005	0.004	0.002	0.002	0.002
03_to_04	0.098	0.004	0.007	0.01	0.013	0.011	0.005	0.007	0.006	0.005	0.007	0.006	0.005	0.004	0.003	0.002	0.002
04_to_05	0.108	0.003	0.007	0.01	0.017	0.015	0.008	0.008	0.006	0.006	0.007	0.007	0.004	0.004	0.002	0.002	0.002
05_to_06	0.117	0.002	0.007	0.01	0.018	0.023	0.011	0.007	0.006	0.005	0.008	0.008	0.004	0.003	0.002	0.002	0.001
06_to_07	0.113	0.002	0.006	0.009	0.02	0.027	0.012	0.006	0.004	0.006	0.007	0.007	0.004	0.001	0.001	0.001	0
07_to_08	0.108	0.001	0.006	0.007	0.019	0.03	0.013	0.005	0.003	0.005	0.006	0.004	0.003	0.001	0.001	0.001	0
08_to_09	0.089	0.001	0.004	0.006	0.017	0.029	0.011	0.004	0.002	0.004	0.005	0.003	0.002	0.001	0.001	0	0
09_to_10	0.067	0	0.004	0.003	0.012	0.024	0.009	0.003	0.001	0.002	0.004	0.002	0.001	0	0	0	0
10_to_11	0.052	0	0.003	0.002	0.008	0.02	0.007	0.002	0.001	0.001	0.003	0.002	0.001	0	0	0	0
11_to_12	0.034	0	0.002	0.002	0.004	0.015	0.004	0.001	0.001	0.001	0.002	0.002	0.001	0	0	0	0
12_to_13	0.021	0	0.001	0.001	0.002	0.009	0.003	0.001	0	0.001	0.001	0.002	0	0	0	0	0
13_to_14	0.013	0	0.001	0	0.002	0.005	0.002	0	0	0	0.001	0.001	0	0	0	0	0
14_to_15	0.007	0	0	0	0.001	0.003	0.001	0	0	0	0.001	0.001	0	0	0	0	0
15_to_16	0.005	0	0	0	0.001	0.002	0	0	0	0	0	0	0	0	0	0	0
16_to_17	0.003	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0
17_to_18	0.002	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0
18_to_19	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19_to_20	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20_to_21	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21_to_22	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22_to_23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23_to_24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Wind Probability Table (Summer Wind)

Grid (081, 038)	Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
V_infinity(m/s)	Sum	0.009	0.011	0.014	0.032	0.099	0.091	0.073	0.073	0.098	0.143	0.137	0.093	0.059	0.031	0.023	0.012
00_to_01	0.026	0.001	0.001	0.001	0.001	0.003	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.001	0.001	0.001
01_to_02	0.065	0.002	0.002	0.002	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.006	0.005	0.007	0.002	0.001	0.001
02_to_03	0.097	0.002	0.002	0.002	0.003	0.005	0.006	0.008	0.009	0.006	0.012	0.014	0.012	0.009	0.003	0.002	0.002
03_to_04	0.107	0.001	0.001	0.001	0.003	0.006	0.005	0.01	0.009	0.009	0.015	0.014	0.014	0.009	0.004	0.003	0.002
04_to_05	0.114	0.001	0.001	0.001	0.003	0.008	0.008	0.009	0.009	0.011	0.016	0.015	0.01	0.011	0.005	0.004	0.003
05_to_06	0.116	0	0.001	0.001	0.003	0.01	0.01	0.007	0.008	0.012	0.016	0.019	0.011	0.007	0.006	0.005	0.001
06_to_07	0.103	0.001	0	0.001	0.002	0.011	0.011	0.006	0.008	0.012	0.016	0.016	0.01	0.003	0.003	0.002	0.001
07_to_08	0.094	0	0	0.001	0.002	0.011	0.012	0.007	0.007	0.013	0.014	0.01	0.009	0.002	0.003	0.002	0.001
08_to_09	0.069	0	0	0	0.002	0.008	0.007	0.004	0.005	0.01	0.012	0.009	0.005	0.002	0.002	0.001	0
09_to_10	0.052	0	0	0	0.002	0.008	0.006	0.004	0.003	0.005	0.01	0.006	0.004	0.001	0.001	0.001	0
10_to_11	0.045	0	0.001	0	0.001	0.007	0.005	0.003	0.003	0.004	0.008	0.007	0.004	0.001	0	0	0
11_to_12	0.034	0	0	0	0.001	0.004	0.004	0.002	0.003	0.003	0.005	0.006	0.002	0.001	0.001	0	0
12_to_13	0.024	0	0	0.001	0.001	0.003	0.004	0.002	0.001	0.002	0.003	0.005	0.001	0.001	0	0	0
13_to_14	0.017	0	0	0.001	0.001	0.003	0.002	0.001	0	0.001	0.003	0.003	0.001	0	0	0	0
14_to_15	0.01	0	0	0	0.001	0.002	0.001	0.001	0	0.001	0.002	0.002	0.001	0	0	0	0
15_to_16	0.009	0	0	0	0.001	0.003	0.001	0	0	0.001	0.001	0.001	0	0	0	0	0
16_to_17	0.005	0	0	0	0.001	0.001	0	0	0	0.001	0	0.001	0	0	0	0	0
17_to_18	0.004	0	0	0	0	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0
18_to_19	0.002	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0
19_to_20	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20_to_21	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21_to_22	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22_to_23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23_to_24	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX C

Test Points Data

Velocity Ratio of Individual Test Points for the Baseline Scheme

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
P1	0.15	0.13	0.19	0.22	0.09	0.10	0.10	0.09	0.24	0.15	0.08	0.17	0.14
P2	0.14	0.12	0.04	0.19	0.05	0.01	0.08	0.08	0.18	0.10	0.06	0.12	0.10
P3	0.12	0.01	0.25	0.07	0.03	0.13	0.05	0.09	0.03	0.02	0.16	0.10	0.07
P4	0.11	0.16	0.21	0.07	0.12	0.20	0.06	0.15	0.18	0.38	0.06	0.15	0.17
P5	0.11	0.17	0.27	0.10	0.15	0.24	0.19	0.23	0.32	0.30	0.15	0.18	0.22
P6	0.09	0.23	0.26	0.12	0.16	0.28	0.36	0.27	0.25	0.35	0.33	0.20	0.27
P7	0.09	0.12	0.33	0.14	0.17	0.25	0.36	0.26	0.19	0.15	0.23	0.19	0.21
P8	0.16	0.17	0.34	0.02	0.09	0.23	0.36	0.26	0.09	0.05	0.02	0.14	0.13
P9	0.20	0.20	0.34	0.03	0.10	0.20	0.34	0.25	0.05	0.07	0.02	0.14	0.12
P10	0.21	0.22	0.35	0.18	0.16	0.20	0.34	0.25	0.04	0.07	0.03	0.20	0.14
P11	0.22	0.21	0.34	0.26	0.21	0.18	0.34	0.26	0.07	0.15	0.05	0.24	0.18
P12	0.29	0.18	0.32	0.27	0.22	0.17	0.34	0.26	0.04	0.02	0.03	0.22	0.15
P13	0.32	0.14	0.25	0.26	0.22	0.15	0.35	0.26	0.03	0.06	0.04	0.21	0.15
P14	0.08	0.08	0.23	0.22	0.20	0.13	0.27	0.23	0.03	0.09	0.07	0.17	0.14
P15	0.14	0.08	0.28	0.18	0.18	0.10	0.22	0.20	0.05	0.10	0.08	0.16	0.13
P16	0.15	0.28	0.45	0.07	0.15	0.07	0.08	0.14	0.07	0.11	0.07	0.18	0.10
P17	0.11	0.29	0.41	0.48	0.11	0.14	0.24	0.08	0.06	0.09	0.05	0.29	0.15
P18	0.14	0.29	0.38	0.46	0.06	0.27	0.28	0.13	0.03	0.07	0.04	0.28	0.15
P19	0.18	0.31	0.41	0.47	0.07	0.35	0.31	0.16	0.35	0.14	0.06	0.33	0.24
P20	0.14	0.33	0.36	0.32	0.07	0.02	0.07	0.14	0.39	0.17	0.04	0.26	0.18
P21	0.12	0.37	0.45	0.15	0.07	0.04	0.16	0.22	0.40	0.18	0.04	0.23	0.18

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
P22	0.12	0.32	0.33	0.02	0.07	0.04	0.15	0.19	0.38	0.17	0.05	0.16	0.15
P23	0.12	0.32	0.19	0.04	0.09	0.05	0.16	0.13	0.30	0.16	0.08	0.14	0.14
P24	0.10	0.30	0.09	0.01	0.15	0.07	0.16	0.02	0.17	0.16	0.05	0.10	0.10
P25	0.06	0.24	0.14	0.05	0.14	0.02	0.16	0.03	0.14	0.14	0.09	0.11	0.10
P26	0.13	0.11	0.21	0.12	0.05	0.10	0.04	0.02	0.23	0.15	0.10	0.14	0.11
P27	0.14	0.07	0.25	0.10	0.11	0.11	0.06	0.07	0.23	0.13	0.08	0.14	0.12
P28	0.07	0.05	0.17	0.13	0.07	0.08	0.01	0.04	0.09	0.08	0.06	0.11	0.07
P29	0.08	0.07	0.07	0.23	0.02	0.02	0.08	0.07	0.22	0.08	0.06	0.12	0.11
P30	0.12	0.10	0.05	0.23	0.04	0.02	0.02	0.13	0.24	0.07	0.11	0.13	0.12
O1	0.13	0.30	0.08	0.18	0.17	0.12	0.34	0.32	0.47	0.29	0.24	0.19	0.28
O2	0.11	0.23	0.08	0.16	0.13	0.17	0.35	0.28	0.40	0.26	0.22	0.17	0.26
O3	0.09	0.16	0.11	0.14	0.12	0.20	0.35	0.27	0.36	0.23	0.17	0.16	0.24
O4	0.14	0.13	0.08	0.12	0.11	0.20	0.35	0.25	0.23	0.15	0.05	0.13	0.18
O5	0.12	0.10	0.16	0.11	0.10	0.23	0.36	0.26	0.19	0.37	0.41	0.15	0.25
O6	0.13	0.27	0.24	0.11	0.15	0.25	0.37	0.26	0.11	0.15	0.06	0.17	0.17
O7	0.12	0.04	0.32	0.07	0.10	0.19	0.22	0.19	0.04	0.05	0.03	0.12	0.10
O8	0.12	0.06	0.32	0.05	0.09	0.21	0.25	0.29	0.01	0.07	0.04	0.12	0.11
O9	0.07	0.18	0.32	0.17	0.14	0.20	0.27	0.33	0.04	0.02	0.03	0.17	0.13
O10	0.13	0.19	0.28	0.24	0.15	0.19	0.31	0.36	0.03	0.13	0.10	0.20	0.17
O11	0.25	0.20	0.22	0.24	0.20	0.17	0.34	0.35	0.05	0.08	0.04	0.20	0.17
O12	0.10	0.13	0.26	0.14	0.18	0.12	0.34	0.32	0.04	0.10	0.09	0.15	0.15
O13	0.07	0.21	0.33	0.15	0.16	0.09	0.33	0.27	0.08	0.11	0.09	0.17	0.15

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O14	0.09	0.11	0.16	0.35	0.14	0.12	0.22	0.25	0.14	0.10	0.08	0.19	0.17
O15	0.16	0.09	0.17	0.07	0.10	0.31	0.12	0.20	0.07	0.06	0.08	0.12	0.12
O16	0.17	0.14	0.20	0.14	0.08	0.13	0.09	0.17	0.02	0.04	0.07	0.13	0.09
O17	0.10	0.12	0.22	0.07	0.10	0.19	0.07	0.16	0.04	0.05	0.07	0.11	0.09
O18	0.15	0.13	0.13	0.17	0.05	0.09	0.22	0.11	0.07	0.09	0.05	0.13	0.10
O19	0.17	0.08	0.07	0.13	0.03	0.07	0.11	0.05	0.08	0.06	0.05	0.09	0.07
O20	0.14	0.06	0.18	0.15	0.08	0.08	0.35	0.23	0.10	0.09	0.07	0.12	0.13
O21	0.11	0.20	0.29	0.43	0.10	0.26	0.14	0.13	0.14	0.11	0.07	0.26	0.17
O22	0.20	0.25	0.32	0.30	0.09	0.34	0.12	0.06	0.09	0.11	0.03	0.24	0.13
O23	0.23	0.31	0.37	0.33	0.31	0.35	0.05	0.08	0.28	0.08	0.06	0.30	0.19
O24	0.24	0.37	0.43	0.39	0.35	0.39	0.34	0.16	0.25	0.07	0.09	0.35	0.24
O25	0.24	0.35	0.39	0.32	0.38	0.35	0.29	0.16	0.24	0.09	0.11	0.32	0.23
O26	0.22	0.34	0.40	0.38	0.38	0.35	0.12	0.14	0.09	0.04	0.08	0.32	0.18
O27	0.05	0.09	0.03	0.12	0.19	0.14	0.17	0.04	0.20	0.13	0.10	0.11	0.14
O28	0.11	0.13	0.09	0.10	0.29	0.16	0.20	0.11	0.22	0.13	0.09	0.14	0.16
O29	0.17	0.27	0.26	0.42	0.20	0.10	0.20	0.15	0.29	0.15	0.07	0.28	0.20
O30	0.16	0.25	0.29	0.25	0.26	0.17	0.25	0.28	0.36	0.30	0.14	0.26	0.26
O31	0.21	0.19	0.05	0.03	0.08	0.22	0.11	0.10	0.02	0.38	0.41	0.11	0.17
O32	0.19	0.21	0.05	0.09	0.02	0.30	0.13	0.15	0.17	0.40	0.40	0.13	0.21
O33	0.12	0.23	0.04	0.01	0.04	0.23	0.13	0.13	0.24	0.46	0.44	0.12	0.23
O34	0.10	0.26	0.09	0.07	0.04	0.21	0.09	0.02	0.18	0.24	0.30	0.12	0.15
O35	0.05	0.37	0.14	0.08	0.05	0.24	0.13	0.10	0.17	0.25	0.40	0.15	0.18

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O36	0.05	0.34	0.08	0.05	0.07	0.26	0.09	0.16	0.30	0.32	0.38	0.14	0.22
O37	0.13	0.15	0.10	0.04	0.10	0.10	0.09	0.09	0.12	0.10	0.13	0.09	0.10
O38	0.08	0.06	0.09	0.05	0.12	0.01	0.07	0.06	0.11	0.02	0.02	0.07	0.06
O39	0.04	0.07	0.11	0.06	0.10	0.03	0.02	0.02	0.13	0.12	0.03	0.08	0.07
O40	0.18	0.11	0.03	0.14	0.09	0.08	0.17	0.07	0.03	0.02	0.03	0.09	0.07
O41	0.09	0.08	0.14	0.09	0.11	0.07	0.11	0.06	0.04	0.04	0.03	0.09	0.07
O42	0.09	0.02	0.13	0.08	0.09	0.08	0.07	0.03	0.03	0.01	0.02	0.08	0.05
O43	0.06	0.11	0.07	0.05	0.10	0.02	0.02	0.04	0.01	0.10	0.14	0.07	0.06
O44	0.23	0.06	0.11	0.08	0.17	0.03	0.09	0.06	0.02	0.09	0.18	0.10	0.09
O45	0.11	0.09	0.10	0.08	0.20	0.05	0.14	0.12	0.01	0.12	0.18	0.10	0.11
O46	0.05	0.10	0.03	0.04	0.04	0.10	0.20	0.11	0.30	0.33	0.25	0.09	0.19
O47	0.12	0.08	0.03	0.33	0.04	0.19	0.15	0.09	0.07	0.02	0.05	0.15	0.11
O48	0.07	0.12	0.13	0.32	0.04	0.22	0.28	0.11	0.08	0.07	0.07	0.17	0.14
O49	0.11	0.12	0.21	0.12	0.10	0.30	0.28	0.29	0.06	0.06	0.07	0.14	0.14
O50	0.21	0.14	0.18	0.03	0.08	0.23	0.18	0.30	0.03	0.05	0.08	0.10	0.11
O51	0.12	0.03	0.04	0.05	0.11	0.04	0.19	0.09	0.03	0.05	0.02	0.06	0.07
O52	0.07	0.03	0.03	0.06	0.10	0.01	0.26	0.16	0.02	0.06	0.06	0.05	0.08
O53	0.09	0.08	0.10	0.05	0.05	0.01	0.18	0.13	0.01	0.06	0.12	0.06	0.07
O54	0.07	0.12	0.09	0.06	0.05	0.04	0.03	0.02	0.02	0.11	0.04	0.07	0.05
O55	0.15	0.10	0.10	0.07	0.05	0.06	0.13	0.02	0.06	0.06	0.10	0.08	0.07
O56	0.22	0.08	0.18	0.01	0.07	0.02	0.05	0.03	0.01	0.05	0.08	0.07	0.04
O57	0.12	0.09	0.18	0.01	0.14	0.04	0.06	0.01	0.04	0.06	0.08	0.08	0.05

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O58	0.21	0.02	0.16	0.06	0.16	0.13	0.10	0.07	0.06	0.03	0.06	0.10	0.08
O59	0.14	0.06	0.11	0.07	0.08	0.04	0.05	0.07	0.04	0.03	0.01	0.08	0.05
O60	0.13	0.07	0.12	0.11	0.13	0.09	0.09	0.03	0.04	0.02	0.05	0.10	0.06
O61	0.28	0.15	0.18	0.12	0.14	0.10	0.09	0.12	0.06	0.04	0.04	0.14	0.09
O62	0.13	0.03	0.10	0.15	0.13	0.06	0.09	0.11	0.04	0.04	0.04	0.10	0.08
O63	0.09	0.03	0.01	0.12	0.16	0.12	0.09	0.08	0.05	0.05	0.04	0.08	0.08
O64	0.14	0.04	0.04	0.02	0.08	0.05	0.05	0.07	0.17	0.04	0.04	0.06	0.07
O65	0.15	0.26	0.30	0.27	0.17	0.23	0.31	0.17	0.34	0.02	0.04	0.24	0.19
O66	0.13	0.24	0.31	0.24	0.20	0.26	0.32	0.07	0.28	0.06	0.03	0.23	0.18
O67	0.12	0.38	0.36	0.33	0.06	0.02	0.15	0.03	0.26	0.06	0.05	0.25	0.13
O68	0.18	0.38	0.43	0.48	0.02	0.31	0.06	0.07	0.11	0.05	0.09	0.31	0.14
O69	0.18	0.24	0.23	0.40	0.26	0.29	0.04	0.08	0.07	0.06	0.09	0.26	0.15
O70	0.23	0.31	0.39	0.42	0.39	0.29	0.05	0.10	0.02	0.07	0.07	0.32	0.16
O71	0.17	0.26	0.35	0.42	0.34	0.29	0.02	0.05	0.07	0.08	0.06	0.30	0.16
O72	0.24	0.37	0.38	0.32	0.34	0.11	0.24	0.15	0.28	0.11	0.03	0.30	0.20
O73	0.19	0.26	0.33	0.33	0.11	0.20	0.18	0.07	0.16	0.12	0.03	0.25	0.15
O74	0.24	0.38	0.38	0.46	0.32	0.07	0.23	0.13	0.29	0.19	0.06	0.35	0.23
O75	0.21	0.36	0.40	0.44	0.16	0.23	0.19	0.18	0.27	0.25	0.08	0.33	0.23
O76	0.13	0.11	0.12	0.03	0.09	0.07	0.03	0.04	0.26	0.17	0.11	0.10	0.11
O77	0.10	0.07	0.18	0.05	0.10	0.08	0.02	0.03	0.22	0.15	0.09	0.11	0.11
O78	0.11	0.03	0.10	0.18	0.07	0.07	0.04	0.02	0.24	0.10	0.08	0.13	0.11
O79	0.10	0.06	0.20	0.24	0.12	0.15	0.05	0.11	0.26	0.09	0.08	0.17	0.15

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O80	0.09	0.09	0.11	0.24	0.03	0.02	0.06	0.02	0.30	0.09	0.02	0.14	0.11
O81	0.12	0.12	0.12	0.20	0.07	0.15	0.06	0.10	0.27	0.08	0.08	0.15	0.13
O82	0.13	0.13	0.03	0.17	0.07	0.10	0.06	0.09	0.24	0.11	0.05	0.12	0.12
O83	0.13	0.15	0.04	0.12	0.05	0.08	0.04	0.05	0.19	0.15	0.02	0.11	0.10
O84	0.11	0.14	0.07	0.31	0.10	0.15	0.12	0.06	0.16	0.13	0.20	0.17	0.15
O85	0.04	0.06	0.45	0.39	0.27	0.17	0.15	0.10	0.13	0.10	0.12	0.27	0.17
O86	0.01	0.03	0.18	0.05	0.10	0.14	0.08	0.15	0.08	0.01	0.08	0.08	0.08
O87	0.29	0.42	0.37	0.43	0.18	0.21	0.04	0.12	0.03	0.18	0.08	0.31	0.15
O88	0.26	0.23	0.19	0.27	0.19	0.23	0.06	0.14	0.04	0.23	0.13	0.22	0.16
O89	0.23	0.21	0.13	0.28	0.18	0.22	0.06	0.15	0.05	0.25	0.13	0.21	0.16
O90	0.23	0.24	0.05	0.33	0.23	0.25	0.10	0.18	0.11	0.29	0.07	0.22	0.20
O91	0.29	0.28	0.05	0.19	0.26	0.28	0.07	0.19	0.10	0.27	0.11	0.19	0.18
O92	0.30	0.26	0.21	0.14	0.23	0.21	0.14	0.07	0.07	0.21	0.14	0.19	0.15
O93	0.24	0.20	0.23	0.13	0.18	0.17	0.09	0.09	0.20	0.14	0.14	0.18	0.15
O94	0.15	0.11	0.39	0.30	0.18	0.15	0.05	0.12	0.16	0.05	0.15	0.24	0.15
O95	0.11	0.15	0.48	0.41	0.29	0.11	0.07	0.13	0.17	0.45	0.37	0.32	0.26
O96	0.15	0.11	0.34	0.10	0.08	0.10	0.22	0.15	0.21	0.17	0.13	0.16	0.15
O97	0.10	0.11	0.13	0.25	0.03	0.05	0.03	0.06	0.15	0.07	0.09	0.14	0.10
O98	0.03	0.11	0.18	0.22	0.04	0.09	0.02	0.07	0.02	0.06	0.15	0.13	0.08
O99	0.17	0.17	0.12	0.19	0.05	0.09	0.02	0.07	0.10	0.11	0.16	0.14	0.10
O100	0.19	0.22	0.07	0.15	0.03	0.16	0.03	0.08	0.07	0.08	0.19	0.12	0.10
O101	0.14	0.16	0.09	0.12	0.02	0.15	0.21	0.11	0.23	0.20	0.13	0.12	0.15

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O102	0.01	0.10	0.28	0.04	0.10	0.20	0.21	0.25	0.31	0.33	0.13	0.15	0.21
O103	0.05	0.17	0.15	0.10	0.11	0.15	0.16	0.26	0.23	0.36	0.15	0.15	0.20
O104	0.04	0.17	0.17	0.12	0.15	0.13	0.04	0.14	0.16	0.29	0.07	0.15	0.15
O105	0.03	0.21	0.05	0.08	0.04	0.04	0.29	0.24	0.43	0.08	0.10	0.10	0.17
O106	0.12	0.12	0.05	0.03	0.03	0.02	0.21	0.08	0.16	0.13	0.10	0.07	0.10
O107	0.03	0.14	0.02	0.15	0.08	0.04	0.14	0.02	0.06	0.17	0.27	0.09	0.12
O108	0.12	0.10	0.26	0.16	0.25	0.15	0.14	0.08	0.16	0.10	0.17	0.17	0.15
S1	0.08	0.10	0.21	0.04	0.11	0.04	0.01	0.02	0.06	0.09	0.07	0.09	0.06
S2	0.16	0.05	0.05	0.14	0.18	0.12	0.14	0.13	0.05	0.10	0.08	0.11	0.11
S3	0.09	0.04	0.20	0.19	0.19	0.13	0.18	0.15	0.03	0.08	0.07	0.15	0.12
S4	0.07	0.08	0.24	0.22	0.20	0.15	0.13	0.09	0.02	0.06	0.05	0.17	0.11
S5	0.25	0.12	0.26	0.25	0.20	0.16	0.06	0.03	0.03	0.03	0.02	0.19	0.09
S6	0.28	0.18	0.32	0.27	0.20	0.17	0.10	0.15	0.05	0.02	0.01	0.22	0.11
S7	0.28	0.21	0.33	0.26	0.18	0.17	0.32	0.27	0.09	0.13	0.02	0.23	0.17
S8	0.23	0.20	0.34	0.17	0.13	0.18	0.31	0.25	0.08	0.06	0.01	0.19	0.14
S9	0.04	0.09	0.07	0.12	0.05	0.15	0.07	0.11	0.05	0.05	0.12	0.09	0.09
S10	0.13	0.18	0.32	0.06	0.07	0.21	0.32	0.26	0.15	0.07	0.03	0.15	0.14
S11	0.10	0.06	0.09	0.13	0.05	0.21	0.11	0.11	0.34	0.24	0.26	0.13	0.20
S12	0.12	0.06	0.11	0.09	0.04	0.18	0.12	0.14	0.26	0.22	0.35	0.12	0.18
S13	0.03	0.03	0.11	0.07	0.08	0.15	0.05	0.04	0.06	0.02	0.12	0.07	0.07
S14	0.03	0.03	0.06	0.01	0.05	0.18	0.03	0.05	0.03	0.19	0.03	0.05	0.07
S15	0.14	0.09	0.19	0.17	0.11	0.16	0.10	0.08	0.19	0.22	0.03	0.16	0.14

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
S16	0.13	0.08	0.12	0.15	0.04	0.05	0.11	0.02	0.12	0.12	0.03	0.11	0.08
S17	0.02	0.04	0.23	0.06	0.12	0.20	0.07	0.02	0.03	0.30	0.04	0.12	0.11
S18	0.06	0.04	0.05	0.08	0.01	0.21	0.05	0.08	0.04	0.15	0.09	0.07	0.09
S19	0.12	0.05	0.07	0.09	0.05	0.20	0.12	0.16	0.28	0.24	0.31	0.11	0.19
S20	0.10	0.13	0.29	0.13	0.08	0.22	0.13	0.14	0.36	0.27	0.28	0.19	0.22
S21	0.03	0.19	0.33	0.16	0.07	0.22	0.28	0.25	0.24	0.15	0.23	0.18	0.20
S22	0.04	0.18	0.34	0.15	0.13	0.24	0.34	0.27	0.22	0.16	0.25	0.19	0.21
S23	0.09	0.17	0.32	0.13	0.11	0.23	0.18	0.19	0.38	0.29	0.30	0.20	0.24
S24	0.12	0.08	0.28	0.09	0.06	0.22	0.14	0.19	0.27	0.27	0.34	0.16	0.20
S25	0.02	0.04	0.26	0.08	0.07	0.22	0.05	0.08	0.05	0.29	0.09	0.12	0.12
S26	0.09	0.04	0.25	0.05	0.10	0.17	0.06	0.07	0.02	0.31	0.09	0.12	0.11
S27	0.13	0.08	0.04	0.14	0.15	0.08	0.12	0.01	0.08	0.05	0.09	0.10	0.09
S28	0.11	0.10	0.14	0.04	0.08	0.14	0.03	0.08	0.01	0.31	0.13	0.10	0.11
S29	0.10	0.15	0.25	0.09	0.11	0.22	0.18	0.21	0.31	0.20	0.12	0.16	0.19
S30	0.12	0.20	0.28	0.12	0.15	0.26	0.25	0.26	0.38	0.27	0.34	0.20	0.26
S31	0.09	0.18	0.31	0.13	0.17	0.25	0.34	0.27	0.32	0.27	0.24	0.20	0.25
S32	0.11	0.07	0.06	0.15	0.03	0.04	0.05	0.07	0.18	0.02	0.05	0.09	0.08
S33	0.08	0.05	0.04	0.12	0.04	0.05	0.02	0.08	0.18	0.04	0.07	0.08	0.08
S34	0.05	0.03	0.06	0.09	0.05	0.06	0.03	0.08	0.16	0.05	0.07	0.07	0.08
S35	0.03	0.02	0.06	0.07	0.05	0.05	0.04	0.06	0.13	0.05	0.06	0.06	0.07
S36	0.03	0.01	0.02	0.08	0.03	0.02	0.02	0.01	0.07	0.03	0.00	0.04	0.04
S37	0.10	0.05	0.06	0.15	0.05	0.08	0.17	0.11	0.34	0.25	0.26	0.13	0.19

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
S38	0.14	0.06	0.07	0.10	0.07	0.18	0.16	0.13	0.25	0.25	0.37	0.12	0.20
S39	0.12	0.07	0.07	0.12	0.11	0.05	0.21	0.10	0.29	0.24	0.18	0.12	0.17
S40	0.13	0.07	0.10	0.08	0.11	0.17	0.15	0.09	0.19	0.24	0.36	0.12	0.18
S41	0.10	0.06	0.10	0.15	0.13	0.07	0.17	0.09	0.06	0.05	0.04	0.11	0.09
S42	0.10	0.06	0.13	0.18	0.13	0.04	0.12	0.05	0.15	0.13	0.23	0.13	0.13
S43	0.07	0.04	0.10	0.18	0.12	0.05	0.10	0.08	0.07	0.07	0.11	0.11	0.10
S44	0.06	0.04	0.11	0.14	0.11	0.02	0.13	0.02	0.16	0.05	0.14	0.10	0.10
S45	0.07	0.03	0.06	0.12	0.06	0.04	0.02	0.06	0.01	0.09	0.16	0.07	0.07
S46	0.10	0.01	0.06	0.07	0.06	0.06	0.10	0.04	0.14	0.07	0.10	0.07	0.08

Velocity Ratio of Individual Test Points for the Proposed Scheme

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
P1	0.17	0.11	0.10	0.20	0.10	0.16	0.11	0.08	0.17	0.14	0.06	0.15	0.13
P2	0.16	0.03	0.03	0.19	0.05	0.12	0.11	0.05	0.13	0.15	0.16	0.11	0.12
P3	0.14	0.07	0.18	0.11	0.16	0.13	0.07	0.06	0.05	0.23	0.21	0.13	0.13
P4	0.12	0.16	0.15	0.13	0.15	0.18	0.11	0.02	0.14	0.28	0.23	0.15	0.16
P5	0.02	0.21	0.26	0.09	0.12	0.22	0.14	0.23	0.16	0.23	0.03	0.16	0.16
P6	0.14	0.30	0.28	0.14	0.13	0.29	0.35	0.33	0.34	0.27	0.33	0.21	0.27
P7	0.16	0.20	0.29	0.17	0.07	0.26	0.38	0.34	0.36	0.30	0.24	0.21	0.27
P8	0.20	0.23	0.26	0.21	0.11	0.23	0.37	0.32	0.21	0.12	0.22	0.20	0.21
P9	0.23	0.23	0.28	0.24	0.13	0.19	0.38	0.34	0.12	0.19	0.06	0.21	0.20
P10	0.25	0.22	0.29	0.24	0.14	0.19	0.32	0.33	0.18	0.19	0.03	0.23	0.20
P11	0.22	0.19	0.30	0.21	0.16	0.17	0.29	0.32	0.18	0.05	0.07	0.20	0.17
P12	0.27	0.17	0.28	0.18	0.18	0.15	0.28	0.31	0.15	0.05	0.08	0.19	0.16
P13	0.29	0.13	0.23	0.12	0.19	0.12	0.27	0.30	0.10	0.01	0.06	0.15	0.14
P14	0.06	0.07	0.22	0.05	0.18	0.09	0.25	0.29	0.09	0.01	0.08	0.10	0.12
P15	0.08	0.07	0.30	0.02	0.16	0.07	0.23	0.26	0.11	0.04	0.09	0.11	0.12
P16	0.21	0.28	0.38	0.34	0.13	0.04	0.09	0.19	0.06	0.07	0.08	0.24	0.12
P17	0.09	0.28	0.36	0.47	0.08	0.22	0.17	0.10	0.03	0.07	0.05	0.28	0.14
P18	0.10	0.29	0.30	0.49	0.14	0.32	0.15	0.10	0.10	0.09	0.03	0.29	0.17
P19	0.14	0.31	0.37	0.52	0.26	0.37	0.26	0.24	0.26	0.14	0.03	0.35	0.25
P20	0.11	0.32	0.24	0.18	0.12	0.08	0.27	0.25	0.34	0.18	0.02	0.20	0.19
P21	0.08	0.34	0.43	0.06	0.13	0.09	0.09	0.25	0.40	0.20	0.03	0.21	0.18

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
P22	0.08	0.30	0.30	0.01	0.12	0.01	0.11	0.17	0.28	0.16	0.03	0.14	0.13
P23	0.05	0.29	0.27	0.03	0.19	0.04	0.17	0.13	0.23	0.13	0.06	0.14	0.13
P24	0.20	0.28	0.17	0.10	0.22	0.04	0.14	0.03	0.07	0.04	0.04	0.14	0.08
P25	0.14	0.23	0.18	0.13	0.15	0.08	0.18	0.02	0.15	0.05	0.02	0.15	0.10
P26	0.18	0.15	0.12	0.12	0.13	0.09	0.08	0.06	0.22	0.10	0.03	0.13	0.11
P27	0.24	0.15	0.07	0.17	0.16	0.10	0.10	0.06	0.19	0.11	0.08	0.15	0.13
P28	0.22	0.11	0.12	0.16	0.14	0.06	0.07	0.06	0.17	0.06	0.05	0.14	0.10
P29	0.19	0.11	0.05	0.21	0.11	0.06	0.04	0.09	0.21	0.07	0.05	0.14	0.11
P30	0.17	0.11	0.15	0.22	0.09	0.02	0.05	0.11	0.26	0.05	0.05	0.15	0.12
O1	0.15	0.32	0.17	0.18	0.12	0.12	0.33	0.27	0.47	0.37	0.38	0.21	0.30
O2	0.14	0.25	0.16	0.09	0.13	0.16	0.34	0.27	0.42	0.37	0.26	0.18	0.27
O3	0.13	0.12	0.08	0.15	0.13	0.19	0.36	0.26	0.34	0.30	0.07	0.16	0.23
O4	0.09	0.06	0.04	0.12	0.13	0.20	0.36	0.26	0.28	0.22	0.14	0.12	0.22
O5	0.14	0.06	0.03	0.10	0.13	0.25	0.37	0.25	0.24	0.35	0.36	0.13	0.26
O6	0.13	0.32	0.14	0.12	0.12	0.27	0.39	0.27	0.17	0.12	0.11	0.16	0.18
O7	0.10	0.13	0.24	0.10	0.10	0.21	0.28	0.23	0.06	0.01	0.06	0.13	0.11
O8	0.11	0.16	0.24	0.16	0.11	0.21	0.26	0.25	0.05	0.02	0.05	0.15	0.12
O9	0.05	0.20	0.29	0.17	0.09	0.19	0.29	0.24	0.05	0.20	0.06	0.17	0.15
O10	0.13	0.19	0.27	0.17	0.10	0.16	0.30	0.26	0.04	0.10	0.07	0.17	0.14
O11	0.27	0.18	0.22	0.07	0.16	0.15	0.31	0.27	0.04	0.02	0.02	0.13	0.11
O12	0.08	0.12	0.25	0.07	0.18	0.10	0.34	0.28	0.01	0.02	0.10	0.12	0.12
O13	0.07	0.22	0.29	0.27	0.17	0.07	0.29	0.28	0.07	0.09	0.10	0.20	0.16

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O14	0.06	0.19	0.16	0.40	0.14	0.14	0.23	0.26	0.09	0.09	0.08	0.21	0.17
O15	0.12	0.13	0.17	0.18	0.10	0.27	0.15	0.21	0.04	0.06	0.07	0.14	0.12
O16	0.17	0.16	0.19	0.18	0.09	0.14	0.06	0.17	0.04	0.07	0.08	0.15	0.10
O17	0.15	0.15	0.20	0.07	0.14	0.18	0.07	0.16	0.05	0.06	0.07	0.12	0.09
O18	0.14	0.12	0.11	0.19	0.07	0.10	0.19	0.10	0.06	0.07	0.13	0.13	0.11
O19	0.16	0.12	0.07	0.11	0.04	0.08	0.08	0.04	0.08	0.05	0.04	0.09	0.06
O20	0.15	0.12	0.15	0.12	0.13	0.07	0.37	0.29	0.10	0.06	0.06	0.12	0.14
O21	0.09	0.25	0.29	0.42	0.06	0.32	0.10	0.13	0.14	0.10	0.07	0.26	0.16
O22	0.18	0.30	0.35	0.43	0.22	0.36	0.03	0.06	0.16	0.11	0.03	0.31	0.17
O23	0.20	0.33	0.39	0.43	0.31	0.40	0.06	0.20	0.21	0.11	0.03	0.34	0.21
O24	0.24	0.37	0.41	0.42	0.34	0.43	0.27	0.18	0.23	0.10	0.05	0.35	0.24
O25	0.25	0.36	0.39	0.33	0.32	0.35	0.31	0.15	0.28	0.13	0.08	0.32	0.23
O26	0.24	0.36	0.41	0.32	0.33	0.34	0.25	0.13	0.13	0.07	0.05	0.30	0.19
O27	0.01	0.10	0.03	0.08	0.23	0.10	0.18	0.05	0.19	0.06	0.01	0.09	0.11
O28	0.04	0.08	0.02	0.09	0.31	0.18	0.20	0.10	0.19	0.13	0.11	0.11	0.16
O29	0.17	0.15	0.27	0.45	0.26	0.15	0.19	0.13	0.29	0.19	0.10	0.29	0.23
O30	0.17	0.18	0.26	0.19	0.29	0.20	0.25	0.24	0.34	0.28	0.16	0.23	0.25
O31	0.19	0.17	0.03	0.07	0.07	0.24	0.10	0.08	0.13	0.35	0.42	0.12	0.19
O32	0.17	0.15	0.04	0.08	0.09	0.31	0.12	0.12	0.21	0.39	0.41	0.14	0.22
O33	0.16	0.22	0.07	0.10	0.06	0.24	0.15	0.05	0.27	0.46	0.43	0.16	0.24
O34	0.03	0.25	0.06	0.02	0.03	0.24	0.08	0.10	0.22	0.20	0.23	0.10	0.15
O35	0.05	0.39	0.16	0.07	0.08	0.24	0.12	0.20	0.19	0.23	0.28	0.15	0.18

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O36	0.05	0.32	0.12	0.04	0.09	0.26	0.08	0.17	0.32	0.28	0.38	0.14	0.21
O37	0.08	0.15	0.10	0.03	0.11	0.05	0.07	0.03	0.08	0.13	0.09	0.08	0.08
O38	0.04	0.05	0.10	0.07	0.03	0.01	0.05	0.02	0.03	0.09	0.02	0.06	0.04
O39	0.02	0.05	0.11	0.08	0.06	0.03	0.04	0.03	0.10	0.08	0.07	0.07	0.07
O40	0.08	0.05	0.06	0.10	0.06	0.04	0.16	0.09	0.05	0.05	0.04	0.07	0.07
O41	0.09	0.11	0.13	0.14	0.08	0.05	0.09	0.07	0.04	0.02	0.04	0.10	0.06
O42	0.07	0.13	0.11	0.14	0.06	0.06	0.05	0.03	0.03	0.03	0.01	0.10	0.05
O43	0.03	0.04	0.04	0.11	0.04	0.03	0.06	0.07	0.06	0.08	0.14	0.06	0.07
O44	0.25	0.13	0.10	0.09	0.18	0.03	0.12	0.04	0.04	0.07	0.16	0.11	0.09
O45	0.11	0.13	0.12	0.06	0.25	0.06	0.15	0.12	0.03	0.10	0.19	0.11	0.11
O46	0.08	0.19	0.06	0.05	0.02	0.11	0.20	0.12	0.34	0.29	0.31	0.11	0.20
O47	0.13	0.06	0.03	0.27	0.05	0.14	0.13	0.10	0.05	0.02	0.01	0.12	0.09
O48	0.08	0.13	0.12	0.24	0.04	0.19	0.25	0.14	0.06	0.03	0.03	0.14	0.11
O49	0.13	0.13	0.19	0.20	0.10	0.23	0.33	0.28	0.04	0.01	0.05	0.15	0.14
O50	0.19	0.10	0.16	0.06	0.08	0.24	0.27	0.27	0.04	0.04	0.05	0.11	0.12
O51	0.12	0.02	0.04	0.05	0.12	0.02	0.17	0.07	0.01	0.03	0.06	0.05	0.06
O52	0.09	0.01	0.03	0.18	0.09	0.02	0.23	0.14	0.04	0.01	0.08	0.08	0.09
O53	0.10	0.08	0.09	0.10	0.07	0.02	0.17	0.09	0.03	0.02	0.13	0.08	0.07
O54	0.08	0.10	0.09	0.05	0.06	0.05	0.02	0.00	0.02	0.05	0.04	0.06	0.04
O55	0.14	0.08	0.10	0.17	0.06	0.07	0.12	0.01	0.07	0.04	0.07	0.11	0.07
O56	0.22	0.04	0.17	0.03	0.08	0.02	0.06	0.03	0.04	0.01	0.10	0.08	0.04
O57	0.11	0.10	0.17	0.13	0.15	0.03	0.04	0.01	0.06	0.03	0.08	0.12	0.07

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O58	0.24	0.05	0.15	0.02	0.16	0.16	0.10	0.04	0.05	0.05	0.08	0.10	0.08
O59	0.16	0.08	0.10	0.08	0.07	0.04	0.05	0.07	0.03	0.02	0.01	0.08	0.05
O60	0.15	0.04	0.12	0.11	0.13	0.12	0.09	0.03	0.04	0.03	0.06	0.10	0.07
O61	0.28	0.14	0.17	0.17	0.14	0.11	0.09	0.13	0.05	0.05	0.09	0.15	0.10
O62	0.17	0.07	0.12	0.15	0.11	0.08	0.07	0.12	0.04	0.04	0.05	0.11	0.08
O63	0.08	0.02	0.01	0.05	0.13	0.12	0.05	0.10	0.04	0.02	0.05	0.05	0.06
O64	0.13	0.10	0.21	0.10	0.04	0.01	0.04	0.09	0.12	0.05	0.01	0.11	0.06
O65	0.15	0.30	0.41	0.23	0.18	0.27	0.30	0.20	0.30	0.14	0.01	0.26	0.20
O66	0.15	0.27	0.14	0.32	0.09	0.30	0.32	0.16	0.26	0.10	0.02	0.22	0.19
O67	0.10	0.36	0.29	0.24	0.05	0.04	0.28	0.19	0.29	0.13	0.03	0.21	0.16
O68	0.15	0.32	0.35	0.44	0.09	0.23	0.15	0.09	0.13	0.06	0.05	0.28	0.15
O69	0.20	0.24	0.23	0.39	0.18	0.23	0.07	0.08	0.11	0.01	0.06	0.25	0.13
O70	0.25	0.35	0.41	0.38	0.36	0.20	0.03	0.05	0.08	0.06	0.05	0.31	0.14
O71	0.16	0.28	0.36	0.39	0.29	0.17	0.04	0.05	0.03	0.04	0.03	0.27	0.12
O72	0.26	0.41	0.37	0.34	0.31	0.23	0.26	0.17	0.27	0.09	0.03	0.31	0.21
O73	0.22	0.36	0.38	0.58	0.13	0.19	0.16	0.03	0.23	0.15	0.06	0.35	0.19
O74	0.25	0.30	0.41	0.52	0.32	0.07	0.22	0.12	0.28	0.19	0.10	0.36	0.23
O75	0.22	0.26	0.41	0.42	0.19	0.17	0.19	0.17	0.27	0.23	0.12	0.31	0.22
O76	0.14	0.11	0.06	0.09	0.05	0.06	0.04	0.02	0.23	0.08	0.04	0.09	0.09
O77	0.20	0.15	0.09	0.19	0.03	0.07	0.07	0.05	0.24	0.08	0.03	0.14	0.10
O78	0.17	0.13	0.07	0.25	0.05	0.08	0.04	0.05	0.19	0.04	0.03	0.14	0.10
O79	0.15	0.10	0.19	0.25	0.05	0.19	0.14	0.09	0.22	0.04	0.10	0.17	0.13

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O80	0.14	0.09	0.08	0.23	0.04	0.01	0.06	0.02	0.28	0.06	0.06	0.14	0.11
O81	0.15	0.11	0.07	0.14	0.05	0.10	0.09	0.06	0.21	0.09	0.11	0.11	0.11
O82	0.13	0.13	0.09	0.08	0.07	0.08	0.07	0.08	0.20	0.06	0.12	0.10	0.10
O83	0.08	0.14	0.06	0.03	0.03	0.06	0.03	0.05	0.20	0.14	0.11	0.07	0.09
O84	0.05	0.10	0.34	0.28	0.27	0.12	0.07	0.08	0.20	0.19	0.10	0.23	0.17
O85	0.11	0.03	0.43	0.33	0.27	0.18	0.14	0.10	0.10	0.09	0.12	0.25	0.16
O86	0.03	0.06	0.16	0.03	0.06	0.15	0.11	0.13	0.07	0.02	0.06	0.07	0.07
O87	0.28	0.32	0.23	0.43	0.15	0.25	0.10	0.13	0.06	0.13	0.11	0.27	0.16
O88	0.30	0.28	0.24	0.36	0.20	0.26	0.14	0.15	0.01	0.16	0.12	0.26	0.16
O89	0.26	0.19	0.17	0.29	0.11	0.26	0.14	0.15	0.02	0.18	0.05	0.20	0.14
O90	0.27	0.21	0.05	0.35	0.18	0.27	0.17	0.18	0.11	0.20	0.07	0.22	0.19
O91	0.30	0.21	0.12	0.29	0.21	0.29	0.20	0.18	0.11	0.21	0.08	0.22	0.19
O92	0.31	0.18	0.22	0.23	0.20	0.20	0.09	0.07	0.08	0.16	0.11	0.21	0.14
O93	0.25	0.07	0.25	0.18	0.16	0.12	0.09	0.09	0.22	0.12	0.13	0.18	0.14
O94	0.04	0.14	0.42	0.15	0.19	0.13	0.08	0.11	0.16	0.05	0.06	0.19	0.11
O95	0.11	0.22	0.49	0.33	0.26	0.08	0.06	0.13	0.19	0.39	0.36	0.30	0.24
O96	0.14	0.05	0.36	0.08	0.06	0.06	0.12	0.12	0.21	0.07	0.12	0.14	0.11
O97	0.10	0.18	0.11	0.15	0.05	0.04	0.04	0.05	0.18	0.07	0.05	0.12	0.09
O98	0.02	0.14	0.09	0.06	0.01	0.07	0.06	0.09	0.11	0.03	0.09	0.07	0.07
O99	0.09	0.18	0.02	0.15	0.04	0.12	0.07	0.07	0.08	0.19	0.18	0.11	0.11
O100	0.16	0.15	0.05	0.15	0.06	0.18	0.02	0.09	0.05	0.12	0.18	0.11	0.10
O101	0.08	0.10	0.05	0.09	0.05	0.13	0.21	0.05	0.22	0.16	0.11	0.10	0.13

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
O102	0.05	0.11	0.28	0.05	0.16	0.21	0.22	0.22	0.32	0.30	0.15	0.16	0.22
O103	0.04	0.14	0.18	0.14	0.16	0.15	0.15	0.26	0.21	0.28	0.21	0.16	0.20
O104	0.08	0.12	0.20	0.16	0.14	0.15	0.04	0.15	0.12	0.08	0.15	0.14	0.12
O105	0.03	0.10	0.18	0.16	0.05	0.06	0.29	0.27	0.51	0.07	0.03	0.15	0.20
O106	0.13	0.11	0.01	0.08	0.09	0.02	0.17	0.12	0.13	0.23	0.05	0.08	0.12
O107	0.12	0.18	0.04	0.12	0.02	0.08	0.13	0.03	0.04	0.15	0.21	0.09	0.10
O108	0.13	0.01	0.04	0.12	0.02	0.13	0.07	0.09	0.04	0.23	0.21	0.09	0.12
S1	0.07	0.09	0.26	0.06	0.14	0.04	0.04	0.13	0.03	0.05	0.07	0.11	0.07
S2	0.18	0.03	0.15	0.09	0.15	0.10	0.12	0.19	0.10	0.04	0.09	0.11	0.11
S3	0.15	0.05	0.18	0.05	0.18	0.12	0.16	0.23	0.14	0.02	0.07	0.11	0.11
S4	0.05	0.07	0.21	0.13	0.18	0.13	0.16	0.24	0.15	0.03	0.04	0.13	0.13
S5	0.27	0.12	0.25	0.15	0.16	0.15	0.22	0.28	0.17	0.05	0.06	0.17	0.15
S6	0.30	0.16	0.29	0.17	0.18	0.16	0.23	0.29	0.20	0.08	0.08	0.20	0.17
S7	0.30	0.17	0.29	0.21	0.15	0.18	0.22	0.30	0.23	0.06	0.13	0.21	0.18
S8	0.25	0.18	0.28	0.21	0.12	0.17	0.24	0.32	0.27	0.17	0.17	0.21	0.21
S9	0.13	0.21	0.29	0.18	0.10	0.18	0.19	0.29	0.22	0.20	0.22	0.19	0.20
S10	0.02	0.04	0.02	0.10	0.07	0.14	0.12	0.07	0.13	0.18	0.27	0.08	0.14
S11	0.05	0.13	0.14	0.11	0.09	0.20	0.09	0.02	0.29	0.13	0.32	0.13	0.16
S12	0.04	0.14	0.16	0.10	0.09	0.17	0.11	0.03	0.28	0.10	0.24	0.13	0.15
S13	0.04	0.13	0.14	0.05	0.10	0.08	0.11	0.02	0.24	0.07	0.13	0.10	0.11
S14	0.18	0.09	0.11	0.19	0.10	0.11	0.10	0.06	0.23	0.16	0.05	0.15	0.14
S15	0.17	0.04	0.05	0.06	0.09	0.16	0.09	0.08	0.16	0.07	0.03	0.08	0.09

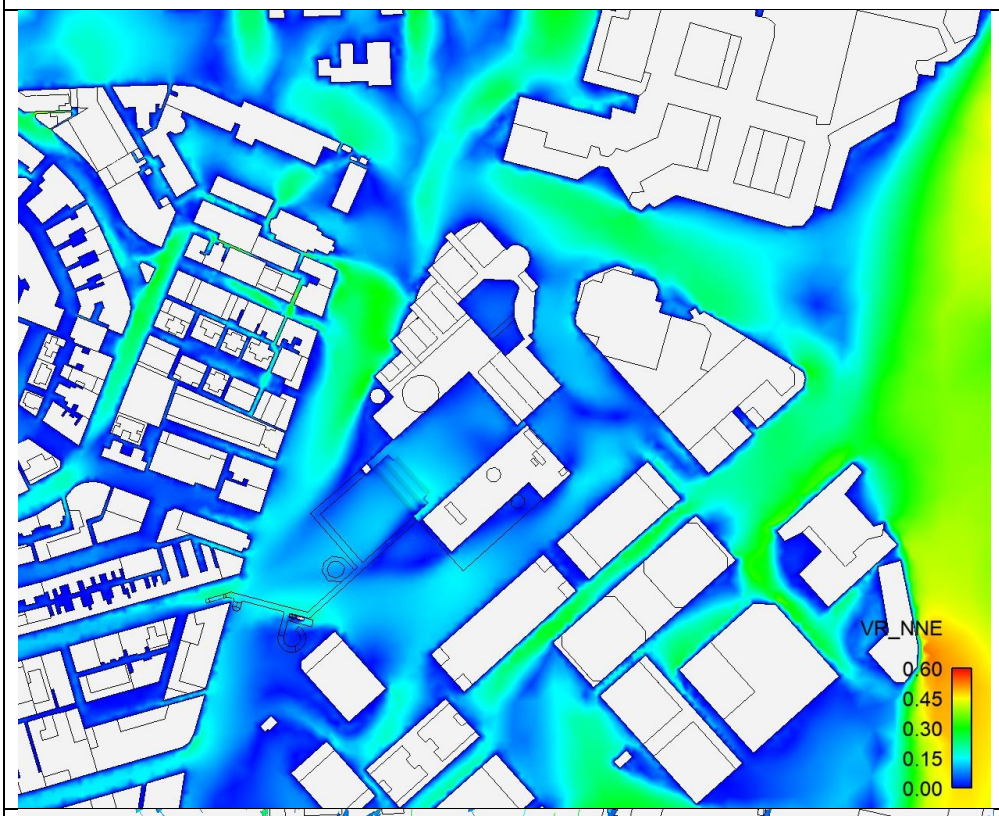
	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Annual Average	Summer Average
Annual	6.10%	7.60%	14.90%	23.50%	9.40%	5.40%			6.30%	5.60%		78.80%	
Summer				9.90%	9.10%	7.30%	7.30%	9.80%	14.30%	13.70%	9.30%		80.70%
S16	0.04	0.04	0.07	0.07	0.08	0.10	0.07	0.09	0.11	0.03	0.04	0.07	0.07
S17	0.02	0.05	0.05	0.06	0.03	0.14	0.09	0.08	0.12	0.14	0.04	0.06	0.09
S18	0.16	0.01	0.02	0.11	0.03	0.16	0.10	0.09	0.04	0.18	0.13	0.08	0.10
S19	0.11	0.06	0.17	0.03	0.18	0.10	0.10	0.03	0.12	0.20	0.16	0.11	0.12
S20	0.03	0.23	0.05	0.06	0.12	0.15	0.09	0.16	0.19	0.09	0.16	0.10	0.13
S21	0.04	0.28	0.27	0.12	0.04	0.23	0.18	0.28	0.17	0.24	0.20	0.17	0.18
S22	0.11	0.26	0.29	0.13	0.09	0.24	0.28	0.33	0.26	0.31	0.25	0.20	0.24
S23	0.15	0.22	0.23	0.20	0.08	0.24	0.29	0.33	0.35	0.32	0.30	0.21	0.27
S24	0.05	0.17	0.23	0.17	0.09	0.21	0.18	0.21	0.24	0.28	0.32	0.18	0.22
S25	0.16	0.05	0.11	0.17	0.02	0.08	0.04	0.05	0.14	0.01	0.05	0.11	0.07
S26	0.16	0.06	0.12	0.15	0.05	0.07	0.08	0.07	0.18	0.08	0.08	0.12	0.10
S27	0.16	0.05	0.10	0.12	0.06	0.07	0.09	0.08	0.19	0.08	0.09	0.10	0.10
S28	0.06	0.02	0.08	0.09	0.03	0.08	0.08	0.09	0.20	0.05	0.08	0.08	0.09
S29	0.04	0.03	0.04	0.08	0.00	0.02	0.01	0.05	0.05	0.03	0.03	0.05	0.04
S30	0.07	0.10	0.09	0.17	0.10	0.03	0.04	0.04	0.03	0.05	0.03	0.10	0.06
S31	0.07	0.06	0.07	0.23	0.12	0.05	0.10	0.11	0.09	0.01	0.05	0.12	0.09
S32	0.06	0.10	0.09	0.16	0.07	0.03	0.09	0.07	0.05	0.05	0.02	0.10	0.07
S33	0.05	0.03	0.14	0.23	0.12	0.05	0.11	0.12	0.09	0.08	0.06	0.13	0.11
S34	0.02	0.08	0.10	0.08	0.06	0.03	0.09	0.07	0.07	0.08	0.03	0.07	0.06
S35	0.01	0.03	0.11	0.13	0.10	0.03	0.05	0.07	0.10	0.14	0.03	0.10	0.09

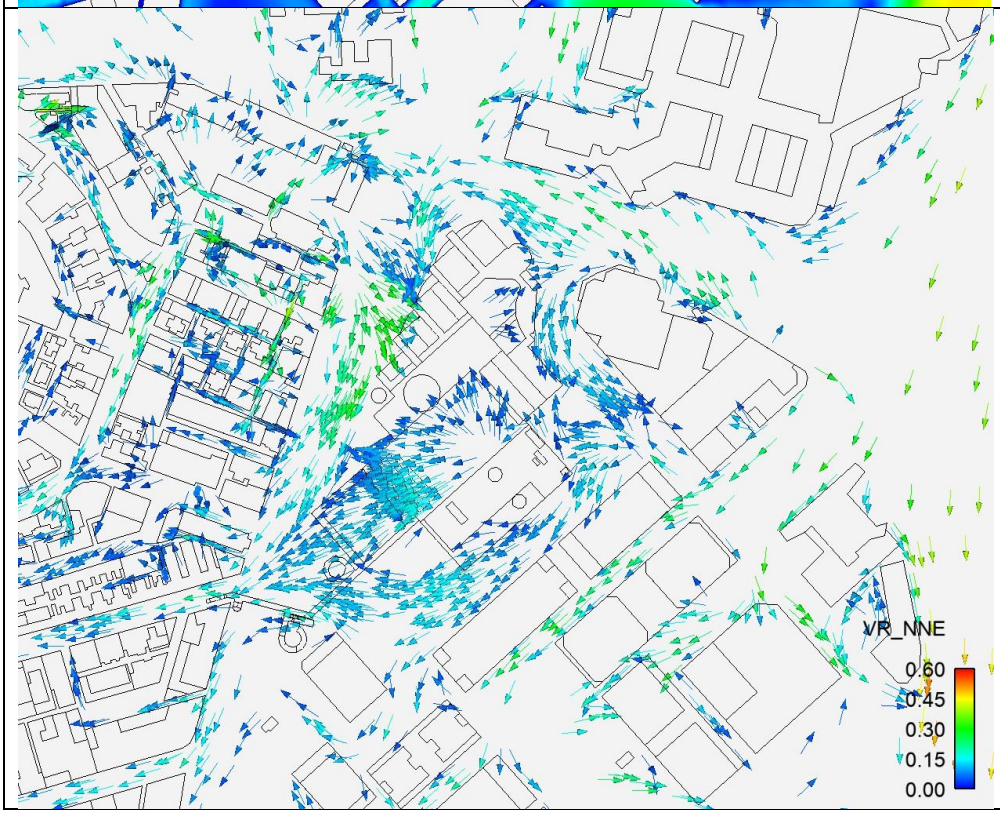
APPENDIX D

Wind Velocity Ratio Contour and Vector Plot at Pedestrian Level under Prevailing Wind Directions

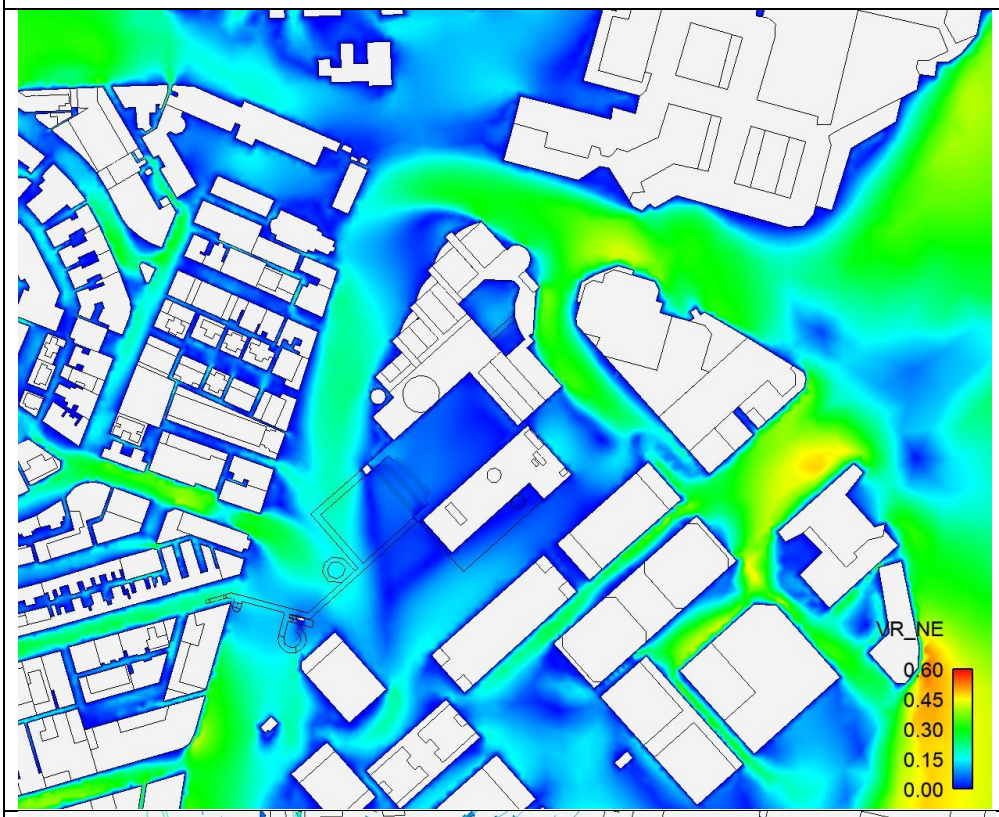
Baseline Scheme

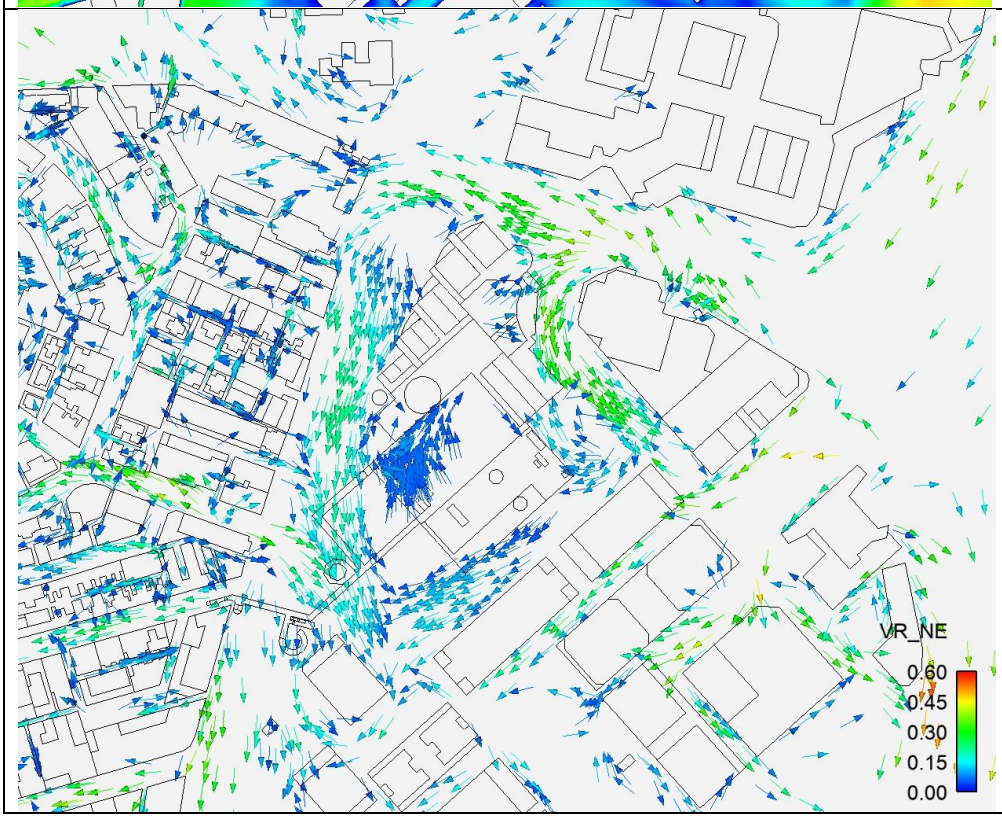
VR Contour and Vector Plot at Pedestrian Level under NNE Wind



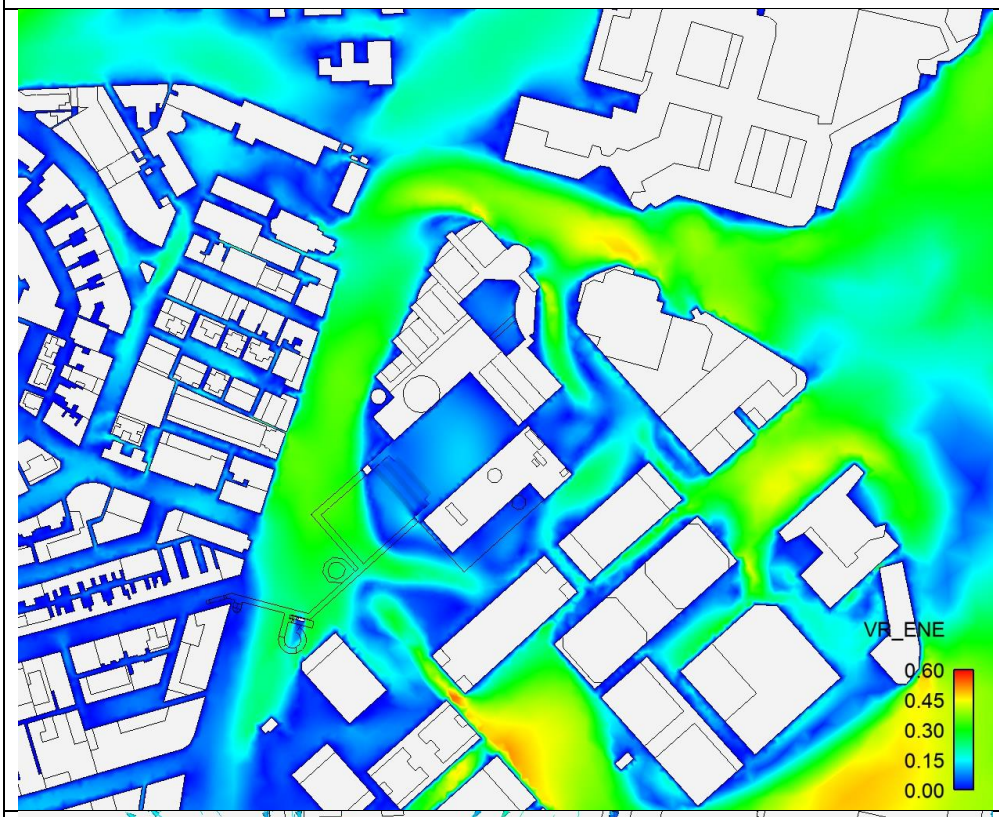


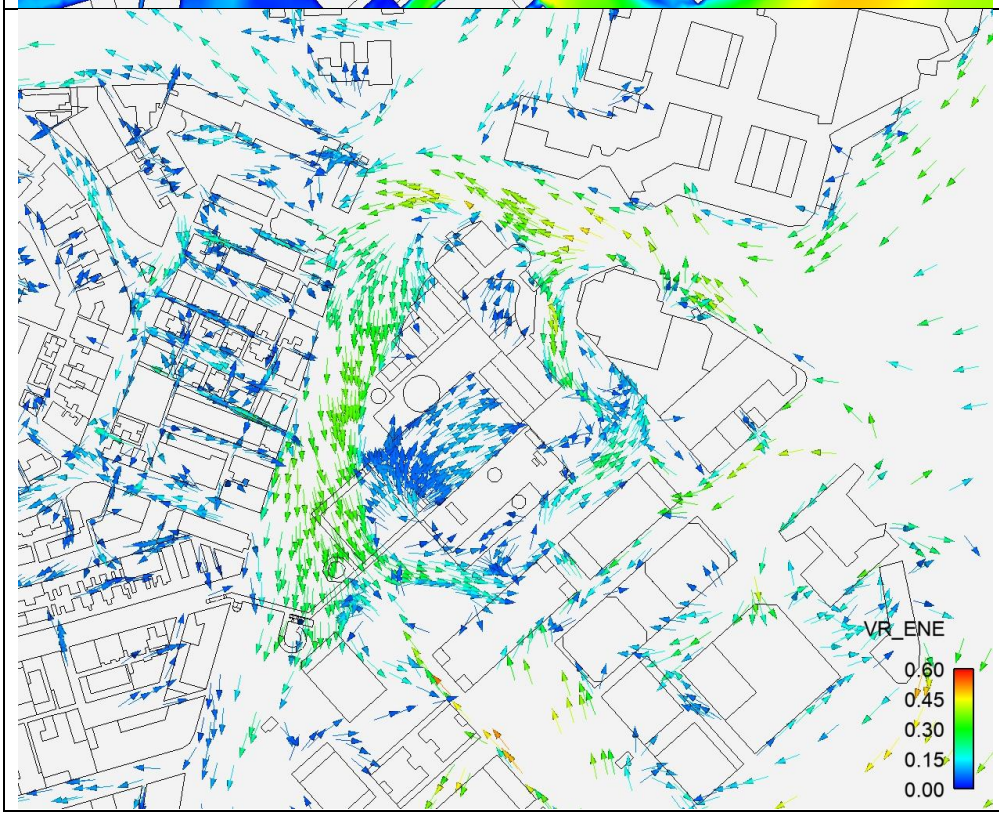
VR Contour and Vector Plot at Pedestrian Level under NE Wind



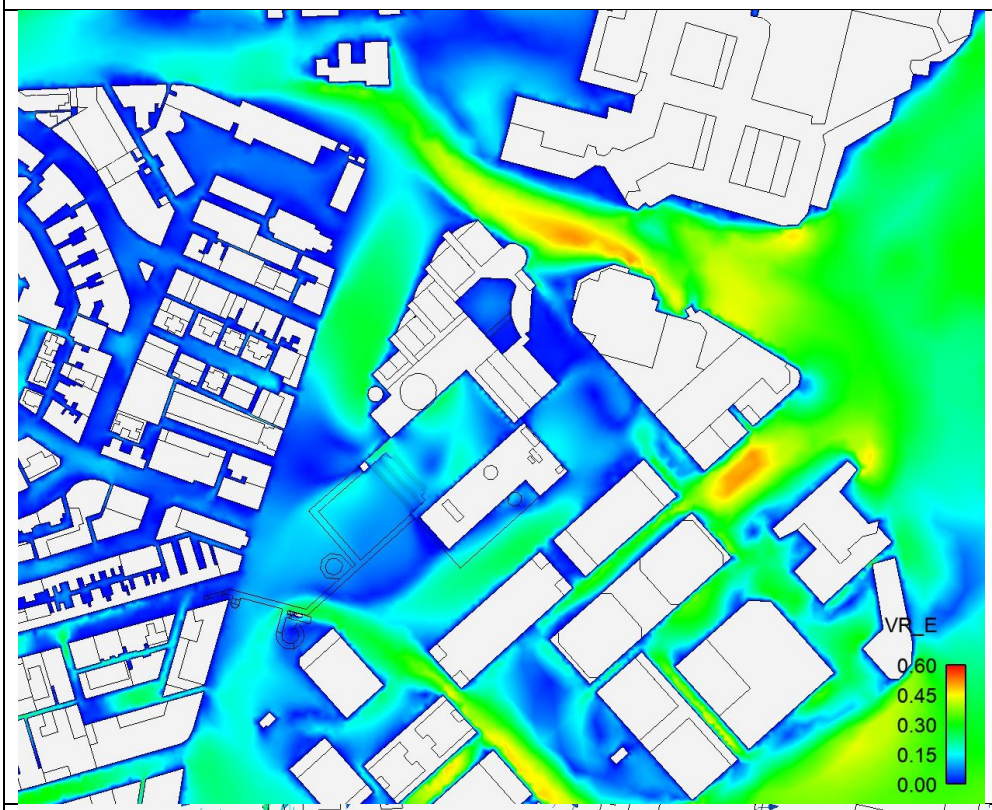


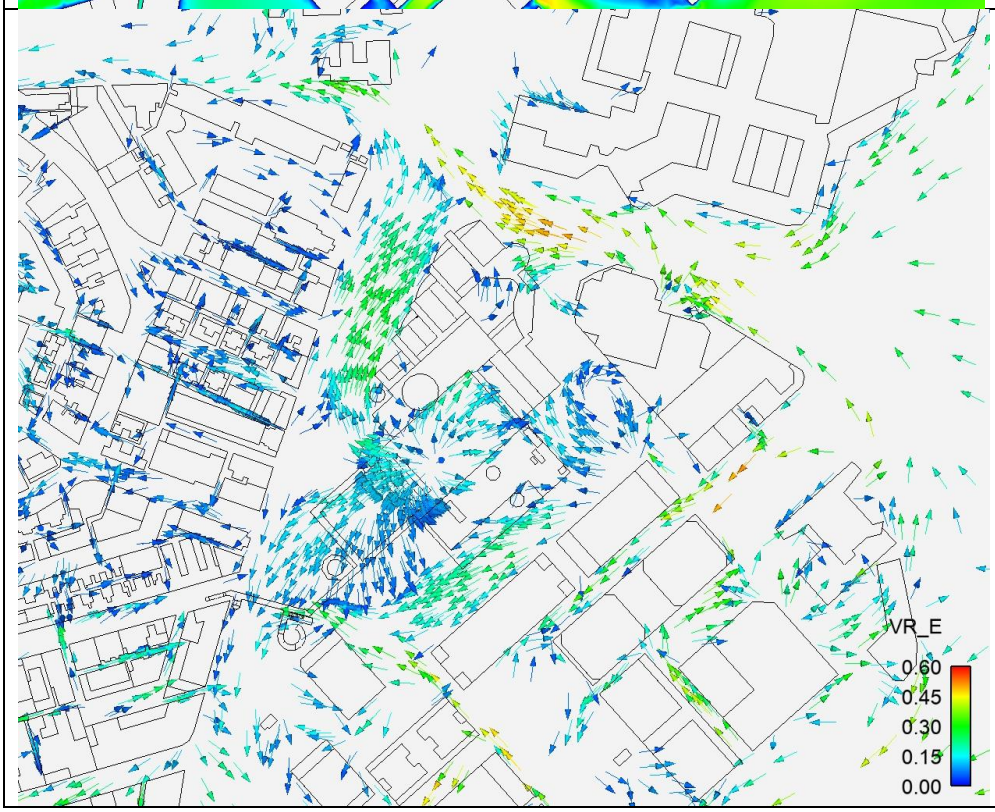
VR Contour and Vector Plot at Pedestrian Level under ENE Wind



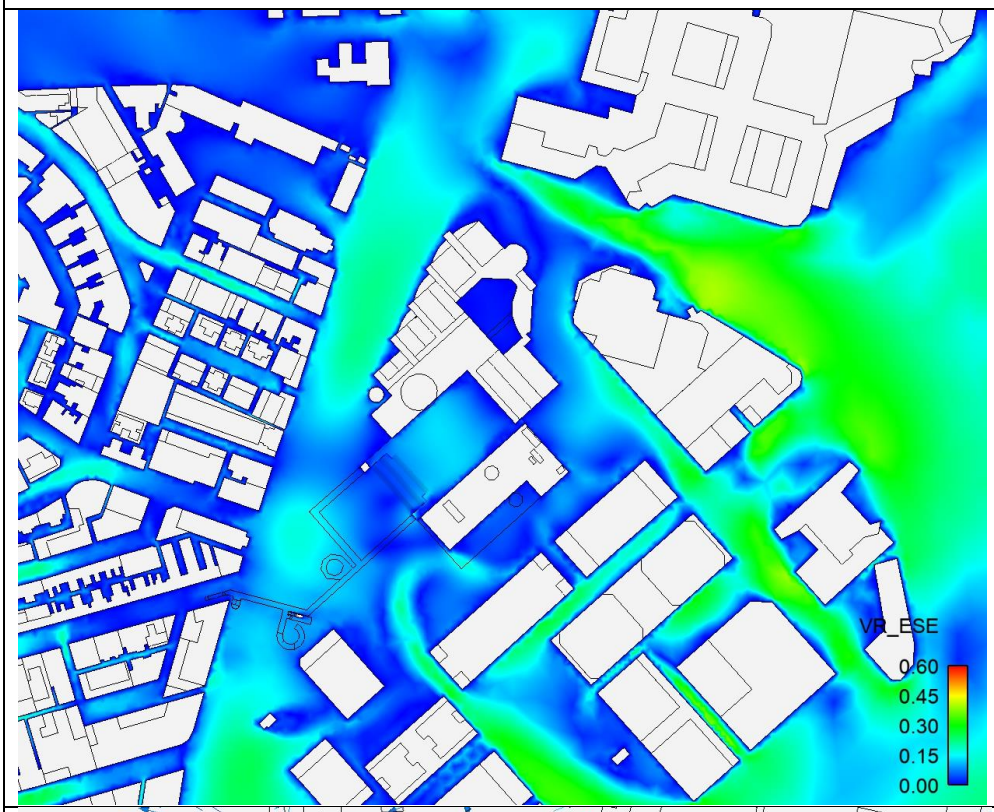


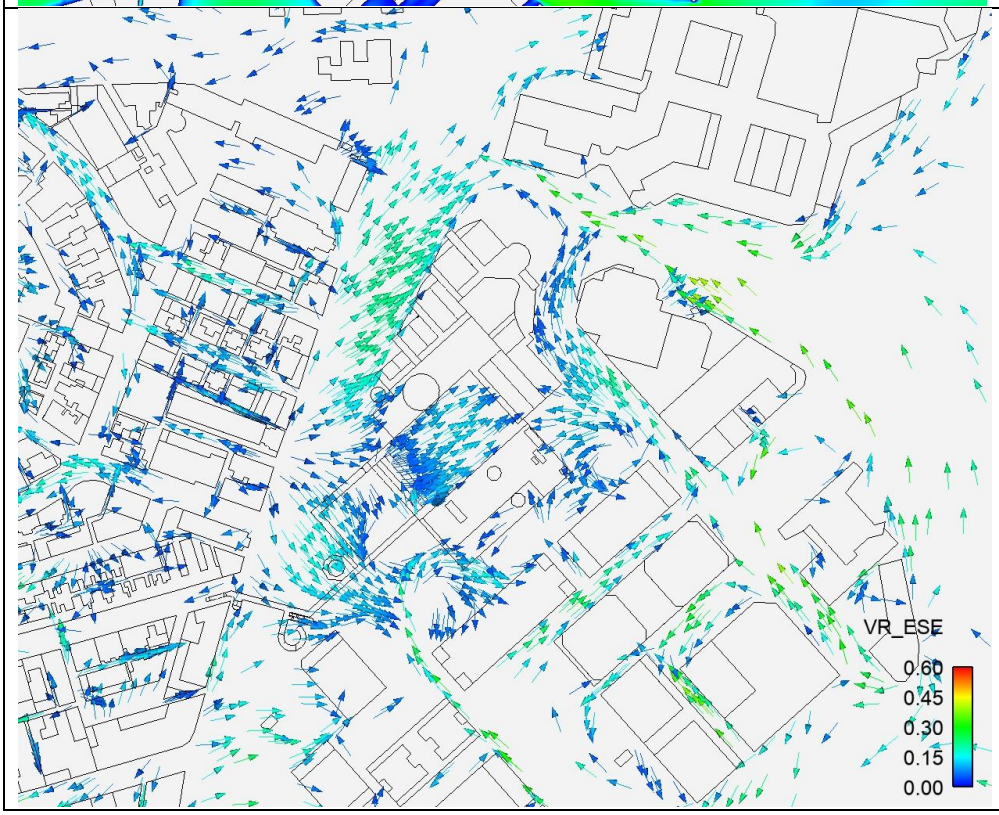
VR Contour and Vector Plot at Pedestrian Level under E Wind



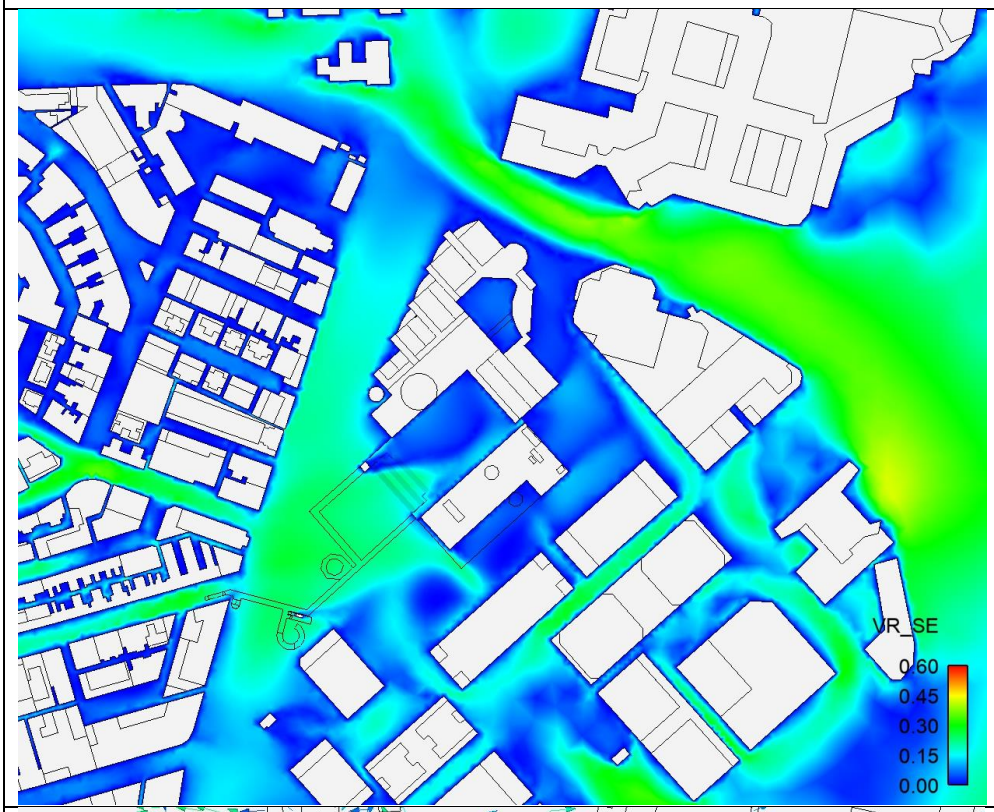


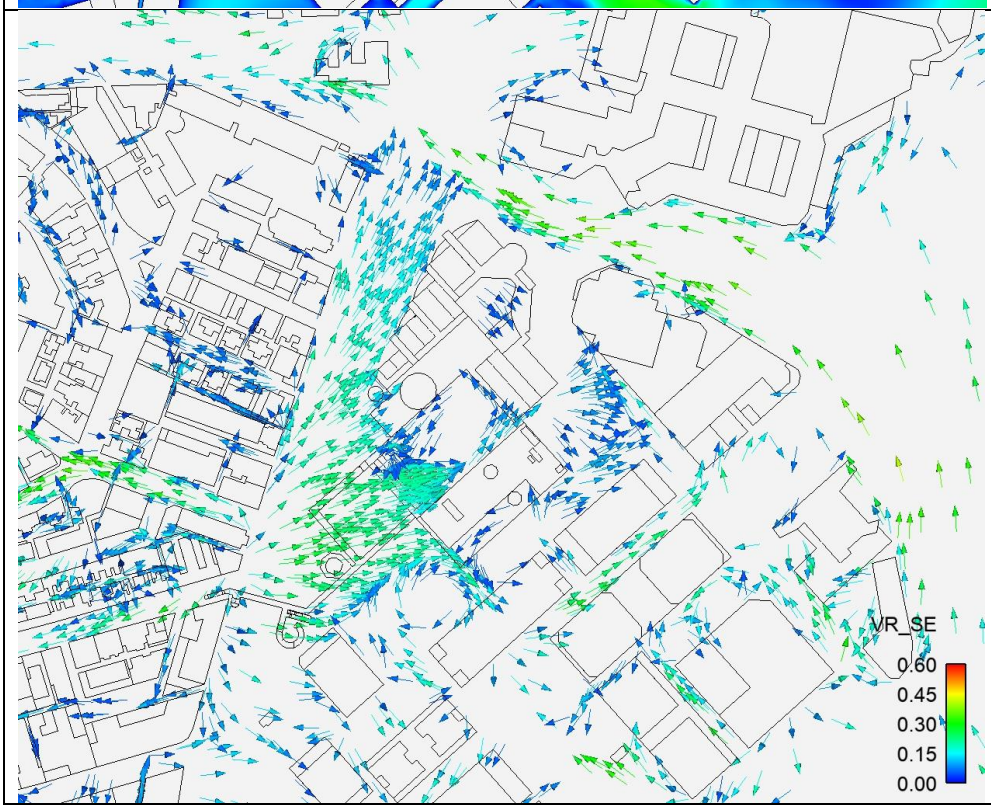
VR Contour and Vector Plot at Pedestrian Level under ESE Wind



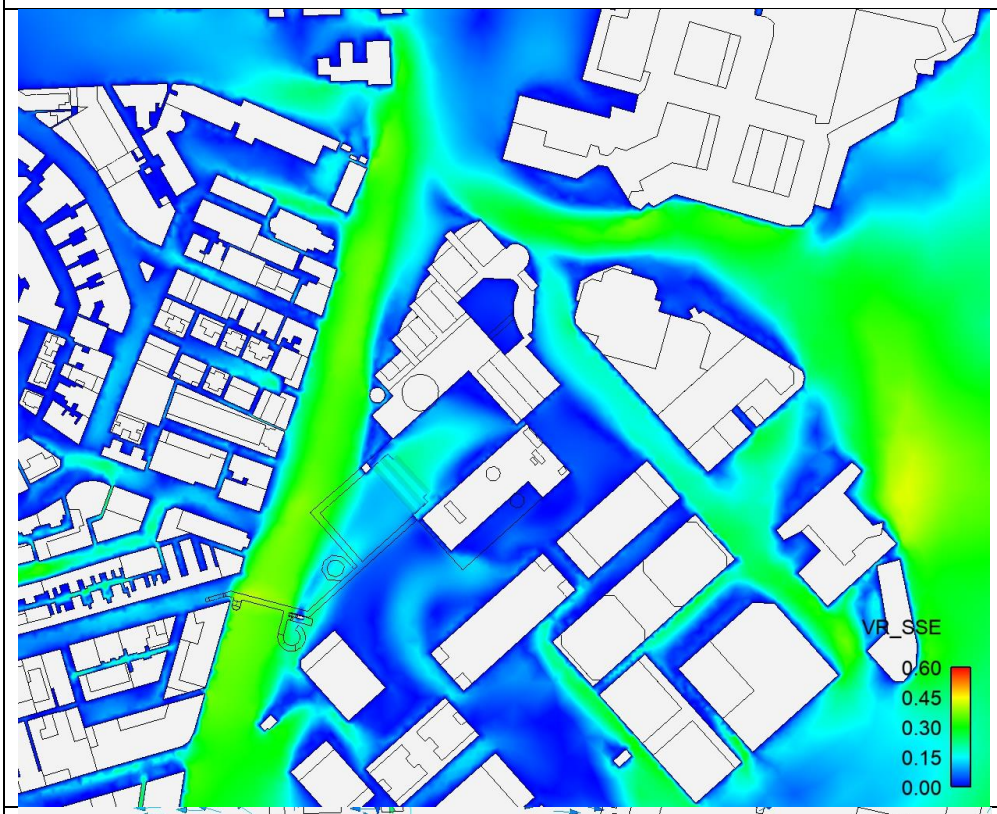


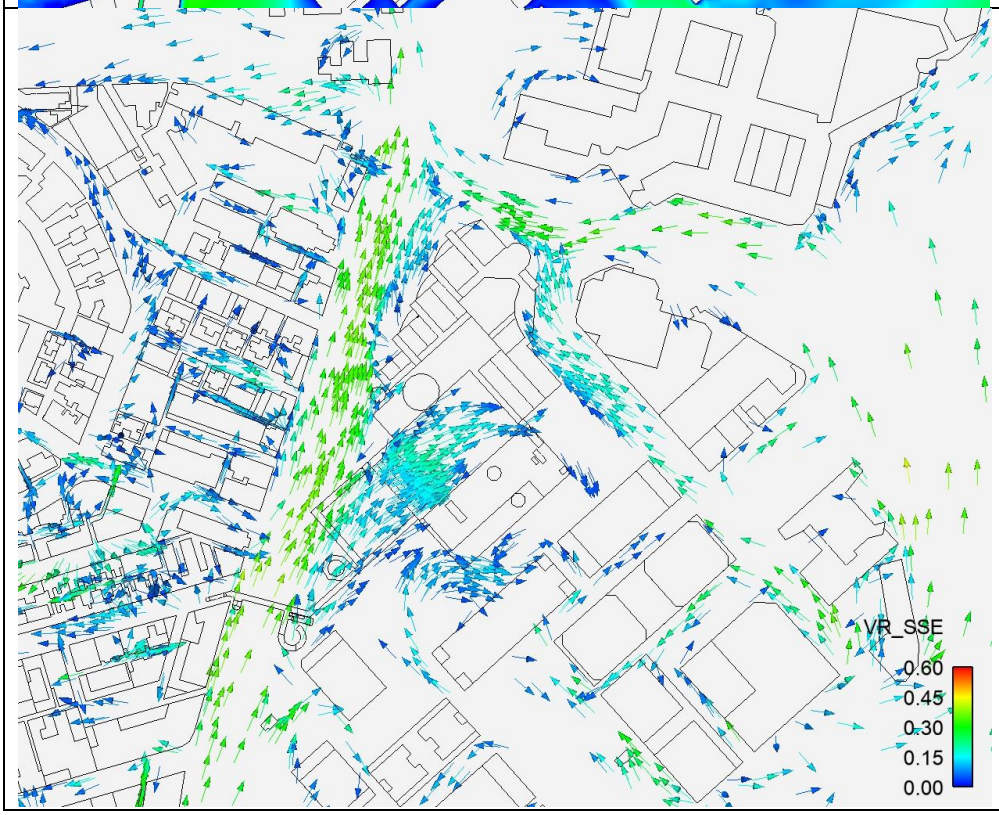
VR Contour and Vector Plot at Pedestrian Level under SE Wind



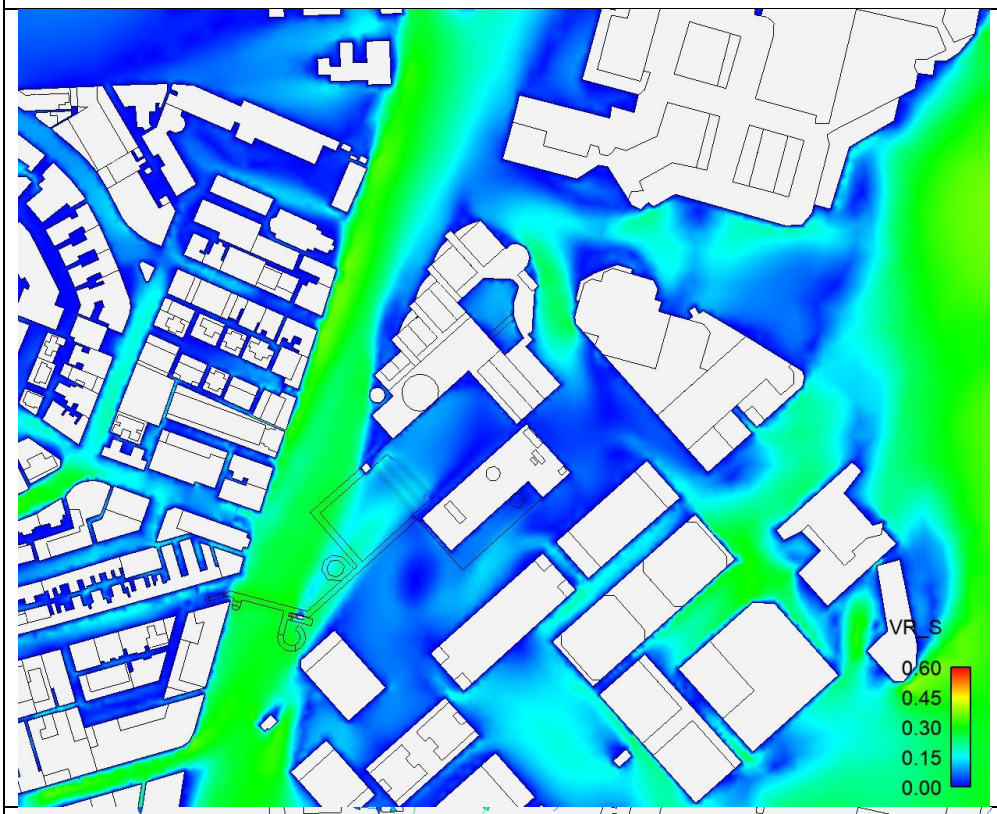


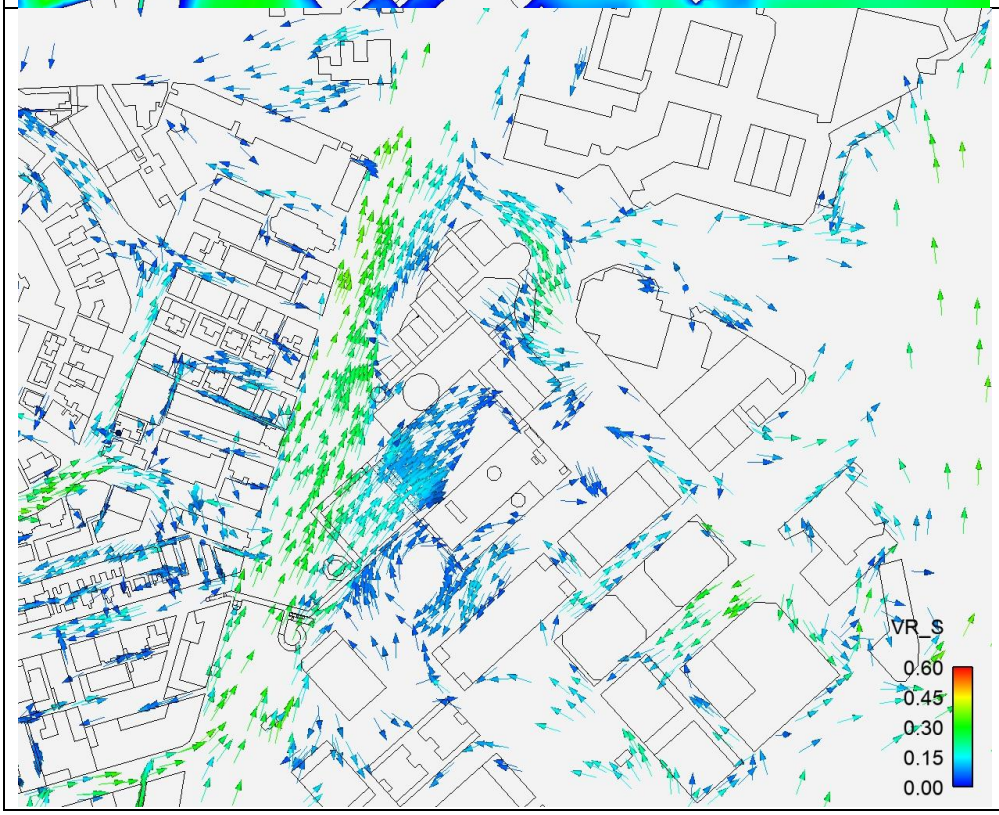
VR Contour and Vector Plot at Pedestrian Level under SSE Wind



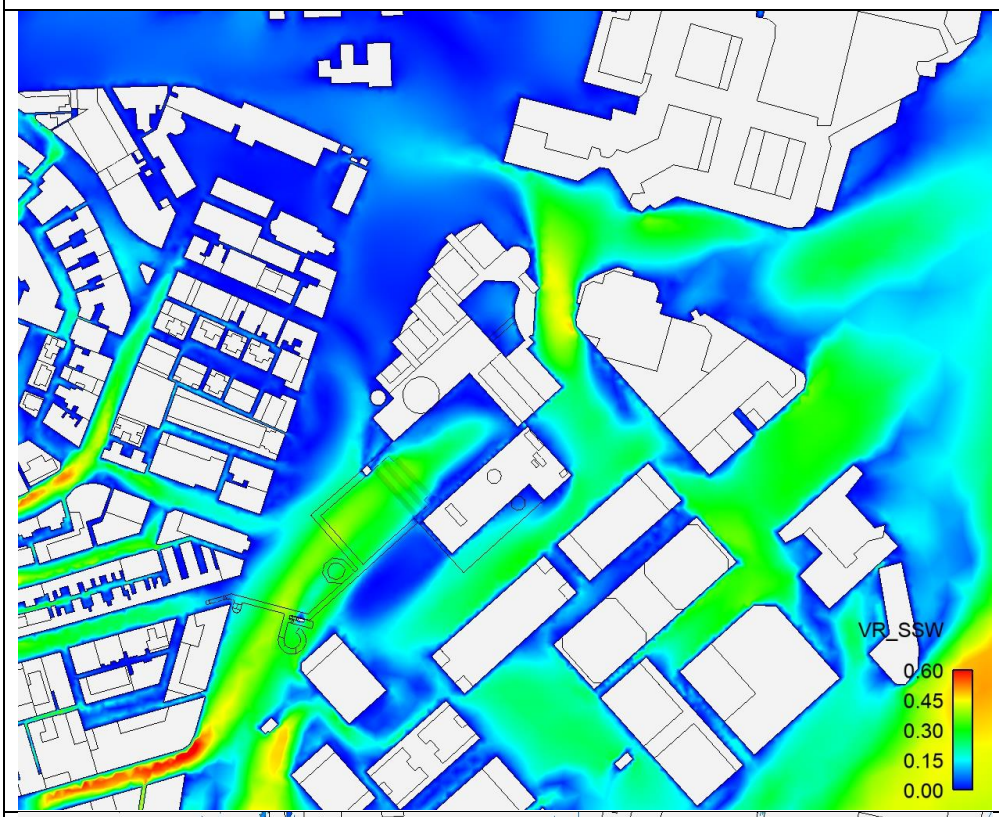


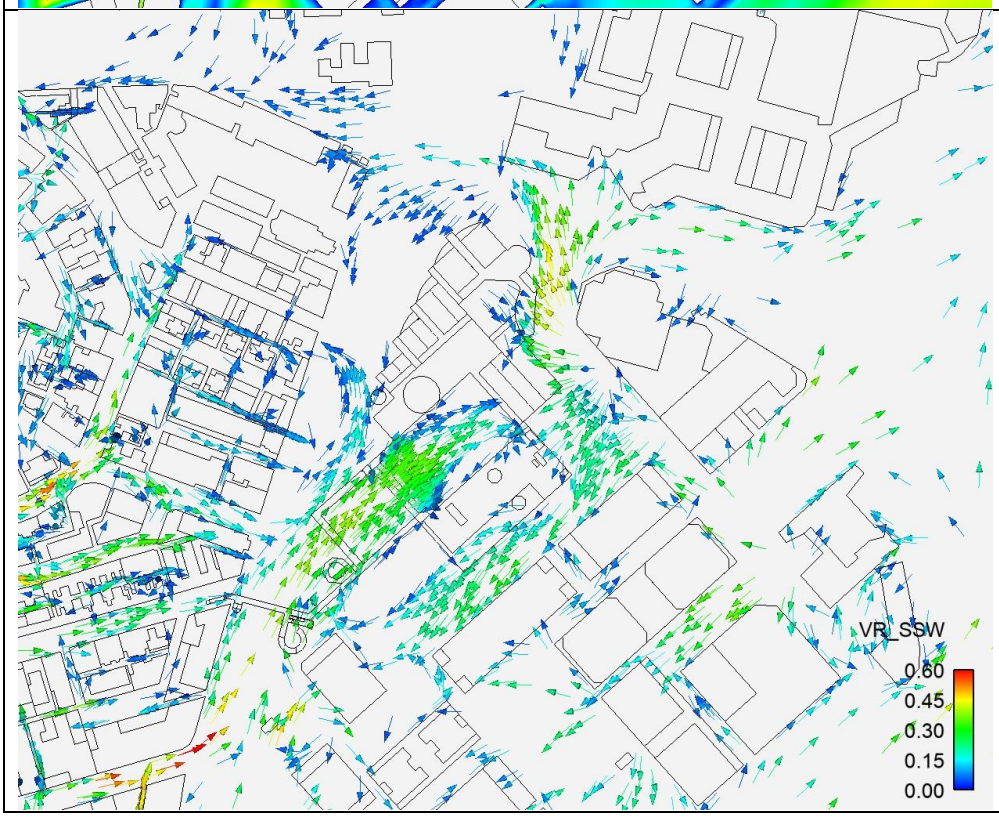
VR Contour and Vector Plot at Pedestrian Level under S Wind



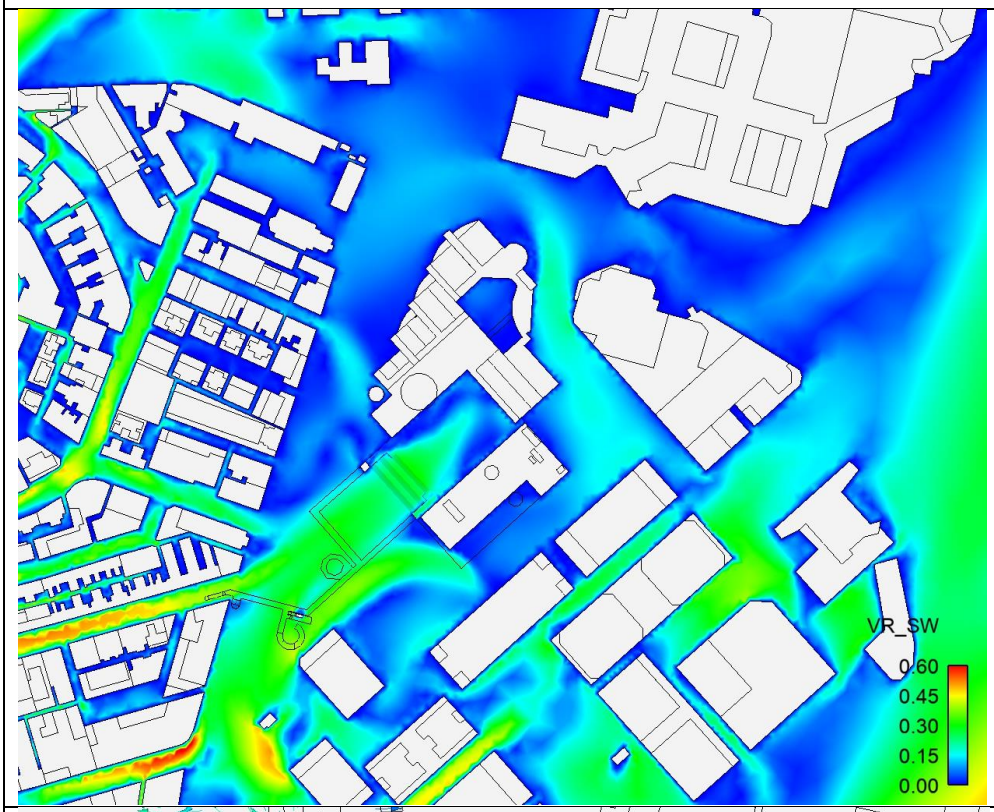


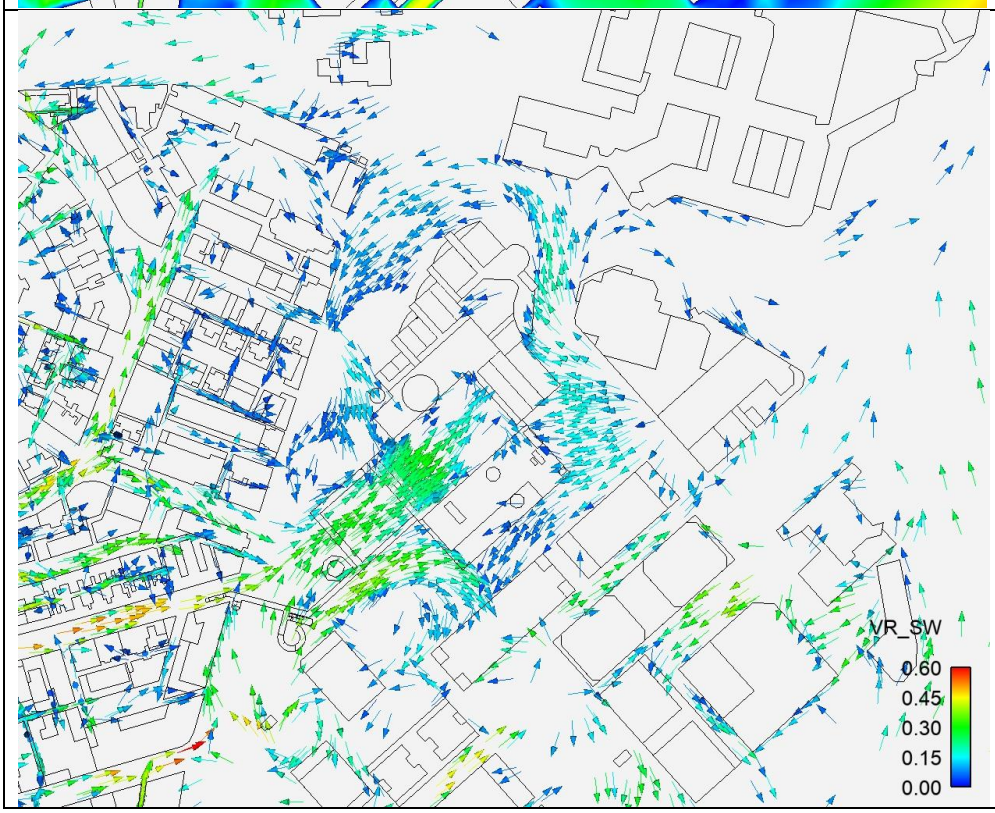
VR Contour and Vector Plot at Pedestrian Level under SSW Wind



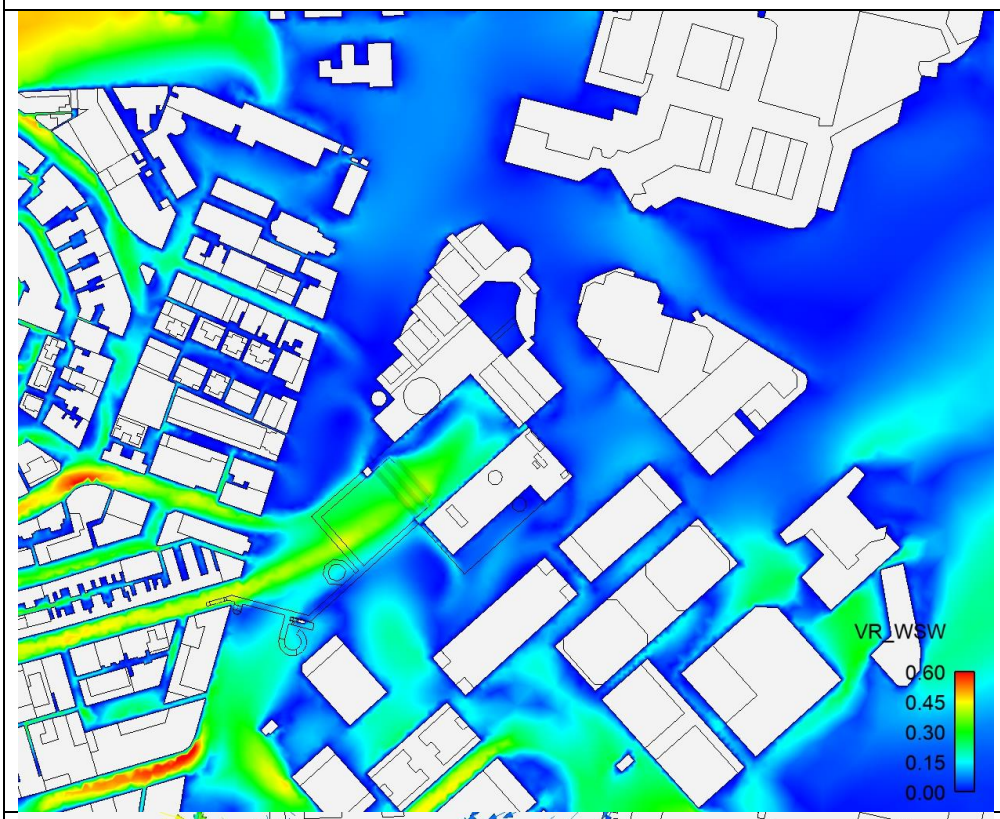


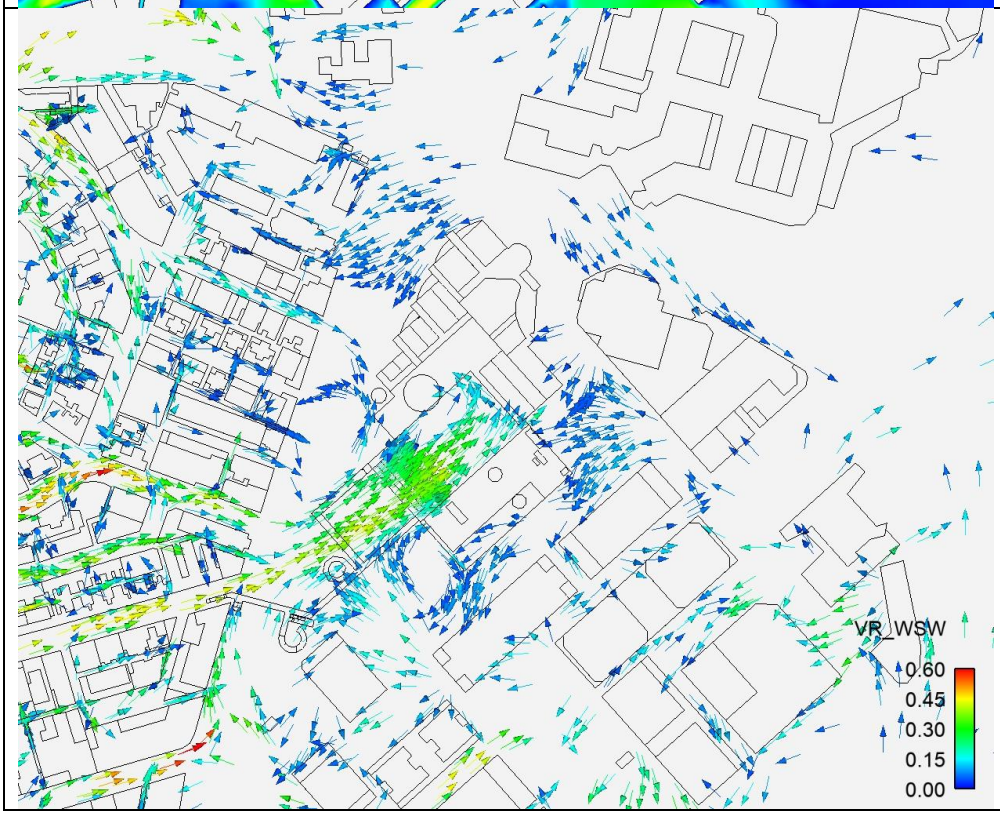
VR Contour and Vector Plot at Pedestrian Level under SW Wind





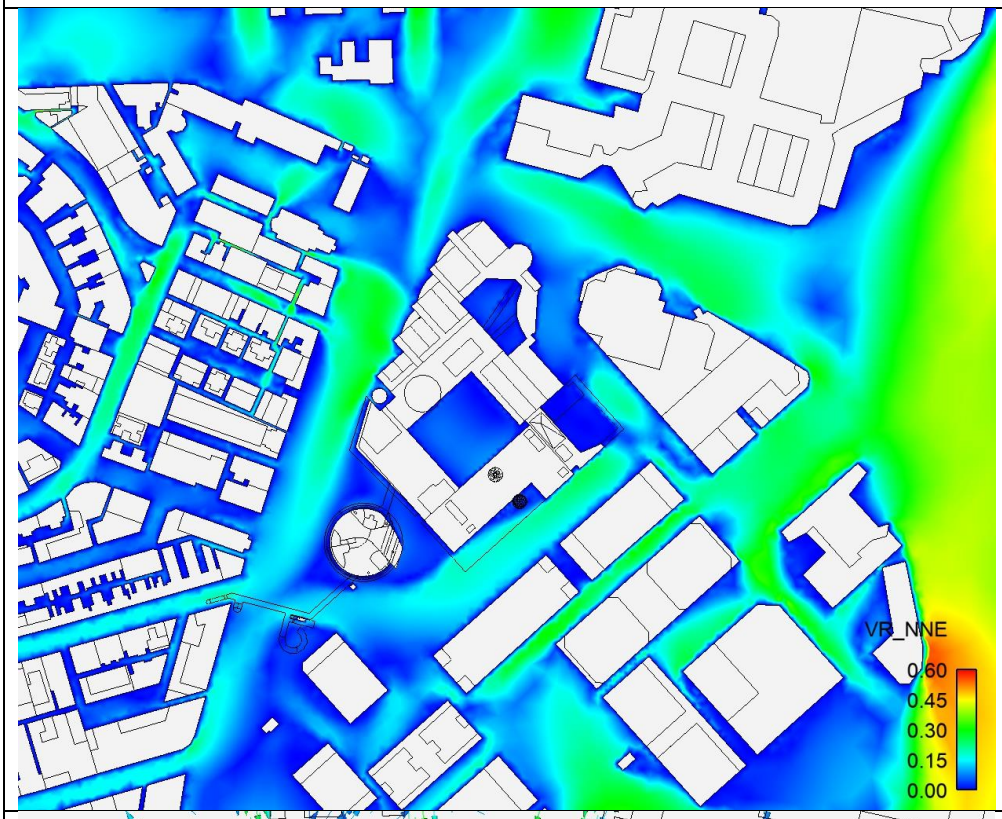
VR Contour and Vector Plot at Pedestrian Level under WSW Wind

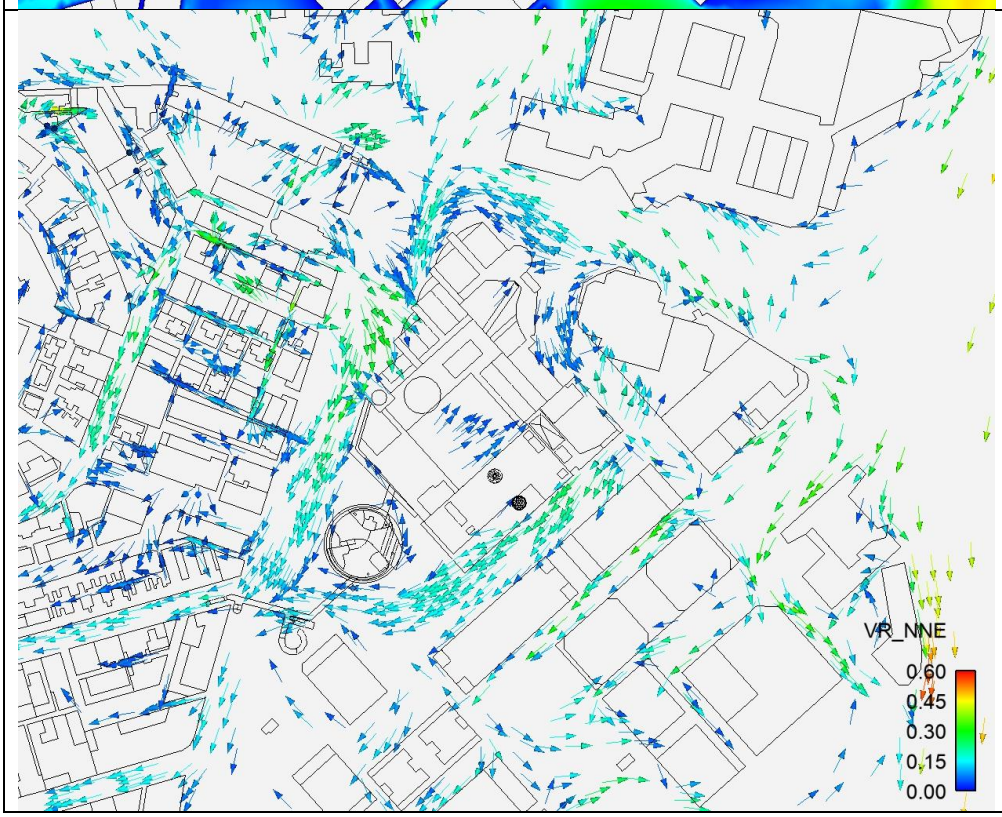




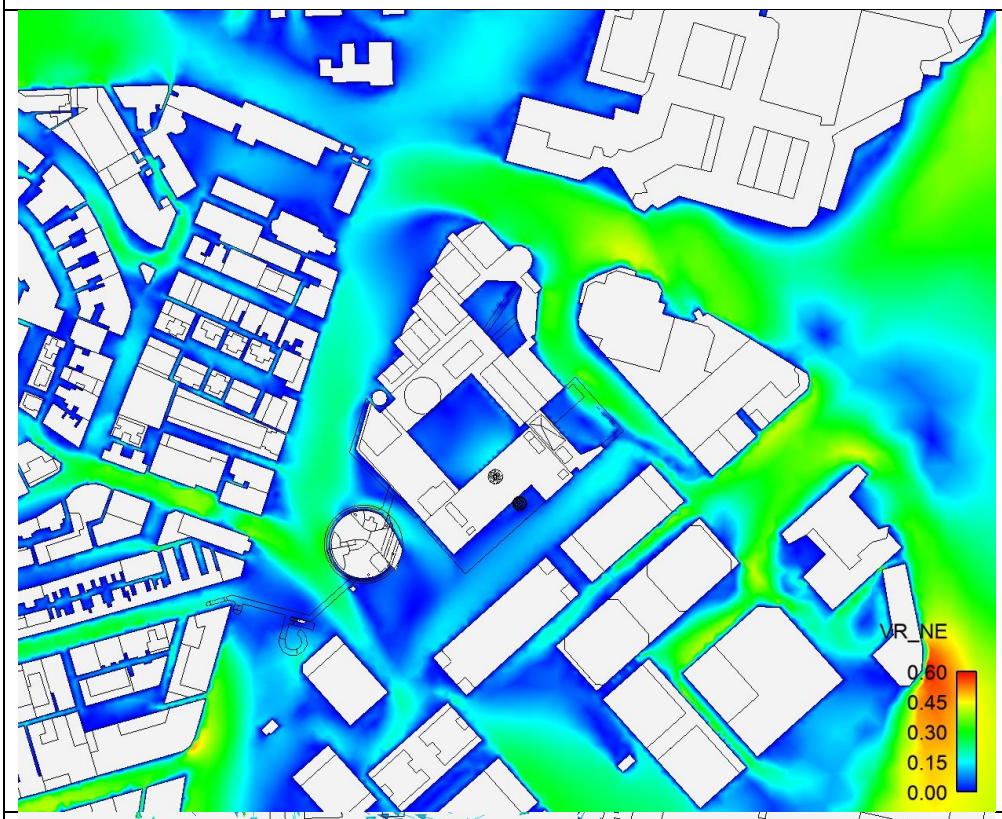
Proposed Scheme

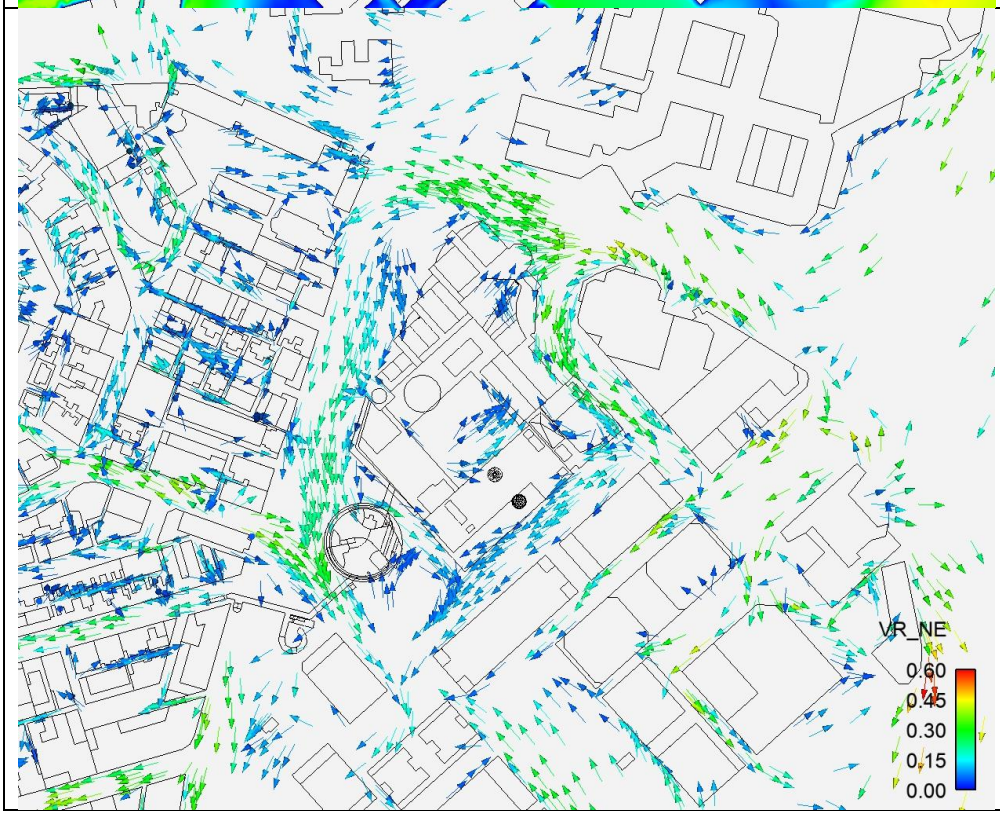
VR Contour and Vector Plot at Pedestrian Level under NNE Wind



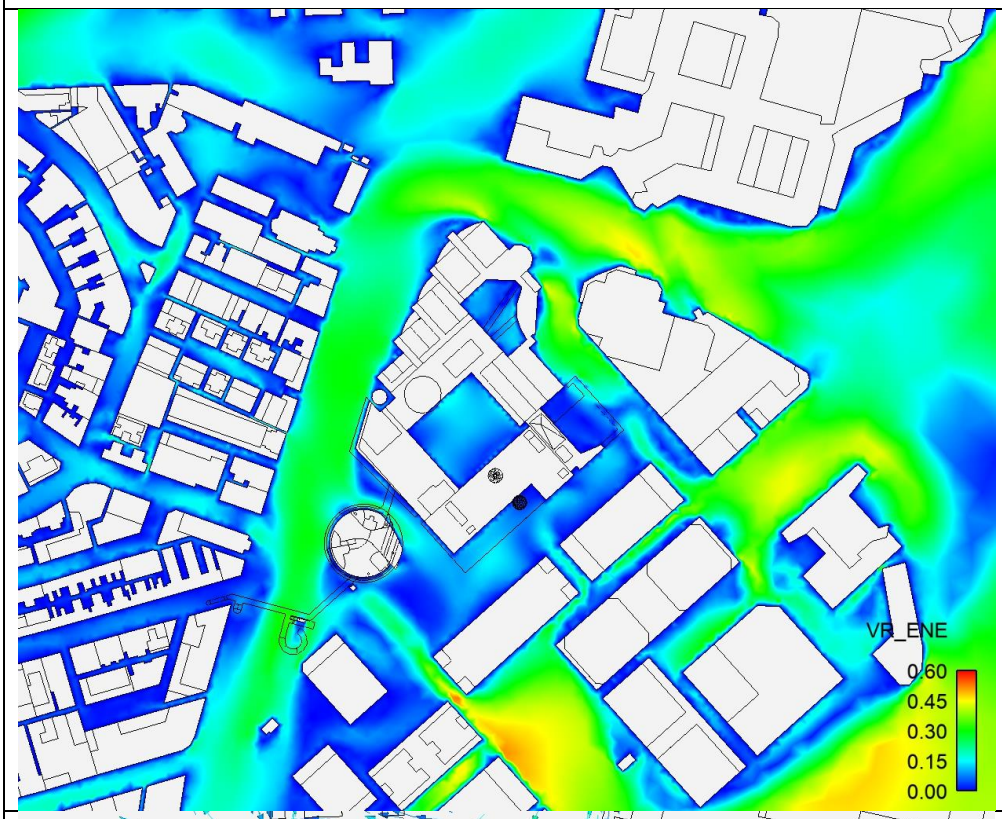


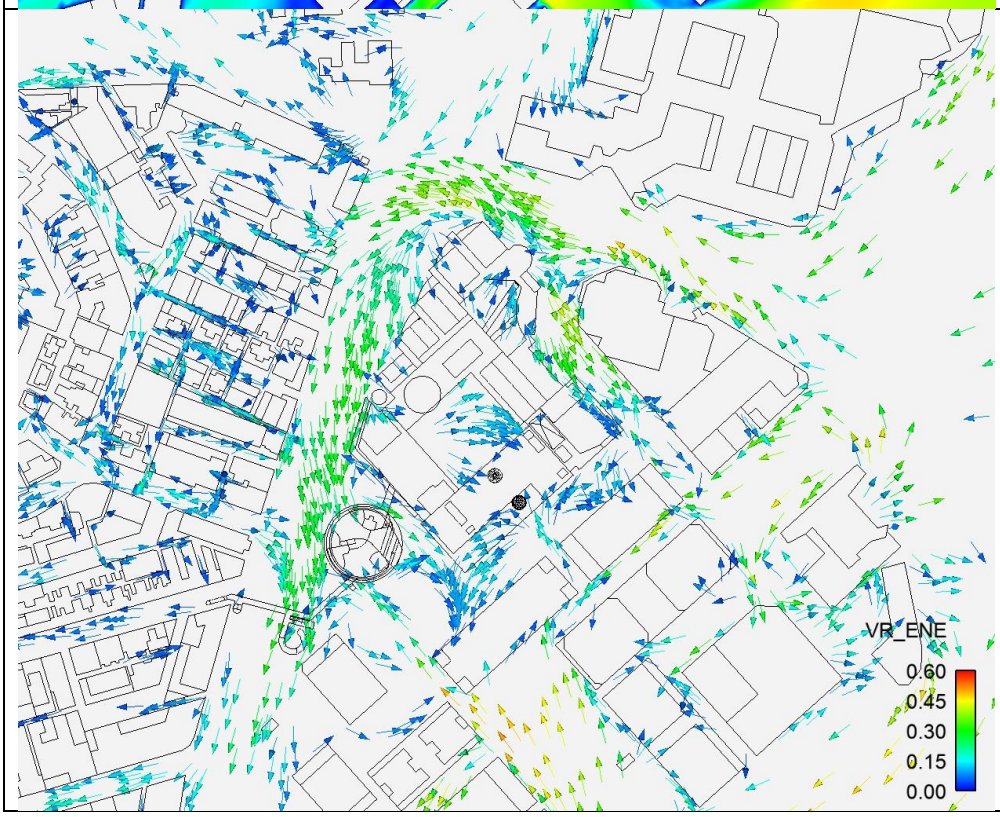
VR Contour and Vector Plot at Pedestrian Level under NE Wind



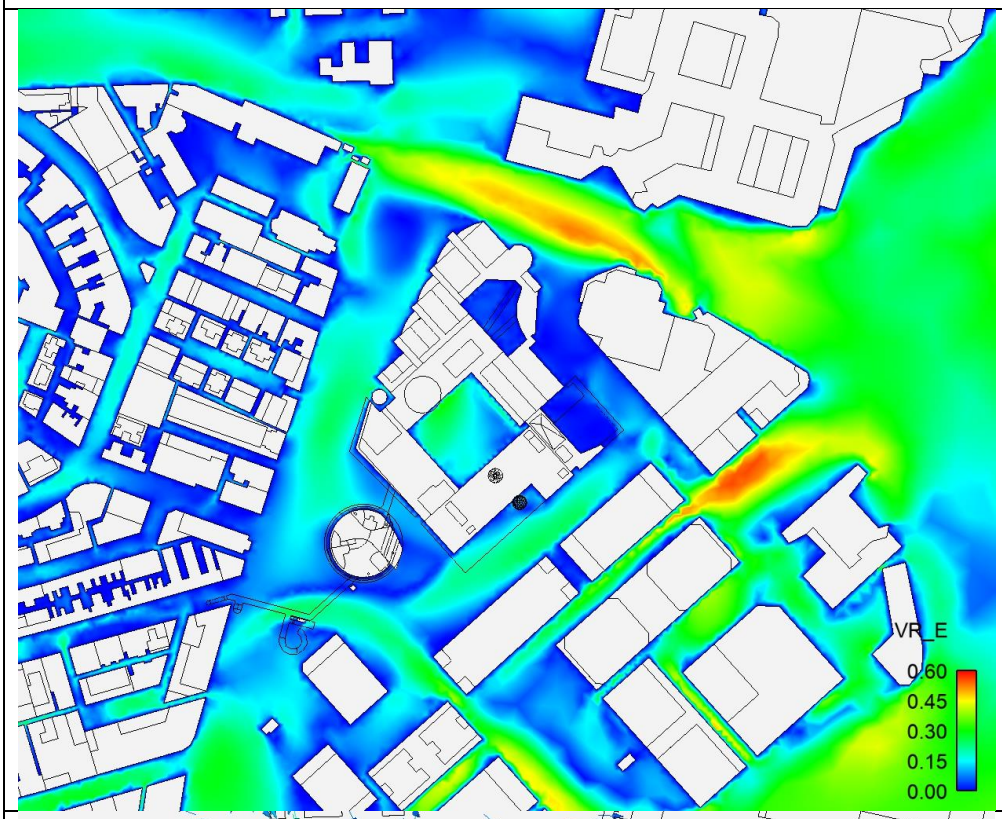


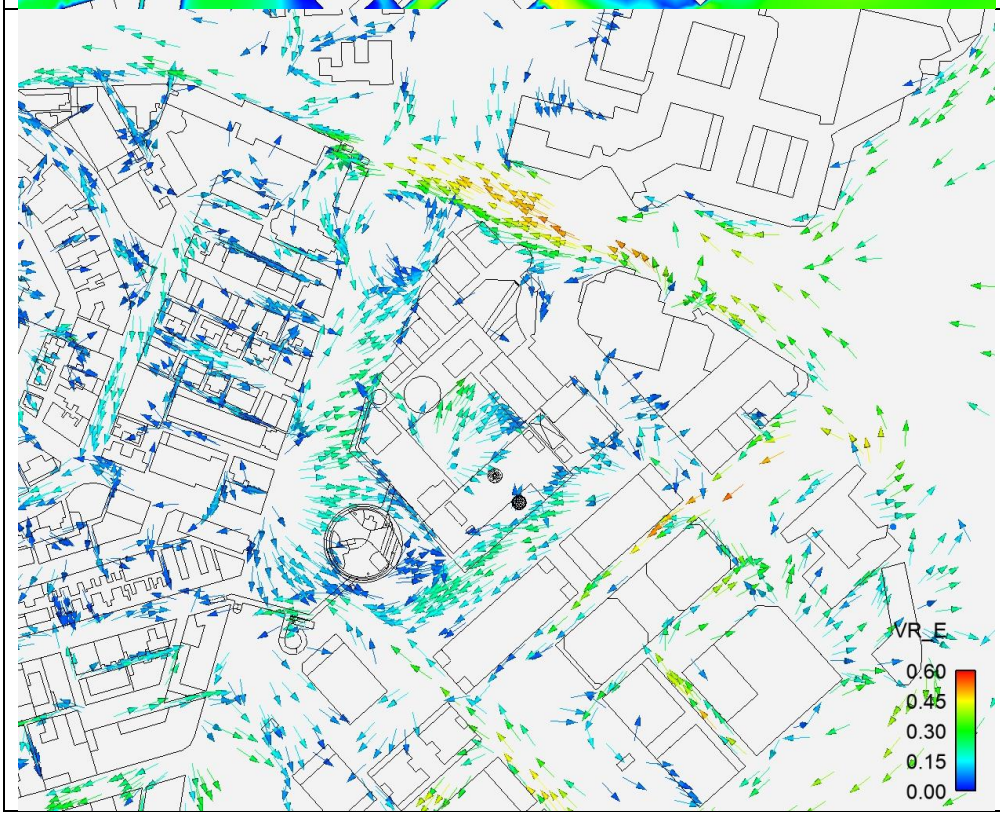
VR Contour and Vector Plot at Pedestrian Level under ENE Wind



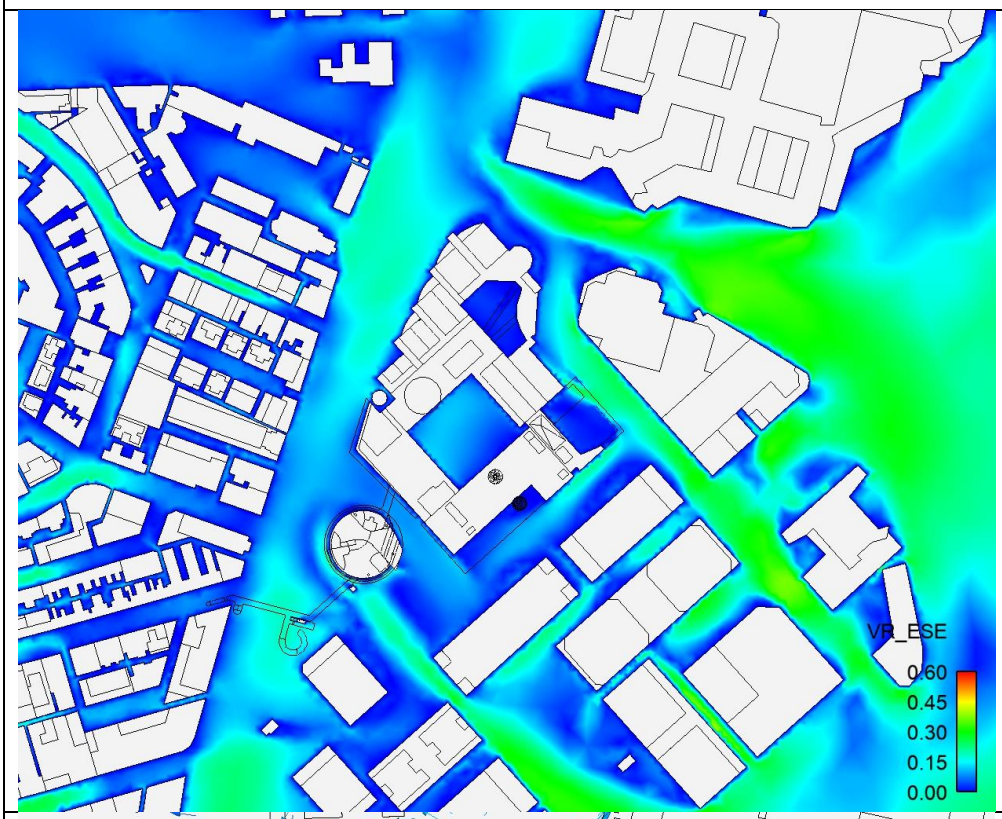


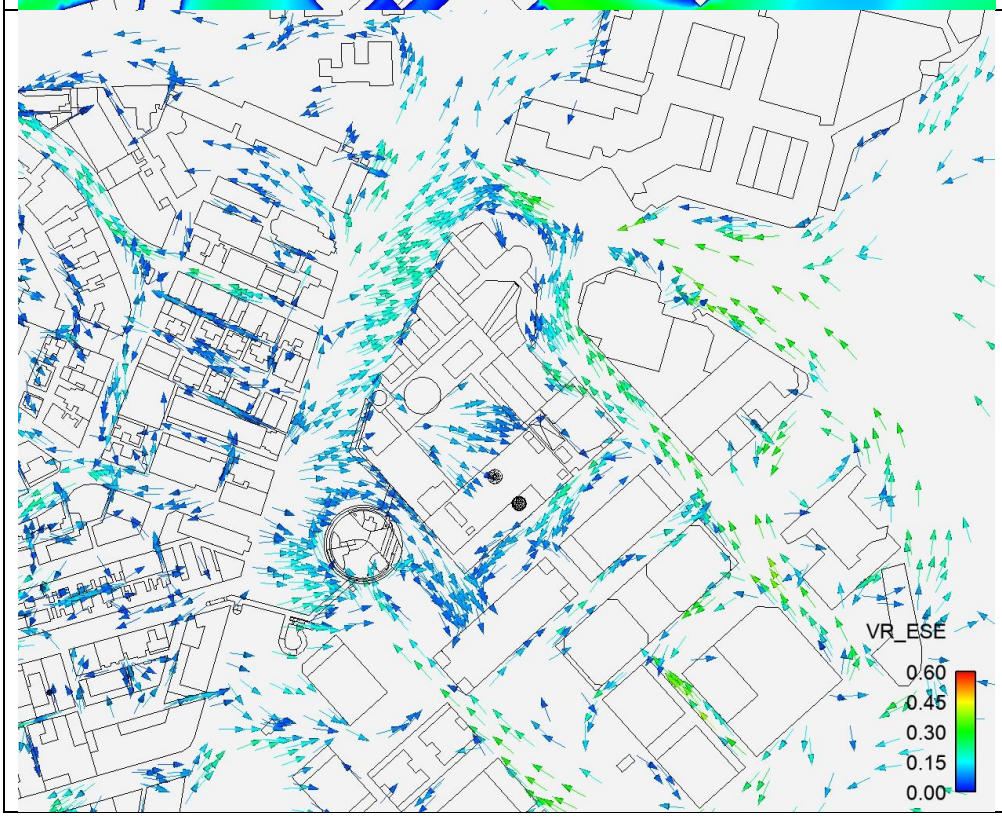
VR Contour and Vector Plot at Pedestrian Level under E Wind



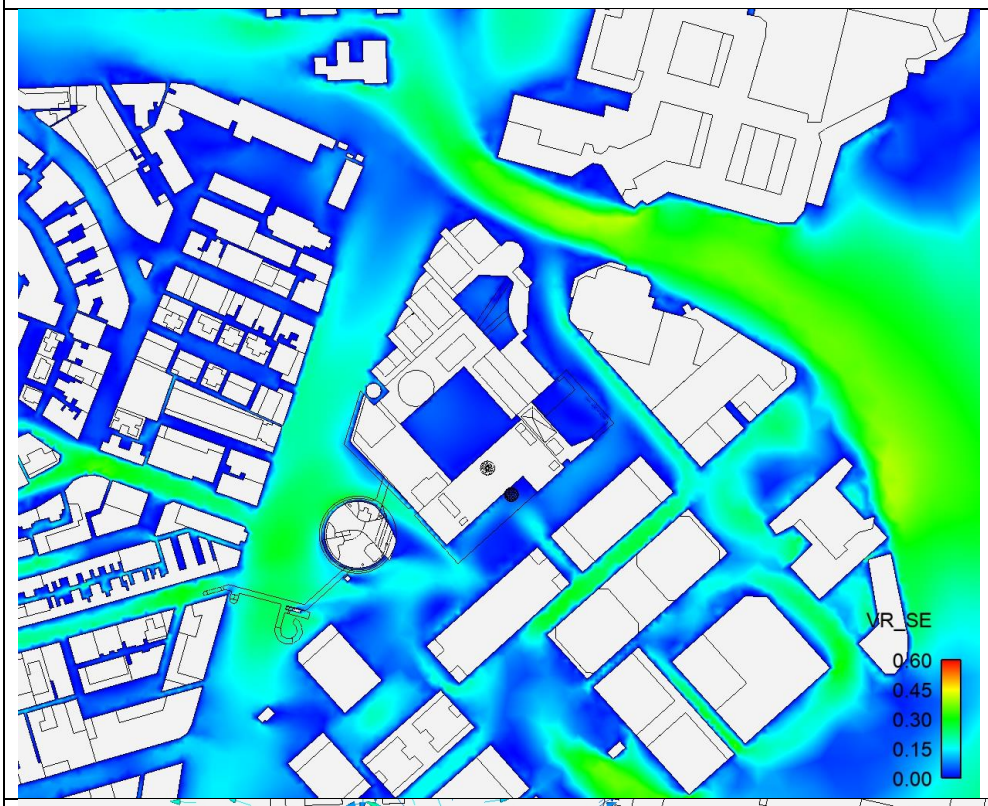


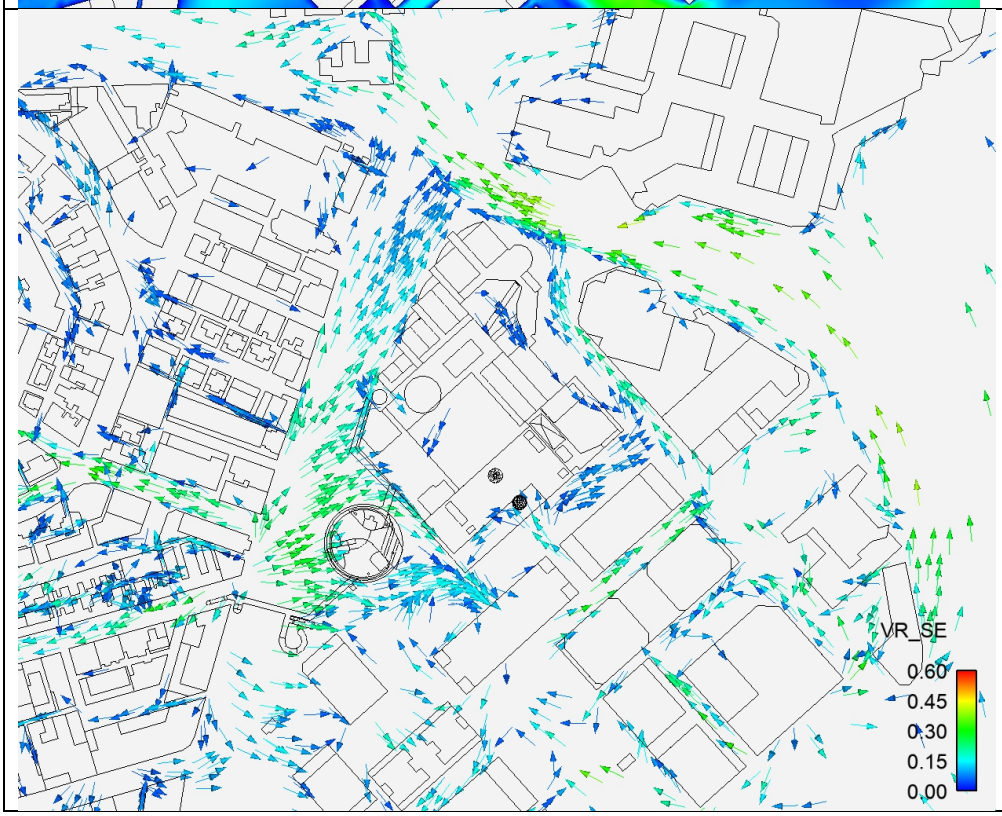
VR Contour and Vector Plot at Pedestrian Level under ESE Wind



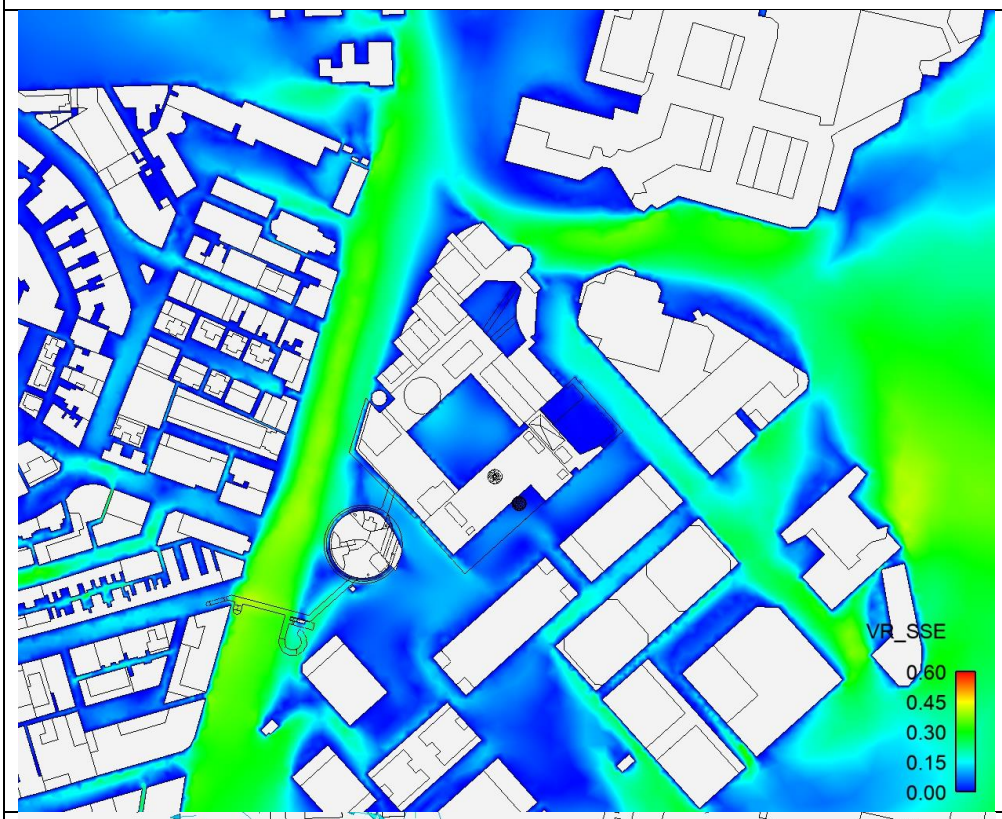


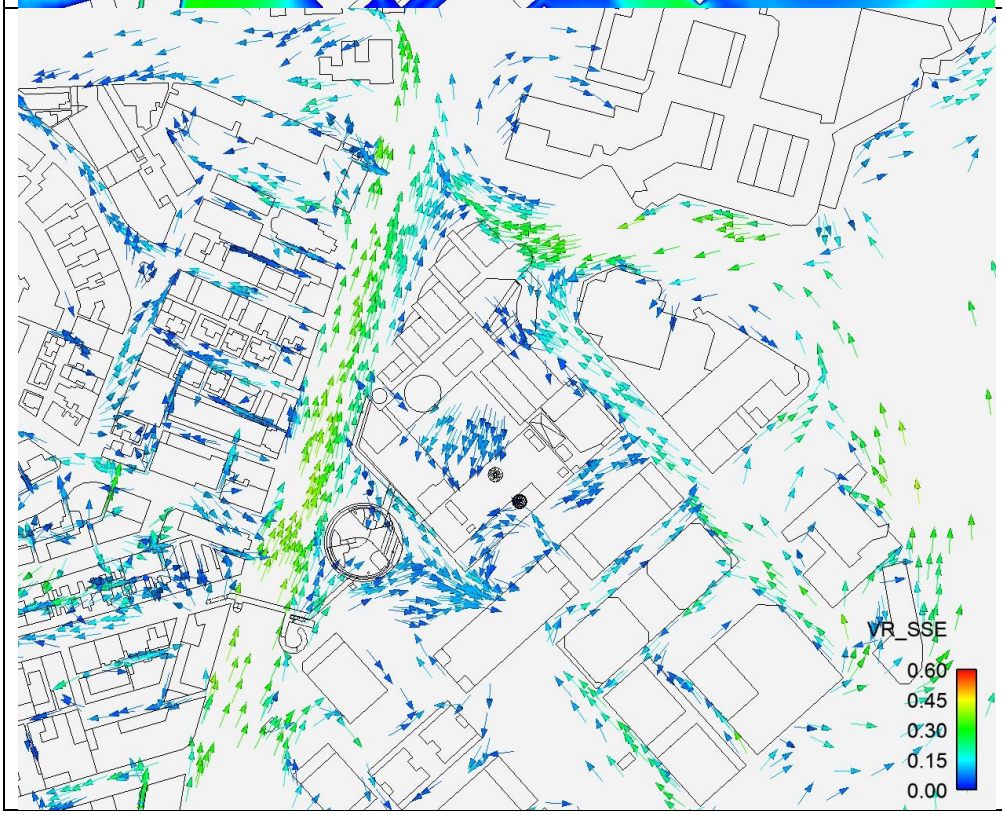
VR Contour and Vector Plot at Pedestrian Level under SE Wind



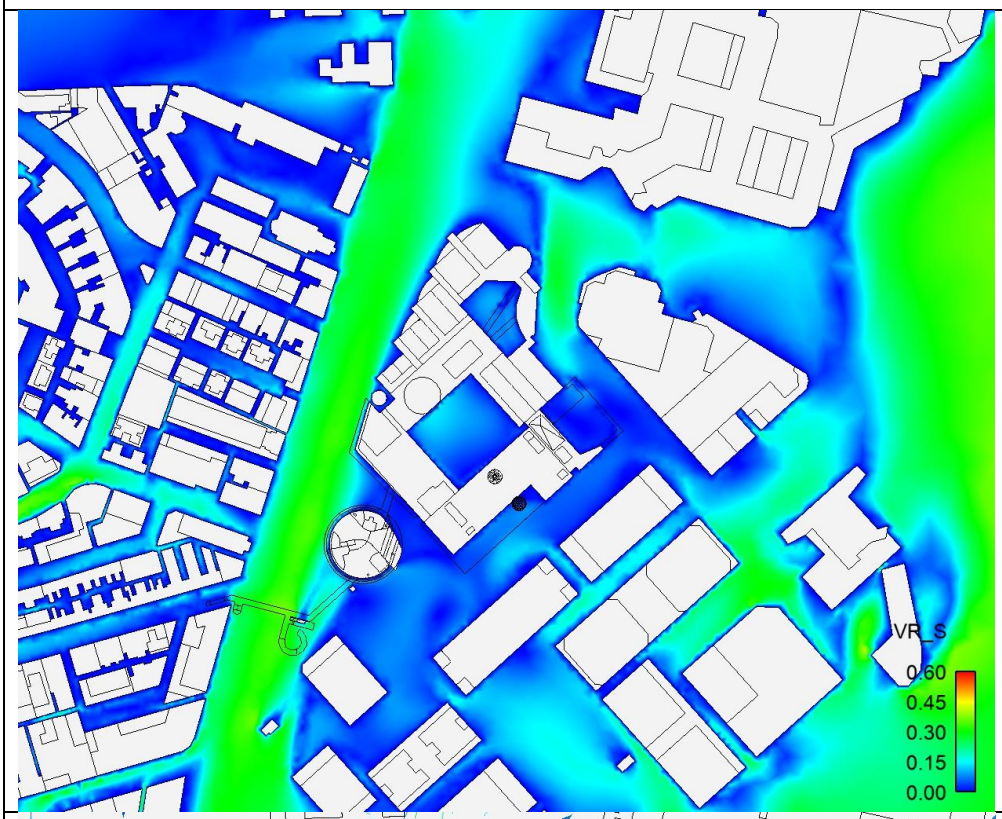


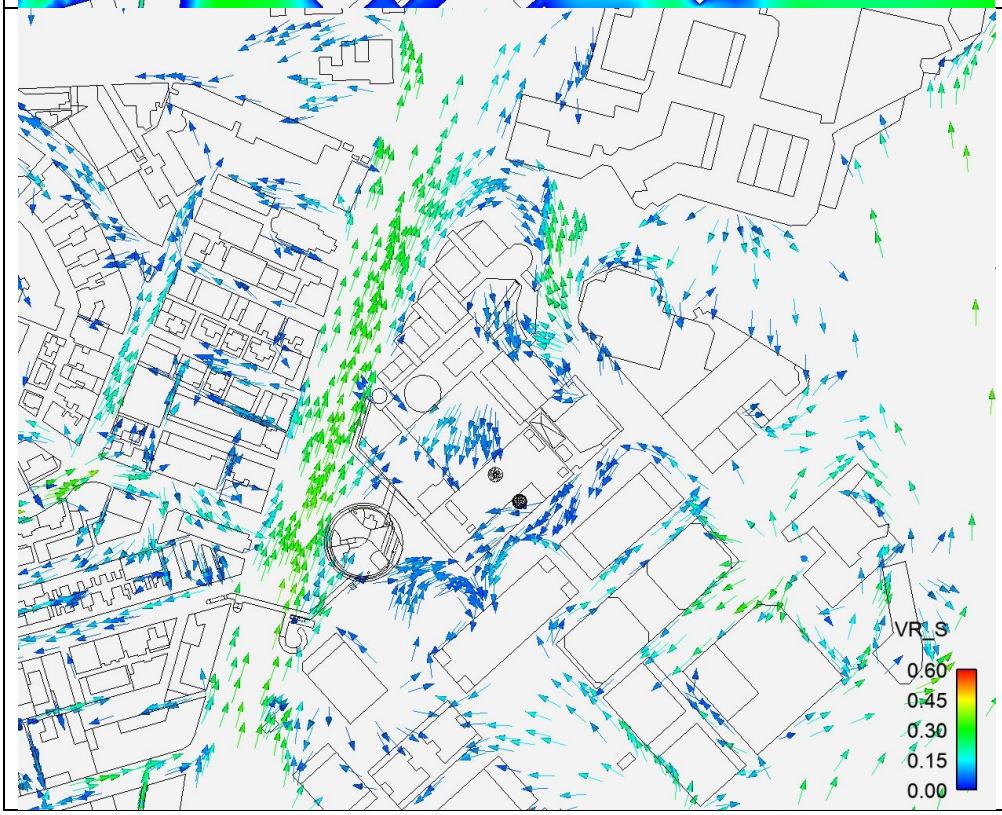
VR Contour and Vector Plot at Pedestrian Level under SSE Wind



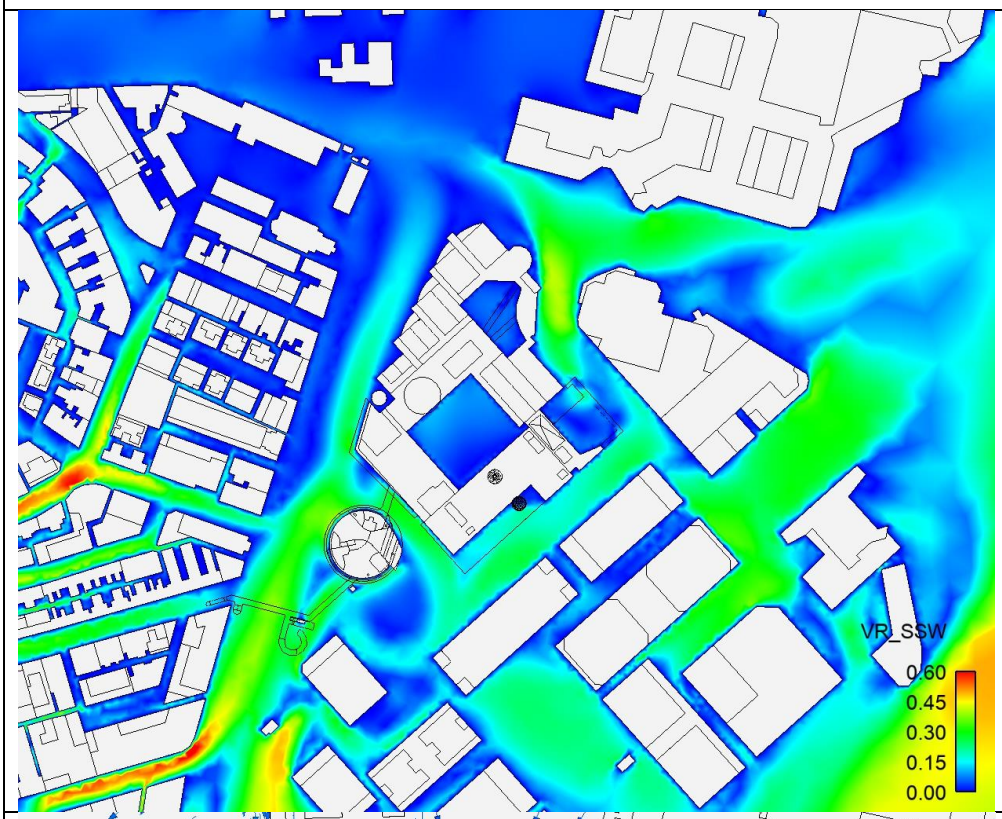


VR Contour and Vector Plot at Pedestrian Level under S Wind

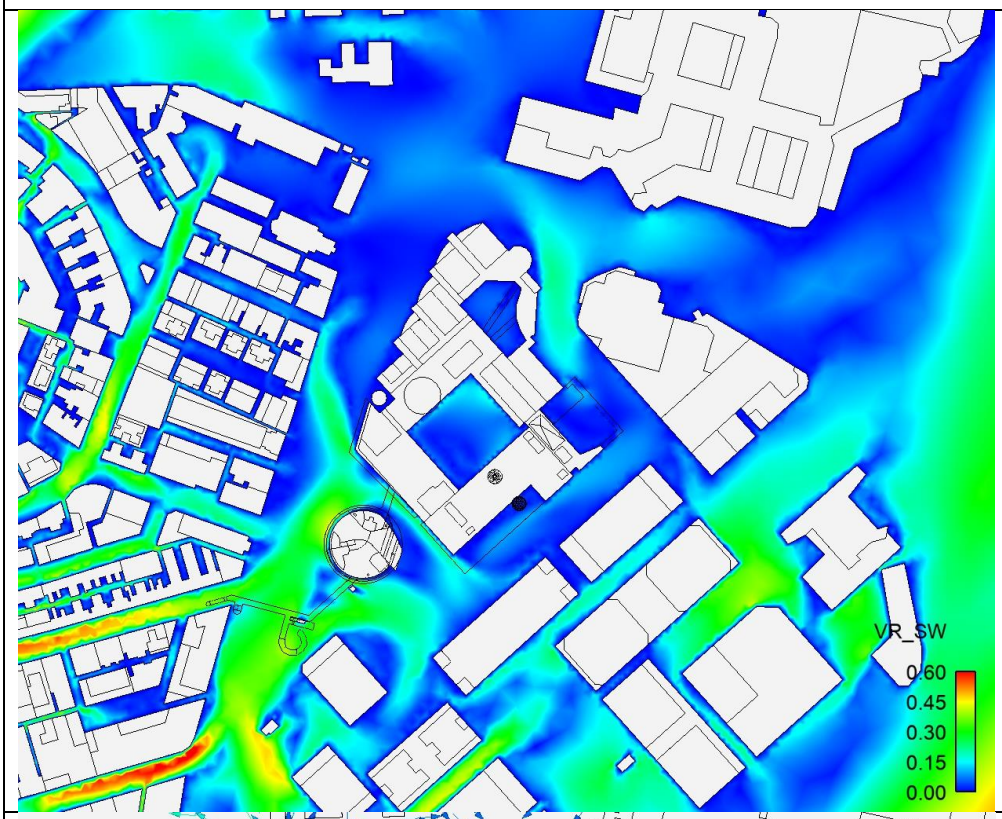


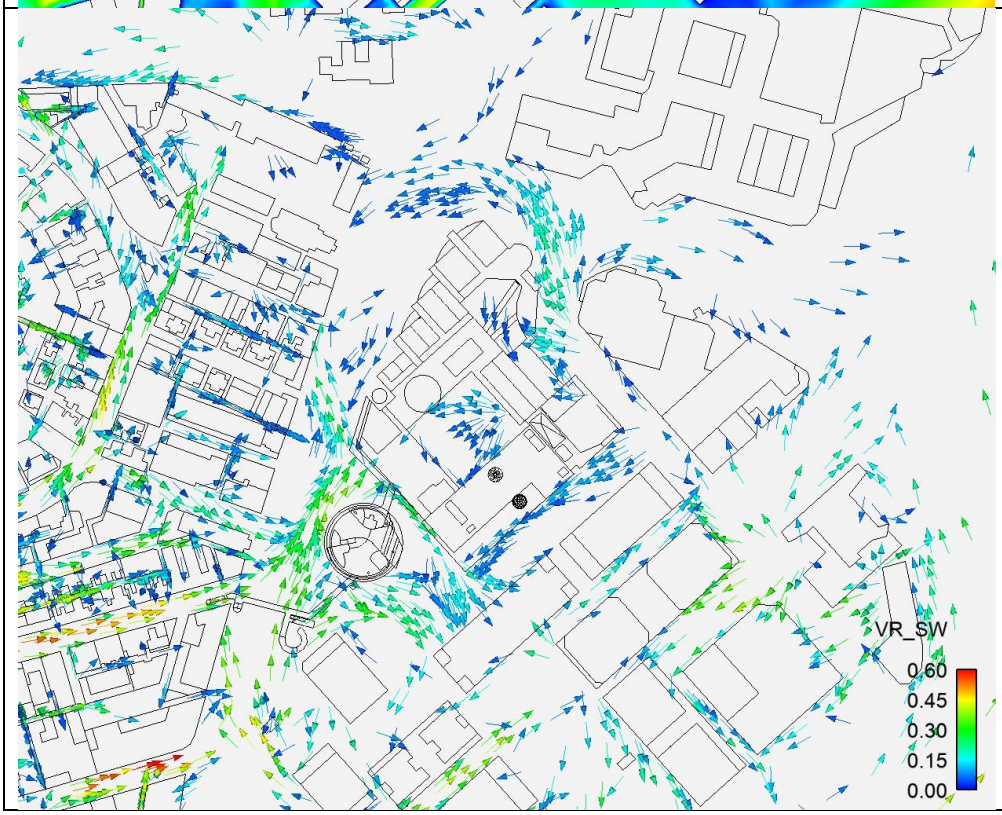


VR Contour and Vector Plot at Pedestrian Level under SSW Wind

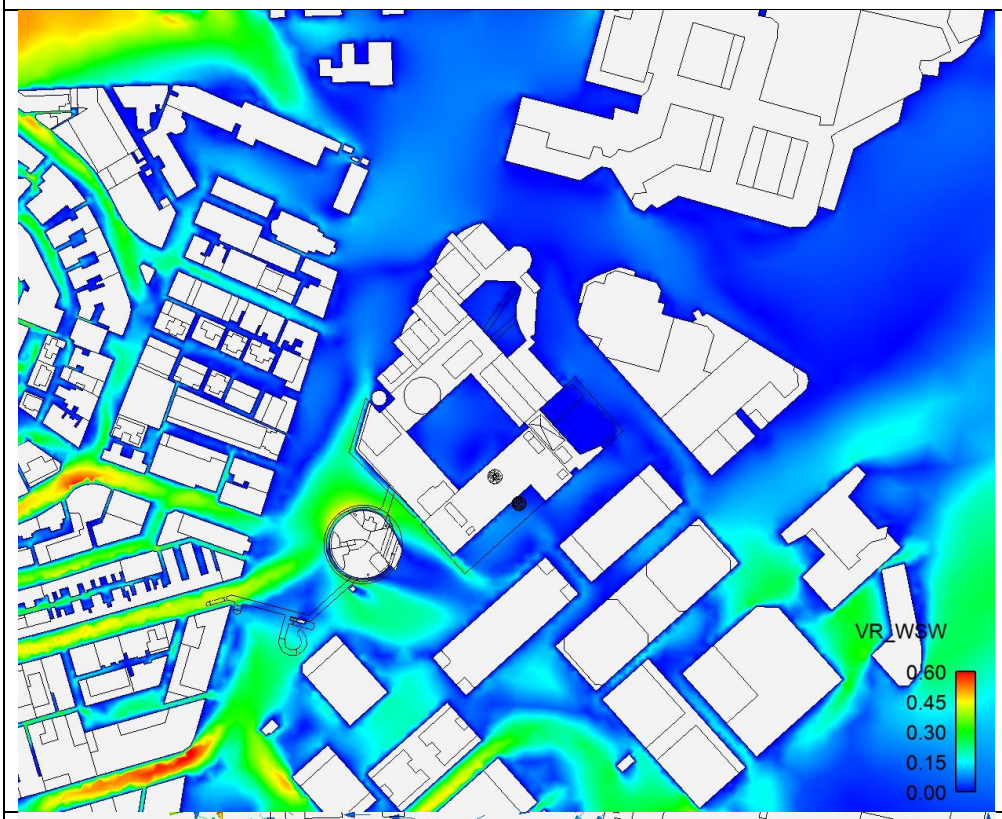


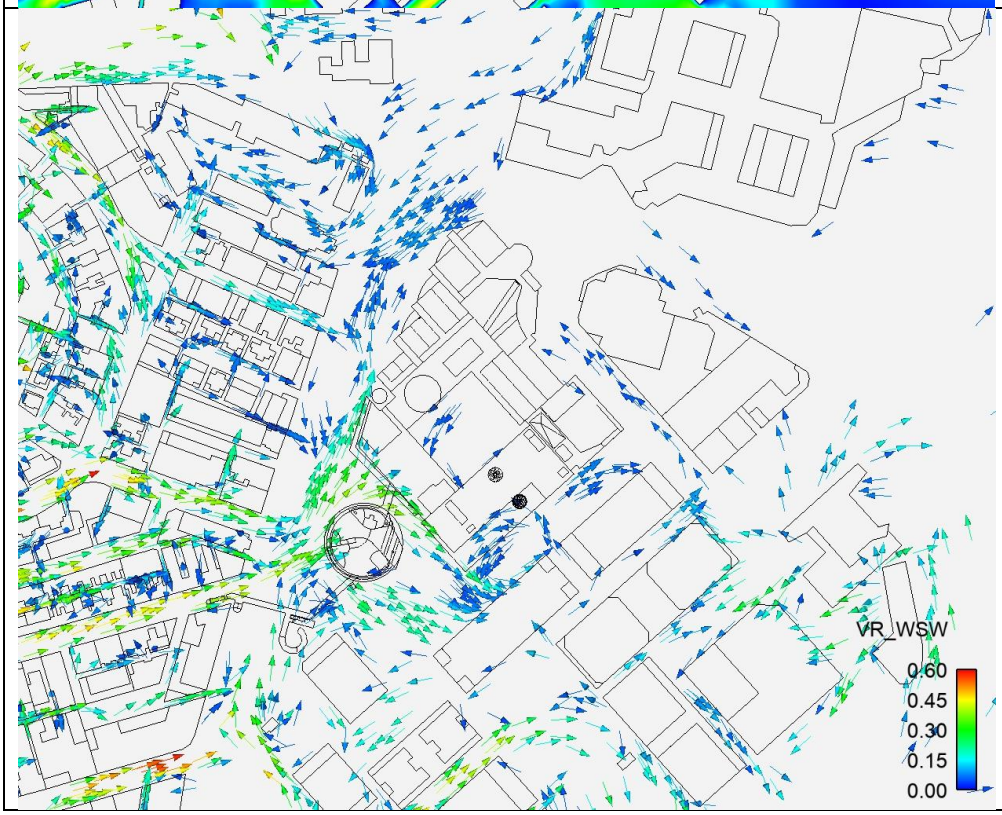
VR Contour and Vector Plot at Pedestrian Level under SW Wind





VR Contour and Vector Plot at Pedestrian Level under WSW Wind



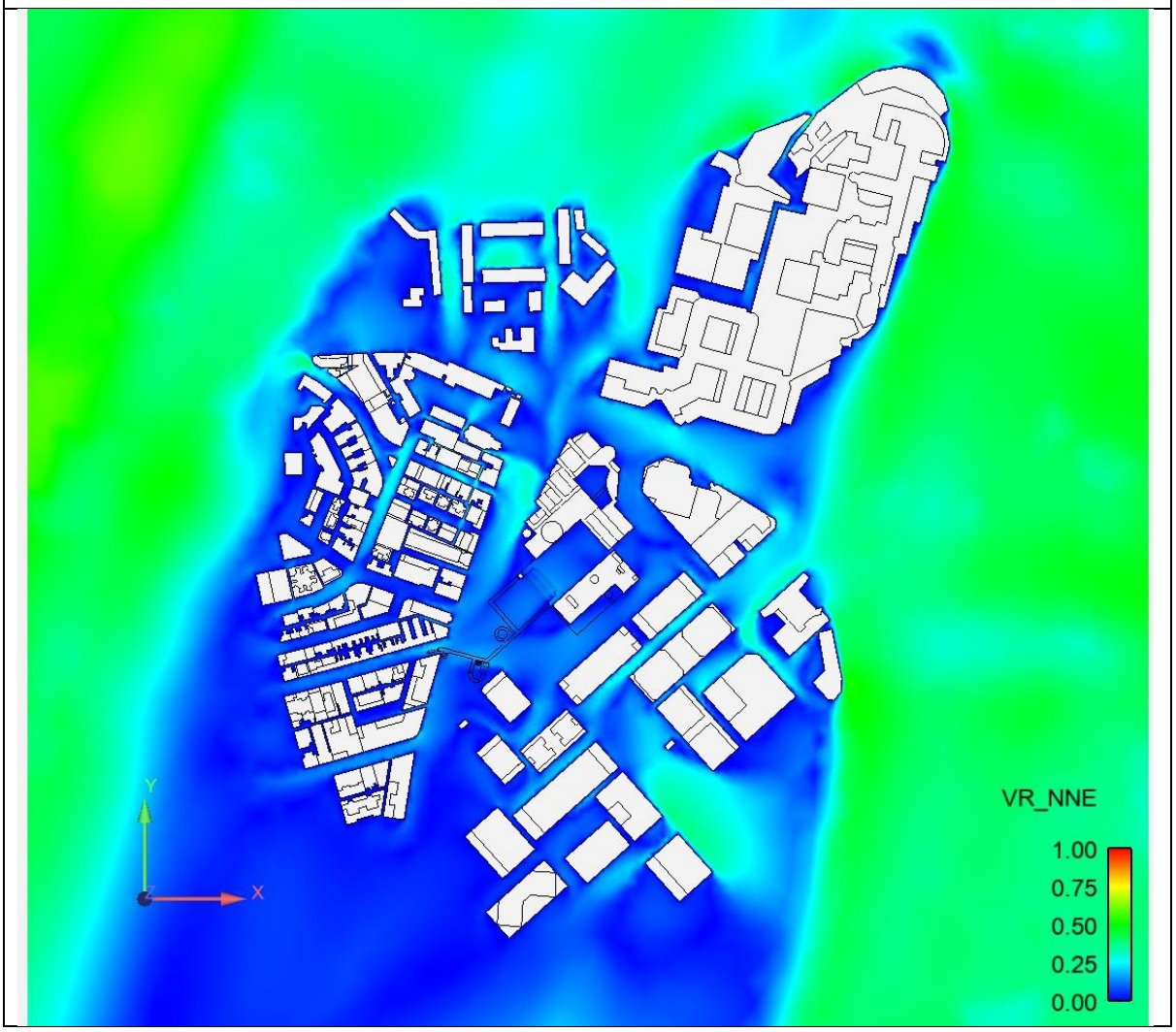


APPENDIX E

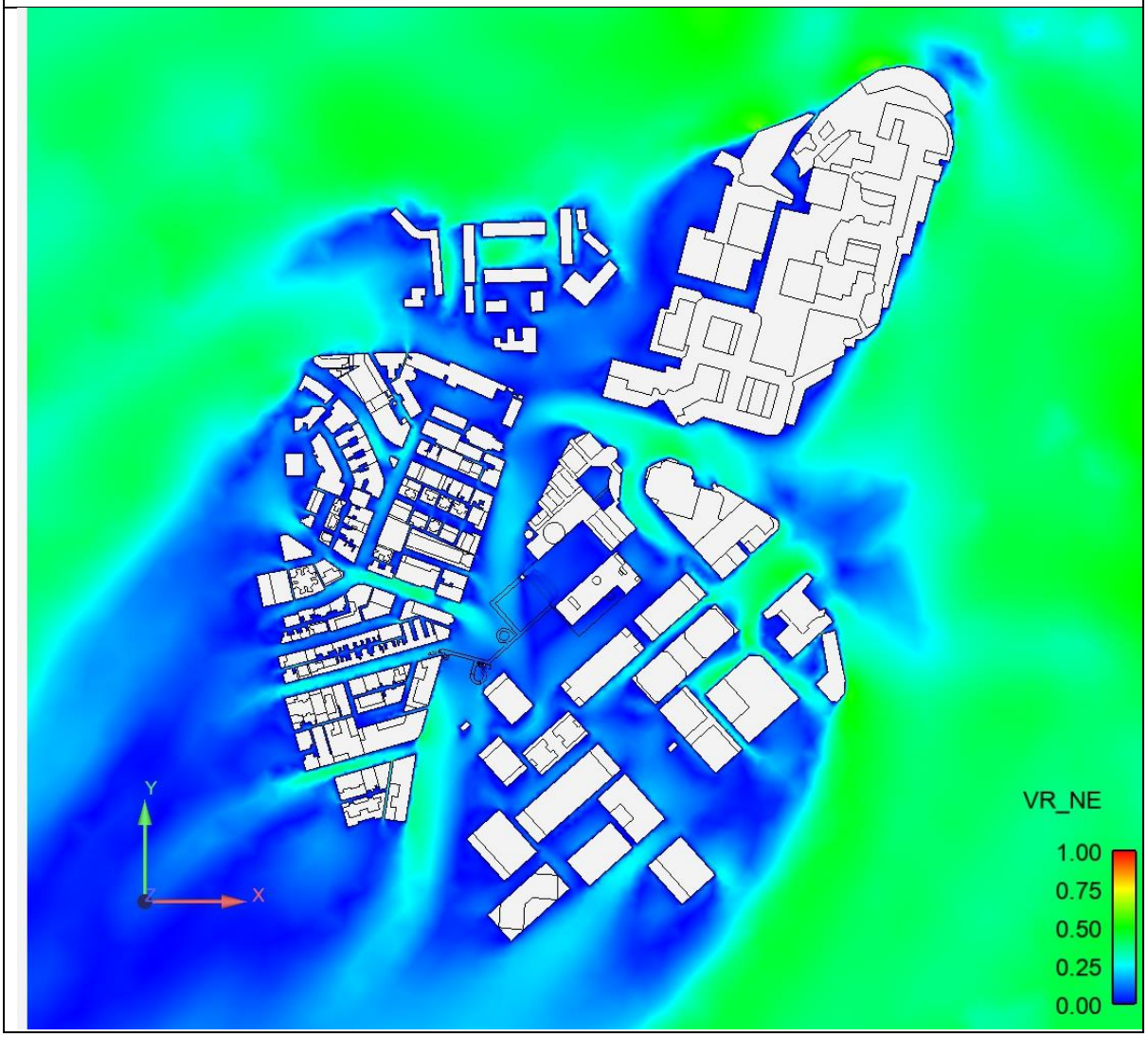
Wind Velocity Ratio Contour and Vector Plot Whole Computational Domain under Prevailing Wind Directions

Baseline Scheme

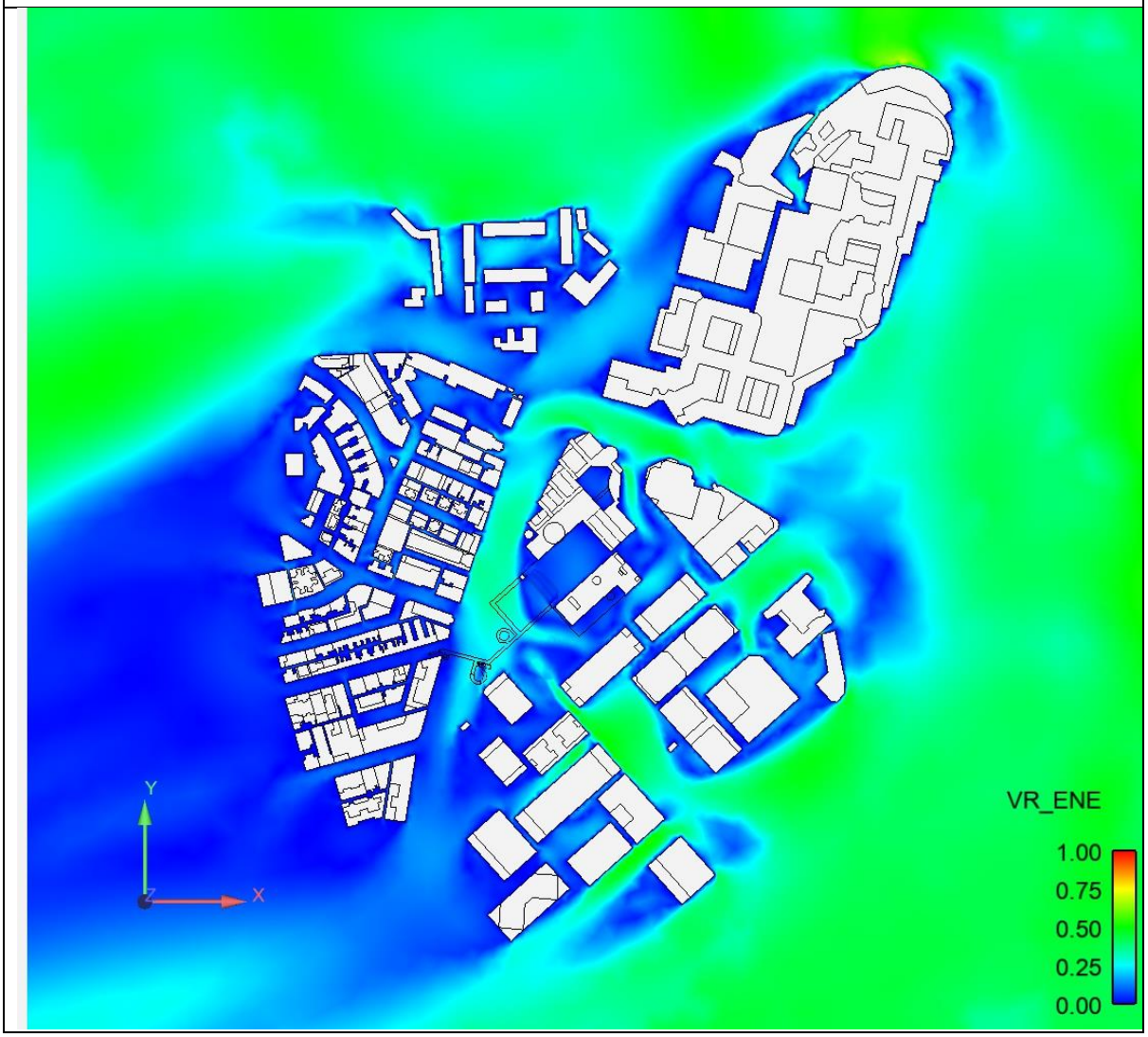
VR Contour Plot at Pedestrian Level under NNE Wind



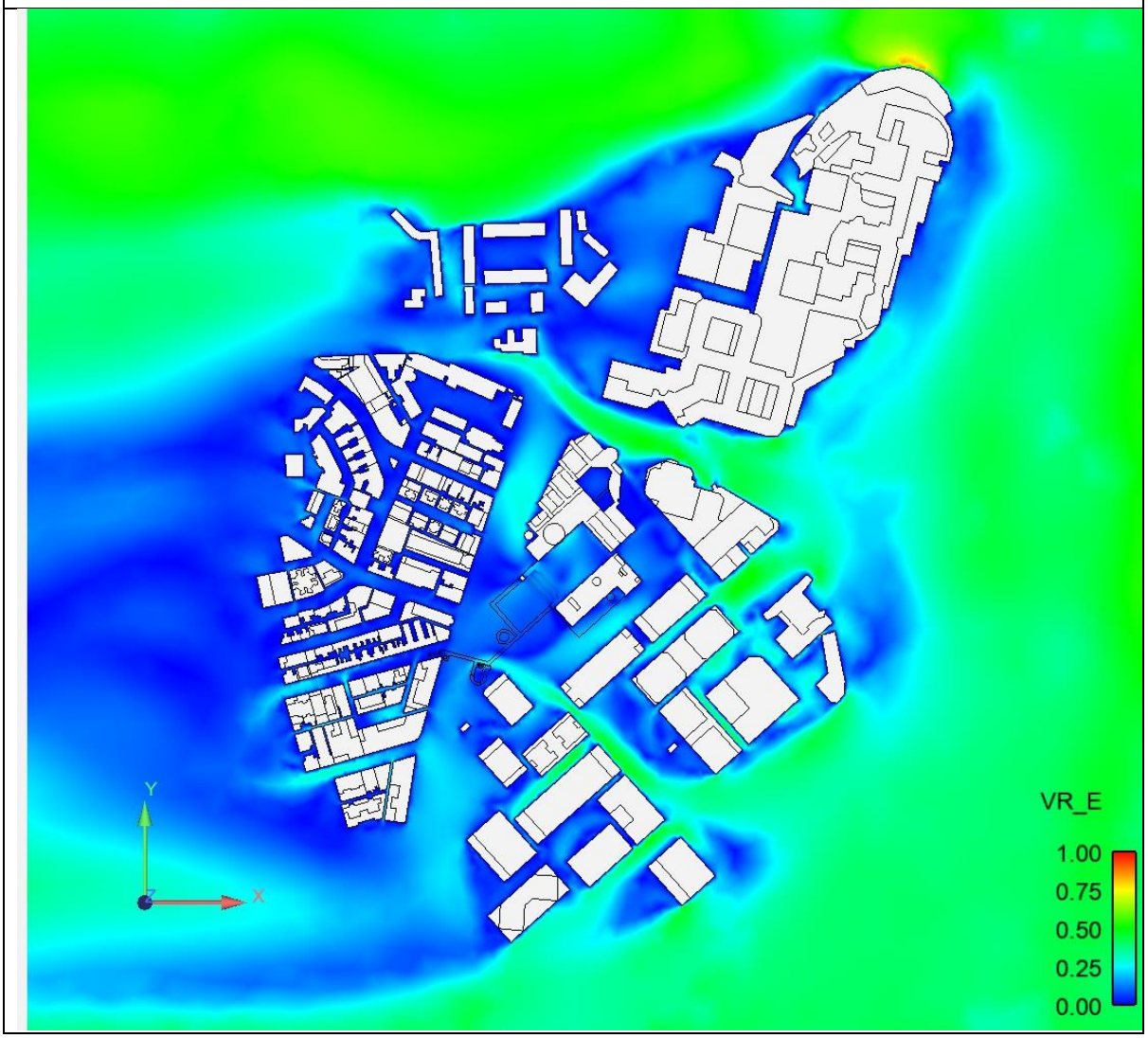
VR Contour Plot at Pedestrian Level under NE Wind



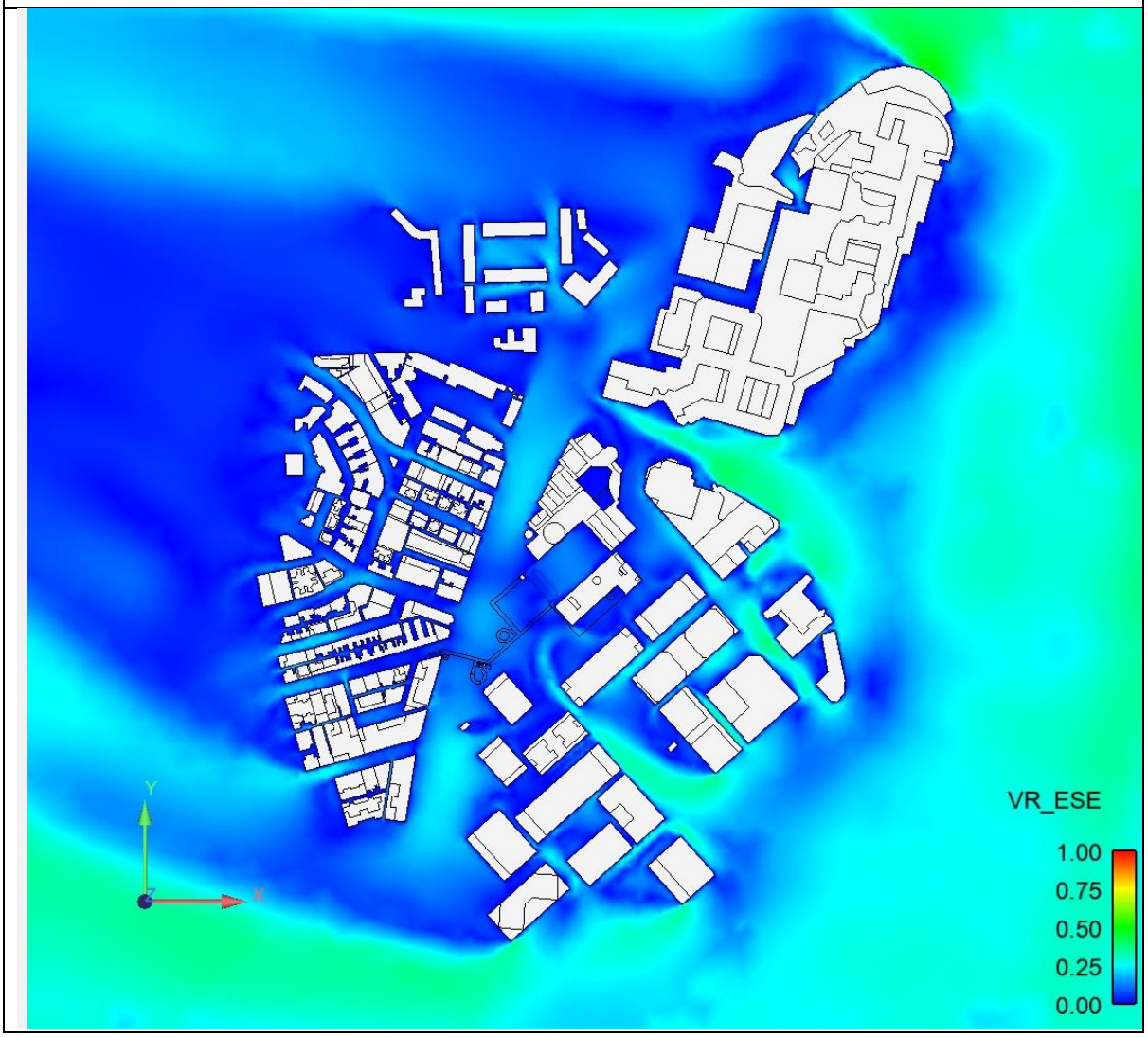
VR Contour Plot at Pedestrian Level under ENE Wind



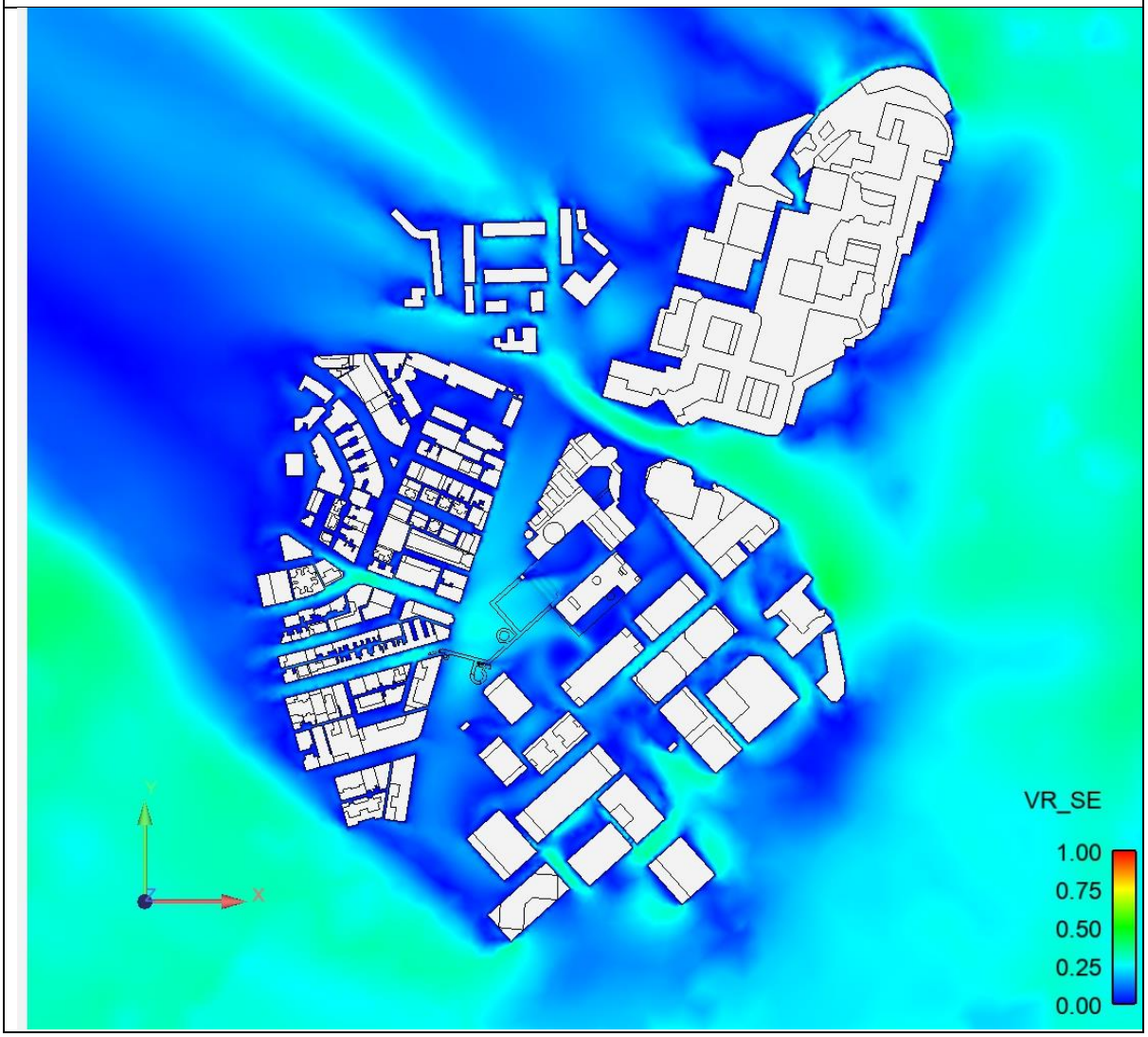
VR Contour Plot at Pedestrian Level under E Wind



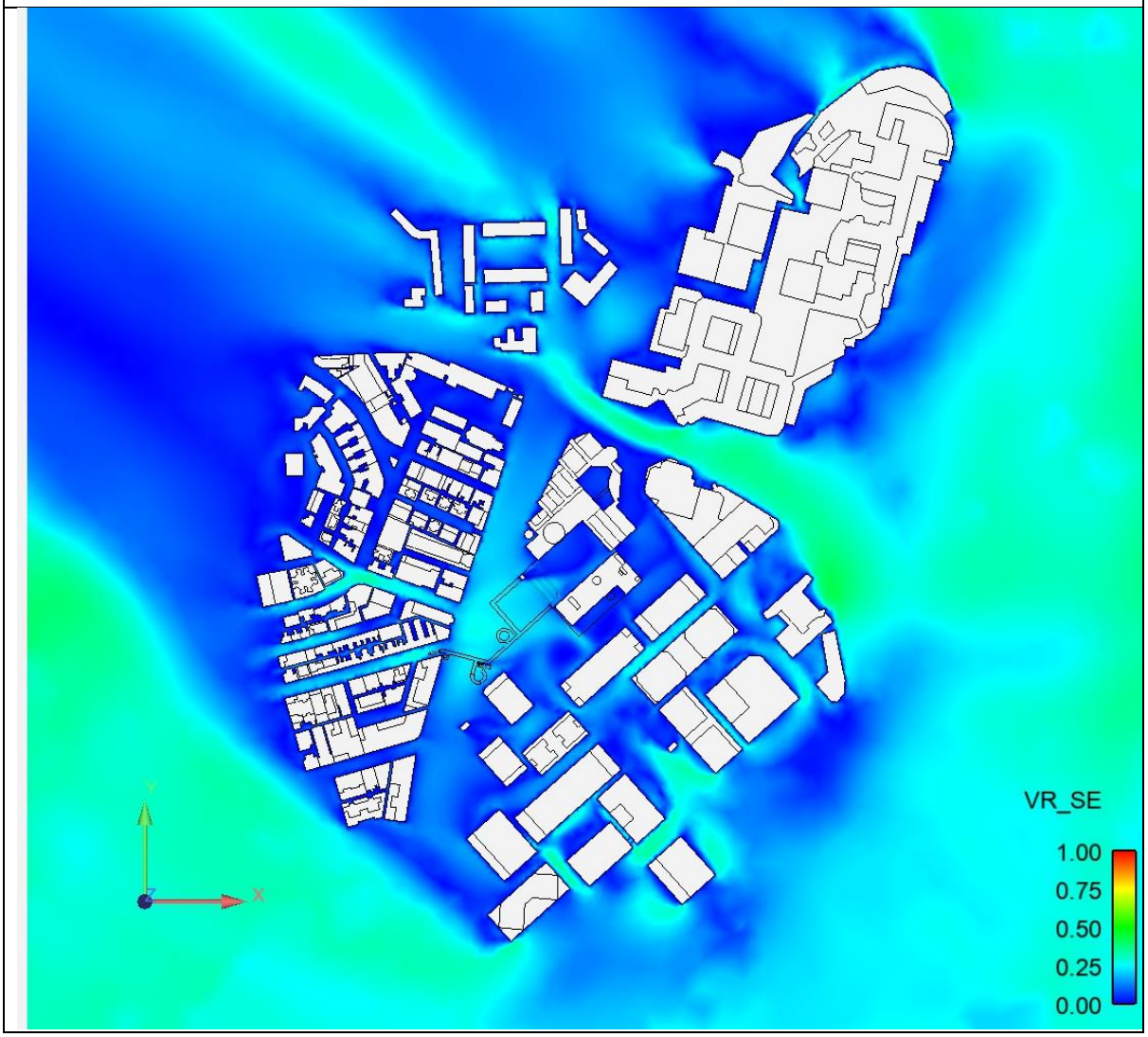
VR Contour Plot at Pedestrian Level under ESE Wind



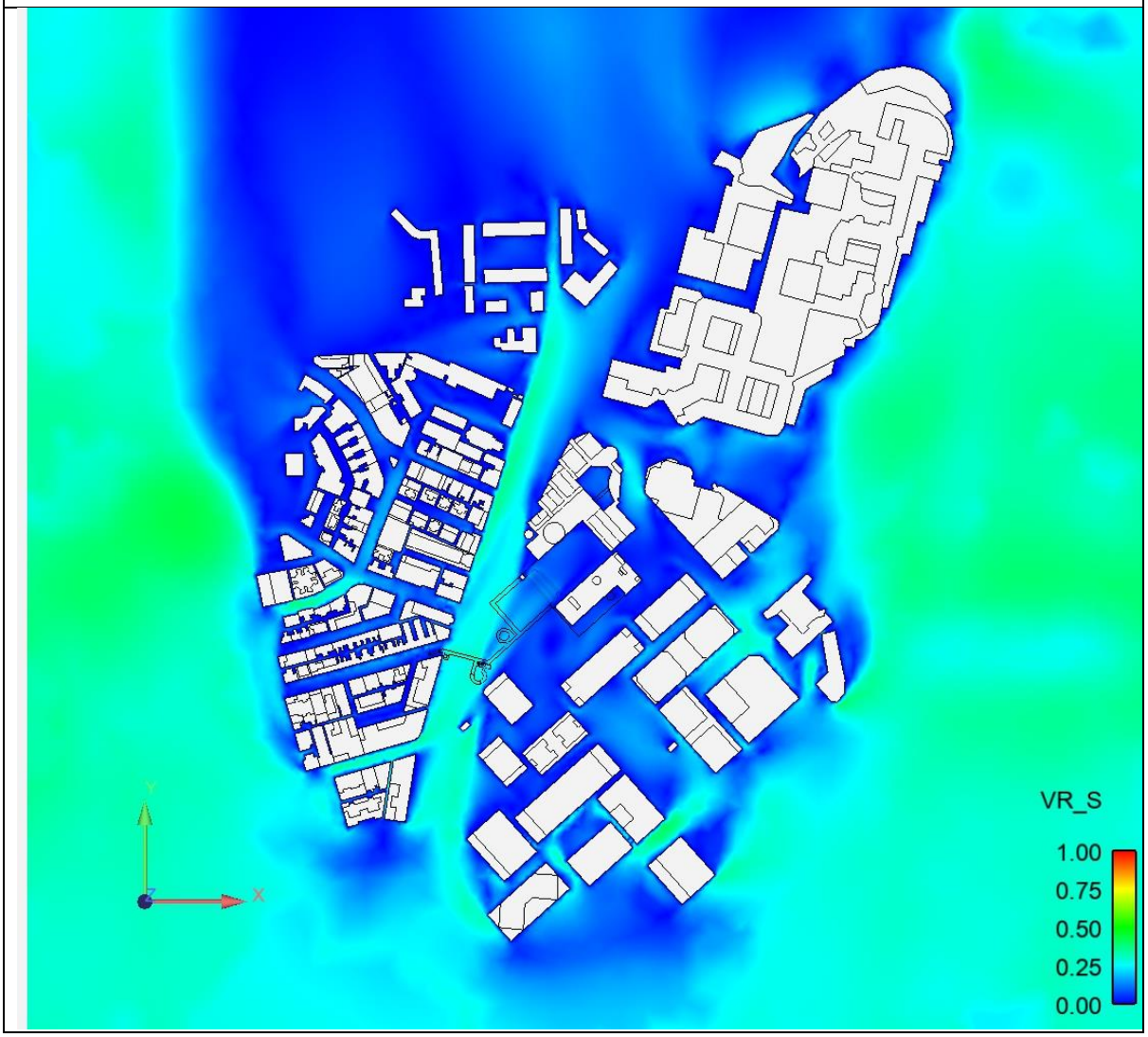
VR Contour Plot at Pedestrian Level under SE Wind



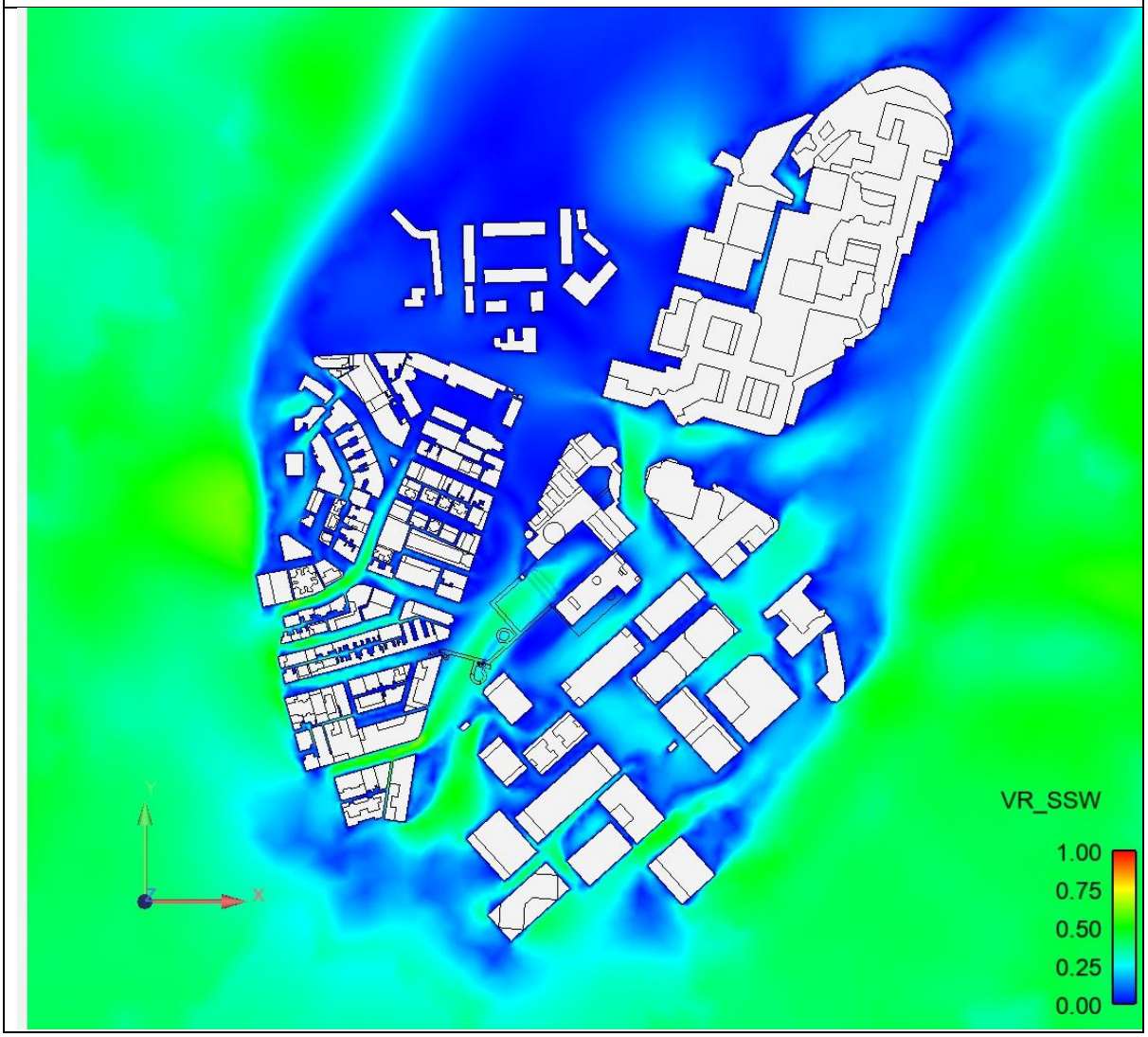
VR Contour Plot at Pedestrian Level under SSE Wind



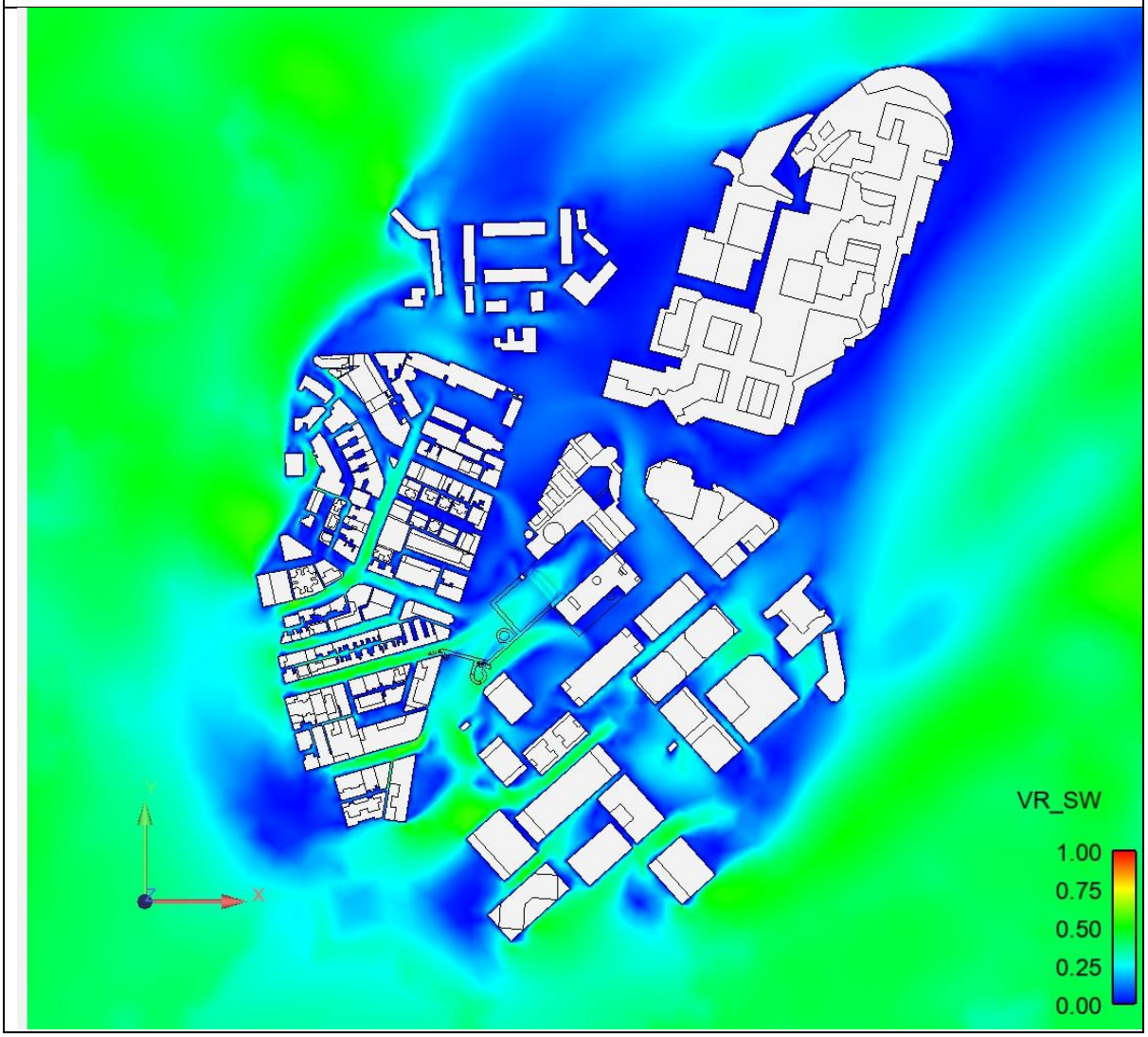
VR Contour Plot at Pedestrian Level under S Wind



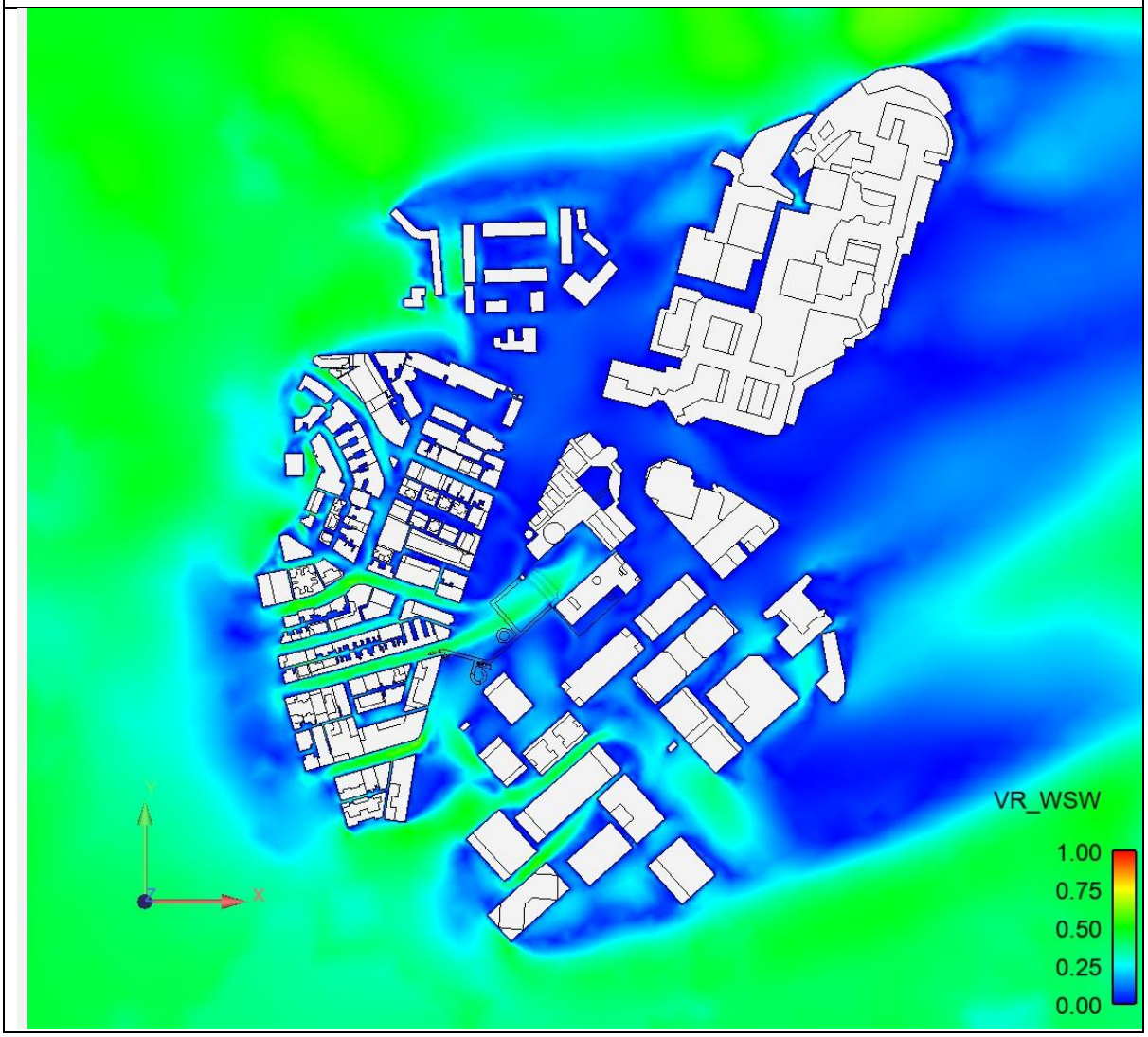
VR Contour Plot at Pedestrian Level under SSW Wind



VR Contour Plot at Pedestrian Level under SW Wind

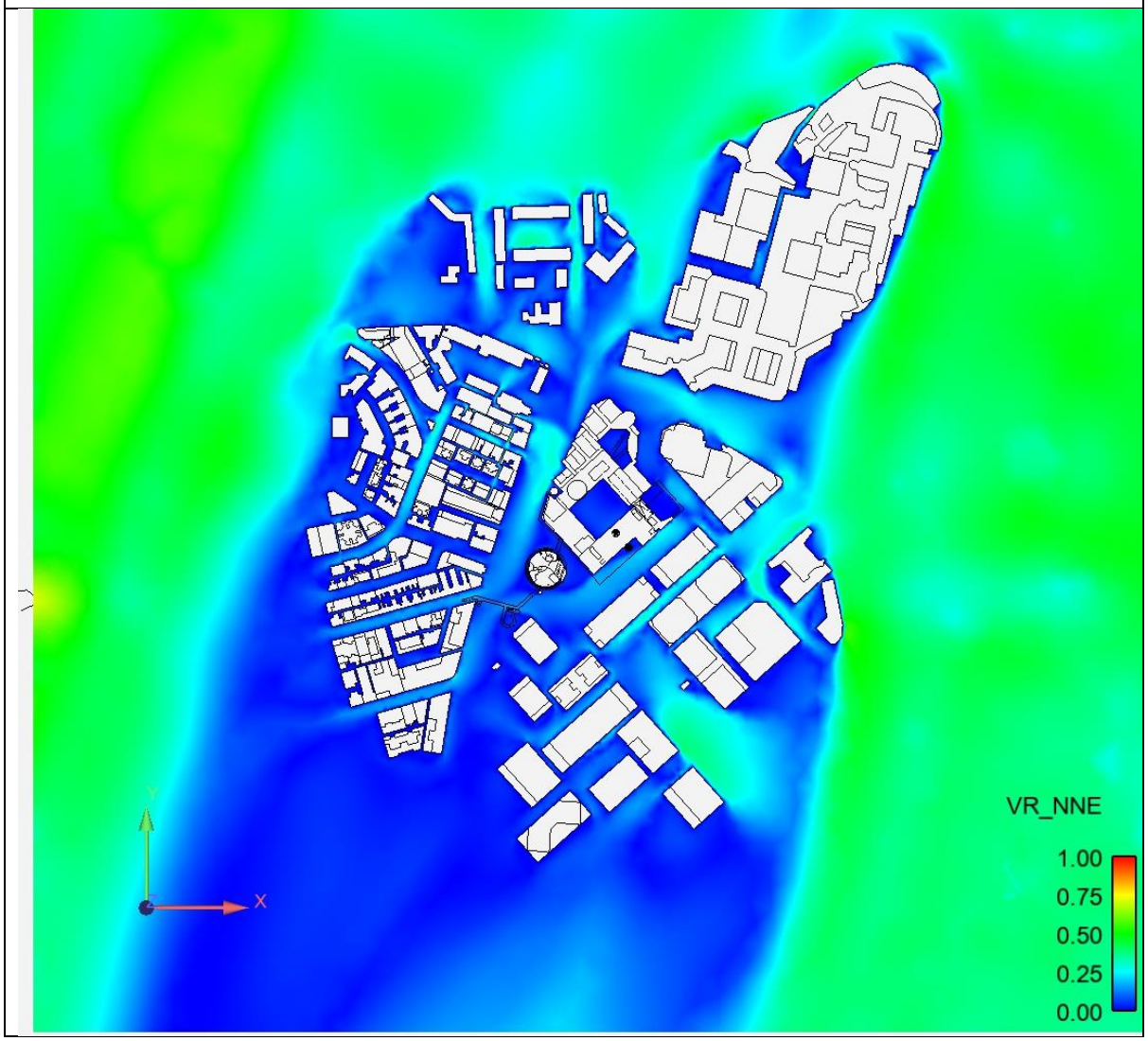


VR Contour Plot at Pedestrian Level under WSW Wind

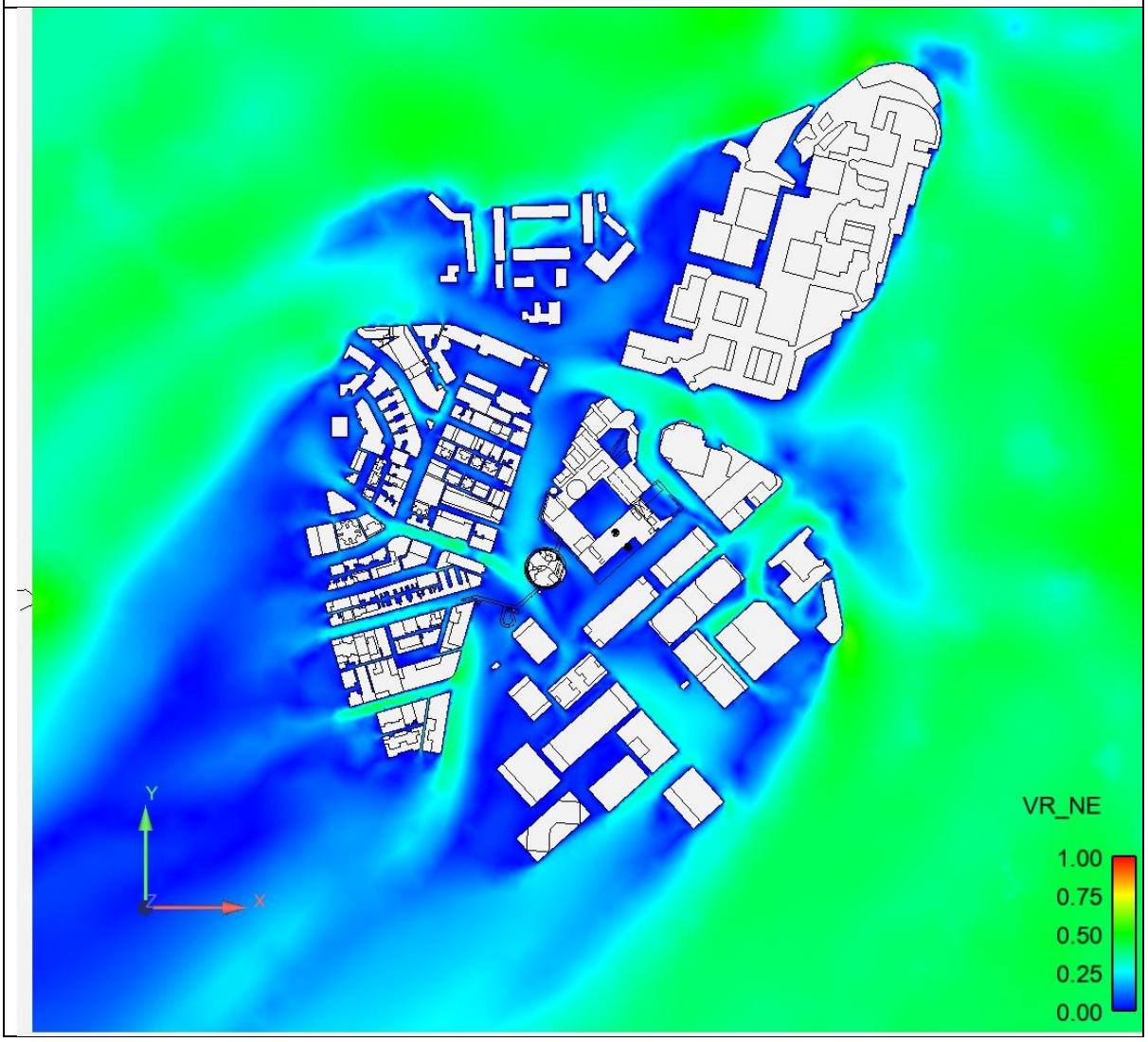


Proposed Scheme

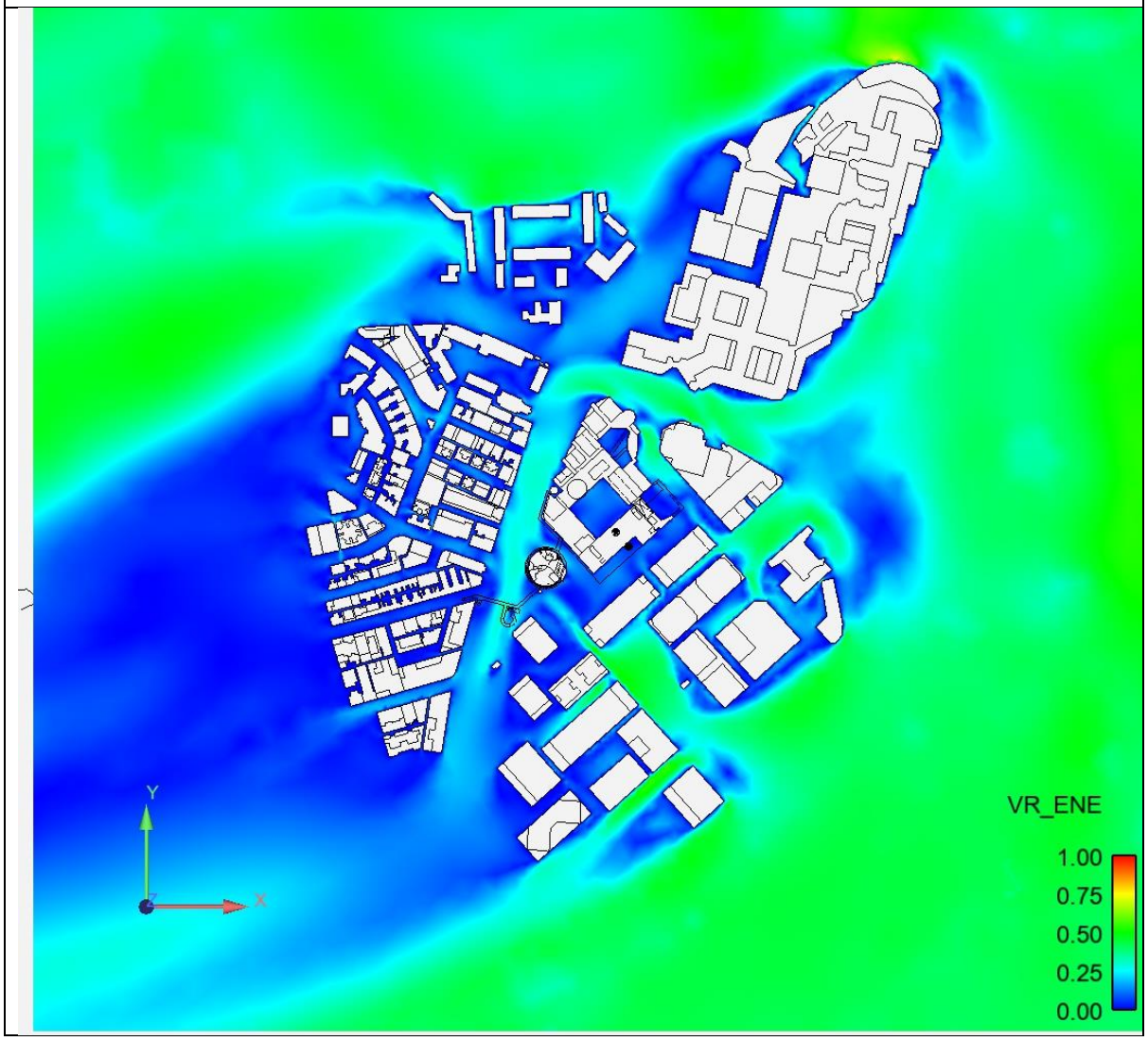
VR Contour Plot at Pedestrian Level under NNE Wind



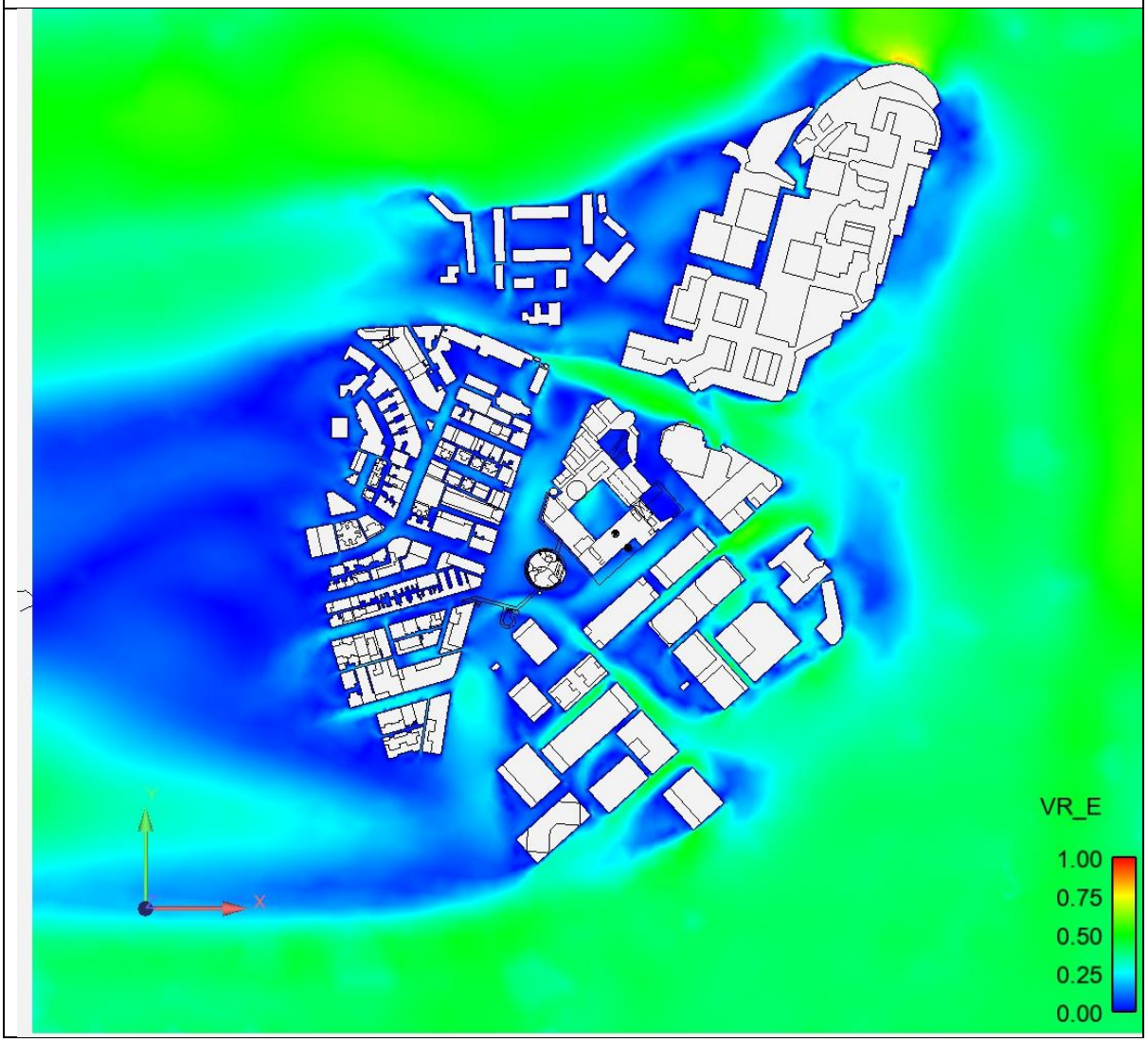
VR Contour Plot at Pedestrian Level under NE Wind



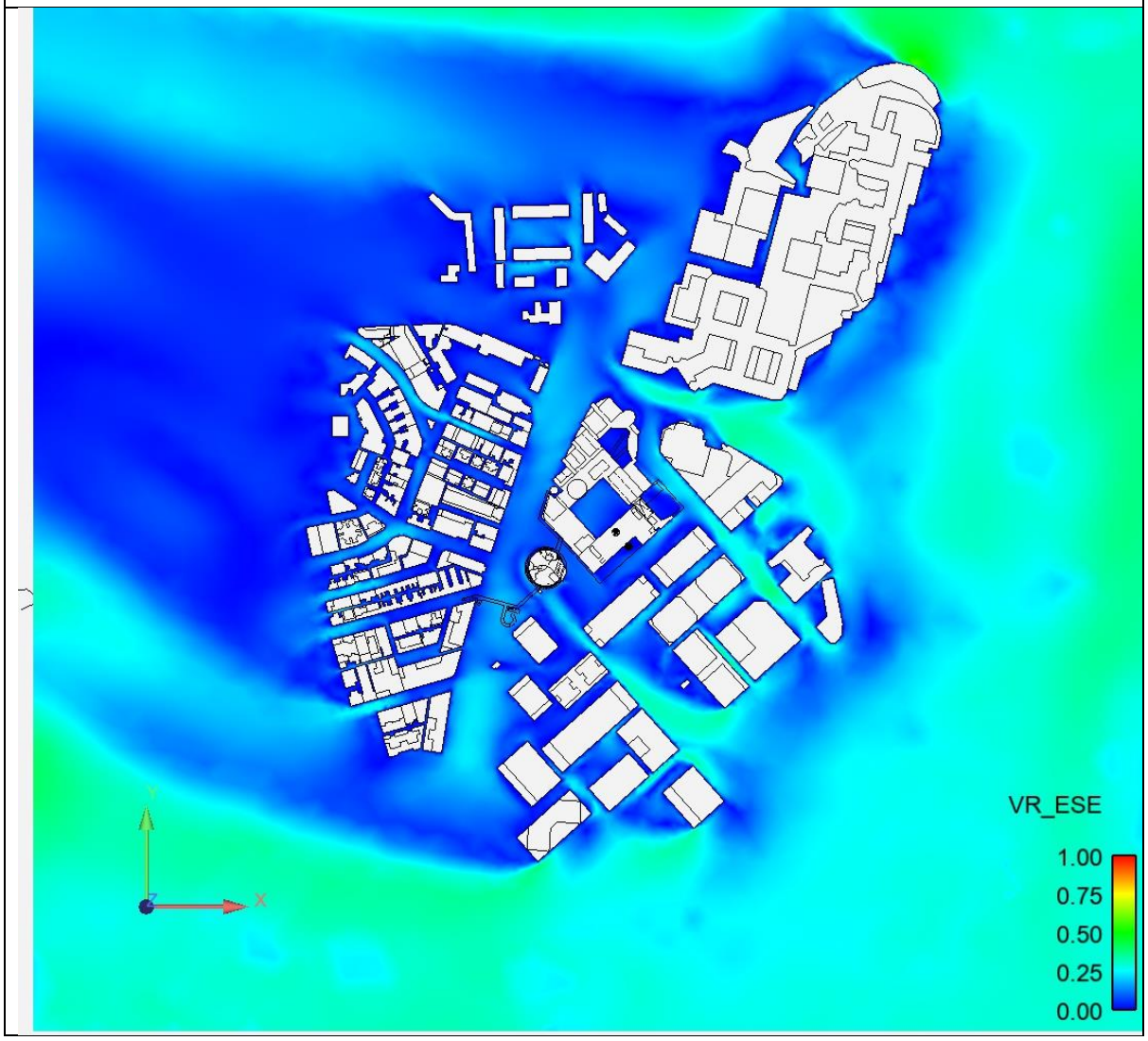
VR Contour Plot at Pedestrian Level under ENE Wind



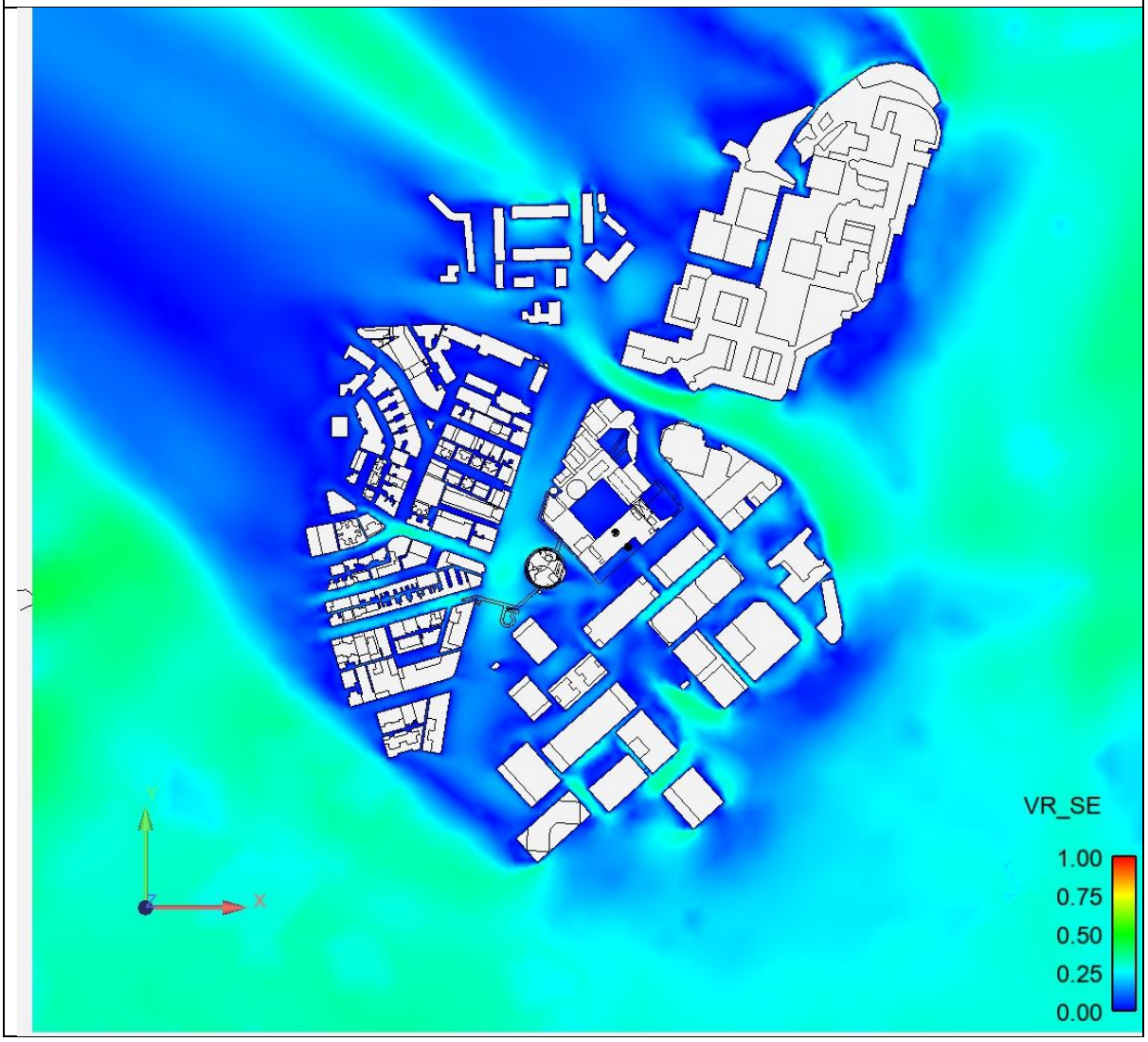
VR Contour Plot at Pedestrian Level under E Wind



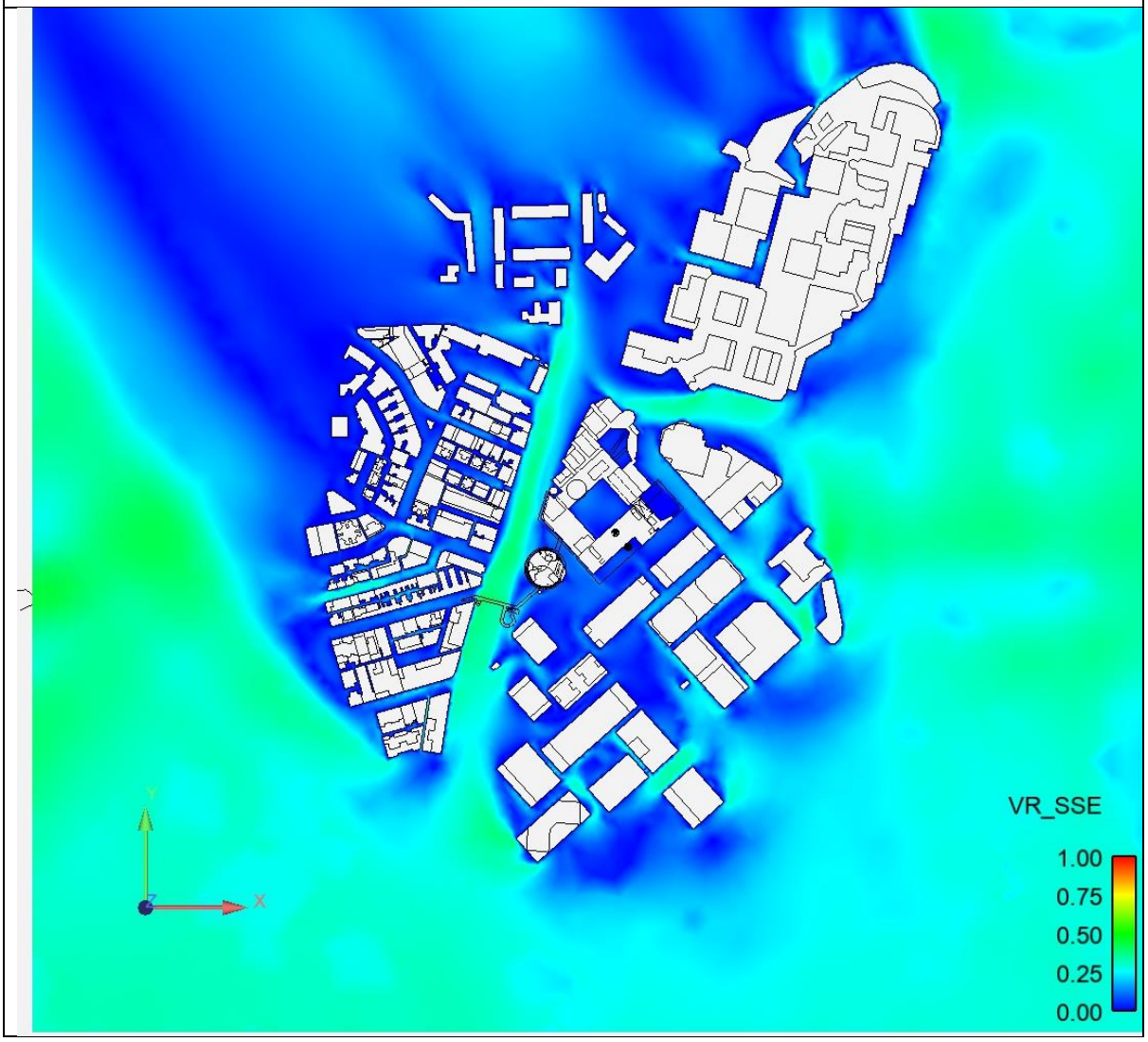
VR Contour Plot at Pedestrian Level under ESE Wind



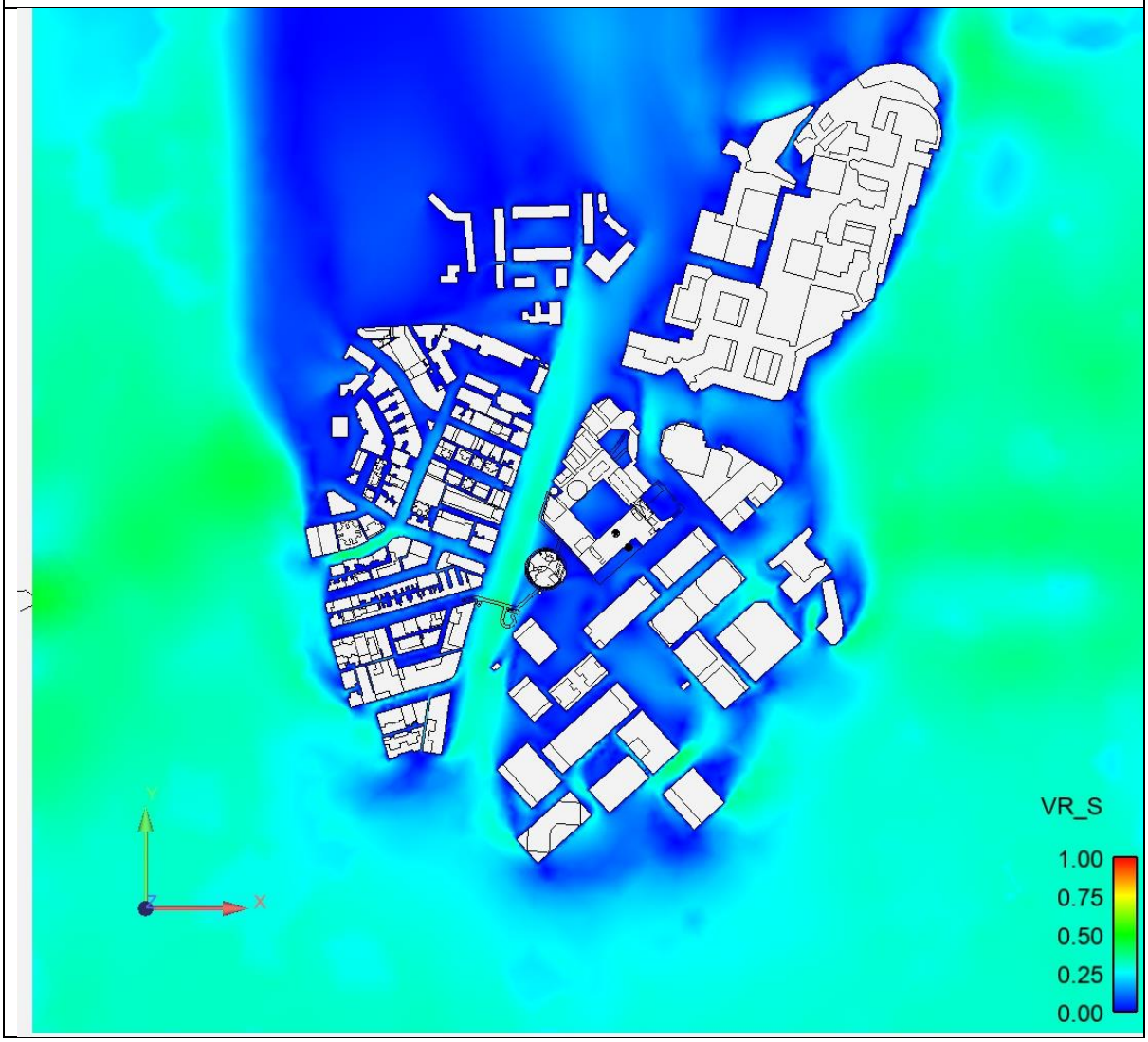
VR Contour Plot at Pedestrian Level under SE Wind



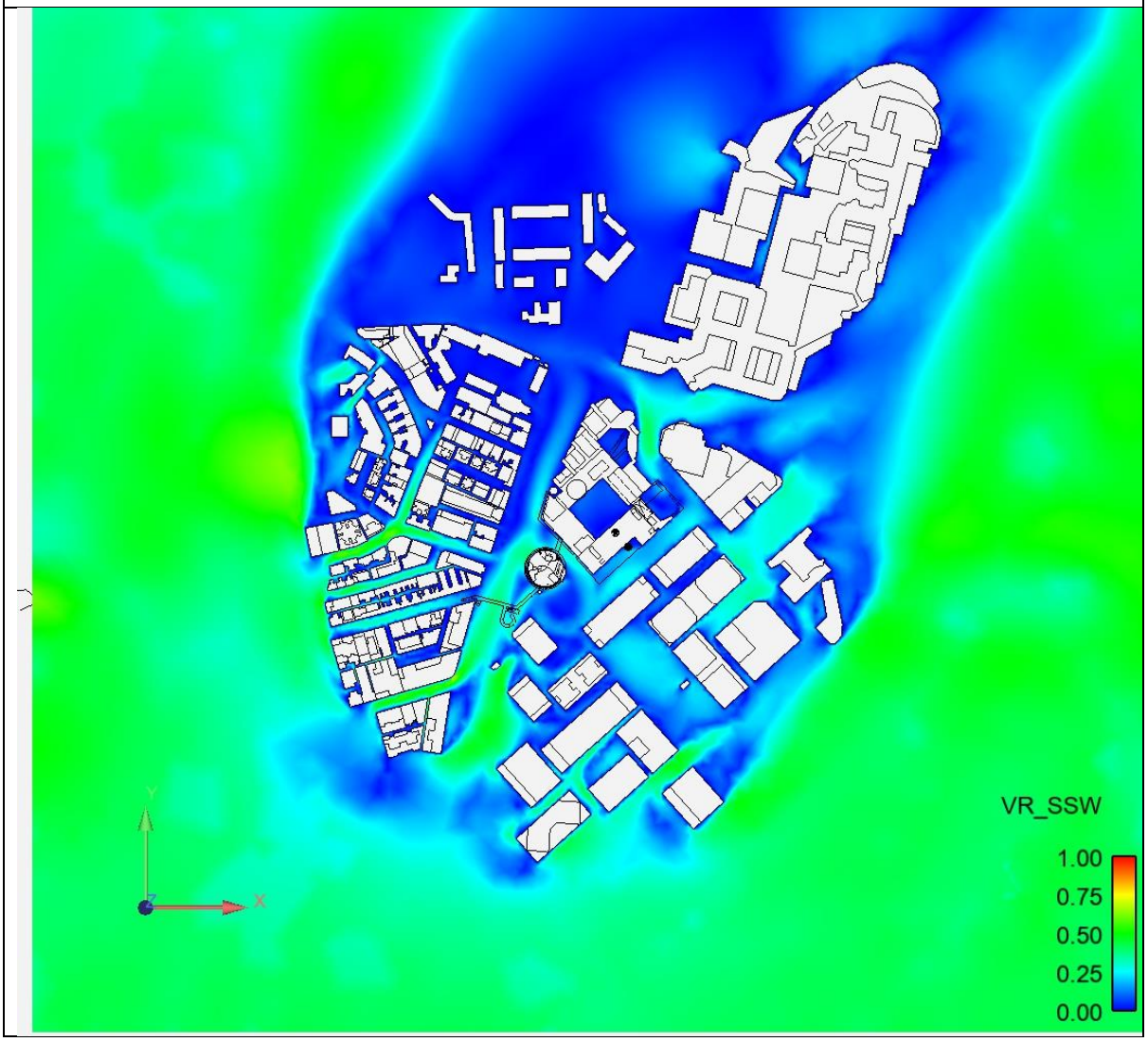
VR Contour Plot at Pedestrian Level under SSE Wind



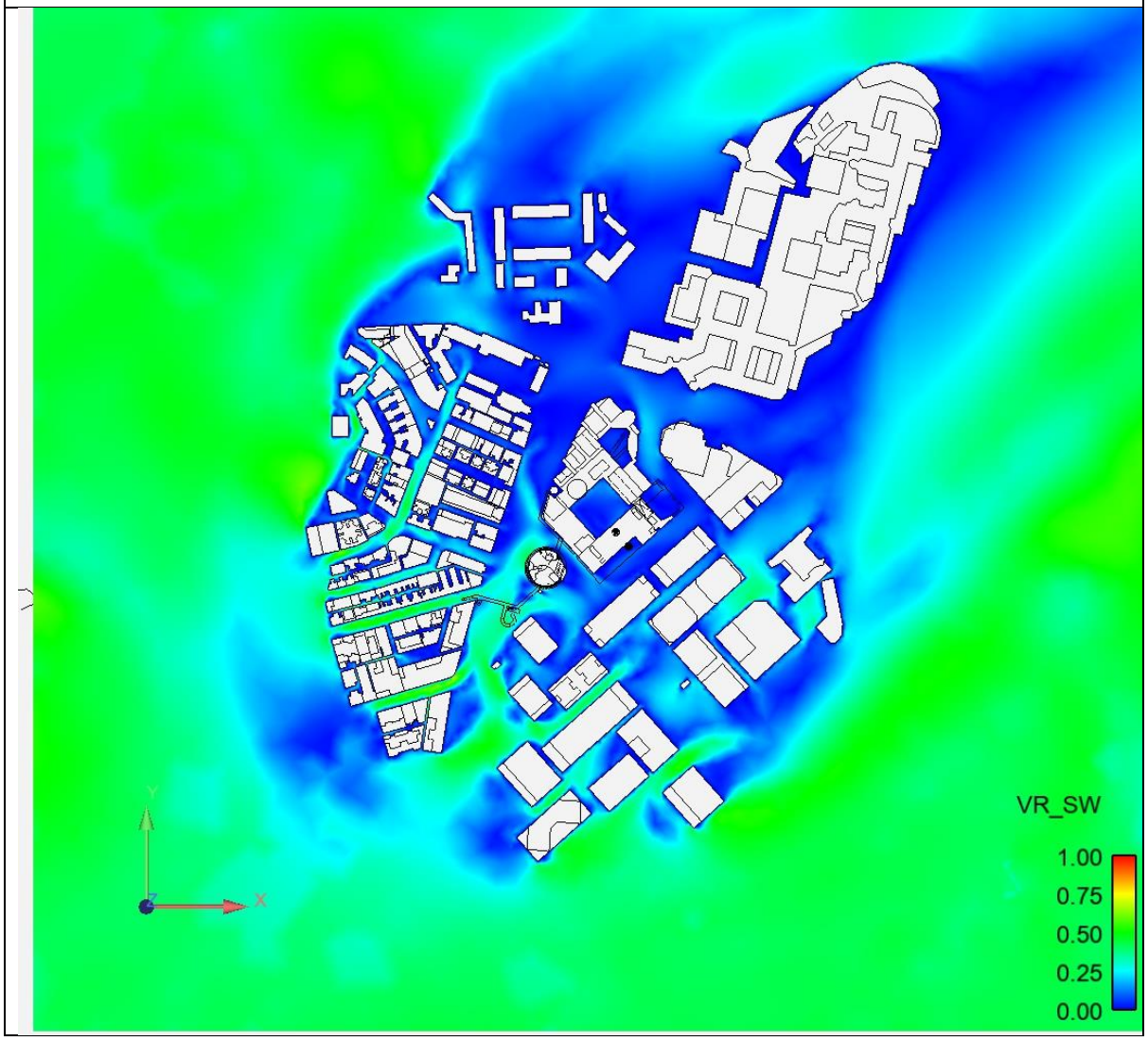
VR Contour Plot at Pedestrian Level under S Wind



VR Contour Plot at Pedestrian Level under SSW Wind



VR Contour Plot at Pedestrian Level under SW Wind



VR Contour Plot at Pedestrian Level under WSW Wind