Hong Kong Housing Authority

Air Ventilation Assessment of Proposed Public Housing Development at Hang Tai Road, MOS Area 86B Phase 2

Air Ventilation Assessment – Initial Study

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Job number --

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ARUP

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1 Introduction

1.1 Background

Ove Arup & Partners Hong Kong Ltd (Arup) was commissioned by the Hong Kong Housing Authority (HKHA) to carry out an Air Ventilation Assessment (AVA) – Expert Evaluation for the Proposed Public Housing Development at Hang Tai Road, MOS Area 86B (hereafter "the Development").

Expert Evaluation has been carried out and submitted to Planning Department (PlanD) to identify the existing wind conditions and good design features to be employed in the Development for the AVA Initial Study.

The *Technical Guide for Air Ventilation Assessment for the Developments in Hong Kong (Annex A of Technical Circular No.1/06 for Air Ventilation Assessments)*[1] *(termed as AVA Technical Circular hereafter)* dated 19 July 2006 lay down the foundation of methodology in this AVA Initial Study.

1.2 Objective of AVA Initial Study

Among all available wind data, an Initial Study will be conducted by using Computational Fluid Dynamics (CFD) techniques. It aims to achieve the following tasks:

- Initially assesses the characteristics of the wind availability of the site;
- Gives a general pattern and a rough quantitative estimate of the wind performance at the pedestrian level using Velocity VR; and
- Identify good design features and problematic areas if any and recommend mitigation measures.

2 Location and Site Characteristics

The Proposed Development of Public Housing at Hang Tai Road is located in the Ma On Shan area of Hong Kong's New Territories, between the Tai Shui Hang and Heng On MTR stations.

The eastern and southern side of the Development is occupied by the Ma On Shan Country Park with hilly terrain and lots of greenery. The Ma On Shan Bypass runs adjacent to the site along the hillside. Tolo Harbour to the west is separated from the Development by some high rise residential clusters (i.e. Baycrest, Oceanaire, Ocean View, La Costa, Sausalito and Mountain Shore. The high rise public housing buildings of Heng On Estate and Kam On Court are located at the north side of the Development.

Figure 1 Topography of Ma On Shan Area from Google Maps

Yan On estate on the West side of the development is situated extremely close to the development as they are separated by the width of a road. These buildings are 120m tall.

The Proposed Development consists of 3 blocks: Block A is 134.99mPD tall and has 41 domestic storeys and a podium kindergarten and Blocks B and C are 124.99mPD and 124.64mPD tall respectively having 40 domestic storeys. All three Blocks contain an entrance lobby at the G/F as well as essential plantrooms. Blocks A and B sit on top of a Basement Carpark, leading to a number of features at GF including doghouses and an entrance ramp, show in Figure 2 below.

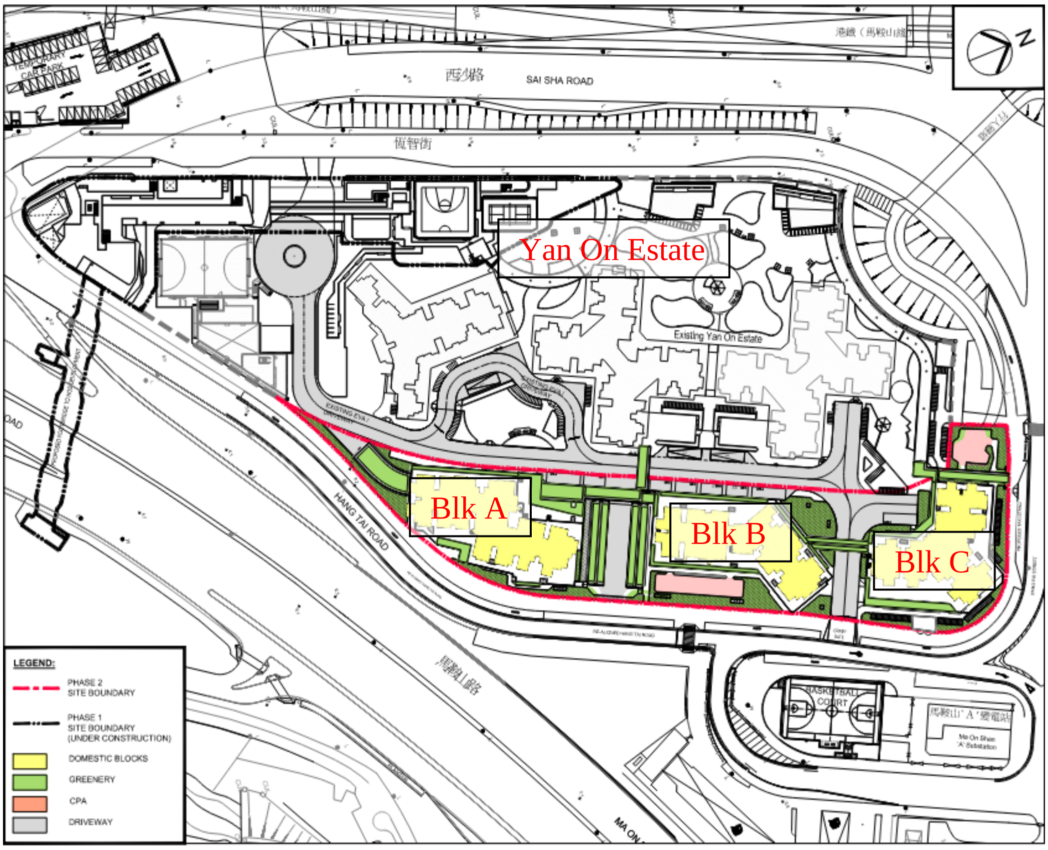


Figure 2 Master Layout Plan of Proposed Hang Tai Road Development

3 Wind Availability Data

As per the *AVA Technical Circular* [1], at least 75% of the time in a typical reference year (frequency of occurrence) would be studied under both annual and summer wind condition in the Initial Study when using a Computational Fluid Dynamics (CFD) modelling technique. Since the CFD approach is adopted for the present project's AVA, this criterion together with the following selected wind data are to be applied as the methodology.

The site wind availability of the Development site and its surrounding is an essential parameter for AVA. As stipulated in the *AVA Technical Circular* [1] the site wind availability would be presented by using appropriate mathematical models. Planning Department (PlanD) has set up a set of simulated meso-scale data of Regional Atmospheric Modelling System (RAMS) of the territory for AVA study, which could be downloaded at Planning Department Website [2]. Simulated meso-scale data of Regional Atmospheric Modelling System (RAMS) from PlanD will therefore be adopted in this AVA Study. The location of the Development falls within the location grid (x: 091, y:063) in the RAMS database as indicated in Figure 3.

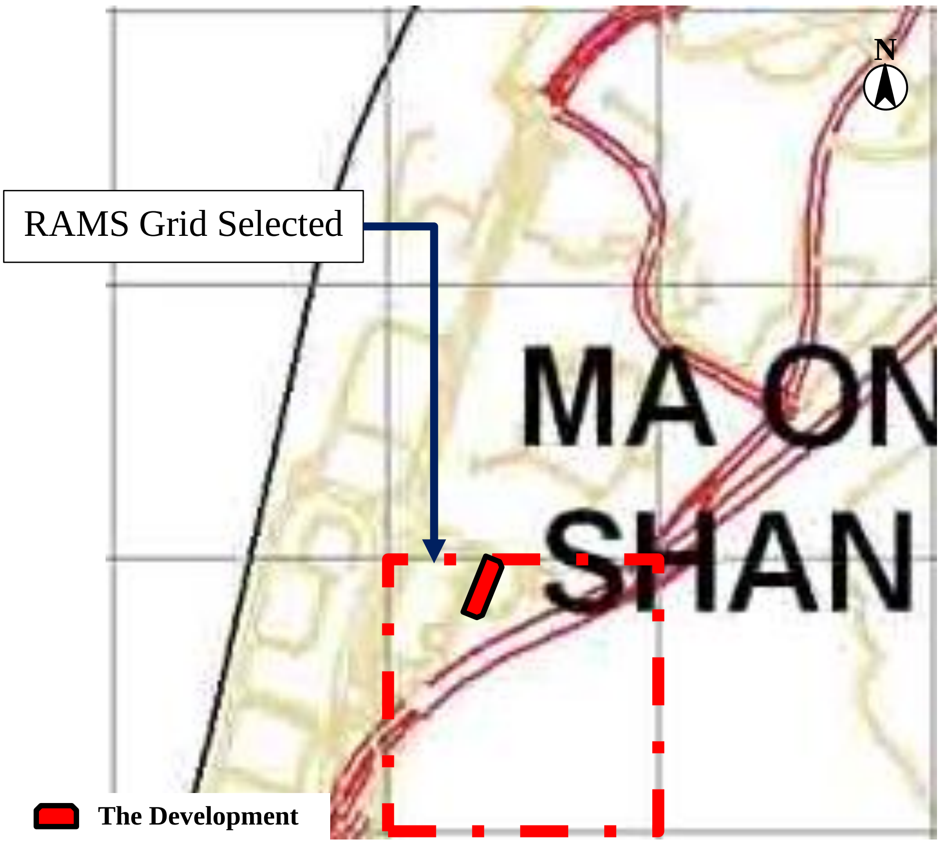


Figure 3 RAMS Grid and the Development Location

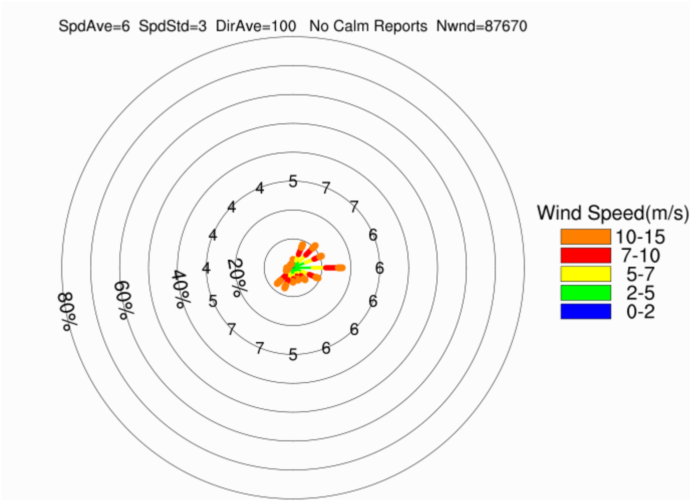


Figure 4 RAMS annual wind rose at 500mPD

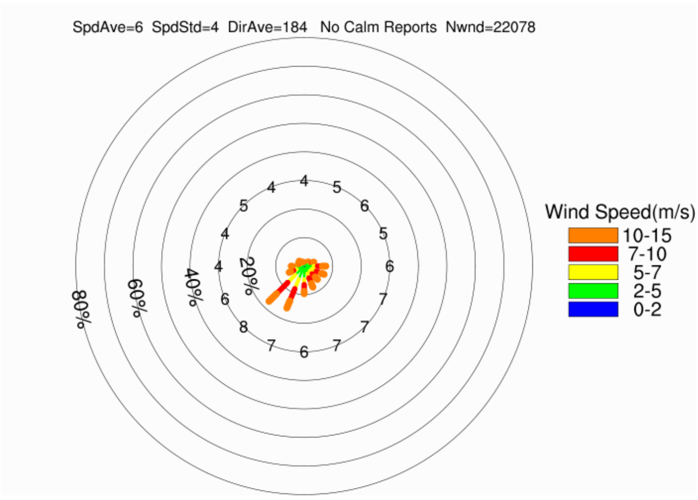


Figure 5 RAMS summer wind rose at 500mPD

3.1 Prevailing Wind Directions

As mentioned above, the RAMS wind data of location grid (x:091, y:063) is adopted for the site wind availability in this study.

3.1.1 Annual Prevailing Wind

Eight prevailing wind directions (highlighted in red colour in Table 1) are considered in this AVA Study which covers 78.4% of the total annual wind frequency. They are north-north-easterly (8.7%), north-easterly (10.9%), east-north-easterly (10.7%), easterly (17.1%), east-south-easterly (9.5%), south-easterly (5.9%), south-south-westerly (7.7%) and south-westerly (7.9%) winds.

Table 1 Annual Wind Frequency

Wind Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	
Frequency	2.9%	8.7%	10.9%	10.7%	17.1%	9.5%	5.9%	4.7%	
Wind Direction	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
Frequency	5.1%	7.7%	7.9%	2.6%	2.2%	1.2%	1.4%	1.5%	78.4%

** The wind frequency showing in red colour represents the selected winds for the CFD simulation.*

3.1.2 Summer Prevailing Wind

Eight prevailing wind directions (highlighted in red colour in Table 2) are considered in this AVA Study which covers 80.5% of the total summer wind frequency. They are easterly (7.8%), east-south-easterly (7.8%), south-easterly (6.8%), south-south-easterly (8.1%), southerly (10%), south-south-westerly (16.3%), south-westerly (18%) and west-south-westerly (5.7%) winds.

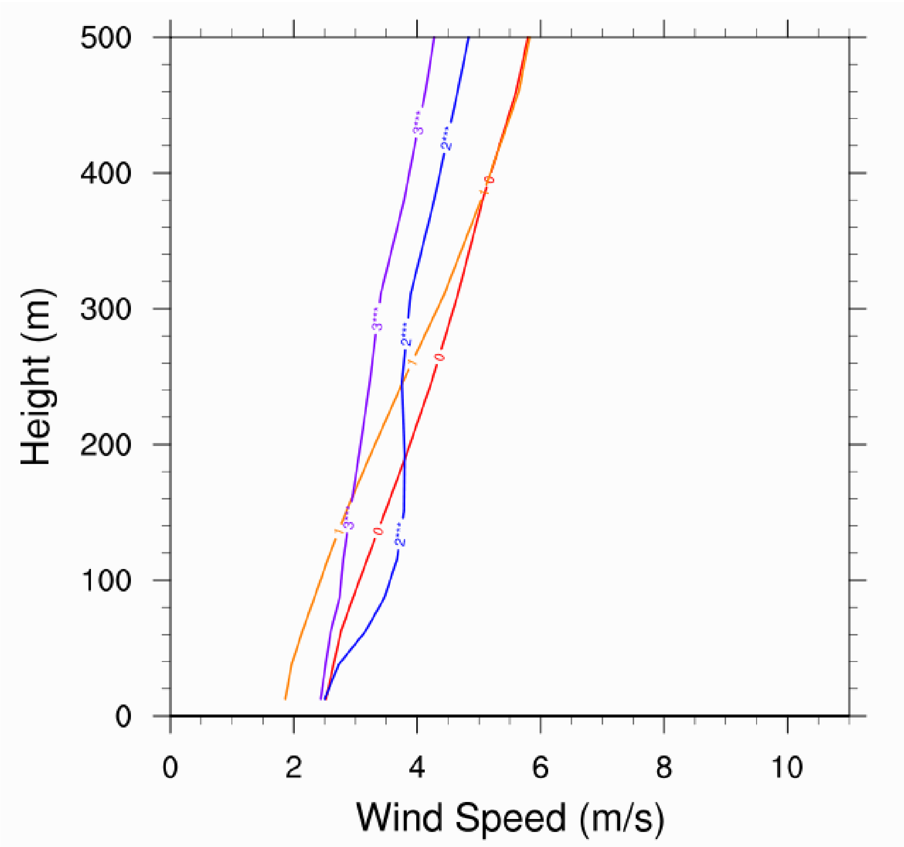
Table 2 Summer Wind Frequency

Wind Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	
Frequency	1.2%	1.4%	2.1%	3.8%	7.8%	7.8%	6.8%	8.1%	
Wind Direction	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
Frequency	10.0%	16.3%	18.0%	5.7%	4.6%	2.3%	2.5%	1.6%	80.5%

** The wind frequency showing in red colour represents the recommended wind direction for the CFD simulation.*

3.2 Wind Profiles

The profiles of wind speed from the RAMS database (x:091, y:063) is studied and extracted. In the RAMS data, the vertical profiles of the normalised mean wind speed were provided, and the exact profile will be modelled in the CFD model for each selected corresponding wind directions. The vertical wind profile for all wind directions to be studied is shown in Figure 6.



0: 22.5º-112.4º

1: 112.5º-202.4º

2: 202.5º-292.4º

3: 292.5º-22.4º

***: <10% total sample size in 2009, i.e. number of samples < 876

Figure 6 Vertical Wind Speed Profile

4 Design Schemes for Initial Study

To investigate the ventilation impacts of the Development and effectiveness of wind enhancement features. Two schemes, the Baseline Scheme and the Proposed Scheme are to be analysed and compared in this AVA Initial Study.

4.1 Baseline Scheme

The Baseline Scheme consists of three blocks; Block A is 43 storeys and 135.4mPD tall and Blocks B and C are both 40 storeys and 122.9mPD tall and 122.85mPD tall respectively. The Baseline scheme includes a number of wind enhancement features:

- ~4m wide empty bay at GF of Block C, shown in Figure 7
- Building separation between Block A and Block B
    - GF: ~24m
    - Typical Floor: ~27m
- Building separation between Block B and Block C
    - GF: ~17m
    - Typical Floor: ~17m
- The car park situated between Block A and Block B is covered – it is permeable, and wind can pass through above and below this roof.
- ~5m wide empty bay at 1F of Block A adjacent to the car park

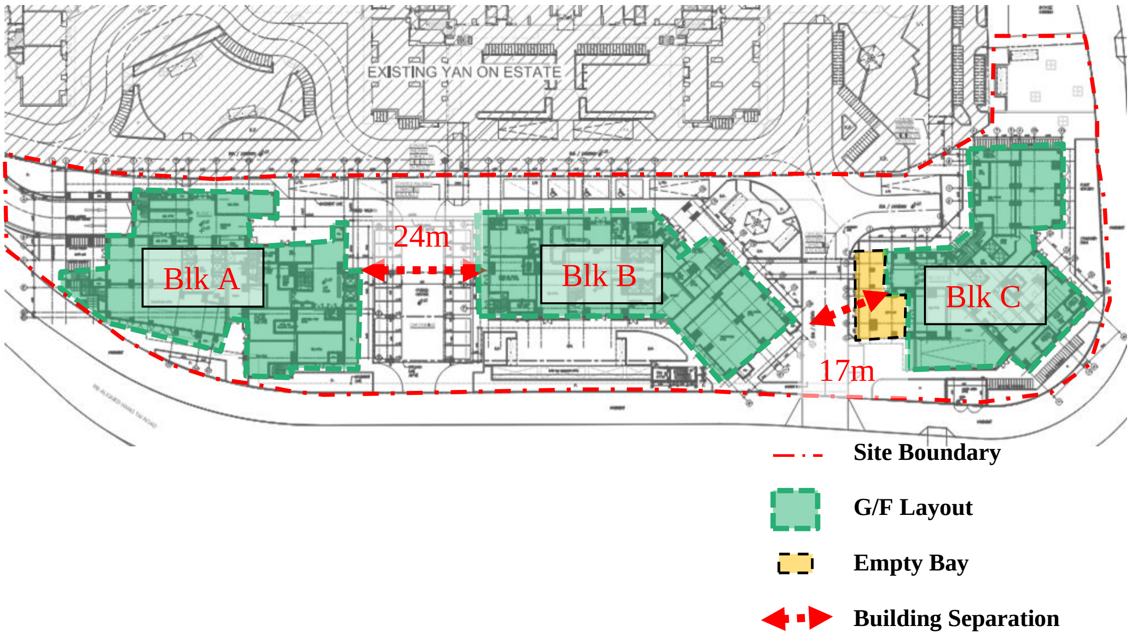


Figure 7 G/F Layout Plan - Baseline Scheme

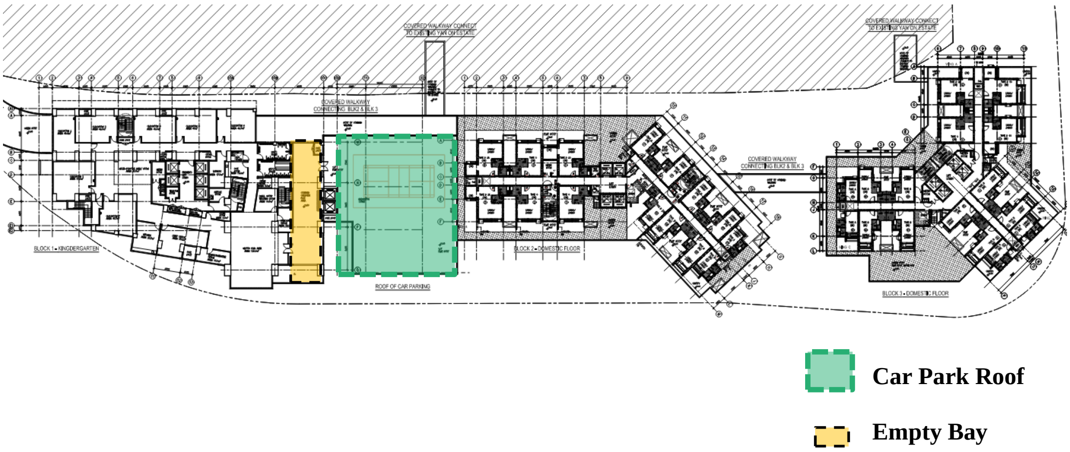


Figure 8 Baseline Scheme - 1F Floor Plan

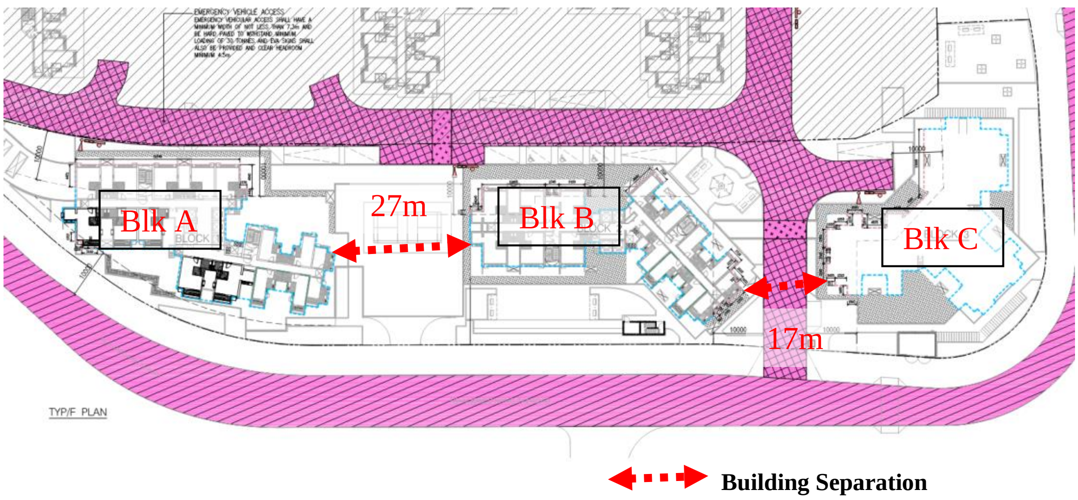


Figure 9 Baseline Scheme – Typical Floor Plan

By referring to the CAD drawings of the Baseline Scheme, the 3D model was constructed as shown in Figure 10 to Figure 13.

Figure 10 Northerly view of Baseline Scheme

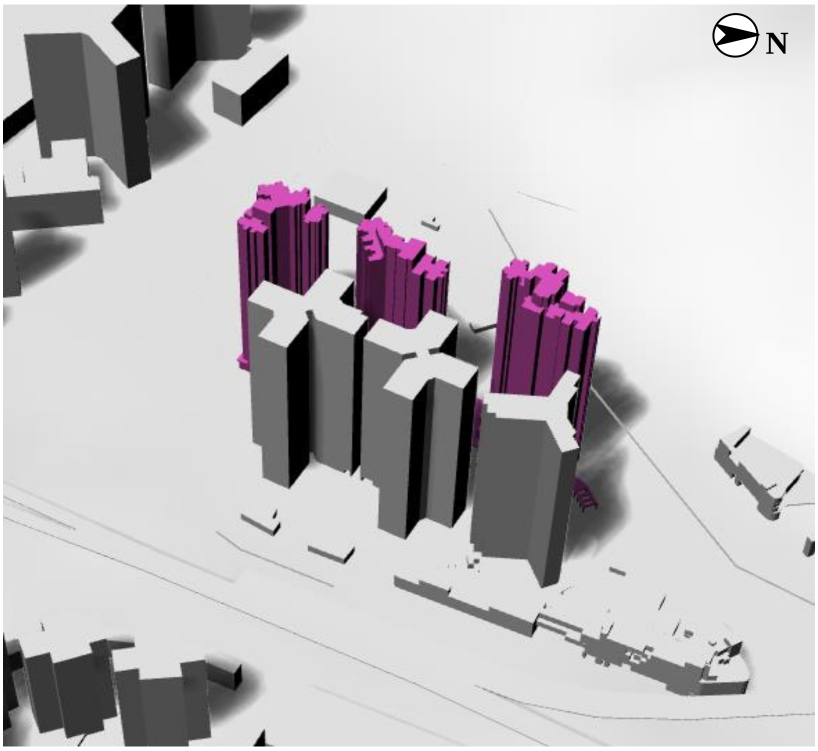


Figure 11 Easterly view of Baseline Scheme

Figure 12 Southerly view of Baseline Scheme

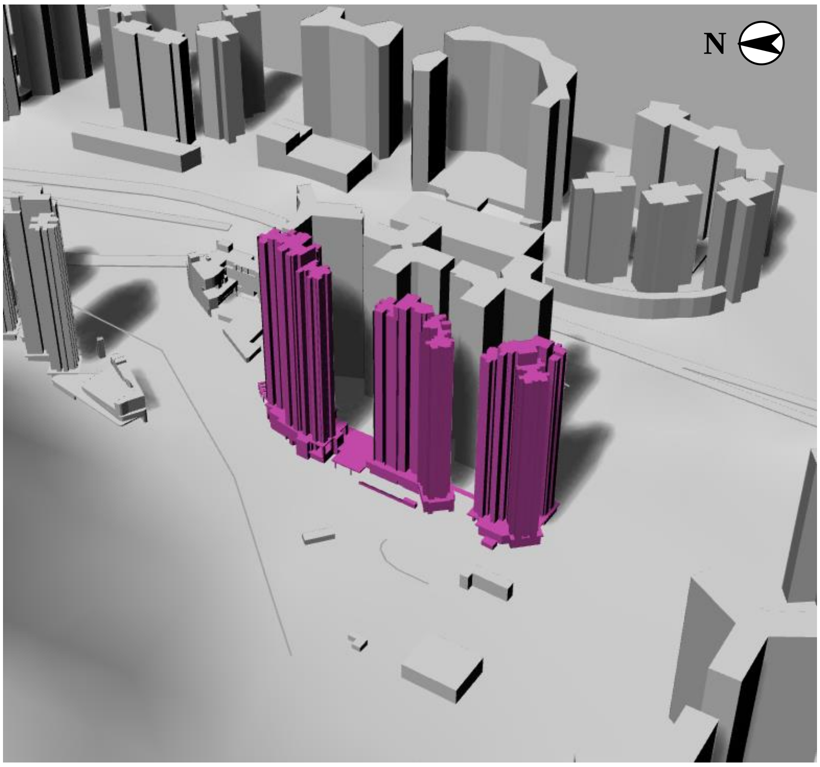


Figure 13 Westerly view of Baseline Scheme

4.2 Proposed Scheme

The Proposed Scheme consists of three blocks; Block A is 134.99mPD tall and has 41 storeys; Blocks B and C are 124.99mPD and 124.64mPD tall respectively having 40 domestic storeys. The Baseline scheme includes a number of wind enhancement features:

- Provide additional 4m wide empty bay at GF of Block B in, shown in Figure 14
- Building separation between Block A and Block B
  - GF: ~24m
  - Typical Floor: ~25m
- Building separation between Block B and Block C
  - GF: ~18m
  - Typical Floor: ~15m
- Increased the permeability of the covered park by removing the central portion of the carpark roof
- Use of scattered doghouses, allowing the removal of smoke vent on the South East side of Block B

The Proposed scheme has, however, removed a number of possible wind enhancement features from the baseline scheme:

- Removal of ~5m wide empty bay at 1F of Block A adjacent to the car park

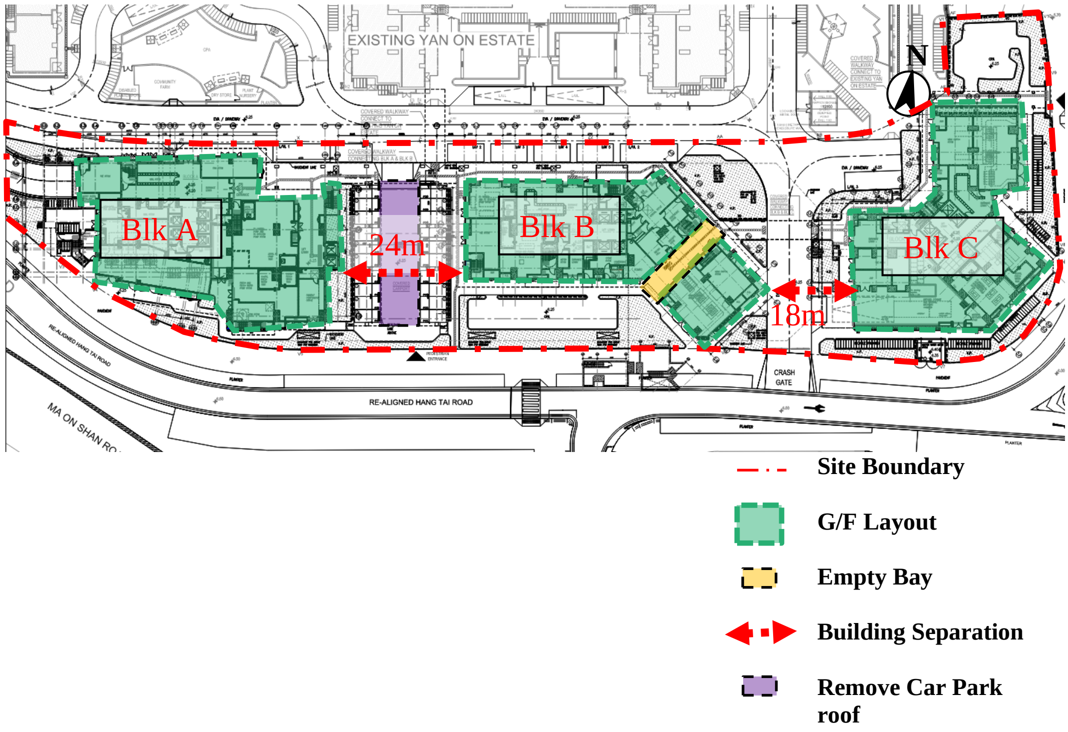


Figure 15 G/F Layout Plan - Proposed Scheme

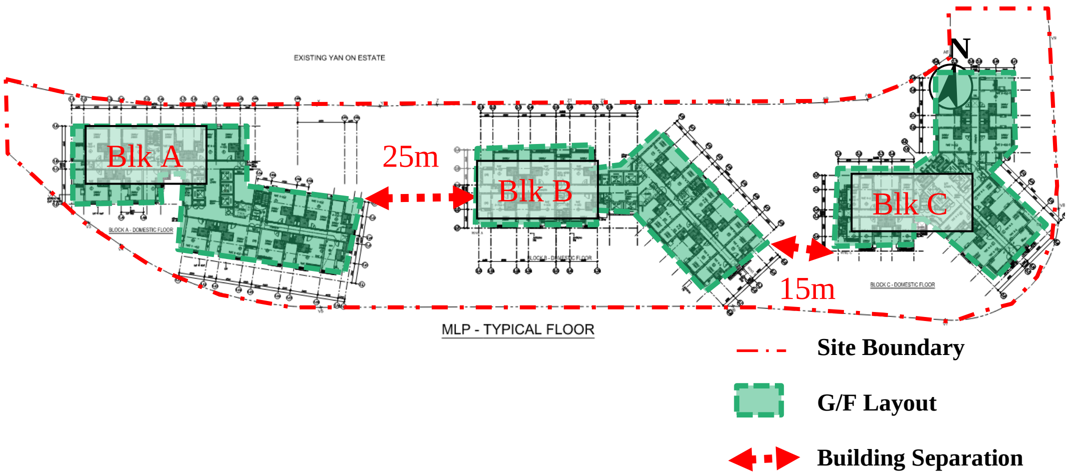


Figure 16 Typical Floor Plan - Proposed Scheme

By referring to the CAD drawings of the Proposed Scheme, the 3D model was constructed as shown in Figure 17 to Figure 20.

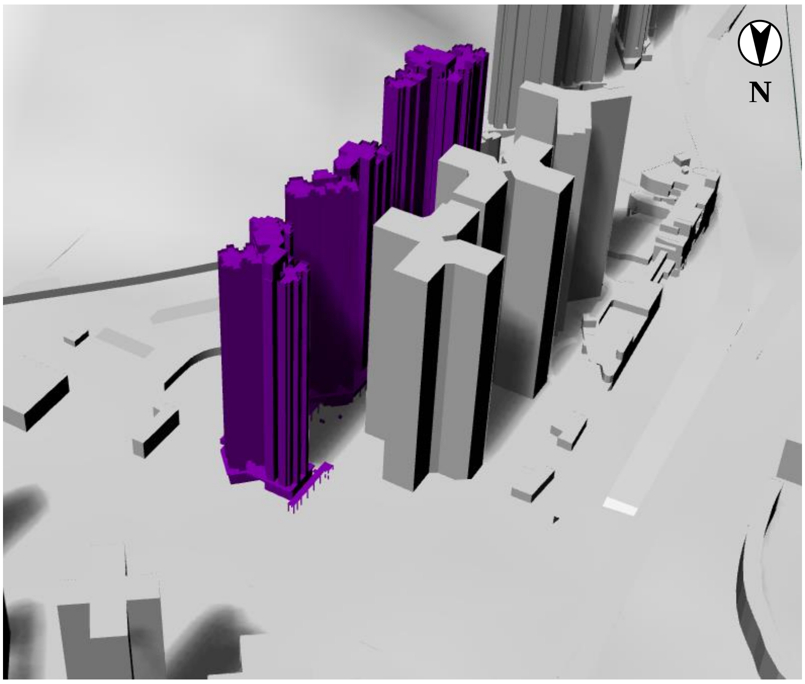


Figure 17 Northerly view of Proposed Scheme

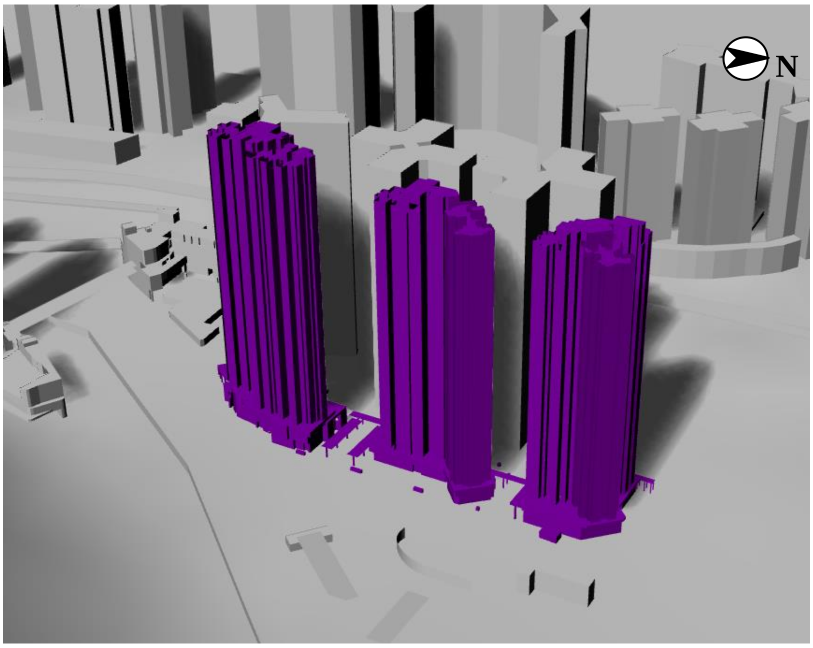


Figure 18 Easterly view of Proposed Scheme

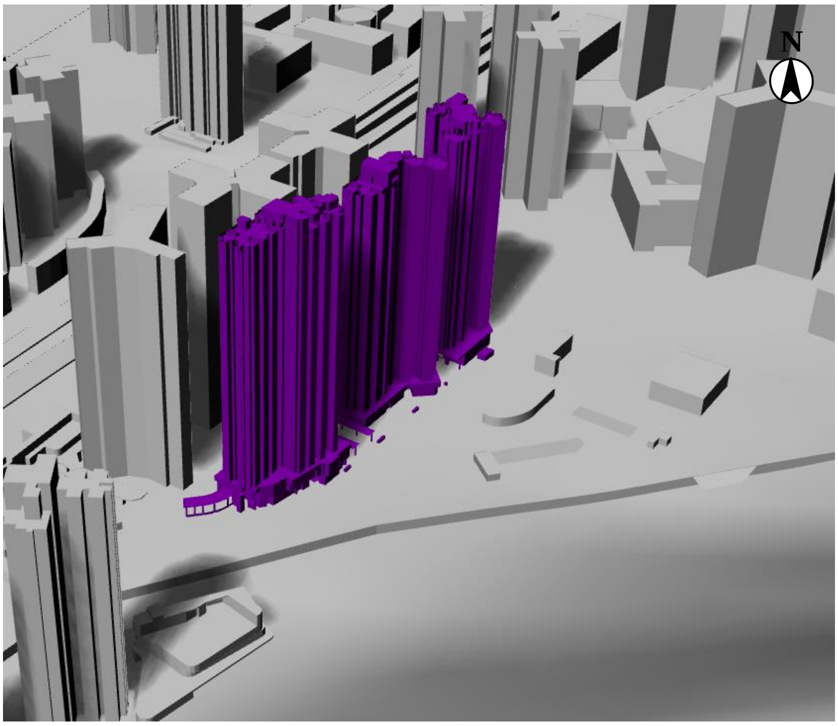


Figure 19 Southerly view of Proposed Scheme

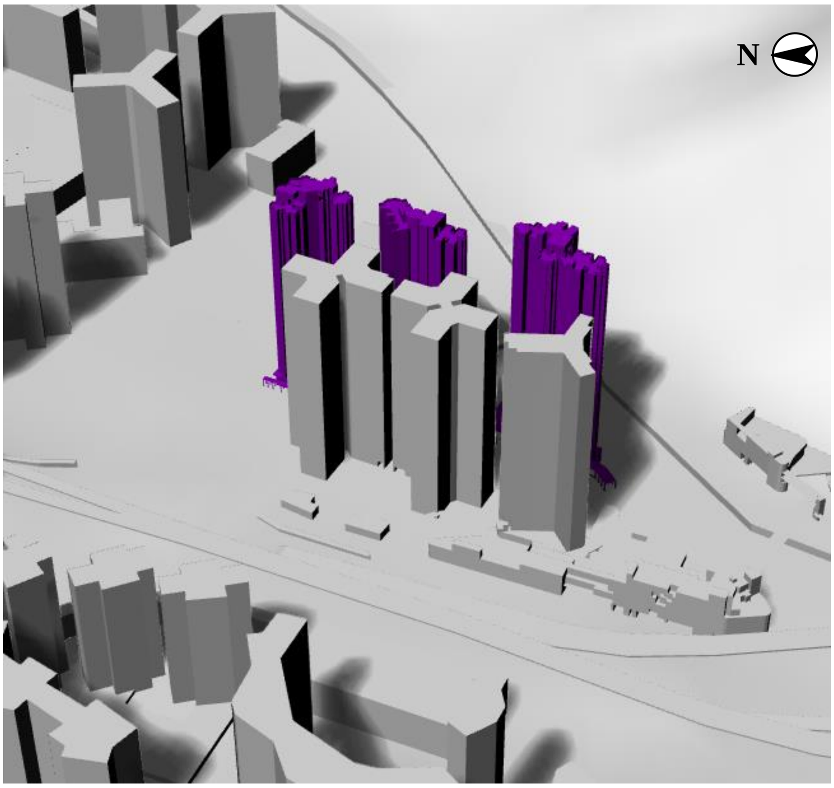


Figure 20 Westerly view of Proposed Scheme

5 Methodology

5.1 Assessment and Surrounding Areas

With the building height of the potential development is around 140m, the Assessment Area and the Surrounding Area are respectively span 140m (1H) and 280m (2H) away from the site boundary of the Study Area. Due to the presence of high-rise buildings e.g. Sausalito and Mountain Shore, the Surrounding Area is slightly extended beyond 2H to include these high-rise buildings. The proposed Assessment Area and the Surrounding Area are indicated as below. The computational domain would be about 3700m (L) x 2900m (W) x 3600m (H) as shown in Figure 21.

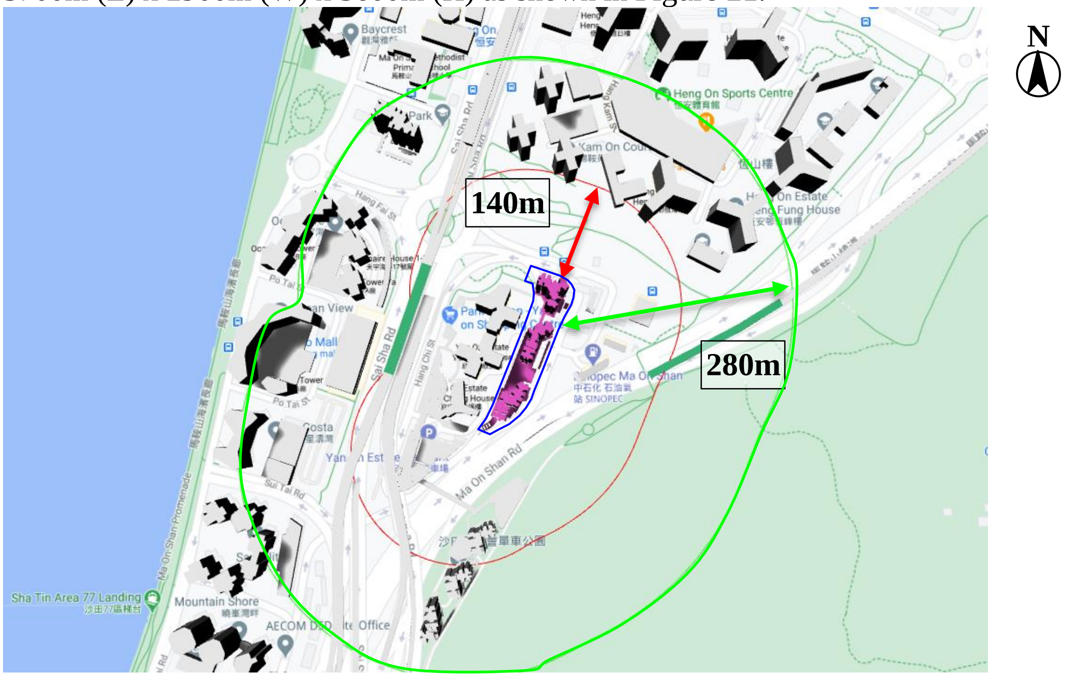


Figure 21 Site boundary (blue), Assessment Area (red) and Surrounding Area (green)

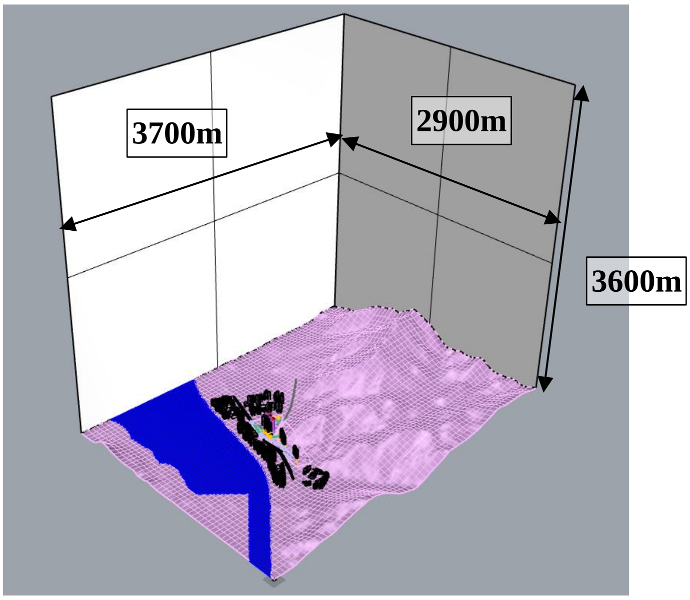


Figure 22 3D View of the Domain

5.2 Technical Details for CFD simulation

5.2.1 Assessment Tools

Computational Fluid Dynamics (CFD) technique is utilized for this AVA study. With the use of three-dimensional CFD method, the local airflow distribution can be visualized in detail. The velocity distribution within the flow domain, being affected by the site-specific design and the nearby topography, will be simulated under selected wind directions as stated in Section 3 for annual and summer wind conditions.

5.2.2 CFD Model

Following the AVA Technical Circular, buildings within Surrounding Area shall be built in the CFD model. In order to simulate the approaching wind turbulence effect in a more accurate manner, the CFD model is built to include the highways or bridges as they may affect the approaching wind, even it is falling outside the Surrounding Area. In addition, the model domain is built far beyond the Surrounding Area as required in the Technical Circular in order to eliminate the boundary effects. Therefore, the studied size of CFD model of the development is approximately 3700m (L) x 2900m (W) x 3600m (H) which contains more than 6,800,000 cells as shown in Figure 23.

The computational domain covers the site of the Development and provides sufficient consideration on surrounding topography. The model contains information of the surrounding buildings and site topography via Geographical Information System (GIS) platform. The site topography would be modelled within the whole computational domain. Body-fitted unstructured grid technique is used to fit the geometry and reflect the complexity of the development geometry. A prism layer of 3m above ground (totally 6 layers and each layer of 0.5m thick, shown in Figure 24 is incorporated in the meshing so as to better capture the approaching wind and wind condition at pedestrian level. A mesh expansion ratio of 1.3 is adopted and the blockage ratio was less than 2%.

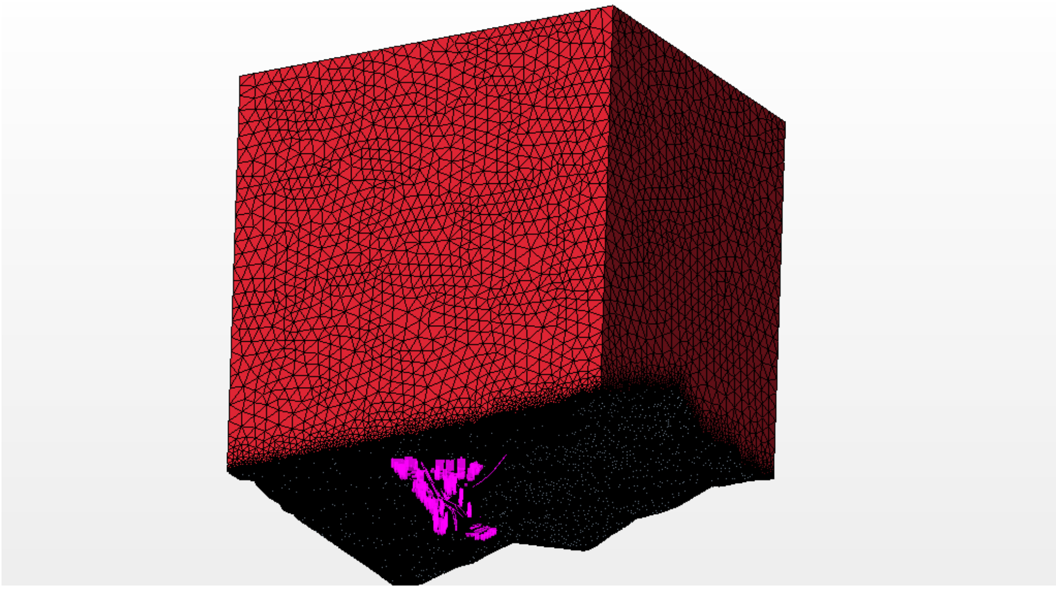


Figure 23 Mesh of Computational Domain

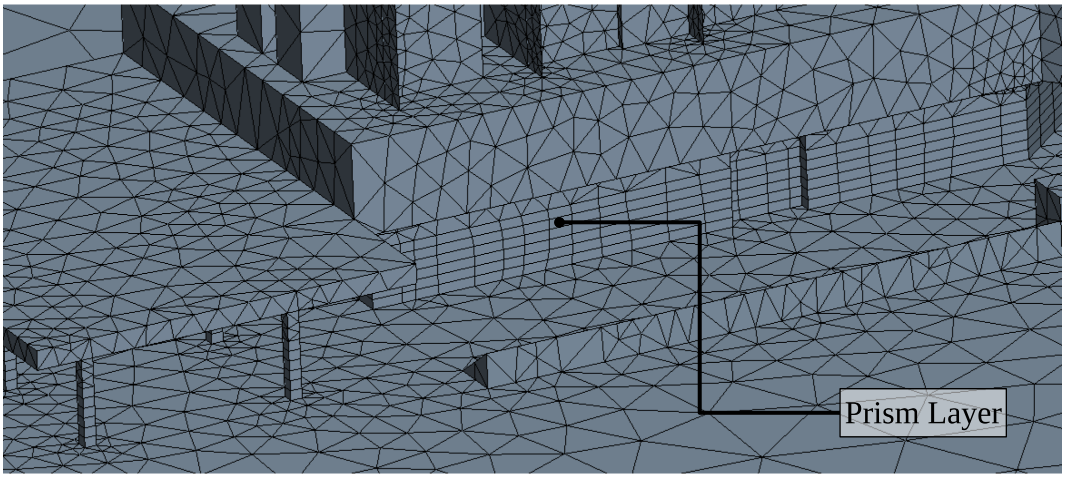


Figure 24 Prism Layers

Table 3 Detail parameters to be adopted in the CFD

	CFD Model
Model Scale	Real Scale model
Model details	Only include Topography, Buildings blocks, Streets/Highways, no landscape is included
Domain	3700m (L) x 2900m (W) x 3600m (H)
Assessment Area	1H area
Surrounding building Area	≥ 2H area
Grid Expansion Ratio	The grid should satisfy the grid resolution requirement with maximum expansion ratio = 1.3
Prismatic layer	6 layer of prismatic layers and 0.5m each (i.e. total 3m above ground)
Inflow boundary Condition	Incoming wind profile as measured from RAMS
Outflow boundary	Pressure boundary condition with dynamic pressure equal to zero
Wall boundary condition	Logarithmic law boundary
Turbulence Model	Realisable k-ε turbulence model
Solving algorithms	Rhie and Chow SIMPLE for momentum equation Hybrid model for all other equations
Blockage ratio	< 2%
Convergence criteria	Below $1.0E^{-4}$

5.3 AVA Indicator

The wind speed information at pedestrian level (2m above ground) will be acquired to determine the Wind Velocity Ratio (*VR*) as stipulated in the *AVA Technical Circular*[1] and as defined as follows:

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

where V_p is the wind speed at the pedestrian height (2m above ground) and V_∞ is the wind velocity at the top of the boundary layer (defined as the height where wind is unaffected by urban roughness and determined by the topographical studies). Measurement will be taken within the Assessment Area.

The Average VR is defined as the weighted average VR with respect to the percentage of occurrence of all considered wind directions. This gives a general idea of the ventilation performance at the considered location at both annual and summer wind condition.

5.3.1 Assessment Parameters

CFD simulations will be conducted to study the wind environment. As specified in the Technical Circular, indicator of ventilation performance should be the Wind Velocity Ratio (VR), defined as the ratio of the wind velocity at the pedestrian level (2m above ground) to the wind velocity at the top of the wind boundary layer. Site spatial average velocity ratio (SVR) and a Local spatial average velocity ratio (LVR) should be determined.

Table 4 Terminology of the AVA Initial

Terminology	Description
Velocity Ratio (VR)	The velocity ratio (VR) represents the ratio of the air velocity at the measurement position to the value at the reference points.
Site spatial average velocity ratio (SVR)	The SVR represent the average VR of all perimeter test points at the site boundary which identified in the report.
Local spatial average velocity ratio (LVR)	The LVR represent the average VR of all points, i.e. perimeter and overall test points at the site boundary which identified in the report.

5.4 Locations of Test Points

As per the technical circular, two types of test points – perimeter test point and overall test point will be adopted to assess the wind performance within the Assessment Area. Special test points are supplemented to assess the effectiveness of the air paths. The allocation of these test points will be distributed evenly as stated in the *AVA Technical Circular* [1].

5.4.1 Perimeter Test Points

A total number of 35 perimeter test points (**Black Spots**), namely P points, are positioned at intervals of around 15m along the project site boundary in accordance with the *AVA Technical Circular*[1]. The locations of perimeter test points are shown in Figure 25.

5.4.2 Overall Test Points

A total number of 114 overall test points (**Red spots**), namely O points, are evenly distributed in open areas within the assessment area, such as the streets and places where pedestrian frequently access. Their locations are shown in Figure 25.

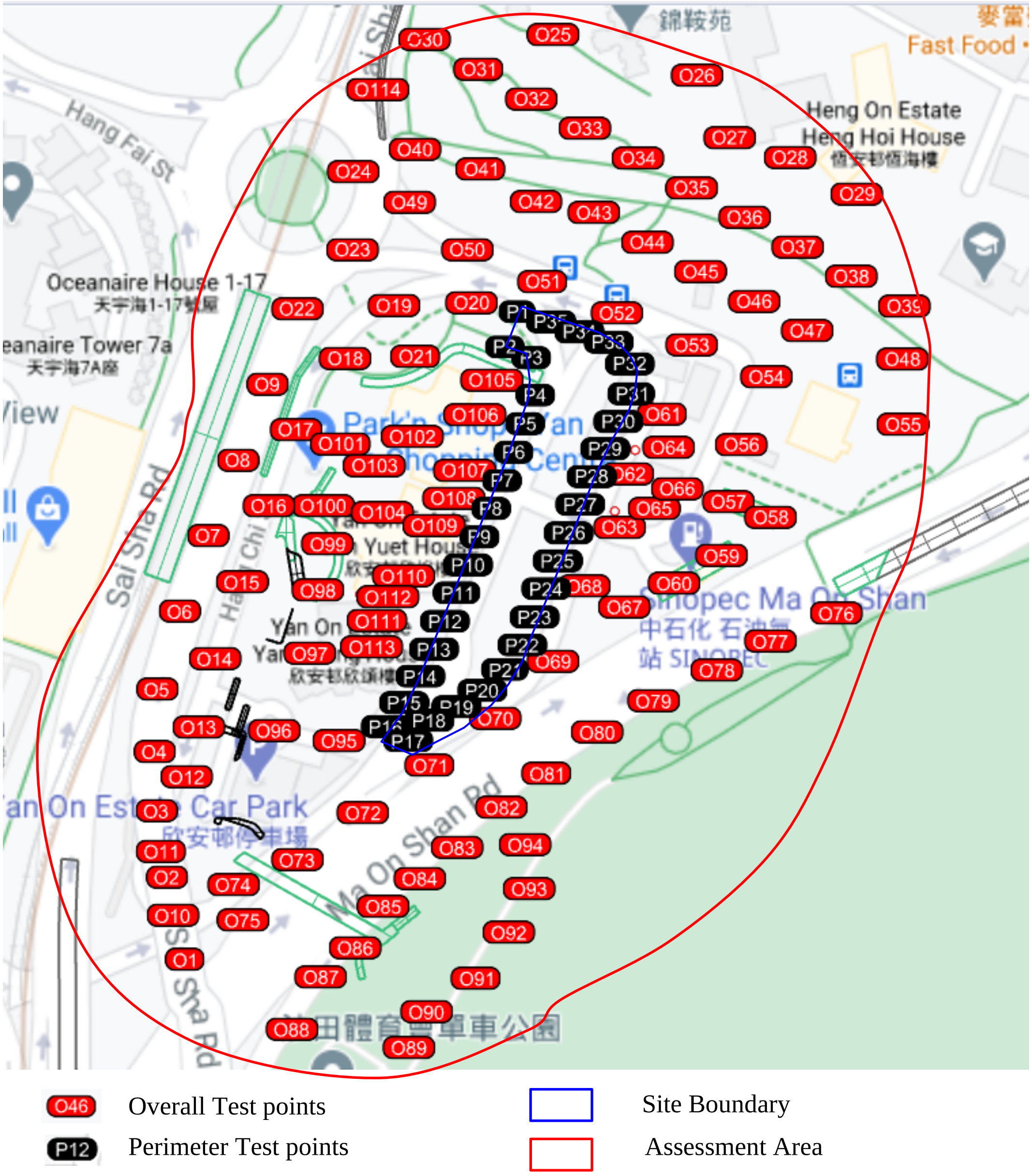


Figure 25 Location of Perimeter and Overall Test Points

5.5 Focus Areas

Within the proposed Assessment Area given in Figure 21, a total of 14 focus areas are proposed within the assessment area. The associated test points for focus areas are tabulated in Table 5. The location of the focus areas area shown in Figure 26.

Table 5 Focus Areas and Corresponding Test Points

	Focus Area	Test Points
P	Perimeter	P1-P35
1	Sai Sha Road (Overpass)	O1-O9
2	Hang Chi Street	O10-O20
3	Sai Sha Road (Ground Level)	O22-O24, O114
4	Kam On Court	O25-O29
5	Hang Fai Street Park	O30-O48
6	Hang Fai Street	O49-O53
7	Ma On Shan Sewage Pumping Station	O54-O56
8	Petrol Station	O57-O60
9	Government Land Allocation	O61-O66
10	Parking Area	O67-O69
11	Hang Tai Road (SE portion)	O70-O75
12	Ma On Shan Road	O76-O88
13	Subsidised Flats De. At Ma On Shan Rd Area 81A	O82-O94
14	Yan On Estate	O21, O95-O113

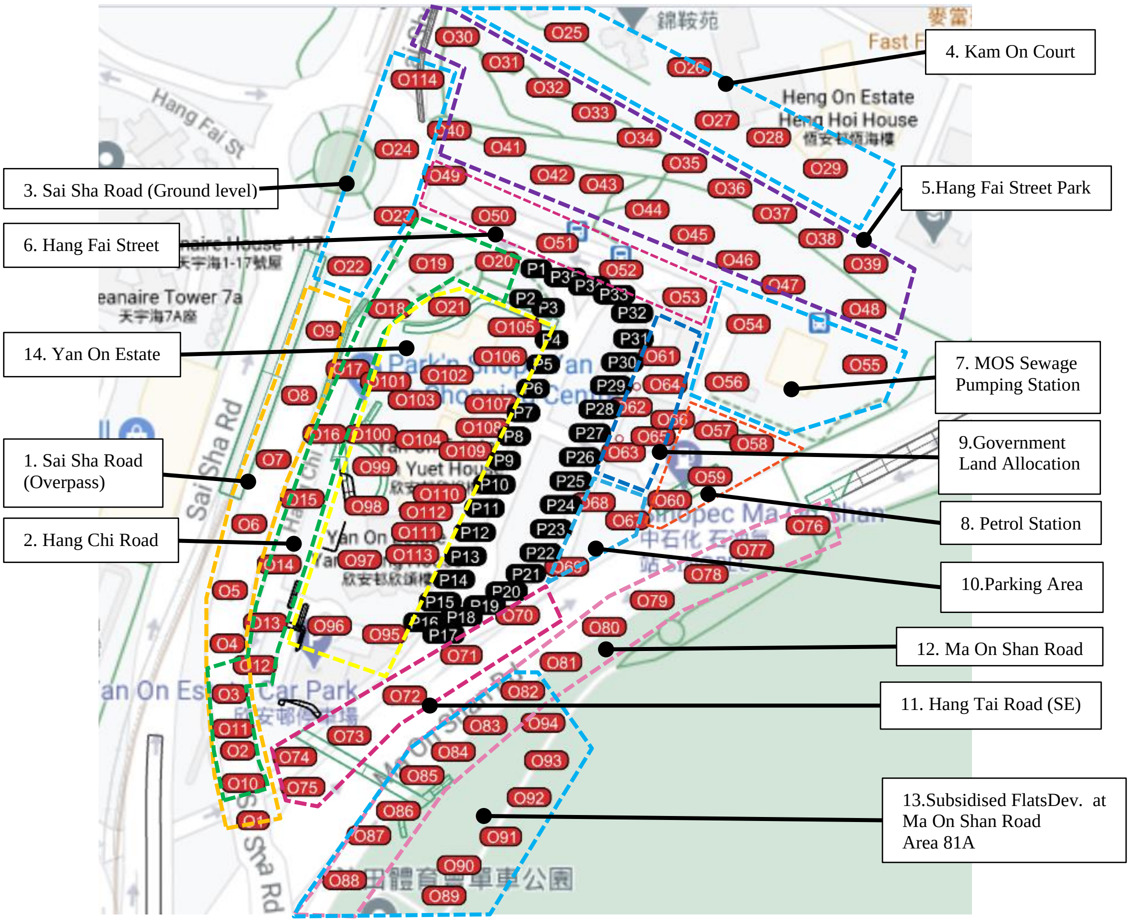


Figure 26 Location of Focus Areas outside the Application Site

6 Results and Discussion

The contour and vector plots for each studied wind directions may refer to Appendix Aof this report.

6.1 Annual Overall Pattern of Ventilation Performance

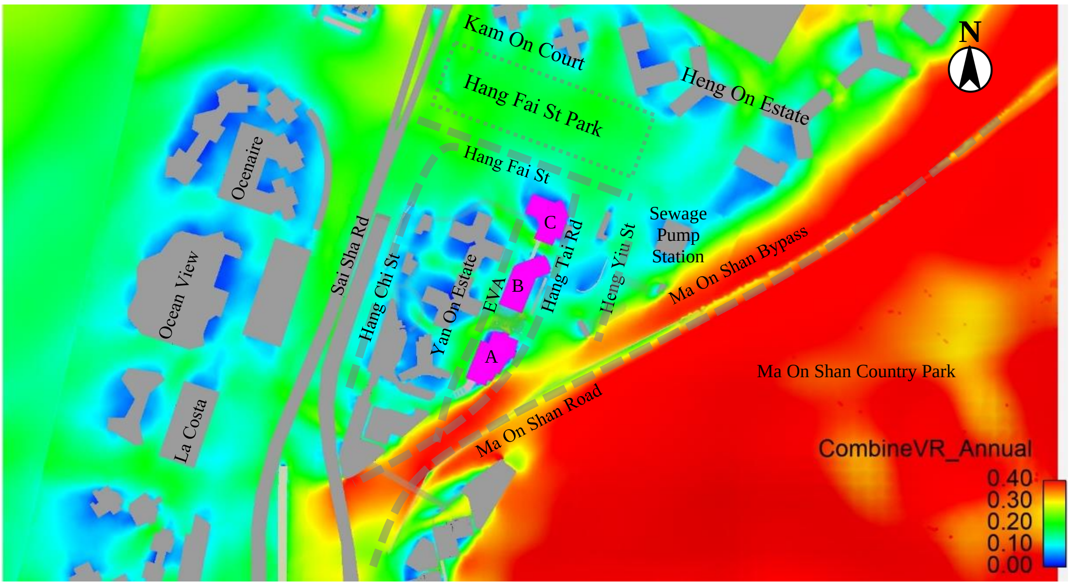


Figure 27 Contour Plot for Annual Weighted Average VR for Baseline Scheme

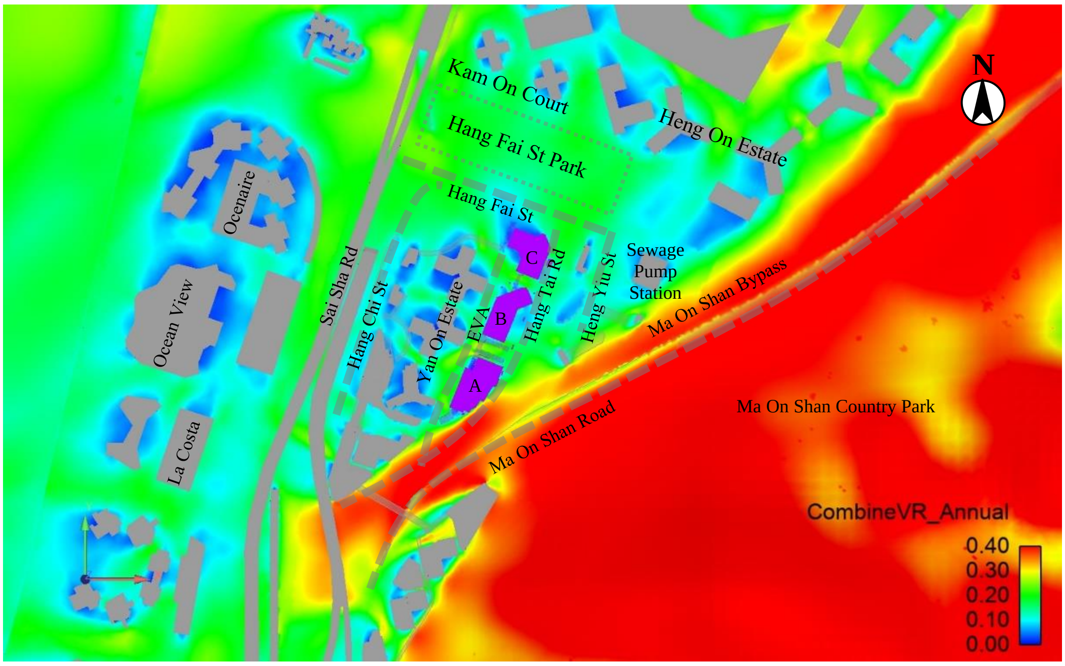


Figure 28 Contour Plot for Annual Weighted Average VR for Proposed Scheme

For the annual condition, eight wind directions were selected, accumulating to 78.4% in occurrence of frequency. The integrated effect of these winds indicates the overall ventilation performance. Annual winds are dominated by the E (17.1%) wind direction. The above contour plots show that:

- The wind mainly approaches from the E wind direction, coming in across Ma On Shan country park which is an area of high elevation to the East, which reduces the strength of wind from this direction;
- The major air paths in the district are along Sai Sha Road and Ma On Shan Bypass to Ma On San Road. These district air paths are not obstructed by the Development, maintaining the performance of prevailing winds channelling in a North Easterly-South Westerly direction along Sai Sha Road and Ma On Shan bypass to Ma On San Road;
- The annual prevailing winds, mostly from the eastern and north-eastern directions would travel along the air path Ma On Shan bypass to Ma On San Road and skim over the open area around Hang Yiu Street and reach the east of the Development;
- The wide building separation is the major contributor to the positive wind environment surrounding the development – most of the annual prevailing wind directions can effectively permeate the development and reach the leeward sides – typically around Yan On Estate and Hang Fai Street Park;
- Southerly prevailing winds reaching the Development would channel along the EVA and Hang Tai Road, Block C would create small wind shadow at the leeward area near Hang Fai Street;
- The overall surrounding wind environment is similar between Baseline and Proposed Scheme under annual condition.

6.2 Summer Overall Pattern of Ventilation Performance

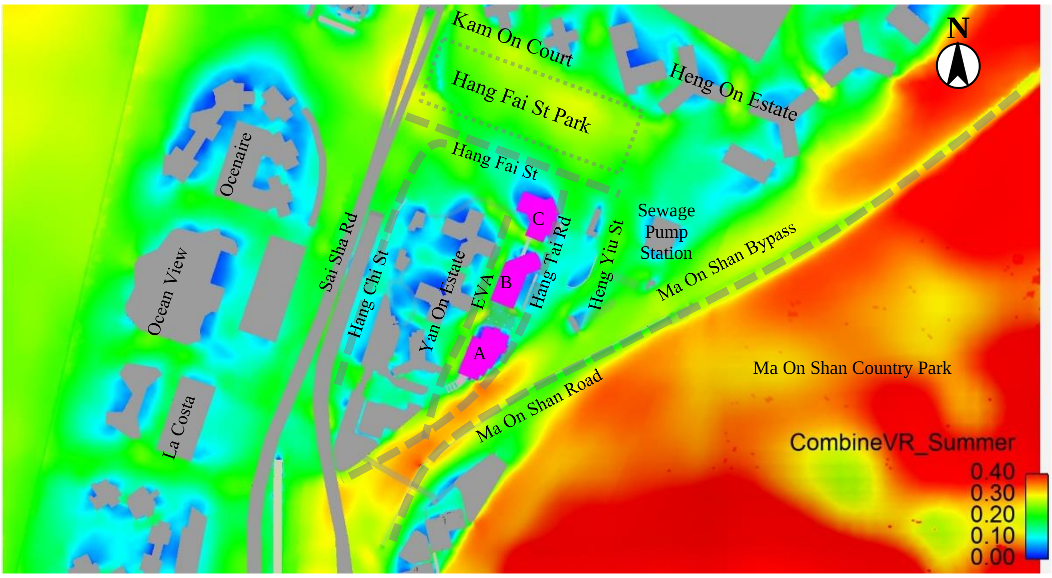


Figure 29 Contour Plot for Summer Weighted Average VR for Baseline Scheme

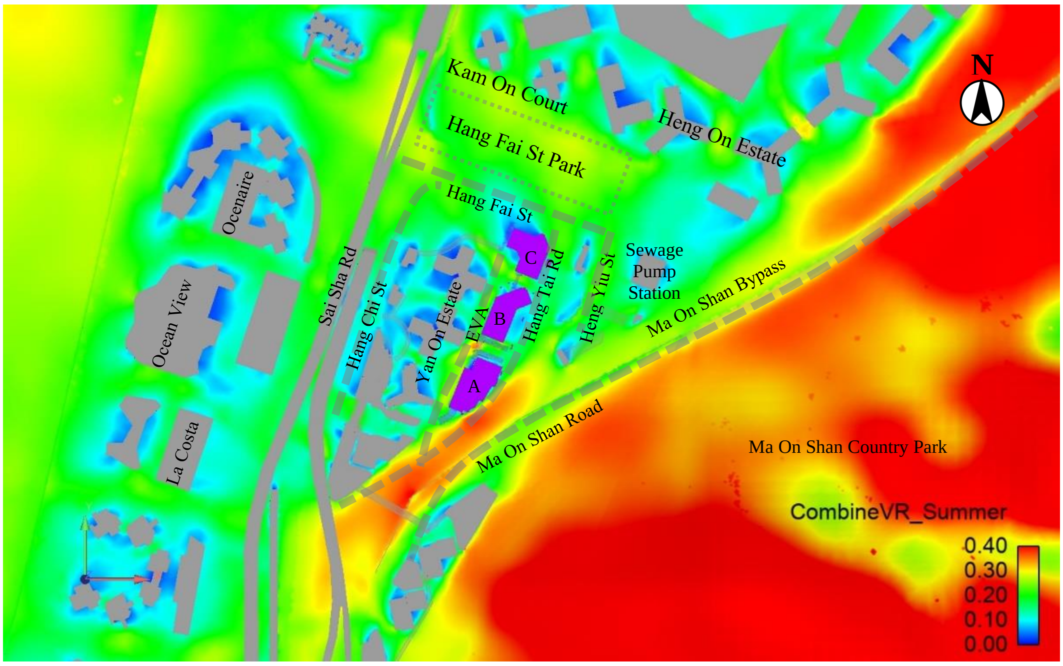


Figure 30 Contour Plot for Summer Weighted Average VR for Proposed Scheme

For the summer condition, eight wind directions were selected, accumulating to 80.5% in occurrence of frequency. The integrated effect of these winds indicates the overall ventilation performance. Summer winds are dominated by SSW (16.3%) and SW (18%) directions. The above contour plots show that:

- The wind mainly approaches from the South and South Eastern directions because it's redirected by the surrounding topography and developments. It reaches the development from two major areas:
    - along the Southern section of Hang Tai Road and Ma On Shan Road
    - from the South Eastern area of Ma On Shan country park, passing over the Ma On Shan Bypass and interacting with the Eastern side of the development;
- The major air paths in the district are along Sai Sha Road and Ma On Shan Bypass to Ma On San Road. These district air paths are not obstructed by the Development, maintaining the performance of prevailing winds channelling in a North Easterly-South Westerly direction along Sai Sha Road and Ma On Shan bypass to Ma On San Road;
- The wide building separation is the major contributor to the positive wind environment surrounding the development – a portion of the summer prevailing wind can effectively permeate the development and reach the leeward sides, e.g. Yan On Estate;
- Southerly prevailing winds reaching the Development would be diverted by Block A and then channel along the EVA and Hang Tai Road, Block C would create small wind shadow at the leeward area near Hang Fai Street;
- The overall surrounding wind environment is similar between Baseline and Proposed Scheme under annual condition.

6.3 Directional Analysis

6.3.1 NNE/NE Wind Direction

The contour plots of VR value for Baseline Scheme and Proposed Scheme are shown in Figure 31 and Figure 32 respectively.

Under NNE/NE wind, the incoming wind travels predominantly along the north section of Sai Sha Road, approaching the development from Hang Fai Street Park. This major wind stream is split into a few smaller wind streams that reach the Development at different directions. The first wind stream is deflected east by the northern side of Block C of the development along Hang Fai Street, improving the wind environment along Hang Fai Street and inside Hang Fai Street Park (**black arrow)**.

The second wind path enters the development through the gap created by the building separation between Block B and Block C where it passes through to the petrol station on the leeward side (red arrow), mitigating the ventilation impact in around Hang Yiu Street.

The final wind stream travels south along Hang Chi Street where it is deflected by the Yan On Estate building towers to reach the west facades of Blocks A and B of the Development.

The second major wind path along district air path Ma On Shan bypass and Ma On San Road. The strong NE-SW channelling effect of the district air path has channelled most NNE/NE prevailing wind towards the SW direction, instead of towards the Development, thus this portion of NNE/NE wind has less significant interaction with the development.

Baseline Scheme

As the incoming wind reaches the development, the second wind stream that passes between Block A and Block B, under the covered car park, is slightly reduced by the carpark roof cover (**red circle).**

Proposed Scheme

As the incoming wind reaches the development, the second wind stream that passes between Block A and Block B, under the covered car park, is slightly enhanced by the removal of the central section of the car park roof, slightly enhances the ventilation in the leeward area in the vicinity e.g. Parking Area at the east of the Development, however, the overall effect is relatively small (**red circle).**

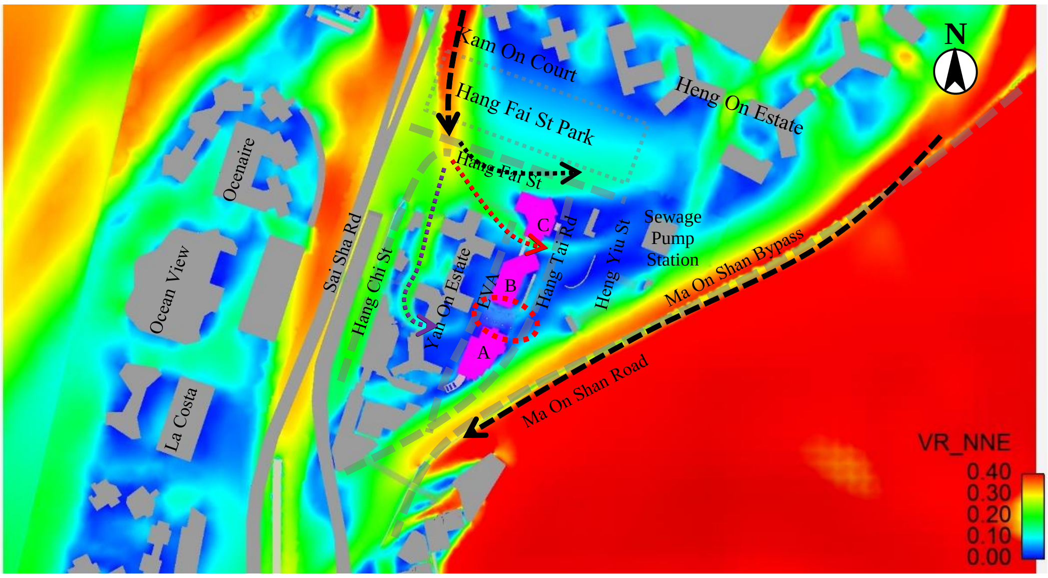


Figure 31 Contour Plot of VR for Baseline Scheme under NNE Wind

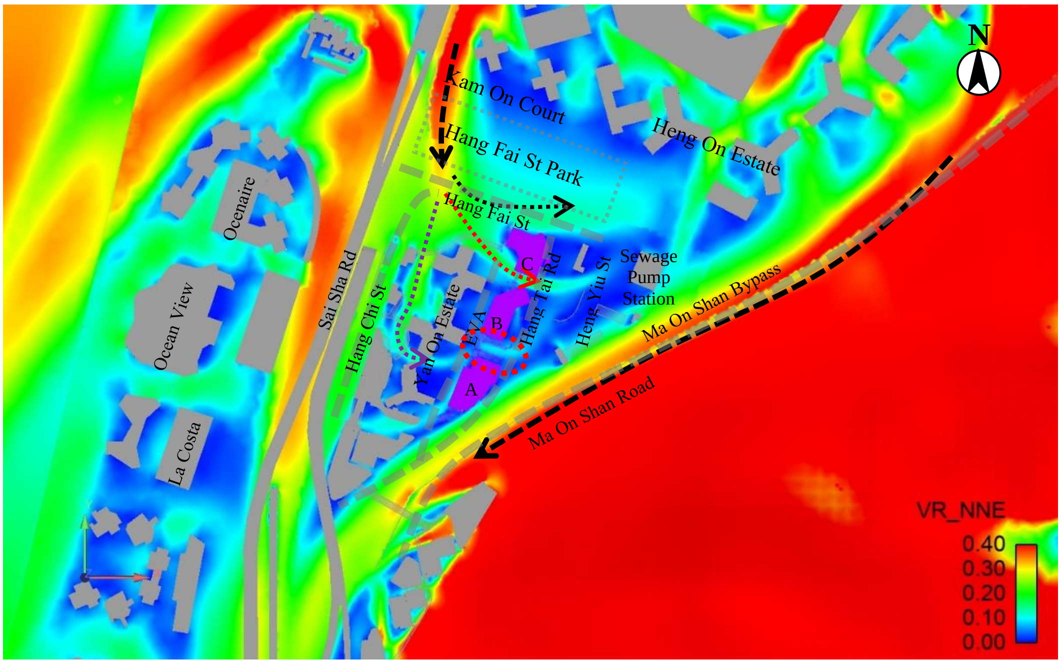


Figure 32 Contour Plot of VR for Proposed Scheme under NNE Wind

6.3.2 ENE/E/ESE Wind Direction

The contour plots of VR value for Baseline Scheme and Proposed Scheme are shown in Figure 34 and Figure 33 respectively.

The area to the east of the development consists of the Ma On Shan country park which slow down the wind approaching the development. Therefore, under ENE/E/ESE winds, the incoming wind follows the major district air path of Ma On Shan Bypass to Ma On Shan Road.

The wind from Ma On Shan Bypass is partially blocked by structures to the east of the development such as the Sewage Pump Station. Despite this, it passes across Heng Yiu Street and Hang Tai Road. A porting of the incoming wind is deflected North by the East face of Block C, reaching the eastern end of Hang Fai Street and improving the wind environment in this area (**black arrow**).

Parallel wind paths created through building separation between Blocks A, B and C. Between Block B and C, the large G/F separation allows the wind to penetrate towards the north side of Yan On Estate and the western end of Hang Fai Street (red arrow). Between Block A and Block B, the G/F building separation allows the wind to penetrate through to the EVA. This wind stream continues through to the Yan On Estate, enhancing the wind environment at southern porting of Yan On Estate (purple arrow).

Finally, there is slight downwashing onto the southern section of Hang Tai Road by Block A of the development. This downwash wind would enhance the wind environment around part of Ma On Shan Road near south of Block A (**black circle**).

Baseline Scheme

The wide building separation allow the wind to permeate through the development because the gaps between each Block align with the direction of the approaching wind. The leeward side of the development has a relatively good wind environment despite the high-density of buildings in this area.

Proposed Scheme

The ventilation performance of Proposed scheme is very similar to the Baseline Scheme.

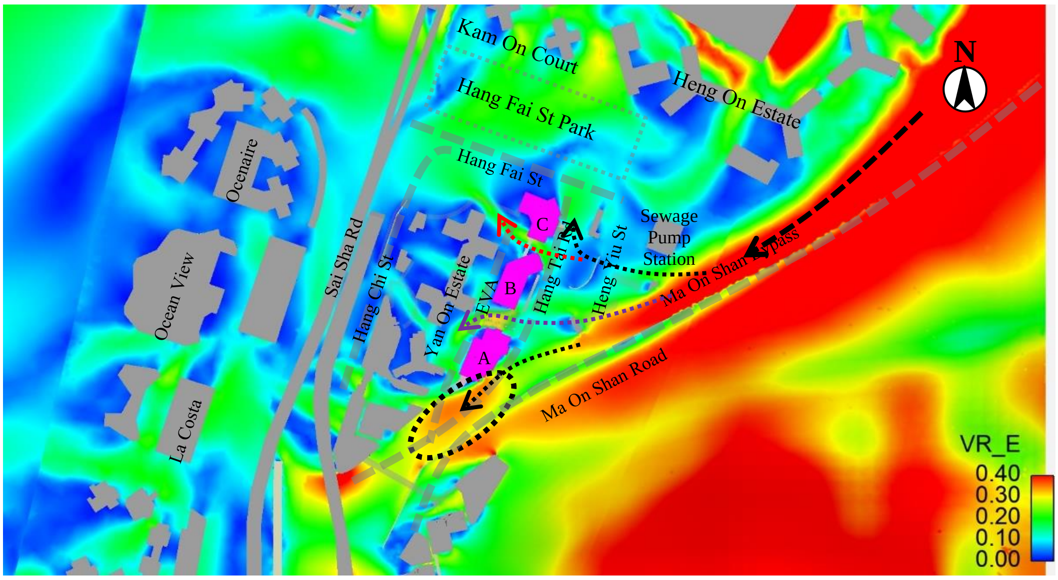


Figure 34 Contour Plot of VR for Baseline Scheme under E Wind

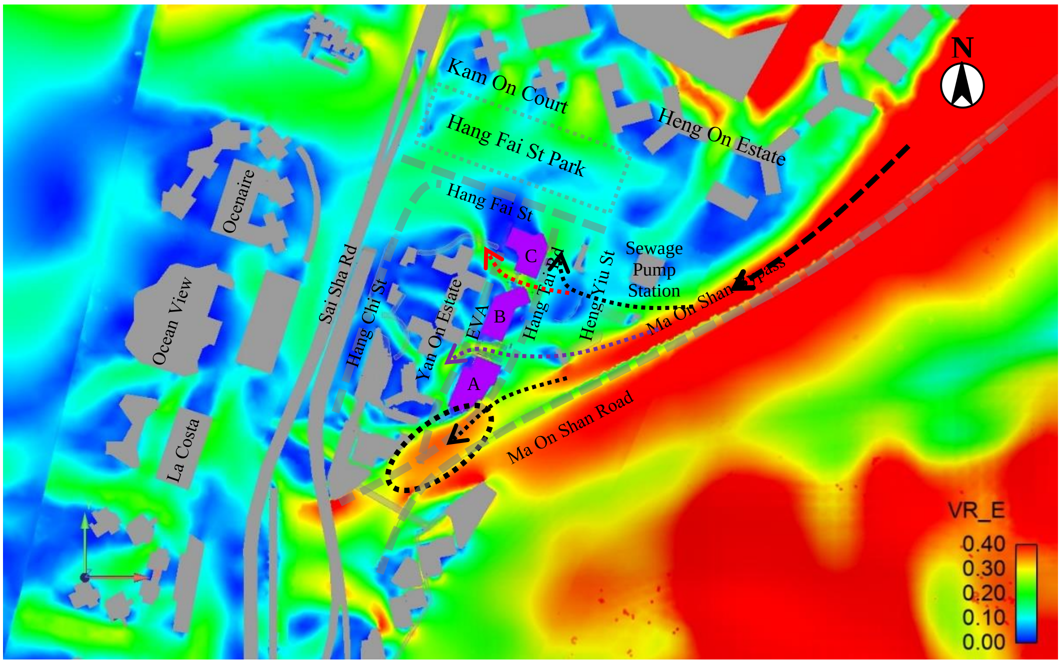


Figure 35 Contour Plot of VR for Proposed Scheme under E Wind

6.3.3 SE/SSE Wind Direction

The contour plots of VR value for Baseline Scheme and Proposed Scheme are shown in Figure 37 and Figure 36 respectively.

Under the SE/SSE wind condition, the wind approaches mostly from the Ma On Shan Country Park to the South East of the development. A small portion of the prevailing wind interacts with the Ma On Shan Bypass and Ma On Shan Road at a low level, but a vast majority of the wind reach the Development at a higher level, where the prevailing would then downwash by the SE face of Block A (**black circle**). The wind downwash to the Hang Tai Road then further travel towards the South Western portion of Ma On Shan Road (purple arrow). Another portion travels west along the south side of Yan On Estate, reaching Sai Sha Road (green arrow).

The major portion of the prevailing wind travels North along the Eastern face of the development – it then penetrate through the development because of the large building separations provided between Block A and B and between Block B and C (**black arrows**) to the leeward area of Yan On Estate and Hang Fai Street. A portion of the incoming wind would be diverted by Block C to reach Hang Fai Street Park and Kam On Court on the leeward side of the development.

Baseline Scheme

Building separation between Block A and B and between Block B and C allows the wind to permeate through the development, reaching Yan On Estate and providing a good wind environment in this area.

Proposed Scheme

In the Proposed scheme, the 4m wide empty bay at the GF of Block B, oriented in a North West-South East direction allows this wind to penetrate directly through the development to the leeward side of the development (red arrow). This enhances the wind environment around Hang Fai Street by increasing the volume of wind that can effectively reach this area (red circle).

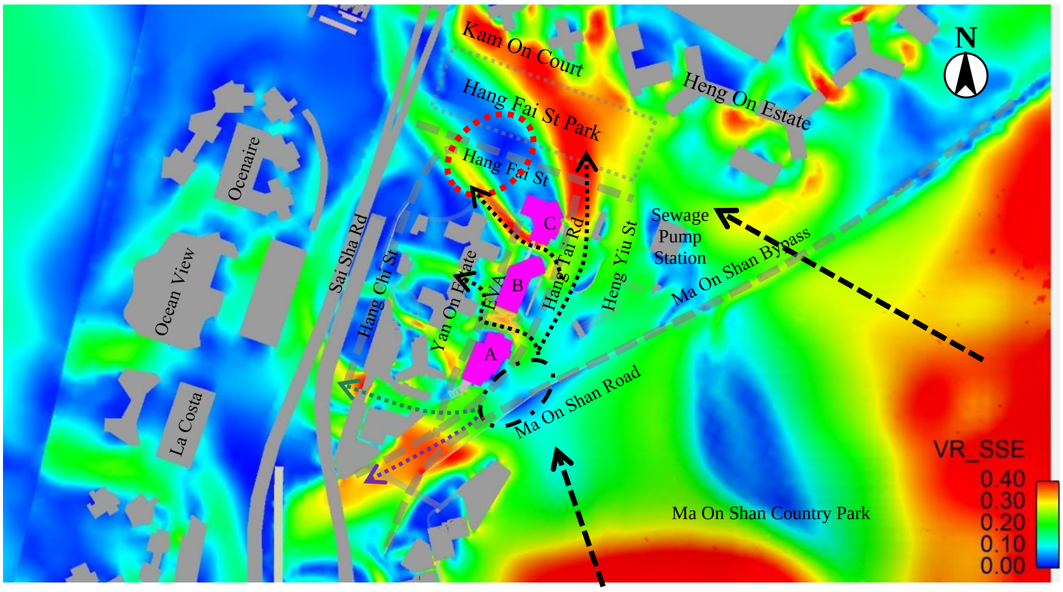


Figure 37 Contour Plot of VR for Baseline Scheme under SSE Wind

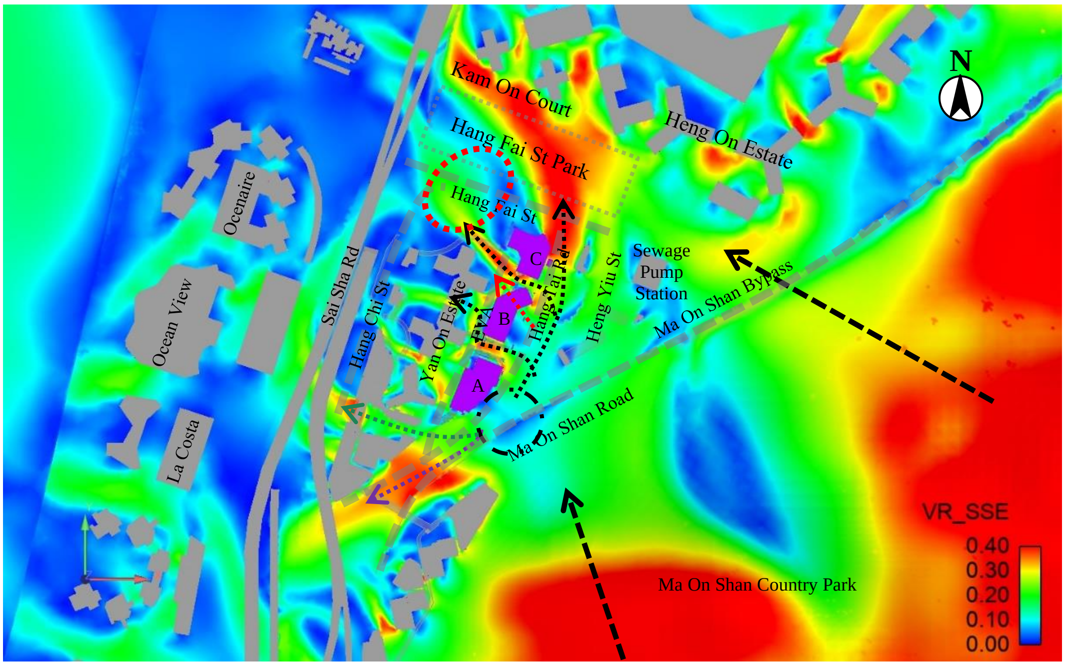


Figure 38 Contour Plot of VR for Proposed Scheme under SSE Wind

6.3.4 S/SSW Wind Direction

The contour plots of VR value for Baseline Scheme and Proposed Scheme are shown in Figure 39 and Figure 40 for SSW wind.

Under the S/SSW wind condition, the major portion of the prevailing wind travels from the Ma On Shan Country park area to the East of the development. It is slightly deflected by the Subsidised Flat Development at Ma On Shan Road. At the Development, the high level incoming wind is downwashed by the SE facade of Block A onto Hang Tai Road (**black circle)**.

A portion of the downwashed wind at Hang Tai Road would further travels towards the South section of Yan On Estate (red arrow). The major portion of the downwash wind would travel North along the Eastern facades of the development where it penetrates through the development. The first wind path between Block A and Block B allows wind to permeate through to the EVA, passing through the gaps in Yan On Estate to Heng Chi Street (purple arrows). The second wind portion travels between Block B and Block C due to the building separation , reaching Hang Fai Street and rejoining the major wind stream along Sai Sha Road (orange arrow). Enhancing the wind environment in the aforementioned areas.

Another wind stream distributed from Ma On Shan Bypass approaches Block C in a more Easterly direction as it is redirected by the Sewage Pumping Station at ground level. This is deflected North by Block C to wards Hang Fai Street Park, facilitating a good wind environment at Hang Fai Street Park (**thin black arrow)**.

Baseline Scheme

Building separation between Block A and B and between Block B and C allows the wind to permeate through the development, reaching Yan On Estate and providing a good wind environment in this area.

Proposed Scheme

In the Proposed Scheme, larger portion of downwash wind by Block A would penetrate through Block A and Block B through the covered car park, due to the removal of the central section of the car park roof. This would slightly enhances the ventilation in the leeward area in the vicinity e.g. Yan On Estate at the west of the Development, however, the overall effect is relatively small (purple arrows**).**

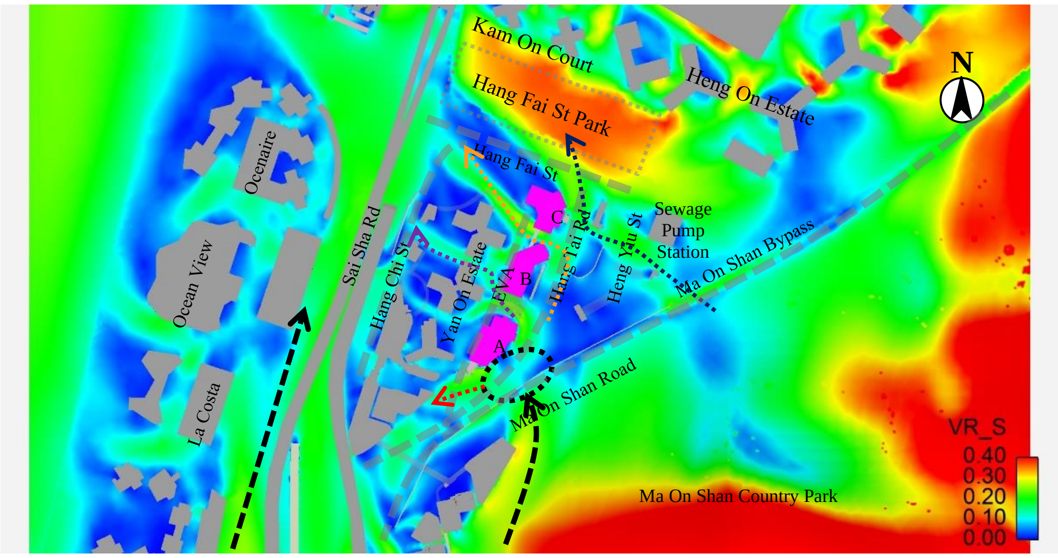


Figure 39 Contour Plot of VR for Baseline Scheme under S Wind

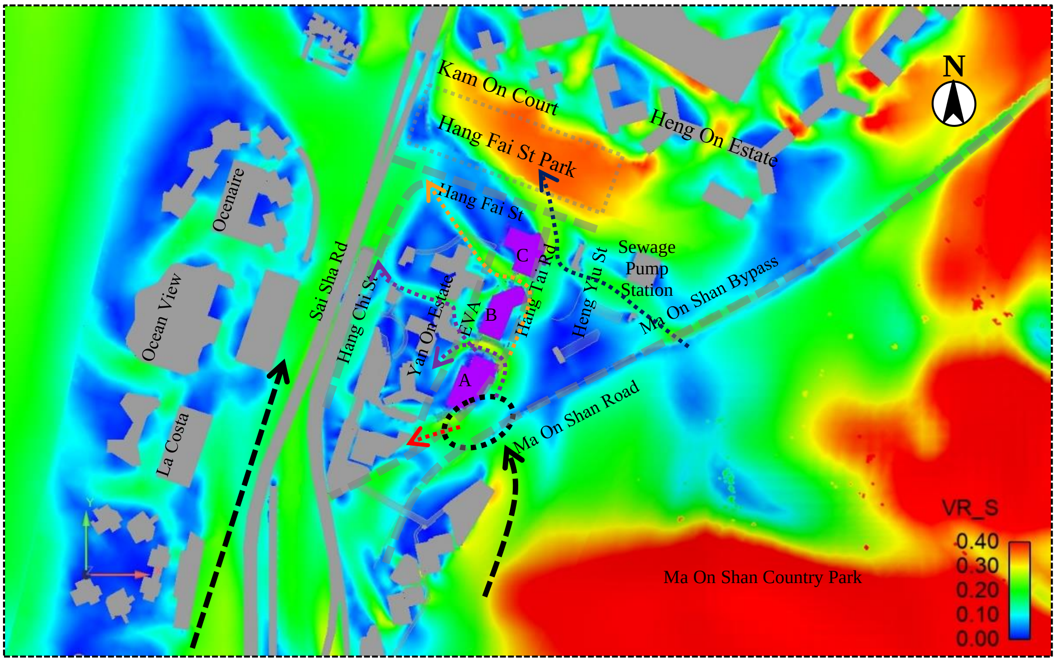


Figure 40 Contour Plot of VR for Proposed Scheme under S Wind

6.3.5 SW/WSW Wind

The contour plots of VR value for Baseline Scheme and Proposed Scheme are shown in Figure 39and Figure 40 for SW wind.

Under the SW/WSW wind condition, due to the surrounding topography – the relatively flat Tolo harbour and the mountainous Ma On Shan, as well as developments along the harbourfront, two major wind paths converge on the development from nearly opposite directions.

Redirected by developments at the North West such as the Subsidised Sale Flats Development at Hang Kin Street, The SW/WSW incoming wind from the Tolo Harbour would approaches from Sai Sha Road and Hang Fai Street Park towards the North West of the Development. Here it passes through the gap between Block C and Yan On Estate, and then through the gap created by the building separation between Block B and C (white arrow).

The second portion of SW/WSW incoming wind approaches from a Southerly direction along Ma On Shan Road then to Hang Tai Road. The wind stream then splited by Block A into two streams – one stream travels along the EVA and passes through the gap between Block A and B (pink arrow). Another stream travel along Hang Tai Road where it would finally join with the the wind from the North West and continue to travel towards to the NW direction such as the Sewage Pumping station on the leeward side (grey arrow).

Baseline Case

The wider empty bay at the G/F of Block C allows more wind to penetrate through the gap between Blocks B and C, improving the wind environment around the Sewage Treatment plant (**black circle**).

Proposed Case

The widened empty bay at G/F and the removal of the Smoke Vent at the South East corner of Block B allows the wind that approaches from the North West to permeate through the development, improving the wind environment very close to the development and also portion of Hang Tai Road (white circle). This has a slight negative effect around the Sewage Treatment station because this North Westerly wind slightly effects wind coming from a Southerly direction, reducing the extend of its penetration towards Heng On Estate (**black circle)**.

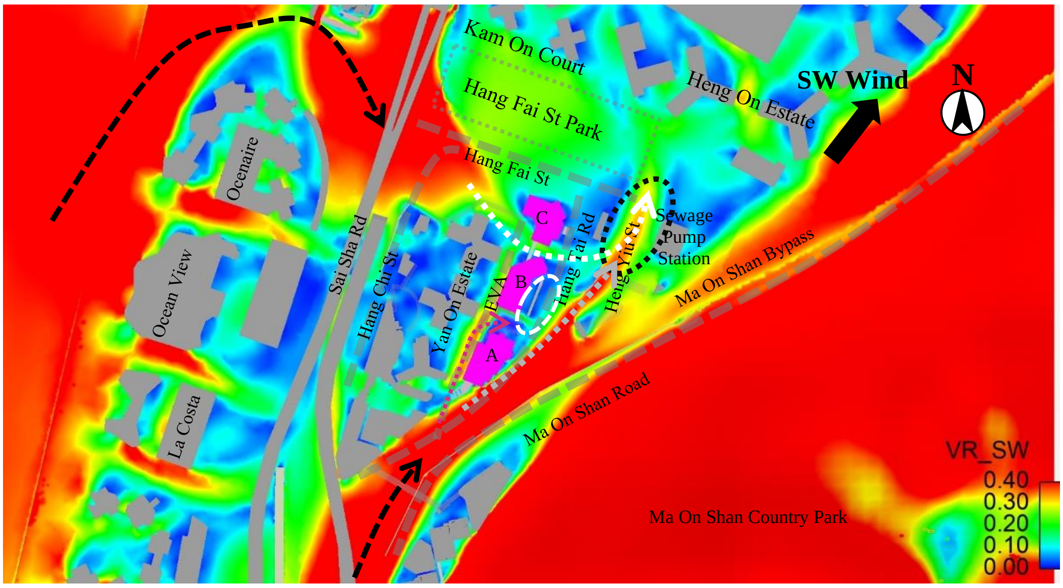


Figure 41 Contour Plot of VR for Baseline Scheme under SW Wind

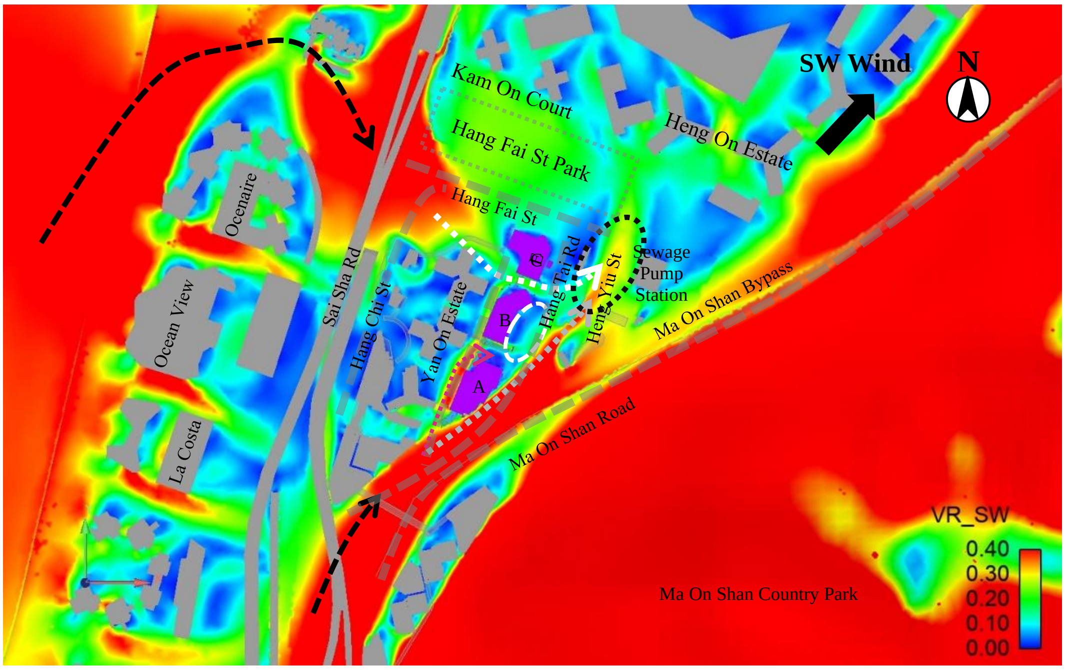


Figure 42 Contour Plot of VR for Proposed Scheme under SW Wind

6.4 VR Results of Test Points

Table 6 summarizes the values of SVR and LVR among Baseline Scheme and Proposed Scheme. The VR of individual test points may refer to Appendix C of this Report.

Table 6 Comparison of the SVR and LVR among Baseline Scheme and Proposed Scheme

	Annual Weighted VR		Summer Weighted VR	
	Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
SVR	0.15	0.15	0.16	0.18
LVR	0.17	0.18	0.18	0.19

6.4.1 Site Air Ventilation Assessment

Under annual wind condition, the SVR for Baseline Scheme and Proposed Scheme is 0.15. Under summer wind condition, the SVR for Baseline Scheme and Proposed Scheme is 0.16 and 0.18, respectively. The results indicate the Proposed Scheme achieves a slightly improved ventilation performance at the immediate surroundings of the developments under the summer condition.

6.4.2 Local Air Ventilation Assessment

Under annual wind condition, the LVR for Baseline Scheme and Proposed Scheme is 0.17 and 0.18 . Under summer wind condition, the LVR for Baseline Scheme and Proposed Scheme is 0.18 and 0.19, respectively. The results indicate the Proposed Scheme achieve a similar ventilation performance at the immediate surroundings of the developments under summer condition.

6.5 Focus Areas

There is a total of 15 focus areas within the assessment area identified for this study. Table 5 summarized the Average VR for each focus areas under annual and summer conditions.

Table 7 Averaged VR for Each Focus Area

Focus Areas		Annual Condition		Summer Condition	
		Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
1	Perimeter	0.15	0.15	0.16	0.18
2	Sai Sha Rd (Overpass)	0.18	0.19	0.20	0.20
3	Hang Chi St	0.15	0.15	0.16	0.16
4	Sai Sha Rd (Ground)	0.19	0.20	0.22	0.24
5	Kam On Court	0.14	0.14	0.18	0.18
6	Hang Fai St Park	0.16	0.16	0.22	0.22
7	Hang Fai St	0.16	0.16	0.17	0.17
8	Ma On Shan Sewage Pumping Station (Surrounding)	0.15	0.15	0.19	0.19
9	Petrol Station	0.20	0.21	0.18	0.19
10	Government Land Allocation	0.10	0.13	0.12	0.16
11	Parking Area	0.20	0.18	0.22	0.25
12	Hang Tai Road	0.37	0.36	0.32	0.33
13	Ma On Shan Road	0.29	0.32	0.23	0.25
14	Proposed Subsidised Sale Flats Dev. at Ma On Shan Rd	0.27	0.28	0.23	0.24
15	Yan On Estate	0.10	0.10	0.10	0.11

Under Annual Condition

In general, the Proposed and Baseline Scheme would achieve similar average VR in around the Perimeter and at Hang Chi Street, Kam On Court, Hang Fai Street Park, Hang Fai Street, Ma On Shan Sewage Pumping Station and Yan On Estate. This indicates that the ventilation performances are considered comparable in the aforementioned areas.

Proposed Scheme has a slightly higher VR for Sai Sha Road (Overpass), Sai Sha Road (Ground), Petrol Station, Government Land Allocation, Ma On Shan Road and the Subsidised Flats Development at Ma On Shan Road. The slightly improved wind environment in these areas mainly due to the Block B empty bay widening and the more permeable car park roof in the Proposed Scheme, which would facilitate more wind channel passing through between Block A and Block B. The Baseline Scheme has a slightly higher VR at the Parking Area and Hang Tai Road.

Under Summer Condition

Most of the Focus Areas show similar average VR values for both schemes, including Sai Sha Road (Overpass), Hang Chi Street, Kam On Court, Hang Fai Street Park, Hang Fai Street and Ma On Shan Sewage Pumping Station. This indicates that the ventilation performances are considered comparable in the aforementioned areas.

Proposed Scheme has a slightly better ventilation performance for the Perimeter as well as Sai Sha Road (Ground), Petrol Station, Government Land Allocation, Parking Area, Hang Tai Road, Ma On Shan Road, Subsidised Flats at Ma On Shan Road and Yan On Estate. The wind environment in this area mainly due to the Block B empty bay widening and the more permeable car park roof in the Proposed Scheme.

7 Conclusion

An Air Ventilation Assessment (AVA) – Initial Study was conducted to assess the ventilation performance of Baseline Scheme and Proposed Scheme in accordance with the AVA Technical Circular No. 1/06.

Two schemes were assessed using Computational Fluid Dynamics (CFD) techniques. A series CFD simulation using Realizable k-ε turbulence model were performed under annual and summer wind conditions with reference to the AVA Technical Circular No. 1/06. For annual wind condition, NNE, NE, ENE, E, ESE, SE, SSW and SW were selected which gives total wind frequency of 78.4% over a year while E, ESE, SE, SSE, S, SSW, SW and WSW were selected for summer condition, which gives total wind frequency of 80.5%.

The Velocity Ratio (VR) as proposed by the AVA Technical Circular No.1/06 was employed to assess the ventilation performance under different schemes and its impact to the surroundings.

With reference to the AVA Technical Circular No. 1/06, 35 perimeter test points and 114 overall test points were allocated to assess the overall ventilation performance in the Assessment Area. Results

The results showed that

- Under annual condition, Proposed Scheme obtained a similar SVR (0.15) but slightly improved LVR (0.17 improved to 0.18) comparing to Baseline Scheme, indicating that the Proposed Scheme would have a slightly improved wind environment in the Focus Areas, slightly away from the Perimeter.
- Under summer condition, Proposed Scheme obtained a slightly improved SVR (0.16 improved to 0.18) and LVR (0.18 to 0.19) comparing to Baseline Scheme, indicating that the Proposed Scheme would have an improved wind environment in close proximity to the development around the 'Perimeter' test points.
- The most important wind enhancement features are the large building separations which help to facilitate a positive wind environment for all wind directions leading to a positive result in both Baseline and Proposed scheme.
- The more permeable car park roof and enlarged empty bay at the G/F of Block B are the wind enhancement features which make the most difference to the difference between the Baseline and Proposed Scheme because they allow more wind permeate the development and reach the leeward side.

8 Reference

[1] Annex A of Technical Circular No. 1/06 issued by the Housing, Planning and Lands Bureau pertaining specifically to Air Ventilation Assessments, 19th July, 2006

(https://www.devb.gov.hk/filemanager/en/content_679/hplb-etwb-tc-01-06.pdf)

[2] Planning Department RAMS Data (http://www.pland.gov.hk/pland_en/info_serv/site_wind/site_wind/)

Appendix A
Contour Plots of Velocity Ratio

A1 Baseline Scheme

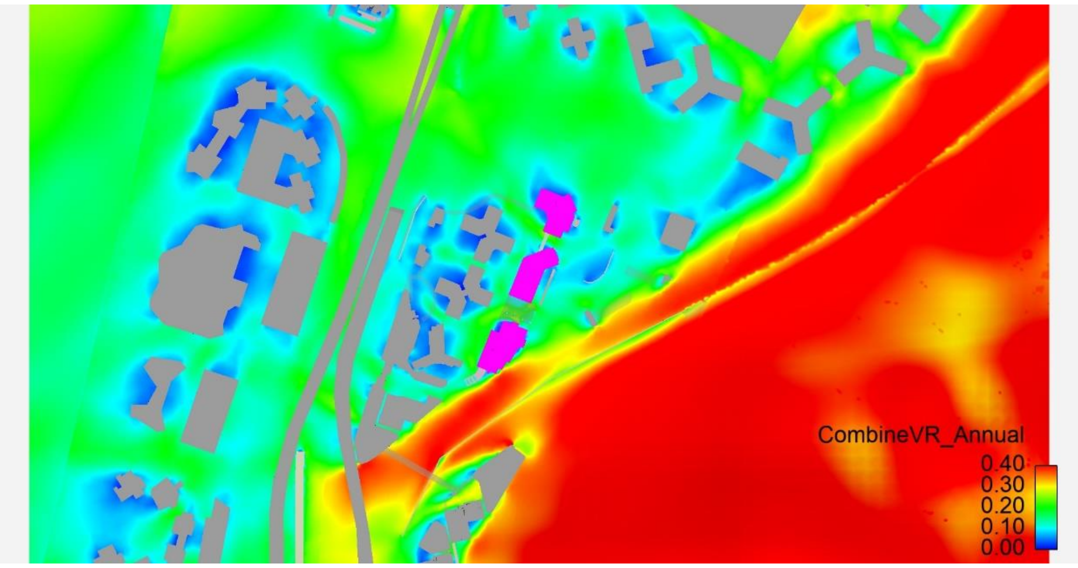


Figure B1 Contour Plot of VR under Annual Wind

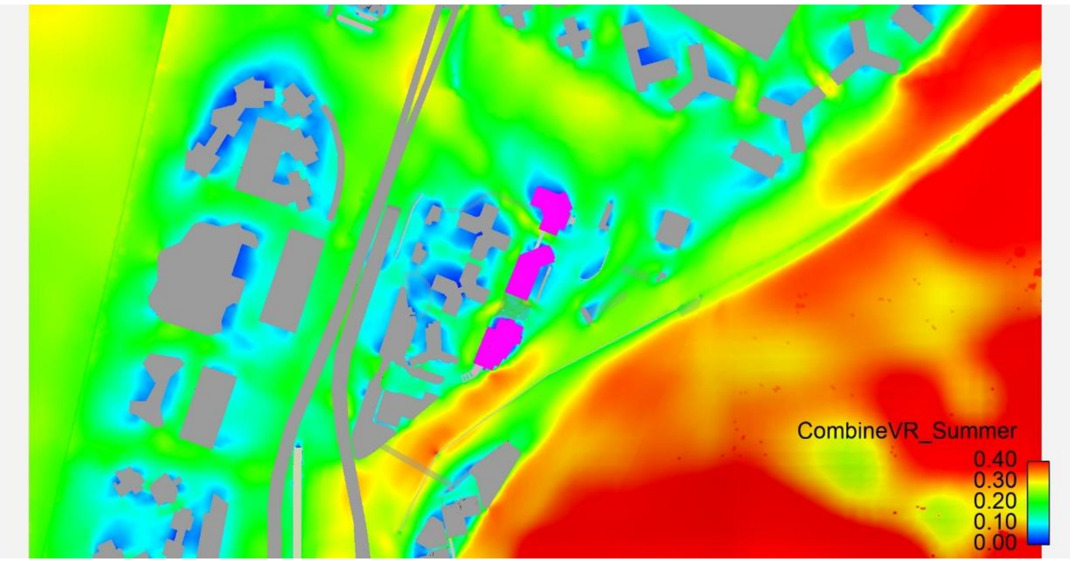


Figure B2 Contour Plot of VR under Summer Wind

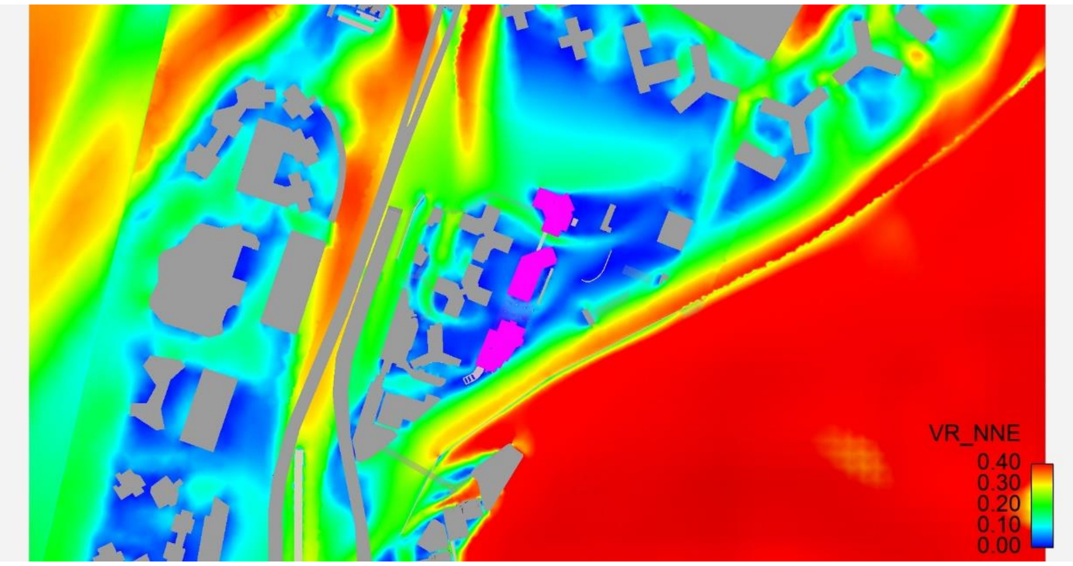


Figure B3 Contour Plot of VR under NNE Wind

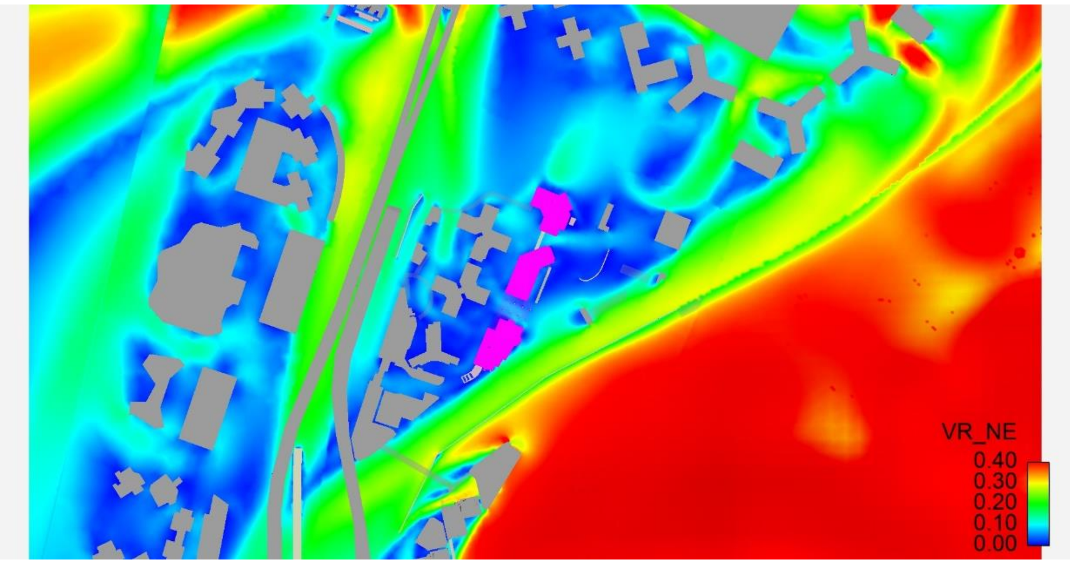


Figure B4 Contour Plot of VR under NE Wind

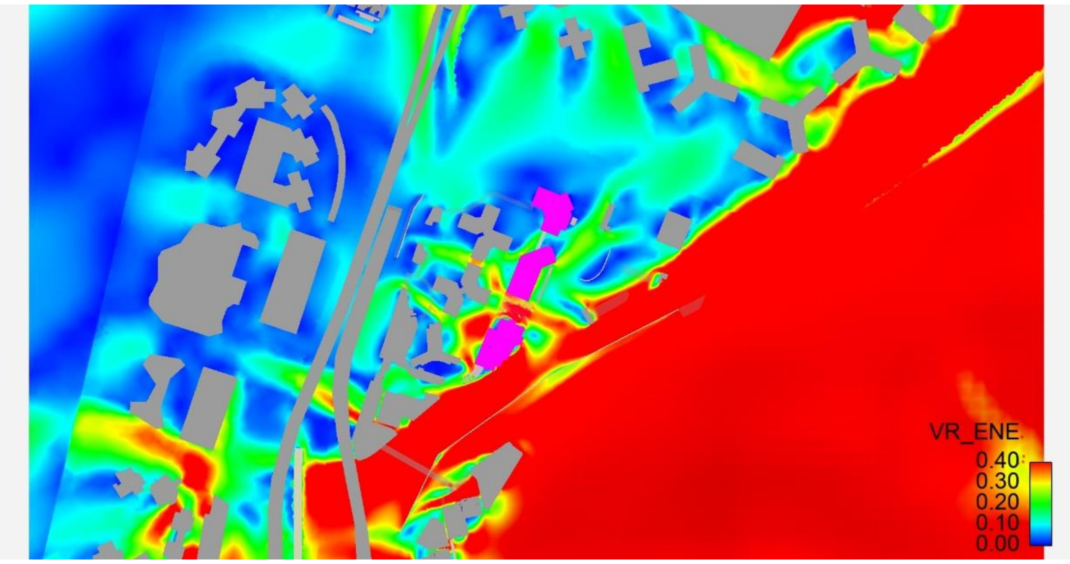


Figure B5 Contour Plot of VR under ENE Wind

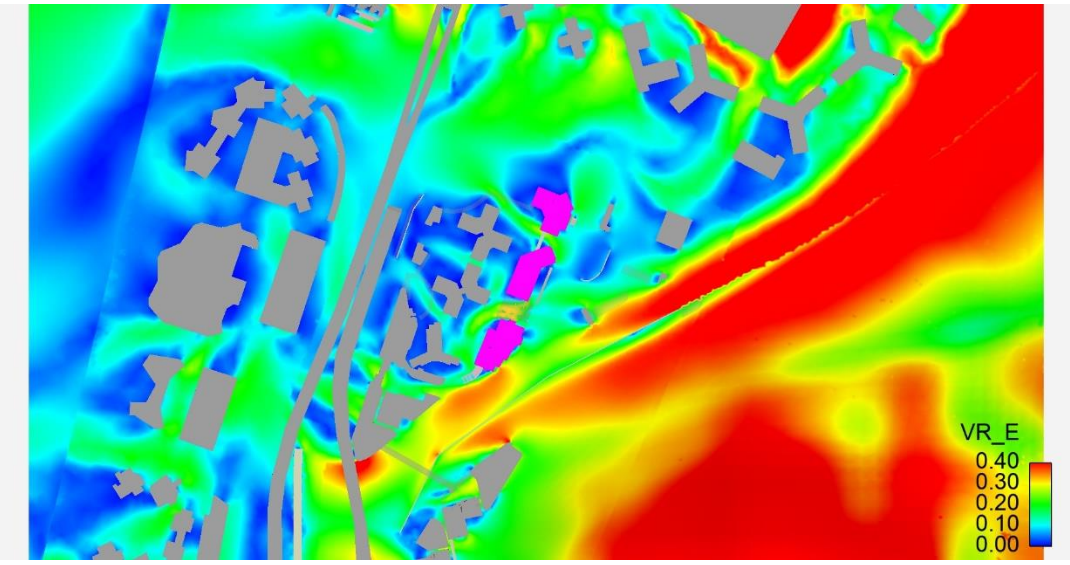


Figure B6 Contour Plot of VR under E Wind

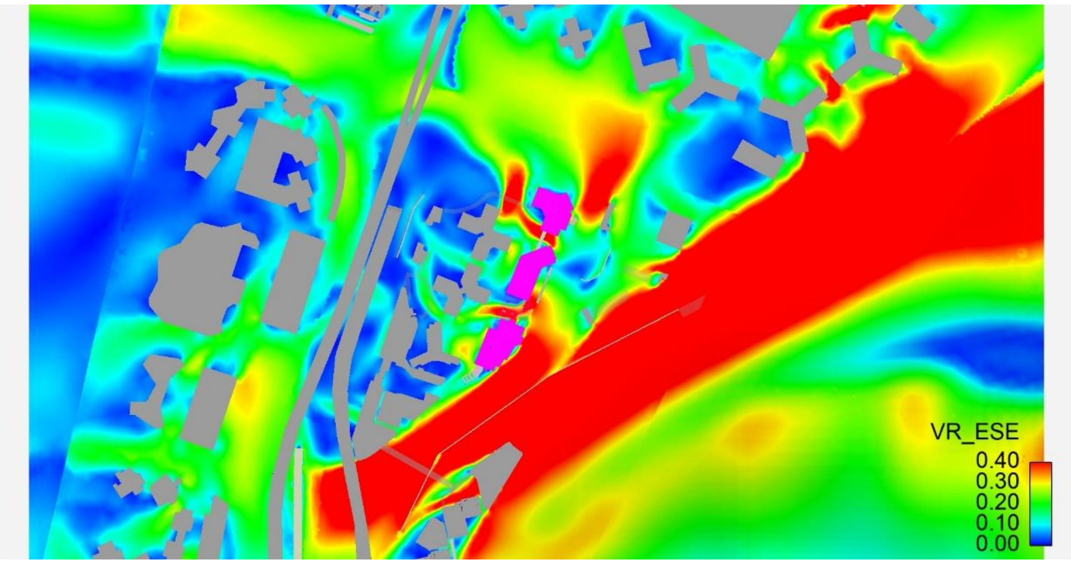


Figure B7 Contour Plot of VR under ESE Wind

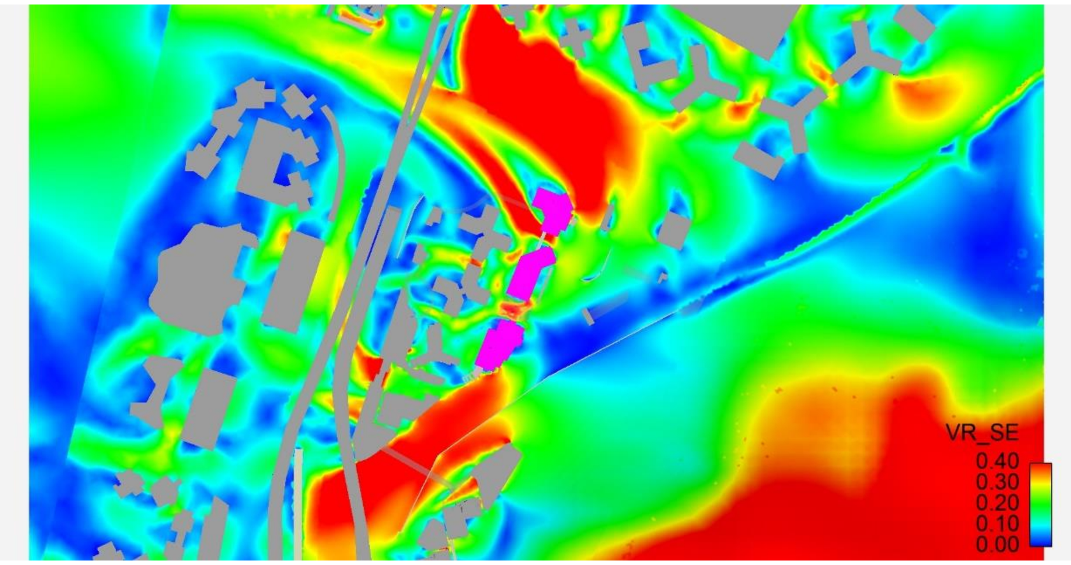


Figure B8 Contour Plot of VR under SE Wind

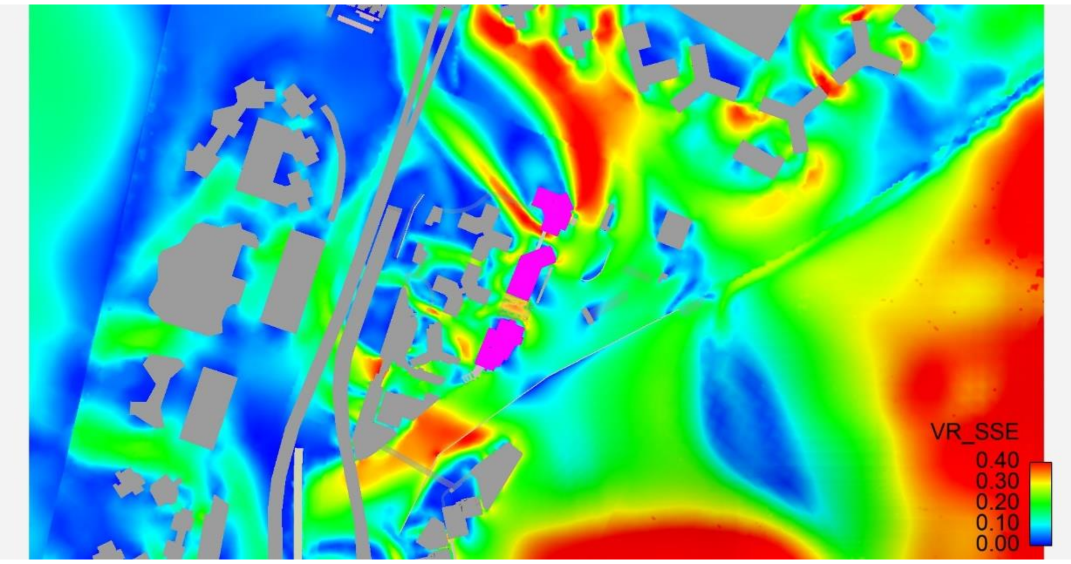


Figure B9 Contour Plot of VR under SSE Wind

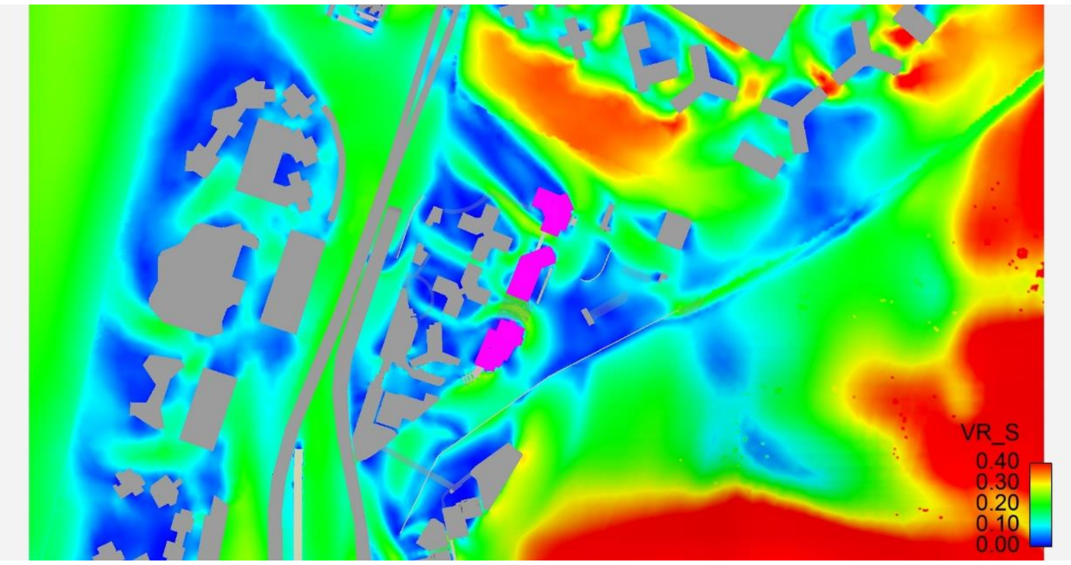


Figure B10 Contour Plot of VR under S Wind

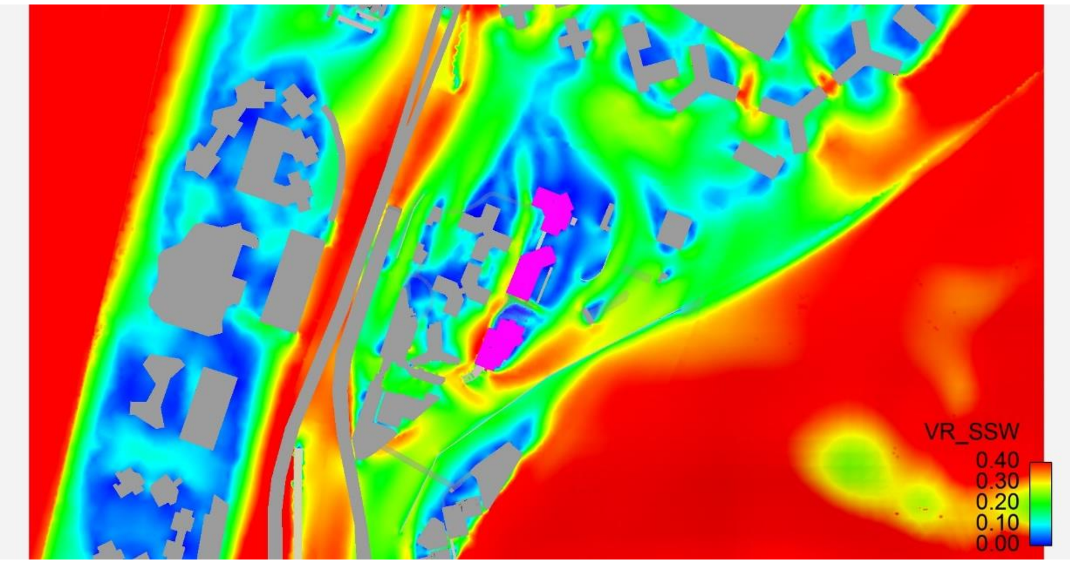


Figure B11 Contour Plot of VR under SSW Wind

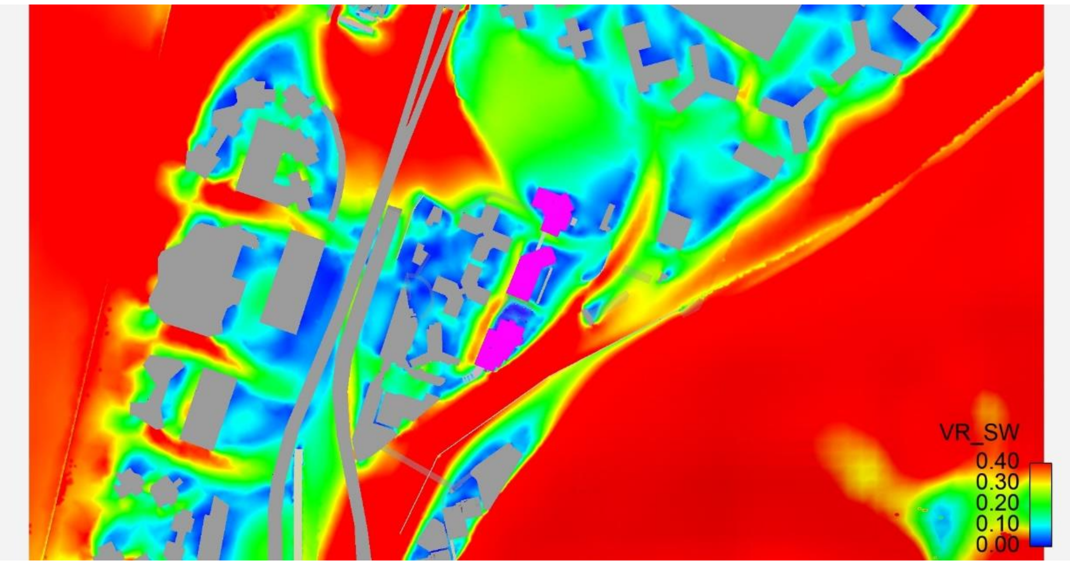


Figure B12 Contour Plot of VR under SW Wind

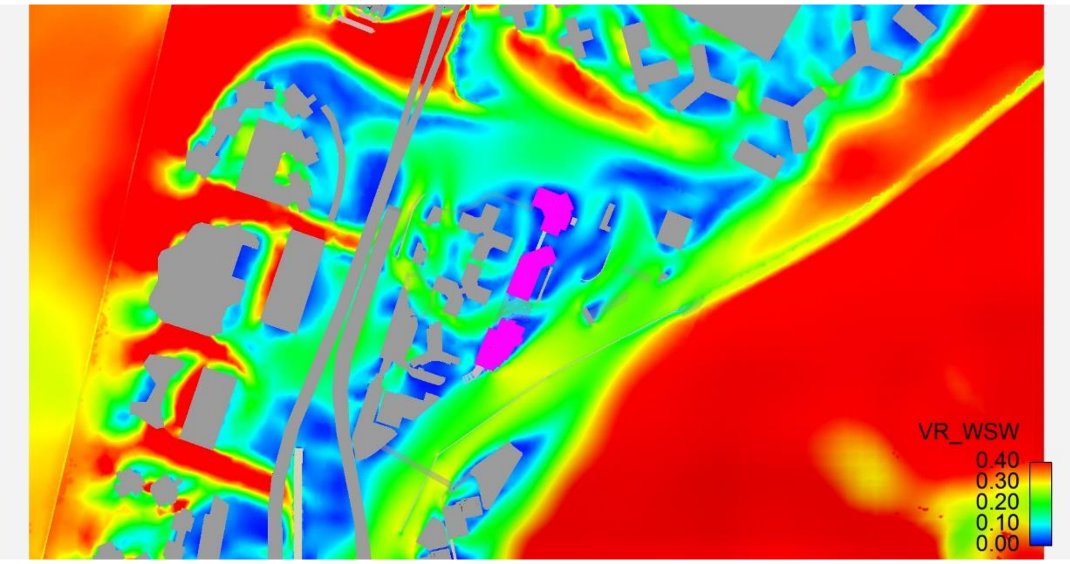


Figure B13 Contour Plot of VR under WSW Wind

A2 Proposed Scheme

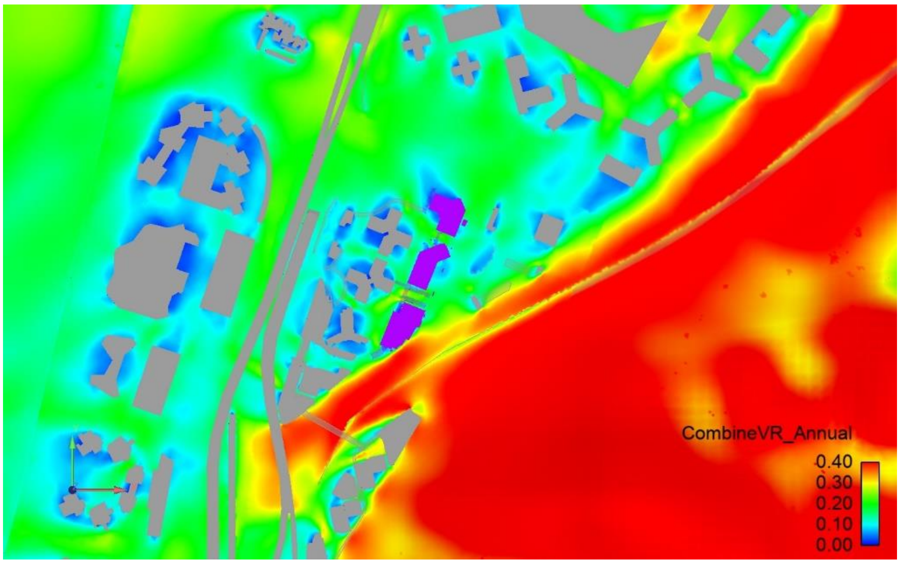


Figure B14 Contour Plot of VR under Annual Wind

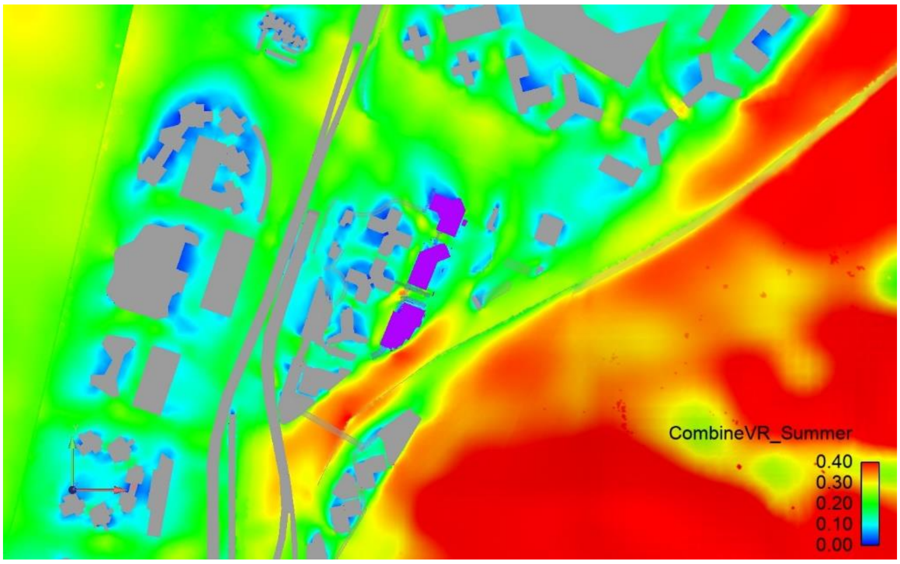


Figure B15 Contour Plot of VR under Summer Wind

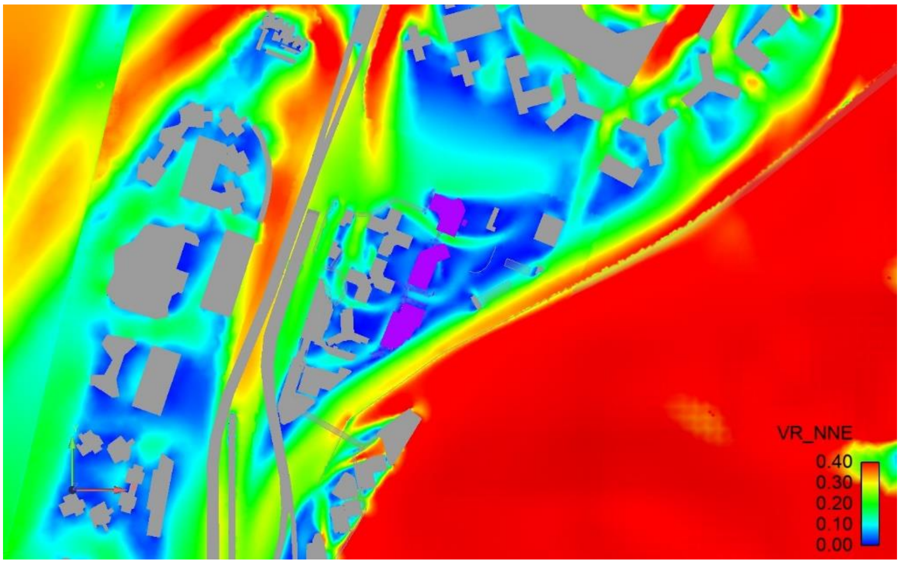


Figure B16 Contour Plot of VR under NNE Wind

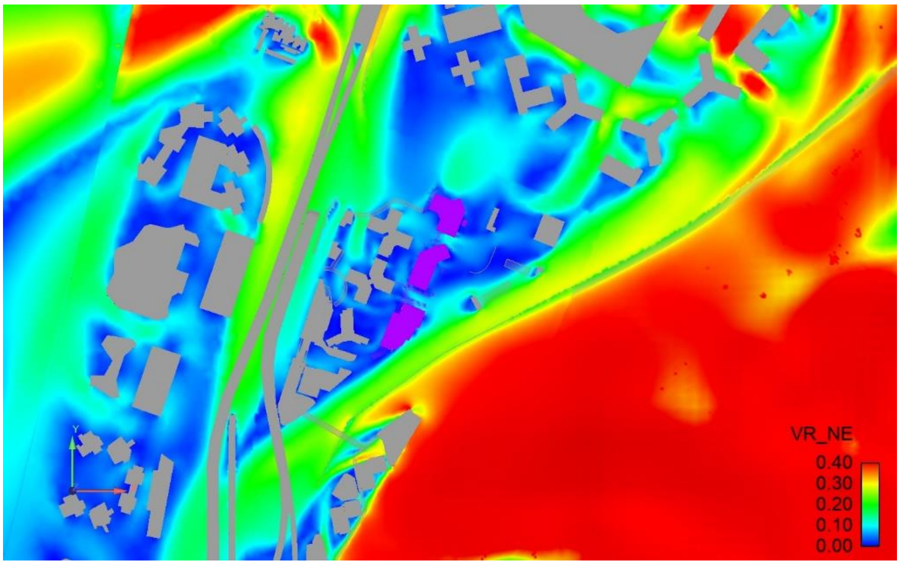


Figure B17 Contour Plot of VR under NE Wind

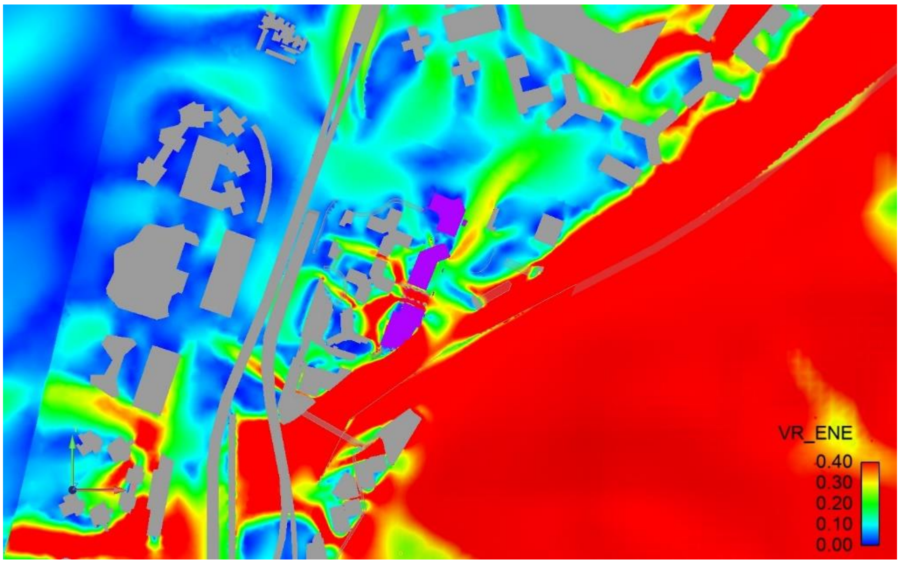


Figure B18 Contour Plot of VR under ENE Wind

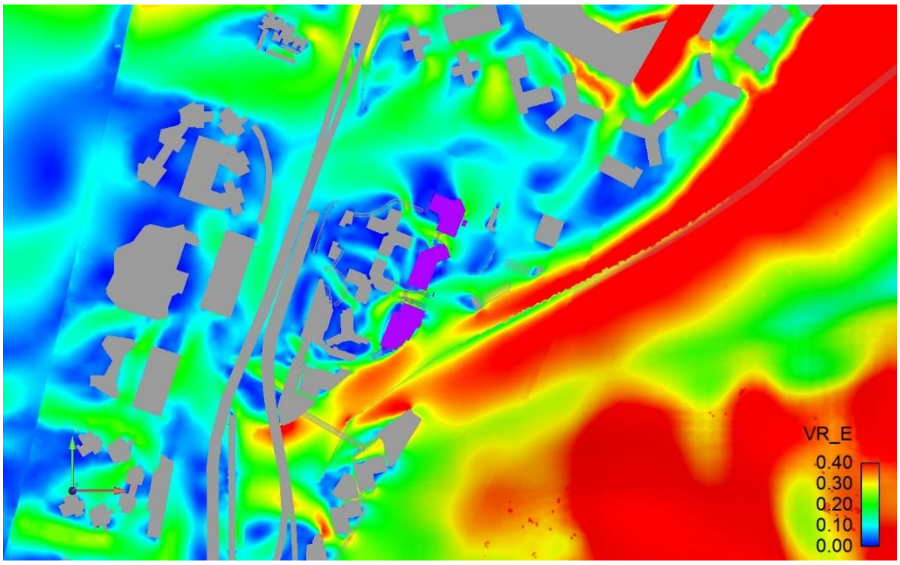


Figure B19 Contour Plot of VR under E Wind

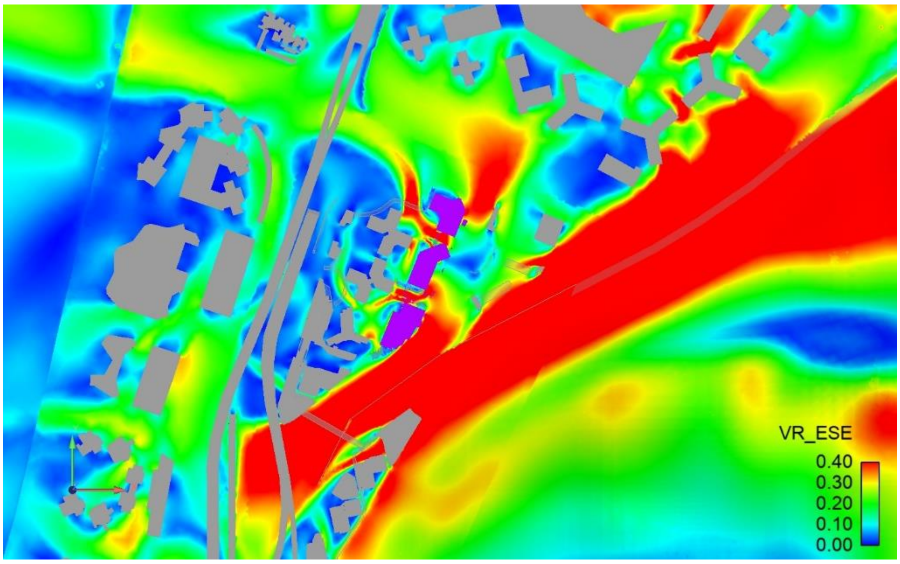


Figure B20 Contour Plot of VR under ESE Wind

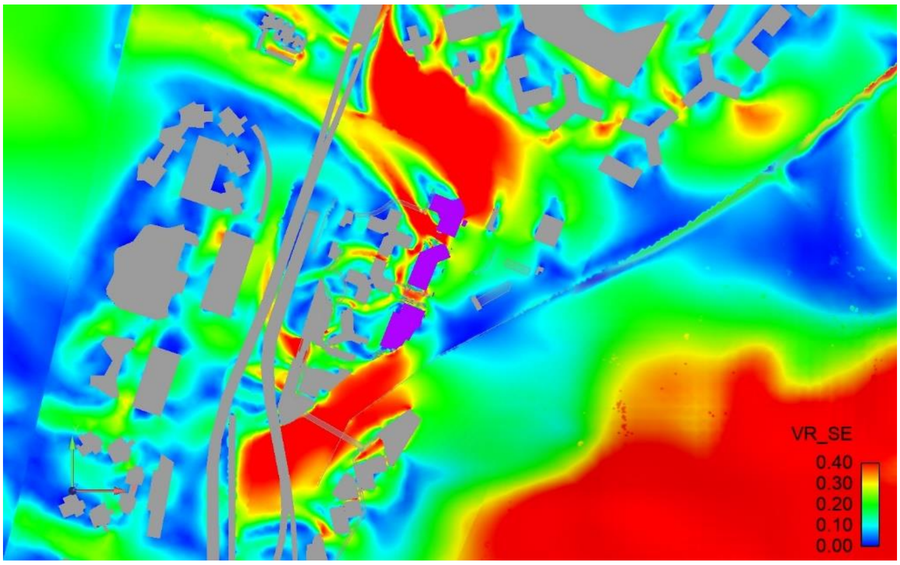


Figure B21 Contour Plot of VR under SE Wind

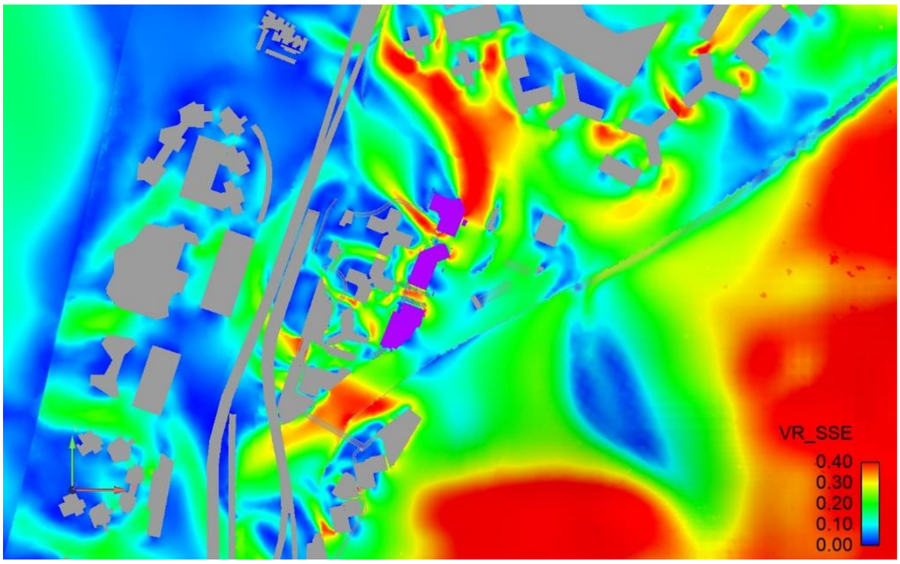


Figure B22 Contour Plot of VR under SSE Wind

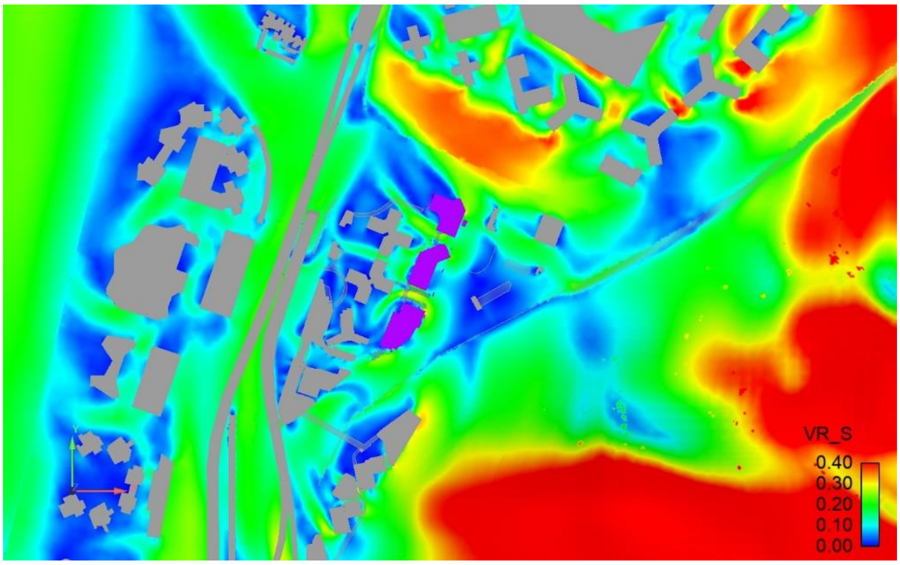


Figure B23 Contour Plot of VR under S Wind

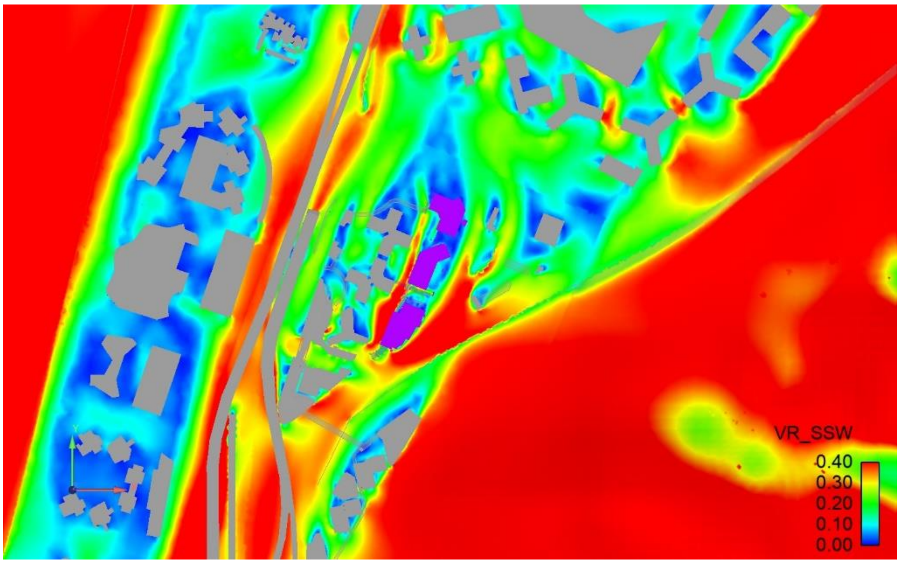


Figure B24 Contour Plot of VR under SSW Wind

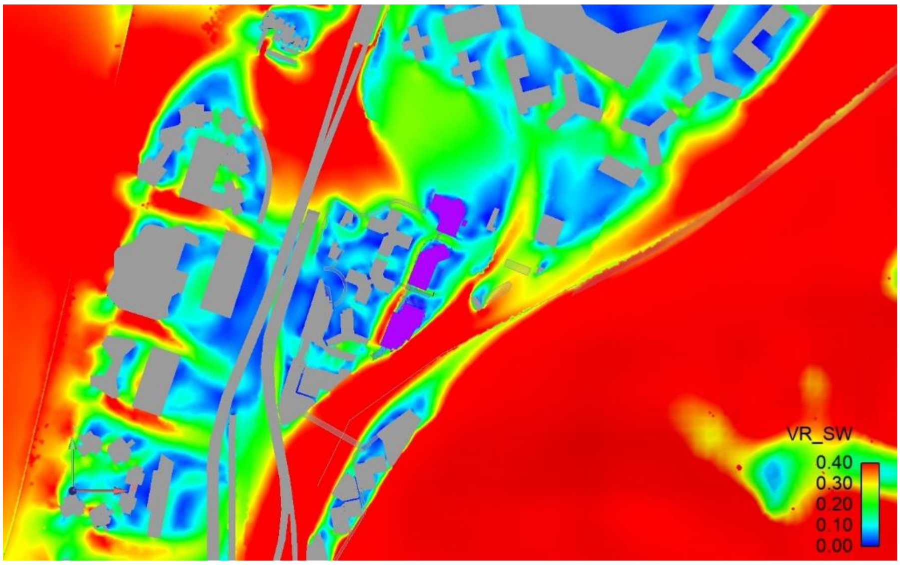


Figure B25 Contour Plot of VR under SW Wind

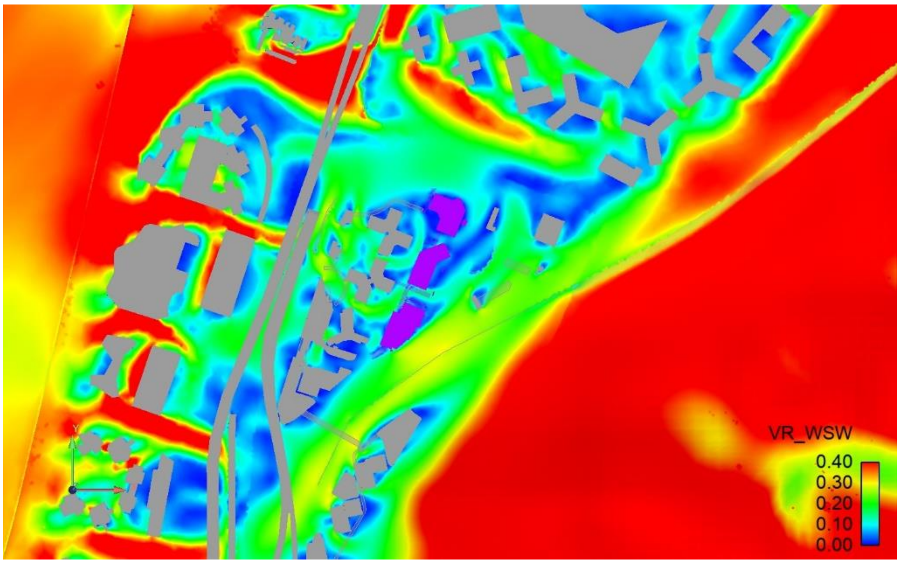


Figure B26 Contour Plot of VR under WSW Wind

Appendix B
Vector Plots of Velocity Ratio

B1 Baseline Scheme

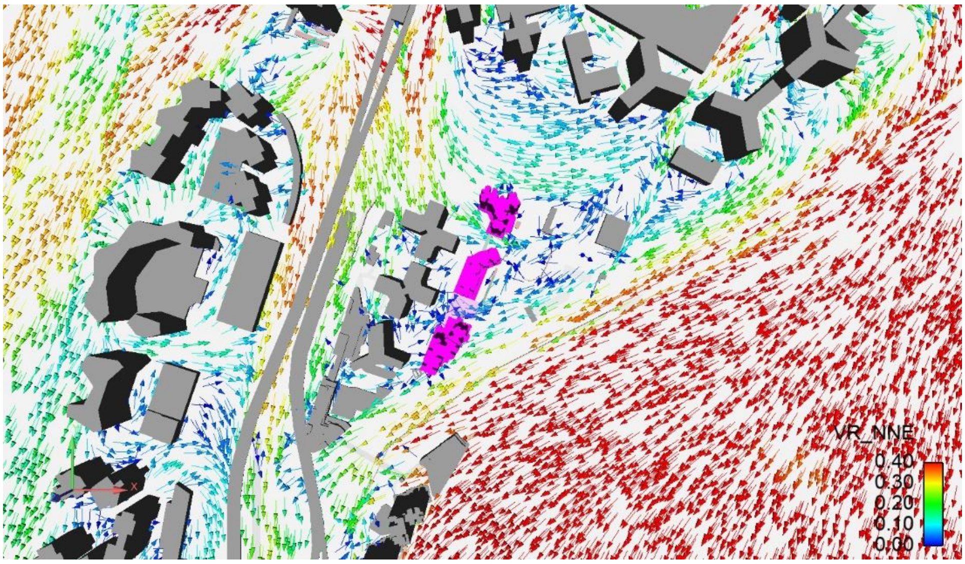


Figure C27 Vector Plot of VR under NNE Wind

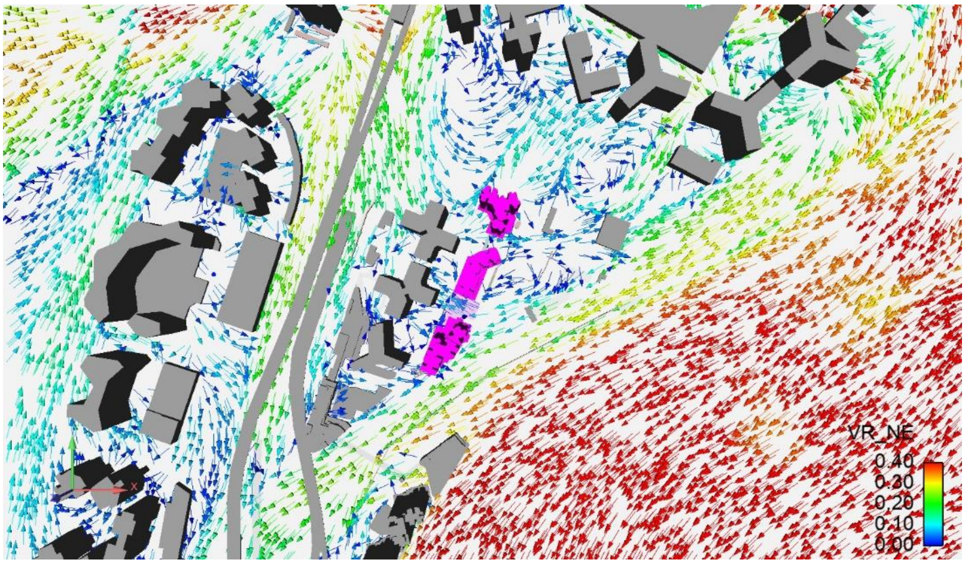


Figure C28 Vector Plot of VR under NE Wind

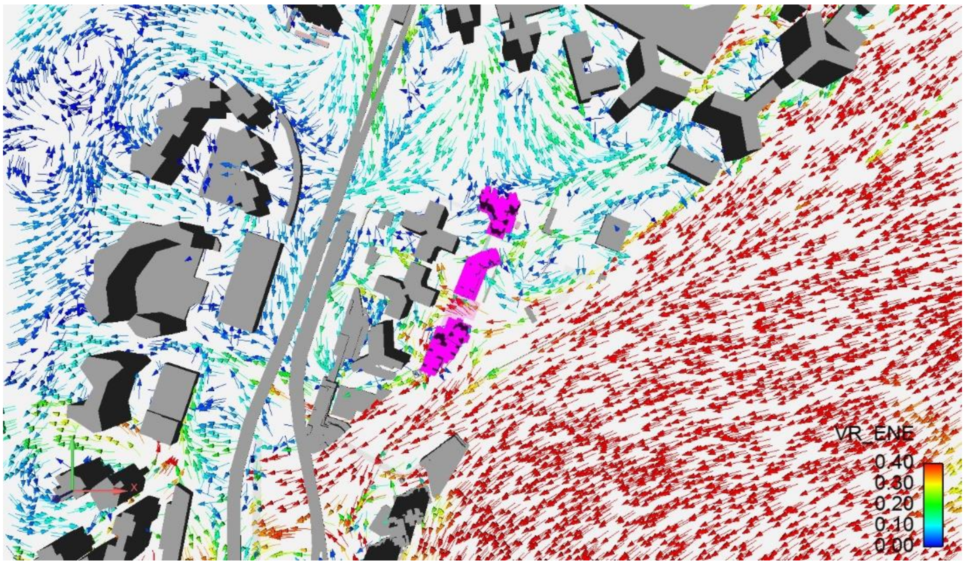


Figure C29 Vector Plot of VR under ENE Wind

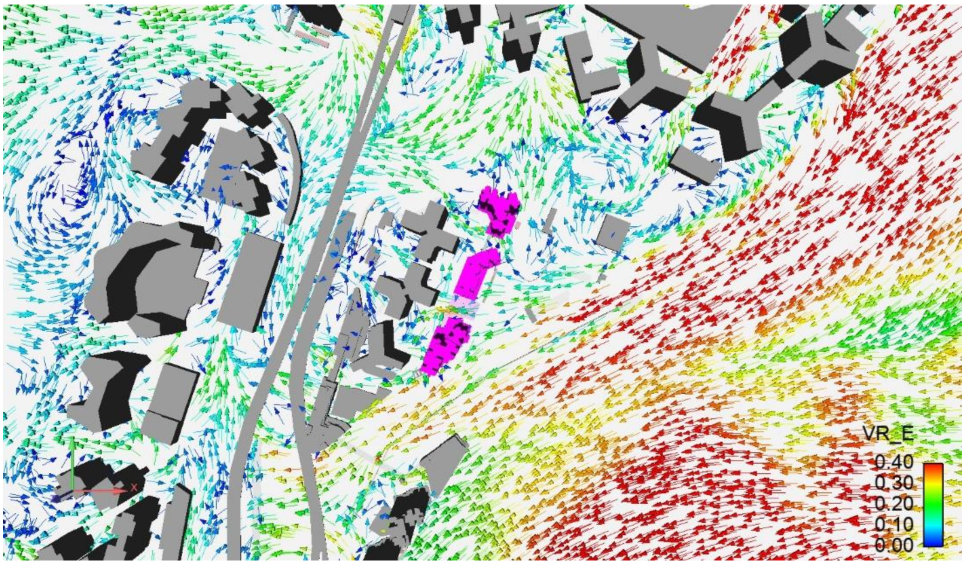


Figure C30 Vector Plot of VR under E Wind

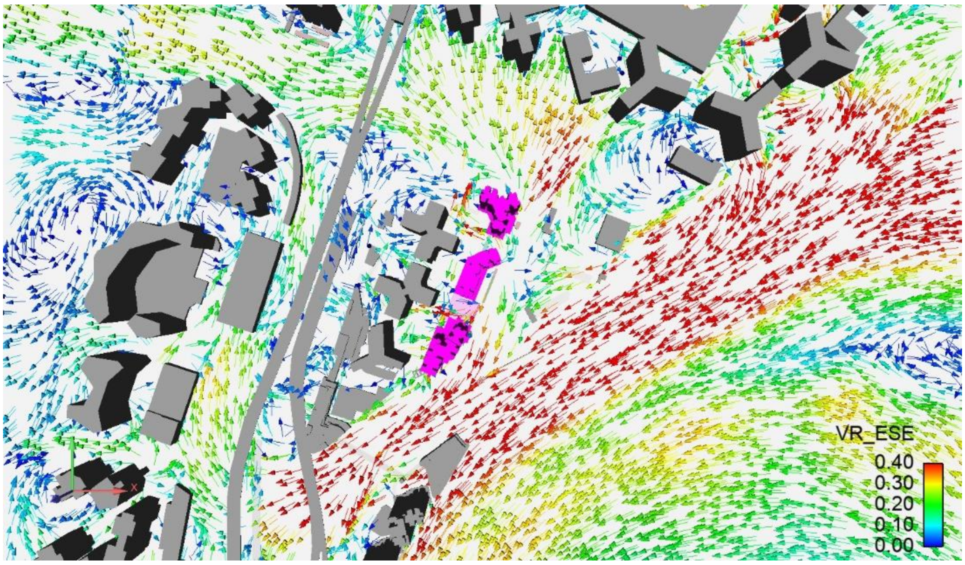


Figure C31 Vector Plot of VR under ESE Wind

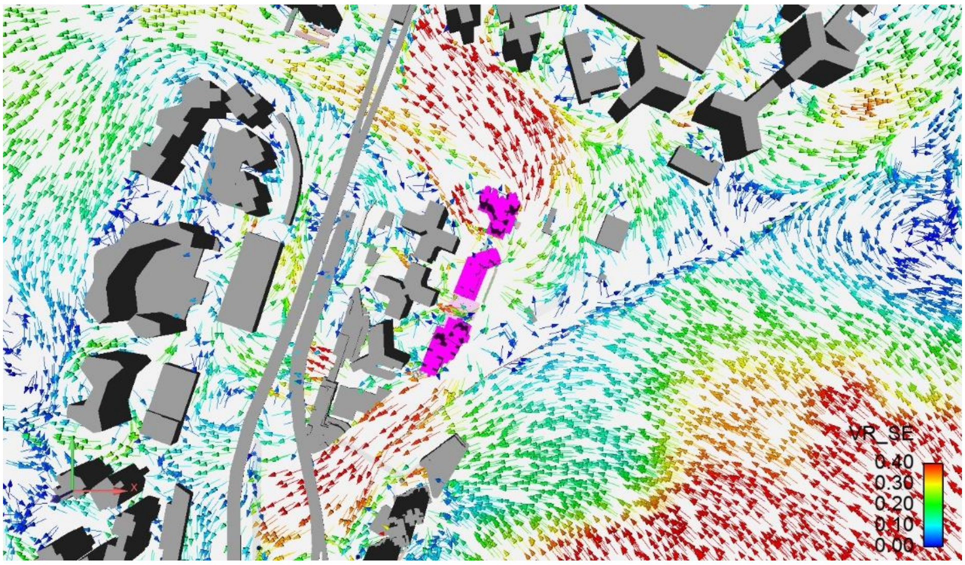


Figure C32 Vector Plot of VR under SE Wind

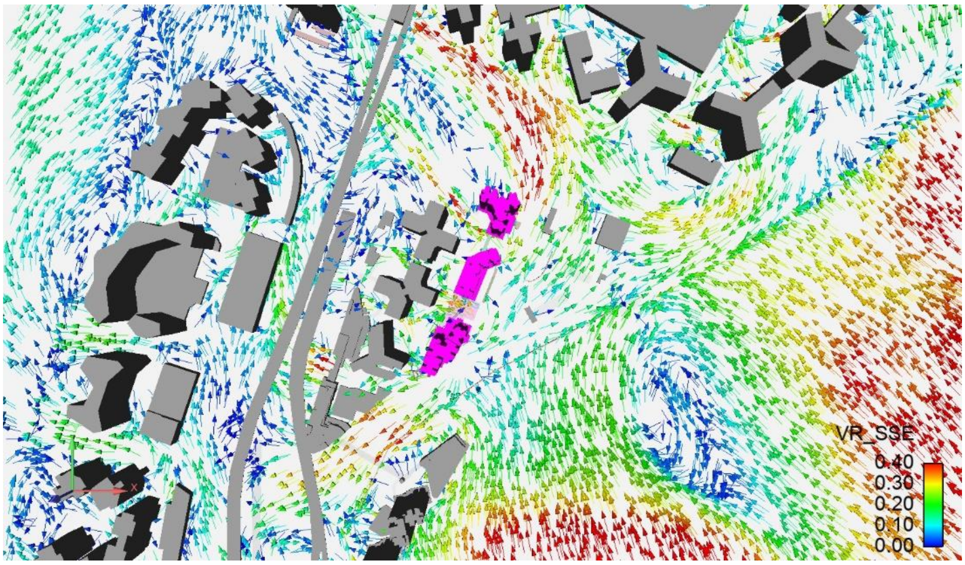


Figure C33 Vector Plot of VR under SSE Wind

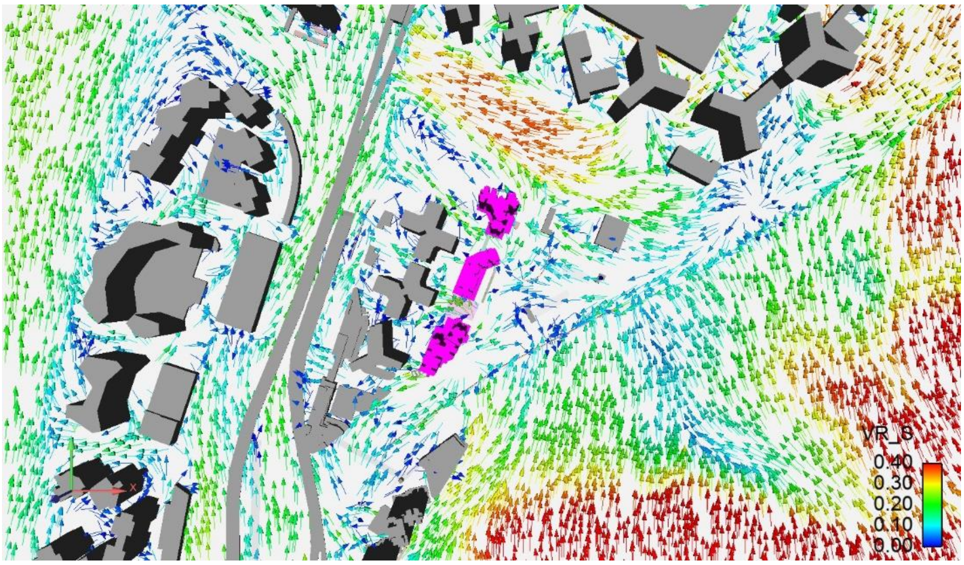


Figure C34 Vector Plot of VR under S Wind

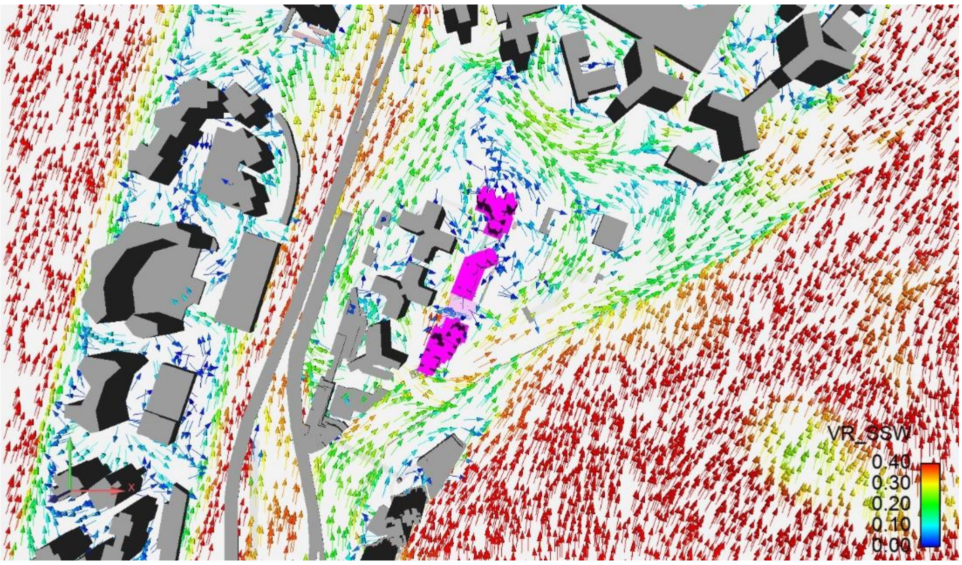


Figure C35 Vector Plot of VR under SSW Wind

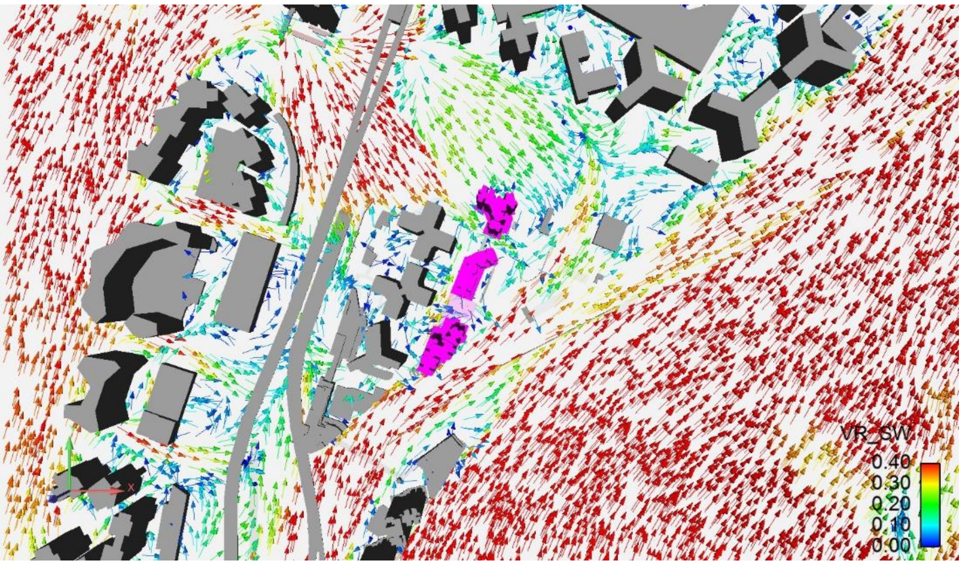


Figure C36 Vector Plot of VR under SW Wind

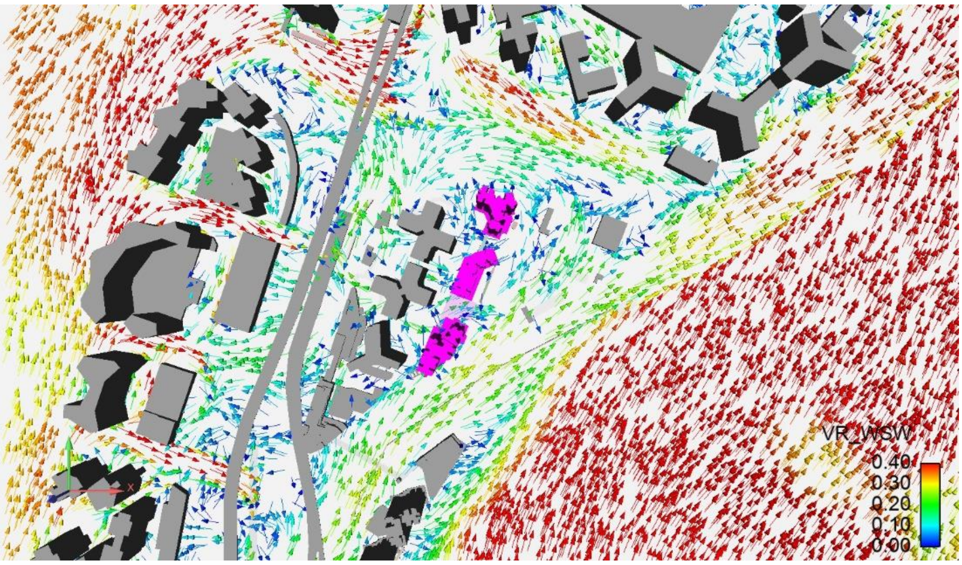


Figure C37 Vector Plot of VR under WSW Wind

B2 Proposed Scheme

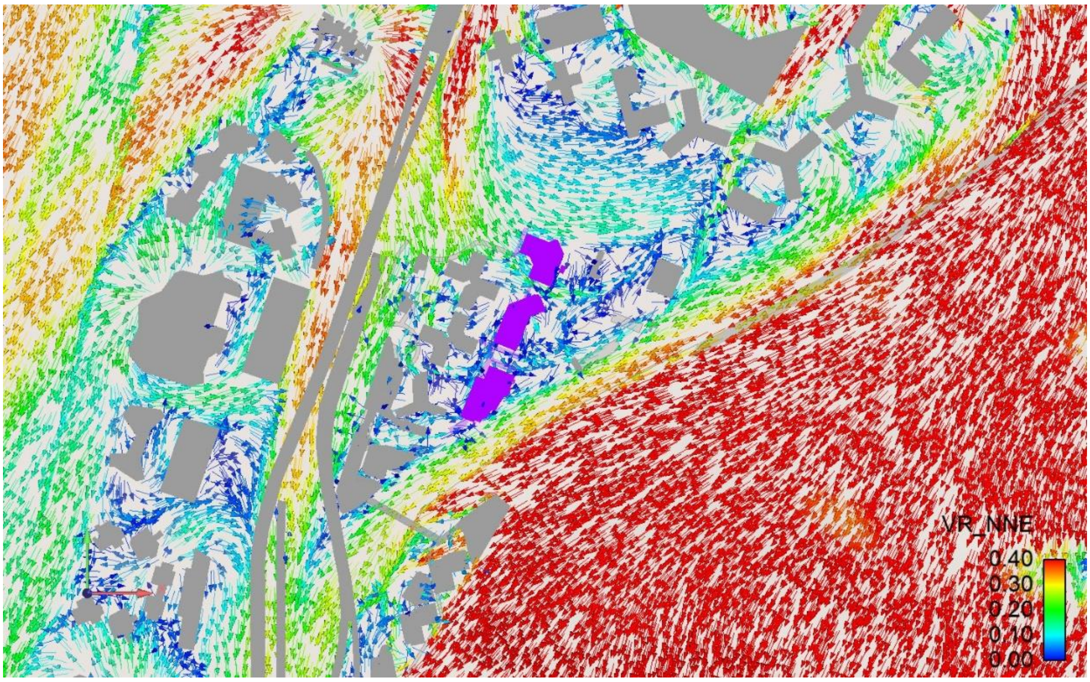


Figure C38 Vector Plot of VR under NNE Wind

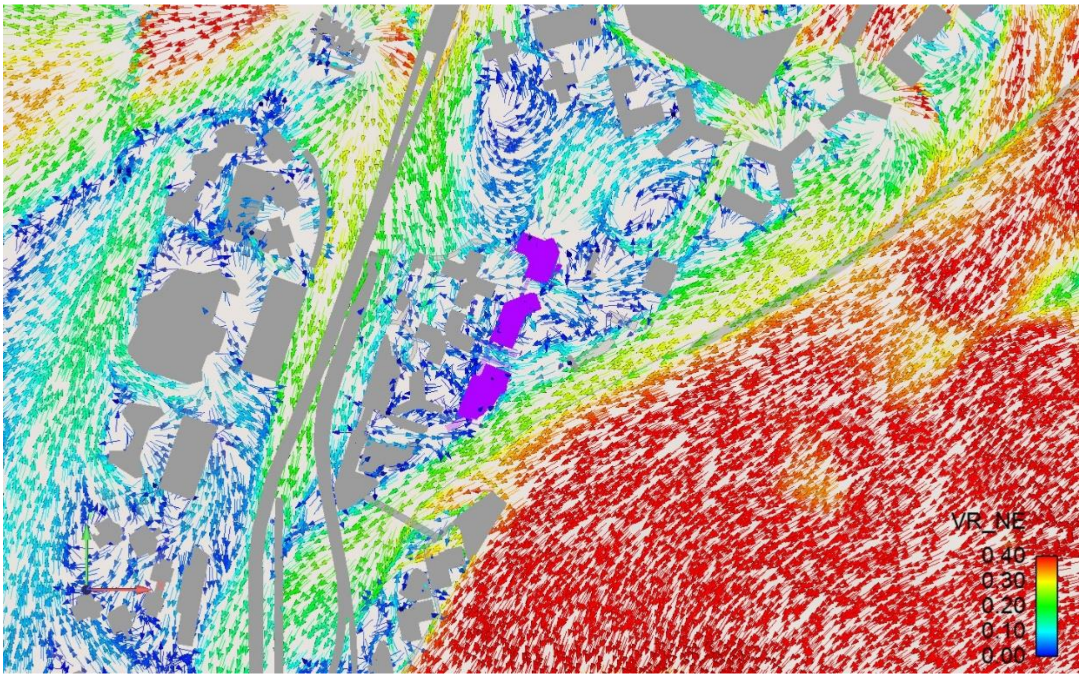


Figure C39 Vector Plot of VR under NE Wind

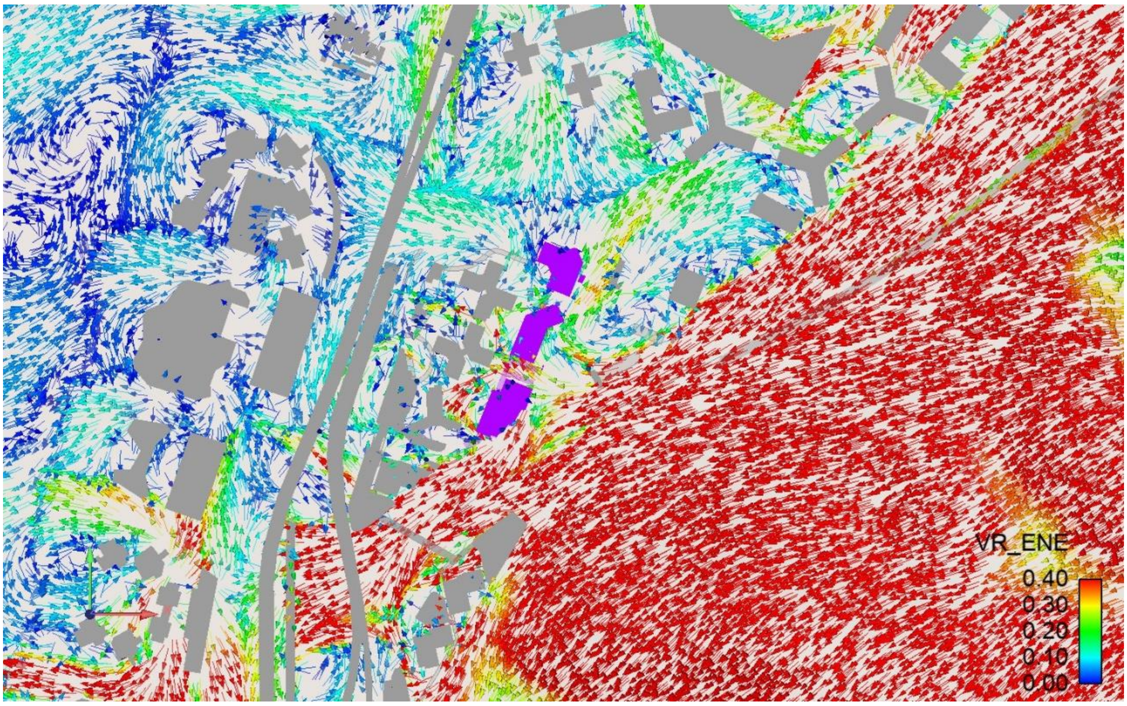


Figure C40 Vector Plot of VR under ENE Wind

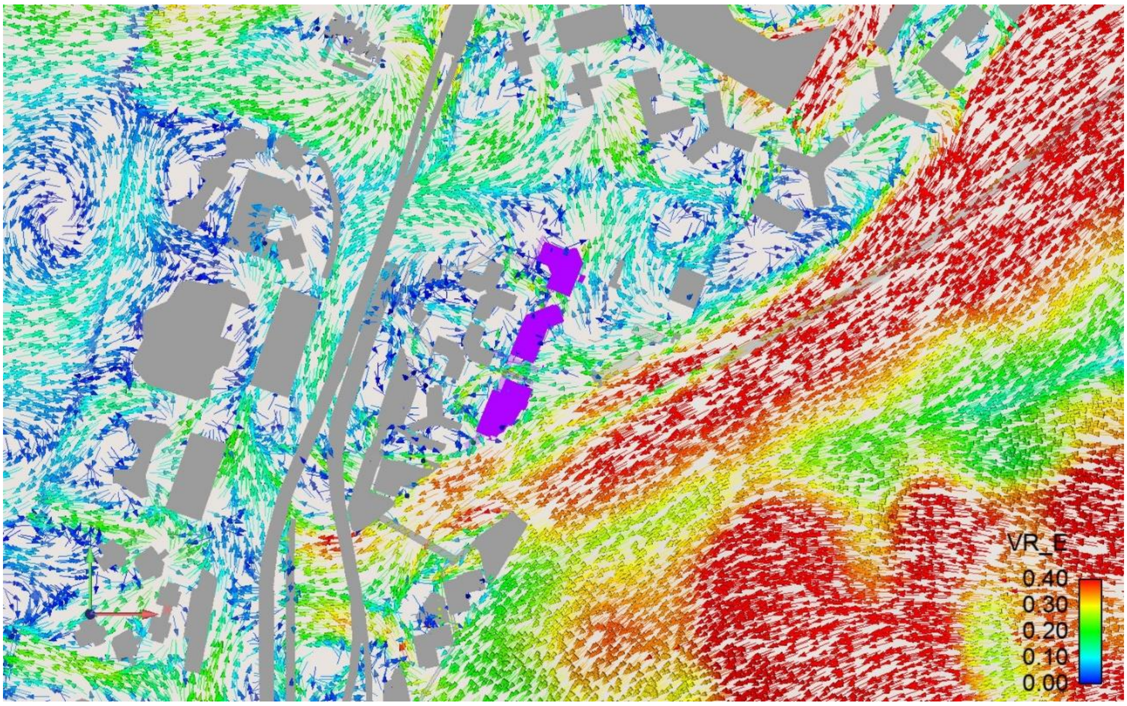


Figure C41 Vector Plot of VR under E Wind

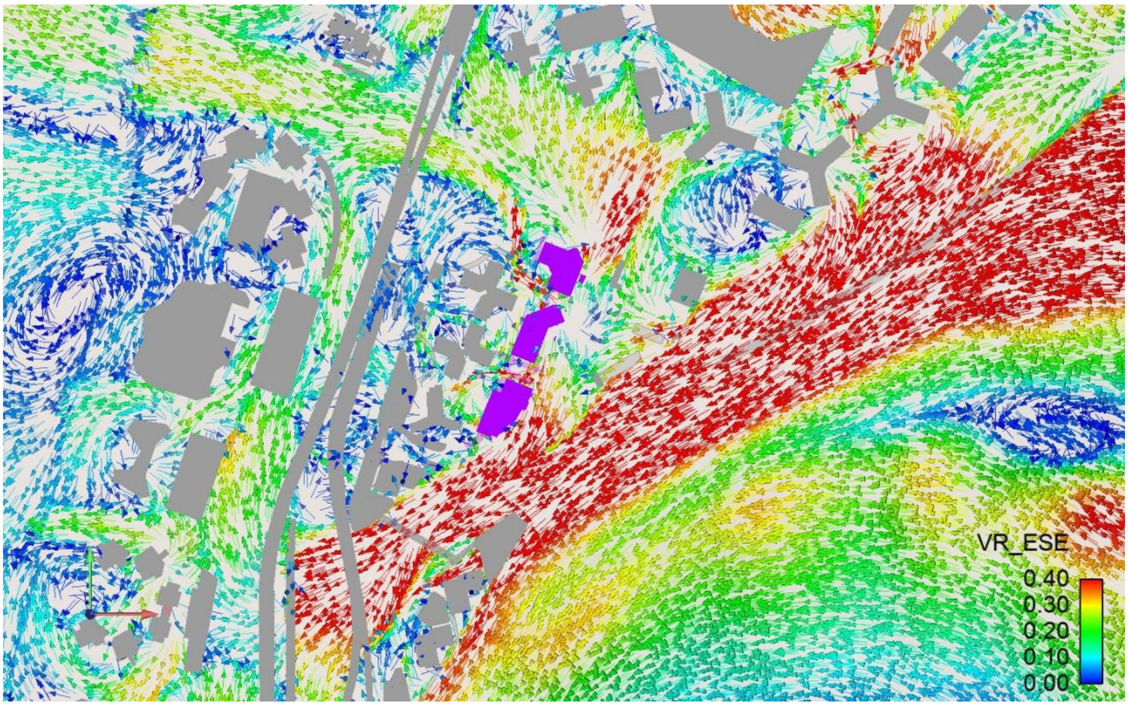


Figure C42 Vector Plot of VR under ESE Wind

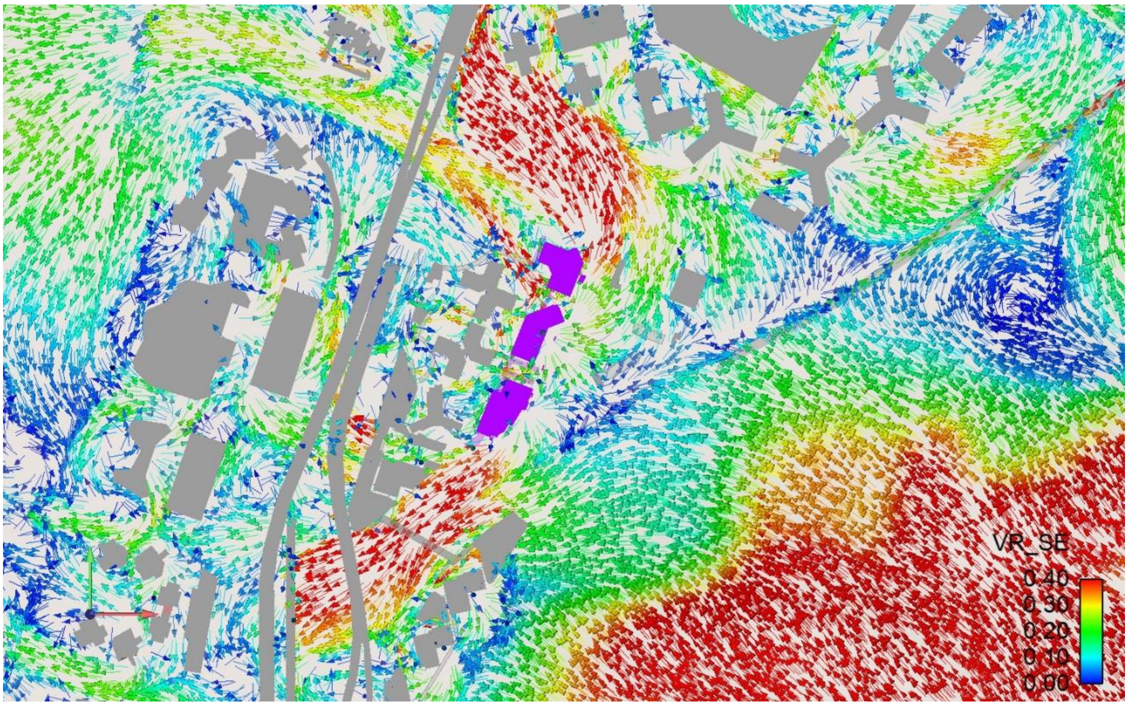


Figure C43 Vector Plot of VR under SE Wind

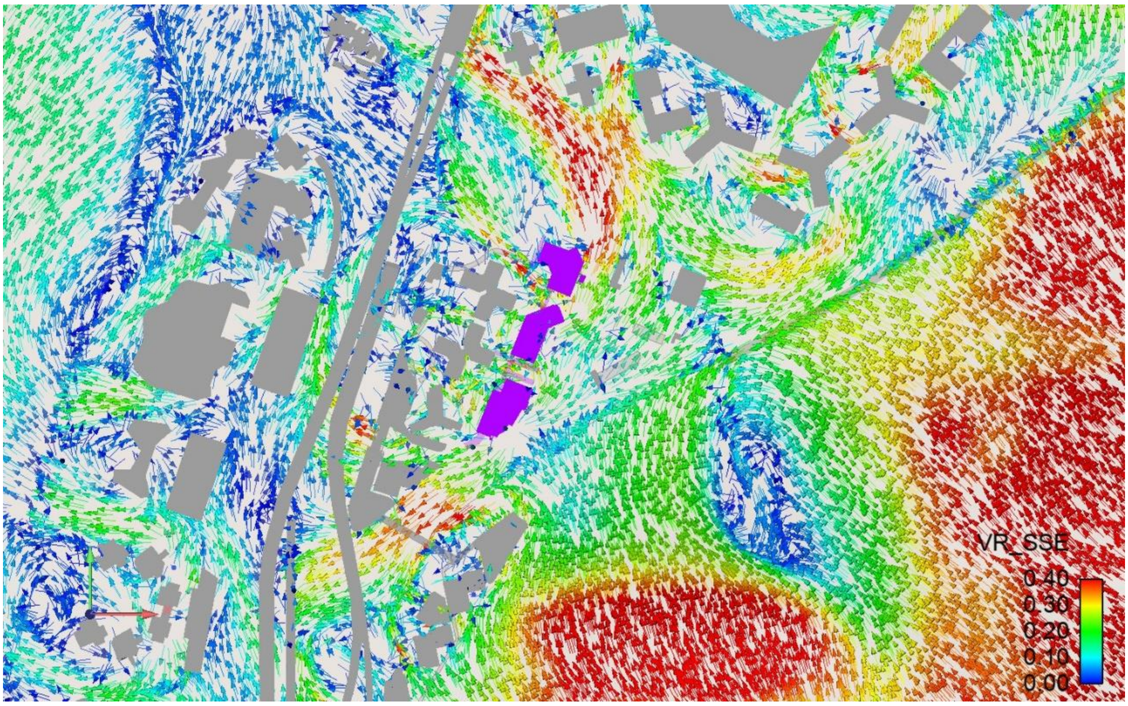


Figure C44 Vector Plot of VR under SSE Wind

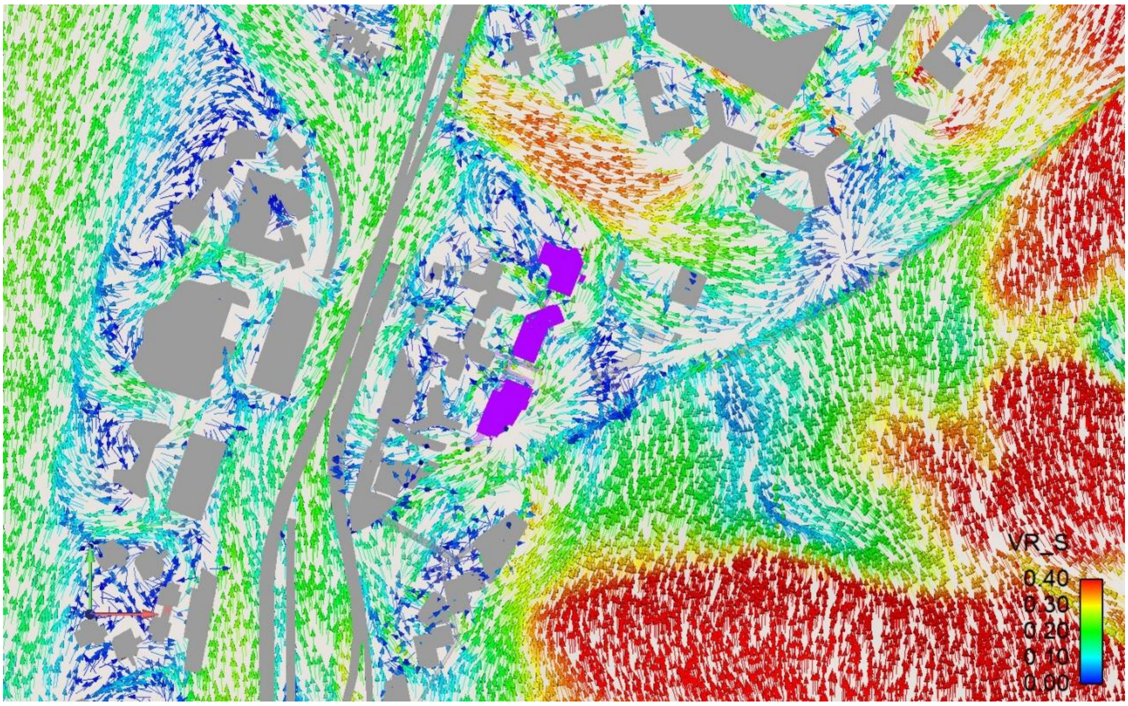


Figure C45 Vector Plot of VR under S Wind

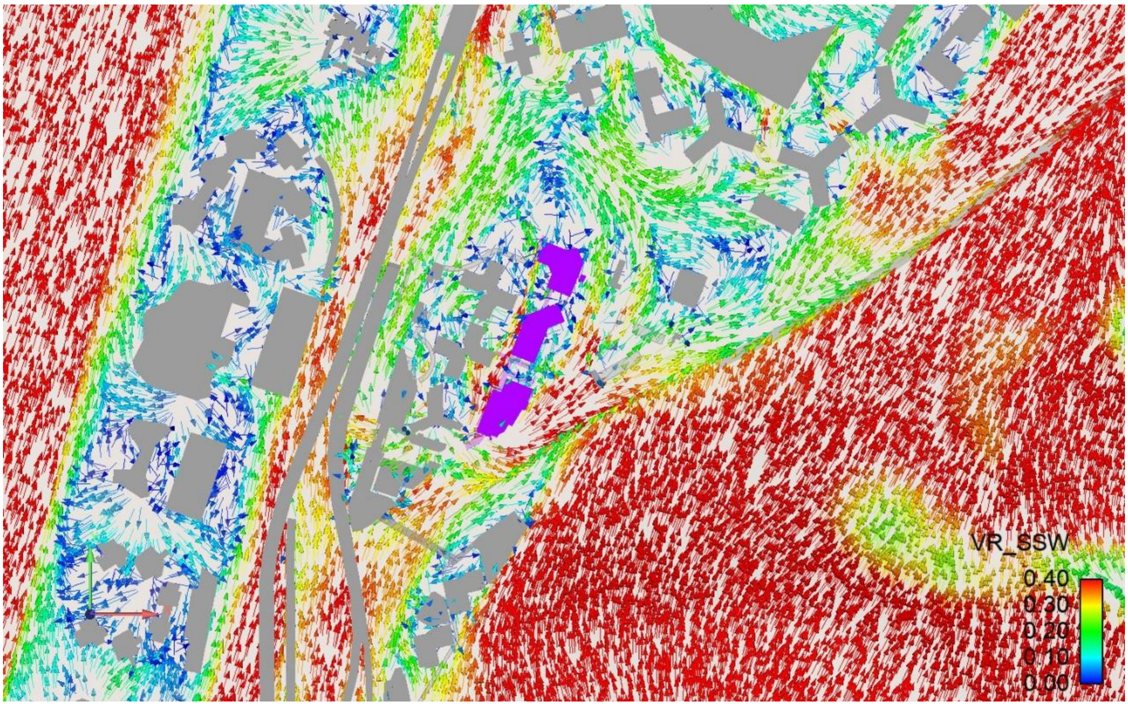


Figure C46 Vector Plot of VR under SSW Wind

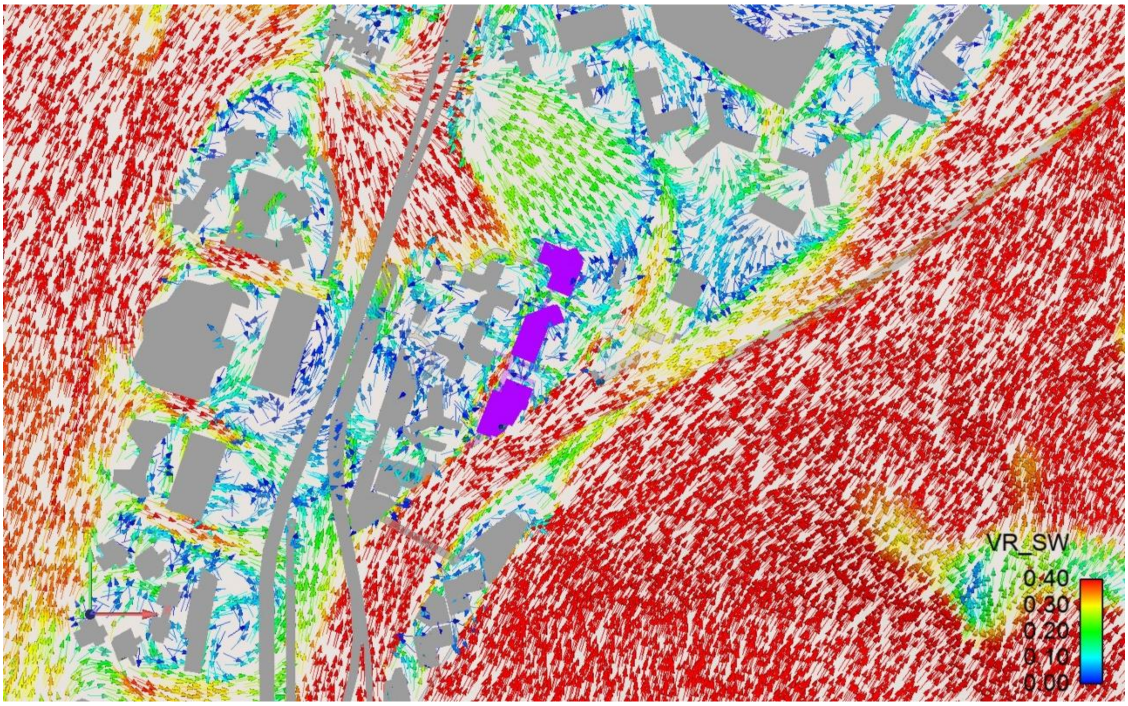


Figure C47 Vector Plot of VR under SW Wind

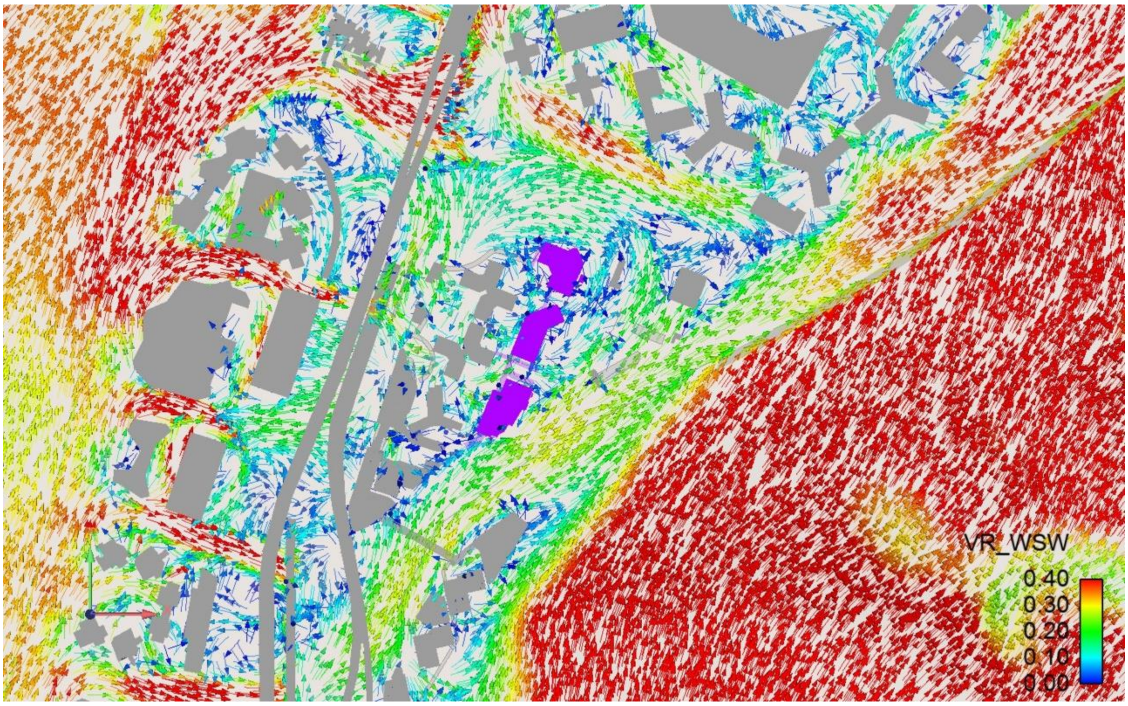


Figure C48 Vector Plot of VR under WSW Wind

Appendix C
Velocity Ratio at Test Points

C1 Baseline Scheme

Table B1 Velocity Ratio of Perimeter Test Points

Baseline	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
P1	0.14	0.06	0.03	0.07	0.38	0.11	0.06	0.05	0.15	0.16	0.11
P2	0.15	0.07	0.03	0.04	0.48	0.45	0.18	0.03	0.04	0.23	0.03
P3	0.08	0.09	0.05	0.03	0.08	0.14	0.05	0.04	0.22	0.06	0.06
P4	0.17	0.07	0.06	0.10	0.27	0.53	0.33	0.19	0.21	0.21	0.07
P5	0.09	0.08	0.07	0.13	0.26	0.37	0.29	0.20	0.22	0.12	0.09
P6	0.02	0.07	0.05	0.05	0.22	0.26	0.21	0.12	0.27	0.26	0.12
P7	0.04	0.05	0.21	0.04	0.24	0.33	0.29	0.18	0.26	0.26	0.11
P8	0.04	0.05	0.08	0.08	0.18	0.16	0.15	0.08	0.28	0.26	0.09
P9	0.05	0.03	0.28	0.11	0.10	0.23	0.20	0.13	0.30	0.28	0.07
P10	0.04	0.06	0.17	0.15	0.13	0.24	0.19	0.11	0.33	0.33	0.13
P11	0.03	0.03	0.35	0.24	0.25	0.17	0.15	0.11	0.33	0.33	0.18
P12	0.02	0.04	0.43	0.07	0.26	0.13	0.18	0.08	0.38	0.34	0.13
P13	0.03	0.03	0.27	0.11	0.23	0.18	0.22	0.04	0.41	0.32	0.05
P14	0.05	0.05	0.31	0.15	0.22	0.21	0.26	0.02	0.38	0.36	0.11
P15	0.09	0.05	0.18	0.13	0.18	0.13	0.11	0.10	0.32	0.21	0.10
P16	0.01	0.03	0.22	0.15	0.14	0.04	0.06	0.10	0.31	0.05	0.07
P17	0.04	0.01	0.32	0.26	0.11	0.32	0.23	0.23	0.33	0.20	0.13
P18	0.05	0.02	0.22	0.20	0.09	0.32	0.23	0.23	0.23	0.27	0.17
P19	0.08	0.07	0.38	0.22	0.21	0.34	0.20	0.24	0.32	0.40	0.21
P20	0.12	0.13	0.54	0.28	0.36	0.24	0.03	0.05	0.07	0.21	0.15

P21	0.09	0.11	0.42	0.20	0.29	0.08	0.08	0.08	0.09	0.15	0.12
P22	0.03	0.06	0.31	0.14	0.43	0.07	0.18	0.16	0.07	0.04	0.03
P23	0.04	0.07	0.21	0.10	0.34	0.17	0.28	0.24	0.06	0.08	0.03
P24	0.06	0.07	0.34	0.12	0.36	0.18	0.18	0.15	0.07	0.09	0.12
P25	0.09	0.04	0.16	0.14	0.34	0.22	0.04	0.05	0.04	0.02	0.06
P26	0.07	0.02	0.15	0.09	0.23	0.18	0.09	0.08	0.07	0.05	0.04
P27	0.06	0.02	0.20	0.07	0.11	0.16	0.17	0.10	0.07	0.04	0.06
P28	0.04	0.02	0.19	0.21	0.18	0.25	0.27	0.15	0.07	0.03	0.04
P29	0.12	0.08	0.11	0.15	0.17	0.22	0.22	0.14	0.05	0.18	0.05
P30	0.01	0.03	0.12	0.11	0.12	0.16	0.18	0.09	0.05	0.04	0.05
P31	0.01	0.03	0.02	0.11	0.23	0.26	0.23	0.13	0.04	0.07	0.05
P32	0.01	0.03	0.02	0.19	0.25	0.40	0.35	0.23	0.02	0.05	0.05
P33	0.11	0.05	0.06	0.02	0.12	0.26	0.10	0.12	0.02	0.10	0.05
P34	0.13	0.06	0.03	0.03	0.14	0.08	0.06	0.02	0.03	0.12	0.06
P35	0.14	0.09	0.02	0.04	0.12	0.10	0.08	0.03	0.03	0.13	0.11

Table B2 Velocity Ratio of Overall Test Points

Baseline	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
O1	0.06	0.25	0.47	0.25	0.51	0.38	0.15	0.13	0.35	0.36	0.03
O2	0.05	0.13	0.63	0.38	0.40	0.42	0.19	0.16	0.31	0.17	0.07
O3	0.13	0.01	0.06	0.03	0.07	0.07	0.10	0.19	0.42	0.21	0.04
O4	0.23	0.09	0.02	0.06	0.03	0.05	0.14	0.19	0.39	0.17	0.05
O5	0.27	0.17	0.08	0.06	0.03	0.04	0.14	0.19	0.37	0.09	0.19
O6	0.29	0.18	0.13	0.12	0.01	0.27	0.18	0.20	0.41	0.10	0.15
O7	0.29	0.18	0.10	0.07	0.12	0.09	0.03	0.20	0.40	0.10	0.07
O8	0.29	0.18	0.08	0.05	0.02	0.05	0.04	0.21	0.40	0.13	0.18
O9	0.28	0.19	0.06	0.07	0.02	0.06	0.02	0.21	0.42	0.30	0.15
O10	0.09	0.13	0.76	0.40	0.48	0.46	0.32	0.14	0.28	0.28	0.05
O11	0.02	0.05	0.12	0.14	0.05	0.20	0.15	0.18	0.37	0.30	0.07
O12	0.11	0.05	0.34	0.23	0.13	0.34	0.23	0.08	0.33	0.29	0.11
O13	0.16	0.07	0.03	0.07	0.03	0.30	0.24	0.06	0.12	0.10	0.08
O14	0.20	0.11	0.11	0.08	0.07	0.15	0.09	0.09	0.17	0.10	0.15
O15	0.20	0.11	0.13	0.03	0.09	0.04	0.05	0.12	0.21	0.09	0.07
O16	0.19	0.11	0.06	0.09	0.02	0.09	0.12	0.15	0.24	0.07	0.25
O17	0.19	0.11	0.06	0.02	0.06	0.08	0.09	0.06	0.23	0.11	0.15
O18	0.20	0.13	0.11	0.06	0.03	0.10	0.05	0.02	0.14	0.27	0.07
O19	0.26	0.17	0.12	0.16	0.06	0.02	0.05	0.13	0.20	0.36	0.15
O20	0.19	0.07	0.07	0.12	0.19	0.41	0.20	0.03	0.06	0.31	0.12
O21	0.18	0.10	0.12	0.07	0.05	0.02	0.02	0.02	0.10	0.22	0.10
O22	0.25	0.17	0.12	0.10	0.05	0.12	0.03	0.18	0.37	0.37	0.18

O23	0.24	0.17	0.08	0.14	0.01	0.12	0.08	0.11	0.33	0.41	0.15
O24	0.26	0.19	0.07	0.07	0.24	0.32	0.18	0.13	0.36	0.45	0.21
O25	0.03	0.03	0.20	0.26	0.19	0.33	0.29	0.15	0.24	0.15	0.30
O26	0.11	0.07	0.20	0.30	0.23	0.14	0.30	0.14	0.17	0.11	0.12
O27	0.03	0.04	0.18	0.22	0.21	0.18	0.32	0.21	0.17	0.11	0.14
O28	0.02	0.09	0.05	0.03	0.27	0.11	0.18	0.16	0.09	0.12	0.10
O29	0.05	0.08	0.07	0.02	0.15	0.29	0.18	0.28	0.22	0.18	0.12
O30	0.38	0.20	0.08	0.12	0.24	0.43	0.25	0.28	0.32	0.13	0.10
O31	0.13	0.04	0.08	0.12	0.25	0.45	0.30	0.34	0.17	0.24	0.25
O32	0.04	0.02	0.16	0.20	0.27	0.44	0.34	0.35	0.13	0.25	0.32
O33	0.06	0.04	0.11	0.18	0.28	0.44	0.39	0.37	0.09	0.25	0.35
O34	0.07	0.06	0.12	0.22	0.30	0.42	0.37	0.36	0.20	0.23	0.36
O35	0.08	0.09	0.15	0.17	0.32	0.40	0.35	0.37	0.26	0.18	0.34
O36	0.09	0.09	0.13	0.12	0.34	0.34	0.30	0.36	0.26	0.14	0.31
O37	0.10	0.06	0.11	0.11	0.21	0.25	0.23	0.33	0.25	0.18	0.27
O38	0.08	0.06	0.15	0.09	0.06	0.21	0.17	0.24	0.19	0.09	0.24
O39	0.14	0.18	0.11	0.16	0.03	0.18	0.15	0.24	0.15	0.12	0.12
O40	0.34	0.15	0.04	0.11	0.26	0.38	0.04	0.11	0.29	0.19	0.08
O41	0.13	0.04	0.14	0.21	0.26	0.44	0.05	0.26	0.19	0.26	0.16
O42	0.10	0.05	0.12	0.20	0.25	0.45	0.08	0.30	0.05	0.24	0.16
O43	0.10	0.08	0.10	0.19	0.28	0.45	0.32	0.36	0.08	0.22	0.17
O44	0.11	0.11	0.11	0.05	0.32	0.44	0.41	0.36	0.17	0.18	0.16
O45	0.12	0.09	0.08	0.10	0.39	0.37	0.30	0.35	0.21	0.13	0.10
O46	0.12	0.06	0.13	0.11	0.25	0.31	0.25	0.32	0.14	0.13	0.04

O47	0.08	0.06	0.15	0.15	0.13	0.16	0.20	0.28	0.16	0.14	0.02
O48	0.13	0.07	0.04	0.06	0.06	0.20	0.24	0.24	0.07	0.06	0.06
O49	0.33	0.15	0.09	0.19	0.25	0.30	0.13	0.04	0.23	0.36	0.09
O50	0.19	0.06	0.11	0.14	0.27	0.24	0.06	0.03	0.18	0.25	0.12
O51	0.13	0.07	0.06	0.06	0.13	0.26	0.08	0.05	0.07	0.19	0.15
O52	0.15	0.12	0.06	0.10	0.19	0.41	0.27	0.24	0.03	0.13	0.13
O53	0.08	0.05	0.16	0.13	0.42	0.33	0.27	0.15	0.05	0.06	0.10
O54	0.03	0.05	0.10	0.04	0.10	0.24	0.20	0.16	0.12	0.33	0.09
O55	0.12	0.18	0.47	0.14	0.39	0.17	0.22	0.17	0.15	0.11	0.14
O56	0.03	0.06	0.10	0.07	0.17	0.22	0.22	0.20	0.19	0.34	0.18
O57	0.03	0.01	0.10	0.12	0.23	0.15	0.18	0.09	0.18	0.24	0.16
O58	0.11	0.12	0.35	0.14	0.27	0.09	0.19	0.08	0.25	0.28	0.22
O59	0.15	0.16	0.49	0.24	0.33	0.07	0.16	0.07	0.26	0.31	0.23
O60	0.16	0.16	0.42	0.25	0.24	0.03	0.08	0.02	0.08	0.13	0.08
O61	0.02	0.01	0.17	0.13	0.32	0.32	0.31	0.18	0.08	0.07	0.11
O62	0.10	0.07	0.25	0.09	0.14	0.24	0.24	0.13	0.04	0.13	0.06
O63	0.04	0.02	0.14	0.09	0.06	0.27	0.21	0.13	0.05	0.10	0.07
O64	0.08	0.06	0.20	0.05	0.12	0.23	0.21	0.09	0.08	0.13	0.03
O65	0.02	0.02	0.08	0.04	0.03	0.25	0.20	0.08	0.08	0.15	0.10
O66	0.01	0.02	0.03	0.06	0.14	0.17	0.09	0.05	0.03	0.08	0.04
O67	0.09	0.08	0.26	0.10	0.22	0.05	0.10	0.03	0.29	0.42	0.23
O68	0.04	0.10	0.23	0.12	0.29	0.15	0.11	0.06	0.14	0.21	0.14
O69	0.19	0.18	0.24	0.21	0.42	0.08	0.17	0.14	0.32	0.50	0.27
O70	0.26	0.23	0.54	0.31	0.53	0.28	0.11	0.09	0.36	0.52	0.29

O71	0.28	0.23	0.64	0.34	0.52	0.39	0.21	0.15	0.31	0.46	0.22
O72	0.29	0.23	0.67	0.31	0.52	0.40	0.36	0.07	0.24	0.49	0.20
O73	0.24	0.22	0.61	0.26	0.50	0.41	0.34	0.15	0.27	0.41	0.16
O74	0.16	0.19	0.71	0.33	0.50	0.47	0.31	0.06	0.26	0.33	0.08
O75	0.17	0.25	0.57	0.27	0.53	0.44	0.30	0.10	0.20	0.40	0.17
O76	0.43	0.34	0.54	0.36	0.61	0.11	0.21	0.10	0.30	0.46	0.35
O77	0.41	0.32	0.49	0.30	0.54	0.08	0.19	0.12	0.30	0.44	0.29
O78	0.43	0.34	0.51	0.32	0.53	0.07	0.16	0.12	0.32	0.41	0.24
O79	0.42	0.33	0.46	0.32	0.52	0.08	0.13	0.09	0.31	0.32	0.23
O80	0.41	0.33	0.39	0.32	0.54	0.12	0.10	0.12	0.22	0.23	0.25
O81	0.40	0.33	0.43	0.33	0.56	0.21	0.10	0.20	0.15	0.19	0.25
O82	0.39	0.32	0.45	0.33	0.54	0.29	0.20	0.11	0.12	0.14	0.24
O83	0.43	0.35	0.63	0.34	0.59	0.38	0.21	0.04	0.09	0.08	0.19
O84	0.26	0.24	0.40	0.22	0.52	0.33	0.09	0.01	0.07	0.09	0.18
O85	0.07	0.09	0.25	0.12	0.31	0.27	0.04	0.03	0.10	0.18	0.27
O86	0.06	0.05	0.13	0.06	0.17	0.23	0.02	0.04	0.11	0.22	0.27
O87	0.21	0.19	0.37	0.11	0.29	0.25	0.05	0.06	0.14	0.41	0.27
O88	0.14	0.07	0.06	0.04	0.21	0.20	0.12	0.09	0.26	0.46	0.28
O89	0.34	0.25	0.43	0.26	0.26	0.23	0.11	0.13	0.30	0.28	0.17
O90	0.24	0.22	0.19	0.09	0.21	0.14	0.14	0.16	0.31	0.33	0.07
O91	0.40	0.37	0.27	0.16	0.38	0.12	0.26	0.29	0.45	0.57	0.15
O92	0.43	0.38	0.39	0.20	0.44	0.18	0.21	0.28	0.42	0.53	0.10
O93	0.41	0.36	0.42	0.21	0.47	0.19	0.21	0.29	0.38	0.42	0.06
O94	0.36	0.30	0.38	0.24	0.45	0.22	0.23	0.26	0.08	0.07	0.05

O95	0.06	0.06	0.25	0.24	0.08	0.21	0.18	0.05	0.16	0.07	0.01
O96	0.12	0.06	0.12	0.15	0.02	0.20	0.14	0.08	0.20	0.14	0.12
O97	0.04	0.02	0.06	0.03	0.03	0.18	0.12	0.07	0.17	0.06	0.09
O98	0.07	0.02	0.04	0.03	0.04	0.15	0.13	0.04	0.10	0.07	0.12
O99	0.19	0.09	0.05	0.11	0.18	0.07	0.08	0.02	0.04	0.02	0.20
O100	0.11	0.06	0.10	0.03	0.15	0.18	0.14	0.04	0.06	0.05	0.13
O101	0.14	0.07	0.11	0.07	0.11	0.13	0.12	0.12	0.11	0.04	0.22
O102	0.04	0.05	0.03	0.01	0.03	0.03	0.02	0.02	0.10	0.05	0.08
O103	0.17	0.12	0.22	0.11	0.12	0.26	0.20	0.13	0.12	0.06	0.08
O104	0.08	0.04	0.06	0.02	0.02	0.06	0.04	0.02	0.02	0.04	0.07
O105	0.19	0.10	0.04	0.19	0.43	0.38	0.31	0.23	0.06	0.21	0.05
O106	0.05	0.06	0.03	0.03	0.15	0.12	0.07	0.06	0.02	0.04	0.05
O107	0.02	0.02	0.15	0.04	0.04	0.15	0.14	0.11	0.08	0.03	0.02
O108	0.02	0.04	0.27	0.10	0.13	0.16	0.08	0.11	0.11	0.08	0.14
O109	0.01	0.05	0.14	0.05	0.07	0.10	0.07	0.08	0.05	0.03	0.04
O110	0.03	0.02	0.12	0.04	0.13	0.08	0.19	0.04	0.11	0.08	0.08
O111	0.05	0.05	0.33	0.09	0.16	0.27	0.23	0.09	0.22	0.08	0.21
O112	0.11	0.05	0.26	0.13	0.18	0.23	0.27	0.09	0.09	0.11	0.20
O113	0.02	0.02	0.14	0.12	0.21	0.11	0.23	0.03	0.16	0.06	0.06
O114	0.25	0.25	0.18	0.11	0.03	0.11	0.06	0.08	0.33	0.25	0.18

C2 Proposed Scheme

Table B3 Velocity Ratio of Perimeter Test Points

Proposed	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
P1	0.13	0.06	0.05	0.04	0.14	0.06	0.08	0.07	0.16	0.17	0.12
P2	0.14	0.07	0.06	0.04	0.41	0.23	0.07	0.02	0.06	0.24	0.06
P3	0.06	0.06	0.02	0.02	0.09	0.11	0.05	0.05	0.28	0.07	0.02
P4	0.13	0.07	0.09	0.03	0.21	0.47	0.31	0.17	0.27	0.14	0.02
P5	0.09	0.07	0.17	0.14	0.37	0.43	0.30	0.20	0.27	0.11	0.08
P6	0.03	0.07	0.11	0.03	0.16	0.34	0.19	0.10	0.33	0.29	0.14
P7	0.05	0.03	0.16	0.07	0.21	0.34	0.29	0.16	0.35	0.28	0.12
P8	0.05	0.02	0.05	0.08	0.20	0.14	0.06	0.14	0.37	0.27	0.09
P9	0.05	0.07	0.34	0.04	0.15	0.27	0.24	0.16	0.35	0.28	0.08
P10	0.02	0.03	0.11	0.11	0.41	0.24	0.24	0.18	0.42	0.36	0.14
P11	0.07	0.02	0.34	0.18	0.14	0.19	0.10	0.06	0.47	0.41	0.19
P12	0.08	0.06	0.22	0.06	0.11	0.13	0.19	0.13	0.53	0.39	0.14
P13	0.09	0.04	0.30	0.08	0.21	0.18	0.17	0.09	0.52	0.36	0.05
P14	0.09	0.04	0.28	0.12	0.21	0.21	0.22	0.09	0.48	0.36	0.14
P15	0.11	0.04	0.26	0.15	0.22	0.18	0.12	0.07	0.36	0.22	0.12
P16	0.06	0.02	0.20	0.16	0.17	0.11	0.08	0.13	0.30	0.20	0.08
P17	0.03	0.01	0.26	0.21	0.16	0.34	0.24	0.27	0.34	0.23	0.12
P18	0.04	0.01	0.14	0.14	0.06	0.35	0.22	0.24	0.24	0.13	0.15
P19	0.05	0.03	0.21	0.12	0.13	0.24	0.11	0.10	0.13	0.22	0.11
P20	0.07	0.11	0.56	0.18	0.34	0.22	0.03	0.04	0.34	0.39	0.18

P21	0.03	0.05	0.53	0.11	0.37	0.11	0.09	0.10	0.35	0.38	0.17
P22	0.04	0.06	0.40	0.10	0.39	0.08	0.19	0.16	0.30	0.10	0.04
P23	0.05	0.07	0.19	0.05	0.31	0.20	0.30	0.23	0.23	0.08	0.06
P24	0.10	0.09	0.24	0.14	0.33	0.10	0.19	0.15	0.12	0.12	0.11
P25	0.06	0.05	0.06	0.15	0.36	0.22	0.04	0.05	0.09	0.08	0.10
P26	0.02	0.01	0.15	0.08	0.25	0.18	0.11	0.11	0.04	0.02	0.02
P27	0.01	0.04	0.24	0.03	0.11	0.21	0.21	0.14	0.05	0.06	0.06
P28	0.02	0.02	0.19	0.21	0.13	0.27	0.29	0.18	0.03	0.02	0.06
P29	0.17	0.08	0.17	0.18	0.17	0.23	0.24	0.14	0.02	0.13	0.08
P30	0.01	0.01	0.18	0.15	0.14	0.20	0.20	0.09	0.05	0.04	0.04
P31	0.01	0.03	0.08	0.10	0.22	0.27	0.23	0.13	0.08	0.07	0.02
P32	0.01	0.04	0.05	0.13	0.35	0.46	0.41	0.24	0.04	0.03	0.01
P33	0.09	0.07	0.05	0.02	0.20	0.32	0.22	0.16	0.04	0.09	0.03
P34	0.12	0.06	0.04	0.02	0.10	0.06	0.06	0.03	0.03	0.12	0.05
P35	0.09	0.07	0.05	0.02	0.11	0.05	0.06	0.04	0.03	0.09	0.06

Table B4 Velocity Ratio of Overall Test Points

Proposed	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
O1	0.26	0.27	0.49	0.27	0.39	0.38	0.16	0.12	0.41	0.30	0.04
O2	0.06	0.14	0.68	0.36	0.40	0.40	0.18	0.17	0.33	0.14	0.10
O3	0.18	0.01	0.08	0.04	0.04	0.08	0.08	0.22	0.43	0.18	0.07
O4	0.25	0.12	0.03	0.13	0.01	0.06	0.13	0.20	0.38	0.14	0.06
O5	0.29	0.18	0.13	0.10	0.04	0.04	0.15	0.20	0.37	0.07	0.16
O6	0.29	0.19	0.15	0.09	0.02	0.26	0.21	0.21	0.42	0.09	0.15
O7	0.29	0.19	0.16	0.08	0.07	0.12	0.10	0.22	0.41	0.07	0.12
O8	0.29	0.19	0.07	0.04	0.05	0.07	0.09	0.24	0.41	0.09	0.08
O9	0.28	0.19	0.07	0.06	0.15	0.08	0.05	0.25	0.44	0.30	0.20
O10	0.03	0.10	0.76	0.35	0.43	0.40	0.22	0.14	0.31	0.24	0.06
O11	0.12	0.04	0.15	0.13	0.08	0.13	0.16	0.22	0.40	0.25	0.08
O12	0.17	0.05	0.43	0.21	0.18	0.33	0.23	0.06	0.31	0.27	0.11
O13	0.18	0.06	0.10	0.08	0.03	0.29	0.25	0.08	0.18	0.08	0.06
O14	0.20	0.09	0.08	0.02	0.07	0.10	0.09	0.10	0.21	0.09	0.13
O15	0.20	0.10	0.08	0.02	0.03	0.07	0.05	0.12	0.24	0.07	0.05
O16	0.19	0.10	0.16	0.12	0.12	0.07	0.12	0.17	0.27	0.09	0.26
O17	0.20	0.11	0.04	0.01	0.03	0.11	0.06	0.11	0.26	0.13	0.15
O18	0.19	0.13	0.11	0.05	0.02	0.08	0.05	0.02	0.16	0.22	0.07
O19	0.26	0.17	0.12	0.13	0.06	0.09	0.12	0.05	0.24	0.35	0.16
O20	0.18	0.07	0.09	0.08	0.33	0.27	0.09	0.05	0.07	0.31	0.13
O21	0.18	0.10	0.16	0.06	0.03	0.03	0.02	0.04	0.11	0.23	0.10
O22	0.24	0.18	0.10	0.10	0.13	0.13	0.11	0.21	0.39	0.36	0.20

O23	0.24	0.18	0.11	0.16	0.05	0.25	0.14	0.17	0.35	0.40	0.15
O24	0.26	0.19	0.05	0.08	0.27	0.32	0.15	0.14	0.37	0.45	0.19
O25	0.03	0.03	0.19	0.25	0.19	0.33	0.28	0.21	0.23	0.16	0.29
O26	0.11	0.07	0.19	0.29	0.27	0.14	0.26	0.15	0.26	0.11	0.13
O27	0.03	0.04	0.15	0.21	0.25	0.19	0.25	0.23	0.18	0.14	0.15
O28	0.02	0.10	0.05	0.02	0.27	0.11	0.16	0.18	0.10	0.13	0.09
O29	0.04	0.08	0.05	0.03	0.12	0.28	0.15	0.28	0.22	0.16	0.11
O30	0.37	0.20	0.07	0.14	0.24	0.43	0.29	0.32	0.32	0.13	0.09
O31	0.12	0.04	0.08	0.12	0.24	0.45	0.35	0.36	0.17	0.24	0.25
O32	0.04	0.02	0.16	0.18	0.26	0.44	0.38	0.38	0.18	0.25	0.32
O33	0.06	0.04	0.10	0.18	0.30	0.44	0.40	0.39	0.11	0.24	0.34
O34	0.07	0.08	0.14	0.22	0.33	0.42	0.36	0.38	0.15	0.22	0.35
O35	0.07	0.10	0.13	0.16	0.35	0.39	0.35	0.39	0.25	0.16	0.32
O36	0.08	0.10	0.08	0.11	0.34	0.34	0.31	0.37	0.23	0.16	0.28
O37	0.09	0.06	0.05	0.11	0.18	0.26	0.24	0.33	0.18	0.19	0.24
O38	0.08	0.06	0.06	0.08	0.06	0.21	0.17	0.24	0.14	0.09	0.19
O39	0.15	0.18	0.07	0.15	0.02	0.19	0.16	0.27	0.12	0.10	0.08
O40	0.33	0.15	0.09	0.15	0.22	0.40	0.04	0.08	0.31	0.18	0.09
O41	0.13	0.04	0.14	0.18	0.23	0.44	0.09	0.28	0.23	0.25	0.17
O42	0.10	0.05	0.11	0.20	0.24	0.45	0.15	0.34	0.08	0.24	0.15
O43	0.09	0.09	0.14	0.18	0.28	0.46	0.37	0.38	0.06	0.21	0.17
O44	0.10	0.12	0.11	0.07	0.33	0.44	0.40	0.38	0.12	0.17	0.15
O45	0.11	0.10	0.04	0.10	0.39	0.37	0.29	0.37	0.20	0.11	0.08
O46	0.12	0.06	0.13	0.07	0.21	0.31	0.25	0.34	0.20	0.21	0.04

O47	0.07	0.06	0.10	0.05	0.12	0.18	0.25	0.30	0.05	0.11	0.04
O48	0.13	0.08	0.06	0.05	0.06	0.21	0.28	0.25	0.02	0.07	0.04
O49	0.31	0.16	0.12	0.19	0.29	0.30	0.09	0.07	0.26	0.36	0.09
O50	0.18	0.07	0.10	0.17	0.31	0.26	0.05	0.03	0.21	0.27	0.13
O51	0.13	0.07	0.08	0.10	0.13	0.29	0.07	0.06	0.04	0.18	0.15
O52	0.14	0.12	0.05	0.06	0.21	0.42	0.34	0.25	0.04	0.12	0.12
O53	0.07	0.06	0.19	0.13	0.40	0.35	0.23	0.16	0.06	0.05	0.11
O54	0.03	0.04	0.05	0.06	0.09	0.27	0.14	0.16	0.18	0.32	0.12
O55	0.13	0.18	0.52	0.07	0.40	0.17	0.24	0.17	0.06	0.10	0.16
O56	0.04	0.05	0.07	0.07	0.16	0.24	0.20	0.20	0.24	0.33	0.18
O57	0.02	0.01	0.13	0.11	0.23	0.19	0.18	0.10	0.20	0.25	0.16
O58	0.12	0.14	0.40	0.12	0.28	0.12	0.17	0.09	0.24	0.30	0.22
O59	0.15	0.17	0.59	0.24	0.34	0.10	0.15	0.08	0.27	0.34	0.23
O60	0.15	0.17	0.40	0.20	0.24	0.05	0.07	0.05	0.12	0.17	0.11
O61	0.02	0.02	0.20	0.16	0.31	0.35	0.32	0.17	0.28	0.08	0.08
O62	0.13	0.07	0.29	0.11	0.14	0.26	0.25	0.12	0.28	0.10	0.08
O63	0.06	0.02	0.24	0.15	0.08	0.28	0.22	0.15	0.36	0.12	0.09
O64	0.11	0.06	0.31	0.05	0.11	0.26	0.21	0.08	0.23	0.13	0.04
O65	0.06	0.03	0.15	0.04	0.03	0.27	0.19	0.11	0.19	0.17	0.11
O66	0.03	0.02	0.10	0.04	0.11	0.20	0.08	0.05	0.14	0.10	0.05
O67	0.05	0.04	0.10	0.04	0.20	0.08	0.10	0.04	0.38	0.43	0.24
O68	0.08	0.11	0.07	0.03	0.29	0.17	0.12	0.05	0.39	0.24	0.14
O69	0.15	0.18	0.26	0.12	0.41	0.10	0.17	0.14	0.46	0.51	0.28
O70	0.26	0.23	0.58	0.23	0.50	0.27	0.11	0.12	0.46	0.53	0.30

O71	0.27	0.23	0.70	0.28	0.50	0.40	0.22	0.19	0.32	0.46	0.22
O72	0.24	0.22	0.72	0.26	0.50	0.39	0.36	0.09	0.31	0.47	0.19
O73	0.16	0.23	0.65	0.21	0.48	0.41	0.34	0.14	0.35	0.40	0.13
O74	0.05	0.17	0.75	0.29	0.49	0.46	0.31	0.13	0.30	0.34	0.08
O75	0.21	0.26	0.59	0.24	0.43	0.43	0.30	0.17	0.29	0.41	0.16
O76	0.45	0.34	0.58	0.42	0.61	0.12	0.18	0.13	0.33	0.44	0.34
O77	0.44	0.34	0.55	0.40	0.59	0.08	0.20	0.14	0.33	0.43	0.27
O78	0.45	0.35	0.55	0.40	0.58	0.06	0.17	0.14	0.35	0.40	0.24
O79	0.44	0.34	0.52	0.39	0.56	0.08	0.14	0.14	0.37	0.31	0.24
O80	0.42	0.33	0.48	0.38	0.55	0.11	0.10	0.13	0.34	0.26	0.26
O81	0.41	0.33	0.50	0.39	0.56	0.20	0.10	0.15	0.19	0.23	0.26
O82	0.40	0.32	0.49	0.38	0.54	0.28	0.19	0.17	0.05	0.20	0.24
O83	0.45	0.36	0.62	0.41	0.61	0.38	0.26	0.08	0.05	0.13	0.20
O84	0.30	0.26	0.47	0.25	0.51	0.35	0.07	0.04	0.03	0.14	0.16
O85	0.08	0.09	0.29	0.12	0.26	0.28	0.05	0.04	0.09	0.25	0.26
O86	0.10	0.08	0.11	0.10	0.09	0.27	0.04	0.02	0.10	0.29	0.27
O87	0.21	0.18	0.39	0.17	0.29	0.26	0.11	0.06	0.18	0.46	0.27
O88	0.10	0.06	0.13	0.04	0.26	0.22	0.13	0.09	0.26	0.48	0.28
O89	0.35	0.26	0.47	0.22	0.29	0.24	0.11	0.14	0.24	0.28	0.17
O90	0.29	0.23	0.26	0.08	0.23	0.16	0.14	0.18	0.28	0.34	0.08
O91	0.40	0.37	0.22	0.15	0.41	0.14	0.27	0.30	0.42	0.57	0.16
O92	0.43	0.38	0.36	0.26	0.46	0.17	0.22	0.28	0.40	0.54	0.11
O93	0.41	0.36	0.39	0.29	0.49	0.19	0.21	0.29	0.39	0.44	0.09
O94	0.35	0.30	0.34	0.30	0.46	0.22	0.23	0.28	0.27	0.07	0.03

O95	0.08	0.05	0.19	0.22	0.12	0.24	0.20	0.12	0.17	0.06	0.05
O96	0.09	0.06	0.07	0.16	0.03	0.21	0.17	0.08	0.26	0.12	0.13
O97	0.05	0.01	0.05	0.02	0.02	0.30	0.20	0.11	0.30	0.06	0.09
O98	0.09	0.04	0.08	0.01	0.05	0.22	0.08	0.03	0.22	0.07	0.05
O99	0.19	0.08	0.16	0.08	0.23	0.10	0.08	0.04	0.07	0.01	0.20
O100	0.10	0.05	0.09	0.03	0.15	0.23	0.10	0.05	0.13	0.09	0.13
O101	0.14	0.06	0.04	0.03	0.10	0.07	0.07	0.12	0.11	0.11	0.23
O102	0.06	0.04	0.04	0.01	0.02	0.03	0.02	0.02	0.12	0.01	0.11
O103	0.17	0.12	0.21	0.10	0.12	0.29	0.22	0.14	0.19	0.09	0.09
O104	0.12	0.04	0.07	0.01	0.01	0.11	0.02	0.01	0.10	0.07	0.08
O105	0.20	0.10	0.15	0.10	0.38	0.44	0.33	0.22	0.07	0.22	0.05
O106	0.05	0.08	0.05	0.04	0.08	0.13	0.07	0.06	0.02	0.08	0.05
O107	0.01	0.01	0.09	0.04	0.05	0.11	0.13	0.08	0.15	0.04	0.04
O108	0.03	0.03	0.19	0.11	0.13	0.18	0.12	0.05	0.20	0.10	0.16
O109	0.01	0.03	0.15	0.04	0.06	0.11	0.07	0.05	0.05	0.03	0.03
O110	0.02	0.03	0.09	0.05	0.10	0.14	0.16	0.06	0.19	0.05	0.08
O111	0.05	0.05	0.17	0.15	0.10	0.27	0.22	0.10	0.13	0.09	0.22
O112	0.15	0.05	0.30	0.18	0.28	0.32	0.34	0.14	0.19	0.13	0.23
O113	0.00	0.01	0.36	0.06	0.25	0.10	0.24	0.08	0.06	0.04	0.05
O114	0.25	0.25	0.14	0.15	0.04	0.12	0.03	0.12	0.36	0.25	0.18