9 WIND ANALYSIS AND PEDESTRIAN COMFORT

INTRODUCTION

9.1 This chapter assesses the microclimate effects of the proposed mixed use development on the application ite. The application site is divided into North and South site, each having clusters of buildings arranged around a number of communal spaces for the pedestrians. Site analysis shows that immediate surrounding buildings comprise mid-rise factories, warehouses and some offices. The assessment will summarise the results of the wind environment assessment for pedestrian comfort and safety. The assessment methodology, legislative and policy context, assessment of potential effects in the foreseen scenario and recommendations for mitigation in case of any adverse impacts will also be included in this chapter.

LEGISLATION, PLANNING, POLICY AND GUIDANCE

National Planning Policy

9.2 There is no national planning policy related to wind microclimate around buildings.

9.3 The Guidance on Tall Buildings (EH, 2007) sets out how English Heritage (EH) evaluate proposals for tall buildings, which is still the most relevant. Paragraph 4.1.9 under the criteria for evaluation states that applicants seeking planning permission should ensure that the following criteria are addressed: "*The effect on the local environment, including microclimate, overshadowing, night-time appearance, vehicle movements and the environment and amenity of those in the vicinity of the building."*

Local Planning Policy – Welwyn Hatfield District Plan (Supplementary Design Guidance Feb 2005)

9.4 Policy D3 Continuity and Enclosure: The Council will expect all new development to incorporate the principles of continuity and enclosure to distinguish between public and private spaces

"For open space to be successful rather than left over space, it needs to be defined and enclosed by buildings, structures and landscape. The key to this is the relationship between buildings on a street and between buildings and the street. Buildings which have a continuous building line along a street

frontage with private space within backyards or courtyards are often more successful than those that stand in the middle of a site."

9.5 Policy D4 Quality of the Public Realm: The Council will expect new development where appropriate to either create or enhance the public realm

"*that the design takes into account the micro climate (i.e. the daylight and sunlight, the wind, the temperature and frost pockets), as this will influence both the orientation and design of buildings and the degree of enclosure; all public spaces should be protected from draughts from buildings. Deciduous trees and climbers can filter heat and pollution in summer and allow winter sunlight."*

Guidance

9.6 The BRE Digest DG 520 Wind Microclimate around Buildings explains general principles of wind flow patterns around buildings to assist designers, planners and developers in developing massing and layout techniques to mitigate unacceptable wind speeds. The BRE Digest also gives advice on methods and criteria for assessing pedestrian wind comfort.

9.7 In the UK, most wind comfort assessments use the Lawson criteria which have become the widely accepted environmental criteria for the assessment of pedestrian comfort and safety. These criteria have been developed by T.V. Lawson (Ref 1).

9.8 The Best Practice Guidelines for Computational Fluid Dynamics Simulation of Flows in Urban Environment COST Action 732 (Ref 2) provides best practice guidelines for undertaking CFD simulations and their application to the prediction of flow and transport processes in urban environments.

ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

9.9 Price & Myers have been involved in CFD analysis for several years and have significant relevant expertise. The analysis was carried out by Deepika Singhal. Deepika has a Masters Degree in Sustainable Environmental Design. She has over 10 years' experience in the built environment including 6 years' experience of environmental design of buildings, with a specific focus on microclimatic design and impact assessments including wind modelling and analysis of pedestrian comfort and safety.

9.10 The methodology for the assessment uses Computational Fluid Dynamics (CFD) to analyse the effect on wind behaviour of the proposed buildings and compare resultant wind speeds with Lawson's criteria for pedestrian comfort and safety.

9.11 A 3-dimensional model of the proposed development is created using CAD software. The extent of the model comprises the Site and the surrounding context within a radius of 500m. It also includes proposed and committed developments detailed as per the information available on the Council's website. The model was constructed based on the Z map provided by the design team and the information available from the Council's website.

9.12 The virtual wind environment is simulated in Star CCM+ CFD software. The air surrounding the 3D model is divided into cells using a finite volume mesh. Fundamental physics equations are solved iteratively over time over all turbulent scales to yield statistically steady solution of flow variables. The Reynolds Averaged Navier Stokes (RANS) realizable $\kappa - \varepsilon$ physics models were selected to model turbulence due to industry wide consensus of an adequate level of accuracy. Wind speed increases with height; it is important that this is captured in the model. Logarithmic equations are used to account for this, in order to accurately simulate the natural environment. This also allows the surface roughness to be accounted for. Through this process, the CFD software will predict wind speed at any point or a horizontal surface in the model.

9.13 The assessment methodology combines the use of the Computational Fluid Dynamics (CFD) to predict wind velocities around the proposed development, ten years hourly wind data from London City Airport meteorological station and the recommended Lawson's criteria for pedestrian comfort and safety.

Lawson's Criteria for Pedestrian Safety and Comfort

9.14 A methodology for assessing acceptable wind speeds has been developed by T.V Lawson at Bristol University (Ref 1). This is widely accepted as an appropriate methodology for pedestrian comfort analysis in the UK.

9.15 The Lawson criteria is used in this study to assess the effects of local wind environment on pedestrian comfort and safety. The criteria outline different mean wind speeds acceptable for different types of pedestrian activity to maintain safety and comfort around the Site.

Significance Criteria

9.16 To maintain pedestrian comfort, the Lawson criteria indicate that the threshold hourly average wind speeds for each pedestrian activity should not be exceeded for more than a certain number of times (Table 9.2). This methodology of using frequencies and associating a different wind speed for each use is considered to be more practical as explained in T.V.Lawson "The Determination of the Wind Environment of a Building Complex before Construction". (Ref 2).

9.17 The frequency of occurrence of the maximum acceptable wind speeds indicates the likely duration of it and the effect it may have on the pedestrians. The Bristol Method stipulates criteria of acceptability to maintain pedestrian comfort for different activities and safety. It relates frequency of occurrence to the hourly average wind speeds ranges of the Beaufort scale. (Table 9.1)

Table 9.1 The Beaufort Scale

Beaufort Force	Hourly Average Wind Speed (m/s)	Description of Wind
0	< 0.45	Calm
1	0.45-1.55	Light
2	1.55-3.35	Light
3	3.35-5.60	Light
4	5.60-8.25	Moderate
5	8.25-10.95	Fresh
6	10.95-14.10	Strong
7	14.10-17.20	Strong
8	17.20-20.80	Gale
9	20.80-24.35	Gale
10	24.35- 28.40	Strong Gale
11	28.40-32.40	Storm
12	>32.40	Hurricane

Table 9.2 Lawson's Comfort Assessment Criteria

Activity	Beaufort Range	Frequency of Occurrence (% of time)
Pedestrian Leisure Walking	B4 (5.60 - 8.25 m/s)	4%
Pedestrian Standing	B3 (3.35 - 5.60 m/s)	6%
Pedestrian Sitting	B3 (3.35 - 5.60 m/s)	1%

9.18 Lawson's safety criteria identifies areas where pedestrians could find walking difficult, stumble or fall. According to the criteria, the exceedance of the acceptable wind speed on Beaufort scale should not occur for more than 1 hour per year or 0.01% of the time, for pedestrian safety. (Table 9.3)

Table 9.3 Lawson's Safety Assessment Criteria

Activity	Beaufort Range	Frequency of Occurrence (% of time)
Pedestrian Safety	B6 (10.95-14.10 m/s)	0.01%

CFD Simulation and Frequency Analysis

9.19 As the Lawson Criteria are based on frequency of occurrence of wind speeds rather than absolute wind speeds alone, a procedure to combine all occurrences on the Site is required:

- Representative locations at which to evaluate pedestrian comfort are identified. These locations are defined as monitoring points at 1.5 metre height from ground level.

- A reference wind speed from the meteorological station, measured at 10 metre height, is used to generate a logarithmic wind velocity profile taking into account the roughness of the surroundings of the Site.

- Using the generated velocity profile, twelve different wind directions are simulated, spaced at 30° intervals to represent all wind directions. The results are generated in the form of CFD contour plots at 1.5 m above the ground level and the magnitude of the wind velocity at each measurement point is extracted for every wind direction.

- A wind speed factor is derived from the simulated wind directions at each measurement point.

- The wind speed factor is scaled by the hourly weather data measured at the metrological station to derive the resulting wind speed experienced at each measurement point.

- A statistical frequency distribution is performed on all the hourly wind speeds at each measurement point based on the Lawson's Bristol method. The wind velocity occurring more frequently than recommended time is then obtained to identify if the criteria for various pedestrian activities and safety is met. .

Limitations and Assumptions

9.20 The study takes into account the effect of geometry, height and massing of the proposed development on the local wind conditions. The buildings are modelled as blocks with smooth surfaces and sharp corners, which is considered as sufficient detail to represent buildings in wind modelling environmental flows.

9.21 The CFD model excludes both soft and hard landscaping (for example, trees and street furniture) therefore the conservative representation of the Site is modelled, as trees and planting will generally improve the local wind environment.

9.22 A logarithmic wind profile is used to model the variation of the wind speed with height and takes into account the roughness of the landscape beyond the modelled Site and surrounding buildings.

9.23 The methodology uses mean hourly wind values. CFD modelling cannot currently be used to predict gusts. High turbulence can result in 'Gust Equivalent Mean' values that are higher than the wind speed. This can presently only be done through the use of wind tunnel testing. The results of this analysis will therefore not include maximum gust speed or predict any impacts of this. Vector plots from CFD modelling have been used to provide qualitative assessment for key areas for the identification of wind acceleration.

9.24 The Lawson Criteria focus on the effect of the wind only and do not factor other environmental variables such as air temperature, rain, solar radiation, relative humidity, and other complex variables like the effect of clothing and age, which will ultimately effect overall pedestrian comfort at a given time. Despite the complexity of defining comfort, Lawson's simplified assessment method presents the best available methodology to anticipate wind effects on pedestrians.

METEOROLOGICAL WIND DATA

9.25 The nearest meteorological station with respect to the Site was found to be located at the Luton Airport. Therefore, ten years hourly data over the period of 2008-2018 was obtained for the purpose of assessment. The summary of this is presented in Table 9.4 and Figure 9.1.

9.26 The frequency distribution indicates that for this region, South-South-West is the most prevailing wind direction with wind blowing for a dominant 15.4% of the times. It was recorded that the wind speed in the region didn't exceed 10m/s for more than 2.2% of the time in last 10 years.

Figure 9.1 Wind Rose at the Luton airport Met Station (2008-2018)

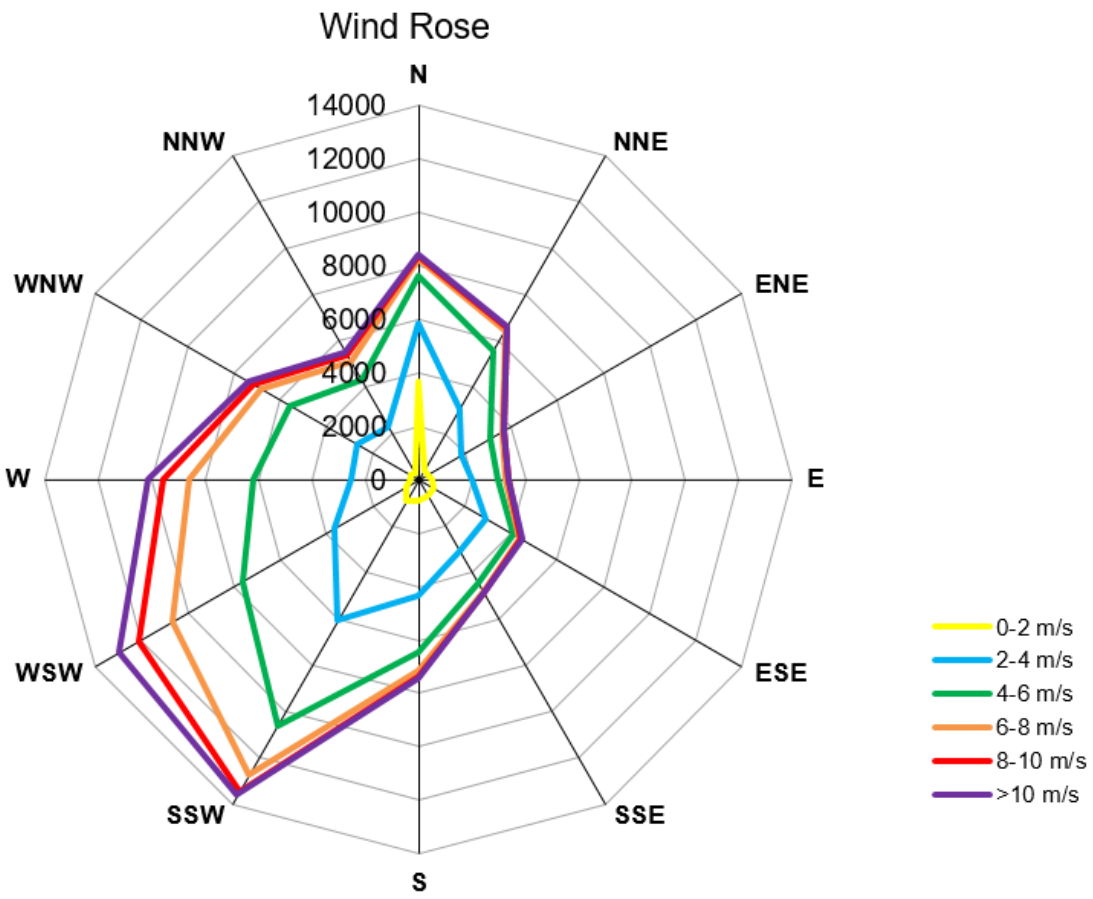


Table 9.0 Directional Frequency of the Wind speeds at Luton airport met station

Direction	0-2 m/s	2-4 m/s	4-6 m/s	6-8 m/s	8-10 m/s	>10 m/s	Events (%)
N	3680	2192	1748	622	151	26	9.5
NNE	431	2658	2467	887	148	23	7.5
ENE	374	1445	1253	515	79	10	4.2
E	490	1478	1011	294	74	6	3.8
ESE	638	2251	1189	300	69	4	5.0
SSE	711	2396	1381	350	42	3	5.5
S	761	3600	2098	685	203	66	8.4
SSW	926	5145	4529	2145	722	173	15.4
WSW	549	3119	3944	3038	1460	843	14.7
W	281	2231	3702	2411	971	527	11.5
WNW	327	2311	2905	1256	389	159	8.3
NNW	300	1976	2012	838	256	128	6.2
Number of events	9468	30802	28239	13341	4564	1968	
Events (%)	10.7	34.9	32.0	15.1	5.2	2.2	

BASELINE CONDITIONS

9.27 The Site is located to th east of the main train station of Welwyn Garden City. Currently, it is occupied by a decommissioned factory and a warehouse. The rest of the Site is vacant with hardstanding as some of the dilapidated buildings have been demolished. The Site is located in an urban context. It doesn't have any major amenity spaces for pedestrians in immediate surrounding.

9.28 The baseline model was modelled to represent the existing scenario (Figure 9.2). On the west orientation, the Site is bound by the mainline railway track and a 2-3 storey warehouse, PW Gates building. To the immediate south, the Site overlooks a 5 storey student accommodation building, Salvisberg Court, and a 3 storey Biopark office to the South-West of the Site. On the east orientation, the Site is surrounded by warehouses and some offices. There are no major pedestrian areas in close proximity except for a few car parking lots.

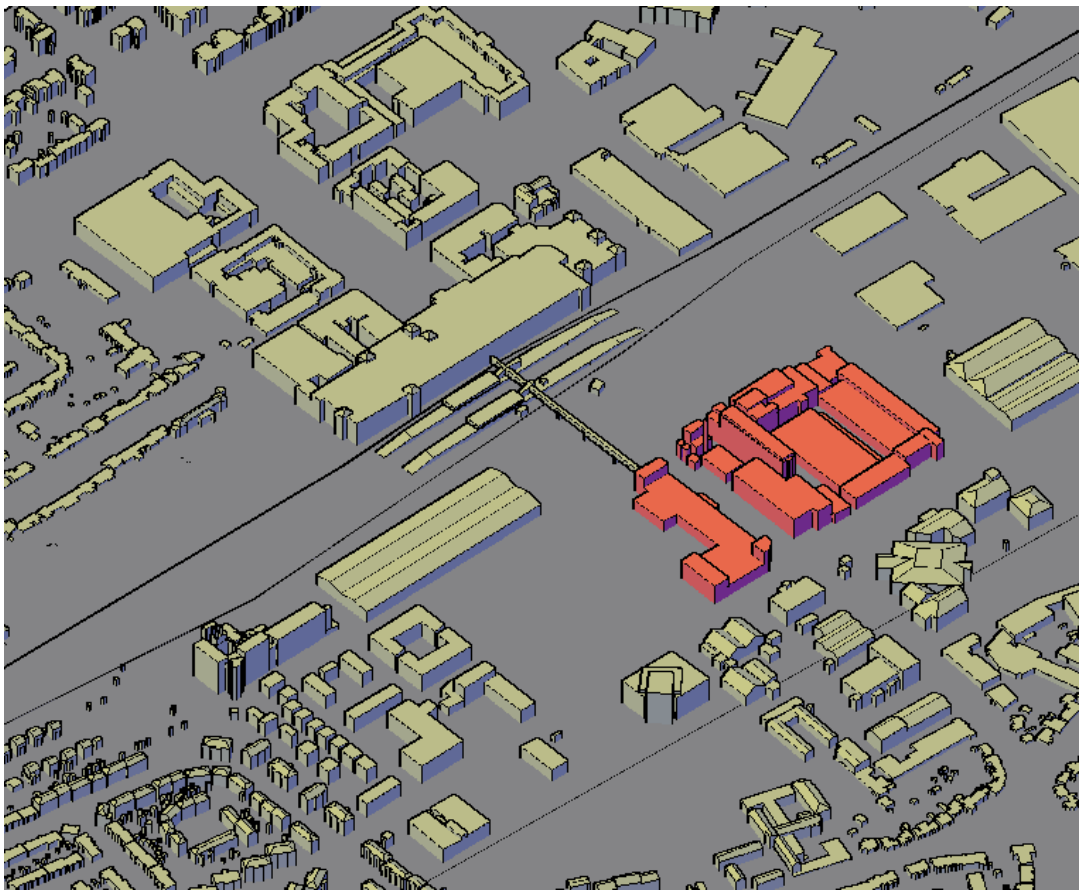


Figure 9.2 3 D model of the Baseline Scenario (Site coloured in

9.29 The result of the pedestrian safety assessment for the 'Baseline Scenario' are presented in Appendix 9.1 in the form of cumulative contour plots. The result of the assessment indicates that most of the site and its surrounding remains within the recommended criterion on the basis that the

wind velocity is unlikely to exceed 14.1m/s for more than 0.01% of the time. There are only some small localised zones of exceedance around the corners of the existing buildings.

9.30 The results also show some acceleration on the north of the Site along Bridge Road and on the southern tip of the Welwyn Garden City Station platforms. However, none of these are sensitive to any pedestrian activities.

9.31 The wind velocity assessment for pedestrian activities like sitting, standing and walking have also been undertaken for the Baseline Scenario. The results are presented in Appendix 9.1 in form of cumulative frequency plots for maximum wind speeds.

9.32 The pedestrian comfort assessment for standing identifies zones where wind velocity exceeds 5.6m/s for more than 6% of the time. The results indicate an area of wind acceleration to the south of Welwyn Garden City Station platforms on the railway tracks. There is another small zone of exceedance around the corner of PW Gates building. However, none of these areas are sensitive to the pedestrian activity of standing.

9.33 The pedestrian comfort assessment for sitting identifies zones where wind velocity exceeds 5.6m/s for more than 1% of the time. The areas of wind acceleration exceeding the comfort criterion for sitting are largely observed in open unused areas and vehicular roads. There are no significant seating areas located within these zones or in close proximity.

9.34 The result of the pedestrian comfort assessment for walking indicates that the Site and its surroundings remain within the recommended comfort criterion for leisure walking. This is on the basis that wind speeds are unlikely to exceed 8.25m/s for more than 4% of the time.

PROPOSED CONDITIONS

Construction Phase

9.35 The wind environment is largely dictated by the building masses which may gradually vary from the construction phase to operational phase. The assessment during the construction phase has not been quantitatively assessed as the resultant effects would be temporary in nature. Therefore, the assessment of wind environment has been limited to the operational phase of the proposed development.

Operational Phase

9.36 The Site is located to the east of the main train station at Welwyn Garden City. It encompasses level ground and comprises two land plots, to the north and south of Hyde Way.

9.37 The Site has been divided into North and South sites. The 5 storey Grade II listed factory building on the North Site will be surrounded by other five to six storey buildings. Blocks 2, 6 and 7 have five to seven storey high towers which are all connected at the podium level. The South site has six blocks arranged along the main vehicular road connecting it to the North site. These blocks have up to 8 storey high towers also connected at the podium level. The podiums will be developed to provide communal amenity spaces for the residents. The proposed scenario was modelled by inserting the proposed development on the Site (Figure 9.3).

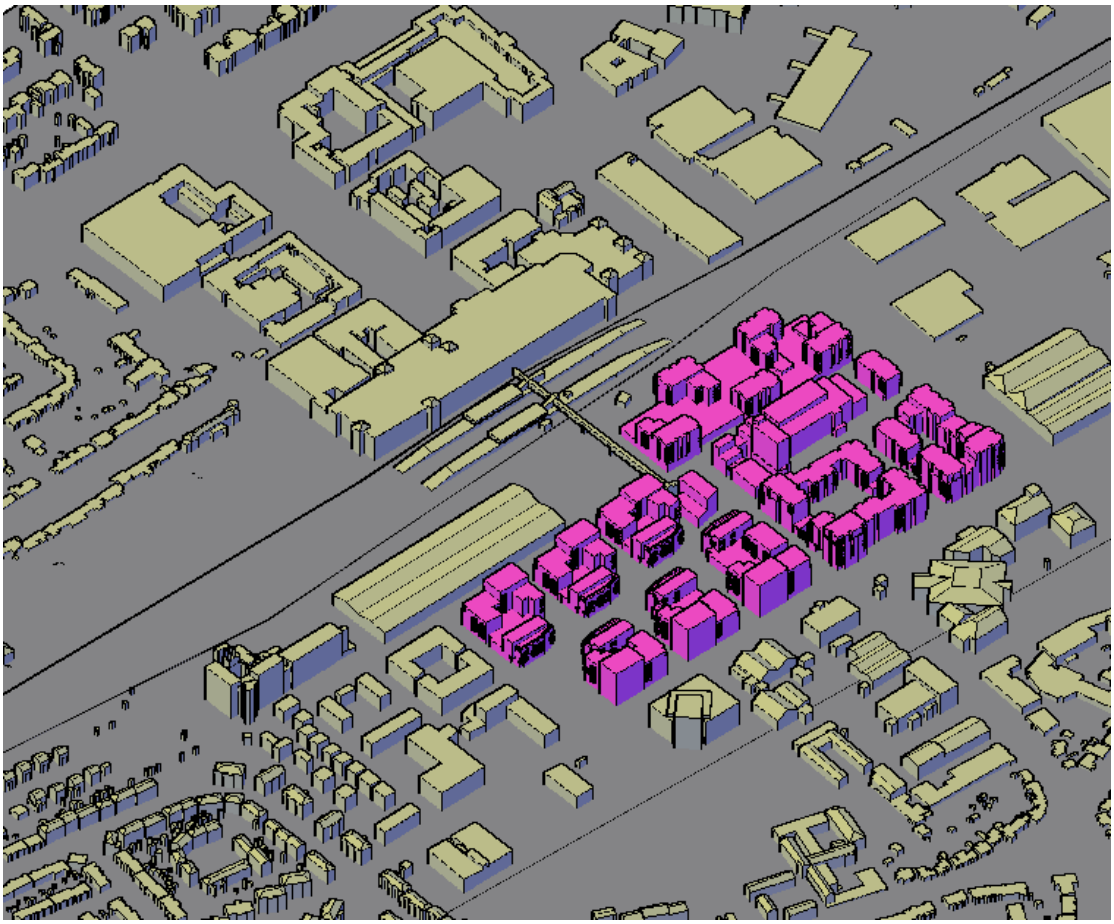


Figure 9.3 3D model of the Proposed Scenario (Proposed development in pink)

9.38 The cumulative frequency plots for the pedestrian safety assessment in case of the 'Proposed Scenario' are presented in Appendix 9.2.

9.39 The result of the safety assessment indicates that the Site and its surrounding pedestrian areas are all within the recommended criteria set out in section 9.14-9.18, on the basis that the wind velocity is unlikely to exceed 14.1m/s for more than 0.01% of the time.

9.40 Some localized zones of wind acceleration are observed on the southern tip of the Welwyn Garden City Station platform and on the north of the Site along Bridge Road. It should be noted that these areas exceed the recommended criteria in the baseline scenario also thus this effect cannot be attributed to the proposed development. It should also be noted that these zones are more localised in the proposed scenario.

9.41 The wind velocity assessment for pedestrian activities like sitting, standing and walking have also been undertaken for the proposed scenario. The results of the pedestrian comfort assessement are presented in Appendix 9.2 in the form of cumulative frequency plots for maximum wind speeds.

9.42 The pedestrian comfort assessment for standing identifies zones where wind velocity exceeds 5.6m/s for more than 6% of the time. The results indicates only one area of wind acceleration on the south of the Welwyn Garden City Station platforms. This area exceeds the comfort criteria for standing (set out in Table 9.2) in the baseline scenario also, therefore, the effect cannot be attributed to the proposed building. The results also show that the proposed development has improved the wind environment for this pedestrian activity as some of the zones of acceleration, which were seen in the baseline scenario, doesn't exist in the proposed scenario.

9.43 The pedestrian comfort assessment for sitting identifies zones where wind velocity exceeds 5.6m/s for more than 1% of the time. The areas of exceedance are located predominantly along vehicular roads and large unused open spaces. Since these exceed in the baseline scenario as well, this effect cannot be attributed to the proposed development. The landscape plan provided by the architects indicates that the zones of exceedance between blocks 11, 12 and 13, and on the corners of Block 2 are not sensitive receptors to the pedestrian activity of sitting as there are no designated seating areas. It also shows trees, low height planters and landscape features are proposed in and around these zones which are likely to mitigate the effect.

9.44 The pedestrian comfort assessment for walking identifies zones where wind velocity exceeds 8.25m/s for more than 4% of the time. The result of the assessment indicates that the pedestrian areas around the Site and on the podium are within the recommended criteria.

CUMULATIVE EFFECTS AND MITIGATION

9.45 The cumulative frequency plots for the pedestrian safety assessment in case of the proposed and baseline scenarios indicate that the areas around each of the blocks on the north and south sites are all within the recommended criteria on the basis that the wind velocity is unlikely to exceed 14.1m/s for more than 0.01% of the time.

9.46 Some localized zones of wind acceleration are observed on the corner of the Welwyn Garden City Station platform and on the north of the Site along Bridge Road. It should be noted that these areas exceeds the recommended criteria in the baseline scenario also. However, the zones are more localised in the proposed scenario. Also, the localised zones of exceedance on the corner of the adjacent PW Gates building is mitigated in the proposed scenario. Overall the result indicates that proposed development is likely to have a positive impact on the wind environment for pedestrians as compared to the baseline scenario.

CONCLUSIONS

9.47 The result of the safety assessment indicates that the Site and its surrounding pedestrian areas are all within the recommended criteria on the basis that the wind velocity is unlikely to exceed 14.1m/s for more than 0.01% of the time. Some localized zones of wind acceleration are observed on the southern tip of the Welwyn Garden City Station platform and on the north of the Site along Bridge Road. It should be noted that these areas exceed the recommended criteria in the baseline scenario alsotherefore this effect cannot be attributed to the proposed development. It should also be noted that these zone are more localised in the proposed scenario.

9.48 The pedestrian comfort assessment for standing indicates only one area where wind velocity exceeds 5.6m/s for more than 6% of the time. This is to the south of the Welwyn Garden City Station platforms. This area exceeds the comfort criteria for standing in the baseline scenario also, therefore, the effect cannot be attributed to the proposed building. The results also show that the proposed devlopment has improved the wind environment for this pedestrian activity as some of the zones of acceleration, which were seen in the baseline scenario, doesn't exist in the proposed scenario.

9.49 The pedestrian comfort assessment for sitting identifies zones where wind velocity exceeds 5.6m/s for more than 1% of the time. The areas of exceedance are located predominantly along vehicular roads and large unused open spaces. Since these exceed in the baseline scenario as well, this effect cannot be attributed to the proposed development. The landscape plan provided by the architects indicates that the zones of exceedance between blocks 11, 12 and 13, and on the corners of Block 2 are not sensitive receptors to the pedestrian activity of sitting as there are no designated seating areas. It also shows trees, low height planters and landscape features are proposed in and around these zones which are likely to mitigate the effect.

9.50 The pedestrian comfort assessment for walking identifies zones where wind velocity exceeds 8.25m/s for more than 4% of the time. The results of the assessment indicate that the pedestrian areas around the Site and on the podium are within the recommended criteria.

9.51 Overall, the results indicate that the proposed development is likely to reduce zones of wind acceleration outside the Site boundary and therefore will have a positive impact on the surrounding wind environment. This is most relevant in context of pedestrian safety as the zones are more localised in the proposed scheme.

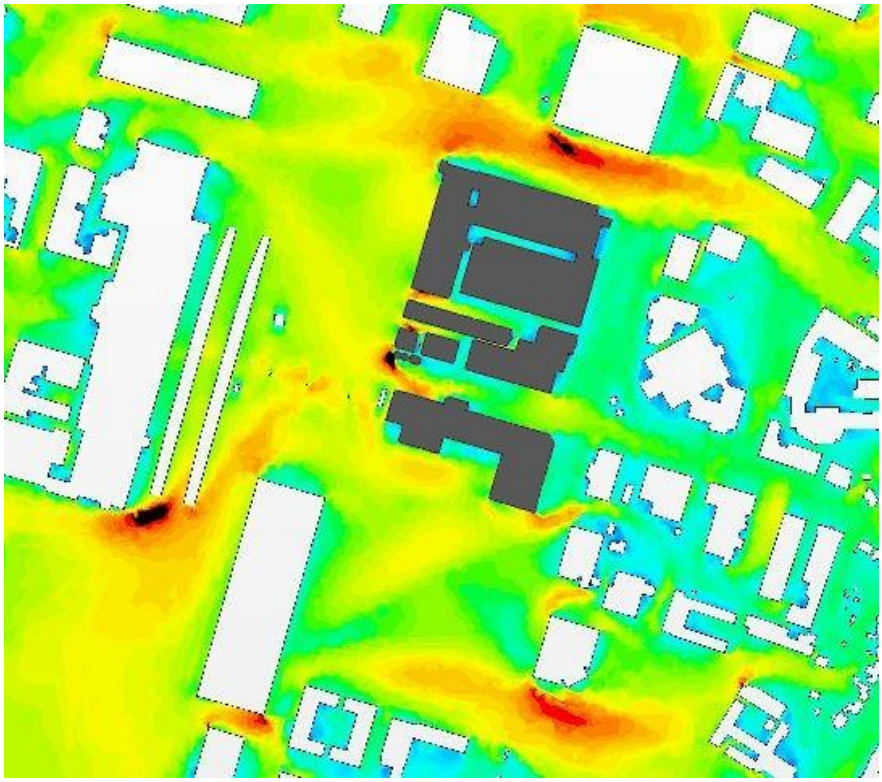
REFERENCES

Lawson, T.V "The Determination of the Wind Environment of a Building Complex before Construction" Department of Aerospace Engineering, University of Bristol Report Number TVL 9025 (May 1990)

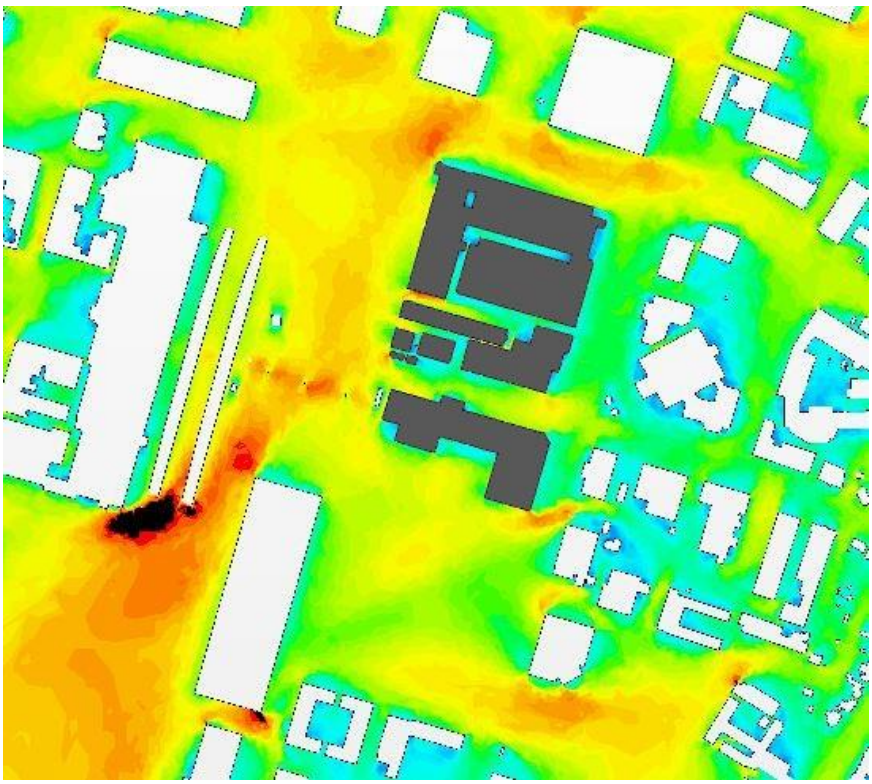
Franke. J, Hellsten. A, Schlunzen. H, Carrisimo.B. (2007). Best Practice guidelines for the CFD Simulation of flows the Urban Environment- Cost Action 732.

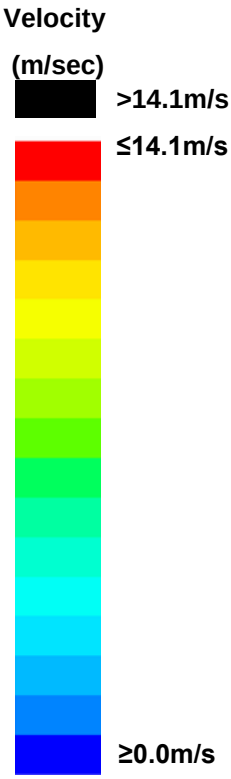
APPENDIX 9.1:BASELINE CUMULATIVE PLOTS FOR PEDESTRIAN SAFETY AND COMFORT

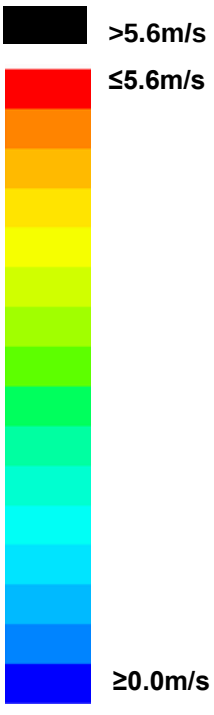
Safety (0.01%)



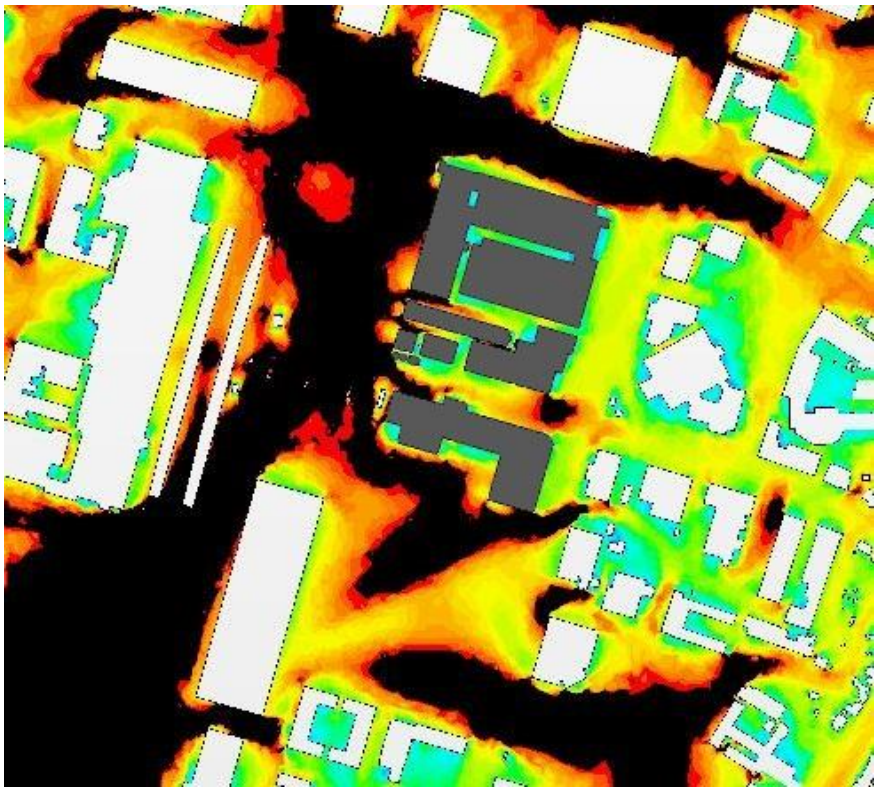
Standing (6%)



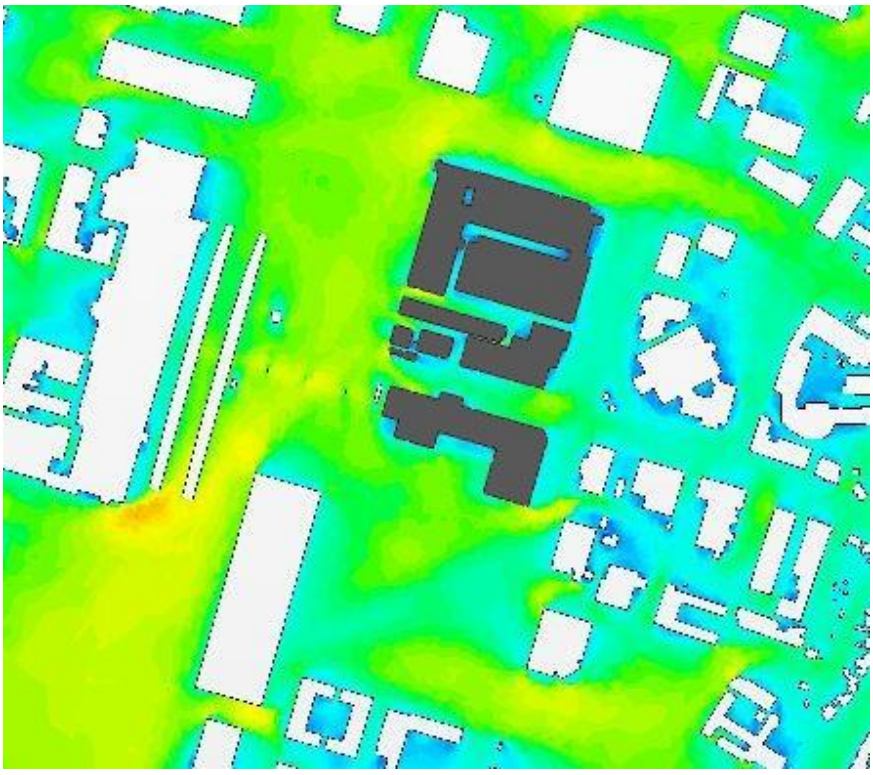




Sitting (1%)

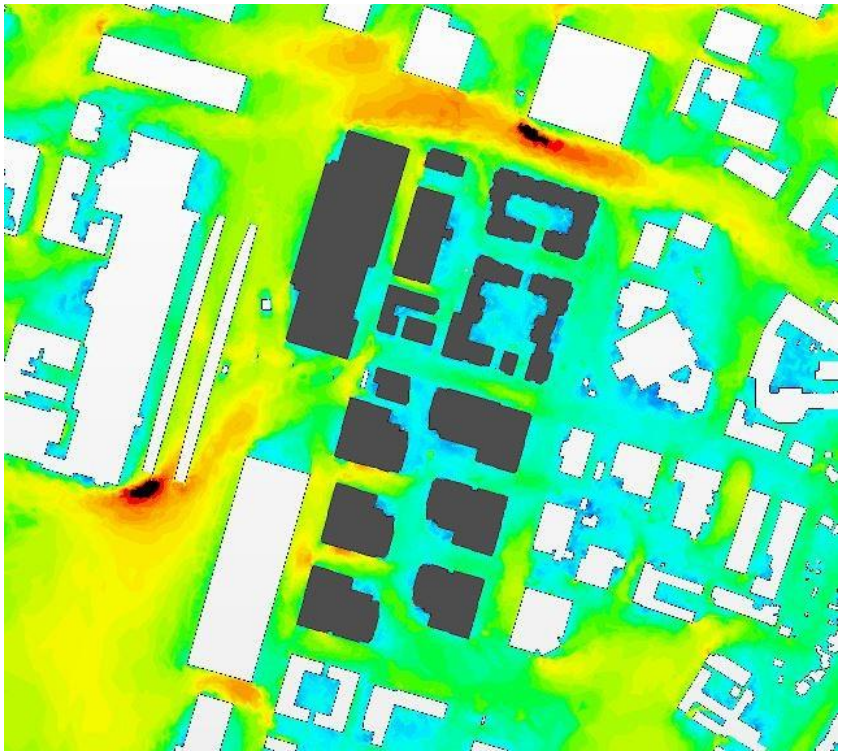


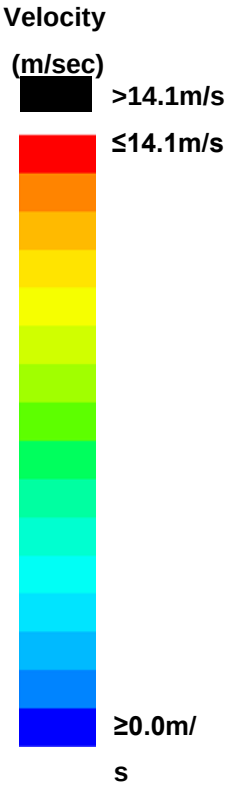
Walking (4%)



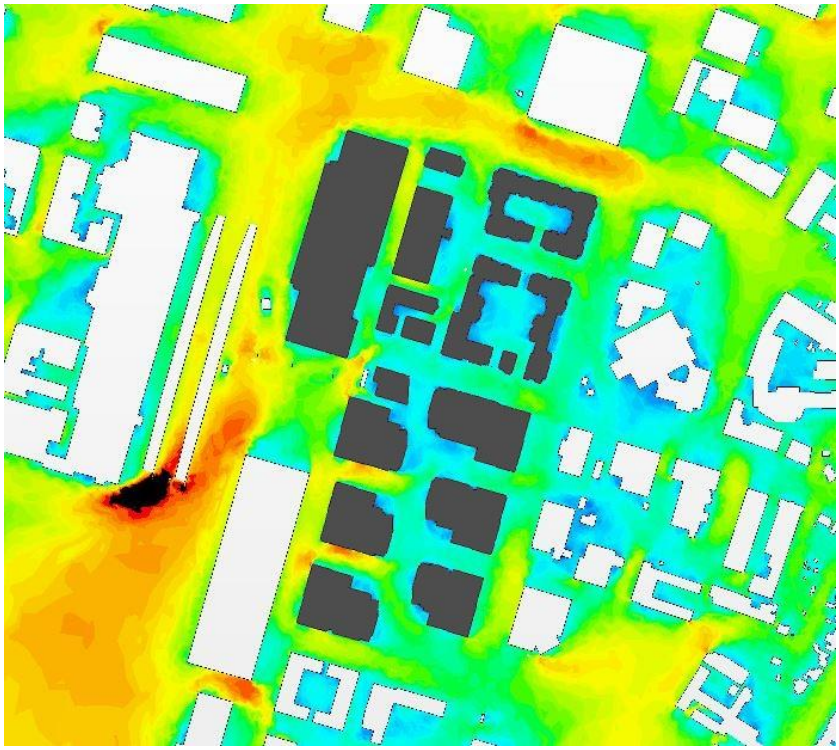
APPENDIX 9.2:PROPOSED CUMULATIVE PLOTS FOR PEDESTRIAN SAFETY & COMFORT

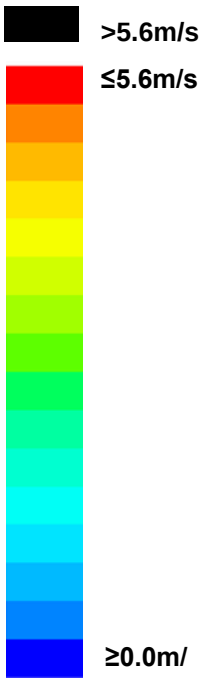
Safety (0.01%)



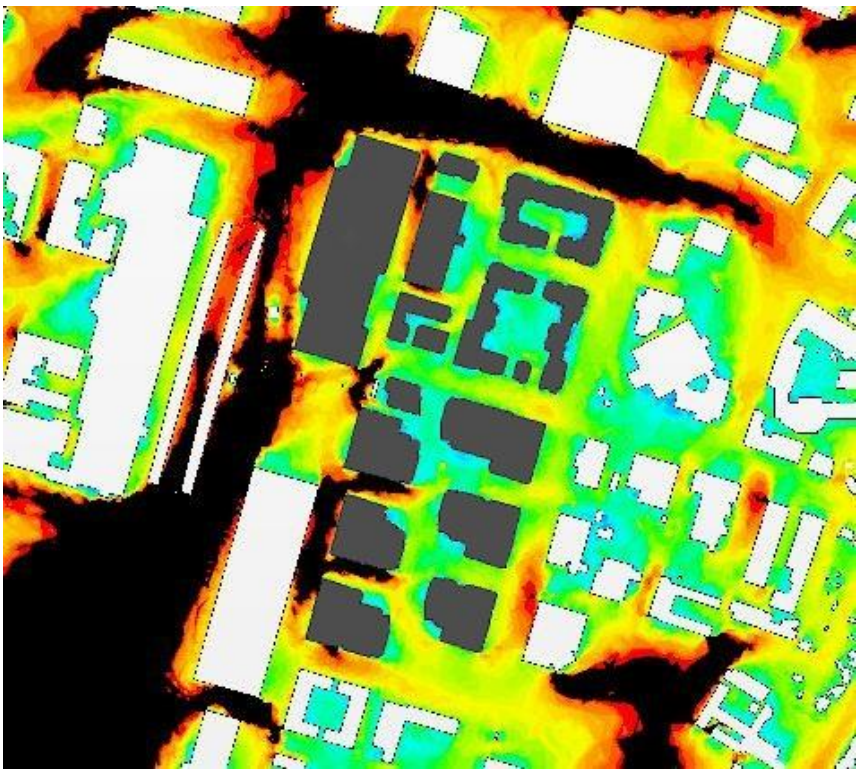


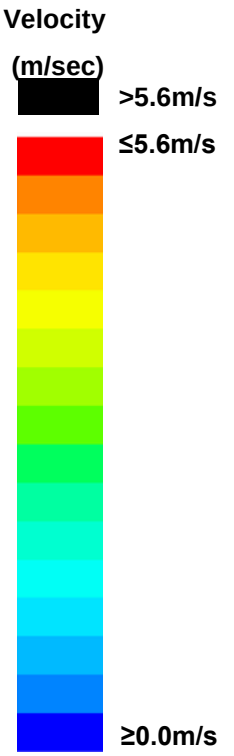
Standing (6%)



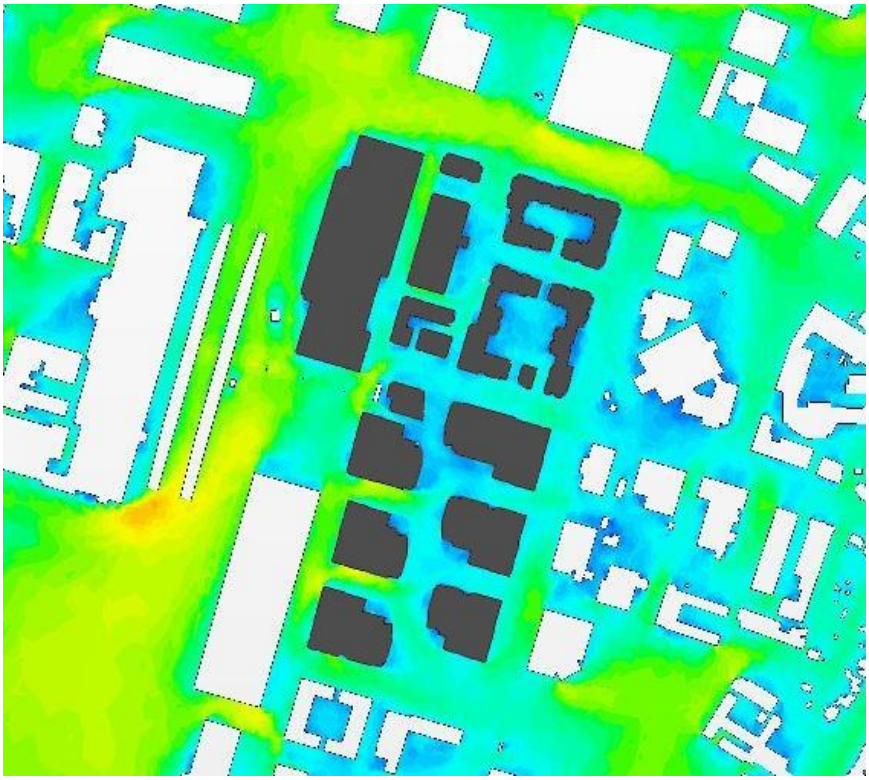


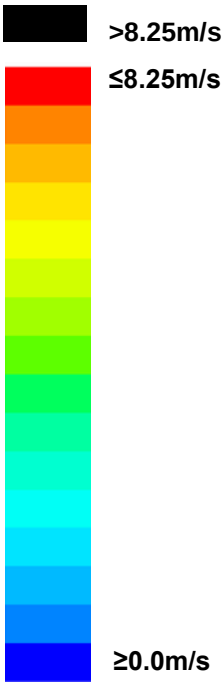
Sitting (1%)





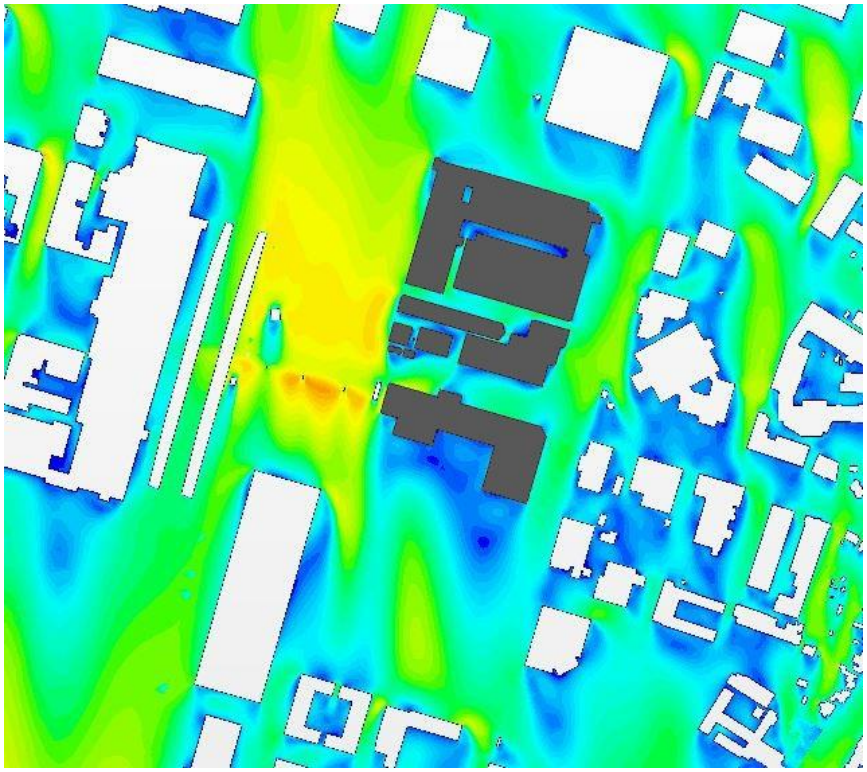
Walking (4%)



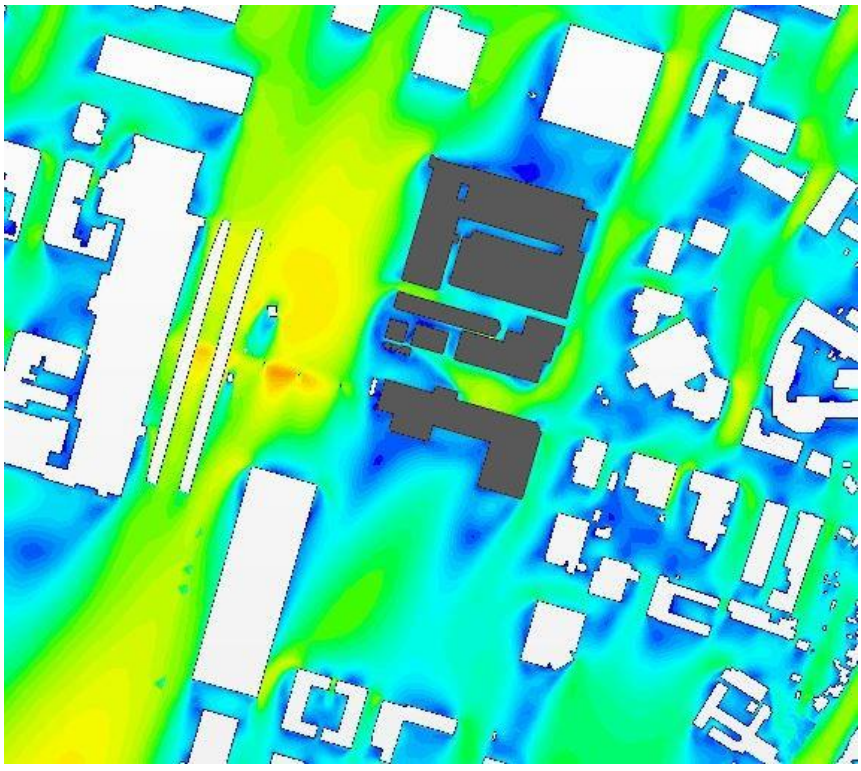


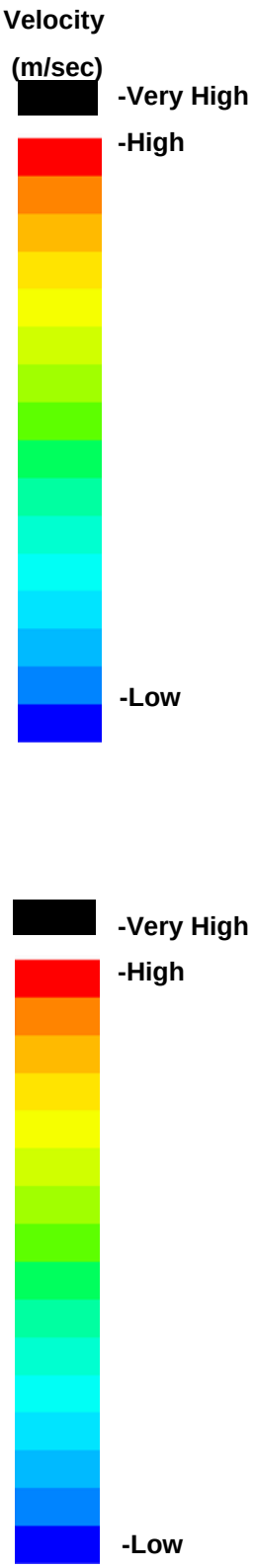
APPENDIX 9.3: CONTOUR PLOTS FOR INDIVIDUAL WIND DIRECTIONS- BASELINE

North (0^0)

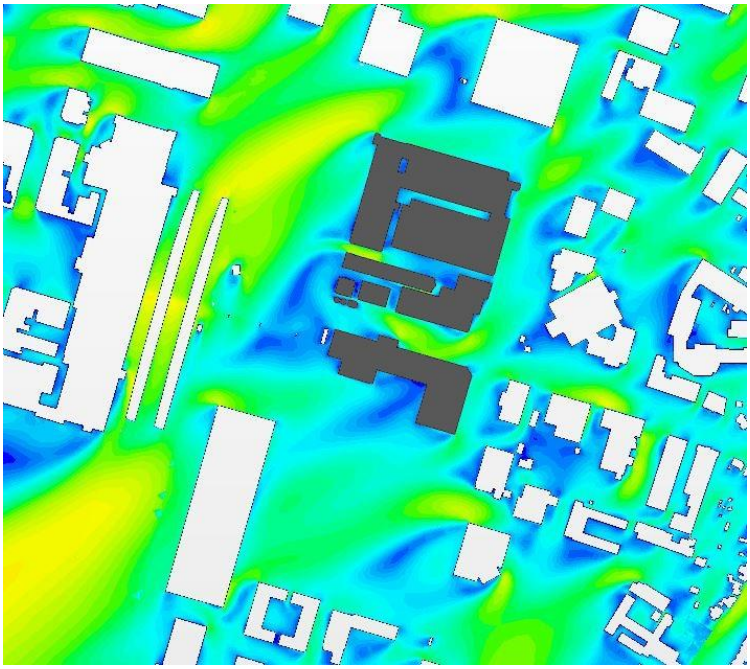


NNE (30^0)

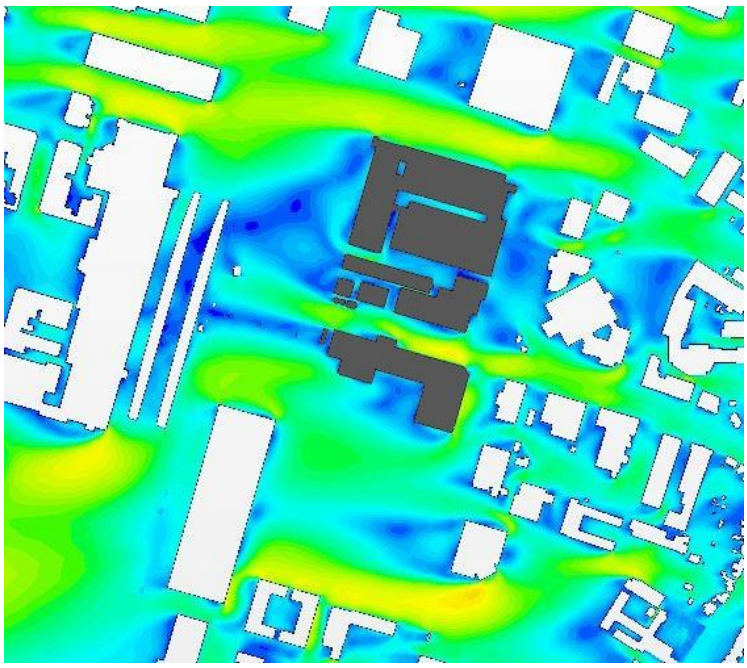


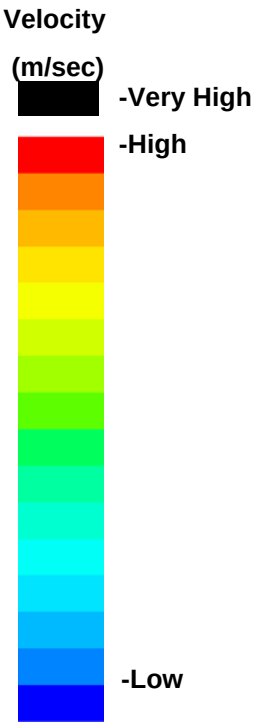


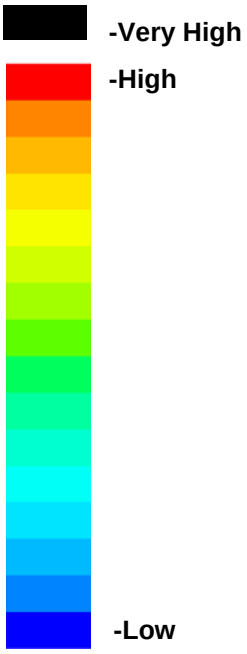
ENE (60^0)



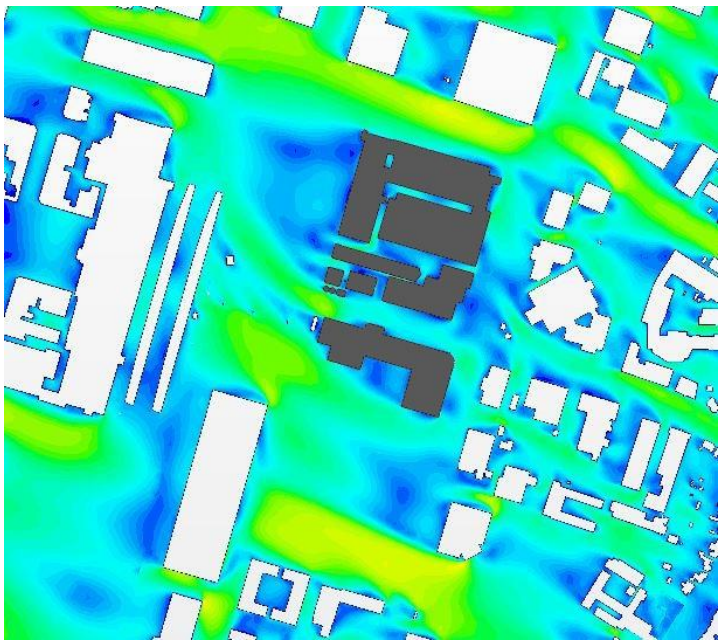
East (90^0)



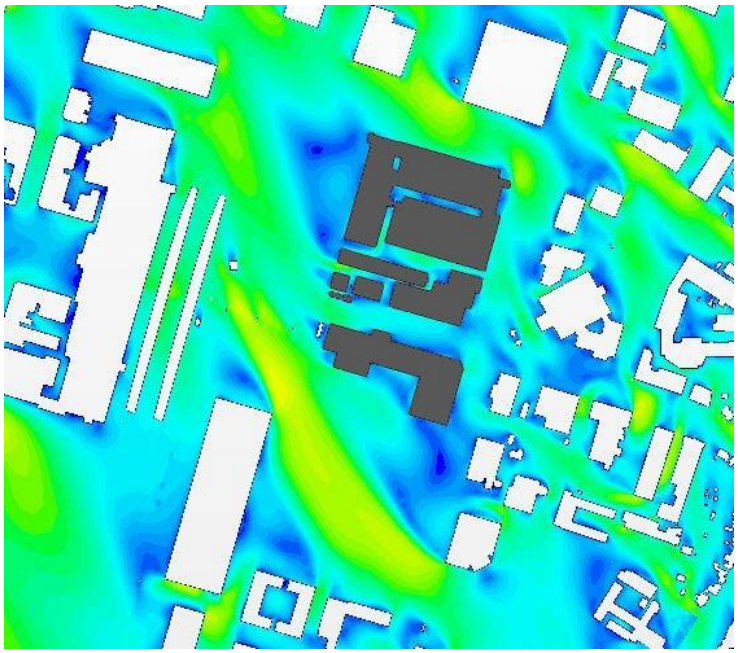


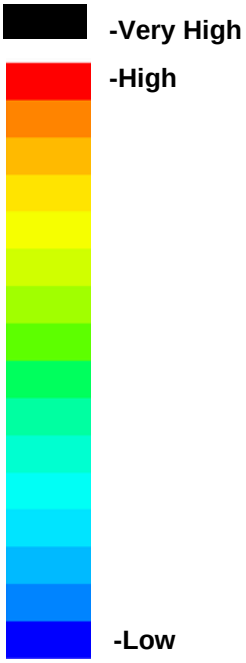


ESE (120^0)

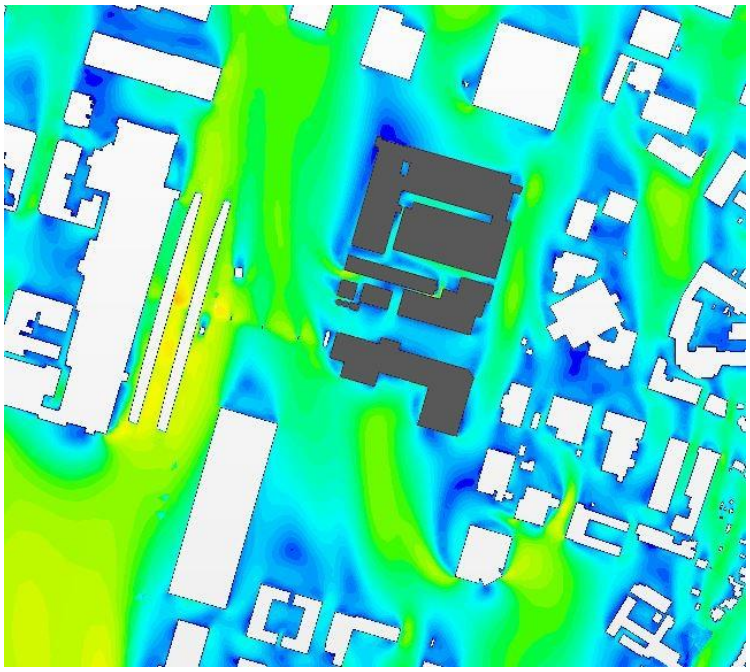


SSE (150^0)

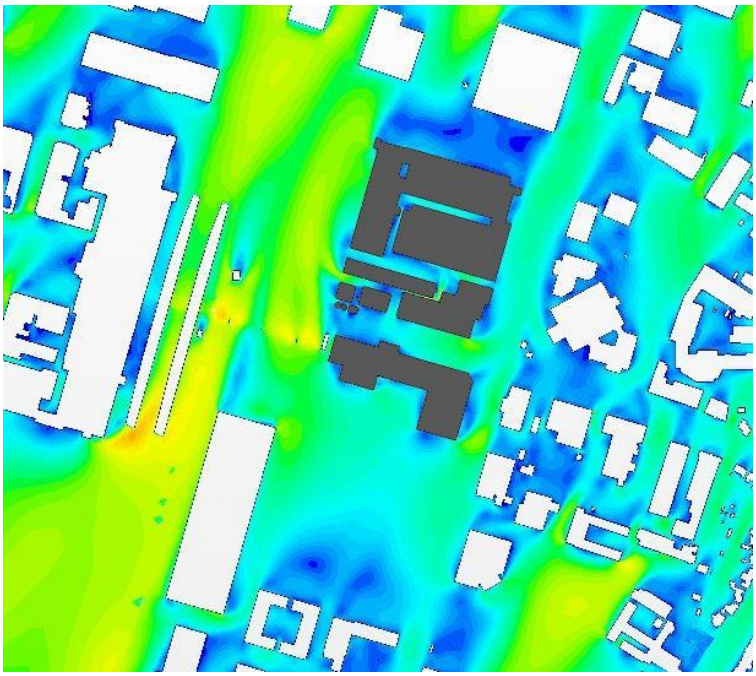


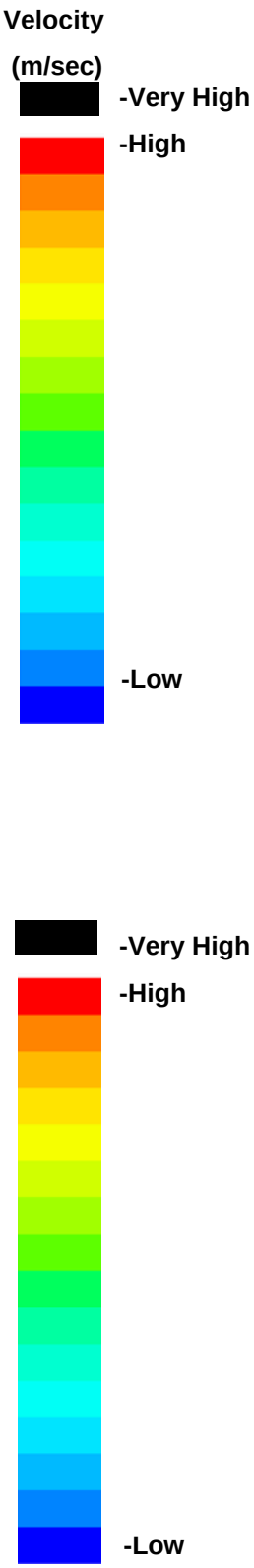


South (180^0)

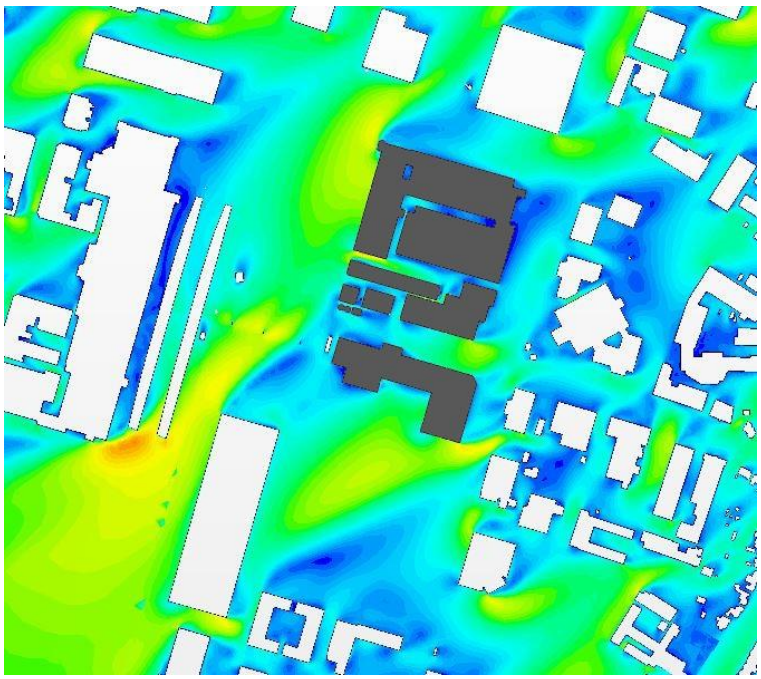


SSW (210^0)

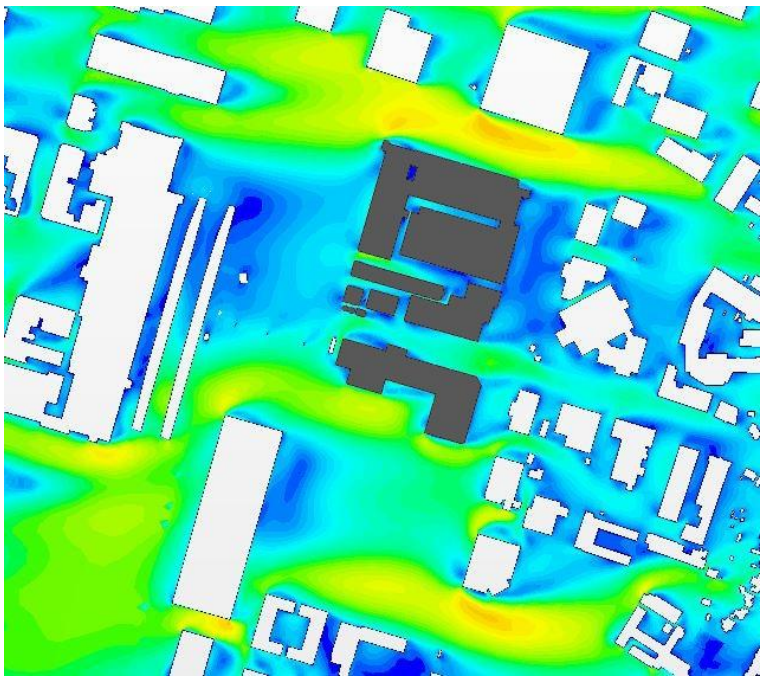




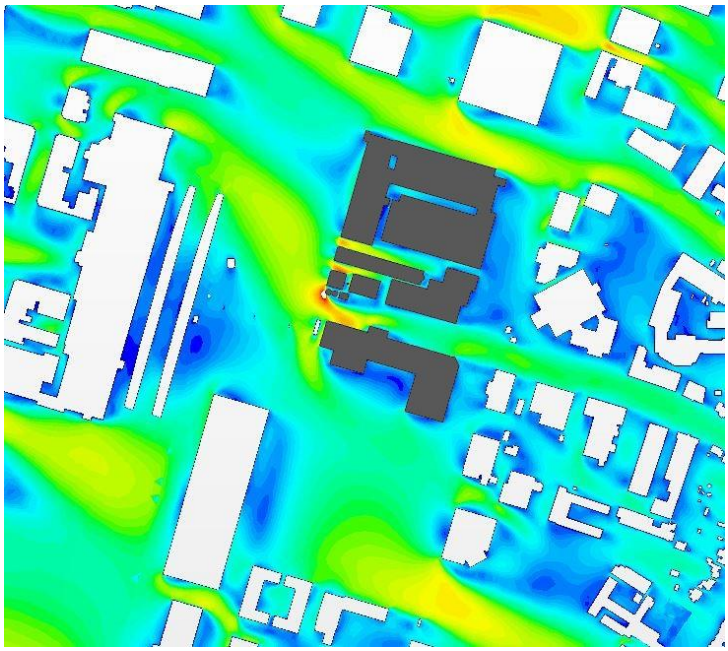
WSW (240^0)



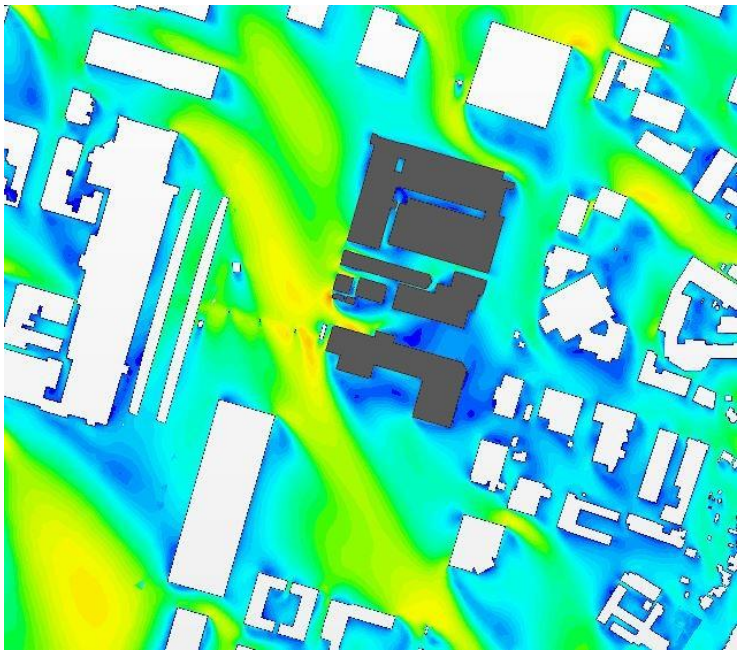
West (270^0)

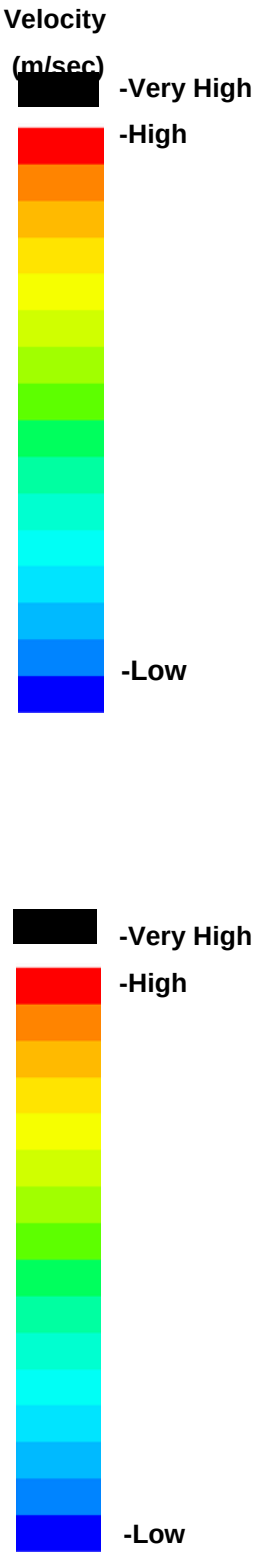


WNW (300^0)



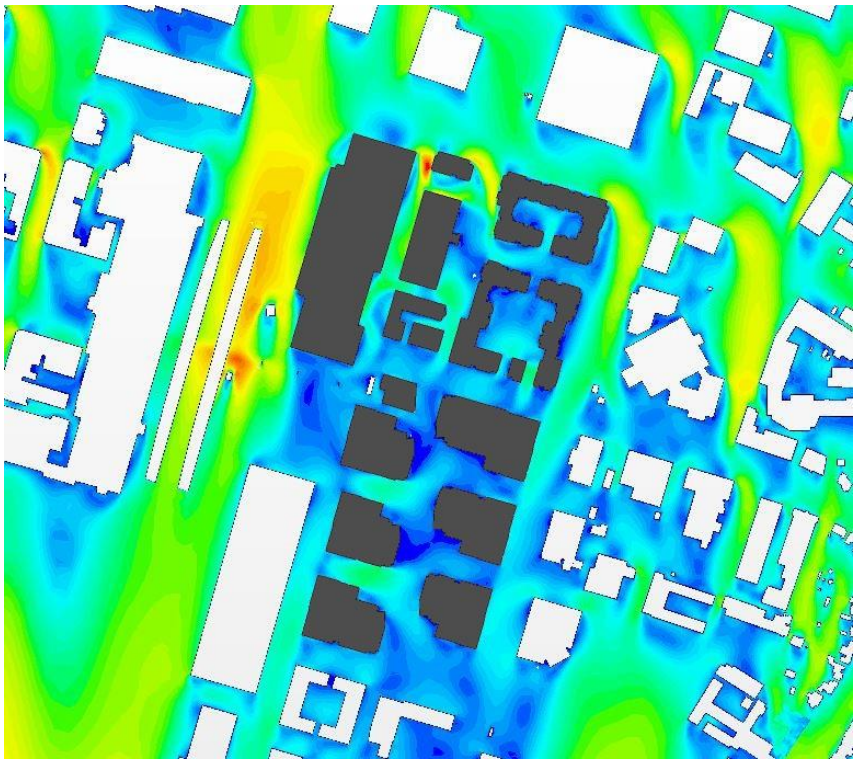
NNW (330^0)



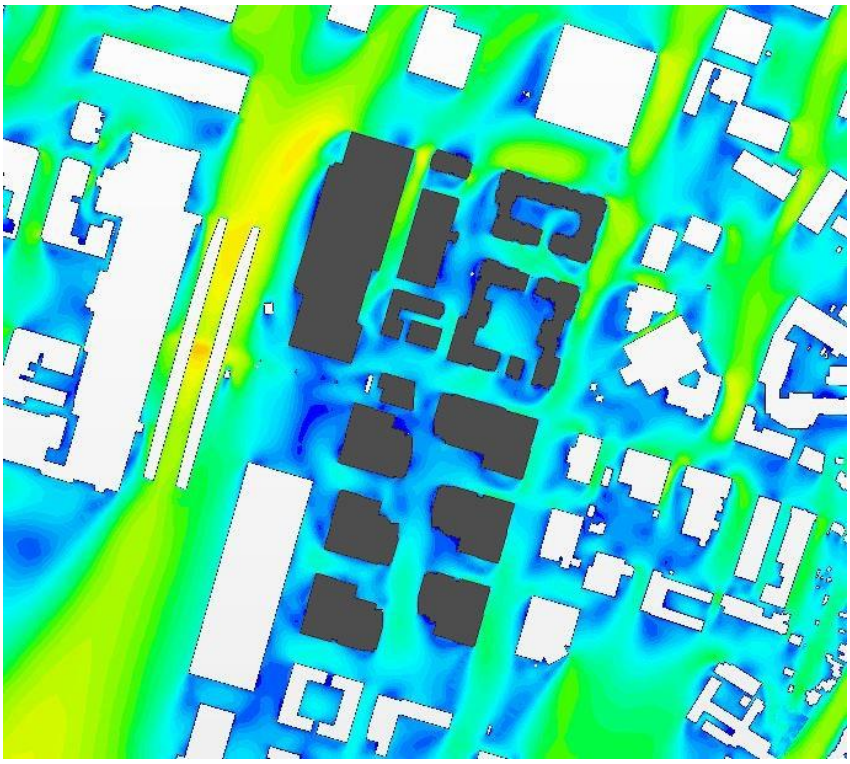


APPENDIX 9.4: CONTOUR PLOTS FOR INDIVIDUAL WIND DIRECTIONS- PROPOSED

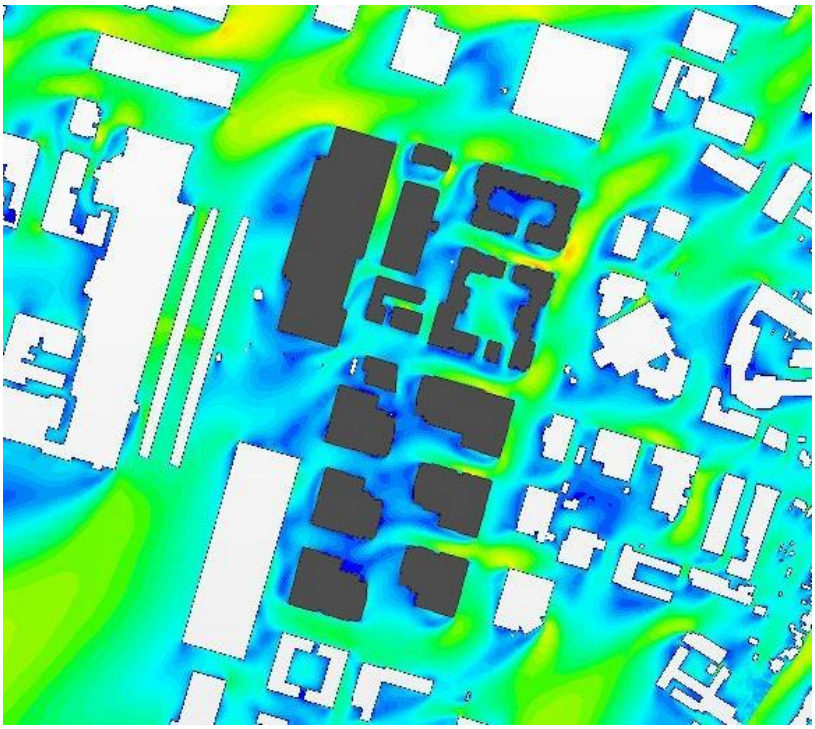
North (0^0)



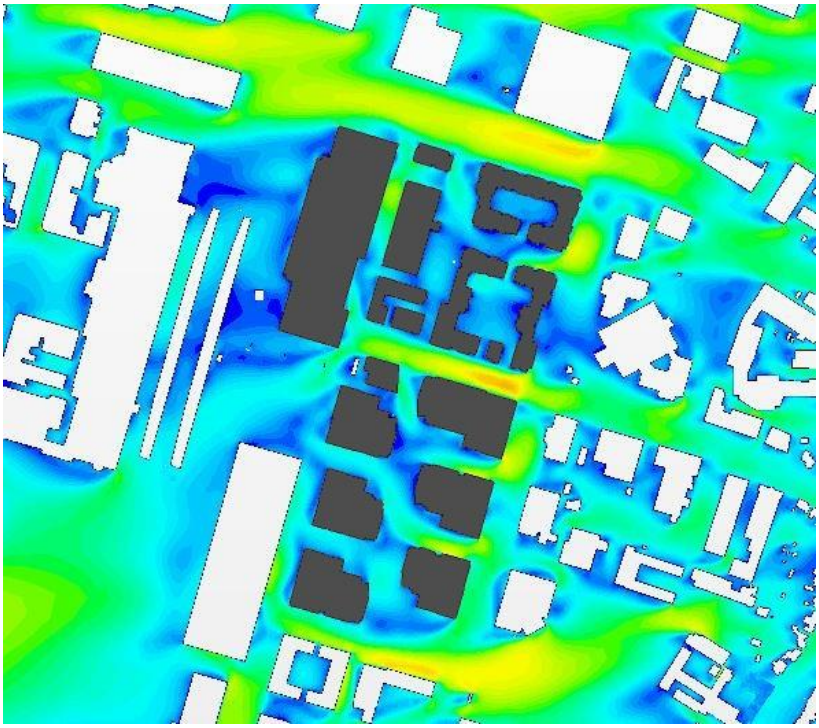
NNE (30^0)

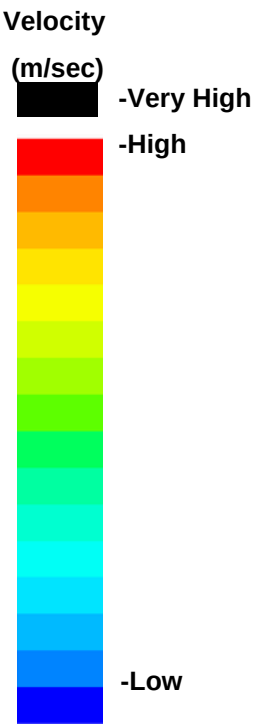


ENE (60^0)

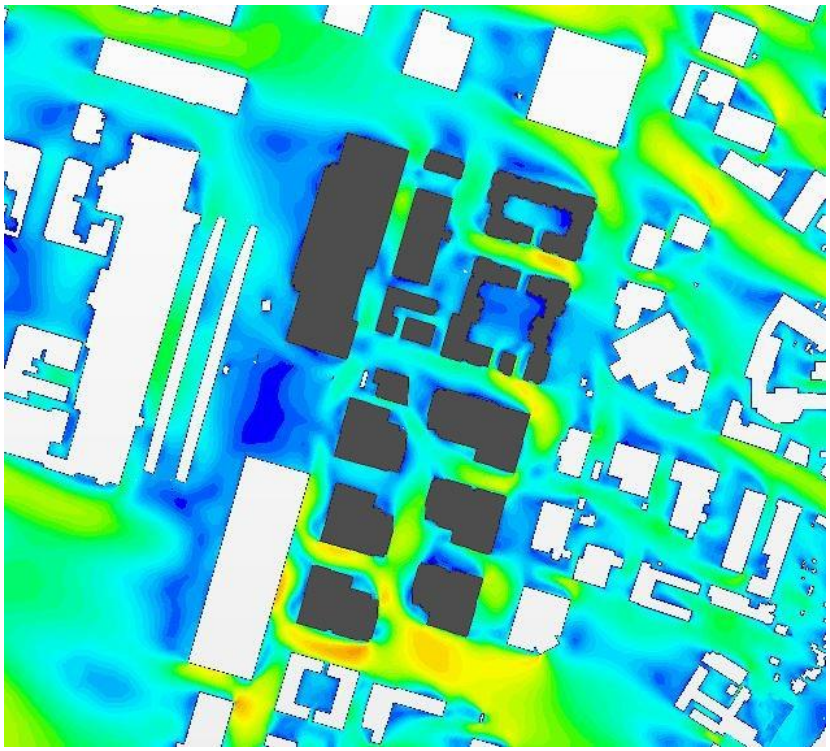


East (90^0)

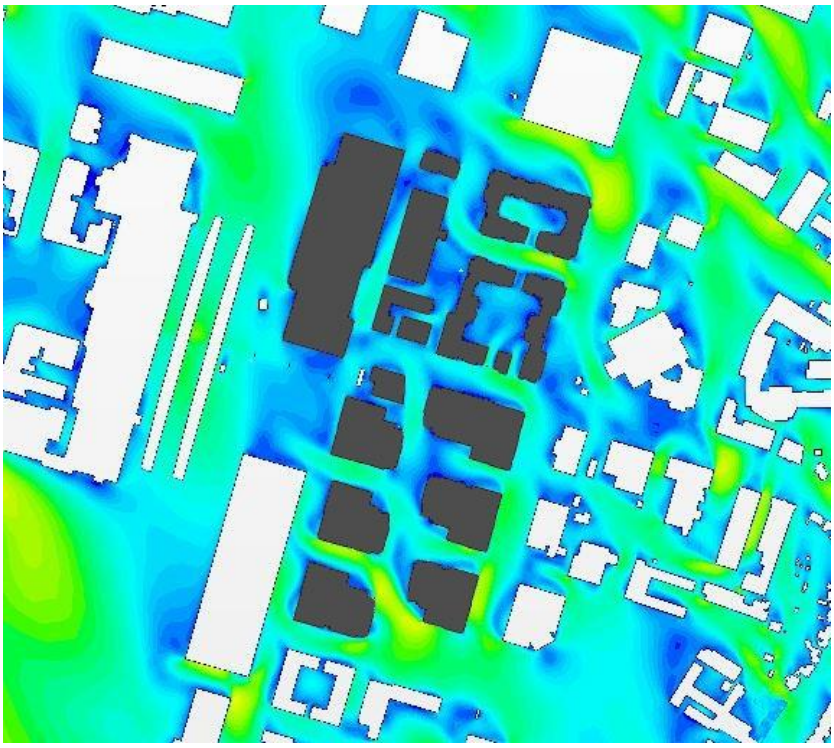


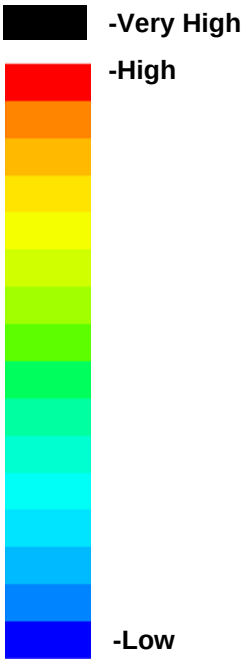


ESE (120^0)

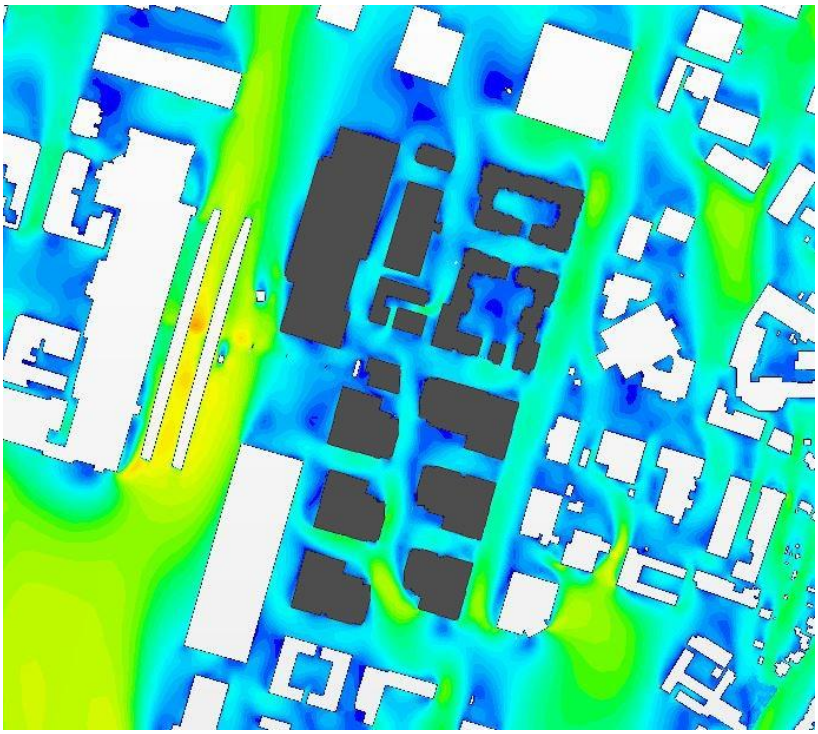


SSE (150^0)





South (180^0)



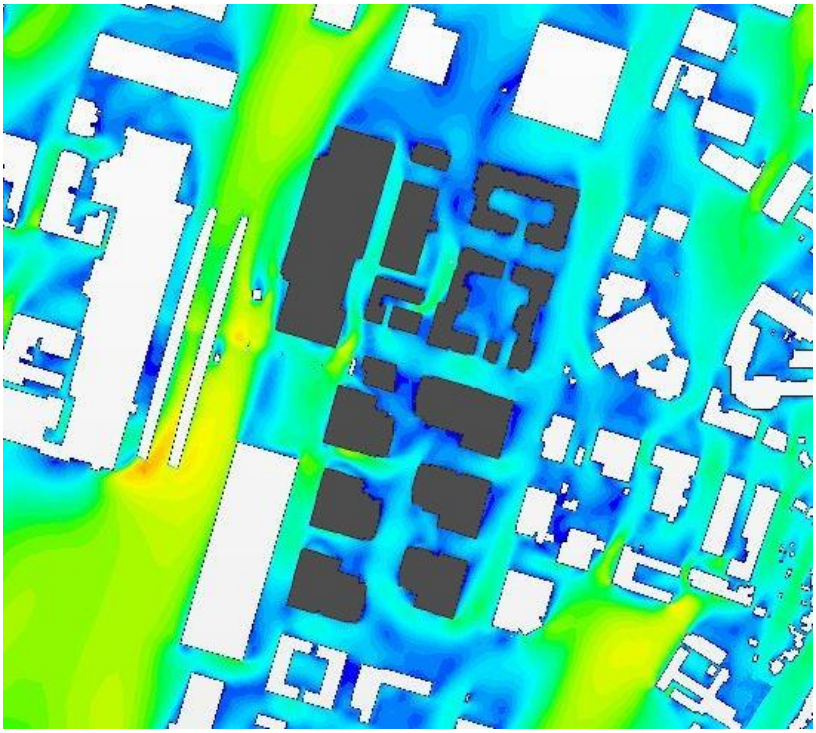
Velocity (m/sec)

-Very High

-High

-Low

SSW (210^0)

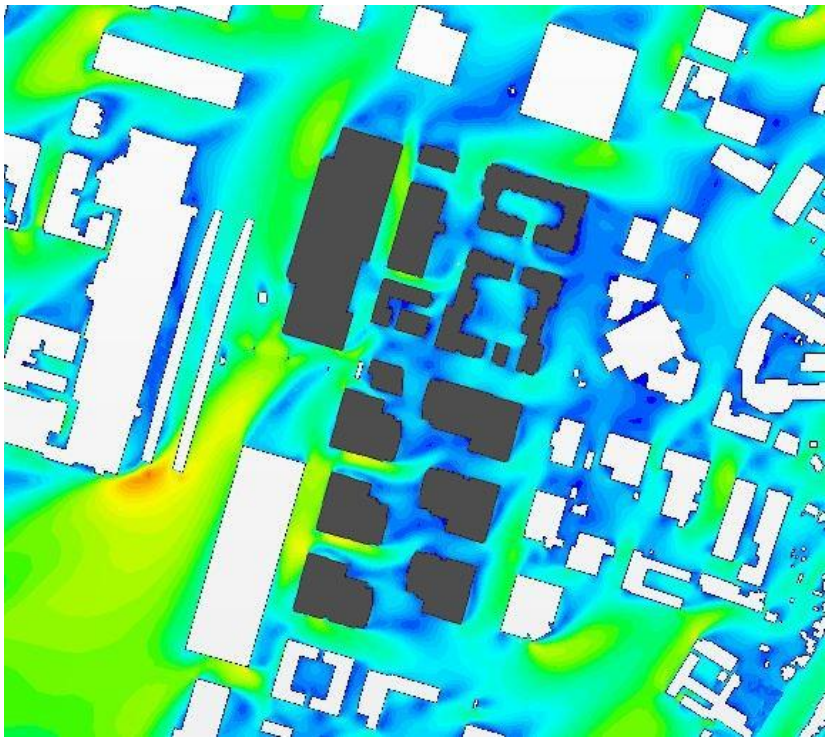


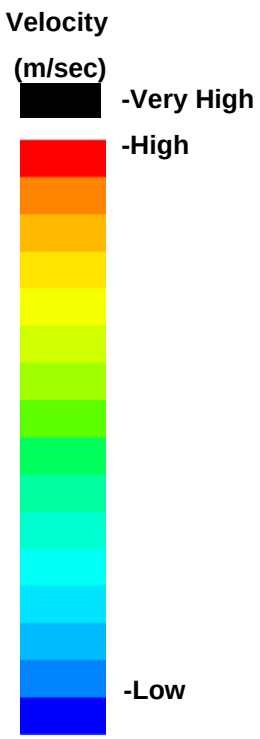
-Very High

-High

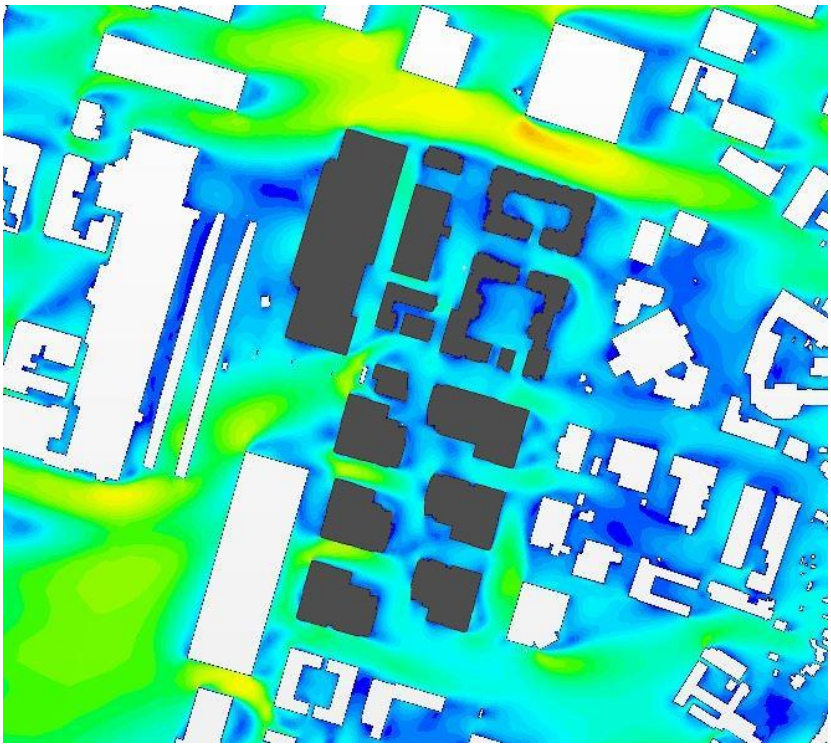
-Low

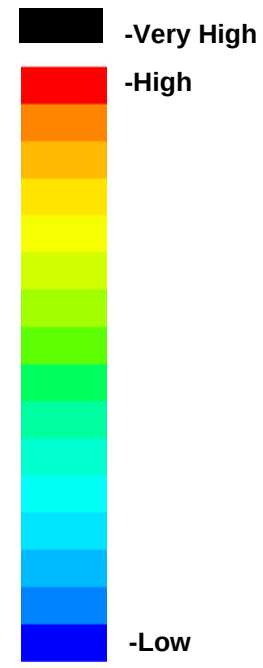
WSW (240^0)



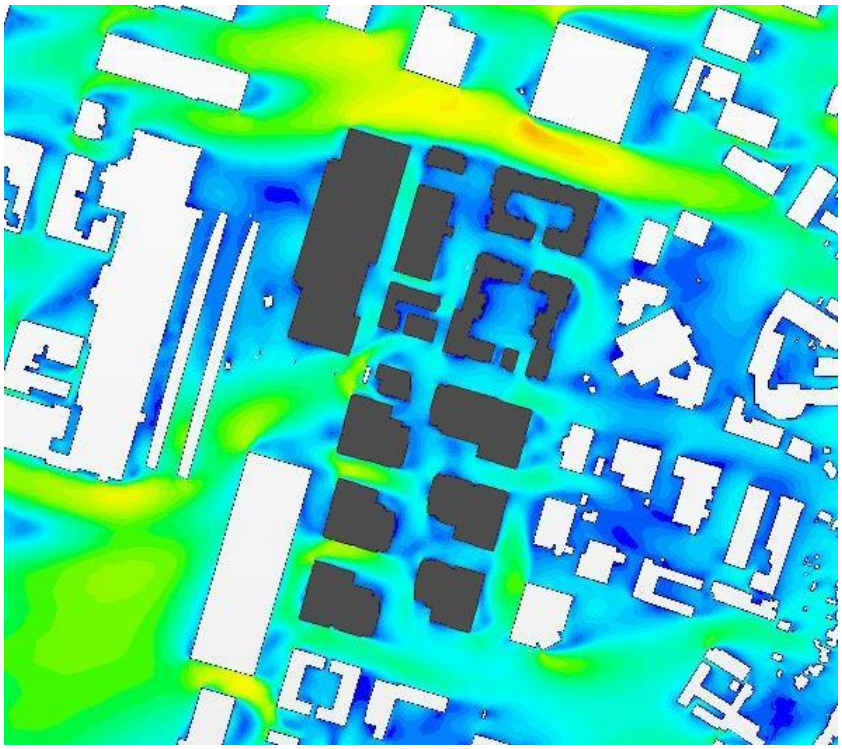


West (270^0)





WNW (300^0)



NNW (330^0)