

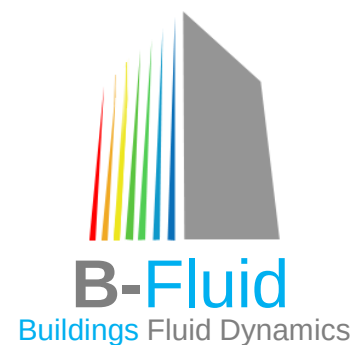
WIND MICROCLIMATE MODELLING

Cherry Orchard Phase 3 Development

Dublin

Prepared by: B-Fluid Ltd. | Buildings Fluid Dynamics Consultants

For: Van Dijk Architects



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1. EXECUTIVE SUMMARY

B-Fluid Limited has been commissioned to perform a Wind Microclimate Study for the Proposed Cherry Orchard Phase 3 Development in Dublin (Figure 1.1). This report is prepared on behalf of Van Dijk Architects.

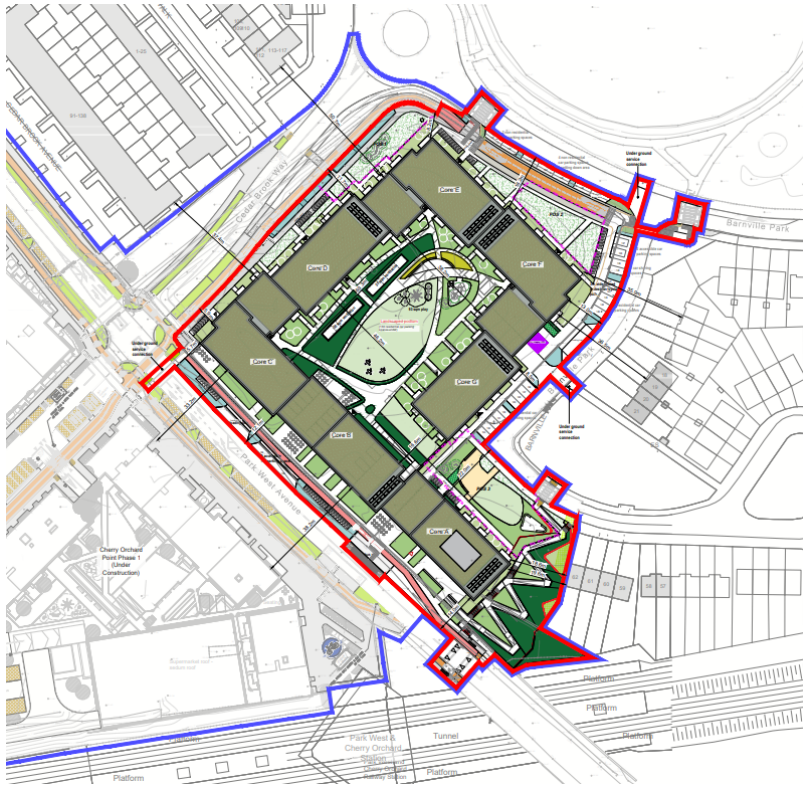


Figure 1.1: Site Layout of Cherry Orchard Phase 3 Development.

Figure 1.2 shows a view of the proposed development (red) and the site area (yellow) within the existing context (white and pink).

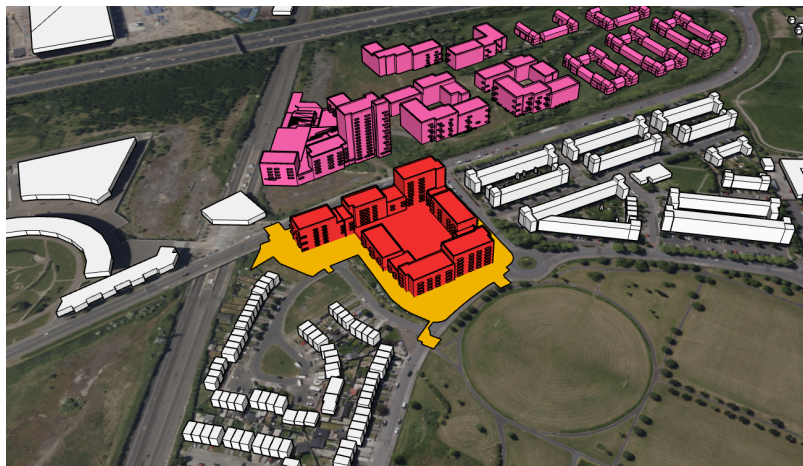


Figure 1.2: Proposed Cherry Orchard Phase 3 Development (red) with Phase 1 and Phase 2 development (pink) and existing context (white).

The method for the study of wind microclimate combines the use of Computational Fluid Dynamics (CFD) to predict wind velocities and wind flow patterns, with the use of wind data from a suitable meteorological station and the recommended comfort and safety standards (Lawson Criteria).

The effect of the geometry, height and massing of the proposed development, existing surroundings, and planning-approved buildings, including topography, ground roughness and landscaping of the site, on local wind speed and direction is considered as well as the pedestrian activity to be expected (sitting, standing, strolling, and business walking).

The results of the assessment are presented in the form of contours of the Lawson Criteria at pedestrian/occupant level for each amenity area.

The assessment has comprised the following scenarios:

- **Baseline Existing Scenario:** this consists of the existing wind microclimate at the site without the proposed development. Figure 1.3 shows a view of the existing buildings (white) including Phase 1 and Phase 2 development (pink) along with the site area (yellow).

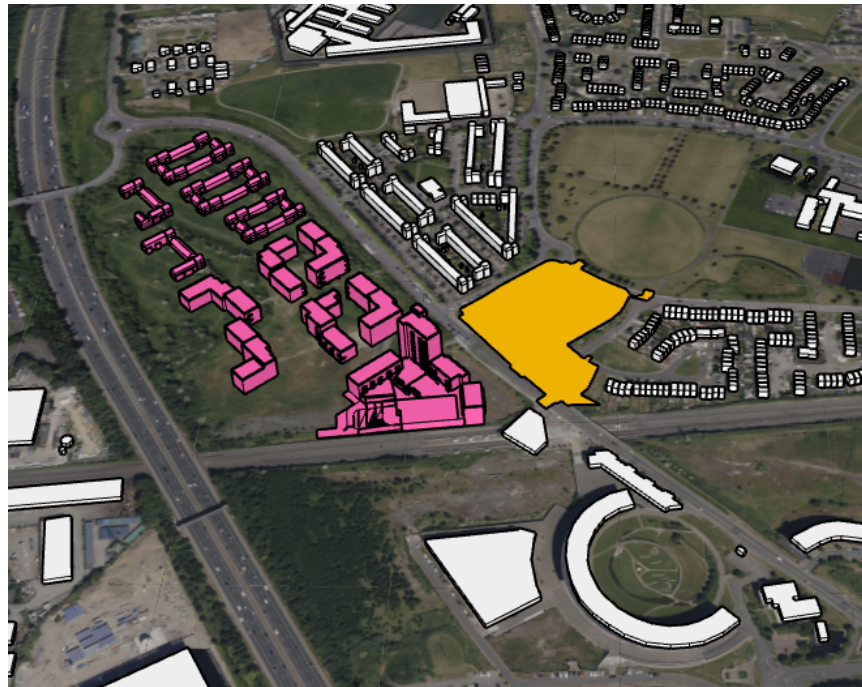


Figure 1.3: Buildings in the Baseline Scenario (white and pink) and Site Area (yellow).

- **Proposed Development Scenario:** this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings. Figure 1.4 shows a view of the buildings in the proposed development (red), existing surrounding buildings (white) including Phase 1 and Phase 2 development (pink), and site area (yellow).

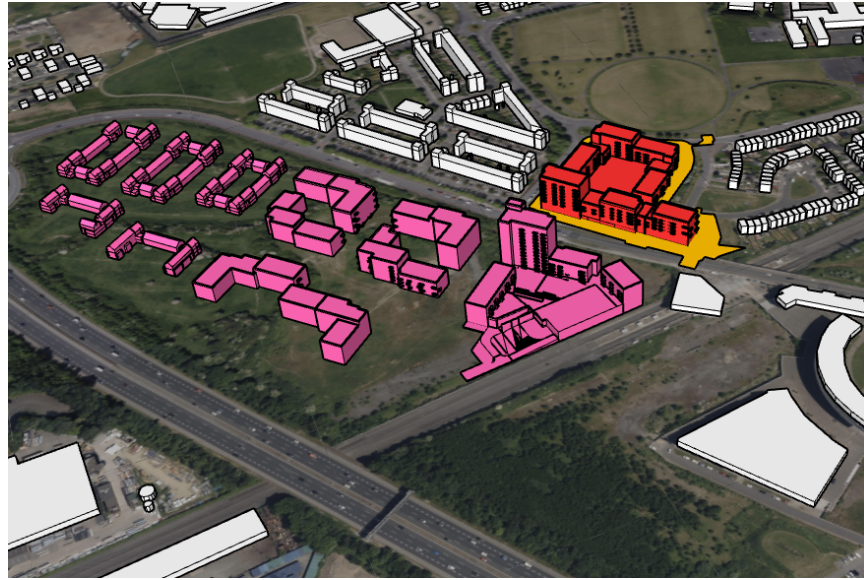


Figure 1.4: Buildings in the Proposed Scenario (Cherry Orchard Phase 3 Development (red), Existing Buildings (white and pink), and Site Area (yellow)).

- **Cumulative Scenario:** this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings, and those buildings that are subject to future planning application (Cherry orchard development - Phase 4). Figure 1.5 shows the buildings in the proposed development (red), the existing surrounding buildings (white) including Phase 1 and Phase 2 development (pink), the potential buildings (green), and the site area (yellow).



Figure 1.5: Buildings in the Cumulative Scenario (Cherry Orchard Phase 3 Development (red), Existing Buildings (white and Pink), Potential Future Buildings (green) and Site Area (yellow)).

Based on the analysis conducted, it can be concluded that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which was obtained from historical meteorological data recorded 10m above ground level at Dublin Airport.
- A 12-discrete set of wind directions is used to evaluate the probability of exceedance at any given threshold speed. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Cherry Orchard Phase 3 Development and its environment was performed utilizing a CFD methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for “Frail persons or cyclists” and for members of the “General Public” in the surrounding of the development.
- The proposed development will not have an impact on the surrounding urban context, including future cumulative buildings. Wind conditions in the Cumulative Scenario remain consistent with those in the Proposed Scenario.

The analysis results include a comparison of Lawson Discomfort Maps for the Baseline, Proposed and the Cumulative Scenario, as presented in Figure 1.6.

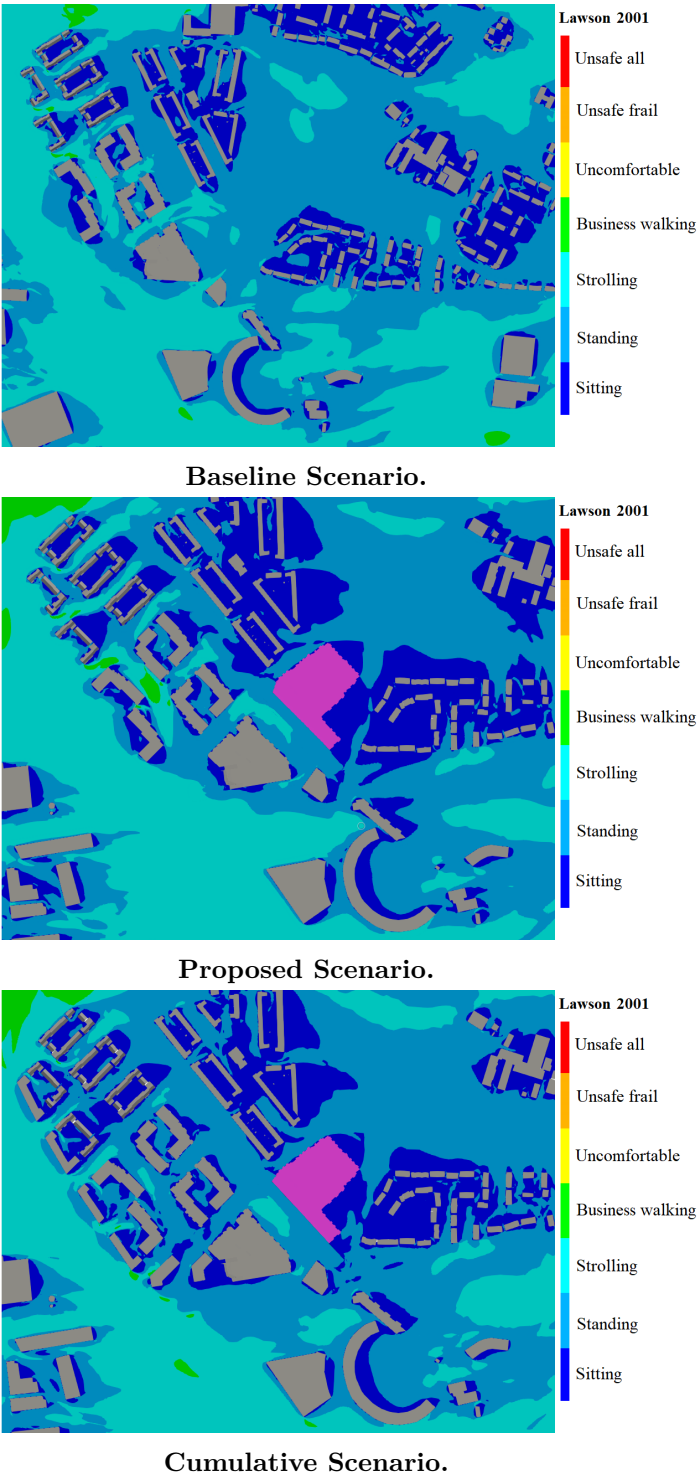


Figure 1.6: Comparison of Wind Microclimate Conditions (Lawson Comfort/Distress Map).

Table 1.2 presents the pedestrian comfort levels for various off-site locations analyzed. The comfort levels are computed at selected receptor locations, as illustrated in Figure 1.7. As shown in the table, none of the areas are deemed unsafe, and all off-site receptors around the development are suitable for at least a standing comfort level.

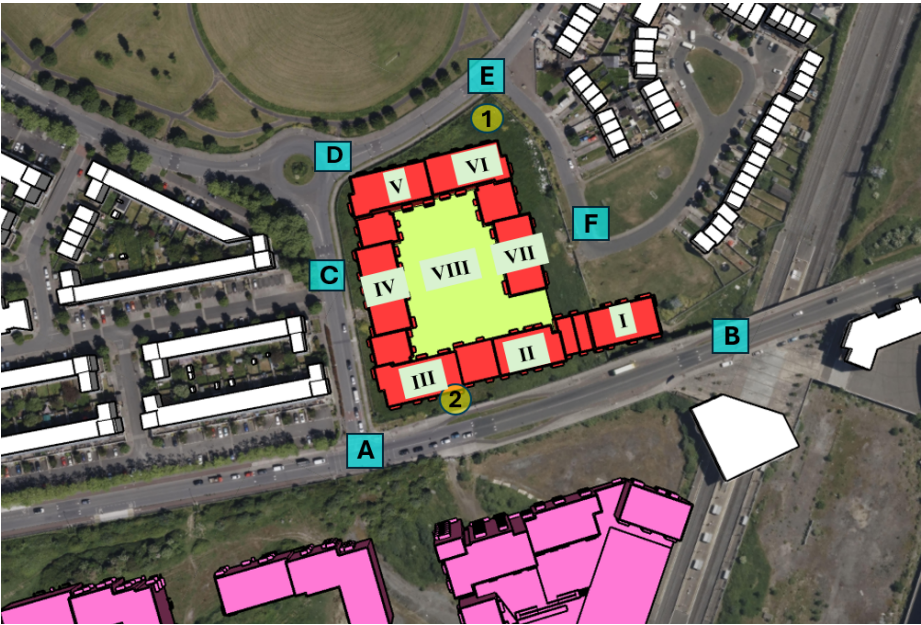


Figure 1.7: Potential Sensitive Receptors on the Ground - Pedestrian Activities Area.

Table 1.1 presents the Lawson discomfort map for the proposed scenario, along with the locations of off-site receptors. The figure illustrates that none of the areas are deemed unsafe, and all off-site receptors around the development are suitable for at least strolling comfort level.

Table 1.1: Ground Floor - Lawson Discomfort Map - 2D View.

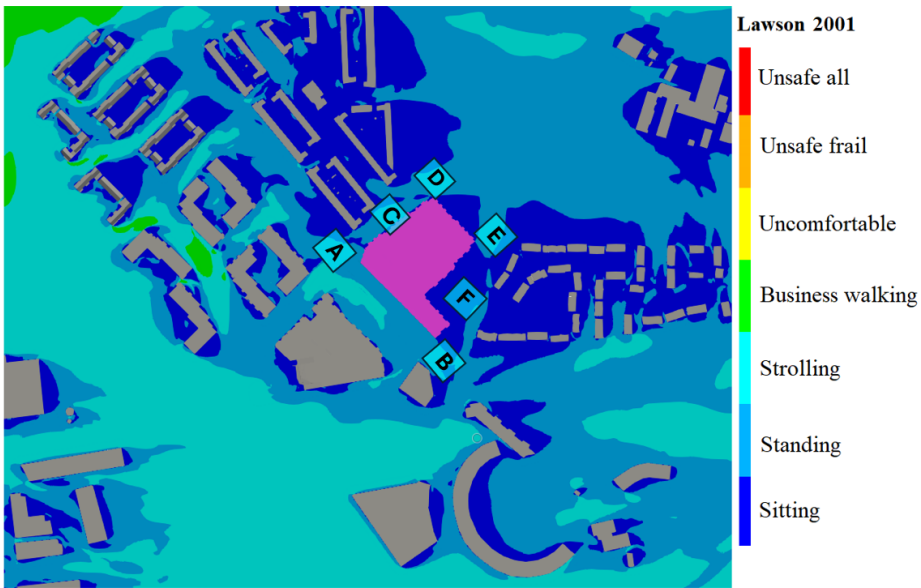


Table 1.2: Pedestrian Comfort Levels Vs Proposed Pedestrian Activities.

Reference point	Description	Sitting	Standing	Strolling	Business walking	Distress and Safety
A.	Park W Ave. - West	Tolerable	Tolerable	Acceptable	Acceptable	Safe.
B.	Park W Ave. - East	Tolerable	Tolerable	Acceptable	Acceptable	Safe.
C.	Cedar Brook Way	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
D.	Cedar Brook Way Junction	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
E.	Barn Ville Park Junction	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
F.	Barn Ville Park	Tolerable	Acceptable	Acceptable	Acceptable	Safe.

Therefore, the CFD study undertaken has demonstrated that, under the wind conditions typically prevailing in Dublin over the past 15 years:

- The development is designed to provide a high-quality environment appropriate to the intended use of each area and building, ensuring comfortable and pleasant conditions for pedestrians.
- The balconies on the 6th and 7th floors of the south-west elevation of Core C experience locally elevated wind exposure due to reduced shielding, resulting in occasional strolling and business-walking conditions under the Lawson criteria.
- The roof terrace areas of Core C and Core D experience locally elevated wind exposure due to reduced shielding, resulting in occasional strolling and business-walking conditions under the Lawson criteria. All remaining terraces provide comfortable conditions for occupants, with no areas of distress identified.
- The podium area remain comfortable for occupants, with no identified distress areas.
- The development introduces no critical impact on the surrounding buildings or adjacent roadways.

2. INTRODUCTION

B-Fluid Limited has been commissioned by 'Van Dijk Architects' to perform a Wind Microclimate Study for the Cherry Orchard Phase 3 Development in Dublin. Figure 2.1 shows a view of the proposed development within the existing urban context.



Figure 2.1: Proposed Cherry Orchard Phase 3 Development.

This report is completed by Dr. Cristina Paduano, Kamal Kishore Pandey and Dr. Sadia Siddiq.

Dr. Cristina Paduano is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for urban environment and the construction industry with over 18 years experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Kamal Pandey is a member of Engineers Ireland and CFD modelling specialist engineer. He holds a Master of Science in Computer Simulation in Science with specialization in Computational Fluid Mechanics and a B.Tech in Mechanical Engineering.

Dr. Sadia Siddiq is a CFD Modelling Engineer and member of Engineers Ireland (MIEI) specialising in computational fluid dynamics applications. With expertise in modeling fluid flows, airflow patterns, and heat/mass transfer, she's skilled at applying her knowledge to solve real-world challenges in fluid dynamics. She holds a PhD in Computational Mathematics from COMSATS University, where her research focused on CFD applications.

A wind microclimate study considers the possible wind patterns formed under both mean and peak wind conditions typically occurring on the site area, accounting for a scenario where the proposed development is inserted in the existing environment (potential impact) and, for a scenario where the proposed development is analyzed together with the existing environment and any permitted development (not constructed yet) that can be influenced by the wind patterns generated by the proposed one (cumulative impact).

The potential receptors include those areas, in the surrounding of the development, which can be exposed to potential risks generated by the elevated wind speed or building massing wind effects. In particular:

- Amenity areas (pedestrian level), areas likely to be utilised for leisure purposes and as such should be comfortable surroundings.
- Pedestrian routes and seating areas – to determine if locations are comfortable for leisure activities.
- Entrance to the buildings – to determine if there is potential for pressure related issues for entrances or lobbies.
- Landscaped areas – where there are sheltered areas.
- Impact to existing or adjoining developments – where the proposed buildings will cause discomfort conditions through proximity related issues.

The acceptance criteria which define the acceptable wind velocities in relation to the perception of comfort level experienced while carrying out a specific pedestrian activity is known as the “Lawson Criteria for Pedestrian Comfort and Distress”. A wind microclimate study analyzes the wind flow in an urban context (considering the wind conditions typically occurring on the site during a typical year) to develop the so called “Lawson Comfort and Distress Map”; the map identifies where a specific pedestrian activity can be carried out comfortably during most of the time.

The assessment can be performed by physical testing in wind tunnels or by performing “virtual wind tunnel testing” through numerical simulation using Computational Fluid Dynamics (CFD), as done for this project. The scope of the numerical study is to simulate the wind around the development, in order to predict the wind speeds the pedestrians will be exposed to and the level of comfort they will experience when carrying out a specific activity (i.e., sitting, standing, strolling, and business walking).

The following sections details the methodology, acceptance criteria, CFD wind simulations and the impact of the proposed development on the local wind microclimate against best practice guidelines for pedestrian comfort and safety.

2.1 GUIDANCE and LEGISLATION

According to the ‘Urban Development and Building Heights, Guidelines for Planning Authorities (Government of Ireland, December 2020)’ document, specific wind impact assessment of the microclimatic effects should be performed for ‘buildings taller than prevailing building heights in urban areas’. In the same guidance, standard buildings height is considered 6-8 storeys. Above this height, buildings are considered ‘taller’.

The recommended approach to wind microclimate studies is outlined in the “Wind Microclimate Guidelines for Developments in the City of London ‘(August 2019) and in the guidelines and recommendations contained in BRE Digest (DG) 520, “Wind Microclimate Around Buildings” (BRE, 2011). The Lawson Criteria of Comfort and Distress is used to benchmark the pedestrian wind microclimate.

The document also indicates how to use CFD to assess wind microclimate conditions and how to generate high quality outputs to provide a good understanding of the fundamental flow features around an urban context.

Usually, the recommended approach to wind microclimate studies is based on the building height, as presented in Figure 2.2.

Building Height	Recommended Approach to Wind Microclimate Studies
Similar or lower than the average height of surrounding buildings Up to 25m	Wind studies are not required, unless sensitive pedestrian activities are intended (e.g. around hospitals, transport hubs, etc.) or the project is located on an exposed location
Up to double the average height of surrounding buildings 25m to 50m	Computational Fluid Dynamics (CFD) Simulations OR Wind Tunnel Testing
Up to 4 times the average height of surrounding buildings 50m to 100m	Computational Fluid Dynamics (CFD) Simulations AND Wind Tunnel Testing
High Rise Above 100m	Early-Stage Massing Optimization: Wind Tunnel Testing OR Computational Fluid Dynamics (CFD) Simulations Detailed Design: Wind Tunnel Testing AND Computational Fluid Dynamics (CFD) Simulations

Figure 2.2: Recommended Approach to Wind Microclimate Studies based on Building Height, as prescribed by the Wind Microclimate Guidelines for Developments in the City of London (August 2019).

2.2 URBAN WIND EFFECTS

Buildings and topography affect the speed and direction of wind flows. Wind speed increases with increasing height above the ground, assuming a parabolic profile.

Flow near the ground level encounters obstacles represented by terrain roughness/buildings that reduce the wind speed and introduce random vertical and horizontal velocity components. This turbulence causes vertical mixing between the air moving horizontally at one level, and the air at those levels immediately above and below it. For this reason, the wind velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 2.3 shows the wind velocity profile, as described above.

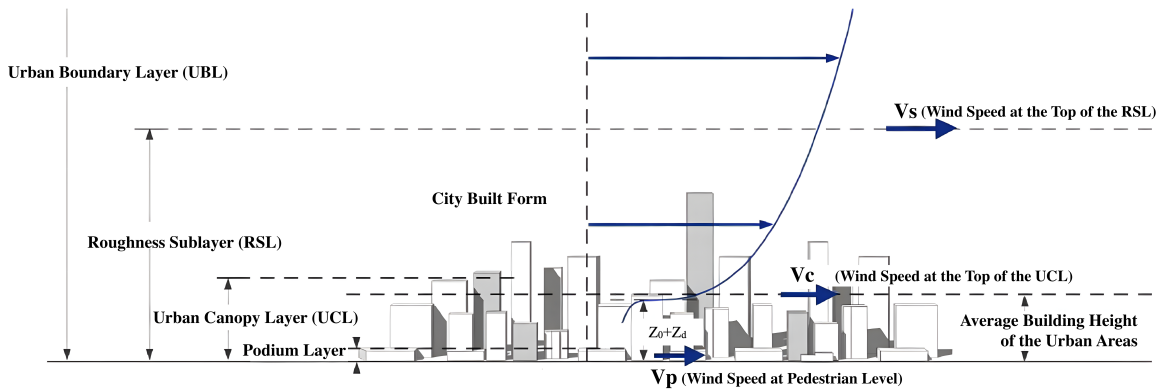


Figure 2.3: Wind Velocity Profile.

In an urban context, wind speeds at pedestrian level are generally low compared with upper-level wind speeds, however, the wind can create adverse patterns when flowing in between buildings which can cause local wind accelerations or re-circulations. This wind patterns effect pedestrian safety and comfort. In general, the wind effects to be avoided/mitigated in an urban context include the following:

- **Funnelling Effects:** The wind can accelerate significantly when flowing through a narrow passage between building structures. The highest speeds are experienced at the point where the restriction of the area is the greatest.
- **Downwash Effects:** The air stream when striking a tall building can flow around it, over it and a part can be deflected towards the ground. This downward component is called downwash effect and its intensity depends on the pressure difference driving the wind. The higher the building, the higher this pressure difference can be.
- **Downdraft Effects:** When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward flow of wind on the windward face of the tall building. This results in accelerated winds at pedestrian level in the space between the two buildings and around the windward corners of the tall building.
- **Corner Effects:** Wind can accelerate around the corners of the buildings. Pedestrians can experience higher wind speeds as well as more sudden changes in wind speeds.

The reason for this is that there are narrow transition zones between the accelerated flows and the adjacent quiescent regions. This effect is linked to the downwash effect as the downward stream component subsequently flows around the corners towards the leeward side of the building.

- **Wake Effect:** Excessive turbulence can occur in the leeward side of the building. This can cause sudden changes in wind velocity and can raise dust or lead to accumulation of debris. This effect is also dependent on the height of the building.

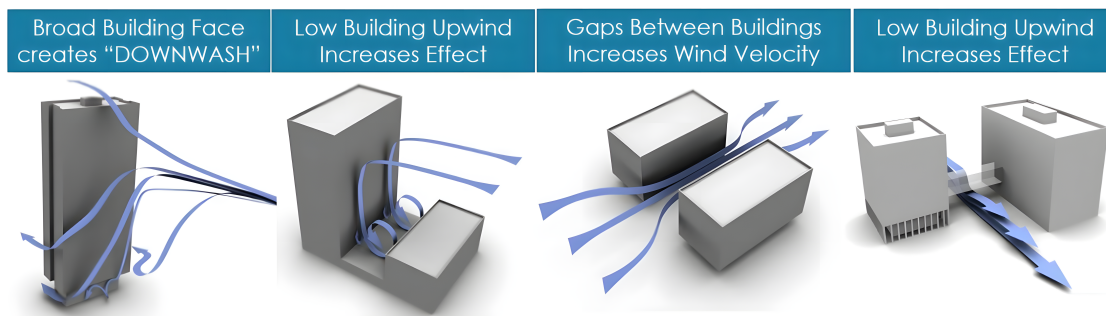


Figure 2.4: Parameters to know for Wind Conditions Assessment.

The anticipation of the likely wind conditions resulting from new developments are important considerations in the context of pedestrian comfort and the safe use of the public realm. While it is not always practical to design out all the risks associated with the wind environment, it is possible to provide local mitigation to minimise risk or discomfort where required.

3. ASSESSMENT METHODOLOGY

3.1 METHOD OF ASSESSMENT

The method for the study of wind microclimate combines the use of Computational Fluid Dynamics (CFD) to predict wind velocities and wind flow patterns, with the use of wind data from suitable meteorological station and the recommended comfort and safety standards (Lawson Criteria). The effect of the geometry, height and massing of the proposed development and existing surroundings including topography, ground roughness and landscaping of the site, on local wind speed and direction is considered as well as the pedestrian activity to be expected (sitting, standing, strolling and business walking). The results of the assessment are presented in the form of contours of the Lawson Criteria at pedestrian level.

The assessment has comprised the following scenarios:

- **Baseline Existing Scenario:** this consists of the existing wind microclimate at the site without the proposed development.
- **Proposed Development in the Existing Scenario:** this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings.
- **Cumulative Scenario:** this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings and potential buildings that are subject to future planning application.

In accordance with the guideline cited in section 2.1, the wind microclimate study should consider the effect of the proposed development together with buildings (existing and/or permitted) that are within 400m from the centre of the site. A radius of 600m is considered here for a more comprehensive analysis, as shown in Figures 3.1 and 3.2. Other taller buildings outside of this zone that could have an influence on wind conditions within the project site should be included for wind directions where they are upwind of the project site.

In particular, the following has been undertaken:

- Topography of the site with buildings (proposed and adjacent existing/permitted developments massing, depending on the scenario assessed “baseline, proposed or cumulative”) have been modelled using OpenFOAM Software.
- Suitable wind conditions have been determined based on historic wind data. Criteria and selected wind scenarios included means and peaks wind conditions that need to be assessed in relation to the Lawson Criteria.
- Computational Fluid Dynamics (CFD) has been used to simulate the local wind environment for the required scenarios (“baseline, proposed, cumulative”).
- The impact of the proposed development massing on the local wind environment has been determined (showing the wind flows obtained at pedestrian level).
- The impact of the proposed cumulative buildings on the local wind environment has been determined (showing the wind flows obtained at pedestrian level).
- Potential receptors (pedestrian areas) have been assessed through review of external

amenity/public areas (generating the Lawson Comfort and Distress Map).

- Potential mitigation strategies for any building related discomfort conditions (where necessary) have been explored and their effect introduced in the CFD model produced.



Figure 3.1: Area of interest to be modelled - **Top View**.



Figure 3.2: Area of interest to be modelled - **3D View**.

3.2 ACCEPTANCE CRITERIA

Pedestrian Wind Comfort is measured in function of the frequency of wind speed threshold exceeded based on the pedestrian activity. The assessment of pedestrian level wind conditions requires a standard against which measured or expected wind velocities can be compared.

Only gust winds are considered in the safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential impact on pedestrian safety. Gusts cause the majority of cases of annoyance and distress and are assessed in addition to average wind speeds. Gust speeds should be divided by 1.85 and these "gust equivalent mean" (GEM) speeds are compared to the same criteria as for the mean hourly wind speeds. This avoids the need for different criteria for mean and gust wind speeds.

The following criteria are widely accepted by municipal authorities as well as the international building design and city planning community:

- **DISCOMFORT CRITERIA:** Relates to the activity of the individual.
Onset of discomfort:
 - Depends on the activity in which the individual is engaged and is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time.
- **DISTRESS CRITERIA:** Relates to the physical well-being of the individual.
Onset of distress:
 - ‘Frail Person Or Cyclist’: equivalent to an hourly mean speed of 15m/s to be exceeded more than 0.023% per year. This is intended to identify wind conditions which less able individuals or cyclists may find physically difficult. Conditions in excess of this limit may be acceptable for optional routes and routes which less physically able individuals are unlikely to use.
 - ‘General Public’: A mean speed of 20m/s or larger speed to be exceeded more than 0.023% per year, when aerodynamic forces approach body weight makes it impossible for anyone to remain standing. If wind speeds exceed these values, pedestrian access should be discouraged.

The above criteria set out four pedestrian activities and reflect the fact that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 3.3. Lawson scale assesses pedestrian wind comfort in absolute terms and defines the reaction of an average person to the wind. Each wind type is associated to a number, corresponding to the Beaufort scale. Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land. A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.

Beaufort Scale	Wind Type	Mean Hourly Wind Speed (m/s)		Acceptance Level Based on Activity–Lawson Criteria			
				Sitting	Standing/ Entrances	Leisure Walking	Business Walking
0-1	Light Air	0 – 1.55	COMFORT				
2	Light Breeze	1.55 - 3.35					
3	Gentle Breeze	3.35 - 5.45					
4	Moderate	5.45 - 7.95					
5	Fresh Breeze	7.95 - 10.75					
6	Strong Breeze	10.75 - 13.85					
7	Near Gale	13.85 - 17.15					
8	Gale	17.15 - 20.75	DISTRESS				
9	Strong Gale	20.75 - 24.45					
Legend		Acceptable	Tolerable	Not acceptable	Dangerous		
							
							

Figure 3.3: Lawson Scale.

These criteria for wind forces represent average wind tolerances. They are subjective and variable depending on thermal conditions, age, health, clothing, etc. which can all affect a person's perception of a local microclimate. Moreover, pedestrian activity alters between winter and summer months. The criteria assume that people will be suitably dressed for the time of year and individual activity. It is reasonable to assume, for instance, that areas designated for outdoor seating will not be used on the windiest days of the year. Weather data measured are used to calculate how often a given wind speed will occur each year over a specified area.

Pedestrian comfort criteria are assessed at 1.8m above ground level. Unless in extremely unusual circumstances, velocities at pedestrian level increase as you go higher from ground level.

A breach of the distress criteria requires a consideration of:

- whether the location is on a major route through the complex,
- whether there are suitable alternate routes which are not distressful.

If the predicted wind conditions exceed the threshold, then conditions are unacceptable for the type of pedestrian activity and mitigation measure should be implemented into the design.

Pedestrian Comfort Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 5% of the time	Description
Sitting	4m/s	Acceptable for frequent outdoor sitting use, i.e., restaurant /café
Standing	6m/s	Acceptable for occasional outdoor sitting use, i.e., public outdoor spaces
Walking/Strolling	8m/s	Acceptable for entrances/bus stops /covered walkaways
Business Walking	10m/s	Acceptable for external pavements, walkways
Unacceptable/Distress	>10m/s	Start of not comfortable/distress level for pedestrian access

Figure 3.4: Lawson Categories Scale - Comfort.

Pedestrian Safety Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 0.0022% of the time	Description
Unsafe for public	>20m/s	Distress/safety concern for pedestrian
Unsafe for cyclists or frail person	>15m/s	Distress/safety concern for cyclist/frail person

Figure 3.5: Lawson Categories Scale - Distress/Safety.

3.3 SIGNIFICANCE CRITERIA

The significance of on-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, using the table provided by the Lawson Comfort and Distress Criteria.

The significance of off-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, prior and after the introduction of the proposed development.

Significance	Trigger	Mitigation required?
Major Adverse	Conditions are “unsafe”	Yes
Moderate Adverse	Conditions are “unsuitable” (in terms of comfort) for the intended pedestrian use.	Yes
Negligible	Conditions are “suitable” for the intended pedestrian use.	No
Moderate Beneficial	Conditions are calmer than required for the intended pedestrian use (by at least one comfort category).	No

Figure 3.6: Significance Criteria for On-Site Receptors.

Significance	Trigger	Mitigation required?
Major Adverse	Conditions that were “safe” in the baseline scenario became “unsafe” as a result of the Proposed Development. <i>OR</i> Conditions that were “suitable” in terms of comfort in the baseline scenario became “unsuitable” because of the Proposed Development. <i>OR</i> Conditions that were “unsafe” in the baseline scenario are made worse because of the Proposed Development.	Yes
Moderate Adverse	Conditions that were “suitable” in terms of comfort in the baseline scenario are made windier (by at least one comfort category) as a result of the Proposed Development but remain “suitable” for the intended pedestrian activity.	No
Negligible	Conditions remain the same as in the baseline scenario.	No
Major Beneficial	Conditions that were “unsafe” in the baseline scenario became “safe” because of the Proposed Development.	No
Moderate Beneficial Potential Receptors	Conditions that were “unsuitable” in terms of comfort in the baseline scenario became “suitable” because of the Proposed Development. <i>OR</i> Conditions that were “unsafe” in the baseline scenario are made better as a result of the Proposed Development (but not so as to make them “safe”).	No

Figure 3.7: Significance Criteria for Off-Site Receptors

4. CFD MODELLING METHOD

4.1 INTRODUCTION OF CFD TECHNIQUE

Computational Fluid Dynamics (CFD) is a numerical technique to simulate fluid flow, heat and mass transfer, chemical reaction and combustion, multiphase flow, and other phenomena related to fluid flows. CFD modelling includes three main stage: pre-processing, simulation and post-processing as described in Figure 4.1. The Navier-Stokes equations, used within CFD analysis, are based entirely on the application of fundamental laws of physics and therefore produce extremely accurate results providing that the scenario modelled is a good representation of reality.

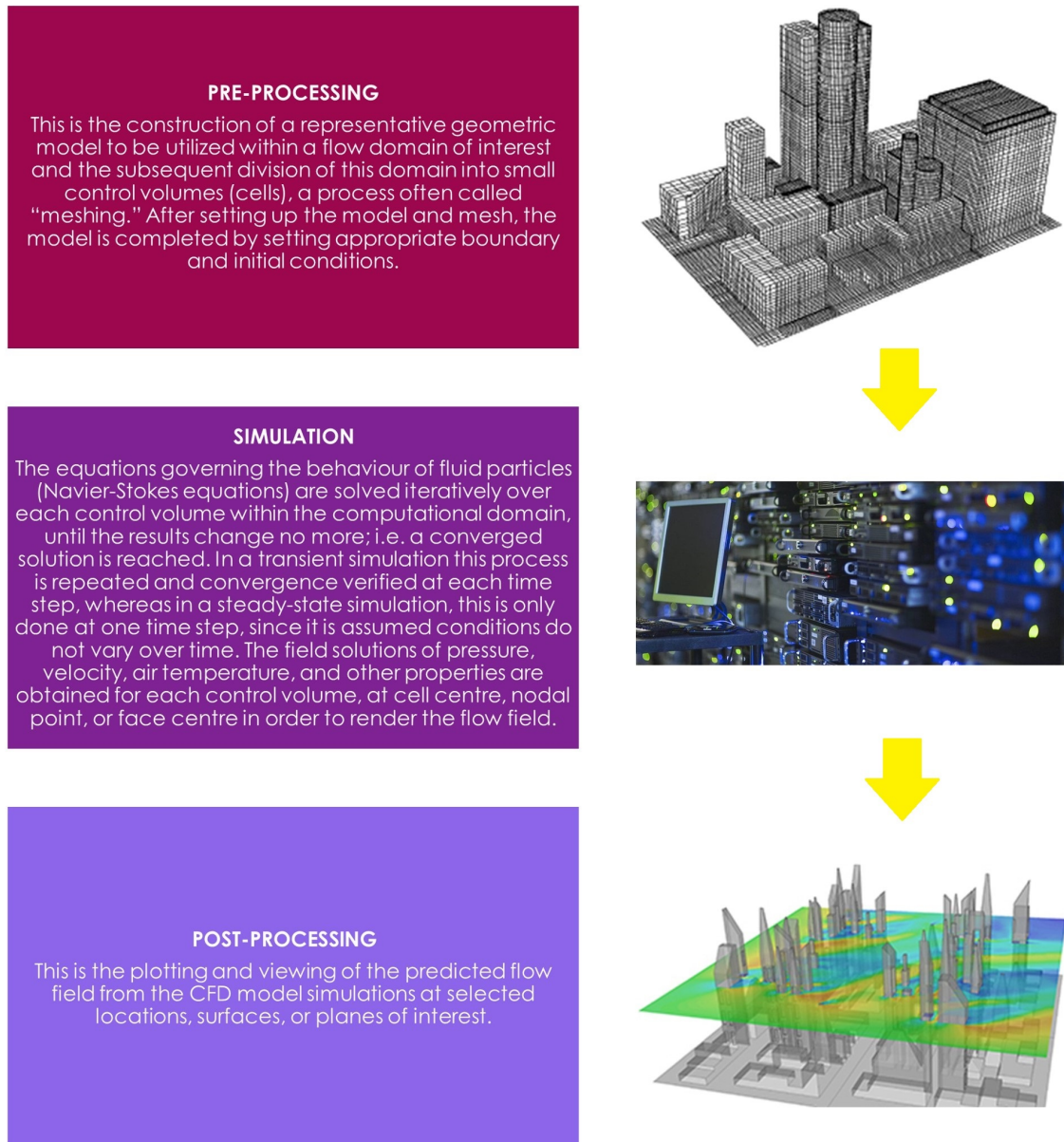


Figure 4.1: CFD Modelling Process Explanation

4.2 CFD SOFTWARE DETAILS

This report employs OpenFOAM Code, based on the concept of Reynolds-Averaged Navier-Stokes (RANS) formulations and the post-processing visualisation tool ParaView. OpenFOAM is a CFD software released and developed primarily by OpenCFD Ltd, since 2004. It has a large user base across most areas of engineering and science, from both commercial and academic organisations. OpenFOAM has an extensive range of features to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics.

4.3 CFD MODEL DETAILS

FLOW ASSUMPTIONS & TURBULENCE MODELLING

In this study, the air flow is assumed to be incompressible, Newtonian, and statistically steady with temperature and gravity effects neglected. The flow is governed by the Reynolds-Averaged Navier-Stokes (RANS) formulation for mass and momentum where the turbulence is modeled using the $k-\omega$ SST turbulence model.

MODELED GEOMETRIES

The extent of the built area (e.g. buildings, structures or topography) that is represented in the numerical domain depends on the influence of the features on the region of interest. According to the Best Practice Guideline (COST Action 732), a building with height H (height of the tallest proposed building is $\approx 33m$) may have a minimal influence if its distance from the region of interest is greater than $6 - 10H$ (we considered $600m$ which is even larger than required).

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 4.1).

Table 4.1: Modelled Environment Dimensions.

	MODELLED CFD ENVIRONMENT DIMENSIONS		
	Width	Length	Height
Computational Domain	1000m	1000m	160m

A 3D view of the proposed development massing model in the domain is presented in Figure 4.2. Geometries used in this study include two parts:

- The massing model of the proposed Cherry Orchard Phase 3 Development, which is generated based on drawings provided by the Van Dijk Architects;
- The massing model of the building blocks within $600m$ from the development (colored in white).



Figure 4.2: 3D View of the Massing Models of the Proposed Cherry Orchard Phase 3 Development (red) and Surrounding Building Blocks (white and pink) and Site area (yellow).

COMPUTATIONAL MESH

The computational mesh used in this report is created using OpenFOAM utilities blockMesh and snappyHexMesh. It is a hybrid mesh containing a structured background grid and an unstructured hexahedron-dominated mesh in the near-wall region. The largest cell has a depth of $5m$, where the smallest has a depth of $0.15m$. The total cell count is approx. 149 million. An isometric view of the geometry captured by the computational mesh is shown in Figure 4.3.

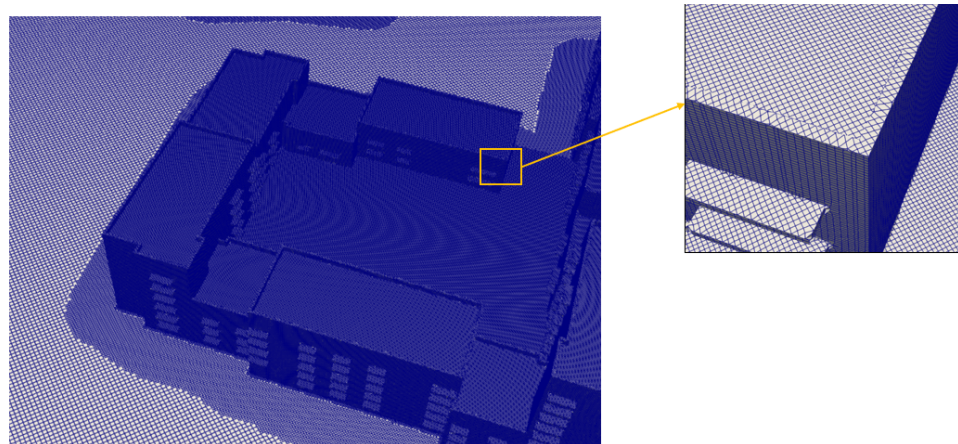


Figure 4.3: Computational Mesh of Cherry Orchard Phase 3 Development.

BOUNDARY CONDITIONS

For each wind directions, an initial wind velocity was set based on logarithmic wind profile. Surfaces within the model were specified as having ‘no slip’ condition. This boundary condition, ensures that flow moving parallel to a surface is brought to rest at the point where

it meets the surface. All the other domain boundaries are set as "Open Boundaries".

ATMOSPHERIC BOUNDARY LAYER

The atmospheric boundary layer is the lowest part of the atmosphere, extending from the earth's surface to a height of approximately $1 - 2\text{km}$, where the wind speed and direction are influenced by the terrain and surface roughness. Eurocode 1: 2005 provides guidelines for determining the wind profile in the atmospheric boundary layer, using the following equation:

$$u_{(z)} = \frac{u^*}{K} \cdot \ln\left(\frac{z + z_0}{z_0}\right) \quad (4.1)$$

where:

- $u_{(z)}$ = wind speed measured at the reference height z .
- z = reference height to measure $u_{(z)}$.
- z_0 = roughness length selected.
- u^* = friction velocity.
- K = Karman constant.

The roughness value, as recommended by the Eurocode standard (Table 4.2), is used to determine the atmospheric wind profiles.

Category	Description	z_0
0	Coastal regions	0.003
I	Flat terrain with minimal obstacles	0.01
II	Open terrain	0.05
III	Suburban area	0.3
IV	Urban area	1

Table 4.2: Eurocode Standard: Roughness Height Parameters by Terrain Category.

Figure 4.4 shows the atmospheric boundary layer profile, highlighting the difference in wind profiles between open terrain and urban areas. The open terrain wind profile ($z_0 = 0.05$) is steeper than the urban wind profile ($z_0 = 1$), resulting in a faster increase in wind speed with height. However, when wind approaches from an open terrain area to an urban area, the wind speed decreases due to the "exposure correction factor". This factor scales down the velocity profile, with a correction factor of 1 for open terrain and 0.7 for urban areas.

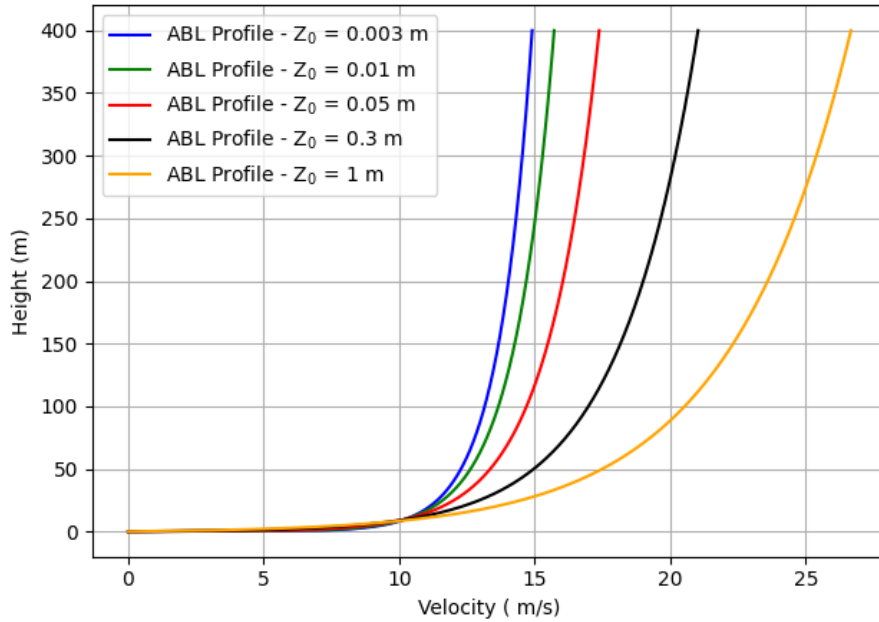


Figure 4.4: Atmospheric Wind Profiles Corresponding to a 10m/s Wind Speed Reference.

NUMERICAL CONFIGURATIONS

In this study, all simulations employ the SIMPLE algorithm to perform the pressure–velocity coupling (simpleFoam solver in OpenFOAM). All terms in the RANS equations are discretized using the nominally second-order cell-centred finite volume method, where gradient and Laplacian terms are discretized using Gaussian integration with linear interpolation. Convection/advection terms are discretized using a second-order accurate linear-upwind scheme.

PARALLEL CONFIGURATIONS

The computational mesh was decomposed using the SCOTCH algorithm. All simulations in this study are performed in parallel on an in-house HPC cluster. Key parameters of the CFD model used in this wind microclimate study are summarised in Table 4.3.

Table 4.3: Key Parameters of the CFD Model for Each Wind Scenario.

KEY PARAMETERS OF THE CFD MODEL	
Air Density (ρ)	1.2kg/m^3
Turbulence Model	$k - \omega$ SST Model
Cell Size	Approx. 0.15m at the development Approx. 0.3m in the surroundings 5m elsewhere
Total Cell Count	Approx. 149 million

5. LOCAL WIND CLIMATE

5.1 THE EXISTING RECEIVING ENVIRONMENT

In this chapter, wind impact has been assessed on the existing receiving environment considered as the existing buildings and the topography of the site prior of the construction of the proposed development. A statistical analysis of 15 years historical weather wind data has been carried out to assess the most critical wind speeds, directions and frequency of occurrence of the same. The aim of this assessment has been to identify if comfort and safety of pedestrian/occupants are inline with the criteria outlined by Lawson for each specific wind condition and human activity carried out.

5.1.1 SITE LOCATION AND SURROUNDING AREA

The Proposed Cherry Orchard Phase 3 Development will be situated in Dublin. The existing environment is shown in Figure 5.1. The area considered for the existing environment and proposed development assessment comprises an Approx. 1.13km^2 area around the Proposed Cherry Orchard Phase 3 Development Site as represented in Figure 5.2.



Figure 5.1: Extents of Analyzed Existing Environment Around the Proposed Cherry Orchard Phase 3 Development.

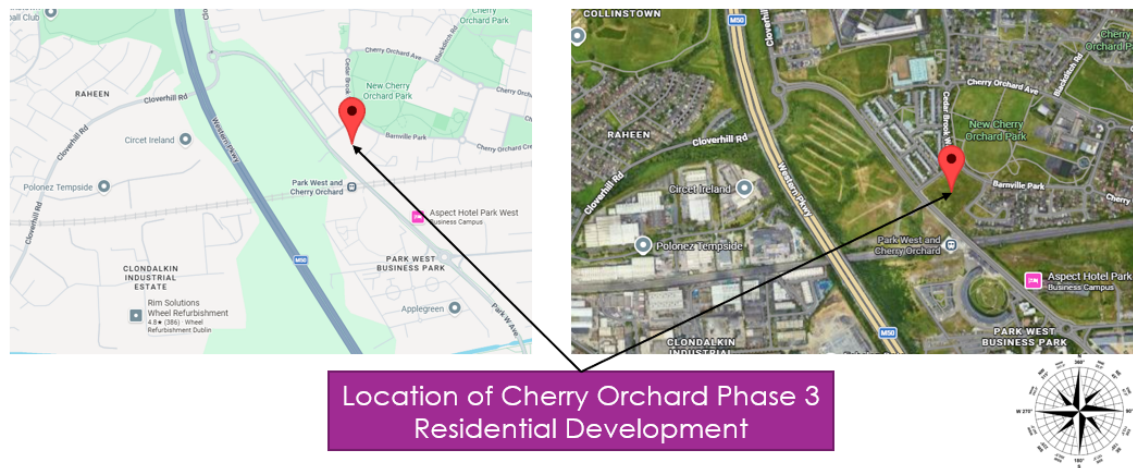


Figure 5.2: Cherry Orchard Phase 3 Development Site Location and Existing Environment.

5.1.2 TOPOGRAPHY AND BUILT IN ENVIRONMENT

Figure 5.3 shows an aerial photograph of the terrain surrounding the subject site at the Proposed Cherry Orchard Phase 3 Development. The Proposed Cherry Orchard Phase 3 is located in Dublin. The area surrounding the site can be characterized as an urban environment.

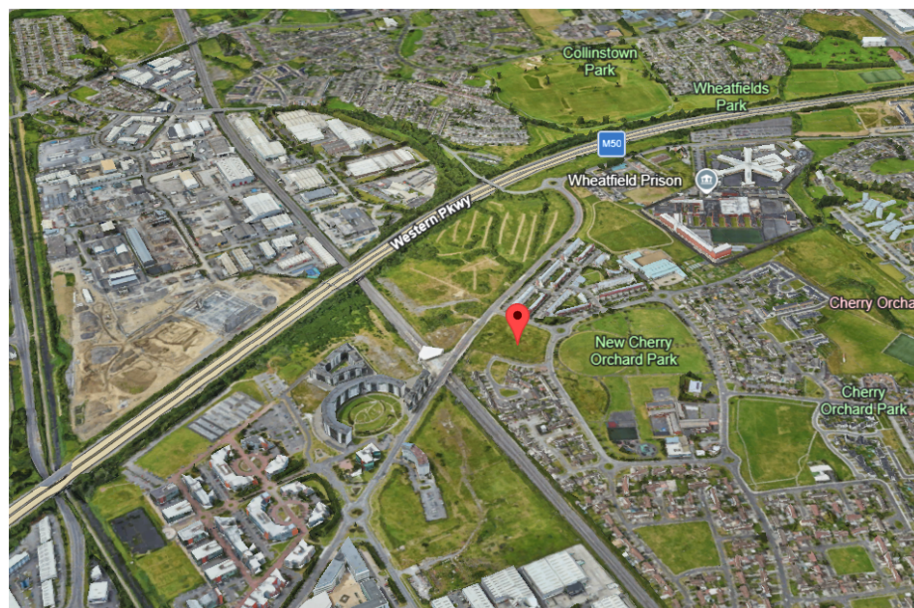


Figure 5.3: Built-in Environment Around Construction Site at the Proposed Cherry Orchard Phase 3 Development.

5.2 LOCAL WIND CONDITIONS

This analysis considers the whole development being exposed to the typical wind condition of the site. The building is oriented as shown in the previous sections. The wind profile is built using the annual average of meteorology data collected at Dublin Airport Weather Station. Figure 5.4 shows on the map, the position of the Proposed Cherry Orchard Phase 3 Development and the position of Dublin Airport.

Regarding the transferability of the available wind climate data, the following considerations have been made:

- *Terrain:* The meteorological station is located on the flat open terrain of the airport, while the development site is situated on flat terrain surrounded by a mix of industrial and residential buildings
- *Wind Directions:* The landscape around the development site can in principle be characterized as flat terrain. With respect to the general wind climate no significant topographical influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Dublin Airport are applicable for the assessment of the wind comfort at the development site.

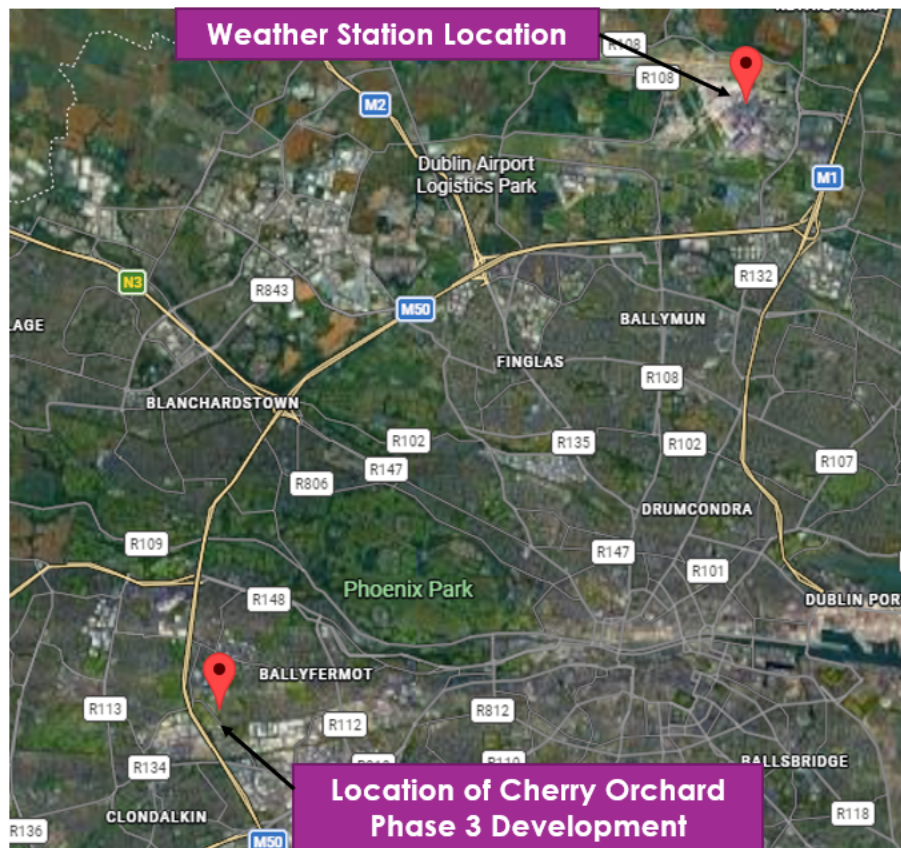


Figure 5.4: Map Showing the Position of the Proposed Cherry Orchard Phase 3 Development and Dublin Airport.

The assessment of the wind comfort conditions at the new development will be based on a discrete set of wind data throughout a year (annual wind statistic) provided by Meteoblue for Dublin Airport meteorological wind station. In this study, a 12-discrete set of wind directions is utilized to evaluate the probability of exceedance at any given threshold speed. A Weibull probability distribution is employed to transform the provided wind data into a continuous distribution for each wind direction. From the Weibull distribution function, the probability (P) for each wind direction can be obtained by:

$$P = e^{(-\frac{U}{c})^k}$$

Where c is the scale parameter and k is the shape parameter for a wind speed U .

Statistical analysis of the number of hours and magnitudes of wind is performed in order to indicate the pedestrian comfort and distress analysis as per Lawson Criteria. Each of the wind directions were interpolated to calculate the probability that a velocity threshold will be exceeded. Based on the criterion of occurrence frequency, if the proposed site is exposed to a wind from a specific direction for more than 5 percent of the time, then the microclimate analysis should consider the impact of this wind (accounting for its direction and most frequent speed) on the local microclimate. However, to get complete picture we ran simulations for wind from 12 distinct directions equally spaced around the development (every 30°).

As stated above, the local wind climate is determined from historical meteorological data recorded at Dublin Airport meteorological wind station. The data set analyzed for this assessment is based on the meteorological data associated with the maximum daily wind speeds recorded over a 15-year period between 2008 and 2023 at a weather station at the airport, which is located 10m above ground. Figure 5.5 shows the wind speed record during the latest 5 years.

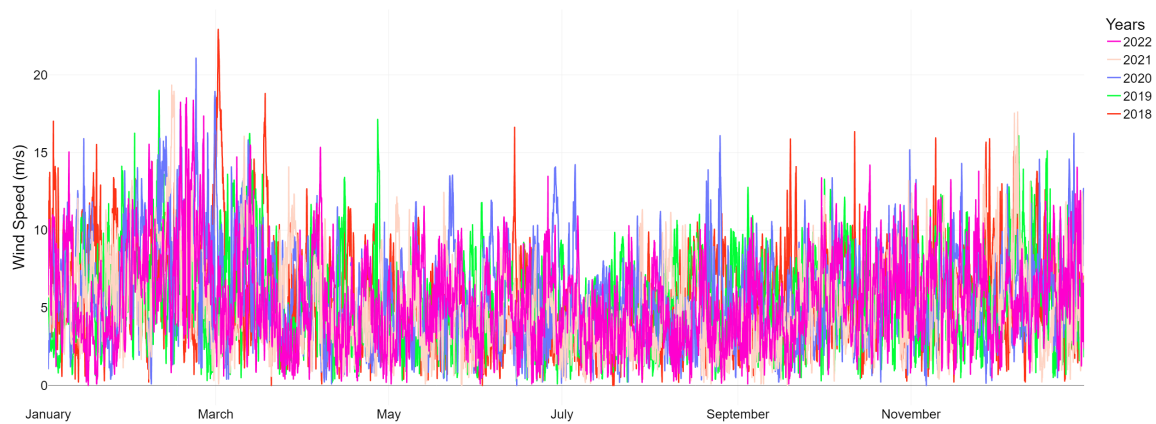


Figure 5.5: Local Wind Conditions - Wind Speed - 2018-2022.

Figure 5.6 displays a wind speed diagram for Dublin, illustrating the number of days per month when the wind attains specific speeds. It is evident from this figure that strong winds

are more prevalent during the winter season (December, January, and February) and the start of spring season (March) compared to other seasons.

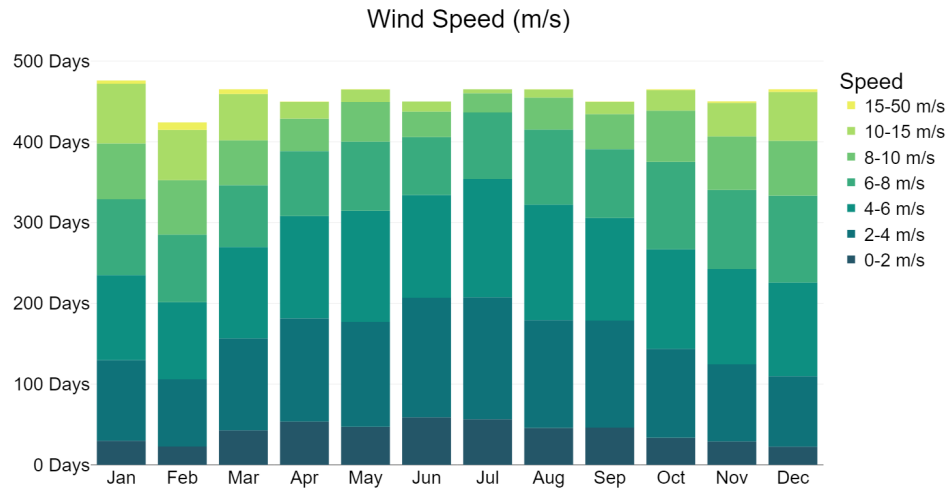


Figure 5.6: Dublin Wind Speed Diagram.

Figure 5.7 displays the wind rose for the Proposed Cherry Orchard Phase 3 revealing the percentage of wind coming from different directions over a 15-year period. Detailed percentages for each direction are outlined in Table 5.1. As depicted in Figure 5.7 and highlighted in Table 5.1, the highest probability of wind occurrence lies in the wind blowing from 240° to 300° with 270° being most prevalent. This finding indicates that west winds contribute significantly to the probability of discomfort exceedance. In addition, seasonal changes were analyzed in order to indicate the prevailing wind directions (Figure 5.8).

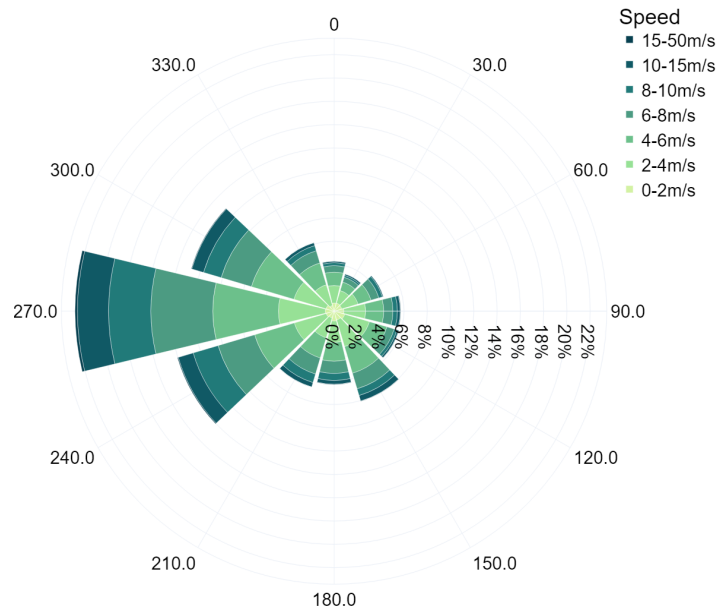


Figure 5.7: Dublin Wind Rose.

Table 5.1: A detailed table includes wind occurrences, wind patterns, and roughness lengths for different wind directions.

Wind Direction	Scale Parameter	Shape Parameter	Roughness Length (z_0)	Frequency
270.00°	1.80	6.11	0.30	22.22%
240.00°	2.07	6.55	0.30	13.98%
300.00°	1.66	5.18	0.30	12.83%
150.00°	1.35	3.88	0.30	8.10%
210.00°	2.05	6.02	0.30	6.75%
180.00°	1.49	4.62	0.30	6.33%
330.00°	1.60	4.38	0.30	6.14%
120.00°	0.92	1.70	0.30	5.86%
90.00°	1.15	3.08	0.30	5.74%
60.00°	1.82	4.80	0.30	4.42%
0.00°	1.42	3.81	0.30	4.28%
30.00°	1.22	3.33	0.30	3.34%

In addition to the annual statistical analysis of wind occurrences (Figure 5.7), a detailed examination has been conducted to comprehend the wind conditions during each season. As illustrated in Figure 5.8, the wind patterns in spring closely resemble those in summer, with a higher percentage of winds coming from the east and north-east compared to the same direction in summer. Although in autumn the wind pattern is similar to winter, during winter, the winds occur more frequently and are stronger. In general, the predominant winds come from the west at higher speeds compared to other wind directions throughout all seasons.

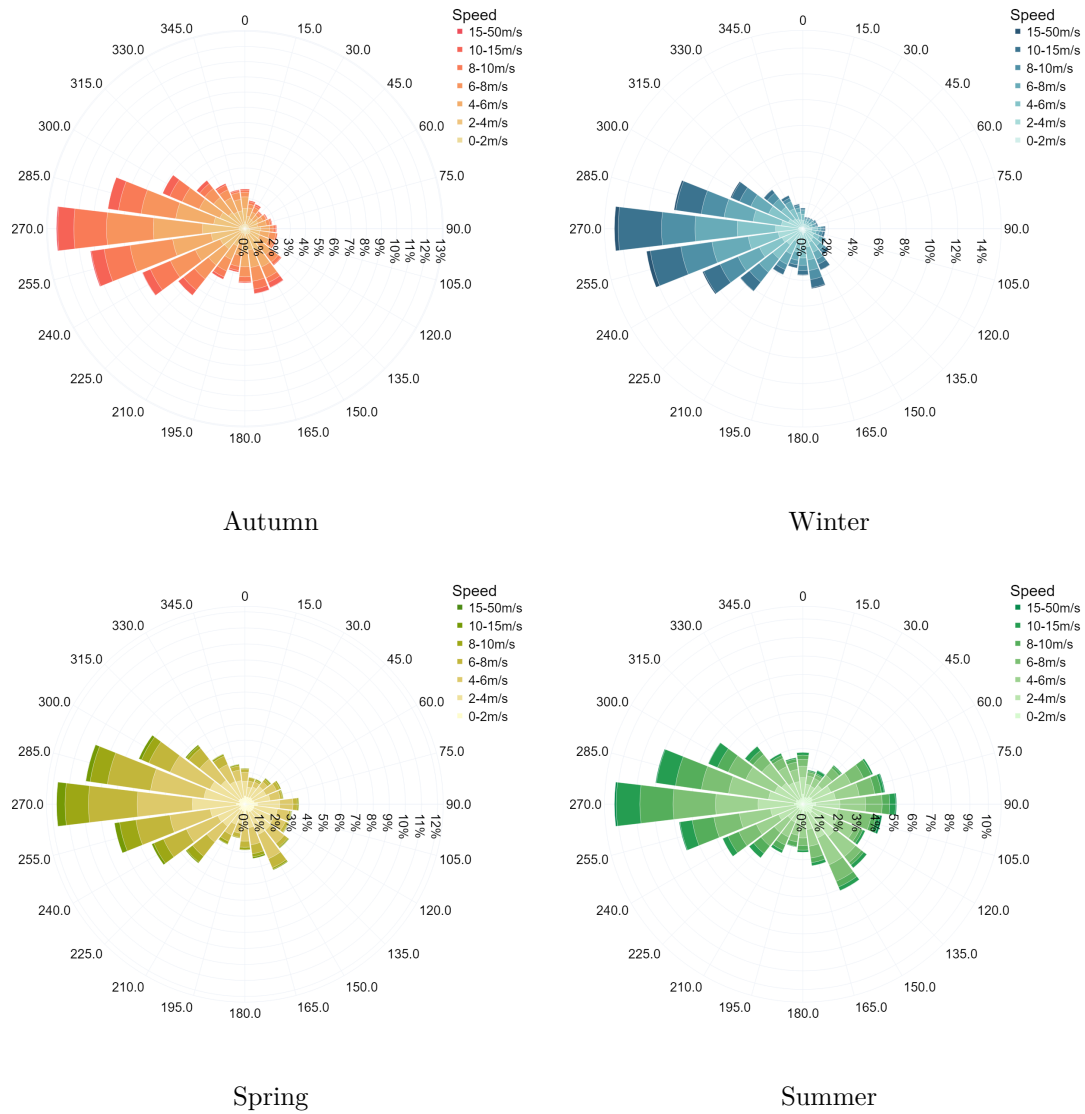


Figure 5.8: Wind Speeds and Wind Directions at Different Seasons.

6. CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

6.1 DESCRIPTION OF PROPOSED DEVELOPMENT

The proposed development will consist of the construction of a residential led mixed-use scheme containing 312no. residential apartments comprising 244no. cost rental and 68no. social units, 8no. local retail and commercial units, landscaped public and communal open space. The proposed development includes a new principal access via Barnville Park to the south, providing entry to an internal undercroft parking court, upgraded pedestrian and cycle footpaths, Barnville link connecting the Park West Avenue and Cherry Orchard railway station and all associated site and development works. The proposed development represents Phase 3 of the overall planned development at Cherry Orchard Point scheme for Development Sites 4 and 5 of the LAP lands. Phase 1 of the overall planned development was granted permission in July 2024 (ACP Case Ref: 318607-23) and Phase 2 was granted in September 2025 (ACP Case Ref: 321931-25). The proposed development comprises the works to be undertaken on Site 5: Barnville, which forms the subject of this planning application.

The proposed development (Total GFA of c. 28413 sq.m) involves construction of 312no. residential apartments (c. 24556 sq.m), across 7 core blocks consisting of 4 to 10 floors, comprising 16no. studio units, 146no. one-bed units, 139no. two-bed units (15no. two-bed three-person and 124no. two-bed four person), 9 no. 3-bed units (9no. three-bed five-person) and 2no. 4-bed units (2no. four-bed seven-person) together with 8no. Local Retail and Commercial units (c. 1441 sq.m GFA), and all ancillary and sundry accommodation (c. 2,416sq.m total GFA). The proposed development also includes the provision of landscaped public open spaces of c.1691 sq.m. and Communal open space of c. 2390 sq.m. The communal open space has been designed to provide a high-quality amenity area, incorporating a community garden with seating, play and fitness facilities, and associated landscaping. The scheme also provides private open space for all residential units.

The proposed development will involve the provision of car parking (including accessible and EV car parking spaces), car sharing spaces, bicycle parking spaces, motorbike spaces and loading bays. The scheme includes a Barnville link to the south of the site connecting Barnville Park with Park West Avenue and providing direct pedestrian access to the railway station, along with overall 4no. pedestrian crossing points connecting Park West Avenue, Barnville Park and New Cherry Orchard Park.

The development will also provide for all associated ancillary site development infrastructure including site clearance, boundary treatment, associated public lighting, internal roads and pathways, substations, switch room, water tank rooms, storage room, meter room, sprinkler tank room, bin storage, bicycle stores, hard and soft landscaping, play equipment, boundary walls, attenuation area, green and blue roof systems, photovoltaic panels and all associated works and infrastructure to facilitate the development including connection to foul and surface water drainage and water supply.

Refer to the enclosed statutory notices for a full description of development as part of this planning application.

Figure 6.1 shows a view of the proposed development (red) and existing surround buildings (pink and white).

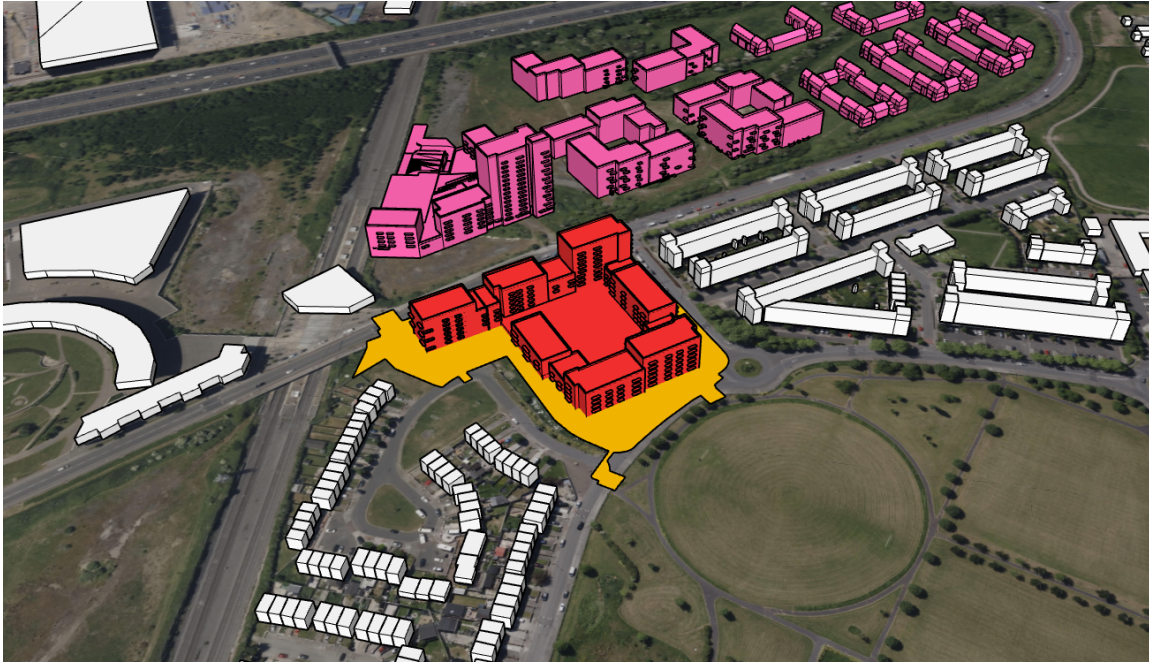


Figure 6.1: Proposed Cherry Orchard Phase 3 Development.

6.2 POTENTIAL RECEPTORS ON GROUND FLOOR LEVEL

Potential receptors for the wind assessment are all pedestrian circulation routes, building entrances and leisure open areas within the site and in neighboring adjacent areas. The pedestrian level is considered at $1.8m$ above ground.

Figure 6.2 shows the pedestrian activity area on the ground around the development. These areas are considered as sensitive potential receptors for the wind microclimate.

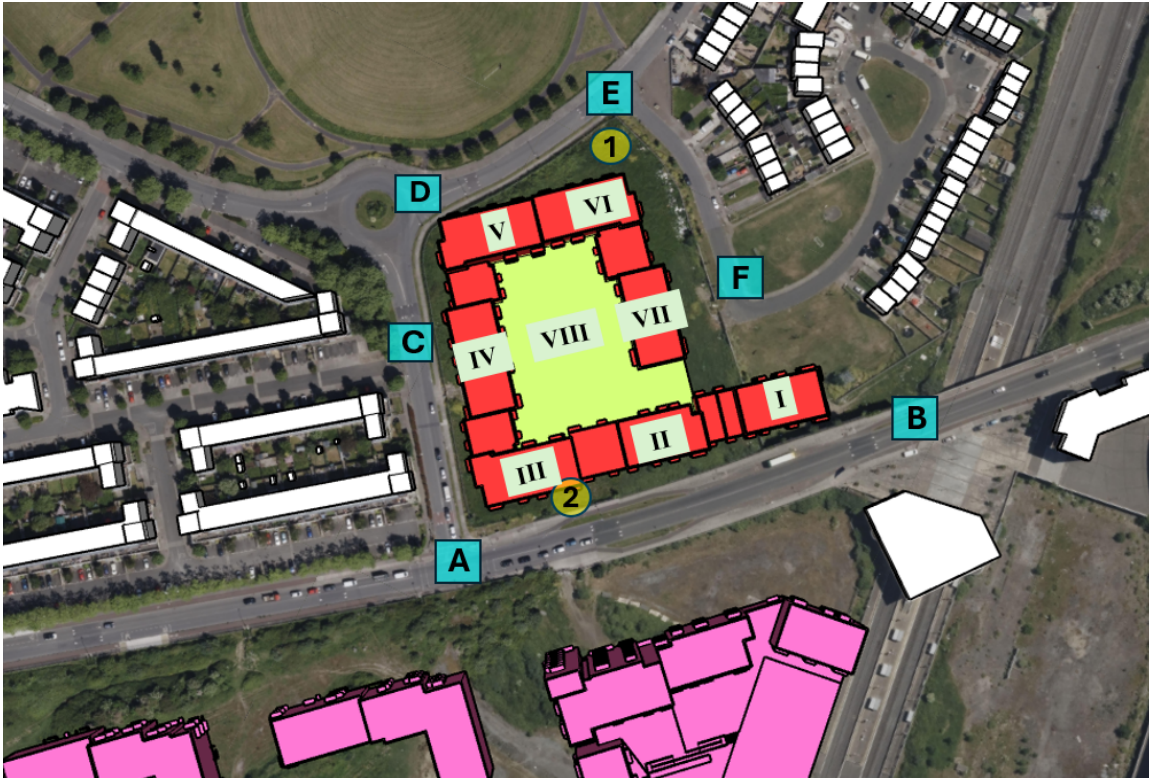


Figure 6.2: Potential Sensitive Receptors on the Ground- Pedestrian Activities Area.

Table 6.1 and Table 6.2 provides the names and descriptions of the potential receptors, while Figure 6.2 illustrates their locations.

Table 6.1: Off-Site list of the Receptors.

Off-Site Potential Receptors ID	Description
A.	Park W Ave. - West
B.	Park W Ave. - East
C.	Cedar Brook Way
D.	Cedar Brook Way Junction
E.	Barn Ville Park Junction
F.	Barn Ville Park

Table 6.2: On-Site list of the Receptors.

On-Site Potential Receptors ID	Description
1.	Backyard of the Development
2.	Front yard of the Development

6.3 POTENTIAL RECEPTORS ON BALCONIES, ROOF TERRACE & PODIUM

Potential receptors for the wind assessment include all balconies and terraces within the development, where occupants may be exposed to wind conditions. The assessment level is taken at 1.5m above the balcony or terrace surface.

Figures 6.3 , 6.4 and 6.5 show the balcony, terrace and podium areas within the development. These areas are considered as sensitive potential receptors for the wind microclimate due to occupant use and exposure.

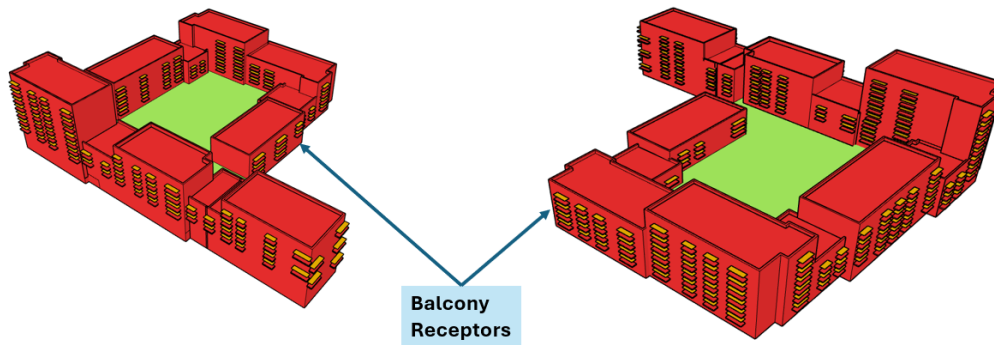


Figure 6.3: Potential Sensitive Receptors on balconies.

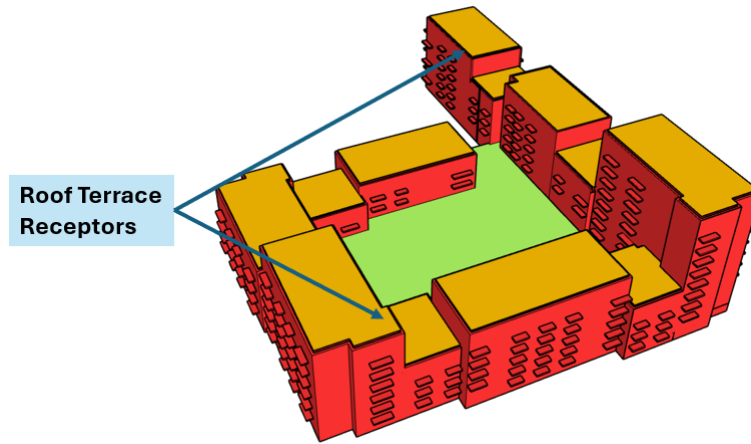


Figure 6.4: Potential Sensitive Receptors on terraces.

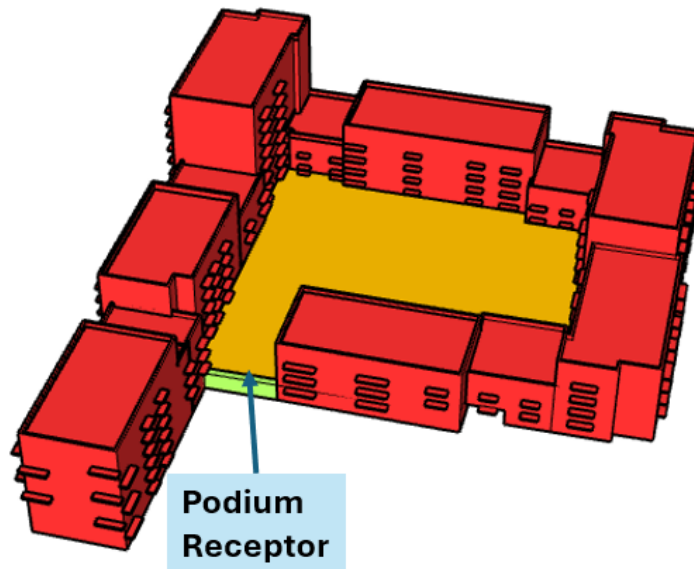


Figure 6.5: Potential Sensitive Receptor on the Podium.

7. BASELINE WIND MICROCLIMATE

7.1 BASELINE SCENARIO

The wind microclimate of the baseline scenario is defined by the wind patterns that develop on the site and its surroundings (existing buildings and topography) under the local wind conditions relevant for the assessment of the Pedestrian Comfort and Distress.

In this scenario the assessment has considered the impact of wind on the existing area. Results of wind microclimate at pedestrian level (1.8m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground and identify the suitability of each area to its prescribed level of usage and activity.

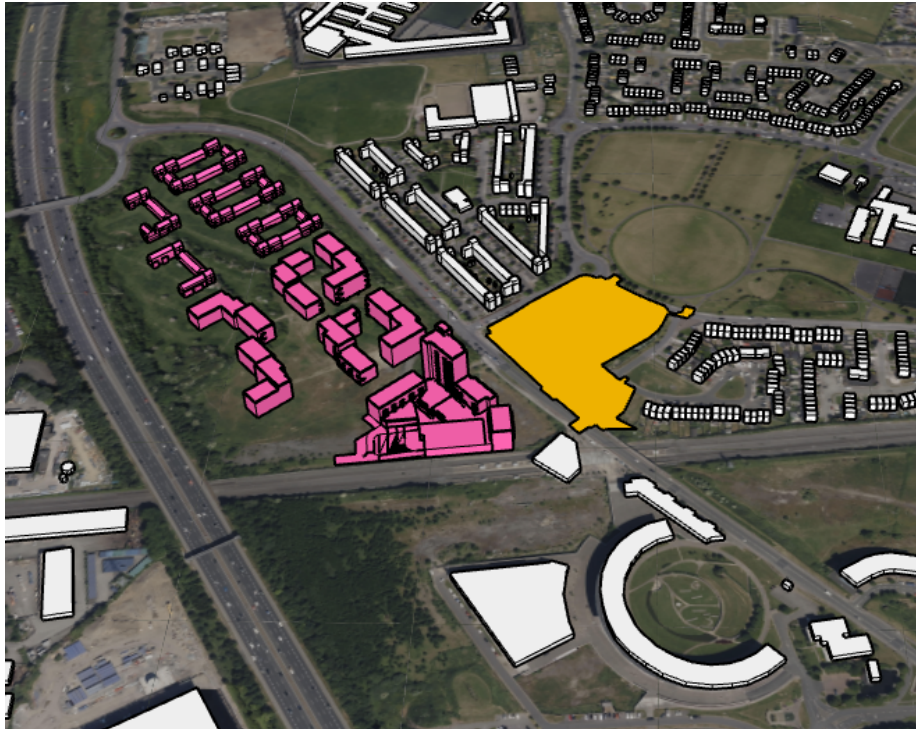


Figure 7.1: 3D View of the Baseline Scenario.

7.1.1 WIND SPEEDS - Pedestrian Level

Comprehensive wind speed and flow circulation results at a pedestrian height of 1.8m are presented in Appendix A. These results support the assessment of ground-level wind conditions during baseline scenario.

7.1.2 BASELINE WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented in Figures 7.2-7.3 using a colour coded diagram formulated in accordance with the Lawson Criteria.

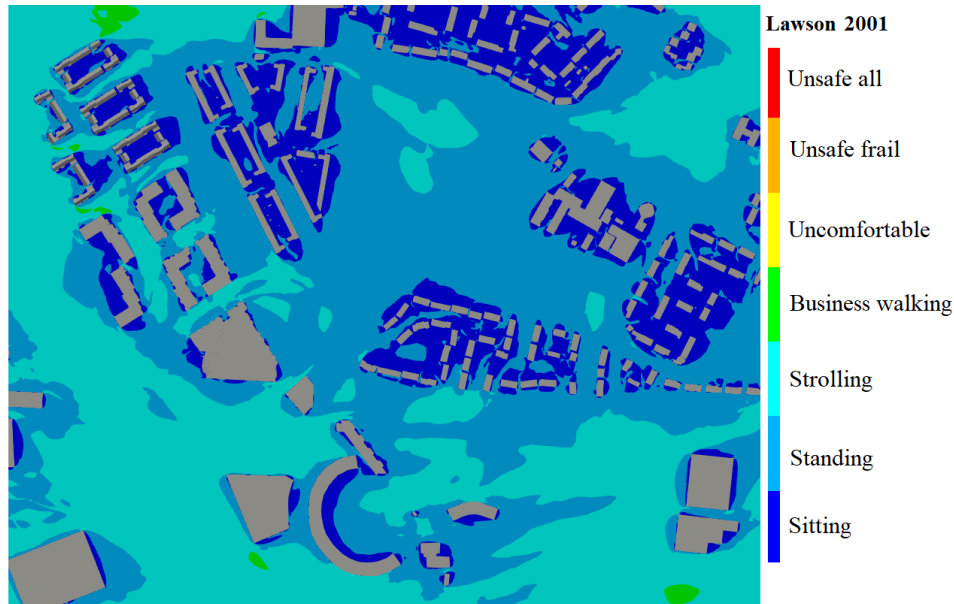


Figure 7.2: Ground Floor - Lawson Discomfort Map - **Top View**.

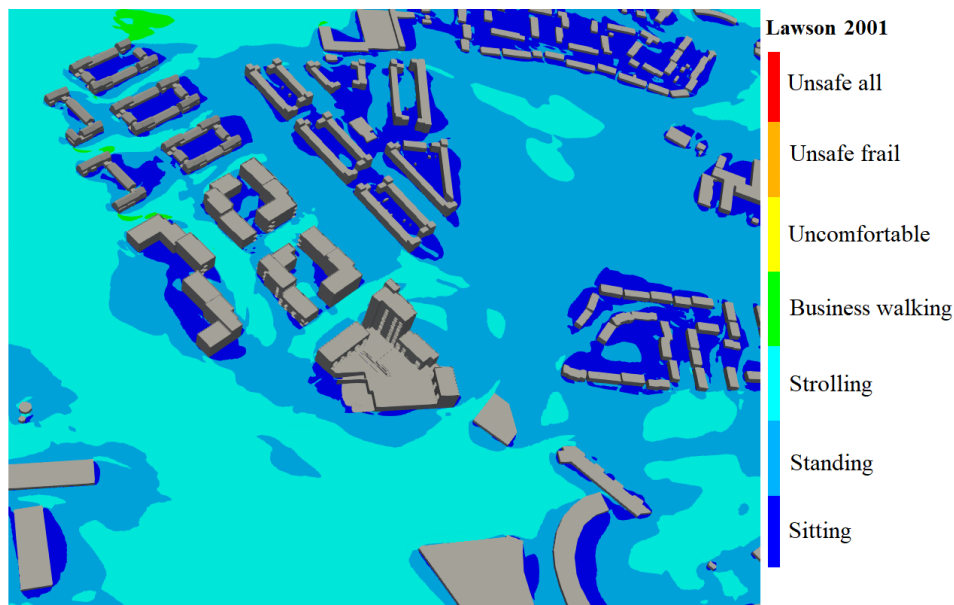


Figure 7.3: Ground Floor - Lawson Discomfort Map - **3D View**.

From the simulation results the following observations are pointed out:

- The assessment of the baseline scenario has shown that no area is unsafe and no conditions of distress are created in the existing environment under the local wind climate.
- The site is usable for sitting/standing/strolling, the roads in the surrounding are usable for their intended scope.

8. IMPACT OF THE PROPOSED DEVELOPMENT

This section assessed the potential impact of the proposed development on the already existing environment, and the suitability of the proposed development to create and maintain a suitable and comfortable environment for different pedestrian activities.

8.1 CONSTRUCTION PHASE

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. Due to the fact that windier conditions are acceptable within a construction area (not accessible to the public), and the proposed development would not be the reason for critical wind conditions on-site (and are slightly calmer when the development is in site), the impacts evaluated on-site are considered to be insignificant. Thus, the predicted impacts during construction phase are identified as not significant or negligible.

In summary, as construction of the Cherry Orchard Phase 3 Development progresses, the wind conditions at the site would gradually adjust to those of the completed development. During the construction phase, predicted impacts are classified as negligible.

8.2 OPERATIONAL PHASE

This section shows CFD results of wind microclimate assessment carried out considering the "Operational Phase" of Cherry Orchard Phase 3 Development. In this case the assessment has considered the impact of wind on the existing area including the proposed Cherry Orchard Phase 3 Development. Wind simulations have been carried out on all the various directions for which the development could show critical areas in terms of pedestrian comfort and safety.

Results of wind microclimate at pedestrian level (1.8m height - flow speeds) are collected throughout the modelled site (potential receptors). These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground or on the courtyards, and identify the suitability of each areas to its prescribed level of usage and activity.

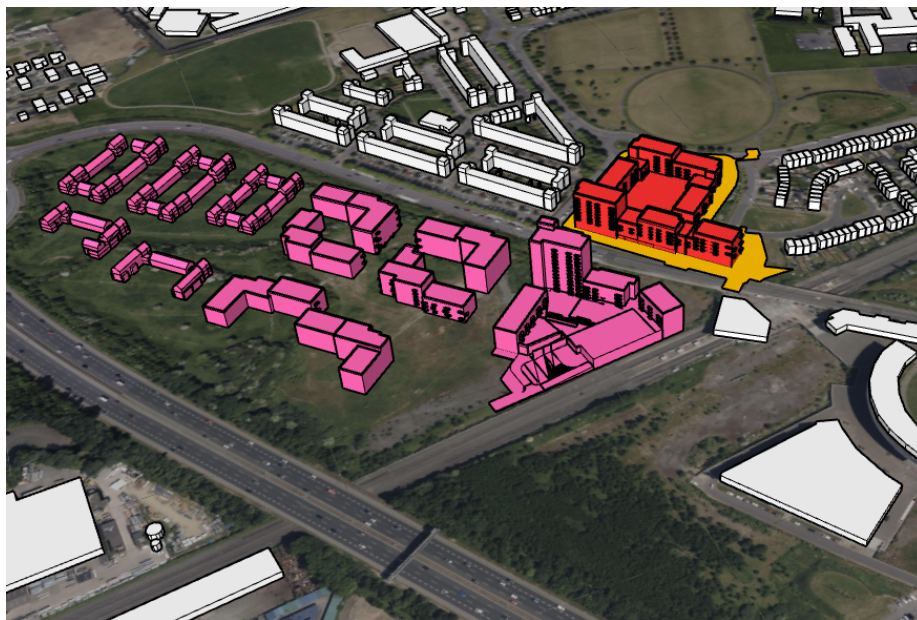


Figure 8.1: 3D View of Proposed Scenario.

8.2.1 WIND SPEEDS – Pedestrian Level

Comprehensive wind speed and flow circulation results are presented in Appendix B for pedestrian-level heights of 1.8,m and 7.1,m, as well as at balcony levels. The 7.1,m assessment height accounts for the elevated portion of Park W Ave, which is approximately 5.3,m above the base level of the proposed development. These results support the assessment of ground-level wind conditions under the proposed scenario.

8.2.2 PROPOSED DEVELOPMENT WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented in Figures 8.2 and 8.3 using a colour coded diagram formulated in accordance with the Lawson Criteria.

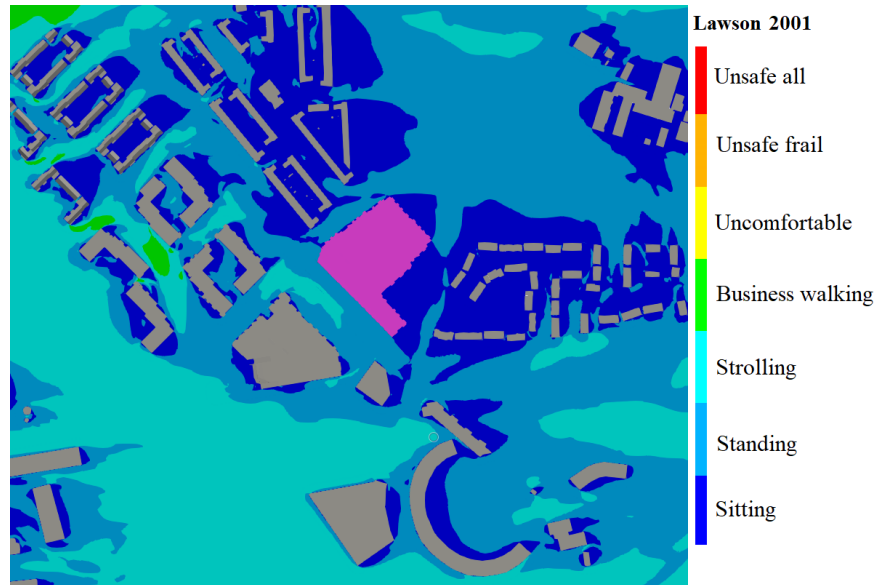


Figure 8.2: Ground Floor - Lawson Discomfort Map - **Top View**.

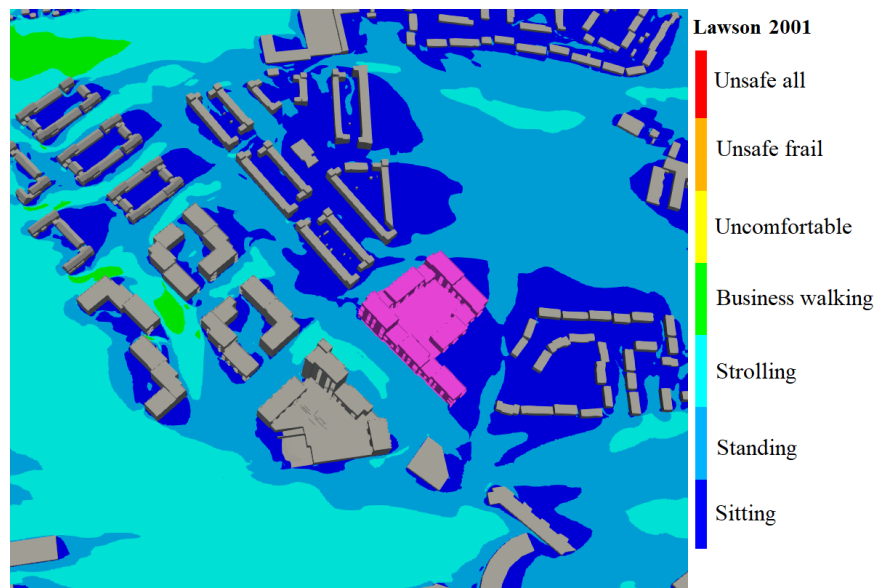


Figure 8.3: Ground Floor - Lawson Discomfort Map - **3D View**.

In summary, the following conclusions can be made observing the results of the wind microclimate analysis and comparing the results obtained, under the same wind conditions for the baseline scenario versus the proposed development scenario:

- The assessment of the proposed scenario has shown that no area is unsafe, and no conditions of distress are created by the proposed development.
- All the roads proposed can be used for their intended scope.
- The wind microclimate of the proposed development is comfortable and usable for pedestrians.

As a result of the proposed development construction, the wind on the surrounding urban context maintains the suitability of the surrounding urban environment for its intended purpose.

8.2.3 ON-SITE AND OFF-SITE RECEPTORS

Tables 8.1 - 8.2 presents the pedestrian comfort levels for various on-site and off-site locations. As shown in the tables, none of the areas are deemed unsafe, and all on-site and off-site receptors around the development are suitable for at least strolling comfort level.

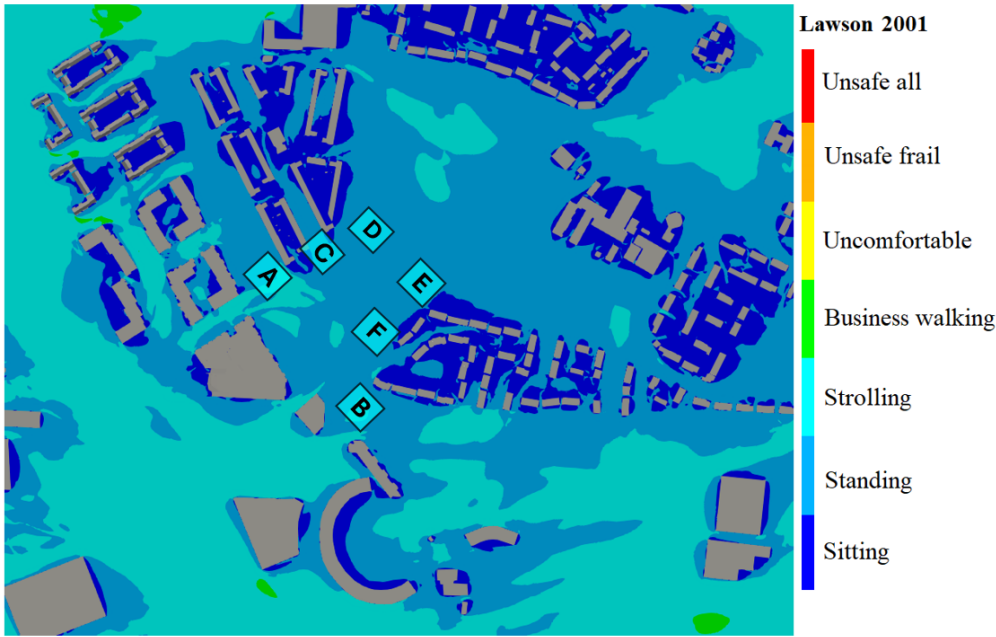
Table 8.1: Pedestrian Comfort Levels versus Proposed Pedestrian Activities.

Reference point	Description	Sitting	Standing	Strolling	Business walking	Distress and Safety
1.	Backyard of the Development	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
2.	Front yard of the Development	Acceptable	Acceptable	Acceptable	Acceptable	Safe.

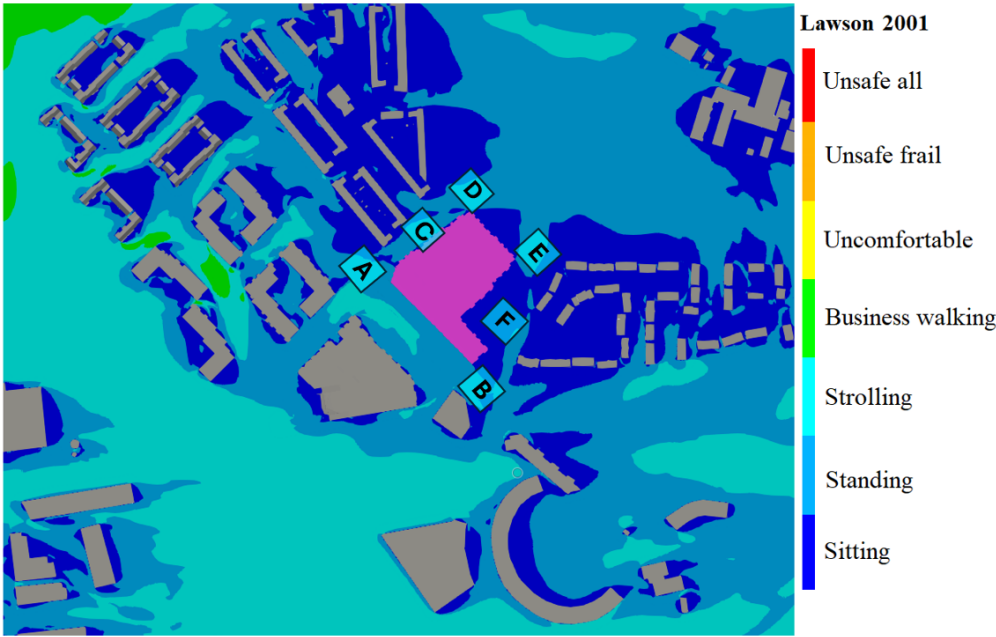
Table 8.2: Pedestrian Comfort Levels versus Proposed Pedestrian Activities.

Reference point	Description	Sitting	Standing	Strolling	Business walking	Distress and Safety
A.	Park W Ave. - West	Tolerable	Tolerable	Acceptable	Acceptable	Safe.
B.	Park W Ave. - East	Tolerable	Tolerable	Acceptable	Acceptable	Safe.
C.	Cedar Brook Way	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
D.	Cedar Brook Way Junction	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
E.	Barn Ville Park Junction	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
F.	Barn Ville Park	Tolerable	Acceptable	Acceptable	Acceptable	Safe.

A comparison of Lawson Discomfort Maps for the baseline scenario and the proposed scenario is presented in Figure 8.4.



Baseline Scenario.



Proposed Development Scenario.

Figure 8.4: Comparison Wind Microclimate Conditions (Lawson Comfort/Distress Map).

Table 8.3 show the intended baseline and proposed wind conditions for potential off-site receptors around the development. This tables show that there are no distress areas for pedestrians including frail users and cyclists. In conclusion, it can be said that the site and surrounding urban areas are safe for all users.

Table 8.3: Significance Impact of the Proposed Development Versus Baseline Conditions for Comfort - Off Site Receptors.

Off-Site Potential Receptors	Baseline Conditions	Proposed Development Conditions	Impact Significance
A. Park W Ave. - West	Suitable for Standing/Strolling.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
B. Park W Ave. - East	Suitable for Standing/Strolling.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
C. Cedar Brook Way	Suitable for Standing/Strolling.	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Negligible
D. Cedar Brook Way Junction	Suitable for Standing/Strolling.	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Negligible
E. Barn Ville Park Junction	Suitable for Standing/Strolling.	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Negligible
F. Barn Ville Park	Suitable for Standing/Strolling.	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Negligible

8.2.4 BALCONIES

The evaluation of comfort levels in relation to the expected pedestrian activities on the balconies, based on the Lawson Comfort and Distress criteria, is presented at a height of $1.5m$ in Figures 8.6 - 8.8.

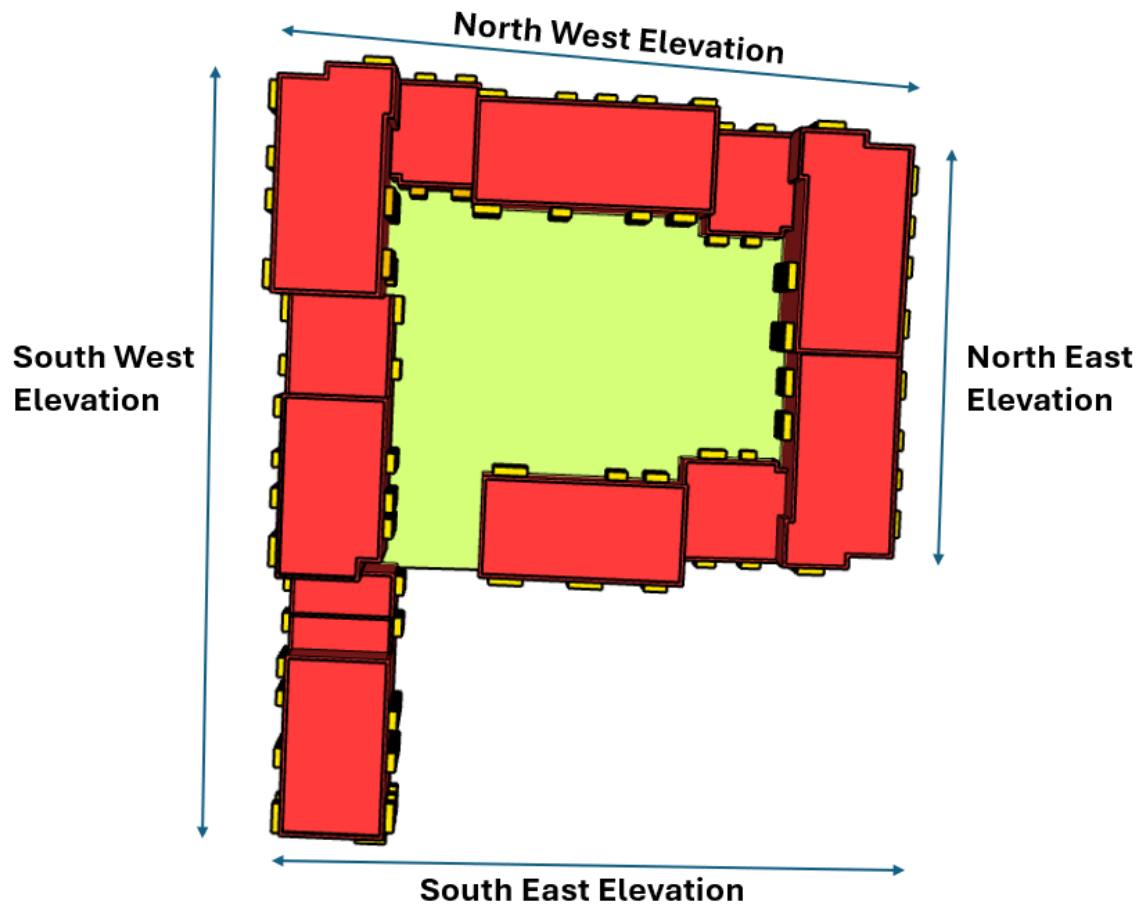


Figure 8.5: Plan View with Building Side Orientations.

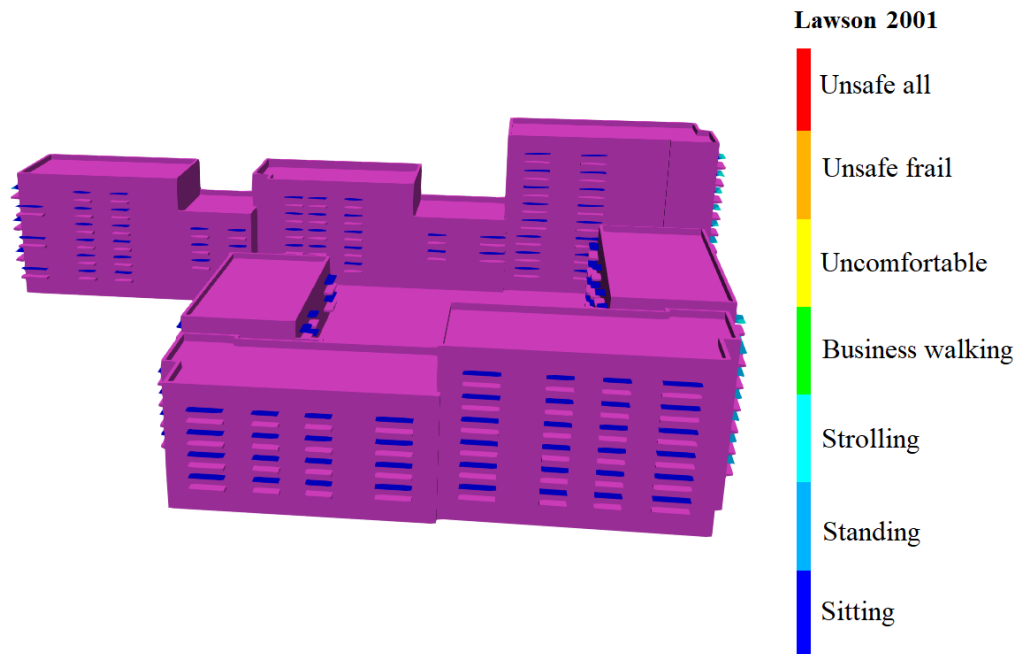


Figure 8.6: Balconies of North East Elevation - Lawson Discomfort Map - Proposed Scenario - 3D View.

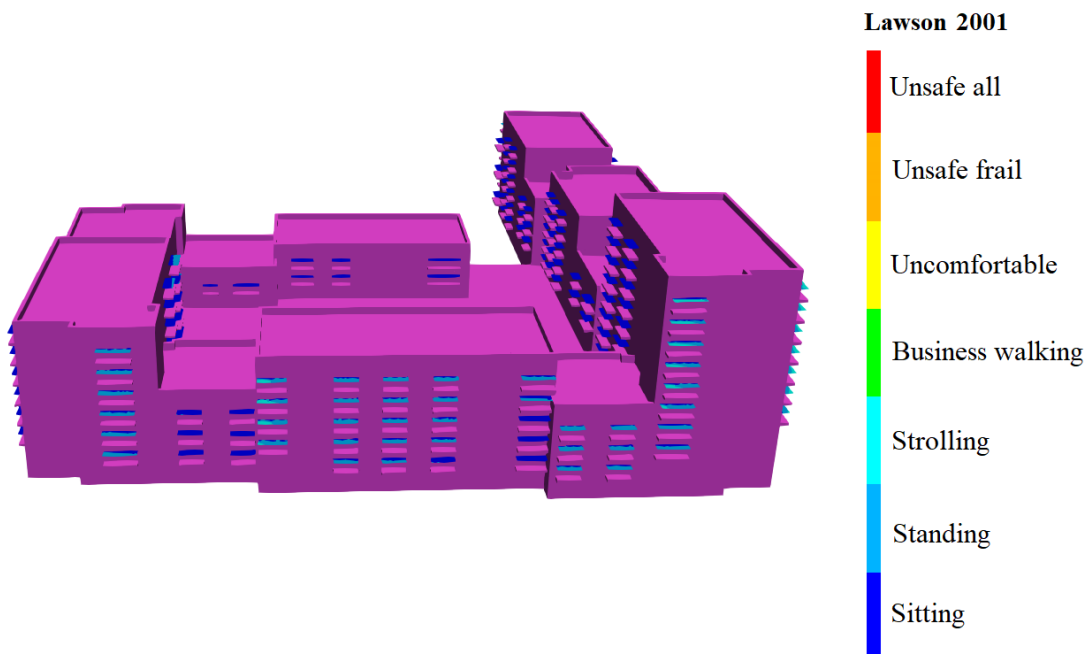


Figure 8.7: Balconies of North West Elevation - Lawson Discomfort Map - Proposed Scenario - 3D View.

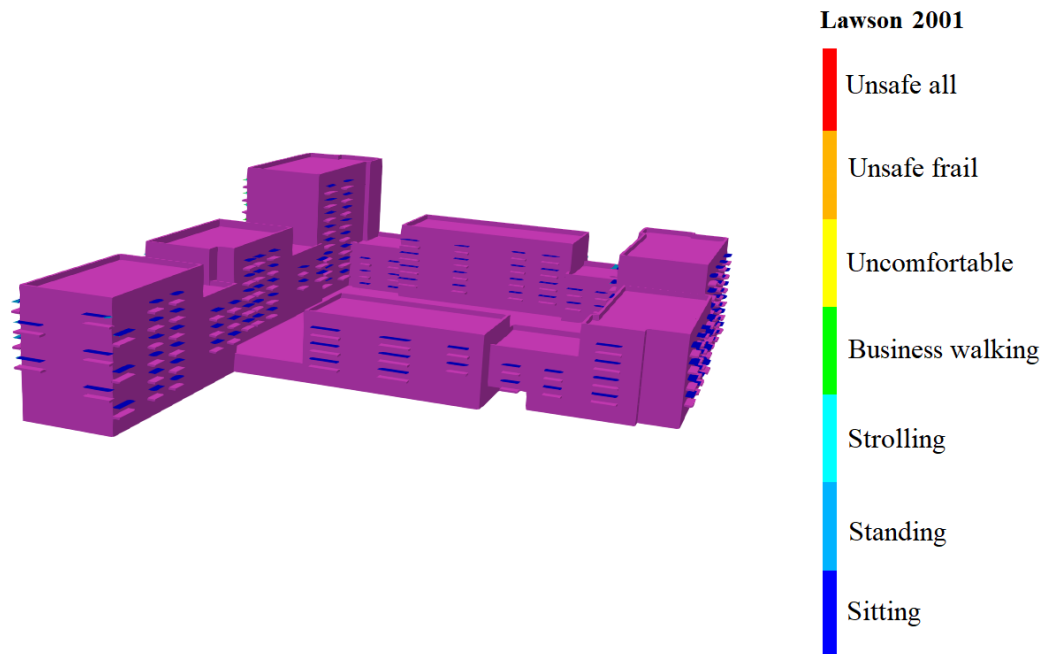


Figure 8.8: Balconies of South East Elevation - Lawson Discomfort Map - Proposed Scenario - 3D View.

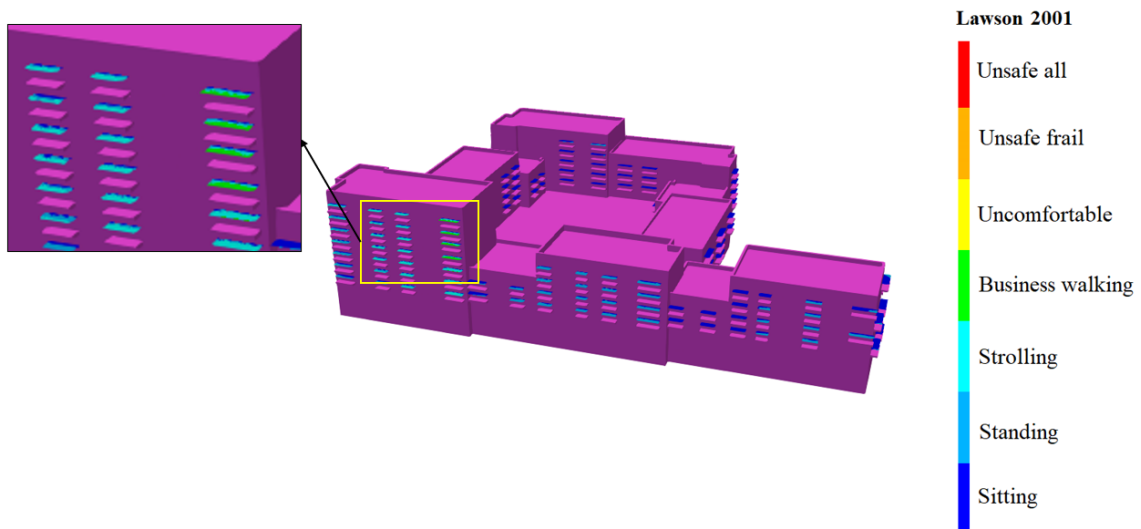


Figure 8.9: Balconies of South West Elevation - Lawson Discomfort Map - Proposed Scenario - 3D View.

8.2.5 ROOF TERRACES

The evaluation of comfort levels in relation to the expected pedestrian activities on the Roof Terraces of the development, based on the Lawson Comfort and Distress criteria, is presented at a height of $1.5m$ in Figure 8.11.

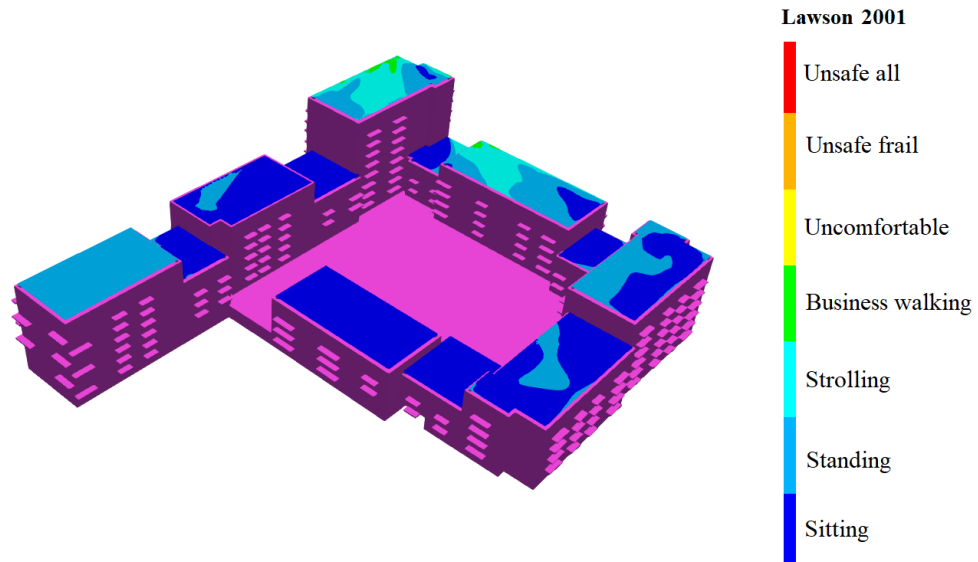


Figure 8.10: Roof Terraces - Lawson Discomfort Map - Proposed Scenario - 3D View.

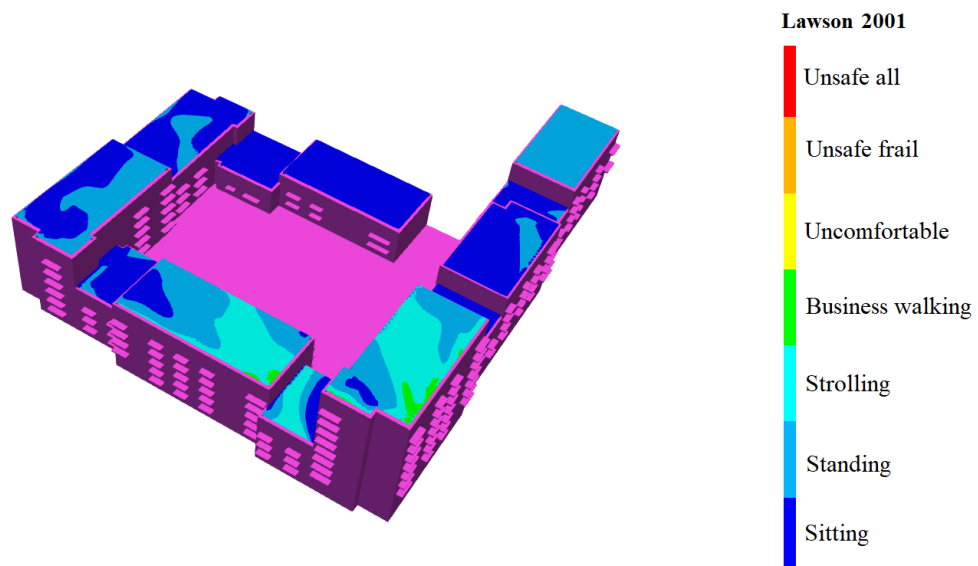


Figure 8.11: Roof Terraces - Lawson Discomfort Map - Proposed Scenario - 3D View.

8.2.6 PODIUM

The evaluation of comfort levels in relation to the expected pedestrian activities on the Podium of the development, based on the Lawson Comfort and Distress criteria, is presented at a height of $1.5m$ in Figure 8.12 and 8.13.

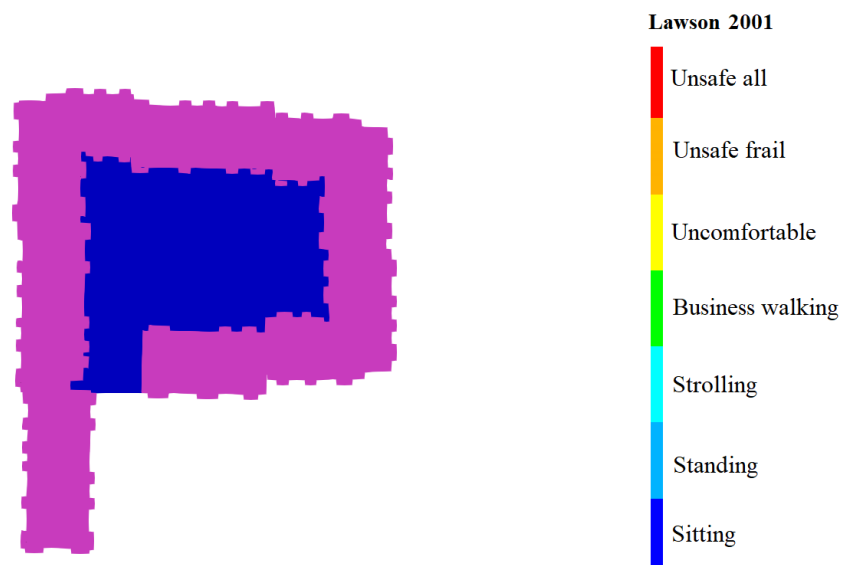


Figure 8.12: Podium - Lawson Discomfort Map - Proposed Scenario - 2D View.

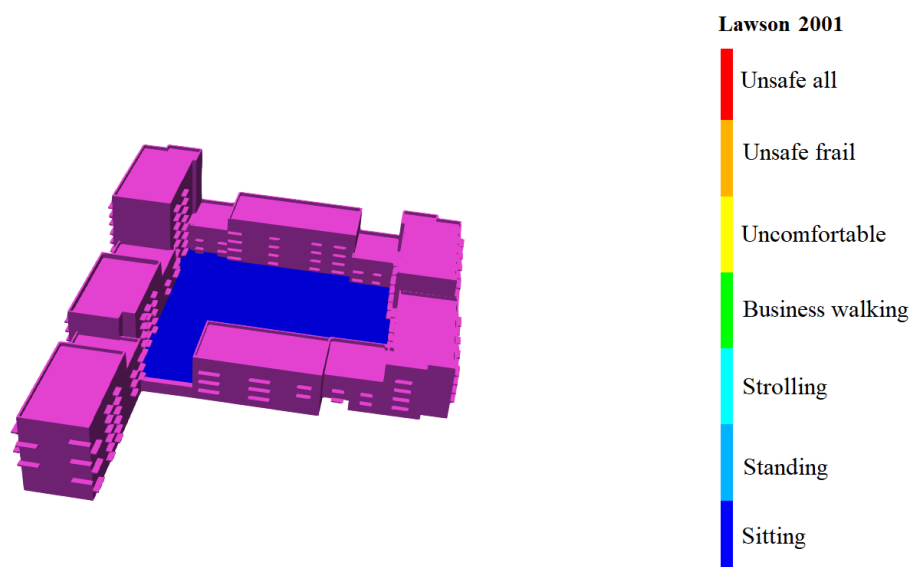


Figure 8.13: Podium - Lawson Discomfort Map - Proposed Scenario - 3D View.

9. CUMULATIVE IMPACT

This section assessed the potential impact of the proposed development on buildings that are subject to future planning application (potential cumulative buildings), and the suitability of the cumulative buildings to create and maintain a suitable and comfortable environment for different pedestrian activities.

9.1 OPERATIONAL PHASE

This section shows CFD results of wind microclimate assessment carried out considering the "Operational Phase" of Cherry Orchard Phase 3 Development. In this case the assessment has considered the impact of wind on the existing area including the proposed Cherry Orchard Phase 3 Development and the permitted potential buildings but not constructed yet. These potential or permitted future buildings include Phase 4 of Cherry Orchard development. Wind simulations have been carried out on all the various directions for which the development could show critical areas in terms of pedestrian comfort and safety.

Results of wind microclimate at pedestrian level (1.8m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment and permitted buildings (but not built yet).

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground identify the suitability of each areas to its prescribed level of usage and activity.



Figure 9.1: A 3D View of the Proposed Development (red), Existing Buildings (white and pink), Potential Future Buildings (green) and Site Area (yellow).

9.1.1 WIND SPEEDS - Pedestrian Level

Comprehensive wind speed and flow circulation results at a pedestrian height of 1.8m are presented in Appendix C. These results support the assessment of ground-level wind conditions during cumulative scenario.

9.1.2 CUMULATIVE IMPACT - Lawson Criteria

A comparison of Lawson Comfort and Distress Maps for proposed development scenario and the cumulative scenario is presented in Figure 9.2 and 9.3.

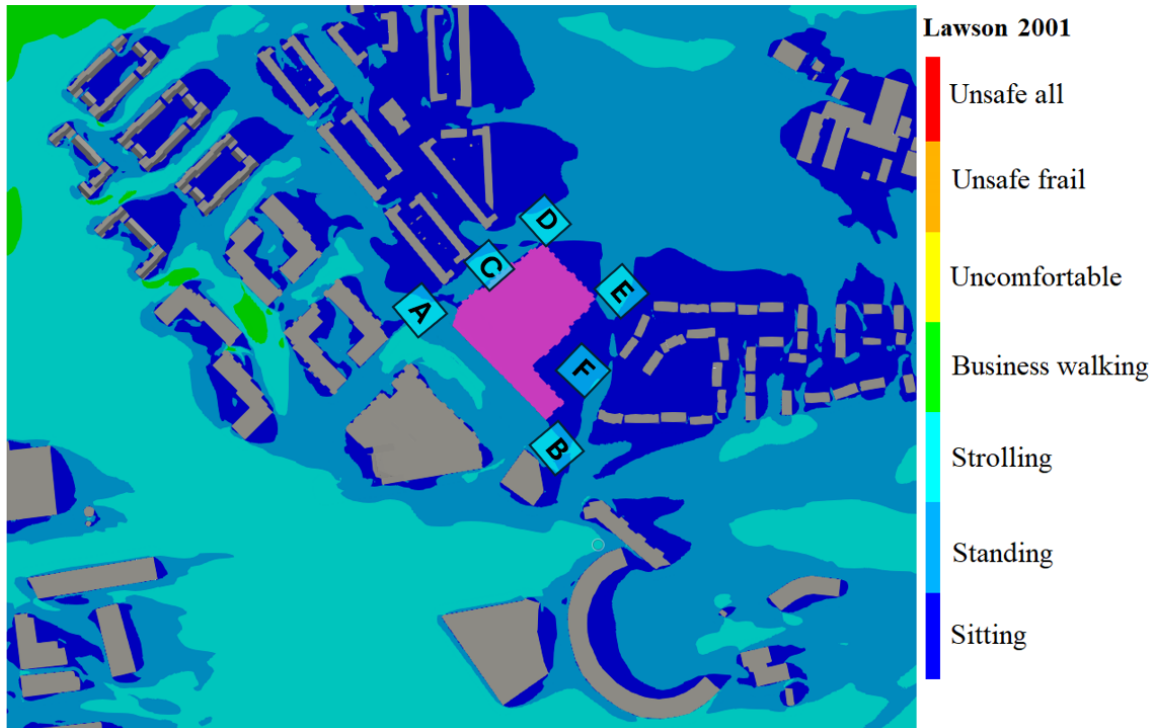


Figure 9.2: Proposed Development Scenario.

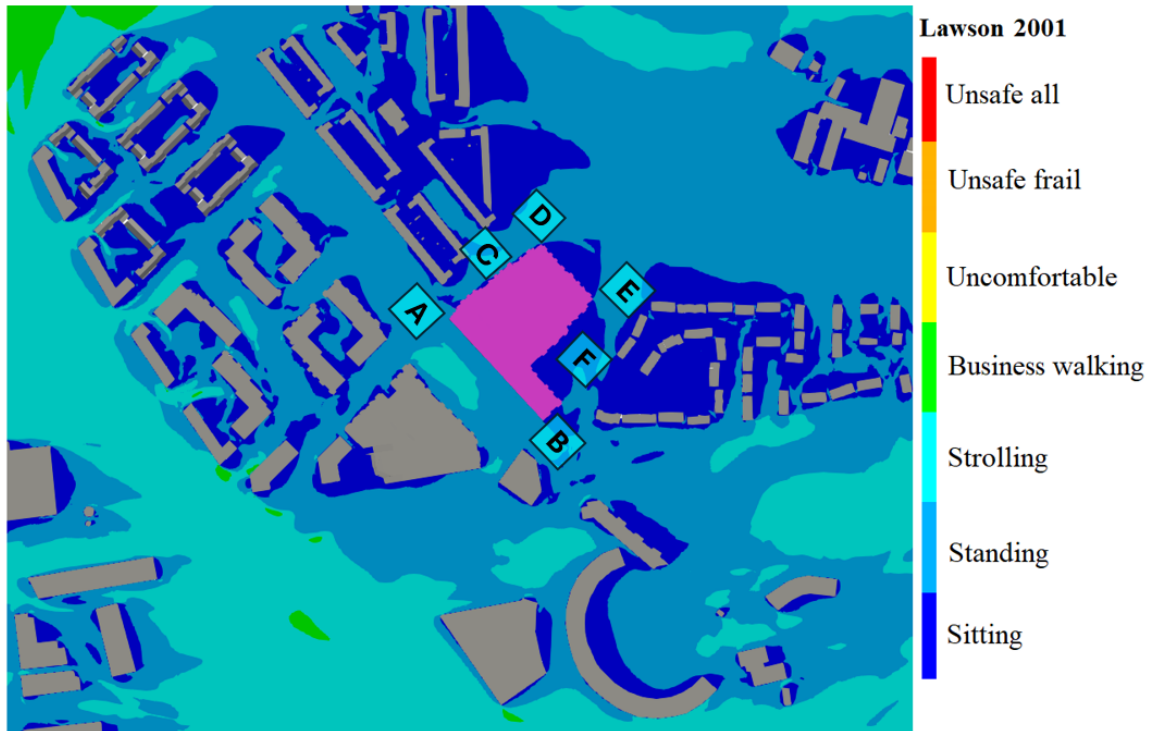


Figure 9.3: **Cumulative Scenario.**

Table 9.1 shows the proposed and cumulative wind conditions at potential off-site receptors around the development.

Table 9.1: Significance Impact of the Cumulative Scenario Versus Proposed Conditions for Comfort - Off-Site Receptors.

Off-Site Potential Receptors	Proposed Development Conditions	Cumulative Conditions	Impact Significance
A. Park W Ave. - West	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling.	Negligible
B. Park W Ave. - East	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling.	Negligible
C. Cedar Brook Way	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Suitable for Sitting/Standing/Strolling.	Negligible
D. Cedar Brook Way Junction	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Suitable for Sitting/Standing/Strolling.	Negligible
E. Barn Vile Park Junction	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Suitable for Sitting/Standing/Strolling.	Negligible
F. Barn Vile Park	Suitable for Sitting/Standing/Strolling. (Safe/No distress)	Suitable for Sitting/Standing/Strolling.	Negligible

In conclusion, there are no distress area for pedestrians including frail users and cyclist. Furthermore, the site and surrounding urban areas when the cumulative assessment is done are safe for all users.

10. CONCLUSIONS

CONCLUSIONS and COMMENTS ON MICROCLIMATE STUDY

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Cherry Orchard Phase 3 Development, Dublin.

This study has been carried out to identify the possible wind patterns around the area proposed, under mean and peak wind conditions typically occurring in Dublin, and also to assess impacts of the wind on pedestrian levels of comfort/distress.

The results of this wind microclimate study are utilized by Van Dijk Architects to configure the optimal layout for Cherry Orchard Phase 3 Development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which was obtained from historical meteorological data recorded 10m above ground level at Dublin Airport.
- A 12-discrete set of wind directions is used to evaluate the probability of exceedance at any given threshold speed. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Cherry Orchard Phase 3 Development and its environment was performed utilizing a CFD methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for “Frail persons or cyclists” and for members of the “General Public” in the surrounding of the development.
- The proposed development will not have an impact on the surrounding urban context, including future cumulative buildings. Wind conditions in the Cumulative Scenario remain consistent with those in the Proposed Scenario.

Therefore, the CFD study undertaken has demonstrated that, under the wind conditions typically prevailing in Dublin over the past 15 years:

- The development is designed to provide a high-quality environment appropriate to the intended use of each area and building, ensuring comfortable and pleasant conditions for pedestrians.
- The balconies on the 6th and 7th floors of the south-west elevation of Core C experience locally elevated wind exposure due to reduced shielding, resulting in occasional strolling and business-walking conditions under the Lawson criteria.
- The roof terrace areas of Core C and Core D experience locally elevated wind exposure due to reduced shielding, resulting in occasional strolling and business-walking conditions under the Lawson criteria. All remaining terraces provide comfortable conditions for occupants, with no areas of distress identified.
- The podium area remain comfortable for occupants, with no identified distress areas.
- The development introduces no critical impact on the surrounding buildings or adjacent roadways.

Comprehensive wind speed and flow circulation results at pedestrian level are presented in the following appendices:

- **Appendix A:** Baseline scenario
- **Appendix B:** Proposed scenario
- **Appendix C:** Cumulative scenario

11. REFERENCES

- Lawson, T.V., 2001, 'Building Aerodynamics', Imperial College Press, London
- Simiu, E., 2011, 'Design of buildings for wind: a guide for ASCE 7-10 Standard users and designers of special structures', 2nd Edition, John Wiley and Sons, Inc., Hoboken, New Jersey, U.S.A.
- Building Aerodynamics, Tom Lawson FREng. Imperial College Press, 2001
- Blocken, B., 2015. Computational Fluid Dynamics for Urban Physics: Importance, scales, possibilities, limitations and ten tips and tricks towards accurate and reliable simulations. Building and Environment.
- Blocken, B., Janssen, W.D. and van Hooff, T., 2012. CFD simulation for pedestrian wind comfort and wind safety in urban areas: General decision framework and case study for the Eindhoven University campus. Environmental Modelling and Software, 30, pp.15–34.
- Franke, J., Hellsten, A., Schlünzen, H., Carissimo, B., 2007, COST Action 732: Quality Assurance and Improvement of Micro-Scale Meteorological Models, In Best practice guideline for the CFD simulation of flows in the urban environment, COST Office, Belgium.

12. APPENDIX

12.1 Appendix A: Baseline Scenario

12.1.1 Appendix A.1: Baseline - WIND SPEEDS - Pedestrian Level (1.8m)

In this appendix the wind speed results are presented at the ground level, evaluated at a height of 1.8m above the surface. The corresponding horizontal slice at 1.8m height is presented in Figure 12.1 for Baseline.

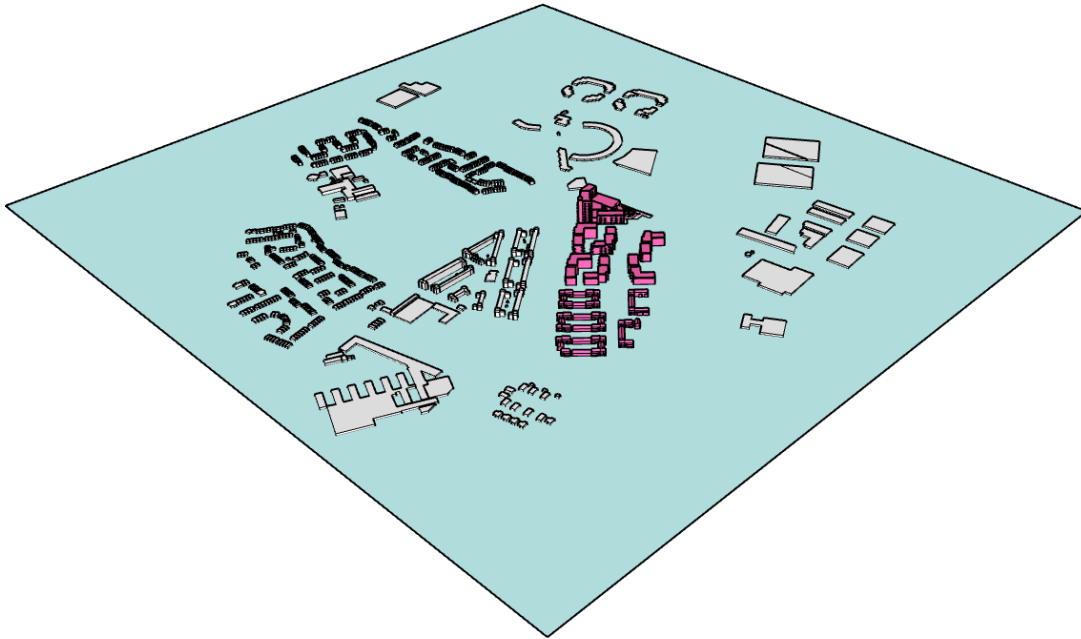


Figure 12.1: Horizontal Slices at 1.8m above Ground level for Cherry Orchard Phase 3 Development.

Results of wind speeds and their circulations at pedestrian level of $1.8m$ above the development ground are presented in Figures 12.2 to 12.25 in order to assess wind flows at ground floor level of Cherry Orchard Phase 3 Development.

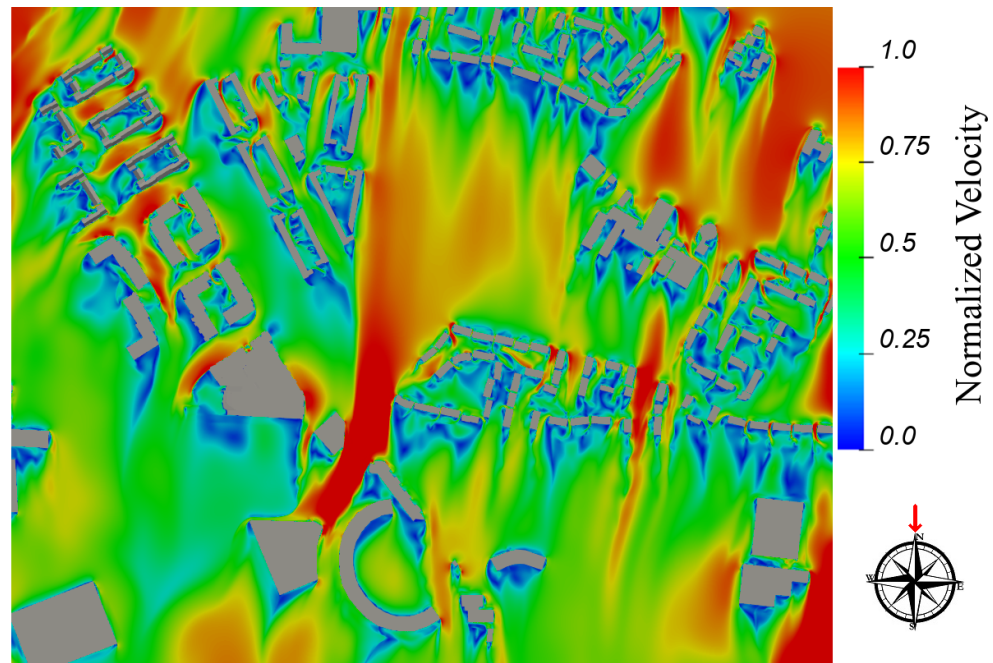


Figure 12.2: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 0° .

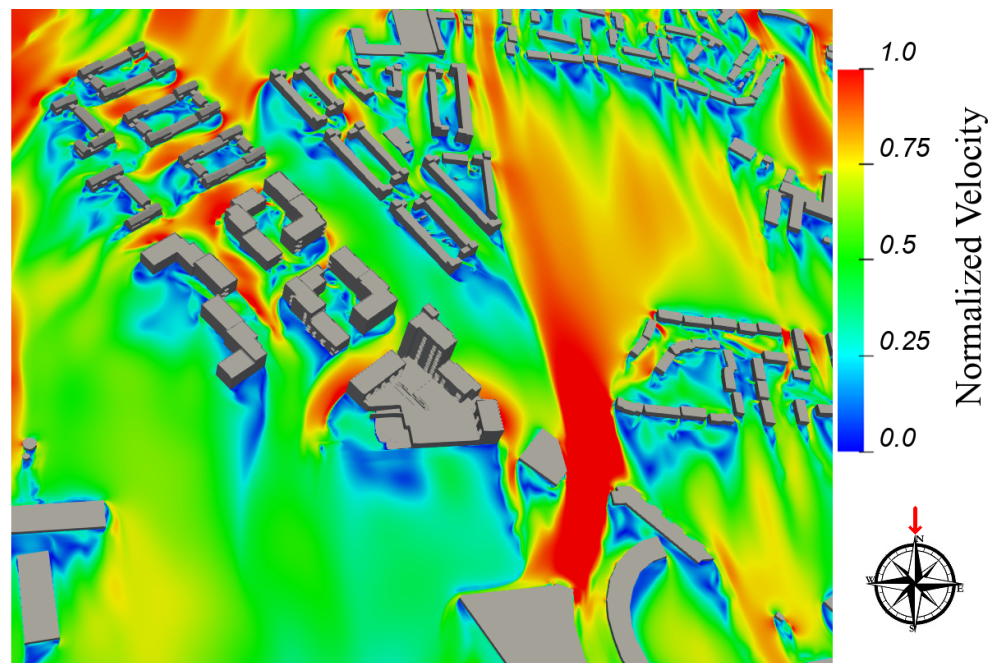


Figure 12.3: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 0° .

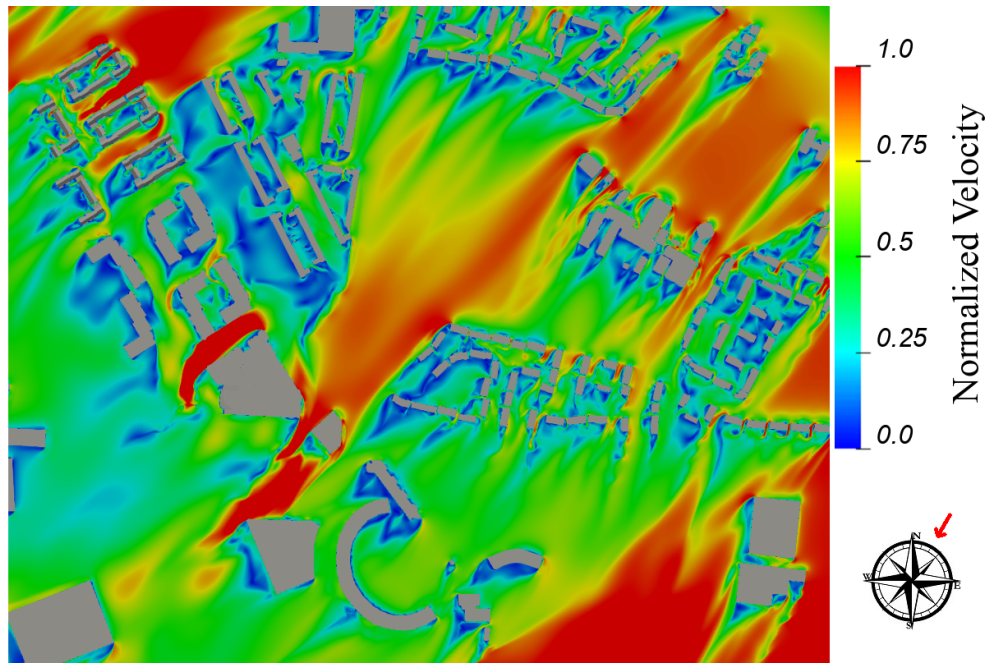


Figure 12.4: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 30° .

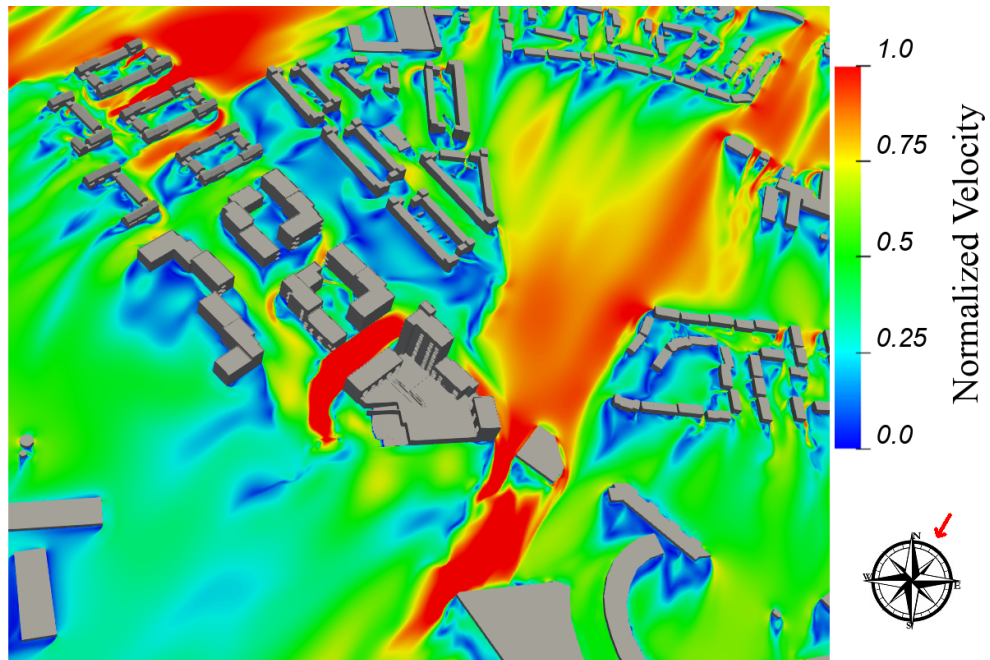


Figure 12.5: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 30° .

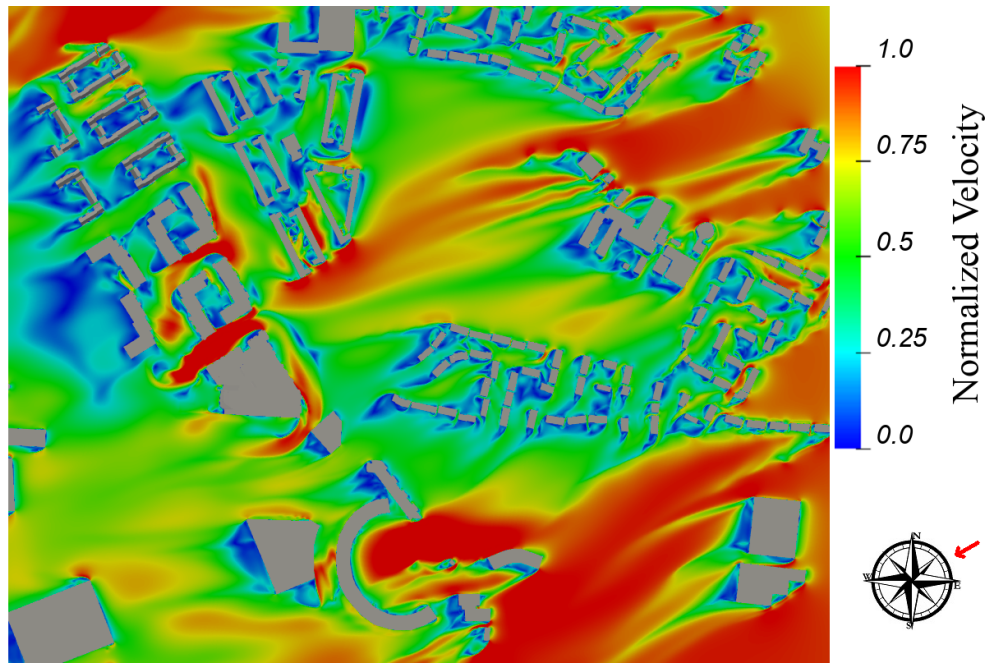


Figure 12.6: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 60° .

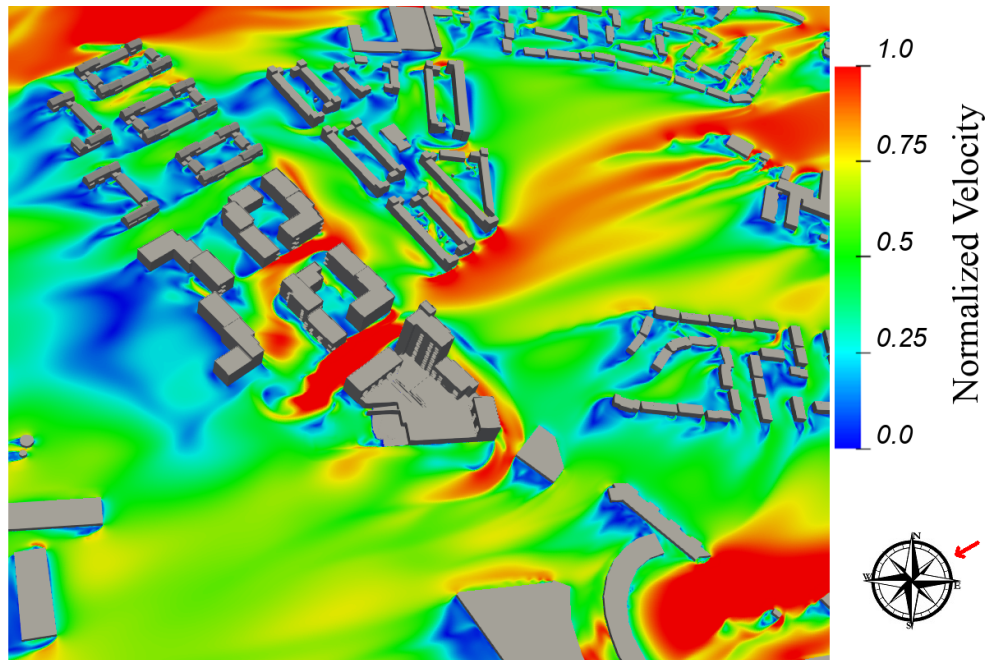


Figure 12.7: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 60° .

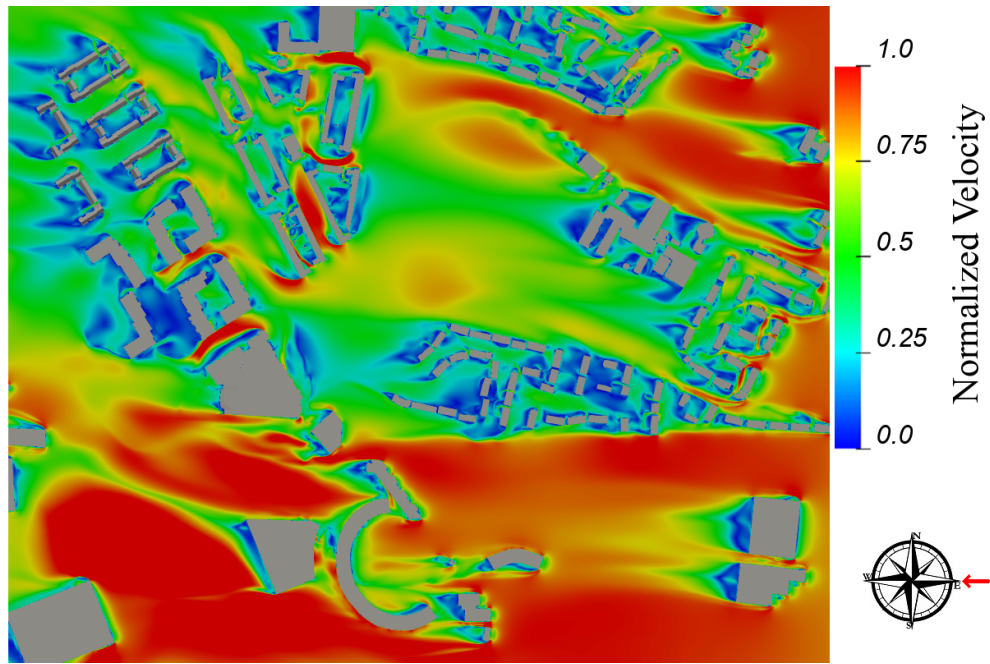


Figure 12.8: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 90° .

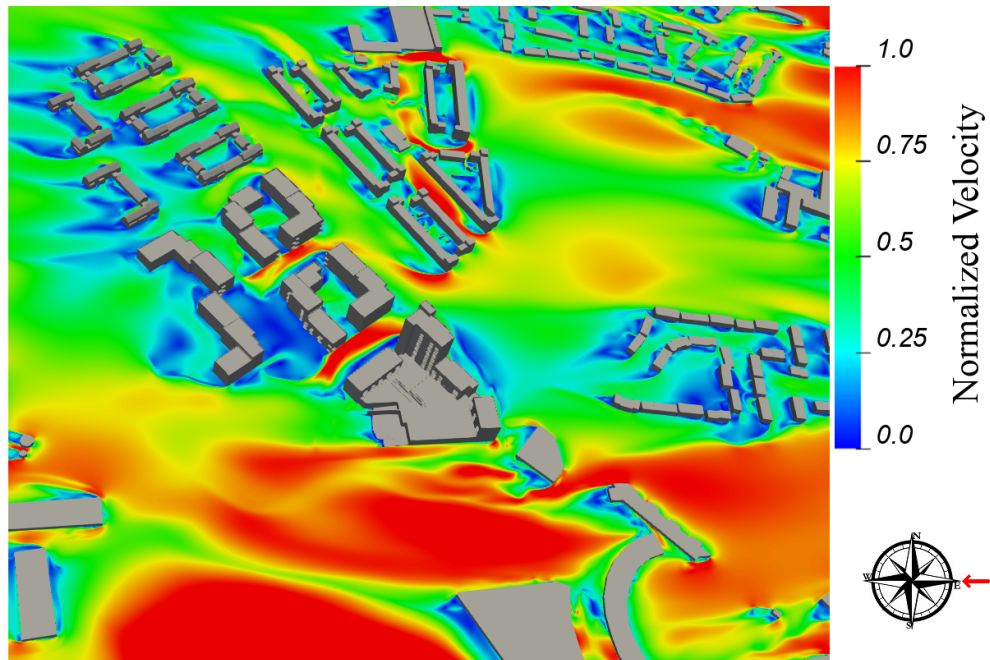


Figure 12.9: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 90° .

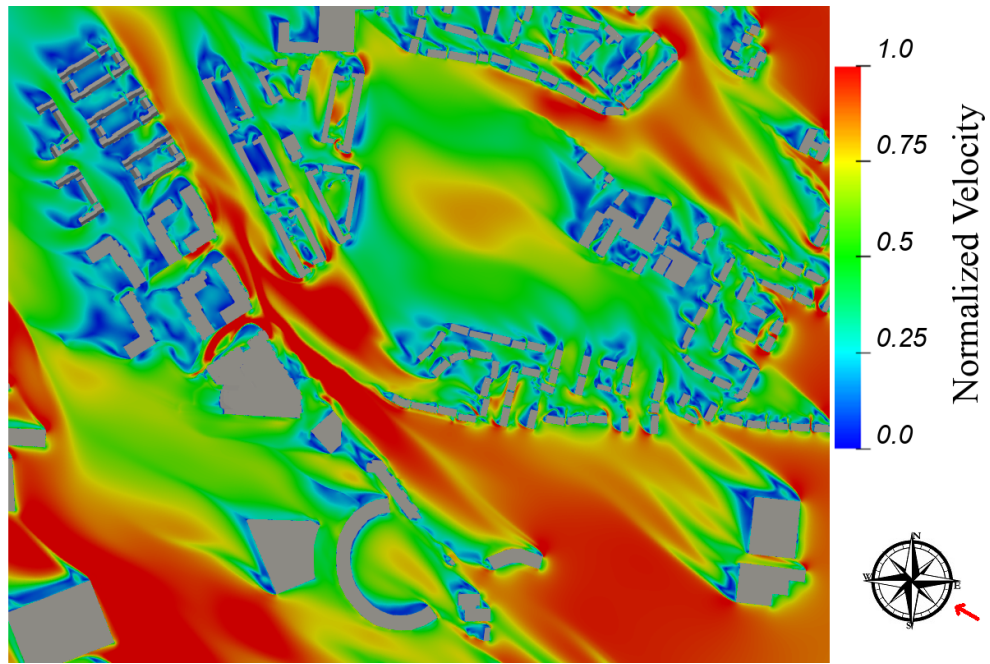


Figure 12.10: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 120° .

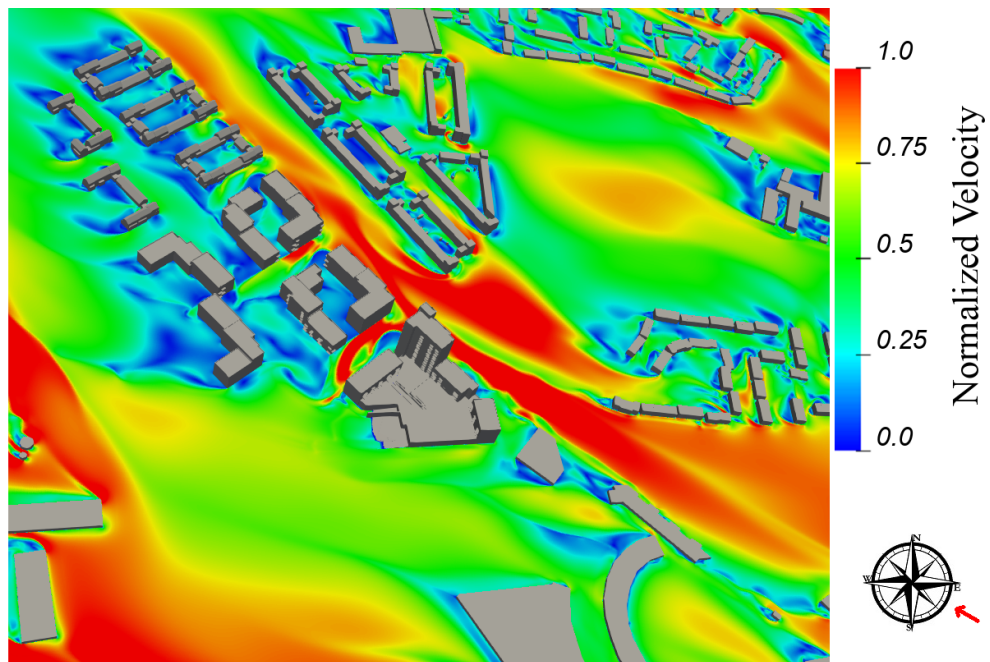


Figure 12.11: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 120° .

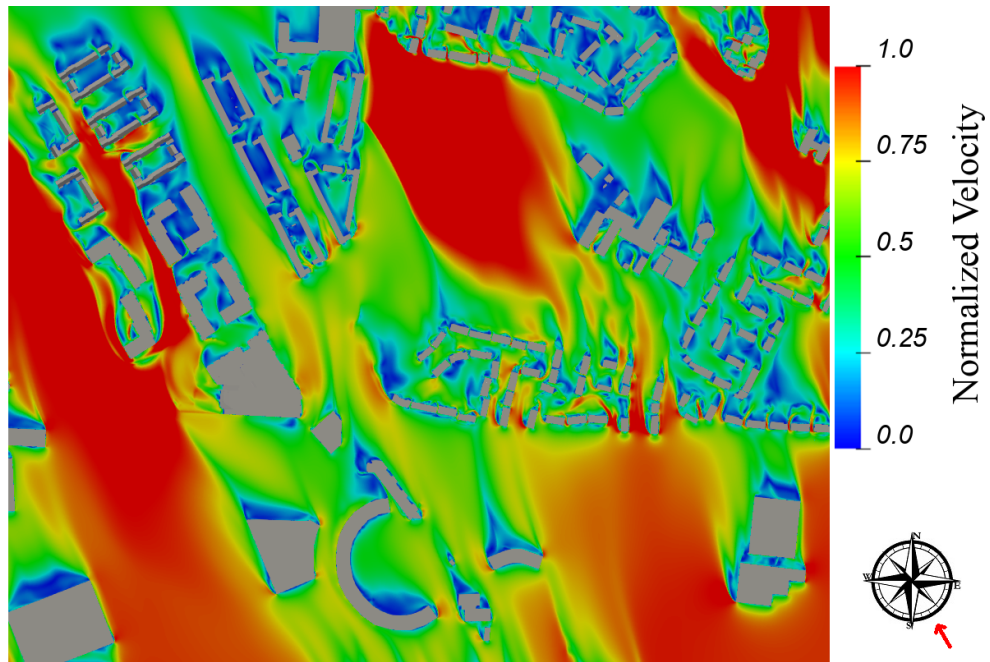


Figure 12.12: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 150° .

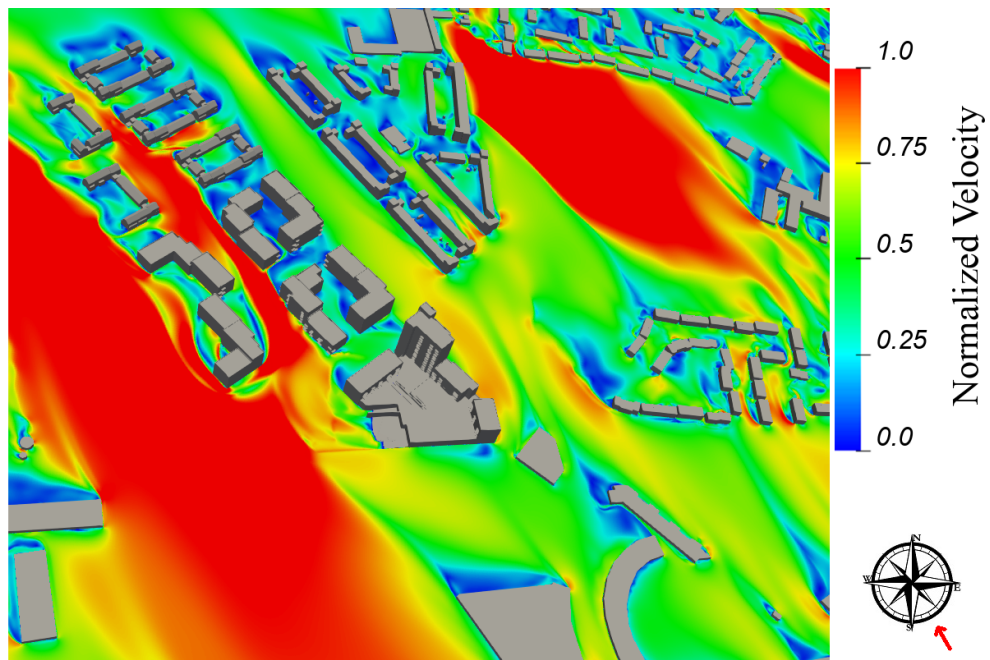


Figure 12.13: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 150° .

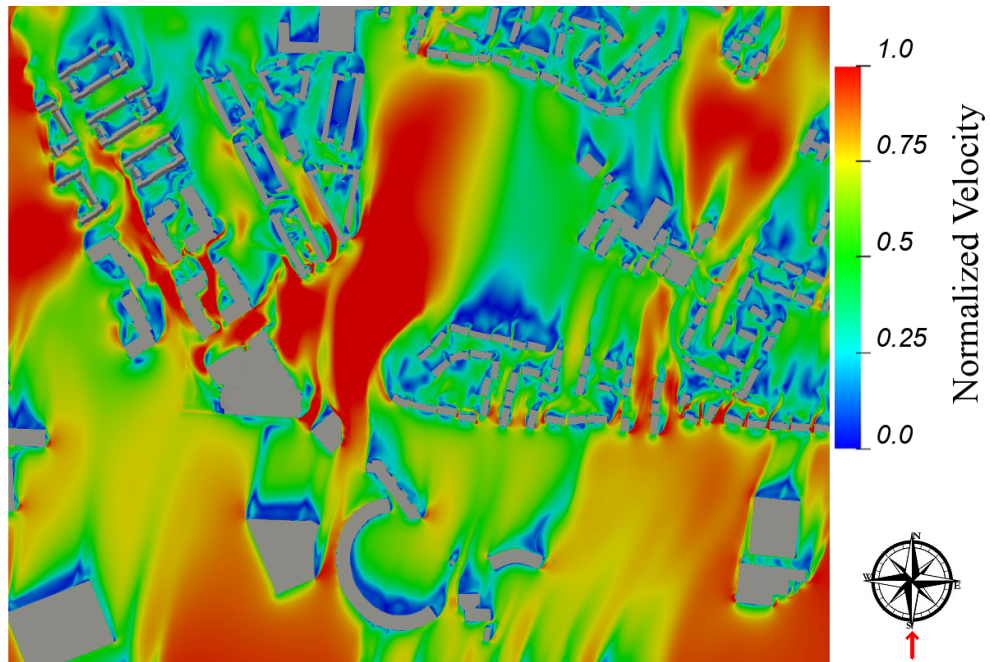


Figure 12.14: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 180° .

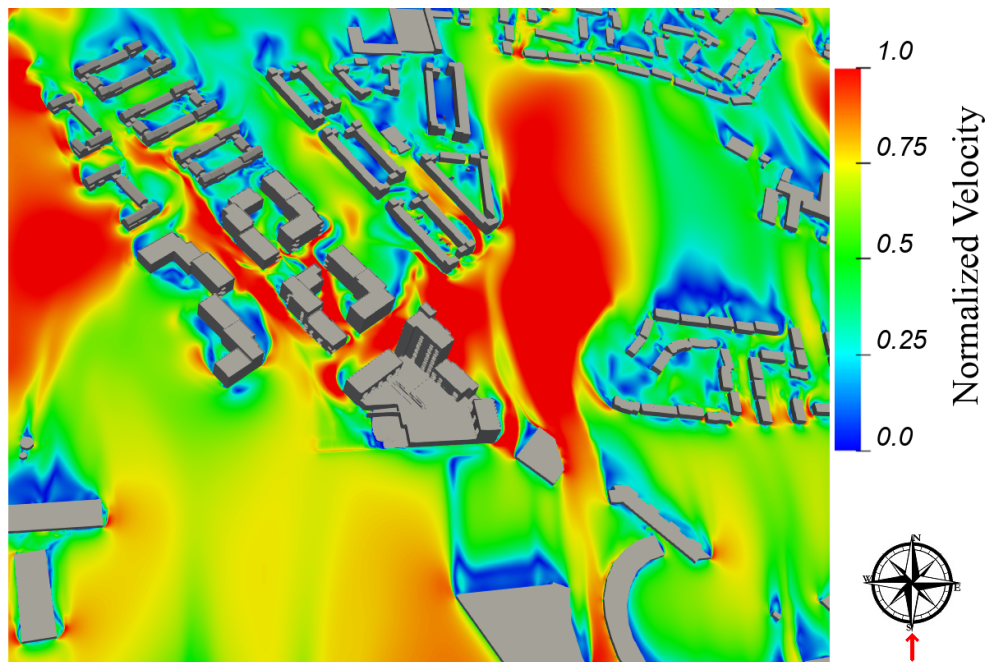


Figure 12.15: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 180° .

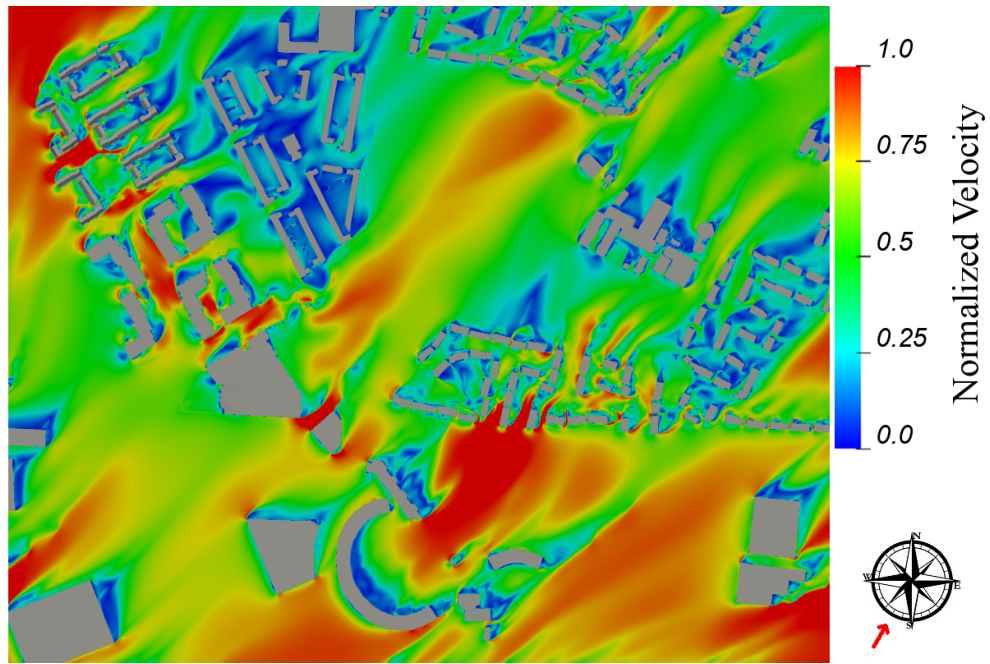


Figure 12.16: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 210° .

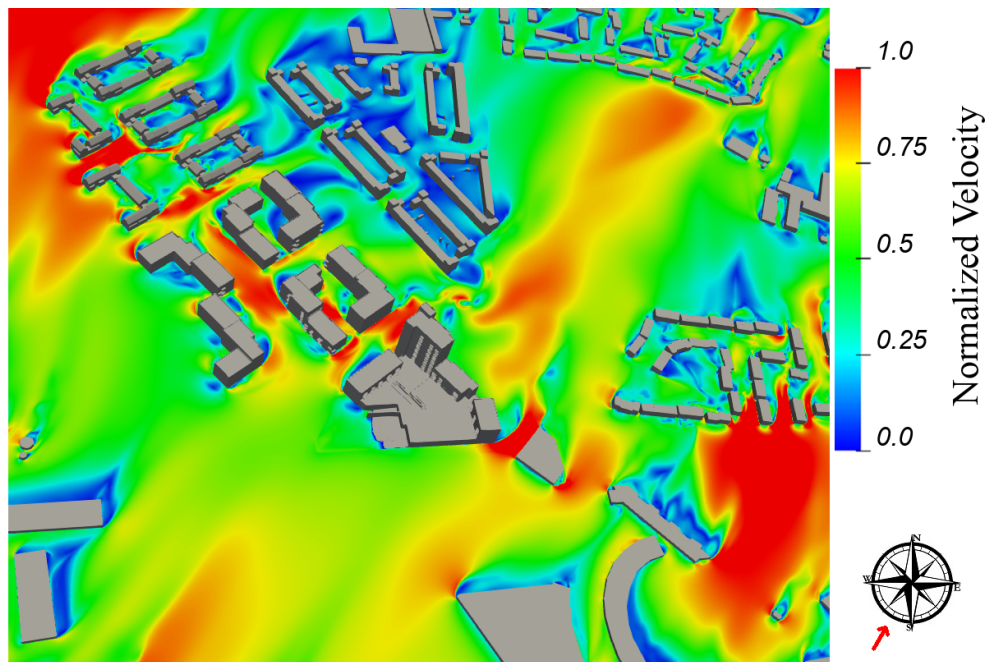


Figure 12.17: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 210° .

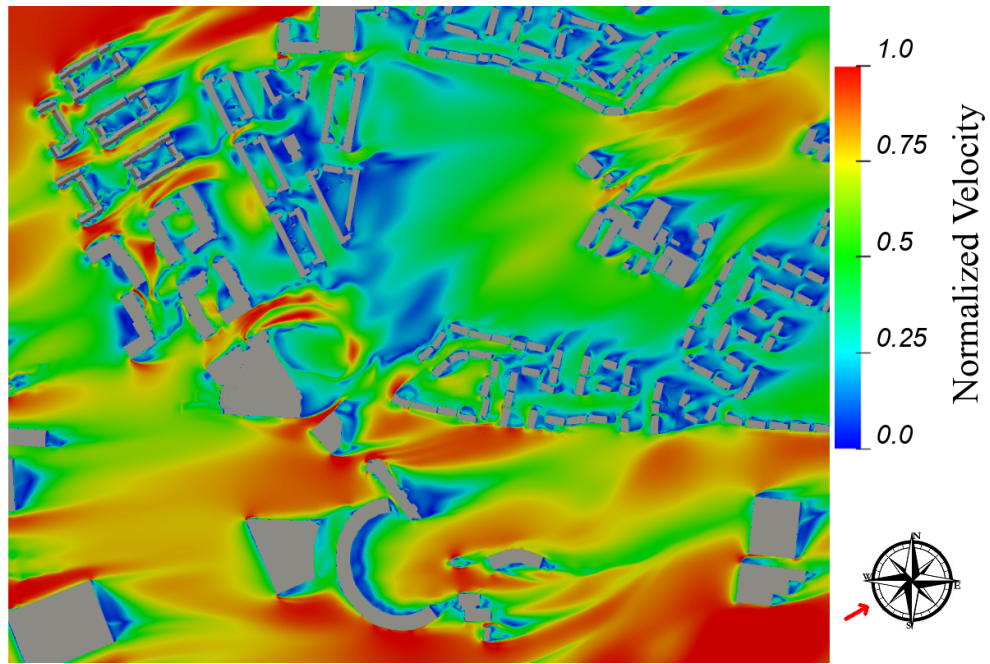


Figure 12.18: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 240° .

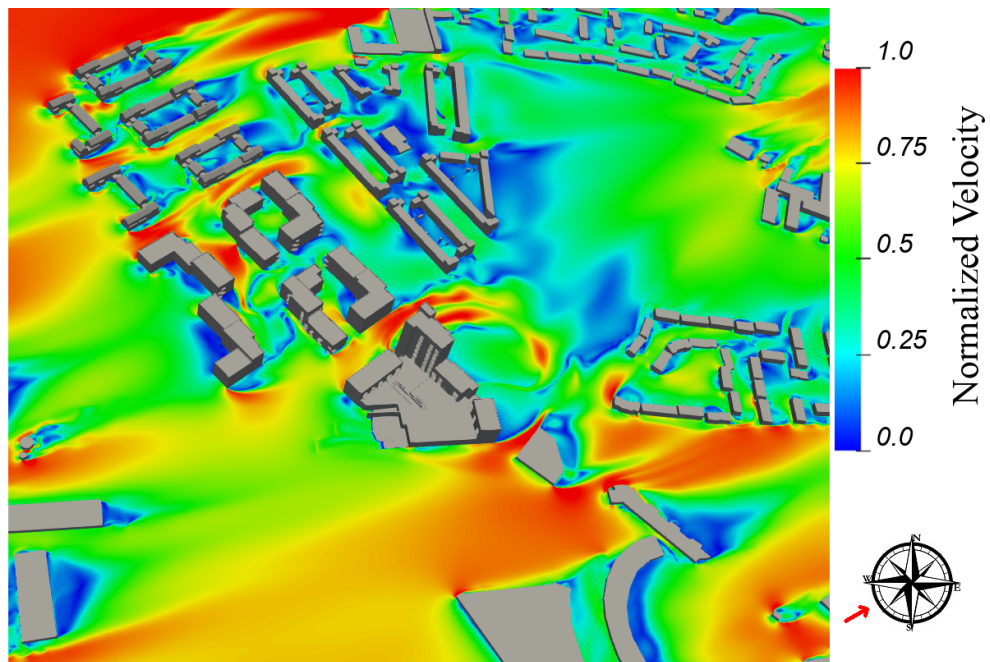


Figure 12.19: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 240° .

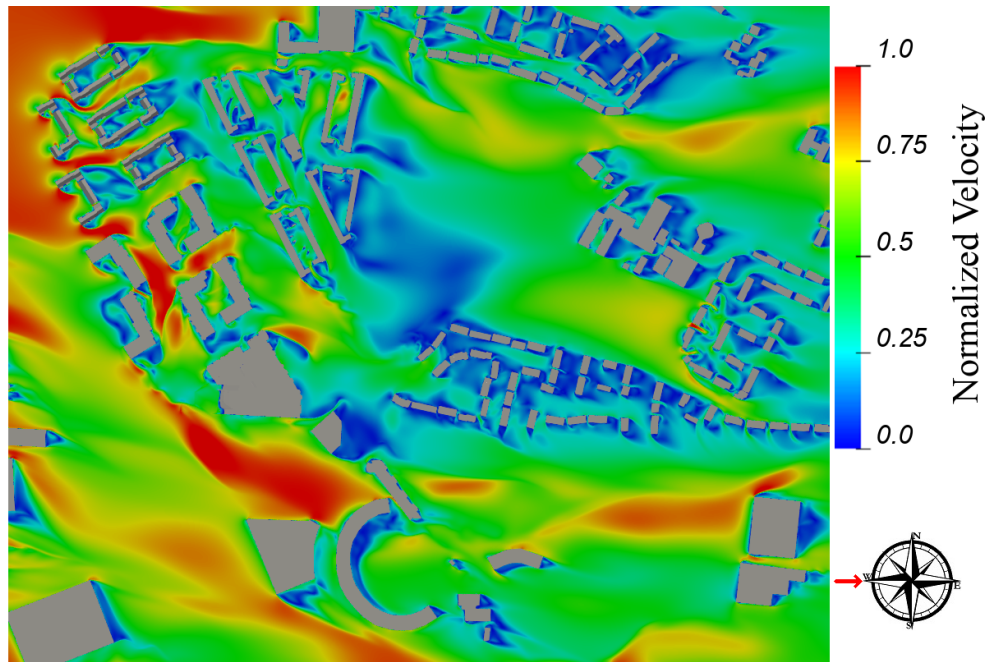


Figure 12.20: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 270° .

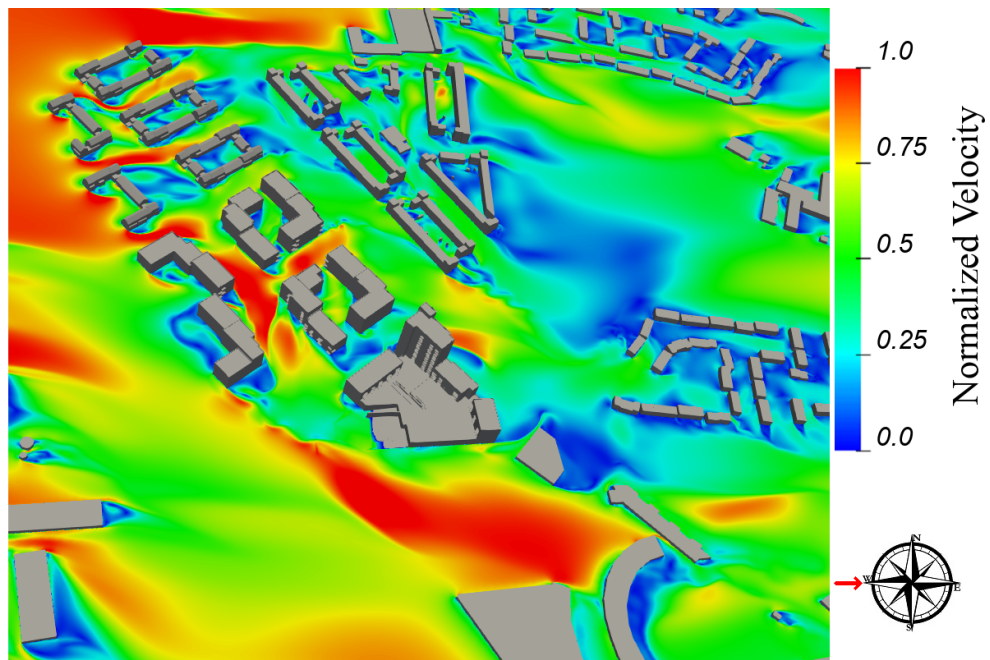


Figure 12.21: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 270° .

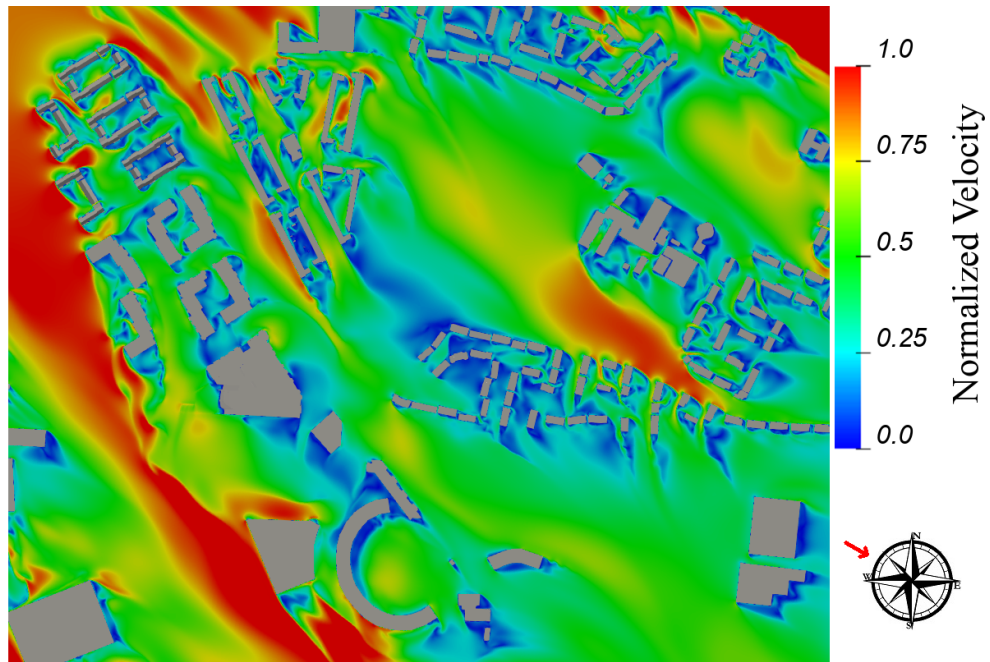


Figure 12.22: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 300° .

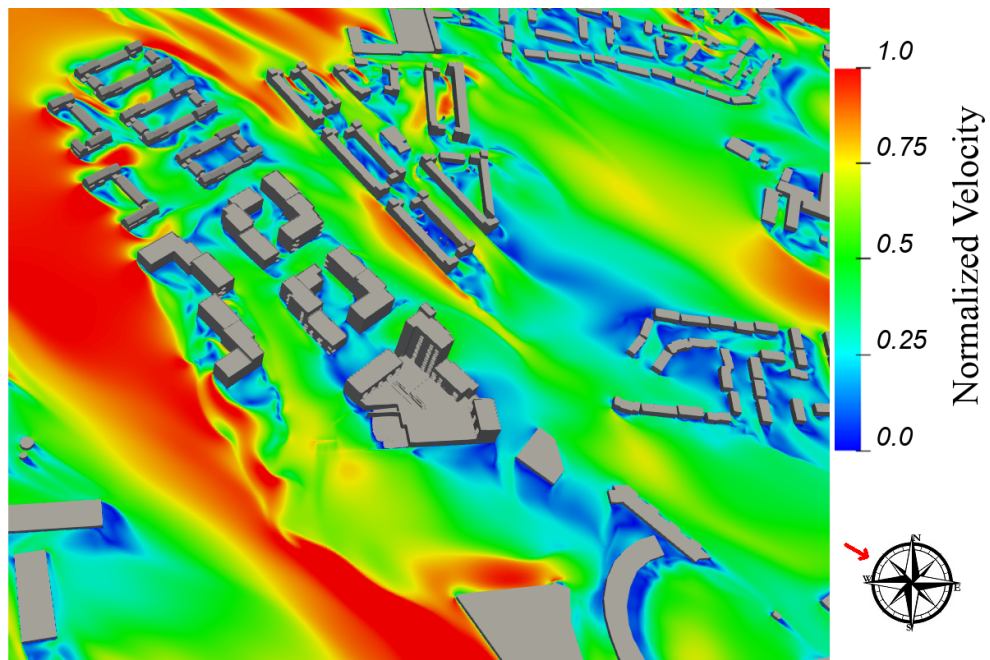


Figure 12.23: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 300° .

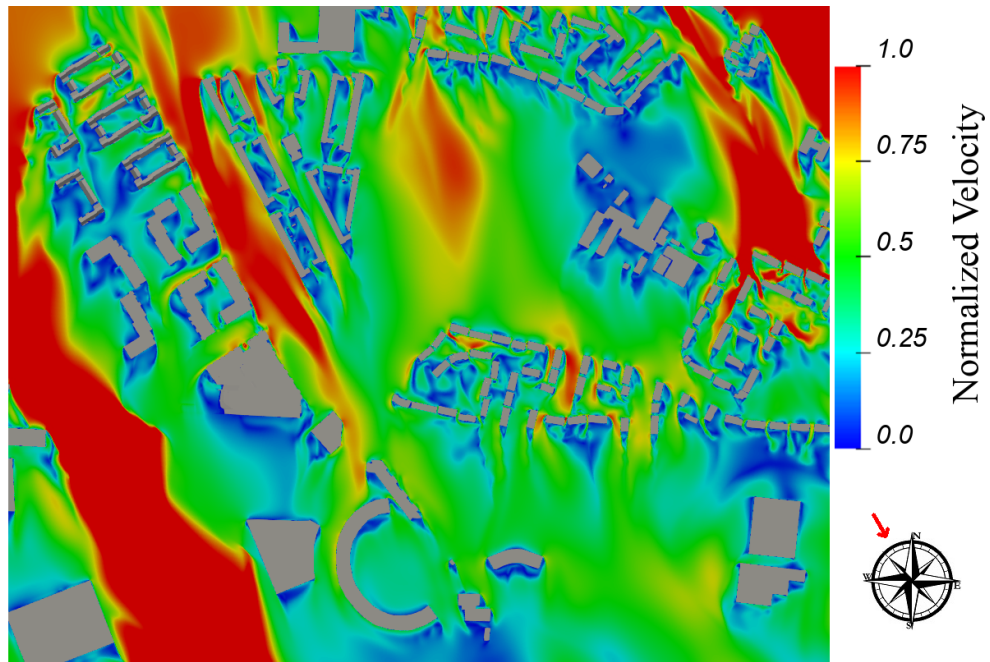


Figure 12.24: Top View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 330° .

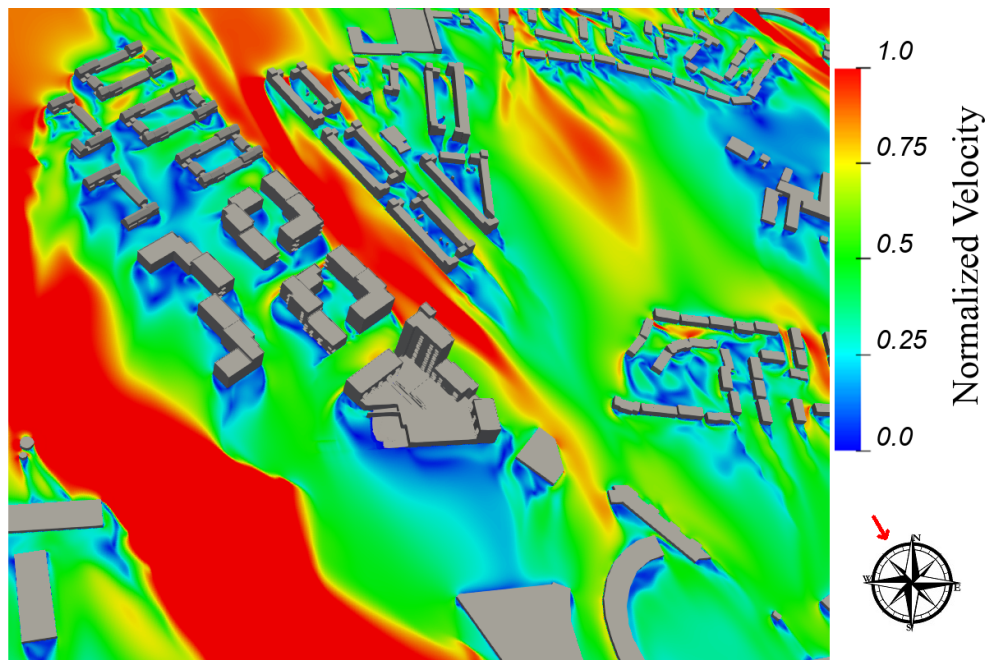


Figure 12.25: 3D View - Ground Floor Level - Flow Velocity Results at $Z = 1.8m$ above the ground - Wind Direction: 330° .

12.2 Appendix B: Proposed Scenario

12.2.1 Appendix B.1: Proposed - WIND SPEEDS - Pedestrian Level (1.8m)

In this appendix the wind speed results are presented at the ground level, evaluated at a height of 1.8m above the surface. The corresponding horizontal slice at 1.8m height is presented in Figure 12.26 for Proposed Development.

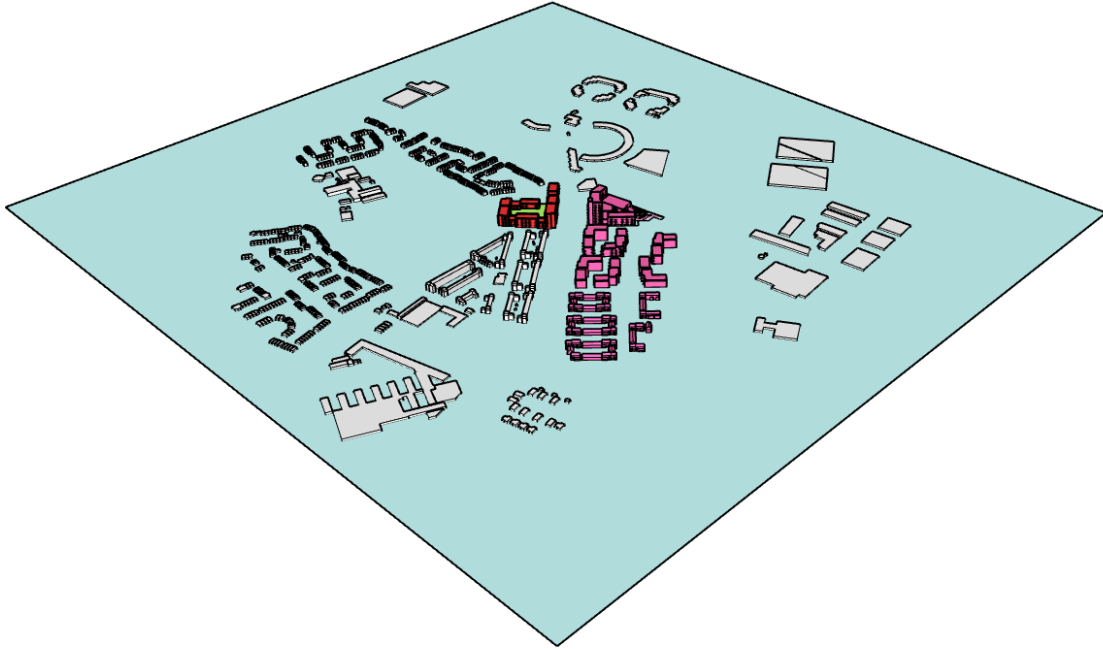


Figure 12.26: Horizontal Slices at 1.8m above Ground level for Cherry Orchard Phase 3 Development.

Results of wind speeds and their circulations at pedestrian level of $1.8m$ above the potential receptors are presented in Figures 12.102 to 12.125 in order to assess wind flows at the ground floor level of Cherry Orchard Phase 3 Development.

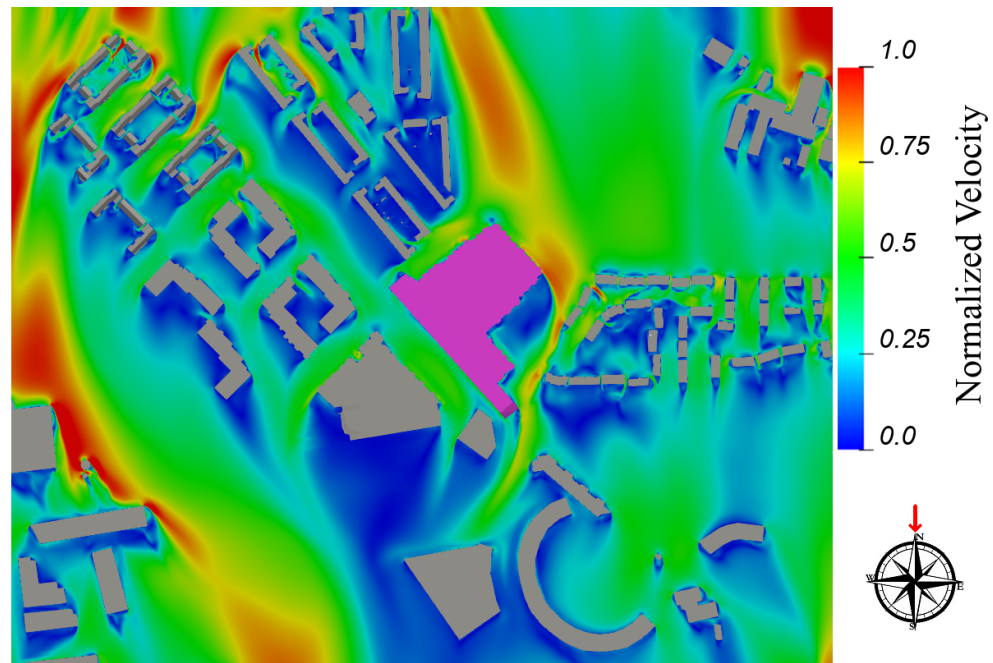


Figure 12.27: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 0° .

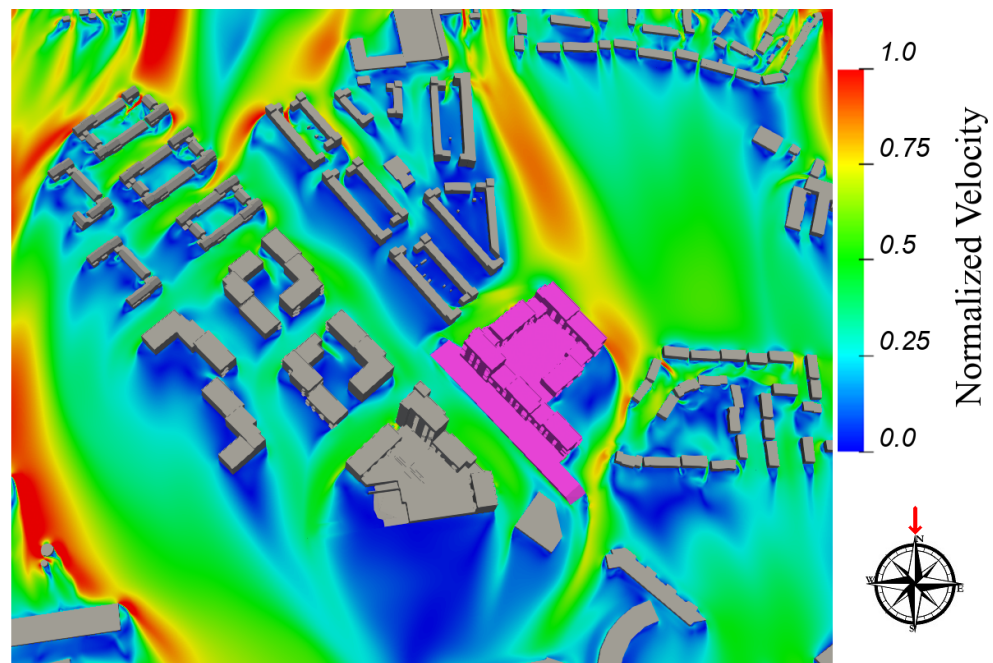


Figure 12.28: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 0° .

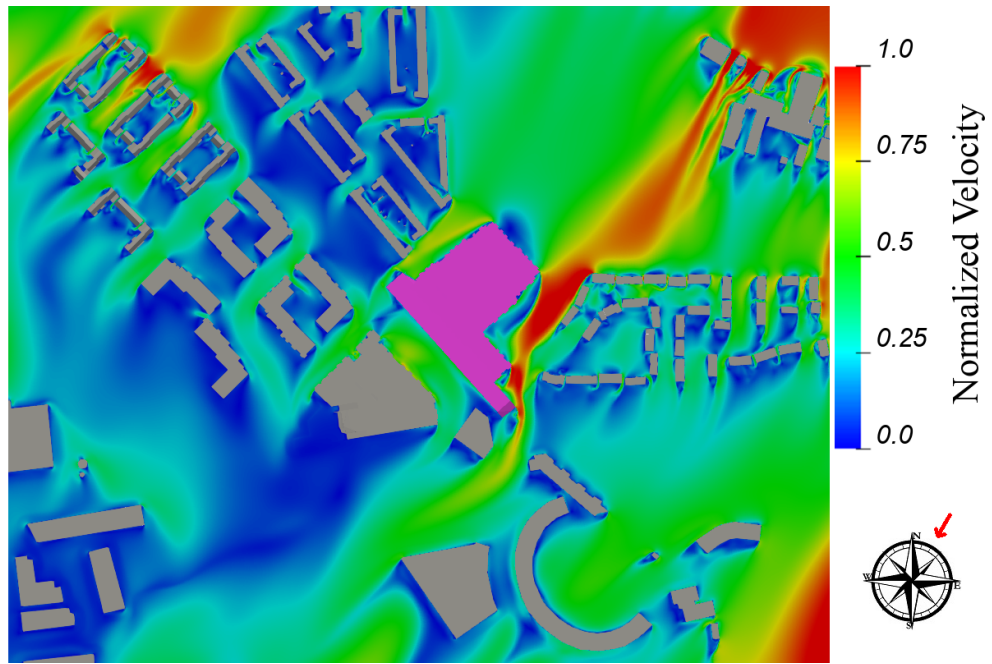


Figure 12.29: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 30° .

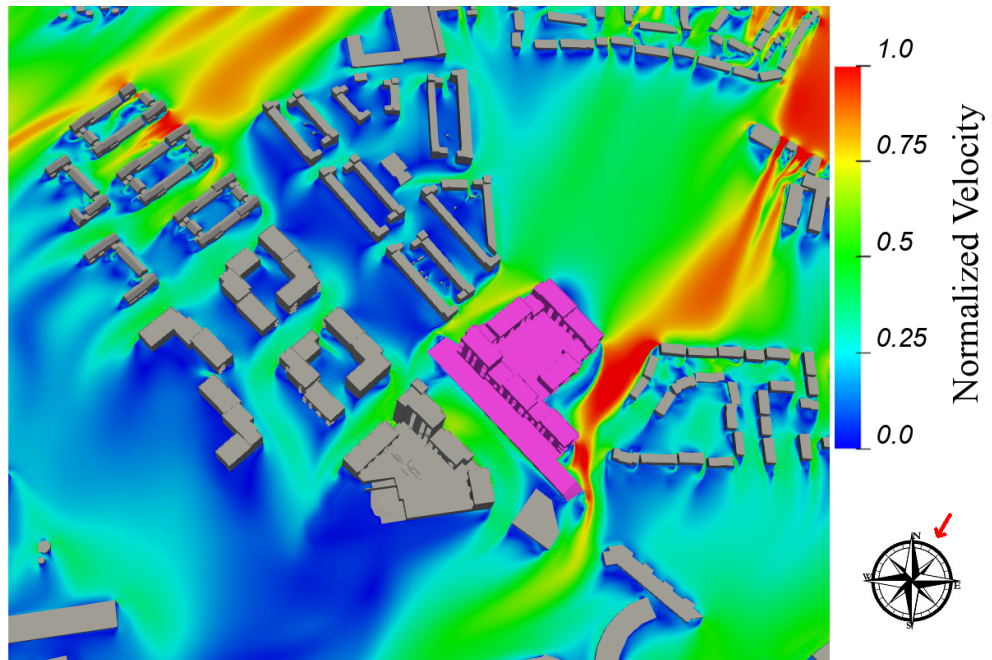


Figure 12.30: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 30° .

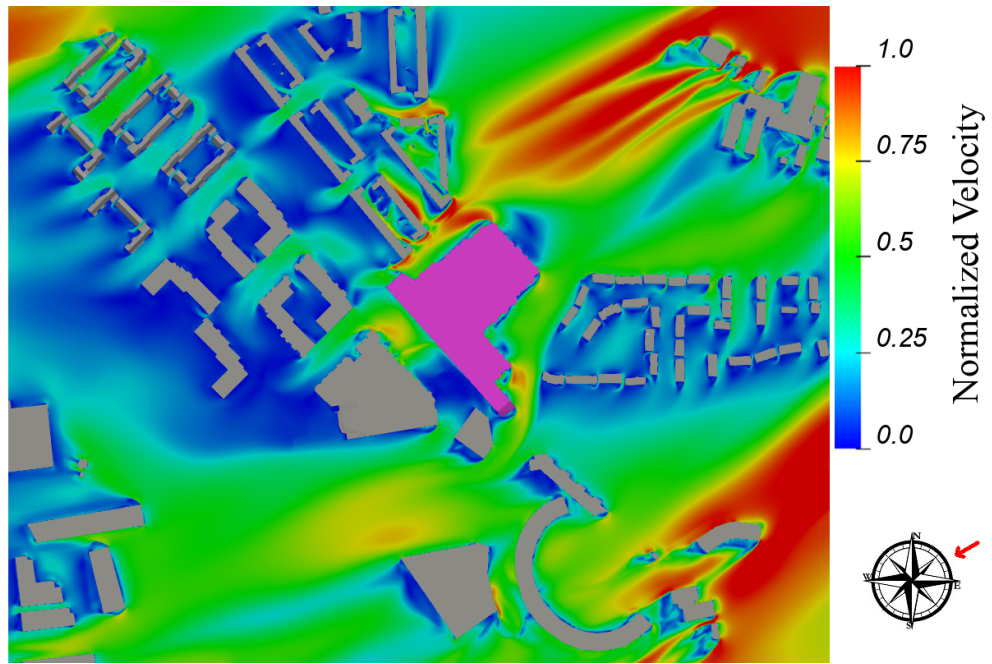


Figure 12.31: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 60° .

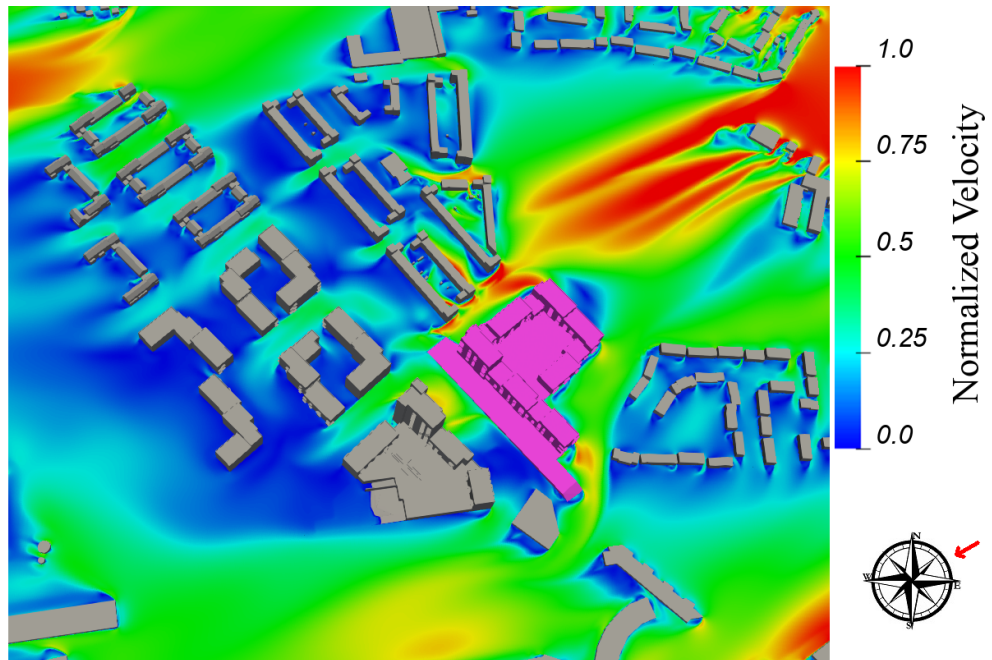


Figure 12.32: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 60° .

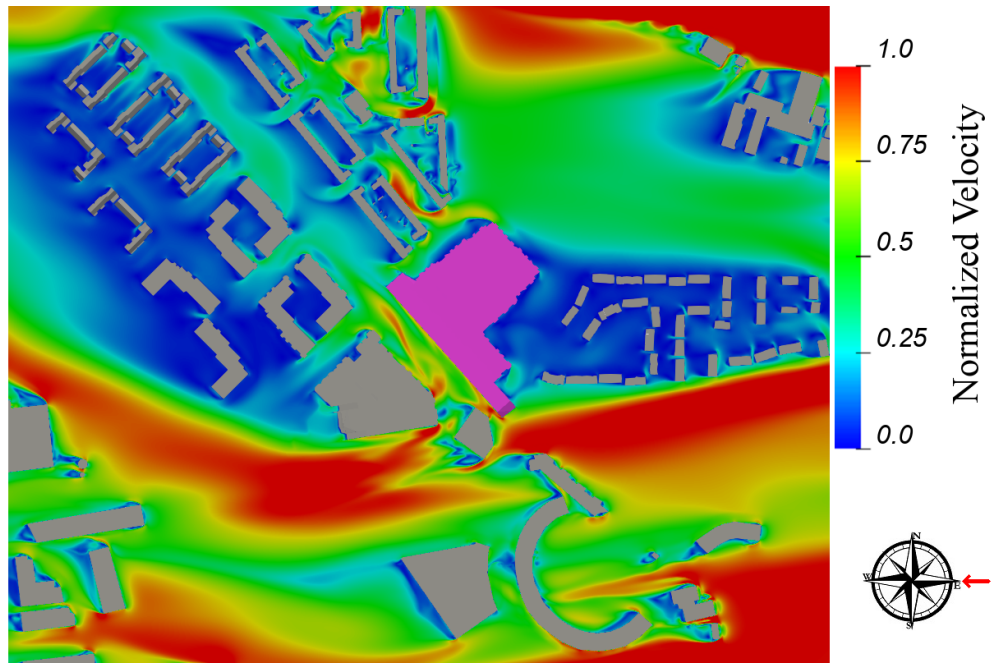


Figure 12.33: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 90° .

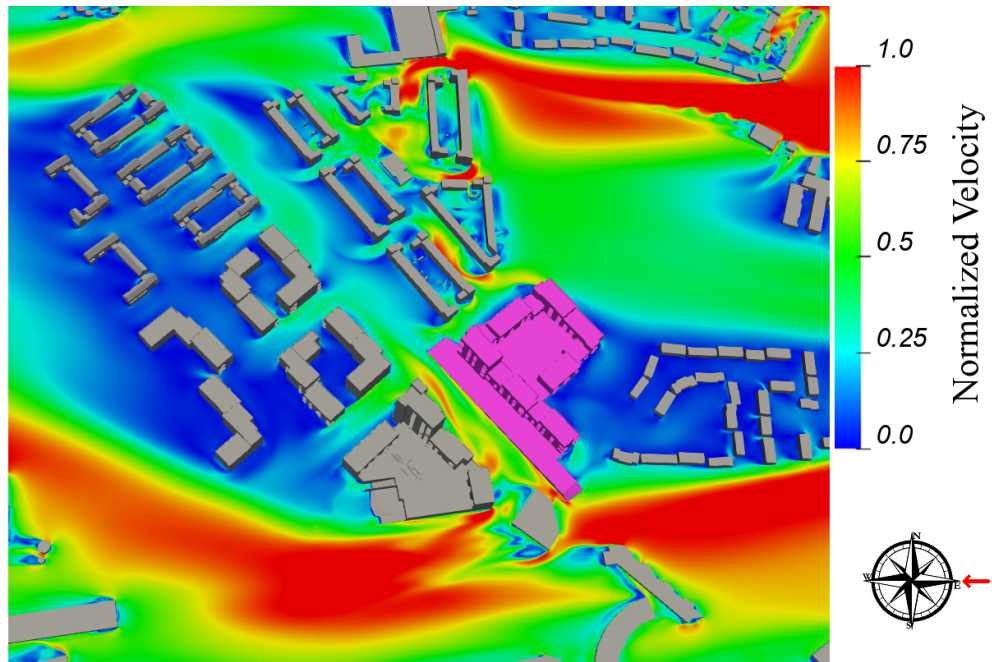


Figure 12.34: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 90° .

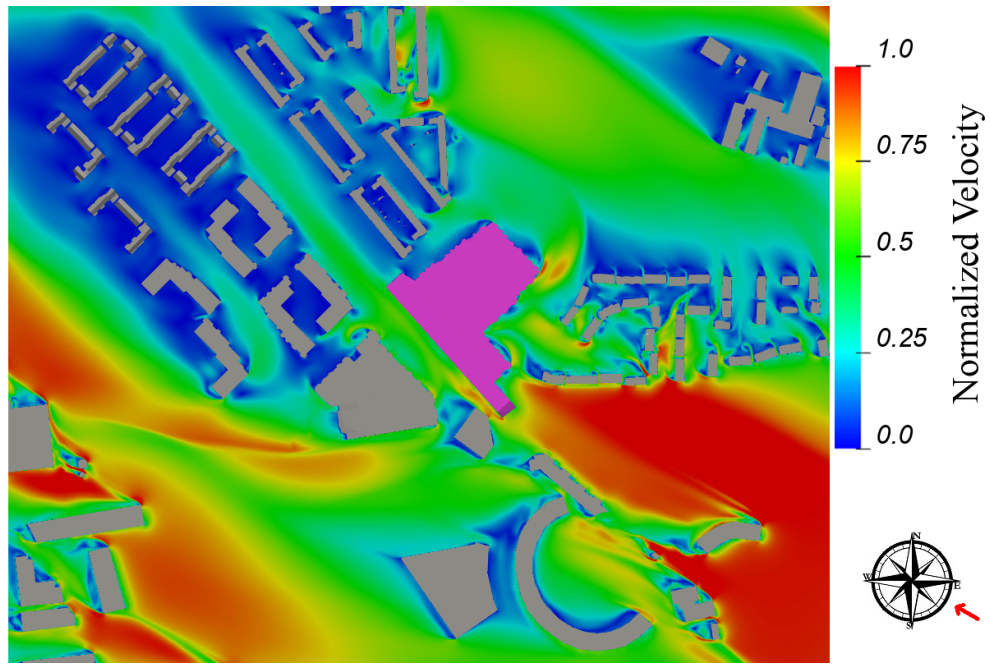


Figure 12.35: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 120° .

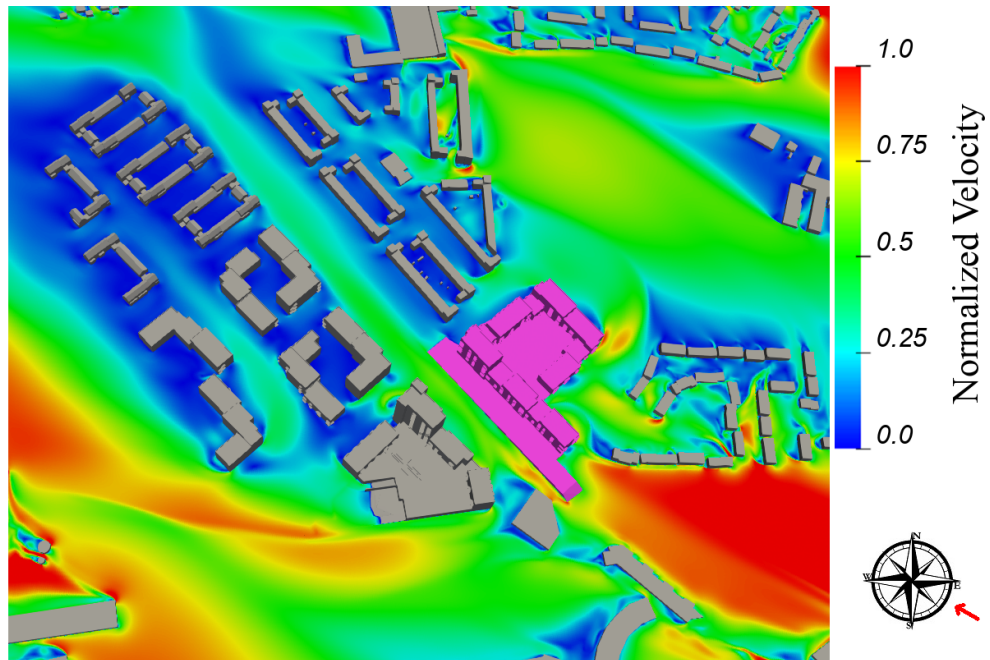


Figure 12.36: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 120° .

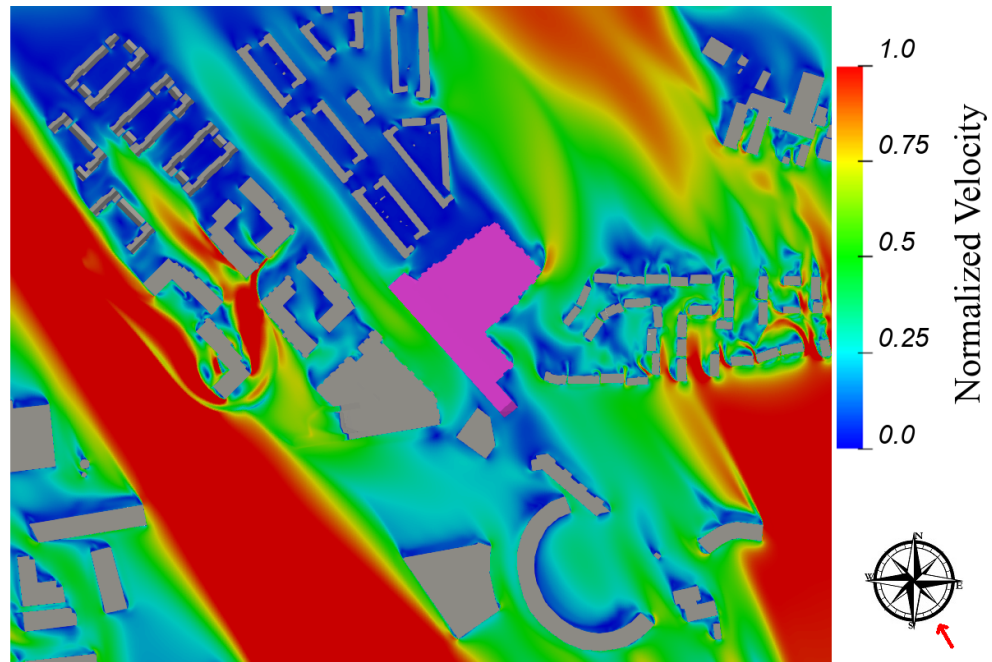


Figure 12.37: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 150° .

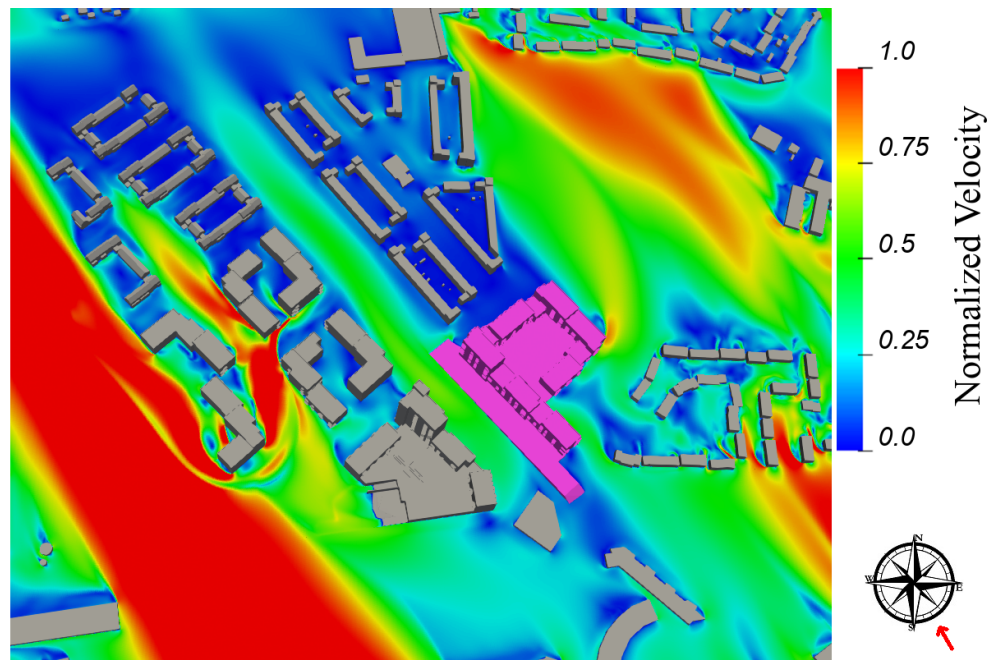


Figure 12.38: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 150° .

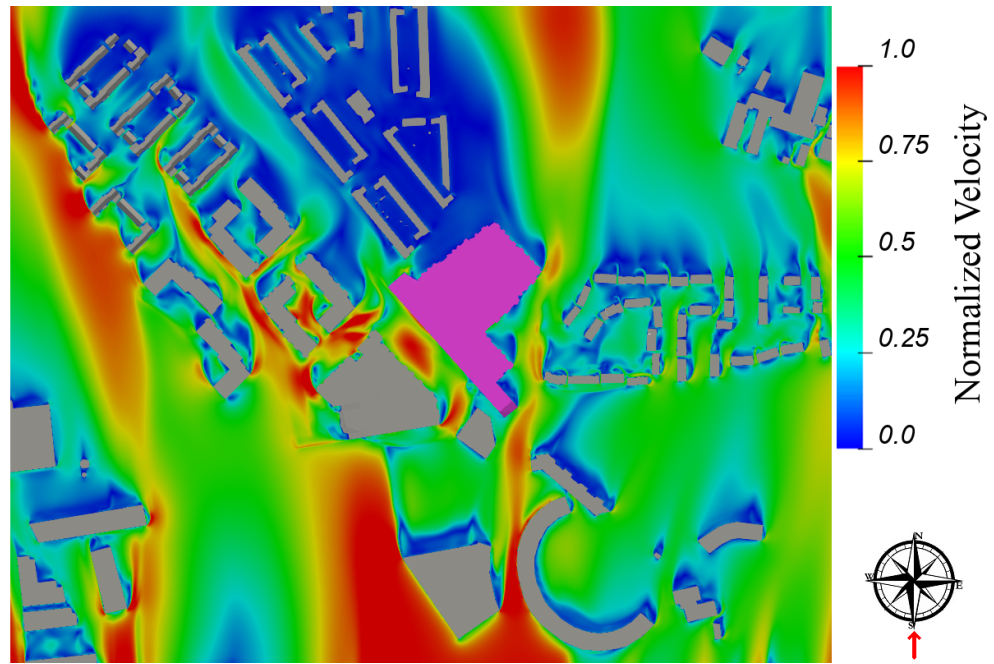


Figure 12.39: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 180° .

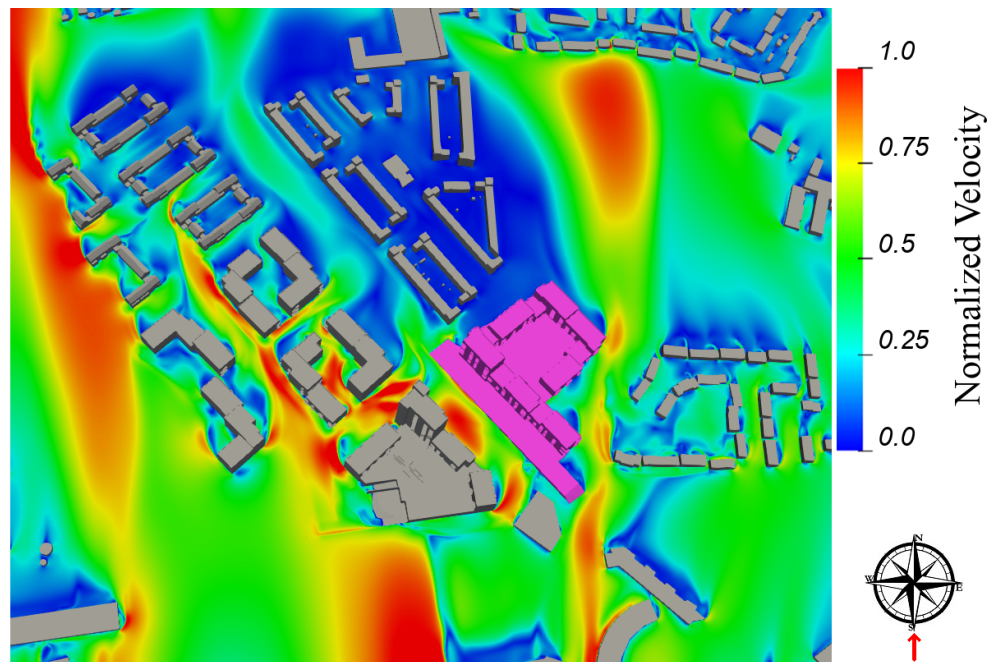


Figure 12.40: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 180° .

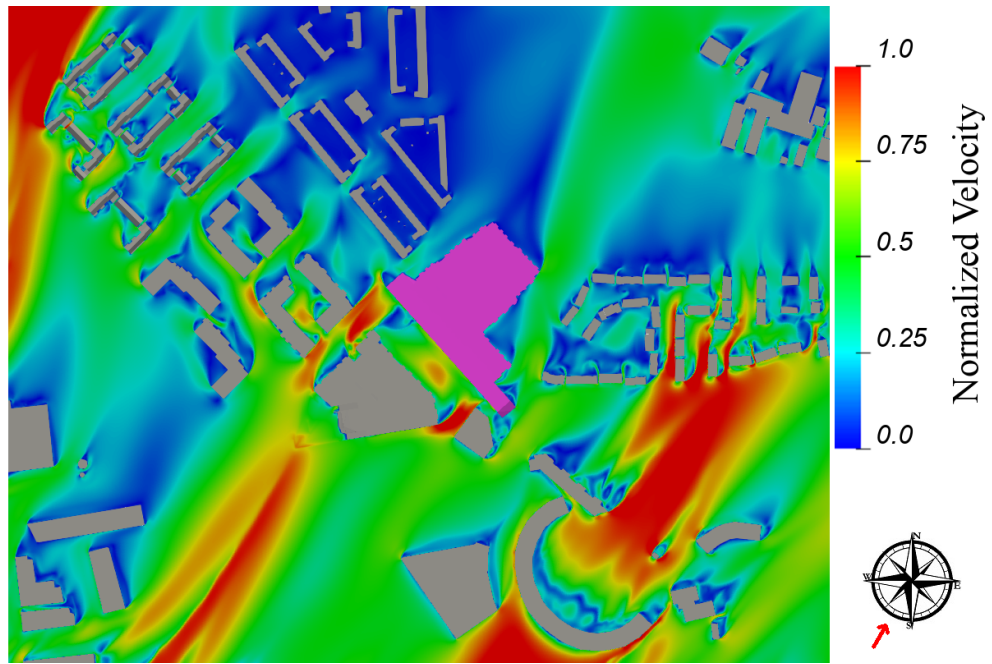


Figure 12.41: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 210° .

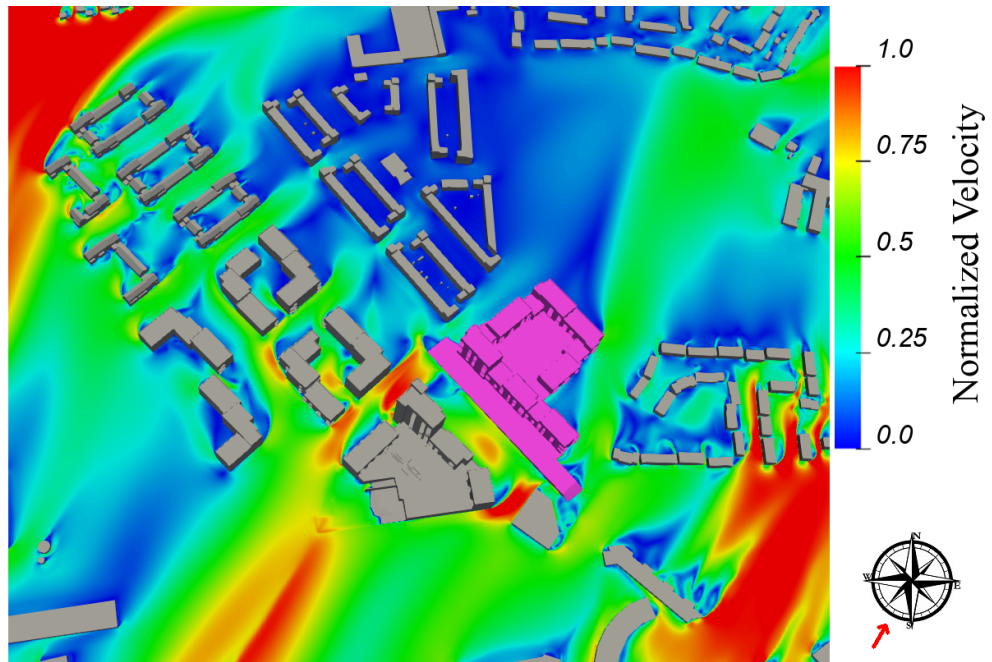


Figure 12.42: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 210° .

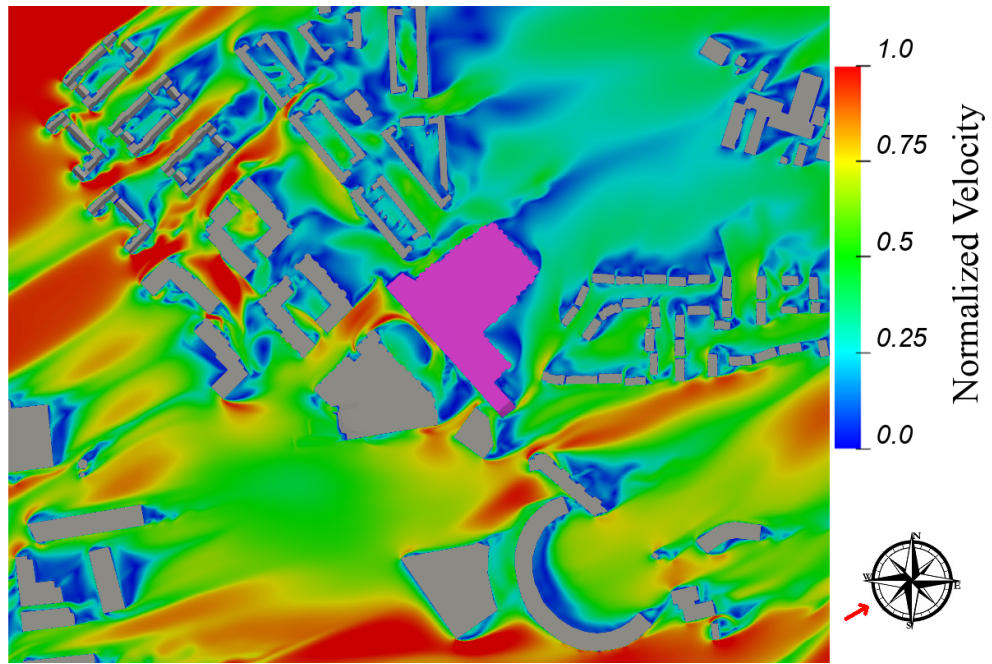


Figure 12.43: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 240° .

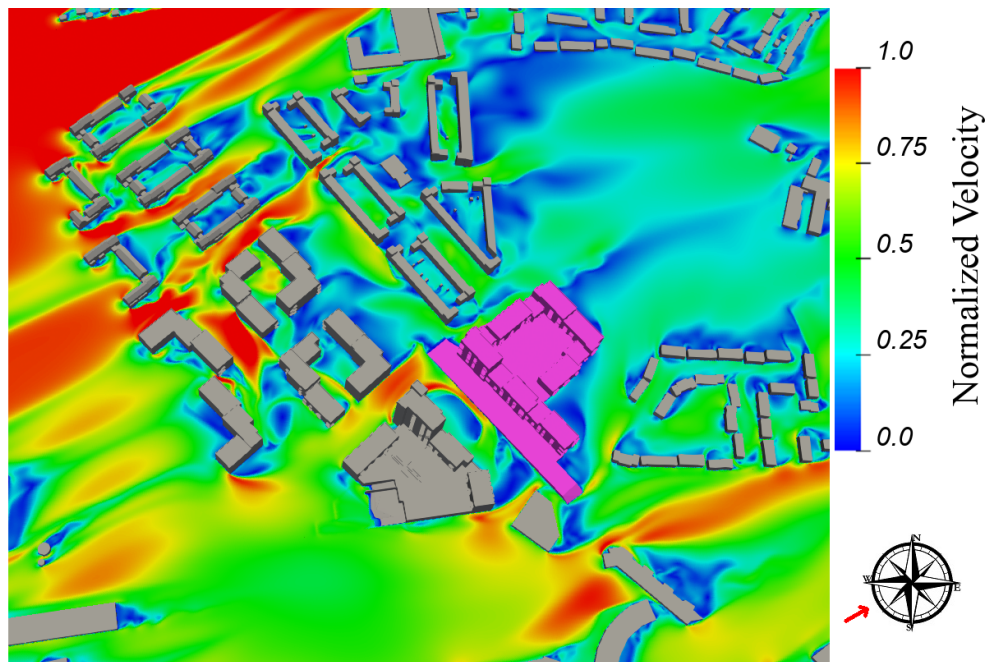


Figure 12.44: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 240° .

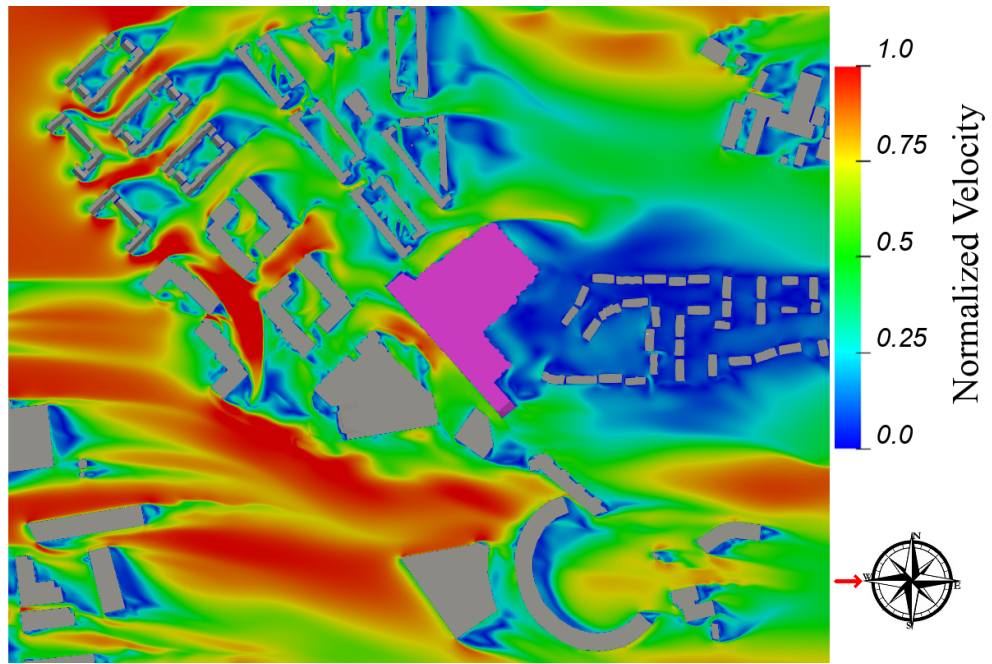


Figure 12.45: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 270° .

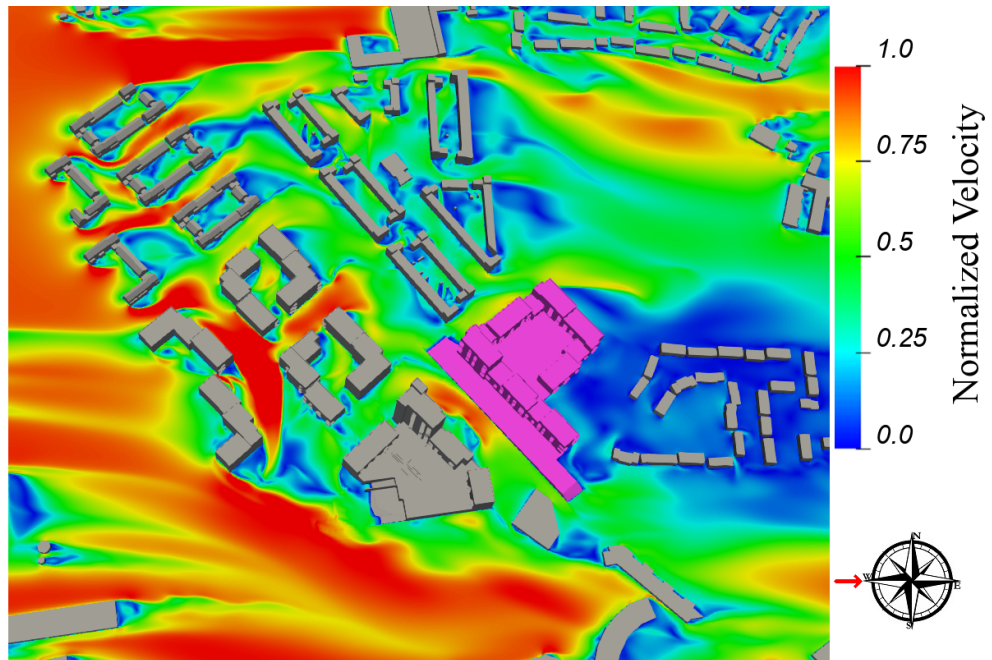


Figure 12.46: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 270° .

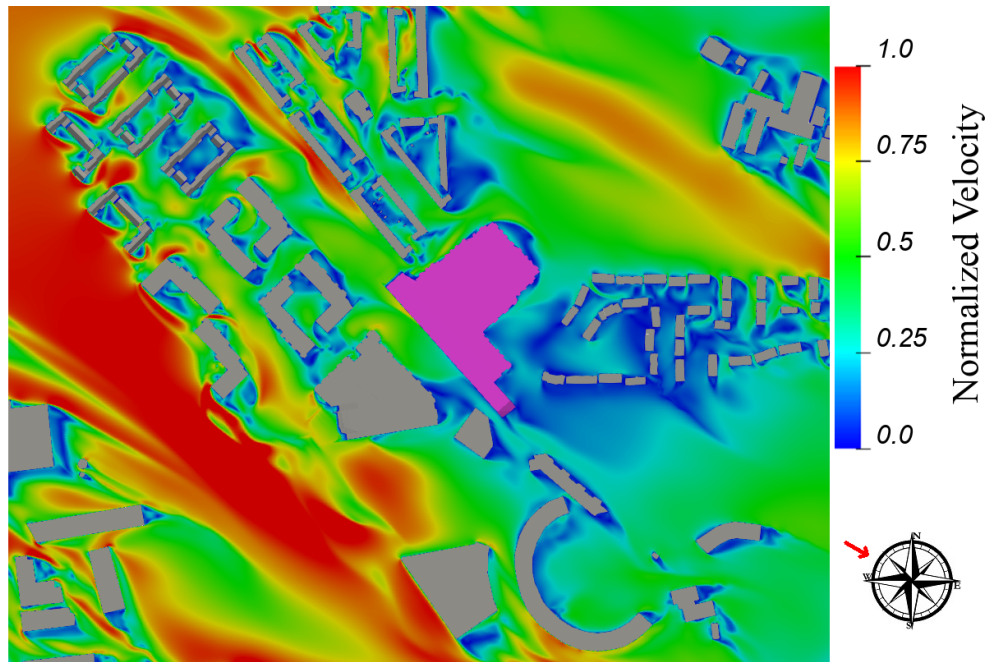


Figure 12.47: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 300° .

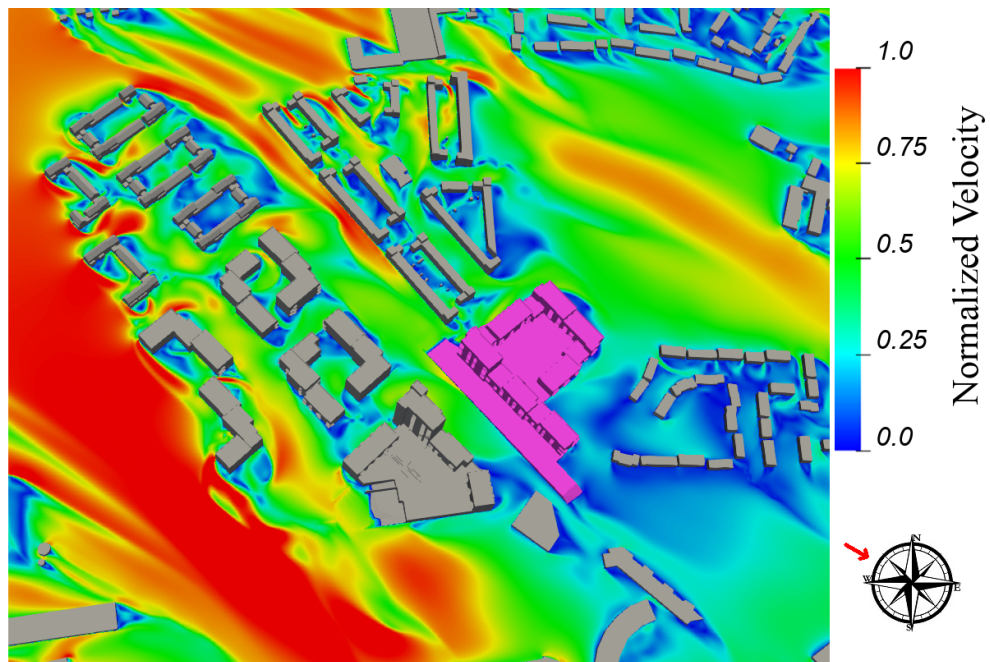


Figure 12.48: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 300° .

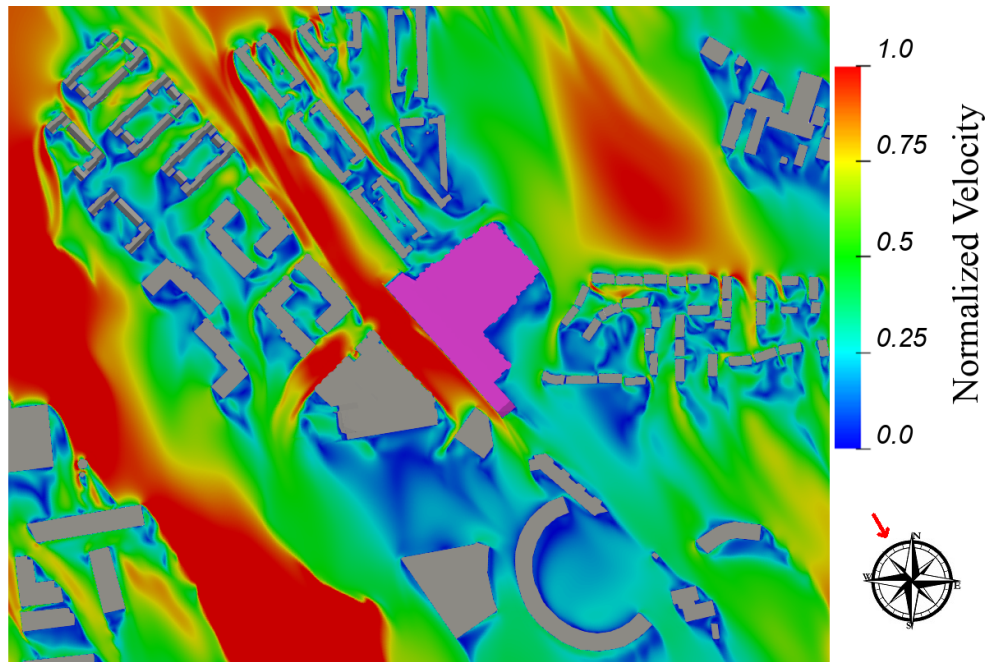


Figure 12.49: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 330° .

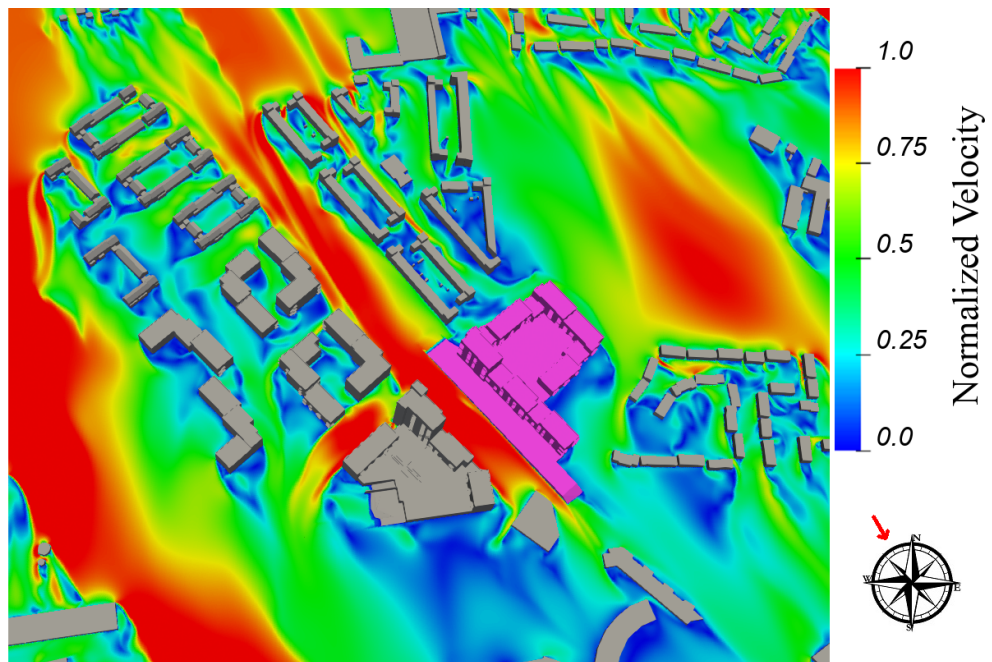


Figure 12.50: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 330° .

12.2.2 Appendix B.2: Proposed – WIND SPEEDS – Pedestrian Level (7.1,m)

This section presents the wind speed results at pedestrian level, assessed at a height of 7.1,m above the surface. This assessment height was selected to account for the elevated section of Park W Ave, where portions of the roadway are approximately 5.3,m above the base level of the proposed development. The corresponding horizontal slice at 7.1,m is presented in Figure 12.51 for the Proposed Development.

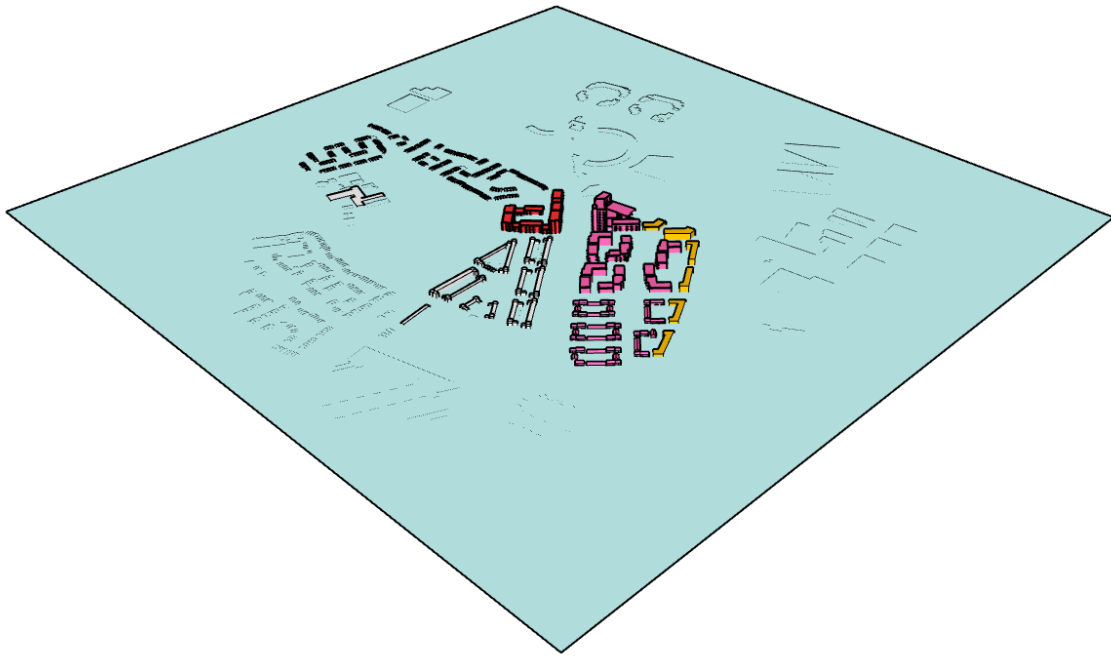


Figure 12.51: Horizontal Slices at 7.1m above Ground level for Cherry Orchard Phase 3 Development.

Results of wind speeds and their circulations at pedestrian level of $7.1m$ above the potential receptors are presented in Figures 12.52 to 12.75 in order to assess wind flows at the ground floor level of Cherry Orchard Phase 3 Development.

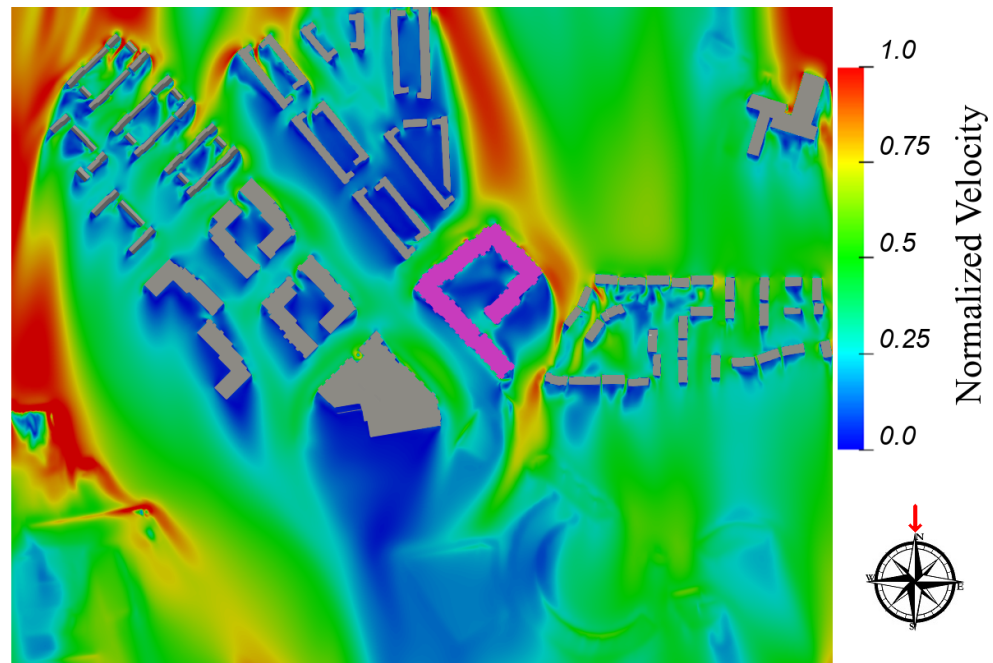


Figure 12.52: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 0° .

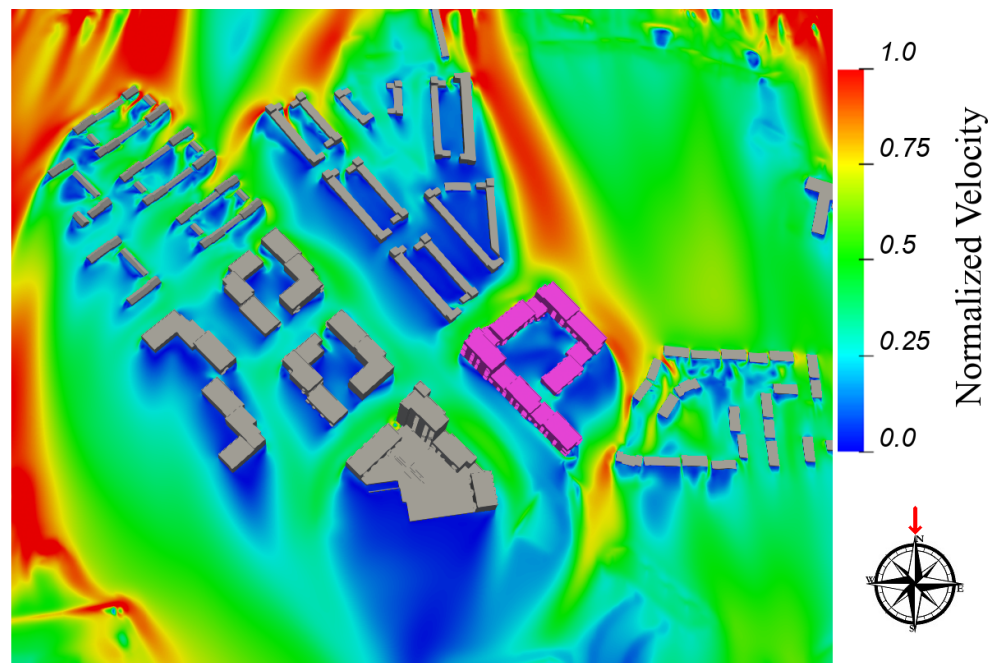


Figure 12.53: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 0° .

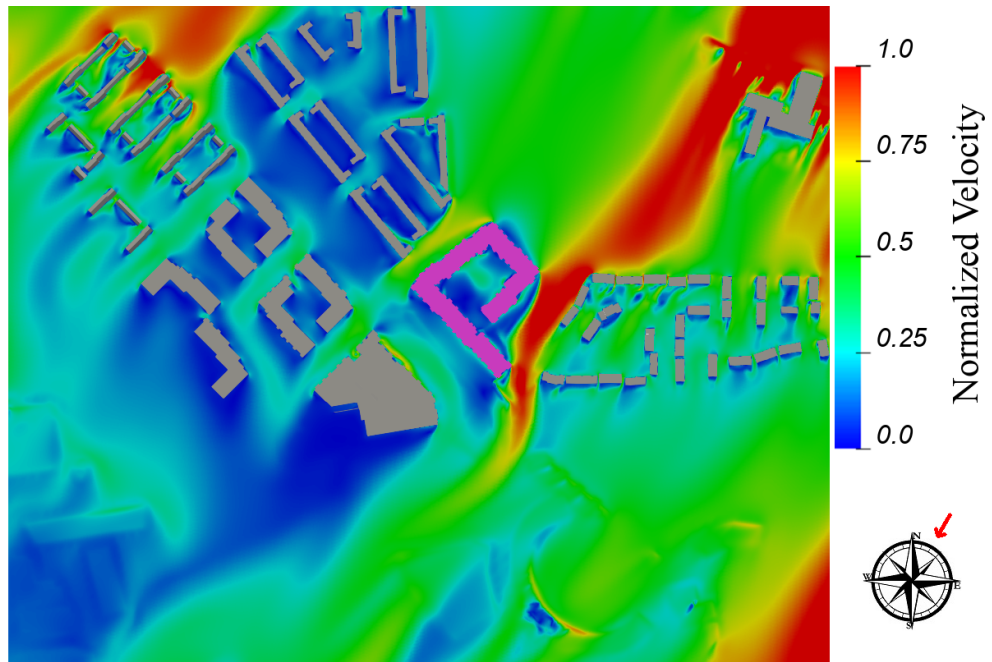


Figure 12.54: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 30° .

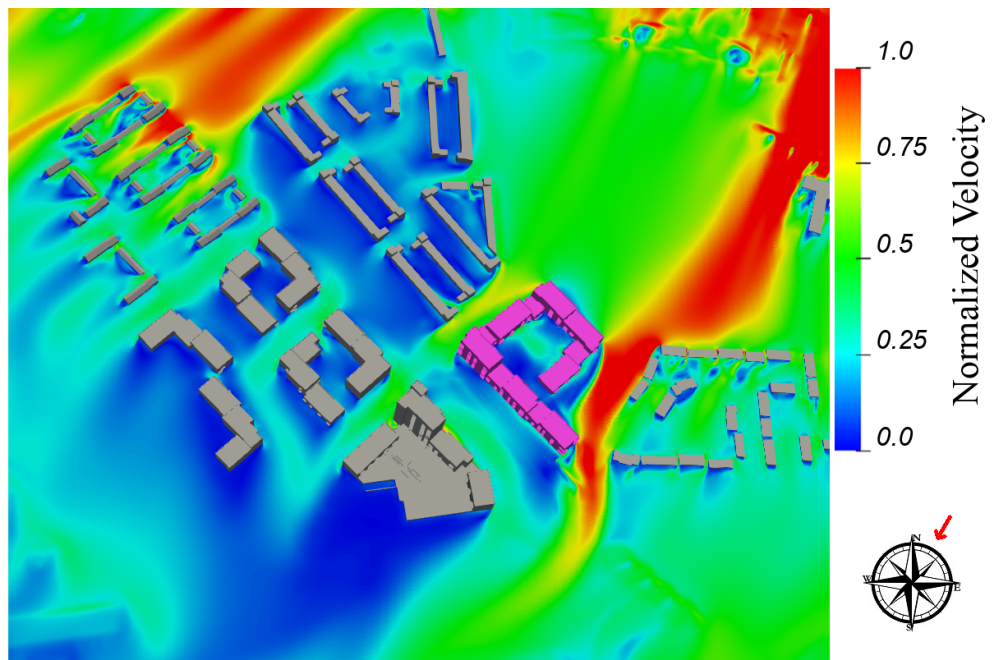


Figure 12.55: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 30° .

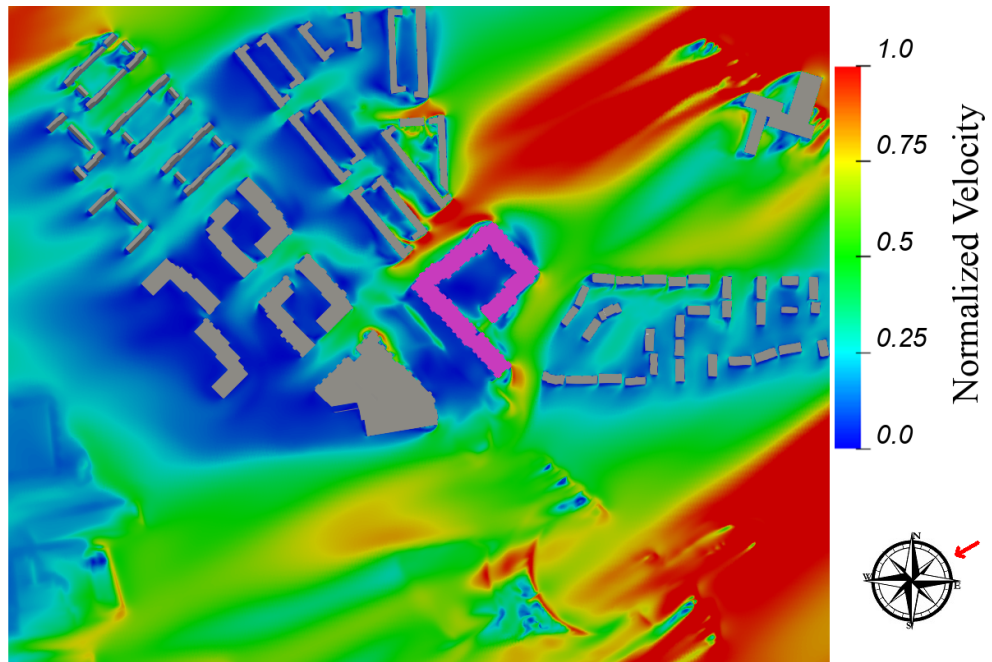


Figure 12.56: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 60° .

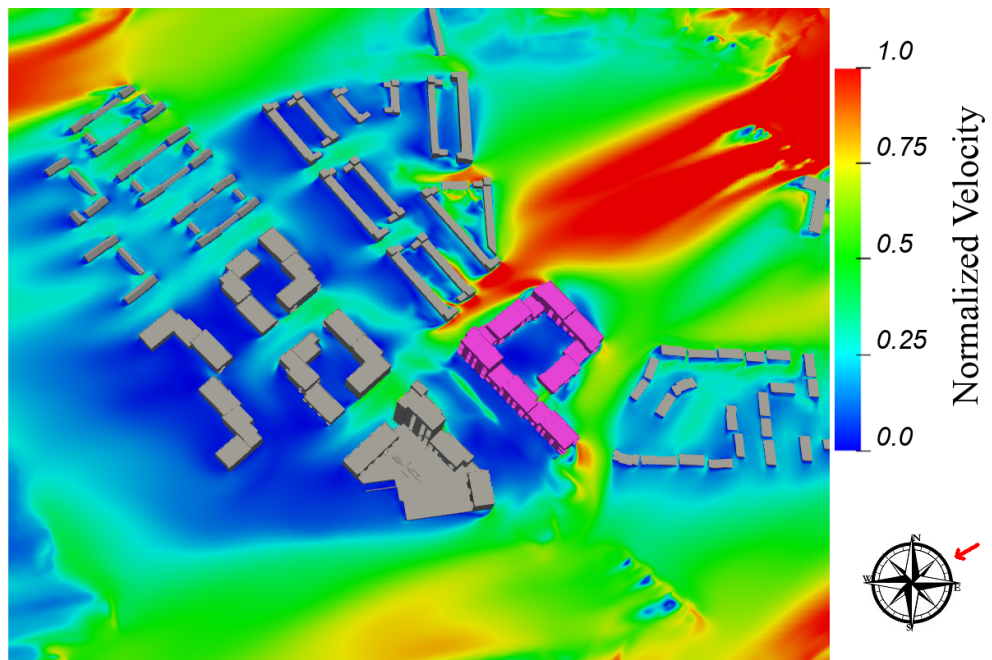


Figure 12.57: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 60° .

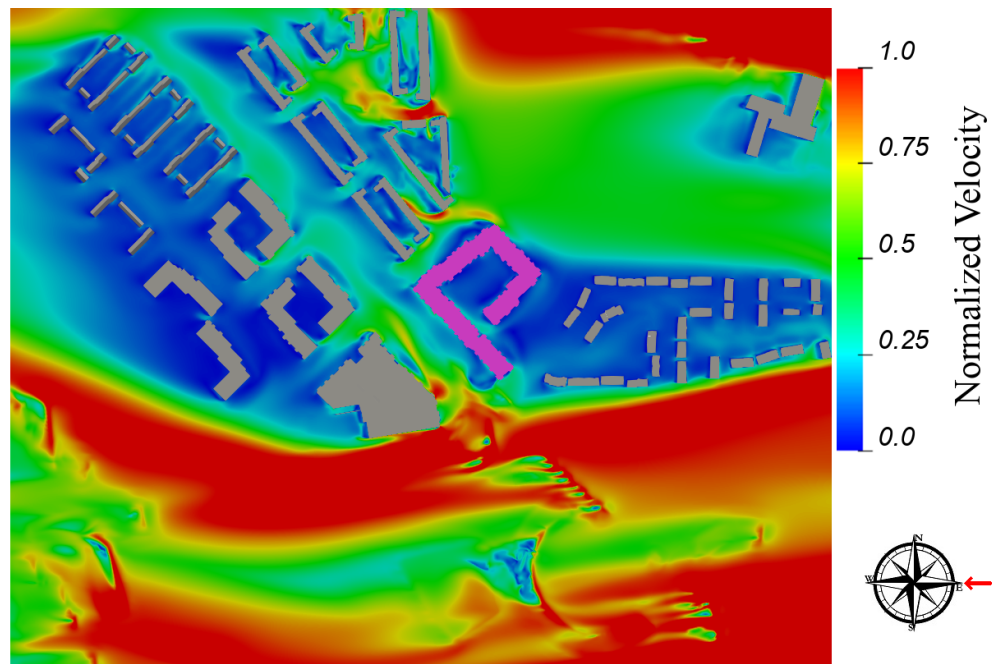


Figure 12.58: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 90° .

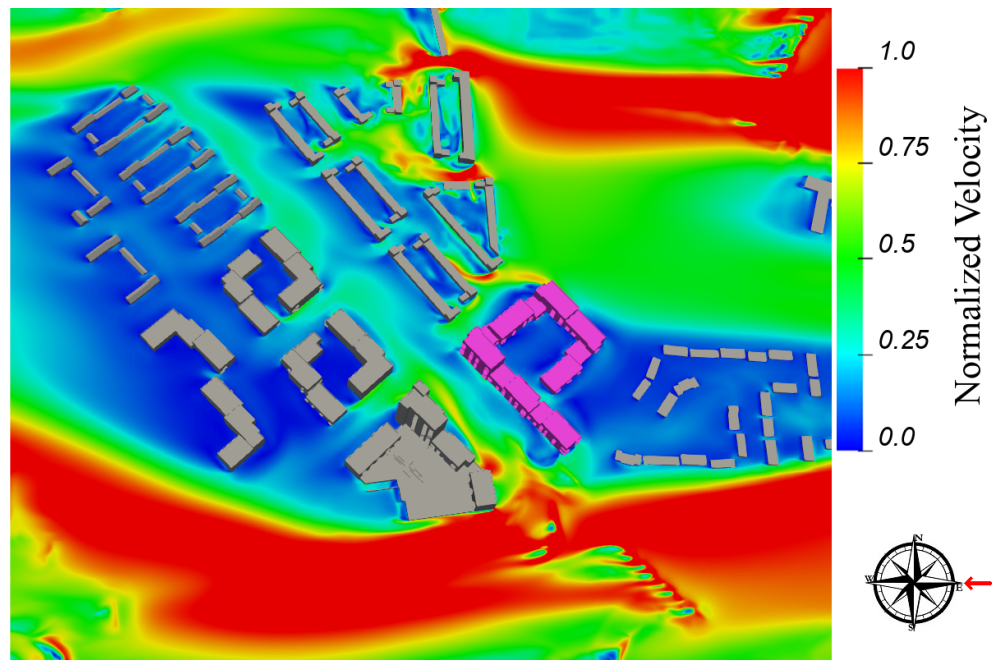


Figure 12.59: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 90° .

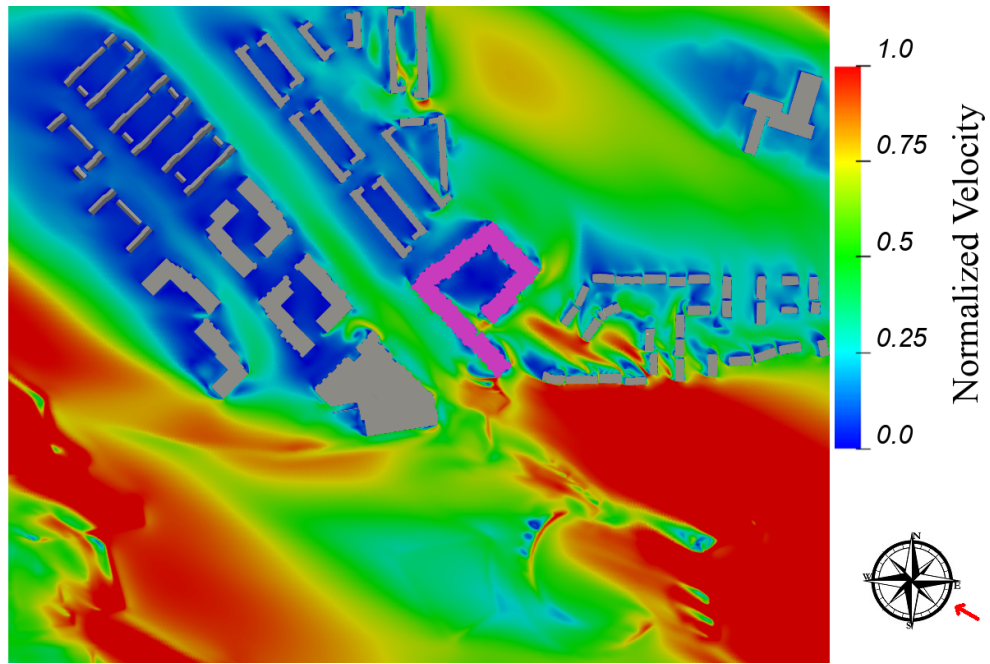


Figure 12.60: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 120° .

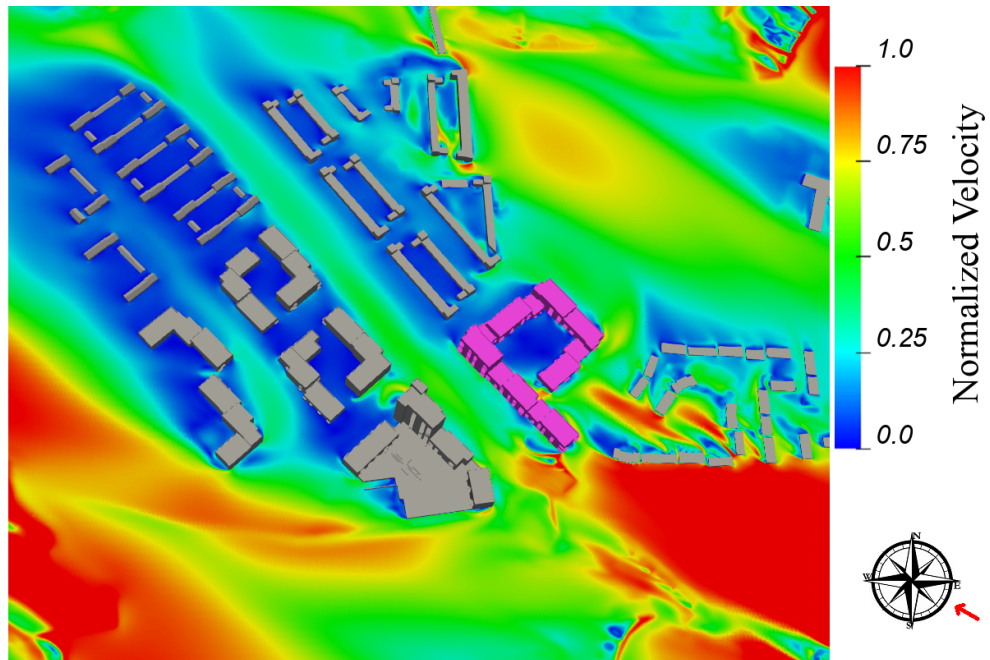


Figure 12.61: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 120° .

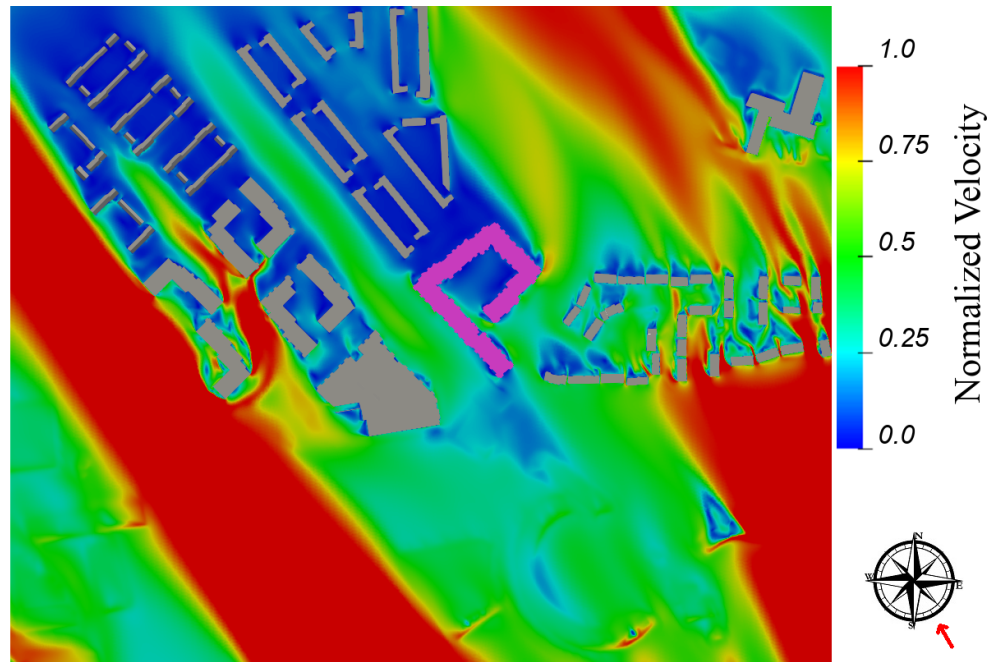


Figure 12.62: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 150° .

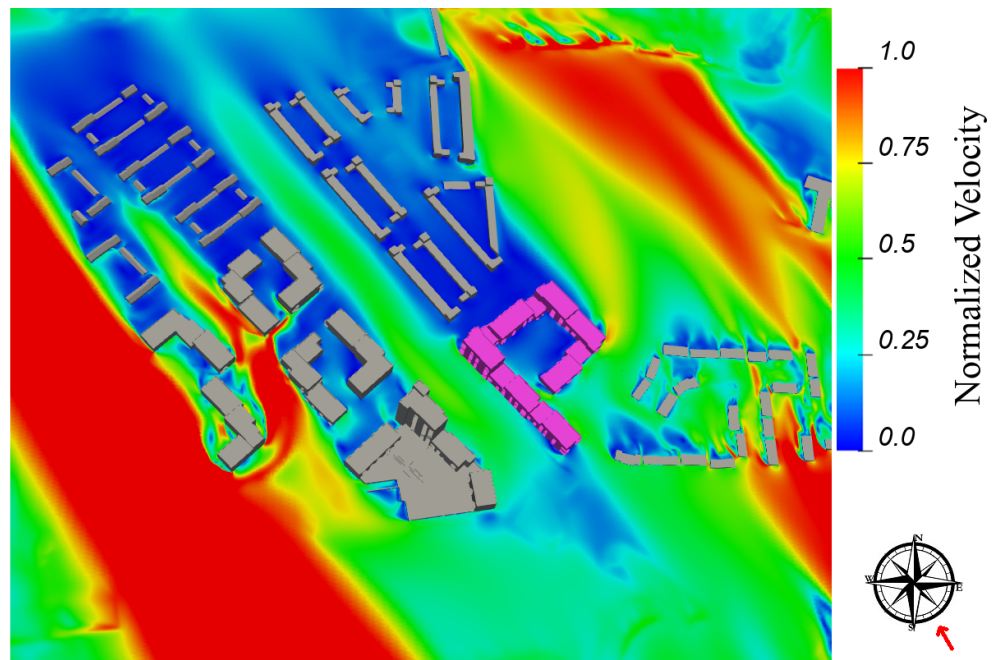


Figure 12.63: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 150° .

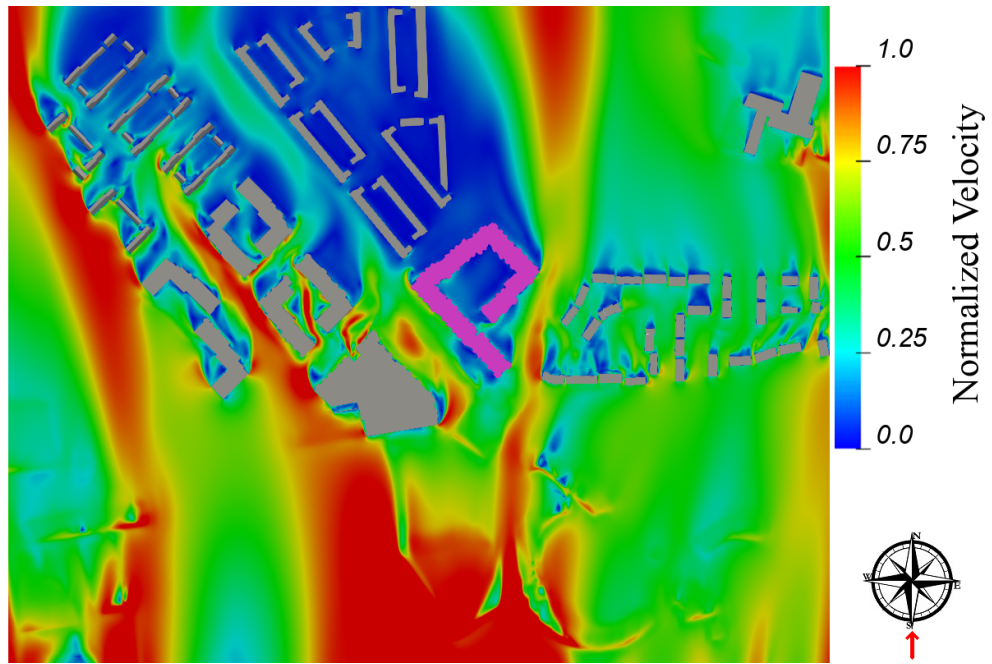


Figure 12.64: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 180° .

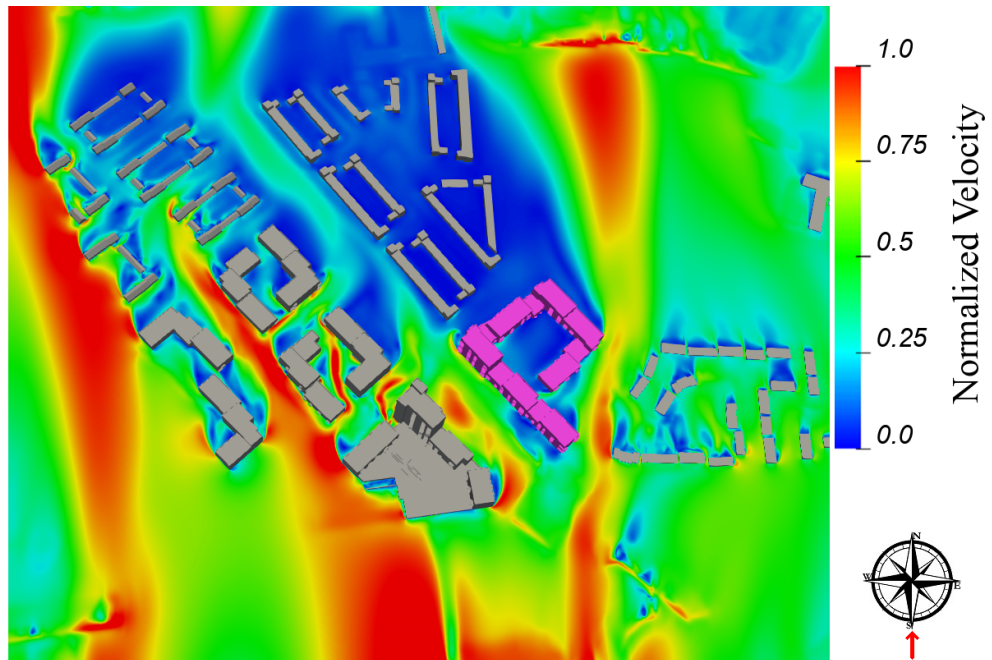


Figure 12.65: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 180° .

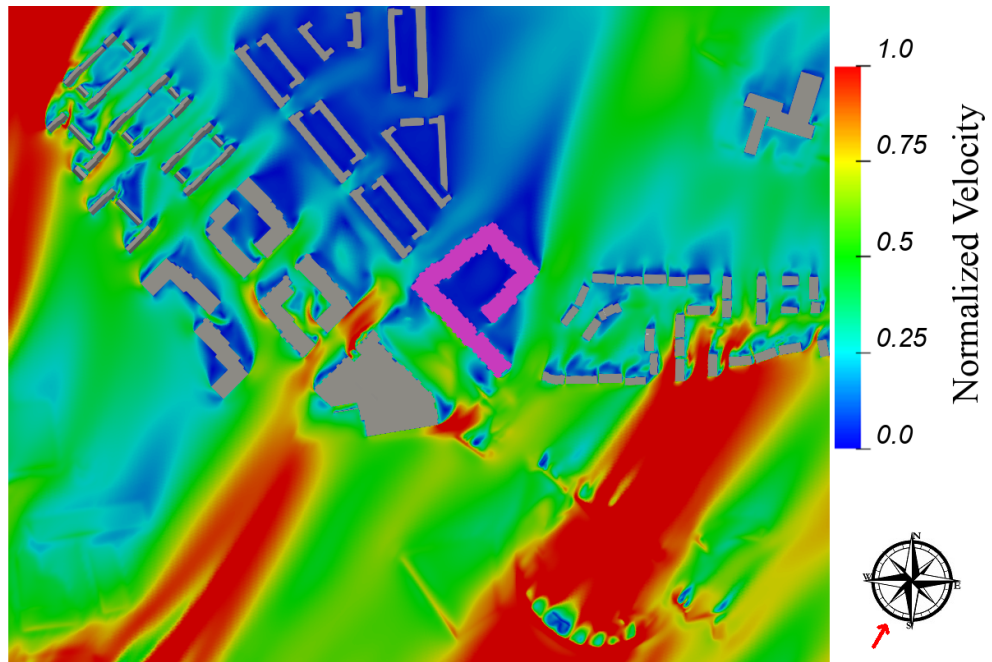


Figure 12.66: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 210° .

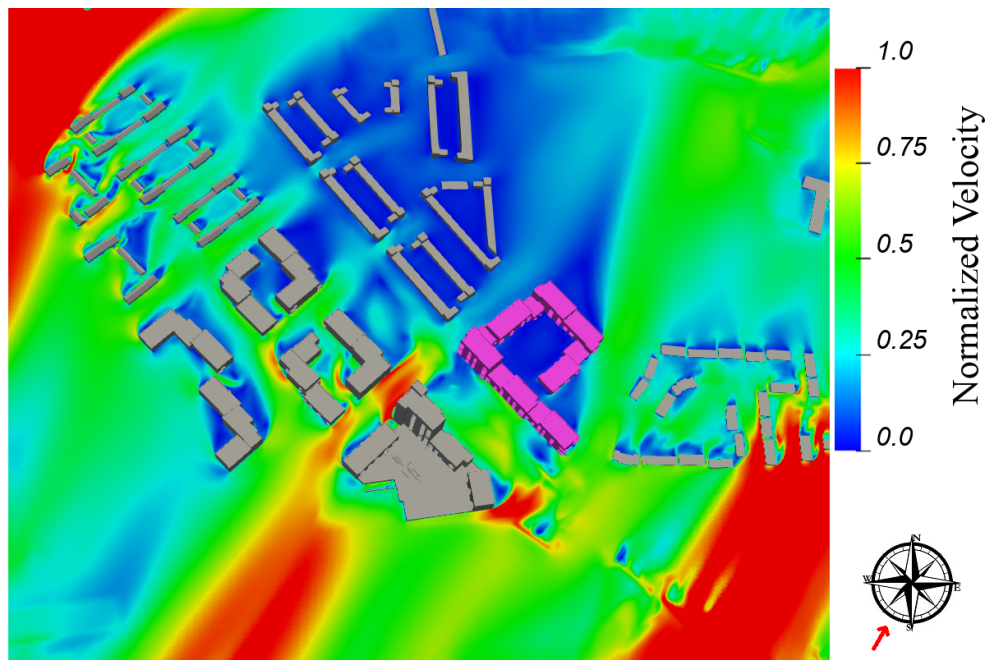


Figure 12.67: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 210° .

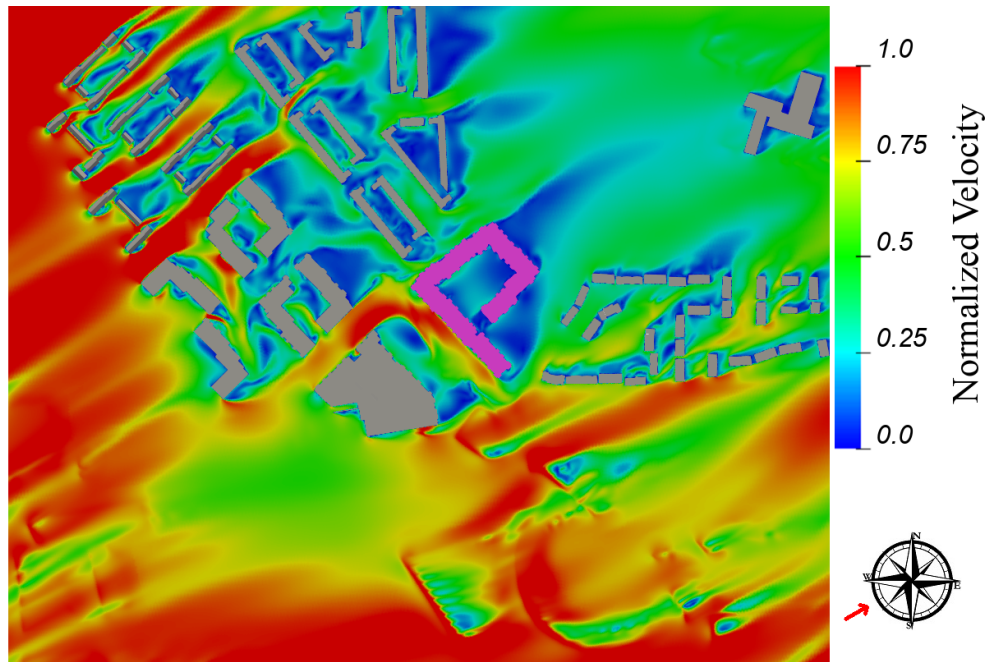


Figure 12.68: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 240° .

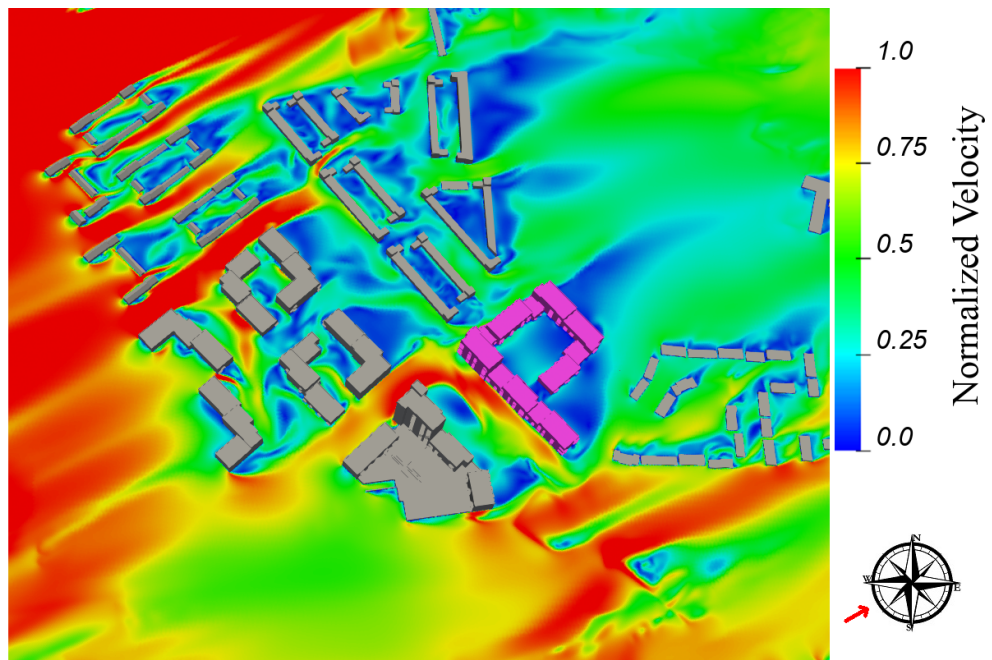


Figure 12.69: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 240° .

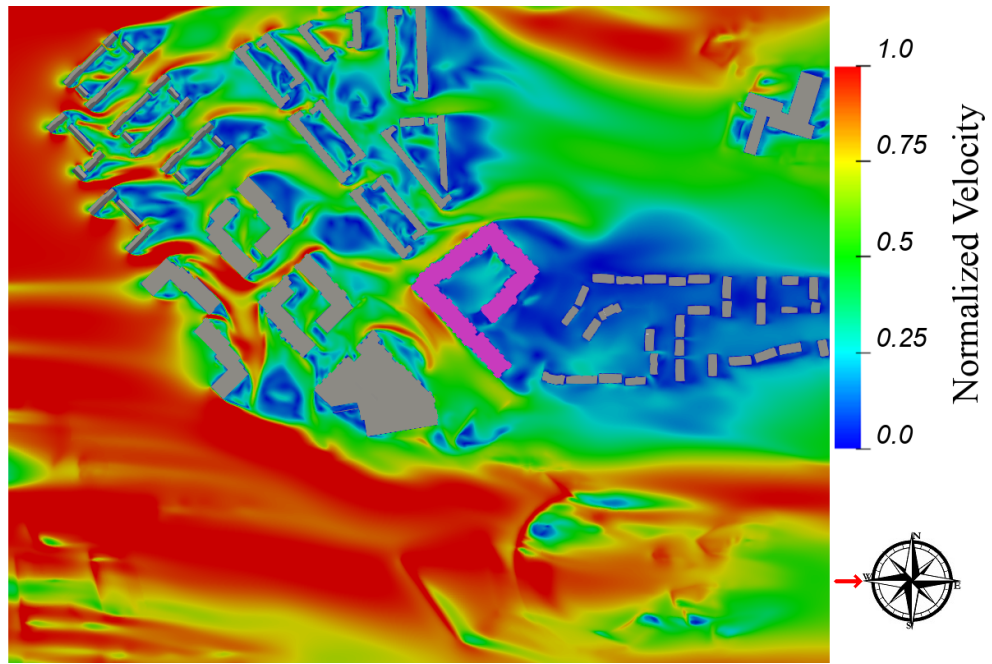


Figure 12.70: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 270° .

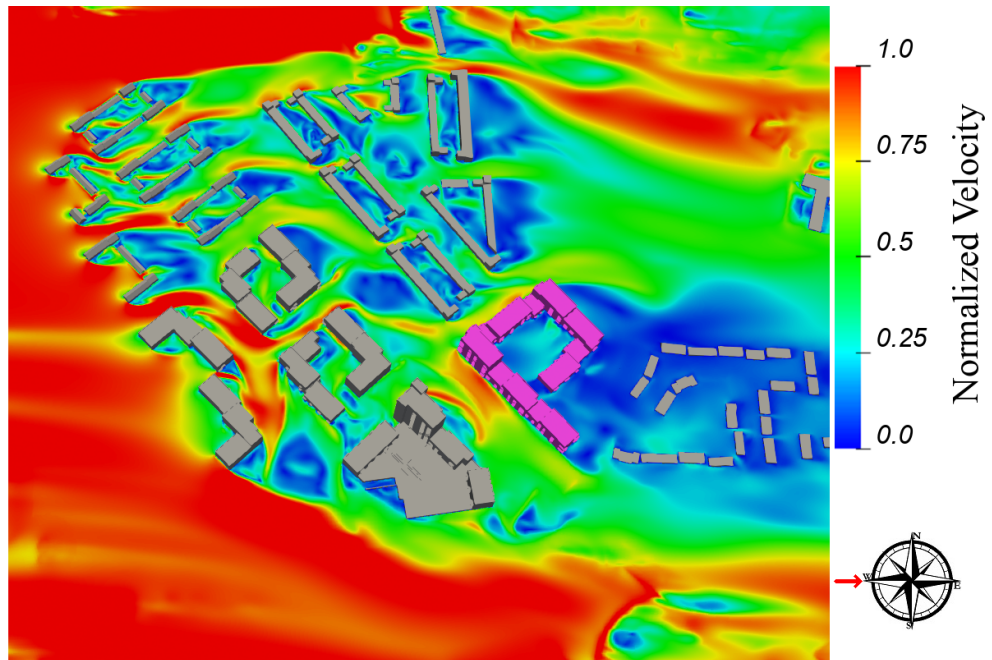


Figure 12.71: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 270° .

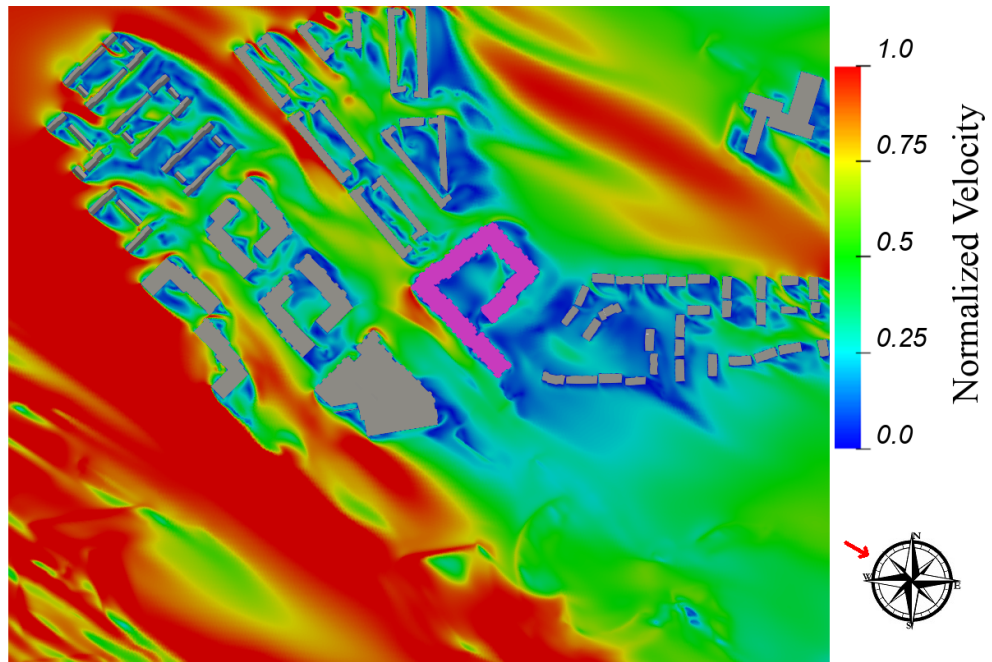


Figure 12.72: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 300° .

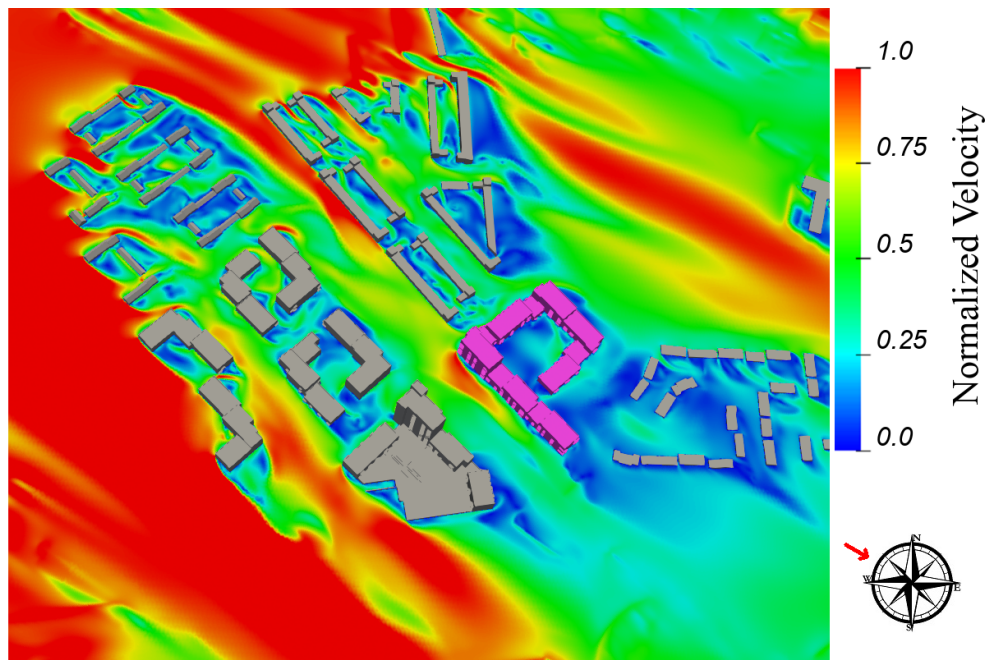


Figure 12.73: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 300° .

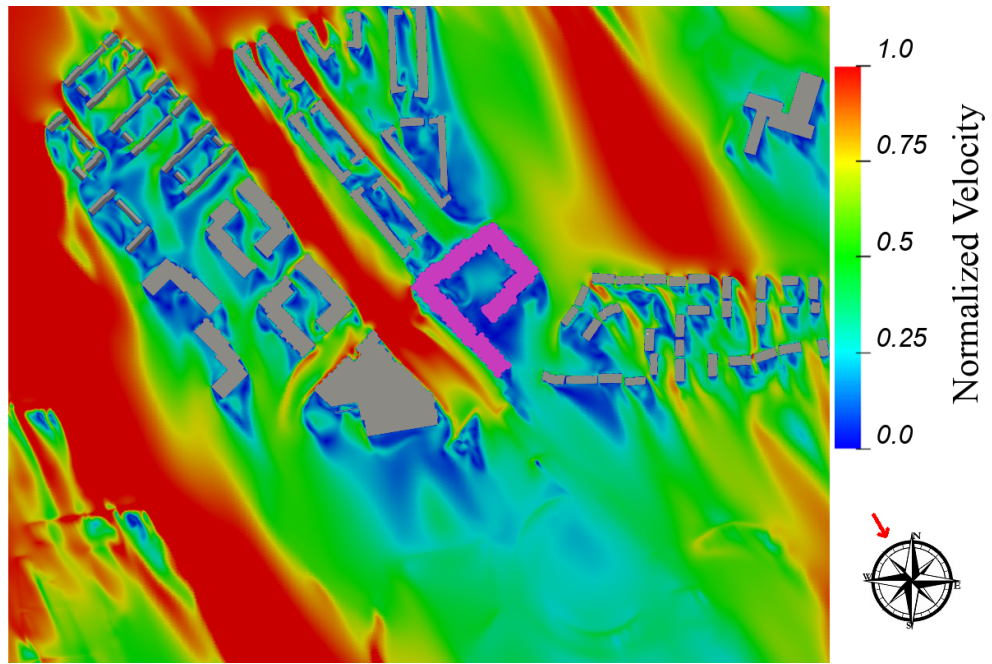


Figure 12.74: Top View -Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 330° .

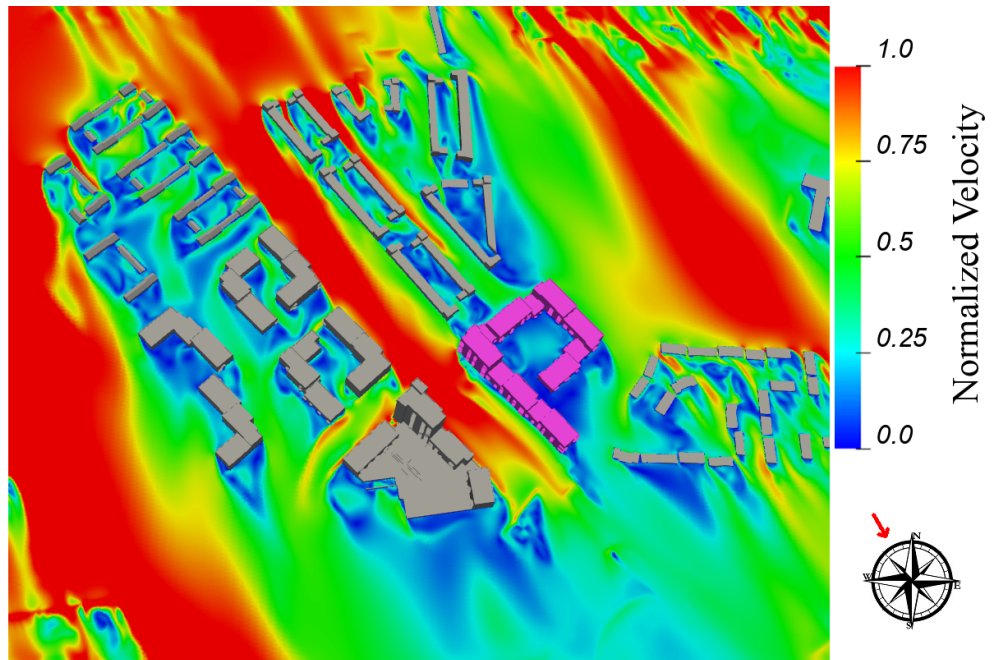


Figure 12.75: 3D View - Flow Velocity Results at $7.1m$ above the ground - Wind Direction: 330° .

12.2.3 Appendix B.3: Proposed - WIND SPEEDS - Balcony Level (1.5m)

In this appendix the wind speed results are presented at the balcony level, evaluated at a height of 1.5m above the surface. The corresponding horizontal slices at 1.5m height are presented in Figures 12.78 - 12.100 for the Proposed development.

Results of wind speeds and their circulation at balcony level of 1.5m above the surface are presented in order to assess wind conditions for balcony areas of Cherry Orchard Phase 3.

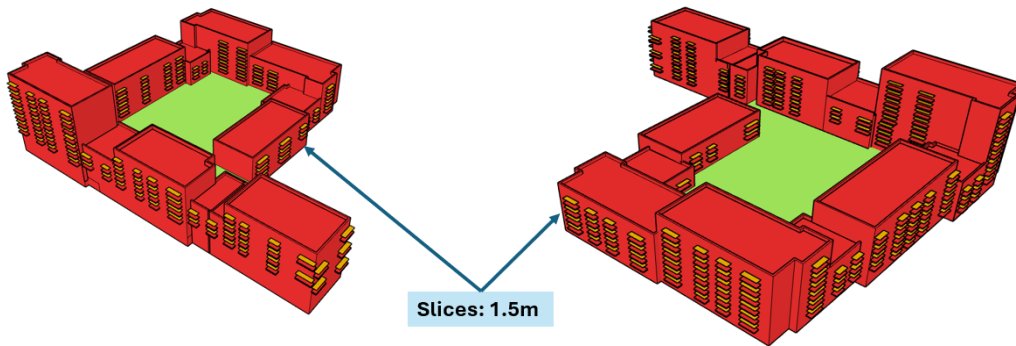
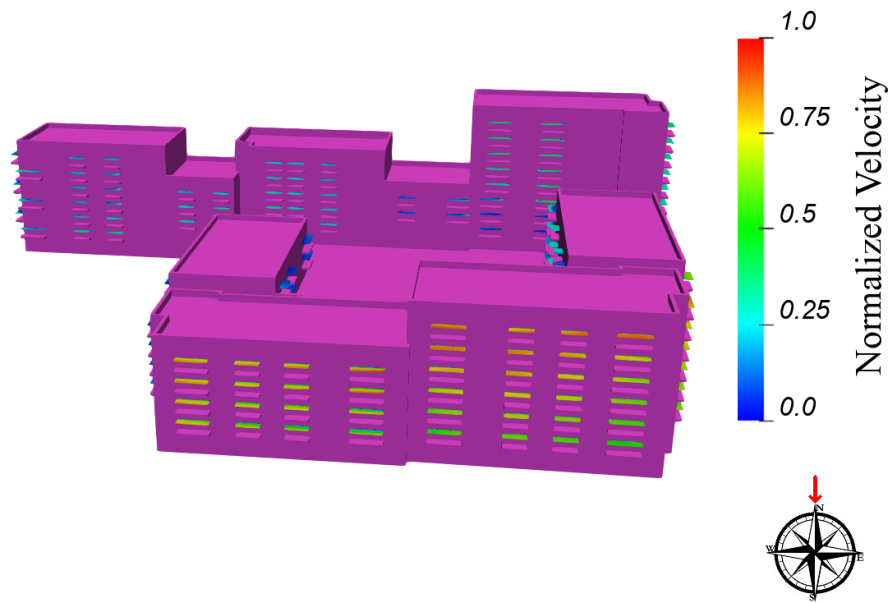
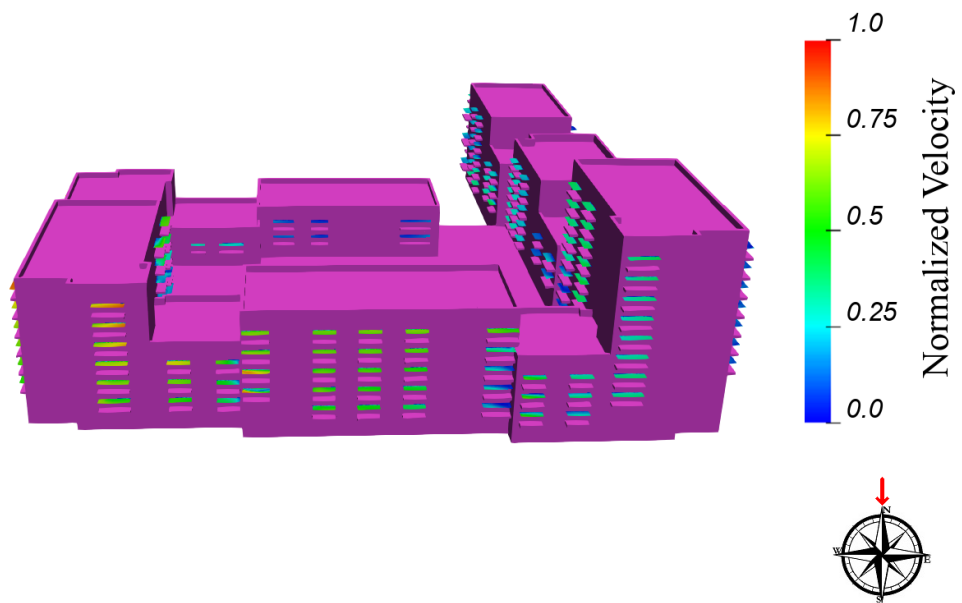


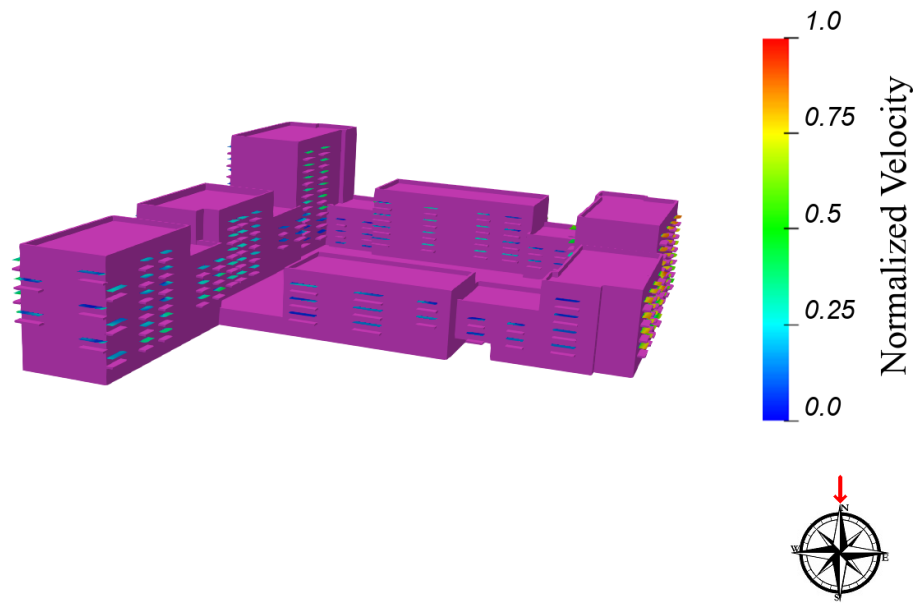
Figure 12.76: Horizontal Slices at 1.5m Above Balcony Level for Cherry Orchard Phase 3.



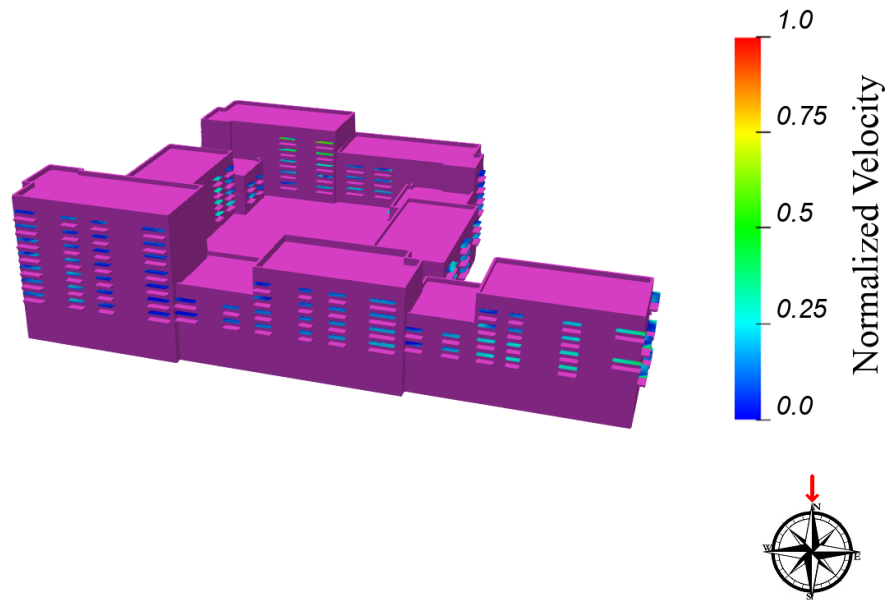
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

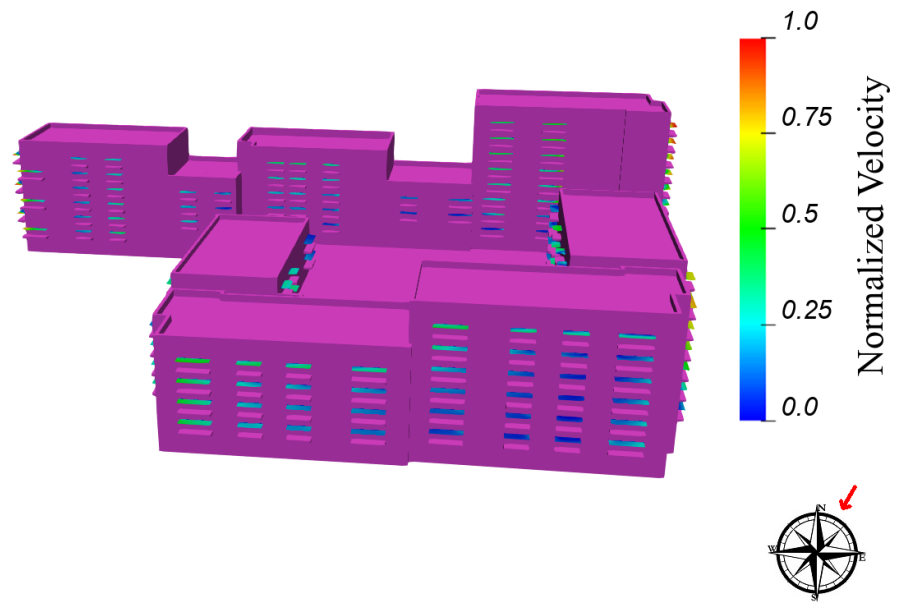


(c) 3D View - South East Elevation

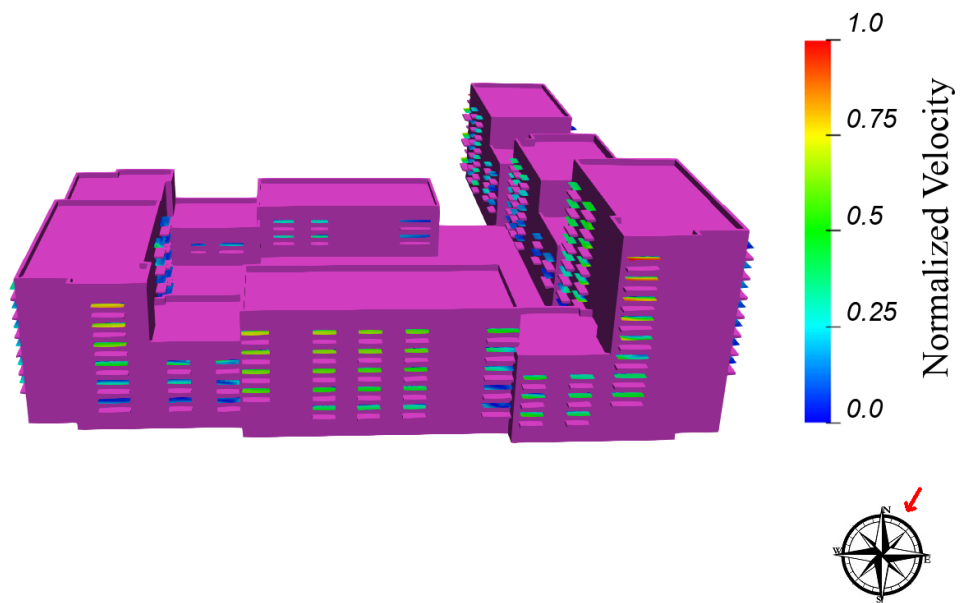


(d) 3D View - South West Elevation

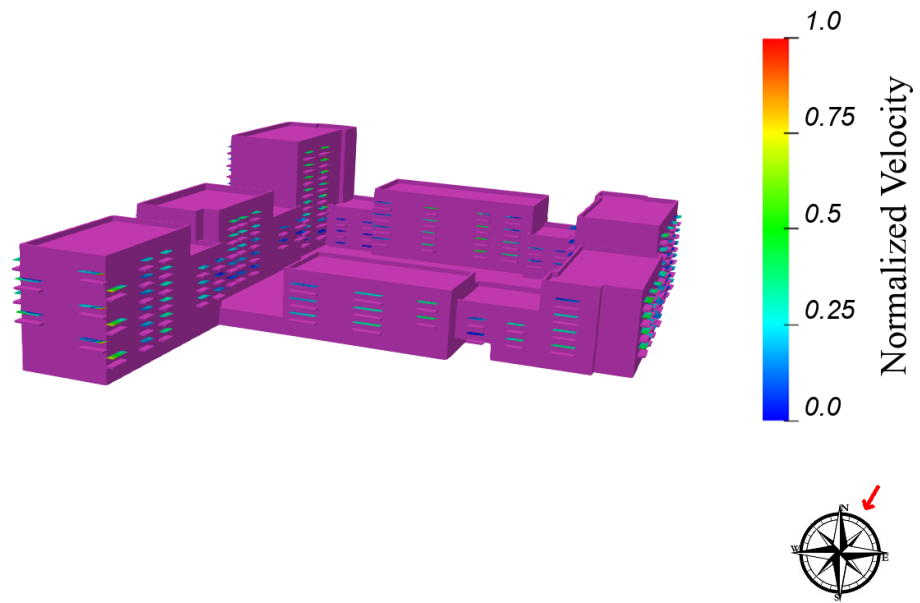
Figure 12.78: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 0°.



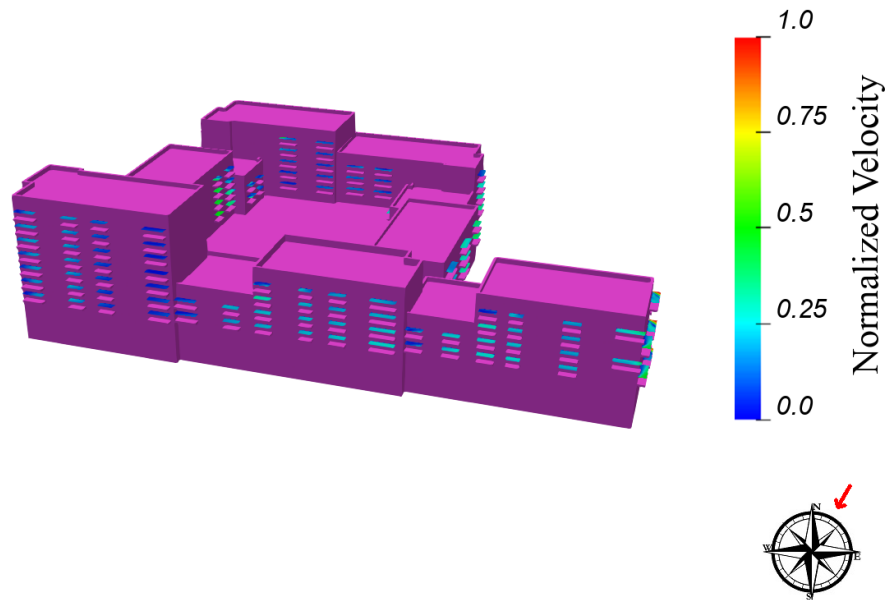
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

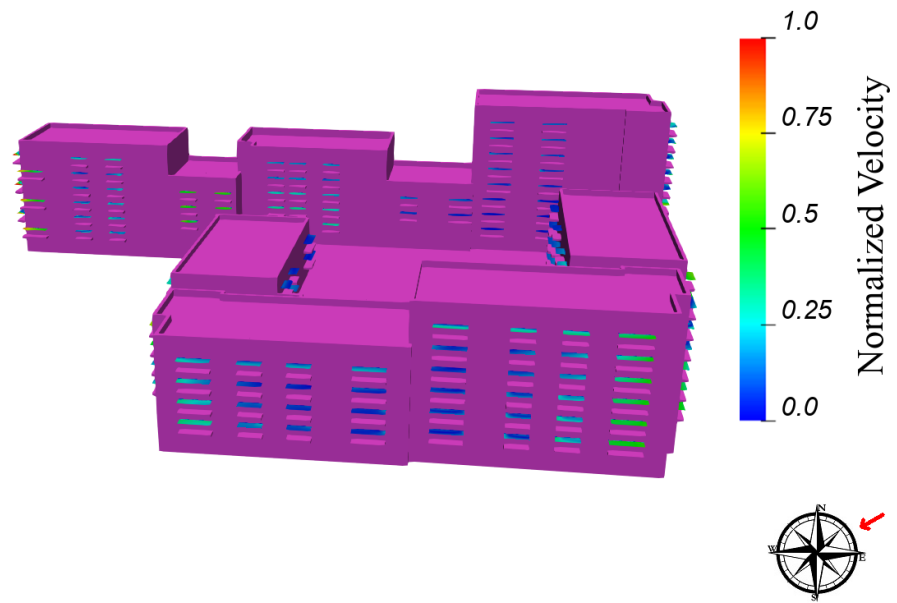


(c) 3D View - South East Elevation

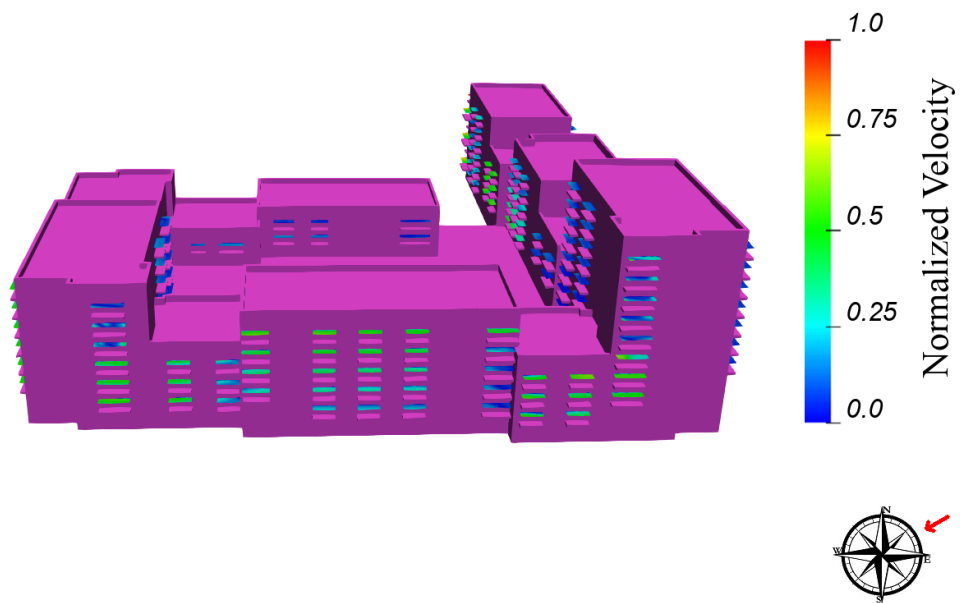


(d) 3D View - South West Elevation

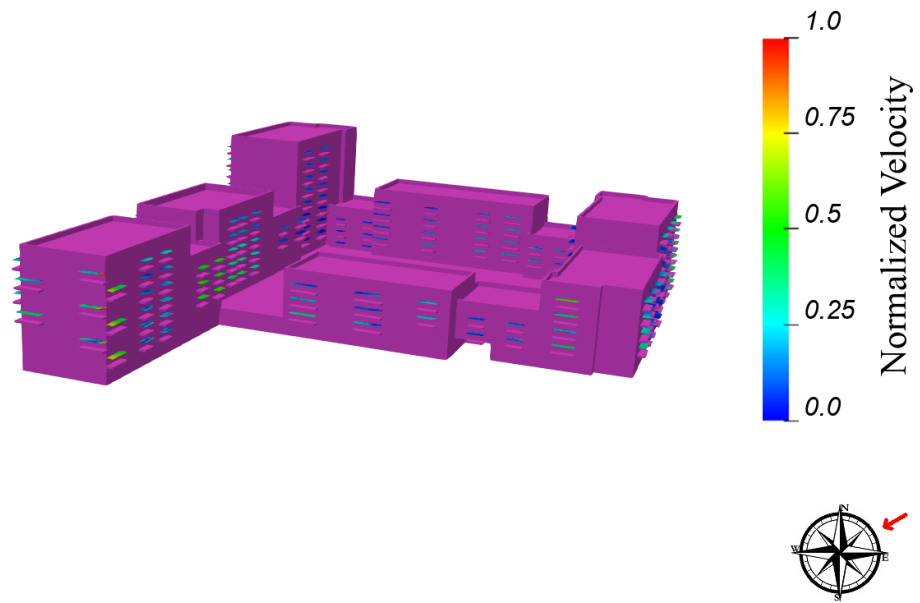
Figure 12.80: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 30°.



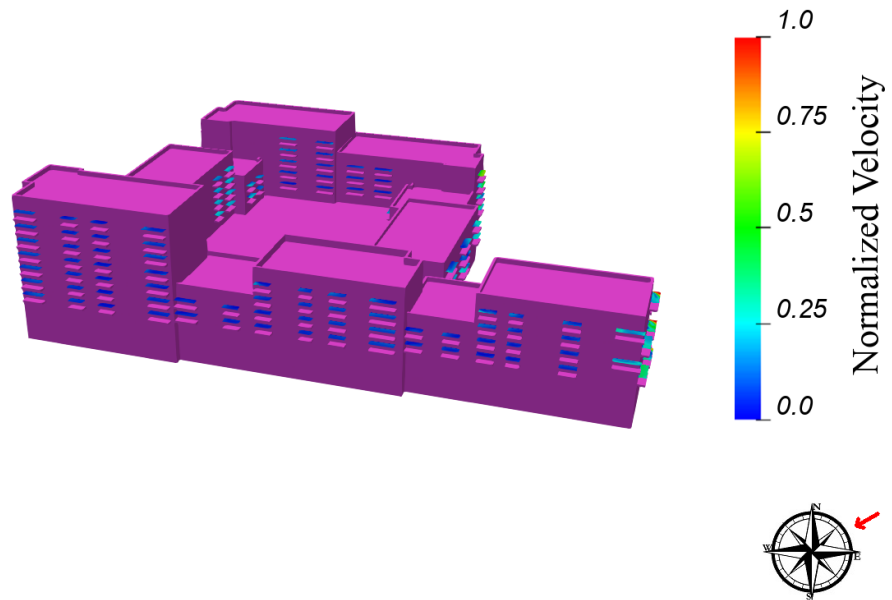
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

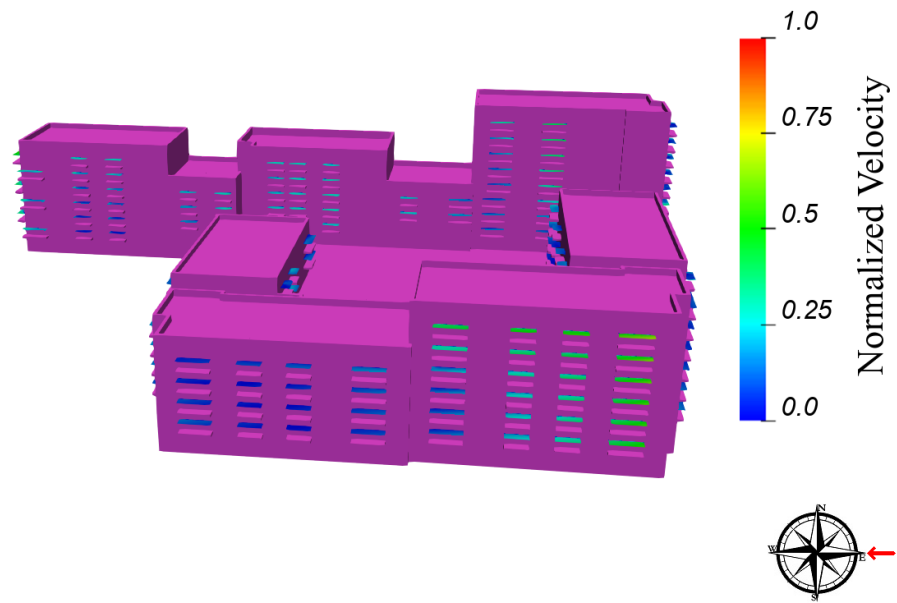


(c) 3D View - South East Elevation

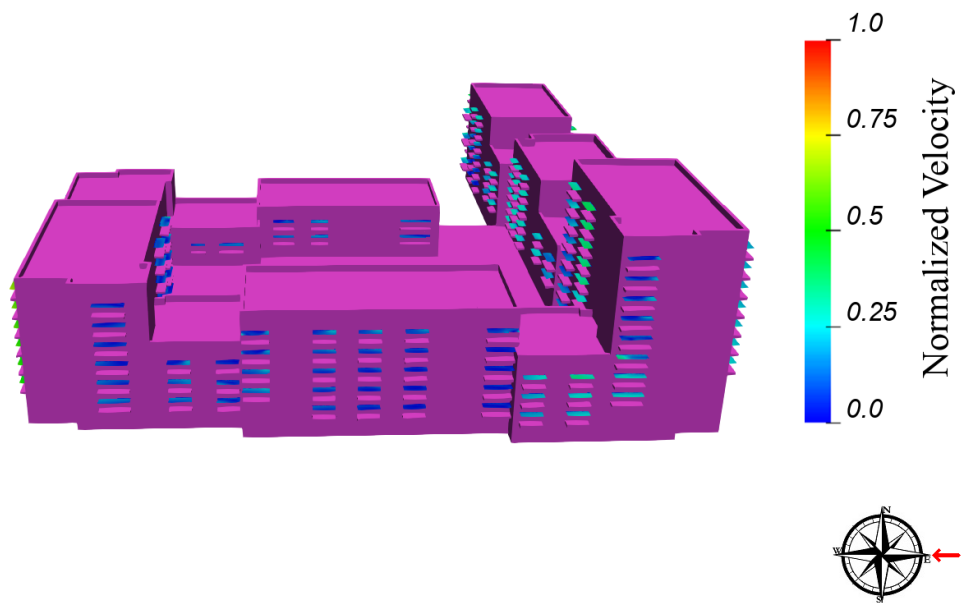


(d) 3D View - South West Elevation

Figure 12.82: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 60°.



(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

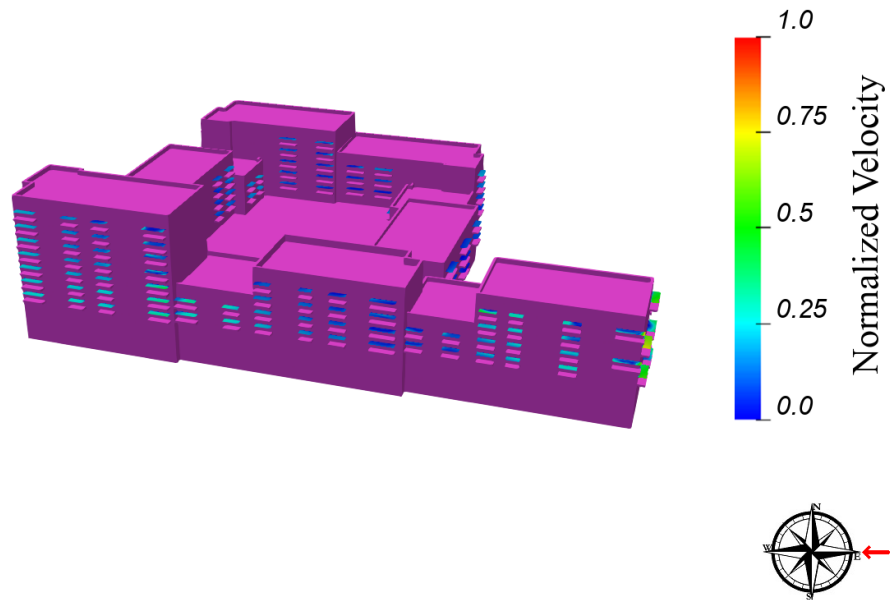
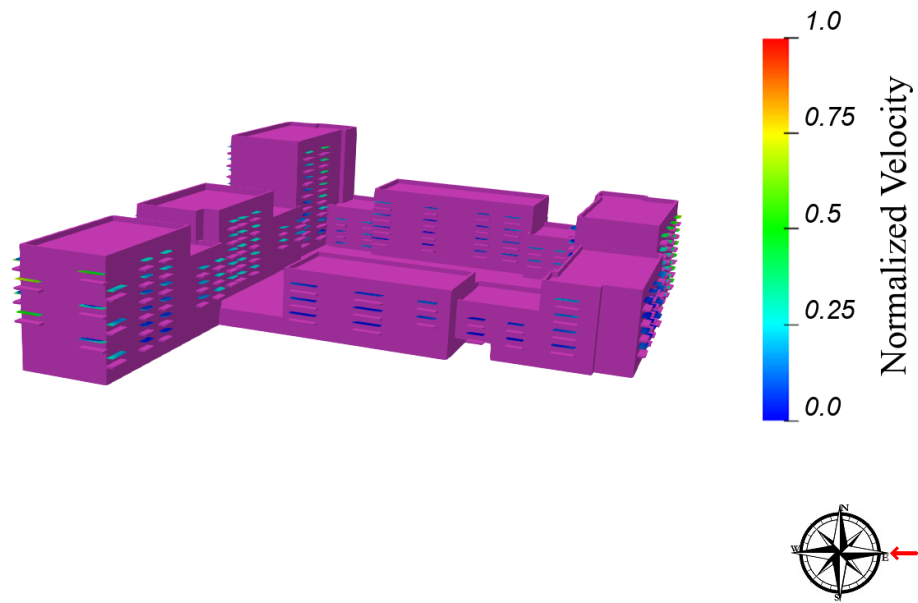
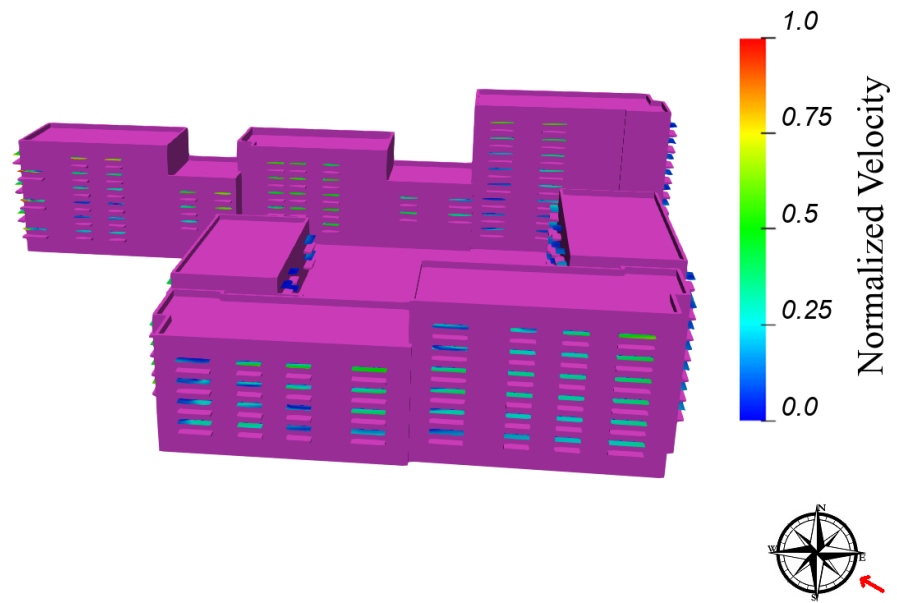
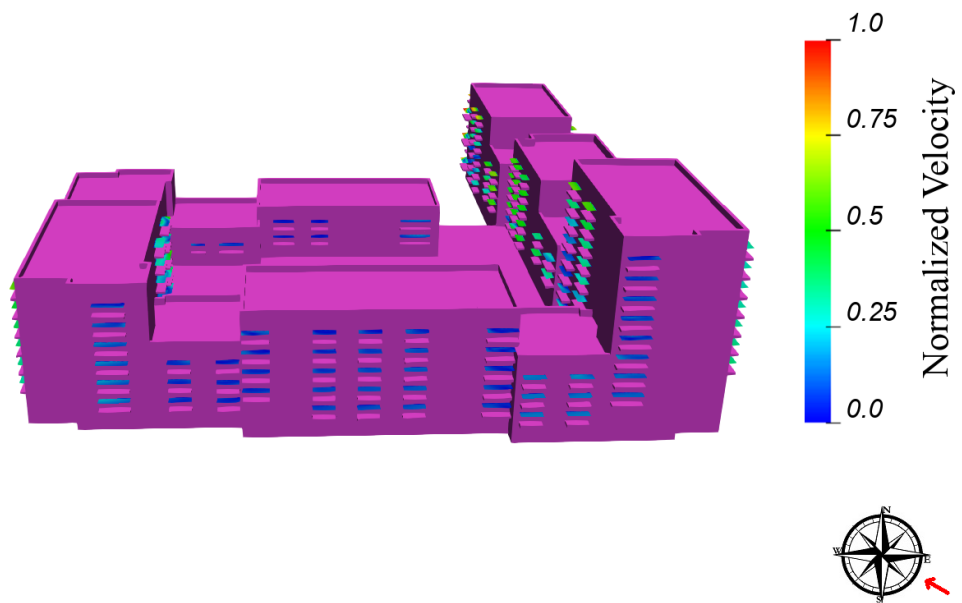


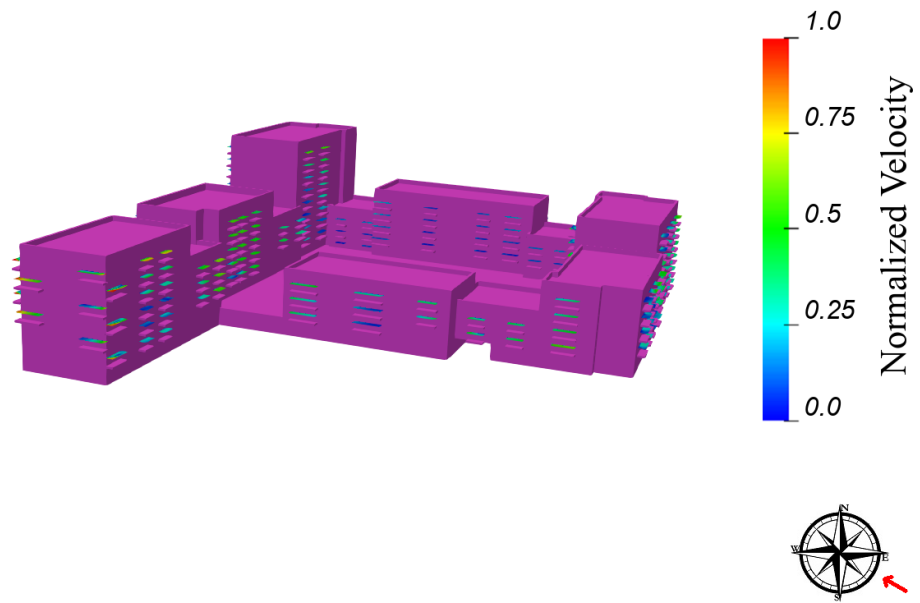
Figure 12.84: Flow Velocity Results at $1.5m$ above the Balcony - Wind Direction: 90° .



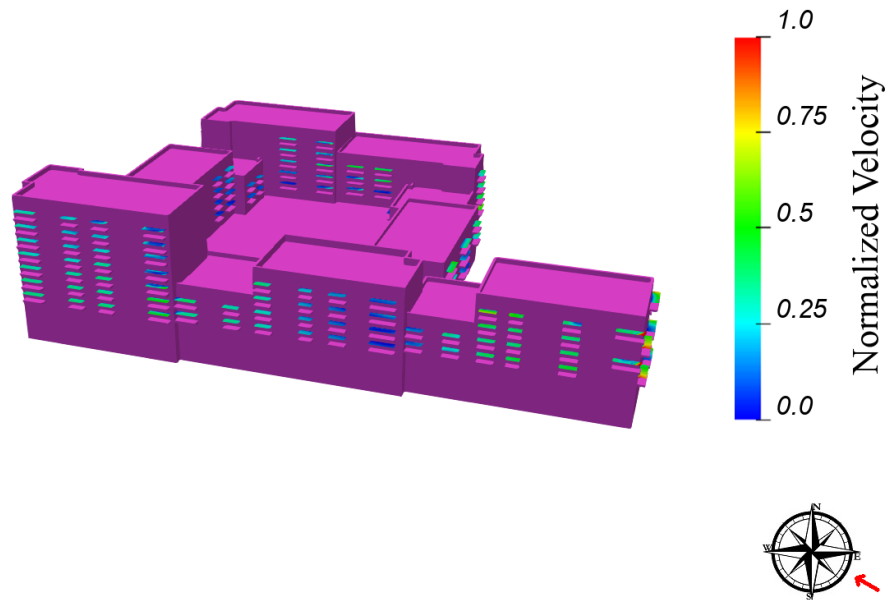
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

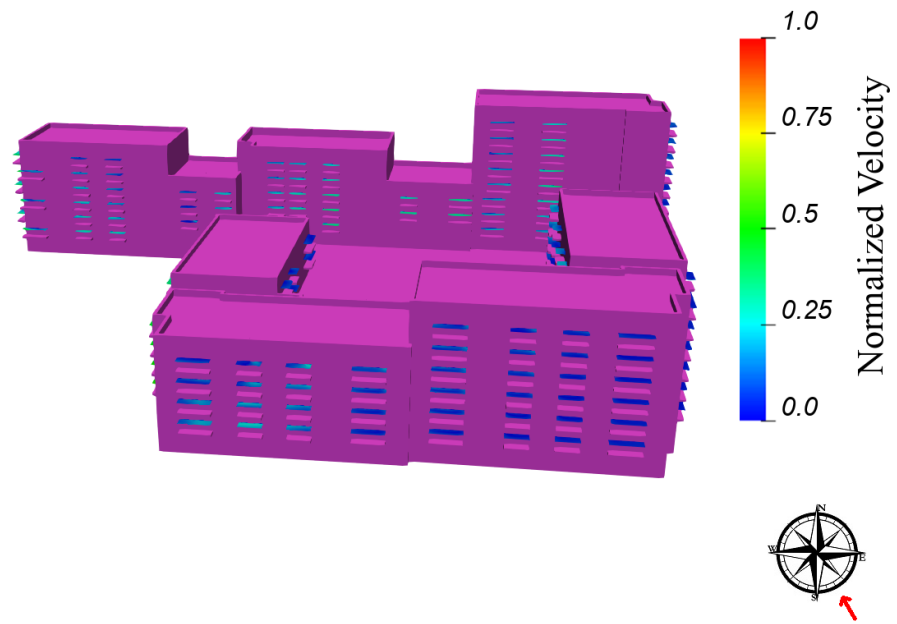


(c) 3D View - South East Elevation

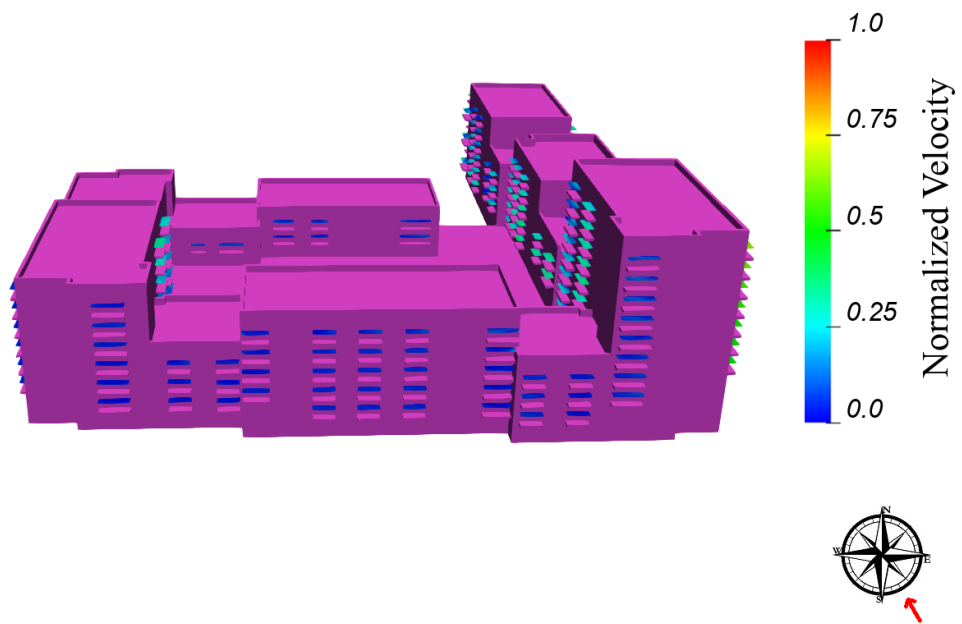


(d) 3D View - South West Elevation

Figure 12.86: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 120°.



(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

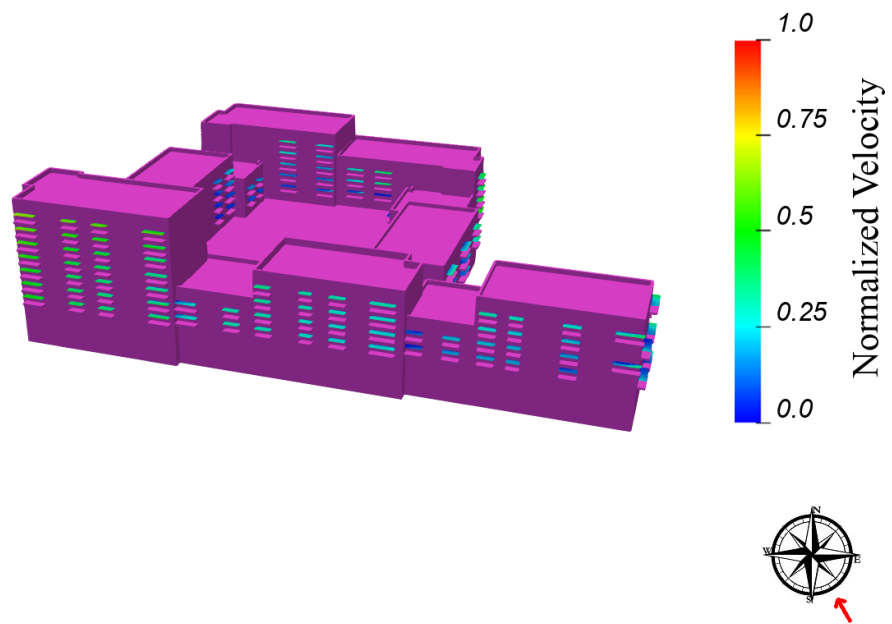
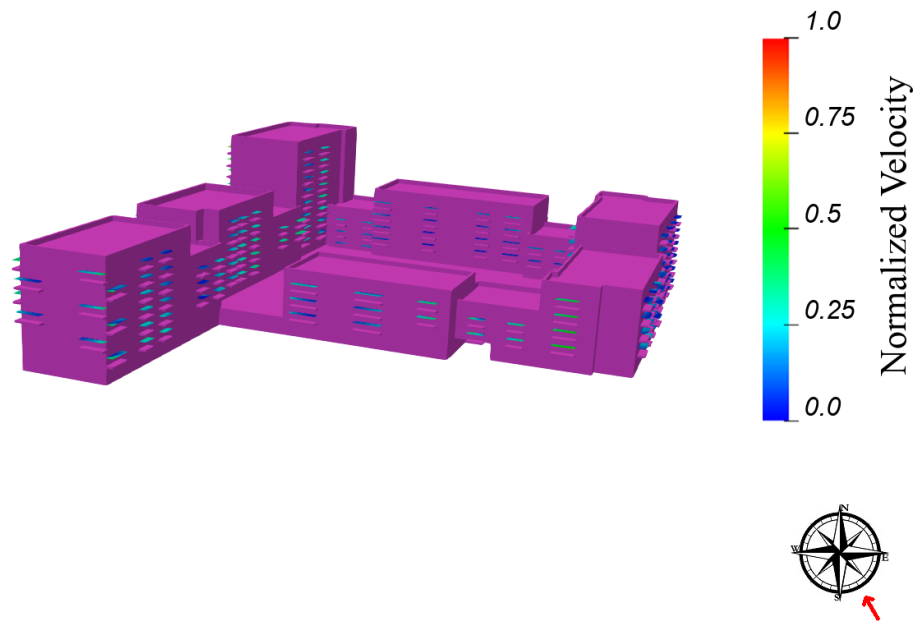
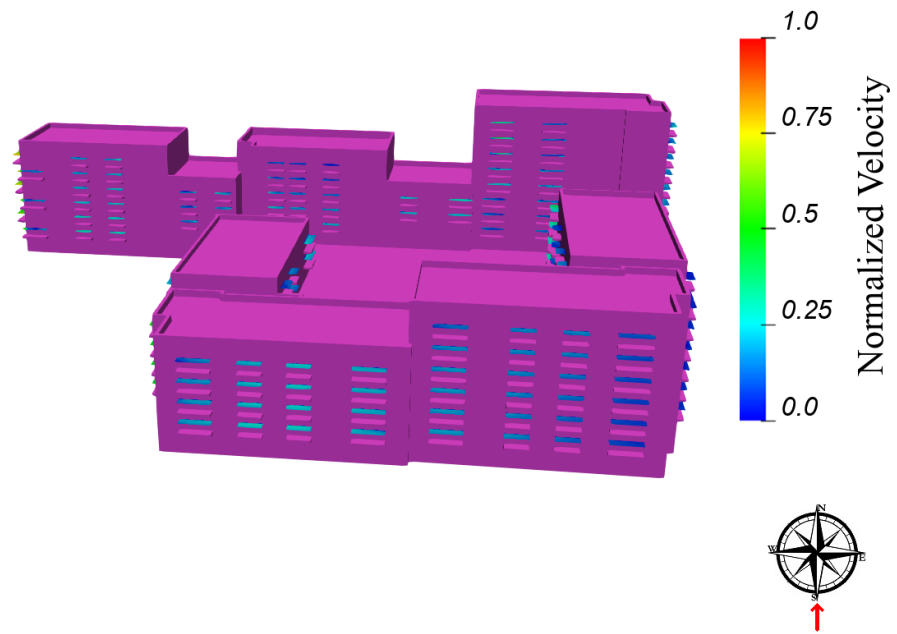
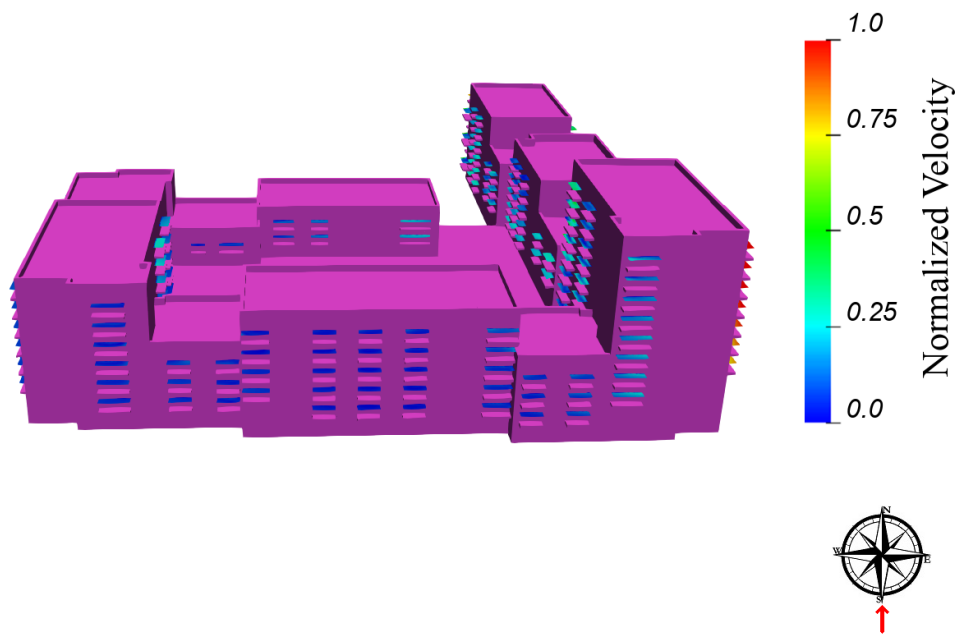


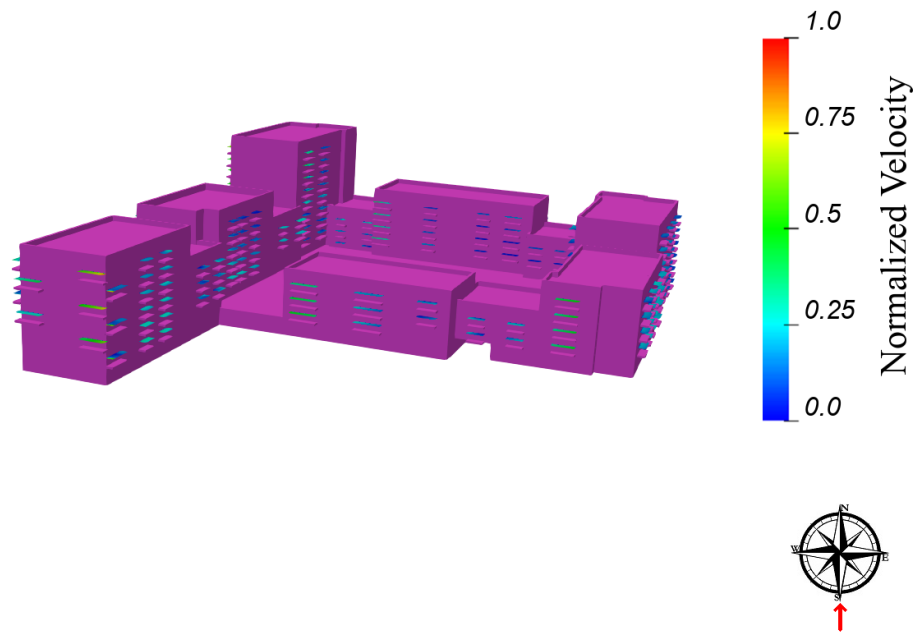
Figure 12.88: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 150°.



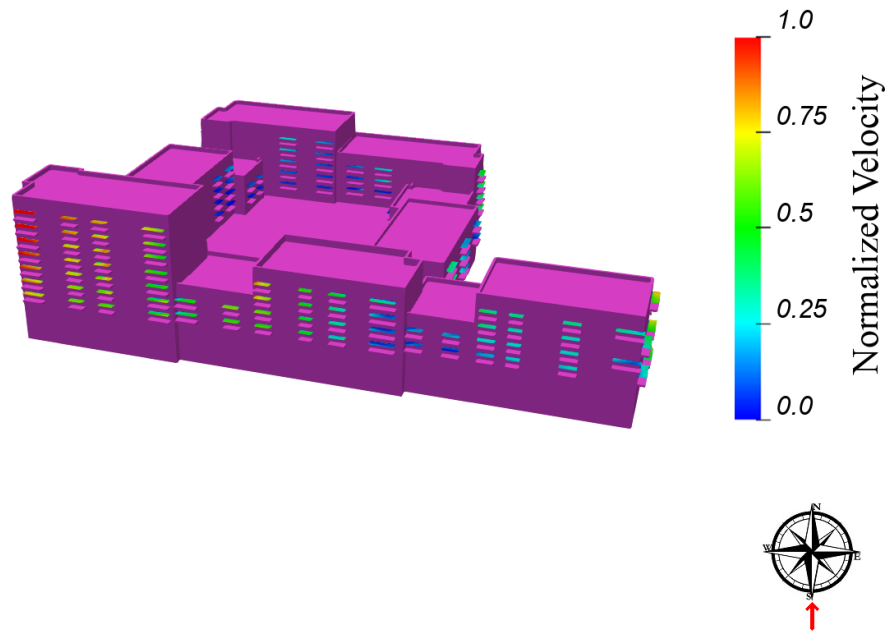
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

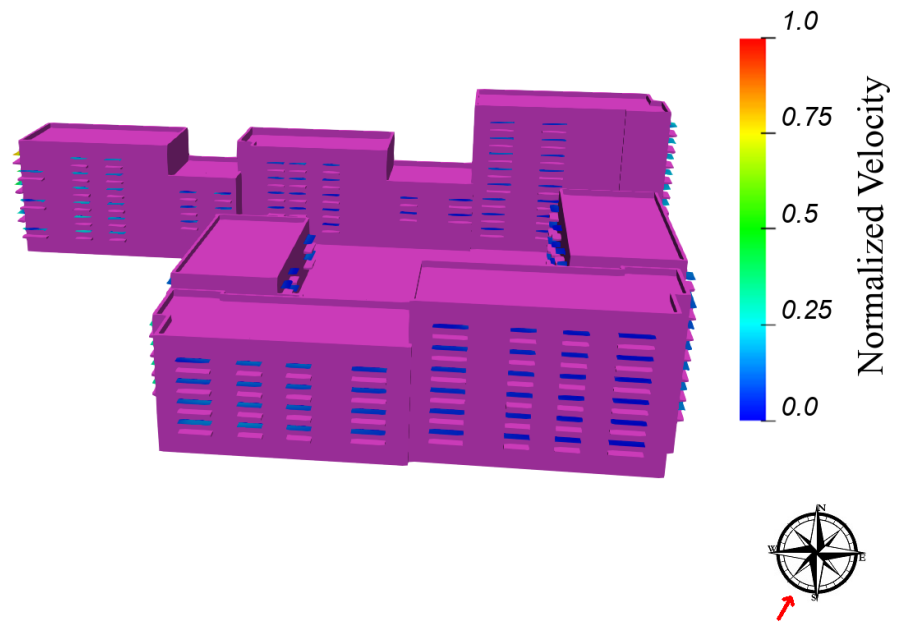


(c) 3D View - South East Elevation

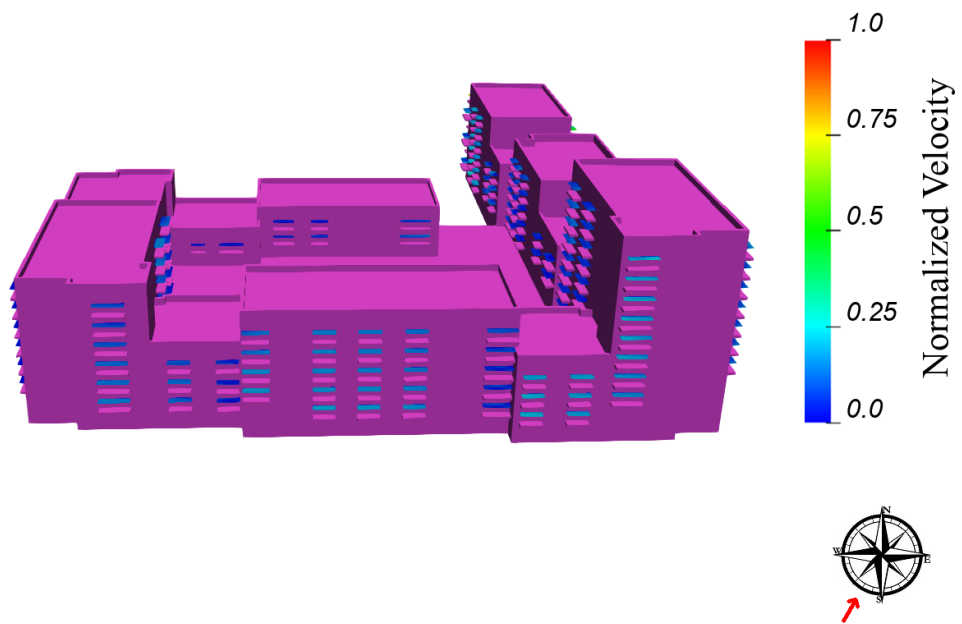


(d) 3D View - South West Elevation

Figure 12.90: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 180°.



(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

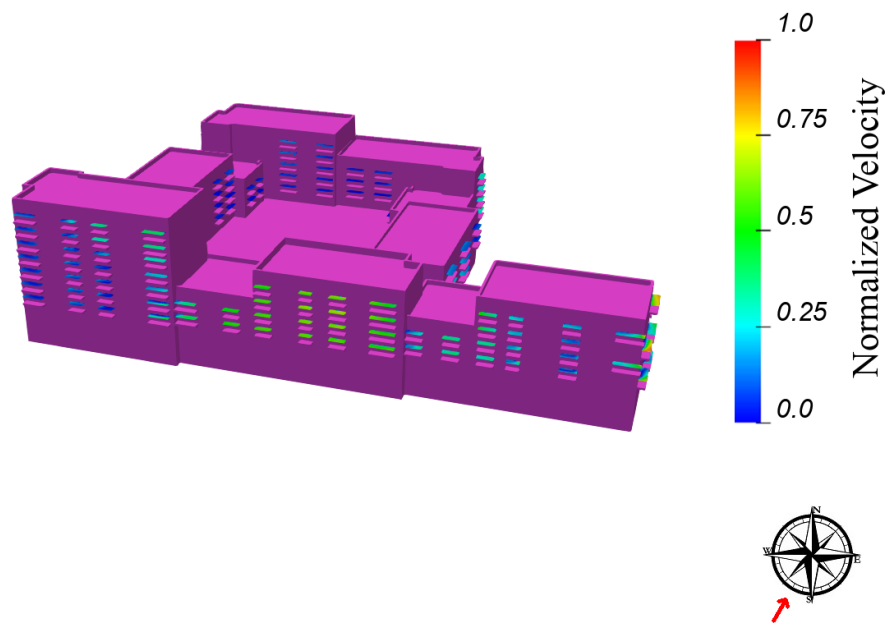
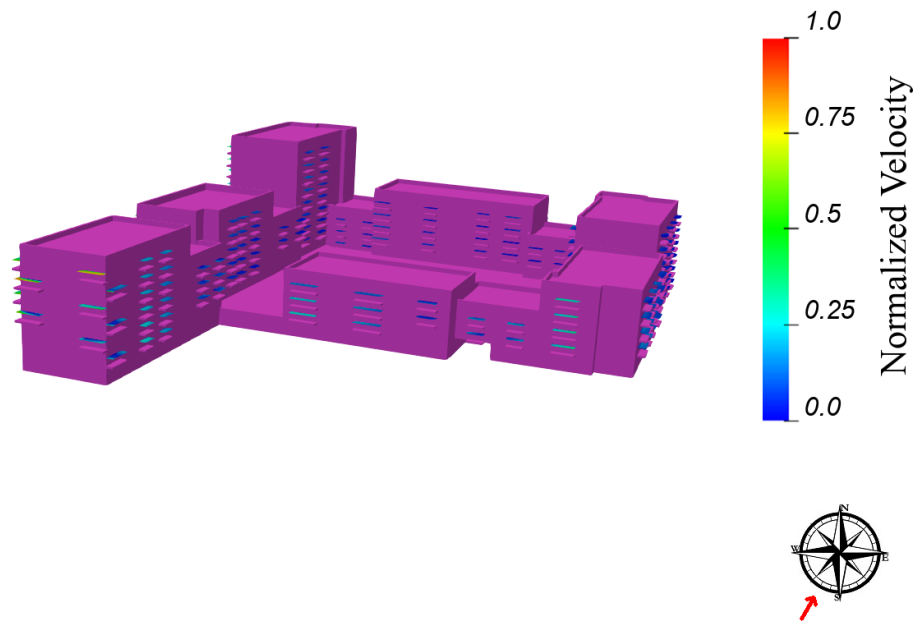
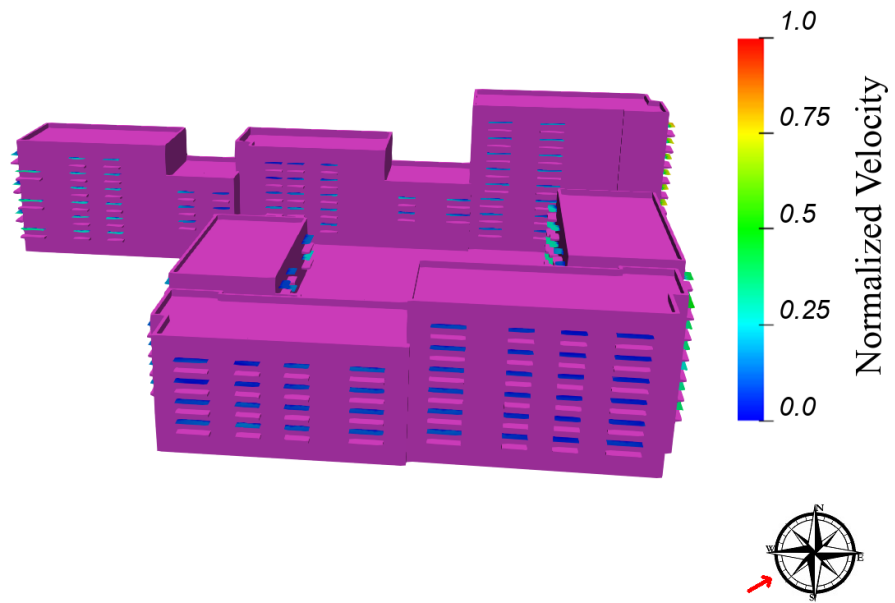
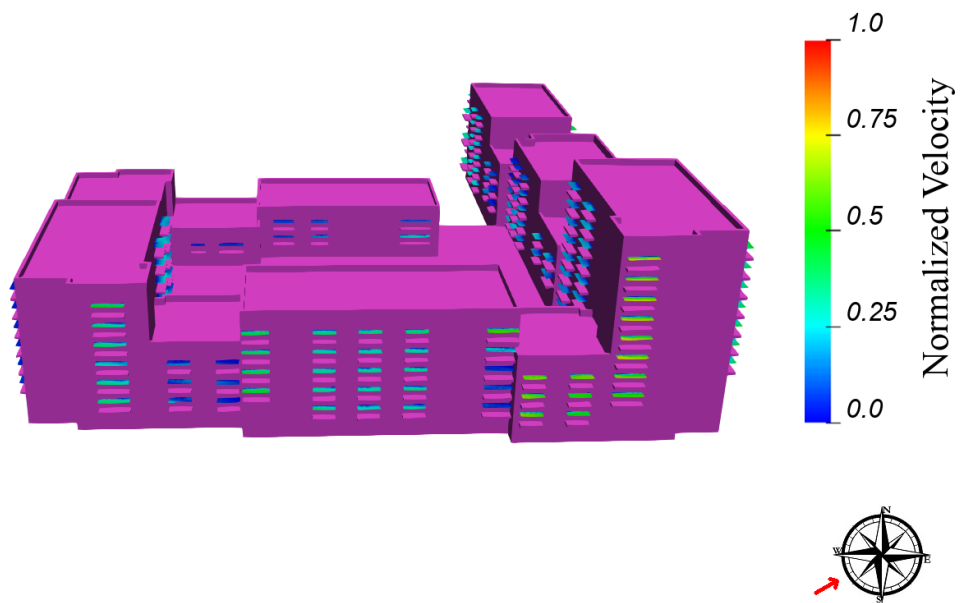


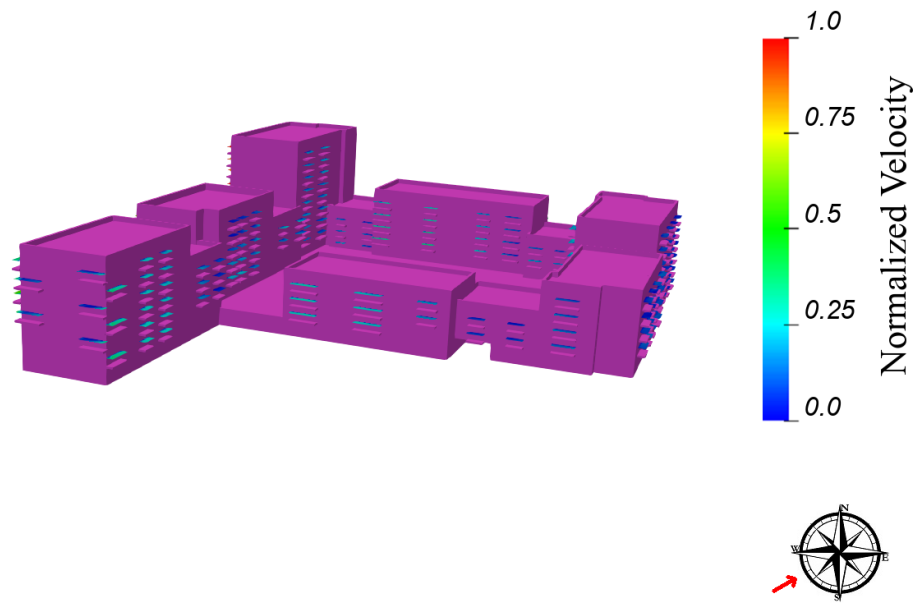
Figure 12.92: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 210°.



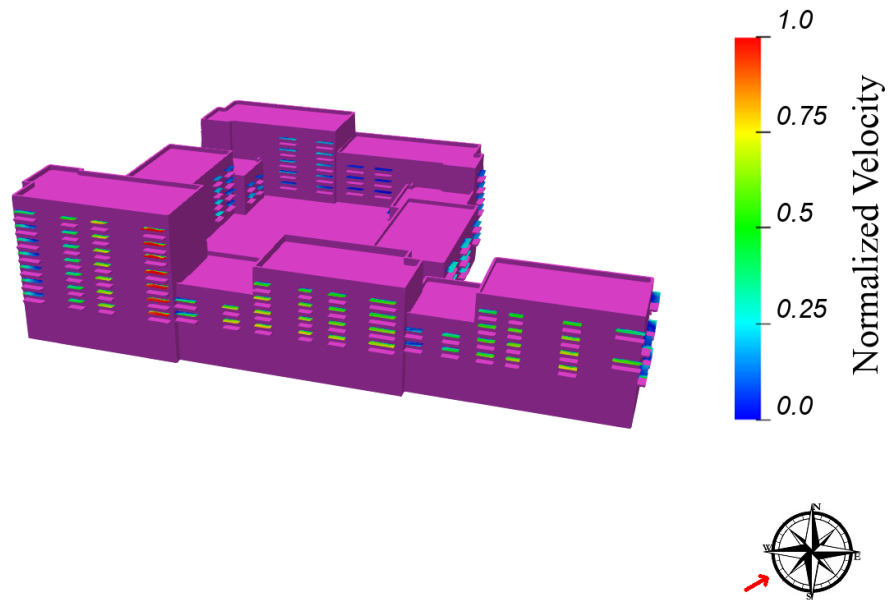
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

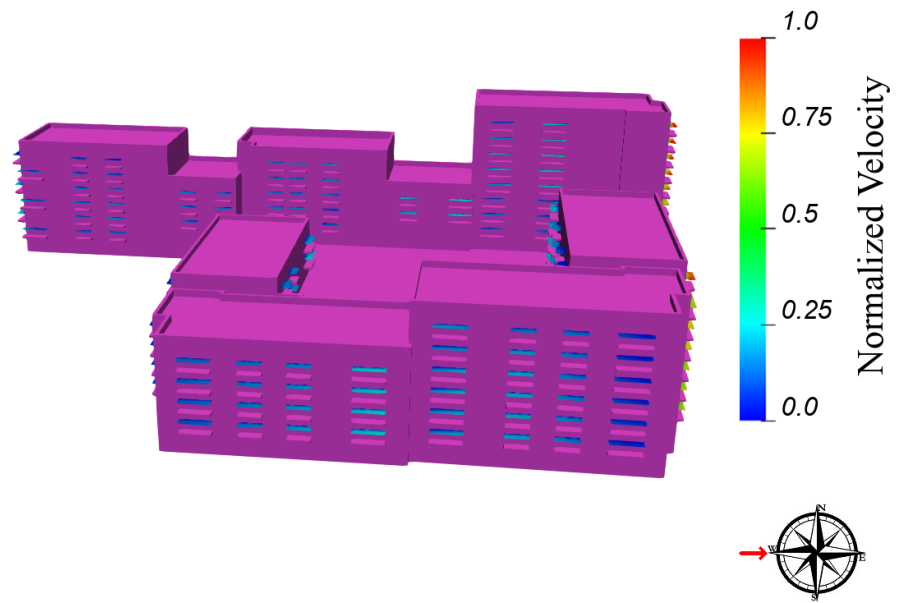


(c) 3D View - South East Elevation

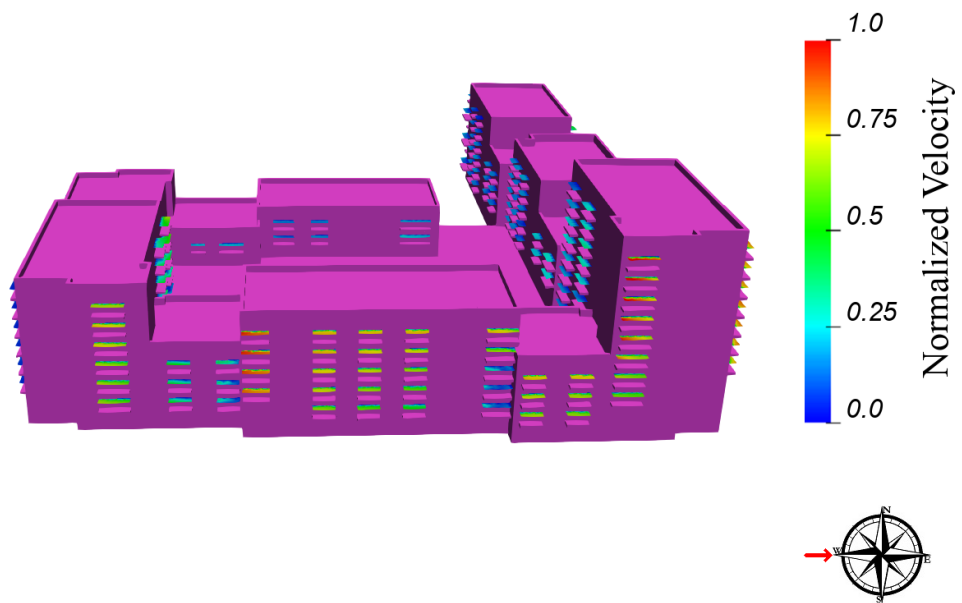


(d) 3D View - South West Elevation

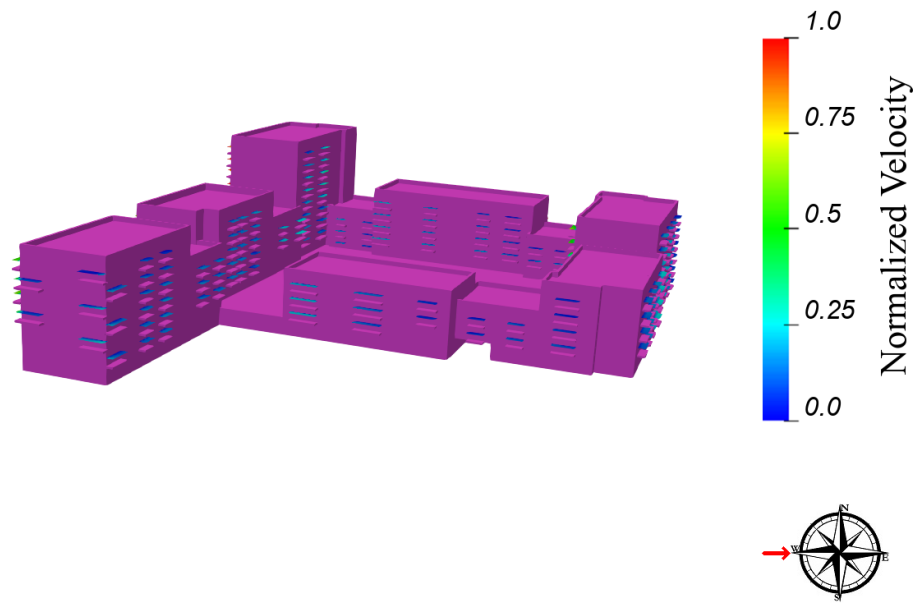
Figure 12.94: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 240°.



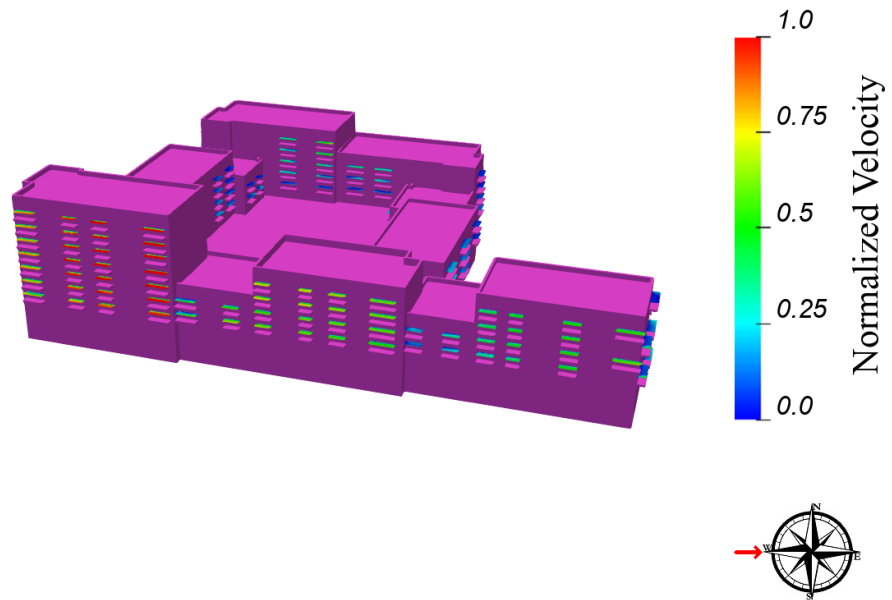
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

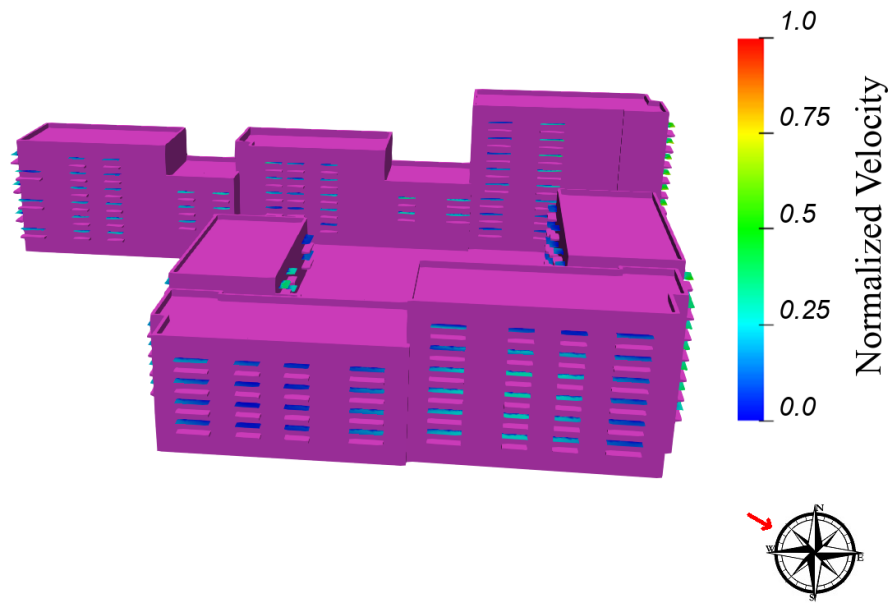


(c) 3D View - South East Elevation

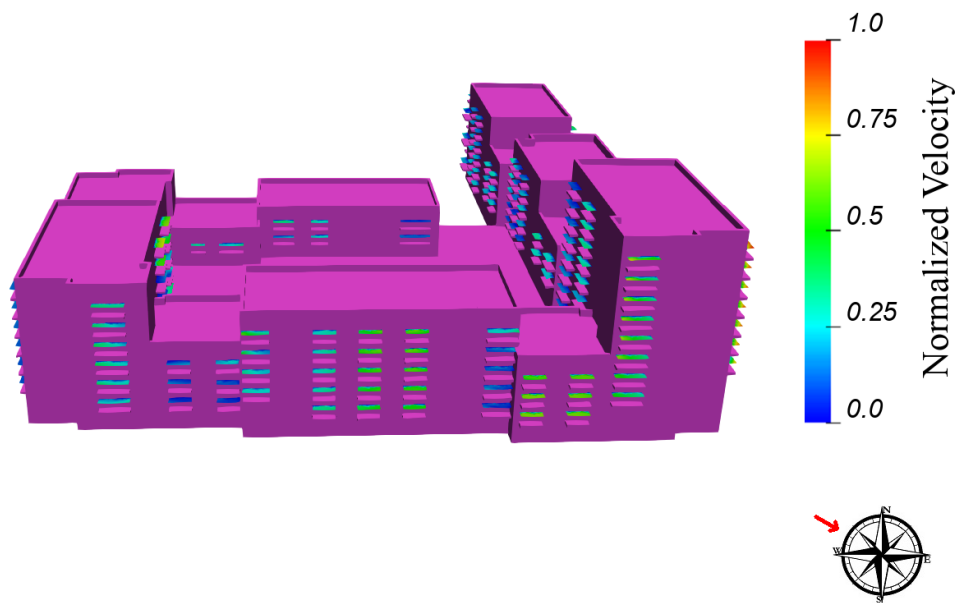


(d) 3D View - South West Elevation

Figure 12.96: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 270°.



(a) 3D View - North East Elevation



(b) 3D View - North West Elevation

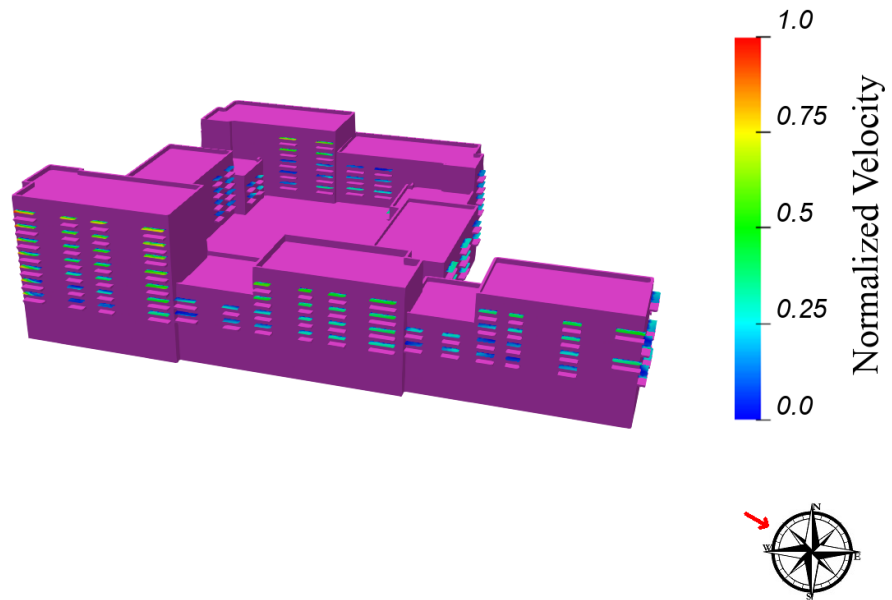
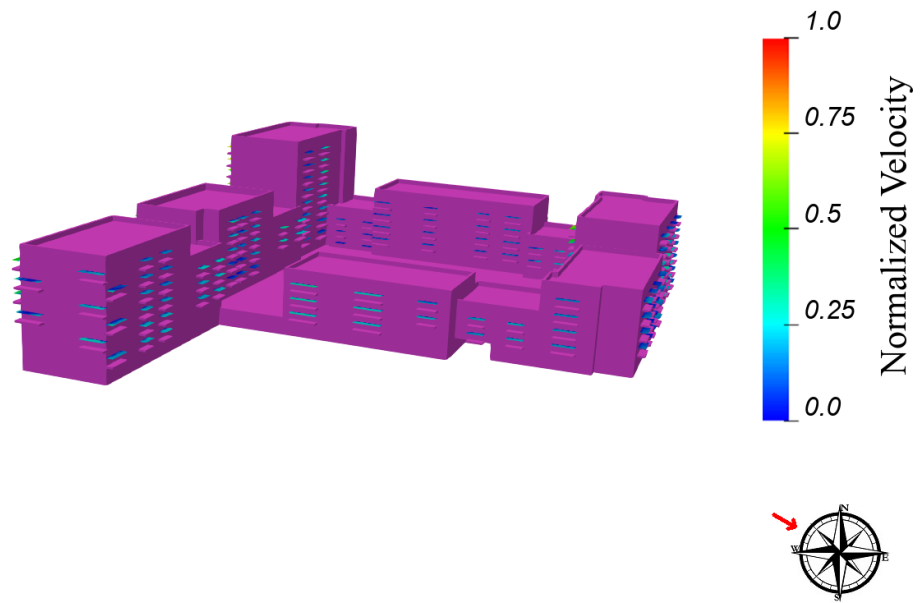
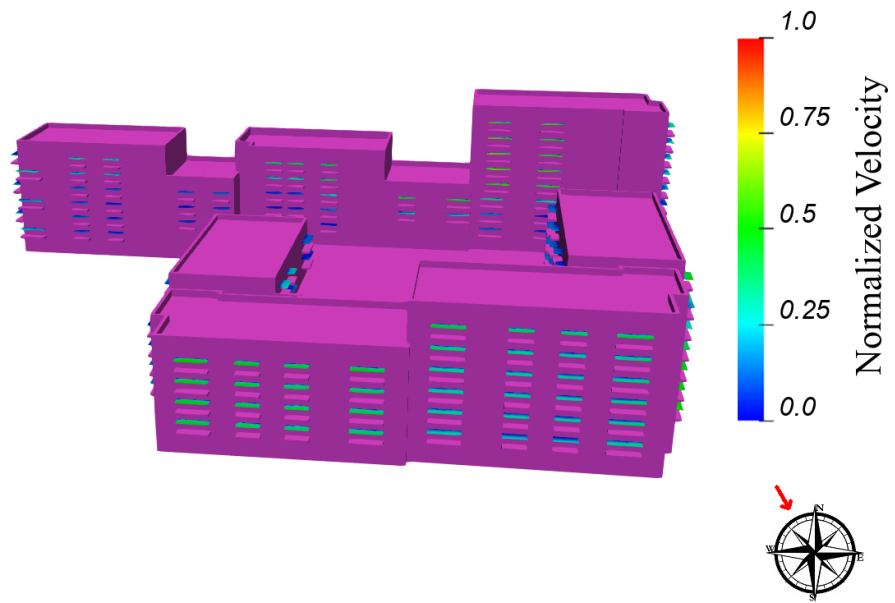
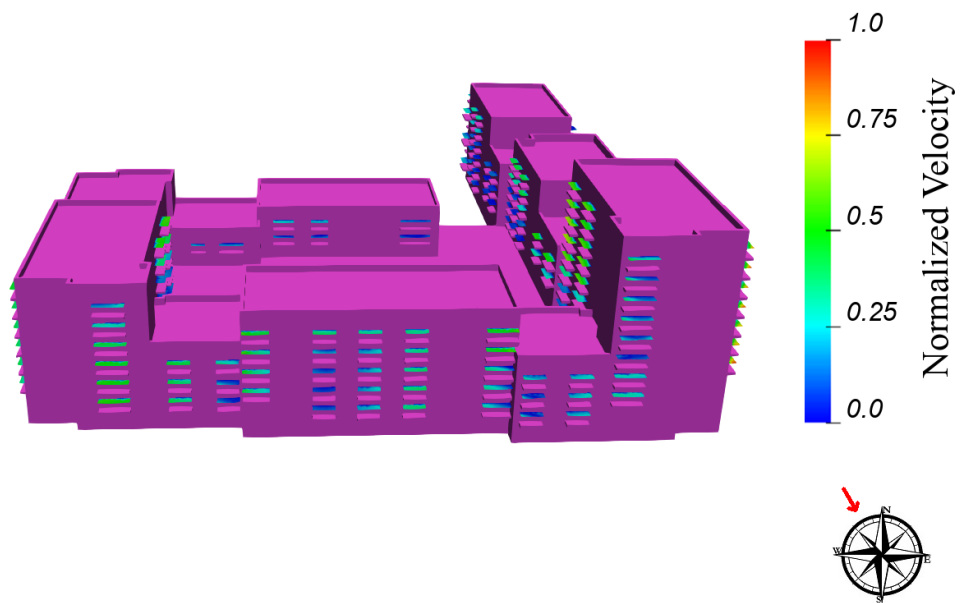


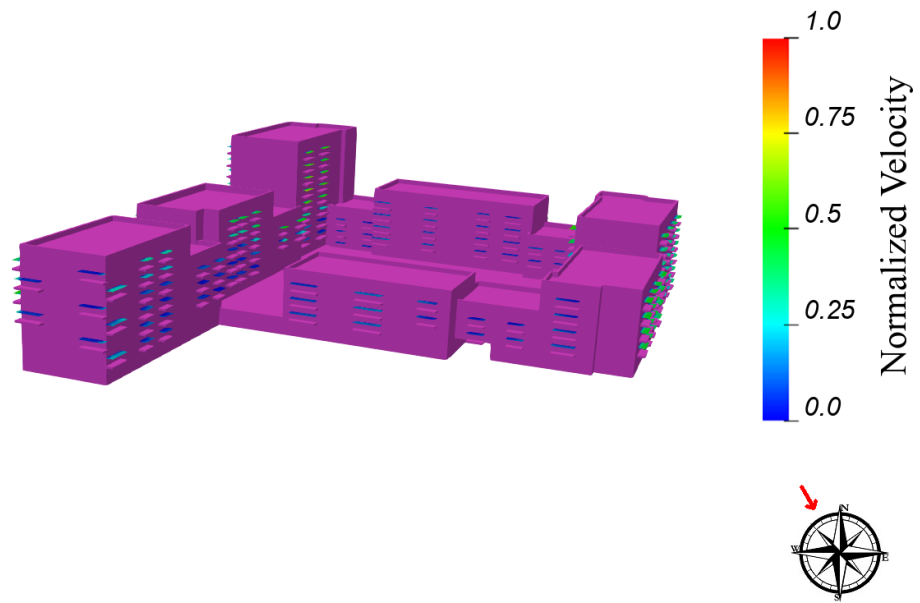
Figure 12.98: Flow Velocity Results at 1.5m above the Balcony - Wind Direction: 300°.



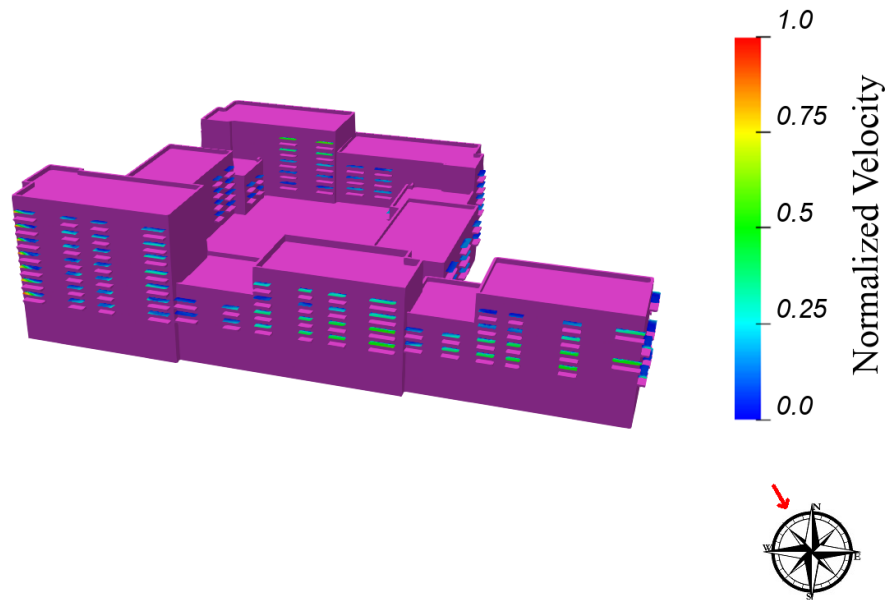
(a) 3D View - North East Elevation



(b) 3D View - North West Elevation



(c) 3D View - South East Elevation



(d) 3D View - South West Elevation

Figure 12.100: Flow Velocity Results at $1.5m$ above the Balcony - Wind Direction: 330° .

12.3 Appendix C: Cumulative Scenario

12.3.1 Appendix C.1: Cumulative - WIND SPEEDS - Pedestrian Level (1.8m)

In this appendix the wind speed results are presented at the ground level, evaluated at a height of 1.8m above the surface. The corresponding horizontal slice at 1.8m height is presented in Figure 12.101 for Cumulative Development.

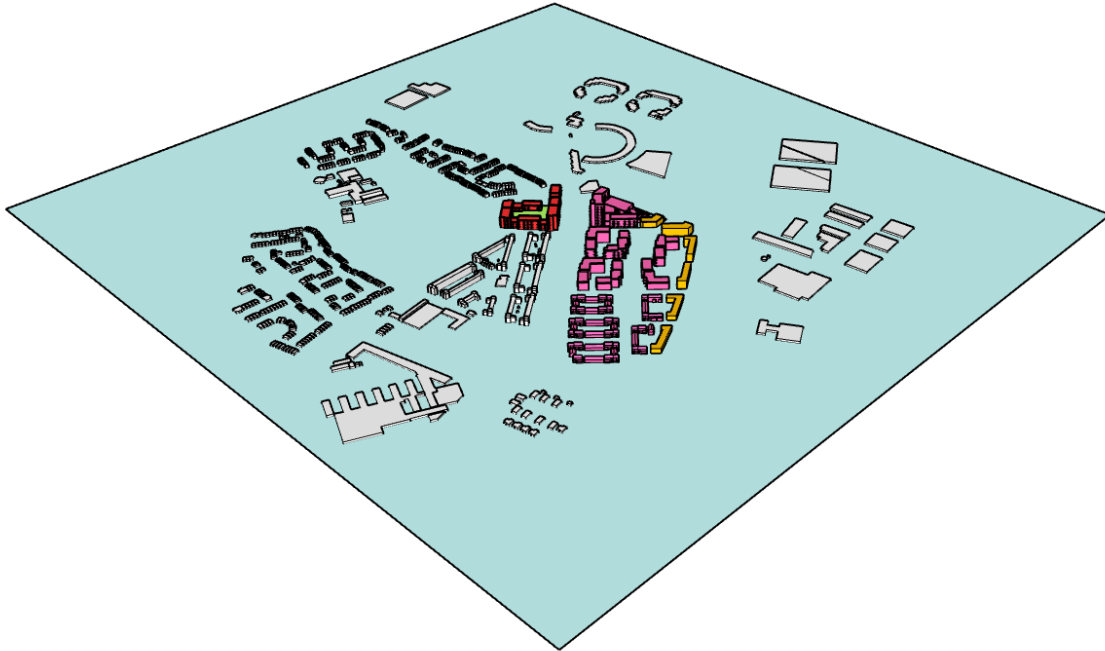


Figure 12.101: Horizontal Slices at 1.8m above Ground level for Cherry Orchard Phase 3 Development.

Results of wind speeds and their circulations at pedestrian level of $1.8m$ above the potential receptors are presented in Figures 12.102 to 12.125 in order to assess wind flows at the ground floor level of Cherry Orchard Phase 3 Development.

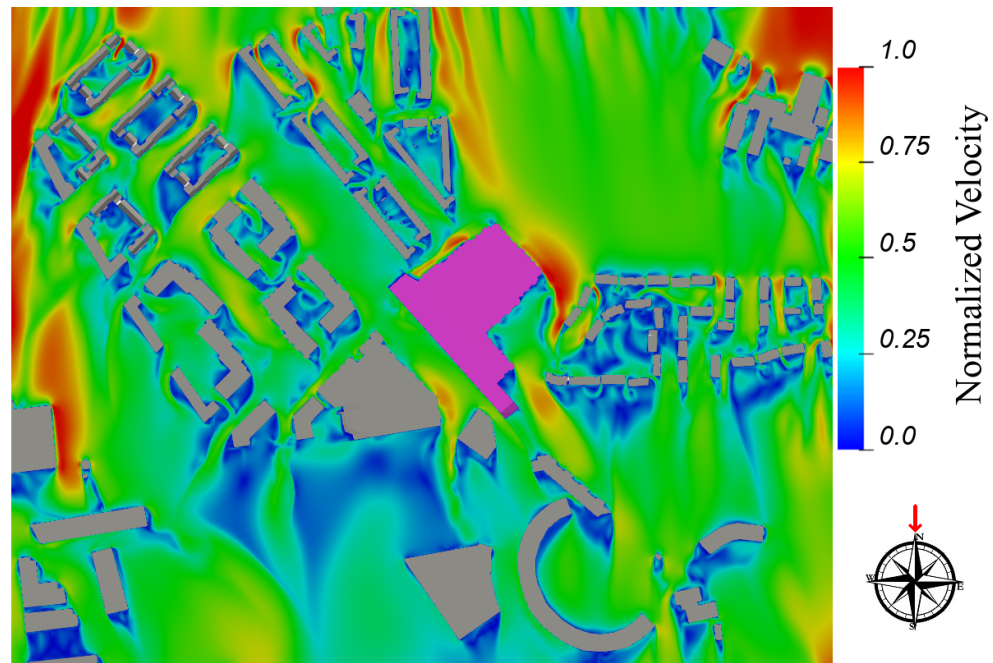


Figure 12.102: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 0° .

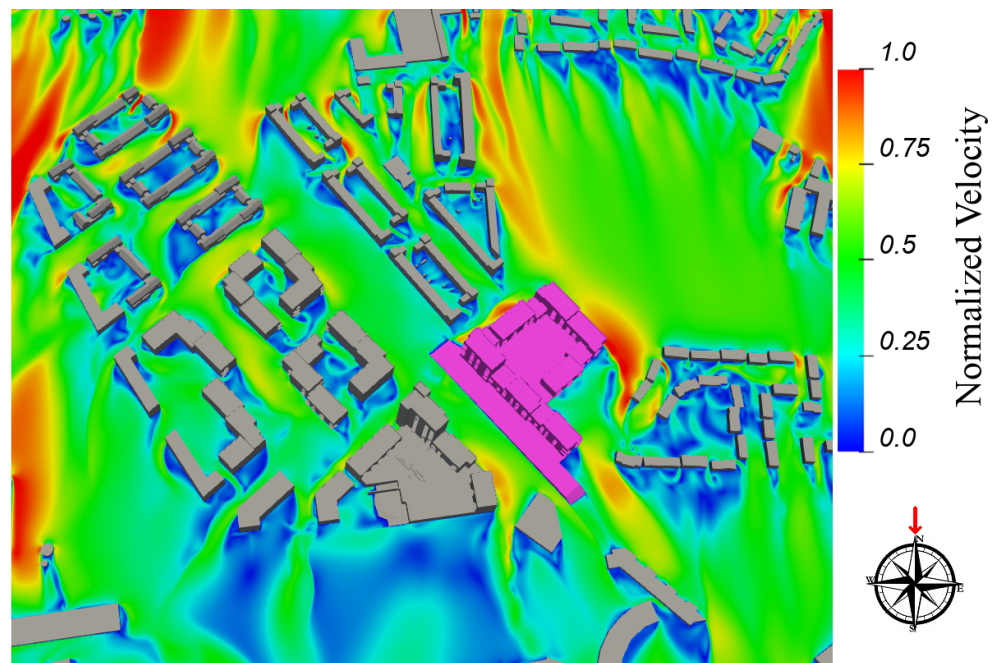


Figure 12.103: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 0° .

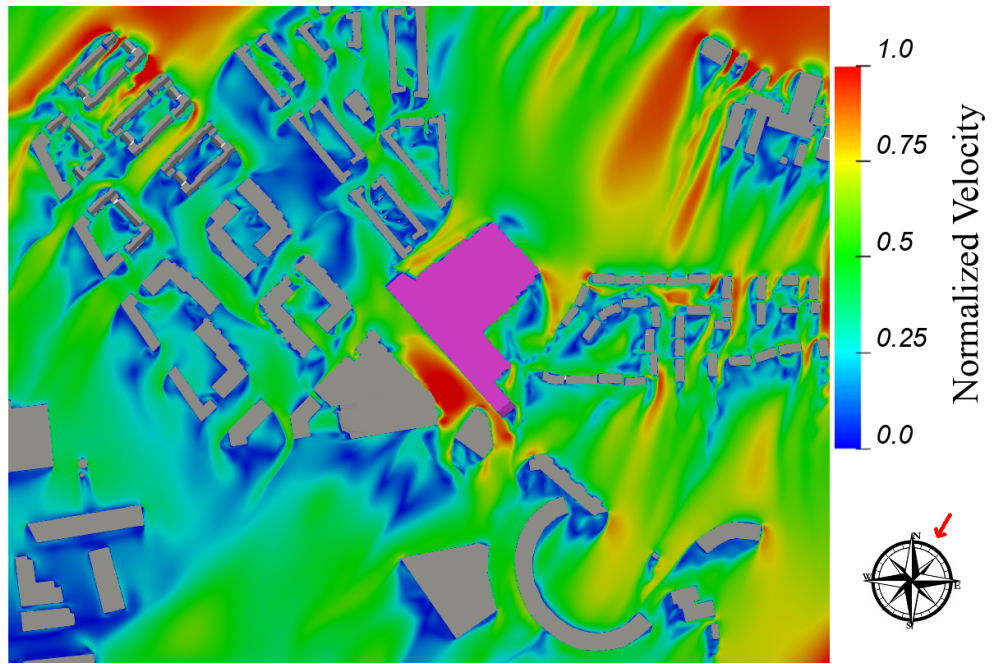


Figure 12.104: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 30° .

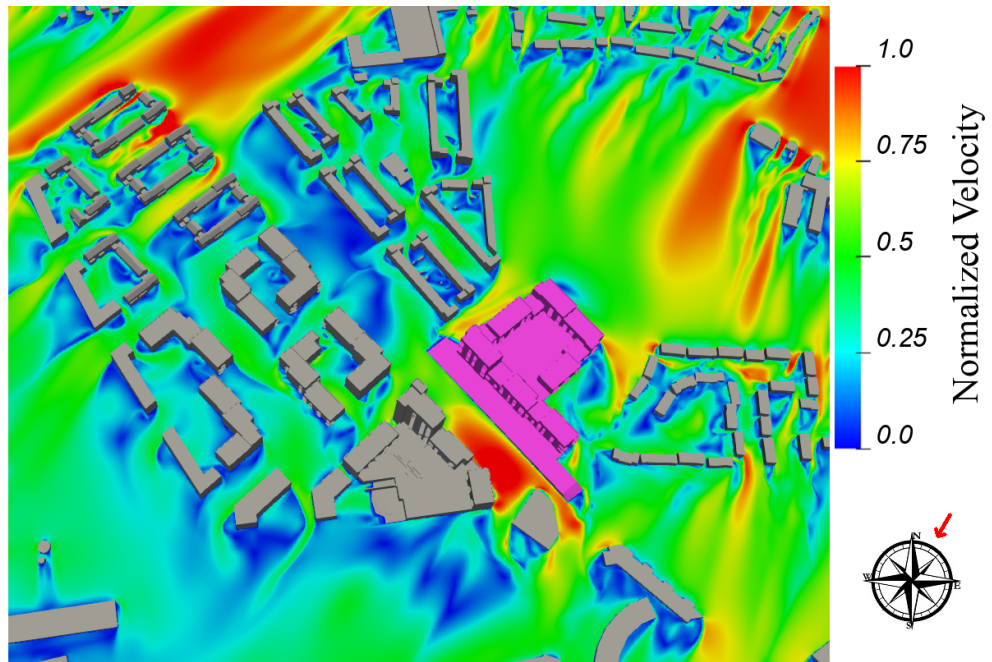


Figure 12.105: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 30° .

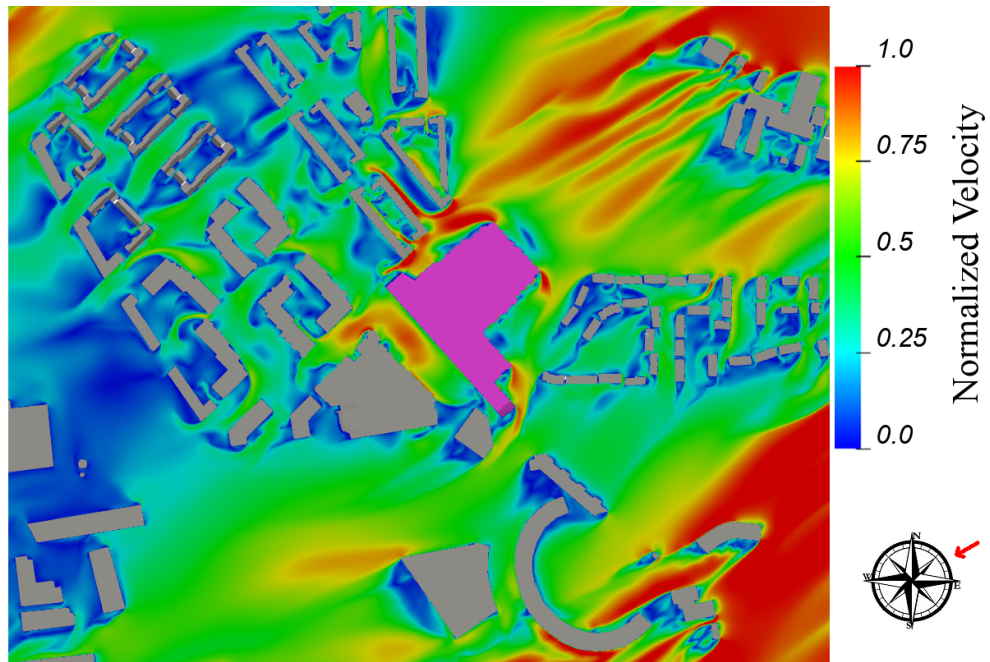


Figure 12.106: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 60° .

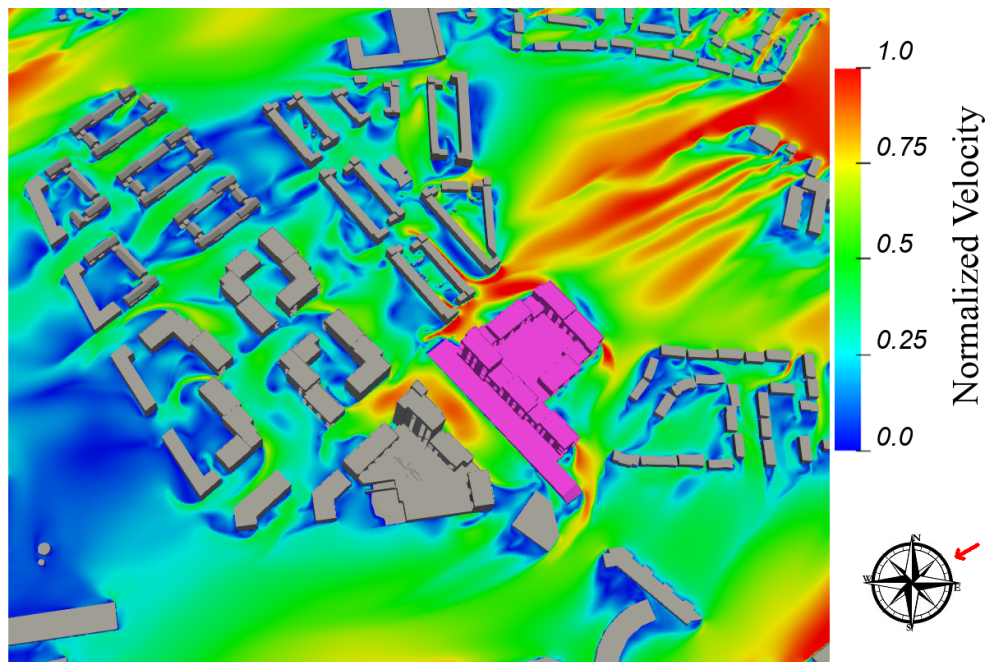


Figure 12.107: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 60° .

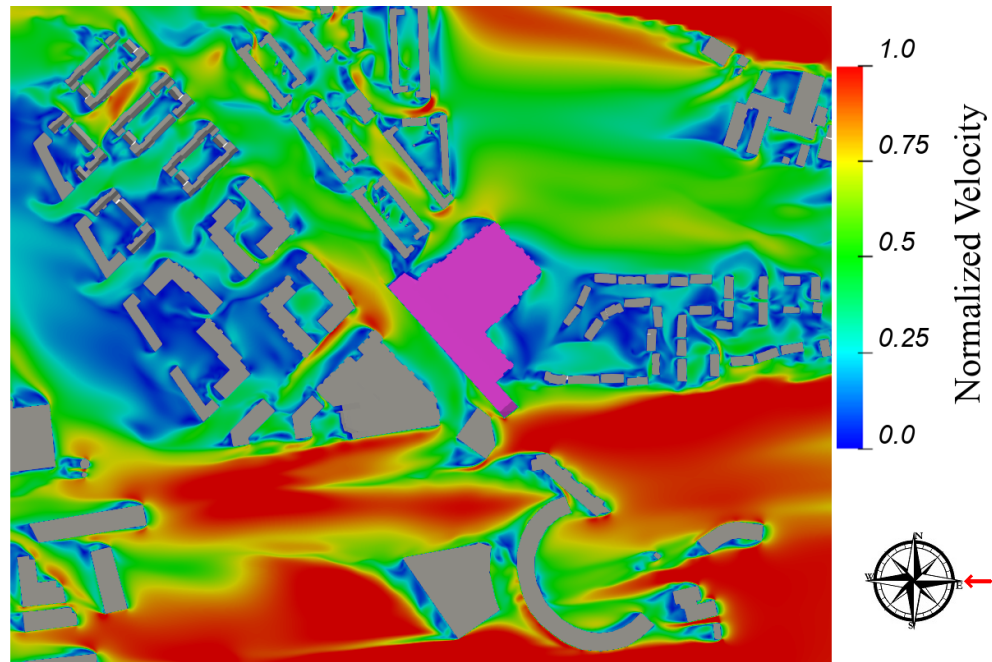


Figure 12.108: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 90° .

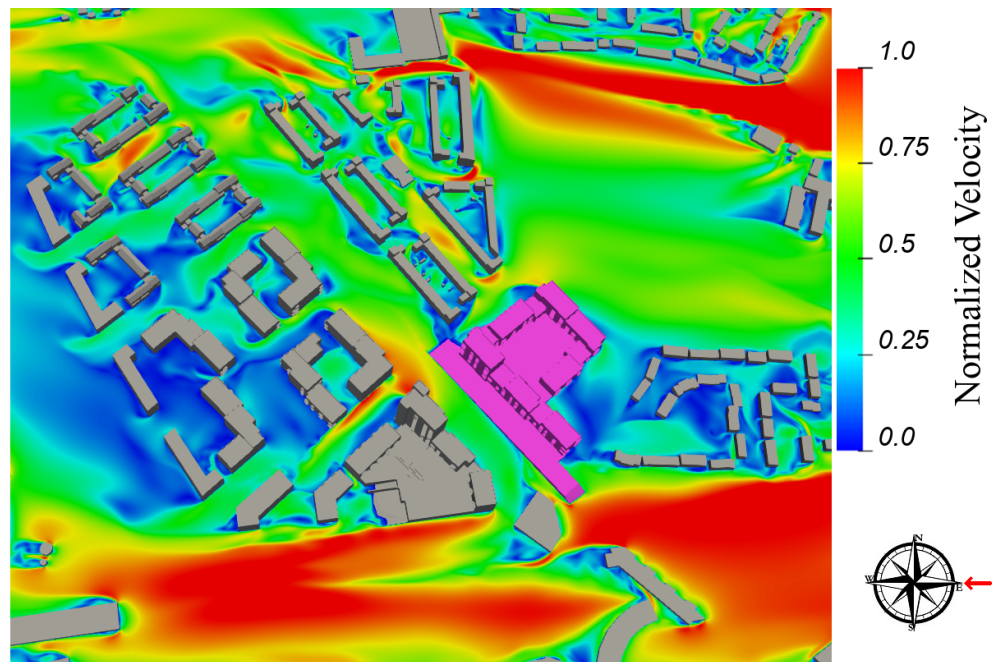


Figure 12.109: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 90° .

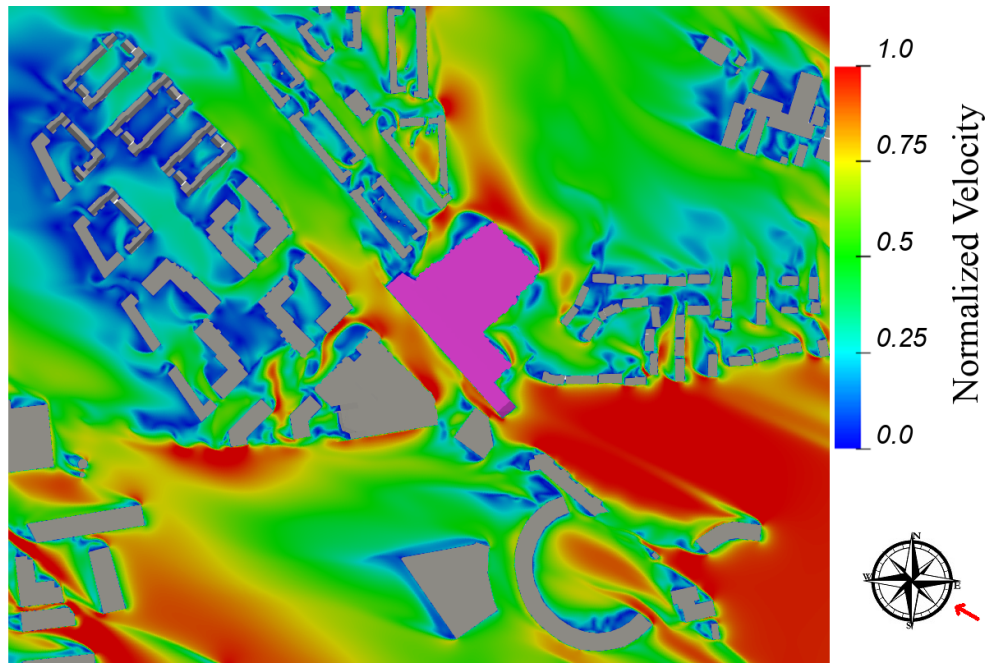


Figure 12.110: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 120° .

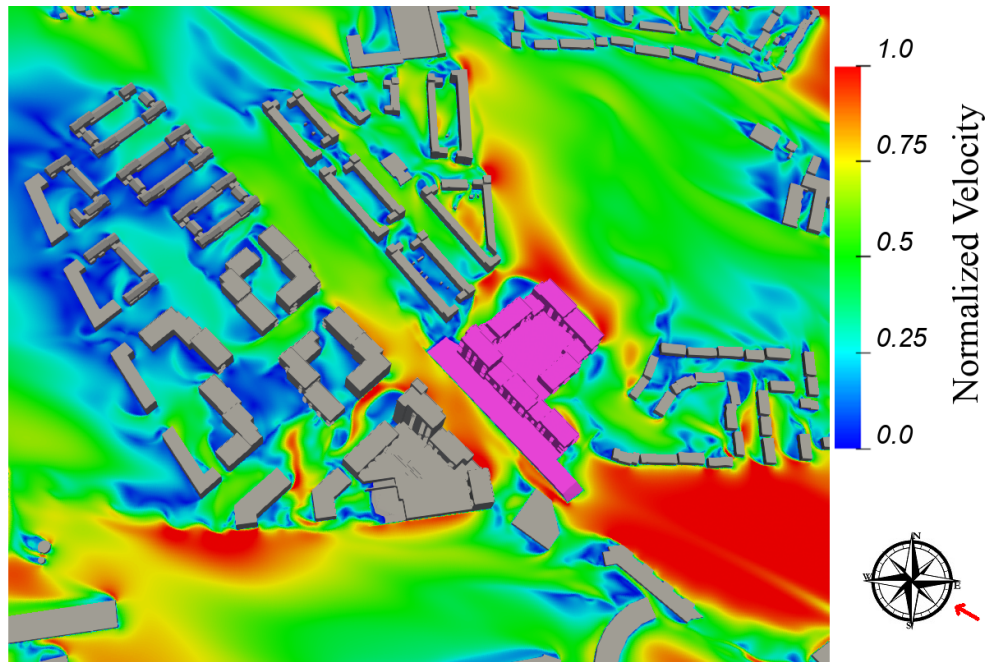


Figure 12.111: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 120° .

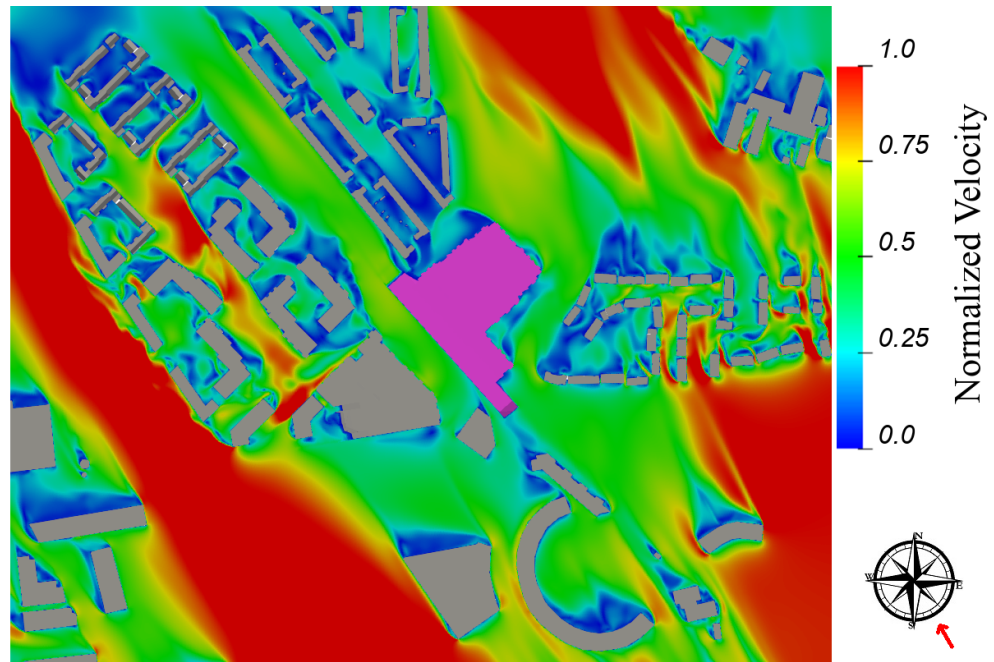


Figure 12.112: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 150° .

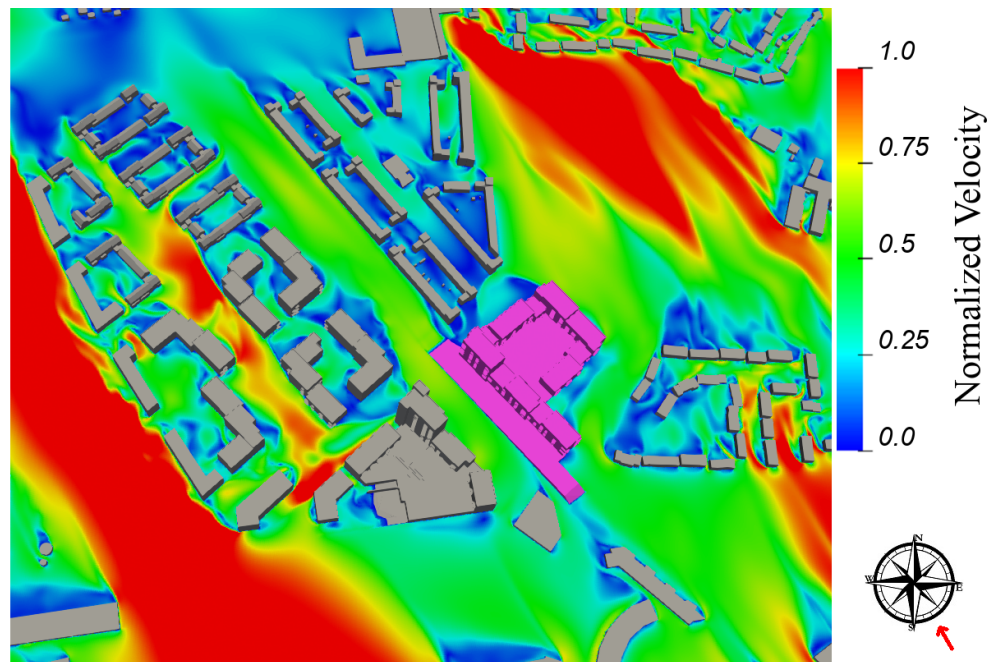


Figure 12.113: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 150° .

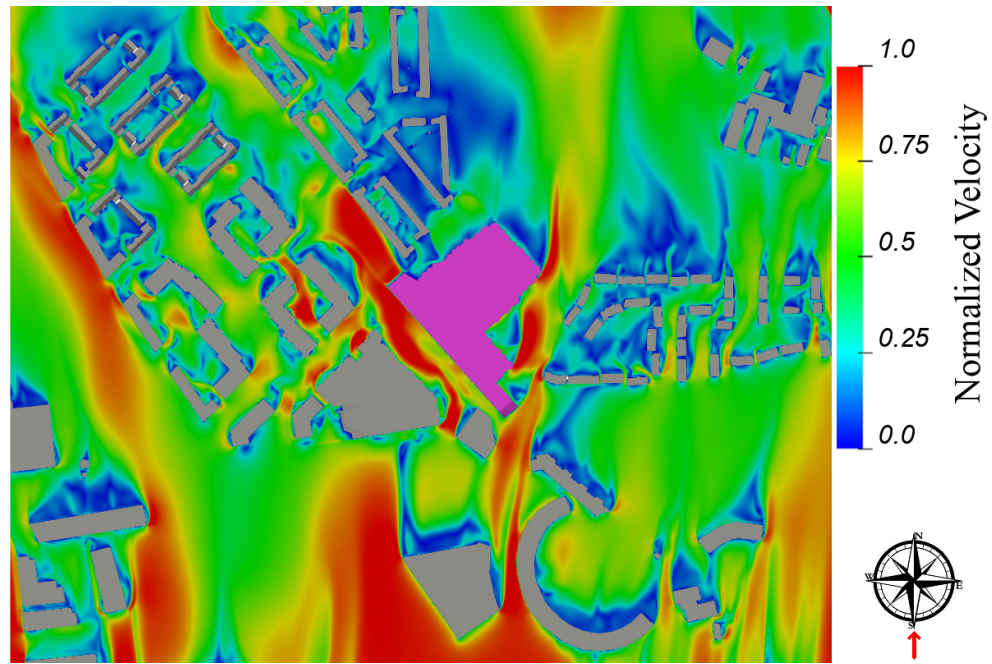


Figure 12.114: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 180° .

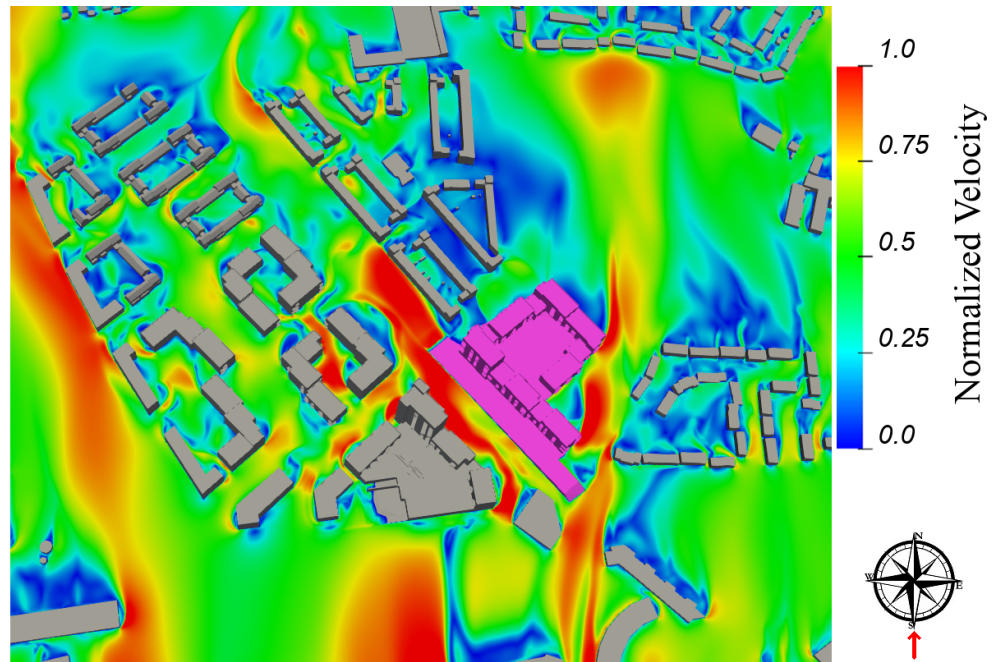


Figure 12.115: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 180° .

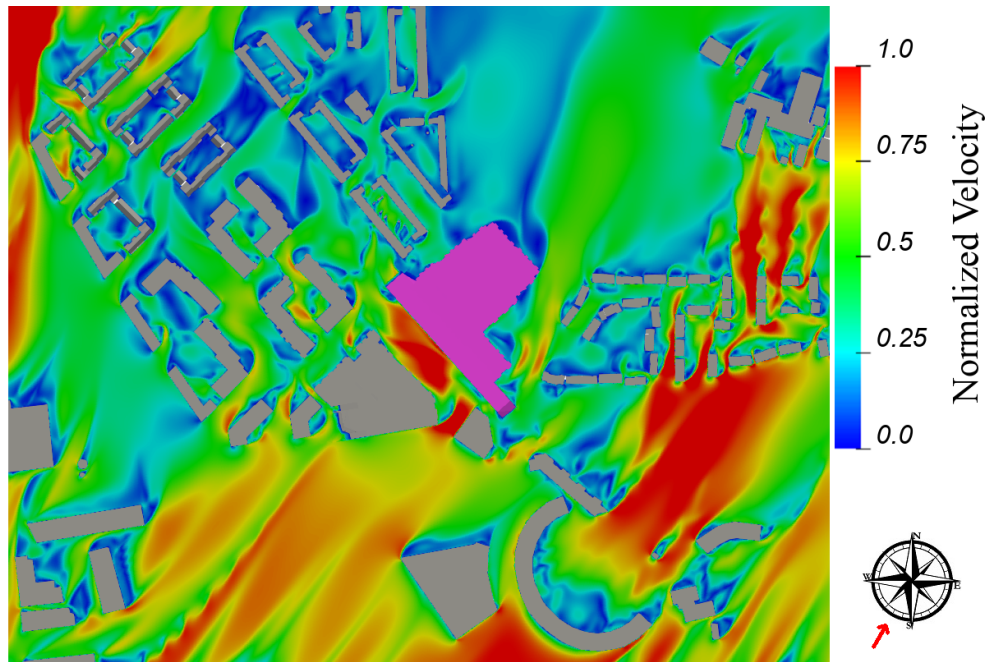


Figure 12.116: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 210° .

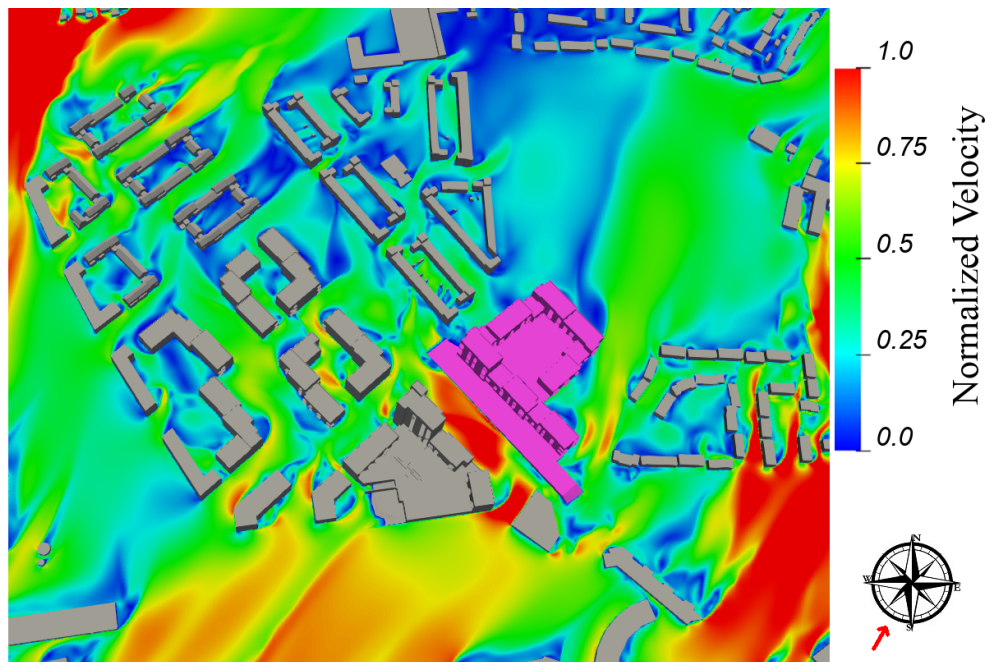


Figure 12.117: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 210° .

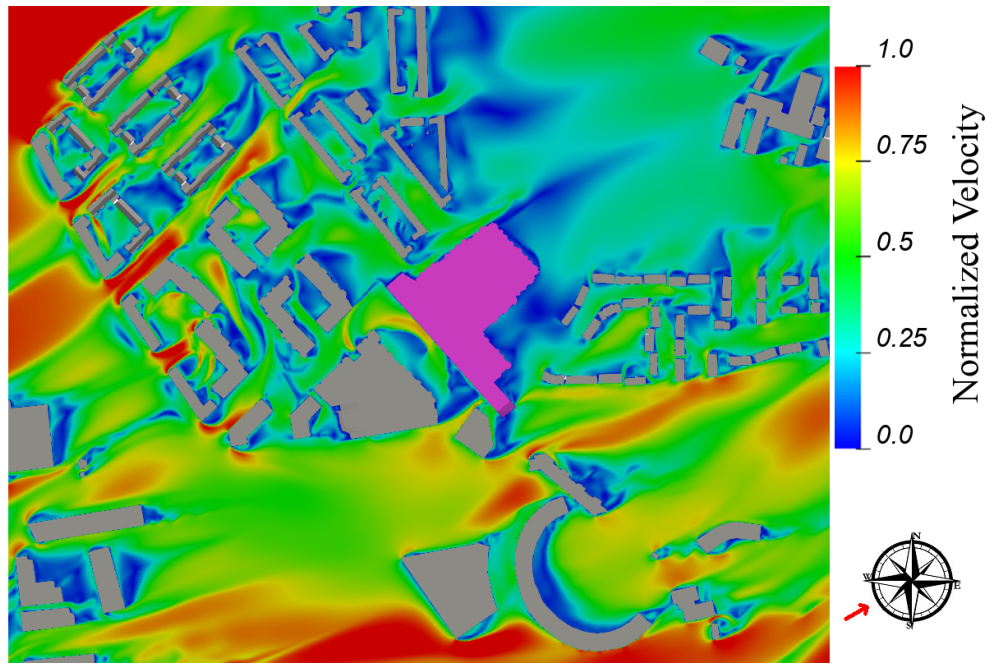


Figure 12.118: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 240° .

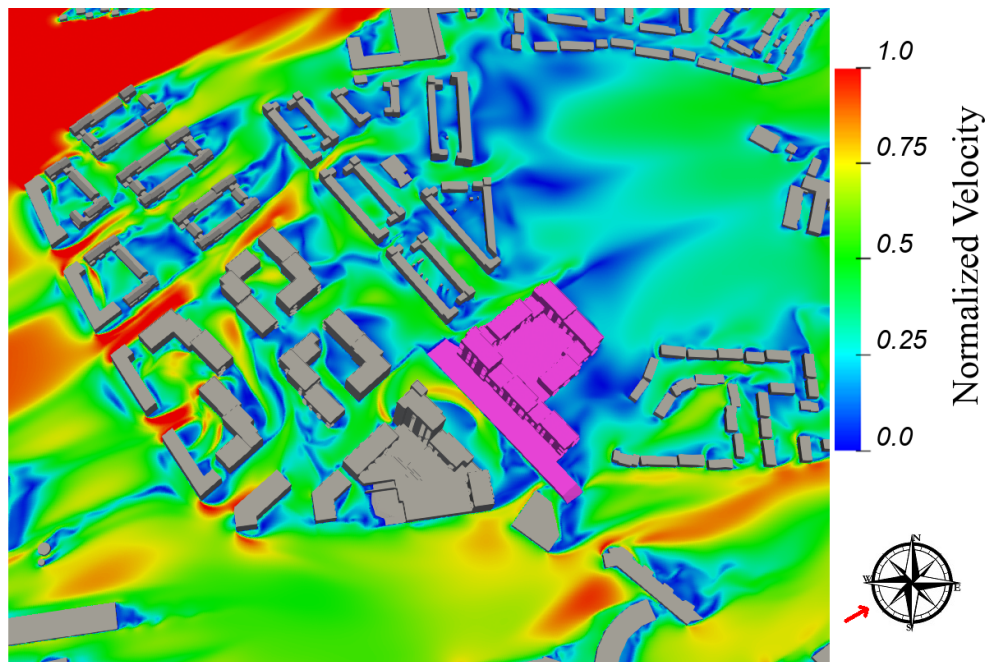


Figure 12.119: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 240° .

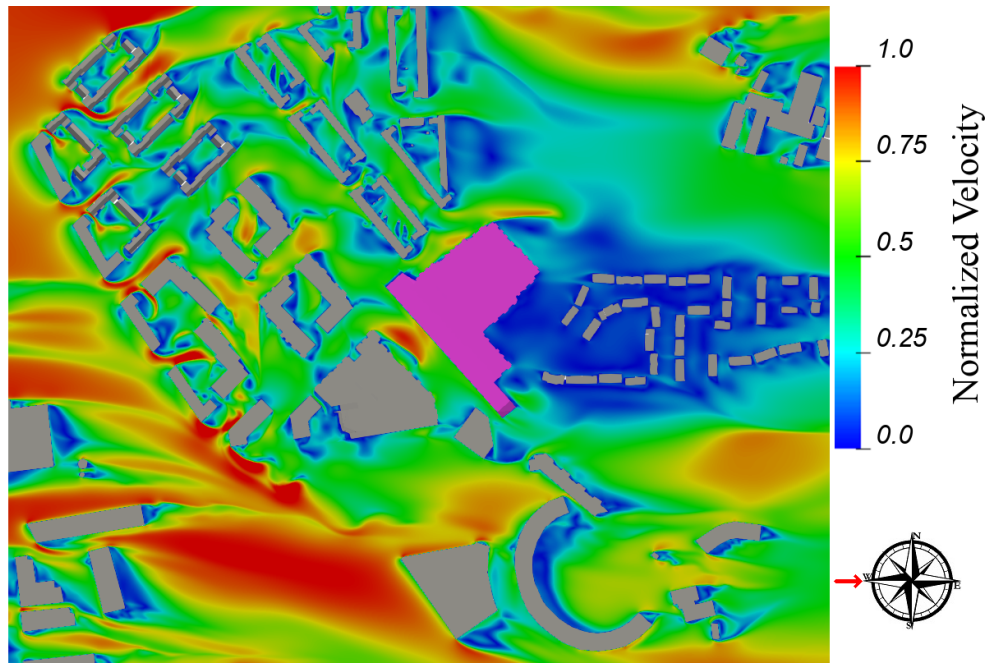


Figure 12.120: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 270° .

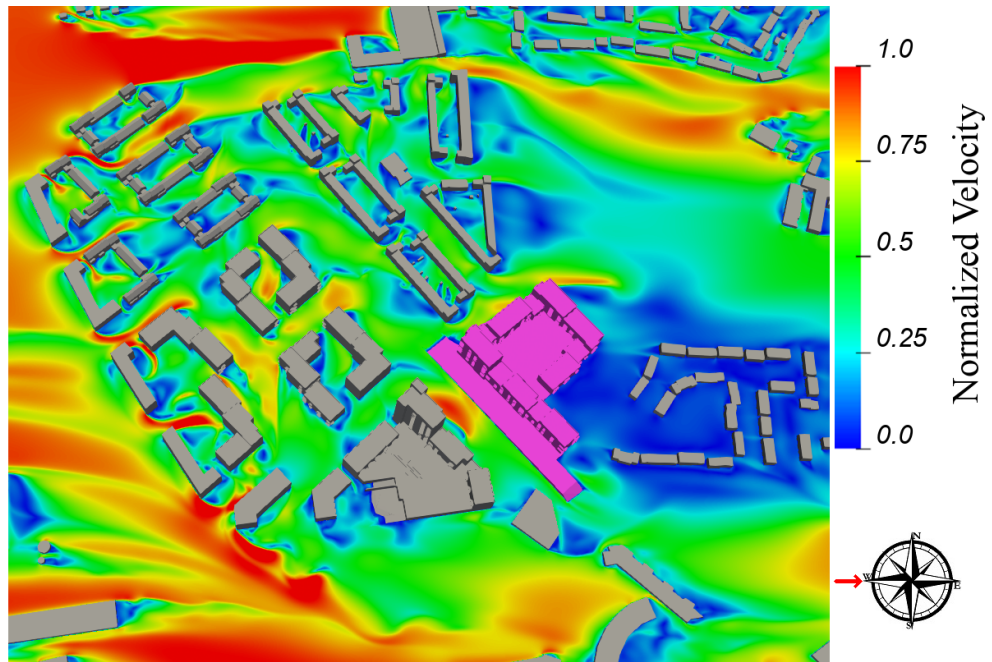


Figure 12.121: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 270° .

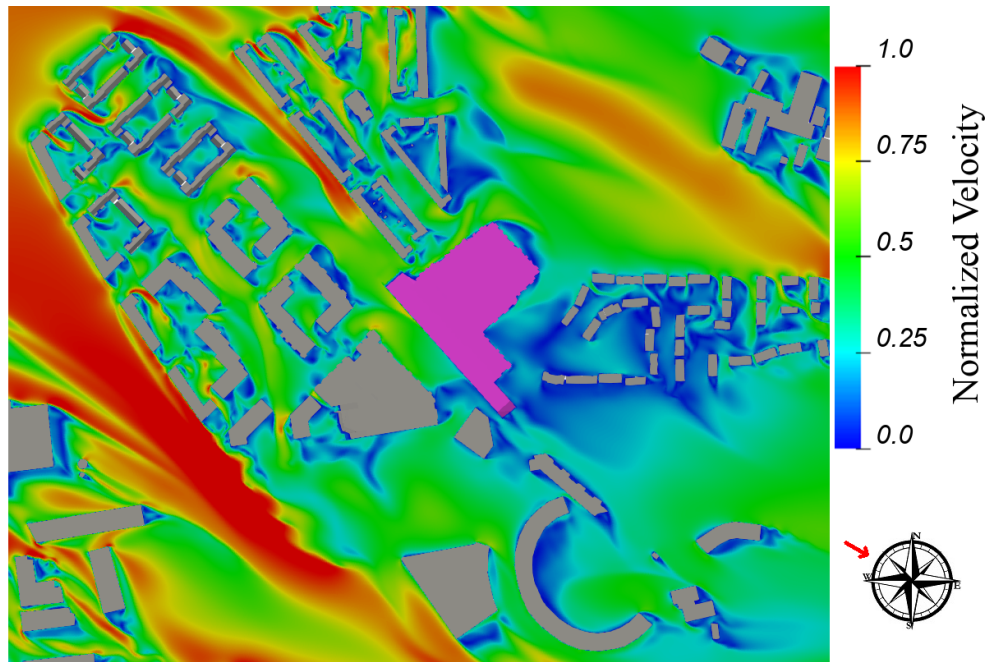


Figure 12.122: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 300° .

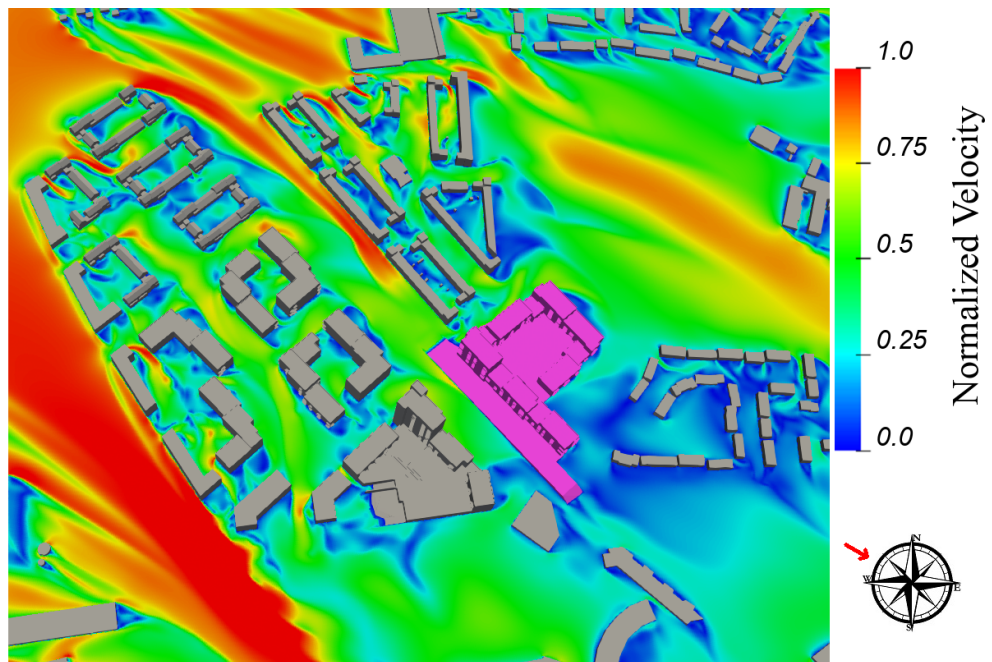


Figure 12.123: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 300° .

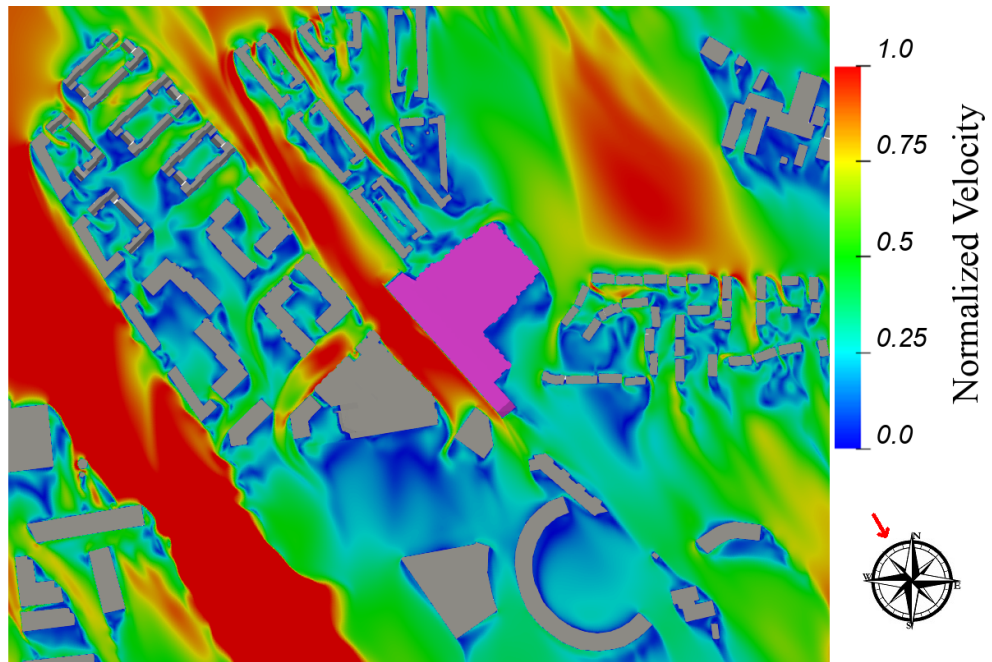


Figure 12.124: Top View -Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 330° .

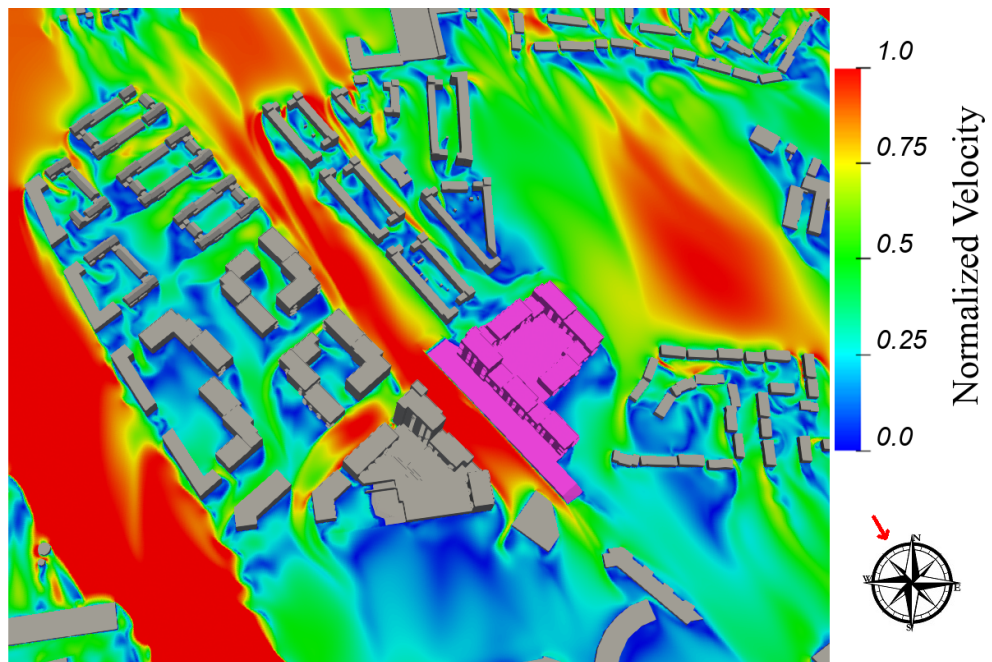


Figure 12.125: 3D View - Flow Velocity Results at $1.8m$ above the ground - Wind Direction: 330° .