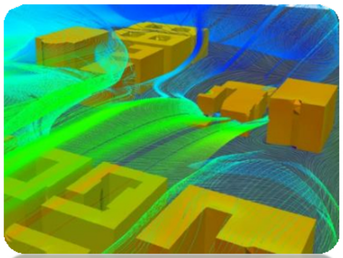
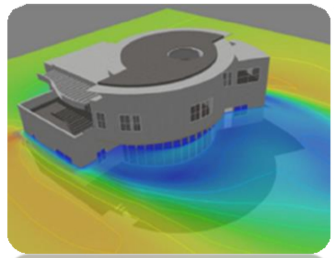
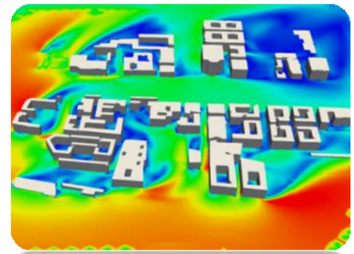

WIND MICROCLIMATE STUDY

Creamfields Development, Kinsale Road, Cork

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

For: KSN Project Management Ltd

B-Fluid
Buildings Fluid Dynamics

Document Reference		
Project Name	WIND MICROCLIMATE STUDY. CREAMFIELDS DEVELOPMENT IN CORK	
Project Ref.	$W\_2009209$	
Site location	Creamfields Development, Kinsale Road, Cork	
CFD Study by	B-Fluid Ltd.	
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Report issued on	February 15, 2022	

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Contents

1. EXECUTIVE SUMMARY

B-Fluid Limited has been commissioned by KSN Project Management Ltd.' to carry out a Wind Microclimate Study for Creamfields Development, Kinsale Road, Cork's Project.

Figure 1.1 shows an isometric view of the proposed development.

Figure 1.1: Proposed Creamfields Development, Kinsale Road, Cork's Project.

In summary, as shown in the details of this report, the wind microclimate study carried out shows that the development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian), and does not introduce any critical impact on the surrounding areas and on the existing buildings. In particular:

- The wind profile around the existing development environment was built using the annual average meteorology data collected at Cork Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Cork Airport.

- The prevailing wind directions for the site are identified as South-South-West, South-West and West, with magnitude of approximately 6m/s.

- The proposed Creamfields Development, Kinsale Road, Cork's Project has been designed in order to produce a high-quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.

- As a result of the final proposed and mitigated design, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South side of the development and areas between the blocks. However, the areas can be utilised for the intended use such as short-term sitting, walking and strolling (as it will be shown in the Lawson map).

- Given the position of the development, major issues of high flow speeds are not expected on footpaths.

- 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 does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.

2. PROJECT DESCRIPTION

2.1 INTRODUCTION

This technical report presents a wind microclimate study carried out for Creamfields Development, Kinsale Road, Cork's Project. The image in Figure 2.1 and the Figure 2.2 shows a 3D View and the model orientation of Creamfields Development, Kinsale Road, Cork's Project respectively. It should be mentioned that the Primary Care Block is subjected to a different application.

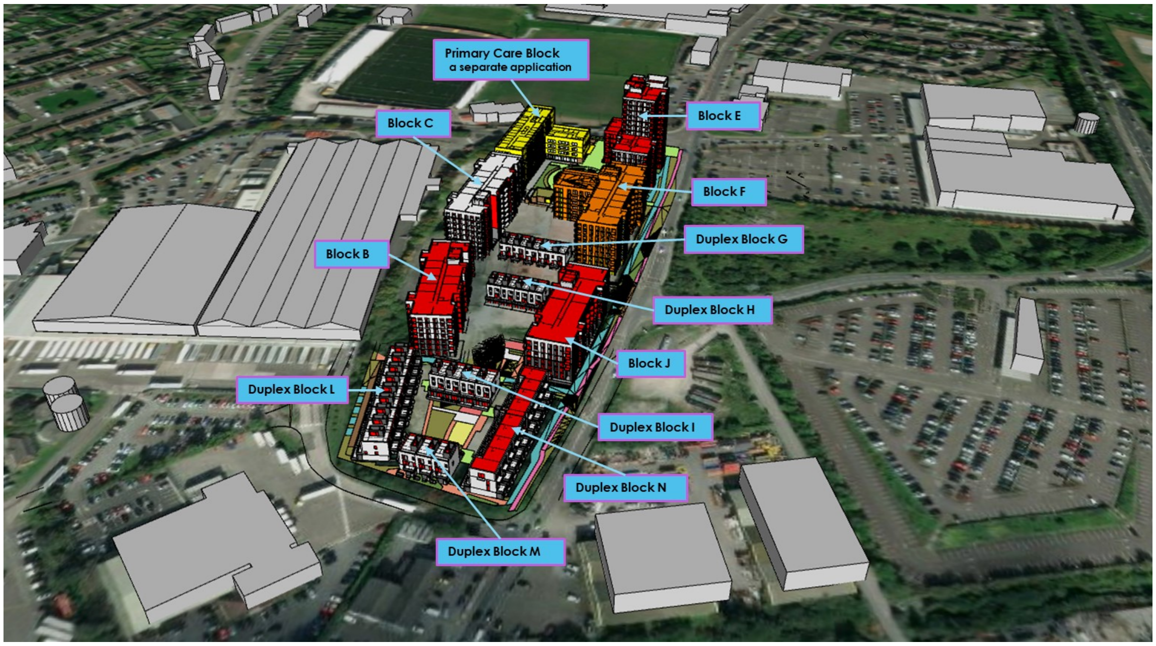


Figure 2.1: 3D View of Creamfields Development, Kinsale Road, Cork's Project.

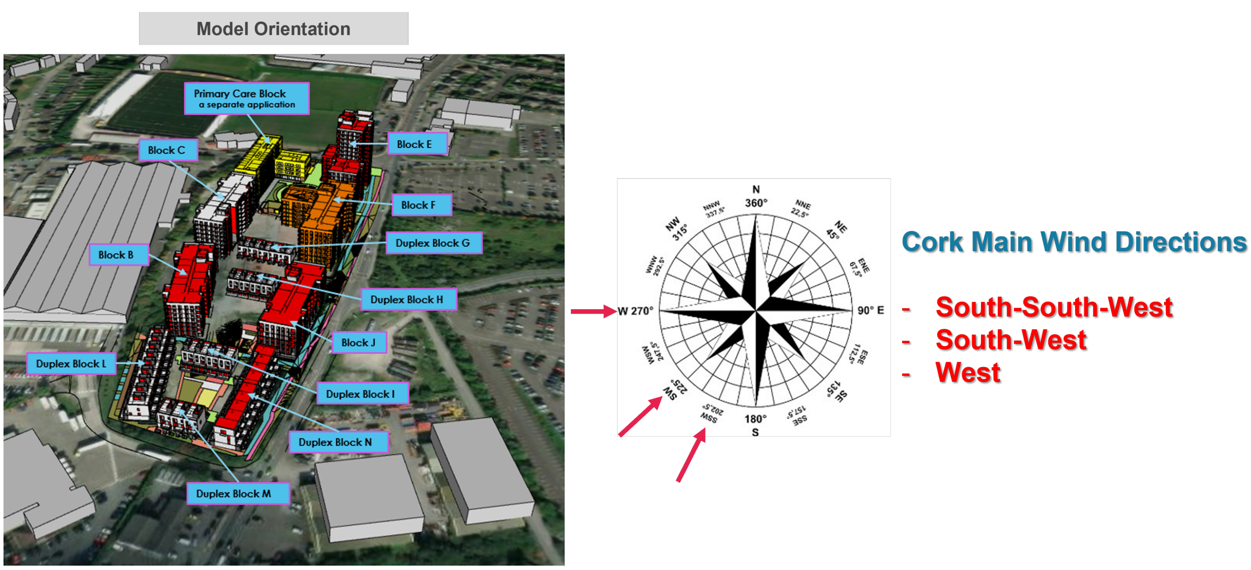


Figure 2.2: Model Orientation of Creamfields Development, Kinsale Road, Cork's Project.

The following paragraphs detail all the project information used throughout the study, together with results of the assessment carried out.

2.2 DESCRIPTION OF THE DEVELOPMENT

The proposed development will consist of a Strategic Housing Development of 609no. dwellings (561no. apartments (of which 257no. are Build To Rent) and 48no. townhouses) in 12no. buildings of between 1-15 storeys in height over ground, to include a coffee kiosk; gym; café; retail use; creche and community hub; public square; car parking; cycle parking; and all associated site development, infrastructural, and landscaping works on the site of the former CMP Dairies site, Kinsale Road and Tramore Road, Cork.

Figure 2.3 shows the top view of the development, locations of its blocks, and also the proposed Primary Care Block, which is subjected to a different application.

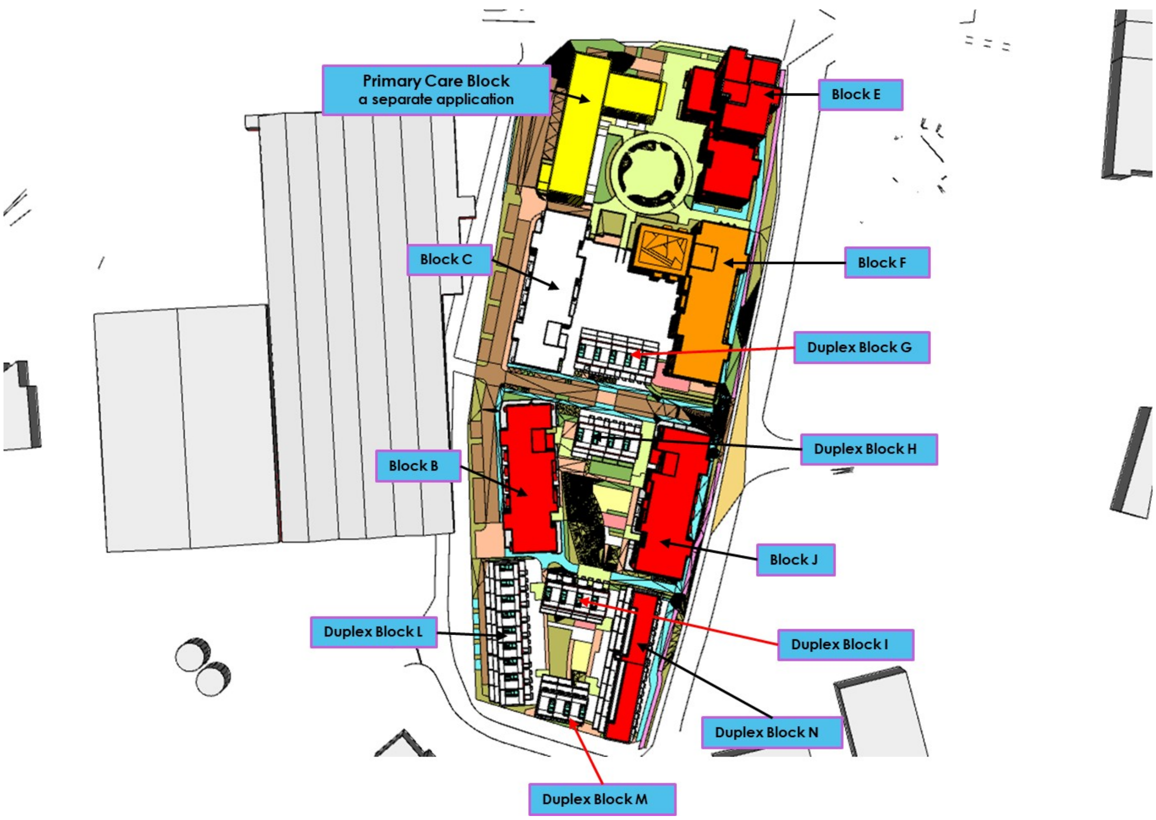


Figure 2.3: Top View of the Creamfields Development, Kinsale Road, Cork's Project

2.3 EXTENTS OF ANALYSED AREA

The Creamfields development is located in Kinsale Road, in Cork city. The site is shown in Figures 2.4 and 2.5. The area considered for the wind microclimate study comprises a 1km^2 area around the Creamfields development.

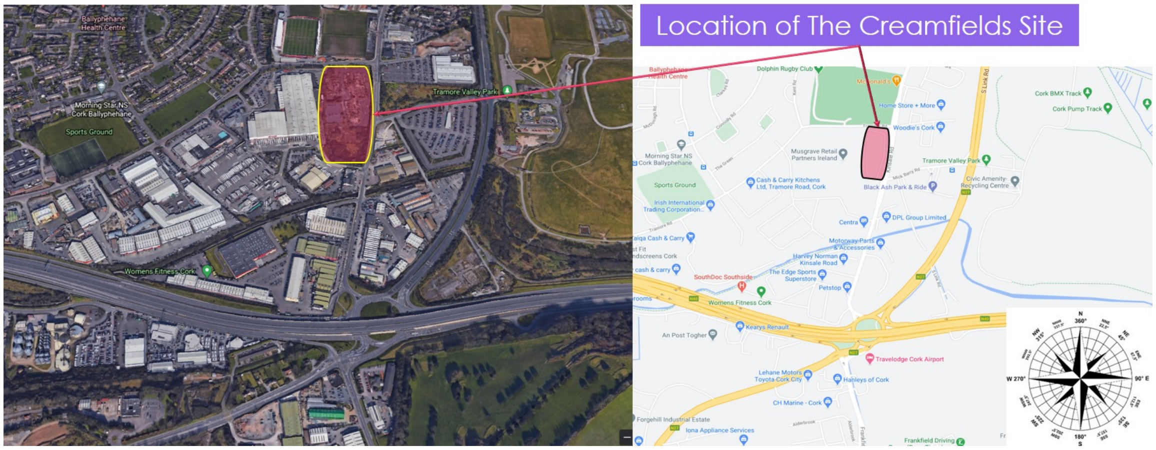


Figure 2.4: The Creamfields's Project Actual Site Location

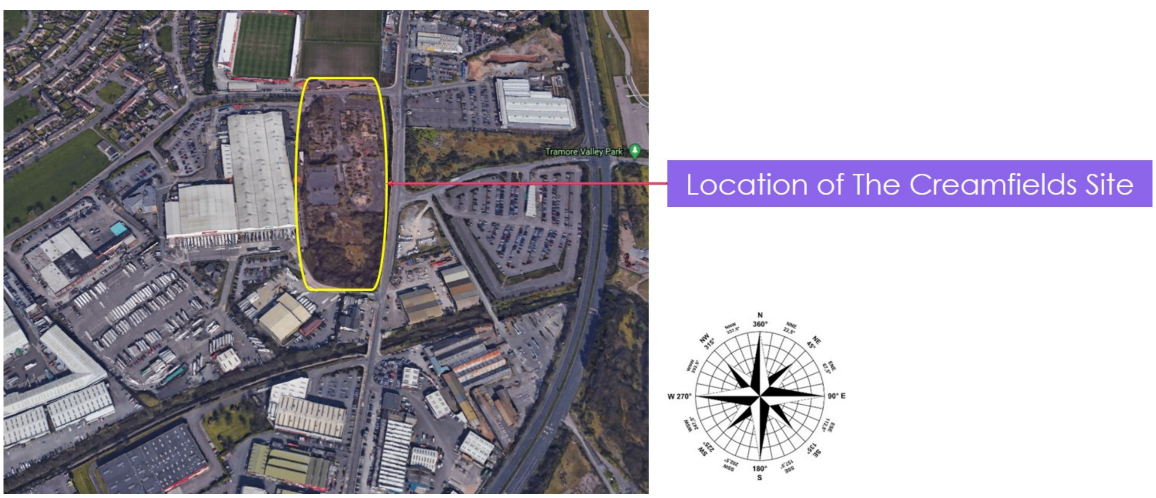


Figure 2.5: The Creamfields's Project Actual Site Location

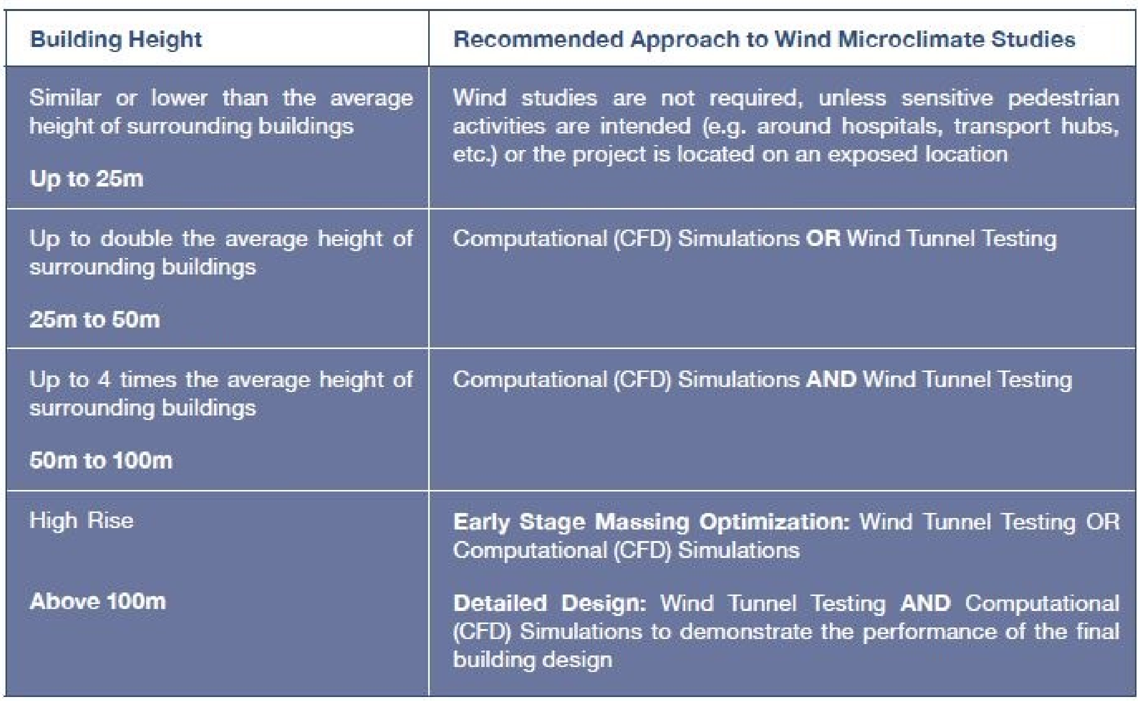
2.4 OBJECTIVE OF THE WIND MICROCLIMATE STUDY

The CFD wind model is adopted to to identify areas of concern in terms of critical flows and areas where the pedestrian safety and comfort could be compromised. Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the development on pedestrian level wind conditions. The objective is to maintain comfortable and safe pedestrian level wind conditions that are appropriate for the season and the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

2.4.1 NATIONAL REGULATIONS

According to the 'Urban Development and Building Heights, Guidelines for Planning Authorities (Government of Ireland, December 2018)' document, specific impact assessment of the micro-climatic 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' for Dublin standards.)

Usually, the recommended approach to wind microclimate studies is based on the building height, as presented in Figure 2.6 and prescibed by the Wind Microclimate Guidelines for Developments in the City of London (August 2019).



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 (CFD) Simulations **OR** Wind Tunnel Testing
Up to 4 times the average height of surrounding buildings **50m to 100m**	Computational (CFD) Simulations **AND** Wind Tunnel Testing
High Rise **Above 100m**	**Early Stage Massing Optimization:** Wind Tunnel Testing OR Computational (CFD) Simulations **Detailed Design:** Wind Tunnel Testing **AND** Computational (CFD) Simulations to demonstrate the performance of the final building design

Figure 2.6: 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)

Good wind microclimate conditions are necessary for creating outstanding public spaces. Adverse wind effects can reduce the quality and usability of outdoor areas, and lead to safety concerns in extreme cases.

Computational fluid dynamics (CFD) tools can create high quality output that provide a good understanding of fundamental flow features. The CFD models must include a detailed three-dimensional representation of the proposed development.

Maximum cell sizes near critical locations (e.g. entrances, corners, etc.) must be 0.3m or smaller. Sufficient cells ahould be also used between buildings with a minimum of 10 across a street canyon. However, the cell size of buildings away from the target can be larger to allow for modelling efficiency. The CFD models should represent all surrounding buildings that are within 400m from the centre of the site. 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. The models must contain at least 3 prism layers below 1.5m height, to capture near-ground effects.

CFD analysis also reports conditions in areas away from the site where cumulative effects of a cluster of tall buildings could lead to adverse wind conditions.

3. STUDY METHODOLOGY

3.1 STUDY METHODOLOGY

The methodology adopted for the wind microclimate analysis of the proposed development is outlined as follows;

The following sections give details on the methodology utilized.

- Perform a wind desktop study of the existing environment.

- Perform computational wind microclimate analysis of the proposed development within the existing environment.

3.2 WIND IMPACT ASSESSMENT ON BUILDINGS

3.2.1 PLANETARY BOUNDARY LAYER AND TERRAIN ROUGHNESS

Due to aerodynamic drag, there is a wind gradient in the wind flow just a few hundred meters above the Earth's surface – "the surface layer of the planetary boundary layer".

Wind speed increases with increasing height above the ground, starting from zero, due to the no-slip condition. In particular, the wind velocity profile is parabolic. Flow near the surface encounters obstacles 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 velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 3.1 shows the wind velocity profile, as described above.

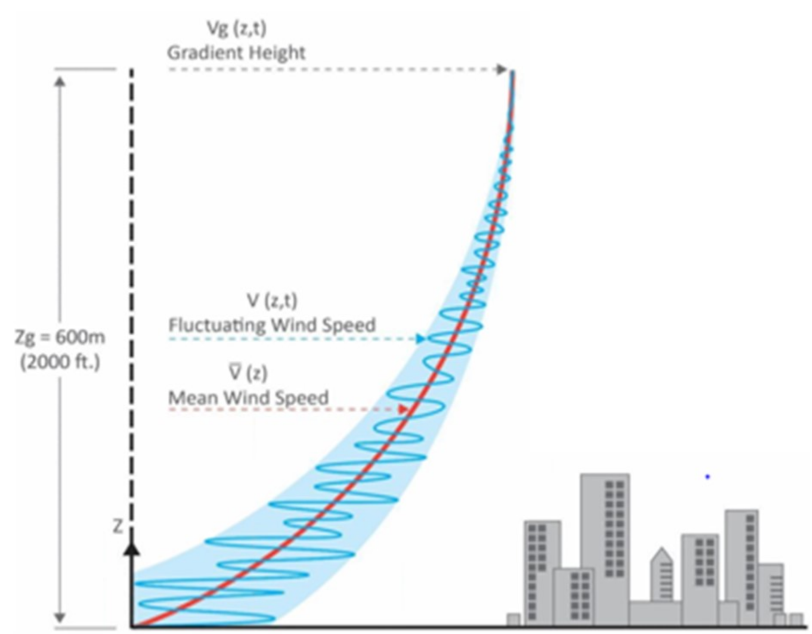


Figure 3.1: Wind Velocity Profile

Two effects influence the shape of the wind speed profile:

- Contours of the terrain: a rising terrain such as an escarpment will produce a fuller profile at the top of the slope compared with the profile of the wind approaching the slope.

- Aerodynamic 'roughness' of the upstream terrain: natural roughness in the form of woods or man-made roughness in the form of buildings. Obstructions near the ground create turbulence and friction, lowering the average wind speed. The higher the obstructions, the greater the turbulence and the lower the windspeed. As a general rule, windspeed increases with height.

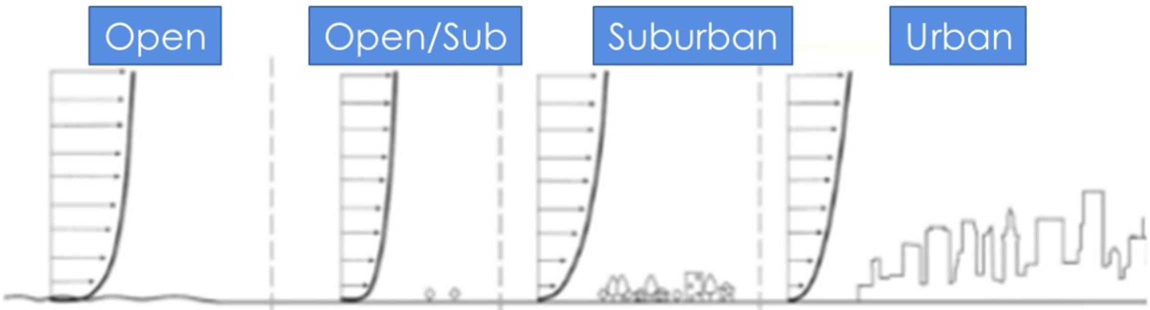


Figure 3.2: Wind Velocity Profile for different terrains

In order to assess the wind conditions in a particular area, it is important to know (Figure 3.3):

- Weather conditions in the area
- Location and orientation of the site
- Buildings distribution in the area
- Flow patterns at the building

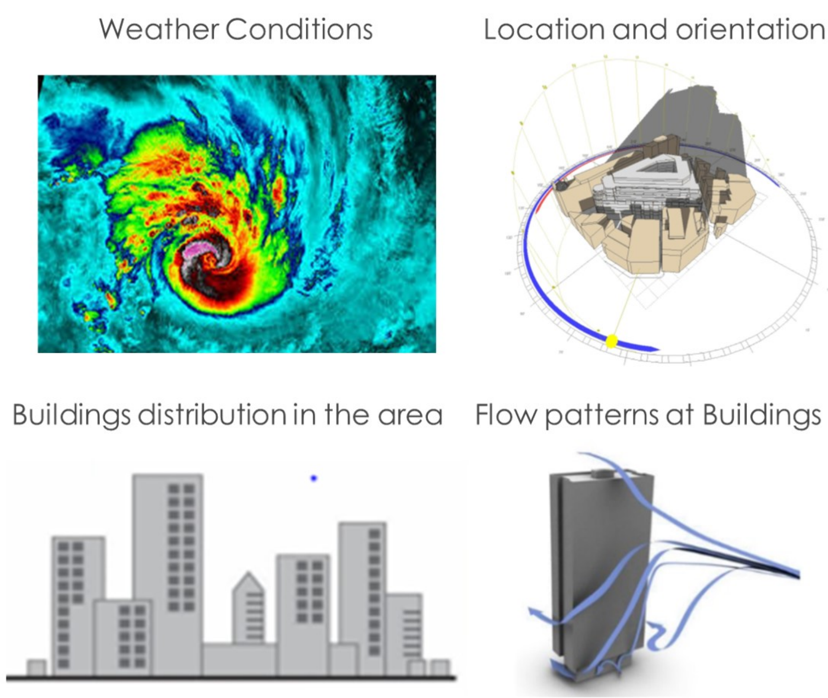


Figure 3.3: Parameters to know for Wind Conditions Assessment

Moreover, it is important to understand key flow features (Figure 3.4):

- Broad Building Face creates “DOWNWASH”
- Low Building Upwind Increases Wind Effects
- Gaps Between Buildings Increases Wind Velocity
- Low Building Upwind Increases Wind Effects

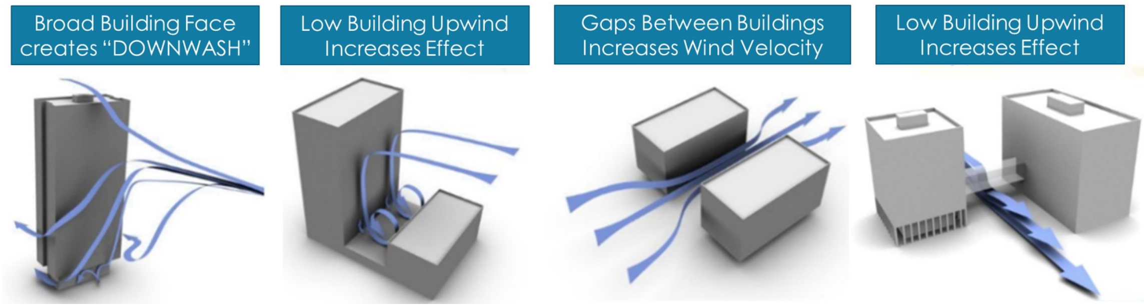


Figure 3.4: Parameters to know for Wind Conditions Assessment

3.3 ACCEPTANCE CRITERIA

3.3.1 PEDESTRIAN COMFORT AND LAWSON 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.

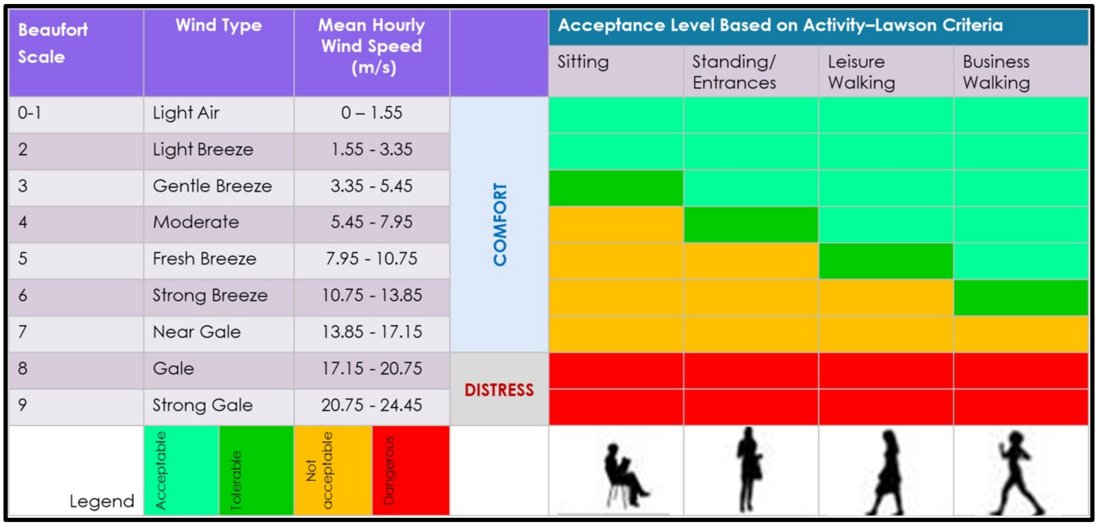
Only gust winds are considered in the safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential impact on pedestrian safety. Gusts cause the majority of cases of annoyance and distress and are assessed in addition to average 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.

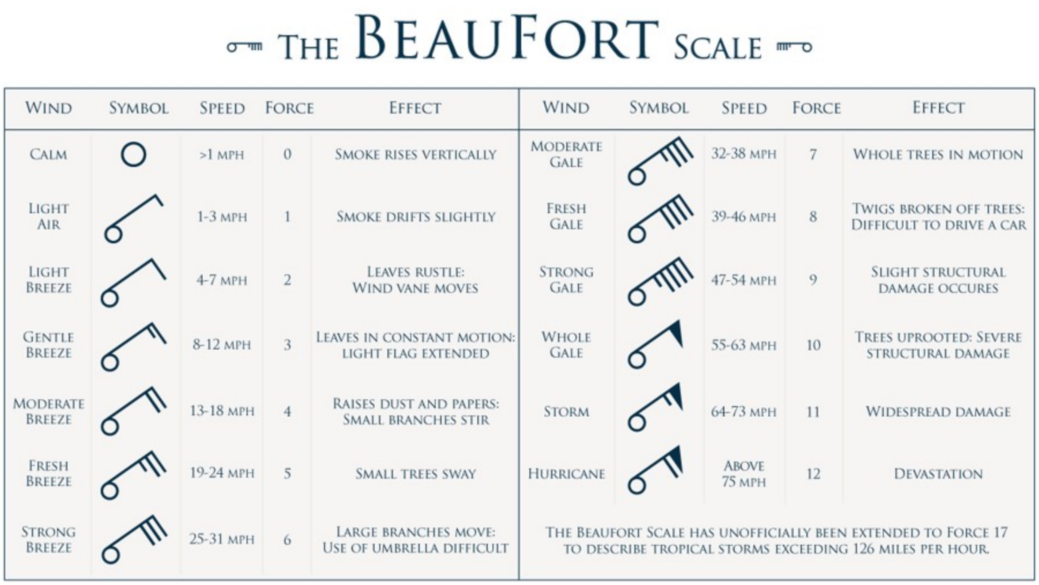
- DISTRESS CRITERIA: Relates to the physical well-being of the individual.
  Onset of distress:
  - ‘Frail Person Or Cyclist’: equivalent to an hourly mean speed of 15 m/s and a gust speed of 28 m/s (62 mph) to be exceeded less often than once a year. This is intended to identify wind conditions which 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 20 m/s and a gust speed of 37 m/s (83 mph) to be exceeded less often than once a year. Beyond this gust speed, aerodynamic forces approach body weight and it rapidly becomes impossible for anyone to remain standing. Where wind speeds exceed these values, pedestrian access should be discouraged.

The above criteria set out six pedestrian activities and reflect the fact that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 3.5. 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, which is represented in Figure 3.6. 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 3.5: Lawson Scale



THE BEAUFORT SCALE

Wind	Speed	Force	Effect
Calm	>1 mph	0	Smoke rises vertically
Light Air	1-3 mph	1	Smoke drifts slightly
Light Breeze	4-7 mph	2	Leaves rustle: Wind vane moves
Gentle Breeze	8-12 mph	3	Leaves in constant motion: Light flag extended
Moderate Breeze	13-18 mph	4	Raises dust and papers: Small branches stir
Fresh Breeze	19-24 mph	5	Small trees sway
Strong Breeze	25-31 mph	6	Large branches move: Use of umbrella difficult
Moderate Gale	32-38 mph	7	Whole trees in motion
Fresh Gale	39-46 mph	8	Twigs broken off trees: Difficult to drive a car
Strong Gale	47-54 mph	9	Slight structural damage occures
Whole Gale	55-63 mph	10	Trees uprooted: Severe structural damage
Storm	64-73 mph	11	Widespread damage
Hurricane	Above 75 mph	12	Devastation

The Beaufort scale has unofficially been extended to force 17 to describe tropical storms exceeding 126 miles per hour.

Figure 3.6: BeaufortScale

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. 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 condition are unacceptable for the type of pedestrian activity and mitigation measure should be implemented into the design.

For the scope of this report, a qualitative analysis is undertaken, therefore the flow pattern will be highlighted but it will not reflect the velocity magnitude developed.

3.4 MITIGATION MEASURES

As stated in the previous section, if the predicted wind conditions exceed the threshold, then condition are unacceptable for the type of pedestrian activity and mitigation measure should be accounted for.

Mitigation measures include:

- Landscaping: the use vegetation to protect buildings from wind
- Sculptural screening (solid or porous): to either deflect the wind or bleed the wind by removing its energy.
- Canopies and Wind gutters: horizontal canopies are used to deflect the wind and redirect the wind around the building and above the canopy.

In particular, it is possible to summarise the different flow features and the corresponding mitigation option as follows (Figures 3.7 and 3.8):

- **Downwash Effects**: when wind hits the windward face of a tall building, the building tends to deflect the wind downwards, causing accelerated wind speeds at pedestrian level and around the windward corners of the building. This can occur when Tall and wide building facades face the prevailing winds.
  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.

  MITIGATION OPTIONS:
  - To mitigate unwanted wind effects it is recommended to introduce a base building or podium with a step back, and setting back a tower relative to the base building, the downward wind flow can be deflected, resulting in reduced wind speed at pedestrian level.
  - Landscaping the base building roof and tower step back, wind speeds at grade can be further reduced, and wind conditions on the base building roof can improve.

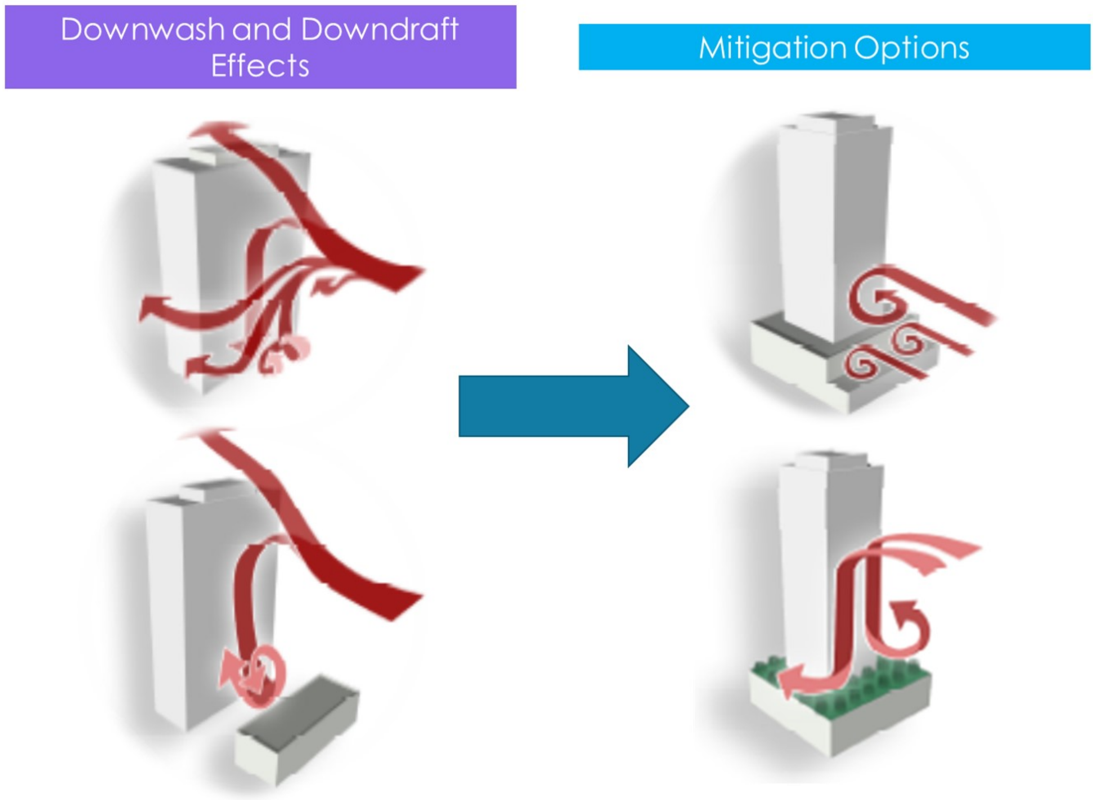


Figure 3.7: Mitigation Measures for Downwash and Downdraft Effects

- **Funneling Effects**: Wind speed is accelerated when wind is funneled between two buildings. This is referred to as the “wind canyon effect”. The intensity of the acceleration is influenced by the building heights, size of the facades, building separation distance and building orientation. Similar effect can be noticed when a bridge is connecting two buildings, the wind passing below the bridge is accelerated, therefore pedestrians can experience high uncomfortable velocities of wind .

  MITIGATION OPTIONS:
  - A horizontal canopy on the windward face of a base building can improve pedestrian level wind conditions. Parapet walls around a canopy can make the canopy more effective.
  - Sloped canopies only provide partial deflection of downward wind flow.
  - A colonnade on the windward face of the base building provides the pedestrian with a calm area where to walk while being protected or a breeze walking space outside the colonnade zone.

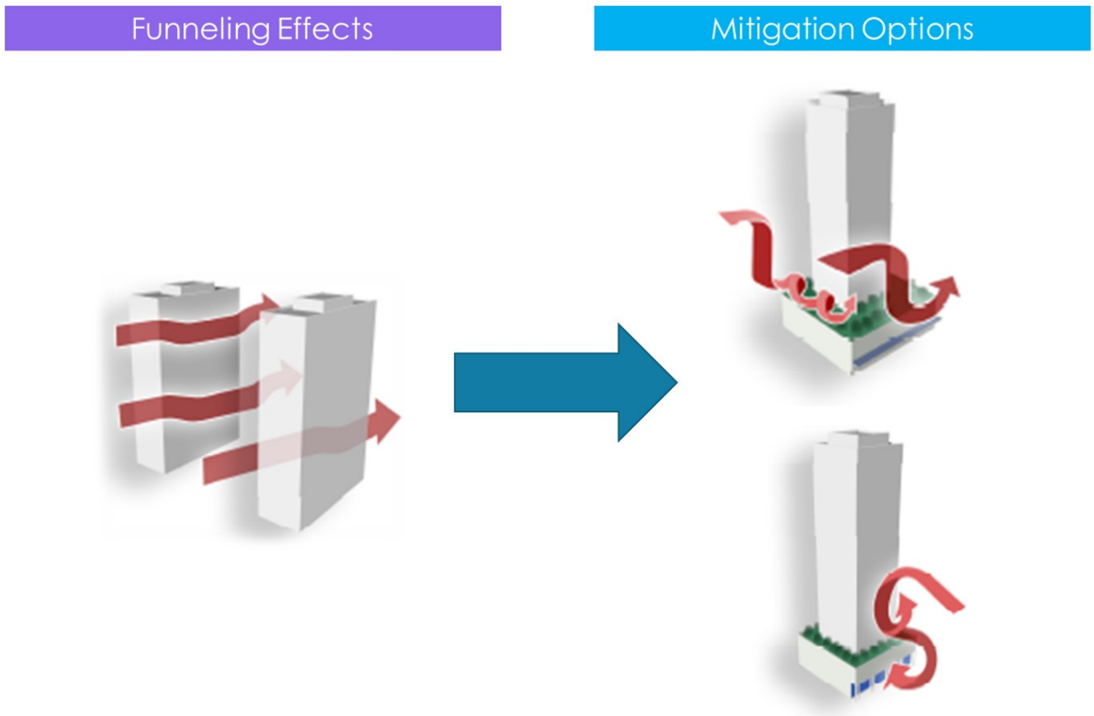


Figure 3.8: Mitigation Measures for Funnelling Effects

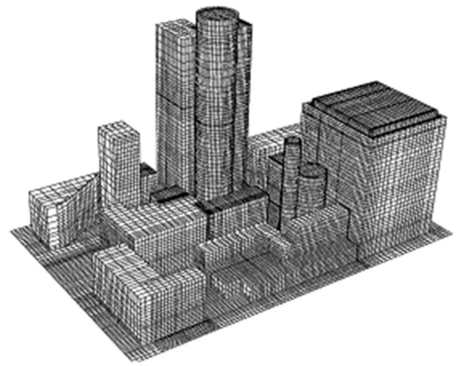
4. CFD MODELLING METHOD

4.1 CFD MODELLING METHOD

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.

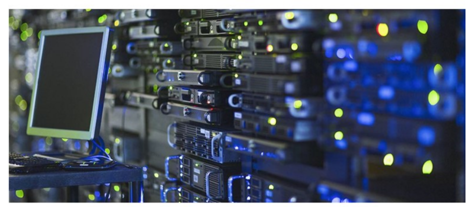
PRE-PROCESSING

This is the construction of a representative geometric model to be utilized within a flow domain of interest and the subsequent division of this domain into small control volumes (cells), a process often called "meshing." After setting up the model and mesh, the model is completed by setting appropriate boundary and initial conditions.



SIMULATION

The equations governing the behaviour of fluid particles (Navier-Stokes equations) are solved iteratively over each control volume within the computational domain, until the results change no more; i.e. a converged solution is reached. In a transient simulation this process is repeated and convergence verified at each time step, whereas in a steady-state simulation, this is only done at one time step, since it is assumed conditions do not vary over time. The field solutions of pressure, velocity, air temperature, and other properties are obtained for each control volume, at cell centre, nodal point, or face centre in order to render the flow field.



POST-PROCESSIONG

This is the plotting and viewing of the predicted flow field from the CFD model simulations at selected locations, surfaces, or planes of interest.

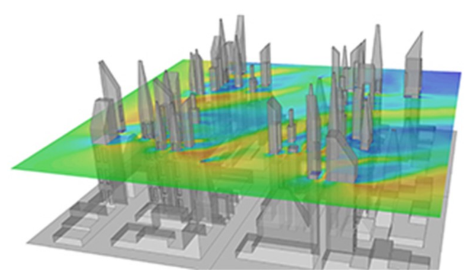


Figure 4.1: CFD Modelling Process Explanation

4.1.1 NUMERICAL SOLVER

This report employs OpenFoam Code, which is based on a volume averaging method of discretization and uses the post-processing visualisation toolkit Paraview version 5.5. OpenFoam is a CFD software code 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 CFD code has capabilities of utilizing a Reynolds Averaged Navier-Stokes (RANS) approach, Unsteady Reynolds Averaged Navier-Stokes (URANS) approach, Detached Eddy Simulation (DES) approach, Large Eddy Simulation (LES) approach or the Direct Numerical Simulation (DNS) approach, which are all used to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics. Quality assurance is based on rigorous testing. The process of code evaluation, verification and validation includes several hundred daily unit tests, a medium-sized test battery run on a weekly basis, and large industry-based test battery run prior to new version releases. Tests are designed to assess regression behaviour, memory usage, code performance and scalability.

The OpenFOAM solver algorithm directly solves the mass and momentum equations for the large eddies that comprise most of the fluid's energy. By solving the large eddies directly no error is introduced into the calculation.

To reduce computational time and associated costs the small eddies within the flow have been solved using the widely used and recognised Smagorinsky Sub-Grid Scale (SGS) model. The small eddies only comprise a small proportion of the fluids energy therefore the errors introduced through the modelling of this component are minimal.

The error introduced by modelling the small eddies can be considered of an acceptable level. Computational time will be reduced by modelling the small eddies (compared to directly solving).

4.2 COMPUTATIONAL MESH

The level of accuracy of the CFD results are determined by the level of refinement of the computational mesh. Details of parameters used to calculate the computational mesh are presented in Table 4.1. The following Figure shows the mesh utilised.

The grid follows the principles of the 'Finite Volume Method', which implies that the solution of the model equations is calculated at discrete points (nodes) on a three-dimensional grid, which includes all the flow volume of interest. The mathematical solution for the flow is calculated at the center of each of these cells and then an interpolation function is used by the software to provide the results in the entire domain.

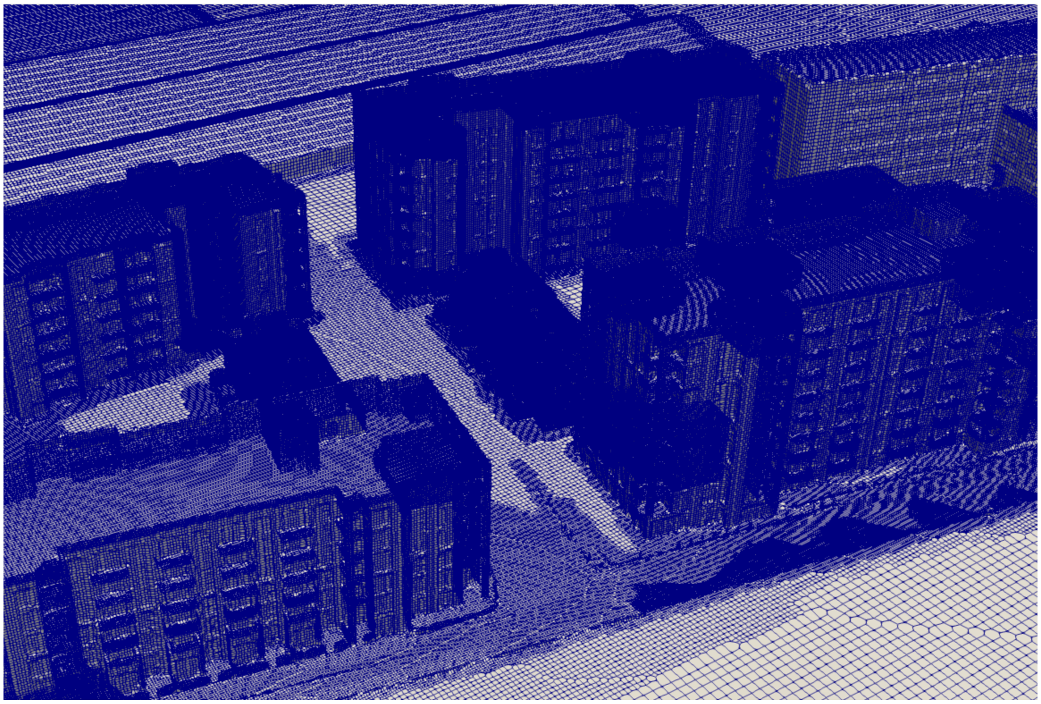


Figure 4.2: Development Mesh

4.3 BOUNDARY CONDITIONS

A rectangular computational domain was used for the analysis. The wind direction were altered without changing the computational mesh. For each dimension, an initial wind velocity was set according to the weather data collected, in order to consider the worst case scenario (see Chapter 5). Surfaces within the model were specified as having 'no slip'. This 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".

PARAMETERS TO CALCULATE COMPUTATIONAL MESH	
Air Density ρ	$1.2 kg/m^3$
Ambient Temperature (T)	$288K(approx.15C^\circ)$
Gravity Acceleration (g)	$9.8 m/s^2$
dx	0.5 m at the building 1m in the surroundings 2m elsewhere
Background Mesh cells ratio	1:1
Total mesh size	Approx. cells number = 10 million

Table 4.1: Paramenters To Calculate Computational Mesh

5. WIND DESKTOP STUDY

5.1 WIND FLOW CONDITIONS

This analysis consider 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 Cork Airport Weather Station. Figure 5.1 shows on the map the position of the Creamfields Development's project and the position of Cork Airport.

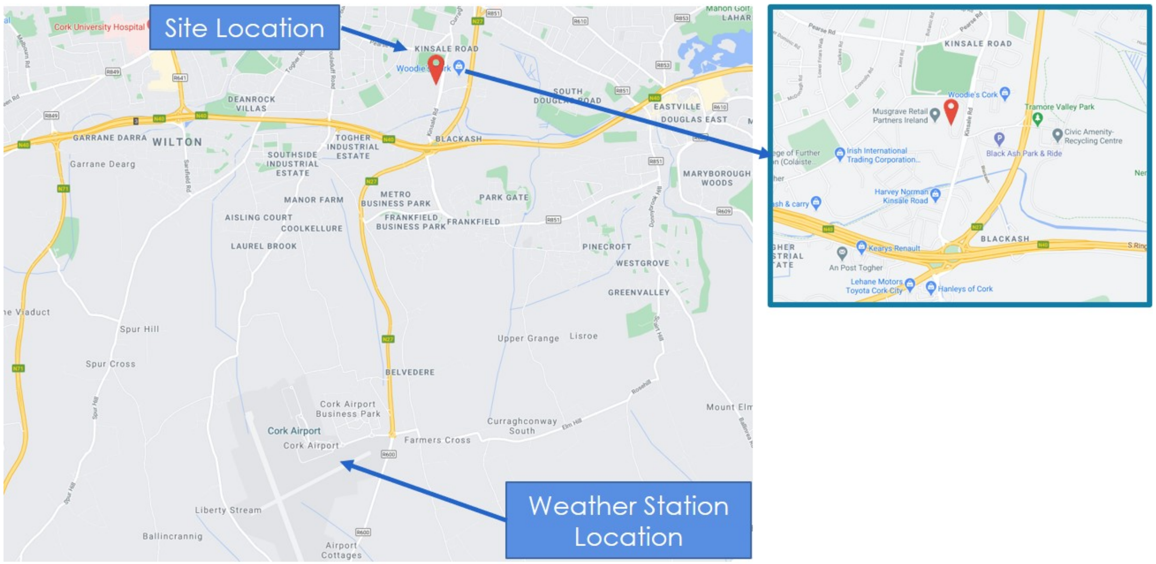


Figure 5.1: Map showing the position of The Creamfields's Project and Cork Airport

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

- Terrain: The meteorological station is located in the flat open terrain of the airport, whereas the development site is located in urban area with dense built-in structure with buildings of at least 15m height in average.

- Mean Wind Speeds: Due to the different terrain environment, the ground-near wind speeds (at pedestrian level) will be lower at the construction site compared to the meteorological station at the airport.

- Wind Directions: The landscape around the development site can in principle be characterized as flat terrain. Isolated elevations in the near area of the development should have no influence on the wind speed and wind directions. With respect to the general wind climate no significant influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Cork Airport are applicable for the desktop assessment of the wind comfort at the development site.

5.2 LOCAL, MAXIMUM AND MEAN WIND CONDITIONS

5.2.1 LOCAL WIND CONDITIONS

The assessment of the wind comfort conditions at the new development will be based on the dominating wind directions throughout a year (annual wind statistic).

As stated above, the local wind climate is determined from historical meteorological data recorded at Cork Airport. Two different data sets are analyzed for this assessment as follows:

- The meteorological data associated with the maximum daily wind speeds recorded over a 30 year period between 1985 and 2019 and,

- The mean hourly wind speeds recorded over a 10 year period between 2009 and 2019. The data is recorded at a weather station at the airport, which is located 10m above ground or 71mOD.

Figure 5.2, presenting the wind speed diagram for Cork, shows the days per month, during which the wind reaches a certain speed. In Figure 5.3, the wind rose for Cork shows how many hours per year the wind blows from the indicated direction, confirming how the predominant directions are W, SW and SSW.

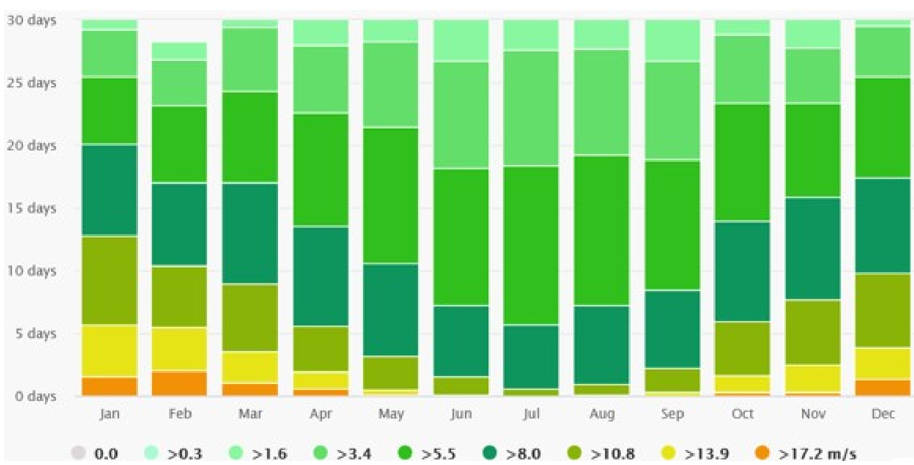


Figure 5.2: Cork Wind Speed Diagram

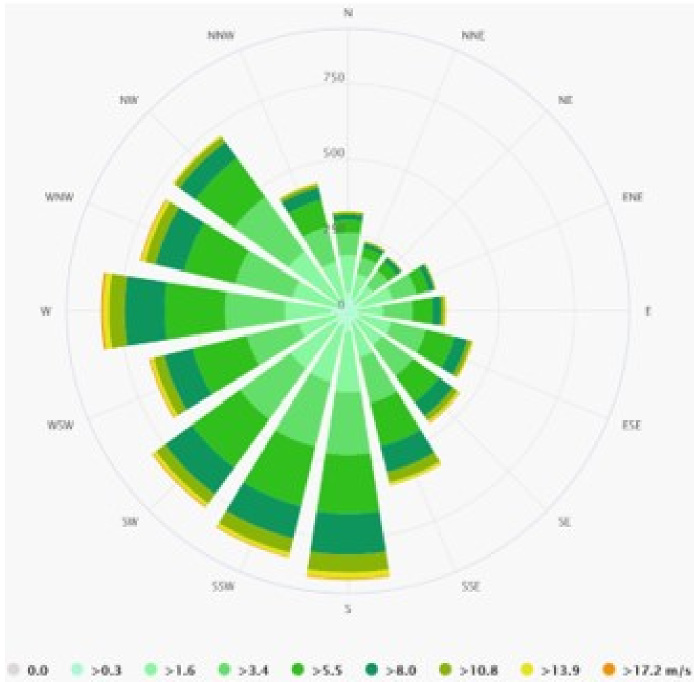


Figure 5.3: Cork Wind Rose

Based on the criterion of occurrence frequency the main wind directions to be considered in pedestrian wind comfort assessment are presented in Figure5.4 and listed below in descending order of dominance:

1. South-South-West with most frequent wind speeds around 6m/s (all year).
2. South-West
3. West.

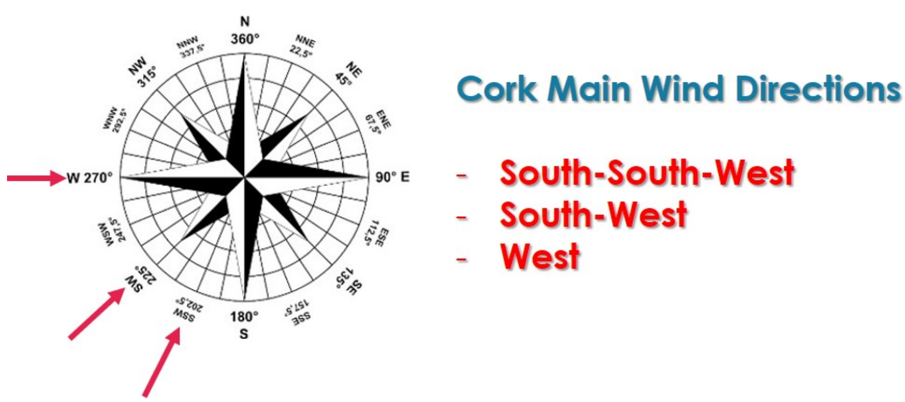


Figure 5.4: Cork Main Wind Direction

The desktop study will mainly focus on the large sector of prevailing wind directions of winds from above. Other wind directions will be discussed if deemed necessary for the study.

Cork WIND SCENARIOS AND DIRECTIONS		
Velocity (m/s)	Direction (deg)	Frequency
4.801	202.5	7.728
5.601	225	5.183
5.888	270	4.874
6.034	247.5	4.715
4.694	180	3.767
4.974	292.5	3.642
4.994	315	3.527
4.267	157.5	3.436
4.418	337.5	3.368
4.626	135	3.196
5.246	112.5	3.151
2.4	360	3.071
4.236	90	2.945
4.285	67.5	2.831
4.006	22.5	2.728
4.169	45	2.717

Table 5.1: Summary of The 16 wind scenarios modelled for Proposed development

5.2.2 MEAN AND MAXIMUM WIND CONDITIONS

Examination of the daily wind data reveals that the wind predominantly blows from South-South-West and Southwest directions, however, there is a secondary wind from the West . It is apparent that winds from other directions are rare. Maximum daily wind speeds of nearly 30 m/s were recorded in the past 30 years, however, the maximum daily winds are commonly found between 6 m/s and 15 m/s. the strongest winds arise from the West and Southwest.

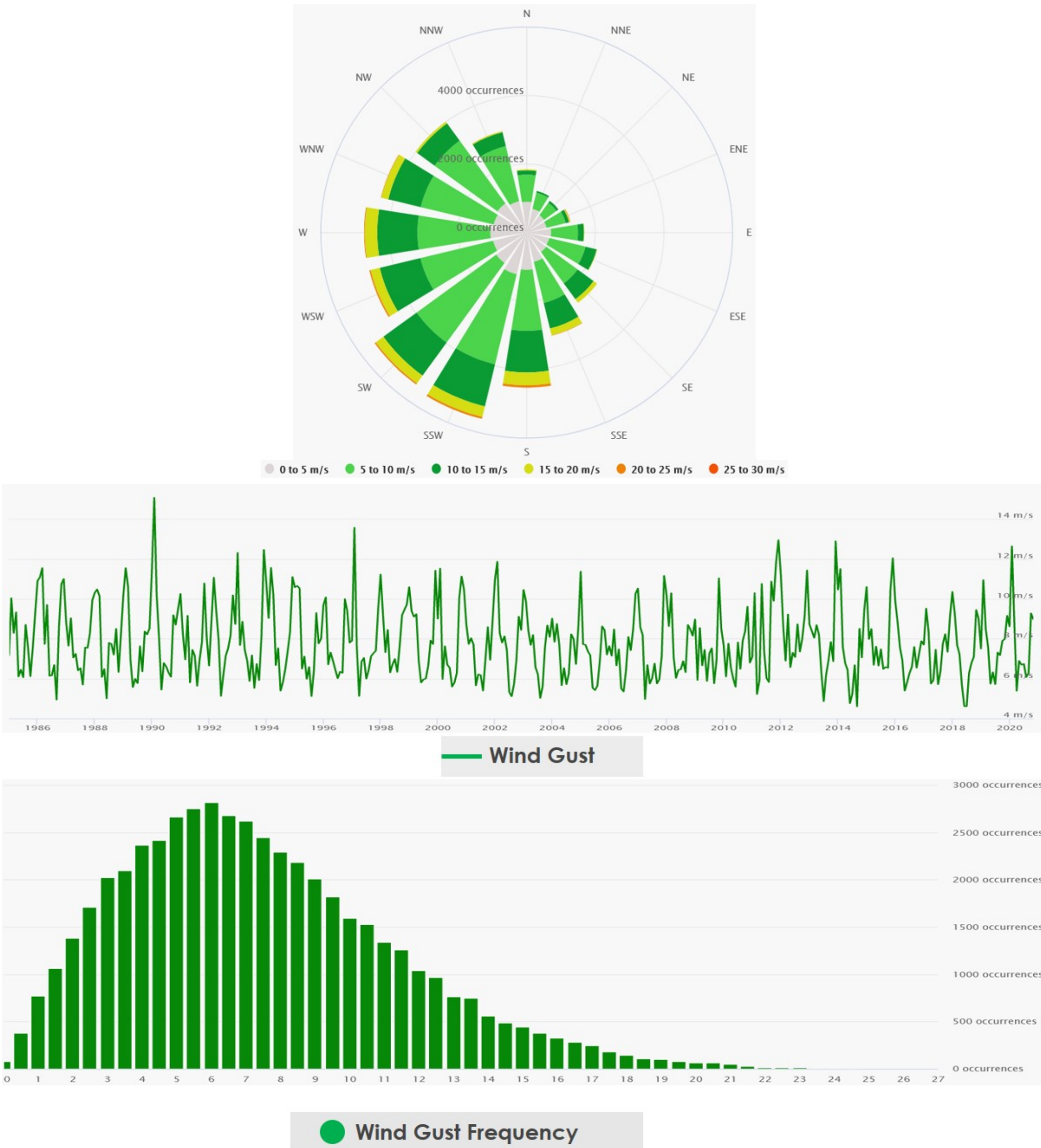


Figure 5.5: Maximum Wind Conditions

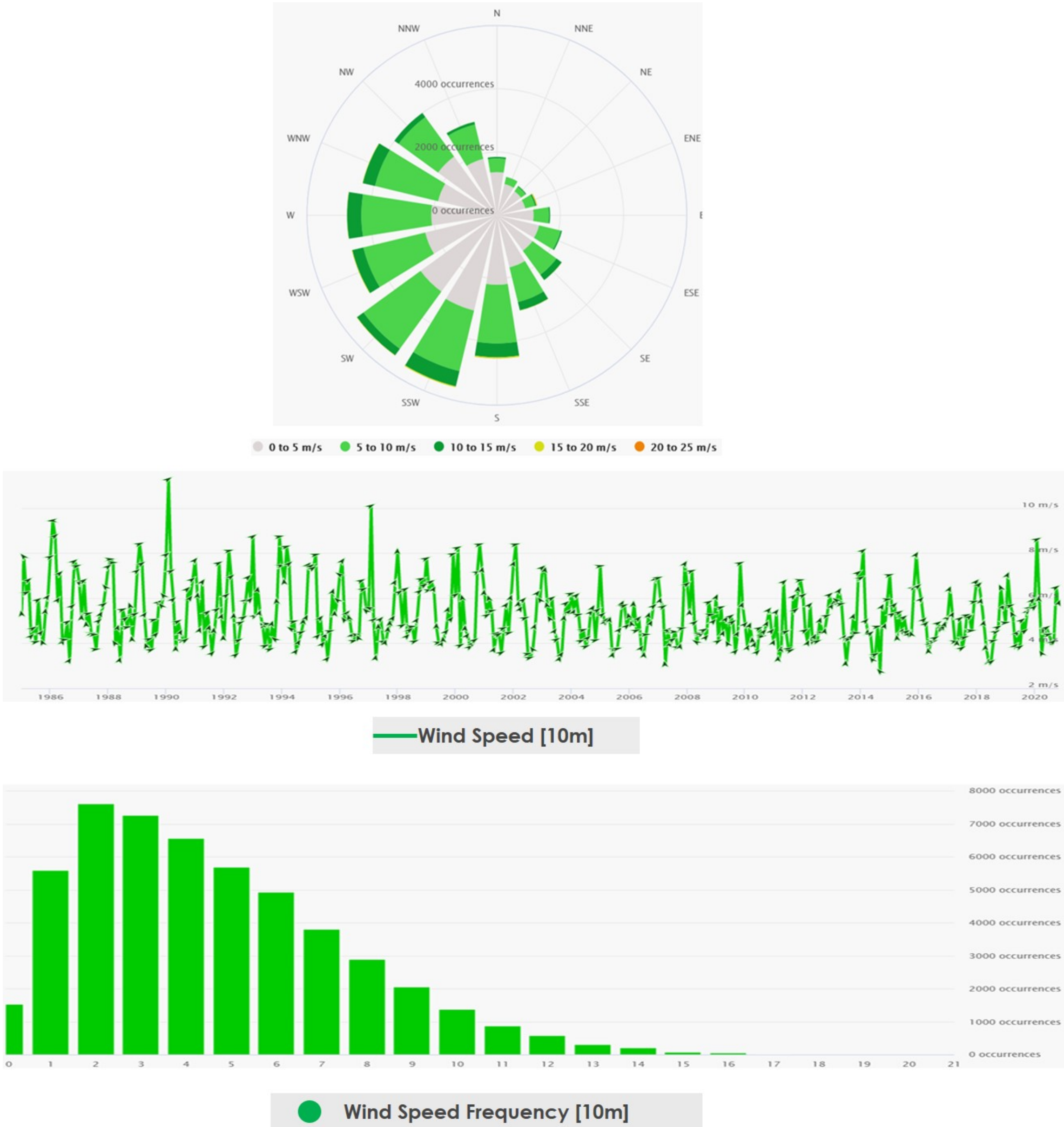


Figure 5.6: Mean Wind Conditions

5.2.3 TOPOGRAPHY and BUILT IN ENVIRONMENT

Figure 5.7 shows an aerial photograph of the Existing Environment surrounding the site of The Creamfields's Project.

The proposed development will consist of a Strategic Housing Development of 609no. dwellings (561no. apartments (of which 257no. are Build To Rent) and 48no. townhouses) in 12no. buildings of between 1-15 storeys in height over ground, to include a coffee kiosk; gym; café; retail use; creche and community hub; public square; car parking; cycle parking; and all associated site development, infrastructural, and landscaping works on the site of the former CMP Dairies site, Kinsale Road and Tramore Road, Cork.

The area surrounding the site can be characterised as urban environment. Some shelter effect can be expected for wind approaching from directions within this sector. All for the study considered main wind directions of west to south-west and south-south-west are in this connection "urban winds" and no distinction will be made between them.

Figure 5.8 shows the model of the proposed development and view of the Built-in environment.

Figure 5.7: Built-in environment around construction site at the Creamfields's project

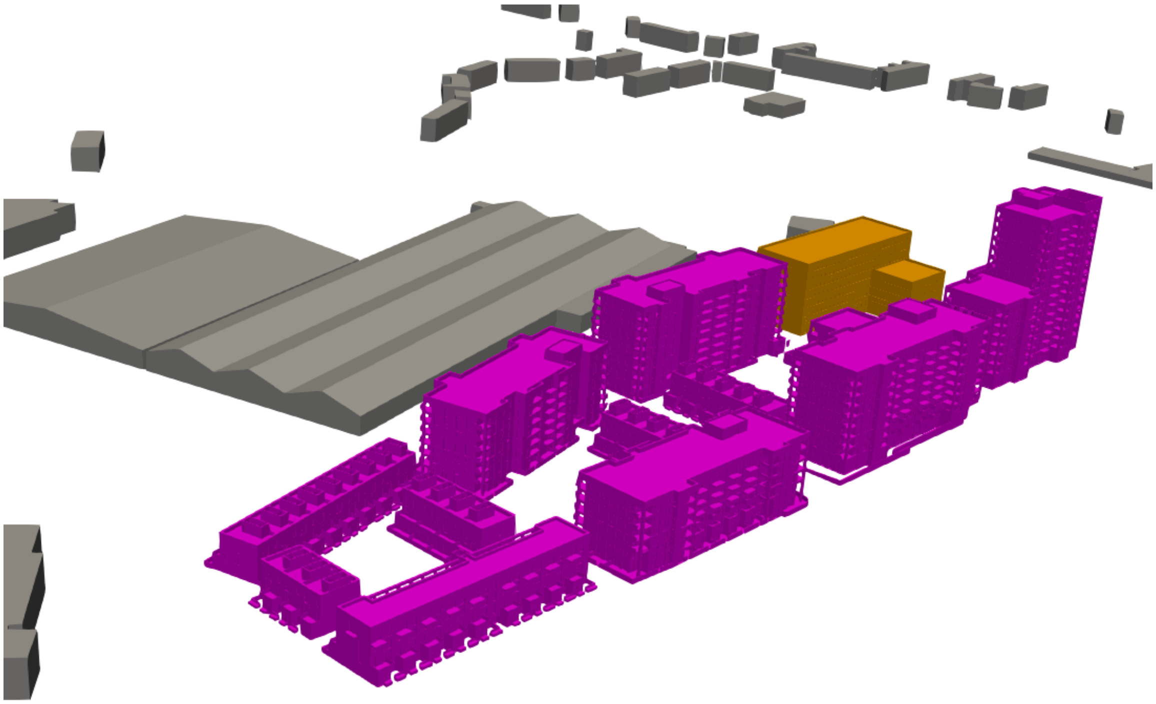


Figure 5.8: Model of the proposed development and view of the Built-in environment.

5.2.4 OPEN AREA FUNCTIONS

The assessment of pedestrian wind comfort in urban areas focuses on activities people are likely to perform in the open space between buildings, which are in turn related to a specific function. For example the activity sitting a longer period of time is typically associated with the location of a street café or similar. Such combinations of activity and area can be grouped in four main categories:

A	Sitting for a long period of time; laying steady position; pedestrian sitting; *Terrace; street café or restaurant; open field theatre; pool*
B	Pedestrian standing; standing/sitting over a short period of time; short steady positions; *Public park; playing field; shopping street; mall*
C	Pedestrian walking; leisurely walking; normal walking; ramble; stroll *Walkway; building entrance; shopping street; mall*
D	Objective business walking; brisk or fast walking *Car park; avenue; sidewalk; belvedere*

Figure 5.9: Main Categories for Pedestrian Activities

5.2.5 WIND COMFORT ASSESSMENT

In order to conduct the wind comfort assessment, Figure 5.10 shows the orientation of the Creamfields development.

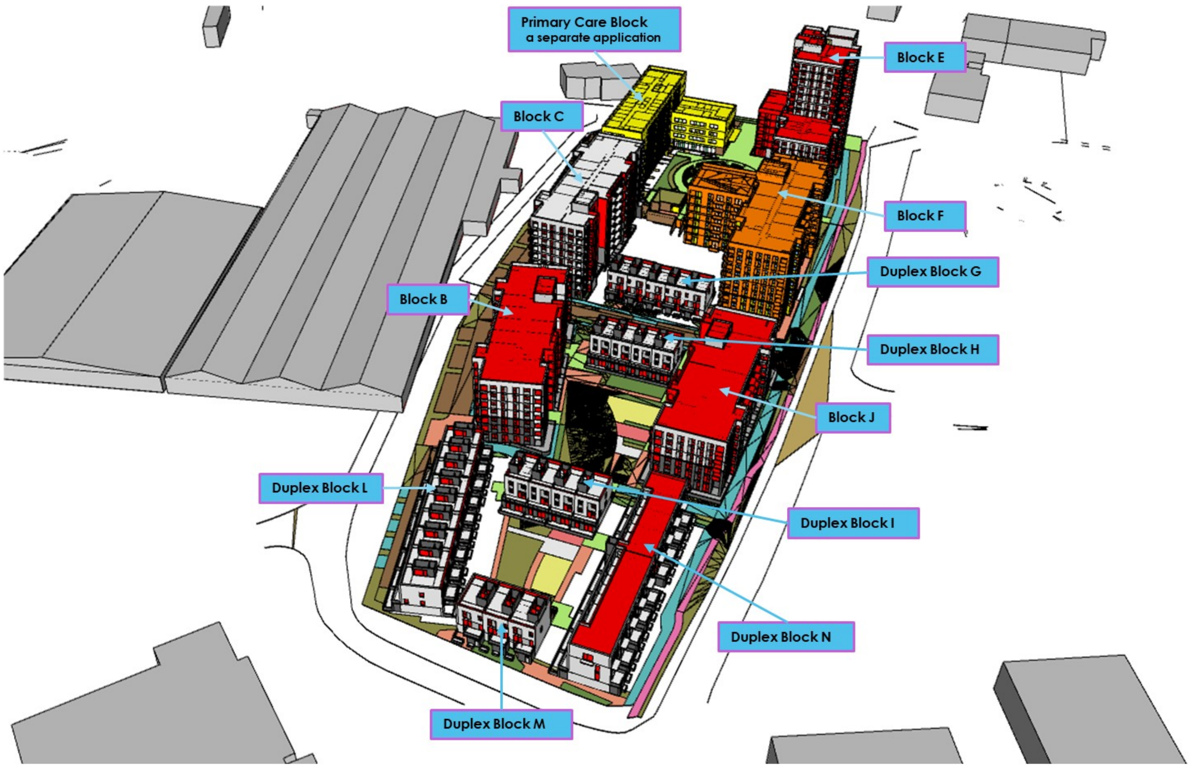


Figure 5.10: Creamfields Development, Kinsale Road, Cork, Blocks Arrangement

WIND FROM SOUTH-WEST

The different flow features are indicated in Figure 5.11 by letters and discussed in the following text. It should be kept in mind that the presented flow pattern is only indicative and based on experience and fundamental fluid mechanical principles and does not reflect the real flow vector in magnitude and direction.

The wind will flow through the West buildings, that provide a good shielding for the entire development. No issues are found to be critical in terms of safety.

Higher velocities effects could be experienced in areas i, ii and iii. However, possible solutions for this could be horizontal canopies on the windward face of a base building, which improve pedestrian level wind conditions. Parapet walls around a canopy can make the canopy more effective. Sloped canopies only provide partial deflection of downward wind flow.The use of rows of trees on either sides of the roads corresponding to these three areas have been implemented to contrast the above effects. It must be considered also that the South West wind will be mitigate at the entrance by flowing through the large courtyard, this area is provided with trees and it is enveloped by buildings of similar heights. The flow will loose speed once entering the courtyard from the South-West direction. Also, an air circulation zone is expected in iv, v, vi and vii that can cause downwash effect. However this seem to be mitigated by the presence of the trees.

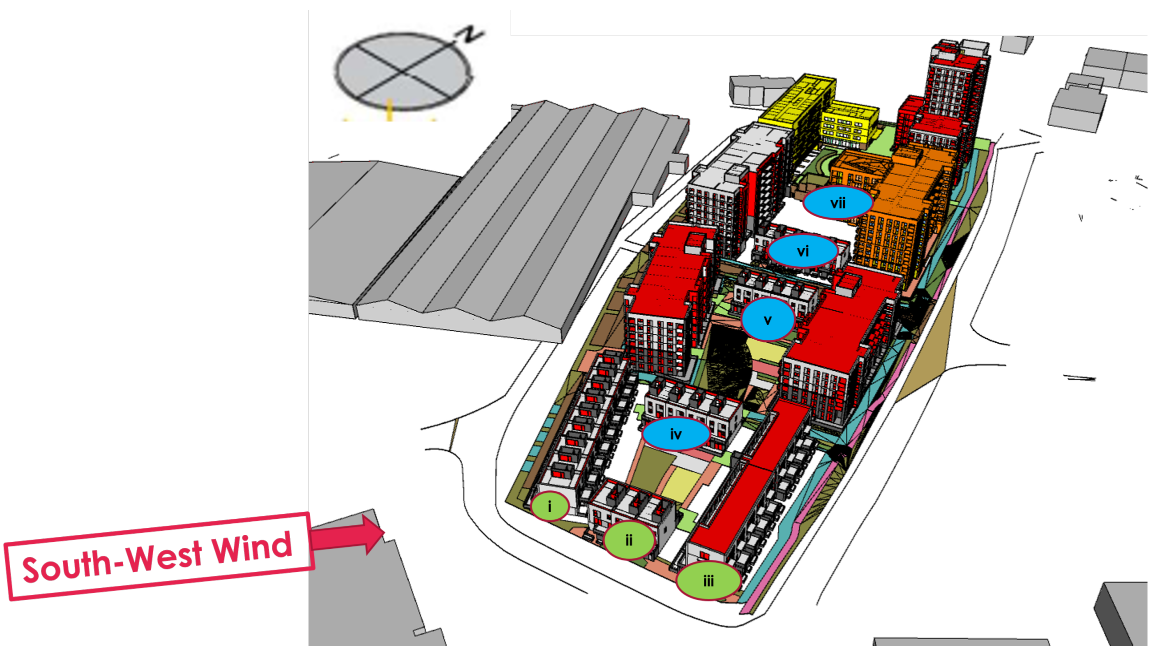


Figure 5.11: Flow around the buildings at the Creamfields development for wind from Southwest

WIND FROM WEST

The wind will flow through the avenue, which is well shielded by the vegetation.The landscape implemented seem to guarantee a good shielding of the areas around the units. No major issues are found to be critical.

The existing Creamfields development, in the west direction of the development will deviate the airflow along its west façades. Wind funnelling effects could be experienced in areas (Viii, iX, X, Xi, Xii and Xiii). However this seem to be mitigated by the presence of the trees.

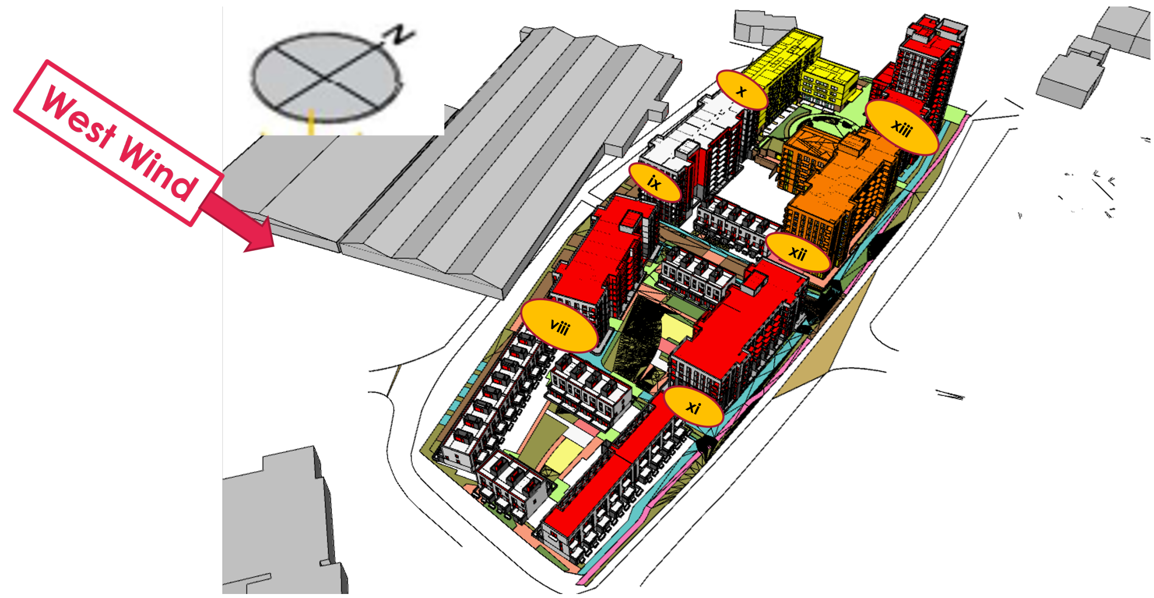


Figure 5.12: Flow around the buildings at the Creamfields development for wind from West

WIND FROM SOUTH-SOUTH-WEST

The wind will flow through the avenue, which is well shielded by the vegetation. The landscape implemented seem to guarantee a good shielding of the areas around the units. No major issues are found to be critical.

Air circulation zone is expected in XIV, XV, XVI, XVII and XVIII that can cause downwash effect. However this seem to be mitigated by the presence of the trees.

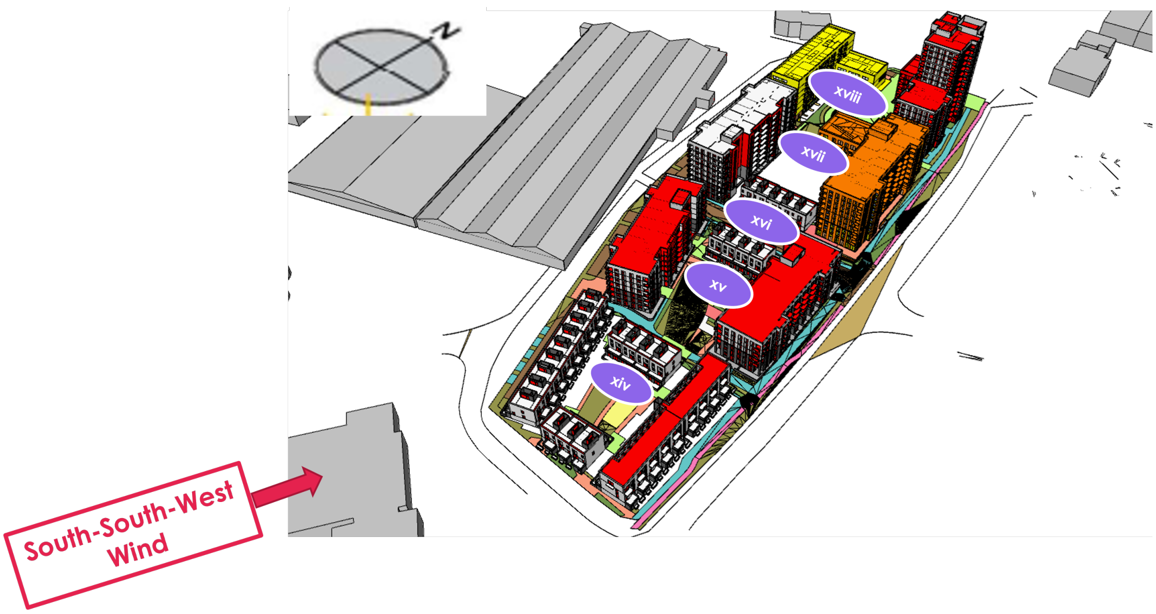


Figure 5.13: Flow around the buildings at the Creamfields development for wind from South-South-West

6. WIND IMPACT RESULTS

6.1 CFD RESULTS

It is of interest at this point to underline again the objectives of the CFD simulations. In particular:

- Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the development on pedestrian level wind conditions.
- The objective is to maintain comfortable and safe pedestrian level wind conditions that are appropriate for the season and the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

Results of the simulations carried out are detailed in the following Sections. The results present the parameters outlined in the acceptance criteria section described previously. Slices of the following parameters are collected throughout the simulation time and shown for steady state times:

- Flow Velocity
- Lawson Map

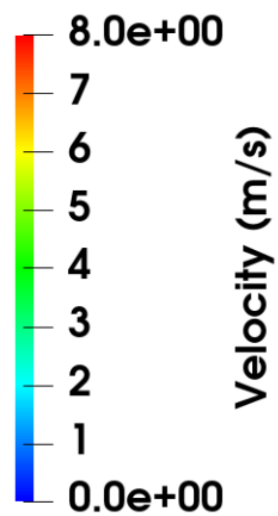


Figure 6.1: Velocity Colour Map

Red colors indicate critical values while blue colors indicate tenable conditions.

The arrangement of blocks are shown in Figure 6.2.

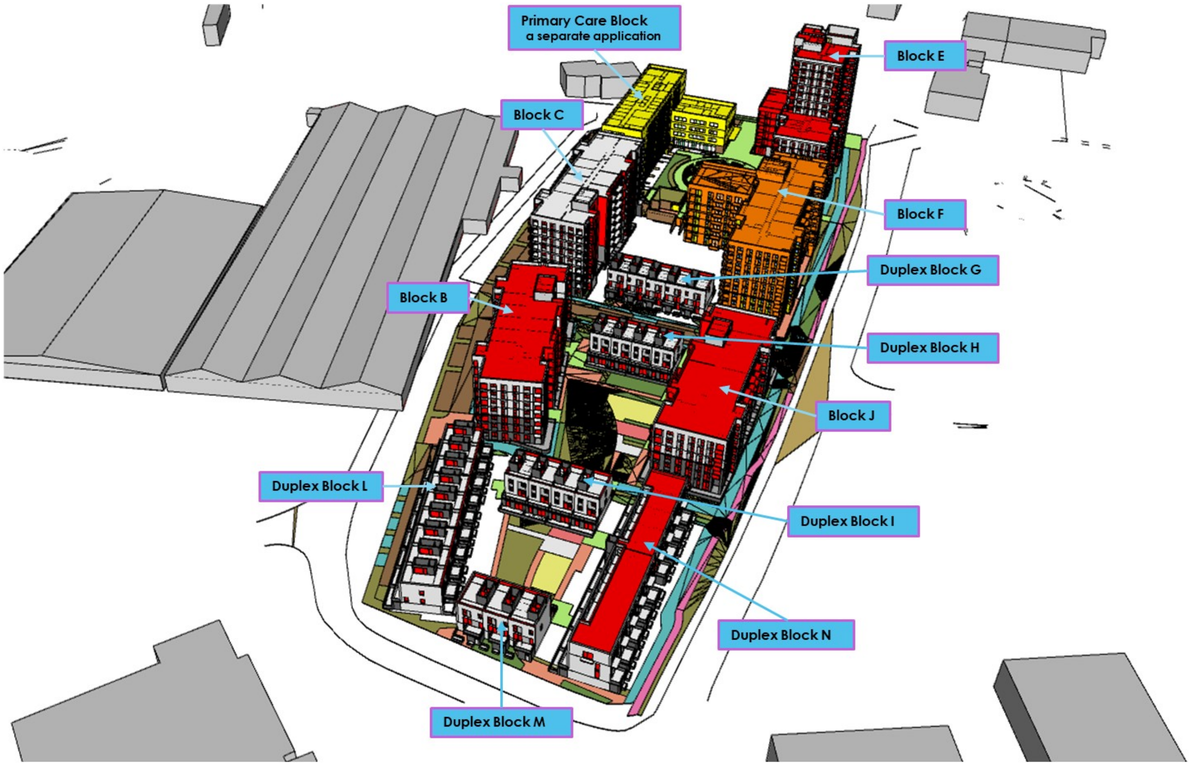


Figure 6.2: Creamfields Development, Kinsale Road, Cork, Blocks Arrangement

6.2 Wind Velocity Impact On Development

Wind 157° Direction

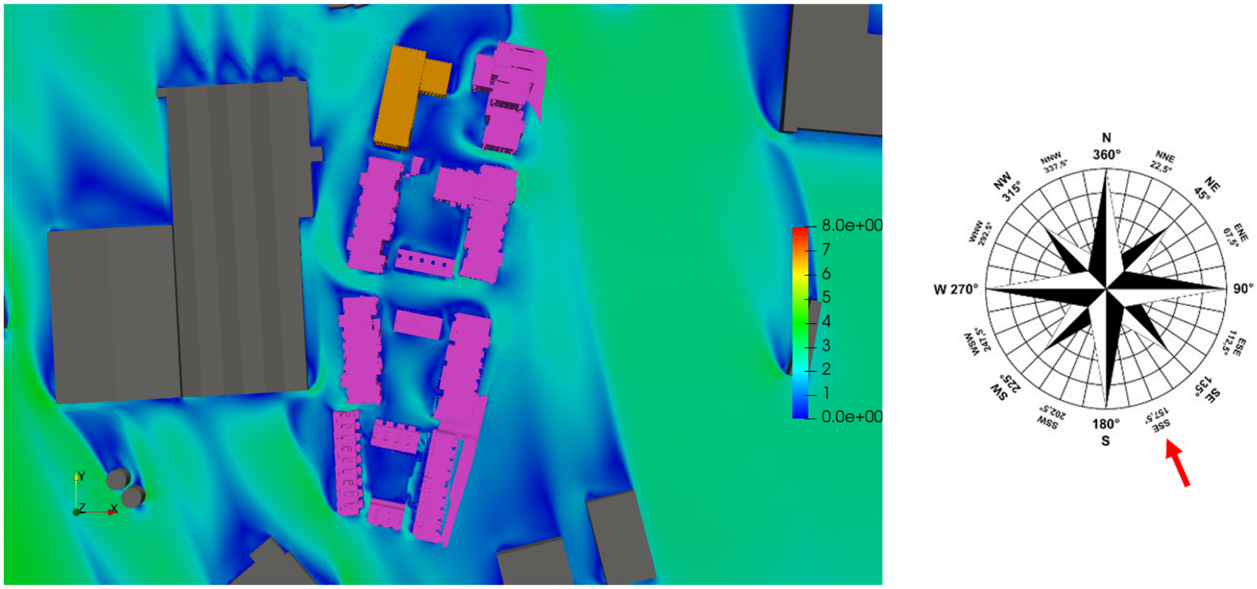


Figure 6.3: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 157°

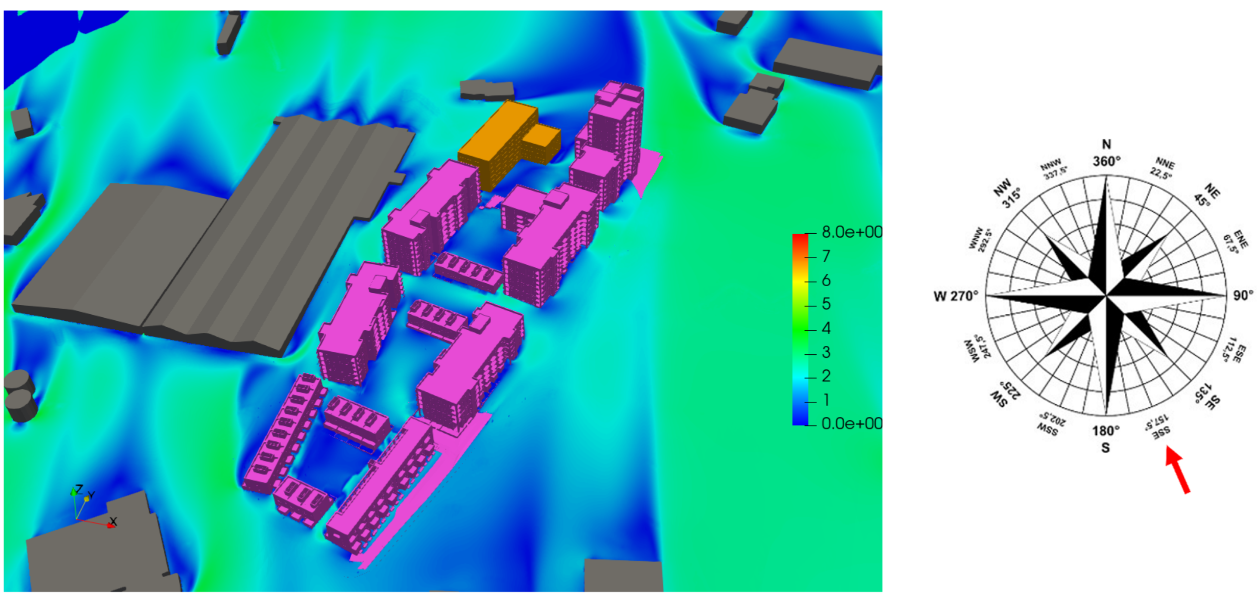


Figure 6.4: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 157°

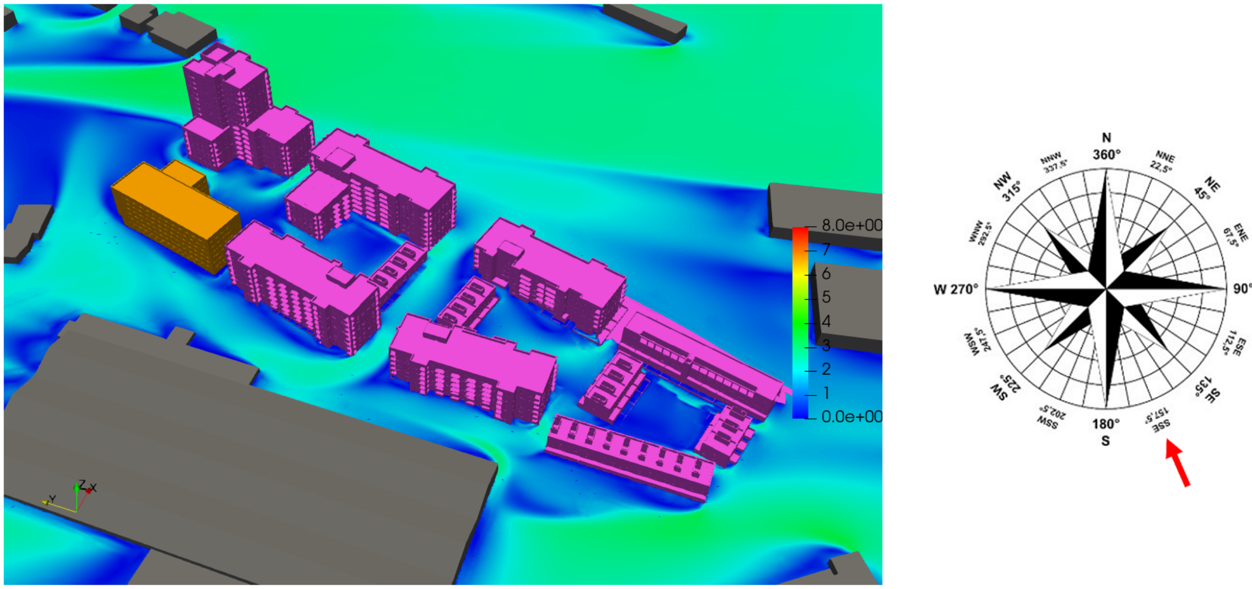


Figure 6.5: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 157°

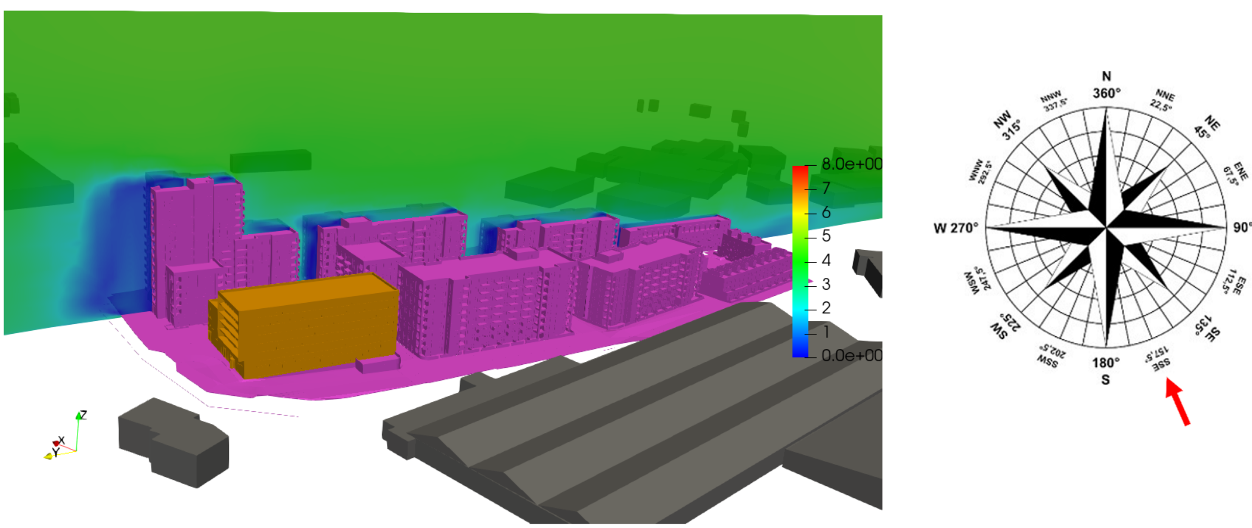


Figure 6.6: Isometric View- Flow Velocity Results - Wind Direction: 157°

Wind 180° Direction

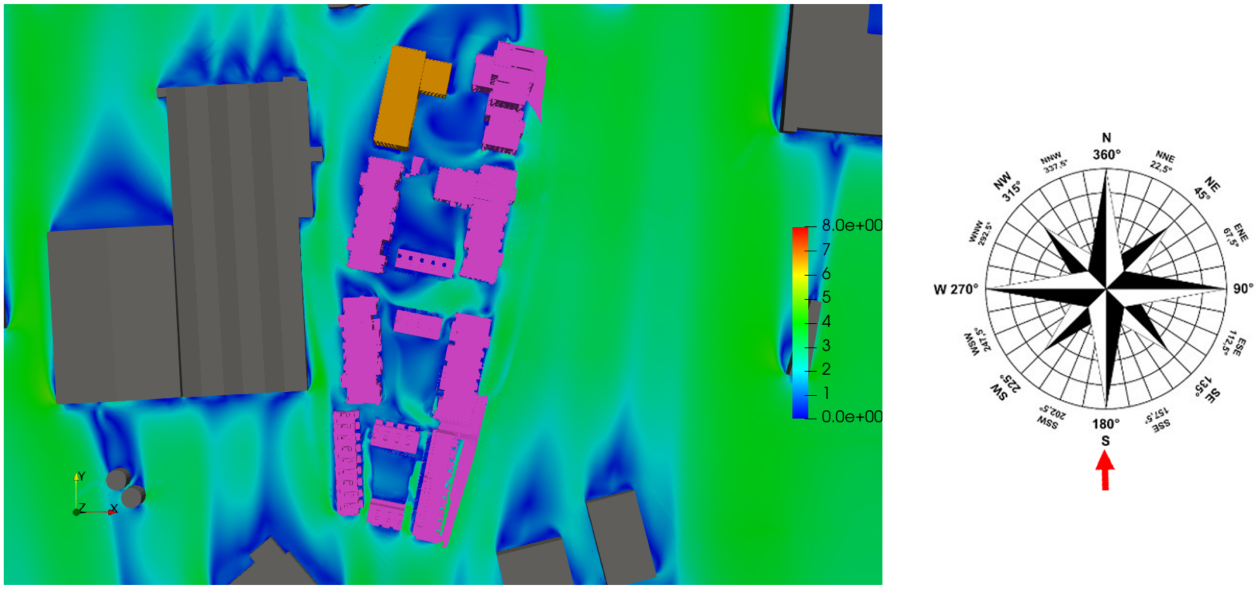


Figure 6.7: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 180°

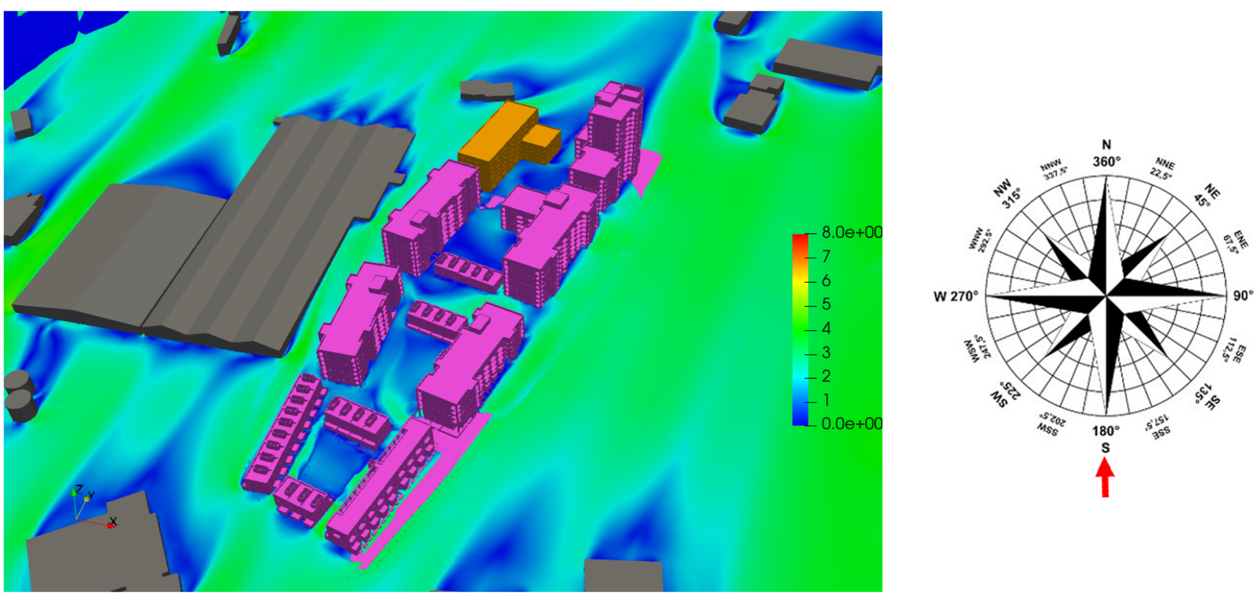


Figure 6.8: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 180°

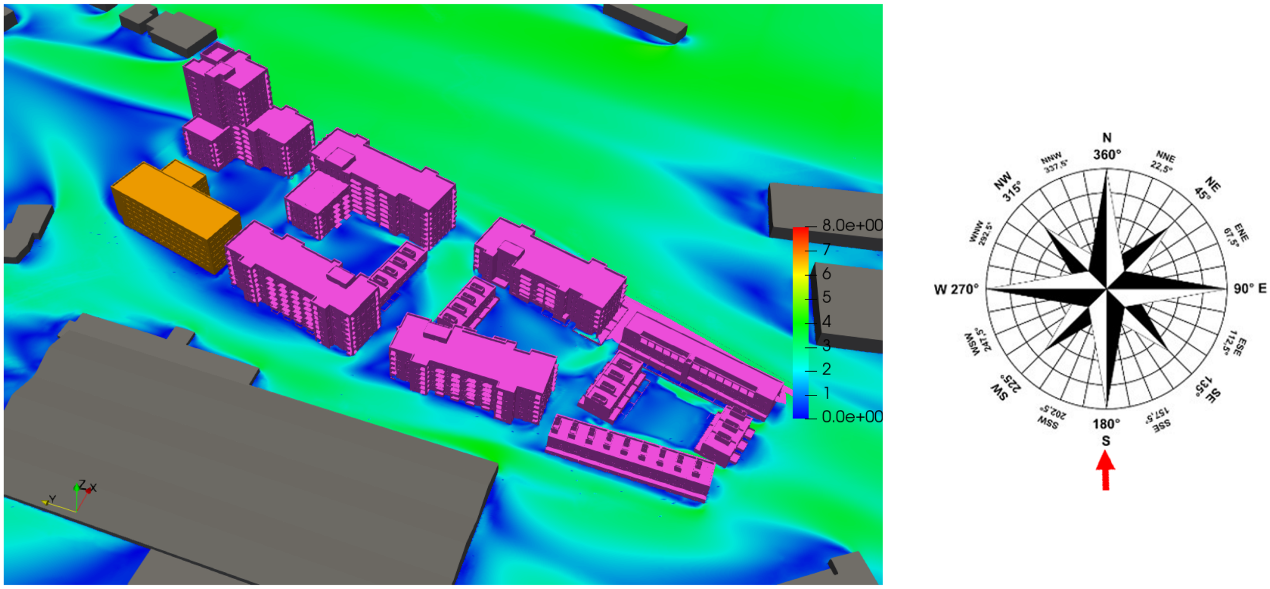


Figure 6.9: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 180°

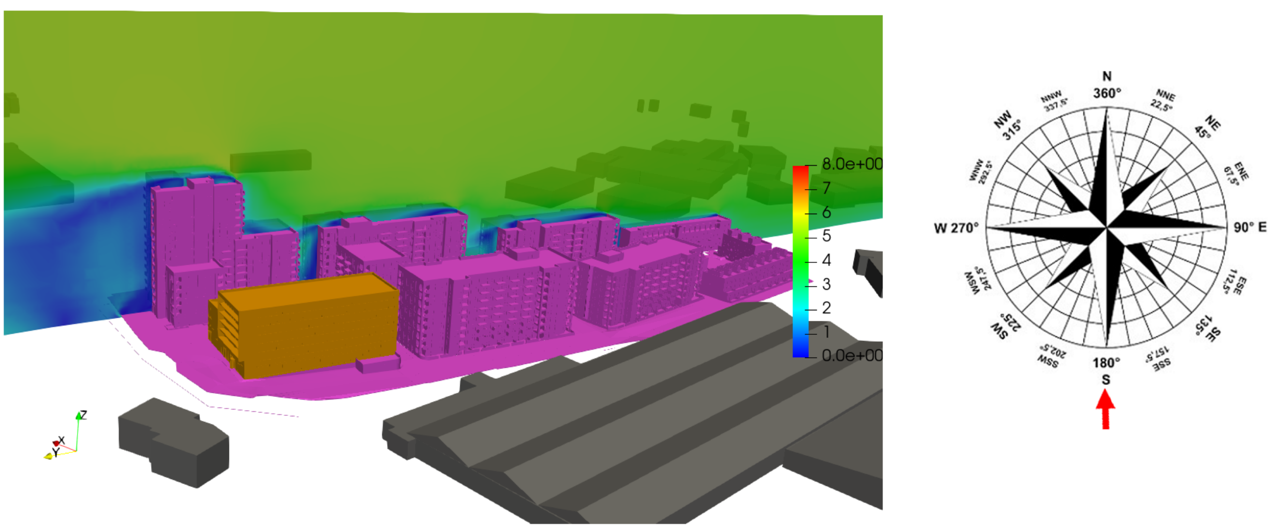


Figure 6.10: Isometric View- Flow Velocity Results - Wind Direction: 180°

Wind 202° Direction

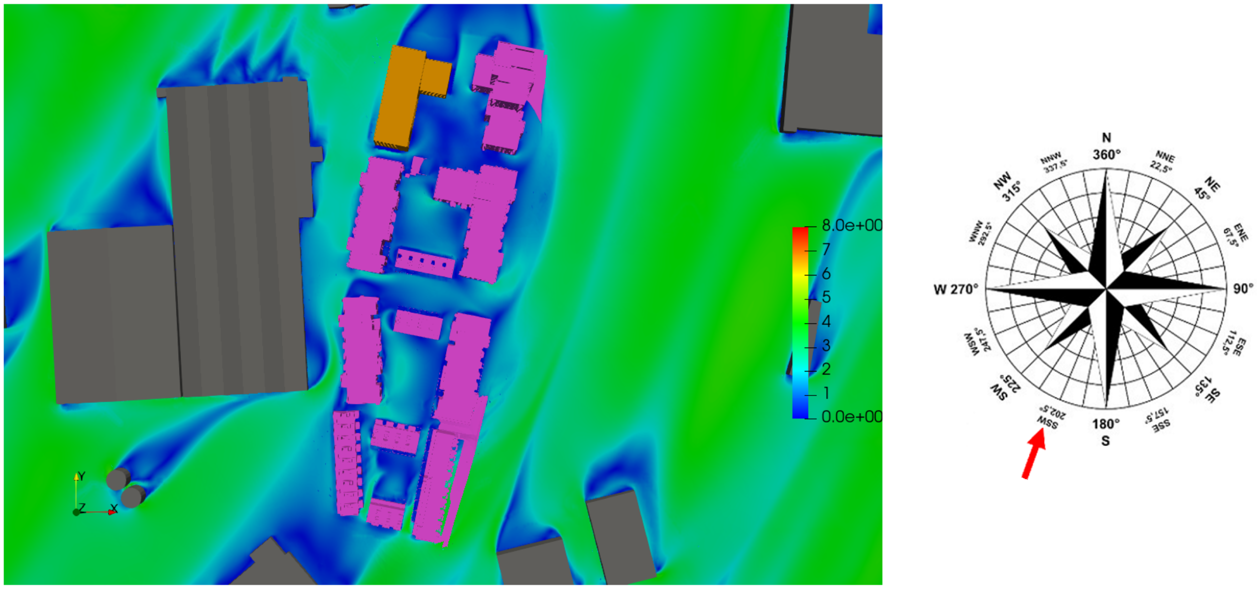


Figure 6.11: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 202°

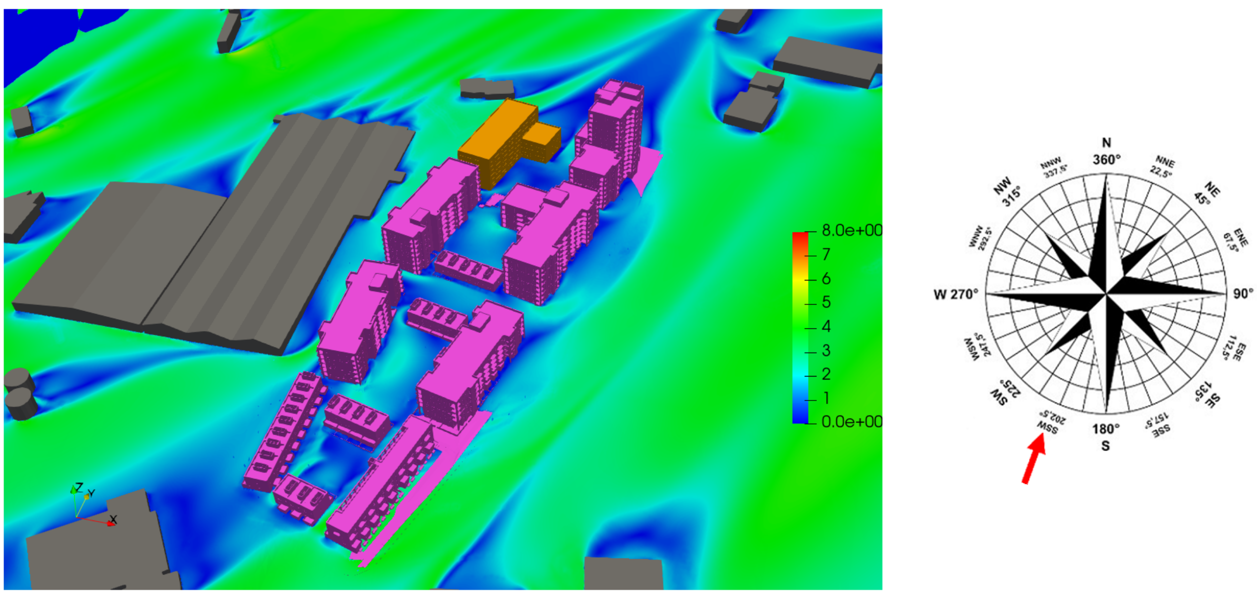


Figure 6.12: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 202°

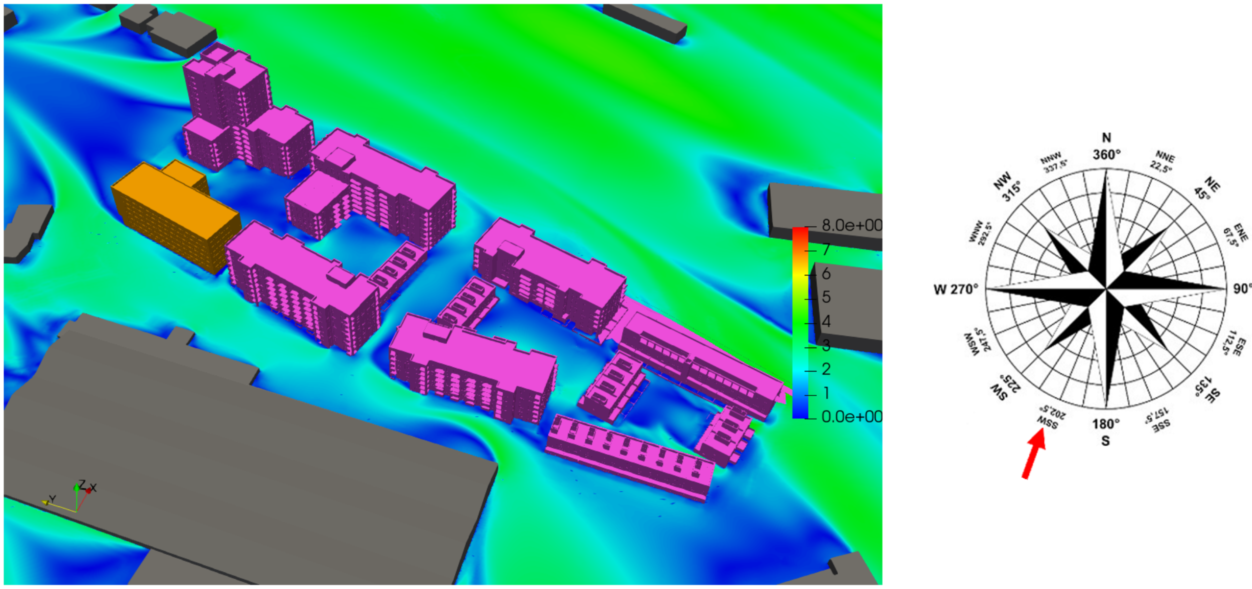


Figure 6.13: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 202°

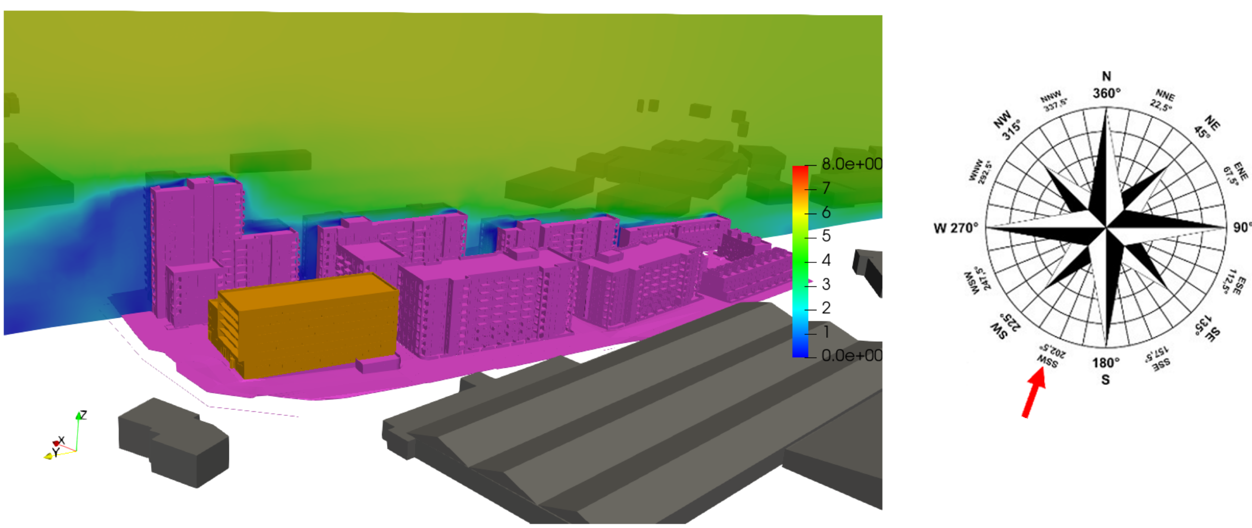


Figure 6.14: Isometric View- Flow Velocity Results - Wind Direction: 202°

Wind 225° Direction

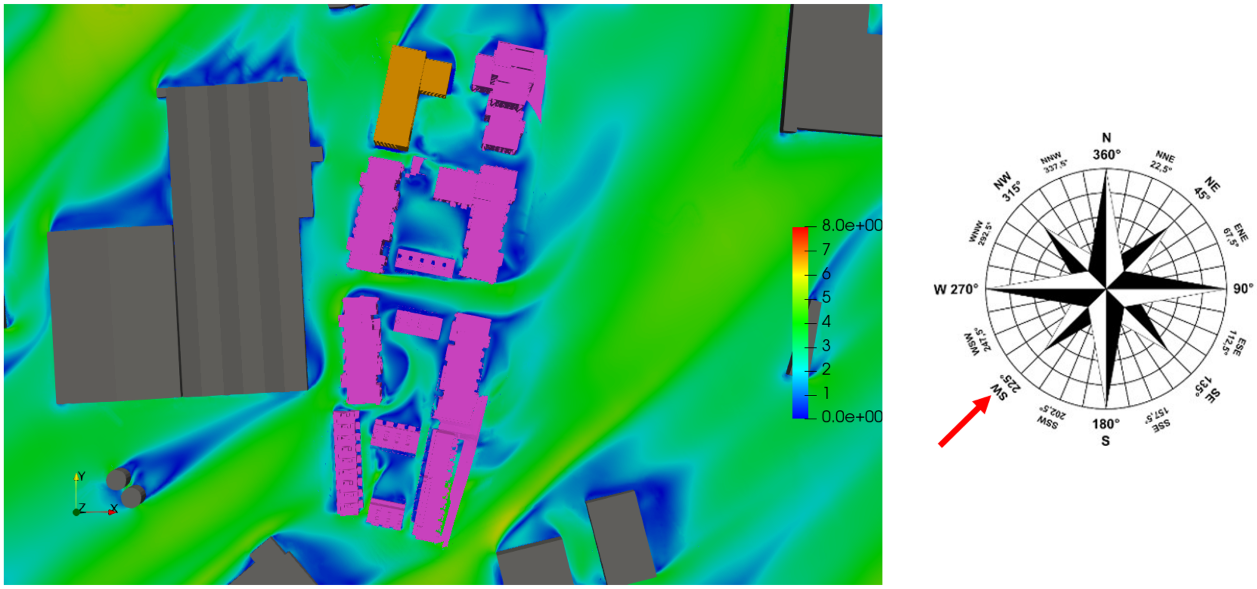


Figure 6.15: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 225°

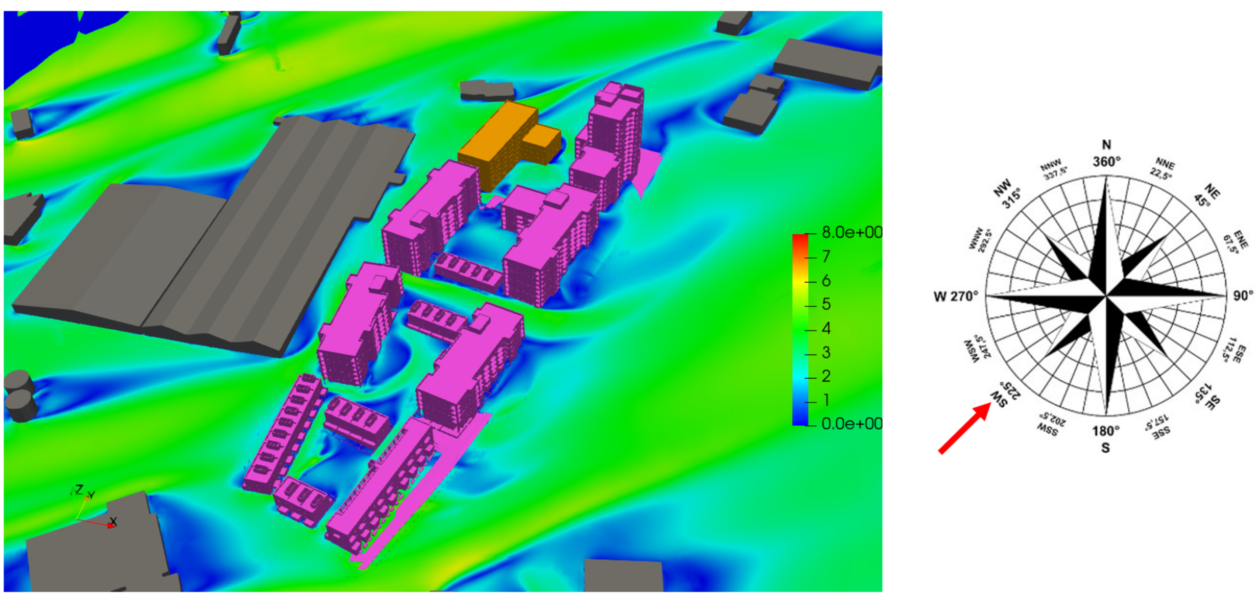


Figure 6.16: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 225°

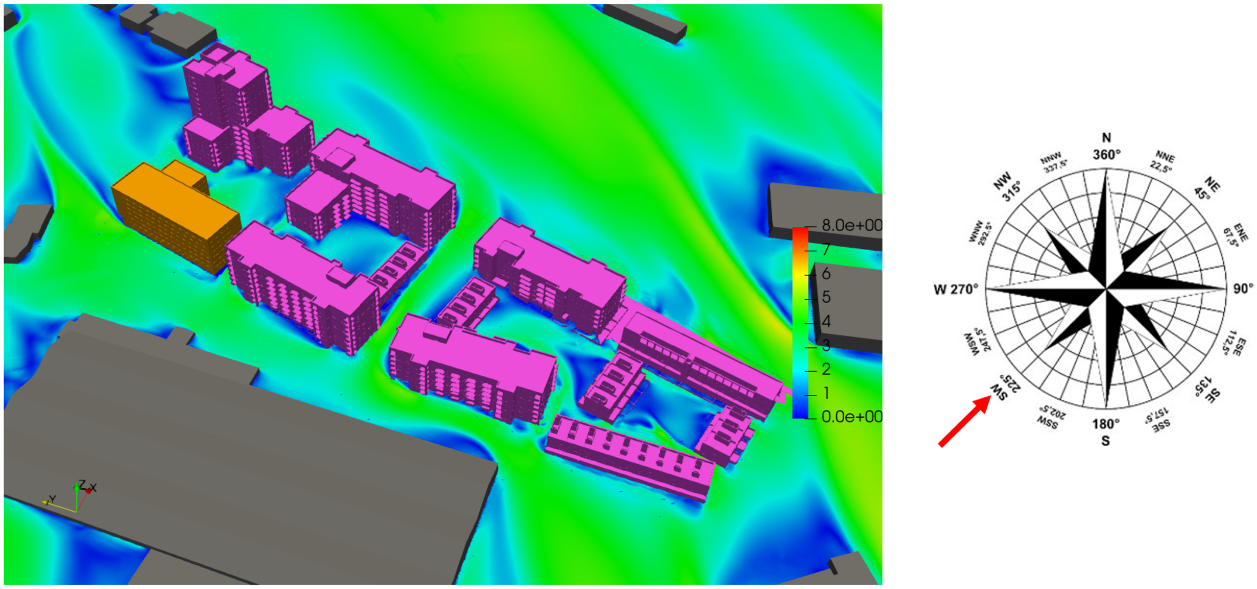


Figure 6.17: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 225°

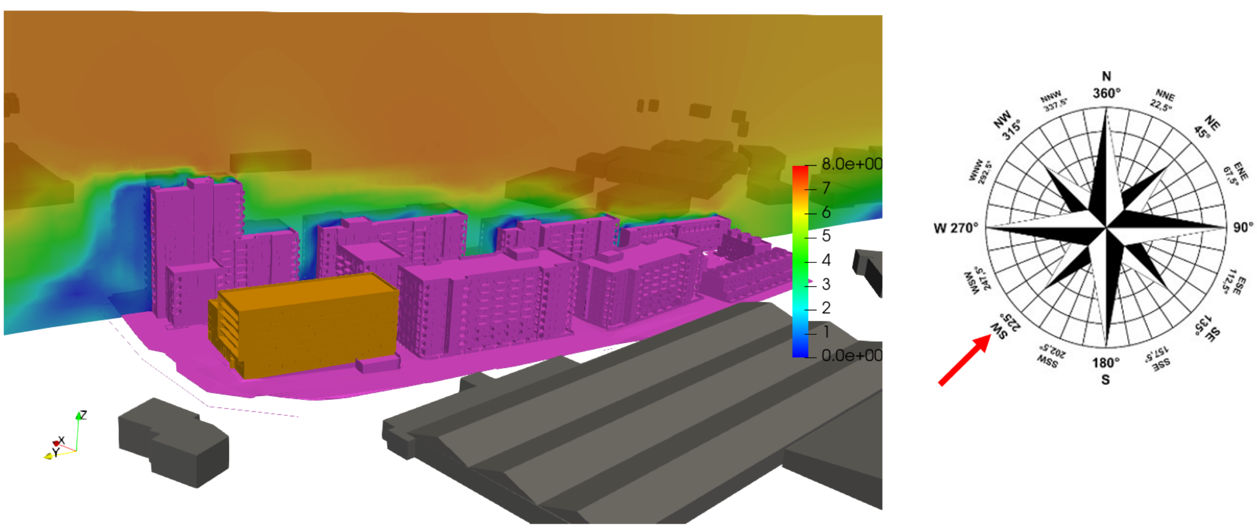


Figure 6.18: Isometric View- Flow Velocity Results - Wind Direction: 225°

Wind 247° Direction

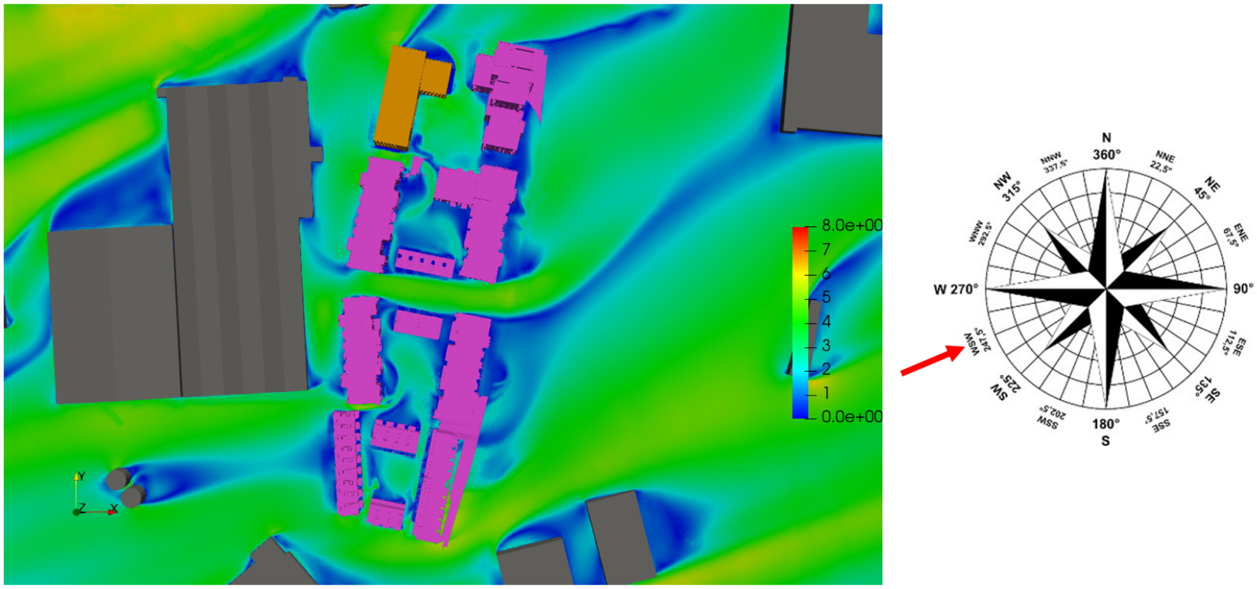


Figure 6.19: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 247°

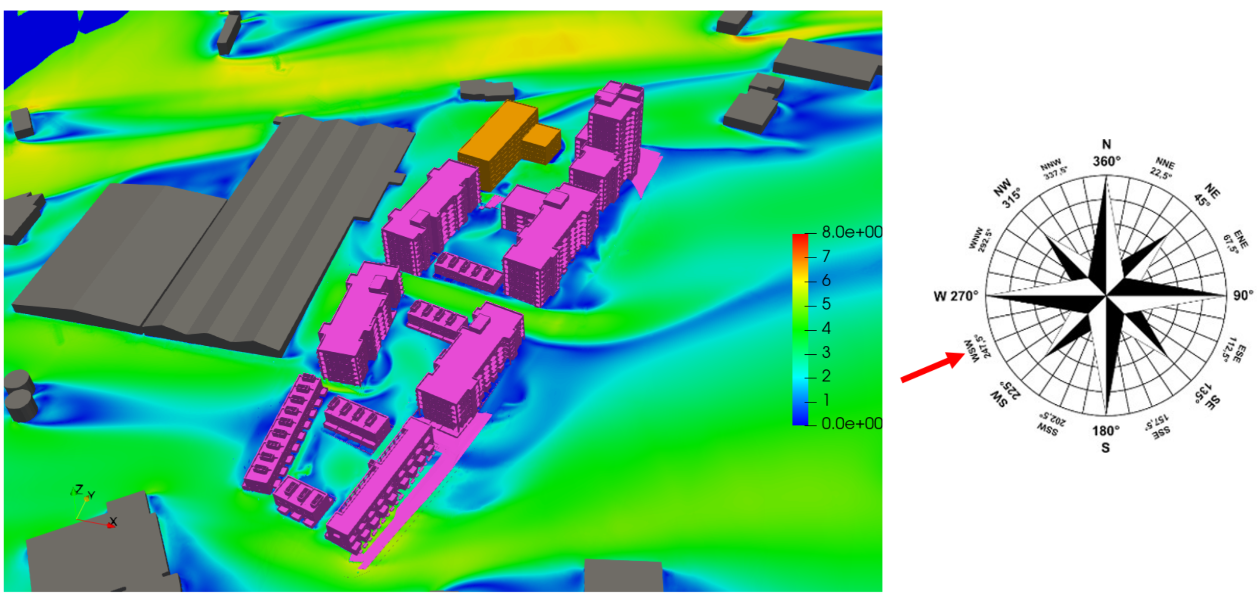


Figure 6.20: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 247°

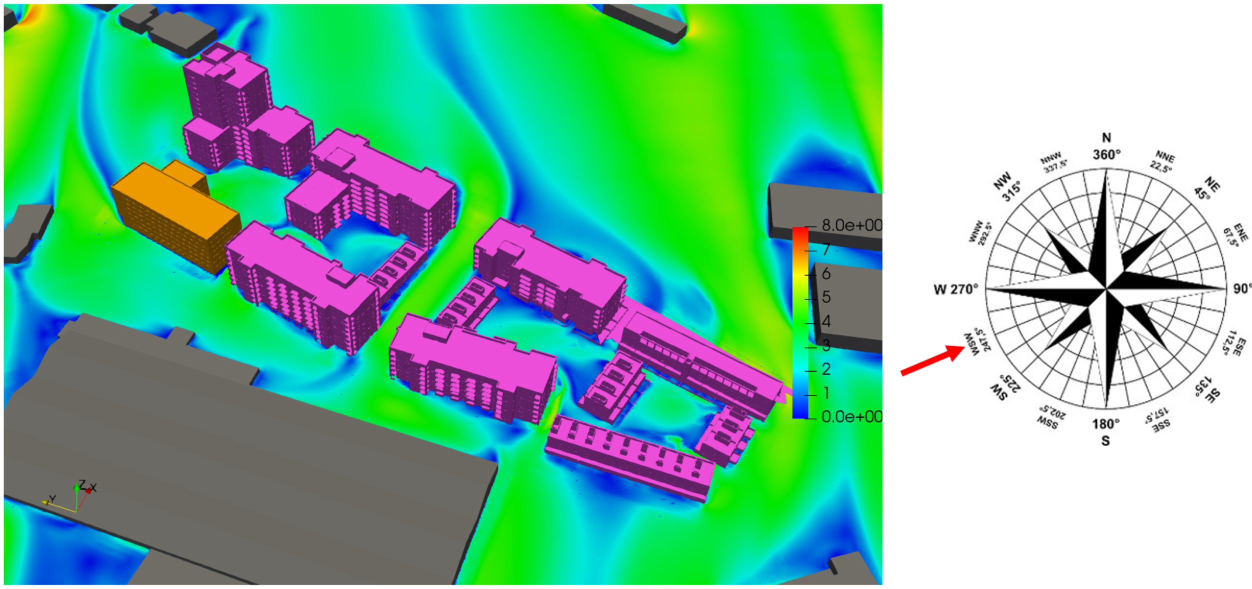


Figure 6.21: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 247°

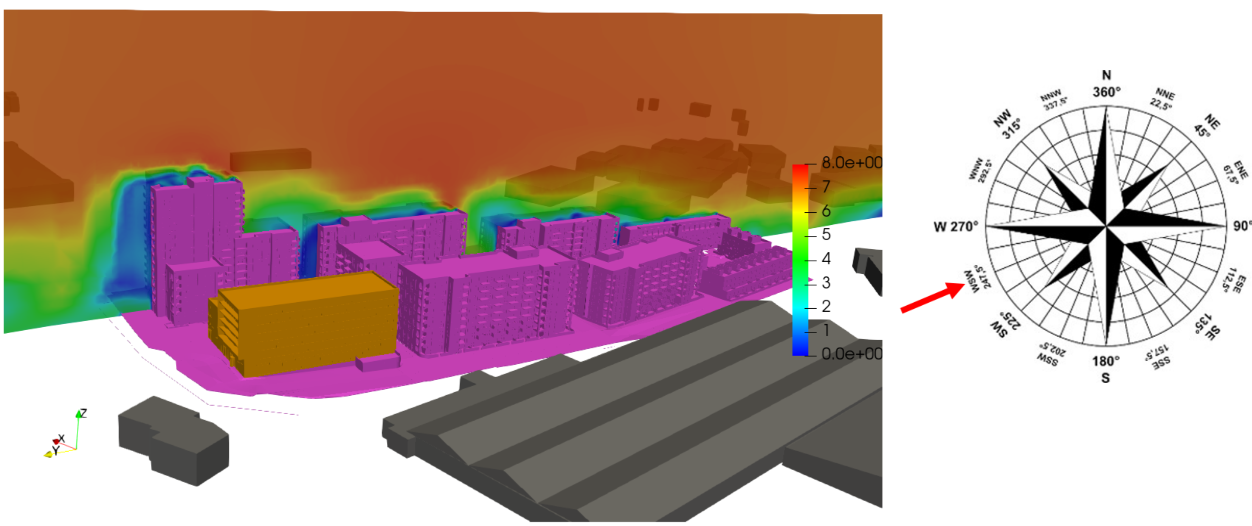


Figure 6.22: Isometric View- Flow Velocity Results - Wind Direction: 247°

Wind 270° Direction

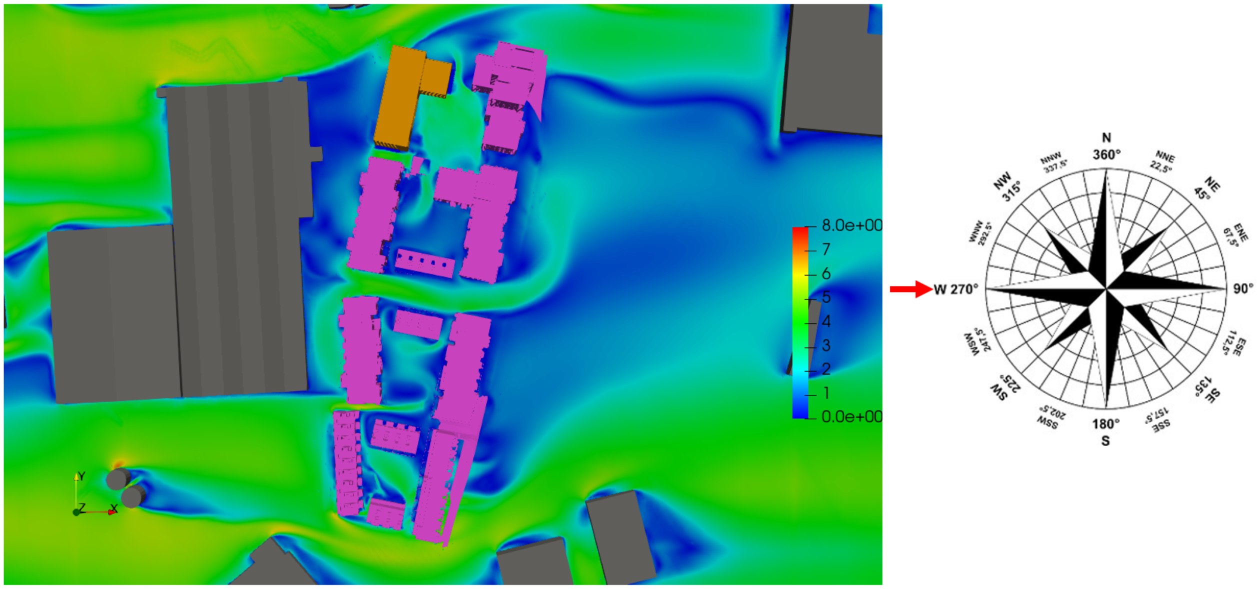


Figure 6.23: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 270°

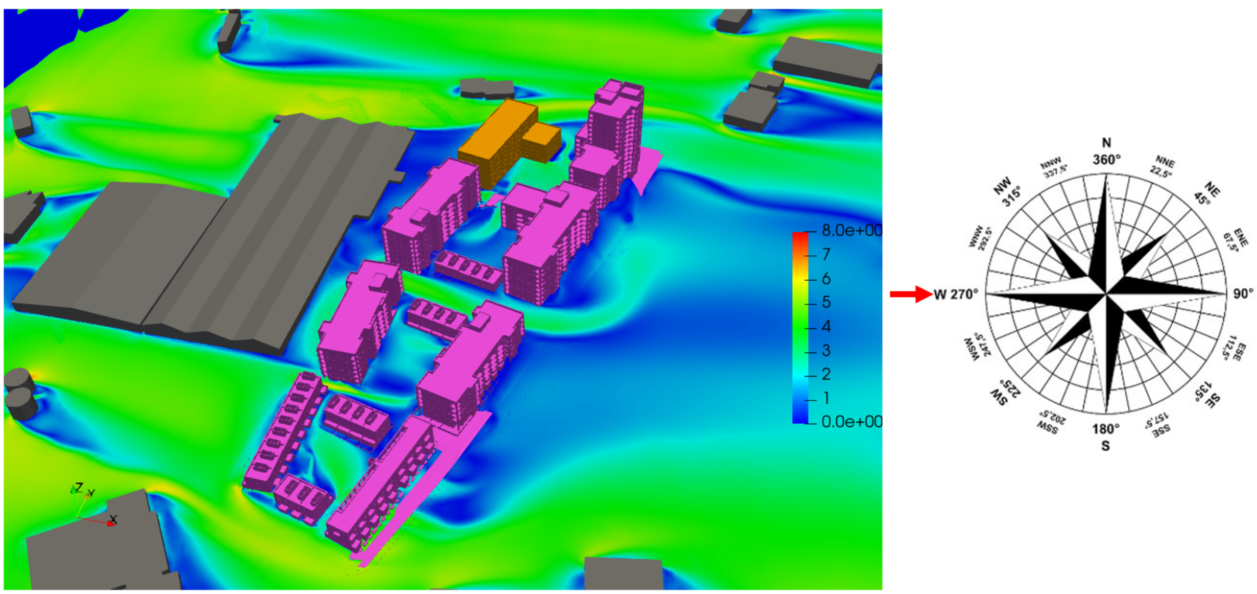


Figure 6.24: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 270°

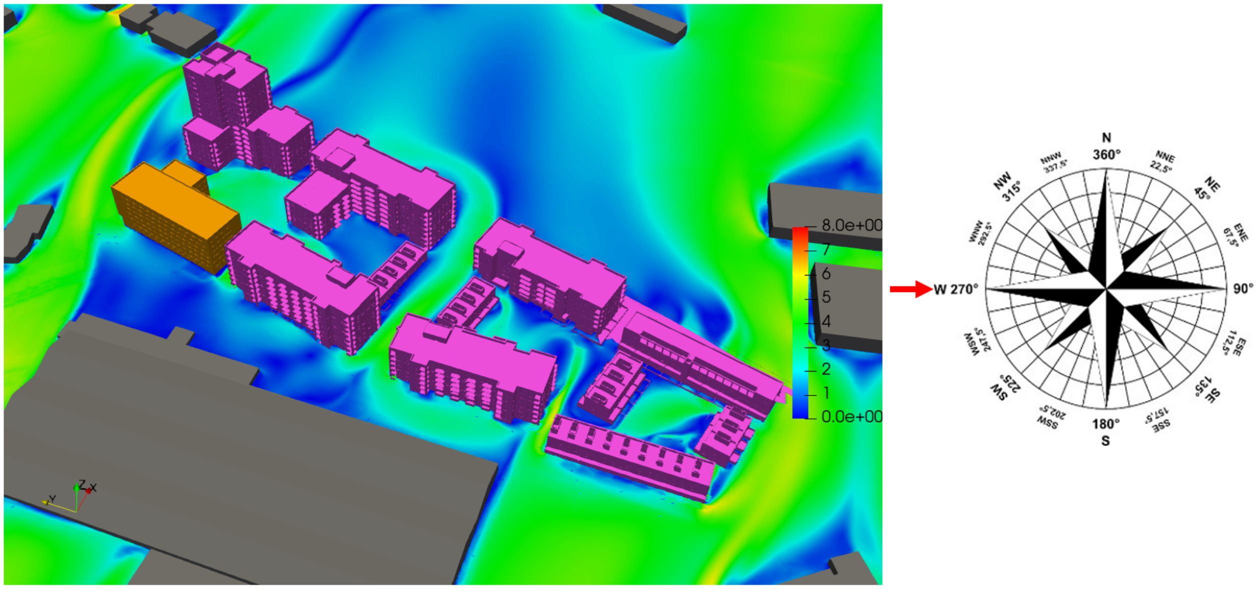


Figure 6.25: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 270°

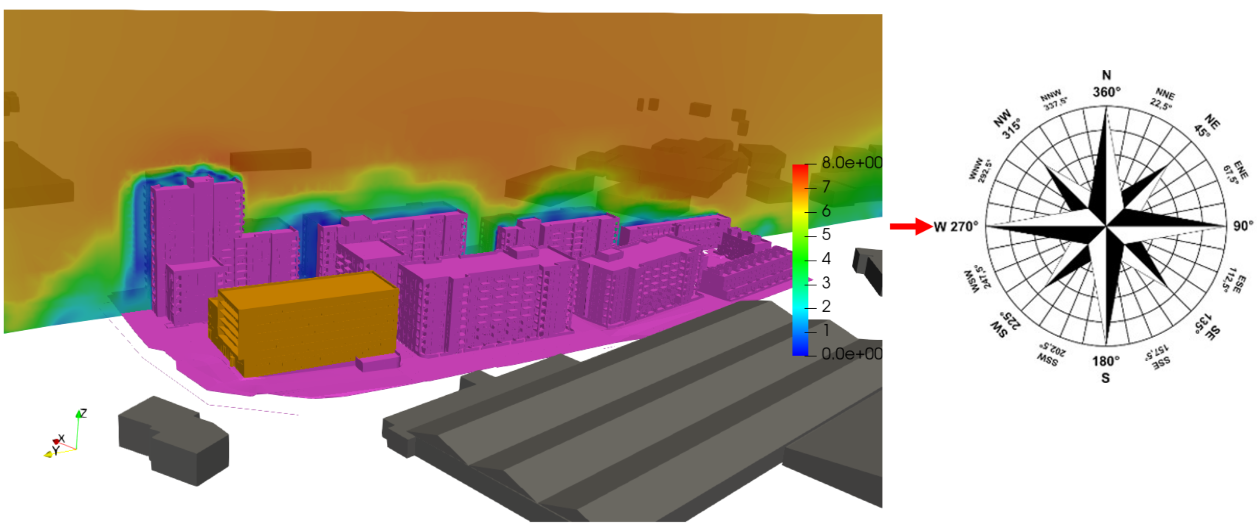


Figure 6.26: Isometric View- Flow Velocity Results - Wind Direction: 270°

Wind 292° Direction

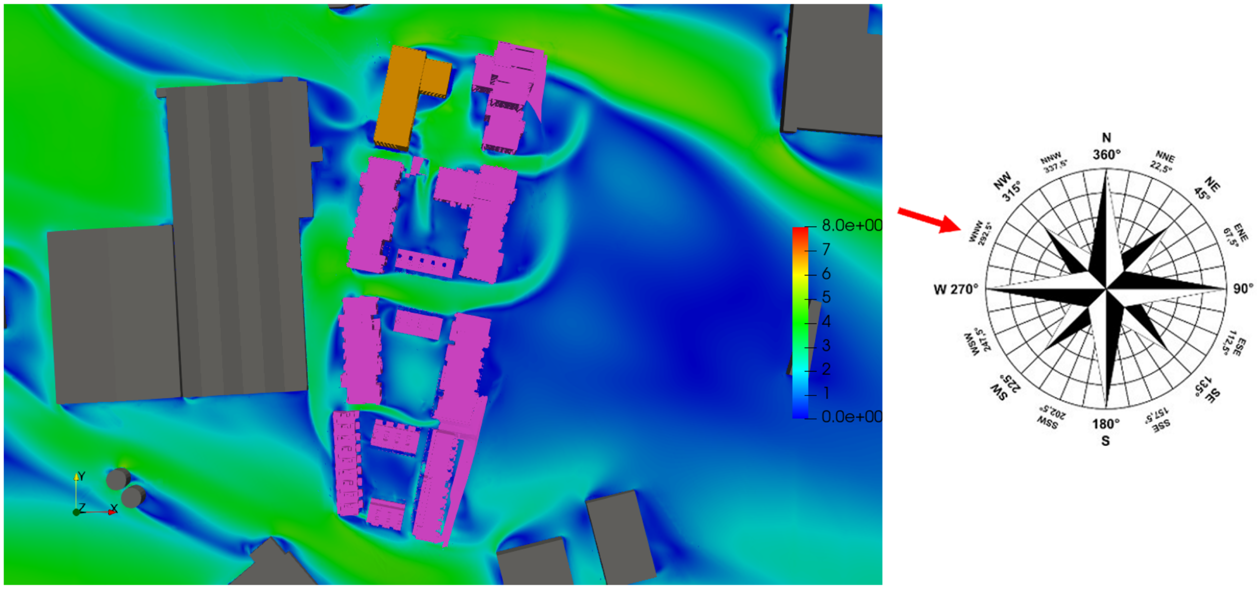


Figure 6.27: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 292°

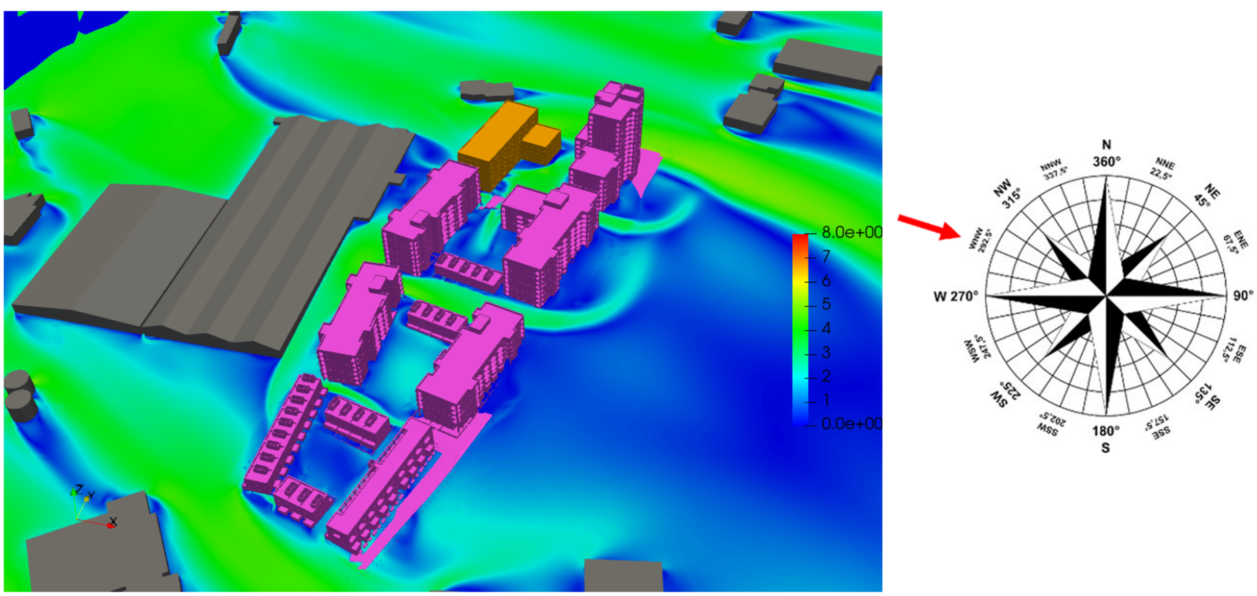


Figure 6.28: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 292°

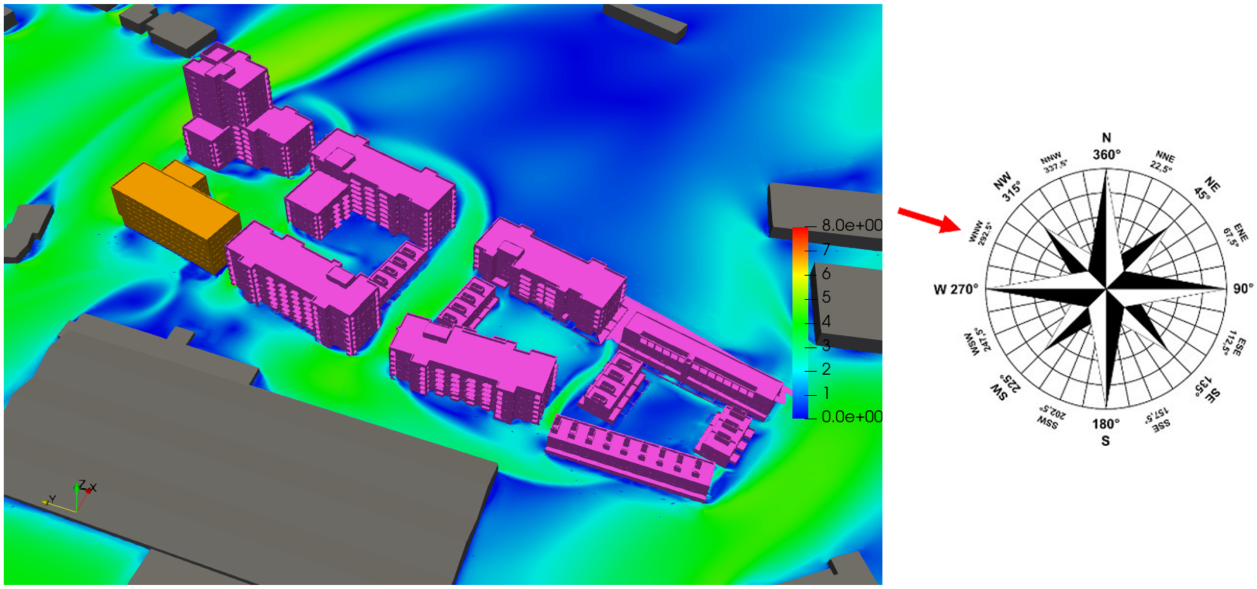


Figure 6.29: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 292°

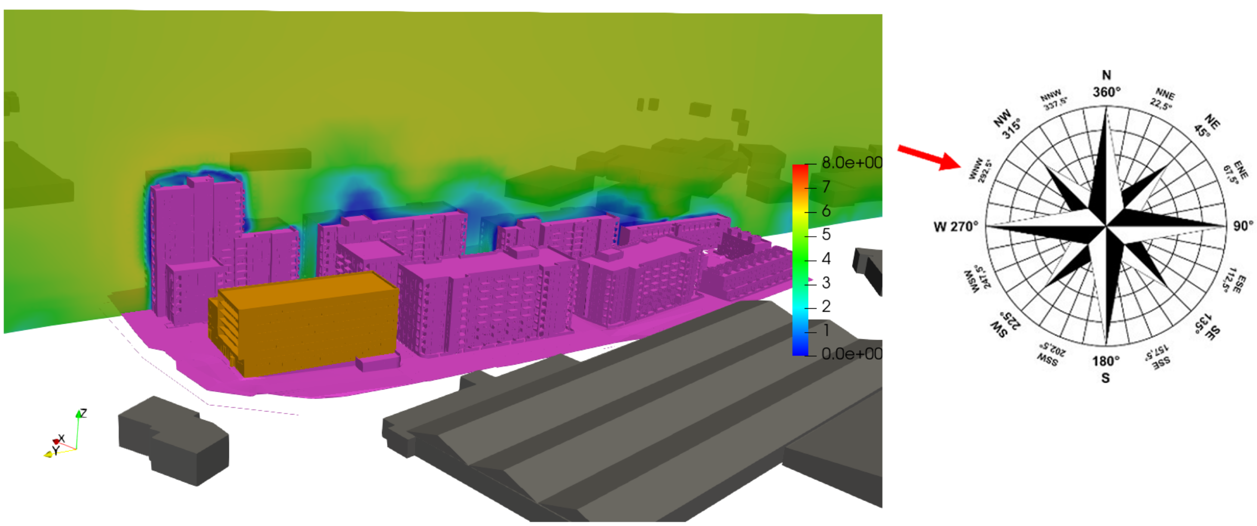


Figure 6.30: Isometric View- Flow Velocity Results - Wind Direction: 292°

Wind 315° Direction

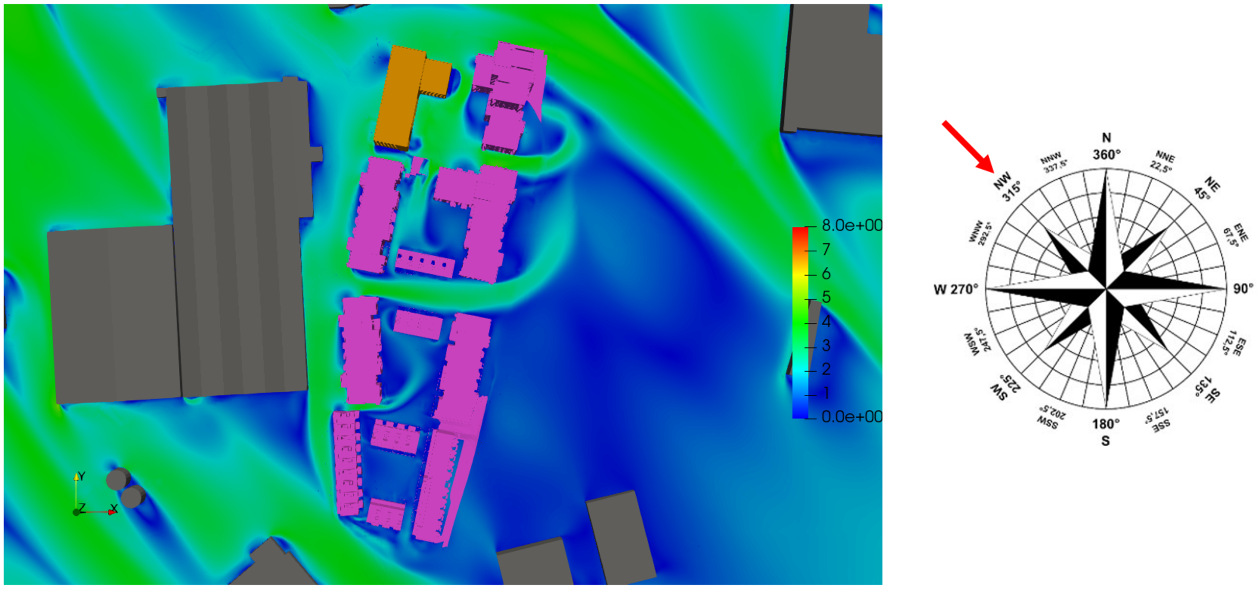


Figure 6.31: Ground Floor Level - Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 315°

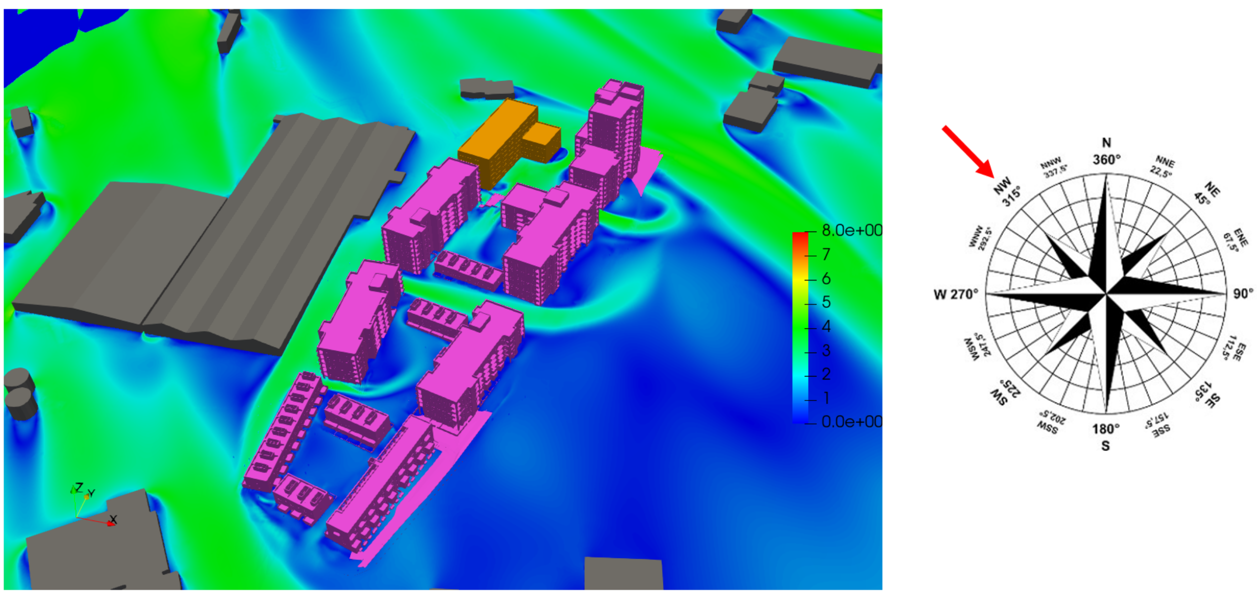


Figure 6.32: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 315°

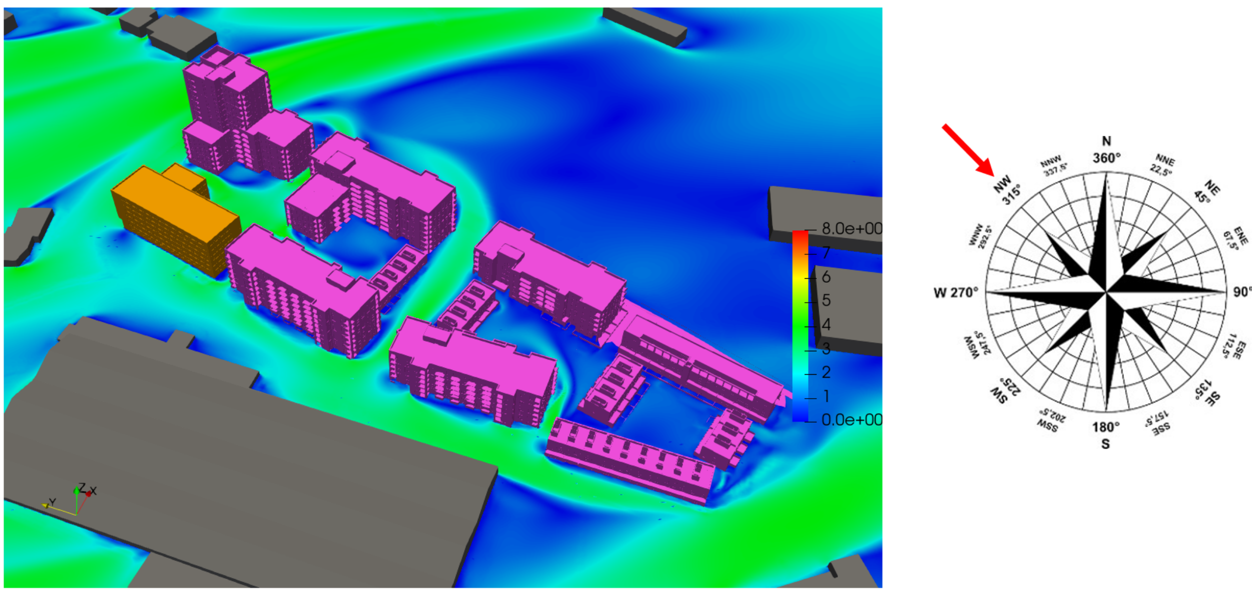


Figure 6.33: Isometric View- Flow Velocity Results at Z=1.8m above the ground - Wind Direction: 315°

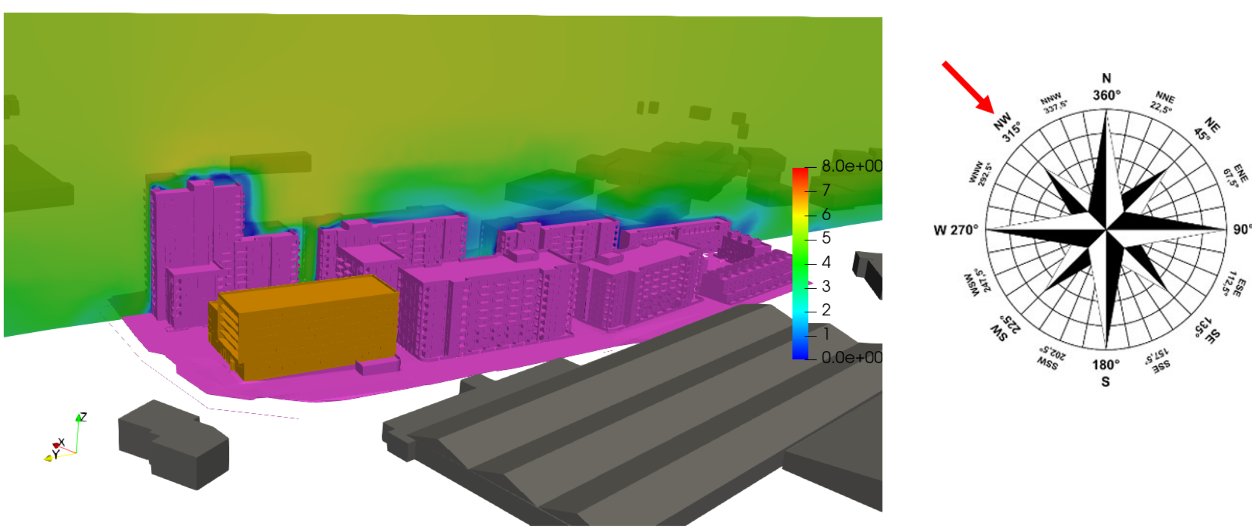


Figure 6.34: Isometric View- Flow Velocity Results - Wind Direction: 315°

6.3 Pedestrian Comfort Assessment

This section aims to identify areas of the Creamfields Development, Kinsale Road, Corkwhere pedestrian safety and comfort could be compromised (in accordance with the Lawson Acceptance Criteria previously described). Pedestrian comfort criteria are assessed at 1.5m above ground level.

Discomfort Criteria

Figure 6.36 shows Lawson comfort categories over the ground floor area, terrace and balconies of Creamfields Development, Kinsale Road, Cork. Thus, depending on the wind direction, the suitability of the different areas can be assessed using these maps.

For the Lawson discomfort criteria, the onset of discomfort depends on the activity in which the individual is engaged and it is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time. It can be seen that the wind conditions range from "suitable for long term sitting" to "suitable for walking and strolling" and really rarely are only suitable for "business walking" or "unacceptable for pedestrian comfort".

The results shown in the maps show that for the Ground Floor Level there are no critical area which are unacceptable for pedestrian comfort. The areas within the development can all be considered suitable for long term sitting, and in some cases, short term sitting.

Ground Floor

The scale used in the following images is set out in Figure 6.35.

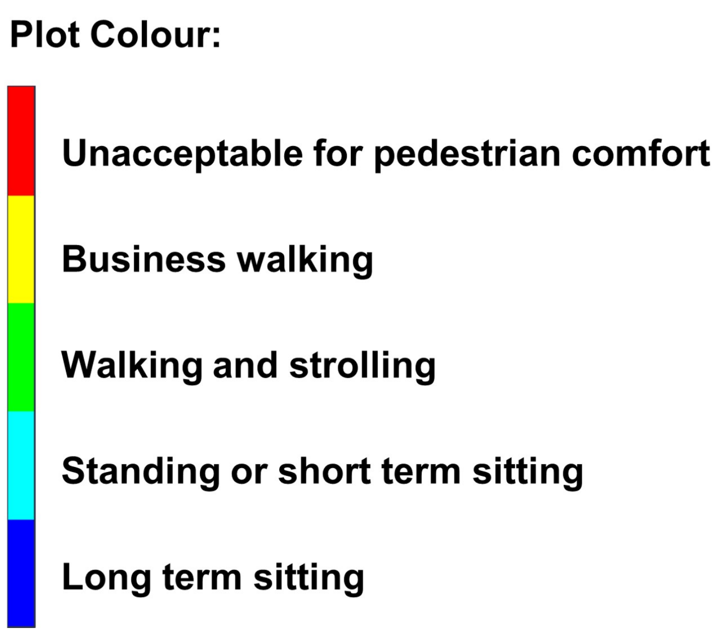


Figure 6.35: Lawson Comfort Categories

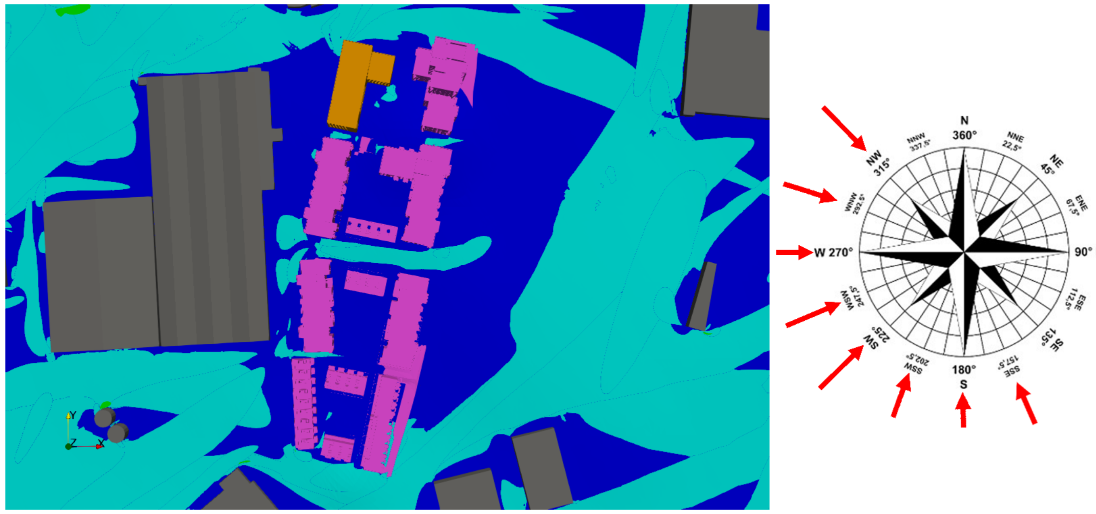


Figure 6.36: Ground Floor - Lawson Discomfort Map

Distress Criteria

The criteria for distress for a frail person or cyclist is 15m/s wind occurring for more than two hours per year.

As explained above, a velocity of 15m/s was reached in Cork only for the following directions (in increasing order of percentage) over the years 1985-2015:

1. West 270°
2. West-South-West 247.5°
3. South-West 225°
4. West-North-West 292.5°
5. South-South-West 202.5°

For this reason, it is of interest to show the distress results for these directions. Figure 6.38 below combines all the above directions together and shows the areas where the measured velocity is above 15 m/s. Figure 6.37 shows the scale used in this case. Results show that there are not critical areas where the velocity increases above 15 m/s, thus the criteria is always satisfied.

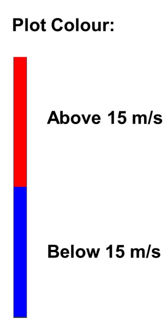


Figure 6.37: Lawson Distress Categories - Frail Person or Cyclist

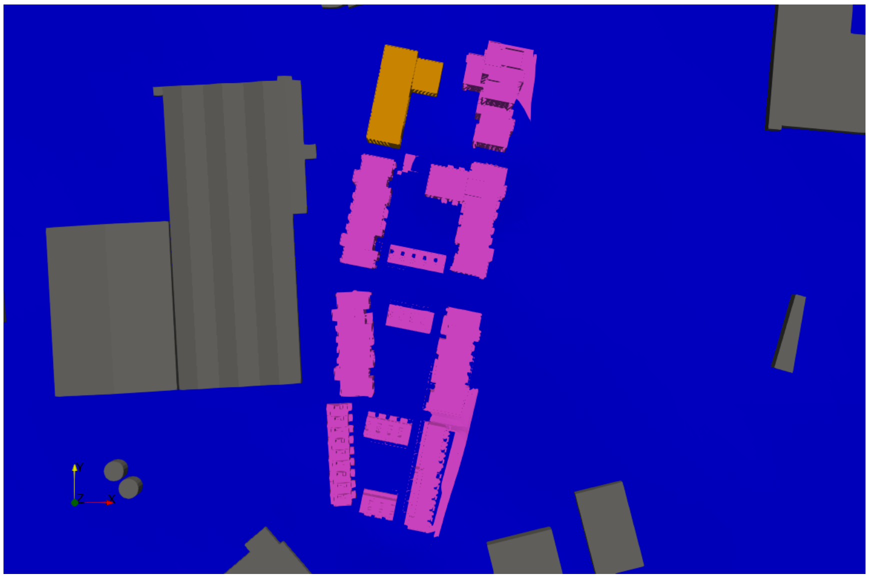


Figure 6.38: Lawson Distress Map - Frail Person or Cyclist

The criteria for distress for a member of the general population is 20m/s wind occurring for more than two hours per year. As explained above, a velocity of 20m/s was never reached in Cork over the years 1985-2015. For this reason, it is not of interest to show the distress results for any of the wind directions and the criteria is always satisfied.

7. CONCLUSIONS

7.1 CONCLUSIONS ON WIND MICROCLIMATE STUDY

This report has presented the Wind Microclimate Study performed for Creamfields Development, Kinsale Road, Cork's Project. This study has been carried out to identify the possible wind patterns around the area proposed, under mean and peaks wind conditions typically occurring in Cork.

The results of the wind study and CFD result are utilized by KSN Project Management Ltd. design team to configure the optimal layout for Creamfields Development, Kinsale Road, Corkfor 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.

In summary, as shown in the details of this report, the wind microclimate study carried out shows that the development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian), and from a qualitative point of view, it is not expected to introduce any critical impact on the surrounding areas and on the existing buildings. In particular:

- The wind profile around the existing development environment was built using the annual average meteorology data collected at Cork Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Cork Airport.
- The prevailing wind directions for the site are identified as South-South-West, South-West and West, with magnitude of approximately 6m/s.
- The proposed Creamfields Development, Kinsale Road, Cork's Project has been designed in order to produce a high-quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.
- As a result of the final proposed and mitigated design, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South side of the development and areas between the blocks. However, as it was shown in the Lawson map, the areas can be utilised for the intended use such as short-term sitting, walking and strolling.
- Given the position of the development, major issues of high flow speeds are not expected on footpaths.
- 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 does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Cork for the past 30 years:

- **The development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian).**
- **The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.**

8. BIBLIOGRAPHY

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