# 12.0 WIND

## 12.1 Introduction

B-Fluid Limited has been commissioned by 'Atlas GP Ltd.' to carry out a Wind and Micro-climate Modelling Study for the Carmanhall Road Strategic Housing Development (the 'Proposed Development'). The Proposed Development is located at the former Avid Technology International site on Carmanhall Road, Sandyford Industrial Estate, Dublin 18, (the 'Site' / 'Application Site'). Figure 12.1 shows a generic view of the Proposed Development.

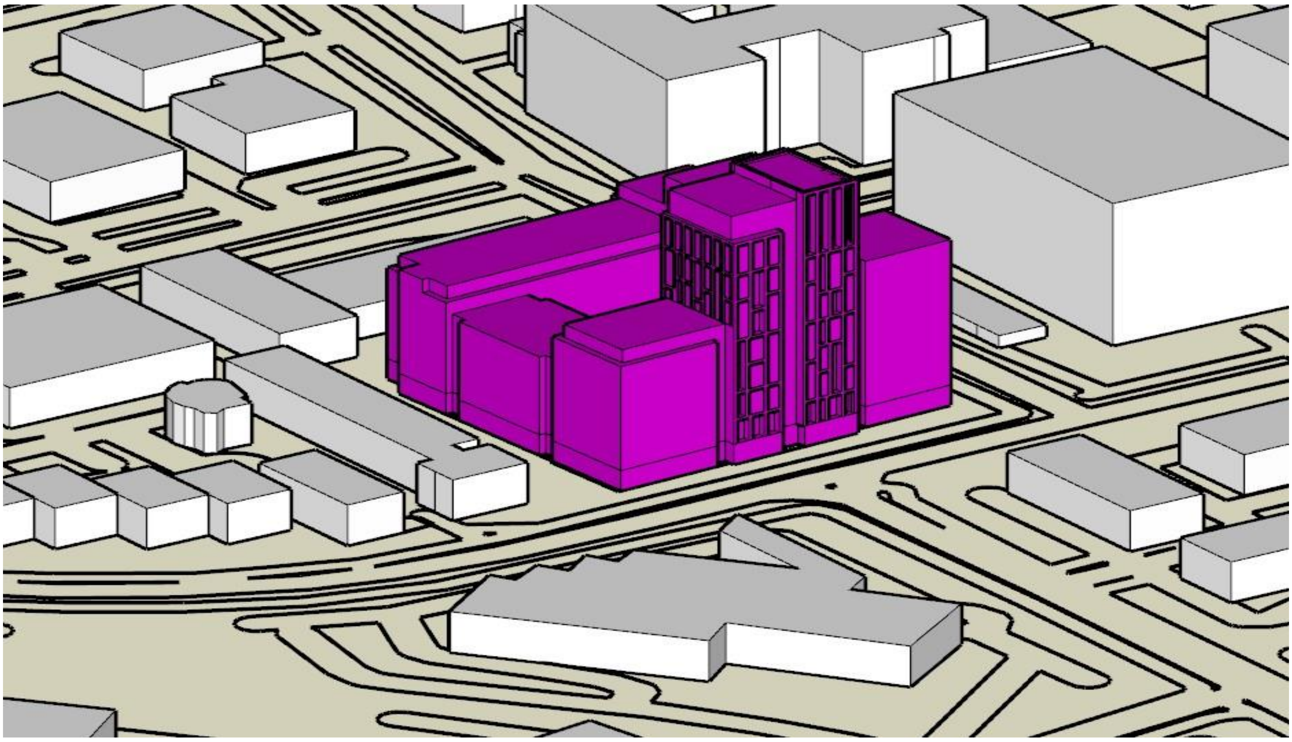


**Figure 12.1: Carmanhall Road Development**

This Chapter is completed by Dr. Cristina Paduano, Dr. Eleonora Neri and Dr. Arman Safdari.

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 10 years experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Dr. Eleonora Neri is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for the urban environment and in wind tunnel measurements for the aerospace industry. She holds a PhD in Aeroacoustics from Trinity College Dublin, a M.Sc. and B.Sc. in Aeronautical Engineering.

Dr. Arman Safdari is a CFD Modelling Engineer who specialises in computational fluid dynamics applications. He is an expert in airflow modelling, heat and mass transfer and multi-phase flow simulations. He holds a PhD in Mechanical Engineering from Pusan National University, a M.Sc. and B.Sc. in Mechanical Engineering.

Wind and Micro-climate study identifies the possible wind patterns around the existing environment and Proposed Development, under mean and peak wind conditions typically occurring in Dublin.

This assessment is performed through Advanced Computational Fluid Dynamics (CFD) which is a numerical method used to simulate wind conditions and its impact on the development and to identify areas of concern in terms of downwash/funnelling/downdraft/critical flow accelerations that may likely occur. The Advanced CFD numerical algorithms applied here are solved using high speed supercomputing computer clusters.

These results will be utilized by Atlas GP Ltd. design team to configure the optimal layout for Carmanhall Road 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 next sections describes in detail the wind and microclimate modelling performed, its methodology and assumptions which B-Fluid Ltd. has adopted for this study, together with impacts of the Proposed Development on the existing environment.

### 12.1.1 Objective of Wind and Microclimate Modelling

CFD wind modelling is adopted to identify areas of concern in terms of critical flows and areas where 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 residential 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, street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

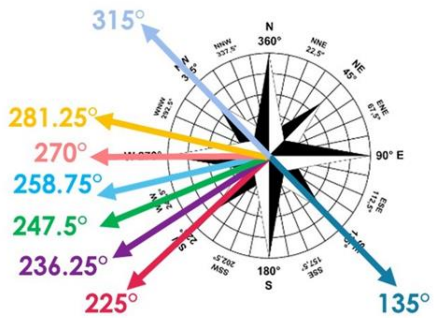
For this purpose, 18 different wind scenarios and directions have been modelled as shown in Table 12.1. in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e., the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

**Table 12.1:Summary of the 18 Wind Scenarios Modelled for Carmanhall Road Development**

| DUBLIN WIND SCENARIOS AND DIRECTIONS | | |
|---|---|---|
| Velocity (m/s) | Direction (deg) | Frequency |
| 5.601 | 225 | 11.233 |
| 4.626 | 135 | 6.849 |
| 5.847 | 236.25 | 6.792 |
| 6.049 | 258.75 | 6.747 |
| 6.034 | 247.5 | 6.689 |
| 5.888 | 270 | 5.662 |
| 4.994 | 315 | 4.338 |
| 5.503 | 281.25 | 3.904 |
| 4.974 | 292.5 | 3.436 |
| 5.357 | 213.75 | 3.288 |
| 4.736 | 123.75 | 3.105 |
| 4.406 | 146.25 | 2.751 |
| 5.101 | 303.75 | 2.648 |
| 5.246 | 112.5 | 2.500 |
| 4.121 | 157.5 | 2.386 |

| DUBLIN WIND SCENARIOS AND DIRECTIONS | | |
|---|---|---|
| **Velocity (m/s)** | **Direction (deg)** | **Frequency** |
| 4.581 | 101.25 | 2.340 |
| 4.169 | 45 | 2.180 |
| 3.558 | 90 | 2.135 |

This modelling study focuses on reporting 8 worst case and most relevant wind speeds, which are the speeds and directions showing the most critical wind speeds relevant to the development. The 8 modelled scenarios reported in this study are presented in Figure 12.2.




| Velocity (m/s) | Direction (°) | Frequency |
|---|---|---|
| 5.601 | 225 | 11.233 |
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| 6.034 | 247.5 | 6.689 |
| 5.888 | 270 | 5.662 |
| 4.994 | 315 | 4.338 |
| 5.503 | 281.25 | 3.904 |

**Figure 12.2: Summary of 8 Wind Scenarios Reported**

## 12.2 Legislative and Policy Context

### 12.2.1 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 Figure 12.3 and prescribed 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<br>**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<br>**25m to 50m** | Computational (CFD) Simulations **OR** Wind Tunnel Testing |
| Up to 4 times the average height of surrounding buildings<br>**50m to 100m** | Computational (CFD) Simulations **AND** Wind Tunnel Testing |
| High Rise<br>**Above 100m** | **Early Stage Massing Optimization:** Wind Tunnel Testing OR Computational (CFD) Simulations<br>**Detailed Design:** Wind Tunnel Testing **AND** Computational (CFD) Simulations to demonstrate the performance of the final building design |

**Figure 12.3: 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 mesh cell sizes near critical locations (e.g., entrances, corners, etc.) must be 0.3 m or smaller. Sufficient cells should be also used between buildings with a minimum of 10 cells 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 400 m 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 1.5 m 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.

# 12.3 Assessment Methodology and Significance Criteria

## 12.3.1 Study Methodology

### *12.3.1.1 Acceptance Criteria*

**Pedestrian Comfort** 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 notes that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 12.4 (long-term sitting, short-term sitting / standing, leisure walking, business walking, unacceptable for pedestrian comfort). The 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 12.5. The 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.

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 1.5 m 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.

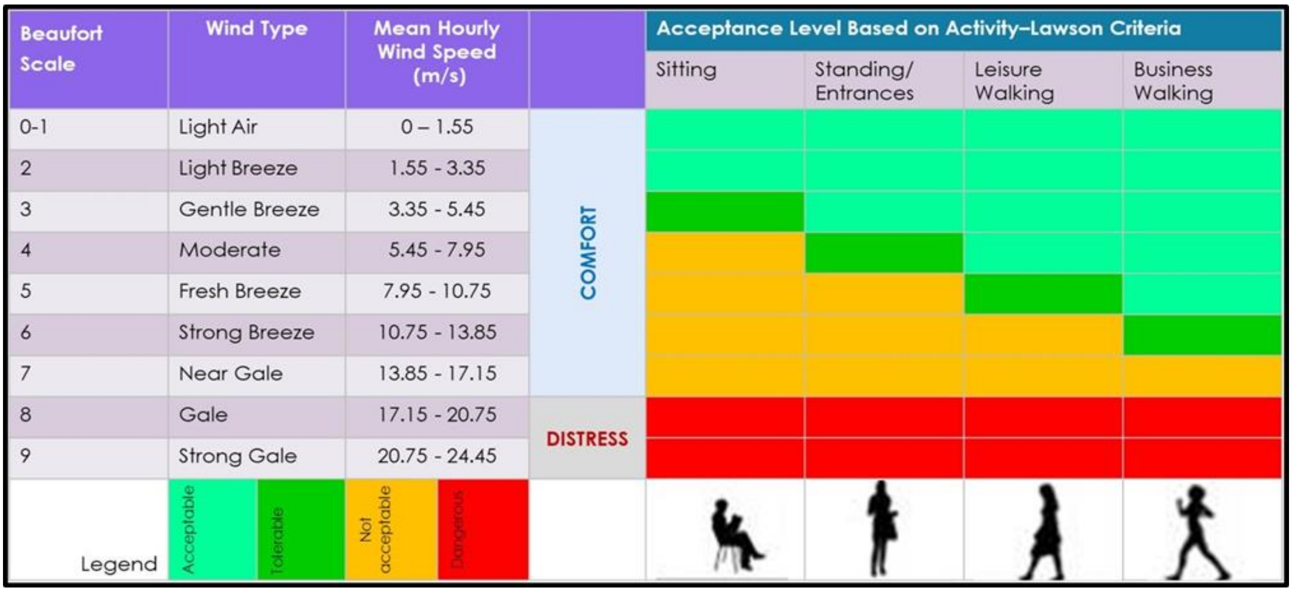



**Figure 12.4: Lawson Scale**

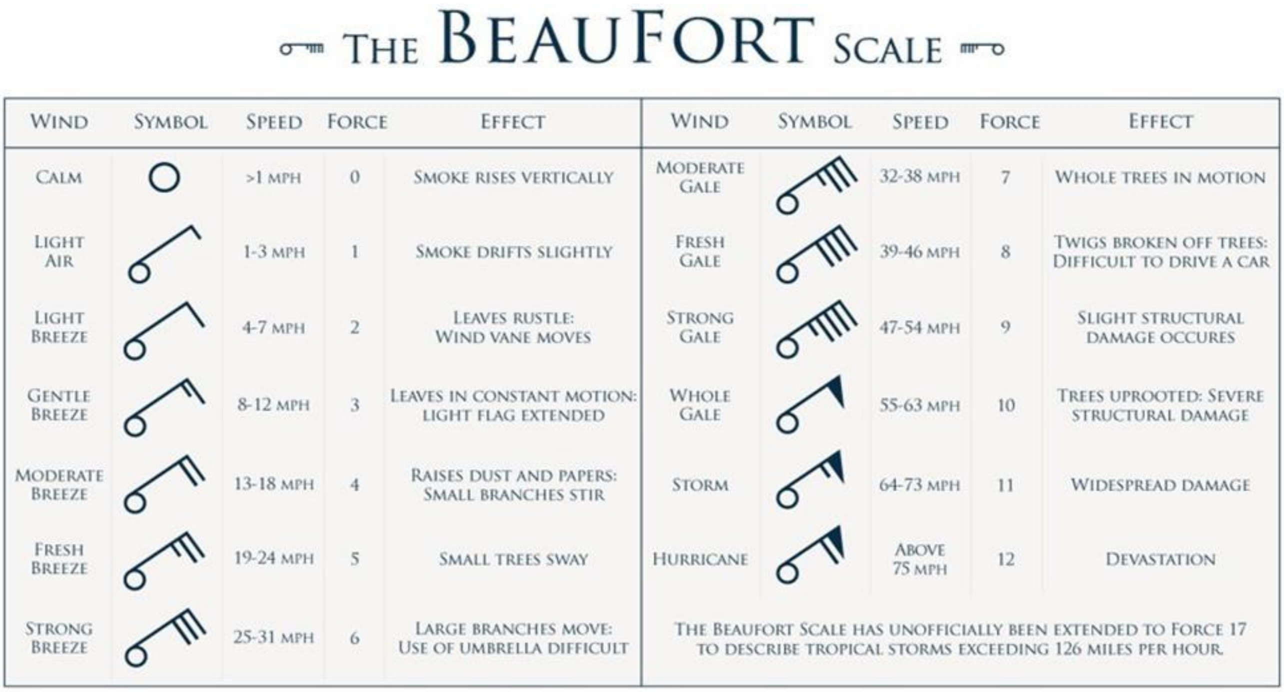



**Figure 12.5: Beaufort Scale**

### *12.3.1.2 CFD Modelling Method*

Computational Fluid Dynamics (CFD) is a numerical technique used 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 12.6. 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 provided that the scenario modelled is a good representation of reality.

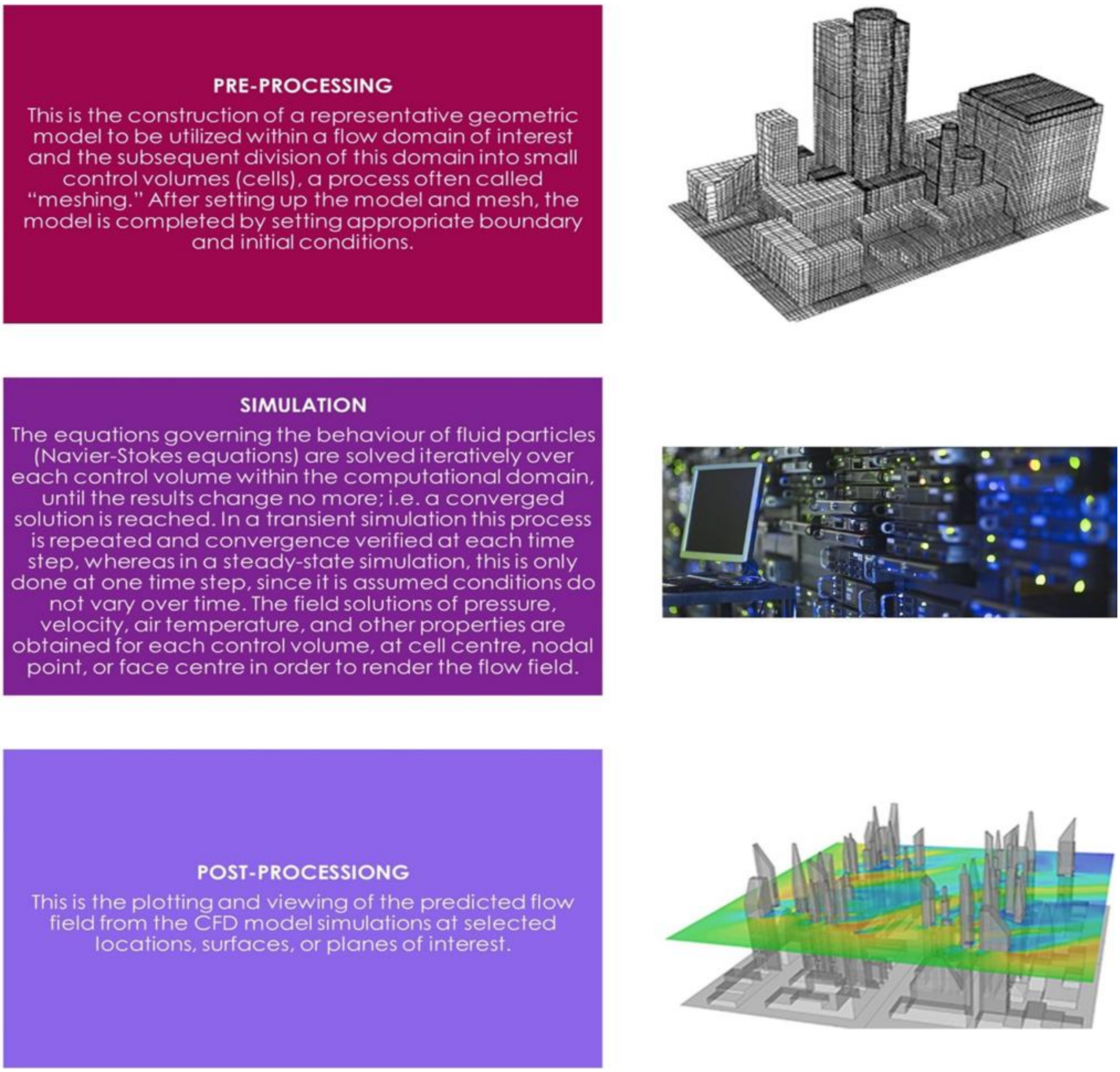



**Figure 12.6: CFD Modelling Process Explanation**

### 12.3.1.3 OpenFOAM Numerical Solver Details

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).

### 12.3.2 The Existing Receiving Environment Assessment

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 to construction of the Proposed Development. A statistical analysis of 30 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 the wind microclimate of the area that may cause critical conditions for pedestrians' comfort criteria.

The Existing Environment site is shown in Figure 12.7.


**Figure 12.7: Existing Receiving Environment (Baseline Situation)**

### *12.3.2.1 Site Location and Surrounding Area*

The Carmanhall Road Site is located in Sandyford, between Blackthorn Road and Carmanhall Road, in Dublin 16. The site is located in the vicinity of both Sandyford and Central Park Luas stops as well as having a Quality Bus Corridor along Leopardstown Road. The Proximity to Sandyford and Central Park also serves to provide nearby employment and Amenities local to the site.

The Existing Environment site is shown in Figure 12.8. The area considered for the existing environment and Proposed Development assessment comprises a 3 km² area around the Carmanhall Road Development as represented in Figure 12.9.

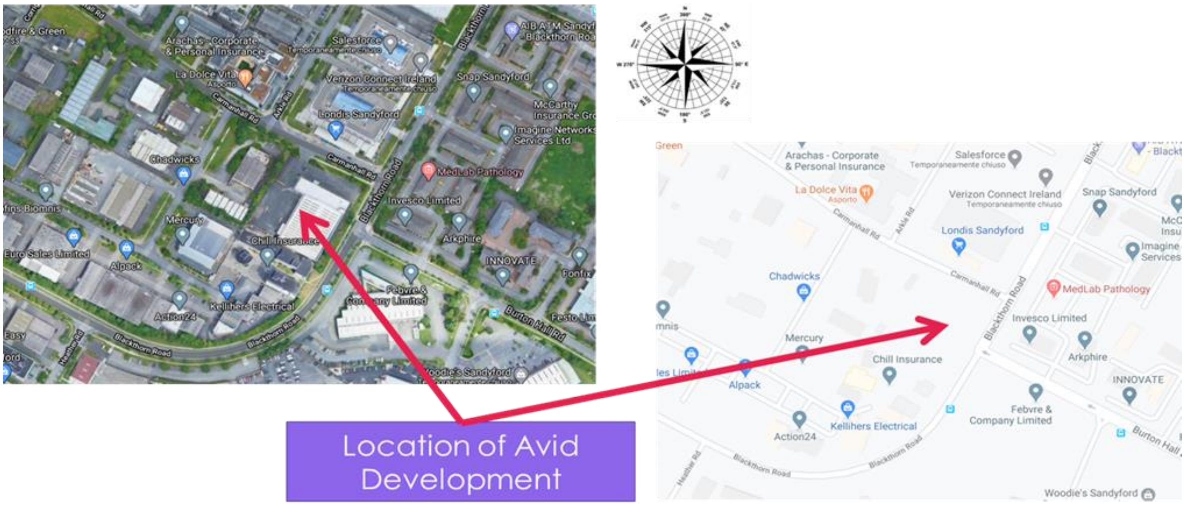



**Figure 12.8: Carmanhall Road Development Site Location and Existing Environment**

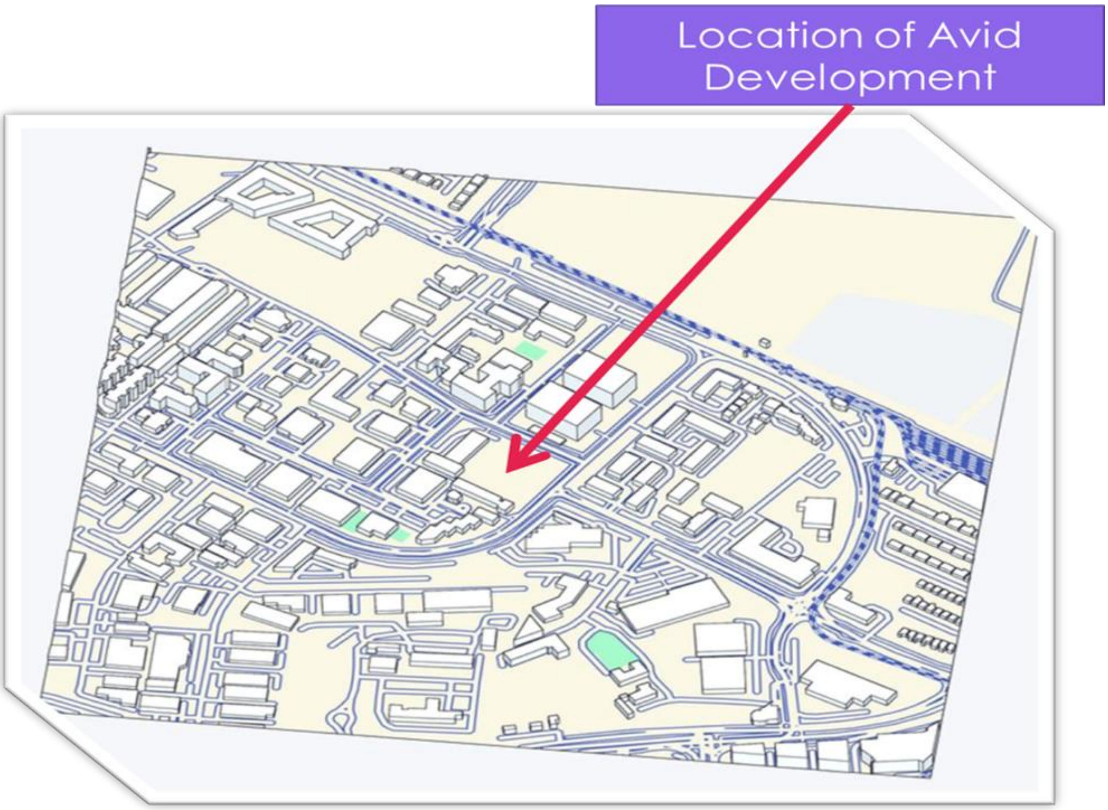



**Figure 12.9: Extents of Analysed Existing Environment around Carmanhall Road Development**

### 12.4.1.2 Topography and Built In Environment

Figure 12.7 shows an aerial photograph of the terrain surrounding the construction site at Carmanhall Road Development.

The Carmanhall Road Site is located in Sandyford, between Blackthorn Road and Carmanhall Road, in Dublin 16.

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 the wind directions considered for this study are in this connection “urban winds” and no distinction will be made between them.

This analysis considers the existing environment being exposed to typical wind conditions of the site. The wind profile is built using the annual average of meteorology data collected at Dublin Airport Weather Station. Figure 12.10 shows on the map the position of Carmanhall Road Development and the position of Dublin Airport.

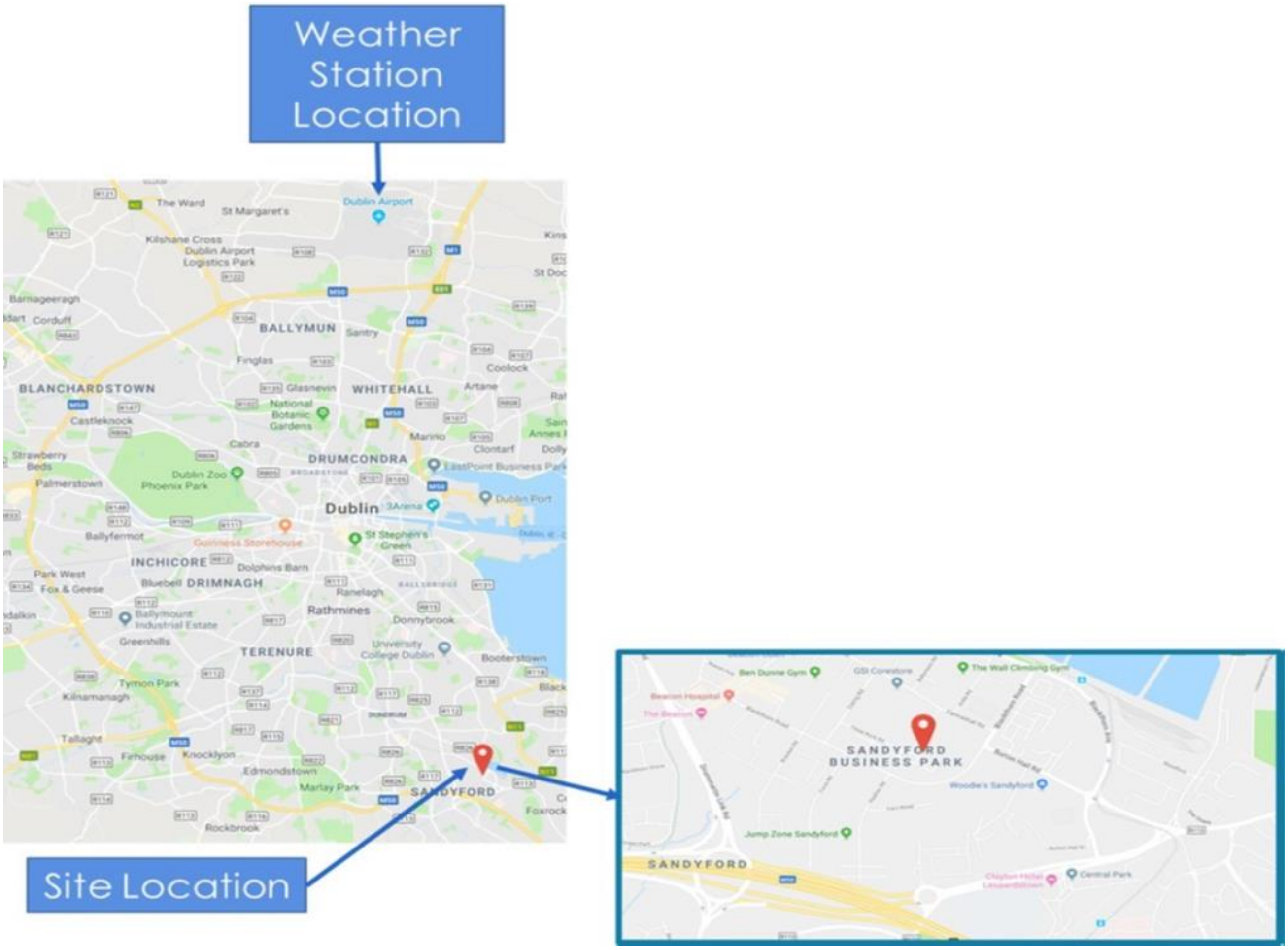



**Figure 12.10: Map showing the Position of Carmanhall Road Development and Dublin Airport**

Regarding the transferability of the available wind climate data, the 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 Dublin Airport are applicable for the desktop assessment of the wind comfort at the development site.

### *12.4.1.4 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 Dublin Airport. Two different data sets are analysed for this assessment as follows:

- The meteorological data associated with the maximum daily wind speeds recorded over a 30-year period between 1985 and 2015 and,
- The mean hourly wind speeds recorded over a 10-year period between 2005 and 2015. The data is recorded at a weather station at the airport, which is located 10 m above ground or 71 mOD.

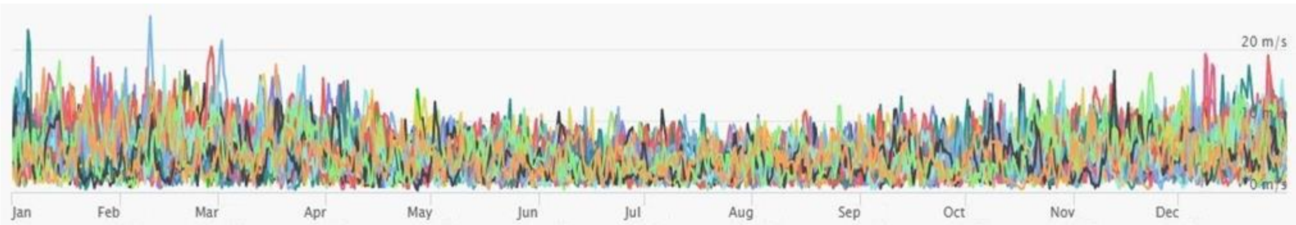



**Figure 12.11: Local Wind Speed (10 m) - 1985-2020**

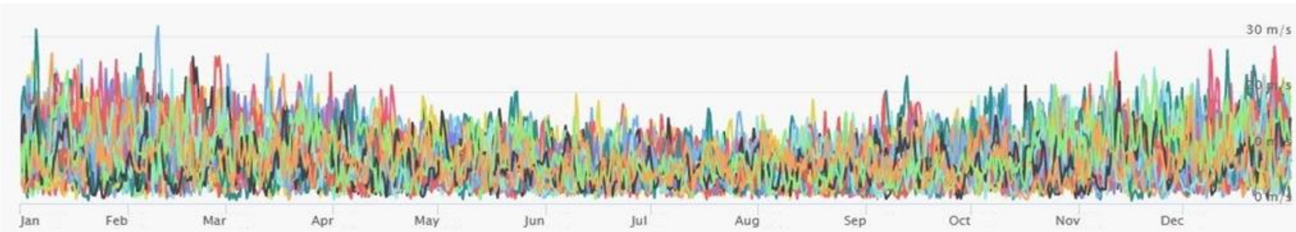



**Figure 12.12: Local Wind Gust (10 m) - 1985-2020**

Figure 12.13, presenting the wind speed diagram for Dublin, shows the days per month, during which the wind reaches a certain speed. In Figure 12.14, the wind rose for Dublin shows how many hours per year the wind blows from the indicated direction, confirming how the predominant directions are WSW, W, and SW.

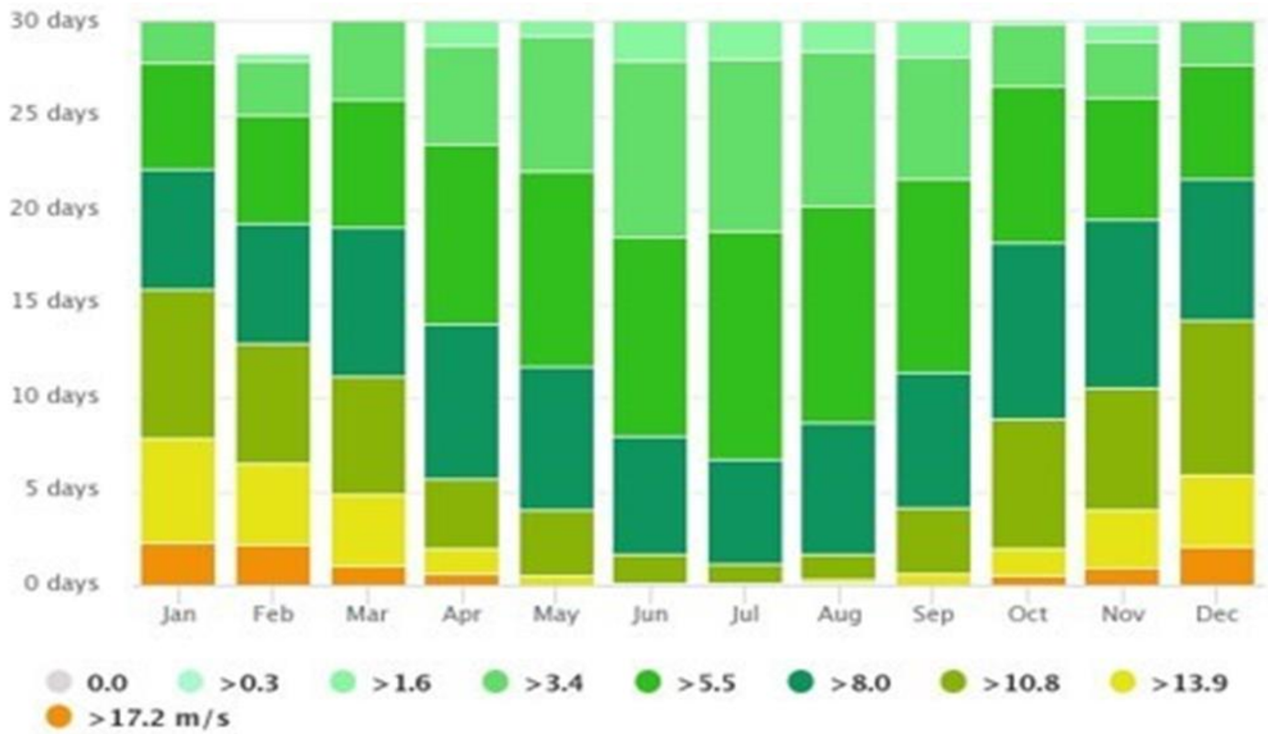



**Figure 12.13: Dublin Wind Speed Diagram**

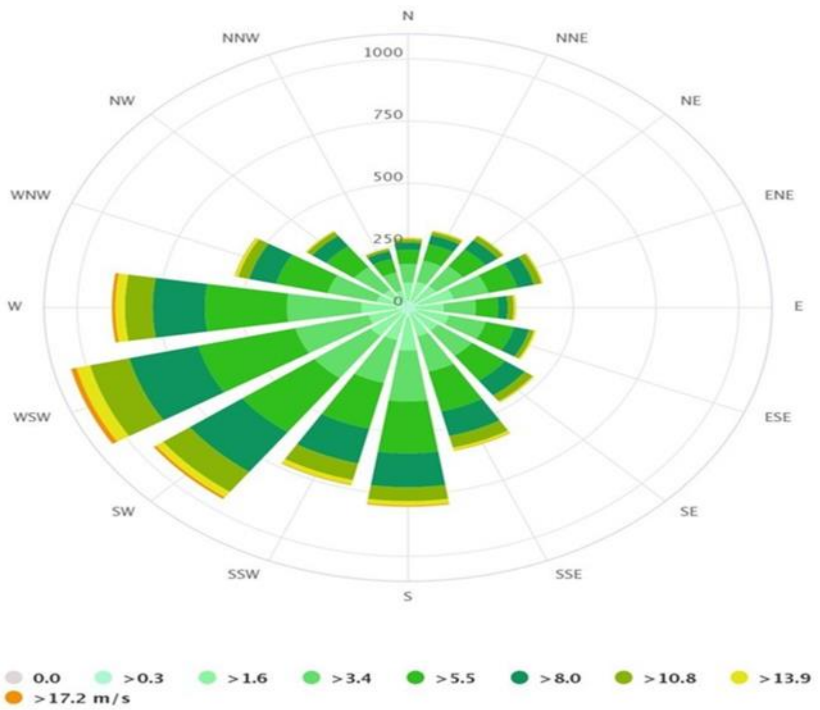



**Figure 12.14: Dublin Wind Rose**

Based on the criterion of occurrence frequency the main wind directions are presented in Figure 12.15 and listed below in descending order of dominance:

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

3. West-South-West.

The analysis 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.

| Velocity (m/s) | Direction (°) | Frequency |
|---|---|---|
| 5.601 | 225 | 11.233 |
| 4.626 | 135 | 6.849 |
| 5.847 | 236.25 | 6.792 |
| 6.049 | 258.75 | 6.747 |
| 6.034 | 247.5 | 6.689 |
| 5.888 | 270 | 5.662 |
| 4.994 | 315 | 4.338 |
| 5.503 | 281.25 | 3.904 |
| 4.974 | 292.5 | 3.436 |
| 5.357 | 213.75 | 3.288 |
| 4.736 | 123.75 | 3.105 |
| 4.406 | 146.25 | 2.751 |
| 5.101 | 303.75 | 2.648 |
| 5.246 | 112.5 | 2.500 |
| 4.121 | 157.5 | 2.386 |
| 4.581 | 101.25 | 2.340 |
| 4.169 | 45 | 2.180 |
| 3.558 | 90 | 2.135 |
| 4.801 | 202.5 | 2.021 |
| 3.689 | 78.75 | 1.963 |
| 3.627 | 168.75 | 1.495 |
| 4.285 | 67.5 | 1.370 |
| 4.863 | 56.25 | 1.279 |
| 4.042 | 191.25 | 1.199 |
| 4.630 | 326.25 | 1.164 |
| 3.844 | 11.25 | 1.142 |
| 4.418 | 337.5 | 1.062 |
| 4.787 | 348.75 | 0.982 |
| 4.006 | 22.5 | 0.959 |
| 3.555 | 180 | 0.879 |
| 4.059 | 33.75 | 0.845 |
| 0.700 | 0 | 0.011 |
| Selected Conditions : 32 | Total Coverage : 95.35 % | |

**Figure 12.15: Main Wind Directions Occurrence Frequency**

### *12.4.1.5 Mean and Maximum Wind Conditions*

Examination of the daily wind data reveals that the wind predominantly blows from West and Southwest directions, however, there is a secondary wind from the Southeast. 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.

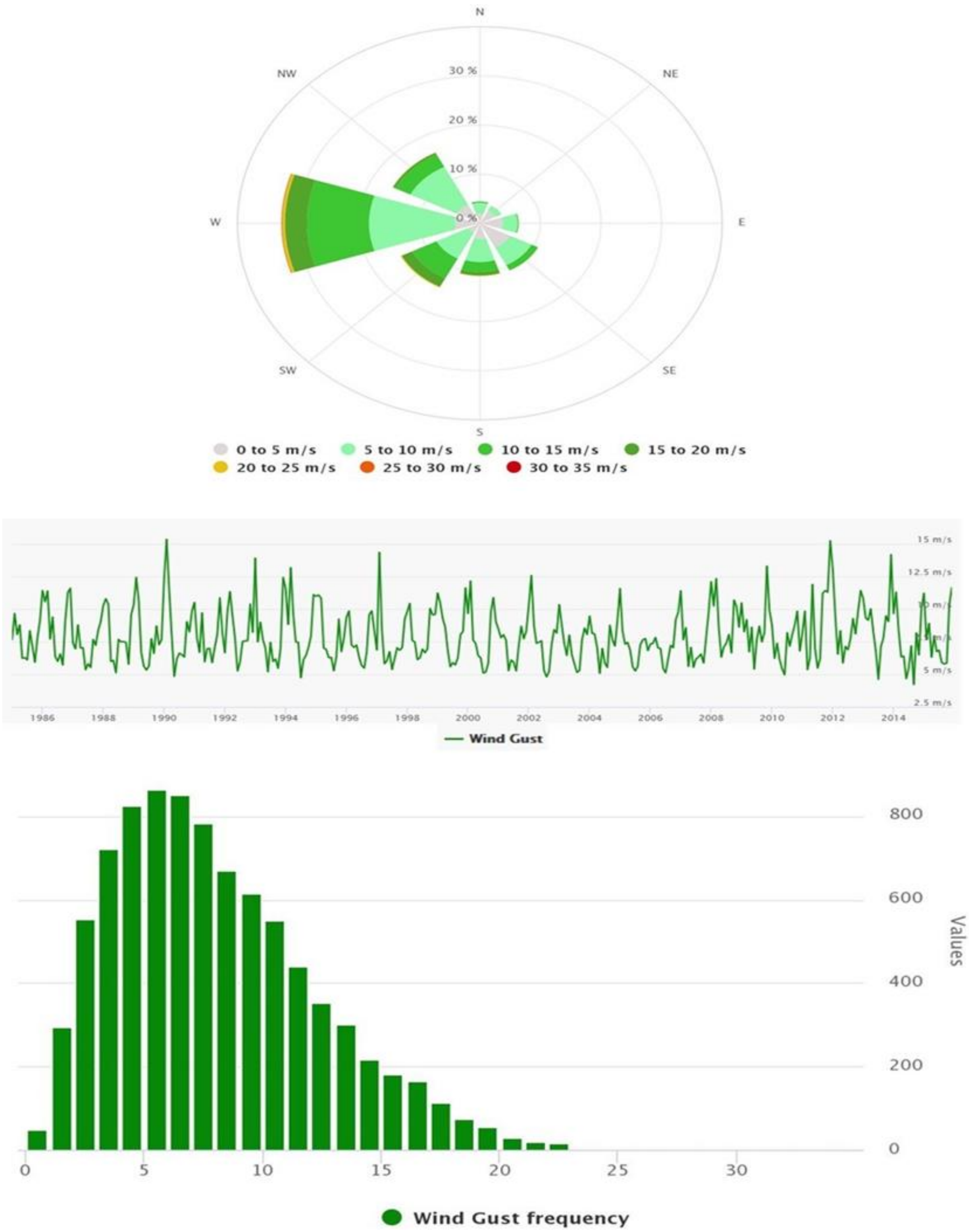



**Figure 12.16: Maximum Wind Conditions**

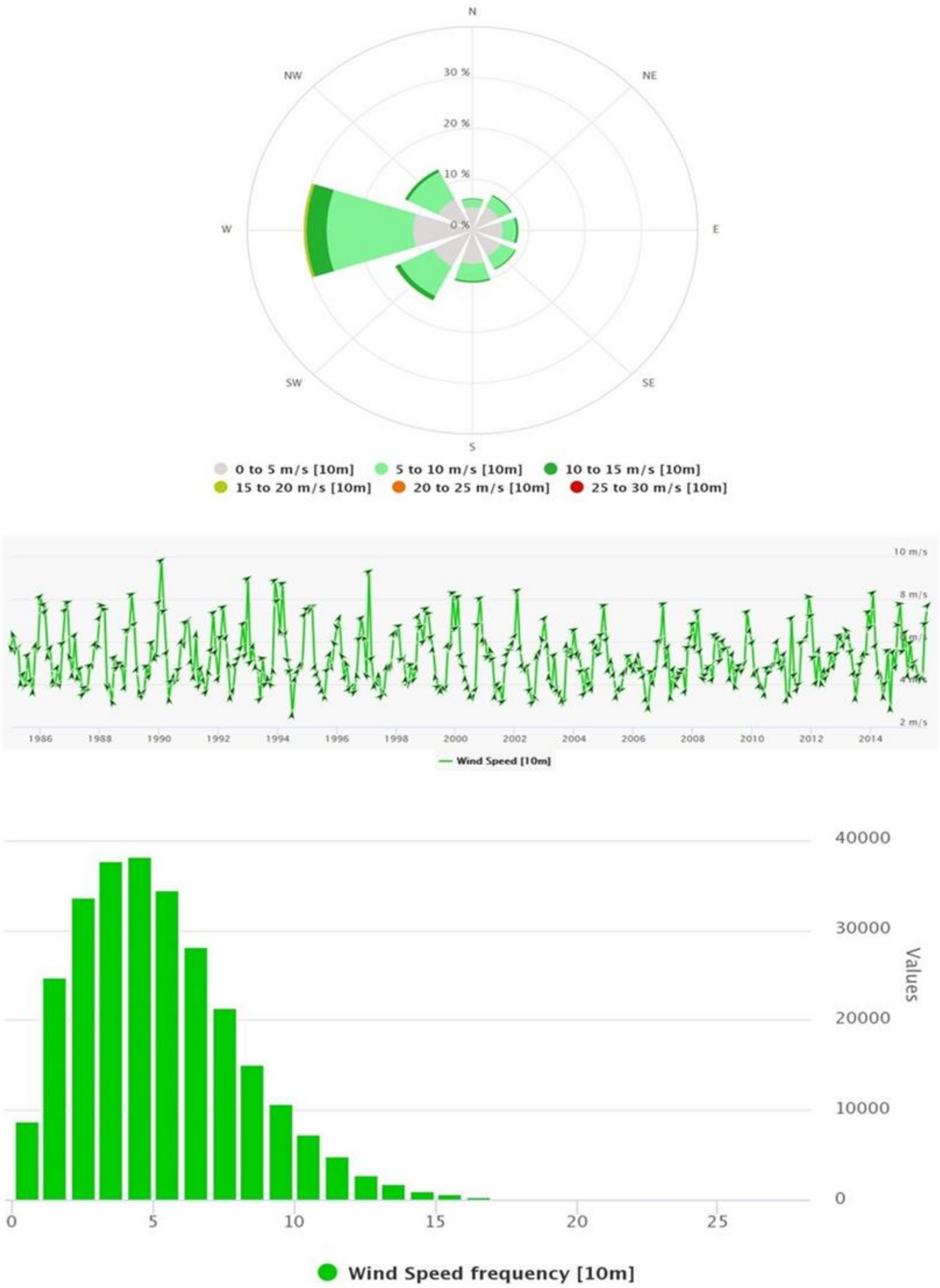



**Figure 12.17: Mean Wind Conditions**

### 12.3.2.2 Comparison with the On-site Weather Station

The wind profile built using the data from Dublin Airport, is also compared with the one obtained using the data collected near the site in the period 17 - 23 March 2020. Figure 12.18 shows B-Fluid weather station.

**Figure 12.18: B-Fluid On-site Weather Station**

Figure 12.19 and Figure 12.20 respectively show the wind speed and direction and wind gust recorded by the on-site weather station. The dark green, blue and black data represent the wind speed/gust daily mean, max and min respectively. The light green line represents the wind direction.


**Figure 12.19: Wind speed and Direction recorded by B-Fluid On-site Weather Station**

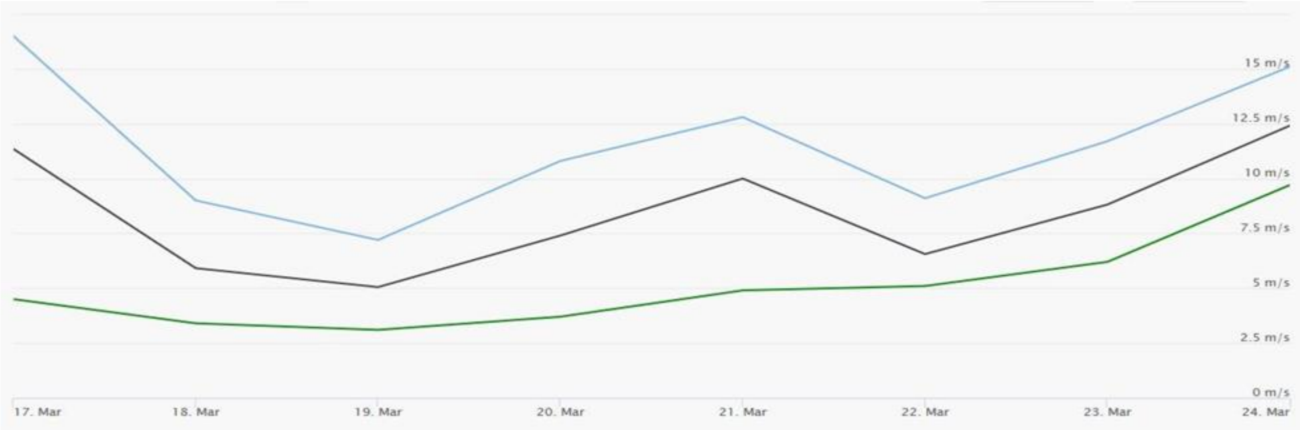



**Figure 12.20: Wind gust recorded by B-Fluid On-site Weather Station**

As it is possible to assess from the comparison between on-site and airport measurements, as presented in Figure 12.21 and Figure 12.22, it can be concluded that the wind speed daily mean and the wind gust daily mean recorded on site follow the same pattern as the one recorded at Dublin Airport. However, the trends of the wind speed levels and the gust wind speed levels registered on-site are in few cases slightly lower. This is due to the fact that the site is located close to the urban environment thus much more shielded if compared with Dublin Airport. This confirms that using wind data from Dublin Airport still ensures a conservative analysis of the wind impact on Carmanhall Road Development.

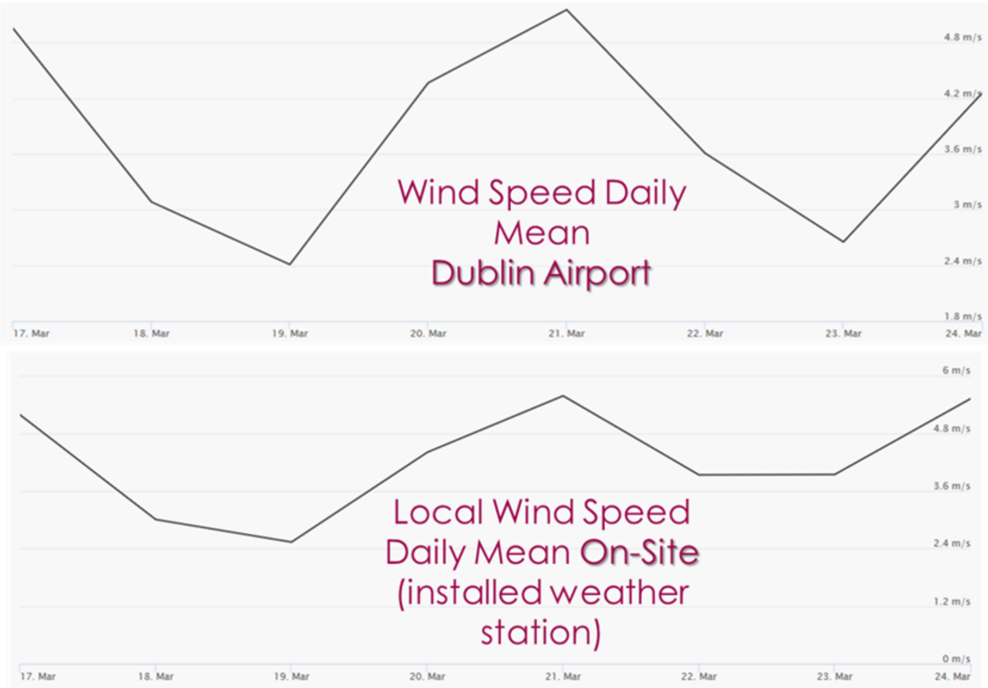



**Figure 12.21: Wind Speed Daily Mean Comparison**

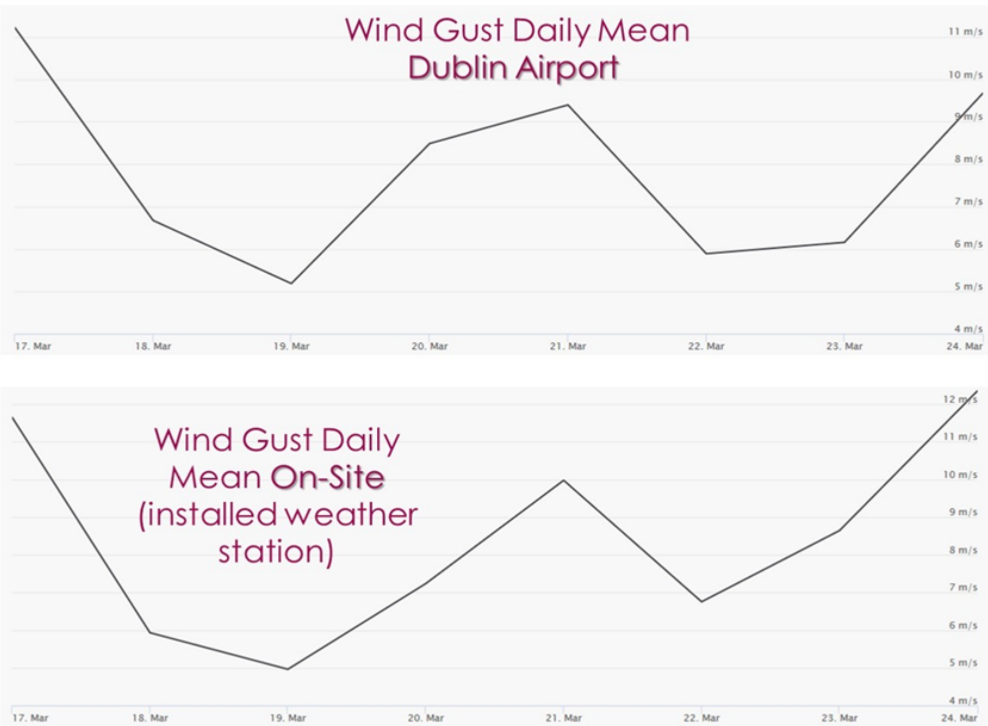



**Figure 12.22: Wind Gust Daily Mean Comparison**

#### 12.3.2.3 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;<br>*Terrace; street café or restaurant; open field theatre; pool* |
| **B** | Pedestrian standing; standing/sitting over a short period of time; short steady positions;<br>*Public park; playing field; shopping street; mall* |
| **C** | Pedestrian walking; leisurely walking; normal walking; ramble; stroll<br>*Walkway; building entrance; shopping street; mall* |
| **D** | Objective business walking; brisk or fast walking<br>*Car park; avenue; sidewalk; belvedere* |

**Figure 12.23: Main Categories for Pedestrian Activities**

#### 12.3.2.4 Existing Receiving Environment Summary

The wind desktop study of the existing receiving environment showed that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport. 18 different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e., the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.
- The wind profile built using the data from Dublin Airport, is also compared with the one obtained using the data collected on-site. Except few differences, both the wind speed daily mean and the wind gust daily mean recorded on site follow the same pattern as the one recorded at Dublin Airport. However, the trends of the wind speed levels and the gust wind speed levels registered on-site are in few cases slightly lower. This is due to the fact that the site is located close to the urban environment thus much more shielded if compared with Dublin Airport. This confirms that using wind data from Dublin Airport still ensures a conservative analysis of the wind impact on Carmanhall Road Development.
- The prevailing wind directions for the site are identified in the West, West South-West and South-East with magnitude of approximately 6m/s.

### 12.3.3 EIA Significance Terminology

As identified in Chapter 2 (Scope and Methodology) of this EIAR, a common framework of assessment criteria and terminology has been used based on the EPA's draft Guidelines on the Information to be Contained in EIARs (EPA, 2017)[1]. This common framework follows a 'matrix approach' to environmental assessment which is based on the characteristics of the impact (magnitude and nature) and the value (sensitivity) of the receptor.

[1] Environmental Protection Agency (2017) Guidelines on the information to be contained in Environmental Impact Assessment Reports, Draft, August 2017

A description of the significance categories used in Table 12.2. effects that are either Large or Profound are considered to be Significant, and effects that are Moderate, Slight or Imperceptible are considered to be Not Significant.

**Table 12.2: Significance categories and typical descriptions.**

| Significance Category | Typical Description |
|---|---|
| Profound | An effect which obliterates sensitive characteristics. |
| Large | An effect which, by its character, magnitude, duration or intensity alters a significant proportion of a sensitive aspect of the environment. |
| Moderate | An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends. |
| Slight | An effect which causes noticeable changes in the character of the environment without affecting its sensitivities. |
| Imperceptible | An effect capable of measurement but without significant consequences. |

## 12.4 Characteristics of the Proposed Development

### 12.4.1 Description of the Proposed Development

The Proposed Development will comprise of:

*(i) construction of a Build-To-Rent residential development within a new part six, part eight, part nine, part eleven storey rising to a landmark seventeen storey over basement level apartment building (40,814sq.m) comprising 428 no. apartments (41 no. studio, 285 no. one-bedroom, 94 no. two-bedroom & 8 no. three-bedroom units) of which 413 no. apartments have access to private amenity space, in the form of a balcony or lawn/terrace, and 15 no. apartments have access to a shared private roof terrace (142sq.m) at ninth floor level;*

*(ii) all apartments have access to 2,600sq.m of communal amenity space, spread over a courtyard at first floor level and roof terraces at sixth, eighth and ninth floor levels, a 142sq.m resident's childcare facility at ground floor level, 392sq.m of resident's amenities, including concierge/meeting rooms, office/co-working space at ground floor level and a meeting/games room at first floor level, and 696sq.m of resident's amenities/community infrastructure inclusive of cinema, gym, yoga studio, laundry and café/lounge at ground floor level. The café/lounge will primarily serve the residents of the development and will be open for community use on a weekly/sessional basis;*

*(iii) provision of 145 no. vehicular parking spaces (including 8 no. mobility parking spaces, 2 no. club-car spaces and 44 no. electric charging spaces), 5 no. motorcycle parking spaces, bin stores, plant rooms, switch room and 2 no. ESB sub-stations all at ground floor level; provision of bicycle parking (752 no. spaces), plant and storage at basement level; permission is also sought for the removal of the existing vehicular entrance and construction of a replacement vehicular entrance in the north-western corner of the site off Carmanhall Road;*

*(iv) provision of improvements to street frontages to adjoining public realm of Carmanhall Road & Blackthorn Road comprising an upgraded pedestrian footpath, new cycling infrastructure, an increased quantum of landscaping and street-planting, new street furniture inclusive of bins, benches and cycle parking facilities and the upgrading of the existing Carmanhall Road & Blackthorn Road junction through provision of a new uncontrolled pedestrian crossing; and,*

*(v) All ancillary works including provision of play equipment, boundary treatments, drainage works - including SuDS drainage, landscaping, lighting, rooftop telecommunications structure and all other*

*associated site services, site infrastructure and site development works. The former Avid Technology International buildings were demolished on foot of Reg. Ref. D16A/0158 which also permitted a part-five rising to eight storey apartment building. The development approved under Reg. Ref. D16A/0158, and a subsequent part-seven rising to nine storey student accommodation development permitted under Reg. Ref. PL06D.303467, will be superseded by the Proposed Development.*

The image in Figure 12.24 shows the development massing and elevations:

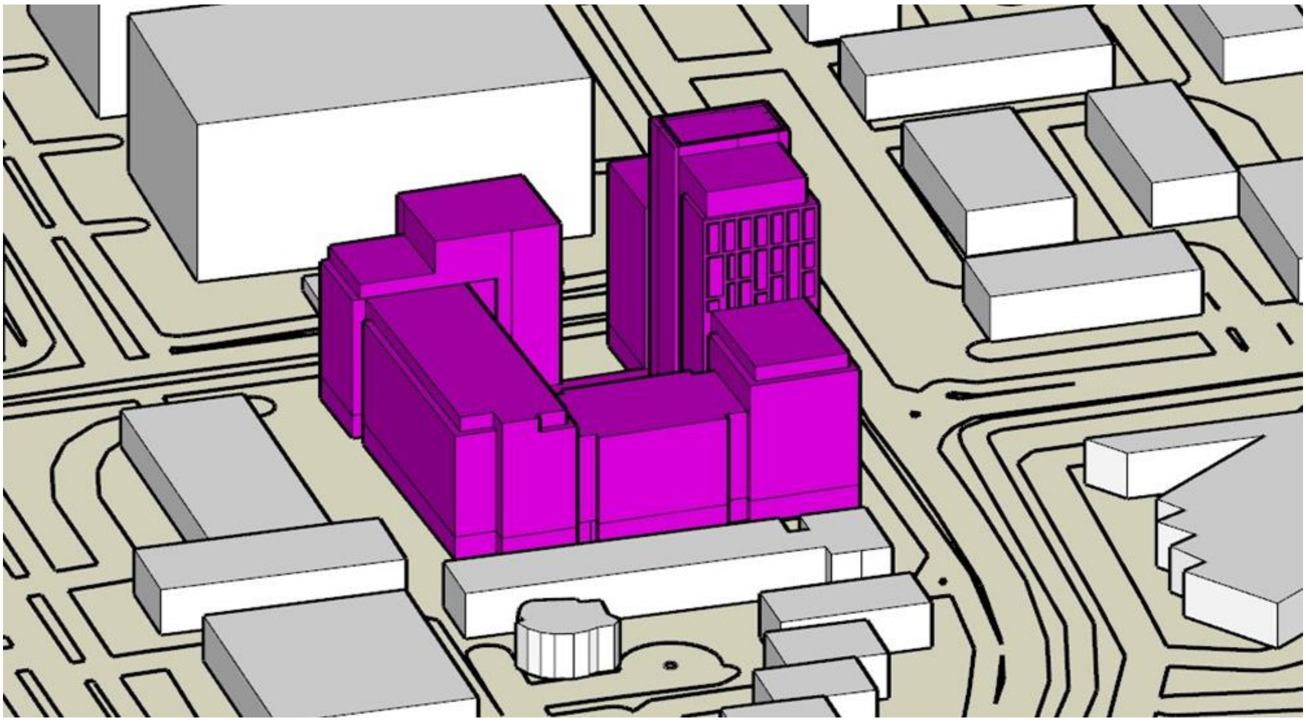


**Figure 12.24: Carmanhall Road Massing**

## 12.5 Potential Effects

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.

### 12.5.1 CFD Model details of the Proposed Development

This subsection describes all features included in the geometrical and physical representation of Carmanhall Road Development CFD model. Any object which may have significant impact on wind movement and circulation are represented within the model. To be accurate, the structural layout of the building being modelled should include only the obstacles, blockages, openings and closures which can impact the wind around the building. It is important to remember that a CFD simulation approximates reality, so providing more details of the geometry within the model will not necessarily increase the understanding of the bulk flows in the real environment.

### 12.5.2 Modelled Geometry

Carmanhall Road Development Model is shown in Figure 12.25 and Figure 12.26.

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 12.3).

In order to represent reality and consider the actual wind impacting on the site, the modelled area for the wind modelling study comprises a wider urban area of 2km² around the Carmanhall Road Development, as shown.

**Table 12.3: Modelled Environment Dimensions**

| Modelled CFD Environment Dimensions | | | |
|---|---|---|---|
| | Width | Length | Height |
| CFD Mesh Domain | 2000 m approx | 2000 m approx | 250 m approx |

**Figure 12.25: Carmanhall Road Development - Extents of Modelled Area**

**Figure 12.26: Carmanhall Road Development**

### 12.5.3 Boundary Conditions

A rectangular computational domain was used for the analysis. The wind directions were altered without changing the computational mesh. For each simulation scenario, an initial wind velocity was set according to the statistical weather data collected in order to consider the worst-case scenario. Building surfaces within the model are specified as ‘no slip’ boundary conditions. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. Air flow inlet boundaries possess the ‘Inlet’ wind profile velocity patch boundary condition with its appropriate inflow turbulence intensity and dissipation rates. Air exits the domain at the ‘pressure outlet’ boundary condition.

The wind velocity data provided by the historical data collection and by the local data measuring are used in the formula below for the logarithmic wind profile to specify the wind velocity profile (wind velocity at different heights) to be applied within the CFD model:

$$v_2 = v_1 \cdot \frac{ln\frac{h_2}{z_0}}{ln\frac{h_1}{z_0}} \qquad (6.1)$$

where:

- $v_1$ = wind speed measured at the reference height $h_1$
- $h_1$ = reference height to measure $v_1$
- $h_2$ = height of the wind speed $v_2$ calculated for the wind profile
- $z_0$ = 0.4 [m] roughness length selected (see table in Figure 12.6.3 below)

**Roughness Classes and Lengths**

| Roughness class | Roughness length $z_0$ | Land cover types |
|---|---|---|
| 0 | 0.0002 m | Water surfaces: seas and Lakes |
| 0.5 | 0.0024 m | Open terrain with smooth surface, e.g. concrete, airport runways, mown grass etc. |
| 1 | 0.03 m | Open agricultural land without fences and hedges; maybe some far apart buildings and very gentle hills |
| 1.5 | 0.055 m | Agricultural land with a few buildings and 8 m high hedges seperated by more than 1 km |
| 2 | 0.1 m | Agricultural land with a few buildings and 8 m high hedges seperated by approx. 500 m |
| 2.5 | 0.2 m | Agricultural land with many trees, bushes and plants, or 8 m high hedges seperated by approx. 250 m |
| 3 | 0.4 m | Towns, villages, agricultural land with many or high hedges, forests and very rough and uneven terrain |
| 3.5 | 0.6 m | Large towns with high buildings |
| 4 | 1.6 m | Large cities with high buildings and skyscrapers |

**Figure 12.27: Roughness length and class to be used for the logarithmic wind profile.**

The wind profile used in the model has been calculated using the formula above and is represented in Figure 12.28.

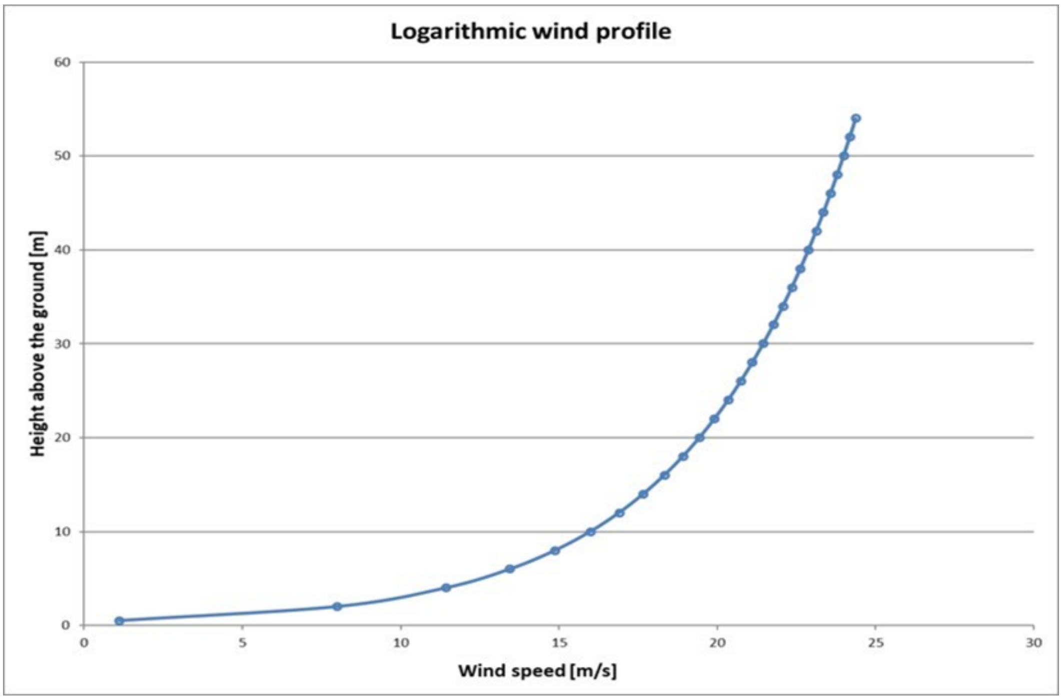



**Figure 12.28: Wind profile used in the model.**

## *12.5.4* Computational Mesh

The level of accuracy of the CFD results are determined by the level of refinement of the computational mesh. A mesh independent analysis is carried out prior to detailed simulation for final results. Details of parameters utilized for air and the computational mesh are presented in Table 12.4, while an example of the utilized computational mesh grid is as shown in Figure 12.29.

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 centre of each of these cells and then an interpolation function is used by the software to provide the results in the entire domain.

**Table 12.4: Air and Computational Mesh Parameters**

| AIR AND COMPUTATIONAL MESH PARAMETERS | |
|---|---|
| **Air Density ρ** | 1.2 kg/m3 |
| **Ambient Temperature (T)** | 288 K(approx.15C◦) |
| **Min mesh cell size** | 0.1 m At Development Building<br>0.5 m In the Refined Volume Surroundings<br>1.5 m At Other Environment Buildings<br>2 m Elsewhere |
| **Min cell size ratio** | 1:1:1 (dx:dy:dz) |
| **Total mesh size** | Approx. cells number = 50 million |

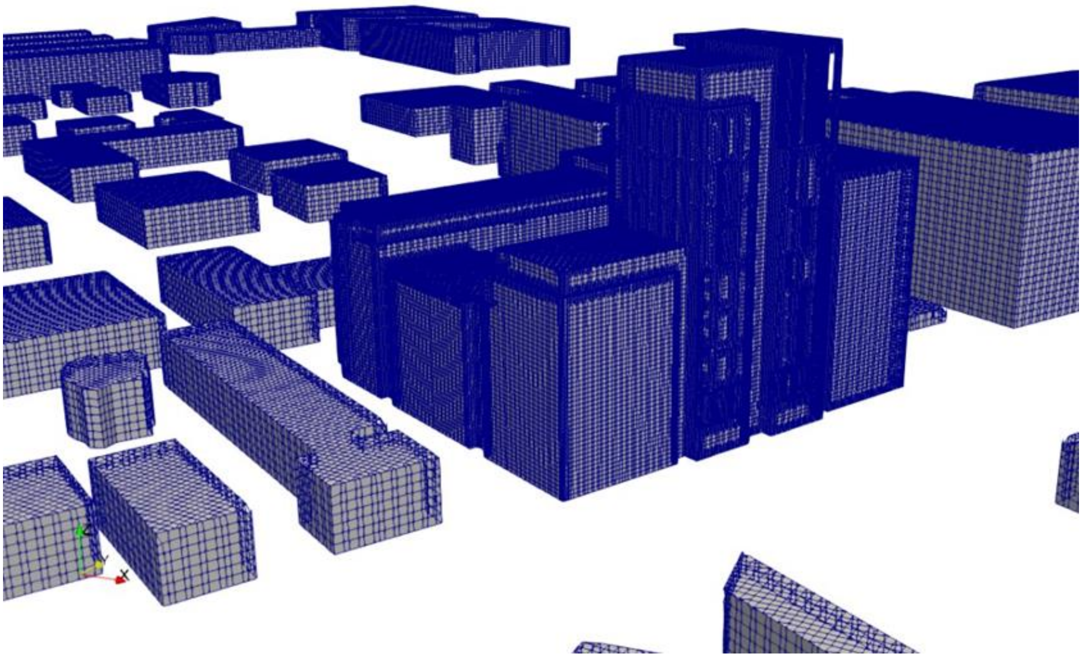


**Figure 12.29: Carmanhall Road Development and adjacent buildings - Computational Mesh Utilized**

## 12.5.5 Construction Phase

The possible effects on wind micro-climate at the site during the construction phase of Carmanhall Road Development has not been directly assessed but was evaluated based on professional judgement. Statistical Dublin historical wind data have been used to carry out this analysis based on the fact that the dominant wind direction is from South-West.

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. It is possible that in the final stages of construction, implementation of the mitigation measures would be needed in areas that are expected to be windier than others should in case some areas of the site are expected to be functional before the construction is finalized.

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 situ), the impacts evaluated on-Site are considered to be not significant. Thus, the predicted impacts during construction phase are identified as slight or imperceptible.

In summary, as construction of the Carmanhall Road 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 imperceptible.

## 12.5.6 Operational Phase

This section shows CFD results of wind and microclimate assessment carried out considering the ”Operational Phase” of Carmanhall Road Development. In this case the assessment has considered the impact of wind on the existing area including the proposed Carmanhall Road Development. For this scenario, Carmanhall Road Development has been simulated. 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. For this, the Lawson and Distress Maps have been presented to identify the suitability of each areas to its prescribed level of usage and activity. The results present parameters outlined within the acceptance criteria previously described.

A summary of CFD model input data used in this project is given in the table shown in Figure 12.30.

| Parameter | CARMANHALL ROAD DEVELOPMENT MODEL |
|---|---|
| Environment Conditions | |
| Ambient pressure | 101325 Pa |
| Wind profile | Logarithmic atmospheric profile |
| Ambient temperature | 15 °C |
| Analysis type | Steady state (LES) |
| Computational Details | |
| Total cells used | > 20,000,000 |
| Mesh size | < 0.2 m |
| Turbulence treatment | K-epsilon turbulence model |
| Convergence Criteria | $< 10^{-6}$ |
| Boundary Conditions | |
| CFD Domain Inlet | Wind Velocity inlet |
| CFD Domain Outlet | Pressure Outlet condition (zero pressure gradient) |
| Carmanhall Road Buildings | Zero velocity gradient (No-slip condition) |

**Figure 12.30: Summary of CFD Model Input Data**

It is also of interest at this point to underline once more the objectives of simulations performed. 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.
- To assess comfortable and safe pedestrian level wind conditions that are appropriate for the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, public spaces, amenity areas, outdoor sitting areas, etc.

Results of simulations carried out are detailed in the following sections. These results present parameters as outlined in the acceptance criteria section described previously for Carmanhall Road development. Results of wind flow speeds are collected throughout the simulation and analysed based on the Lawson Discomfort Criteria.

Figure 12.31 shows a 3D example of wind speed results collected at 1.5 m height above ground floor level of the development. Red colours generally indicate critical values while blue colours indicate tenable conditions.

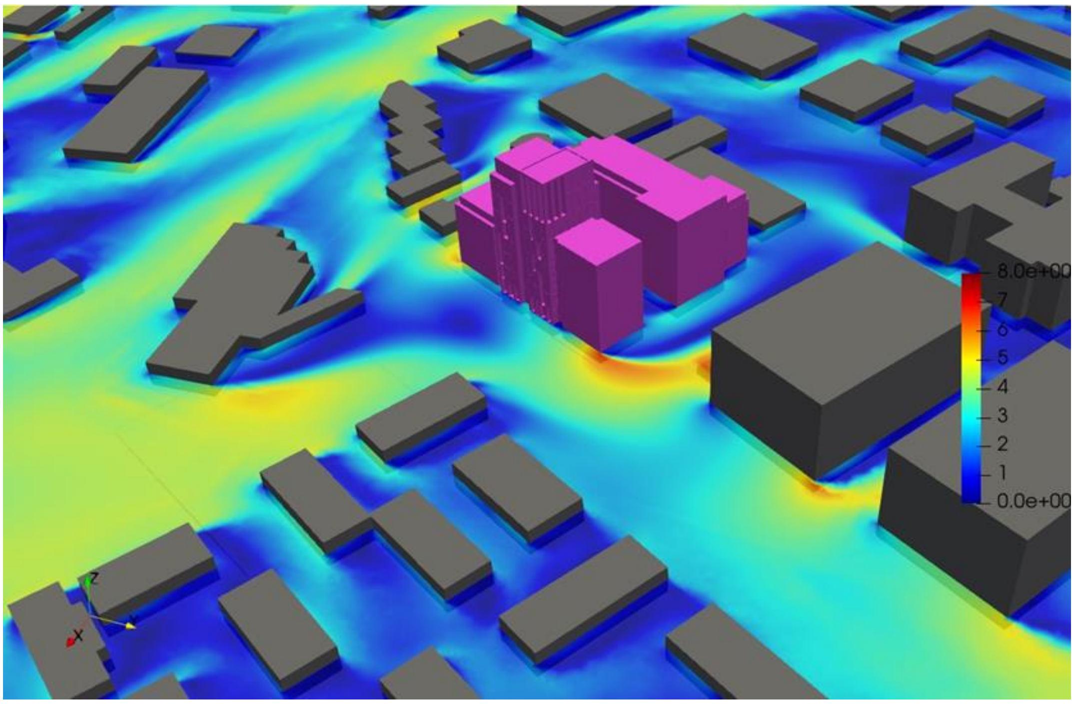



**Figure 12.31: Wind Flow Results Collected At 1.5 m Height Above Ground Floor**

## Flow Velocity Results - Ground Floor Level

Results of wind speeds and their circulations around the Proposed Development at pedestrian level of 1.5 m above the development ground are presented for all the simulated wind directions in Figure 12.32 to Figure 12.52 (both top views and 3D views, as well as courtyard results), in order to assess wind flows at ground floor level of Carmanhall Road Development.

Some higher velocities are experienced around the building for certain wind directions. In particular, some recirculation effects are expected near the corners of the unit and at the main entrance. However, the implementation of tree landscaping on the main roads and all around the development, with particular attention to the corners and to the entrance have been planned and will mitigate these effects.

Depending on the wind direction, slight funnelling effects are experienced on the main roads around the development, especially on the road on the south side of the development. The implementation of tree landscaping in these areas have been planned and will mitigate these effects.

The courtyard seems to be well shielded. However, some recirculation effect has been found for certain wind directions, especially near the main entrance. The implementation of tree landscaping has been planned for these areas will mitigate these effects.

Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the ground floor are identified as slight or imperceptible.

Figure 12.53 shows the mitigation measures implemented for the development, at ground floor level, courtyard, and main entrance.

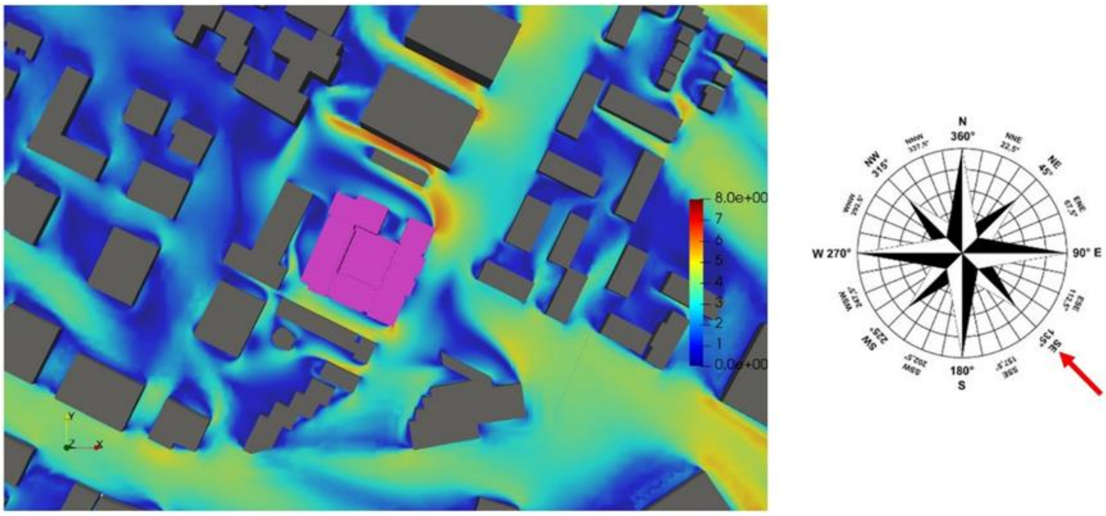



**Figure 12.32: Wind Speed Results at 1.5 m Above Ground - Top View: 135°**

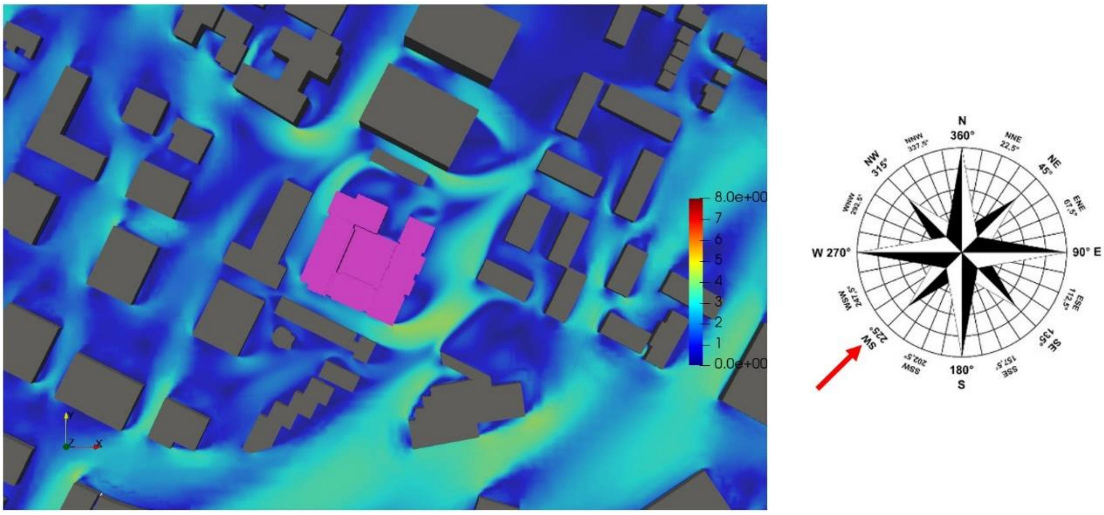



**Figure 12.33: Wind Speed Results at 1.5 m Above Development Ground - Top View: 225°**

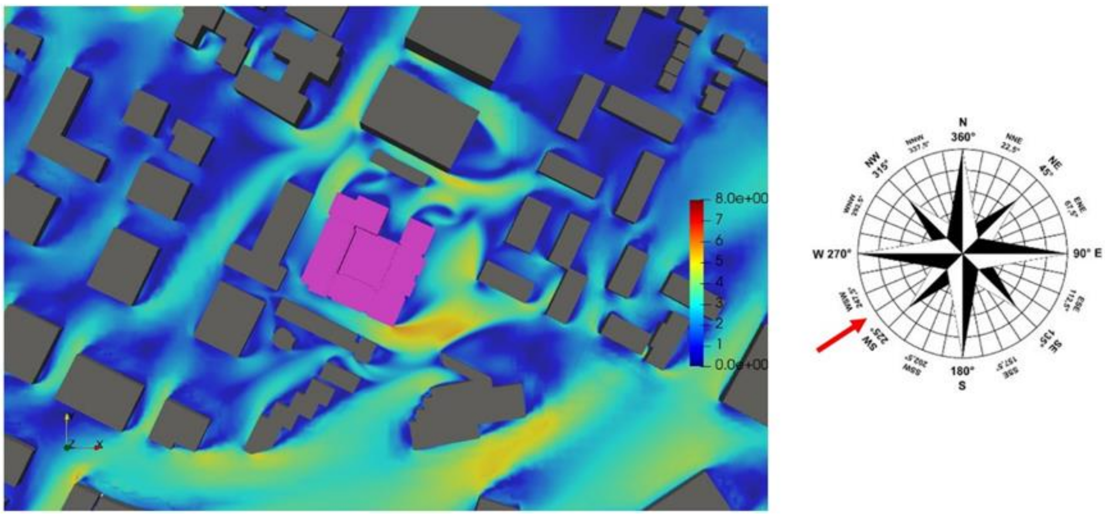



**Figure 12.34: Wind Speed Results at 1.5 m Above Development Ground - Top View: 236°**

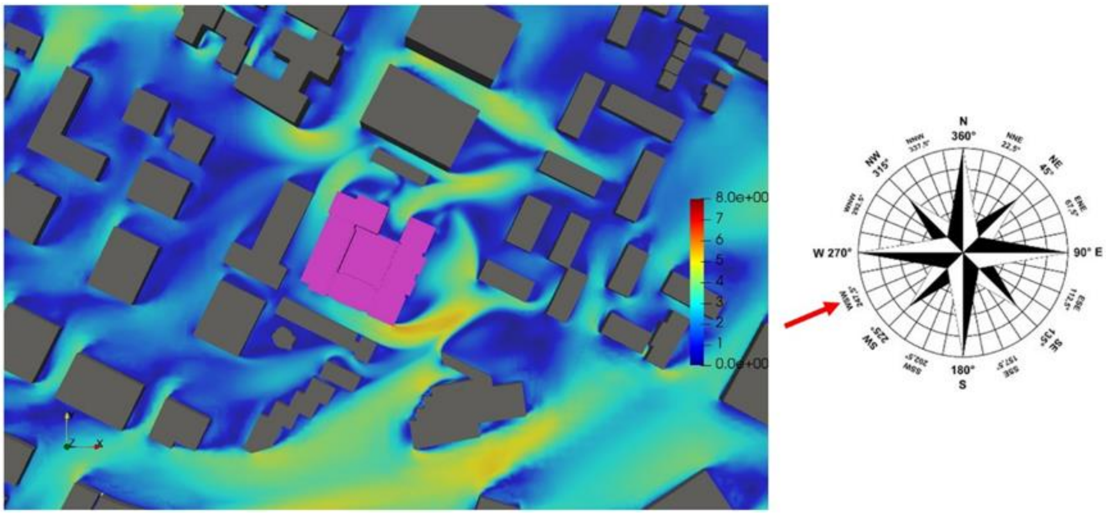


**Figure 12.35: Wind Speed Results at 1.5m Above Development Ground - Top View: 247°**

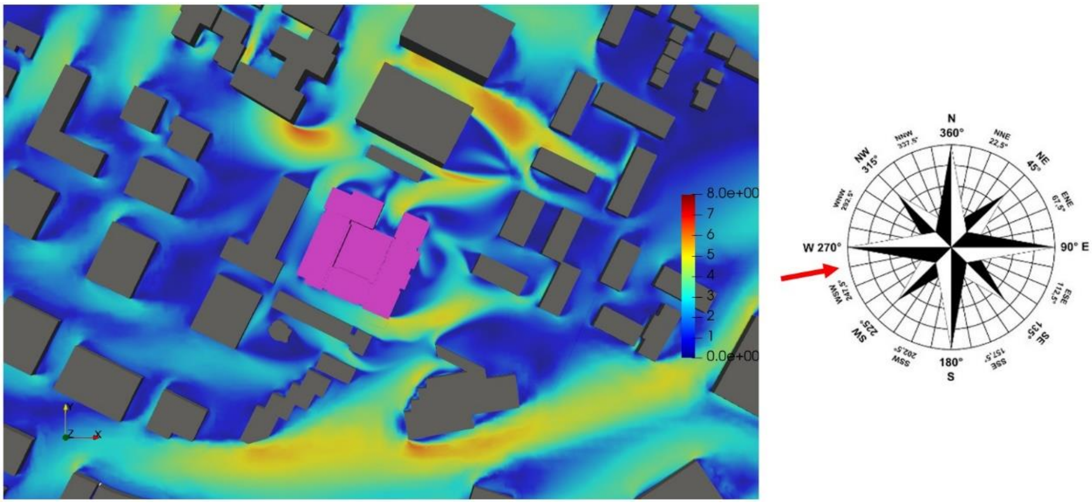


**Figure 12.36: Wind Speed Results at 1.5 m Above Development Ground - Top View: 258°**

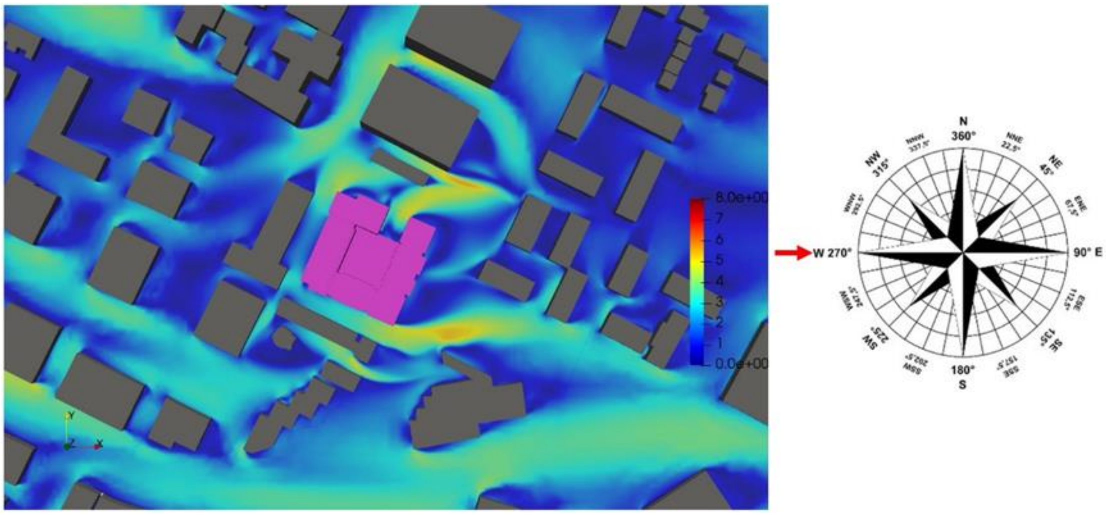


**Figure 12.37: Wind Speed Results at 1.5 m Above Development Ground - Top View: 270°**

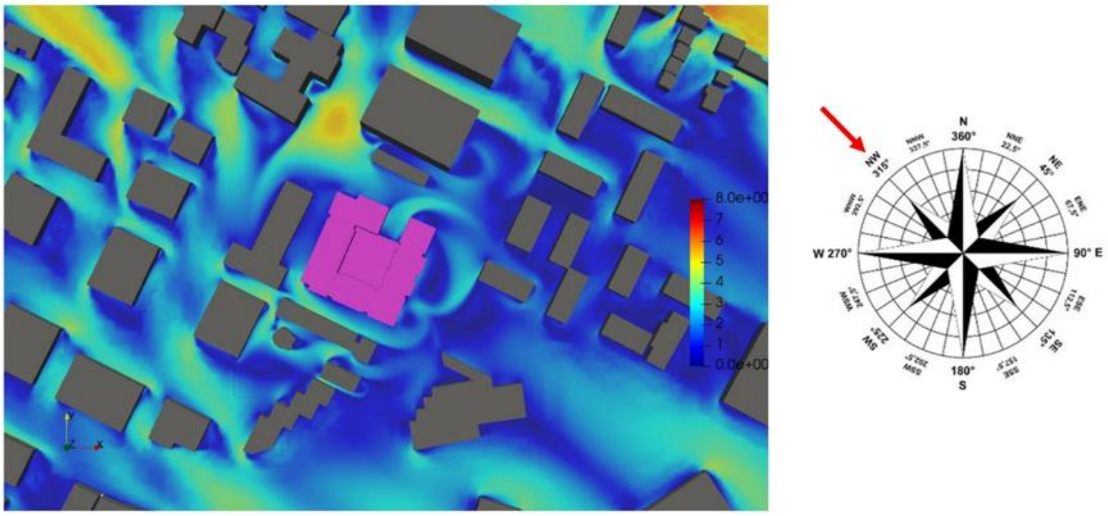



**Figure 12.38: Wind Speed Results at 1.5 m Above Development Ground - Top View: 315°**

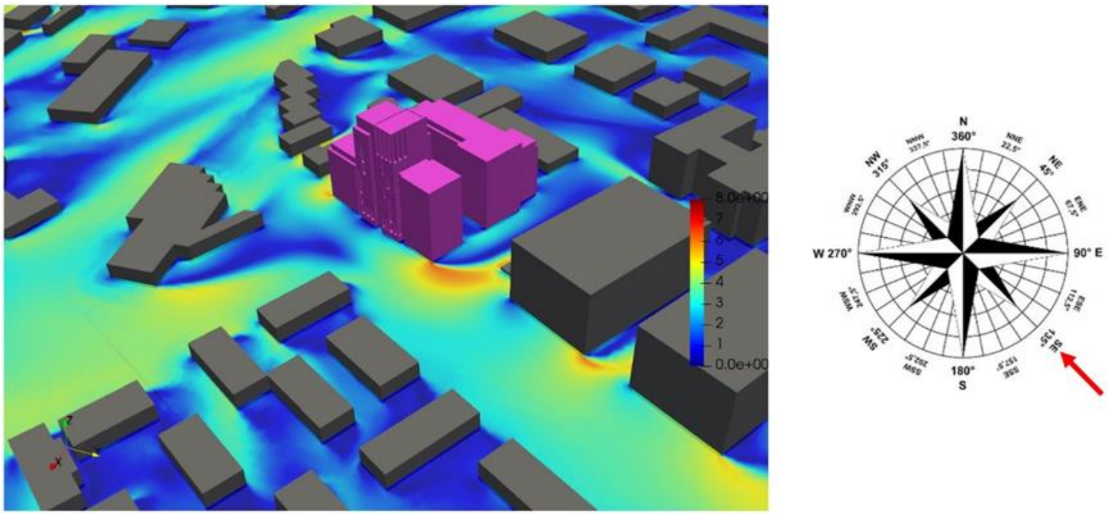



**Figure 12.39: Wind Speed Results at 1.5 m Above Ground - 3D View: 135°**

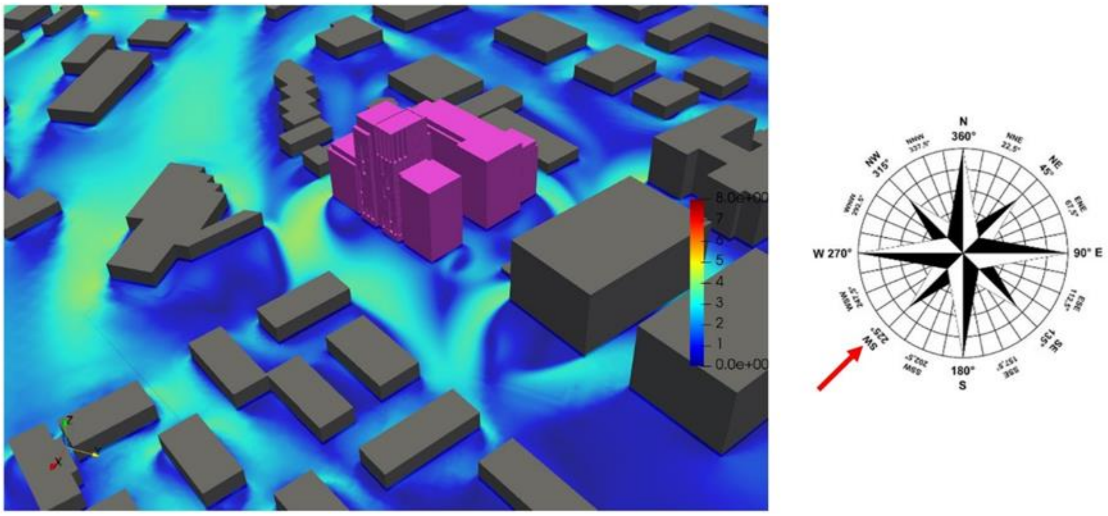



**Figure 12.40: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 225°**

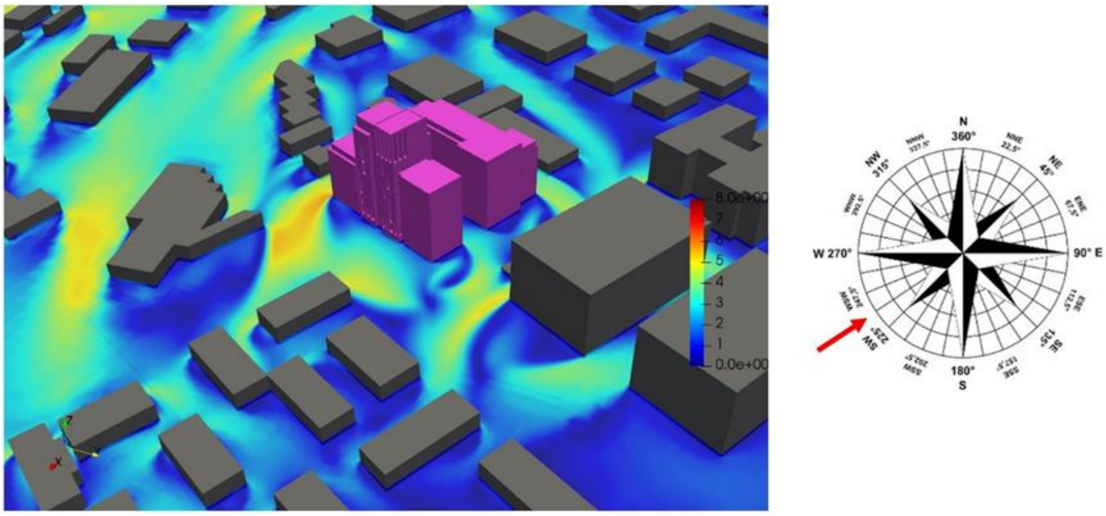


Figure 12.41: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 236°

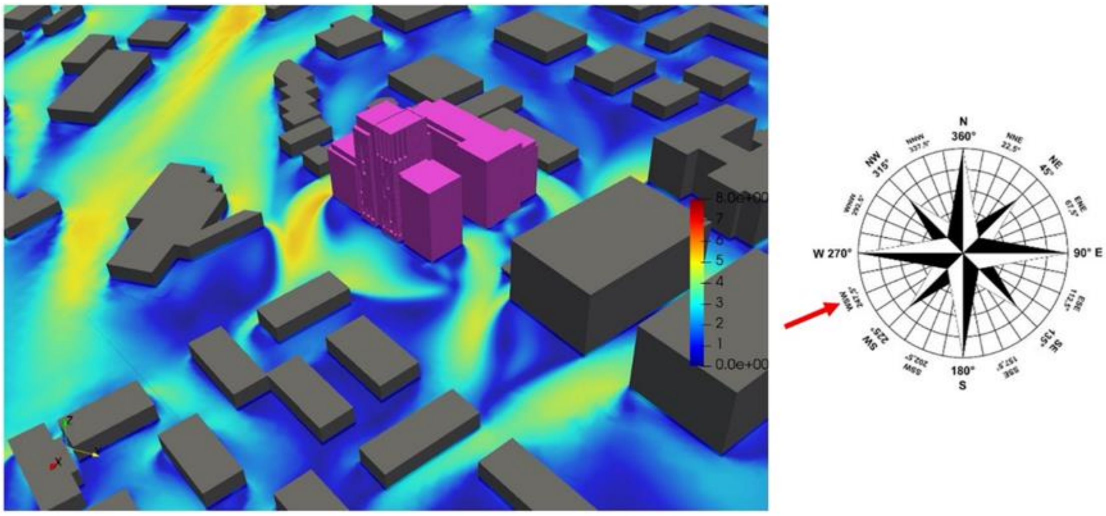


Figure 12.42: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 247°

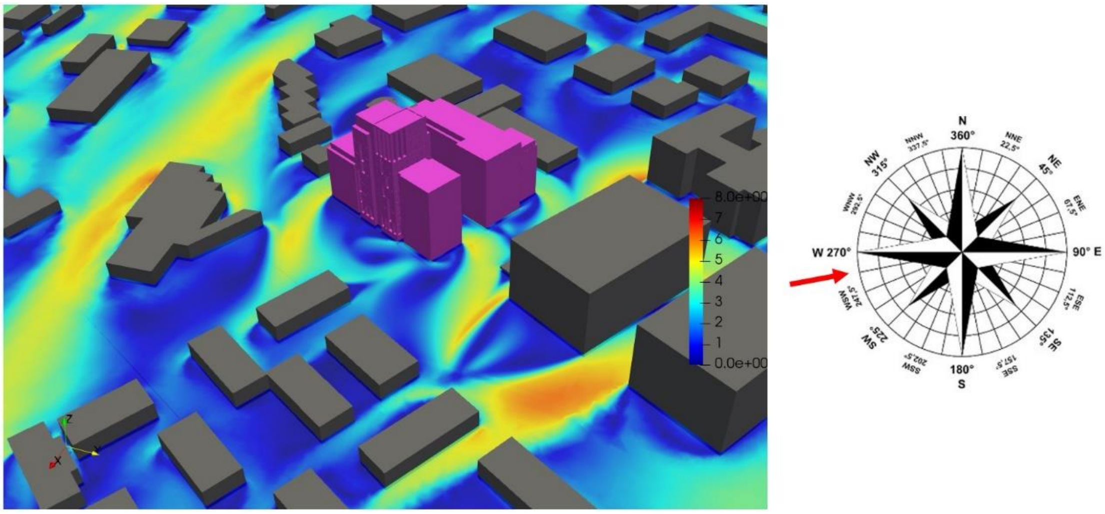


Figure 12.43: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 258°

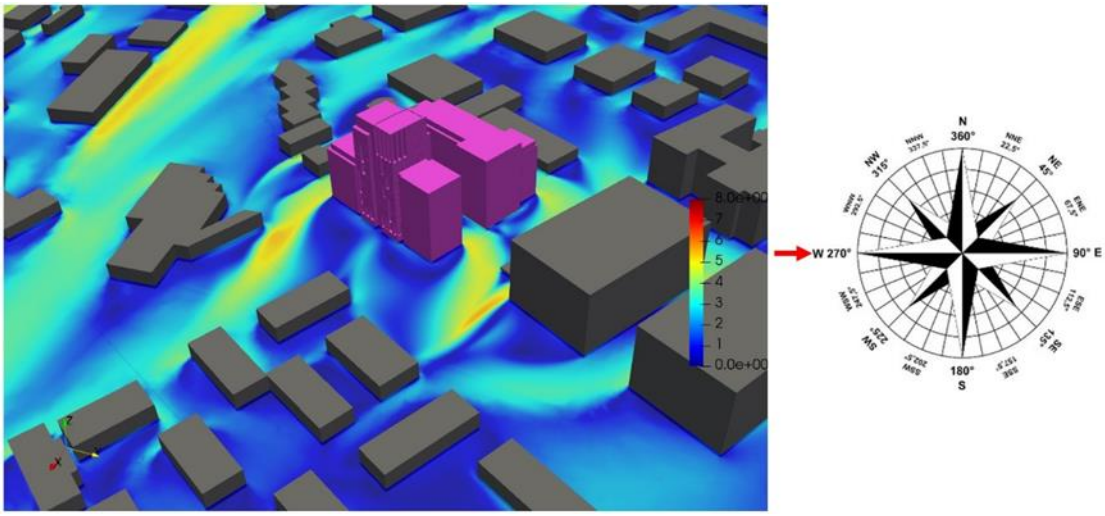



**Figure 12.44: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 270°**

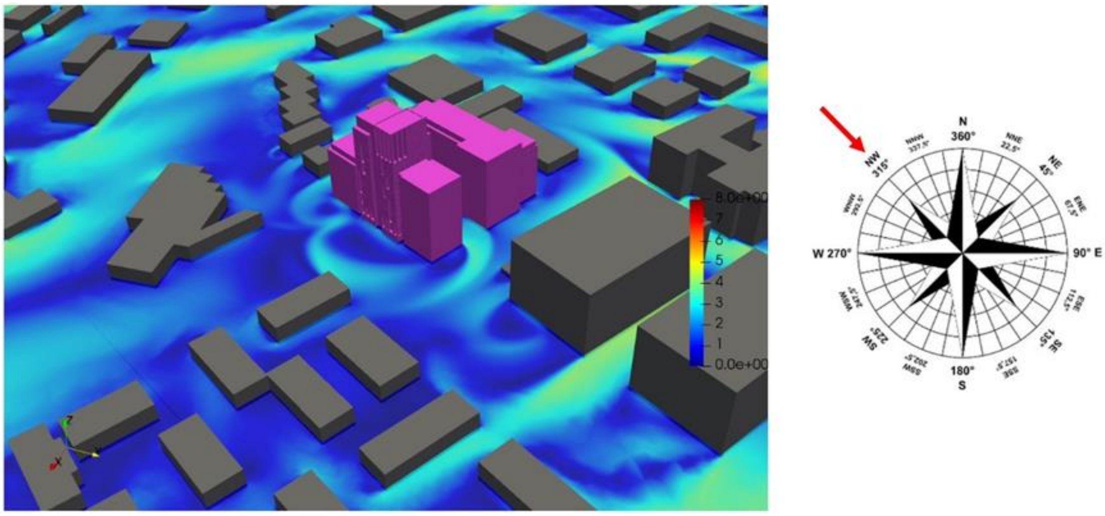



**Figure 12.45: Wind Speed Results at 1.5 m Above Development Ground - 3D View: 315°**

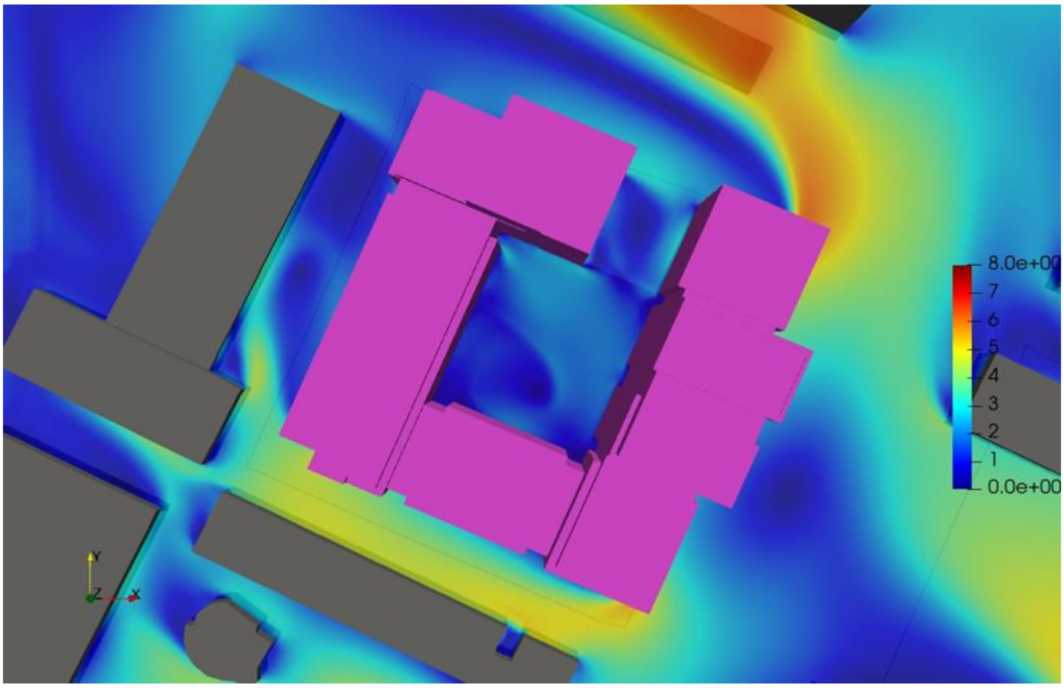



**Figure 12.46: Courtyard - Wind Speed Results at 1.5 m Above Ground - Top View: 135°**

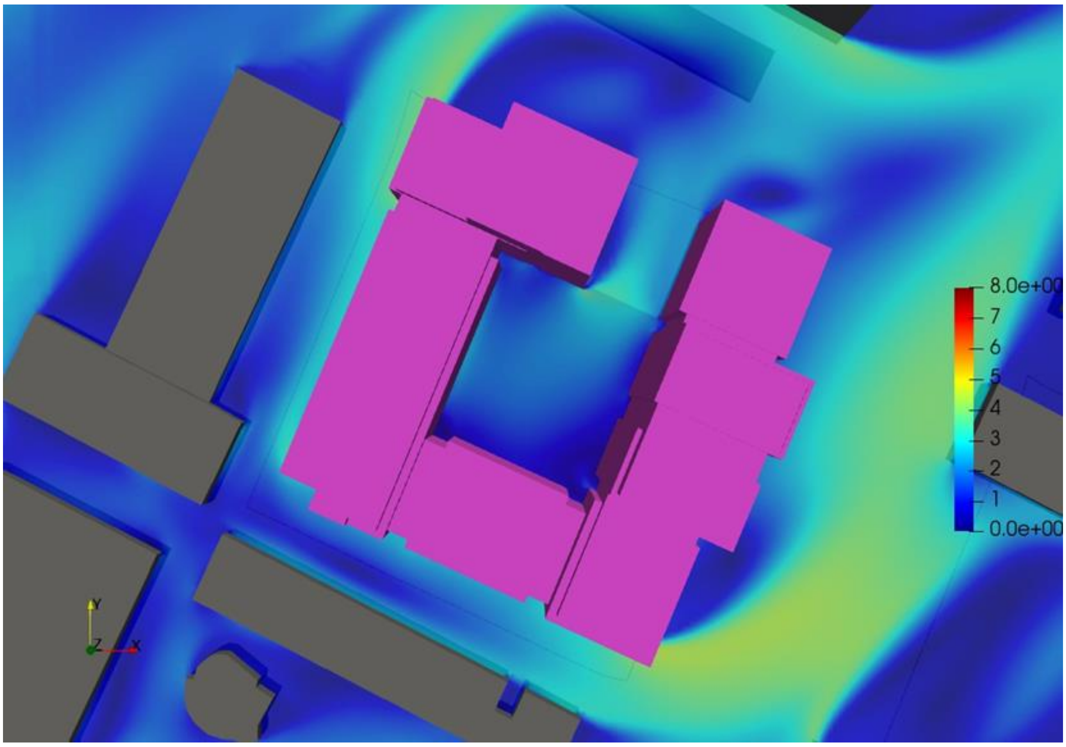



**Figure 12.47: Courtyard - Wind Speed Results at 1.5 m Above Development Ground - Top View: 225**

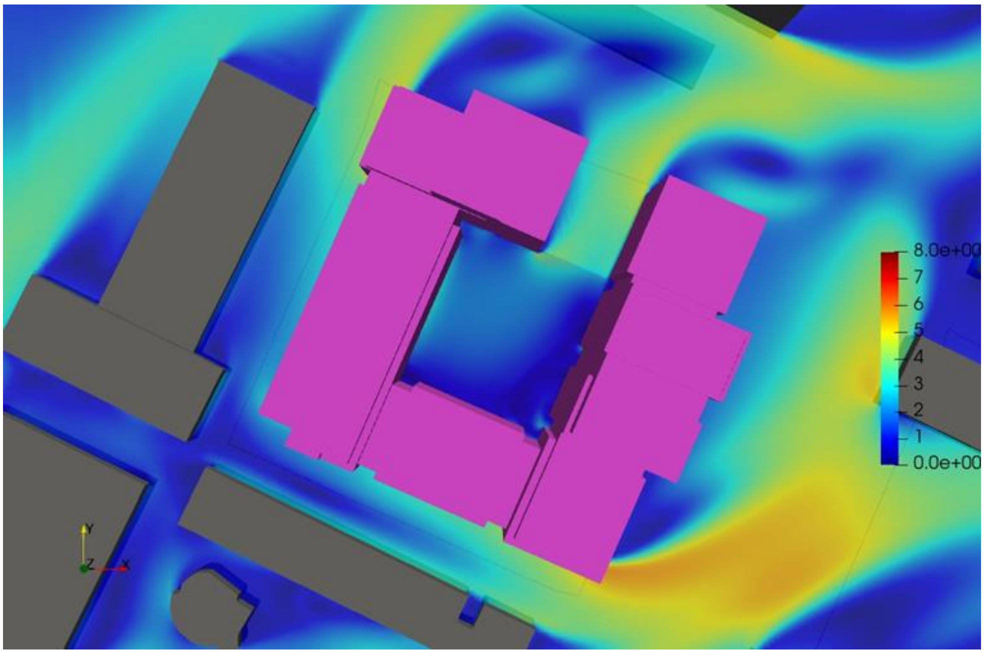



**Figure 12.48: Courtyard - Wind Speed Results at 1.5 m Above Development Ground - Top View: 236°**

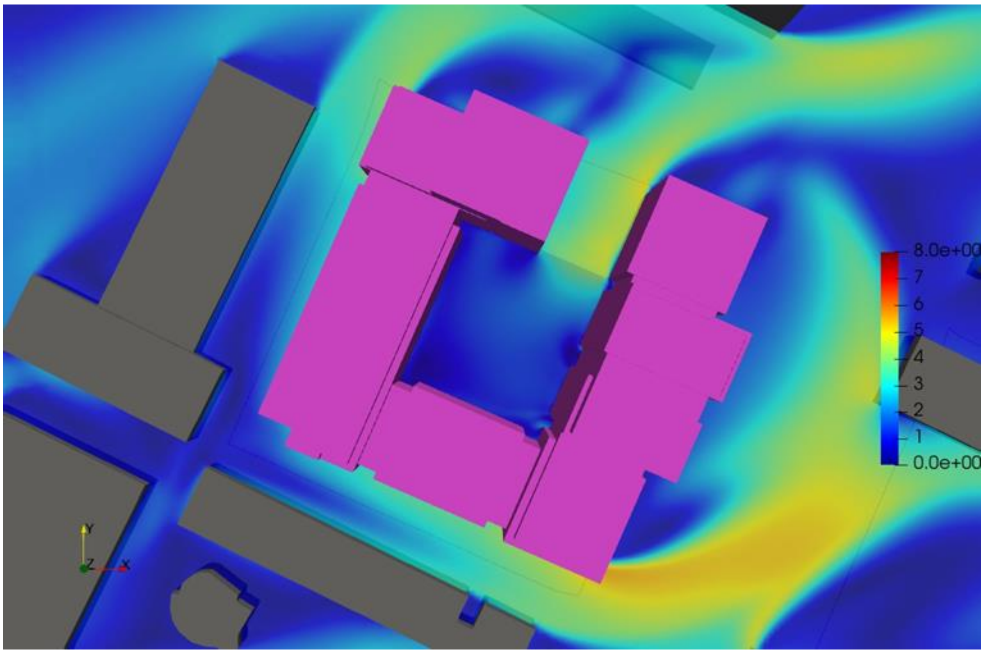



**Figure 12.49: Courtyard - Wind Speed Results at 1.5 m Above Development Ground - Top View: 247°**

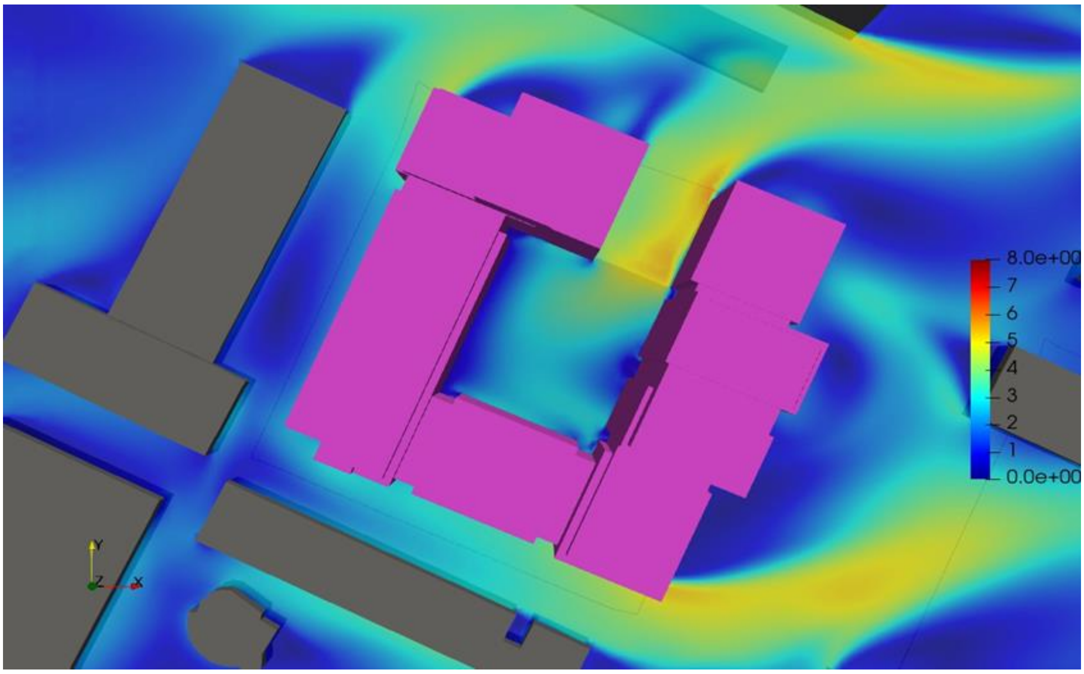



Figure 12.50: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 258°

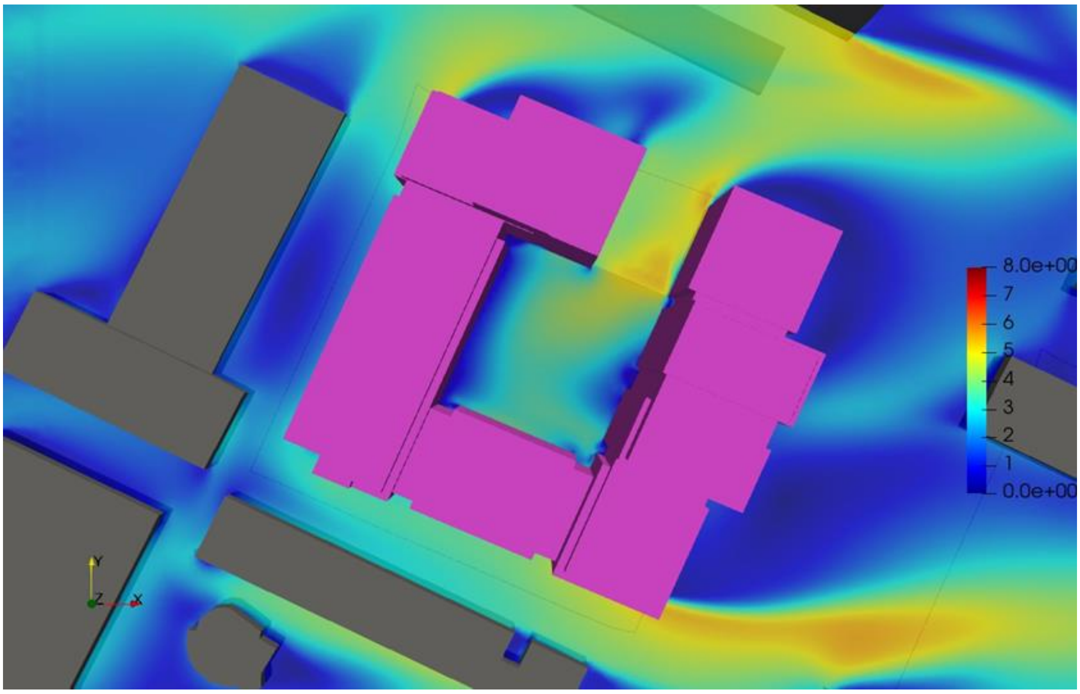



Figure 12.51: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 270°

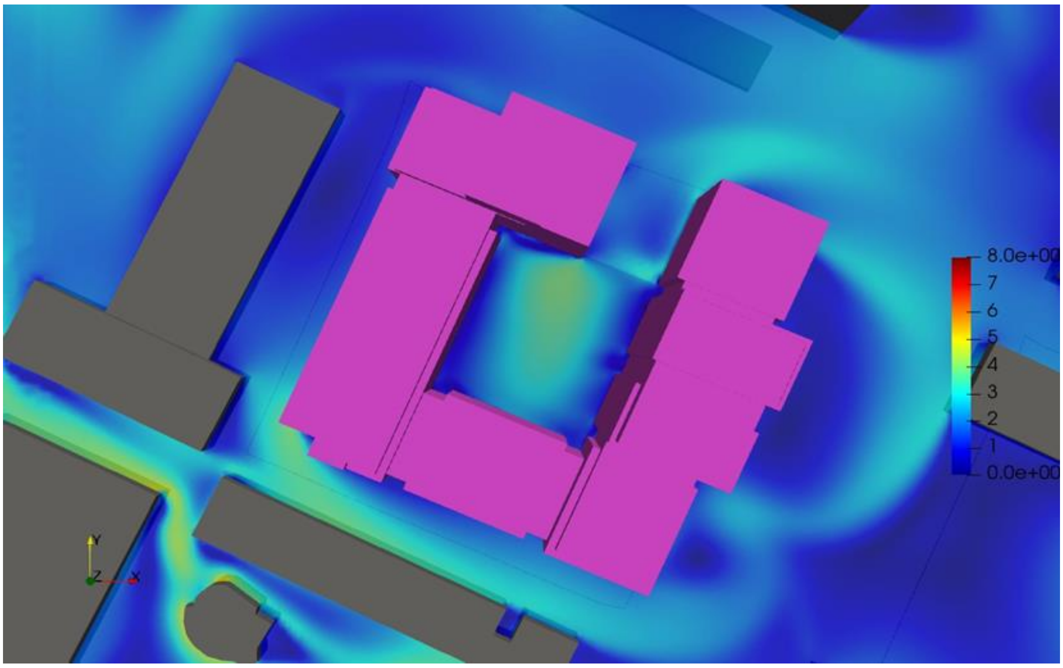



**Figure 12.52: Courtyard - Wind Speed Results at 1.5 m Above Development Ground - Top View: 315°**

**Figure 12.53: Mitigation Measures implemented at ground floor, courtyard and main entrance.**

### 12.5.7 Roof Terraces

Figure 12.6.30 shows the position of the four terraces on the development. Terrace 1 and 4 are at the same level, approx. 34 m, Terrace 1 is at approximately 25 m and Terrace 3 at approx. 30 m.

Results of velocity at slice location of 1.5 m above the ground are presented in Figure 12.55 to Figure 12.57, for wind assessment of the terraces at Carmanhall Road Development.

Higher velocities can be found for some directions, only in some areas of the terraces and often corresponding to the edges of it. However, these velocities are below critical values for safety. Moreover, mitigation measures with balustrade, planters and trees have been implemented as presented in Figure 12.58 and Figure 12.59 and will mitigate these effects.

Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the terraces are identified as slight or imperceptible.


**Figure 12.54: Terraces at Carmanhall Road Development**

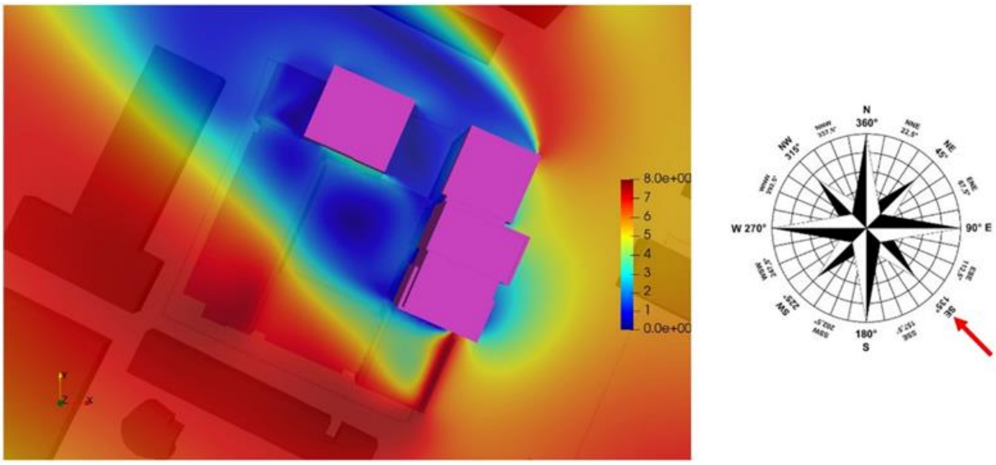



**Figure 12.55: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 135°**

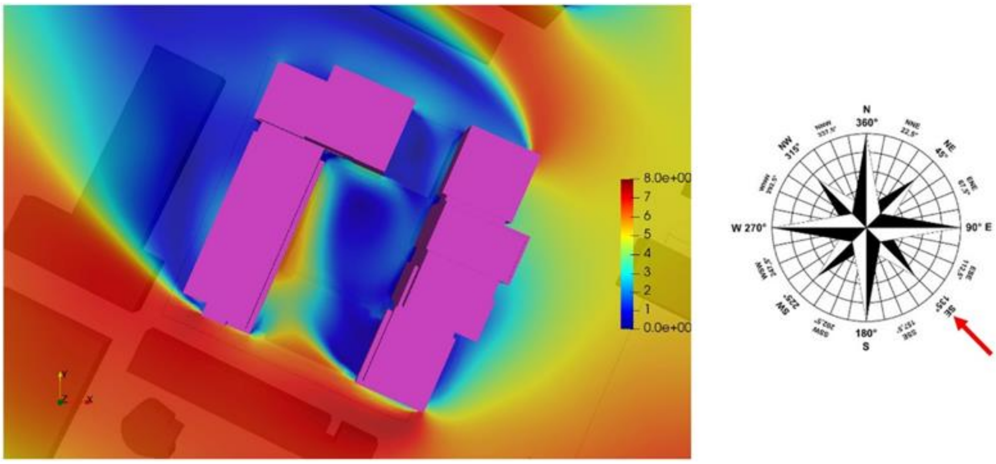



**Figure 12.56: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 135°**

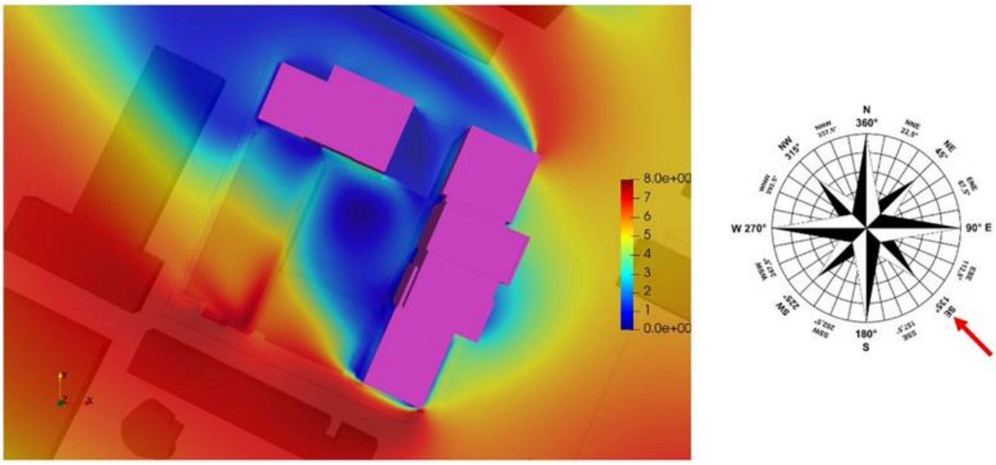



**Figure 12.57: Terrace 3 - Wind Speed Results at 1.5 m Above Terrace - Top View: 135°**

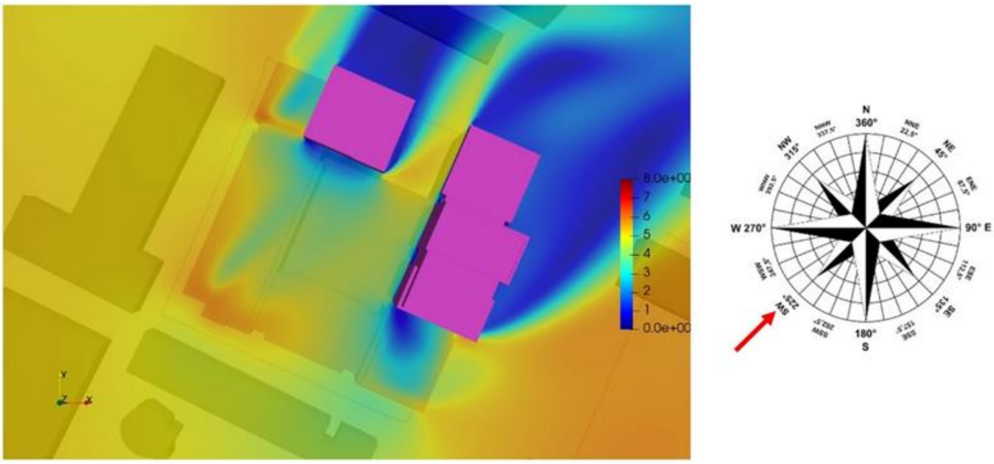



**Figure 12.58: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 225°**

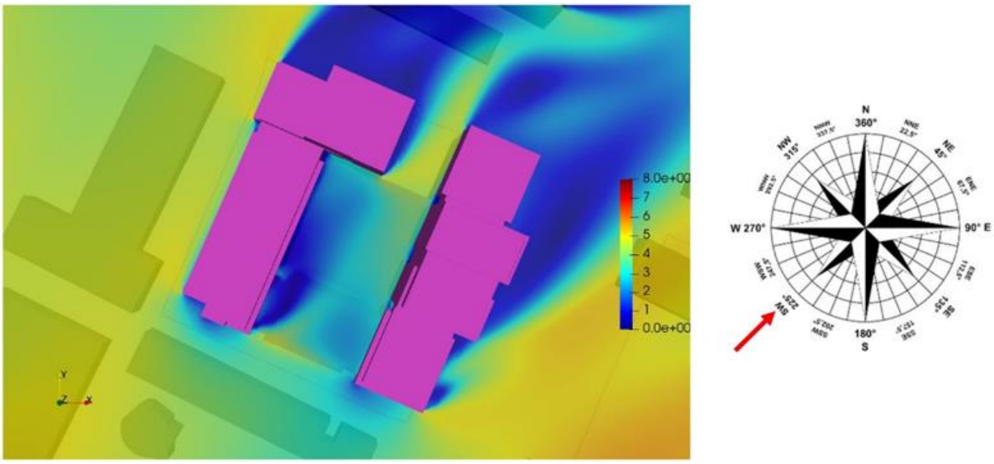



**Figure 12.59: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 225°**

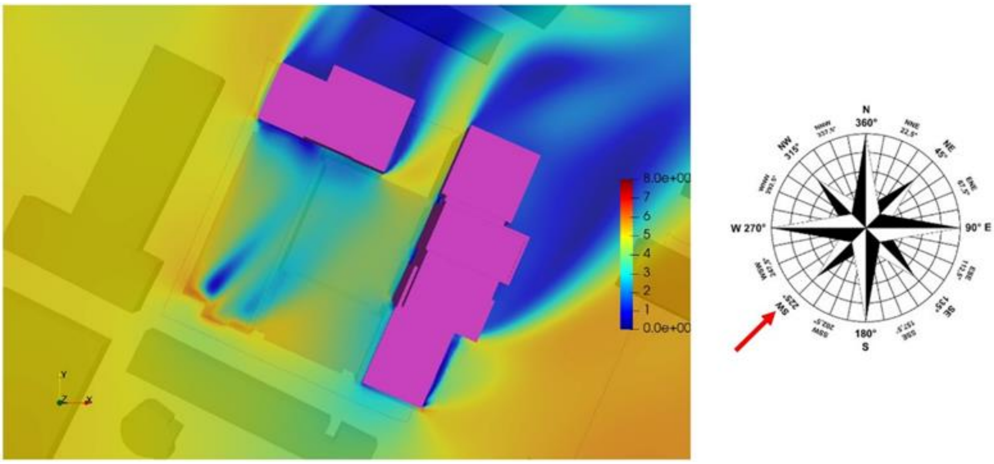



**Figure 12.60: Terrace 3 - Wind Speed Results at 1.5 m Above Terrace - Top View: 225°**

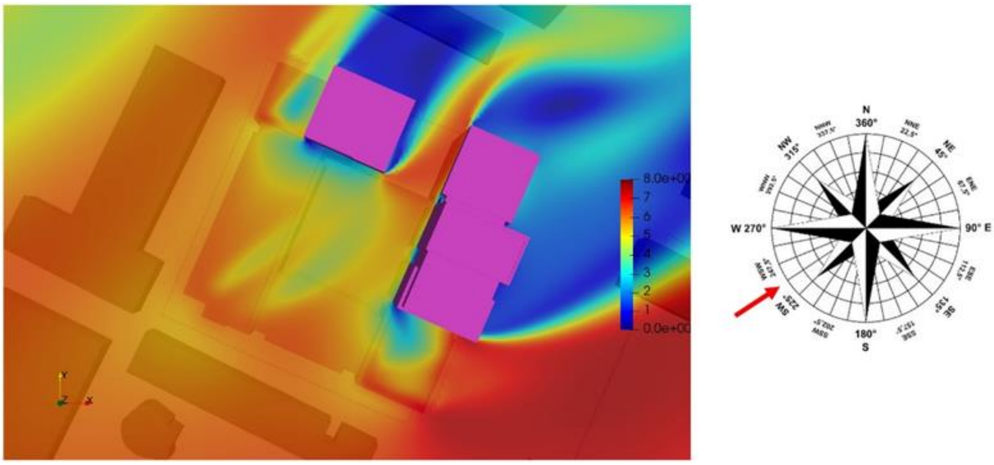



**Figure 12.61: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 236°**

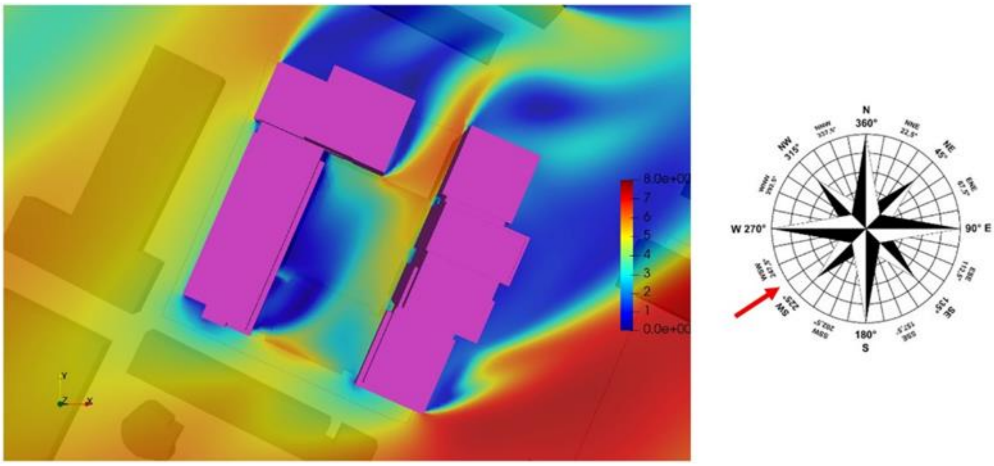



**Figure 12.62: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 236°**

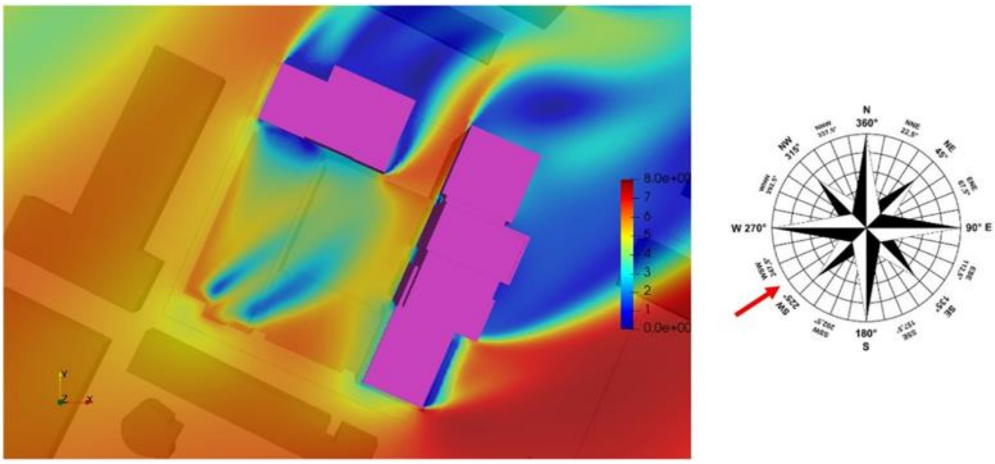



**Figure 12.63: Terrace 3 - Wind Speed Results at 1.5 m Above Terrace - Top View: 236°**

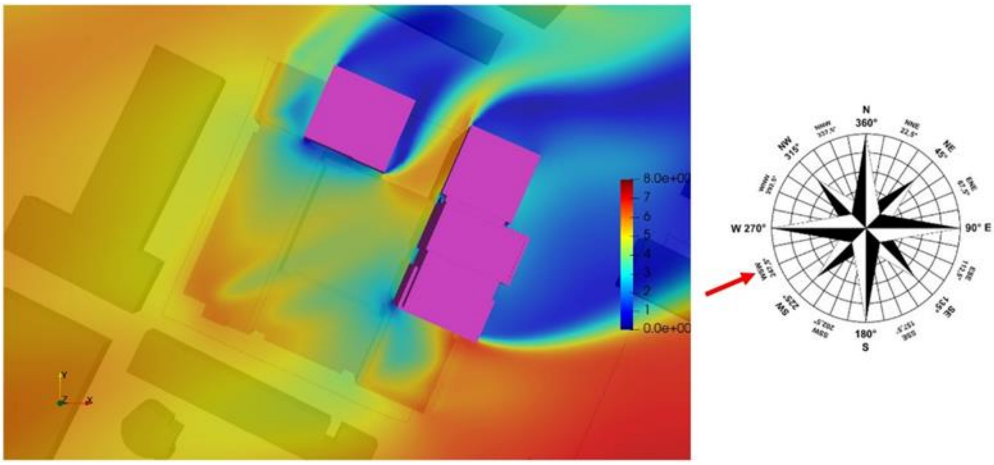



**Figure 12.64: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 247°**

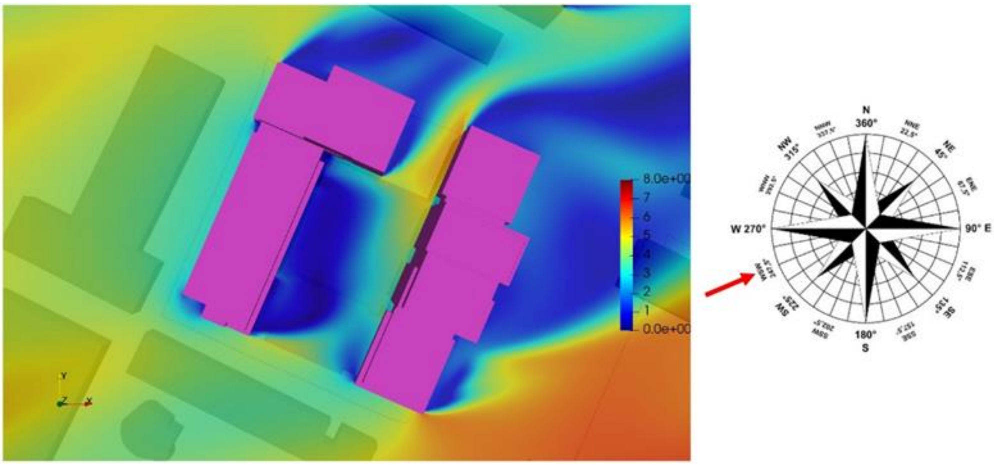



**Figure 12.65: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 247**

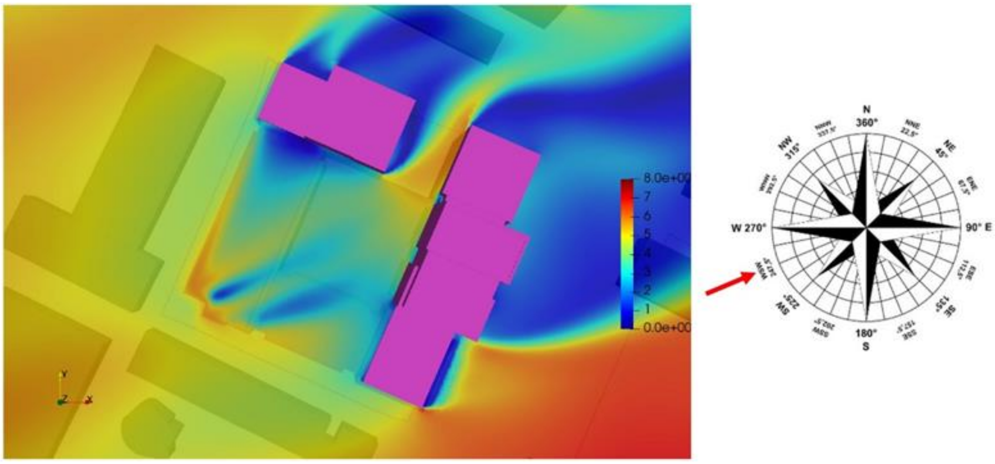



**Figure 12.66: Terrace 3 - Wind Speed Results at 1.5 m Above Terrace - Top View: 247°**

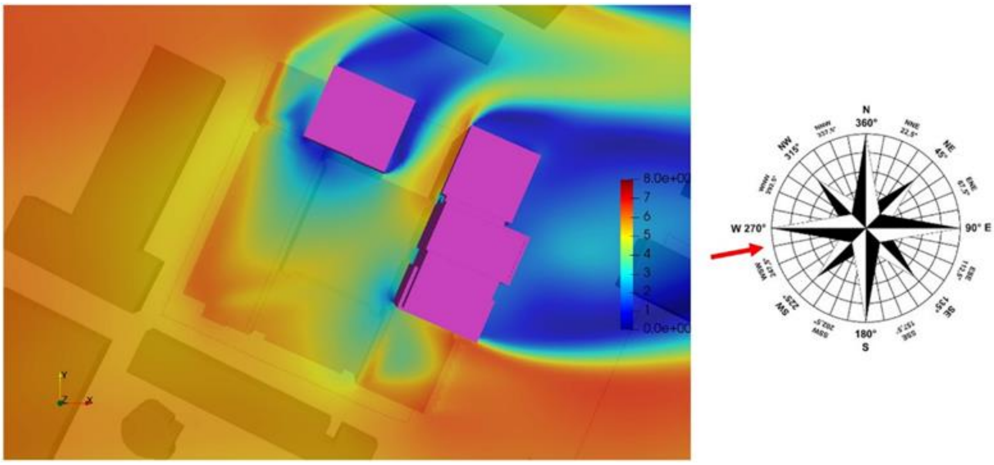



**Figure 12.67: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 258°**

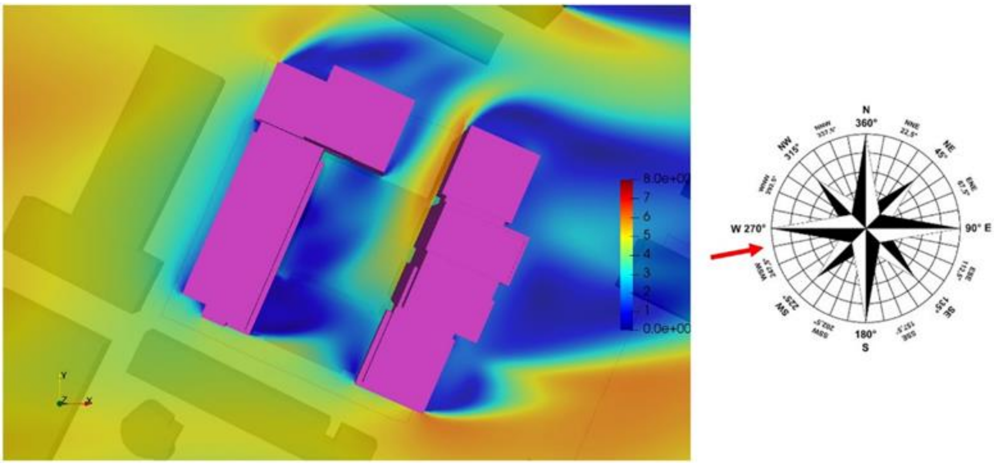



**Figure 12.68: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 258°**

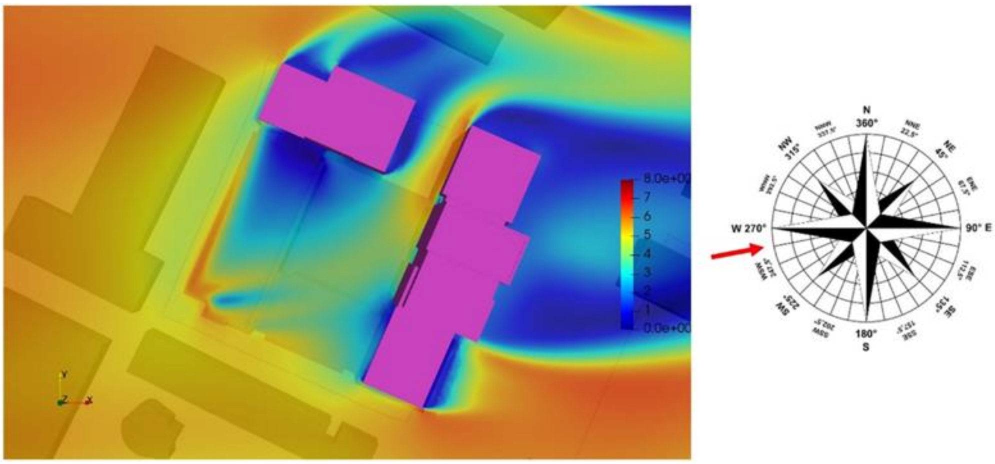



**Figure12. 69: Terrace 3 - Wind Speed Results at 1.5 m Above Terrace - Top View: 258°**

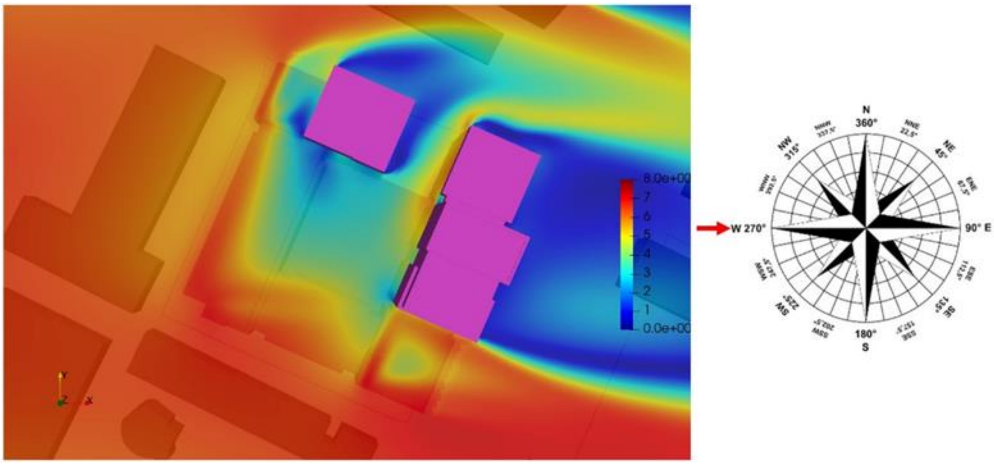



**Figure 12.70: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 270°**

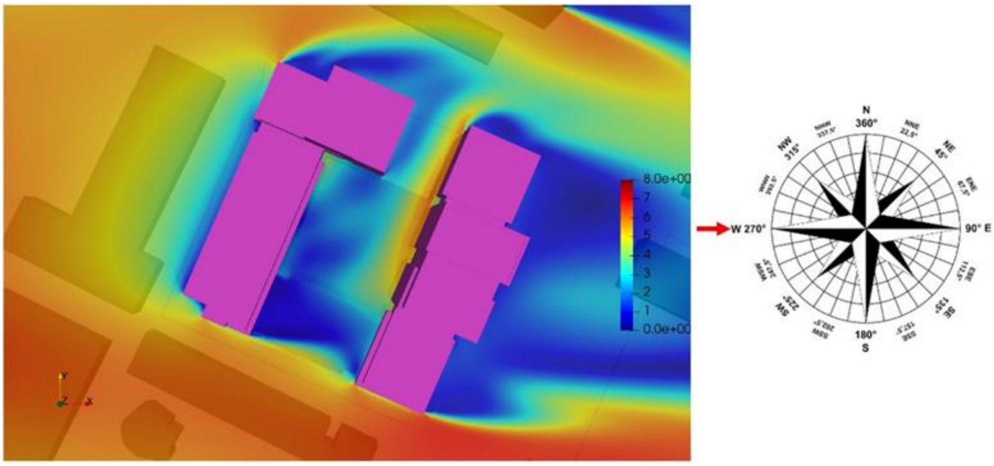



**Figure 12.71: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 270°**

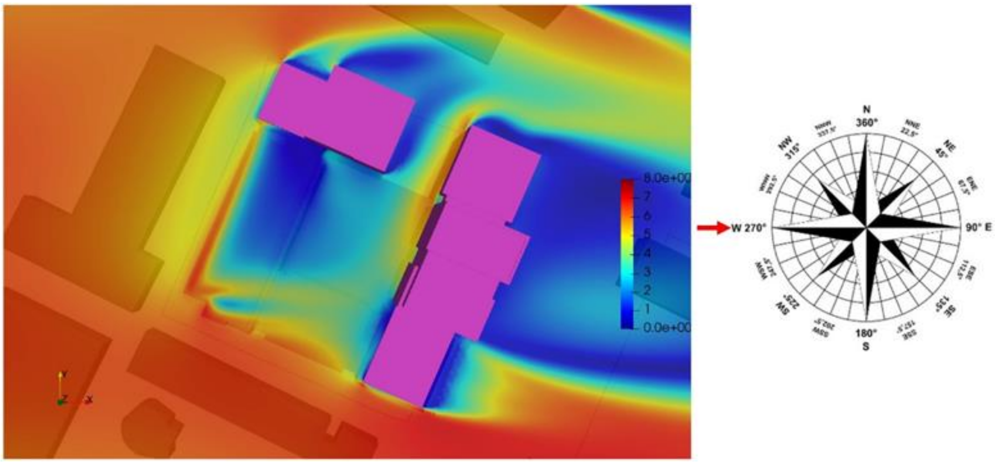



**Figure 12.72: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 270°**

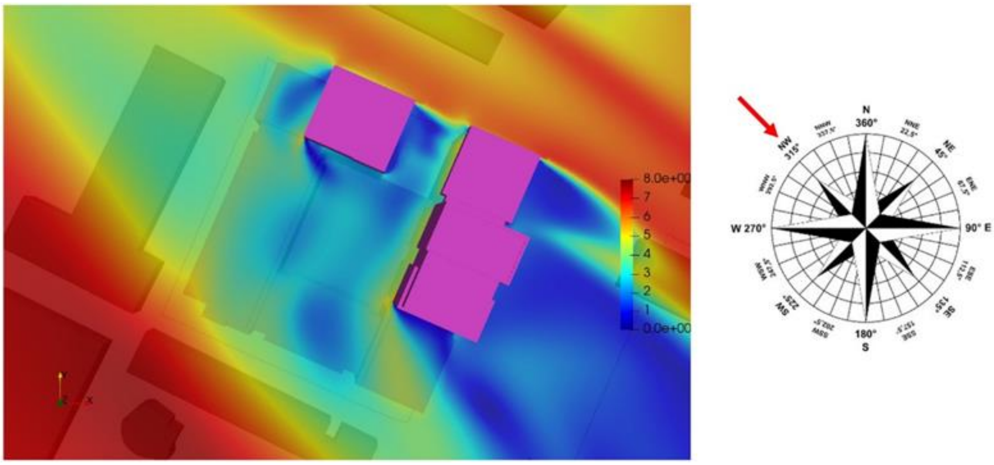



**Figure 12.73: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5 m Above Terrace – Top View: 315°**

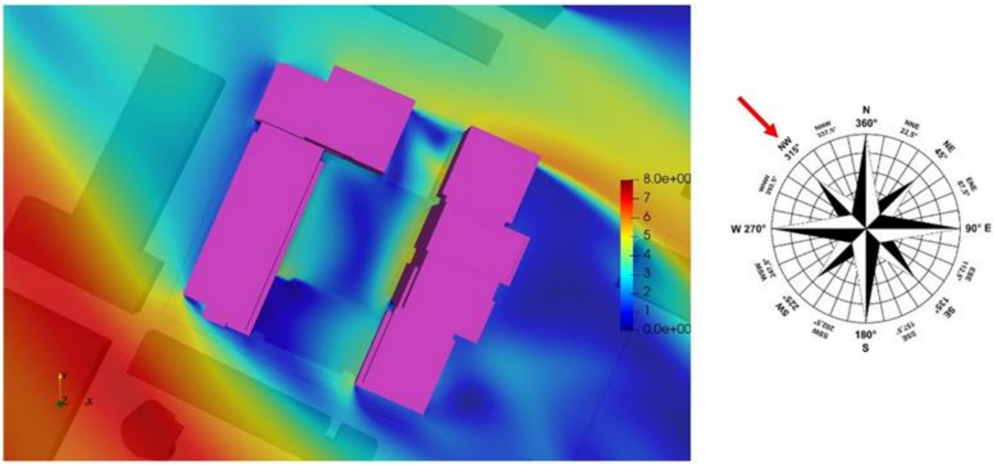



**Figure 12.74: Terrace 2 - Wind Speed Results at 1.5 m Above Terrace - Top View: 315°**

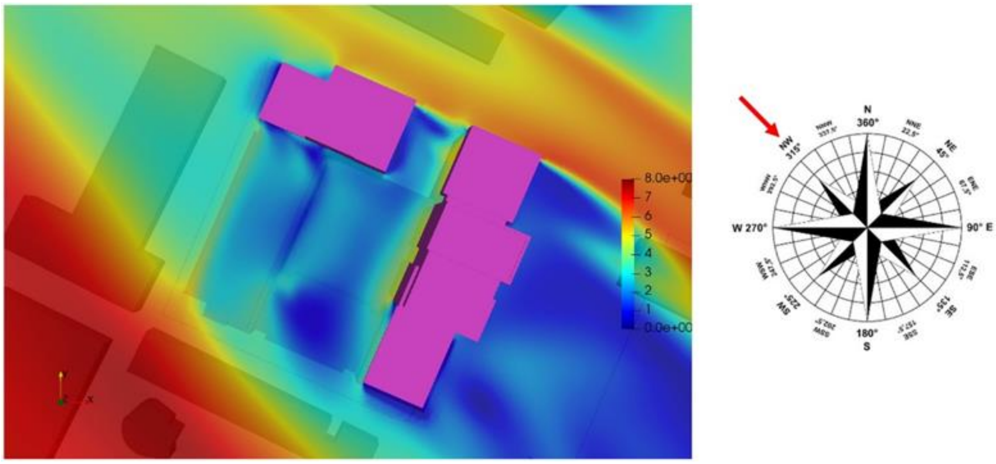



**Figure 12.75: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 315°**

**Figure 12.76: Mitigation Measures implemented on the Terraces.**

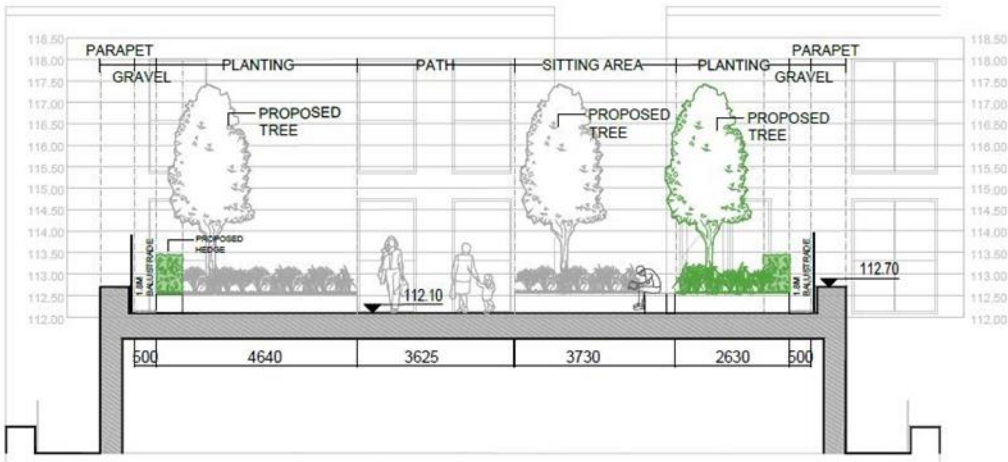



**Figure 12.77: Section View of the Mitigation Measures implemented on the Terraces - Details of Mitigations**

### 12.5.8 Flow Velocity Results Conclusions

The existing environment and proposed Carmanhall Road Development would receive prevailing winds from South-West. As discussed in the previous sections and demonstrated through this assessment of CFD modelling, all adverse wind impacts have been considered and shows to be suitable to its intended use.

The existing site cumulative assessment has accounted for the modelling and simulation of all the topography and existing developments in the surrounding as the presence of adjacent buildings dictates how the wind will approach the Proposed Development.

From the wind modelling results, Carmanhall Road Development will introduce imperceptible wind effect on adjacent, nearby developments within its vicinity. Wind modelling of future phases around this development will need to be performed for all future phase developments.

#### *12.5.8.1 Risks to Human Health*

This subsection aims to identify areas of Carmanhall Road Development where the 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.

#### *12.5.8.2 Discomfort Criteria*

Figures 12.6.55 to 12.6.91 show the Lawson comfort categories over the ground floor area, the courtyard (including the main entrance) and the terraces of Carmanhall Road Development for each direction. The scale used is set out in Figure 12.6.54.

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. Depending on the wind direction, the suitability of the different areas can be assessed using the maps. 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”.

At ground floor there are no critical area which are unacceptable for pedestrian comfort. Thus, the discomfort criteria are satisfied for all the different cases and in all directions and the area all around the development seems to be always suitable for long-term sitting, apart from the corners of the building, which are however suitable for any other activity.

The courtyard is always suitable for long-term sitting, short-term sitting, standing, walking and strolling activities. Only the main entrance is not suitable for long-term sitting.

Regarding the terraces, results show that there are areas of the roof terraces that are not suitable for long-term sitting, and some small areas that are not suitable for standing or short-term sitting, while they are suitable for all the other activities. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. A roof terrace is not an area that is used all year around and long-term sitting is an activity performed during spring/summer months, when the frequency of such high wind is below 5%. It is not expected that people would be making use of such roof areas during the worst-case conditions. Moreover, mitigation measures with balustrade, planters, and trees have been implemented as shown in the previous Section and will mitigate these effects. Additionally, it has to be notices that, in any case there are not critical issues in regard to safety.


**Figure 12.78: Lawson Comfort Categories**


**Figure 12.79: Ground Floor - Lawson Discomfort Map - 135°**

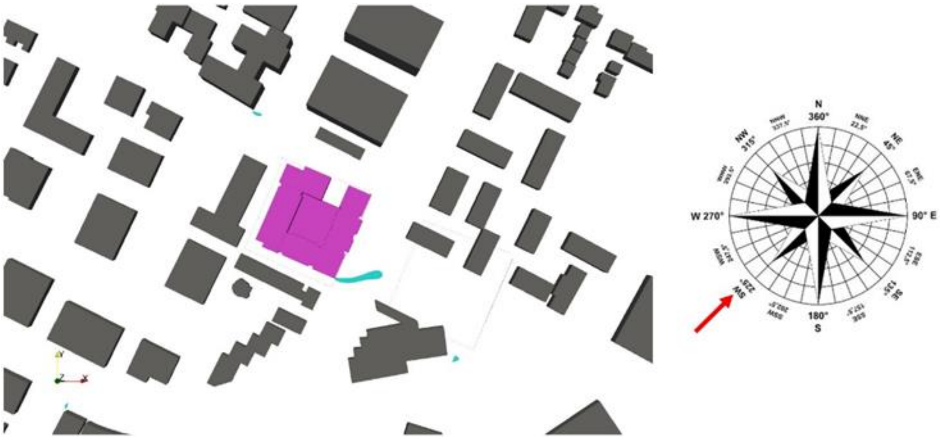



**Figure 12.80: Ground Floor - Lawson Discomfort Map - 225°**

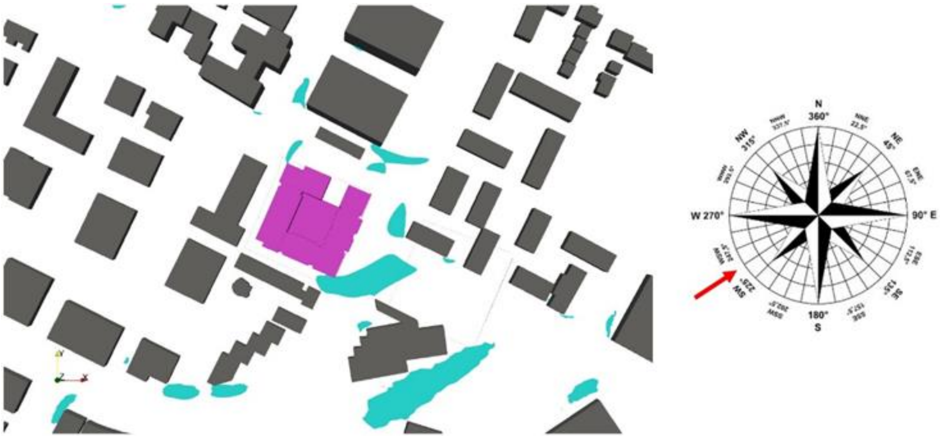


**Figure 12.81: Ground Floor - Lawson Discomfort Map - 236°**

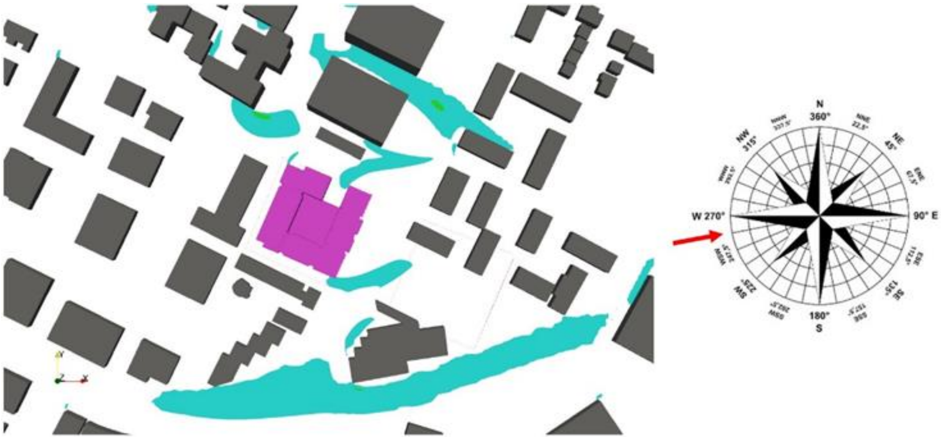


**Figure 12.82: Ground Floor - Lawson Discomfort Map - 258°**

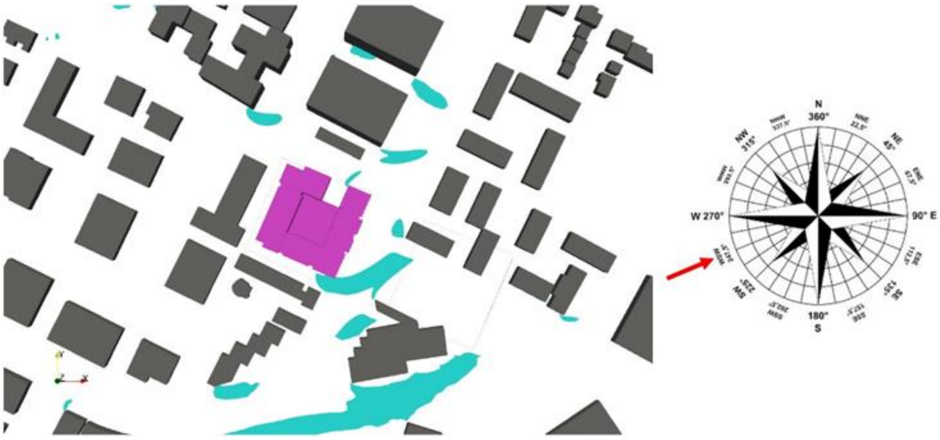


**Figure 12.83: Ground Floor - Lawson Discomfort Map - 247°**

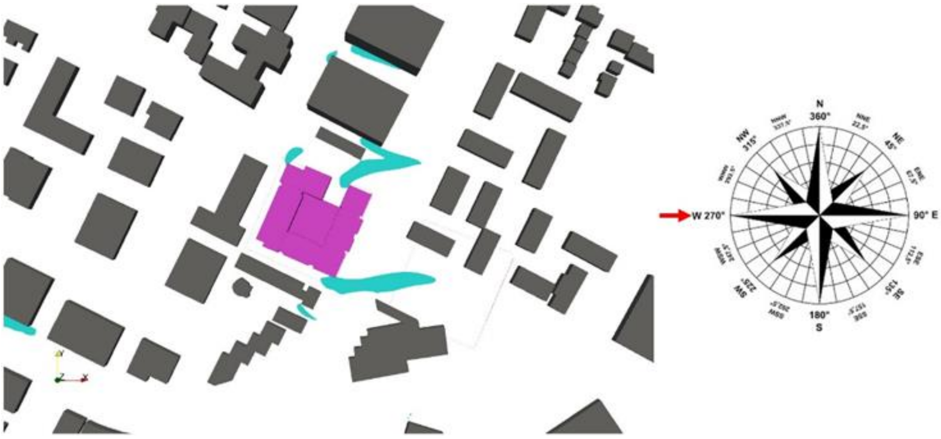



**Figure 12.84: Ground Floor - Lawson Discomfort Map - 270°**


**Figure 12.85: Ground Floor - Lawson Discomfort Map - 315°**


**Figure 12.86: Ground Floor - Lawson Discomfort Map - 281°**

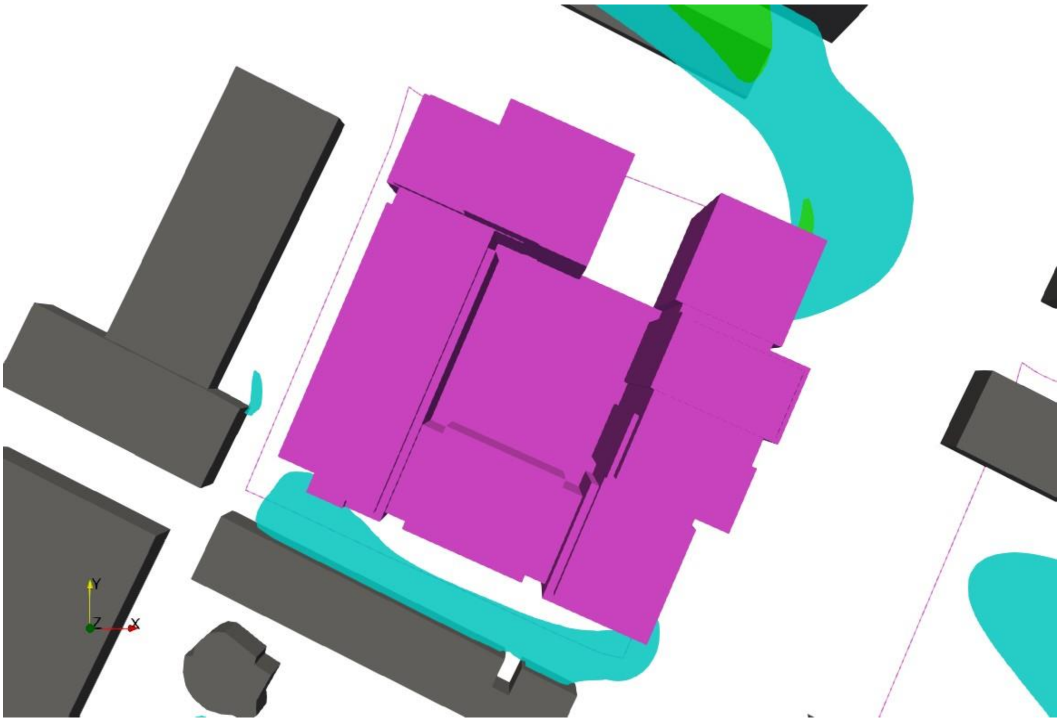



**Figure 12.87: Courtyard - Lawson Discomfort Map - 135°**

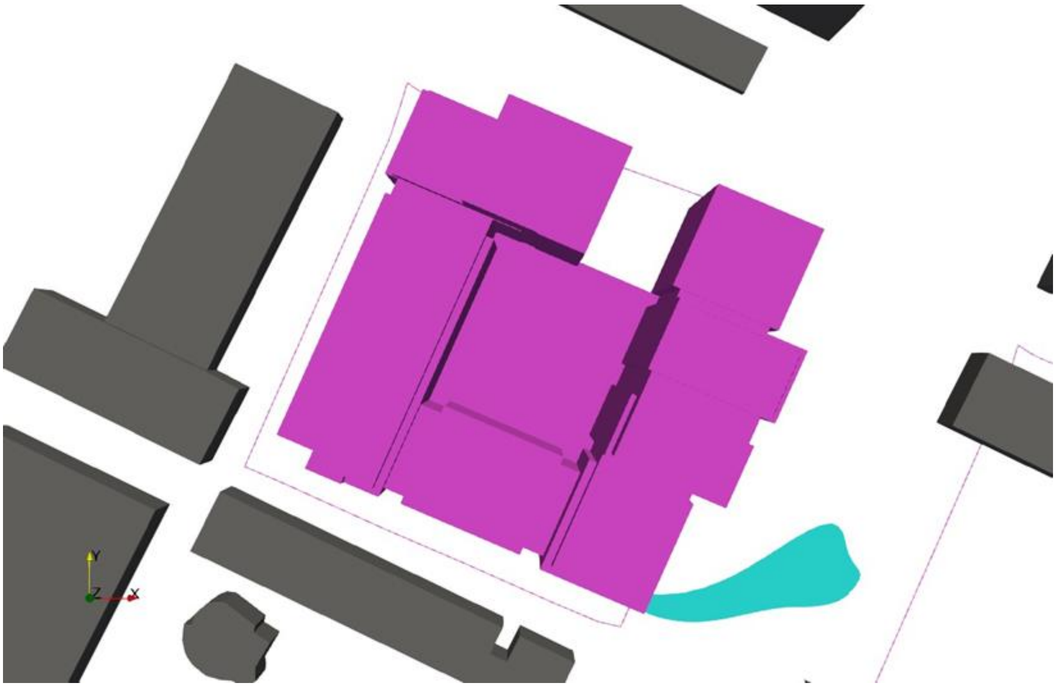



**Figure 12.88: Courtyard - Lawson Discomfort Map - 225°**

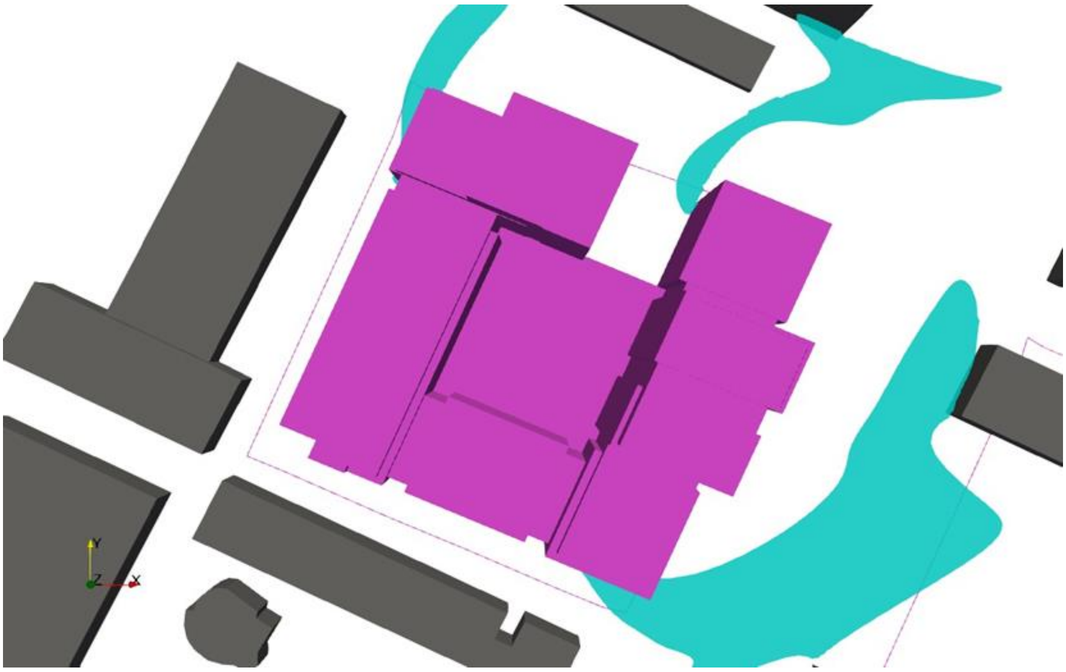



**Figure 12.89: Courtyard - Lawson Discomfort Map - 236°**

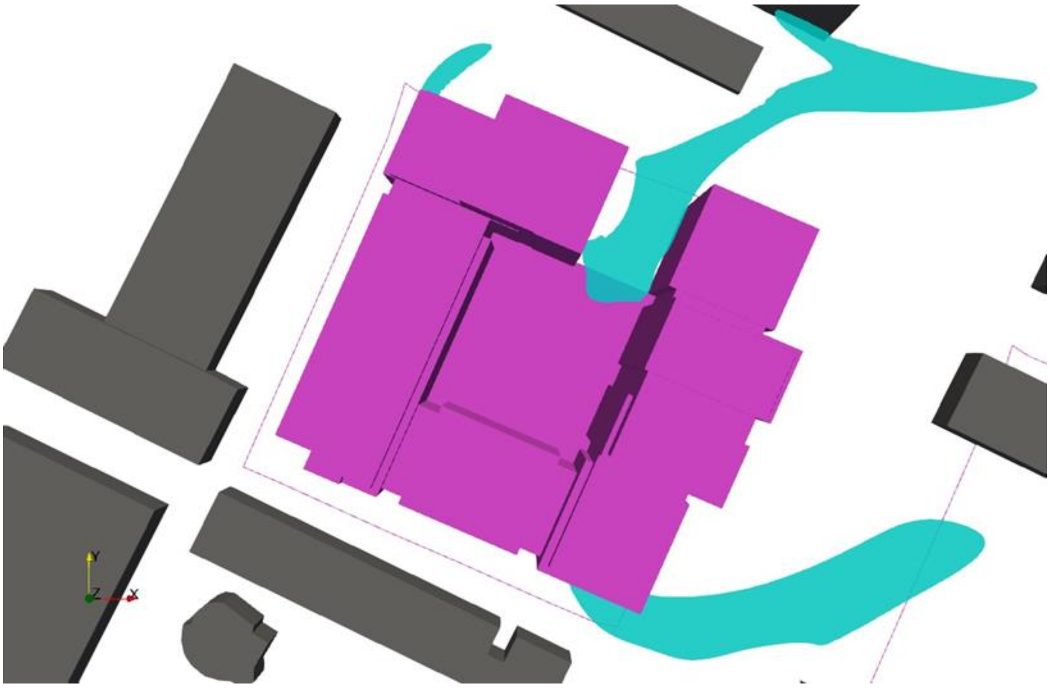



**Figure 12.90: Courtyard - Lawson Discomfort Map - 258°**

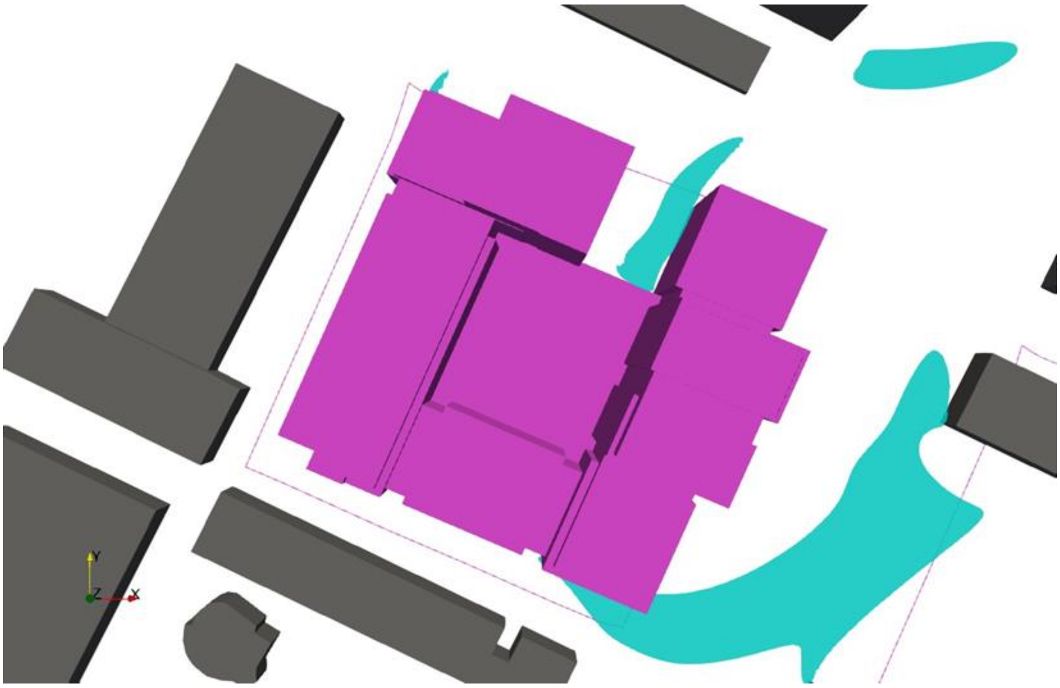



**Figure 12.91: Courtyard - Lawson Discomfort Map - 247°**

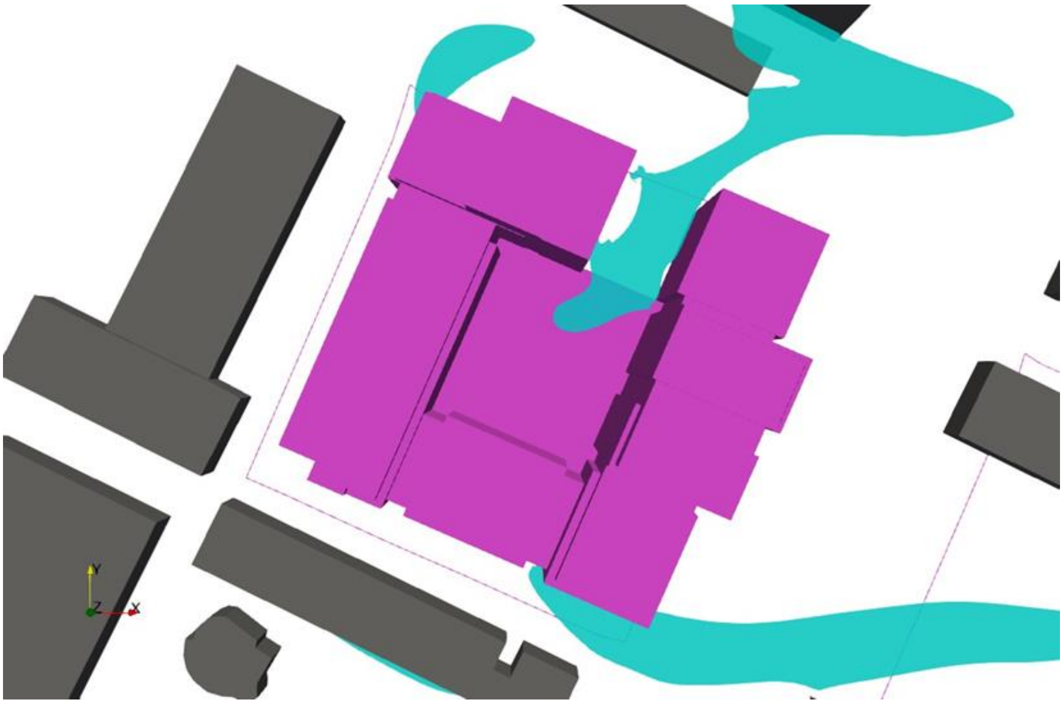



**Figure 12.92: Courtyard - Lawson Discomfort Map - 270°**

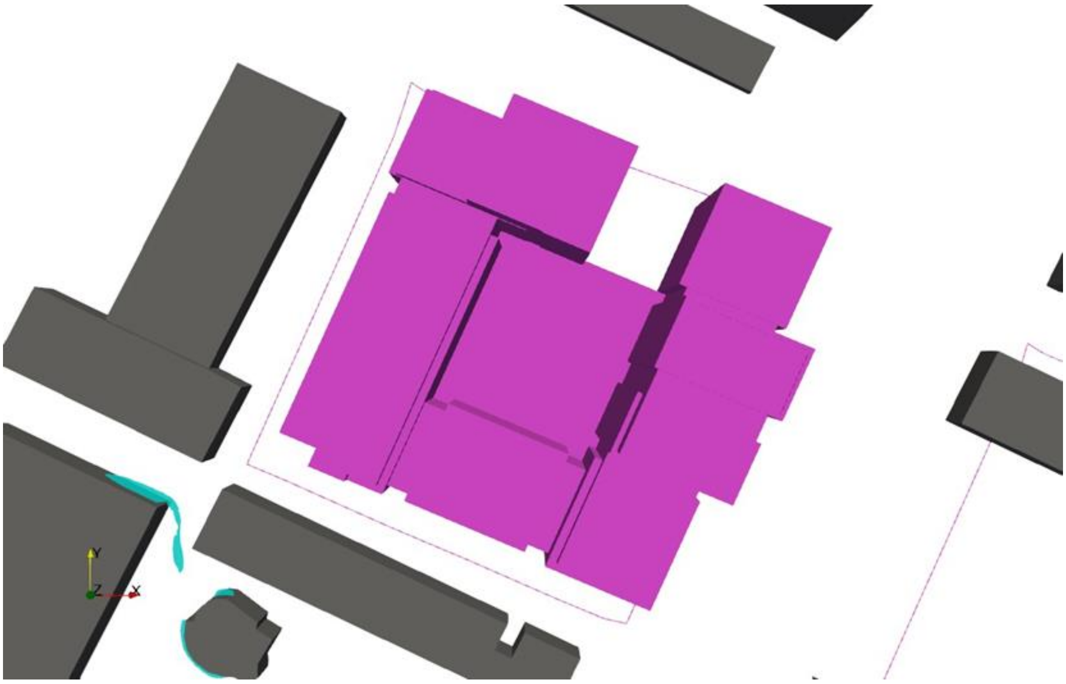


Figure 12.93: Courtyard - Lawson Discomfort Map - 315°

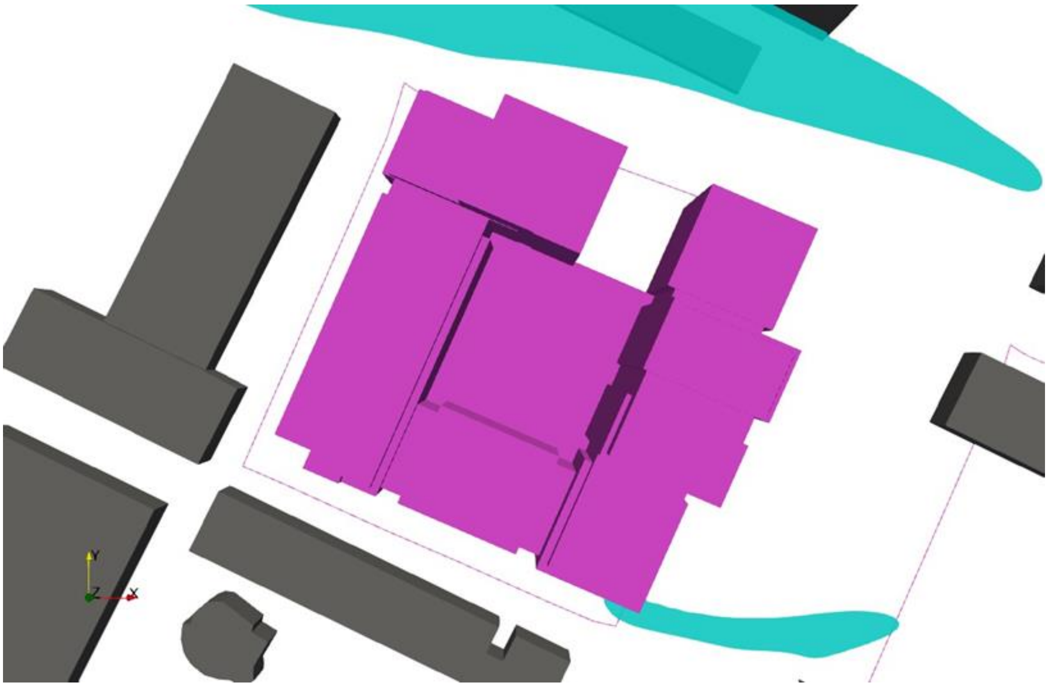


Figure 12.94: Courtyard - Lawson Discomfort Map - 281°


**Figure 12.95: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 135°**

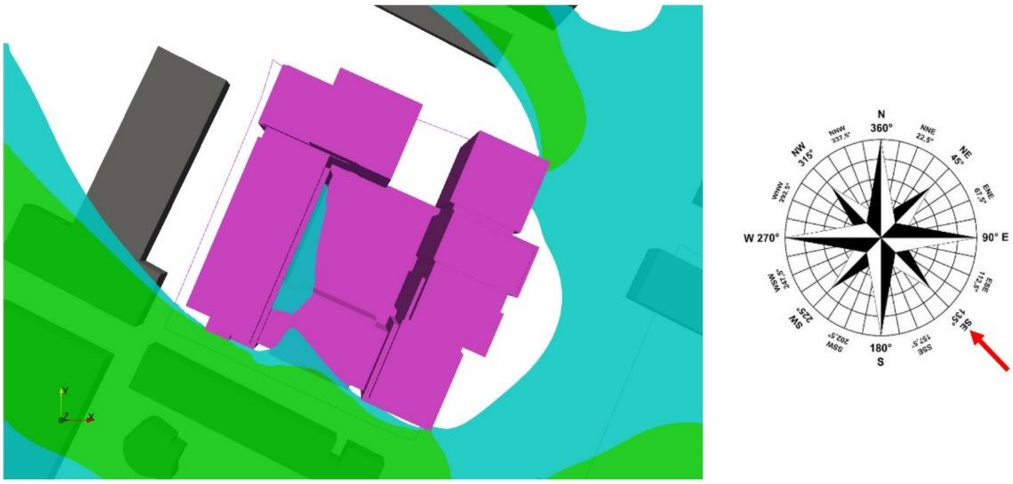



**Figure 12.96: Terrace 2 - Lawson Discomfort Map - 135°**


**Figure 12.97: Terrace 3 - Lawson Discomfort Map - 135°**

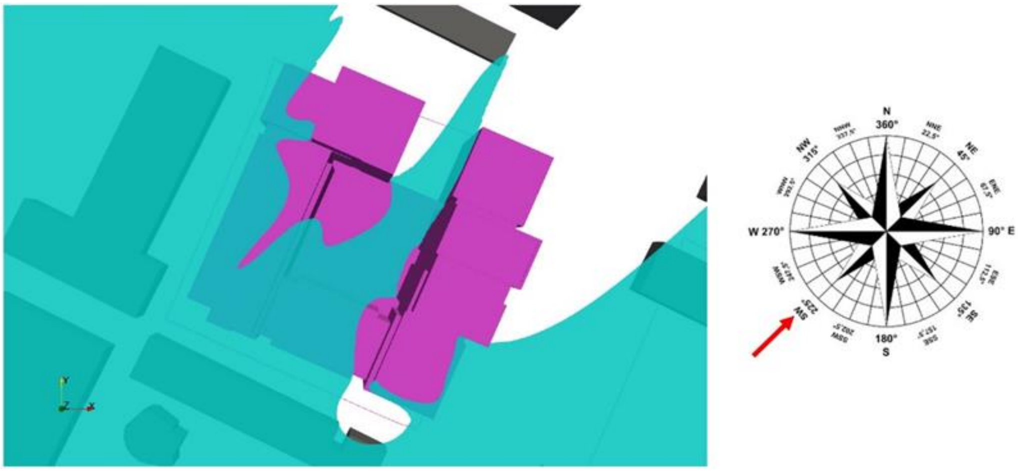



**Figure 12.98: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 225°**


**Figure 12.99: Terrace 2 - Lawson Discomfort Map – 225**

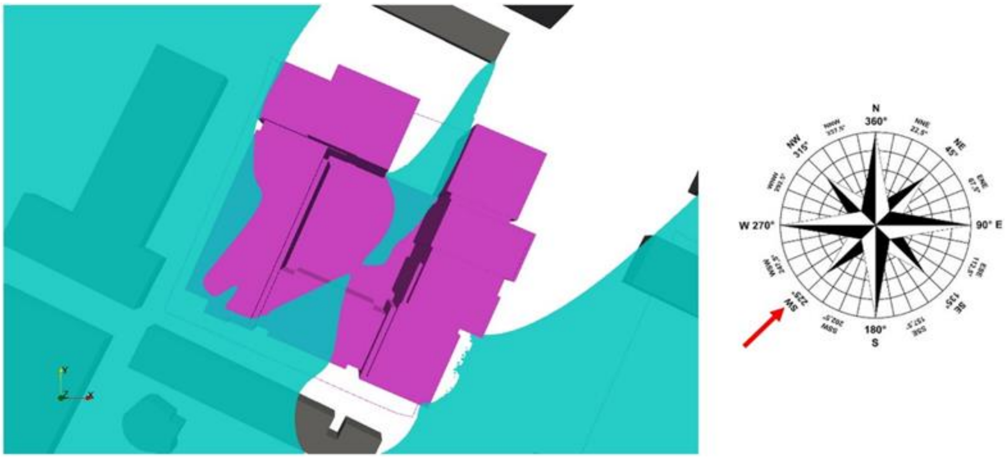



**Figure 12.100: Terrace 3 - Lawson Discomfort Map - 225°**

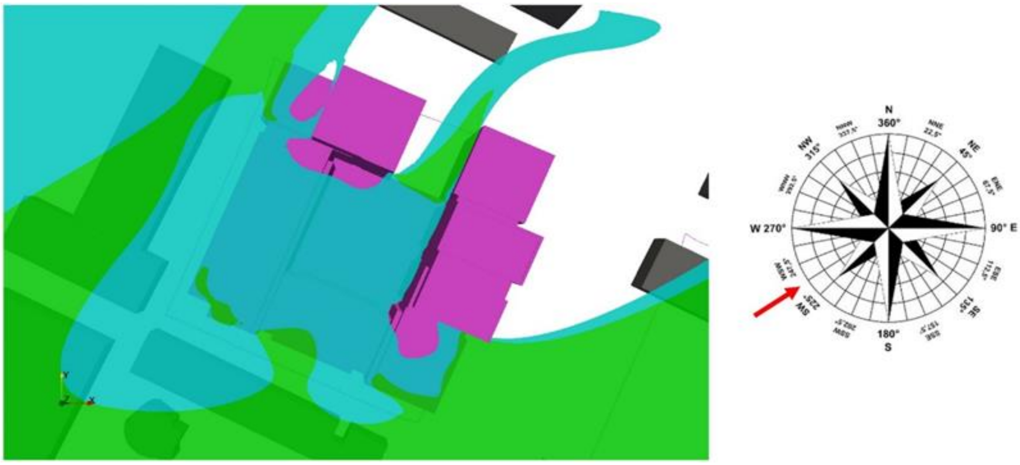



**Figure 12.101: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 236°**

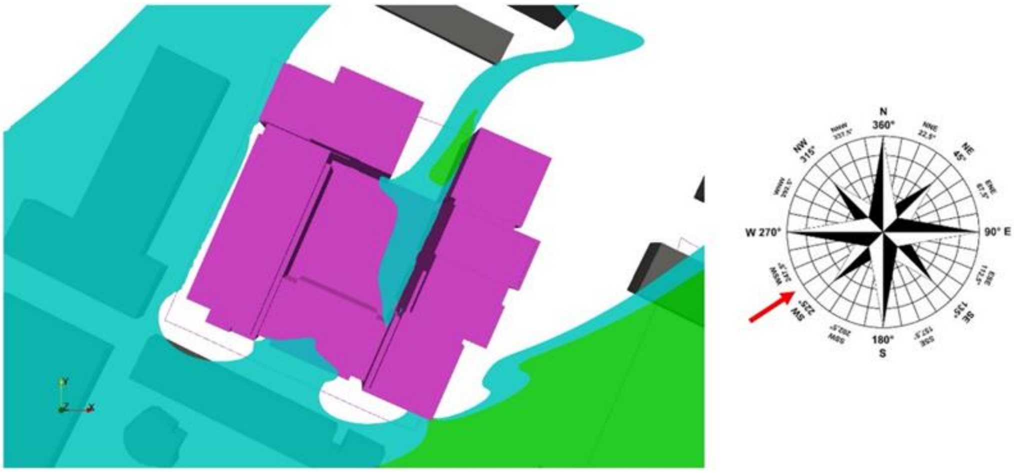



**Figure 12.102: Terrace 2 - Lawson Discomfort Map - 236°**


**Figure 12.103: Terrace 3 - Lawson Discomfort Map - 236°**

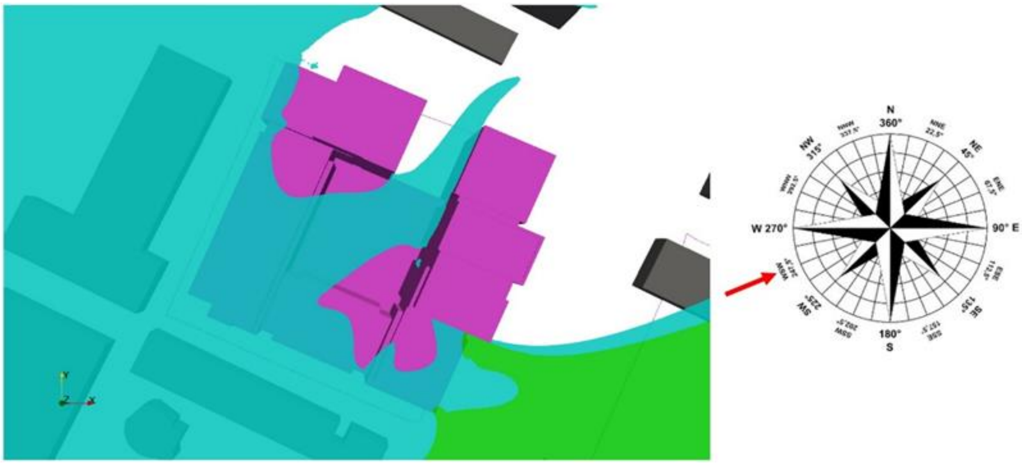



**Figure 12.104: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 247°**

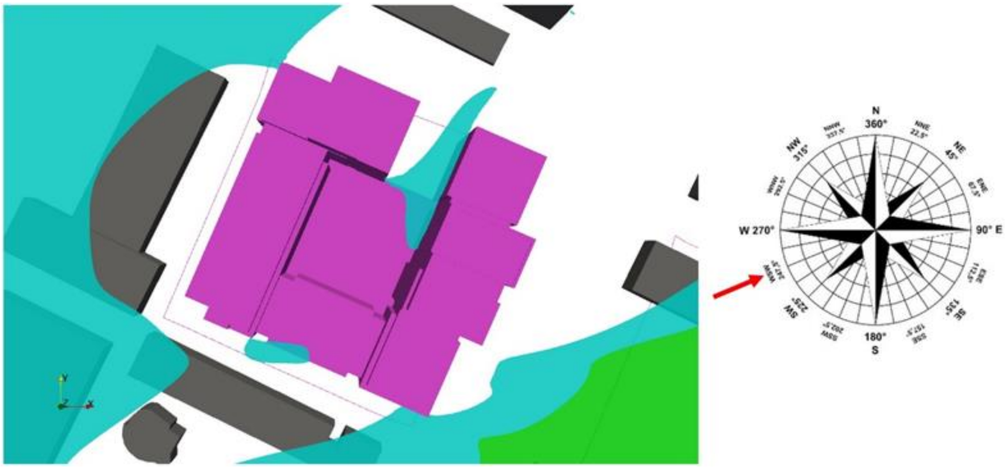



**Figure 12.105: Terrace 2 - Lawson Discomfort Map - 247°**

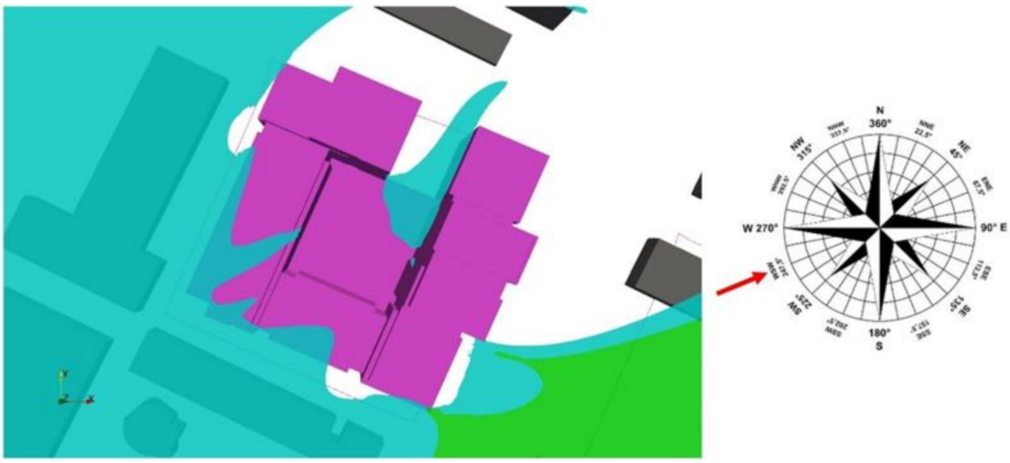



**Figure 12.106: Terrace 3 - Lawson Discomfort Map - 247°**

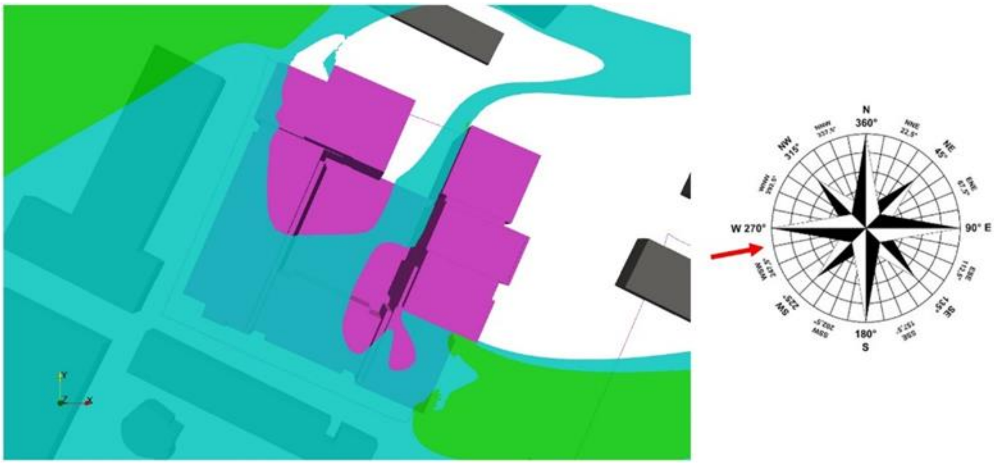



Figure 12.107: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 258°

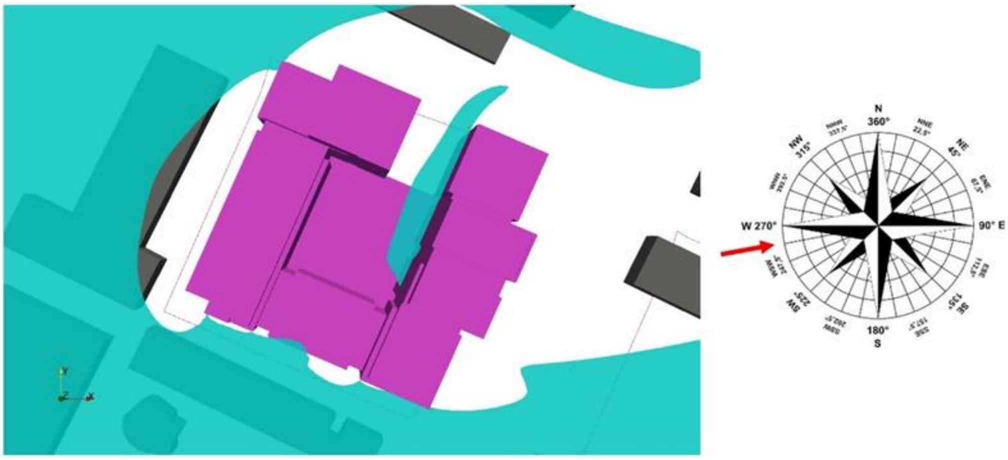



Figure 12.108: Terrace 2 - Lawson Discomfort Map - 258°

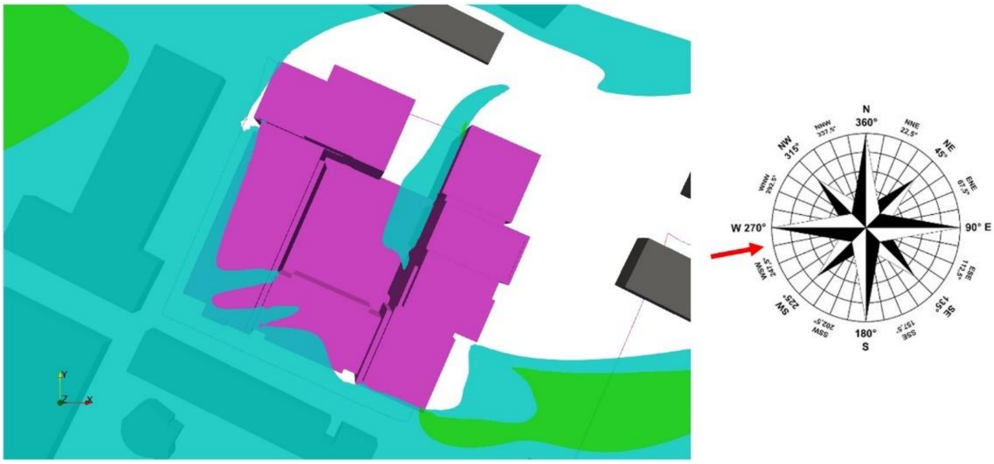



Figure 12.109: Terrace 3 - Lawson Discomfort Map - 258°

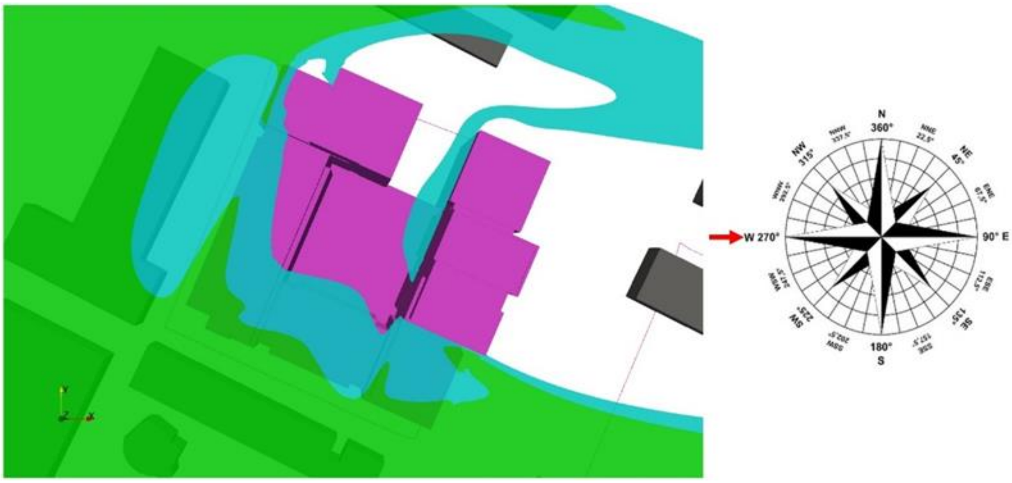



**Figure 12.110: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 270°**

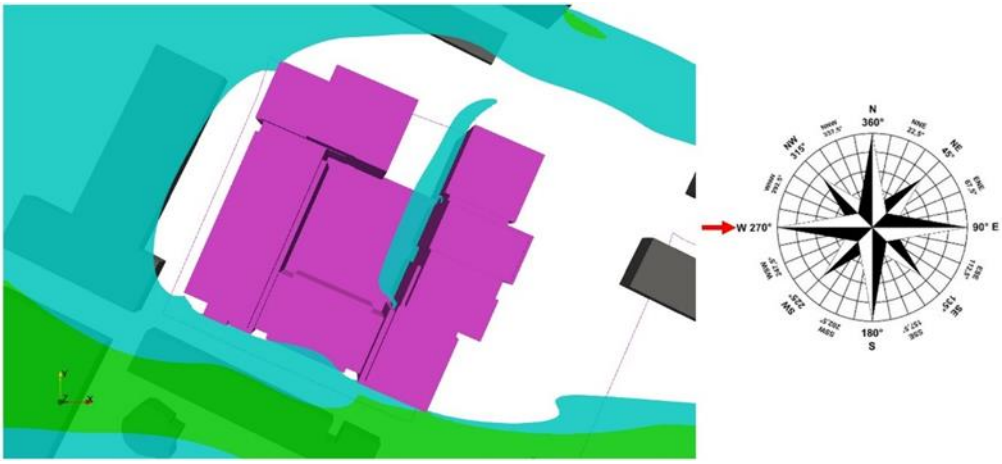



**Figure 12.111: Terrace 2 - Lawson Discomfort Map - 270°**

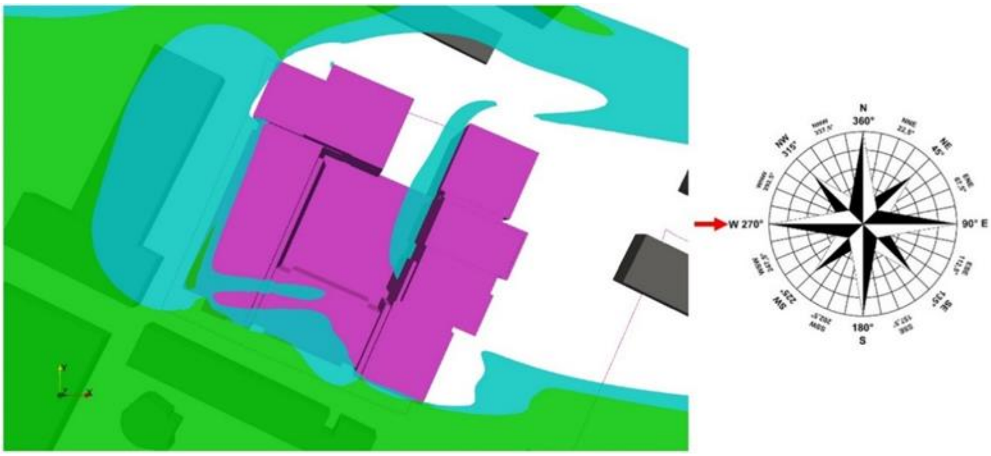



**Figure 12.112: Terrace 3 - Lawson Discomfort Map - 270°**

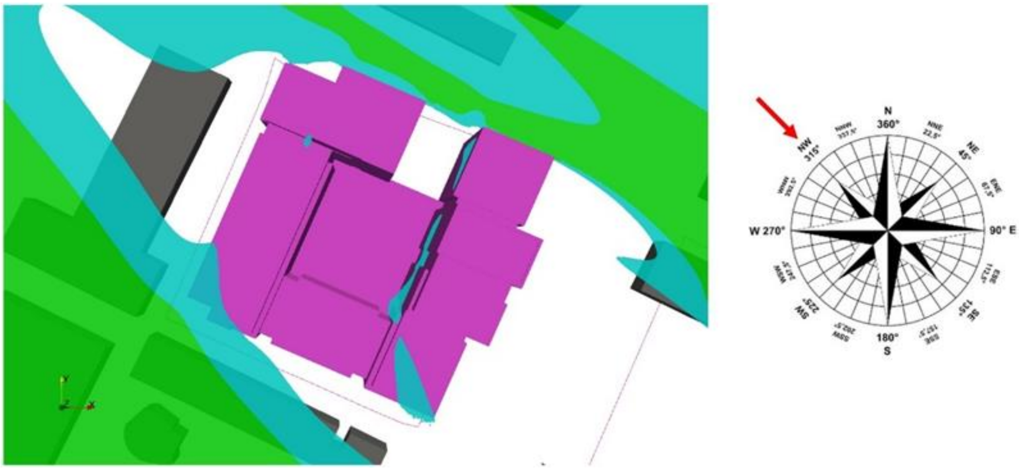



**Figure 12.113: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 315°**

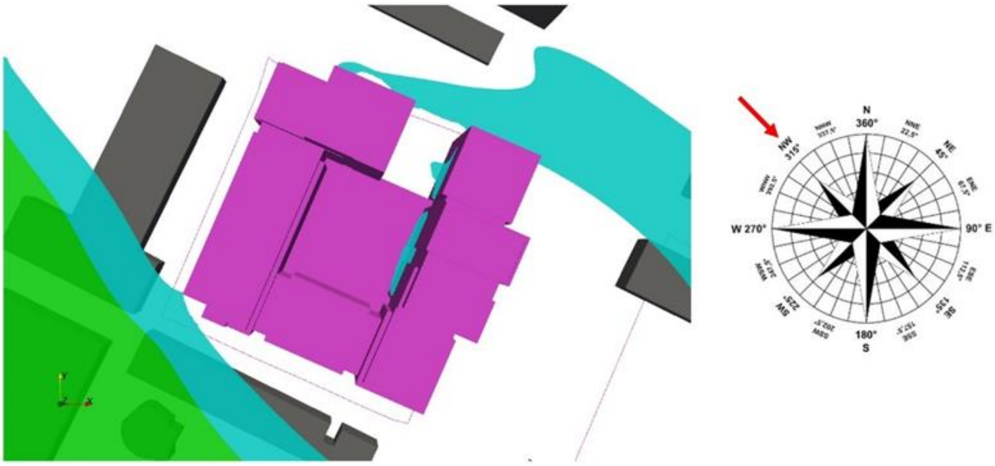



**Figure 12.114: Terrace 2 - Lawson Discomfort Map - 315°**

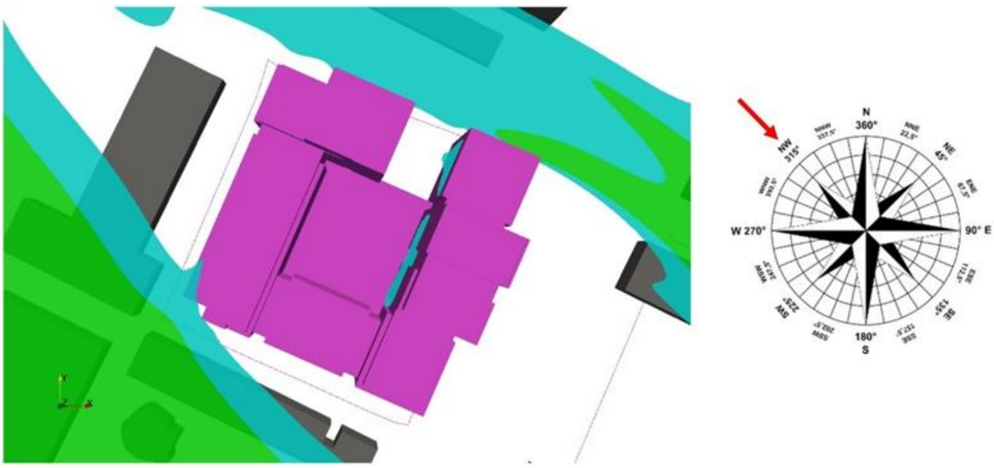



**Figure 12.115: Terrace 3 - Lawson Discomfort Map – 315**

### 12.5.8.3 *Distress Criteria*

In addition to the criteria for "discomfort" the Lawson method presents criteria for "distress". The discomfort criteria focus on wind conditions which may be encountered for hundreds of hours per year. The distress criteria require higher wind speeds to be met but focus on two hours per year. These are rare wind conditions but with the potential for injury rather than inconvenience.

Figure 12.116 shows the hourly wind gust rose for Dublin, from 1985 to 2015. This will be necessary to assess how many hours per year on average the velocity exceed the threshold values.

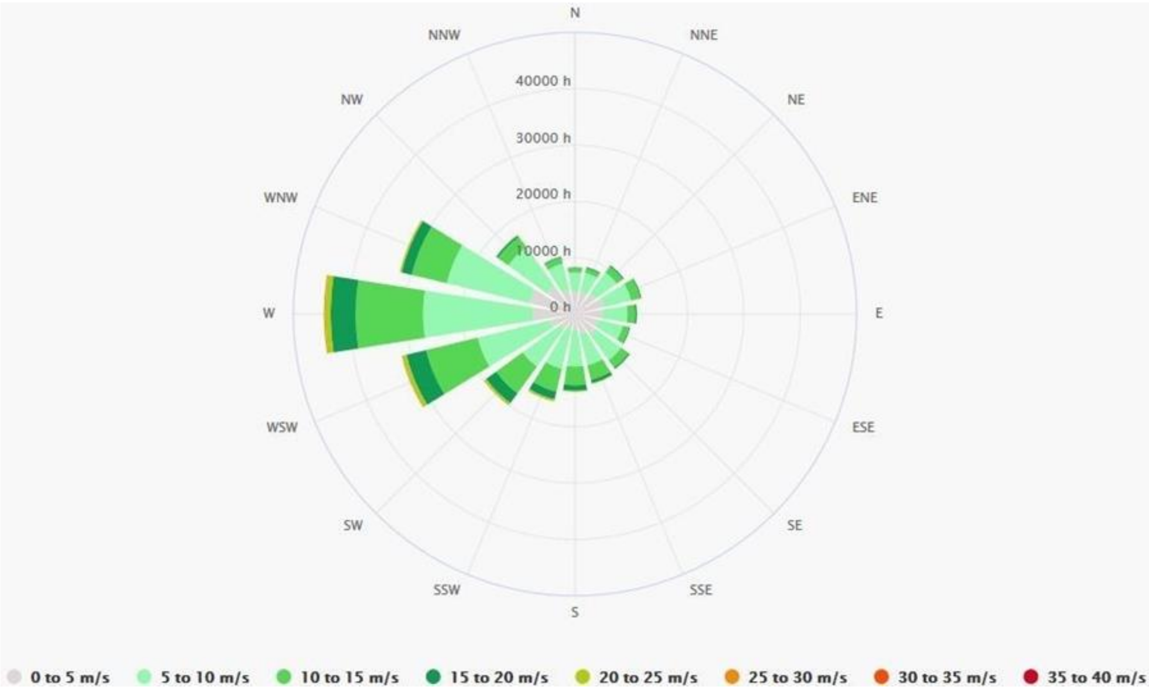



**Figure 12.116: Hourly Dublin Wind Gust Rose**

The criteria for distress for a frail person or cyclist is 15m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 15m/s (as reported in Figure 12.117 and Figure 12.118 respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 15m/s is exceed at pedestrian level in each direction.

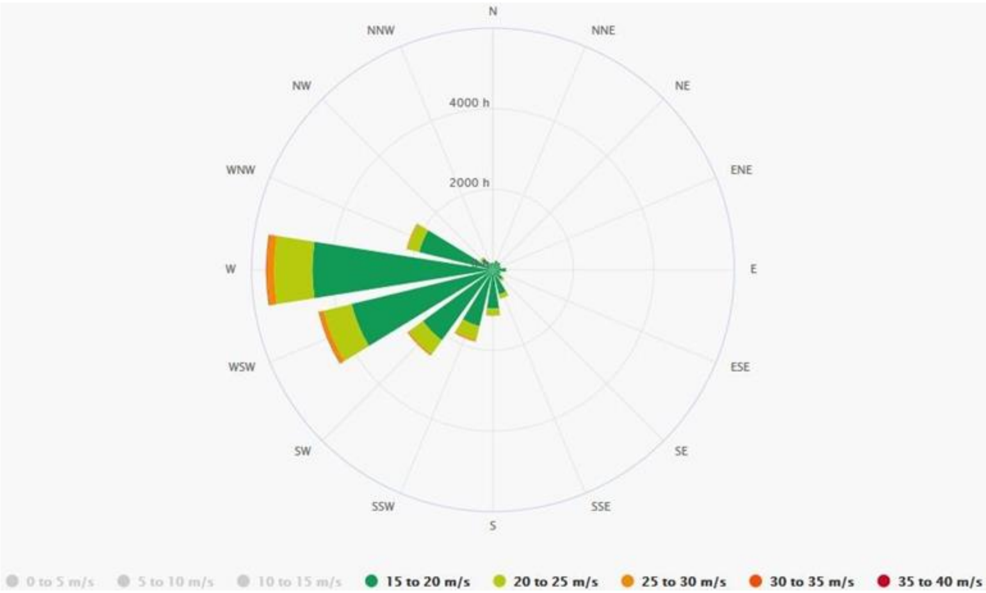



**Figure 12.117:: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 15m/s**

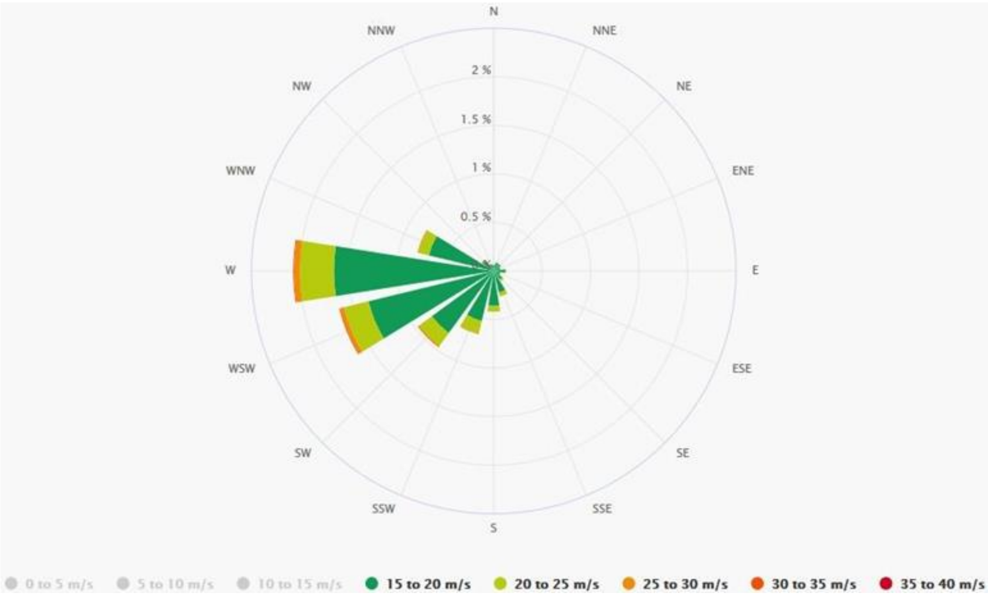



**Figure 12.118:: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 15m/s.**

A total of 2 hours per years corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 15m/s was reached in Dublin 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°

For this reason, it is of interest to show the distress results for these directions. Figure 12.120 below combines all the above directions together and shows the areas where the measured velocity is above 15 m/s. Figure 12.119 shows the scale used in this case. Results show that there are not critical areas where the velocity increases above 15 m/s.

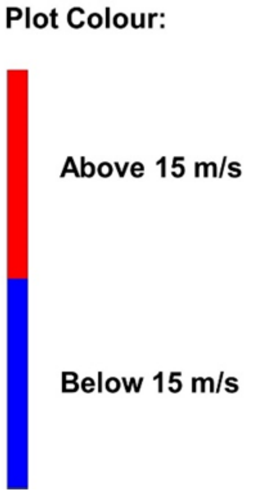



**Figure 12.119: Lawson Distress Categories - Frail Person or Cyclist**

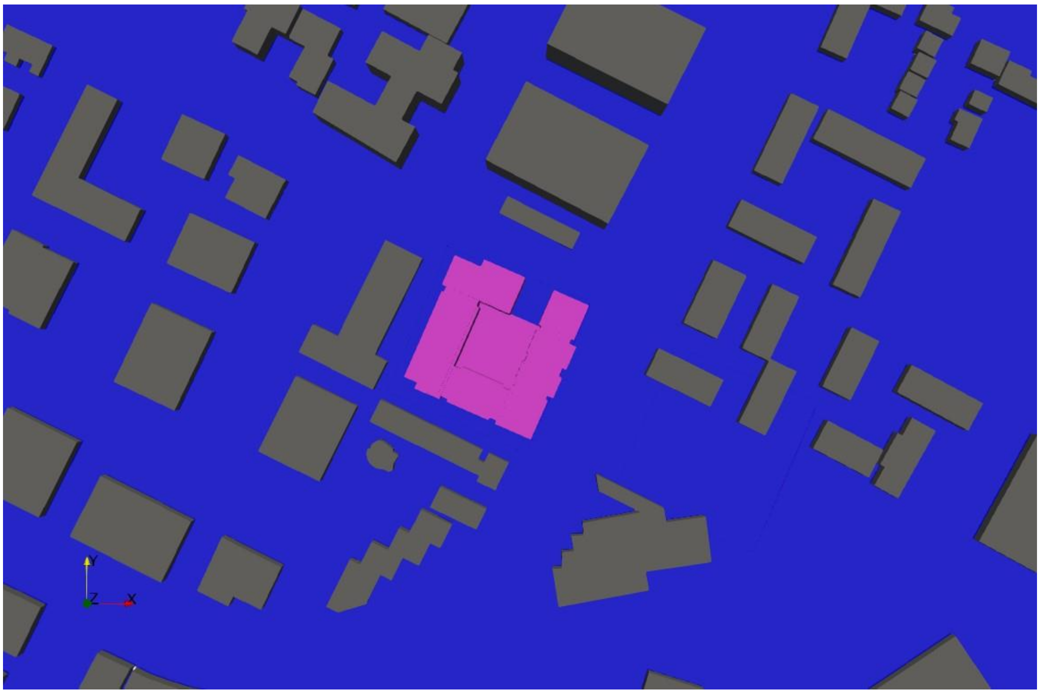


**Figure 12.120: Lawson Distress Map - Frail Person or Cyclist**

The criteria for distress for a member of the general population is 20m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 20m/s (as reported in **Error! Reference source not found.** and Figure 12.178 respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 20m/s is exceed at pedestrian level in each direction.

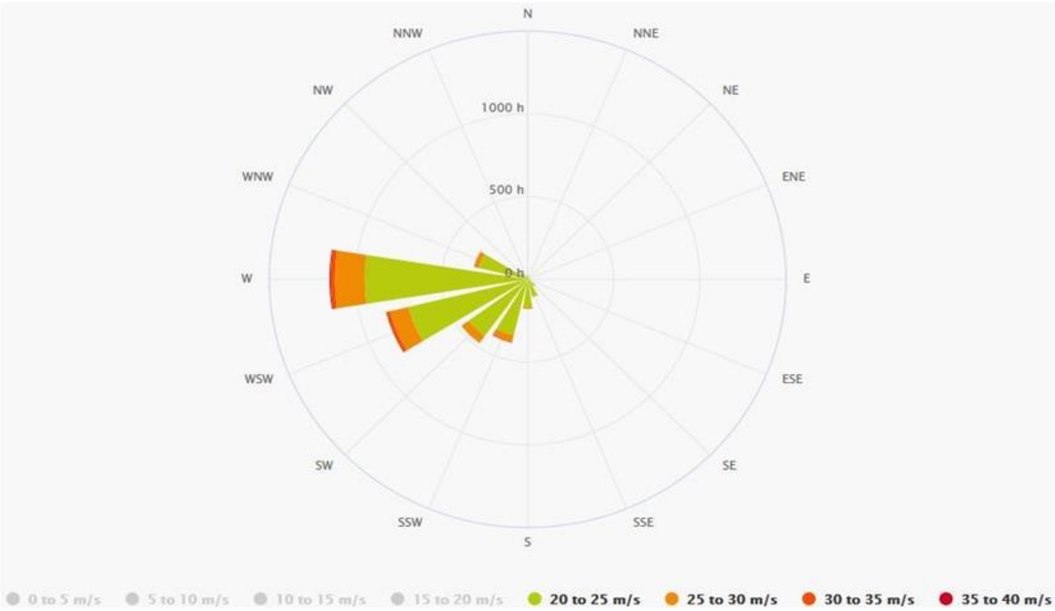



**Figure 12.121: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 20 m/s.**

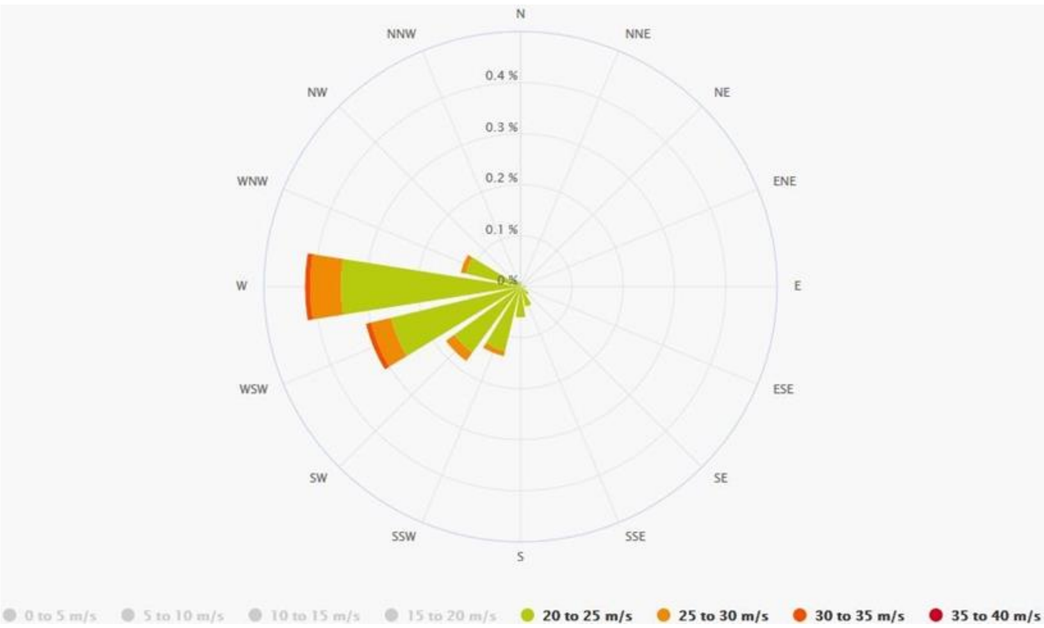



**Figure 12.122: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 20 m/s.**

A total of 2 hours per years corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 20m/s was never reached in Dublin 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.

### 12.5.8.4 Summary of Potential Effects of the Proposed Development

From the simulation results the following observations are pointed out:

- The proposed Carmanhall Road Development will produce a quality environment that is attractive and comfortable for pedestrians at ground floor.
- Some slightly higher velocities are experienced around the building for certain wind directions. In particular some recirculation effects are expected near the corners of the unit and at the main entrance. However, tree landscaping on the main roads and all around the development, with particular attention to the corners and to the entrance, have been implemented and will mitigate these effects.
- Depending on the wind direction, some slight funnelling effects are experienced on the main roads around the development, especially on the road on the south-side of the development. However, the implementation of tree landscaping that have been planned for these areas will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on ground floor are identified as slight or imperceptible.
- Due to its position and shape, the courtyard, seems to be well shielded. However, some recirculation effects have been found for certain wind directions, especially near the main entrance. The implementation of tree landscaping that have been planned for these areas will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the courtyard are identified as slight or imperceptible.
- Regarding the terraces, higher velocities can be found for some directions, only in some areas of the terraces and often corresponding to the edges of it. However, these velocities are below critical values for safety. Moreover, mitigation measures with balustrade, planters and trees that have been planned for the terraces will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the terraces are identified as slight or imperceptible.
- The pedestrian comfort assessment, performed at Ground Floor level, on the courtyard (including the main entrance) and on the terraces according to the Lawson criteria, identified the areas that are suitable for the different pedestrian activities in order to guarantee pedestrian comfort. In particular, the area all around the development seems to be suitable for every activity, including long-term sitting, apart from the corners of the building that are not suitable for long-term sitting. The courtyard is always suitable for long-term sitting, short-term sitting, standing, walking and strolling activities. The main entrance is not suitable for long-term sitting. Regarding the terraces, there are areas of the that are not suitable for long-term sitting, and some small areas that are not suitable for standing or short-term sitting, while they are suitable for all the other activities. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. It is not expected that people would be making use of such roof areas during the worst-case conditions. Moreover, the mitigation measures that have been planned with balustrade, planters and trees will mitigate these effects. Additionally, it has to be noticed that, in any case, there are not critical issues in regard to safety. In terms of distress, no critical conditions were found for “Frail persons or cyclists” and” General Public” in the surrounding of the development.

#### 12.5.8.5 *Do-Nothing Scenario*

The effects on wind if the development was not built are imperceptible.

#### *12.5.8.6 Monitoring*

#### *Construction Phase*

There is no particular requirement to monitor wind impact during construction phase as the designated amenity areas will not be in use during this phase of the project.

#### *Operational Phase*

During the development operational phase, it has been designed to conform to acceptable Lawson Criteria for Comfort and Distress in accordance with the Wind Beaufort Scale.

## 12.6 Cumulative impact

This section assessed the potential impact of the Proposed Development on the already existing environment (also considering future buildings that have been granted planning permission but that are not built yet), and the suitability of the Proposed Development to create and maintain a suitable and comfortable environment for different pedestrian activities.

### 12.6.1 CFD Model Details of the Proposed Development

This subsection describes all features included in the geometrical and physical representation of Carmanhall Road Development CFD model. Any object which may have significant impact on wind movement and circulation are represented within the model. To be accurate, the structural layout of the building being modelled should include only the obstacles, blockages, openings and closures which can impact the wind around the building. It is important to remember that a CFD simulation approximates reality, so providing more details of the geometry within the model will not necessarily increase the understanding of the bulk flows in the real environment.

### 12.6.2 Modelled Geometry

The two buildings that have been added in this cumulative analysis, that have been granted planning permission but are not yet built, are Rockbrook Development and Sandyford Central Development.

Carmanhall Road Development and adjacent buildings Model is shown in Figure 12.123 and Figure 12.124 (top views) and Figure 12.125 and Figure 12.126 (3D views).

Carmanhall Road Development is represented in pink, Rockbrook Development is represented in light blue and Sandyford Central Development is represented in yellow).

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 12.5).

In order to represent reality and consider the actual wind impacting on the site, the modelled area for the wind modelling study comprises a wider urban area of 2km² around the Carmanhall Road Development, as shown.

**Table 12.5: Modelled Environment Dimensions**

| | Modelled CFD Environment Dimensions | | |
|---|---|---|---|
| | Width | Length | Height |
| CFD Mesh Domain | 2000 m approx | 2000 m approx | 250 m approx |

**Figure 12.123: Top View - Carmanhall Road Development - Cumulative Impact - Carmanhall Road Development (in pink), Rockbrook Development (in light blue) and Sandyford Central Development (in yellow)- Extents of Modelled Area**

**Figure 12.124: Top View - Carmanhall Road Development (in pink), Rockbrook Development (in light blue) and Sandyford Central Development (in yellow) - Cumulative Impact**

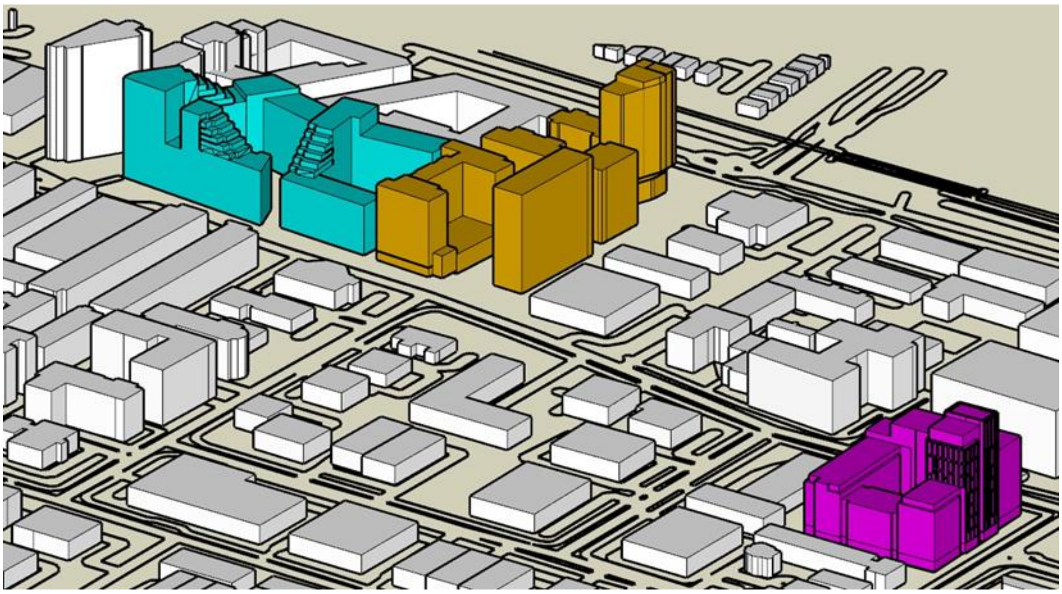


**Figure 12.125: 3D View - Carmanhall Road Development (in pink), Rockbrook Development (in light blue) and Sandyford Central Development (in yellow) - Cumulative Impact**

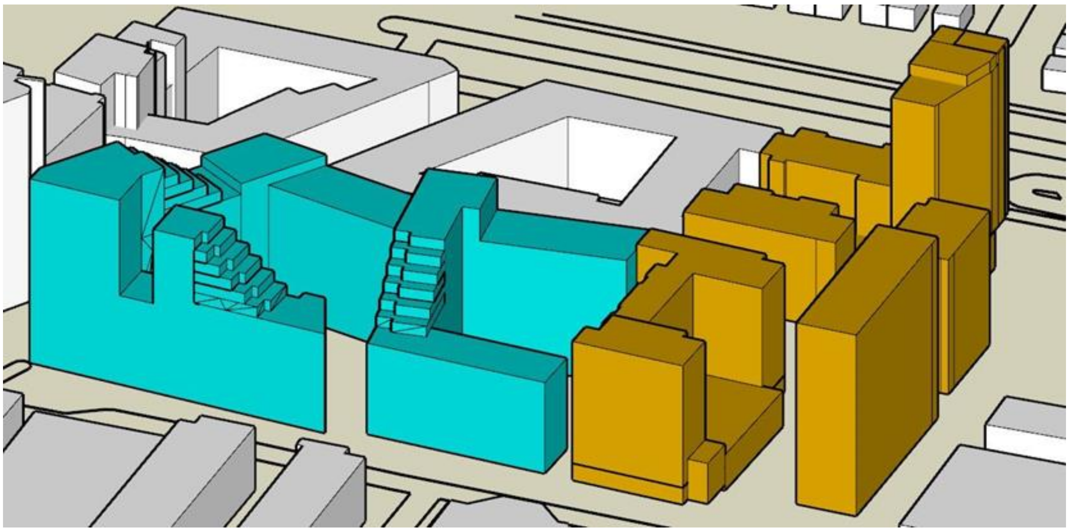


**Figure 12.126: 3D View - Rockbrook Development (in light blue) and Sandyford Central Development (in yellow) - Cumulative Impact**

## 12.6.3 Boundary Conditions

A rectangular computational domain was used for the analysis. The wind directions were altered without changing the computational mesh. For each simulation scenario, an initial wind velocity was set according to the statistical weather data collected in order to consider the worst-case scenario. Building surfaces within the model are specified as 'no slip' boundary conditions. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. Air flow inlet boundaries possess the 'Inlet' wind profile velocity patch boundary condition with its appropriate inflow turbulence intensity and dissipation rates. Air exits the domain at the 'pressure outlet' boundary condition.

The wind velocity data provided by the historical data collection and by the local data measuring are used in the formula below for the logarithmic wind profile to specify the wind velocity profile (wind velocity at different heights) to be applied within the CFD model:

$$v_2 = v_1 \cdot \frac{ln\frac{h_2}{z_0}}{ln\frac{h_1}{z_0}} \tag{7.1}$$

where:

- $v_1$ = wind speed measured at the reference height $h_1$
- $h_1$ = reference height to measure $v_1$
- $h_2$ = height of the wind speed $v_2$ calculated for the wind profile
- $z_0$ = 0.4 [m] roughness length selected (see table in Figure 12.7.5 below)

**Roughness Classes and Lengths**

| Roughness class | Roughness length $z_0$ | Land cover types |
|---|---|---|
| 0 | 0.0002 m | Water surfaces: seas and Lakes |
| 0.5 | 0.0024 m | Open terrain with smooth surface, e.g. concrete, airport runways, mown grass etc. |
| 1 | 0.03 m | Open agricultural land without fences and hedges; maybe some far apart buildings and very gentle hills |
| 1.5 | 0.055 m | Agricultural land with a few buildings and 8 m high hedges seperated by more than 1 km |
| 2 | 0.1 m | Agricultural land with a few buildings and 8 m high hedges seperated by approx. 500 m |
| 2.5 | 0.2 m | Agricultural land with many trees, bushes and plants, or 8 m high hedges seperated by approx. 250 m |
| 3 | 0.4 m | Towns, villages, agricultural land with many or high hedges, forests and very rough and uneven terrain |
| 3.5 | 0.6 m | Large towns with high buildings |
| 4 | 1.6 m | Large cities with high buildings and skyscrapers |

**Figure 12.127: Roughness length and class to be used for the logarithmic wind profile.**

The wind profile used in the model has been calculated using the formula above and is represented in Figure 12.178.

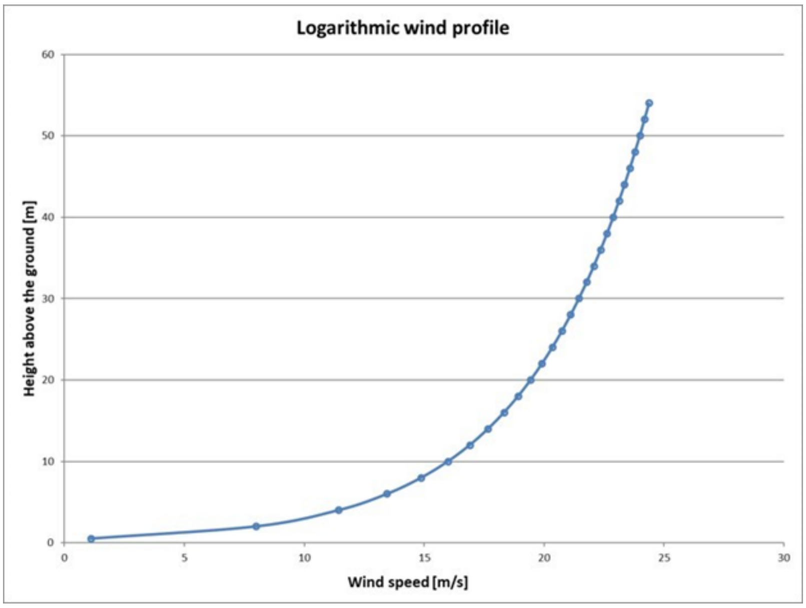



**Figure 12.128: Wind profile used in the model.**

### 12.6.4 Computational Mesh

The level of accuracy of the CFD results are determined by the level of refinement of the computational mesh. A mesh independent analysis is carried out prior to detailed simulation for final results. Details of parameters utilized for air and the computational mesh are presented in Table 12.6, while an example of the utilized computational mesh grid is as shown in Figure 12.179.

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 centre of each of these cells and then an interpolation function is used by the software to provide the results in the entire domain.

**Table 12.6: Air and Computational Mesh Parameters**

| AIR AND COMPUTATIONAL MESH PARAMETERS | |
|---|---|
| Air Density ρ | 1.2 kg/m3 |
| Ambient Temperature (T) | 288 K(approx.15C◦) |
| Min mesh cell size | 0.1 m At Development Building<br>0.5 m In the Refined Volume Surroundings<br>1.5 m At Other Environment Buildings<br>2 m Elsewhere |
| Min cell size ratio | 1:1:1 (dx:dy:dz) |
| Total mesh size | Approx. cells number = 50 million |

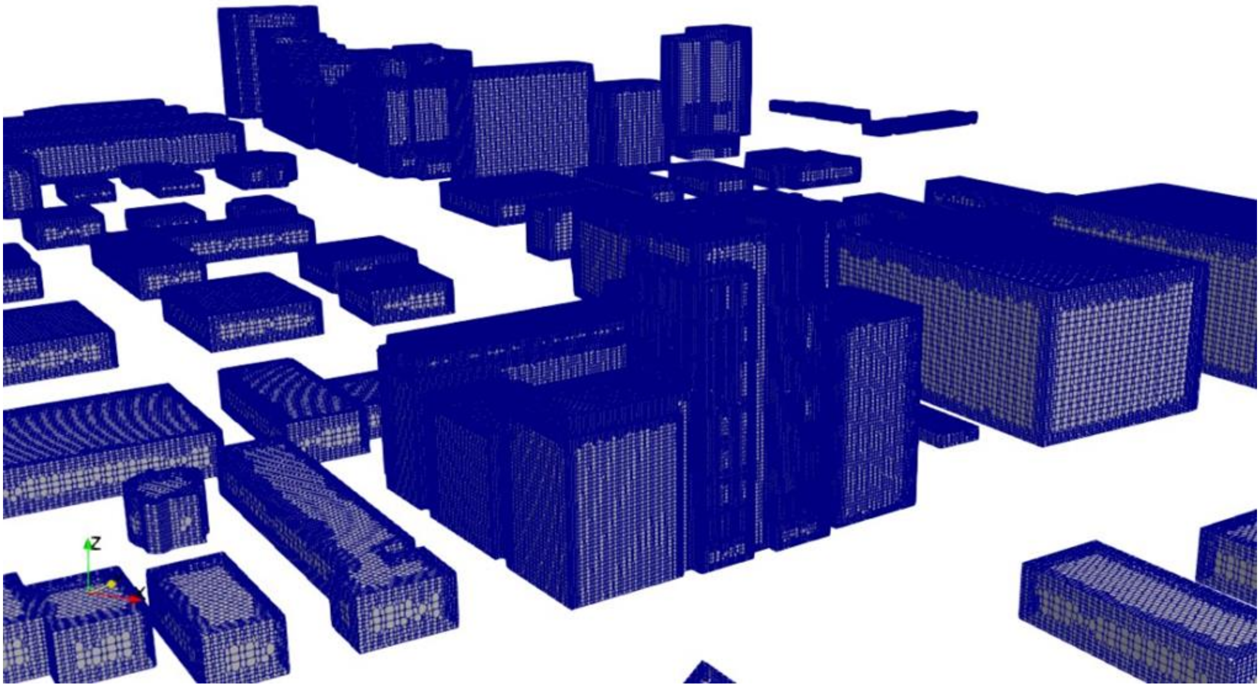



**Figure 12.129: Carmanhall Road Development and adjacent buildings - Computational Mesh Utilized for cumulative impact assessment**

#### 12.6.4.1 Construction Phase

The possible effects on wind micro-climate at the site during the construction phase of Carmanhall Road Development has not been directly assessed but was evaluated based on professional judgement. Statistical Dublin historical wind data have been used to carry out this analysis based on the fact that the dominant wind direction is from South-West.

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. It is possible that in the final stages of construction, implementation of the mitigation measures would be needed in areas that are expected to be windier than others should in case some areas of the site are expected to be functional before the construction is finalized.

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 situ), the impacts evaluated on-Site are considered to be not significant. Thus, the predicted impacts during construction phase are identified as slight or imperceptible.

In summary, as construction of the Carmanhall Road 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 imperceptible.

#### 12.6.4.2 Operational Phase

This section shows CFD results of wind and microclimate assessment carried out considering the" Operational Phase" of Carmanhall Road Development. In this case the assessment has considered the impact of wind on the existing area including the proposed Carmanhall Road Development. For this scenario, Carmanhall Road Development has been simulated. 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. For this, the Lawson and Distress Maps have been presented to identify the suitability of each areas to its prescribed level of usage and activity. The results present parameters outlined within the acceptance criteria previously described.

A summary of CFD model input data used in this project is given in the table shown in Figure 12.130

| Parameter | CARMANHALL ROAD DEVELOPMENT MODEL |
|---|---|
| Environment Conditions | |
| Ambient pressure | 101325 Pa |
| Wind profile | Logarithmic atmospheric profile |
| Ambient temperature | 15 °C |
| Analysis type | Steady state (LES) |
| Computational Details | |
| Total cells used | > 20,000,000 |
| Mesh size | < 0.2 m |
| Turbulence treatment | K-epsilon turbulence model |
| Convergence Criteria | $< 10^{-6}$ |
| Boundary Conditions | |
| CFD Domain Inlet | Wind Velocity inlet |
| CFD Domain Outlet | Pressure Outlet condition (zero pressure gradient) |
| Carmanhall Road Buildings | Zero velocity gradient (No-slip condition) |

**Figure 12.130: Summary of CFD Model Input Data**

It is also of interest at this point to underline once more the objectives of simulations performed. 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.
- To assess comfortable and safe pedestrian level wind conditions that are appropriate for the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, public spaces, amenity areas, outdoor sitting areas, etc.

Results of simulations carried out are detailed in the following sections. These results present parameters as outlined in the acceptance criteria section described previously for Carmanhall Road development. Results of wind flow speeds are collected throughout the simulation and analysed based on the Lawson Discomfort Criteria.

Figure 12.131 shows a 3D example of wind speed results collected at 1.5m height above ground floor level of the development. Red colours generally indicate critical values while blue colours indicate tenable conditions.

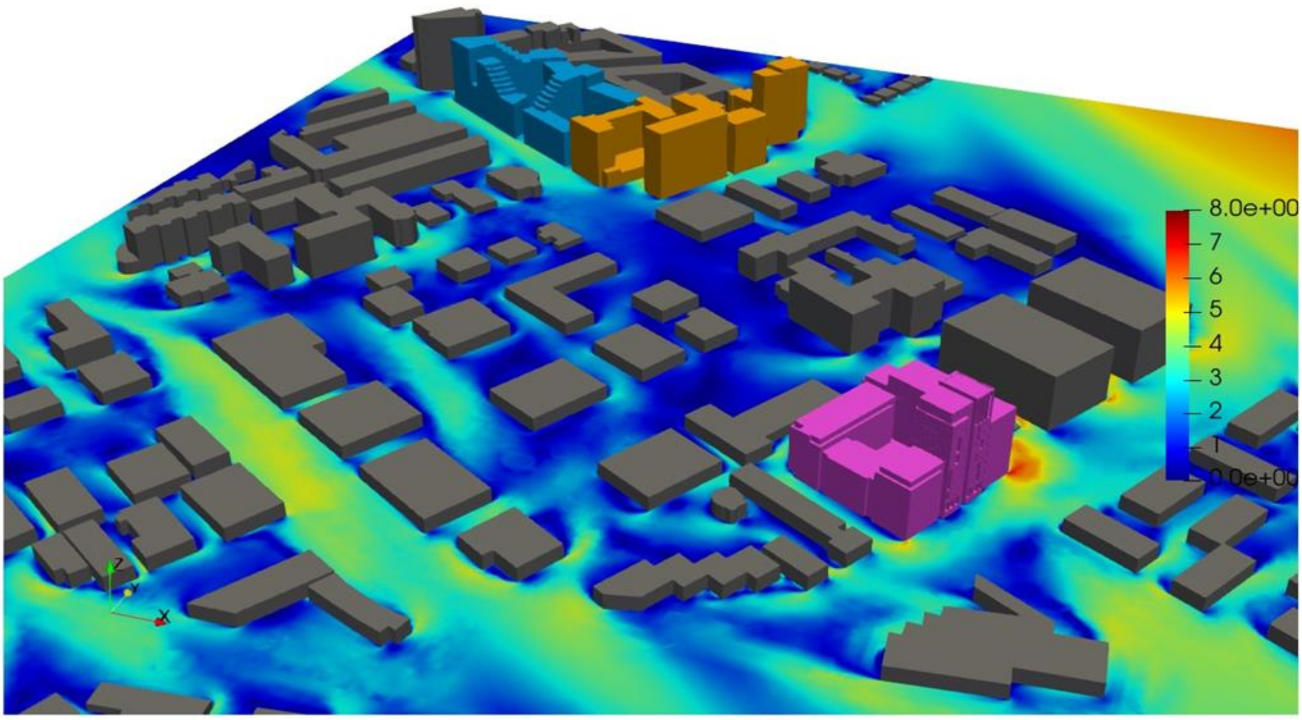



**Figure 12.131: Wind Flow Results Collected At 1.5 m Height Above Ground Floor - Cumulative Case**

## *Flow Velocity Results – Ground Floor Level*

Results of wind speeds and their circulations around the Proposed Development at pedestrian level of 1.5m above the development ground are presented for all the simulated wind directions in Figure 12.132 to Figure 12.152 (both top views and 3D views, as well as courtyard results), in order to assess wind flows at ground floor level of Carmanhall Road Development.

Some higher velocities are experienced around the building for certain wind directions. In particular, some recirculation effects are expected near the corners of the unit and at the main entrance. However, the implementation of tree landscaping on the main roads and all around the development, with particular attention to the corners and to the entrance, have been planned and will mitigate these effects.

Depending on the wind direction, slight funnelling effects are experienced on the main roads around the development, especially on the road on the south-side of the development. The implementation of tree landscaping planned for these areas will mitigate these effects.

The courtyard seems to be well shielded. However, some recirculation effects have been found for certain wind directions, especially near the main entrance. The implementation of tree landscaping that have been planned in these areas will mitigate these effects.

Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on ground floor are identified as slight or imperceptible.

Figure 12.153 shows the mitigation measures implemented for the development, at ground floor level, courtyard and main entrance.

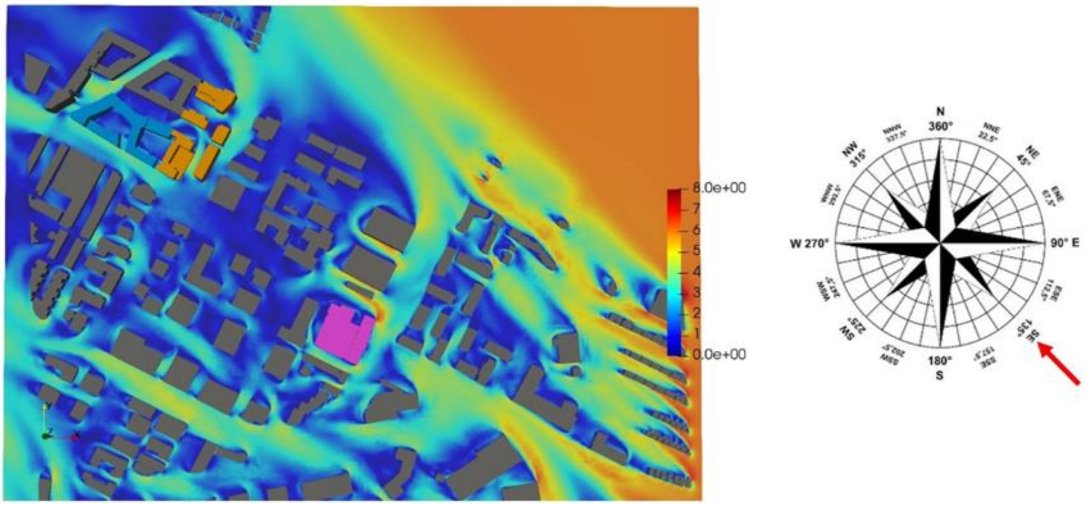


**Figure 12.132: Wind Speed Results at 1.5 m Above Development Ground Floor - Top View: 135° - Cumulative Impact Assessment**

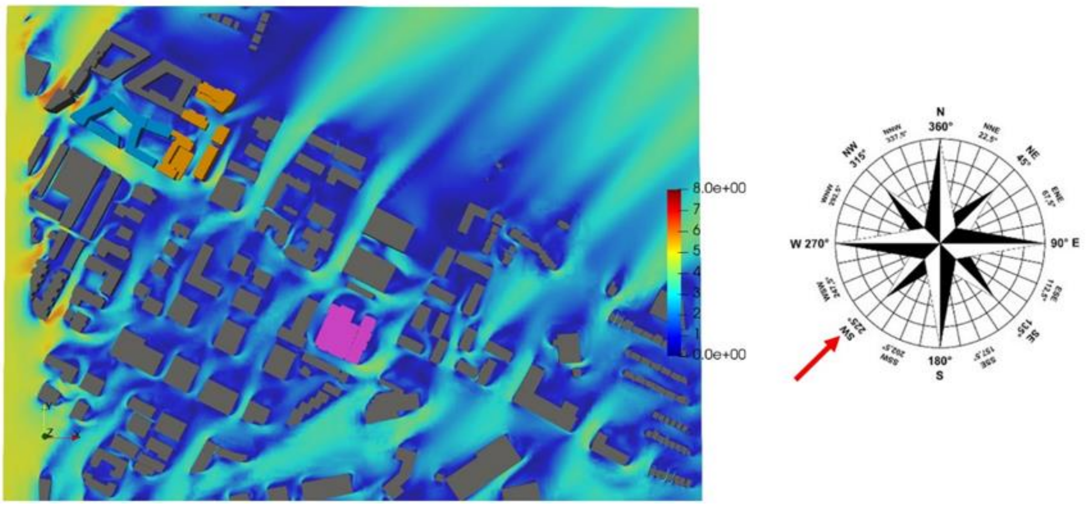


**Figure 12.133: Wind Speed Results at 1.5m Above Development Ground Floor - Top View: 225° - Cumulative Impact Assessment**

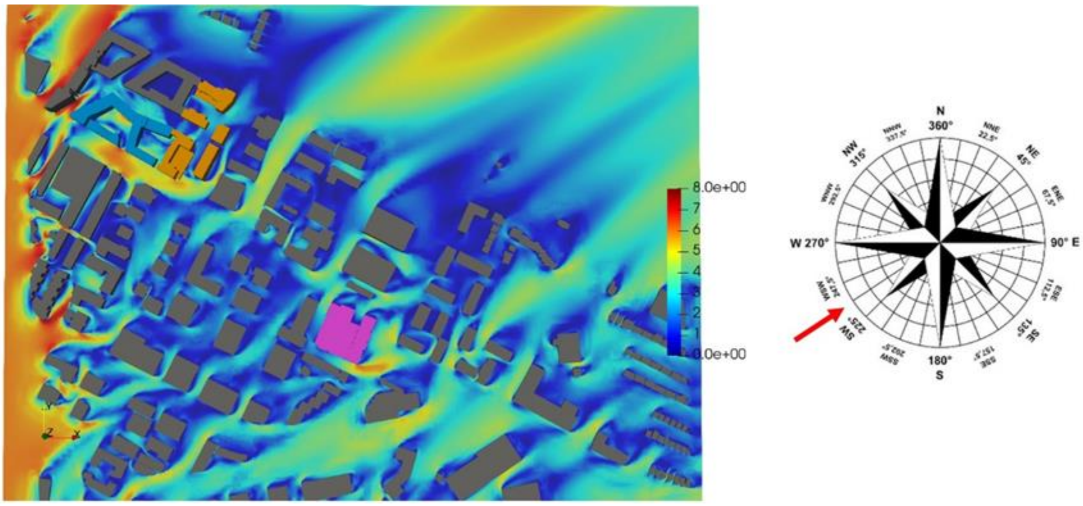



**Figure 12.134: Wind Speed Results at 1.5 m Above Development Ground Floor - Top View: 236° - Cumulative Impact Assessment**

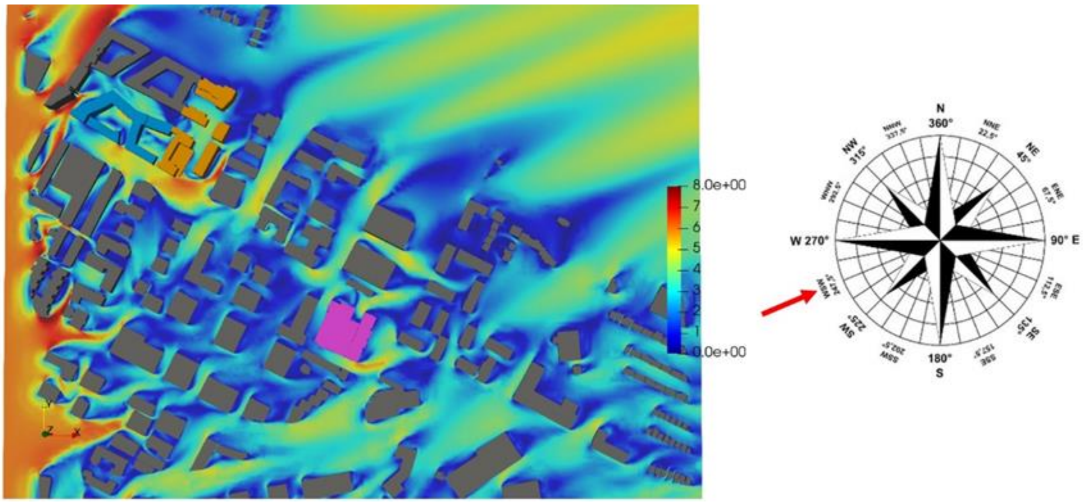



**Figure 12.135: Wind Speed Results at 1.5 m Above Development Ground Floor - Top View: 247° - Cumulative Impact Assessment**

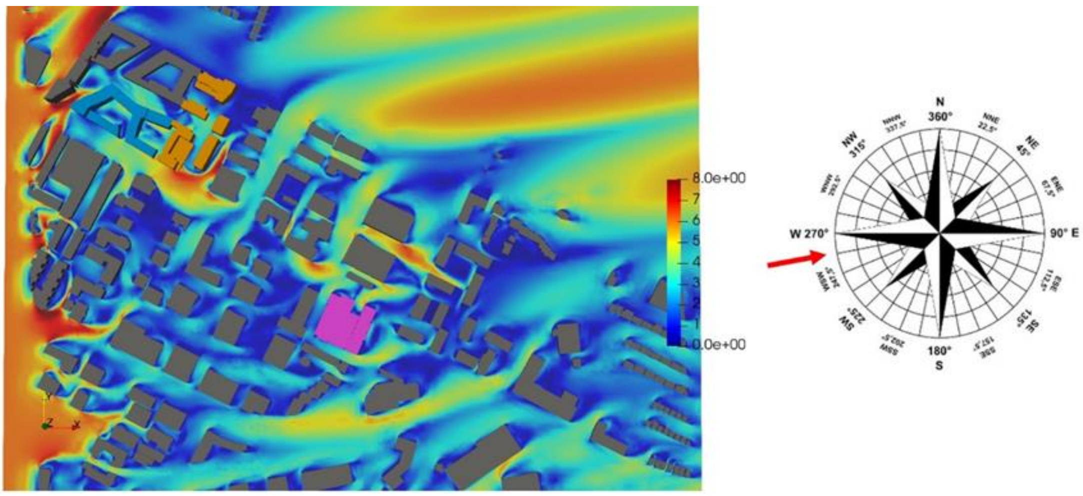



**Figure 12.136: Wind Speed Results at 1.5m Above Development Ground Floor - Top View: 258° - Cumulative Impact Assessment**

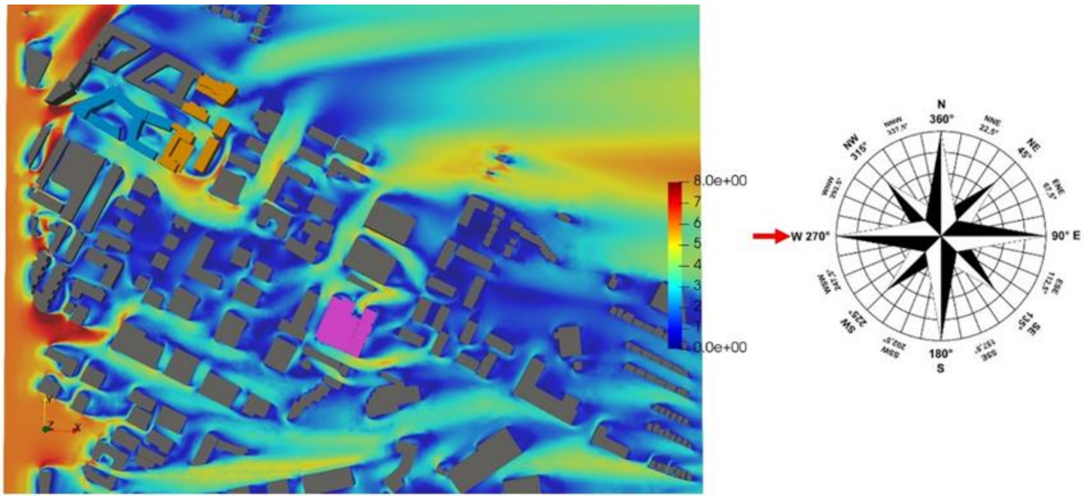


**Figure 12.137: Wind Speed Results at 1.5m Above Development Ground Floor - Top View: 270° - Cumulative Impact Assessment**

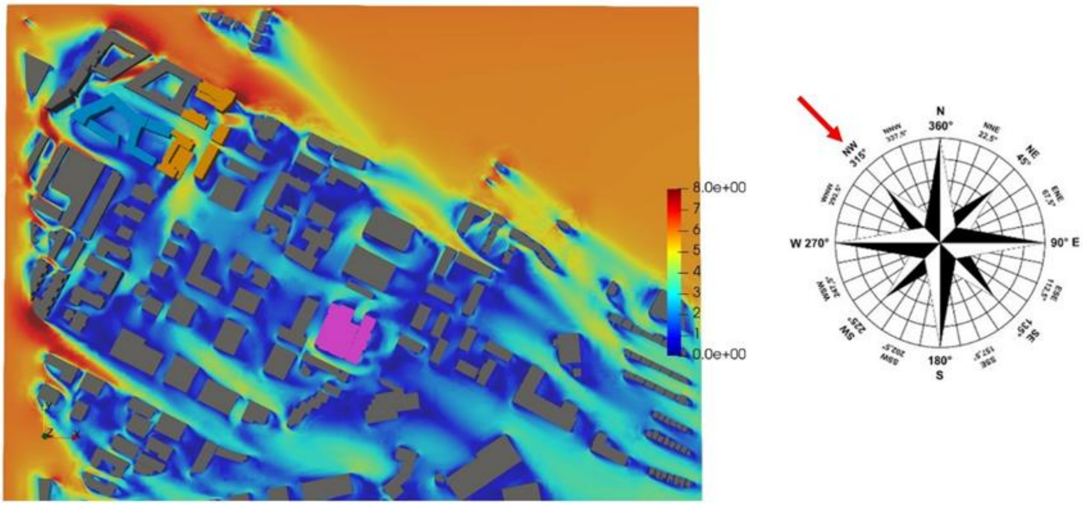


**Figure 12.138: Wind Speed Results at 1.5m Above Development Ground Floor - Top View: 315° - Cumulative Impact Assessment**

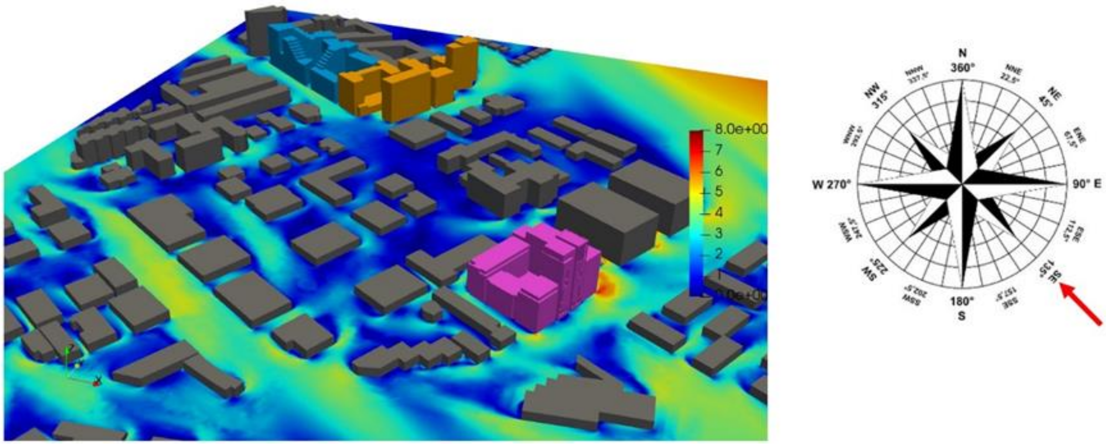


**Figure 12.139: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View: 135° - Cumulative Impact Assessment**

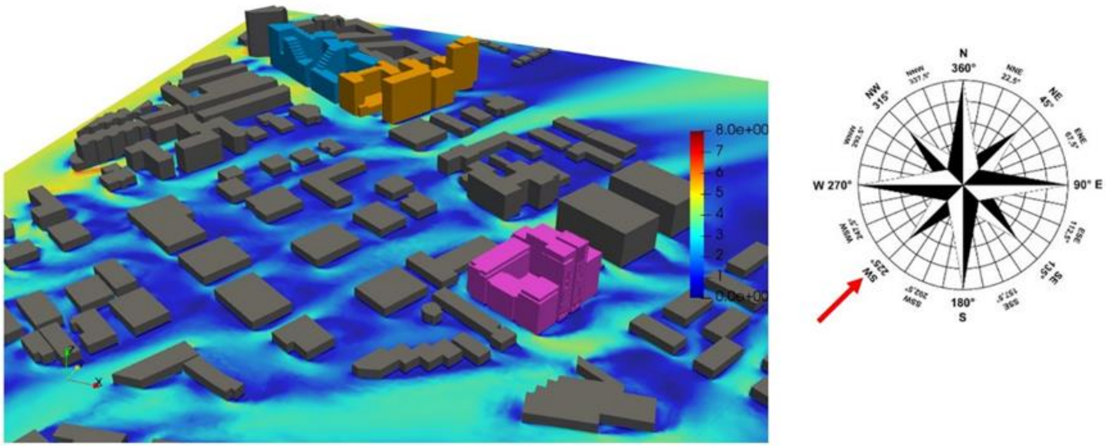



**Figure 12.140: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View: 225° - Cumulative Impact Assessment**

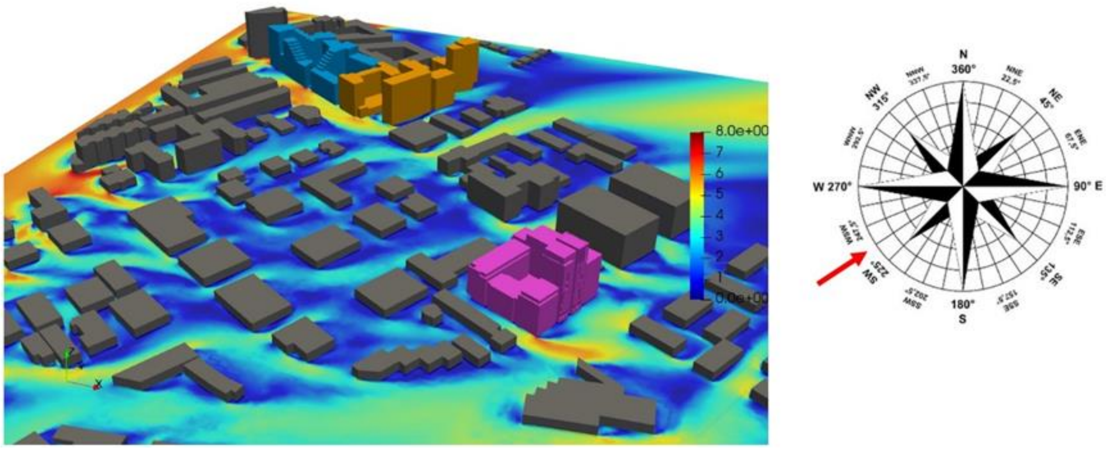



**Figure 12.141: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View: 236° - Cumulative Impact Assessment**

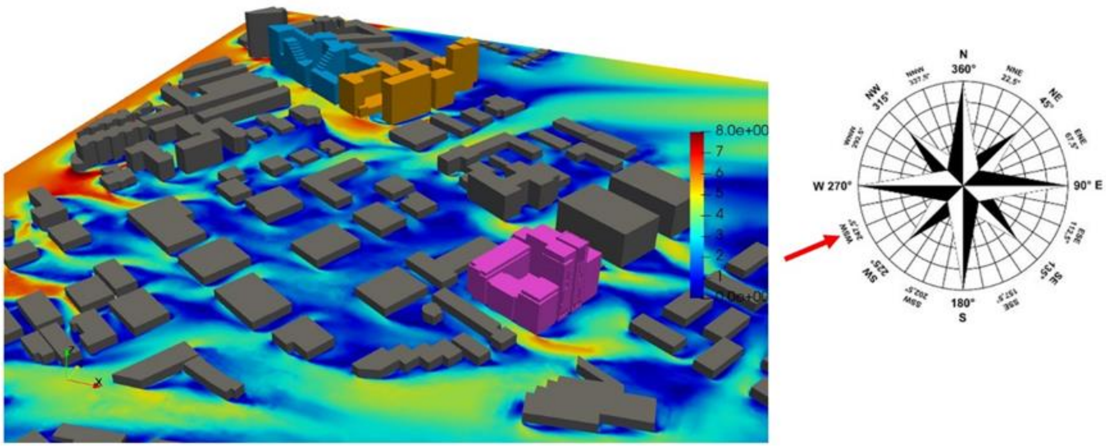



**Figure 12.142: Wind Speed Results at 1.5m Above Ground Floor - 3D View: 247° - Cumulative Impact Assessment**

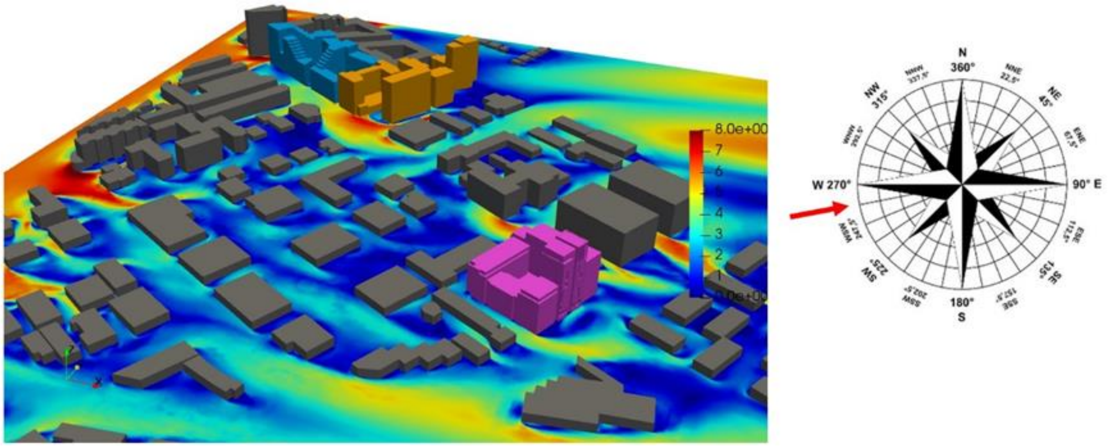



**Figure 12.143: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View 258° - Cumulative Impact Assessment**

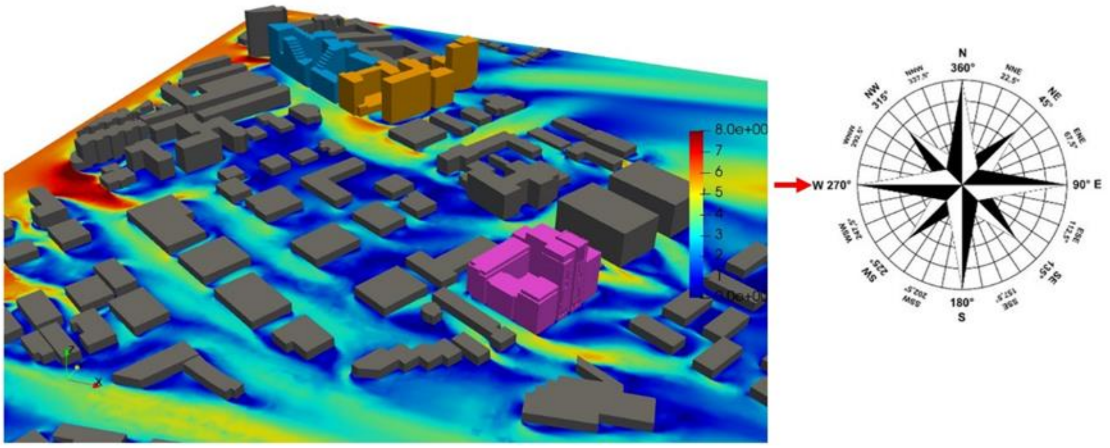



**Figure 12.144: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View: 270° - Cumulative Impact Assessment**

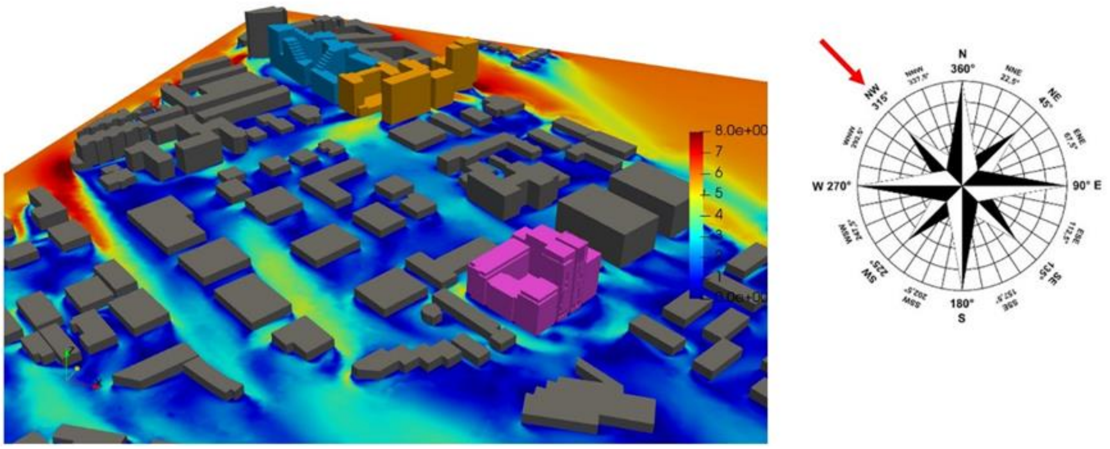



**Figure 12.145: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View: 315° - Cumulative Impact Assessment**

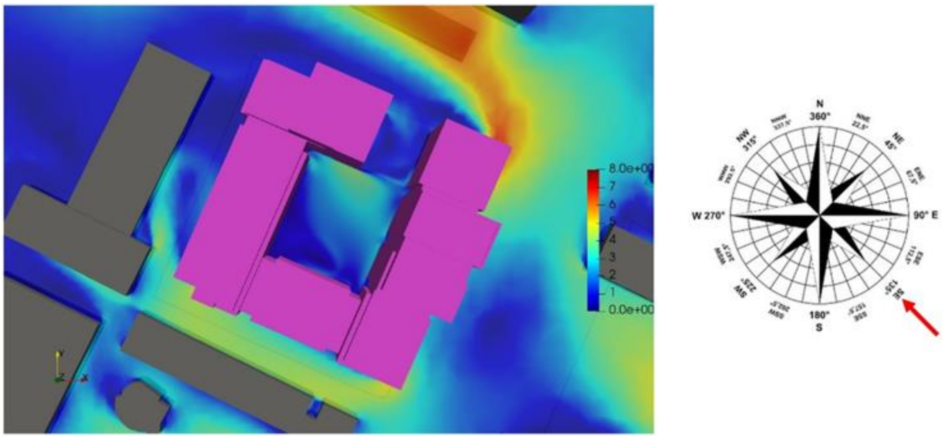



**Figure 12.146: Courtyard - Wind Speed Results at 1.5m Above Ground - Top View: 135° - Cumulative Impact Assessment**

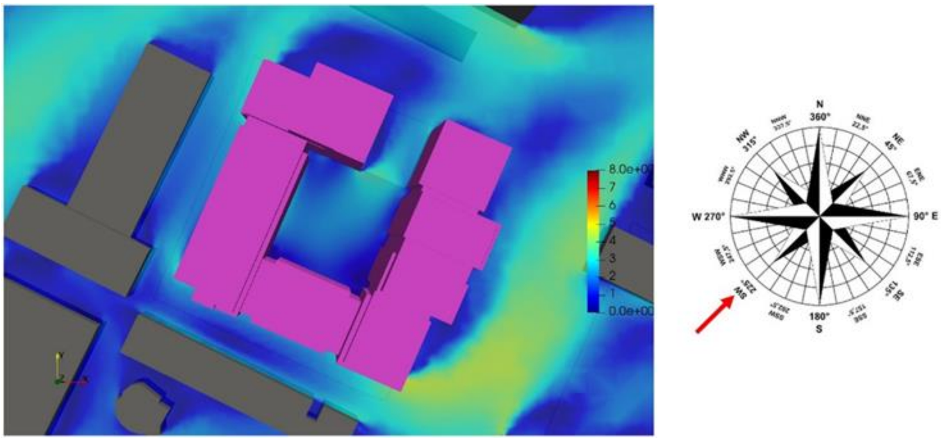



**Figure 12.147: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 225° - Cumulative Impact Assessment**

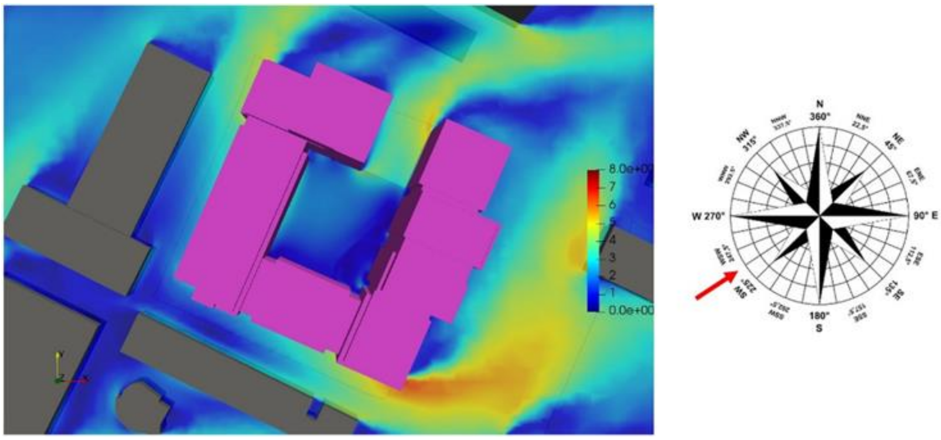



**Figure 12.148: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 236° - Cumulative Impact Assessment**

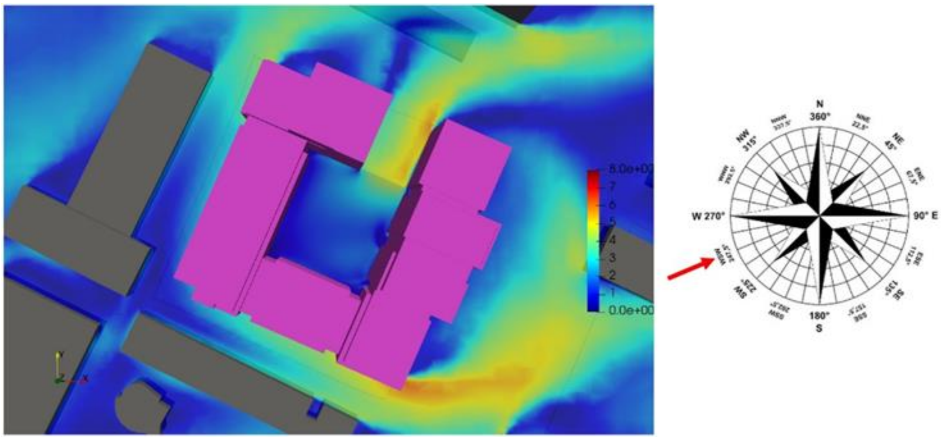



**Figure 12.149: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 247° - Cumulative Impact Assessment**

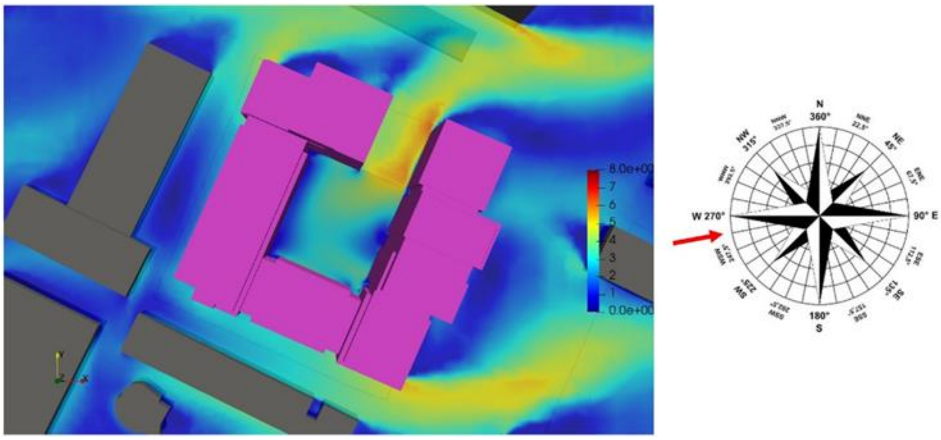



**Figure 12.150: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 258° - Cumulative Impact Assessment**

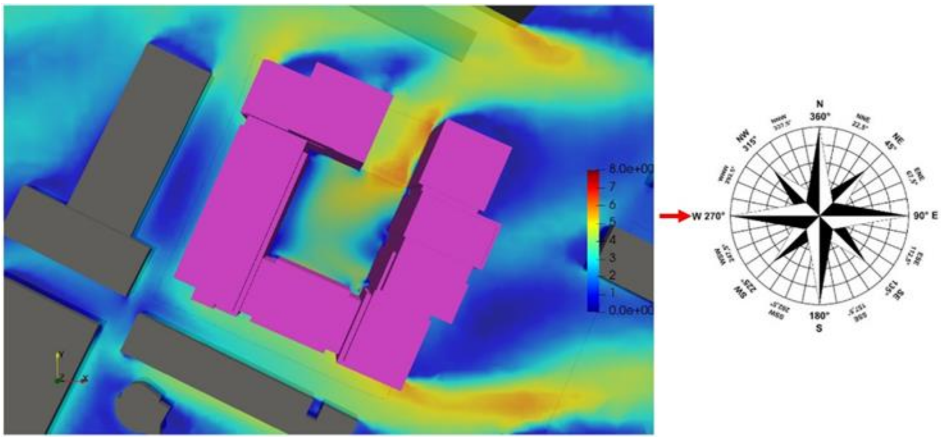



**Figure 12.151: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 270° - Cumulative Impact Assessment**

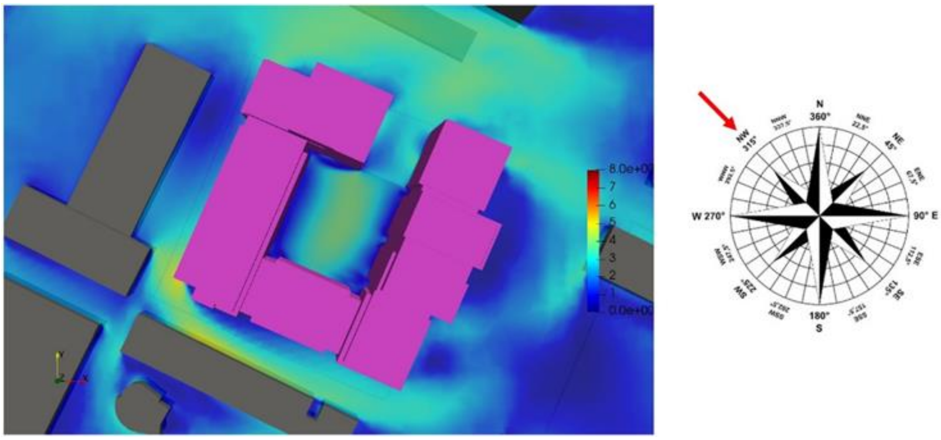



**Figure 12.152: Courtyard - Wind Speed Results at 1.5m Above Development Ground - Top View: 315° - Cumulative Impact Assessment**

**Figure 12.153: Mitigation Measures implemented at ground floor, courtyard and main entrance.**

### 12.6.5 Roof Terraces

Figure 12.154 shows again the position of the four terraces on the development. Terrace 1 and

4 are at the same level, approx. 34m, Terrace 1 is at approximately 25m and Terrace 3 at approx. 30m.

Results of velocity at slice location of 1.5m above the ground are presented in Figures Figure 12.155 to Figure 12.175 for wind assessment of the terraces at Carmanhall Road Development.

Higher velocities can be found for some directions, only in some areas of the terraces and often corresponding to the edges of it. However, these velocities are below critical values for safety. Moreover, mitigation measures with balustrade, planters and trees have been implemented as presented in Figures Figure 12.176 and Figure 12.177 and will mitigate these effects.

Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the terraces are identified as slight or imperceptible.

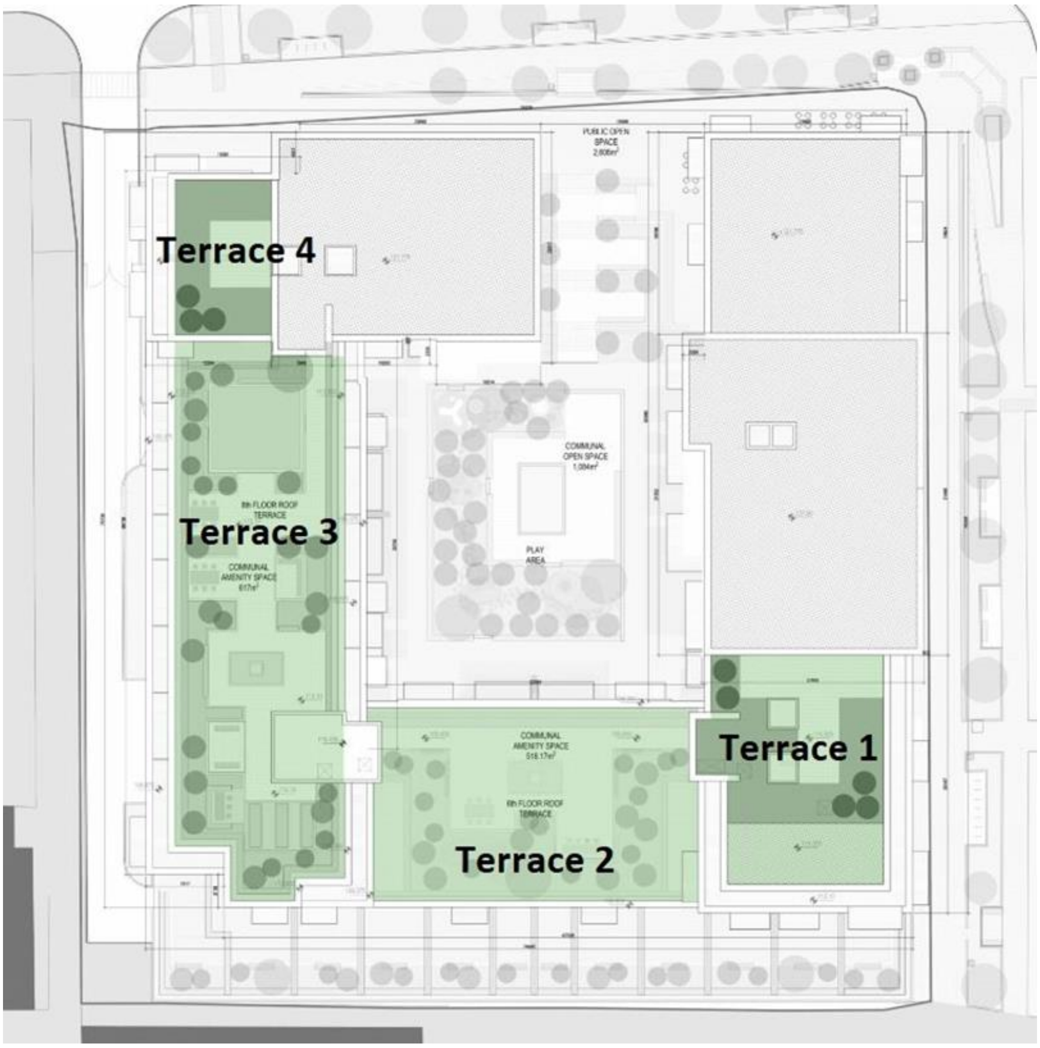



**Figure 12.154: Terraces at Carmanhall Road Development**

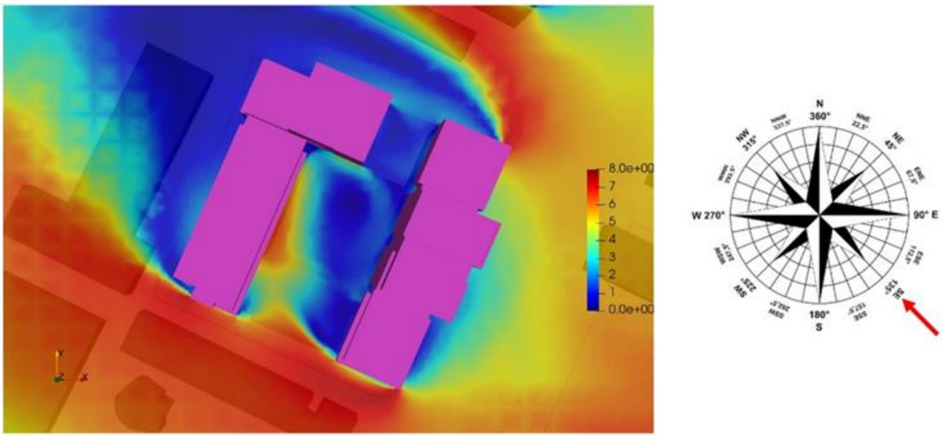



**Figure 12.155: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace - Top View: 135° - Cumulative Impact Assessment**

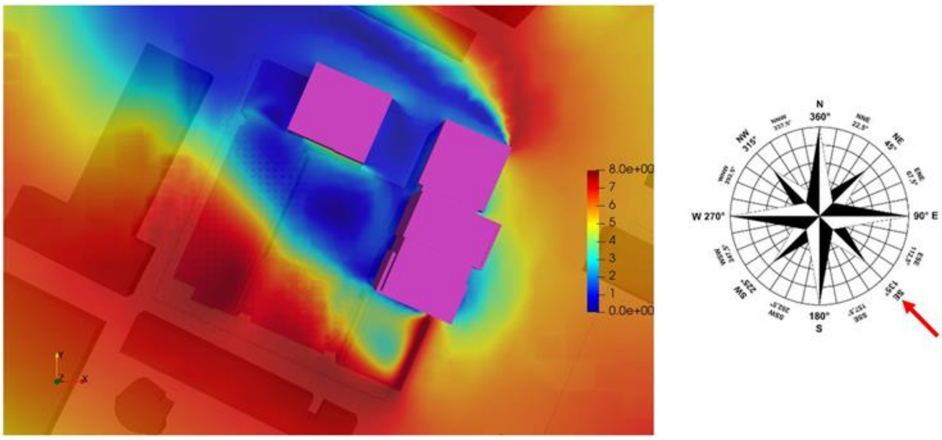



**Figure 12.156: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 135° Cumulative Impact Assessment**

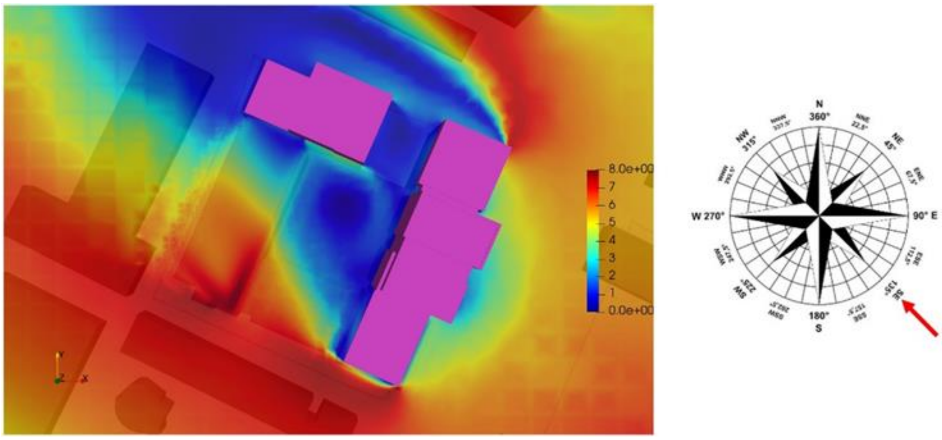



**Figure 12.157: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 135°**

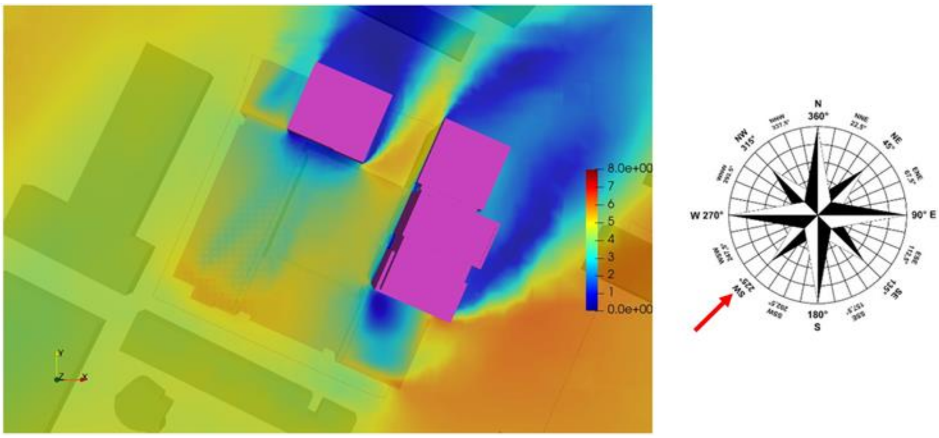



**Figure 12.158: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace – Top View: 225° - Cumulative Impact Assessment**

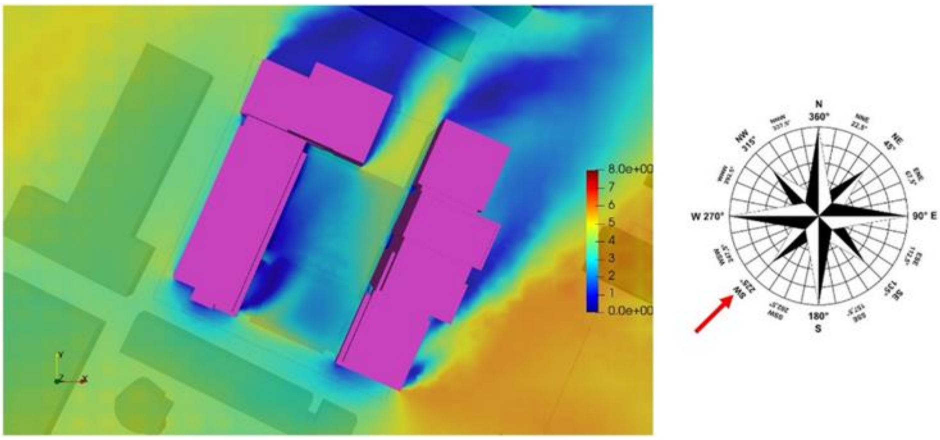



**Figure 12.159: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 225° Cumulative Impact Assessment**

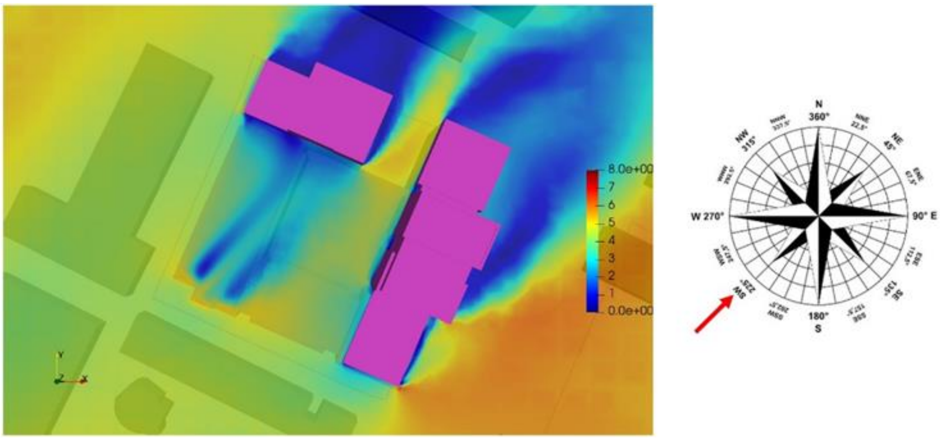



**Figure 12.160: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 225°**

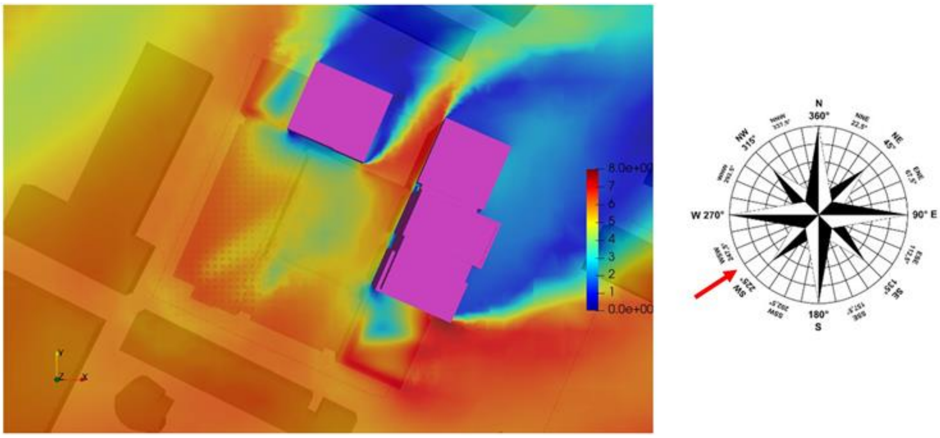


**Figure 12.161: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace - Top View: 236° - Cumulative Impact Assessment**

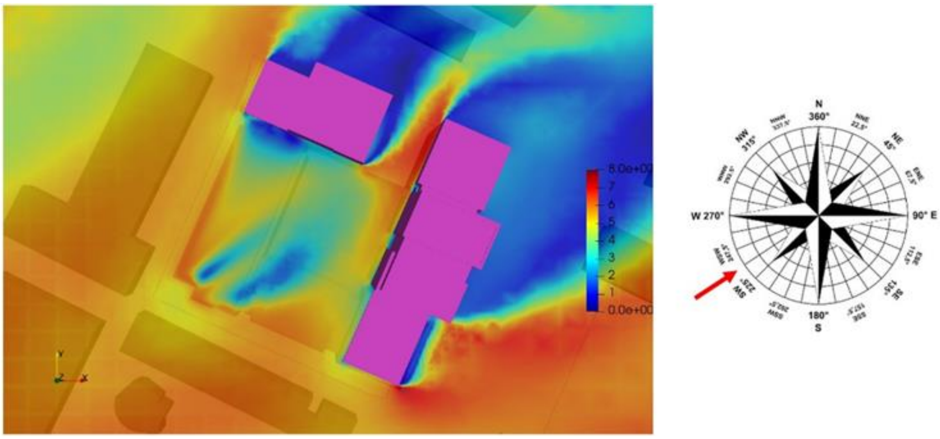


**Figure 12.162: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 236° Cumulative Impact Assessment**

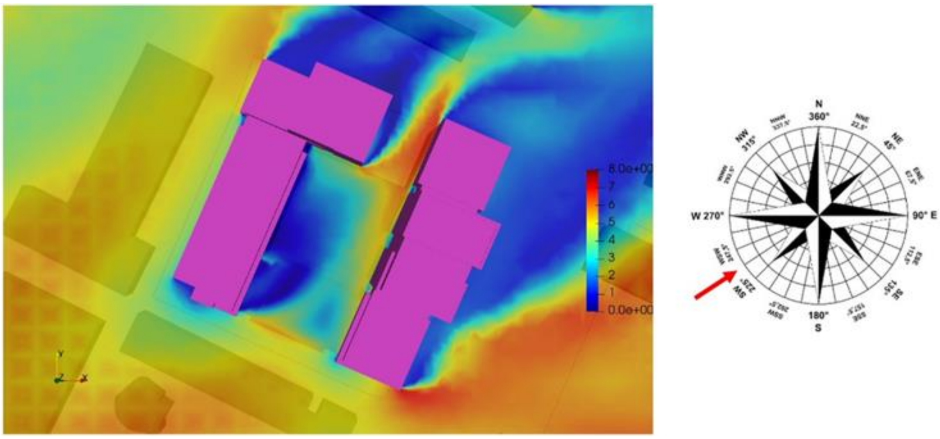


**Figure 12.163: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 236° Cumulative Impact Assessment**

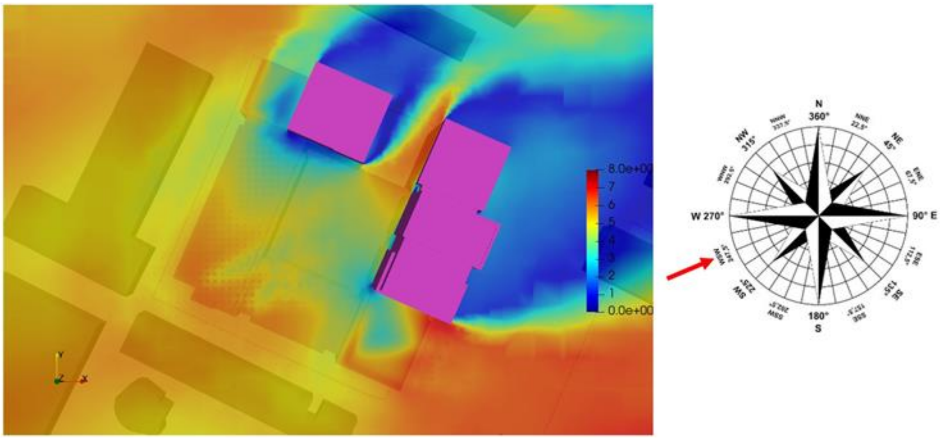



**Figure 12.164: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace – Top View: 247° - Cumulative Impact Assessment**

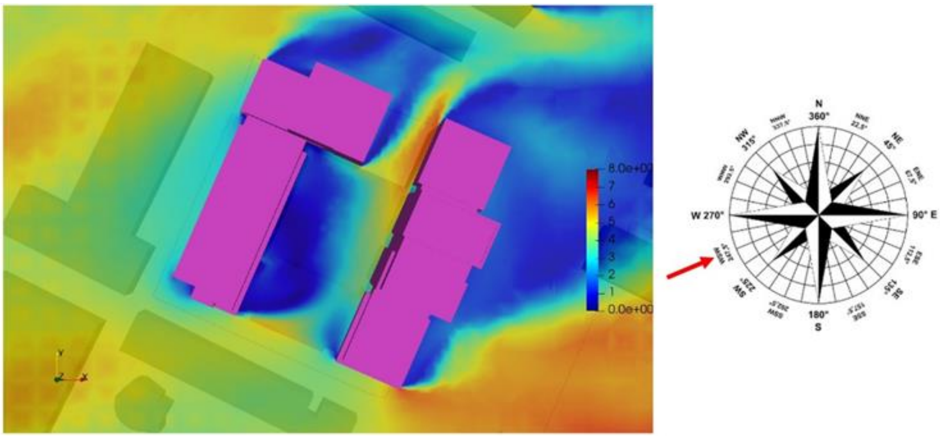



**Figure 12.165: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 247° Cumulative Impact Assessment**

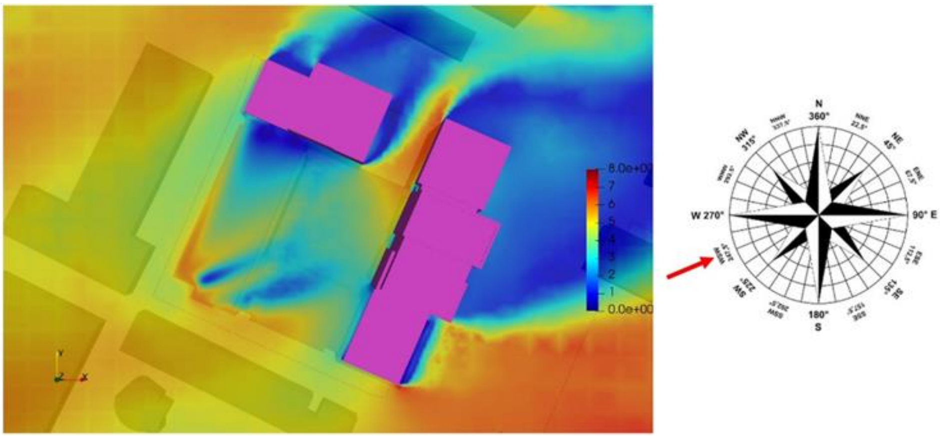



**Figure 12.166: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 247° - Cumulative Impact Assessment**

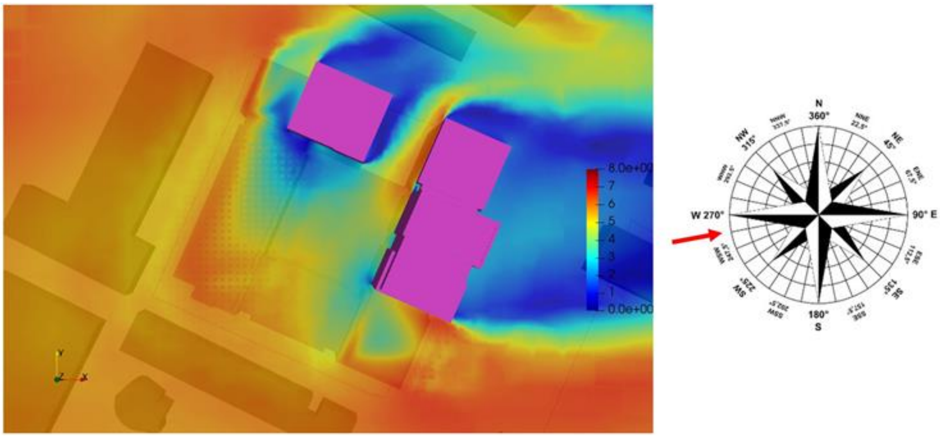



**Figure 12.167: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace – Top View: 258° - Cumulative Impact Assessment**

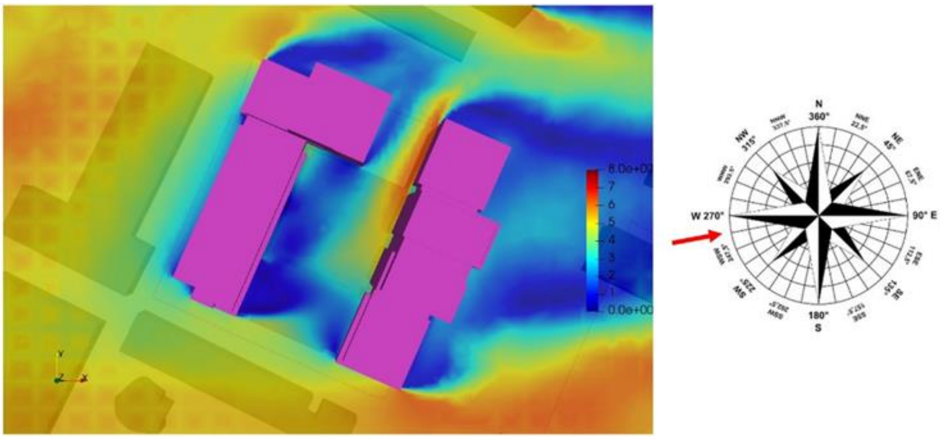



**Figure 12.168: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 258° - Cumulative Impact Assessment**

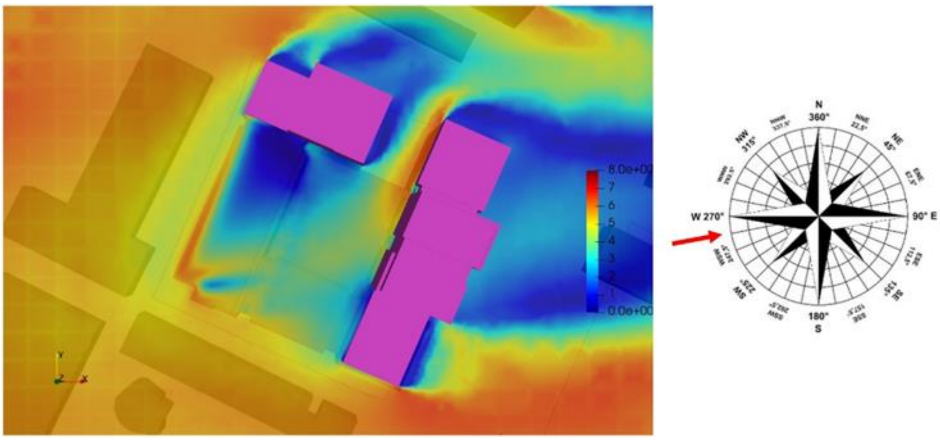
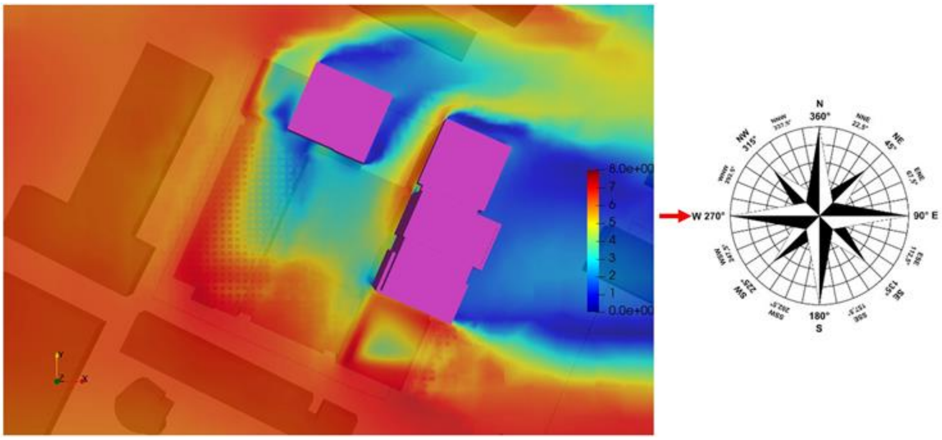



**Figure 12.169: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 258° Cumulative Impact Assessment**




**F Figure 12.170: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace – Top View: 270° - Cumulative Impact Assessment**

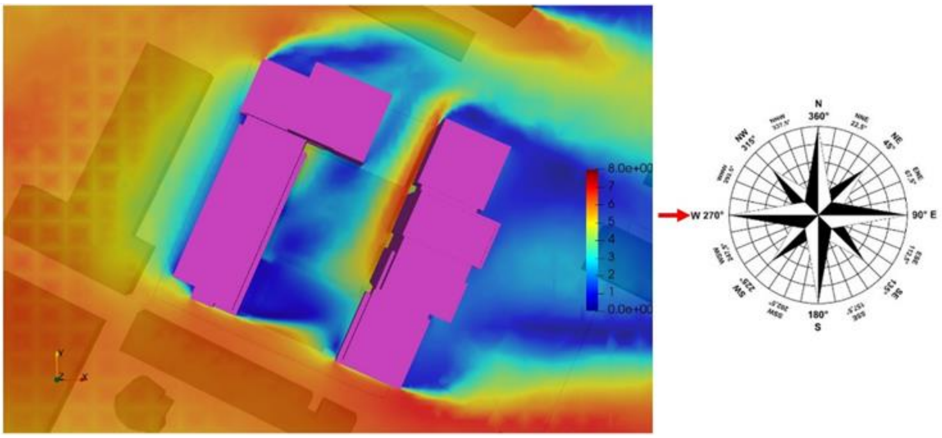



**Figure 12.171: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 270° Cumulative Impact Assessment**

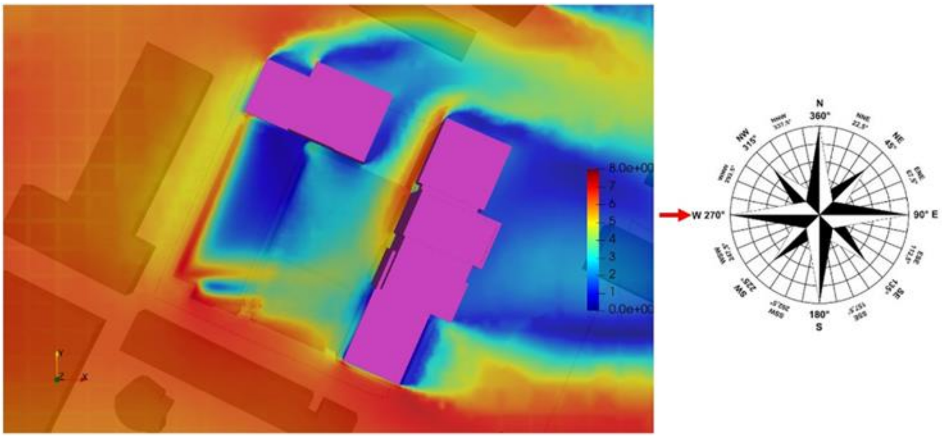



**Figure 12.172: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 270° - Cumulative Impact Assessment**

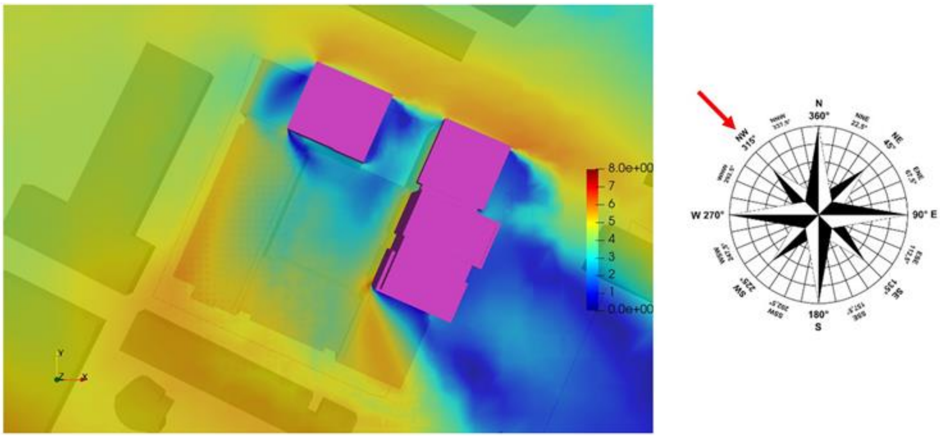



**Figure 12.173: Terrace 1 and Terrace 4 - Wind Speed Results at 1.5m Above Terrace – Top View: 315° - Cumulative Impact Assessment**

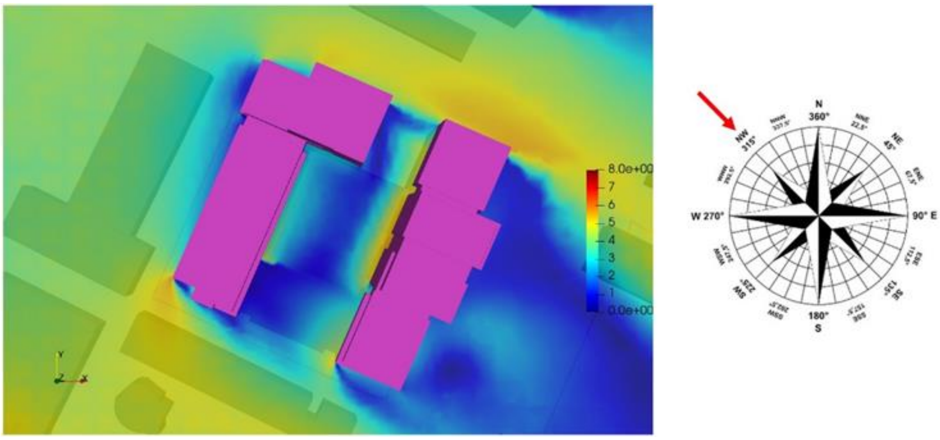



**Figure 12.174: Terrace 2 - Wind Speed Results at 1.5m Above Terrace - Top View: 315° Cumulative Impact Assessment**

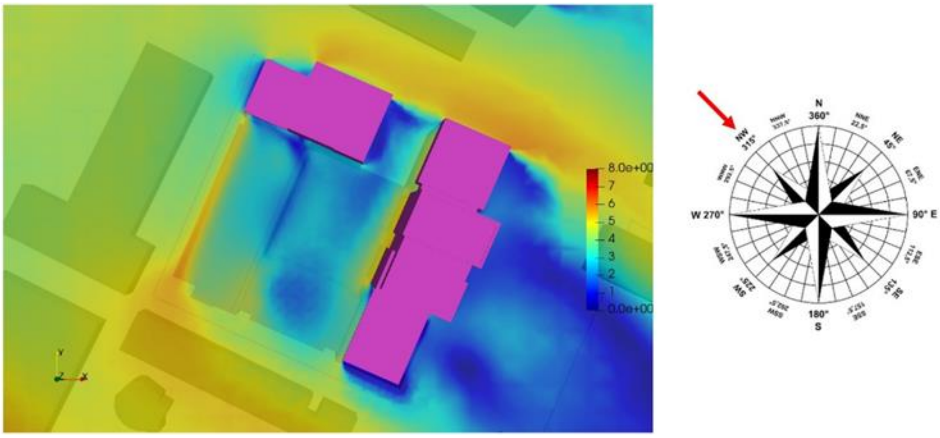



**Figure 12.175: Terrace 3 - Wind Speed Results at 1.5m Above Terrace - Top View: 315° -° Cumulative Impact Assessment**

**Figure 12.176: Mitigation Measures implemented on the Terraces.**

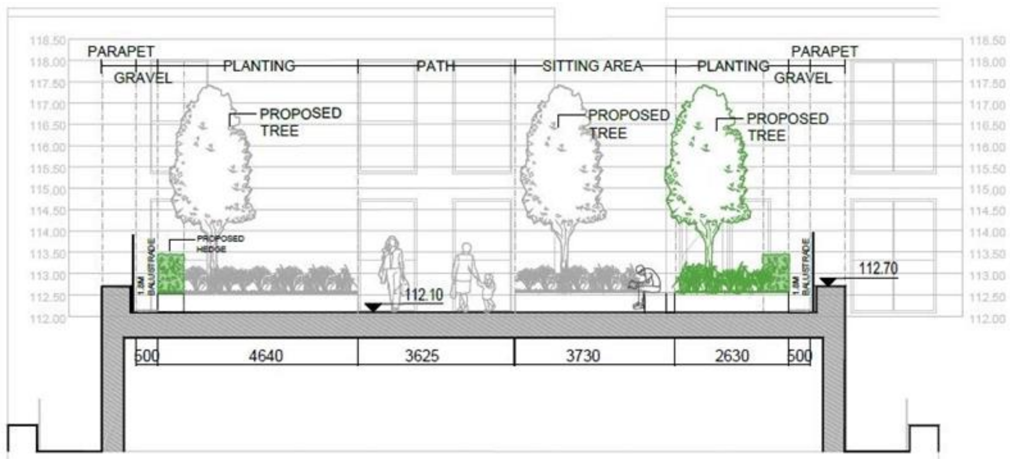



**Figure 12.177: Section View of the Mitigation Measures implemented on the Terraces - Details of Mitigations**

### 12.6.6 Velocity Results Conclusions

The existing environment and proposed Carmanhall Road Development would receive prevailing winds from South-West. As discussed in the previous sections and demonstrated through this assessment of CFD modelling, all adverse wind impacts have been considered and shows to be suitable to its intended use.

The existing site cumulative assessment has accounted for the modelling and simulation of all the topography and existing developments in the surrounding (including developments that have been granted planning application and that have not been built yet) as the presence of adjacent buildings dictates how the wind will approach the Proposed Development.

From the wind modelling results, Carmanhall Road Development will introduce imperceptible wind effect on future developments within its vicinity which have been granted planning application. Wind modelling of future phases around this development will need to be performed for all future phase developments.

#### *12.6.6.1 Risks to Human Health*

This subsection aims to identify areas of Carmanhall Road Development where the 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.

#### *12.6.6.2 Discomfort Criteria*

Figure 12.179 to Figure 12.215 show the Lawson comfort categories over the ground floor area, the courtyard (including the main entrance) and the terraces of Carmanhall Road Development for each direction. The scale used is set out in Figure 12.178.

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. Depending on the wind direction, the suitability of the different areas can be assessed using the maps. 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”.

At ground floor there are no critical area which are unacceptable for pedestrian comfort. Thus, the discomfort criteria are satisfied for all the different cases and in all directions and the area all around the development seems to be always suitable for long-term sitting.

The courtyard is always suitable for long-term sitting, short-term sitting, standing, walking and strolling activities.

Regarding the terraces, results show that there are areas of the roof terraces that are not suitable for long-term sitting, and some small areas that are not suitable for standing or short-term sitting, while they are suitable for all the other activities. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. A roof terrace is not an area that is used all year around and long-term sitting is an activity performed during spring/summer months, when the frequency of such high wind is below 5%. It is not expected that people would be making use of such roof areas during the worst-case conditions. Moreover, mitigation measures with balustrade, planters, and trees have been implemented as shown in the previous Section and will mitigate these effects. Additionally, it has to be noticed that, in any case, there are not critical issues in regard to safety.


**Figure 12.178: Lawson Comfort Categories**


**Figure 12.179: Ground Floor - Lawson Discomfort Map - 135° - Cumulative Impact Assessment**


**Figure 12.180: Ground Floor - Lawson Discomfort Map - 225° - Cumulative Impact Assessment**


**Figure 12.181: Ground Floor - Lawson Discomfort Map - 236° - Cumulative Impact Assessment**

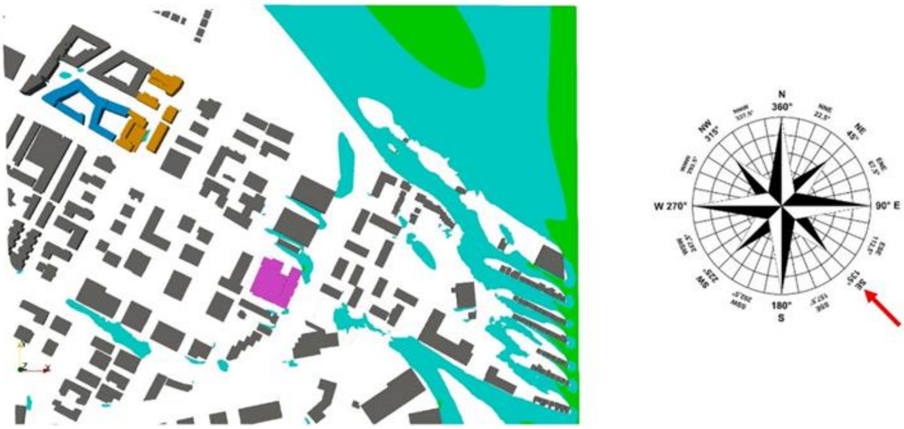



**Figure 12.182: Ground Floor - Lawson Discomfort Map - 258° - Cumulative Impact Assessment**

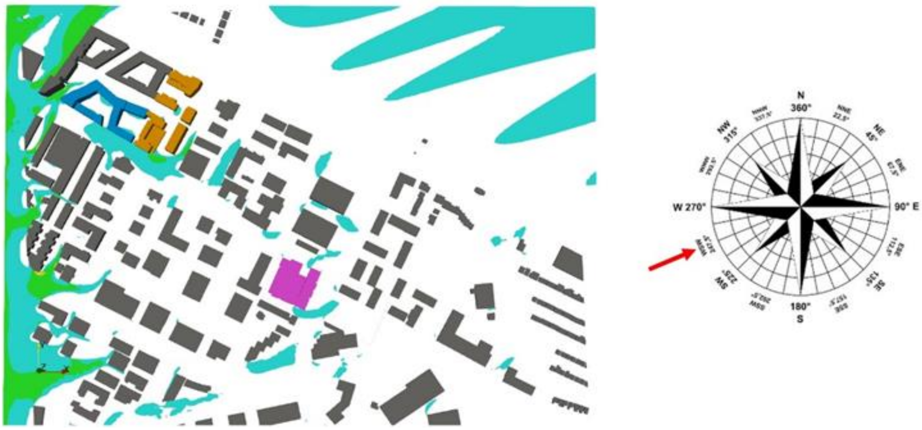



**Figure 12.183: Ground Floor - Lawson Discomfort Map - 247° - Cumulative Impact Assessment**


**Figure 12.184: Ground Floor - Lawson Discomfort Map - 270° - Cumulative Impact Assessment**


**Figure 12.185: Ground Floor - Lawson Discomfort Map - 315° - Cumulative Impact Assessment**


**Figure 12.186: Ground Floor - Lawson Discomfort Map - 281° - Cumulative Impact Assessment**

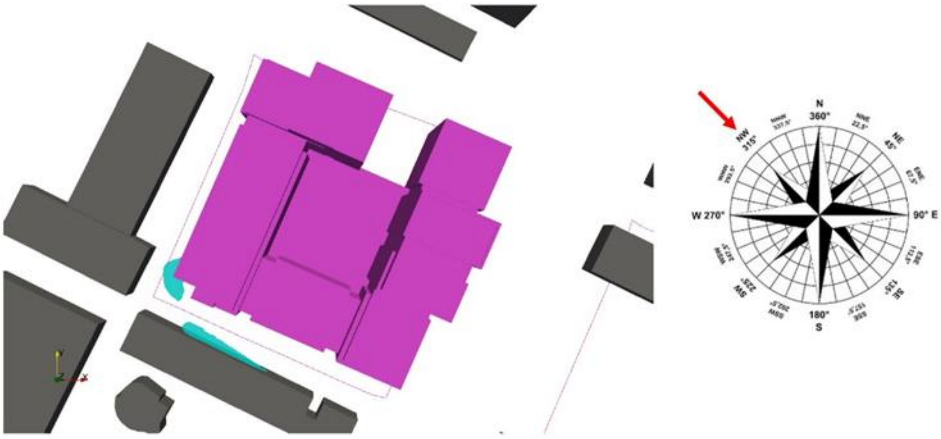



**Figure 12.187: Courtyard - Lawson Discomfort Map - 135° - Cumulative Impact**

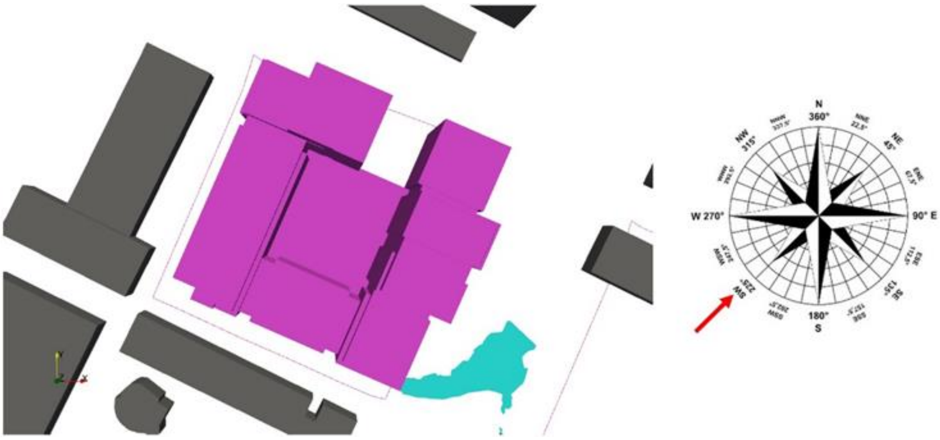



**Figure 12.188: Courtyard - Lawson Discomfort Map - 225° - Cumulative Impact**

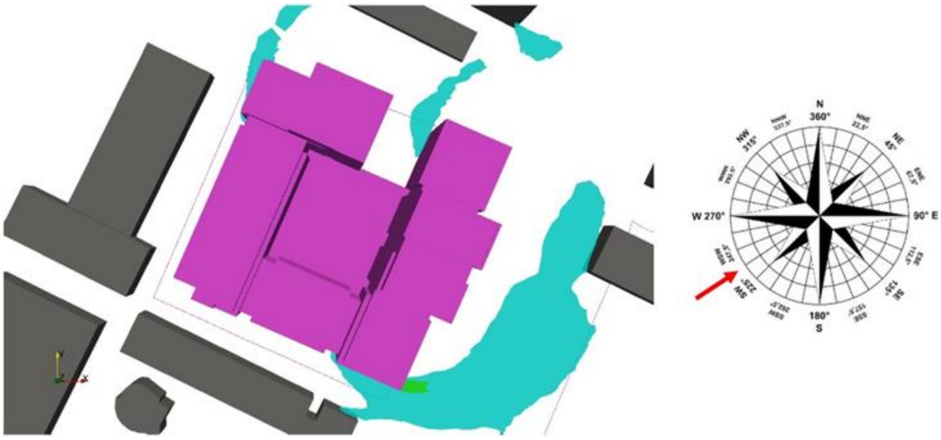



**Figure 12.189: Courtyard - Lawson Discomfort Map - 236° - Cumulative Impact**

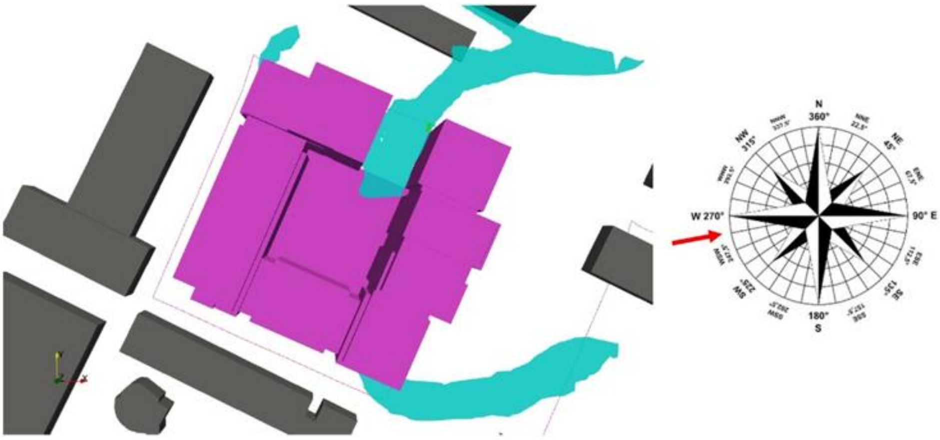



**Figure 12.190: Courtyard - Lawson Discomfort Map - 258° - Cumulative Impact**

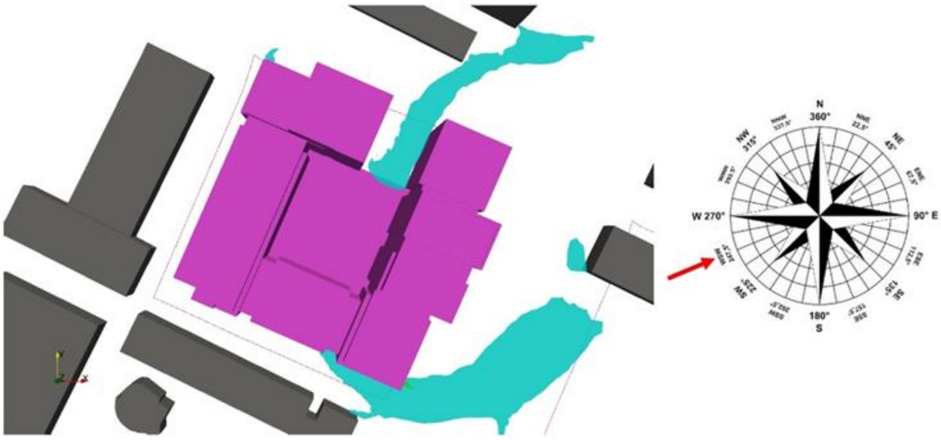



**Figure 12.191: Courtyard - Lawson Discomfort Map - 247° - Cumulative Impact**

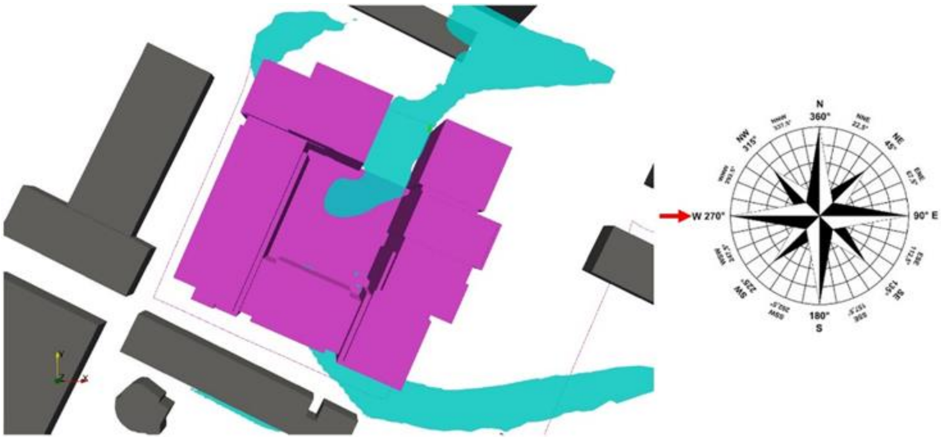



**Figure 12.192: Courtyard - Lawson Discomfort Map - 270° - Cumulative Impact**

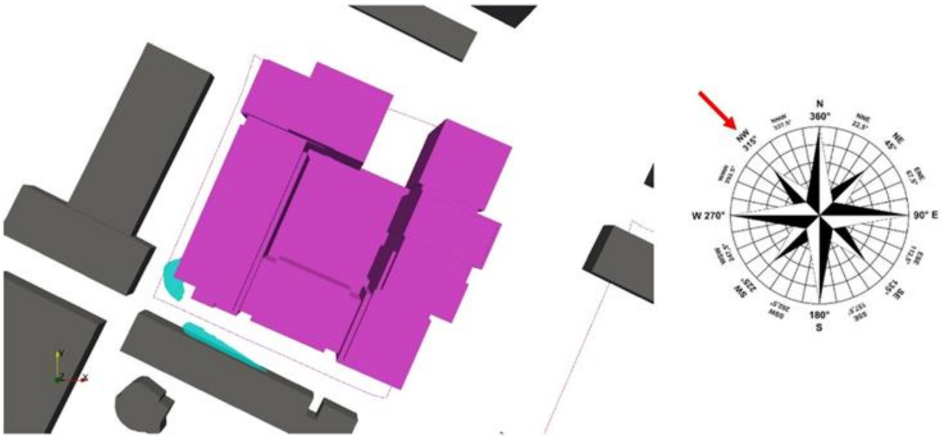



**Figure 12.193: Courtyard - Lawson Discomfort Map - 315° - Cumulative Impact**

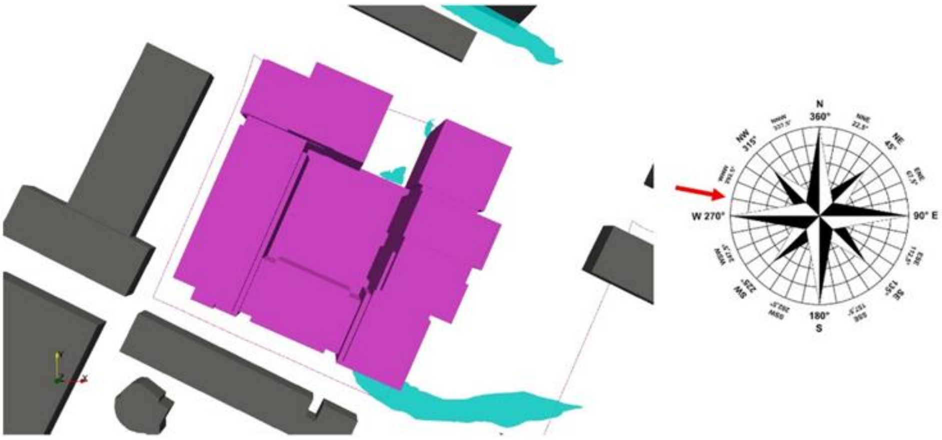



**Figure 12.194: Courtyard - Lawson Discomfort Map - 281° - Cumulative Impact**


**Figure 12.195: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 135° - Cumulative Impact**

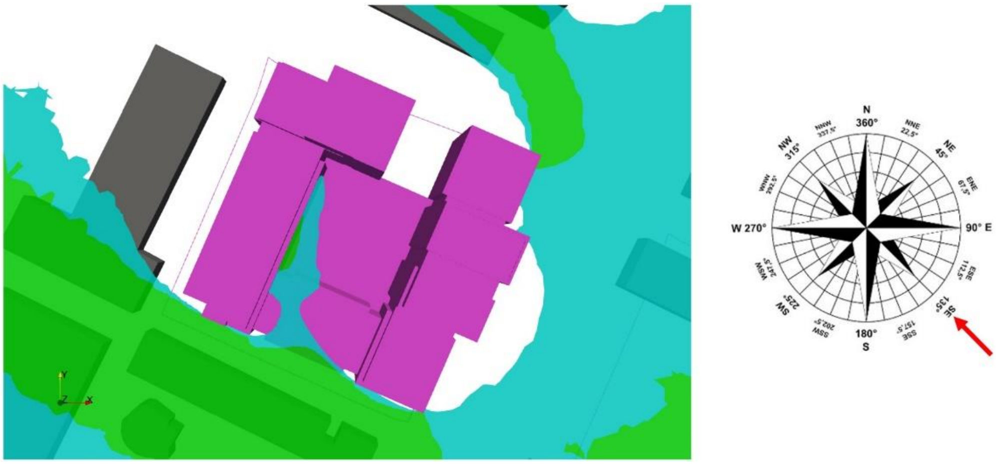



**Figure 12.196: Terrace 2 - Lawson Discomfort Map - 135° - Cumulative Impact**


**Figure 12.197: Terrace 3 - Lawson Discomfort Map - 135° - Cumulative Impact**


**Figure 12.198: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 225° - Cumulative Impact**

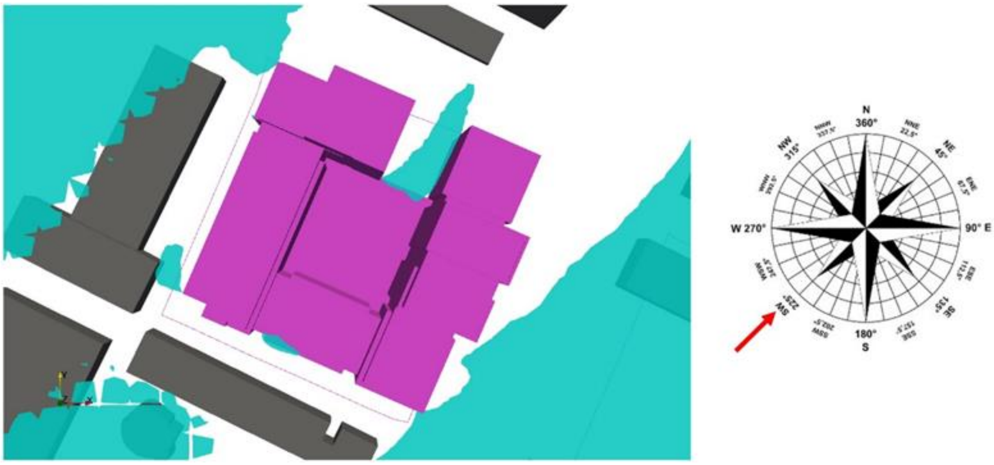



**Figure 12.199: Terrace 2 - Lawson Discomfort Map - 225° - Cumulative Impact**

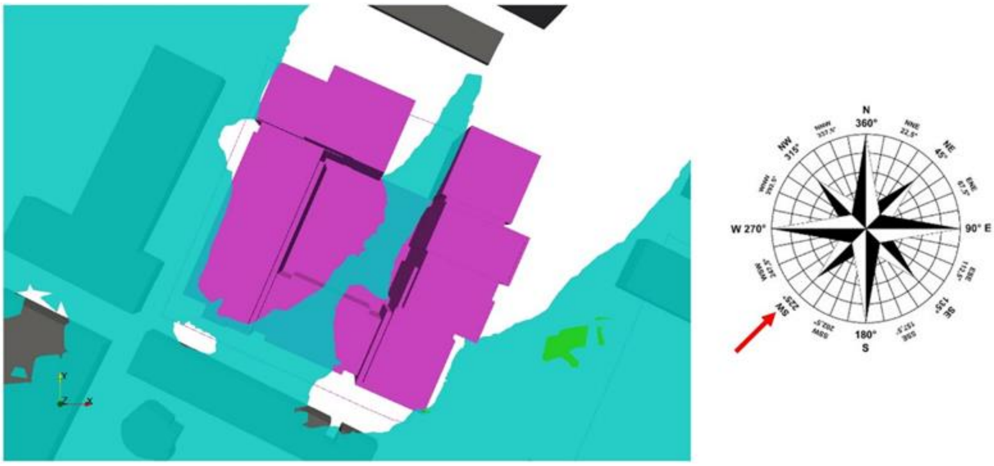



**Figure 12.200: Terrace 3 - Lawson Discomfort Map - 225° - Cumulative Impact**

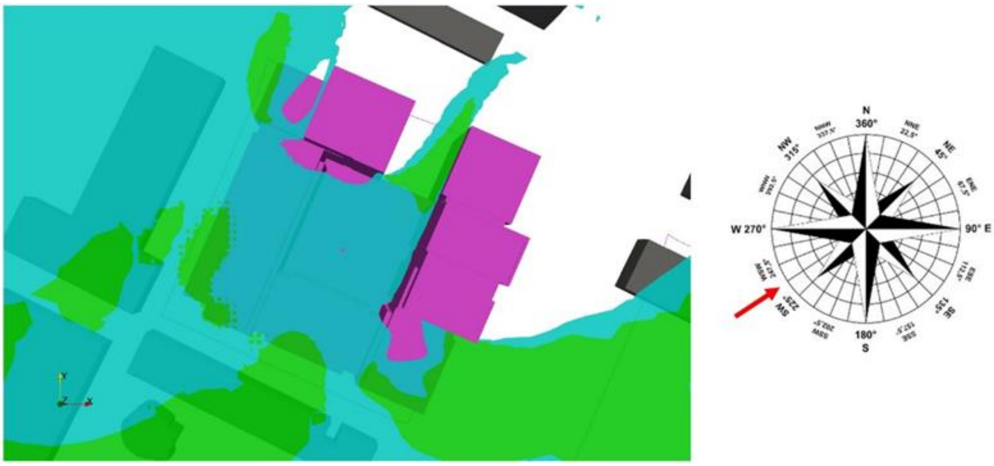



**Figure 12.201: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 236° - Cumulative Impact**

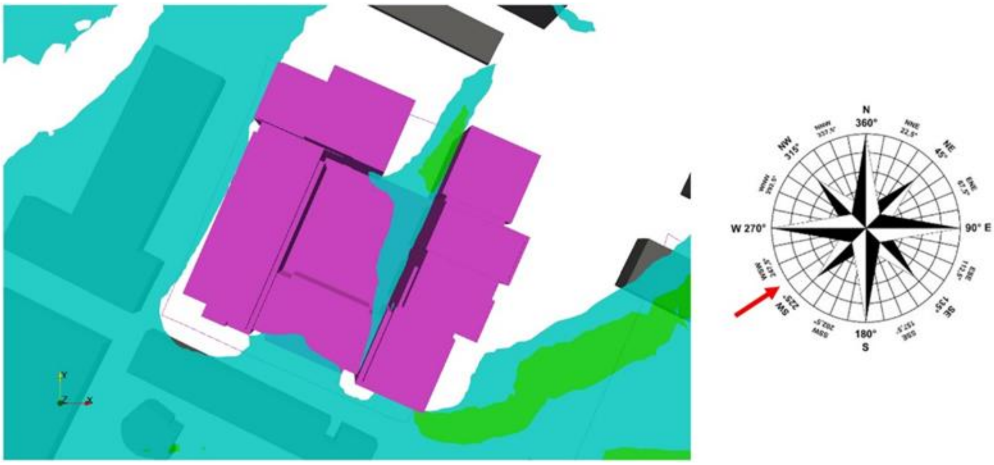



**Figure 12.202: Terrace 2 - Lawson Discomfort Map - 236° - Cumulative Impact**

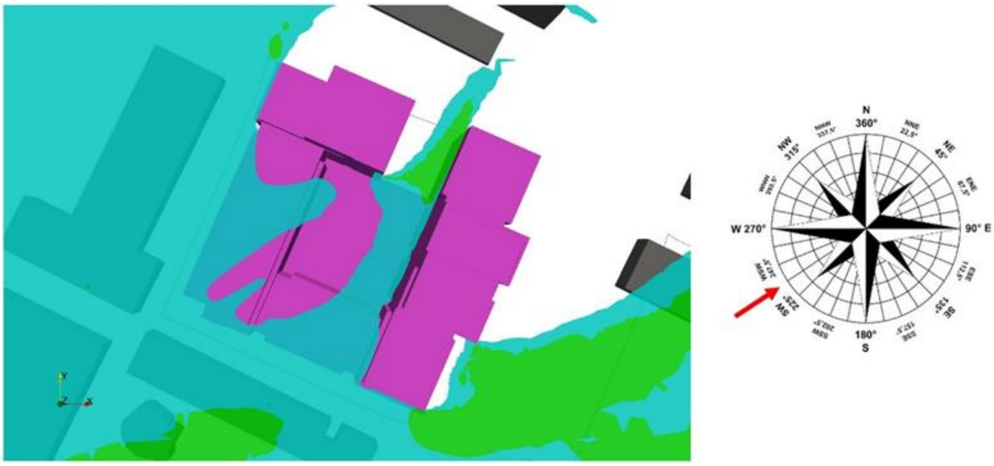



**Figure 12.203: Terrace 3 - Lawson Discomfort Map - 236° - Cumulative Impact**

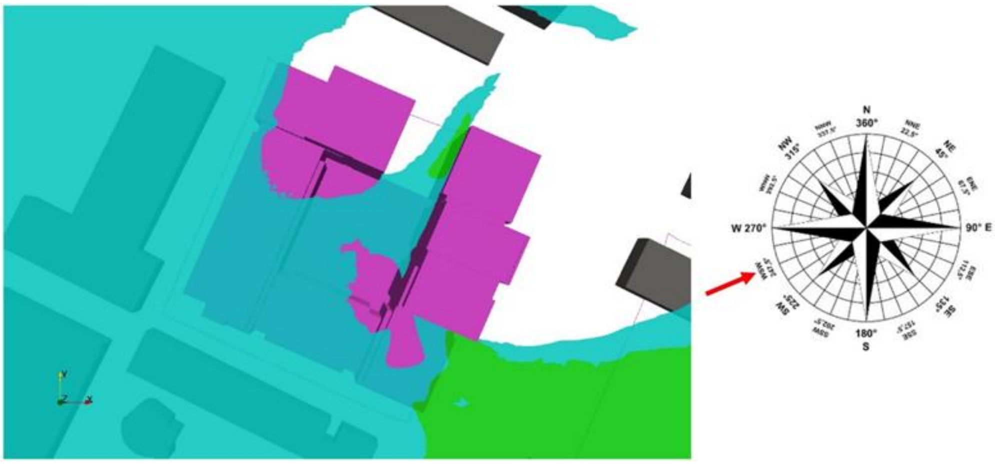



**Figure 12.204: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 247° - Cumulative Impact**

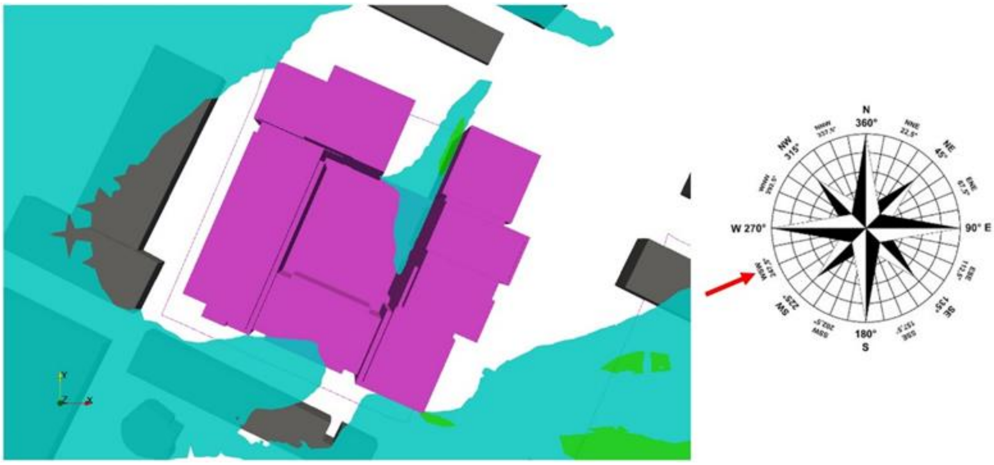


**Figure 12.205: Terrace 2 - Lawson Discomfort Map - 247° - Cumulative Impact**

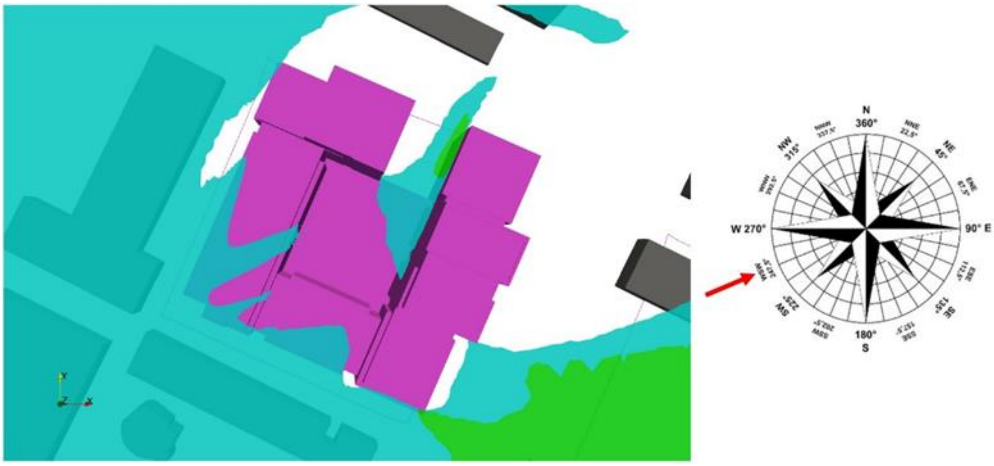


**Figure 12.206: Terrace 3 - Lawson Discomfort Map - 247° - Cumulative Impact**

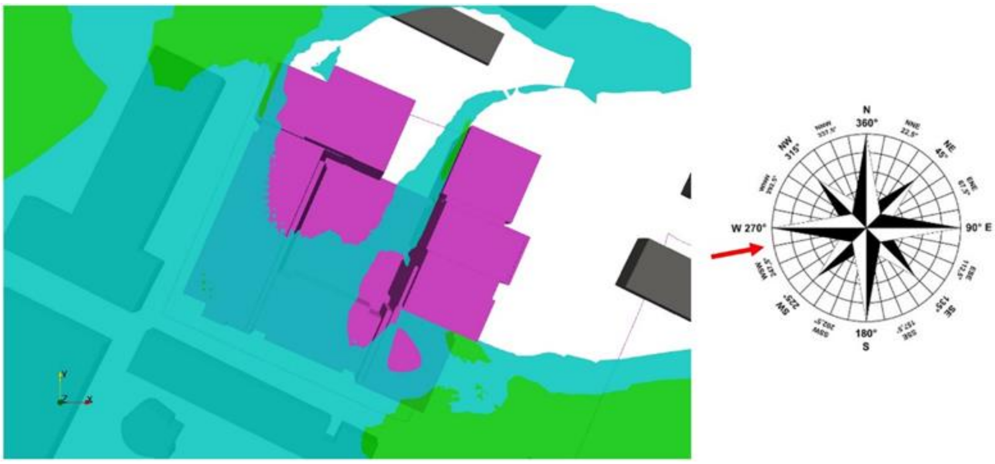


**Figure 12.207: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 258° - Cumulative Impact**

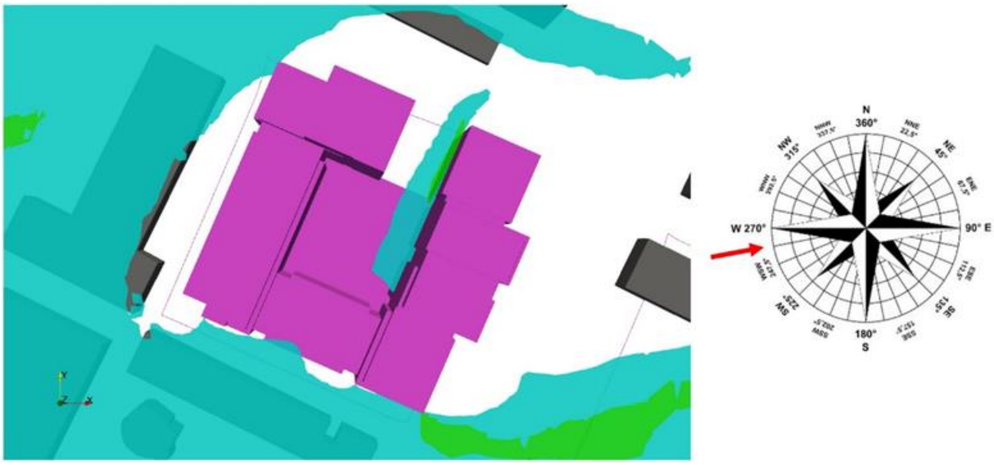


**Figure 12.208: Terrace 2 - Lawson Discomfort Map - 258° - Cumulative Impact**

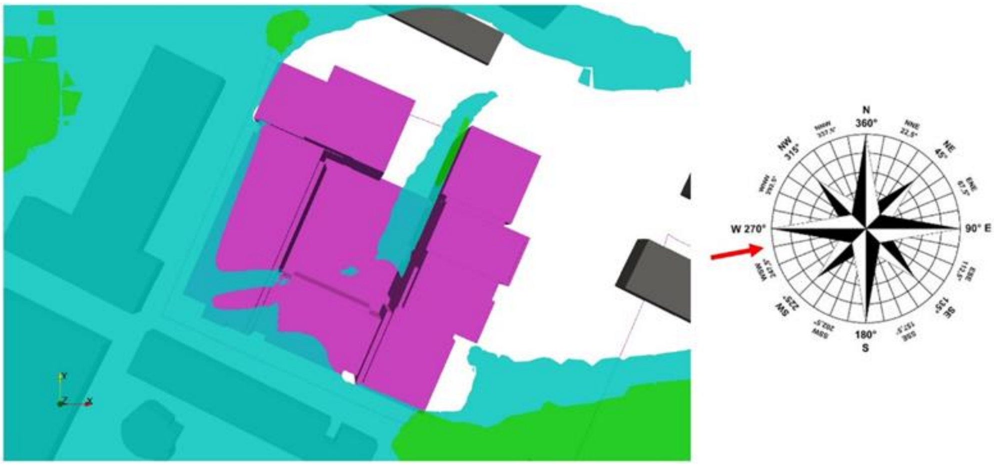


**Figure 12.209: Terrace 3 - Lawson Discomfort Map - 258° - Cumulative Impact**

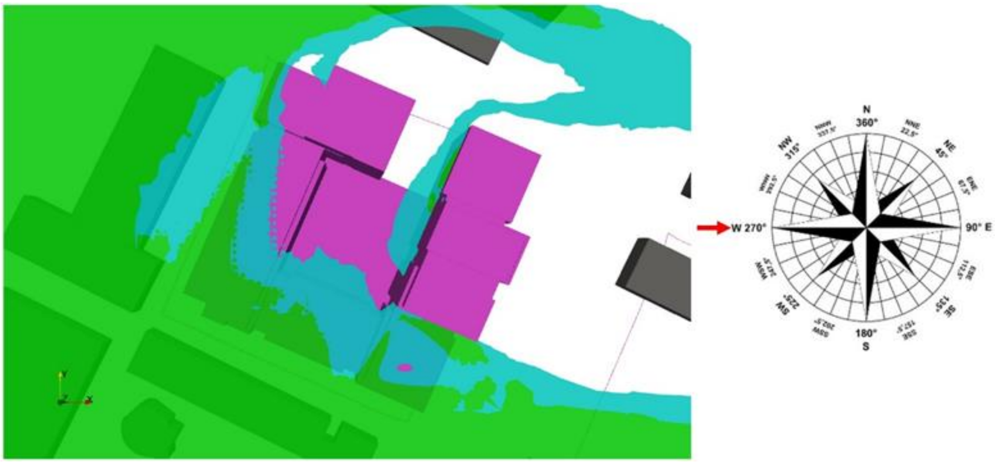


**Figure 12.210: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 270° - Cumulative Impact**

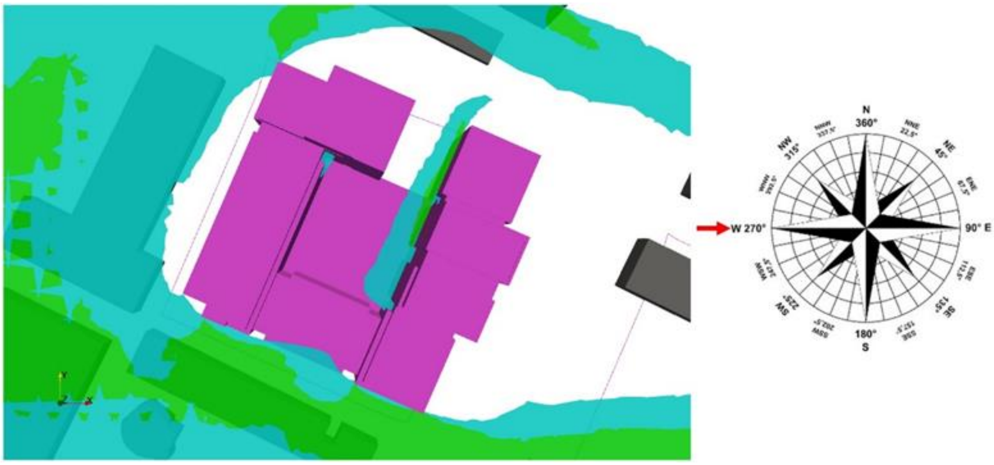



**Figure 12.211: Terrace 2 - Lawson Discomfort Map - 270° - Cumulative Impact**

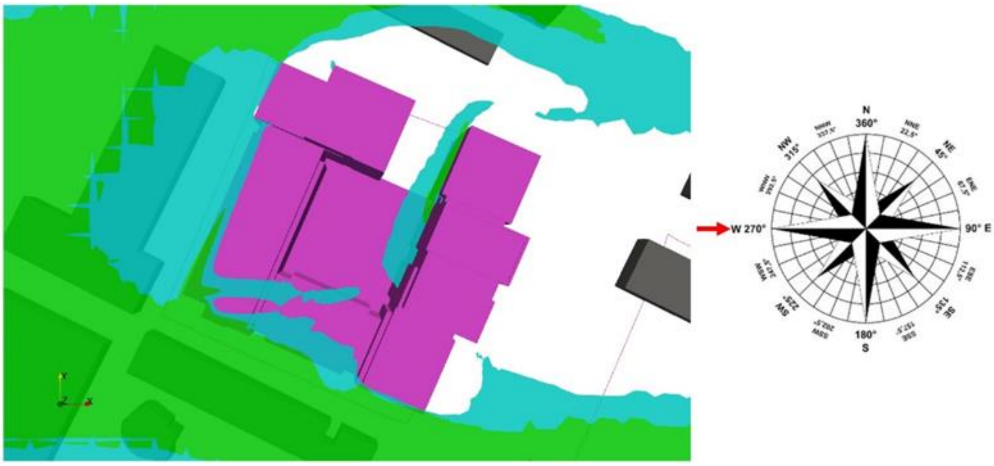



**Figure 12.212: Terrace 3 - Lawson Discomfort Map - 270° - Cumulative Impact**

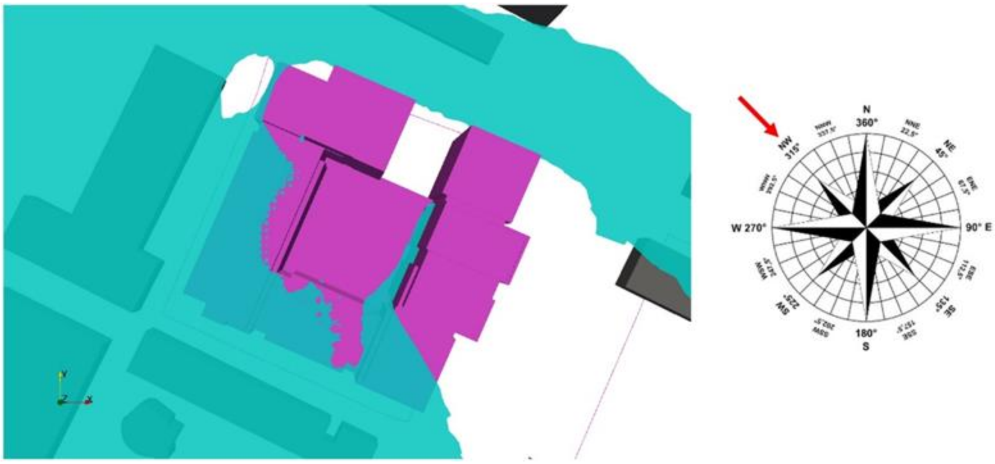



**Figure 12.213: Terrace 1 and Terrace 4 - Lawson Discomfort Map - 315° - Cumulative Impact**

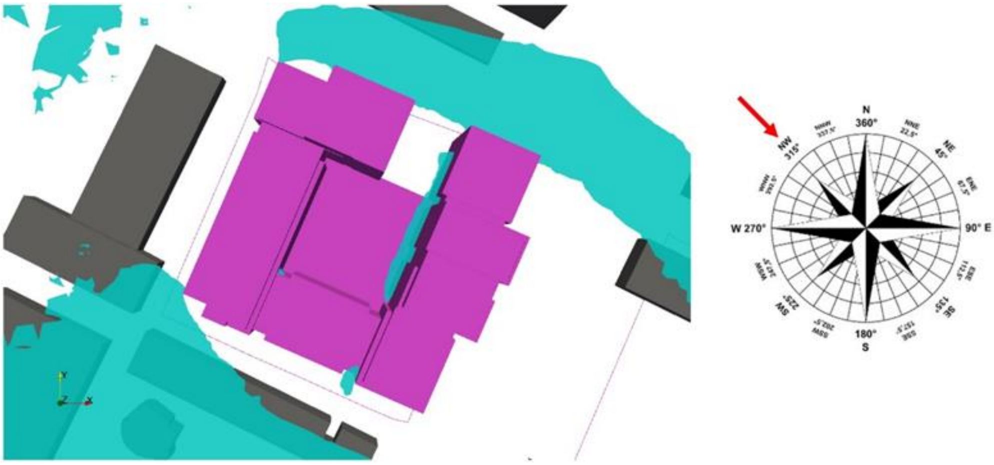


**Figure 12.214: Terrace 2 - Lawson Discomfort Map - 315° - Cumulative Impact**

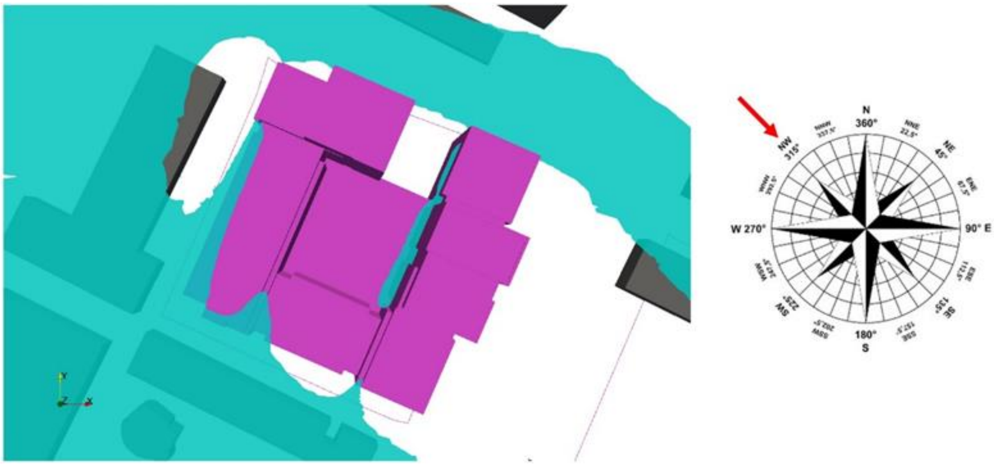


**Figure 12.215: Terrace 3 - Lawson Discomfort Map - 315° - Cumulative Impact**

### *12.6.6.3 Distress Criteria*

In addition to the criteria for “discomfort” the Lawson method presents criteria for “distress”. The discomfort criteria focus on wind conditions which may be encountered for hundreds of hours per year. The distress criteria require higher wind speeds to be met but focus on two hours per year. These are rare wind conditions but with the potential for injury rather than inconvenience.

Figure 12.216 shows the hourly wind gust rose for Dublin, from 1985 to 2015. This will be necessary to assess how many hours per year on average the velocity exceed the threshold values.

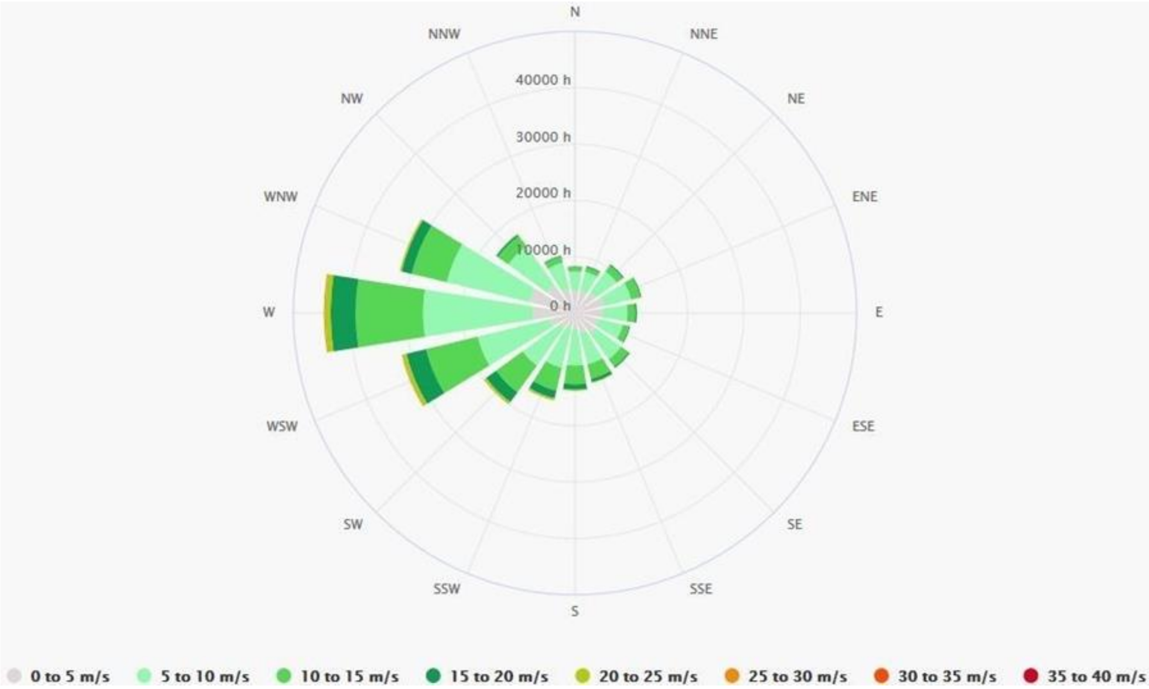



**Figure 12.216: Hourly Dublin Wind Gust Rose**

The criteria for distress for a frail person or cyclist are 15m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 15m/s (as reported in Figure 12.217 and Figure 12.218 respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 15m/s is exceed at pedestrian level in each direction.

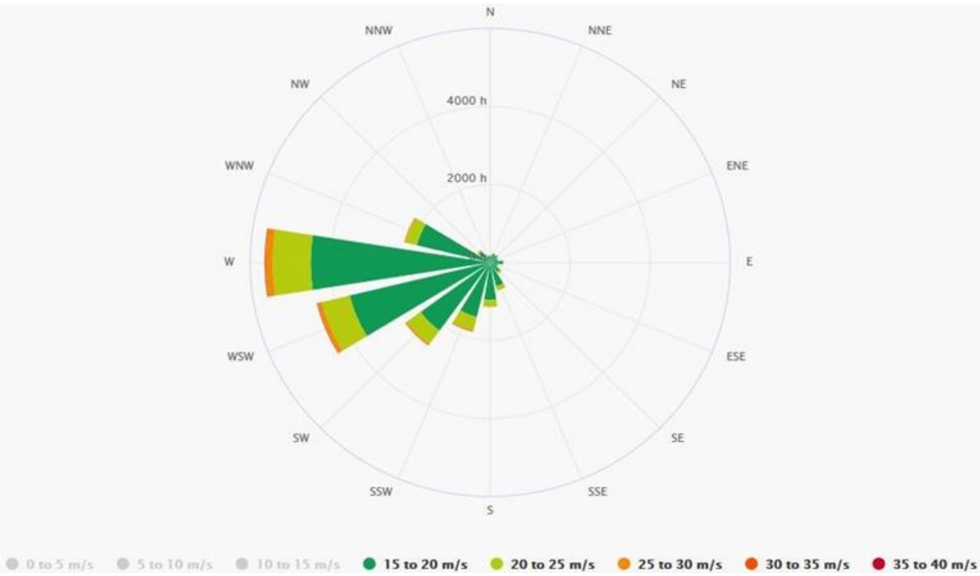



**Figure 12.217: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 15m/s.**

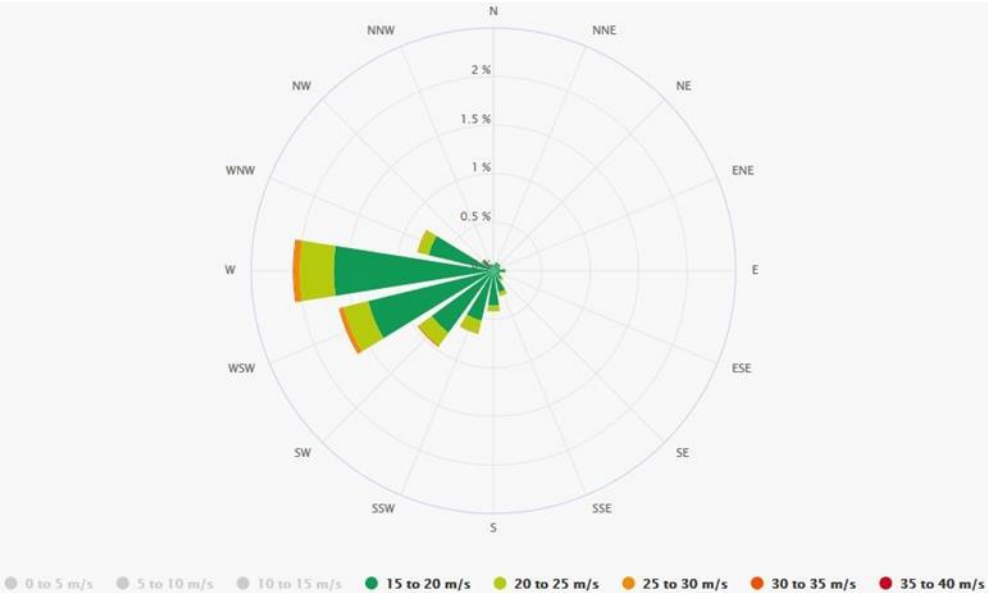



**Figure 12.218: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 15m/s.**

A total of 2 hours per years corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 15m/s was reached in Dublin 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°

For this reason, it is of interest to show the distress results for these directions. Figure 12.219 below combines all the above directions together and shows the areas where the measured velocity is above 15 m/s. Results show that there are not critical areas where the velocity increases above 15 m/s.

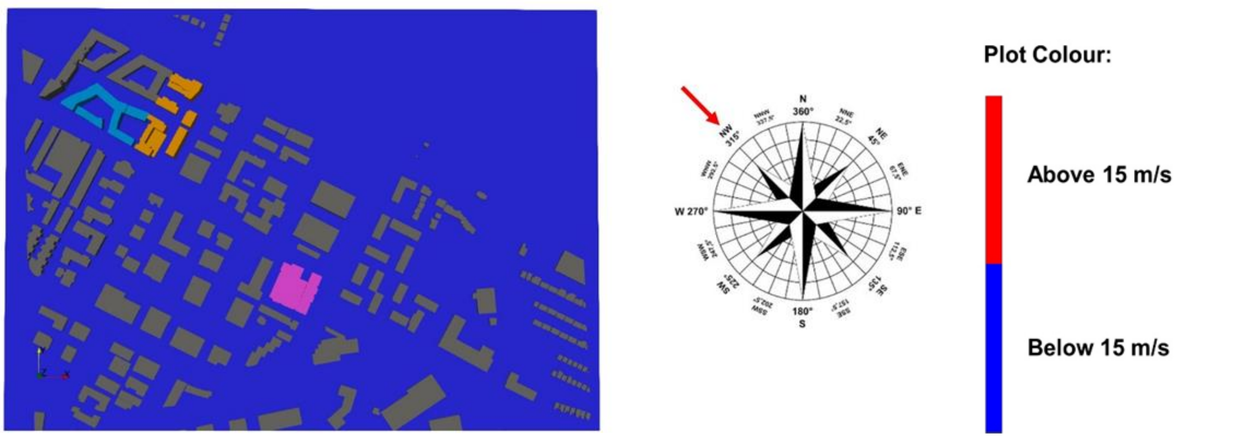



**Figure 12.219: Lawson Distress Map - Frail Person or Cyclist - Cumulative Impact Assessment**

The criteria for distress for a member of the general population is 20m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 20m/s (as reported in Figure 12.220 and Figure 12.221Figure 12 respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 20m/s is exceed at pedestrian level in each direction.

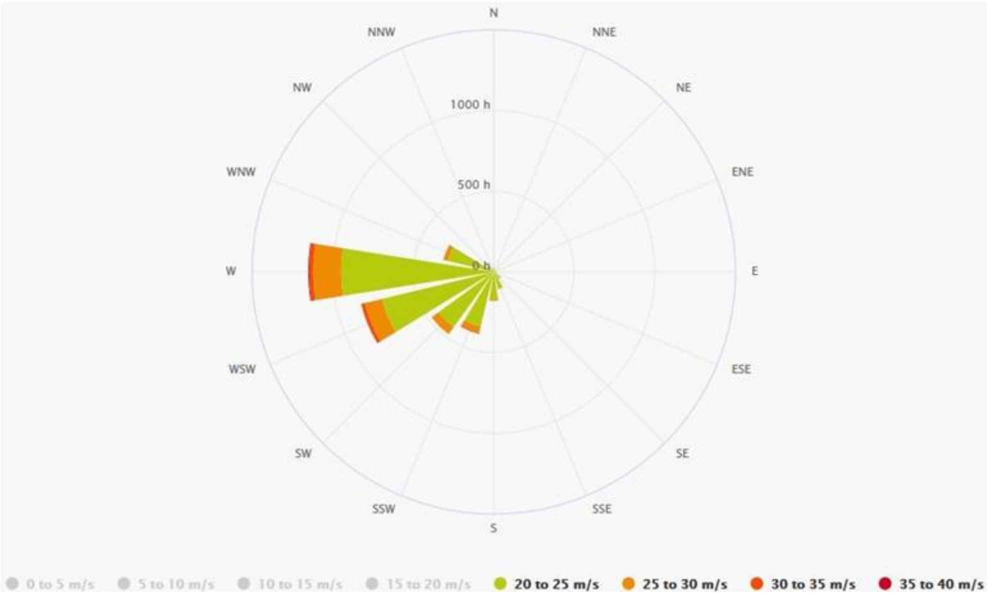



**Figure 12.220: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 20m/s.**

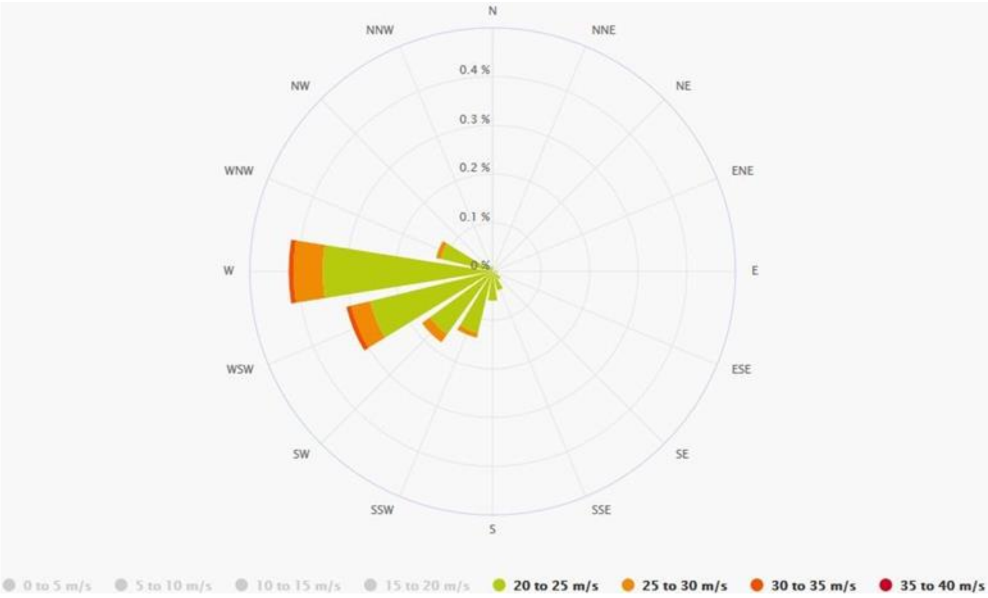



**Figure 12.221: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 20m/s.**

A total of 2 hours per years corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 20m/s was never reached in Dublin 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.

### *12.6.6.4 Summary of Cumulative Impact of the Proposed Development*

From the simulation results the following observations are pointed out:

- The proposed Carmanhall Road Development will produce a quality environment that is attractive and comfortable for pedestrians at ground floor.

- Some slightly higher velocities are experienced around the building for certain wind directions. In particular, some recirculation effects are expected near the corners of the unit and at the main entrance. However, tree landscaping on the main roads and all around the development, with particular attention to the corners and to the entrance, have been implemented and will mitigate these effects.
- Depending on the wind direction, some slight funnelling effects are experienced on the main roads around the development, especially on the road on the south-side of the development. However, the implementation of tree landscaping that have been planned for these areas will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on ground floor are identified as slight or imperceptible.
- Due to its position and shape, the courtyard, seems to be well shielded by the development itself. However, some recirculation effects have been found for certain wind directions, especially near the main entrance. The implementation of tree landscaping that have been planned for these areas will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the courtyard are identified as slight or imperceptible.
- Regarding the terraces, higher velocities can be found for some directions, only in some areas of the terraces and often corresponding to the edges of it. However, these velocities are below critical values for safety. Moreover, mitigation measures with balustrade, planters and trees that have been planned for the terraces will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the terraces are identified as slight or imperceptible.
- The pedestrian comfort assessment, performed at Ground Floor level, on the courtyard (including the main entrance) and on the terraces according to the Lawson criteria, identified the areas that are suitable for the different pedestrian activities in order to guarantee pedestrian comfort. In particular, the area all around the development seems to be suitable for every activity, including long-term sitting, apart from the corners of the building that are not suitable for long-term sitting. The courtyard is always suitable for long-term sitting, short-term sitting, standing, walking and strolling activities. The main entrance is not suitable for long-term sitting. Regarding the terraces, there are areas of the that are not suitable for long-term sitting, and some small areas that are not suitable for standing or short-term sitting, while they are suitable for all the other activities. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. It is not expected that people would be making use of such roof areas during the worst-case conditions. Moreover, the mitigation measures that have been planned with balustrade, planters and trees will mitigate these effects. Additionally, it has to be noticed that, in any case, there are not critical issues in regard to safety. In terms of distress, no critical conditions were found for “Frail persons or cyclists” and” General Public” in the surrounding of the development.

### 12.6.6.5 Do-Nothing Scenario

The effects on wind if the development was not built are imperceptible.

### 12.6.6.6 Monitoring

#### Construction Phase

There is no particular requirement to monitor wind impact during construction phase as the designated amenity areas will not be in use during this phase of the project.

*Operational Phase*

During the development operational phase, it has been designed to conform to acceptable Lawson Criteria for Comfort and Distress in accordance with the Wind Beaufort Scale.

## 12.7 Mitigation and Management

### 12.7.1 Mitigation Measures

#### *12.7.1.1 Construction Phase*

The effects on wind microclimate at the Site during the construction phase have been assessed using professional judgement.

As construction of the Proposed Development progresses the wind conditions at the Site would gradually adjust to those of the completed development, and mitigation measures would need to be implemented before completion and operation.

#### *12.7.1.2 Operational Phase*

As stated above, if the wind conditions exceed the threshold, these conditions become unacceptable for favourable pedestrian activities and mitigation measure should be accounted for.

Examples of 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 general, it is possible to summarise the different possible flow features and the corresponding mitigation option as follows (Figure 12.222 and Figure 12.223):

- **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.

  *Example of Typical Possible 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.

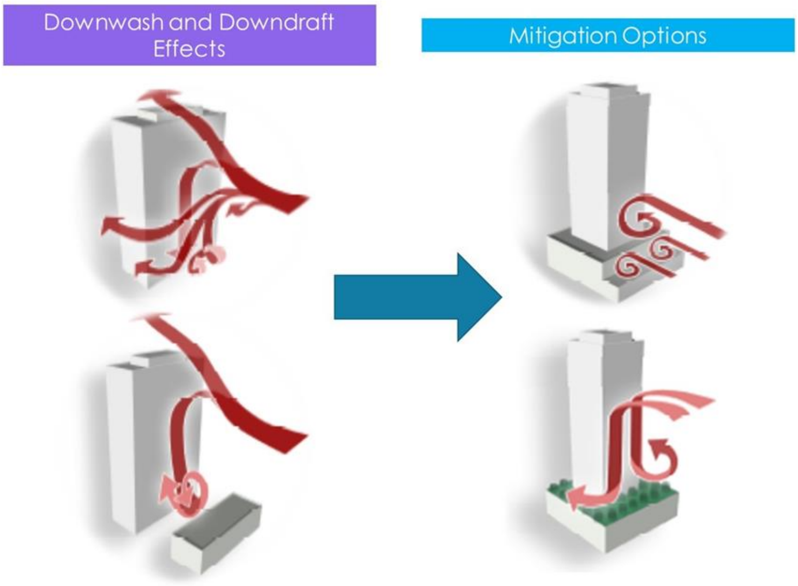



**Figure 12.222: Mitigation Measures for Downwash and Downdraft Effects**

- **Funnelling Effects**: Wind speed is accelerated when wind is funnelled 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.

*Example of Typical Possible 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.

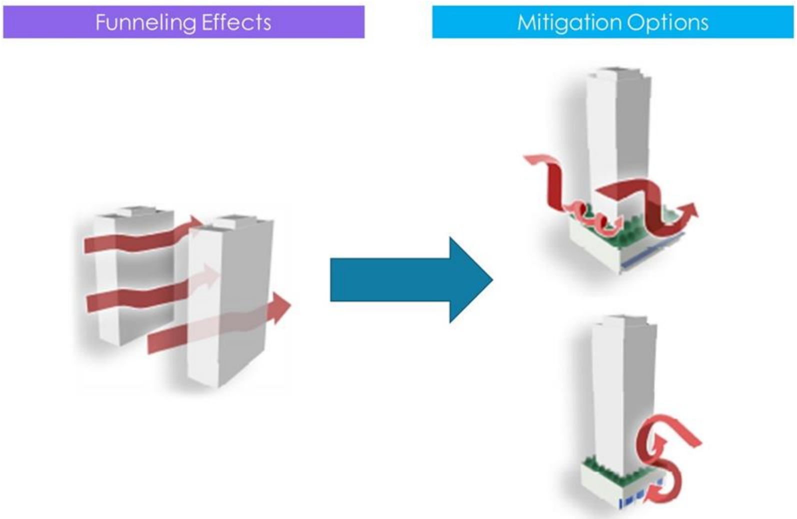



**Figure 12.223: Mitigation Measures for Funnelling Effects**

The mitigation measures utilized for this development is landscaping using tree plantings, which creates a reduced vorticity, making it possible to reduce incoming velocities, thus reducing wind impacts on the buildings, public spaces or pedestrian paths. Small particles randomly distributed within an area are normally used in numerical modelling to model trees, as shown in Figure 12.224. These introduce a pressure drop in the model and therefore causes the wind to reduce its speed when passing through the trees, as expected in reality. The CFD plot shown in Figure 12.225 demonstrate this effect. On the terraces, a combination of trees, balustrade and planters have been used.

Figure 12.226 shows a plan view of the mitigation measures that will be implemented at ground level and on the terraces of Carmanhall Road Development. Figure 12.227 shows a detailed section of the mitigation measures implemented on the terraces.

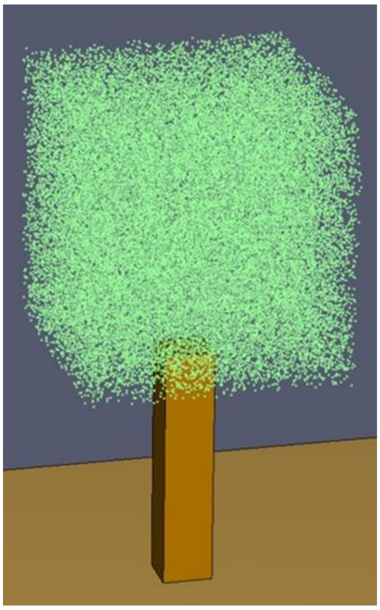


**Figure 12.224: CFD Modelling of a tree**

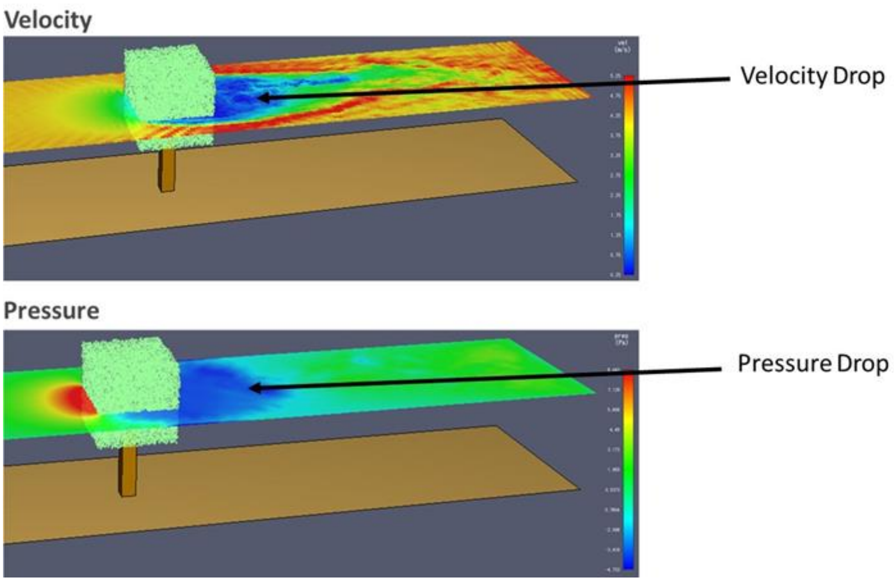



**Figure 12.225: Generic Result of Wind Impacting on a Tree**

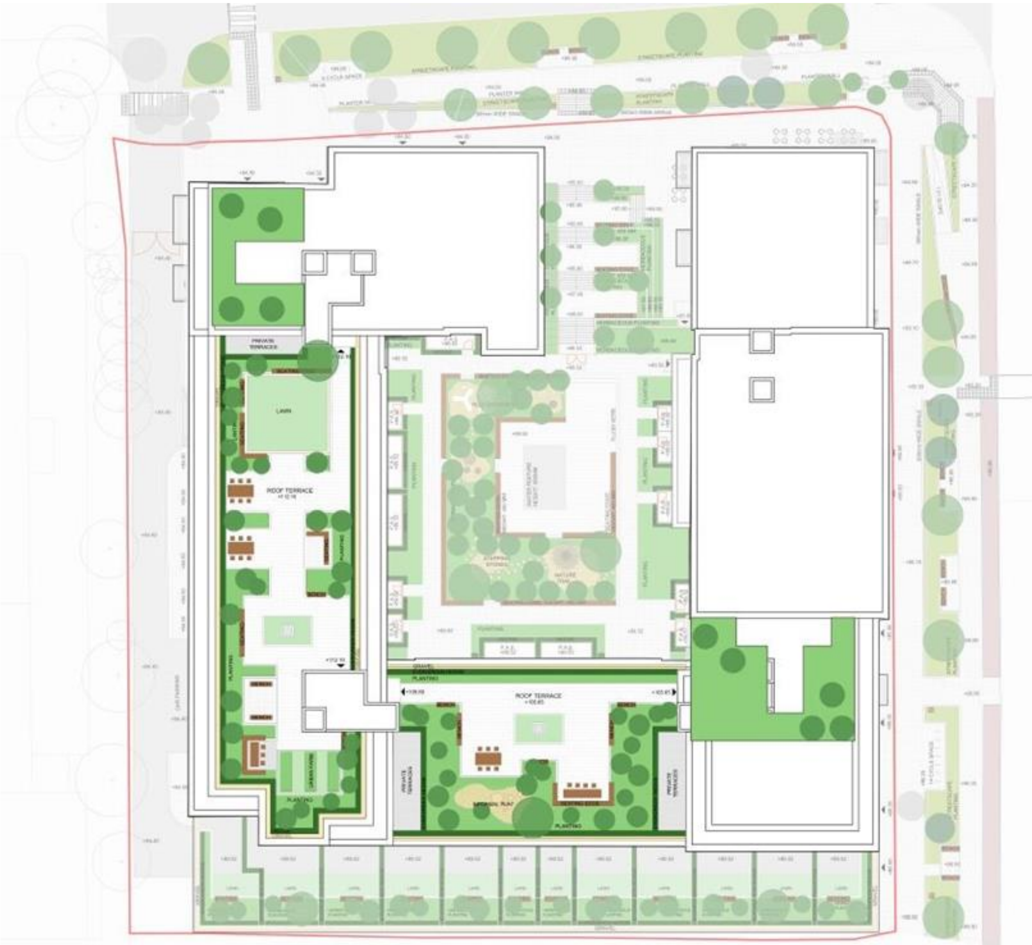


**Figure 12.226: Mitigation Measures implemented at Ground Floor and on the Terraces**

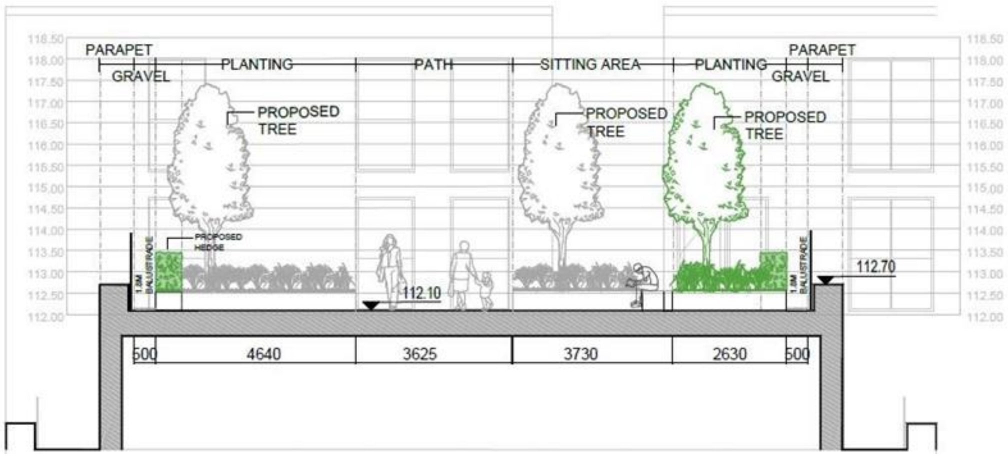



**Figure 12.227: Section View of the Mitigation Measures implemented on the Terraces - Details of Mitigations**

## 12.8 Residual Effects

Some slightly higher velocities will be still experienced around the building for certain wind directions. In particular, some recirculation effects are expected near the corners of the unit and at the main entrance. Depending on the wind direction, some slight funnelling effects will be experienced on the main roads around the development, especially on the road on the south-side of the development. Some low recirculation effect might still happen for certain wind directions near the main entrance. However, the tree landscaping on the main roads and all around the development, with particular attention to the corners of the building and to the entrance, will mitigate these effects. Moreover, these velocities are below critical values for safety.

Regarding the terraces, some slightly higher velocities will be still found for some directions, only in some areas of the terraces and often corresponding to the edges of it. safety. However, mitigation measures with balustrade, planters and trees will mitigate these effects. Moreover, these velocities are below critical values for safety.

Therefore, taking into consideration the impact of the mitigation measures, the residual impacts during the operational phase on ground floor, courtyard and terraces are identified as slight or imperceptible. Having considered the above residual impacts, no change to the development design is suggested, as safety and pedestrian comfort is always maintained.

## 12.9 Difficulties Encountered

### 12.9.1 Difficulties Encountered in Compiling

No difficulties were encountered during the assessment of wind and microclimate impacts on Carmanhall Road Development or its existing environments.

## 12.10 Summary and Conclusions

### 12.10.1 Conclusions and Comments on Microclimate Study

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Carmanhall Road Development, Dublin 16.

Results of this are utilized by the design team to configure the optimal layout for Carmanhall Road Development for the aim of achieving a high-quality environment for the scope of use intended for 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 accordance with the Lawson Acceptance Criteria).

#### *12.10.1.1 Existing Receiving Environment Summary*

The wind desktop study of the existing receiving environment showed that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport. 18 different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e., the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

- The wind profile built using the data from Dublin Airport, is also compared with the one obtained using the data collected on-site. Except few differences, both the wind speed daily mean and the wind gust daily mean recorded on site follow the same patterns as the ones recorded at Dublin Airport. The speed levels registered on-site are in few cases slightly lower. This is due to the fact that the site is located close to the urban environment thus much more shielded if compared with Dublin Airport. This confirms the fact that using wind data from Dublin Airport still ensures a conservative analysis of the wind impact on the development.

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

### 12.10.1.2 Potential and Cumulative Impact of the Proposed Development Summary

Micro-climate Model Assessment of Carmanhall Road Development and its environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology. 8 worst case wind scenarios are selected for presentation in this report, as these scenarios and directions showed to be the most relevant wind speeds.

CFD modelled results of the development scheme (both potential effects and cumulative impact) showed that:

- The proposed Carmanhall Road Development will produce a high-quality environment that is attractive and comfortable for pedestrians of all categories.
- The Surrounding environment and developments properly shields all paths/walkways around and within the development. Pedestrian footpaths are always successfully shielded and comfortable.
- Some slightly higher velocities are experienced around the building for certain wind directions. In particular, some recirculation effects are expected near the corners of the unit and at the main entrance. However, tree landscaping on the main roads and all around the development, with particular attention to the corners and to the entrance, have been planned and will mitigate these effects.
- Depending on the wind direction, some slight funnelling effects are experienced on the main roads around the development, especially on the road on the south-side of the development. However, the implementation of tree landscaping has been planned for these areas and will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the ground floor are identified as slight or imperceptible.
- Due to its position and shape, the courtyard seems to be well shielded. However, some low recirculation effects have been found for certain wind directions, especially near the main entrance. The implementation of tree landscaping that have been planned for these areas will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the courtyard are identified as slight or imperceptible.
- Regarding the terraces, higher velocities can be found for some directions, only in some areas of the terraces and often corresponding to the edges of it. However, these velocities are below critical values for safety. Moreover, mitigation measures with balustrade, planters and trees have been planned and will mitigate these effects. Therefore, taking into consideration the impact of the mitigation measures, the predicted impacts during the operational phase on the terraces are identified as slight or imperceptible.
- The Proposed Development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.
- The pedestrian comfort assessment, performed at Ground Floor level, on the courtyard (including the main entrance) and on the terraces according to the Lawson criteria, identified the areas that are suitable for the different pedestrian activities in order to guarantee pedestrian comfort. In particular, the area all around the development seems to be suitable for every activity, including long-term sitting, apart from the corners of the building that are not suitable for long-term sitting. The courtyard is always suitable for long-term sitting, short-term sitting, standing, walking and strolling activities. The main entrance is not suitable for long-term sitting. Regarding the terraces, there are areas of the that are not suitable for long-term sitting, and some small areas that are not suitable for standing or short-term sitting, while they are suitable for all the other activities. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. It is not expected that people would be making use of such roof areas during the worst-case conditions. Moreover, mitigation

measures with balustrade, planters and trees have been planned and will mitigate these effects. Additionally, it has to be noticed that, in any case, there are not critical issues in regard to safety. In terms of distress, no critical conditions were found for “Frail persons or cyclists” and ”General Public” in the surrounding of the development.

- During Carmanhall Road Development construction phase the predicted impacts are classified as imperceptible.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Dublin 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), and,
- The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.

## 12.11 References

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