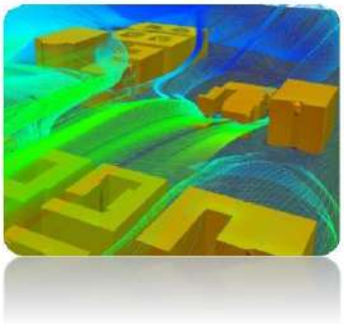 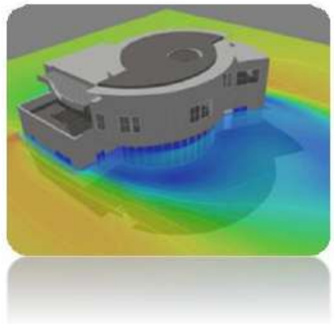 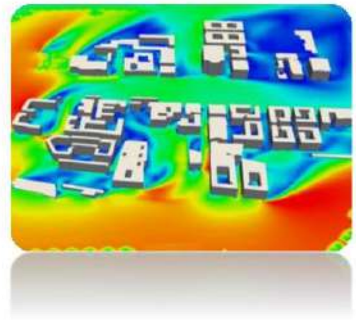

WIND MICROCLIMATE MODELLING

Forbes Lane Development

Forbes Lane, Dublin 8

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

For: Dublin City Council

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<table>
<tr><th colspan="3">Document Reference</th></tr>
<tr><td>Project Name</td><td colspan="2">WIND MICROCLIMATE MODELLING
Forbes Lane Development
Forbes Lane, Dublin 8</td></tr>
<tr><td>Project Ref.</td><td colspan="2">W_2309496</td></tr>
<tr><td>Site location</td><td colspan="2">Forbes Lane, Dublin 8</td></tr>
<tr><td>CFD Study by</td><td colspan="2">B-Fluid Ltd.</td></tr>
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<tr><td>Report issued on</td><td colspan="2">September 2, 2024</td></tr>
</table>

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Contents

1. EXECUTIVE SUMMARY

B-Fluid Limited has been commissioned by 'Dublin City Council' to perform a Wind Microclimate Study for the Forbes Lane Development in Forbes Lane, Dublin 8.

Figure 1.1 shows a view of the proposed development (in orange) within the existing urban context.

Figure 1.1: Proposed Forbes Lane Development

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

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

The results of the assessment are presented in the form of contours of the Lawson criteria at pedestrian/occupant level for each amenity area (including balconies and communal open space).

The assessment has comprised the following scenarios:

- **Baseline Existing Scenario**: this consists of the existing wind microclimate at the site without the proposed development. Figure 1.2 shows a view of the existing surrounding buildings (in grey).

Figure 1.2: Buildings in the Baseline Scenario (Existing buildings in grey)

- **Proposed Development Scenario**: this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings. Figure 1.3 shows a view of the buildings in the proposed development (in orange) and existing surrounding buildings (in grey).

Figure 1.3: Buildings in the Proposed Scenario (Forbes Lane Development in orange and existing buildings in grey)

- **Cumulative Scenario**: this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings, and also buildings that are subject to future planning application. Figure 1.4 shows a view of the buildings in the proposed development (in orange), existing surrounding buildings (in grey), and cumulative buildings (in blue).

Figure 1.4: Buildings in the Proposed Scenario (Forbes Lane Development in orange, existing buildings in grey, cumulative buildings in blue)

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

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which was obtained form historical meteorological data recorded 10m above ground level at Dublin Airport.
- A 12-discrete set of wind directions is used to evaluate the probability of exceedance at any given threshold speed. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Forbes Lane Development and its environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- The Lawson Comfort and Distress Map on 1.5m above balcony floor indicates that all balconies are safe for occupants with no identified distress areas.
- The following mitigation measures will be implemented to further improve pedestrian comfort around the development:
  - *Introducing additional trees on ground amenities of the development:*
    These additional plants will help reduce wind speed, increasing comfort levels in all ground amenities of the development.
- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind

speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for "Frail persons or cyclists" and for members of the "General Public" in the surrounding of the development.

- As a result of the construction of cumulative buildings in the future, the wind conditions on the surrounding urban context remains the same when compared with the proposed development situation. The cumulative buildings will have a negligible effect on the surrounding wind microclimate.
- A revised iteration of the proposed scheme was reviewed on 22 August 2024. The main key differences and similarities between the revised design and the original design are:
  - Block A has moved 900 mm to the west in the revised design.
  - Block B remains unchanged.
  - The dimensions and shapes of Blocks A and B are identical in both designs.
- Since the revised design's massing and height remain unchanged, and the reduced distance between Block A and Block B by 0.9 meter has a negligible effect on wind conditions, it can be concluded that the revised design maintains a comfortable and safe environment for pedestrians at ground level, remaining suitable for sitting/standing comfort level.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Dublin for the past 15 years:

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

2. INTRODUCTION

B-Fluid Limited has been commissioned by 'Dublin City Council' to perform a Wind Microclimate Study for the Forbes Lane Development in Forbes Lane, Dublin 8.

Figure 2.1 shows a view of the proposed development within the existing urban context.

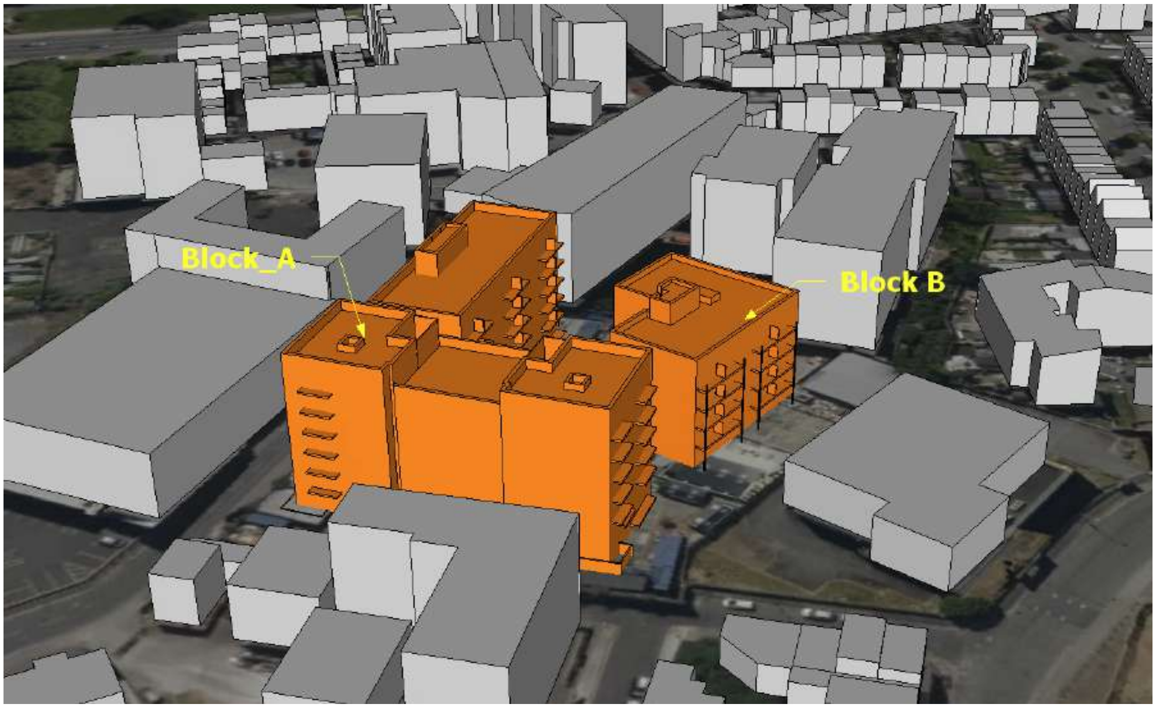


Figure 2.1: Proposed Forbes Lane Development

This report is completed by Dr. Cristina Paduano, Dr. Yuxiang Zhang, 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 18 years experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Dr. Yuxiang Zhang is a member of Engineers Ireland and CFD Engineer who specialises in flow-structure interactions and bridge aerodynamics. He holds a PhD in Civil Engineering from University College Dublin, a M.Sc. in Structural Engineering and a B.Eng in Civil Engineering.

Dr. Filip Volaric is a CFD Modelling Engineer who specialises in computational fluid dynamics applications. He is an expert in heat and mass transfer and structural analysis. He holds a PhD, M.Sc. and B.Sc. in Mechanical Engineering from University College Dublin.

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

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

- Amenity areas (pedestrian level), areas likely to be utilised for leisure purposes and as such should be comfortable surroundings.

- Pedestrian routes and seating areas – to determine if locations are comfortable for leisure activities.

- Entrance to the buildings – to determine if there is potential for pressure related issues for entrances or lobbies.

- Landscaped areas – where there are sheltered areas.

- Impact to existing or adjoining developments – where the proposed buildings will cause discomfort conditions through proximity related issues.

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

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

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

2.1 GUIDANCE and LEGISLATION

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

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

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

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

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

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

2.2 URBAN WIND EFFECTS

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

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

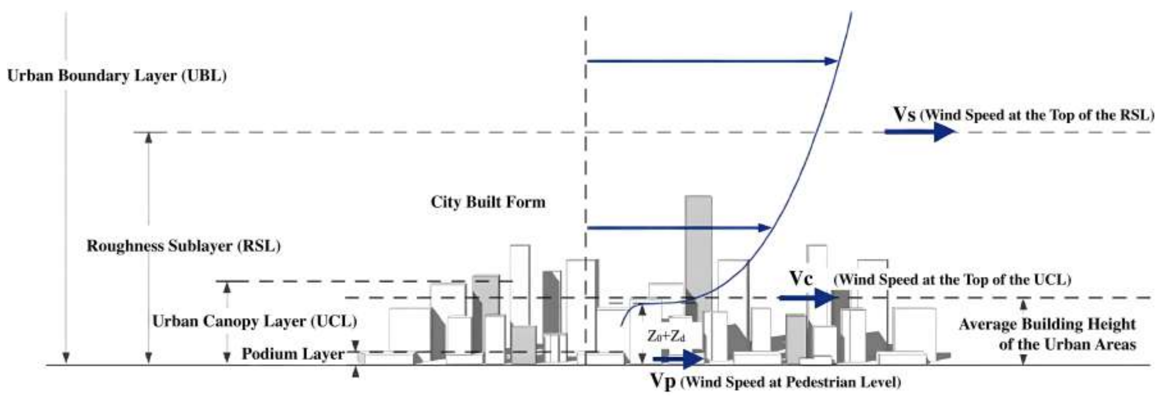


Figure 2.3: Wind Velocity Profile

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

- **Funnelling Effects**: The wind can accelerate significantly when flowing through a narrow passage between building structures. The highest speeds are experienced at the point where the restriction of the area is the greatest.

- **Downwash Effects**: The air stream when striking a tall building can flow around it, over it and a part can be deflected towards the ground. This downward component is called downwash effect and its intensity depends on the pressure difference driving the wind. The higher the building, the higher this pressure difference can be.

- **Corner Effects**: Wind can accelerate around the corners of the buildings. Pedestrians can experience higher wind speeds as well as more sudden changes in wind speeds. The reason for this is that there are narrow transition zones between the accelerated flows and the adjacent quiescent regions. This effect is linked to the downwash effect as the downward stream component subsequently flows around the corners towards the leeward side of the building.

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

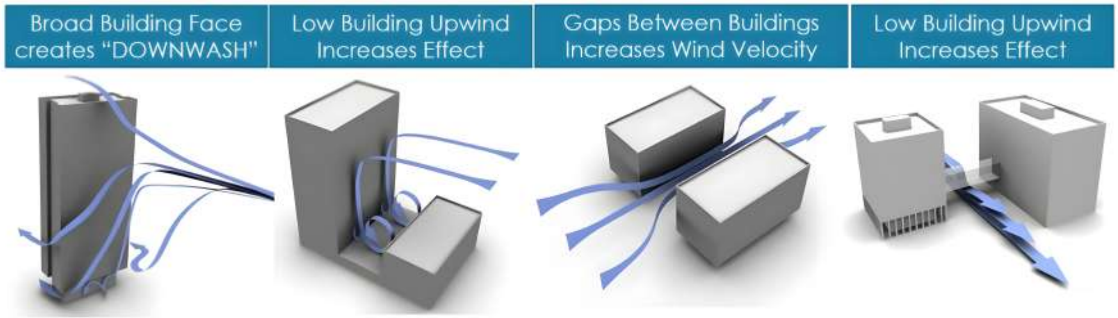


Figure 2.4: Parameters to know for Wind Conditions Assessment

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

3. ASSESSMENT METHODOLOGY

3.1 METHOD OF ASSESSMENT

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

The assessment has comprised the following scenarios:

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

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

In particular, the following has been undertaken:

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

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

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

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

3.2 ACCEPTANCE CRITERIA

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

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

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

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

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

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

Figure 3.3: Lawson Scale

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

Pedestrian comfort criteria are assessed at 1.5m above ground level. Unless in extremely unusual circumstances, velocities at pedestrian level increase as you go higher from ground level.

A breach of the distress criteria requires a consideration of:

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

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

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

Figure 3.4: Lawson Categories Scale - Comfort

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

Figure 3.5: Lawson Categories Scale - Distress/Safety

3.3 SIGNIFICANCE CRITERIA

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

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

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

Figure 3.6: Significance Criteria for On-site Receptors

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

Figure 3.7: Significance Criteria for Off-site Receptors

4. CFD MODELLING METHOD

4.1 INTRODUCTION OF CFD TECHNIQUE

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

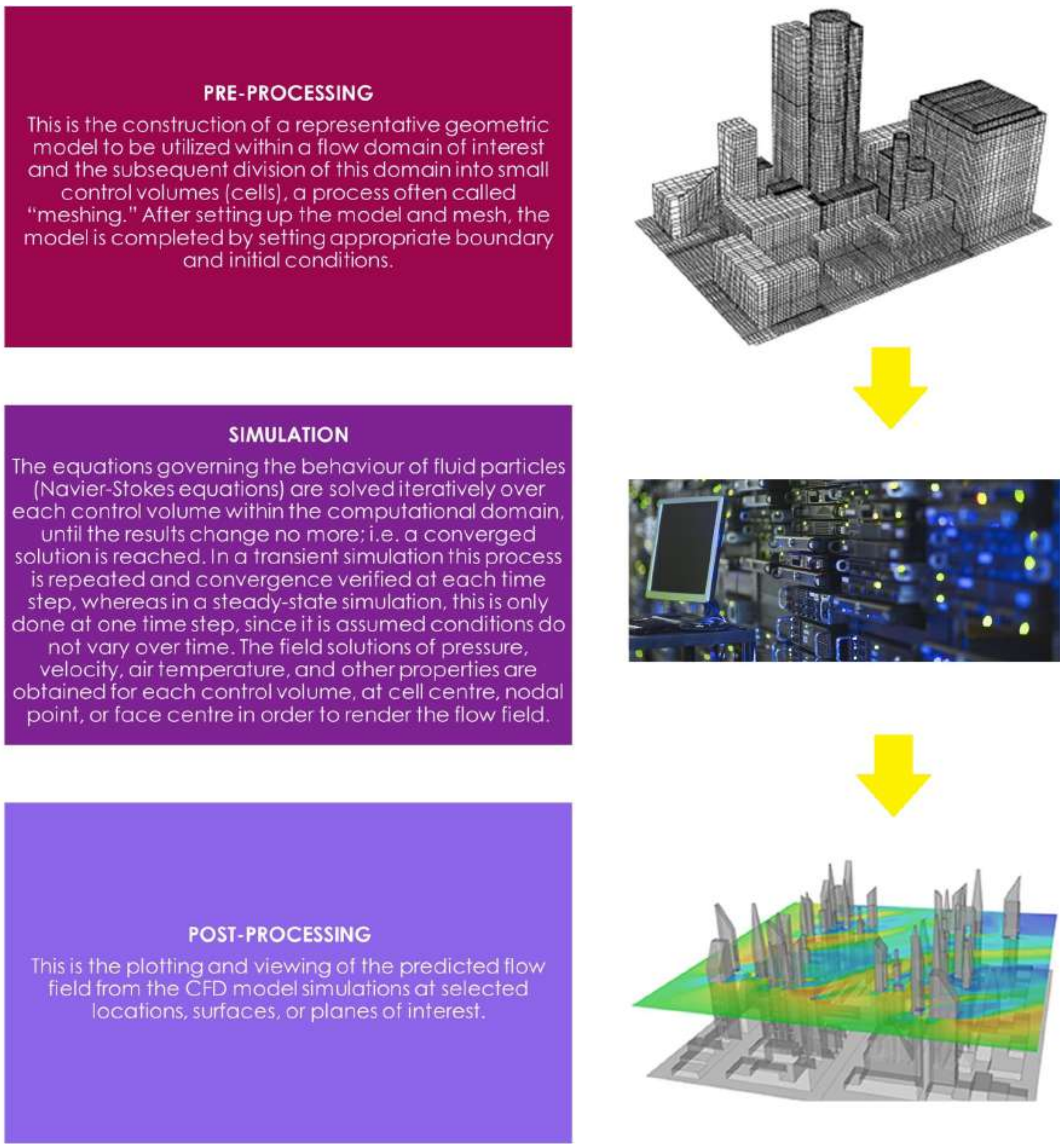


Figure 4.1: CFD Modelling Process Explanation

4.2 CFD SOFTWARE DETAILS

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

4.3 CFD MODEL DETAILS

FLOW ASSUMPTIONS & TURBULENCE MODELLING

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

MODELED GEOMETRIES

The extent of the built area (e.g. buildings, structures or topography) that is represented in the numerical domain depends on the influence of the features on the region of interest. According to the Best Practice Guideline (COST Action 732), a building with height H (height of the tallest proposed building is ≈22 m) may have a minimal influence if its distance from the region of interest is greater than 6-10H (we considered 600 m which is even larger than required).

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

Table 4.1: Modelled Environment Dimensions

	MODELLED CFD ENVIRONMENT DIMENSIONS		
	Width	Length	Height
Computational Domain	Approx. 1200 m	Approx. 1200 m	Approx. 160 m

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

- The massing model of the proposed Forbes Lane Development, which is generated based drawings provided by Dublin City Council;
- The massing model of the building blocks within 600 m from the development (colored in grey).

Figure 4.2: 3D View of the Massing Models of the Proposed Forbes Lane Development (colored in orange) and Surrounding Building Blocks (colored in grey)

COMPUTATIONAL MESH

The computational mesh used in this report is created using OpenFOAM utilities blockMesh and snappyHexMesh. It is a hybrid mesh containing a structured background grid and an unstructured hexahedron-dominated mesh in the near-wall region. The largest cell has a depth of 5 m, where the smallest has a depth of 0.15 m. The total cell count is approx. 120 million. An isometric view of the geometry captured by the computational mesh is shown in Figure 4.3.

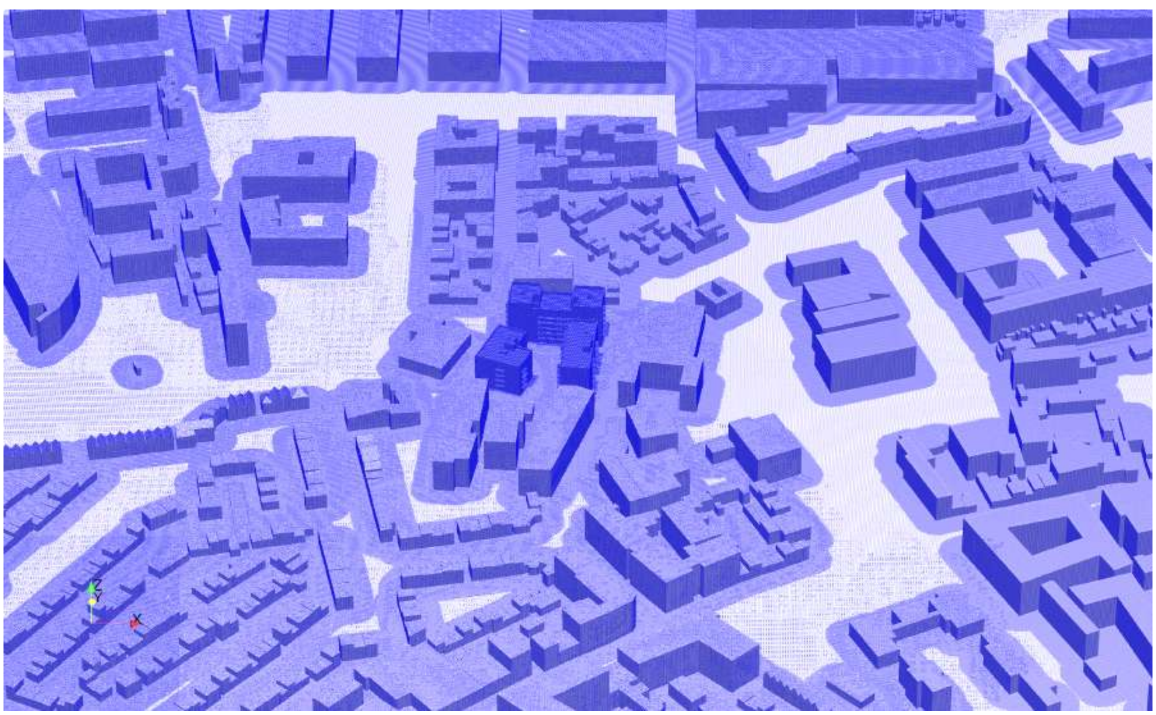


Figure 4.3: Computational Mesh of Forbes Lane Development

BOUNDARY CONDITIONS

For each wind directions, an initial wind velocity was set based on logarithmic wind profile. Surfaces within the model were specified as having 'no slip' condition. This boundary condition, ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. All the other domain boundaries are set as "Open Boundaries".

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:

$$u_{(z)} = \frac{u^{\star}}{K} \cdot ln(\frac{z+z_0}{z_0}) \tag{4.1}$$

where:

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

NUMERICAL CONFIGURATIONS

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

PARALLEL CONFIGURATIONS

The computational mesh was decomposed using the SCOTCH algorithm. All simulations in this study are performed in parallel on an in-house HPC cluster. Key parameters of the CFD model used in this wind microclimate study are summarised in Table 4.2.

Table 4.2: Key parameters of the CFD model for each wind scenario

KEY PARAMETERS OF THE CFD MODEL	
Air Density (ρ)	1.2 kg/m^3
Turbulence Model	k-ω SST Model
Cell Size	Approx. 0.15 m at the development Approx. 0.3 m in the surroundings 5 m elsewhere
Total Cell Count	Approx. 120 million

5. LOCAL WIND CLIMATE

5.1 THE EXISTING RECEIVING ENVIRONMENT

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

5.1.1 SITE LOCATION AND SURROUNDING AREA

The Proposed Forbes Lane Development will be situated in Forbes Lane, Dublin 8. The existing environment is shown in Figure 5.1. The area considered for the existing environment and proposed development assessment comprises an Approx. 0.7 km² area around the Proposed Forbes Lane Development as represented in Figure 5.2.

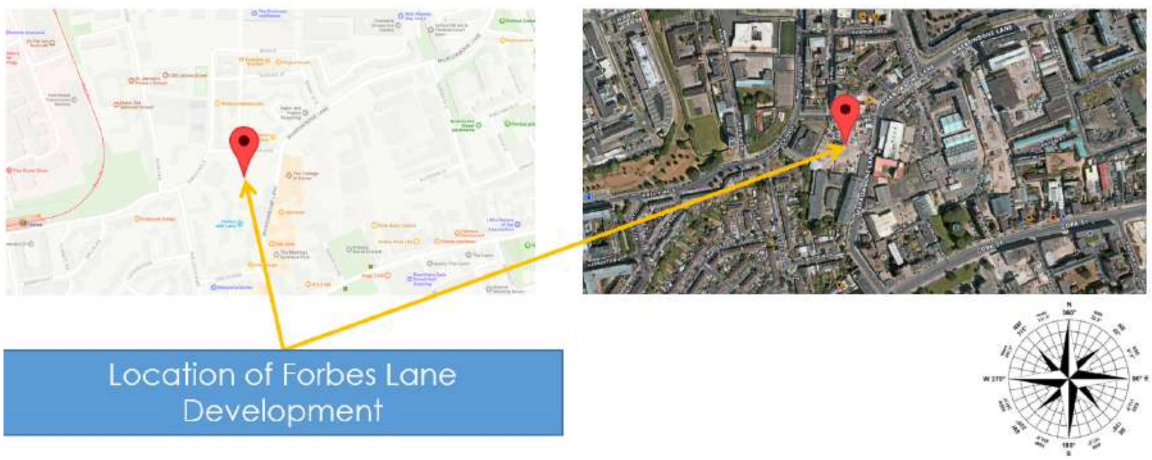


Figure 5.1: Forbes Lane Development Site Location and Existing Environment

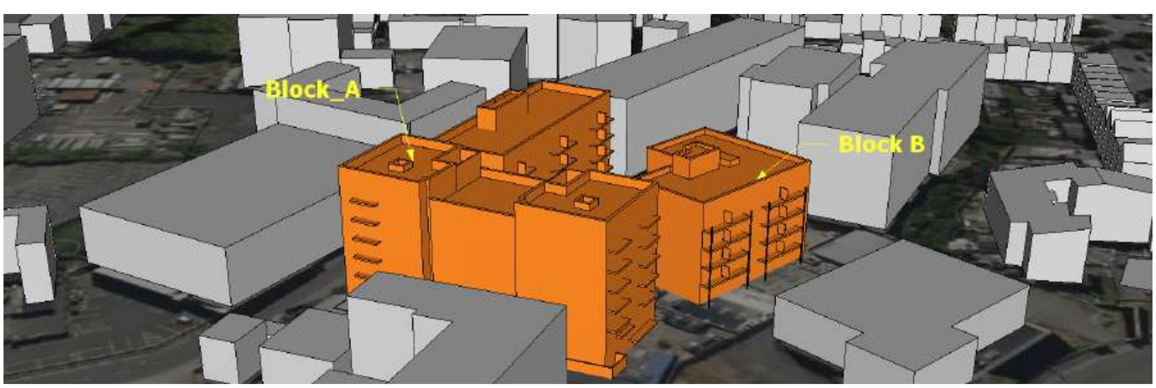


Figure 5.2: Extents of Analyzed Existing Environment Around the Proposed Forbes Lane Development

5.1.2 TOPOGRAPHY AND BUILT IN ENVIRONMENT

Figure 5.3 shows an aerial photograph of the terrain surrounding the construction site at the Proposed Forbes Lane Development. The Proposed Forbes Lane Development Site is located in Forbes Lane, Dublin 8. The area surrounding the site can be characterized as an urban environment.

Figure 5.3: Built-in Environment Around Construction Site at the Proposed Forbes Lane Development

5.2 LOCAL WIND CONDITIONS

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

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

- *Terrain*: The meteorological station is located on the flat open terrain of the airport, while the development site is situated on flat terrain surrounded by a mix of industrial and residential buildings.

- *Wind Directions*: The landscape around the development site can in principle be characterized as flat terrain. With respect to the general wind climate no significant influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Dublin Airport are applicable for the assessment of the wind comfort at the development site.

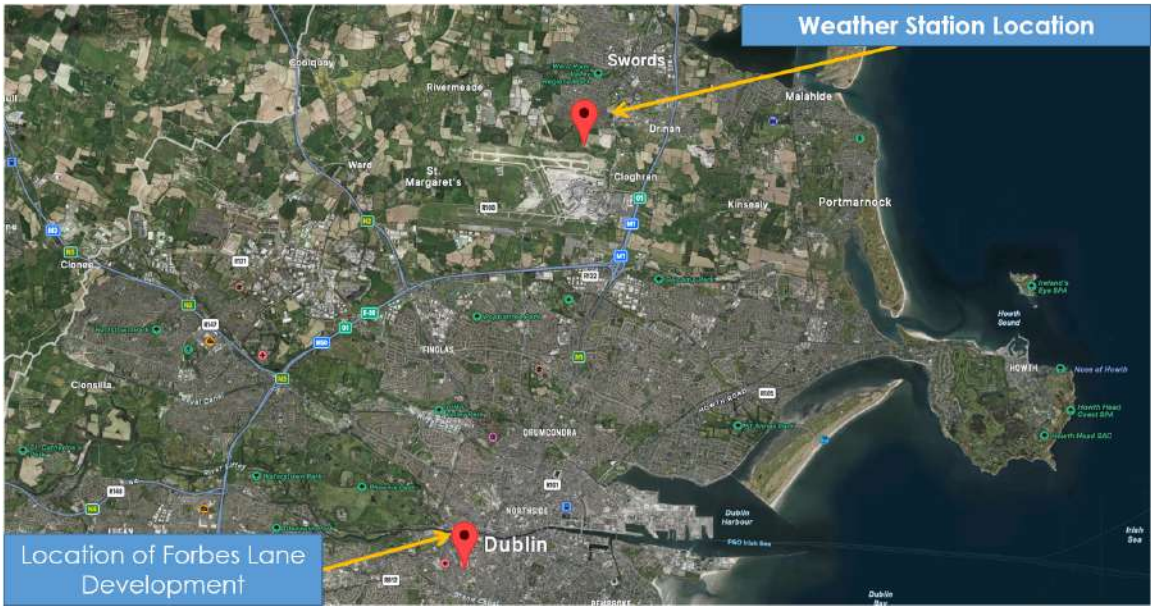


Figure 5.4: Map showing the position of the Proposed Forbes Lane Development and Dublin Airport

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

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

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

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

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

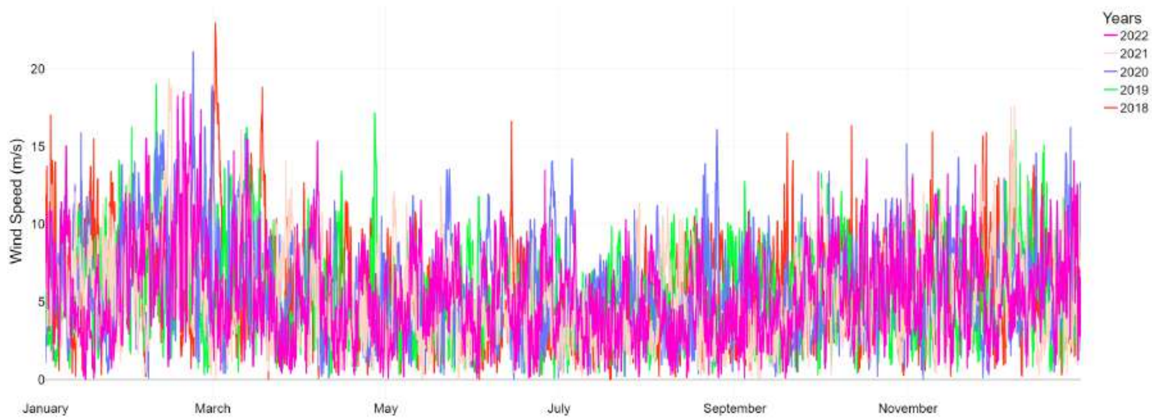


Figure 5.5: Local Wind Conditions - Wind Speed - 2018-2022

Figure 5.6 displays a wind speed diagram for Dublin, illustrating the number of days per month when the wind attains specific speeds. It is evident from this figure that strong winds are more prevalent during the winter season (December, January, and February) and the start of spring season (March) compared to other seasons.

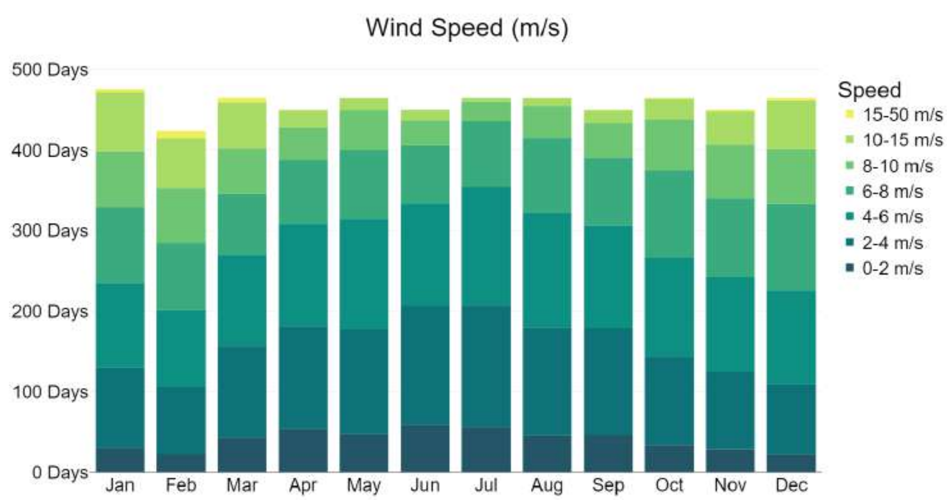


Figure 5.6: Dublin Wind Speed Diagram

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

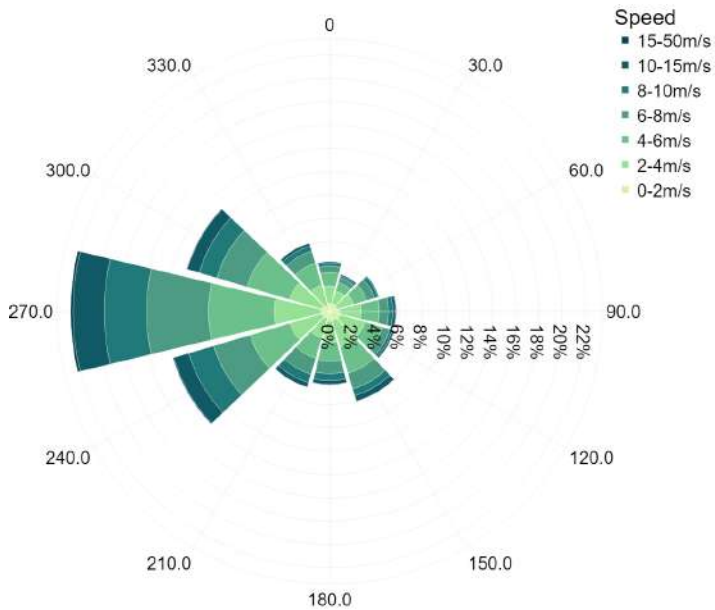


Figure 5.7: Dublin Wind Rose

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

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

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

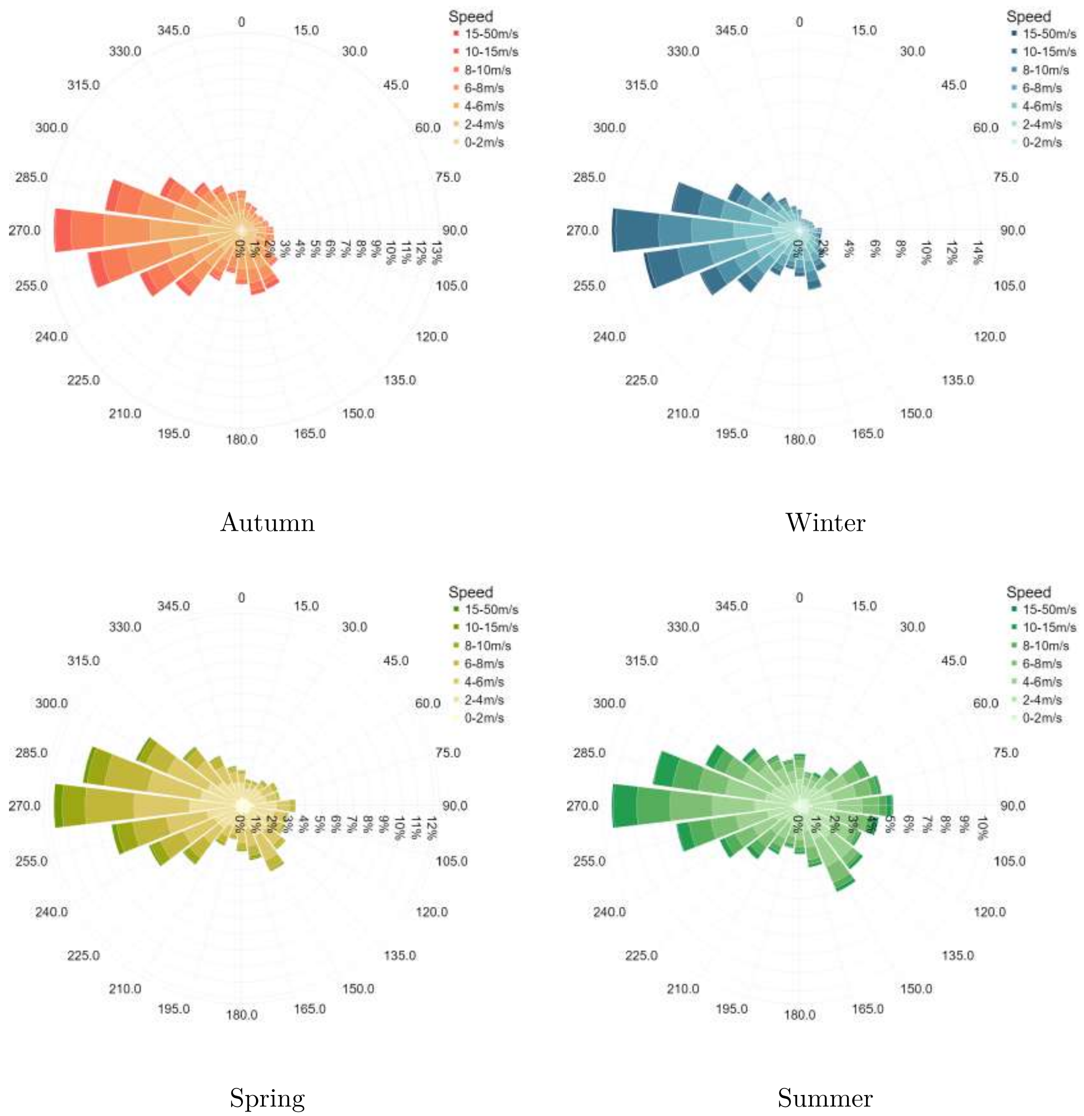


Figure 5.8: Wind speeds and wind directions at different seasons

6. CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

6.1 DESCRIPTION OF PROPOSED DEVELOPMENT

The description of the proposed development will be updated using the latest version received.

Figures 6.1 and 6.2 show views of the proposed development (colored in orange) and existing surround buildings (colored in grey).

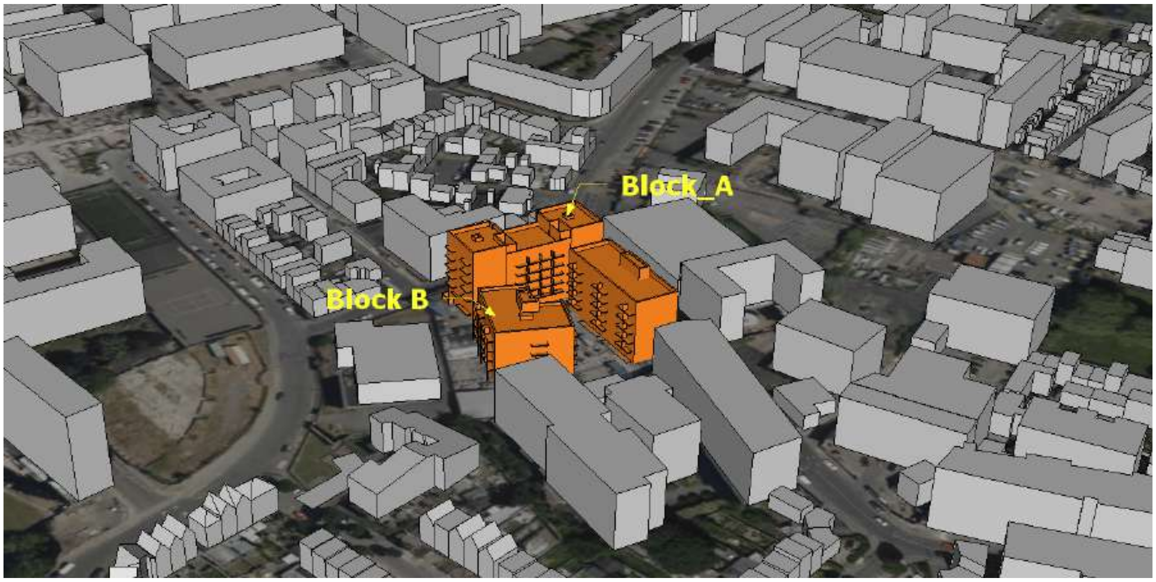


Figure 6.1: Proposed Forbes Lane Development - View 1

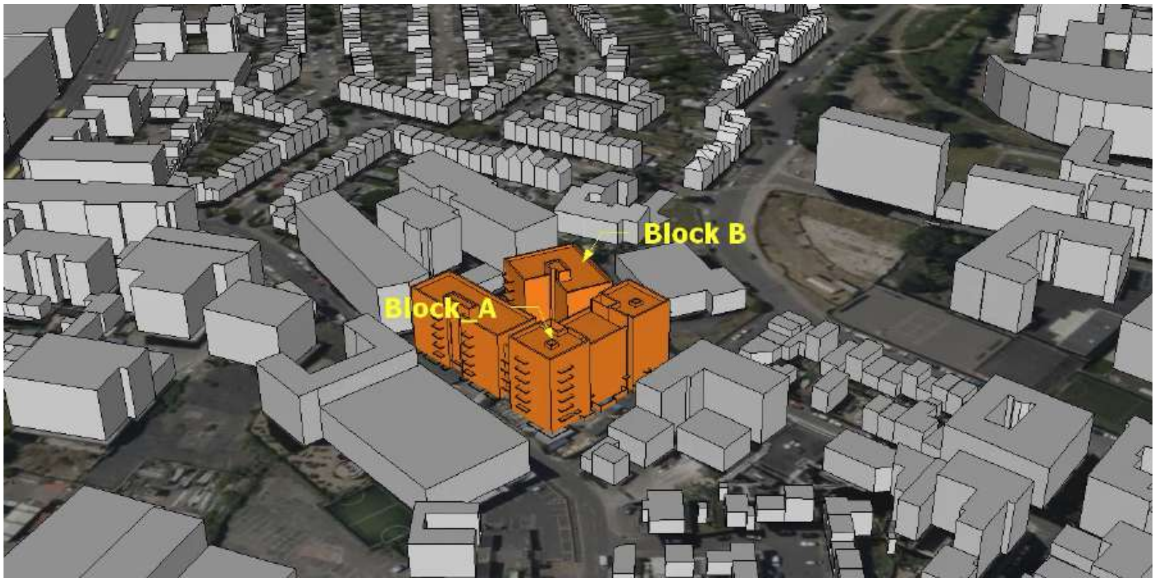


Figure 6.2: Proposed Forbes Lane Development - View 2

6.2 POTENTIAL RECEPTORS

Potential receptors for the wind assessment are all pedestrian circulation routes, building entrances and leisure open areas within the site and in neighboring adjacent areas. The pedestrian level is considered at 1.5m above ground.

Figure 6.3 shows the pedestrian activity area on the ground around the development. These areas are considered as sensitive potential receptors for the wind microclimate.

Figure 6.3: Potential Sensitive Receptors on the Ground - Pedestrian Activities Area

Table 6.1 lists the descriptions of potential receptors as shown in Figure 6.3.

Table 6.1: List of the Receptors

On-Site Potential Receptors ID	Description	Off-Site Potential Receptors ID	Description
1.	Crossing of Pim Street and Forbes Lane	A.	Jame's Walk
2.	Western Pedestrian Walkway	B.	Parking Lot
3.	Accessible Parking Space	C.	Pedestrian Walkway
4.	Courtyard	D.	Marrowbone Lane
5.	Southern Pedestrian Walkway	E.	Parking Lot
6.	Southern Entrance on Marrowbone Lane	F.	Forbes Lane
7.	Eastern Pedestrian Walkway	G.	Pim Street
8.	Northern Entrance on Forbes Lane	H.	Parking Lot
9.	Northern Pedestrian Walkway	I.	Long's Place

7. BASELINE WIND MICROCLIMATE

7.1 BASELINE SCENARIO

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

In this scenario the assessment has considered the impact of wind on the existing area. Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

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

7.1.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures 7.1 to 7.12 in order to assess wind flows at ground floor level of Forbes Lane Development.

Wind flow speeds are shown to be within tenable conditions. Higher velocity and recirculation effects are found in the existing site.

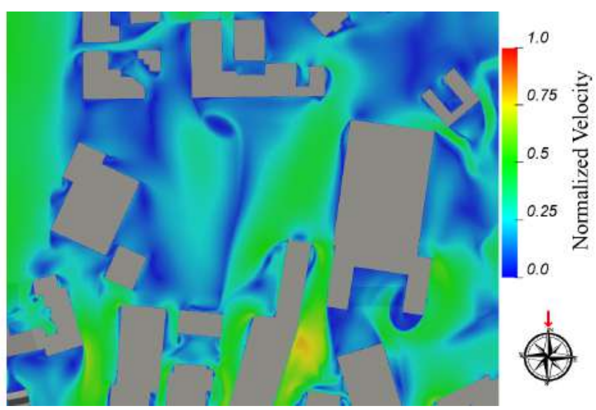


Figure 7.1: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 0°

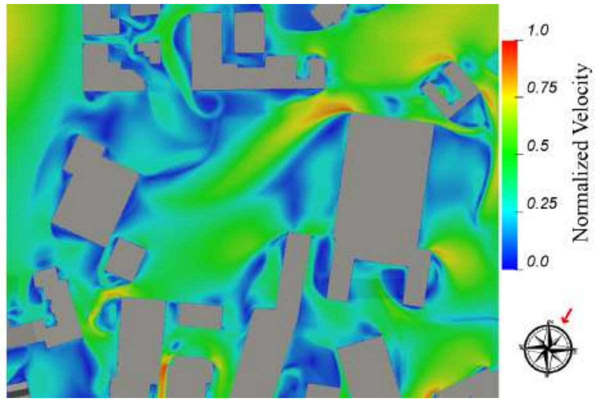


Figure 7.2: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 30°

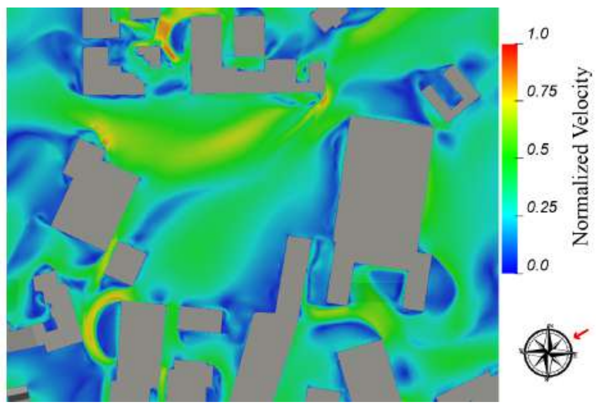


Figure 7.3: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 60°

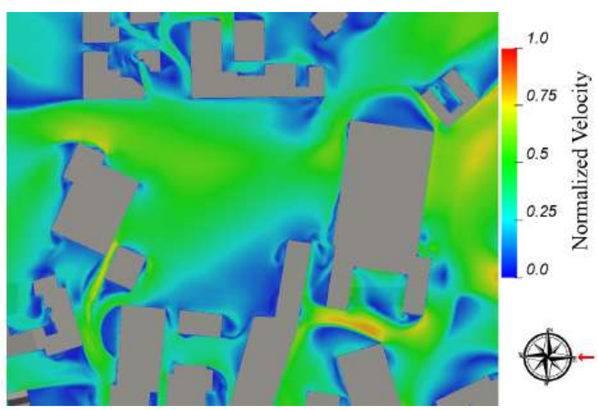


Figure 7.4: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 90°

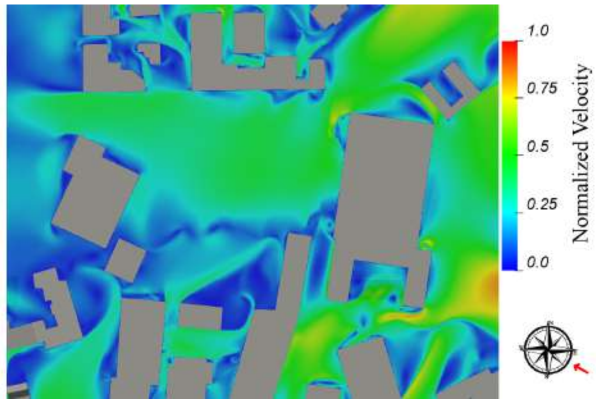


Figure 7.5: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 120°

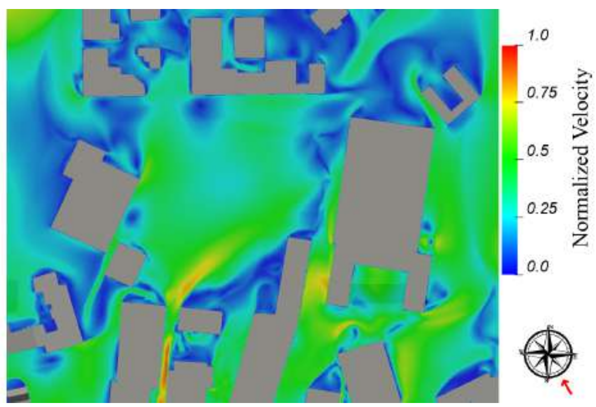


Figure 7.6: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 150°

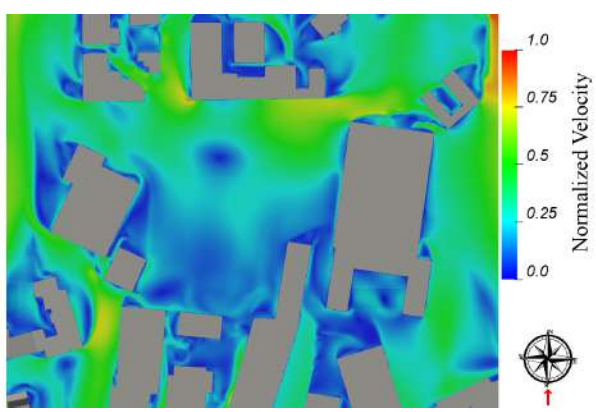


Figure 7.7: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 180°

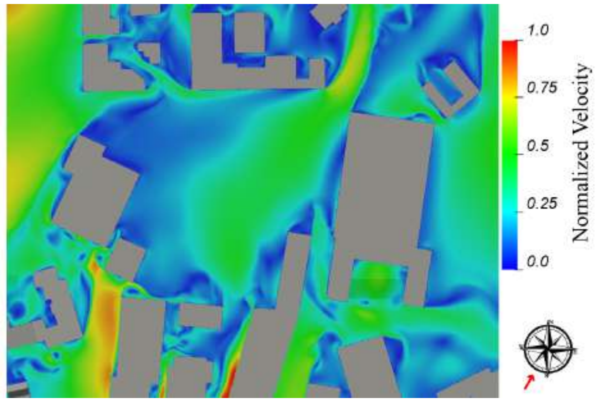


Figure 7.8: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 210°

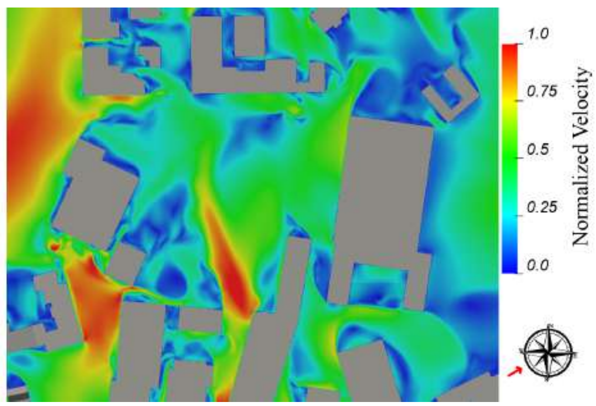


Figure 7.9: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 240°

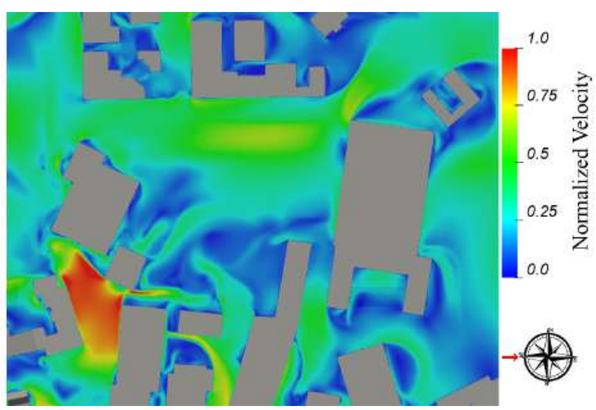


Figure 7.10: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

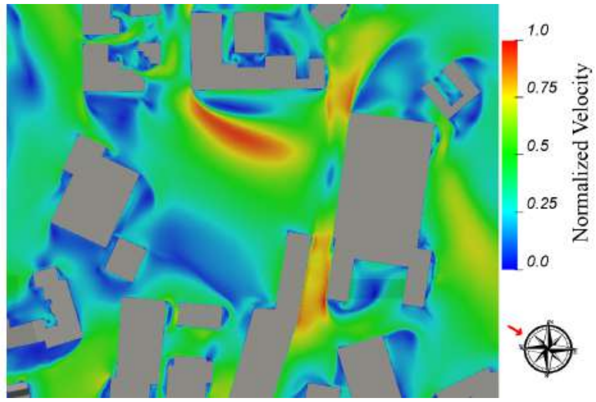


Figure 7.11: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 300°

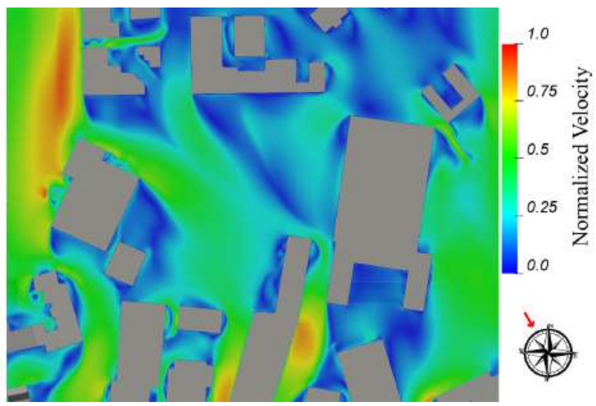


Figure 7.12: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 330°

7.1.2 BASELINE WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented in Figures 7.13 and 7.14 using a colour coded diagram formulated in accordance with the Lawson Criteria.

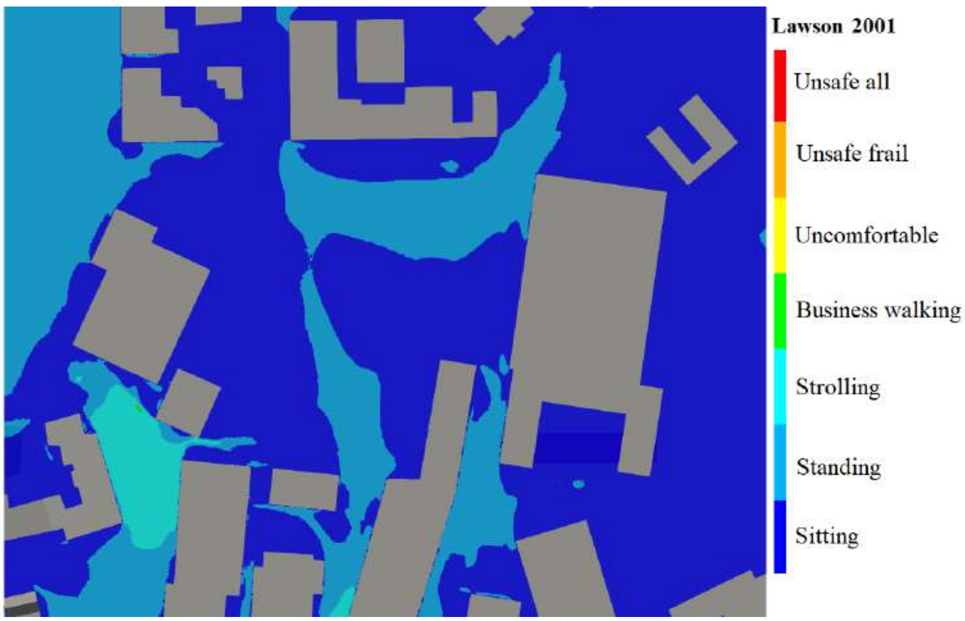


Figure 7.13: Ground Floor - Lawson Discomfort Map - **Top View**

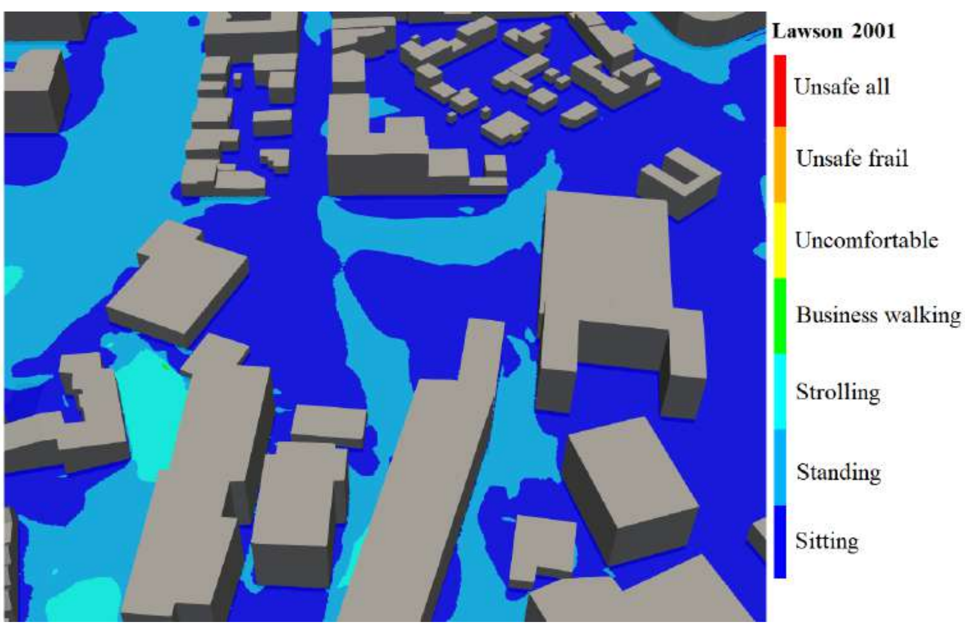


Figure 7.14: Ground Floor - Lawson Discomfort Map - **3D View**

From the simulation results the following observations are pointed out:

- The assessment of the baseline scenario has shown that no area is unsafe and no conditions of distress are created in the existing environment under the local wind climate.

- The site is usable for standing/strolling, the roads in the surrounding are usable for their intended scope.

8. IMPACT OF THE PROPOSED DEVELOPMENT

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

8.1 CONSTRUCTION PHASE

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

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

8.2 OPERATIONAL PHASE

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

Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site (potential receptors). These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

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

8.2.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the potential receptors are presented in Figures 8.1 to 8.24 in order to assess wind flows at the ground floor level of Forbes Lane Development.

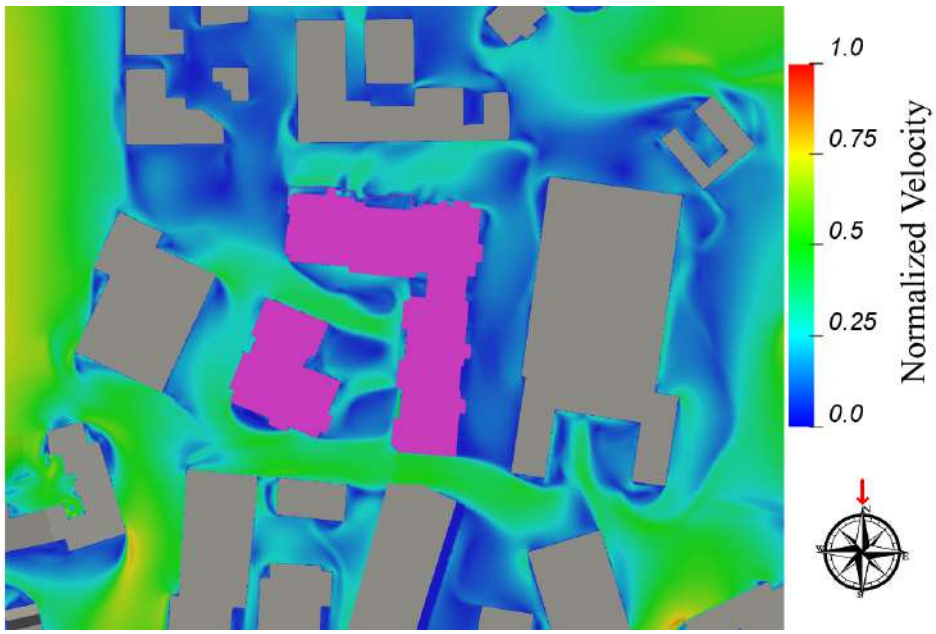


Figure 8.1: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 0°

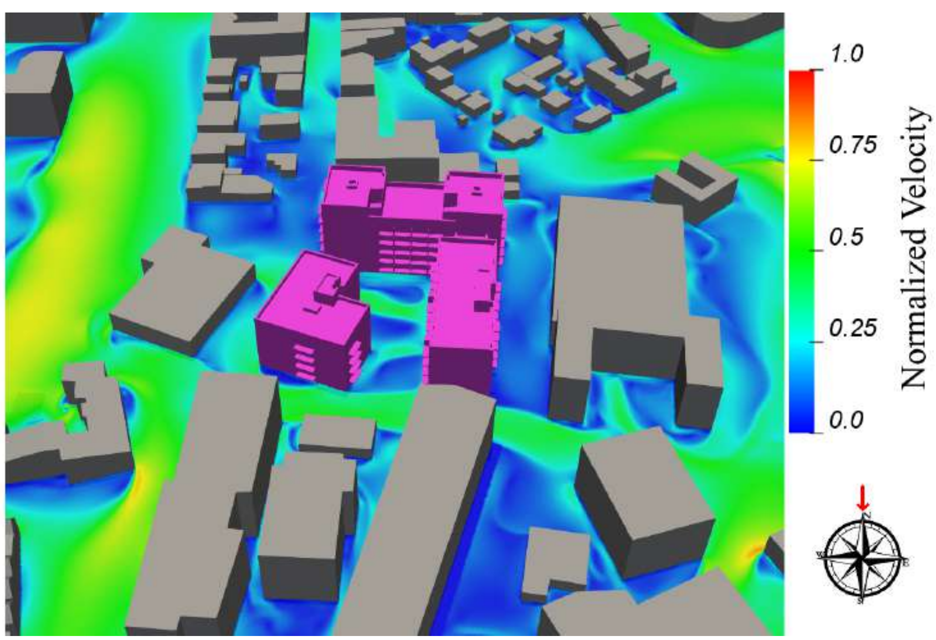


Figure 8.2: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 0°

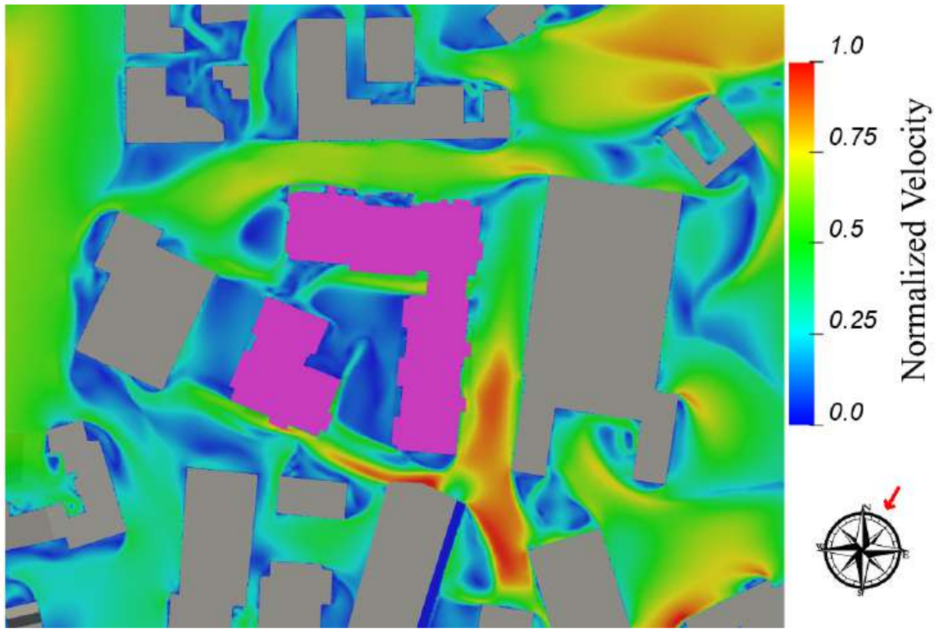


Figure 8.3: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 30°

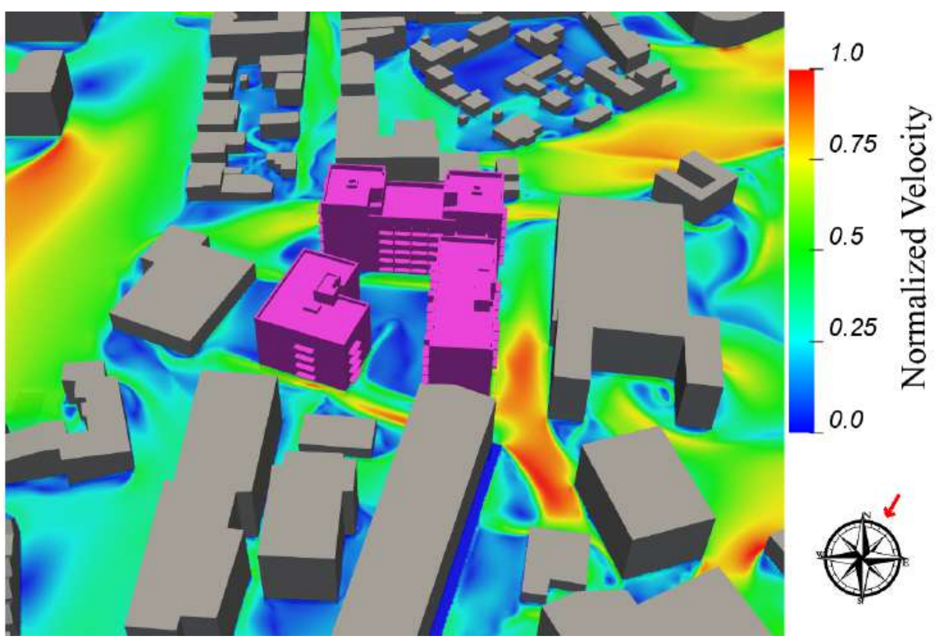


Figure 8.4: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 30°

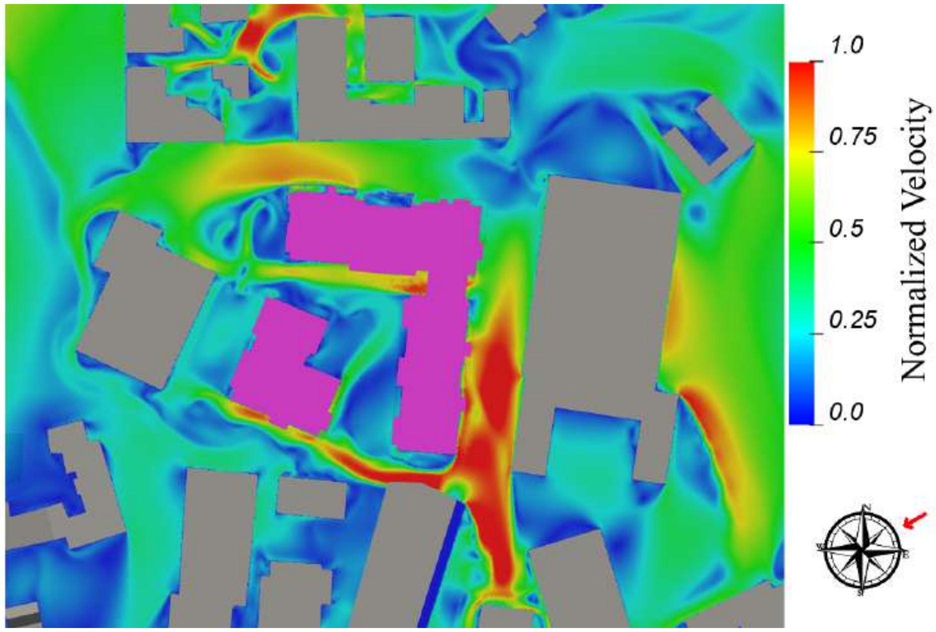


Figure 8.5: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 60°

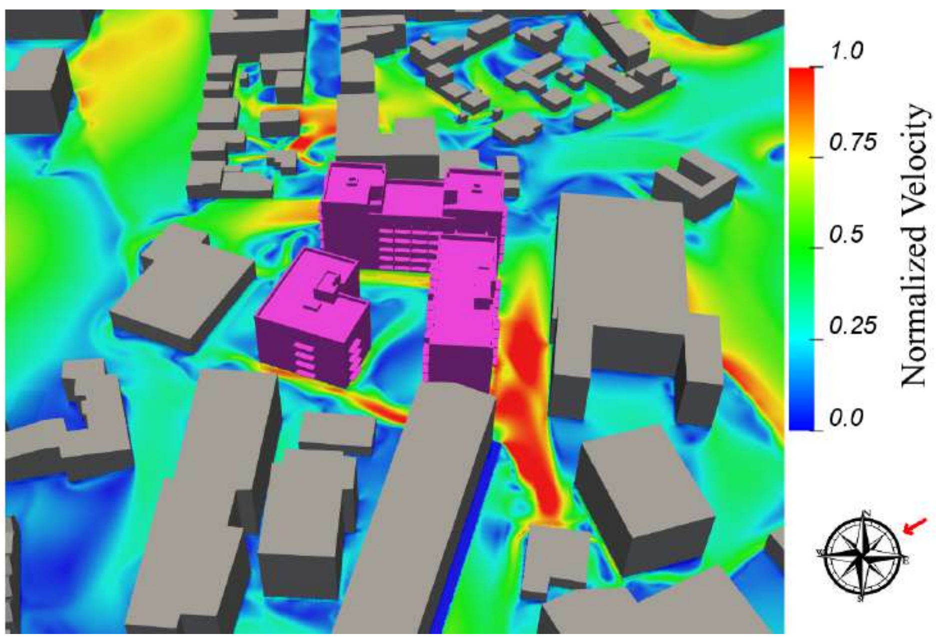


Figure 8.6: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 60°

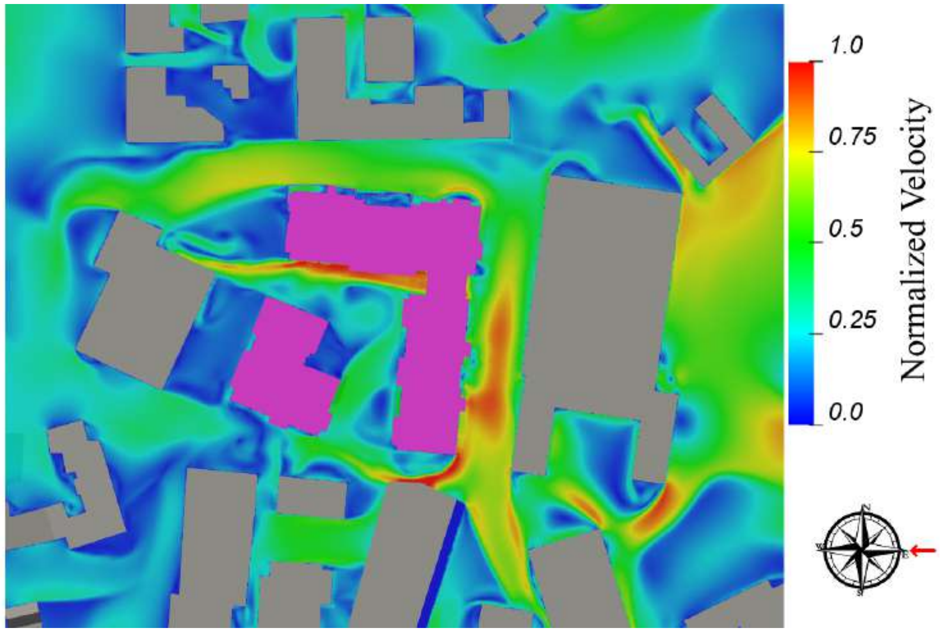


Figure 8.7: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 90°

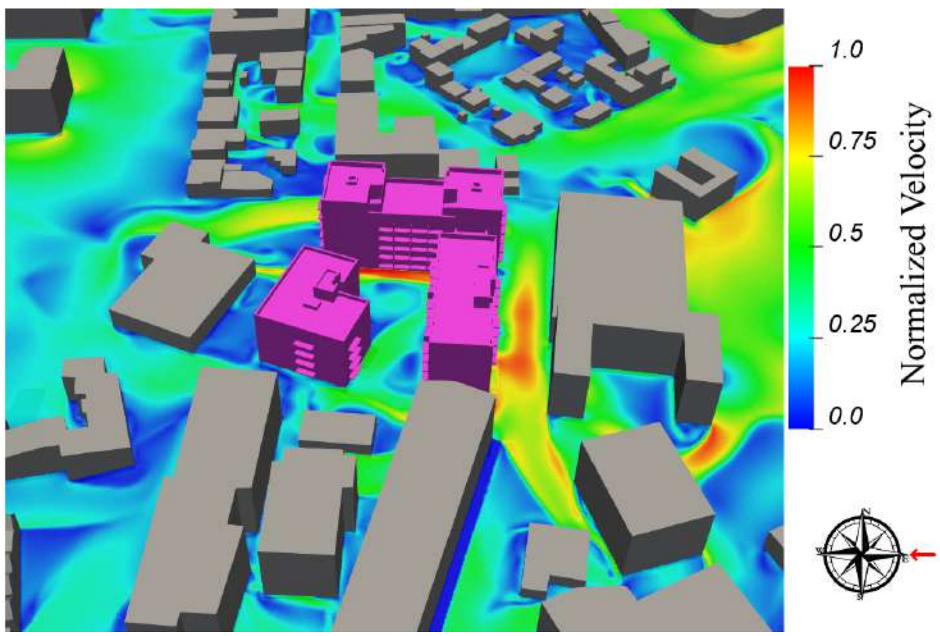


Figure 8.8: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 90°

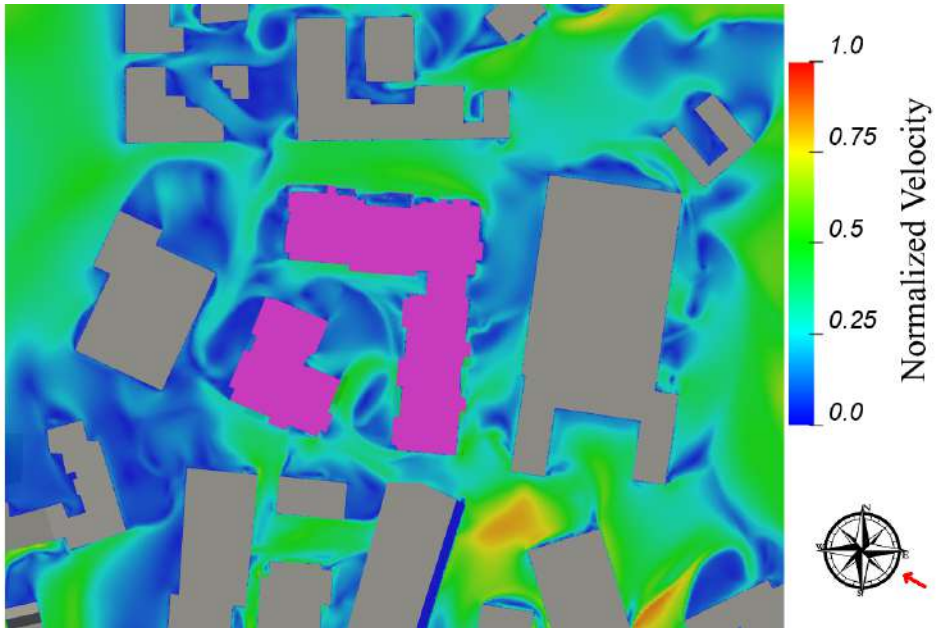


Figure 8.9: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 120°

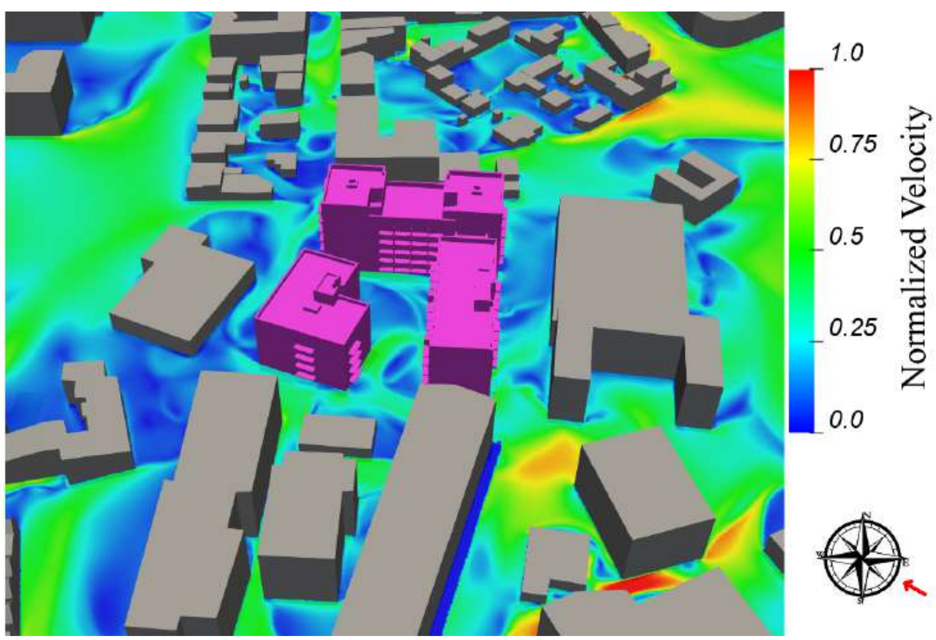


Figure 8.10: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 120°

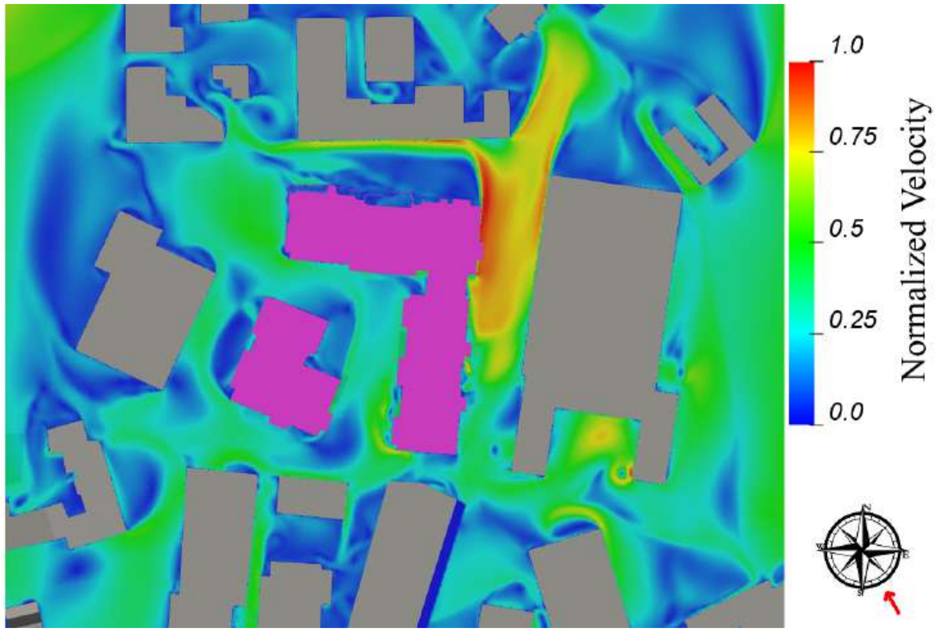


Figure 8.11: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 150°

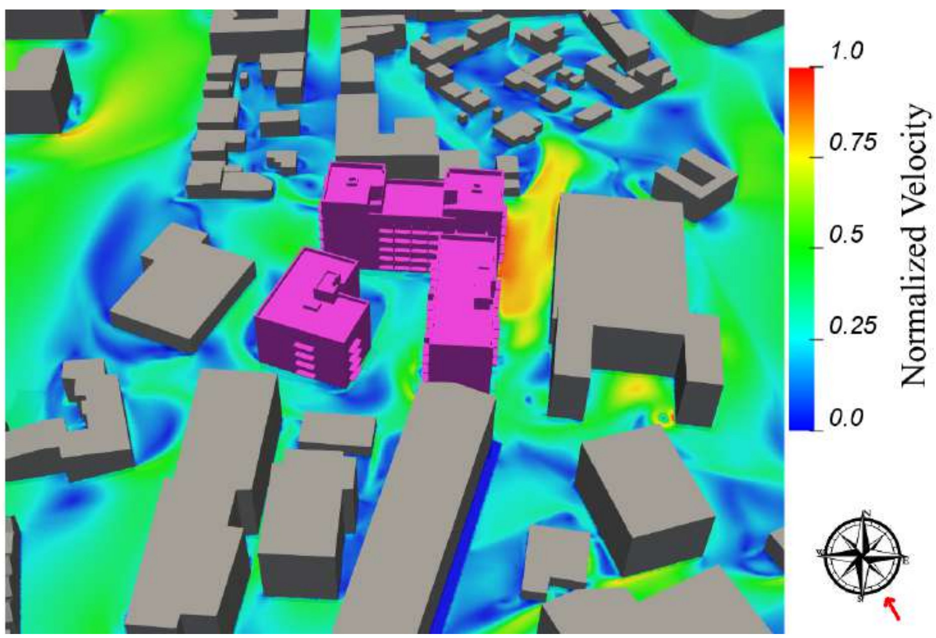


Figure 8.12: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 150°

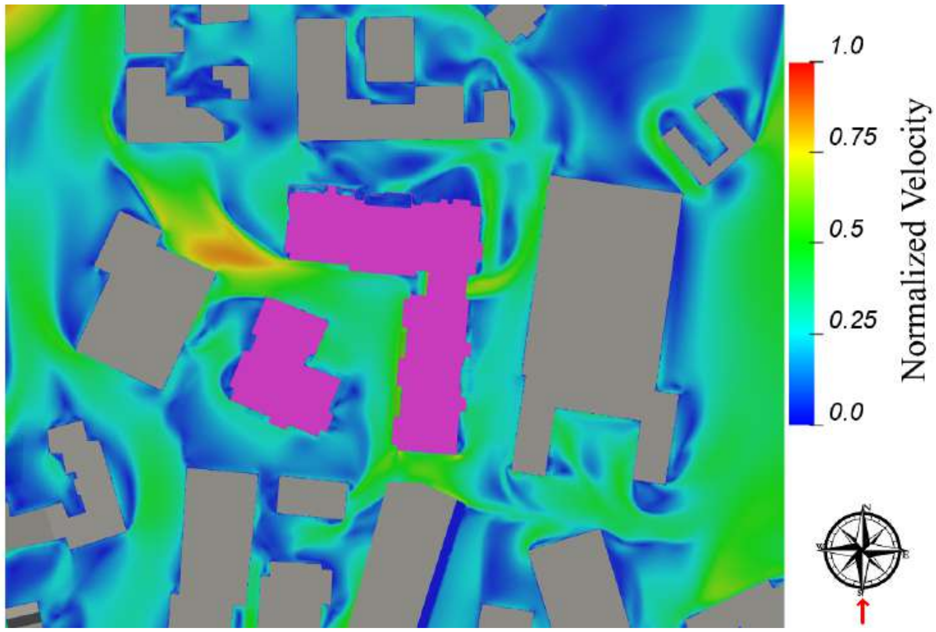


Figure 8.13: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 180°

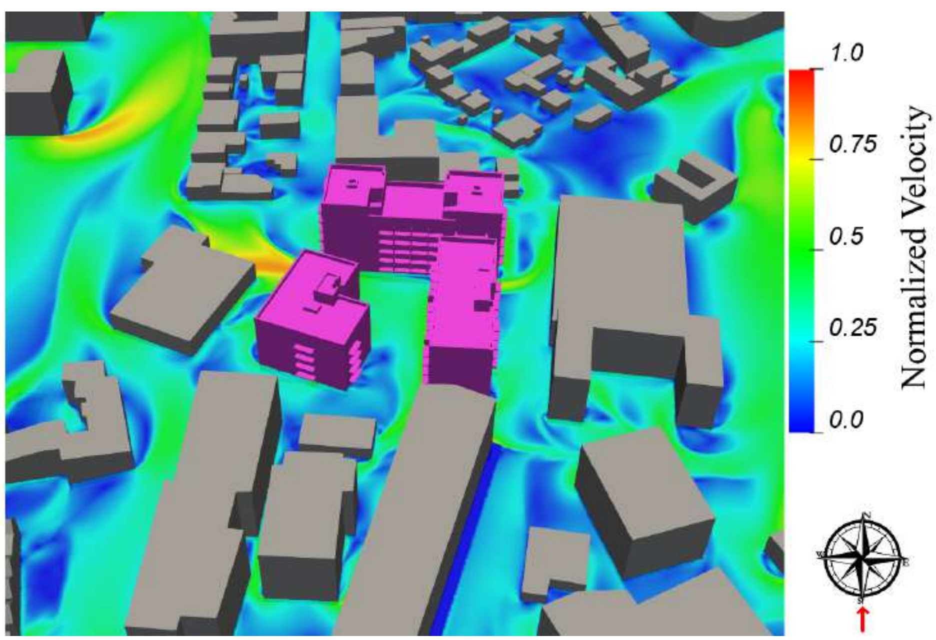


Figure 8.14: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 180°

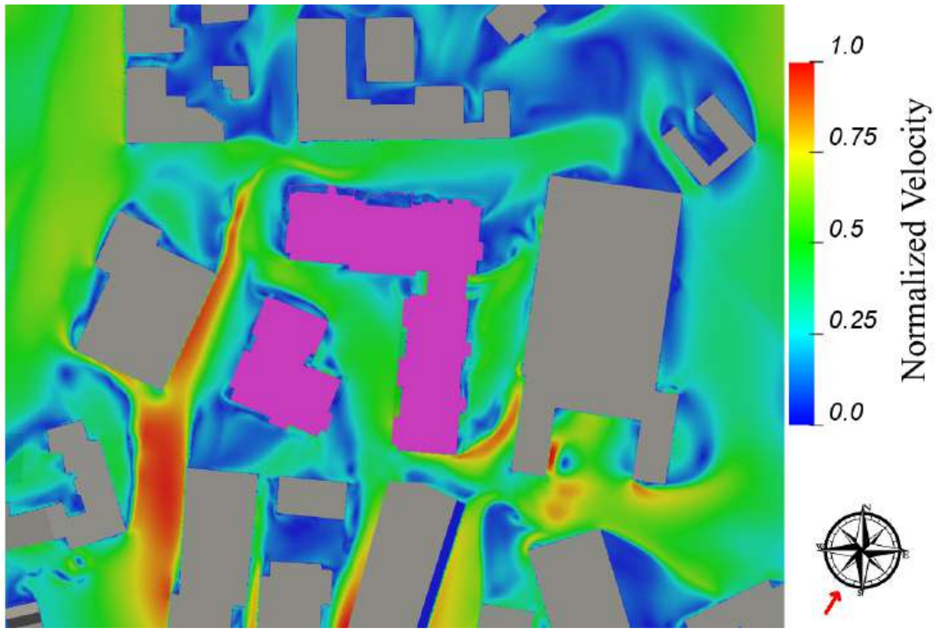


Figure 8.15: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 210°

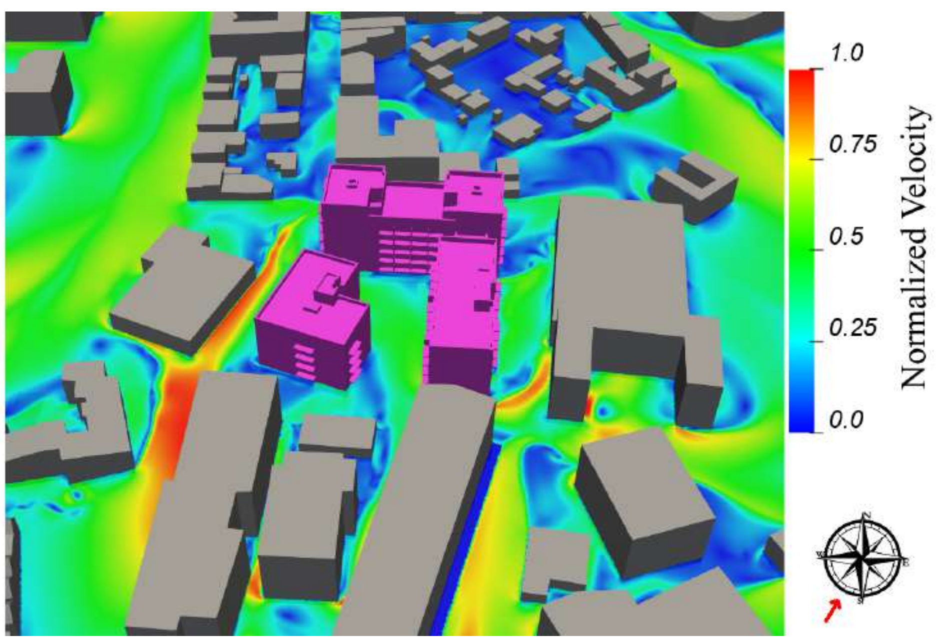


Figure 8.16: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 210°

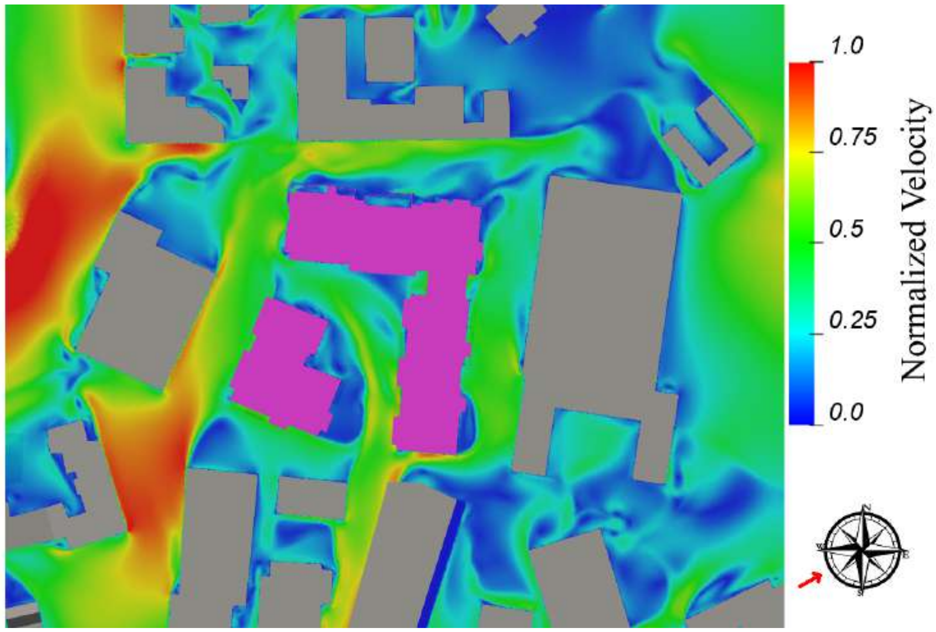


Figure 8.17: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 240°

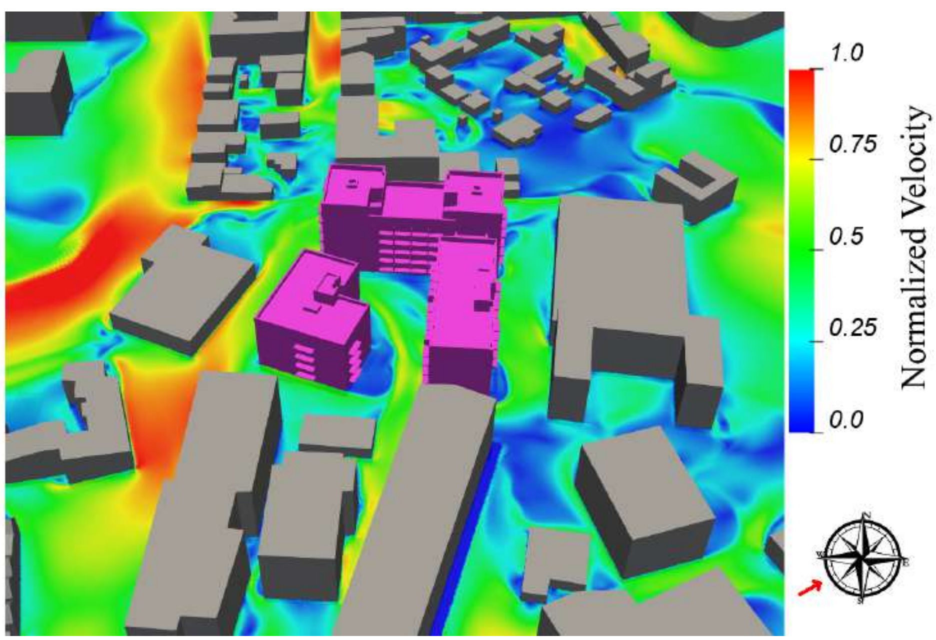


Figure 8.18: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 240°

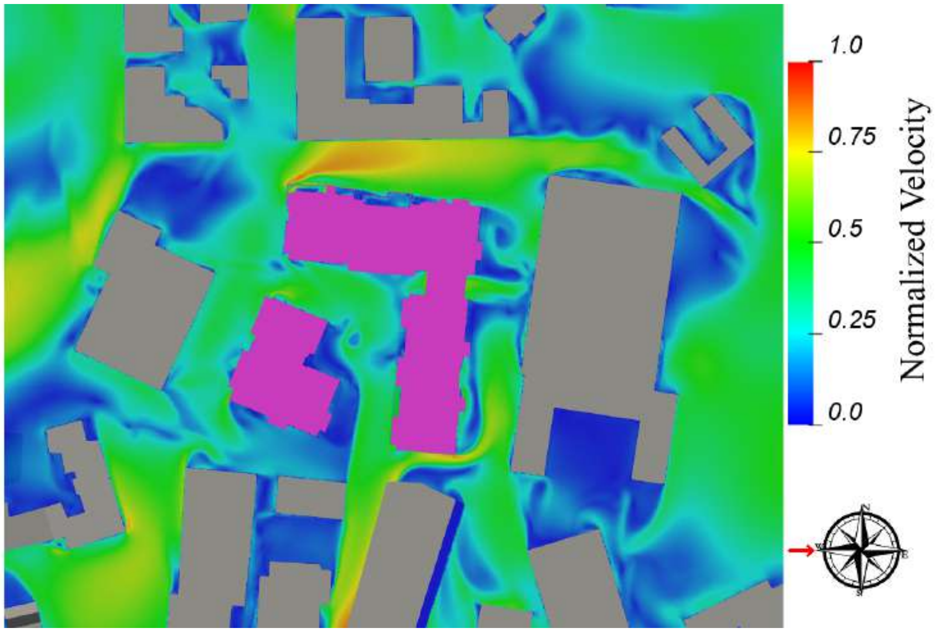


Figure 8.19: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 270°

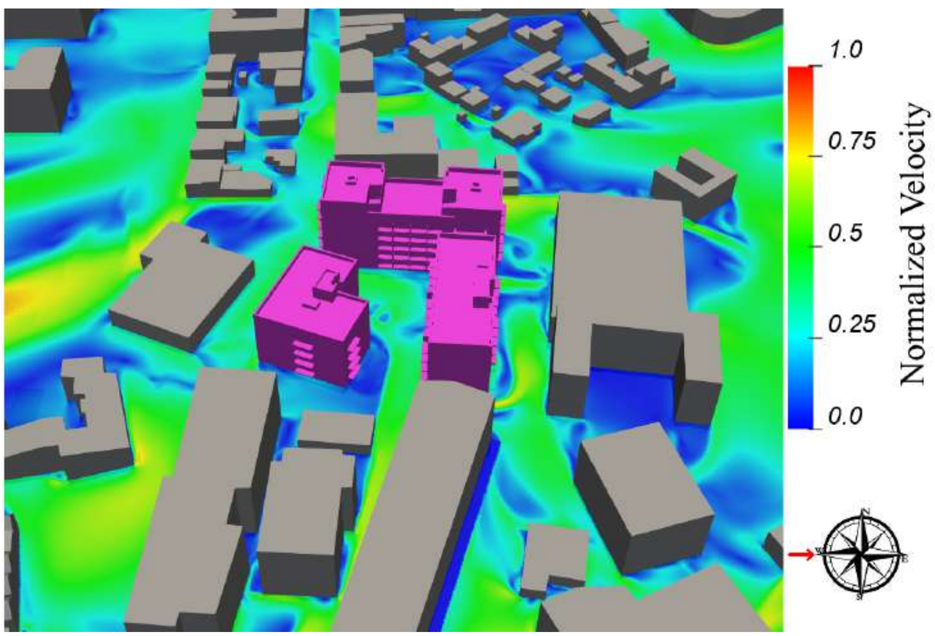


Figure 8.20: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 270°

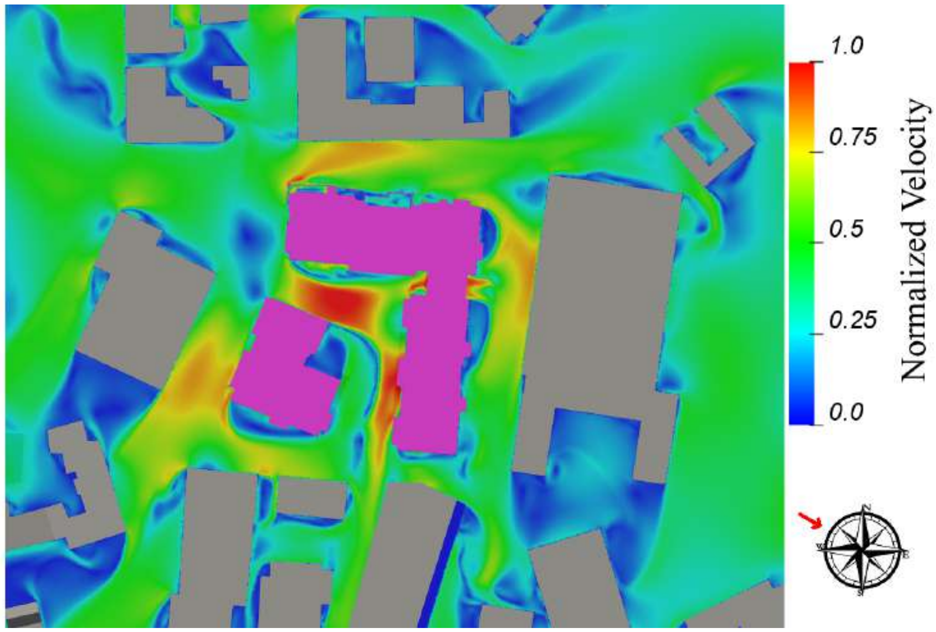


Figure 8.21: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 300°

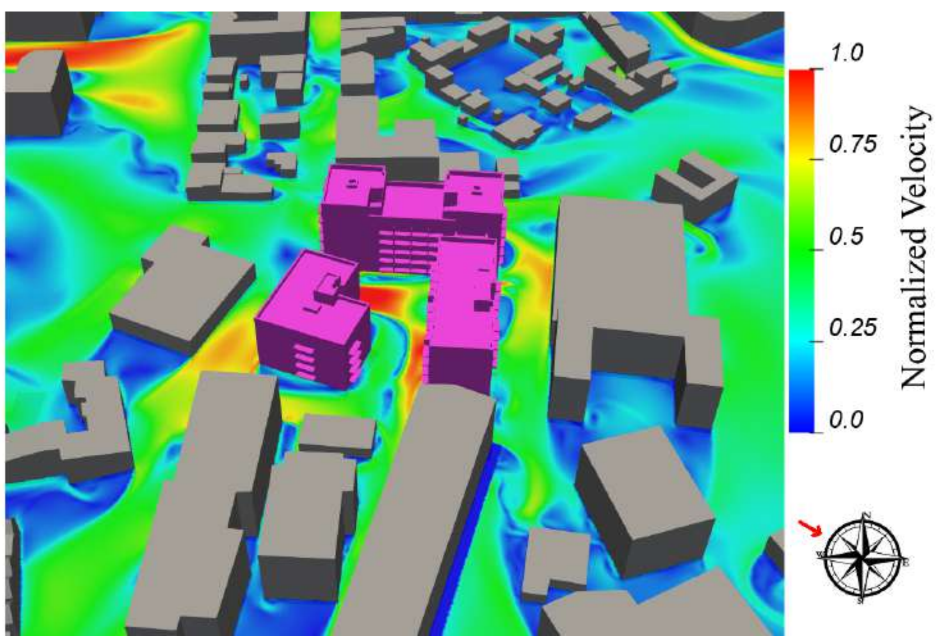


Figure 8.22: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 300°

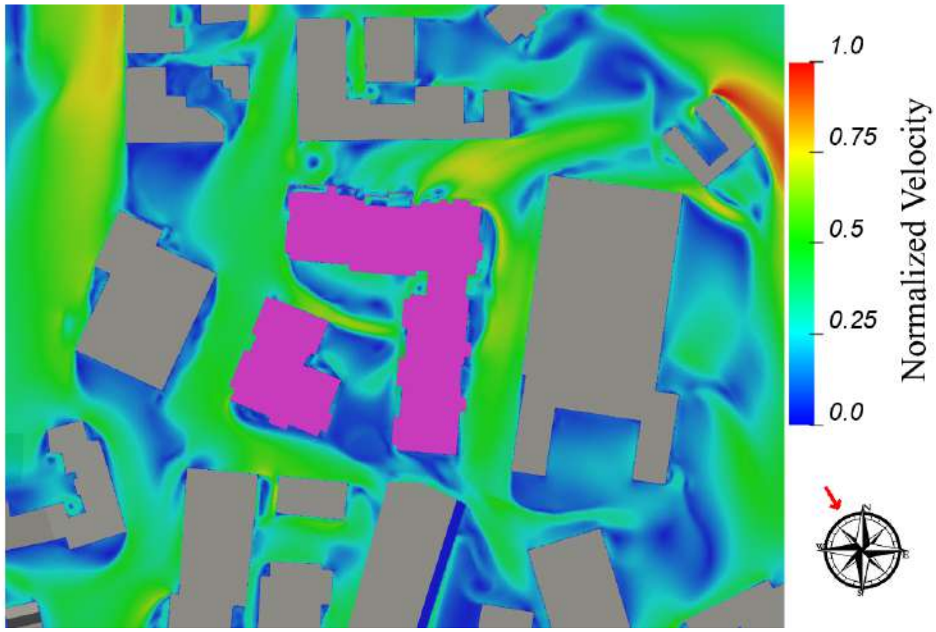


Figure 8.23: Top View -Flow Velocity Results at 1.5m above the ground - Wind Direction: 330°

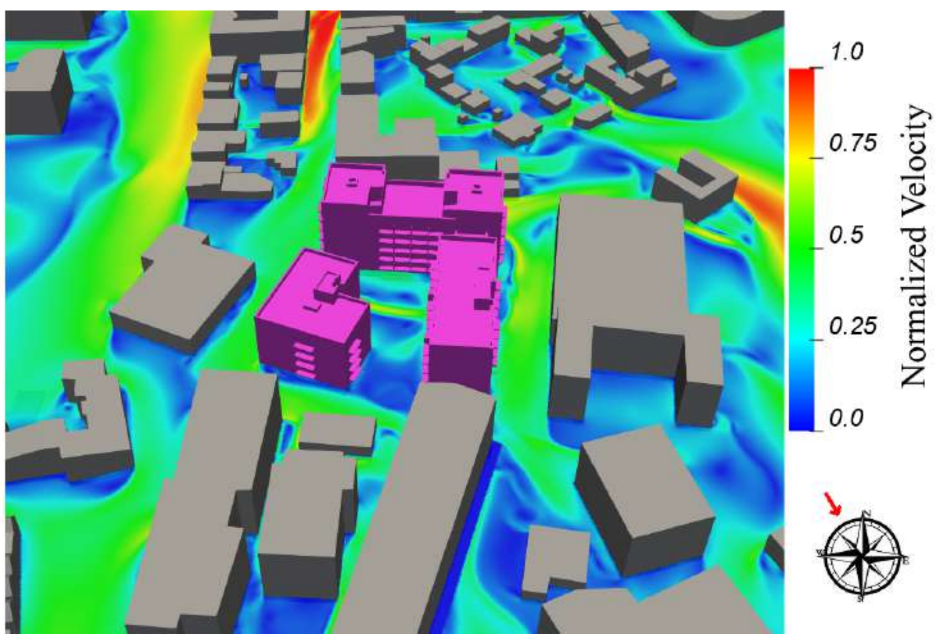


Figure 8.24: 3D View - Flow Velocity Results at 1.5m above the ground - Wind Direction: 330°

8.2.2 PROPOSED DEVELOPMENT WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented in Figures 8.25 and 8.26 using a colour coded diagram formulated in accordance with the Lawson Criteria.

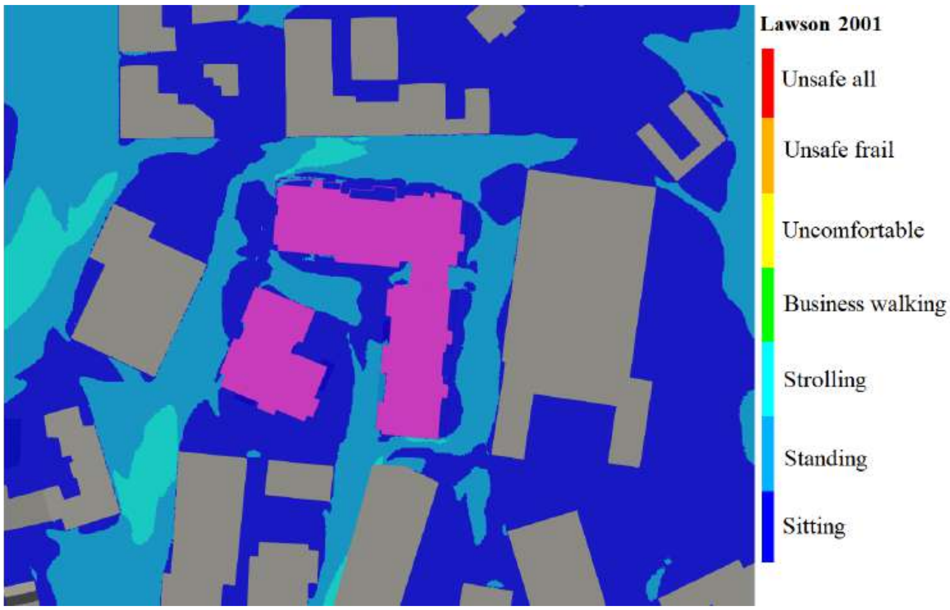


Figure 8.25: Ground Floor - Lawson Discomfort Map - **Top View**

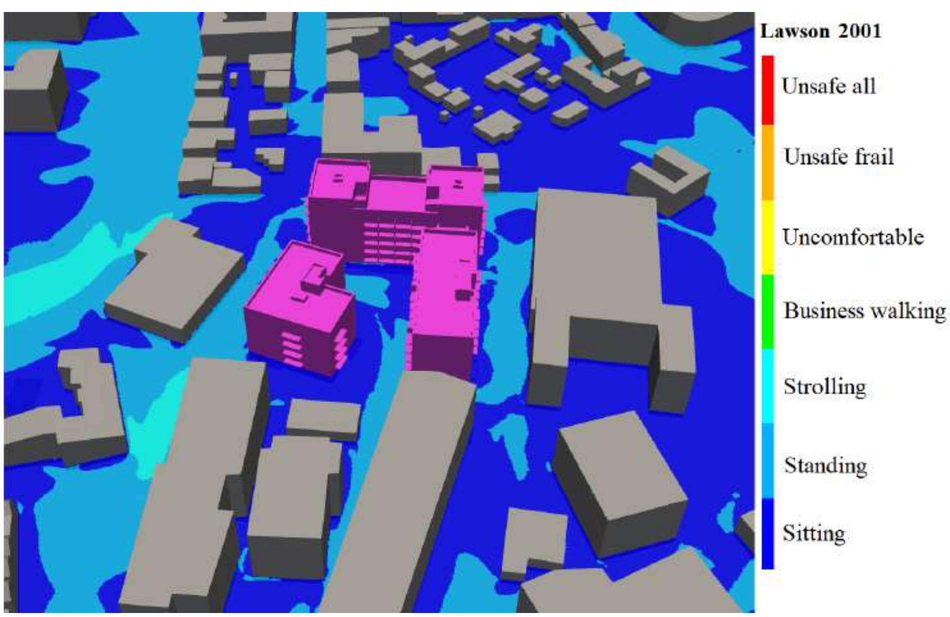


Figure 8.26: Ground Floor - Lawson Discomfort Map - **3D View**

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

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

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

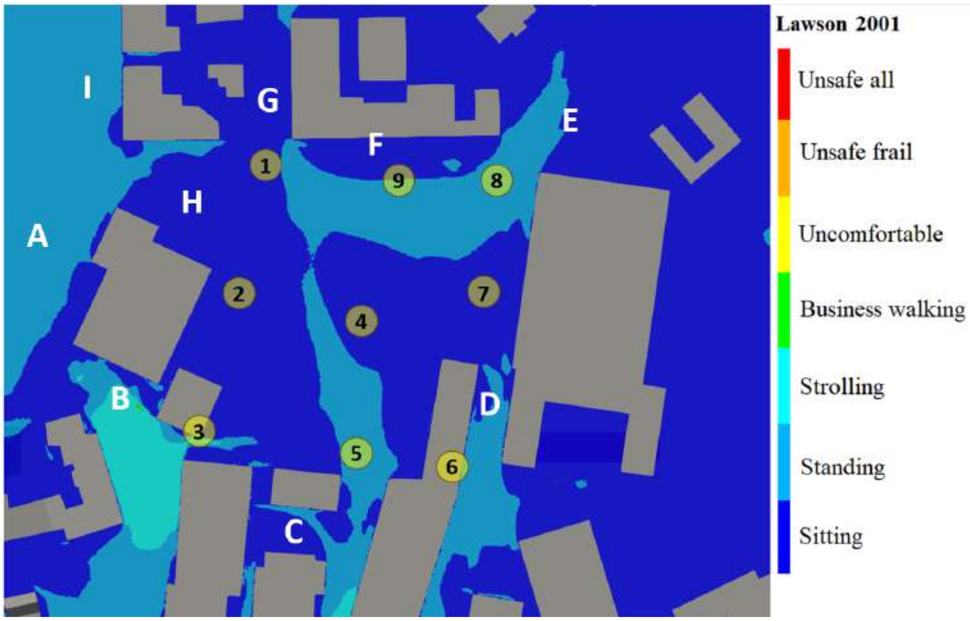
8.2.3 ON-SITE AND OFF-SITE RECEPTORS

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

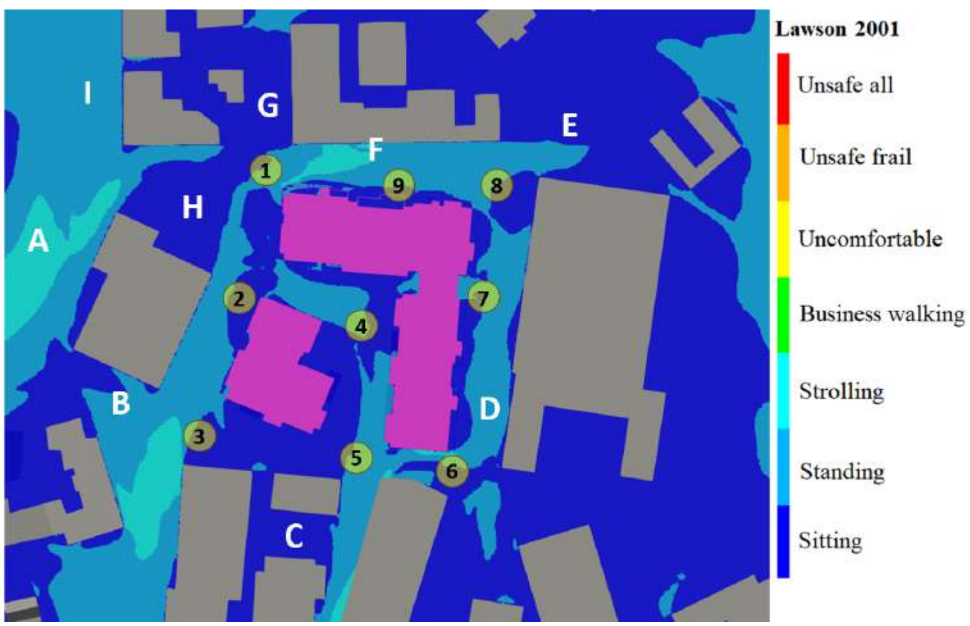
Table 8.1: Pedestrian Comfort Levels versus Proposed Pedestrian Activities

Reference point	Description	Sitting	Standing	Strolling	Business walking		Distress and Safety
1.	Crossing of Pim Street and Forbes Lane	Tolerable	Acceptable	Acceptable	Acceptable		Safe.
2.	Western Pedestrian Walkway	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
3.	Accessible Parking Space	Tolerable	Acceptable	Acceptable	Acceptable		Safe.
4.	Courtyard	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
5.	Southern Pedestrian Walkway	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
6.	Southern Entrance on Marrowbone Lane	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
7.	Eastern Pedestrian Walkway	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
8.	Northern Entrance on Forbes Lane	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
9.	Northern Pedestrian Walkway	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
A.	Jame's Walk	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
B.	Parking Lot	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
C.	Pedestrian Walkway	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
D.	Marrowbone Lane	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
E.	Parking Lot	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
F.	Forbes Lane	Tolerable	Acceptable	Acceptable	Acceptable		Safe.
G.	Pim Street	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
H.	Parking Lot	Acceptable	Acceptable	Acceptable	Acceptable		Safe.
I.	Long's Place	Acceptable	Acceptable	Acceptable	Acceptable		Safe.

A comparison of Lawson Discomfort Maps for the baseline scenario and the proposed scenario is presented in Figure 8.27



Baseline Scenario



Proposed Development Scenario

Figure 8.27: Comparison Wind Microclimate Conditions (Lawson Comfort/Distress Map)

Tables 8.2 and 8.3 show the intended baseline and proposed wind conditions on-site as well as some potential off-site receptors around the development. These tables show that there are no distress areas for pedestrians including frail users and cyclists. Furthermore, the site and surrounding urban areas are safe for all users.

Table 8.2: Significance Impact of the Proposed Development Versus Baseline Conditions for Comfort - On Site Receptors

On-Site Potential Receptors	Baseline Conditions	Proposed Development Conditions	Impact Significance
1. Crossing of Pim Street and Forbes Lane	Suitable for Sitting/Standing.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
2. Western Pedestrian Walkway	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
3. Accessible Parking Space	Suitable for Standing/Strolling.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
4. Courtyard	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
5. Southern Pedestrian Walkway	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
6. Southern Entrance on Marrowbone Lane	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
7. Eastern Pedestrian Walkway	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
8. Northern Entrance on Forbes Lane	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
9. Northern Pedestrian Walkway	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

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

Off-Site Potential Receptors	Baseline Conditions	Proposed Development Conditions	Impact Significance
A. Jame's Walk	Suitable for Sitting/Standing.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
B. Parking Lot	Suitable for Standing/Strolling.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
C. Pedestrian Walkway	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
D. Marrowbone Lane	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
E. Parking Lot	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
F. Forbes Lane	Suitable for Sitting/Standing.	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
G. Pim Street	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
H. Parking Lot	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
I. Long's Place	Suitable for Sitting/Standing.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

8.2.4 BALCONIES

The comparison of comfort ratings with the intended pedestrian activities is depicted in the Lawson Comfort and Distress Map on the 1.5m balcony floor, as illustrated in Figures 8.28 to 8.31. It is evident that all the balconies are deemed safe for occupants, with no distress areas identified

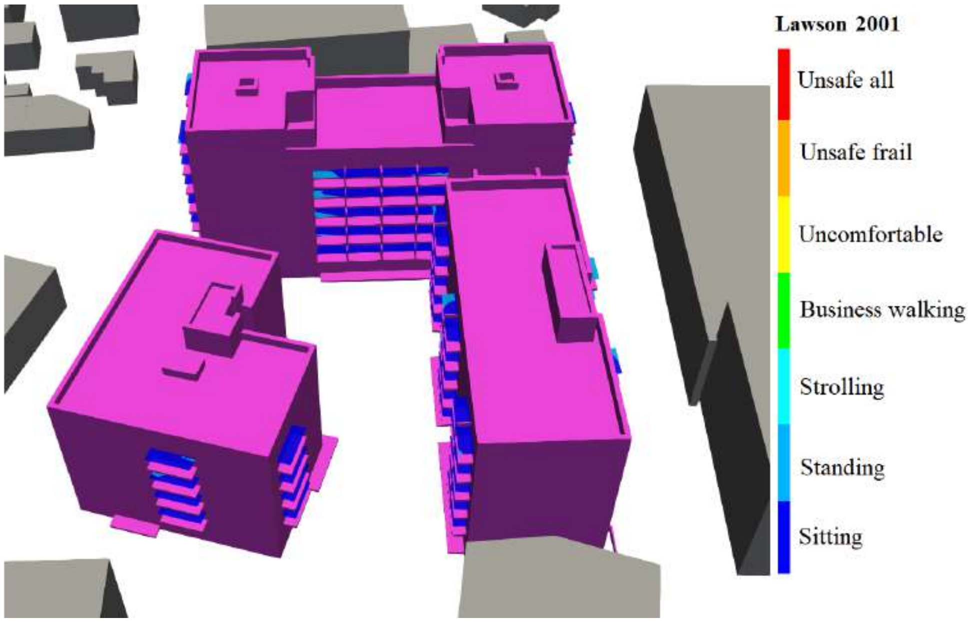


Figure 8.28: Balconies - Lawson Discomfort Map - Proposed scenario - South Balconies

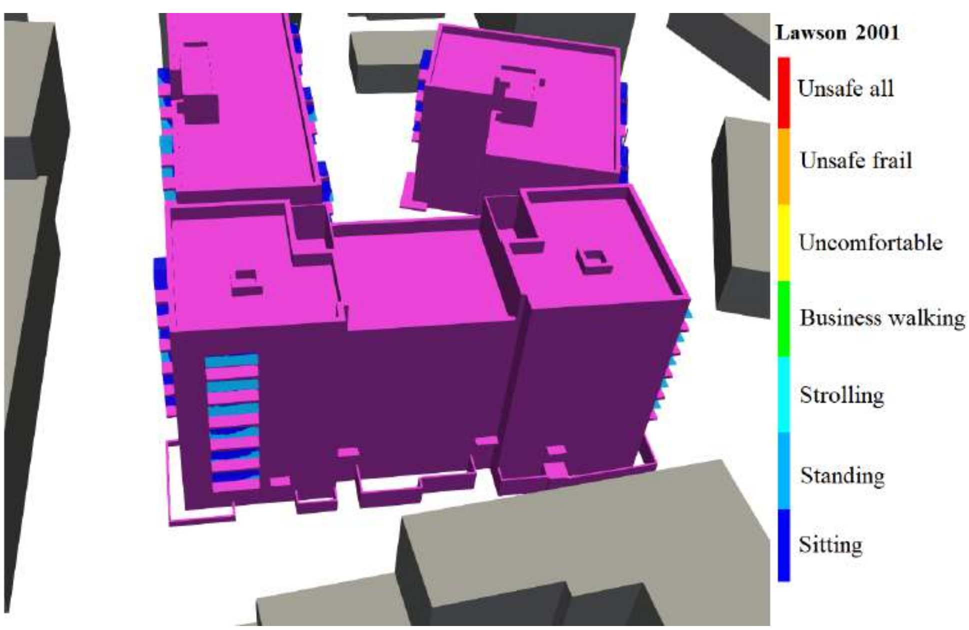


Figure 8.29: Balconies - Lawson Discomfort Map - Proposed scenario - North Balconies

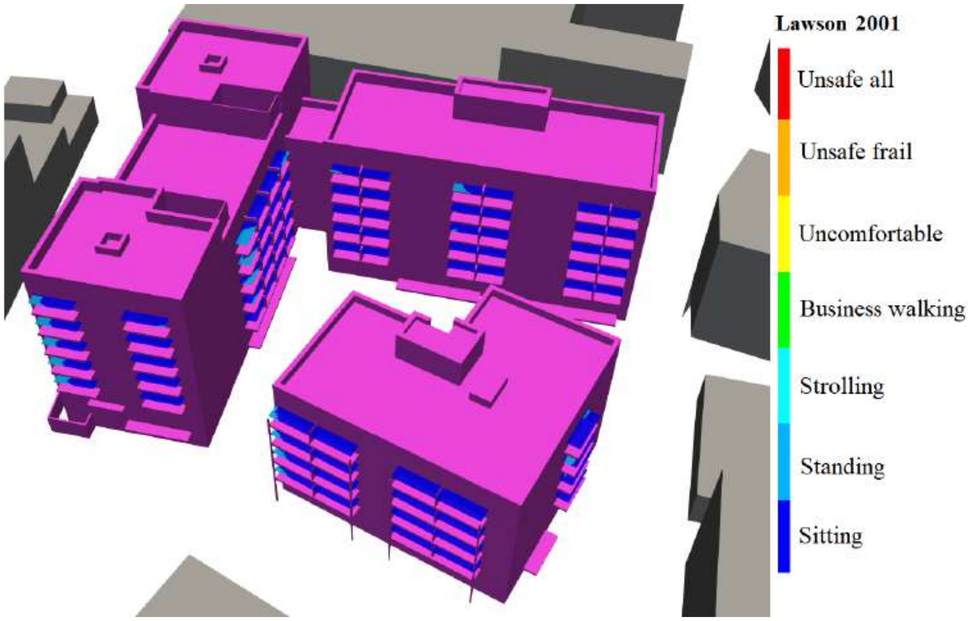


Figure 8.30: Balconies - Lawson Discomfort Map - Proposed scenario - West Balconies

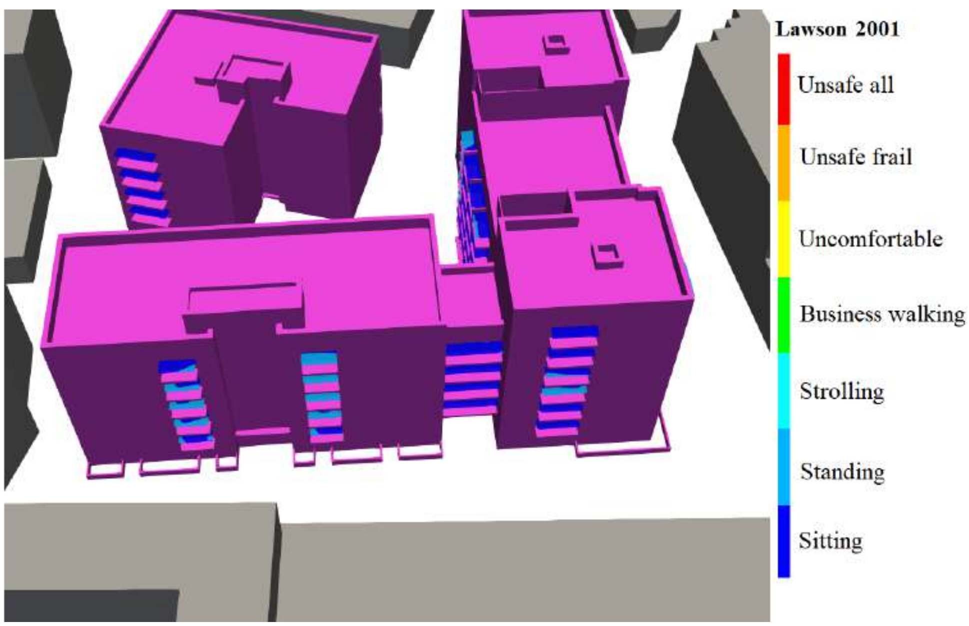


Figure 8.31: Balconies - Lawson Discomfort Map - Proposed scenario - East Balconies

8.2.5 PLANNED MITIGATION

As mentioned in the previous section, there are several wind effects that can occur at the development site, such as downwash, downdraft, and funneling. These phenomena can cause accelerated wind speeds at pedestrian level, leading to potential pedestrian discomfort. In order to address these issues, several mitigation options were evaluated. The chosen options were implemented with the aim of reducing the impact of these wind effects and enhancing pedestrian comfort around the development.

To address these wind impacts, existing trees along the walkway on the west side of the development have been preserved, extra trees have been introduced within ground amenities of the development. These measures collectively contribute to mitigating wind impacts at ground floor of the development as shown in Figures 8.32 to 8.33.

In addition, the presence of balconies on the East, West, and South sides of the development can alter the path of the wind before it reaches ground level, which provides further mitigation on wind impacts.

The following mitigation measure is implemented to reduce Funneling/Corner effect:
- Introduction of additional trees and other plants at ground amenities of the development.

The **"Funneling Effect"** in wind analysis refers to the phenomenon where wind speeds are amplified as they flow through a narrow or constricted area, such as between two. This effect occurs because the wind is forced to converge and compress as it moves through the restricted space, resulting in higher velocities and potentially creating turbulent or gusty conditions.
The **"Corner Effect"** refers to the intensification of wind speeds that can occur at the corners of buildings or other structures, due to the convergence and acceleration of wind flow as it encounters the sharp edges and turns. This effect can create areas of increased turbulence and downdraft.

Figure 8.32: Mitigation Measures for Funneling and Corner Effects

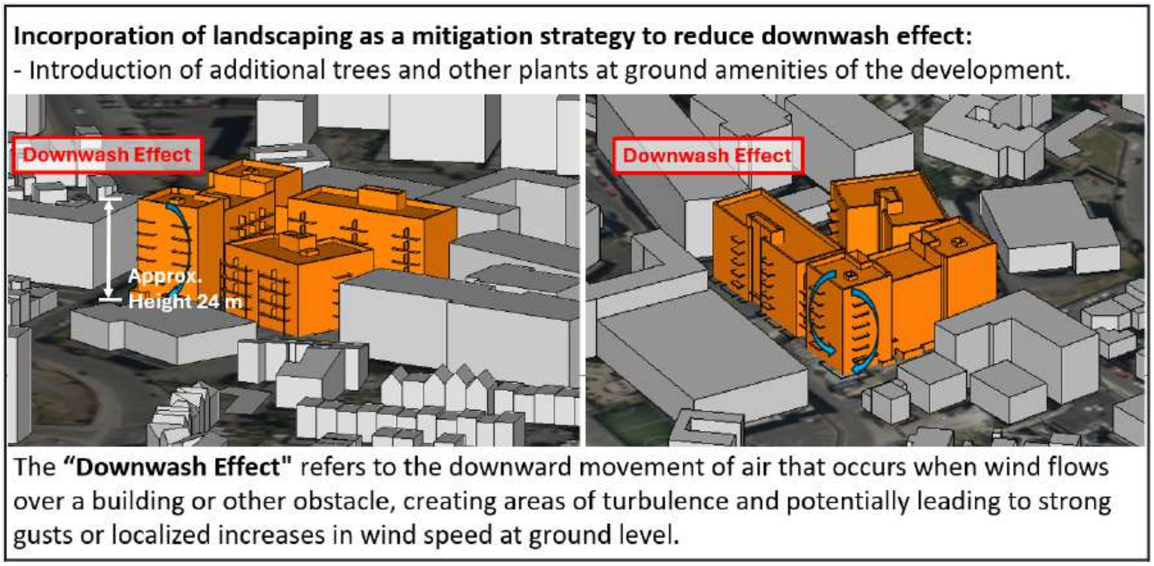


Figure 8.33: Mitigation Measures for Downwash Effect

According to the Lawson Map (Figure 8.25), the receptor area around the development is safe for pedestrians and provides suitable comfort levels for activities such as sitting and standing. It is important to note that the Lawson Map was calculated based on worst-case scenarios without considering trees planting. The addition of trees and plants can help mitigate wind impact and enhance pedestrian comfort levels. As shown in Figure 8.34, the following mitigation measure is implemented to improve pedestrian comfort around the development:

- *Introducing additional trees on ground amenities of the development:*
  These additional plants will help reduce wind speed, increasing comfort levels in all ground amenities of the development.

Figure 8.34: Mitigation Plans around the Development

The Lawson Map in Figure 8.35 indicates that the designated area is already suitable for strolling and standing, and the strategic addition of trees as a mitigation measure is set to enhance pedestrian comfort further, creating an even more inviting and pleasant environment for pedestrian activities. Therefore, it is worth noting that no further mitigation measures are required as all amenity areas are already comfortable for the intended use as shown in Figure 8.35.

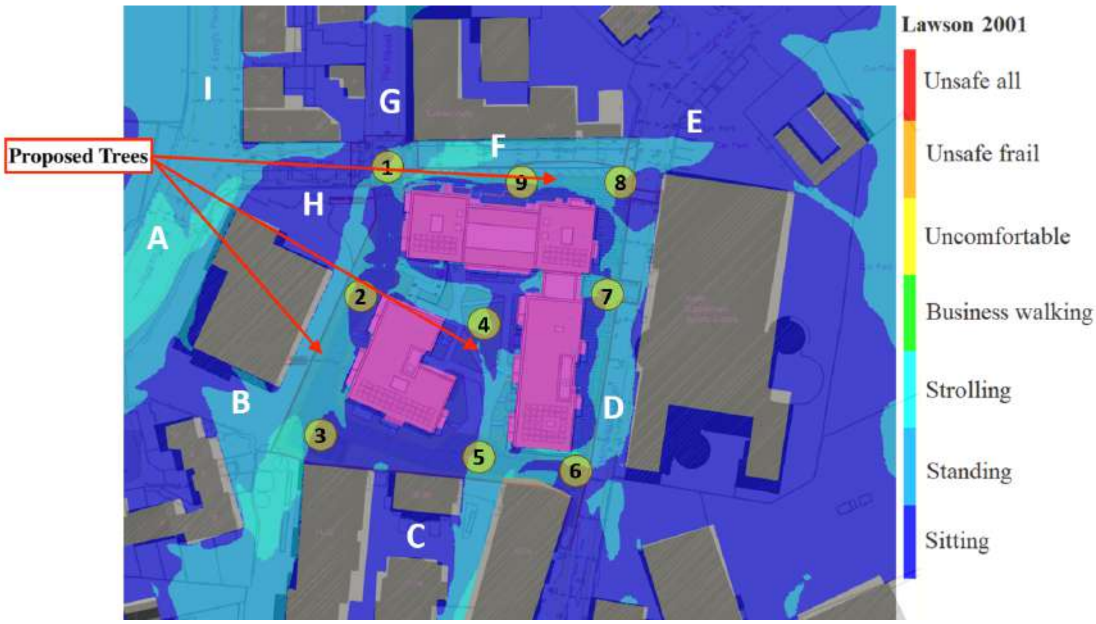


Figure 8.35: Lawson Discomfort Map and Mitigation around the Development

9. CUMULATIVE IMPACT

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

9.1 OPERATIONAL PHASE

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

Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment and permitted buildings (but not built yet).

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

Figure 9.1: A 3D View of the Proposed Development Buildings (Colored in Orange) and the Cumulative Buildings (Colored in Blue)

9.1.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the ground are presented in Figures 9.2 to 9.25 in order to assess wind flows at ground floor level of Forbes Lane Development.

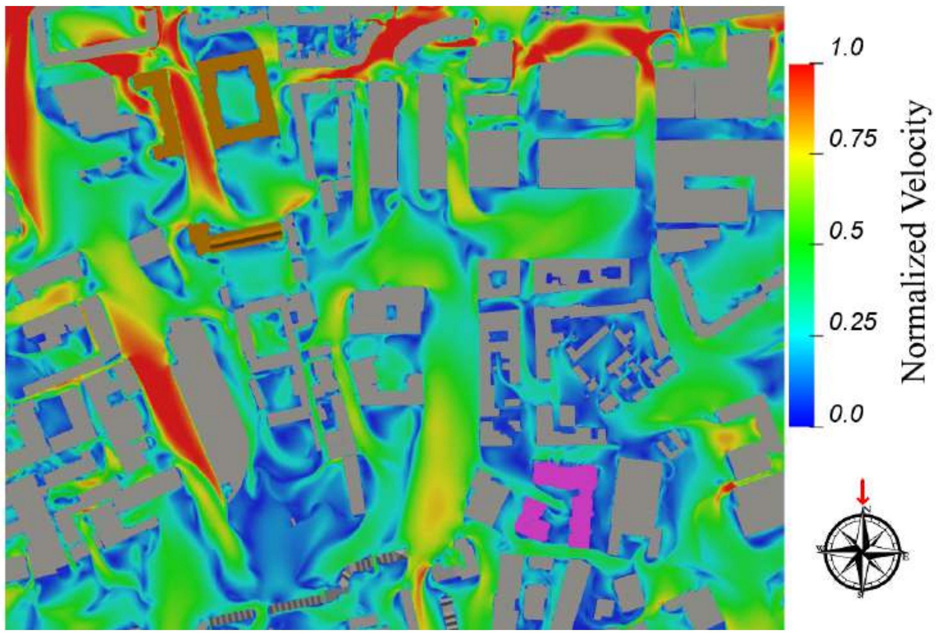


Figure 9.2: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 0°

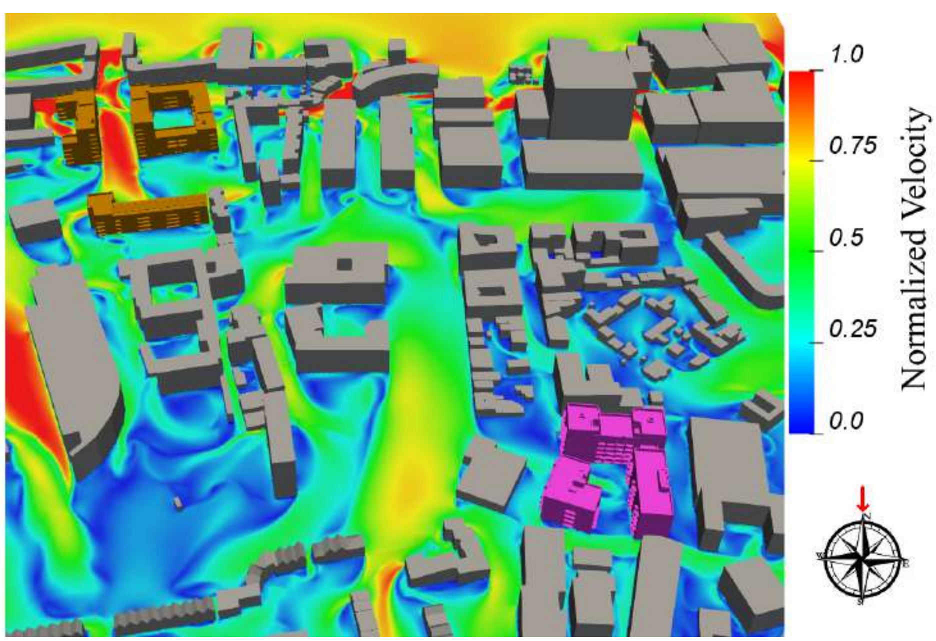


Figure 9.3: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 0°

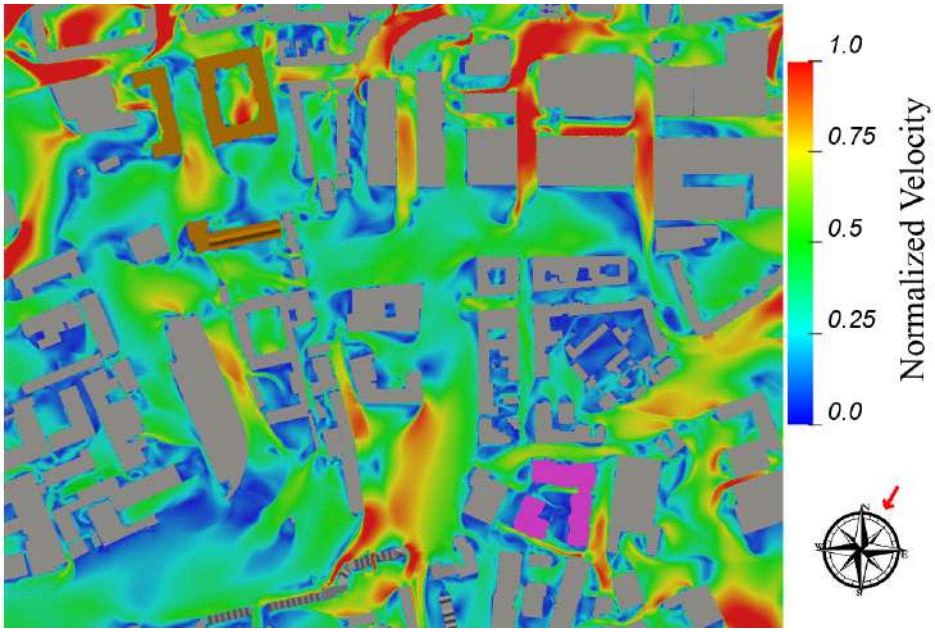


Figure 9.4: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 30°

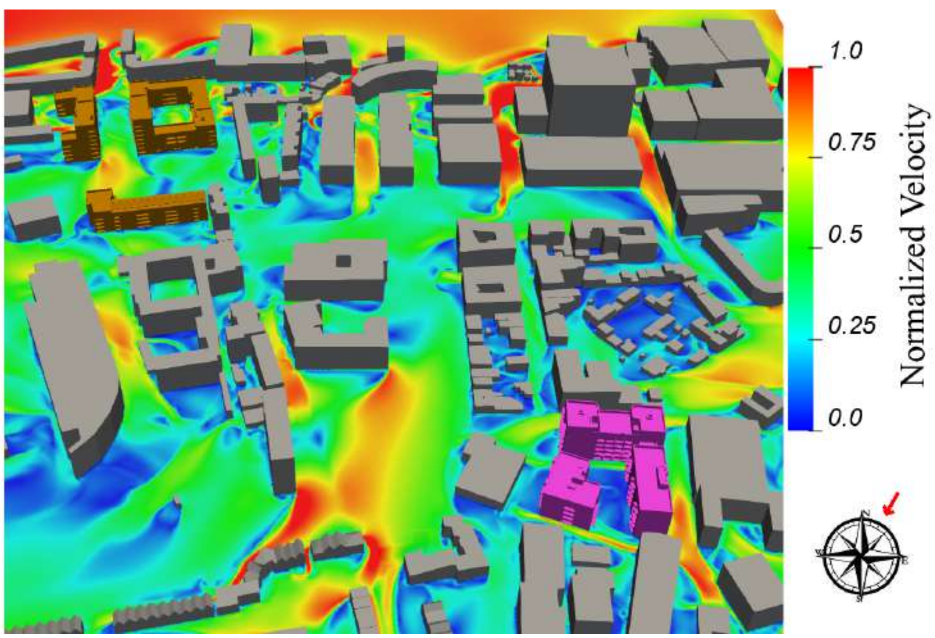


Figure 9.5: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 30°

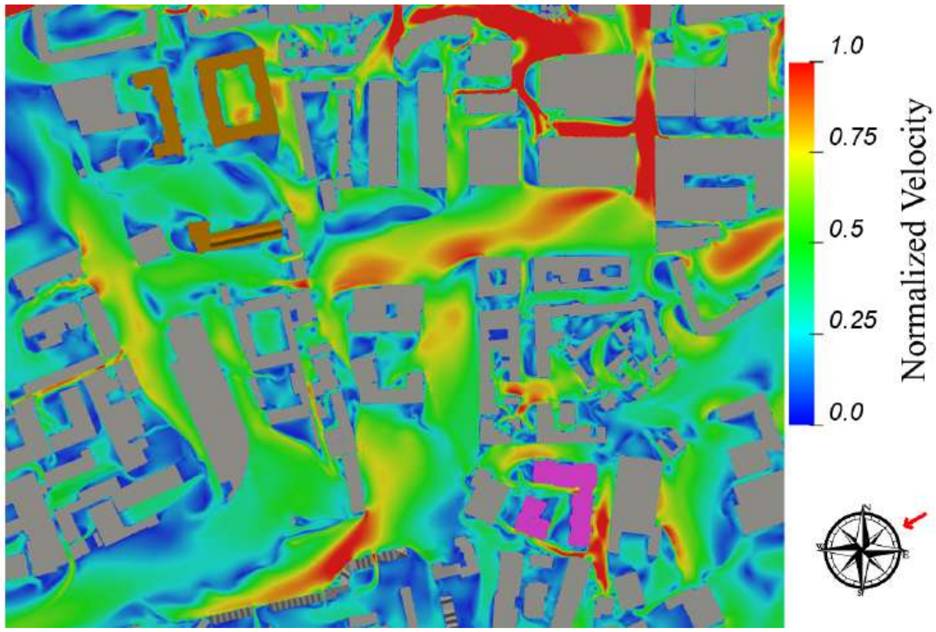


Figure 9.6: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 60°

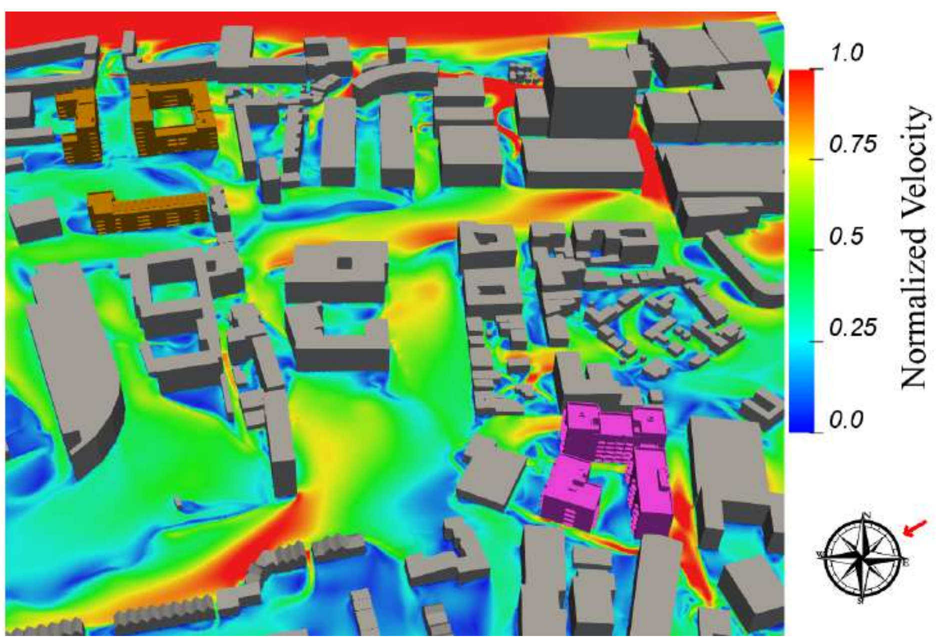


Figure 9.7: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 60°

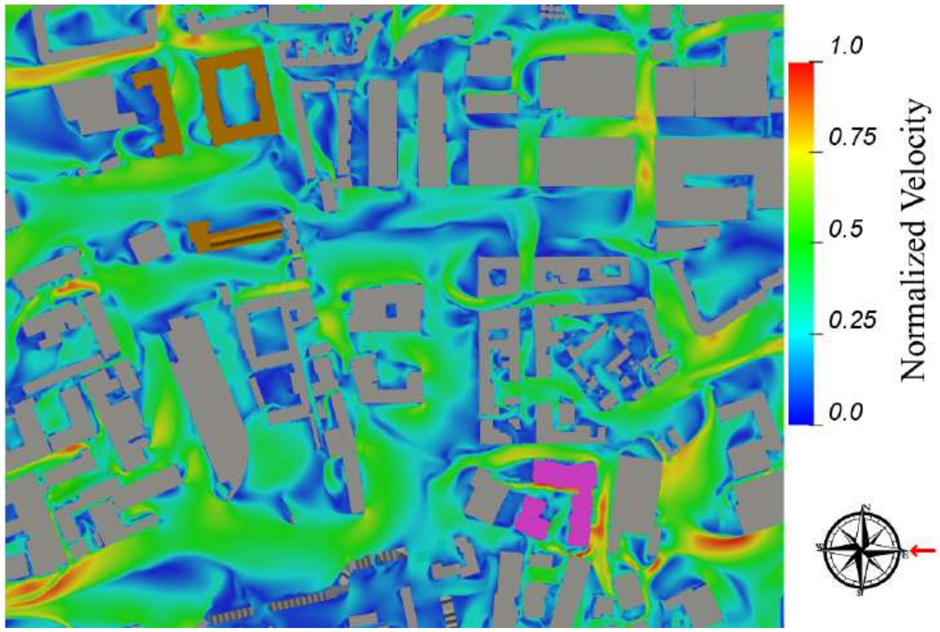


Figure 9.8: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 90°

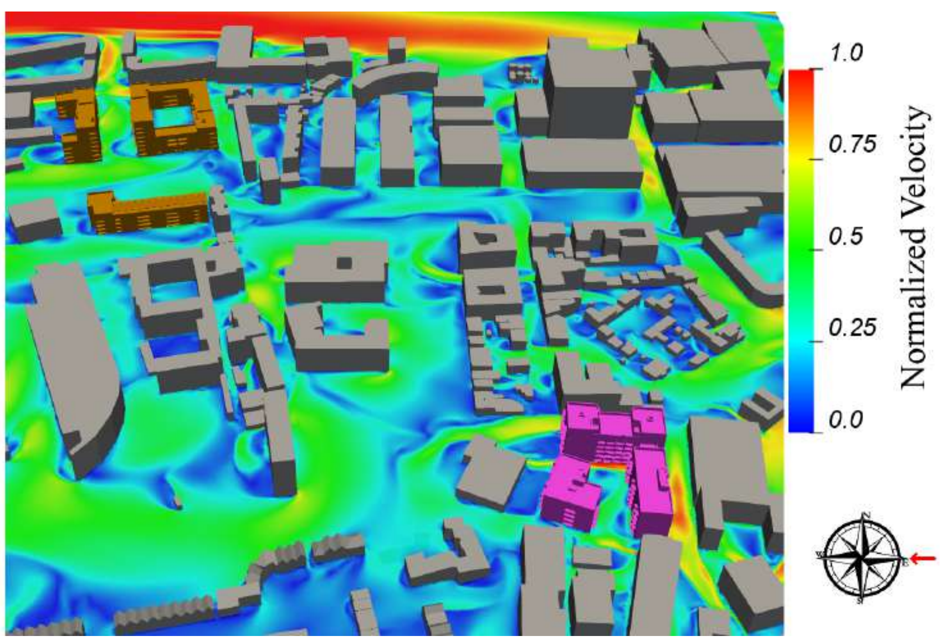


Figure 9.9: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 90°

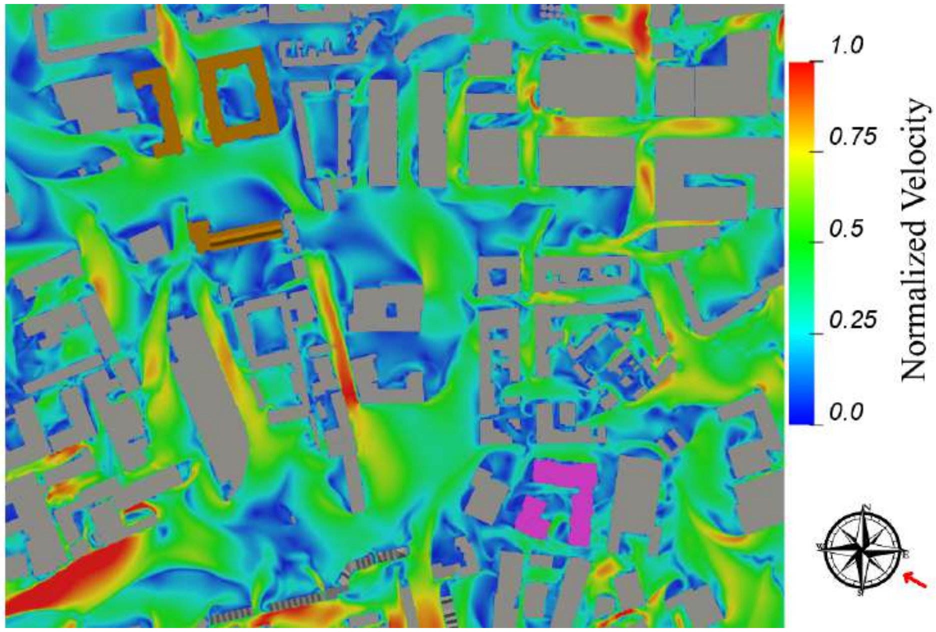


Figure 9.10: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 120°

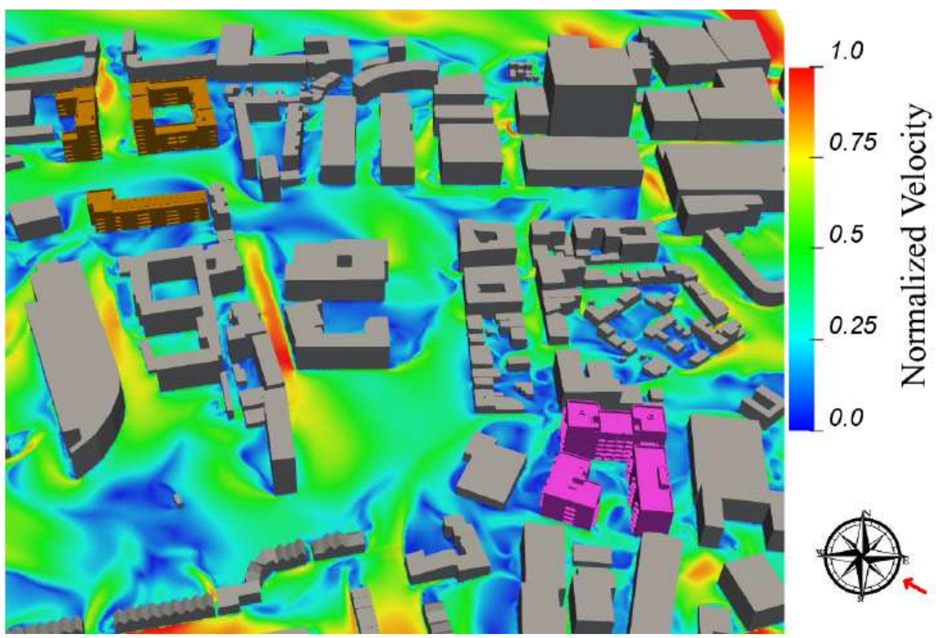


Figure 9.11: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 120°

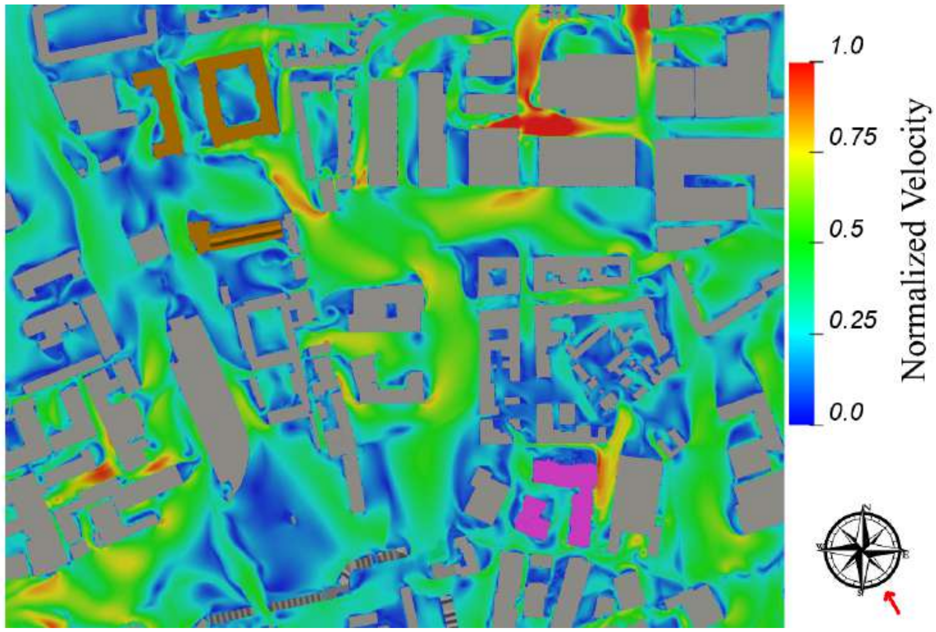


Figure 9.12: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 150°

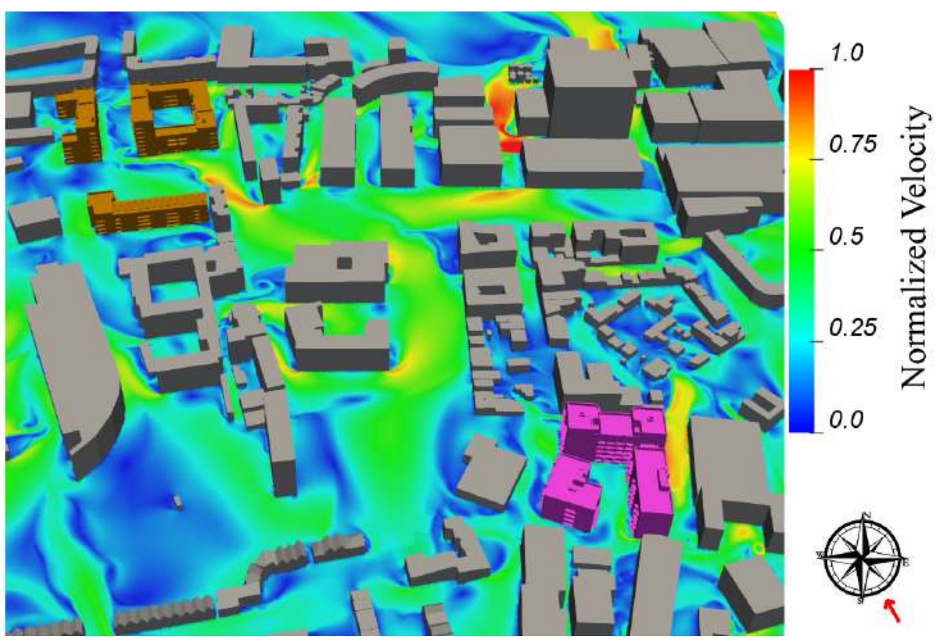


Figure 9.13: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 150°

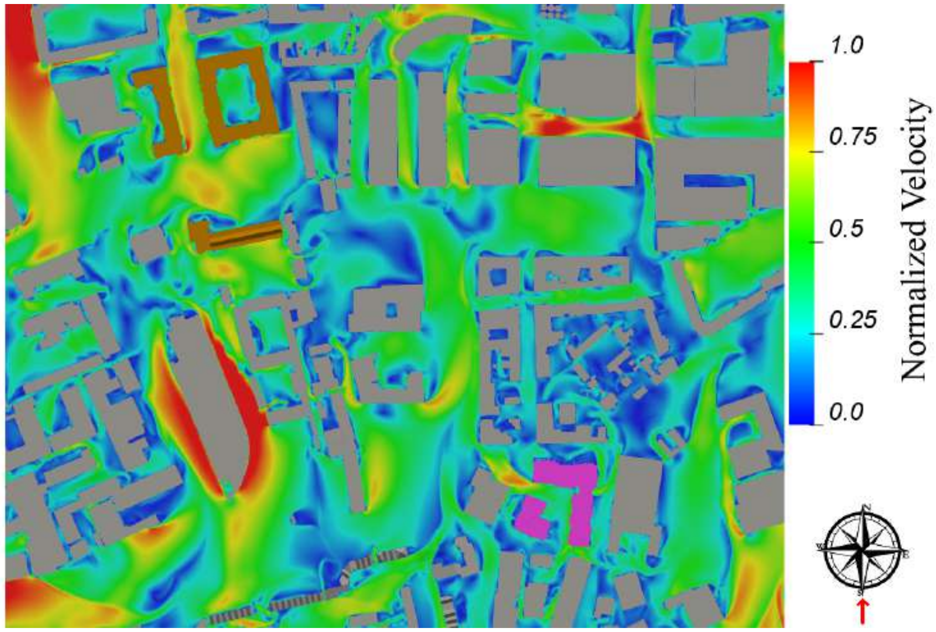


Figure 9.14: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 180°

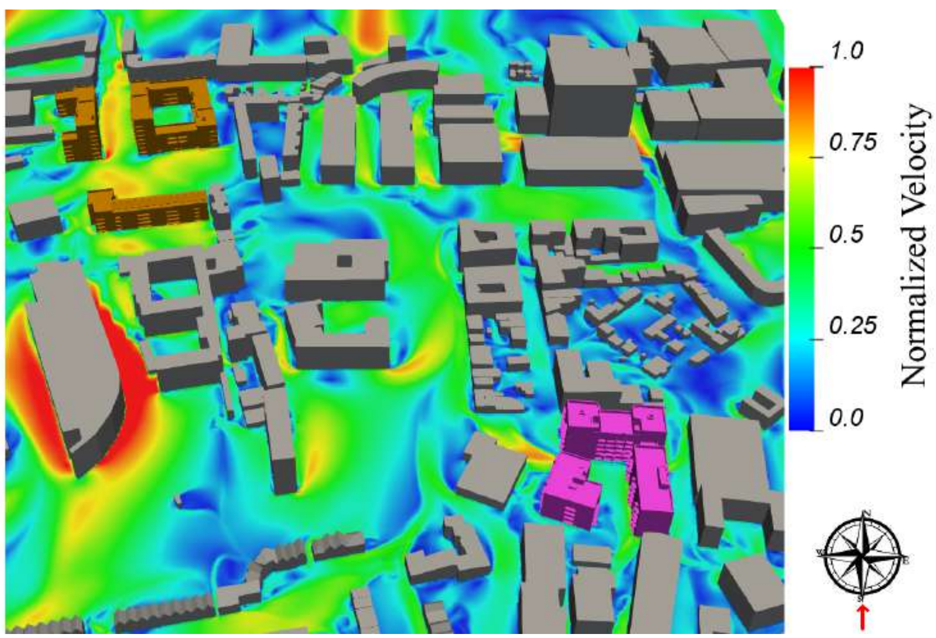


Figure 9.15: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 180°

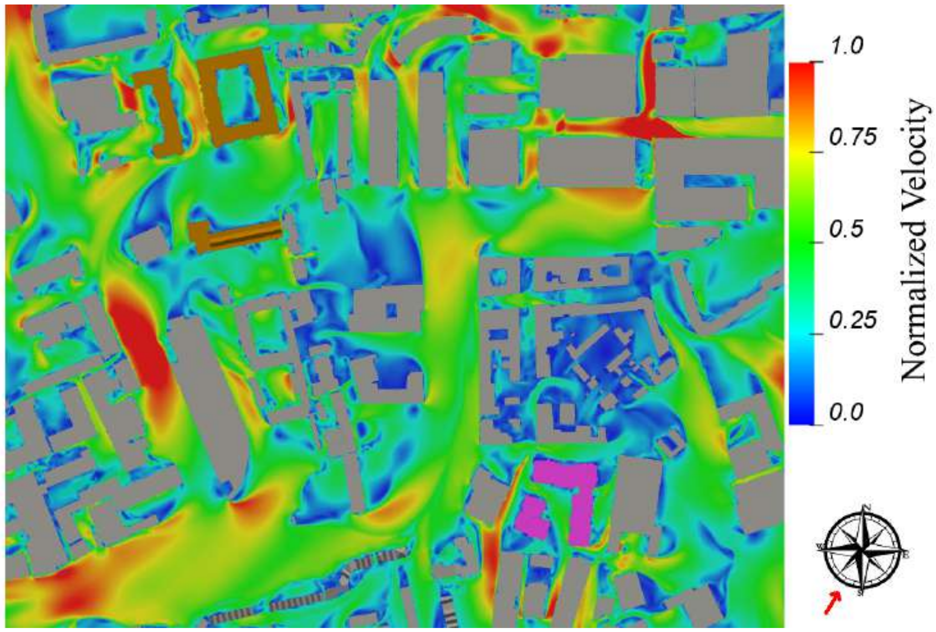


Figure 9.16: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 210°

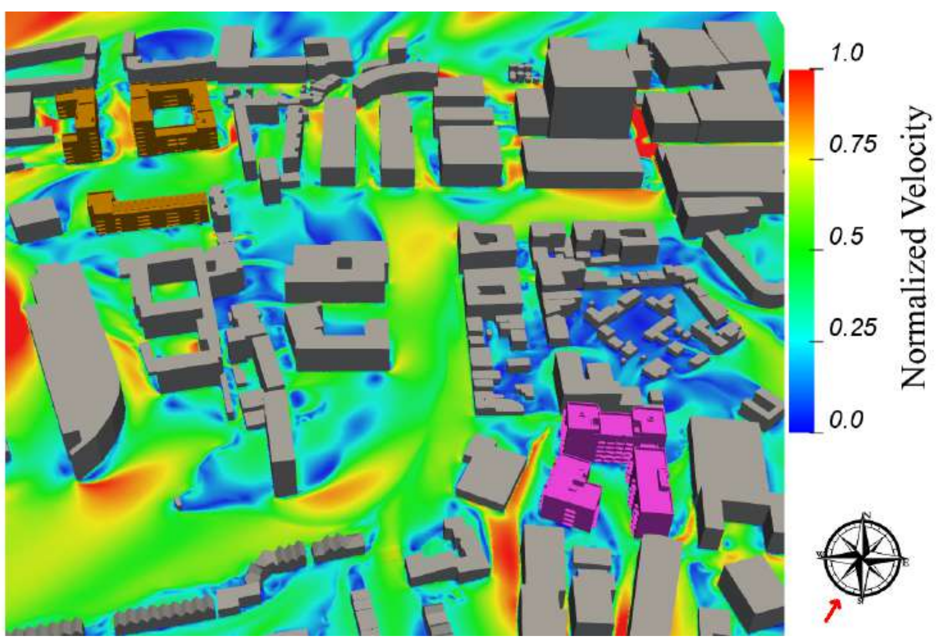


Figure 9.17: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 210°

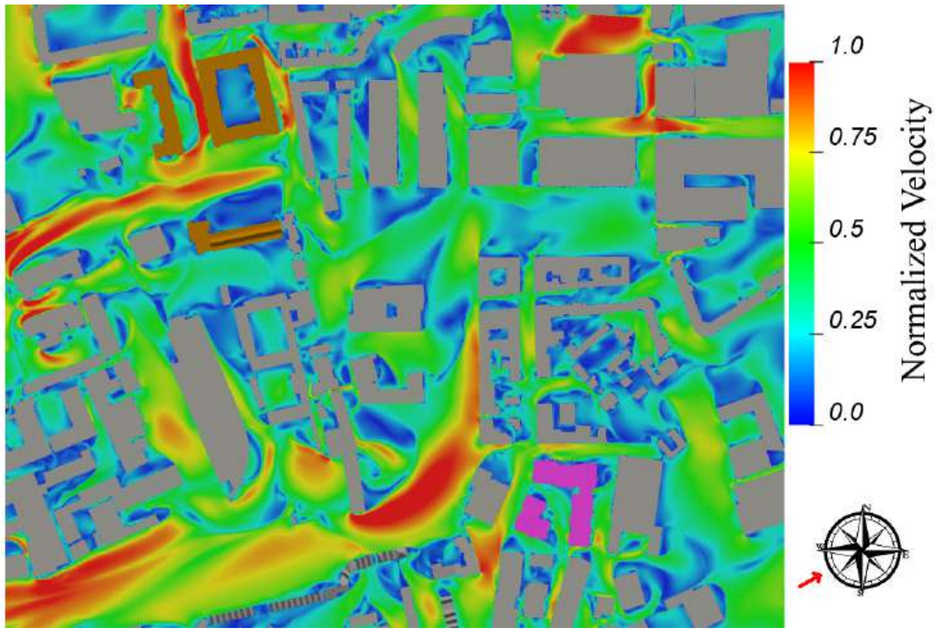


Figure 9.18: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 240°

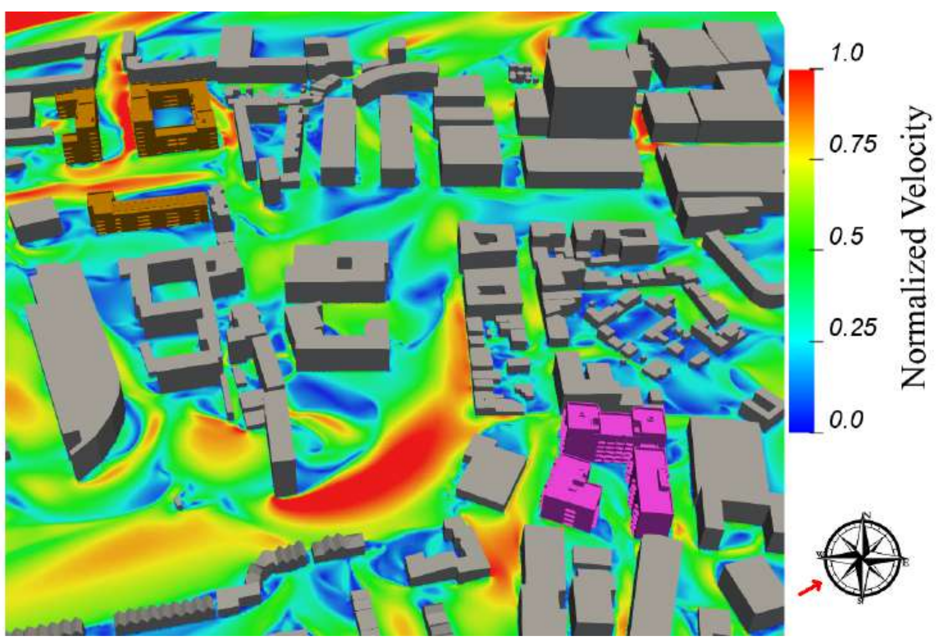


Figure 9.19: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 240°

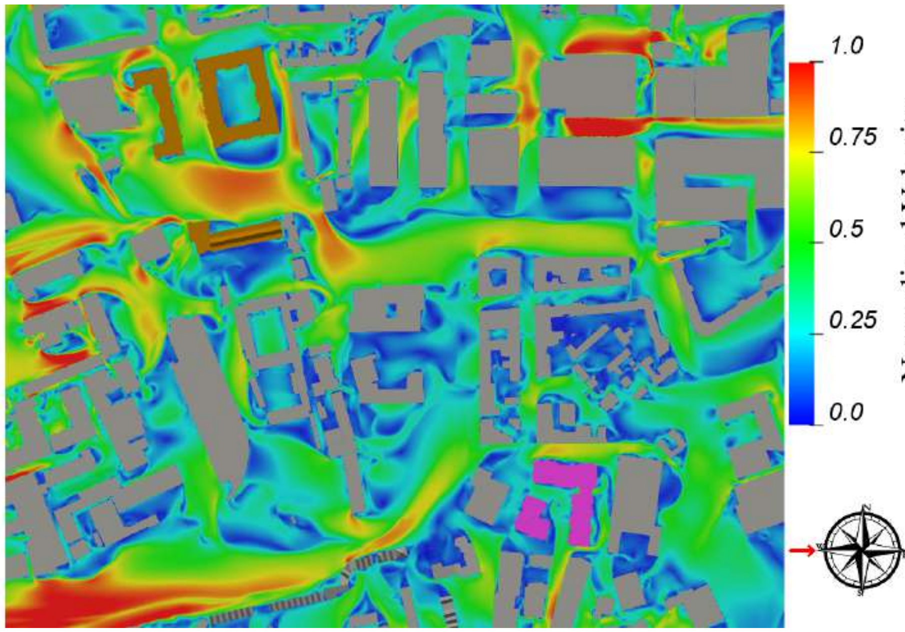


Figure 9.20: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

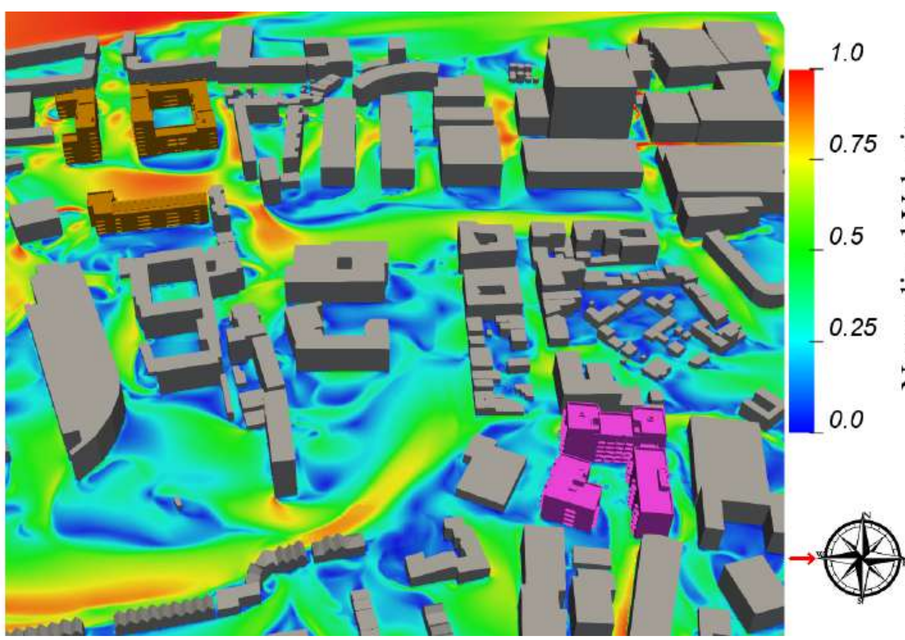


Figure 9.21: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 270°

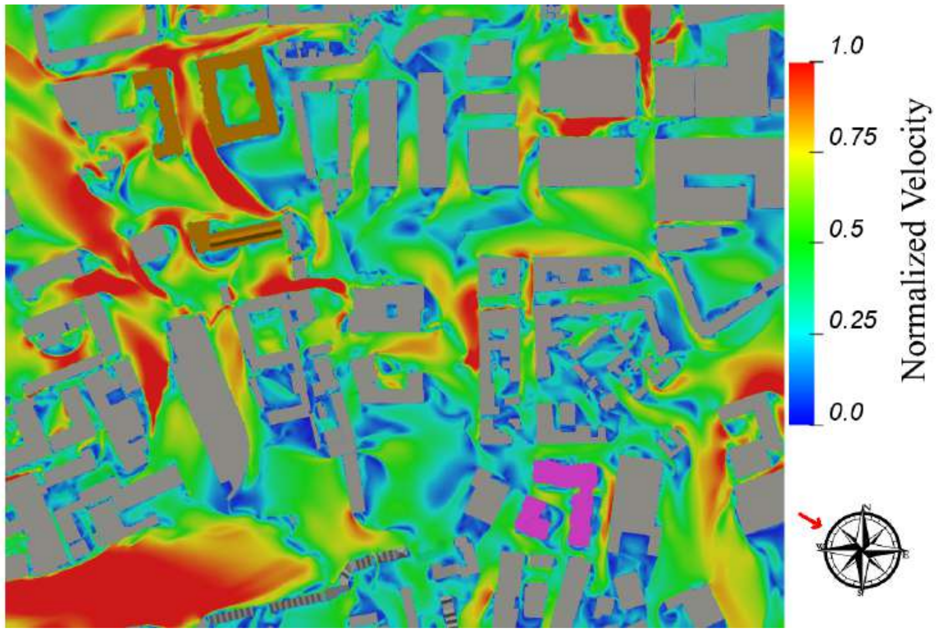


Figure 9.22: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 300°

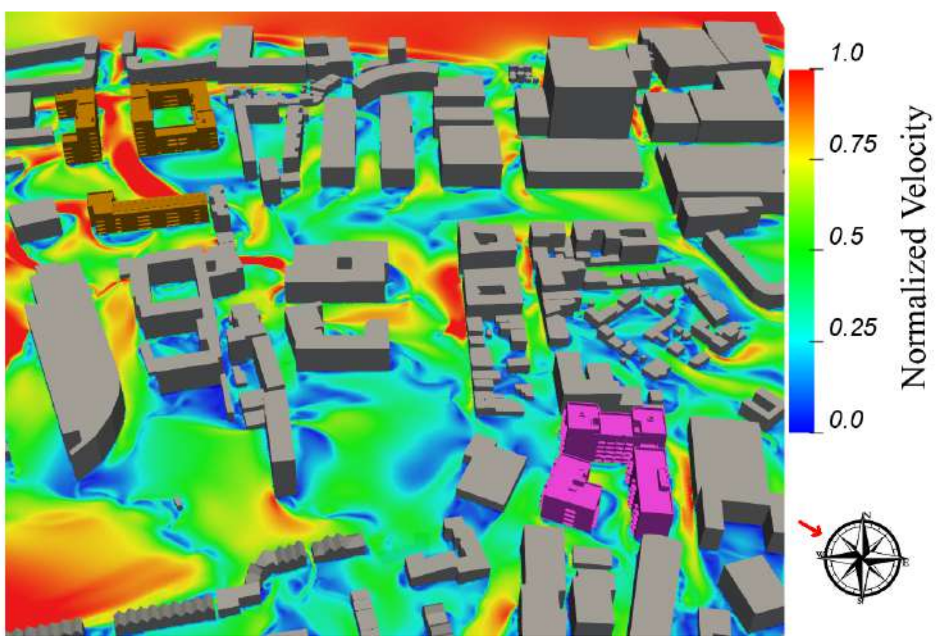


Figure 9.23: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 300°

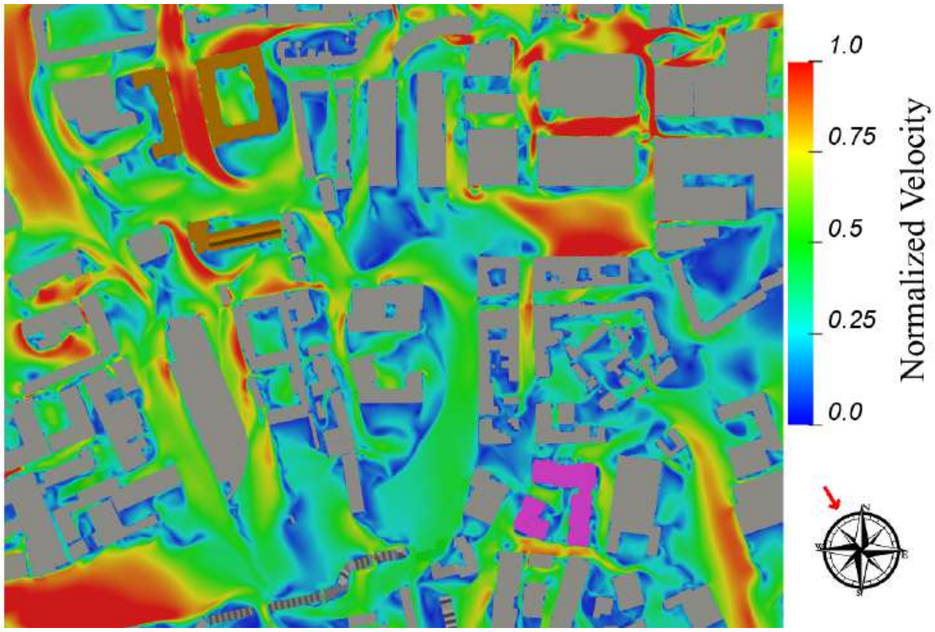


Figure 9.24: Top View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 330°

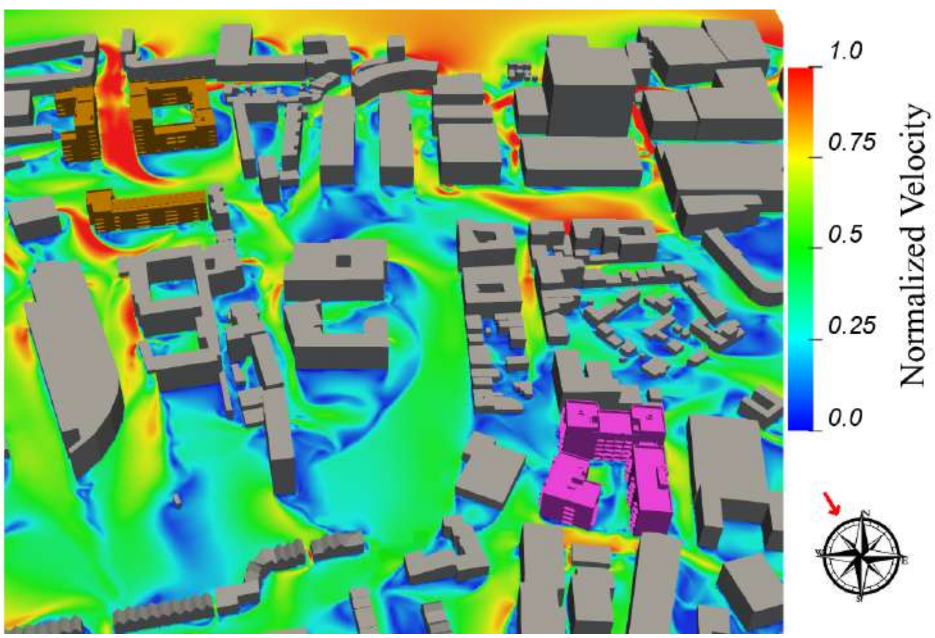
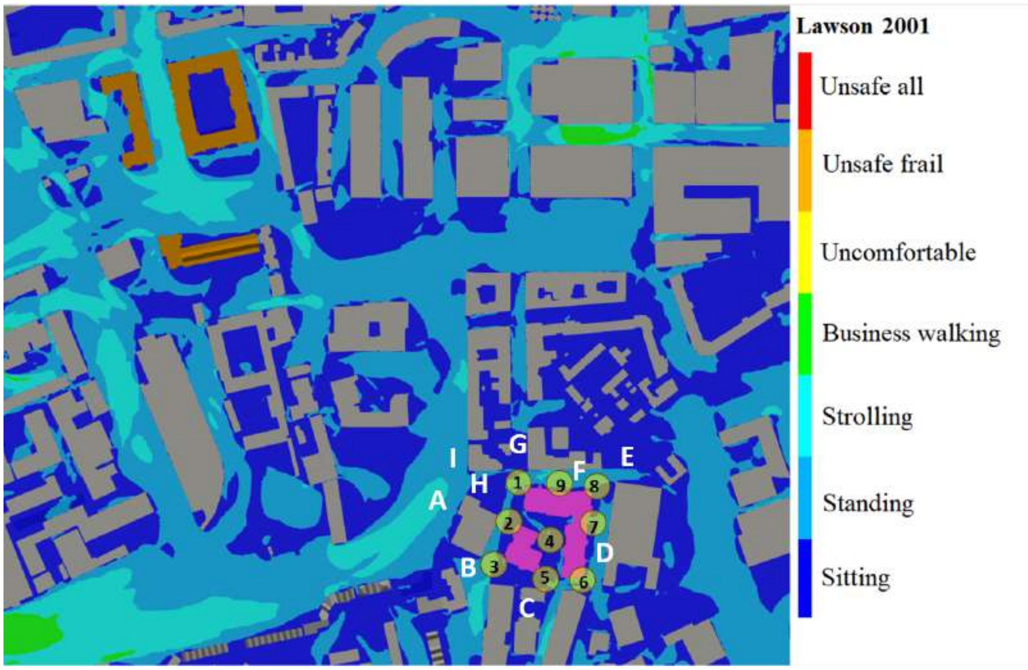


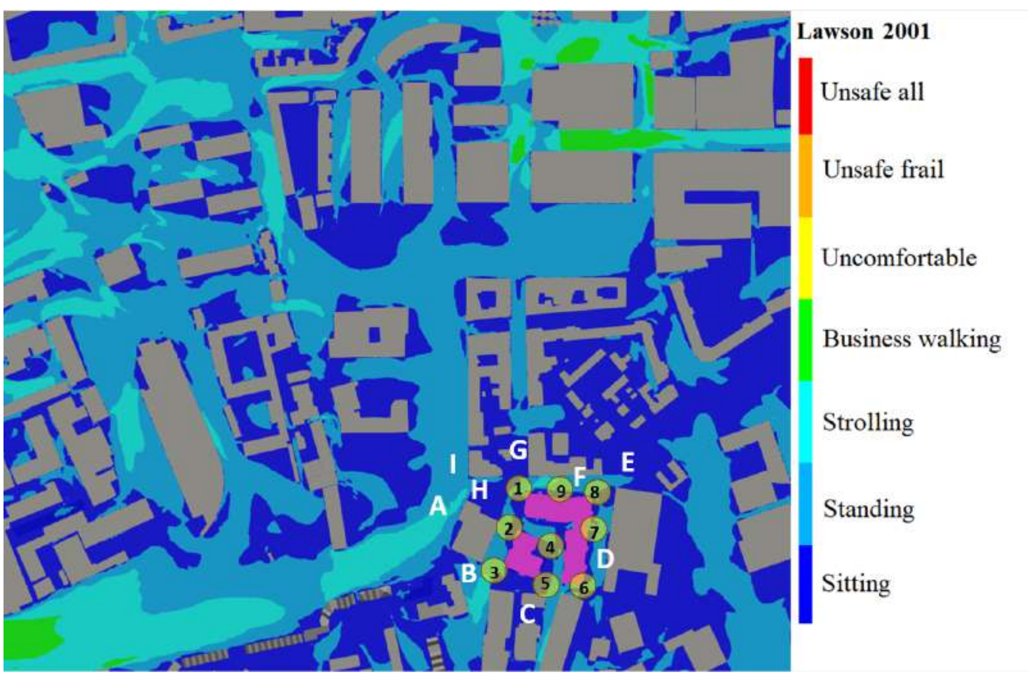
Figure 9.25: 3D View - Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 330°

9.1.2 CUMULATIVE IMPACT - Lawson Criteria

A comparison of Lawson Comfort and Distress Maps for proposed development scenario and the cumulative scenario is presented in Figure 9.26



Cumulative Scenario



Proposed Development Scenario

Figure 9.26: Comparison Wind Microclimate Conditions (Lawson Comfort/Distress Map)

Tables 9.1 and 9.2 show the proposed and cumulative wind conditions on-site as well as some potential off-site receptors around the development. Locations of the ground amenity areas listed in these Tables are indicated in Figure 9.27.

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

On-Site Potential Receptors	Proposed Development Conditions	Cumulative Conditions	Impact Significance
1. Crossing of Pim Street and Forbes Lane	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
2. Western Pedestrian Walkway	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
3. Accessible Parking Space	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
4. Courtyard	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
5. Southern Pedestrian Walkway	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
6. Southern Entrance on Marrowbone Lane	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
7. Eastern Pedestrian Walkway	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
8. Northern Entrance on Forbes Lane	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
9. Northern Pedestrian Walkway	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

Table 9.2: Significance Impact of the Cumulative Scenario Versus Proposed Conditions for Comfort - Off Site Receptors

Off-Site Potential Receptors	Proposed Development Conditions	Cumulative Conditions	Impact Significance
A. Jame's Walk	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
B. Parking Lot	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
C. Pedestrian Walkway	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
D. Marrowbone Lane	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
E. Parking Lot	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
F. Forbes Lane	Suitable for Standing/Strolling. (Safe/No distress)	Suitable for Standing/Strolling. (Safe/No distress)	Negligible
G. Pim Street	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
H. Parking Lot	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
I. Long's Place	Suitable for Sitting/Standing. (Safe/No distress)	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

Figure 9.27: Locations of the On-Site (Yellow Label) and Off-Site Receptors (Blue Label)

As shown in Tables 8.2 and 8.3, there are no distress area for pedestrians including frail users and cyclist. furthermore, the site and surrounding urban areas are safe for all users.

10. CONCLUSIONS

CONCLUSIONS and COMMENTS ON MICROCLIMATE STUDY

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Forbes Lane Development, Forbes Lane, Dublin 8.

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

The results of this wind microclimate study are utilized by Dublin City Council to configure the optimal layout for Forbes Lane Development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which was obtained form historical meteorological data recorded 10m above ground level at Dublin Airport.
- A 12-discrete set of wind directions is used to evaluate the probability of exceedance at any given threshold speed. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Forbes Lane Development and its environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- The Lawson Comfort and Distress Map on 1.5m above balcony floor indicates that all balconies are safe for occupants with no identified distress areas.
- The following mitigation measures will be implemented to further improve pedestrian comfort around the development:
  - *Introducing additional trees on ground amenities of the development:*
    These additional plants will help reduce wind speed, increasing comfort levels in all ground amenities of the development.
- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for “Frail persons or cyclists” and for members of the ”General Public” in the surrounding of the development.

- As a result of the construction of cumulative buildings in the future, the wind conditions on the surrounding urban context remains the same when compared with the proposed development situation. The cumulative buildings will have a negligible effect on the surrounding wind microclimate.
- A revised iteration of the proposed scheme was reviewed on 22 August 2024. The main key differences and similarities between the revised design and the original design are:
  - Block A has moved 900 mm to the west in the revised design.
  - Block B remains unchanged.
  - The dimensions and shapes of Blocks A and B are identical in both designs.
- Since the revised design's massing and height remain unchanged, and the reduced distance between Block A and Block B by 0.9 meter has a negligible effect on wind conditions, it can be concluded that the revised design maintains a comfortable and safe environment for pedestrians at ground level, remaining suitable for sitting/standing comfort level.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Dublin for the past 15 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.**

11. REFERENCES

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