155		50.27%	35.12%	15.15%	50.27%	35.12%	15.15%	50.27%	35.12%	15.15%	50.27%	35.12%	15.15%	Yes	Yes	1.00	1.00	No	
156	Floor 04	50.89%	34.26%	16.63%	50.89%	34.26%	16.63%	50.89%	34.26%	16.63%	50.89%	34.26%	16.63%	Yes	Yes	1.00	1.00	No	Imperceptible
157		41.49%	26.96%	14.53%	41.10%	26.57%	14.53%	41.49%	26.96%	14.53%	41.10%	26.57%	14.53%	No	Yes	0.99	1.00	No	
158		21.21%	13.83%	7.38%	14.92%	8.16%	6.76%	21.21%	13.83%	7.38%	14.92%	8.16%	6.76%	No	No	0.70	0.92	Yes	
159		4.35%	4.35%	0.00%	3.88%	3.88%	0.00%	0.93%	0.93%	0.00%	0.47%	0.47%	0.00%	No	No	0.11	1.00	No	
160		29.14%	18.81%	10.33%	29.14%	18.81%	10.33%	28.83%	18.50%	10.33%	28.83%	18.50%	10.33%	No	No	0.99	1.00	No	
161		27.74%	17.56%	10.18%	27.74%	17.56%	10.18%	27.74%	17.56%	10.18%	27.74%	17.56%	10.18%	Yes	Yes	1.00	1.00	No	

* For the purposes of this calculation, summer is taken to mean the period between March and September, and winter is considered to be the period between September and March.

** Survey information of all structures on private lands surrounding the application site was not available. Where insufficient survey information was available and window sizes / locations could not be informed by information available from the online planning register or from aerial photography, window sizes / locations were estimated by ARC.

* The "Cumulative Existing" scenario refers to the existing receiving environment, together with the Whitehaven development permitted under ABP Ref. TA06F.313317 on the adjoining site to the east of the application site. This scenario assumes no change to the application site.

** The "Cumulative Proposed" scenario refers to the existing receiving environment, together with the Whitehaven development permitted under ABP Ref. TA06F.313317 on the adjoining site to the east of the application site.

Detailed analysis of the potential cumulative impact of the proposed development, in combination with the permitted Whitehaven development (ABP Ref. TA06F.313317) on the adjoining site to the east, on sunlight access to existing gardens and amenity areas outside the application site

This analysis assesses the potential for the proposed development, in combination with the permitted Whitehaven development (ABP Ref. TA06F.313317) on the adjoining site to the east, to result in cumulative impacts on all potential receptors surrounding the application site - these impacts are described in the overview section above. However, by way of example in order to illustrate briefly the findings outlined in the overview section, ARC conducted detailed analysis of the potential for the proposed development, in combination with the permitted Whitehaven development (ABP Ref. TA06F.313317) on the adjoining site to the east, to result in impacts on sunlight access to a representative sample of existing gardens and amenity areas in proximity to the application site (please see **Figure 10-7** above).

The results of ARC's analysis are set out in **Table 10.6** below:

Table 10.6: Potential impact of the proposed development on sunlight access to sample neighbouring gardens / amenity spaces

Rear Garden	Proportion of space (grid points) capable of receiving two hours of sunlight on 21st March				Change	Potential Impact	Comment
	Existing	Existing Cumulative	Proposed	Cumulative Proposed	Change under Cumulative Scenario expressed as "times existing value"	(The impact of the cumulative scenario on existing development)	(The impact of the cumulative scenario on existing development)
29 Cedarview	64.65%	64.65%	64.65%	64.65%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (65 sq m) capable of receiving two hours of sunlight on 21st March.
30 Cedarview	62.64%	62.64%	62.64%	62.64%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (59 sq m) capable of receiving two hours of sunlight on 21st March.
31 Cedarview	84.22%	84.22%	84.22%	84.22%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (68 sq m) capable of receiving two hours of sunlight on 21st March.
32 Cedarview	56.19%	56.19%	56.19%	56.19%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (67 sq m) capable of receiving two hours of sunlight on 21st March.
33 Cedarview	49.93%	49.93%	49.93%	49.93%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (56 sq m) capable of receiving two hours of sunlight on 21st March.
34 Cedarview	53.92%	53.92%	53.92%	53.92%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (62 sq m) capable of receiving two hours of sunlight on 21st March.
35 Cedarview	77.59%	77.59%	77.59%	77.59%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (76 sq m) capable of receiving two hours of sunlight on 21st March.
36 Cedarview	58.05%	58.05%	58.05%	58.05%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (61 sq m) capable of receiving two hours of sunlight on 21st March.
37 Cedarview	24.88%	24.88%	24.88%	24.88%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (40 sq m) capable of receiving two hours of sunlight on 21st March.
38 Cedarview	36.06%	36.06%	36.06%	36.06%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (52 sq m) capable of receiving two hours of sunlight on 21st March.
39 Cedarview	39.12%	39.12%	39.12%	39.12%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (52 sq m) capable of receiving two hours of sunlight on 21st March.
40 Cedarview	37.81%	37.81%	37.81%	37.81%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (57 sq m) capable of receiving two hours of sunlight on 21st March.
41 Cedarview	56.68%	56.68%	56.68%	56.68%	1.00	None	ARC's analysis indicates that, under a cumulative scenario, shadows cast by the proposed development will not result in any change in the proportion of this space (58 sq m) capable of receiving two hours of sunlight on 21st March.

10.4.8 Residual Impact

Construction Phase

As no mitigation measures are now proposed, the residual impact of the proposed development on sunlight access is likely to be as described under **Section 10.4.5** above.

Operational Phase

As no mitigation measures are now proposed, the residual impact of the proposed development on sunlight access is likely to be as described under **Section 10.4.5** above.

Cumulative Impact

As no mitigation measures are now proposed, the residual cumulative impact of the proposed development, in combination with development envisaged for the neighbouring site, on sunlight access is likely to be as described under **Section 10.4.7** above.

10.4.9 Risks to Human Health

The Building Research Establishment's Site layout planning for daylight and sunlight: a guide to good practice (the BRE Guide) states: *"People like sunlight. In surveys around 90% said they appreciated having sunlight in their homes. The sun is seen as providing light and warmth, making rooms look bright and cheerful and also having a therapeutic health giving effect."*

Whereas the BRE Guide point out that sunlight access has implications for human health and recommends minimum levels for sunlight access, the BRE Guide does not suggest levels of sunlight required to ensure human health or discuss the implications of a reduction in sunlight access on human health.

10.4.10 Interactions

As is always the case where a development will result in a change to the sunlight environment within existing buildings, the impacts of the development on sunlight access will result in interactions with population and human health.

10.5 Monitoring

Monitoring of avoidance, remedial and mitigation measures is not relevant to the assessment of impacts on daylight and sunlight access in the case of the subject application.

10.6 Reinstatement

Reinstatement is not relevant to the assessment of impacts of the proposed development on daylight and sunlight access in the case of the subject application. It is intended that the proposed development will be permanent.

10.7 Difficulties Encountered

It was considered neither possible nor practical for the Design Team to gain unfettered access to every parcel of private property within the study area surrounding the application site in order to carry out measured building survey. Therefore, while ARC has confidence that the three dimensional model used in the assessment of the impact of the proposal on daylight access achieves a high degree of accuracy, it should be noted that some level of assumption was necessary in completing the model.

It was considered neither possible nor practical to carry out detailed quantitative analysis of the potential impact of the construction phase of the proposed development as insufficient detail was available regarding what structures or objects related to the construction (e.g. hoarding, machinery, etc) capable of resulting in an obstruction of sunlight or daylight access would be on the site or exactly where those structures or objects would be on the site. Even if this information was available, any such detailed quantitative analysis would represent only a snapshot in time.

As noted above, in assessing sunlight and daylight access, Irish practitioners tend to refer to PJ Littlefair's *Site layout planning for daylight and sunlight: a guide to good practice* for the Building Research

Establishment (the BRE Guide). However, it is noted that the BRE Guide does not set out rigid standards or limits and is preceded by the following very clear warning as to how the design advice contained therein should be used: *"The advice given here is not mandatory and the guide should not be seen as an instrument of planning policy; its aim is to help rather than constrain the designer. Although it gives numerical guidelines, these should be interpreted flexibly since natural lighting is only one of many factors in site layout design."* [Emphasis added.]

To the west of the application site, a dense band of mature deciduous trees, which are protected under a Tree Protection Order, intervene between the development now proposed and the eastern façade of the recently constructed, residential development at Blackwood Square. These trees overshadow the eastern façade of Blackwood Square. Including trees within an assessment model for sunlight analysis can be problematic as, given that trees are living and growing things, even if accurate three dimensional survey information of existing trees is available, that survey would only illustrate a snapshot in time. Moreover, having regard to the constraints of proprietary sunlight and daylight analysis software, existing trees are modelled in simple forms and as solid objects and would not accurately reflect the impact of deciduous trees, which have irregularities and gaps allowing sunlight to pass through and which change over the course of the year. For these reasons and having regard to the recommendations of the BRE Guide on the inclusion of trees in assessment models, this dense band of mature deciduous trees was not included in the assessment model for this EIAR Chapter. However, it should be noted that, as a result of this omission, the potential impact of the proposed development on the eastern façade of the Blackwood Square development (particularly in terms of the impact on sunlight access) described in this EIAR Chapter is greater than would actually be the case.

10.8 Legal Notice

This assessment has been prepared by ARC Architectural Consultants Ltd for the benefit of the Applicant only and in accordance with our instructions. ARC Architectural Consultants Ltd disclaims any liability, legal or otherwise, from any party, other than the Applicant, seeking to rely upon the content of this Chapter.

10.9 References

- British Standards Institution (2008) BS8206: Part 2: 2008 Lighting for Buildings: Part 2 – Code of Practice for Daylight. Milton Keynes, BSI.
- B.S. EN 17037:2018: Daylight in Buildings.
- Council Directive 14/52/EU (amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment) (Official Journal No. L 124/1, 25.4.2014)
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- Littlefair, PJ. 2011. Site Layout Planning for Daylight and Sunlight: A Good Practice Guide. Watford: Building Research Establishment.
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11 MICROCLIMATE: WIND

11.1 Introduction

B-Fluid Limited has been commissioned by JOM Investments Unlimited to perform a Wind Micro-climate Modelling Study in relation to a proposed development which comprises a large-scale residential (LRD) development on a site off Northwood Avenue, Santry, Dublin 9, generally incorporating the existing surface car parking area associated with Swift Square Office Park and adjacent lands.

In summary, the proposed development will consist of the following:

- Site clearance, including the removal of all structures on site part of existing surface car parking;
- Relocation of existing surface car parking spaces catering for Swift Square Office Park personnel to the new basement accessible via a new ramp off the local road from Northwood Avenue, and the new undercroft parking area with access at street level off the local road to the north of the site;
- Construction of 3 no. apartment blocks (1, 2 and 3) over a partially shared podium structure, with heights ranging from 4 to 9 storeys, comprising 192 no. apartment units (4 no. 1-bedroom units and 188 no. 2-bedroom units), ancillary residential uses and associated car and bicycle parking;
- Provision of public and communal open spaces, public realm, boundary treatments, landscaping and lighting; refuse storage, associated drainage, attenuation and services; temporary car parking area and construction access; and all associated site development works.

A full description of the proposed development is set out in **Chapter 5** (Project Description) of Volume 2 of this EIAR and the statutory public notices part of the application. A suite of supporting documentation and drawings is also enclosed with the application and should be read in conjunction with this report. The site location of the proposed development is shown in **Figure 11-1.**

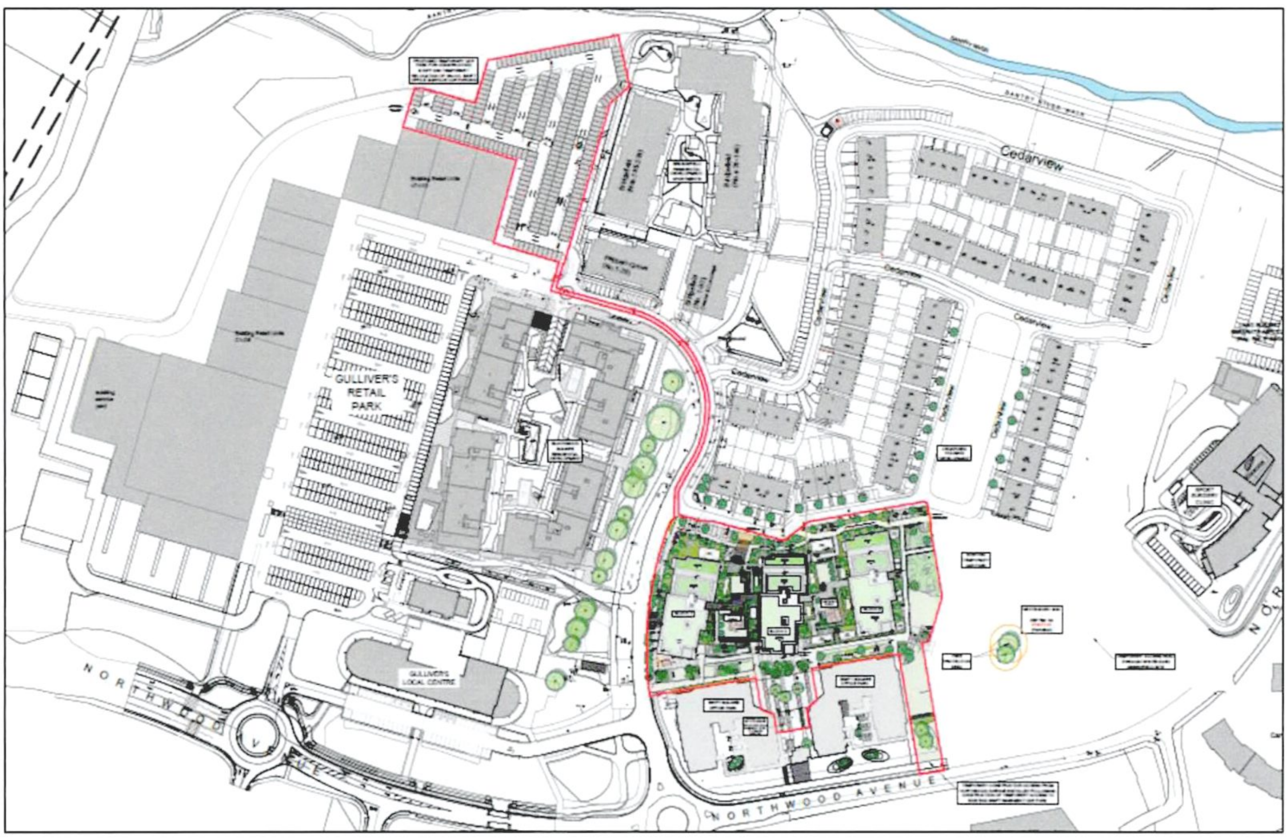


Figure 11-1: Site Location Map with Proposed Development in the Red Line Boundary

11.1.1 Author Information

This Chapter is completed by Dr. Cristina Paduano, Dr. Patrick Okolo 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 of experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Dr. Patrick Okolo 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. He holds a PhD in Aeroacoustics from Trinity College Dublin, a M.Sc. and B.Sc. in Mechanical 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.

11.1.2 Objective Of the Wind Microclimate Analysis

A Wind Microclimate Study identifies the possible wind patterns that form when the wind moves through a built environment and evaluates how new development is going to modify those patterns. Wind Microclimate is defined as the wind flow experienced by people and the subsequent influence it has on their activities. Wind can accelerate or re-circulate through buildings in a way that compromise the comfort/safety of pedestrians and the usage of public realm/ external places per their designated intended purpose.

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 analysed 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), are 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 on 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 concerning 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 analyses 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 to predict under which wind speeds pedestrians will be exposed and what level of comfort pedestrians will experience when carrying out a specific activity (i.e., walking, strolling, sitting).

The following sections detail 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.

11.1.3 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, the standard building height is considered 6-8 storeys. Above this height, buildings are considered 'taller' for Dublin standards.

The recommended approach to wind microclimate studies is outlined in the "*Wind Microclimate Guidelines for Developments in the City of London* '(August 2020) and 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.

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

Figure 11-2: Recommended Approach to Wind Microclimate Studies based on Building Height,

Source: Wind Microclimate Guidelines for Developments in the City of London (2020)

11.1.4 Urban Wind Effects

Buildings and topography affect the speed and direction of wind flow. 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, showing the wind velocity profile, as described above.

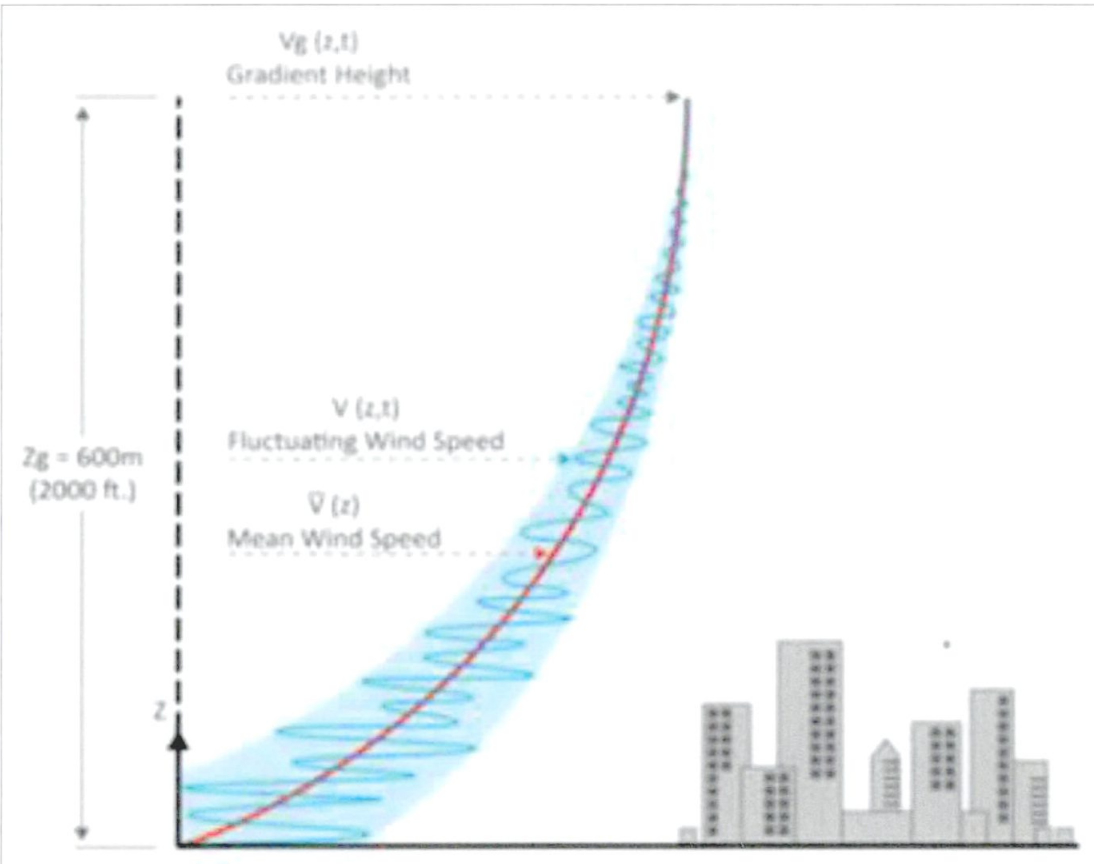


Figure 11-3: Atmospheric wind velocity profile

Source: Building Aerodynamics, Tom Lawons -. Imperial College Press, 2001

In an urban context, wind speeds at the 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 (Error! Reference source not found.). This pattern affects 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 the 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 on the leeward side of the building. This can cause sudden changes in wind velocity and can raise dust or lead to the accumulation of debris. This effect is also dependent on the height of the building.

The anticipation of the likely wind conditions resulting from new developments is an important consideration 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.

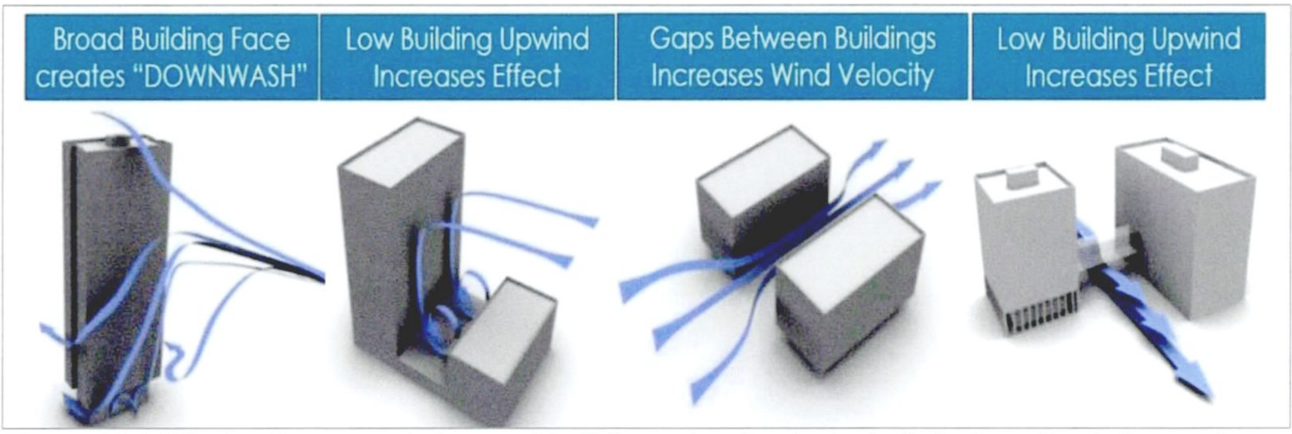


Figure 11-4: Wind patterns created around buildings showing typical wind microclimate in an urban context

Source: B-Fluid image renderings

11.2 Assessment Methodology

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 stations 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 the pedestrian level.

The assessment has comprised the following scenarios:

- **Baseline Existing Scenario**: this consists of the existing wind microclimate at the site.
- **Proposed Development in the Existing Scenario**: this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by the existing buildings.
- **Cumulative Scenario**: this consists of the assessment of the wind microclimate of the site with the proposed development considering the impacts of the existing and permitted buildings.

In particular, the following steps have 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 modeled using CFD OpenFOAM Software (CFD model and details are in **Appendix 11.1**).
- 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 with the Lawson Criteria.
- Computational Fluid Dynamics (CFD) has been used to simulate the local wind environment for the required scenarios ('baseline, proposed, cumulative").
- The impact of the proposed development massing on the local wind environment has been determined (showing the wind flows obtained at the pedestrian level).
- Potential receptors (pedestrian areas) have been assessed through a 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.

11.2.1 Definition of Study Area

Following the guideline cited in **Section 11.1.3**, the wind microclimate study should consider the effect of the proposed development together with buildings (existing and/or permitted) that area within at least 400m from the centre of the site. Other taller buildings outside of this zone that could have an influence on wind conditions within the project site should be included for wind directions where they are upwind of the project site.

Figure 11-5: Extents of Study Area in the Circle, following the Guidelines (Ref. 11.1.3)

Source: Google Maps, annotations by B-Fluid

11.2.2 Assessment Criteria

11.2.2.1 Pedestrian Comfort and Distress Criteria

"Lawson Comfort and Distress Criteria" has been developed for wind microclimate studies as a means of assessing the long-term suitability of urban areas for walking or sitting, accounting for both microclimatic wind effects (i.e., site location and prevailing winds) and microclimatic air movement associated with wind forces influenced by the localised built environment forms and landscaping effects.

The Lawson scale assesses pedestrian wind comfort in absolute terms and defines the reaction of an average person to the wind.

For the distress (safety) criterion, only gust winds are considered. 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 most 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 local authorities as well as the international building design and city planning community:

- COMFORT CRITERIA: Relates to the activity of the individual.
  The 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 5% of the time.
- DISTRESS CRITERIA: Relates to the physical well-being of the individual.
  The 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 (0.022% of the times). This is intended to identify wind conditions that 'less physically able' individuals or cyclists may find physically difficult. Conditions more than this limit may be acceptable for optional routes and routes that '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.

Table 11.1: Lawson Pedestrian Comfort/Distress Criteria Details

Pedestrian Comfort Category (Lawson Scale)	Mean And Gem Wind Speed Not to Be Exceeded More Than 5% Of The Time	Description
Long-Term 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

Table 11.2: Lawson Pedestrian Comfort/Distress Criteria Details of Unsafe Conditions

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 cyclists/frail person

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 the 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 and distress criteria are assessed at 1.5m above ground level as required by the guideline cited in **Section 11.1.1.** If the predicted wind conditions exceed the threshold, then conditions are unacceptable for the type of pedestrian activity and mitigation measures should be implemented into the design.

11.2.2.2 Significance Criteria

The significance of on-site measurement locations is 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.

Table 11.3: On-site Receptors Significance Criteria extracted by Wind Microclimate Guidelines for Developments in the City of London (August 2020)

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

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

Table 11.4: Off-site Receptors Significance Criteria extracted by Wind Microclimate Guidelines for Developments in the City of London (August 2019)

Significance	Trigger	Mitigation Required?
Major Adverse	Conditions that were "safe" in the baseline scenario became "unsafe" because 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) because 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 to make them "safe").	No

11.2.3 Potential Receptors

Potential receptors for the wind assessment are all pedestrian circulation routes, building entrances, and leisure open areas within the site and in neighbouring adjacent areas. The pedestrian level is considered at 1.5m above ground in line with guidance recommendations as cited in **Section 11.1.3.** For the Swift Square Development, the potential on-Site receptors, comprise the following as shown in **Figure 11-6:**

- 2 Semi-private Courtyards between Block 1 and 2 and 2 and 3;
- A Communal Open Space;
- A Linear Park/Public Open Space;
- A Public Plaza;
- A Play Area.

Figure 11-6: Potential On-site Receptors for Swift Square Development

Source: Landscape Drawing 100 -0420

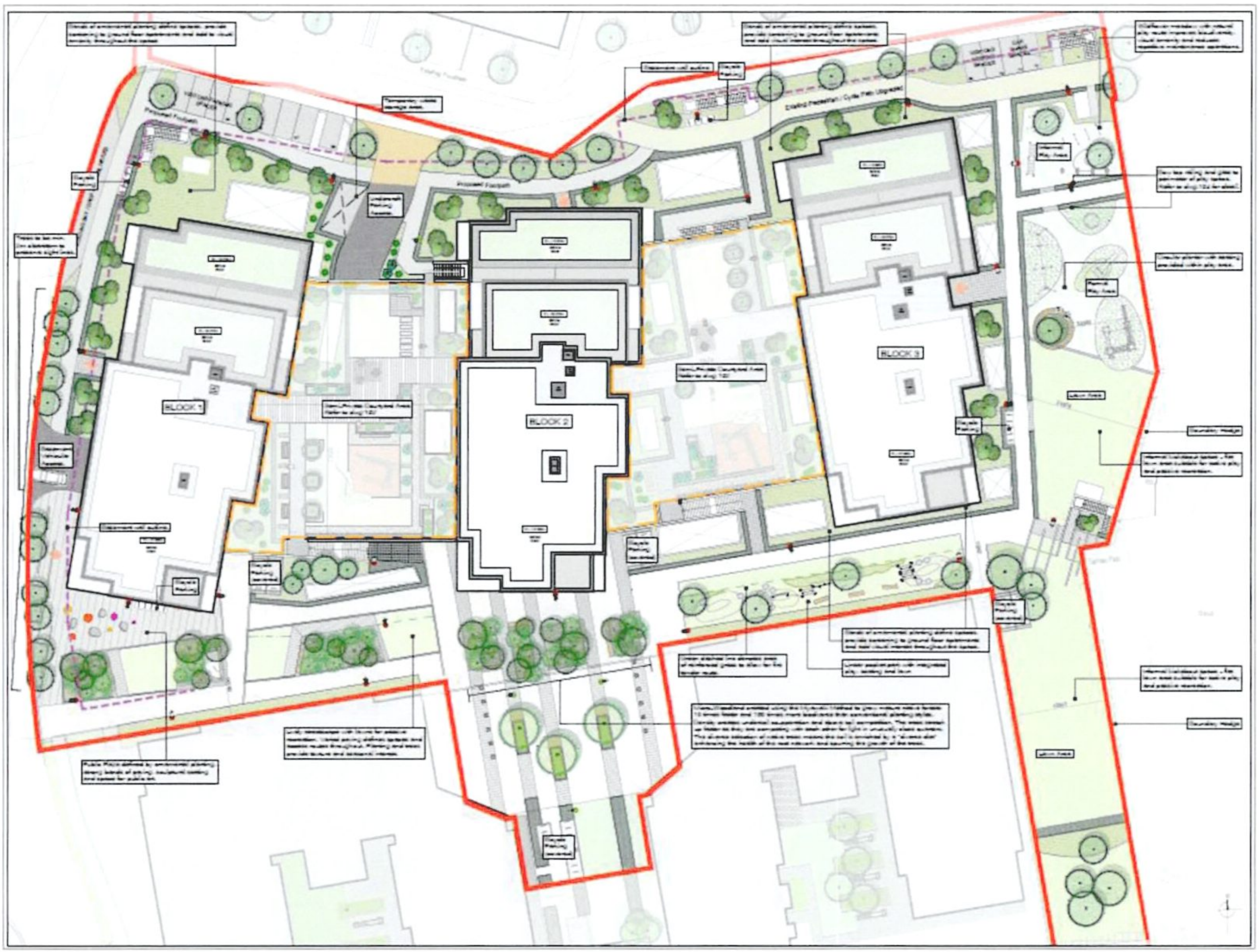


Figure 11-7: Potential On-site Receptors for Swift Square Development with Proposed Landscaping

Source: Landscape Drawing 101 – 0420

11.3 Baseline Conditions (Existing Environment)

The baseline environment consists of the area to be developed as shown in Error! Reference source not found. and **Figure 11-9** and its surroundings. The wind microclimate of the baseline environment is defined by the wind patterns that develop on the existing site under the local wind conditions shown in **Section 11.3.1.1** that follows. The existing context is analysed, and Lawson criteria are applied considering that pedestrian activities (walking, strolling) are taking place in the existing area.

Figure 11-8: Built-in Environment Around the Construction Site at Swift Square Development

Source: Google background with model by B-Fluid

Figure 11-9: 3D Model of the Existing Environment at Swift Square Development

Source: Google Maps background with model by B-Fluid

11.3.1 Local Wind Climate

A statistical analysis of 30 years of historical wind data has been carried out to characterise the existing wind climate in terms of wind speeds, frequency, and directions.

The existing wind conditions are obtained using the annual average of meteorology data collected at Dublin Airport Weather Station. **Figure 11-10** shows on the map the position of the subject site and the position of Dublin Airport.

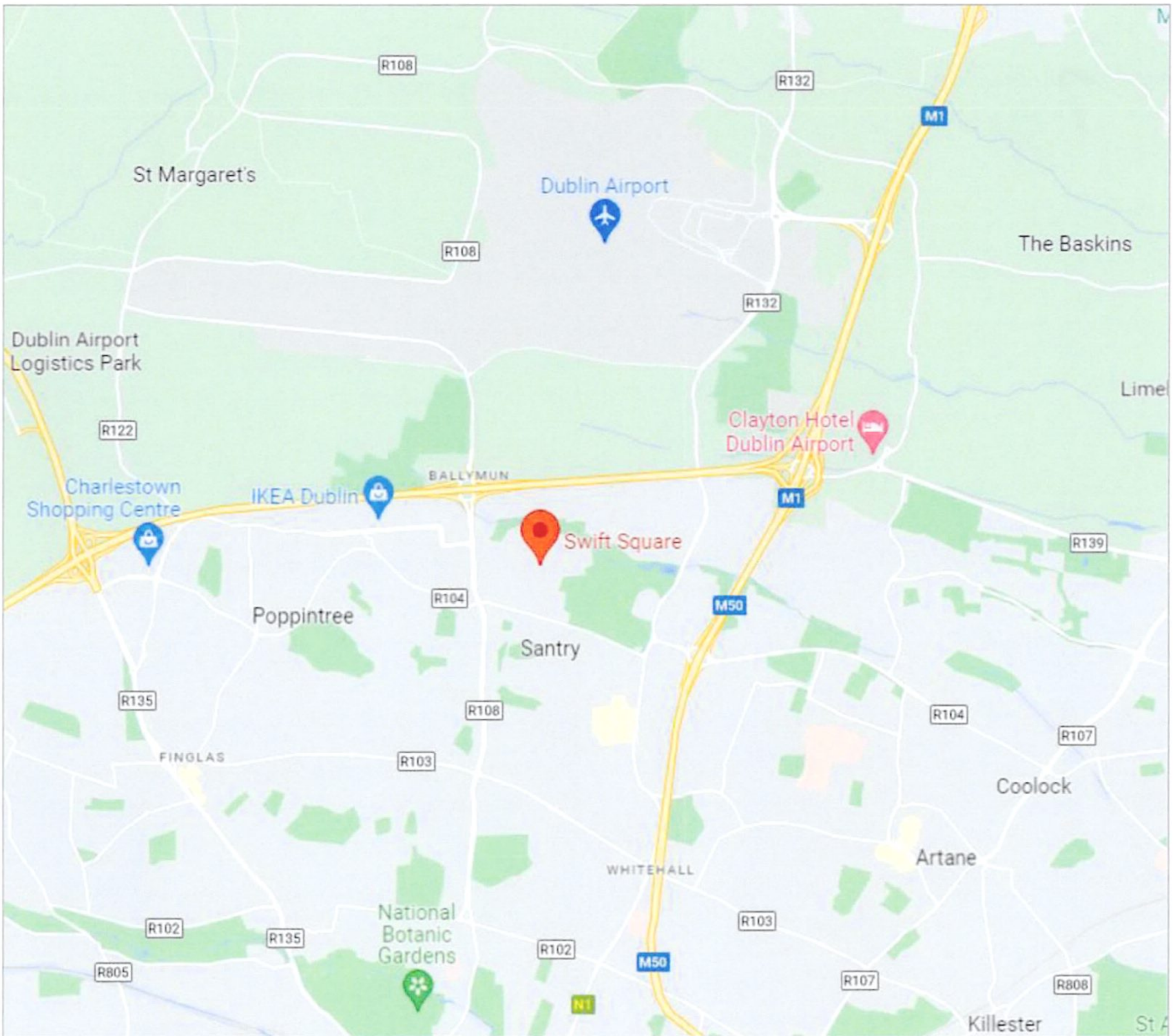


Figure 11-10: Map showing the position of Swift square development and Dublin Airport

Source: Google Maps, annotations by B-Fluid

Regarding the transferability of the available wind data from the Dublin Airport Weather Wind station to the site location, the following considerations have been made:

- **Terrain**: The meteorological station is located on the flat open terrain of the airport, whereas the development site is in an urban area with dense built-in structures with buildings of more than 20 m in height in average and with some buildings even taller.
- **Mean Wind Speeds**: Due to the different terrain environments, the ground-near wind speeds (at pedestrian level) will be lower at the proposed site compared to the meteorological station at the airport.
- **Wind Directions**: The landscape around the development site can principally be characterised as flat terrain. Isolated elevations in the near area of the development should not influence wind speed and wind directions. For 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 climate at the development site.

Two different data sets are analysed as follows:

- The meteorological data associated with the maximum daily wind speeds recorded over 30 years between 1990 and 2020 and,

- The mean hourly wind speeds were recorded over 10 years between 1990 and 2020. The data is recorded at a weather station at the airport, which is located 10m above ground or 71mOD.

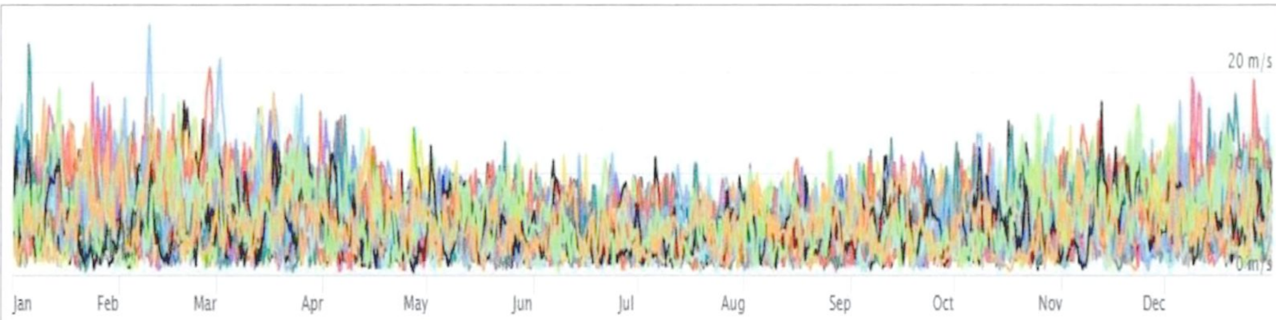


Figure 11-11: Local Wind Conditions - Wind Speed (Mean Values per Months)- historic data 1990-2020

Source: www.meteoblue.com

Furthermore, a Weibull distribution was fitted to the wind data for each wind direction simulated through the adoption of an appropriate dispersion parameter, c, and a shape parameter, k. In-house-based 'Python script' applies the factors to the simulation input wind conditions directly. The local data from Dublin Airport was transposed to the development site using the ESDU (Engineering Sciences Data Unit) methodology.

11.3.1.1 Local Wind for the Assessment of Pedestrian Comfort and Distress

The predominant wind directions on the baseline environment identify from which direction the wind is blowing on the site for most of the time during a typical year.

Following Lawson Criteria, if the proposed site is exposed to wind from a specific direction more than 5% 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.

A statistical analysis was carried out based on 2 historical wind data sources:

- Meteoblue (over 40 years of historical data – since 1979) – Dublin Airport
- Openweather (over 40 years of historical data – since 1979) – Dublin Airport and Site location

To understand and correctly validate the weather conditions at the site, a comparison was carried out between the historical data provided by both sources (Meteoblue and Openweather) at the weather station (Dublin Airport).

Data analysis and data visualization were obtained with an in-house program that is coded based on Python language. The speed and frequency of wind per direction were considered, and seasonal changes were analysed to indicate the prevailing wind directions (as shown in the following Figures).

Furthermore, statistical analysis of the number of hours and magnitudes of wind for 36 angles (10° increments) is performed to produce the Lawson plots. Each of the 36 wind directions was interpolated to calculate the probability that a velocity threshold will be exceeded.

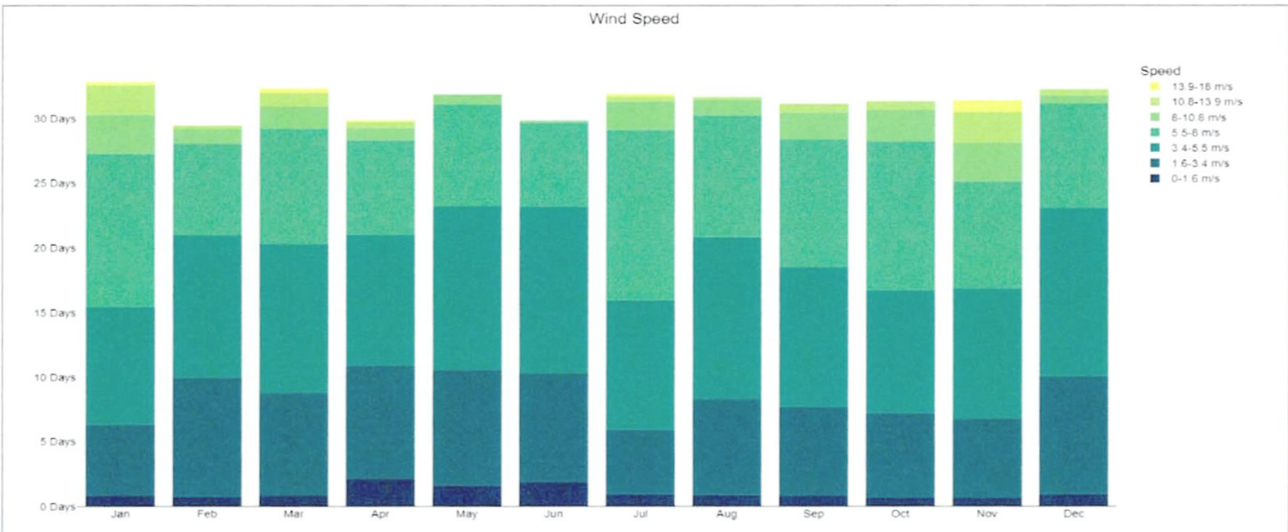
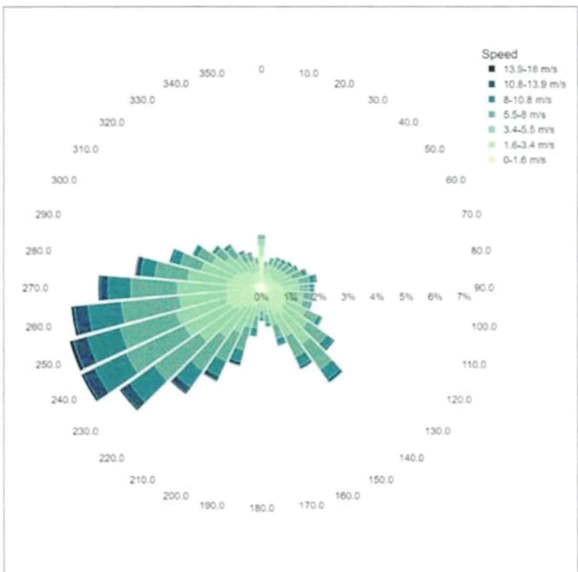


Figure 11-12: Dublin Wind Speed Diagram

Source www.Meteoblue.com- Graphics elaborated by B-Fluid



, presents the wind speed diagram for Dublin, the diagram shows how often (how many days per month) the wind blows with a specific speed.

Figure 11-13, shows the wind rose for Dublin and details how often (how many hours per year in this case) the wind blows from a specific direction, these data highlight that the predominant wind directions for the site are West-South-West, West, and South-West.

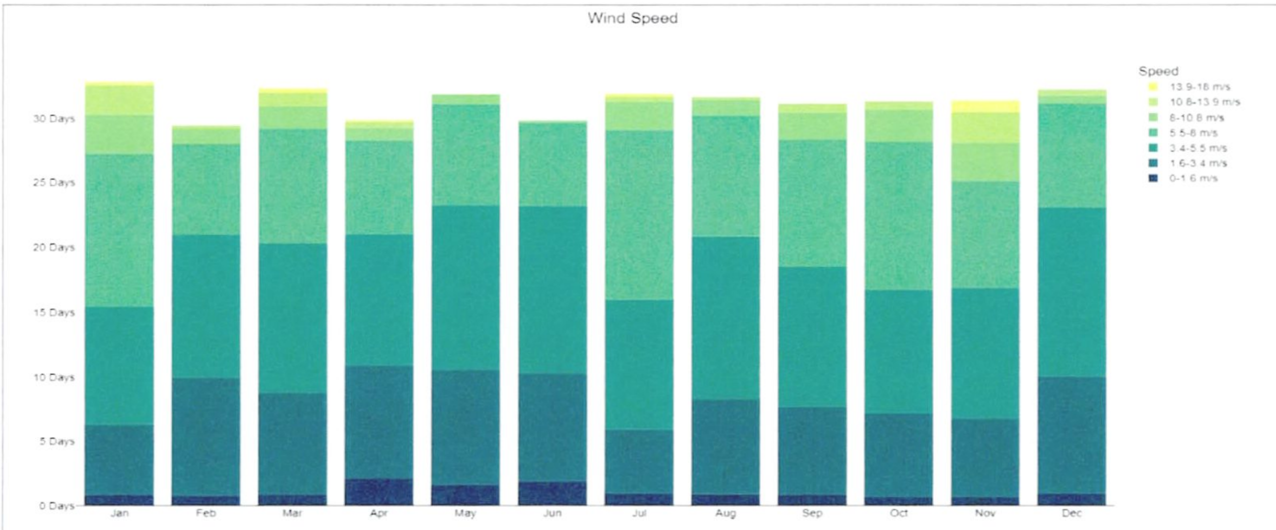


Figure 11-12: Dublin Wind Speed Diagram

Source [www.Meteoblue.com-](www.Meteoblue.com) Graphics elaborated by B-Fluid

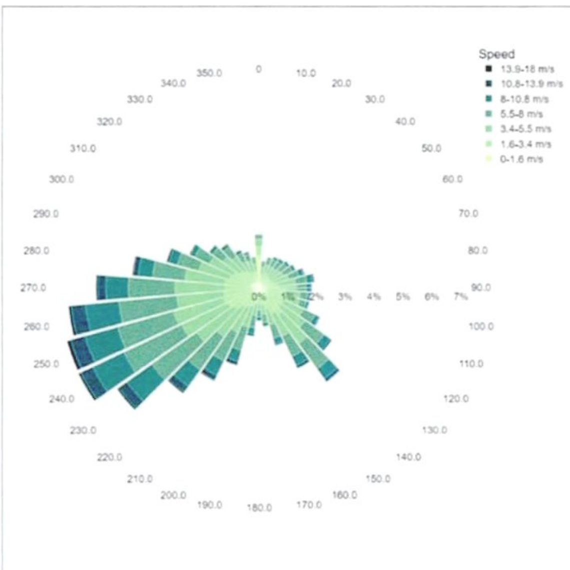


Figure 11-13: Local Wind Rose with wind frequency of occurrence details

Source [www.Meteoblue.com -](www.Meteoblue.com) Graphics elaborated by B-Fluid

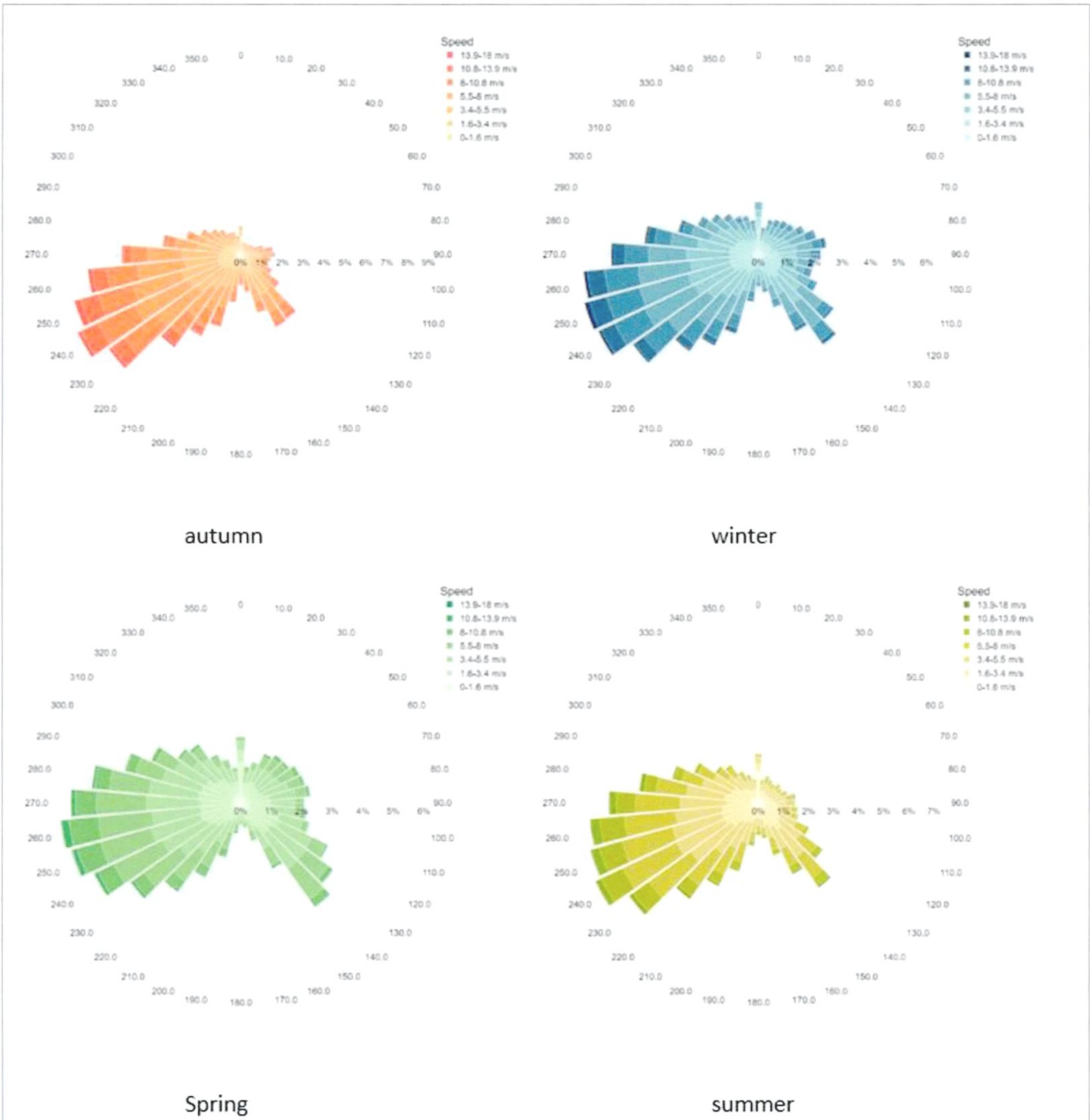


Figure 11-14: Wind speeds and wind directions at different seasons in Ireland

Source www.Meteoblue.com - Graphics elaborated by B-Fluid

The table that follows reports all the wind directions and their corresponding velocity, displayed in order of frequency of occurrence with those most frequent on the top.

As it can be noted, the wind at the site is mostly blowing (higher frequency of occurrence) from the South-West (225deg) direction with a wind velocity of approximately 5m/s. A similar wind speed is blowing also from the South-South-West direction (213deg), however, the frequency of occurrence of this wind is less than 5% (only 3.288% of the time, as indicated in the table) therefore, this wind is not relevant for the scope of performing the pedestrian comfort and distress analysis as per Lawson Criteria. For assessing the wind microclimate for the proposed development, the study has considered the site exposed to all the wind directions which exceed the 5% of frequency, as required for the Lawson Criteria, and some additional high-speed winds, which are occurring less often (below 5% of the times) but that can cause distress conditions because of their speed.

Table 11.5:Main Wind Directions Occurrence Frequency

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
4.581	101.25	2.340
4.169	45	2.180
3.558	90	2.135

For assessing the wind microclimate for the proposed development, the study has considered the site exposed to all the wind directions which exceed the 5% of frequency, as required for the Lawson Criteria, and some additional high-speed winds, which are occurring less often (below 5% of the times) but that can cause distress conditions because of their speed.

11.3.2 Wind Microclimate at Pedestrian Level (Existing Environment)

The results of the wind simulations carried out are detailed in the following sections. Results of wind microclimate at ground level (1.5m height - flow speeds) are collected throughout the modeled site and the impact of these on the potential receptors presented in the map shows the area of comfort and distress following Lawson Criteria.

These flow velocities identify if locally, wind speeds at the pedestrian level are accelerated or decelerated because of the presence of the existing baseline environment, when compared with the 'undisturbed' wind speed (i.e. wind speed recorded in an open area without developments).

As can be seen, wind speeds are shown to be within tenable conditions and in general similar to the wind speeds of the undisturbed flow for the direction considered, however, a slight acceleration is visible for the wind coming from the Southeast direction.

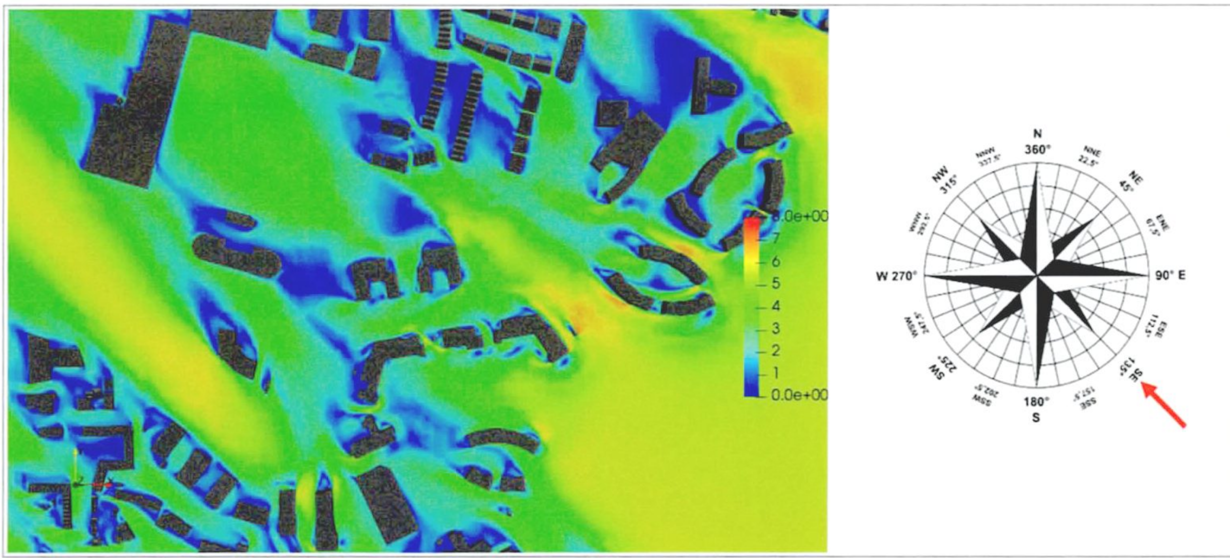


Figure 11-15: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 135°

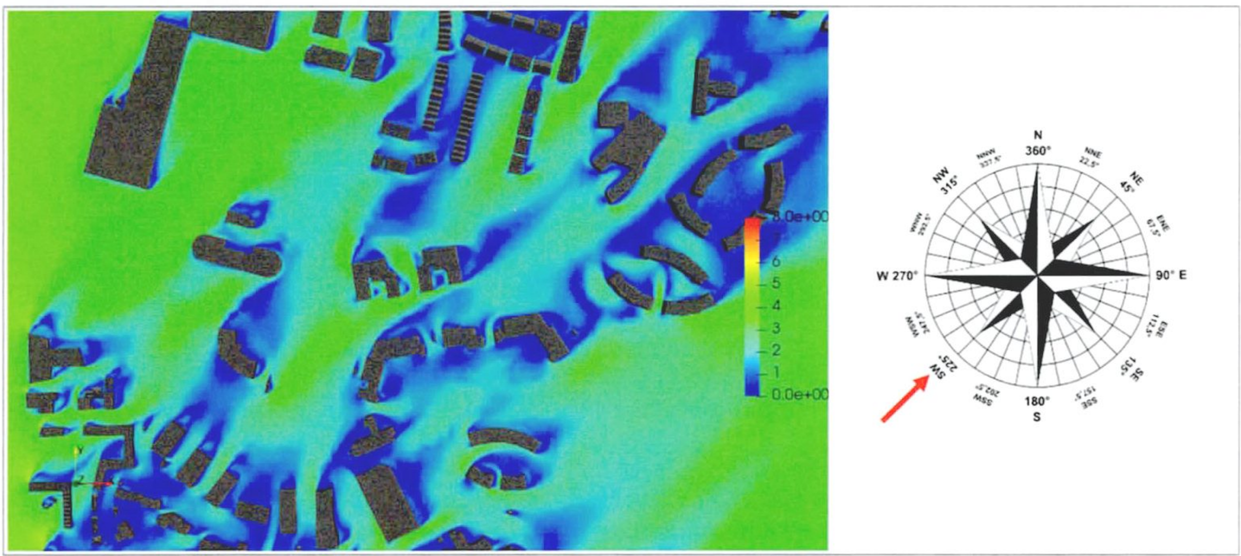


Figure 11-16: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 225°

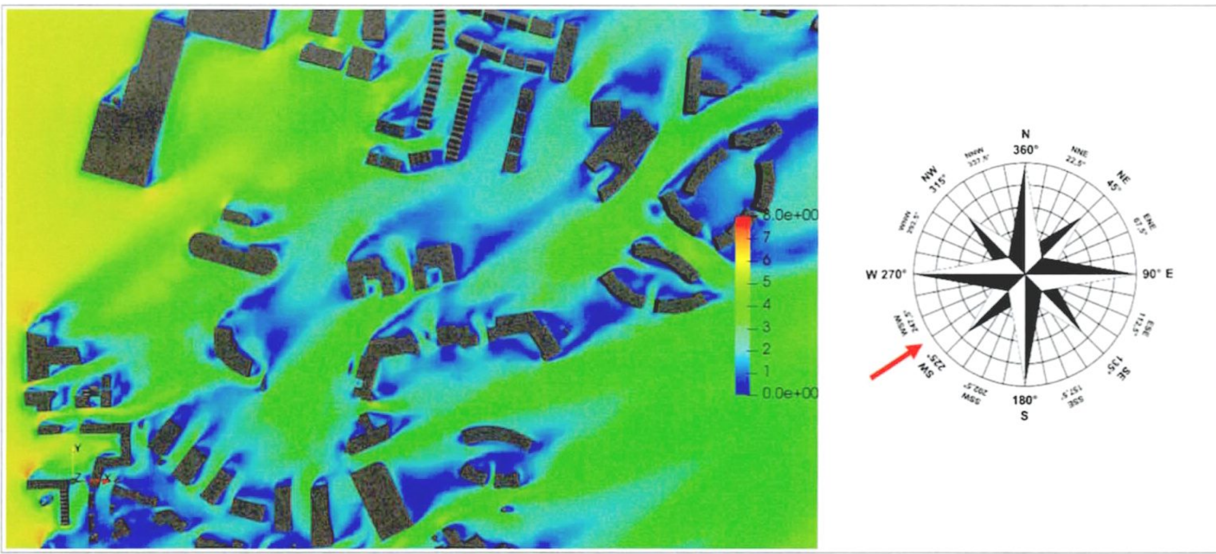


Figure 11-17: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 236°

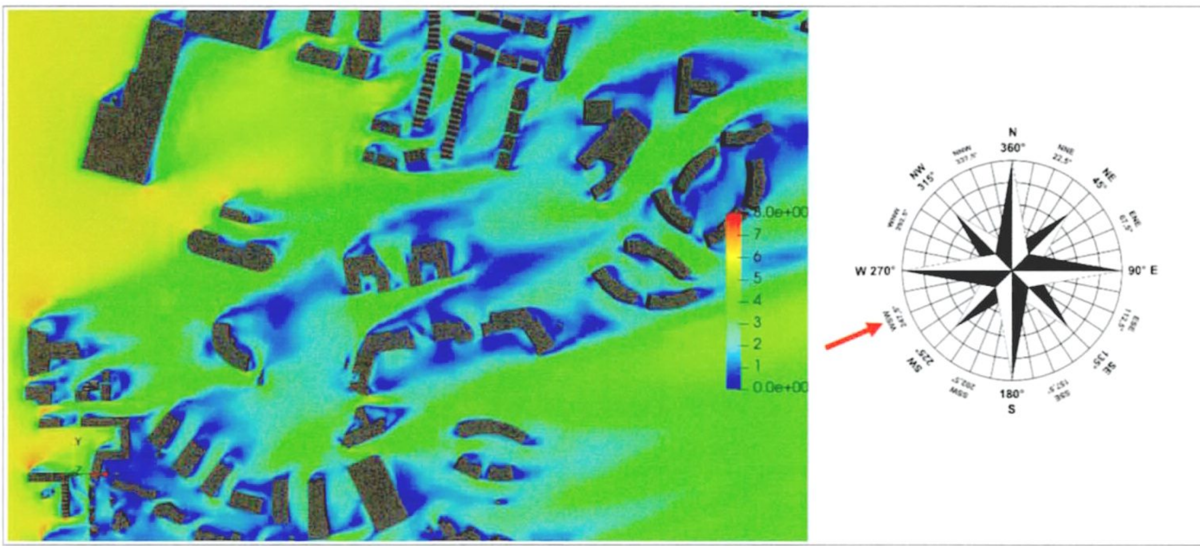


Figure 11-18: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 247°

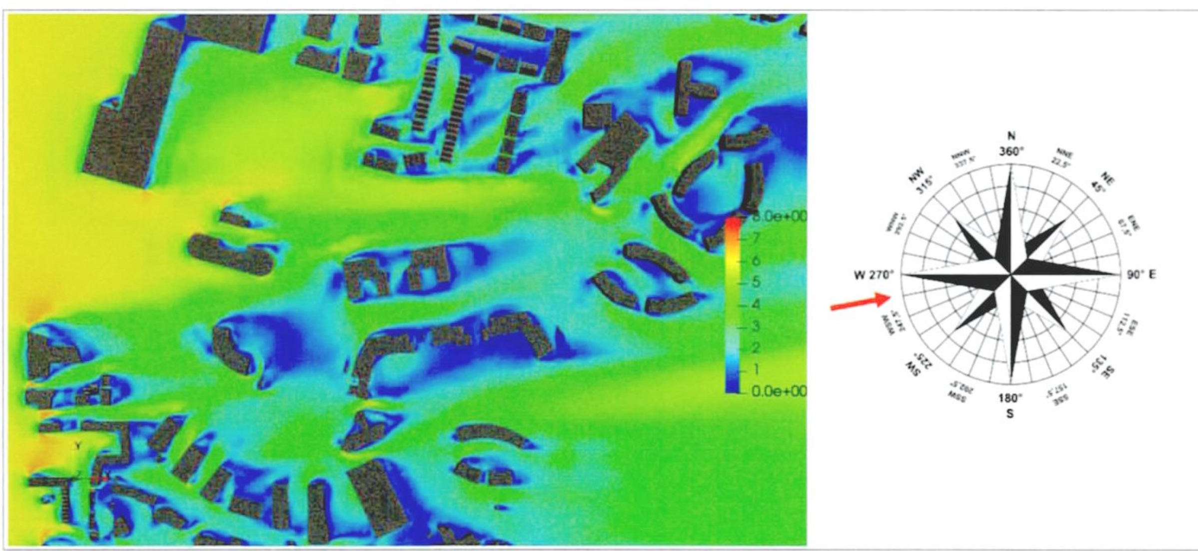


Figure 11-19: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 258°

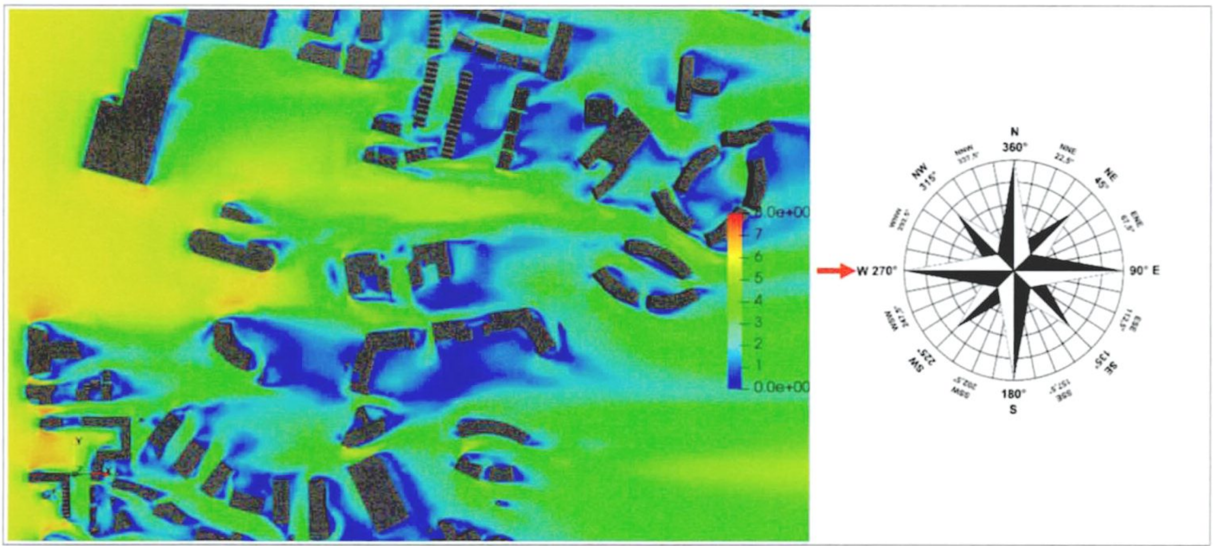


Figure 11-20: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 270°

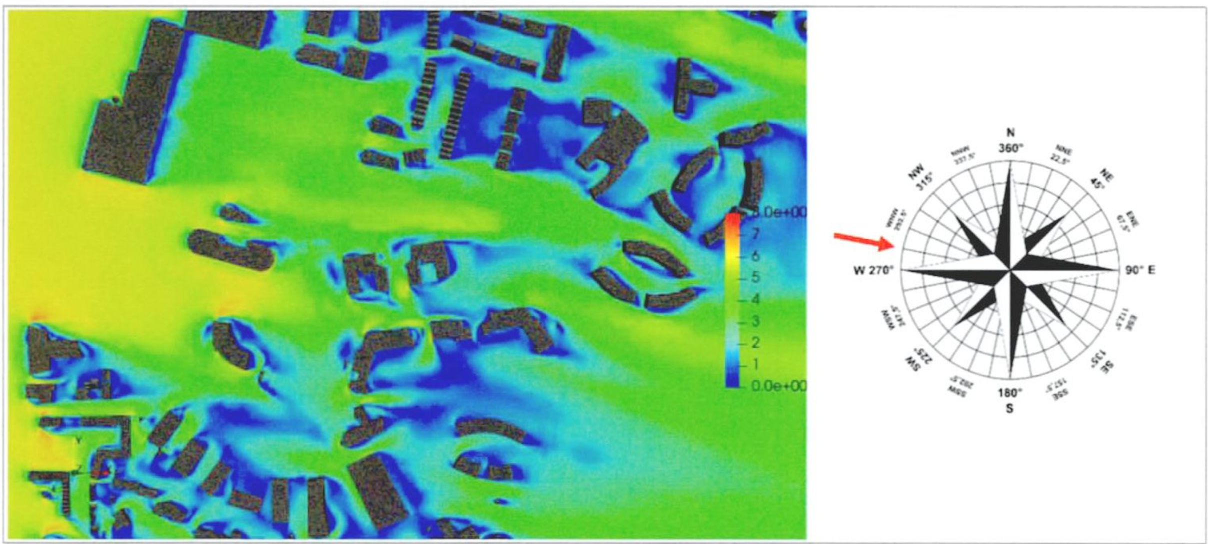


Figure 11-21: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 281°

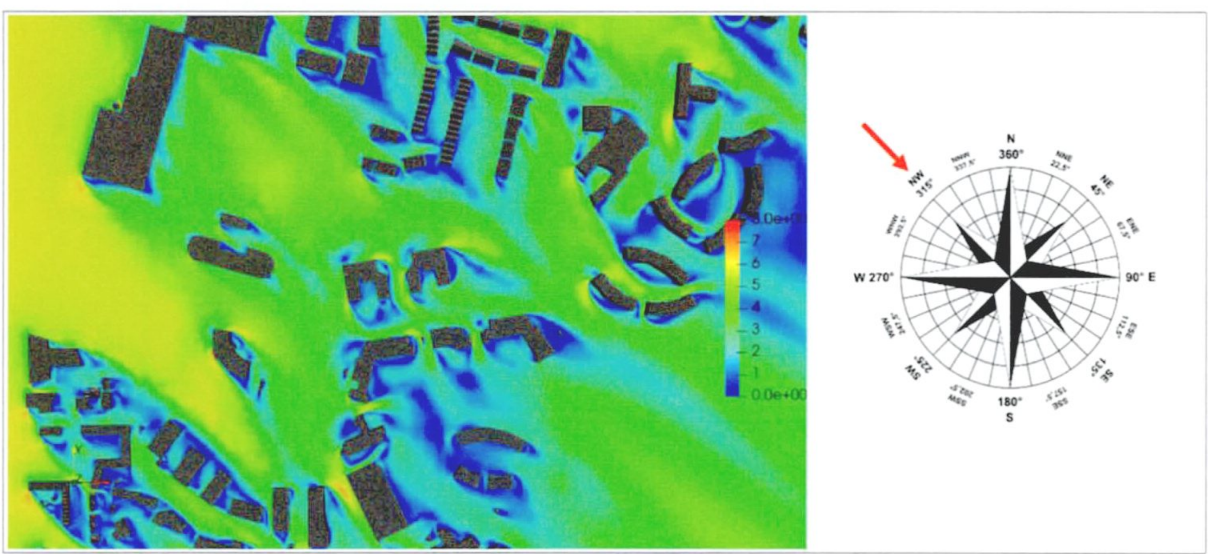


Figure 11-22: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 315°

__3DViews__

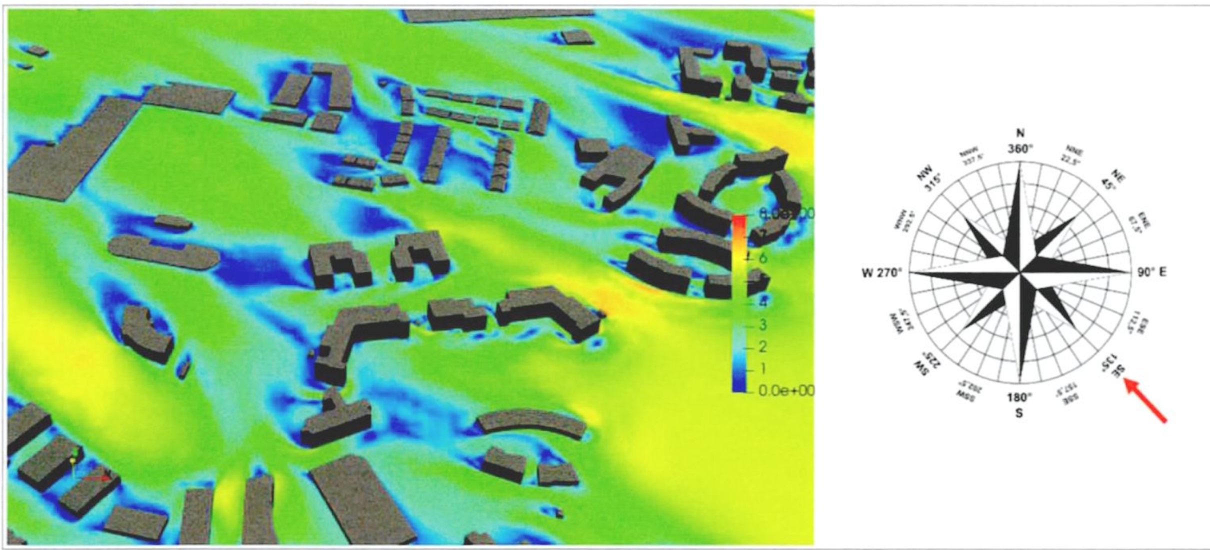


Figure 11-23: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 135°

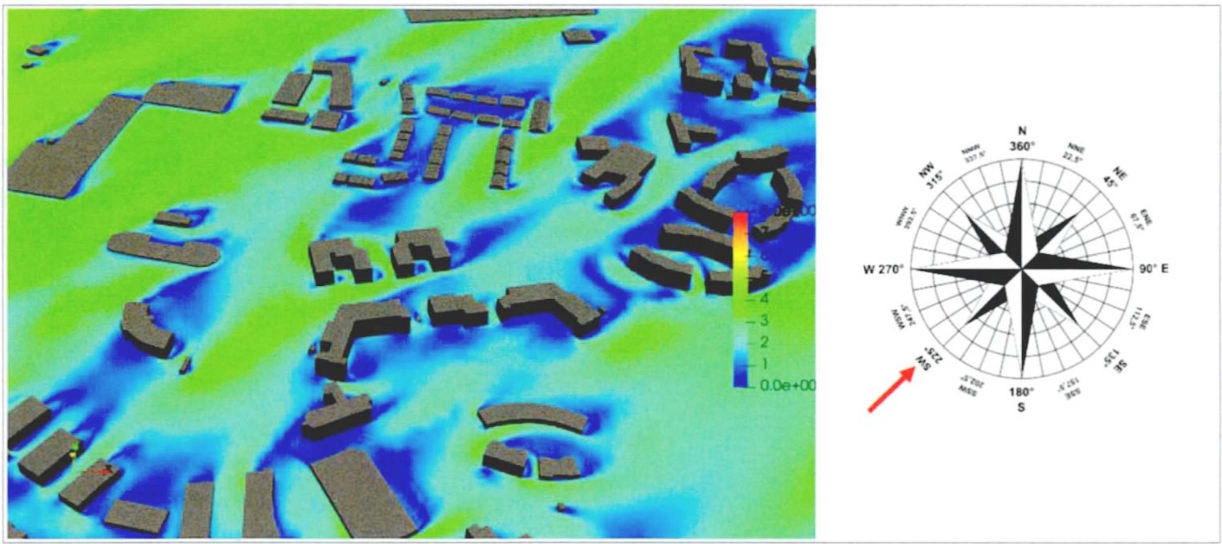


Figure 11-24: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 225°

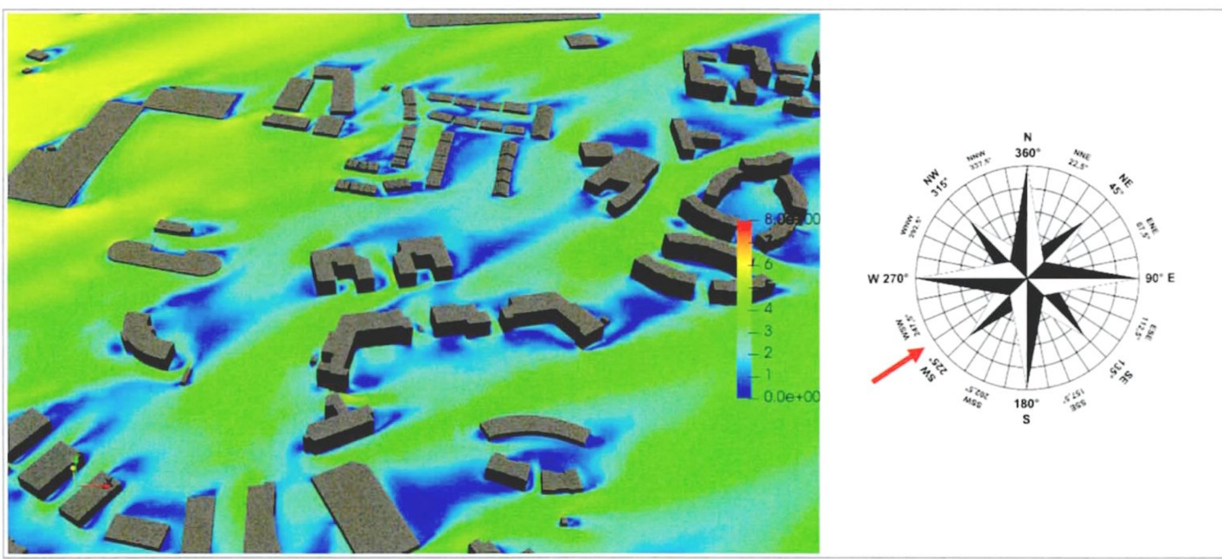


Figure 11-25: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 236°

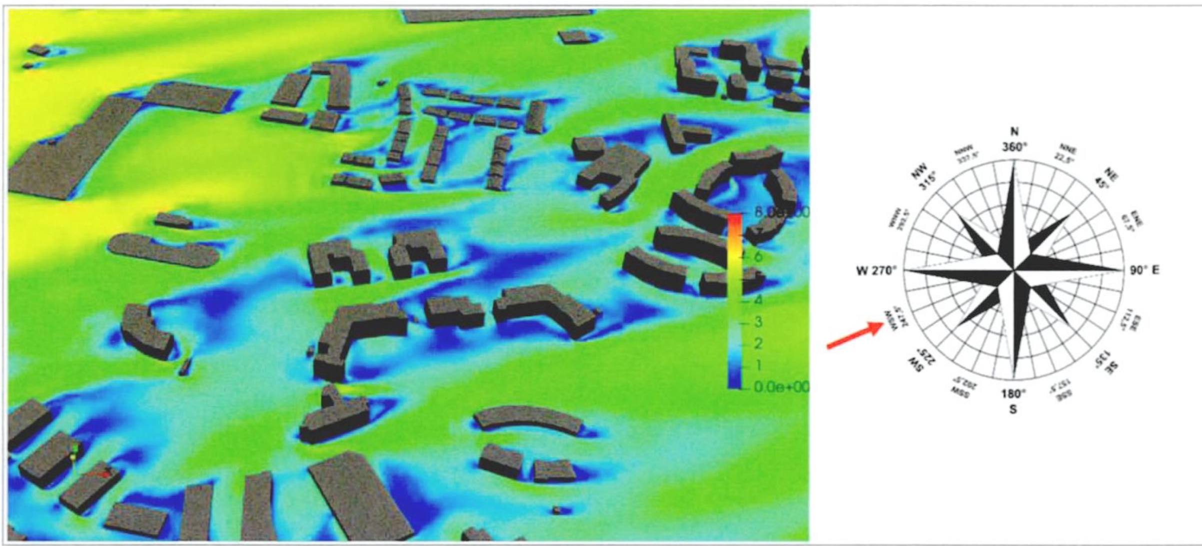


Figure 11-26: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 247°

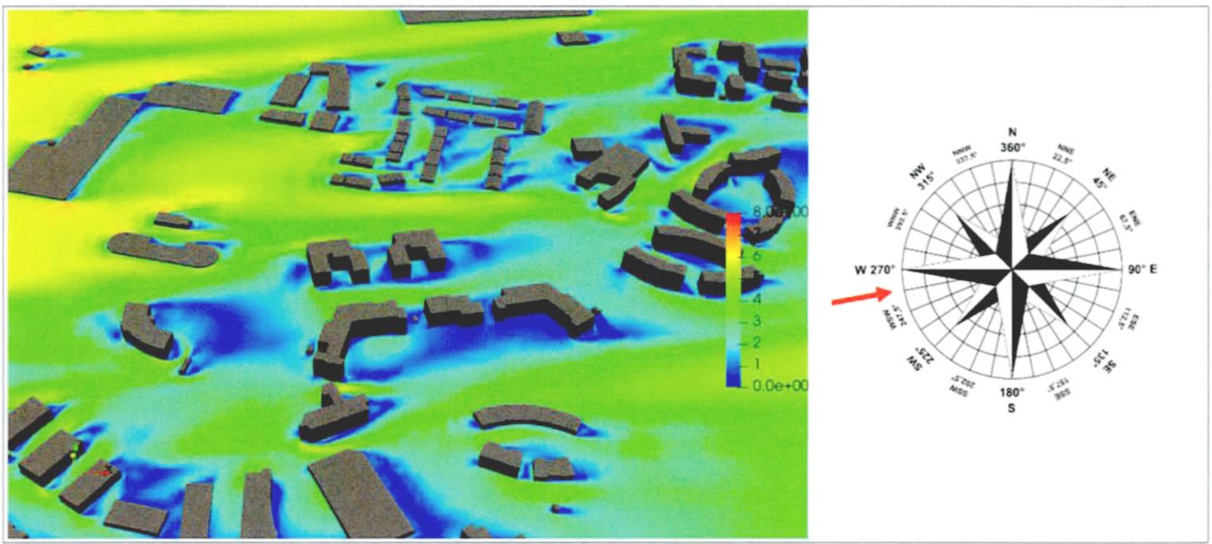


Figure 11-27: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 258°

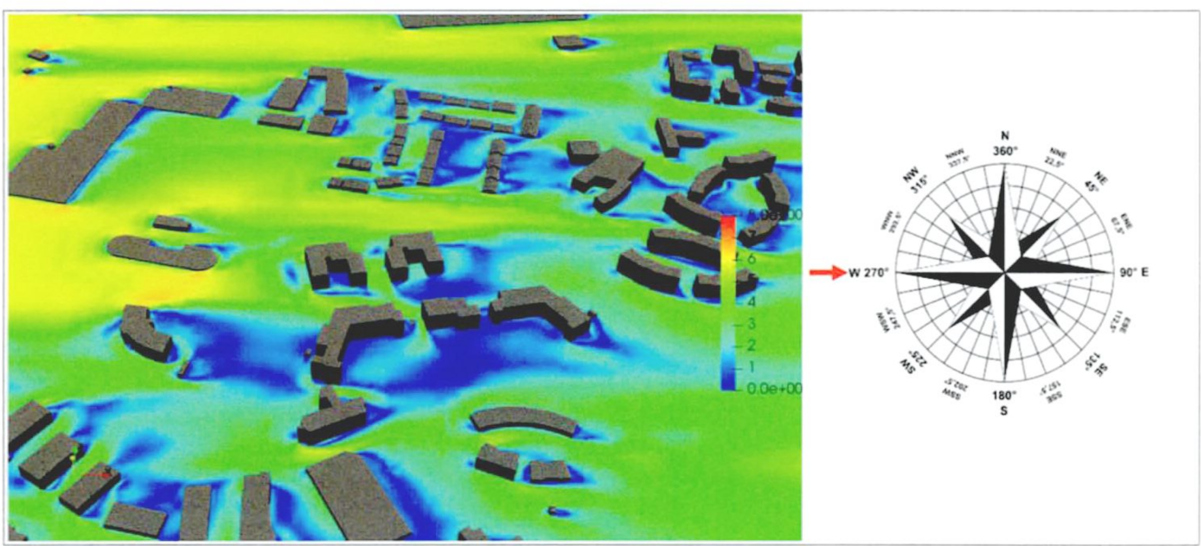


Figure 11-28: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 270°

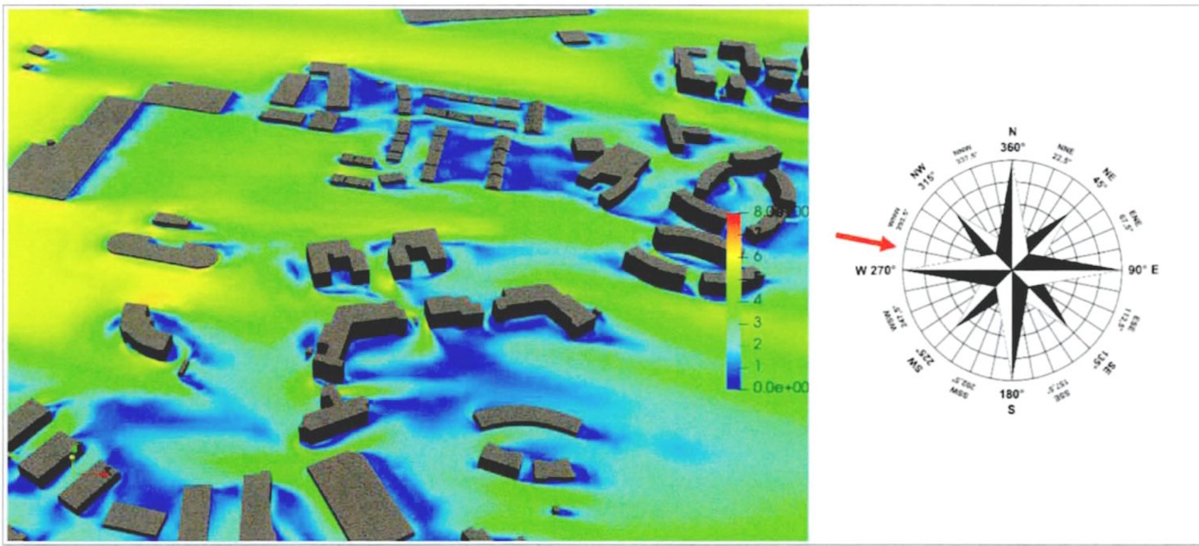


Figure 11-29: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 281°

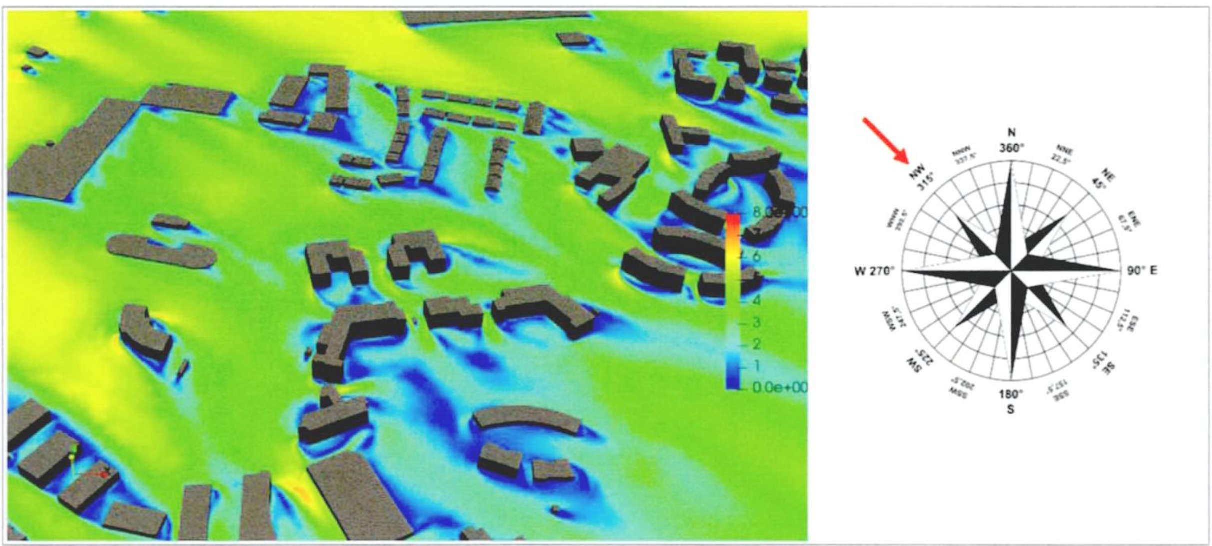


Figure 11-30: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 315°

11.3.3 Impact on Pedestrian Comfort and Distress

The wind flow results obtained simulating the different directions and wind speeds are combined with their frequencies of occurrence to obtain comfort ratings at the 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 using a colour-coded diagram below formulated following the Lawson Criteria.

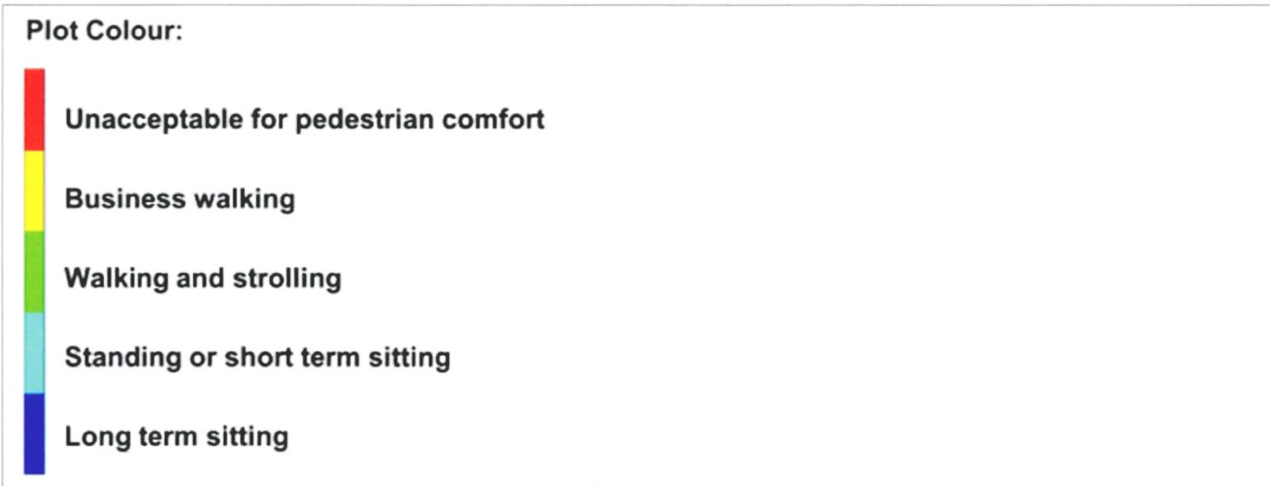


Figure 11-31: Lawson Map Plot for Criteria rating

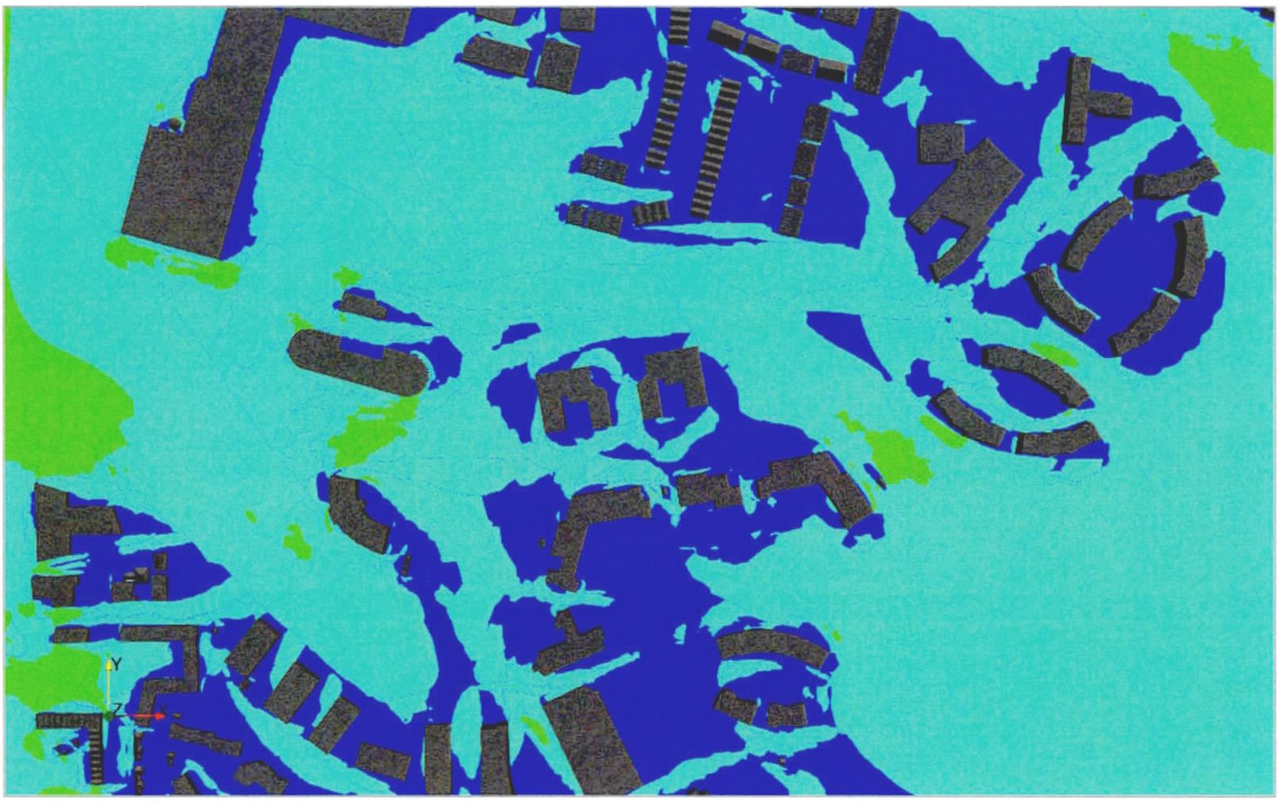


Figure 11-32: Lawson Map of Comfort and Distress- Baseline Environment

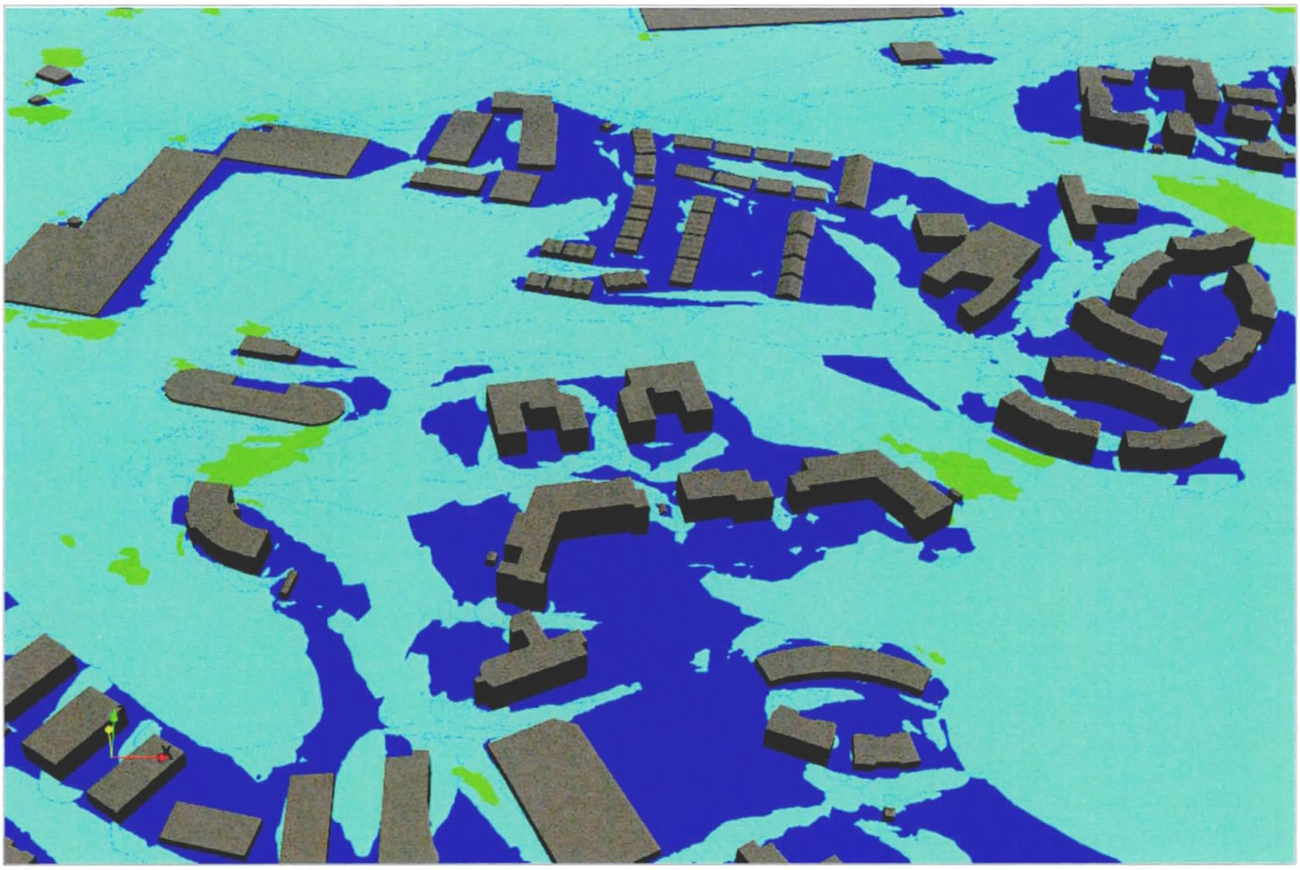


Figure 11-33: Lawson Map of Comfort and Distress- Baseline Environment (3D view)

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 walking and short-term sitting, and the roads in the surrounding are usable for their intended scope (walking).
- Now there is no designated area for public long-term sitting, as the site is a car parking area therefore the actual comfort level is in line with the Lawson category for the type of activity expected in such an area.

11.4 Impact Assessment

The wind microclimate of the proposed development is defined by the wind patterns that develop in the surroundings of the proposed development under the local wind conditions relevant for the Lawson Criteria and considering the existing buildings and topography.

11.4.1 Do Nothing

In case the development will not be constructed, the wind conditions on the site will be in line with those observed and shown as results of the wind analysis of the "Baseline Wind Microclimate" section.

11.4.2 Construction Phase

The criteria for wind comfort and distress at the site during the construction phase of Swift Square development in Northwood Avenue Santry, Dublin is not applicable as the construction will not involve pedestrian activities. From the statistical historical wind data carried out, it can be noted that the most onerous wind conditions during the construction phase will be South-West direction with a wind of approximately 5m/s.

Since 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 insignificant. Thus, the predicted impacts during the construction phase are identified as "not significant" or "negligible".

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.

In summary, as the construction of the Swift Square 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.

11.4.3 Operational Phase

The results of the wind simulations carried out are detailed in the following sections. Results of wind microclimate at ground level (1.5m height - flow speeds) are collected throughout the modeled site and the impact of these on the potential receptors presented in the map shows the area of comfort and distress following Lawson Criteria.

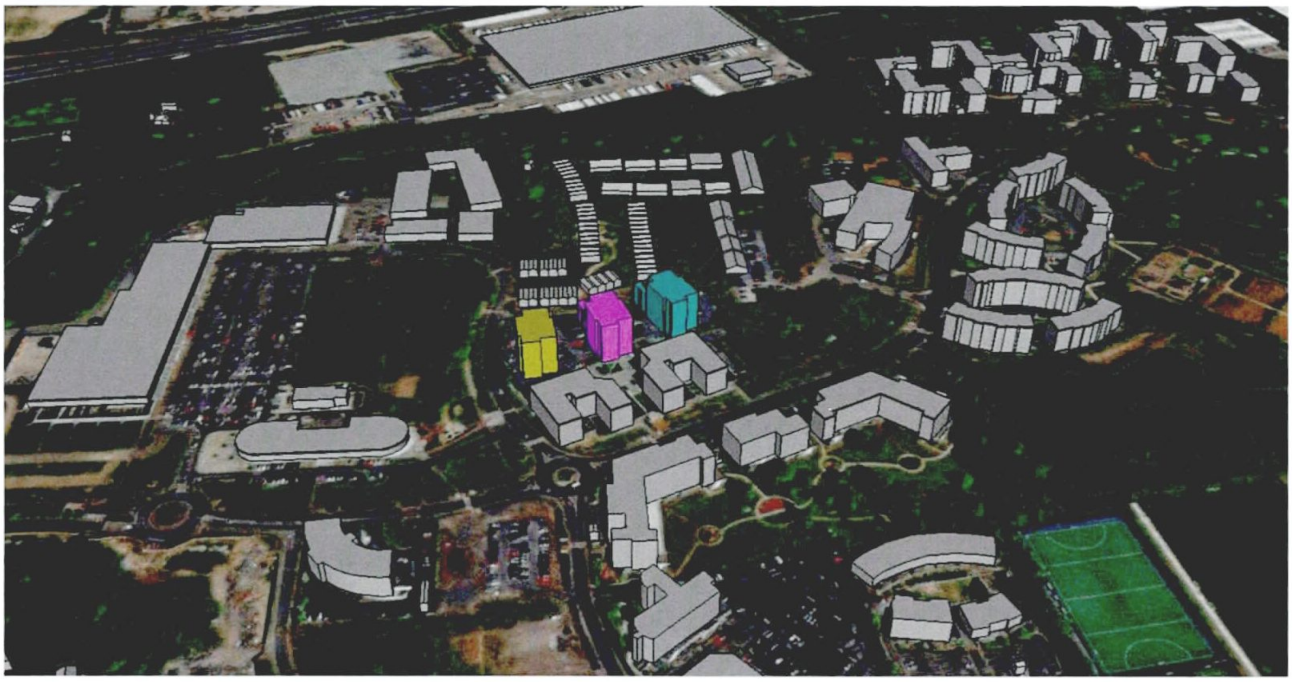


Figure 11-34: Proposed Development Scenario –View Of Proposed Block (In Colour) In The Existing Context

11.4.4 Wind Microclimate at Pedestrian Level

Results of wind speeds and their circulations at a pedestrian level of 1.5m above the development ground are presented in the images that follow in order of frequency of occurrence, from the most frequent wind direction to the least frequent one.

These flow velocities identify if locally, wind speeds at the pedestrian level are accelerated or decelerated when compared with the 'undisturbed' reference wind speed (i.e. the baseline wind speed) by the presence of the proposed development. As it can be seen, wind speeds are shown to be within tenable conditions and in general similar to the wind speed of the undisturbed flow for the direction considered.

Some of the wind patterns in between the blocks indicate minor funneling effects, this can be noted near the South-West side of the development which receives the prevailing South-West and South-East winds at approximately 5m/s. However, considering that the baseline wind speed is ranging from 3.9ms/ to 6m/s, throughout the area the wind is not accelerating to significant values (green colour indicated velocity of max 6m/s) and the wind is also decelerated with respect the undisturbed wind speed, in some area, because of the presence of the proposed development (blue colour indicate speeds of max 3m/s which are less than baseline winds.

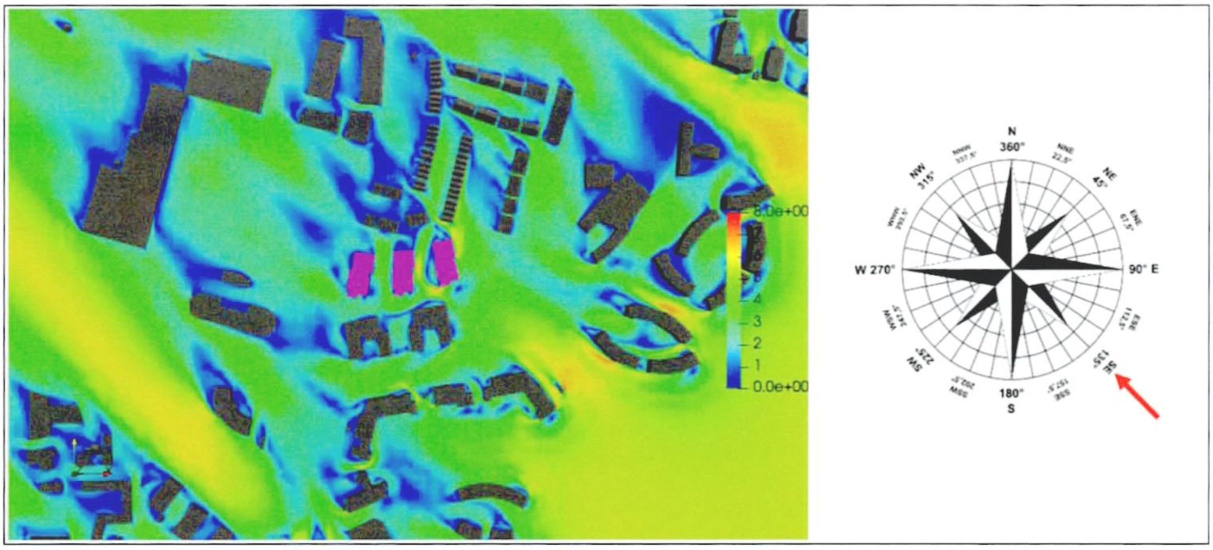


Figure 11-35: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 135°

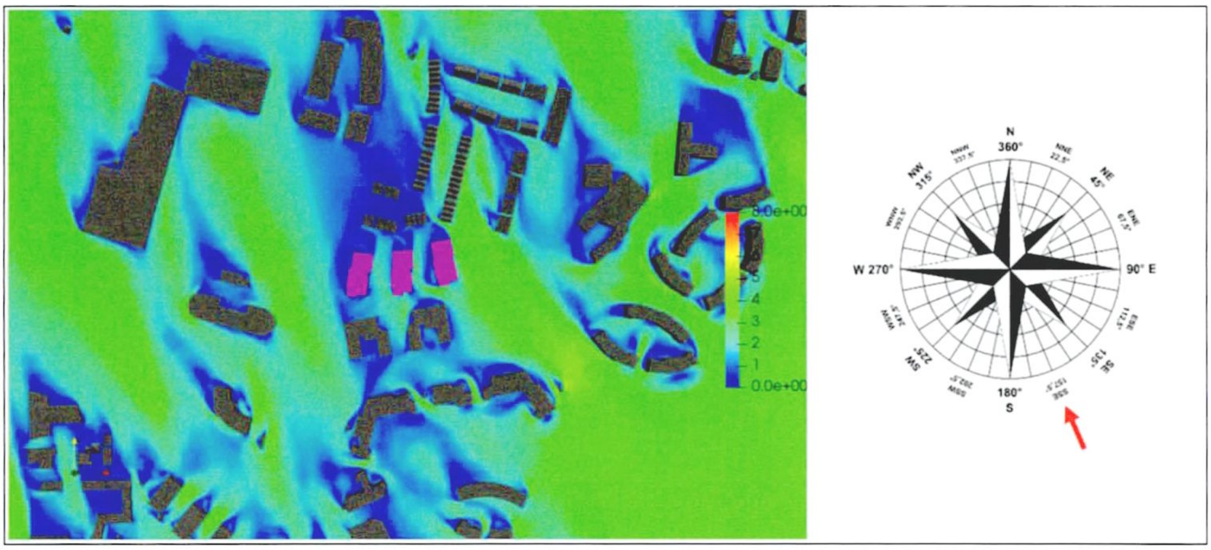


Figure 11-36: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 157°

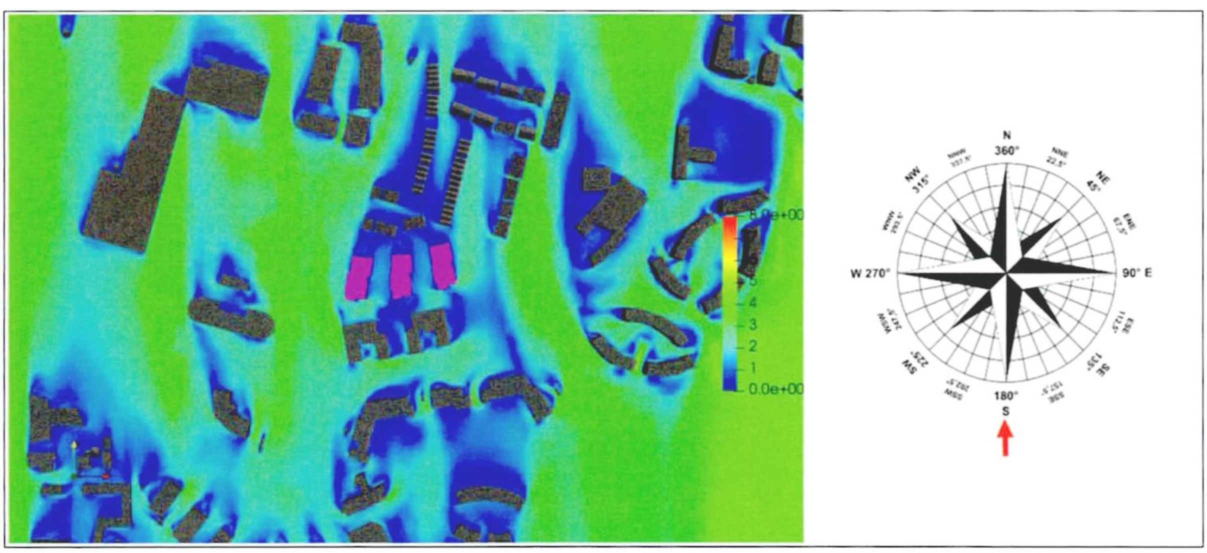


Figure 11-37: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 180°

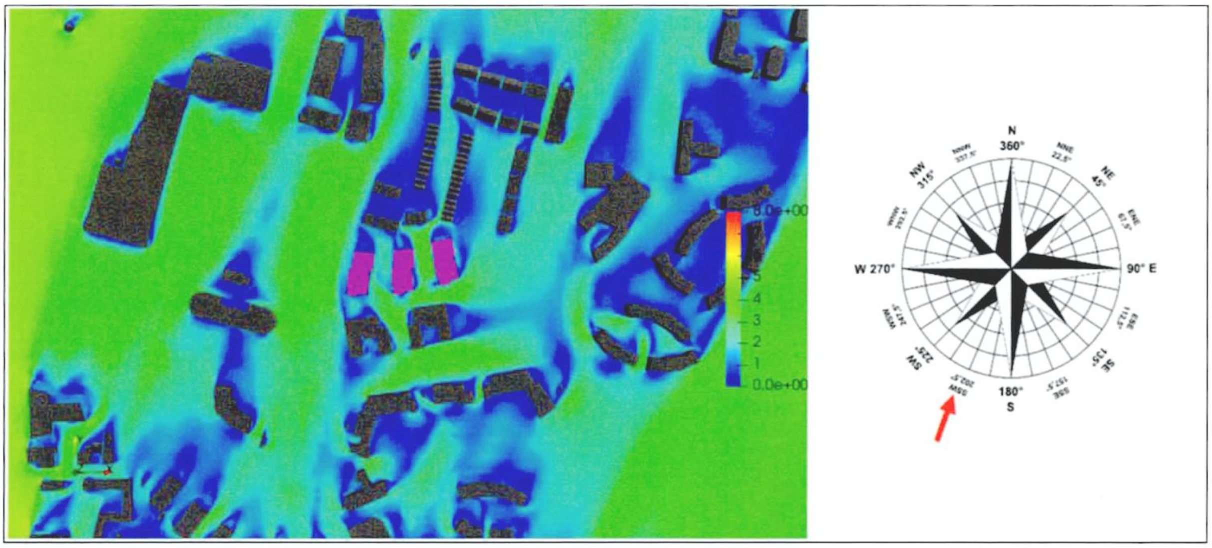


Figure 11-38: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 202°

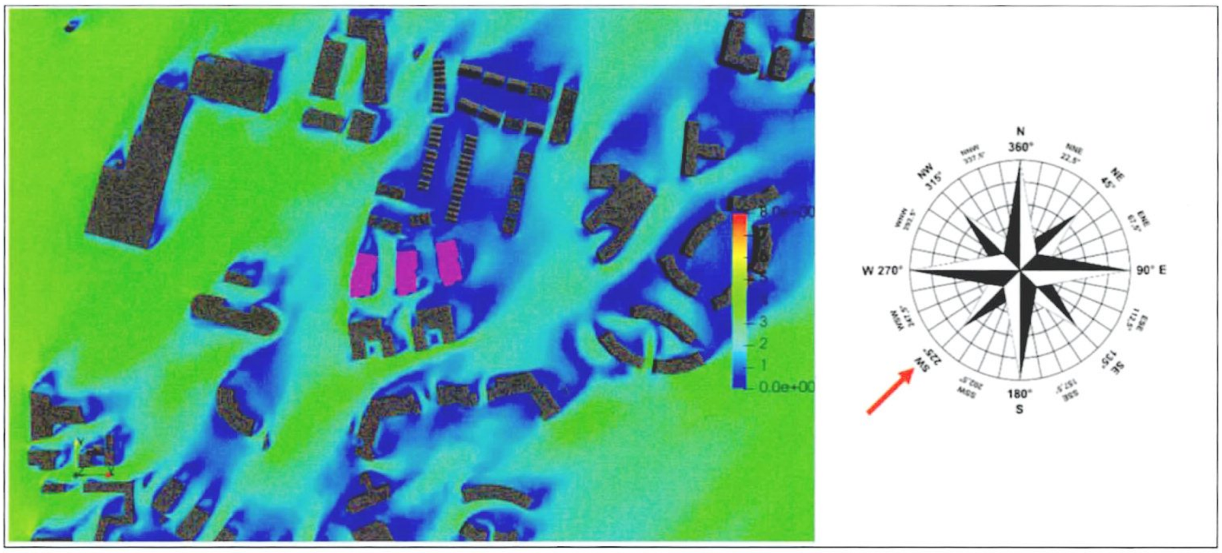


Figure 11-39: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 225°

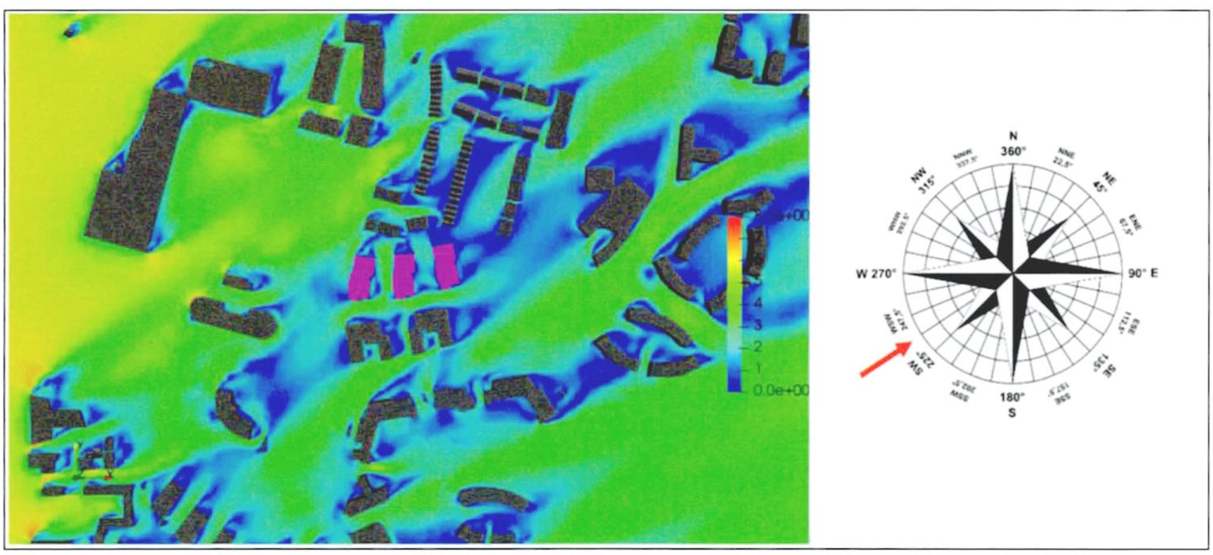


Figure 11-40: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 236°

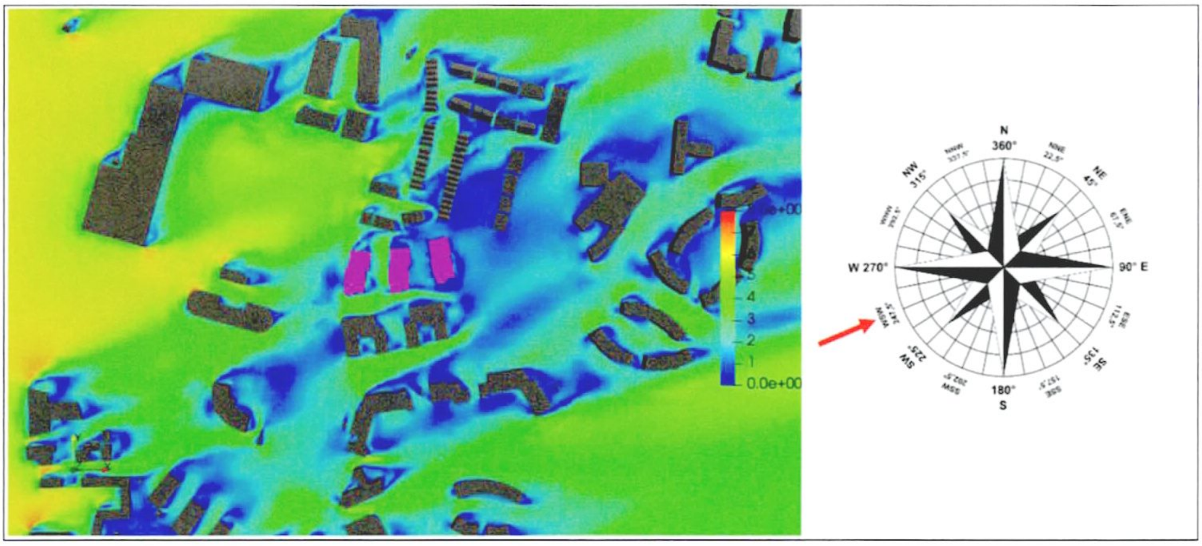


Figure 11-41: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 247°

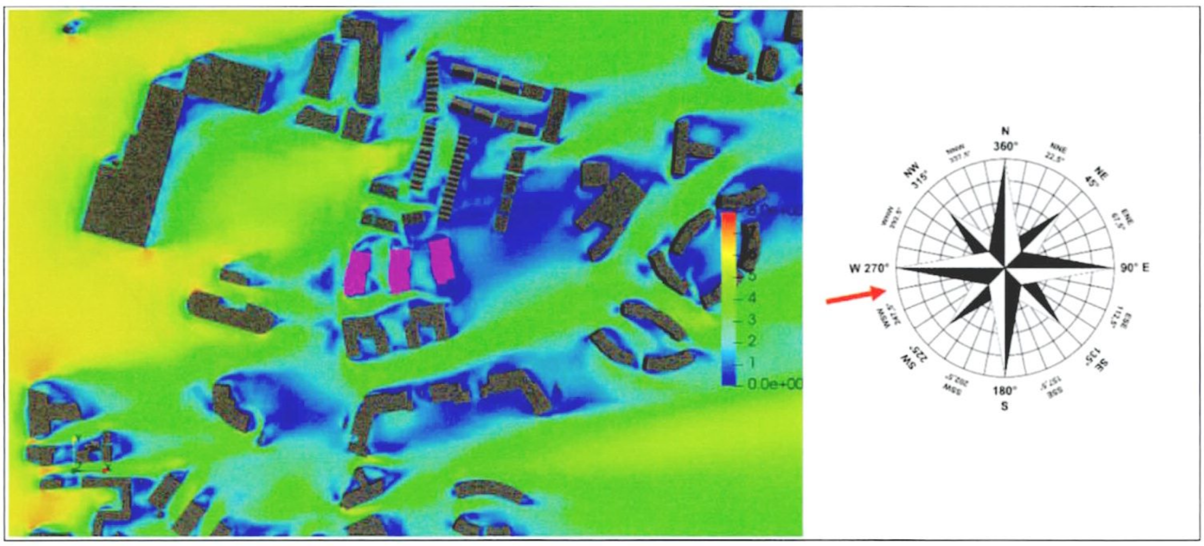


Figure 11-42: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 258°

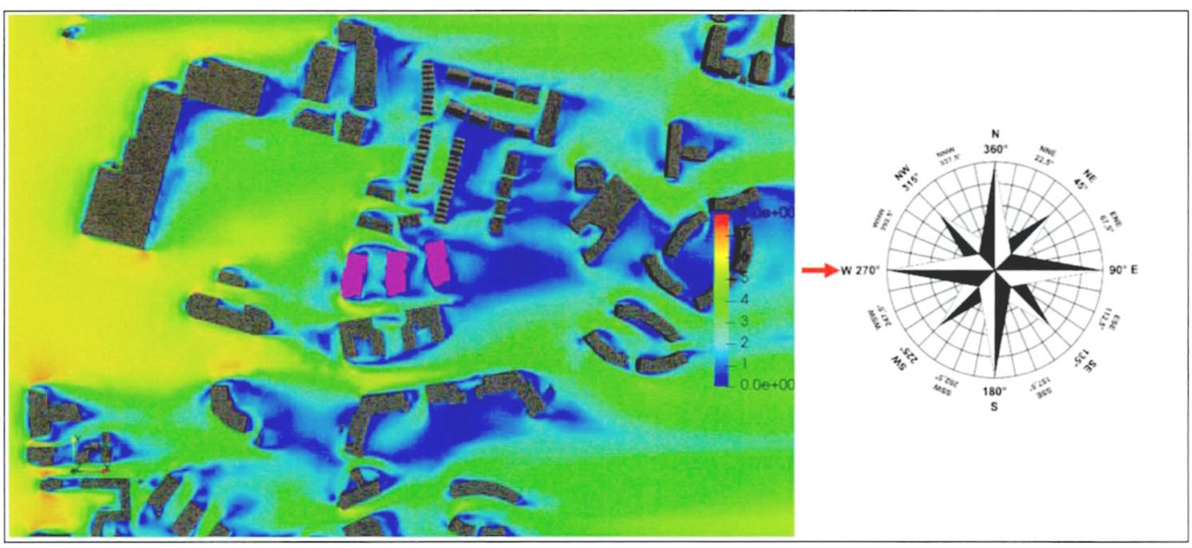


Figure 11-43: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 270°

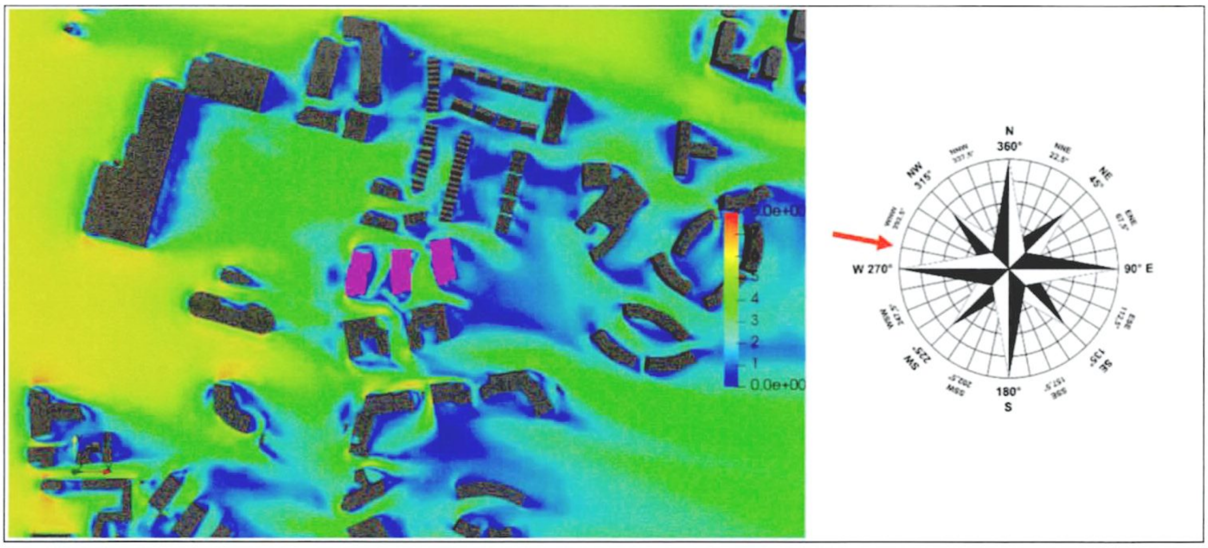


Figure 11-44: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 281°

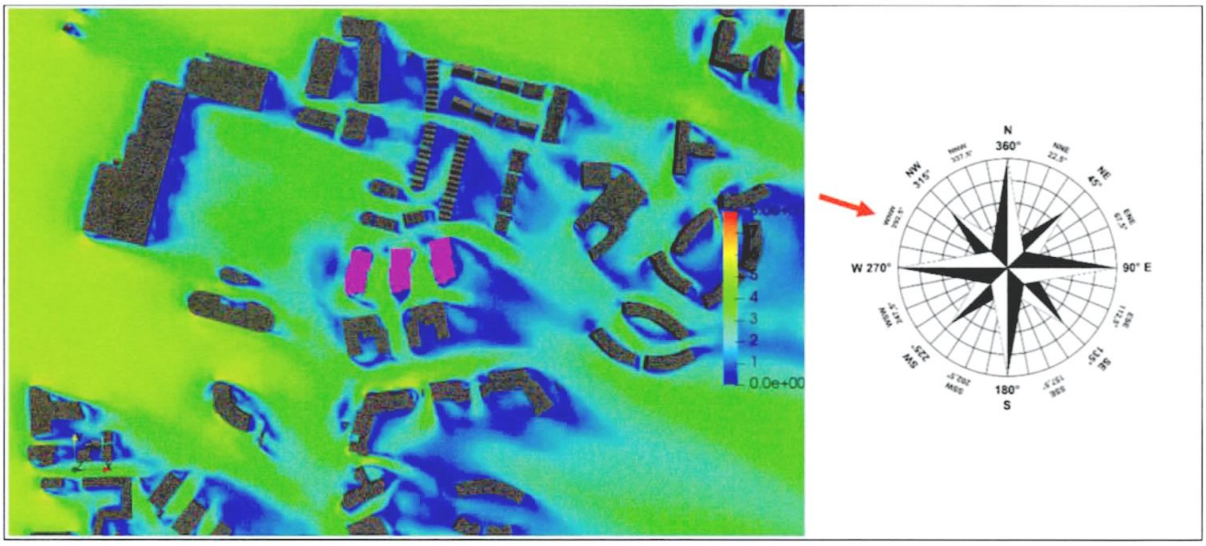


Figure 11-45: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 292°

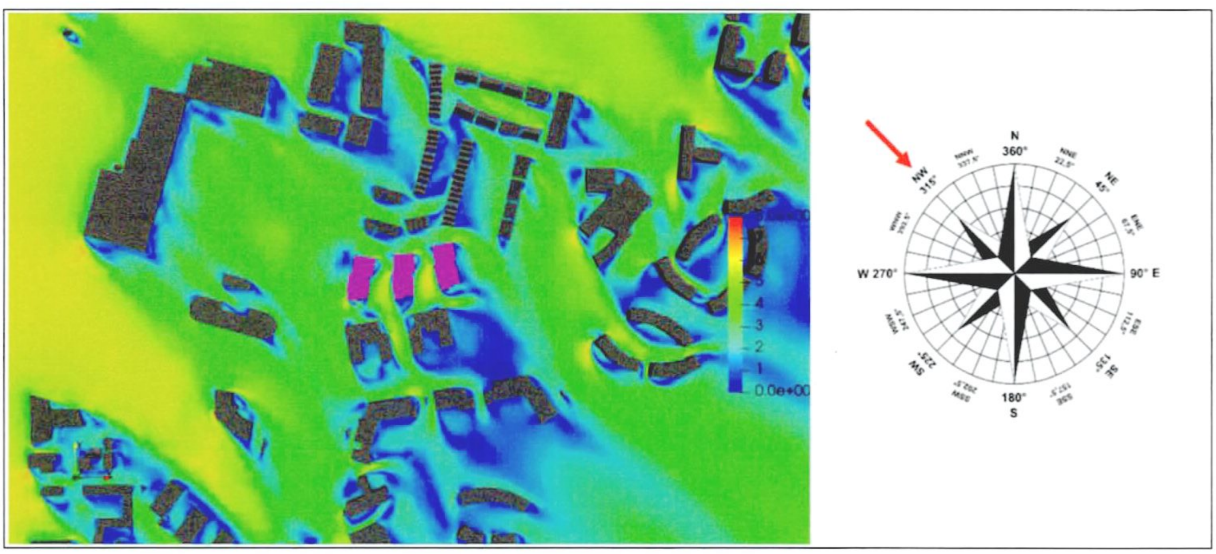


Figure 11-46: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 315°

3D Views

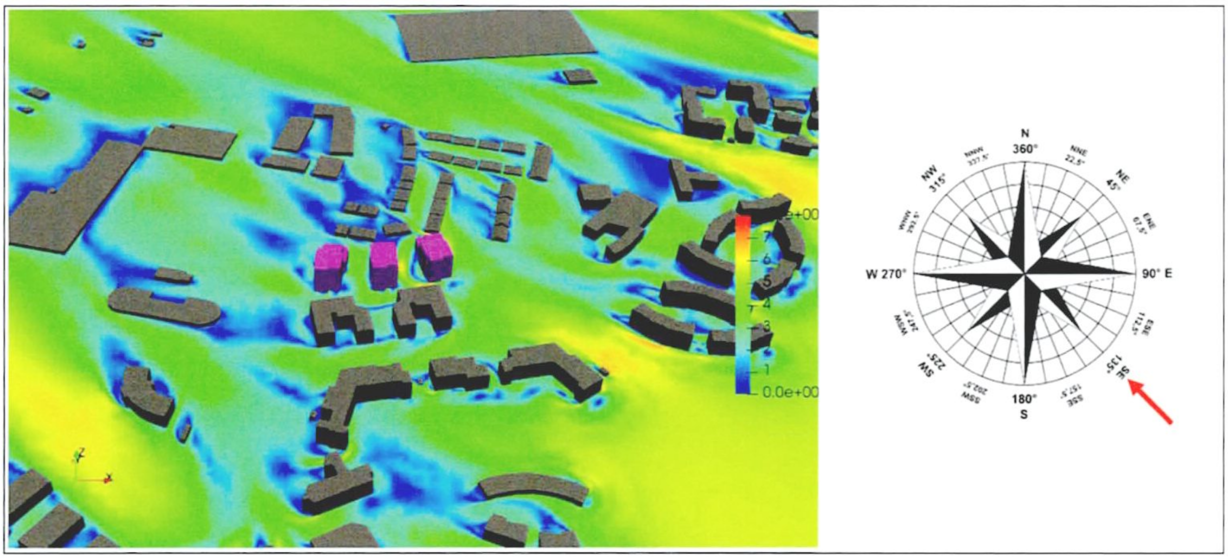


Figure 11-47: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 135°

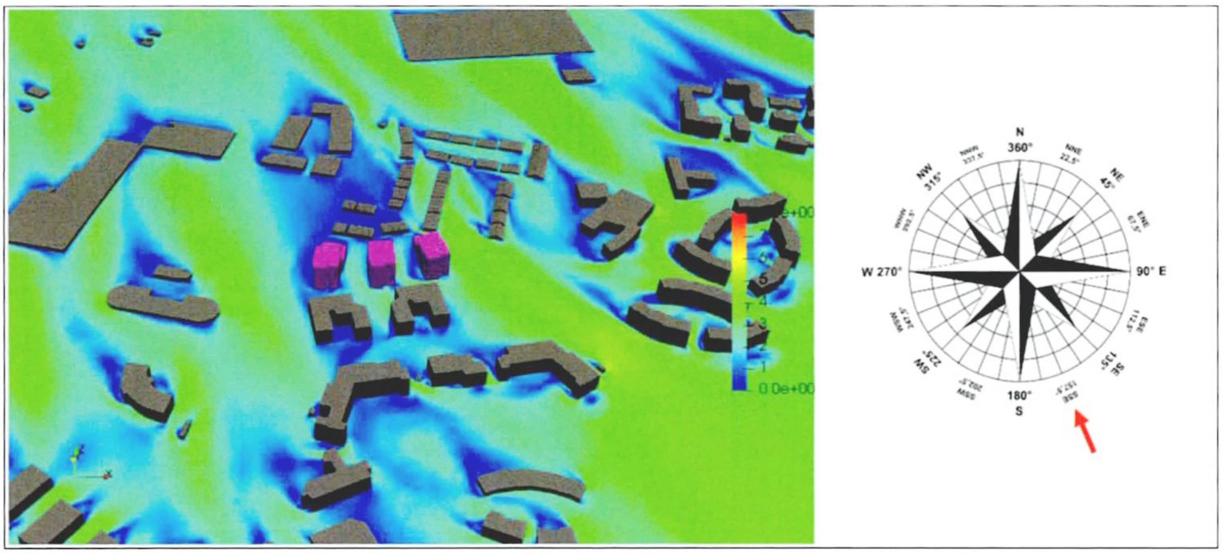


Figure 11-48: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 157°

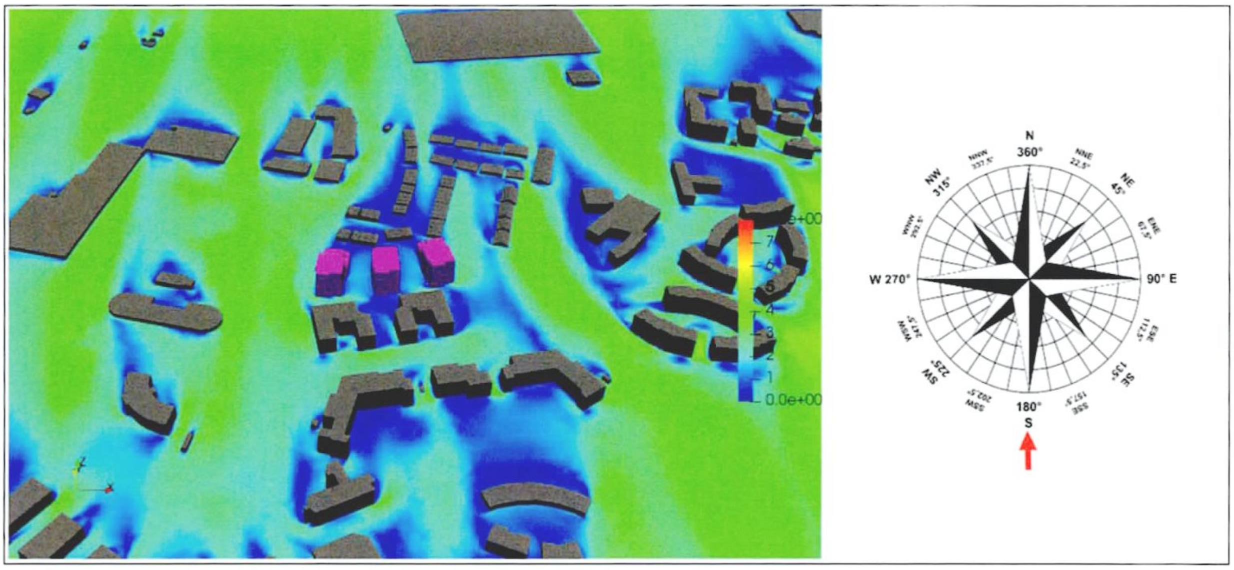


Figure 11-49: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 180°

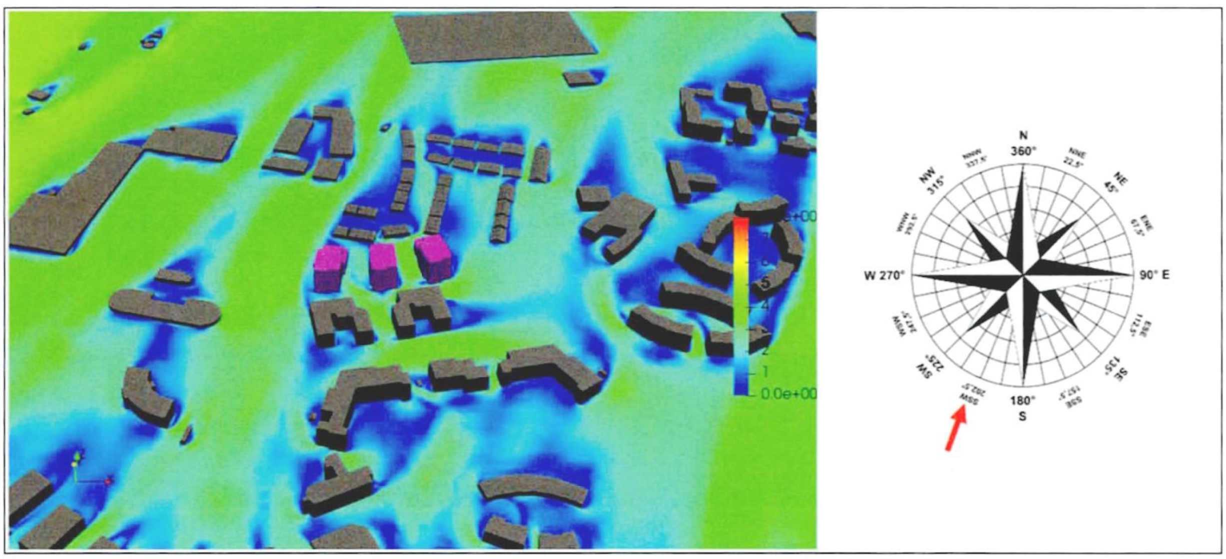


Figure 11-50: Pedestrian Level - Velocity Results at 1.5m above the ground - Wind Direction: 202°