CFD Analysis of Wind Microclimate Pedestrian Comfort and Distress
Whitworth Street West



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1. Executive Summary

A new hotel development is proposed for Whitworth Street West, Manchester. CFD simulations of the wind microclimate under 36 different wind directions have been undertaken for both the pre-existing and proposed built environments. The results of these simulations have been combined with processed wind statistics to produce plots of both existing and proposed conditions, according to the Lawson comfort and distress criteria. These plots have been compared with proposed activities around the proposed development.

1.1. Effects of the development

Pedestrian comfort and distress conditions are largely unaffected by the proposed development, with the exception of two minor adverse effects:

1) Simulations for the pre-existing scenario show that the wind conditions for the off-site café seating areas along Deansgate Locks are currently unacceptable for long term sitting according to LDDC Lawson comfort criteria. Simulations conducted for the proposed development show that wind speeds in this area may increase becoming unacceptable for standing in some places according to the LDDC Lawson comfort criteria. Typically a one-step increase in LDDC Lawson comfort criteria is considered a minor adverse effect;
2) Wind conditions for the pedestrian region adjacent to the north façade of the proposed development are largely unchanged and would remain unacceptable for long term sitting (acceptable for standing according to LDDC Lawson comfort criteria). However, the proposed development would introduce café-type seating in this area. Since this proposed activity is one category more sensitive than the acceptable LDDC Lawson comfort criteria this is typically considered a minor adverse effect.

No other assessed adverse effects are introduced by the proposed development. Some small areas may exist (~1.5m wide) that are likely to present pedestrian distress during certain weather scenarios, although these are not considered to be adverse effects according to the LDDC Lawson distress criteria since: i) they are not on major routes; and ii) alternative pedestrian routes exist.

1.2. Mitigation

Mitigation of the regions identified above could take the form of either:

- Changing the proposed activity to one that would be acceptable for the conditions;

  and/or
- Localised shelter, such as landscaping and/or semi-porous fences/balustrades.

1.3. Residual Effects

If significant localised shelter is provided at the corners of the proposed development, there are likely to be no residual adverse effects on the pedestrian wind microclimate from the proposed development.

If this shelter is not provided, there are likely to be two minor adverse effects, on two long term sitting areas:

1) Cafés north of Deansgate Locks;
2) Area adjacent to the north of the proposed development.

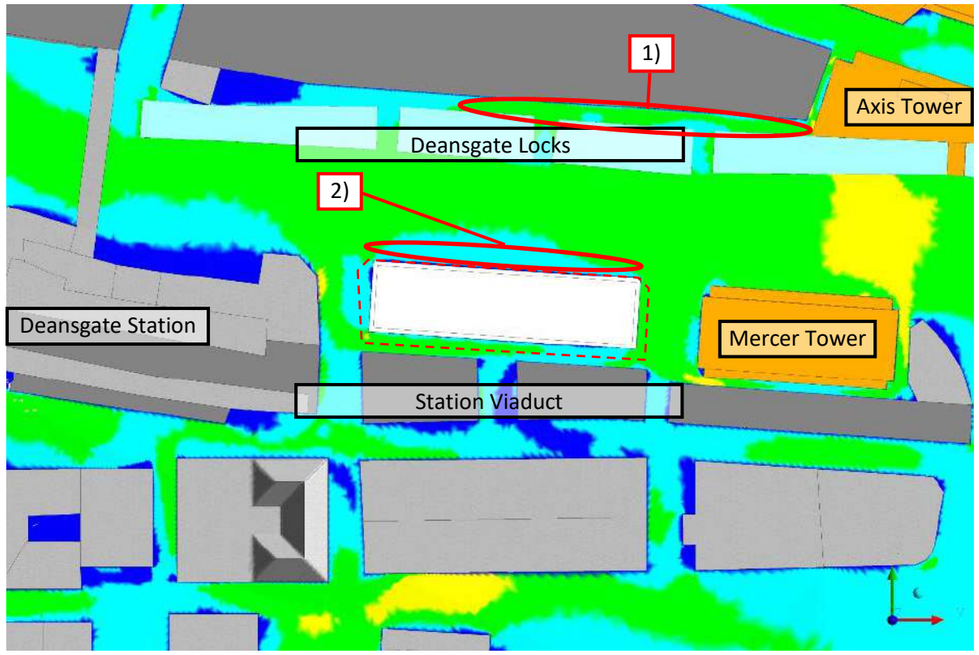


Figure 1.1: Lawson Comfort Plot: Proposed

Table 1.1: LDDC Lawson Comfort Criteria Typical Activities

	Comfort category	Colour	Location examples
I	Pedestrian sitting		Cafés, Outdoor Auditoria
II	Pedestrian standing		Bus stops, Main entrances, Playgrounds, Park Benches, Markets
III	Pedestrian walking		Retail Areas, Parks, Canals
IV	Business walking		“Busy” getting from A-to-B (i.e. not necessarily financial)
	Unacceptable		Roads and Car Parks

1.4. Geometry Changes

Following completion of the simulations, the proposals were revised, including some minor changes to the geometry. The height of the building has been reduced by 2.2m. These changes are unlikely to have any significant influence on the results. Any difference in the results due to these changes is likely to be beneficial. As a result the conclusions of this assessment are unchanged.

2. Introduction

2.1. Outline of the Proposed Development

A new 9 storey hotel development is proposed at No. 2-4 Whitworth Street West, near Deansgate Station in Manchester. Hilson Moran has been appointed by Jones Lang LaSalle to provide a wind microclimate assessment for the proposed development. The objective of this study is to provide a ground level wind microclimate assessment based on a series of computational models.

The site is bordered to the north by Whitworth Street and Deansgate Locks beyond; to the west by Bugle Street and Deansgate train station beyond; to the south by the station viaduct and Hewitt Street beyond; and to the east by Cameron Street and an existing 4-storey building which has planning permission for a ~120m building which is not yet under construction.

The location is also close to three other prospective towers; one under construction which will be ~90m high, and two which have planning permission but are not yet under construction, of~ 70m height and ~140m height.

With the exception of nearby Beetham Tower (~160m), the existing built environment around the proposed site is typically low to medium rise (10m - 30m).

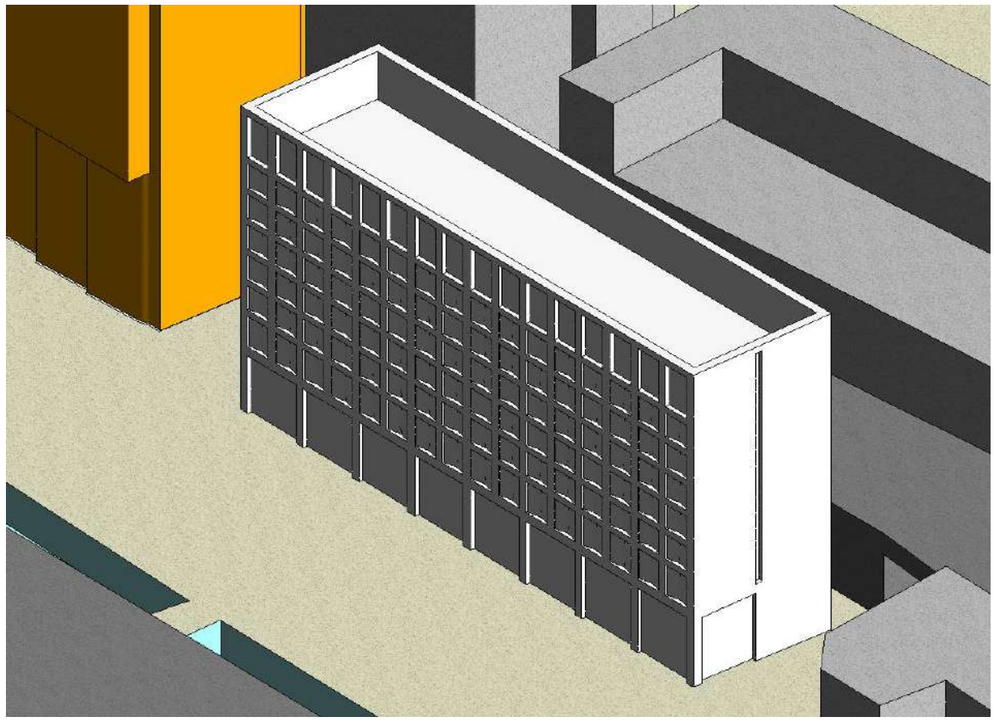


Figure 2.1: Proposed Development on Whitworth Street West

2.2. Scope of the CFD Study

This analysis considers two scenarios: Existing and proposed.

The investigation was performed using a CFD model constructed using the general purpose ANSYS-Fluent CFD package. The models enable a quantitative analysis of flow characteristics in the microclimate around the buildings. Simulations were performed from 36 wind directions in 10° increments around the compass.

This report summarises the models constructed, the simulation methodology, main assumptions made and the boundary conditions applied. The results of the CFD simulations were interrogated to compare the proposed uses with metrics of user comfort criteria.

Levels of pedestrian comfort and distress were quantitatively assessed against the widely used Lawson Criteria, as set out in Building Aerodynamics by Tom Lawson, [Imperial College Press (2001)].

The CFD results were analysed including a brief discussion of possible causes of undesirable flow features and possible measures to counteract these. This report includes appropriate conclusions and recommendations.

2.3. Limitations of Modelling

2.3.1. Suitability for Purpose

The analysis reported in this document uses CFD models to simulate the likely wind speeds under a variety of wind conditions, for comparison against the LDDC Lawson comfort criteria. CFD is widely used for this purpose, and more importantly is well-validated against both empirical data and other modelling methods.

Irrespective of modelling methodology, the results of modelling physical phenomena have uncertainty compared with the real life performance. All modelling techniques fail to predict reality with perfect precision, due to necessary assumptions, unpredictable boundary conditions or other simplifications. It is therefore important to address the purpose for which the modelling was undertaken.

This assessment considers wind pedestrian comfort and distress for general patterns of use (i.e. sitting, standing, strolling, and walking). The following effects were not considered in this analysis:

- More specialised wind design requirements (e.g. sailing, aviation, sports, particle transport, fire safety, etc.)
- Structural effects, resonance calculations, fluid-structure interactions, and acoustic effects;
- Ventilation of internal spaces, wind gusting, urban heat island effects and pollutant tracking;
- Wind effects during construction.

2.3.2. High Resolution

The two predominant methods currently used to model wind flow are CFD (used in this study) and wind tunnel testing.

CFD simulation presents an efficient and comprehensive solution to predicting pedestrian comfort. Results are able to be reported in high resolution throughout the full 3D domain. This allows all features of the simulation to be accounted for in the analysis.

Methods that require physical measuring equipment, such as wind tunnel testing provide data at significantly fewer locations. For example, the CFD results presented in this report use more than 350,000 data points at pedestrian level for each wind direction, combined into a continuous plot of pedestrian wind comfort. A wind tunnel approach would use typically around 100 discrete data points and as such may miss important flow features that CFD analysis could have reported.

3. Legislation and Planning Policy

Legislation and planning documents of relevance to this assessment include the following:

- The National Planning Policy Framework (2018);
- Planning Practice Guidance (2014)
- Manchester Core Strategy Development Plan (2012)
- Guide to Development in Manchester (2007)

National planning policies do not impose specific limits on the microclimate wind environment around a new development, but there is a requirement to inform the planning process, so that specific site conditions and functions can be assessed, and to show that other users around the development will not be unreasonably affected by the wind microclimate.

As a result it is proposed to assess effects based on UK industry standards, assessing the pedestrian level wind microclimate against the Lawson pedestrian comfort criteria. The Lawson criteria define acceptable windiness for different activities such as sitting, walking and standing.

3.1. Legislation

There is no legislation which specifically governs wind microclimate planning policy.

3.2. National Planning Policy

3.2.1. National Planning Policy Framework (2018)

The National Planning Policy Framework (NPPF) does not specifically reference wind or microclimate; however, the NPPF emphasises the benefits of high quality built environment, for example:

Paragraph 89.b)	*"This should include assessment of [...] the impact of the proposal on town centre vitality and viability."*
Paragraph 124	*"Good design […] creates better places in which to live and work and helps make development acceptable to communities."*
Paragraph 127.f)	*"Planning policies and decisions should ensure that developments create places that are safe, inclusive and accessible [...] with a high standard of amenity for existing and future users."*

3.2.2. Planning Practice Guidance (2014)

Planning Practice Guidance identifies the potential for a development's size and shape to affect the wind microclimate. In particular, paragraphs 25 and 26 state:

"*Design: How should buildings and the spaces between them be considered?*

Consider Form: Some forms pose specific design challenges, for example how taller buildings meet the ground and how they affect local wind … patterns should be carefully considered.

Consider Scale: Account should be taken of local climatic conditions, including … wind".

3.3. Local Planning Policy

3.3.1. Core Strategy Development Plan (2012)

The Manchester Core Strategy Development Plan was adopted in July 2012.

Policy EN2 states:

"*By their very size tall buildings can have a significant impact on the local environment and its micro-climate. It is therefore expected that this impact be modelled and that submissions for tall buildings also include appropriate measures to create an attractive, pedestrian friendly local environment.*"

Section 12.13 states:

"*Tall buildings … can also have an impact on the micro-climatic conditions, for example, by creating wind tunnels. It is for these reasons that it is considered particularly important that they are designed to the highest quality, both in terms of appearance and their impact on the functioning of surrounding space.*"

3.3.2. Guide to Development in Manchester (2007)

The Guide to Development in Manchester was adopted in April 2007.

Section 2.4 states:

"*Where the public realm includes hard landscaped areas, its design should reflect the level and nature of their use, and should consider issues such as overshadowing, prevailing winds and rain, and the potential to contribute to sustainable urban drainage. The opportunity will be taken to improve the quality of existing areas of public realm and to ensure that areas of public realm in new developments, are designed so that they can be enjoyed by residents and users, rather than being simply functional.*"

Section 12.8 states:

"*Schemes will be considered on an individual basis, by reference to their appearance, their impact on the immediate area and the effect on the City's skyline. Key questions will be the quality and interest of the roofline; the design of the lower floors; the relationship to the surrounding streets; the impact of servicing and parking requirements; the microclimate, including overshadowing and air turbulence effects, created by the relationship of the building to those adjacent; and the quality and usability of the spaces surrounding the building.*"

4. Inputs

4.1. Geometry

The 3D model of the existing built environment for the development site was based on publicly available LiDAR data. This data does not include buildings constructed in recent years, or buildings currently under construction.

Additional developments were identified for inclusion in the CFD model of the existing built environment. The locations of these developments are shown in Figure 4.1. The MCC planning references for these developments are listed in Table 4.1.

Geometry for these buildings was based on publicly available drawings from the MCC online planning portal.

Table 4.1: List of Additional Developments

ID No.	MCC Planning Reference	Construction Status
1	115871/FO/2017	Planning Permission
2	106490/FO/2014/C1	Under Construction
3	111003/FO/2016/C1	Planning Permission
4	113870/FO/2016	Planning Permission
5	115591/FO/2017	Planning Permission
6	101937/NMC/2013/C1	Recently Built
7	098438/VO/2012/C1	Recently Built
8	105505/FO/2014/C1	Recently Built
9	111719/FO/2016/C1	Under Construction
10	108963/FO/2015/C1	Under Construction
11	083763/FO/2007/C3	Recently Built
12	101194/FO/2012/C1	Recently Built
13	118683/FO/2017	Under Construction
14	111170/FO/2016/C1	Planning Permission

4.1.1. Outline Building

Documents for additional development #1 (115871/FO/2017) make reference to a neighbouring consented building, for which no geometry was found on the MCC online planning portal. This building is not currently in existence, but since it has consent, has been included in the CFD model for the purposes of this analysis.

Geometry for this building has been based on the footprint and building height shown in the following two documents available (on the MCC online planning portal) for additional development #1:

- MASTERPLAN_-_PROPOSED_EAST_ELEVATION-724154.pdf
- MASTERPLAN_-_ZONING_DIAGRAM-724140.pdf

4.1.2. Strategic Regeneration Framework

Manchester City Council have adopted a Strategic Regeneration Framework (SRF) for Great Jackson Street. These buildings will not be included in the CFD model, but are likely to be significant. The conclusions of this report briefly consider the SRF within the context of the proposed development.

4.1.3. Proposed Development

The geometry of the proposed development in the CFD model was based on the file "2068-A-xx-3M-Elev-180705-Current in Context-GP1.skp", provided by Glenn Howells Architects Ltd.

Following completion of the simulations, the proposals were revised, including some minor changes to the geometry. The height of the building has been reduced by 2.2m. These changes are unlikely to have any significant influence on the results. Any difference in the results due to these changes is likely to be beneficial. As a result the conclusions of this assessment are unchanged.

4.2. Location

Figure 4.1, shows:

- The location of the proposed development;
- The location of the additional developments listed for inclusion in the model of the existing built environment;
- The locations of:
  - A The Outline Building, as described in section 4.1.1;
  - B The Strategic Regeneration Framework (SRF) for Great Jackson Street, as described in section 4.1.2.

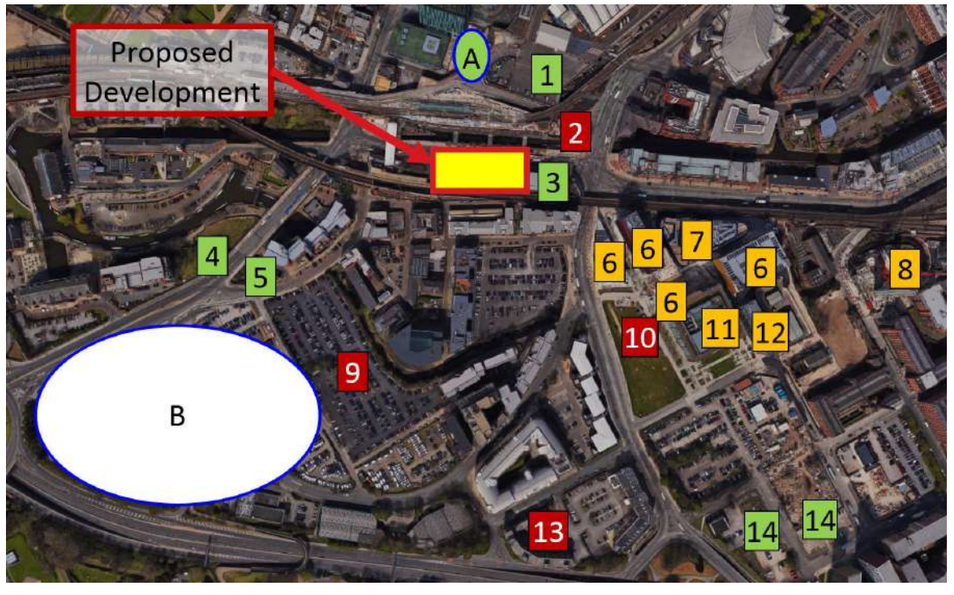


Figure 4.1: Location of Proposed Development and Additional Developments

4.3. Raw Wind Data

Twenty years of hourly-averaged wind measurements for Manchester Airport (14km south of the proposed development) and Woodford Aerodrome (20km SSW) were used for the study. The resulting wind rose for the raw wind data is shown in Figure 4.2, which indicates that the prevailing wind direction is from the south. The wind data used increments of 0.1m/s for speed and 10° for direction, and was reported for a reference height of 10m above ground level.

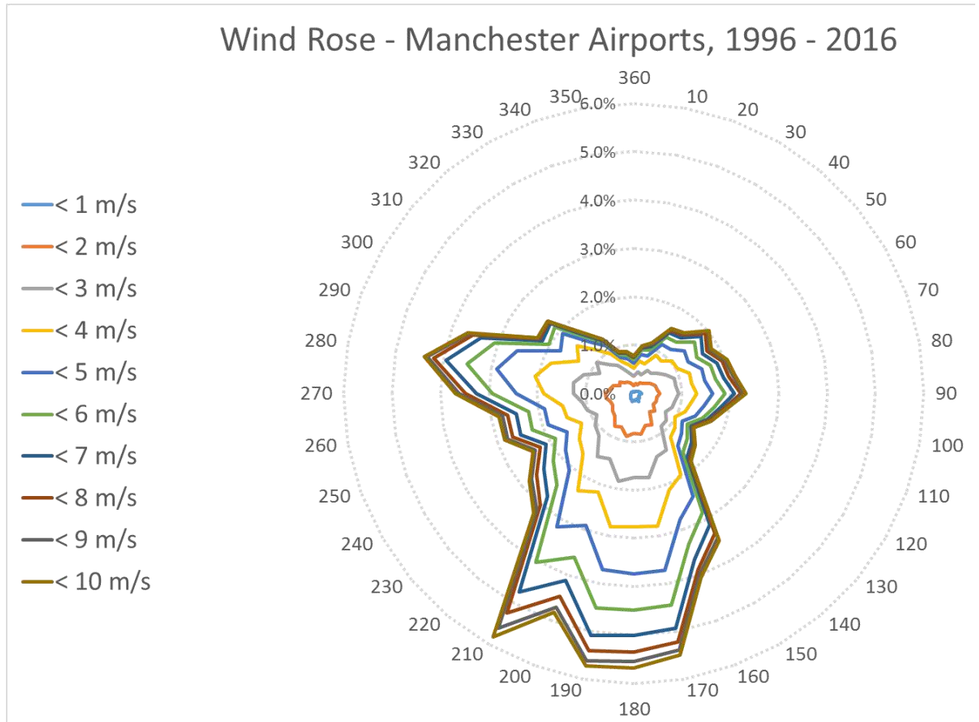


Figure 4.2: Wind Rose for Manchester Airports (Raw Data)

4.4. Surface Roughness

Average wind speed increases with distance from the ground and this, along with turbulence effects has a significant impact on the resulting wind profiles around the buildings.

The roughness of the upwind ground surface is important in the formulation of the wind boundary layer. It affects the variation in atmospheric boundary layer, thus affecting the wind velocity felt at pedestrian level on the site.

The raw wind data is processed to produce Weibull functions representing all 36 wind directions to be simulated, accounting for upwind terrain roughness for both the measurement sites and also the proposed development. Weibull functions are a way of statistically analysing large quantities of data to establish probabilities of occurrence, in this case wind speed and direction.

Table 4.2 indicates the roughnesses appropriate for various terrains surrounding the proposed development. For each direction an approaching terrain roughness was chosen, at 30° intervals, according to the method described in 'EN 1991-1-4:2 05+A1:2010 (E)'. The terrain roughness categories used are shown in Table 4.3.

Table 4.2: Terrain Roughnesses Applied To Incoming Wind Profiles

Degrees from north	Category	z0
0	III	0.3
30	III	0.3
60	III	0.3
90	III	0.3
120	III	0.3
150	III	0.3
180	III	0.3
210	III	0.3
240	III	0.3
270	III	0.3
300	III	0.3
330	III	0.3
360	III	0.3

Table 4.3: Terrain Categories

Terrain Category	Description	K_R	z_0 (m)	z_{min} (m)
I	Rough open sea; Lake shore with at least 5 km fetch up-wind and smooth flat country without obstacles	0.17	0.01	2
II	Farm land with boundary hedges, occasional small farm structures, houses or trees	0.19	0.05	4
III	Suburban or industrial areas and permanent forests	0.22	0.30	8
IV	Urban areas in which at least 15% of surface is covered with buildings of average height exceeding 15m	0.24	1.00	16

4.5. Vegetation

It is extremely difficult to precisely quantify the effect of an individual tree on airflow. The porosity and resistance to flow is highly sensitive to many factors such as species, age, health, aspect, soil, season, etc. In addition, the highest wind speeds experienced in the United Kingdom tend to occur during winter, when deciduous trees are leafless.

Although the presence of a particular tree might conceivably cause an acceleration of flow in one localised region under a specific scenario, its overall effect on the pedestrian environment will be to reduce the average velocity experienced. As a result, vegetation has not been included in the simulations. The omission of individual trees from the models may be considered to be an appropriate conservative measure.

4.6. Proposed Pedestrian Usage

Levels of pedestrian comfort strongly depend on individual activity. Therefore, the Lawson comfort criteria are defined for each activity in terms of a threshold wind speed which should not be exceeded for a given time throughout the year.

Glen Howells Architects have provided an indicative diagram (Figure 4.3) showing the proposed pedestrian usage in the streets around the proposed development in the context of Lawson Comfort Criteria.

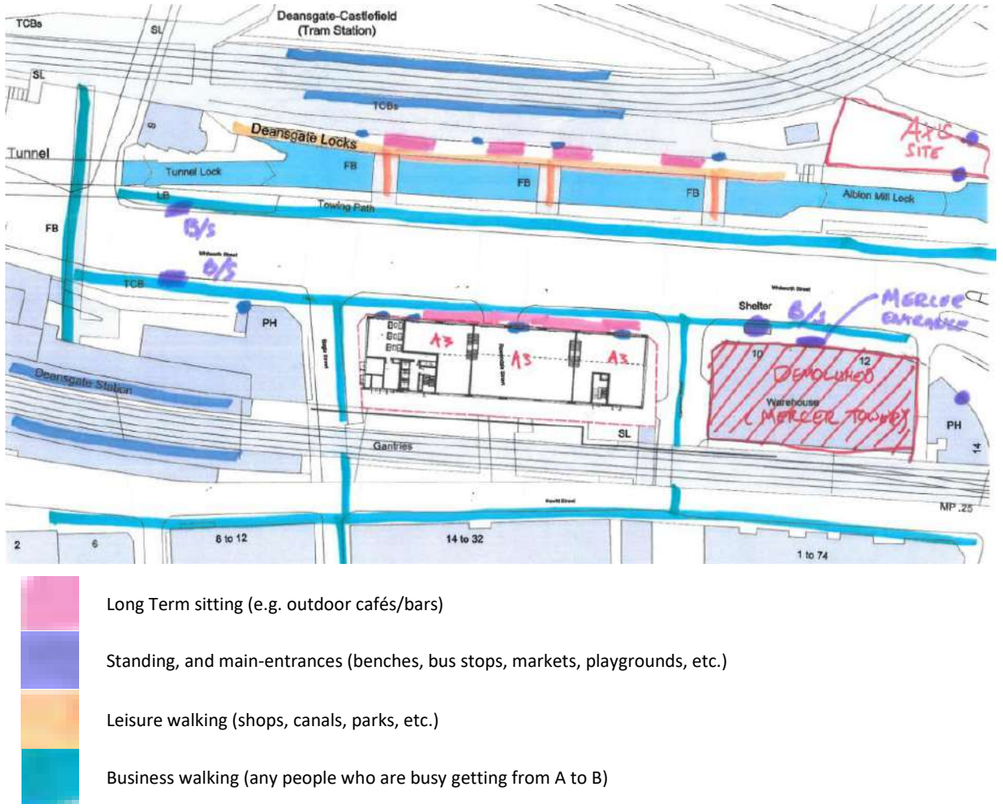


Figure 4.3: Proposed Pedestrian Usage

5. Methodology

To identify the likely effect of the proposed development on the pedestrian level wind environment, 3D CFD models of the proposed development and surrounding site were created. This section describes the methodology for the creation of this model and the inputs used.

5.1. Computational Fluid Dynamics

Simulations of the microclimate were conducted using ANSYS-Fluent CFD software.

The computational process involves the solution of fundamental equations of fluid motion within the CFD software. A computational mesh was created to represent the geometry by dividing the domain into a large number of cell volumes. During the simulation, the values of each variable are determined in each cell of the mesh and so a comprehensive assessment of velocity and scalar variation within the calculation domain is obtained. The dependent variables are as follows:

- Velocities in the three co-ordinate directions (U, V, W)
- Pressure (P)
- Turbulence Kinetic Energy (k)
- Turbulence Dissipation Rate (ε)
- Turbulence Specific Dissipation (ω)

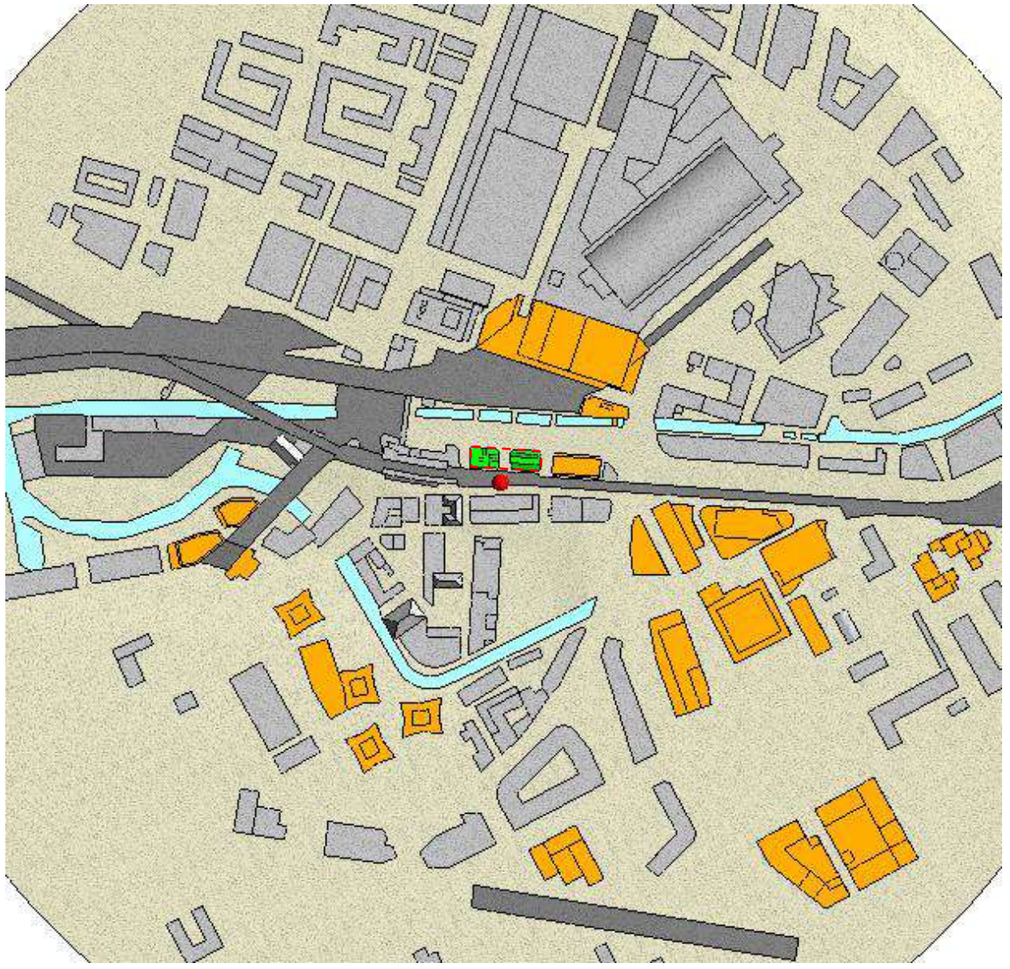
Steady-state simulations were conducted to convergence for 36 wind directions for each geometrical model, using the k-ω SST turbulence model. The coupled, pseudo-transient solver was used with second order discretization for all variables, including pressure.

5.2. Geometry

CFD simulation of likely wind patterns requires the generation of a 3D computer model of the site and surrounding buildings. The proposed development is located in an area in which several very tall buildings are either in existence or under construction. To account for the effect of these, the simulated geometry includes buildings up to 500m in radius around the proposed development.

The data listed in section 4.1 was used to construct a model of the buildings and surrounding area. Figure 4.1 to Figure 4.4 show the modelled geometry.

Following completion of the simulations, the proposals were revised, including some minor changes to the geometry. The height of the building has been reduced by 2.2m. These changes are unlikely to have any significant influence on the results. Any difference in the results due to these changes is likely to be beneficial. As a result the conclusions of this assessment are unchanged.



	Ground
	Canal
	Longstanding buildings
	Viaduct
	Additional buildings (Recently Built, Under Construction, Planning Permission)
	Existing site
	Proposed Development

Figure 5.1: Simulated Geometry: Plan View

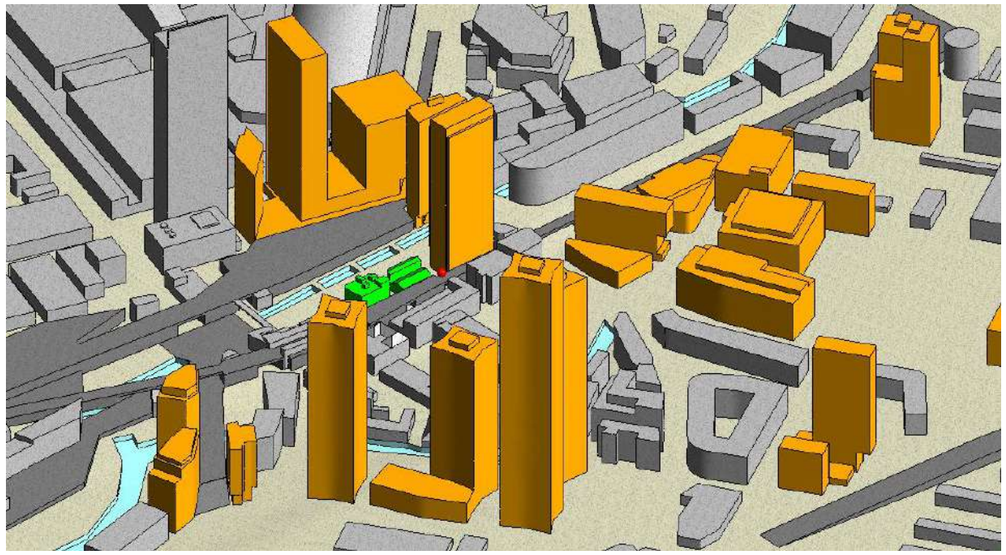


Figure 5.2: Simulated Geometry: Isometric View from Southwest

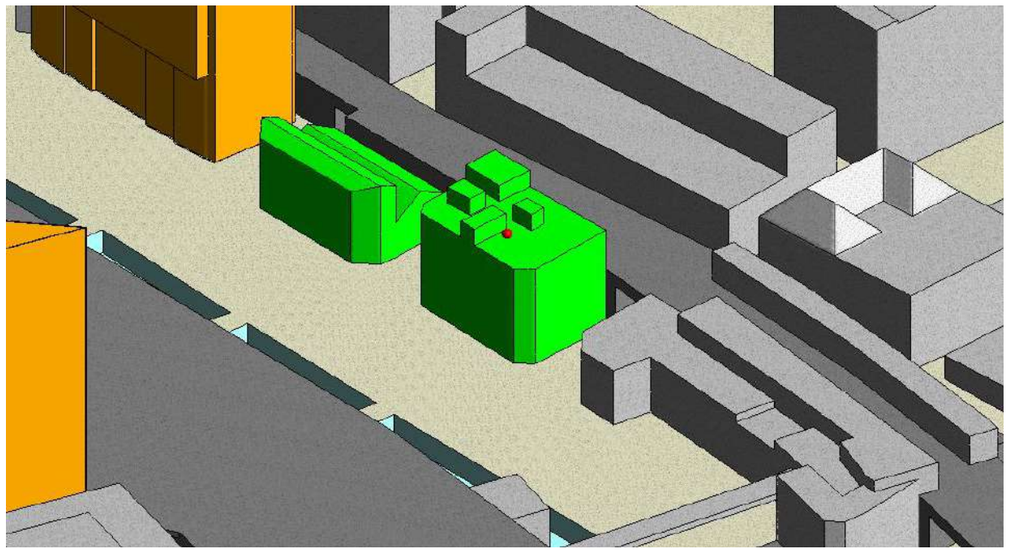


Figure 5.3: Simulated Geometry: Isometric View of Existing Site

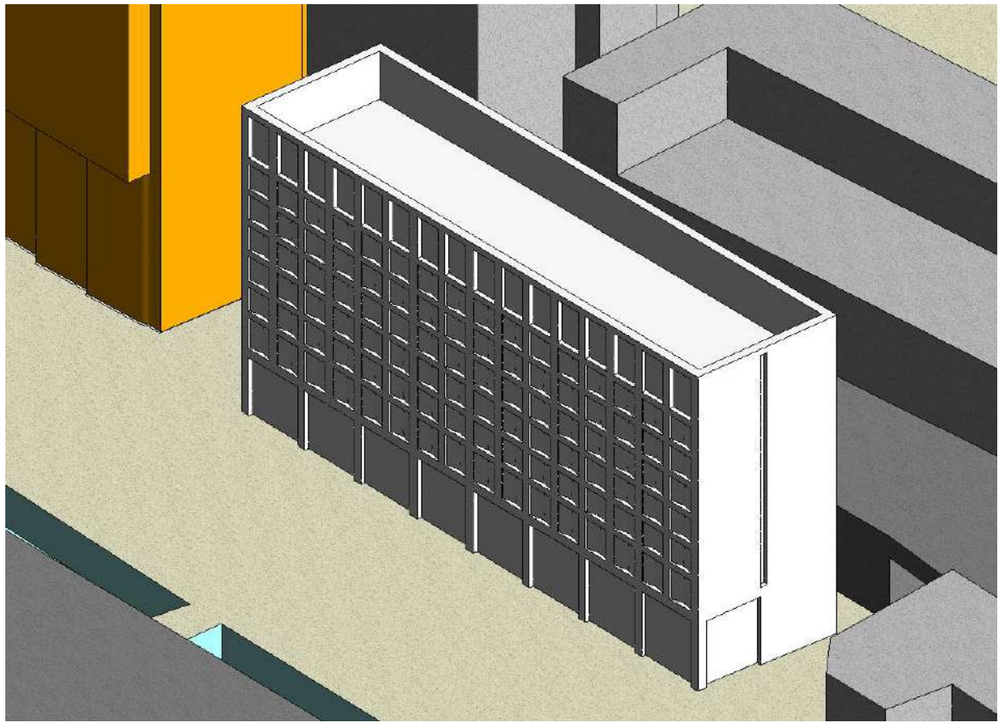


Figure 5.4: Simulated Geometry: Isometric View of Proposed Development

5.3. Mesh

To improve the resolution of the results, the mesh was concentrated in the areas of most interest (at pedestrian level around the Proposed Development) and around significant small-scale flow features. This ensures greater accuracy of the variables under investigation. Layers of thin prisms were applied to all solid boundaries, to improve resolution of boundary layers at these locations. The models used more than 9.4 million cells.

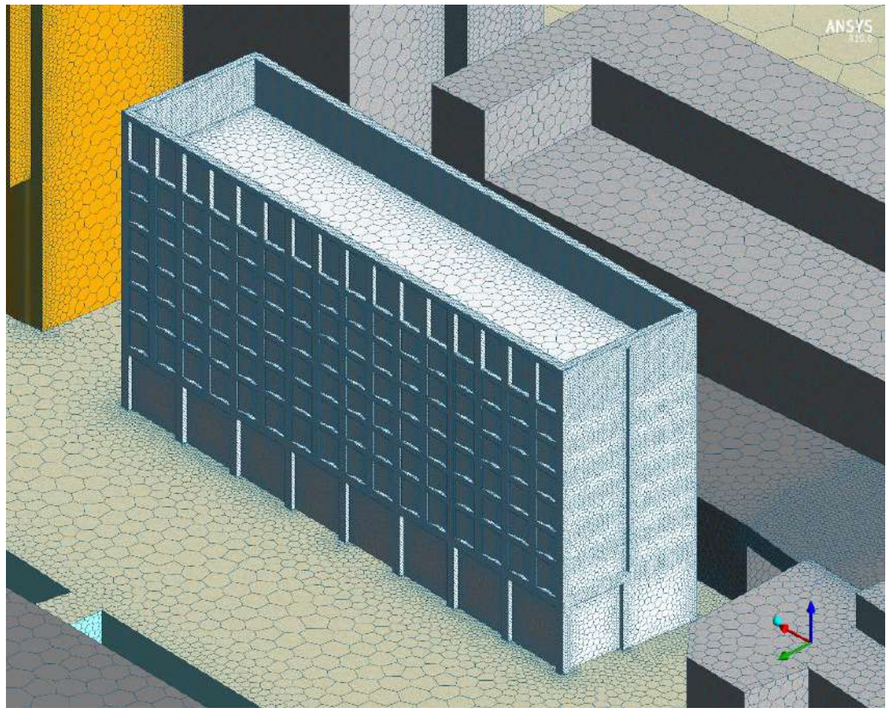


Figure 5.5: CFD Mesh of Proposed Site with Adjacent Buildings

5.4. Boundary Conditions

A cylindrical computational domain was used for the analysis. This allows the wind direction to be altered without changing the computational mesh. Around the perimeter of the domain, a profile for the velocity and turbulence parameters was specified to take into account how the wind speed changes with the height from the ground. Surfaces within the model were specified as having 'no slip'. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface.

Accurate specification of the boundary layer wind profile is crucial in correctly simulating the pedestrian level wind environment. For this reason, a logarithmic profile was assumed, which creates a neutral wind boundary layer profile based on the assumption that wind speed increases proportionally with the natural logarithm of the height from the ground. The upstream logarithmic velocity profile has been applied for the simulations. This profile is for a wind in the highest decile of measured wind speeds, and is representative of typical strong winds.

5.5. Lawson Criteria

This report compares simulated results against the widely used LDDC Lawson Criteria, as set out in Building Aerodynamics by Tom Lawson, [Imperial College Press (2001)].

To produce the Lawson plots shown in section 7.1, statistical analysis of the number of hours and magnitudes of wind for 36 angles (10° increments) around the compass is performed. Results from each of the 36 simulated wind directions (as shown in Appendix 2 of this document) were measured at 1.5m above pedestrian level. These were interpolated to calculate the probability that a velocity threshold will be exceeded. This was performed at each point on the site, according to the wind data shown in Figure 4.2.

5.5.1. Comfort Criteria

For reporting the Lawson comfort criteria, this report uses the colour scale shown in Table 5.1. Regions coloured according to a given category are acceptable for the corresponding activity and all those with faster thresholds. E.g., if an area is coloured with the green shown for 'category III' then it will be acceptable for pedestrian walking and business walking but not acceptable for pedestrian standing and pedestrian sitting.

The Lawson comfort criteria take full account of reduced use during windier times of the year. They are based on a user's typical expectations, given the general weather conditions.

Table 5.1: LDDC Lawson Comfort Criteria Definitions

	Comfort category	Colour	Threshold wind velocity (m/s)	% Exceedance
I	Pedestrian sitting		4	5%
II	Pedestrian standing		6	5%
III	Pedestrian walking		8	5%
IV	Business walking		10	5%
	Unacceptable for pedestrian comfort			

Table 5.2: LDDC Lawson Comfort Criteria Typical Activities

	Comfort category	Colour	Location examples
I	Pedestrian sitting		Cafés, Outdoor Auditoria
II	Pedestrian standing		Bus stops, Main entrances, Playgrounds, Park Benches, Markets
III	Pedestrian walking		Retail Areas, Parks, Canals
IV	Business walking		"Busy" getting from A-to-B, not financial transactions
	Unacceptable		Roads and Car Parks

5.5.2. Distress Criteria

The distress criteria used will also use the LDDC Lawson method, as set out in Building Aerodynamics, [Imperial College Press (2001)]. These state that for elderly or infirm pedestrians, the hourly mean wind speed should exceed 15 m/s for less than 0.025% of the year (approximately 2 hours). For able-bodied pedestrians, the hourly mean wind speed limit should exceed 20 m/s for less than 0.025% of the year. Should these be exceeded for more than 0.025% of the year, the method informs the wind engineer to consider if "the location [is] on a major route through the complex, and are there suitable alternate routes which are not 'distressful'.

6. Typical Aerodynamic Effects of Buildings

6.1. Downwash Effect

Downwash is the term used to describe wind striking the front of a tall building and being deflected downwards. The effect is driven by the pressure difference between fast moving winds at height, and relatively slower winds at lower levels. As wind speed increases with height, this effect is more pronounced in taller buildings. It is estimated that downwash velocity increases discomfort by 20% for a 5 storey building, and 50% by a 16 storey building.

Figure 6.1 shows this effect diagrammatically.

The downwash effect can be reduced by certain designs of the building massing, rounding corners, and canopies/podiums/setbacks above pedestrian level.

6.2. Corner Effects

The corner effect, shown schematically in Figure 6.2, is linked to the downwash effect. This happens when air brought down from higher levels by downwash attempts to round the building and escape into the lower pressure region behind the building.

This causes most problems at pedestrian locations within one width of the building, with the associated increase in discomfort level similar to that of the downwash effect. For tall buildings, the downwash effect exacerbates the corner effect, as the wind running down the building picks up speed before rounding the building.

The corner effect can be reduced by the use of rounded corners, and evergreen planting and/or porous structures at the corners to break up the separation effects.

6.3. Funnelling Effects

Funnelling arises in regions where multiple structures are close together, which only allows the wind a narrow passage to flow through, as shown in Figure 6.3. This forces the wind to accelerate and can result in very high speeds at the narrowest point between the structures.

Funnelling is most pronounced in regions with tall buildings, particularly those over 5 storeys, coupled with an unobstructed passage longer than 100m. Especially tall buildings, such as those with 18 storeys, can raise discomfort at ground level through funnelling effects by up to 60%. A 30% increase can be expected for buildings with heights of around 8 storeys.

6.4. Wake Effects

As the wind passes around a building, as described above in the corner effect discussion, it eventually reaches the lee-edges and separates from the side faces. This results in a very unstable region downstream of the building, known as the wake, as the wind rotates inwards towards the low pressure region and interacts with the wind separated from the other side. This region can be described as very turbulent and is characterised by swirling winds which can be uncomfortable and also raise detritus such as leaves and rubbish, leaving them in heaps.

Once again, increasing building height increases this effect. A 16 storey building, away from other buildings and thus not causing any funnelling effects, can still result in an increase in discomfort of 40%. Double the height can lead to as much as a 120% increase. See Figure 6.4.

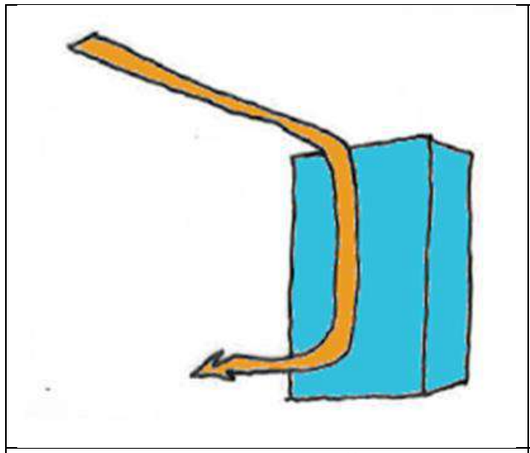


Figure 6.1: Downwash Effect

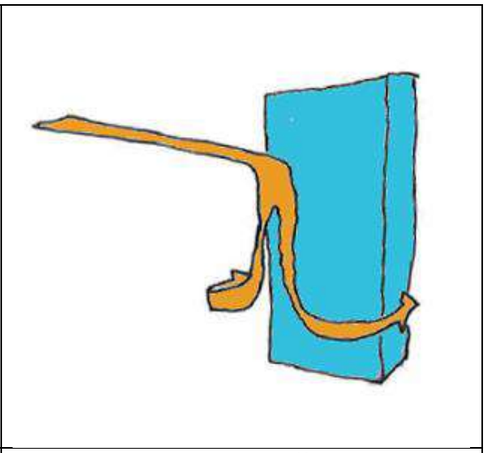


Figure 6.2: Corner Effect

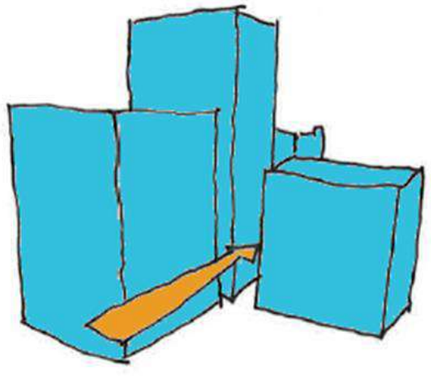


Figure 6.3: Funnelling Effect

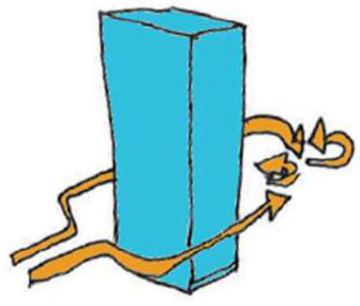


Figure 6.4: Wake Effect

7. Results

7.1. Comfort

7.1.1. Existing

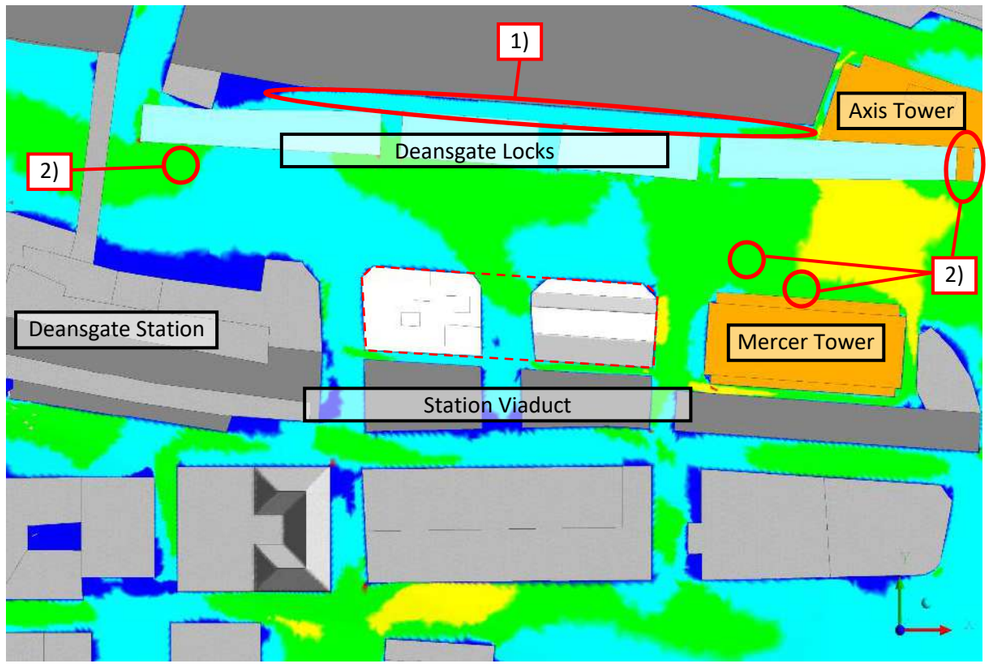


Figure 7.1: Lawson Comfort Plot: Existing

Comparing the simulated existing comfort conditions shown in Figure 7.1 to the proposed activities shown in Figure 4.3 shows that:

1) Wind conditions for the existing café seating areas along Deansgate Locks are currently likely to be unacceptable for use as long-term sitting.
2) The main entrances to Axis Tower and Mercer Tower, the westbound bus stop adjacent to Mercer Tower, and the eastbound bus stop by the station footbridge are currently likely to be unacceptable for standing and main entrances.

Table 7.1: LDDC Lawson Comfort Criteria Typical Activities

	Comfort category	Colour	Location examples
I	Pedestrian sitting		Cafés, Outdoor Auditoria
II	Pedestrian standing		Bus stops, Main entrances, Playgrounds, Park Benches, Markets
III	Pedestrian walking		Retail Areas, Parks, Canals
IV	Business walking		"Busy" getting from A-to-B (i.e. not necessarily financial)
	Unacceptable		Roads and Car Parks

7.1.2. Proposed

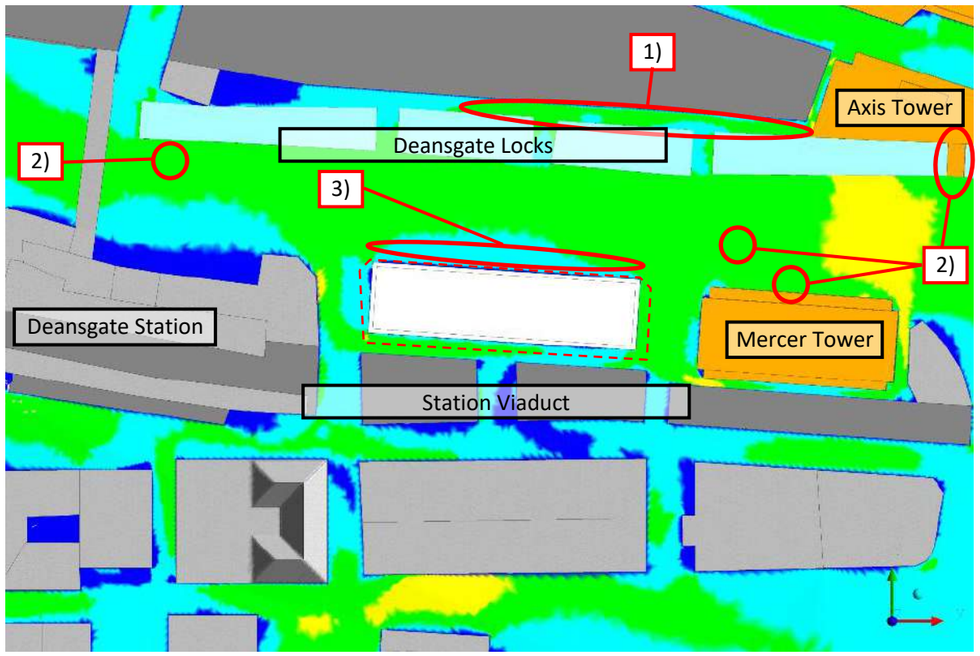


Figure 7.2: Lawson Comfort Plot: Proposed

Comparing the simulated proposed comfort conditions shown in Figure 7.2 with both the proposed activities shown in Figure 4.3 and the simulated existing comfort conditions shown in Figure 7.1 shows that:

1) Wind conditions for the existing café seating areas along Deansgate Locks are likely to remain unacceptable for use as long-term sitting, and in places are likely to become unacceptable for standing and main entrances;
2) Wind conditions for the main entrances to Axis Tower and Mercer Tower, the westbound bus stop adjacent to Mercer Tower, and the eastbound bus stop by the station footbridge are likely to remain unacceptable for standing and main entrances.
3) Wind conditions for the proposed long term sitting area in front of the proposed development are likely to be unacceptable for that activity. This area might still be used for long term sitting frequently during summer months, and occasionally throughout the year, but this could not be relied upon regularly;

Causes of these effects and their potential mitigation are discussed in section 8

7.2. Distress

7.2.1. Existing

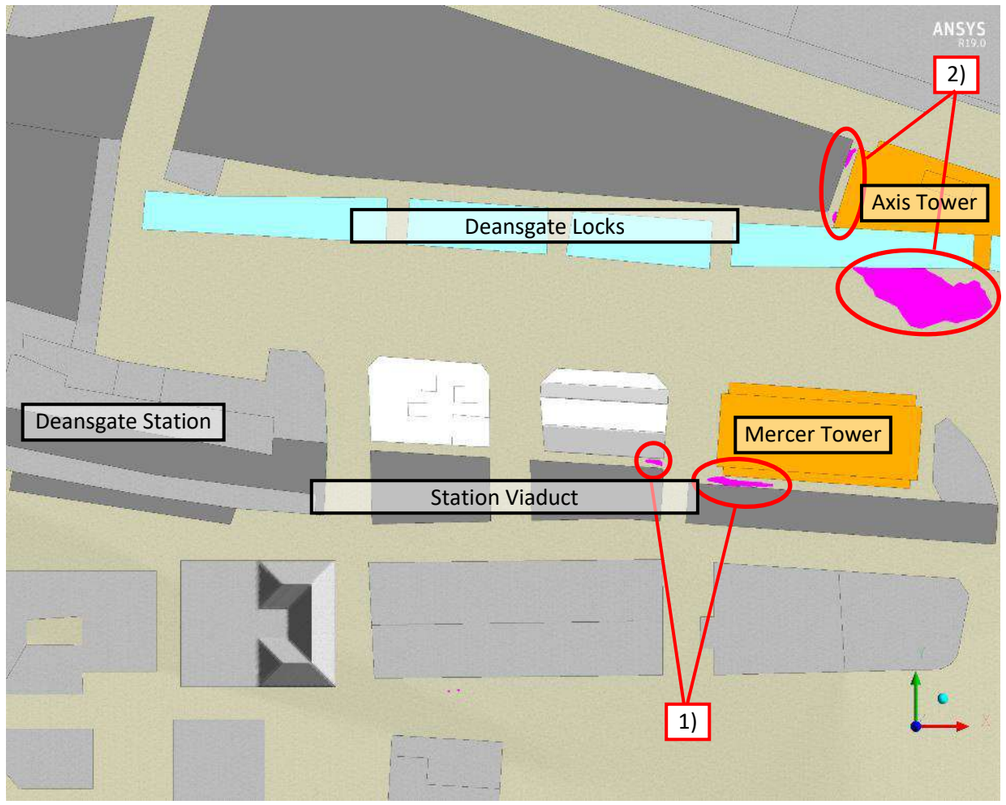


Figure 7.3: Lawson Distress Plot: Existing

The definition of the LDDC Lawson distress criteria is described in section 5.5.2.

Simulations show that there are currently likely to be areas breaching the pedestrian distress criterion in the following locations:

1) A small strip close to the southwest corner of Mercer Tower, and another smaller region across Cameron Street. These are not on a major route;
2) A large region south of Axis Tower, and two small regions to the west of Axis Tower.

7.2.2. Proposed

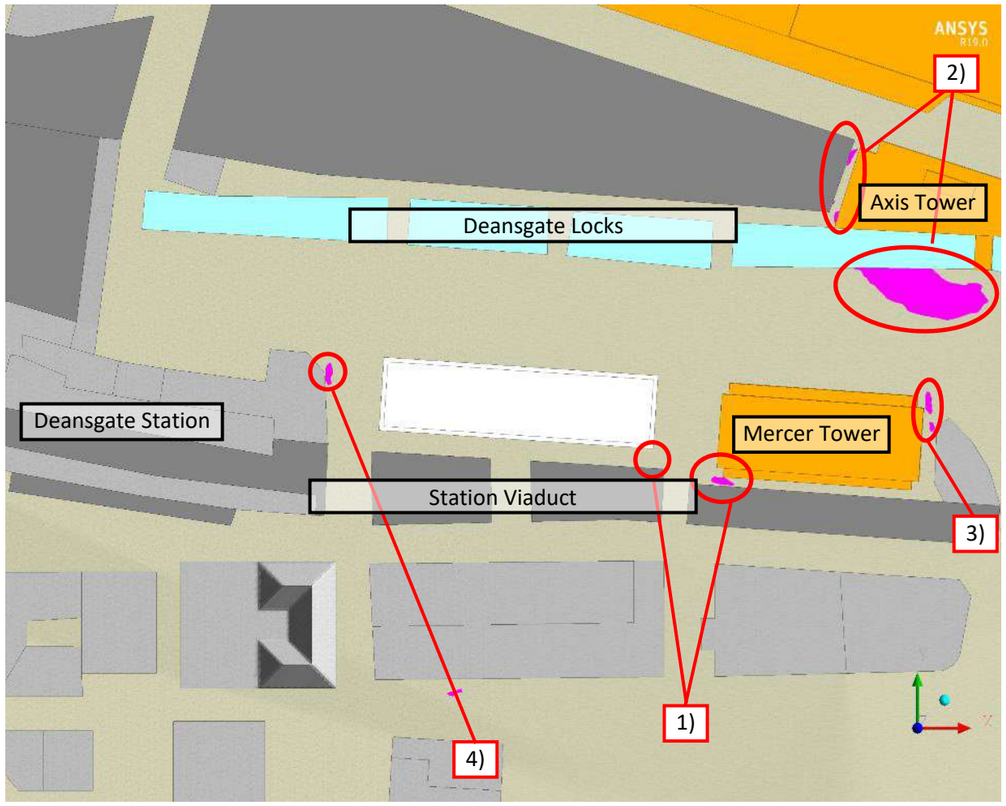


Figure 7.4: Lawson Distress Plot: Proposed

Comparing the simulated existing distress conditions shown in Figure 7.3 to the simulated proposed distress conditions shown in Figure 7.4 shows that there are likely to be changes to pedestrian distress conditions in the following locations:

1) The small strip close to the southwest corner of Mercer Tower may become smaller and the small region across Cameron Street may be eliminated. These are not on a major route;
2) The regions near Axis tower may be largely unchanged.
3) A new region may appear close to the northeast corner of Mercer Tower. This is adjacent to, but not lying on the major route.
4) A new region may appear across Bugle Street from the proposed development. Although this is close to a major route, alternative routes exist.

Causes of these effects and their potential mitigation are discussed in section 8

8. Conclusions

A new hotel development is proposed for Whitworth Street West, Manchester. CFD simulations of the wind microclimate under 36 different wind directions have been undertaken for both the existing and proposed built environments around the proposed development. The results of these simulations have been combined with processed wind statistics to produce plots of both existing and proposed conditions, according to the Lawson comfort and distress criteria. These plots have been compared with proposed activities around the proposed development.

8.1. Effects of the development

Pedestrian comfort and distress conditions are largely unaffected by the proposed development, with the exception of two minor adverse effects.

8.1.1. Comfort

- Simulations for the pre-existing scenario show that the wind conditions for the off-site café seating areas along Deansgate Locks are currently unacceptable for long term sitting according to LDDC Lawson comfort criteria. Simulations conducted for the proposed development show that wind speeds in this area may increase becoming unacceptable for standing in some places according to the LDDC Lawson comfort criteria. Typically a one-step increase in LDDC Lawson comfort criteria is considered a minor adverse effect;
- Wind conditions for the pedestrian region adjacent to the north façade of the proposed development are largely unchanged and would remain unacceptable for long term sitting (acceptable for standing according to LDDC Lawson comfort criteria). However, the proposed development would introduce café-type seating in this area. Since this proposed activity is one category more sensitive than the acceptable LDDC Lawson comfort criteria this is typically considered a minor adverse effect.

8.1.2. Distress

No other assessed adverse effects are introduced by the proposed development. Some small areas may exist (~1.5m wide) that are likely to present pedestrian distress during certain weather scenarios, although these are not considered to be adverse effects according to the LDDC Lawson distress criteria since: i) they are not on major routes; and ii) alternative pedestrian routes exist.

8.1.3. Aerodynamic Causes of Adverse Effects

The unacceptable comfort conditions along Deansgate Locks are likely to occur under prevailing southerly winds. Downwash from these winds on the south façade of the proposed development and the adjacent Mercer tower are likely to accelerate around the two southern corners, interacting with the downwash from the nearby Axis tower. This is illustrated in Figure 8.1.

The unacceptable comfort conditions along the north façade of the proposed development are likely to occur under secondary westerly winds. Downwash from these winds on the west façade of the proposed development are likely to accelerate around the northwest corner. This is illustrated in Figure 8.2

8.2. Existing Vegetation

There are seven large mature deciduous trees along the south side of Deansgate Locks. These have been excluded from the CFD model, as described in section 4.5.

During summer months, these trees are likely to provide shelter to the cafés on the north side of the canal from the prevailing southerly winds. They are also likely to act as a drag on and therefore slow secondary westerly winds.

Simulations show that, in the absence of these trees, it is likely that the existing café areas are unacceptable for long term sitting. It is therefore likely that these cafés do not rely upon outdoor seating during winter.

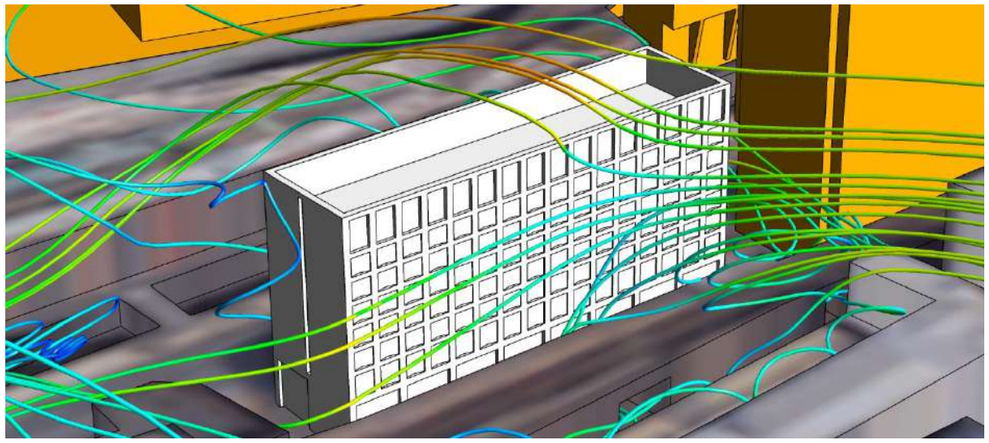


Figure 8.1: Streamlines From the Prevailing Southerly Wind

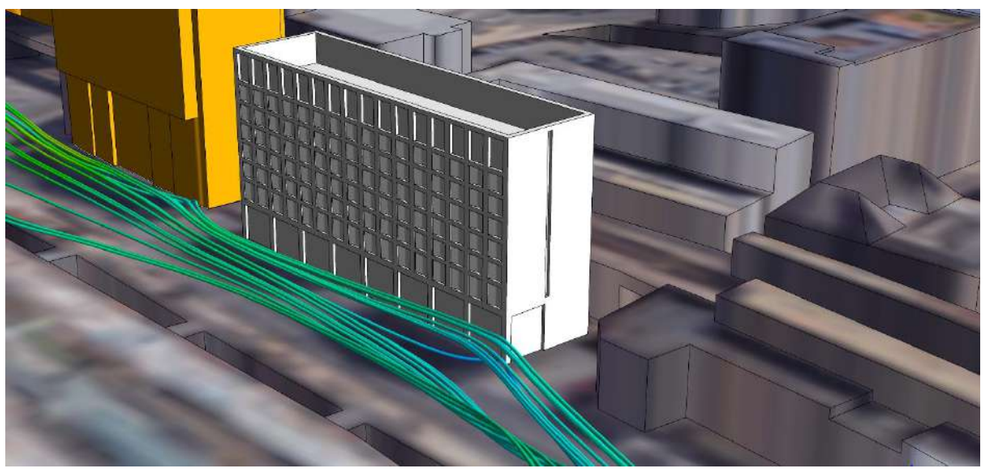


Figure 8.2: Streamlines From the Secondary Westerly Wind

8.3. Possible Mitigation

8.3.1. Comfort

Mitigation of the regions identified above could take the form of either:

- Changing the proposed activity to one that would be acceptable for the conditions;
  and/or
- Localised shelter.

8.3.1.1. Changing the proposed activity

The Lawson comfort criteria take full account of reduced use during windier times of the year. They are based on a user's typical expectations, given the general weather conditions.

The proposed long term sitting area in front of the proposed development is likely to still be useable for seating when the weather is mild. But there are likely to be days when, given the general weather conditions, a user's expectations of sitting comfortably would not be met.

8.3.1.2. Localised shelter

Effective localised shelter would take the form of either mature vegetation/planting, or semi-porous fences/balustrades. The porous structures could also be in the form of bespoke artwork. This shelter would need to be comparable in height to the seven existing large mature deciduous trees (~10m), although it needn't be as broad.

The most effective shelters are mostly solid, with an increasing graduated porosity towards the edge, to reduce turbulent gusting downwind of the shelter.

The most effective location for such shelters would be at the four corners of the proposed development to diffuse the acceleration of the wind around the corners.

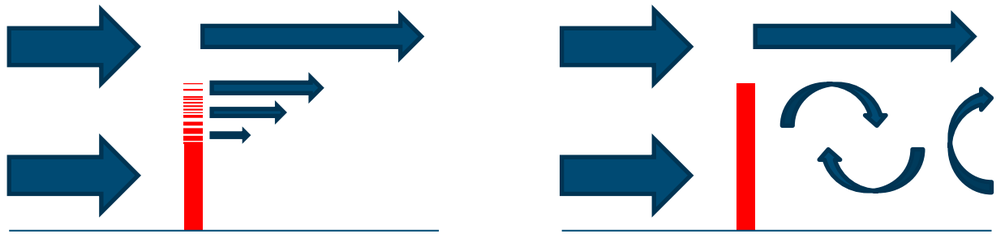


Figure 8.3: Shelter, Best Practice Vs Solid

8.4. Residual Effects

If significant localised shelter is provided at the corners of the proposed development, there are likely to be no residual effects on the pedestrian wind microclimate from the proposed development.

If this shelter is not provided, there are likely to be two minor adverse effects, on two long term sitting areas:

- Cafés north of Deansgate Locks;
- North façade of proposed development.

8.5. Geometry Changes

Following completion of the simulations, the proposals were revised, including some minor changes to the geometry. The height of the building has been reduced by 2.2m. These changes are unlikely to have any significant influence on the results. Any difference in the results due to these changes is likely to be beneficial. As a result the conclusions of this assessment are unchanged.

8.6. Strategic Regeneration Framework

The Strategic Regeneration Framework for Great Jackson Street proposes nearly 20 new buildings, ranging from 18 to 50 storeys. These are likely to provide significant obstacles to high level winds, creating shelter for other tall buildings far downstream, but also creating localised regions of high wind at pedestrian level nearby.

This region is ~250m southwest of the proposed development on Whitworth Street West. Other buildings (in particular the Deansgate Station viaduct) are likely to provide shelter from much of the direct localised effects.

As a result, general wind conditions around the proposed hotel development on Whitworth Street West are unlikely to become significantly faster or slower. Some areas are likely to get a little windier, although these may be balanced by other areas becoming more sheltered.



Figure 8.4: Strategic Regeneration Framework – Great Jackson Street

Appendix 1 – Geometry of Additional Developments

The following drawings related to the listed existing developments were available from https://pa.manchester.gov.uk/online-applications, and were used as the basis of the model geometry.

No.	Reference	Address	Drawings Used
1	115871/FO/2017	Former Bauer Millet Site Albion Street Manchester	MASTERPLAN_-_LONG_SECTION_AA-724152.pdf MASTERPLAN_-_PROPOSED_PLAN_-_GROUND-724143.pdf MASTERPLAN_-_PROPOSED_PLAN_-_PODIUM_LEVEL_02-724146.pdf MASTERPLAN_-_PROPOSED_PLAN_-_PODIUM_LEVEL_03-724147.pdf MASTERPLAN_-_PROPOSED_PLAN_-_ROOF_PLAN-724151.pdf
2	106490/FO/2014/C1	Land Bounded By Albion Street, Trafford Street & The Rochdale Canal Manchester	C1-2nd_floor_plan__typical_floors_2-5__-_general_arrangement-411592.pdf C1-Elevations_-_south___east-347971.pdf C1-Footbridge_details-568273.pdf C1-Ground_floor_plan_-_general_arrangement-459708.pdf C1-Roof_plant_plan_-_general_arrangement-369139.pdf C1-Roof_plant_plan__Floor_27__-_general_arrangement-545519.pdf
3	111003/FO/2016/C1	10-12 Whitworth Street West Manchester M1 5WY	C1-First_Floor_Plan_Drawing__05247_B1_02_2201_Rev_D-465531.pdf C1-Ground_Floor_Plan_Drawing__05247_B1_02_2200_Rev_F-396145.pdf C1-Rooftop_Amenity_Plan_Drawing__05247_B1_02_2235_Rev_D-565662.pdf C1-Roof_Plan_Drawing__05247_B1_02_2236_Rev_A-455519.pdf C1-Second_Floor_Plan_Drawing__05247_B1_02_2202_Rev_D-515640.pdf C1-South_Elevation_Drawing__05247_B1_04_2200_Rev_B-416161.pdf C1-Third_Floor_Plan_Drawing__05247_B1_02_2203_Rev_B-542665.pdf
4	113870/FO/2016	2 - 4 Chester Road Manchester M15 4QG	Elevation_A_-_L1600B-462948.pdf Roof_-_L1024A-383493.pdf
5	115591/FO/2017	Land At Chester Road(A56) Bridgewater Viaduct Manchester M3 4LB	DRAWINGS-713407.pdf
6	101937/NMC/2013/C1	Plots 1, 1A, 3 And 3A Of The First Street North Site Manchester City Centre Manchester	Plot_1__ref_7290-P-004-Z1-G200-P-00_02_-16837.pdf Plot_1__ref_7290-P-006-Z1-G200-P-01_02_-111435.pdf Plot_1__ref_7290-P-011-Z1-G200-P-RF_02_-150587.pdf Plot_1__ref_7290-P-012-Z1-F200-A-MATRIX_02_-101335.pdf Plot_1__ref_7290-P-013-Z1-G200-P-AA_02_-50069.pdf Plot_1__ref_7290-P-014-Z1-G200-S-EE_02_-174854.pdf Plot_1__ref_7290-P-016-Z1-G200-E-E_02_-254122.pdf Plot_1A__ref__7290-P-024-Z1A-G200-P-00_02_-271316.pdf Plot_1A__ref__7290-P-025-Z1A-G200-P-01_02_-233986.pdf Plot_1A__ref__7290-P-026-Z1A-G200-P-RF_02_-106847.pdf Plot_1A__ref__7290-P-027-Z1A-G200-S-AA_02_-11800.pdf Plot_3__ref__7290-P-034-Z3-G200-P-00_03_-100836.pdf Plot_3__ref__7290-P-041-Z3-G200-P-RF_03_-26318.pdf Plot_3__ref__7290-P-046-Z3-A-G200-E-E_03_-117262.pdf Plot_3A__ref__7290-P-054-Z3A-G200-P-00_02_-321102.pdf Plot_3A__ref__7290-P-056-Z3A-G200-S-AL_02_-244779.pdf

7	098438/VO/2012/C1	Land At Plot 2 Of The First Street North Site Bounded By Whitworth Street West To The North, River Medlock To The East , The No.1 First Street Building To The South And Medlock Street To The West Manchester M15 4FN.	C1-Proposed_upper_roof_plan-268470.pdf
8	105505/FO/2014/C1	Land Bounded By The River Medlock, River Street & Cambridge Street Manchester M1 5BZ	C1-Block_A_heights_key-390263.pdf C1-Section_D-D-490269.pdf
9	111719/FO/2016/C1	Land Bounded By Owen Street, Pond Street, Deansgate And The River Medlock Manchester M15 4QA	C1-GA_Elevation_E01_Building_E_Owen_St_-_7359_A_DRG_PL_G200_4501-370113.pdf C1-GA_Elevation_E01_E03_Tower_B_Lobby_River_Place_-_7359_A_DRG_PL_G200_4201-373451.pdf C1-Roof_Plan_-_7359_A_DRG_PL_G000_2081-464509.pdf C1-Tower_Heights_with_Great_Jackson_Masterplan_included_-_7359_A_DRG_PL_G100_1000-502588.pdf
10	108963/FO/2015/C1	Land Bounded By Medlock Street / River Street And Number One First Street, Manchester City Centre Plot 5 Of The First Street Masterplan.	C1-roof_plan-500500.pdf C1-sections_AA-BB-A1-528622.pdf
11	083763/FO/2007/C3	BT Grand Island Between Medlock Street And Whitworth Street Manchester M15 4BB	C3--62435.pdf C3--68752.pdf
12	101194/FO/2012/C1	Plot 4, 1 First Street, Manchester, M15 4FN	C1-Mezzanine_floor_general_arrangement_plan__ref__05164_P4_02_220M_-236249.pdf C1-Roof__01__general_arrangement_plan__ref__05164_P4_02_2211_-66982.pdf C1-Section_AA__BB___CC__ref__05164_P4_05_1200_-344923.pdf
13	118683/FO/2017	Land Bound By River Street, A Premier Inn And Associated Carpark, Mancunian Way And Garwood Street Manchester M1 5BG	ROOF_LEVEL_PLAN-831660.pdf SECTION_AA-831666.pdf SECTION_BB-831669.pdf
14	111170/FO/2016/C1	First Street South (Plot 8) First Street Manchester M15 4FN	Level_00_GA_Plan__Rev_1_-650655.pdf Level_01_GA_Plan__Rev_1_-445010.pdf Level_02_GA_Plan__Rev_1_-589225.pdf Level_08-09_GA_Plan__Rev_1_-541376.pdf Level_10_GA_Plan__Rev_1_-435567.pdf Level_21_GA_Plan__Rev_1_-578011.pdf Level_23_GA_Plan__Rev_1_-640618.pdf Level_24_GA_Plan__Rev_1_-658146.pdf Level_26_GA_Plan__Rev_1_-488636.pdf South_elevation__Rev_1_-536895.pdf

Appendix 2 – Additional Velocity Plots

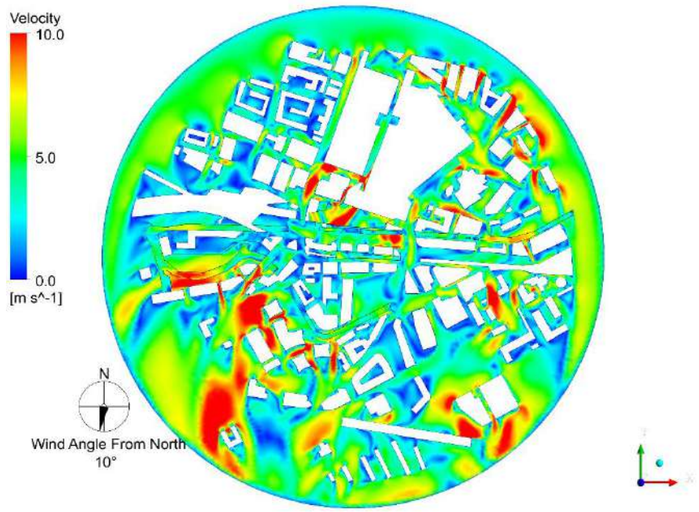


Figure 8.5: Simulated Wind Velocities: Existing, 10° From North

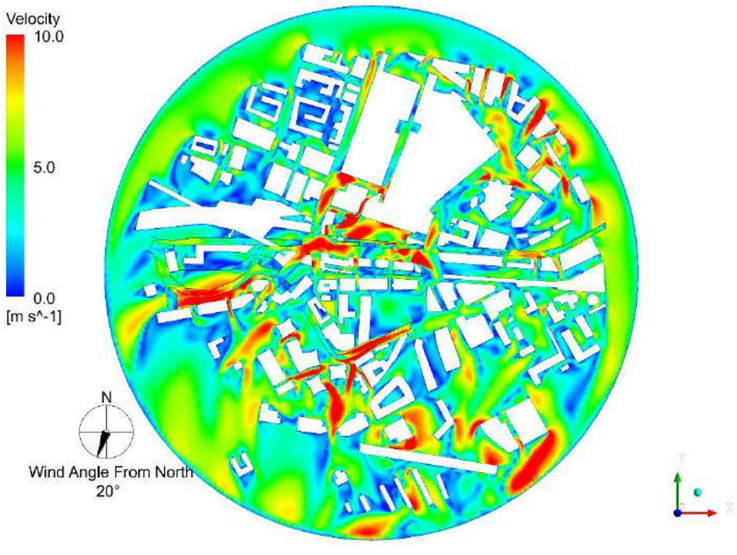


Figure 8.6: Simulated Wind Velocities: Existing 20° From North

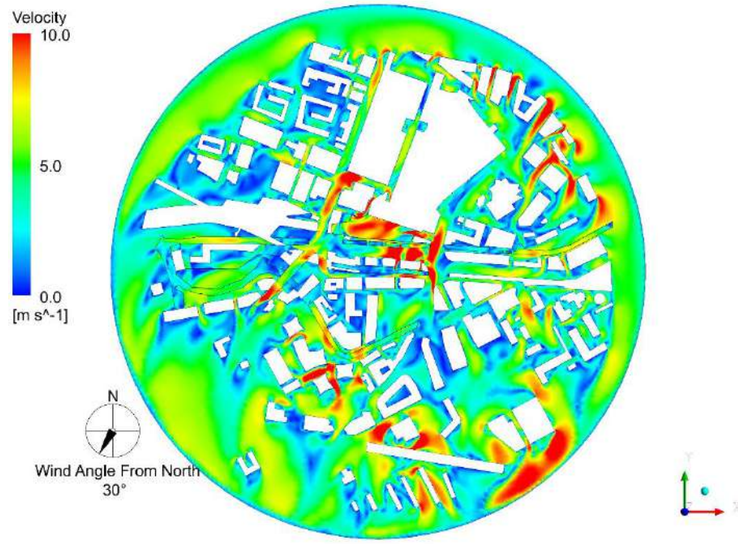


Figure 8.7: Simulated Wind Velocities: Existing 30° From North

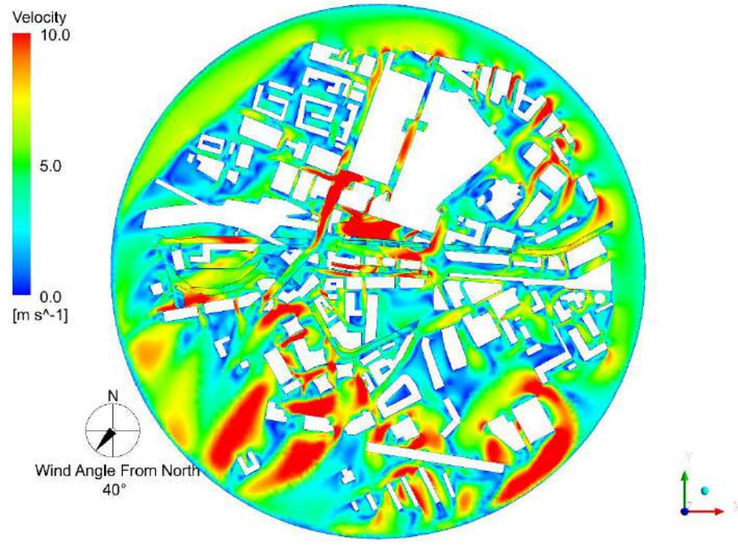


Figure 8.8: Simulated Wind Velocities: Existing 40° From North

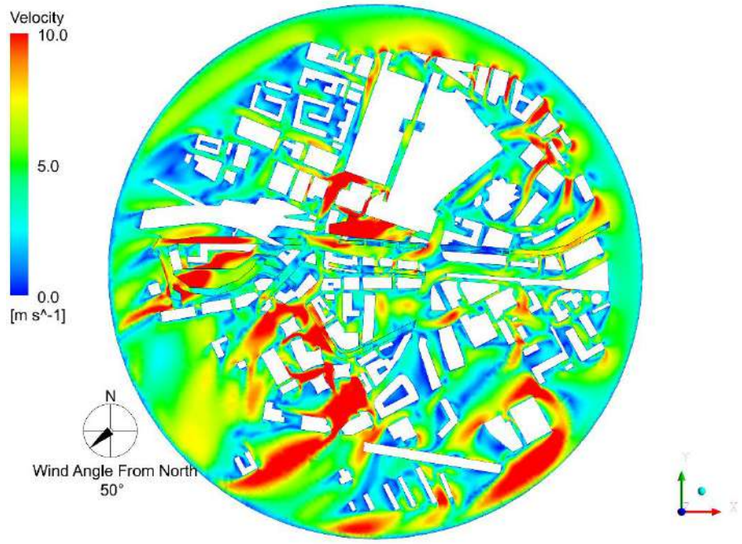


Figure 8.9: Simulated Wind Velocities: Existing 50° From North

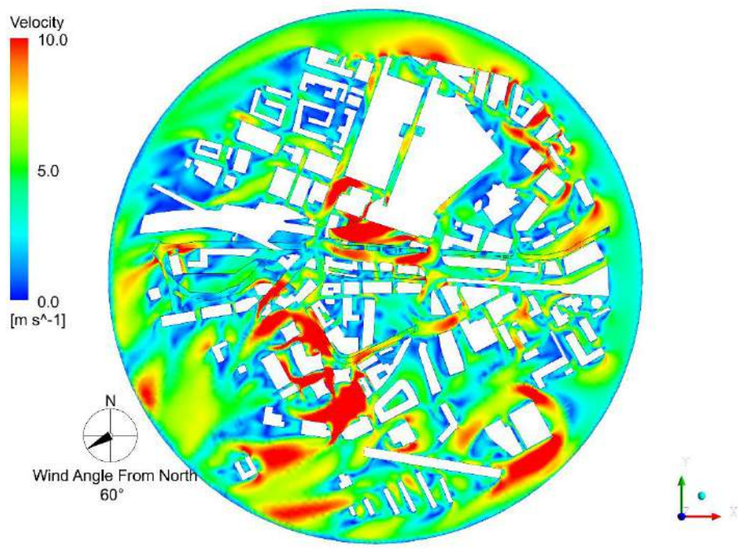


Figure 8.10: Simulated Wind Velocities: Existing 60° From North

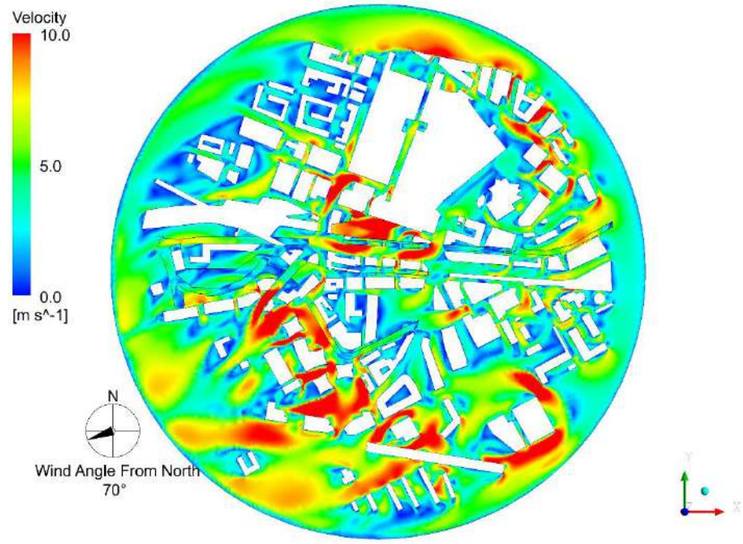


Figure 8.11: Simulated Wind Velocities: Existing 70° From North

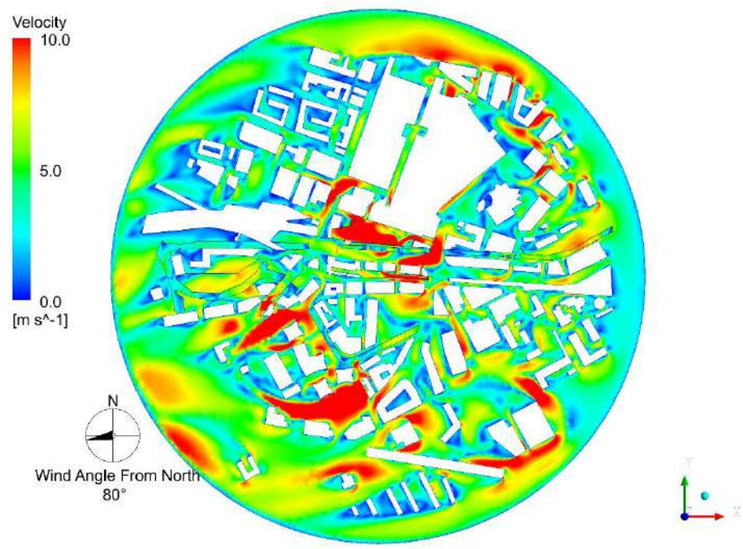


Figure 8.12: Simulated Wind Velocities: Existing 80° From North

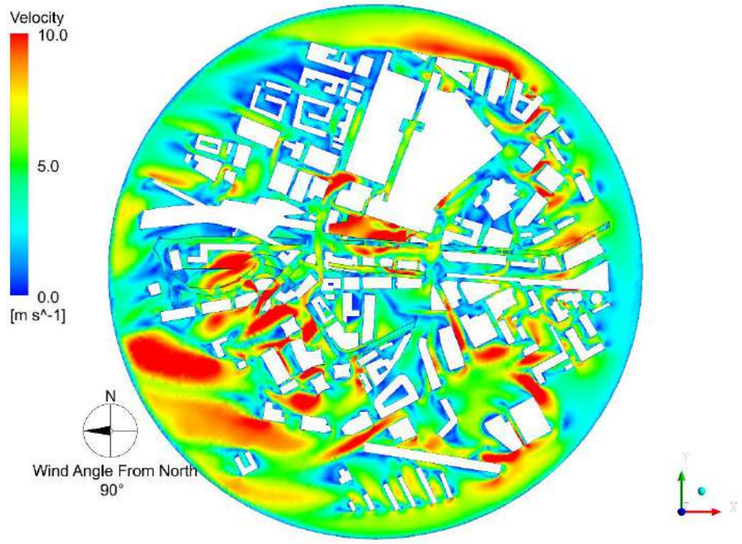


Figure 8.13: Simulated Wind Velocities: Existing 90° From North

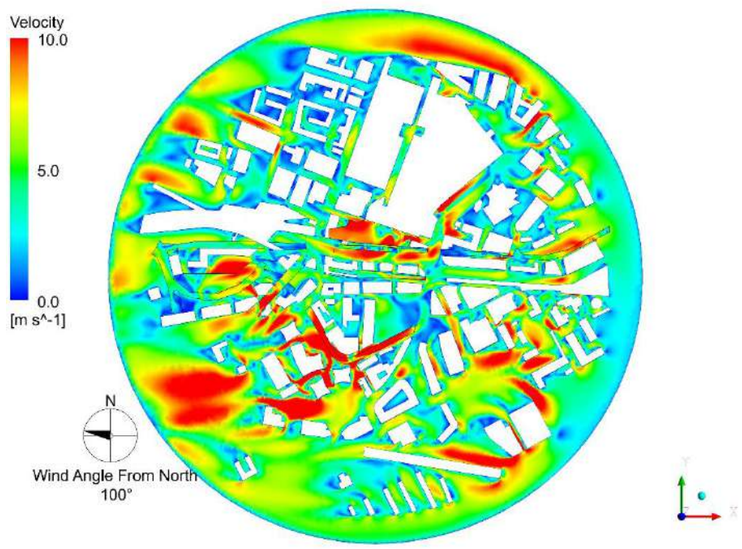


Figure 8.14: Simulated Wind Velocities: Existing 100° From North

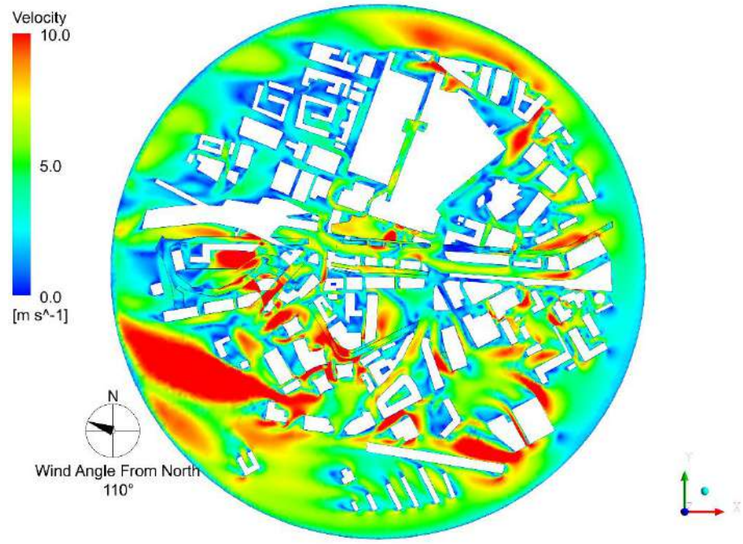


Figure 8.15: Simulated Wind Velocities: Existing 110° From North

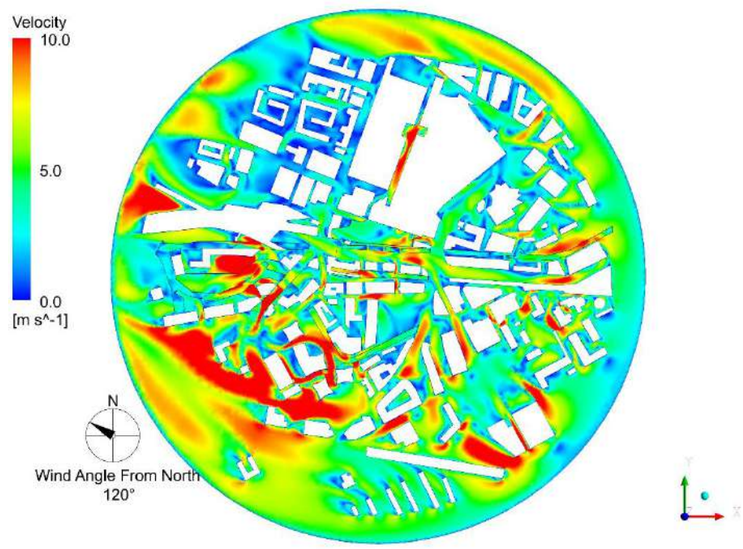


Figure 8.16: Simulated Wind Velocities: Existing 120° From North

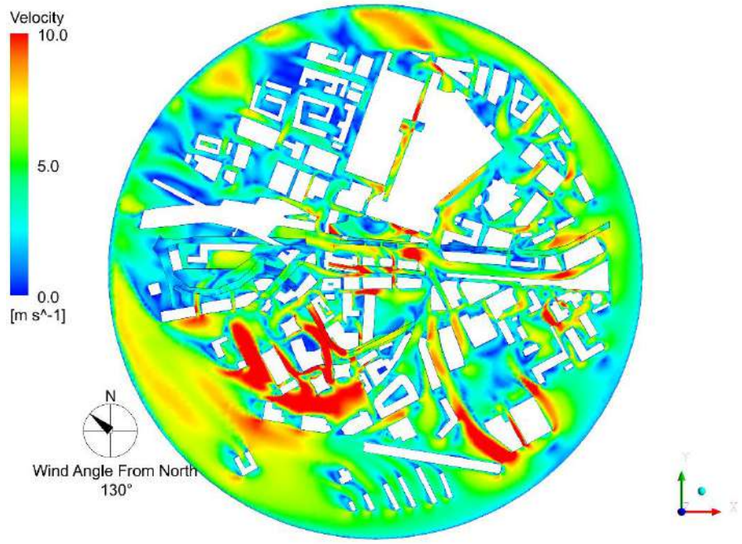


Figure 8.17: Simulated Wind Velocities: Existing 130° From North

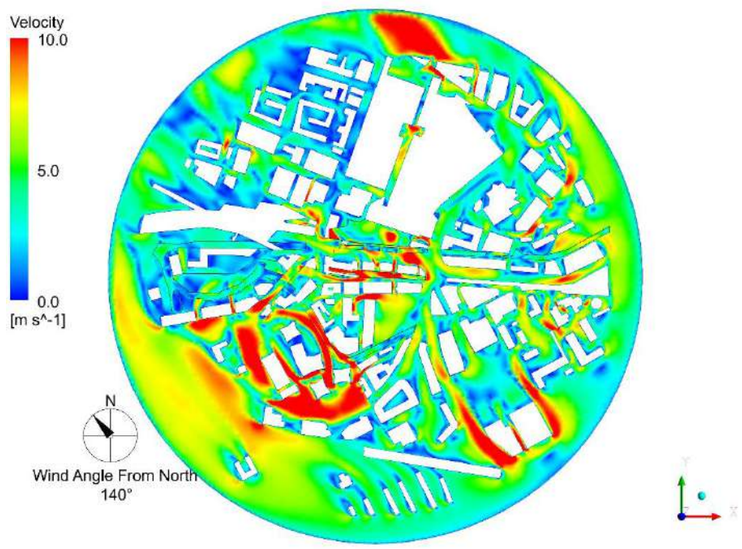


Figure 8.18: Simulated Wind Velocities: Existing 140° From North

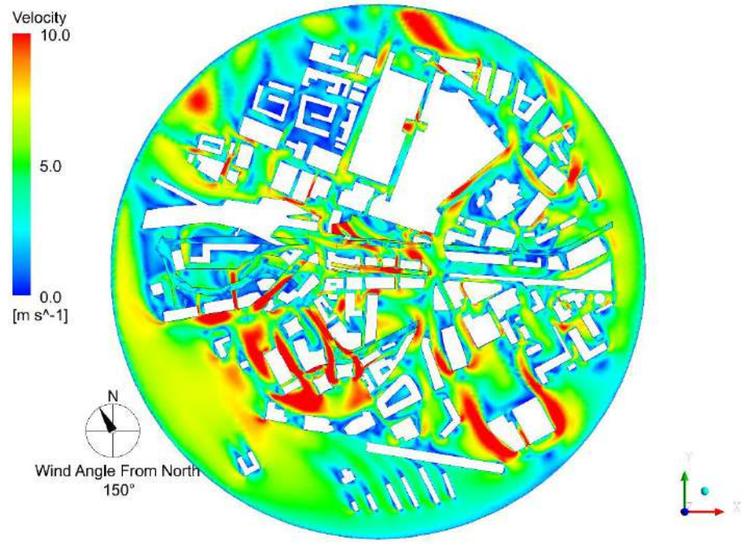


Figure 8.19: Simulated Wind Velocities: Existing 150° From North

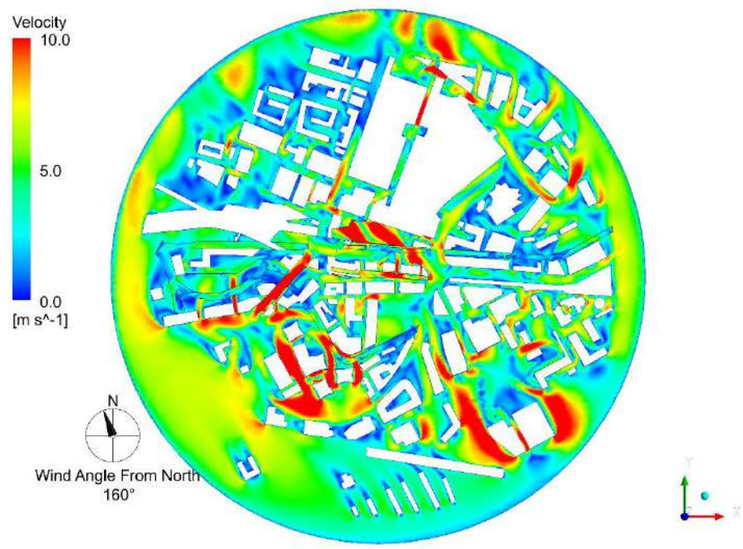


Figure 8.20: Simulated Wind Velocities: Existing 160° From North

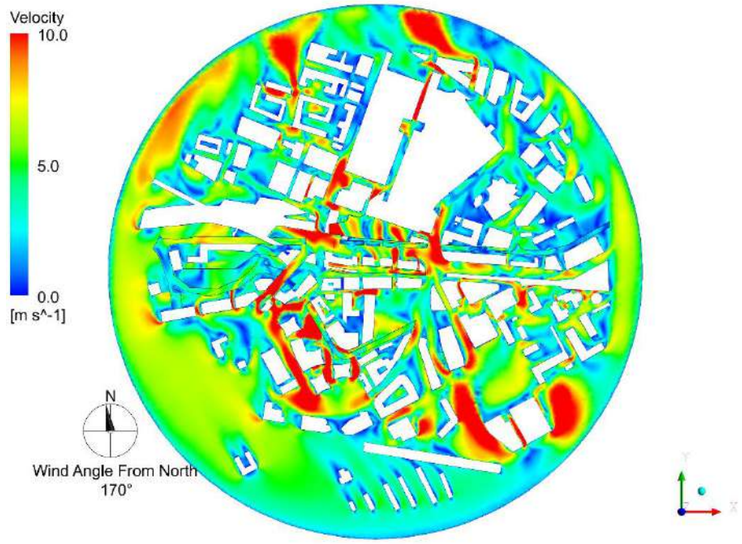


Figure 8.21: Simulated Wind Velocities: Existing 170° From North

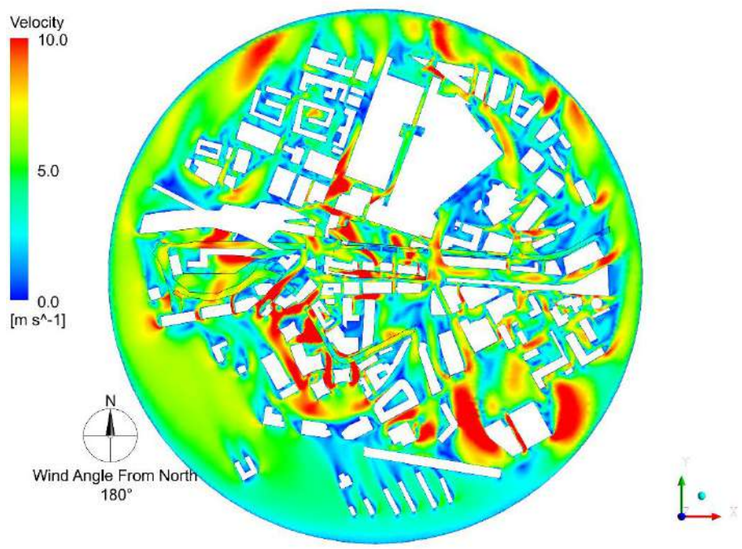


Figure 8.22: Simulated Wind Velocities: Existing 180° From North

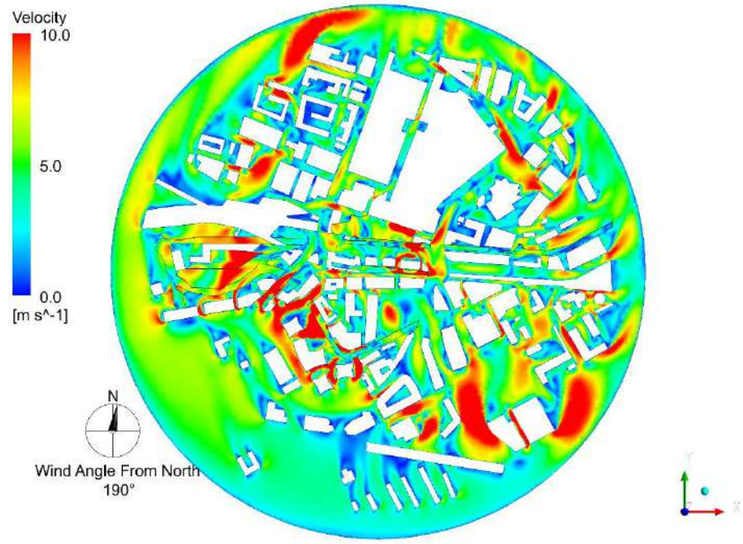


Figure 8.23: Simulated Wind Velocities: Existing 190° From North

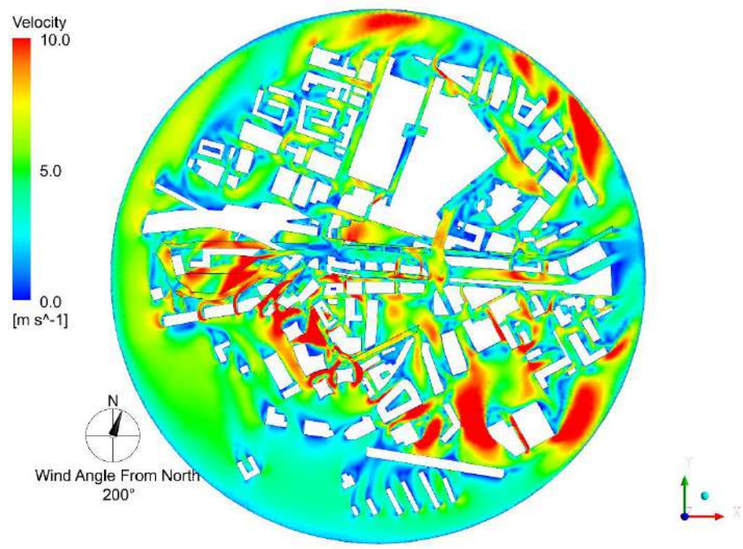


Figure 8.24: Simulated Wind Velocities: Existing 200° From North

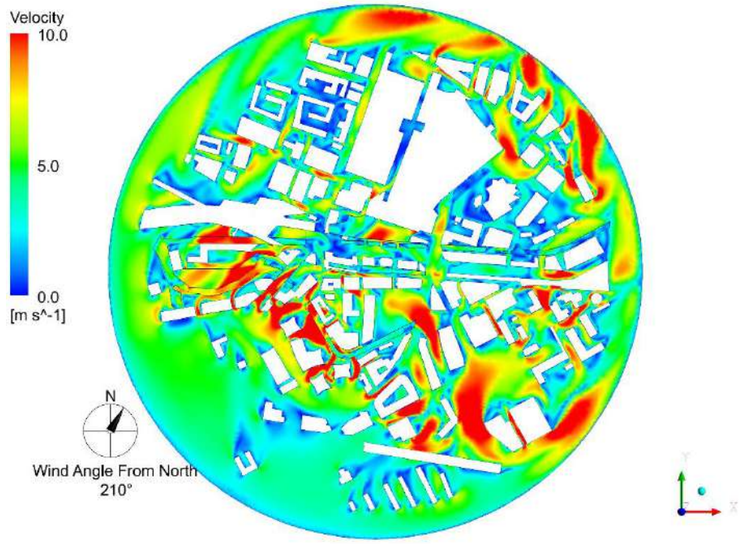


Figure 8.25: Simulated Wind Velocities: Existing 210° From North

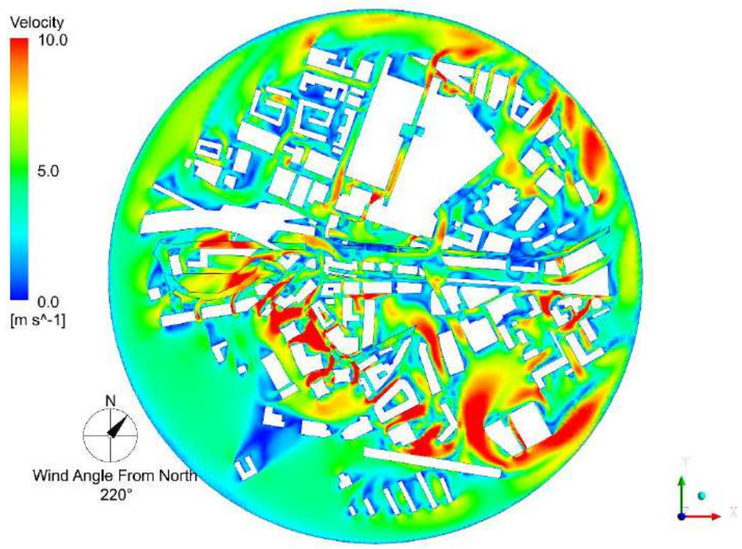


Figure 8.26: Simulated Wind Velocities: Existing 220° From North

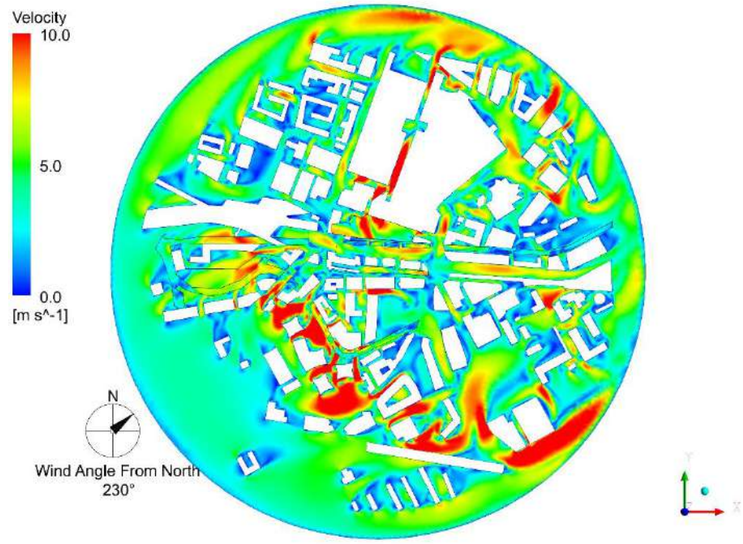


Figure 8.27: Simulated Wind Velocities: Existing 230° From North

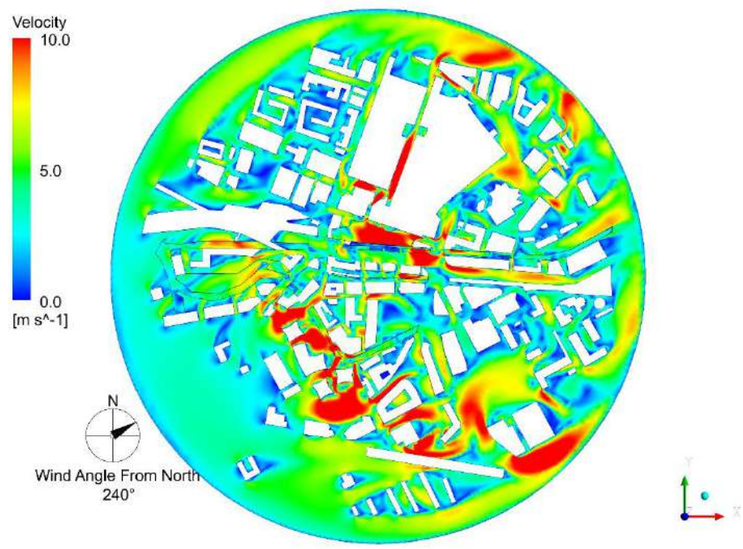


Figure 8.28: Simulated Wind Velocities: Existing 240° From North

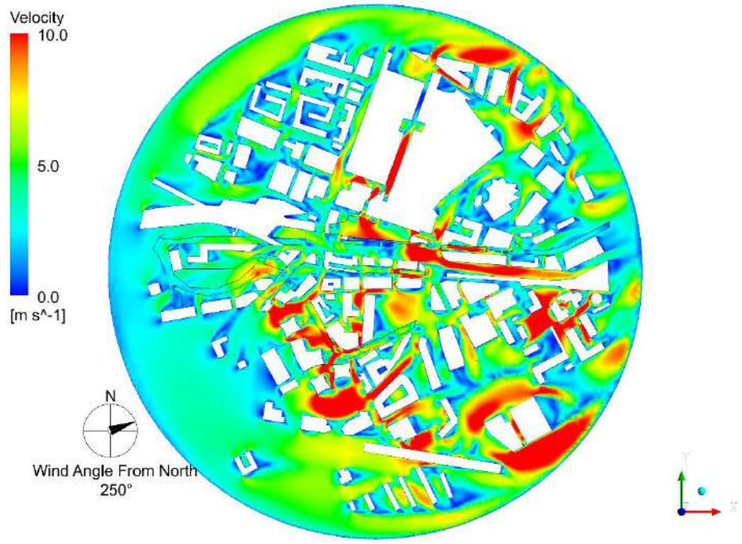


Figure 8.29: Simulated Wind Velocities: Existing 250° From North

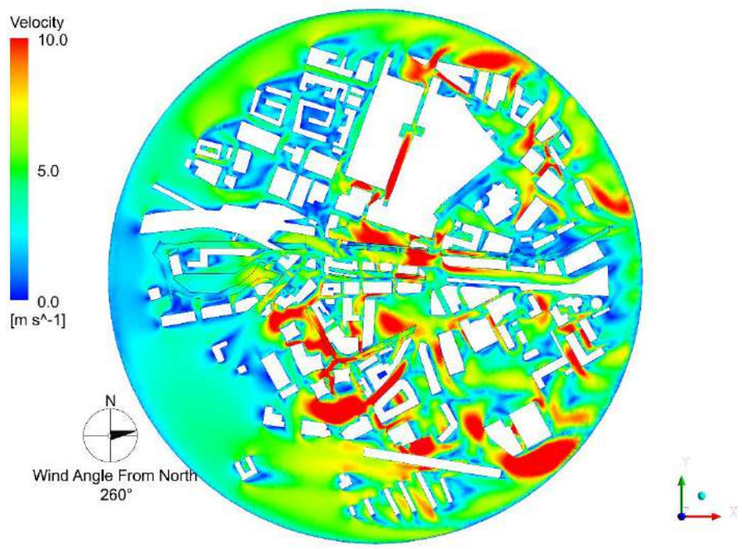


Figure 8.30: Simulated Wind Velocities: Existing 260° From North

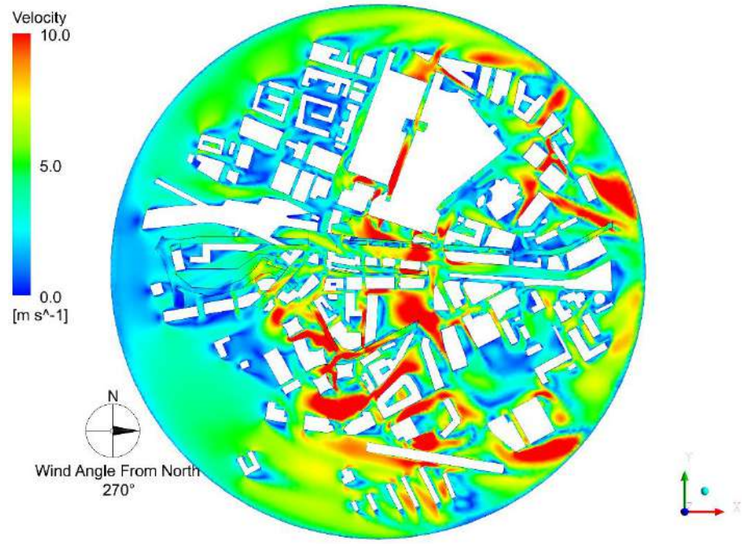


Figure 8.31: Simulated Wind Velocities: Existing 270° From North

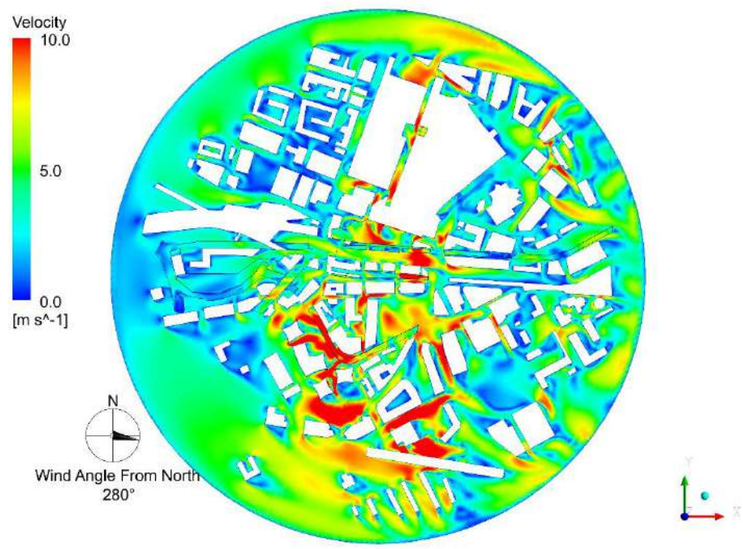


Figure 8.32: Simulated Wind Velocities: Existing 280° From North

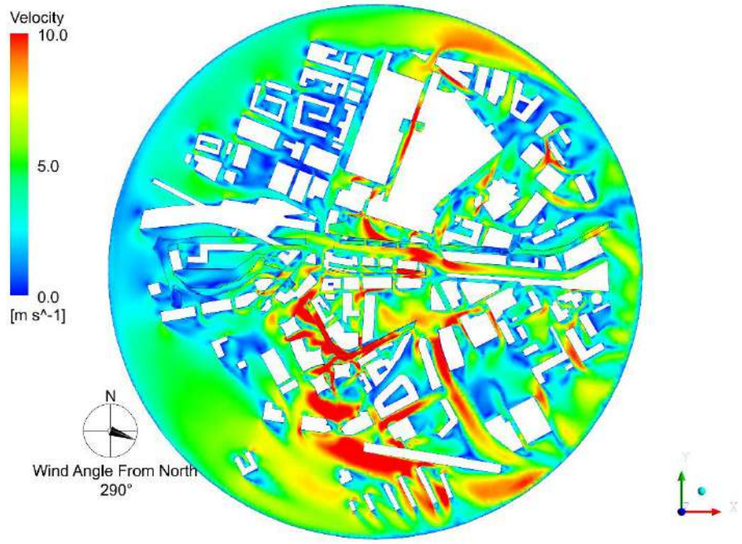


Figure 8.33: Simulated Wind Velocities: Existing 290° From North

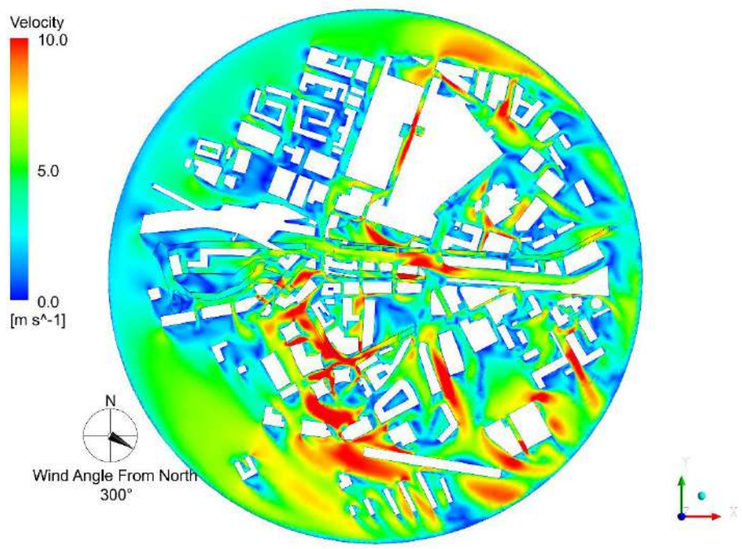


Figure 8.34: Simulated Wind Velocities: Existing 300° From North

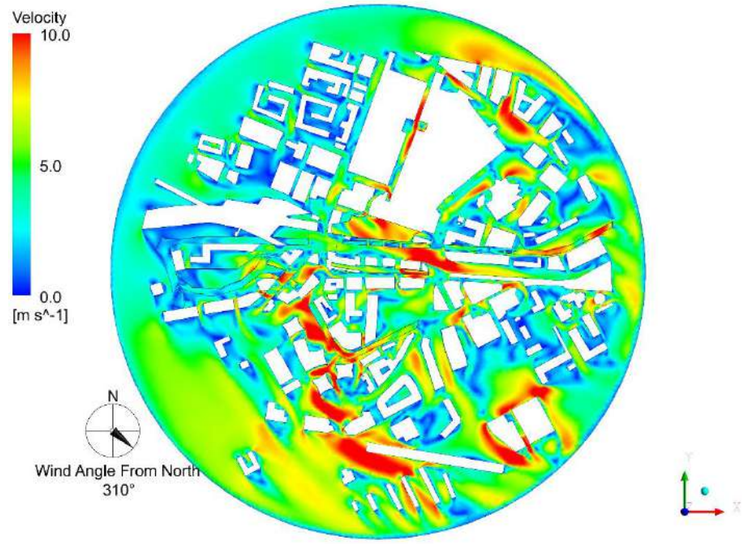


Figure 8.35: Simulated Wind Velocities: Existing 310° From North

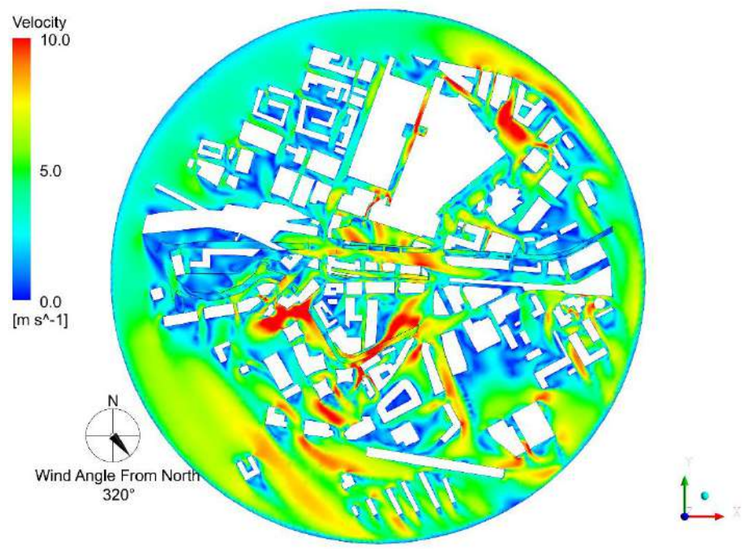


Figure 8.36: Simulated Wind Velocities: Existing 320° From North

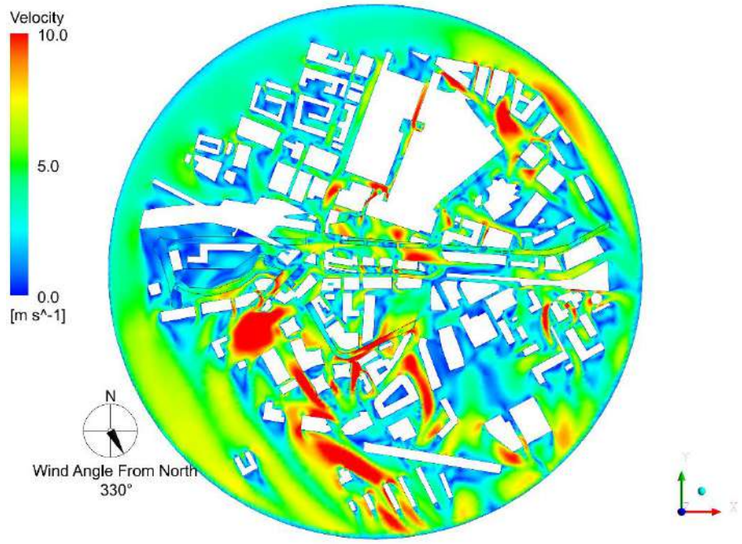


Figure 8.37: Simulated Wind Velocities: Existing 330° From North

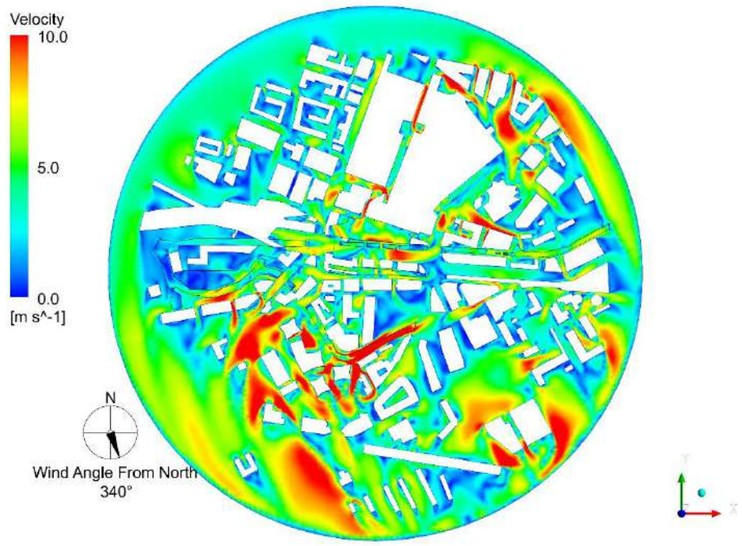


Figure 8.38: Simulated Wind Velocities: Existing 340° From North

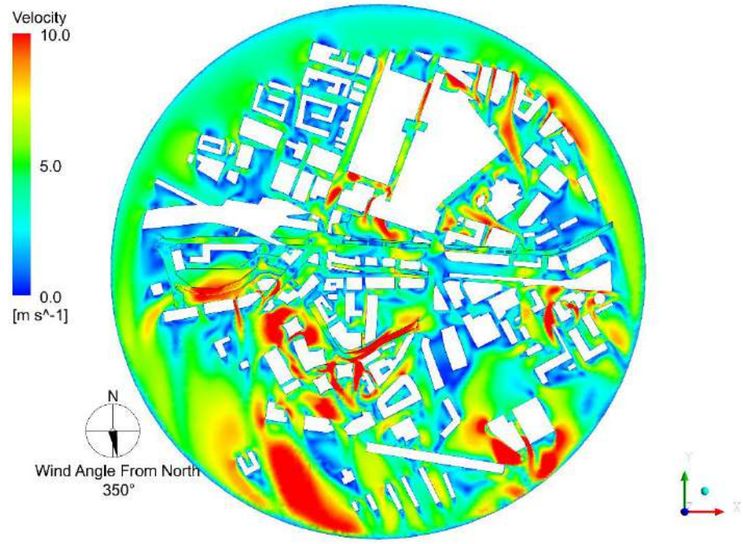


Figure 8.39: Simulated Wind Velocities: Existing 350° From North

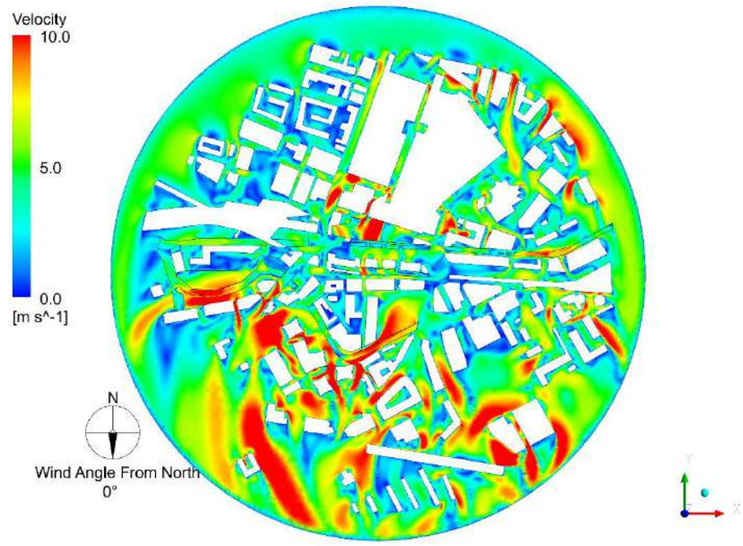


Figure 8.40: Simulated Wind Velocities: Existing 360° From North

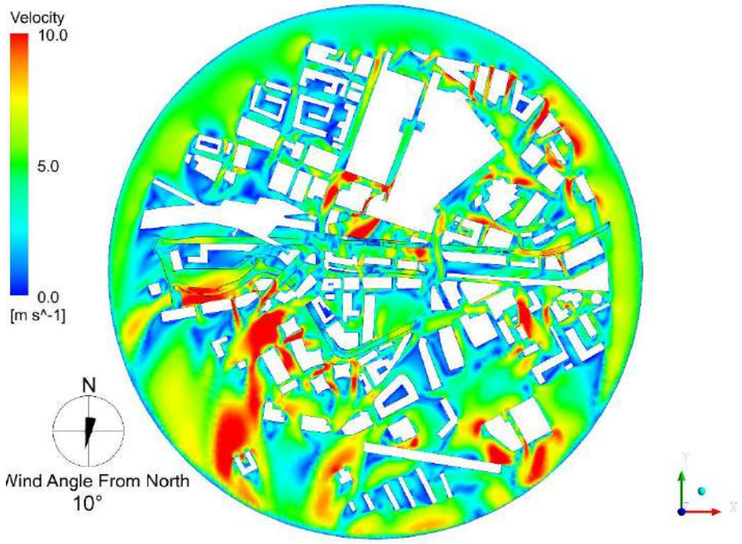


Figure 8.41: Simulated Wind Velocities: Proposed 10° From North

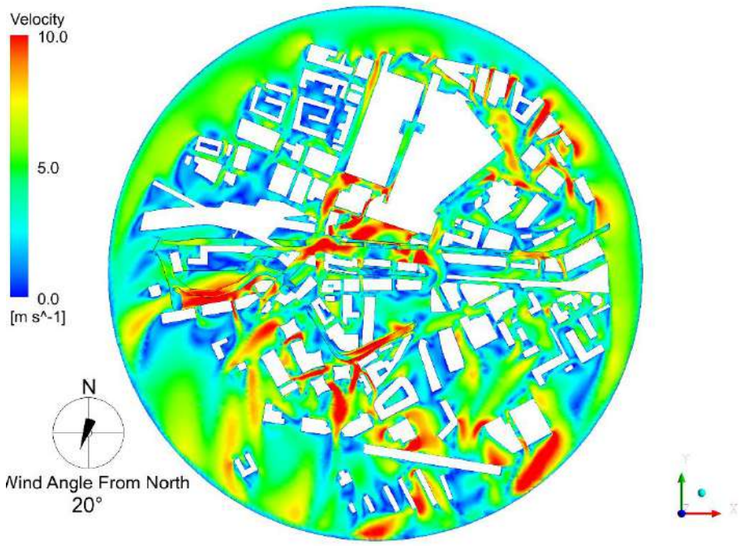


Figure 8.42: Simulated Wind Velocities: Proposed 20° From North

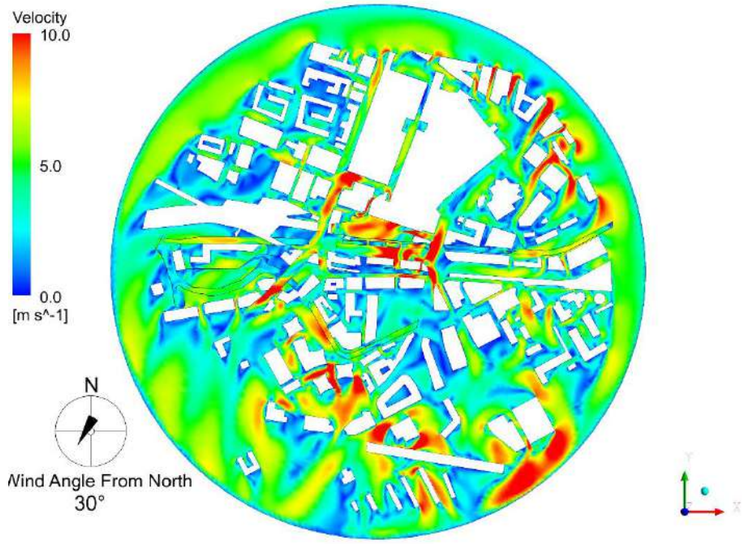


Figure 8.43: Simulated Wind Velocities: Proposed 30° From North

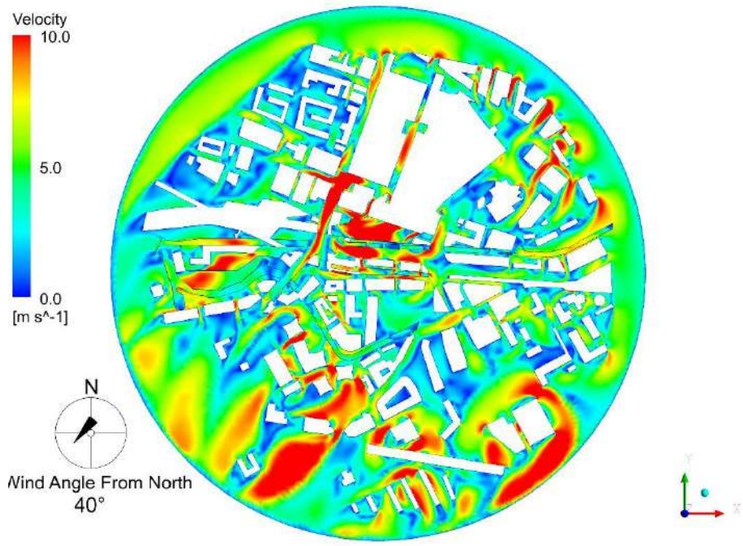


Figure 8.44: Simulated Wind Velocities: Proposed 40° From North

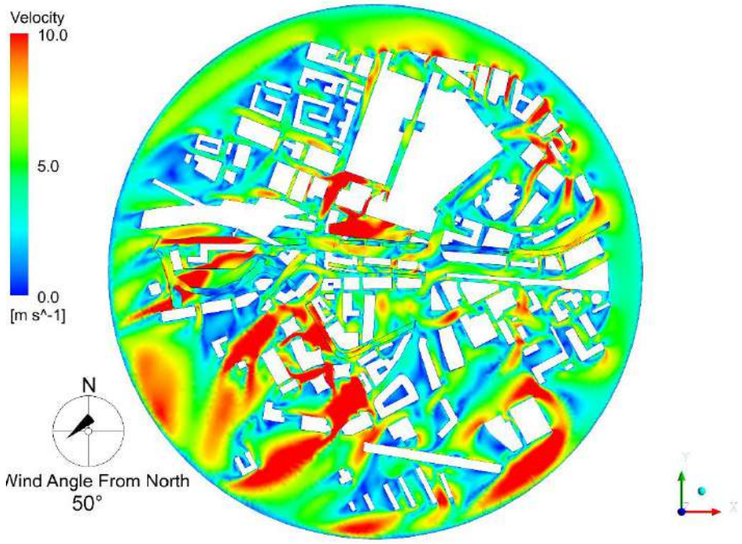


Figure 8.45: Simulated Wind Velocities: Proposed 50° From North

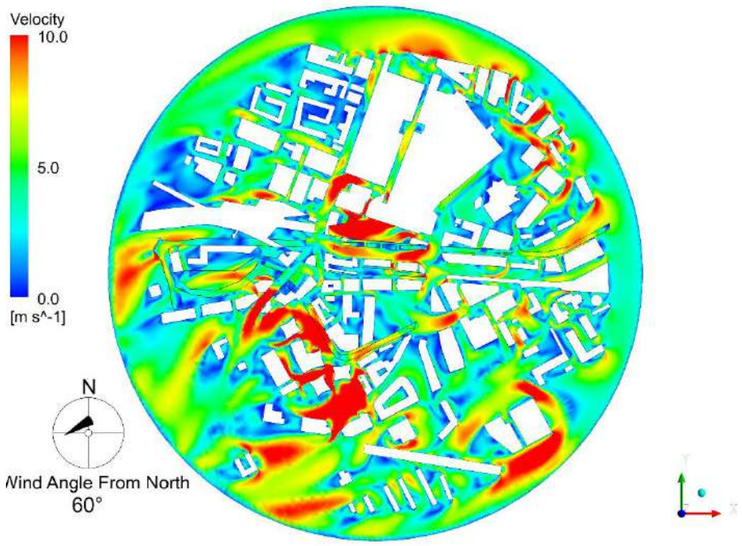


Figure 8.46: Simulated Wind Velocities: Proposed 60° From North

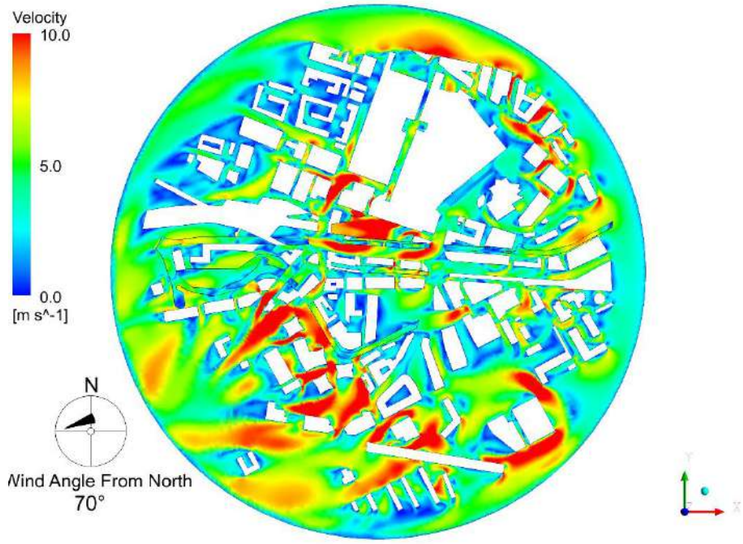


Figure 8.47: Simulated Wind Velocities: Proposed 70° From North

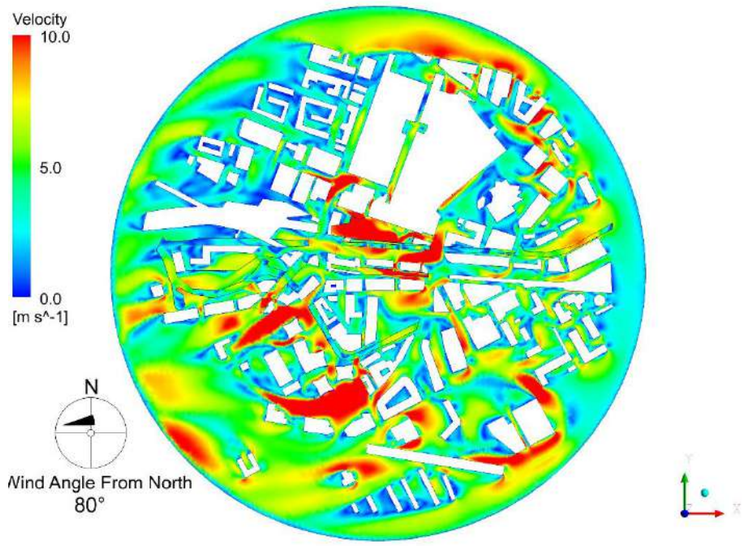


Figure 8.48: Simulated Wind Velocities: Proposed 80° From North

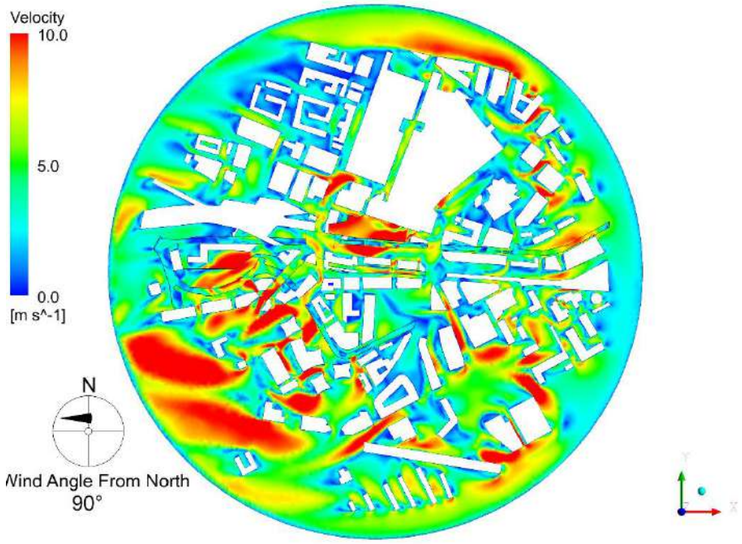


Figure 8.49: Simulated Wind Velocities: Proposed 90° From North

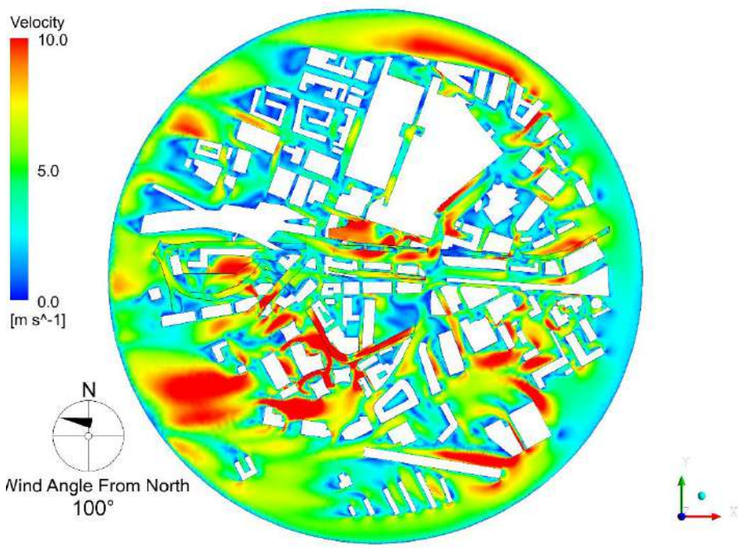


Figure 8.50: Simulated Wind Velocities: Proposed 100° From North

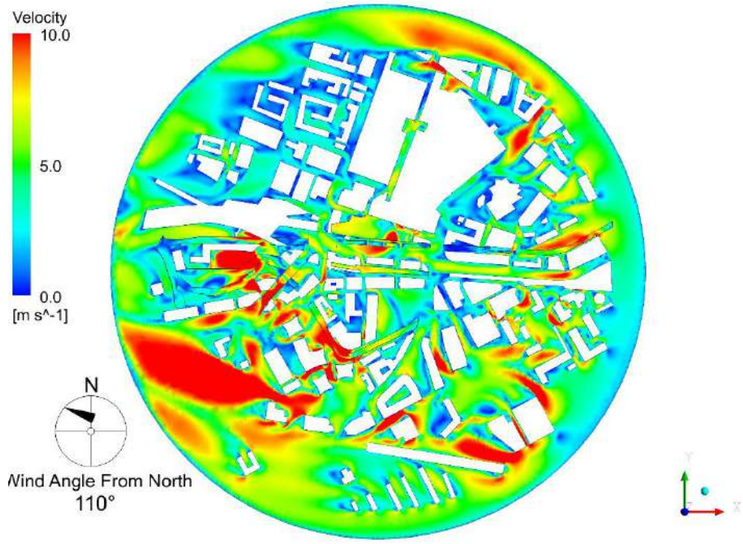


Figure 8.51: Simulated Wind Velocities: Proposed 110° From North

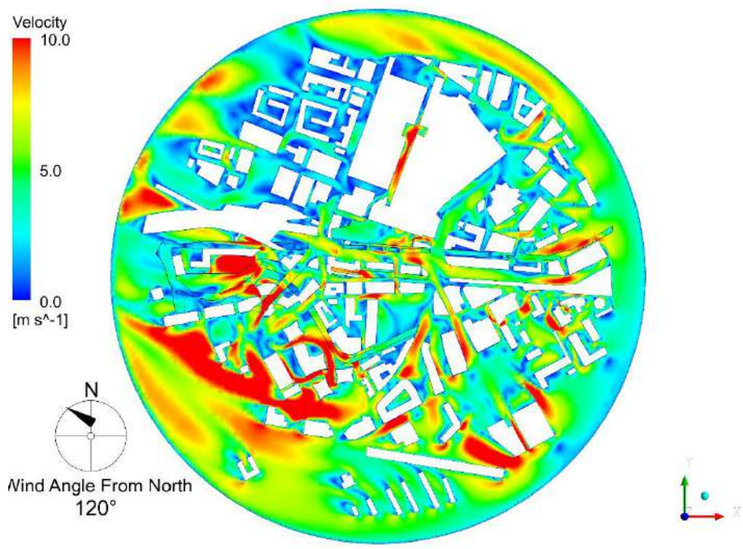


Figure 8.52: Simulated Wind Velocities: Proposed 120° From North

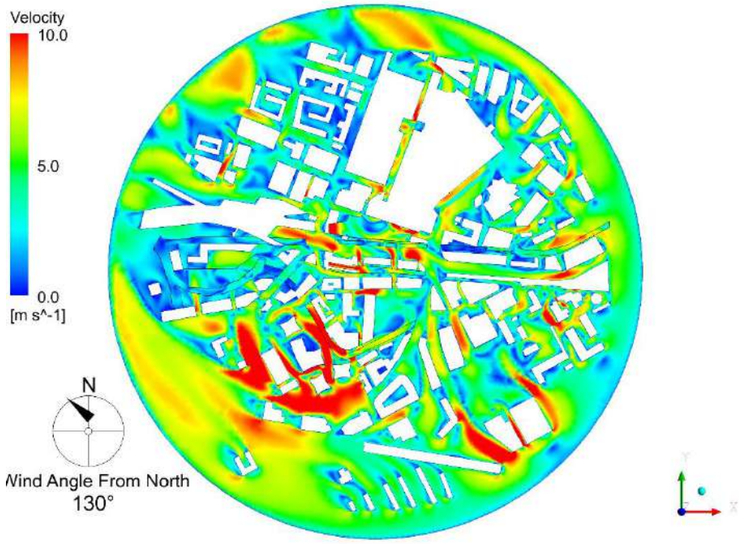


Figure 8.53: Simulated Wind Velocities: Proposed 130° From North

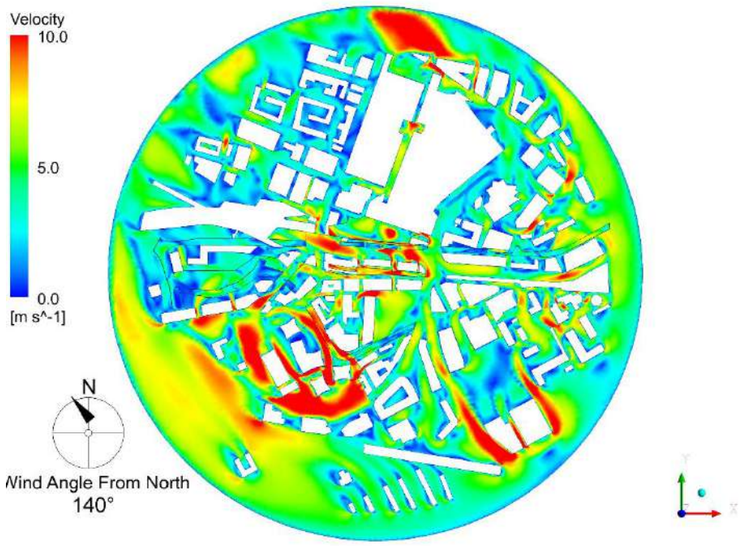


Figure 8.54: Simulated Wind Velocities: Proposed 140° From North

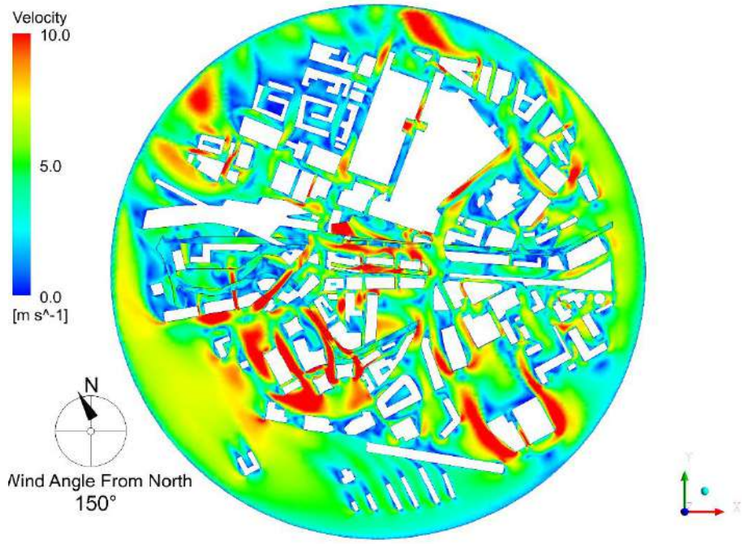


Figure 8.55: Simulated Wind Velocities: Proposed 150° From North

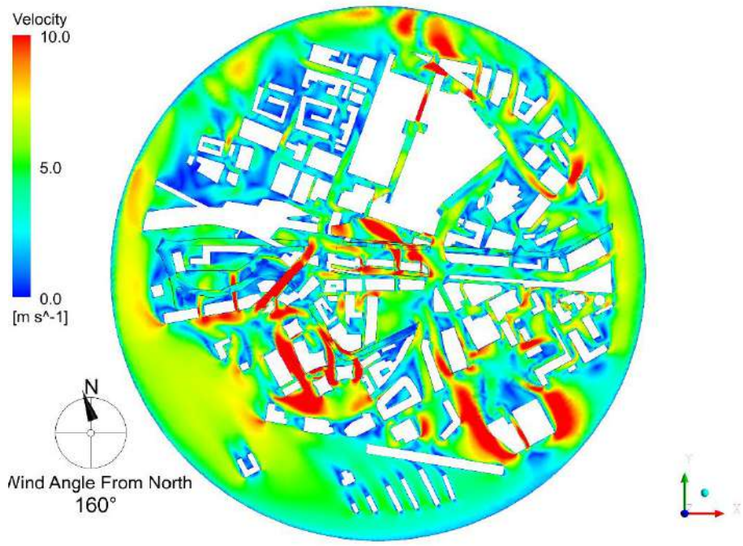


Figure 8.56: Simulated Wind Velocities: Proposed 160° From North

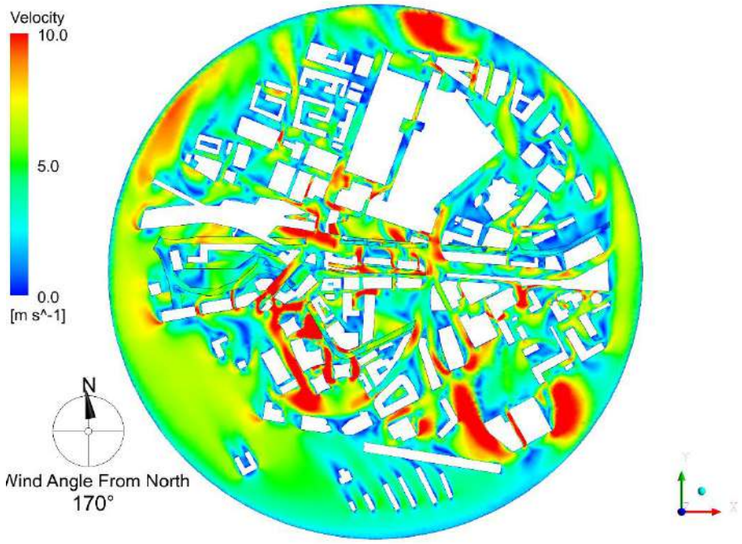


Figure 8.57: Simulated Wind Velocities: Proposed 170° From North

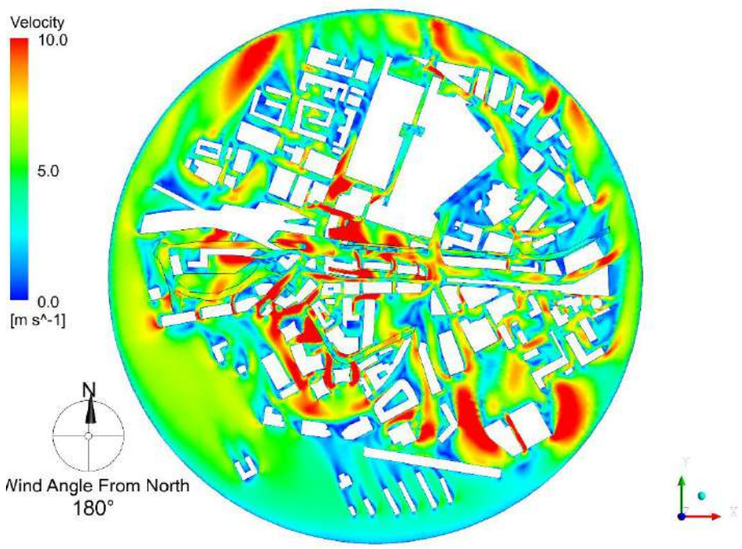


Figure 8.58: Simulated Wind Velocities: Proposed 180° From North

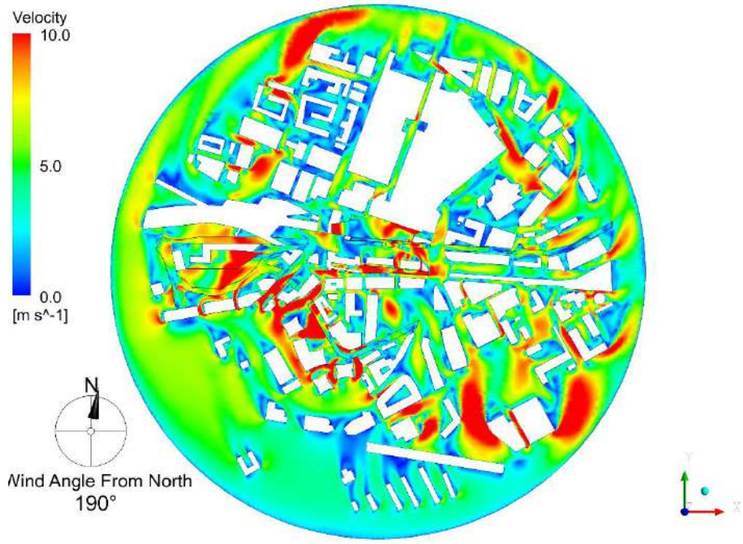


Figure 8.59: Simulated Wind Velocities: Proposed 190° From North

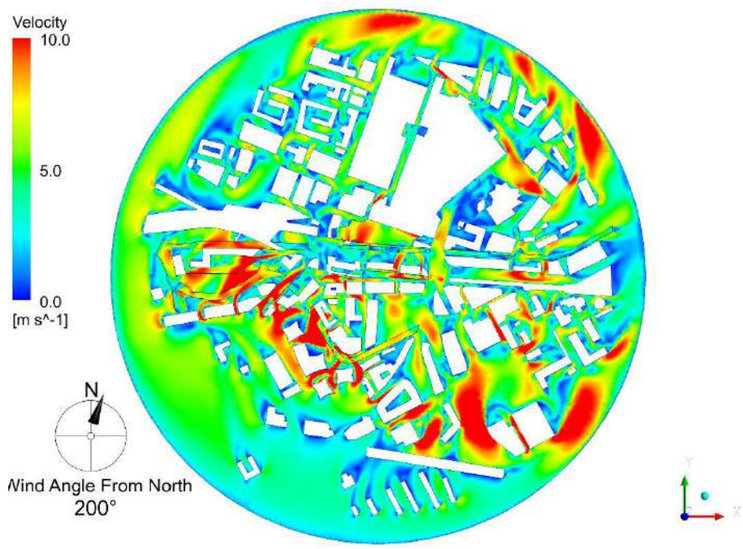


Figure 8.60: Simulated Wind Velocities: Proposed 200° From North

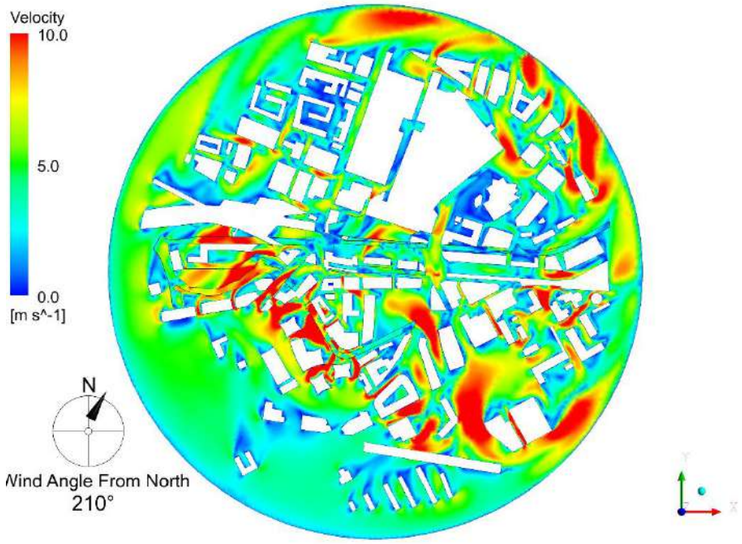


Figure 8.61: Simulated Wind Velocities: Proposed 210° From North

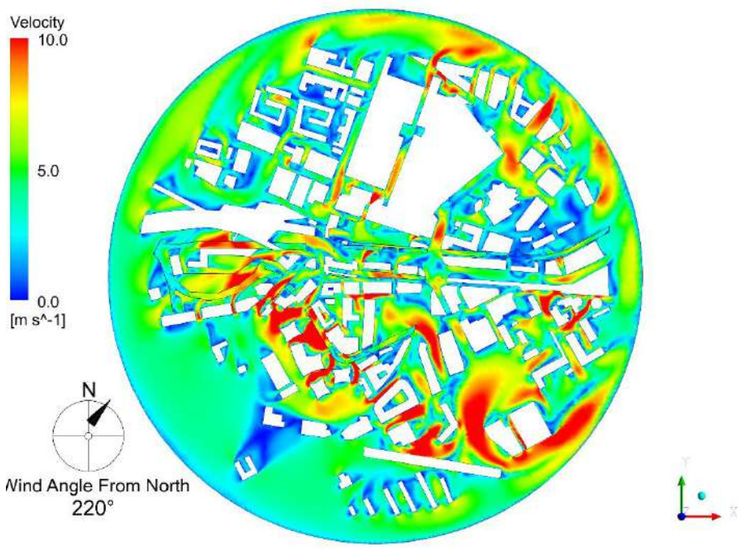


Figure 8.62: Simulated Wind Velocities: Proposed 220° From North

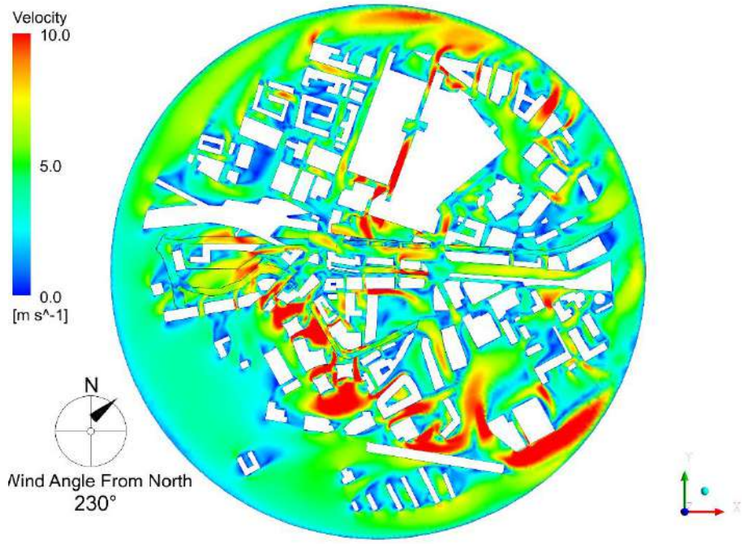


Figure 8.63: Simulated Wind Velocities: Proposed 230° From North

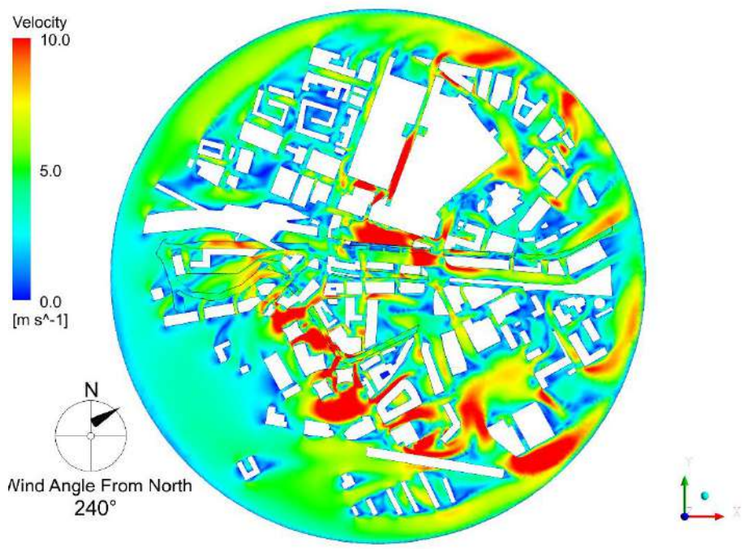


Figure 8.64: Simulated Wind Velocities: Proposed 240° From North

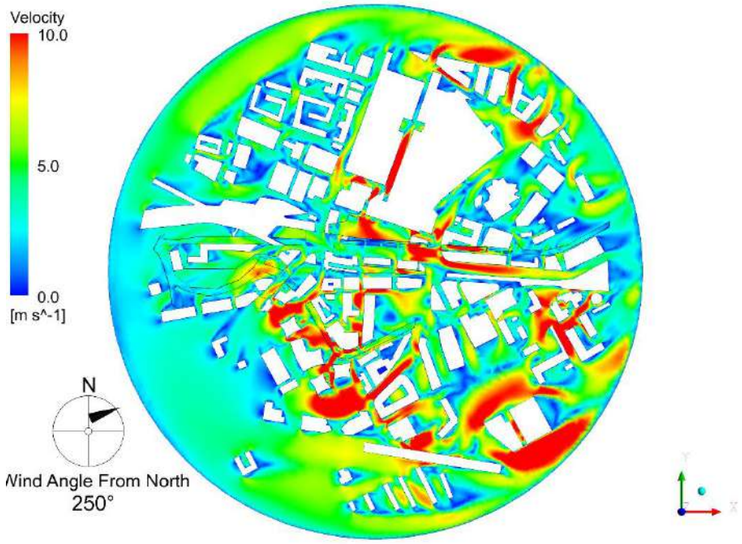


Figure 8.65: Simulated Wind Velocities: Proposed 250° From North

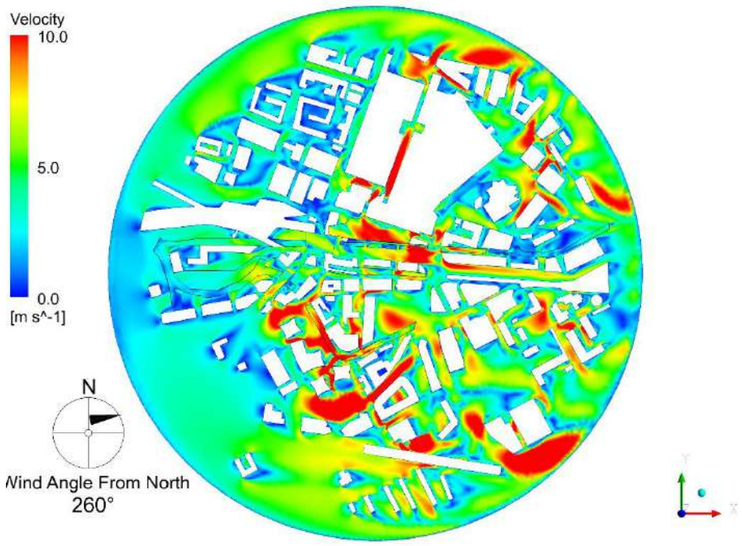


Figure 8.66: Simulated Wind Velocities: Proposed 260° From North

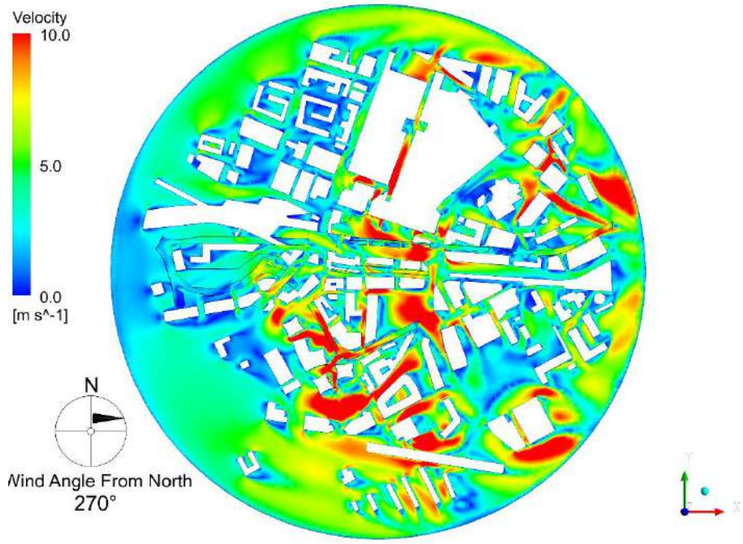


Figure 8.67: Simulated Wind Velocities: Proposed 270° From North

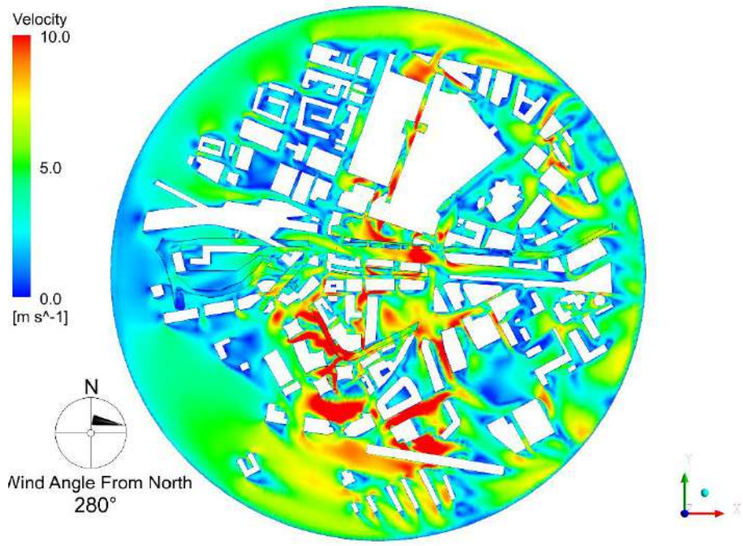


Figure 8.68: Simulated Wind Velocities: Proposed 280° From North

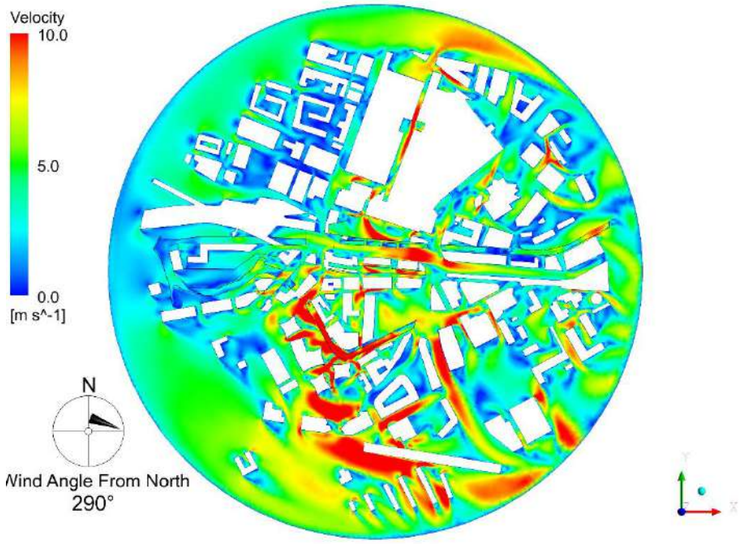


Figure 8.69: Simulated Wind Velocities: Proposed 290° From North

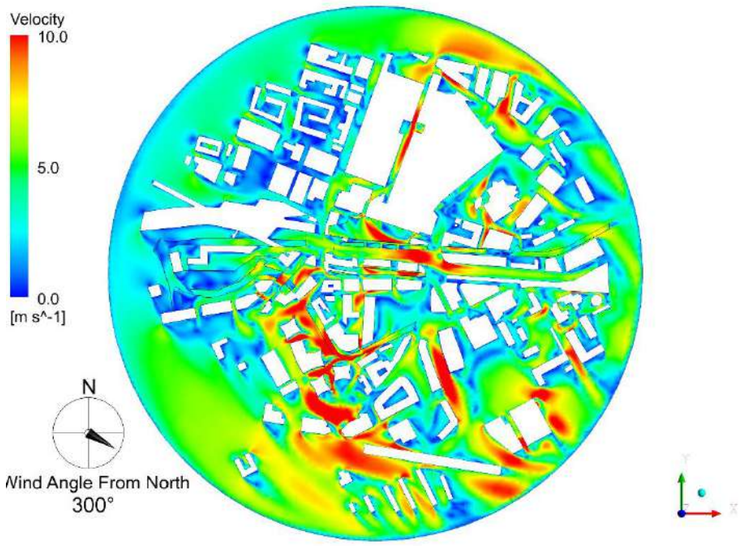


Figure 8.70: Simulated Wind Velocities: Proposed 300° From North

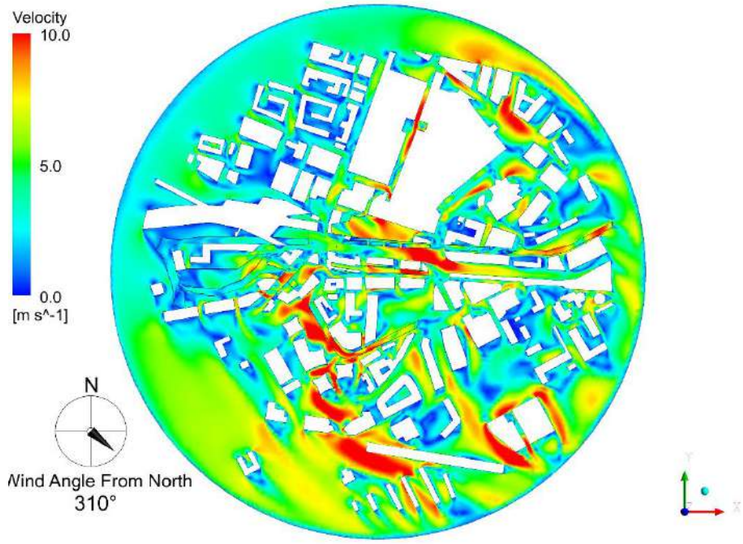


Figure 8.71: Simulated Wind Velocities: Proposed 310° From North

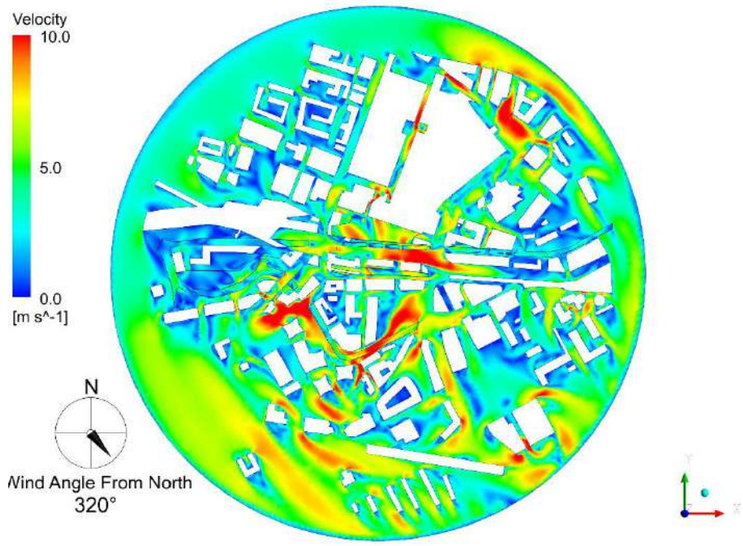


Figure 8.72: Simulated Wind Velocities: Proposed 320° From North

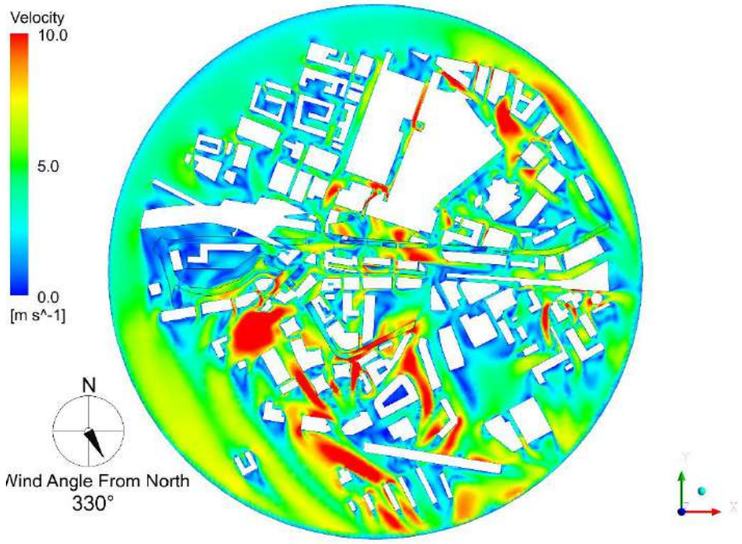


Figure 8.73: Simulated Wind Velocities: Proposed 330° From North

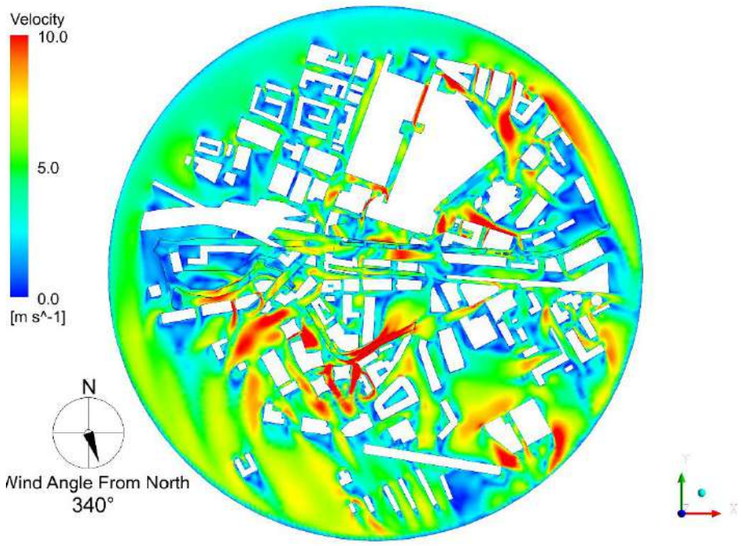


Figure 8.74: Simulated Wind Velocities: Proposed 340° From North

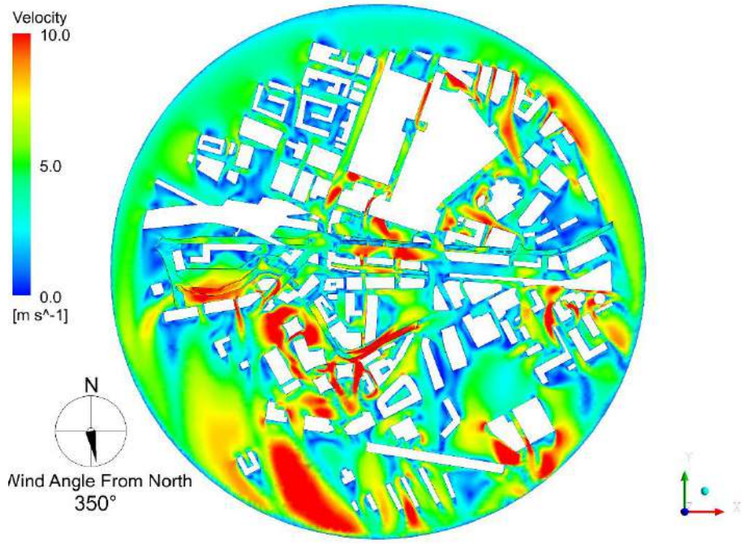


Figure 8.75: Simulated Wind Velocities: Proposed 350° From North

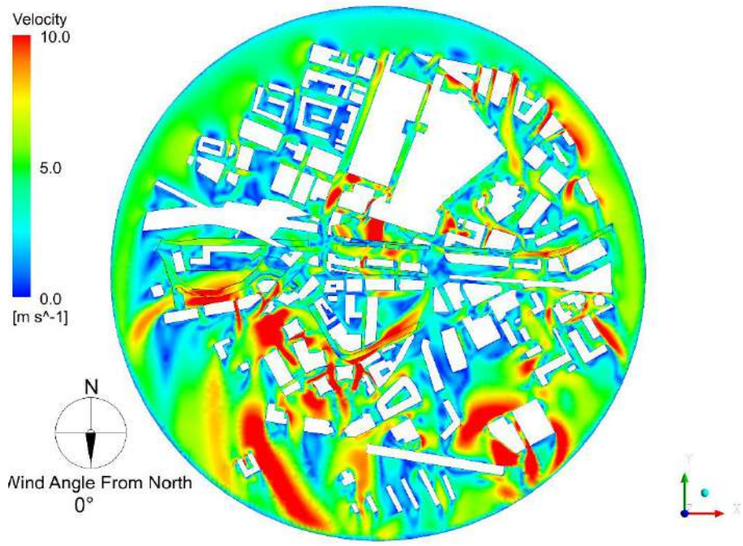


Figure 8.76: Simulated Wind Velocities: Proposed 360° From North